Gust factor based on research aircraft measurements: A new methodology applied to the Arctic marine boundary layer - DTU Orbit (08/12/2018)

Gust factors in the Marine Arctic

There is as yet no standard methodology for measuring wind gusts from a moving platform. To address this, we have developed a method to derive gusts from research aircraft data. First we evaluated four different approaches, including Taylor's hypothesis of frozen turbulence, to derive the gust length-scales that correspond to the gust time-scales, namely the gust duration (s) and the sample period (typically 10 min). The novelty of our method lies in using peak factors (deviation of the gust from the mean wind speed normalized by the local turbulence) to convert between the scales. After devising a way to derive the gust length-scales, we calculated the gust factors from aircraft observations and tested them against those from four parametrizations originally developed for weather stations. Three of them performed well (R²=0.66 or higher), while the fourth overestimated the gust factors in unstable conditions (R²=0.52). The mean errors for all methods were low, from -0.02 to 0.05, indicating that wind gust factors can indeed be measured from research aircraft. Moreover, we showed that aircraft can provide gust measurements within the whole boundary layer, if horizontal legs are flown at multiple levels over the same track. This is a significant advance, as gust measurements are usually limited to heights reached by weather masts. In unstable conditions over the open ocean, the gust factor was nearly constant with height throughout the boundary layer, the near-surface values only slightly exceeding those at upper levels. Furthermore, we found gust factors to be strongly dependent on surface roughness conditions, which differed between the open ocean and sea ice in the Arctic marine environment. The roughness effect on the gust factor was stronger than the effect of boundary-layer stability.

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