Rain Quality Control for SeaWinds Near Real-time Data

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1. Introduction

SeaWinds on QuikSCAT, launched in June 1999, provides a new source of surface wind information over the world's oceans. The primary mission of the SeaWinds instrument on the QuikSCAT satellite is to retrieve the surface vector wind over the global ocean (Shirtliffe 1999). This new window on global surface vector winds has been a great aid to real-time operational users, especially in remote areas of the world. As with in situ observations, the quality of remotely-sensed geophysical data is closely tied to the characteristics of the instrument. But remotely-sensed scatterometer winds also have a whole range of additional quality control concerns different from those of in situ observation systems. The retrieval of geophysical information from the raw satellite measurements introduces uncertainties but also produces diagnostics about the reliability of the retrieved quantities.

SeaWinds is an active, Ku-band microwave radar operating near $14\ Ghz$ and is sensitive to centimeter-scale or capillary waves on the ocean surface. These waves are usually in equilibrium with the wind. Each radar backscatter observation samples a patch of ocean about $25\times\ 35\ km$. The vector wind is retrieved by combining several backscatter observations made from multiple viewing geometries as the scatterometer passes overhead. The resolution of the retrieved winds is $\sim 25\ km$. Backscatter from capillary waves on the ocean surface, therefore, is the desired signal, since therein lies information about the vector wind. However, many other factors can influence backscatter observations and thereby effect the retrieved winds. Rain, for example, changes the ocean surface roughness, as well as attenuating and scattering the radar energy.

2. Rain Contamination

Many of the special characteristics of a scatterometer data are revealed by examining the likelihood function which is maximized during the wind retrieval. The closer the likelihood function is to zero, the more likely the wind solution. In Fig. 1, the upper panel shows a highlighted row of selected wind vectors (QuikSCAT rev 6659, 2207 UTC 28 September 2000) while the lower three panels show likelihood functions for selected cells. The underlying infrared satellite image shows Hurricane Isaac (2215 UTC 28 September 2000). Cells 41 and 36 are rain free according to the rain flags which accompany the data, but cells 40-37 (in blue) are affected by the heavy rain in the front.

The well-known ambiguity of wind direction in scatterometer data is apparent when the likelihood function is plotted with respect to the retrieved values of the u and v wind components. Likelihood functions for the the rain-free wind vector cells (41 and 35) show deep and distinct minima (two each). These minima represent likely wind solutions. The rain-affected wind vector cells (39, for example) however, have minima which are much further from zero, and are not nearly so well-defined. Also notice rain has nearly doubled the wind speed compared to neighboring rain-free cells. Rain has equalized backscatter for cell 39 from all view points and virtually no wind direction signal remains.

Rain flags were developed for SeaWinds after the launch of QuikSCAT. Original plans paired SeaWinds with a passive microwave sensor that would have provided a rain flag. Instead a variety of alternative rain flags have been proposed (Boukabara et al. 2002), and several of these have been combined into a multi-dimensional histogram (MUDH) rain indicator and rain flag (Huddleston and Stiles 2000).

SeaWinds and other scatterometer data in general have many potential uses, but it is important to understand their peculiar error characteristics for proper quality control and application.

References

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Fig. 1: *An example of rain-contaminated winds from SeaWinds. The upper panel shows the wind vector cell row of interest in bold wind barbs. Winds suspected of rain contamination are blue. The panels below show the QuikSCAT objective wind retrieval function for cells 41, 39 and 36. Notice that the wind speeds for cell 39 are very large compared to its neighbors, and the minima in the objective function are much larger than in adjacent, non-raining cells.*