Convex-hull algorithms: Implementation, testing, and experimentation
From a broad perspective, we study issues related to implementation, testing, and experimentation in the context of geometric algorithms. Our focus is on the effect of quality of implementation on experimental results. More concisely, we study algorithms that compute convex hulls for a multiset of points in the plane. We introduce several improvements to the implementations of the studied algorithms: PLANE-SWEEP, TORCH, QUICKHULL, and THROW-AWAY. With a new set of space-efficient implementations, the experimental results-in the integer-arithmetic setting-are different from those of earlier studies. From this, we conclude that utmost care is needed when doing experiments and when trying to draw solid conclusions upon them.

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25 years of elevation changes of the Greenland Ice Sheet from ERS, Envisat, and CryoSat-2 radar altimetry
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25 Year Time Series of Multiple-Satellite Ice Sheet Changes: the ESA Climate Change Initiative

Understanding the long-term changes in the ice sheets of Greenland and Antarctica has global climate significance, especially on long term global sea level rise predictions. Having validated satellite data on current and recent past changes of the ice sheets are crucial for validating climate and earth system models, and give good opportunities for space geodesy to play an important role for society. Under the ESA Climate Change Initiative two projects on Greenland and Antarctica ice sheet changes are making past and present space measurements of the ice sheets available for use by scientists, stakeholders and the general public. The data are part of a large set of ECV’s (Essential Climate Variables) made available by the ESA Climate Initiative, as a contribution to the global Climate Observing System. The ECV data produced include detailed elevation change data from radar altimetry ice flow velocities from synthetic aperture radar missions, mass changes from GRACE, as well as data of glacier and ice shelf grounding lines and (for Greenland) glacier calving front locations from radar and optical data.

In the poster we highlight current CCI results on changes in Greenland, with special focus on 25 year elevation changes from ERS-1, ERS-2, Envisat and CryoSat, as well as the Greenland-wide velocity mapping, and the GRACE mass change results.

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Contributors: Forsberg, R., Sørensen, L., Simonsen, S., Barletta, V., Kusk, A., Nagler, T., Hetzenecker, M., Shepherd, A., Groh, A., Solgaard, A., Engdahl, M.
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275 Candidates and 149 Validated Planets Orbiting Bright Stars in K2 Campaigns 0–10

Since 2014, NASA’s K2 mission has observed large portions of the ecliptic plane in search of transiting planets and has detected hundreds of planet candidates. With observations planned until at least early 2018, K2 will continue to identify more planet candidates. We present here 275 planet candidates observed during Campaigns 0–10 of the K2 mission that are orbiting stars brighter than 13 mag (in Kepler band) and for which we have obtained high-resolution spectra (R = 44,000). These candidates are analyzed using the vespa package in order to calculate their false-positive probabilities (FPP). We find that 149 candidates are validated with an FPP lower than 0.1%, 39 of which were previously only candidates and 56 of which were previously undetected. The processes of data reduction, candidate identification, and statistical validation are described, and the demographics of the candidates and newly validated planets are explored. We show tentative evidence of a gap in the planet radius distribution of our candidate sample. Comparing our sample to the Kepler candidate sample investigated by Fulton et al., we conclude that more planets are required to quantitatively confirm the gap with K2 candidates or validated planets. This work, in addition to increasing the population of validated K2 planets by nearly 50% and providing new targets for follow-up observations, will also serve as a framework for validating candidates from upcoming K2 campaigns and the Transiting Exoplanet Survey Satellite, expected to launch in 2018.

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A 3D particle Monte Carlo approach to studying nucleation

The nucleation of sulphuric acid molecules plays a key role in the formation of aerosols. We here present a three-dimensional particle Monte Carlo model to study the growth of sulphuric acid clusters as well as its dependence on the ambient temperature and the initial particle density. We initiate a swarm of sulphuric acid–water clusters with a size of 0.329 nm with densities between $10^7$ and $10^8$ cm$^{-3}$ at temperatures between 200 and 300 K and a relative humidity of 50%. After every time step, we update the position of particles as a function of size-dependent diffusion coefficients. If two particles encounter, we merge them and add their volumes and masses. Inversely, we check after every time step whether a polymer evaporates liberating a molecule. We present the spatial distribution as well as the size distribution calculated from individual clusters. We also calculate the nucleation rate of clusters with a radius of 0.85 nm as a function of time, initial particle density and temperature. The nucleation rates obtained from the presented model agree well with experimentally obtained values and those of a numerical model which serves as a benchmark of our code. In contrast to previous nucleation models, we here present for the first time a code capable of tracing individual particles and thus of capturing the physics related to the discrete nature of particles.

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A benchmark study of numerical implementations of the sea-level equation in GIA modelling

The ocean load in glacio-isostatic adjustment (GIA) modelling is represented by the so-called sea-level equation (SLE). The SLE describes the mass redistribution of water between ice sheets and oceans on a deforming Earth. Despite various teams independently investigating GIA, there has been no systematic intercomparison amongst the numerical solvers of the SLE through which the methods may be validated. The goal of this paper is to present a series of synthetic examples designed for testing and comparing the numerical implementations of the SLE in GIA modelling. The ten numerical codes tested combine various temporal and spatial parameterizations. The time-domain or Laplace-domain discretizations are...
used to solve the SLE through time, while spherical harmonics, finite differences or finite elements parameterize the GIA-related field variables spatially. The surface ice-water load and solid Earth’s topography are represented spatially either on an equi-angular grid, a Gauss-Legendre or an equi-area grid with icosahedron-shaped spherical pixels. Comparisons are made in a series of five benchmark examples with an increasing degree of complexity. Due to the complexity of the SLE, there is no analytical solution to it. The accuracy of the numerical implementations is therefore assessed by the differences of the individual solutions with respect to a reference solution. While the benchmark study does not result in GIA predictions for a realistic loading scenario, we establish a set of agreed-upon results that can be extended in the future by including more complex case studies, such as solutions with realistic loading scenarios, the rotational feedback in the linear-momentum equation, and by considering a three-dimensional viscosity structure of the Earth’s mantle. The test computations performed so far show very good agreement between the individual results and their ability to capture the main features of sea-surface variation and the surface vertical displacement. The differences found can often be attributed to the different approximations inherent in the various algorithms. This shows the accuracy that can be expected from different implementations of the SLE, which helps to assess differences noted in the literature between predictions for realistic loading cases.

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Contributors: Martinec, Z., Klemann, V., van der Wal, W., Riva, R. E. M., Spada, G., Sun, Y., Melini, D., Kachuck, S. B., Barletta, V., Simon, K., A. G., James, T.
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Accurate Fiducial Mapping For Pose Estimation Using Manifold Optimization
The accurate pose estimation for moving objects within a given workspace is one of the most fundamental tasks for many applications including augmented reality, robotics’ control, planning and navigation. The information of objects’ pose is often given by motion capture systems and global positioning systems indoor and outdoor respectively. However, motion capture systems are costly and limited in workspace, while global positioning systems degrade severely in clustering environments. In this paper, we propose an approach to build a map of fiducial markers based on manifold optimization and then extend the fiducial map for pose estimation. The fiducial map based pose estimation system is cost-effective, lightweight and can work both indoor and outdoor. The proposed method starts by fiducial detection and pose estimation for collected images in order to establish an initial graph which stacks measurements of markers’relative poses. Then for each relative pose, multiple measurements are fused using manifold optimization for an optimal estimation. To deal with pose ambiguity problem, inlier poses are selected using the random sample consensus algorithm. Finally, a global pose optimization is done on manifold to minimize per frame reprojection errors. Mapping experiments with synthetic and realdata demonstrated the accuracy and consistency of the proposed approach. The accuracy of pose estimation using prebuilt fiducial map was evaluated by benchmark tests with motion capturesystems.
A chemical survey of exoplanets with ARIEL

Thousands of exoplanets have now been discovered with a huge range of masses, sizes and orbits: from rocky Earth-like planets to large gas giants grazing the surface of their host star. However, the essential nature of these exoplanets remains largely mysterious: there is no known, discernible pattern linking the presence, size, or orbital parameters of a planet to the nature of its parent star. We have little idea whether the chemistry of a planet is linked to its formation environment, or whether the type of host star drives the physics and chemistry of the planet's birth, and evolution. ARIEL was conceived to observe a large number (textasciitilde1000) of transiting planets for statistical understanding, including gas giants, Neptunes, super-Earths and Earth-size planets around a range of host star types using transit spectroscopy in the 1.25–7.8 \text{ m}\text{s} spectral range and multiple narrow-band photomery in the optical. ARIEL will focus on warm and hot planets to take advantage of their well-mixed atmospheres which should show minimal condensation and sequestration of high-Z materials compared to their colder Solar System siblings. Said warm and hot atmospheres are expected to be more representative of the planetary bulk composition. Observations of these warm/hot exoplanets, and in particular of their elemental composition (especially C, O, N, S, Si), will allow the understanding of the early stages of planetary and atmospheric formation during the nebular phase and the following few million years. ARIEL will thus provide a representative picture of the chemical nature of the exoplanets and relate this directly to the type and chemical environment of the host star. ARIEL is designed as a dedicated survey mission for combined-light spectroscopy, capable of observing a large and well-defined planet sample within its 4-year mission lifetime. Transit, eclipse and phase-curve spectroscopy methods, whereby the signal from the star and planet are differentiated using knowledge of the planetary ephemerides, allow us to measure atmospheric signals from the planet at levels of 10–100 part per million (ppm) relative to the star and, given the bright nature of targets, also allows more sophisticated techniques, such as eclipse mapping, to give a deeper insight into the nature of the atmosphere. These types of observations require a stable payload and satellite platform with broad, instantaneous wavelength coverage to detect many molecular species, probe the thermal structure, identify clouds and monitor the stellar activity. The wavelength range proposed covers all the expected major atmospheric gases from e.g. H2O, CO2, CH4 NH3, HCN, H2S through to the more exotic metallic compounds, such as TiO, VO, and condensed species. Simulations of ARIEL performance in conducting exoplanet surveys have been performed -- using conservative estimates of mission performance and a full model of all significant noise sources in the measurement -- using a list of potential ARIEL targets that incorporates the latest available exoplanet statistics. The conclusion at the end of the Phase A study, is that ARIEL -- in line with the stated mission objectives -- will be able to observe about 1000 exoplanets depending on the details of the adopted survey strategy, thus confirming the feasibility of the main science objectives.
A Coastal Mean Sea Surface with Associated Errors along the Norwegian Coast Based on New-Generation Altimetry

The coastal mean sea surface (MSS) has applications within oceanography as well as geodesy. Together with a geoid model, it forms an important component for geodetic mapping of ocean surface currents that are in geostrophic balance. Furthermore, it forms a bridge between open ocean MSS and in situ measurements of mean sea level at or close to land, it contributes to the mapping of the geoid and the marine gravity field, and it is essential for connecting tidal nautical chart datums to physical height systems or global geodetic reference frames. In this study, we determine a coastal MSS with an associated error field for Norway. The MSS is solely based on new-generation altimetry data, i.e., SAR(In) data from Sentinel-3A and CryoSat-2, as well as Ka-band data from Saral/AltiKa. The data sets partly overlap in time and cover the time period from 2010 to 2017 inclusive. We have chosen these altimeters because they represent evolutions of conventional altimetry, with reduced footprint diameters as a main benefit. This is especially advantageous in the coastal zone, as a smaller footprint reduces the probability of radar pulses being contaminated by energy backscattered from land areas. The satellite missions were harmonized by applying inter-mission biases calculated in a regional crossover analysis. Furthermore, in a zone closer to land than 25 km, we have replaced the global ocean tide model with a regional ocean tide model provided by the Norwegian Mapping Authority. We explore different data editing strategies, compare two methods for optimal interpolation of the along-track data to a regular grid, and discuss these in the context of the estimated error field. We assess our coastal MSS by comparison to existing state-of-the-art MSS products, as well as ellipsoidal mean sea level as observed by an array of tide gauges within the study area. The Norwegian coast is characterized by thousands of small islands, narrow fjords, rough topography, and complex tidal patterns, making the altimetric measurement of the sea surface height particularly demanding in this area.

A Combined Mean Dynamic Topography Model – DTU17cMDT

Within the ESA supported Optimal Geoid for Modelling Ocean Circulation (OGMOC) project a new geoid model have been derived. It is based on the GOCC05C setup though the newer DTU15GRA altimetric surface gravity has been used in the combination. Subsequently the model has been augmented using the EIGEN-6C4 coefficients to d/o 2160. Compared to the DTU13MSS, the DTU15MSS has been derived by including re-tracked CRYOSAT-2 altimetry also, hence, increasing its resolution. Also, some issues in the Polar regions have been solved. The new DTU17MDT has been derived using this new geoid model and the DTU15MSS mean sea surface. Compared to other geoid models the new OGMOC geoid model has been optimized to avoid striations and orange skin like features. The filtering was re-evaluated by adjusting the quasi-gaussian filter width to optimize the fit to drifter velocities. The results show that the new MDT improves the resolution of the details of the ocean circulation. Subsequently, the drifter velocities were integrated to enhance the resolution of the MDT. As a contribution to the ESA supported GOCE++ project DYCOT a special concern was devoted to the coastal areas to optimize the extrapolation towards the coast and to integrate mean sea levels at tide gauges into that process. The presentation will focus on the coastal zone when assessing the methodology, the data and the final model DTU17cMDT.
A Compact Multi-planet System with a Significantly Misaligned Ultra Short Period Planet

We report the discovery of a compact multi-planet system orbiting the relatively nearby (78 pc) and bright (K = 8.9) K-star, K2-266 (EPIC 248435473). We identify up to six possible planets orbiting K2-266 with estimated periods of P_b = 0.66, P_c = 6.1, P_d = 14.7, P_e = 19.5, and P_{06} = 56.7 days, and radii of R_b = 3.3 R_⊕, R_c = 0.646 R_⊕, R_d = 0.705 R_⊕, R_{02} = 2.73 R_⊕, and R_{06} = 0.90 R_⊕, respectively. We are able to confirm the planetary nature of two of these planets (d and e) by analyzing their transit timing variations (m_d = 8.9 ± 5.7 / , m_e = 14.3 ± 6.4 / ) and confidently validate the planetary nature of two other planets (b and c), and classify the last two as planetary candidates (K2-266.02 and .06). From a simultaneous fit of all six possible planets, we find that K2-266 b's orbit has an inclination of 75°± 32° while the other five planets have inclinations of 87°–90°. This observed mutual misalignment may indicate that K2-266 b formed differently from the other planets in the system. The brightness of the host star and the relatively large size of the sub-Neptune sized planets d and e make them well-suited for atmospheric characterization efforts with facilities like the Hubble Space Telescope and upcoming James Webb Space Telescope. We also identify an 8.5 day transiting planet candidate orbiting EPIC 248435395, a co-moving companion to K2-266.

A complex dynamo inferred from the hemispheric dichotomy of Jupiter’s magnetic field

The Juno spacecraft, which is in a polar orbit around Jupiter, is providing direct measurements of the planet’s magnetic field close to its surface. A recent analysis of observations of Jupiter’s magnetic field from eight (of the first nine) Juno orbits has provided a spherical-harmonic reference model (JRM09) of Jupiter’s magnetic field outside the planet. This model is of particular interest for understanding processes in Jupiter’s magnetosphere, but to study the field within the planet and thus the dynamo mechanism that is responsible for generating Jupiter’s main magnetic field, alternative models are preferred. Here we report maps of the magnetic field at a range of depths within Jupiter. We find that Jupiter’s magnetic field is different from all other known planetary magnetic fields. Within Jupiter, most of the flux emerges from the
dynamo region in a narrow band in the northern hemisphere, some of which returns through an intense, isolated flux patch near the equator. Elsewhere, the field is much weaker. The non-dipolar part of the field is confined almost entirely to the northern hemisphere, so there the field is strongly non-dipolar and in the southern hemisphere it is predominantly dipolar. We suggest that Jupiter’s dynamo, unlike Earth’s, does not operate in a thick, homogeneous shell, and we propose that this unexpected field morphology arises from radial variations, possibly including layering, in density or electrical conductivity, or both.
A curious case of the accretion-powered X-ray pulsar GX 1+4

We present detailed spectral and timing studies using a NuSTAR observation of GX 1+4 in 2015 October during an intermediate-intensity state. The measured spin period of 176.778 s is found to be one of the highest values since its discovery. In contrast to a broad sinusoidal-like pulse profile, a peculiar sharp peak is observed in profiles below ∼25 keV. The profiles at higher energies are found to be significantly phase shifted compared to the soft X-ray profiles. Broad-band energy spectra of GX 1+4, obtained from NuSTAR and Swift observations, are described with various continuum models. Among these, a two-component model consisting of a bremsstrahlung and a blackbody component is found to best fit the phase-averaged and phase-resolved spectra. Physical models are also used to investigate the emission mechanism in the pulsar, which allows us to estimate the magnetic field strength to be in (5–10) × 10¹² G range. Phase-resolved spectroscopy of NuSTAR observation shows a strong blackbody emission component in a narrow pulse phase range. This component is interpreted as the origin of the peculiar peak in the pulse profiles below ≤25 keV. The size of emitting region is calculated to be ∼400 m. The bremsstrahlung component is found to dominate in hard X-rays and explains the nature of simple profiles at high energies.

A deep X-ray view of the bare AGN Ark120. IV. XMM-Newton and NuSTAR spectra dominated by two temperature (warm, hot) Comptonization processes.

Context. The physical characteristics of the material closest to supermassive black holes (SMBHs) are primarily studied through X-ray observations. However, the origins of the main X-ray components such as the soft X-ray excess, the FeKα line complex, and the hard X-ray excess are still hotly debated. This is particularly problematic for active galactic nuclei (AGN) showing a significant intrinsic absorption, either warm or neutral, which can severely distort the observed continuum. Therefore, AGN with no (or very weak) intrinsic absorption along the line of sight, so-called “bare AGN”, are the best targets to directly probe matter very close to the SMBH.Aims. We perform an X-ray spectral analysis of the brightest and cleanest bare AGN known so far, Ark120, in order to determine the process(es) at work in the vicinity of the SMBH.Methods. We present spectral analyses of data from an extensive campaign observing Ark120 in X-rays with XMM-Newton (4 × 120 ks, 2014 March 18–24), and NuSTAR (65.5 ks, 2014 March 22).Results. During this very deep X-ray campaign, the source was caught in a high-flux state similar to the earlier 2003 XMM-Newton observation, and about twice as bright as the lower-flux observation in 2013. The spectral analysis confirms the “softer when brighter” behavior of
Ark 120. The four XMM-Newton/pn spectra are characterized by the presence of a prominent soft X-ray excess and a significant Fe Kα complex. The continuum is very similar above about 3 keV, while significant variability is present for the soft X-ray excess. We find that relativistic reflection from a constant-density, flat accretion disk cannot simultaneously produce the soft excess, broad Fe Kα complex, and hard X-ray excess. Instead, Comptonization reproduces the broadband (0.3–79 keV) continuum well, together with a contribution from a mildly relativistic disk reflection spectrum. Conclusions. During this 2014 observational campaign, the soft X-ray spectrum of Ark 120 below ~0.5 keV was found to be dominated by Comptonization of seed photons from the disk by a warm (kT_e ~ 0.5 keV), optically-thick corona (τ ~ 9). Above this energy, the X-ray spectrum becomes dominated by Comptonization from electrons in a hot optically thin corona, while the broad Fe Kα line and the mild Compton hump result from reflection off the disk at several tens of gravitational radii.

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A Framework for Prioritizing the TESS Planetary Candidates Most Amenable to Atmospheric Characterization
A key legacy of the recently launched the Transiting Exoplanet Survey Satellite (TESS) mission will be to provide the astronomical community with many of the best transiting exoplanet targets for atmospheric characterization. However, time is of the essence to take full advantage of this opportunity. The James Webb Space Telescope (JWST), although delayed, will still complete its nominal five year mission on a timeline that motivates rapid identification, confirmation, and mass measurement of the top atmospheric characterization targets from TESS. Beyond JWST, future dedicated missions for atmospheric studies such as the Atmospheric Remote-sensing Infrared Exoplanet Large-survey (ARIEL) require the discovery and confirmation of several hundred additional sub-Jovian size planets (R_p < 10 R_⊕) orbiting bright stars, beyond those known today, to ensure a successful statistical census of exoplanet atmospheres. Ground-based extremely large telescopes (ELTs) will also contribute to surveying the atmospheres of the transiting planets discovered by TESS. Here we present a set of two straightforward analytic metrics, quantifying the expected signal-to-noise in transmission and thermal emission spectroscopy for a given planet, that will allow the top atmospheric characterization targets to be readily identified among the TESS planet candidates. Targets that meet our proposed threshold values for these metrics would be encouraged for rapid follow-up and confirmation via radial velocity mass measurements. Based on the catalog of simulated TESS detections by Sullivan et al., we determine appropriate cutoff values of the metrics, such that the TESS mission will ultimately yield a sample of ~300 high-quality atmospheric characterization targets across a range of planet size bins, extending down to Earth-size, potentially habitable worlds.

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A NICER Look at the Aql X-1 Hard State

We report on a spectral-timing analysis of the neutron star low-mass X-ray binary (LMXB) Aql X-1 with the Neutron Star Interior Composition Explorer (NICER) on the International Space Station (ISS). Aql X-1 was observed with NICER during a dim outburst in 2017 July, collecting approximately 50 ks of good exposure. The spectral and timing properties of the source correspond to that of a (hard) extreme island state in the atoll classification. We find that the fractional amplitude of the low-frequency (<0.3 Hz) band-limited noise shows a dramatic turnover as a function of energy: it peaks at 0.5 keV with nearly 25% rms, drops to 12% rms at 2 keV, and rises to 15% rms at 10 keV. Through the analysis of covariance spectra, we demonstrate that band-limited noise exists in both the soft thermal emission and the power-law emission. Additionally, we measure hard time lags, indicating the thermal emission at 0.5 keV leads the power-law emission at 10 keV on a timescale of ~100 ms at 0.3 Hz to ~10 ms at 3 Hz. Our results demonstrate that the thermal emission in the hard state is intrinsically variable, and is driving the modulation of the higher energy power-law. Interpreting the thermal spectrum as disk emission, we find that our results are consistent with the disk propagation model proposed for accretion onto black holes.

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A large impact crater beneath Hiawatha Glacier in northwest Greenland
We report the discovery of a large impact crater beneath Hiawatha Glacier in northwest Greenland. From airborne radar surveys, we identify a 31-kilometer-wide, circular bedrock depression beneath up to a kilometer of ice. This depression has an elevated rim that cross-cuts tributary subglacial channels and a subdued central uplift that appears to be actively eroding. From ground investigations of the deglaciated foreland, we identify overprinted structures within Precambrian bedrock along the ice margin that strike tangent to the subglacial rim. Glaciofluvial sediment from the largest river draining the crater contains shocked quartz and other impact-related grains. Geochemical analysis of this sediment indicates that the impactor was a fractionated iron asteroid, which must have been more than a kilometer wide to produce the identified crater. Radiocarbon dating of the ice in the crater shows that the Holocene ice is continuous and conformable, but all deeper and older ice appears to be debris rich or heavily disturbed. The age of this impact crater is presently unknown, but from our geological and geophysical evidence, we conclude that it is unlikely to predate the Pleistocene inception of the Greenland Ice Sheet.

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ALES+: Adapting a homogenous ocean retracker for satellite altimetry to sea ice leads, coastal and inland waters
Water level from sea ice-covered oceans is particularly challenging to retrieve with satellite radar altimeters due to the different shapes assumed by the returned signal compared with the standard open ocean waveforms. Valid measurements are scarce in large areas of the Arctic and Antarctic Oceans, because sea level can only be estimated in the openings in the sea ice (leads and polynyas). Similar signal-related problems affect also measurements in coastal and inland waters.
This study presents a fitting (also called retracking) strategy (ALES+) based on a subwaveform retracker that is able to adapt the fitting of the signal depending on the sea state and on the slope of its trailing edge. The algorithm modifies the existing Adaptive Leading Edge Subwaveform retracker originally designed for coastal waters, and is applied to Envisat and ERS-2 missions.
The validation in a test area of the Arctic Ocean demonstrates that the presented strategy is more precise than the dedicated ocean and sea ice retrackers available in the mission products. It decreases the retracking open ocean noise by over 1cm with respect to the standard ocean retracker and is more precise by over 1cm with respect to the standard sea ice retracker used for fitting specular echoes. Compared to an existing open ocean altimetry dataset, the presented strategy increases the number of sea level retrievals in the sea ice-covered area and the correlation with a local tide gauge. Further tests against in-situ data show that also the quality of coastal retrievals increases compared to the standard ocean product in the last 6km within the coast.
ALES+ improves the sea level determination at high latitudes and is adapted to fit reflections from any water surface. If
used in the open ocean and in the coastal zone, it improves the current official products based on ocean retrackers. First results in the inland waters show that the correlation between water heights from ALES+ and from in-situ measurement is always over 0.95.

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**A New DTU18 MSS Mean Sea Surface – Improvement from SAR Altimetry**

In this presentation we outline the new DTU18MSS mean sea surface which is the latest release of the global high resolution mean sea surface from DTU Space. The major new advance leading up to the release of this DTU18MSS the use of 3 years of Sentinel-3A and an improved 7 years Cryosat-2 LRM record. A new processing chain with updated editing and data correction (i.e., using FES2014 as Ocean tide model) has been implemented. The use of consistent ocean tide model for the Mean sea surface and the subsequent processing of sun-synchronous satellites has proven to be important to reduce the error that the MSS contributes to the total error budget. The presentation will also also focus on the difficult issues as consolidating Cryosat-2 and Sentinel-3 onto a past 20 year mean sea surface derived using multiple LRM satellites as well as the importance of merging Cryosat-2 data from different perating modes like LRM, SAR and SAR-In as these requires different retrackers.

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**A new global GPS data set for testing and improving modelled GIA uplift rates**

Glacial isostatic adjustment (GIA) is the response of the solid Earth to past ice loading, primarily, since the Last Glacial Maximum, about 20 K yr BP. Modelling GIA is challenging because of large uncertainties in ice loading history and also the viscosity of the upper and lower mantle. GPS data contain the signature of GIA in their uplift rates but these also contain other sources of vertical land motion (VLM) such as tectonics, human and natural influences on water storage that can mask the underlying GIA signal. In this study, we use about 4000GPS vertical velocities as observational estimates of global GIA uplift rates, after correcting for major elastic deformation effects. A novel fully automatic strategy is developed to postprocess the GPS time-series and to correct for non-GIA artefacts. Before estimating verticalvelocities and uncertainties, we detect outliers and jumps and correct for atmospheric massloading displacements. We correct the resulting velocities for the elastic response of the solid Earth to global changes in ice sheets, glaciers and ocean loading,
as well as for changes in the Earth’s rotational pole relative to the 20th century average. We then apply a spatial median filter to remove sites where local effects are dominant to leave approximately 4000 GPS sites. The resulting novel global GPS data set shows a clean GIA signal at all post-processed stations and is therefore suitable to investigate the behavior of global GIA forward models. The results are transformed from a frame with its origin in the centre of mass of the total Earth’s system (CM) into a frame with its origin in the centre of mass of the solid Earth (CE) before comparison with 13 global GIA forward model solutions, with best fits with Pur-6-VM5 and ICE-6G predictions. The largest discrepancies for all models were identified for Antarctica and Greenland, which may be due to either uncertain mantle rheology, ice loading history/magnitude and/or GPS errors.

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A New Model of Jupiter's Magnetic Field from Juno's First Nine Orbits
A spherical harmonic model of the magnetic field of Jupiter is obtained from vector magnetic field observations acquired by the Juno spacecraft during its first nine polar orbits about the planet. Observations acquired during eight of these orbits provide the first truly global coverage of Jupiter's magnetic field with a coarse longitudinal separation of ~45° between perijoves. The magnetic field is represented with a degree 20 spherical harmonic model for the planetary (“internal”) field, combined with a simple model of the magnetodisc for the field (“external”) due to distributed magnetospheric currents. Partial solution of the underdetermined inverse problem using generalized inverse techniques yields a model (“Juno Reference Model through Perijove 9”) of the planetary magnetic field with spherical harmonic coefficients well determined through degree and order 10, providing the first detailed view of a planetary dynamo beyond Earth.

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A New OGMOC Mean Dynamic Topography Model – DTU17MDT

Within the ESA supported Optimal Geoid for Modelling Ocean Circulation (OGMOC) project a new geoid model has been derived. It is based on the GOCO05C setup though the newer DTU15GRA altimetric surface gravity has been used in the combination. Subsequently the model has been augmented using the EIGEN-6C4 coefficients to d/o 2160. The new DTU17MDT has been derived using this new geoid model and the DTU15MSS mean sea surface. Compared to other geoid models the new OGMOC geoid model has been optimized to avoid striations and orange skin like features. Finally, the filtering was reevaluated by adjusting the quasi-gaussian filter width to optimize the fit to drifter velocities. The results show that the new geodetic MDT improves the resolution of the details of the ocean circulation.

A new tracking algorithm for sea ice age distribution estimation

A new algorithm for estimating sea ice age (SIA) distribution based on the Eulerian advection scheme is presented. The advection scheme accounts for the observed divergence or convergence and freezing or melting of sea ice and predicts consequent generation or loss of new ice. The algorithm uses daily gridded sea ice drift and sea ice concentration products from the Ocean and Sea Ice Satellite Application Facility. The major advantage of the new algorithm is the ability to generate individual ice age fractions in each pixel of the output product or, in other words, to provide a frequency distribution of the ice age allowing to apply mean, median, weighted average or other statistical measures. Comparison with the National Snow and Ice Data Center SIA product revealed several improvements of the new SIA maps and time series. First, the application of the Eulerian scheme provides smooth distribution of the ice age parameters and prevents product undersampling which may occur when a Lagrangian tracking approach is used. Second, utilization of the new sea ice drift product void of artifacts from EUMETSAT OSI SAF resulted in more accurate and reliable spatial distribution of ice age fractions. Third, constraining SIA computations by the observed sea ice concentration expectedly led to considerable reduction of multi-year ice (MYI) fractions. MYI concentration is computed as a sum of all MYI fractions and compares well to the MYI products based on passive and active microwave and SAR products.
An improved and homogeneous altimeter sea level record from the ESA Climate Change Initiative

Sea level is a very sensitive index of climate change since it integrates the impacts of ocean warming and ice mass loss from glaciers and the ice sheets. Sea level has been listed as an essential climate variable (ECV) by the Global Climate Observing System (GCOS). During the past 25 years, the sea level ECV has been measured from space by different altimetry missions that have provided global and regional observations of sea level variations. As part of the Climate Change Initiative (CCI) program of the European Space Agency (ESA) (established in 2010), the Sea Level project (SL_cci) aimed to provide an accurate and homogeneous long-term satellite-based sea level record. At the end of the first phase of the project (2010-2013), an initial version (v1.1) of the sea level ECV was made available to users (Ablain et al., 2015). During the second phase of the project (2014-2017), improved altimeter standards were selected to produce new sea level products (called SL_cci v2.0) based on nine altimeter missions for the period 1993-2015 (https://doi.org/10.5270/esa-sea_level_cci-1993_2015-v_2.0-201612; Legeais and the ESA SL_cci team, 2016c). Corresponding orbit solutions, geophysical corrections and altimeter standards used in this v2.0 dataset are described in detail in Quartly et al. (2017). The present paper focuses on the description of the SL_cci v2.0 ECV and associated uncertainty and discusses how it has been validated. Various approaches have been used for the quality assessment such as internal validation, comparisons with sea level records from other groups and with in situ measurements, sea level budget closure analyses and comparisons with model outputs. Compared with the previous version of the sea level ECV, we show that use of improved geophysical corrections, careful bias reduction between missions and inclusion of new altimeter missions lead to improved sea level products with reduced uncertainties on different spatial and temporal scales. However, there is still room for improvement since the uncertainties remain larger than the GCOS requirements (GCOS, 2011). Perspectives on subsequent evolution are also discussed.
An Instrument Anomaly in the Mars Exploration Rover Panoramic Camera (Pancam) 1009 nm Filter (R7): Characterisation, Simulation, Correction and Preliminary Verification

During pre-flight calibration of the Panoramic Camera (Pancam) instrument on board the Mars Exploration Rovers MER A (Spirit) and MER B (Opportunity), a discrepancy was noted between 11-band spectra extracted from Pancam images of the camera's radiometric calibration target and reflectance spectra obtained with a spectrometer. This discrepancy was observed in the longest-wavelength filter of the camera (the longpass R7 filter with system λ_{eff} = 1009 nm), and consisted of a reduction in contrast between bright and dark regions. Here, we describe and characterise this effect. We propose that the effect arises because long-wavelength photons close to the silicon band-gap at 1100 nm, are allowed through the R7 filter, pass through the bulk CCD, scatter from the backside, pass through the CCD again, and are registered in a pixel other than the pixel through which they originally entered. Based on this hypothesis we develop a model capable of accurately simulating the effect, and correct for it. We present preliminary results from testing this correction on pre-flight, as well as in-flight, images. The effect is small, but in some specific cases in small regions of high contrast, the effect is significant. In in-flight images of martian terrain we observed the signal in dark shadows to be artificially inflated by up to ~33% and analysis of early-mission cal target images indicated that the reduced contrast due to the artifact is equivalent to >100 DN (full well = 4095 DN) for a hypothetical perfectly dark pixel.

Anomalously high geothermal flux near the South Pole

Melting at the base of the Antarctic Ice Sheet influences ice dynamics and our ability to recover ancient climatic records from deep ice cores. Basal melt rates are affected by geothermal flux, one of the least constrained properties of the Antarctic continent. Estimates of Antarctic geothermal flux are typically regional in nature, derived from geological, magnetic or seismic data, or from sparse point measurements at ice core sites. We analyse ice-penetrating radar data upstream of South Pole revealing a similar to 100 km long and 50 km wide area where internal ice sheet layers converge
with the bed. Ice sheet modelling shows that this englacial layer configuration requires basal melting of up to 6 ± 1 mm a⁻¹ and a geothermal flux of 120 ± 20 mW m⁻², more than double the values expected for this cratonic sector of East Antarctica. We suggest high heat producing Precambrian basement rocks and hydrothermal circulation along a major fault system cause this anomaly. We conclude that local geothermal flux anomalies could be more widespread in East Antarctica. Assessing their influence on subglacial hydrology and ice sheet dynamics requires new detailed geophysical observations, especially in candidate areas for deep ice core drilling and at the onset of major ice streams.

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**An Optical Transmission Spectrum for the Ultra-hot Jupiter WASP-121b Measured with the Hubble Space Telescope**

We present an atmospheric transmission spectrum for the ultra-hot Jupiter WASP-121b, measured using the Space Telescope Imaging Spectrograph on board the Hubble Space Telescope. Across the 0.47–1 wavelength range, the data imply an atmospheric opacity comparable to—and in some spectroscopic channels exceeding—that previously measured at near-infrared wavelengths (1.15–1.65 μm). Wavelength-dependent variations in the opacity rule out a gray cloud deck at a confidence level of 3.7σand may instead be explained by VO spectral bands. We find a cloud-free model assuming chemical equilibrium for a temperature of 1500 K and a metal enrichment of 10–30× solar matches these data well. Using a free-chemistry retrieval analysis, we estimate a VO abundance of dex. We find no evidence for TiO and place a 3σ upper limit of −7.9 dex on its abundance, suggesting TiO may have condensed from the gas phase at the day–night limb. The opacity rises steeply at the shortest wavelengths, increasing by approximately five pressure scale heights from 0.47 to 0.3 in wavelength. If this feature is caused by Rayleigh scattering due to uniformly distributed aerosols, it would imply an unphysically high temperature of 6810 ± 1530 K. One alternative explanation for the short-wavelength rise is absorption due to SH (mercapto radical), which has been predicted as an important product of non-equilibrium chemistry in hot Jupiter atmospheres. Irrespective of the identity of the NUV absorber, it likely captures a significant amount of incident stellar radiation at low pressures, thus playing a significant role in the overall energy budget, thermal structure, and circulation of the atmosphere.

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An Ultra-short Period Rocky Super-Earth with a Secondary Eclipse and a Neptune-like Companion around K2-141

Ultra-short period (USP) planets are a class of low-mass planets with periods shorter than one day. Their origin is still unknown, with photo-evaporation of mini-Neptunes and in situ formation being the most credited hypotheses. Formation scenarios differ radically in the predicted composition of USP planets, and it is therefore extremely important to increase the still limited sample of USP planets with precise and accurate mass and density measurements. We report here the characterization of a USP planet with a period of 0.28 days around K2-141 (EPIC 246393474), and the validation of an outer planet with a period of 7.7 days in a grazing transit configuration. We derived the radii of the planets from the K2 light curve and used high-precision radial velocities gathered with the HARPS-N spectrograph for mass measurements. For K2-141b, we thus inferred a radius of 1.51 ± 0.05 R⊕ and a mass of 5.08 ± 0.41 M ⊕, consistent with a rocky composition and lack of a thick atmosphere. K2-141c is likely a Neptune-like planet, although due to the grazing transits and the non-detection in the RV data set, we were not able to put a strong constraint on its density. We also report the detection of secondary eclipses and phase curve variations for K2-141b. The phase variation can be modeled either by a planet with a geometric albedo of 0.30 ± 0.06 in the Kepler bandpass, or by thermal emission from the surface of the planet at ~3000 K. Only follow-up observations at longer wavelengths will allow us to distinguish between these two scenarios.

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Arctic Freshwater Fluxes from Satellite Altimetry and Earth Observation Data
The ArcFlux project aims to determine the largest component to the Arctic Freshwater budget, namely the contribution from large rivers, glaciers as well as in-out flow of freshwater through the ocean pathways. The main objectives of the project is to: Identify the major challenges associated with estimation of the Arctic Freshwater budget and Explore, develop and validate different approaches to address the identified challenges and enhance current approaches to compute the freshwater budget in the Arctic and compute a multi-year assessment of the Arctic freshwater budget based on the developed methodology. Finally the obtained results will be evaluated and the project will develop a scientific roadmap for future research activities in this domain of estimating the FWB of the Arctic Ocean. Arcflux is supported in 2017 and 2018 within the ESA CLIC initiative which is a part of the support to Science Elements framework.

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Arctic Mission Benefit Analysis: impact of sea ice thickness, freeboard, and snow depth products on sea ice forecast performance
Assimilation of remote-sensing products of sea ice thickness (SIT) into sea ice-ocean models has been shown to improve the quality of sea ice forecasts. Key open questions are whether assimilation of lower-level data products such as radar freeboard (RFB) can further improve model performance and what performance gains can be achieved through joint assimilation of these data products in combination with a snow depth product. The Arctic Mission Benefit Analysis system was developed to address this type of question. Using the quantitative network design (QND) approach, the system can evaluate, in a mathematically rigorous fashion, the observational constraints imposed by individual and groups of data products. We demonstrate the approach by presenting assessments of the observation impact (added value) of different Earth observation (EO) products in terms of the uncertainty reduction in a 4-week forecast of sea ice volume (SIV) and snow volume (SNV) for three regions along the Northern Sea Route in May 2015 using a coupled model of the sea ice-ocean system, specifically the Max Planck Institute Ocean Model. We assess seven satellite products: three real products and four hypothetical products. The real products are monthly SIT, sea ice freeboard (SIFB), and RFB, all derived from CryoSat-2 by the Alfred Wegener Institute. These are complemented by two hypothetical monthly laser free-board (LFB) products with low and high accuracy, as well as two hypothetical monthly snow depth products with low and high accuracy.

On the basis of the per-pixel uncertainty ranges provided with the CryoSat-2 SIT, SIFB, and RFB products, the SIT and RFB achieve a much better performance for SIV than the SIFB product. For SNV, the performance of SIT is only low, the performance of SIFB is higher and the performance of RFB is yet higher. A hypothetical LFB product with low accuracy (20 cm uncertainty) falls between SIFB and RFB in performance for both SIV and SNV. A reduction in the uncertainty of the LFB product to 2 cm yields a significant increase in performance. Combining either of the SIT or freeboard products with a hypothetical snow depth product achieves a significant performance increase. The uncertainty in the snow product matters: a higher-accuracy product achieves an extra performance gain. Providing spatial and temporal uncertainty correlations with the EO products would be beneficial not only for QND assessments, but also for assimilation of the products.

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Arctic Sea Ice Characterization Using Spaceborne Fully Polarimetric L-, C-, and X-Band SAR With Validation by Airborne Measurements

In recent years, spaceborne synthetic aperture radar (SAR) polarimetry has become a valuable tool for sea ice analysis. Here, we employ an automatic sea ice classification algorithm on two sets of spatially and temporally near coincident fully polarimetric acquisitions from the ALOS-2, Radarsat-2, and TerraSAR-X/TanDEM-X satellites. Overlapping coincident sea ice freeboard measurements from airborne laser scanner data are used to validate the classification results. The automated sea ice classification algorithm consists of two steps. In the first step, we perform a polarimetric feature extraction procedure. Next, the resulting feature vectors are ingested into a trained neural network classifier to arrive at a pixelwise supervised classification. Coherency matrix-based features that require an eigendecomposition are found to be either of low relevance or redundant to other covariance matrix-based features, which makes coherency matrix-based features dispensable for the purpose of sea ice classification. Among the most useful features for classification are matrix invariant-based features (geometric intensity, scattering diversity, and surface scattering fraction). Classification results show that 100% of the open water is separated from the surrounding sea ice and that the sea ice classes have at least 96.9% accuracy. This analysis reveals analogous results for both X-band and C-band frequencies and slightly different for the L-band. The subsequent classification produces similarly promising results for all four acquisitions. In particular, the overlapping image portions exhibit a reasonable congruence of detected sea ice when compared with high-resolution airborne measurements.

Arctic Sea Ice Characterization Using Spaceborne Fully Polarimetric L-, C-, and X-Band SAR With Validation by Airborne Measurements

In recent years, spaceborne synthetic aperture radar (SAR) polarimetry has become a valuable tool for sea ice analysis. Here, we employ an automatic sea ice classification algorithm on two sets of spatially and temporally near coincident fully polarimetric acquisitions from the ALOS-2, Radarsat-2, and TerraSAR-X/TanDEM-X satellites. Overlapping coincident sea ice freeboard measurements from airborne laser scanner data are used to validate the classification results. The automated sea ice classification algorithm consists of two steps. In the first step, we perform a polarimetric feature extraction procedure. Next, the resulting feature vectors are ingested into a trained neural network classifier to arrive at a pixelwise supervised classification. Coherency matrix-based features that require an eigendecomposition are found to be either of low relevance or redundant to other covariance matrix-based features, which makes coherency matrix-based features dispensable for the purpose of sea ice classification. Among the most useful features for classification are matrix invariant-based features (geometric intensity, scattering diversity, and surface scattering fraction). Classification results show that 100% of the open water is separated from the surrounding sea ice and that the sea ice classes have at least 96.9% accuracy. This analysis reveals analogous results for both X-band and C-band frequencies and slightly different for the L-band. The subsequent classification produces similarly promising results for all four acquisitions. In particular, the overlapping image portions exhibit a reasonable congruence of detected sea ice when compared with high-resolution airborne measurements.
Arctide2017, a high-resolution regional tidal model in the Arctic Ocean

The Arctic Ocean is a challenging region for tidal modelling. The accuracy of the global tidal models decreases by several centimeters in the Polar Regions, which has a large impact on the quality of the satellite altimeter sea surface heights and the altimetry-derived products.

NOVELTIS, DTU Space and LEGOS have developed Arctide2017, a regional, high-resolution tidal atlas in the Arctic Ocean, in the framework of an extension of the CryoSat Plus for Ocean (CP4O) ESA STSE (Support to Science Element) project. In particular, this atlas benefits from the assimilation of the most complete satellite altimetry dataset ever used in this region, including Envisat data up to 82°N and CryoSat-2 data between 82°N and 88°N. The combination of these satellite altimetry missions gives the best possible coverage of altimetry-derived tidal constituents. The available tide gauge data were also used for data assimilation and validation. This paper presents the implementation methodology and the performance of this new regional tidal model in the Arctic Ocean, compared to the existing global and regional tidal models.

Assimilation of ground and satellite magnetic measurements: inference of core surface magnetic and velocity field changes

We jointly invert for magnetic and velocity fields at the core surface over the period 1997–2017, directly using ground-based observatory time-series and measurements from the CHAMP and Swarm satellites. Satellite data are reduced to the form of virtual observatory time-series distributed on a regular grid in space. Such a sequential storage helps incorporate voluminous modern magnetic data into a stochastic Kalman filter, whereby spatial constraints are incorporated based on a norm derived from statistics of a numerical geodynamo model. Our algorithm produces consistent solutions both in terms of the misfit to the data and the estimated posterior model uncertainties. We retrieve core flow features previously documented from the analysis of spherical harmonic field models, such as the eccentric anticyclonic gyre. We find enhanced diffusion patterns under both Indonesia and Africa. In contrast to a steady flow that is strong under the Atlantic hemisphere but very weak below the Pacific, interannual motions appear evenly distributed over the two hemispheres. Recovered interannual to decadal flow changes are predominantly symmetrical with respect to the equator outside the tangent cylinder. In contrast, under the Northern Pacific we find an intensification of a high latitude jet, but see no evidence for a corresponding feature in the Southern hemisphere. The largest flow accelerations that we isolate over the studied era are associated with meanders, attached to the equatorward meridional branch of the planetary gyre in the Eastern hemisphere, that are linked to the appearance of an eastward equatorial jet below the Western Pacific.
Automatic delineation of debris-covered glaciers using InSAR coherence derived from X-, C- and L-band radar data: A case study of Yazgyl Glacier

Despite their importance for mass-balance estimates and the progress in techniques based on optical and thermal satellite imagery, the mapping of debris-covered glacier boundaries remains a challenging task. Manual corrections hamper regular updates. In this study, we present an automatic approach to delineate glacier outlines using interferometrically derived synthetic aperture radar (InSAR) coherence, slope and morphological operations. InSAR coherence detects the temporally decorrelated surface (e.g. glacial extent) irrespective of its surface type and separates it from the highly coherent surrounding areas. We tested the impact of different processing settings, for example resolution, coherence window size and topographic phase removal, on the quality of the generated outlines. We found minor influence of the topographic phase, but a combination of strong multi-looking during interferogram generation and additional averaging during coherence estimation strongly deteriorated the coherence at the glacier edges. We analysed the performance of X-, C- and L-band radar data. The C-band Sentinel-1 data outlined the glacier boundary with the least misclassifications and a type II error of 0.47% compared with Global Land Ice Measurements from Space inventory data. Our study shows the potential of the Sentinel-1 mission together with our automatic processing chain to provide regular updates for land-terminating glaciers on a large scale.
Basal Settings Control Fast Ice Flow in the Recovery/Slessor/Bailey Region, East Antarctica
The region of Recovery Glacier, Slessor Glacier, and Bailey Ice Stream, East Antarctica, has remained poorly explored, despite representing the largest potential contributor to future global sea level rise on a centennial to millennial time scale. Here we use new airborne radar data to improve knowledge about the bed topography and investigate controls of fast ice flow. Recovery Glacier is underlain by an 800 km long trough. Its fast flow is controlled by subglacial water in its upstream and topography in its downstream region. Fast flow of Slessor Glacier is controlled by the presence of subglacial water on a rough crystalline bed. Past ice flow of adjacent Recovery and Slessor Glaciers was likely connected via the newly discovered Recovery-Slessor Gate. Changes in direction and speed of past fast flow likely occurred for upstream parts of Recovery Glacier and between Slessor Glacier and Bailey Ice Stream. Similar changes could also reoccur here in the future.

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Calibration Challenges for the Biomass P-band Sar Instrument
The BIOMASS mission gives completely new challenges in external calibration arising from the orbital pattern needed for the tomographic and Pol-InSAR phases of the mission, the strong effects of the ionosphere at P-band, and the lack of pre-existing P-band data except over very limited parts of the globe. Together these create problems that can only be solved by combining infrequent visits to instrumented calibration sites with systematic exploitation of the properties of distributed targets and targets of opportunity. Proposed approaches to performing radiometric and polarimetric calibration are described, together with meeting geolocation accuracy requirements.

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CASTAway: An asteroid main belt tour and survey
CASTAway is a mission concept to explore our Solar System's main asteroid belt. Asteroids and comets provide a window into the formation and evolution of our Solar System and the composition of these objects can be inferred from space-based remote sensing using spectroscopic techniques. Variations in composition across the asteroid populations provide a tracer for the dynamical evolution of the Solar System. The mission combines a long-range (point source) telescopic survey of over 10,000 objects, targeted close encounters with 10–20 asteroids and serendipitous searches to constrain the distribution of smaller (e.g. 10 m) size objects into a single concept. With a carefully targeted trajectory that loops through the asteroid belt, CASTAway would provide a comprehensive survey of the main belt at multiple scales. The scientific payload comprises a 50 cm diameter telescope that includes an integrated low-resolution (R = 30–100) spectrometer and visible context imager, a thermal (e.g. 6–16 µm) imager for use during the flybys, and modified star tracker cameras to detect small (∼10 m) asteroids. The CASTAway spacecraft and payload have high levels of technology readiness and are designed to fit within the programmatic and cost caps for a European Space Agency medium class mission, while delivering a significant increase in knowledge of our Solar System.
Changes in Antarctic Ice Sheet Surface Elevation from a Quarter-century of Combined Radar and Laser Altimetry

Satellite altimetry provides the longest continuous record of elevation change for assessing the mass balance of the Antarctic Ice Sheet, providing a unique opportunity to observe the ice sheet’s response to changes in atmosphere and ocean over the last few decades. The accuracy of altimetry-measured elevation change, from which this mass balance is derived, is of vital importance for quantifying Antarctica's contribution to sea-level rise, and for understanding the physical processes governing changes of the ice sheet. Studies have shown that the rate of Antarctica's mass loss has accelerated over the last decade, largely a result of accelerated ice flow from the Amundsen Sea sector of West Antarctica. Not all areas of the ice sheet are thinning however. Increases in precipitation have resulted in rapid thickening over parts of East Antarctica, especially in Dronning Maud Land. A key question is how these relatively recent changes contrast against the observed longer-term trend and variability. Observations from overlapping satellite altimeter mission over the last three decades can help to answer this question. Here, we have developed a novel framework for cross-calibrating and synthesizing multimission altimetry records, with a further emphasis on generating state-of-the-art corrections for issues affecting the altimeter measurement (such as surface slope and variations in surface scattering) in order to increase the reliability and accuracy of the full altimetry record. The framework allows us to construct consistent time series at fine spatial and temporal scales for the majority of the ice sheet, with a corresponding assessment of the overall uncertainty of the solutions. We present results detailing the complex long-term pattern of elevation change, observed by the altimeters, and discuss the current improvement and imitations of the altimeter record. This effort will allow us to improve upon existing records of the long-term evolution of the Antarctic Ice Sheet, providing an invaluable dataset for advancing ice sheet modeling efforts and for disentangling the causal mechanisms responsible for ice sheet mass change.

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Changes in Greenland’s peripheral glaciers linked to the North Atlantic Oscillation

Glaciers and ice caps peripheral to the main Greenland Ice Sheet contribute markedly to sea-level rise1,2,3. Their changes and variability, however, have been difficult to quantify on multi-decadal timescales due to an absence of long-term data4. Here, using historical aerial surveys, expedition photographs, spy satellite imagery and new remote-sensing products, we map glacier length fluctuations of approximately 350 peripheral glaciers and ice caps in East and West Greenland since 1890. Peripheral glaciers are found to have recently undergone a widespread and significant retreat at rates of 12.2 m per year and 16.6 m per year in East and West Greenland, respectively; these changes are exceeded in severity only by the early twentieth century post-Little-Ice-Age retreat. Regional changes in ice volume, as reflected by glacier length, are further shown to be related to changes in precipitation associated with the North Atlantic Oscillation (NAO), with a distinct east–west asymmetry; positive phases of the NAO increase accumulation, and thereby glacier growth, in the eastern periphery, whereas opposite effects are observed in the western periphery. Thus, with projected trends towards positive NAO in the future5,6, eastern peripheral glaciers may remain relatively stable, while western peripheral glaciers will continue to diminish.

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The Greenland ice sheet has experienced an average mass loss of 142 ± 49 Gt/yr from 1992 to 2011 (Shepherd et al. 2012), making it a significant contributor to sea-level rise. Part of the ice-sheet mass loss is the result of increased dynamic response of outlet glaciers (Rignot et al. 2011). The ice discharge from outlet glaciers can be quantified by coincident measurements of ice velocity and ice thickness (Thomas et al. 2000; van den Broeke et al. 2016). As part of the Programme for monitoring of the Greenland Ice Sheet (PROMICE; Ahlstrøm et al. 2008), three airborne surveys were carried out in 2007, 2011 and 2015, with the aim of measuring the changes in Greenland ice-sheet thicknesses. The purpose of the airborne surveys was to collect data to assess the dynamic mass loss of the Greenland ice sheet (Andersen et al. 2015). Here, we present these datasets of observations from ice-penetrating radar and airborne laser scanning, which, in combination, make us able to determine the ice thickness precisely. Surface-elevation changes between surveys are also presented, although we do not provide an in-depth scientific interpretation of these.

Coastal Sea Level from CryoSat-2 SARIn Altimetry in Norway

Conventional (pulse-limited) altimeters determine the sea surface height with an accuracy of a few centimeters over the open ocean. Sea surface heights and tide-gauge sea level serve as each other’s buddy check. However, in coastal areas, altimetry suffers from numerous effects, which degrade its quality. The Norwegian coast adds further challenges due to its complex coastline with many islands, mountains, and deep, narrow fjords. The European Space Agency CryoSat-2 satellite carries a synthetic aperture interferometric radar altimeter, which is able to observe sea level closer to the coast than conventional altimeters. In this study, we explore the potential of CryoSat-2 to provide valid observations in the Norwegian coastal zone. We do this by comparing time series of CryoSat-2 sea level anomalies with time series of in situ sea level at 22 tide gauges, where the CryoSat-2 sea level anomalies are averaged in a 45-km area around each tide gauge. For all tide gauges, CryoSat-2 shows standard deviations of differences and correlations of 16 cm and 61%, respectively. We further identify the ocean tide and inverted barometer geophysical corrections as the most crucial, and note that a large amount of observations at land-confined tide gauges are not assigned an ocean tide value. With the availability of local air pressure observations and ocean tide predictions, we substitute the standard inverted barometric and ocean tide corrections with local corrections. This gives an improvement of 24% (to 12.2 cm) and 12% (to 68%) in terms of standard deviations of differences and correlations, respectively. Finally, we perform the same in situ analysis using data from three conventional altimetry missions, Envisat, SARAL/AltiKa, and Jason-2. For all tide gauges, the conventional altimetry missions show an average agreement of 11 cm and 60% in terms of standard deviations of differences and correlations, respectively. There is a tendency that results improve with decreasing distance to the tide gauge and a smaller footprint, underlining the potential of SAR altimetry in coastal zones.
We present freeboard measurements from airborne laser scanner (ALS), the Airborne Synthetic Aperture and Interferometric Radar Altimeter System (ASIRAS), and CryoSat-2 SIRAL radar altimeter; ice thickness measurements from both helicopter-borne and ground-based electromagnetic-sounding; and point measurements of ice properties. This case study was carried out in April 2015 during the N-ICE2015 expedition in the area of the Arctic Ocean north of Svalbard. The region is represented by deep snow up to 1.12 m and a widespread presence of negative freeboards. The main scattering surfaces from both CryoSat-2 and ASIRAS are shown to be closer to the snow freeboard obtained by ALS than to the ice freeboard measured in situ. This case study documents the complexity of freeboard retrievals from radar altimetry. We show that even under cold (below −15°C) conditions the radar freeboard can be close to the snow freeboard on a regional scale of tens of kilometers. We derived a modal sea-ice thickness for the study region from CryoSat-2 of 3.9 m compared to measured total thickness 1.7 m, resulting in an overestimation of sea-ice thickness on the order of a factor 2. Our results also highlight the importance of year-to-year regional scale information about the depth and density of the snowpack, as this influences the sea-ice freeboard, the radar penetration, and is a key component of the hydrostatic balance equations used to convert radar freeboard to sea-ice thickness.
Confirmation of the detection of B modes in the Planck polarization maps

One of the main problems of extracting the cosmic microwave background (CMB) from submm/mm observations is correcting for the galactic components, mainly synchrotron, free–free, and thermal dust emission, with the required accuracy. Through a series of papers, it has been demonstrated that this task can be fulfilled by means of simple neural networks with high confidence. The main purpose of this paper is to demonstrate that the CMB BB power spectrum detected in the Planck 2015 polarization maps is present in the improved Planck 2017 maps with higher signal-to-noise ratio. Two features have been detected in the EB power spectrum in the new dataset, both with S/N ~ 4. The origin of these features is most likely leakage from E to B with a level of about 1%. This leakage does not significantly contribute to the detected BB power spectrum. The TB power spectrum is consistent with a zero signal. Altogether, the BB power spectrum is not consistent with the “canonical” tensor-to-scalar models combined with gravitational lensing spectra. These results will provide additional strong arguments for support to the proposed polarization satellite projects to follow up on the Planck mission.

Contribution of deformation to sea-ice mass balance: a case study from an N-ICE2015 storm

The fastest and most efficient process of gaining sea ice volume is through the mechanical redistribution of mass as a consequence of deformation events. During the ice growth season divergent motion produces leads where new ice grows thermodynamically, while convergent motion fractures the ice and either piles the resultant ice blocks into ridges or rafts one floe under the other. Here we present an exceptionally detailed airborne dataset from a 9km² area of first and second year ice in the Transpolar Drift north of Svalbard that allowed us to estimate the redistribution of mass from an observed deformation event. To achieve this level of detail we analyzed changes in sea ice freeboard acquired from two airborne laser scanner surveys just before and right after a deformation event brought on by a passing low pressure system. A linear regression model based on divergence during this storm can explain 64% of freeboard variability. Over the survey region we estimated that about 1.3% of level sea ice volume was pressed together into deformed ice and the new ice formed in leads in a week after the deformation event would increase the sea ice volume by 0.5%. As the region is impacted by about 15 storms each winter a simple linear extrapolation would result in about 7% volume increase and 20% deformed ice fraction at the end of the season.
Cryorad: A Low Frequency Wideband Radiometer Mission for the Study of the Cryosphere

Earth's cold regions are key elements of the planet's climate system: they have strong feedbacks with global change and they have a direct impact on human activities. Despite their importance, at present they are not adequately monitored by state-of-the-art instruments. In order to fill this gap, a dedicated spaceborne mission called Cryorad has been proposed in the framework of the ESA Earth Explorer 10 call. The mission would comprise a 0.4-2 GHz nadir-looking radiometer installed on a polar-orbit satellite. Scientific and technical studies are underway, as well as experimental campaigns in Greenland and Antarctica.

CryoSat-2 for Inland Water Applications – Potential, Challenges and Future Prospects

CryoSat-2 is a European Space Agency (ESA) mission that was launched in 2010 with the primary goal of monitoring the thickness and extent of the world's ice sheets. The mission has contributed significantly to our understanding of the Earth's cryosphere, which is crucial for climate change studies. In this paper, the authors discuss the potential, challenges, and future prospects of CryoSat-2 for inland water applications, with a focus on its capabilities and limitations in monitoring inland water bodies.
Detecting Exomoons via Doppler Monitoring of Directly Imaged Exoplanets

Teachey et al. recently reported the detection of a candidate exomoon, tentatively designated Kepler-1625b I, around a giant planet in the Kepler field. The candidate exomoon would be about the size and mass of Neptune, considerably larger than any moon in our solar system, and if confirmed, would be the first in a new class of giant moons or binary planets. Motivated by the large mass ratio in the Kepler-1625b planet and satellite system, we investigate the detectability of similarly massive exomoons around directly imaged exoplanets via Doppler spectroscopy. The candidate moon around Kepler-1625b would induce a radial velocity (RV) signal of about 200 nm/s on its host planet, large enough that similar moons around directly imaged planets orbiting bright, nearby stars might be detected with current or next generation instrumentation. In addition to searching for exomoons, an RV survey of directly imaged planets could reveal the orientations of the planets’ spin axes, making it possible to identify Uranus analogs.

Detection of Reflection Features in the Neutron Star Low-mass X-Ray Binary Serpens X-1 with NICER

We present Neutron Star Interior Composition Explorer (NICER) observations of the neutron star (NS) low-mass X-ray binary Serpens X-1 during the early mission phase in 2017. With the high spectral sensitivity and low-energy X-ray passband of NICER, we are able to detect the Fe L line complex in addition to the signature broad, asymmetric Fe K line. We confirm the presence of these lines by comparing the NICER data to archival observations with XMM-Newton /Reflection Grating Spectrometer (RGS) and NuSTAR.

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Development of the ATHENA mirror

The development of the X-ray optics for ATHENA (Advanced Telescope for High ENergy Astrophysics)[1-4], the selected second large class mission in the ESA Science Programme, is progressing further, in parallel with the payload preparation and the system level studies. The optics technology is based on the Silicon Pore Optics (SPO) [5-48], which utilises the excellent material properties of Silicon and benefits from the extensive investments made in the semiconductor industry. With its pore geometry the SPO is intrinsically very robust and permits the use of very thin mirrors while achieving good angular resolution. In consequence, the specific mass of the resultant ATHENA optics is very low compared to other technologies, and suitable to cope with the imposed environmental requirements. Further technology developments preparing the ATHENA optics are ongoing, addressing additive manufacturing of the telescope structure, the integration and alignment of the mirror assembly, numerical simulators, coating optimisations, metrology, test facilities, studies of proton reflections and meteorite impacts, etc. A detailed Technology Development Plan was elaborated and is regularly being updated, reflecting the progress and the mission evolution. The required series production and integration of the many hundred mirror modules constituting the ATHENA telescope optics is an important consideration and a leading element in the technology development. The developments are guided by ESA, implemented in industry and supported by research institutions. The many ongoing SPO technology development activities aim at demonstrating the readiness of the optics technology at the review deciding the adoption of ATHENA onto the ESA Science flight programme, currently expected for 2021. Technology readiness levels of 5/6 have to be demonstrated for all critical elements, but also the compliance to cost and schedule constraints for the mission.

General information

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Developments in SAR Altimetry over Coastal and Open Ocean: A Retrospective of Developments in SAR Altimetry Processing and the Improvements Achieved through the SAMOSA, CP4O and SCOOP Projects

The European CryoSat-2 and Sentinel-3A satellites, soon to be followed by Sentinel-3B, were the first to operate SAR mode altimeters. These missions initiated a new era in satellite altimetry over the oceans, in which a step change in improvement in measurements over the open ocean and coastal zone has been achieved, in terms of accuracy of measurement, the capability to map features that could not previously be resolved, and to provide measurements closer to the coast than ever before. This presentation looks back at a series of three projects initiated by ESA: SAMOSA, CP4O and SCOOP, reviews the development and assessment of new processing schemes for SAR mode altimeter measurements, plots the performance improvements achieved and then looks ahead to further developments. SAMOSA (SAR Altimetry Mode Studies and Applications) was an ESA-funded project initiated in 2007 to investigate the improvements offered by SAR mode altimetry over ocean, coastal and inland water surfaces, developing practical implementation of new theoretical models for the SAR echo waveform as part of this process. SAMOSA developed physical based models for SAR altimeter ocean waveforms, and applied them to develop re-trackers for SAR mode products, which were further developed and tested on simulated data, airborne data, and then on real satellite data from CryoSat-2. Approaches to reduce SAR mode data to "RDSAR" data were also investigated, to infer the statistical equivalence between SAR mode and the traditional low-resolution altimetry. Subsequent work further developed the "SAMOSA" model, balancing the aim to improve the modelling of the waveform from efficiency of processing to achieve a practical scheme that could be implemented in the Sentinel-3 Ground Segment. CP4O (CryoSat Plus for Oceans) was a project supported under the ESA Programme Element coined "Support to Science Element" (STSE) with the objectives to build a sound scientific basis for new scientific and operational applications of CryoSat-2 data, generate and evaluate new methods and products to enable the full exploitation of the CryoSat-2 SAR mode altimeter, extending their application beyond the initial mission objectives, and to ensure that the scientific return of the CryoSat-2 mission is maximised. Within CP4O, processing schemes for CryoSat-2 data were developed and evaluated for SAR and RDSAR products over the open ocean, and SAR and SARin modes data over the coastal ocean. New geophysical correction products and models (Wet Troposphere, Ionosphere, and Regional Tide Models) were developed and assessed, as was specialized processing of SAR mode data to improve Polar Ocean bathymetry and tidal modelling. SCOOP (SAR Altimetry Coastal & Open Ocean Performance) is a project funded under the ESA SEOM (Scientific Exploitation of Operational Missions) Programme Element, to characterise the expected performance of Sentinel-3 SRAL SAR mode altimeter products, in the coastal zone and open ocean, and then to develop and evaluate enhancements to the baseline processing scheme in terms of improvements to ocean measurements. Another objective is to develop and evaluate an improved Wet Troposphere correction for Sentinel-3, and provide recommendations for use. Recommendations for further developments and implementations are provided through a scientific roadmap.

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Dual Frequency Radar Altimetry-Measuring Greenland Firn Properties from Space
For the last eight years, the ESA CryoSat-2 Ku-band radar altimeter has been measuring the elevation of the Greenland Ice Sheet. Ku-band enables surface penetration at firm covered areas, which hampers the direct interpretation of surface elevation change from Cryosat-2 and other Ku-band altimeters. However, mapping the changes in penetration depth can provide information on firm stratigraphy. If the physical surface (snow/air interface) of the ice sheet can be determined from an independent source, the differences in the two surfaces may directly be linked to the penetration depth of Ku-band radar...
altimetry, and hence to the temperature and density of the upper firm. Here, we use independent estimates of the surface elevation changes from the Ka-band radar altimeter (AltiKa) operated onboard the French/Indian satellite SARAL. The higher frequency of Ka-band reduces surface penetration to a minimum and combining the records from both Ku- and Ka-band satellites are the key to utilizing the full potential of CryoSat-2. Hence, providing both high spatial-resolution surface elevation change and insights into changes in firm properties. The interpretation of dual-frequency altimetry is supported by firn modeling.

The model has previously been applied to gain mass balance from ICESat and is now updated with a conceptual model for Ku-band radar penetration. Ultimately, a dual-band radar altimeter operating from space may provide ice sheet wide measurements of firm densities, a key parameter in determining direct ice mass balance from satellite altimetry.

Early 21st century spatially detailed elevation changes of Jammu and Kashmir glaciers (Karakoram–Himalaya)

Although a number of studies indicate the regional heterogeneity of the glacier elevation and mass changes in high-mountain Asia in the early 21st century, little is known about these changes with high spatial detail for some of the regions. In this study we present respective glacier elevation and mass change estimates in the Indian state of Jammu and Kashmir (JK) for the period 2000–2012. Our estimates are based on the interferometric analysis of SRTM DEM and the bistatic TanDEM-X data. On an average the JK East (Karakoram) glaciers showed less negative elevation changes (∼ 0.19 ± 0.22 m yr⁻¹) compared to the JK West (Himalaya) glaciers (∼ 0.50 ± 0.28 m yr⁻¹). This agrees very well with previous studies that show a transition from larger changes in the western Himalaya to a steady-state situation in the Karakoram. We observe distinct elevation change patterns on a glacier scale that is most likely linked to debris insulation and the enhanced ice melting due to supraglacial lakes, ponds and ice cliffs. We also found 16 surge-type glaciers in the JK East which were not documented before. In total, 25 glaciers surged and 4 others appeared to be in a quiescent phase in the observation period. Our results also reveal that the glacier-averaged elevation change rates of surge-type and non-surge-type glaciers in the JK East region are not significantly different.

Earth's Magnetic Field: Understanding Geomagnetic Sources from the Earth's Interior and its Environment

This volume provides a comprehensive view on the different sources of the geomagnetic field both in the Earth’s interior and from the field’s interaction with the terrestrial atmosphere and the solar wind. It combines expertise from various relevant areas of geomagnetic and near Earth space research with the aim to better characterise the state and dynamics
of Earth’s magnetic field. Advances in the exploitation of geomagnetic observations hold a huge potential not only for an improved quantitative description of the field source but also for a better understanding of the underlying processes and physics. Key is the separation of the field sources in the observations, especially, but not solely, during times of quiet geomagnetic conditions, when the most subtle geomagnetic effects can be identified and become significant. The collected articles are based on the current constellation of ground and space observations, and on state-of-the-art empirical models and physics-based simulations. Thus, it provides an in-depth overview over recent achievements, current limitations and challenges, and future opportunities in the field of geomagnetism and space sciences.

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EPIC211682544 b: A 50-day period sub-Neptune with a mass measurement using HARPS-N
This paper reports on the validation and mass measurement of EPIC211682544 b, a sub-Neptune orbiting a quiet G9V star. Using K2 data from campaigns C5 and C16, we find this planet to have a period of 50.818947 ± 0.000094 days and a radius of 2.41 ± 0.12 R⊕. We followed this system with HARPS-N to obtain 67 precise radial velocities. A combined fit of the transit and radial velocity data reveals that EPIC211682544 b has a mass of 14.8 ± 3.1 M⊕. Its bulk density (5.7±1.6/1.4 g cm⁻³) implies that this planet has a significant envelope of water or other volatiles around a rocky core. EPIC211682544 b likely formed in a similar way as the cores of the four giant planets in our own Solar System, but for some reason, did not accrete much gas. The planetary mass was confirmed by an independent Gaussian process-based fit to both the radial velocities and the spectroscopic activity indicators. EPIC211682544 b belongs to only a handful of confirmed K2 exoplanets with periods longer than 40 days. It is among the longest periods for a small planet with a precisely determined mass using radial velocities.

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EPIC 219217635: A Doubly Eclipsing Quadruple System Containing an Evolved Binary

We have discovered a doubly eclipsing, bound, quadruple star system in the field of K2 Campaign 7. EPIC 219217635 is a stellar image with Kp = 12.7 that contains an eclipsing binary (‘EB’) with PA = 3.59470 d and a second EB with PB = 0.61825 d. We have obtained followup radial-velocity (‘RV’) spectroscopy observations, adaptive optics imaging, as well as ground-based photometric observations. From our analysis of all the observations, we derive good estimates for a number of the system parameters. We conclude that (1) both binaries are bound in a quadruple star system; (2) a linear trend to the RV curve of binary A is found over a 2-year interval, corresponding to an acceleration, $\gamma = 0.0024 \pm 0.0007 \text{ cm s}^{-2}$; (3) small irregular variations are seen in the eclipse-timing variations (‘ETVs’) detected over the same interval; (4) the orbital separation of the quadruple system is probably in the range of 8-25 AU; and (5) the orbital planes of the two binaries must be inclined with respect to each other by at least 25°. In addition, we find that binary B is evolved, and the cooler and currently less massive star has transferred much of its envelope to the currently more massive star. We have also demonstrated that the system is sufficiently bright that the eclipses can be followed using small ground-based telescopes, and that this system may be profitably studied over the next decade when the outer orbit of the quadruple is expected to manifest itself in the ETV and/or RV curves.
Estimating the Rate of Cessation of Magnetospheric Activity in AMPERE Field-Aligned Currents
The decay of magnetospheric activity when driving is turned off (to a minimum) was measured in total field-aligned current estimates from the AMPERE project. Events of distinct northward turnings of the IMF were identified, with prolonged periods of stable southward driving conditions followed by northward IMF conditions. All but four of 43 identified events exhibit a well-defined exponential decay in the total hemispheric field-aligned current following the northward turning. A superposed epoch analysis yields a generic decay constant of 0.9, corresponding to an e-folding time of 1.1 hour. A statistical analysis of the ensemble of events also reveals a seasonal variation in the decay parameter with faster decay observed in the winter than in the summer hemisphere. This result can be understood in terms of stronger/weaker line-tying of the ionospheric foot-points of magnetospheric field-lines for higher/lower conductivity.

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Evaluation of multi-mode CryoSat-2 altimetry data over the Po River against in situ data and a hydrodynamic model
Coverage of in situ observations to monitor surface waters is insufficient on the global scale, and decreasing across the globe. Satellite altimetry has become an increasingly important monitoring technology for continental surface waters. The ESA CryoSat-2 altimetry mission, launched in 2010, has two novel features. (i) The radar altimeter instrument on board of CryoSat-2 is operated in three modes; two of them reduce the altimeter footprint by using Delay-Doppler processing. (ii) CryoSat-2 is placed on a distinct orbit with a repeat cycle of 369 days, leading to a drifting ground track pattern. The drifting ground track pattern challenges many common methods of processing satellite altimetry data over rivers. This study evaluates the observation error of CryoSat-2 water level observations over the Po River, Italy, against in situ observations. The average RMSE between CryoSat-2 and in situ observations was found to be 0.38 meters. CryoSat-2 was also shown to be useful for channel roughness calibration in a hydrodynamic model of the Po River. The small across-track distance of CryoSat-2 means that observations are distributed almost continuously along the river. This allowed resolving channel roughness with higher spatial resolution than possible with in situ or virtual station altimetry data. Despite the Po River being extensively monitored, CryoSat-2 still provides added value thanks to its unique spatio-temporal sampling pattern.

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Contributors: Schneider, R., Tarpanelli, A., Nielsen, K., Madsen, H., Bauer-Gottwein, P.
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BFI (2018): BFI-level 1
Experimental study of $\text{H}_2\text{SO}_4$ aerosol nucleation at high ionization levels

One hundred and ten direct measurements of aerosol nucleation rate at high ionization levels were performed in an 8m$^3$ reaction chamber. Neutral and ion-induced particle formation from sulfuric acid ($\text{H}_2\text{SO}_4$) was studied as a function of ionization and $\text{H}_2\text{SO}_4$ concentration. Other species that could have participated in the nucleation, such as $\text{NH}_3$ or organic compounds, were not measured but assumed constant, and the concentration was estimated based on the parameterization by Gordon et al. (2017). Our parameter space is thus $[\text{H}_2\text{SO}_4] = 4 \times 10^6 - 3 \times 10^7 \text{ cm}^{-3}$, $[\text{NH}_3 + \text{org}] = 2.2 \text{ ppb}$, $T = 295 \text{ K}$, $\text{RH} = 38\%$, and ion concentrations of 1700–19000 cm$^{-3}$. The ion concentrations, which correspond to levels caused by a nearby supernova, were achieved with gamma ray sources. Nucleation rates were directly measured with a particle size magnifier (PSM Airmodus A10) at a size close to critical cluster size (mobility diameter of $\sim 1.4 \text{ nm}$) and formation rates at a mobility diameter of $\sim 4 \text{ nm}$ were measured with a CPC (TSI model 3775). The measurements show that nucleation increases by around an order of magnitude when the ionization increases from background to supernova levels under fixed gas conditions. The results expand the parameterization presented in Dunne et al. (2016) and Gordon et al. (2017) (for $[\text{NH}_3 + \text{org}] = 2.2 \text{ ppb}$ and $T = 295 \text{ K}$) to lower sulfuric acid concentrations and higher ion concentrations. The results make it possible to expand the parameterization presented in Dunne et al. (2016) and Gordon et al. (2017) to higher ionization levels.

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Organisations: National Space Institute, Astrophysics and Atmospheric Physics
Contributors: Tomicic, M., Bødker Enghoff, M., Svensmark, H.
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Research output: Contribution to journal › Journal article – Annual report year: 2018 › Research › peer-review

Feed Array Breadboard for Future Passive Microwave Radiometer Antennas
The pattern of a 265 mm x 200 mm breadboard made of 35 x-polarized and 32 y-polarized Vivaldi antennas located above a finite ground plane is computed and measured at 6.9 GHz. The breadboard constitutes the feed array illuminating a 5 m conical scan antenna working at 6.9 GHz for next generation microwave radiometers for ocean observation. The analysis is done including mutual coupling between the elements, and in two commercial software, the MoM add-on to GRASP and CST. The breadboard is measured at the Spherical Near-Field Antenna Test Facility at the Technical University of Denmark.
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Organisations: Microwaves and Remote Sensing, National Space Institute, TICRA, Chalmers University of Technology, ESTEC
Contributors: Cappellin, C., de Lasson, J. R., Iupikov, O., Ivashina, M., Skou, N., Pontoppidan, K., Fiorelli, B.
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FIES fiber injection upgrade
We report on the upgrade of the fiber link of FIES, the high-resolution echelle spectrograph at the Nordic Optical Telescope (NOT). In order to improve the radial velocity (RV) stability of FIES, we replaced the circular fibers by octagonal and rectangular ones to utilize their superior scrambling performance. Two additional fibers for a planned polarimetry mode were added during the upgrade. The injection optics and the telescope front-end were also replaced. The first on-sky RV measurements indicate that the influence of guiding errors is greatly suppressed, and the overall RV precision of FIES has significantly improved.

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Organisations: National Space Institute, Astrophysics and Atmospheric Physics, University of Chicago, Macquarie University, University of Turin, Instituto de Astrofísica de Canarias
Contributors: Stürmer, J., Seifahrt, A., Schwab, C., Gandolfi, D., Montanés Rodriguez, P., Buchhave, L.
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Research output: Chapter in Book/Report/Conference proceeding – Article in proceedings – Annual report year: 2018 – Research – peer-review

Final Results from GOCE++ Dynamical Coastal Topography and Tide Gauge Unification Using Altimetry and GOCE.
The major results from the ESA – GOCE ++ project on the potential of ocean levelling as a novel approach to the study of height system unification taking the recent development in geoid accuracy trough GOCE data into account. The suggested investigation involves the use of measurements and modelling to estimate Mean Dynamic Topography (MDT) of the ocean along a coastline which contributes/requires reconciling altimetry, tide gauge and vertical land motion. The fundamental use of the MDT computed using altimetry, ocean models or through the use of tide gauges has values of between -2 and +1 meters at different points in the ocean. However, close to the coast the determination of the MDT is problematic due to i.e., the altimeter footprint, land motion or parameterization/modelling of coastal currents. The presentation also outlines a new addendum to the project on the use of GPS reflectometry as Coastal tide gauge and the correspondence with SAR altimetry from Cryosat-2 and Sentinel-3.
Fully Polarimetric L-Band Brightness Temperature Signatures of Azimuthal Permittivity Patterns - Measurements and Model Simulations

L-Band microwave radiometry over land mainly focuses on observations of horizontally (H) and vertically (V) polarized brightness temperatures. However, it has been demonstrated that measurements of the full Stokes vector [1] are sensitive to additional environmental properties, e.g. azimuthal plant row orientation. Furthermore, model simulations show that also a smooth surface with a periodic permittivity pattern can cause azimuthal dependencies of the Stokes parameters. The objective of this paper is to present fully polarimetric L-band measurement results from observations of a striped wood and styrodur target, when rotated 360° in small steps. Measurement results of a striped soil and open water target are also reported. Finally, measurements are compared to model simulations, with very good agreement within the validity range of the model (stripe thickness <λ/2).
Global sea-level budget 1993 - present

Global mean sea level is an integral of changes occurring in the climate system in response to unforced climate variability as well as natural and anthropogenic forcing factors. Its temporal evolution allows changes (e.g., acceleration) to be detected in one or more components. Study of the sea-level budget provides constraints on missing or poorly known contributions, such as the unsurveyed deep ocean or the still uncertain land water component. In the context of the World Climate Research Programme Grand Challenge entitled "Regional Sea Level and Coastal Impacts", an international effort involving the sea-level community worldwide has been recently initiated with the objective of assessing the various datasets used to estimate components of the sea-level budget during the altimetry era (1993 to present). These datasets are based on the combination of a broad range of space-based and in situ observations, model estimates, and algorithms. Evaluating their quality, quantifying uncertainties and identifying sources of discrepancies between component estimates is extremely useful for various applications in climate research. This effort involves several tens of scientists from about 50 research teams/institutions worldwide (www.wcrp-climate.org/grand-challenges/gc-sea-level, last access: 22 August 2022).
The results presented in this paper are a synthesis of the first assessment performed during 2017–2018. We present estimates of the altimetry-based global mean sea level (average rate of $3.1\pm0.3\text{mm yr}^{-1}$ and acceleration of $0.1\text{mm yr}^{-2}$ over 1993–present), as well as of the different components of the sea-level budget (http://doi.org/10.17882/54854, last access: 22 August 2018). We further examine closure of the sea-level budget, comparing the observed global mean sea level with the sum of components. Ocean thermal expansion, glaciers, Greenland and Antarctica contribute 42%, 21%, 15% and 8% to the global mean sea level over the 1993–present period. We also study the sea-level budget over 2005–present, using GRACE-based ocean mass estimates instead of the sum of individual mass components. Our results demonstrate that the global mean sea level can be closed to within $0.3\text{mm yr}^{-1}$ (1σ). Substantial uncertainty remains for the land water storage component, as shown when examining individual mass contributions to sea level.

Studies of the sea level budget are a means of assessing and understanding how sea level is changing and what are the causes. Closure of the total sea level budget implies that the observed changes of global mean sea level as determined from satellite altimetry equal the sum of observed (or otherwise assessed) contributions, namely changes in ocean mass and ocean thermal expansion and haline contraction. Here, ocean mass changes can be either derived from GRACE
GNSS Transpolar Earth Reflectometry explorIng System (G-TERN): Mission Concept

The global navigation satellite system (GNSS) Transpolar Earth Reflectometry explorIng system (G-TERN) was proposed in response to ESA’s Earth Explorer 9 revised call by a team of 33 multi-disciplinary scientists. The primary objective of the mission is to quantify at high spatio-temporal resolution crucial characteristics, processes and interactions between sea ice, and other Earth system components in order to advance the understanding and prediction of climate change and its impacts on the environment and society. The objective is articulated through three key questions. 1) In a rapidly changing Arctic regime and under the resilient Antarctic sea ice trend, how will highly dynamic forcings and couplings between the various components of the ocean, atmosphere, and cryosphere modify or influence the processes governing the characteristics of the sea ice cover (ice production, growth, deformation, and melt)? 2) What are the impacts of extreme events and feedback mechanisms on sea ice evolution? 3) What are the effects of the cryosphere behaviors, either rapidly changing or resiliently stable, on the global oceanic and atmospheric circulation and mid-latitude extreme events? To contribute answering these questions, G-TERN will measure key parameters of the sea ice, the oceans, and the atmosphere with frequent and dense coverage over polar areas, becoming a “dynamic mapper” of the ice conditions, the ice production, and the loss in multiple time and space scales, and surrounding environment. Over polar areas, the G-TERN will measure sea ice surface elevation (<10 cm precision), roughness, and polarimetry aspects at 30-km resolution and 3-days full coverage. G-TERN will implement the interferometric GNSS reflectometry concept, from a single satellite in near-polar orbit with capability for 12 simultaneous observations. Unlike currently orbiting GNSS reflectometry missions, the G-TERN uses the full GNSS available bandwidth to improve its ranging measurements. The lifetime would be 2025–2030 or optimally 2025–2035, covering key stages of the transition toward a nearly ice-free Arctic Ocean in summer.

This paper describes the mission objectives, it reviews its measurement techniques, summarizes the suggested implementation, and finally, it estimates the expected performance.
GOCE User Toolbox and Tutorial
The GOCE User Toolbox GUT is a compilation of tools for the utilisation and analysis of GOCE Level 2 products. GUT support applications in Geodesy, Oceanography and Solid Earth Physics. The GUT Tutorial provides information and guidance in how to use the toolbox for a variety of applications. GUT consists of a series of advanced computer routines that carry out the required computations. It may be used on Windows PCs, UNIX/Linux Workstations and Mac. The toolbox is supported by The GUT Algorithm Description and User Guide and The GUT Install Guide. A set of a-priori data and models are made available as well. Without any doubt the development of the GOCE user toolbox have played a major role in paving the way to successful use of the GOCE data for oceanography. The GUT version 2.2 was released in April 2014 and beside some bug-fixes it adds the capability for the computation of Simple Bouguer Anomaly (Solid-Earth). During this fall a new GUT version 3 has been released. GUTv3 was further developed through a collaborative effort where the scientific communities participate aiming on an implementation of remaining functionalities facilitating a wider span of research in the fields of Geodesy, Oceanography and Solid earth studies. Accordingly, the GUT version 3 has:
- An attractive and easy to use Graphic User Interface (GUI) for the toolbox,
- Enhance the toolbox with some further software functionalities such as to facilitate the use of gradients, anisotropic diffusive filtering and computation of Bouguer and isostatic gravity anomalies.
- An associated GUT VCM tool for analyzing the GOCE variance covariance matrices.

General information
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Contributors: Knudsen, P., Benveniste, J., All, E.
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Research output: Contribution to conference › Conference abstract for conference – Annual report year: 2018 › Research › peer-review
Greenland CCI Surface Elevation Change Products from Cryosat-2 and SARAL/ALtiKa

A long, unbroken sequence of satellite altimetry elevation changes is an essential climate variable. Here, we present the surface elevation change (SEC) record provided in the ESA Greenland ice sheet CCI project, as 5-year running means spanning back to 1992. The 5-year running mean is chosen to show the imprint of climate change on the Greenland ice sheet surface elevation change and limits the imprint of weather variability. We mainly focus on the novel results from ESA’s Cryosat-2 and the French-Indian SARAL/ALtiKa satellite, as this latest generation of radar altimeters provides new opportunities for monitoring Greenland ice sheet SEC. The orbit of Cryosat-2 enables the generation of a higher temporal-resolution data product from Ku-band radar altimetry; a 2-year running mean SEC. This 2-year product shows the inter-annual variability in weather and its imprint in surface elevation. The observational period of SARAL/ALtiKa satellite has now matured, and an experimental SEC product from Ka-band altimetry is being provided in the Greenland ice sheet CCI. The Kaband radar altimetry is less subject to surface penetration in firn covered areas, and map changes in snowfall in the interior region of the Greenland ice sheet. The Greenland ice sheet CCI now provides 11 maps of Greenland SEC generated from Cryosat-2 or SARAL/ALtiKa data. All giving insight into the complex nature of the changing Greenland ice sheet. The emerging patterns from comparing both Cryosat-2 5-year vs. 2-year SEC and Ku-band vs. Ka-band SEC may relate to the interplay between the surface mass balance and internal ice sheet dynamics.

General information
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Contributors: Simonsen, S., Khvostovsky, K., Sandberg Sørensen, L., Forsberg, R.
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Greenlandic Coastal Sea Ice Freeboard and Thickness From CryoSat-2 SARIn Data


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Contributors: Di Bella, A., Kwok, R., Skourup, H., Forsberg, R.
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HATS-59b,c: A Transiting Hot Jupiter and a Cold Massive Giant Planet around a Sunlike Star

We report the first discovery of a multi-planetary system by the HATSouth network, HATS-59b,c, a planetary system with an inner transiting hot Jupiter and an outer cold massive giant planet, which was detected via radial velocity. The inner transiting planet, HATS-59b, is on an eccentric orbit with $e = 0.129 \pm 0.049$, orbiting a $V = 13.951 \pm 0.030$ mag solar-like star ($M_{\text{star}} = 1.038 \pm 0.039 \ M_{\odot}$ and $R_{\text{star}} = 1.036 \pm 0.067 \ R_{\odot}$) with a period of $5.416081 \pm 0.000016$ days. The outer companion, HATS-59c is on a circular orbit with $m \sin i = 12.70 \pm 0.87 \ M_J$ and a period of $1422 \pm 14$ days. The inner planet has a mass of $0.806 \pm 0.069 \ M_J$ and a radius of $1.126 \pm 0.077 \ R_J$, yielding a density of $0.70 \pm 0.16 \ g \ cm^{-3}$. Unlike most planetary systems that include only a single hot Jupiter, HATS-59b,c includes, in addition to the transiting hot Jupiter, a massive outer companion. The architecture of this system is valuable for understanding planet migration.

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Helicopter Test of a Strapdown Airborne Gravimetry System

Airborne gravimetry from a helicopter has been a feasible tool since the 1990s, with gravimeters mounted on a gyro-stabilised platform. In contrast to fixed-wing aircrafts, the helicopter allows for a higher spatial resolution, since it can move slower and closer to the ground. In August 2016, a strapdown gravimetry test was carried out over the Jakobshavn Glacier in Greenland. To our knowledge, this was the first time that a strapdown system was used in a helicopter. The strapdown configuration is appealing because it is easily installed and requires no operation during flight. While providing additional information over the thickest part of the glacier, the survey was designed to assess repeatability both within the survey and with respect to profiles flown previously using a gyro-stabilised gravimeter. The system's ability to fly at an altitude following the terrain, i.e., draped flying, was also tested. The accuracy of the gravity profiles was estimated to 2 mGal and a method for inferring the spatial resolution was investigated, yielding a half-wavelength spatial resolution of 4.5 km at normal cruise speed.

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Organisations: National Space Institute, Geodynamics
Contributors: Jensen, T. E., Forsberg, R.
High-Energy Emissions induced by air density fluctuations of discharges

Bursts of X- and γ-rays are observed from lightning and laboratory sparks. They are bremsstrahlung from energetic electrons interacting with neutral air molecules, but it is still unclear how the electrons achieve the required energies. It has been proposed that the enhanced electric field of streamers, found in the corona of leader tips, may account for the acceleration, however, their efficiency is questioned because of the relatively low production rate found in simulations. Here we emphasize that streamers usually are simulated with the assumption of homogeneous gas, which may not be the case on the small temporal and spatial scales of discharges. Since the streamer properties strongly depend on the reduced electric field $E/n$, where $n$ is the neutral number density, fluctuations may potentially have a significant effect. To explore what might be expected if the assumption of homogeneity is relaxed, we conducted simple numerical experiments based on simulations of streamers in a neutral gas with a radial gradient in the neutral density, assumed to be created, for instance, by a previous spark. We also studied the effects of background electron density from previous discharges. We find that X- and γ-radiation is enhanced when the on-axis air density is reduced by more than $\frac{1}{425}\%$. Pre-ionization tends to reduce the streamer field and thereby the production rate of high-energy electrons, however, the reduction is modest. The simulations suggest that fluctuations in the neutral densities, on the temporal and spatial scales of streamers, may be important for electron acceleration and bremsstrahlung radiation.

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High energy radiation profile of Jupiter as observed by the JunoASC

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Organisations: Measurement and Instrumentation Systems, National Space Institute, NASA Goddard Space Flight Center, Technical University of Denmark
Contributors: Jørgensen, F. E., Jørgensen, J. L., Jørgensen, P. S., Herceg, M., Denver, T., Benn, M., Shushkova, J., Connerney, J. E. P., Oliversen, R. J., Gershman, D. J., Kotsiaros, S.
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High resolution Gravity Field Modelling Using SAR Altimetry in the Northeast Atlantic Ocean
Over the past year SHOM, DTU Space and Novelits has corporated on updating altimetric data and on the use of these for gravity field modelling in the Northeast European shelf. The joint investigating has particularly focused on studying the effect on the use of SAR altimetry from the Cryosat-2 mission which is operating in SAR mode in the Northeast part of the Atlantic Ocean. In this presentation we investigate the effect of using SAR altimetry for marine gravity field modelling in comparison with RDSAR altimetry. We select CryoSat-2 altimetry products over a time interval of 6-years from October 2010 to December 2016 along the Northeastern coasts of the Atlantic Ocean. The ESA GPOD processors SARVatore was applied to retrack the 20 Hz Cryosat-2 SAR. The SAMOSA-2 (Ray et al., 2014) and SAMOSA+ SAR products have been evaluated in the presentation. They initially differ in the way the SAR waveforms are build (i.e. Hamming weighting window on the burst data prior to the azimuth FFT, zero-padding prior to the range FFT, doubling of the extension for the radar range swath) and in the retracking methodology. The Cryosat-2 waveforms were turned into conventional LRM like data and the RDSAR waveforms have been retracked by the RADS altimetry system and this dataset were also introduced into the validation in order to investigating the effect of using SAR altimetry using two near-similar datasets.

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Holocene history of the Helheim Glacier, southeast Greenland
Helheim Glacier ranks among the fastest flowing and most ice discharging outlets of the Greenland Ice Sheet (GrIS). After undergoing rapid speed-up in the early 2000s, understanding its long-term mass balance and dynamic has become increasingly important. Here, we present the first record of direct Holocene ice-marginal changes of the Helheim Glacier following the initial deglaciation. By analysing cores from lakes adjacent to the present ice margin, we pinpoint periods of advance and retreat. We target threshold lakes, which receive glacial meltwater only when the margin is at an advanced position, similar to the present. We show that, during the period from 10.5 to 9.6cal ka BP, the extent of Helheim Glacier was similar to that of todays, after which it remained retracted for most of the Holocene until a re-advance caused it to reach its present extent at c. 0.3cal ka BP, during the Little Ice Age (LIA). Thus, Helheim Glacier's present extent is the largest since the last deglaciation, and its Holocene history shows that it is capable of recovering after several millennia of warming and retreat. Furthermore, the absence of advances beyond the present-day position during for example the 9.3 and 8.2 ka cold events as well as the early-Neoglacial suggest a substantial retreat during most of the Holocene.
Hubble PanCET: An extended upper atmosphere of neutral hydrogen around the warm Neptune GJ 3470b

GJ 3470b is a warm Neptune transiting an M-dwarf star at the edge of the evaporation desert. It offers the possibility of investigating how low-mass, close-in exoplanets evolve under the irradiation from their host stars. We observed three transits of GJ 3470b in the Lyman-α line with the Hubble Space Telescope (HST) as part of the Panchromatic Comparative Exoplanet Treasury (PanCET) program. Absorption signatures are detected with similar properties in all three independent epochs, with absorption depths of 35 ± 7% in the blue wing of the line, and 23 ± 5% in the red wing. The repeatability of these signatures, their phasing with the planet transit, and the radial velocity of the absorbing gas allow us to conclude that there is an extended upper atmosphere of neutral hydrogen around GJ 3470b. We determine from our observations the stellar radiation pressure and XUV irradiation from GJ 3470 and use them to perform numerical simulations of the upper atmosphere of GJ 3470b with the EVaporating Exoplanets (EVE) code. The unusual redshifted signature can be explained by the damping wings of dense layers of neutral hydrogen that extend beyond the Roche lobe and are elongated in the direction of the planet motion. This structure could correspond to a shocked layer of planetary material formed by the collision of the expanding thermosphere with the wind of the star. The blueshifted signature is well explained by neutral hydrogen atoms escaping at rates of about 10^{10} g s⁻¹ that are blown away from the star by its strong radiation pressure and are quickly photoionized, resulting in a smaller exosphere than that of the warm Neptune GJ 436b. The stronger escape from GJ 3470b, however, may have led to the loss of about 4–35% of its current mass over its ~2 Gyr lifetime.
Improved Arctic Ocean Bathymetry and Regional Tide Atlas – a CP4O Initiative.

CryoSat Plus for Oceans (CP4O) is a project under the ESA STST program which aims to develop and evaluate new ocean products from CryoSat data and so maximize the scientific return of CryoSat over oceans. The main focus of CP4O has been on the additional measurement capabilities that are offered by the SAR mode of the SIRAL altimeter, with further work in developing improved geophysical corrections. The Arctic Ocean is a challenging region, because of its complex and not well-documented bathymetry, together combined with the intermittent presence of sea ice and the fact that the in situ tidal observations are scarce at such high latitudes. The current initiative initially addresses the bathymetry in the Arctic in attempting to improve altimetric bathymetry using the near 7 years of Cryosat-2 high quality and high resolution "geodetic" SAR altimetry all the way up to 88N. Subsequently the project progresses to use Cryosat-2 in TWO ways for improved ocean tide modelling in the Arctic Ocean. One is to use Cryosat-2 improved bathymetry the second is to use Cryosat-2 derived harmonic tidal constituents for assimilation into a regional tide model. The first project bathymetry in the Arctic will be presented and evaluated in this presentation. It will also present the methodology to derive bathymetry from the high resolution DTU17 marine gravity field derived from Cryosat-2. Secondly this presentation highlights the methodology followed to develop the model and the performances of this new regional tidal model in the Arctic Ocean.

Improvement of downward continuation values of airborne gravity data in Taiwan

An airborne gravity survey was carried out to fill gaps in the gravity data for the mountainous areas of Taiwan. However, the downward continuation error of airborne gravity data is a major issue, especially in regions with complex terrain, such as Taiwan. The root mean square (RMS) of the difference between the downward continuation values and land gravity was approximately 20 mGal. To improve the results of downward continuation we investigated the inverse Poisson's integral, the semi-parametric method combined with regularization (SPR) and the least-squares collocation (LSC) in this paper. The numerically simulated experiments are conducted in the Tibetan Plateau, which is also a mountainous area. The results show that as a valuable supplement to the inverse Poisson's integral, the SPR is a useful approach to estimate systematic errors and to suppress random errors. While the LSC approach generates the best results in the Tibetan Plateau in terms of the RMS of the downward continuation errors. Thus, the LSC approach with a terrain correction (TC) is applied to the downward continuation of real airborne gravity data in Taiwan. The statistical results show that the RMS of the differences between the downward continuation values and land gravity data reduced to 11.7 mGal, which shows that an improvement of 40% is obtained.
Informing a hydrological model of the Ogooué with multi-mission remote sensing data

Remote sensing provides a unique opportunity to inform and constrain a hydrological model and to increase its value as a decision-support tool. In this study, we applied a multi-mission approach to force, calibrate and validate a hydrological model of the ungauged Ogooué river basin in Africa with publicly available and free remote sensing observations. We used a rainfall–runoff model based on the Budyko framework coupled with a Muskingum routing approach. We parametrized the model using the Shuttle Radar Topography Mission digital elevation model (SRTM DEM) and forced it using precipitation from two satellite-based rainfall estimates, FEWS-RFE (Famine Early Warning System rainfall estimate) and the Tropical Rainfall Measuring Mission (TRMM) 3B42 v.7, and temperature from ECMWF ERA-Interim. We combined three different datasets to calibrate the model using an aggregated objective function with contributions from (1) historical in situ discharge observations from the period 1953–1984 at six locations in the basin, (2) radar altimetry measurements of river stages by Envisat and Jason-2 at 12 locations in the basin and (3) GRACE (Gravity Recovery and Climate Experiment) total water storage change (TWSC). Additionally, we extracted CryoSat-2 observations throughout the basin using a Sentinel-1 SAR (synthetic aperture radar) imagery water mask and used the observations for validation of the model. The use of new satellite missions, including Sentinel-1 and CryoSat-2, increased the spatial characterization of river stage. Throughout the basin, we achieved good agreement between observed and simulated discharge and the river stage, with an RMSD between simulated and observed water amplitudes at virtual stations of 0.74m for the TRMM-forced model and 0.87m for the FEWS-RFE-forced model. The hydrological model also captures overall total water storage change patterns, although the amplitude of storage change is generally underestimated. By combining hydrological modeling with multi-mission remote sensing from 10 different satellite missions, we obtain new information on an otherwise unstudied basin. The proposed model is the best current baseline characterization of hydrological conditions in the Ogooué in light of the available observations.

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Bibliographical note
NICER and Fermi GBM Observations of the First Galactic Ultraluminous X-Ray Pulsar Swift J0243.6+6124

Swift J0243.6+6124 is a newly discovered Galactic Be/X-ray binary, revealed in late 2017 September in a giant outburst with a peak luminosity of $2 \times 10^{39} (d/7 \text{ kpc})^2 \text{ erg s}^{-1}$ (0.1–10 keV), with no formerly reported activity. At this luminosity, Swift J0243.6+6124 is the first known galactic ultraluminous X-ray pulsar. We describe Neutron star Interior Composition Explorer (NICER) and Fermi Gamma-ray Burst Monitor (GBM) timing and spectral analyses for this source. A new orbital ephemeris is obtained for the binary system using spin frequencies measured with GBM and 15–50 keV fluxes measured with the Neil Gehrels Swift Observatory Burst Alert Telescope to model the system’s intrinsic spin-up. Power spectra measured with NICER show considerable evolution with luminosity, including a quasi-periodic oscillation near 50 mHz that is omnipresent at low luminosity and has an evolving central frequency. Pulse profiles measured over the combined 0.2–100 keV range show complex evolution that is both luminosity and energy dependent. Near the critical luminosity of $L \sim 10^{38}$ erg s$^{-1}$, the pulse profiles transition from single peaked to double peaked, the pulsed fraction reaches a minimum in all energy bands, and the hardness ratios in both NICER and GBM show a turnover to softening as the intensity increases. This behavior repeats as the outburst rises and fades, indicating two distinct accretion regimes. These two regimes are suggestive of the accretion structure on the neutron star surface transitioning from a Coulomb collisional stopping mechanism at lower luminosities to a radiation-dominated stopping mechanism at higher luminosities. This is the highest observed (to date) value of the critical luminosity, suggesting a magnetic field of $B \sim 10^{13}$ G.

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NICER Detection of Strong Photospheric Expansion during a Thermonuclear X-Ray Burst from 4U 1820–30

The Neutron Star Interior Composition Explorer (NICER) on the International Space Station (ISS) observed strong photospheric expansion of the neutron star in 4U 1820–30 during a Type I X-ray burst. A thermonuclear helium flash in the star’s envelope powered a burst that reached the Eddington limit. Radiation pressure pushed the photosphere out to ~200 km, while the blackbody temperature dropped to 0.45 keV. Previous observations of similar bursts were performed with instruments that are sensitive only above 3 keV, and the burst signal was weak at low temperatures. NICER's 0.2–12 keV passband enables the first complete detailed observation of strong expansion bursts. The strong expansion lasted only 0.6 s, and was followed by moderate expansion with a 20 km apparent radius, before the photosphere finally settled back down at 3 s after the burst onset. In addition to thermal emission from the neutron star, the NICER spectra reveal a second component that is well fit by optically thick Comptonization. During the strong expansion, this component is six times brighter than prior to the burst, and it accounts for 71% of the flux. In the moderate expansion phase, the Comptonization flux drops, while the thermal component brightens, and the total flux remains constant at the Eddington limit. We speculate that the thermal emission is reprocessed in the accretion environment to form the Comptonization
component, and that changes in the covering fraction of the star explain the evolution of the relative contributions to the total flux.

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**NICER Detects a Soft X-Ray Kilohertz Quasi-periodic Oscillation in 4U 0614+09**
We report on the detection of a kilohertz quasi-periodic oscillation (QPO) with the Neutron Star Interior Composition Explorer (NICER). Analyzing approximately 165 ks of NICER exposure on the X-ray burster 4U 0614+09, we detect multiple instances of a single-peak upper kHz QPO, with centroid frequencies that range from 400 to 750 Hz. We resolve the kHz QPO as a function of energy, and measure, for the first time, the QPO amplitude below 2 keV. We find the fractional amplitude at 1 keV is on the order of 2% rms, and discuss the implications for the QPO emission process in the context of Comptonization models.

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**NICER Observes the Effects of an X-Ray Burst on the Accretion Environment in Aql X-1**

Accretion disks around neutron stars regularly undergo sudden strong irradiation by Type-I X-ray bursts powered by unstable thermonuclear burning on the stellar surface. We investigate the impact on the disk during one of the first X-ray burst observations with the Neutron Star Interior Composition Explorer (NICER) on the International Space Station. The burst is seen from Aql X-1 during the hard spectral state. In addition to thermal emission from the neutron star, the burst spectrum exhibits an excess of soft X-ray photons below 1 keV, where NICER's sensitivity peaks. We interpret the excess as a combination of reprocessing by the strongly photoionized disk and enhancement of the pre-burst persistent flux, possibly due to Poynting–Robertson drag or coronal reprocessing. This is the first such detection for a short sub-Eddington burst. As these bursts are observed frequently, NICER will be able to study how X-ray bursts affect the disk and corona for a range of accreting neutron star systems and disk states.

**In situ study of electric field controlled ion transport in the Fe/BaTiO$_3$ interface**

Electric field controlled ion transport and interface formation of iron thin films on a BaTiO$_3$ substrate have been investigated by in situ nuclear resonance scattering and x-ray reflectometry techniques. At early stage of deposition, an iron-II oxide interface layer was observed. The hyperfine parameters of the interface layer were found insensitive to the evaporated layer thickness. When an electric field was applied during growth, a 10 angstrom increase of the nonmagnetic/magnetic thickness threshold and an extended magnetic transition region was measured compared to the case where no field was applied. The interface layer was found stable under this threshold when further evaporation occurred, contrary to the magnetic layer where the magnitude and orientation of the hyperfine magnetic field vary continuously. The obtained results of the growth mechanism and of the electric field effect of the Fe/BTO system will allow the design of novel applications by creating custom oxide/metallic nanopatterns using laterally inhomogeneous electric fields during sample preparation.
INTEGRAL Observations of Gravitational-Wave Counterparts & Future Perspectives: Searching for GBM Un-Triggered SGRB with PICsIT

The X-ray/gamma-ray mission INTEGRAL detected the short GRB170817A and demonstrated its association to a gravitational wave trigger, GW170817. This marks the first time a binary neutron star merger was detected by the LIGO-Virgo collaboration and that an electromagnetic counterpart to a gravitational wave event has been observed. GRB170817A was detected by the SPI-ACS on-board INTEGRAL and the Fermi/GBM instruments ∼ 1.7 s after the GW event. Following the prompt emission, INTEGRAL performed pointed observations for 5.4 days. During this time the instruments provided stringent upper limits on any electromagnetic signal in the 3 keV to 8 MeV range. Interestingly, the GRB was found to be extremely subluminous. In light of these results from GRB170817A, we have begun analysis of soft gamma-ray data (200 keV - 2.6 MeV) from INTEGRAL/PICsIT. With this wide field-of-view instrument, we have begun searching for untriggered SGRBs reported by Fermi/GBM as well as preparing for real-time analysis during future LIGO-Virgo observing runs.
**INTEGRAL results on the electromagnetic counterparts of gravitational waves**

Thanks to its high orbit and a set of complementary detectors providing continuous coverage of the whole sky, the INTEGRAL satellite has unique capabilities for the identification and study of the electromagnetic radiation associated to gravitational waves signals and, more generally, for multi-messenger astrophysics. Here we briefly review the results obtained during the first two observing runs of the advanced LIGO/Virgo interferometers.

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**Intercomparison and validation of SAR-based ice velocity measurement techniques within the Greenland Ice Sheet CCI project**

Ice velocity is one of the products associated with the Ice Sheets Essential Climate Variable. This paper describes the intercomparison and validation of ice-velocity measurements carried out by several international research groups within the European Space Agency Greenland Ice Sheet Climate Change Initiative project, based on space-borne Synthetic Aperture Radar (SAR) data. The goal of this activity was to survey the best SAR-based measurement and error characterization approaches currently in practice. To this end, four experiments were carried out, related to different processing techniques and scenarios, namely differential SAR interferometry, multi aperture SAR interferometry and offset-tracking of incoherent as well as of partially-coherent data. For each task, participants were provided with common datasets covering areas located on the Greenland ice-sheet margin and asked to provide mean velocity maps, quality characterization and a description of processing algorithms and parameters. The results were then intercompared and validated against GPS data, revealing in several cases significant differences in terms of coverage and accuracy. The algorithmic steps and parameters influencing the coverage, accuracy and spatial resolution of the measurements are discussed in detail for each technique, as well as the consistency between quality parameters and validation results. This allows several recommendations to be formulated, in particular concerning procedures which can reduce the impact of analyst decisions, and which are often found to be the cause of sub-optimal algorithm performance.

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Interplanetary magnetic field $B_x$ component influence on horizontal and field-aligned currents in the ionosphere

Statistical analyses have shown that the sunward component of the interplanetary magnetic field, $B_x$ (GSM), moderately but significantly affects the auroral intensity. These observations have been interpreted as signatures of a similar IMF $B_x$ control on Birkeland currents, yet to be observed directly. Such a control, attributed to differences in magnetic tension on newly opened magnetic field lines, would lead to stronger region 1 (R1) Birkeland currents for $B_x$ negative (positive) conditions in the northern (southern) hemisphere than when $B_x$ is positive (negative). In this paper we perform a detailed investigation of three different sets of magnetic field measurements, from the CHAMP and Swarm low-Earth-Orbit satellites, from the AMPERE products derived from the Iridium satellite constellation, and from the SuperMAG ground magnetometer network, each analyzed using different techniques, to test these predictions. The results show that a change in sign of $B_x$ changes the Birkeland currents by no more than $\approx 10\%$. The current patterns show little support for an inter-hemispheric asymmetry of the kind proposed to explain auroral observations. Instead we propose an alternative interpretation, which is consistent with most of the auroral observations and with the current observations in the present paper, except for those based on AMPERE: The solar wind-magnetosphere coupling is more efficient when the dipole tilt angle and $B_x$ have the same sign than when they are different. We suggest the higher coupling is because the dayside reconnection region is closer to the subsolar point when the dipole tilt angle and $B_x$ have the same sign.
projected semi-major axis of ∼1.23 lt-s. With the binary mass function, we estimate a minimum companion mass of 0.42 M, obtained assuming a neutron star mass of 1.4 M and an inclination angle lower than 60°, as suggested by the absence of eclipses or dips in the light curve of the source. The broad-band energy spectrum, obtained by combining NuSTAR, Swift and INTEGRAL observations, is dominated by Comptonisation of soft thermal seed photons with a temperature of ∼0.7 keV by electrons heated to 21 keV. We also detect black-body-like thermal direct emission that is compatible with an emission region of a few kilometers and a temperature compatible with the seed source of Comptonisation. A weak Gaussian line centred on the iron Kα complex can be interpreted as a signature of disc reflection. A similar spectrum characterises the NICER spectra, which was measured when the outburst faded.

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NuSTAR observations of Mrk 766: distinguishing reflection from absorption
We present two new NuSTAR observations of the narrow line Seyfert 1 (NLS1) galaxy Mrk 766 and give constraints on the two scenarios previously proposed to explain its spectrum and that of other NLS1s: relativistic reflection and partial covering. The NuSTAR spectra show a strong hard (>15 keV) X-ray excess, while simultaneous soft X-ray coverage of one of the observations provided by XMM-Newton constrains the ionised absorption in the source. The pure reflection model requires a black hole of high spin (a > 0.92) viewed at a moderate inclination (i=46° ± 4°). The pure partial covering model requires extreme parameters: the cut-off of the primary continuum is very low (22° ± 5° keV) in one observation and the intrinsic X-ray emission must provide a large fraction (75%) of the bolometric luminosity. Allowing a hybrid model with both partial covering and reflection provides more reasonable absorption parameters and relaxes the constraints on reflection parameters. The fractional variability reduces around the iron K band and at high energies including the Compton hump, suggesting that the reflected emission is less variable than the continuum.

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Planck Intermediate results - LIV. The Planck multi-frequency catalogue of non-thermal sources

This paper presents the Planck Multi-frequency Catalogue of Non-thermal (i.e. synchrotron-dominated) Sources (PCNT) observed between 30 and 857 GHz by the ESA Planck mission. This catalogue was constructed by selecting objects detected in the full mission all-sky temperature maps at 30 and 143 GHz, with a signal-to-noise ratio (S/N) > 3 in at least one of the two channels after filtering with a particular Mexican hat wavelet. As a result, 29 400 source candidates were selected. Then, a multi-frequency analysis was performed using the Matrix Filters methodology at the position of these objects, and flux densities and errors were calculated for all of them in the nine Planck channels. This catalogue was built using a different methodology than the one adopted for the Planck Catalogue of Compact Sources (PCCS) and the Second Planck Catalogue of Compact Sources (PCCS2), although the initial detection was done with the same pipeline that was used to produce them. The present catalogue is the first unbiased, full-sky catalogue of synchrotron-dominated sources published at millimetre and submillimetre wavelengths and constitutes a powerful database for statistical studies of non-thermal extragalactic sources, whose emission is dominated by the central active galactic nucleus. Together with the full multi-frequency catalogue, we also define the Bright Planck Multi-frequency Catalogue of Non-thermal Sources (PCNTB), where only those objects with a S/N > 4 at both 30 and 143 GHz were selected. In this catalogue 1146 compact sources are detected outside the adopted Planck GAL070 mask; thus, these sources constitute a highly reliable sample of extragalactic radio sources. We also flag the high-significance subsample (PCNTBh), a subset of 151 sources that are detected with S/N > 4 in all nine Planck channels, 75 of which are found outside the Planck mask adopted here. The remaining 76 sources inside the Galactic mask are very likely Galactic objects.
Juno ASC observations of low light phenomena on the Jovian night side

The Juno spacecraft entered into a highly elliptic polar orbit about Jupiter on the 4th of July 2016. The orbit and attitude profile of the spinning spacecraft is, orbit by orbit, optimized to afford the best viewing conditions for Juno’s science instruments. The orbit plane progressively drifts from dawn-dusk towards noon-midnight, as Jupiter moves about the sun. By 2020, perijove will have advanced from dusk to midday, with each 53-day orbit increasing local time by ~15 minutes. Juno’s magnetometer investigation is mapping the Jovian magnetic field with unprecedented accuracy, for which each of its two vector magnetometers is paired with two star trackers (ASCs) providing attitude determination whenever viewing the celestial sphere. Juno’s evolving orbit and attitude profile will, however, for a short period around the perijove, bring Jupiter through the field of view of the ASC cameras. The ASC cameras will view the night side of Jupiter during these perijove passes. Jupiter will be viewed at high slant angles, typically from the horizon to the terminator; this vantage point will naturally preclude a study of details, but yields an excellent overview of luminous night side phenomena. The ASC cameras have thus far been acquiring low-light wide-field images of these regions. We present an overview of the ASC night-side Jupiter observations obtained during the first 14 orbits, including giant lightning discharges, large scale noctilucent cloud top phenomena, and perspective views of the Great Red spot facilitating an assessment of cloud height.

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Jupiter Analogs Orbit Stars with an Average Metallicity Close to That of the Sun

Jupiter played an important role in determining the structure and configuration of the Solar System. Whereas hot-Jupiter type exoplanets preferentially form around metal-rich stars, the conditions required for the formation of planets with masses, orbits, and eccentricities comparable to Jupiter (Jupiter analogs) are unknown. Using spectroscopic metallicities, we show that stars hosting Jupiter analogs have an average metallicity close to solar, in contrast to their hot-Jupiter and eccentric cool-Jupiter counterparts, which orbit stars with super-solar metallicities. Furthermore, the eccentricities of Jupiter analogs increase with host-star metallicity, suggesting that planet-planet scatterings producing highly eccentric cool Jupiters could be more common in metal-rich environments. To investigate a possible explanation for these metallicity trends, we compare the observations to numerical simulations, which indicate that metal-rich stars typically form multiple Jupiters, leading to planet-planet interactions and, hence, a prevalence of either eccentric cool Jupiters or hot Jupiters with circularized orbits. Although the samples are small and exhibit variations in their metallicities, suggesting that numerous processes other than metallicity affect the formation of planetary systems, the data in hand suggests that Jupiter analogs and terrestrial-sized planets form around stars with average metallicities close to solar, whereas high-metallicity systems preferentially host eccentric cool Jupiter or hot Jupiters, indicating that higher metallicity systems may not be favorable for the formation of planetary systems akin to the Solar System.

General information
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Marine Gravity Field Mapping from Altimetry – Advancement with 2nd Generation Altimeters

Until the launch of Cryosat in 2010 the only geodetic data available for deriving high resolution marine gravity fields were the 1985 Geosat GM and 1995 ERS-1 phases E and F. Geodesists therefore spent the better of 15 years improving these GEOSAT and ERS-1 data. With the launch of the second generation altimeters CryoSat and SARAL/AltiKa and the completed geodetic missions from Jason-1 as part of the retirement orbit, a new era in satellite altimetry has been initiated. Since 2010 the amount of geodetic mission altimetry has nearly four-doubled. At the same time the signal-to-noise ratio in these new satellite’s range measurements is better than that of Geosat and ERS-1, and this is leading to huge improved resolution of marine gravity anomalies. Today the quality of altimetric marine gravity is on the order of 1.5 to 2 mGal depending on region. This surpasses what can be obtained from marine gravity in many regions of the world. The quality of global high resolution marine gravity field will always be limited by the random noise level in the radar range measurement as well as the ground track spacing. Over the years geodesists have made significant advances in retracking algorithms, cutting range error nearly in half, and leading to improvements that have been a benefit to oceanography. Cryosat-2 provides for the first time altimetry throughout the Arctic Ocean up to 88°N as well as delay-Doppler (SAR) altimeter in scattered regions around the world where the multi-looked on-board processing can be used for improved range precision at even higher Altimetric Contributions to Gravity Field, Marine Geodesy, Bathymetry Modeling
along track resolution than conventional satellite altimetry (LRM). In the near future we are looking towards several new revolution in high resolution marine gravity field mapping. The first will be the completion of the 2-year Jason-2 End of Life geodetic mission which will decrease the groundtrack spacing from 8 km today to 4 km which will enable scientist to resolve further high resolution in the marine gravity field. The second will be the availability of ultrahigh resolution SWOT altimetry from year 2021.

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Mass balance of the Antarctic Ice Sheet from 1992 to 2017
The Antarctic Ice Sheet is an important indicator of climate change and driver of sea-level rise. Here we combine satellite observations of its changing volume, flow and gravitational attraction with modelling of its surface mass balance to show that it lost 2,720 ± 1,390 billion tonnes of ice between 1992 and 2017, which corresponds to an increase in mean sea level of 7.6 ± 3.9 millimetres (errors are one standard deviation). Over this period, ocean-driven melting has caused rates of ice loss from West Antarctica to increase from 53 ± 29 billion to 159 ± 26 billion tonnes per year; ice-shelf collapse has increased the rate of ice loss from the Antarctic Peninsula from 7 ± 13 billion to 33 ± 16 billion tonnes per year. We find large variations in and among model estimates of surface mass balance and glacial isostatic adjustment for East Antarctica, with its average rate of mass gain over the period 1992–2017 (5 ± 46 billion tonnes per year) being the least certain.

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Research output: Contribution to journal › Journal article – Annual report year: 2018 › Research › peer-review
Mean Sea Level and Mean Dynamic Topography Determination From Cryosat-2 Data Around Australia

Determination of Mean Sea Surface (MSS) is of great importance in some geodesy and oceanographic applications and a couple of centimeters would change the calculated parameter significantly. The dense spatial coverage of Cryosat-2 data offers the opportunity of investigating the Sea Level Anomaly (SLA) over ocean in higher resolution from a single mission data. In other words, although multi mission data sets may have a considerable spatial density, the variation in data set qualities from different missions make the processing difficult, particularly in crossovers. Despite the fact that the main aim of Cryosat-2 mission is monitoring the thickness of ice sheets, it is also used over oceans for different purposes. To study the contribution of the Cryosat-2 data around Australia, 6 years data set of this mission are used. As the SSH values are too large in magnitude and any small variations would not be appeared clearly in the analysis, to investigate the changes, SLA based on DTUMSS13 model is analysed as the main parameter. The strong striping effects, particularly in Gulf Carpentaria and South East, characterizes a substantial part of the map. This, in fact, implies presence of a strong periodic signal in the SLA data. The main reason behind the strong striping in the Gulf Carpentaria is related to presence of annual signal. To solve this issue, the annual signal should be extracted from the SLA data so that all of them refer to the same epoch of the year. The determined annual signal amplitude from Topex/Posseidon and follow-on missions are interpolated into the Cryosat-2 data points. The subtraction of constructed annual signal from the SLA of Cryosat-2 data reduce the striping effect substantially though a slight averaging is required to eliminate it completely. The final product represents a smooth mean SLA. The mean SLA is then added to DTUMSS13 to provide us with the MSS model of Cryosat-2 data. This MSS model is used to calculate the mean dynamic topography around Australia.

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Organisations: Geodesy, National Space Institute, Newcastle University
Contributors: Agha Karimi, A., Andersen, O., Deng, X.
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Measured Performance of Improved Cross Frequency Algorithm for Detection of RFI from DTV

Ku-band is used for measuring ocean wind velocities from meteorological satellites. Ku-band is also used for broadcasting DirectTV signals from satellites over the United States. The reflection of these signals are seen as RFI by the meteorological satellites and algorithms for detecting and blanking natural signals affected by RFI have to be developed. This paper presents a new algorithm targeted for detecting these DirectTV signals. The algorithm is implemented in firmware and its performance measured using a bread-board real time RFI processor developed for spaceborne radiometers and the DTU Space Ku-band radiometer POLRAD. It is shown that the new algorithm has a better performance than the traditional cross frequency algorithm for wideband RFI. It is also shown that the traditional cross frequency algorithm has a better performance than the new with respect to narrowband RFI. The new algorithm can thus augment but not substitute the traditional cross frequency algorithm.

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Organisations: National Space Institute, Microwaves and Remote Sensing, Harp Technologies Ltd., ESTEC
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Publication date: 2018

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Modelling of hydrodynamic and wave conditions for a new harbor in Søndre Strømfjord (Kangerlussuaq)

General information
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Organisations: Innovation and Research-based consultancy, National Space Institute, Department of Civil Engineering, Geotechnics and Geology, Marine Science & Consulting
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Monitoring of surface water resources in East Africa using CryoSat-2 radar altimetry and Sentinel-1 SAR imagery

General information
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Research output: Contribution to journal › Conference abstract in journal – Annual report year: 2018 › Research › peer-review

Monitoring Riverscapes with Unmanned Airborne Vehicles

General information
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Host publication information
Title of host publication: Danish Water Forum Annual Water Conference 2018 - abstract book
Place of publication: Lyngby, Denmark
Publisher: Danish Water Forum
Multi-Beam Focal Plane Arrays with Digital Beamforming for High Precision Space-Borne Ocean Remote Sensing

The present-day ocean remote sensing instruments that operate at low microwave frequencies are limited in spatial resolution and do not allow for monitoring of the coastal waters. This is due to the difficulties of employing a large reflector antenna on a satellite platform, and generating high-quality pencil beams at multiple frequencies. Recent advances in digital beamforming focal-plane-arrays (FPAs) have been exploited in the current work to overcome the above problems. A holistic design procedure for such novel multi-beam radiometers has been developed, where (i) the antenna system specifications are derived directly from the requirements to oceanographic surveys for future satellite missions; and (ii) the numbers of FPA elements/receivers are determined through a dedicated optimum beamforming procedure minimizing the distance to coast. This approach has been applied to synthesize FPAs for two alternative radiometer systems: a conical scanner with an off-set parabolic reflector, and stationary wide-scan torus reflector system; each operating at C, X and Ku bands. Numerical results predict excellent beam performance for both systems with as low as 0.14% total received power over the land.

Multi-Mission Based River Levels

Rivers levels typically show large seasonal variations. In Arctic rivers, the water level rises rather quickly in the spring when the snow and ice are melting. This abrupt rise is challenging to capture for missions such as Sentinel-3 and SARAL/AltiKa that has a repeat period of approximately one month. However, by combining levels from several missions the temporal resolution is significantly improved. Here we use data from CryoSat-2, SARAL/AltiKa, and Sentinel-3A for a river segment to make a joint solution of the river level. We set up a model that consists of state-space model and two spline functions. The statespace model is composed of an AR1 process and an observational part, where the error follows a mixture between normal and Cauchy distributions. The spline functions account for the change in topography and a potential variation in water level amplitude along the river. We demonstrate the model for the Ob River and other selected Arctic rivers.
Multiple Satellite Analysis of the Earth's Thermosphere and Interplanetary Magnetic Field Variations Due to ICME/CIR Events During 2003–2015

We present a refined statistical analysis based on interplanetary coronal mass ejections (ICMEs) as well as corotating interaction regions (CIRs) for the time period 2003–2015 to estimate the impact of different solar wind types on the geomagnetic activity and the neutral density in the Earth's thermosphere. For the time-based delimitation of the events, we rely on the catalog maintained by Richardson and Cane and the corotating interaction region lists provided by S. Vennerstrom and Jian et al. (2011, https://doi.org/10.1007/s11207-011-9737-2). These archives are based on in situ measurements from the Advanced Composition Explorer and/or the Wind spacecraft. On this basis, we thoroughly investigated 196 Earth-directed ICME and 195 CIR events. To verify the impact on the Earth's thermosphere we determined neutral mass densities by using accelerometer measurements collected by the low-Earth-orbiting satellites Gravity Recovery and Climate Experiment and Challenging Minisatellite Payload. Subsequently, the atmospheric densities are related to characteristic ICME parameters. In this process a new calibration method has been examined. Since increased solar activity may lead to a decrease of the satellites orbital altitude we additionally assessed the orbital decay for each of the events and satellites. The influence of CIR events is in the same range of magnitude as the majority of the ICMEs (186 out of 196). Even though, the extended investigation period between 2011 and 2015 has a lack of extreme solar events the combined analysis reveals comparable correlation coefficients between the neutral densities and the various ICME and geomagnetic parameters (mostly >0.85). The evaluation of orbit decay rates at different altitudes revealed a high dependency on the satellite actual altitude.

New Magnetic Anomaly Map of the Antarctic

The second generation Antarctic magnetic anomaly compilation (ADMAP-2) for the region south of 60oS includes some 3.5 million line-km of aeromagnetic and marine magnetic data that more than doubles the initial map's near-surface database. For the new compilation, the magnetic datasets were corrected for the International Geomagnetic Reference Field, diurnal effects, and high-frequency errors, and levelled, gridded, and stitched together. The new magnetic data further constrain the crustal architecture and geological evolution of the Antarctic Peninsula and the West Antarctic Rift System in West Antarctica, as well as Dronning Maud Land, the Gamburtsev Subglacial Mountains, the Prince Charles Mountains, Princess Elizabeth Land, and Wilkes Land in East Antarctica, and the circumjacent oceanic margins. Overall, the magnetic anomaly compilation helps unify disparate regional geologic and geophysical studies by providing new constraints on major tectonic and magmatic processes that affected the Antarctic from Precambrian to Cenozoic times.
NICER Discovers mHz Oscillations in the "Clocked" Burster GS 1826−238

We report the discovery with the Neutron Star Interior Composition Explorer (NICER) of mHz X-ray brightness oscillations from the “clocked burster” GS 1826−238. NICER observed the source in the periods 2017 June 20−29, July 11−13, and September 9−15, for a total useful exposure of 34 ks. Two consecutive dwells obtained on 2017 September 9 revealed highly significant oscillations at a frequency of 8 mHz. The fractional, sinusoidal modulation amplitude increases from 0.7% at 1 keV to ≈2% at 6 keV. Similar oscillations were also detected at lower significance in three additional dwells. The oscillation frequency and amplitude are consistent with those of mHz QPOs reported in other accreting neutron star systems. A thermonuclear X-ray burst was also observed on 2017 June 22. The burst properties and X-ray colors are both consistent with GS 1826 being in a soft spectral state during these observations, findings that are confirmed by ongoing monitoring with MAXI and SWIFT-BAT. Assuming that the mHz oscillations are associated with blackbody emission from the neutron star surface, modeling of the phase-resolved spectra shows that the oscillation is consistent with being produced by modulation of the temperature component of this emission. In this interpretation, the blackbody normalization, proportional to the emitting surface area, is consistent with being constant through the oscillation cycle. We place the observations in the context of the current theory of marginally stable burning and briefly discuss the potential for constraining neutron star properties using mHz oscillations.

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Organisations: National Space Institute, Astrophysics and Atmospheric Physics, NASA Goddard Space Flight Center, University of Arizona, University of Michigan, Ann Arbor, University of Maryland, SRON Netherlands Institute for Space Research, Istanbul University, Universite de Toulouse, Massachusetts Institute of Technology, University of Southampton
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NICER Discovers the Ultracompact Orbit of the Accreting Millisecond Pulsar IGR J17062–6143

We present results of recent Neutron Star Interior Composition Explorer (NICER) observations of the accreting millisecond X-ray pulsar (AMXP) IGR J17062–6143 that show that it resides in a circular, ultracompact binary with a 38-minute orbital period. NICER observed the source for ≈26 ks over a 5.3-day span in 2017 August, and again for 14 and 11 ks in 2017 October and November, respectively. A power spectral analysis of the August exposure confirms the previous detection of pulsations at 163.656 Hz in Rossi X-ray Timing Explorer (RXTE) data, and reveals phase modulation due to orbital motion of the neutron star. A coherent search for the orbital solution using the Z2 method finds a best-fitting circular orbit with a period of 2278.21 s (37.97 minutes), a projected semimajor axis of 0.00390 lt-s, and a barycentric pulsar frequency of 163.6561105 Hz. This is currently the shortest known orbital period for an AMXP. The mass function is 9.12 × 10⁻⁸ M⊙, presently the smallest known for a stellar binary. The minimum donor mass ranges from ≈0.005 to 0.007 M⊙ for a neutron star mass from 1.2 to 2 M⊙. Assuming mass transfer is driven by gravitational radiation, we find donor mass and binary inclination bounds of 0.0175–0.0155 M⊙ and 19°.

Numerical insights into the early stages of nanoscale electrodeposition: nanocluster surface diffusion and aggregative growth

Fundamental understanding of the early stages of electrodeposition at the nanoscale is key to address the challenges in a wide range of applications. Despite having been studied for decades, a comprehensive understanding of the whole process is still out of reach. In this work, we introduce a novel modelling approach that couples a finite element method (FEM) with a random walk algorithm, to study the early stages of nanocluster formation, aggregation and growth, during electrochemical deposition. This approach takes into account not only electrochemical kinetics and transport of active species, but also the surface diffusion and aggregation of adatoms and small nanoclusters. The simulation results reveal that the relative surface mobility of the nanoclusters compared to that of the adatoms plays a crucial role in the early growth stages. The number of clusters, their size and their size dispersion are influenced more significantly by nanocluster mobility than by the applied overpotential itself. Increasing the overpotential results in shorter induction times and leads to aggregation prevalence at shorter times. A higher mobility results in longer induction times, a delayed transition from
nucleation to aggregation prevalence, and as a consequence, a larger surface coverage of smaller clusters with a smaller size dispersion. As a consequence, it is shown that a classical first-order nucleation kinetics equation cannot describe the evolution of the number of clusters with time, N(t), in potentiostatic electrodeposition. Instead, a more accurate representation of N(t) is provided. We show that an evaluation of N(t), which neglects the effect of nanocluster mobility and aggregation, can induce errors of several orders of magnitude in the determination of nucleation rate constants. These findings are extremely important towards evaluating the elementary electrodeposition processes, considering not only adatoms, but also nanoclusters as building blocks.

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Organisations: National Space Institute, Astrophysics and Atmospheric Physics, Vrije Universiteit Brussel
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Research output: Contribution to journal › Journal article – Annual report year: 2018 › Research › peer-review

Observed rapid bedrock uplift in Amundsen Sea Embayment promotes ice-sheet stability
The marine portion of the West Antarctic Ice Sheet (WAIS) in the Amundsen Sea Embayment (ASE) accounts for one-fourth of the cryospheric contribution to global sea-level rise and is vulnerable to catastrophic collapse. The bedrock response to ice mass loss, glacial isostatic adjustment (GIA), was thought to occur on a time scale of 10,000 years. We used new GPS measurements, which show a rapid (41 millimeters per year) uplift of the ASE, to estimate the viscosity of the mantle underneath. We found a much lower viscosity (4 \times 10^{18} \text{ pascal-second}) than global average, and this shortens the GIA response time scale from tens to hundreds of years. Our finding requires an upward revision of ice mass loss from gravity data of 10% and increases the potential stability of the WAIS against catastrophic collapse.

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Organisations: National Space Institute, Geodynamics, Department of Applied Mathematics and Computer Science, Geodesy, Technical University of Denmark, Ohio University, University of Washington, University of Colorado Boulder, University of Texas at Austin, University of Memphis, Colorado State University, Pennsylvania State University, Washington University St. Louis
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Occultations from an Active Accretion Disk in a 72-day Detached Post-Algol System Detected by K2

Disks in binary systems can cause exotic eclipsing events. MWC 882 (BD –22 4376, EPIC 225300403) is such a disk-eclipsing system identified from observations during Campaign 11 of the K2 mission. We propose that MWC 882 is a post-Algol system with a B7 donor star of mass in a 72-day orbit around an A0 accreting star of mass . The disk around the accreting star occults the donor star once every orbit, inducing 19-day long, 7% deep eclipses identified by K2 and subsequently found in pre-discovery All-Sky Automated Survey and All Sky Automated Survey for Supernovae observations. We coordinated a campaign of photometric and spectroscopic observations for MWC 882 to measure the dynamical masses of the components and to monitor the system during eclipse. We found the photometric eclipse to be gray to ≲1%. We found that the primary star exhibits spectroscopic signatures of active accretion, and we observed gas absorption features from the disk during eclipse. We suggest that MWC 882 initially consisted of a ≈3.6 M⊙ donor star transferring mass via Roche lobe overflow to a ≈2.1 M⊙ accretor in a ≈7-day initial orbit. Through angular momentum conservation, the donor star is pushed outward during mass transfer to its current orbit of 72 days. The observed state of the system corresponds with the donor star having left the red giant branch ∼0.3 Myr ago, terminating active mass transfer. The present disk is expected to be short-lived (10^2 yr) without an active feeding mechanism, presenting a challenge to this model.

On the 2018 Outburst of the Accreting Millisecond X-Ray Pulsar Swift J1756.9–2508 As Seen with NICER

We report on the coherent timing analysis of the 182 Hz accreting millisecond X-ray pulsar Swift J1756.9−2508 during its 2018 outburst as observed with the Neutron Star Interior Composition Explorer (NICER).
Optical instrument design of the high-energy x-ray probe (HEX-P)

The High-Energy X-ray Probe (HEX-P) is a probe-class next-generation high-energy X-ray mission concept that will vastly extend the reach of broadband X-ray observations. Studying the 2-200 keV energy range, HEXP has 40 times the sensitivity of any previous mission in the 10-80 keV band, and will be the first focusing instrument in the 80-200 keV band. A successor to the Nuclear Spectroscopic Telescope Array (NuSTAR), a NASA Small Explorer launched in 2012, HEX-P addresses key NASA science objectives, and will serve as an important complement to ESA's L-class Athena mission. HEX-P will utilize multilayer coated X-ray optics, and in this paper we present the details of the optical design, and discuss the multilayer prescriptions necessary for the reflection of hard X-ray photons. We consider multiple module designs with the aim of investigating the tradeoff between high- and low-energy effective area, and review the technology development necessary to reach that goal within the next decade.

Optical/X-ray correlations during the V404 Cygni June 2015 outburst

Context. We present a multiwavelength analysis of the simultaneous optical and X-ray light curves of the microquasar V404 Cyg during the June 2015 outburst.Aims. We have performed a comprehensive analysis of all the INTEGRAL/IBIS, JEM-X, and OMC observations during the brightest epoch of the outburst, along with complementary NuSTAR, AAVSO, and VSNET data, to examine the timing relationship between the simultaneous optical and X-ray light curves, in order to understand the emission mechanisms and physical locations.Methods. We have identified all optical flares that have simultaneous X-ray observations, and performed a cross-correlation analysis to estimate the time delays between the
optical and soft and hard X-ray emission. We also compared the evolution of the optical and X-ray emission with the hardness ratios.

Results. We have identified several types of behaviour during the outburst. On many occasions, the optical flares occur simultaneously with X-ray flares, but at other times, positive and negative time delays between the optical and X-ray emission are measured.

Conclusions. We conclude that the observed optical variability is driven by different physical mechanisms, including reprocessing of X-rays in the accretion disc and/or the companion star, interaction of the jet ejections with surrounding material or with previously ejected blobs, and synchrotron emission from the jet.

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Optimal estimation of sea surface temperature from AMSR-E
The Optimal Estimation (OE) technique is developed within the European Space Agency Climate Change Initiative (ESA-CCI) to retrieve subskin Sea Surface Temperature (SST) from AQUA's Advanced Microwave Scanning Radiometer-Earth Observing System (AMSR-E). A comprehensive matchup database with drifting buoy observations is used to develop and test the OE setup. It is shown that it is essential to update the first guess atmospheric and oceanic state variables and to perform several iterations to reach an optimal retrieval. The optimal number of iterations is typically three to four in the current setup. In addition, updating the forward model, using a multivariate regression model is shown to improve the capability of the forward model to reproduce the observations. The average sensitivity of the OE retrieval is 0.5 and shows a latitudinal dependency with smaller sensitivity for cold waters and larger sensitivity for warmer waters. The OE SSTs are evaluated against drifting buoy measurements during 2010. The results show an average difference of 0.02 K with a standard deviation of 0.47 K when considering the 64% matchups, where the simulated and observed brightness temperatures are most consistent. The corresponding mean uncertainty is estimated to 0.48 K including the in situ and sampling uncertainties. An independent validation against Argo observations from 2009 to 2011 shows an average difference of 0.01 K, a standard deviation of 0.50 K and a mean uncertainty of 0.47 K, when considering the best 62% of retrievals. The satellite versus in situ discrepancies are highest in the dynamic oceanic regions due to the large satellite footprint size and the associated sampling effects. Uncertainty estimates are available for all retrievals and have been validated to be accurate. They can thus be used to obtain very good retrieval results. In general, the results from the OE retrieval are very encouraging and demonstrate that passive microwave observations provide a valuable alternative to infrared satellite observations for retrieving SST.

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Journal: Remote Sensing
Performance and stability of mirror coatings for the ATHENA mission

We present the expected coating performance based on design and simulations, tested coating performance evaluated by means of X-ray reflectometry and short and long term stability of several materials considered as coating options for the X-ray mirrors of the ATHENA mission. As part of this study we also report on the compatibility of the X-ray reflecting coatings to the industrial processes involved in the assembly of mirror modules using Silicon Pore Optics technology.

Planck intermediate results: LIII. Detection of velocity dispersion from the kinetic Sunyaev-Zeldovich effect

Using the Planck full-mission data, we present a detection of the temperature (and therefore velocity) dispersion due to the kinetic Sunyaev-Zeldovich (kSZ) effect from clusters of galaxies. To suppress the primary CMB and instrumental noise we derive a matched filter and then convolve it with the Planck foreground-cleaned "2D-ILC" maps. By using the Meta Catalogue of X-ray detected Clusters of galaxies (MCXC), we determine the normalized rms dispersion of the temperature fluctuations at the positions of clusters, finding that this shows excess variance compared with the noise expectation. We then build an unbiased statistical estimator of the signal, determining that the normalized mean temperature dispersion of 1526 clusters is \((\Delta T/T)^2 = (1.64 \pm 0.48) \times 10^{-11}\). However, comparison with analytic calculations and simulations suggest that around 0.7 \(\sigma\) of this result is due to cluster lensing rather than the kSZ effect. By correcting this, the temperature dispersion is measured to be \((\Delta T/T)^2 = (1.35 \pm 0.48) \times 10^{-11}\), which gives a detection at the 2.8 \(\sigma\) level. We further convert uniform-weight temperature dispersion into a measurement of the line-of-sight velocity dispersion, by using estimates of the optical depth of each cluster (which introduces additional uncertainty into the estimate). We find that the velocity dispersion is \((\upsilon^2) = (123 000 \pm 71 000) \text{ (km s}^{-1}\text{)}^2\), which is consistent with findings from other large-scale...
structure studies, and provides direct evidence of statistical homogeneity on scales of 600 h^{-1} Mpc. Our study shows the promise of using cross-correlations of the kSZ effect with large-scale structure in order to constrain the growth of structure.

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Source: Scopus
Source-ID: 85054085590
Research output: Contribution to journal › Journal article – Annual report year: 2018 › Research › peer-review

Planck intermediate results - XV. A study of anomalous microwave emission in Galactic clouds (Corrigendum)
There is a typographical error in the unit of the 250 column of Table 3 of Planck Collaboration XVI (2014), resulting in all 250 values listed being a factor of 10 smaller than they should be. Corresponding author: C. Dickinson, e-mail: clive.dickinson@manchester.ac.uk The values have been multiplied by 104 and not 105 as listed in the previously published version. All the values relating to r250 in the main body of text and figures remain correct.

General information
Publication status: Published
Organisations: National Space Institute, Astrophysics and Atmospheric Physics, Innovation and Research-based consultancy, University of Copenhagen
Potential of the Radar Altimetry for Estimation of the River Input to the Arctic Ocean

Since already ten years, the radar altimetry have been successfully used for estimation of water discharge of large rivers. The arctic rivers are the most challenging objects from methodological point of view as 1) they are covered by ice during the most part of the year and 2) significant part of the water flow passes after the snow melt during only several weeks. In the framework of the ESA ArcFlux project, aiming an estimation of the fresh water fluxes in the Arctic Ocean, a performance of the radar altimetry for precise estimation of the water flux for different types of the arctic rivers was studied. The test was performed for two large rivers: the Ob River (regular gentle flooding regime) and the Lena River (rapid and sharp spring and summer floods) and for one middle size river Pur (Western Siberia). We investigated different approaches to retrieve water level from different altimetric missions starting from 2002 (singlemission/ single-track, single-mission/multi-tracks, multimissions) and investigated two different methods of discharge estimation (stage-discharge rating curves and Manning solution). The results show very high potential for multi-mission and multi-tracks approaches. The Manning solution, which can be used for discharge estimation for ungauged rivers, also provides very good results. The accuracy of the annual water flow estimates for middle size river is of 17%, while for large rivers it is of 4-7%.
Quantifying Atlantic Water Transport to the Nordic Seas by Combined Use of Gravimetry and Altimetry

In this study the variability of Atlantic Water (AW) entering the Nordic Seas from the North Atlantic through the passage between Iceland, the Faroe Islands and Scotland has been investigated. The poleward transport of this warm AW is a key component in maintaining a relatively mild climate in the northwestern Europe. Satellite remote sensing datasets from altimetry and the Gravity field and steady state Ocean Circulation Explorer (GOCE) mission, in combination with surface drifters, fixed current meter, and hydrographic data are used. The high-resolution mean dynamic topography (MDT) is shown to resolve the time-invariant surface currents in the inflow region. In addition to the improved MDT, we take benefit of the new reprocessed sea level anomaly data in the estimation of absolute dynamic topography. Analysis of the monthly surface velocities from 1993-2016 demonstrates significant influence of the large scale atmospheric forcing associated with the North Atlantic Oscillation (NAO). Furthermore, a significant increase in surface velocities along the slope current, front current and the Norwegian Coastal Current are found during winter. Finally, combining altimetry with hydrographic data, we demonstrate that the variability in surface velocities of the inflow region is also reflected in the deeper layers, and that altimetry therefore can be used to monitor the variability of the poleward transport of AW in this region.

Quantifying Atlantic Water Transport to the Nordic Seas by remote sensing

In this study the variability of Atlantic Water (AW) entering the Nordic Seas from the North Atlantic through the passage between Iceland, the Faroe Islands and Scotland has been investigated. The poleward transport of this warm AW is a key component in maintaining a relatively mild climate in the northwestern Europe. Satellite remote sensing datasets from altimetry and the Gravity field and steady state Ocean Circulation Explorer (GOCE) mission, in combination with surface drifters, fixed current meter, and hydrographic data are used. The high-resolution mean dynamic topography (MDT) is shown to resolve the time-invariant surface currents in the inflow region. In addition to the improved MDT, we take benefit of the new reprocessed sea level anomaly data in the estimation of absolute dynamic topography. Analysis of the monthly surface velocities from 1993 to 2016 demonstrates significant influence of the large scale atmospheric forcing associated with the North Atlantic Oscillation (NAO). Furthermore, a significant increase in surface velocities along the slope current, front current and the Norwegian Coastal Current are found during winter. Finally, combining altimetry with hydrographic data, we demonstrate that the variability in surface velocities of the inflow region is also reflected in the deeper layers, and that altimetry therefore can be used to monitor the variability of the poleward transport of AW in this region.
Real-Time RFI Processor for the Next Generation Satellite Radiometers

Anthropogenic Radio Frequency Interference (RFI) within radiometer bands is a serious problem in passive microwave remote sensing. Since this problem is ever-increasing, the next generation satellite radiometers will require efficient methods to mitigate the effects of RFI. In this paper, we present one solution: a spaceborne RFI processor to detect and blank the RFI in real time. The processor was designed to be compatible with the Microwave Imager (MWI) instrument, 18.7 GHz channel, onboard the European MetOp Second Generation satellite system. The developed RFI processor applies the following detection algorithms: (1) anomalous amplitude detection, (2) kurtosis, and (3) cross-frequency. In the processing, the data are divided into sub-samples in time and frequency with fine resolution. The RFI processor can detect and filter out RFI with this fine resolution in real time and then integrate the clean (non-contaminated) subsamples over time and frequency. Thus, a cleaned version of the radiometer data can be downlinked at traditional low data rate. The processing is implemented in a reprogrammable FPGA with high processing capacity, which provides high flexibility. The applied processing bandwidth is 200 MHz (+ 25 MHz transition bands at both sides). The measured performance of the RFI processor corresponds to the simulations and good overall detection capability has been achieved for narrow-band RFI. The power consumption of the RFI processor is approx. 12 W (at room temperature) and the mass is approx. 1 kg.

Relationship between PC index and magnetospheric field-aligned currents measured by Swarm satellites

Abstract The relationship between the magnetospheric field-aligned currents (FAC) monitored by the Swarm satellites and the magnetic activity PC index (which is a proxy of the solar wind energy incoming into the magnetosphere) is examined. It is shown that current intensities measured in the R1 and R2 FAC layers at the poleward and equatorward boundaries of the auroral oval are well correlated, the R2 currents being evidently secondary in relation to R1 currents and correlation in the dawn and dusk oval sectors being better than in the noon and night sectors. There is evident relationship between the PC index and the intensity of field-aligned currents in the R1 dawn and dusk layers: increase of FAC intensity in the course of substorm development is accompanied by increasing the PC index values. Correlation between PC and FAC intensities in the R2 dawn and dusk layers is also observed, but it is much weaker. No correlation is observed between PC and field-aligned currents in the midnight as well as in the noon sectors ahead of the substorm expansion phase. The results are indicative of the R1 field-aligned currents as a driver of the polar cap magnetic activity (PC index) and currents in the R2 layer.
Rethinking Coastal Community Approaches to Climate Change Impacts and Adaptation

Low-lying coastal communities face almost insurmountable challenges from floods and climate change. Research work on adaptation and mitigation particularly emphasizes on cities and mega-cities as a natural consequence of their agglomeration of people and assets. Less focus is put on smaller coastal communities and their challenges, one of which is a lack of local expertise and knowledge. Adaptation to climate change is often a local governance level task, however. Co-work between municipal and national authorities, the utility company, research, business, consultants and citizens has resulted in a common framework to address and deal with water-related challenges in a Danish coastal community. From an assessment of combined impacts of climate change (i.e. sea level rise and storm surges, precipitation and cloudbursts and associated groundwater level responses) and stresses from degrading sewer systems and land subsidence, impact zones are mapped. The multi-player, end-user defined work transcends sectors and builds capacity by sharing data and knowledge. It mainstreams climate change issues into business, management, planning and early warning: the overall goal is an adaptation strategy unfolded from stakeholder involvement and responsibility, cost-effective decision making, climate-related asset management processes and a holistic livable cities approach to this highly vulnerable coastal community. The collaboration and common framework enable the actors to articulate need of information and establish feedback mechanisms between local level work and e.g. sea level research and climate services.

Retrievals of Arctic Sea-Ice Volume and Its Trend Significantly Affected by Interannual Snow Variability

We estimate the uncertainty of satellite-retrieved Arctic sea-ice thickness, sea-ice volume, and their trends stemming from the lack of reliable snow-thickness observations. To do so, we simulate a Cryosat2-type ice-thickness retrieval in an ocean-model simulation forced by atmospheric reanalysis, pretending that only freeboard is known as model output. We then convert freeboard to sea-ice thickness using different snow climatologies and compare the resulting sea-ice thickness retrievals to each other and to the real sea-ice thickness of the reanalysis-forced simulation. We find that different snow
climatologies cause significant differences in the obtained ice thickness and ice volume. In addition, we show that Arctic ice-volume trends derived from ice-thickness retrievals using any snow-depth climatology are highly unreliable because the estimated trend in ice volume can strongly be influenced by the neglected interannual variability in snow volume.

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Contributors: Bunzel, F., Notz, D., Pedersen, L. T.
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Research output: Contribution to journal › Journal article – Annual report year: 2018 › Research › peer-review

REVIEW: 25 years of Sea Level Records from the Arctic Ocean Using Radar Altimetry
In recent years, there has been a large focus of the Arctic due the rapid changes of the region. The sea level of the Arctic Ocean is an important climate indicator. The Arctic sea ice is decreasing and has since 1997 experienced a steepening in the decrease. The Arctic sea level determination is challenging due to the seasonal to permanent sea ice cover, the lack of regional coverage of satellites, the satellite instruments ability to measure ice, insufficient geophysical models, residual orbit errors, challenging retracking of satellite altimeter data. We present the DTU/TUM 25-year sea level record based on satellite altimetry data in the Arctic Ocean from the ERS1 (1991) to CryoSat-2 (present) satellites. The sea level record is compared with several tide gauges and other available partial sea level records contributing to the ESA CCI Sea level initiative. We use updated geophysical corrections and a combination of altimeter data: REAPER (ERS1), ALES+ retracker (ERS2, Envisat), combined Rads and DTUs in-house retracker LARS (CryoSat-2). The ALES+ is an upgraded version of the Adaptive Leading Edge Subwaveform Retracker that has been developed to improve data quality and quantity in the coastal ocean, without degrading the results in the open ocean. ALES+ aims at retracking peaky waveforms typical of lead reflections without modifying the fitting model used in the open ocean. Finally, we discuss the seasonal and regional variations over the past 25 years in the Arctic sea level.

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Organisations: Geodesy, National Space Institute, Technical University of Munich, ESRIN - ESA Centre for Earth Observation
Contributors: Rose, S., Andersen, O., Passaro, M., Benveniste, J.
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Research output: Contribution to conference › Conference abstract for conference – Annual report year: 2018 › Research › peer-review

Revisiting the Phase Curves of WASP-43b: Confronting Re-analyzed Spitzer Data with Cloudy Atmospheres
Recently acquired Hubble and Spitzer phase curves of the short-period hot Jupiter WASP-43b make it an ideal target for confronting theory with data. On the observational front, we re-analyze the 3.6 and 4.5 μm Spitzer phase curves and demonstrate that our improved analysis better removes residual red noise due to intra-pixel sensitivity, which leads to greater fluxes emanating from the nightside of WASP-43b, thus reducing the tension between theory and data. On the theoretical front, we construct cloud-free and cloudy atmospheres of WASP-43b using our Global Circulation Model (GCM), THOR, which solves the non-hydrostatic Euler equations (compared to GCMs that typically solve the hydrostatic primitive equations). The cloud-free atmosphere produces a reasonable fit to the dayside emission spectrum. The multi-
phase emission spectra constrain the cloud deck to be confined to the nightside and have a finite cloud-top pressure. The multi-wavelength phase curves are naturally consistent with our cloudy atmospheres, except for the 4.5 μm phase curve, which requires the presence of enhanced carbon dioxide in the atmosphere of WASP-43b. Multi-phase emission spectra at higher spectral resolution, as may be obtained using the James Webb Space Telescope, and a reflected-light phase curve at visible wavelengths would further constrain the properties of clouds in WASP-43b.

**General information**

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**Scale separated low viscosity dynamos and dissipation within the Earth's core**

The mechanism by which the Earth's magnetic field is generated is thought to be thermal convection in the metallic liquid iron core. Here we present results of a suite of self-consistent spherical shell computations with ultra-low viscosities that replicate this mechanism, but using diffusivities of momentum and magnetic field that are notably dissimilar from one another. This leads to significant scale separation between magnetic and velocity fields, the latter being dominated by small scales. We show a zeroth order balance between the azimuthally-averaged parts of the Coriolis and Lorentz forces at large scales, which occurs when the diffusivities of magnetic field and momentum differ so much, as in our model. Outside boundary layers, viscous forces have a magnitude that is about one thousandth of the Lorentz force. In this dynamo dissipation is almost exclusively Ohmic, as in the Earth, with convection inside the so-called tangent cylinder playing a crucial role; it is also in the “strong field” regime, with significantly more magnetic energy than kinetic energy (as in the Earth). We finally show a robust empirical scaling law between magnetic dissipation and magnetic energy.

**General information**

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Organisations: National Space Institute, Geomagnetism, Swiss Federal Institute of Technology, Swiss National Supercomputing Centre
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Science with e-ASTROGAM: A space mission for MeV–GeV gamma-ray astrophysics

e-ASTROGAM (‘enhanced ASTROGAM’) is a breakthrough Observatory space mission, with a detector composed by a Silicon tracker, a calorimeter, and an anticoincidence system, dedicated to the study of the non-thermal Universe in the photon energy range from 0.3 MeV to 3 GeV – the lower energy limit can be pushed to energies as low as 150 keV for the tracker, and to 30 keV for calorimetric detection. The mission is based on an advanced space-proven detector technology, with unprecedented sensitivity, angular and energy resolution, combined with polarimetric capability. Thanks to its performance in the MeV-GeV domain, substantially improving its predecessors, e-ASTROGAM will open a new window on the non-thermal Universe, making pioneering observations of the most powerful Galactic and extragalactic sources. With a line sensitivity in the MeV energy range one to two orders of magnitude better than previous generation instruments, e-ASTROGAM will determine the origin of key isotopes fundamental for the understanding of supernova explosion and the chemical evolution of our Galaxy. The mission will provide unique data of significant interest to a broad astronomical community, complementary to powerful observatories such as LIGO-Virgo-GEO600-KAGRA, SKA, ALMA, E-ELT, TMT, LSST, JWST, Athena, CTA, IceCube, KM3NeT, and LISA.

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Web of Science (2018): Indexed yes
Seamless Geoids across Coastal Zones: Comparison of Satellite and Airborne Gravity across the Seven Continents – and an Azores Heritage Case

An accurate coastal geoid model is important for determination of near-shore ocean dynamic topography and currents, as well as for land GPS surveys and global geopotential models. Since many coastal regions across the globe are regions of intense development and coastal protection projects, precise geoid models at cm-level accuracy are essential. The only way to secure cm-level geoid accuracies across coastal regions is to acquire more marine gravity data; here airborne gravity is the obvious method of choice due to the uniform accuracy, and the ability to provide a seamless geoid accuracy across the coastline. Current practice for gravity and geoid models, such as EGM2008 and many national projects, is to complement land gravity data with satellite radar altimetry at sea, a procedure which can give large errors in regions close to the coast. To quantify the coastal errors in satellite gravity, we compare results of a large set of recent airborne gravity surveys, acquired across a range of coastal zones globally from polar to equatorial regions, and quantify the errors as a function of distance from the coast line for a number of different global altimetry gravity solutions. We find that accuracy in satellite altimetry solutions depend very much on the availability of gravity data along the coast-near land regions in the underlying reference fields (e.g., EGM2008), with satellite gravity accuracy in the near-shore zone ranging from anywhere between 5 to 20 mGal r.m.s., with occasional large outliers; such errors may typically propagate into coastal geoid errors of 5-10 cm r.m.s. or more, and highlight the needs for airborne gravity surveys in the coastal zones. One of the first examples of such a dedicated effort is the Azores airborne gravity campaign, carried out more than 20 years ago as part of the AGMASCO (Airborne Geoid Mapping System for Coastal Oceanography) EU project 1996-98.

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Contributors: Forsberg, R., Olesen, A., Barnes, D., Ingalls, S., Minter, C., Presicci, M.
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Seamless Transition from LRM to SAR in the Arctic Ocean

Conventional altimetry from ERS-1/ERS-2 and ENVISAT provides LRM altimetry in the Arctic Ocean since 1991 which have enabled us to derive a continuous record within the ESA sea level CCI initiative for 20 years up to latitude 82. With the launch of SAR altimetry onboard Cryosat-2 and with the availability of SARAL/AltiKa Ka band altimetry two new sensors providing accurate the sea level mapping in the Arctic Ocean has been available since 2010. Extending the sea level time series derived with LRM altimetry with SAR sea level time series in the Arctic Ocean is far from trivial. The first results from studies indicate that the difference in spatio-temporal coverage of the two sensors and the possibility to discriminate sea level within leads using SAR gives a spatially varying bias between the two sensors depending on ice concentration. Another problem for the combination of the time series is the fact that Cryosat-2 does not carry a radiometer. Subsequently care has to be taken to which corrections are applied to the LRM and SAR altimetry datasets, respectively. Our initial finding is that spatial averaged data (and the related timeseries) from Cryosat-2 is lower than the corresponding time series for ENVISAT in the overlapping period during 2010 and 2011. Trying to integrate and extend the sea level time series in the Arctic Ocean with SARAL/AltiKa since 2013 has the further complication that the Ka band vs the Ku band altimeter has different scattering positions in the icecolumn. In this presentation we will present our results to compute and quantify the inter-satellite biases between ENVISAT Cryosat-2 and SARAL/AltiKa in the icecovered parts of the Arctic Ocean.

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Contributors: Rose, S., Andersen, O., Ludwigsen, C.
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Searching for Short GRBs in Soft Gamma Rays with INTEGRAL/PICsIT

With gravitational wave (GW) detections by the LIGO/Virgo collaboration over the past several years, there is heightened interest in gamma-ray bursts (GRBs), especially "short" GRBs (T <2s). The high-energy PICsIT detector (~0.2 – 10 MeV) on-board the INTErnational Gamma-Ray Astrophysics Laboratory (INTEGRAL) is able to observe sources out to approximately 70° off-axis, making it essentially a soft gamma-ray, all-sky monitor for impulsive events, such as SGRBs. Because SGRBs typically have hard spectra with peak energies of a few hundred keV, PICsIT with its ~ 300 cm$^2$ collecting area is able to provide spectral information about these sources at soft gamma-ray energies. We have begun a study of PICsIT data for faint SGRB similar to the one associated with the binary neutron star (BNS) merger GW170817, and also are preparing for future GW triggers by developing a realtime burst analysis for PICsIT. Searching the PICsIT data for significant excesses during ~30 min-long pointings containing times of SGRBs, we have been able to differentiate between SGRBs and spurious events. Also, this work allows us to assess what fraction of reported SGRBs have been detected by PICsIT, which can be used to provide an estimate of the number of GW BNS events seen by PICsIT during the next LIGO/Virgo observing run starting in Fall 2018.

Seasonal ice dynamics of the Northeast Greenland Ice Stream

Previous studies about the seasonal ice dynamics of the marine-terminating glaciers of Greenland and their dynamic mass losses are limited by the temporal resolution of the existing data. Sentinel-1 radar mission opens the possibility for continuous monitoring of glaciers with very high spatial and temporal details. This study focus on the Northeast Greenland Ice Stream (NEGIS), which consists of three main outlets, 79 North glacier (79N), Zachariae Isstrøm (ZI) and Storstrømmen Glacier (SG). While both 79 North and Storstrømmen have floating tongues, Zachariae Isstrøm is mostly grounded. In this study, we present the seasonal ice dynamics of these three outlets of NEGIS as well as their implications on bedrock displacements during 2015-2017. We derive surface velocities using SAR offset tracking applied over Sentinel-1 SAR data. We use radar backscatter from Sentinel SAR data to mark the onset of surface melt and the extent of the melt season. Moreover, we include the changes in ice front from Sentinel SAR data, surface elevation changes from Cryosat-2 data and GPS derived bedrock displacements in our analysis. We find that among these outlets, ZI is the fastest varying between 5.6 m/day and 7.0 m/day during 2015-2017. 79 N fluctuates between 3.6 m/day and 4.2 day, while the velocity of SG is less than 1 m/day throughout our observation period. All three of them speed up with the onset of surface melt and attain maximum velocity in the middle of the melt season. Afterwards they slowdown and attain minimum velocity at the end of the melt season followed by either moderate winter speedup (ZI) or stable flow (79 N, SG). This indicates the surface melt induced changes in the subglacial hydrology governs the seasonal flow dynamics of these outlets. We also notice dynamic thinning from Cryosat-2 data and corresponding elastic displacements (detected by GPS) of the bedrock due to ice mass unloading of the crust.
Sentinel-1 SAR for wind energy roughness maps over land

For the wind energy application, updated information on aerodynamic surface roughness is important for an accurate prediction of the land surface effect on the atmosphere. Tall wind turbines are commonly sited in forested areas, and since the forest both increase turbulence levels and decrease the wind resource, the parametrization of forest roughness in wind models has high relevance. Here, we investigate whether the Sentinel-1 SAR images can be used to identify high-roughness forested areas. The backscatter properties of the SAR images are compared to digital surface models and vegetation density maps derived from near-concurrent aerial lidar scans (ALS). These ALS products have previously shown good results in wind models for the wind energy application, but the scans are costly to perform and therefore typically only represent a snapshot in time, whereas the Sentinel mission SAR images provide frequent updated information. We investigate how the SAR images vary with season over both deciduous and needle-leaf forests and in addition test whether nearby meteorological observations can explain image to image differences in the backscatter level. In order to understand the backscatter level, new products from the ALS point cloud are derived and compared with the SAR images. This part of the work is focused on whether we also can quantify the roughness based on the SAR backscatter. Since SAR images are affected by speckle noise, they are averaged over monthly and bimonthly intervals after careful inspection of each image. The work is focused on the Østerild test site for large wind turbines in Northern Denmark, where extensive wind experiments have been performed.

General information
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Organisations: Meteorology & Remote Sensing, Department of Wind Energy, Microwaves and Remote Sensing, National Space Institute
Contributors: Dellwik, E., Karagali, I., Svensson, E., Skriver, H., Badger, M.
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Silicon pore optics mirror module production and testing

Silicon Pore Optics (SPO) has been established as a new type of x-ray optics that enables future x-ray observatories such as Athena. SPO is being developed at cosine with the European Space Agency (ESA) and academic and industrial partners. The optics modules are lightweight, yet stiff, high-resolution x-ray optics, that shall allow missions to reach an unprecedentedly large effective area of several square meters, operating in the 0.2 - 12 keV band with an angular resolution better than 5 arc seconds. In this paper we are going to discuss the latest generation production facilities and we are going to present results of the production of mirror modules for a focal length of 12 m, including x-ray test results.

General information
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Simulating ice thickness and velocity evolution of Upernavik Isstrom 1849-2012 by forcing prescribed terminus positions in ISSM

Tidewater glacier velocity and mass balance are known to be highly responsive to terminus position change. Yet it remains challenging for ice flow models to reproduce observed ice margin changes. Here, using the Ice Sheet System Model (ISSM; Larour et al., 2012), we simulate the ice velocity and thickness changes of Upernavik Isstrom (north-western Greenland) by prescribing a collection of 27 observed terminus positions spanning 164 years (1849-2012). The simulation shows increased ice velocity during the 1930s, the late 1970s and between 1995 and 2012 when terminus retreat was observed along with negative surface mass balance anomalies. Three distinct mass balance states are evident in the reconstruction: (1849-1932) with near zero mass balance, (1932-1992) with ice mass loss dominated by ice dynamical flow, and (1998-2012), when increased retreat and negative surface mass balance anomalies led to mass loss that was twice that of any earlier period. Over the multi-decadal simulation, mass loss was dominated by thinning and acceleration responsible for 70% of the total mass loss induced by prescribed change in terminus position. The remaining 30% of the total ice mass loss resulted directly from prescribed terminus retreat and decreasing surface mass balance. Although the method can not explain the cause of glacier retreat, it enables the reconstruction of ice flow and geometry during 1849-2012. Given annual or seasonal observed terminus front positions, this method could be a useful tool for evaluating simulations investigating the effect of calving laws.

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Simulating the optical performances of the ATHENA X-ray telescope optics

The ATHENA (Advanced Telescope for High Energy Astrophysics) X-ray observatory is an ESA-selected L2 class mission. In the proposed configuration, the optical assembly has a diameter of 2.2 m with an effective area of 1.4 m² at 1 keV, 0.25 m² at 6 keV, and requires an angular resolution of 5 arcsec. To meet the requirements of effective area and angular resolution, the technology of Silicon Pore Optics (SPO) was selected for the optics implementation. The ATHENA's optic assembly requires hundreds of SPOs mirror modules (MMs), obtained by stacking wedged and ribbed silicon wafer plates onto silicon mandrels to form the Wolter-I configuration. Different factors can contribute to limit the imaging performances of SPOs, such as i) diffraction through the pore apertures, ii) plate deformations due to fabrication errors and surface roughness, iii) alignment errors among plates in an MM, and iv) co-focality errors within the MMs assembly. In order to determine the fabrication and assembling tolerances, the impact of these contributions needs to be assessed prior to manufacturing. A set of simulation tools responding to this need was developed in the framework of the ESA-financed projects SIMPOSIuM and ASPHEA. In this paper, we present the performance simulation obtained for the recently proposed ATHENA configuration in terms of effective area, and we provide a simulation of the diffractive effects in a pair of SPO MMs. Finally, we present an updated sizing of magnetic diverter (a Halbach array) and the magnetic fields levels that can be reached in order to deviate the most energetic protons out of the detector field.
SN 2017ens: The Metamorphosis of a Luminous Broadlined Type Ic Supernova into an SN IIn
We present observations of supernova (SN) 2017ens, discovered by the ATLAS survey and identified as a hot blue object through the GREAT program. The redshift $z = 0.1086$ implies a peak brightness of $M_V = -21.1$ mag, placing the object within the regime of superluminous supernovae. We observe a dramatic spectral evolution, from initially being blue and featureless, to later developing features similar to those of the broad-lined Type Ic SN 1998bw, and finally showing $\sim 2000$ km s$^{-1}$ wide H$\alpha$ and H$\beta$ emission. Relatively narrow Balmer emission (reminiscent of a SN IIn) is present at all times. We also detect coronal lines, indicative of a dense circumstellar medium. We constrain the progenitor wind velocity to $\sim 50-60$ km s$^{-1}$ based on P-Cygni profiles, which is far slower than those present in Wolf-Rayet stars. This may suggest that the progenitor passed through a luminous blue variable phase, or that the wind is instead from a binary companion red supergiant star. At late times we see the $\sim 2000$ km s$^{-1}$ wide H$\alpha$ emission persisting at high luminosity ($\sim 3 \times 10^{40}$ erg s$^{-1}$) for at least 100 day, perhaps indicative of additional mass loss at high velocities that could have been ejected by a pulsational pair instability.

Solar wind and seasonal influence on ionospheric currents from Swarm and CHAMP measurements
We present a new climatological model of the ionospheric current system, determined from magnetic measurements taken by the CHAMP and Swarm satellites. The model describes the horizontal currents in the ionosphere, below the satellites, and the field-aligned (Birkeland) currents that connect the ionosphere with the magnetosphere. The model provides ionospheric current values at any location as continuous functions of solar wind speed, interplanetary magnetic field (IMF), dipole tilt angle, and the F10.7 index of solar flux. Geometric distortions due to variations in the Earth's main magnetic field...
are taken into account, thus allowing for precise comparisons between the two hemispheres. The model is the first of its kind to describe the full 3D electric currents, and not only the field-aligned or the equivalent horizontal current. We use this capability to demonstrate a key difference between seasons: During winter, the total horizontal current is almost entirely confined to the auroral oval, for all IMF orientations, where it connects upward and downward Birkeland currents. During more sunlit conditions, the horizontal current extends beyond the auroral oval, and is a sum of currents connecting Birkeland currents and currents that circulate in the ionosphere. The westward electrojet is the only large-scale current structure that is persistent across seasons. Comparison with average convection maps suggests that it is comprised largely of Hall currents, which connect to Birkeland currents in the winter but not in summer.

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Sounding the Antarctic ice sheet from space: a feasibility study based on airborne P-band radar data
Space-based radio echo sounding of the continental ice sheets can potentially provide full coverage with uniform sampling and data quality as well as detection of change in environmentally sensitive areas. This paper addresses the feasibility of sounding the Antarctic ice sheets with a space-based P-band radar. The assessment firstly makes use of an electromagnetic model of the ice sheets where the key model parameters are determined from data that have been acquired in Antarctica with an airborne P-band ice sounding radar. The performance of a space-based radar with a nadir-looking geometry but otherwise similar to ESA's Biomass SAR, is then simulated for a set of Antarctic scenarios that are defined based on the statistics of key ice regions. It is found that in about 2/3 of the simulation scenarios clutter and/or thermal noise will obscure the echo from the ice bed.

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Spectral and timing studies of 2S 1417-624 during a giant outburst

We present the results obtained from timing and spectral studies of the accretion powered X-ray pulsar 2S 1417-624 during a giant outburst in 2009 by using Rossi X-ray Timing Explorer (RXTE) observations. X-ray pulsations were detected in the light curves obtained from all epochs of observations. The pulsar was found to be spinning-up during the outburst. The pulse profiles were observed to be strongly dependent on photon energy and luminosity. A double peaked profile at lower luminosity evolved into a triple peaked profile at the peak of the outburst which is further reverted back to a double peaked structure during the decay of the outburst. An anti-correlation was also observed between the pulse fraction and the source flux. The 3-70 keV energy spectrum of pulsar was well described with a power law modified with high energy cutoff model along with an iron fluorescence line at 6.4 keV. Based on the evolution of pulse profile, pulse fraction and spectral parameters across observed luminosity, we interpret our results in terms of changes in the pulsar beam configuration from sub-critical to super-critical regimes.

Streamer properties and associated x-rays in perturbed air

Streamers are ionization waves in electric discharges. One of the key ingredients of streamer propagation is an ambient gas that serves as a source of free electrons. Here, we explore the dependence of streamer dynamics on different spatial distributions of ambient air molecules. We vary the spatial profile of air parallel and perpendicular to the ambient electric field. We consider locally sinusoidal perturbations of 5%–100%, as induced from discharge shock waves. We use acylindrically symmetric particle-in-cell code to simulate the evolution of bidirectional streamers and compare the electron density, electric field, streamer velocity and electron energy of streamers in uniform air and in perturbed air. In all considered cases, the motion is driven along in decreasing air density and damped along increasing air density. Perturbations of at most 5%–10% change the velocity differences by up to approximately 40%. Perturbations perpendicular to the electric field additionally squeeze or branch streamers. Air variations can thus partly explain the differences of velocities and morphologies of streamer discharges. In cases with large perturbations, electrons gain energies of up to 30 keV compared to 100 eV in uniformly distributed air. For such perturbations parallel to the ambient electric field, we see the spontaneous initiation of a negative streamer; for perpendicular perturbations, x-rays with energies of up to 20 keV are emitted within 0.17 ns.
STROBE-X: A probe-class mission for X-ray spectroscopy and timing on timescales from microseconds to years

We describe the Spectroscopic Time-Resolving Observatory for Broadband Energy X-rays (STROBE-X), a probe-class mission concept that will provide an unprecedented view of the X-ray sky, performing timing and spectroscopy over both a broad energy band (0.2-30 keV) and a wide range of timescales from microseconds to years. STROBE-X comprises two narrow-field instruments and a wide field monitor. The soft or low-energy band (0.2-12 keV) is covered by an array of lightweight optics (3-m focal length) that concentrate incident photons onto small solid-state detectors with CCD-level (85-175 eV) energy resolution, 100 ns time resolution, and low background rates. This technology has been fully developed for NICER and will be scaled up to take advantage of the longer focal length of STROBE-X. The higher-energy band (2-30 keV) is covered by large-area, collimated silicon drift detectors that were developed for the European LOFT mission concept. Each instrument will provide an order of magnitude improvement in effective area over its predecessor (NICER in the soft band and RXTE in the hard band). Finally, STROBE-X offers a sensitive wide-field monitor (WFM), both to act as a trigger for pointed observations of X-ray transients and also to provide high duty-cycle, high time-resolution, and high spectral-resolution monitoring of the variable X-ray sky. The WFM will boast approximately 20 times the sensitivity of the RXTE All-Sky Monitor, enabling multi-wavelength and multi-messenger investigations with a large instantaneous field of view. This mission concept will be presented to the 2020 Decadal Survey for consideration.
STROBE-X: X-ray Timing & Spectroscopy on Dynamical Timescales from Microseconds to Years

We describe a probe-class mission concept that provides an unprecedented view of the X-ray sky, performing timing and 0.2-30 keV spectroscopy over timescales from microseconds to years. The Spectroscopic Time-Resolving Observatory for Broadband Energy X-rays (STROBE-X) comprises three primary instruments. The first uses an array of lightweight optics (3-m focal length) that concentrate incident photons onto solid state detectors with CCD-level (85-130 eV) energy resolution, 100 ns time resolution, and low background rates to cover the 0.2-12 keV band. This technology is scaled up from NICER, with enhanced optics to take advantage of the longer focal length of STROBE-X. The second uses large-area collimated silicon drift detectors, developed for ESA's LOFT, to cover the 2-30 keV band. These two instruments each provide an order of magnitude improvement in effective area compared with its predecessor (NICER and RXTE, respectively). Finally, a sensitive sky monitor triggers pointed observations, provides high duty cycle, high time resolution, high spectral resolution monitoring of the X-ray sky with ~20 times the sensitivity of the RXTE ASM, and enables multi-wavelength and multi-messenger studies on a continuous, rather than scanning basis. We include updated instrument designs resulting from the GSFC IDL run in November 2017. For the first time, the broad coverage provides simultaneous study of thermal components, non-thermal components, iron lines, and reflection features from a single platform for accreting black holes at all scales. The enormous collecting area allows detailed studies of the dense matter equation of state using both thermal emission from rotation-powered pulsars and harder emission from X-ray burst oscillations. The combination of the wide-field monitor and the sensitive pointed instruments enables observations of potential electromagnetic counterparts to LIGO/Virgo and neutrino events. Extragalactic science, such as constraining bulk metallicity of medium to high redshift clusters and nearby compact groups and unprecedented timing investigations of active galactic nuclei, is also obtained.

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Swarm Optical Bench Stability

Swarm mission constellation, launched into orbit on November 22, 2013, consists of three satellites that precisely measure magnetic signal of the Earth. Each of the three satellites is equipped with three μASC Camera Head Units (CHU) mounted on a common optical bench (OB), which has a purpose of transference of the precisely determined attitude from the star trackers to the vector magnetometer (VFM) measurements. Although pre-launch analyses were made to minimize thermal and mechanical instabilities of the OB, significant signal with thermal signature is discovered when comparing relative attitude between the three CHU's. These misalignments between CHU's, and consequently geomagnetic reference frame, are found to be correlated with the optical bench temperature variation.

In this paper, we investigate the propagation of thermal effects into the μASC attitude observations and demonstrate how thermally induced attitude variation can be predicted and corrected in the Swarm data processing. The results after applying thermal model significantly improves attitude determination which, after correction, meets the requirements of Swarm satellite mission. This study demonstrates the importance of the OB pre-launch analysis to ensure minimum thermal gradient on satellite optical system and therefore maximum attitude accuracy.
Technical note: Bathymetry observations of inland water bodies using a tethered single-beam sonar controlled by an unmanned aerial vehicle

High-quality bathymetric maps of inland water bodies are a common requirement for hydraulic engineering and hydrological science applications. Remote sensing methods, such as space-borne and airborne multispectral imaging or lidar, have been developed to estimate water depth, but are ineffective for most inland water bodies, because of the attenuation of electromagnetic radiation in water, especially under turbid conditions. Surveys conducted with boats equipped with sonars can retrieve accurate water depths, but are expensive, time-consuming, and unsuitable for unnavigable water bodies. We develop and assess a novel approach to retrieve accurate and high-resolution bathymetry maps. We measured accurate water depths using a tethered floating sonar controlled by an unmanned aerial vehicle (UAV) in a lake and in two different rivers located in Denmark. The developed technique combines the advantages of remote sensing with the potential of bathymetric sonars. UAV surveys can be conducted also in unnavigable, inaccessible, or remote water bodies. The tethered sonar can measure bathymetry with an accuracy of ~2.1 % of the actual depth for observations up to 35 m, without being significantly affected by water turbidity, bed form, or bed material.

Temperature trends with reduced impact of ocean air temperature

Temperature data 1900–2010 from meteorological stations across the world have been analyzed and it has been found that all land areas generally have two different valid temperature trends. Coastal stations and hill stations facing ocean winds are normally more warm-trended than the valley stations that are sheltered from dominant oceans winds.

Thus, we found that in any area with variation in the topography, we can divide the stations into the more warm trended ocean air-affected stations, and the more cold-trended ocean air-sheltered stations. We find that the distinction between ocean air-affected and ocean air-sheltered stations can be used to identify the influence of the oceans on land surface. We can then use this knowledge as a tool to better study climate variability on the land surface without the moderating effects of the ocean.

We find a lack of warming in the ocean air sheltered temperature data – with less impact of ocean temperature trends –
after 1950. The lack of warming in the ocean air sheltered temperature trends after 1950 should be considered when evaluating the climatic effects of changes in the Earth’s atmospheric trace amounts of greenhouse gasses as well as variations in solar conditions.

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**TESS Discovery of a Transiting Super-Earth in the π Mensae System**

We report the detection of a transiting planet around π Men (HD 39091), using data from the Transiting Exoplanet Survey Satellite (TESS). The solar-type host star is unusually bright (V = 5.7) and was already known to host a Jovian planet on a highly eccentric, 5.7 yr orbit. The newly discovered planet has a size of 2.04 ± 0.05 R⊕ and an orbital period of 6.27 days. Radial-velocity data from the High-Accuracy Radial-velocity Planet Searcher and Anglo-Australian Telescope/University College London Echelle Spectrograph archives also displays a 6.27 day periodicity, confirming the existence of the planet and leading to a mass determination of 4.82 ± 0.85 M⊕. The star's proximity and brightness will facilitate further investigations, such as atmospheric spectroscopy, asteroseismology, the Rossiter-McLaughlin effect, astrometry, and direct imaging.

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The Biomass Mission: Objectives and Requirements

The Earth Explorer Biomass mission will provide the scientific community with accurate maps of tropical, temperate and boreal forest biomass, including height and disturbance patterns. This information is urgently needed to improve our understanding of the global carbon cycle and to reduce uncertainties in the calculation of carbon stocks and fluxes associated to the terrestrial biosphere. It is also crucial for approaches to managing climate, such as the UNFCCC initiative known as Reducing Emissions through Degradation and Deforestation (REDD+), aimed at climate change mitigation through conservation and better management of tropical forests. The required measurements are forest biomass and forest height at resolution of 200 m, and detection of deforestation at 50 m. Global maps of biomass are required with accuracy of 20% (or 10 t ha⁻¹ when above-ground biomass are less than 50 t ha⁻¹). To achieve this Biomass will be implemented as a P-band SAR mission. It will exploit the unique sensitivity of P-band SAR together with advanced retrieval methods including polarimetric interferometry (Pol-InSAR) and SAR tomography to measure biomass, height and disturbances across the entire biomass range every 6 months. The mission will also support important secondary objectives, including sub-surface imaging in arid zones, production of a bare-earth DTM and ice applications.

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Contributors: Toan, T. L., Chave, J., Dall, J., Papathanassiou, K., Paillou, P., Rechstein, M., Quegan, S., Saatchi, S., Seipel, K., Shugart, H., Tebaldini, S., Ulander, L., Williams, M.
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The Coastal Mean Dynamic Topography in Norway Observed by CryoSat-2 and GOCE

The Norwegian Coastal Current (NCC) transports warm and relatively fresh water along the Norwegian coast and into the Barents Sea, with its origin in Baltic water entering Skagerrak. Along its way northward it is fed by additional freshwater discharge. The NCC is important for the regional marine ecosystem and contributes to the poleward transport of warm Atlantic Water, maintaining the relatively mild climate in northwest Europe. Although satellite altimetry is a mature technique, globally observing the sea surface height with an accuracy of a few centimeters, numerous effects degrade the observations in the coastal zone. For example, the radar footprint is contaminated by land and bright targets, and the range and geophysical corrections become difficult to model. The rugged Norwegian coast presents a further challenge, and the NCC, at times only a few tens of kilometers wide, typically falls into a zone where conventional altimeters do not deliver reliable observations. The European Space Agency's CryoSat-2 (CS2) satellite is the first to carry a SAR altimeter instead of the conventional pulse-limited system, resulting in higher range precision and along-track resolution. This allows for tracking finer structures of the sea surface and get closer to the coast. We use CS2 low resolution and SARIn observations along the Norwegian coast and determine a mean dynamic topography (MDT) that is validated using tide gauges. In turn, geostrophic surface currents are derived from both the CS2 MDT and the operational coastal numerical ocean model of the Norwegian Meteorological Institute, and compared. For the first time, the NCC is revealed by space-geodetic techniques, giving confidence in the new-generation SAR altimeters for coastal sea level recovery.
The Contribution of DTU17 Marine Gravity for the Arctic Bathymetry Prediction

The Arctic Ocean is a challenging region, because of its complex and not well-documented bathymetry, together combined with the intermittent presence of sea ice and the fact that the in situ tidal observations are sparse at such high latitudes. The existing bathymetry map of the Arctic is purely derived from the sparse ship-sounding data, particularly on latitudes higher than 81° (e.g., IBCAOv3). The gaps (or data holes) are filled by extrapolation and somehow inaccurate. Smith & Sandwell combined the ship sounding data with bathymetry predicted from gravity up to latitude 81° to fill the gaps. However, even on higher latitudes, the gravity to bathymetry prediction is not ever tried due to the lack of high resolution (e.g., altimetry derived) marine gravity maps. As part of the ESA CryoSat Plus for Oceans (CP4O) project, the Arctic bathymetry will be predicted from the DTU17 marine gravity, which showed massive improvement compared to the previous models (e.g., DTU15) in the Arctic. The aim of this work is to demonstrate the contribution of marine gravity for the bathymetry prediction in the Arctic. With this presentation, the methodology to develop the gravity to bathymetry prediction will be represented. Due to the presence of thick sediments on the seafloor, the gravity and seafloor topography correlation is not significant in some areas. Such areas will be flagged and the accuracy of the predicted bathymetry will be evaluated.

The Dependence of the Peak Velocity of High-Speed Solar Wind Streams as Measured in the Ecliptic by ACE and the STEREO satellites on the Area and Co-Latitude of their Solar Source Coronal Holes

We study the properties of 115 coronal holes in the time-range from 2010/08 to 2017/03, the peak velocities of the corresponding high-speed streams as measured in the ecliptic at 1AU, and the corresponding changes of the Kp index as marker of their geo-effectiveness. We find that the peak velocities of high-speed streams depend strongly on both the areas and the co-latitudes of their solar source coronal holes with regard to the heliospheric latitude of the satellites. Therefore, the co-latitude of their source coronal hole is an important parameter for the prediction of the high-speed stream properties near the Earth. We derive the largest solar wind peak velocities normalized to the coronal hole areas for coronal holes located near the solar equator, and that they linearly decrease with increasing latitudes of the coronal holes. For coronal holes located at latitudes > 60°, they turn statistically to zero, indicating that the associated high-speed streams have a high chance to miss the Earth. Similar, the Kp index per coronal hole area is highest for the coronal holes located near the solar equator and strongly decreases with increasing latitudes of the coronal holes. We interpret these results as an effect of the three-dimensional propagation of high-speed streams in the heliosphere, i.e., high-speed streams arising from coronal holes near the solar equator propagate in direction towards and directly hit the Earth, whereas solar wind streams arising from coronal holes at higher solar latitudes only graze or even miss the Earth.

The Dependence of the Peak Velocity of High-Speed Solar Wind Streams as Measured in the Ecliptic by ACE and the STEREO satellites on the Area and Co-Latitude of their Solar Source Coronal Holes

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The e-ASTROGAM gamma-ray space observatory for the multimessenger astronomy of the 2030s

e-ASTROGAM is a concept for a breakthrough observatory space mission carrying a γ-ray telescope dedicated to the study of the non-thermal Universe in the photon energy range from 0.15 MeV to 3 GeV. The lower energy limit can be pushed down to energies as low as 30 keV for gamma-ray burst detection with the calorimeter. The mission is based on an advanced space-proven detector technology, with unprecedented sensitivity, angular and energy resolution, combined with remarkable polarimetric capability. Thanks to its performance in the MeV-GeV domain, substantially improving its predecessors, e-ASTROGAM will open a new window on the non-thermal Universe, making pioneering observations of the most powerful Galactic and extragalactic sources, elucidating the nature of their relativistic outflows and their effects on the surroundings. With a line sensitivity in the MeV energy range one to two orders of magnitude better than previous and current generation instruments, e-ASTROGAM will determine the origin of key isotopes fundamental for the understanding of supernova explosion and the chemical evolution of our Galaxy. The mission will be a major player of the multiwavelength, multimessenger time-domain astronomy of the 2030s, and provide unique data of significant interest to a broad astronomical community, complementary to powerful observatories such as LISA, LIGO, Virgo, KAGRA, the Einstein Telescope and the Cosmic Explorer, IceCube-Gen2 and KM3NeT, SKA, ALMA, JWST, E-ELT, LSST, Athena, and the Cherenkov Telescope Array.
The effect of nitrogen incorporation in boron carbide and iridium thin films

Thin film coated mirrors enable pioneering observations of X-rays and soft gamma rays. The performance of the reflective mirrors is key in expanding knowledge of the hot and energetic Universe. A critical part of maturing the optics technology is firstly, to establish a smooth surface and interface of the selected materials and, secondly, to obtain an in-depth understanding of the contamination in the thin films and ultimately, to ensure long-term stability. The aim of this study is to investigate the chemical composition, roughness and stability of boron carbide and iridium thin films and the effects of nitrogen incorporation.

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The enhanced X-ray Timing and Polarimetry mission—eXTP

In this paper we present the enhanced X-ray Timing and Polarimetry mission—eXTP. eXTP is a space science mission designed to study fundamental physics under extreme conditions of density, gravity and magnetism. The mission aims at determining the equation of state of matter at supra-nuclear density, measuring effects of QED, and understanding the dynamics of matter in strong-field gravity. In addition to investigating fundamental physics, eXTP will be a very powerful observatory for astrophysics that will provide observations of unprecedented quality on a variety of galactic and extragalactic objects. In particular, its wide field monitoring capabilities will be highly instrumental to detect the electromagnetic counterparts of gravitational wave sources. The paper provides a detailed description of: (1) the technological and technical aspects, and the expected performance of the instruments of the scientific payload; (2) the elements and functions of the mission, from the spacecraft to the ground segment.

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The Geomed2 Combined Geoid Model

The GEOMED 2 project computed a high-accuracy and resolution marine geoid model based on the availability of improved models for gravity, thanks to GRACE and GOCE in particular, for land topography and bathymetry, and the compilation of a cleaned-up and de-biased gravity database of the Mediterranean area based on BGI and SHOM data. Land and marine gravity data, the latest combined GOCE/GRACE based Global Geopotential Models and a combination of MISTRALS, EMODnet and SRTM/bathymetry terrain models were used in the gravimetric geoid computation.

Computation of a gravimetric marine geoid of the Mediterranean is challenging due to:

• The poor coverage of the marine gravity data for certain areas;
• The inhomogeneous quality of the marine gravity data (bias, precision);
• The data reduction is not as efficient as achieved over land.

Marine gravity data is not available for large parts of the Mediterranean and consequently the gravimetric geoid solution is significantly less accurate there. Gravity inferred from altimetry data, or a mean sea surface corrected for mean dynamic topography (i.e., an 'oceanographic' geoid model), can be used to fill the gaps. However, ocean dynamic signal may contaminate the derived gravity or geoid, which is why a pure gravimetric solution is preferred in an ideal world. The effect on the geoid solution of using several altimeter-based datasets, such as DTU10, DTU15 and UCSD V24 gravity, using simple gap filling, weighted combinations with the gravimetric data, and combination through collocation, will be evaluated and quantified. The combined models are compared with the gravimetric geoid solution as well as with the oceanographic geoid. The (local) errors and increased uncertainty due to the data gaps, and the subsequent effect on the ocean mean dynamic topography and geostrophic currents, can be estimated via the results of all comparisons. All models are equally compared to drifter-inferred current velocities, which constitutes an independent quality evaluation. This type of evaluation leads to a very detailed quality assessment of the models, notably as a function of spatial scale.
The high energy particle flux distribution of Jupiter measured by the ASCs of the Magnetometer Investigation

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The HST PanCET Program: Hints of Na I and Evidence of a Cloudy Atmosphere for the Inflated Hot Jupiter WASP-52b
We present an optical to near-infrared transmission spectrum of the inflated hot Jupiter WASP-52b using three transit observations from the Space Telescope Imaging Spectrograph mounted on the Hubble Space Telescope, combined with Spitzer/Infrared Array Camera photometry at 3.6 and 4.5 μm. Since WASP-52 is a moderately active (log(Lx/Lbol) = −4.7) star, we correct the transit light curves for the effect of stellar activity using ground-based photometric monitoring data from the All-sky Automated Survey for Supernovae (ASAS-SN) and Tennessee State University’s Automatic Imaging Telescope. We bin the data in 38 spectrophotometric light curves from 0.29 to 4.5 μm and measure the transit depths to a median precision of 90 ppm. We compare the transmission spectrum to a grid of forward atmospheric models and find that our results are consistent with a cloudy spectrum and evidence of sodium at 2.3σ confidence, but we find no observable evidence of potassium absorption even in the narrowest spectroscopic channel. We find that the optical transmission spectrum of WASP-52b is similar to that of the well-studied inflated hot Jupiter HAT-P-1b, which has comparable surface gravity, equilibrium temperature, mass, radius, and stellar irradiation levels. At longer wavelengths, however, the best-fitting models for WASP-52b and HAT-P-1b predict quite dissimilar properties, which could be confirmed with observations at wavelengths longer than ~1 μm. The identification of planets with common atmospheric properties and similar system parameters will be insightful for comparative atmospheric studies with the James Webb Space Telescope.

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**The Influence of Stellar Spin on Ignition of Thermonuclear Runaways**

Runaway thermonuclear burning of a layer of accumulated fuel on the surface of a compact star provides a brief but intense display of stellar nuclear processes. For neutron stars accreting from a binary companion, these events manifest as thermonuclear (type-I) X-ray bursts, and recur on typical timescales of hours to days. We measured the burst rate as a function of accretion rate, from seven neutron stars with known spin rates, using a burst sample accumulated over several decades. At the highest accretion rates, the burst rate is lower for faster spinning stars. The observations imply that fast (>400 Hz) rotation encourages stabilization of nuclear burning, suggesting a dynamical dependence of nuclear ignition on the spin rate. This dependence is unexpected, because faster rotation entails less shear between the surrounding accretion disk and the star. Large-scale circulation in the fuel layer, leading to enhanced mixing of the burst ashes into the fuel layer, may explain this behavior; further numerical simulations are required to confirm this.

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**The K2-138 System: A Near-resonant Chain of Five Sub-Neptune Planets Discovered by Citizen Scientists**

K2-138 is a moderately bright (V = 12.2, K = 10.3) main-sequence K star observed in Campaign 12 of the NASA K2 mission. It hosts five small (1.6-3.3 R⊕) transiting planets in a compact architecture. The periods of the five planets are 2.35, 3.56, 5.40, 8.26, and 12.76 days, forming an unbroken chain of near 3:2 resonances. Although we do not detect the predicted 2-5 minute transit timing variations (TTVs) with the K2 timing precision, they may be observable by higher-cadence observations with, for example, Spitzer or CHEOPS. The planets are amenable to mass measurement by precision radial velocity measurements, and therefore K2-138 could represent a new benchmark system for comparing radial velocity and TTV masses. K2-138 is the first exoplanet discovery by citizen scientists participating in the Exoplanet Explorers project on the Zooniverse platform.

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The McXtrace AstroX toolbox: a general ray tracing software package for end to end simulation of x-ray optics for astronomical instrumentation

McXtrace is a general, highly modular, X-ray tracing open source software package for simulating X-ray optics. While initially intended for simulating synchrotron beamlines, it has recently found use in astrophysics. Here it is being used to evaluate the projected performance of X-ray telescope designs. We present the software add-on toolbox "AstroX" to McXtrace containing all of the common optical elements found in satellite based X-ray telescopes. In addition, the toolbox contains detector and source models relevant for astronomical applications. As an added benefit, users may exploit the heritage of McXtrace and use its beamline elements, to simulate characterization measurements of optical elements. McXtrace AstroX allows for simulation of X-rays telescopes based on different optical concepts such as nested mirror shells and Silicon Pore Optics technology. In this study we present examples of McXtrace AstroX use for ATHENA-, and NuSTAR-like telescope concepts.
The Permanent Facility for Satellite Altimetry Calibration in Gavdos/Crete, Greece: Fifteen years of Cal/Val Service.

This work describes the gradual development of the Gavdos/Crete Cal/Val permanent facility as of 2001 in terms of infrastructure, instrumentation and the seasurface as well as transponder calibrations along ascending and descending orbits of satellite altimeters. The difficulties encountered during this period are described, along with measures taken to overcome them. Absolute calibration results are given for Jason-1, Jason-2 and Jason-3 along their ascending Pass No. 109 together with the descending Pass No.18 for 2004-2017. Sea-surface Cal/Val results for Jason-3 are compared against transponder calibrations carried out along the same orbit at the CDN1 Cal/Val site on the mainland of Crete. Relative calibrations are also given between Jason-3 and Sentinel-3A & 3B simultaneously with seasurface and transponder techniques. Other Cal/Val results for past satellites such as SARAL/Altika and the Chinese HY-2 will also be reported. Guidelines for keeping an accurate, reliable, objective, homogeneous and continuous monitoring of oceans, inland waters as well as Polar Regions with altimetry will also be given. Transparent protocols and best practices for establishing new Cal/Val sites according to the standards of Fiducial Reference Measurement for altimetry will be presented.

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The Properties of GRB 120923A at a Spectroscopic Redshift of z = 7.8

Gamma-ray bursts (GRBs) are powerful probes of early stars and galaxies, during and potentially even before the era of reionization. Although the number of GRBs identified at z ≥ 6 remains small, they provide a unique window on typical star-forming galaxies at that time, and thus are complementary to deep field observations. We report the identification of the optical drop-out afterglow of Swift GRB 120923A in near-infrared Gemini-North imaging, and derive a redshift of Z=7.84 ±0.06/−0.13 from Very Large Telescope/X-shooter spectroscopy. At this redshift the peak 15–150 keV luminosity of the burst was 3.2 × 1052 erg s−1, and in this sense it was a rather typical long-duration GRB in terms of rest frame luminosity. This burst was close to the Swift/Burst Alert Telescope detection threshold, and the X-ray and near-infrared afterglow were also faint. We present ground- and space-based follow-up observations spanning from X-ray to radio, and find that a standard external shock model with a constant-density circumburst environment of density n ≈ 4 × 10−2 cm−3 gives a good fit to the data. The near-infrared light curve exhibits a sharp break at t ≈ 3.4 days in the observer frame which, if interpreted as being due to a jet, corresponds to an opening angle of θjet ≈ 5º. The beaming-corrected γ-ray energy is then Ey ≈ 2 x 1050 erg, while the beaming-corrected kinetic energy is lower, erg, suggesting that GRB 120923A was a comparatively low kinetic energy event. We discuss the implications of this event for our understanding of the high-redshift population of GRBs and their identification.

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The role of binaries in the enrichment of the early Galactic halo - II. Carbon-enhanced metal-poor stars – CEMP-no stars (Corrigendum)

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The Swarm mission high energy particle flux investigation

Swarm mission constellation, launched into orbit on November 22, 2013, consists of three satellites that precisely measure magnetic signal of the Earth using the ASM and VFM, integrated with three Advanced Stellar Compass star trackers cameras. By using a minimum of magnetic material close to the magnetometer sensors (optimal for the magnetic measurements), the resulting shielding is insufficient to stop the more energetic part of the particle flux encountered in the Swarm constellation orbit, where protons above 60MeV and electrons above 10MeV may penetrate to the focal plane detectors. To eliminate the ASC cameras sensitivity to passing energetic particles, the ASC employ a suite of morphological filters removing the effects from such particles before the stars observed are matched to the onboard catalogue. The efficacy of these filters is high enough to ensure full performance even during the most intense CMEs, moreover, the measured rate of these penetrating particles, effectively monitors the high energy particle flux. Since May 2018, the spacecraft thus have sent the measured fluxes to ground, enabling very precise map of this part of the energetic flux. World map of the AP-8 MAX integral proton flux >10 MeV at 500 km altitude (Heynderickx, 1996) Particles flux for Swarm spacecrafts Ionizing particles in the Swarm orbits DTU Space μASC We present world maps of the energetic particle flux, its variation with altitude, local time, direction and seasonal variations. We further present a view of the dynamic part of the flux, from injection sources such as CMEs, which gives a detailed profiling of the direction, injection
The THESEUS space mission concept: science case, design and expected performances

THESEUS is a space mission concept aimed at exploiting Gamma-Ray Bursts for investigating the early Universe and at providing a substantial advancement of multi-messenger and time-domain astrophysics. These goals will be achieved through a unique combination of instruments allowing GRB and X-ray transient detection over a broad field of view (more than 1sr) with 0.5–1 arcmin localization, an energy band extending from several MeV down to 0.3keV and high sensitivity to transient sources in the soft X-ray domain, as well as on-board prompt (few minutes) follow-up with a 0.7m class IR telescope with both imaging and spectroscopic capabilities. THESEUS will be perfectly suited for addressing the main open issues in cosmology such as, e.g., star formation rate and metallicity evolution of the inter-stellar and intra-galactic medium up to redshift 10, signatures of Pop III stars, sources and physics of re-ionization, and the faint end of the galaxy luminosity function. In addition, it will provide unprecedented capability to monitor the X-ray variable sky, thus detecting, localizing, and identifying the electromagnetic counterparts to sources of gravitational radiation, which may be routinely detected in the late ‘20s/early ‘30s by next generation facilities like aLIGO/ aVirgo, eLISA, KAGRA, and Einstein Telescope. THESEUS will also provide powerful synergies with the next generation of multi-wavelength observatories (e.g., LSST, ELT, SKA, CTA, ATHENA).

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The Total Electron Content From InSAR and GNSS: A Midlatitude Study
The total electron content (TEC) measured from the interferometric synthetic aperture radar (InSAR) and from a dense network of global navigation satellite system (GNSS) receivers are used to assess the capability of InSAR to retrieve ionospheric information, when the tropospheric contribution to the interferometric phase is reasonably negligible. With this aim, we select three night-time case studies over Italy and investigate the correlation between TEC from advanced land observing satellite-phased array type L-band synthetic aperture radar (ALOS-PALSAR) and from the Rete Integrata Nazionale GPS (RING) network, the latter considered as the reference true ionospheric TEC. To retrieve the TEC variability from ALOS-PALSAR, we first investigate the correlation between the integral of the azimuth shifts and the interferometric phase in the absence of ground motions (e.g., earthquakes) and/or heavy rain events. If correlation exists (as in two out of three case studies under investigation), we can assume the tropospheric contribution to the interferometric phase as negligible and the TEC variability from L-band InSAR can be retrieved. For these two case studies, the comparison between the TEC from the InSAR images and from the RING network is quite encouraging as the correlation coefficient is R similar to 0.67 in the first case and R similar to 0.83 in the second case. This result highlights the potential to combine InSAR and GNSS experimental measurements to investigate small-scale spatial variability of TEC, in particular over regions scarcely covered by ground-based GNSS receivers.

The wide field monitor onboard the eXTP mission
The eXTP (enhanced X-ray Timing and Polarimetry) mission is a major project of the Chinese Academy of Sciences (CAS) and China National Space Administration (CNSA) currently performing an extended phase A study and proposed for a launch by 2025 in a low-earth orbit. The eXTP scientific payload envisages a suite of instruments (Spectroscopy Focusing Array, Polarimetry Focusing Array, Large Area Detector and Wide Field Monitor) offering unprecedented simultaneous wide-band X-ray timing and polarimetry sensitivity. A large European consortium is contributing to the eXTP study and it is expected to provide key hardware elements, including a Wide Field Monitor (WFM). The WFM instrument for eXTP is based on the design originally proposed for the LOFT mission within the ESA context. The eXTP/WFM envisages a wide field X-ray monitor system in the 2-50 keV energy range, achieved through the technology of the large-area Silicon Drift Detectors. The WFM will consist of 3 pairs of coded mask cameras with a total combined Field of View (FoV) of 90×180 degrees at zero response and a source localization accuracy of ∼1 arcmin. In this paper we provide an overview of the WFM instrument design, including new elements with respect to the earlier LOFT configuration, and
anticipated performance.

Three-Dimensional Circulation Driving Chemical Disequilibrium in WASP-43b

Spectral features in the observed spectra of exoplanets depend on the composition of their atmospheres. A good knowledge of the main atmospheric processes that drive the chemical distribution is therefore essential to interpret exoplanetary spectra. An atmosphere reaches chemical equilibrium if the rates of the forward and backward chemical reactions converge to the same value. However, there are atmospheric processes, such as atmospheric transport, that destabilize this equilibrium. In this work we study the changes in composition driven by a 3D wind field in WASP-43b using our Global Circulation Model, THOR. Our model uses validated temperature- and pressure-dependent chemical timescales that allow us to explore the disequilibrium chemistry of CO, CO$_2$, H$_2$O, and CH$_4$. In WASP-43b the formation of the equatorial jet has an important impact on the chemical distribution of the different species across the atmosphere. At low latitudes the chemistry is longitudinally quenched, except for CO$_2$ at solar abundances. The polar vortexes have a distinct chemical distribution since these are regions with lower temperature and atmospheric mixing. Vertical and latitudinal mixing have a secondary impact on the chemical transport. We determine graphically the effect of disequilibrium on the observed emission spectra. Our results do not show any significant differences in the emission spectra between the equilibrium and disequilibrium solutions for C/O = 0.5. However, if C/O is increased to 2.0, differences in the spectra due to the disequilibrium chemistry of CH$_4$ become non-negligible. In some spectral ranges the emission spectra can have more than 15% departure from the equilibrium solution.
Three-phase Evolution of a Coronal Hole. I. 360° Remote Sensing and In Situ Observations

We investigate the evolution of a well-observed, long-lived, low-latitude coronal hole (CH) over 10 solar rotations in the year 2012. By combining extreme ultraviolet (EUV) imagery from the Solar TErrestrial RElations Observatories (STEREO-A/B) and the Solar Dynamics Observatory (SDO), we are able to track and study the entire evolution of the CH having a continuous 360° coverage of the Sun. The remote sensing data are investigated together with in situ solar wind plasma and magnetic field measurements from STEREO-A/B, the Advanced Composition Explorer (ACE), and WIND. From this, we obtain how different evolutionary states of the CH as observed in the solar atmosphere (changes in EUV intensity and area) affect the properties of the associated high-speed stream measured at 1 au. Most distinctly pronounced for the CH area, three development phases are derived: (a) growing, (b) maximum, and (c) decaying phase. During these phases the CH area (a) increases over a duration of around three months from about 1 · 10^{10} km² to 6 · 10^{10} km², (b) keeps a rather constant area for about one month of >9 · 10^{10} km², and (c) finally decreases in the following three months below 1 · 10^{10} km² until the CH cannot be identified anymore. The three phases manifest themselves also in the EUV intensity and in situ measured solar wind proton bulk velocity. Interestingly, the three phases are related to a different range in solar wind speed variations, and we find for the growing phase a range of 460–600 km s⁻¹, for the maximum phase 600–720 km s⁻¹, and for the decaying phase a more irregular behavior connected to slow and fast solar wind speeds of 350–550 km s⁻¹.

Topographic Steering of Enhanced Ice Flow at the Bottleneck Between East and West Antarctica

Hypothesized drawdown of the East Antarctic Ice Sheet through the "bottleneck" zone between East and West Antarctica would have significant impacts for a large proportion of the Antarctic Ice Sheet. Earth observation satellite orbits and a sparseness of radio echo sounding data have restricted investigations of basal boundary controls on ice flow in this region until now. New airborne radio echo sounding surveys reveal complex topography of high relief beneath the southernmost Weddell/Ross ice divide, with three subglacial troughs connecting interior Antarctica to the Foundation and Patuxent Ice Streams and Siple Coast ice streams. These troughs route enhanced ice flow through the interior of Antarctica but limit potential drawdown of the East Antarctic Ice Sheet through the bottleneck zone. In a thinning or retreating scenario, these topographically controlled corridors of enhanced flow could however drive ice divide migration and increase mass discharge from interior West Antarctica to the Southern Ocean.
Topological information extraction from buildings in CityGML

The demand for 3D city modelling for various applications continue to grow with the capabilities of 3D city modelling. One of the uses of 3D city models is to facilitate 3D analysis which usually requires information regarding the topology of the objects within the city model. CityGML as the international standard for 3D city modelling maintains topological information with the use of a 'topology-incidence' where objects are referenced to each other with the condition that the objects share a common surface. This paper explains the extraction of topological information based on the data structure of the geometries in CityGML files and discusses the usability of the existing topology mechanism of CityGML. The topological information was extracted from the CityGML files using the hierarchical geometric structure of CityGML as a stand-in model to describe the topological properties of the object. The extracted information consisted of building surfaces which have been decomposed to 0D points with their respective identification and coordinates. Based on the extracted topological information and related literature, it was found that the topological information extracted from the geometric structure of CityGML was limited to the locality of the object in question and could not extend beyond the dimension of the primitive.
Toward Consistent Modeling of Atmospheric Chemistry and Dynamics in Exoplanets: Validation and Generalization of the Chemical Relaxation Method

Motivated by the work of Cooper & Showman, we revisit the chemical relaxation method, which seeks to enhance the computational efficiency of chemical kinetics calculations by replacing the chemical network with a handful of independent source/sink terms. Chemical relaxation solves the evolution of the system and can treat disequilibrium chemistry, as the source/sink terms are driven toward chemical equilibrium on a prescribed chemical timescale, but it has surprisingly never been validated. First, we generalize the treatment by forgoing the use of a single chemical timescale, instead developing a pathway analysis tool that allows us to identify the rate-limiting reaction as a function of temperature and pressure. For the interconversion between methane and carbon monoxide, and between ammonia and molecular nitrogen, we identify the key rate-limiting reactions for conditions relevant to currently characterizable exo-atmospheres (500-3000 K, 0.1 mbar to 1 kbar). Second, we extend chemical relaxation to include carbon dioxide and water. Third, we examine the role of metallicity and the carbon-to-oxygen ratio in chemical relaxation. Fourth, we apply our pathway analysis tool to diagnose the differences between our chemical network and that of Moses and Venot. Finally, we validate the chemical relaxation method against full chemical kinetics calculations in one dimension. For WASP-18b-, HD 189733b-, and GJ 1214-b-like atmospheres, we show that chemical relaxation is mostly accurate to within an order of magnitude, a factor of 2, and similar to 10%, respectively. The level of accuracy attained allows for the chemical relaxation method to be included in three-dimensional general circulation models.

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Transiting planet candidate from K2 with the longest period
Context. We present the transit and follow-up of a single transit event from Campaign 14 of K2, EPIC248847494b, which has a duration of 54 h and a 0.18% depth.
Aims. Using photometric tools and conducting radial velocity follow-up, we vet and characterise this very strong candidate. Methods. Owing to the long, unknown period, standard follow-up methods needed to be adapted. The transit was fitted using Namaste, and the radial velocity slope was measured and compared to a grid of planet-like orbits with varying masses and periods. These used stellar parameters measured from spectra and the distance as measured by Gaia. Results. Orbiting around a sub-giant star with a radius of 2.70 ± 0.12 R\textsubscript{Sol}, the planet has a radius of 1.11−0.07+0.07 R\textsubscript{Jup} and a period of 3650−1130+1280 days. The radial velocity measurements constrain the mass to be lower than 13 M\textsubscript{Jup}, which implies a planet-like object.
Conclusions. We have found a planet at 4.5 AU from a single-transit event. After a full radial velocity follow-up campaign, if confirmed, it will be the longest-period transiting planet discovered.
Twenty-Five Years of Progress in Sea Floor Mapping by Satellite Altimetry

Although ships equipped with deep-water multi-beam echo-sounding (MBES) swath mapping systems and satellite (GPS) navigation have been around for the last 25 years, they rarely collect data in unexplored ocean areas. The most accurate and detailed sea floor sounding data are mostly confined to shallow coastal areas around developed countries, and a few deepwater areas that have been the focus of particular efforts (such as the search for the missing Malaysia Airlines flight MH370 aircraft). Almost all the global ocean floor area lies more than a few hundred kilometers from the nearest GPS-navigated MBES data, and global ocean floor depth models must rely on older, low-tech single-wide-beam echo soundings recorded on analog scrolls and often positioned with only celestial navigation (most of the available data in the remote oceans was collected prior to 1965). If the ocean floor area is divided into squares one nautical mile (1.85 km) on a side, and all data, both GPS-MBES and old, low-tech data, are combined, only 8 percent of squares have any data at all.

For this reason, global ocean floor mapping relies on satellite altimetry to guide the interpolation of gaps in unmapped areas. The largest variations in sea surface topography are time-invariant and exhibit geoid height anomalies produced by the Earth's gravity field. At high wavenumber (full wavelengths approximately 10 to 160 km) these anomalies are usually correlated with sea floor topography, but can also arise from sub-seafloor tectonic structure buried beneath seafloor sediment. Resolving anomalies at this scale requires satellite altimeter profiles of sea surface height along a dense network of ground tracks, so that the inter-track spacing adequately samples scales as short as 5 km or less. The first altimeter mission to yield a dense network of tracks was the European Space Agency's ERS-1 mission, completed in March of 1995. Marine gravity maps made from these data were exhibited at the Spring 1995 American Geophysical Union meeting, and this may have prompted the U.S. Navy to release the Geosat dense track data, collected in 1985-86 but classified Secret until July 1995. Some southern ocean Geosat data had been previously released in 1990 and 1992, allowing algorithm development for bathymetric estimation from dense track altimetry. After the 1990s there was a long period with no new dense-track altimetry, and so seafloor mapping made incremental improvements as geodesists learned to improve the along-track resolution at high wavenumber using specialized retractors and high-data-rate filters designed to extract the seafloor topography signal. With CryoSat-2 in a long-repeat orbit since 2010, and the Jason-1, Jason-2, and SARAL/AltiKa missions also going into dense-track orbits at the end of their primary missions, there is now a renaissance in seafloor mapping. Efforts are underway to see how many previously uncharted seamounts may be found, and how much resolution may be squeezed out of the newer mission data.
UBAT of UFFO/Lomonosov: The X-Ray Space Telescope to Observe Early Photons from Gamma-Ray Bursts

The Ultra-Fast Flash Observatory (UFFO) Burst Alert and Trigger Telescope (UBAT) has been designed and built for the localization of transient X-ray sources such as Gamma Ray Bursts (GRBs). As one of main instruments in the UFFO payload onboard the Lomonosov satellite (hereafter UFFO/Lomonosov), the UBAT’s roles are to monitor the X-ray sky, to rapidly locate and track transient sources, and to trigger the slewing of a UV/optical telescope, namely Slewing Mirror Telescope (SMT). The SMT, a pioneering application of rapid slewing mirror technology has a line of sight parallel to the UBAT, allowing us to measure the early UV/optical GRB counterpart and study the extremely early moments of GRB evolution. To detect X-rays, the UBAT utilizes a 191.1 cm² scintillation detector composed of Yttrium Oxyorthosilicate (YSO) crystals, Multi-Anode Photomultiplier Tubes (MAPMTs), and associated electronics. To estimate a direction vector of a GRB source in its field of view, it employs the well-known coded aperture mask technique. All functions are written for implementation on a field programmable gate array to enable fast triggering and to run the device’s imaging algorithms. The UFFO/Lomonosov satellite was launched on April 28, 2016, and is now collecting GRB observation data. In this study, we describe the UBAT’s design, fabrication, integration, and performance as a GRB X-ray trigger and localization telescope, both on the ground and in space.

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UFFO/Lomonosov: The Payload for the Observation of Early Photons from Gamma Ray Bursts
The payload of the UFFO (Ultra-Fast Flash Observatory)-pathfinder now onboard the Lomonosov spacecraft (hereafter UFFO/Lomonosov) is a dedicated instrument for the observation of GRBs. Its primary aim is to capture the rise phase of
the optical light curve, one of the least known aspects of GRBs. Fast response measurements of the optical emission of GRB will be made by a Slewing Mirror Telescope (SMT), a key instrument of the payload, which will open a new frontier in transient studies by probing the early optical rise of GRBs with a response time in seconds for the first time. The SMT employs a rapidly slewing mirror to redirect the optical axis of the telescope to a GRB position prior determined by the UFFO Burst Alert Telescope (UBAT), the other onboard instrument, for the observation and imaging of X-rays. UFFO/Lomonosov was launched successfully from Vostochny, Russia on April 28, 2016, and will begin GRB observations after completion of functional checks of the Lomonosov spacecraft. The concept of early GRB photon measurements with UFFO was reported in 2012. In this article, we will report in detail the first mission, UFFO/Lomonosov, for the rapid response to GRB observations.

Ultra-High Performance C & L-Band Radiometer System for Future Spaceborne Ocean Missions

A next generation spaceborne radiometer system for hi-quality ocean measurements is discussed. Instead of a classical horn, a focal plane array is used as antenna feed. The antenna beam is created by adding the outputs from many small antenna elements, thus providing an antenna beam of unsurpassed quality. This solves the classical polarization purity and land / sea contamination issues. The concept requires many microwave receivers and fast analog-to-digital converters as well as fast digital signal processing on-board the satellite. This is discussed, and resource budgets, especially concerning power, are provided.
Uncertainty Reduction of Arctic Sea Ice Freeboard from CryoSat-2 Interferometric Mode

Abstract A study by Armitage and Davidson (2014) has shown that the extra information from the CryoSat-2 (CS2) SARIn mode increases the number of valid sea surface height estimates which are usually discarded in the SAR mode due to snagging of the radar signal. As the number of valid detected leads increases, the uncertainty of the freeboard heights decreases. In this study, the freeboard heights estimated by processing CS2 SARIn level 1b waveforms are validated using the information from airborne laser and radar altimetry as well as snow radar measurements acquired during the CryoVEx 2012 and Operation IceBridge 2012 campaigns, respectively. The possible reduction in the random freeboard uncertainty is investigated comparing two scenarios, i.e. a SAR-like and a SARIn acquisition. A very good agreement is found between average airborne and satellite radar freeboards although, at the CS2 footprint scale, they do not show along-track spatial correlation. It is observed that using the extra phase information, CS2 is able to detect leads up to 2300 m off-nadir. A reduction in the total random freeboard uncertainty of ~ 40% is observed by taking advantage of the CS2 interferometric capabilities, which enable to include ~ 35% of the waveforms discarded in the SAR-like scenario.

Understanding the spectral and timing behaviour of a newly discovered transient X-ray pulsar Swift J0243.6+6124

We present the results obtained from timing and spectral studies of the newly discovered accreting X-ray binary pulsar Swift J0243.6+6124 using Nuclear Spectroscopy Telescope Array observation in 2017 October at a flux level of ~280 mCrab. Pulsations at 9.854 23(5) s were detected in the X-ray light curves of the pulsar. Pulse profiles of the pulsar were found to be strongly energy dependent. A broad profile at lower energies was found to evolve into a double-peaked profile in ≥ 30 keV. The 3-79 keV continuum spectrum of the pulsar was well described with a negative and positive exponential cutoff or high-energy cutoff power-law models modified with a hot blackbody at ~3 keV. An iron emission line was also detected at 6.4 keV in the source spectrum. We did not find any signature of cyclotron absorption line in our study. Results obtained from phase-resolved and time-resolved spectroscopy are discussed in the paper.
Unmanned aerial vehicle observations of water surface elevation and bathymetry in the cenotes and lagoons of the Yucatan Peninsula, Mexico

Observations of water surface elevation (WSE) and bathymetry of the lagoons and cenotes of the Yucatan Peninsula (YP) in southeast Mexico are of hydrogeological interest. Observations of WSE (orthometric water height above mean sea level, amsl) are required to inform hydrological models, to estimate hydraulic gradients and groundwater flow directions. Measurements of bathymetry and water depth (elevation of the water surface above the bed of the water body) improve current knowledge on how lagoons and cenotes connect through the complicated submerged cave systems and the diffuse flow in the rock matrix. A novel approach is described that uses unmanned aerial vehicles (UAVs) to monitor WSE and bathymetry of the inland water bodies on the YP. UAV-borne WSE observations were retrieved using a radar and a global navigation satellite system on-board a multi-copter platform. Water depth was measured using a tethered floating sonar controlled by the UAV. This sonar provides depth measurements also in deep and turbid water. Bathymetry (wet-bed elevation amsl) can be computed by subtracting water depth from WSE. Accuracy of the WSE measurements is better than 5–7 cm and accuracy of the water depth measurements is estimated to be ~3.8% of the actual water depth. The technology provided accurate measurements of WSE and bathymetry in both wetlands (lagoons) and cenotes. UAV-borne technology is shown to be a more flexible and lower cost alternative to manned aircrafts. UAVs allow monitoring of remote areas located in the jungle of the YP, which are difficult to access by human operators.

Validation of CryoSat-2 SARIn Data over Austfonna Ice Cap Using Airborne Laser Scanner Measurements

The study presented here is focused on the assessment of surface elevations derived from CryoSat-2 SARIn level 1b data over the Austfonna ice cap, Svalbard, in 2016. The processing chain that must be applied to the CryoSat-2 waveforms to
derive heights is non-trivial, and consists of multiple steps, all requiring subjective choices of methods such as the choice of retracker, geo-relocation, and outlier rejection. Here, we compare six CryoSat-2 level-2 type data sets of surface elevations derived using different SARIn processing chains. These data sets are validated against surface elevation data collected from an airborne laser scanner, during a dedicated CryoSat validation experiment field campaign carried out in April 2016. The flight pattern of the airborne campaign was designed so that elevations were measured in a grid pattern rather than along single lines, as has previously been the standard procedure. The flight grid pattern was chosen to optimize the comparison with the CryoSat-2 SARIn elevation data, the location of which can deviate from nadir by several kilometers due to topography within the satellite footprint. The processing chains behind the six data sets include different outlier/error rejection approaches, and do not produce the same number of data points in our region of interest. To make a consistent analysis, we provide statistics from the validation of both the full data sets from each processing chain, and on only those data that all the six data sets provide a geo-located elevation estimate for. We find that the CryoSat-2 data sets that agree best with the validation data are those derived from dedicated land ice processing schemes. This study may serve as a benchmark for future CryoSat-2 retracker developments, and the evaluation software and data set are made publicly available.

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Validation of Satellite Cryosphere Altimetry with Airborne Surveys – Results of CryoVEx Campaigns
In preparations for the first CryoSat mission ESA initiated a series of validations campaigns called CryoVEx – CryoSat Validation Experiment. For the first time DTU Space carried out a validation campaign in 2003 and continued in the following years with several pre-launch experiment followed by the first direct validation campaign in spring 2011 after the successful launch of CryoSat-2 in 2010. Since then validation experiments have been carried out both in the Arctic and Antarctic with different instrumental setup. The performance of CryoSat-2 has been validated using an airborne version of the SIRAL altimeter (ASIRAS, manufactured by Radar System Technology) combined with laser scanner altimeter observations together with e.g visual imagery. Also in the very recent campaigns a Ka-band radar system (KAREN) manufactured by MetaSensing has been added to the observations providing the opportunity to collect coincident dual frequency radar altimetry. Combined with in situ observations on ground at selected validations sites, these airborne observations provide a unique dataset of observations coincident in time and space of surface elevations and elevation changes for validation of the CryoSat products. These data have been used for studies that assess the accuracy and error sources of CryoSat-2 (e.g. the CryoVal sea ice and land ice projects). The presentation will give an overview of the airborne campaigns and summarize the main results obtained with the datasets gathered.

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Vertical Land Motion Determined by Satellite Altimetry and Tide-Gauge Data in Fennoscandia

Present-day vertical land motion in Fennoscandia reaches values up to around 1 cm/year. The primary cause of the uplift is Glacial Isostatic Adjustment, i.e., the ongoing response of the Earth and the ocean to the melting of late-Pleistocene ice sheets. Additional signals caused, e.g., by the elastic rebound from contemporary melting of glaciers, tectonics, and hydrology contribute less. The relation between relative sea-level change (Sdot), change in the sea surface height (Ndot), and vertical land motion (Udot) is given by Sdot = Ndot – Udot. All three quantities can be observed directly by means of tide gauges, satellite altimetry, and Global Navigation Satellite Systems (GNSS), respectively. Alternatively, Udot may be estimated from observations of Sdot and Ndot. In the present study, we combine satellite altimetry and tide-gauge data to determine vertical land motion at tide gauges in Fennoscandia. Considering the discrepancies in the spatial sampling of conventional altimeters, where the mean distance between conventional altimetry sites and tide gauges along the Norwegian coast is 53 km, we take advantage of the CryoSat-2 geodetic orbit. The European Space Agency’s CryoSat-2 satellite is the first to carry a synthetic aperture interferometric radar altimeter, resulting in higher range precision and along-track resolution. This allows us to get closer to the coast, with observations of the sea surface at the tide-gauge stations as a main benefit when combining altimetry and tide-gauge data. In turn, we compare the estimated vertical land motion rates with the independent semi-empirical land uplift model NKG2016LU for the Nordic-Baltic region, based on GNSS and levelling.

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Contributors: Idžanović, M., Breili, K., Gerlach, C., Andersen, O.
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VLF Signal Anomalies During Cyclone Activity in the Atlantic Ocean

In this paper we present ionospheric disturbances during the simultaneous presence of two to three Large Meteorological Systems, classified as hurricanes and tropical storms, in the Atlantic Ocean from August to November 2016. The ionospheric disturbances were detected by very low frequency (3–30 kHz) signals from two North American transmitters observed in Algiers (36.75°N, 03.47°E). The results show clear anomalies in the amplitude both at nighttime and at daytime. At nighttime, the anomalies were observed in association with all Large Meteorological Systems even at low stage of storm intensity (tropical depression). The anomalies showed periodicities between 2 and 3 hr with a strong decrease in the signal amplitude. The wave-like features were confirmed by the mother wavelet analysis of the normalized signal amplitude. These signal anomalies may result from traveling ionospheric disturbances generated by tropical storms and hurricanes associated gravity waves.

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What drives 20th century polar motion?
Astrometric and geodetic measurements show that the mean position of Earth's spin axis drifted through the solid crust toward Labrador, Canada at an average speed of 10.5 +/- 0.9 cm/yr during the 20th century. Understanding the origins of this secular polar motion (SPM) has significance for modeling the global climate, as it provides a link to ice mass balance and sea-level rise. A perplexing issue, however, is that while glacial isostatic adjustment (GIA) models satisfactorily explain the direction of SPM, the associated prediction of the amplitude is insufficient. Our Bayesian GIA analysis, with constraints from relative sea-level and vertical land motion data, reveals that this process only accounts for 33 +/- 18% of the observed SPM amplitude. This shortfall motivates a more broadly scoped reassessment of SPM drivers. To address this, we assemble a complete reconstruction of Earth's surface mass transport derived from recent advancements in modeling the global 20th century cryospheric, hydrologic, oceanic, and seismogenic mass exchange. The summed signals, nonetheless, cannot fully reconcile the observed SPM, even when considering the error statistics of each driver. We investigate an additional excitation source: changes in Earth's inertia tensor caused by mantle convection. Sophisticated models have recently been advanced in tectonic plate reconstructions, in conjunction with geoid and seismic tomographic models. Here we use these models to compute new estimates of SPM. While the convection-driven SPM has considerable uncertainty, the average direction of 283 recent models aligns with the residual SPM (within 2.7 +/- 14.8 degrees), significantly reducing the gap between observation and prediction. We assert that one key mechanism for driving 20th century SPM is long-term mass movement due to mantle convection. (C) 2018 Elsevier B.V. All rights reserved.

Zodiacal Exoplanets in Time (ZEIT). VII. A Temperate Candidate Super-Earth in the Hyades Cluster
Transiting exoplanets in young open clusters present opportunities to study how exoplanets evolve over their lifetimes. Recently, significant progress detecting transiting planets in young open clusters has been made with the K2 mission, but so far all of these transiting cluster planets orbit close to their host stars, so planet evolution can only be studied in a high-irradiation regime. Here, we report the discovery of a long-period planet candidate, called HD 283869 b, orbiting a member of the Hyades cluster. Using data from the K2 mission, we detected a single transit of a super-Earth-sized (1.96 ± 0.12 R⊕) planet candidate orbiting the K-dwarf HD 283869 with a period longer than 72 days. As we only detected a single-transit event, we cannot validate HD 283869 b with high confidence, but our analysis of the K2 images, archival data, and
follow-up observations suggests that the source of the event is indeed a transiting planet. We estimated the candidate’s orbital parameters and find that if real, it has a period $P \approx 100$ days and receives approximately Earth-like incident flux, giving the candidate a 71% chance of falling within the circumstellar habitable zone. If confirmed, HD 283869 b would have the longest orbital period, lowest incident flux, and brightest host star of any known transiting planet in an open cluster, making it uniquely important to future studies of how stellar irradiation affects planetary evolution.