Inter-Comparison of Radiometric Calibration Accuracy among CrIS, AIRS and IASI using GSICS GEO-LEO Inter-calibration

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Outline

- Use of hyperspectral radiometers (AIRS/IASI) to monitor and improve the GOES infrared (IR) radiometric calibration accuracy

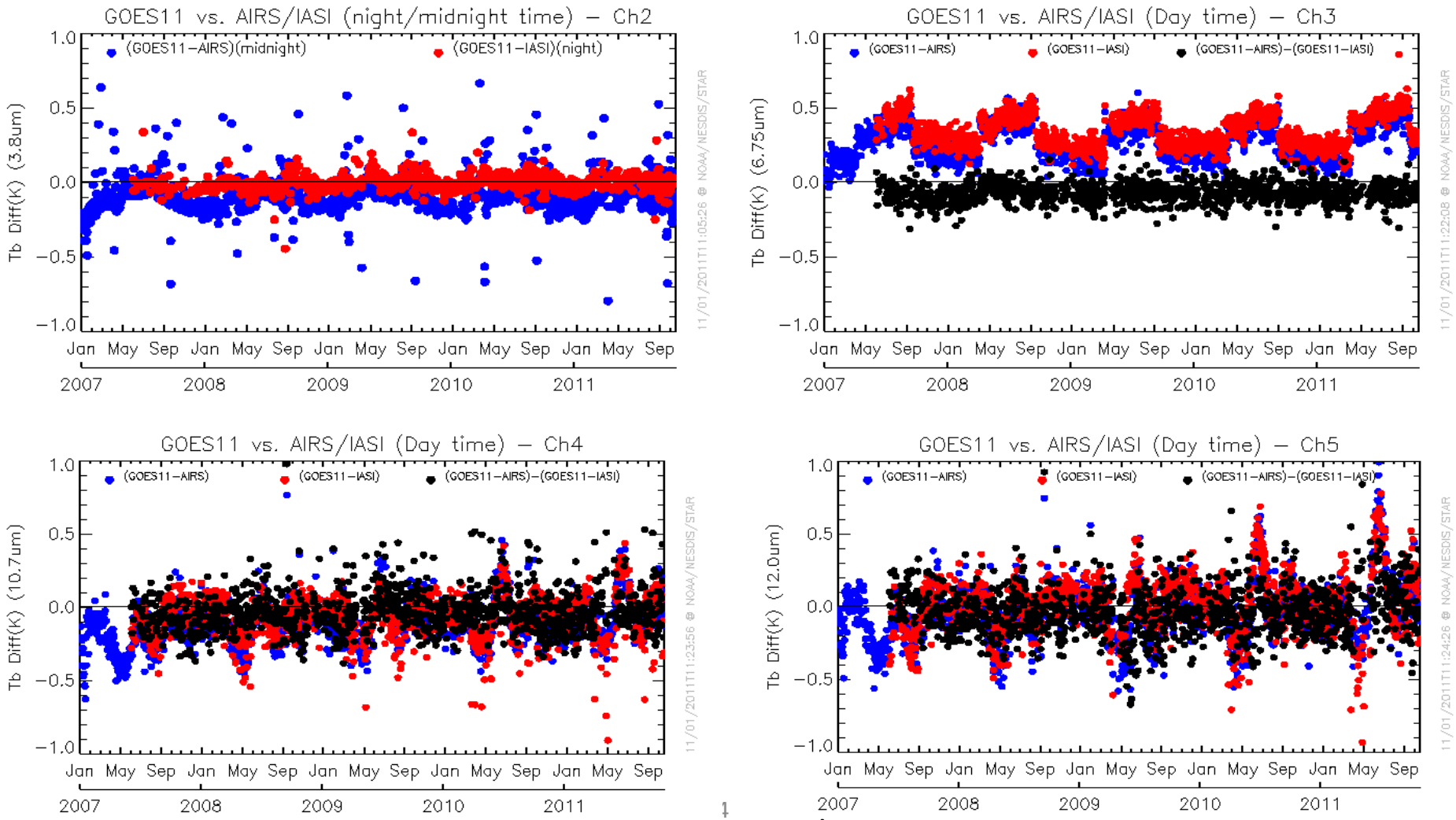
- AIRS/CrIS/IASI inter-comparison using GOES IR data as transfer

- Evaluation of gap-filling method for the AIRS missing/bad channels

Hyperspectral Radiometers vs. Broad-Band Infrared Instruments

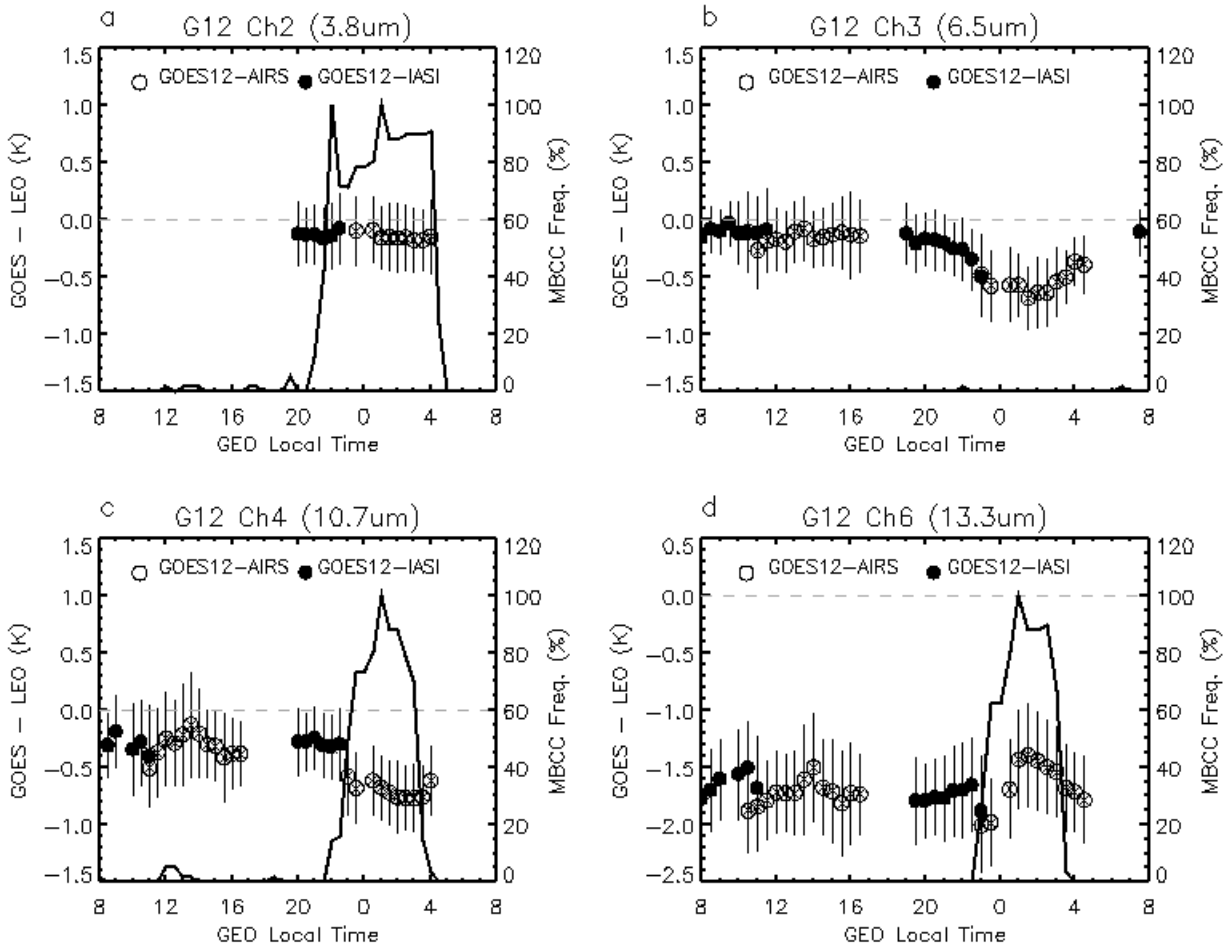
- **High quality hyperspectral radiometers play a critical role in monitoring and improving the broad-band GOES IR radiometric calibration accuracy in the Global Space-based Inter-Calibration System (GSICS) project**
  - Bias monitoring, radiance corrections using AIRS/IASI as references
  - Diurnal calibration variation
  - Spectral response function revisions

GOES Imager IR Bias Monitoring



Wang et al. , JGR 2011

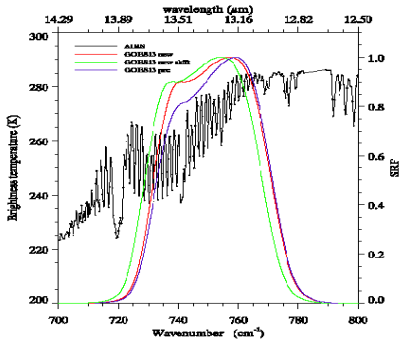
GOES Imager IR Diurnal Calibration Variation

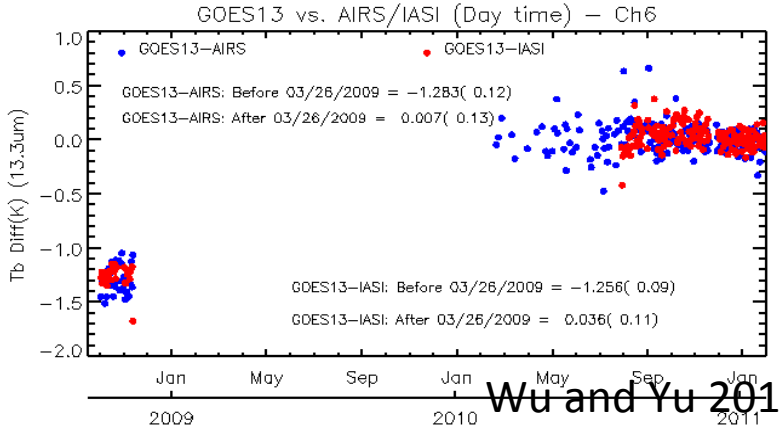


Yu et al. 2012 IEEE, in press

Spectral Response Function Corrections

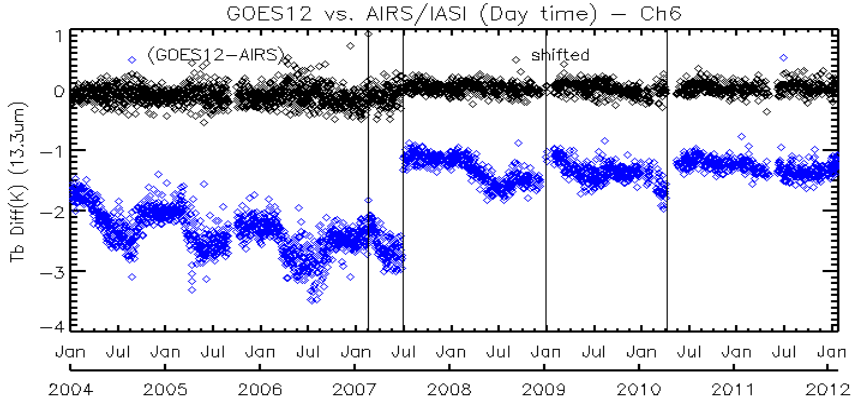
- **AIRS V5 data used to**
  - revise GOES-13 Imager Ch6(13.3um) SRF, AIRS has few bad detectors within this spectral range

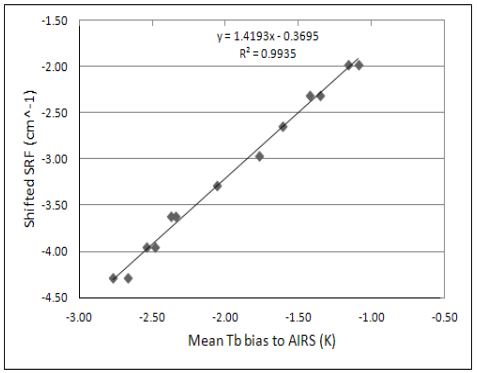




Wu and Yu 2012 IEEE, in review

  - revise GOES-12 Imager Ch6(13.3um) SRF

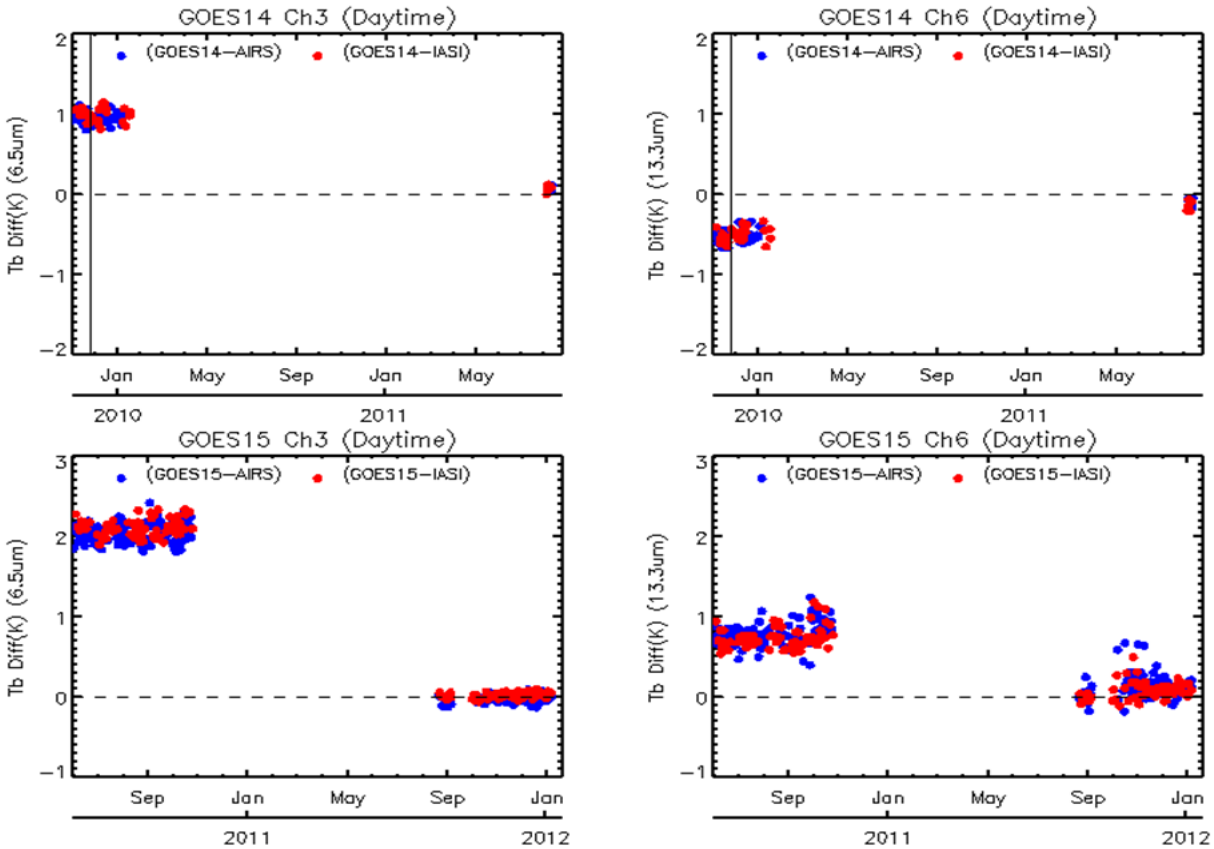




Yu and Wu 2012 IEEE, in review

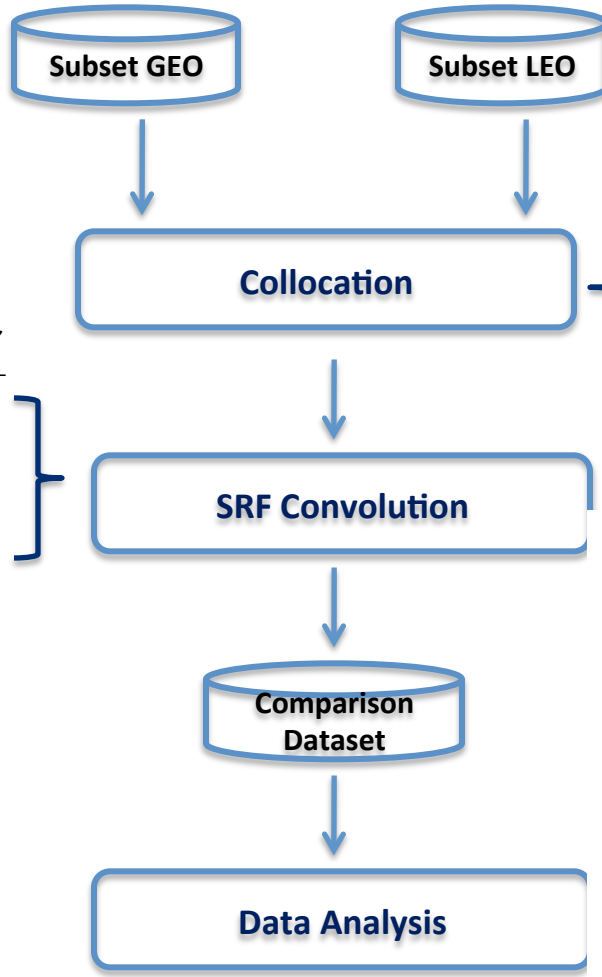
Spectral Response Function Corrections

- **IASI used to shift GOES-14/15 Imager Ch3(6.5um) and Ch6(13.3um)**



Yu and Wu 2012 IEEE, in review

GSICS GEO-LEO Collocation Criteria



AIRS
CrIS
IASI

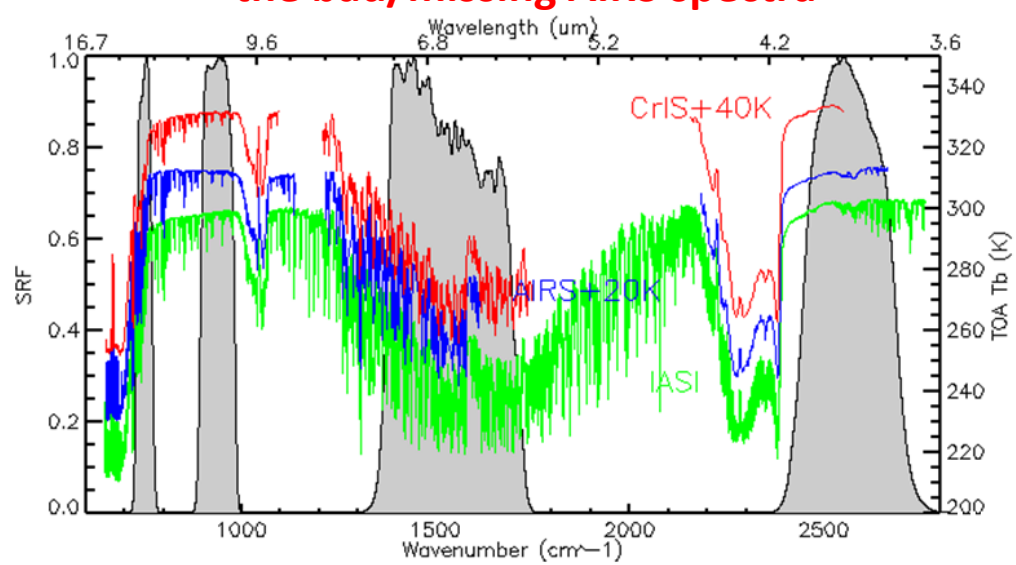
Collocation Criteria:

- closest pixel center < 4km
- time difference: < 5 minutes
- viewing zenith angle difference: $\left|\frac{\cos(geo_zen)}{\cos(leo_zen)} - 1\right| < 1\%$

$$R_{GEO} = \frac{\int_\nu R_\nu \Phi_\nu d\nu}{\int_\nu \Phi_\nu d\nu}$$

JMA's gap filling method used to fill the missing **AIRS** spectra

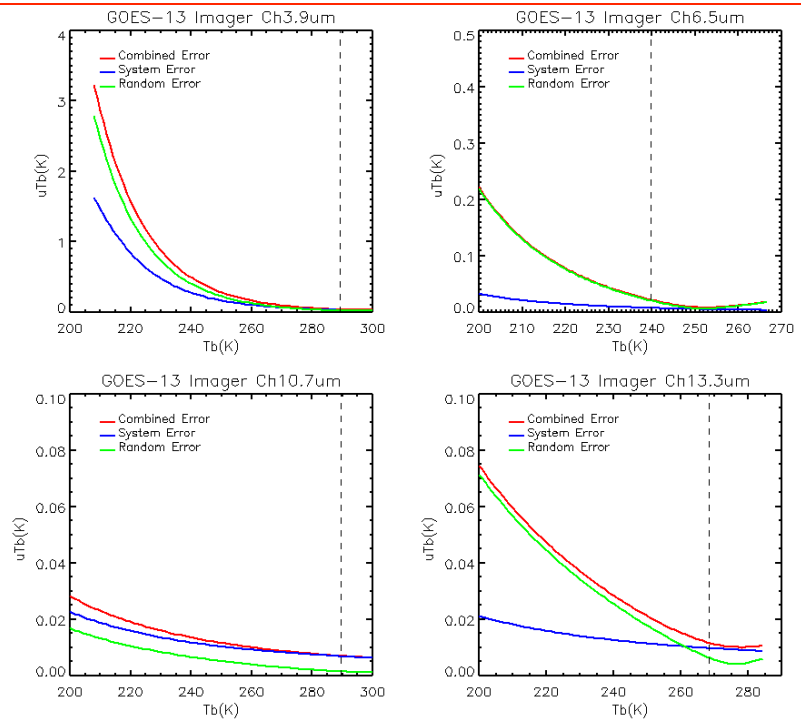
Gap-filling is essential to fill the bad/missing AIRS spectra



JMA's Gap-Filling Method

- **Japanese Meteorological Agency (JMA) gap-filling method**
  - Line-by-line model radiometric transfer model to simulate atmospheric spectra of eight different atmospheric profiles
  - Generate regression relationship between the simulated and observed radiances for the AIRS good channels
  - Apply the linear regression to simulate the bad/missing channels
  - Doesn't involve radiative transfer computation and numerical weather prediction fields in operation
  - Tahara, Y. and K. Kato, 200, Jpn. Tech. Note 52, http://mscweb.kishou.go.jp/monitoring/gsics/ir/msctechrep52-1.pdf.

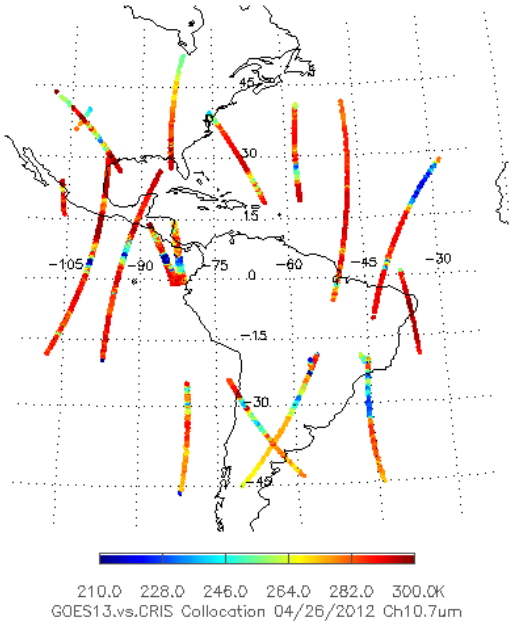
GOES-IASI GSICS Correction Uncertainty



GOES-13	Ch2 (3.9um)	Ch3 (6.5um)	Ch4 (10.um)	Ch6 (13.3um)
Standard temperature	289.08K	239.7K	289.59K	268.47K
Random Uncertainty	0.027K	0.016K	0.001K	0.004K
Systematic uncertainty	0.033K	0.008K	0.006K	0.010K
Combined Uncertainty	0.043K	0.018K	0.01K	0.01K

New reference instrument: CrIS

- **NPP CrIS provided more opportunities for the GSICS GEO-LEO inter-calibration**
  - bias monitoring – AIRS/CrIS/IASI inter-comparison
  - More night time reference data to correct the GOES midnight calibration anomaly
  - Evaluate the gap-filling method



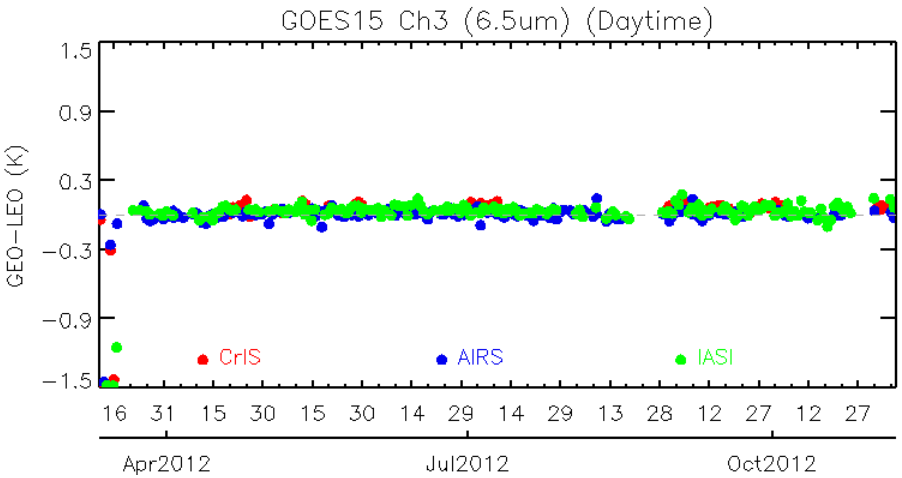
AIRS/CrIS/IASI Inter-comparisons using GOES

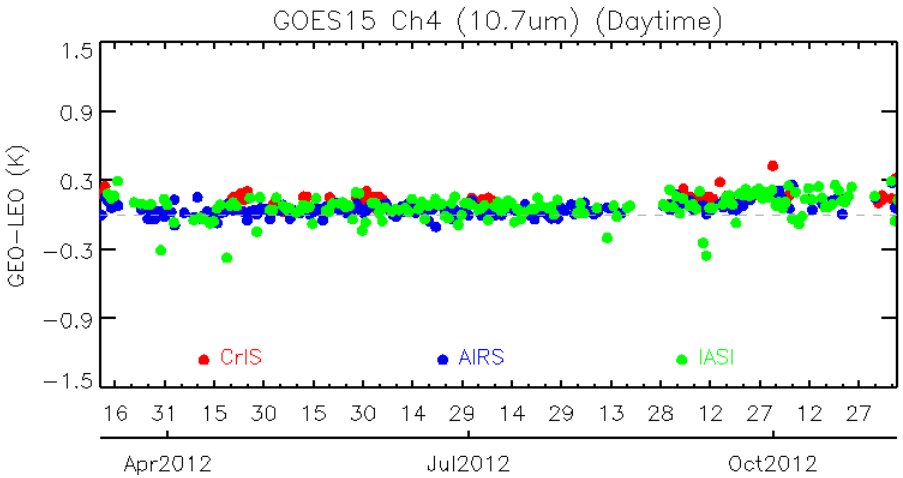
- **GOES IR data can be used as transfer to evaluate the performances of hyperspectral radiometers at different spacecrafts.**
  - Double difference technique
  - GOES radiometric calibration is stable between the LEO overpass times in a day

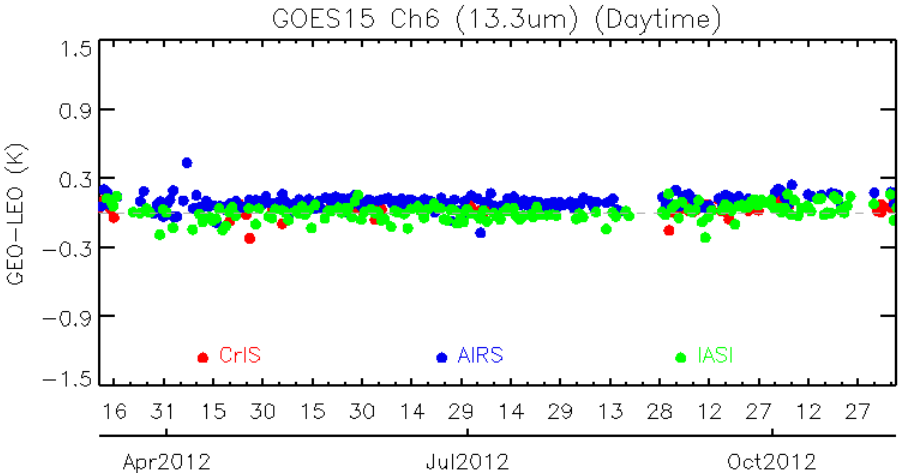
$$LEO_{A,t1} - LEO_{B,t2} = (LEO_{A,t1} - GEO_{t1}) - (LEO_{B,t2} - GEO_{t2}) - (GEO_{t2} - GEO_{t1}) + \varepsilon$$

A and B are two LEO instruments with equatorial crossing times at t1 and t2, respectively.
GEO_{t1} and GEO_{t2} are the GOES measurements at t1 and t2 time.
ε is the uncertainty of GEO-LEO inter-calibration algorithm

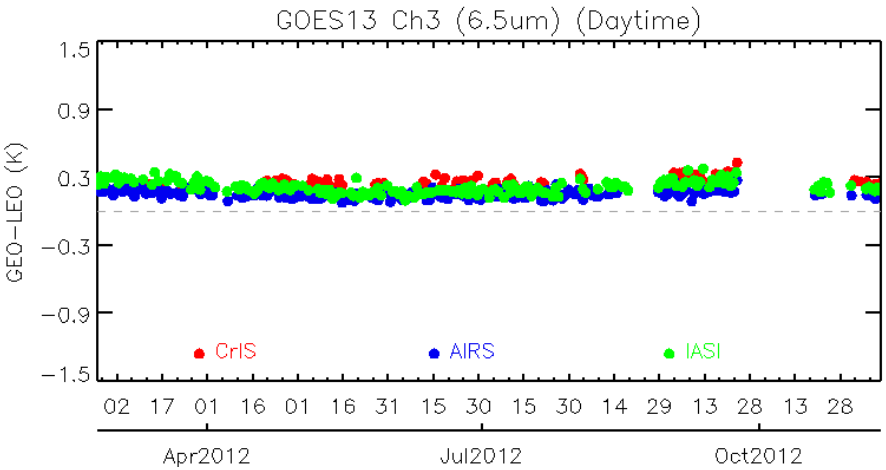
GOES-15 vs. AIRS/CrIS/IASI

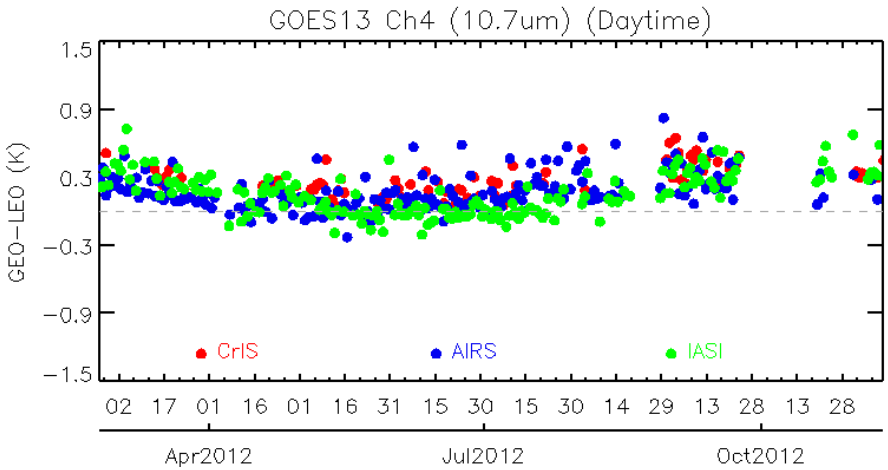


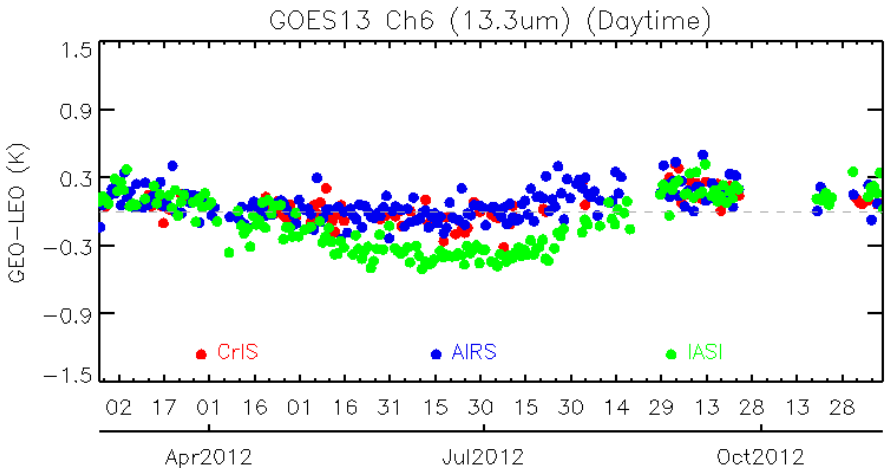




GOES-13 vs. AIRS/CrIS/IASI

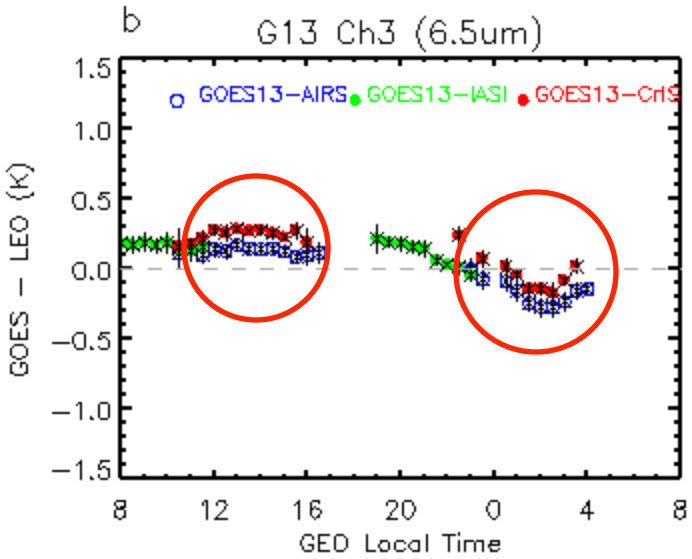


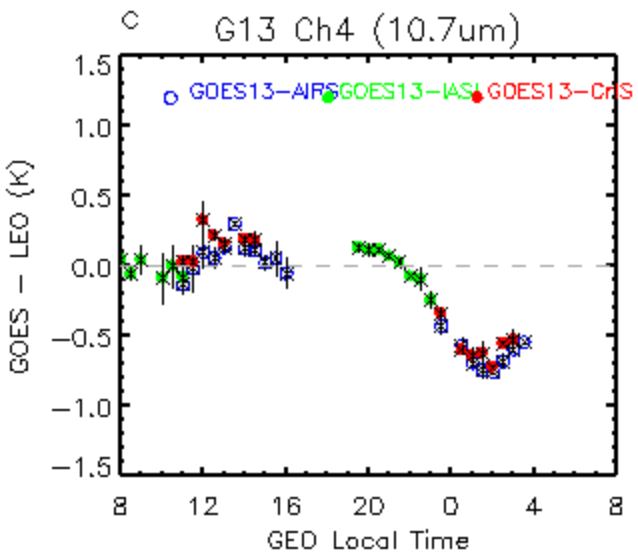


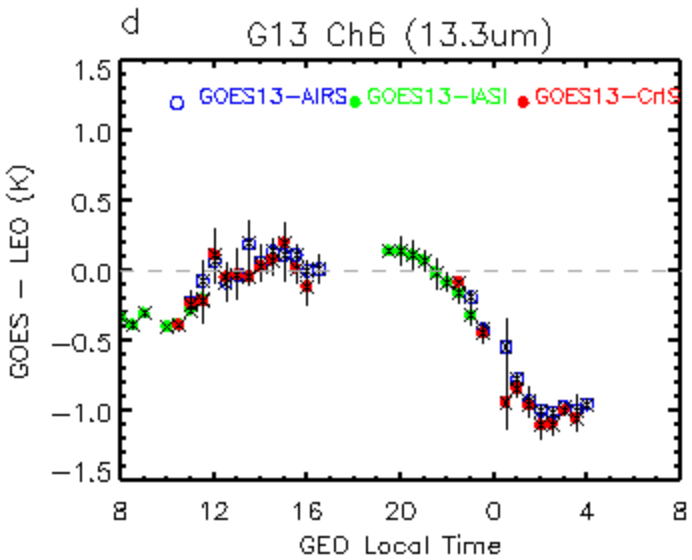


More Night Reference Data to Correct Diurnal Calibration Variation

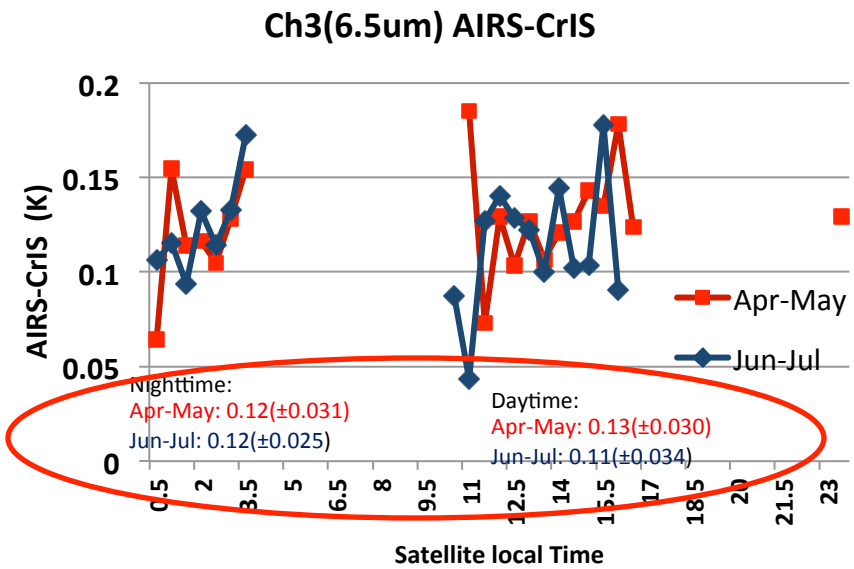
Need to understand the calibration difference between reference instruments

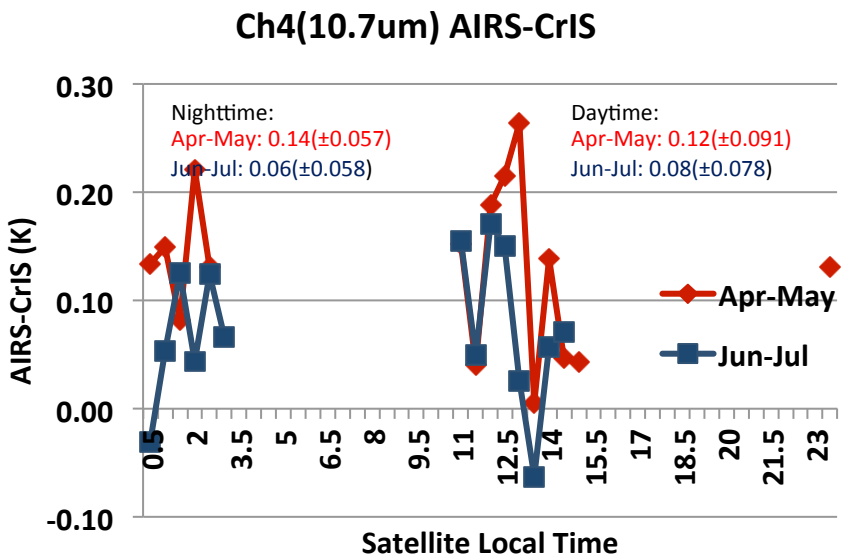




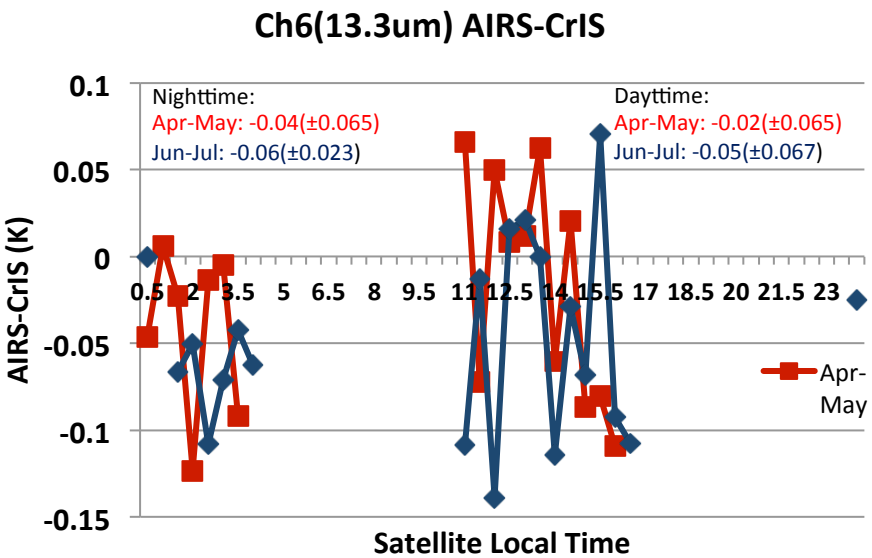


ARIS-CrIS (diurnal variation)

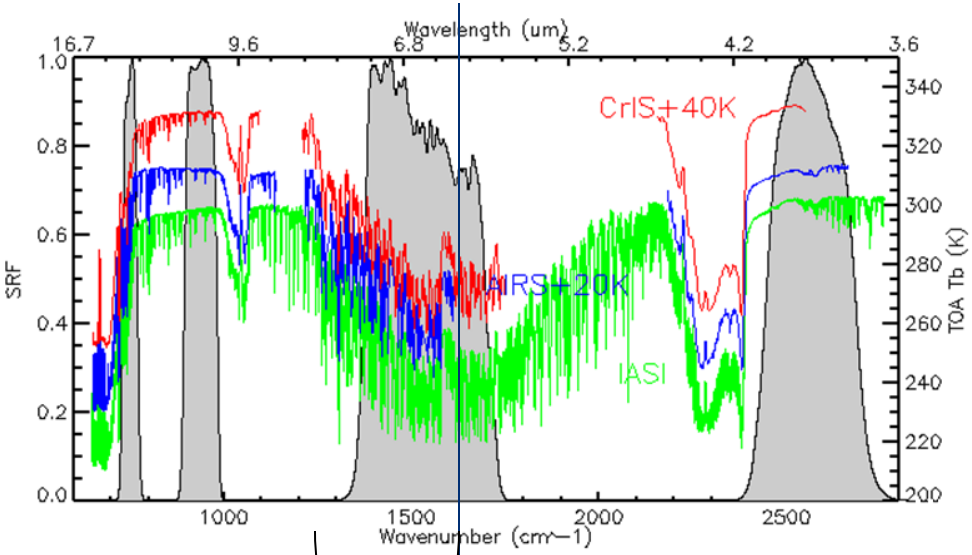




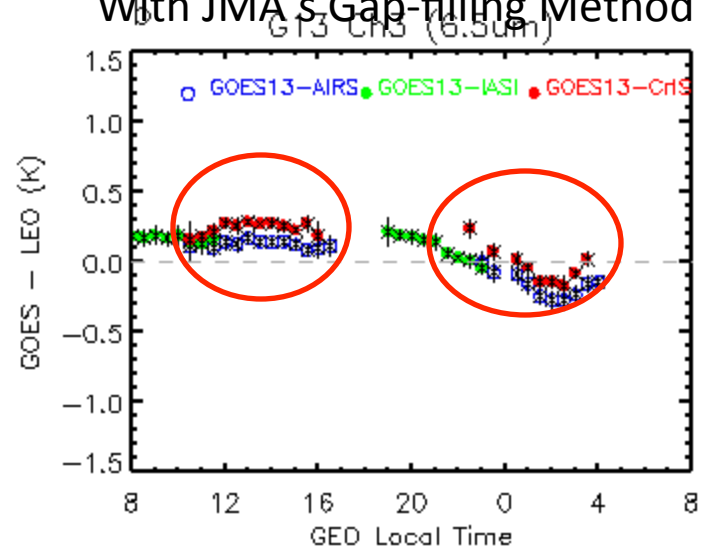
Compared to Global-SNO (David Tobin, Calcon 2012), the AIRS-CrIS difference seems slightly warmer up to ~0.1K

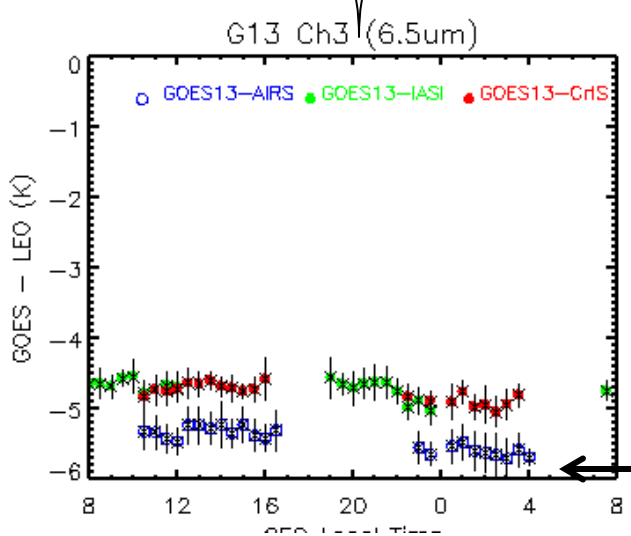


Gap-filling Method Evaluation



With JMA's Gap-filling Method





A good gap-filling method is not only essential to develop reliable simulated reference radiances for the GOES radiance correction, but also useful for the AIRS vs. IASI/CrIS in-direct inter-comparisons.

No filling of the bad detectors

Summary

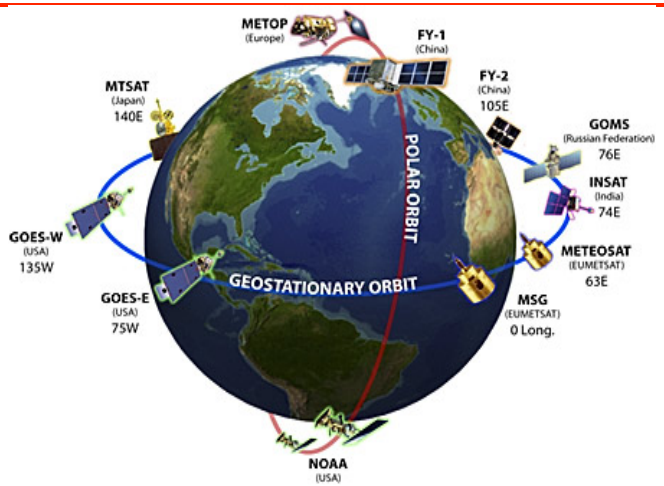
- **High quality hyperspectral radiometers have been successfully used as references to improve and correct the GOES IR radiances**

- **Inter-calibrations between GOES and AIRS/CrIS/IASI can be used to monitor and evaluate both hyperspectral and broad-band radiometers**

- **A good gap-filling method for the missing/bad AIRS measurements is essential to correct the GOES IR midnight calibration anomaly**
  - AIRS covers GOES-8 thru 15 since 2002
  - We would like to compare the JPL(AIRS team)'s gap-filling method with the current JMA (GSICS)'s method.
  - Consider using AIRS V6 data

Double difference

Instrument/ Satellite	LECT– ascending node	LECT – descending node
AIRS/Aqua	1:30pm	1:30am
CrIS/Soumi-NPP	1:30pm	1:30am
IASI/Metop-A	9:30pm	9:30am



Using GOES measurements as the transfer:

$$LEO_{A,t1} - LEO_{B,t2} = (LEO_{A,t1} - GEO_{t1}) - (LEO_{B,t2} - GEO_{t2}) - (GEO_{t2} - GEO_{t1}) + \varepsilon$$

A and B are two LEO instruments with equatorial crossing times at t1 and t2, respectively.

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ε is the uncertainty of GEO-LEO inter-calibration algorithm