STUDIES OF RADIO FREQUENCY INTERFERENCE AT L-BAND USING AN AIRBORNE 2-D INTERFEROMETRIC RADIOMETER

Martti Hallikainen, Kimmo Rautiainen, Juha Kainulainen, Jaakko Seppänen, Anssi Hakkarainen

Helsinki University of Technology

Department of Radio Science and Engineering

P.O. Box 3000, 02015 TKK, Finland

Email: martti.hallikainen@tkk.fi

1. BACKGROUND AND STATEMENT OF PROBLEM

Data from two satellites carrying microwave radiometers will be available in 2010. European Space Agency (ESA) launched in November 2009 its SMOS satellite in order to provide global soil moisture and ocean salinity data on a regular basis. National Aeronautics and Space Administration (NASA) will launch its sea surface salinity satellite Aquarius in 2010. Both microwave radiometers operate within the protected L-band (1400-1427 MHz). The usefulness of these satellite data over land may be reduced in regions close to cities, airports and industrial areas due to man-made sources emitting radiation within this band. An analysis of the effect of Radio Frequency Interference (RFI) to the MIRAS radiometer onboard the SMOS satellite has been carried out [1]. Potential RFI sources include L-band radars (long range air surveillance, airport radars, air route surveillance); mobile, navigation and other satellite services; and various land services (TV broadcasts, military services). However, few experimental studies have been conducted on RFI over urban areas [2]. RFI sources may distort satellite data and regionally prevent soil moisture retrieval. It is of great importance to collect a geographically and temporally extensive data set on RFI and develop detection and, if possible, compensation methods to ensure high-quality global soil moisture retrieval from space-borne radiometer data. Our project is the first to include collection of experimental data on RFI using an airborne 2-D interferometric radiometer. We examine the level of the RFI problem using data collected in Finland, Central Europe and Southern Europe.

2. INSTRUMENTATION, DATA COLLECTION AND DISCUSSION

We have collected data with our airborne L-band interferometric HUT-2D radiometer in order to support the SMOS mission. The HUT-2D instrument is highly suitable for these studies, because it employs the same technology as SMOS and, additionally, provides a spatial resolution much better than that of SMOS.

Consequently, we detect also local and weak RFI that do not show up in SMOS images but, rather, somewhat increase the pixel brightness temperature. This increase will lead to interpreted soil moisture values that are too low. In fact, RFI not visible in SMOS images (due to the small increase in brightness temperature) may be the most harmful type of RFI. Man-made sources that totally saturate HUT-2D -derived brightness temperature values can be expected to show up in SMOS data, too.

We participated in April-May 2008 in ESA's rehearsal campaign for SMOS satellite validation activities and collected radiometer data over test sites in the Upper Danube Catchment area near Munich, Germany, and the Valencia Anchor Station west of Valencia, Spain. Data were collected also during transfer flights between Finland, southern Germany and Spain in both directions. In addition to HUT-2D, our research aircraft carried (a) the L-band non-scanning radiometer EMIRAD (Technical University of Denmark) and (b) the Paris instrument (Institute for Space Studies of Catalunia) that measures the GPS signal reflected from the ground. The HUT-2D and EMIRAD instruments detected noticeable interfering signals during these flights (Fig. 1). The most problematic locations in Europe concerning RFI were observed to be southern France in general, and all big cities including their surrounding areas.

In 2007 we recorded HUT-2D data during transfer flights between Helsinki (southern Finland) and Rovaniemi (Arctic Circle). In Finland most of the RFI seems to occur in the Greater Helsinki area. Two basic categories of RFI were observed: (1) Point-wise weak sources of interference that do not saturate the HUT-2D instrument, and (2) strong sources of interference that totally saturate the sensor over a large area.

Category 1 sources, although weak, disturb the radiometer correlations to an extent that the brightness temperatures of some pixels are higher than expected. These sources can be localized accurately due to their small size; they should not have a noticeable effect on SMOS data. Category 2 sources appear to be strong and they show up in HUT-2D data over the whole swath (about 600 m) over an extended flight path. Their accurate localization is more difficult, because a strong source can cause RFI even when it is located way outside the swath. The effect of Category 2 RFI in SMOS data may range from slightly elevated pixel brightness temperature values (causing a bit too low soil moisture values to be interpreted) to strongly elevated values (soil moisture substantially too low) and to values that are higher than the physical temperature of the target (causing RFI to be detected in a straightforward manner). Several Category 1 spots were detected in Central Helsinki. Category 2 RFI was observed in the region surrounding the Malmi Airport in the Greater Helsinki area. The strong RFI is very likely caused by the airport radar.

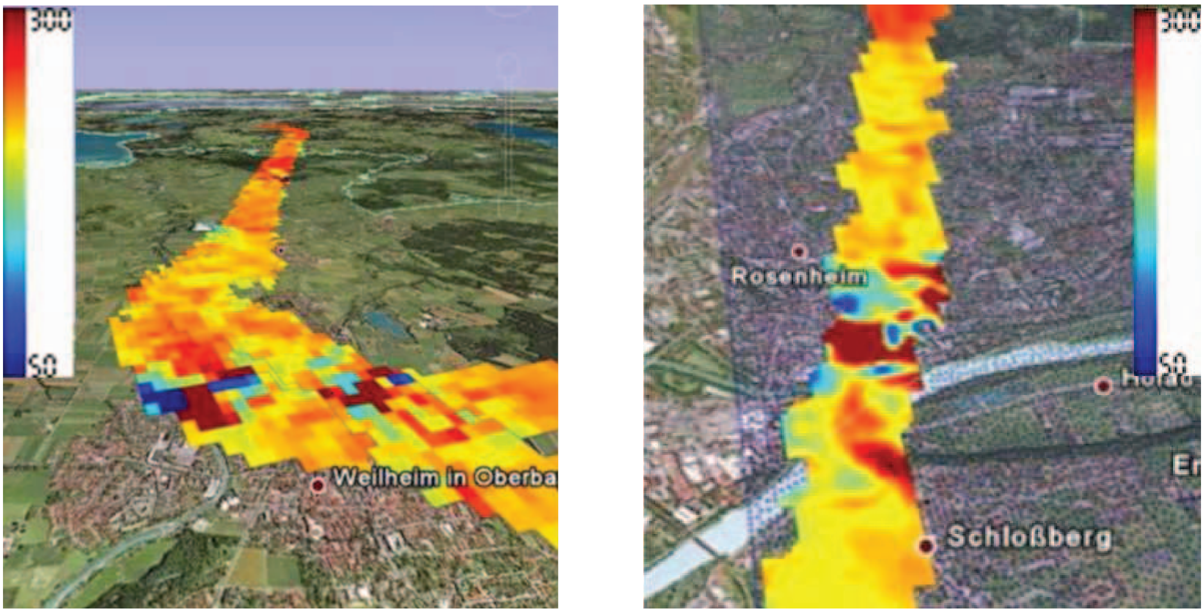

Fig. 1. Samples of HUT-2D measurements over urban area near the test sites in the Upper Danube Catchment area in 2008 (background: Google© map; brightness temperature scale: 50 to 300 K). RFI shows up as exceedingly high brightness temperatures.

3. CONCLUSIONS

We have collected airborne interferometric radiometer data on RFI in 2007-2008 in Finland, Central Europe and Southern Europe. A database allowing detailed analysis of RFI effects has been established. Two basic categories have been observed: weak point-wise sources (having very likely no effect on SMOS data) and strong sources saturating HUT-2D radiometer data over large areas (possibly having effects on SMOS data). We will collect more RFI data in the spring of 2010 during the ESA SMOS cal/val airborne campaign in Denmark and Central Europe. Analysis of the whole data set will be continued and a detailed discussion on the topic will be presented at IGARSS'10.

4. REFERENCES

[1] A. Camps, I. Corbella, F. Torres, J. Bara, and J. Capdevila, "RF interference analysis in aperture synthesis interferometric radiometers: Application to L-band MIRAS instrument," *IEEE Trans. Geoscience Remote Sensing*, vol. 38, no. 2, pp. 942 – 950, March 2000.

[2] D.M. Le Vine, T.J. Jackson, and M. Haken, "Initial images of the synthetic aperture radiometer 2D-STAR," *IEEE Trans. Geoscience Remote Sensing*, vol. 45, no. 11, part 2, pp. 3623 – 3632, November 2007.