Terra Instrument Calibration: The first 22 months

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CERES Instrument Status

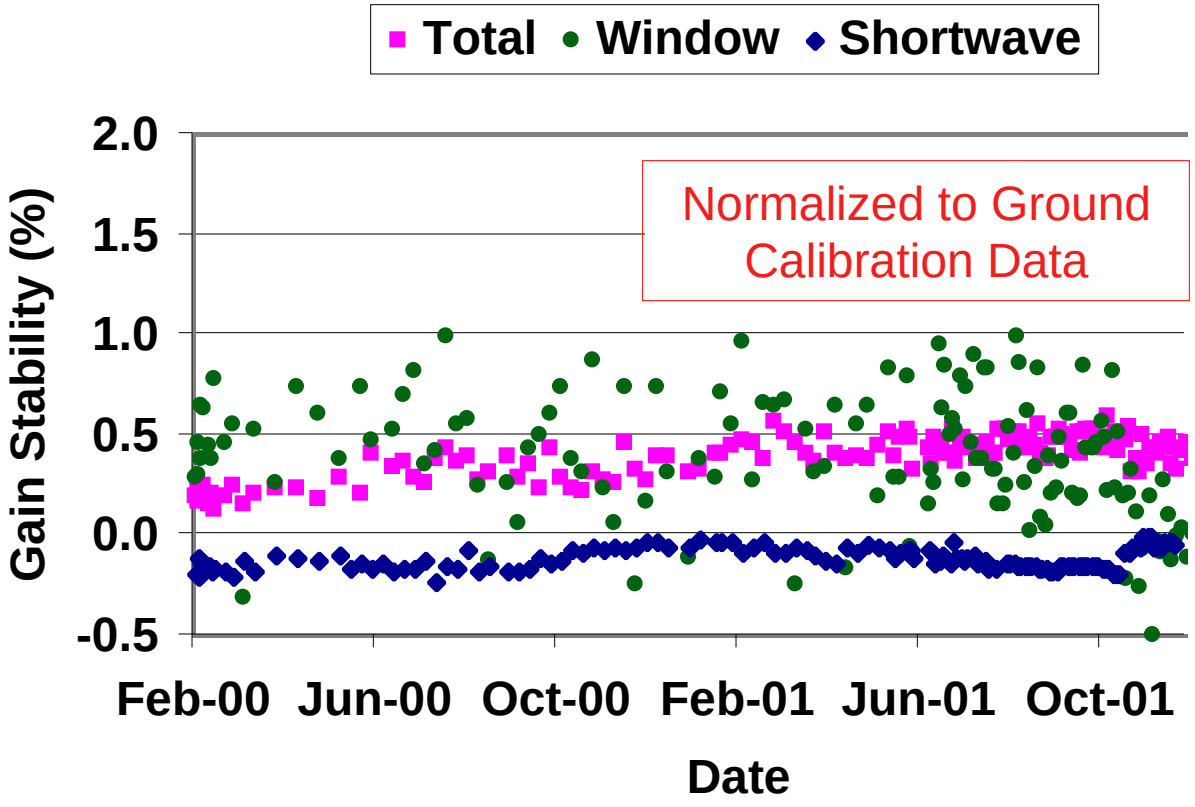
- Terra instruments nominal: no electrical, telemetry, or mechanical anomalies to date on either instrument
- Terra (1030 sunsynch) data covers March, 2000 to current
- TRMM instrument off: Jan-Aug 1998, Mar/Apr 2000 data.
  - Voltage converter decay caused problems with digital/analog convertgers. No success in trying to recover further data.
  - Last good data in April, 2000
  - 6 weeks of overlapping intercalibrations with Terra instruments after Terra covers opened: March to mid-April of 2000.
  - Calibrations for all channels agreed to 0.5%.
- Aqua (130 pm sunsynch) launch planned for April 18, 2002 but little slack in schedule. One spacecraft issue to work, and an unidentified film was recently found on one of the two CERES MAM (solar diffuser) contamination covers.
- FM-5 instrument remains in storage. Waiting for a mission of opportunity to fill the data gap from Aqua (2008 nominal end) to NPOESS (2011 nominal start)

CERES Instrument Calibration Results

- A variety of independent methods used to verify calibration:
  - Internal calibration sources (blackbody, lamps)
  - Mirror Attenuator Mosaics (MAM) solar diffusers
  - 3-channel deep convective cloud test
    - Use night-time 8-12um window to predict LW: cloud < 205K
    - Total - SW = LW, vs Window predicted LW in daytime for same clouds <205K temperatures.
  - 3-channel day/night tropical ocean test
  - Instrument intercalibration:
    - rotate scan plane to align scanning instruments TRMM, Terra during orbital crossings (Haeffelin: reached 0.1% LW, window, 0.5% SW 95% conf in 6 weeks of orbital crossings of Terra and TRMM.
    - FM-1 and FM-2 instruments on Terra at nadir

Terra/CERES Flight Model 1 Lifetime Radiometric Stability

Determined with the Internal Calibration Module



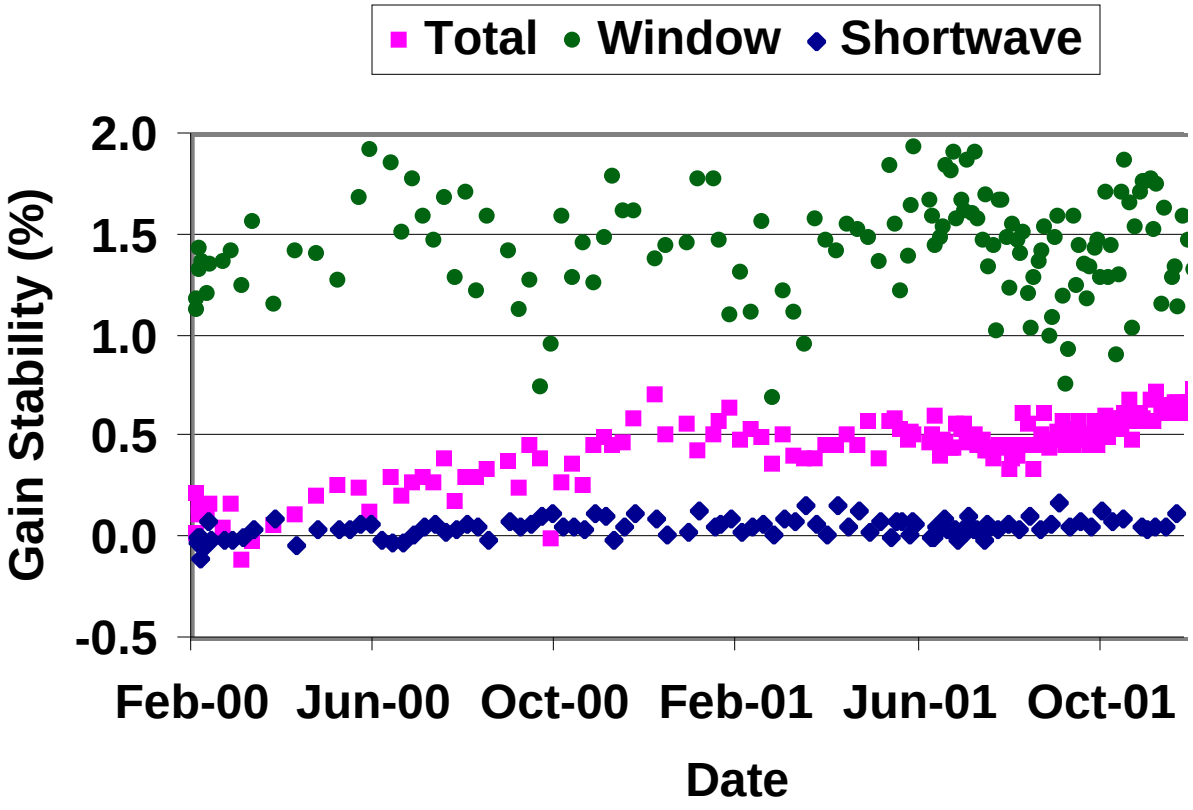
Terra FM-1 Calibration

- Internal Calibration Modules: Blackbodies and Lamps
- MAM: Mirror Attenuator Mosaic: solar diffuser

- All channel gains begin in orbit within 0.5% of ground values.
- No detectable gain change in SW channel at 0.1%/yr
- Total channel gain change of ~ 0.2%/yr
- No detectable window channel gain change.
- Noisier blackbody calibration than Total: much less signal
- Semi-annual cycle in calibration data at 0.1 to 0.2%?
  - Need further investigation vs beta angle, instrument temperature.
- Correct Total channel gain change in Spring, 2002 reprocessing.

Terra/CERES Flight Model 2 Lifetime Radiometric Stability

Determined with the Internal Calibration Module



All Gains Referenced to Ground Calibration Data

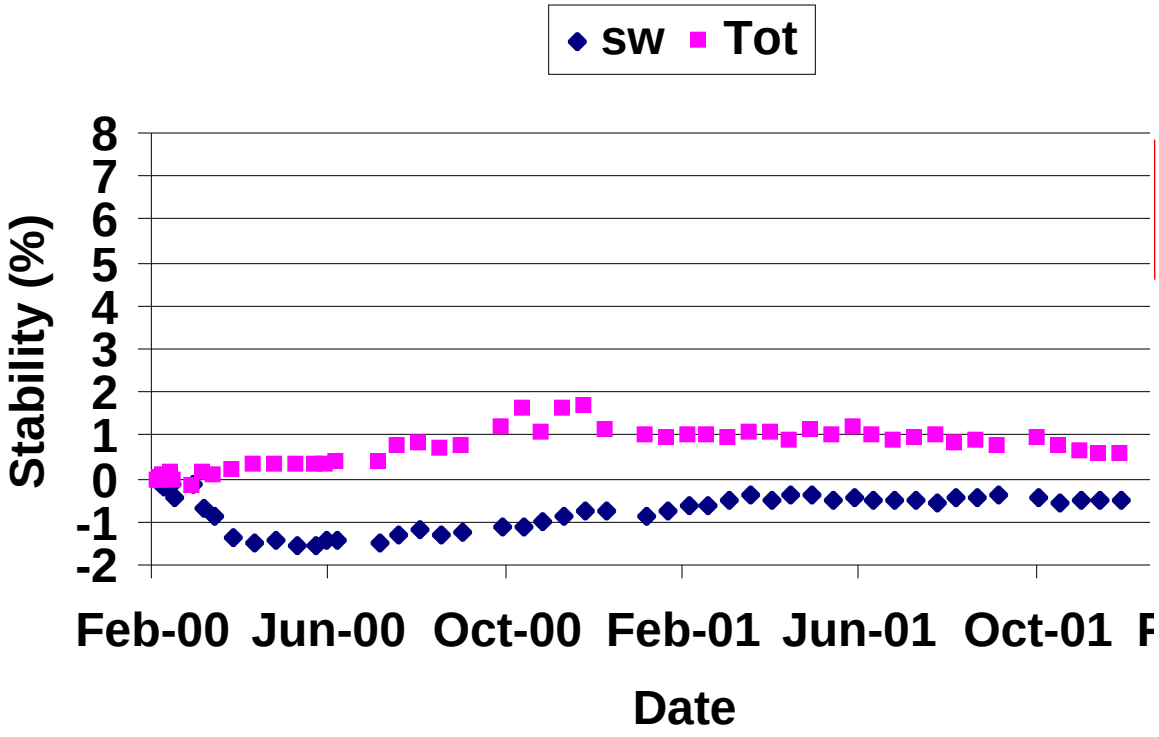
Terra FM-2 Calibration

- Internal Calibration Modules: Blackbodies and Lamps
- MAM: Mirror Attenuator Mosaic: solar diffuser

- Total and SW channel gains begin in orbit within 0.2% of ground values.
- Window channel higher by 1.3%: detector change in vacuum.
- No detectable gain change in SW channel at 0.1%/yr
- Total channel gain change of ~ 0.4%/yr
- No detectable window channel gain change.
- Semi-annual cycle in calibration data at 0.1% Total and 0.3% Window?
  - Study vs beta angle, instrument temperature.
- Correct Total channel gain change in Spring, 2002 reprocessing

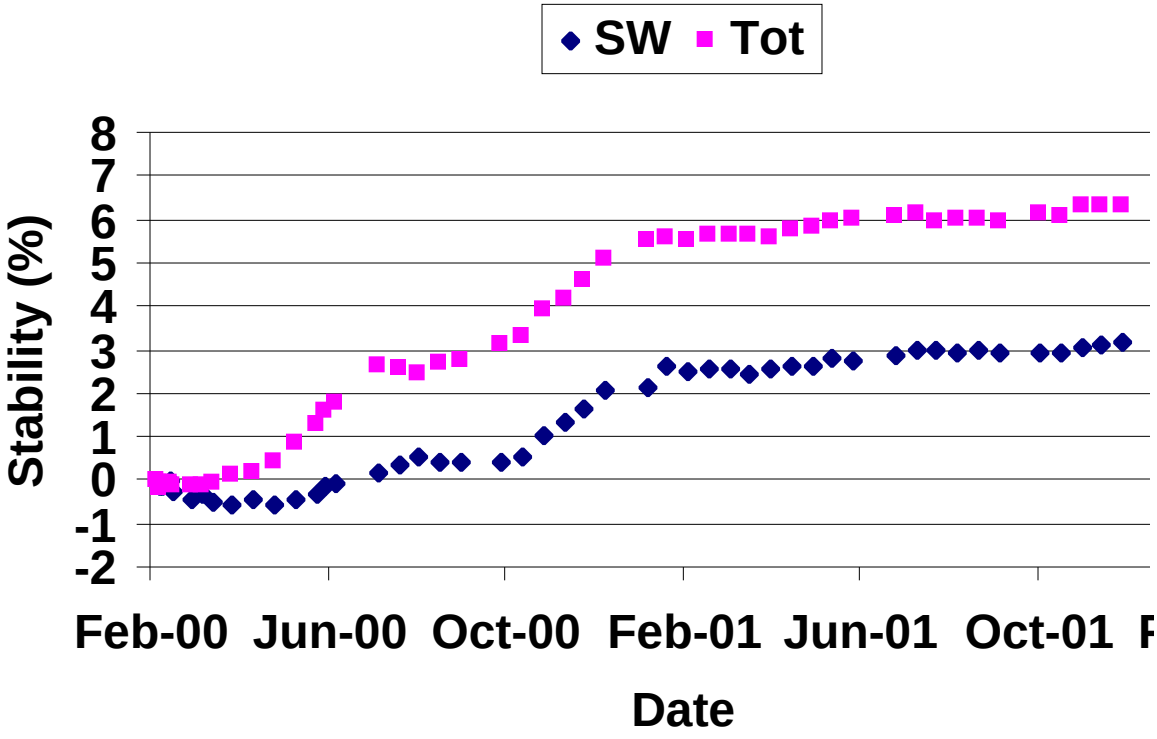
Terra/CERES Flight Model 1
On-Orbit SW Radiometric Stability

Solar Calibration Results



Terra/CERES Flight Model 2
On-orbit SW Radiometric Stability

Solar Calibration Results



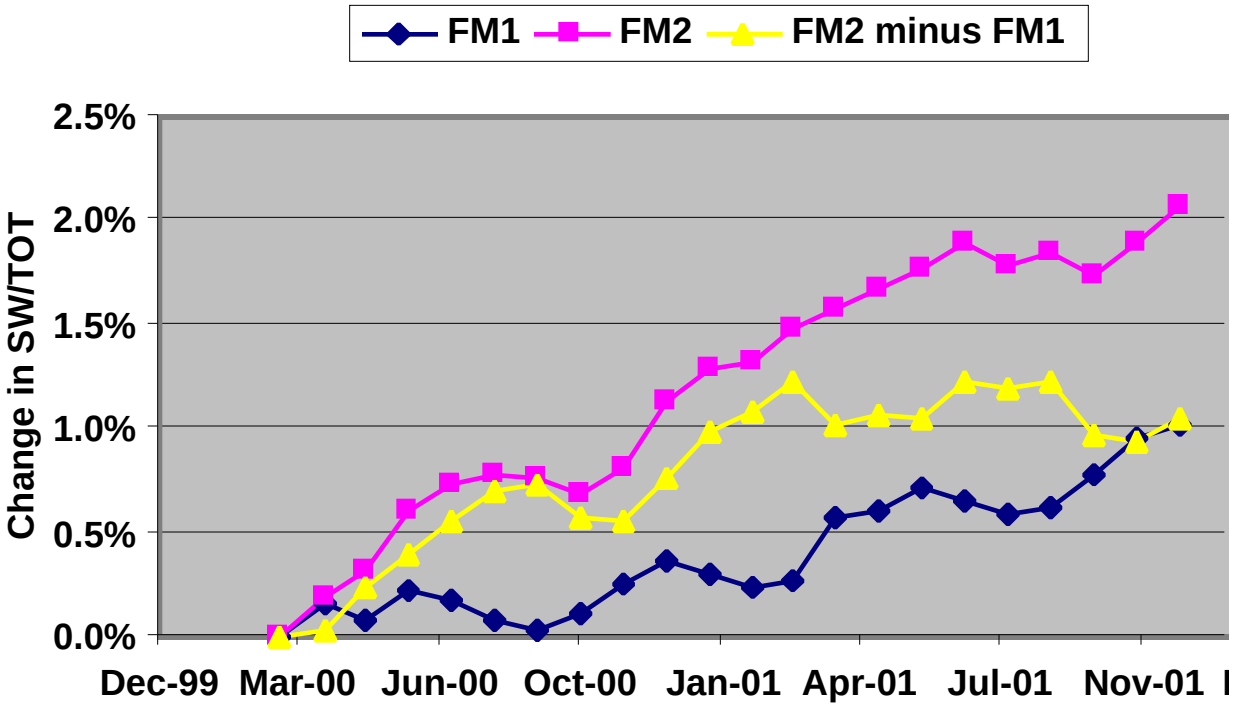
Terra MAM Performance

- While TRW black coated MAMs performed very well on TRMM, the 2 vendors used following loss of TRW capability had extensive problems with blistering of MAM black coatings.
- While repeated efforts at the coatings was thought to have solved most of the coating problems, FM-1 performed marginally (1% changes), and FM-2 very poorly (3-6% changes). Increased response consistent with degradation of black coating between the reflective MAM “dimples” in the aluminum surface.
- MAMs not useable for Terra instruments unless they later demonstrate a stable condition. FM-1 looks promising, FM-2 unclear.
- Expect similar MAM concerns on Aqua instruments.
- Confirms the importance of multiple calibration verification methods.

Three Channel Inter-Comparison

Using Deep Convective Clouds:

Win=>LW at night, then SW vs (TOT minus Win=>LW) day

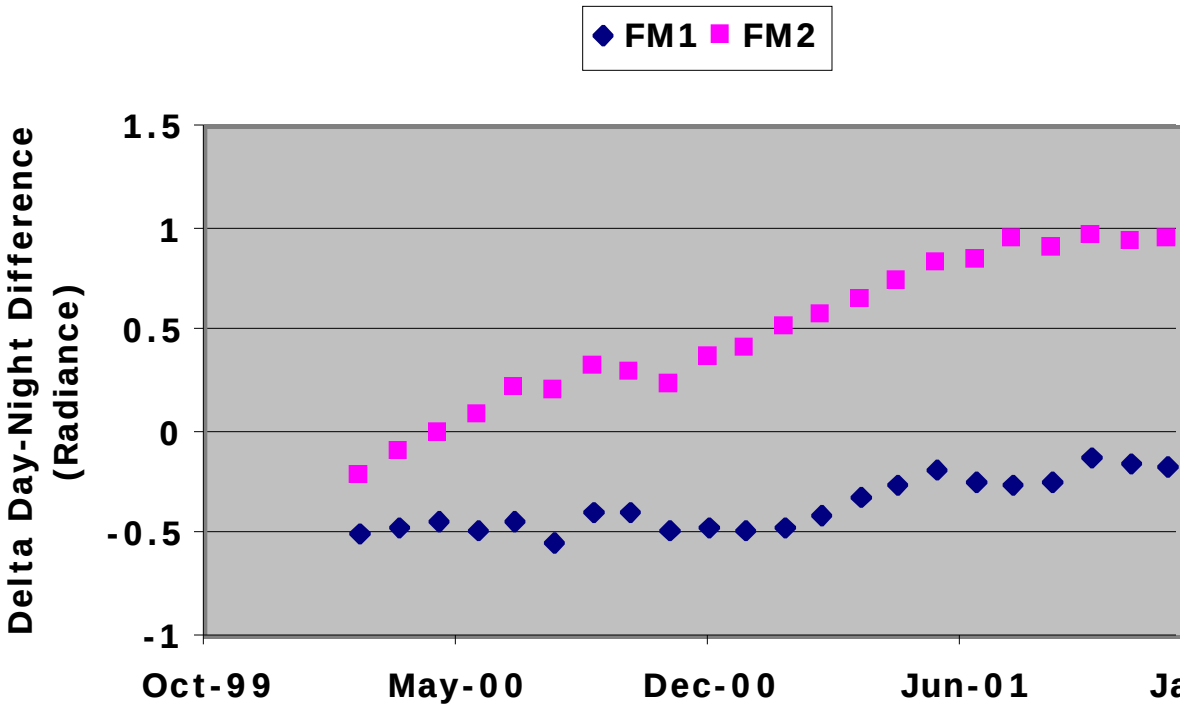


Change in
SW part of T
About 3 time
magnitude'
Of LW part o
Total (blackb

The SW portions of both the FM1 and FM2 Total channels are changing with time: especially FM-2

Tropical Mean Self Consistency

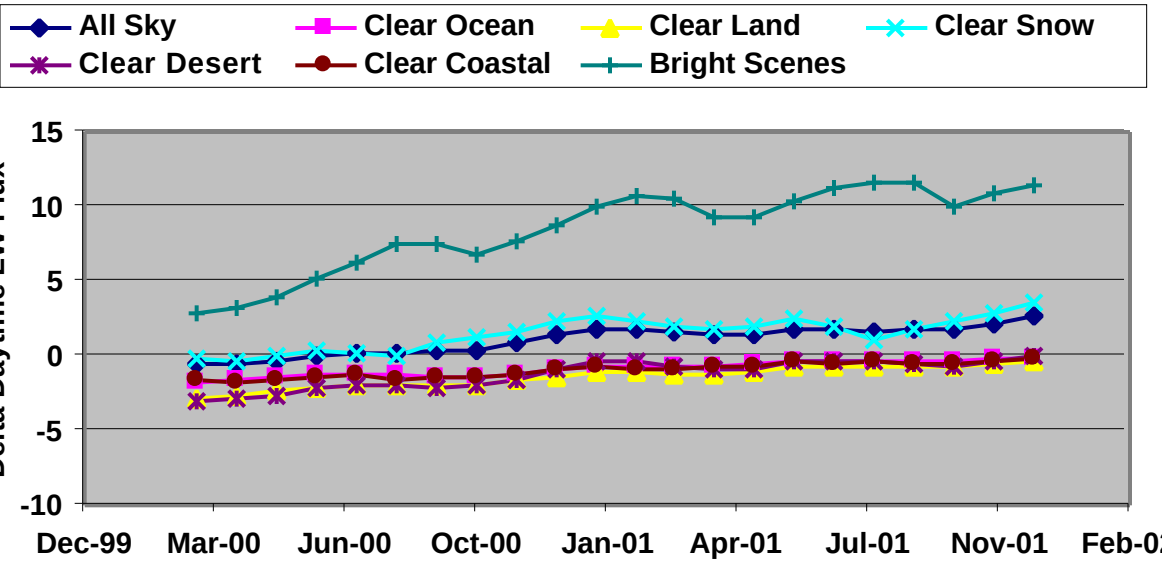
Tropical Ocean, All Sky



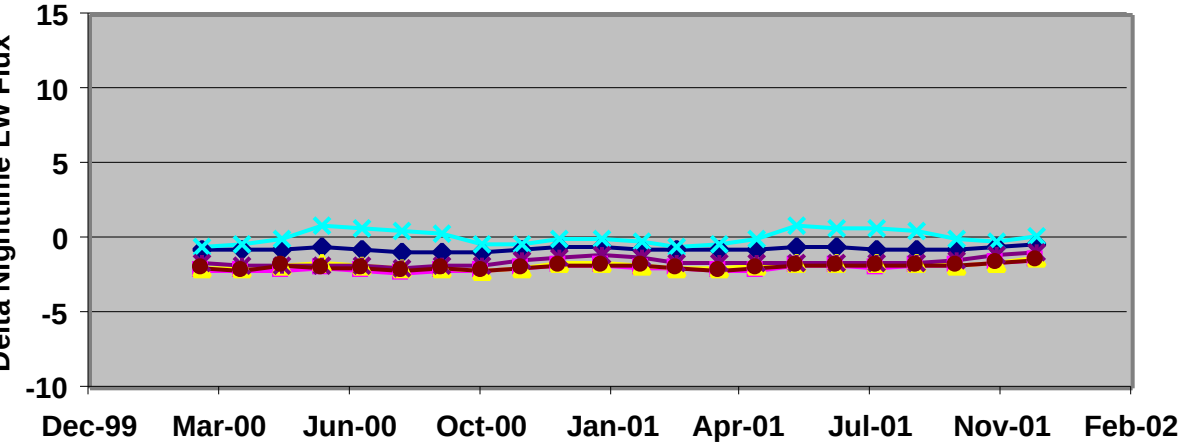
By comparing two estimates of Tropical Mean Day vs. Night Differences (Tot-SW & WN) Inconsistencies are revealed

Co-located Nadir Flux Comparisons

(FM2 minus FM1)



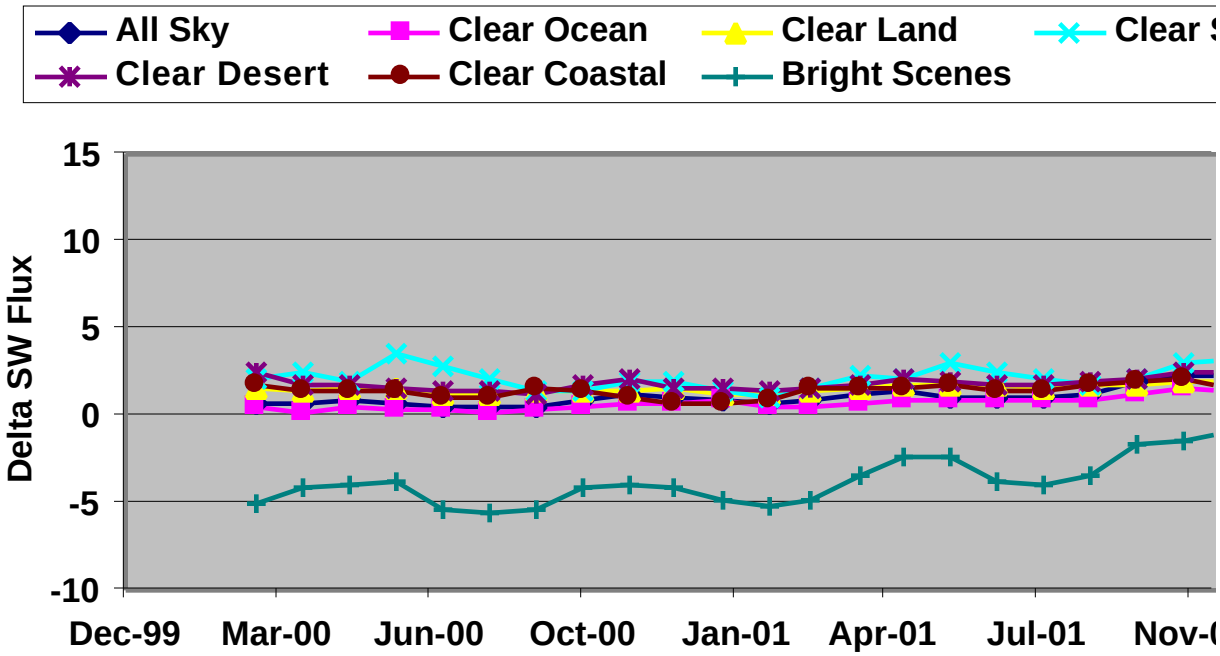
LW Daytime



LW Nighttime

Co-located Nadir Flux Comparisons

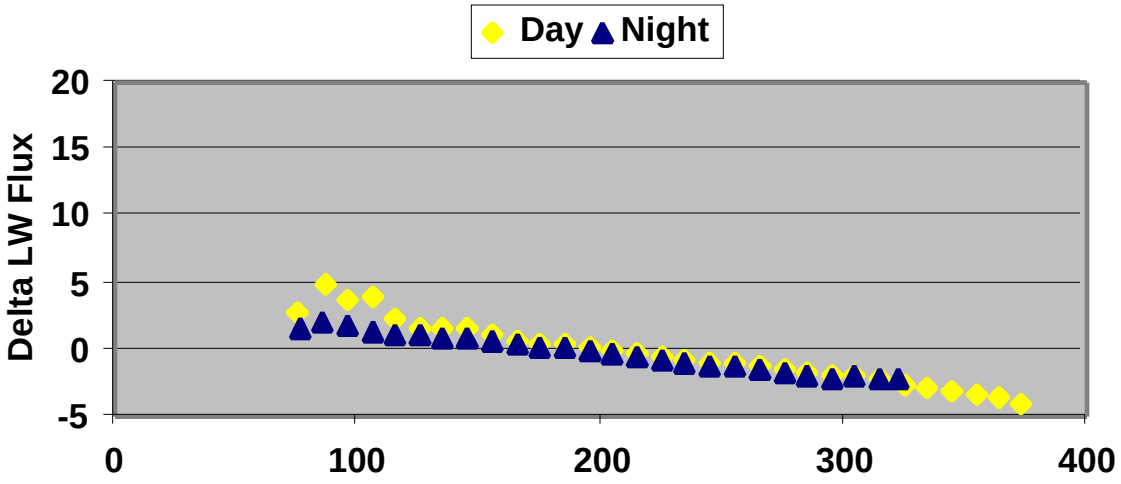
(FM2 minus FM1)



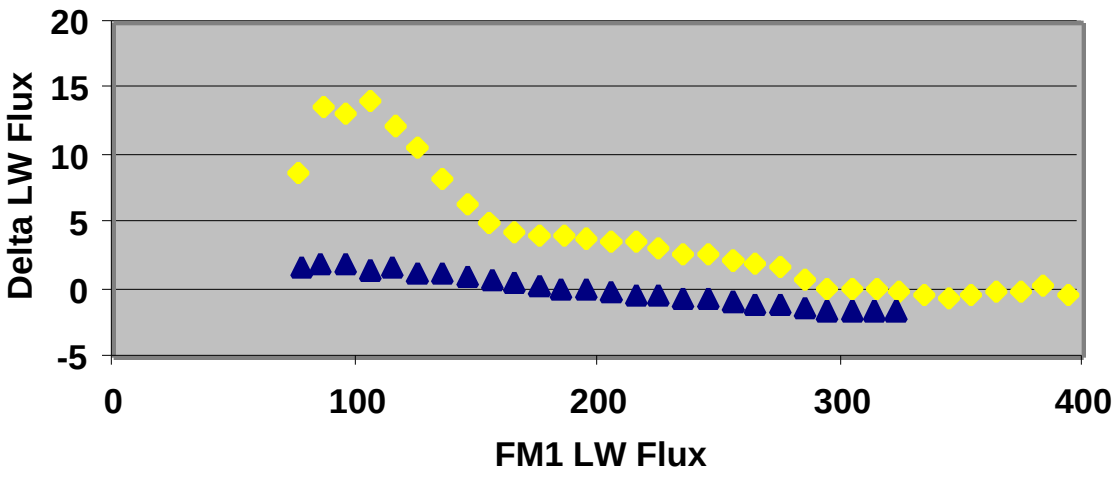
Increasing difference in Daytime LW is caused by the SW portion of the FM-2 Total Channel

Co-located Nadir Flux Comparisons

(FM2 minus FM1)



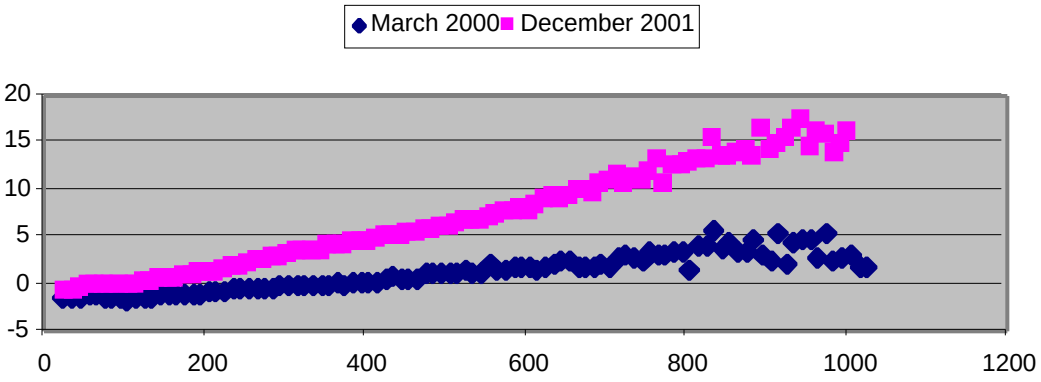
March, 2000



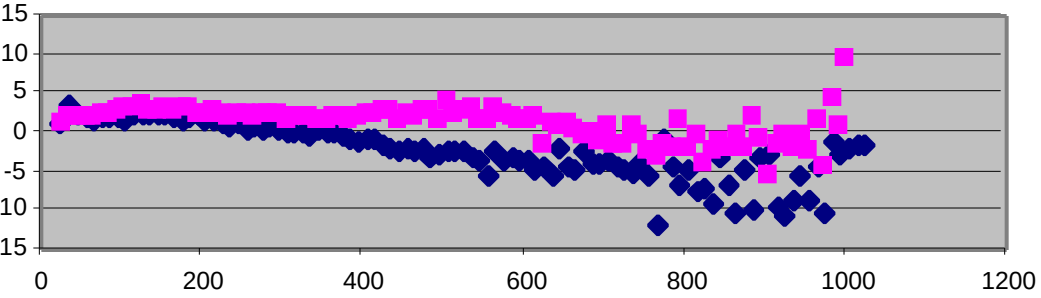
December, 200

Co-located Nadir Flux Comparisons

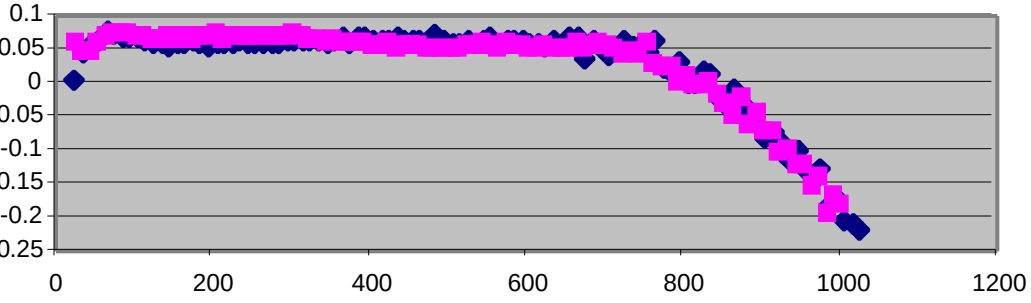
(FM2 minus FM1)



LW Flux

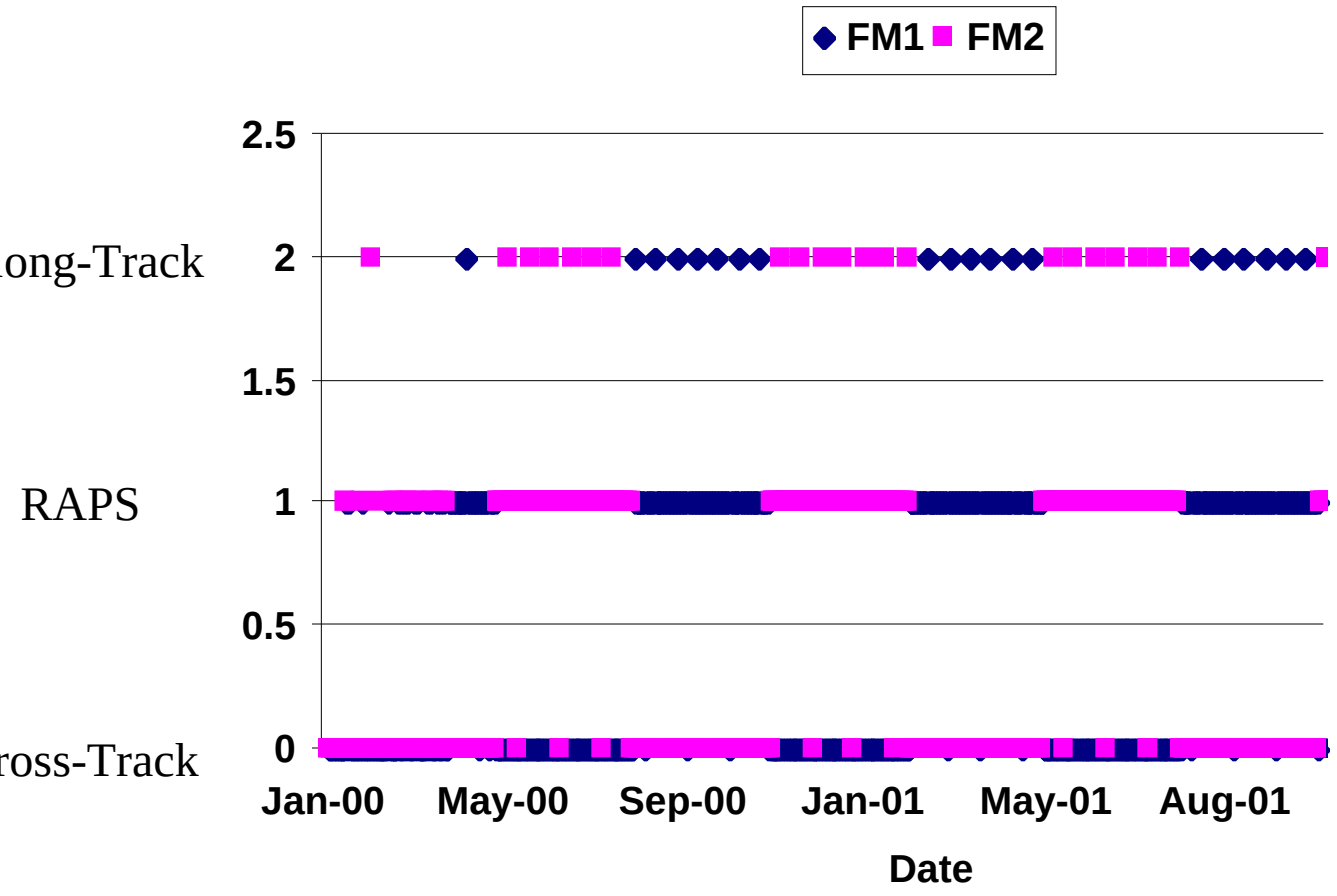


SW Flux



WN Radiance

CERES/Terra Mission Modes



//earth-www.larc.nasa.gov/ceresweb/INSTRUMENT/terra_daily_modes.

Processing Automation for BDS, IE

Data product generation requires 2 steps

(1) Process using baseline radiometric gains and spectral correction coefficients (SCC)

- Production strategy “Baseline-1”, not available to public

- Generates BDS, ES8 (no IES)

(2) Reprocess using updated daily interpolated monthly derived gains and SCC

- Production strategy “Edition 2”, available to public

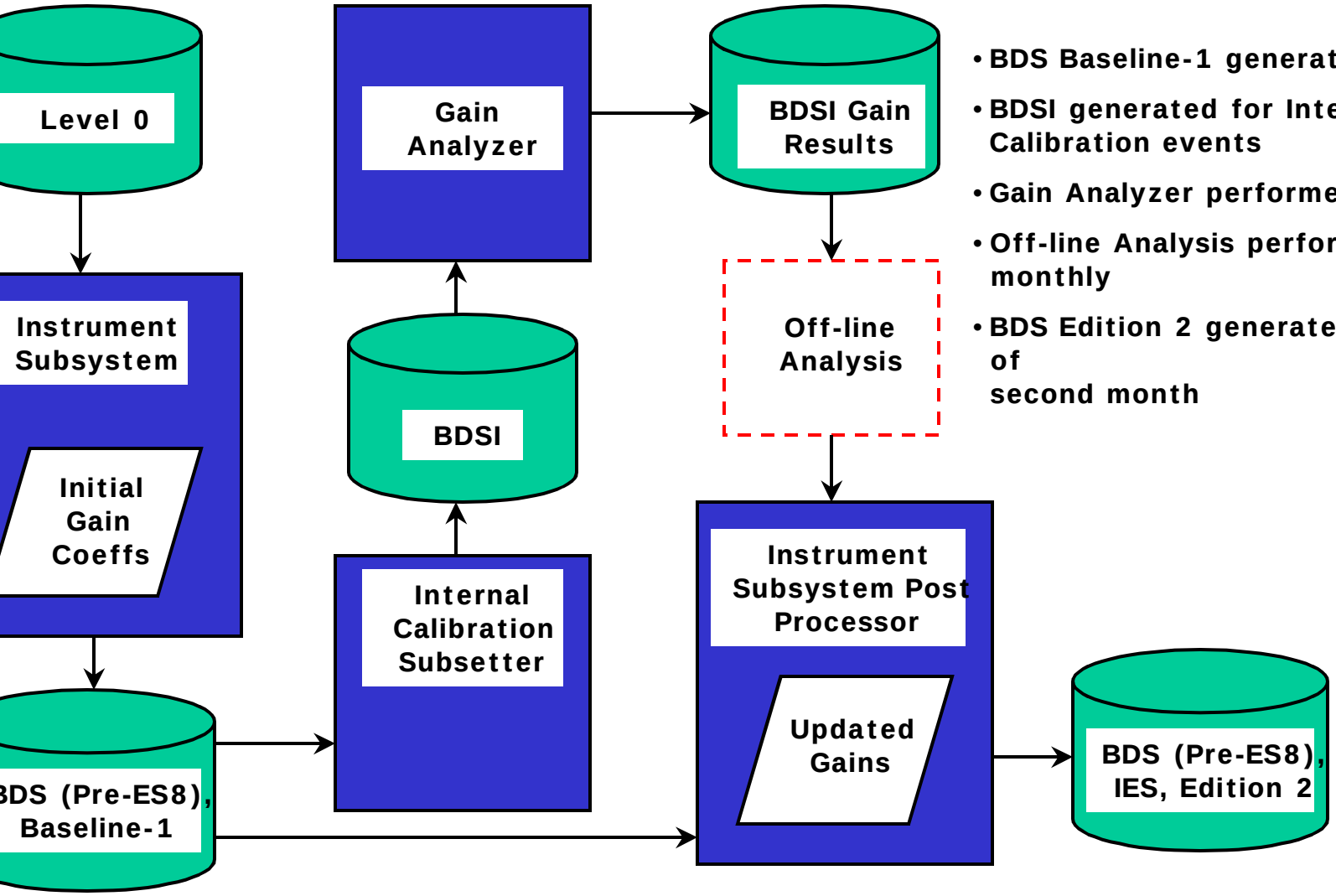
- Generates BDS, ES8, IES

Automated data reduction and off-line analyses using baseline data is required

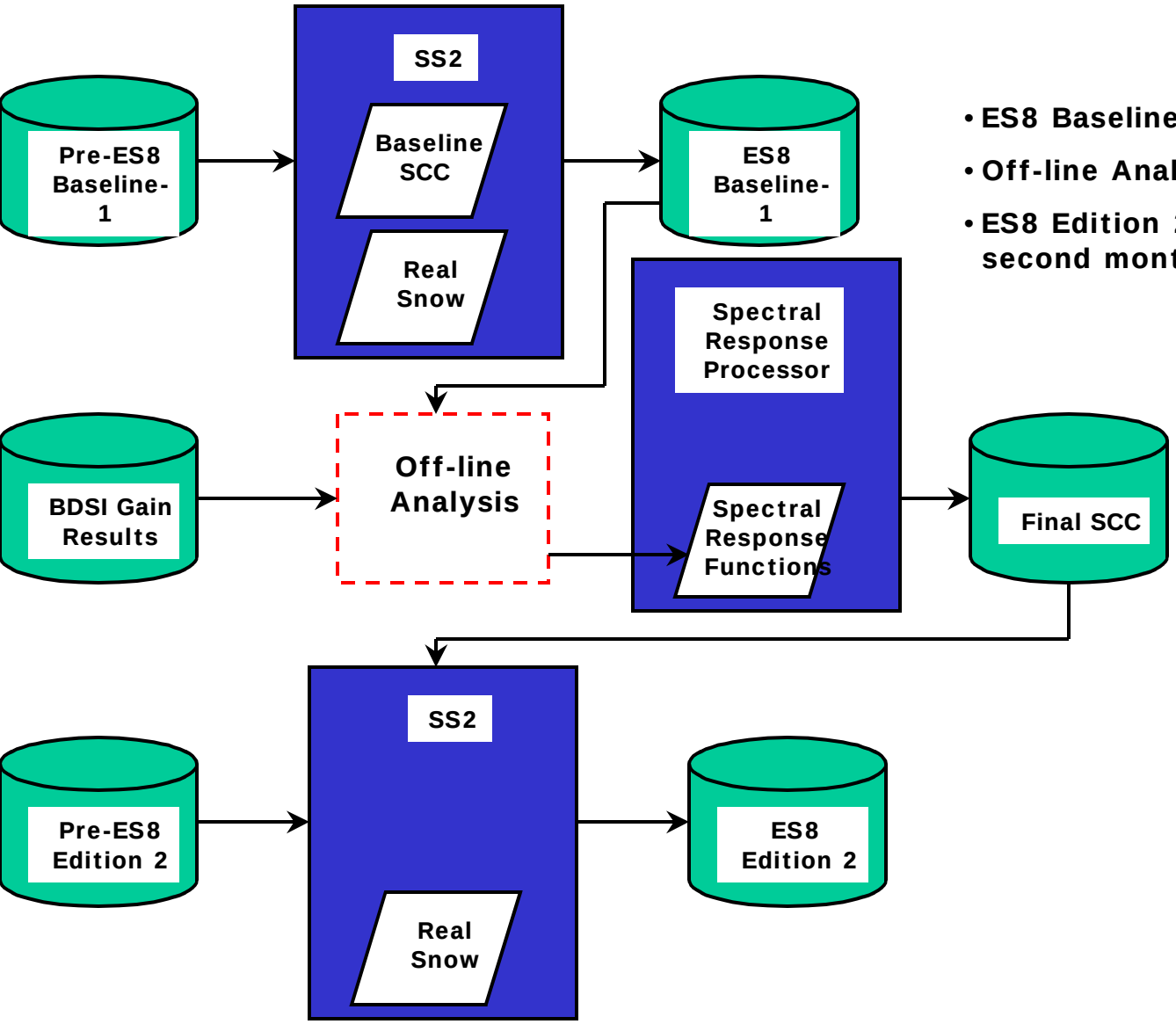
Edition 2 products 3 months behind real-time instead of 2 months.

Removes > 80% of the instrument drifts without waiting for long term da sets for reprocessing

Gain Analysis - Update Automat



Spectral Analysis - Update Auton



- ES8 Baseline-1 generated mo
- Off-line Analysis performed r
- ES8 Edition 2 generated at e second month

Summary

- For Edition 1 Terra ERBE-Like data, use FM-1
  - All 3 channels within 0.5% of ground cal through 2001
  - No drift correction for SW or Window channels.
  - 0.15%/yr LW part of total channel gain drift corrected in Edition 2.
  - 0.35%/yr SW part of total channel gain drift corrected in Edition 2.
- FM-2 corrections will be applied in Edition 2 BDS and ERBE-Like in Spring, 2002 (planned delivery April, 2002):
  - 1.5% in vacuum response change of detector
  - No gain drift correction for SW or Window channels
  - 0.35%/yr LW part of Total gain drift corrected in Edition 2
  - 0.7%/yr SW part of Total gain drift corrected in Edition 2
- These gain changes not seen on TRMM, unclear if they will be seen by Aqua. Response increases over time.
- Consistent results for internal calibration sources, three channel deep convection test, and day/night 3-channel test, and FM-1 FM-2 intercalibration at nadir.