Soil Moisture Active Passive (SMAP) Microwave Radiometer Radio-Frequency Interference (RFI) Mitigation: Initial On-Orbit Results

SMAP CAL VAL WORKSHOP #6

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Outline

- L1B_TB RFI algorithms
- RFI Maps and Statistics
- Challenging RFI cases
Radiometer RFI Processing

- SMAP includes a digital backend to improve RFI detection and mitigation
- Digital backend enables a variety of detection algorithms
- RFI detection and filtering of TA performed by L1B processor; applied prior to APC, FR, and other corrections to get TB
- Setting algorithm parameters part of cal/val process
RFI Detection Algorithms

- Nine RFI detection algorithms used (thresholds selectable)
  1) Pulse detection fullband
  2) Kurtosis fullband
  3) T3 and 4) T4 fullband
  5) Cross frequency @ 9.6 msec resolution
  6) Kurtosis sub-band (spectrogram points)
  7) T3 and 8) T4 sub-band
  9) Cross frequency @ 1.2 msec resolution

- All algorithms have a detection threshold (Beta) that can vary spatially, for fore/aft looks, and for ascending and descending passes
- Using ‘two-sided’ detectors to avoid introducing calibration biases
- The RFI flag outputs from all the detectors are combined using a logical OR to produce a maximum probability of detection array
- The flagged data are excluded from the average of good time-frequency samples to produce RFI free footprints
- Subset of RFI detection/mitigation algorithms also applied to cal data before computing cal coefficients
- All running currently with global beta=3 except 3rd/4th Stokes detectors set to very high thresholds
L1B RFI processor

- TA computed by averaging over 8x16 spectrogram
- RFI detection algorithms can flag pixels out
- RFI info in qual flag:
  - bit 2: > 2 K RFI detected (info only)
  - bit 3: < 2 pixels left in spectrogram
  - bit 4: NEDT>2 K
  - bit 14: >100 K RFI detected
- NEDT after mitigation also output

Fullband detection algorithms operate at 4x finer time resolution; detection flags all channels of entire ~ 1.2 msec interval

MAXPD example
Peak Hold TA H-pol April 1 to 8

1° grid

TA H-pol (Kelvin)
Peak Hold TA filtered H-pol April 1 to 8

1° grid
Peak Hold TA H-pol April 1 to 8
Peak Hold TA H-pol May 1 to 8

1° grid

TA H-pol (Kelvin)
Peak Hold RFI H-pol (TA – TA filtered)

May 1 to 8, ASC/FORE RFI H-pol

1° grid

RFI H-pol (Kelvin)
Peak Hold RFI H-pol (TA – TA filtered)

May 1 to 8, ASC/AFT RFI H-pol

1° grid

RFI H-pol (Kelvin)
Peak Hold RFI H-pol (TA – TA filtered)

May 1 to 8, DESC/FORE RFI H-pol

1° grid

RFI H-pol (Kelvin)
Peak Hold RFI H-pol (TA – TA filtered)

May 1 to 8, DESC/AFT RFI H-pol

1° grid

RFI H-pol (Kelvin)
Fullband Kurtosis May 1 to 8

Kurtosis excess = Kurtosis – 3

Plot shows peak hold data

Indicator of short pulsed sources

1° grid
Fullband Kurtosis May 1 to 8

Kurtosis excess = 3 – Kurtosis

Plot shows min of data

Indicator of longer pulsed or continuous wave sources

1° grid
SB MAXPD Detection Rate

FAR ~ 5.5%

1° grid

Detection Rate (%)

Time domain threshold = 5 at coastlines
Summary Ta_H Statistics

- 5/1-5/26/15, Global data

RFI Detection Algorithms and Quality Checks Clearly Eliminate Large RFI

~1% of Samples Have RFI >30K detected
NEDT and Fraction of Spectrogram Blanked Stats

- 5/1-5/26/15, H pol

- ~2% of data flagged for too high NEDT or NEDT not computable
- ~2% of data flagged for RFI overall (not including ‘out of range’ flag applied at TB level)
TA unfiltered Europe

Max H-pol Ta (K) CRID:11580_001

0.25° grid
TA filtered Europe

Max H-pol Ta filtered (K) CRID:11580_001

0.25° grid
Discarding measurements flagged by TB quality flag, residual RFI appear to still be in product.
TA unfiltered Asia

Max H-pol Ta (K) CRID:11580_001

0.25° grid
TA filtered Asia

Max H-pol Ta filtered (K) CRID:11580_001

0.25° grid
Discarding measurements flagged by TB quality flag, residual RFI appear to still be in product
Example Japan Frequency Spectrum

RFI at both band edges

Cross-freq detector catches this due to non-uniform spectrum shape

“Two-sided” detector problematic here
Conclusions

• RFI detection and filtering working well in general, but some cases remain challenging
• For beta release of data, all thresholds for all detectors except the time domain are uniform over the globe
  – The time domain thresholds for the beta product were changed to be higher along the coastlines to reduce FAR in those areas
• ‘Wideband continuous’ RFI is not detected by pulse, kurtosis, or cross frequency methods
  – Can occur at modest power levels that are not obvious
  – Can occupy majority of SMAP’s spectrum, not possible to recover Earth TB in these situations
  – At least need to make sure that algorithms are flagging these data out from further science processing