A Methodology to Determine Radio Frequency Interference in AMSR2 Observations

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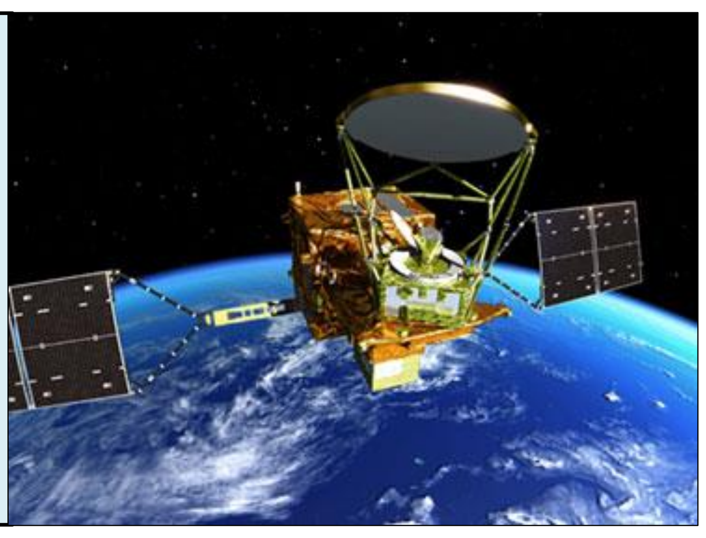


Introduction

The Advanced Microwave Scanning Radiometer – 2 (AMSR2) is a passive microwave radiometer onboard the Global Change Observation Mission 1st – Water (GCOM-W1). The sensor was developed by the Japanese Aerospace Exploration Agency (JAXA) and launched in May 2012. The AMSR2 is the successor of the succesful Advanced Microwave Scanning Radiometer – Earth Observing System (AMSR-E). AMSR-E observations provided valuable information for hydrological and climate research for years, but was switched off in October 2011 due to antenna rotation problems. The AMSR2 and AMSR-E are both multi-channeled sensors, with the lowest frequency (6.9 GHz) in the C-band range. Previous studies have shown the existence of radio frequency interference (RFI) in AMSR-E data due to man-made emissions, whereby the 6.9 GHz channel is mainly contaminated (Li et al., 2004, Njoku et al., 2005, and Ying et al. 2011). Since scientist use C-band frequency observations for the retrieval of soil moisture products, it is essential to detect RFI properly. In this study, the additional 7.3 GHz channel of the AMSR2 sensor is used for a new RFI detection method. A decision tree approach is set up that selects reliable brightness temperature observations in the lowest frequency free of any man-made contamination.

The Spectral Difference Method

Former studies used a spectral difference method, developed by Li et al. (2004), to detect RFI sources in AMSR-E observations and quantify its intensity (Equation 1):

RI6.9p=TB6.9p-TB10.7p (Eq. 1)

RI: RFI Index
p: Polarization (horizontal or vertical)
TB: Brightness Temperature

Intervals were classified as follows:
1) -5 K < RI < 5 K: **weak** RFI or RFI-**free**
2) 5 K < RI < 10 K: **moderate** RFI
3) RI > 10 K: **strong** RFI.

The method was applied to AMSR2 brightness temperature obervations from September 2012 – August 2013, whereby the RI of 7.3 GHz was measured similarly. In Fig. 1, pixels with moderate (purple) and strong (red) RFI are shown.

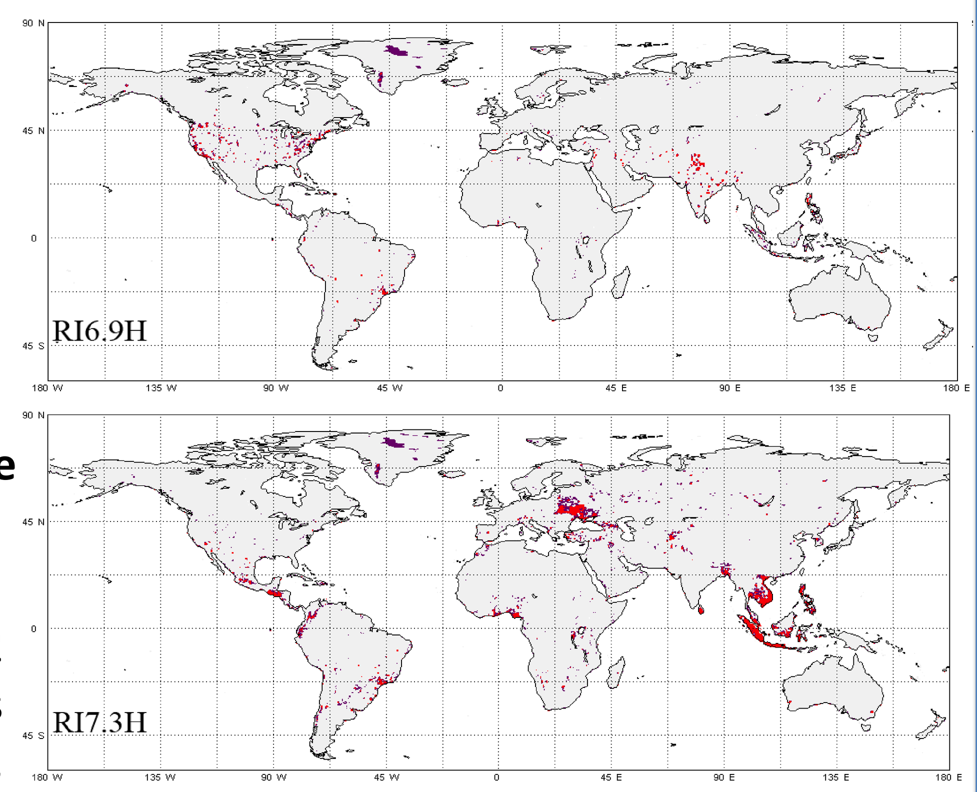


Figure 1: RI of 6.9 and 7.3 GHz. Strong (red) and moderate (purple) RFI contamination in AMSR2 brightness temperature observations according the spectral difference method. (Horizontal polarization, descending-pass observations).

This method works well to detect strong and moderate RFI. However, weak RFI signals are very difficult to distinguish from natural emissions and the method often fails in extreme environments such as snow-covered or desert regions.

Time Series of Single Pixels

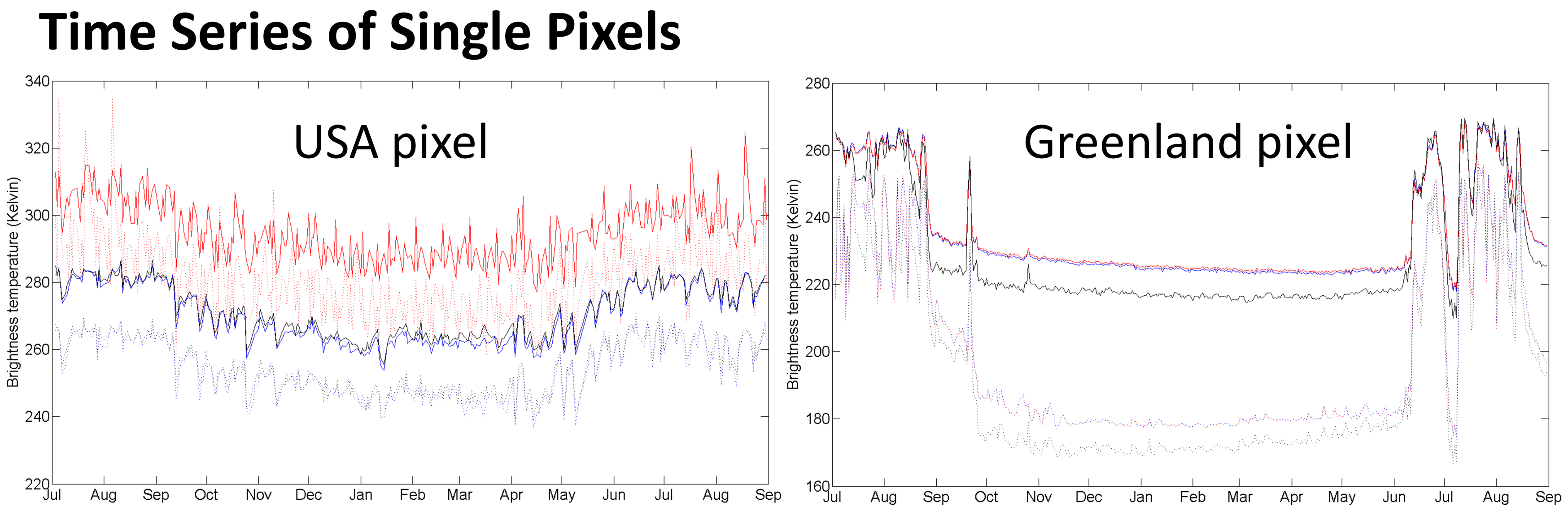


Figure 2: Time series of a pixel in the USA (left) and Greenland (right) for horizontal (dotted) and vertical polarization (solid) brightness temperature observations at 6.9 (red), 7.3 (blue), and 10.7 (black) GHz. Time period: July 2012 – August 2013.

- Patterns and values of 6.9 GHz are totally different from 7.3 and 10.7 GHz observations.
- Due to the offset of 6.9 GHz, the spectral difference method would truly denote this pixels as contaminated at 6.9 GHz.

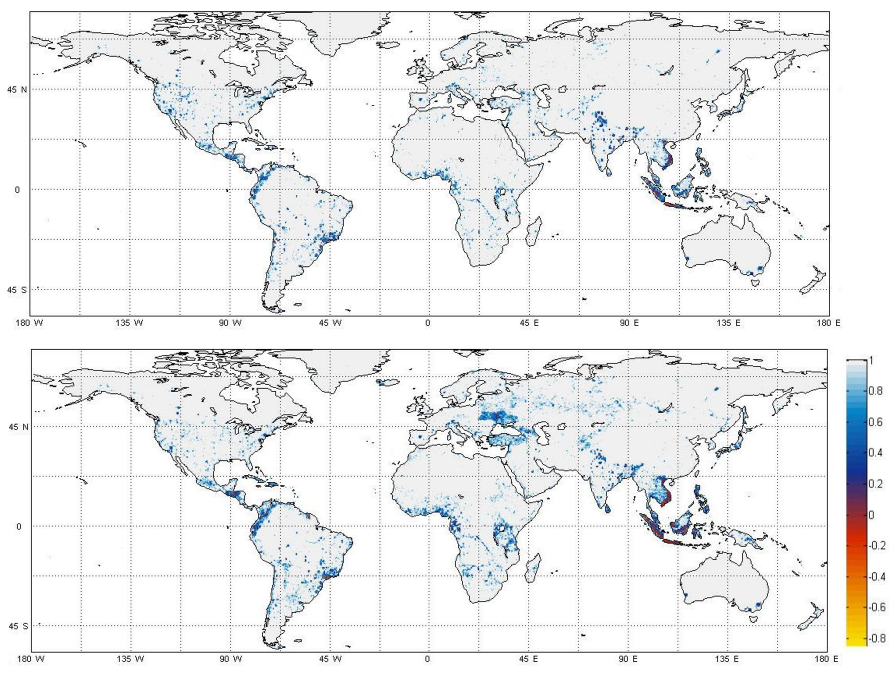
- Patterns of 6.9, 7.3, and 10.7 GHz are similar, values are not (offset of 10.7 GHz).
- The spectral difference method would erroneously denote this pixel as contaminated at 6.9 and 7.3 GHz.

Look at the correlation coefficients

Frequency channels	USA pixel	Greenland pixel
6.9H – 7.3H	0.70	1.00
6.9V – 7.3V	0.82	1.00
6.9H – 10.7H	0.62	0.99
6.9V – 10.7V	0.83	0.99
7.3H – 10.7H	0.97	0.99
7.3V – 10.7V	0.99	0.99

If we assume that RFI signals cause noisy and deviating patterns of brightness temperatures through time and natural influences affect only absolute values, RFI sources can be detected by the correlation of time series of two frequency channels.

Global Correlation Coefficient Maps



- Natural emissions are of minor influence on the correlation of 6.9 – 7.3 GHz.
- Pixels with a low correlation are contaminated by RFI in 6.9, 7.3 GHz or in both frequencies.
- Correlations between 6.9 – 10.7, 7.3 – 10.7, and 10.7 – 18.7 GHz are somewhat more influenced by natural emissions.

Figure 3: Correlation Coefficients between 6.9 and 7.3 GHz for horizontal (upper) and vertical (lower) polarization brightness temperature observations. Time period: 1 September 2013 – 31 August 2013, descending-pass measurements.

RFI Detection in 6.9 and 7.3 GHz Observations

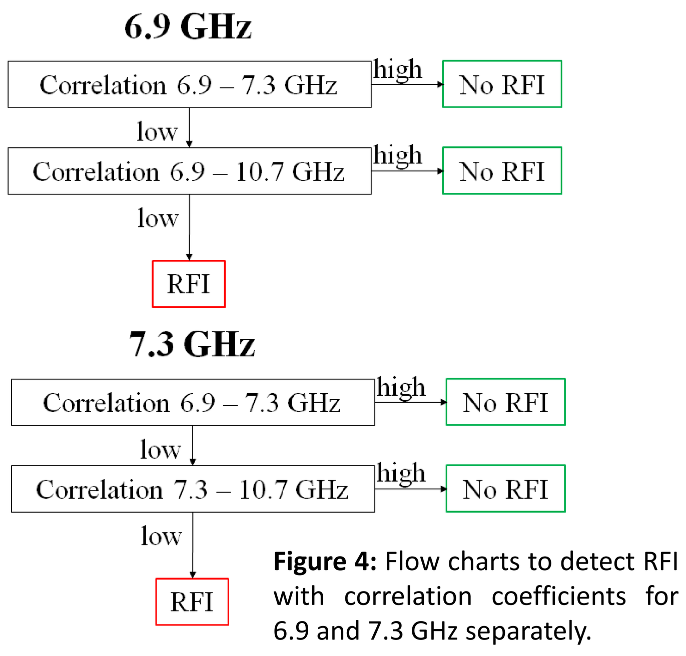


Figure 4: Flow charts to detect RFI with correlation coefficients for 6.9 and 7.3 GHz separately.

RFI in 6.9 and 7.3 GHz can be detected as shown in Fig. 4. This approach needs a minimum satellite time record of 6 months to become statistically valid. The method is sensitive for the threshold value that is being used to distinguish between pixels with RFI (low) and no RFI (high), as is shown in Fig. 4 with different colors. Correlation coefficients between 6.9, 7.3 and 10.7 are somewhat more vulnerable for natural influences. Therefore, the threshold value of the second step should not be too high in order to prevent false RFI-contaminated areas.

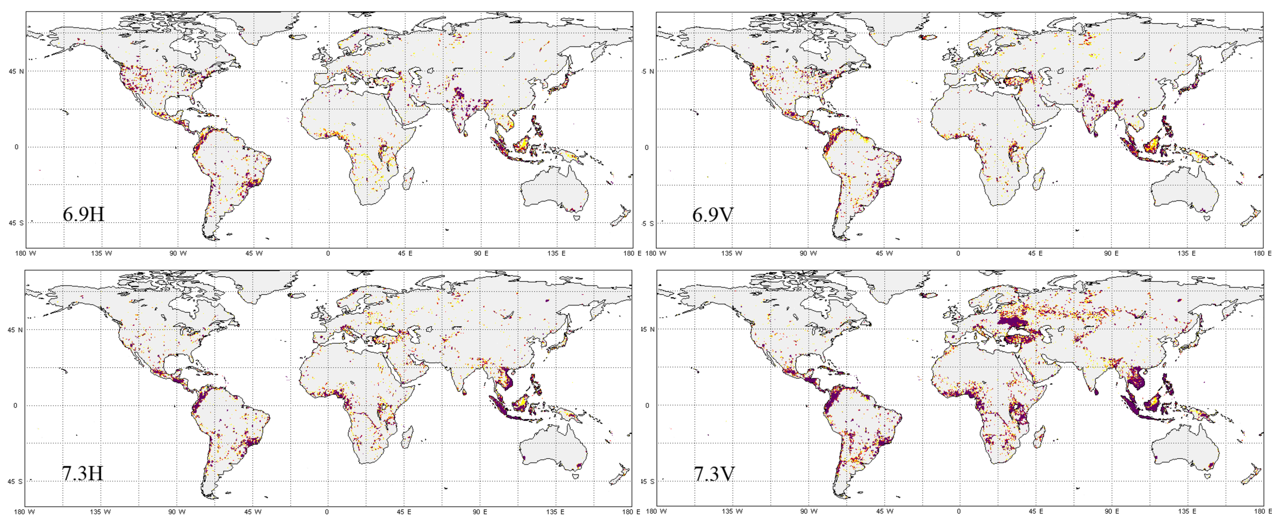


Figure 5: RFI contamination at 6.9 and 7.3 GHz in horizontal (H) and vertical (V) polarization when a threshold value of 0.93 is applied. Purple: pixels with a correlation below 0.90; red: 0.90 – 0.93; yellow: 0.93 – 0.96. Time record: September 2012 – August 2013.

Application for Soil Moisture Studies: Decision Tree Approach

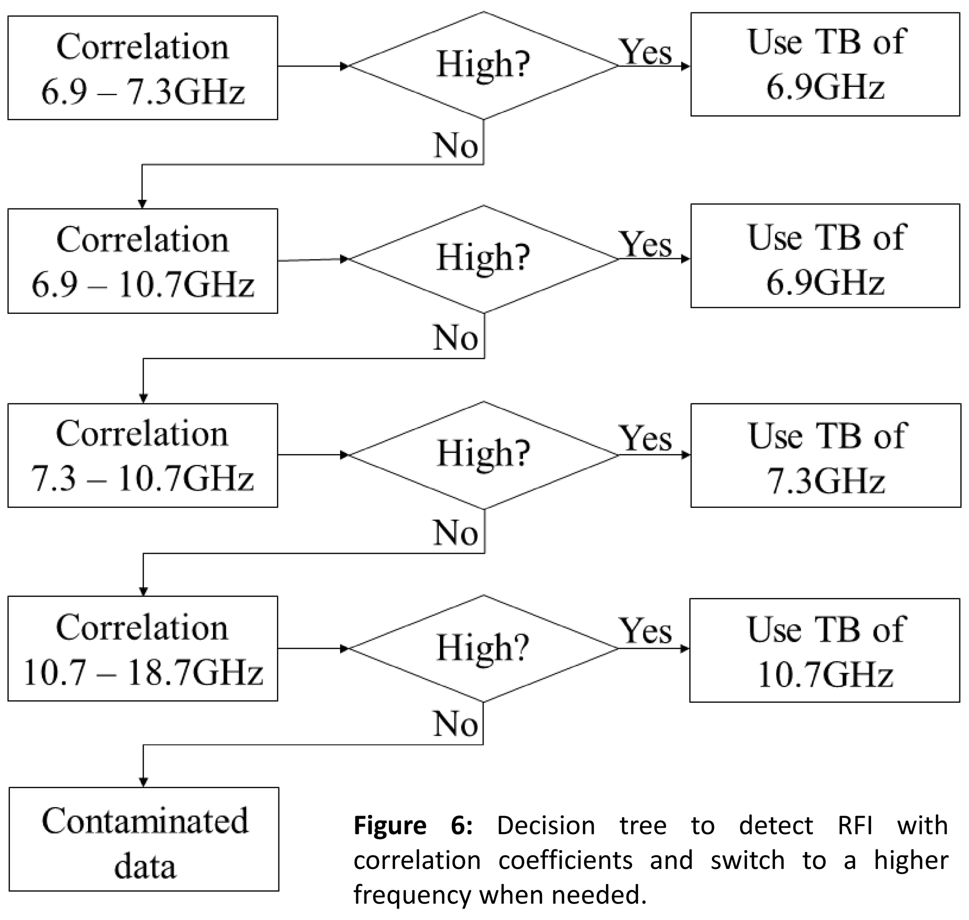


Figure 6: Decision tree to detect RFI with correlation coefficients and switch to a higher frequency when needed.

A decision tree is set up in order to provide brightness temperatures in the lowest frequency free of any man-made emissions (Fig. 6) and decides whether 6.9, 7.3, or 10.7 GHz observations should be used. Some contaminated pixels with RFI at 6.9 and 7.3 GHz can be replaced by 10.7 GHz observations in case of a high correlation between 10.7 and 18.7 GHz. An example of an output is given in Fig. 7. This demonstrates the added value of additional low frequency channels, because the total contaminated areas in the 6.9 GHz channel were reduced by 60% when 7.3 and 10.7 GHz were used for a time record of one year.

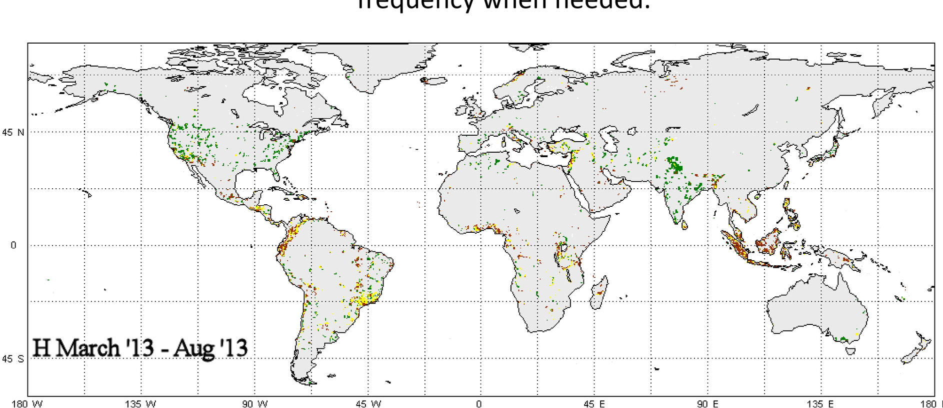


Figure 7: Output of the decision tree for the time record March 2013 – August 2013 (horizontal polarization). Grey: use 6.9 GHz observations; green: use 7.3 GHz, yellow: use 10.7 GHz, brown: 'contaminated data'.

A case-study: USA street map

Since RFI is caused by man-made emissions, sources are expected to be located in urbanized areas. This was tested by linking RFI maps with a USA street map (Fig. 8). Purple pixels are contaminated at 6.9 GHz, the red pixels at 7.3 GHz. RFI coincides indeed mainly with urbanized areas, because RFI pixels overlay mainly cities and roads.

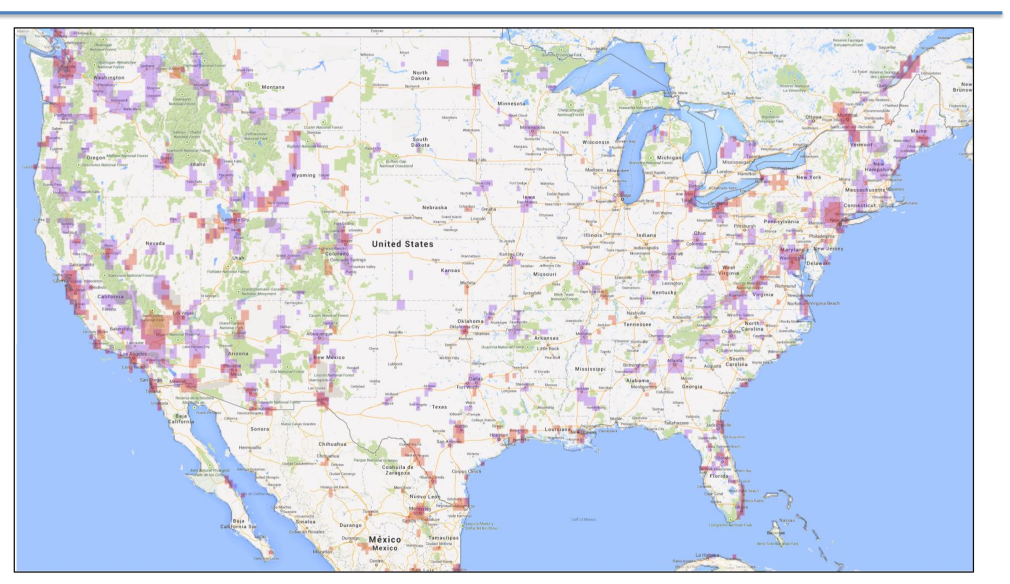


Figure 8: Street map of the USA. Purple pixels indicate areas with RFI at 6.9 GHz, red pixels indicate contaminated areas at 7.3 GHz (for the period 1 September 2012 – 31 August 2013 in horizontal polarization and descending-pass observations).

- **A simple correlation method is developed to determine RFI in 6.9 and 7.3 GHz.**
- **The correlation method does not produce false RFI pixels over natural surfaces as seen in the spectral difference method.**
- **For soil moisture retrieval, 60% of the contaminated data in 6.9 GHz can be reduced by using 7.3 and 10.7 GHz frequencies.**

soil moisture cci earth2Observe VU VRIJE UNIVERSITEIT AMSTERDAM

This poster is based on:
de Nijs et al., A methodology to determine radio frequency interference in AMSR2 observations, in preparation.

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