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>NEΔT</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>

<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.
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

SUSMAI
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

\[ X \]

o out of control

Upper Control Limit

Center Line

Lower Control Limit

Time or Order of Production

• 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?