On the Estimation of Wind Vectors over the Sea Surface from Near-Nadir Radar Observations

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The remote sensing of wind vectors over the sea surface using microwave scatterometry has a long history. Traditional scatterometer systems operate at moderate incidence angles in order to emphasize the Bragg scatter component of the sea surface normalized radar cross section (NRCS), and typically require multiple azimuth "looks" in order to reduce ambiguities in the determination of wind direction. In contrast, radar systems designed for atmospheric sensing from aircraft frequently operate in a near-nadir configuration, with cross-track scanning utilized in some cases. This study explores the potential use of such atmospheric radar measurements for wind vector retrieval through a Monte Carlo simulation method. A maximum likelihood estimation of wind vectors is utilized for simulated measurements corrupted by speckle and thermal noise.

This study relies upon a forward model for the backscattered returns from the sea surface. Unlike traditional scatterometry, the configuration considered emphasizes the geometrical optics (GO) portion of the sea surface NRCS. Utilizing the GO in theory requires knowledge of the sea surface RMS slopes as a function of the wind vector. The determination of these RMS slopes however is complicated by the need for a "cutoff" wavenumber dividing "long" and "short" waves in the sea spectrum. To avoid this issue, a "cutoff invariant two-scale" approach is used instead; this approach essentially is based on the first order small slope approximation of sea scattering so that no cutoff wavenumber is required. The model uses the Elfouhaily et al sea spectrum model in producing a look-up table of the sea surface near nadir NRCS values as a function of the wind vector.

Measurement data is generated using a geometry similar to that of JPL's Airborne Precipitation Radar-2 (APR-2), a cross-track scanning Ka- and Ku-band aircraft radar. The cross-track scan provides a range of both incidence and azimuth angles. The Monte Carlo maximum likelihood retrieval process enables the production of simulated wind retrievals as a function of the wind vector so that retrieval error statistics can be examined. Results from this study indicate that retrieval performance in the presence of speckle noise is highly dependent on the "true" wind vector. The presentation will review the simulation approach and discuss the results as well as their potential use in practice.