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

SMAP CAL VAL WORKSHOP #6

Priscilla N. Mohammed[1,2]
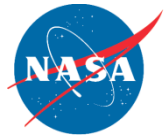
Jeffrey R. Piepmeier[1]

Joel T. Johnson[3]

Mustafa Aksoy[3]

Alexandra Bringer[3]
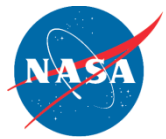
(1) NASA Goddard Space Flight Center
(2) Morgan State University
(3) The Ohio State University

Outline

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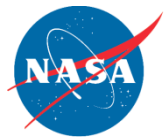- Challenging RFI cases

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

Max-Hold Log10(H pol RFI) 5/1-5/8

- Setting algorithm parameters part of cal/val process
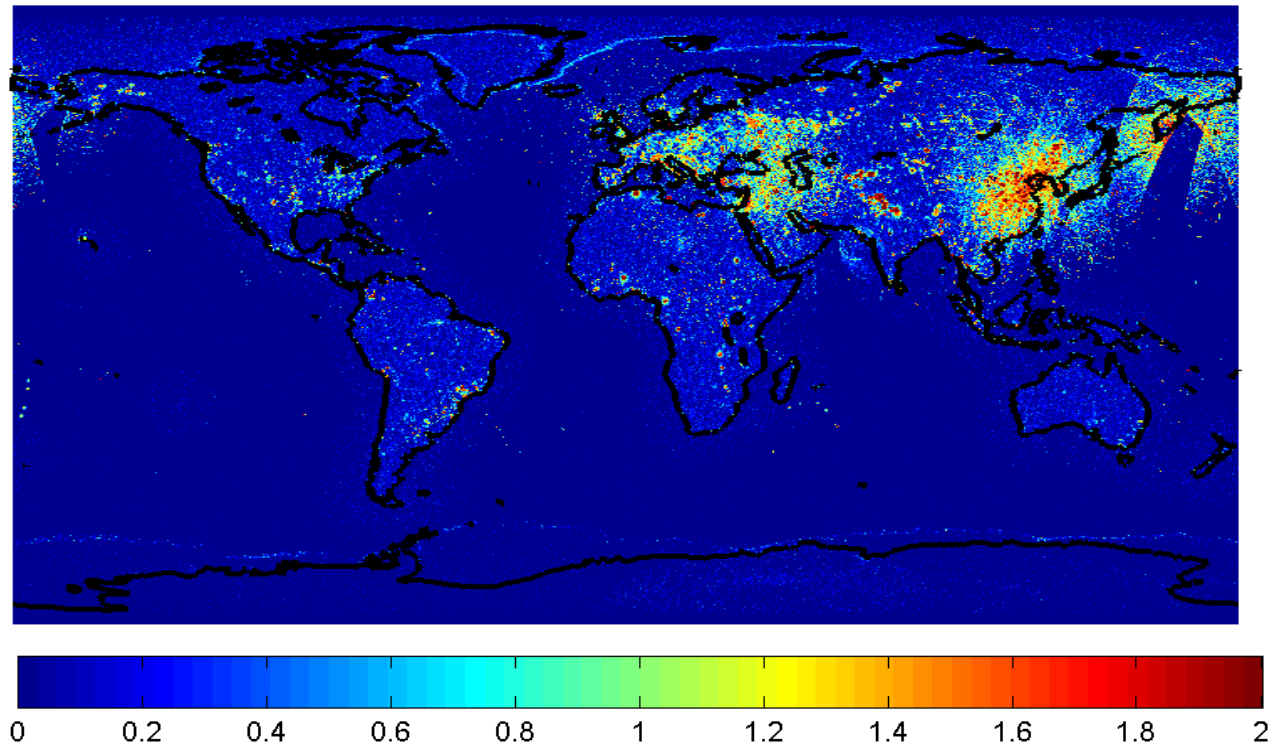
RFI Detection Algorithms

- Nine RFI detection algorithms used (thresholds selectable)

    1) Pulse detection fullband   **5)** Cross frequency @ 9.6 msec resolution

    2) Kurtosis fullband   **6)** Kurtosis sub-band (spectrogram points)

    3) T3 and **4)** T4 fullband   **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

3

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

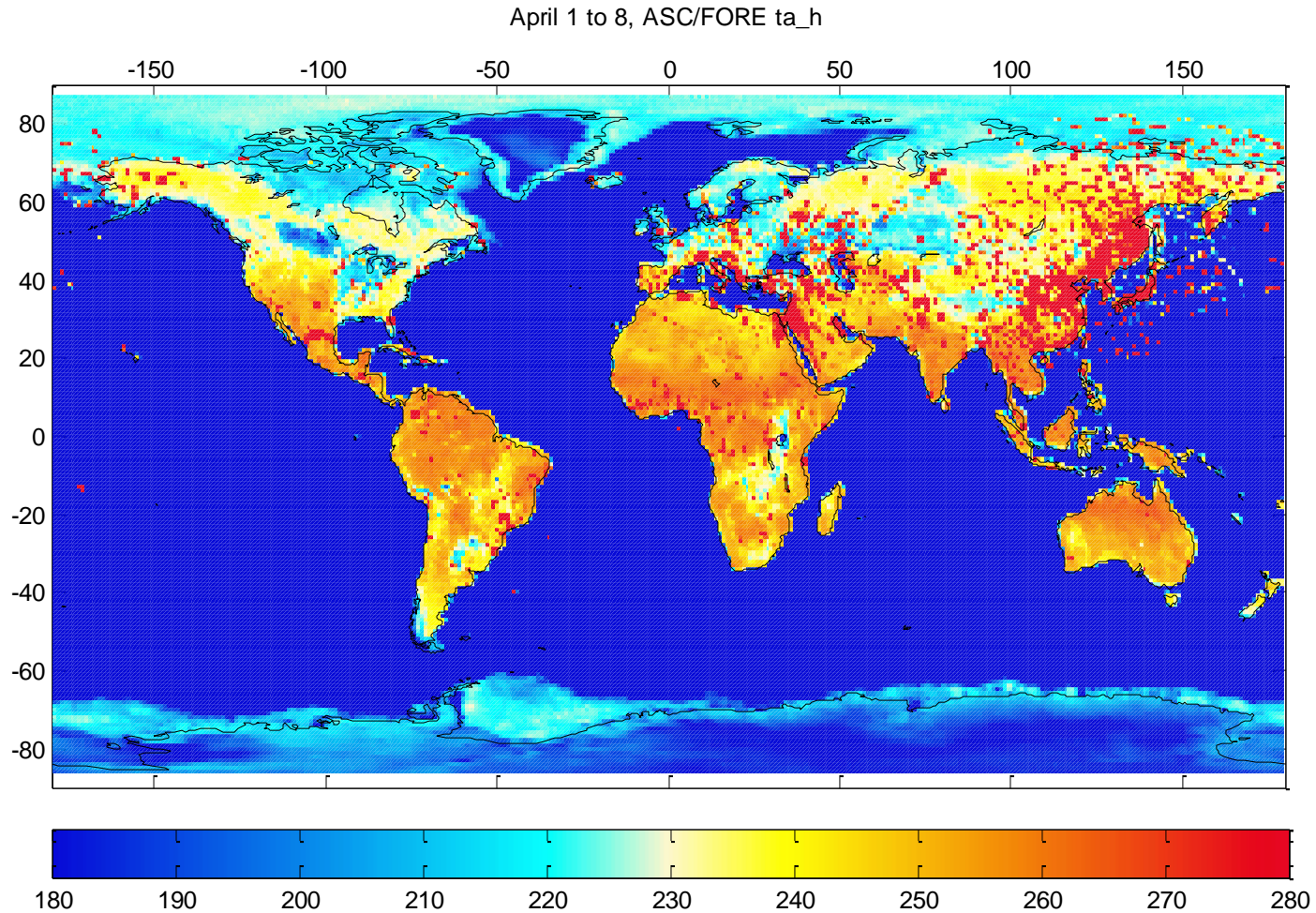 **bit 14: >100 K RFI detected**

- NEDT after mitigation also output

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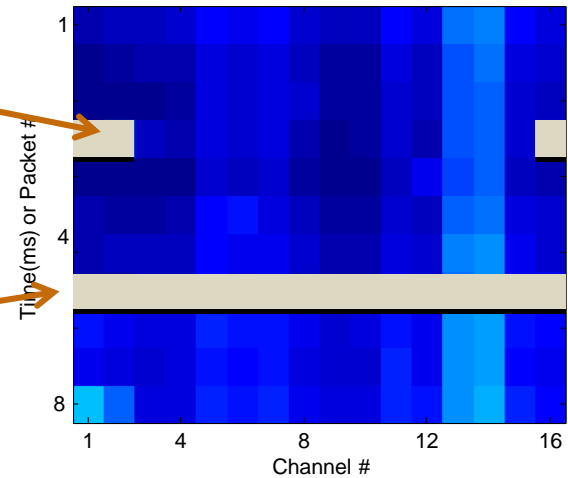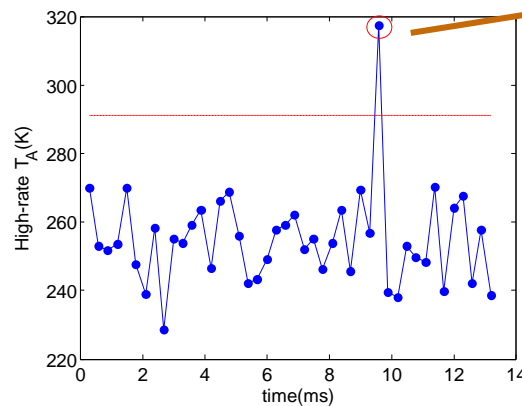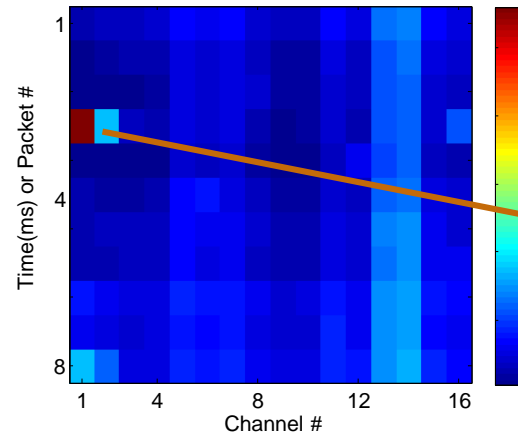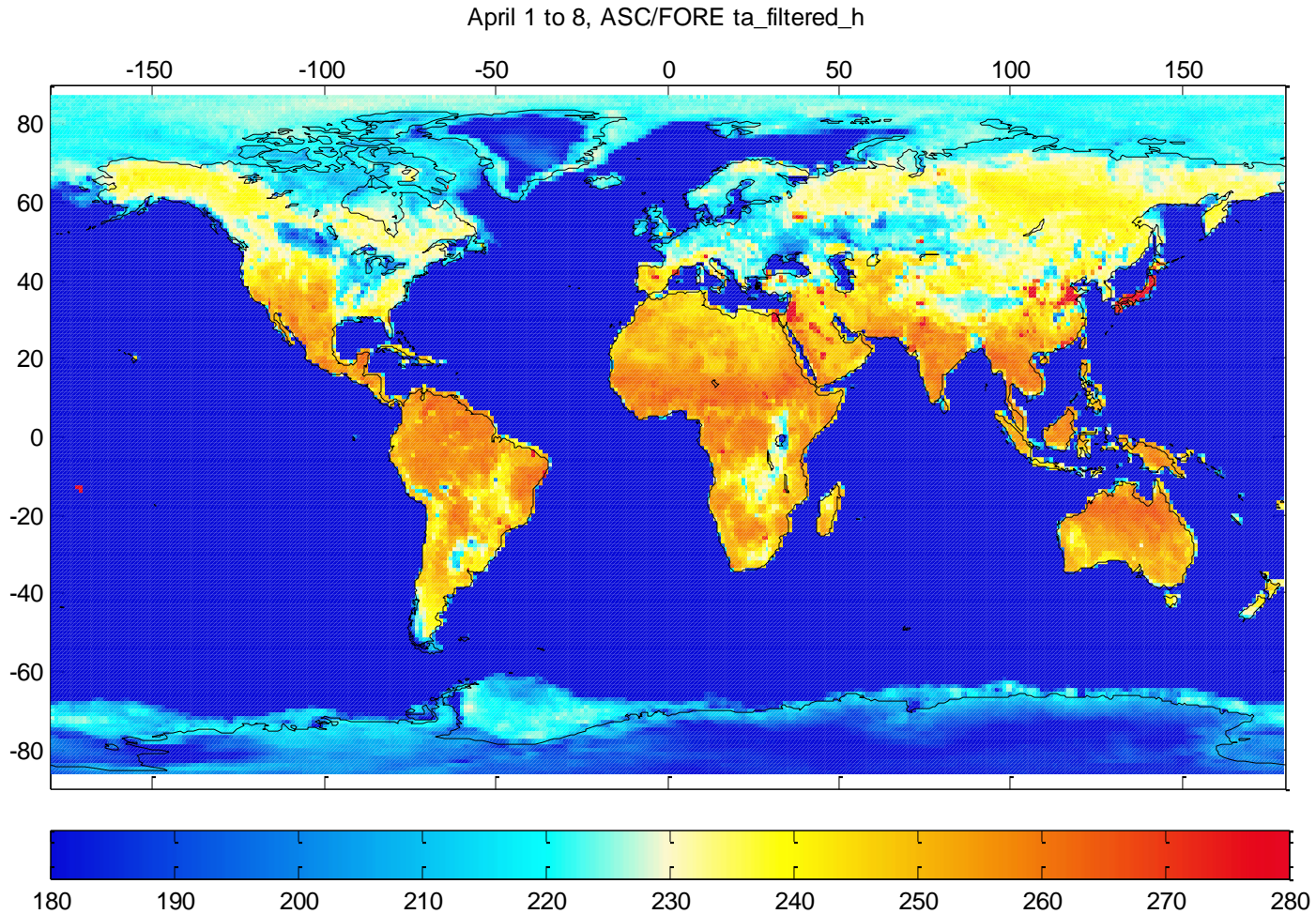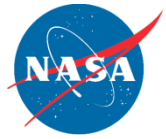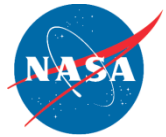

MAXPD example

Peak Hold TA H-pol April 1 to 8

April 1 to 8, ASC/FORE ta_h

1° grid

TA H-pol (Kelvin)

Peak Hold TA filtered H-pol April 1 to 8

April 1 to 8, ASC/FORE ta_filtered_h

1° grid

TA H-pol (Kelvin)

Peak Hold TA H-pol April 1 to 8

April 1 to 8, ASC/FORE ta_h

1° grid
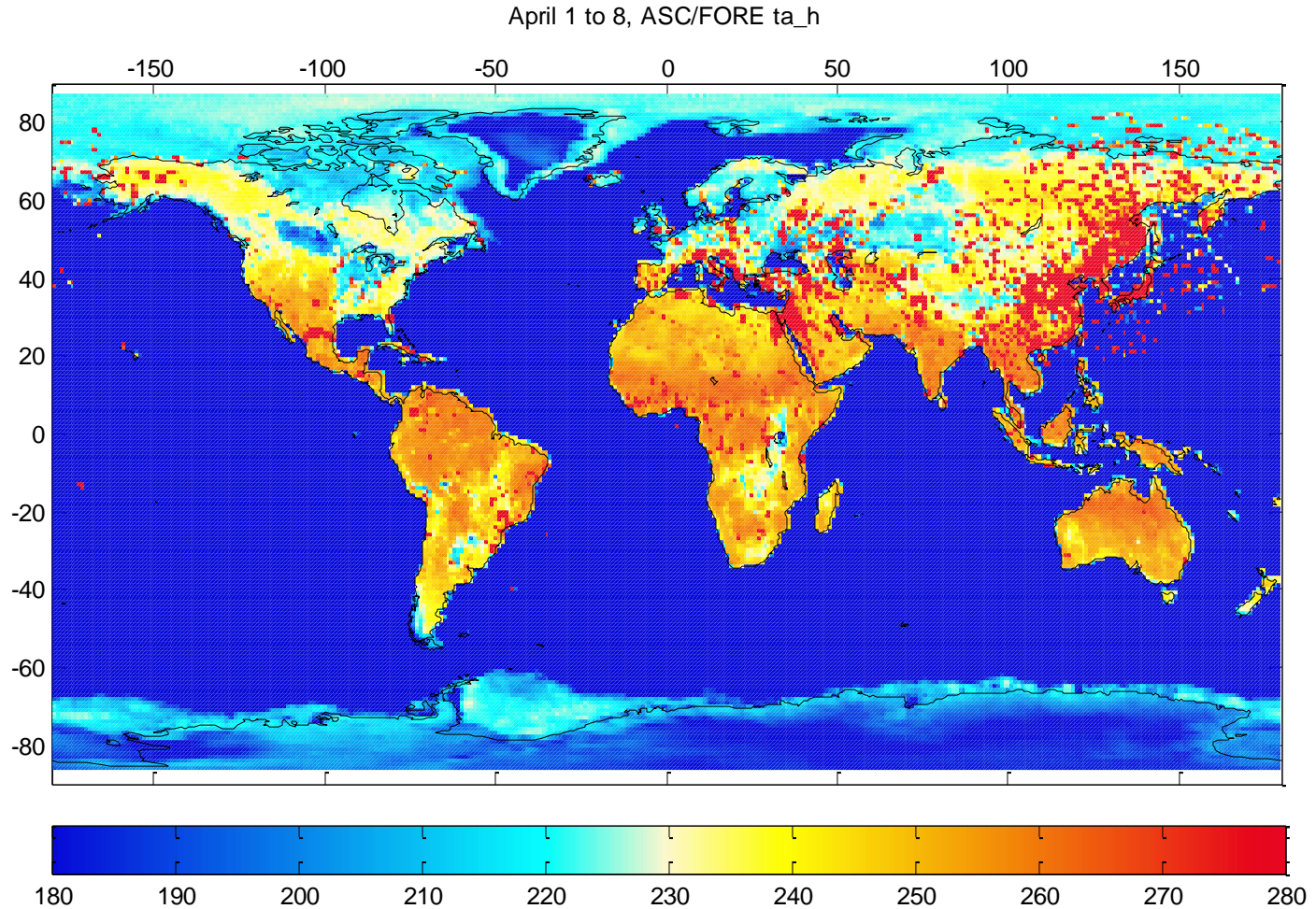
TA H-pol (Kelvin)
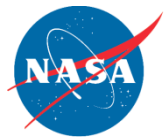
Peak Hold TA H-pol May 1 to 8
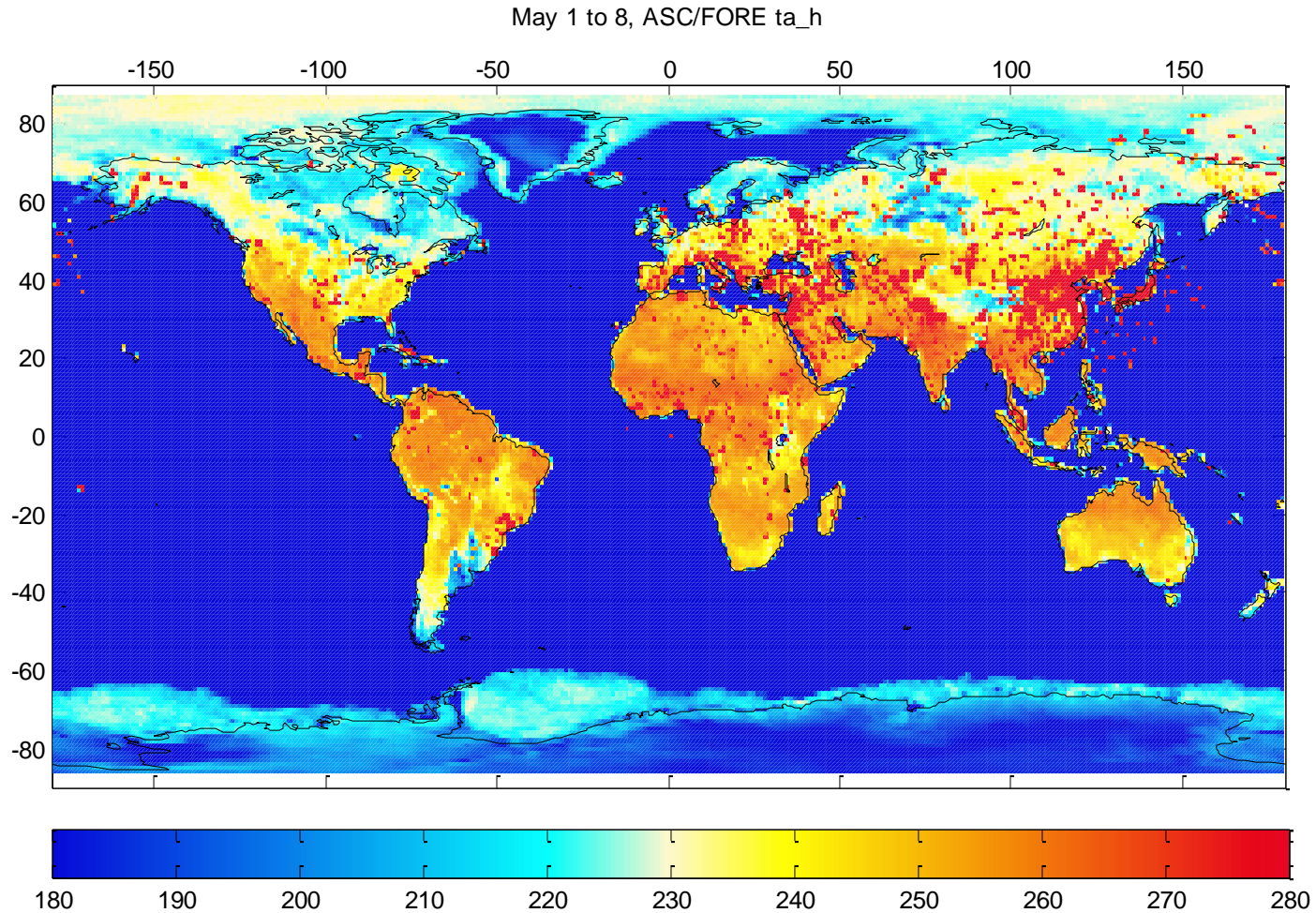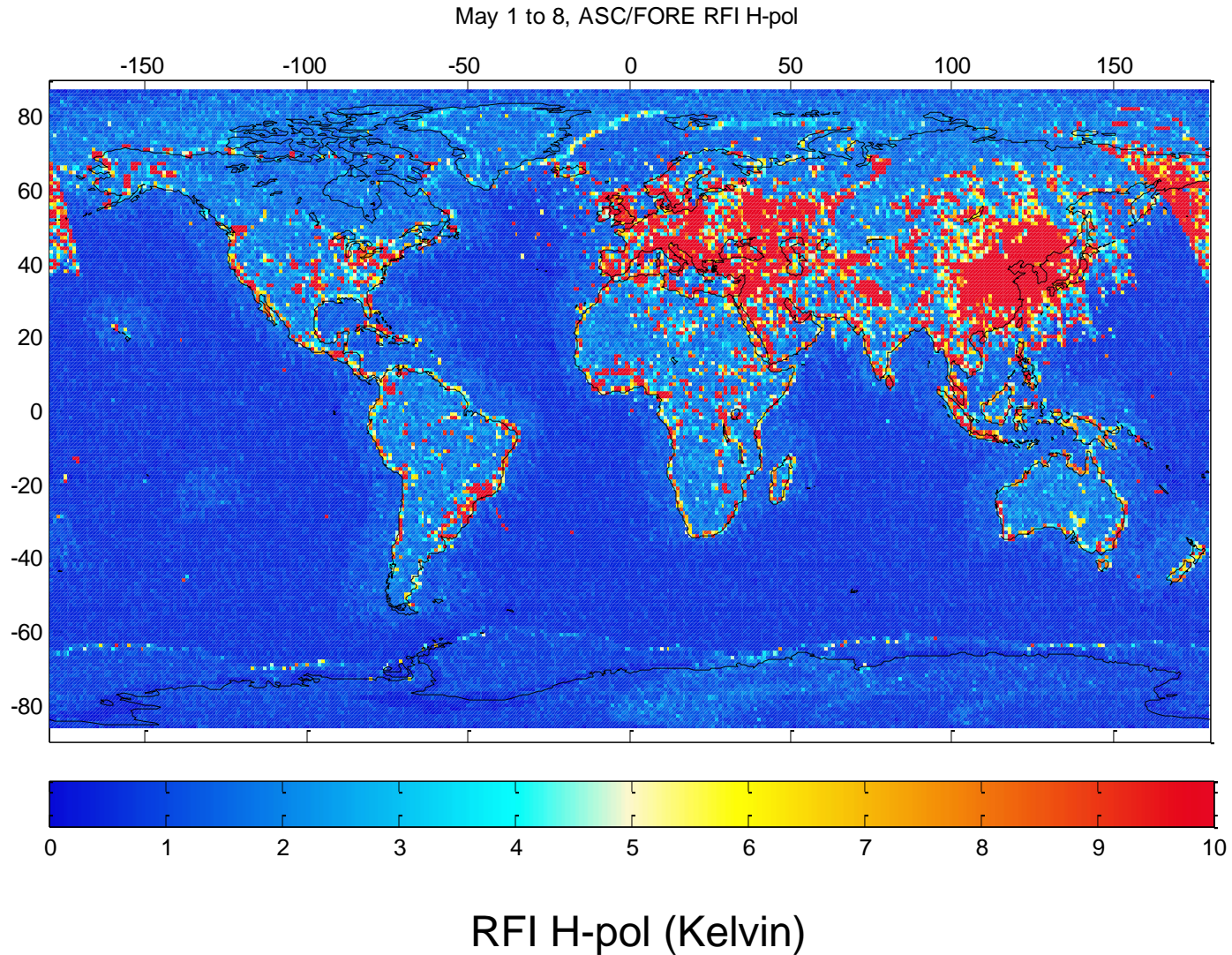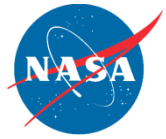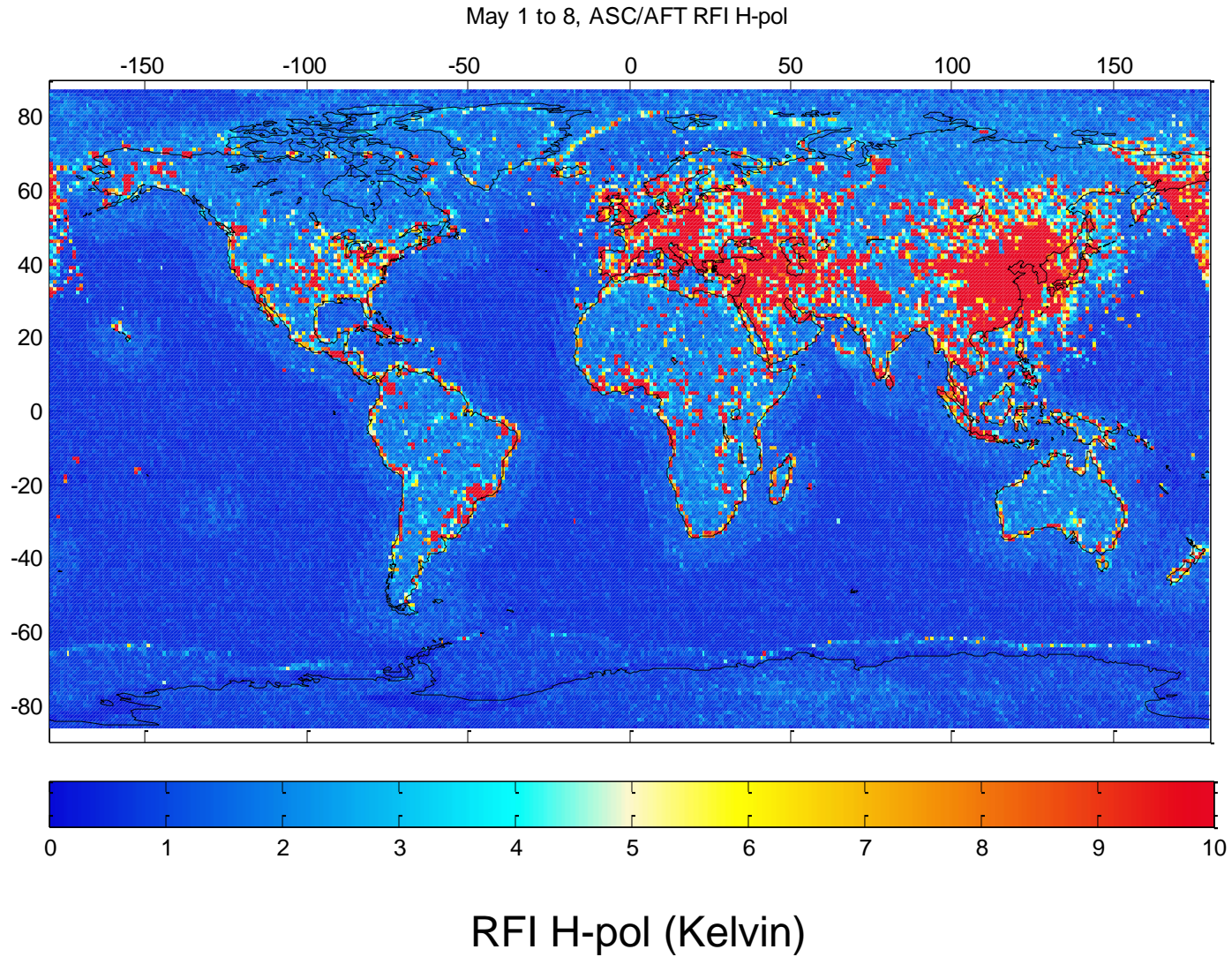
May 1 to 8, ASC/FORE ta_h

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

FB Kurtosis H-pol excess Asc/Fore PULSE
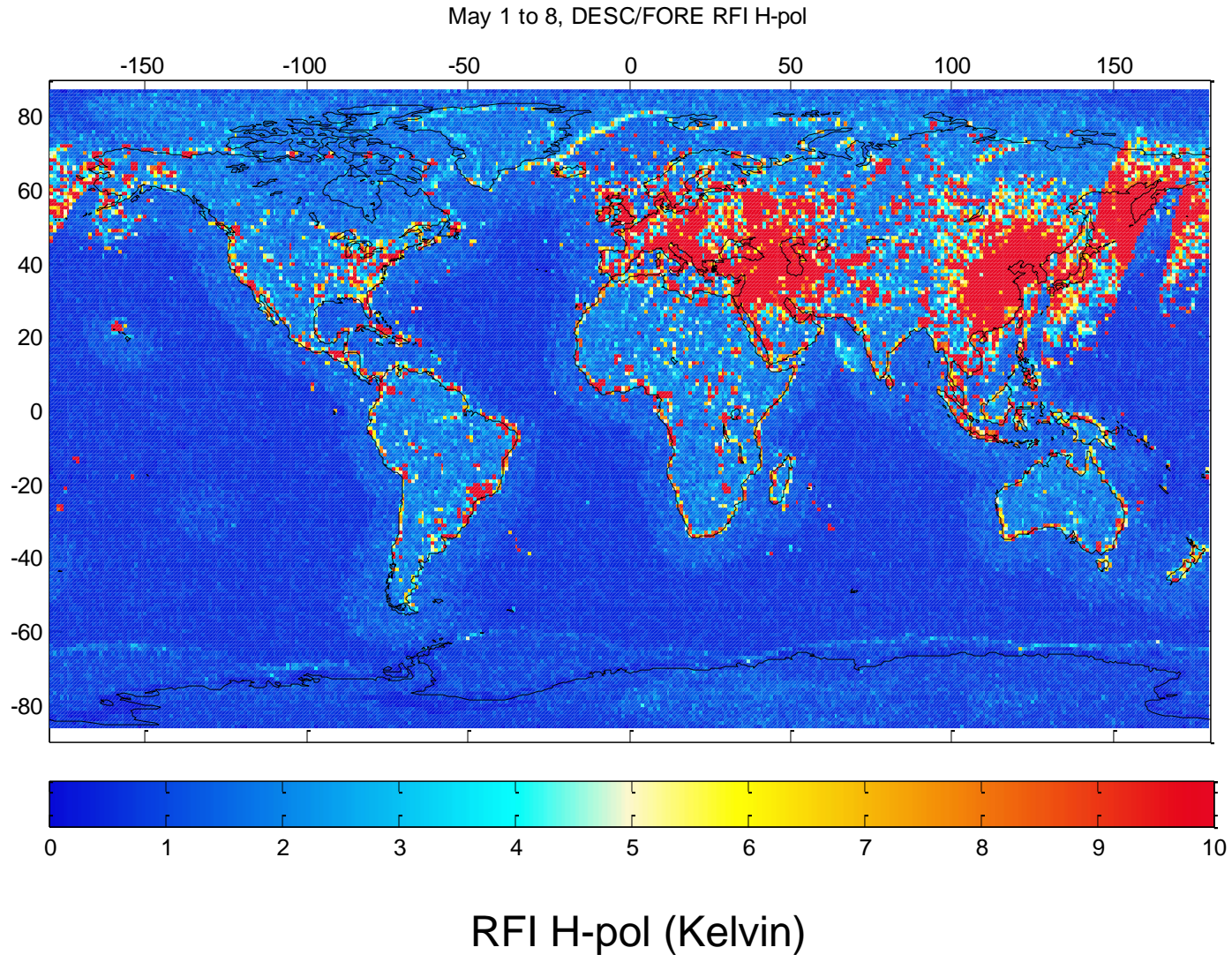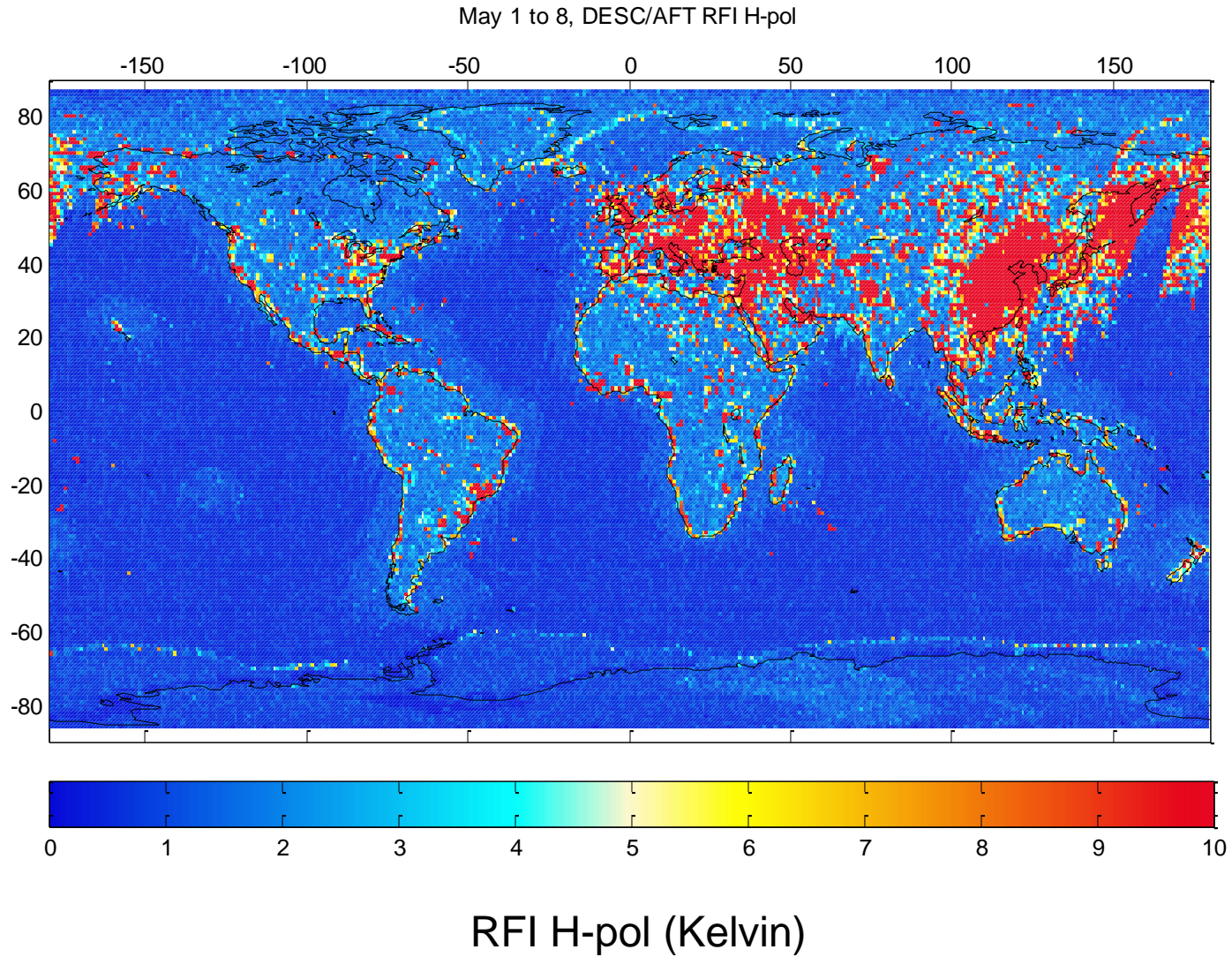
Kurtosis excess = Kurtosis – 3

Plot shows peak hold data

Indicator of short pulsed sources

1° grid

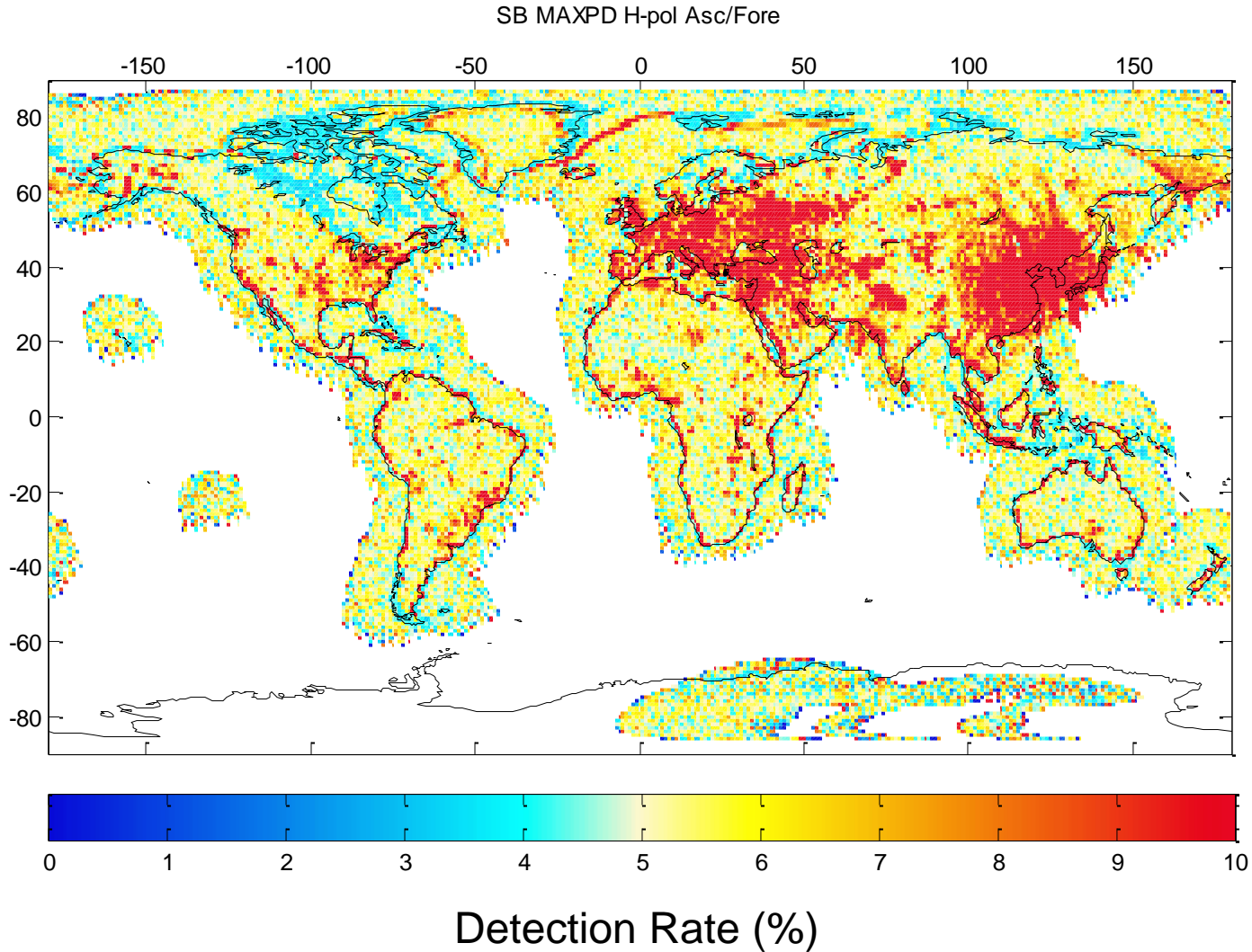# Fullband Kurtosis May 1 to 8

FB Kurtosis H-pol excess Asc/Fore CW
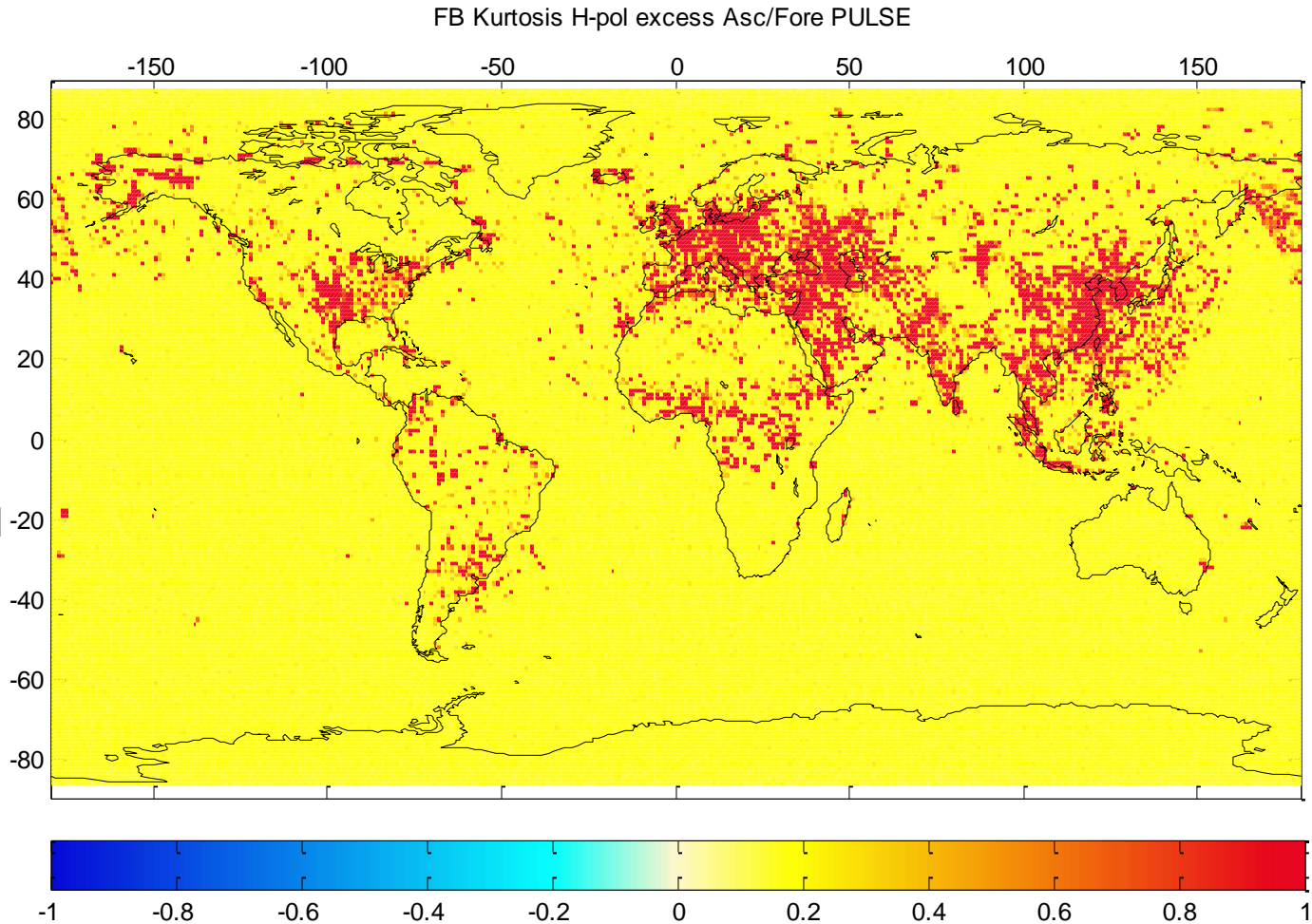
Kurtosis
excess = 3 −
Kurtosis

Plot shows
min of data

Indicator of
longer pulsed
or continuous
wave sources

1° grid
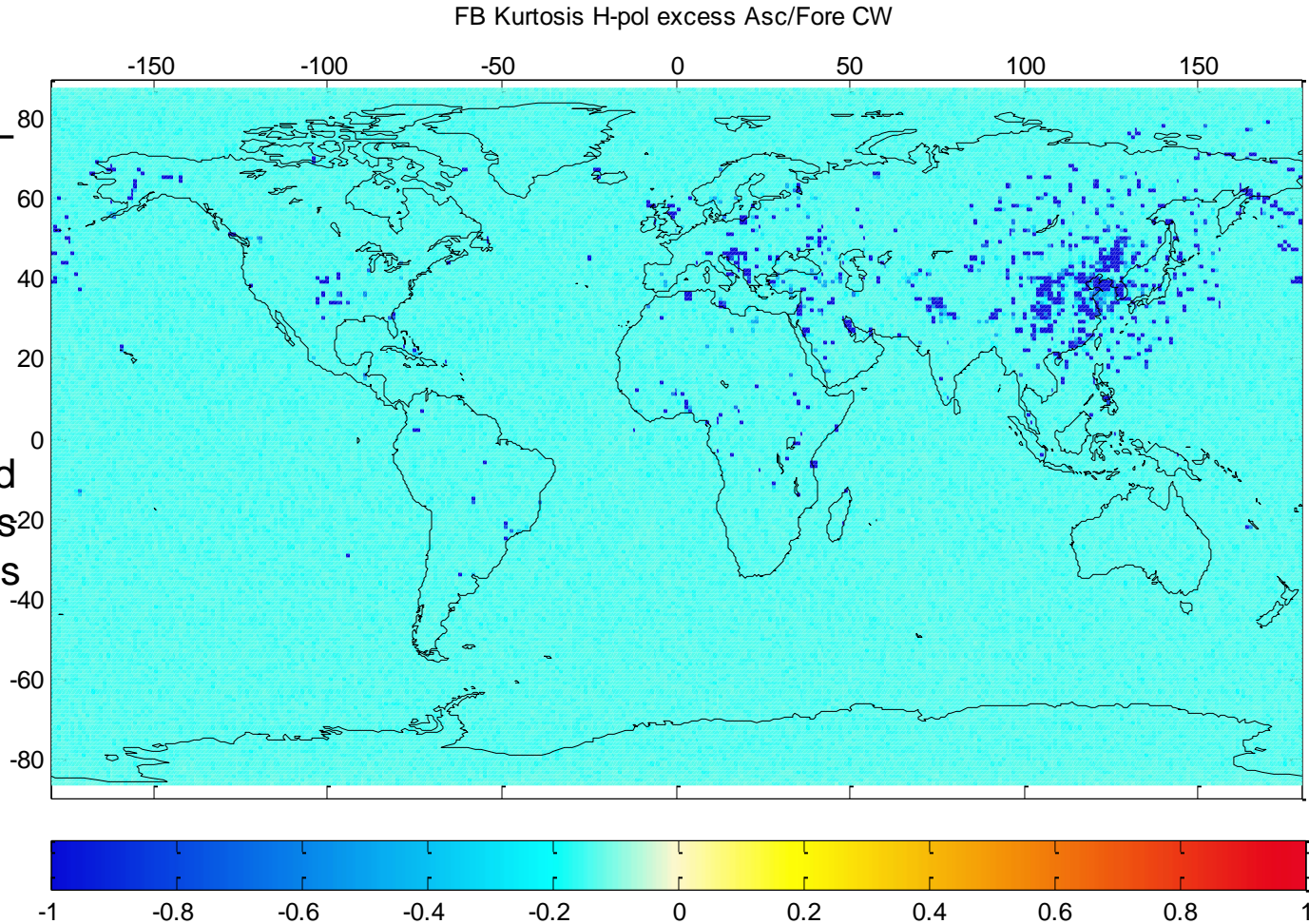
SB MAXPD Detection Rate

SB MAXPD H-pol Asc/Fore

FAR ~
5.5 %

1° grid
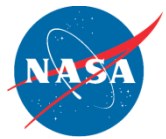
Detection Rate (%)

Time domain threshold = 5 at coastlines

Summary Ta_H Statistics

- 5/1-5/26/15, Global data
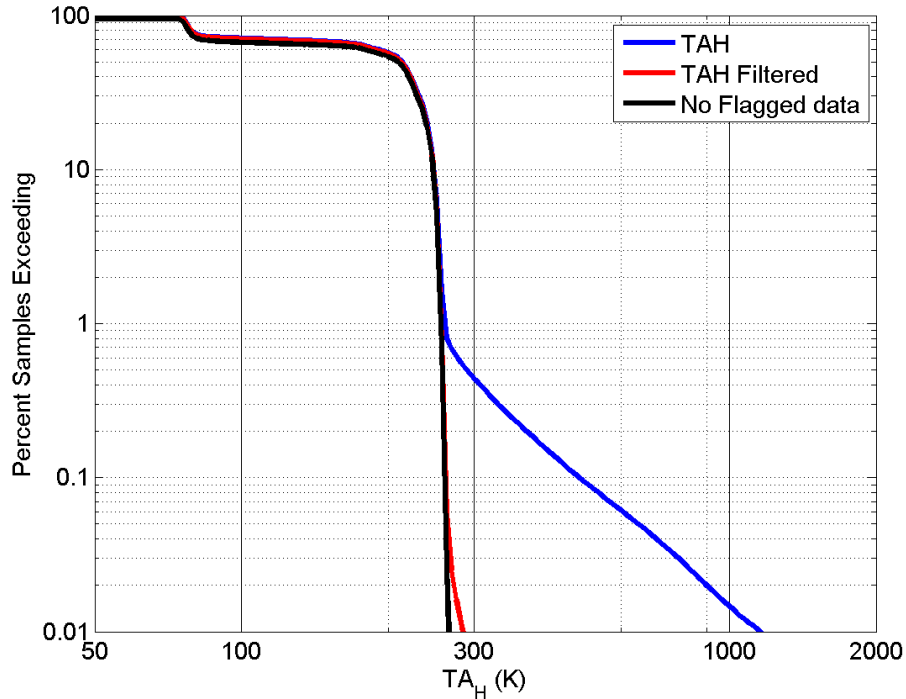
RFI Detection
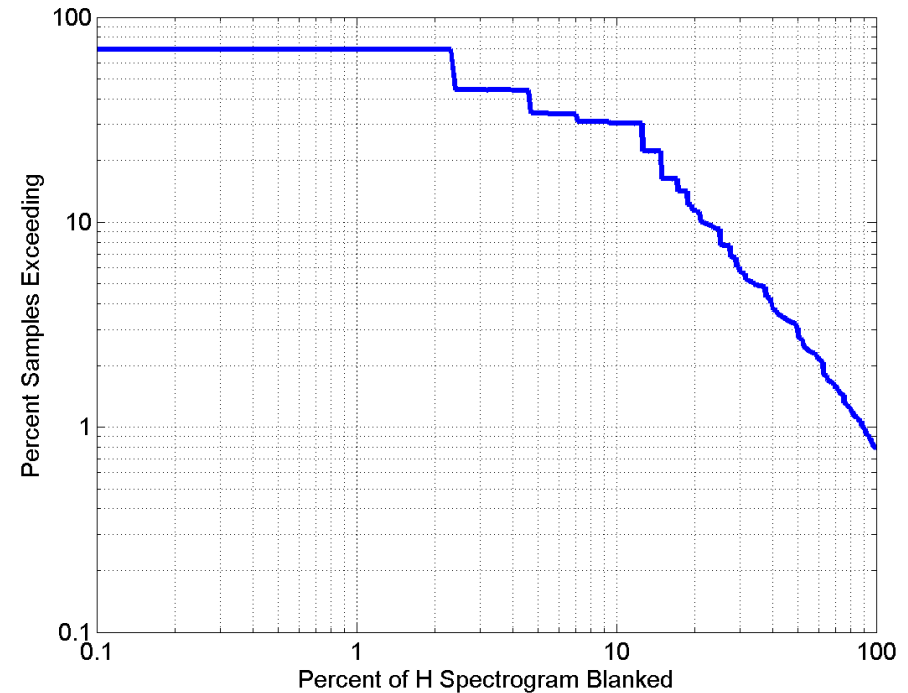Algorithms and
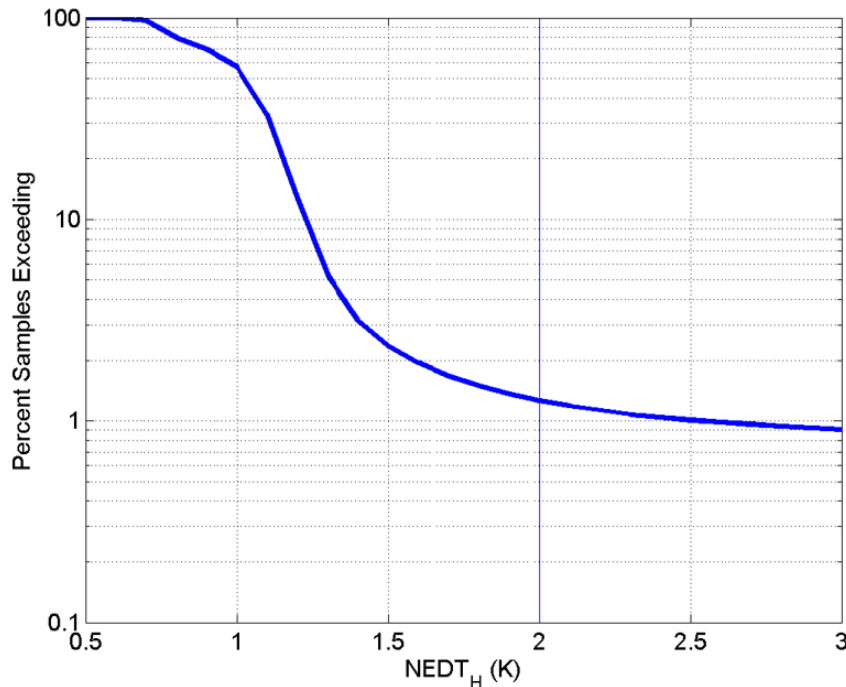Quality Checks
Clearly Eliminate
Large RFI
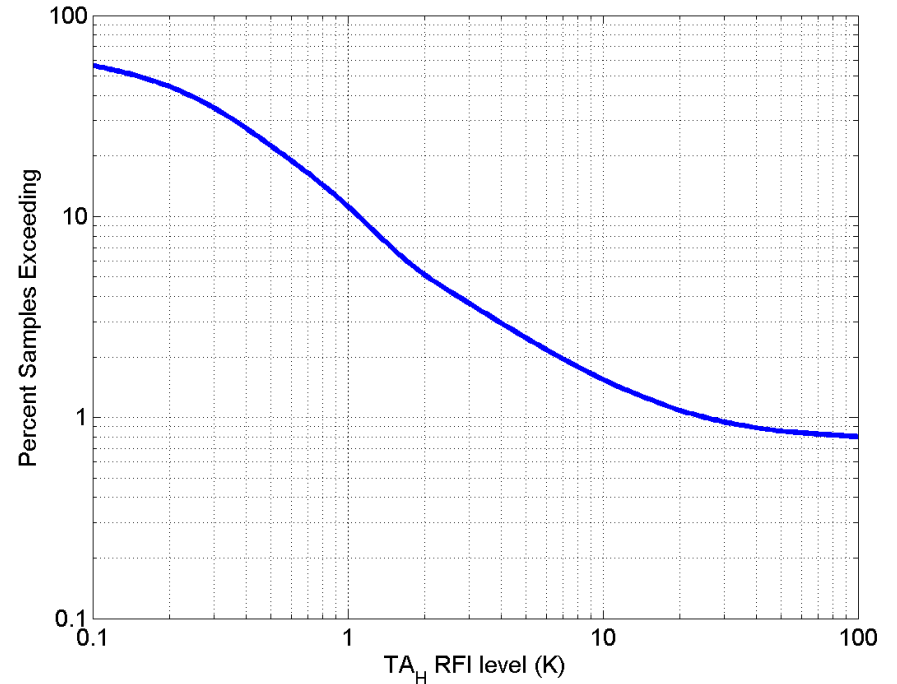
~1% of Samples Have
RFI >30K detected

NEDT and Fraction of Spectrogram Blanked Stats
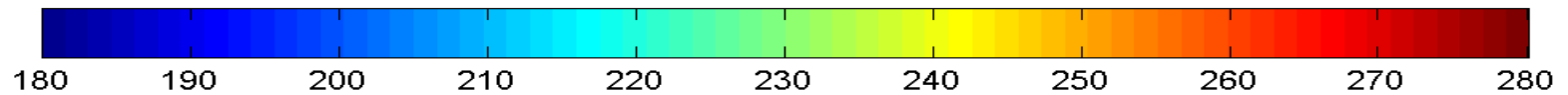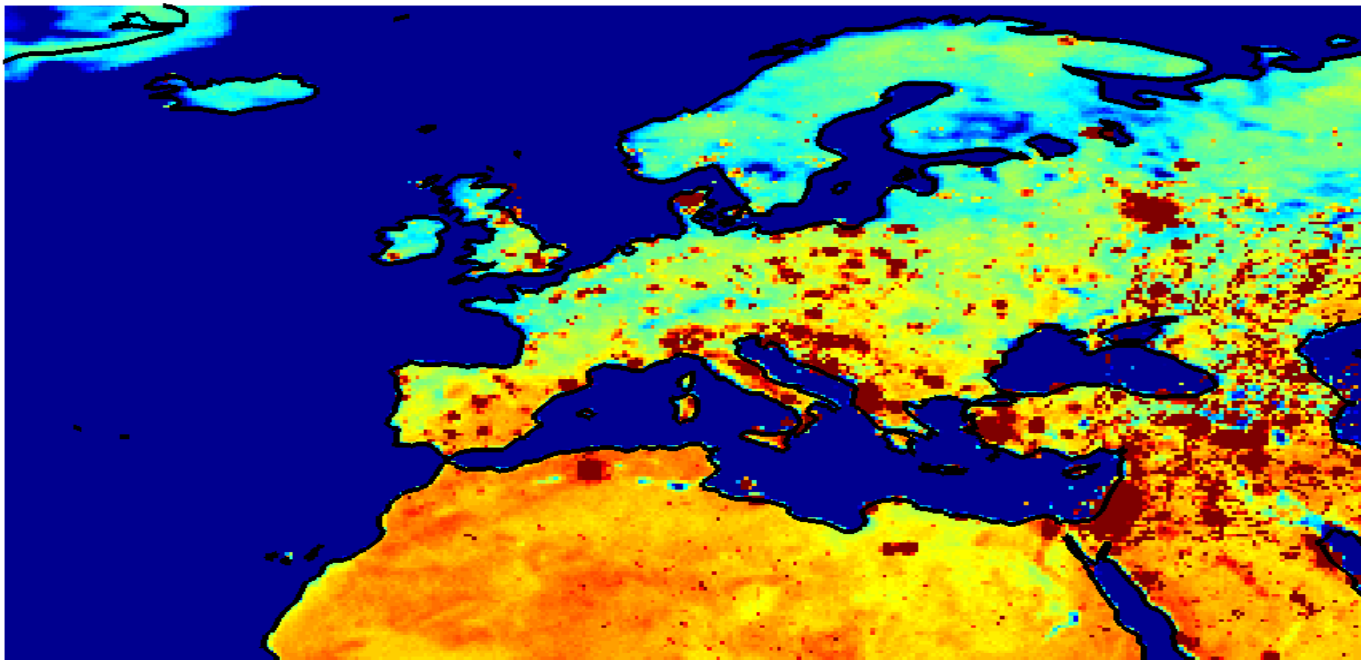
- 5/1-5/26/15, H pol

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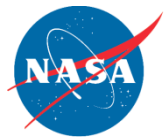- ~ 2% of data flagged for RFI overall (not including 'out of range' flag applied at TB level)

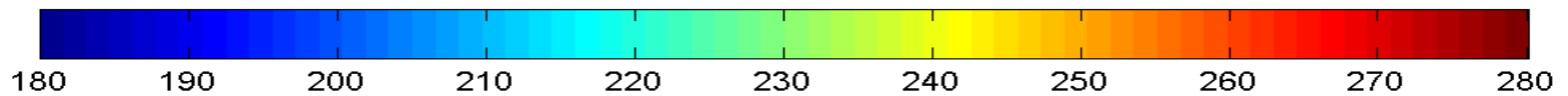# TA unfiltered Europe

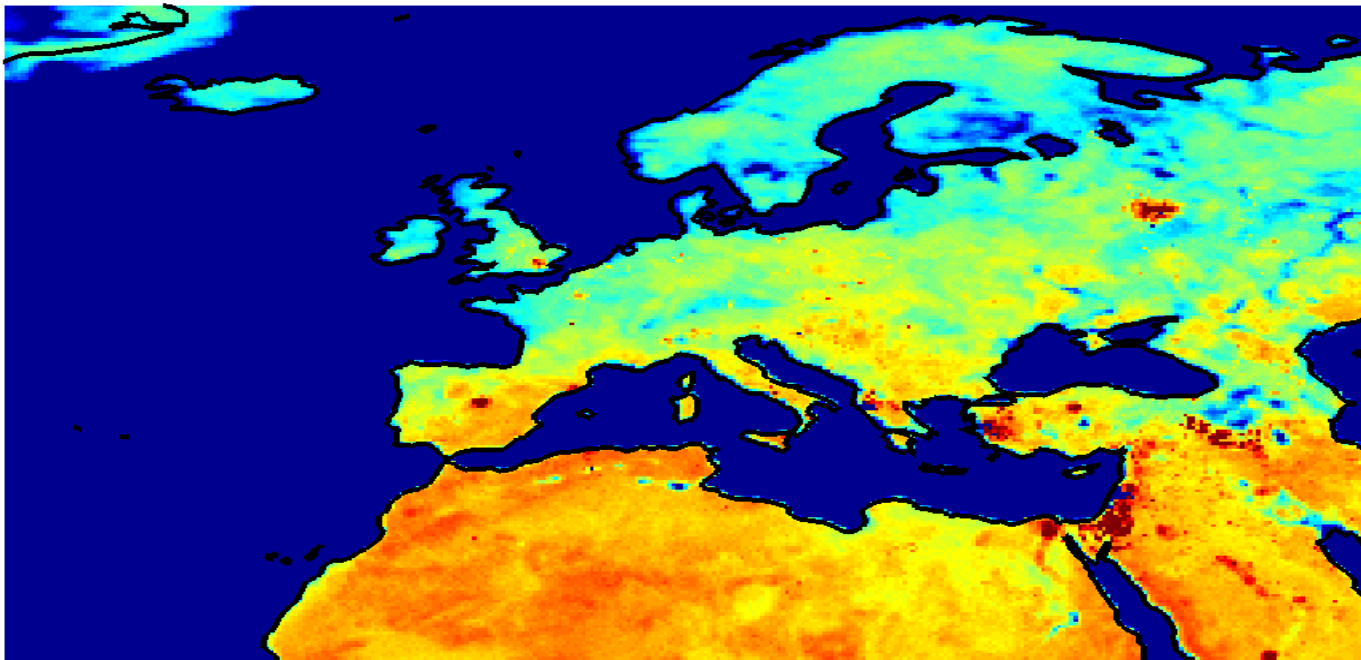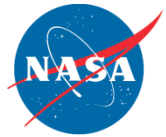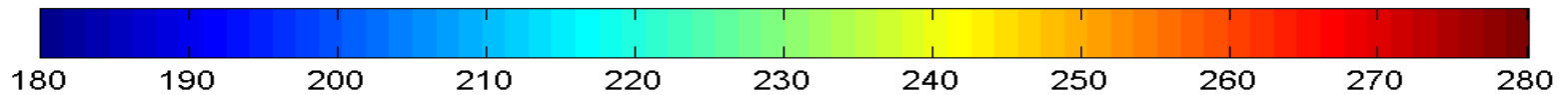Max H-pol Ta (K) CRID:11580_001
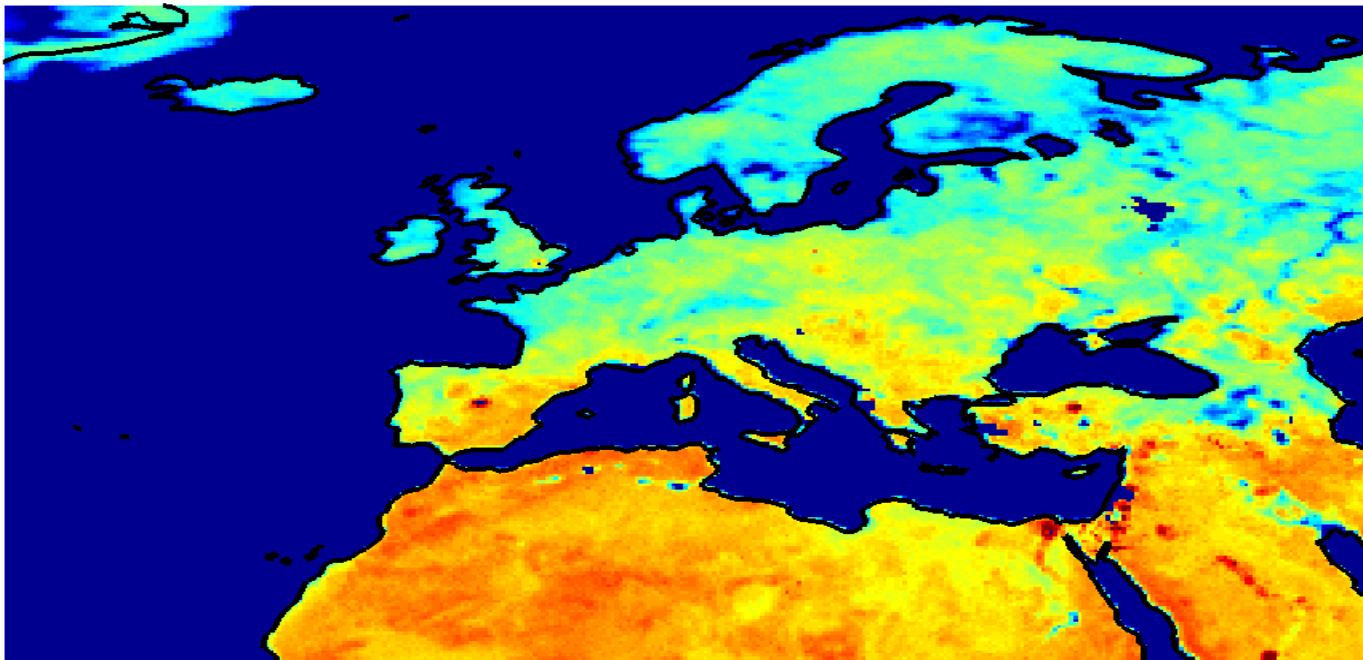
0.25° grid

TA filtered Europe

TA filtered Europe
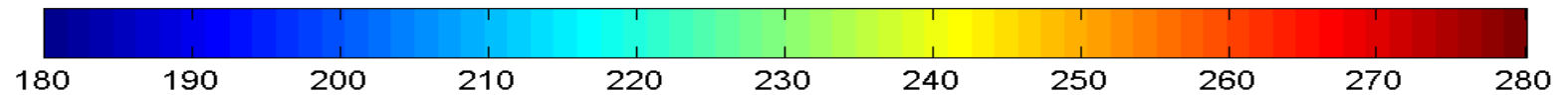

Max H-pol Ta filtered (K) CRID:11580_001
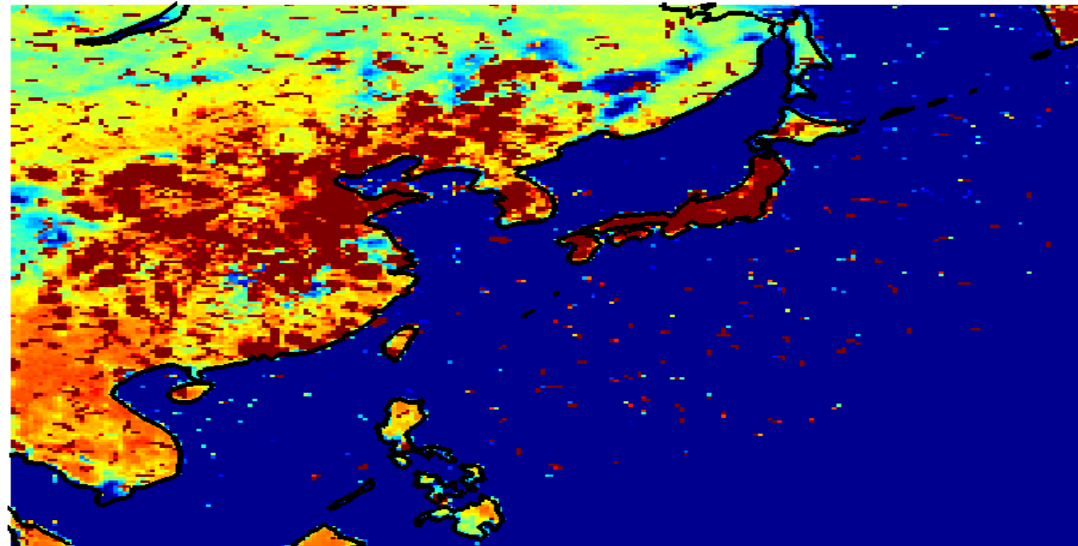
0.25° grid

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

TA filtered Asia

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

0.25° grid

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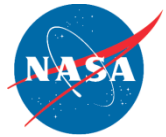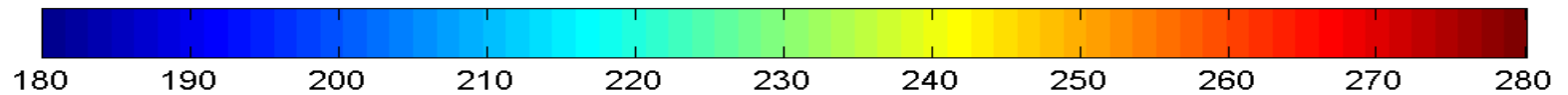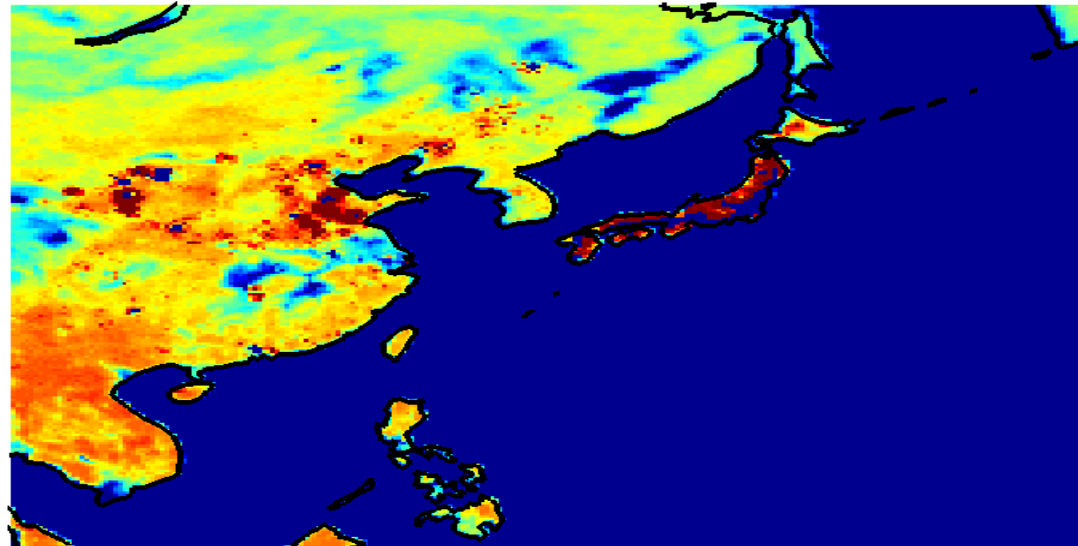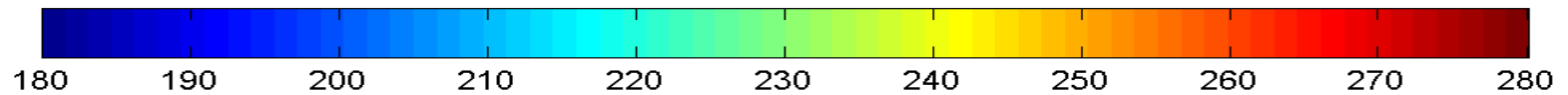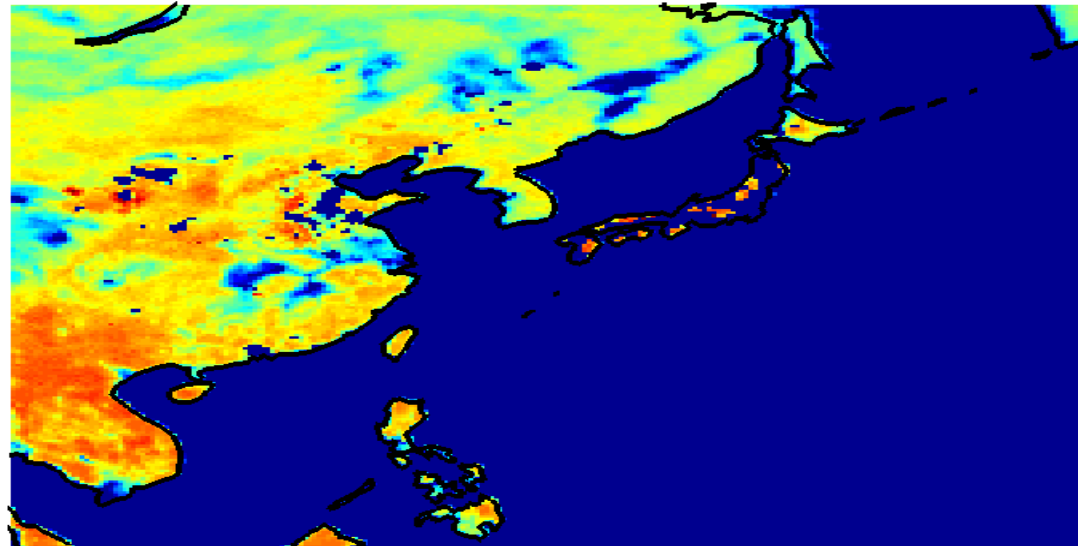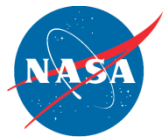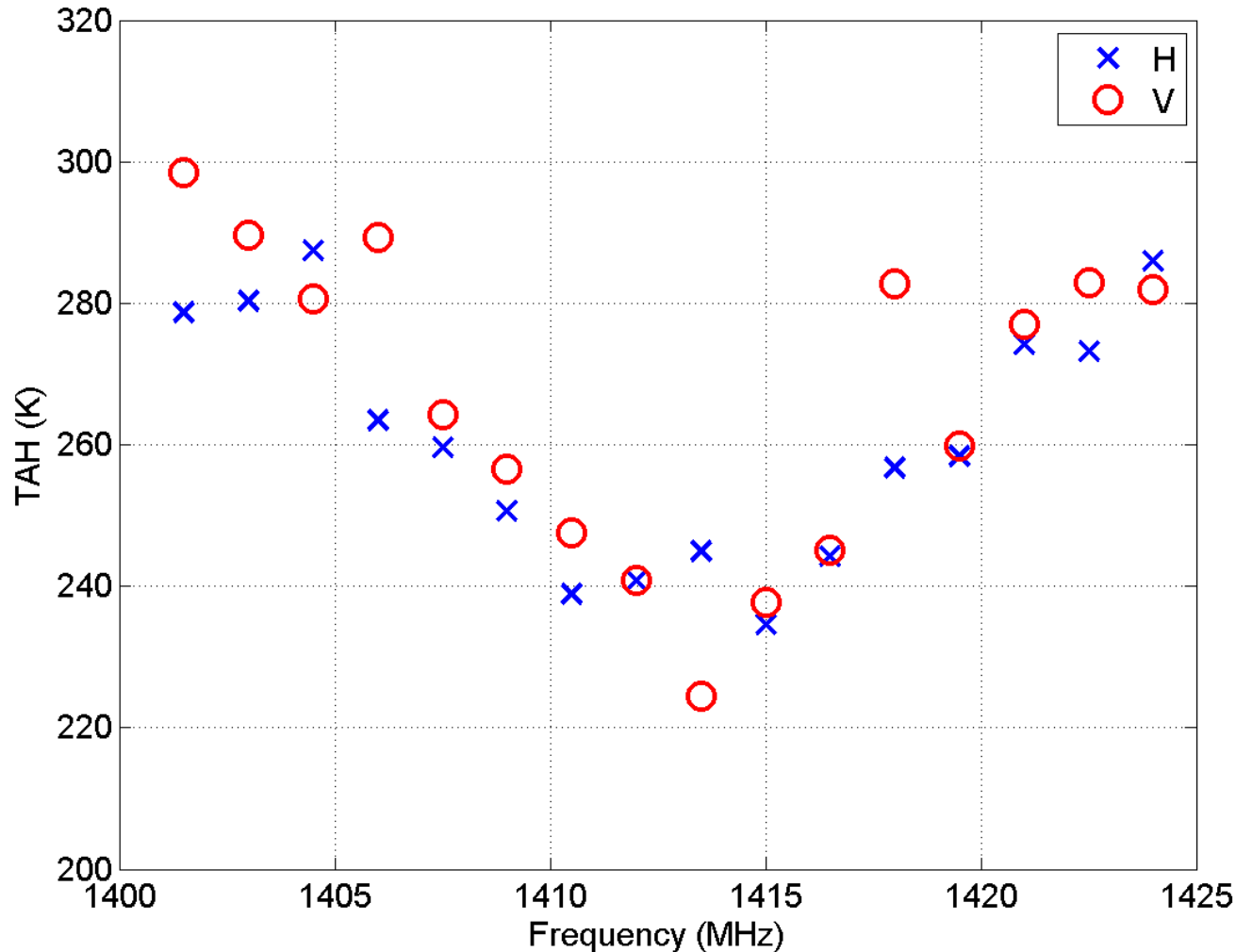residual RFI appear to still be in product

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