A comparative look of CERES OLR from Aqua and S-NPP

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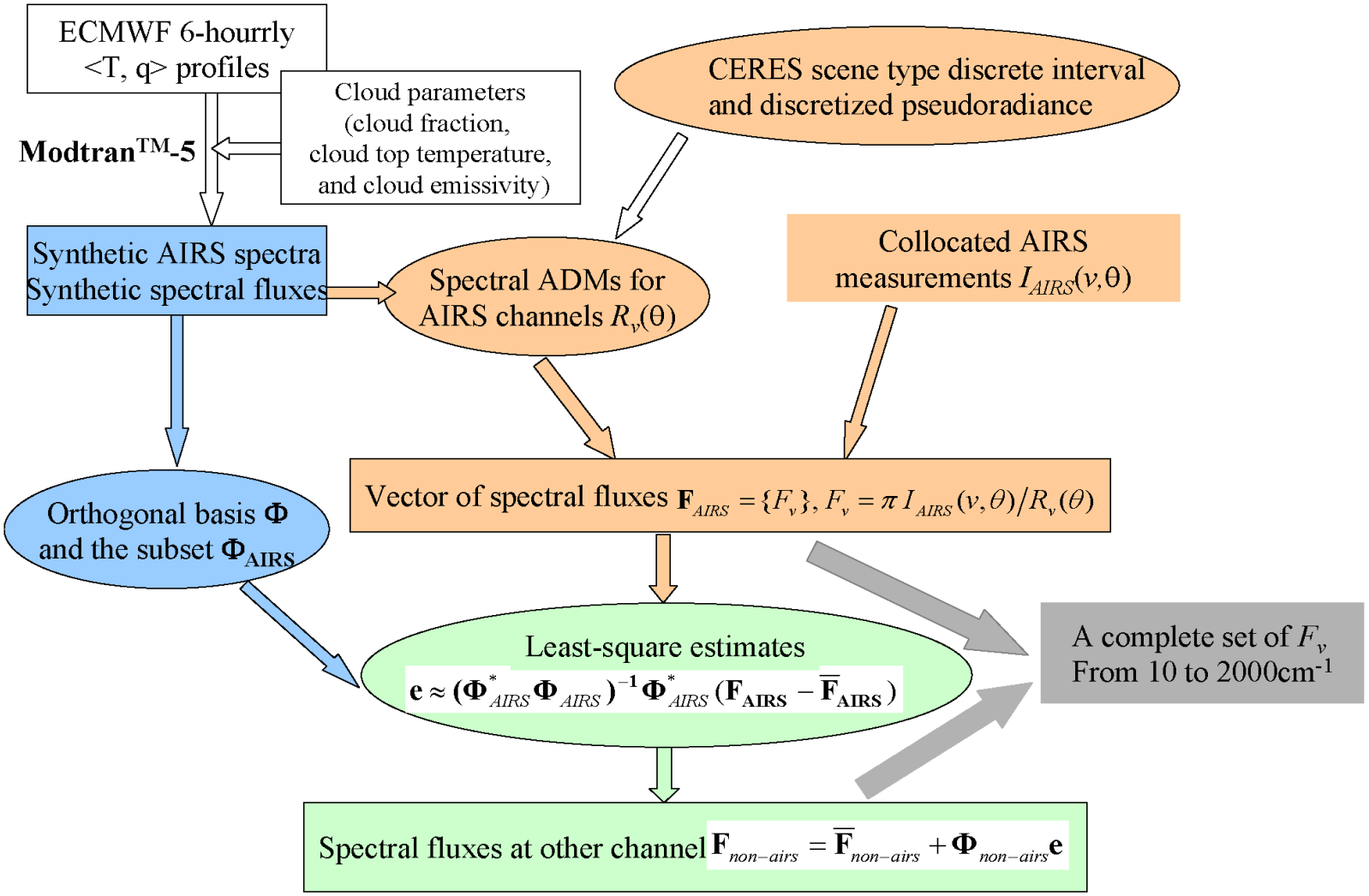
Acknowledgement: the CERES team

- With AIRS and CERES on Aqua, we have showed the synergy between hyperspectral sounder and broadband radiometer
  - At flux level
    - LW spectral flux derived from the AIRS footprint using collocated scene type info from CERES-SSF
    - Good agreement with CERES OLR over multiple years and multiple scene types
  - At radiance level
    - Assess the CERES radiance stability over multiple years

Can we use the CrIS and CERES on S-NPP to show the same synergy, paving a road for future synergistic use of data from JPSS-1, JPSS-2?

On spectral flux

(Huang et al., 2008; 2010; 2014; Chen et al., 2013)



CERES flux and radiance are never used. Only scene-type info in the CERES SSF datasets.

Output: spectral flux at 10cm^{-1} intervals through the entire longwave spectral range

All collocated clear-sky observations in 2004 (80°S-80°N)

Surface Type	Daytime	Nighttime
	OLR_{AIRS_Huang}-OLR_{CERES} (Wm^{-2})	OLR_{AIRS_Huang}-OLR_{CERES} (Wm^{-2})
Forest	0.58±1.43	-0.42±1.41
Savannas	-0.03±2.52	0.68±1.50
Grasslands	0.19±2.61	0.63±1.65
Dark Desert	-0.71±2.85	0.36±1.74
Bright Desert	1.67±2.62	1.42±2.28
Ocean	1.09±1.55	0.90±1.26

Footprint statistics

❑ AIRS

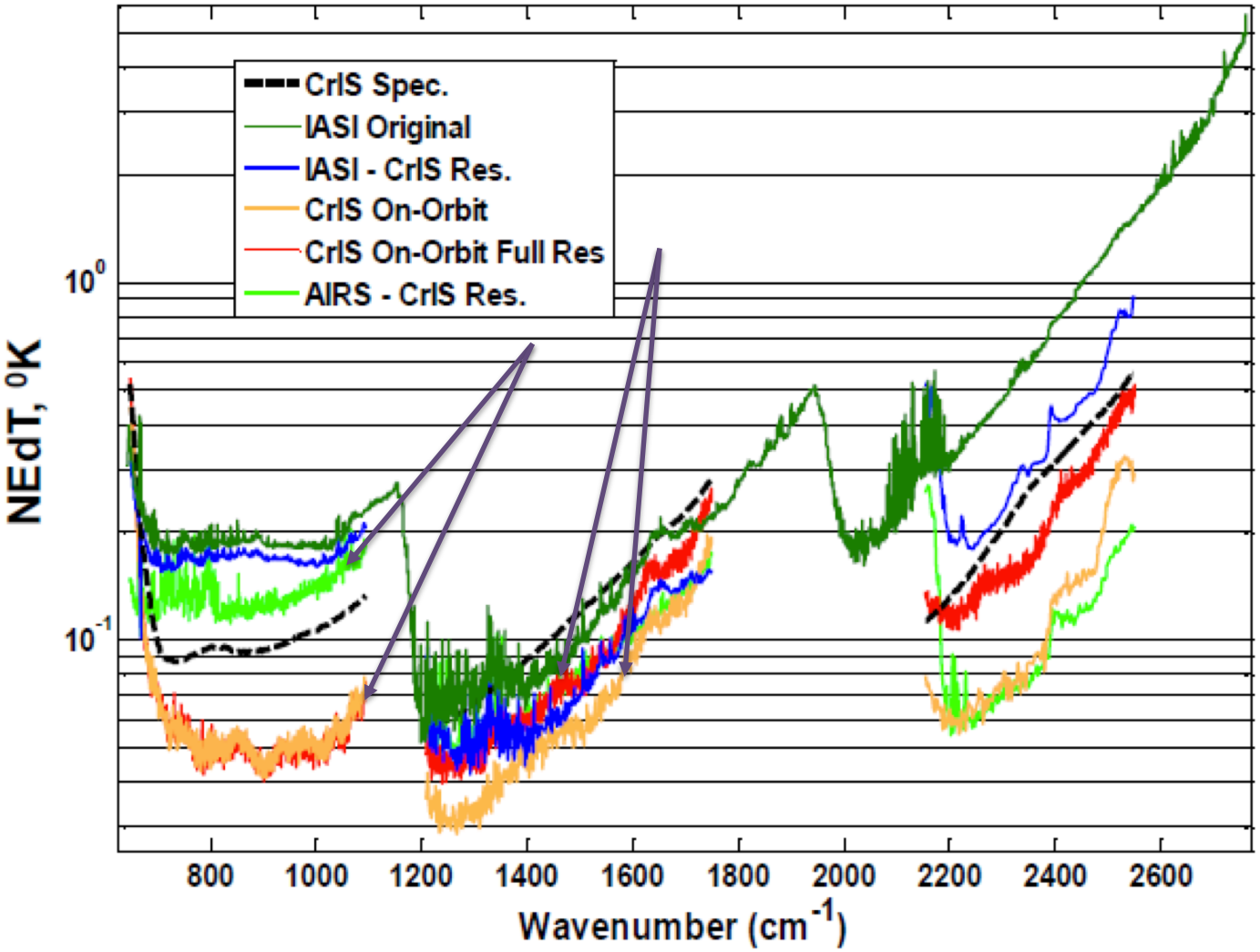
- Aboard Aqua with a 1:30 AM/PM equatorial crossing time
- A field of view 13.5 km (nadir)
- 2378 channels with a spectral resolving power ($\lambda / \Delta\lambda$) of 1200 from 650 to 2670 cm^{-1} (non-continuous coverage)
- Data collection from Sep 2002 to present
- *Stability: 0.002-0.003 K/yr in B.T.* (Aumann et al., 2019, GRL)
- Radiometric Uncertainty: 0.05-0.2K in B.T.

❑ CrIS

- Aboard Suomi-NPP with ~1:30 AM/PM equatorial crossing time
- 14-km nadir-view footprint
- 1305 channels over 3.92–4.64, 5.71–8.26, and 9.14–15.38 μm
- Data collection from Feb 2012 to present
- *Stability: 0.003-0.016 K/yr in B.T.* (Hepplewhite et al., 2019/2020)
- Radiometric Uncertainty: 0.03-0.2K in B.T.

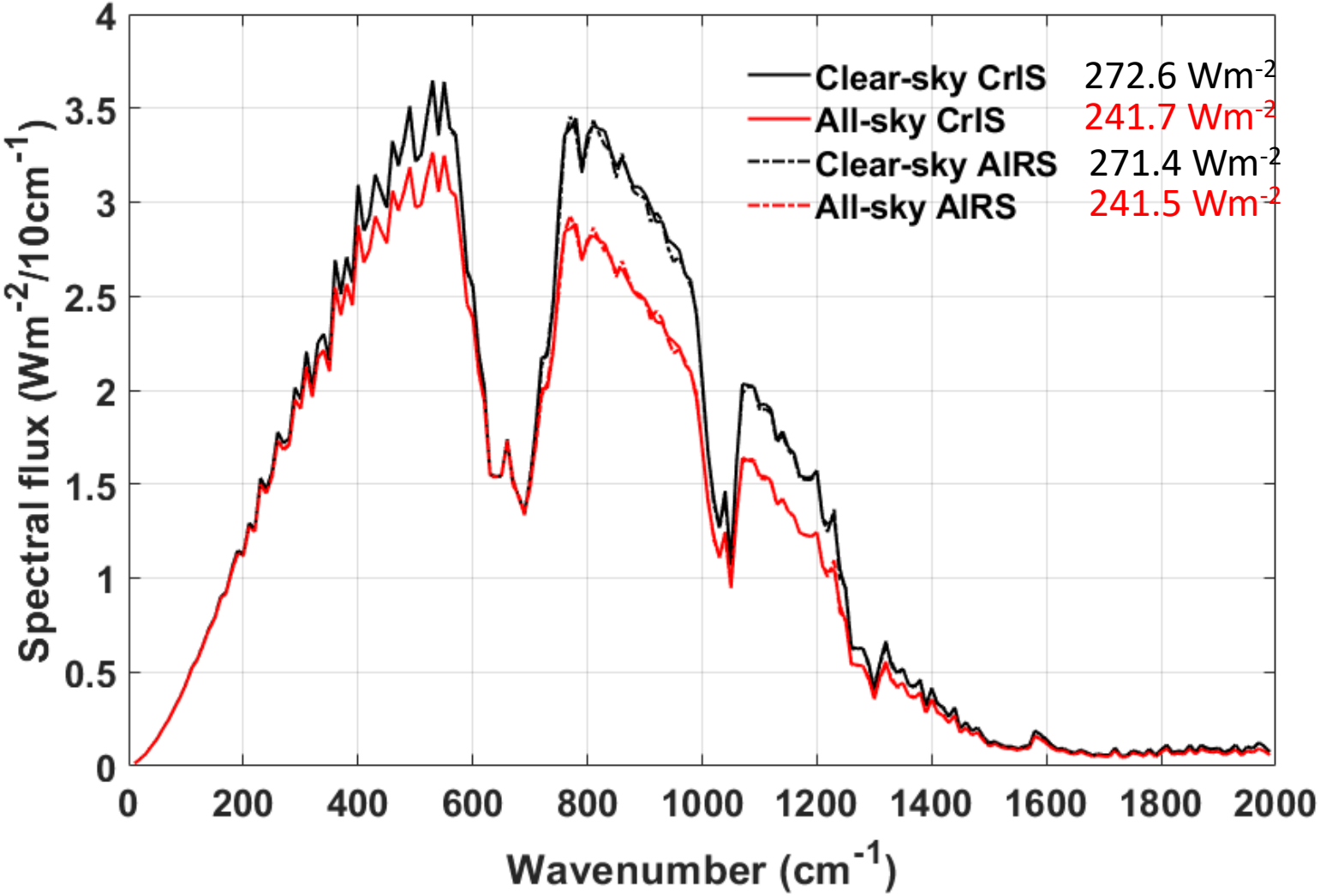
CrIS NEdT vs AIRS and IASI at native instrument resolution (T=270K)

In thermal IR, CrIS has smaller noise levels than both AIRS and IASI



Zavyalov et al,
https://cimss.ssec.wisc.edu/itwg/itsc/itsc18/program/files/links/1.07_Zavyalov_po.pdf

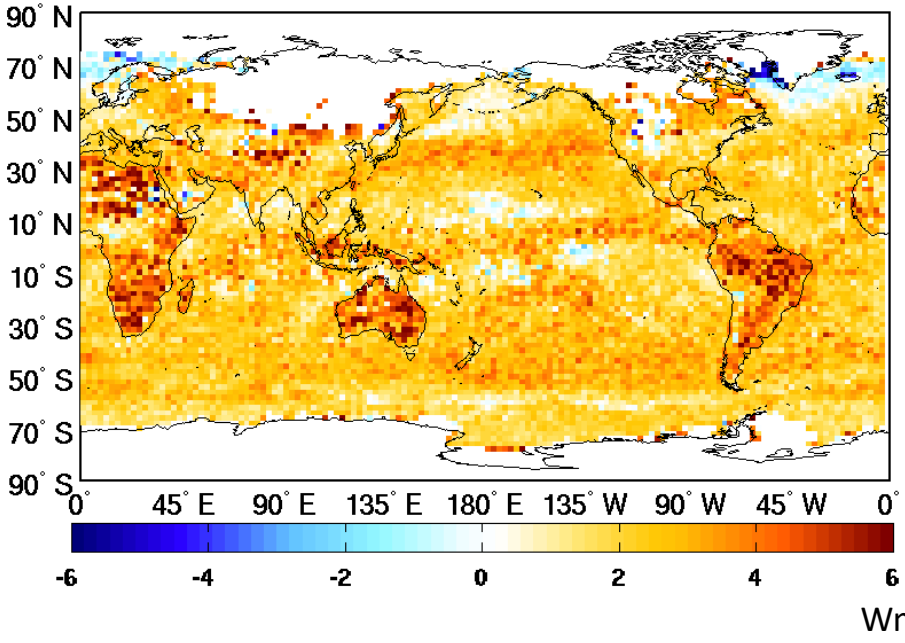
Multi-year-mean spectral flux from Aug. 2012 to Jul. 2018



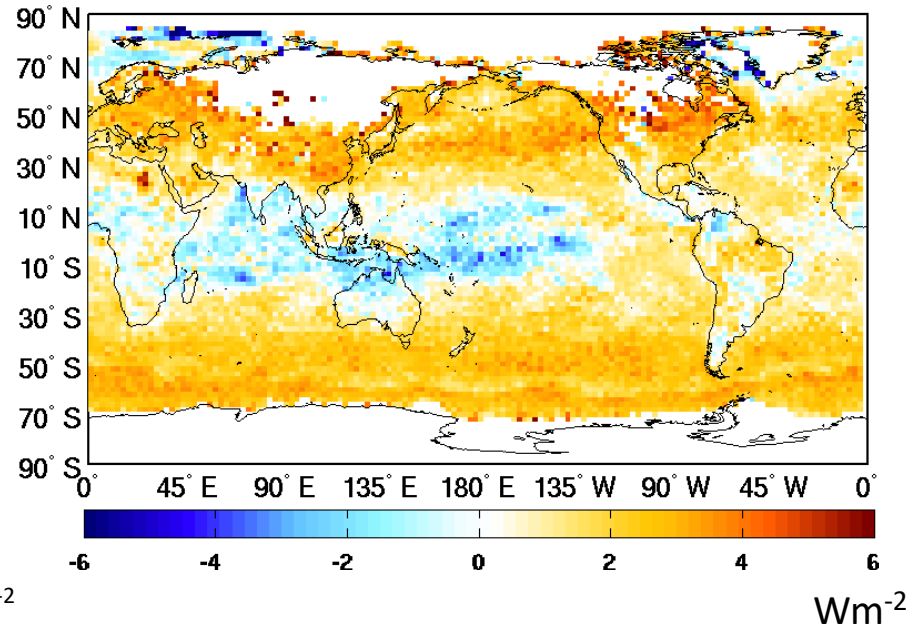
Spectra flux derived from CrIS

Cloudy-sky over nonfrozen surface $OLR_{CRIS} - OLR_{CERES_NPP}$ (Jan2016)

Daytime

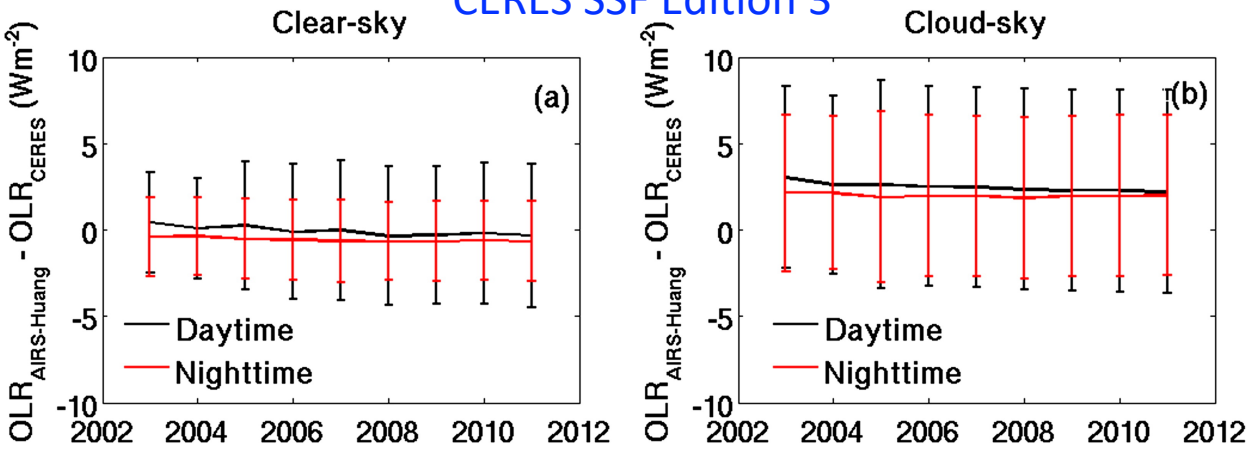


Nighttime



Multiple-year global comparisons: AIRS spectral OLR vs. CERES

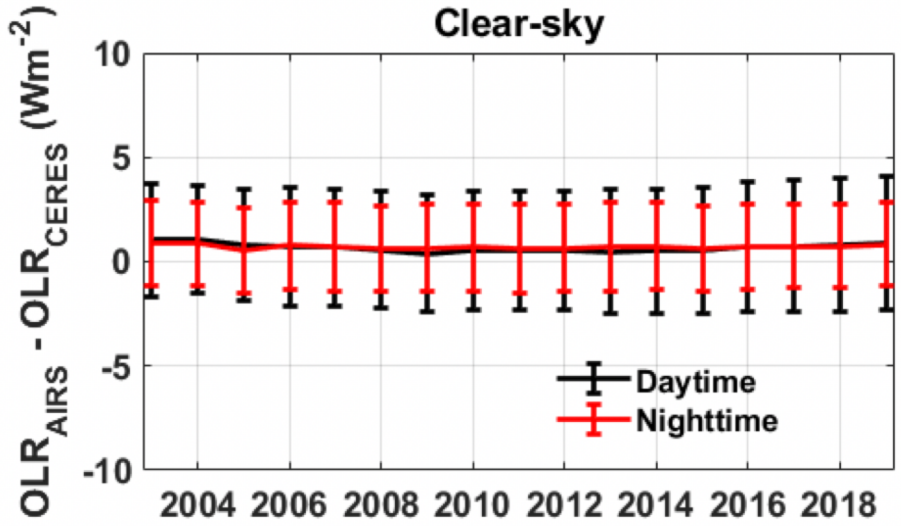
CERES SSF Edition 3



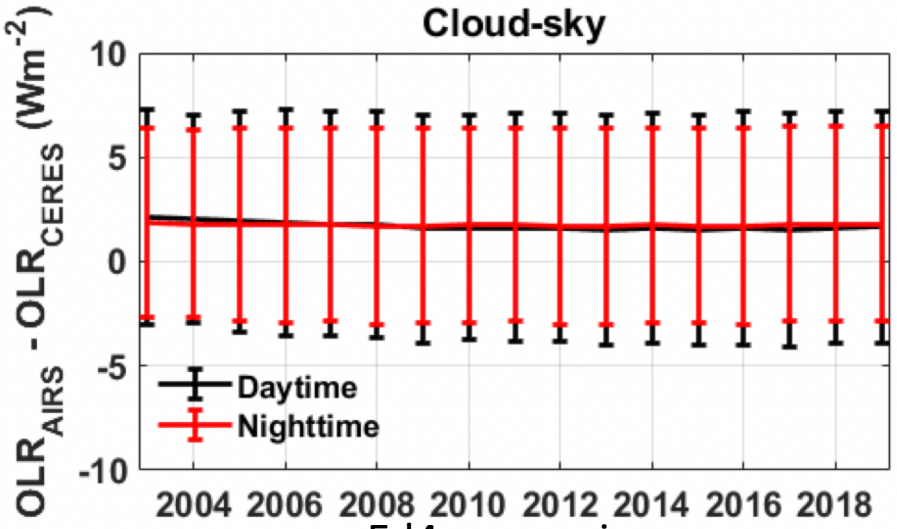
(Huang et al., 2014, J Climate)

Footprint statistics

CERES SSF Edition 4



Ed3 comparison



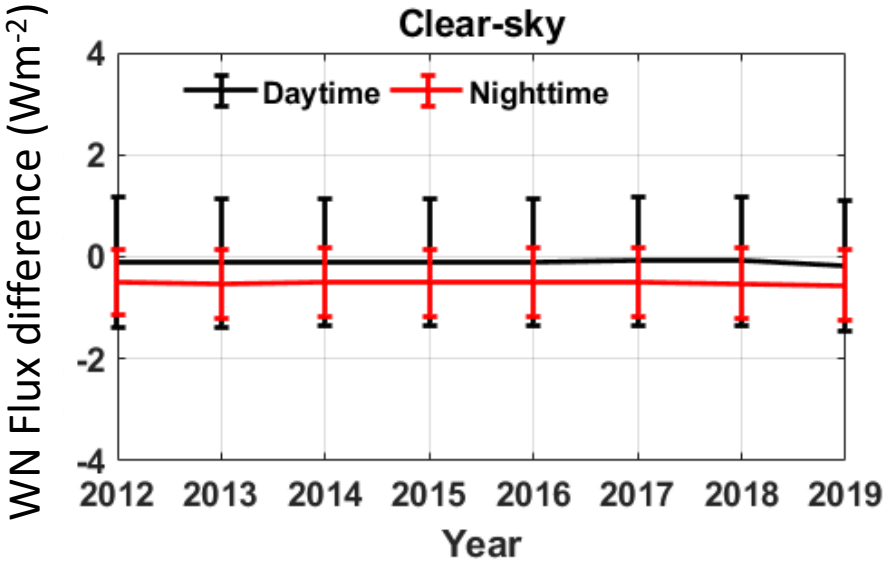
Ed4 comparison

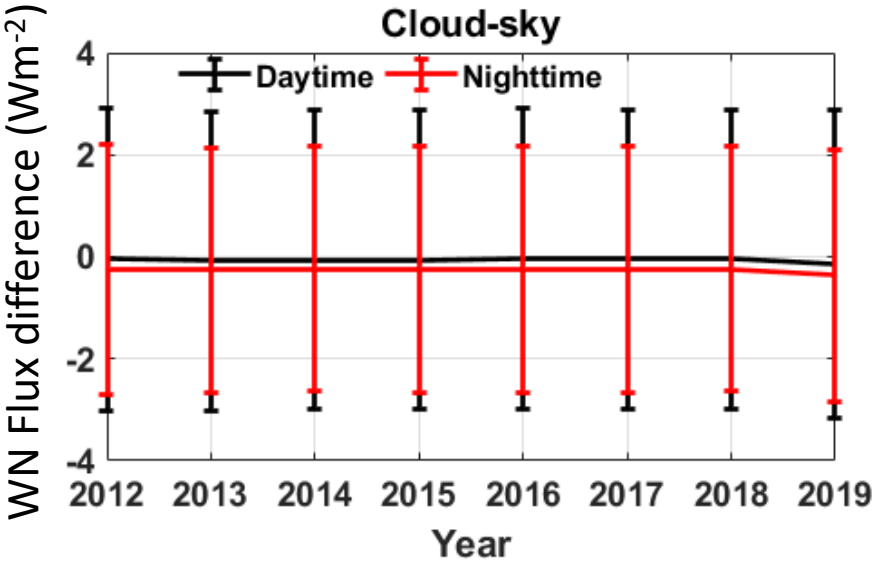
	Clear-sky	Cloudy-sky
Daytime	[-0.34, 0.42]	[2.20, 3.00]
Nighttime	[-0.67, -0.38]	[1.85, 2.12]

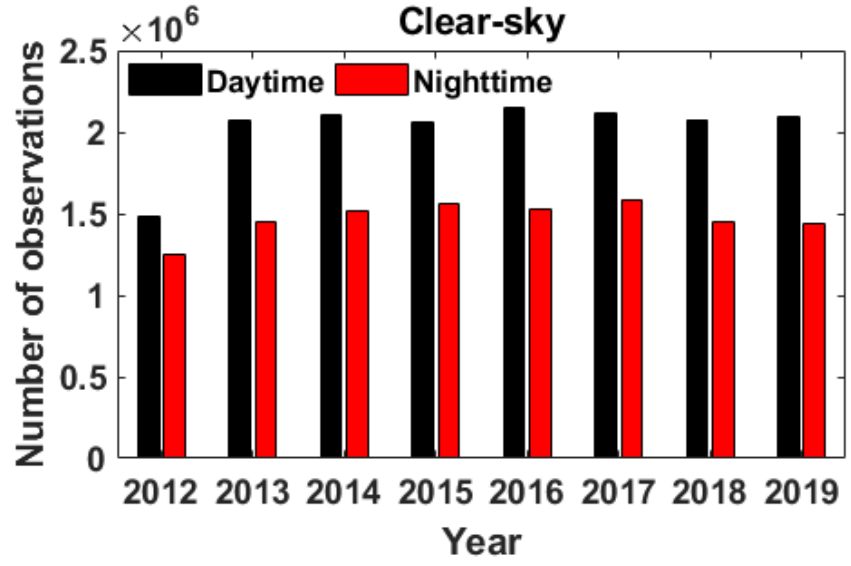
	Clear-sky	Cloudy-sky
Daytime	[0.39, 1.07]	[1.48, 2.10]
Nighttime	[0.57, 0.89]	[1.69, 1.87]

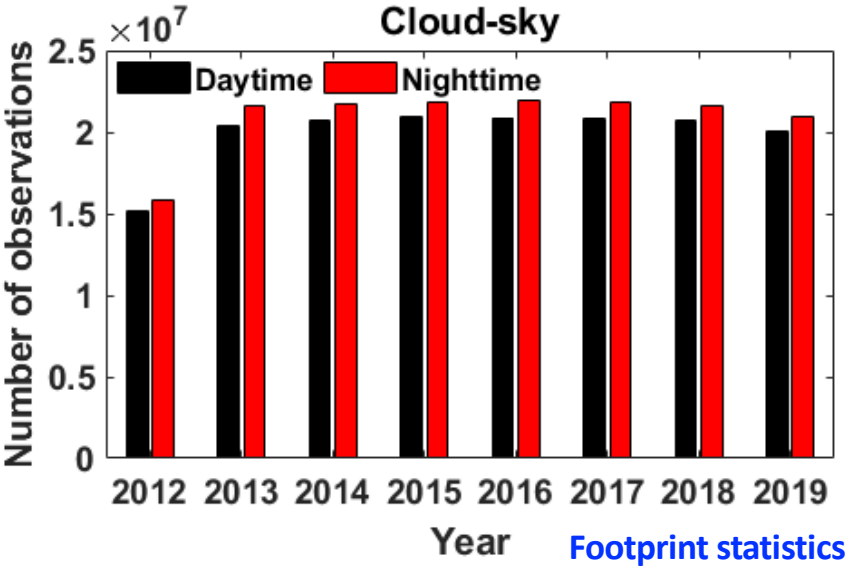
WN-band Flux difference (CrIS – CERES)

- 2012 only includes Apr-Dec
- CERES FM5 Ed1







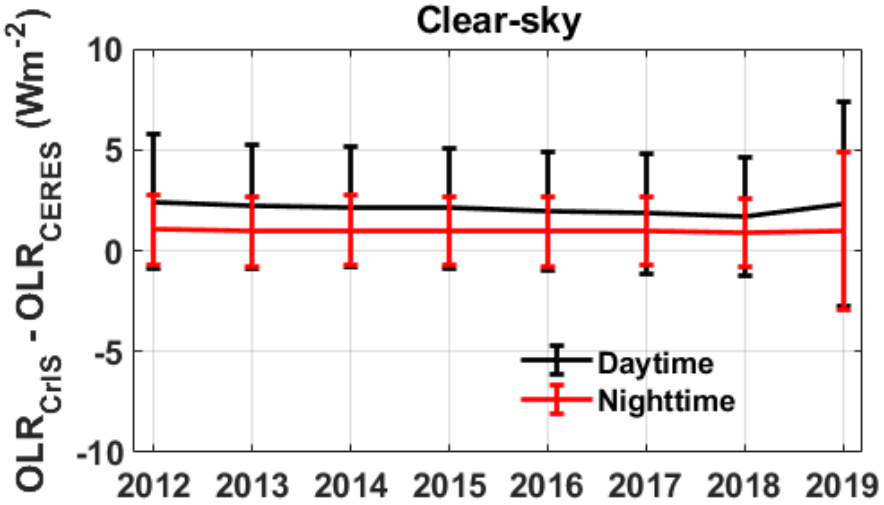


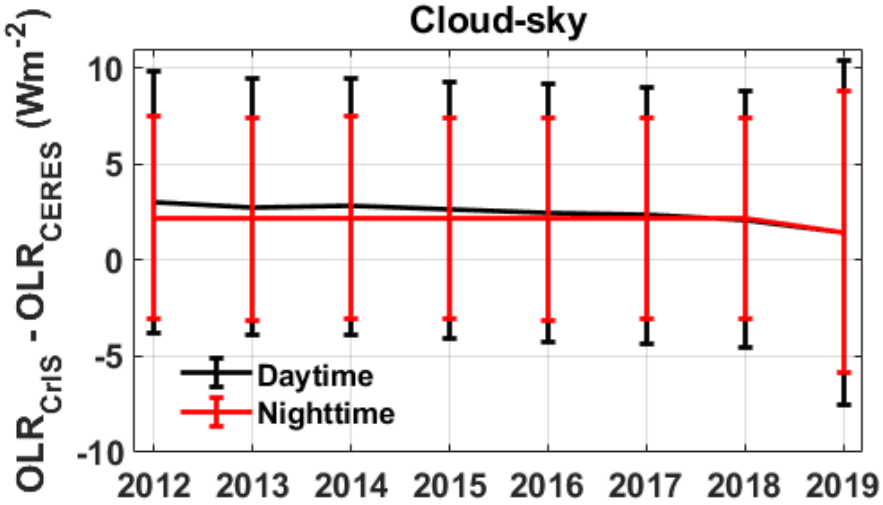
Footprint statistics

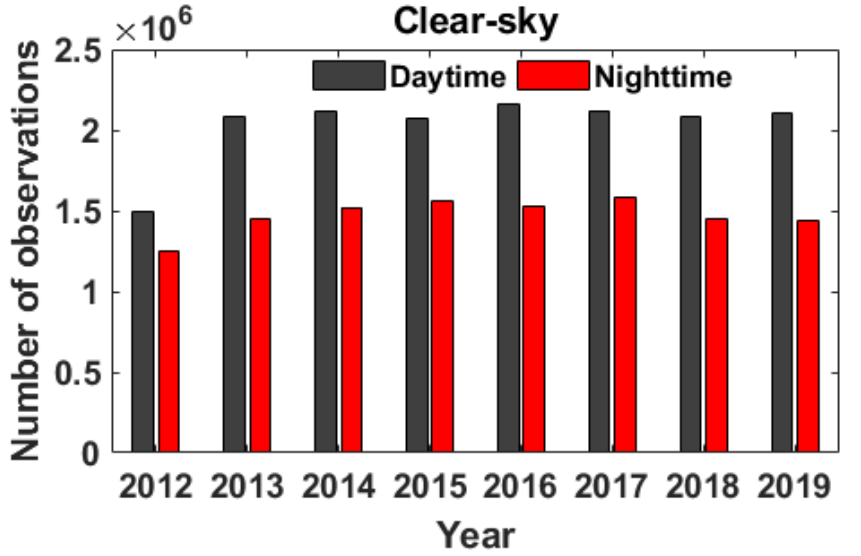
OLR difference (CrIS – CERES)

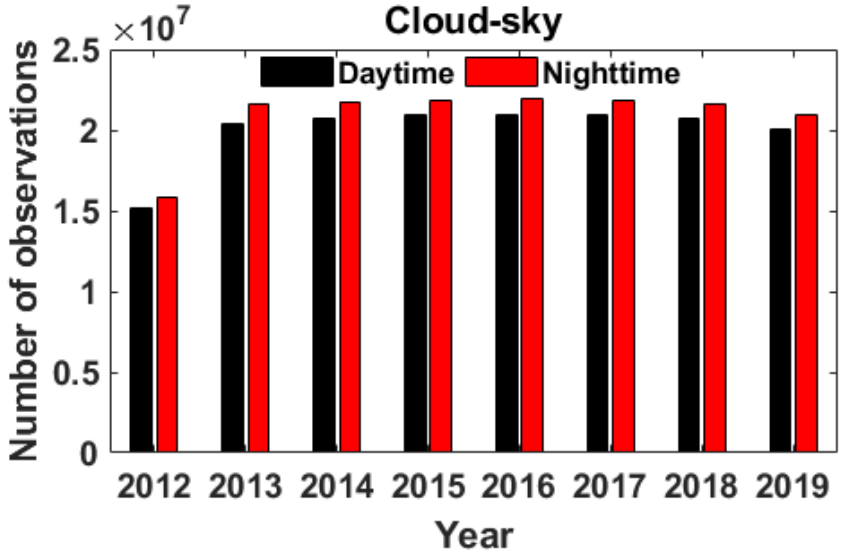
	Clear-sky	Cloudy-sky
Daytime	[1.71, 2.43]	[1.42, 3.02]
Nighttime	[0.88, 1.03]	[1.45, 2.23]

2012 only includes Apr-Dec
CERES FM5 Ed1
2019 error bar is large due to missing CrIS data

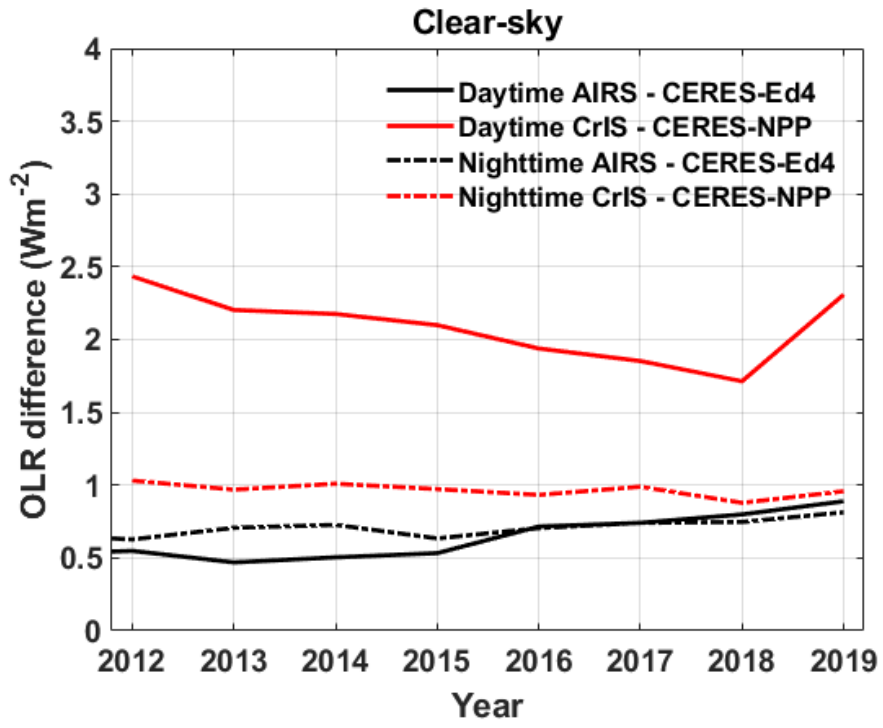


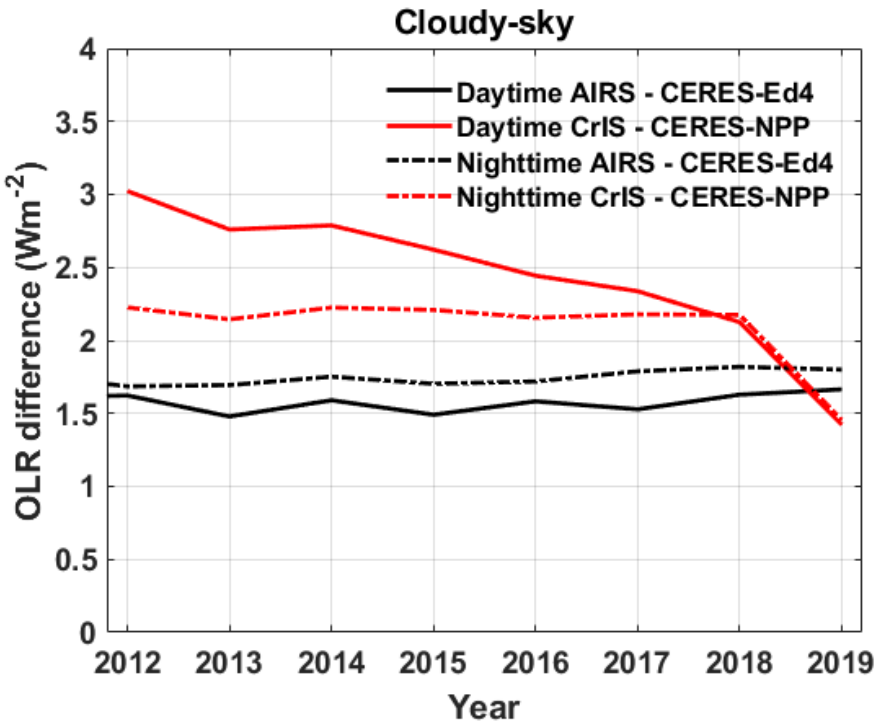






AIRS-CERES Ed4 on Aqua vs. CrIS – CERES Ed 1 on S-NPP





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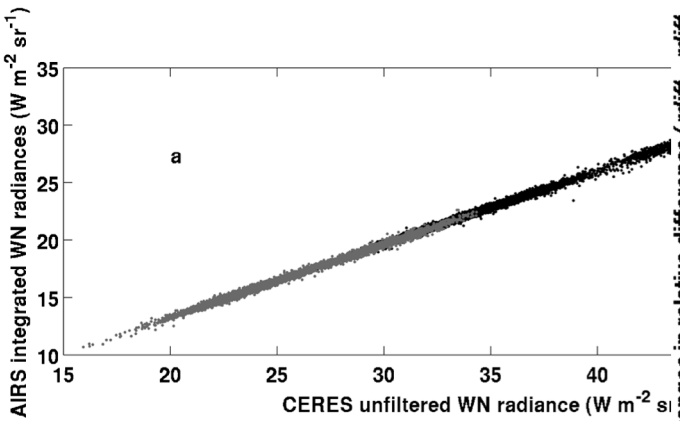
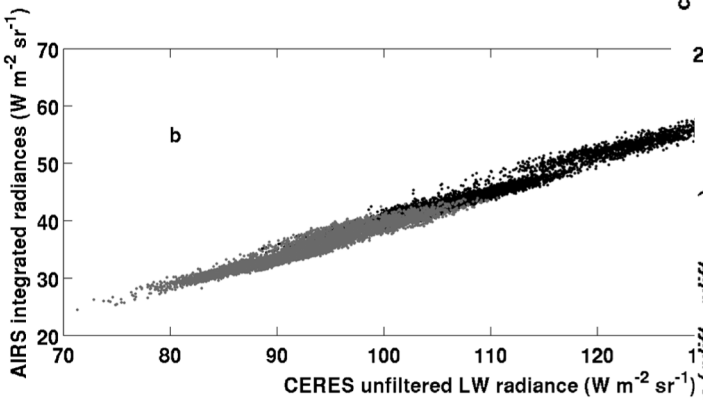
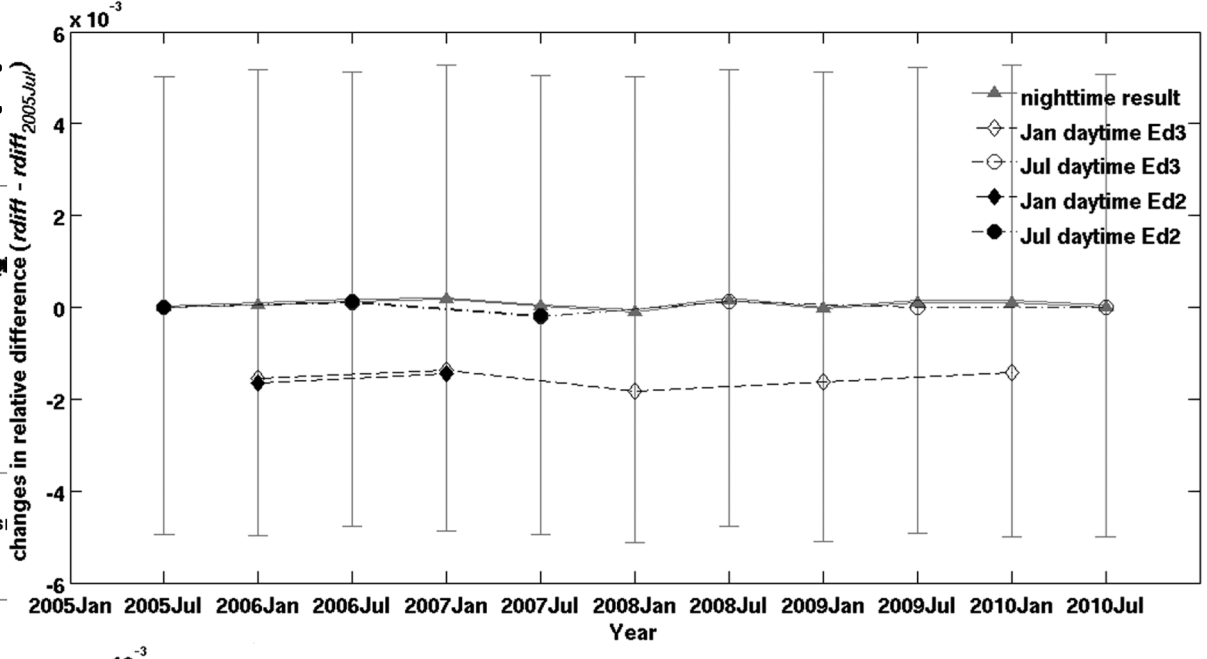
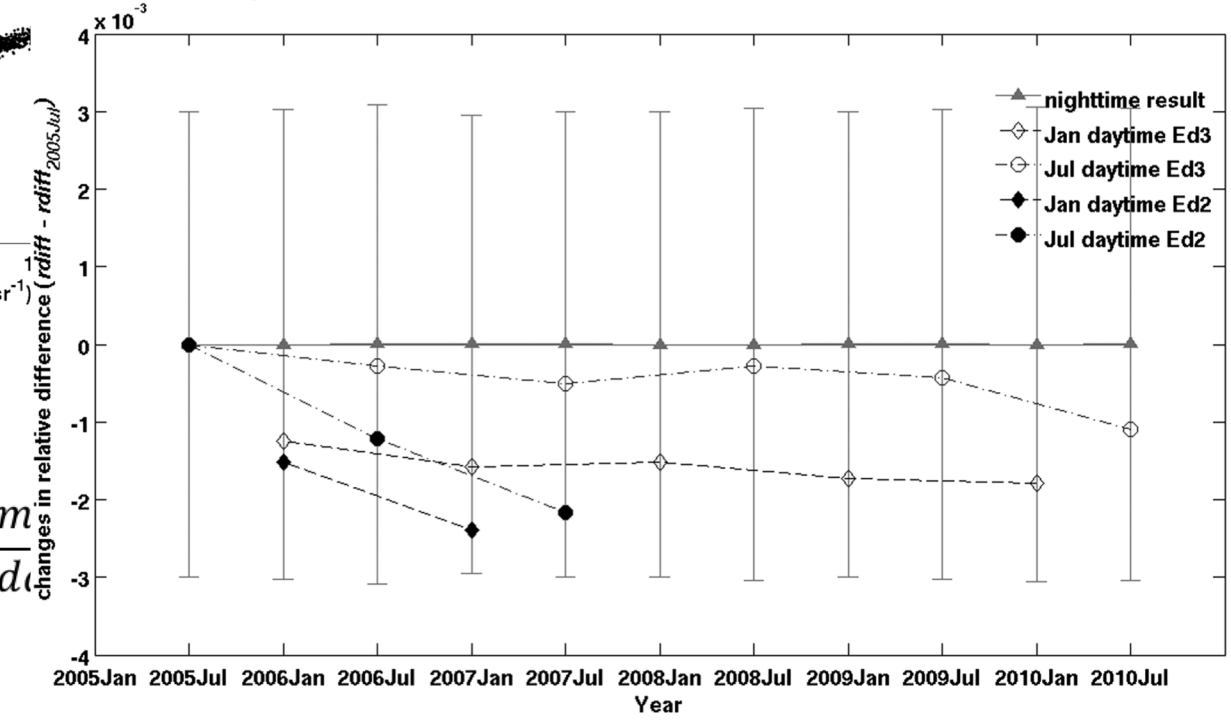






$$rdiff = \frac{I_{LW_CERES}(daytim}{I_{est}(d}$$



On stability assessment

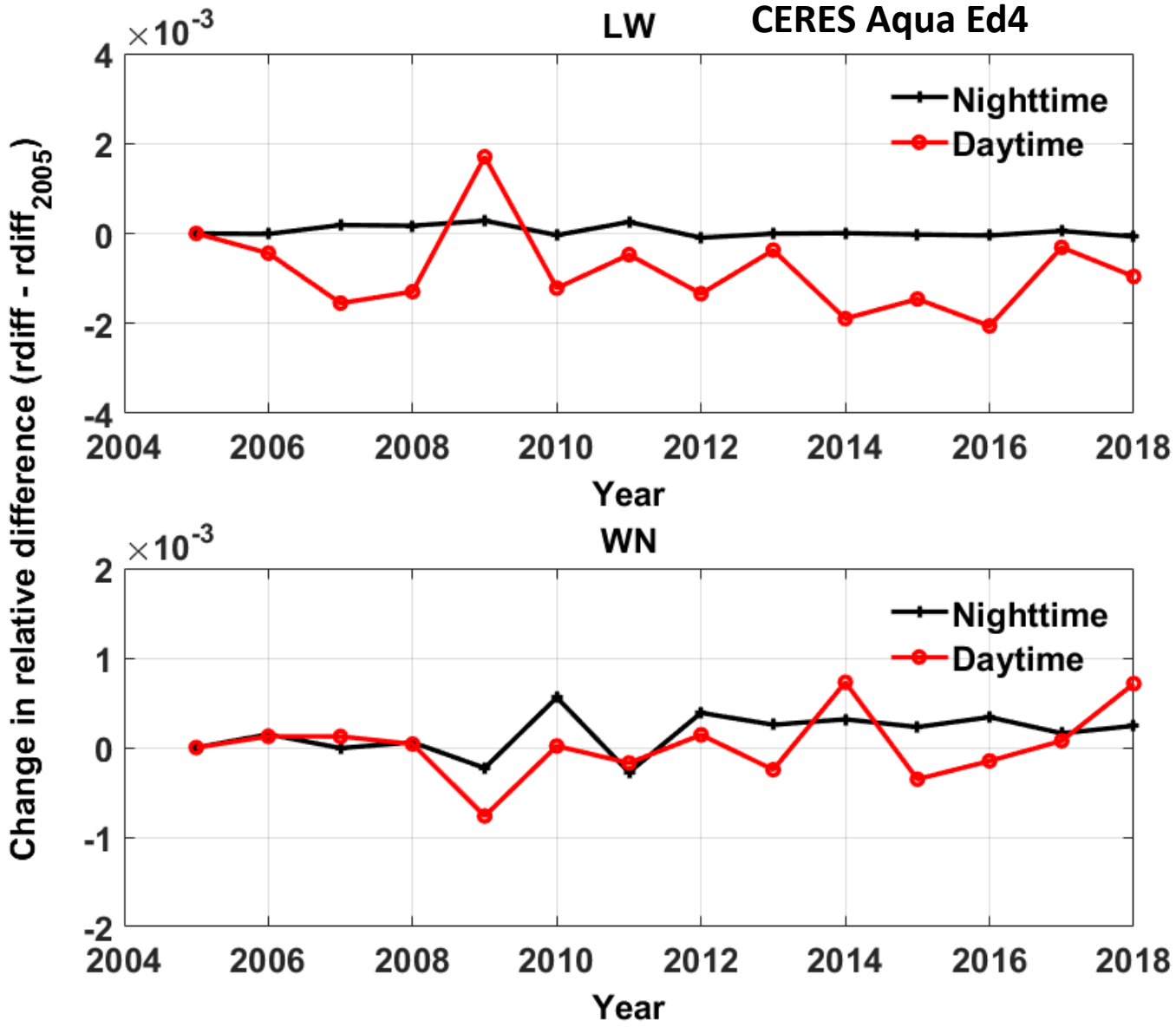
Following Huang et al. (2012, JTECH)

1) Do regression using nighttime CrIS (or AIRS) and CERES WN and LW radiance
2) Estimate CERES LW daytime radiance using the regression coefficients from 1)
3) Estimate the relative difference for the daytime

$$rdiff = \frac{I_{LW_CERES}(daytime) - I_{est}(daytime)}{I_{est}(daytime)}$$

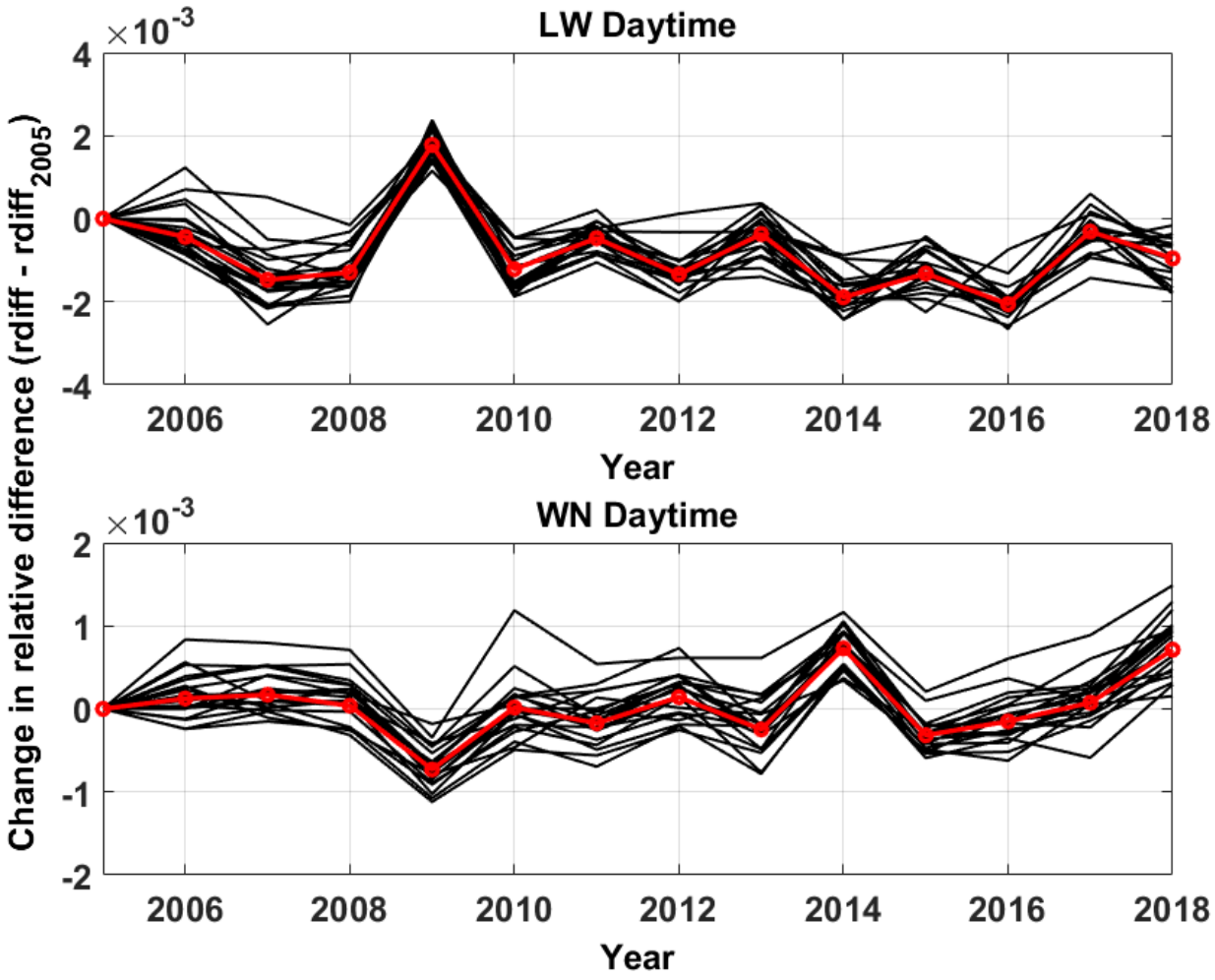
Premise: if daytime vs. nighttime has changes with time, rdiff should be able to tell

The shift of mean r_{diff} in Julies with respect to the mean r_{diff} of July 2005



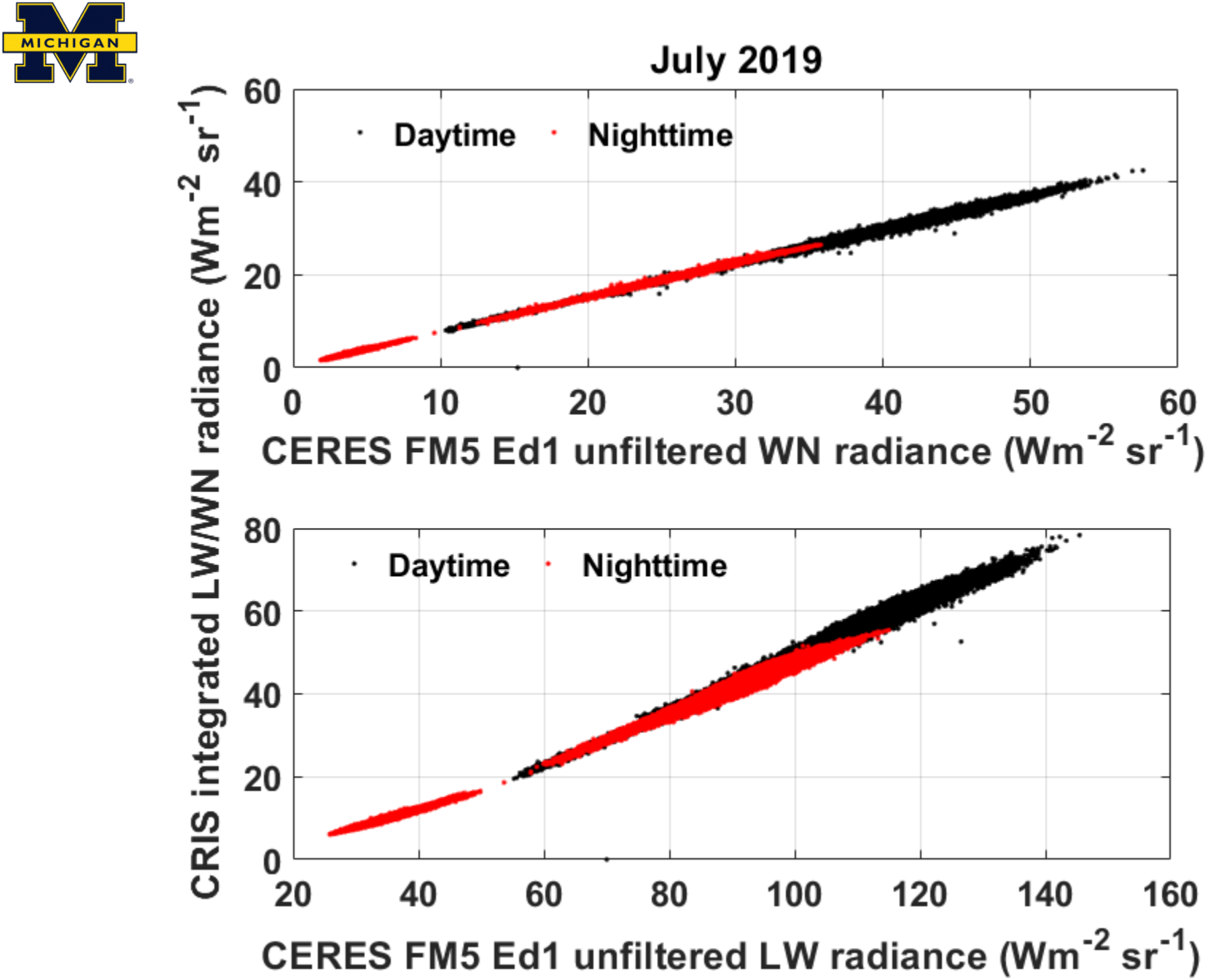
Smaller Y-scale here

For Julies, randomly select 20 subset of data, which include 13~20 days, respectively. Then compute daytime shift for CERES FM3 Ed4.

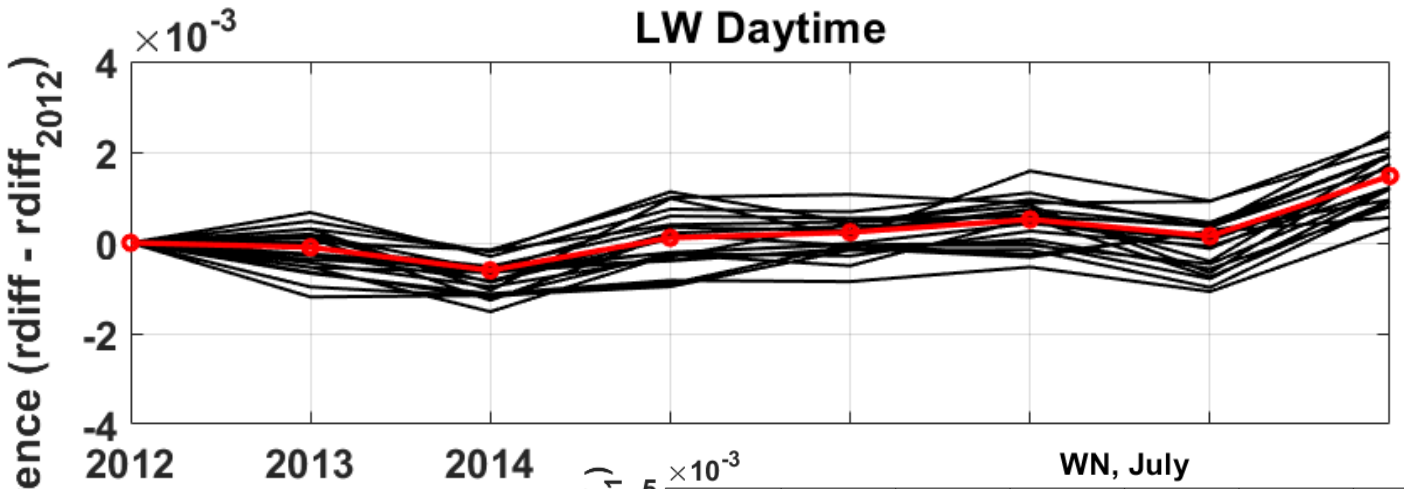


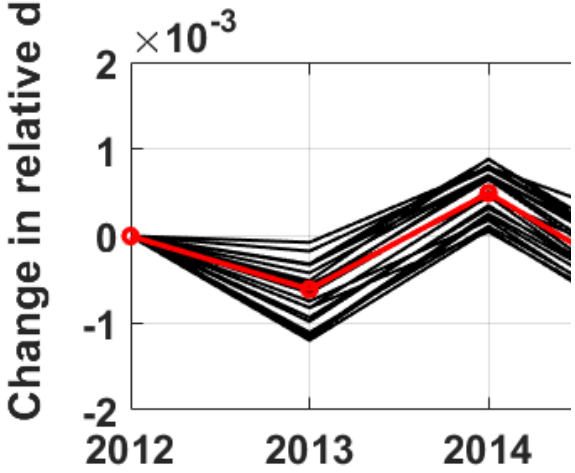
Red line is obtained using all data

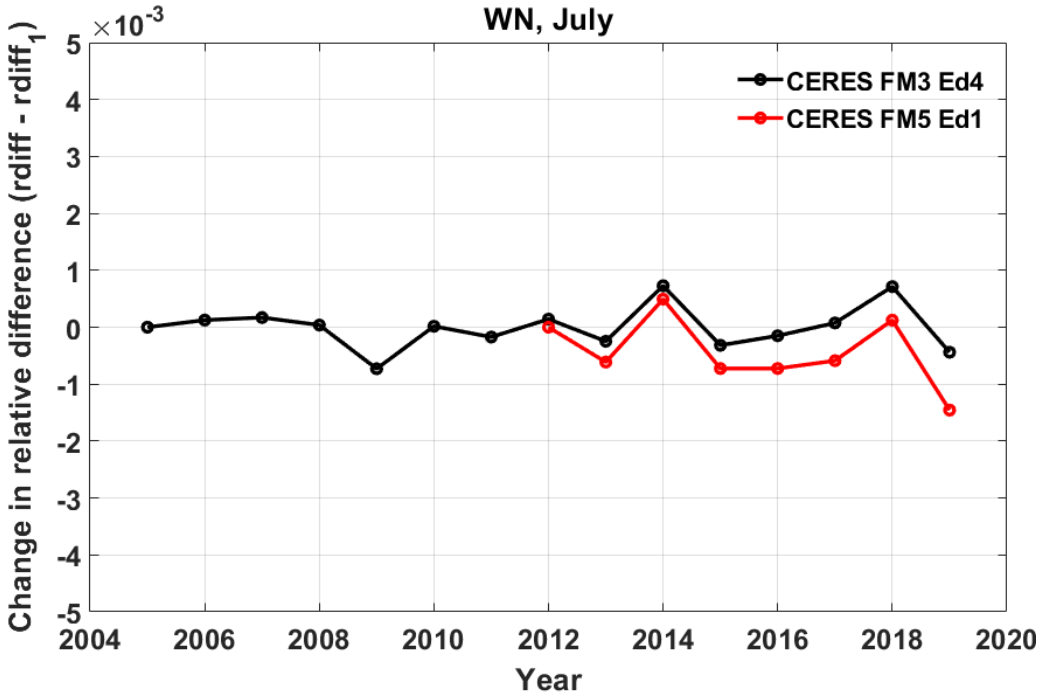
Black line: randomly chosen 50% data


July 2019
Daytime
Nighttime
CRIS integrated LW/WN radiance (Wm-2 sr-1)
CERES FM5 Ed1 unfiltered WN radiance (Wm-2 sr-1)
0
20
40
60
0
10
20
30
40
50
60
Daytime
Nighttime
CRIS integrated LW/WN radiance (Wm-2 sr-1)
CERES FM5 Ed1 unfiltered LW radiance (Wm-2 sr-1)
0
20
40
60
80
20
40
60
80
100
120
140
160

Daytime shift for CERES FM5 Ed1 (Julies)



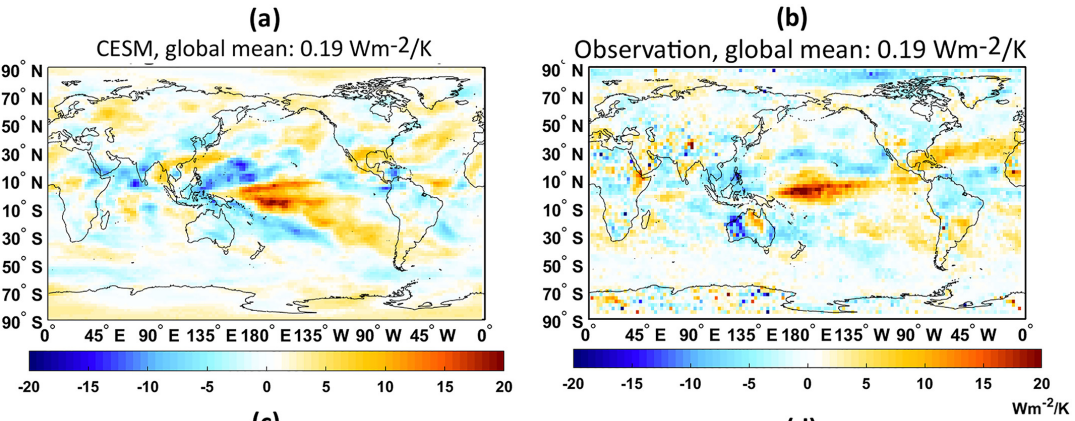




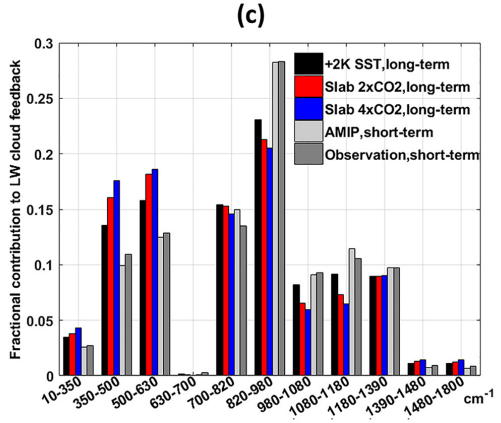
Red line is obtained using all data

Black line: bootstrap with randomly chosen 50% data

Why bother with the WN band?



It can provide additional infect for cloud feedback vs. cloud change

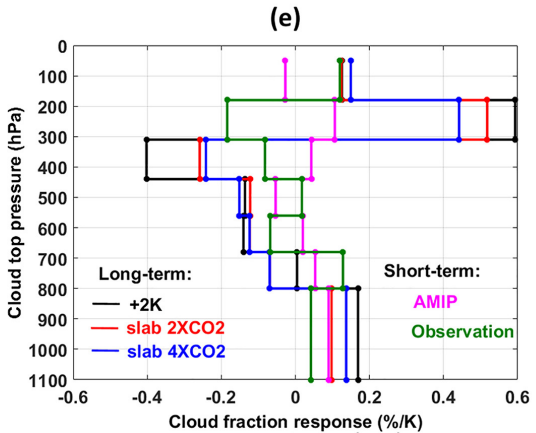


(d)

	Total fractional contribution from 10-630 cm^{-1} (far-IR)	Total fractional contribution from 820-1180 cm^{-1} (window)	LW broadband cloud radiative feedback (Wm^{-2}/K)
+2K SST	0.33	0.40	0.20
Slab 2xCO_2	0.38	0.35	0.18
Slab 4xCO_2	0.40	0.33	0.14
AMIP	0.25	0.49	0.19
Observation	0.26	0.48	0.19

Long-term change

Short-term (10yr+) fluctuation



Reference: Huang, X.L., X. H. Chen, Q. Yue, Band-by-band contributions to the longwave cloud radiative feedbacks, *Geophysical Research Letters*, 46, doi.org/10.1029/2019GL083466, 2019.

Conclusions and discussions

- Synergy exists between the CERES and hyperspectral observations
  - Agreements at both the radiances and flux are both reassuring the synergy
  - Collocated radiances can help assess CERES unfiltered radiance
- Window-band flux from CERES is under-utilized.
  - Channel performances stable over the year
  - Flux is consistent with the ones from AIRS/CrIS

References

- **Huang, X.L.**, X. H. Chen, Q. Yue, Band-by-band contributions to the longwave cloud radiative feedbacks, *Geophysical Research Letters*, 46, doi.org/10.1029/2019GL083466, 2019.
- **Huang, X. L.**, X.H. Chen, G. L. Potter, L. Oreopoulos, J. N.S. Cole, D.M. Lee, N. G. Loeb, A global climatology of outgoing longwave spectral cloud radiative effect and associated effective cloud properties, *J. Climate*, 27, 7475-7492, doi:10.1175/JCLI-D-13-00663.1, 2014.
- **Huang, X.L.**, N. G. Loeb, H.W. Chuang, Assessing stability of CERES-FM3 daytime longwave unfiltered radiance with AIRS radiances, *Journal of Atmospheric and Oceanic Technology*, 29(3), 375-381, doi:10.1175/JTECH-D-11-00066.1, 2012.
- **Huang, X.L.**, N.G. Loeb, and W.Z. Yang, Spectrally resolved fluxes derived from collocated AIRS and CERES measurements and their application in model evaluation: 2. cloudy sky and band-by-band cloud radiative forcing over the tropical oceans, *JGR-Atmospheres*, 115, D21101, doi:10.1029/2010JD013932, 2010.
- **Huang, X.L.**,W.Z. Yang, N.G. Loeb, and V. Ramaswamy, Spectrally resolved fluxes derived from collocated AIRS and CERES measurements and their application in model evaluation: 1. clear sky over the tropical oceans, *JGR-Atmospheres*, 113, D09110, doi:10.1029/2007JD009219, 2008.

Thank You!