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Clear-Sky LW Flux Simulation Using GMAO Datasets and Its Comparison to CERES and Ground Observations

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Backgrounds

- Global Modeling Assimilation Office (GMAO) GEOS assimilated datasets are used to describe temperature and humidity profiles in the Clouds and the Earth's Radiant Energy System (CERES) data processing (GEOS-5.2.0 for Ed3 and GEOS-5.4.1 for Ed4).
- Recently, advanced versions of GMAO datasets such as Modern-Era Retrospective Analysis for Research and Applications version 2 (MERRA-2) and Forward Processing (FP) datasets are also available.
- It is interesting to see if accuracy of clear-sky simulation is improved with these newer versions of GMAO datasets when their temperature and humidity profiles are used.

GMAO Products Considered in This Study

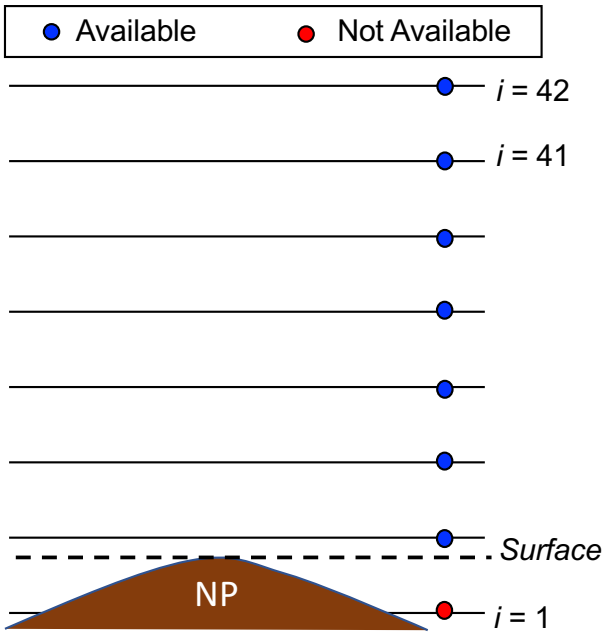
1) GEOS-5.2.0 is used for CERES Ed3. ⟶ "G520"
2) GEOS-5.4.1 is used for CERES Ed4. ⟶ "G541"
3) MERRA-2 is a continuous reanalysis ⟶ "MERRA2" dataset for 1980 – current.
4) FP v5.13 is an operational forward ⟶ "FP513" processing (FP) dataset for year 2015-2016

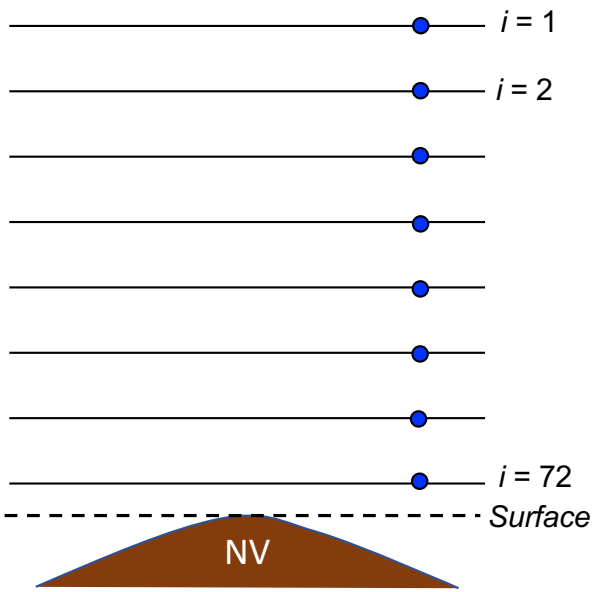
Objectives

- We apply four different GMAO datasets to assume atmospheric profiles, and perform clear-sky flux simulation at TOA and surface using Fu-Liou radiative transfer model (RTM).
- We compare the simulated results with ground and CERES satellite observations for cloud-free pixels.

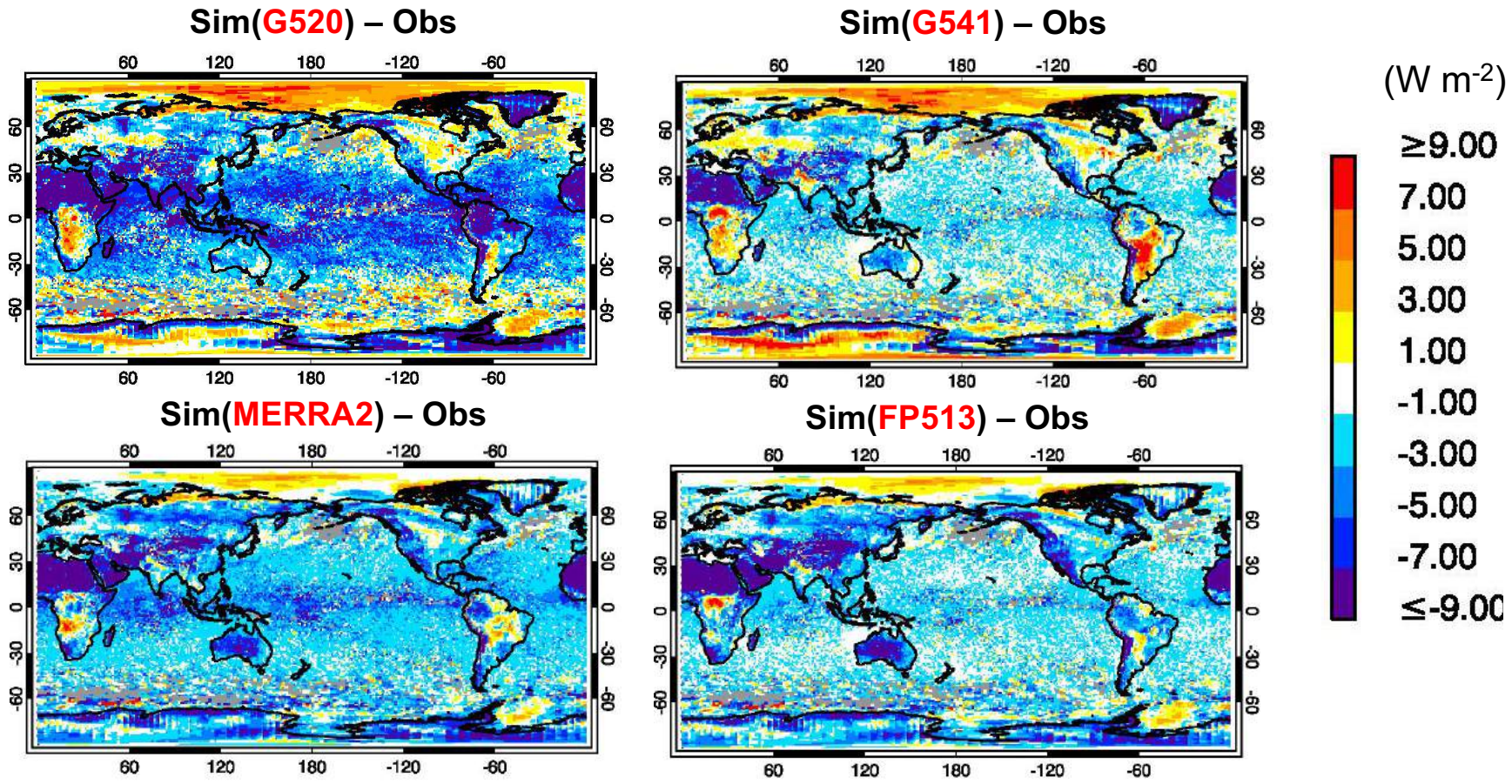
Setting Up Fu-Liou Radiative Transfer Model for Clear-Sky Simulation

- 12 narrow band simulation for longwave broadband flux (> 4 μm)
- LW surface emissivity from 0.5º gridded and 12 monthly data based on observations (Huang et al., 2016)
- Aerosol properties from assimilated dataset (MATCH) using MODIS observations (Collins et al., 2001)
- For G520, up to 43 model levels are considered (42 GMAO NP levels + Surface).
- For G541, MERRA2, and FP513, up to 73 model levels are considered (72 GMAO NV levels + Surface).



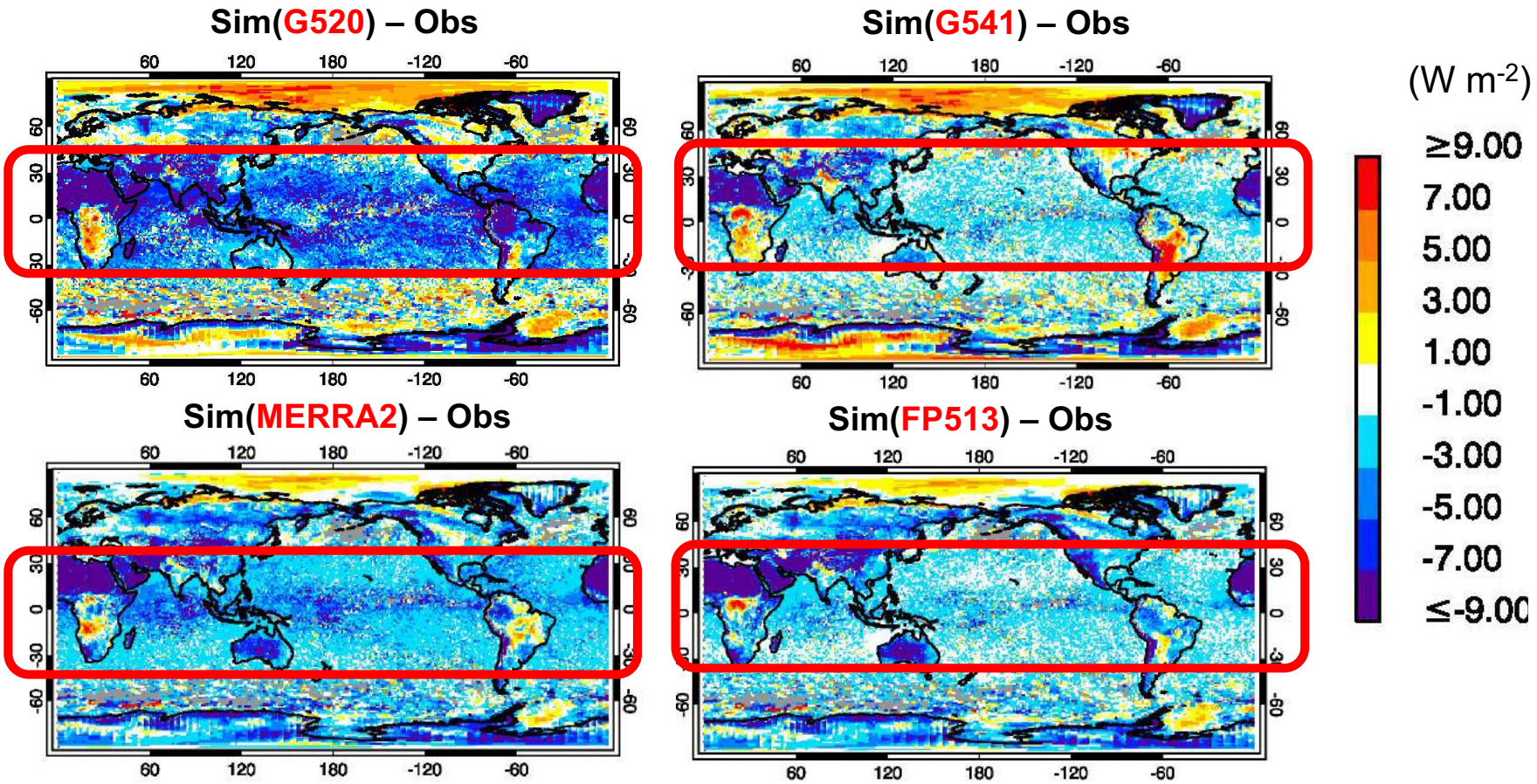


Comparison of Computed LW TOA Upward Fluxes with CERES Ed4 Observations (Cloud-Free Pixels Only)



CF in one-hour period < 5%, Four-seasonal months

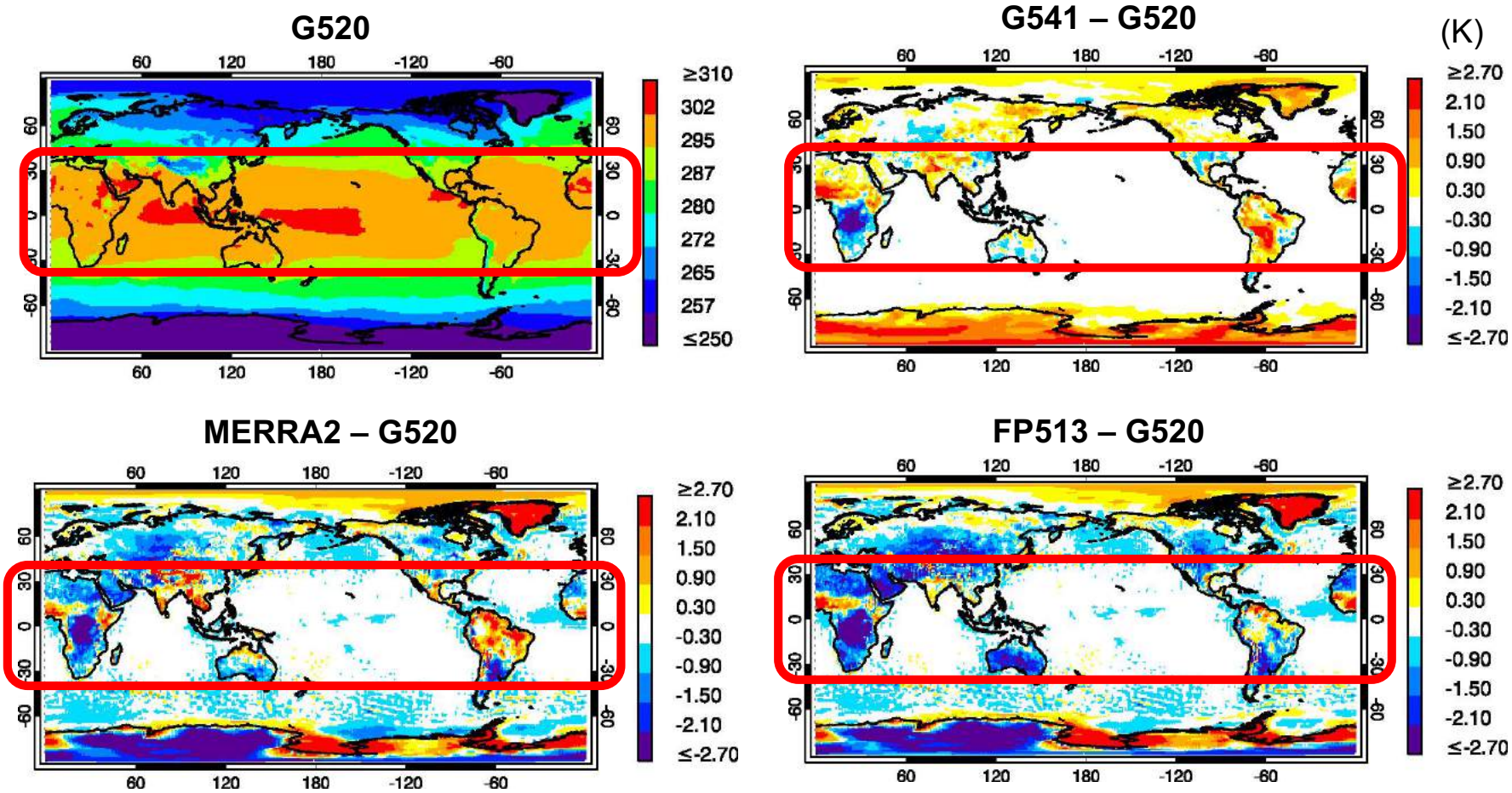
Comparison of Computed LW TOA Upward Fluxes with CERES Ed4 Observations (Cloud-Free Pixels Only)



Over tropical oceans, LW TOA fluxes from G520 are negatively biased, while other datasets produce smaller biases.

Skin Temperature (K) relative to G520

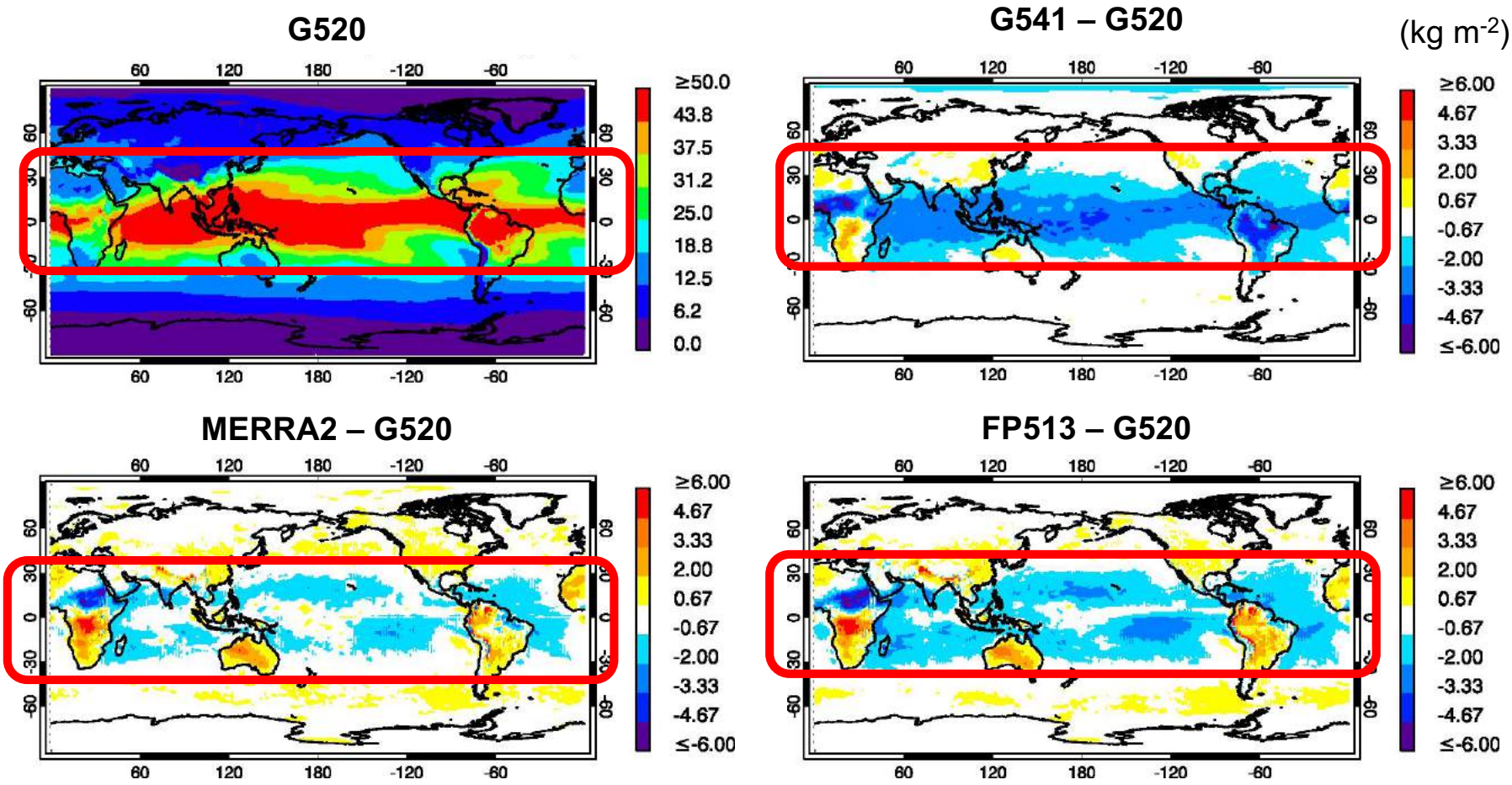
Four-Seasonal Months



Over tropical ocean, skin temperatures from the four GMAO datasets agree well.

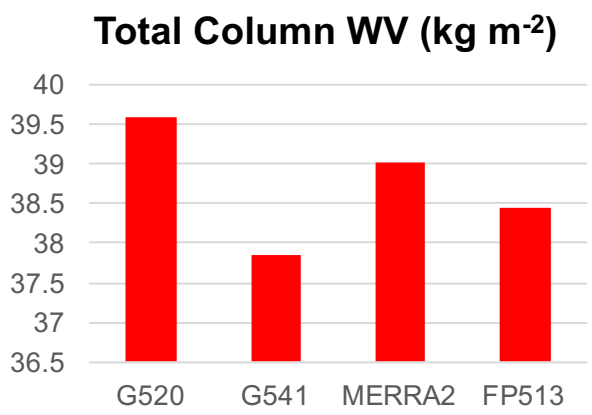
Total Column WV (kg m^{-2}) relative to G520

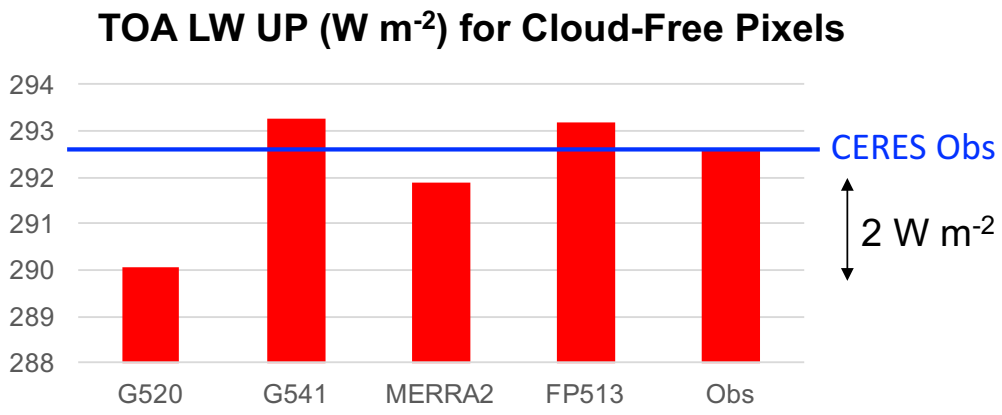
Four-Seasonal Months

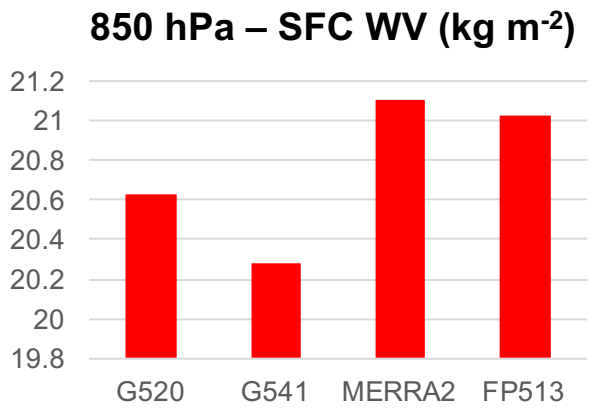


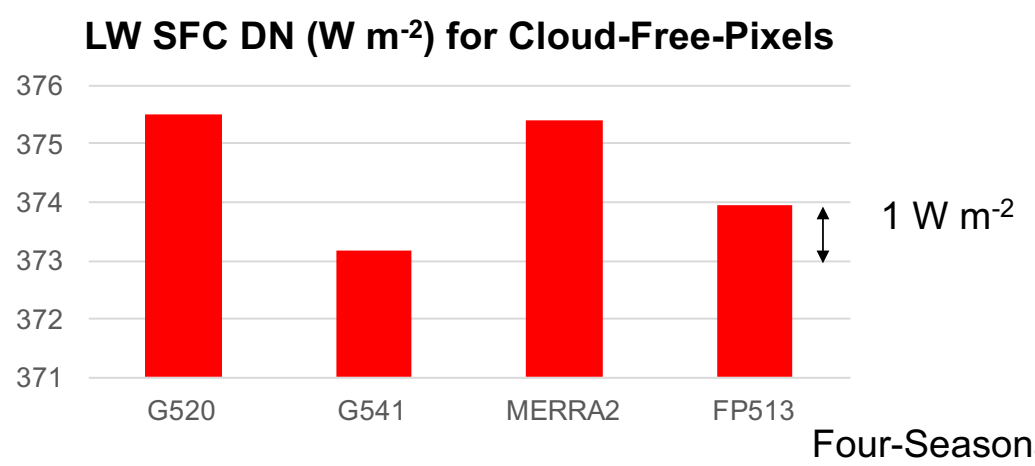
Over the tropical oceans, G520 has the largest column WV amount, compared to other datasets, which explain the larger negative LW TOA biases shown in G520. MERRA2 shows the second largest column WV.

Flux Changes by Different GMAO Products over Tropical Ocean (30˚S–30˚N)

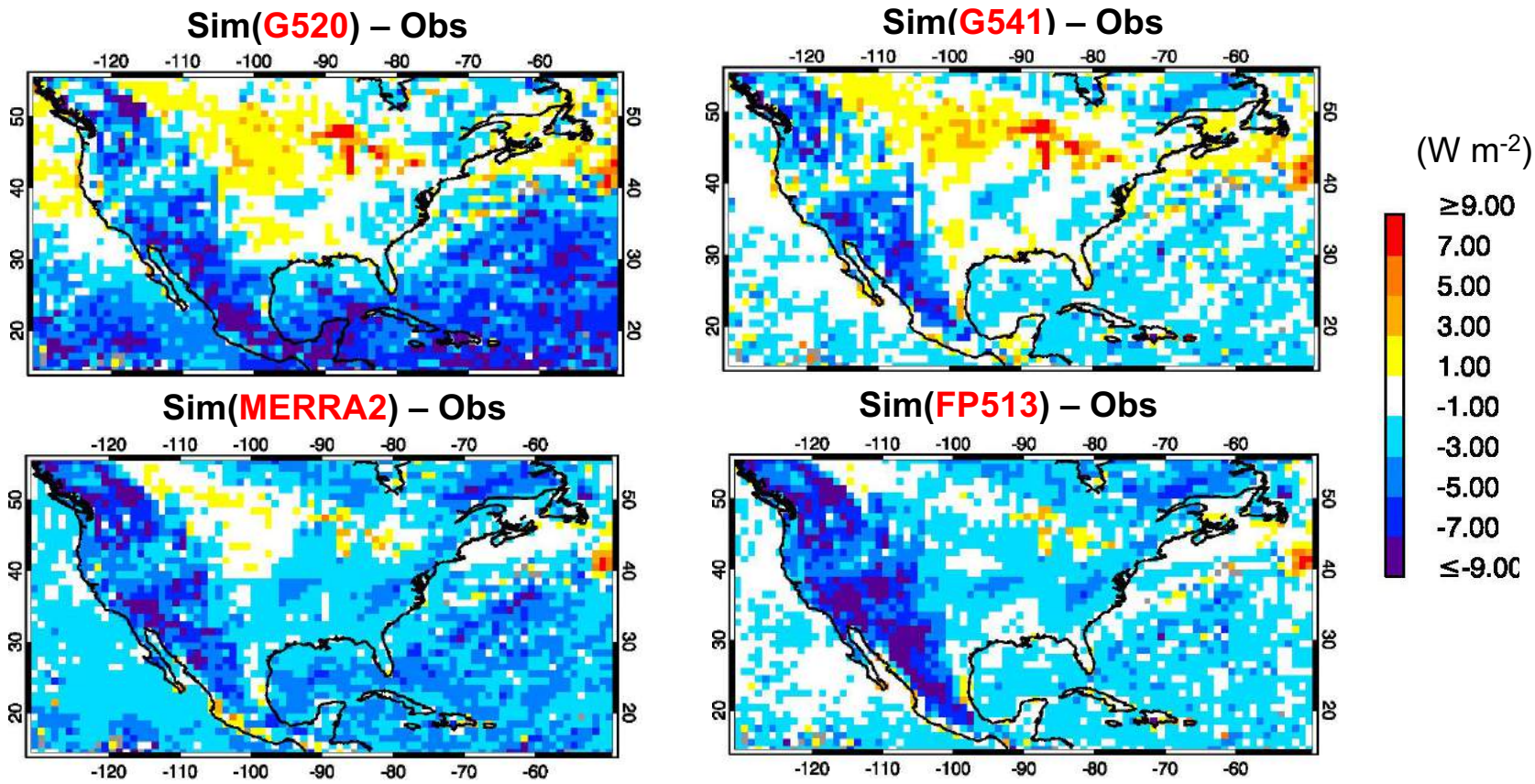








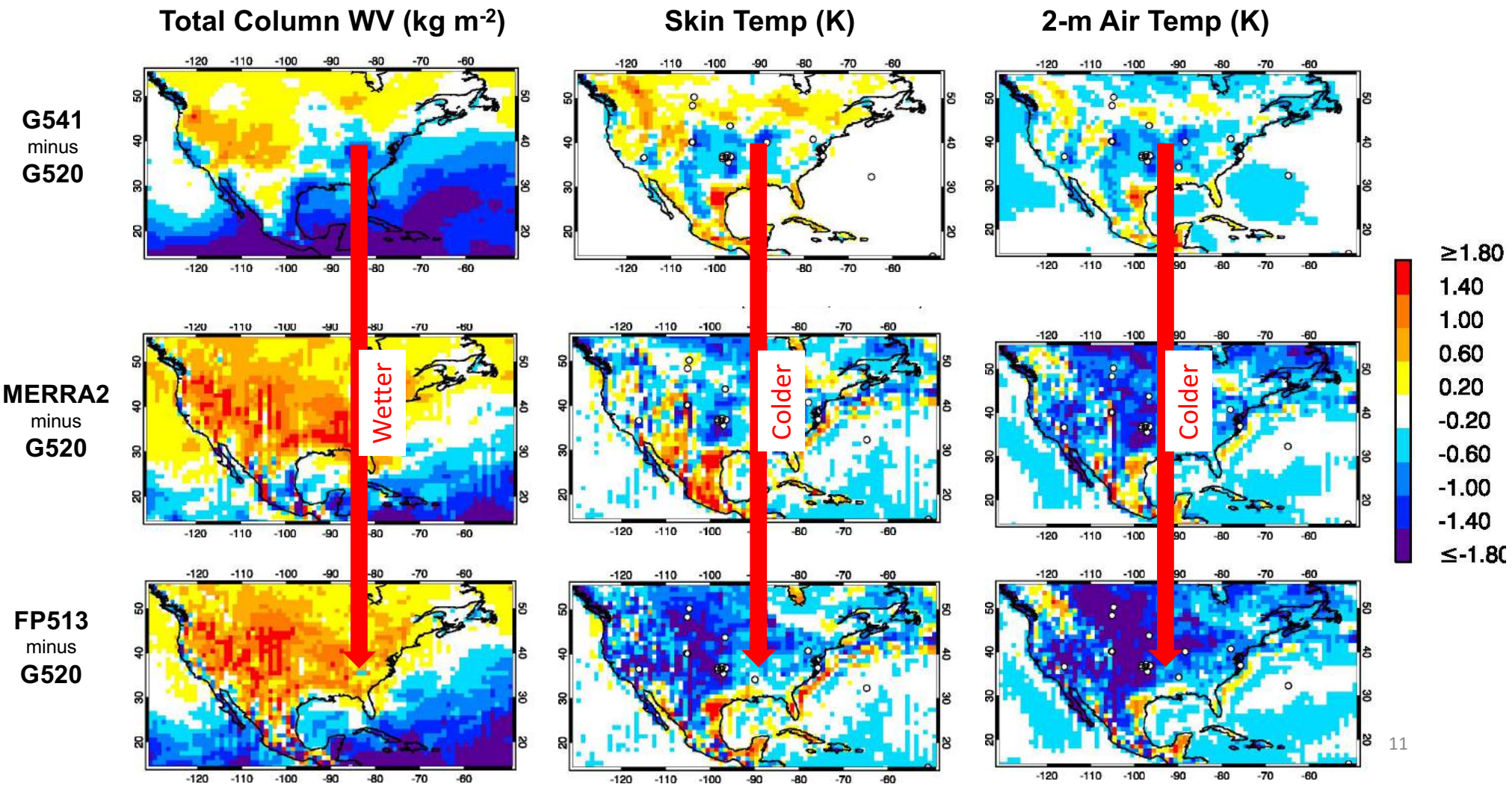
Comparison of Computed LW TOA Upward Fluxes with CERES Ed4 Observations over North America



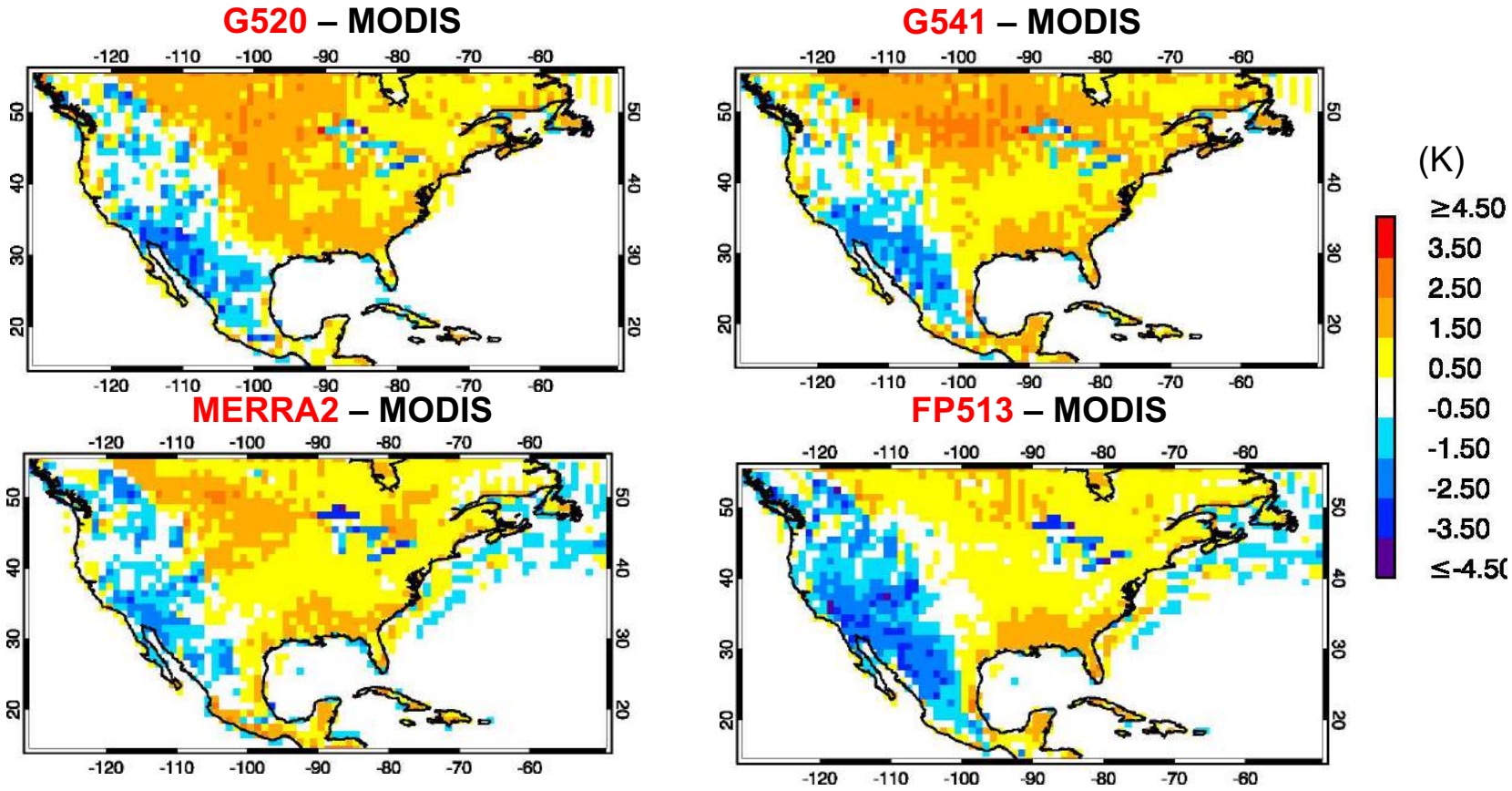
When G520 and G541 are used, positive LW TOA biases are shown in the east side of Rocky Mountains, while the biases are reduced (or slightly negative) in MERRA2 and FP513 simulations.

(Four-Seasonal Months)

WV and Temp Relative to G520 over North America



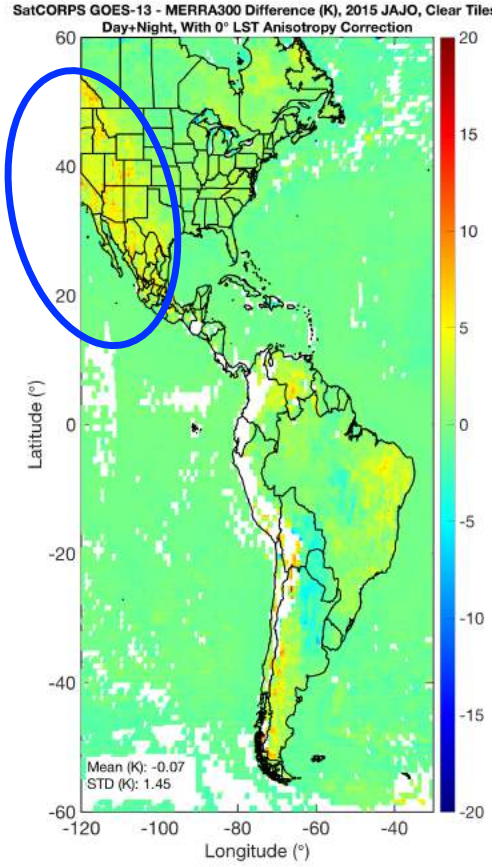
GMAO minus MODIS-Derived (SYN Ed4) Skin Temperature (Four-Seasonal Months)



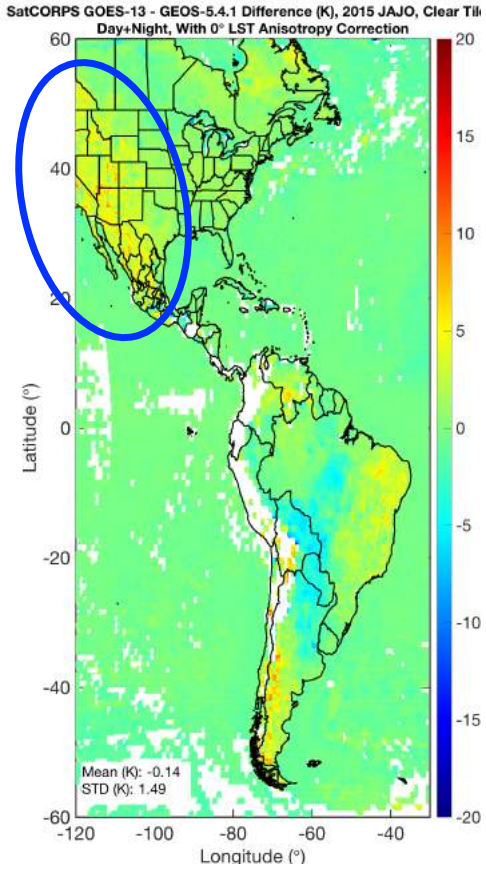
If difference is obtained for each month, July shows larger positive biases in the east side of Rockies, compared to January.

[GOES-13 Derived Skin Temperature] minus [GMAO Skin Temp]

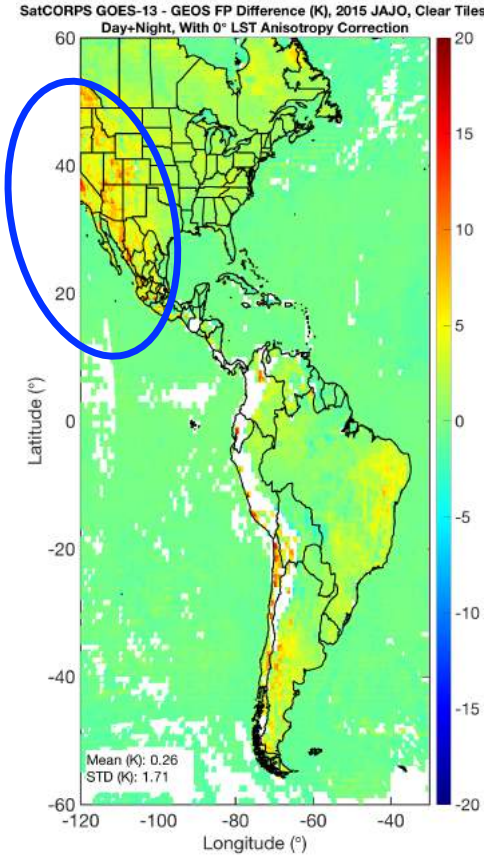
GOES minus MERRA300 (G520 like)



GOES – G541



GOES – FP513



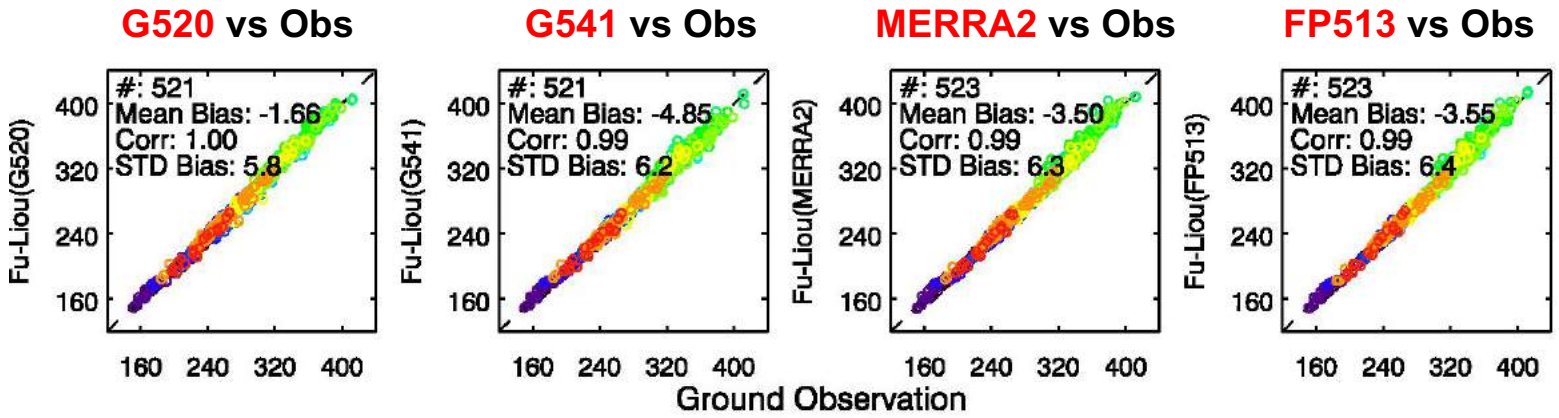
GOES SkinT > GMAO SkinT

GOES SkinT < GMAO SkinT

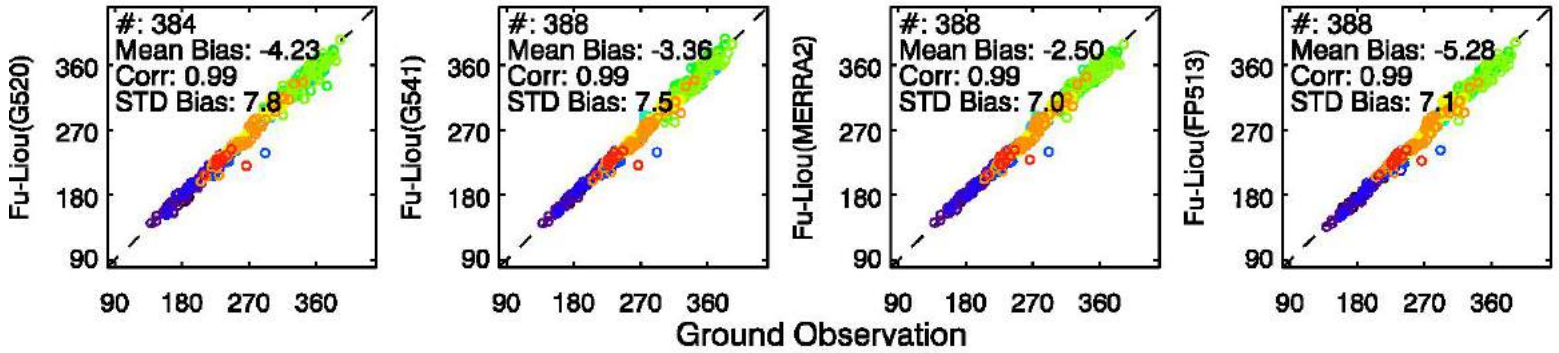
Data available at http://satcorps.larc.nasa.gov/

Good agreements of Computed LW SFC DN Fluxes with Ground Observations

BON (Bondville, IL) 88.4W 40.1N 0.230 km



PSU (Penn State, PA) 77.9W 40.7N 0.376 km

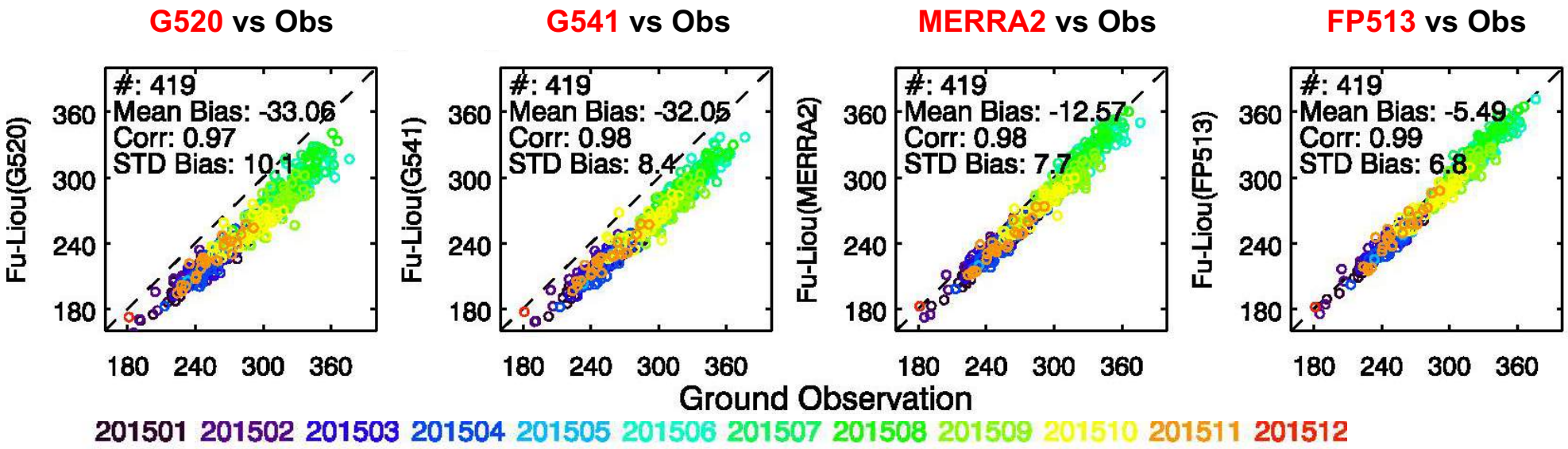


201501 201502 201503 201504 201505 201506 201507 201508 201509 201510 201511 201512

- Surface downward flux is not affected by skin temperature and surface emissivity.
- Aerosol effect is larger in surface downward flux than in TOA LW upward flux (up to 2 W m^{-2})
- Near-surface WV and temperature largely change surface flux.

Improvement of LW SFC Flux Simulation over Mountain Area When Higher-Resolution of FP dataset is used

BOU (Boulder Tower) 105.0W 40.1N Alt 1.58 km

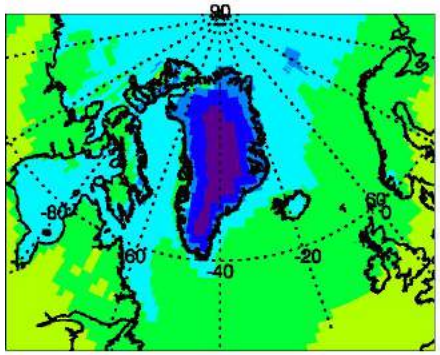


- LW SFC downward computation is much improved in FP513, compared to G520 or G541.
- This is because FP513 is provided at a higher spatial resolution, which gives a closer GMAO pixel point to the BOU ground site.
- Aerosol assumption and the method of vertical interpolation near surface can change SFC LW downward flux up to 5 W m^{-2}.

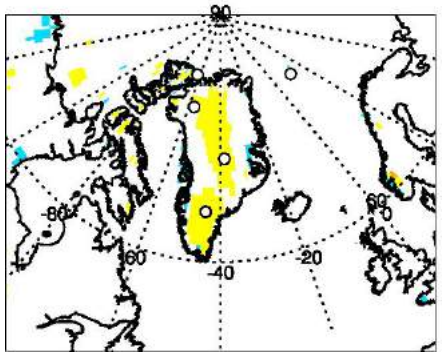
Increased Skin Temperature over Greenland

Summer Time (July 2015)

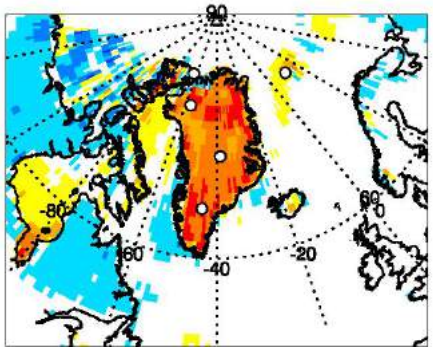
G520



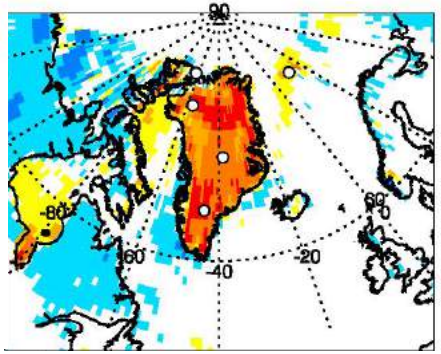
G541 – G520



MERRA2 – G520

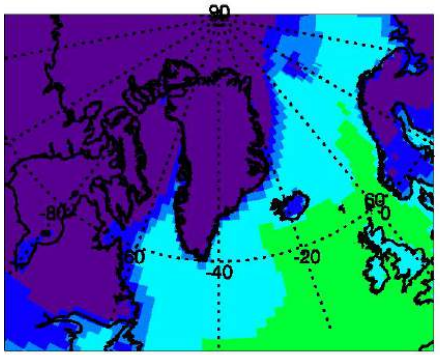


FP513 – G520

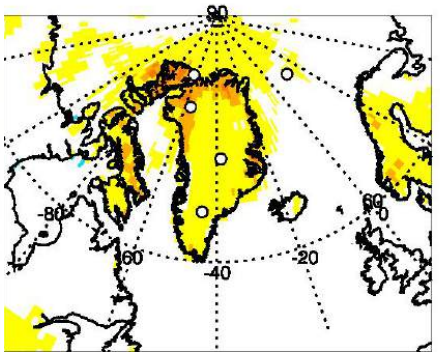


Winter Time (Jan 2016)

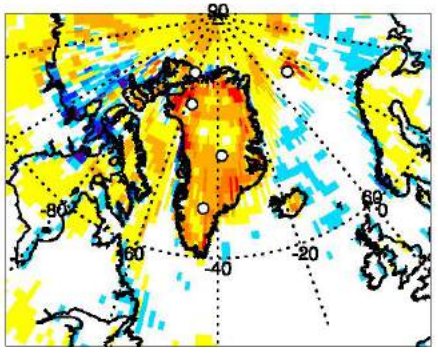
G520



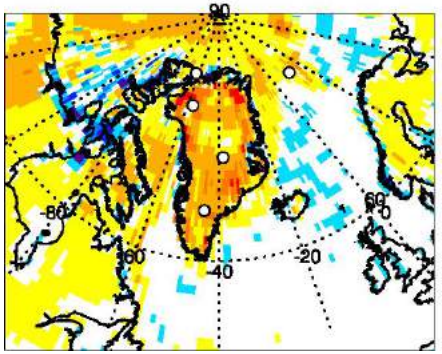
G541 – G520

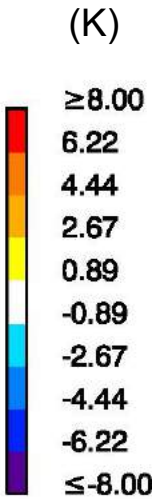


MERRA2 – G520



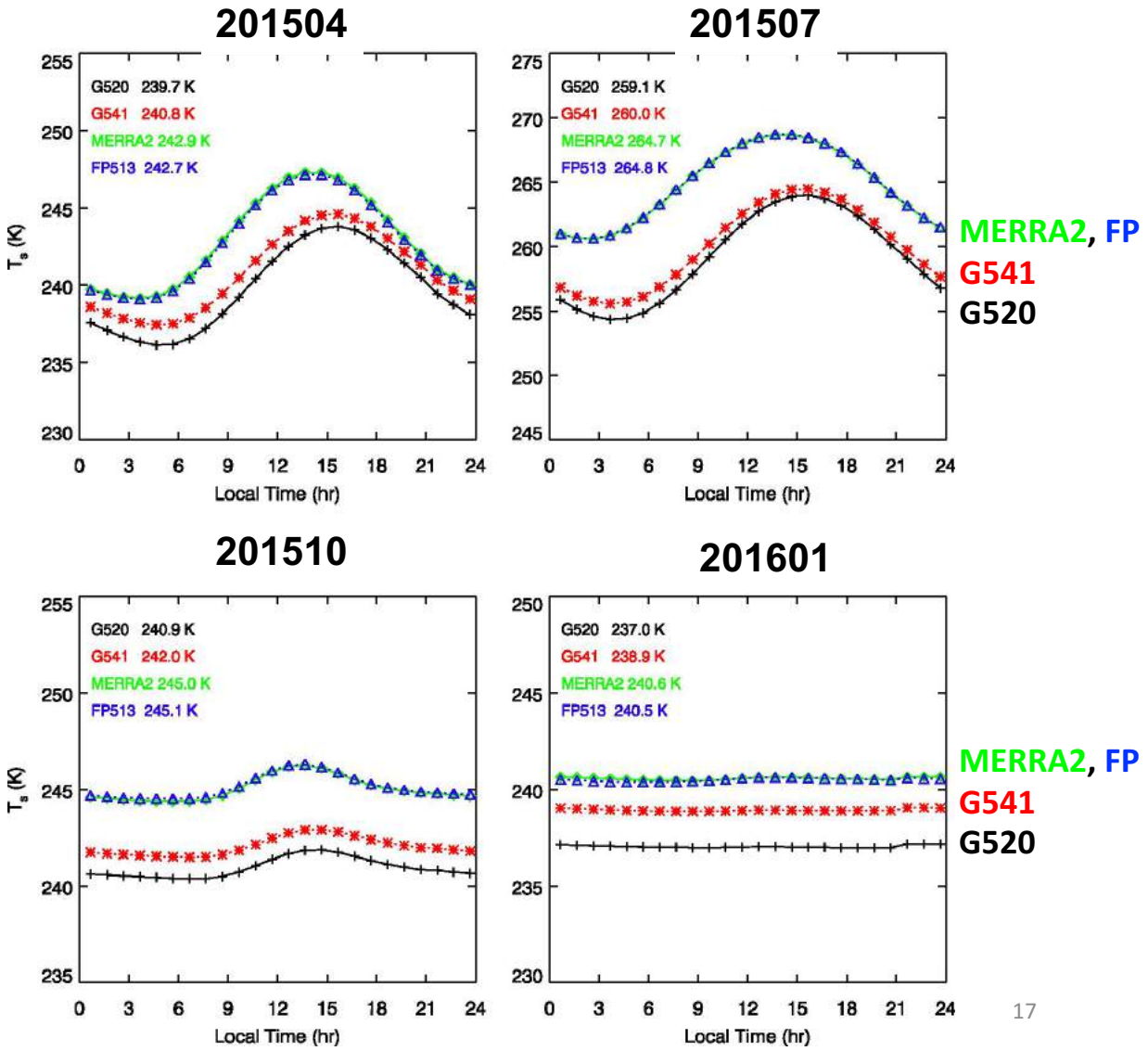
FP513 – G520



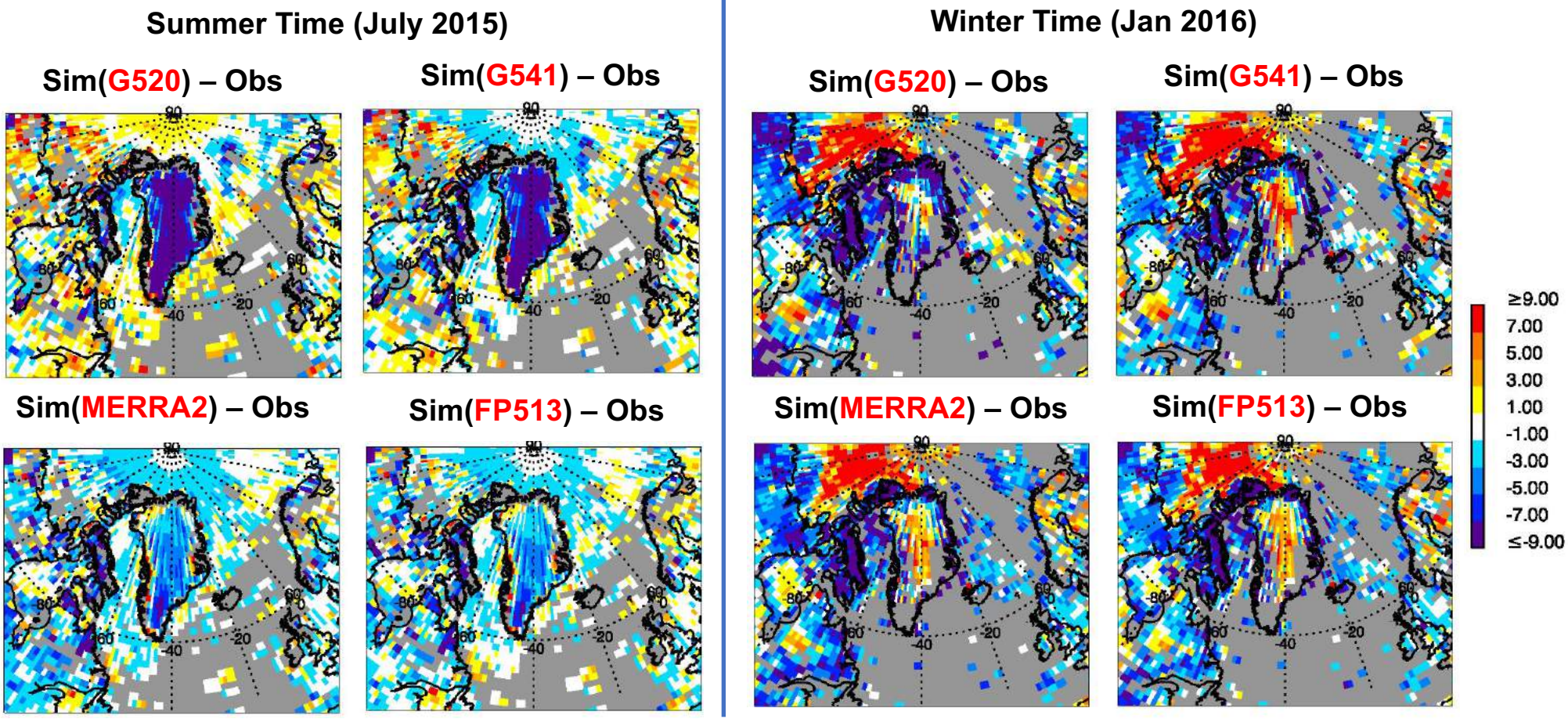


Diurnal Cycle of Skin Temperature over Greenland (Domain-averaged skin temperature 60N-80N, 60W-25W)

G520
G541
MERRA2
FP513



LW TOA Upward Fluxes over Greenland



Note: Winter time, there is no daytime observation over Greenland.

Summary and Conclusions

- Four different GMAO datasets are used to describe temperature and water vapor profiles in the radiative transfer model and the results are compared with TOA CERES and ground observations.
- Over tropical oceans, negative LW biases are appeared to the CERES TOA observations when G520 is used. The biases get smaller when other datasets are used. This implies that WV amounts of G520 are overestimated over tropical oceans.
- When G520 and G541 are used, TOA LW fluxes are positively biased In eastern side of Rocky mountains, and negatively biased in western side. Colder skin temperatures in MERRA2 and FP513 improve LW TOA biases in eastern side, but not in western side. This is consistent with skin temperature comparison with satellite-derived skin temperatures.
- Over Greenland, skin temperatures of FP513 and MERRA2 are warmer than G520 and G541. This results in improvements of LW TOA simulation in summer time, but not in winter time.