Evaluation of GEOS products with Ed4 SYN and EBAF

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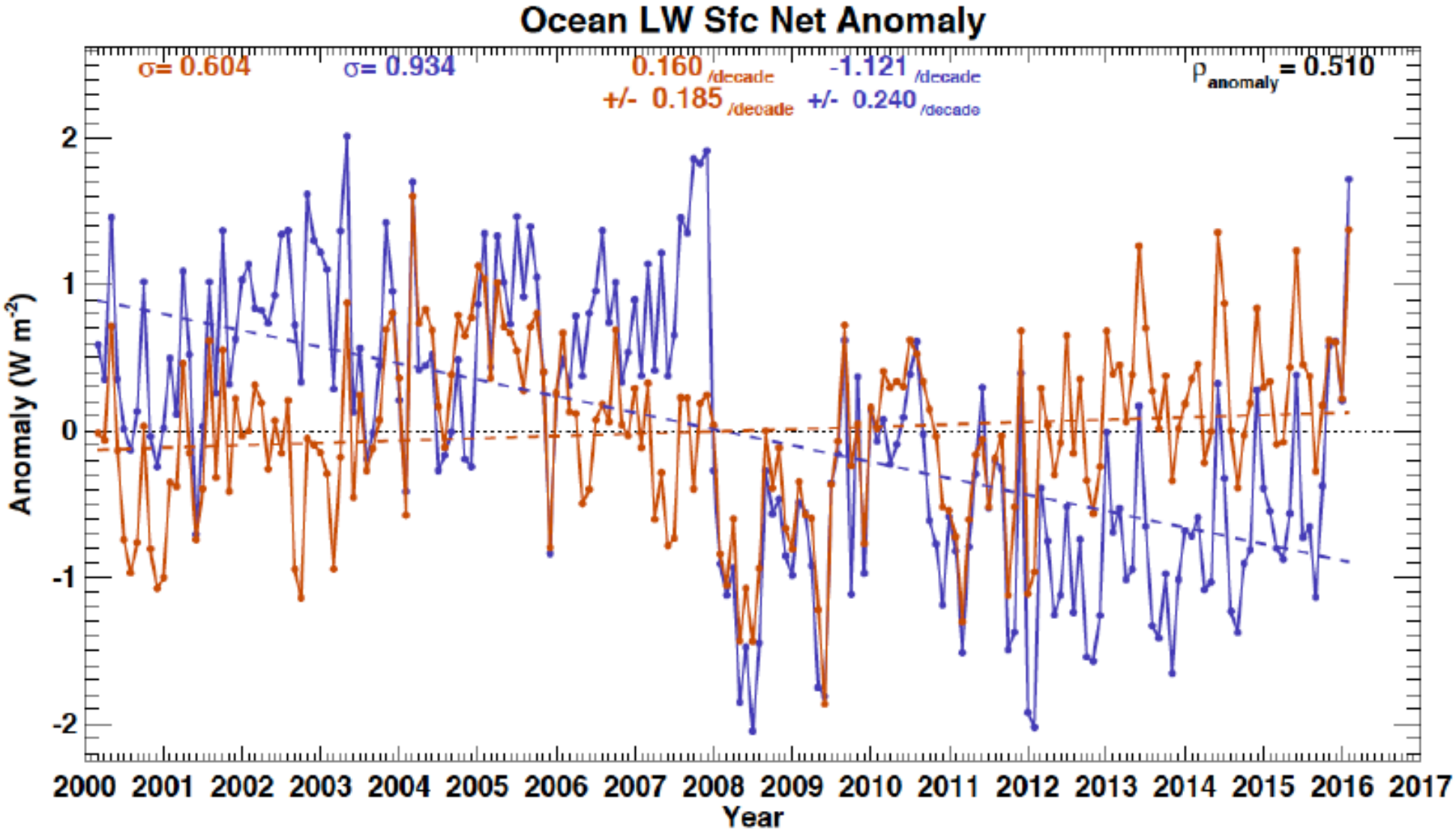
CERES Science team meeting
September 26-28, 2017
Goddard Space Flight Center, Greenbelt, MD

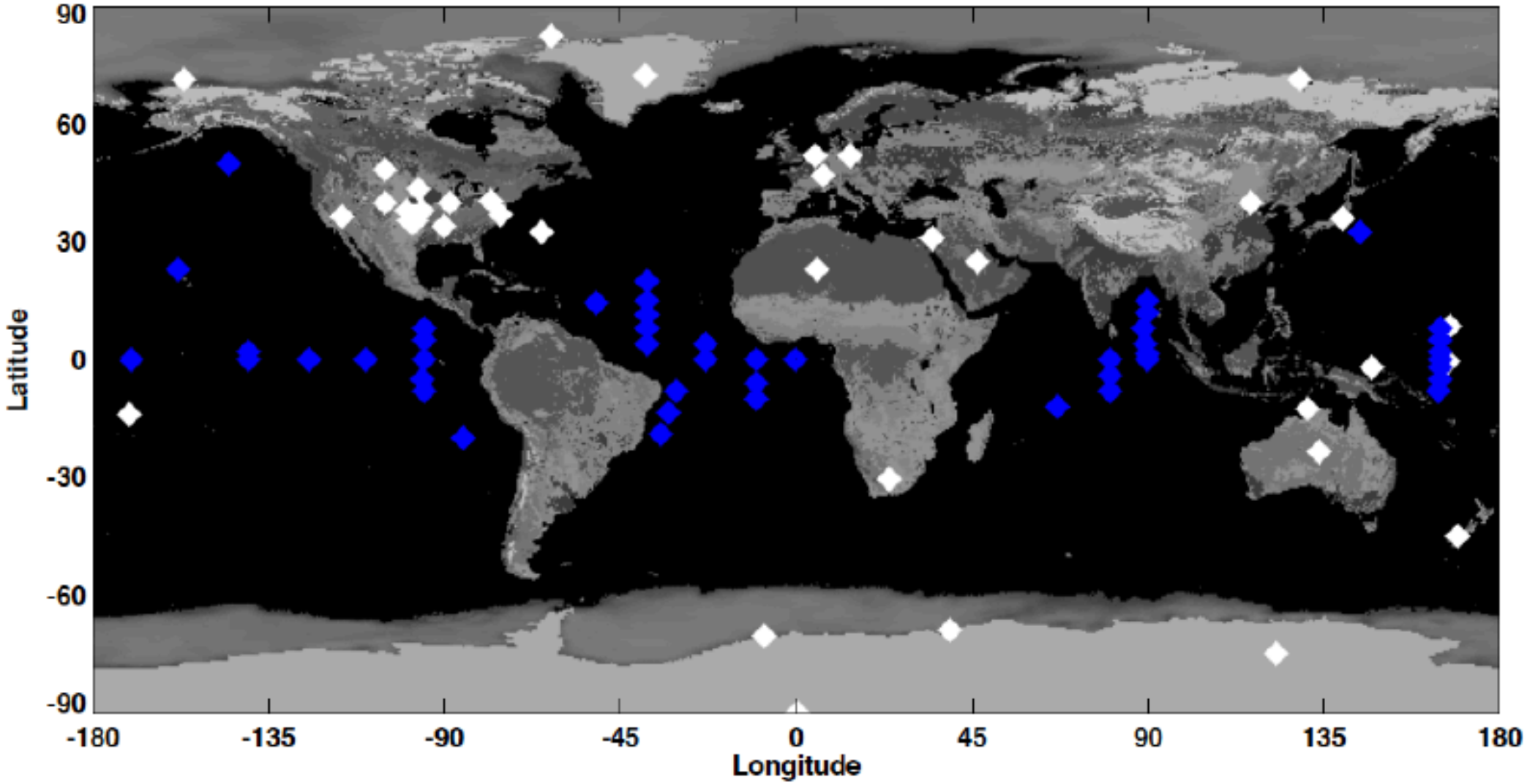
Surface downward longwave irradiance Ed2.8 vs. Ed4.0



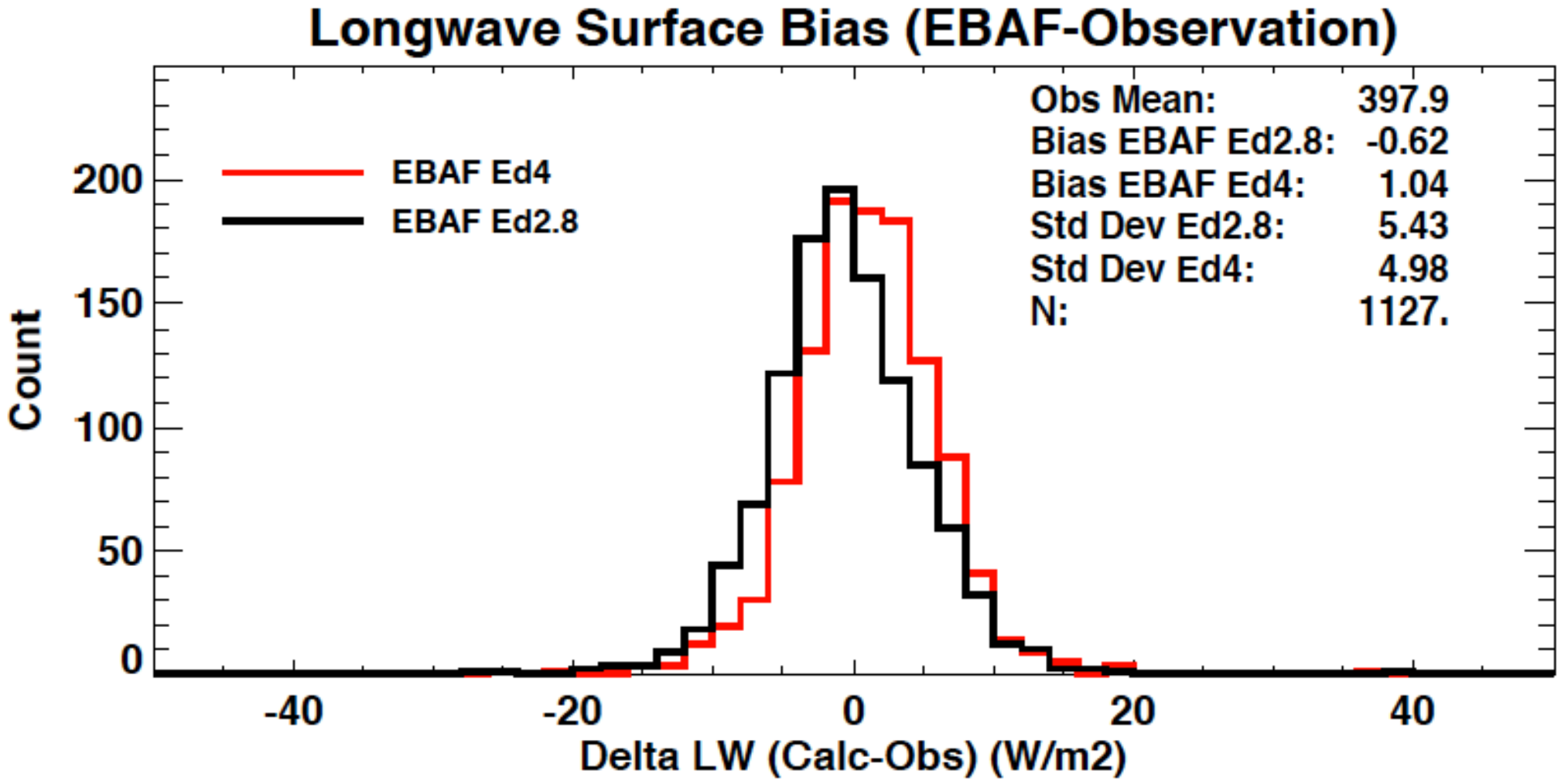
Outline of this talk

- Mean downward longwave irradiance bias over ocean and land
- All-sky surface downward longwave irradiance evaluation with surface observations
  - Other variables (cloud fraction and base height) affect the longwave but temperature and humidity are significant driver of surface longwave irradiances.
- Variables need to be improved
  - Upper tropospheric humidity
  - Near surface temperature and humidity over polar regions
  - Skin temperature over land

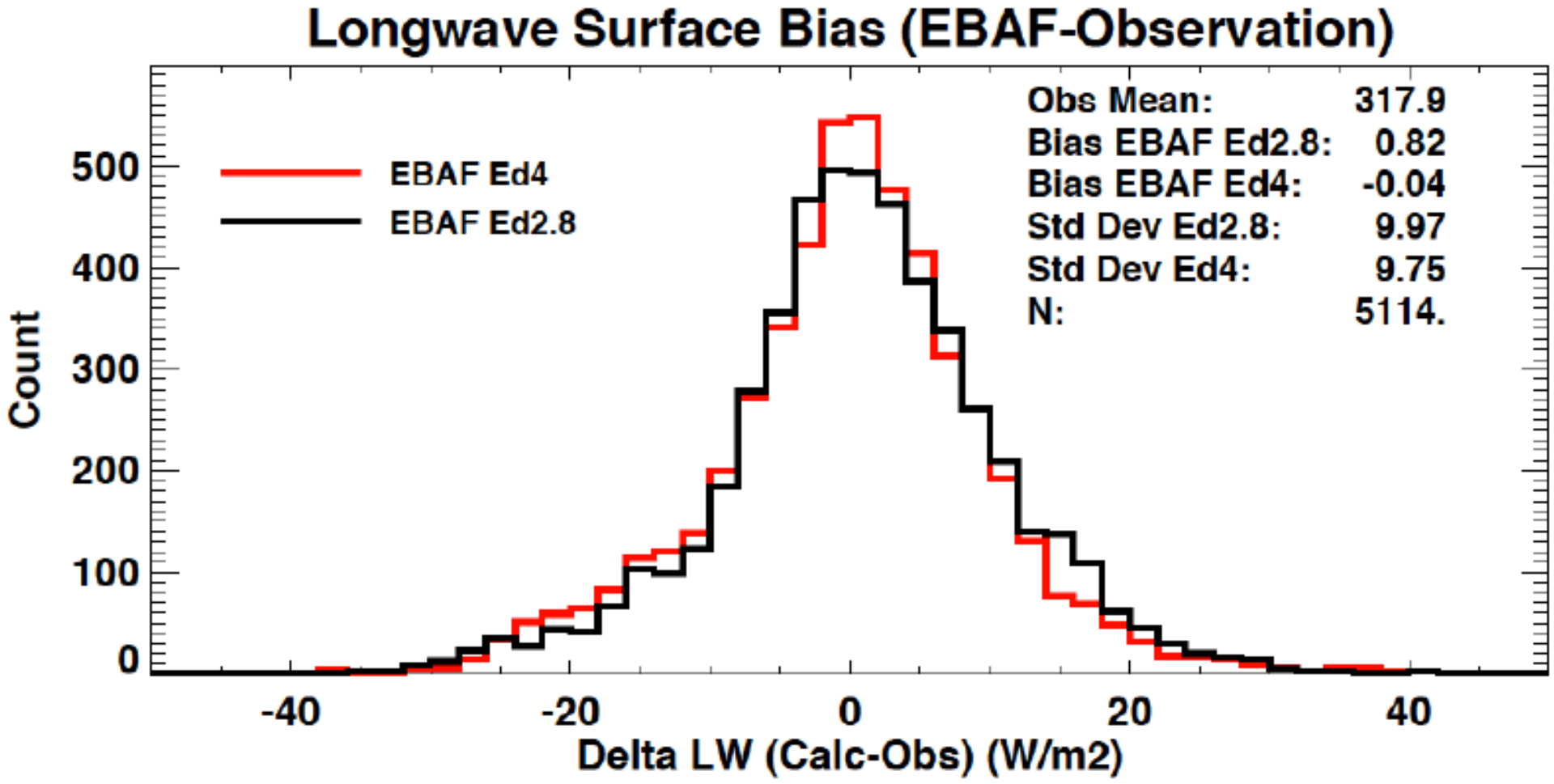
Surface validation sites



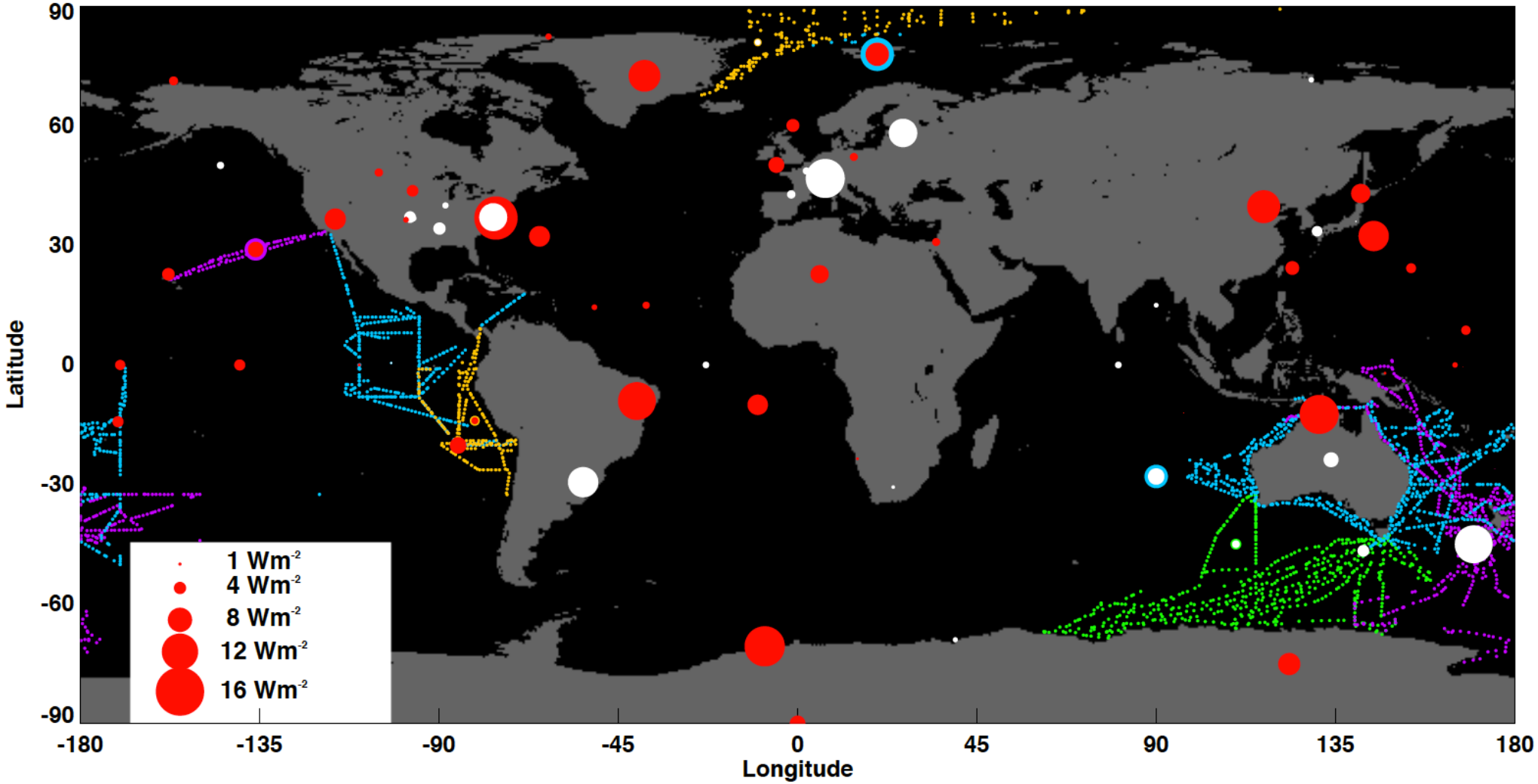
Monthly mean surface downward longwave irradiance comparisons (ocean)



Monthly mean surface downward longwave irradiance comparisons (Land)



Surface downward longwave irradiance bias (Ed4 SYN – Obs.)



Red: positive
White: negative

Blue open circle
Ship data

Relatively large LW bias:
Greenland Summit
N-Ice2015

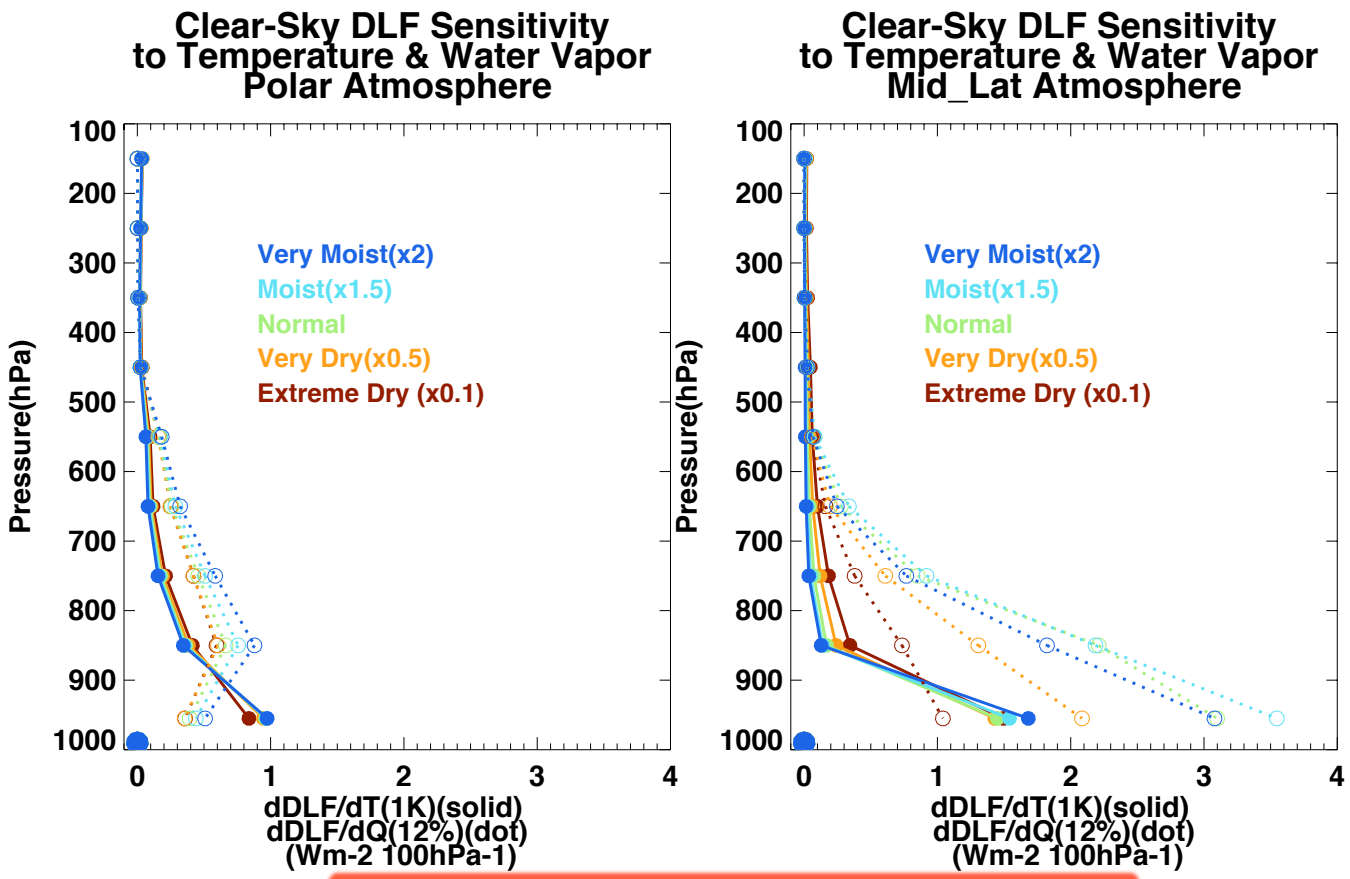
Subtropical ocean (MAGIC, WHOI and Kuroshio buoys)

Clear Sky Surface Downward Longwave Sensitivity

Fu-Liou code for a wide range of temperature and water vapor conditions.

Clear DLF is most sensitive to lower troposphere T & Q , near surface has largest sensitivity.

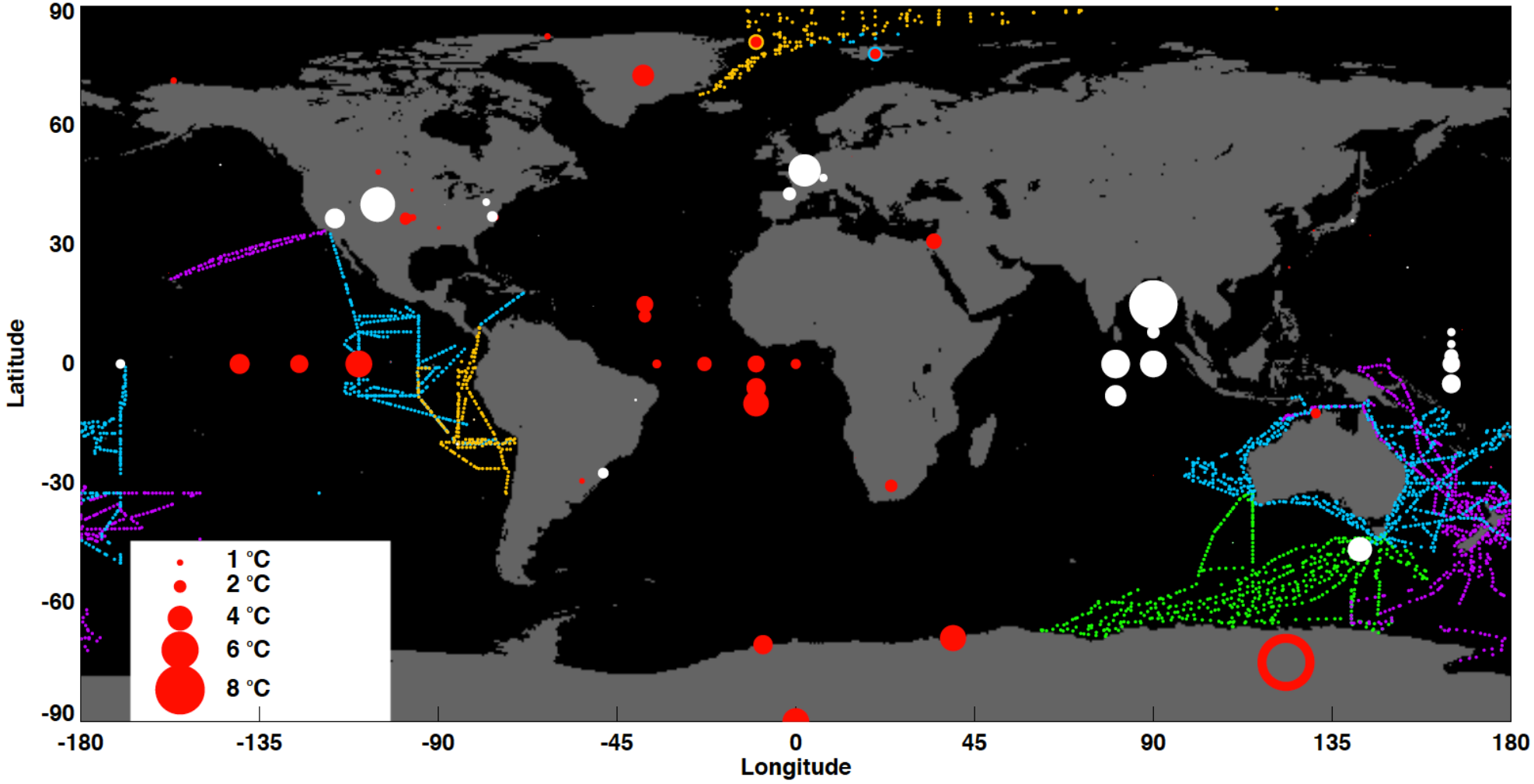
Later we adopt Dilley & O'Brien parameterization of Clear DLF sensitivity which uses surface air temperature and total precipitable water differences.



$$\Delta \mathrm{DLR} = 6\beta\left(\frac{T}{T_*}\right)^5\frac{\Delta T}{T_*} + \frac{1}{2}\gamma\left(\frac{w}{w_*}\right)^{-1/2}\frac{\Delta w}{w_*}. \qquad (2)$$

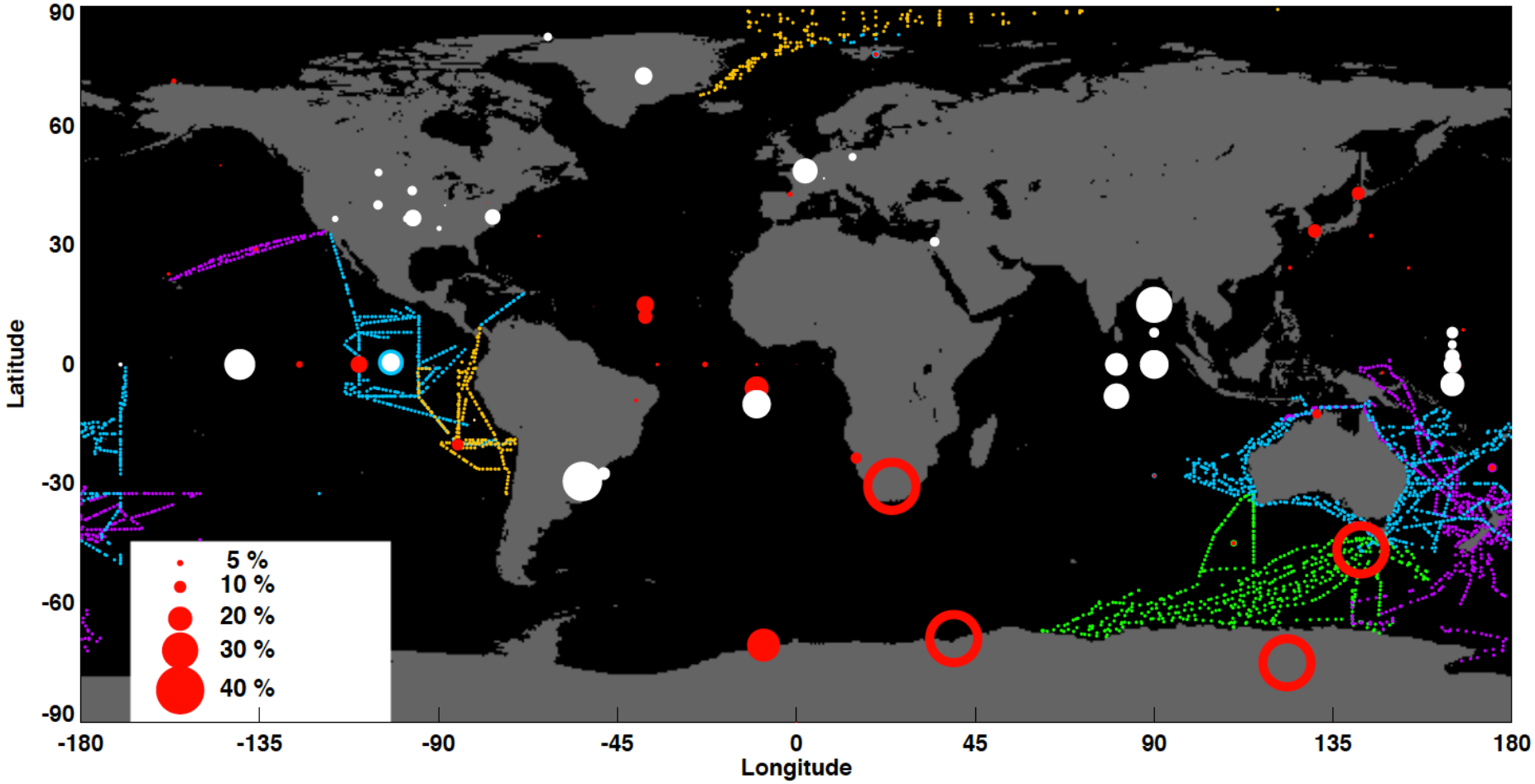
Rose 2015 spring CERES science team presentation

Near Surface Air Temperature (2 m) bias (GEOS-5.4.1 – Obs.)



Circles are scaled to Max bias: 7.8 °C
Red -> Positive Bias
White -> Negative Bias
Open Circle -> Bias > Max on Scale

Near surface (2m) Water vapor mixing ratio relative bias in % ((GEOS-Obs.)/Obs.)

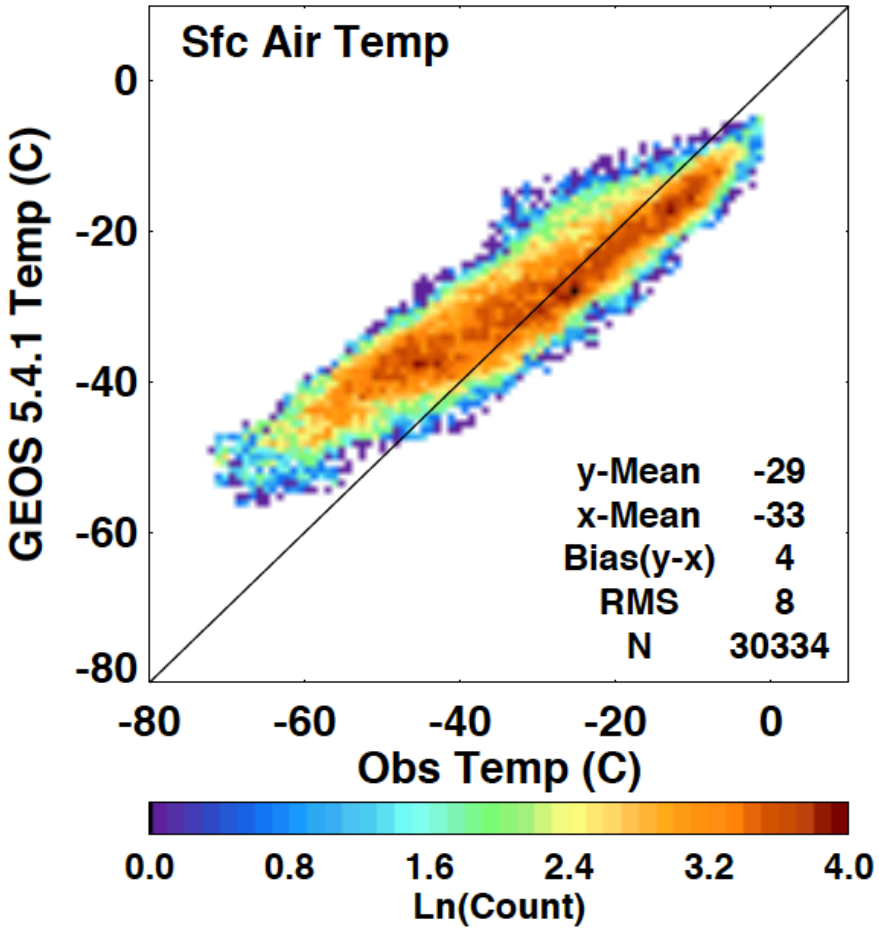


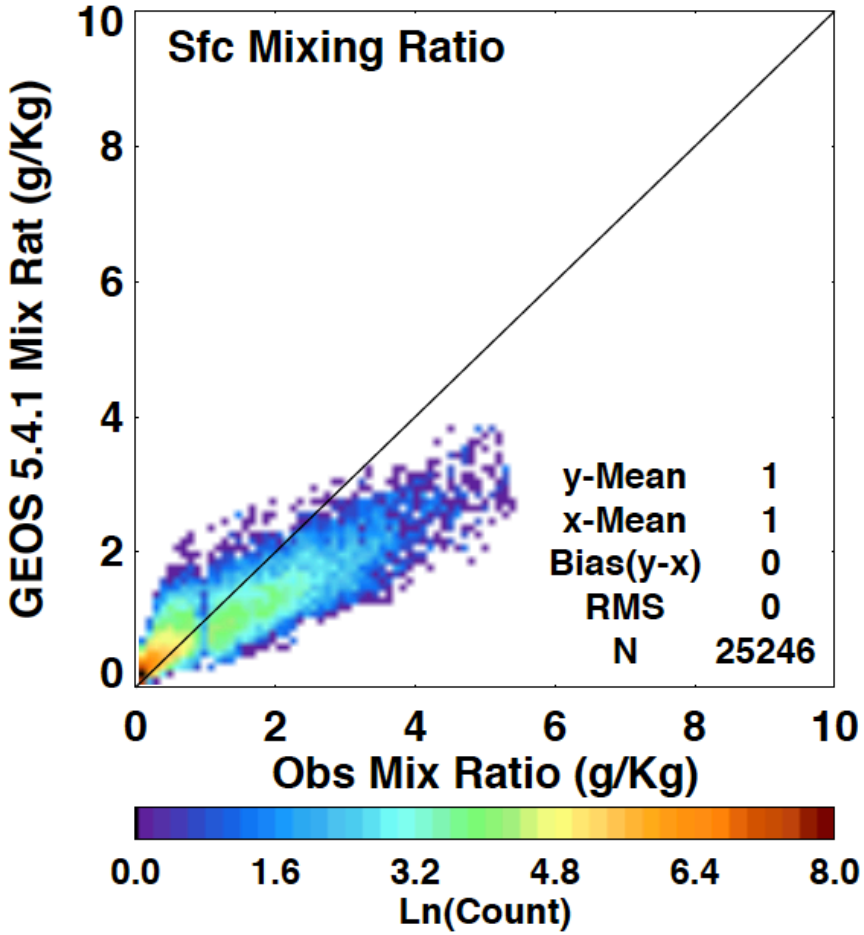
Circles are scaled to Max bias: 40. %
Red -> Positive Bias
White -> Negative Bias
Open Circle -> Bias > Max on Scale

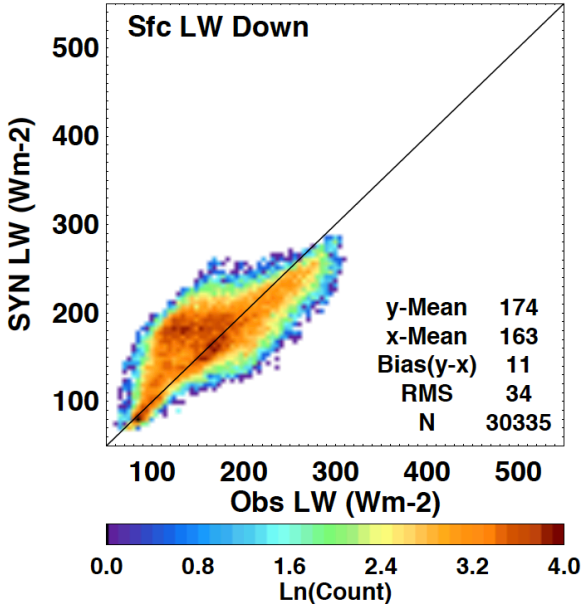
Sites with a large longwave bias

- Greenland summit
- N-ICE2015 (10 grid boxes)
- WHOI stratus buoy
- Kuroshio buoy
- MAGIC
- Australian Ship R/V Aurora Australis (532 grid boxes)

Greenland Summit





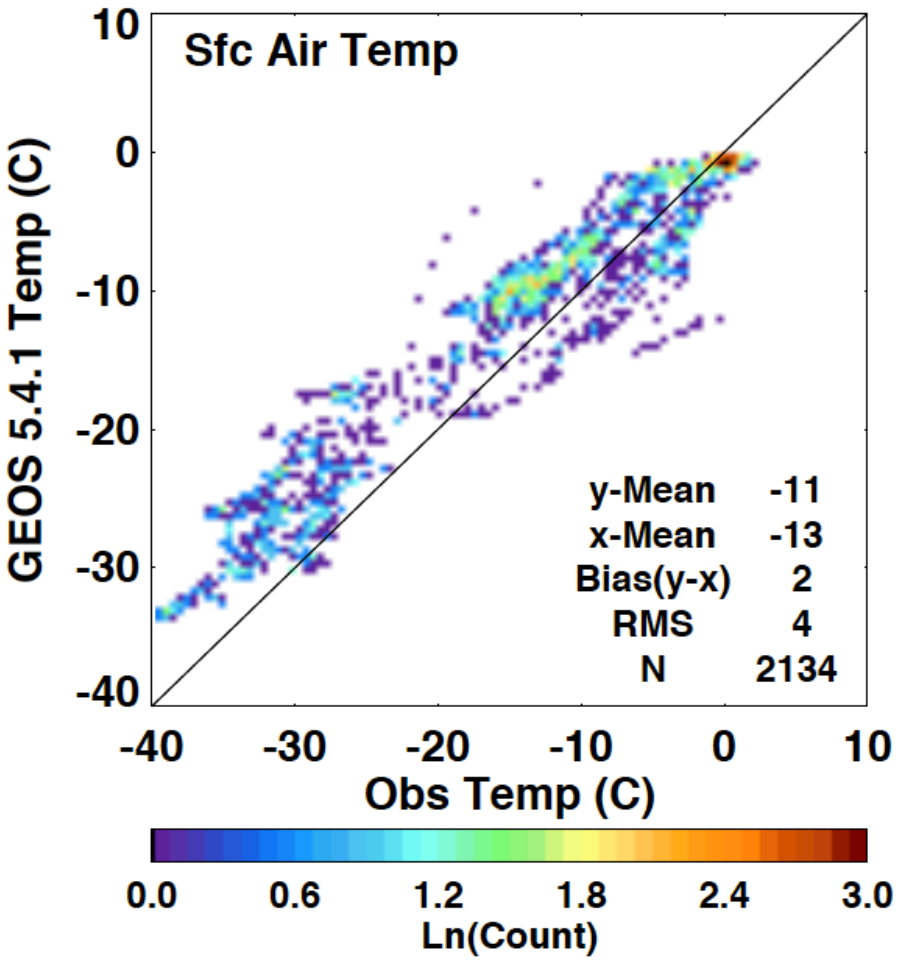


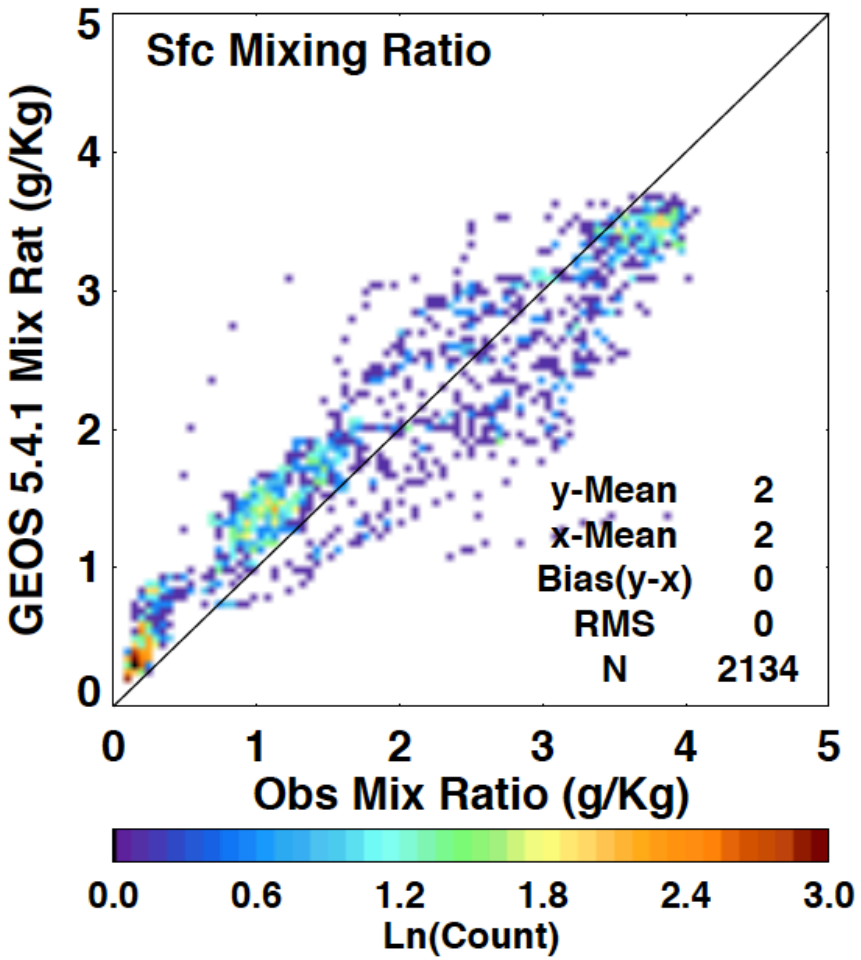
Air temperature is too cold during summer and too warm during winter

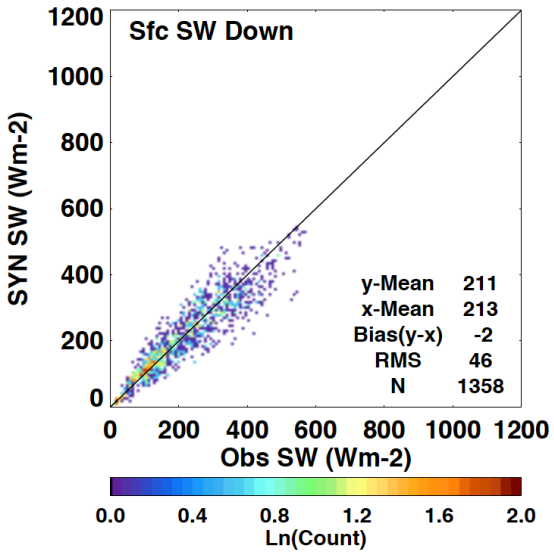
Low bias of GEOS-5.4.1 mixing ratio during summer might be due to the vertical resolution (5 g kg^{-1} is almost saturation at 0C)

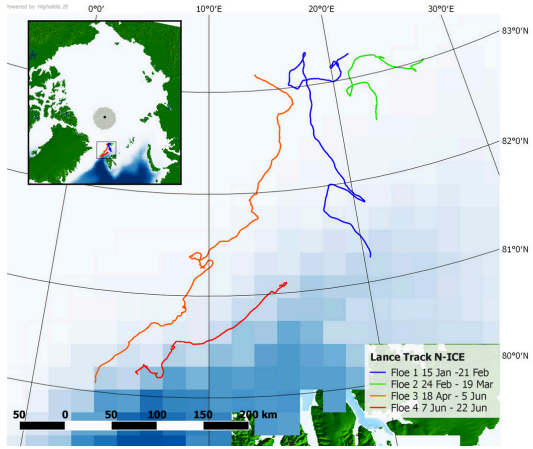
Mixing ratio tends to be high during winter

N-ICE2015 (Norwegian young sea ice cruise, January to June 2015)



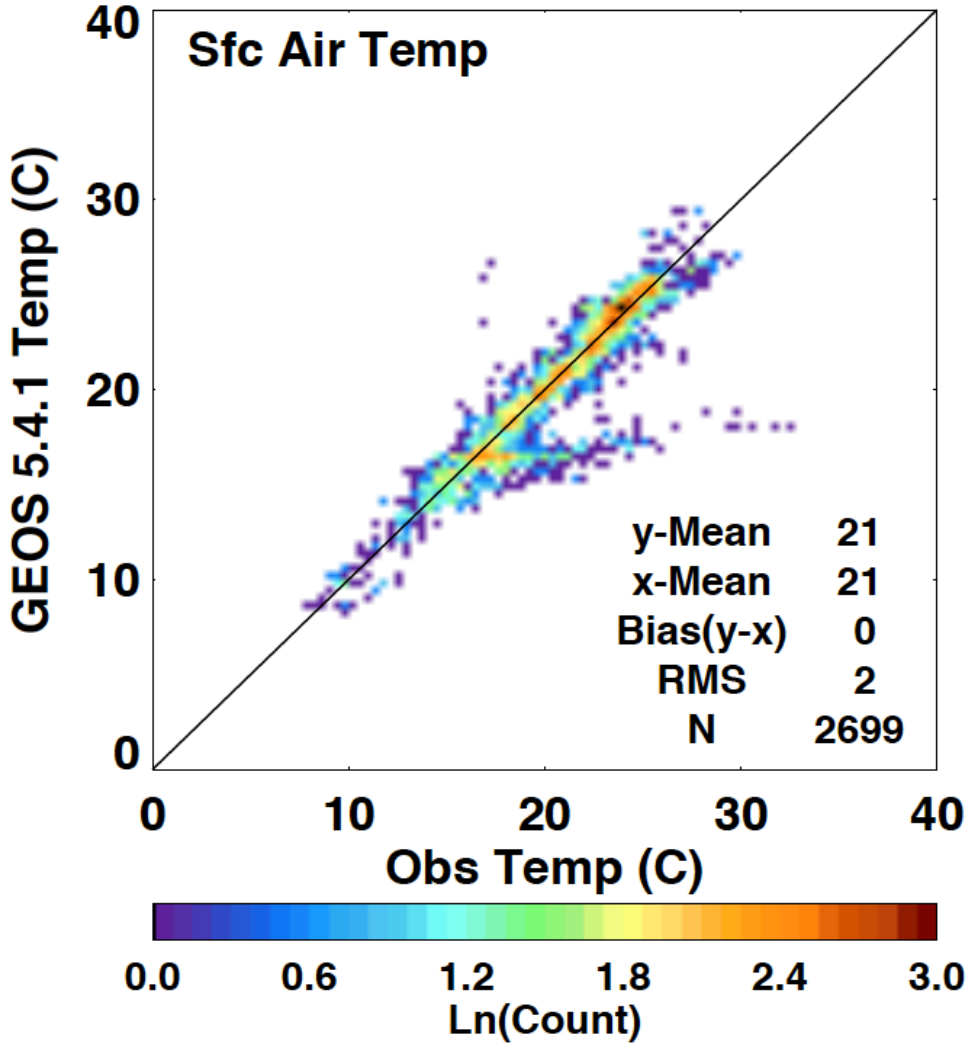


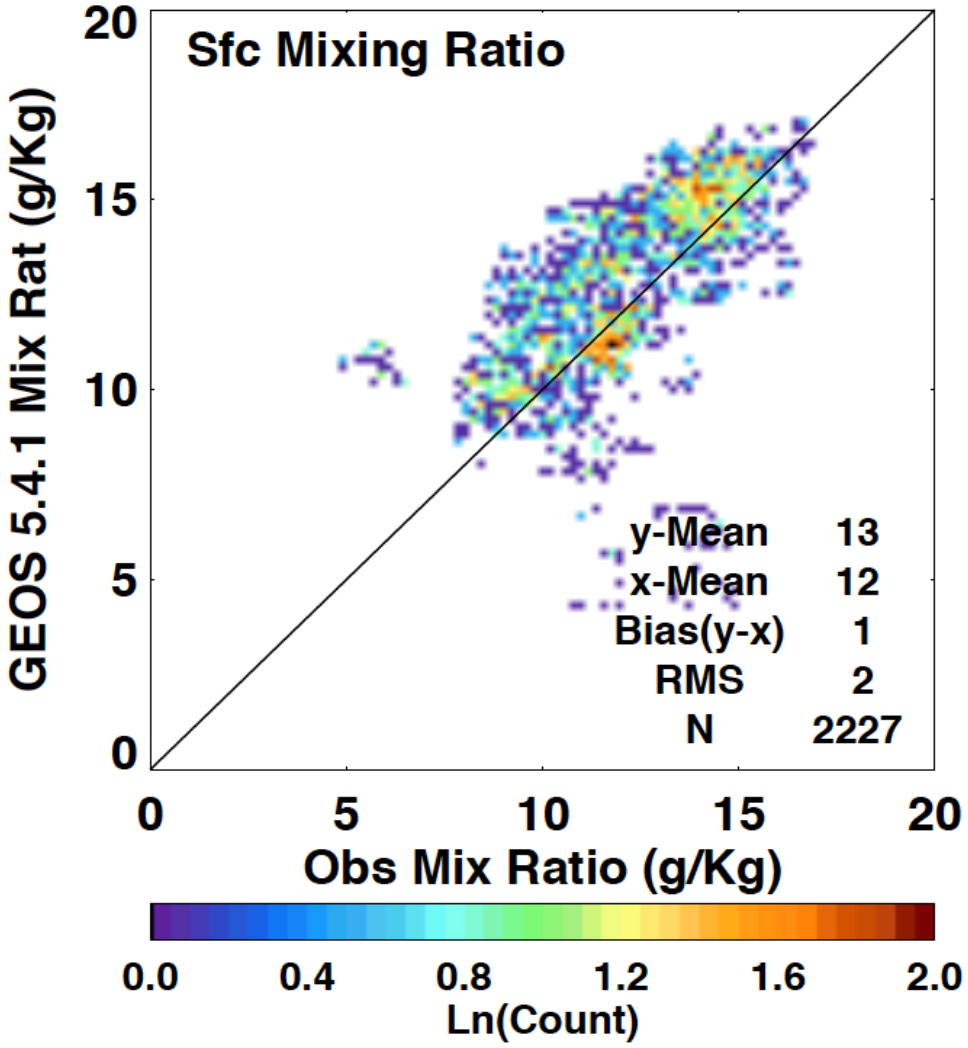




Longwave irradiance bias is small but air temperature is biased high during winter

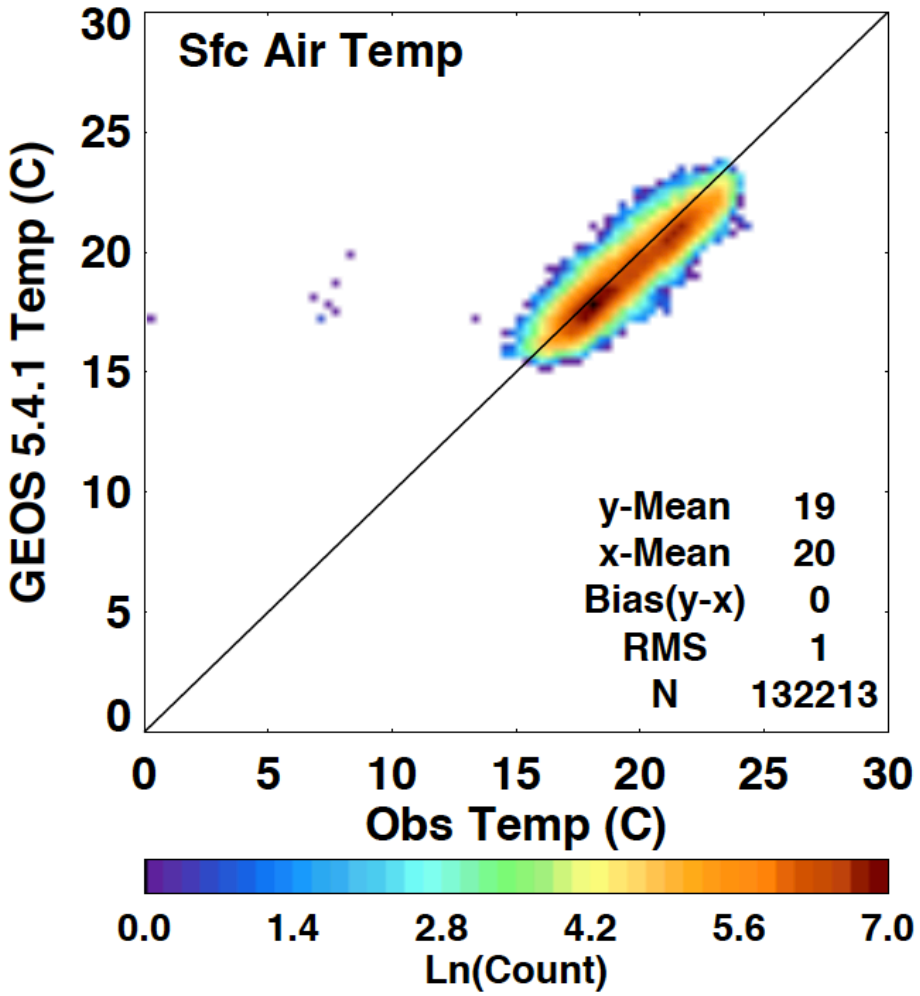
MAGIC (Eastern pacific stratocumulus region)

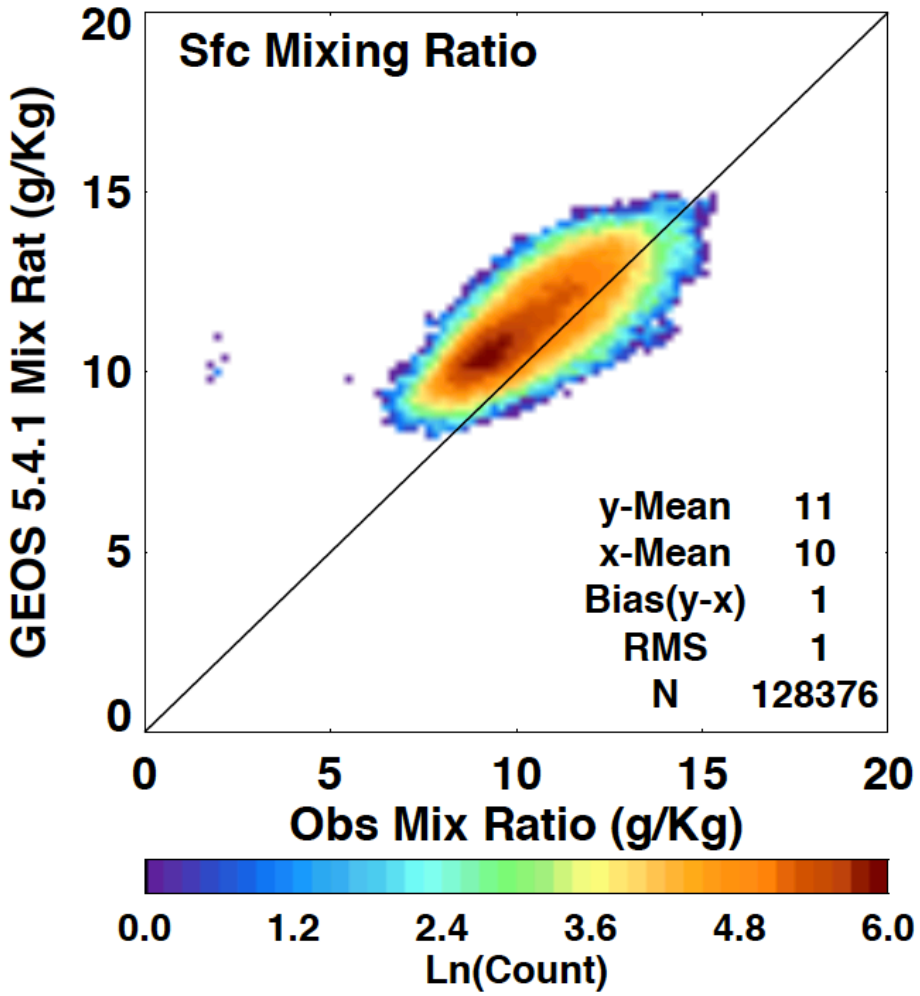




Water vapor mixing ratio tends to be too high during moist periods

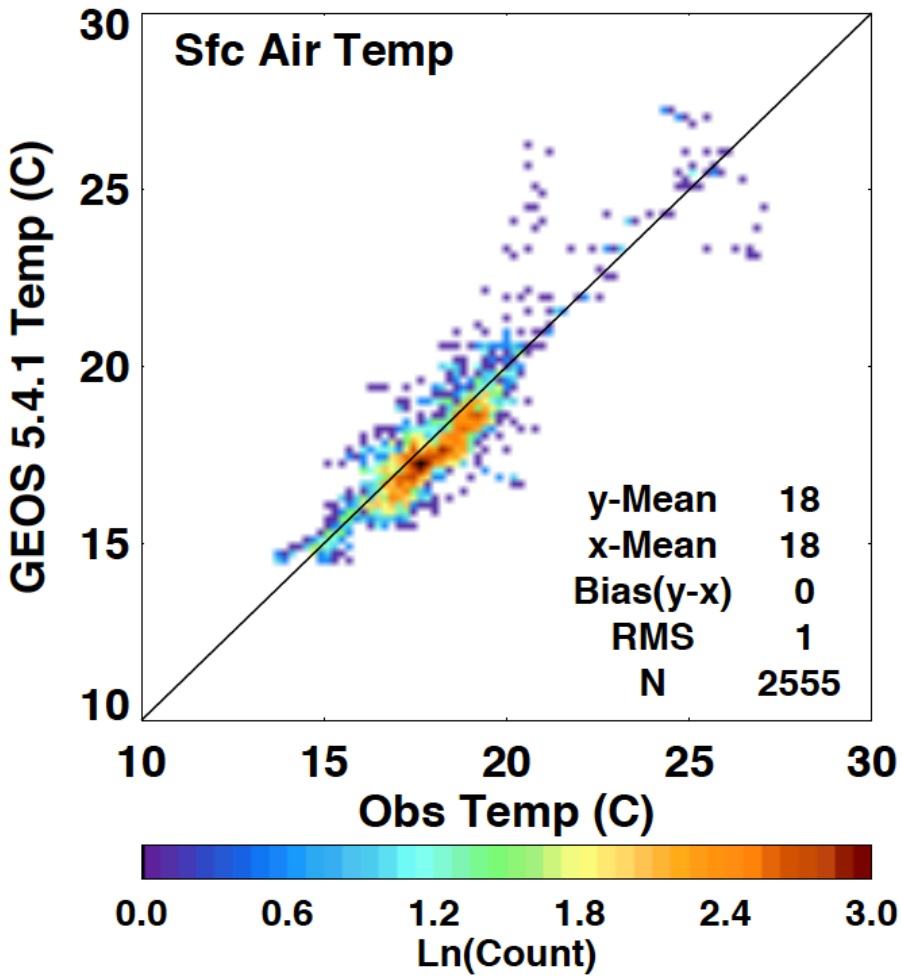
WHOI STRATUS Buoy (south eastern pacific)

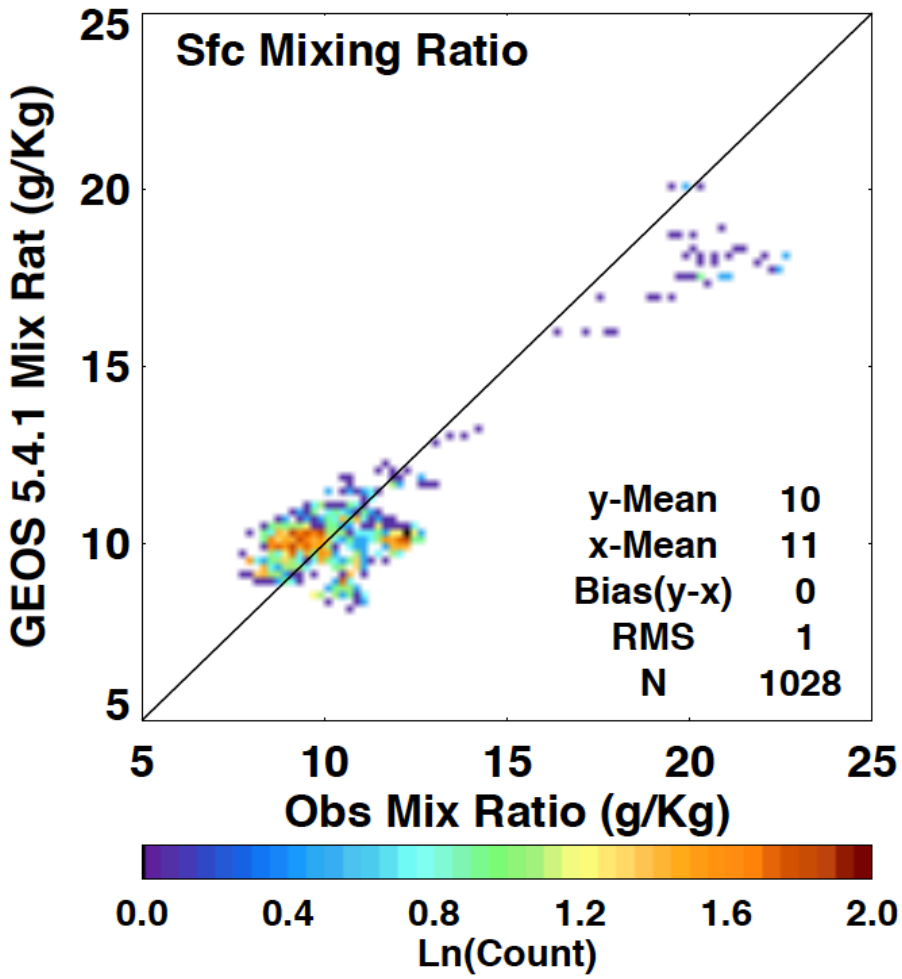




Water vapor mixing ratio is too high

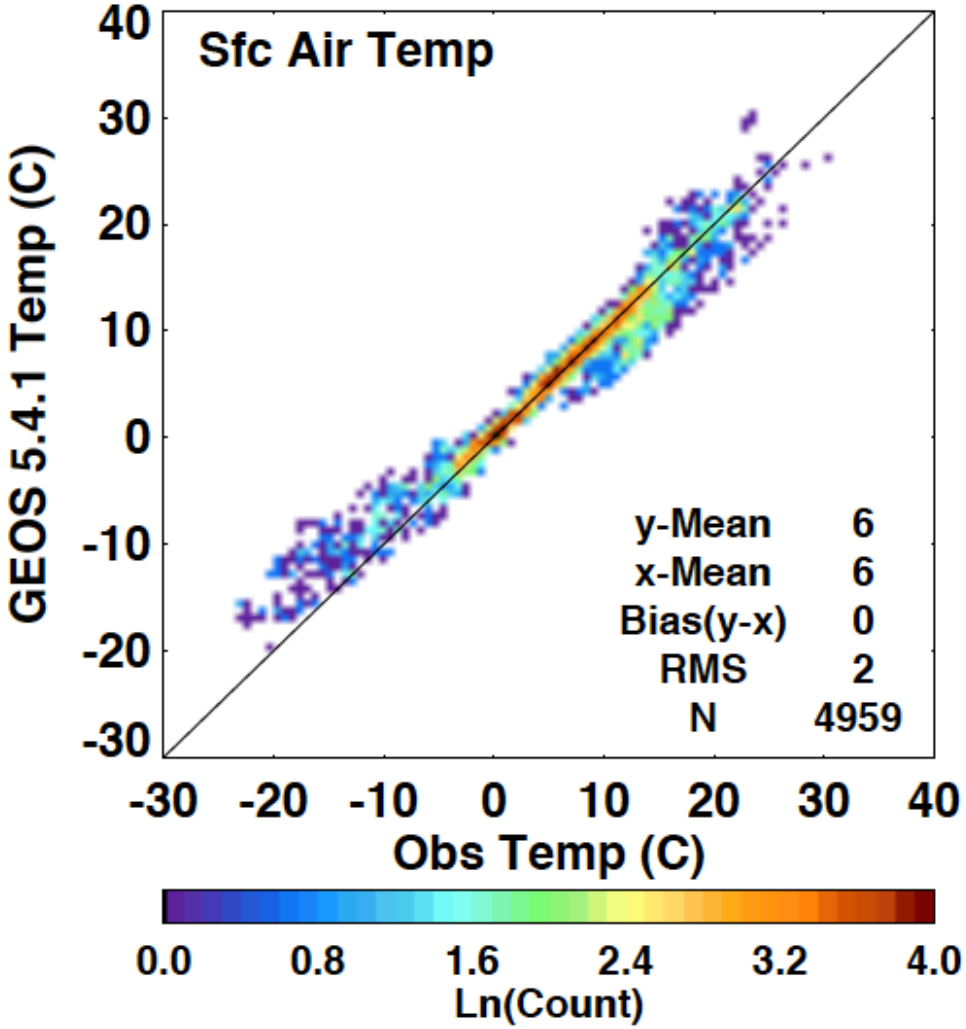
NOAA STRATUS Cruises (199 grid boxes)

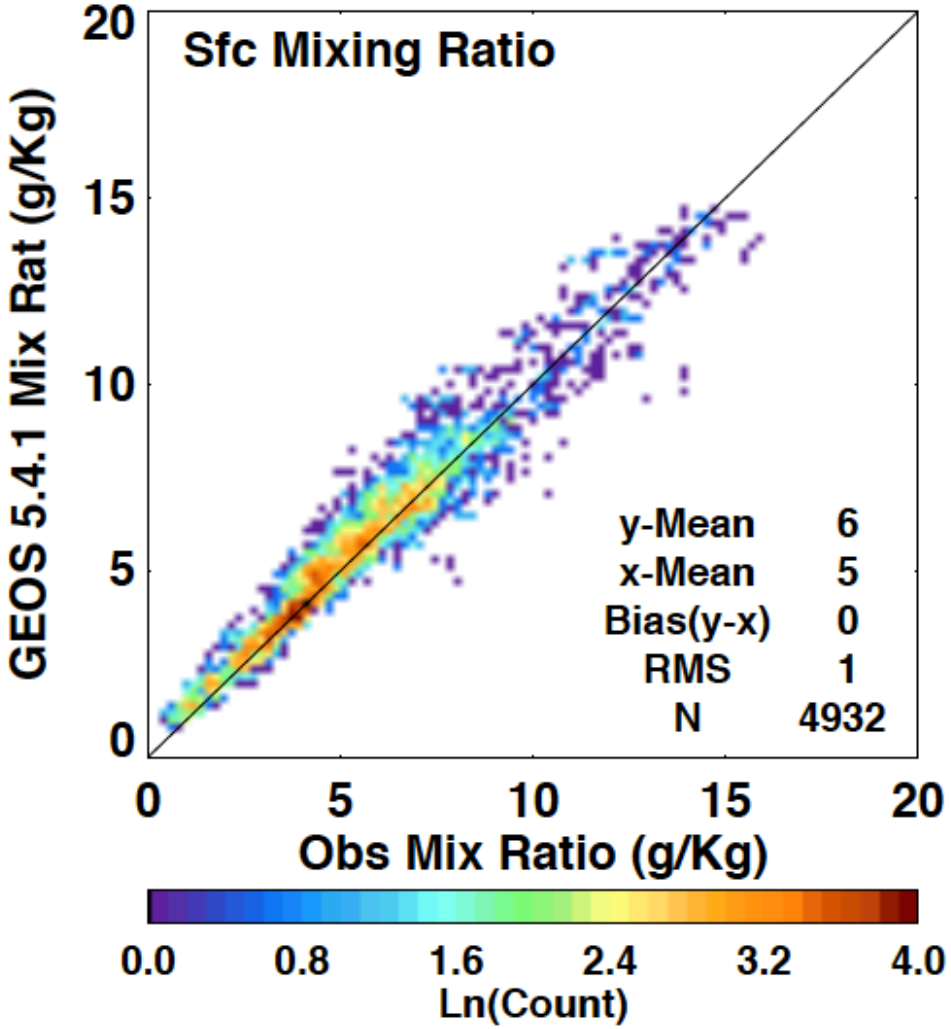




Humidity is too high
Consistent with WHOI STRATUS Buoy

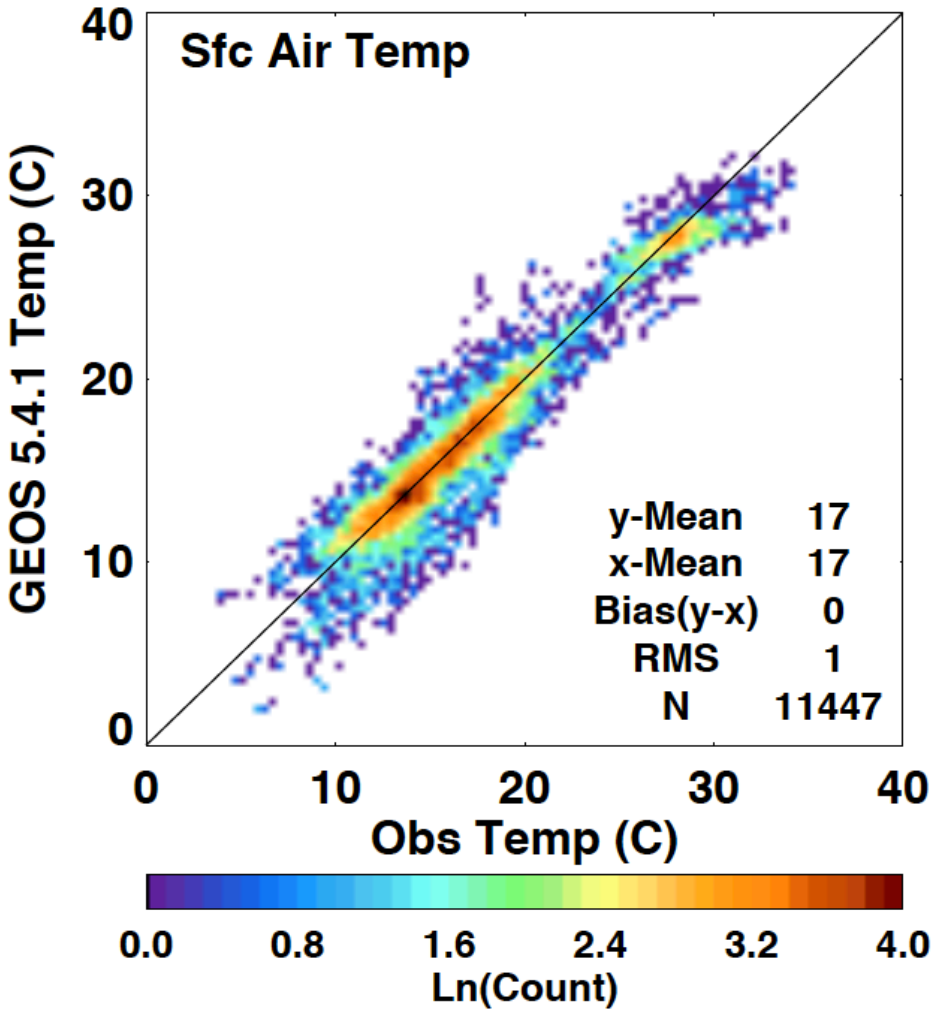
Australian Ship R/V Aurora Australis (532 grid boxes)

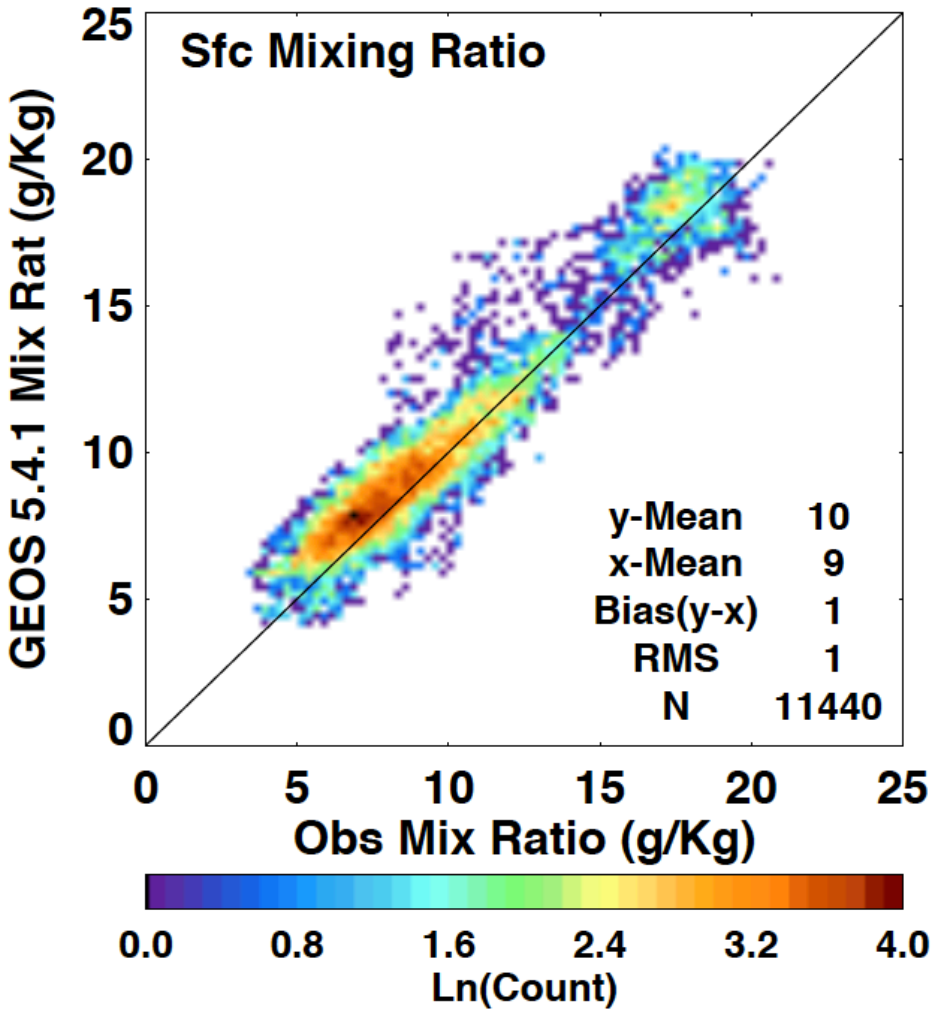




Temperature and mixing ratio agree well with observations

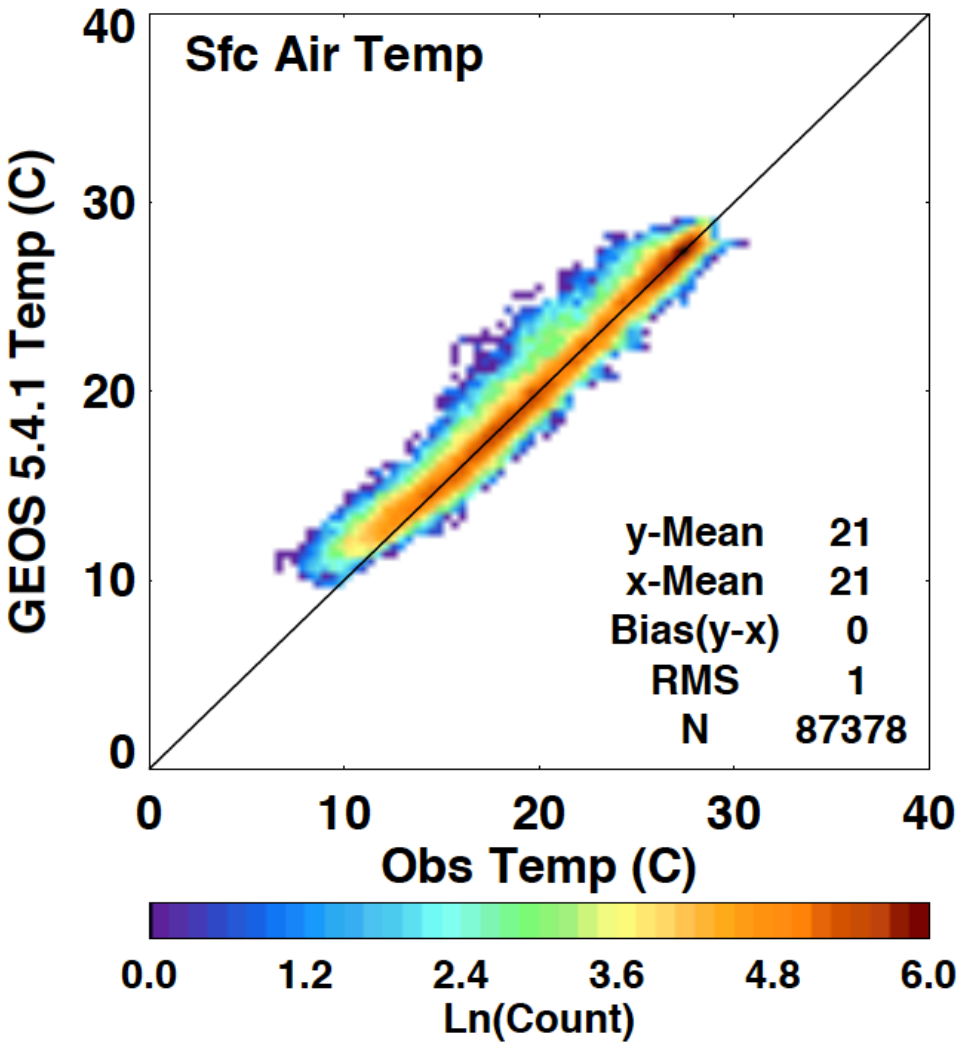
Australian Ship R/V Tangaroa (633 grid boxes)

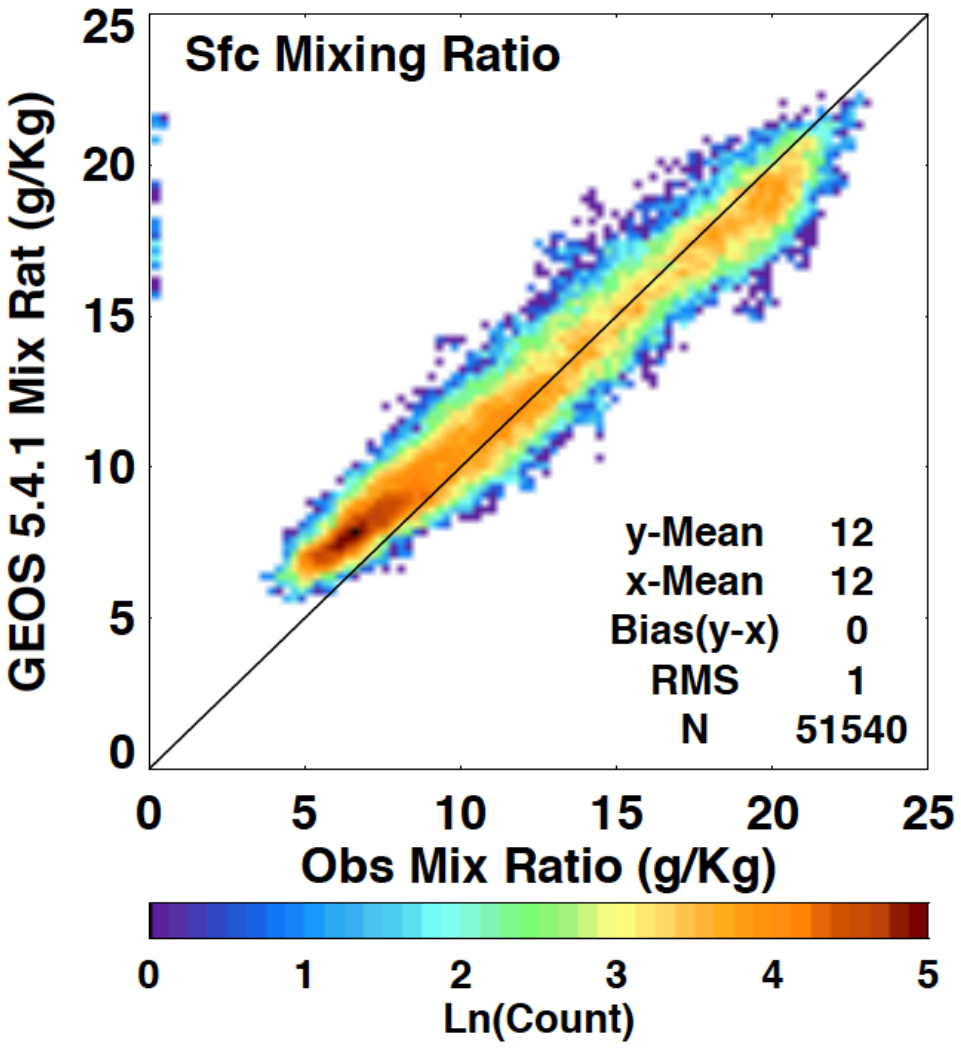




Mixing ratio tends to be too high during winter

Kuroshio buoy





Water vapor mixing ratio is too high during winter

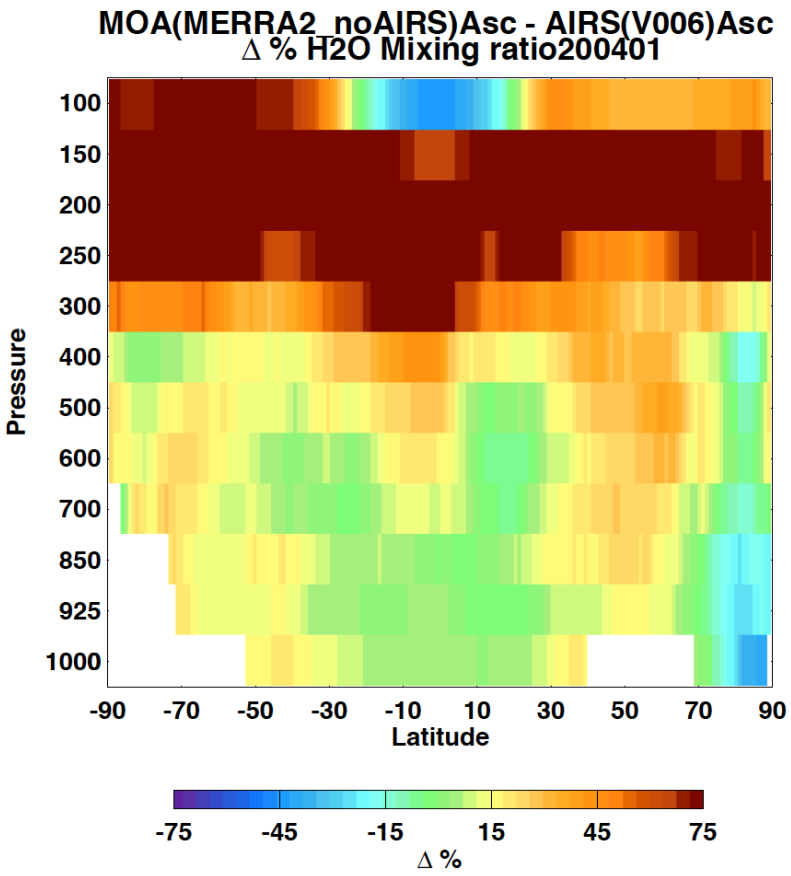
Summary of T and RH bias possibly contributing LW down bias

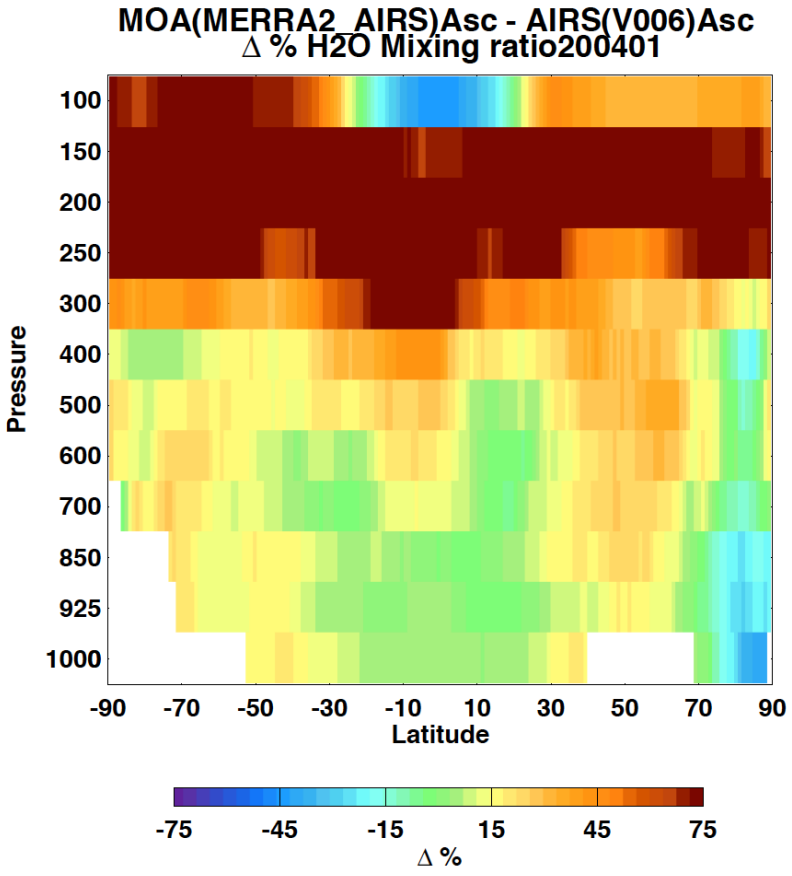
- Arctic and Greenland summit
  - Near surface temperature is too low during summer and too warm during winter.
  - Near surface water vapor mixing ratio is low in summer and slightly high in winter.
  - N-ICE2015 data supports temperature to be too high during winter and Near surface water vapor mixing ratio results for summer and winter.
- Subtropical Eastern pacific (MAGIC)
  - Near surface water vapor mixing ratio tends to be too high during moist periods (summer).
- South Eastern pacific (stratus region, WHOI STRATUS Buoy and NOAA STRATUS Cruises)
  - Near surface relative humidity tends to be too high
- North western Pacific (Kuroshio buoy)
  - Near surface relative humidity is too high during dry periods (winter)
- Summarizing the bias of mixing ratio over subtropical regions is difficult but it tends to be high (either during summer time or winter time or both).

Upper tropospheric relative humidity

- Comparison of MERRA2 water vapor mixing ratio and water vapor mixing ratio derived from AIRS (AIRSX3STM.006 TQ joint)
- AIRSX3STM.006 TQ joint is used to correct GEOS-5.4.1 upper tropospheric relative humidity
- Selected month January 2004.
- MERRA2 native temporal and spatial resolutions are converted to those used as inputs to CERES products (MOA) (6 hourly T and Q profiles, 1 hourly skin T).
- Select an hour box that has AIRS overpass [ascending (daytime) and descending (nighttime) separately]. [75-80NS use a 2 hr window, 80-85NS use a 3 hr window, and 85-90NS include all hours].

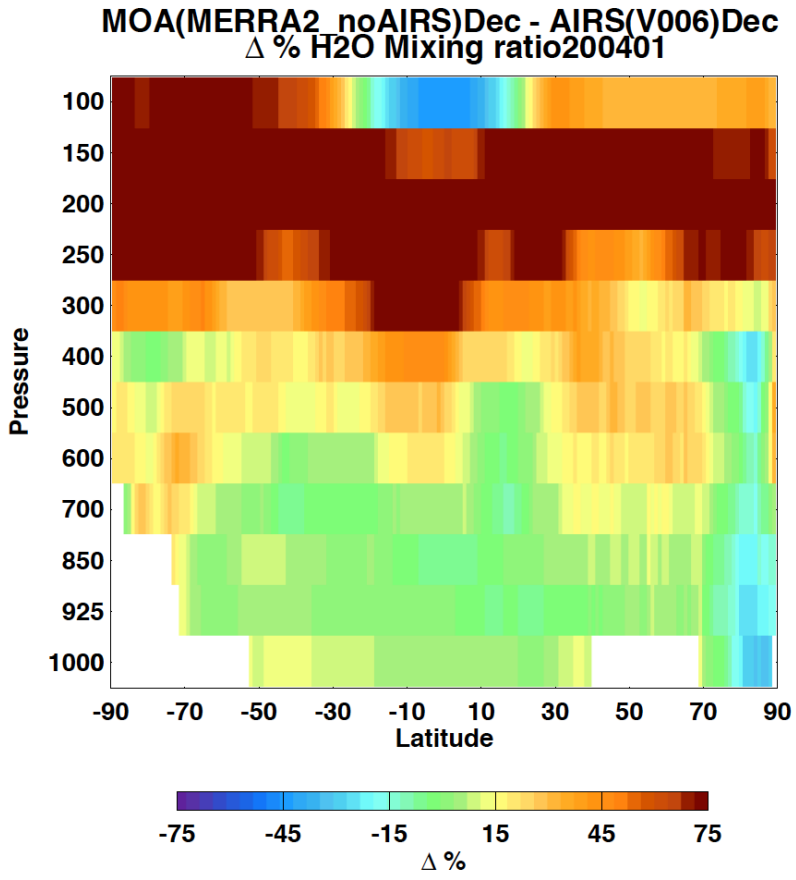
H2O mixing ratio, Daytime

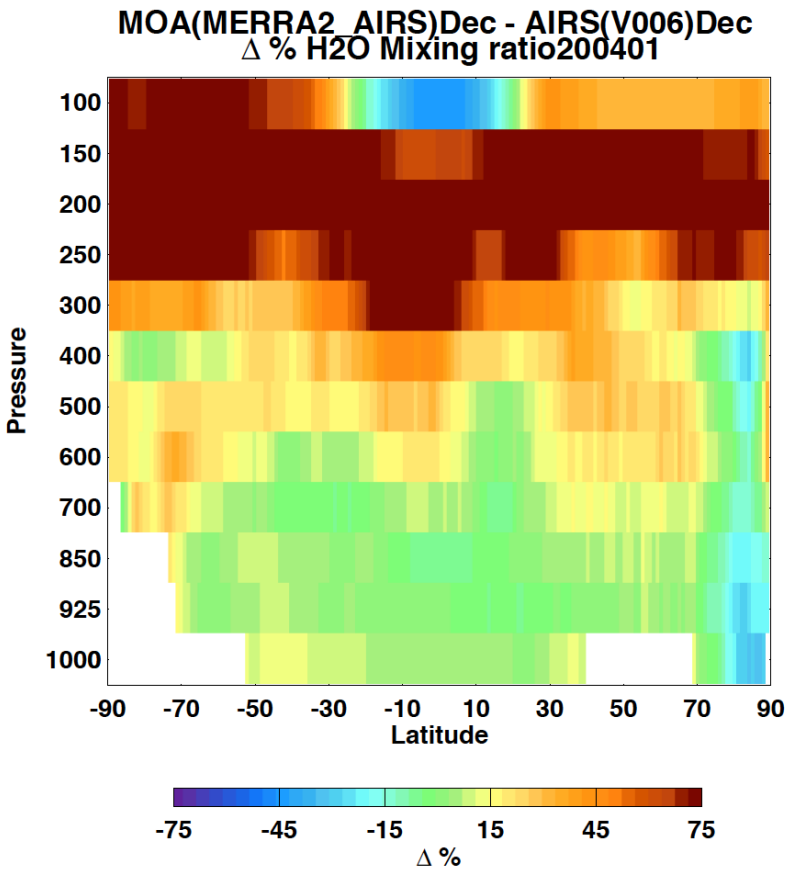




- MERRA upper atmosphere is much more moist compared to AIRS and GEOS-5.4.1
- 30% mixing ratio bias in a 200 hPa to 300 hPa layer causes about 1 Wm-2 OLR bias

H2O mixing ratio, nighttime



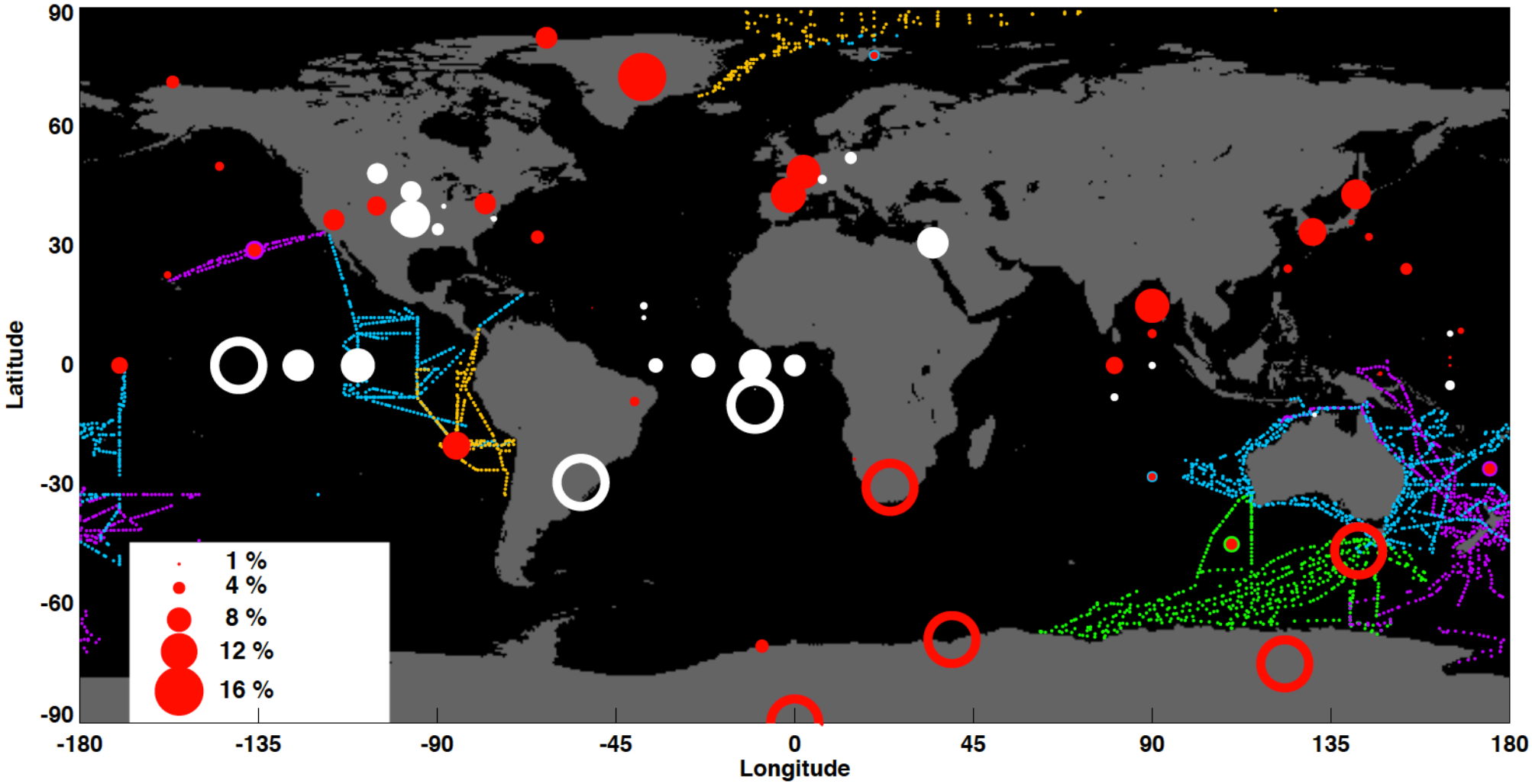


How to improve CERES GEOS from the CERES perspective

- Collaborating with GMAO to improve reanalysis product to be used in the future CERES data production.
  - Once a month telecon led by Mike Bosilovich and Norman Loeb
- Evaluating variables (temperature and humidity) from FP
  - A better version of FP will become next reanalysis for CERES
- Developing an algorithm to correct monthly gridded mean temperature and humidity
  - Correction based on observed and computed spectral radiance differences

Back-ups

Near Surface Relative humidity (2 m) bias (GEOS-5.4.1 – Obs.)



Circles are scaled to Max bias: 15.8 %
Red -> Positive Bias
White -> Negative Bias
Open Circle -> Bias > Max on Scale

Observation sites

- NPL: 71.3 203.4 N Slope AL (NSA), Tiksi Rus (TIK), Alert Canada (ALE)
- SPL: -85.0 0.0 Syowa (SYO), Georg v Neuymeyer (GVN), S. Pole (SPO), Dome C (DOM)
- RAM: 10.0 65.0 RAMA Array Buoys in Indian ocean - 10 buoys
- TAO: 0.0 200.0 TAO Array Buoys Pacific Ocean - 17 buoys
- PIR: 10.0 335.0 PIRATA Array Atlantic Ocean - 14 buoys
- SMT: 72.6 321.6 ETH Greenland Summit (SMT) (Single site)
- ABS: -46.7 142.0 ABOS buoy (S of Australia) (ABS) (Single Site)
- NTS: 14.5 309.0 WHOI N Tropical Atlantic Buoy (NTS) (Single site)
- STR: -20.0 274.5 WHOI STRATUS Buoy, SE Pacific Ocean (STR) (Single site)
- HTS: 22.8 202.1 WHOI Hawaii Time Series Buoy, (HTS) (Single site)
- PPA: 32.4 144.6 PAPA Buoy (PPA) (Single site)
- KEO: 50.1 215.2 Kuroshio Current Buoy (KEO) (Single site)
- CUS: 42.0 260.0 Continental USA: SURFRAD(FPK, BON, GCR, PSU, SXF) ARM-SGP (BEF) - 6 Sites
- DES: 20.0 13.0 Desert Sites: Desert Rock, (DRA) Sede Boqer IS (SBO), Tamanrraset Alg (TAM), Alice Springs, AU (ASP) - 4 Sites
- JPN: 36.1 140.1 Japanese Met Sites: Tateno (TAT), Ishigakijima (ISH), Minamitorishima (MNM), Fukuoka (FUA), Sapporo (SAP) - 5 Sites
- MAGC: 29.0 224.0 ARM MAGIC Cruises (84 grid boxes)
- EPIC: 0.5 258.0 NOAA EPIC Cruises (355 grid boxes)
- STRT: -14.0 279.0 NOAA STRATUS Cruises (199 grid boxes)
- VNAA: -28.0 90.0 Australian Ship R/V Aurora Australis (532 grid boxes)
- ZMFR: -45.0 110.0 Australian Ship R/V Tangaroa (633 grid boxes)
- VLHJ: -26.0 175.0 Australian Ship R/V Southern Surveyor (794 grid boxes)
- NICE: 78.0 20.0 N-ICE2015 (10 grid boxes)
- NPEO: 81.0 350.0 NPEO Drifting Ice buoys (multiple years/grid boxes) (Used 2002, 2003, 2004, 2007, 2008)