Ed4 Energy Balanced and Filled (EBAF)-surface

Seiji Kato[1], Fred G. Rose[2], David A. Rutan[2],

Tyler J. Thorsen[1], Xianglei Huang[3],

Norman G. Loeb[1], David R. Doelling[1]

William L. Smith, and Wenying Su

[1]NASA Langley Research Center

[2]Science System & Applications Inc.

[3]University of Michigan

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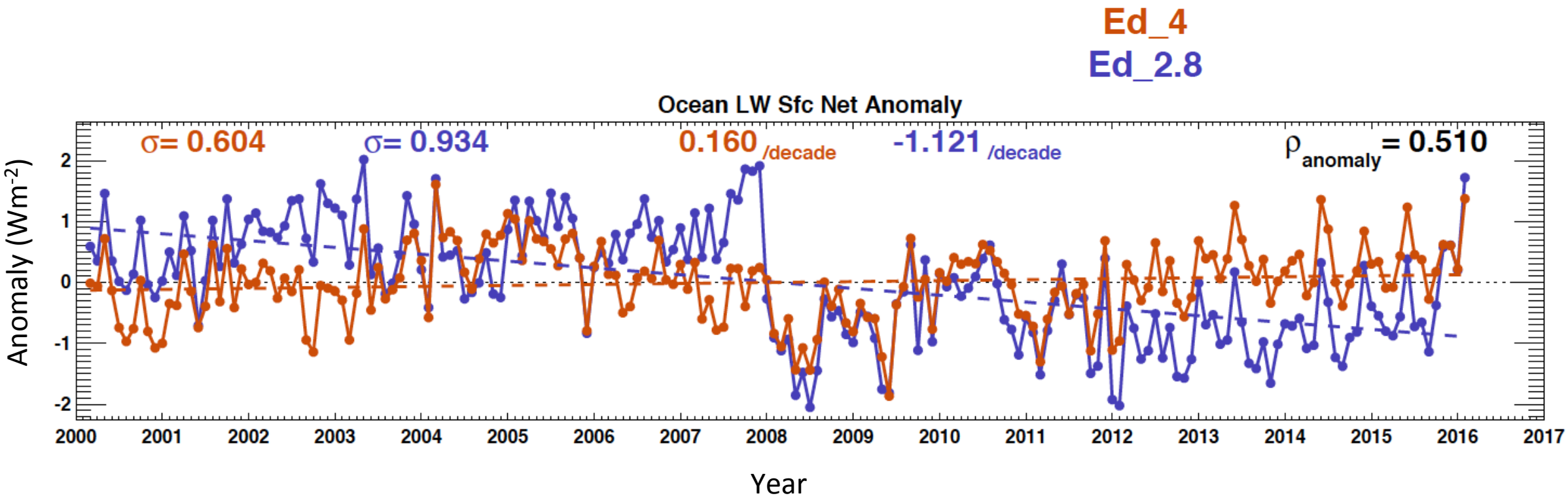
Hampton, VA

Outline of this talk

- Ed4 Improvements from Ed2.8
  - GEOS-5.4.1 is used for the entire record
  - MODIS collection 5 is used for the entire record
  - Nighttime GEO clouds (Ed4 SYN)
  - Better surface irradiance bias correction
  - Better radiative kernels
- Validation with surface data
  - Downward longwave irradiances are improved because of better nighttime cloud properties
- Uncertainty in surface irradiances
- Standard deviation of anomalies

Improvements from Ed 2.8

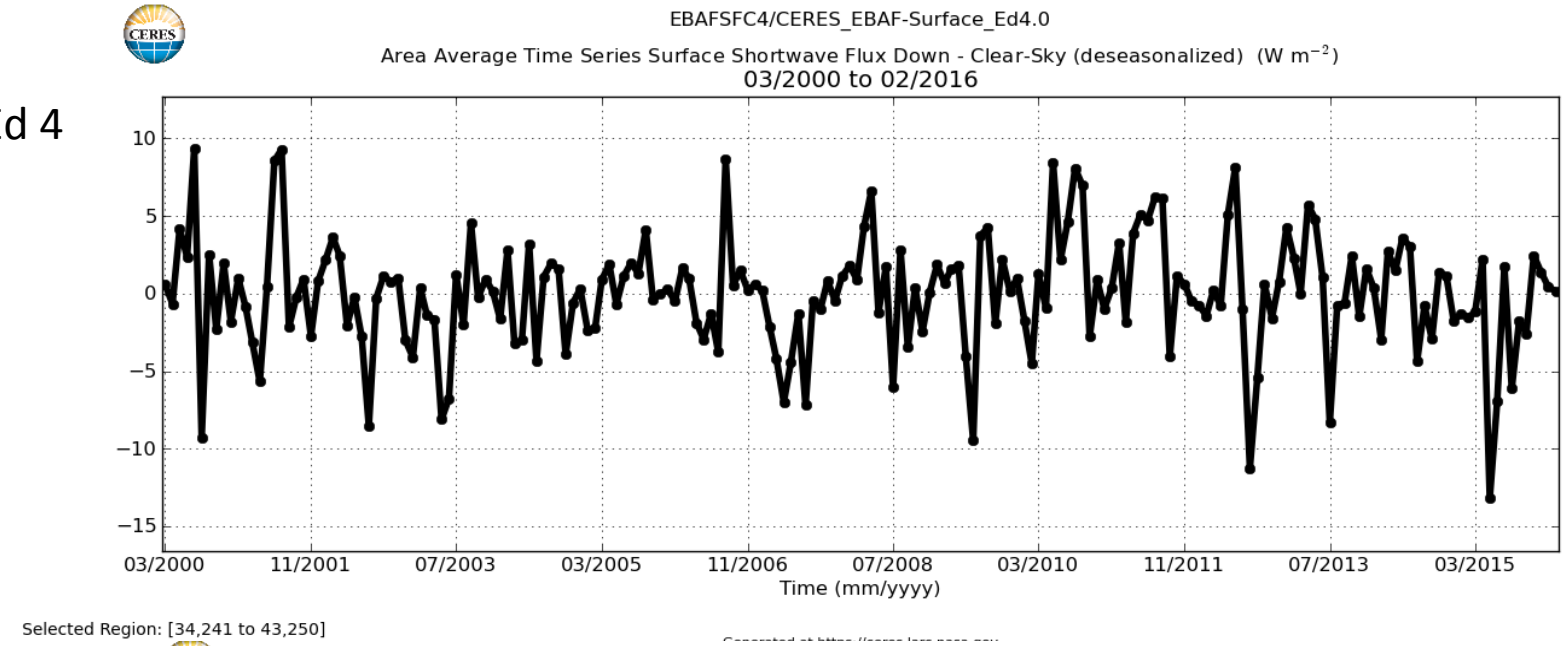
Time series of LW net irradiance deseasonalized anomalies over ocean



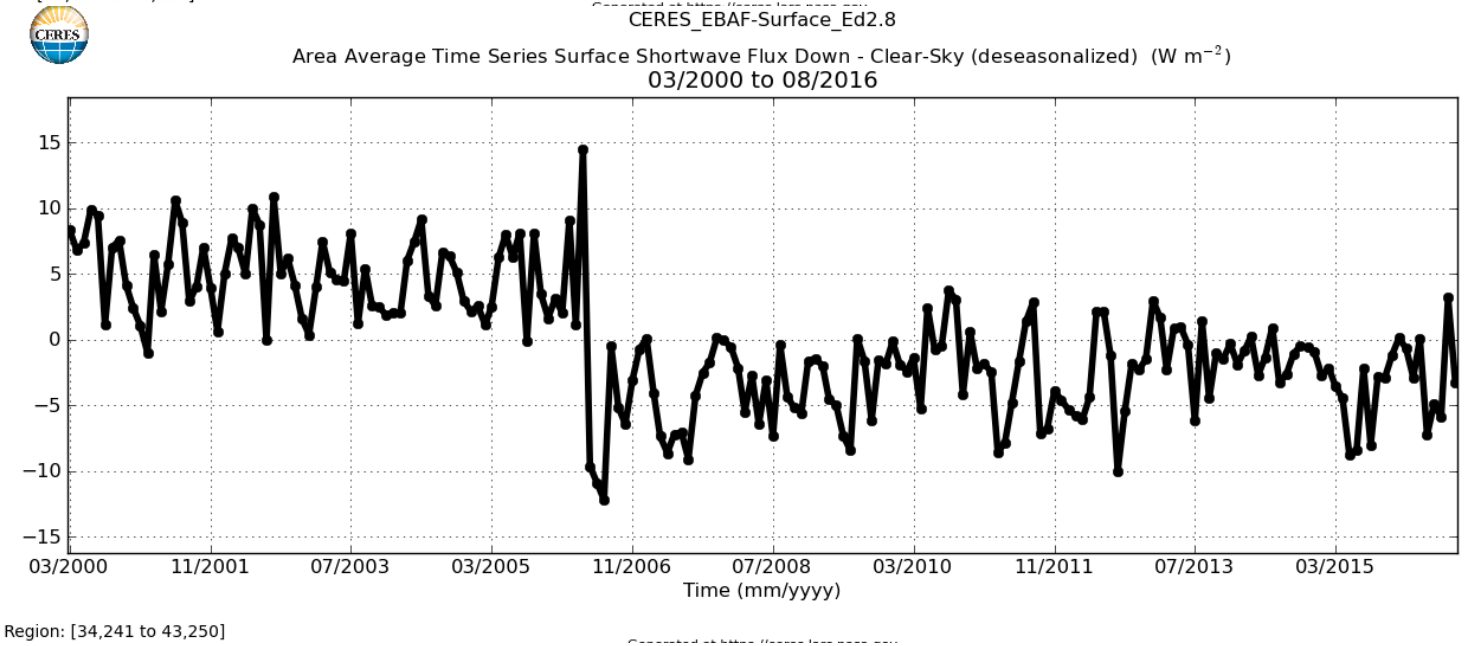
Ed4 eliminated a discontinuity exists at the beginning of 2008 caused by GEOS switch in Ed2.8

Downward clear-sky downward shortwave over land

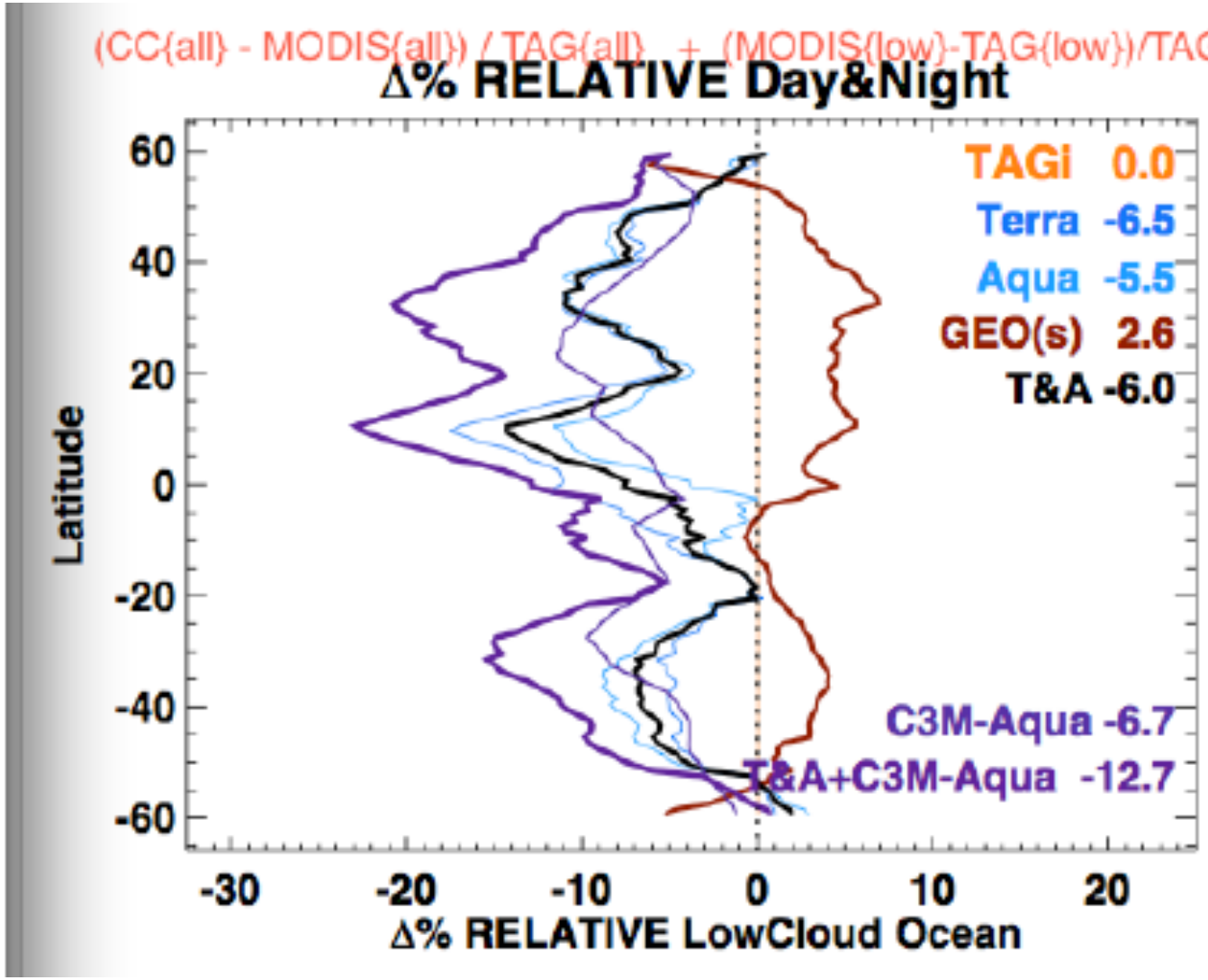
Ed 4



Ed 2.8



Downward longwave bias correction (reduces LW down)



Relative to Terra+Aqua+GEO (TAGI)

= (GEO-TAGi) / TAGi

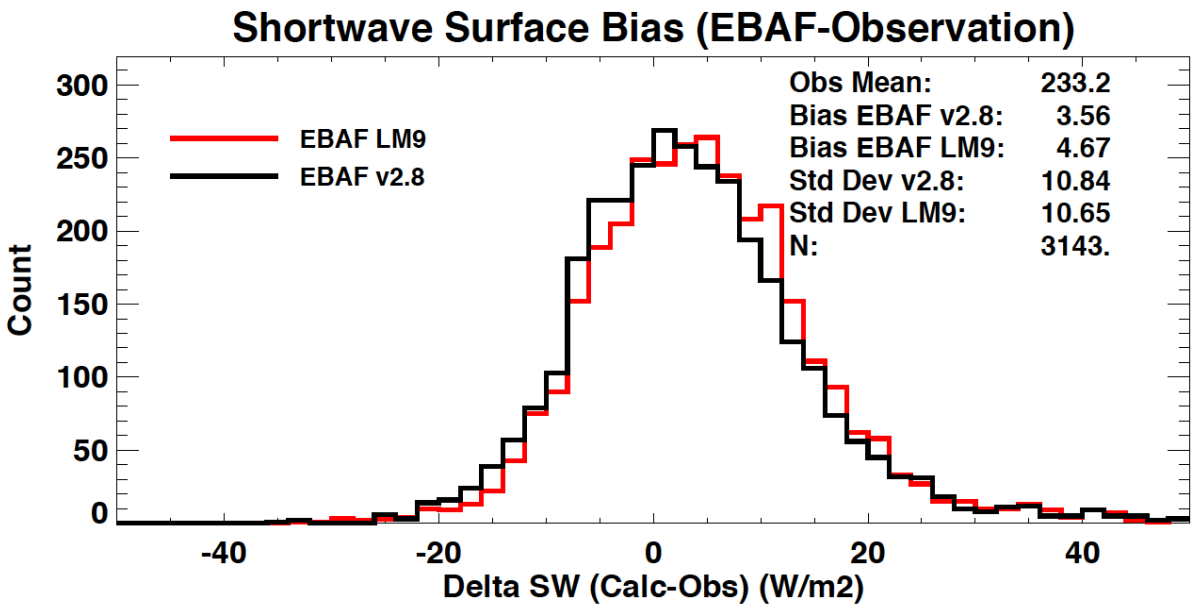
= (Terra+Aqua-TAGi) / TAGi

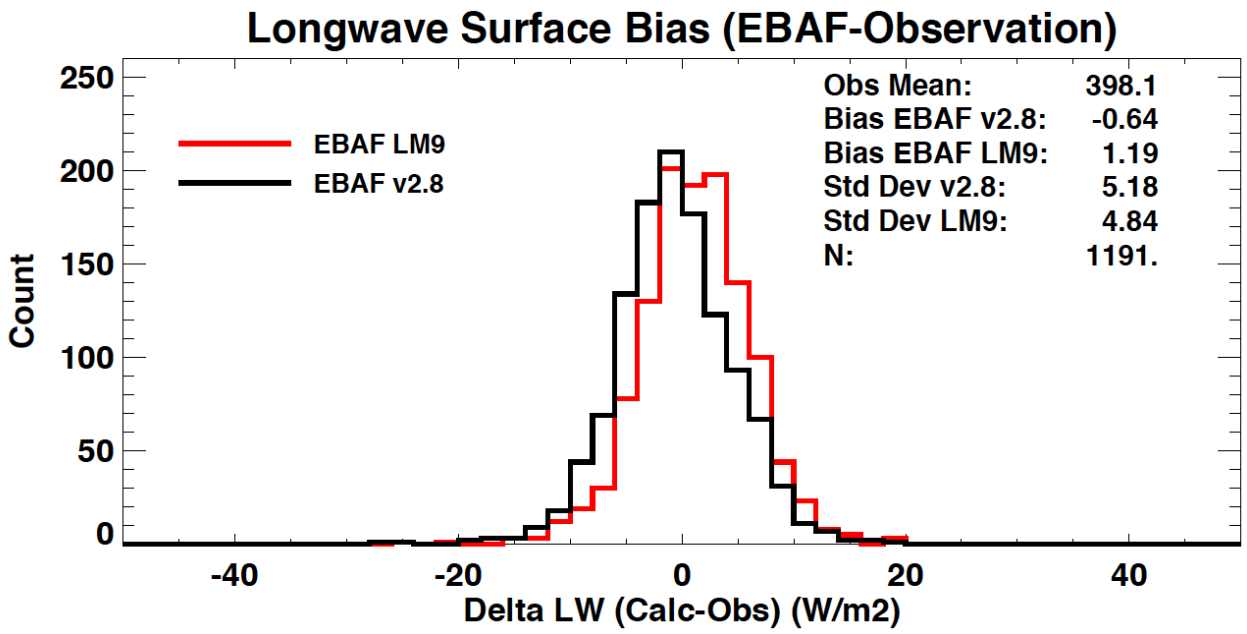
= (CC-Aqua) / TAGi

=(CC-Aqua) / TAGi + (Terra+Aqua-TAGi) / TAGi

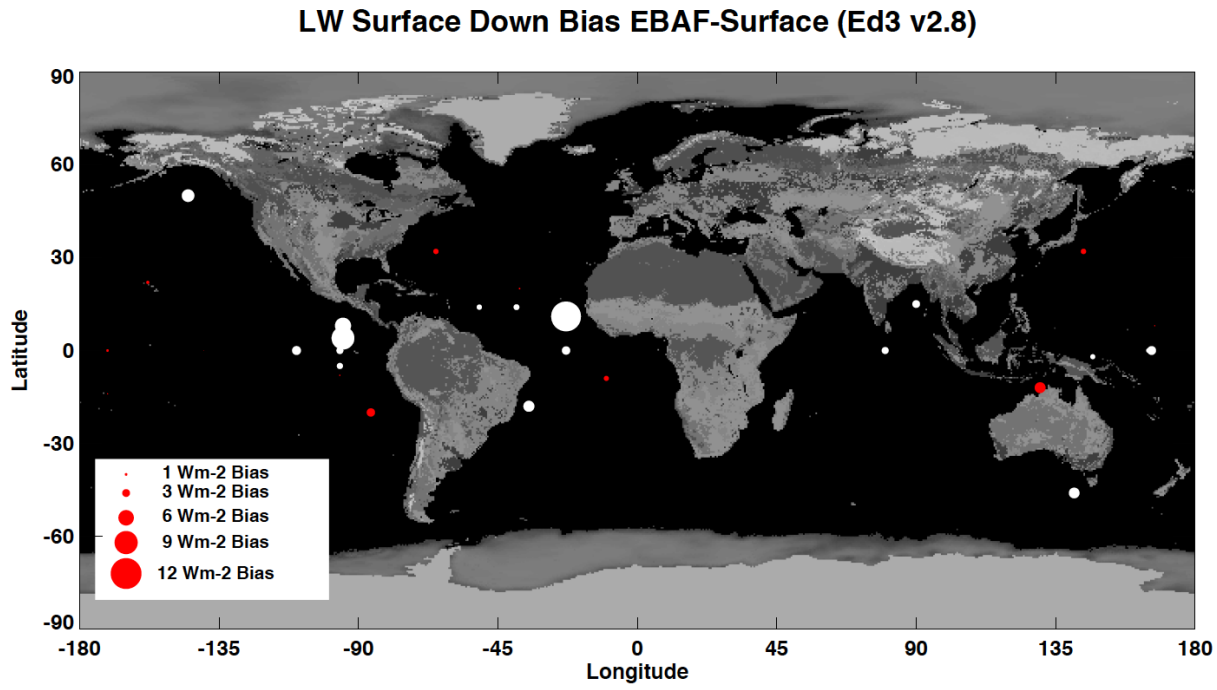
Validation with surface observations

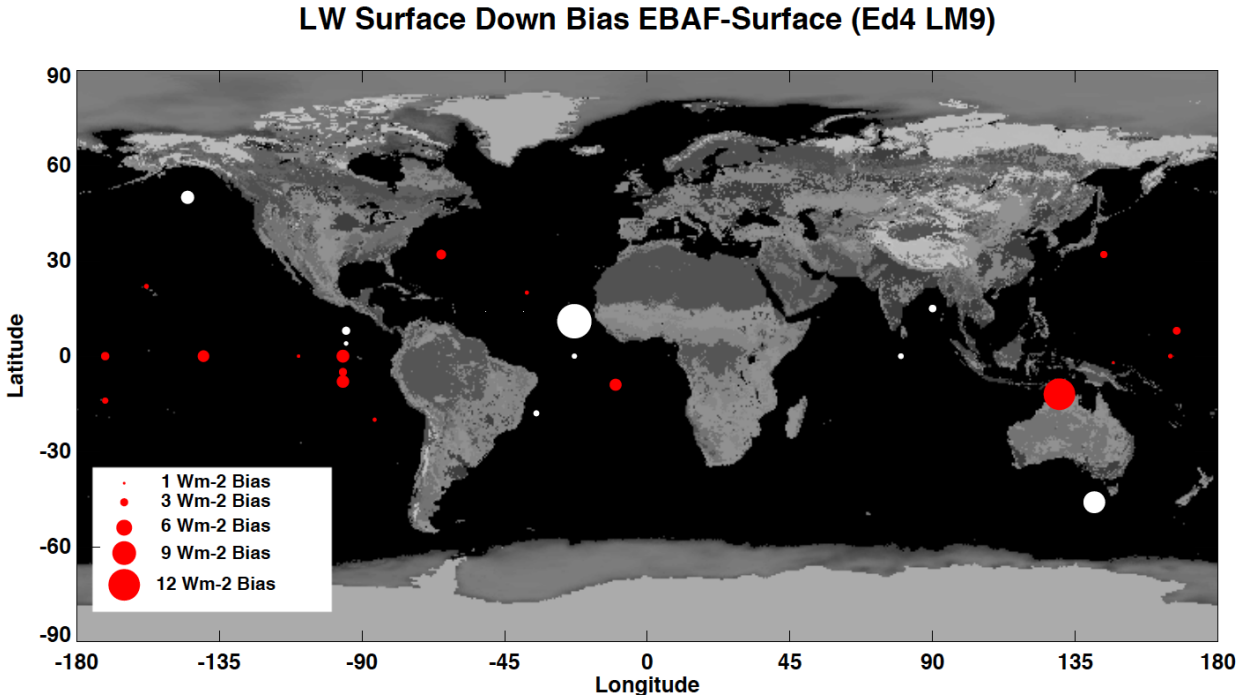
Ocean


Shortwave Surface Bias (EBAF-Observation)
EBAF LM9
EBAF v2.8
Obs Mean: 233.2
Bias EBAF v2.8: 3.56
Bias EBAF LM9: 4.67
Std Dev v2.8: 10.84
Std Dev LM9: 10.65
N: 3143.
Count
Delta SW (Calc-Obs) (W/m2)


Longwave Surface Bias (EBAF-Observation)
EBAF LM9
EBAF v2.8
Obs Mean: 398.1
Bias EBAF v2.8: -0.64
Bias EBAF LM9: 1.19
Std Dev v2.8: 5.18
Std Dev LM9: 4.84
N: 1191.
Count
Delta LW (Calc-Obs) (W/m2)

Downward longwave over ocean

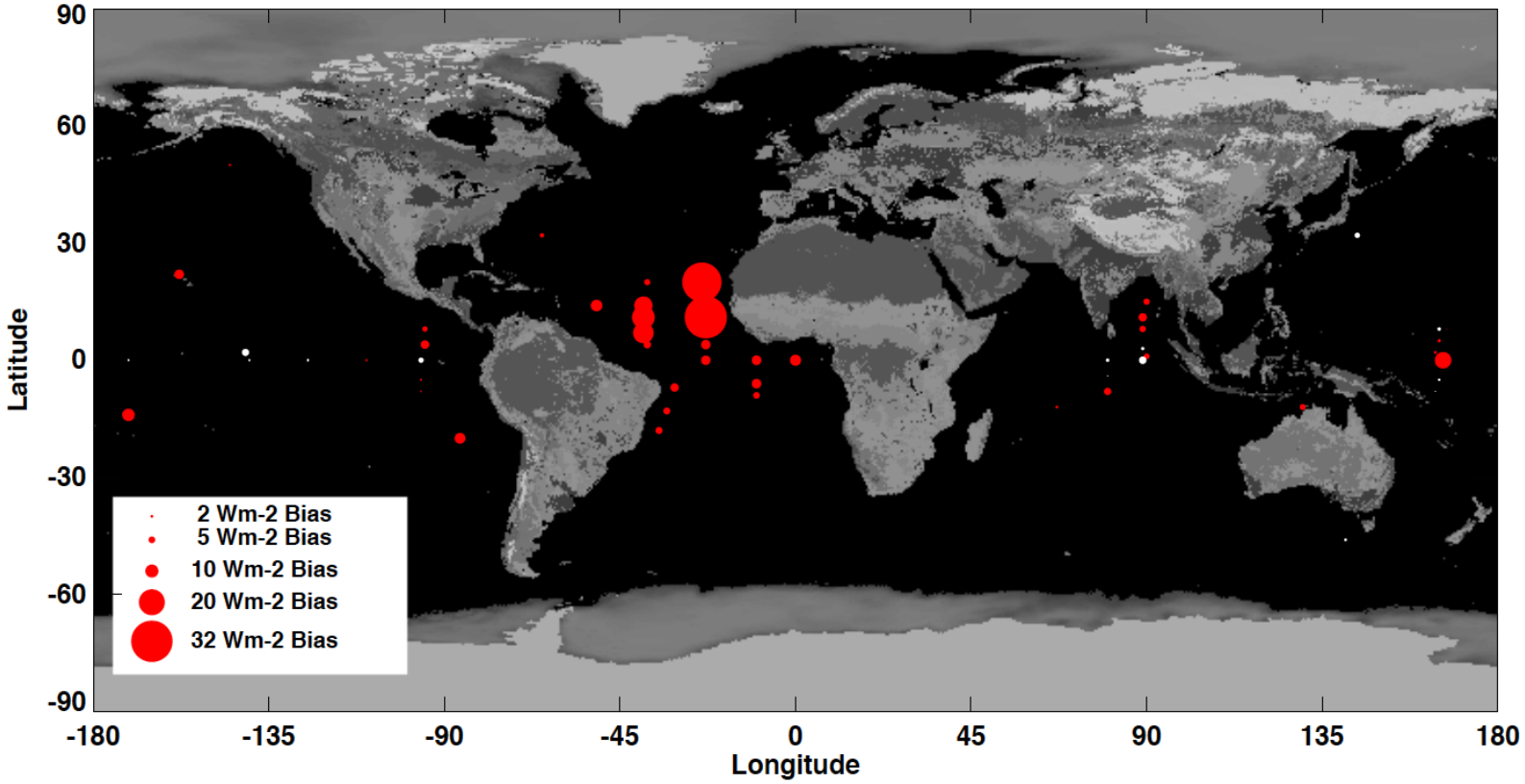


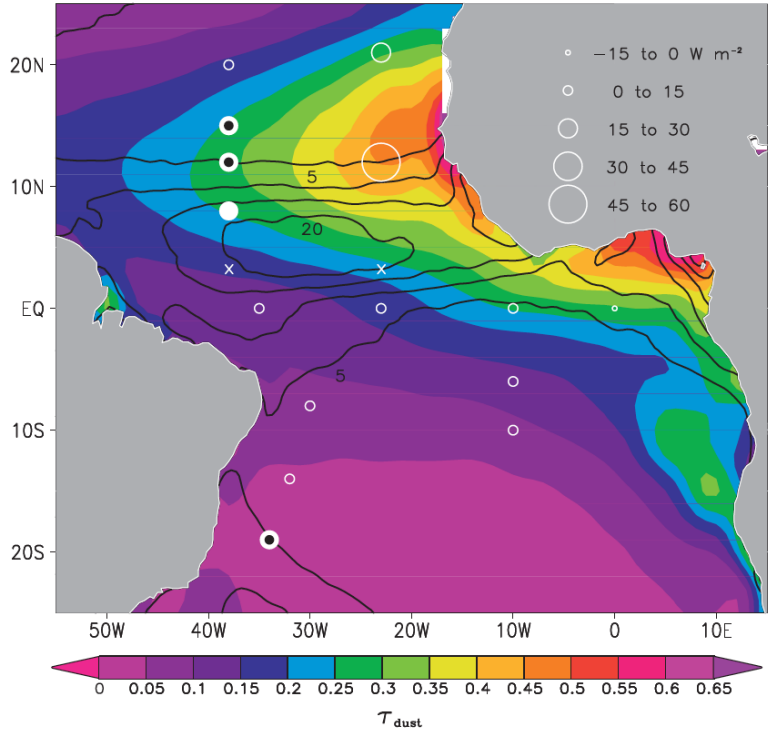


Red -> Positive Bias
White -> Negative Bias

GEO algorithms are changed from 2ch to 5ch over the Eastern Pacific for 2000 through 2016

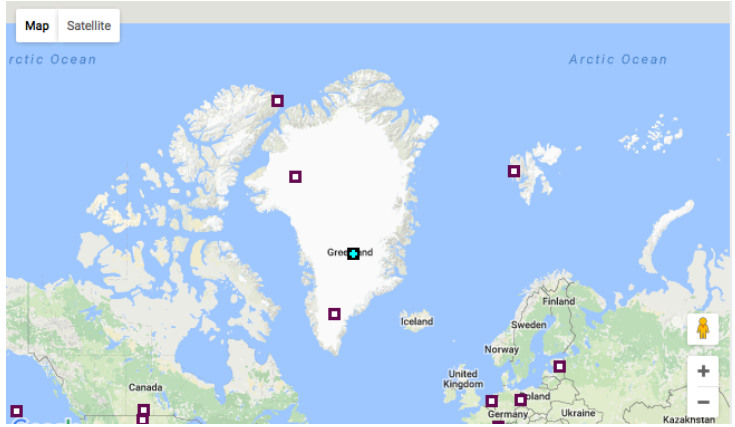
Spatial distribution of SW down bias



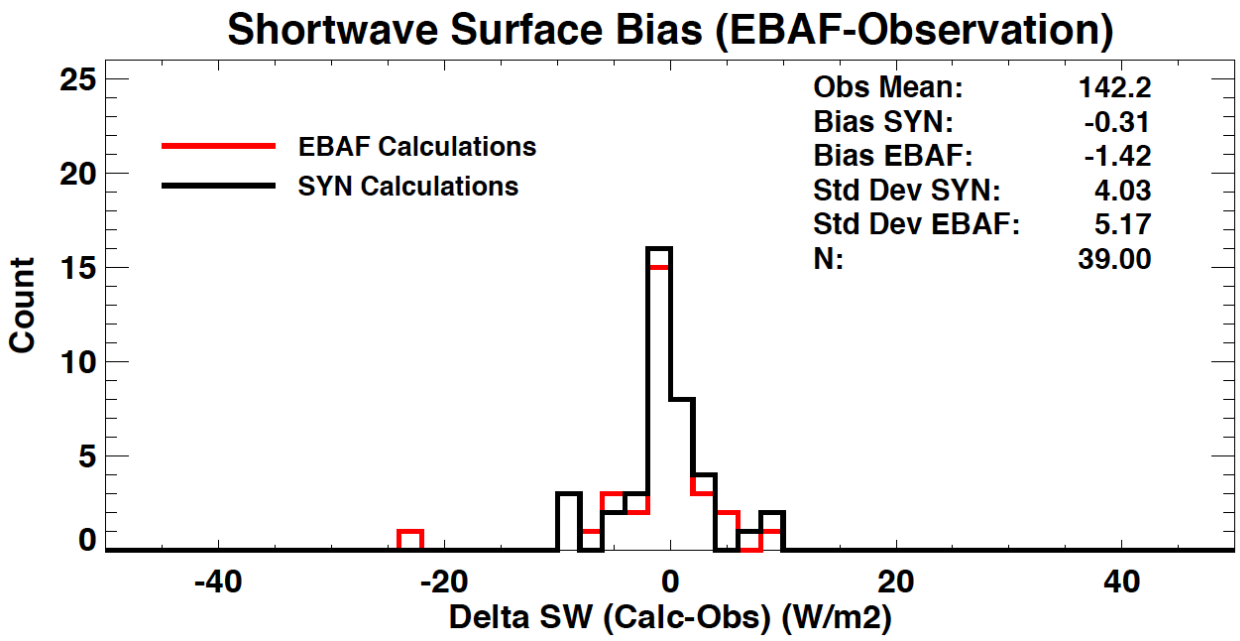


Color: annual mean aerosol optical depth
Contour: precipitation cm month^{-1}
Open circles: dust accumulation bias index
Foltz et al. 2013

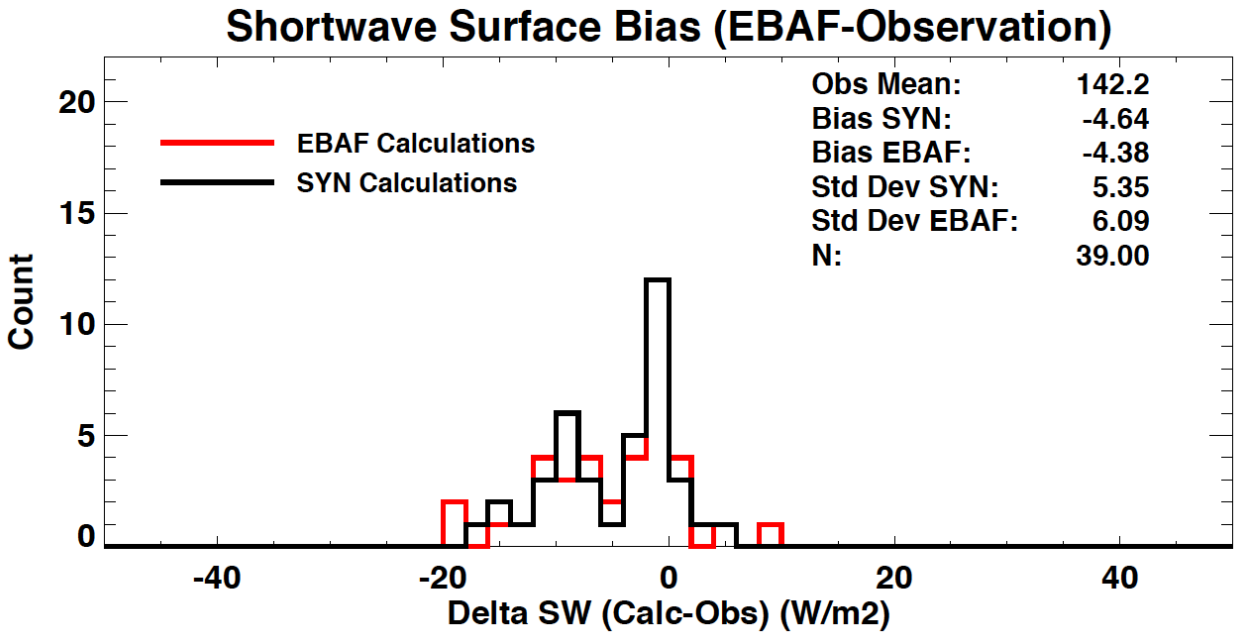
Greenland Summit site (shortwave)



Edition 2.8

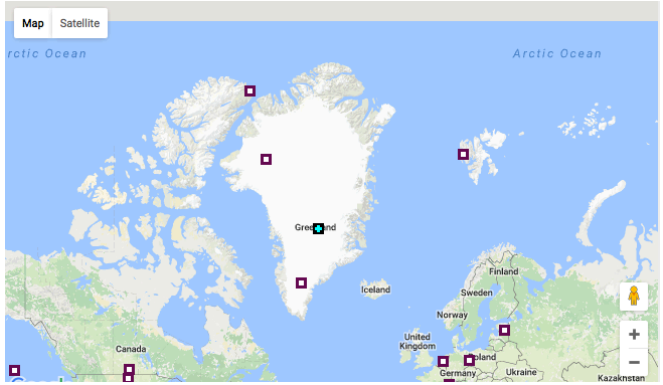


Edition 4

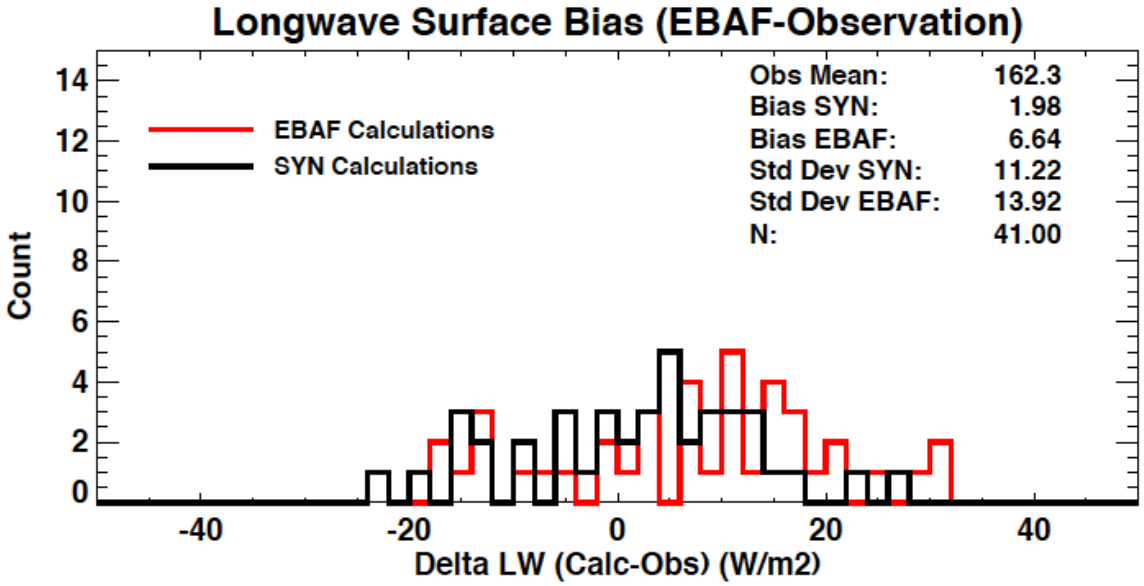


Smaller shortwave irradiances compared with observatons

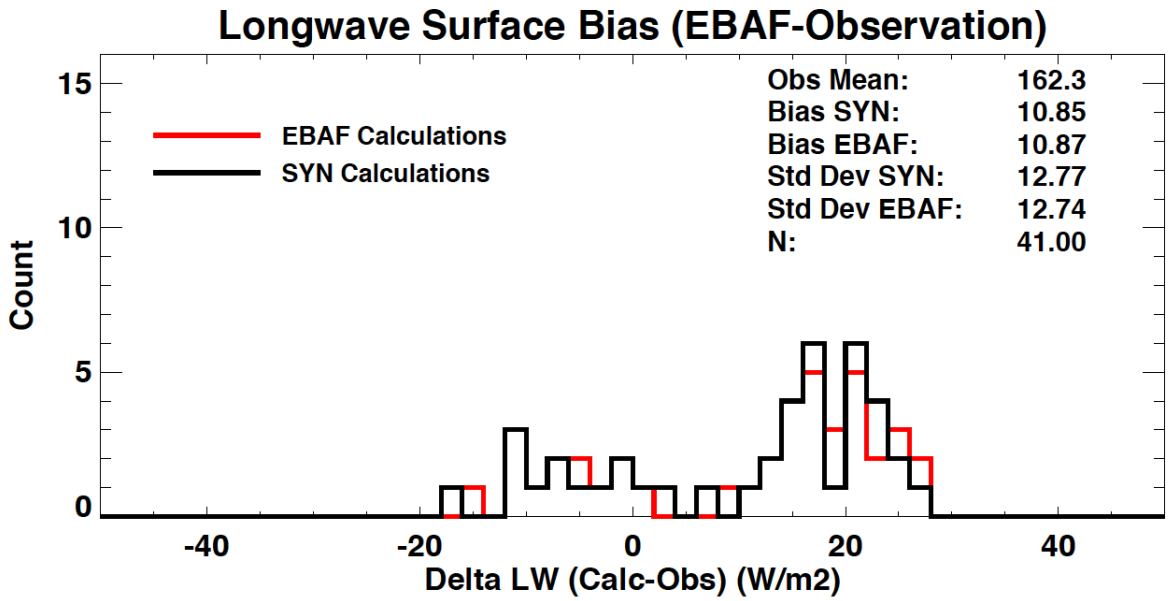
Greenland problem



Edition 2.8

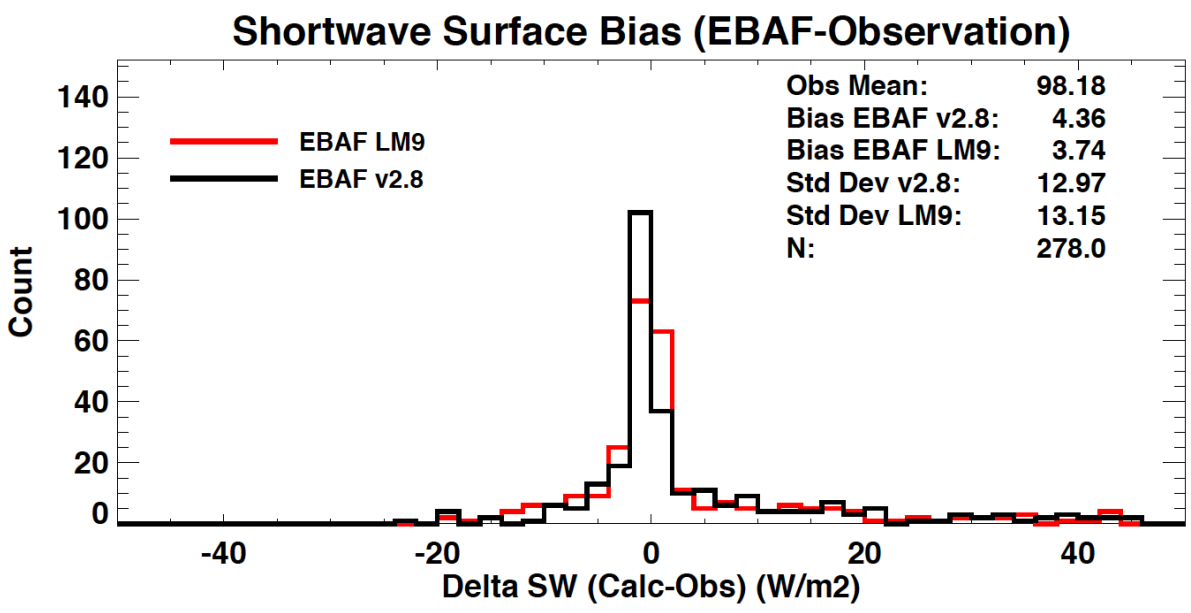


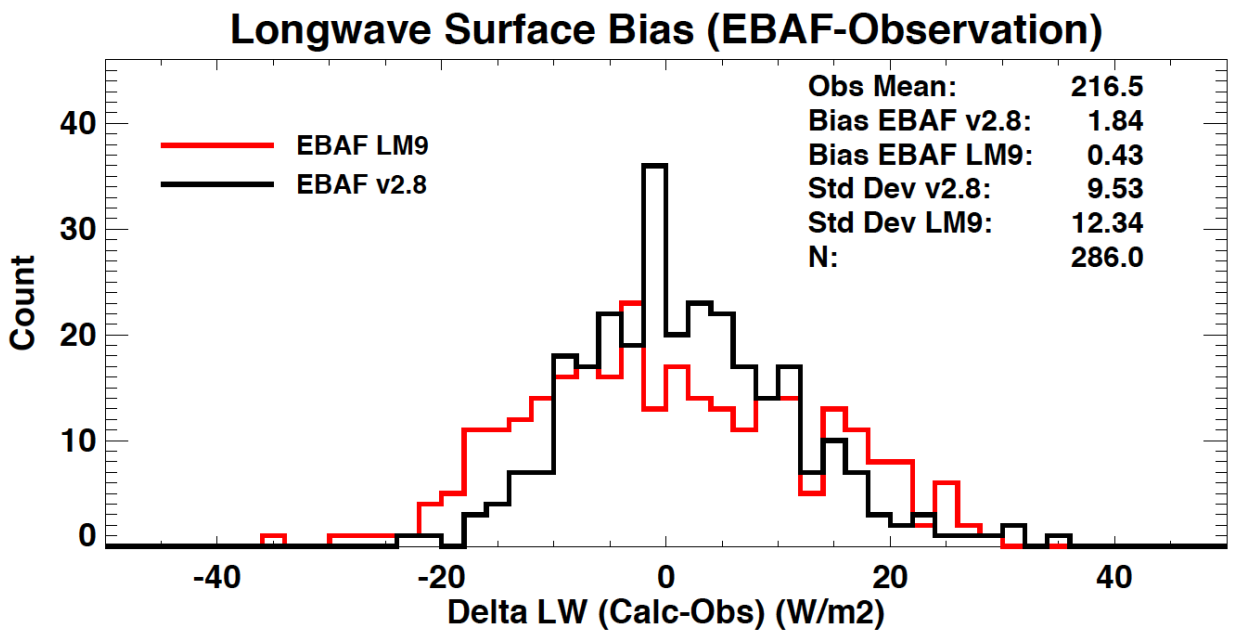
Edition 4



This is primarily due to a positive bias of cloud fraction over high elevation regions. Low-mid and high-mid cloud fraction is biased high over the Summit site except for summer time.

Large cloud fraction problem is probably limited over high elevation polar regions





Uncertainty estimate

- Regional (1 deg by 1 deg) monthly mean
  - RMS difference between computed and observed surface irradiances
  - Sum of all uncertainties considered in adjustment processes (bias correction and Lagrange multiplier)

Uncertainties used in adjustment process

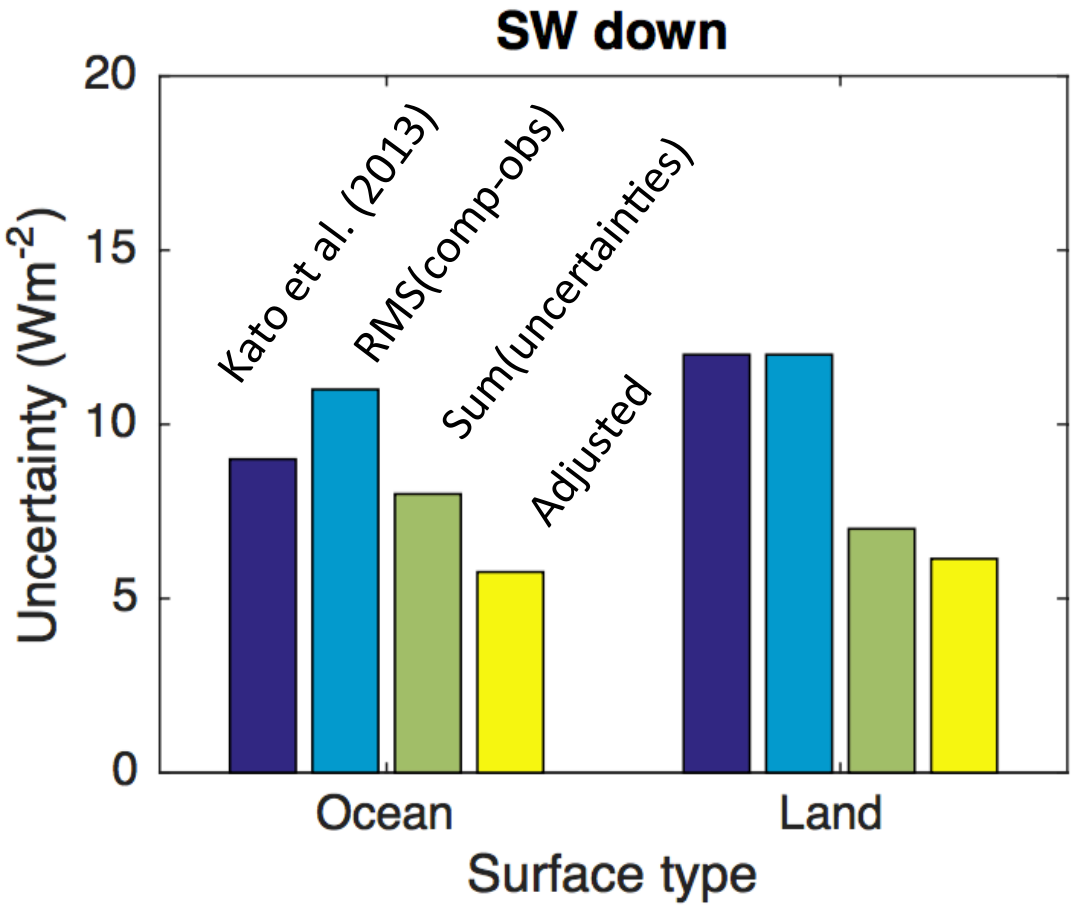
Table 3: All-sky and clear-sky 1σ uncertainty of surface, atmospheric, and cloud properties for 1°×1° monthly flux

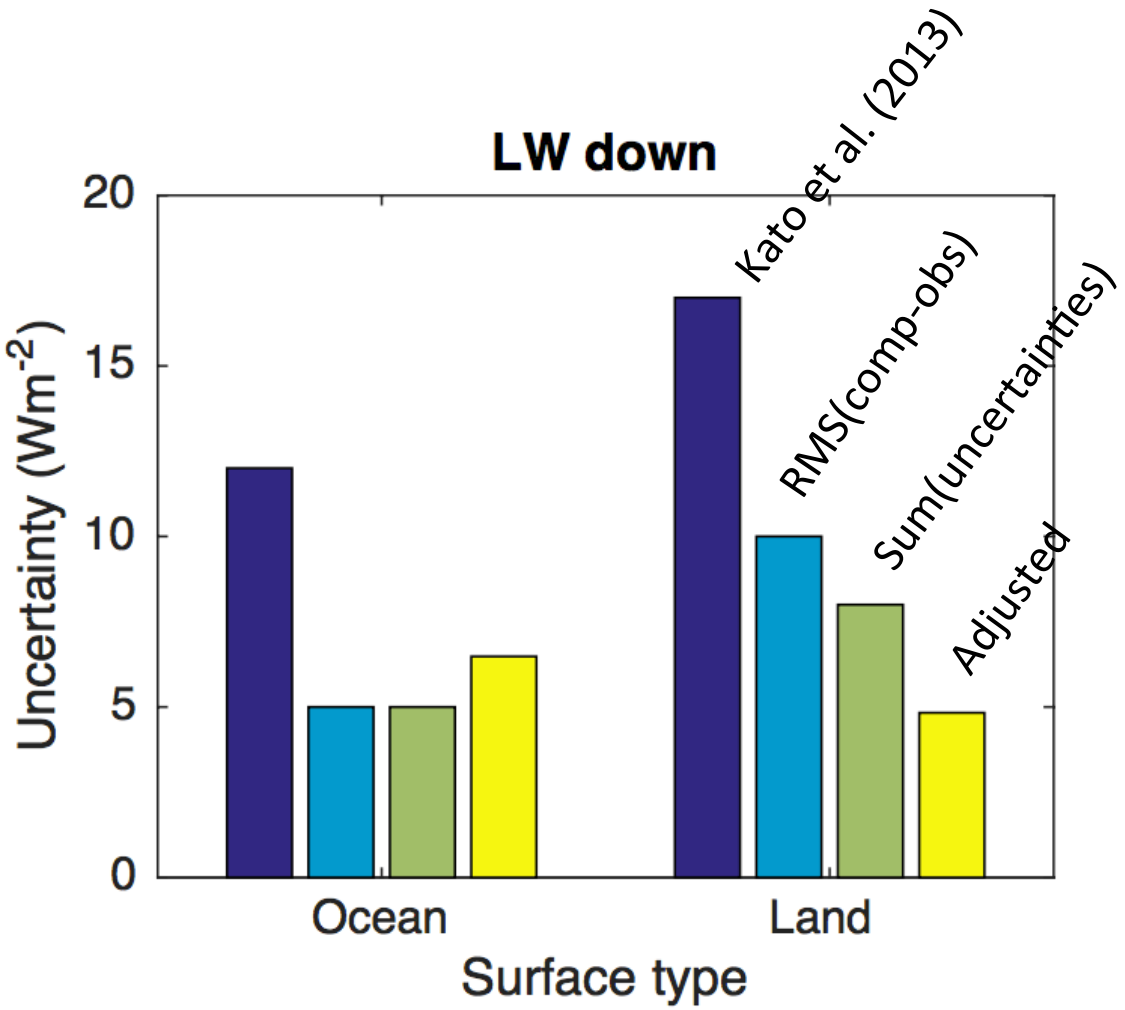
Variable	Uncertainty (1σ)
Skin temperature[1]	Monthly 1°×1° AIRS – GEOS-5.4.1 absolute difference
Surface air temperature[1]	Monthly 1°×1° AIRS – GEOS-5.4.1 absolute difference
Upper tropospheric relative humidity[1]	Monthly 1°×1° AIRS – GEOS-5.4.1 absolute difference
Precipitable water[1]	Monthly 1°×1° AIRS – GEOS-5.4.1 absolute difference
Aerosol optical thickness (relative)	Ocean: 15%, Land: 10%, Cryosphere: 10%
Surface albedo (relative)	Ocean: 1%, Land: 4%, Cryosphere: 8%
Cloud fraction (absolute)	0.05
Cloud optical thickness (relative)	15%
Cloud top pressure (hPa)	10
Cloud base pressure (hPa)	10

[1] Uncertainty value varies depending on month and 1°×1° region

Additional uncertainties come from surface shortwave and longwave irradiances from bias correction processes

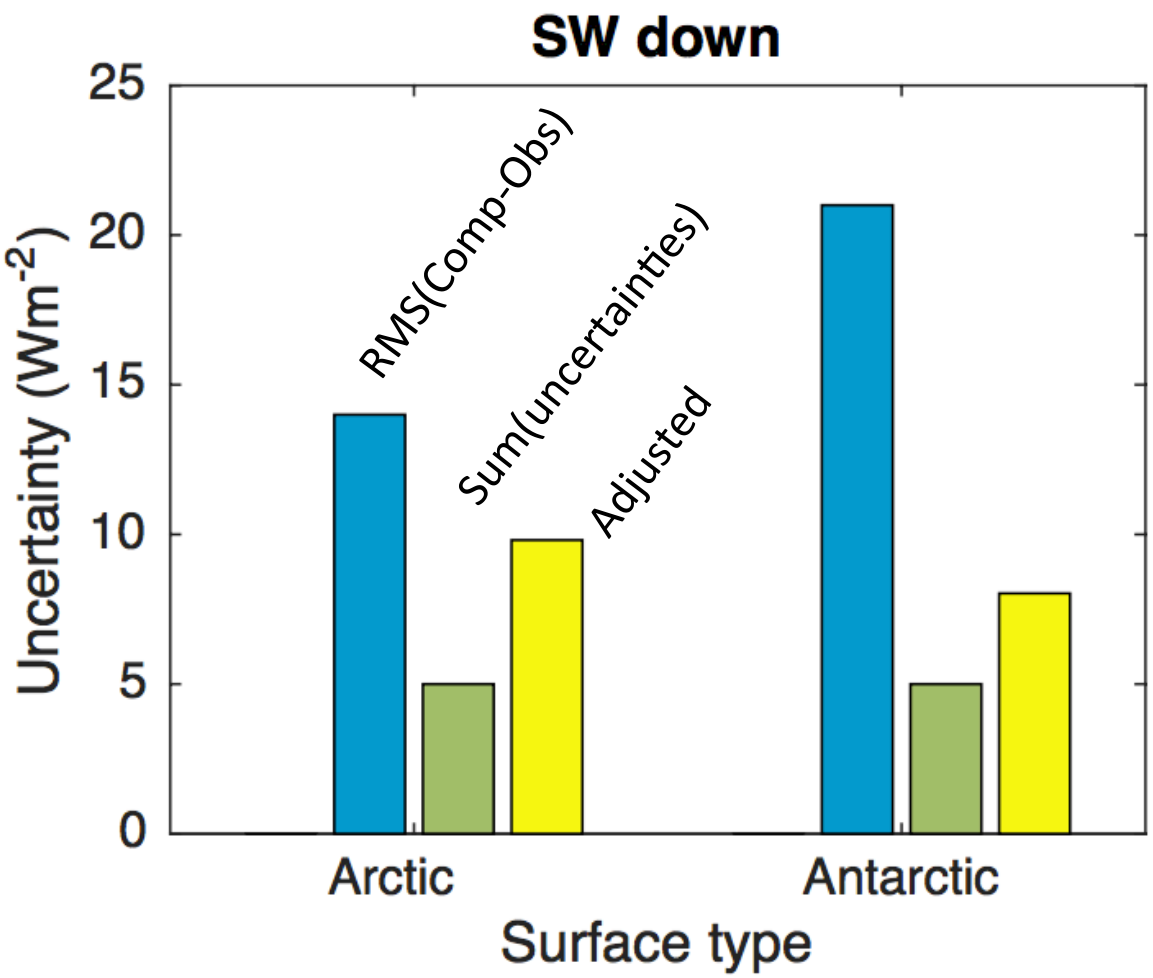
Uncertainties in regional (1deg by 1deg) monthly mean

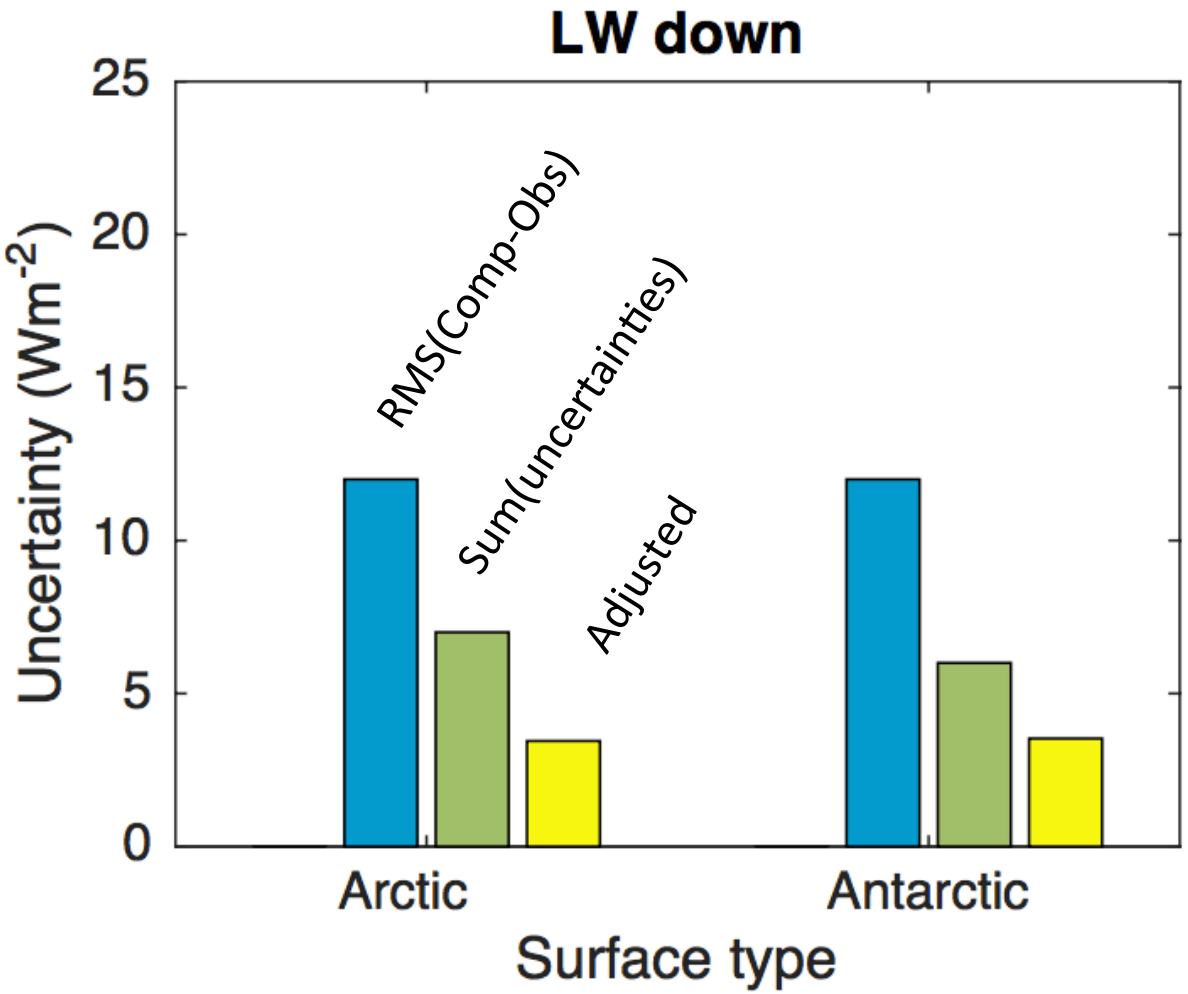




Use RMS difference as uncertainties

Uncertainties in regional (1deg by 1deg) monthly mean





Use the RMS differences as uncertainties

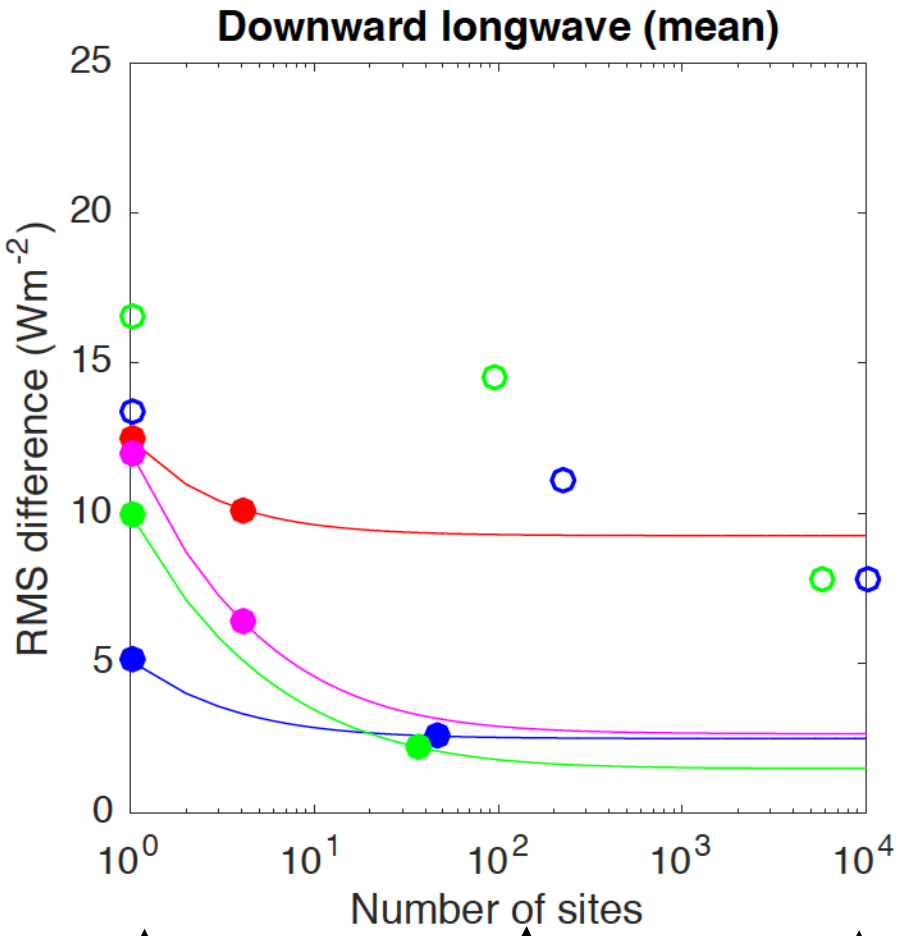
Uncertainty in regional (1deg by 1deg) monthly mean irradiances

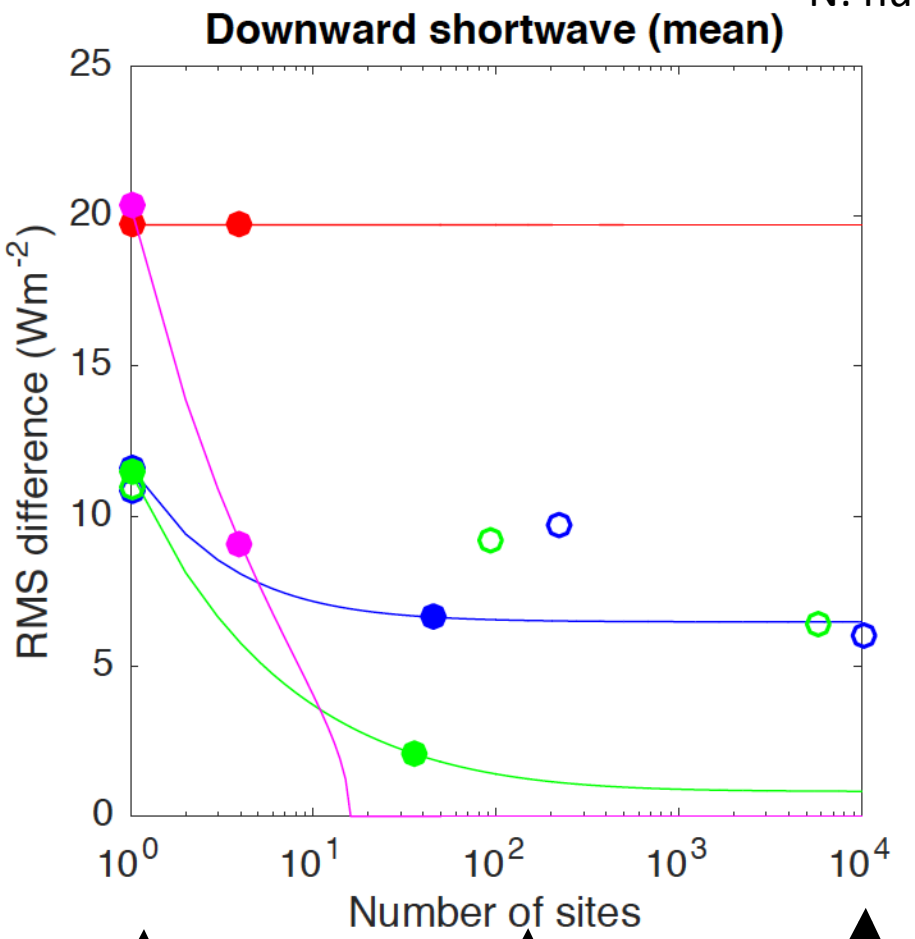
	Shortwave down (Wm^{-2})	Shortwave up (Wm^{-2})	Longwave down (Wm^{-2})	Longwave up (Wm^{-2})
Ocean	11	1	5	5
Land	12	4	10	18
Arctic	14	6	12	12
Antarctic	21	24	12	13

Uncertainty estimate with surface observations

Assumption:
$RMS^2 = bias^2 + random^2/N$

N: number of surface sites





Blue: Ocean
Green: Land
Red: Arctic
Magenta: Antarctic

Closed circles are estimated from EBAF-observation differences

Open circles are from Kato et al. (2013)

1deg by 1deg Monthly | Zonal Monthly | Global Monthly

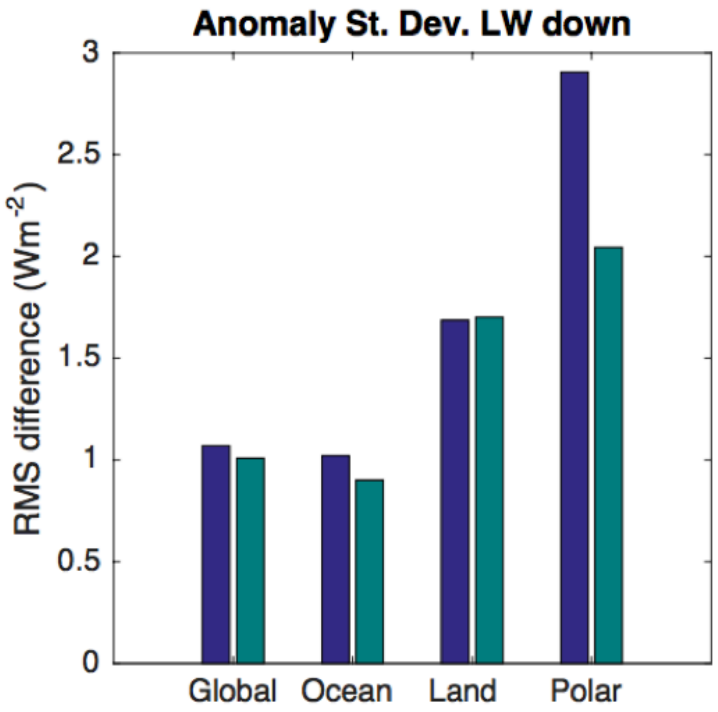
1deg by 1deg Monthly | Zonal Monthly | Global Monthly

Standard deviation of deseasonalized monthly anomalies averaged over different surface types

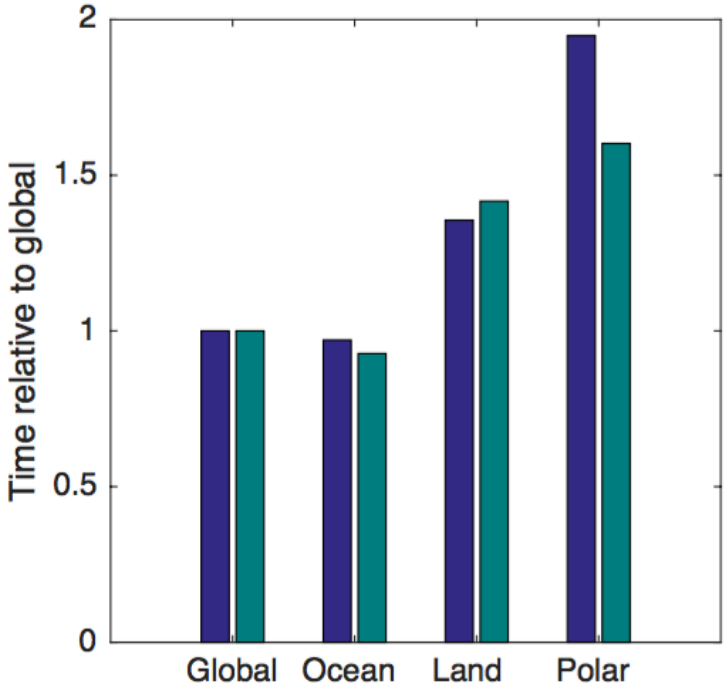
	Global	Ocean	Land	Polar
All-sky				
SW down	0.78 (0.42)	1.00 (0.53)	1.35 (0.69)	1.83 (1.54)
SW up	0.29 (1.21)	0.22 (1.79)	0.54 (1.46)	2.20 (2.56)
LW down	1.07 (0.31)	1.02 (0.28)	1.69 (0.51)	2.91 (1.58)
LW up	0.78 (0.20)	0.66 (0.16)	1.45 (0.37)	2.68 (1.22)
Clear-sky				
SW down	0.50 (0.21)	0.55 (0.22)	0.80 (0.32)	1.07 (0.74)
SW up	0.34 (1.12)	0.26 (1.51)	0.68 (1.47)	2.37 (2.38)
LW down	1.01 (0.32)	0.90 (0.27)	1.70 (0.55)	2.05 (1.43)
LW up	0.78 (0.20)	0.68 (0.16)	1.44 (0.36)	2.70 (1.24)

Consequence to the trend detection

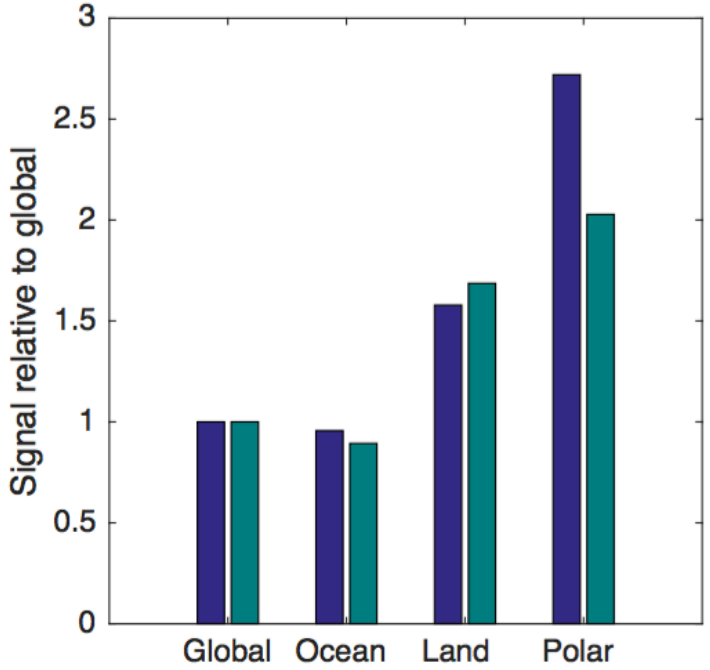
All-sky
Clear-sky



Time to detect trend if the trend is the same as the global trend

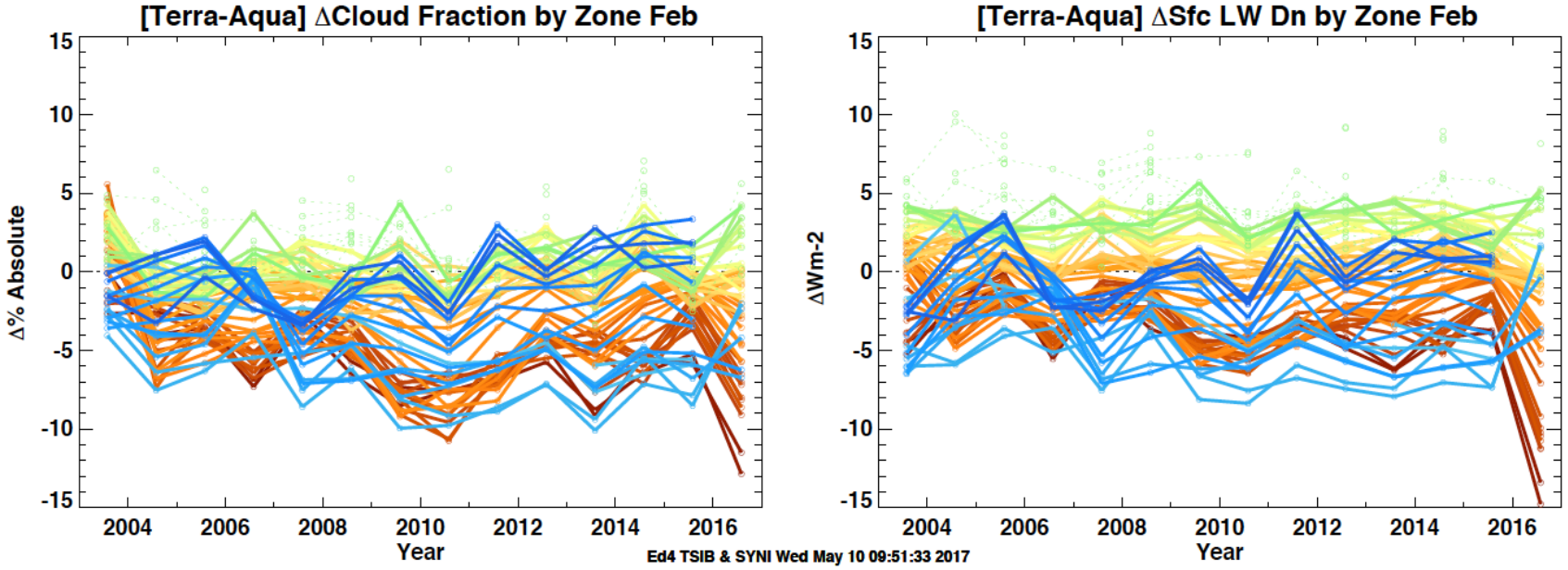


Size of the trend relative to the global trend to have the same time to detect the trend

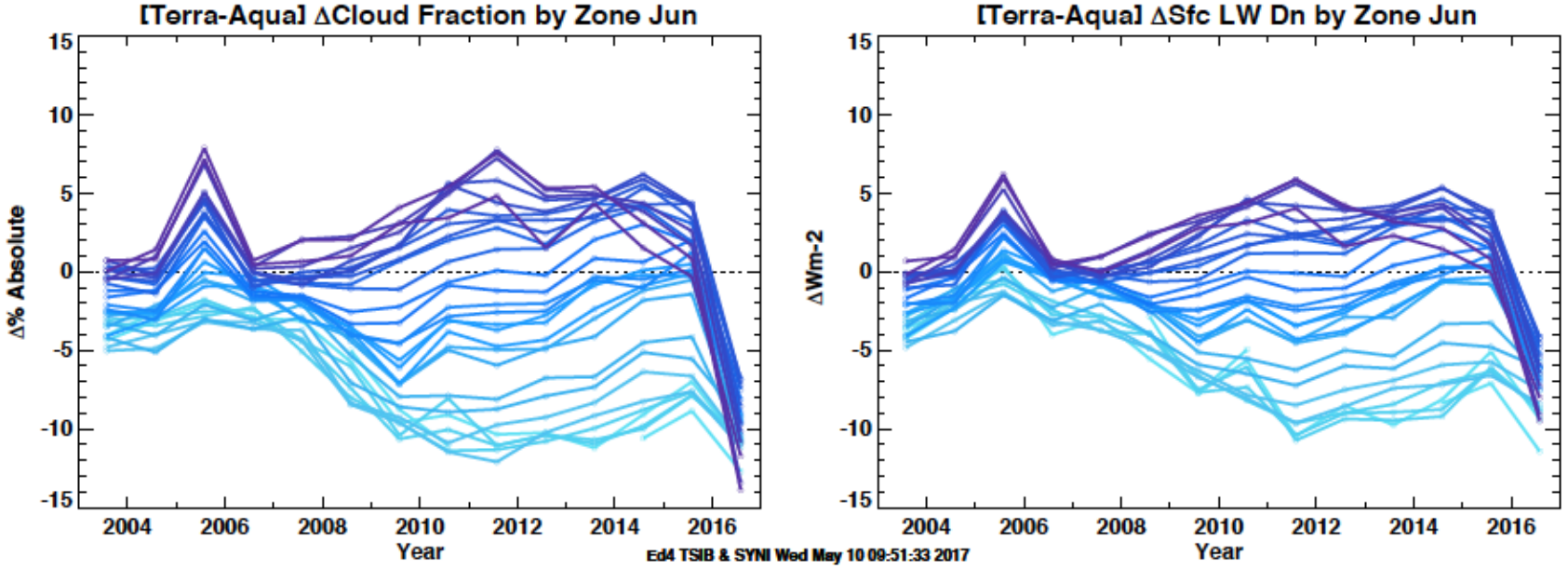


Polar night cloud fraction problem

February



June

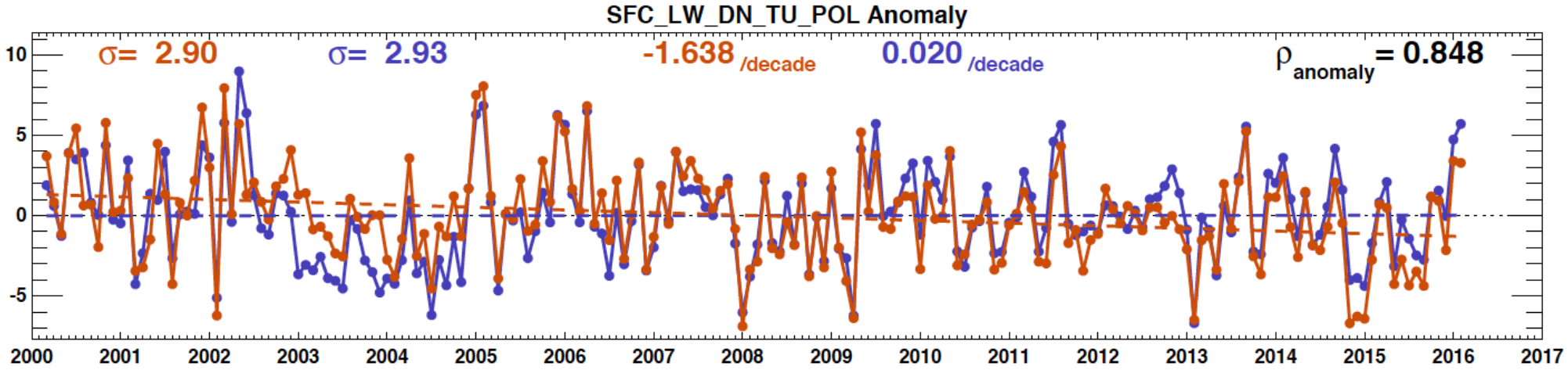


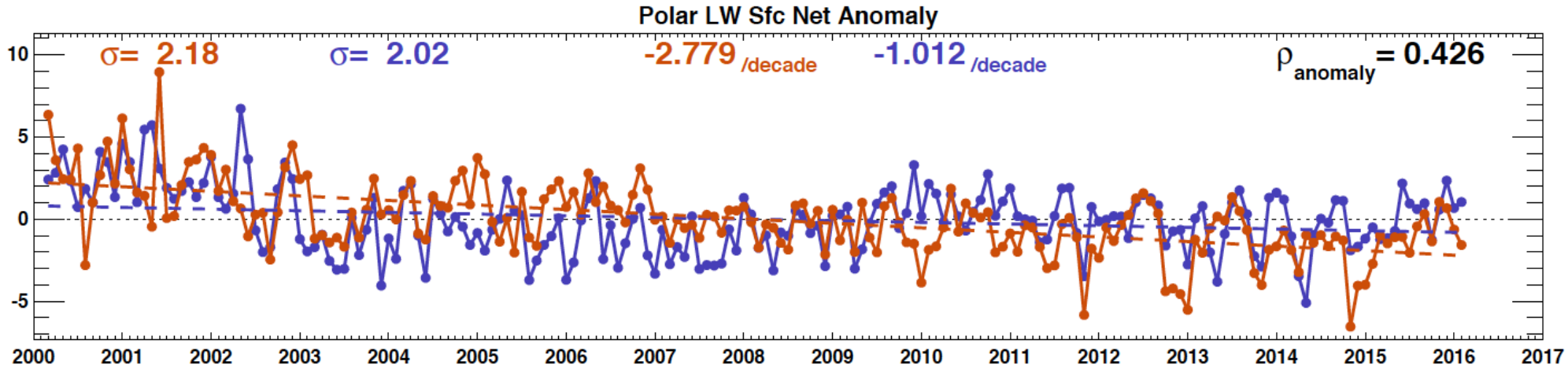
Latitude

90
85
80
75
70
65
60
55

-55
-60
-65
-70
-75
-80
-85
-90

But trend analyses with EBAF-surface are not recommended

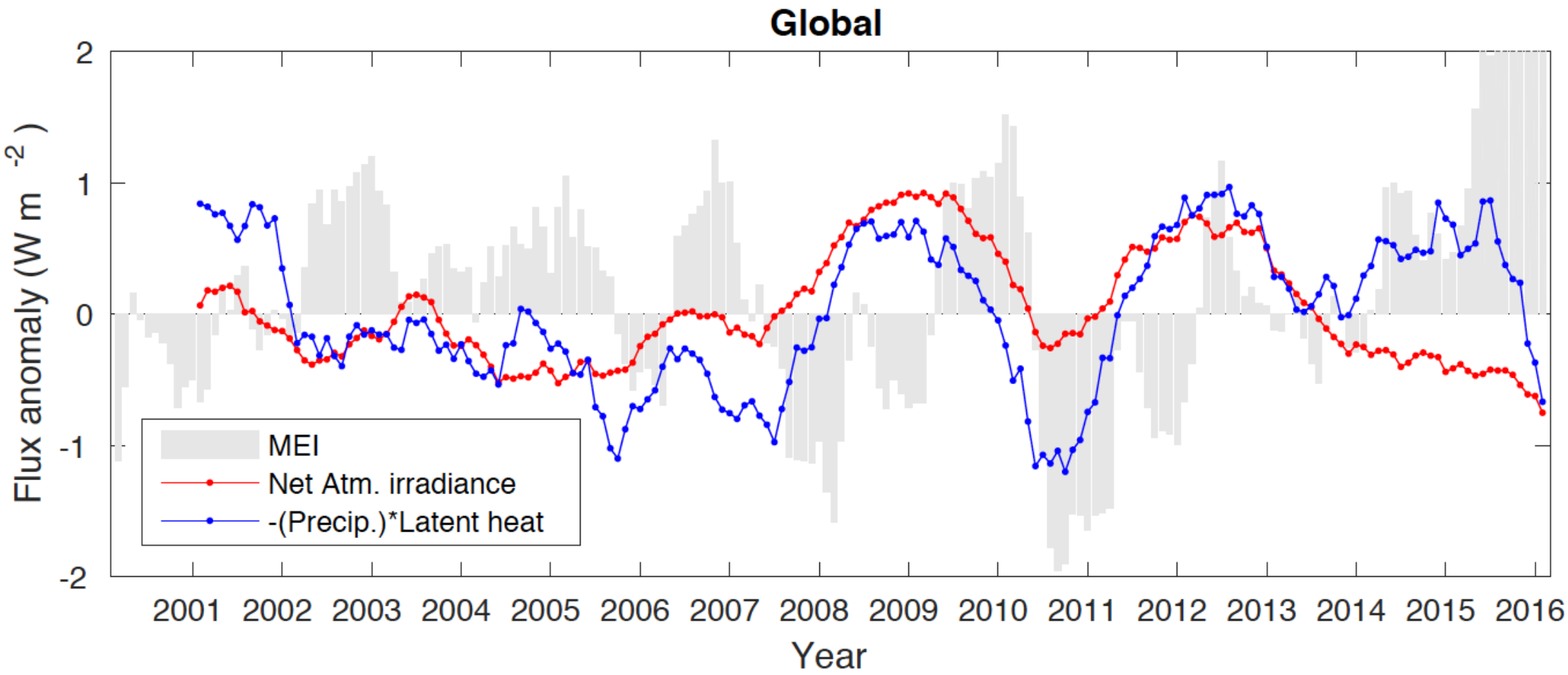




The downward longwave flux has a negative trend that needs to be explained.

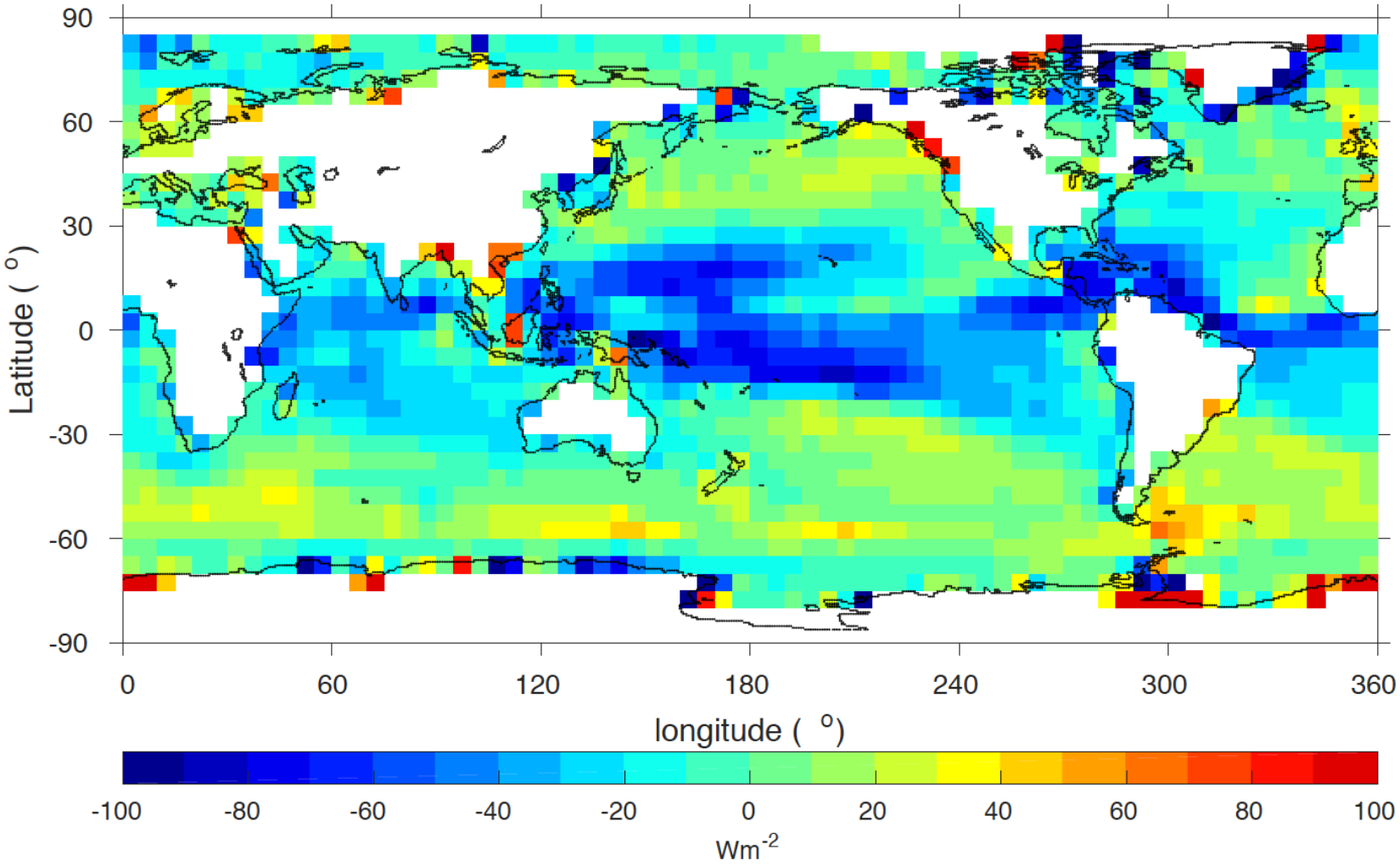
The magnitude of the trend seems to be too large for the trend of near surface temperature of ~0.4 K per decade over the Arctic. (Serreze and Barry 2011)

Atmospheric net irradiance anomalies



Atmospheric net = TOA net EBAF-TOA Ed4 – Surface net EBAF-surface LM9
Precipitation: GPCP V2.3

Residual in balancing Atmospheric energy budget (From March 2000 though Feb. 2010)



EBAF-TOA Ed4
EBAF-surface LM9
GPCP v2.3
ERA-Interim
SeaFlux

Summary

- Ed4 improvements from Ed2.8
  - Discontinuity caused by GEOS-4.1 to GEOS-5.2 is eliminated.
  - Discontinuity caused by MODIS collection 4 to 5 is eliminated.
  - Nighttime cloud properties and surface longwave irradiances are improved.
- Trend analyses of surface irradiances over polar regions are not recommended because of potential effects of degradation of Terra MODIS water vapor channel on surface irradiances.
- EBAF-surface data release (from March 2000 through February 2016) ~May 24th 2017 (by the end of this month).
- Data quality summary will be available with the data.