2.2 AN EMPIRICAL EMISSIVITY MODEL FOR COMPLEX SURFACES

Janice Bytheway * and C. Kummerow
Colorado State University, Fort Collins, Colorado

1. INTRODUCTION

Passive microwave radiometers are frequently employed in the retrieval of rainfall over ocean where the radiometrically cold ocean background allows for accurate discrimination of cloud features. Over land, however, this technique is less useful, as the warm land background prevents such discrimination in the absence of ice scattering (Wilheit et al. 2003). For this reason, microwave over-land rain retrievals are prone to failure over warm rain systems and the edges of convective systems where cloud ice is not present (Panegrossi et al. 1998). The high spatial and temporal variability of land emissivity further complicates precipitation retrieval, and its dependence on soil moisture, soil type, vegetation, and other surface characteristics prevents the simple assumption of a characteristic land emissivity value (Weng et al. 2001).

The difficult task of over-land rainfall retrieval can be simplified if the value of the land surface emissivity can be determined independent of its many influencing factors. For this reason, an empirical emissivity model has been developed with surface emissivities retrieved using surface and atmospheric data from the suite of instruments aboard the Earth Observing System (EOS) Aqua spacecraft, described in section 2 below. The method was developed and tested over ocean, and is discussed along with preliminary land results in section 3. Planned and suggested future work will be outlined in section 4.

2. DATA AND METHODOLOGY

The EOS-Aqua satellite was launched in May of 2002, and carries the Advanced Microwave Scanning radiometer for EOS (AMSR-E), Atmospheric Infrared Sounder (AIRS), Moderate Resolution Imaging Spectroradiometer (MODIS), Advanced Microwave Sounding Unit (AMSU-A), Humidity Sounder for Brazil (HSB), and Clouds and the Earths Radiation Energy System (CERES) (NASA 2007). Using AMSR-E horizontally and vertically polarized brightness temperatures at 10.65, 18.7, 23.8, 36.5, and 89.0 GHz in conjunction with the MODIS cloud mask and the surface skin temperature, surface pressure, and profiles of temperature and humidity from AIRS in a plane-parallel radiative transfer model, cloud-free global surface emissivities were retrieved. For this study, the AMSR-E 6.925 GHz channels were not used to avoid contamination from surface transmissions sometimes observed over developed nations.

Using the retrieved emissivities, empirical relationships were developed between each channel and the 10.7 GHz horizontal channel for each degree Kelvin of surface temperature over the oceans and for 0.5 x 0.5 degree boxes over land (Figure 1).

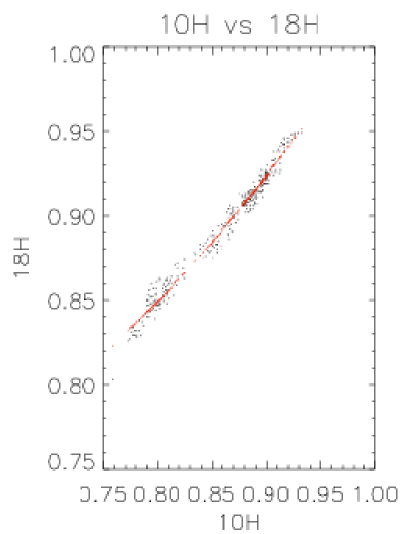

Fig. 1. Example of the relationship between the retrieved emissivity at the 10.65 and 18.7 GHz channels for a 0.5 x 0.5 degree box in Oklahoma. The red curve represents the best fit to the retrieved values, the coefficients of which are used in the empirical emissivity model.

3. RESULTS

The empirical relationships were implemented in an optimal estimation retrieval of the 10.65 GHz horizontally polarized emissivity, column water vapor, and liquid water path over both ocean and land surfaces.

3.1 Ocean Results

Retrieved quantities of column water vapor and liquid water path from the empirical model were compared to those retrieved by Remote Sensing Systems (Wentz 2000) and were found to be in good agreement. Additionally, pixels with high chi squared values where the optimal estimation retrieval failed to converge on a unique solution, were also compared to results from the GPROF rain retrieval algorithm. The

Corresponding author address: Janice L. Bytheway, Colorado State Univ., Dept, of Atmospheric Science, Fort Collins, CO, 80523-1371; email: janice@atmos.colostate.edu

non-convergent pixels matched well to pixels deemed precipitating by the GPROF algorithm.

These ocean results indicate that with some modifications, a similar technique can be employed over land.

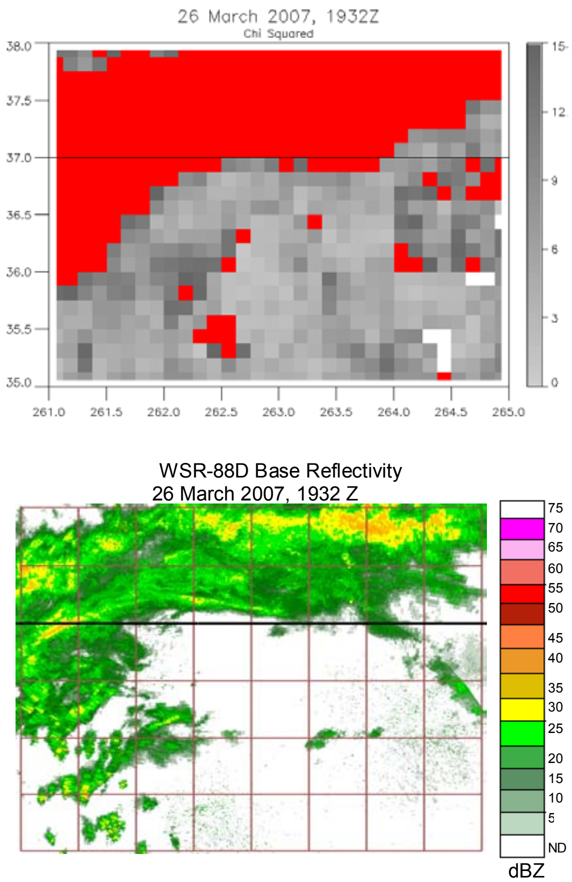

Fig. 2. Chi-squared values from the optimal estimation retrieval for a case in northern Oklahoma/southern Kansas, with values greater than 15 masked in red as likely precipitation (top) and the observed radar reflectivity from the same case (bottom).

3.2 Land Results

The dielectric properties of soils differ from those of oceans, and therefore empirical emissivity relationships were created based on uniform surface properties rather than surface temperature. Land surface properties are highly variable, and therefore multiple grid sizes were attempted using data from January-February-March of 2007 to determine the ideal size that can be considered uniform. Little difference in the results was seen between $1^{o}x1^{o}$, $0.5^{o}x0.5^{o}$, and $0.25^{o}x0.25^{o}$ boxes. Therefore, half-degree boxes were chosen to minimize scatter due to surface variations, while maximizing the possible number of clear sky pixels available to create empirical emissivity relationships.

Use of these preliminary relationships in the optimal estimation retrieval has demonstrated the capacity to distinguish raining and non-raining areas based on a chi-squared threshold (figure 2). These results have also demonstrated the need for separate relationships for frozen and non-frozen soils. To avoid further complication, snow covered pixels have been omitted from this study using the method described by Connor and Petty (1998).

4. CONCLUSION AND CONTINUED STUDY

The employment of an empirical emissivity model has shown promise for use in determining raining and non-raining regions over land. Continued research on this prospect is focusing on the need for separate relationships for both frozen and non-frozen ground, as well as determining whether the empirical emissivity model will need to be modified on a monthly or seasonal basis due to changes in vegetation. This technique is currently being tested over multiple regions, with the eventual goal of creating a global database of emissivity coefficients for use in the empirical model.

5. REFERENCES

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