CHARACTERIZATION OF K-BAND RADIO FREQUENCY INTERFERENCE FROM AMSR-E, WINDSAT AND SSM/I

Darren McKague, John J. Puckett and Christopher Ruf

University of Michigan

1. INTRODUCTION

Radio Frequency Interference (RFI) from human sources is a significant issue for passive microwave observations of the Earth. Numerous studies have shown the influence of RFI on Earth remote sensing in a number of bands including L [1], C [2, 3], and X [2, 3]. An understanding of the sources and frequency ranges of the RFI will help guide the design of future radiometers. To that end, this presentation shows characteristics of K-band RFI over the continental US in two different frequency ranges, the first centered at 18.7 GHz (AMSR-E, WindSat), and the second centered at 19.35 GHz (SSM/I). RFI is seen for both frequency ranges over water and over land, but is more wide-spread and higher in magnitude at 18.7 GHz. The source of the 18.7 GHZ RFI is traced to commercial television broadcasts from the DirecTV satellite. While the magnitude of this RFI is greater over water, it can be significant over land as well, particularly for snow covered land where the much stronger diffuse component of RFI reflection creates a relatively large region of contamination. Because the strength of RFI reflection depends on the degree of snow cover, it is possible to estimate its snow water equivalent (SWE) from the level of RFI present. An SWE estimator will be developed and tested using AMSR-E data.

2. RFI DETECTION ALGORITHM

A relatively simple algorithm for detecting RFI was used. Data over the continental US are collected in ¼ degree latitude, longitude cells. In each of these cells, the maximum difference between co-polar brightness temperature (Tb) measurements at two frequencies for each instrument of interest is recorded for each month. In general, large negative or positive signals in these maximum differences result from either spectral variability in the geophysical signal or RFI in one of the two bands. By choosing co-polar bands that are close in frequency, the geophysical variability between bands can be minimized, though not eliminated. The difference between geophysical variability and RFI can generally be identified, as will be shown.

3. RFI DETECTION RESULTS

K-band data from the WindSat, Special Sensor Microwave Imager (SSM/I) F13 and Advanced Microwave Scanning Radiometer-EOS (AMSR-E) radiometers have been analyzed using the RFI detection algorithm. The center frequencies, polarizations, incidence angle and bandwidths of the K-band channels for each instrument are shown in Table 1. Data were analyzed for the periods July 2005 – June 2006 and July 2008 – June 2009. Differences between the co-polar channels near 23 GHz were used for RFI detection.

Table 1. Relevant characteristics of WindSat, AMSR-E, and SSM/I.

Instrument	Center Frequency (GHz)	Bandwidth (MHz)	Polarization	K-band Incidence Angle (degrees)	Comparison Channels (to compute Tb difference)
WindSat	18.7	500	V, H	55.35	23.8 V, H
AMSR-E	18.7	200	V, H	55	23.8 V, H
SSM/I	19.35	200	V, H	53.1	22.235 V

Selected Tb difference maps are shown in Figs. 1 through 4. Several features of note are seen in the data:

1) In addition to naturally occurring large positive differences over water, there are large negative differences that indicate the presence of RFI. The RFI is largest in the 2008-2009 data over water, suggesting that it due to specular reflection by the water.
2) SSM/I shows significantly less RFI for both the 2005-2006 and the 2008-2009 data.
3) AMSR-E and WindSat show significantly more RFI in 2008-2009 than in 2005-2006. This RFI is predominantly located along an arc peaking around 45 degrees North latitude centered at around 100 degrees West longitude at the equator. This signal first appears in the data just after the launch of the DirecTV 10 satellite in July of 2007, which is located in geosynchronous orbit with a sub-satellite point at around 100 degrees West longitude at the equator and which has channels operating in the 18.3 to 18.9 GHz range. The observed RFI is therefore very likely from DirecTV. Since the broadcasts aren't high enough in frequency to overlap the SSM/I K-band channel, they do not show up in SSM/I data.
4) The DirecTV RFI increases significantly over land in the winter months. This is likely due to increased reflection from snow, which has a higher reflectivity at these frequencies than bare or vegetated land surfaces. This signal also has a wider spatial extent than the RFI over water, which is likely due to the higher diffuse component of reflection from snow relative to water. This reflection of the RFI off of

snow will be used to retrieve snow water equivalent (SWE) data by correlating the signal to existing estimates of SWE.

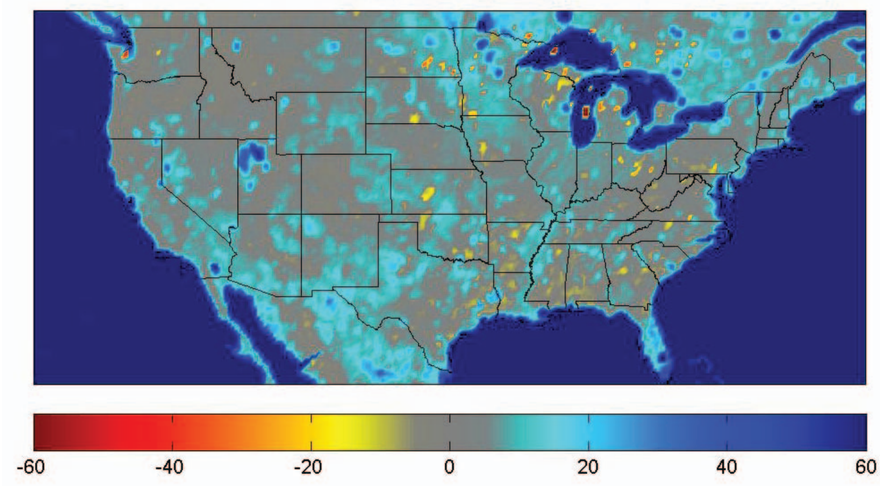

Figure 1. 23.8H – 18.7H Tb differences for AMSR-E, July 2005.

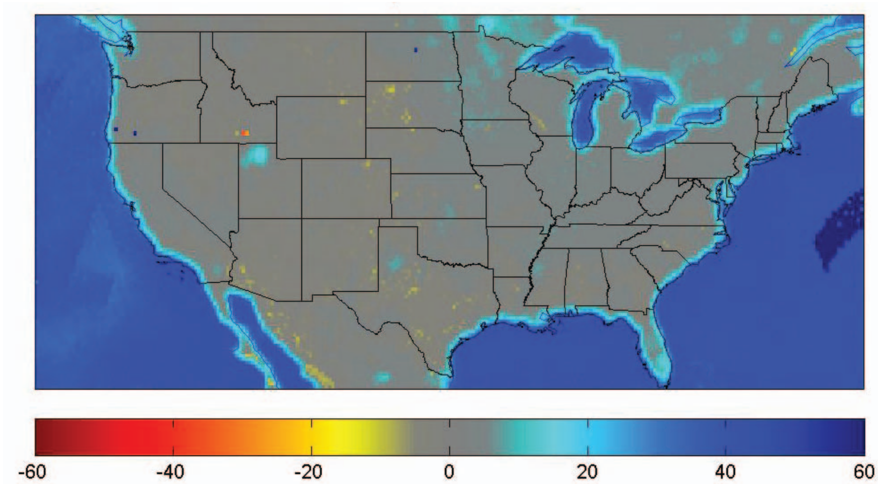

Figure 2. 22.235V – 19.35V Tb differences for SSM/I, July 2005.

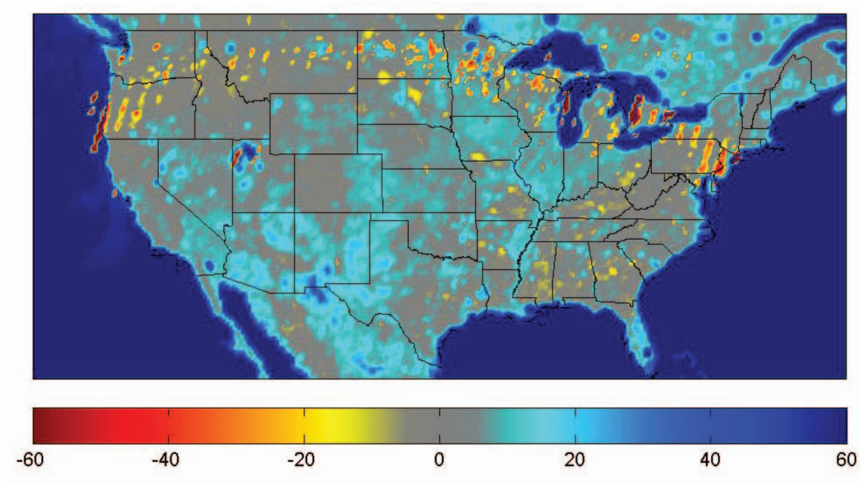

Figure 3. 23.8H – 18.7H Tb differences for AMSR-E, July 2008.

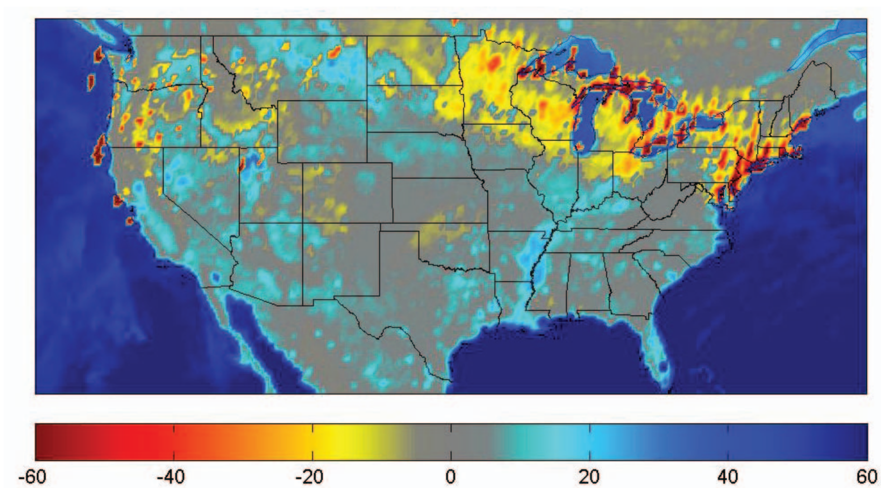

Figure 4. 23.8H – 18.7H Tb differences for AMSR-E, January 2009.

REFERENCES

[1] Le Vine, D.M., “ESTAR experience with RFI at L-band and implications for future passive microwave remote sensing from space,” *Geosci. Rem. Sens. Symposium, 2002*, vol. 2, pp. 847-849, 24-28 June 2002.

[2] Njoku, E.G., P. Ashcroft, T.K. Chan, and L. Li, “Global survey and statistics of radio-frequency interference in AMSR-E land observations," *IEEE Trans. Geosci. Rem. Sens.*, vol. 43, pp. 938-947, 2005.

[3] Li, Li, P.W. Gaiser, and M. Bettenhausen, “WindSat radio-frequency interference signature and its identification over land and ocean,” *IEEE Trans. Geosci. Rem. Sens.*, vol. 44, pp. 530-539, 2006.