TISA Edition4 LW Development Update

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CERES Science Team Meeting
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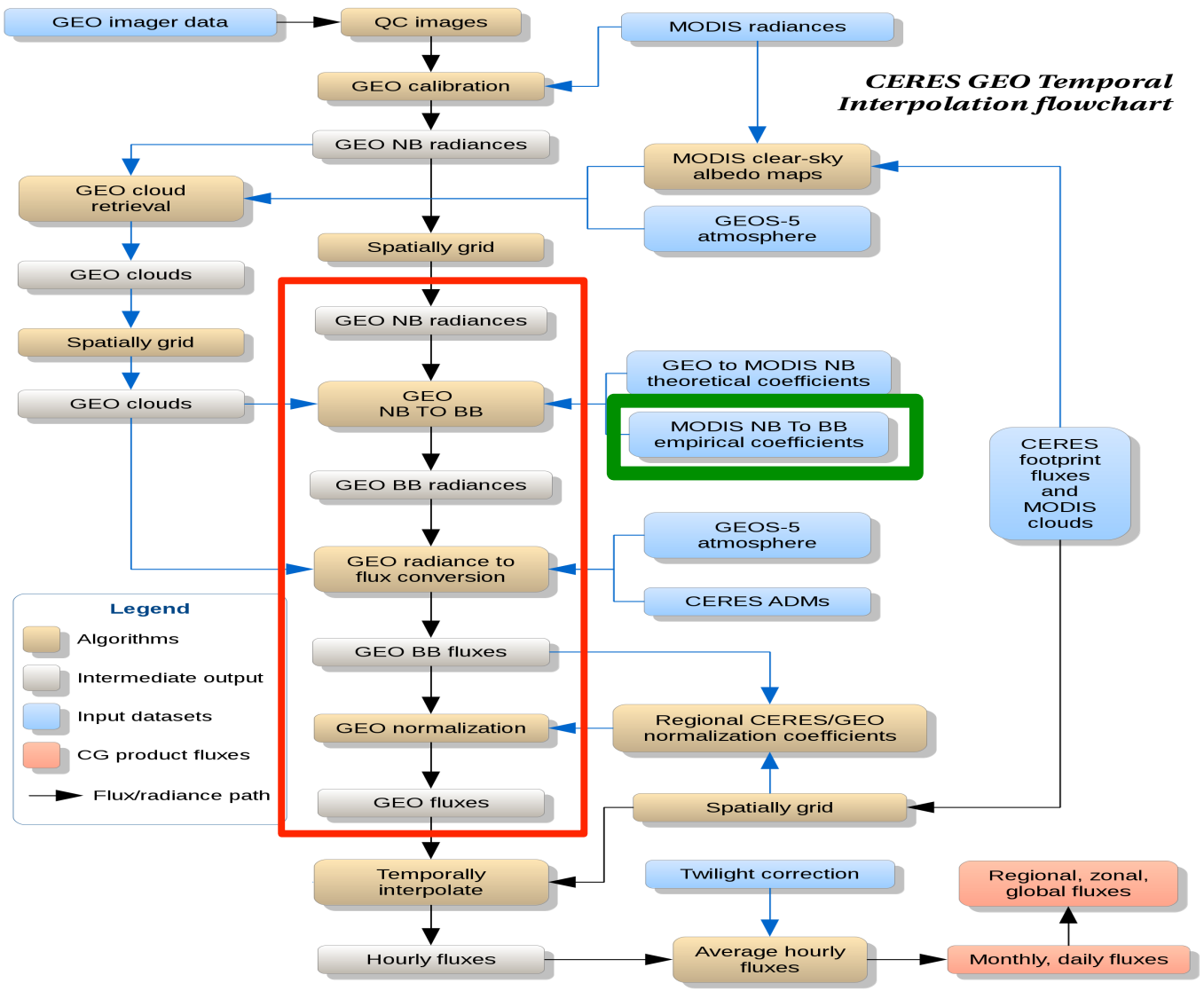
Outline

- Current GEO LW flux Status
- Review previous Ed4 LW work based on MODIS/CERES SSF
- Ed4 GGEO LW Flux: NB2BB, ADM, Normalization
- Preliminary Results
- Summary
- Future work

CERES GEO LW Processing



Doelling

Edition2 GEO LW NB->BB Flux Algorithm

- **WN => Nadir NB flux**

WN Rad VZA

$$F_{NB} = 1.97\pi L_{WN}(\theta)/\gamma(\theta)$$

$$\gamma(\theta) = \begin{cases} 1 & \theta \le 11.7 \\ 1.000665 + 0.0324721\ln(\cos\theta) & \theta > 11.7 \end{cases}$$

Limb darkening function

- **NB flux => BB flux (OLR)**

Column Relative Humidity

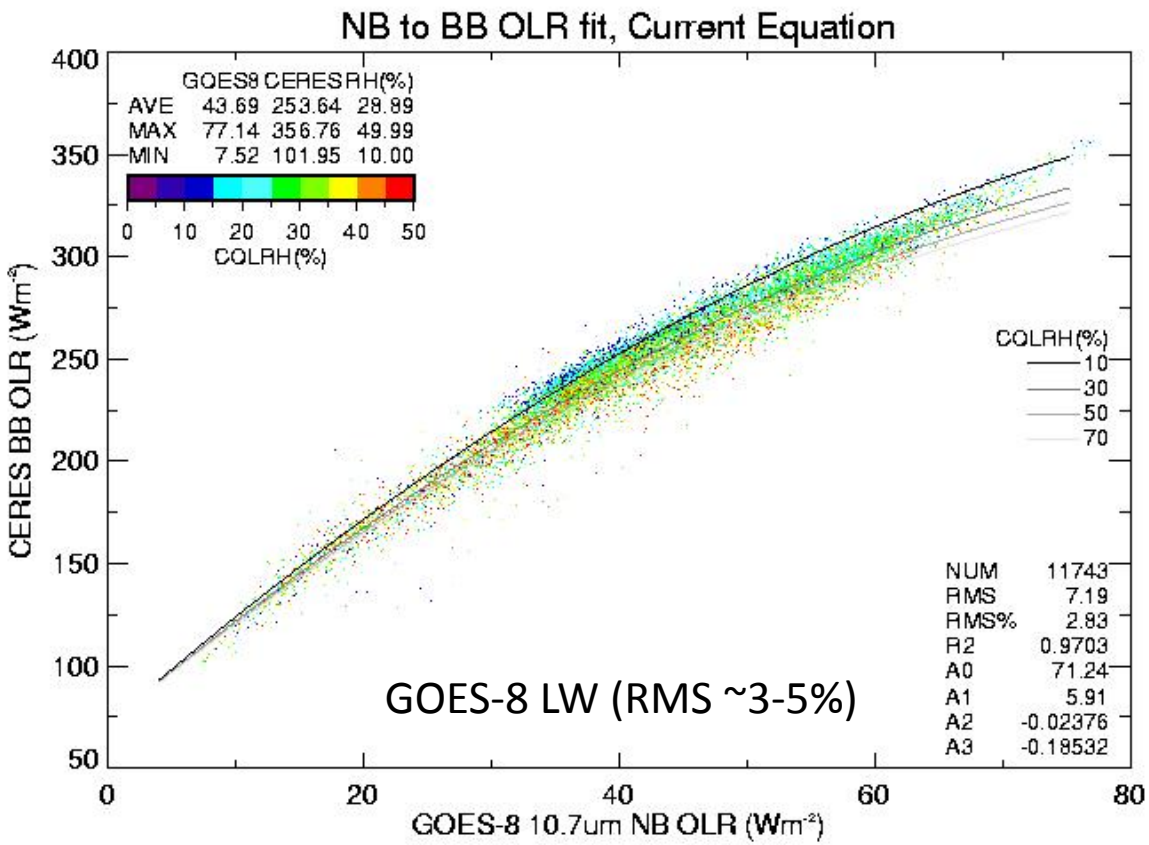
$$OLR_{BB} = a_0 + a_1 F_{NB} + a_2 F_{NB}^2 + a_3 F_{NB} \ln(RH)$$

NB flux

a_0, a_1, a_2, a_3 Coefficients for ocean and land separately

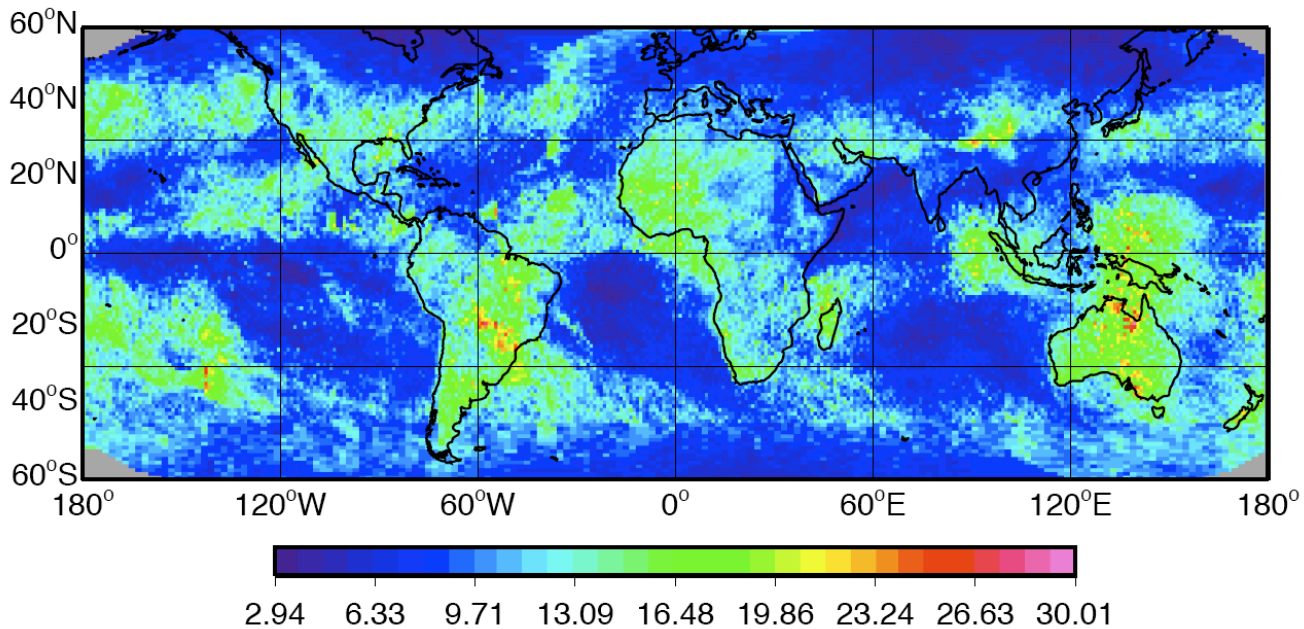
Minnis, Young and Harrison, J. of Cli., 1991

Edition2 GEO NB->BB Flux Algorithm



- Doelling et al. (1998 and 2003) validate the algorithm over ocean and land area and investigate the effects of different channels and relative humidity on RMS.

SYN1deg Edition3a GEO NB-BB Flux Matched GEO vs. Terra, January 2006



Average regional RMS: 8.39 W/m²

GEO LW and CERES-Terra Matched within 1.5 hours LW fluxes

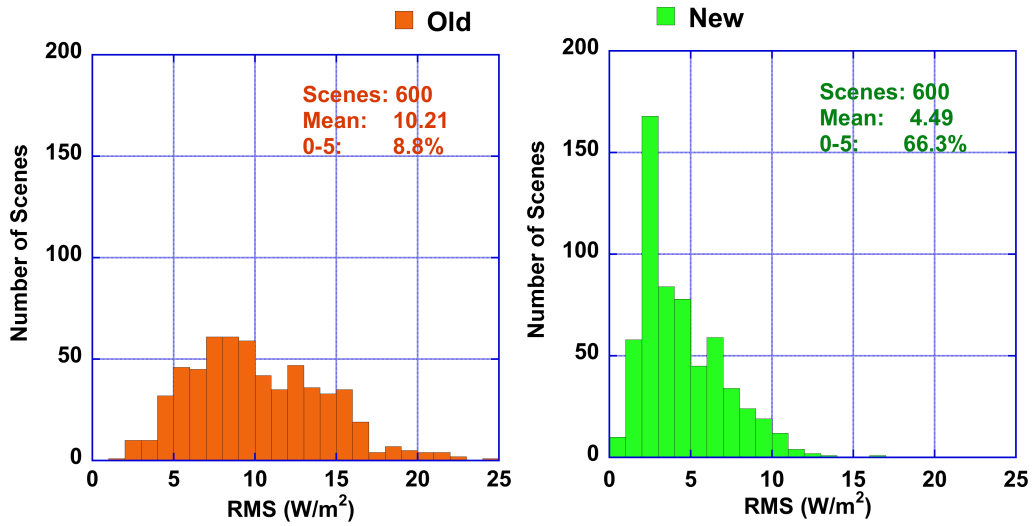
SSF MODIS radiance to CERES LW flux model

- Data: SSF-Ed4 (MODIS radiance and CERES flux)
- Test multiple channels:

  3.79µm (Night only), 6.72µm, 11.03µm, 12.02µm

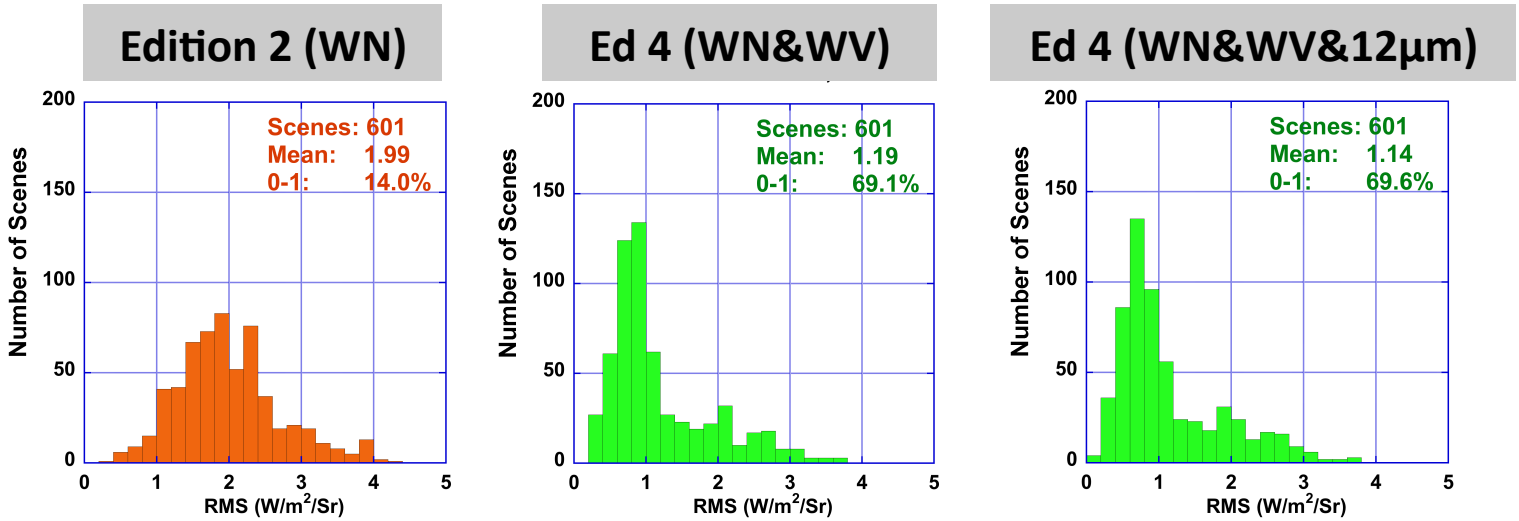
- Create scene types:
  - **Ocean/land (6):** Ocean, Forests, Savannas, Grass-Crop, Dark and Bright Deserts.
  - **Day/Night (2)**
  - **Clear/cloud (2)**
  - **Precipitable Water (4):** 0-1, 1-3, 3-5, 5-10 cm
  - **Viewing Zenith Angle (7):** 0°-70°, every 10°
  - **Total: 672 scene types**

NB Rad -> BB Flux
New Ed4 2-ch vs. Old Ed2



Based on SSF-Ed4 April, 2000

NB -> BB Radiance Conversion



April, 2000

NB Rad -> BB Flux Table

Types	Total Scenes	Ed2/Ed3 WN-only		Ed4 WN + WV		Ed4 vs. Ed2/3 RMS diff (%)
		Mean RMS	(%) RMS < 5	Mean RMS	(%) RMS < 5	
All	600	10.21	8.8	4.49	66.3	**56.02**
land	490	10.26	8.0	4.47	65.7	**56.43**
ocean	110	10.01	12.7	4.56	69.1	**54.45**
day	296	11.18	11.5	5.59	49.0	**50.00**
night	304	9.27	6.3	3.42	83.2	**63.11**
clear	287	8.61	18.5	2.64	99.0	**69.34**
cloud	313	11.68	0.0	6.19	36.4	**47.00**

Ed4 GGEO LW Flux Algorithm

- GGEO Narrowband-Broadband Radiance Conversion
- GGEO BB Radiance-Flux Conversion using Ed2 LW ADM
- GGEO LW Flux Normalization to CERES flux

Step 1: Ed4 LW NB-BB Radiance Conversion

- Derive regression coefficients based on MODIS narrow-band (11.03μm and 6.72μm) and CERES broad-band radiance using ADM-like bins.
- Apply above coefficients to GGEO narrow-bands to obtain broad-band radiance.

ADM Like Bins: Clear sky

Sfc Type (6)	PW (3)	Tdiff (Sfc-T_{300}) (5)	VZA (7)
Ocean Forests Savannas Grass/Crop Dark Desert Bright Desert	0-33 33-66 66-100 Percentile(%)	Inversion 0-25 25-50 50-75 75-100 Percentile(%)	0-70 Every 10 deg.

Total Bins: 90 * 7

ADM Like Bins: Cloud sky

Sfc Type (6)	Cloud (5)	PW (3)	Tdiff (Sfc-T_{cld}) (6)	IR Emissivity (6)	VZA (7)
Ocean Forests Savannas Grass/Crop Dark Desert Bright Desert	0.1-25 25-50 50-75 75-99.9 99.9-100	0-33 33-66 66-100 Percentile	Inversion 0-20 20-40 40-60 60-80 80-100 Percentile	0-5 5-10 10-25 25-50 50-75 75-100 Percentile	0-70 Every 10

Total Bins: 3240 * 7

Step 2-3: LW BB Radiance-Flux Conversion by CERES ADM and LW Regional Normalization

- Use Ed2 LW ADM to convert GEO derived BB Radiance to Flux.
  - Improvement over Ed2 limb darkening correction.
- Normalize the GGEO Flux against matched CERES flux.
  - This method has been applied to SW and cloud properties and it shows great improvement.

GEO derived LW improvement

	Edition 2/3	Edition 4
GEO resolution Cloud code	• 3-hourly • 2-channel code (visible and IR)	• 1-hourly • 5-channel code (visible and multiple IR)
LW NB to BB Radiance	• Window (11µm) Limb-darkening Function from Radiance to NB Flux	• WN (11µm) + WV (6.7µm) to BB radiance conversion based on ADM scene types
LW ADM (Radiance to Flux Conversion)	• WN NB flux and column weighted humidity, global regression	• CERES LW ADM
GEO/CERES Normalization	• Instantaneous	• 5° by 5° regional normalization (adjust by linear fitting)

Implementation and Validation: April, 2010 Met9

- Input:
  - SFC: CERES flux (Terra), MODIS cloud
  - GGEO: 3-hourly, GOES-5 Surface and atmospheric profile , GGEO cloud, GEO IR and WV Radiance
  - IGBP surface types
- Relative RMS (%)

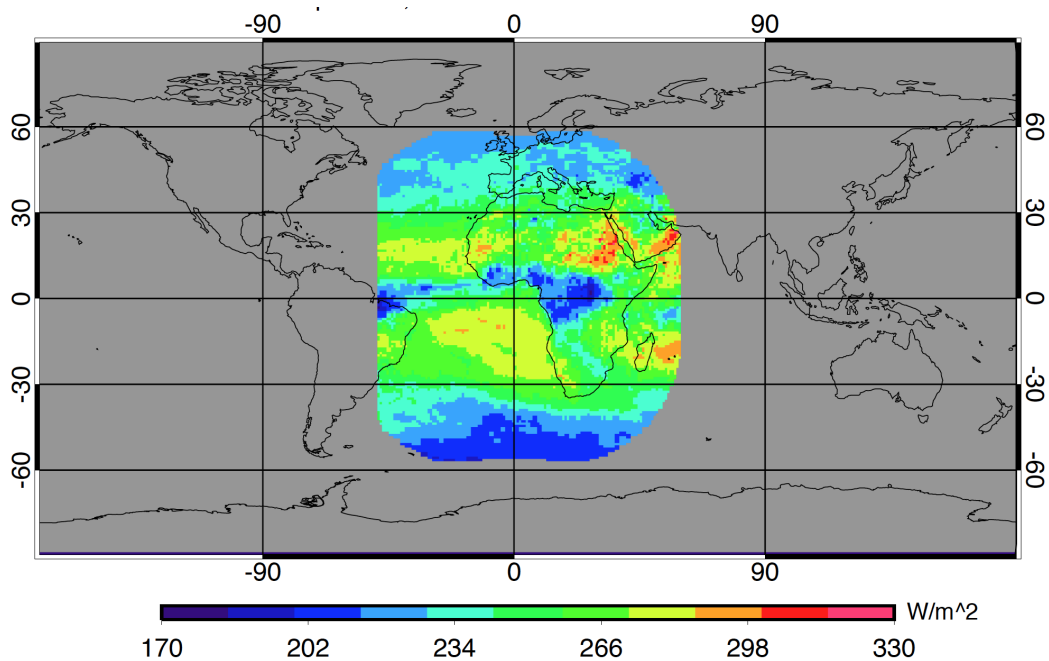
$$RMS(\%) = \frac{\sqrt{\frac{1}{n}\sum_{i=1}^{n}(LW_i^{GEO} - LW_i^{CERES})^2}}{Mean(CERES)}$$

Implementation and Validation: April, 2010 Met9

- Apply the MODIS/CERES LW NB to BB radiance coefficients to the Met-9 3-hourly WN and WV
  - use scene types based on the new 5-channel cloud properties for April 2010
- Apply the CERES Ed2 LW ADM
  - Same ADM as applied to the CERES footprint radiances
- Apply LW regional normalization
  - Regress regional LW flux GEO and CERES flux pairs coincident within 1.5 hours over the month and over 25 regions centered at the given region
- Validate GGEO derived flux against CERES flux matched within 1.5 hour

Preliminary Results
April, 2010 CERES Terra LW flux

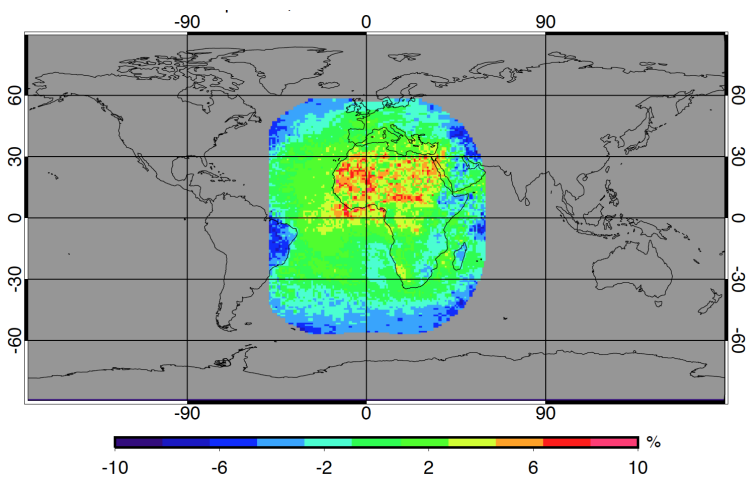
CERES Terra LW Flux over MET9 Satellite Area



Domain Average: 242.33 (W/m²)

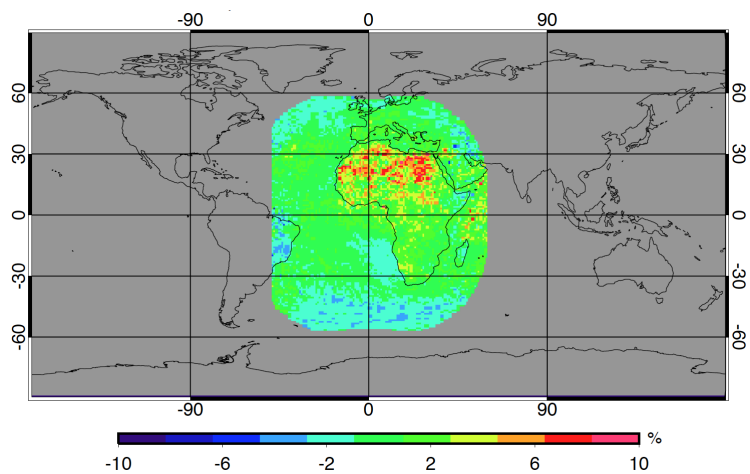
Preliminary Results
April, 2010 LW Flux BIAS

Ed2 GGEO – CERES Flux



Mean Bias: 0.14%

Ed4 GGEO – CERES Flux

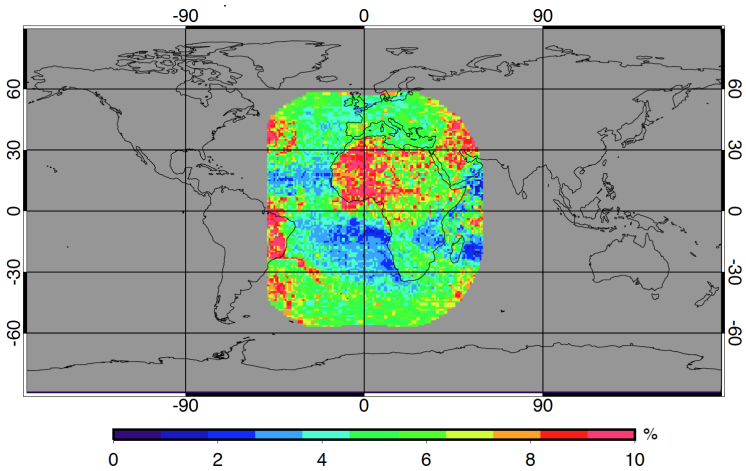


Mean Bias: 0.44%

Before Normalization

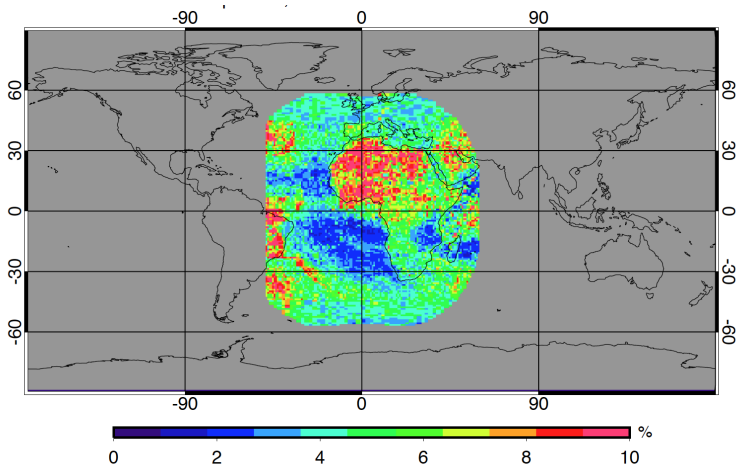
Preliminary Results
April, 2010 LW Flux RMS

Ed2 GGEO – CERES RMS



Mean RMS: 4.75%

Ed4 GGEO – CERES RMS

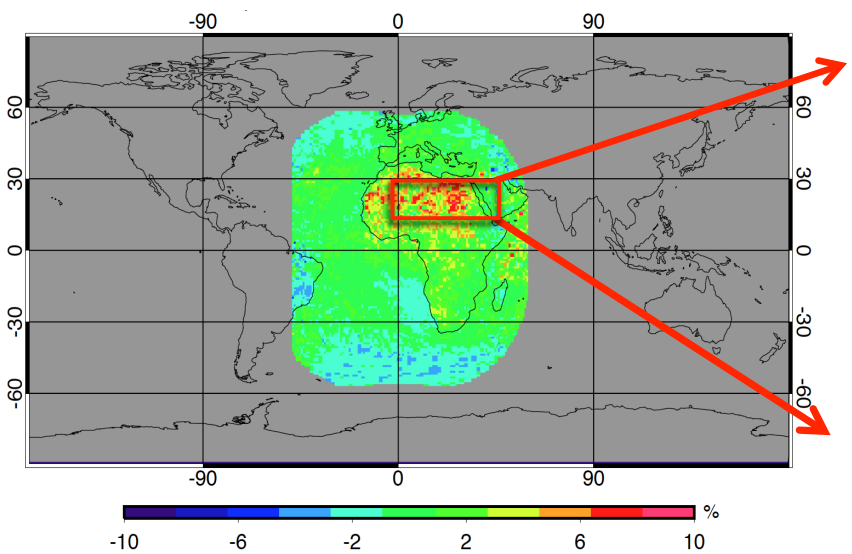


Mean RMS: 4.38%

Before Normalization

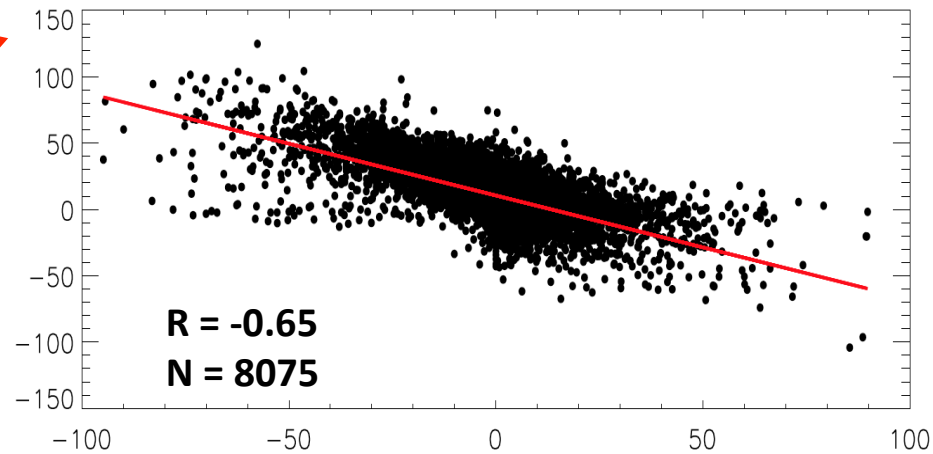
Preliminary Results
April, 2010 LW Flux BIAS

Ed4 GGEO – CERES Flux



Mean Bias: 0.44%

Ed4 GGEO – CERES Flux



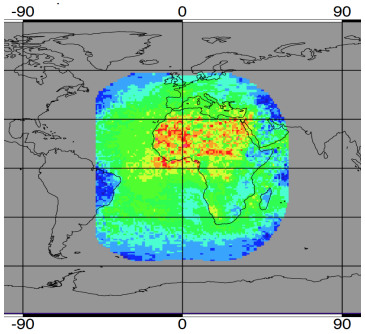
GGEO – CERES Cloud Fraction (%)

Preliminary Results: Normalization
April, 2010 LW Flux : GGEO-CERES Bias

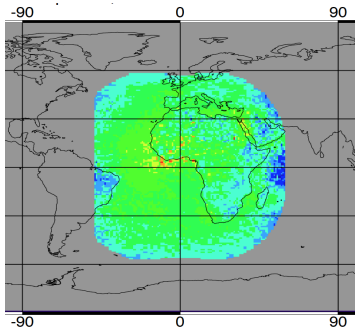
Bias

Before | *After*

Ed2

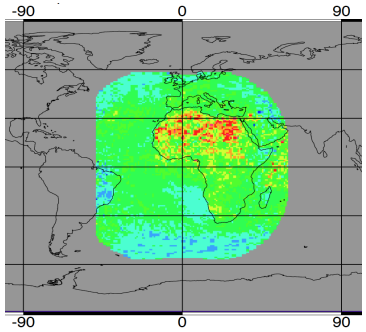


Bias: 0.14%

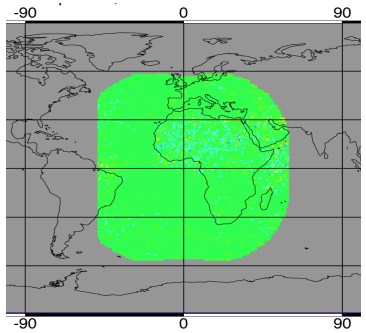


Bias: -0.26%

Ed4

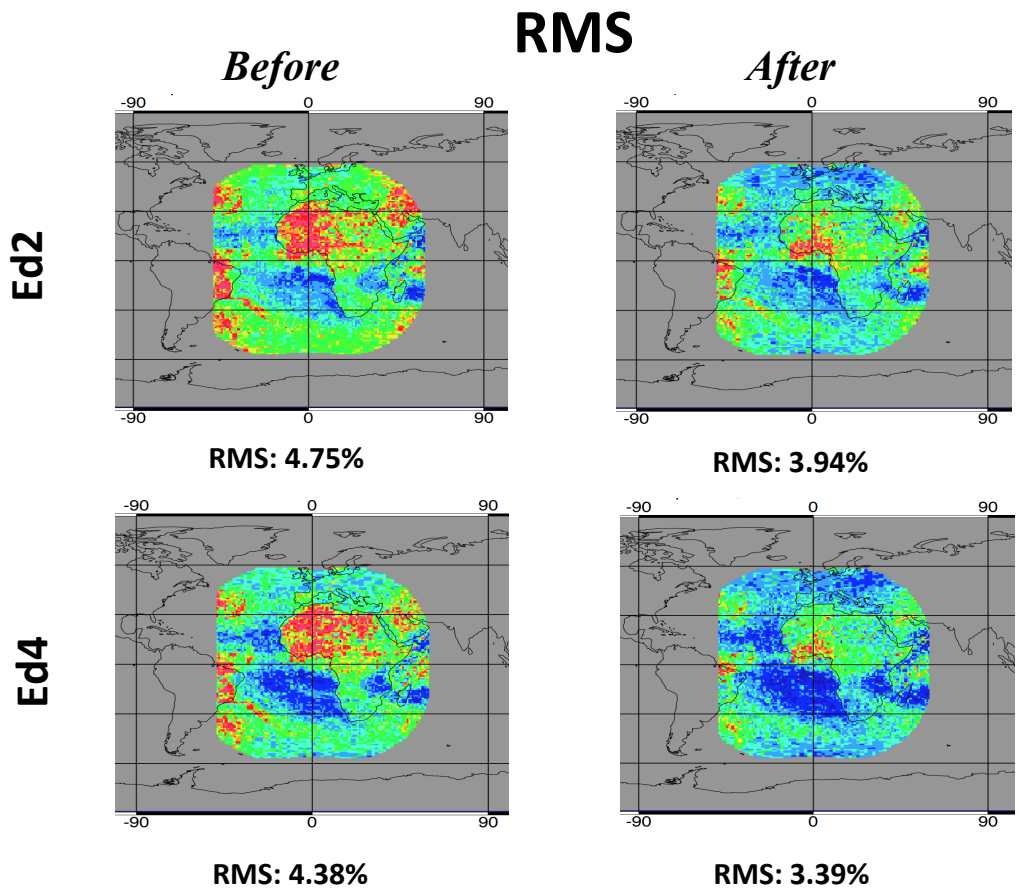


Bias: 0.44%

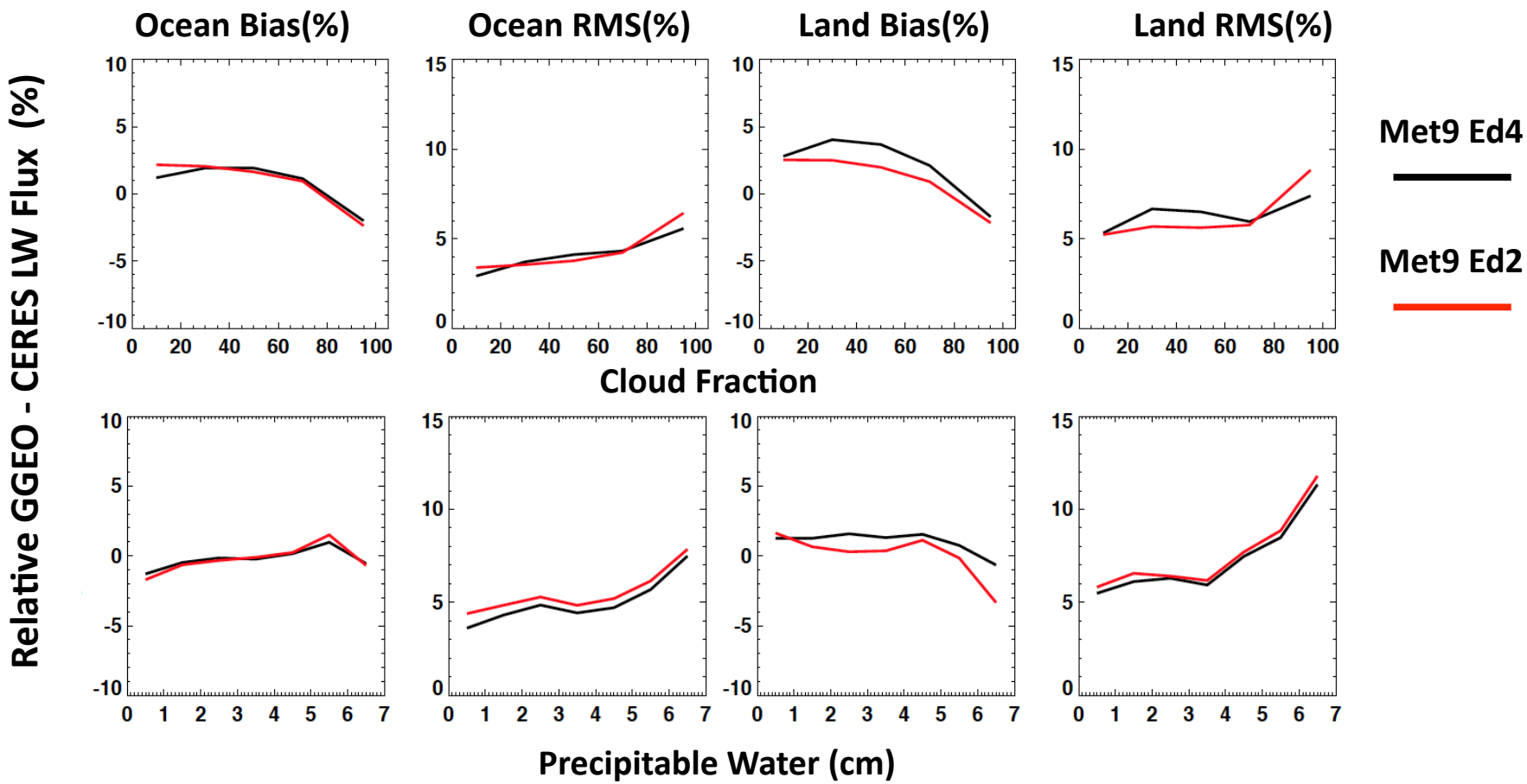


Bias: 0.18%

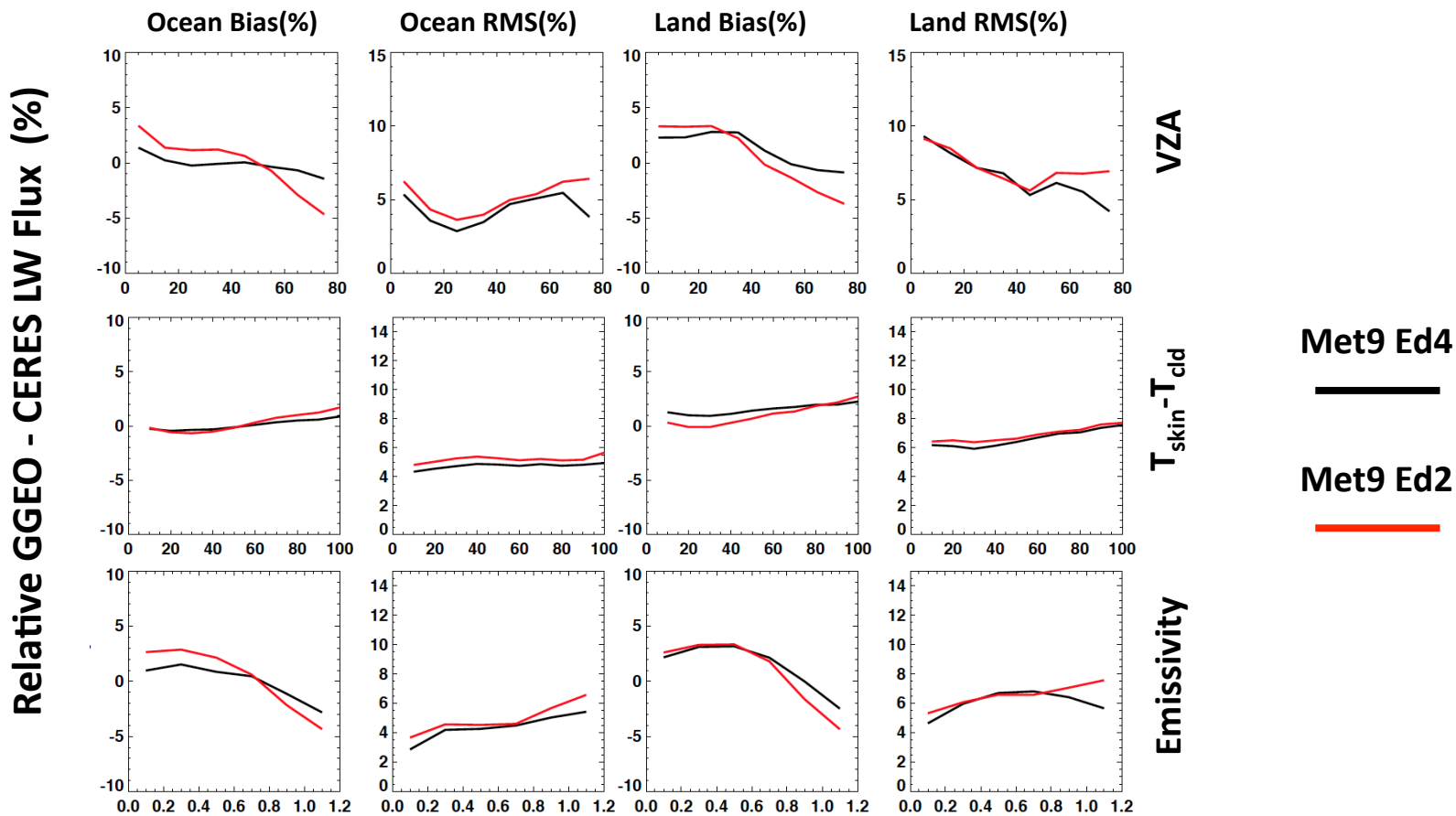
Preliminary Results: Normalization
April, 2010 LW Flux : GGEO-CERES RMS



Preliminary Results
April, 2010 LW Flux Sensitivity Study



Preliminary Results
April, 2010 LW Flux Sensitivity Study



Summary

- The New NB-BB Radiance algorithm combined with LW ADM show both regional and domain average improvement for the month of April, 2010. It shows great improvement over large view zenith angle area. The land area over desert region improve moderately. The ocean shows little or no improvement.
- The normalization reduces bias greatly and RMS moderately.
- The Ed4 LW model shows less dependence on binning parameters, but the difference is insignificant for most of the parameters. There is much room to improve.

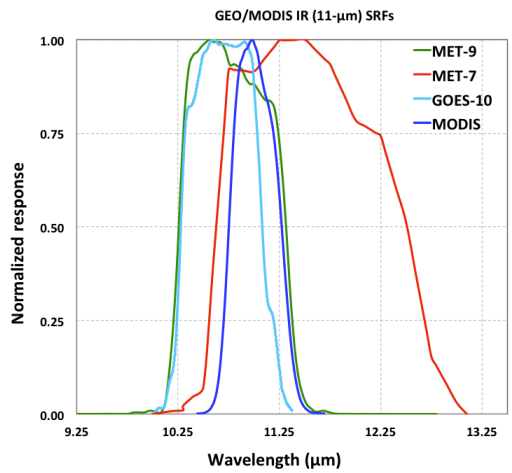
Future Work

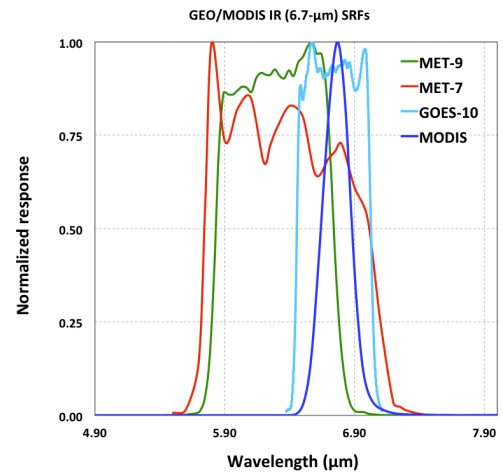
- Investigate the causes for the relatively large bias and RMS over the Sahara desert.
- Study the impact of GGEO and MODIS Spectral Response Function on the LW flux. MODIS has much narrow band.
- Continue to refine the current algorithms based on the diagnosis to improve TISA Ed4 LW data.
- Improve validation when more GEO cloud data are available.
- Create NB-BB coefficients using more data to improve sampling.

Thank You!

Back up

MODIS vs. MET9 SRF





backup

MET9 vs. MODIS