In-flight stability analyses applied to the Clouds and the Earth's Radiant Energy System scanning thermistor bolometer instruments on the Terra satellite

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Outline of Talk

- Drift in CERES Measurements on Terra
- Analyses Used to Monitor CERES Measurements
  - 3-Channel Inter-comparison using Deep Convective Clouds (DCC)
  - Direct Comparison of Temporally Synchronized Nadir Views Between Two Instruments
  - On orbit Calibrations
- Drift Correction
- Results
- Conclusions

CERES Instruments

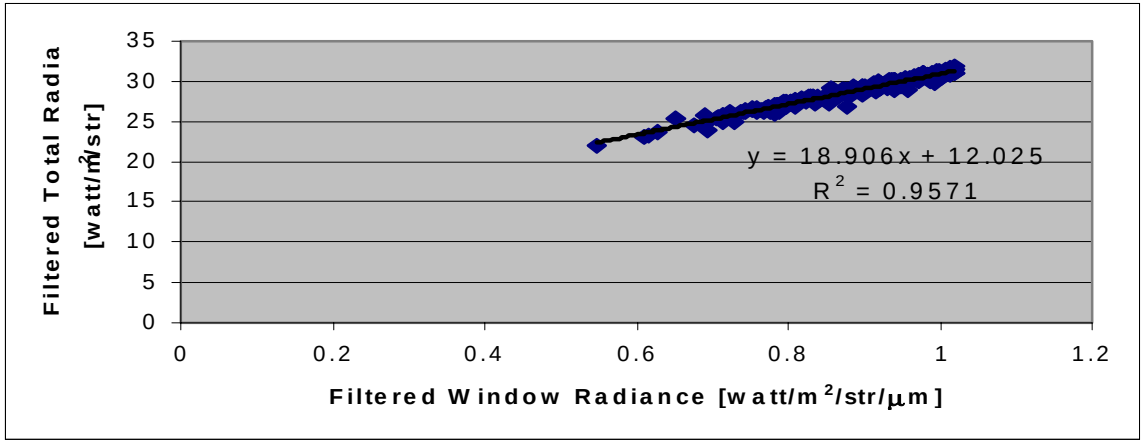
- **5 Instruments on 3 Satellite Platforms**
  - **TRMM (PFM) (no longer operational)**
  - **Terra (FM1, FM2)**
  - **Aqua (FM3, FM4)**
- **3 Sensors per instrument**
  - **Shortwave (0.3 μm – 5.0 μm)**
  - **Window (8.0 μm – 12.0 μm)**
  - **Total (0.3 μm – >100 μm)**

3-Channel Inter-comparison Using Deep Convective Clouds (DCC)

- DCC – Groups (>2 consecutive) of Nadir Footprints with Brightness Temperatures < 215K Detected by the Window Channel Sensor
- Sampling Between +- 35 degrees Latitude
- >60 degree Solar Zenith for Footprint
- Footprints Comprising a DCC Are Averaged for 1 Radiance Value and 1 Geolocation

3-Channel Inter-comparison Using DCC

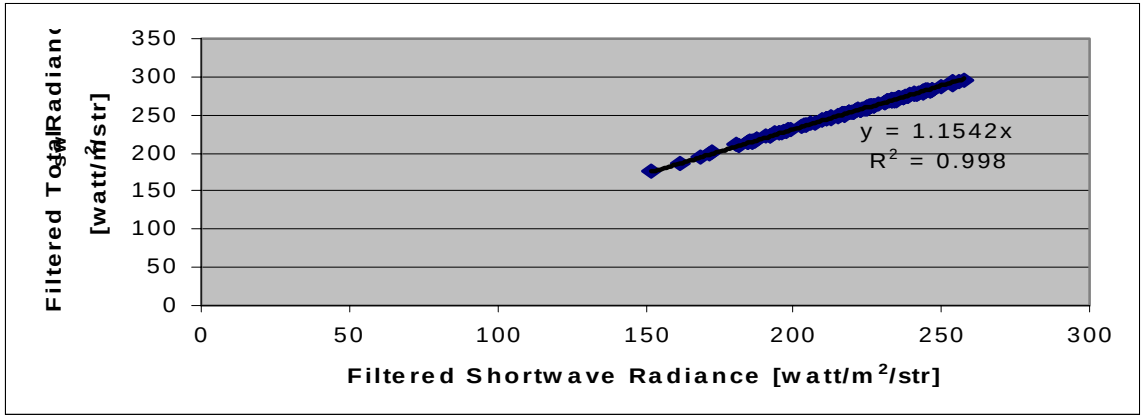
- **Regress Nighttime Window Radiance Measurement to Longwave Radiance**
- **This Relationship is Very Linear for These "Cold" Footprints**



FM1, March 2000

3-Channel Inter-comparison Using DCC

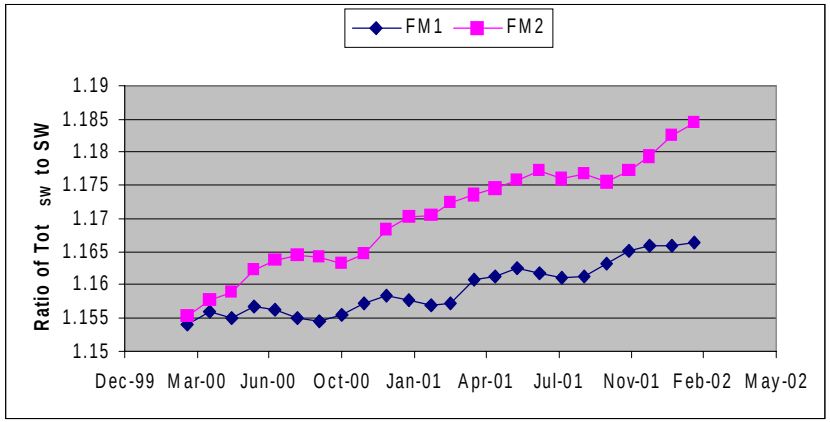
- **Regression Coefficients Are Used to Derive a Daytime Longwave**
- **Total – "Derived" Longwave = Shortwave Portion of Total Channel Sensor**

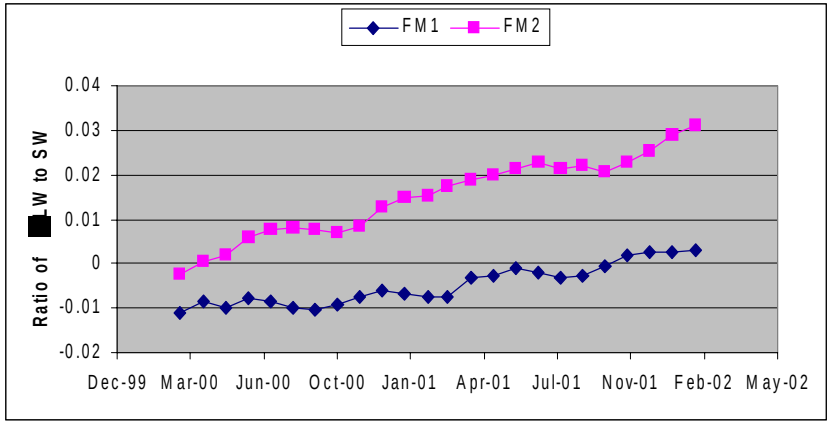


FM1, March 2000

3-Channel Inter-comparison Using DCC

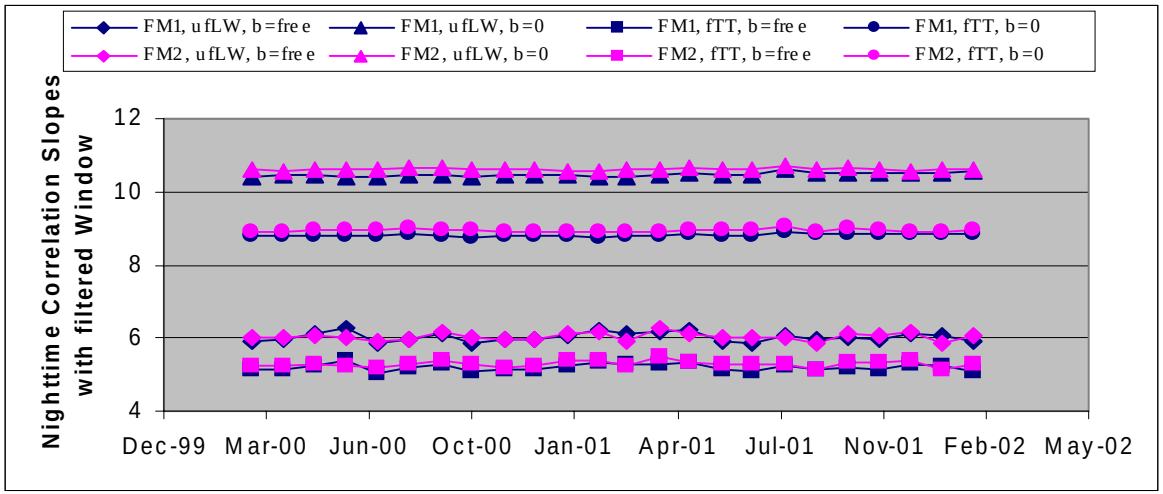
- **2 Inter-comparisons:**
  - **Nighttime Filtered Window vs. Filtered Total**
    - **Shortwave Portion of the Filtered Total Channel**
  - **Nighttime Filtered Window vs. Unfiltered LW**
    - **Daytime Δ LW = "Derived" – Measured LW**





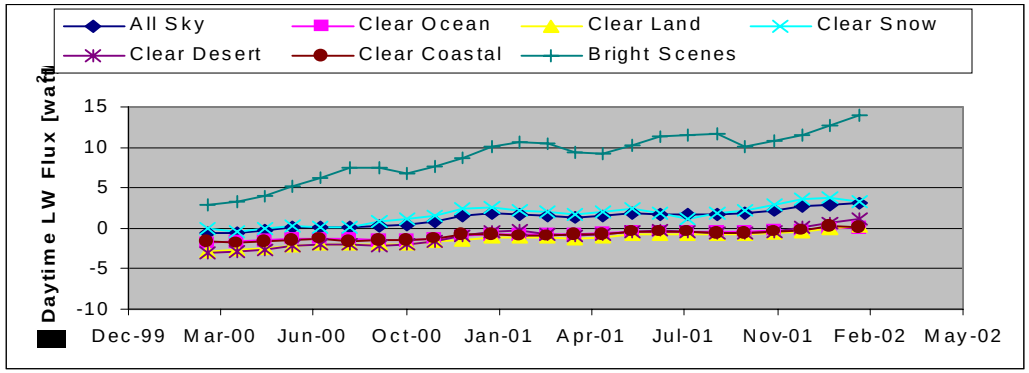
3-Channel Inter-comparison Using DCC

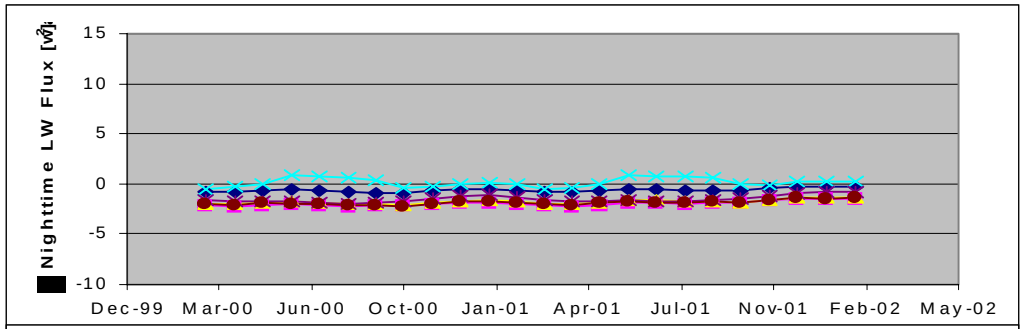
- **Nighttime Correlations Are Stable with Time**
  - **Filtered WN vs. Filtered Total**
  - **Filtered WN vs. Unfiltered LW**

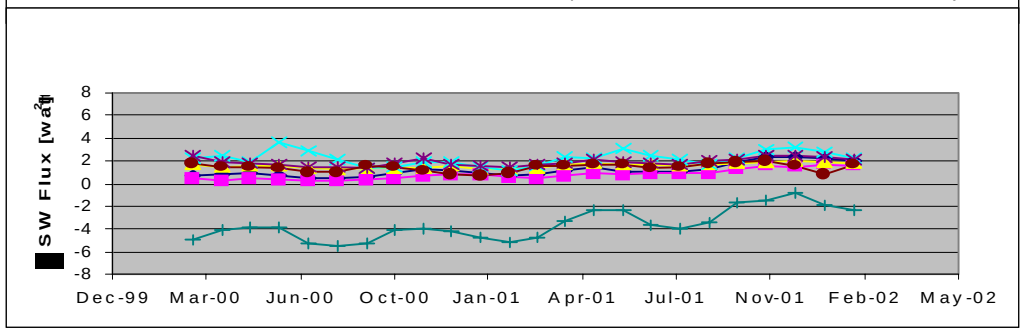


Direct Comparison

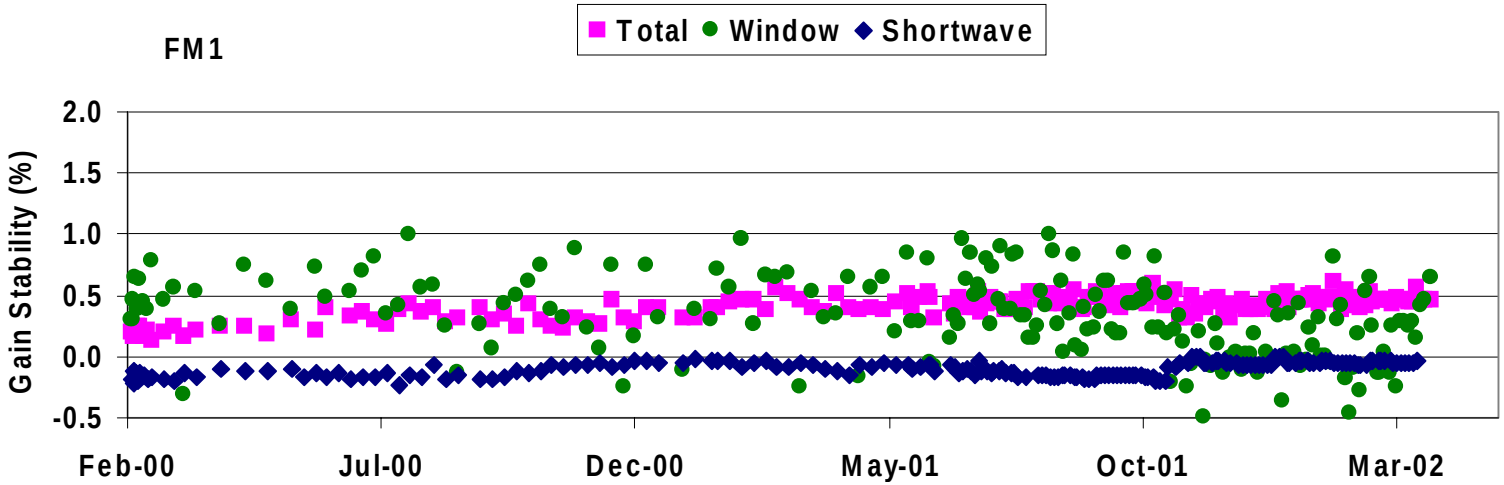
- **Matched Nadir Footprints Between FM1 and FM2 within 1.65 seconds (6.6/4 sec) (FM2-FM1)**

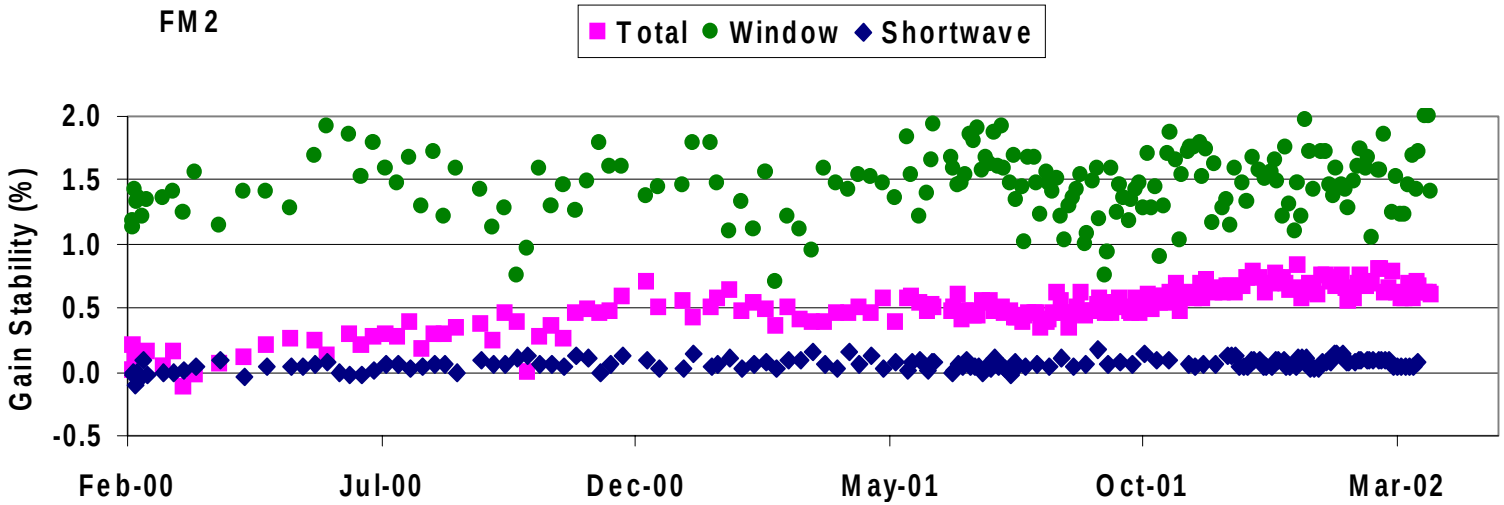






On Orbit Calibrations





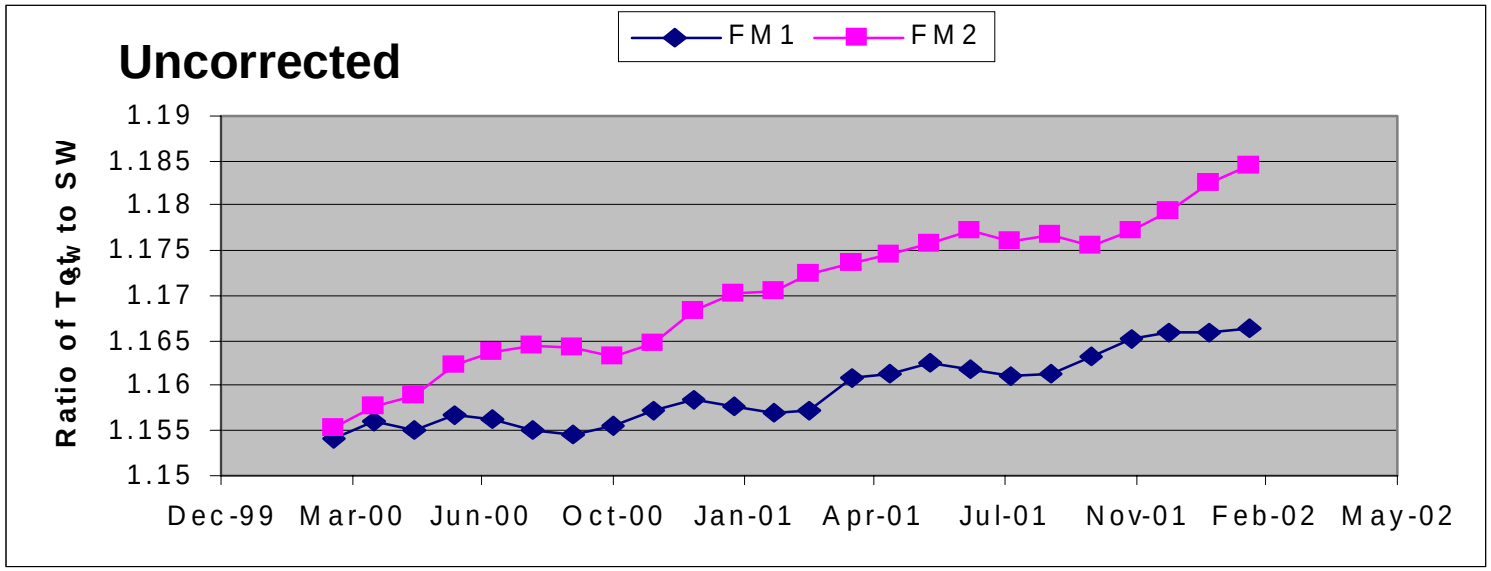
Summary of Analyses

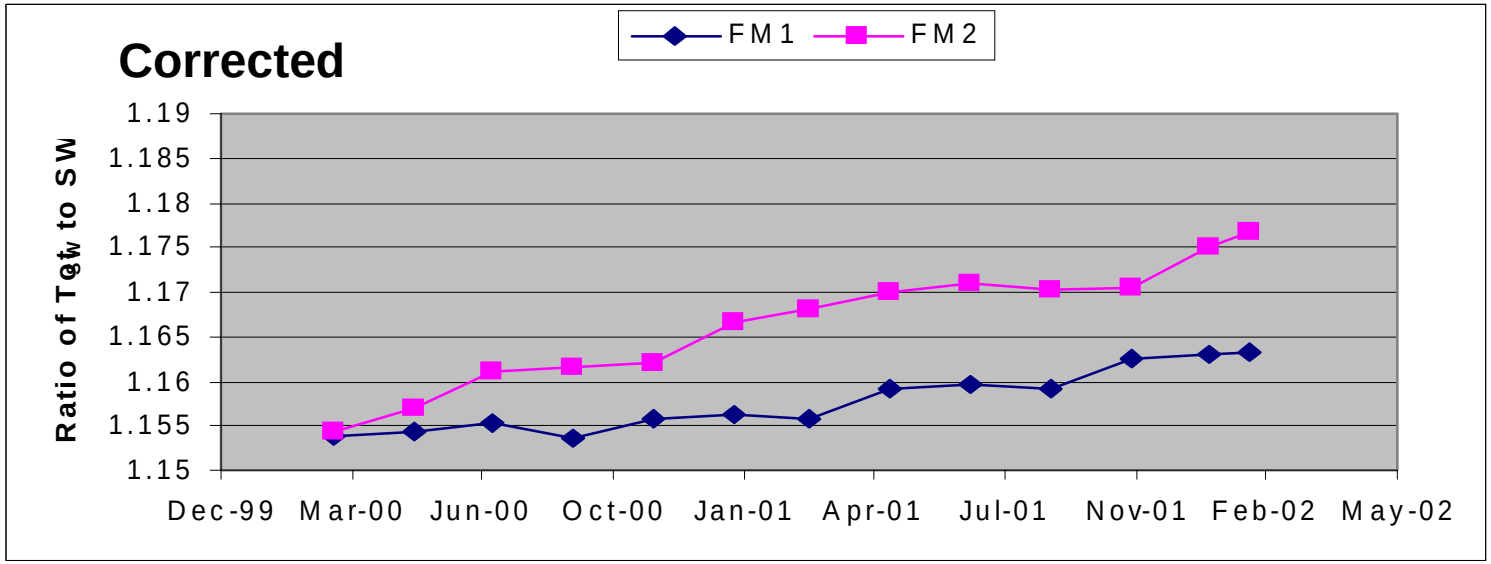
- **3-Channel Inter-comparison:**
  - **Ratio of $Total_{SW}$ to SW is Increasing with Time**
  - **Ratio of Day ΔLW to SW is Increasing with Time**
    - **Both Instruments; More Severe with FM2**
- **Direct Comparison:**
  - **Average Monthly Differences (FM2-FM1) in Coincident Day LW Nadir Fluxes Are Increasing with Time**
  - **No Trend for Night LW or WN Differences**
- **On Orbit Calibrations:**
  - **Total Channel Gain Increasing with Time**
  - **No Trending for SW and WN Gains**

Drift Correction

- **Analyses Conclusion:**
  - **$Total_{SW}$ is Drifting, Increasing with Time for FM2**
  - **SW Possibly Decreasing with Time for FM1 (?)**
- **Gain Adjustment:**
  - **Initial Ground to Orbit Change for All 3 Sensors on Both Instruments**
  - **Linear Time Varying Gains Over Mission Life for Total Channel Only on Both Instruments**
- **Spectral Response Adjustment:**
  - **Linear Time Varying Spectral Response Over Mission Life for Total Channel on FM2 Only**

Drift Correction Results





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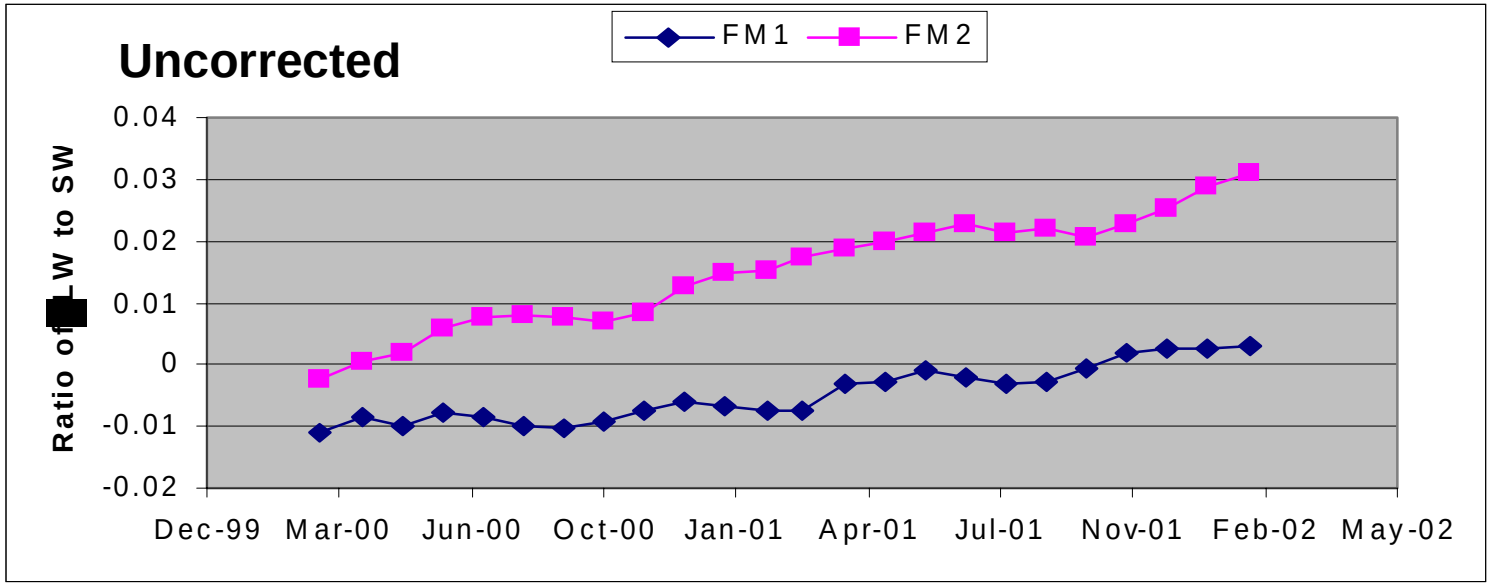

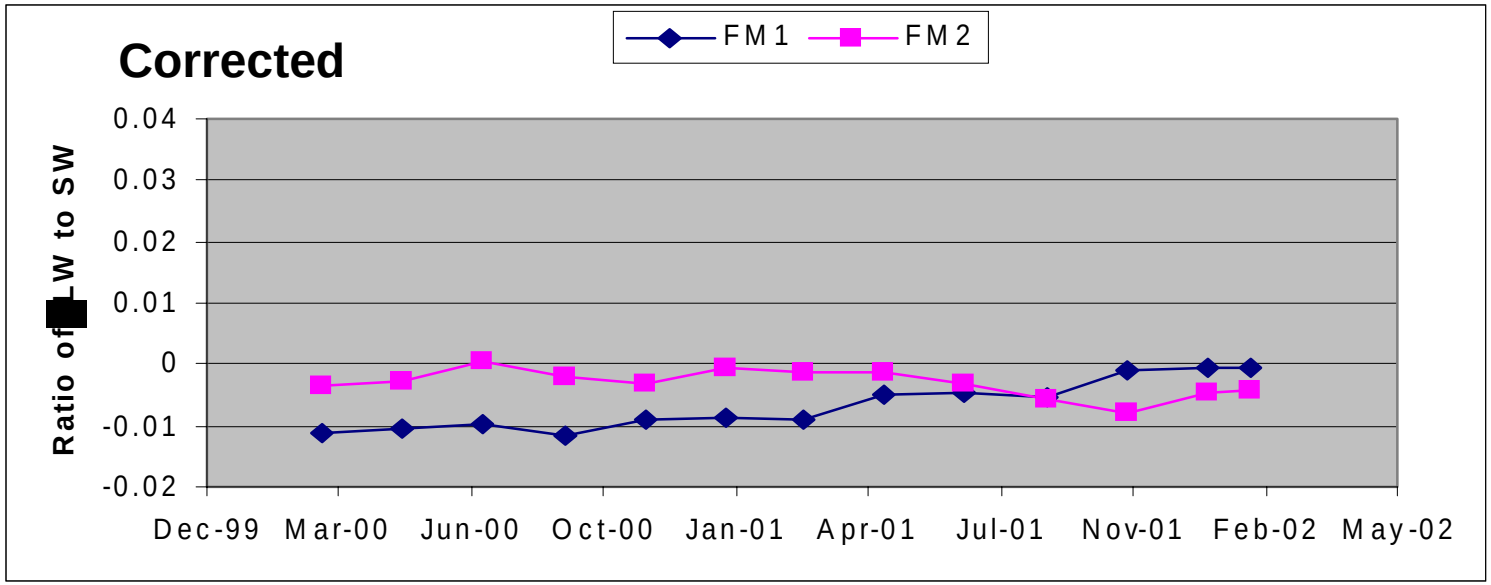

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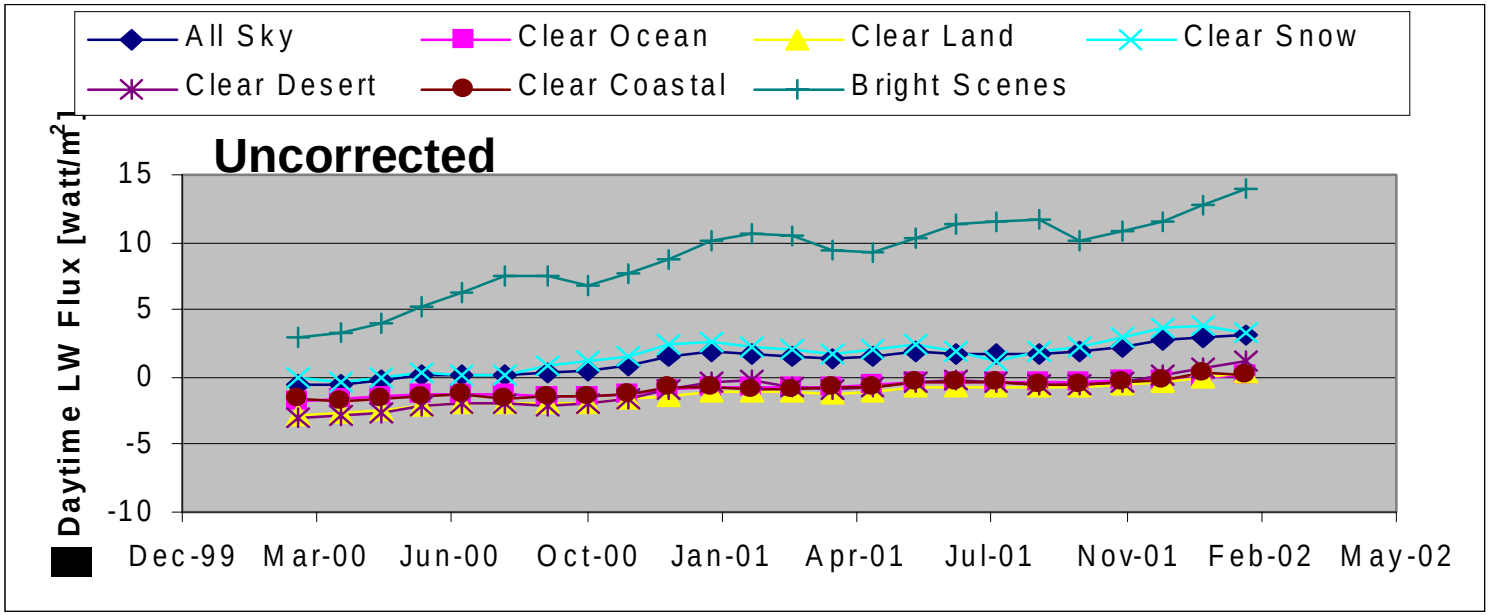

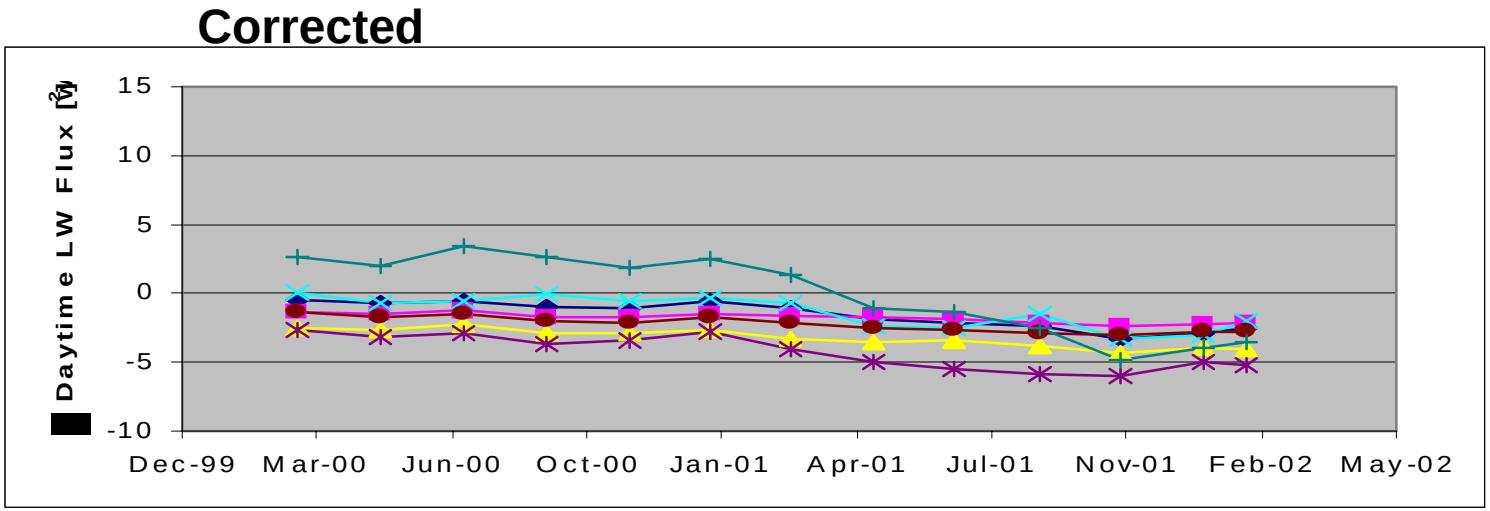

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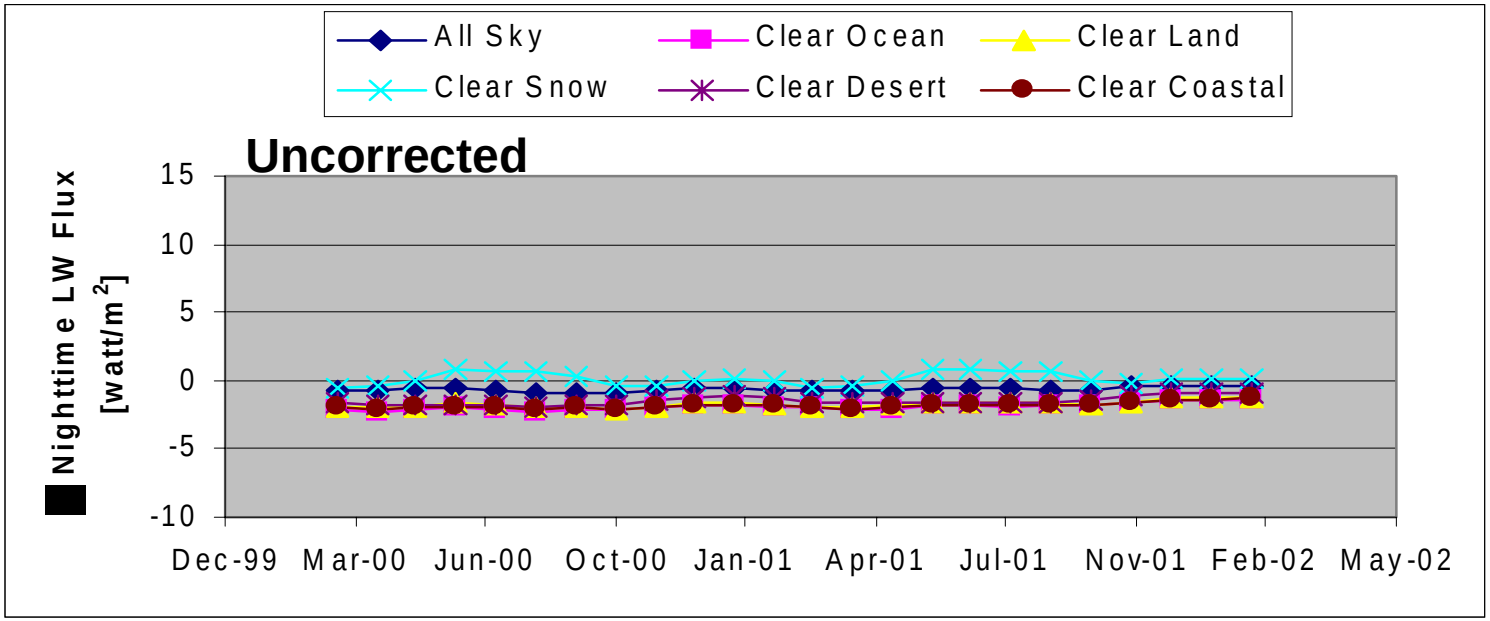

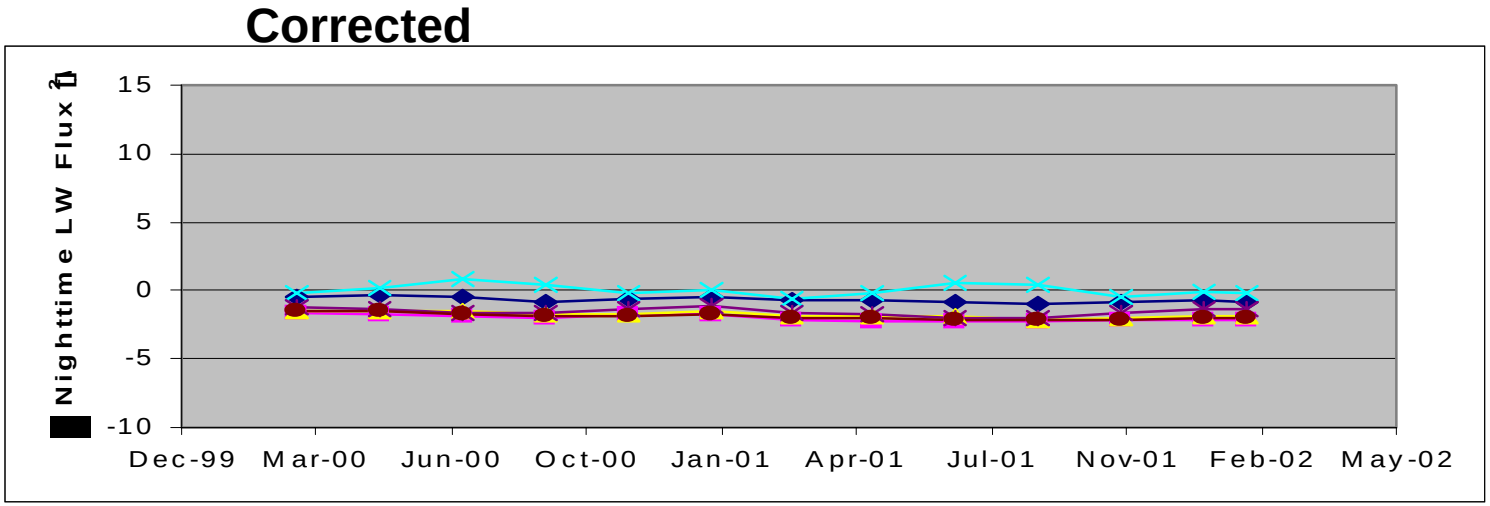

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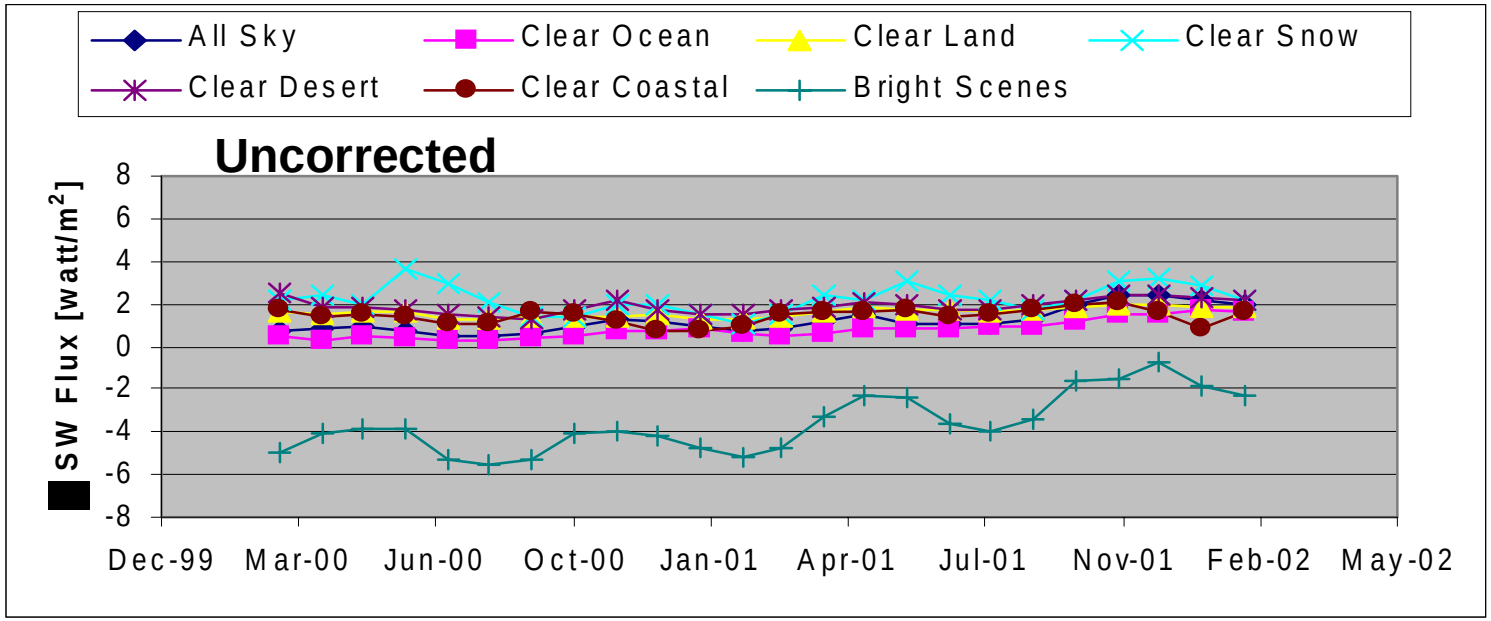

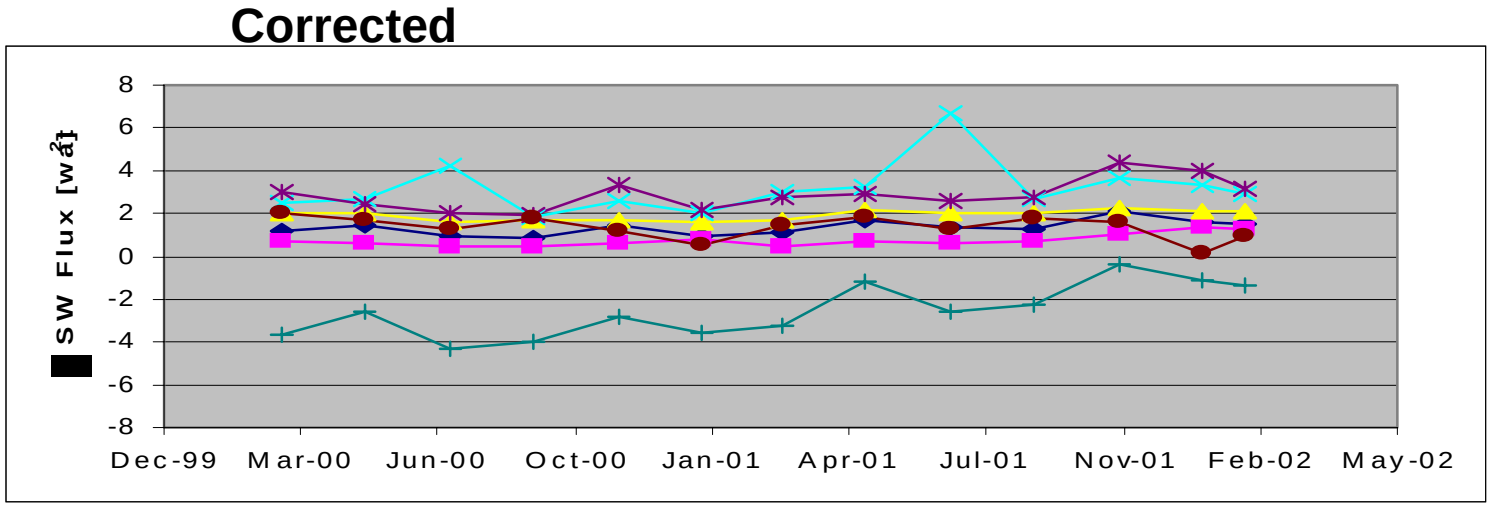

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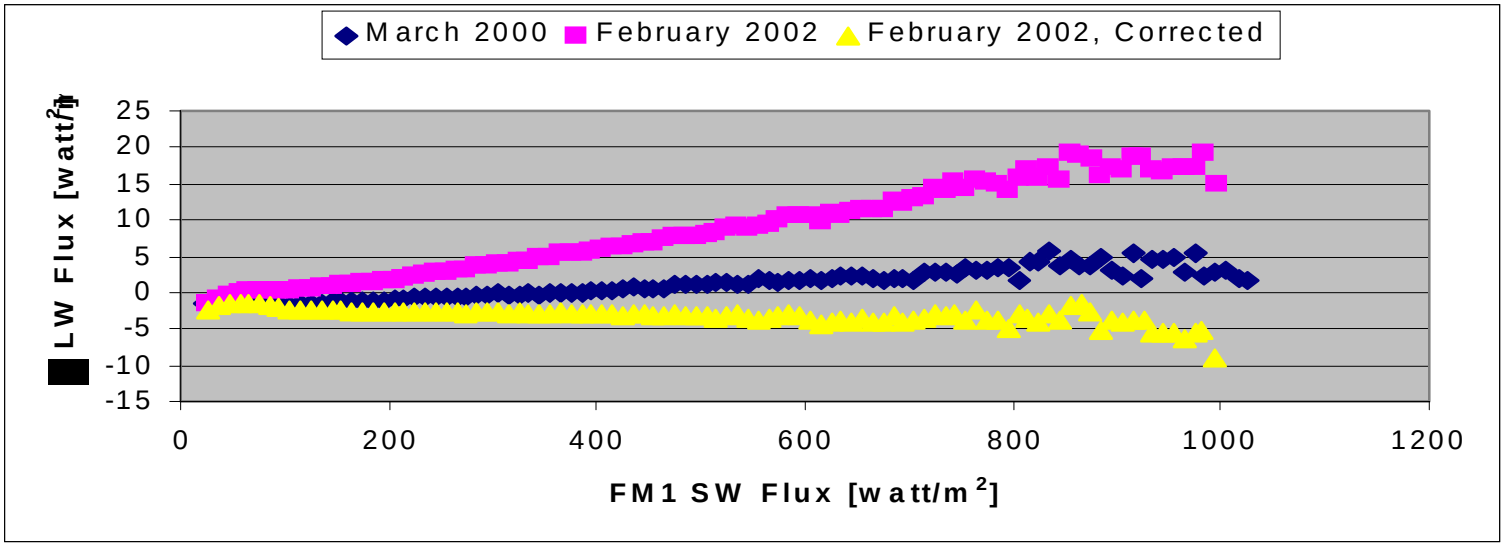

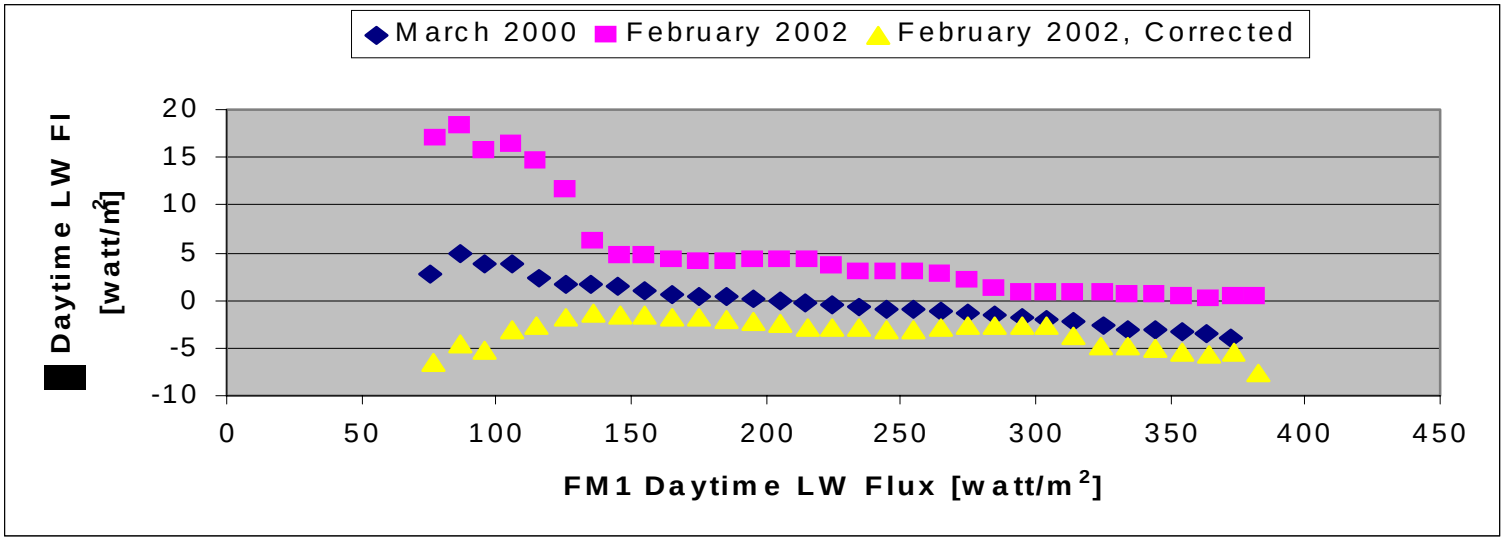

Conclusions

- **Drift in CERES Instruments on Terra**
- **Analyses to Monitor CERES Measurements**
  - **3-Channel Inter-comparison**
  - **Direct Comparison**
  - **On Orbit Calibrations**
- **Drift in $Total_{SW}$ in FM2 Instrument**
- **Drift Correction**
  - **Initial Ground to Flight Gain Correction**
  - **Time Varying Gain Correction**
  - **Time Varying Spectral Response for Total Sensor**
  - **Promising Results**