A Study of RFI in the WindSat C- and X-Band Channels

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Introduction

• AMSR-E C- & X-band data already known to be plagued by RFI (Li et al. [2004], *IEEE T. GRS*, 42, 380). For AMSR-E:
  – 6.925 GHz: $\Delta\nu = 350$ MHz, $\tau = 2.6$ ms, IFOV = 43 x 75 km
  – 10.65 GHz: $\Delta\nu = 100$ MHz, $\tau = 2.6$ ms, IFOV = 27 x 48 km

• So what does WindSat see? For WindSat:
  – 6.8 GHz: $\Delta\nu = 125$ MHz, $\tau = 5.0$ ms, IFOV = 40 x 60 km (V/H)
  – 10.7 GHz: $\Delta\nu = 300$ MHz, $\tau = 3.5$ ms, IFOV = 25 x 38 km (V/H/U/4)

• 6 months of WindSat Data (October 2003 – February 2004) has been analyzed from an RFI perspective

• Some differences from analysis of Li et al. (2004):
  – Somewhat different center frequencies / bandwidths (In effect, sampling lower third of AMSR-E C-Band channel)
  – X-band correlation channels
Analysis Method

- Data gridded with spacing \(~\frac{1}{2}\) beamwidth at C-band

- Every point observed at least 500 times over 6 month duration
  - About 3/day on average
6.8 GHz $T_B$ Statistics: V & H

$T_B [K]$:

- 100
- 150
- 200
- 250
- 300
- 350

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10.7 GHz $T_B$ Statistics: V & H

- 10.7 GHz V Max Hold
- 10.7 GHz H Max Hold
- 10.7 GHz V Mean
- 10.7 GHz H Mean

$T_B$ [K]: 100 150 200 250 300

Ohio State University
Virginia Tech
10.7 GHz Statistics: U & 4

10.7 GHz |U| Max Hold

10.7 GHz |4| Max Hold

10.7 GHz |U| Mean

10.7 GHz |4| Mean

T [K]:

0.5  1  1.6  2  2.6  3  3.5  4  4.6
Some X-Band Sources Exhibit Directivity

10.7 GHz $|U|$ Max Hold
(Northern California)

Scatter Plot of $|U|$ vs. Azimuth (CAA)
“Big” RFI at 6.8 GHz

- “Excess Brightness Event” (EBE) defined as $T_B > 330K$ (thus, not geophysical in origin)
- About 1% of all locations exhibit EBEs ever
- About 0.01% of all locations exhibit EBEs most of the time

\[ \text{“O” = V pol, 6.8 GHz} \]
\[ \text{“x” = H pol., 6.8 GHz} \]
6.8 GHz EBE Statistics (V & H)
Is 6.8 GHz RFI Associated with Ground Transportation?
“Spectral Index” \( T_B, 6.8 \text{ GHz} - T_B, 10.7 \text{ GHz} \)

- This index is nominally < 5 K (typically, negative) for the geophysical signal
- Values > 5K indicate RFI
- May be a more sensitive test for RFI than absolute \( T_B \)’s
“Polarization Index”

6.8 GHz: \( \frac{T_{B, H} - T_{B, V}}{T_{B, H} + T_{B, V}} \)
Max Hold over 6 Months
Concluding Remarks (1)

• Findings:
  – Much RFI visible in 6.8 GHz V&H. Weak correlation with population density & ground transportation corridors. Much of it is persistent.
  – Much RFI visible in 10.7 GHz correlation channels; apparently with similar spatial/temporal characteristics.
  – 6.8 GHz RFI shows tendency to be horizontally-polarized
  – Some 10.7 GHz RFI observed to be azimuthally-directional
  – RFI in US is dramatically worse than Canada or Mexico; Nothing significant seen in Atlantic or Pacific.
  – Because data are incoherent & temporally sparse, difficult to satisfactorily characterize RFI sources and mitigation techniques (but: CISR)
Concluding Remarks (2)

- **Possible Post-Observation Mitigation Schemes:**
  - Use absolute brightness temperature as a detection metric (not very sensitive)
  - Use spectral index (between bands) as a detection metric
  - Use polarization index within band as a detection metric
  - Use X-Band correlation channels as detection metric
  - Hybrid schemes?

- **Current Work:**
  - Sources will need to be intermittent for simple RFI excision schemes to useful – seems to be the case but this needs to be better understood
  - Test efficacy of various mitigation schemes
  - Characterization & mitigation with higher time/frequency resolution (CISR)
C-Band Interference Suppressing Radiometer (CISR)

- OSU + NOAA + Virginia Tech project with NPOESS support
- OSU’s FPGA-based Digital Receiver as a PSR backend
- $\nu = 5.5-7.7$ GHz, $\Delta \nu = 100$ MHz, Multiple modes: Coherent sampling, FFT spectroscopy, Max hold/averaging, Blanking, …
- Initial results available (see Johnson et al., IGARSS 04), analysis continues…
Spatial PDFs of Mean $T_B$ (V & H)

- No obvious RFI in these PDFs
Mid-Atlantic Plume Event

- Appears in just 5 minutes of data around 0400 UT 09 Feb 2004.

- Possible causes:
  - Severe weather? (Still, astoundingly bright at 6.8 GHz)
  - Blinded by Sun?
  - Blinded by strong RFI (not necessarily in band or in beam)?
  - Instrument / processing glitch?