ATMS Airborne SDR Validation, Spectral Analysis, & Correlation Analysis

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Outline

- **NAST-M cross-validation from S-NPP Field Campaign**
- **S-NPP and J1 ATMS Spectral Analysis**
- **S-NPP and J1 ATMS Correlation Coefficients Analysis**

Radiance Versus Modeling Verification

Radiance to Radiance Comparisons

- Separate sensors measuring nearly the same point at the same time
- Examples include Simultaneous Nadir Observations (SNO) or aircraft underflights
- Pros: same atmosphere and surface conditions with similar instrumentation
- Cons: Different spectral or spatial characteristics and small data sets

Radiance to Model Comparisons

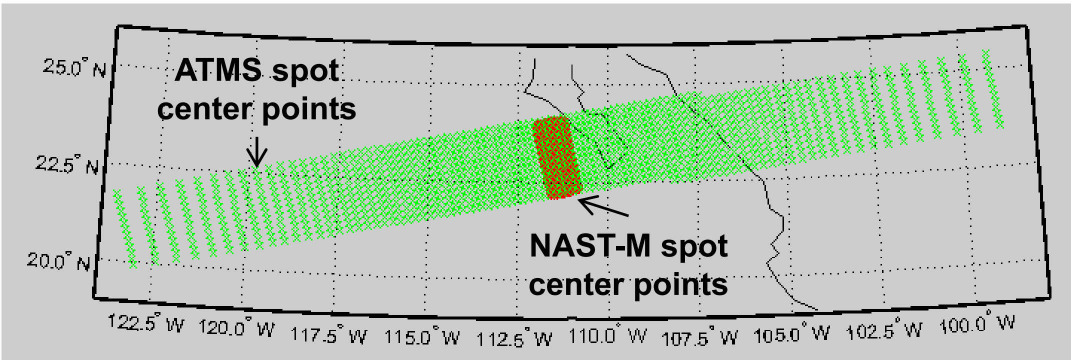
- Model the sensor and the atmosphere
- Examples include using state-of-the-art NWP, radiative transfer, and surface models
- Pros: large amounts of data
- Cons: Idealized or measured spectral or spatial characteristics and modeling errors

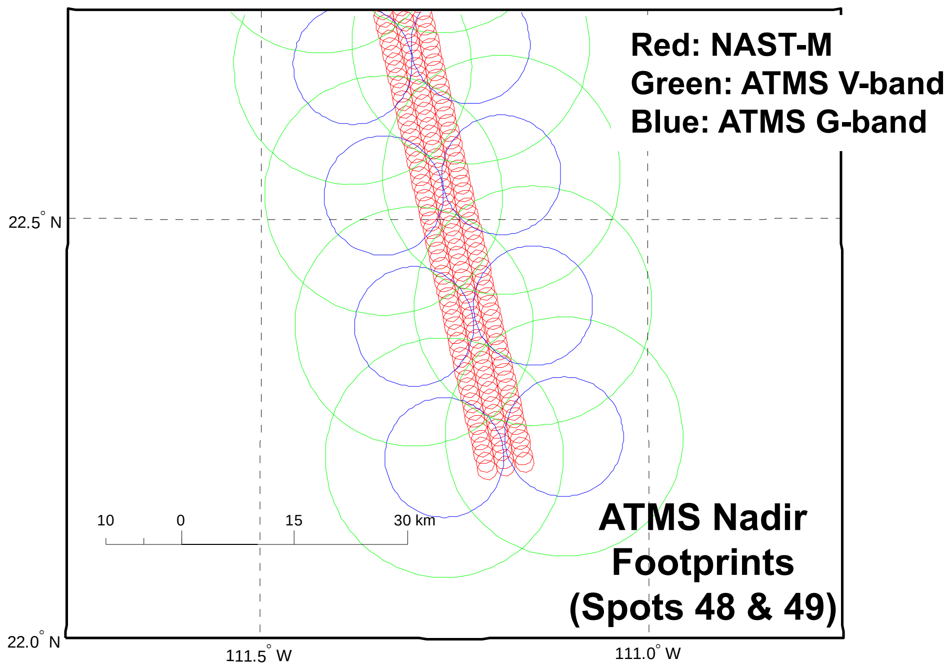
Airborne Validation Status

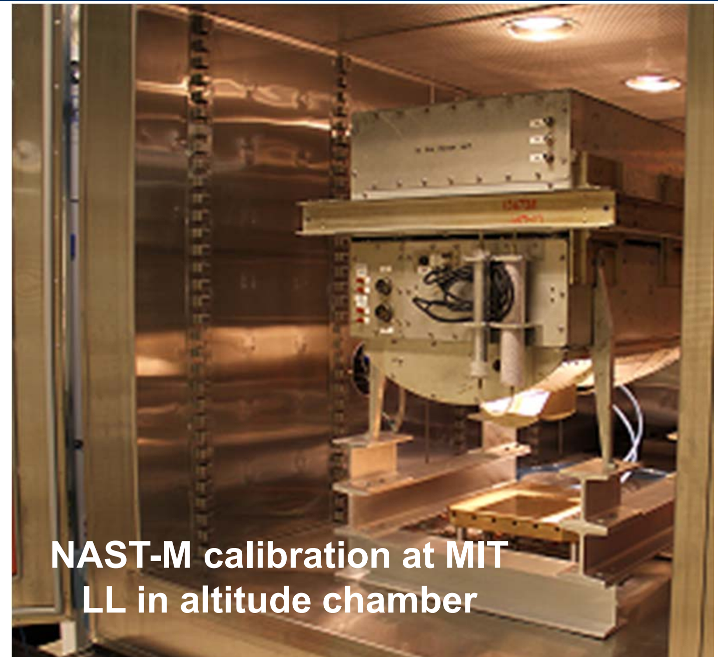
- **Calibrated NAST-M (V-band & upper G-band) in altitude chamber using precision microwave calibration target from 100-325 K at the instrument's high-altitude operating temperature**
- **NAST-M calibrated to these residual errors:**
  - **V-band: <0.25 K from 200-325 K**
  - **G-band: <0.30 K from 200-325 K**
- **Compared S-NPP ATMS measurements against NAST-M for the 10May2013 sortie**

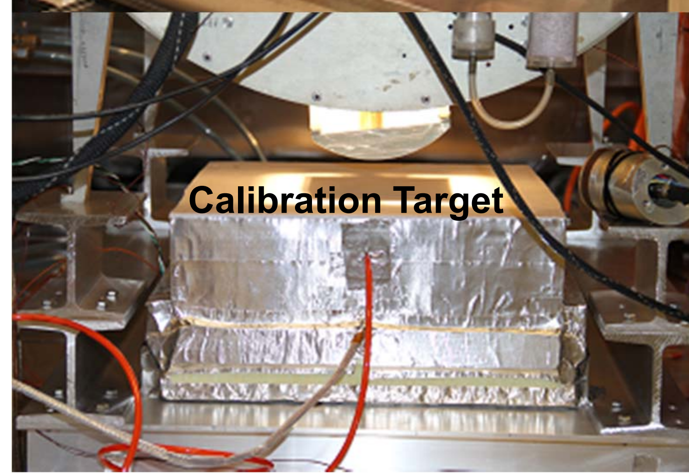
S-NPP Mission Cal/Val Campaign

10 May 2013 Sortie over Gulf of CA









Science Sorties During S-NPP Mission

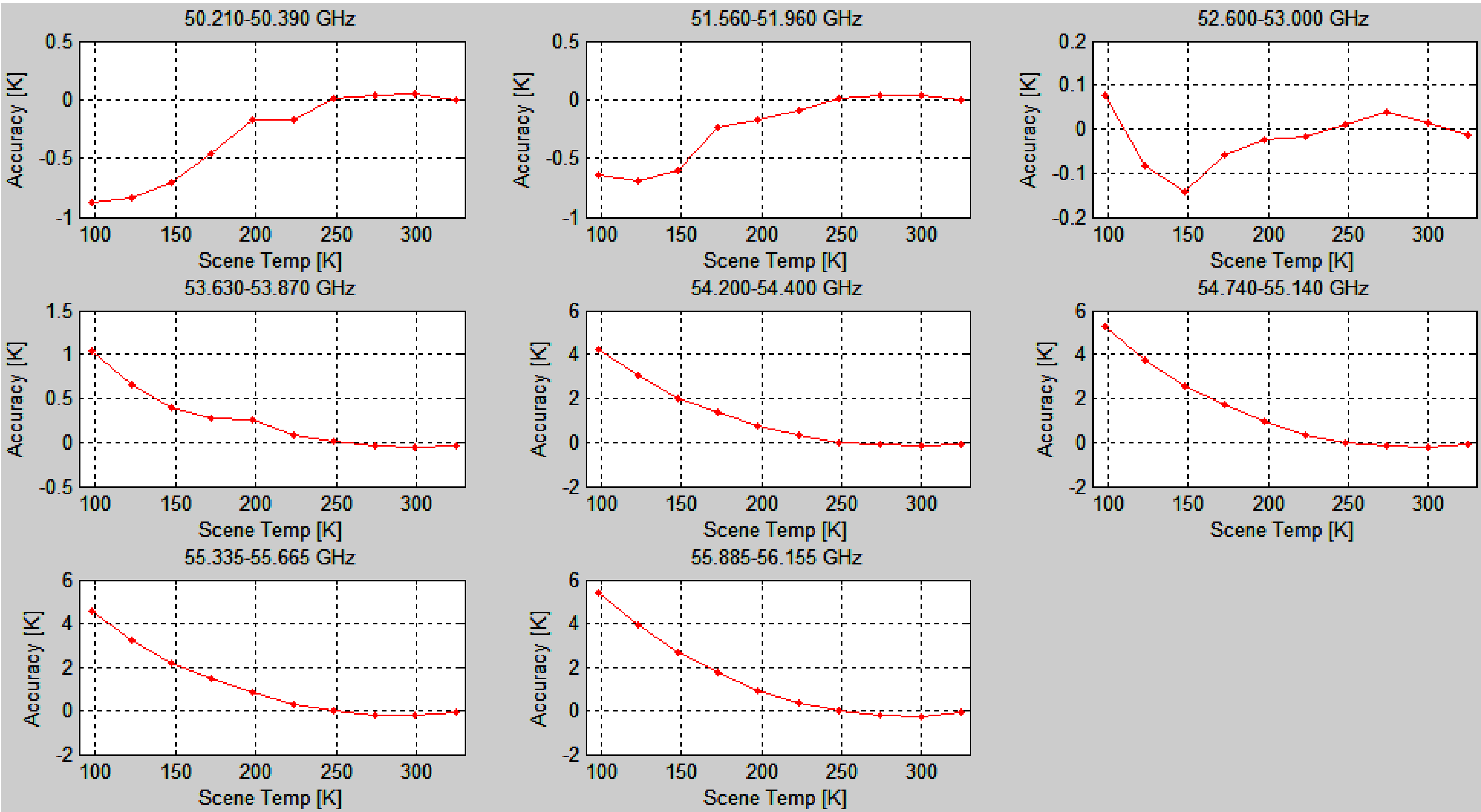
NAST-M has data from 12 flights ~81 hours

Data Collected (✓)
No Data Collected (✗)

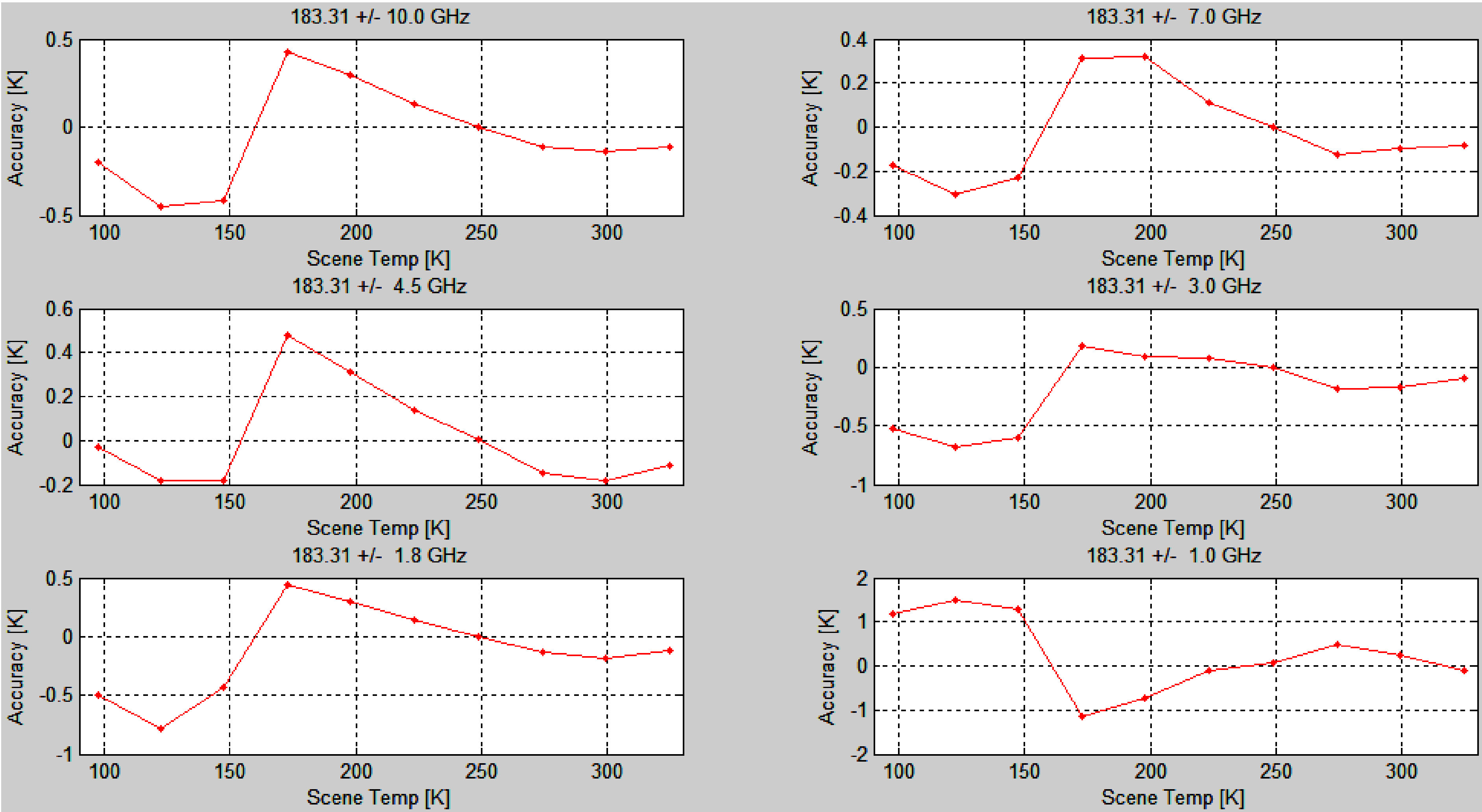
Data Source	May 7th	May 10th	May 15th	May 16th	May 18th	May 20th	May 22nd	May 23rd	May 24th	May 30th	May 31th	June 1st
NAST-M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗
GPS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗
Video	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗
ER-2 NAV	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗
Drop Sonde	✗	✗	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗
Radioondes	✗	✗	✗	✓	✓	✓	✗	✓	✓	✗	✗	✗
Salton Sea	✗	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗
NAM	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗
ECMWF	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗
Overpass												
NPP	✓	✓	✓	✗	✓	✓	✗	✓	✓	✓	✓	✗
Aqua	✓	✓	✓	✗	✓	✓	✓	✓	✗	✗	✗	✗
Metop-A	✗	✗	✓	✓	✓	✓	✗	✗	✗	✓	✓	✗
Metop-B	✗	✓	✓	✗	✓	✓	✓	✗	✓	✗	✗	✗
Conditions												
Time Of Day	Day	Day	Day	Day	Day	Day	Day	Day	Day	Night	Night	✗
Surface type	Ocean	Mixed	Mixed	Mixed	Land	Land	Land	Ocean	Land	Ocean	Mixed	✗
Weather	Cloudy	Clear	Clear	Scattered	Thin Cirrus	Scattered	Clear	Cloudy	Scattered	Scattered	Clear	✗
Flight Time (H)	6.35	5.98	7.63	8.13	6.25	8.47	9.2	6.58	8.03	6.22	8.18	0

Collected data from 9 S-NPP overflights

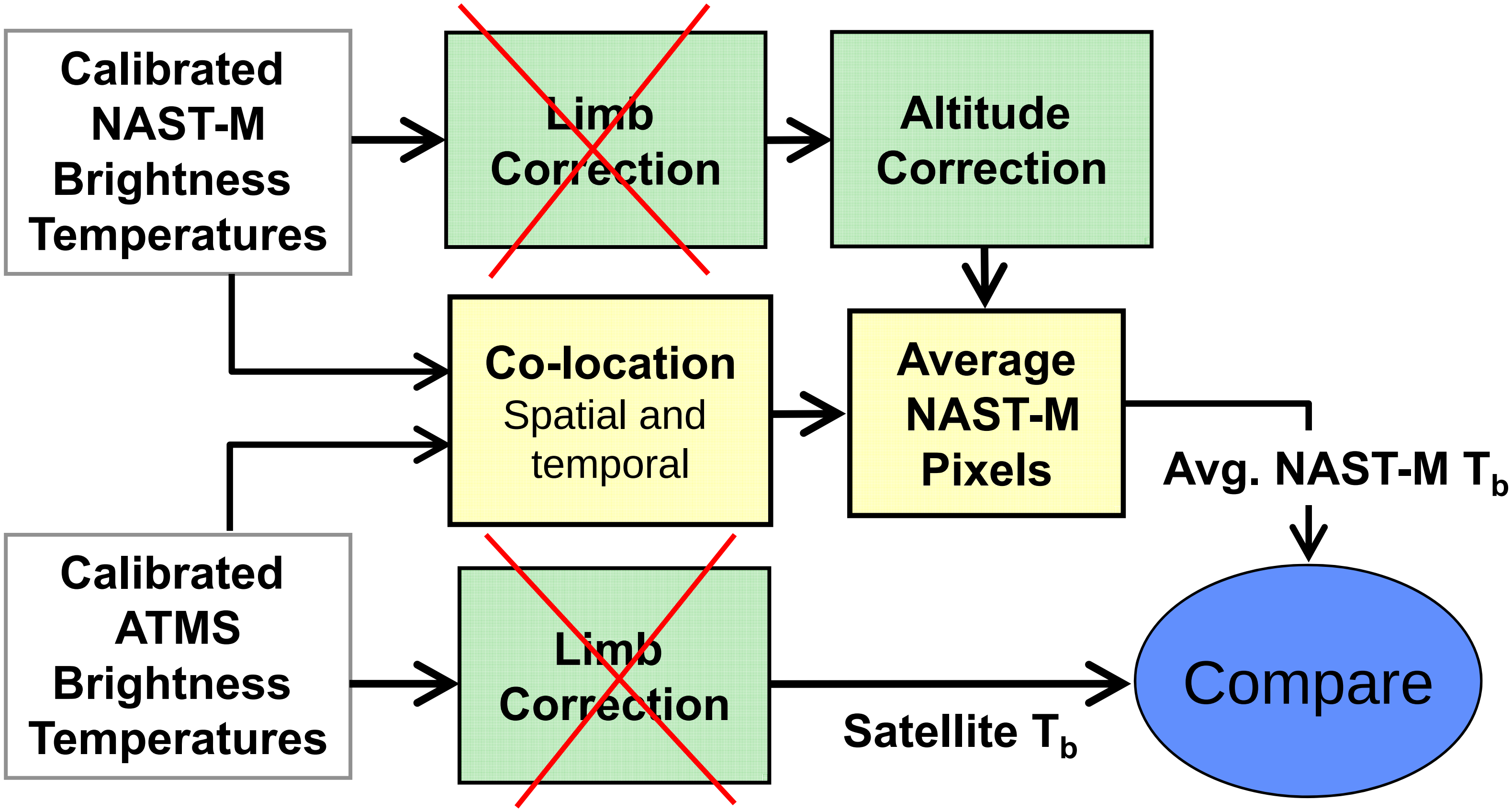
NAST-M Calibration Accuracy: 54 GHz Band



NAST-M Calibration Accuracy: 183 GHz Band



Matchup Flowchart



Green boxes need one of these:

1) **Radiosonde or dropsonde (Most desirable)**
2) **Simulated model output (e.g., ECMWF)**
3) **Retrieved profile from a different instrument**

Altitude-Corrected Aircraft Brightness Temperature (T_b)

AC– Aircraft
NWP– Numerical Weather Prediction
SAT– Satellite
TOA– Top of Atmosphere

NWP: Temperature, Pressure, H_2O, O_3 → **Radiative Transfer Model** → $T_b^{NWP}\left(\text{sim} \updownarrow_{\text{Surface}}^{x}\right)$

T_b^{SAT}

$$T_b^{\Delta} = T_b^{SAT} - T_b^{AC}$$
$$\approx 0.1 \leftrightarrow 1\,\text{K}\,(54\,\text{GHz})$$
$$\approx 0.01 \leftrightarrow 0.1\,\text{K}\,(183\,\text{GHz})$$

Use Simulated Brightness Temperatures

$$T_b^{SAT} \approx T_b^{NWP}\left(\text{sim} \updownarrow_{\text{Surface}}^{\text{TOA}}\right)$$
$$T_b^{AC} = T_b^{NWP}\left(\text{sim} \updownarrow_{\text{Surface}}^{\text{AC}}\right)$$

T_b^{AC}

Surface

$$T_b^{\text{Alt-Corrected}} = T_b^{AC}\left(\text{meas} \updownarrow_{\text{Surface}}^{\text{AC}}\right) + T_b^{\Delta}$$

S-NPP 10 May 2013 Matchup

Residual Error between ATMS measurements and NAST-M (ATMS – NAST-M) at nadir

Lower V-Band ATMS Channels

ATMS	Ch. 3	Ch. 4	Ch. 5	Ch. 6	Ch. 7	Ch. 8	Ch. 9
TDR	0.95	-0.22	-1.6	0.59	-0.07	0.00	-0.36
SDR	1.38	0.34	-0.89	1.04	0.41	0.35	-0.19

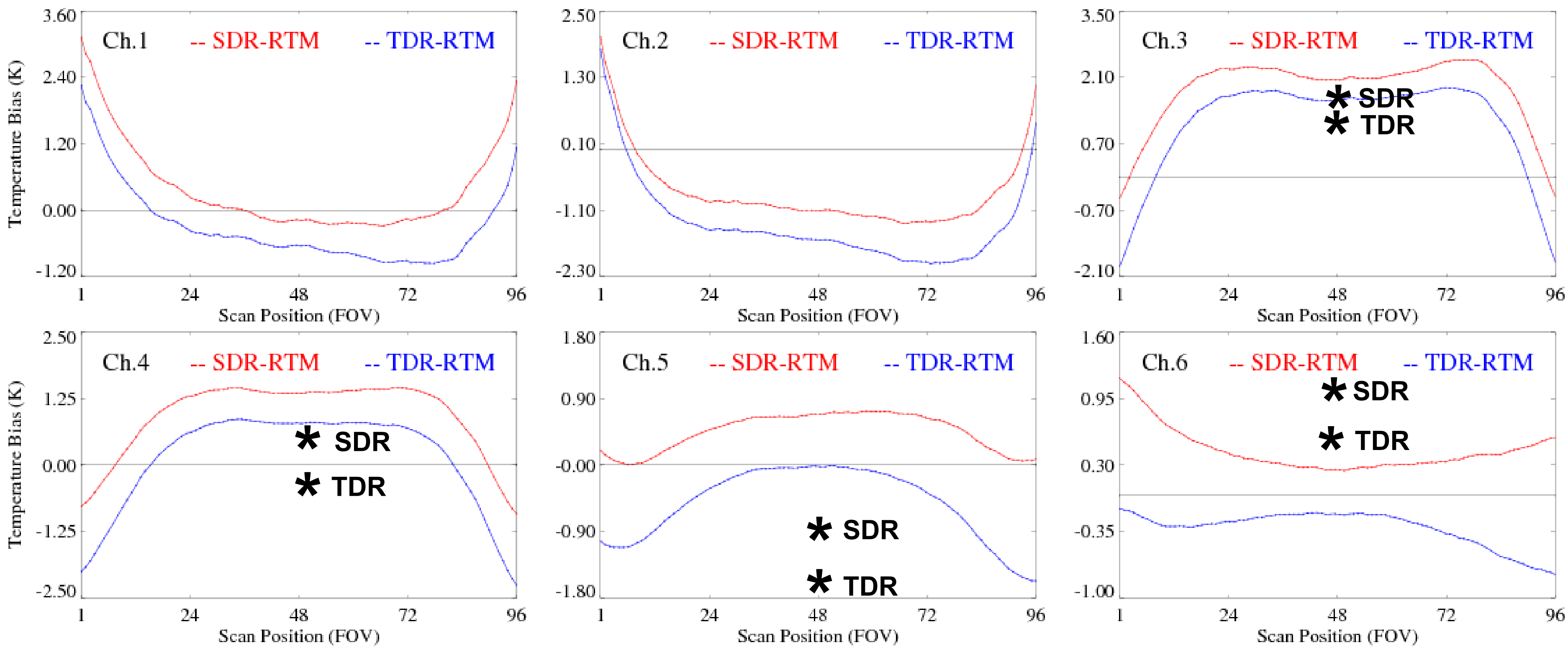
Upper G-Band ATMS Channels

ATMS	Ch. 18	Ch. 19	Ch. 20	Ch. 21	Ch. 22
TDR	-2.52	-2.11	-2.23	-1.24	1.58
SDR	-3.38	-2.93	-3.08	-2.11	0.62

TDR = Temperature Data Record or antenna temperature
SDR = Sensor Data Record or brightness temperature (scan bias corrected)

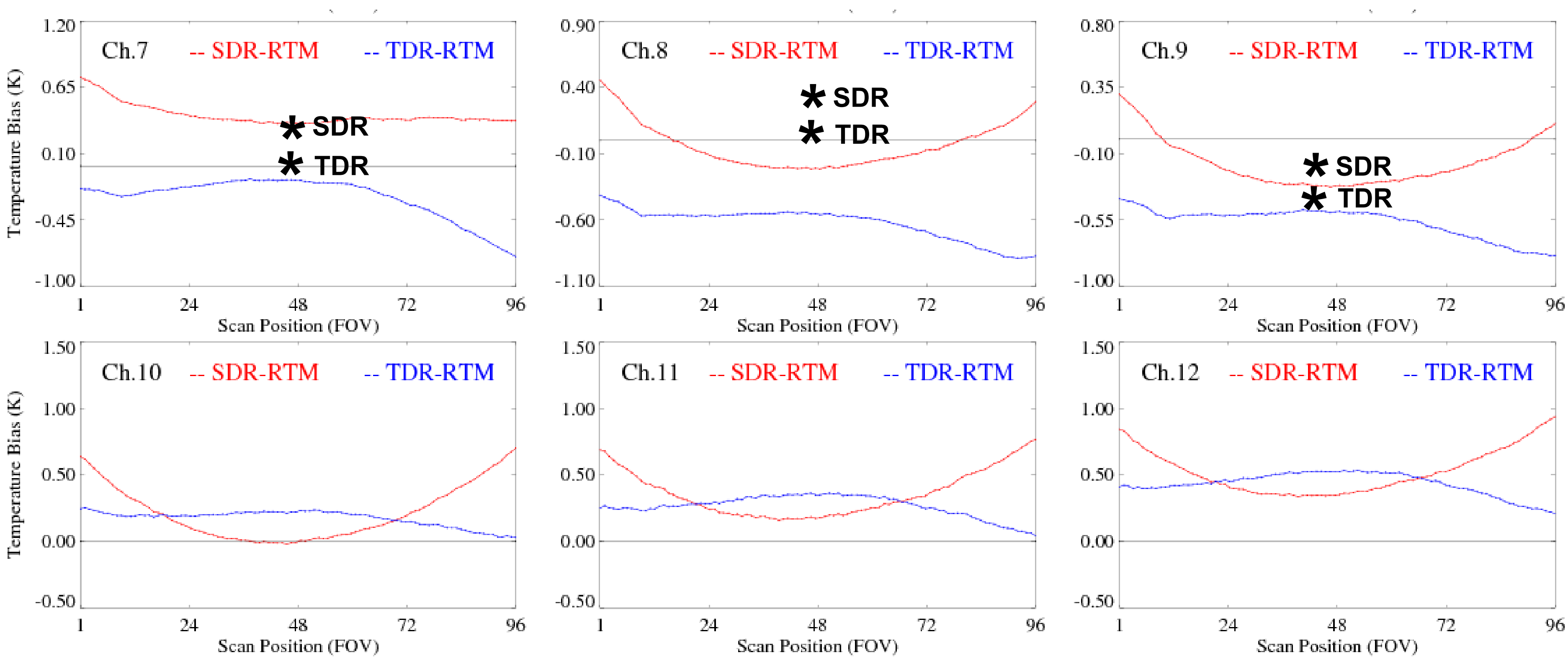
TDR-to-SDR Results: K and Lower V Band

ATMS Residuals of SDR and TDR against ECMWF/CRTM for May 24, 2013 over ocean and under clear skies from STAR



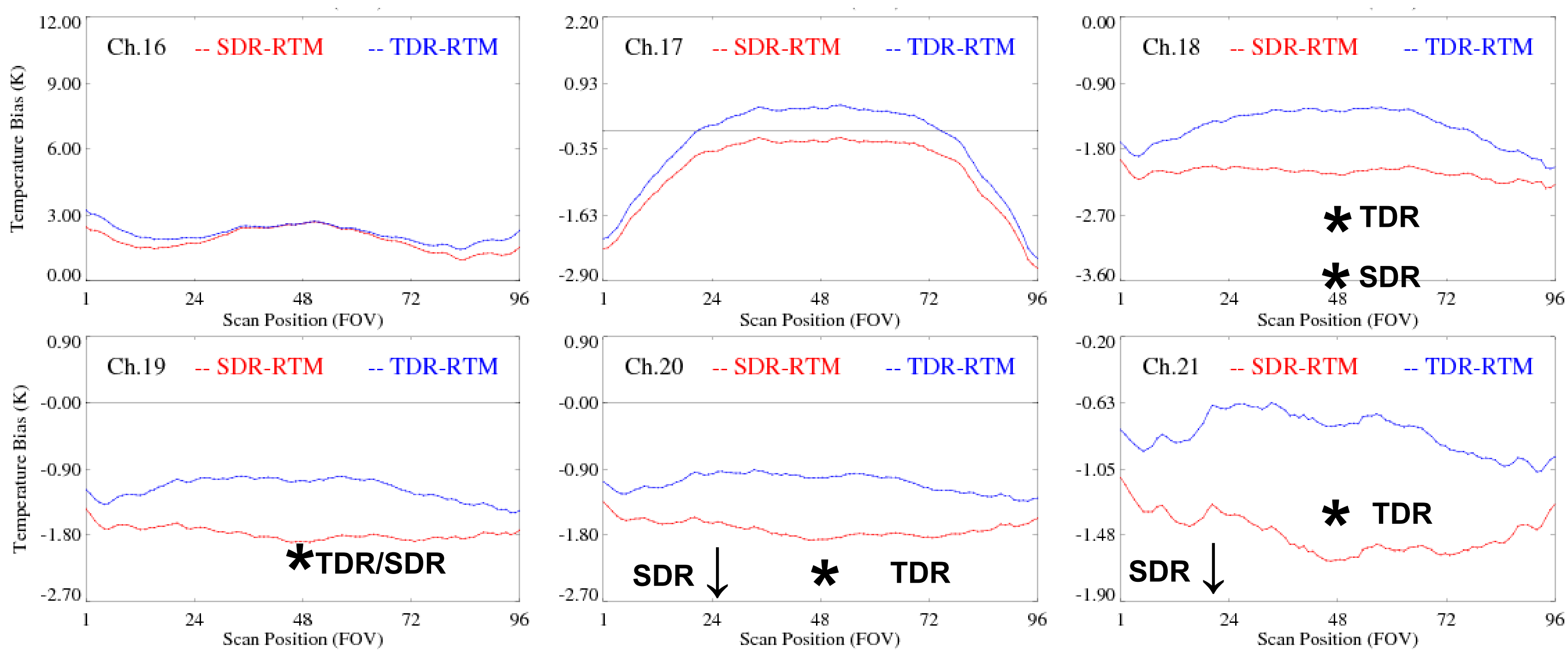
*** NAST-M Result from 10 May 2013; clear skies over ocean with limited # of high quality matchups**

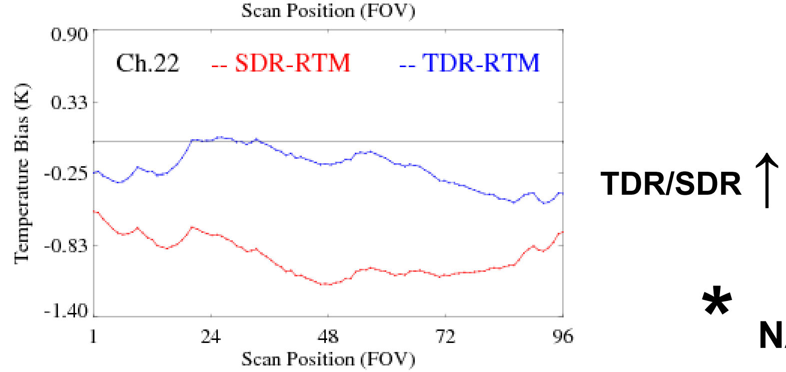
TDR-to-SDR Results: Upper Air Sounding



* NAST-M Result from 10 May 2013; clear skies over ocean

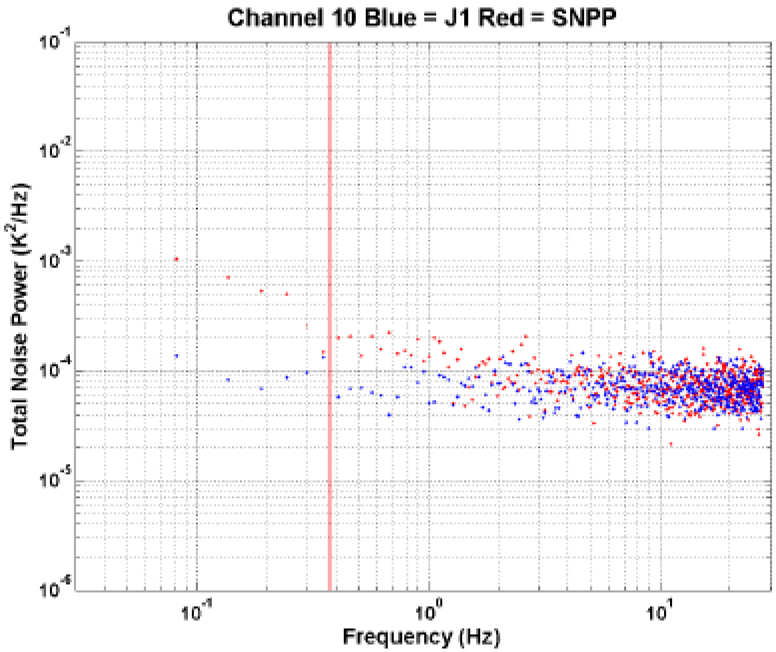
TDR-to-SDR Results for W/G Band

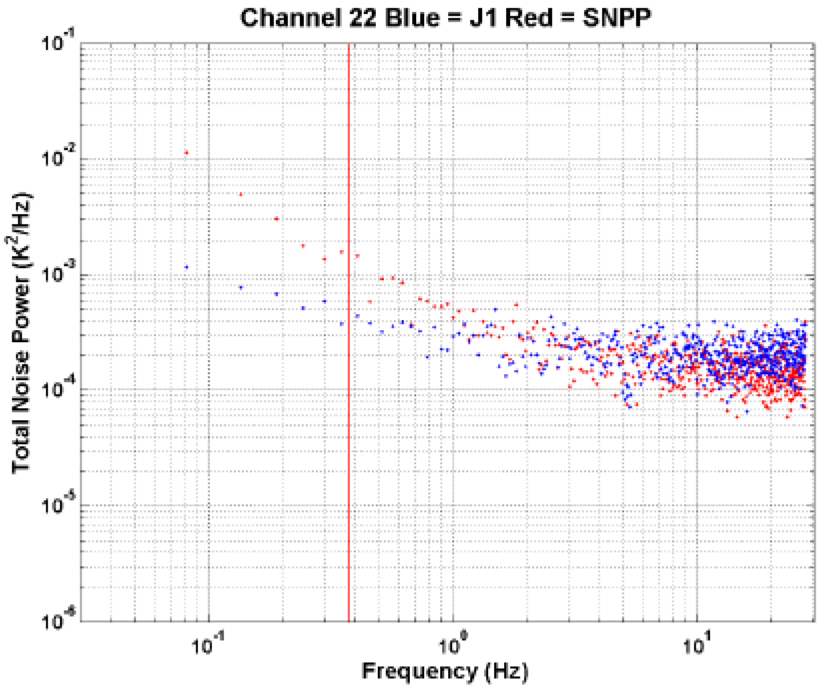




*** NAST-M Result from 10 May 2013; clear skies over ocean with limited # of high quality matchups**

Example Power Spectral Densities





- PSD show the 1/f noise on the left and the thermal noise to the right
- The red vertical line is the calibration frequency (scan period) and the calibration algorithm effectively applies a highpass filter to the spectrum

Brightness Temperature Correlation

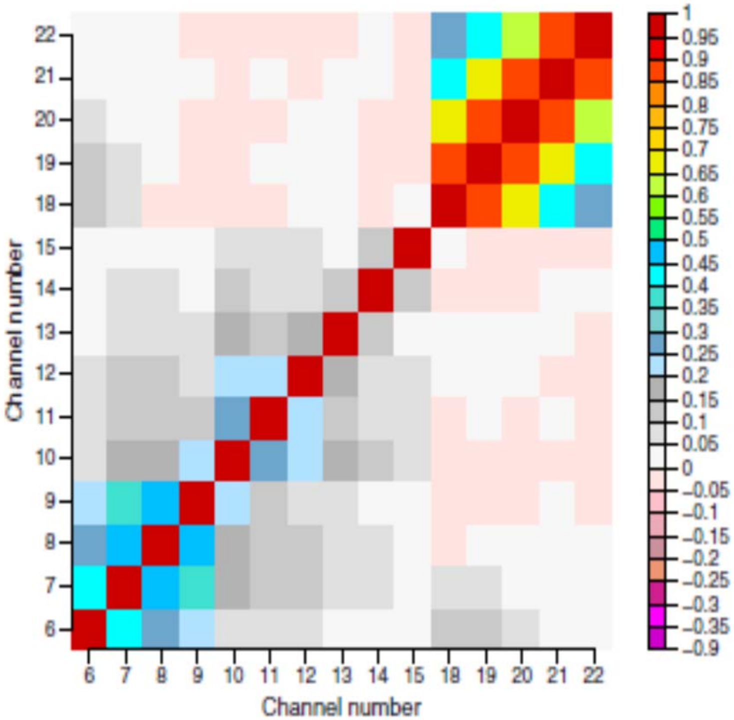
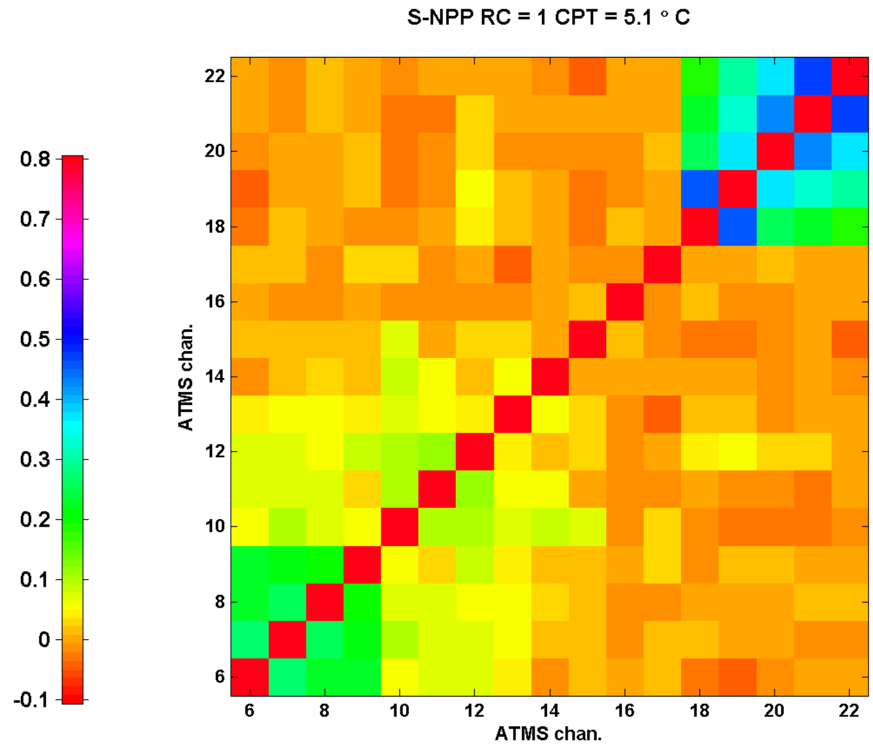


Figure 6. Estimates of interchannel error correlations based on the Desroziers diagnostics for ATMS. Statistics are based on used data over sea for 1–31 July 2012 (only scenes for which all considered channels are assimilated).



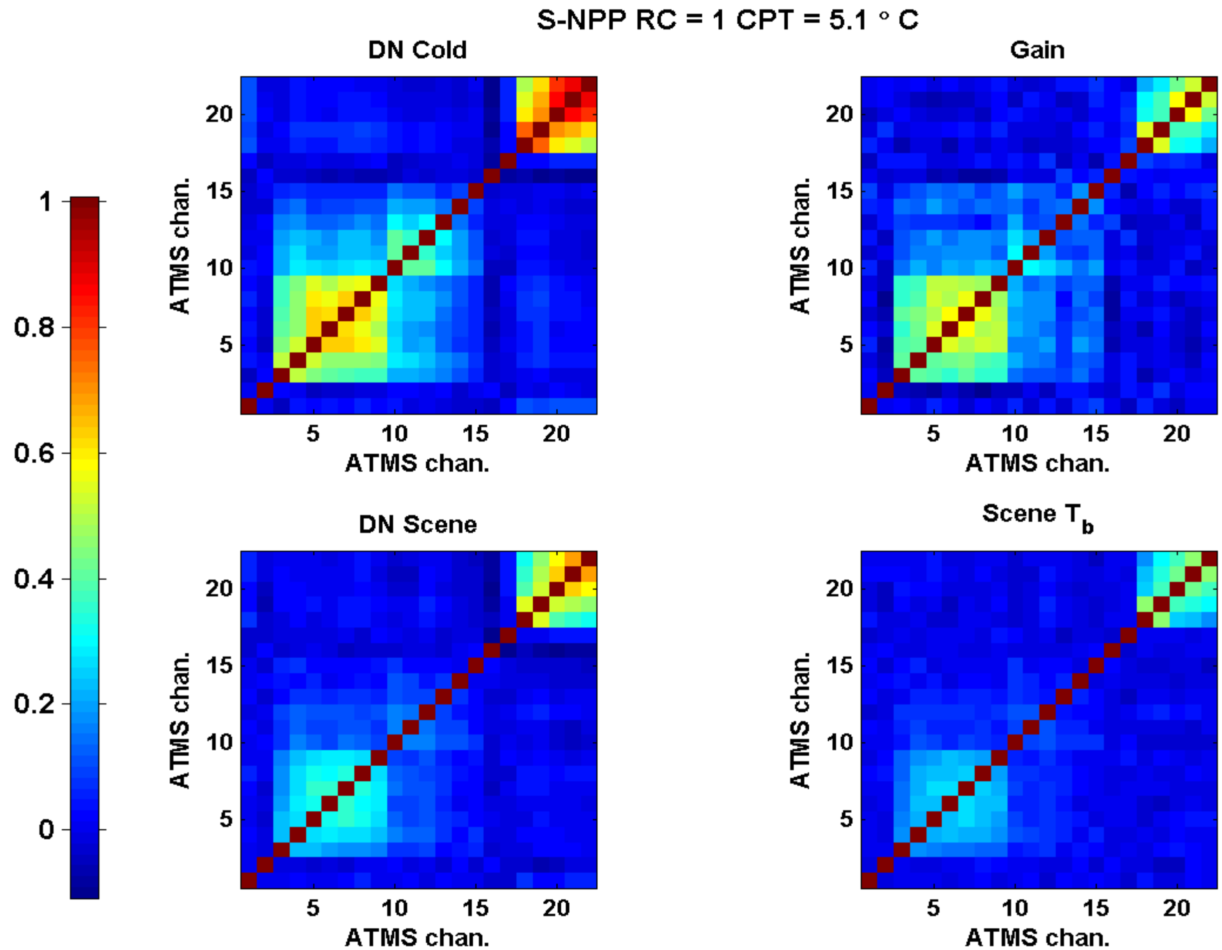
S-NPP Brightness temperature correlation coefficient matrix from pre-launch TVAC calibration

Bormann et al., "Evaluation and assimilation of ATMS data in ECMWF" JGR-A Vol. 118 12,970-12,980

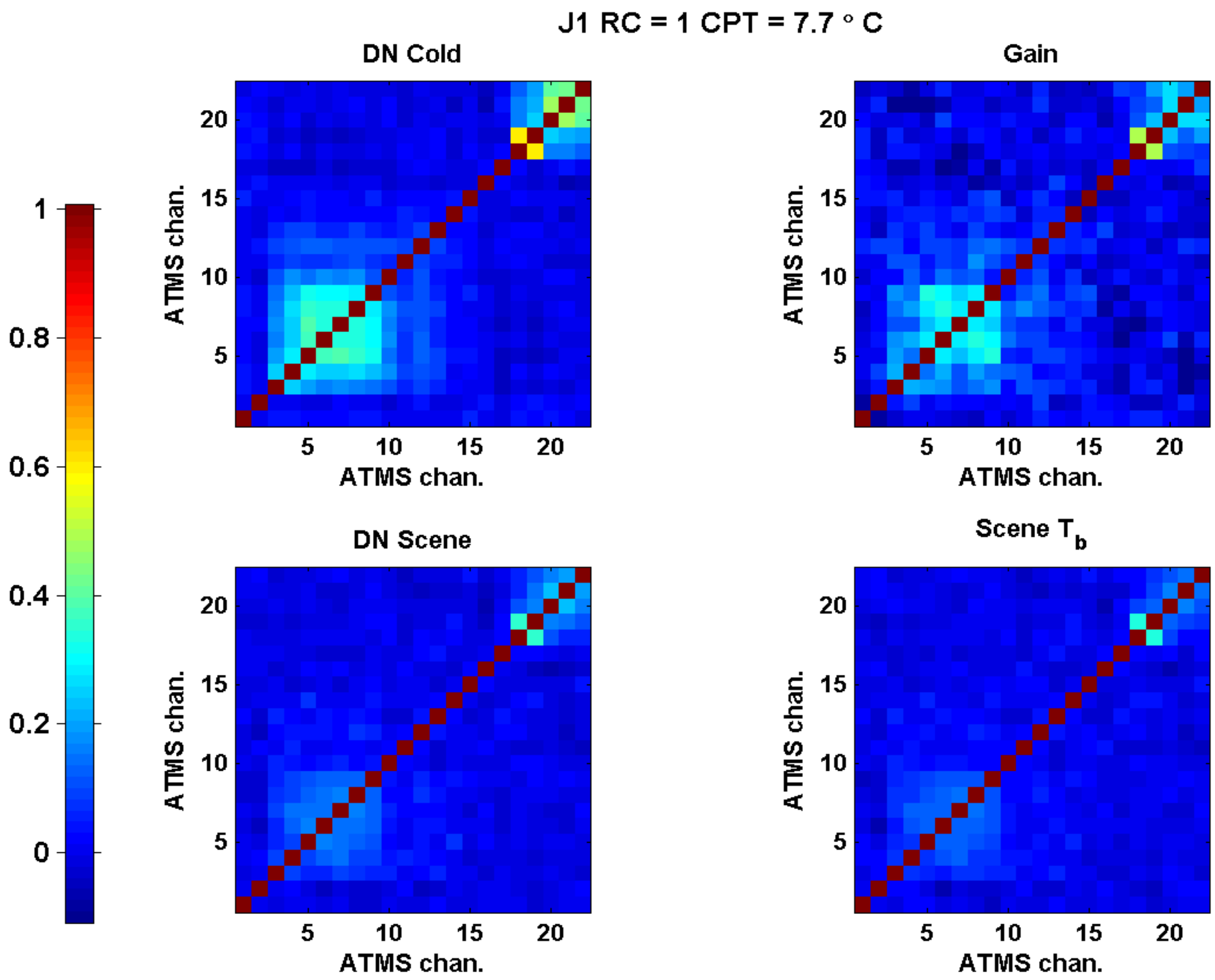
Correlation and the Calibration Algorithm

- **Pre-launch TVAC**
- **Two external targets and internal target**
- **Correlation matrix calculated for eleven scene temperatures**
- **Correlation matrices averaged after Fisher transform**
- **DN cold is the averaged four Space View measurements**
- **Gain uses eight scans in calculation**

$$T_b = gain \times \left(DN_{scene} - DN_{cold\ target}\right) + T_{cold\ target}$$



J1 ATMS Results



Summary

- Successful airborne campaign, but need to finish processing all sorties and investigate ATMS bias
- J1 ATMS 1/f noise and correlation is lower than S-NPP ATMS
- Need to analyze how the J1 & S-NPP spectra and correlation matrices impact data products and instrumentation

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