Geophysical Research Abstracts
Vol. 13, EGU2011-8393, 2011
EGU General Assembly 2011

Development of a Passive Microwave Ocean Wind Vector Retrieval Algorithm in Tropical Cyclones

Amanda Mims (1), Chris Ruf (2), and Darren McKague (3)

(1) University of Michigan, Ann Arbor, United States (mimsa@umich.edu), (2) University of Michigan, Ann Arbor, United States (cruf@umich.edu), (3) University of Michigan, Ann Arbor, United States (dmckague@umich.edu)

Polarimetric microwave radiometry was first applied to satellite remote sensing with the instrument WindSat, launched in 2003. It measures upwelling brightness temperatures (TB) over five frequency channels, three of which are fully polarimetric. The distribution of channels between 6.8 GHz and 37 GHz allows a number of useful remote sensing applications, ranging from atmospheric modeling to land or ocean surface retrievals. This paper concerns ocean surface wind vector retrievals and presents an atmospheric clearing algorithm which corrects for the effects of optically thick atmospheres on the surface TBs. Most commonly used surface wind retrieval methods are valid only in calm to moderate ocean states (winds under 25 m/s, rain-free to light precipitation). The method developed in this paper uses WindSat overpasses of tropical cyclones to provide observations under conditions of moderate to heavy precipitation and strong winds.

Our wind vector retrieval algorithm utilizes the vertically and horizontally polarized (V and H-pol) channels for wind speed and the modified 3rd and 4th Stokes parameters to determine wind direction. The basis for the speed retrieval is the surface foam fraction. As the wind increases, it generates sea foam which is a mixture of water and air and has a composite emissivity near unity. Therefore, the more WindSat's observing footprint becomes foam covered, the higher the emissivity of the target, which then increases the TBs. Surface wind speed and emissivity are thus monotonically related. The direction retrieval depends on asymmetry in the 3rd and 4th Stokes parameters. Increasing winds drives up wave amplitudes as well, and the resulting directional variation in the wave fronts produces a sinusoidal trend in the Stokes channels. However, atmospheric emission also contributes to the TBs and its attenuation lowers the contribution of the surface emission to the observations. These effects must be carefully characterized for robust surface wind retrievals in tropical cyclones.

The atmospheric clearing algorithm described in this paper relies on a scattering-inclusive radiative transfer model (RTM). The RTM is subjected to a non-linear successive approximation inversion until the $\chi 2$ difference between the WindSat tropical cyclone TB observations and simulated TBs is minimized. The clearing algorithm solves for rain rate and column integrated water vapor, which are then inserted back into the RTM to determine the atmospheric optical depth and the attenuation. The clearing algorithm utilizes the WindSat high frequency V-pol channels for this process. The shorter wavelengths of these channels ensure their sensitivity to clouds and precipitation, while the choice of V-pol minimizes sensitivity to surface wind variations. Specular emissivity at V-pol is by nature higher than H-pol, so the additional increase in emissivity due to wind driven sea foam is lower. Once the atmospheric attenuation is explained, the surface emissivity is extracted from the WindSat TBs using the radiative transfer equation. The emissivities are collocated with footprint matched H*wind analyses for each cyclone overpass, which serves as the "ground truth" wind speed and direction. The match-ups provide the basis for two empirical model functions (EMF) for the wind vector retrieval algorithm. The H-pol and V-pol emissivity EMF determines the wind speed and the 3rd and 4th Stokes EMF supports the retrieval of wind direction.