

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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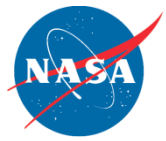
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(2) Morgan State University

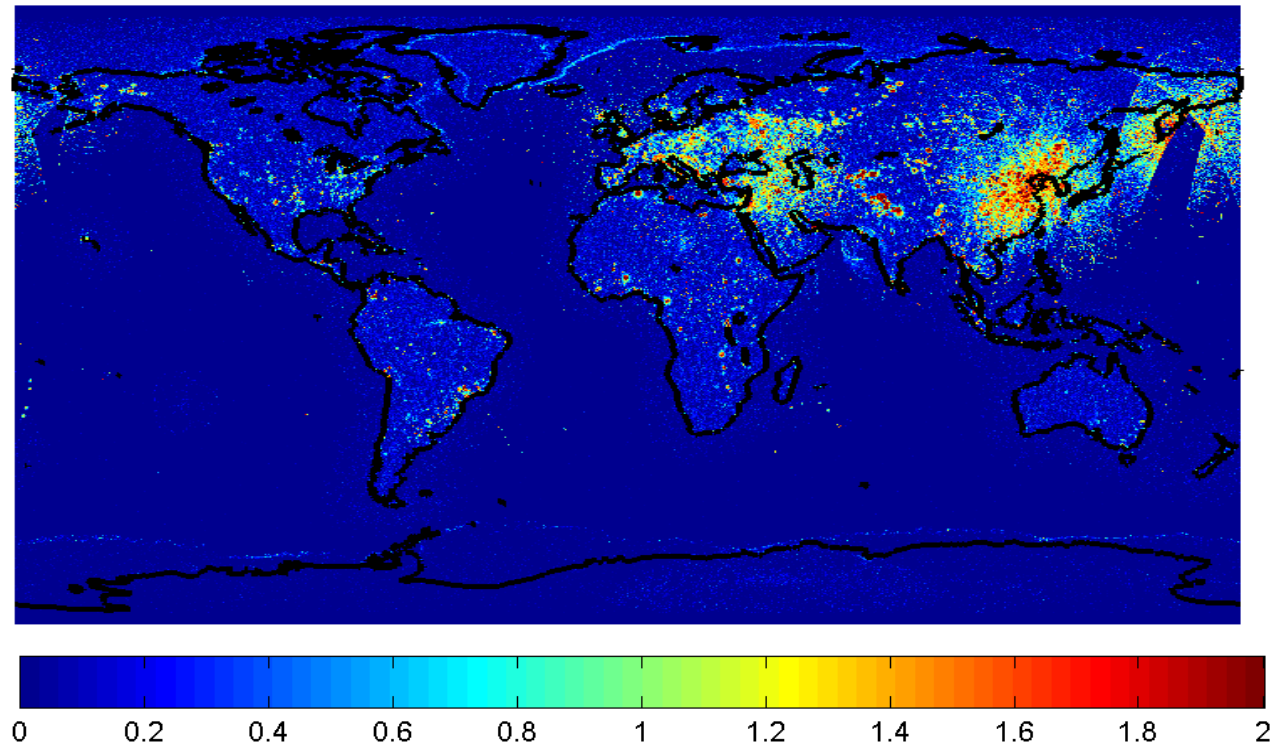
(3) The Ohio State University

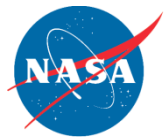


Radiometer RFI Processing

- 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

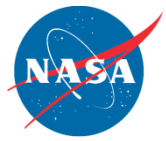
Max-Hold Log₁₀(H pol RFI) 5/1-5/8





RFI Detection Algorithms

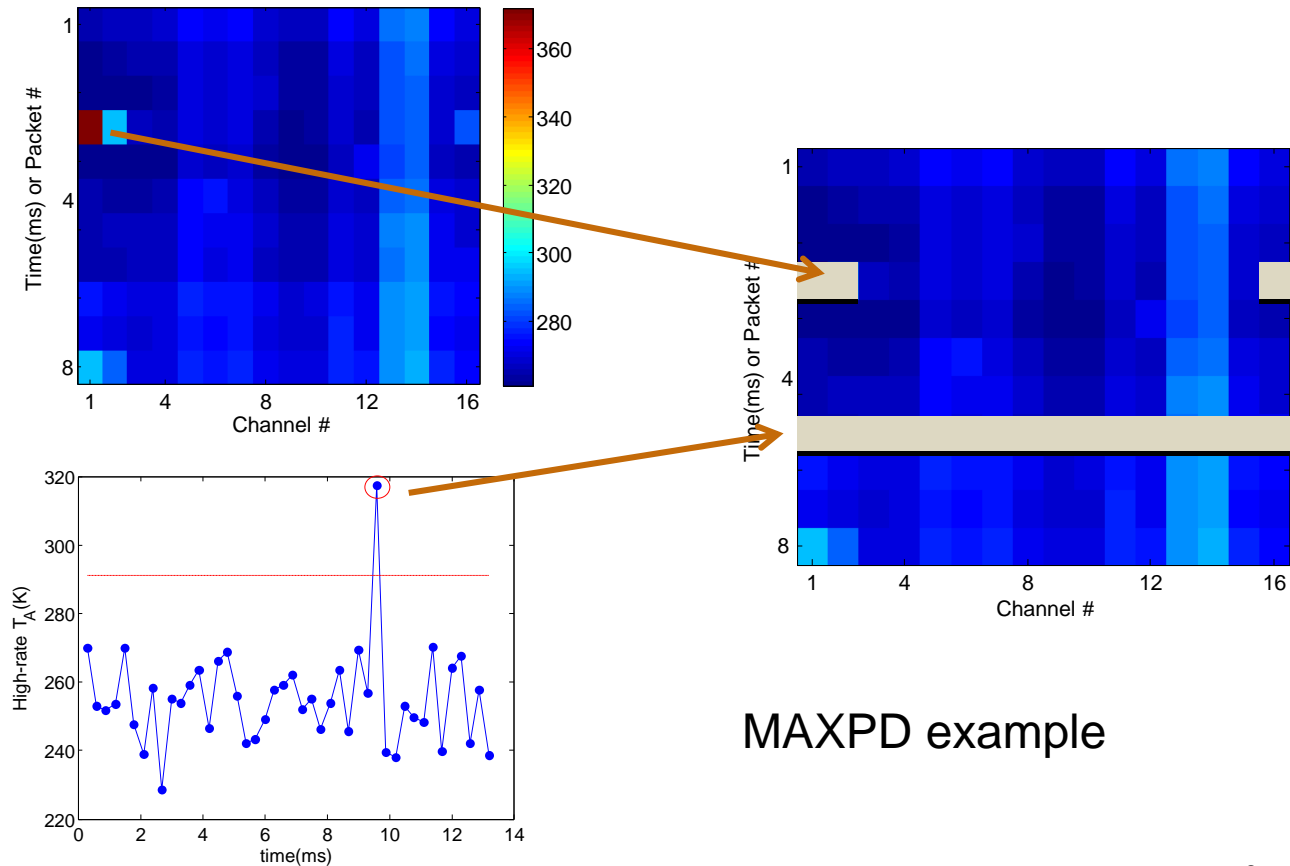
- Nine RFI detection algorithms used (thresholds selectable)
 - 1) Pulse detection fullband
 - 2) Kurtosis fullband
 - 3) T3 and 4) T4 fullband
 - 5) Cross frequency @ 9.6 msec resolution
 - 6) Kurtosis sub-band (spectrogram points)
 - 7) T3 and 8) T4 sub-band
 - 9) Cross frequency @ 1.2 msec resolution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



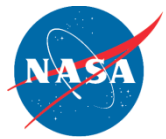
L1B RFI processor

- 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

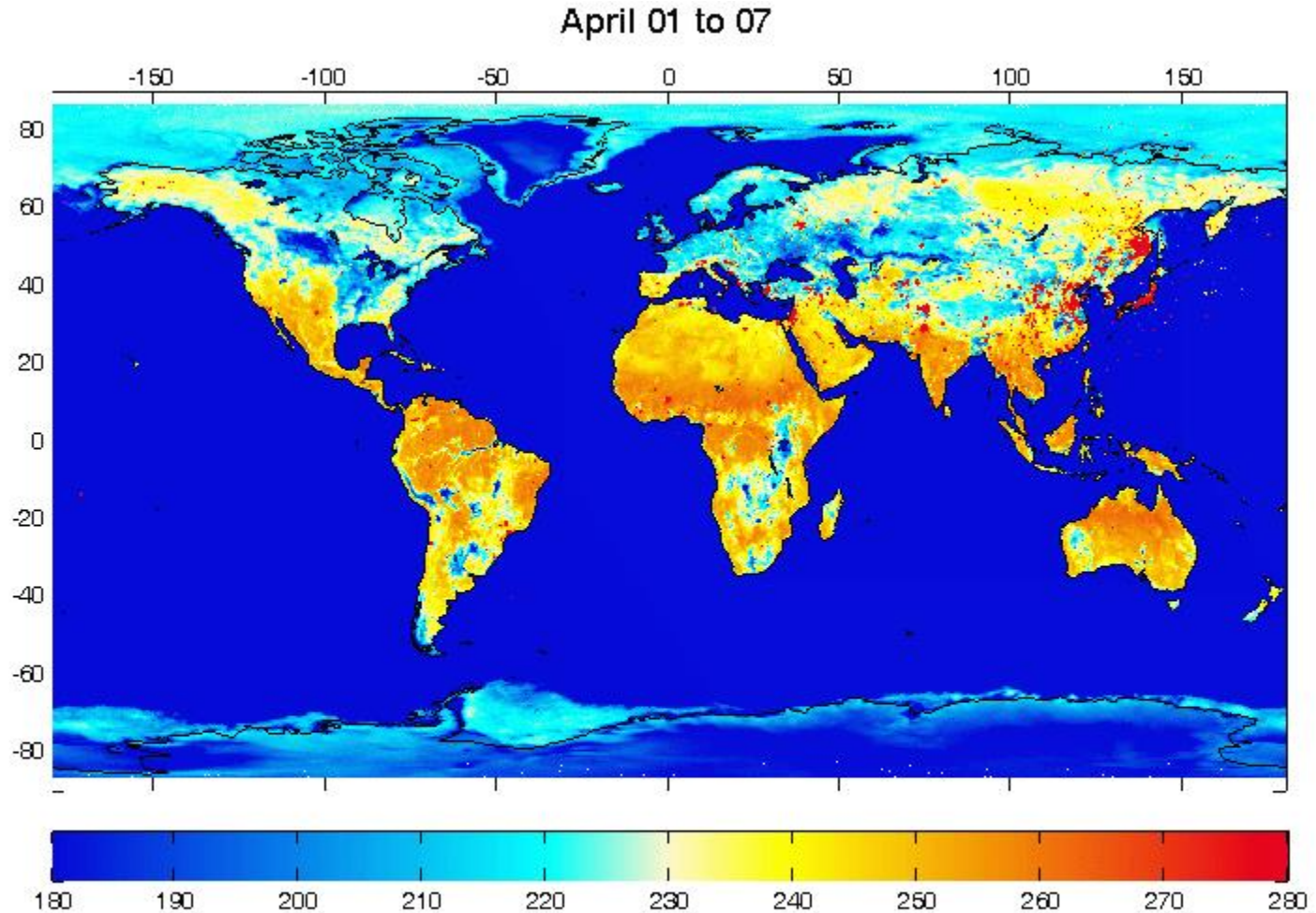
Fullband detection algorithms operate at 4x finer time resolution; detection flags all channels of entire ~ 1.2 msec interval

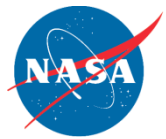


MAXPD example

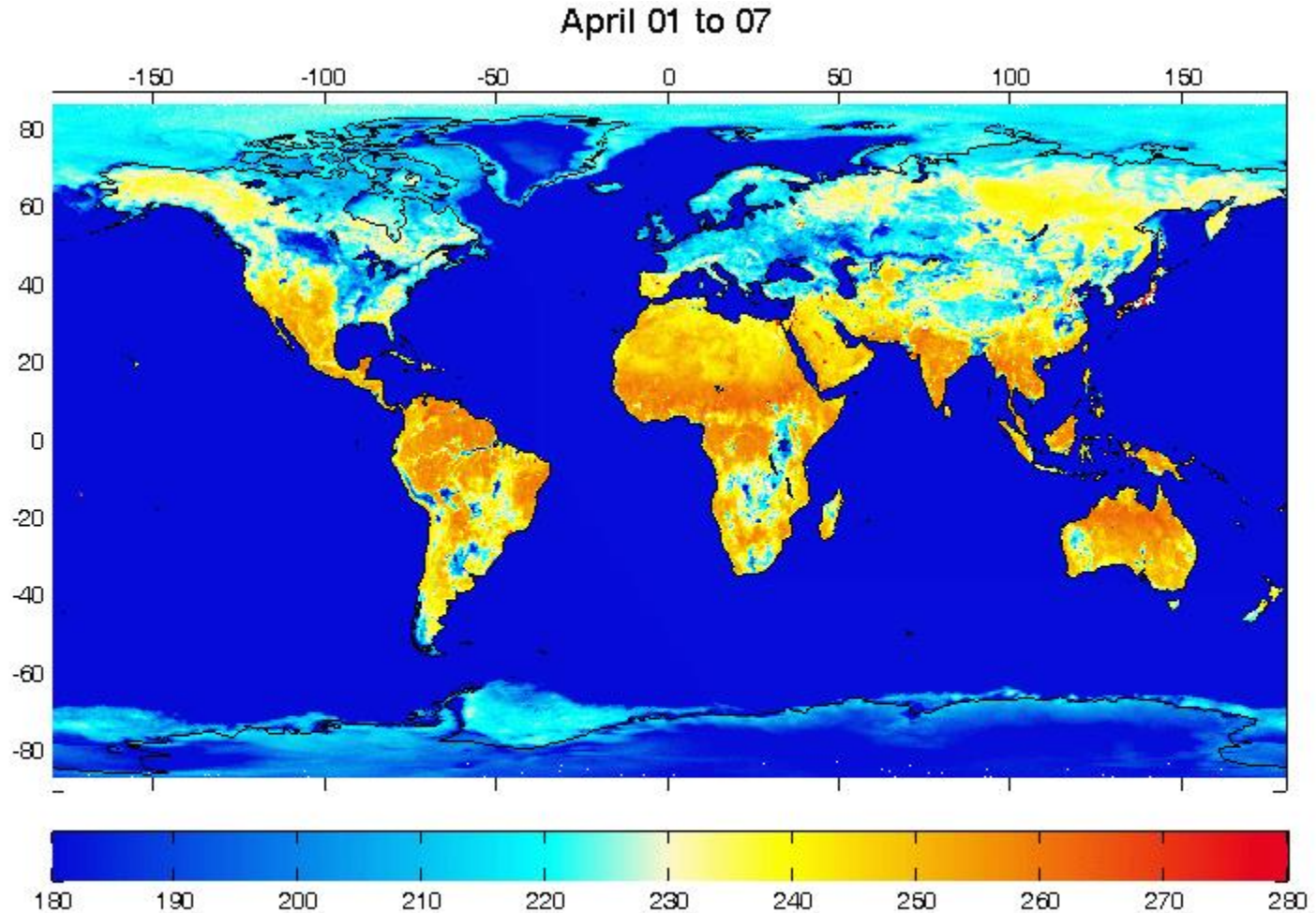


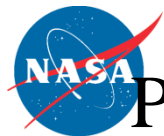
Peak Hold TA H-pol R11850_001



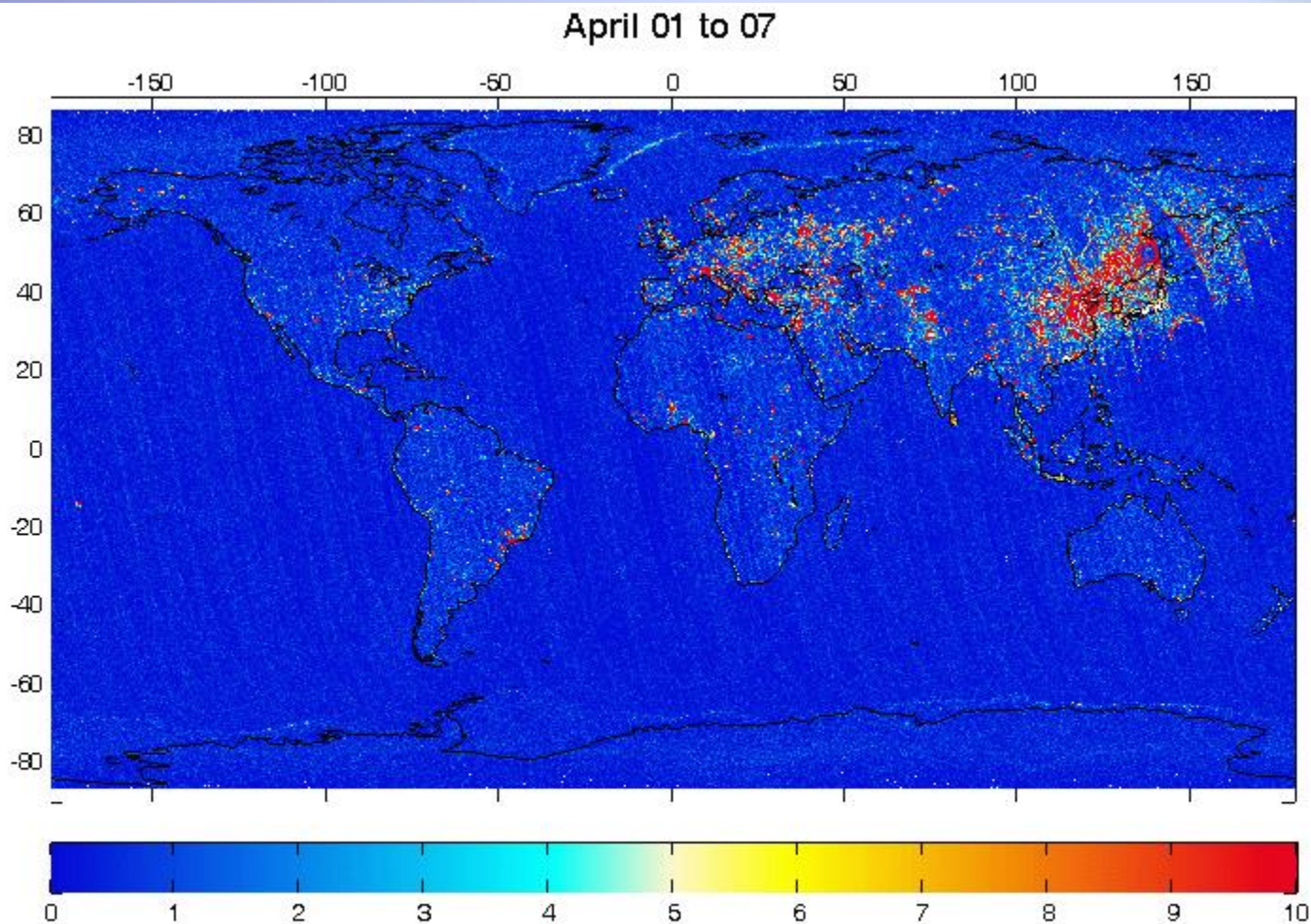


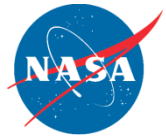
Peak Hold TA filtered R11850_001





Peak Hold RFI H-pol (TA – TA filtered) R11850_001



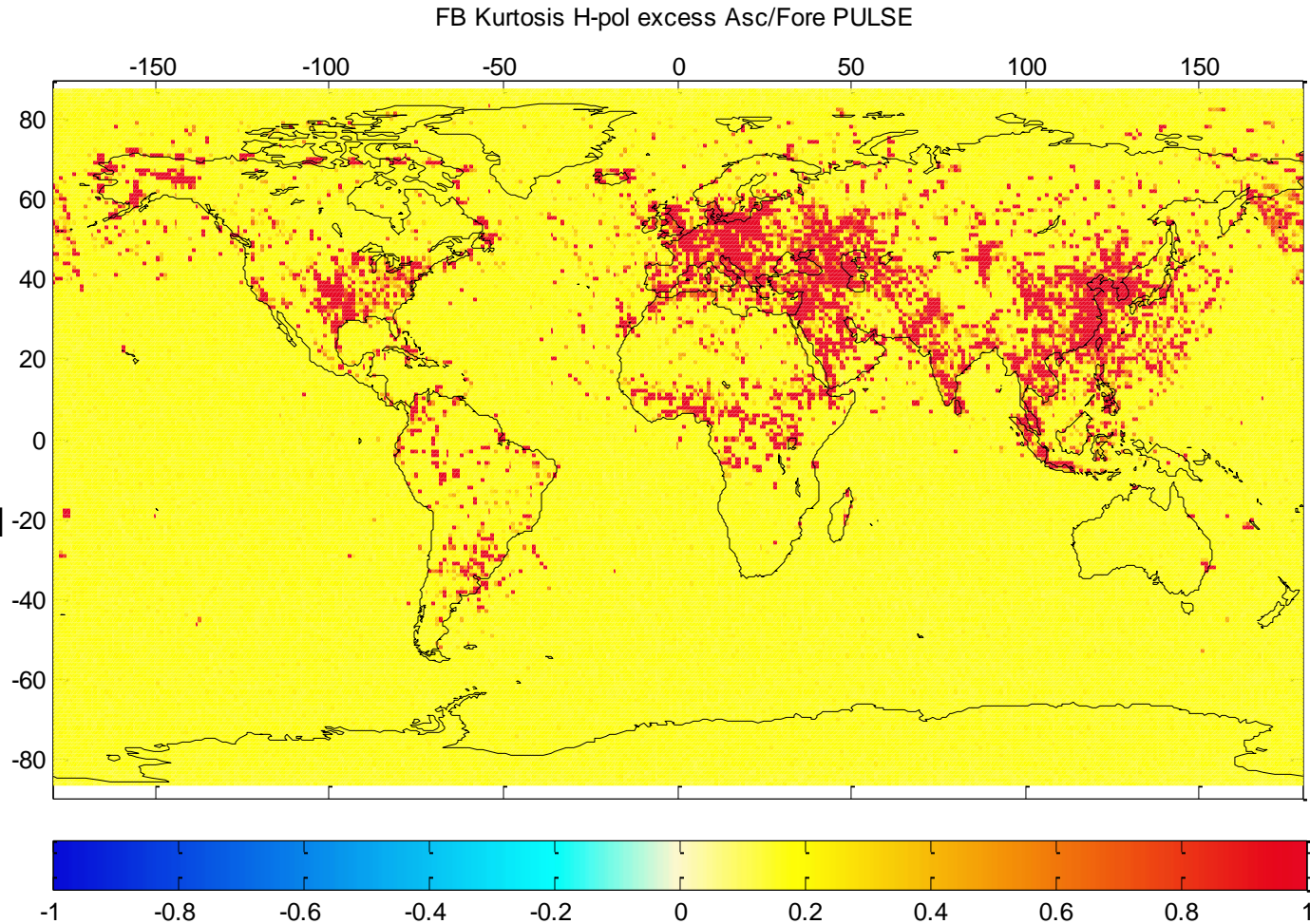


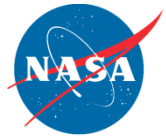
Fullband Kurtosis May 1 to 8

Kurtosis
excess =
 $\text{Kurtosis} - 3$

Plot shows
peak hold
data

Indicator of
short pulsed
sources



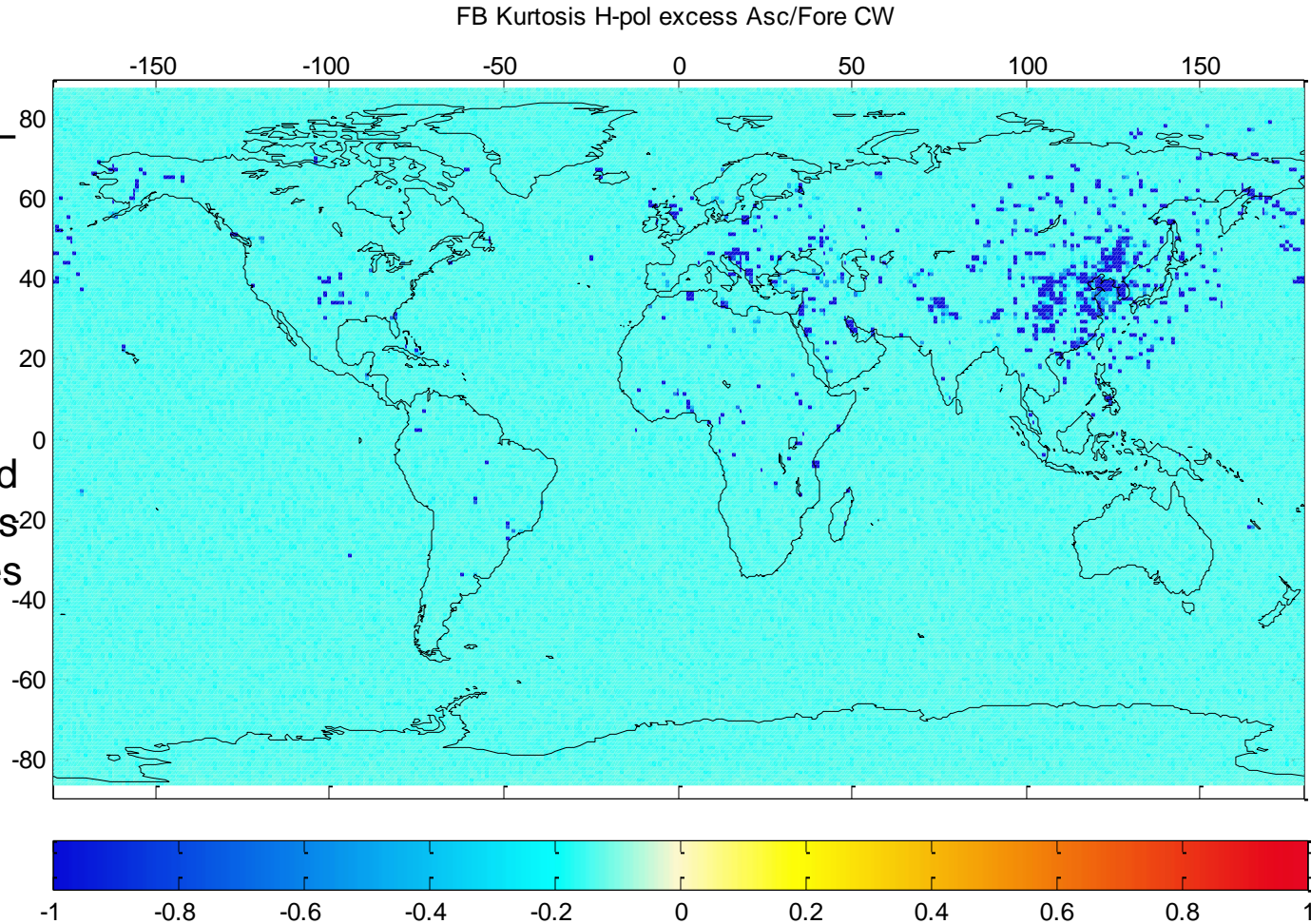


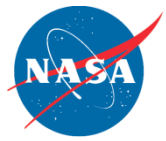
Fullband Kurtosis May 1 to 8

Kurtosis
excess = 3 -
Kurtosis

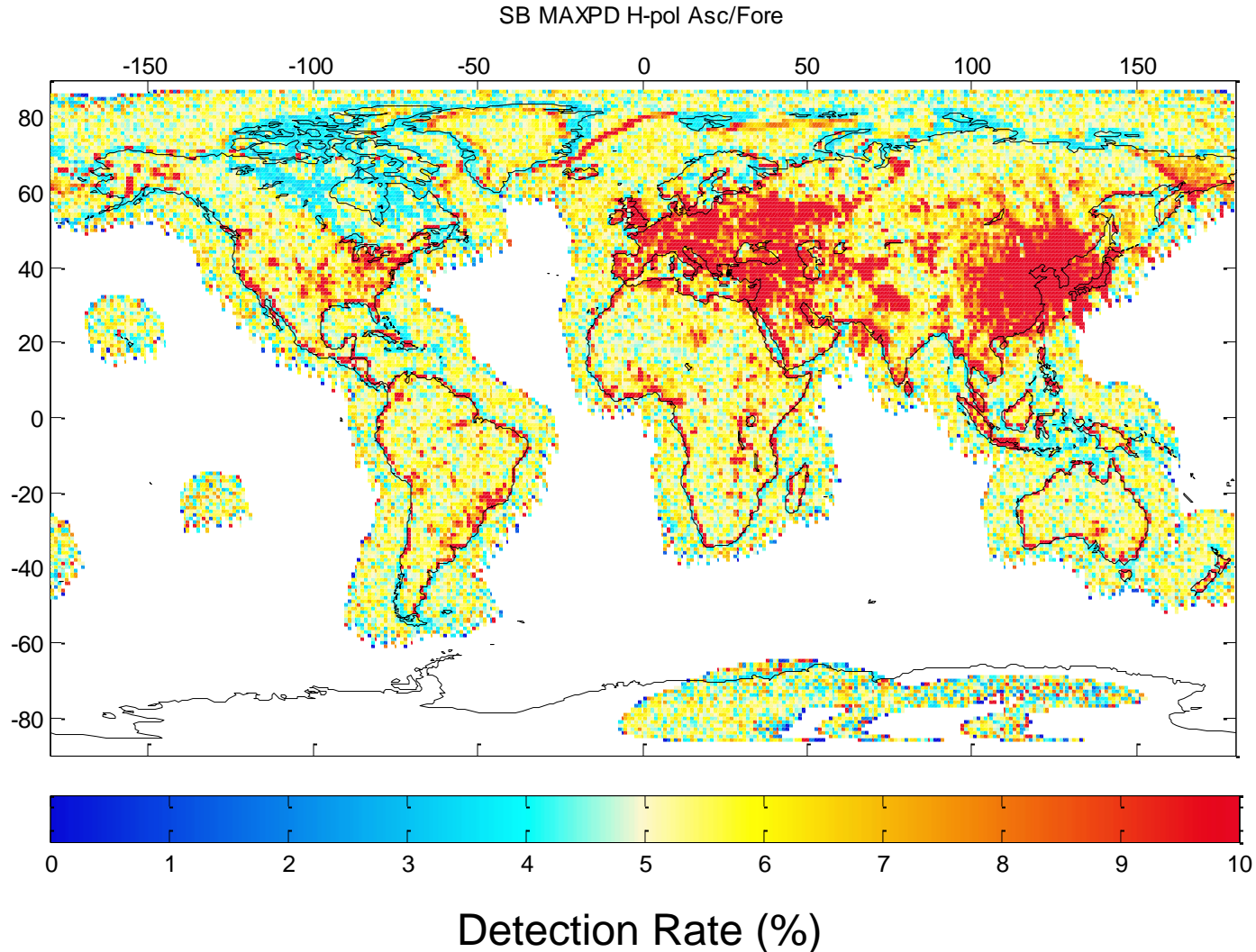
Plot shows
min of data

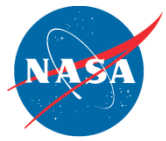
Indicator of
longer pulsed
or continuous
wave sources





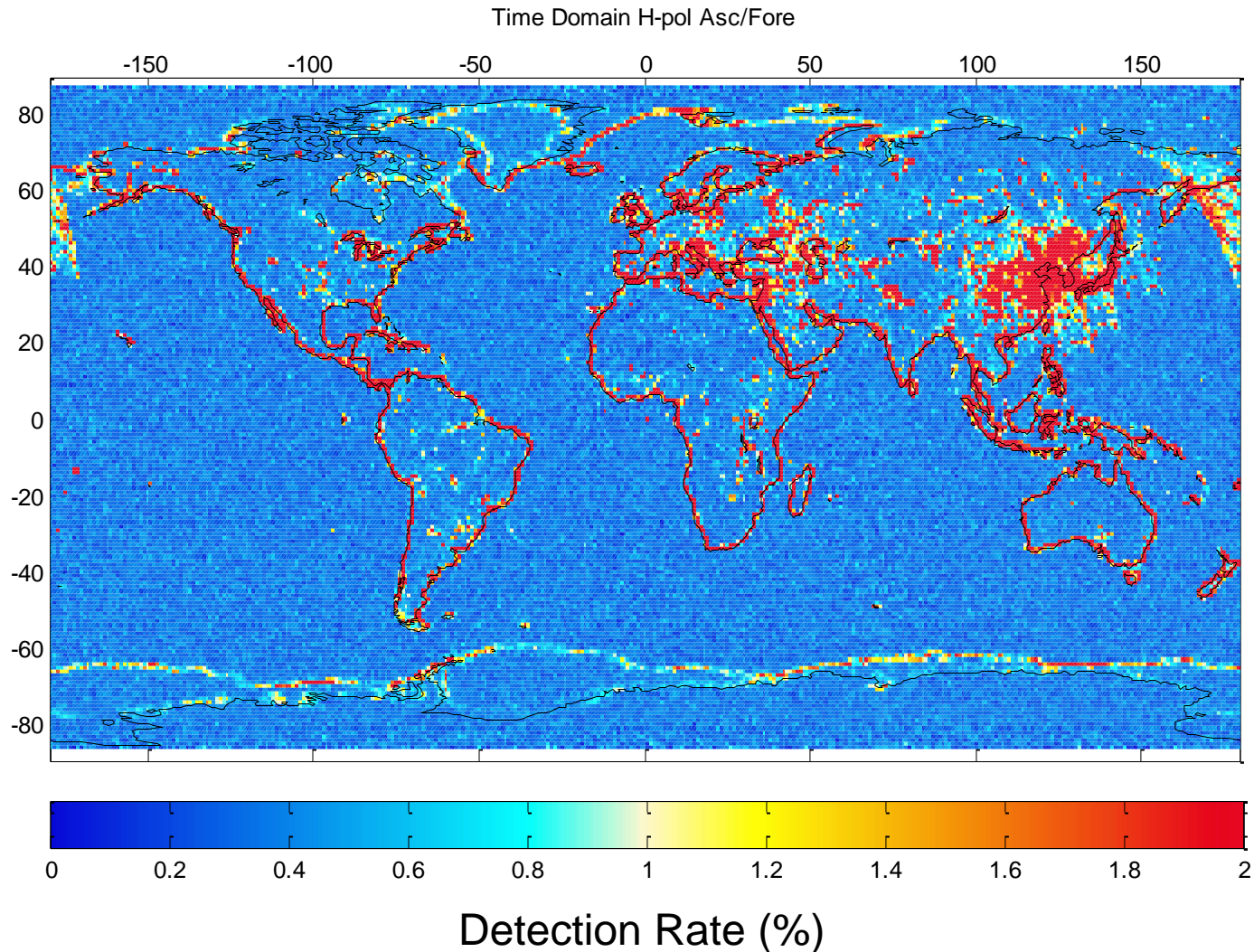
SB MAXPD Detection Rate May 1 to 8

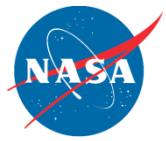




Time Domain Detection Rate May 1 to 8

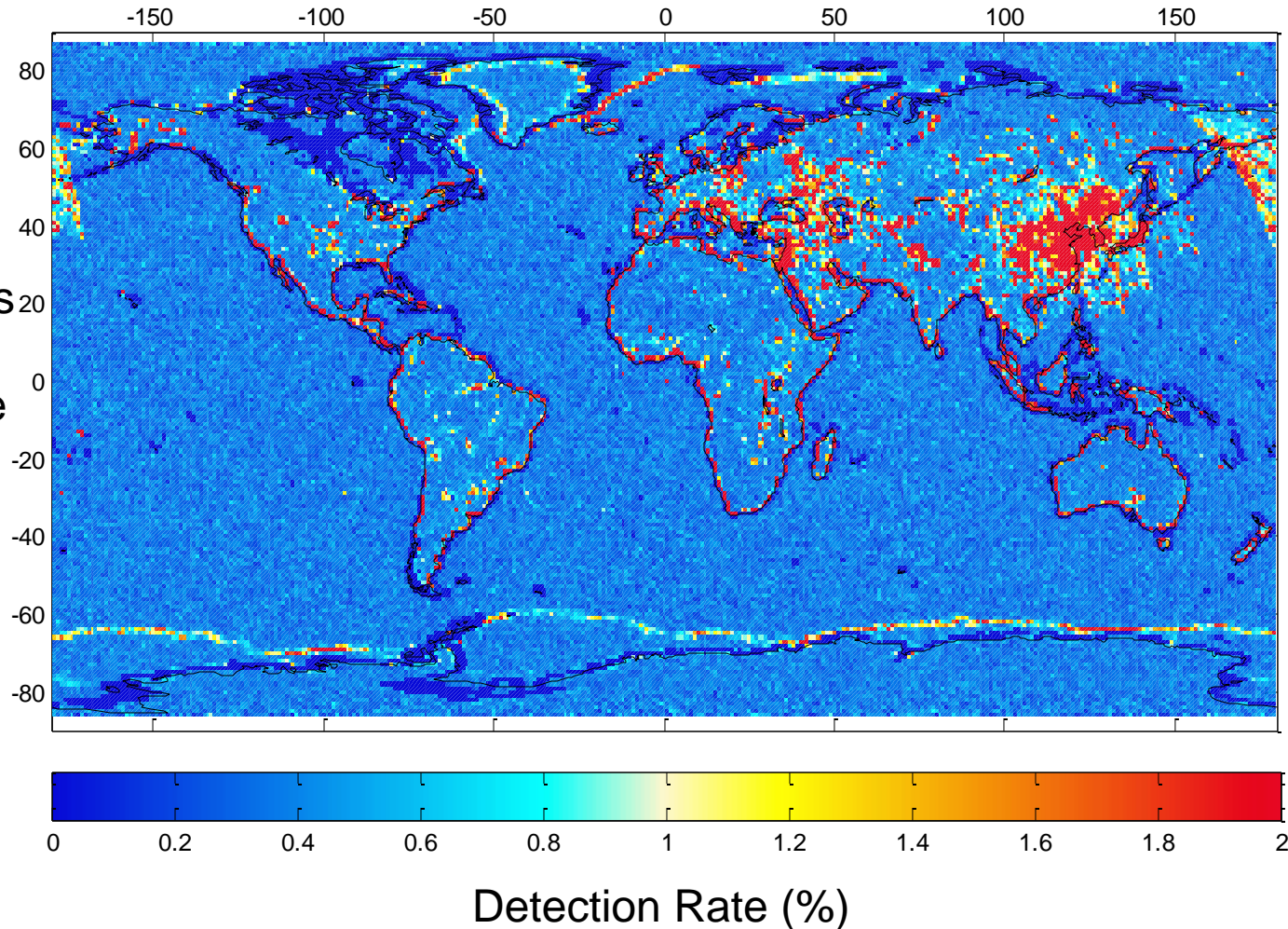
- FAR ~ 0.36 %
- $\beta = 3$
- 1° grid

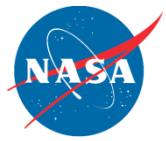




Time Domain Detection Rate May 1 to 8

Time Domain H-pol Asc/Fore

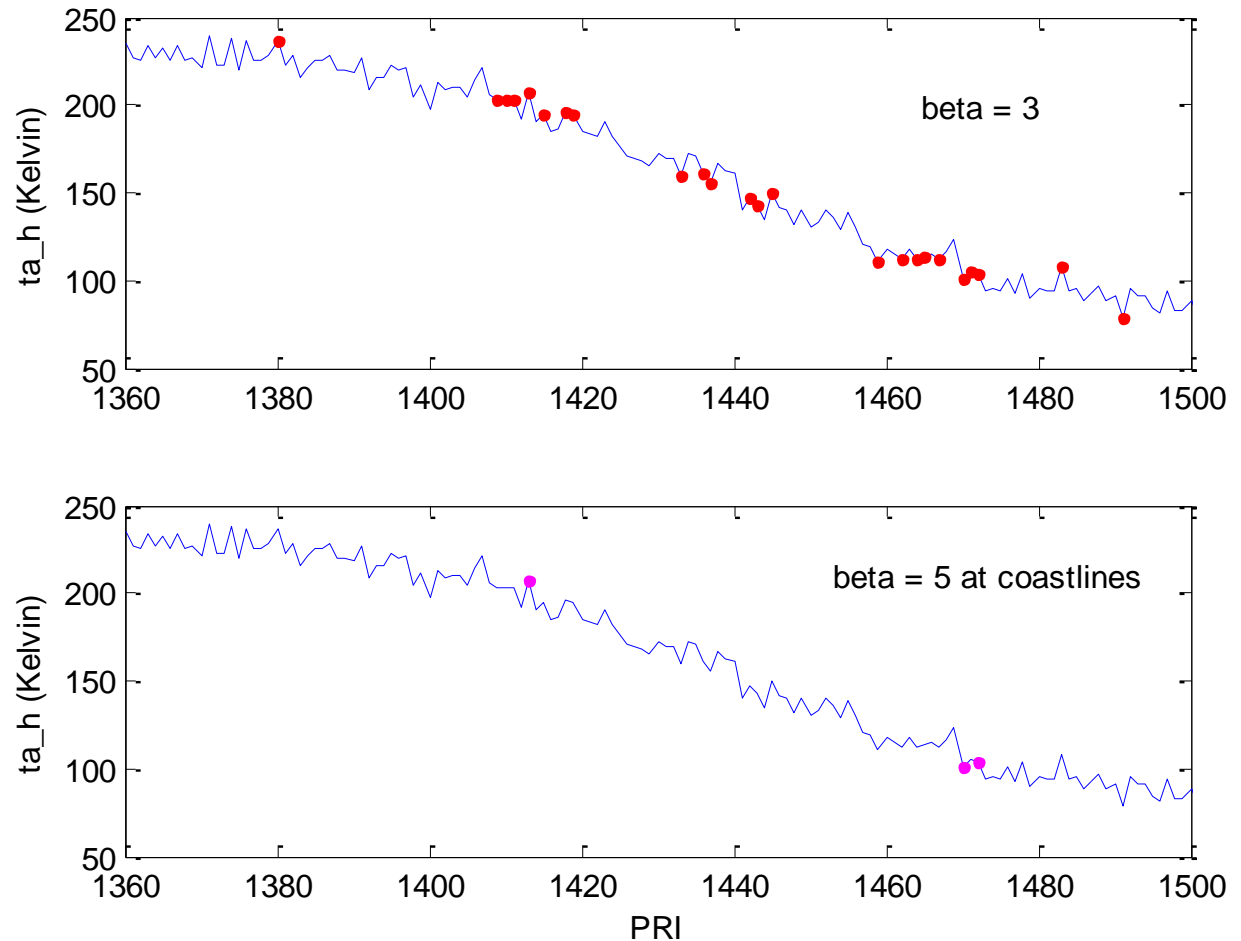


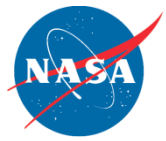


FAR Pulse Detector Coastline Example

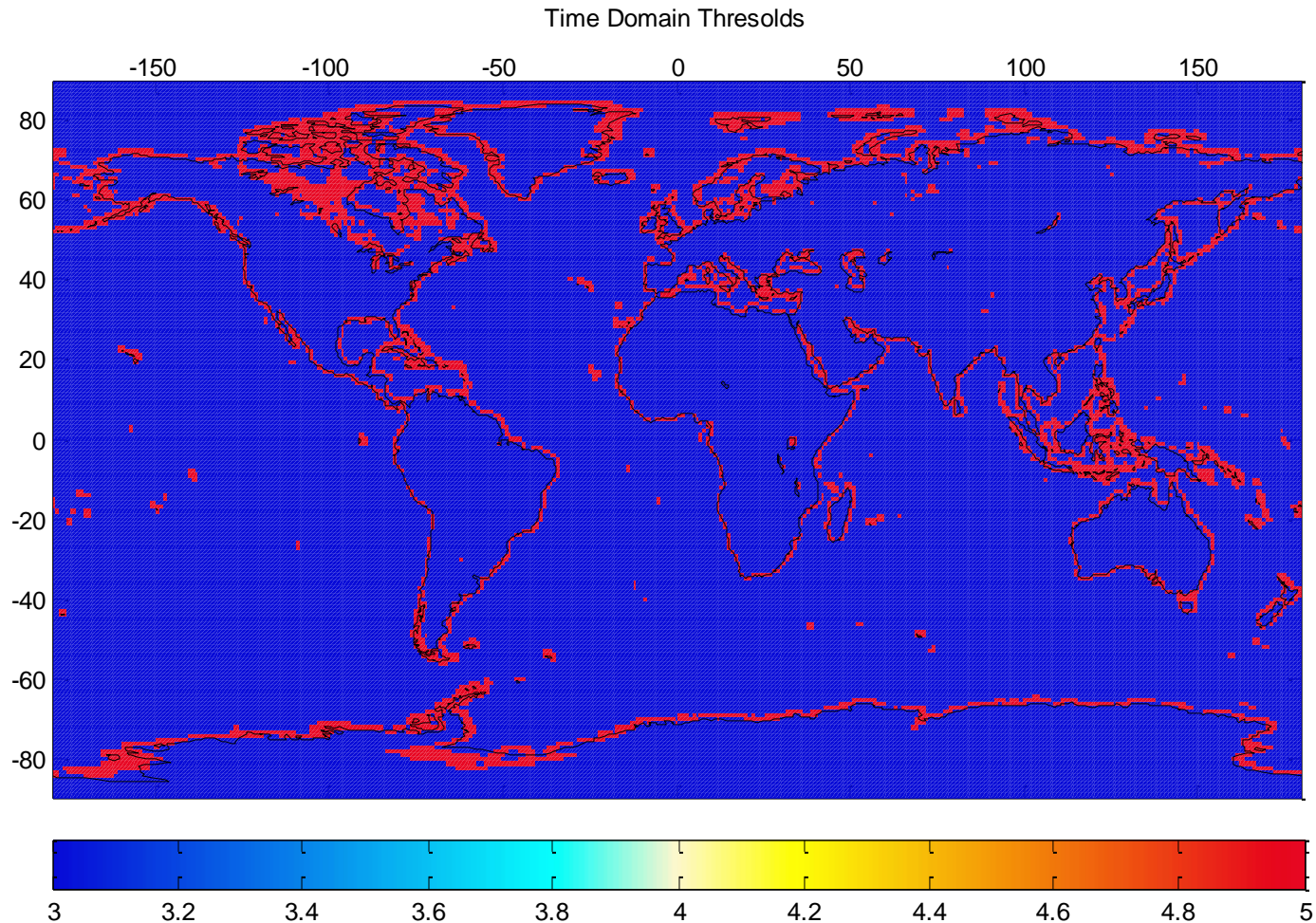
Orbit 01309_D, scan 435

- Top figure shows flags when β is 3 globally
- In bottom figure, β is increased to 5 at the coastlines

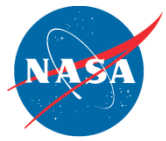




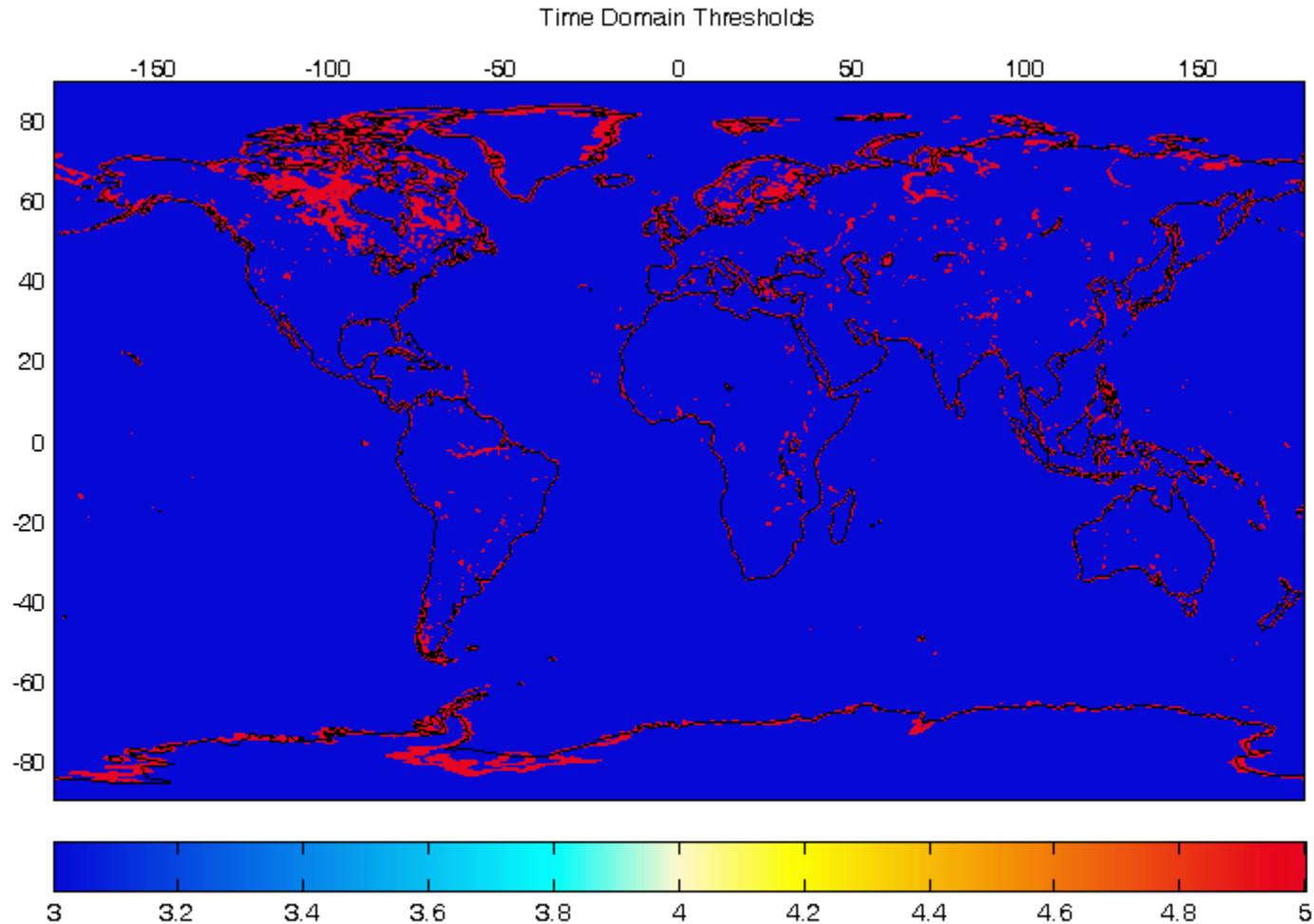
Variable Time Domain Thresholds



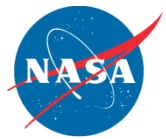
β_{td} , number of stds above or below mean



Variable Time Domain Thresholds

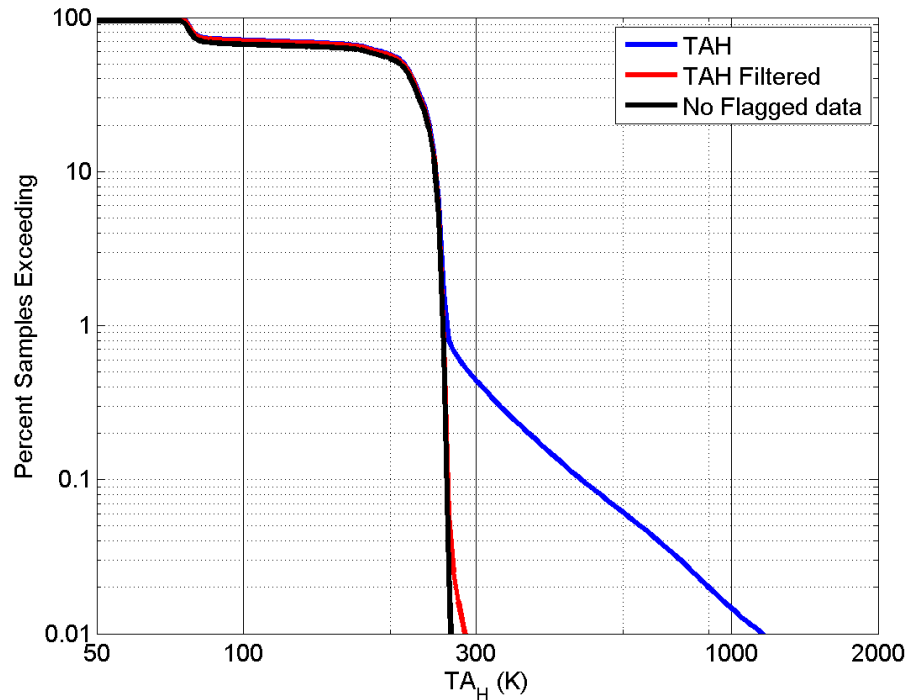


β_{td} , number of stds above or below mean

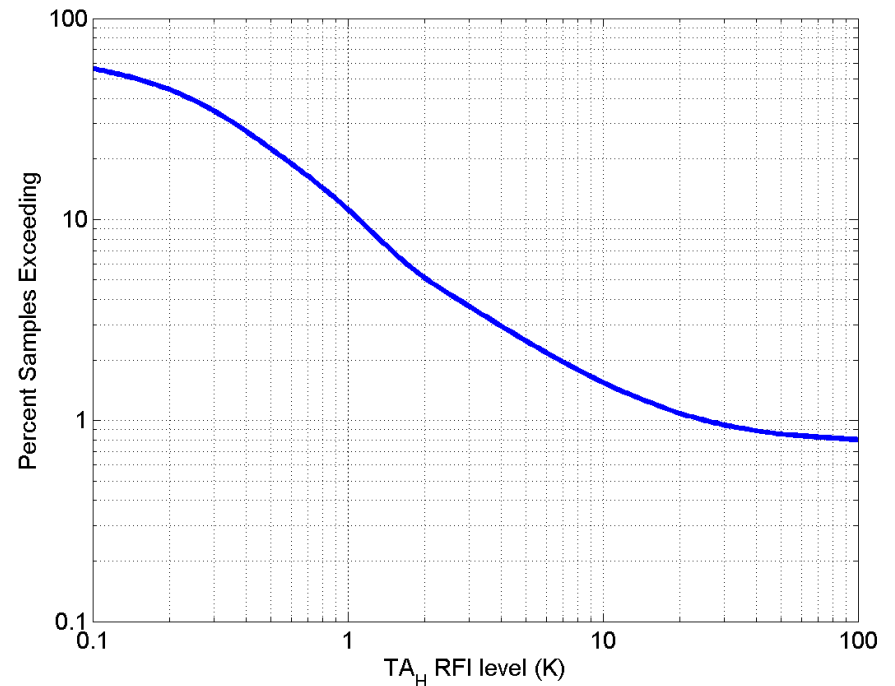


Summary Ta_H Statistics

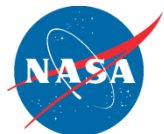
- 5/1-5/26/15, Global data



RFI Detection
Algorithms and
Quality Checks
Clearly Eliminate
Large RFI

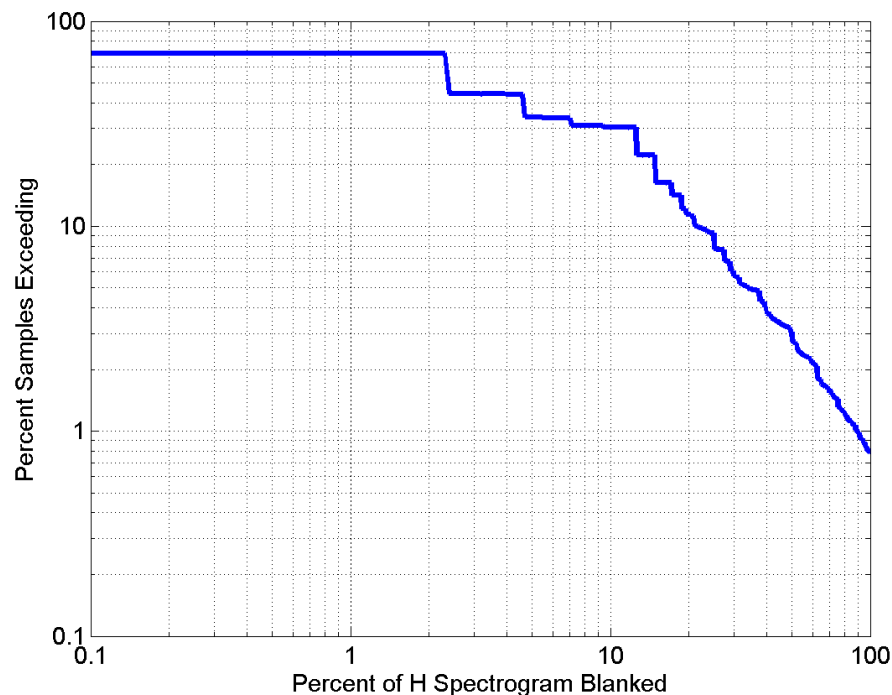
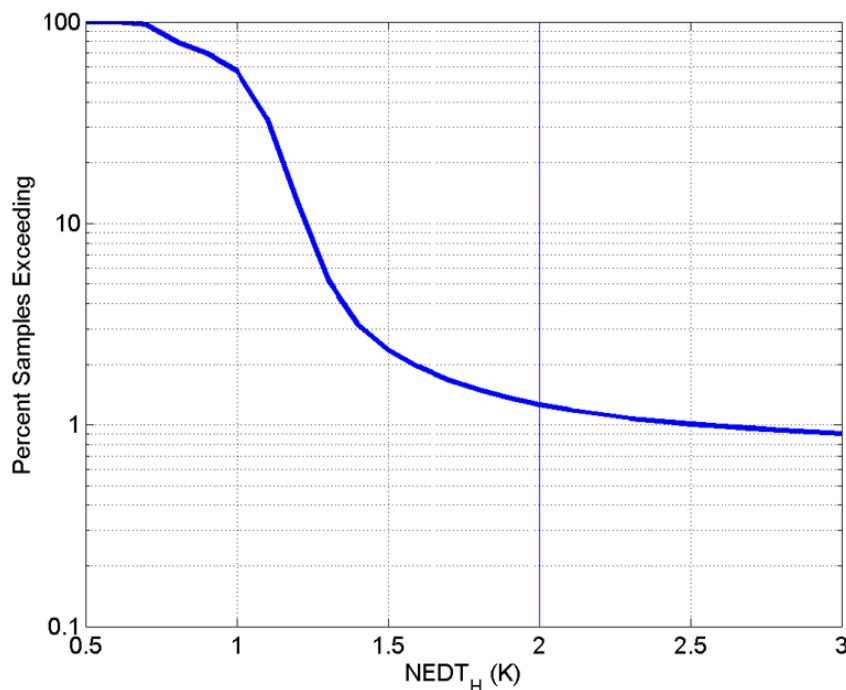


~1% of Samples Have
RFI >30K detected

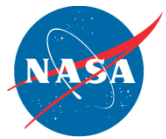


NEDT and Fraction of Spectrogram Blanked Stats

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



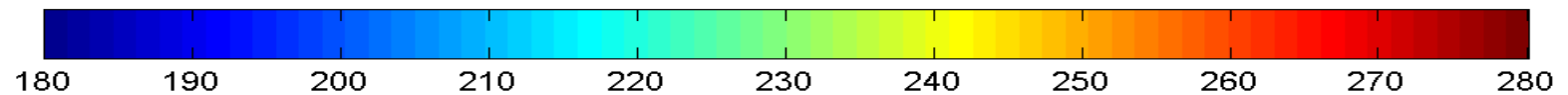
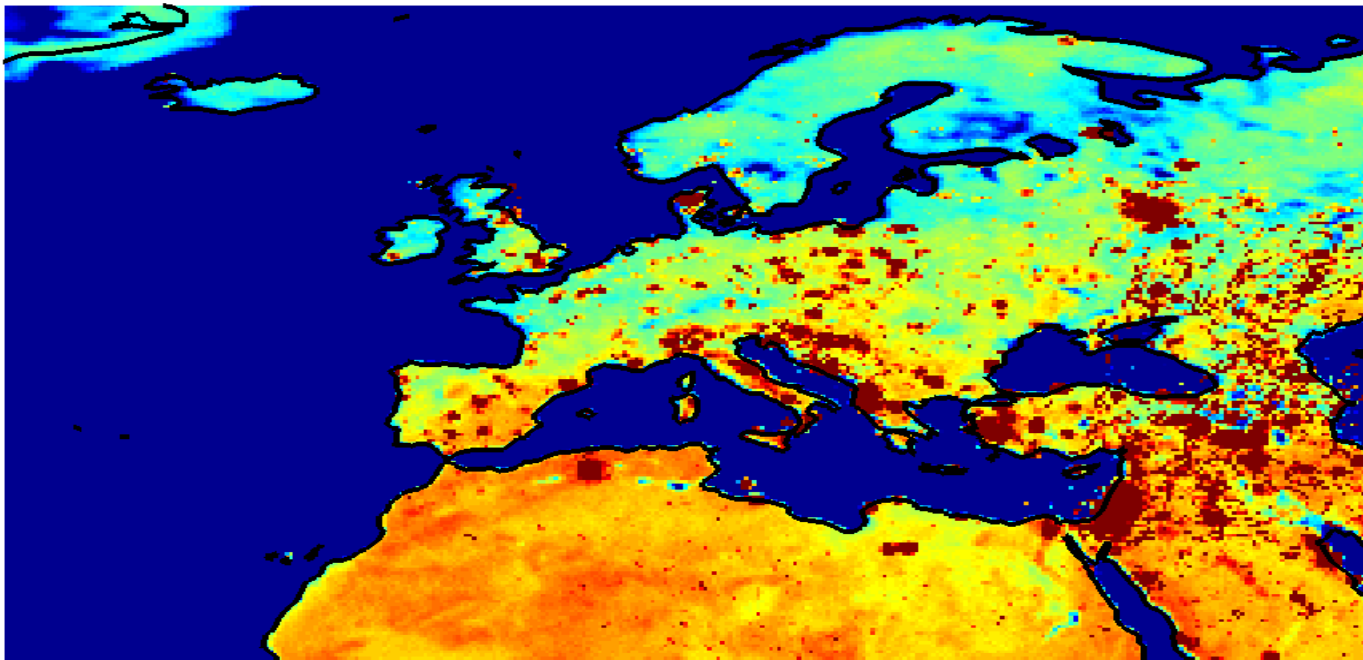
- ~ 2% of data flagged for too high NEDT or NEDT not computable
- ~ 2% of data flagged for RFI overall (not including 'out of range' flag applied at TB level)

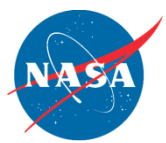


TA unfiltered Europe

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

0.25° grid

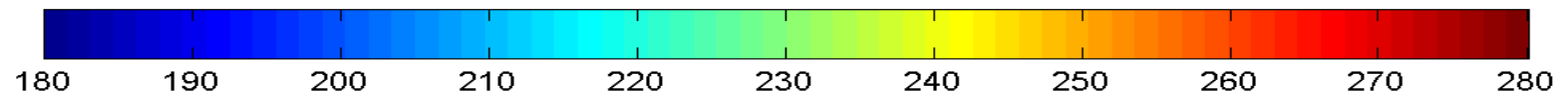
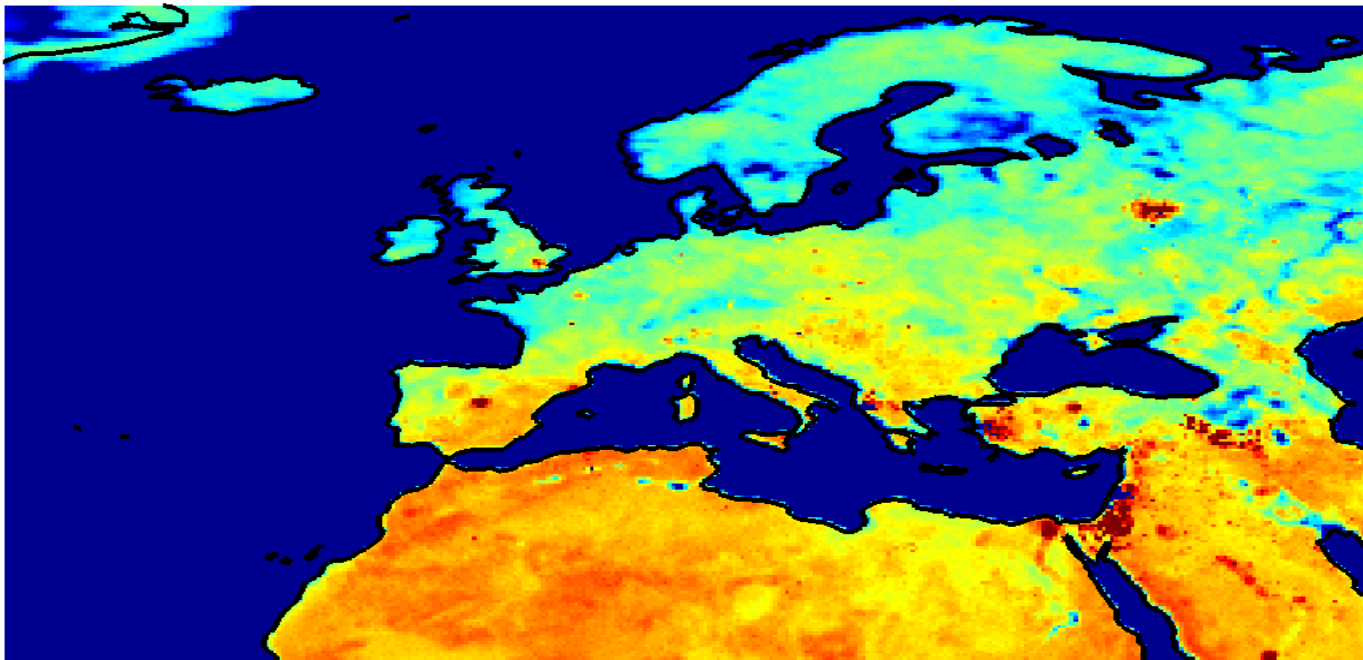


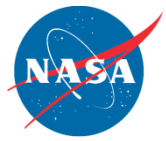


TA filtered Europe

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

0.25° grid

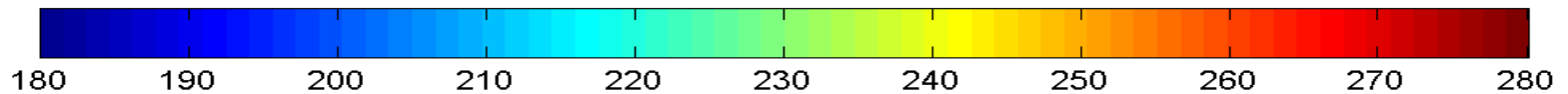
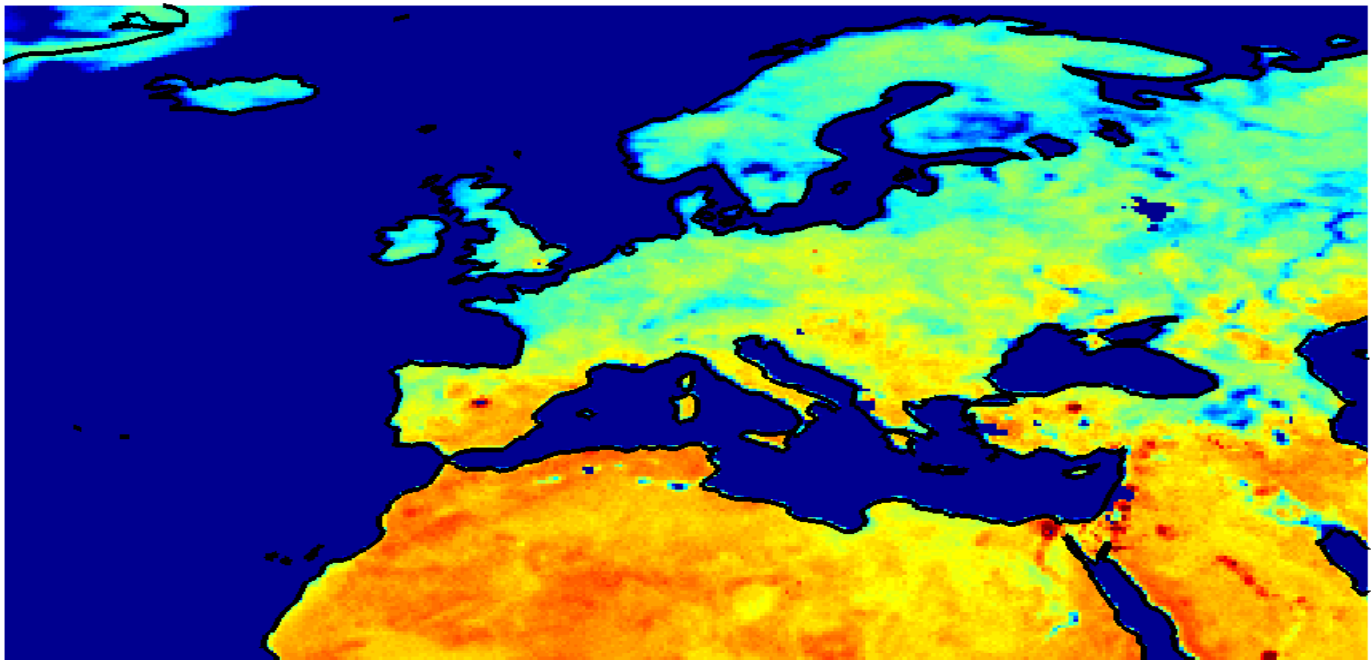




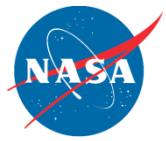
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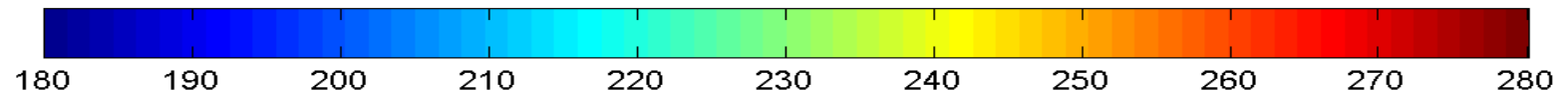
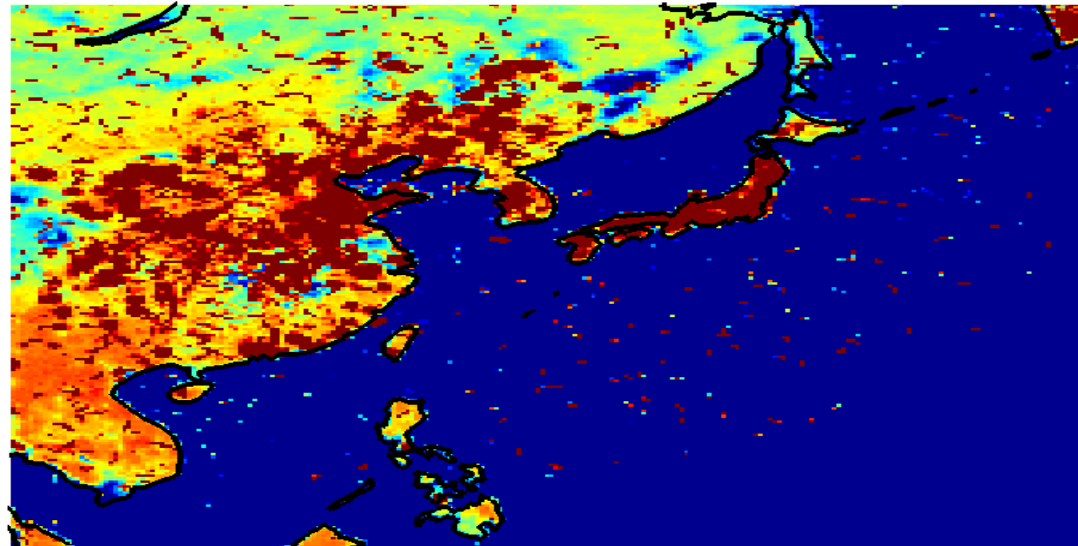
Discarding measurements flagged by TB quality flag,
residual RFI appear to still be in product

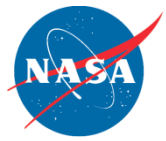


TA unfiltered Asia

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

0.25° grid

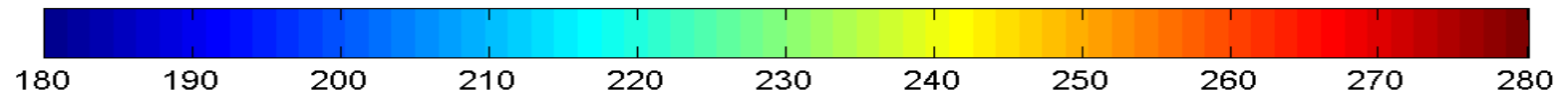
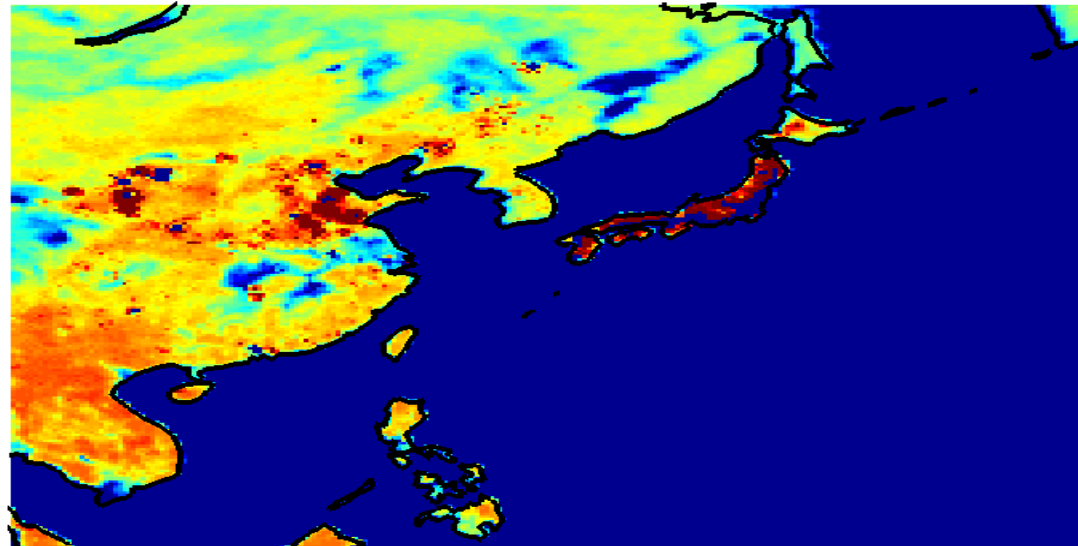


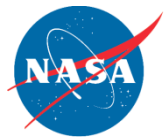


TA filtered Asia

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

0.25° grid

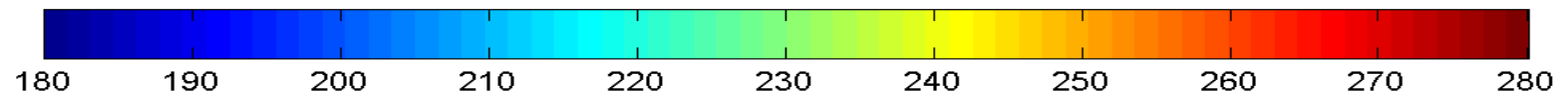
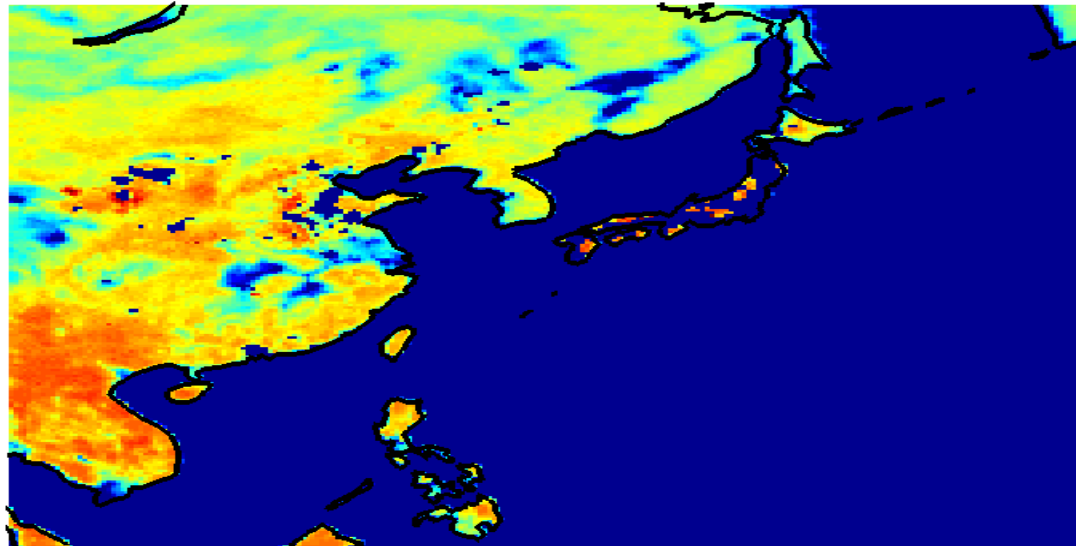




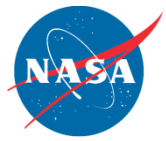
TA filtered Asia

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



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