Validation of CERES Cloud and Radiative Swath (CRS) data product at Siple Dome, Antarctica

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Outline

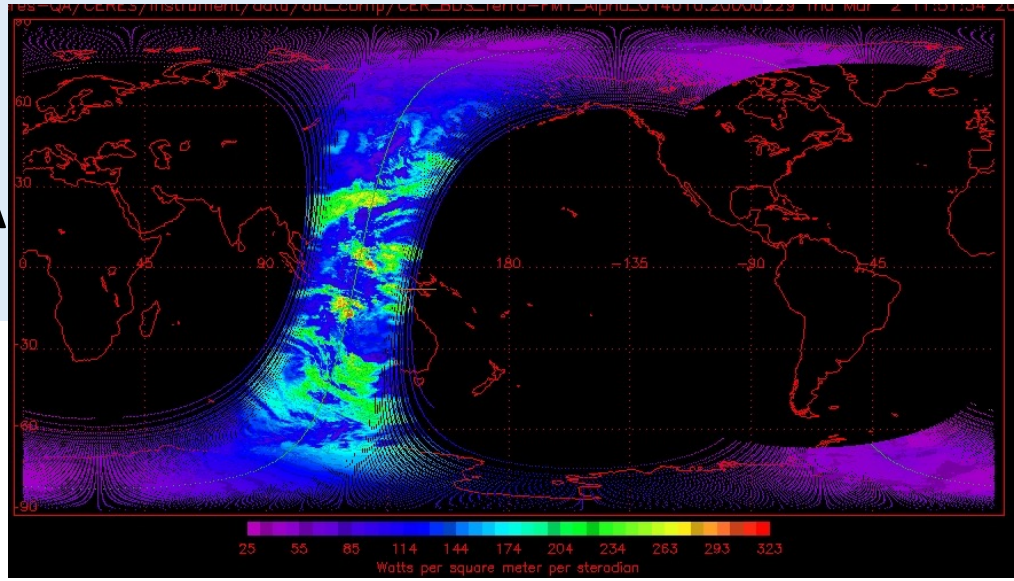
- **Briefly describe the CERES Clouds & Radiative Swath (CRS) data product.**
- **Compare CRS radiative transfer (RT) calculations to surface observations at Siple Dome, Antarctica**
- **Discuss implications of re-analysis inputs for RT calculations comparing GEOS-541 (current) to GOES-IT (future) using MODIS & AIRS retrievals as "truth".**

Clouds & Radiative Swath (CRS)*

Radiative Transfer (RT) calculation.
Langley Fu & Liou (2-stream LW, 4-stream-SW)

Clouds: Terra/Aqua MODIS retrievals (CERES version).
Atmosphere: P, T, q from re-analysis (current GMAO GEOS-5v4.1)
Aerosol: MATCH chemical transport model (assimilates MODIS)
Albedo: Clear sky CERES retrieval
Cloudy sky 'history map' based on clear sky retrievals
Spatial Sampling: per footprint ~20km at nadir to 130x40 km at 70°VZA
Temporal Sampling: ~2.4million (SSF) footprints/day

Outputs:
LW/SW irradiance up/down at 6 levels
Sfc, 850hPa, 500hPa, 200hPa, 70hPa, TOA
Clouds, aerosol and surface properties



* Scott et. al 2022: "Clouds and the Earth's Radiant Energy System (CERES) Cloud and Radiative Swath (CRS) Edition 4 Data Product, J. Atmos and Ocean. Tech doi: 10.1175/JTECH-D-22-0021.1.

CRS Sampling at Poles

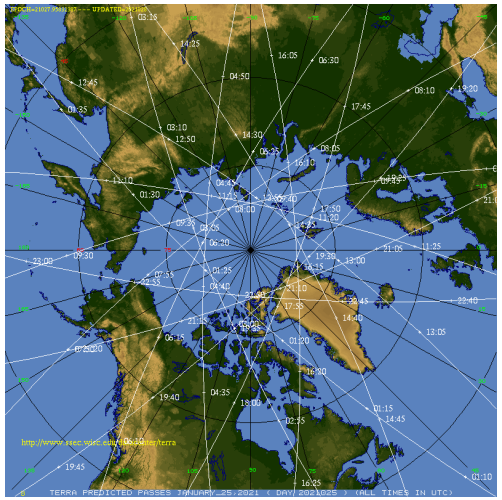
Terra and Aqua are syn-synchronous satellites with equator crossing times of 10:30AM and 1:30PM respectively.

Implies ~4 CRS results per day in the mid-latitudes.

At the poles have significantly more overpass times.

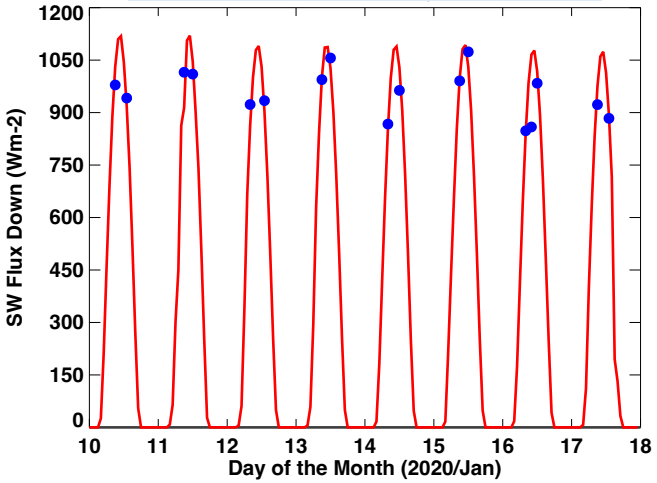
CRS product appropriate for high temporal resolution studies at high latitudes.

Terra Orbit Tracks
N Pole for 1 Day

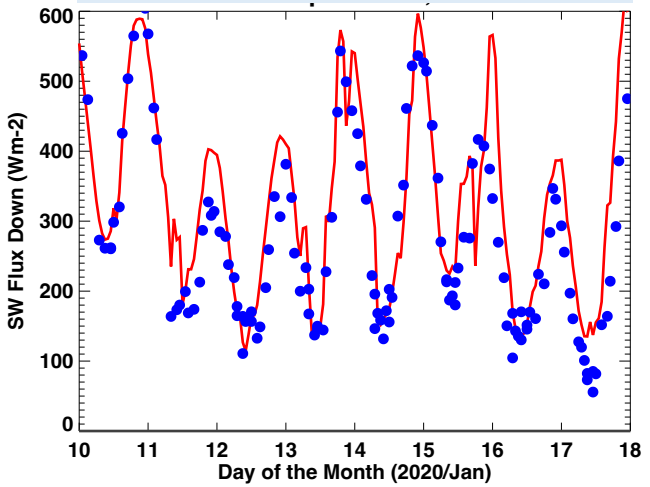


CRS Surface SW Down for 7 Days (Jan 2020) Terra & Aqua

Gobabeb, Namibia (23S)



Siple Dome Antarctica (81S)



Siple Dome, Antarctica

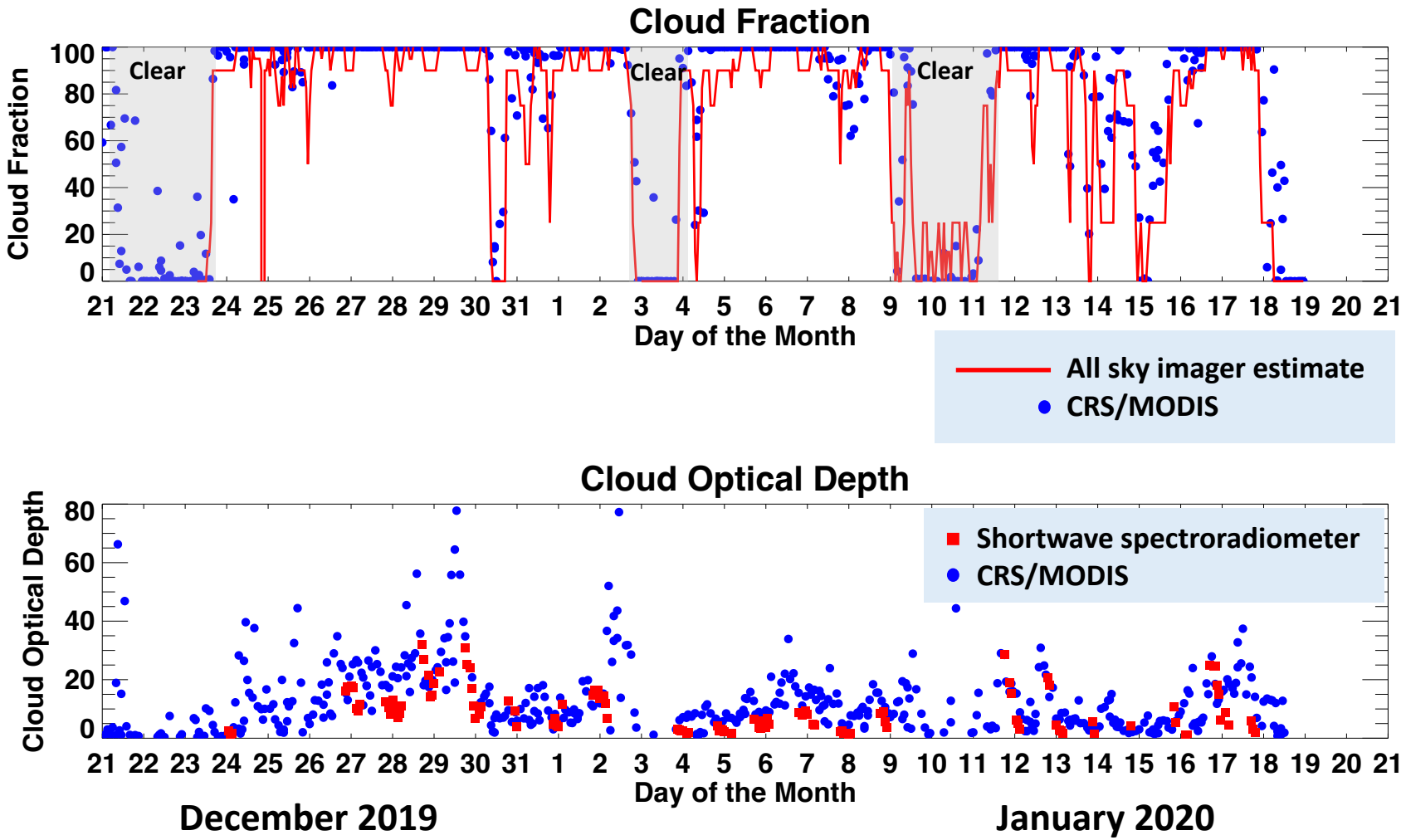
Dan Lubin from Scripps maintained

- **LW/SW radiation observations**
- **shortwave spectroradiometer**
- **all sky imager**

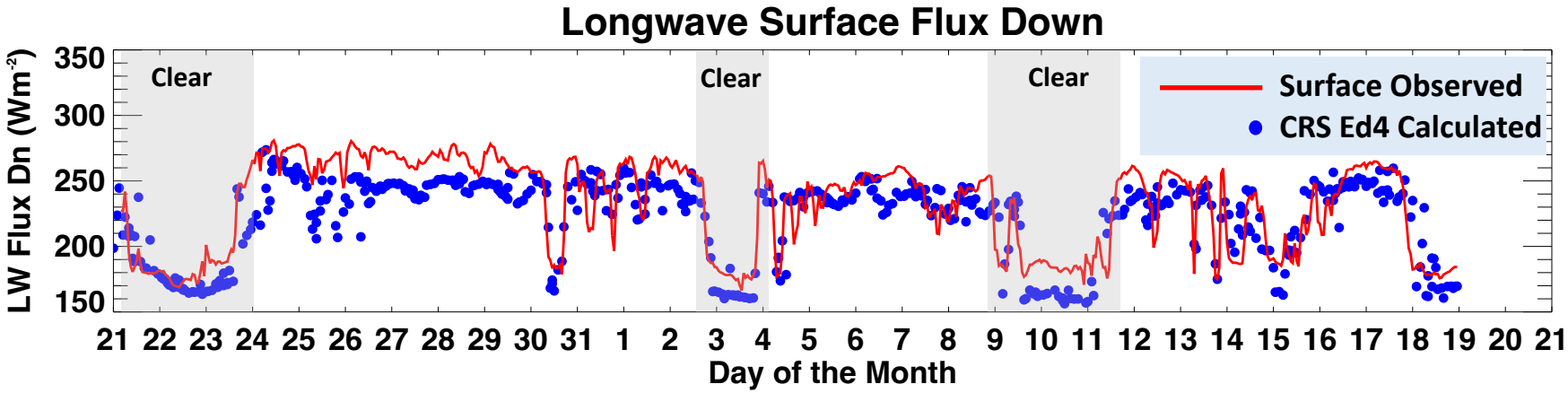
for 30 days over two summer months (Dec 2019, Jan 2020)

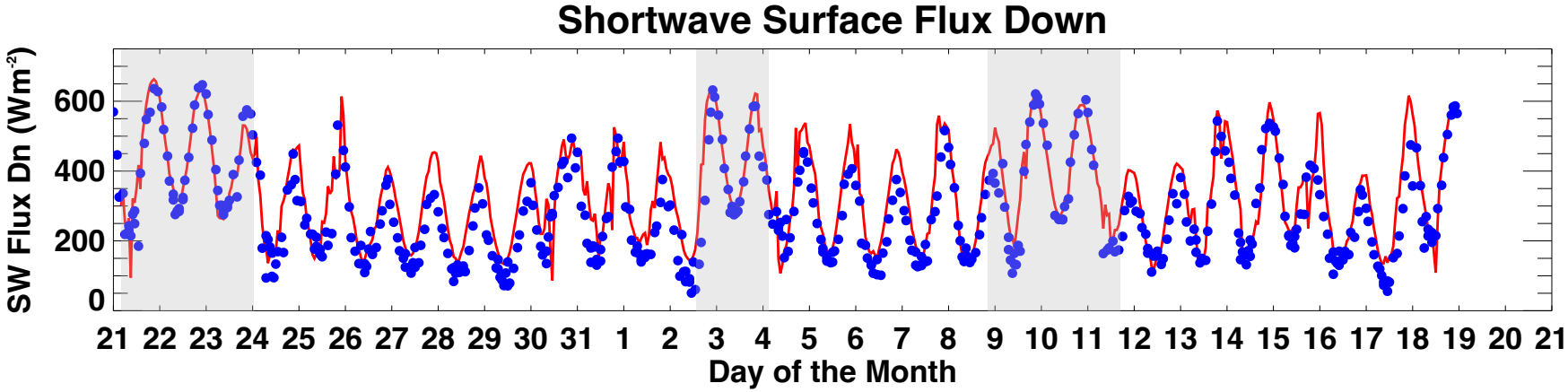
Lubin, D., and M. Ghiz, 2022: Siple Dome Surface Energy Flux. U.S. Antarctic Program (USAP) Data Center, (https://doi.org/10.15784/601540.)

Cloud Property Comparisons



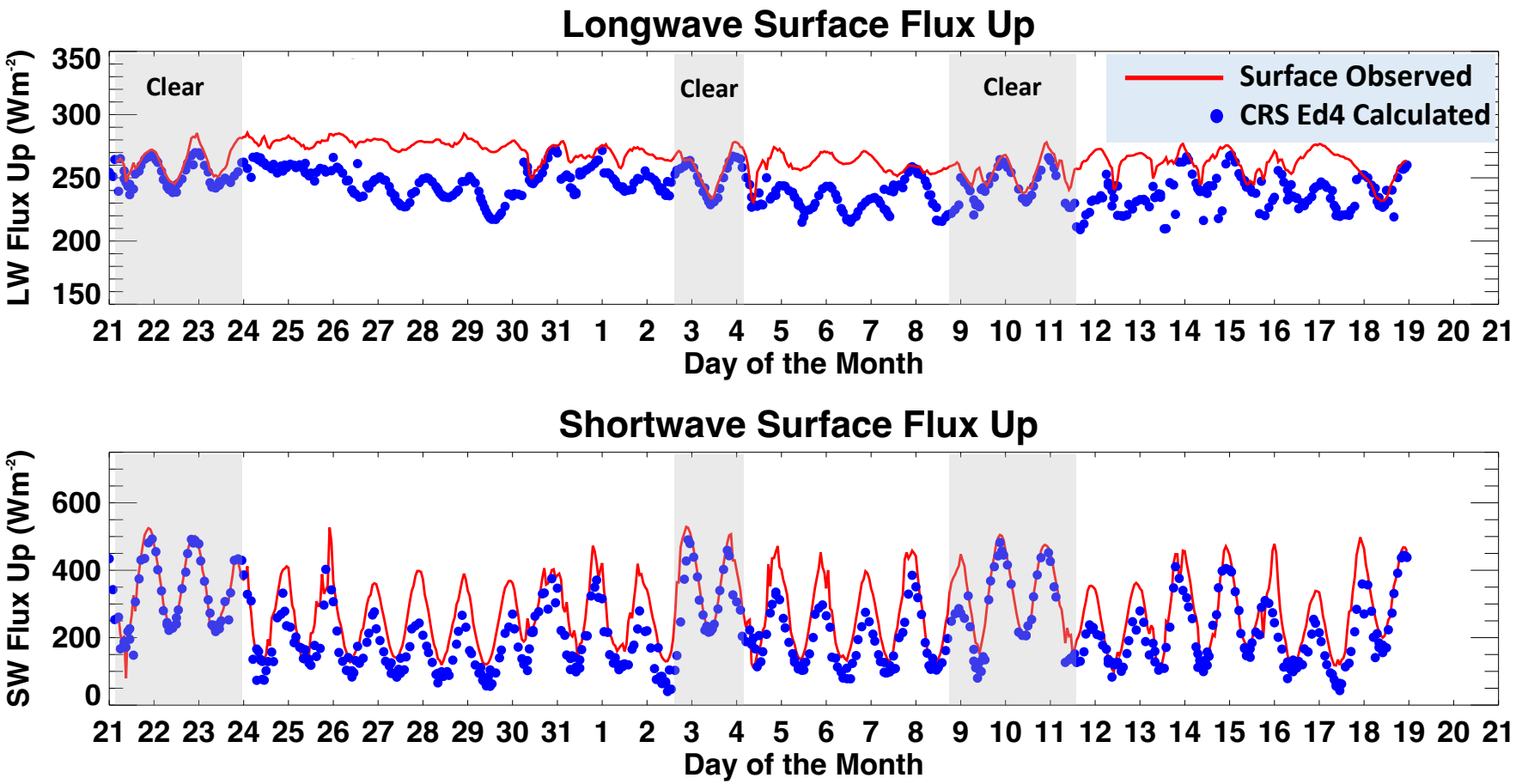
Surface Downward Irradiance





Calculated LW down is too low for both clear and cloudy skies.
Calculated SW down is low for cloudy skies, matches well with clear.

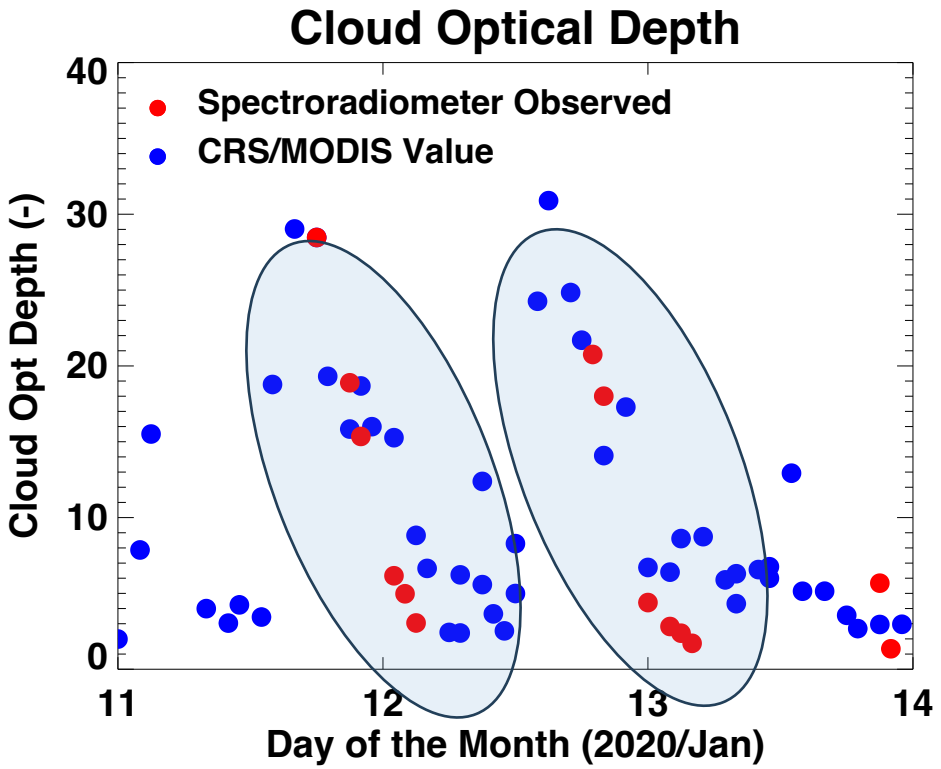
Surface Upward Irradiance



Calculated LW up is very low for cloudy skies, better for clear skies.
Calculated SW up is low for cloudy skies, matches well with clear.

Siple Dome: A Close Look
Observed Diurnal Cycle of Clouds/Radiation*

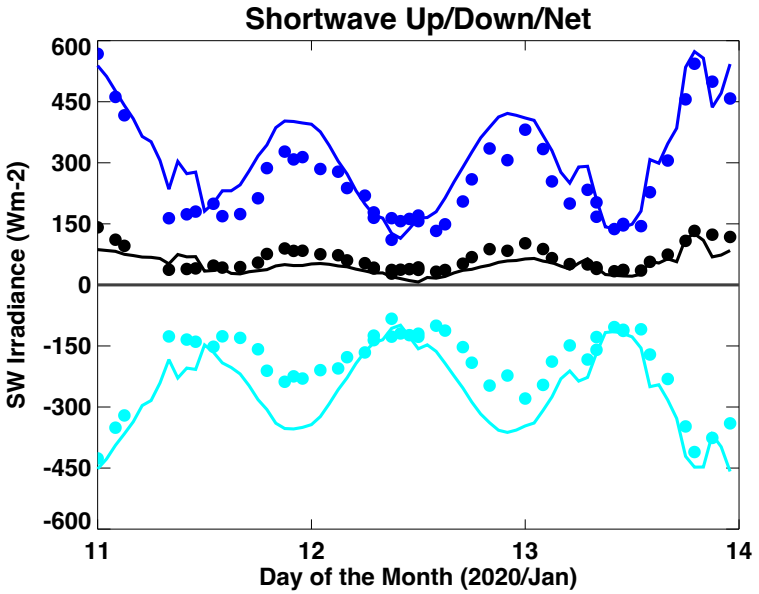
Situation: (Visually) mixed phase clouds were advected up the dome from the Amundson Sea by a high-pressure system.
They would precipitate out (snow) leaving behind thin water clouds.

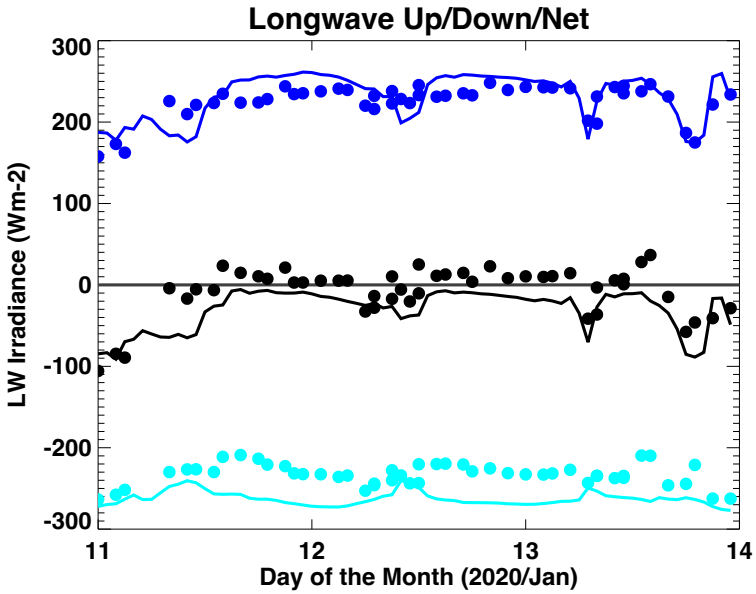


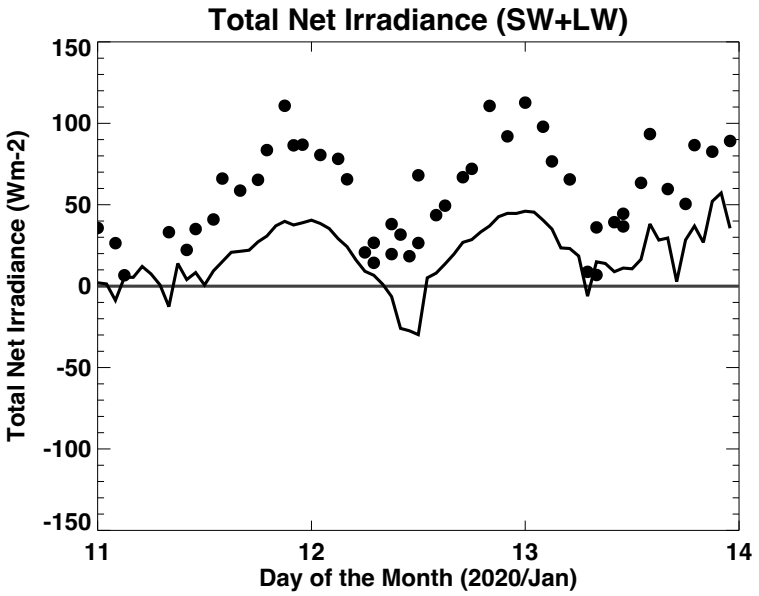
Lubin et al. 2021: A Surface Radiation Balance Data Set from Siple Dome in West Antarctica for Atmospheric and Climate Model Evaluation, J Climate. DOI: https://doi.org/10.1175/JCLI-D-22-0731.1

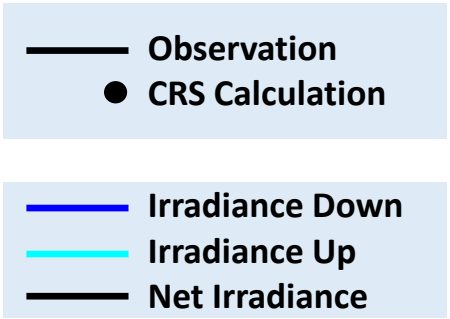
Up/Down & Net Irradiance

Observed and CRS Calculated









GMAO: GEOS-541 & GEOS-IT

GMAO - Global Modeling & Assimilation Office (NASA/Goddard)
GEOS - Goddard Earth Observing System

- **Re-analysis model run for CERES project that minimized the comings/goings of assimilated satellite data across 22 years**
- **Provides pressure, water vapor, temperature profiles**
  - **Land skin temperature when cloudy.**
- **GEOS-5v4.1 was used for all CERES Edition 4 products.**
- **GEOS-IT will be used for all CERES Edition 5 products.**

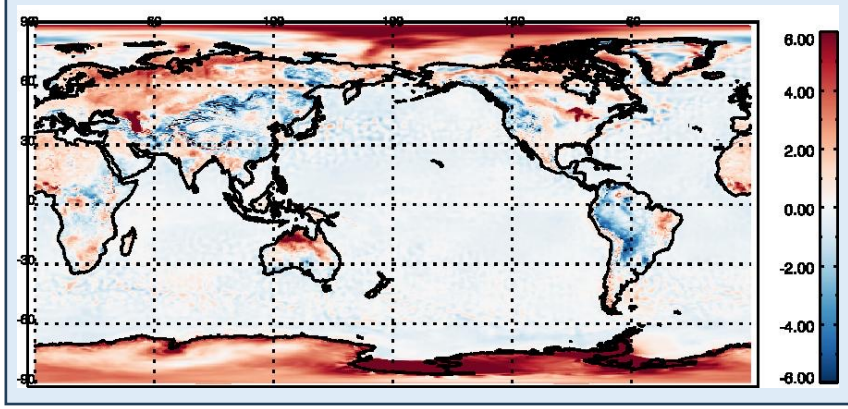
For "truth" compare to MODIS and AIRS derived skin temperatures.

GEOS-IT minus GEOS-541 (2008)

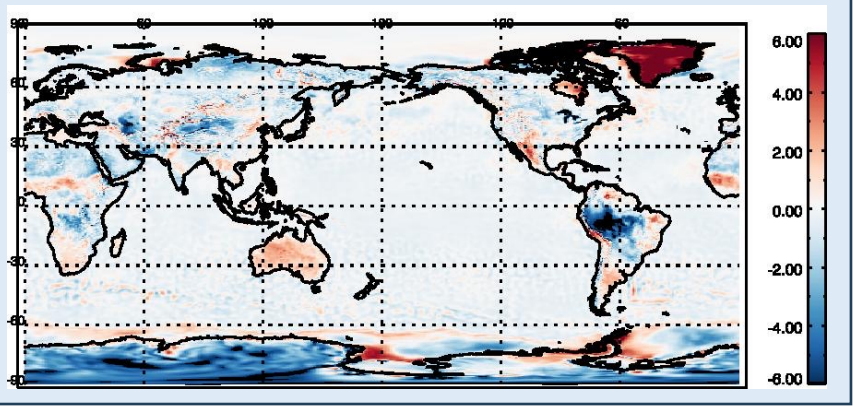
(Seung-Hee Ham)

Surface Skin Temp

ΔT_{skin} (avg: 0.6K, σ : 2K) January

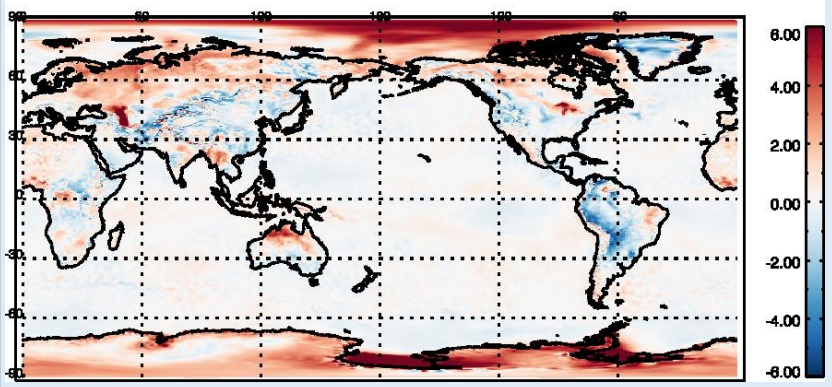


ΔT_{skin} (avg: -0.4K, σ : 1.8K) July

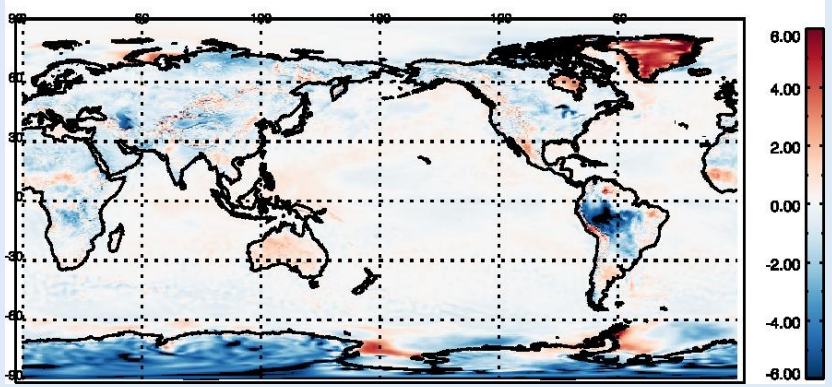


Air Temp (2m)

ΔT_{air} (avg: 0.6K, σ : 1.6K) January



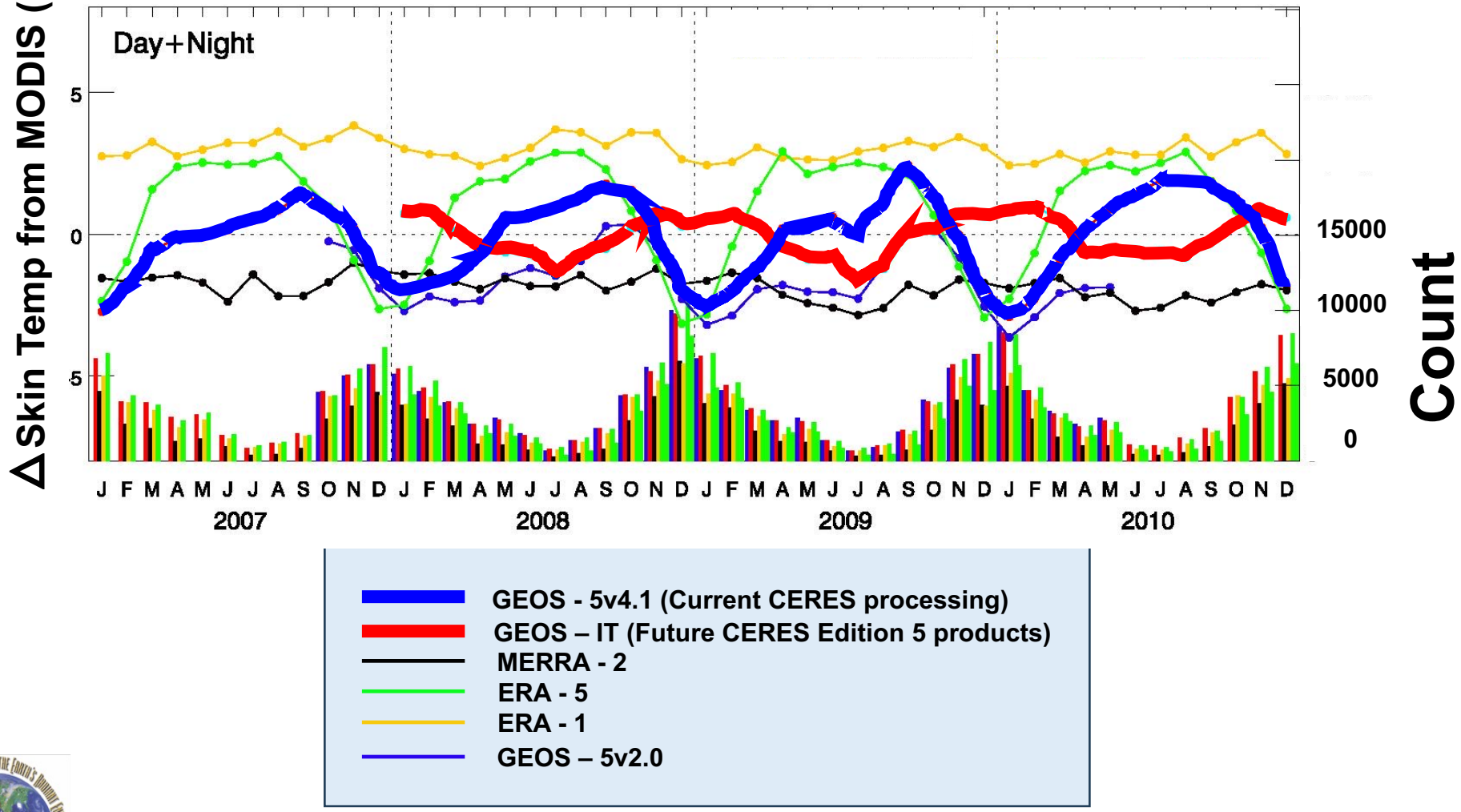
ΔT_{air} (avg: -0.4K, σ : 1.6K) July



For surface skin and air temperatures, GEOS-541 is colder in Antarctic summer, warmer in Antarctic winter.

Reanalysis Skin Temperature Differenced from Clear Sky MODIS Retrieval 66S – 90S over Snow

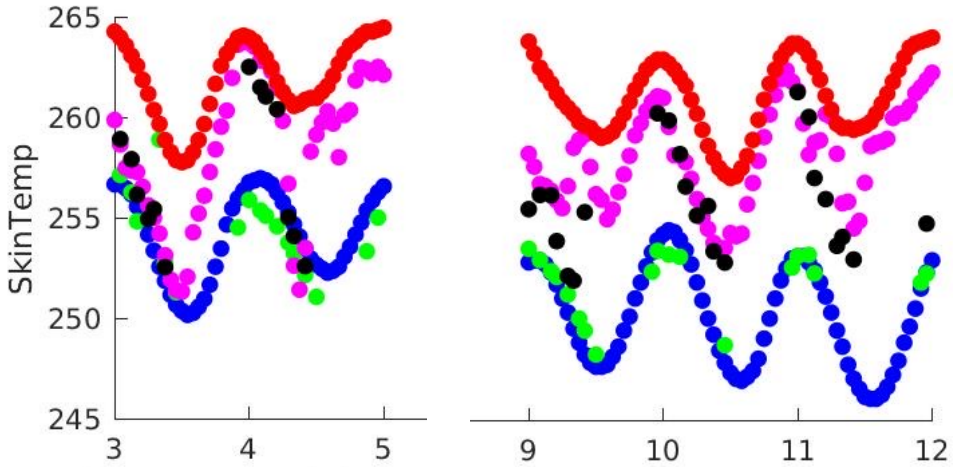
(Seung-Hee Ham)



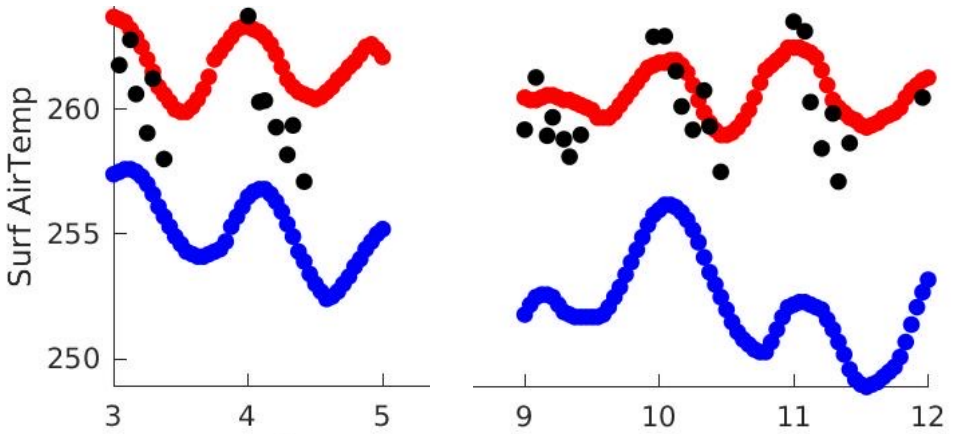
AIRS Dual Regression Retrieval[1,2] (T_{skin}, T_{air} for "Clear Sky"), Jan 2020

(Anthony DiNorscia)

Sfc Skin Temp



Sfc Air Temp



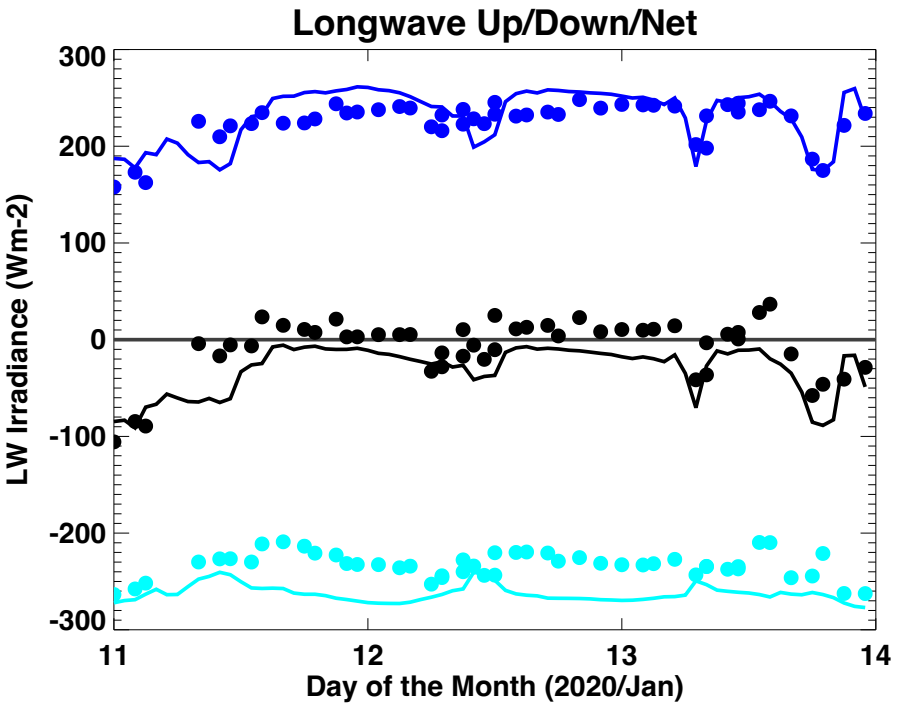
GEOS-IT
AIRS
Observation
GEOS-541
Aqua-CRS

[1] Smith et al. 2012, Dual-regression retrieval algorithm for real-time processing of satellite ultraspectral radiances. JAMC 51: 1455–1476.

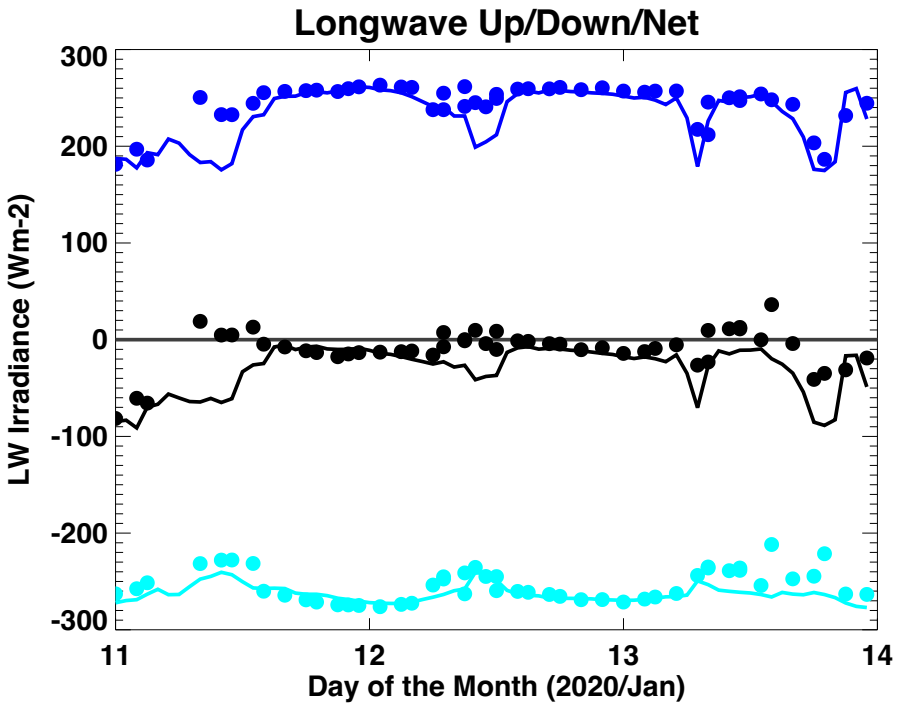
[2] Smith and Weisz, 2018, Dual-regression approach for high-spatial-resolution infrared soundings, Comprehensive Remote Sensing Vol 7, 297-311.

LW UP/Down/Net Irradiances

GEOS-541



GEOS-IT



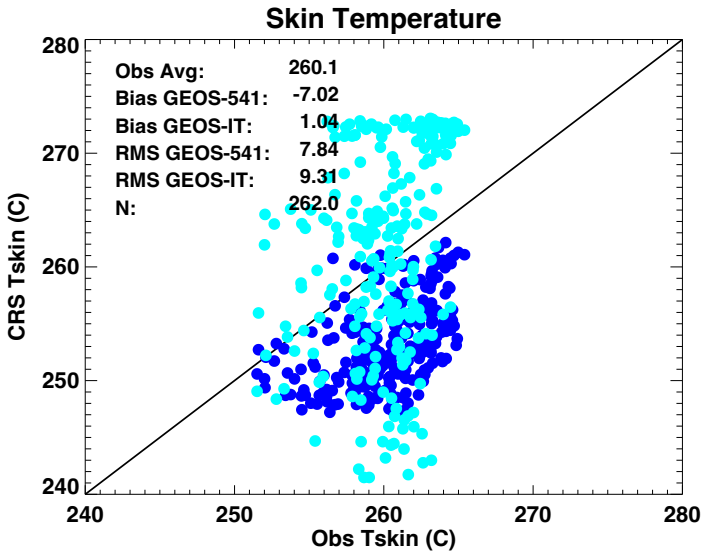
Significant improvement, at this site, in the upward/downward irradiance with the GEOS-IT reanalysis.

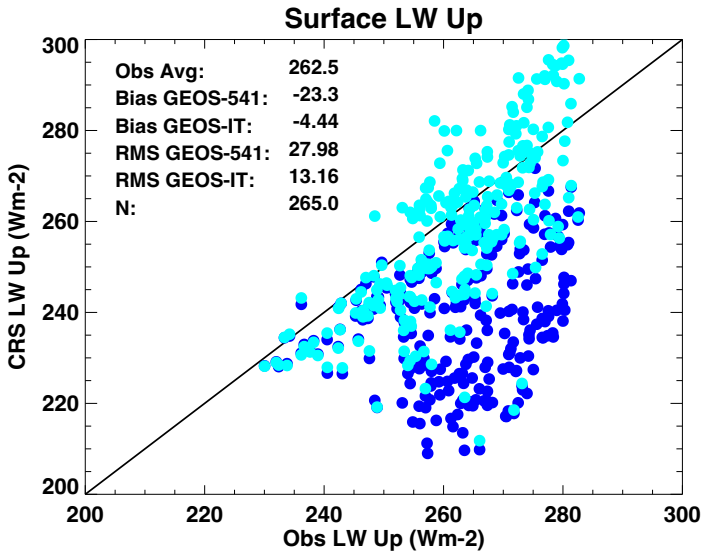
Summary

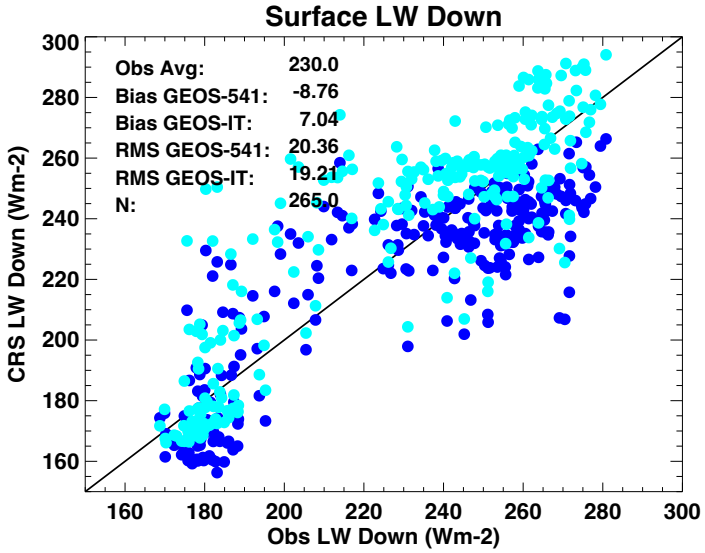
- **Compared CERES CRS calculated irradiance and cloud properties to observed/retrieved values from Siple Dome, Antarctica.**
- **Increased sampling at high latitudes allowed for nearly complete diurnal cycle comparison using two sun-synchronous satellites.**
- **The CRS product captured dynamical changes in observed irradiance and cloud optical depth.**
- **LW irradiance both up and down were too low with respect to observations.**
- **SW irradiance both up and down matched well in clear sky but was too absorptive (due to larger COD) in cloudy conditions.**
- **Comparisons of lower air and surface skin temperatures to MODIS and AIRS retrievals show GEOS-541 Tskn & Tair are too low and tropospheric water vapor (not shown) is too dry.**
- **LW surface upward, downward and net fluxes improved with GEOS-IT product, SW surface irradiance was little changed.**

Thanks for you attention

GEOS-541 & GEOS-IT Effect on Surface LW







GEOS-541 & GEOS-IT Effect on Surface SW