An Anisotropic Ocean Surface Emissivity Model Based on WindSat Polarimetric Brightness Observations

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The goal of this research has been to develop a standardized fast full-Stokes ocean surface emissivity model with Jacobian for a wind-driven ocean surface applicable at arbitrary microwave frequencies, polarizations, and incidence angles. The resulting model will thus be relevant to assimilation of radiances from all existing and planned conically and cross-track scanned sensors. The model is derived by modifying the Ohio State University (OSU) two-scale code for surface emission developed by Johnson (2006, IEEE TGRS, 44, 560) as follows: The Meissner-Wentz dielectric permittivity (2004, IEEE TGRS, 42, 1836) replaces the original permittivity. The Elfouhaily sea surface spectrum (1997, JGR, 102, C7,15781) replaces the Durden-Vesecky spectrum (1985, IEEE TGRS, OE-10, 445), but the Durden-Vesecky angular spreading function is retained. The high-frequency portion of the Elfouhaily spectrum is multiplied by the Pierson-Moskowitz shape spectrum to correct an error in the original paper. The generalized Phillips-Kitaigorodskii equilibrium range parameter for short waves is modeled as a continuous function of the friction velocity at the water surface to eliminate a discontinuous jump in the original paper. As a result a total of five physical tuning parameters were identified. Both the spectral strength and the hydrodynamic modulation are allowed to vary. The short wave part of the spectrum is allowed to have an arbitrary ratio relative to the long wave part of the spectrum. The foam fraction is multiplied by a variable correction factor. The foam fraction is also modulated to allow an anisotropic foam fraction with more foam on the leeward side of a wave, and the degree of modulation is taken as a tuning parameter. A nine month sequence of WindSat data as analyzed by Meissner and Wentz (2005, Oceans MTS/IEEE) and these results were used for all four Stokes brightnesses in all harmonics in the angle between the wind direction and the azimuth-look angle, in ten wind bins from 0-20 m/s of 2 m/s width. There are three WindSat frequencies with polarimetric data at 10.7, 18.7, and 37.0 GHz. As a result there are 30 brightnesses per wind bin for a total of 300 brightnesses used to constrain the modified two-scale code with the five tuning parameters mentioned above. The tuning criterion used was the rms difference between the 30 WindSat brightnesses and the two-scale OSU brightnesses in each wind bin. Prior to tuning the rms difference summed over all wind bins was 2.04 K. The tuned rms difference was reduced to 0.50 K. These results were taken as input to the construction of a bias table valid for all incidence angles. These biases will be subtracted from all OSU code radiances before comparing them with satellite radiances. The model is presently being validated against the Aqua AMSU-A and HSB data sets from May 2002 to February 2003 (when the HSB ceased to function) using the DOTLRT microwave radiative transfer code to model the downwelling and upwelling atmospheric brightnesses. This validation may lead to some small further model adjustments pursuant to the goal of a standardized fast full-Stokes ocean surface emissivity model applicable at arbitrary microwave frequencies and incidence angles.

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