NPP after launch: Characterizing ATMS performance

The NPOESS Preparatory Project (NPP) mission is scheduled to launch in the fall of 2011. Although several teams from the government and the instrument contractor will be assessing and characterizing the performance of the Advanced Technology Microwave Sounder (ATMS) and the Cross-track Infrared Sounder (CrIS) sounding suite, the NASA NPP Science Team will be paying particular attention to the aspects of these sensors that affect their utility for atmospheric and climate research. In this talk we discuss relevant aspects of ATMS and our post-launch analysis approach.

Bjorn Lambrigtsen
Jet Propulsion Laboratory, California Institute of Technology

April 28, 2011

Lambrigtsen@jpl.nasa.gov
Tel: 818 354 8932

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A decade earlier...

Microwave Instrument Validation

Bjorn Lambrigtsen
October 4, 2000

Lambrigtsen@jpl.nasa.gov
Tel: 818 354 8932
MICROWAVE INSTRUMENT VALIDATION

Scope of Early Activities

- **Instrument operations**
  - Commanding
  - Health & safety monitoring
- **Instrument assessment**
  - Activation
  - Performance
  - Calibration
  - Pointing
- **Data product assessment**
  - L1a validation
  - L1b validation
  - QA assessment
MICROWAVE INSTRUMENT VALIDATION

Instrument Operations

• All activities focused at EOC/GSFC
  – Distribution of HK data
  – Receipt of command requests

• Phase 1 — Activation & verification
  – First 1-2 months
  – All instrument teams at EOC: Aerojet, INPE, JPL/DPIO
  – Aerojet/INPE prime responsibility; JPL “shadowing”

• Phase 2 — Validation
  – Next 1-2 months
  – DPIO assumes operational responsibility

• Phase 3 — Routine operations
  – Rest of mission
  – Instruments monitored from JPL IST by DPIO
  – DPIO has full operational responsibility
  – Command requests through AIRS ops advisory board
MICROWAVE INSTRUMENT VALIDATION

Instrument Assessment

- **Prime responsibility of Aerojet & INPE**
  - JPL will shadow and supplement

- **Activation (by EOC) ~ 1 week**
  - Monitor passive telemetry
  - Get OK from S/C team

- **Performance assessment (by Aerojet/INPE) ~1-2 months**
  - Instrument performance & calibration verification
  - JPL will monitor & check process & conclusions
  - Period ends when performance is “verified” ⇒ Hand-over to JPL/DPIO

- **Pointing verification (by JPL) ~3-9 months**
  - MW instrument pointing
  - MW-IR coalignment
MICROWAVE INSTRUMENT VALIDATION

Data Product Assessment

- **Responsibility of JPL**
  - Assistance from Science Team
- **Requires instruments in “science mode”**
  - Occasionally in the early assessment phase
  - Regularly in the late assessment phase
- **L1a first: ~2 months**
  - Verify engineering data (temp’s, limits, etc.)
  - Preliminary verification: “Use w/caution” ⇒ Proceed with L1b, etc.
- **L1b next: ~3 months**
  - Verify calibration
  - Preliminary verification: “Use w/caution” ⇒ Proceed with L2, etc.
- **QA assessment: ongoing**
  - Verify QA parameters
  - Assess their values
  - Issue regular summary reports
**MICROWAVE INSTRUMENT VALIDATION**

**L1a Validation**

<table>
<thead>
<tr>
<th>Start: L+0.5m</th>
<th>End: L+3m</th>
<th>Duration: 2.5m</th>
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<td><strong>Description</strong></td>
<td><strong>Milestones</strong></td>
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<tr>
<td></td>
<td>“Use with caution”</td>
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<tr>
<td></td>
<td>“Validated” Validation Report</td>
<td>L+75d</td>
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<td>L+90d</td>
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<td><strong>Triggers</strong></td>
<td>MW instruments in occasional science mode; L1a processed</td>
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<tr>
<td><strong>Critical input</strong></td>
<td>MW L1a</td>
<td>Continuous</td>
</tr>
<tr>
<td><strong>Other input</strong></td>
<td>AMSU-A performance rep’t</td>
<td>L+45d (once)</td>
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<tr>
<td></td>
<td>HSB performance rep’t</td>
<td>L+45d (once)</td>
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<td></td>
<td>Scan symmetry analysis</td>
<td>L+50d (once)</td>
</tr>
<tr>
<td></td>
<td>Pointing analysis</td>
<td>L+35d (once)</td>
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</tbody>
</table>

- **Approach**
  - Statistical analysis: noise, trends, correlations
  - Comparison with pre-launch & predicted on-orbit values
  - Cross-comparisons between parameters (PRT’s, etc.)
### MICROWAVE INSTRUMENT VALIDATION

#### L1b Validation

<table>
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<td><strong>Description</strong></td>
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<tr>
<td>Deliverables</td>
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<tr>
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<td>L+3m</td>
<td>Project (world)</td>
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<tr>
<td>“P-elim. Validated”</td>
<td>L+4m</td>
<td>Project (world)</td>
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<tr>
<td>Preliminary Validation Report</td>
<td>L+5m</td>
<td>Team</td>
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<tr>
<td>Preliminary Tb Comparison Report</td>
<td>L+6m</td>
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<td>“Definitive Validated”</td>
<td>L+7m</td>
<td>Project (world)</td>
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<td>Definitive Validation Report</td>
<td>L+12m</td>
<td>Project (world)</td>
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<tr>
<td>Final Tb Comparison Report</td>
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</tbody>
</table>

**Triggers**
- MW instruments in occasional science mode; L1b processed
- TE comparisons: MW instruments in continuous science mode

- **Critical input**
  - MW L1b
  - NOAA L1
  - Continuous
  - Continuous
  - TDS
  - NOAA

- **Other input**
  - ARM/CART MWR (+others?)
  - AMSR-E L1b
  - Residual analysis
  - L+2m overps.
  - L+2.5m cont.
  - L+3m (once)
  - UW
  - DAAC
  - MIT

### Approach
- Statistical analysis: noise, trends, correlations
- Comparison with pre-launch & predicted on-orbit values
- Cross-comparisons between parameters
- Comparisons with other instruments (NOAA-AMSU, AMSR-E, others?)
- Residual analysis with in situ data
MICROWAVE INSTRUMENT VALIDATION

QA Verification & Assessment

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<th>Duration: 12m</th>
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<td>Deliverables</td>
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<td>Preliminary Report L1b</td>
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<td>Final Report L1a</td>
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<td>Final Report L1b</td>
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<td>Monthly assessment reports</td>
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<td>Triggers</td>
<td>Respective products generated</td>
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<td>L+15d cont.</td>
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<td>MW L1b</td>
<td>L+1m cont.</td>
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<td>QA (subset)</td>
<td>L+3m cont.</td>
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<tr>
<td>Other input</td>
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**Approach**

- Verify correctness of QA parameters
- Assess their values
- Statistical analysis: variance, trends, correlations
- Assessment of red/yellow limits
MICROWAVE INSTRUMENT VALIDATION

Pointing

<table>
<thead>
<tr>
<th>Start: L+0.5m</th>
<th>End: L+12m</th>
<th>Duration: 12m</th>
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<td><strong>Milestones</strong></td>
<td><strong>Source/Destination</strong></td>
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<td>Deliverables</td>
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<tr>
<td></td>
<td>“Use for retrievals”</td>
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<td>“Validated”</td>
<td>L+9m</td>
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<td></td>
<td>Validation Report</td>
<td>L+12m</td>
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<tr>
<td>Triggers</td>
<td>MW instruments in occasional science mode; L1b processed</td>
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<tr>
<td>Critical input</td>
<td>MW L1a and/or L1b</td>
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<td></td>
<td>DEM</td>
<td>L+20d (once)</td>
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<td></td>
<td>AIRS pointing analysis results</td>
<td>L+50d (once)</td>
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<tr>
<td>Other input</td>
<td>None</td>
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</tr>
</tbody>
</table>

- **Approach — Pointing**
  - Detect edges in swath (counts or Tb’s); Compare with map
  - Determine pointing offsets; Translate to boresight rotations

- **Approach — Co-alignment**
  - Emphasis on along-track alignment (cross-track alignment in S/W)
  - Determine avg. scan line from IR & MW pointing analysis
  - Compare IR & MW scan lines: parallel? offset along-track?
  - Translate scan offset to time offset
Pointing Analysis: Objectives

- Validate instrument pointing: actuals vs. specs
- Verify AIRS-MW coalignment: actuals vs. specs
- Determine instrument rotation matrix corrections
- Determine AIRS scan sync correction
- Determine scanset/golfball groupings
- Determine any necessary S/W modifications
MICROWAVE INSTRUMENT VALIDATION

Pointing Analysis

- **Methodology**
  - Compare edges in swath with coastline map
  - Determine offsets
  - Translate map offsets to angular offsets

- **Instrument rotation matrix corrections**
  - Overall yaw, pitch, roll from angular offsets
  - Use to adjust geolocation coord. transformation matrices
  - After correction: maps should line up

- **Pointing validation**
  - Errors = angular offsets corrected for overall yaw, pitch, roll

- **Co-alignment validation**
  - Compare MW & IR yaw errors ⇒ Helix angle errors
  - Determine along-track MW-IR offsets ⇒ Scan sync errors

- **AIRS scan sync correction**
  - Optimal along-track offset, translated to sync time offset
MICROWAVE INSTRUMENT VALIDATION
Coastline Analysis

- **Reference maps**
  - HSB: 1-km (30") DEM
  - AMSU-A: 4-km (2') DEM

- **Edge detection**
  - Convolution of swath data with 2D edge filter
  - Baseline filter: 3x3 “stochastic gradient” operator
    - *Noise tolerant operator*

- **Comparison**
  - Visually select suitable edge points/features/patterns
  - Determine lat/lon offsets from map; transform to angular offsets

- **Accumulation**
  - Accumulate statistics, indexed by scan position
  - Determine avg., std.dev.

- **Analysis**
  - Determine avg. scan lines: along-track offset & “helix angle”
  - Determine cross-track asymmetry
  - Determine per-scanposition offsets from avg. scan line
MICROWAVE INSTRUMENT VALIDATION

Early Timeline

Activation

+30

+60

+ 90 days

Aerojet

AMSU-A Eng

HSB Eng

INPE

JPL

MW L1a

“Use w. caution”

AMSU-A performance verification

HSB performance verification

L1a Validation Report

MW L1b

“Use w. caution”

“AIRS pointing analysis”

L1a Validation Report

Scan symmetry

AMSU-A Tb’s

HSB Tb’s

NUAA Tb’s

CART data

AMS R Tb’s

Final verification

(10% of BW)

Residual
analysis

Lambertsen — 10/4/00
Selected ATMS analyses

- **Calibration**
  - Determine orbital variability of calibration parameters
    - $N$(cold-cal), $N$(warm-cal)
    - Cal-coefficients ($a_0$, $a_1$, $a_2$), gain

- **Lunar contamination**
  - Identify lunar intrusion into cold-cal FOV
  - Characterize lunar anomaly
  - Evaluate flag

- **Scan bias**
  - Compare with CrIS
    - *Identify equivalent channels (similar weighting functions)*
    - Track $\Delta Tb$(ATMS-CrIS) vs. scan angle
  - Analyze S/C maneuver data
  - Accumulate statistics for “pure” scenes

- **Pointing**
  - Accumulate Tb “maps”, compare with true maps
  - Stare mode: coast crossings