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Ocean Reflected GPS Signals

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Abstract:
Ocean reflected signals from the GPS satellites (received at low-Earth orbiting satellites, airplanes and fixed mountain locations) describe the ocean surface mean height, waves, roughness, spectral reflectivity and emissivity. The estimated accuracy of the average surface height is of the order of 10 cm for smooth conditions. Thus global observations can be an important new contribution to long-term variations of the ocean mean height as well as the monitoring of the ocean mesoscale eddies.
The ocean reflected signals can be divided into two set of measurements, 1) high elevation measurements (equal to low incidence angles) and 2) low elevation grazing angle measurements. For the first type the ocean reflection cross-section has a limited extent. The reflected signal is coherent with smaller errors due to ocean waves, sampling rate and the internal processing method of the receiver. For low elevations, the signal reveals the incoherent scatter process at the reflection zone.
To quantify the potential of the GPS signals for determining spectral reflectivity at low elevations, we present ocean reflection measurements from the Haleakala Summit on Maui, Hawaii, revealing the spectral characteristics of both the direct satellite signal and the ocean reflected signal for low elevation angles.
The characteristics of the reflected signal depend on the scattering properties of the sea surface and the footprint of the reflection zone. While the footprint size and shape in turn depends on the signal incidence angle, the ocean mean tilt, and the relative velocities of transmitter and receiver to the reflection point. Thus the scattering properties of the sea surface are related to the sea surface roughness. We present the spectral properties of the signals as received by a high precision GPS instrument, simultaneously in both phase-locked mode and open-loop raw mode in separate receiver channels.
The measurements of the low elevation grazing signals reveal the incoherent scatter process in the reflection zone, the spectral skewness and width of the reflected signals, and the relation to surface winds, temperature and sea surface roughness. Thus, such observations are able to determine the spectral reflectivity of the ocean surface at GPS wavelengths.