Surface Atmosphere Radiation Budget (SARB) working group update

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CERES Science team meeting
Oct. 7-10, 2014
Toulouse, France

Outline of this talk

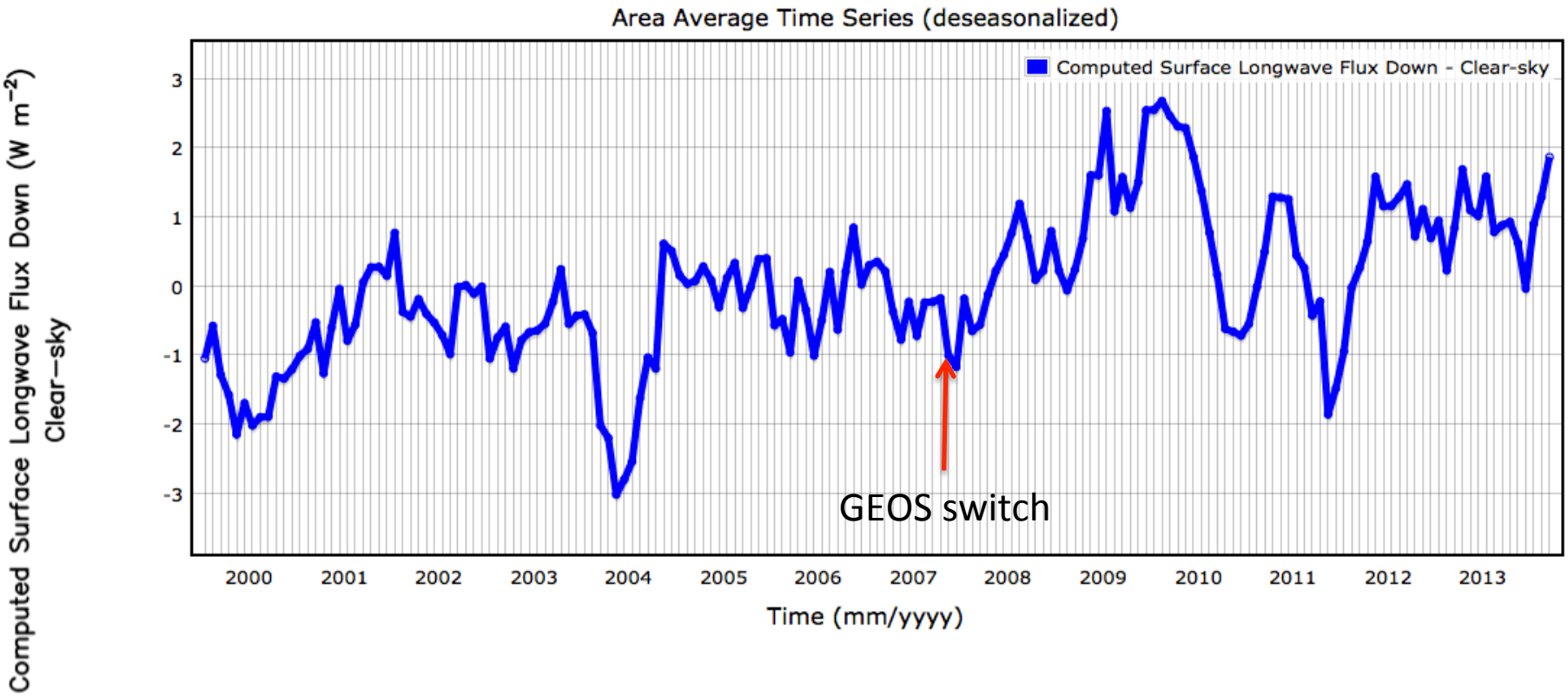
- Progress of Ed4 SYN development,
- EBAF-surface tuning, focusing on surface skin and near surface air temperatures over the Arctic
- Modeled and observed radiance comparison over Dome-C
- Evaluations of multi-layer cloud algorithm, and
- Ed4 MATCH aerosol transport model
- Atmospheric irradiance profiles computed with CALIPSO and CloudSat vertical cloud profiles

SYN Ed4

Changes in Ed4 SYN from Ed3

- A consistent GEOS version throughout the observation period
- Higher temporal and vertical resolution of T and Q (resolve T and Q max. and min.)
- Hourly GEO-cloud retrieval using, in part, 5 channels (Improve night time cloud retrieval)
- Better surface albedo history map (use partly clear scenes for the albedo retrieval).
- Revised radiative transfer code (more number of bands, cloud overlap)

Global clear-sky downward longwave irradiance anomalies



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

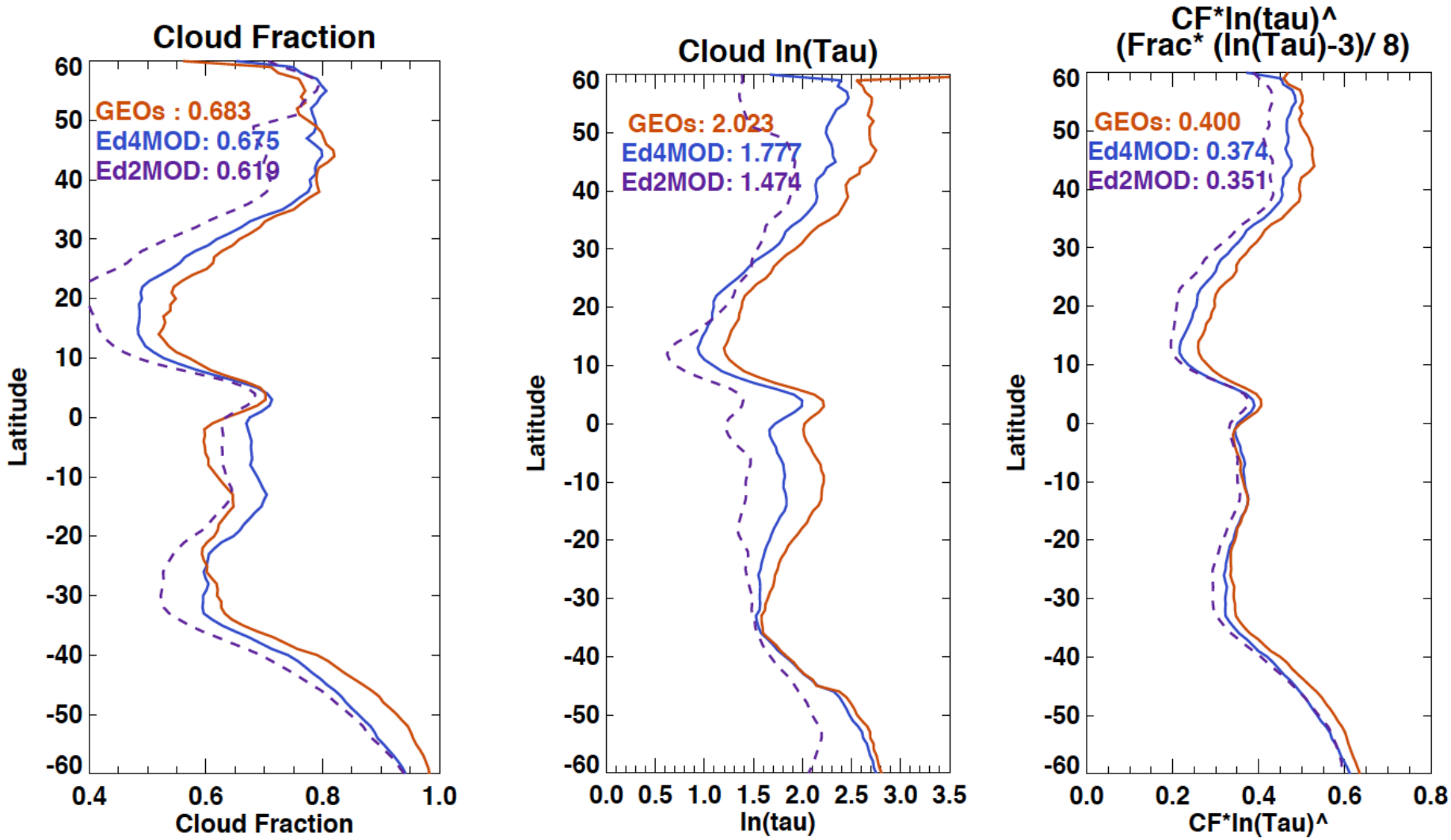
SYNI Ed4 (in progress)

- Cloud
  - ✓ Use 4 significant cloud vertical profiles (combination of 4 cloud types)
  - ✓ Include cloud overlap (random overlap)
  - – Incorporate cloud group's lapse rate and consistent phase function.
- Aerosols
  - – Hourly MATCH (file size ~700 Mb/day) (test data month July 2010)
  - – Include tropospheric SO4, stratospheric SO4, Ammonium sulfate, and volcanic ash in addition to small dust, large dust, sulfate, sea salt, black carbon, soluble, and insoluble.
  - – MODIS aerosols (collection 5)
- Surface albedo
  - – Ed4 surface history map (include partly clear-sky albedo derived from MODIS radiances)
  - – new spectral shape (using MODIS MCD43C product) over land and snow
  - – Solar zenith angle dependent surface albedo look-up table
- Radiative transfer code
  - ✓ 18 SW bands
  - – SW, GWTSA (inhomogeneous scenes) /4-stream (homogeneous scenes) hybrid; homogeneous cloud SF >= 10 4-stream, inhomogeneous cloud (SF< 10, GWTSA), clear-sky 4-stream.
- Tuning
  - – Regional, seasonal, scene (cloud/clear) and surface type (land and ocean) dependent tuning
- TSI
  - – 5-channel GEO cloud properties (test data month Jan. 2010 no temp 4GEO, July 2004 Terra only + 4GEO, April 2008 Terra+Aqua +4GEO)
  - – Including MODIS and GEO retrieved skin temperature
  - – Improved NB-BB LW irradiance
  - – Include lapse rate retrieved by the cloud group (at least two heights of temperature and pressure)
- Snow/Ice map
  - – Use 1/16 mesh of EICE and ESNOW maps.
- New variables
  - – Aerosol radiative effect product from SYN pristine, clear-sky, all-sky, and all-sky no aerosol fluxes (proposed)
  - ✓ Entropy computations

Problem fixed and progress since April 2014

- Large cloud optical thickness derived from 1.24 µm during daytime over snow and sea ice [ln(tau Fix) = ln(tau) -1.0].
- GEO-derived cloud top height
- GEO-derived skin temperature
- GEO 15 min offset in southern hemisphere
- Surface albedo history map using both Terra and Aqua (Aqua had an issue because 1.6 micron channel is not available).
- Evaluated tuned surface irradiances by comparing with surface observations
- Treatment of thin clouds near tropopause (cloud base is higher than cloud top)
- GEOS interpolation issues in the GEO code (extreme RH)

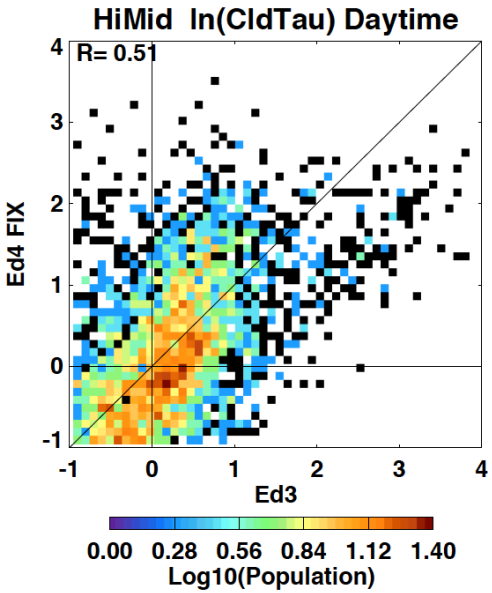
Cloud property difference MODIS vs. GEO daytime only (201001)



Polar cloud tau fix

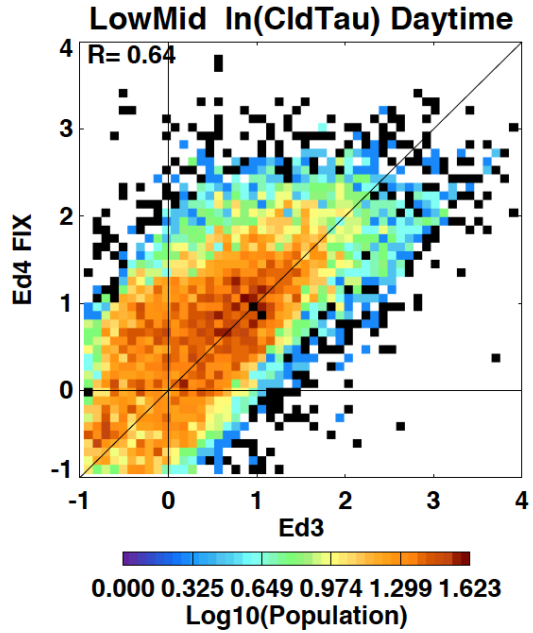
ln(tau Fix) = ln(tau) -1.0

tau Fix = 0.368 tau



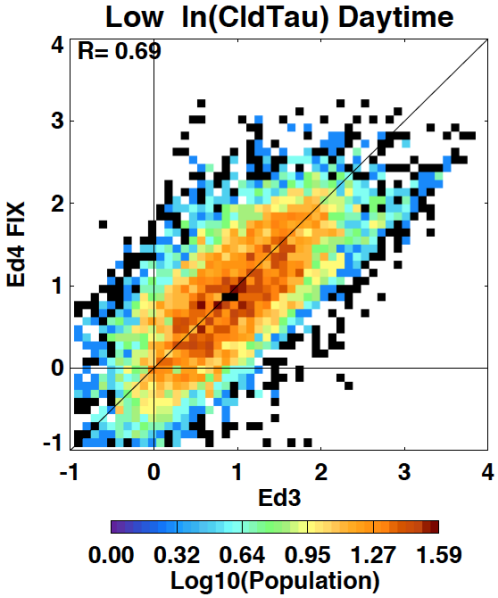
N= 4064.

	Mean	(StdDev)
Ed3	0.169(	0.773)
Ed4 FIX	0.061(	0.974)
Y-X	0.003(	0.785)
RMS(	0.784).....	



N= 12689.

	Mean	(StdDev)
Ed3	0.471(	0.880)
Ed4 FIX	0.697(	0.908)
Y-X	0.248(	0.724)
RMS(	0.766).....	



N= 8035.

	Mean	(StdDev)
Ed3	0.938(	0.797)
Ed4 FIX	0.883(	0.799)
Y-X	-0.047(	0.613)
RMS(	0.614).....	

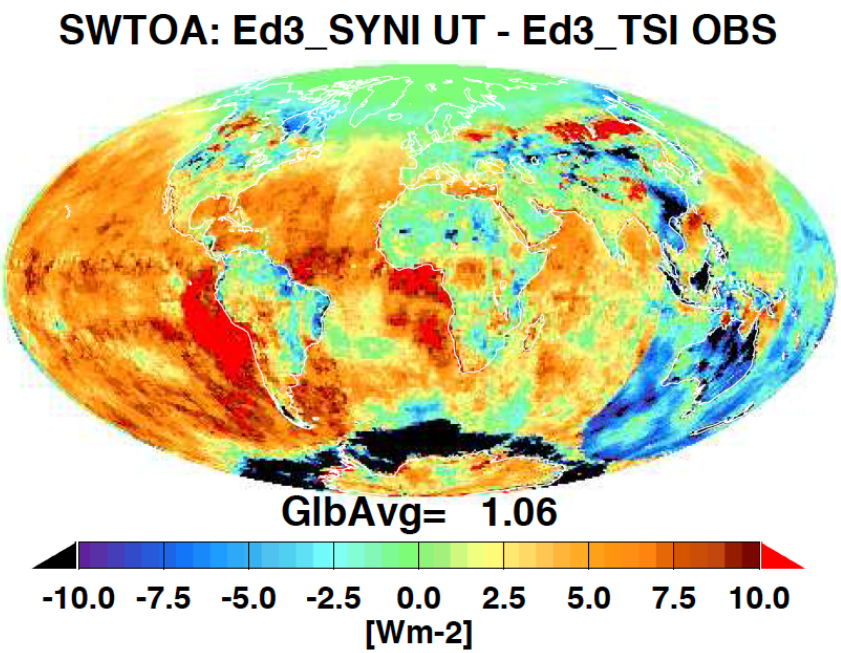
Satellite	Oct. 2002	July 2004	April 2008	Jan. 2010	April 2013	GEO type
GOES-8	X					4
GOES-12		X	X	X		5
GOES-13					X	5
GOES-10	X	X				4
GOES-11			X	X		4
GOES-15					X	5
Met-7 0°E	X					3
Met-8		X				6
Met-9			X	X		6
Met-10					X	6
Met-5	X	X				3
Met-7 60°E			X	X	X	3
GMS-5	X					3
GOES-9		X				4
MTSAT-1			X	X		4
MTSAT-2					X	4
Terra MODIS	Ed4-ASDC	Ed4-ASDC		?	?	1
Aqua MODIS	Ed4-ASDC	Ed4-ASDC		Ed4-offline	?	2
GERB		X		X		

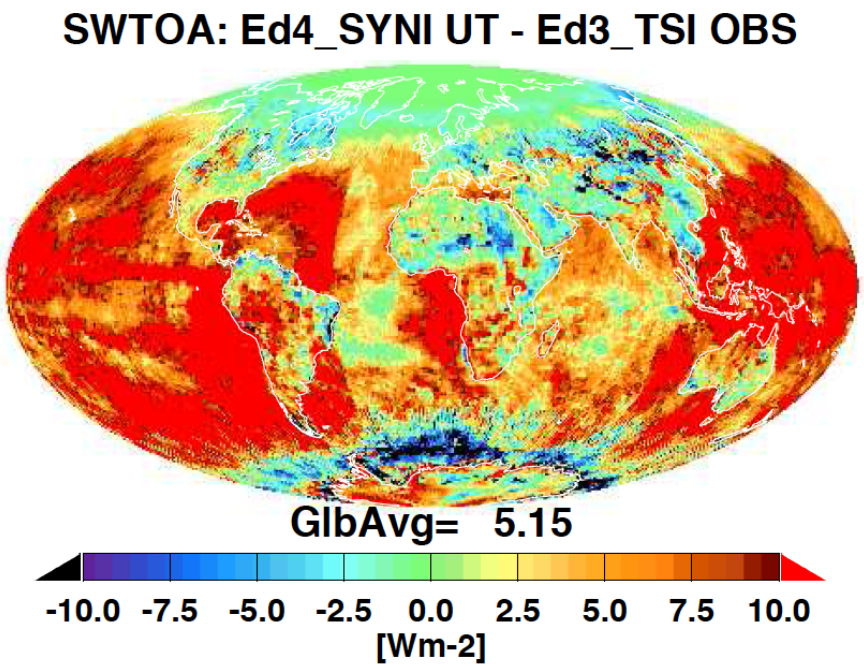
3: 3 channels
4: 5 channels with 12 micron channel GEO
5: 5 channels with 12 micron channel is replaced by 13.2 channel
6: 5 channels with both 12 and 13 channels

Summary of Ed4 MODIS and GEO cloud property selections

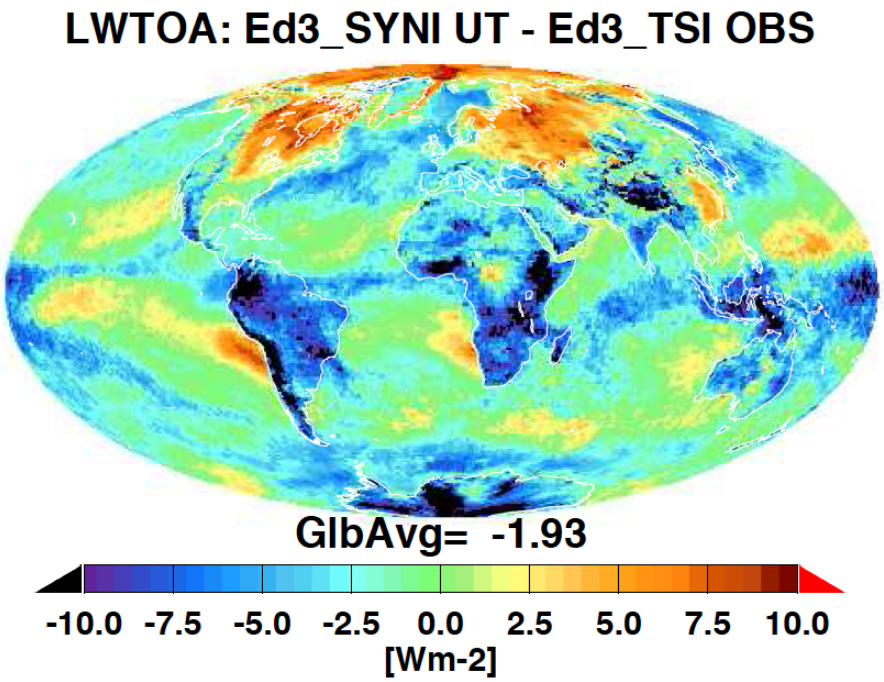
- **MODIS**
  - Use effective cloud top pressure (Peff) for daytime and nighttime
  - Apply the new extinction coefficient to ice water content relationship
- **3-channel**
  - Use effective cloud top pressure (Peff) for daytime and cloud top pressure (Ptop) for nighttime
  - Apply the new extinction coefficient to ice water content relationship
- **5 channels with 12 micron channel**
  - Use effective cloud top pressure (Peff) for daytime and nighttime
  - Apply the new extinction coefficient to ice water content relationship
- **5 channels with 12 micron channel is replaced by 13.2 channel**
  - Use effective cloud top pressure (Peff) for daytime and nighttime
  - Turn off CO2 for daytime and use 2-channel for nighttime
  - Apply the new extinction coefficient to ice water content relationship
- **5 channels with both 12 and 13 channels**
  - Use effective cloud top pressure (Peff) for daytime and nighttime
  - Turn off CO2 for both daytime and nighttime
  - Apply the new extinction coefficient to ice water content relationship

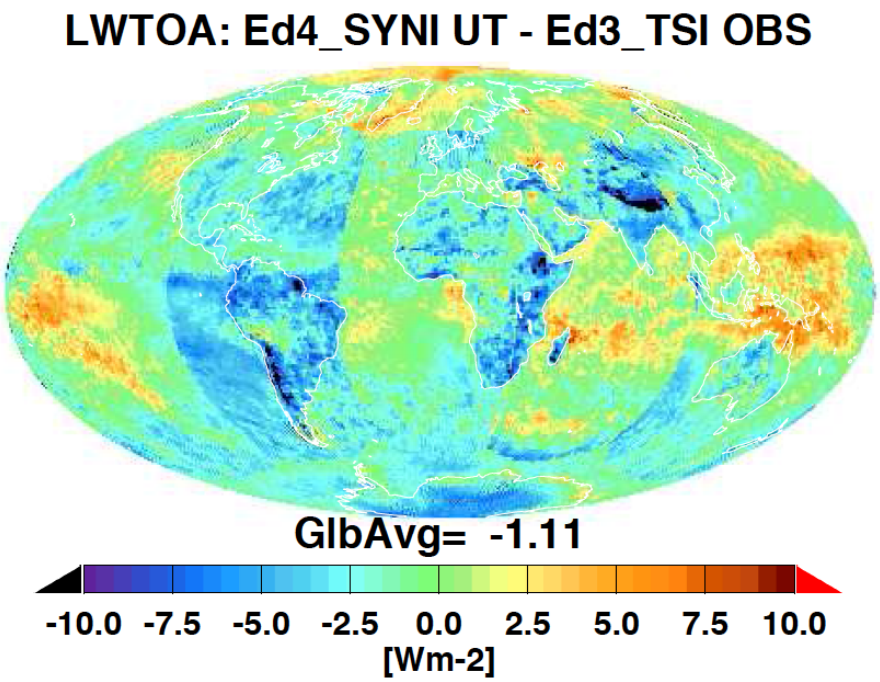
Ed3 and Ed4 TOA irradiance differences
(daytime SW 201001)



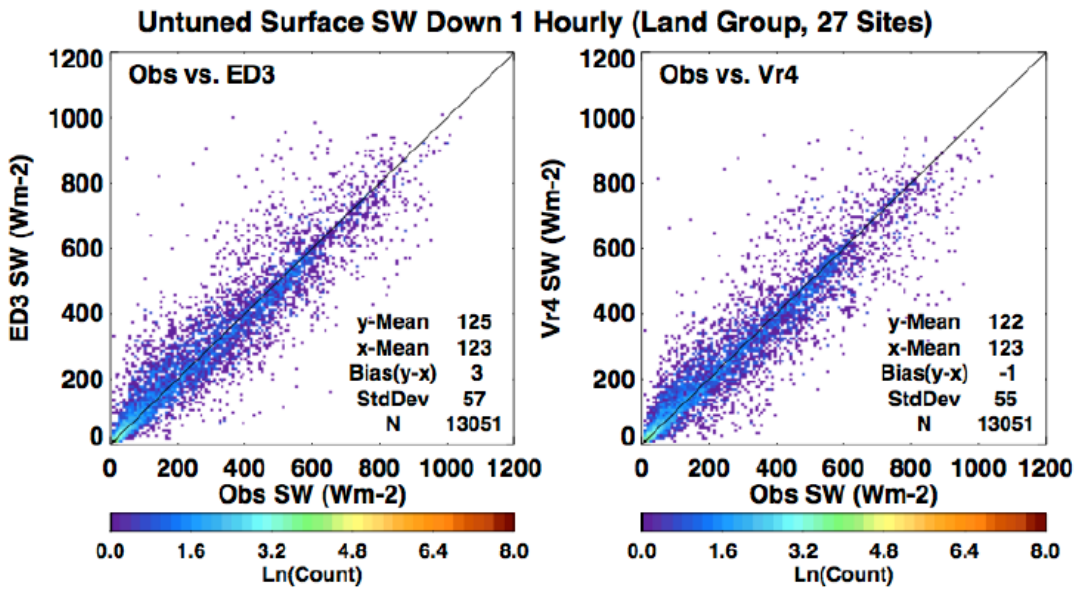


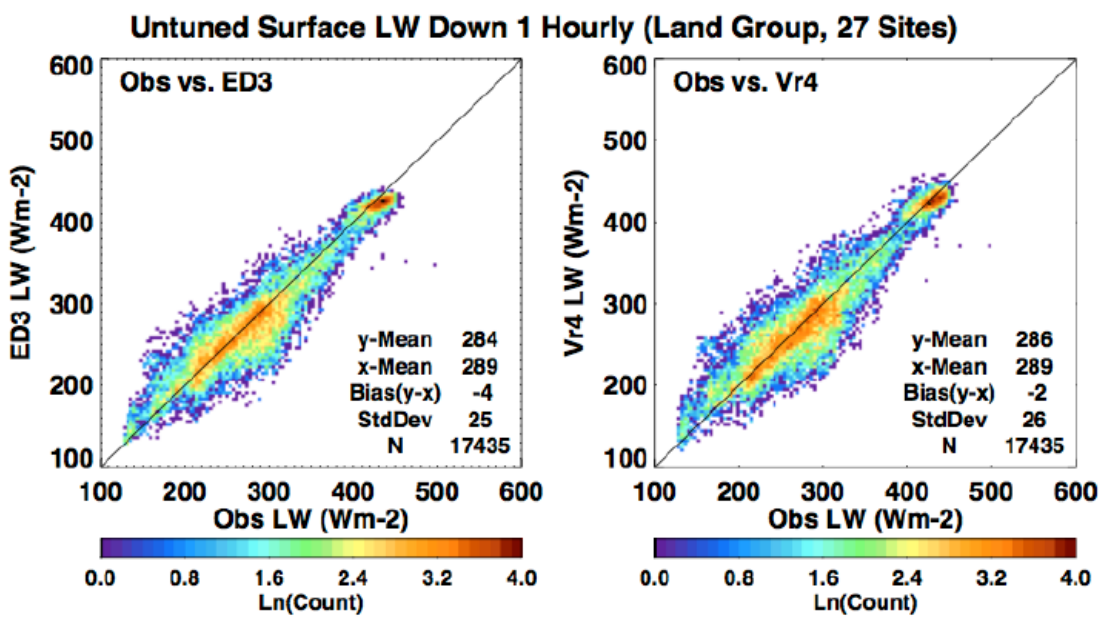
Ed3 and Ed4 TOA irradiance differences (day + nighttime LW, 201001)



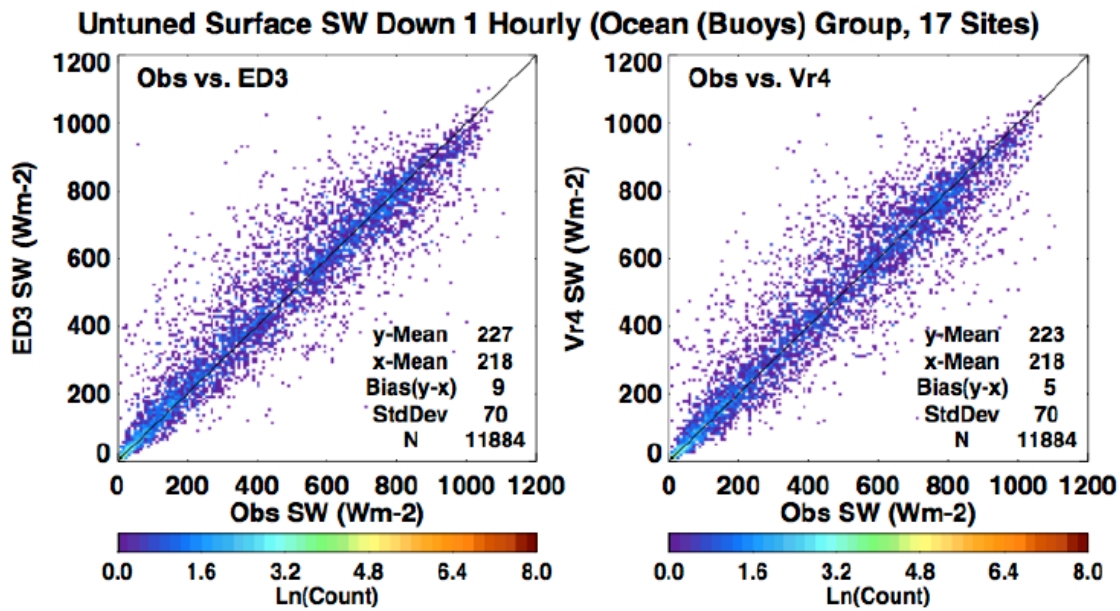


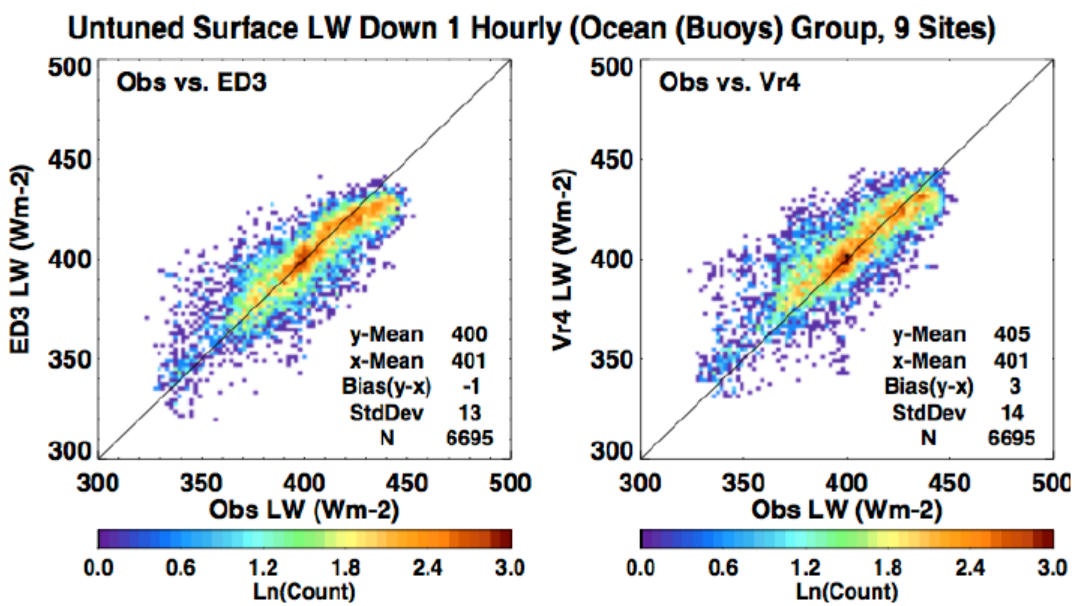
Comparison with surface observations (land)





Comparison with surface observations (Ocean)



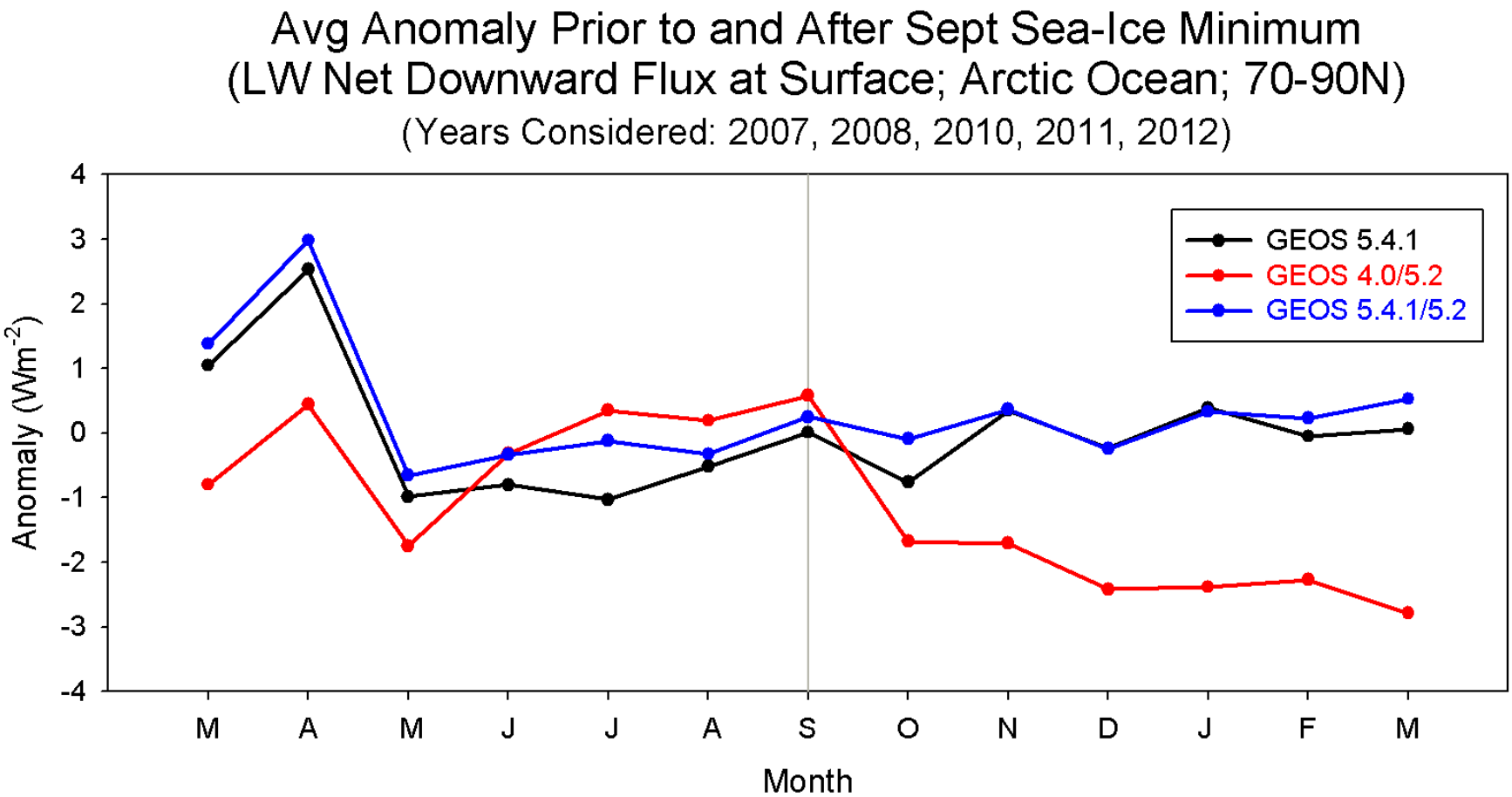


Remaining issues (not yet evaluated)

- Observed window fluxes in TSI
- NB to BB over desert, southern ocean and any other regions (index issue?)
- Consistency check among clouds from SSF1deg, SYN CERES time, SYN GEO time (e.g. Cloud optical thickness averaging linear vs. log mean)
- Treatment of local vs. GMT time (SW clear-sky issue)
- Ozone absorption treatment in the GEO code
- Cloud overlap

EBAF-surface
Evaluation of tuning

Available months: 200003-201311
Under evaluation: 201312 - 201403



LW net downward flux anomalies for lower than average sea ice fraction in September depends on reanalysis used for irradiance computations

Skin temperature and surface air temperature affects LW anomalies.

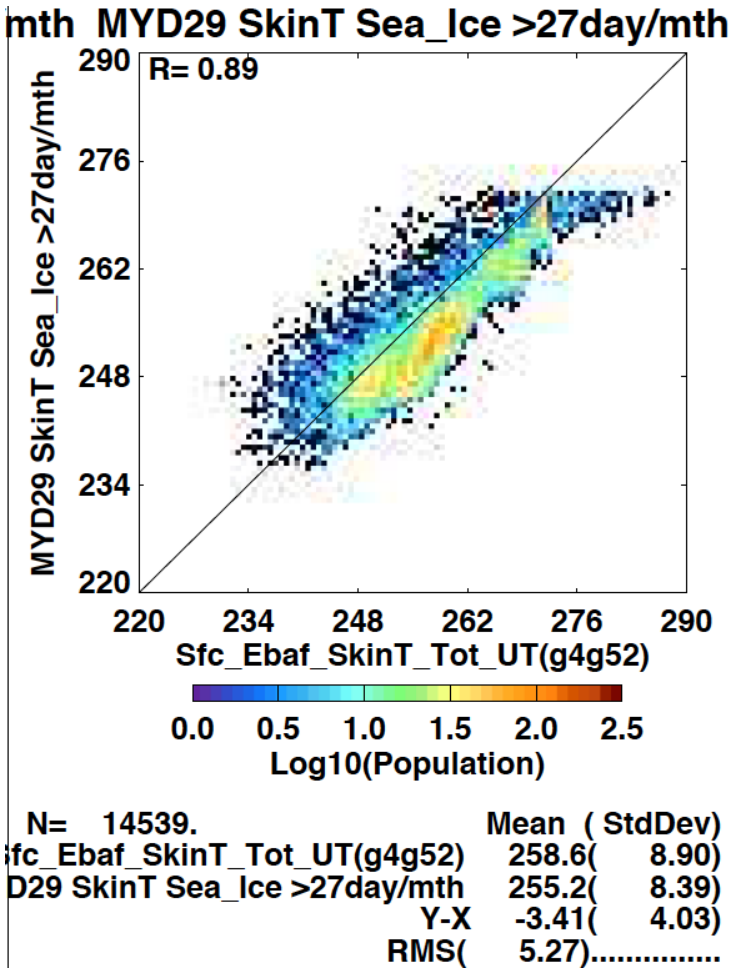
By N. Loeb

Questions to answer

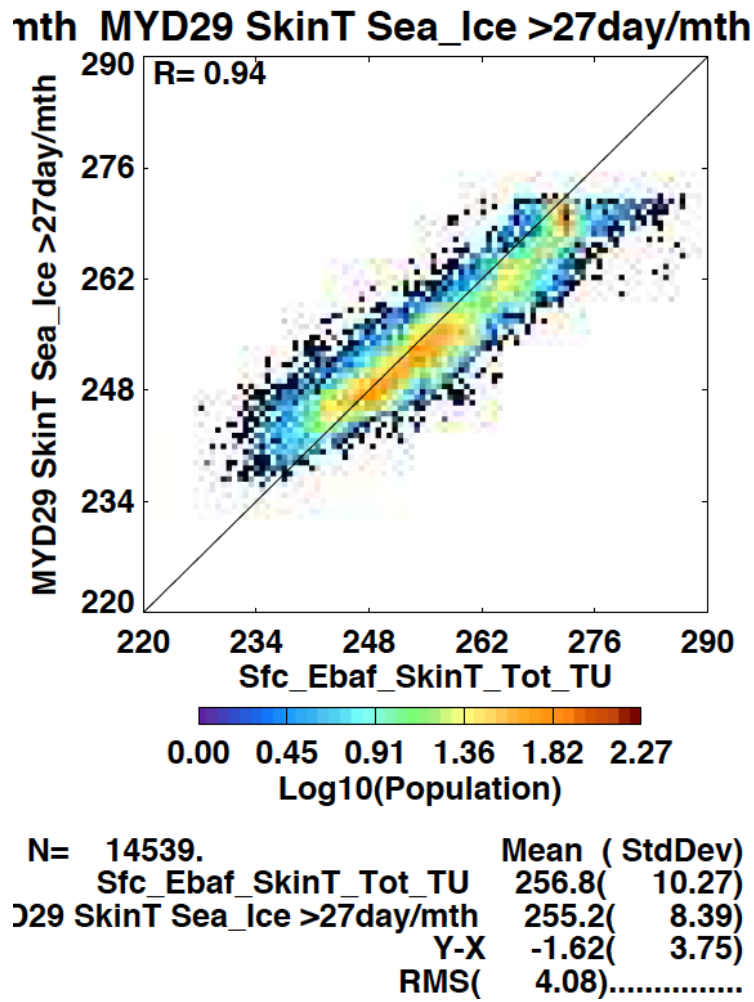
- What is the error in skin temperature and near surface air temperature used in irradiance computations?
- Does EBAF-tuning correct the error or perturb these variables in the right direction?

Sea ice skin temperature comparison with MODIS (all-sky)

Untune



Tune

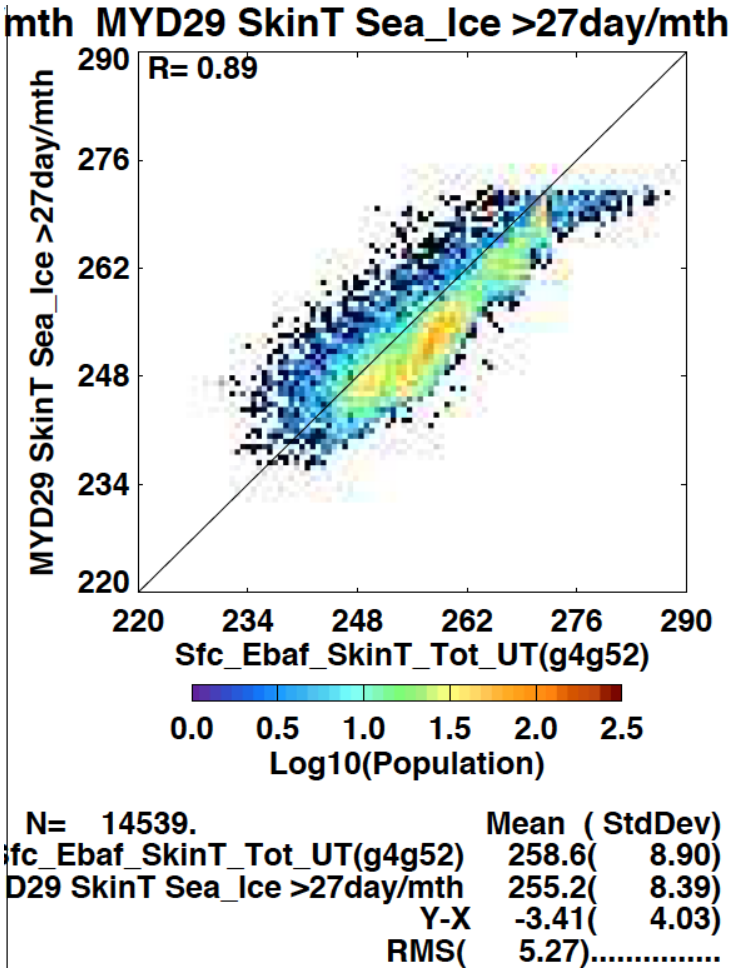


RMS error of MODIS skin temperature 1.3K
Hall et al. (2004)

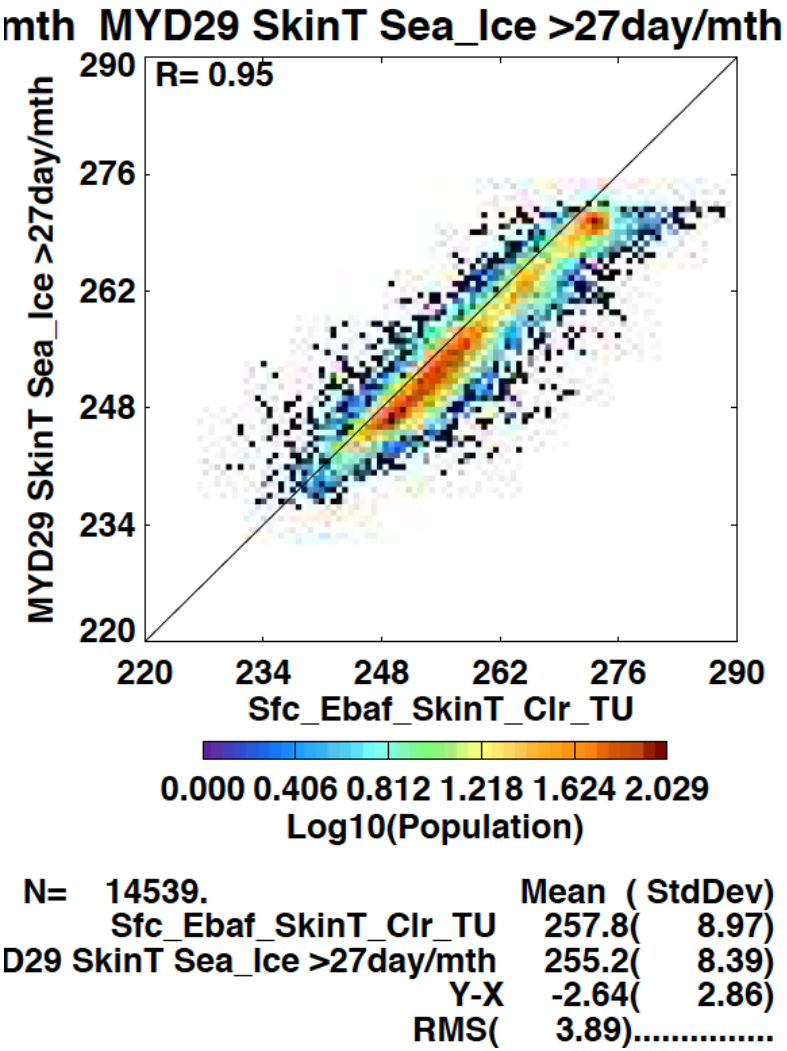
Mismatch between a grid box mean vs. MODIS sampling is an issue.
But bias is reduced by tuning.

Sea ice skin temperature comparison with MODIS (clear-sky)

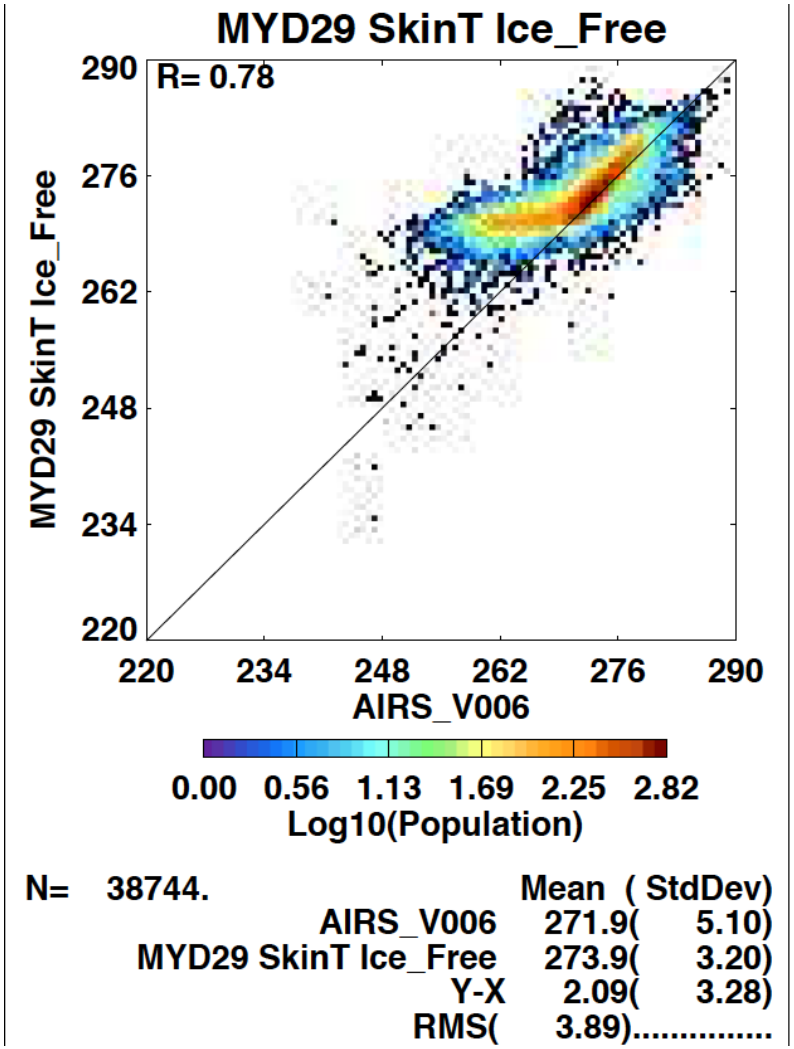
Untune (same as all-sky)

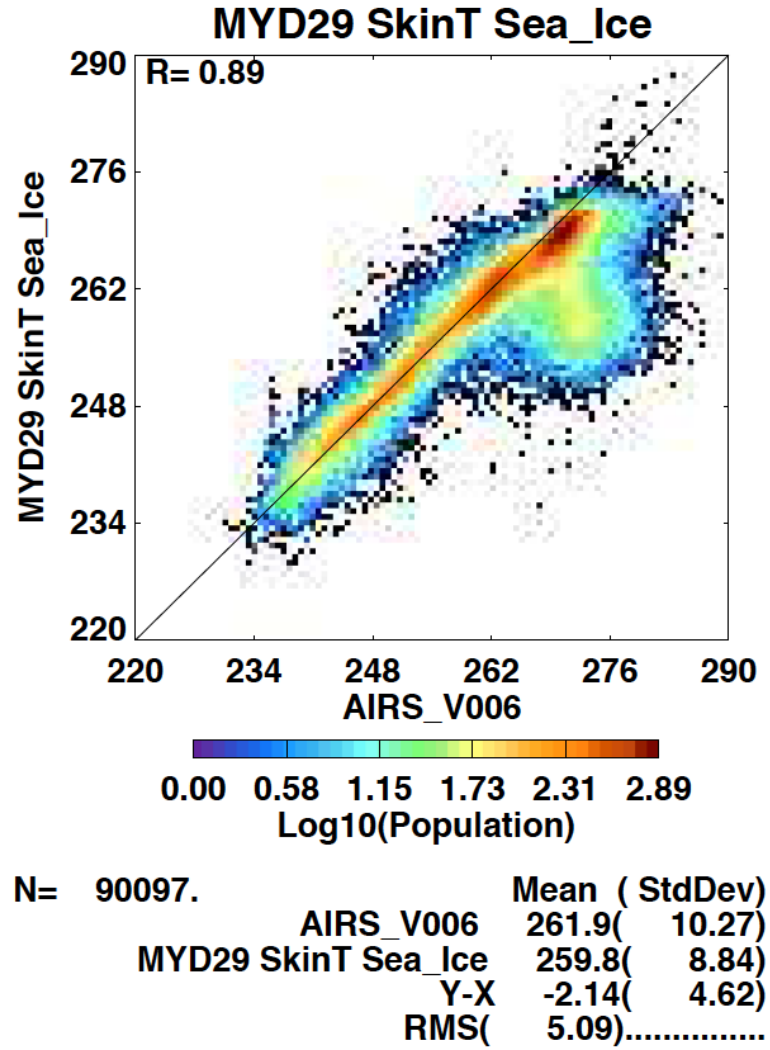


Tune



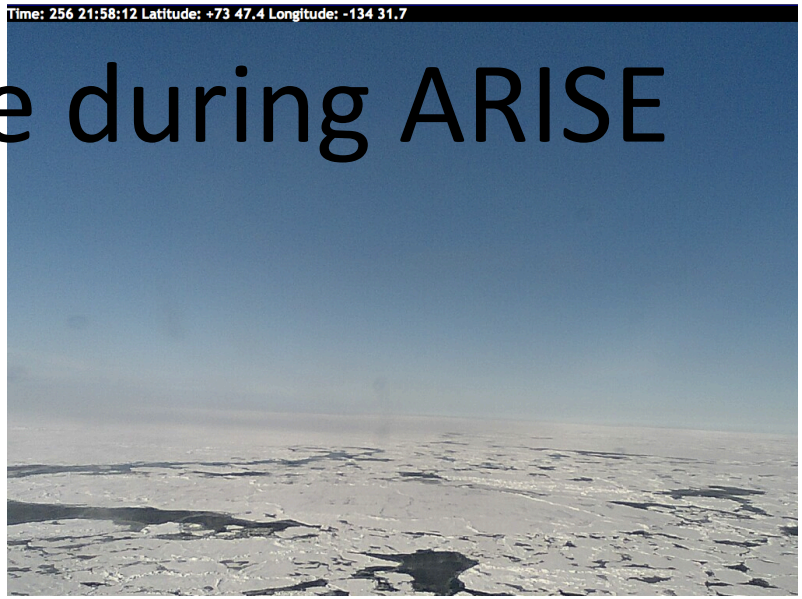
MODIS vs. AIRS

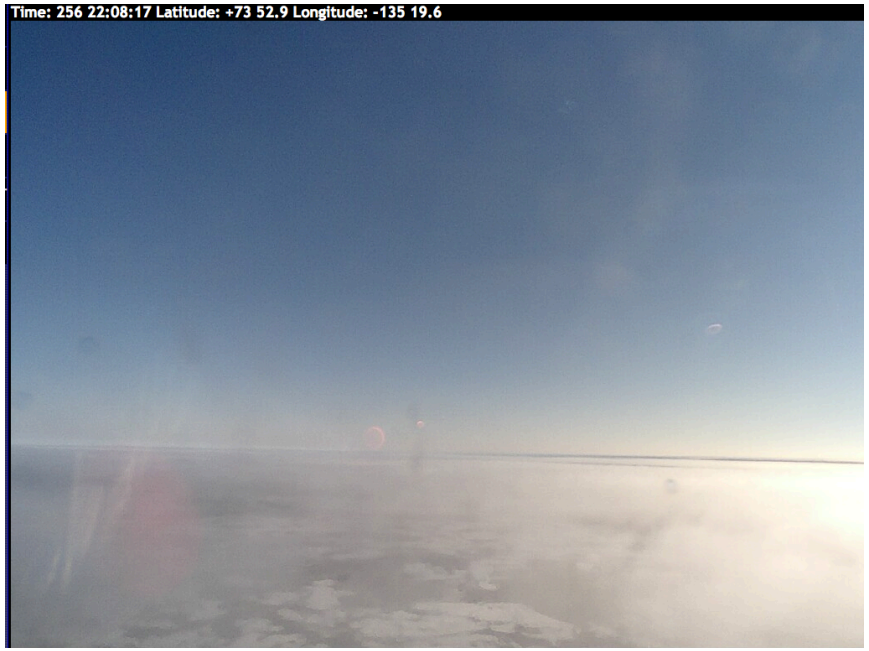


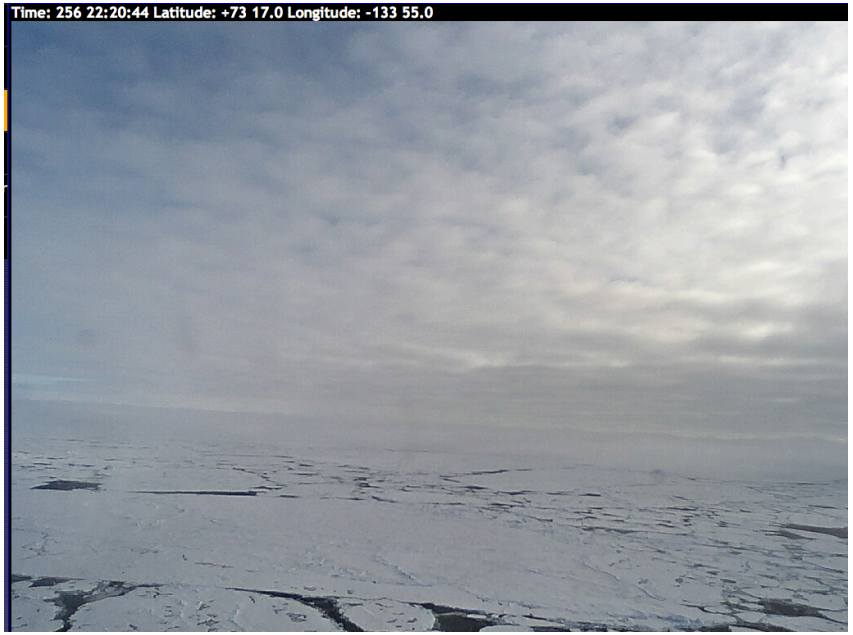


Ice free: MODIS skin temp is higher than AIRS skin temp by 2.0 K
Sea ice: MODIS skin temp is lower than AIRS skin temp by 2.1 K
Broke sea ice is an issue?

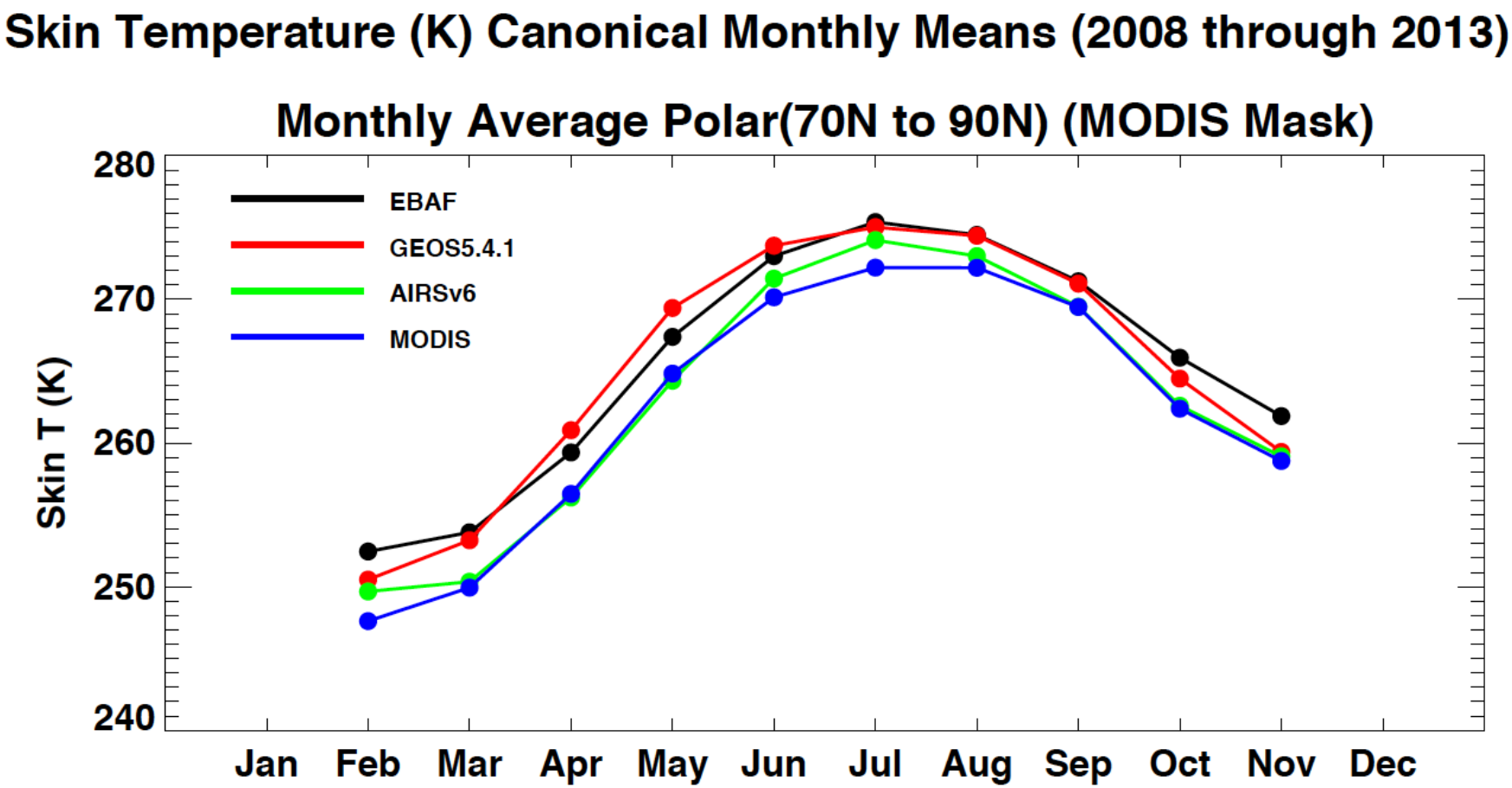
September sea ice during ARISE







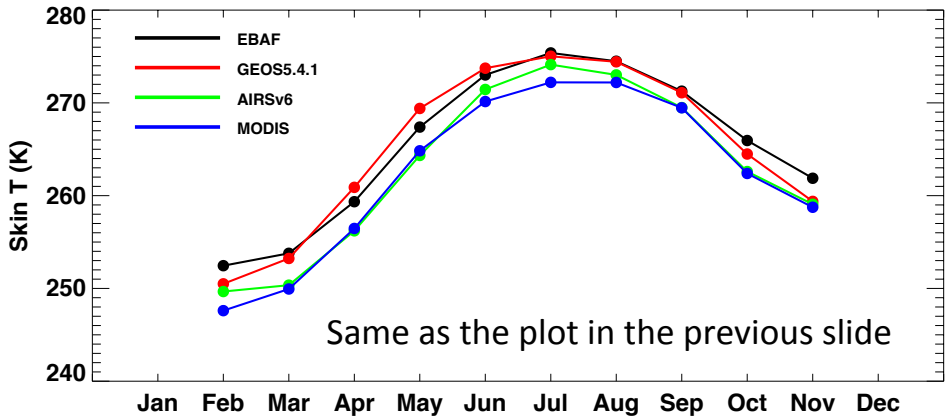
Summary (sea ice and open water mix)



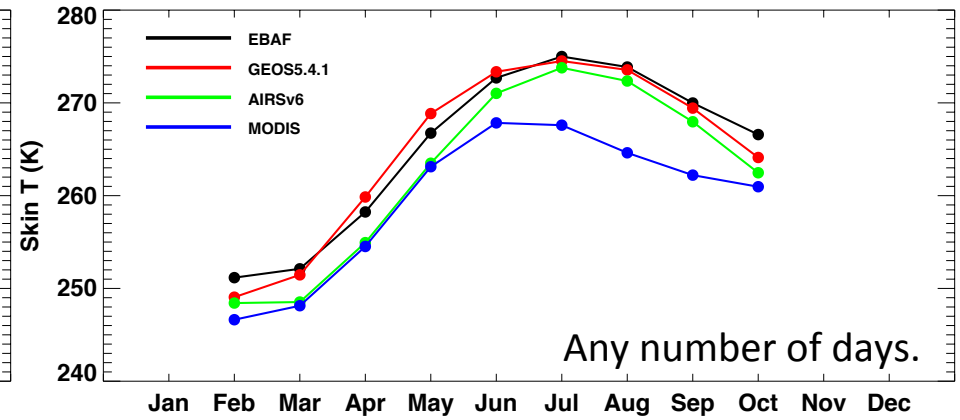
Can we do sea ice and open water separately with MODIS mask?

Canonical Monthly Mean Surface Skin Temperature
Arctic Averages (70N-90N)
Jan 2008 through Dec 2013

MODIS mask, Ice and or Ocean

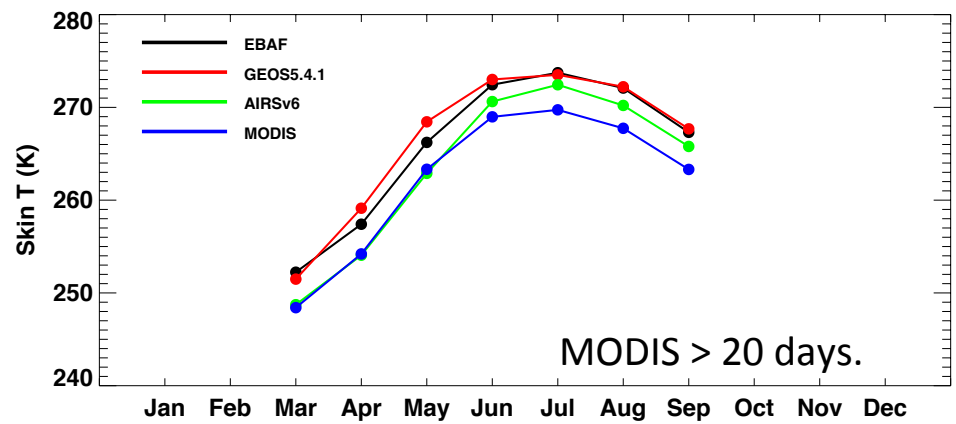


MODIS mask: Ice Only in Grid Box



Tuning makes sea ice skin temperature closer to AIRS in spring when MODIS and AIRS-derived skin temperature agree

MODIS mask: Ice Only in Grid Box



Canonical Monthly Mean Surface Skin Temperature
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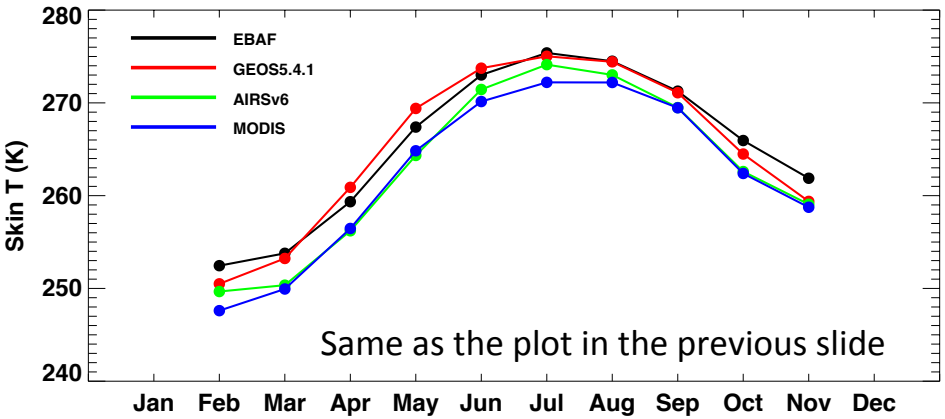
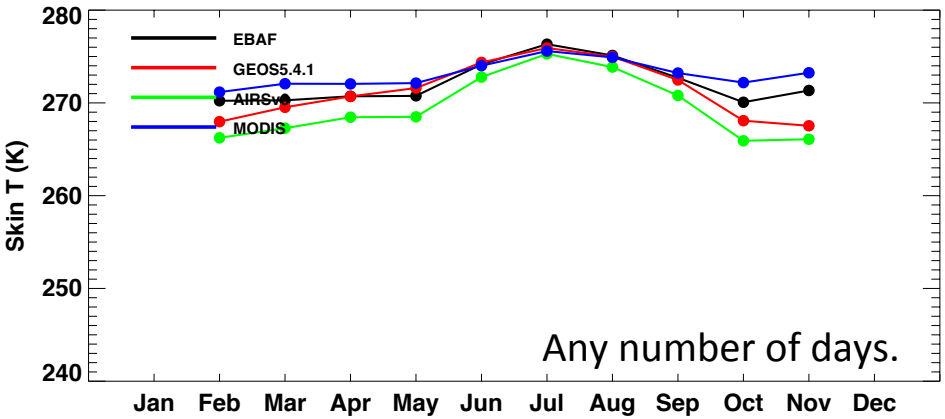
MODIS mask, Ice and or Ocean

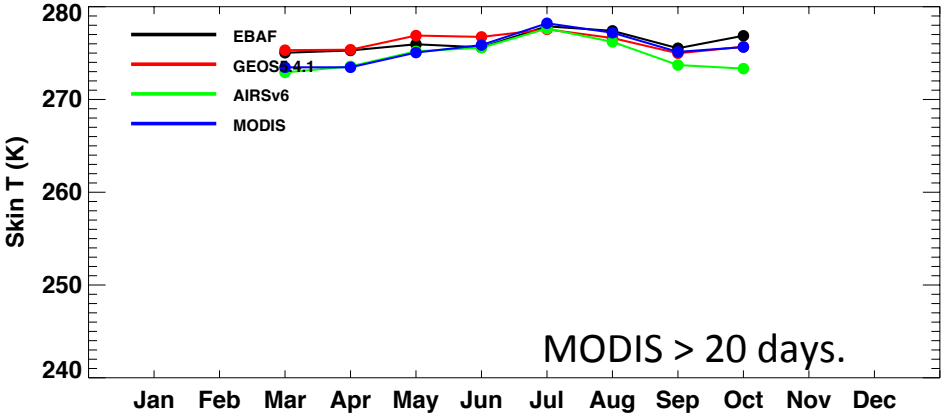


MODIS mask: Water Only in Grid Box



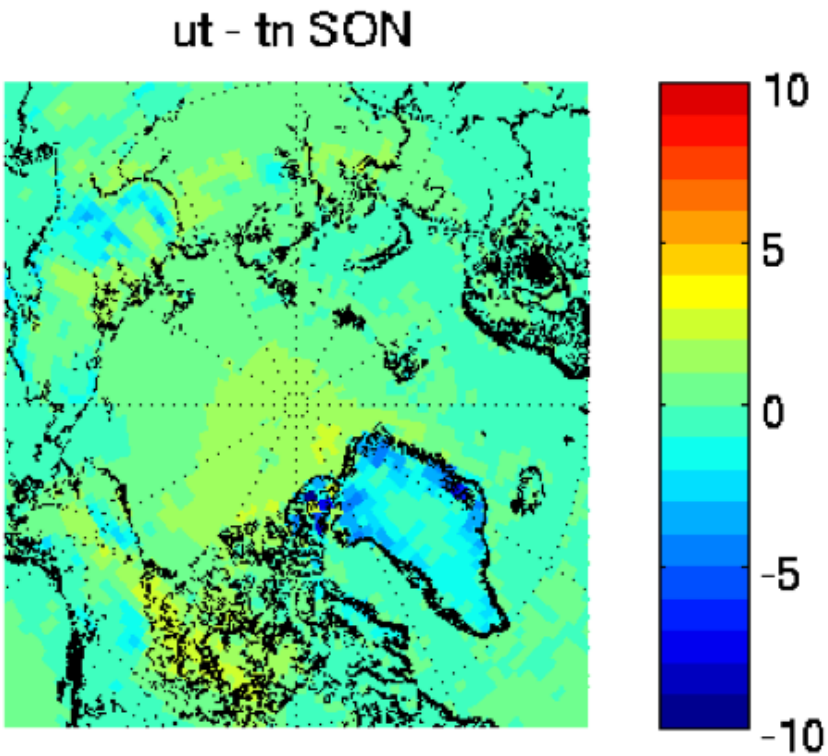
EBAF Open water skin temperature agrees with MODIS-derived skin temperature in summer and spring

MODIS mask: Water Only in Grid Box

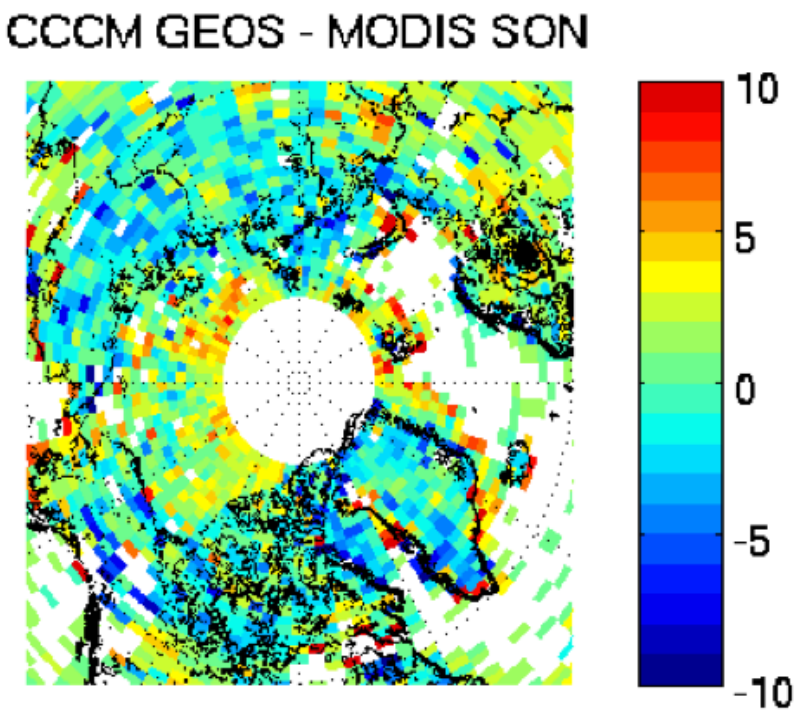


Evaluation of tuning for G52 period (SON, year??)

Untune - Tune



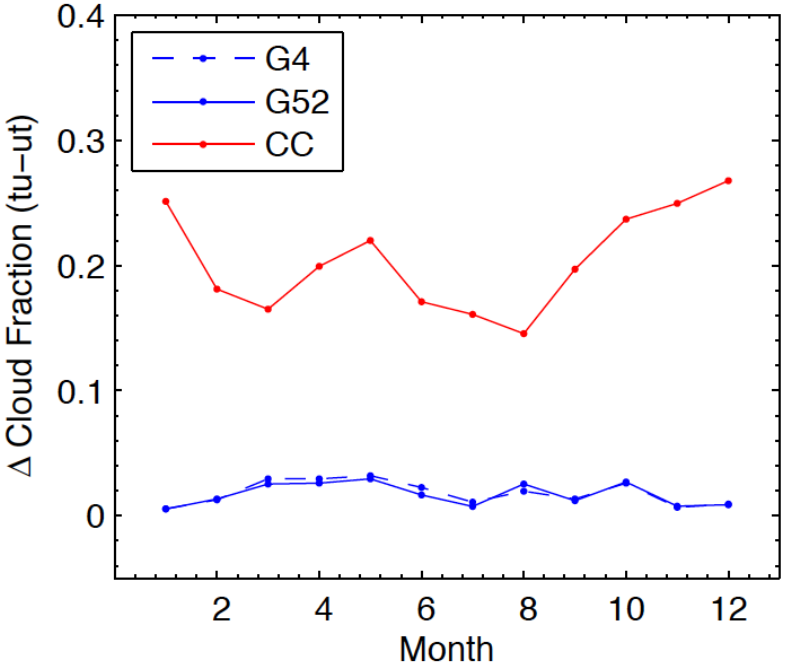
G52 skin temp – MODIS derived skin temp under clear conditions according to CALIPSO



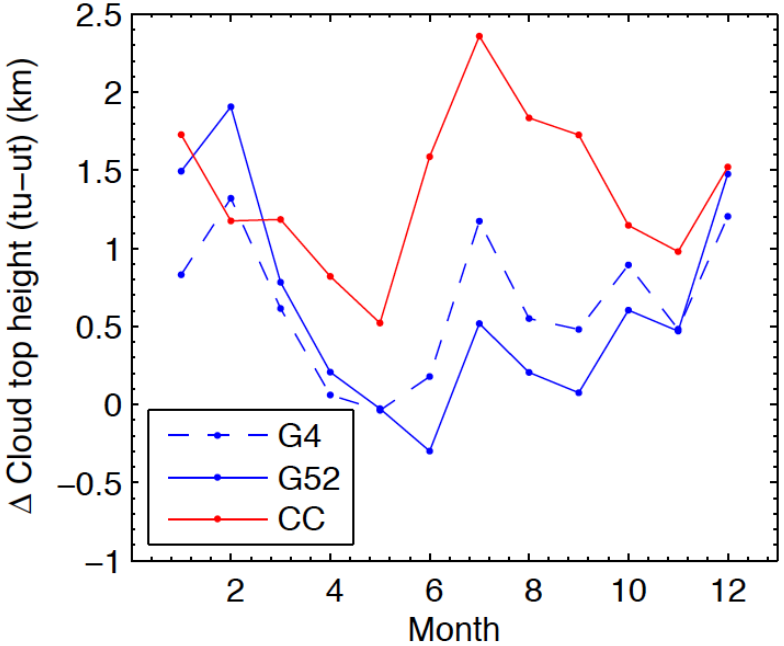
Tuning reduces the surface skin temperature

Cloud fraction and tip height adjustments

Cloud fraction adjustment 70N to 83N
Tune - Untune

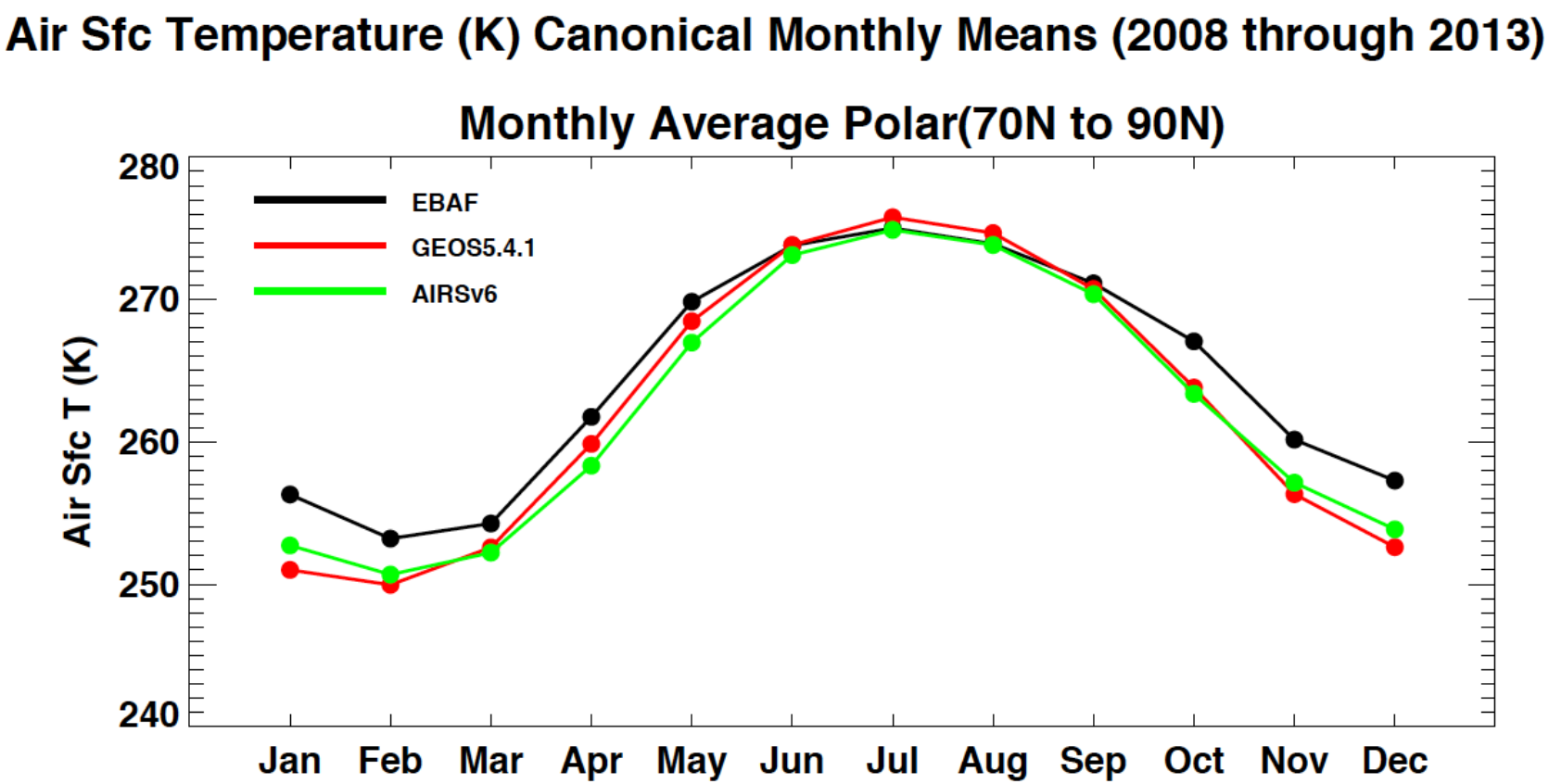


Cloud top height adjustment 70N to 83N
Tune - untune



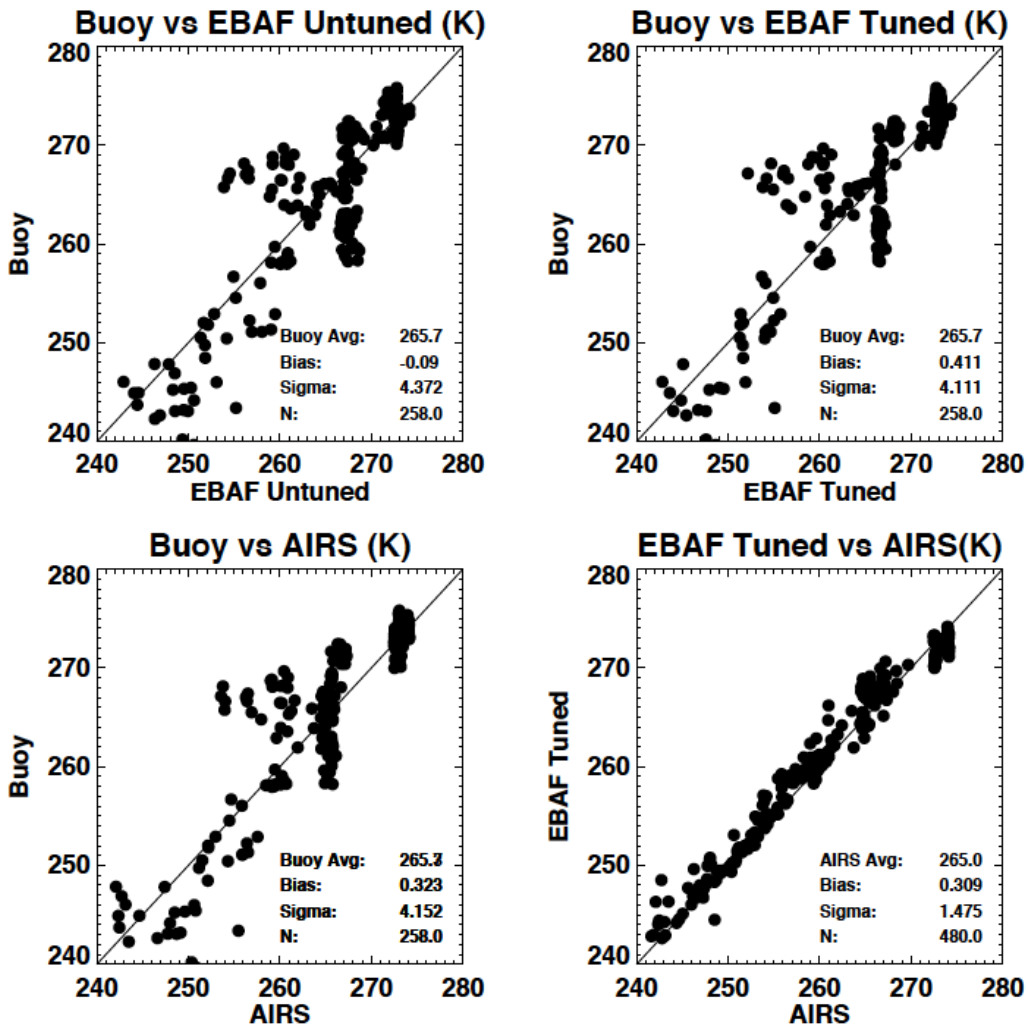
G4: GEOS 4 period 200607 - 200712
G52: Geos 5.2 period 200801 – 201012
CC: CALIPSO/CloudSat - MODIS

Surface air temperature



2007 & 2008 IPY: DAMOCLES Drift Buoy Surface Air Temperature Comparisons to EBAF Untuned and Tuned & AIRSv6 data.

Buoy values represent 'monthly means' for length of time they were in a CERES equal area grid box. All comparisons here include at least 200 hours of observations in a CERES grid box to make the plot. Those hours, though rare, can be from separate buoys. Tuning does reduce the standard deviation of the surface air temperature w.r.t. observations, particularly at lower temperatures, though bias does increase.



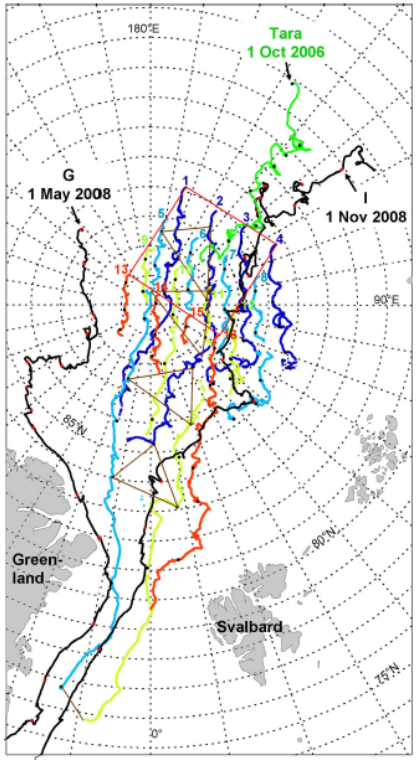
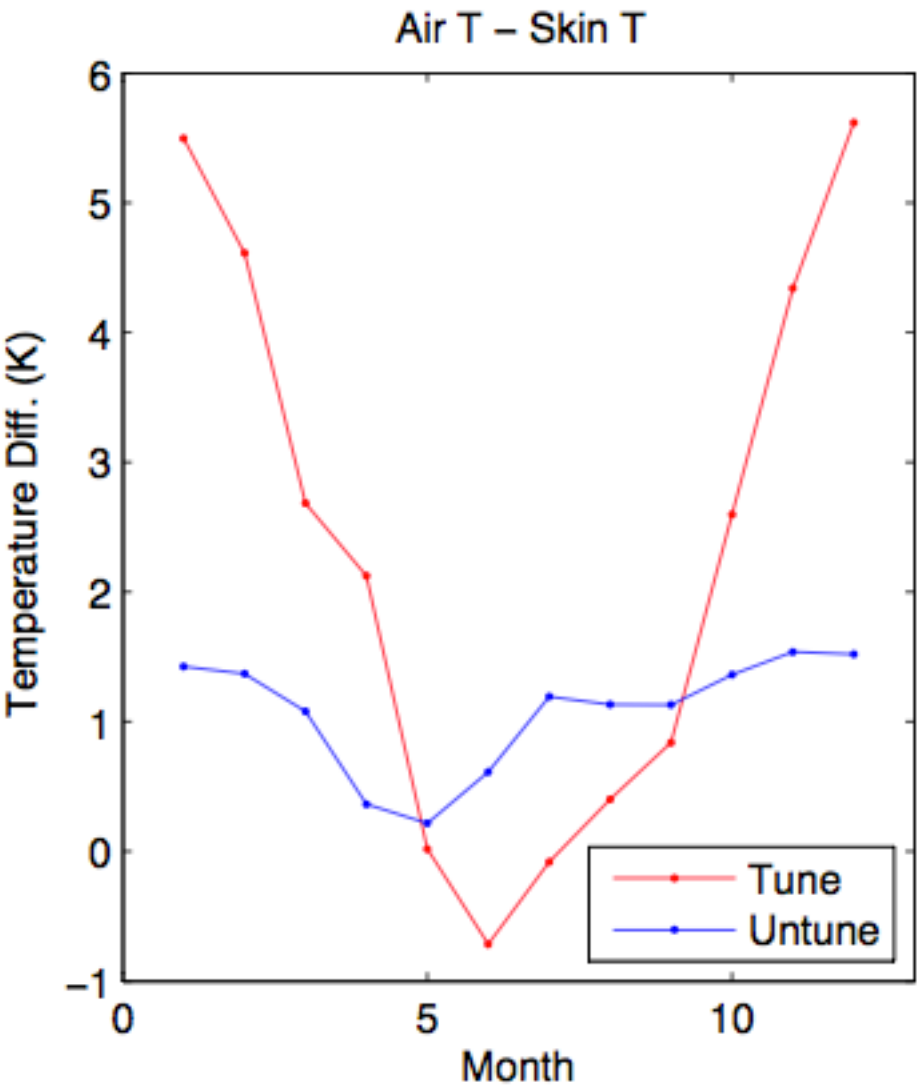


Fig. 4. Drift trajectories of all 16 D07 CALIB buoys, the French sailing vessel *Tara* (green), and the D08 PAWS buoys G and I (black). Dots in trajectories mark buoy position on first day of each month. Red square surrounds the D07 buoy array at the beginning on 24 April 2007. For a better visualisation of the ice motion the position of the buoy triangle 2-5-11 is given in 2 months intervals on 1 May, 1 July, 1 September, and 1 November 2007.

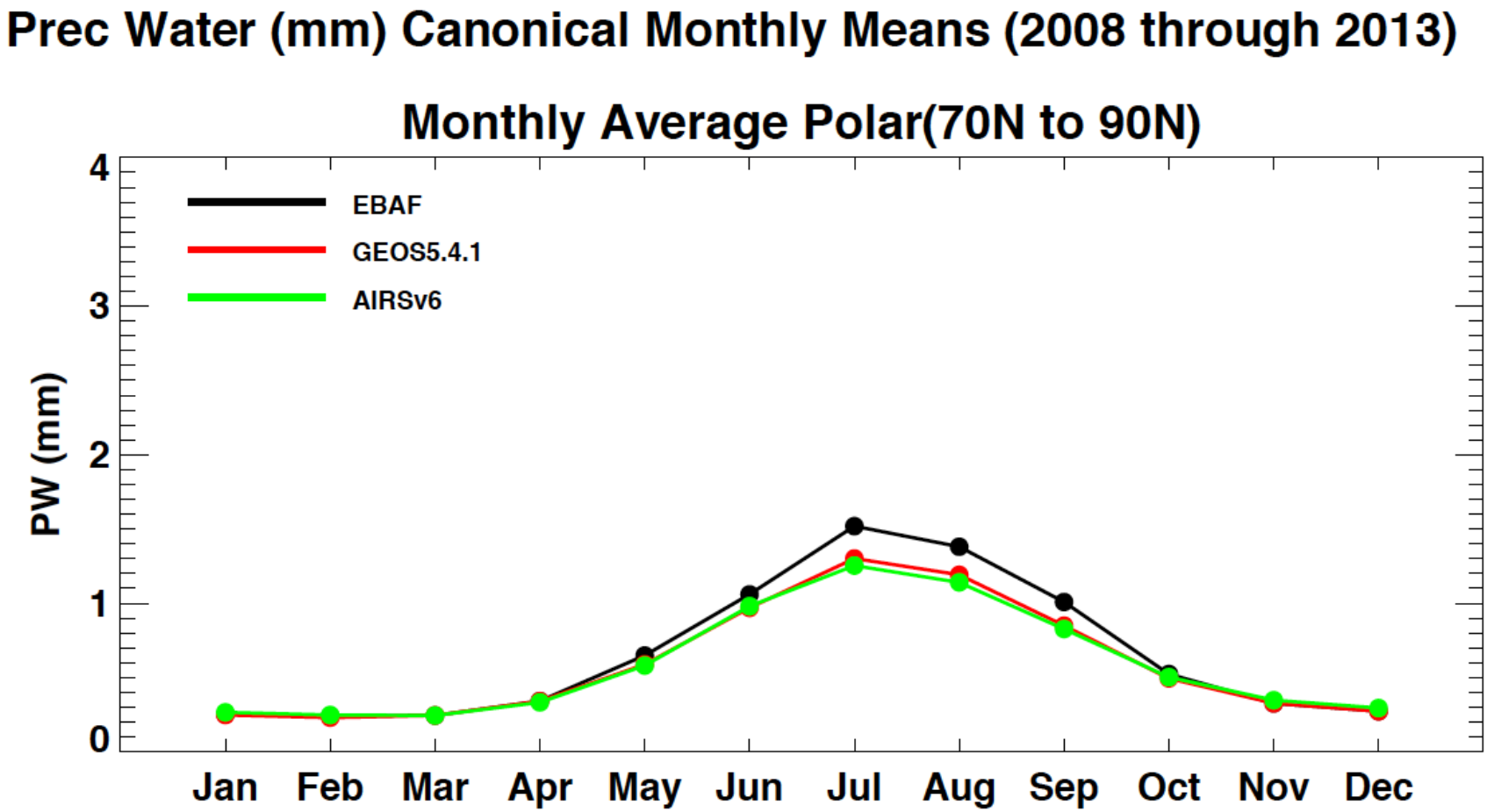
Haller et al. 2014

Surface air and skin temperature difference (70N to 90N mean)



During the cold episodes, the daily surface temperature at SHIBA could be as much as 5C lower than tat the 10-m level (Persson et al. 2002)

Precipitable water



Arctic skin and air temperature Summary

- Mean and RMS difference of AIRS and MODIS-derived skin temperature over sea ice are 2.1 K and 5.1 K, respectively. (1.3 RMS difference given by Hall et al.)
- Tuning reduces the skin temperature over sea ice
- Tuning brings the skin temperature to a closer agreement with MODIS-derived skin temperature, especially spring and summer.
- Mean and RMS difference of AIRS and MODIS-derived skin temperate over open water are 0.7K and 1.7 K, respectively.
- Tuning increases surface air temperature and skin temperature differences (Tair > Tskin)

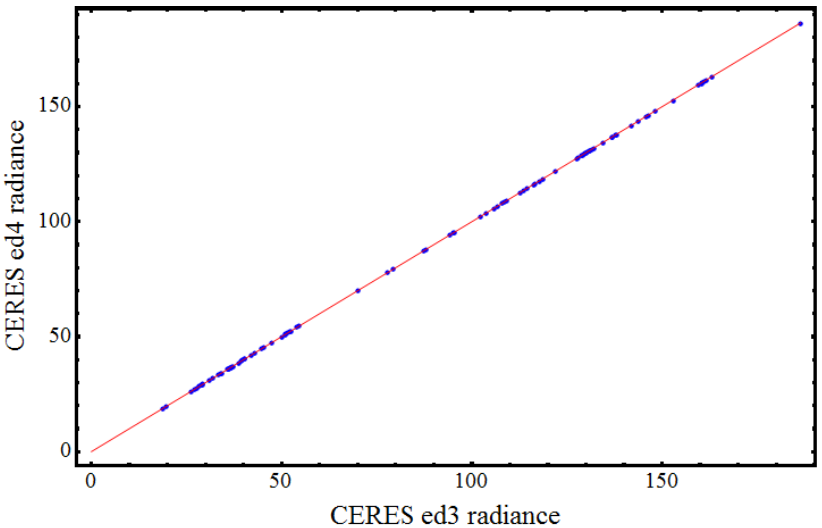
Future comparison

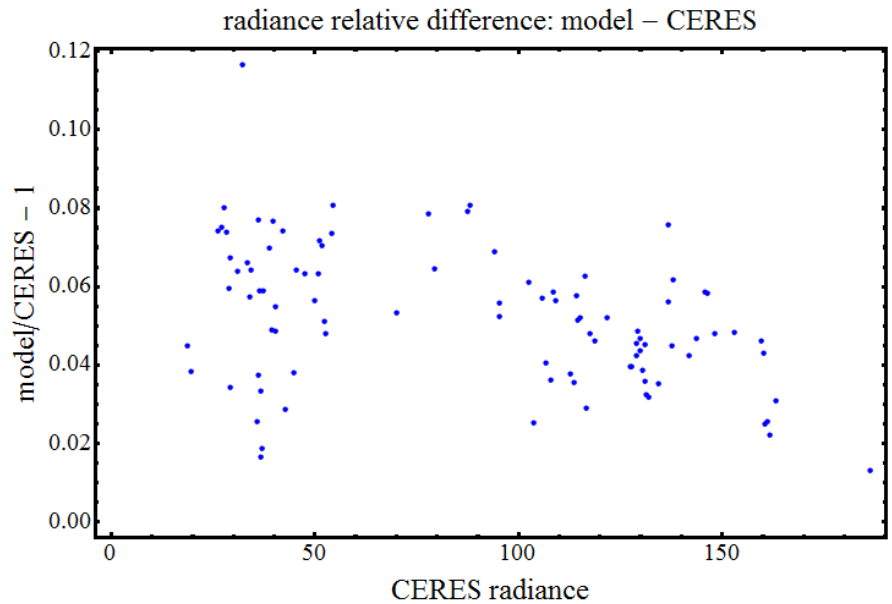
- Temperature and humidity comparison will be extended to other regions (MAGIC, DYNAMO, and other field campaign data).
- MERRA2 versus GEOS-5.4.1 (collaboration with GMAO)
- Multiple reanalyses (MERRA2, ERA-Interim, JRA-55, GEOS-5.4.1, etc.) and observations (AIRS) for an ensemble approach (determine discontinuity)

Radiance comparison over Dome-C

Modeled and observed SW Radiance comparison over Dome-C

Aqua FM-4



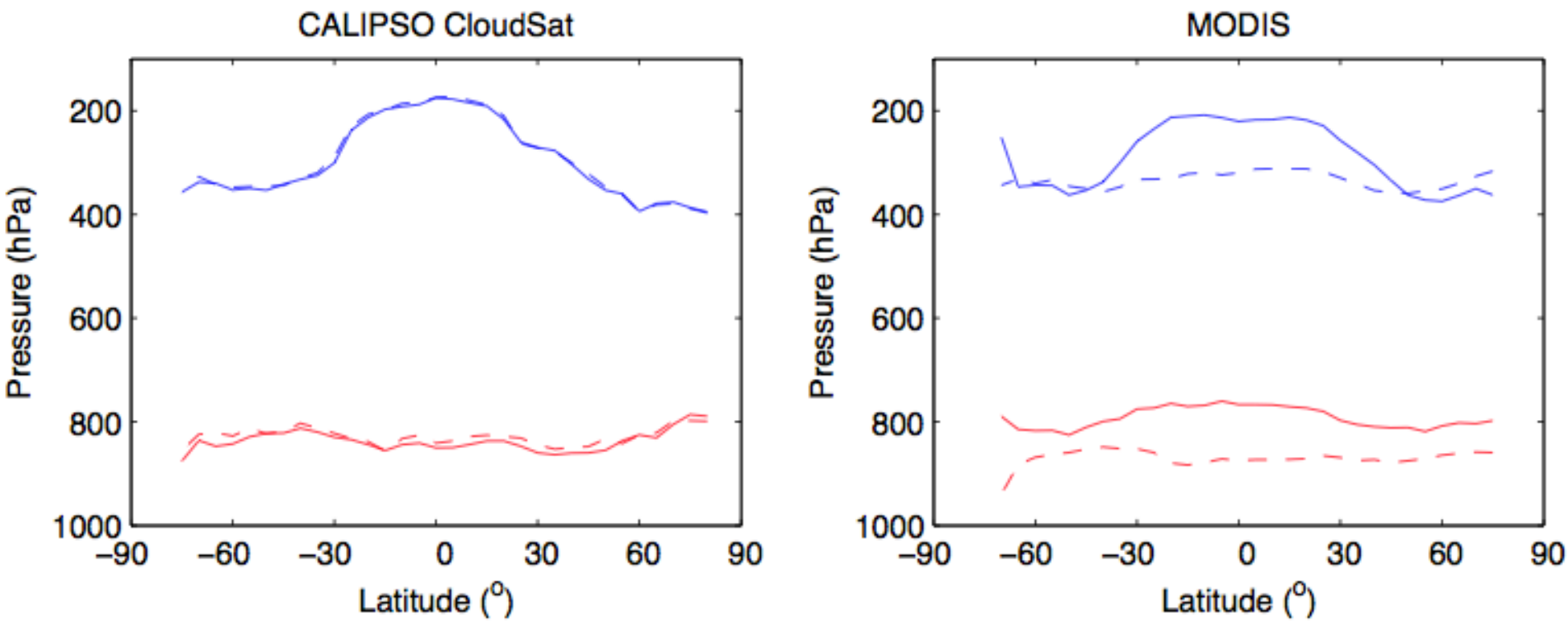


Modeled radiance = slope * CERES radiance

	Ed3		Ed4	
	Terra	Aqua	Terra	Aqua
Slope	1.0531	1.0454	1.0462	1.0468

Evaluation of Ed4 SSF multi-layer cloud

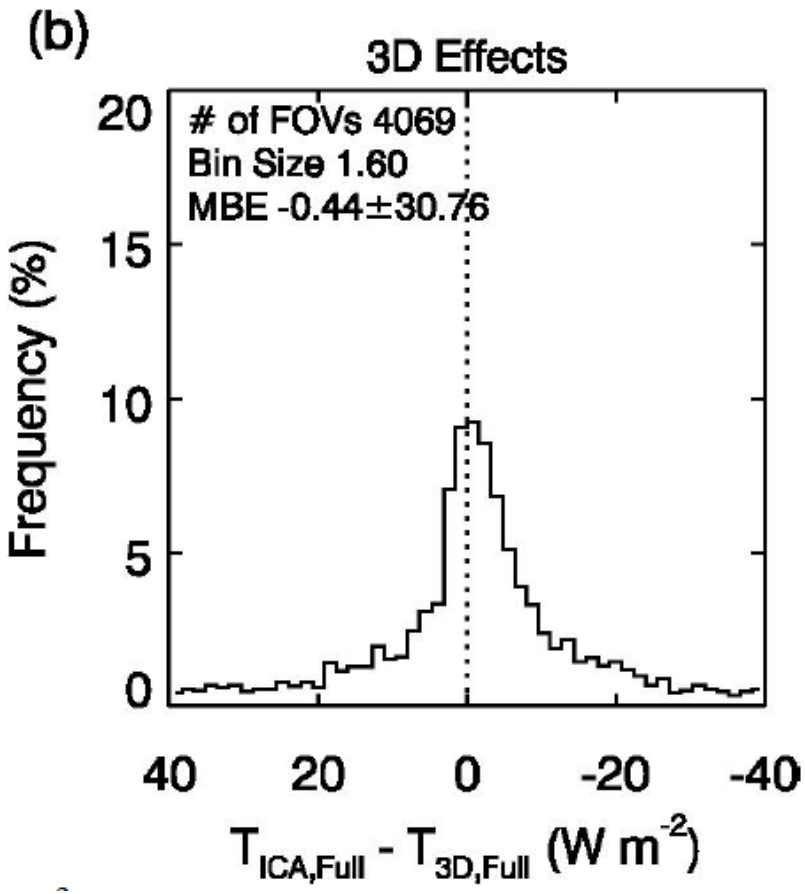
Multi-layer cloud height (over ocean)



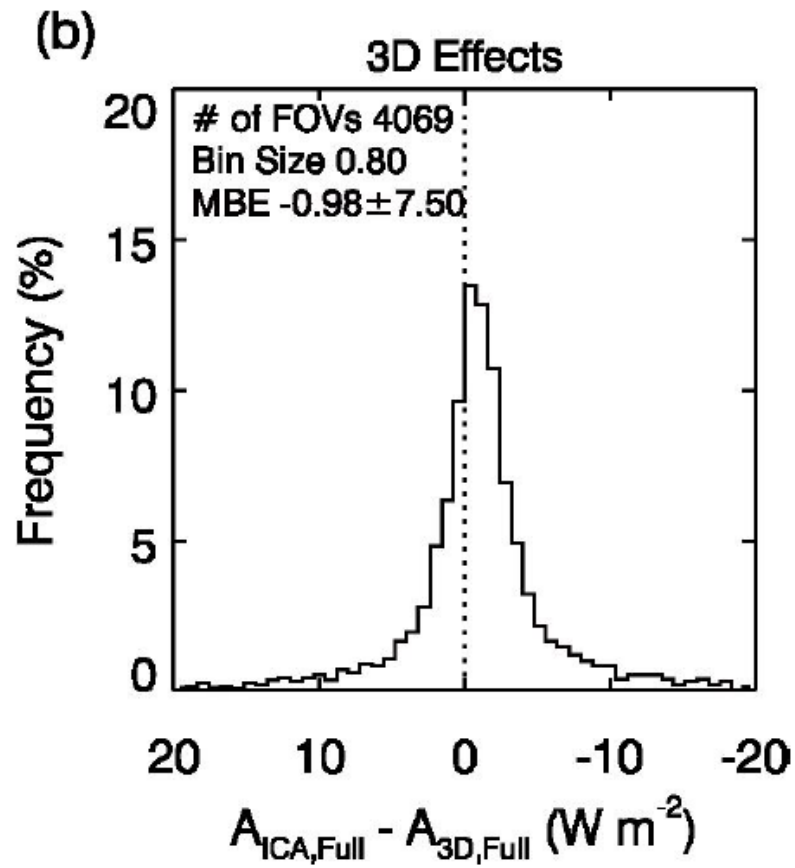
Solid line: Single layer high and low-level clouds
Dashed line: Multi-layer high and low-level clouds

3D effect on the instantaneous Surface and Atmospheric irradiances

Downward Surface Irradiance



Absorbed irradiance by atmosphere



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List of publications

- Ham, S.-H., S. Kato, H. W. Barker, F. G. Rose, and S. Sun-Mack (2014), Effects of 3-D clouds on atmospheric transmission of solar radiation: Cloud type dependencies inferred from A-train satellite data, *J. Geophys. Res. Atmos*., 119, doi:10.1002/2013JD020683.
- Rutan, A. D., with S. Kato, D. Doelling, F. Rose, C. Nguyen, T. Caldwell, and N. G. Loeb, 2014; CERES synoptic (SYN) surface radiant flux product: Methodology and validation, submitted to *J. Atmos. Oceanic. Technol*.
- Ham, S.-H., S. Kato, H. W. Barker, F. G. Rose, and S. Sun-Mack (2014), Improving the modeling of shortwave radiation through the use of a 3D scene construction algorithm, submitted to *Q. J. Royal Meteorol. Soc*.