Improved Calibration through SMAP RFI Change Detection

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Outline

• SMAP Error Budget
• How SMAP RFI Detection and Filtering Works
• Error Performance in Lab Environment
• Motivation
• Control Charting for Process Monitoring
• RFI Statistics
• Case #1: Kerrville, TX
• Case #2: Europe
• What’s next?
Radiometer Hardware and Algorithm Have Error Budget (Margin When RFI Mitigation Succeeds)

<table>
<thead>
<tr>
<th>Error Term</th>
<th>Current Best Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multi-look averaged TB</td>
<td></td>
</tr>
<tr>
<td>Antenna Pattern Correction – Instrument component</td>
<td>0.40 K</td>
</tr>
<tr>
<td>Antenna Pattern Correction – Algorithm component</td>
<td>0.40 K</td>
</tr>
<tr>
<td>NEAT</td>
<td>0.45 K</td>
</tr>
<tr>
<td>Antenna Temperature Calibration</td>
<td>0.44 K</td>
</tr>
<tr>
<td>RFI</td>
<td>0.23 K</td>
</tr>
<tr>
<td>Long Term Drift</td>
<td>0.2 K</td>
</tr>
<tr>
<td>Atmospheric Correction</td>
<td>0.04 K</td>
</tr>
<tr>
<td><strong>RSS Total</strong></td>
<td><strong>0.90 K</strong></td>
</tr>
<tr>
<td><strong>Requirement</strong></td>
<td><strong>1.3 K</strong></td>
</tr>
<tr>
<td>Margin (Unencumbered RSS)</td>
<td>0.93 K</td>
</tr>
<tr>
<td>Margin (Unencumbered Linear)</td>
<td>0.40 K</td>
</tr>
</tbody>
</table>

Single-look TB Performance
Assessed by Cal/Val Team for the Level 1B_TB product

<table>
<thead>
<tr>
<th>Metric</th>
<th>Allocation</th>
<th>Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ocean Model RMSD (incl. NEDT)</td>
<td>1.4 K</td>
<td>1.2 K</td>
</tr>
<tr>
<td>NEDT (land)</td>
<td>1.6 K</td>
<td>1.2 K</td>
</tr>
<tr>
<td>NEDT (ocean)</td>
<td>1.1 K</td>
<td>0.9 K</td>
</tr>
<tr>
<td>Monthly Drift</td>
<td>0.4 K</td>
<td>+0.1/-0.25</td>
</tr>
</tbody>
</table>
Locations where soil moisture has the greatest influence on precipitation. (Fig. 17 from *SMAP Decadal Survey Workshop Report* from Koster et al. (2004) *Science*)

Presence of ground radar RFI indicated by kurtosis measurements.
How SMAP RFI Detection and Filtering Works

Subband detection algorithms detect and flag RFI; also flag adjacent channels

Time domain detectors detect and flag RFI; MPD flags corresponding time slice in subband data

Drop all flagged data and average remaining clean pixels of subband data to get RFI free footprint, $T_A$
Error Performance in Lab Environment

Low-amplitude Narrowband RFI Lab Test Example

0.23-K mean bias From J. Johnson TVAC assessment report

Mohammed, et al.
Global Time-Averaged RFI
Average RFI Intensity Time Series Distributions

Pacific Ocean Sample

North America (Dew Line Radar)

UK

China

Italy

France

10/12/17
SUSMAP - Cambridge, MA
Time Series Skewness
Sticky RFI: Choose Your Flavor

Results in DoS

Low level

Residual

Courtesy A. Bringer, OSU
Control Charting for Process Monitoring

- Hypothesis: time series monitoring can reveal new sources or problematic sources that are not detected by current processes
- Borrow the classical “Shewhart X-bar and s Control Chart”
- +3/-1 standard deviations

Theoretical Basis for a Control Chart

- o out of control
- o process in control

Center Line

Upper Control Limit

Lower Control Limit

Time or Order of Production

Data Preparation

- 0.4-degree bins posted on 0.2 degree grid
- 8-day orbit cycle statistics computed in bin
- Mean, std, min, max of $T_A$, RFI intensity, NEDT
- September 2015 to August 2017

- Create geographic “control charts”
Case #1: Kerrville, TX
Case #2: Europe
What’s next?

• Current state:
  • Project/ST automate monitoring and geolocation tool

• SUSMAP Plan
  • Target low-level RFI: push the wall to the left
  • Binning of RFICAL file data
    • Kurtosis, spectrograms, detection flags
    • Data prior to application of filtering algorithms
  • Research feature vector composition
  • Research utility of classification using feature vectors
  • Test change detection using different norms

• What’s most important for SMAP L2/3 users?