EBAF-surface update

Seiji Kato[1], Fred Rose[2], David Rutan[2],

Tyler Thorsen[1,3], and Xianglei Huang[4]

[1]NASA Langley Research Center

[2]Science System & Applications Inc.

[3]NASA Postdoctoral program

[4]University of Michigan

CERES Science team meeting

October 18-21, 2016

Reading, UK

Outline of this talk

- Ed2.8 EBAF-surface
  - Clear-sky surface irradiance sampling
- Changes from Ed2.8
- Use of AIRS spectral irradiance
- Use of AIRS spectral radiance (confirmation only)
- Water vapor kernel comparisons
- Consistency between atmospheric net radiation, precipitation, and turbulent fluxes anomalies (Ed2.8)
- Anomalies in surface irradiances in 2015

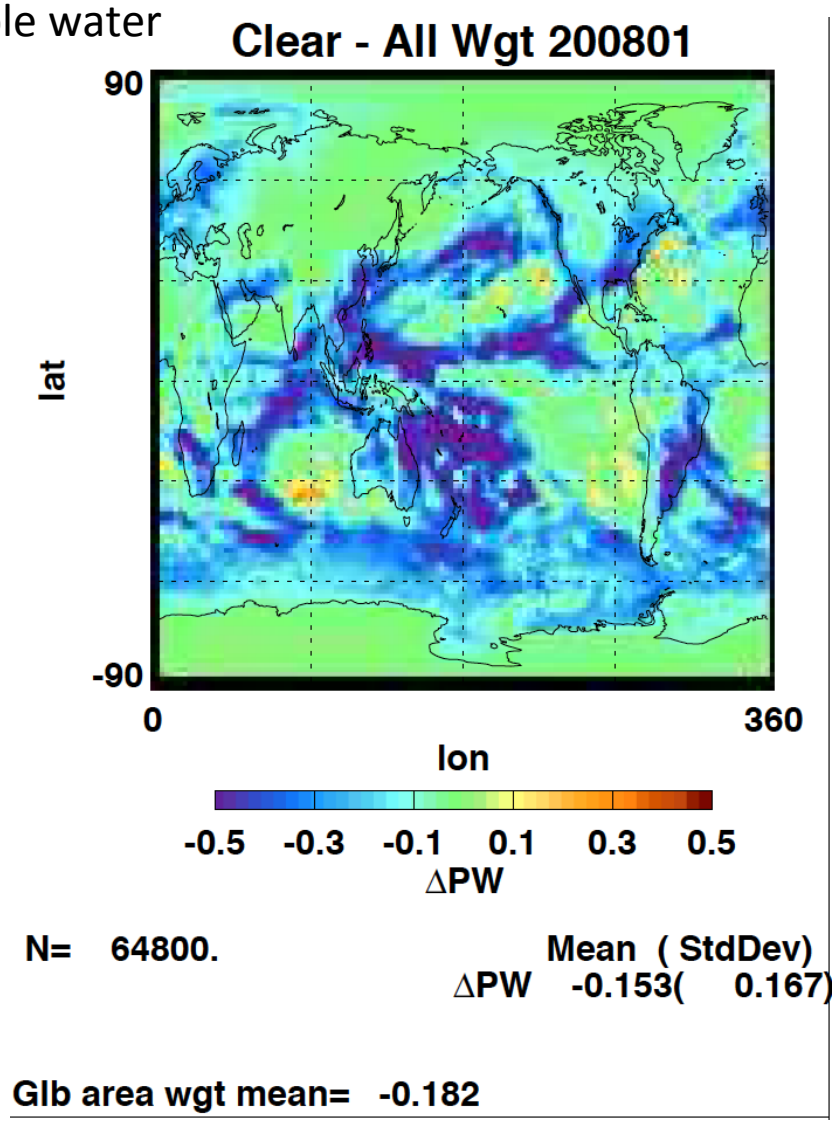
Edition 2.8

Clear-sky issues

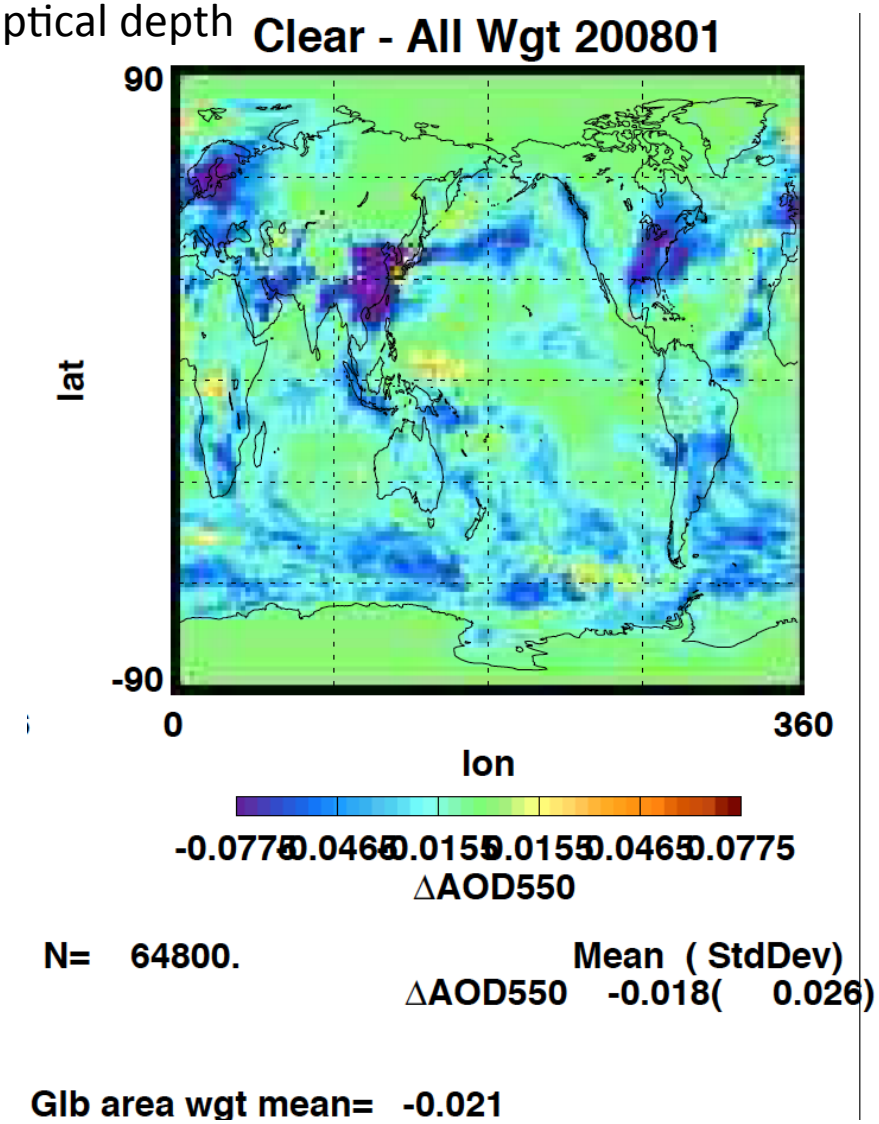
- Testing whether clear-sky conditions are properly represented in GEOS (reanalysis CERES uses)
- EBAF-surface clear-sky sampling is the same as EBAF-TOA clear-sky sampling (clear-sky fraction weight)
- Clear-sky surface irradiances computed by removing clouds are included in SYN1deg (all-sky weight)

Clear-sky versus all-sky sampling

Precipitable water

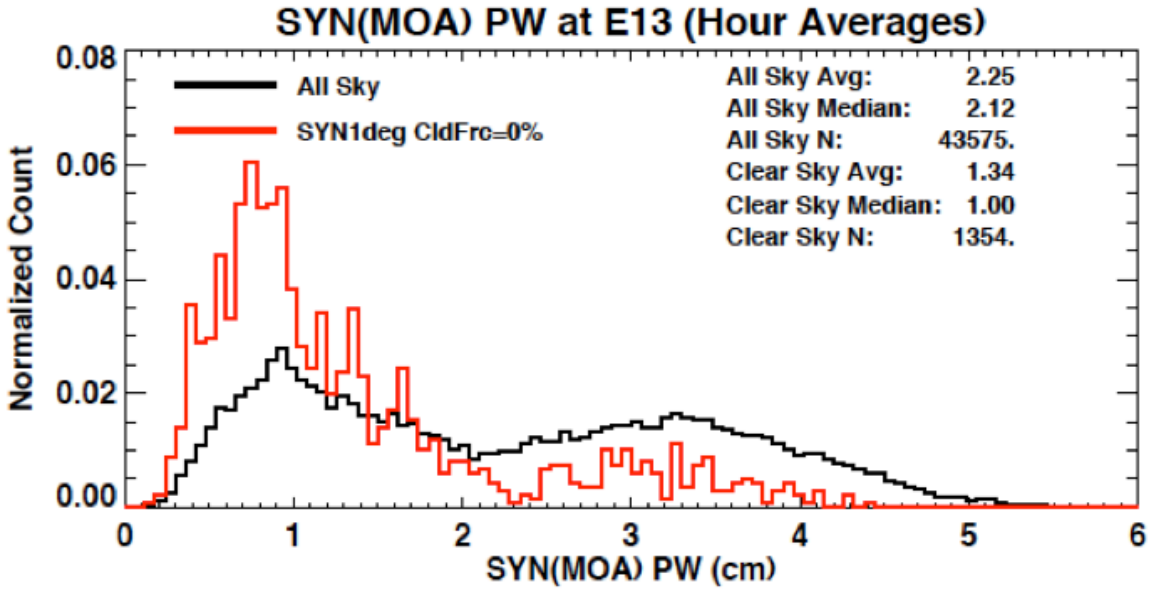


Aerosol optical depth

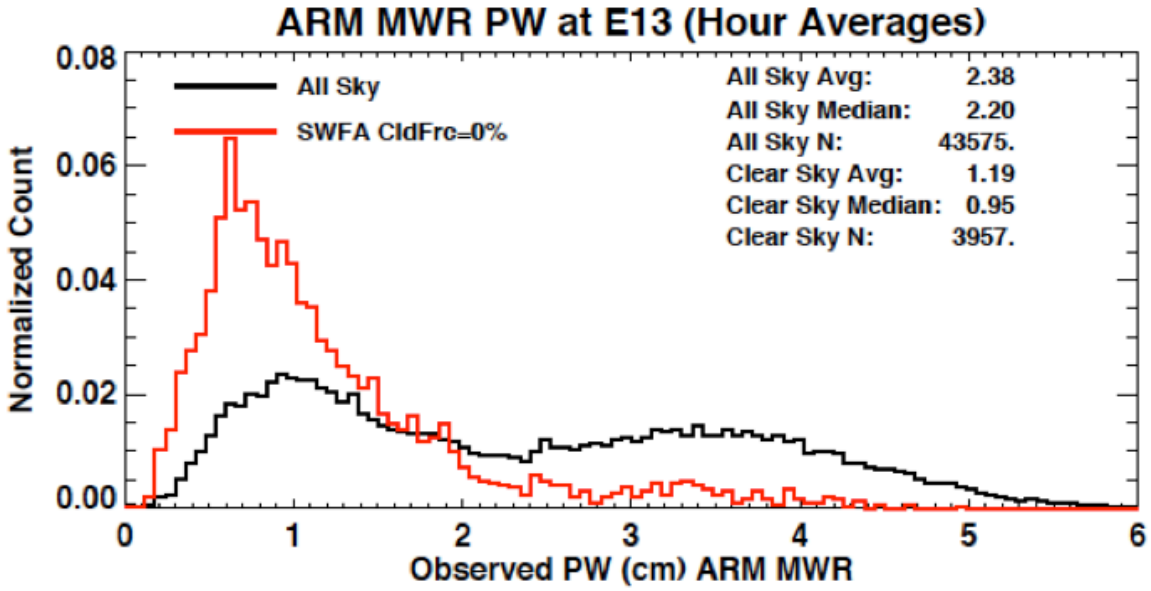


Precipitable water at ARM SGP

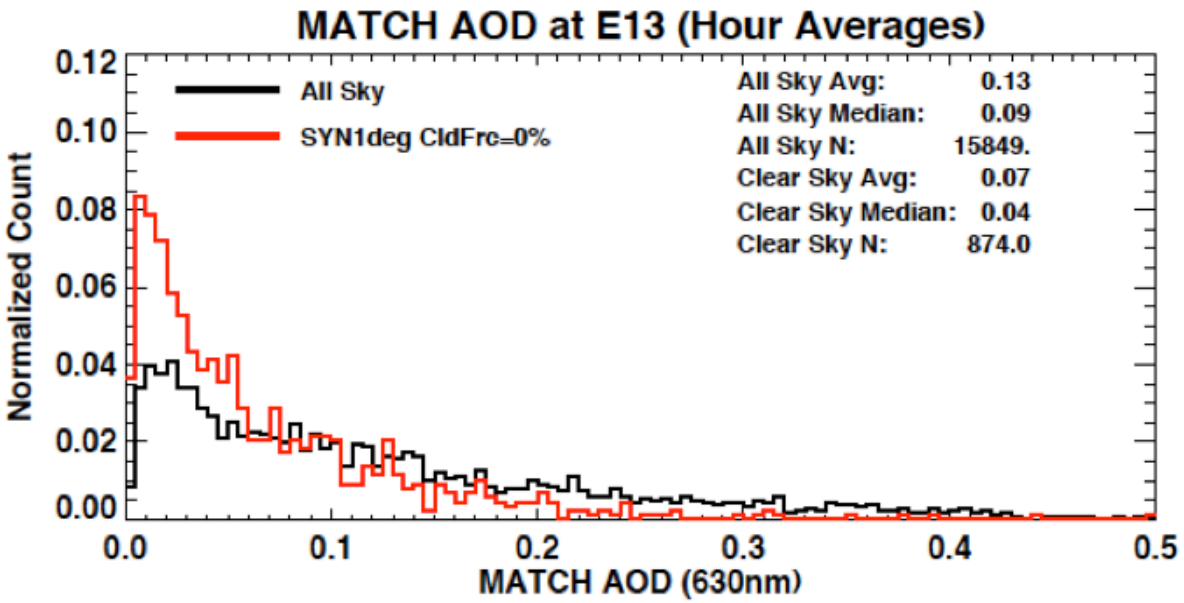
Reanalysis (GEOS)

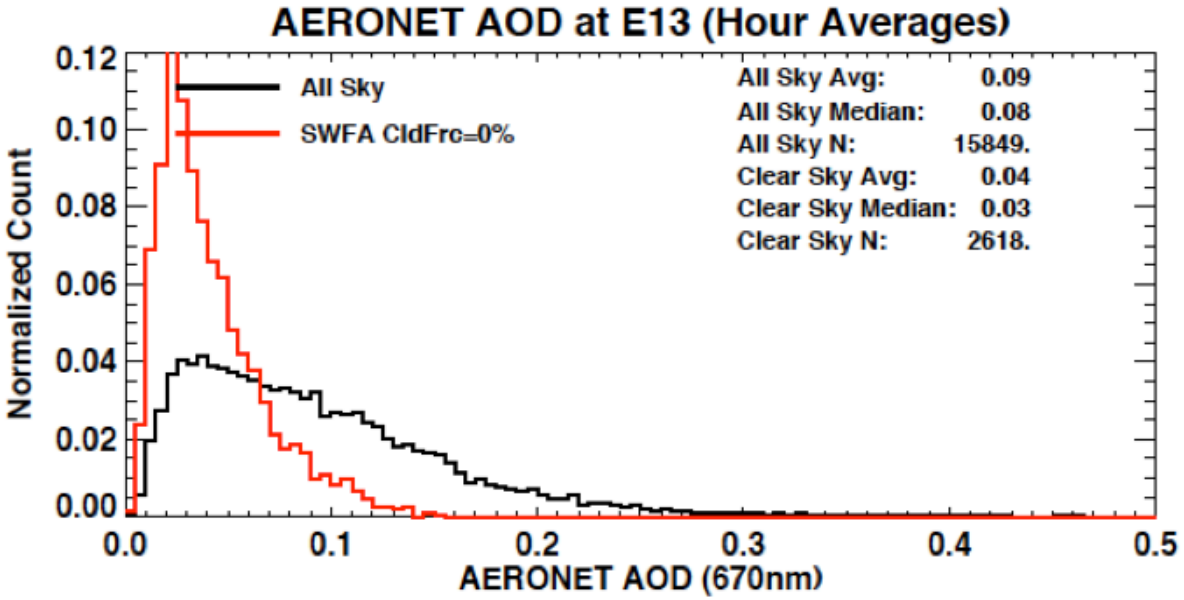


Surface observations (microwave)

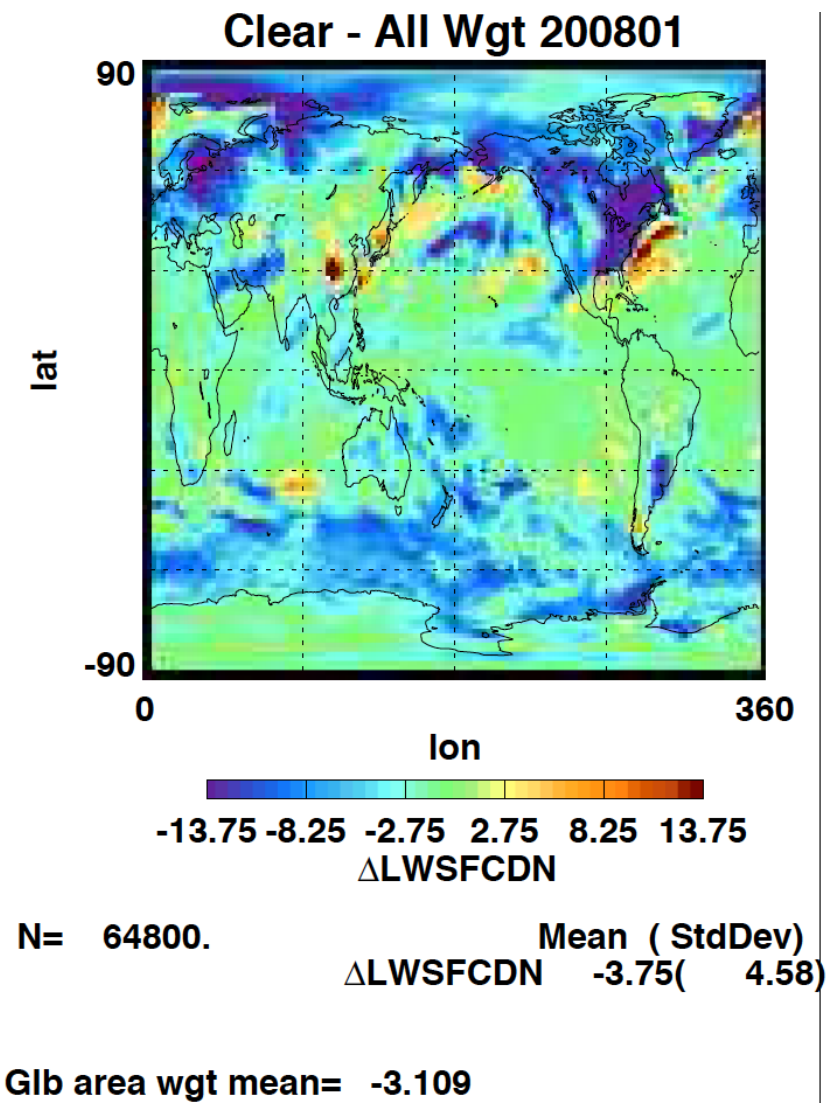


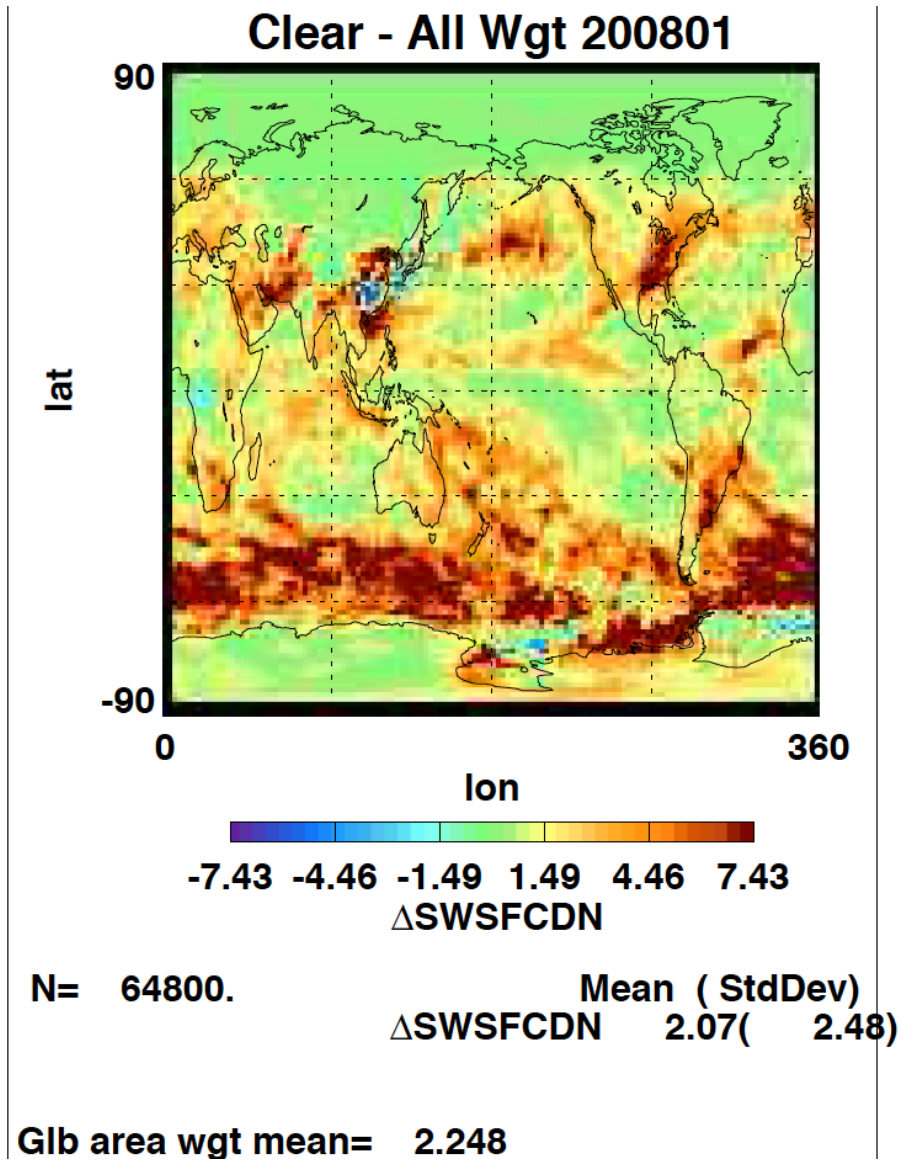
Aerosol optical depth at ARM SGP



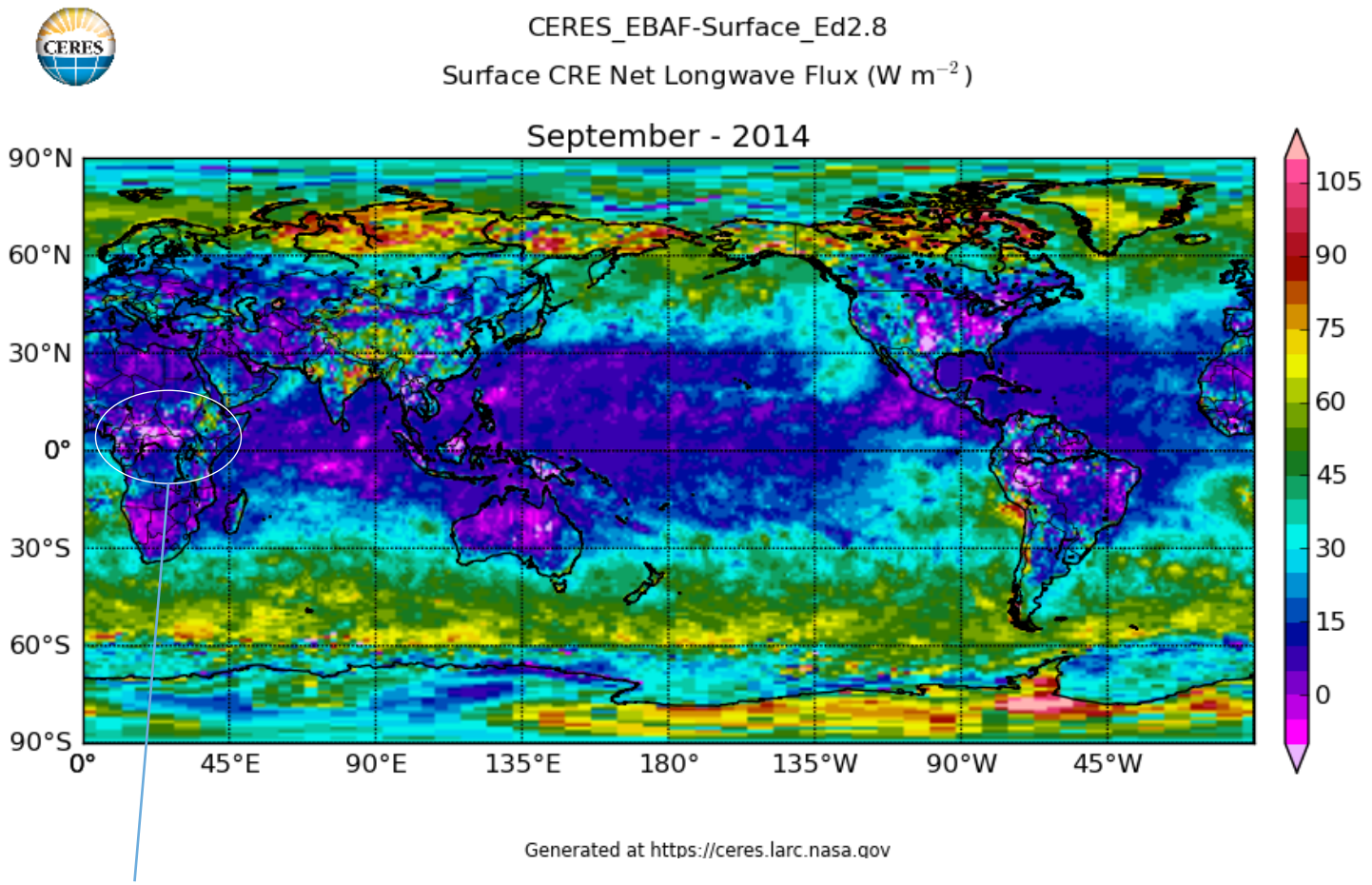


Surface downward SW and LW



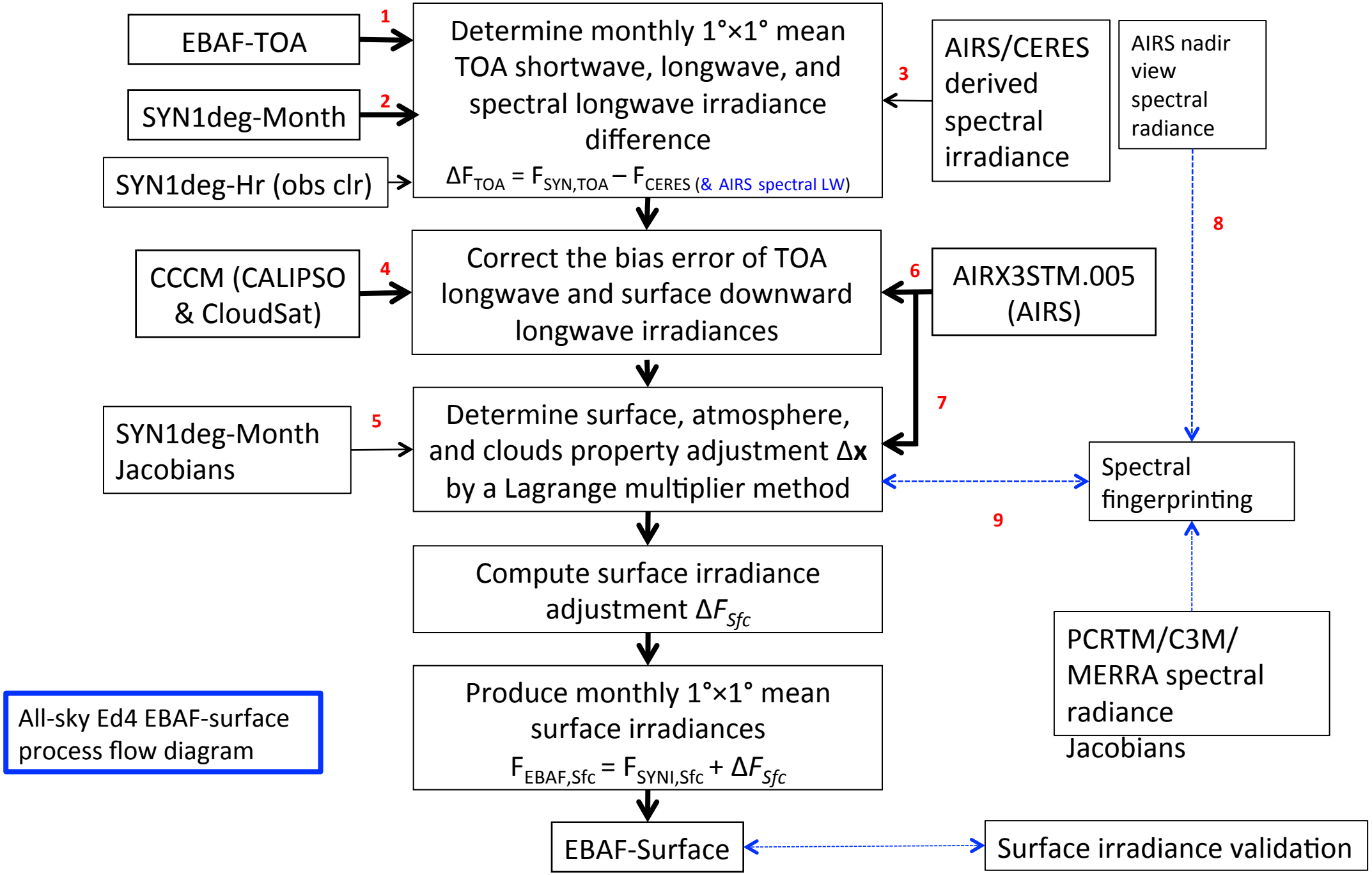


LW CRE at the surface (clear-sky sampling issue)



All-sky dn 405.1 Wm-2 Clear-sky dn 390.5 Wm-2
All-sky up 460 Wm-2 Clear-sky up 429 Wm-2
LW CRE is negative because clear-sky up is smaller due to a sampling issue.

Edition 4



All-sky Ed4 EBAF-surface process flow diagram

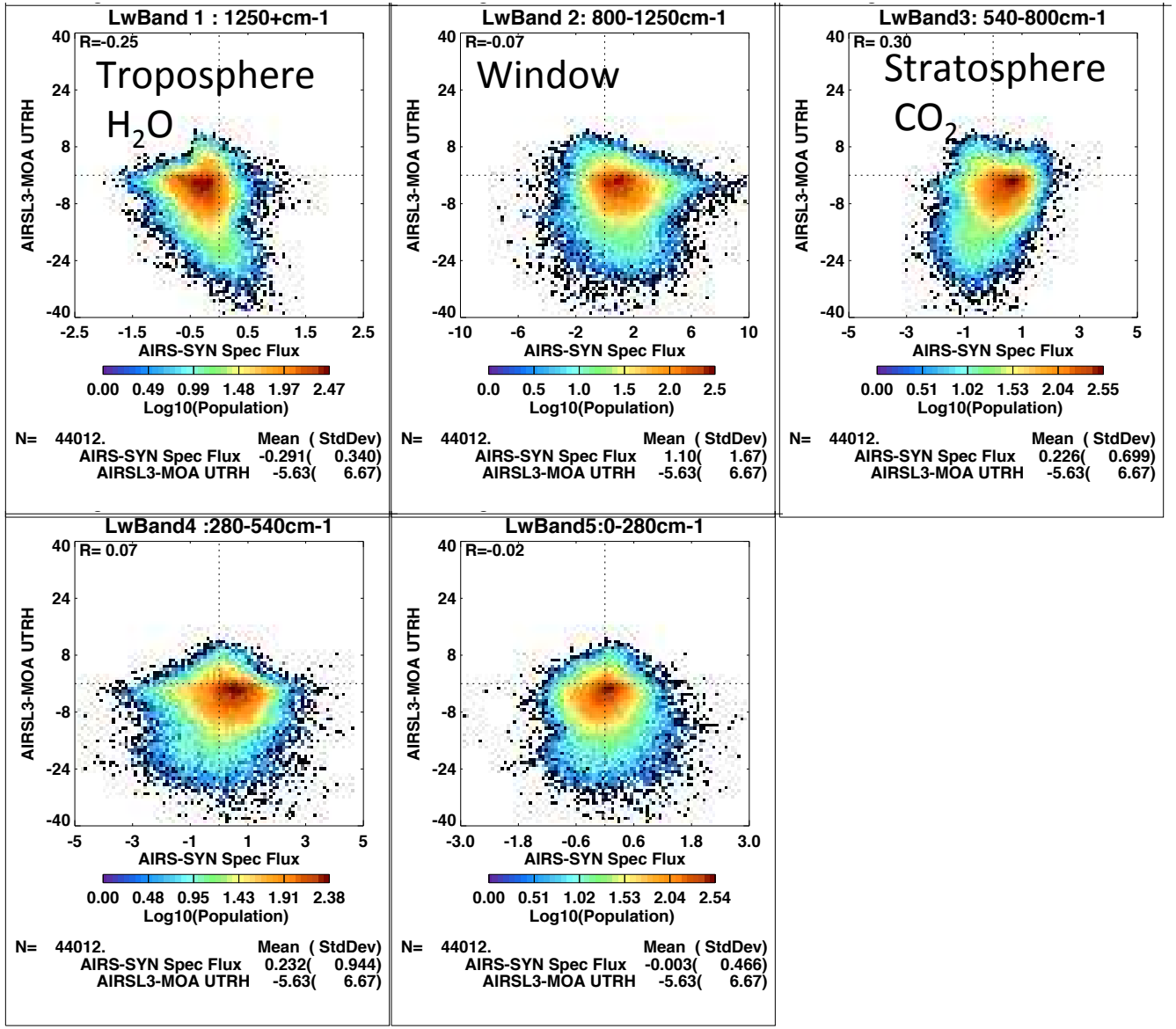
Ed4 EBAF-surface: Changes from Ed2.8

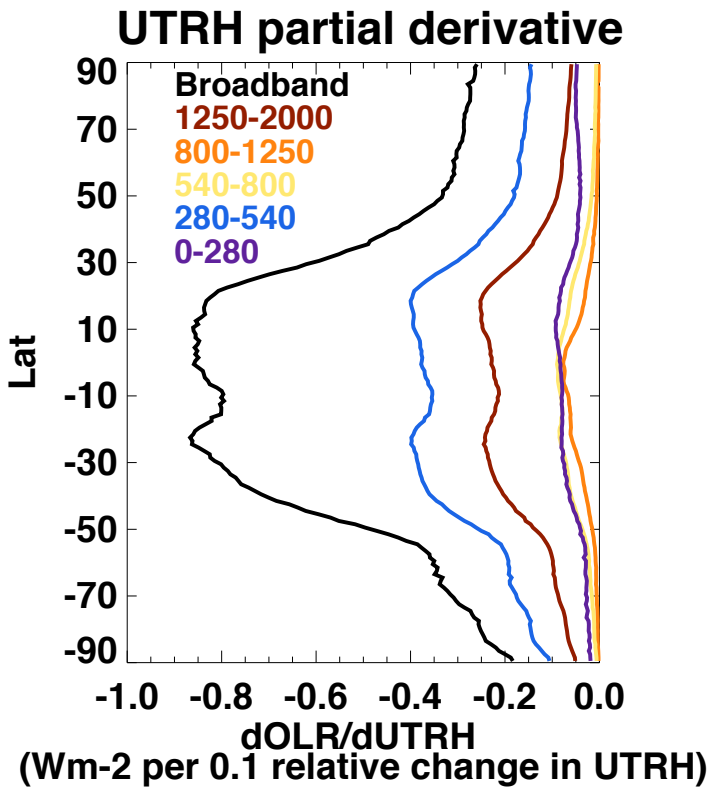
- All-sky AIRS spectral irradiance in constraining upper tropospheric humidity (500 hPa to 200 hPa) in Lagrange multiplier process
  - A) AIRX3STM.006 UTRH (Level 3 AIRS data used in Ed2.8 EBAF-surface)
  - B) Use both AIRX3STM.006 UTRH and AIRS spectral radiances
  - C) Eliminate the pre UTRH bias correction process and AIRS spectral irradiance in Lagrange multiplier
  - Use AIRS spectral radiance and computed spectral radiance as a confirmation of T and Q correction.
- Ed4 SYN includes cloud overlap
  - New downward longwave irradiance bias correction
- New uncertainty table for Lagrange multiplier
- Consistent clear-sky weights with TOA

AIRS spectral irradiance

- If successful, including AIRS spectral can eliminate UTRH bias correction with Level 3 AIRS data.
- Work needs to be done
  - Determine uncertainty in spectral irradiances
  - Treatment of Fu-Liou code bias

AIRS vs. G5.4.1 UTRH (500 hPa to 200 hPa) and Airs vs. Syn1deg All Sky Spectral Irradiance Differences





Far-IR (0-670 cm^{-1}) Clear-sky irradiance

	LBLRTM	Fu-Liou - LBLRTM	PCRTM - LBLRTM
Tropics	124.7	2.3	0.6
Mid-latitude summer	124.8	2.4	0.6
Mid-latitude winter	116.0	1.7	0.6
Sub-Arctic summer	122.1	1.7	0.3
Sub-Arctic winter	109.5	1.1	0.6
US standard	118.0	2.3	0.4

Wm^{-2}

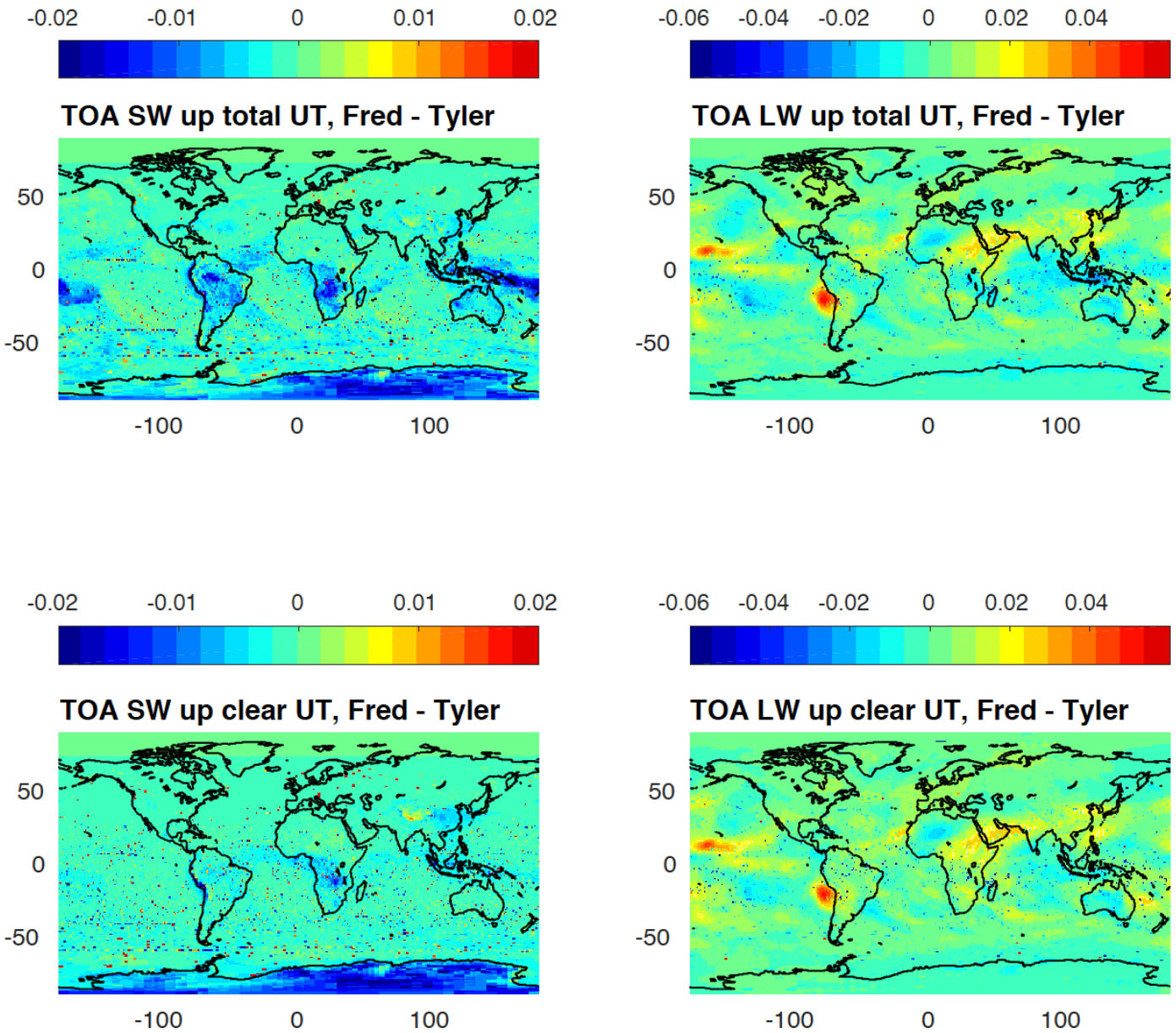
Correcting the Fu-Liou model bias makes the difference between AIRS and model worse

Table is provided by X. Huang

Comparison of TOA and surface irradiance change due to a 1% perturbation of WV above (UT) or below (LT) 500 hPa level

- Ed2.8 (Fred's) kernels are computed with monthly mean properties
- High resolution (Tyler's) kernels are computed at a 3 hourly resolution
- The difference of TOA and surface irradiance change computed with two different kernels depends on the distribution of water vapor amount over the course of the month.

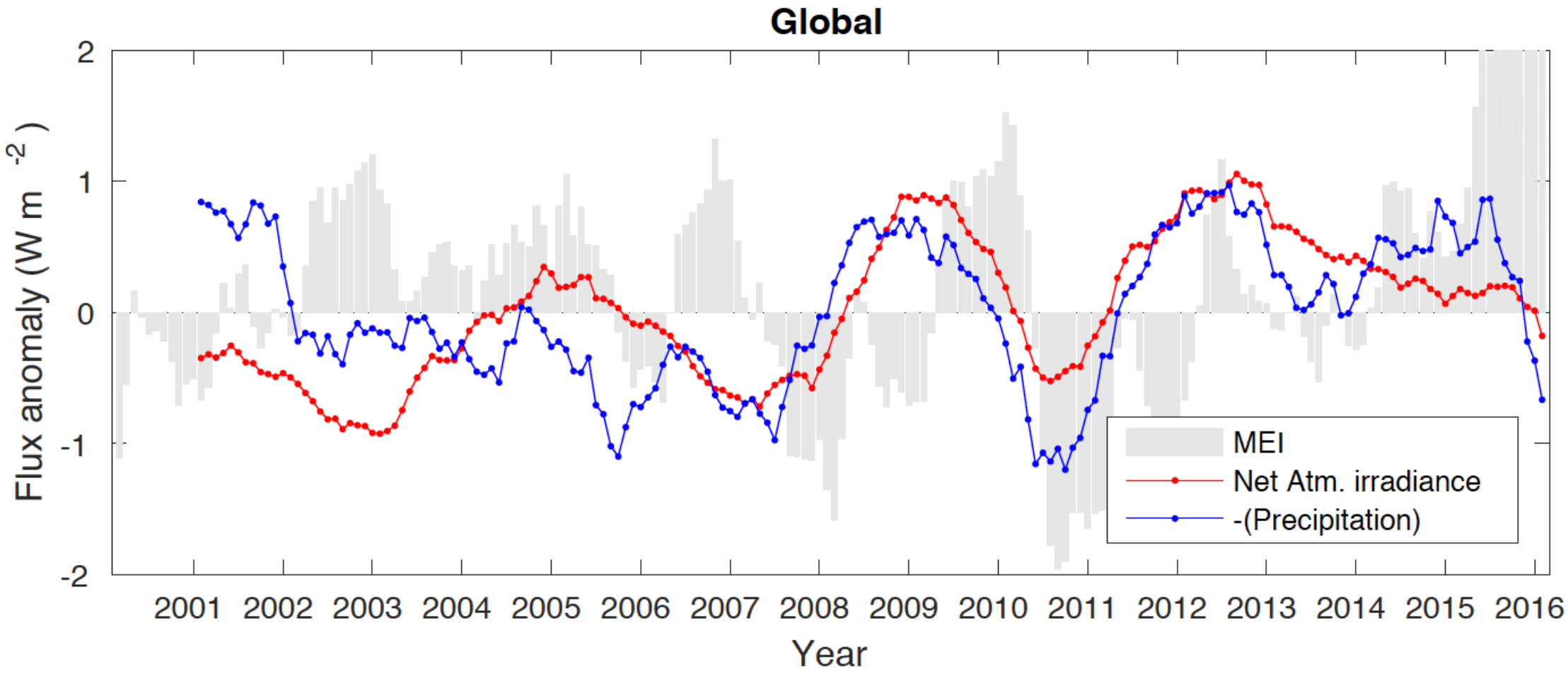
TOA irradiance sensitivity to 1% UTWV perturbation in Wm^{-2}



Longwave
A positive difference means that Fred's kernel gives a less negative OLR change than Tyler's kernel does for a 1% UTWV perturbation.

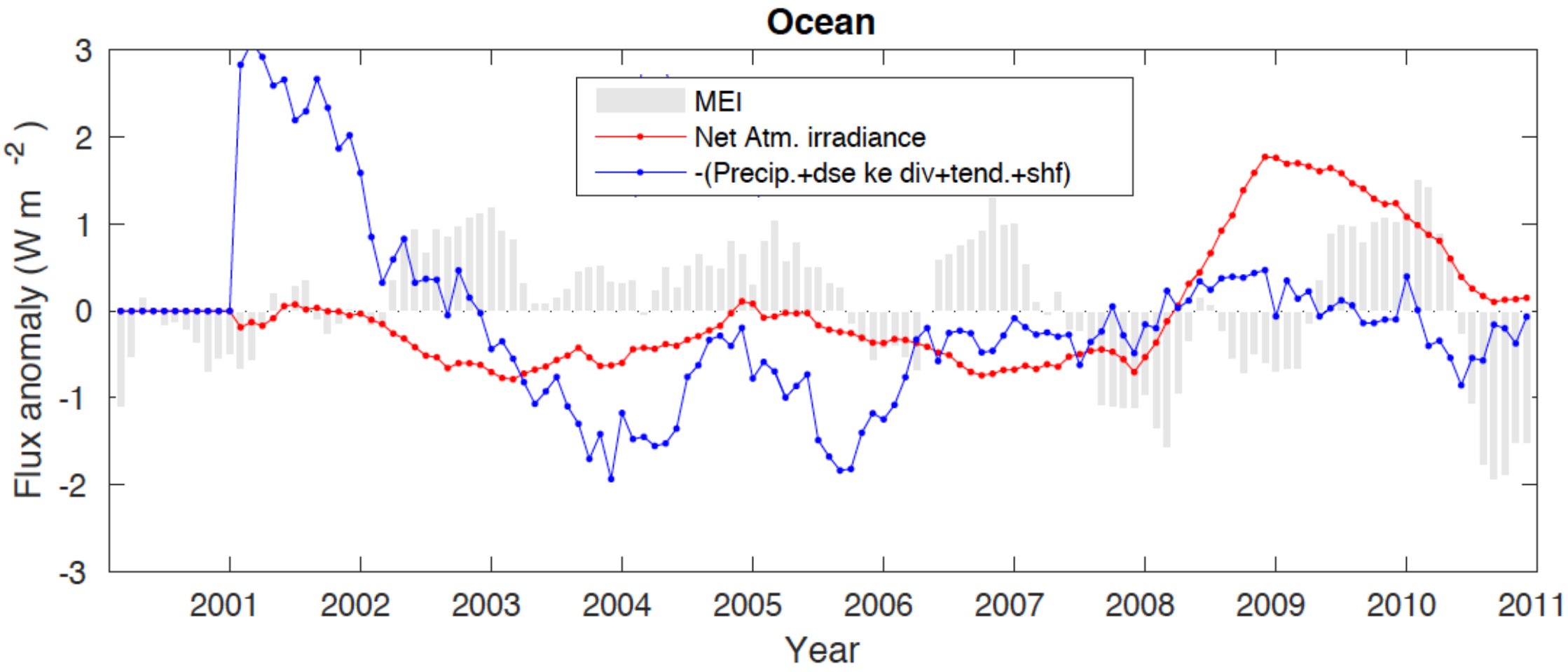
Over positive regions, for a given Delta OLR, a larger WV change is needed when Fred's kernel is used.

Atmospheric net irradiance (EBAF ed2.8) vs. precipitation(GPCP v2.3) anomalies



Computed with 12 month running mean
Surface sensible heat anomaly contributions are not included

Anomalies over ocean
EBAF, GPCP, ERA-Interim, OA-flux

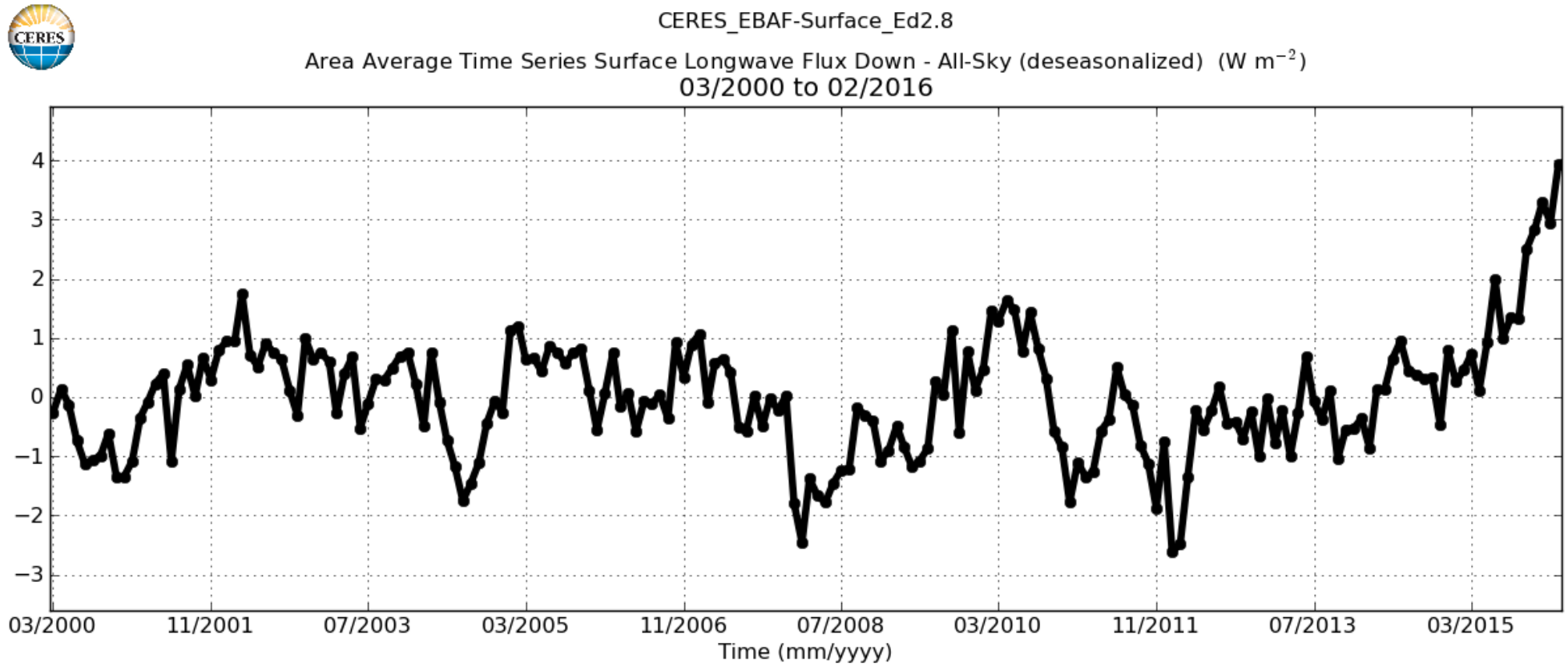


Summary

- Clear-sky scenes in Ed2.8 only occur clear-sky scenes are observed
  - Generally clear-sky scenes are dryer and have less aerosol loading
- AIRS spectral irradiances will be used in Lagrange multiplier in Ed4
  - Affects UTRH bias correction
- Water vapor kernels and possibly other kernels will be revised in Ed4

Back-ups

Anomaly of global mean downward longwave



Selected Region: [-90,0 to 90,360]

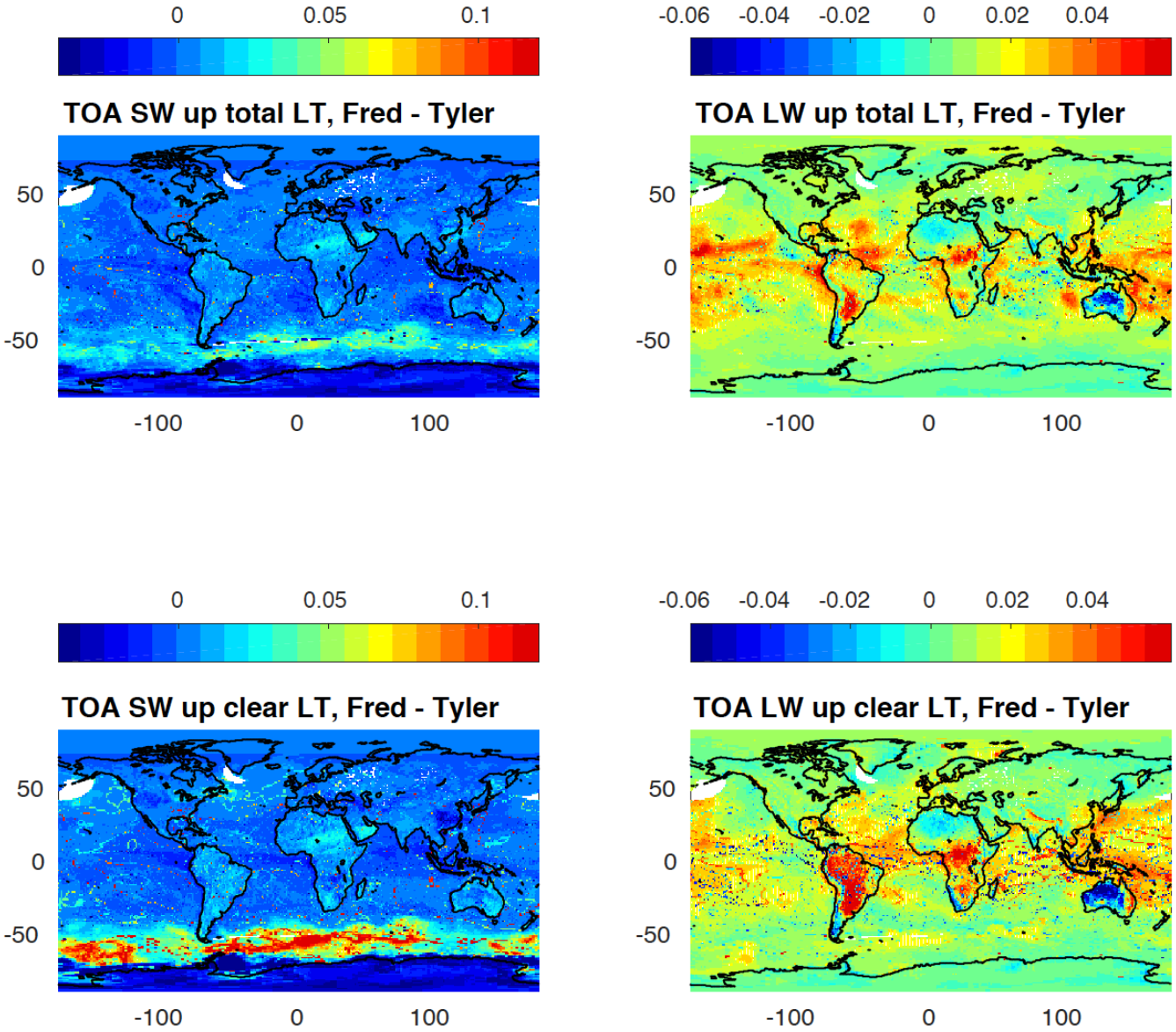
EBAF-surface

- EBAF-surface algorithm overview
- EBAF-surface (Ed2.8)+ GPCP + ERA-interim
- WV kernel test with Tyler's kernel
- Assessing LW bias correction (leaning toward no bias correction)
- AIRS spectral irradiance and UTRH bias correction
  - Status update (asf_syn_regutrh.pdf)
  - Assessing the impact of far-IR in constraining UTRH
- Uncertainty table update
- Fingerprinting

EBAF

- Known problem of Ed 2.8
  - Problem caused by GEOS switch should be fixed in Ed4 SYN
  - Any artifacts in anomaly time series should be mitigated in Ed4 EBAF
- UTRH bias correction
- Downward longwave bias correction

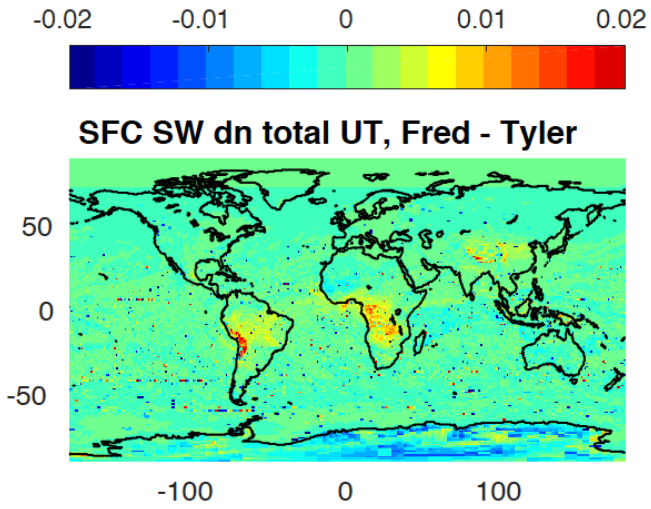
TOA irradiance sensitivity to 1% LTWV perturbation in Wm^{-2}

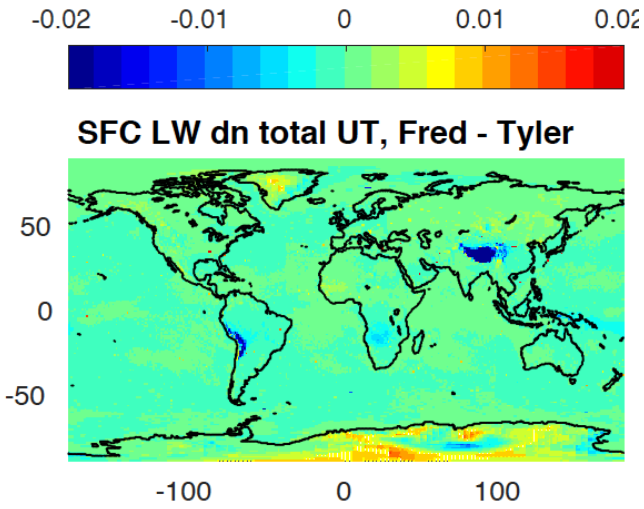


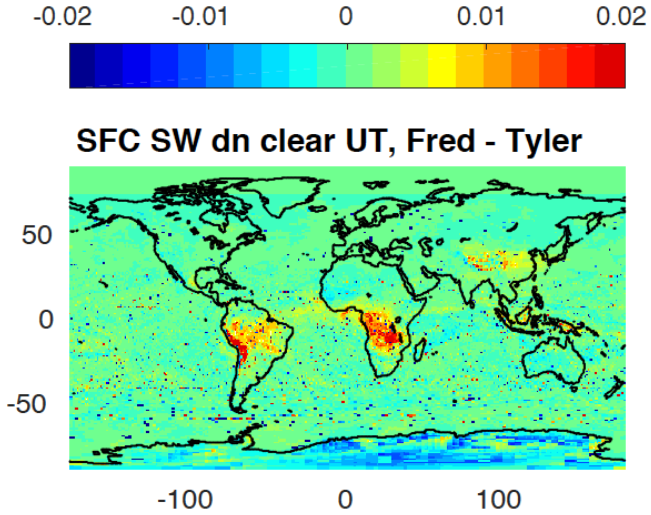
Longwave
Similarly, a positive difference means that Fred's kernel gives a less negative OLR change than Tyler's kernel does for a 1% UTWV perturbation.

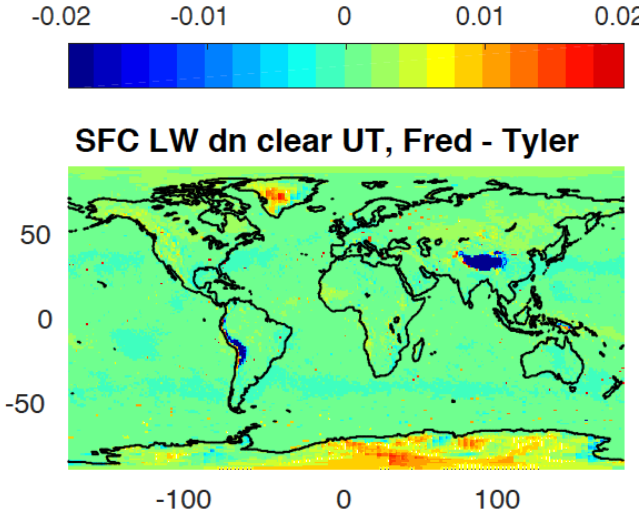
Over positive regions, for a given Delta OLR, a larger WV change is needed if Fred's kernel is used.

Surface irradiance sensitivity to 1% UTWV perturbation in Wm^{-2}

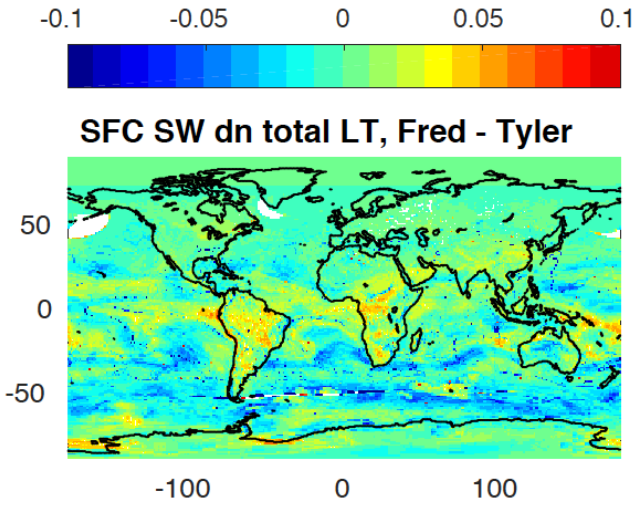


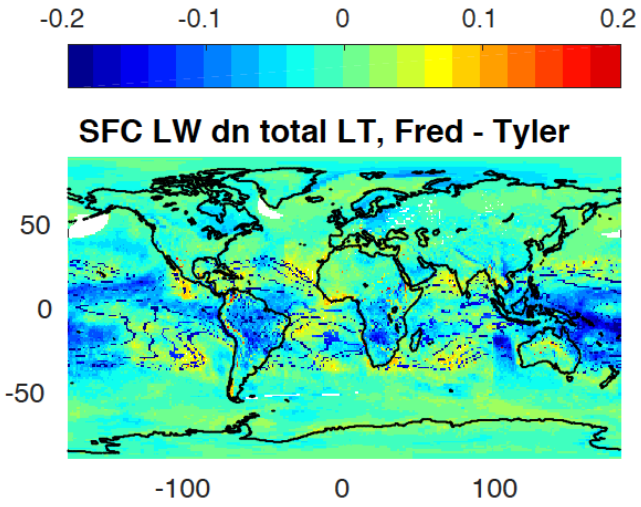




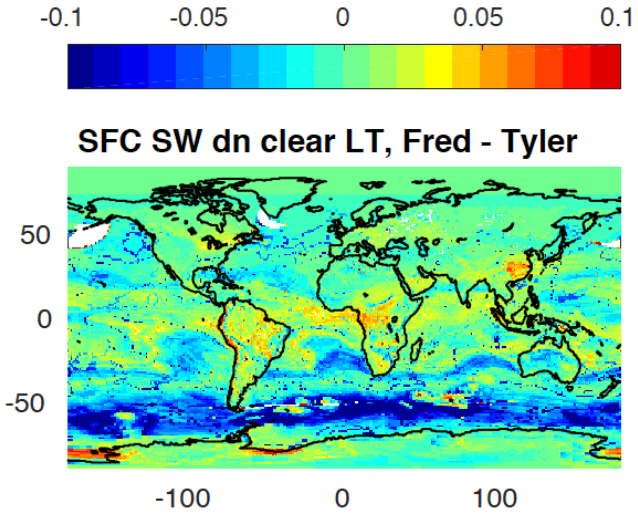


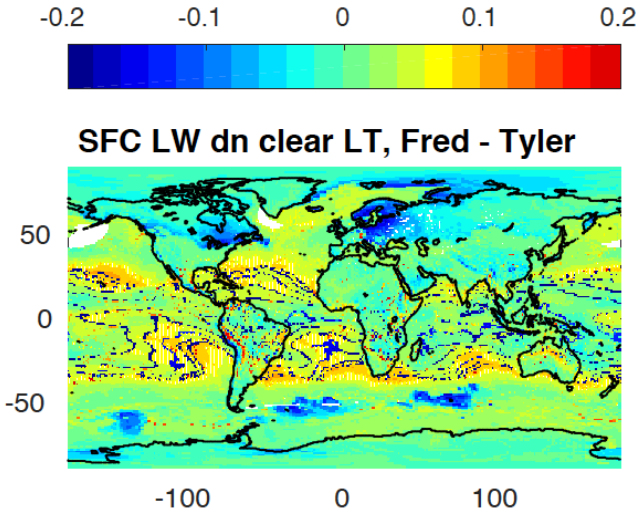
TOA irradiance sensitivity to 1% LTWV perturbation in Wm^{-2}





Total sky
Fred's kernel gives a smaller LW down than Tyler's kernel does for a given Delta WV. Therefore, the TOA kernel difference partially cancels and Fred's and Tyler's kernels might give similar LW down irradiances.

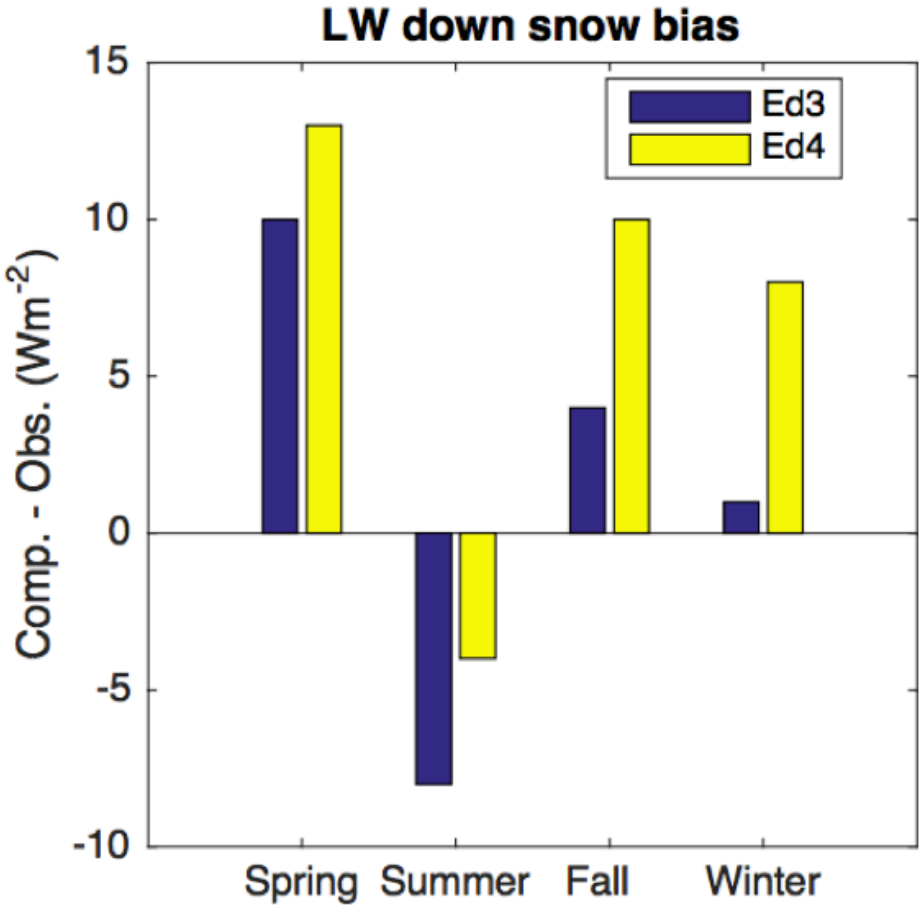




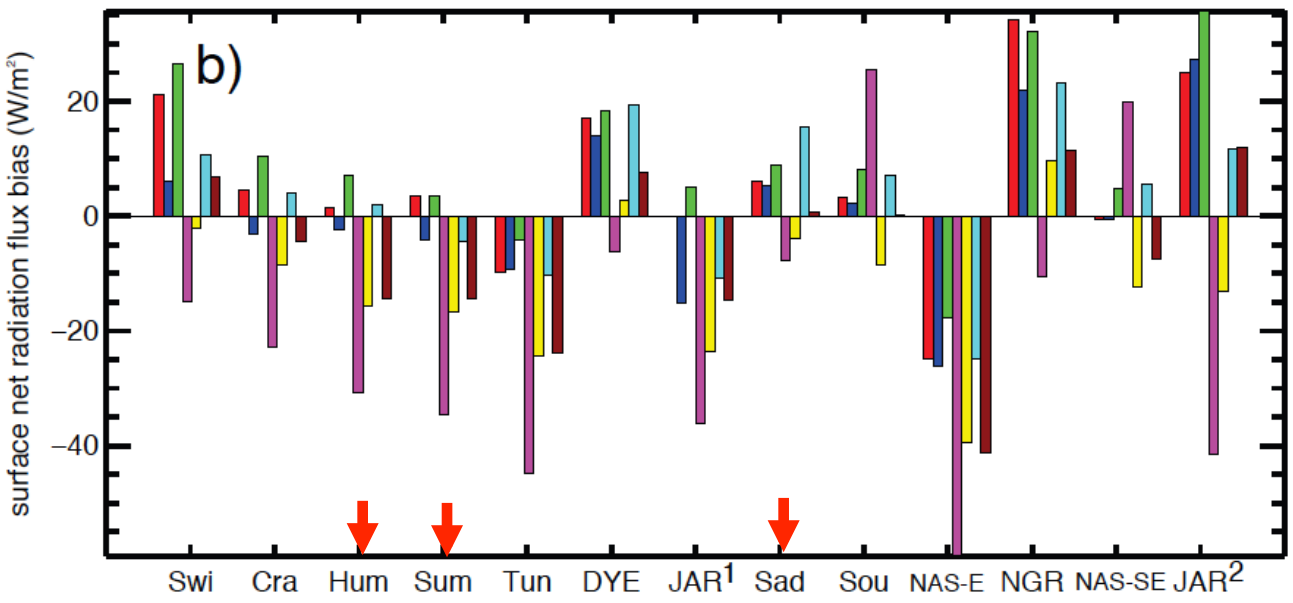
Clear-sky
Fred's kernel gives a larger LW down than Tyler's kernel does for a given Delta WV. Therefore, LW down with Fred's kernel is larger than LW down with Tyler's kernel.

Downward LW bias correction

Net LW down over Greenland



Need net longwave comparison



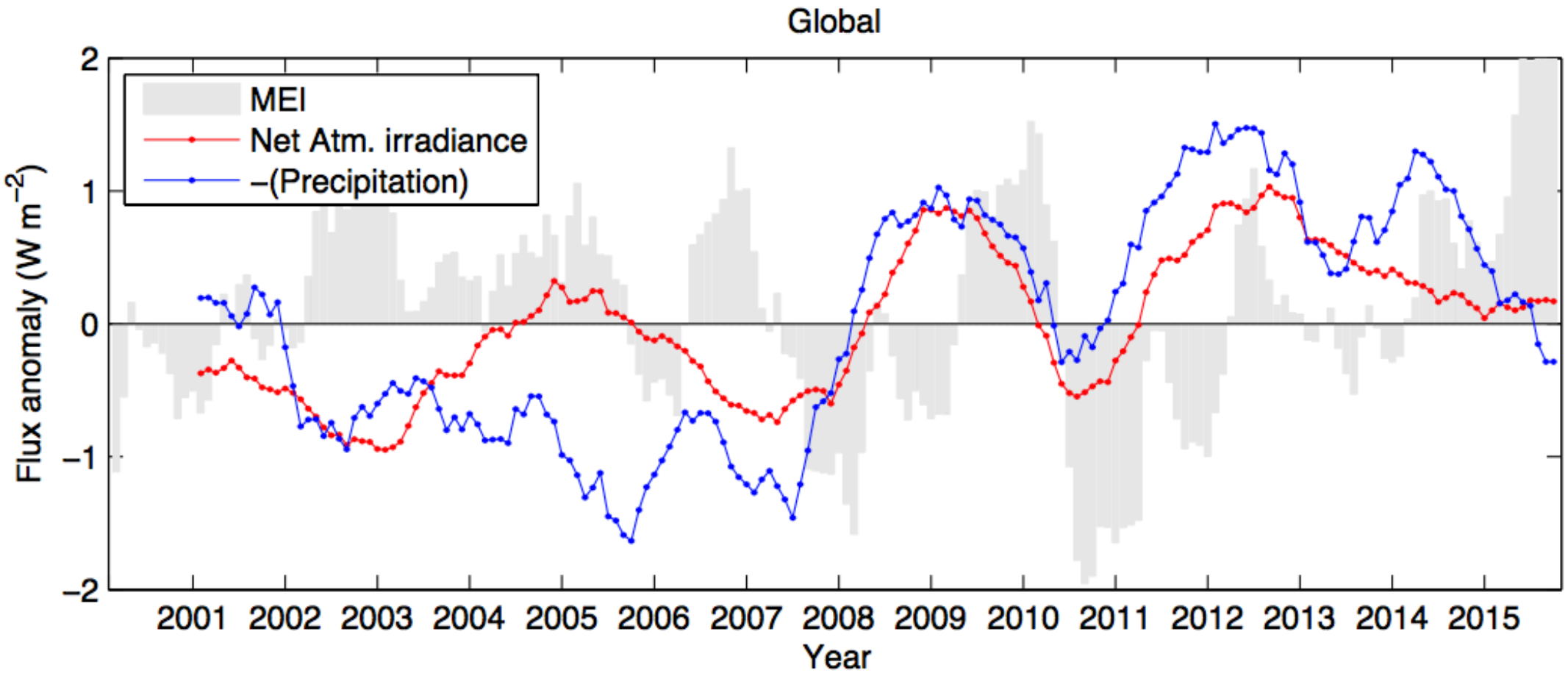
Red: CERES
Christensen et al. (2016)

Ed4 LW down over Greenland might be more positively biased

Downward longwave bias correction

- Ed 3 and Ed4 cloud fraction comparison by cloud type (e.g. high, mid-high, mid-low, low)
- Compare Ed3 and Ed4 downward longwave irradiances (Delta LW down)
- Correct Ed 3 downward bias correction based on Delta LW down
- Compare Ed4 cloud fraction with CALIPSO/CloudSat by cloud type for consistency check

Atmospheric net irradiance (EBAF ed2.8) vs. precipitation(v2.2) anomalies



Computed with 12 month running mean
Surface sensible heat anomaly contributions are not included