An Overview of the NPP ATMS RDR/TDR/SDR Cal/Val Plan

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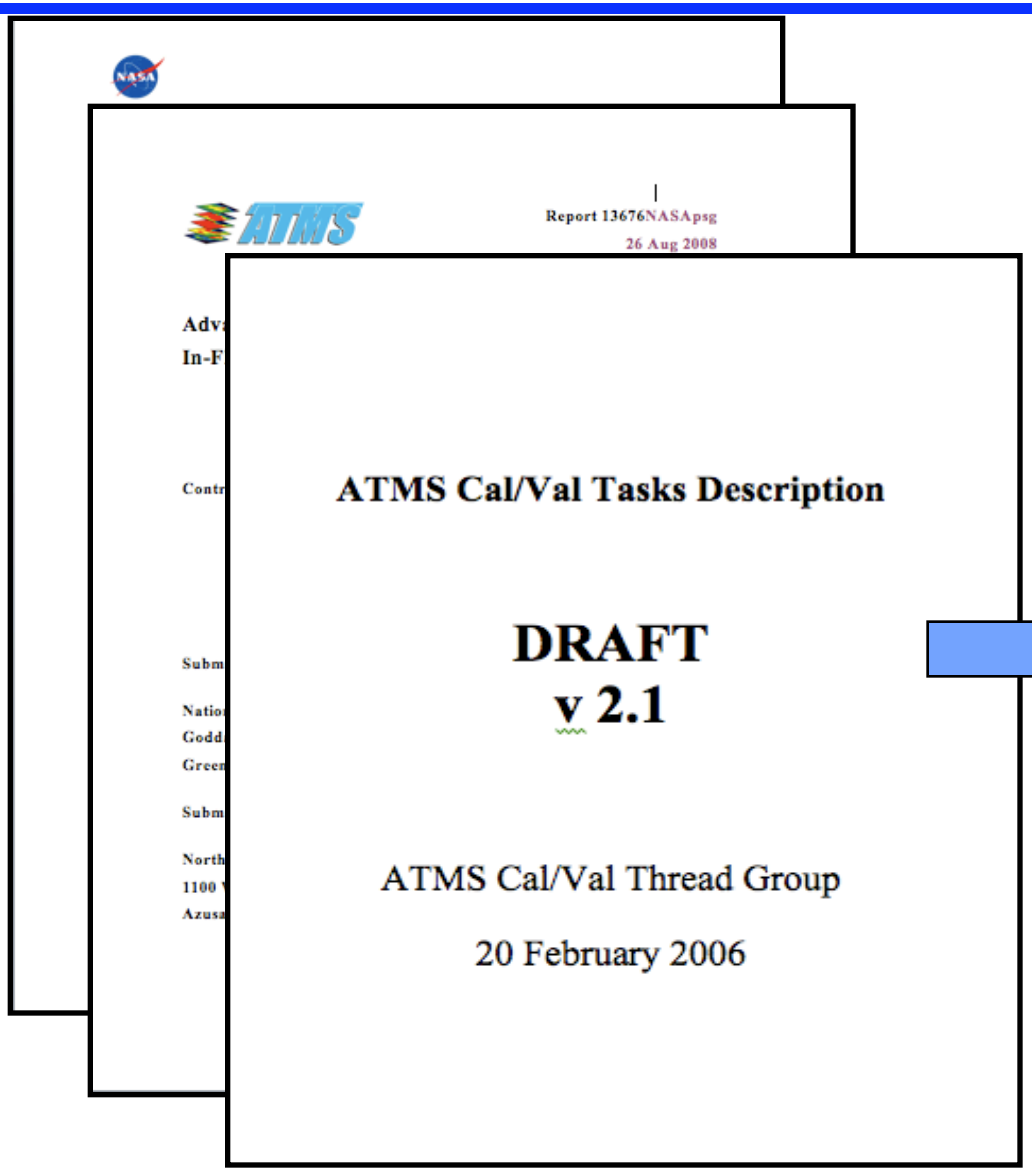
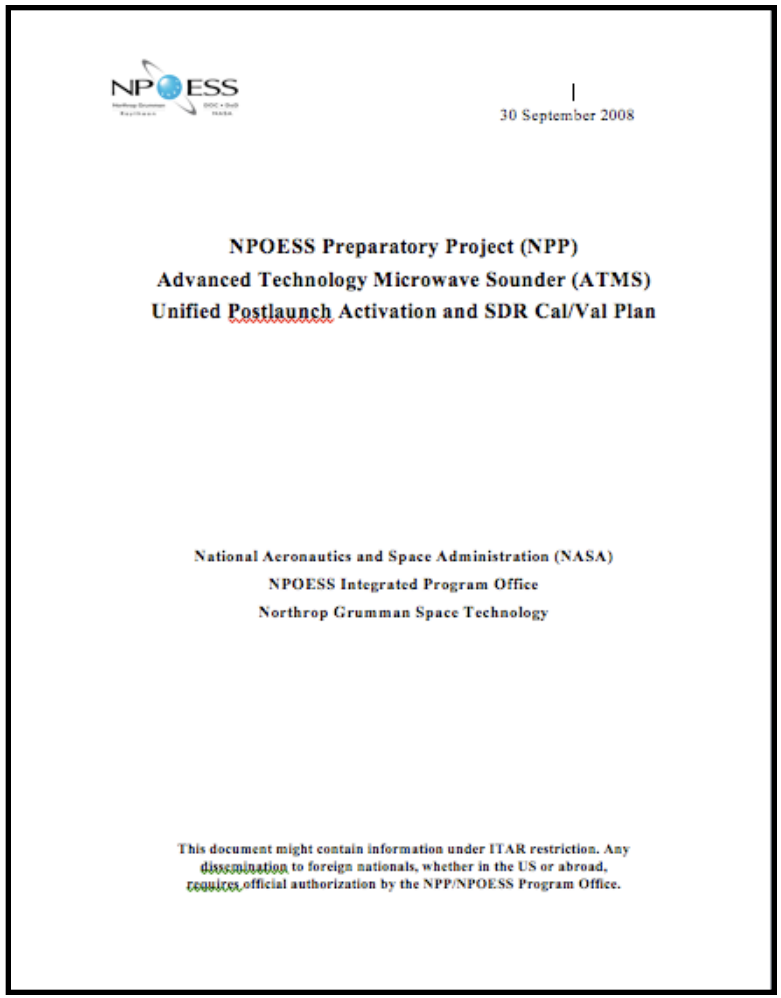
- Many others have graciously lent their time and talents to the ATMS Cal/Val planning effort over the years

Today's Objective

- Present a snapshot of a rapidly evolving unification of ATMS plan components developed by NASA/NGST/IPO+
  - Overview of Cal/Val task descriptions and goals
  - General sense of the Cal/Val timeline
  - Broad breakout of roles and responsibilities (preliminary)
  - Identify CrIS (and other) synergies to facilitate optimal coordination
    - Correlative resources
    - Analysis tools
    - Cross-comparisons
- Solicit feedback, suggestions for improvement (performance, efficiency), etc.

ATMS SDR Cal/Val Plan Unification
Led by SDL (Chidester, Fish, & Bingham)





ATMS Status

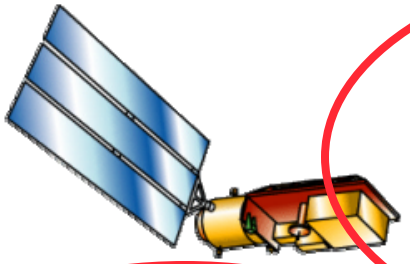
- ATMS flight unit (so-called “Proto-Flight Module”, or PFM) for NPP delivered in 2005
- ATMS FU2 (“Flight Unit 2”) for NPOESS C1 recently held ΔCDR
  - Delivery scheduled for June 2011
  - Recent discussions held involving additional pre-launch testing (more details later this morning)
- NPP Activation plan currently begin finalized
- NPP Spacecraft maneuver plan currently being finalized
  - There will be no NPOESS C1 S/C maneuvers

Five Space Segment Phases

GSFC 429-00-07-04

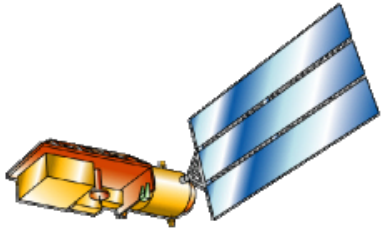
NPOESS NPP Space Segment Operations Concept

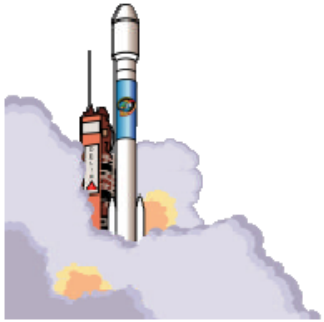
Launch/Ascent Phase (Days)
Liftoff thru Separation
S-Band C&T on pad through to on-orbit
Earth Acquisition-Coarse Pointing
Array Deployment
Energy Balance



Science Phase (5 years)
Science Calibration Evaluation **"Intensive Cal/Val (ICV)"**
Science Data Collection
Fine Pointing
Daily Command load (nominal) HRD,SMD Downlink

Activation & Checkout Phase (Weeks/Months)
Mission Orbit Acquisition
Establish Fine Pointing
Sensor Calibrations
Instrument Outgas
Instrument Activation





Prelaunch Phase
I&T
Launch checkouts
Launch rehearsals
Launch Mode

Disposal Phase (Days)
Retrograde Thrust
230 m/s ΔV
C&T.ACS.Props.Power

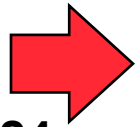
Space Segment Phase Descriptions

- Activation and Checkout Phase – "Once the satellite has completed its Launch/Ascent phase operations (nominally within an orbit or two), the satellite will enter the phase of operations where all other spacecraft and instrument capabilities are brought on-line and checked out in preparation for nominal operations." – NPOESS NPP Space Segment Operation Concept (Jan. 2002)

- Science Phase – "Routine Science phase operations are interrupted only for periodic orbit maintenance and science calibration maneuvers. These maneuvers will be typically of short duration and supported by increase ground commanding and monitoring of the spacecraft."
  - Intensive Cal/Val – Verify sensor performance and assess/ improve sensor calibration (~6 months)

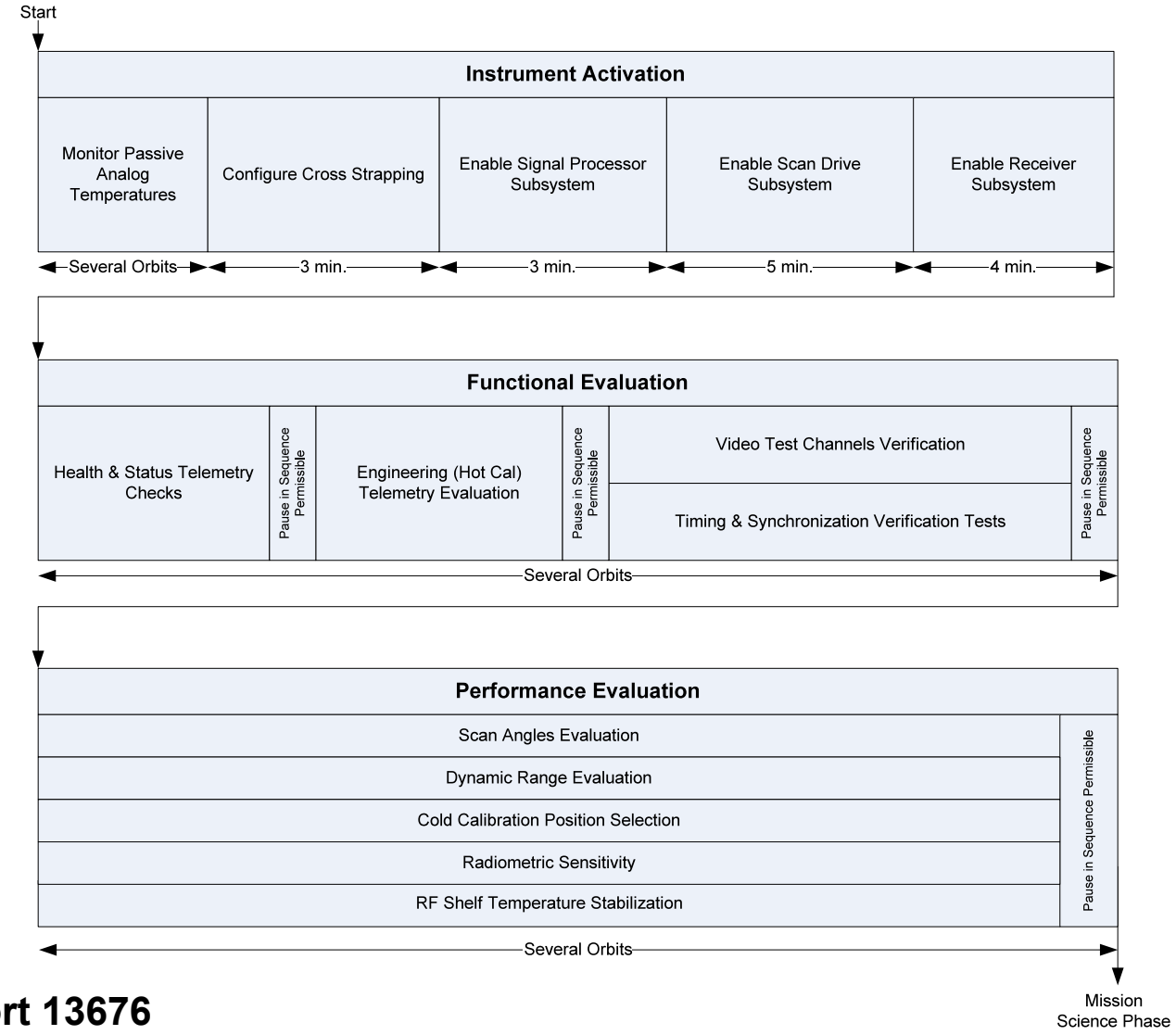
Activation & Checkout Phase

- Source: ATMS In-Flight Activation and Checkout Plan
- Report 13676 (26Aug08)
- Authors: NGES with edits by the NASA Project Science Group
- Consists of three stages:
  - Instrument Activation
  - Functional Evaluation
  - Performance Evaluation
- Duration is approximately 24 hours
- Some exceptions:
  - Testing various redundancy configurations
  - Allocating more time (SV selection needs weeks)



- *Instrument Activation*
  - Passive telemetry assessment
  - Select redundancy configuration
  - Instrument turn on
  - Select scan pattern
- *Functional Evaluation*
  - Health & Status evaluation
  - Onboard Calibration Target (OBCT) evaluation
  - Video channel verification
  - Timing and sync. verification
- *Performance Evaluation*
  - Scan angle verification
  - Dynamic range
  - Space view selection
  - Radiometric sensitivity
  - RF shelf temp. stabilization

Activation and Checkout Timeline



NGES Report 13676

Instrument Activation

- Passive Telemetry Assessment: Monitor that the temperatures for the SDM; near the OBCT; K, Ka, & V shelf; W & G shelf; and instrument base plate are within the "yellow" limits for instrument turn-on
- Configure operational power bus
- Configure cross strapping for the Signal Processing Assembly (SPA) and Surface Acoustic Wave (SAW) filter assembly
- Enable Scan Drive Mechanism (SDM) and verify telemetry
- Send command to select and execute scan profile
- Enable receiver subsystem
- Verify critical telemetry data after each step across red and yellow limits

Functional Evaluation

- Verify Health and Status telemetry are within yellow limits
- Could take several orbits for temperatures to reach limits
- Evaluate Engineering (Hot Cal.) telemetry: Verify the 4-wire PRT data from the hot calibration load are within the operational range of 260 to 330 K, and that all PRTs within each load agree within ± 1° C
- Enable diagnostic data packets to verify scan synchronization and video test channel data
  - Compare time stamp of beam position one of the Science Data Packet with the Start of Scan time value of the Diagnostic Data Packet
  - Monitor the test channel data in the Diagnostic Data Packet to verify that the noise level is well below the sensitivity of the radiometric channels (use ADC or Video test in the Diagnostic mode)

Performance Evaluation

- Scan Angles: Compare scan angle readouts in Science Data Packet with the specified scan table and verify errors are within limits
- Cold Calibration Selection: Compare radiometric counts for the four Space View (SV) positions and choose the position with the minimum contribution from the satellite, earth intercept, and lunar contamination. Each position is monitored for one week.
- Dynamic Range: Verify radiometric counts in Science Data Packet do not exceed the maximum allowable for the instrument analog-to-digital conversion (operational mode with two SPAs)
- Radiometric Sensitivity: monitor the gain and radiometric sensitivity (operational mode with two RCV and two SAW options)
- Temperature stabilization: monitor RF shelf temperatures and verify that the orbit-to-orbit variation of the four shelf PRTs are less than 2° C

Intensive Cal/Val Tasks Overview

Six Categories:

1) *Parameter Trending*: gain, offset, sensitivity, scan position, counts, PRTs, voltages, etc.
2) *Calibration Target Assessment*: Space view evaluation, lunar analysis, radiometrically image loads
3) *Interference:* Sat. communications, terrestrial sources, other NPP sensors, intra-sensor
4) *Geolocation:* land/sea analysis (operational and stare mode), resampling with CrIS, ascending/descending SDR comparisons, terrestrial transmitter
5) *SDR Comparisons* with RAOB, NWP, sat., and aircraft
6) *Scan Bias*: Characterization and mitigation through SDR analysis and spacecraft maneuvers

The order roughly relates to sequence of the tasks

Parameter Trending

- Starts in the Activation and Checkout Phase and continues throughout the five-year Science Phase
- Good indicator of anomalous behavior
- Includes: radiometric sensitivity, gain, offset, cal. target counts and PRTs, monitor voltages, instrument temperatures, etc.

Calibration Target Tasks

- The space view evaluation will analyze the corruption from any sidelobes viewing the spacecraft or earth's limb and any periodic lunar intrusion.
- The space view with the minimum corruption will be named the "optimal" space view. There may be the need to periodically change the space view to avoid lunar intrusion. It is estimated that the four space views (and repeating one for a total of five) will take a week each (5 wks)
- A custom scan pattern will be used to image across the space view angles and the OBCT with small angular increments. The goal is to evaluate the best viewing angle or weight the multiple cal. target measurements that are made during a single scan.
- In stare mode, take continuous measurements of both the space view and OBCT. Transform using a FFT to plot the noise spectrum and compare with pre-launch thermal-vacuum measurements. This will be a periodic test done as often as is feasible.
- Characterize the temperature difference between the MUX and OBCT PRTs and compare with thermal-vacuum (T/V) data. The goal is to validate that the instrument is in a similar thermal state on-orbit as it was in the T/V to increase confidence in the temperature-dependent non-linearity correction derived in T/V testing.

RF/EM Interference Tasks

- Investigate whether the communication links affect either the radiometric or housekeeping data
- Investigate any terrestrial inference around metropolitan areas
- Monitor the ATMS trending data during the Activation and Checkout phases of the other NPP sensors. (Other sensors activate after ATMS due to outgassing requirements.)
- Monitor ATMS subsystems interference through the ADC, Video, and Telemetry Dwell tests in Diagnostic mode:
  - ADC: “Monitor reference voltage injected into multiplexer/ADC”
  - Video: “Provide a calibrated video signal channel”
  - Dwell: “Sample a specific housekeeping channel at maximum acquisition rate (55 Hz)”

Geolocation Tasks

- Investigate the accuracy of mapping the brightness temperature of surface sensitive channels as the satellite crosses land-to-sea or sea-to-land boundaries (operational or stare mode)
- Bin global brightness temperatures from ascending and descending orbits separately to identify navigation errors
- Verify the ATMS resampling to the CrIS FOV by convolving ATMS FOV to CrIS FOV and then comparing estimated ATMS T_B derived from CrIS clear-air radiances with the CrIS-FOV ATMS data

Scan Bias Tasks

- **Global comparison analyses** (relative to NWP, for example) to characterize any scan bias (possibly asymmetric) in the cross-track scan pattern

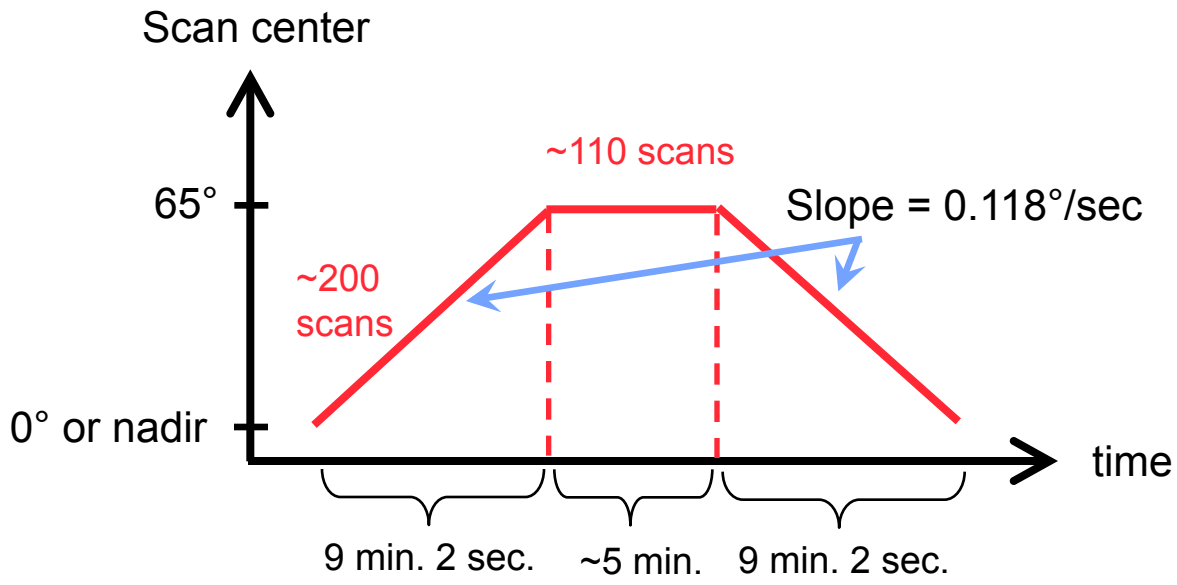
- **Custom scan patterns** are used to evaluate the radiometric contributions outside the standard viewing angles (i.e., the angles between the spacecraft and the end and start of scan)

- The goal of the **spacecraft maneuvers** is to characterize the earth-view antenna pattern sidelobe contribution by viewing the large T_B difference at the boundary of atmosphere and deep space
  - "Image deep space" roll maneuver: a 65° anti-sun satellite roll
  - "Image Earth's limb" roll maneuver: a 25° sun-side satellite roll
  - Pitch over maneuver: satellite executes a 360° pitch over in 1/3 of an orbit
  - "Image moon" roll maneuver: similar to the anti-sun maneuver but the moon will be imaged instead of deep space

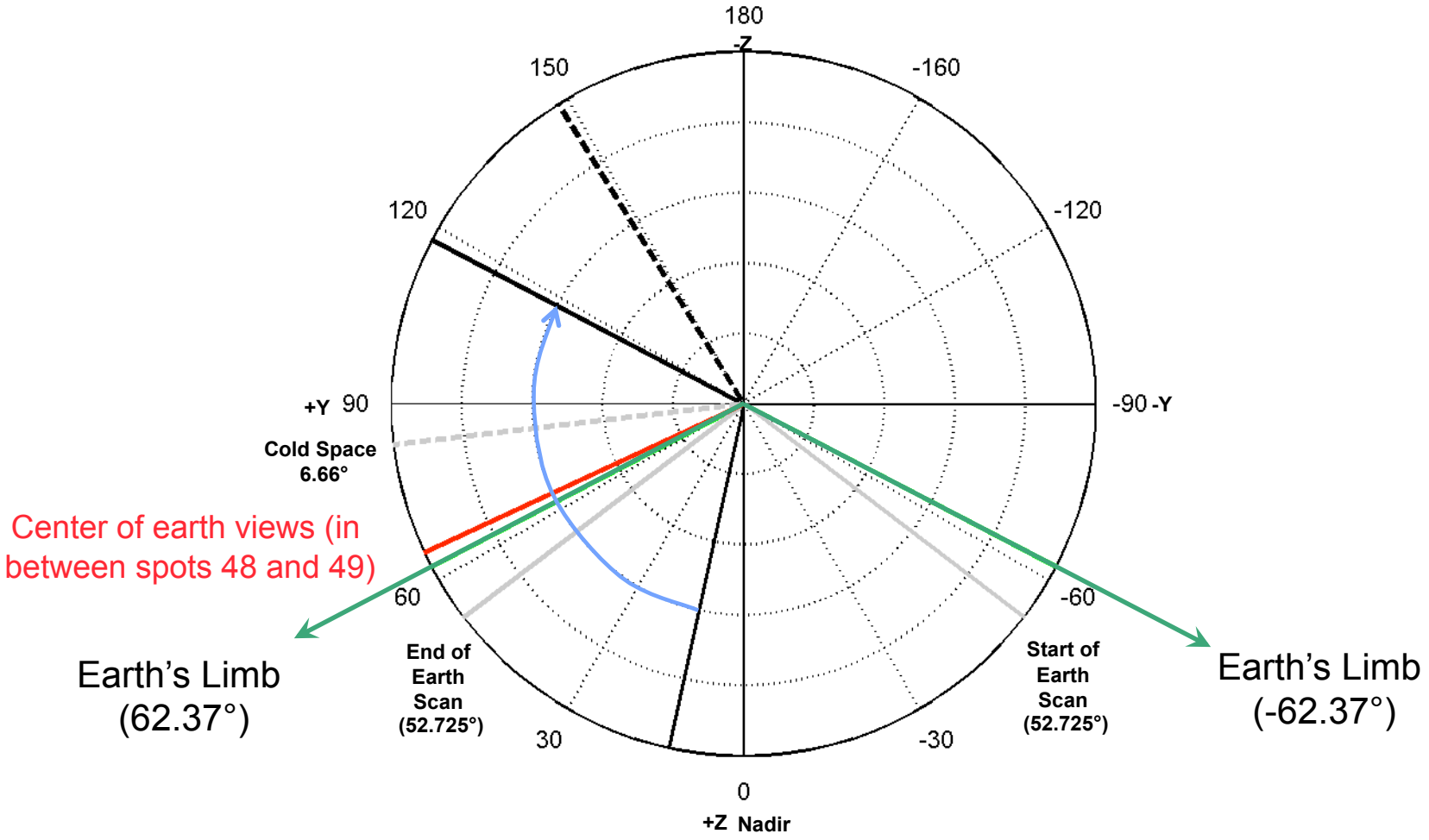
NPP Roll Maneuver 1

Cross Track Scan Check

- Normal scan mode (scan period of 2.666 sec; two cal. loads)
- Maneuver lasts less than a 1/3 of an orbit
- Roll is toward cold sky (a.k.a. anti-sun)
- Moves ~0.31° per scan
- Spots 49 to 96 will cross over the earth's limb



Roll Maneuver # 1

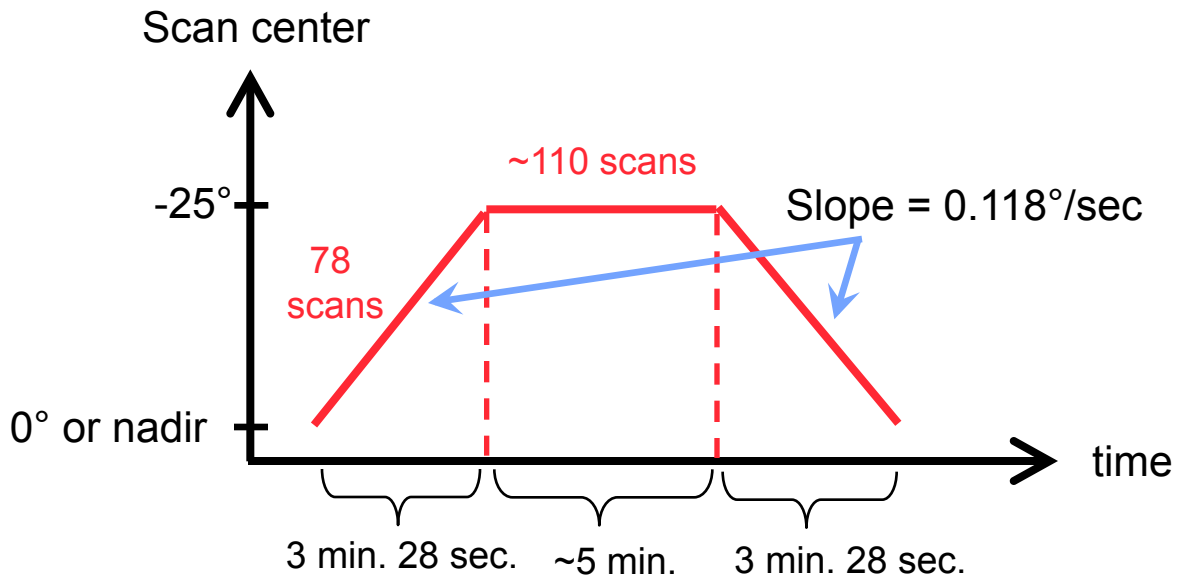


Gray lines denote standard orientation
Black lines denote plateau (max. roll) in this maneuver

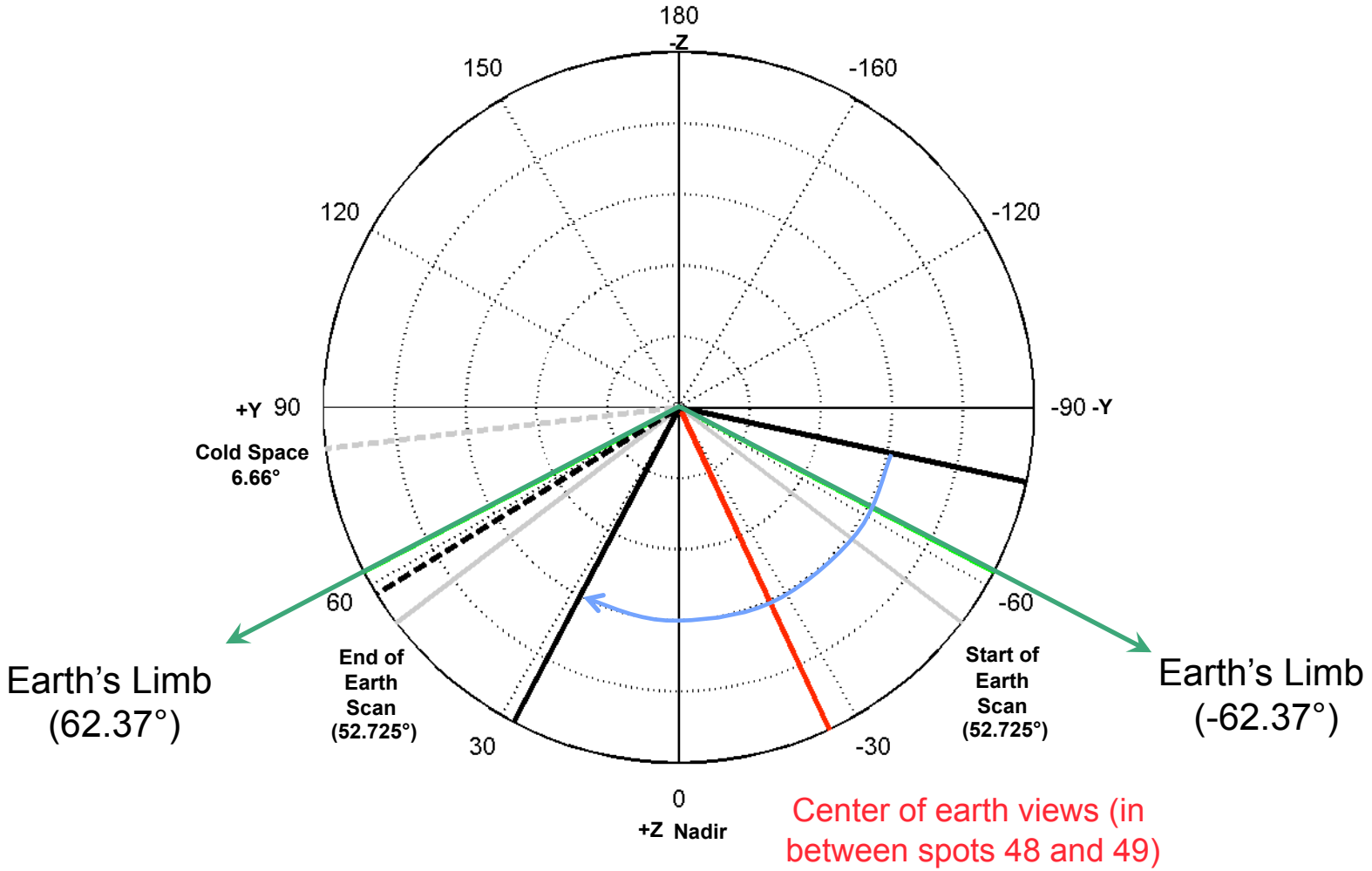
NPP Roll Maneuver 2

Imaging of Earth's Limb

- **Normal scan mode (scan period of 2.666 sec; two cal. loads)**
- **Roll is toward the sun**
- **Moves ~0.31° per scan**
- **Spots 1 to ~14 will cross over the earth's limb**



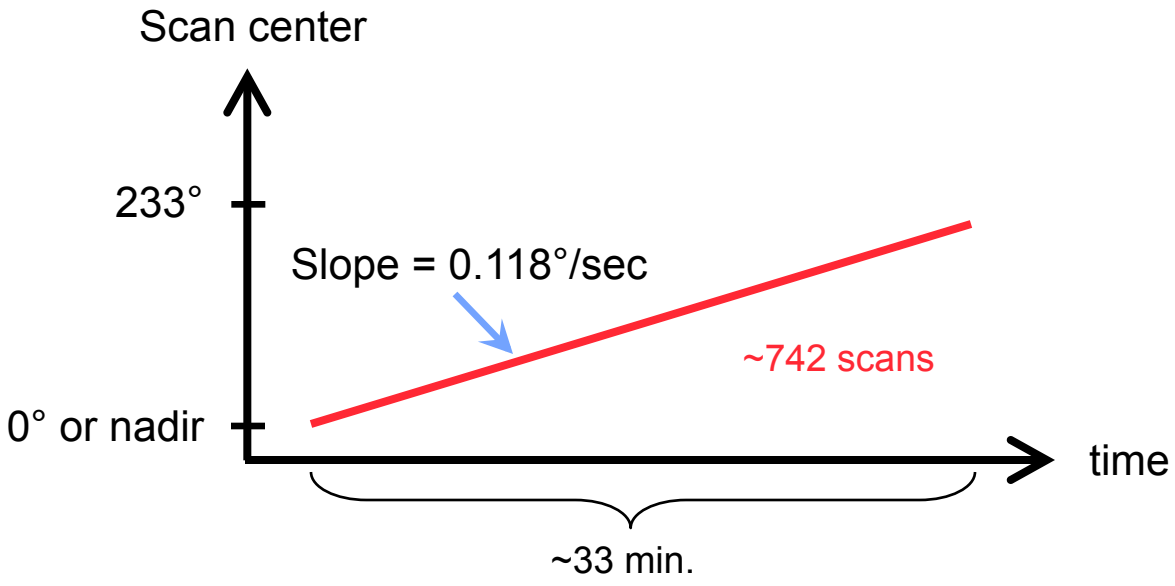
Roll Maneuver # 2

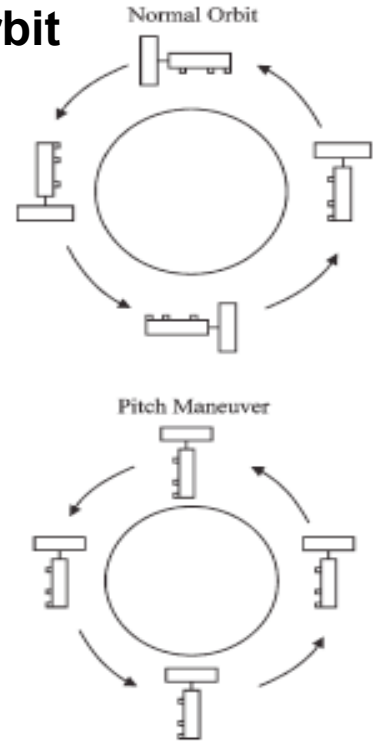


Gray lines denote standard orientation
Black lines denote plateau (max. roll) in this maneuver

NPP Pitch Maneuver

- Normal scan mode (scan period of 2.666 sec; two cal. loads)
- Constant pitch maneuver at 0.118°/sec for 33 minutes (~233°)
- Orbital pitch rate is 0.064°/sec, which will make up the rest of the 127°
- Moves ~0.485° per scan
- Maneuver starts at the terminator crossing of day to night (night portion of an orbit)
- NPP will essentially do a "back flip" during 1/3 of the orbit





Airborne Radiometric and Model Validation To Be Performed at End of ICV Period

OBJECTIVES

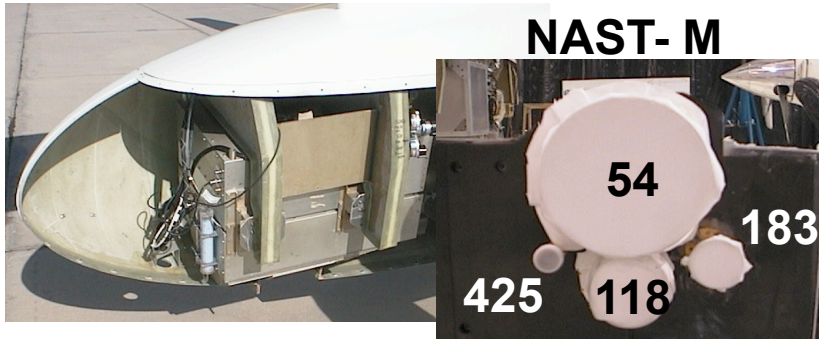
- *Satellite calibration/validation*
- Simulate spaceborne instruments (i.e. CrIS, ATMS, IASI)
  - Preview high-resolution products
  - Evaluate models and algorithms

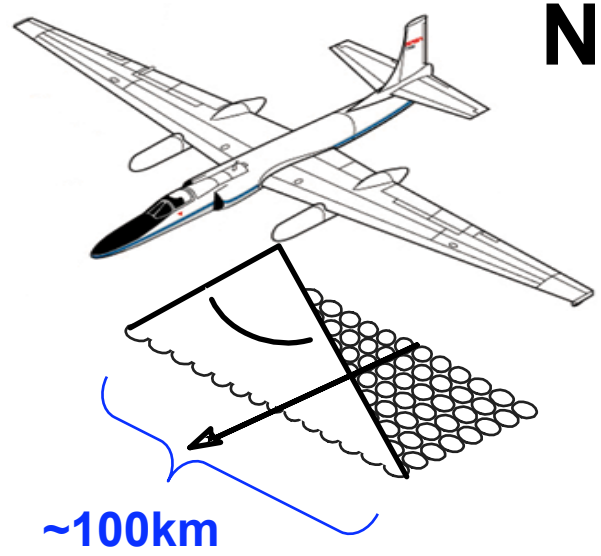
INSTRUMENTS: NAST-I & NAST-M

NAST- I: IR Interferometer Sounder

NAST- M: Microwave Sounder

- 4 Bands: 54, 118, 183, 425 GHz



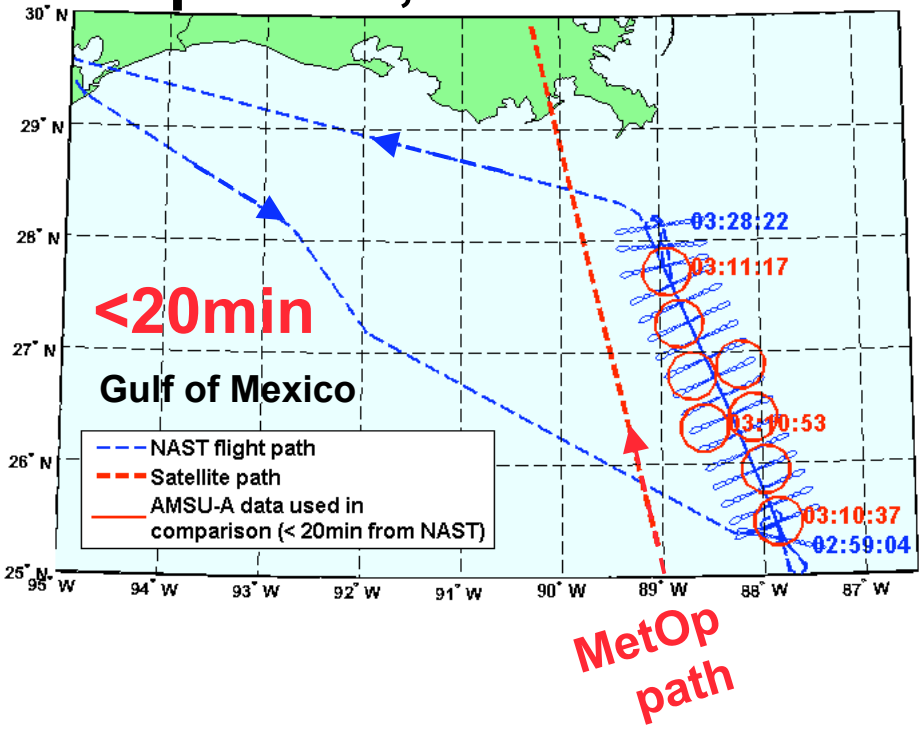


Cruising altitude: ~17-20 km

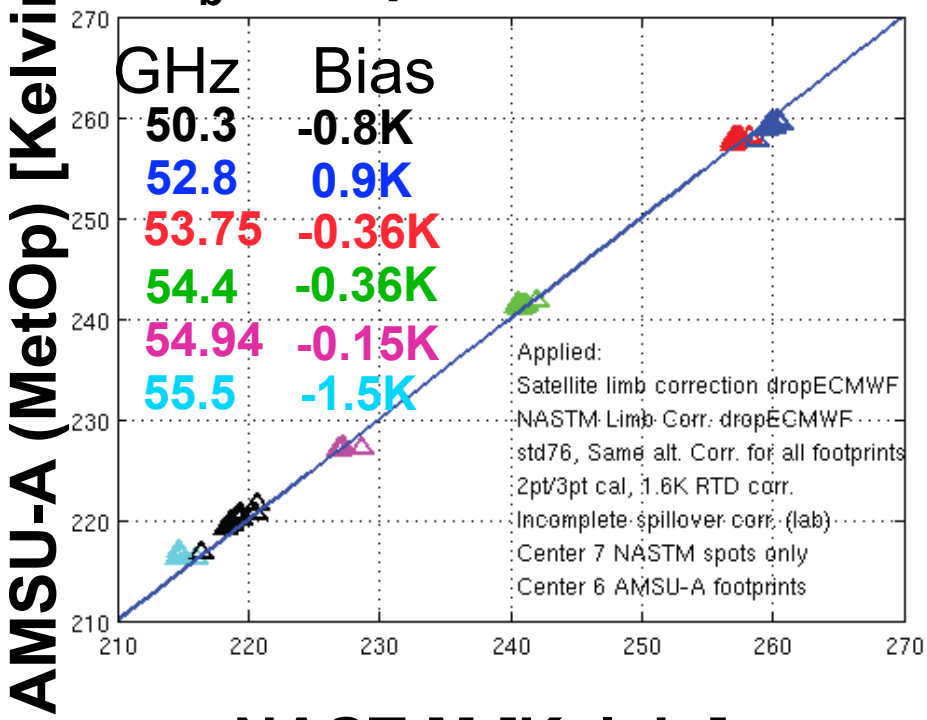
Cross-track scanning: -65º to 65º

MetOp Radiometric Validation
JAIVEx

April 20th, 2007 collection

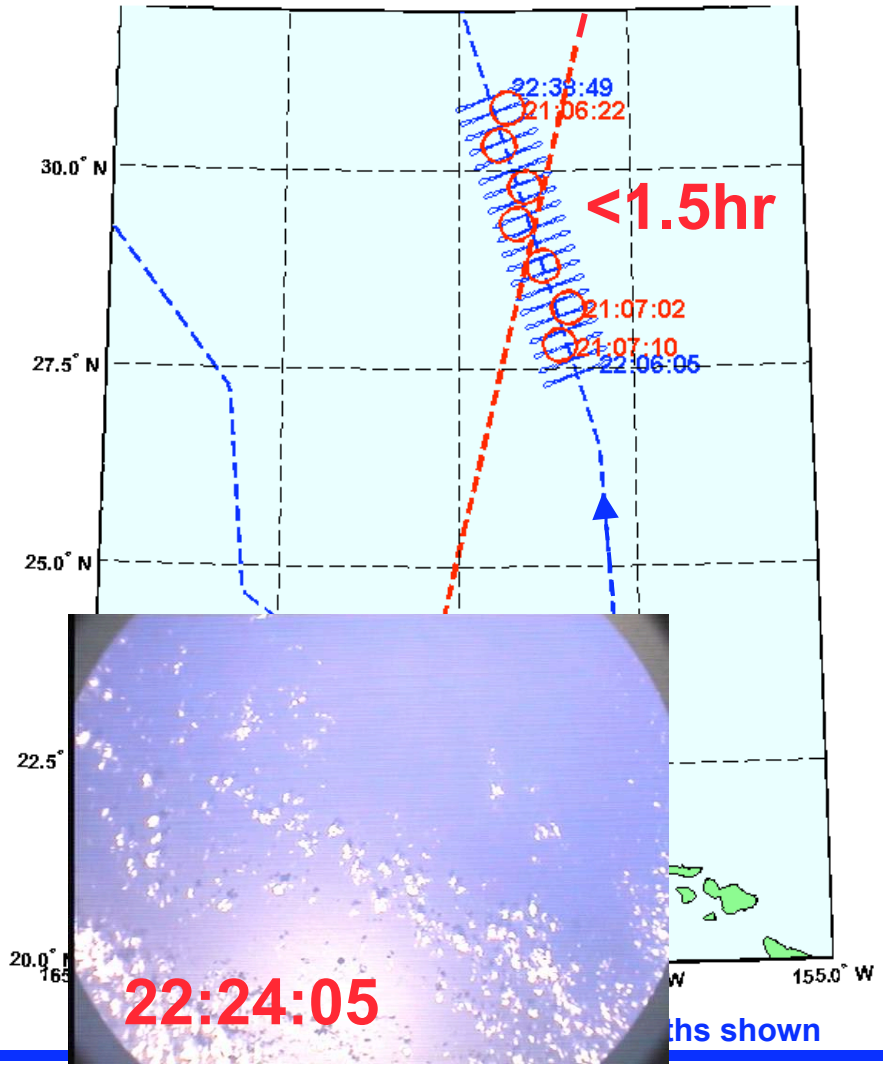


T_b Comparison AMSU-A



Validation of Cloud Models for Improved EDR Performance

March 12th, 2003 collection



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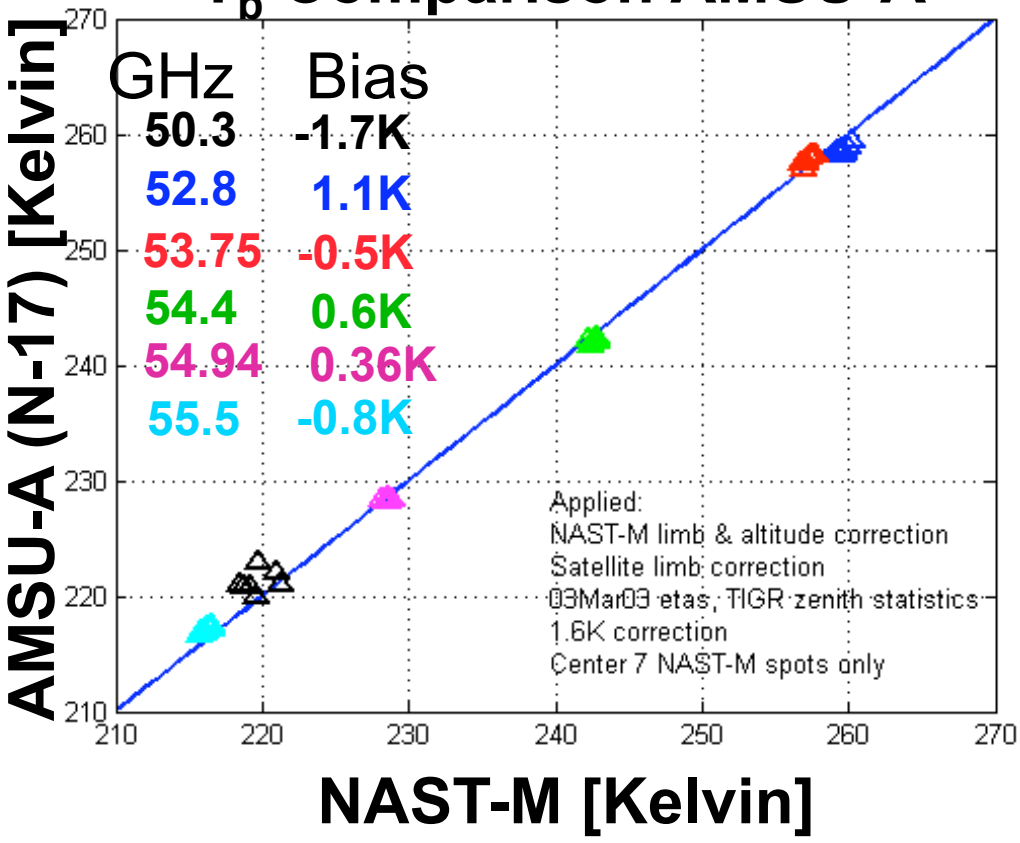
LL-Cal/Val-SOAT-26
RVL 1/15/10

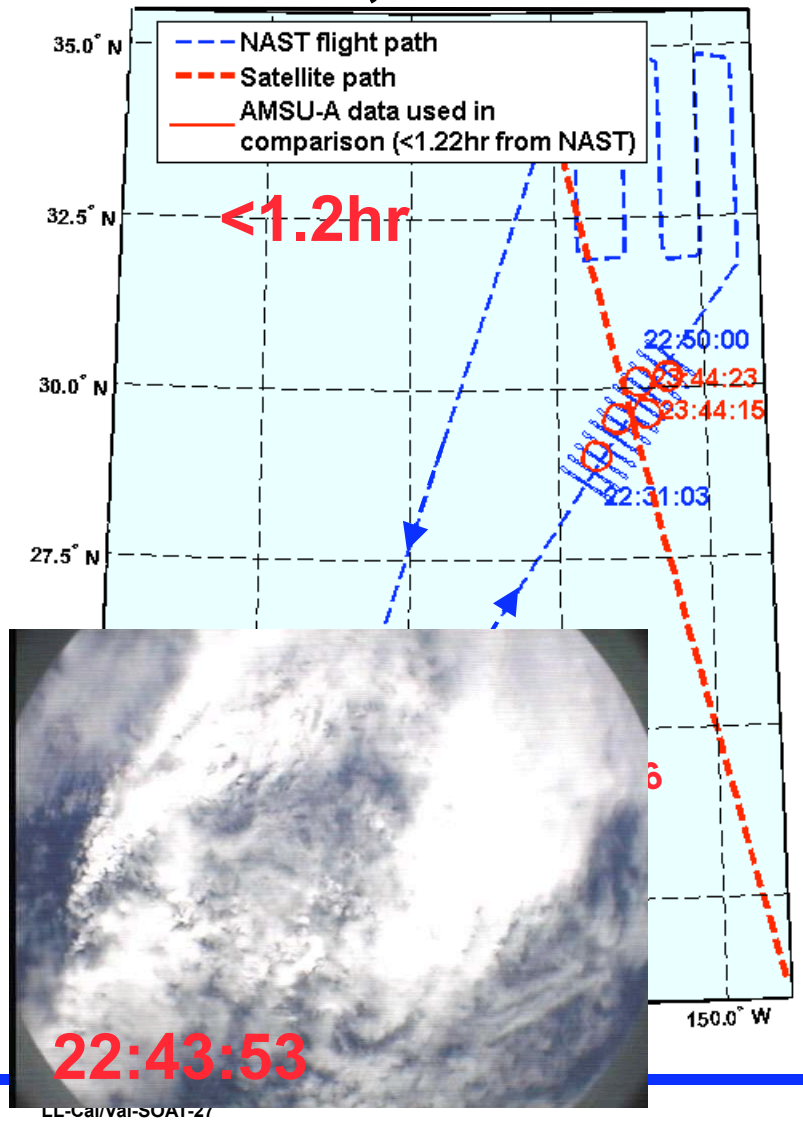
T_b Comparison AMSU-A



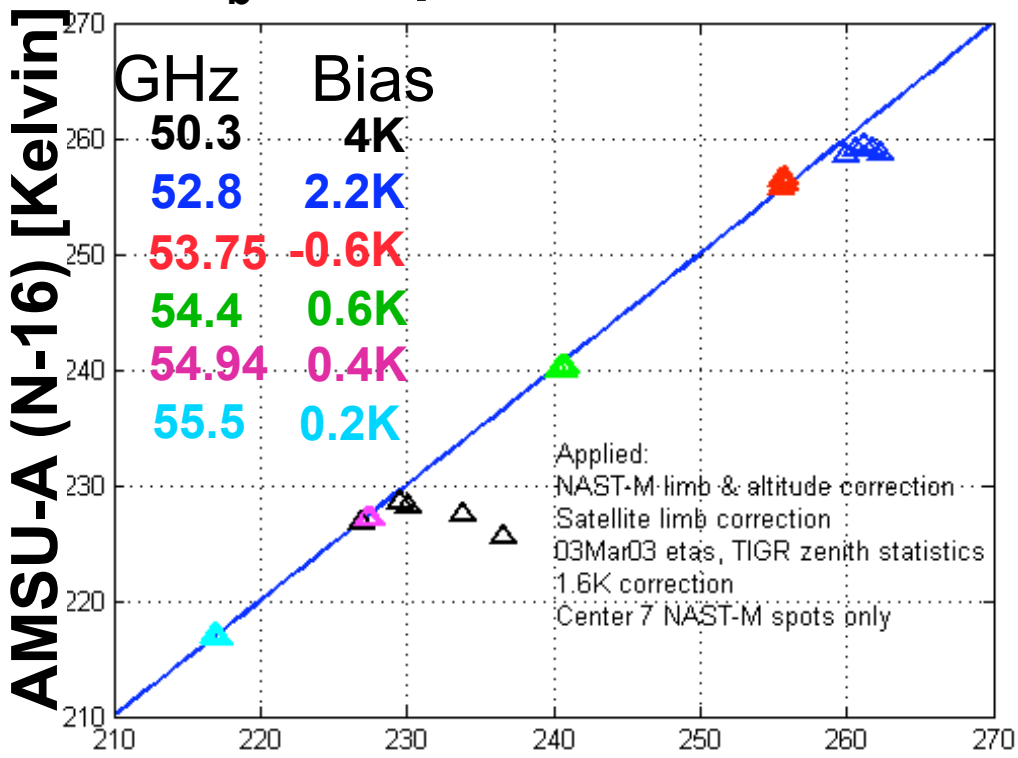
NOAA-17 Satellite Validation

Validation of Cloud Models for Improved EDR Performance

March 11th, 2003 collection



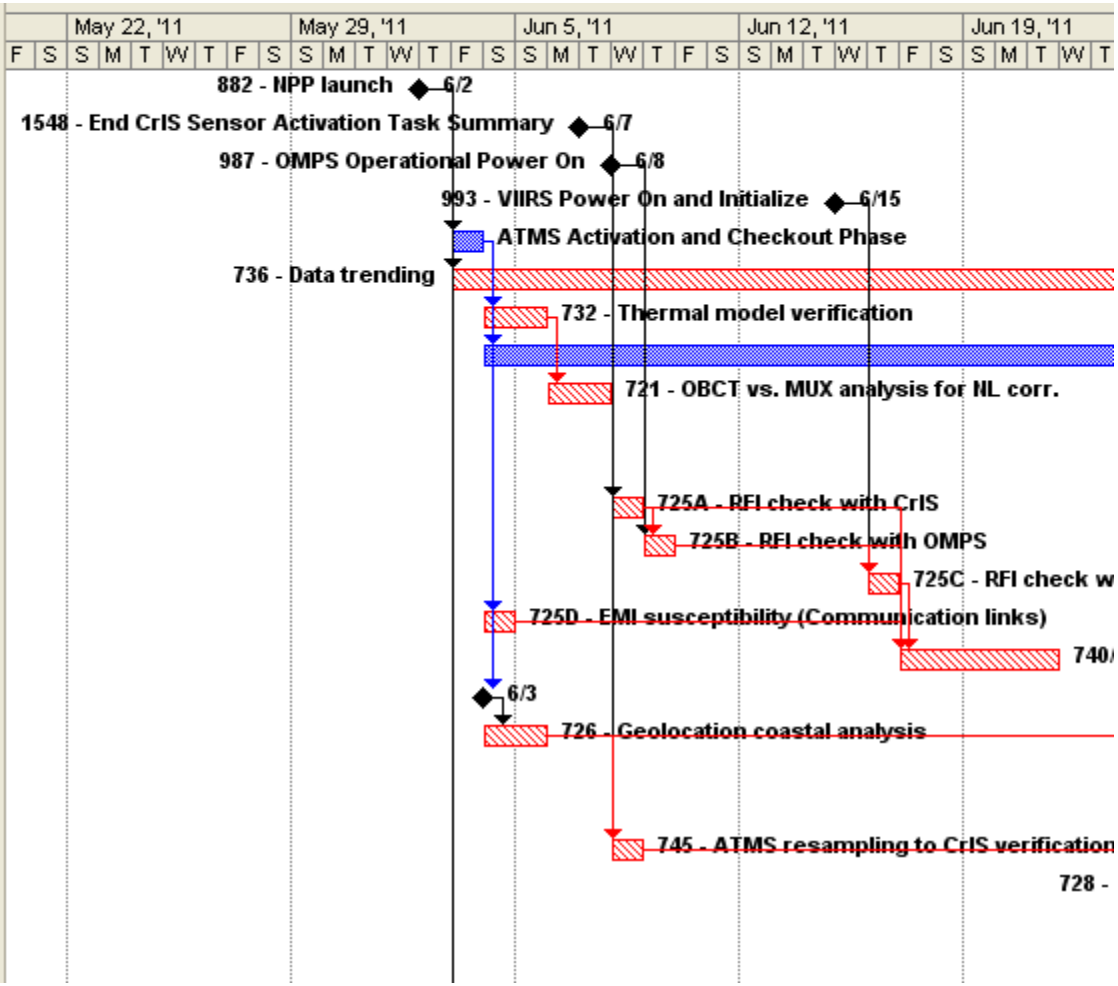
T_b Comparison AMSU-A



NOAA-16 Satellite Validation

Task Scheduling

	Task Name	Duration
1	882 - NPP launch	1 day?
2	1548 - End CrIS Sensor Activation Task Sumr	1 day?
3	987 - OMPS Operational Power On	1 day?
4	993 - VIIRS Power On and Initialize	1 day?
5	ATMS Activation and Checkout Phase	1 day?
6	736 - Data trending	90 days
7	732 - Thermal model verification	2 days
8	979 - 983 Space View evaluation (#1-#4, #1)	35 days
9	721 - OBCT vs. MUX analysis for NL corr.	2 days
10	Image Cal. Targets	1 day?
11	727 - OBCT & cold space dwell test	1 day?
12	725A - RFI check with CrIS	1 day
13	725B - RFI check with OMPS	1 day?
14	725C - RFI check with VIIRS	1 day?
15	725D - EMI susceptibility (Communication links	1 day
16	740/982 - RFI analysis	5 days
17	Geolocation Verification Begins	0 days
18	726 - Geolocation coastal analysis	2 days
19	729 - Geolocation analysis in stare mode	2 days
20	743 - Geolocation surface-based transmitter	1 day
21	745 - ATMS resampling to CrIS verification	1 day
22	728 - Ascending & descending orbit comparis	90 days
23	SDR Comparisons Begin	0 days
24	740 - SDR comparison with RAOB	90 days



Blue tasks require either ATMS or the satellite to be outside its normal operating mode

Schedule Notes

- NASA controls satellite for 90 days after launch at which point NGST will take control of day-to-day operations
- The interference tasks and geolocation tasks can be done using the data from the five-week optimal Space View (SV) evaluation
- The SDR and scan bias tasks must wait until after the optimal SV is determined, and, therefore, the interference and geolocation has been quantified or verified
- Scan bias will start after initial SDR comparisons are verified

Summary and Future Work

- The Activation and Checkout phase ➔ Intensive Cal/Val phase ➔ Science Phase
- Cal/Val task list has been consolidated to remove redundant tasks
- The tasks now fit into six categories: data trending, calibration target verification, interference, geolocation verification, SDR validation, and scan bias characterization
- A tentative schedule has been drafted
- Further work
  - Organizing a list of organizations and individuals responsible for executing the tasks
  - Develop optimal sequence (i.e., better coordinate with CrIS) of the condensed task list
  - Provide a detailed description of correlative resources needed