THE CALIBRATION OF GEOSTATIONARY SATELLITES

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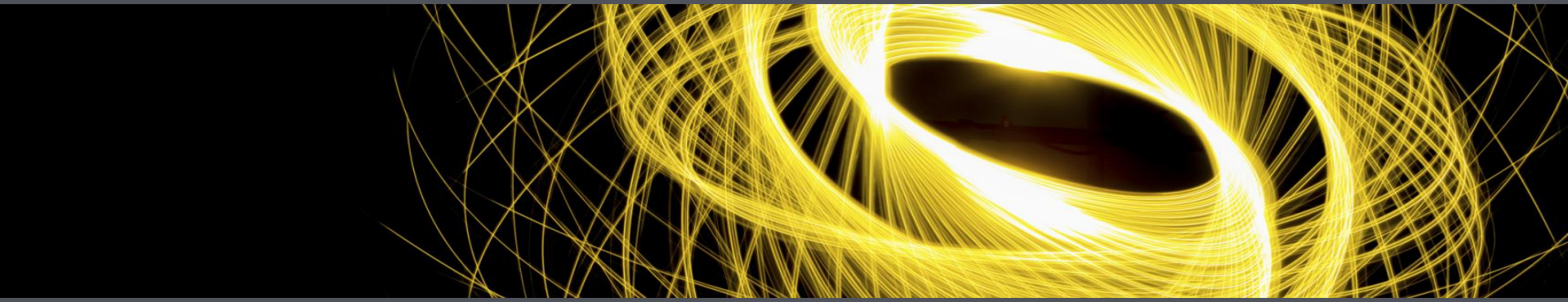

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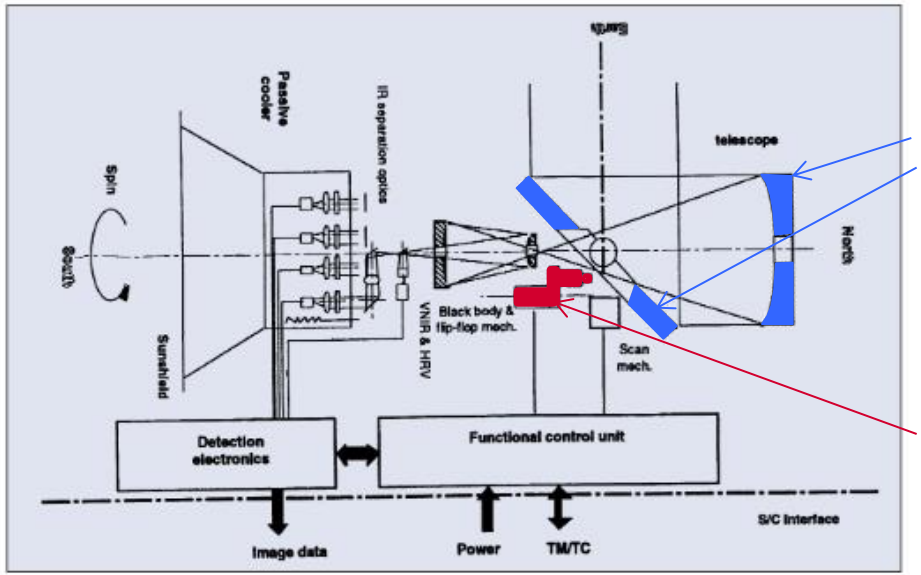
INTRODUCTION

- Accurate SSTs require accurate IR radiances/BTs
- Geostationary satellites have specific calibration issues that can impact accuracy
  - 3-axis stabilised platforms can have thermal instrumental effects due to large instrument temperature variations
  - Spinning instruments (e.g. SEVIRI) can have compromised calibration systems
- Plus other ‘normal’ calibration issues (SRF problems, straylight issues, solar contamination etc.)

SEVIRI ISSUES (1)

- Due to spinning nature calibration path does not include all of Earth viewing light path
- Extra radiance outside calibration path has to be modeled
- Possible source of error
  - Bear in mind for very accurate work…

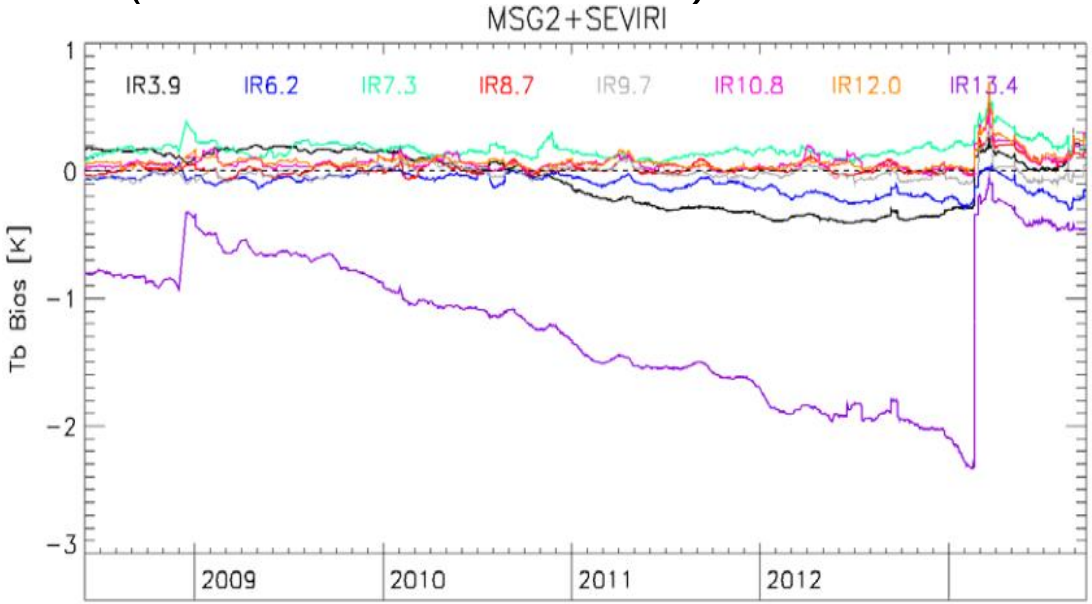


Not in calibration path

BB inserted into light path

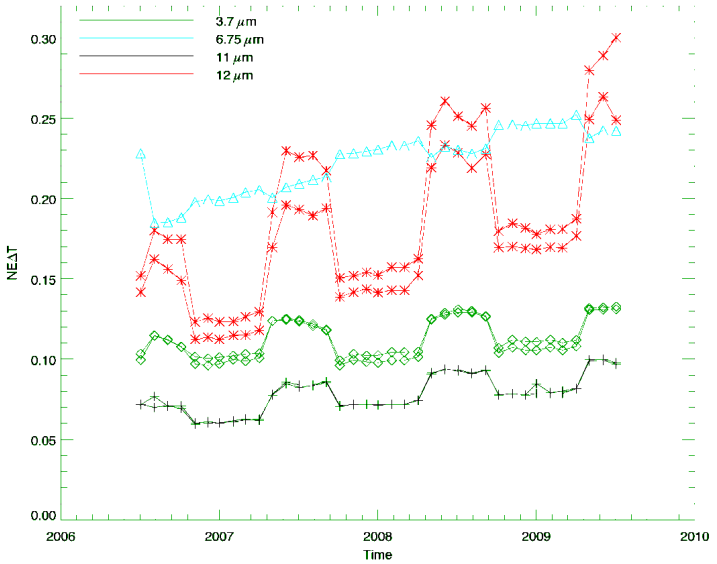
SEVIRI ISSUES (2)

- Ice buildup on 13.4μm channel (Hewison & Müller 2013)
  - Based on GSICS analysis
    - Compared to IASI
  - Clearly see decontamination events
  - Correction available for GSICS period
    - for climate may need to correct for earlier sensors



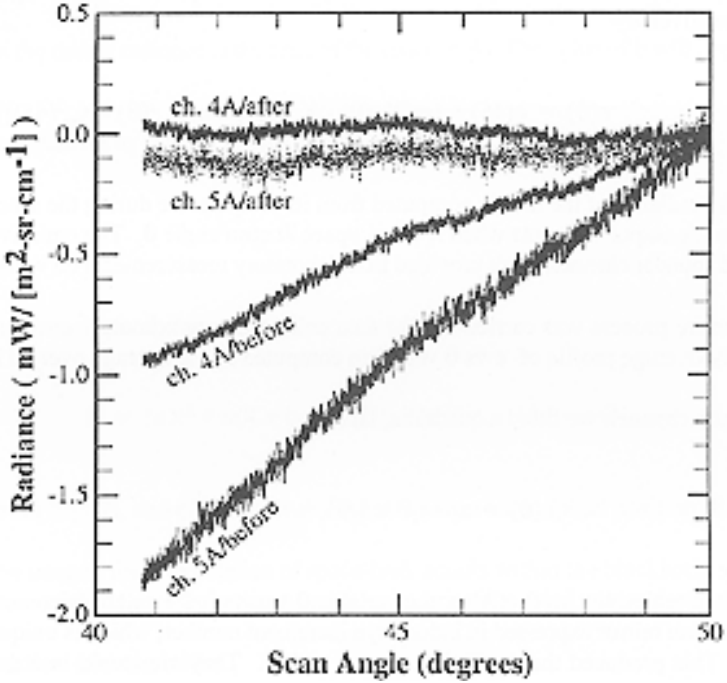
GOES ISSUES (1)

- Requires two detector temperatures around a year
- Impacts the NeΔT
  - Seasonal variation
- Long term time variation
- Should not assume constant NeΔT…

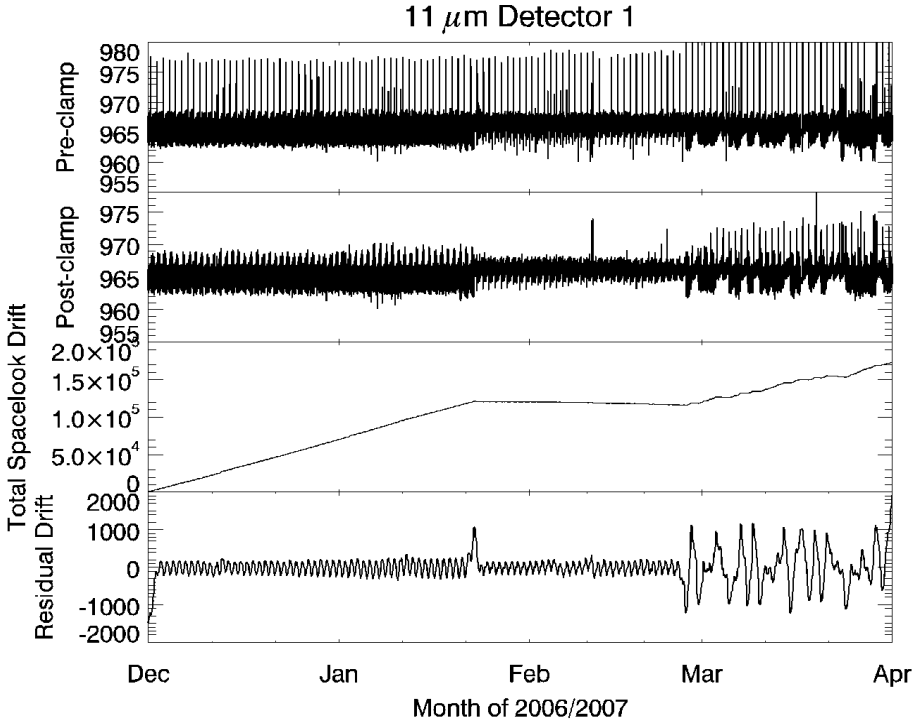


GOES (2) - MIRROR EMISSIVITY CORRECTION

- Paddle mirror means different incident angles for different scan locations
- Change in mirror emissivity
  - Variation in mirror radiance
- Effect up to a few Kelvin across scan
- Correction based on Space view scans



GOES (3) – SEASONAL CALIBRATION PROBLEMS



Eclipse season

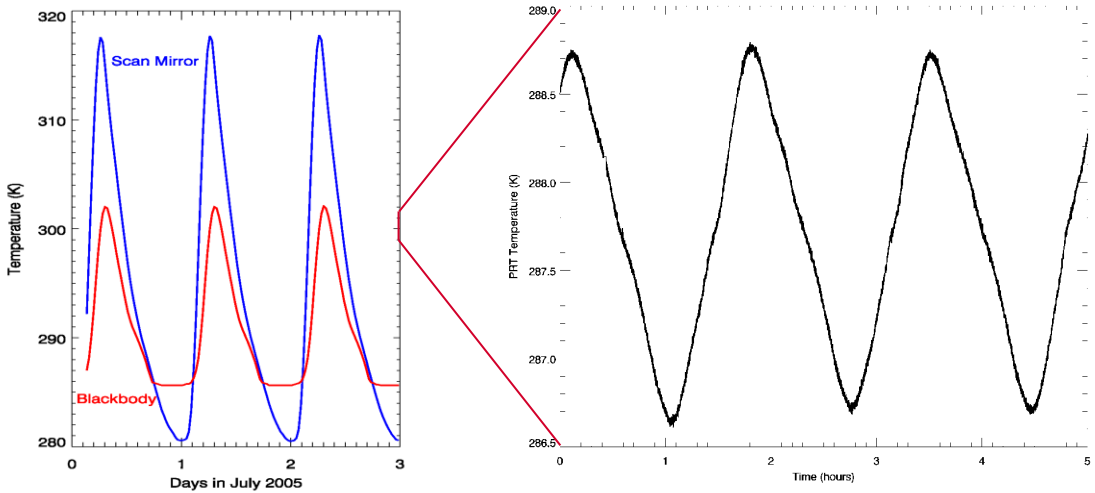
Use accumulated space counts as a proxy for the instrument self-emission radiance

Instrument well behaved until eclipse season (can see diurnal self emission variations)

When eclipse season starts instrument seems to go haywire…

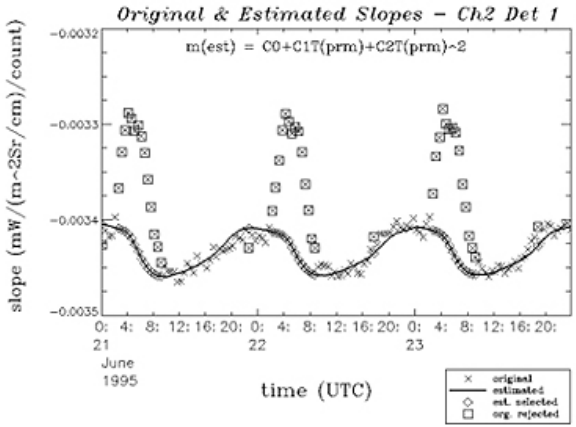
GOES ISSUES (4) – INSTRUMENT TEMPERATURES

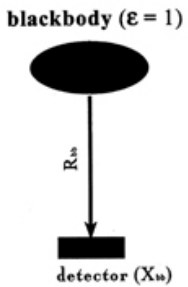
- 3-axis stabilized
  - Large thermal variations compared to LEO satellites



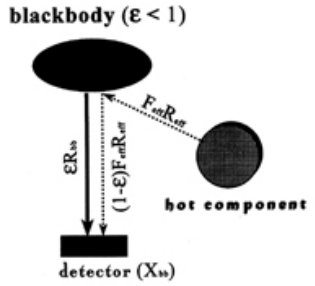
THE MIDNIGHT BLACKBODY CALIBRATION CORRECTION (MBCC)

- Corruption of the calibration system around the time of local midnight – stray light from a heated part of the instrument (thought to be the sun shield) reflected off BB





$$m = \frac{R_{bb}}{X_{bb} - X_{sp}}$$

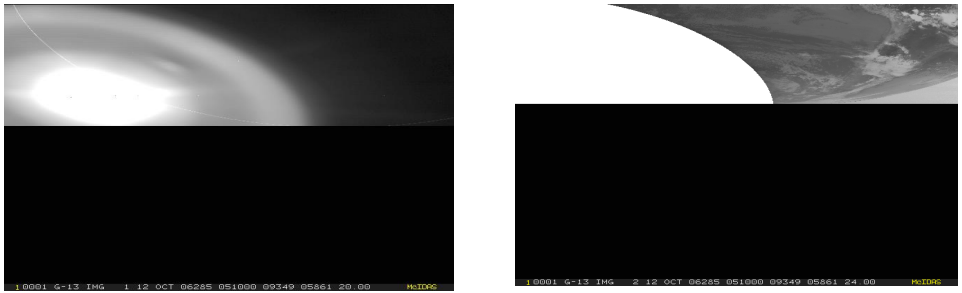


$$m_{true} = \frac{\epsilon R_{bb} + (1-\epsilon) F_{eff} R_{eff}}{X_{bb} - X_{sp}}$$

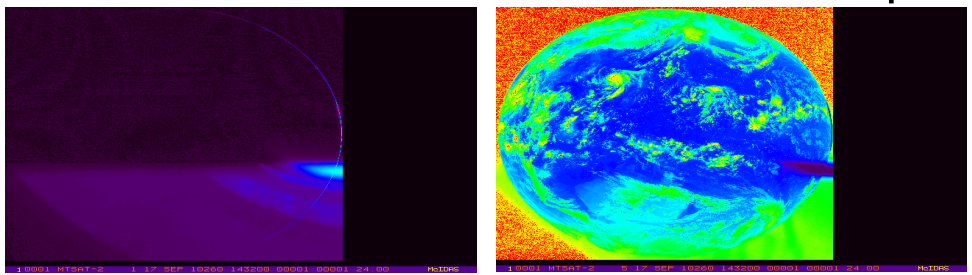
SOLAR CONTAMINATION

- Solar contamination in the image plane seen close to local midnight
  - Worst can be masked out
  - But still can have residual effects…

GOES-13



Visible MTSAT-2 3.8μm



Scattered light in MTSAT-2

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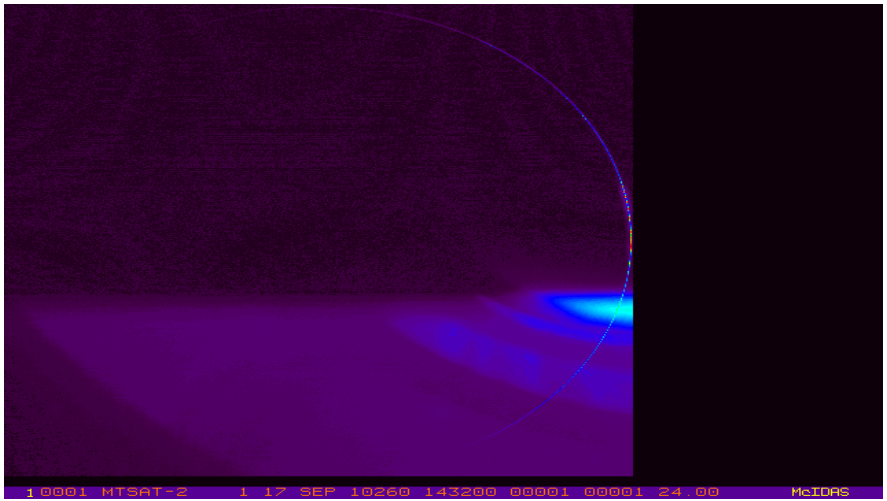
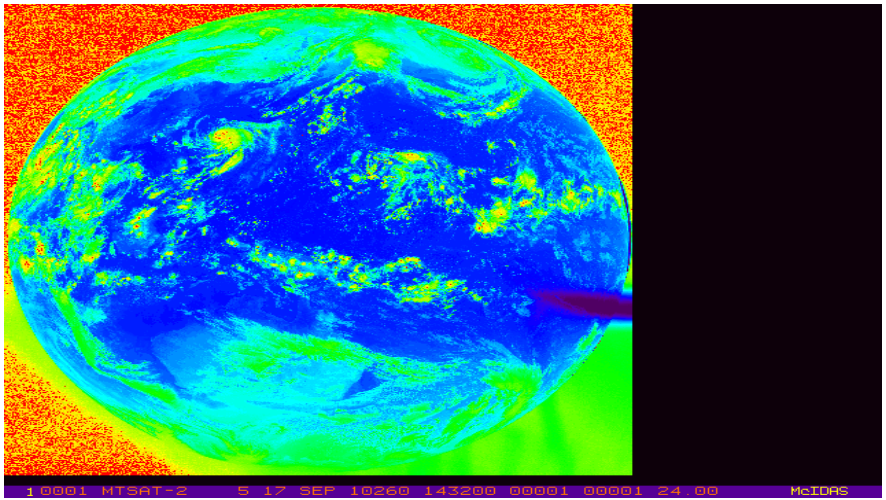
Visible channel



3.9 micron channel



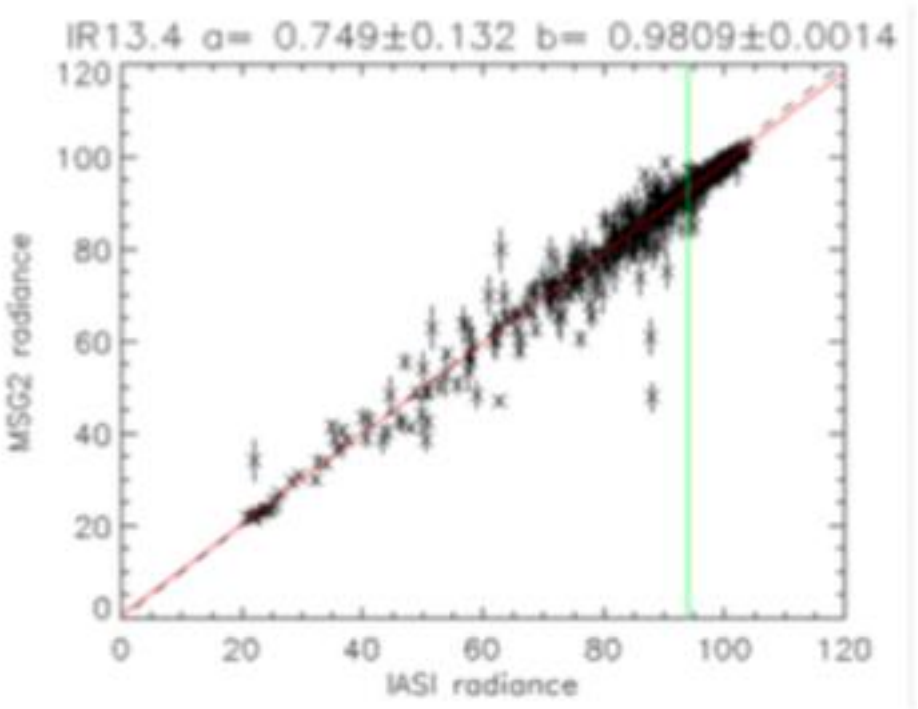
Occurs during eclipse season around local midnight

CALIBRATION FIXES

- There are a number of different approaches to fix GEO calibration biases/error
  - GSICS (Global Space-based Inter-Calibration System)
    - Provides scene temperature dependent bias based on a linear model
  - Modification to calibration algorithms and/or recalibration
    - Updated MBCC algorithm
  - Model solar contamination
    - Doesn't work very well…

GSICS + GOES

- Provides a correction to BTs
- Detailed Uncertainty analysis of matchup process applied (e.g. Hewison 2013)
- Ordinary Least Squares fit
  - This may introduce biases due to not taking into account uncertainties in both X & Y ordinates



Wu & Yu, 2013,GOES GSICS ATBD

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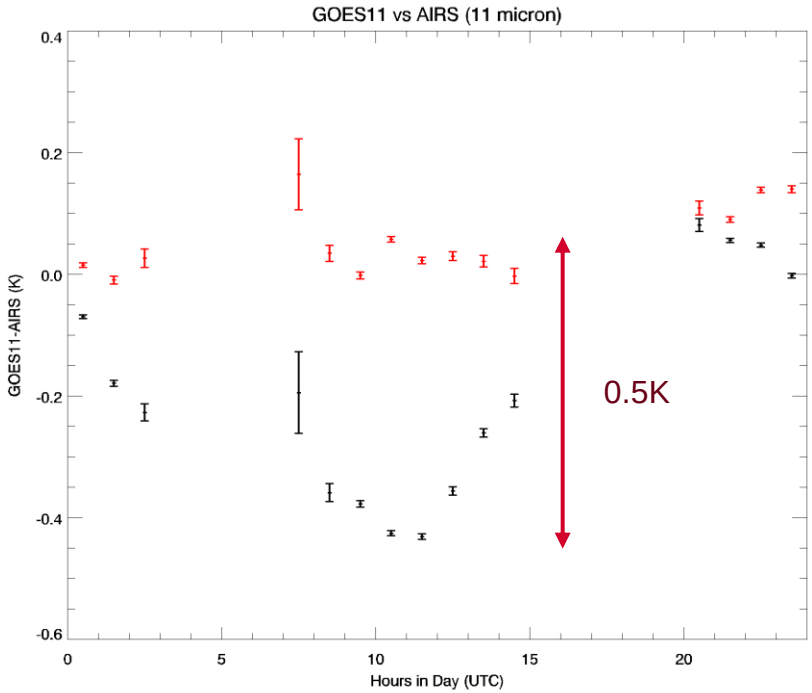
GSICS CORRECTIONS FOR GOES

- Nightime only data used for correction
- Data averaged over 30 days
  - Midnight effect not corrected for but added to uncertainty (Yu & Wu, 2012, “GSICS GOES-IASI Inter-Calibration Uncertainty Evaluation”)

Systematic Error	Ch2(3.9μm)	Ch3(6.5μm)	Ch4(10.7μm)	Ch6(13.3μm)	unit
Radiance bias at standard scenes	0.0047	0.0802	1.7695	1.8216	$mW/m^2/Sr/cm^{-1}$
Tb bias at standard scenes	-0.1928	-0.4455	-1.168	-1.2775	K

SOLUTION – UPDATE MBCC ALGORITHM

- Can correct by updating MBCC
  - Change algorithm on th basis of physical model
- Initial tests indicate can significantly improve calibration
- BUT
  - Currently only theoretical
  - Not included in operations



CONCLUSION

- Calibration of Geostationary imagers is complex
  - Especially for historic 3-axis stabilized
- Many corrections need to be applied that will all have errors/uncertainties associated with them
- GSICS will help with some of them but
  - Not Midnight BB effects
  - Will smooth transition to eclipse seasons
  - No correction across scan line
- For climate applications recommend thorough calibration algorithm/ uncertainty analysis