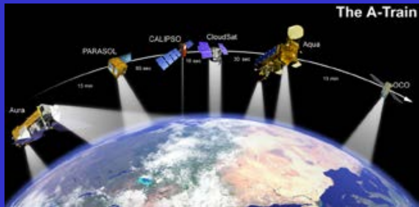
Comparison of TOA and Surface Radiation from Multiscale Modeling Framework Simulation with CERES TOA and Surface EBAFs

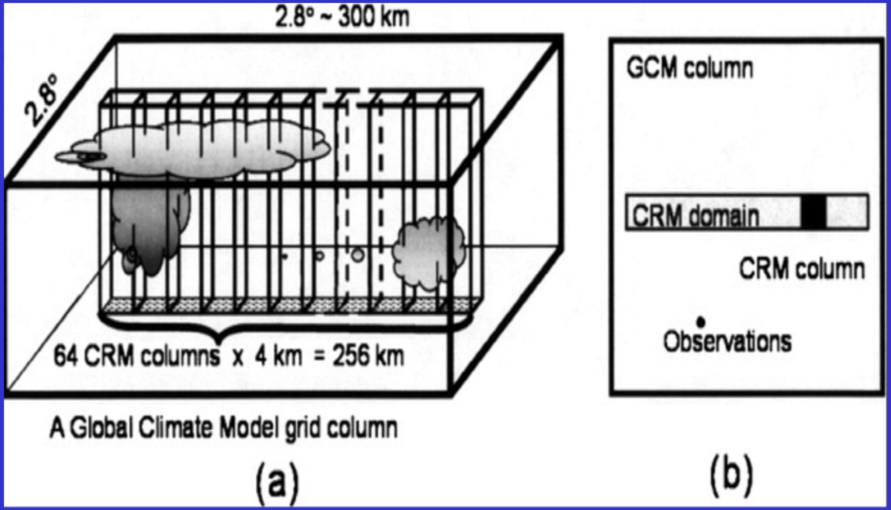
Anning Cheng[1] and Kuan-Man Xu[2]

1. Science Systems and Applications, Inc., Hampton, VA
2. NASA Langley Research Center, Hampton, VA



Multiscale Modeling Framework
(Grabowski 2001; Khairoutdinov and Randall 2001)

- ✦ A CRM is embedded at each grid column (~100s km) of the host GCM to represent cloud physical processes
- ✦ The CRM explicitly simulates cloud-scale dynamics (~1s km) and processes
- ✦ Periodic lateral boundary condition for CRM (not extend to the edges)

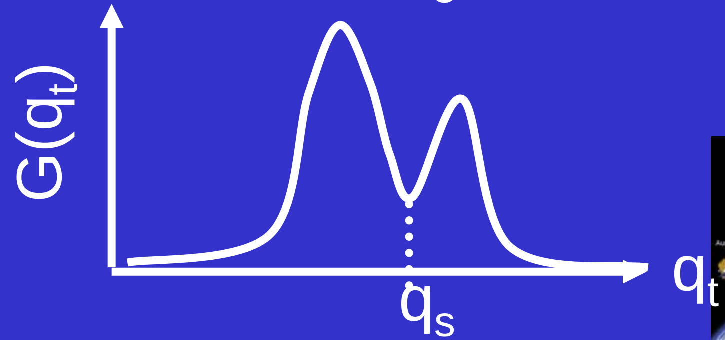


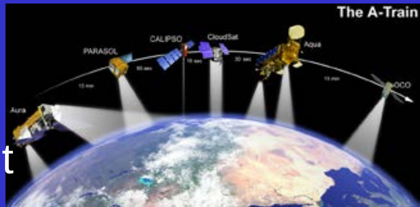
Upgraded CRM with a third-order turbulence closure (IPHOC):

✦Double-Gaussian distribution of liquid-water potential temperature, total water mixing ratio and vertical velocity

✦Skewnesses, i.e., the three third-order moments, predicted

✦All first-, second-, third- and fourth-order moments, subgrid-scale condensation and buoyancy based on the same PDF





MMF climate simulation

- The model, SPCAM-IPHOC, is Community Atmosphere Model version 3.5 with finite-volume dynamic core as the host GCM.
- The CRM is the 2-D version of System for Atmospheric Modeling (SAM) with IPHOC higher-order turbulence closure, the grid spacing is 4 km, with 32 columns within a GCM grid box.
- Simulation IP-12L: SPCAM-IPHOC with grid spacing of 1.9°x2.5°; doubling the number of levels below 700 hPa (6 to 12); the total number of vertical layers is 32. The simulation is forced with climatological SST and sea ice distributions.
- Simulation duration is 10 years; with last nine years analyzed (Xu and Cheng 2012; *J. Climate*, submitted).

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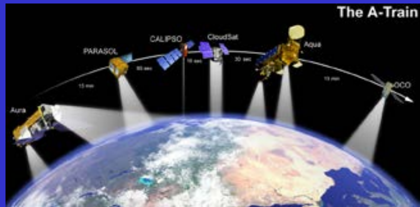
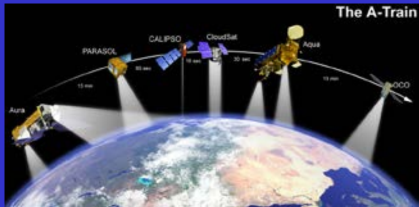
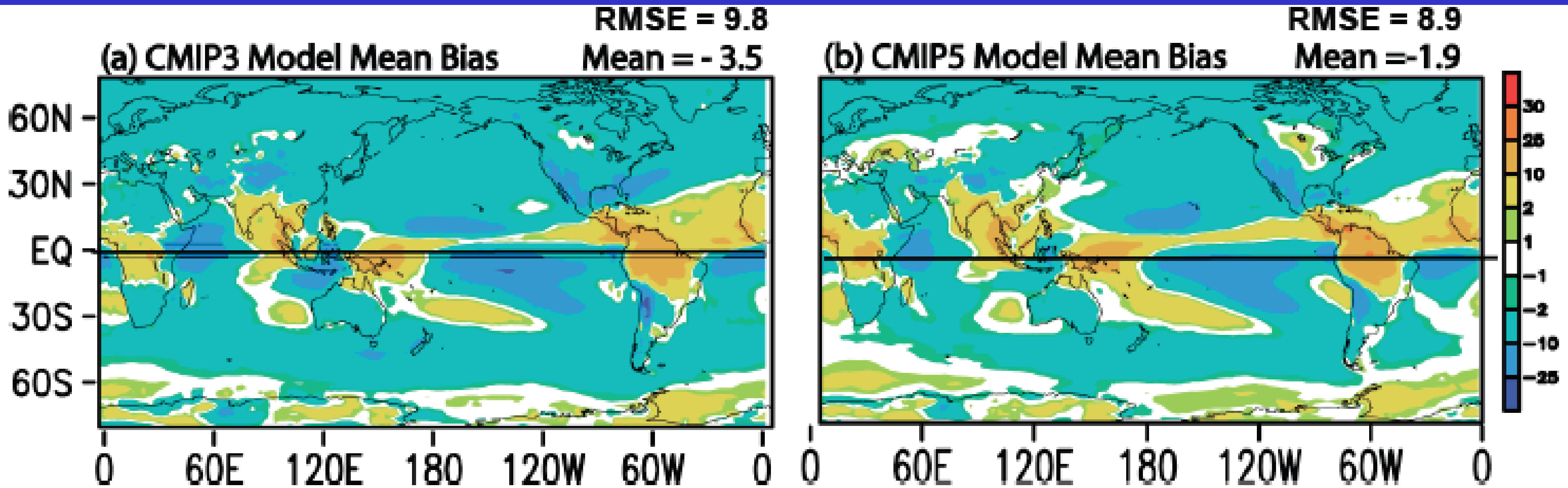


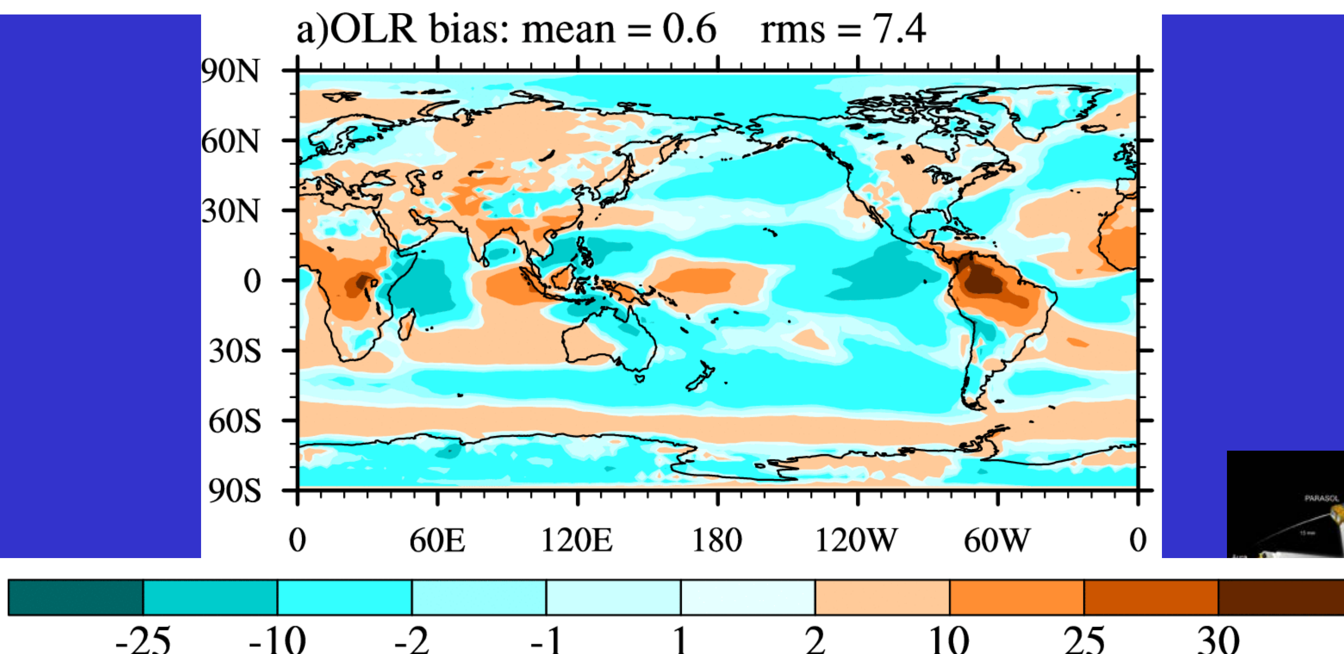
Annual mean biases vs CMIP3 & CMIP5

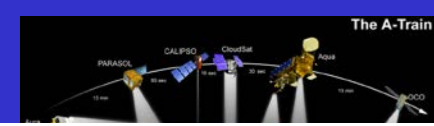
- Biases relative to CERES-EBAF version 2.6
- CMIP3 (IPCC AR4) and CMIP5 (IPCC AR5) model ensembles; plots were provided by Frank Li of JPL.
- Liquid water path is compared with SSM/I.
- Total cloud amount is compared with CloudSat, CALIPSO, CERES and MODIS merged data (C3M; Kato et al. 2010, 2011).



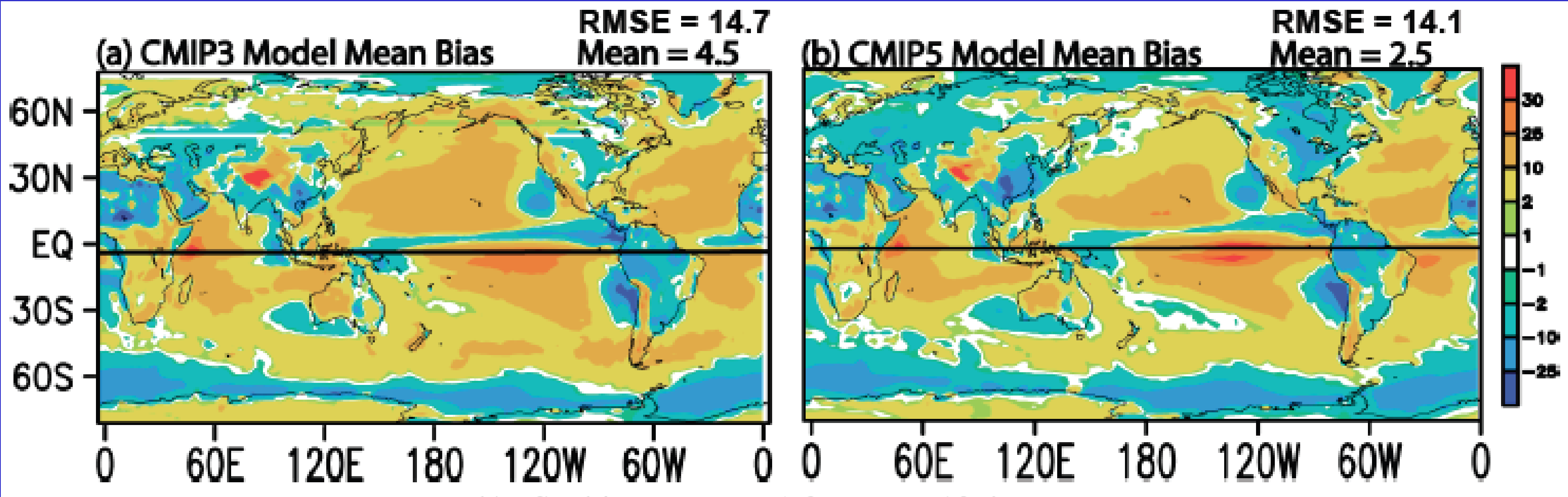
LW radiative flux biases @ TOA

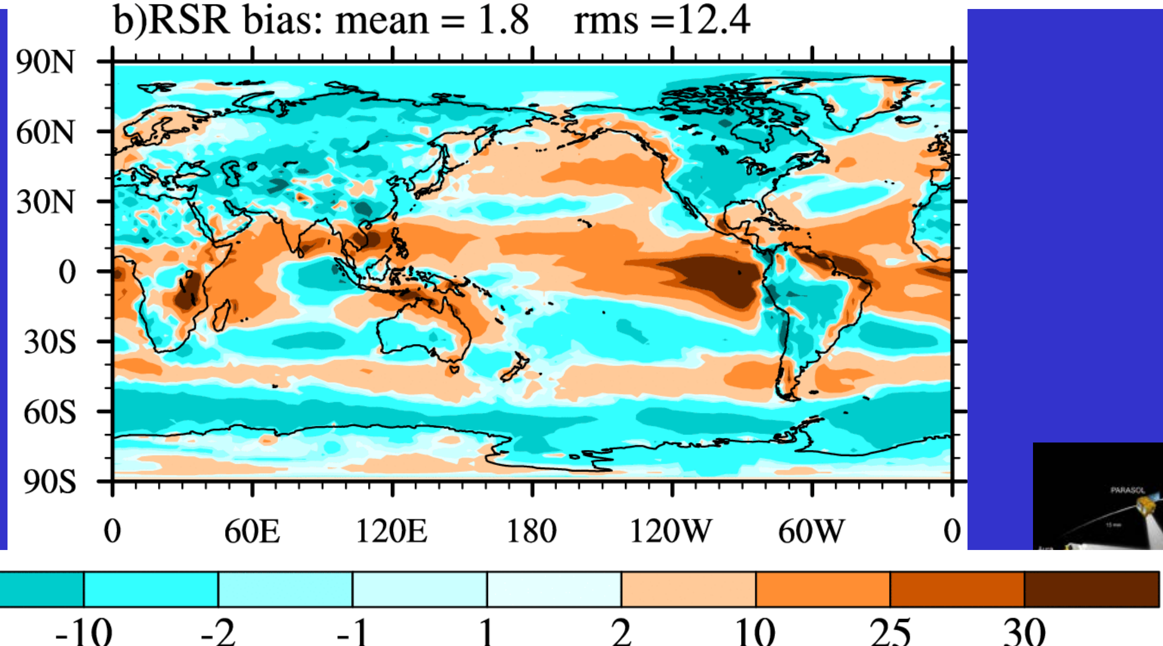






SW radiative flux biases @ TOA





Liquid water paths: CMIP3, CMIP5, MMF

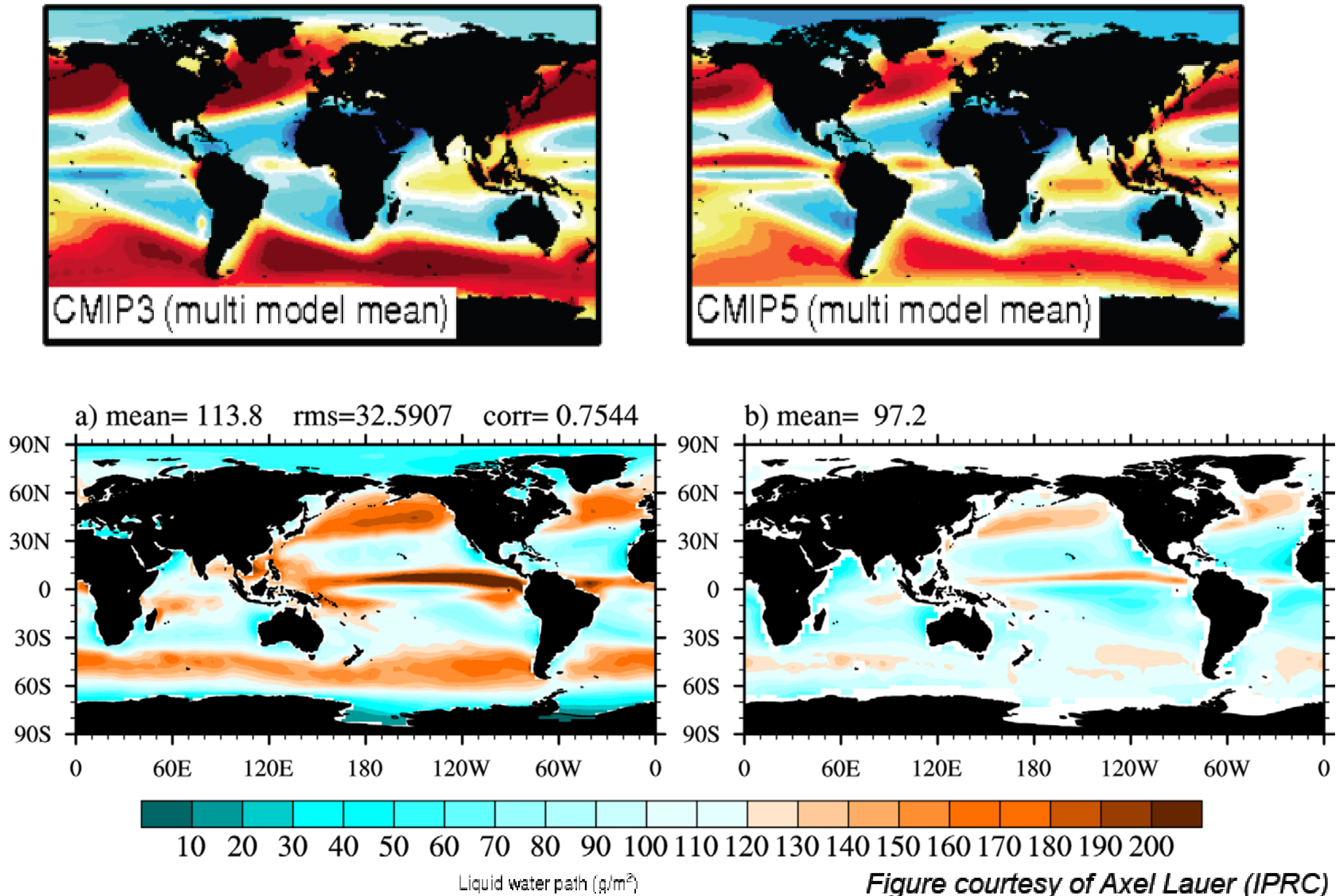
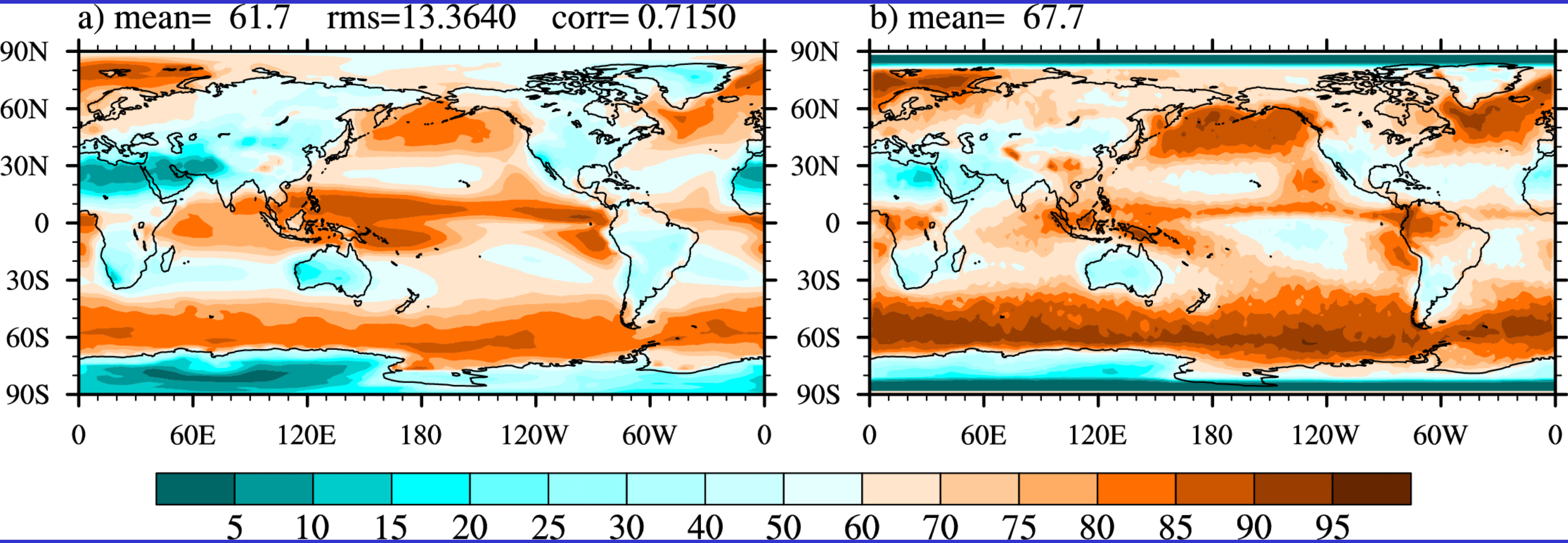
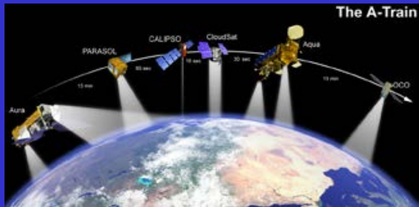


Figure courtesy of Axel Lauer (IPRC)

Total cloud amount from MMF and C3M

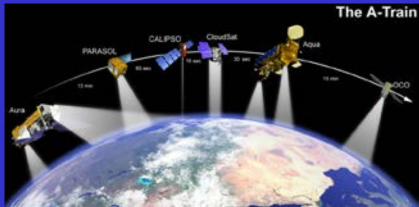




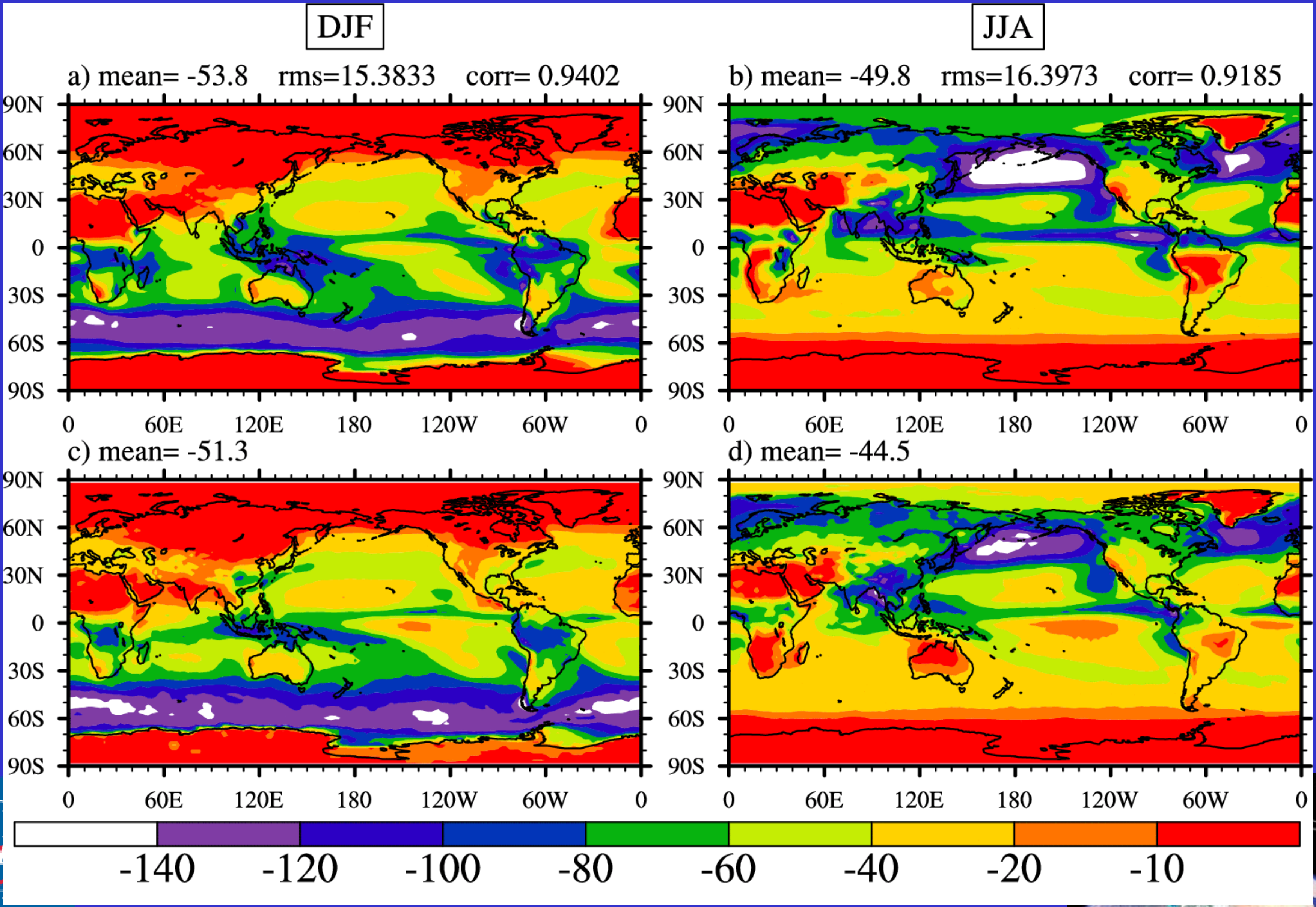
Global Seasonal Climatology

- December-February (DJF) and June-August (JJA)
- Cloud radiative effects at the TOA and surface: CERES EBAF version 2.6 (TOA) and surface EBAF2.6

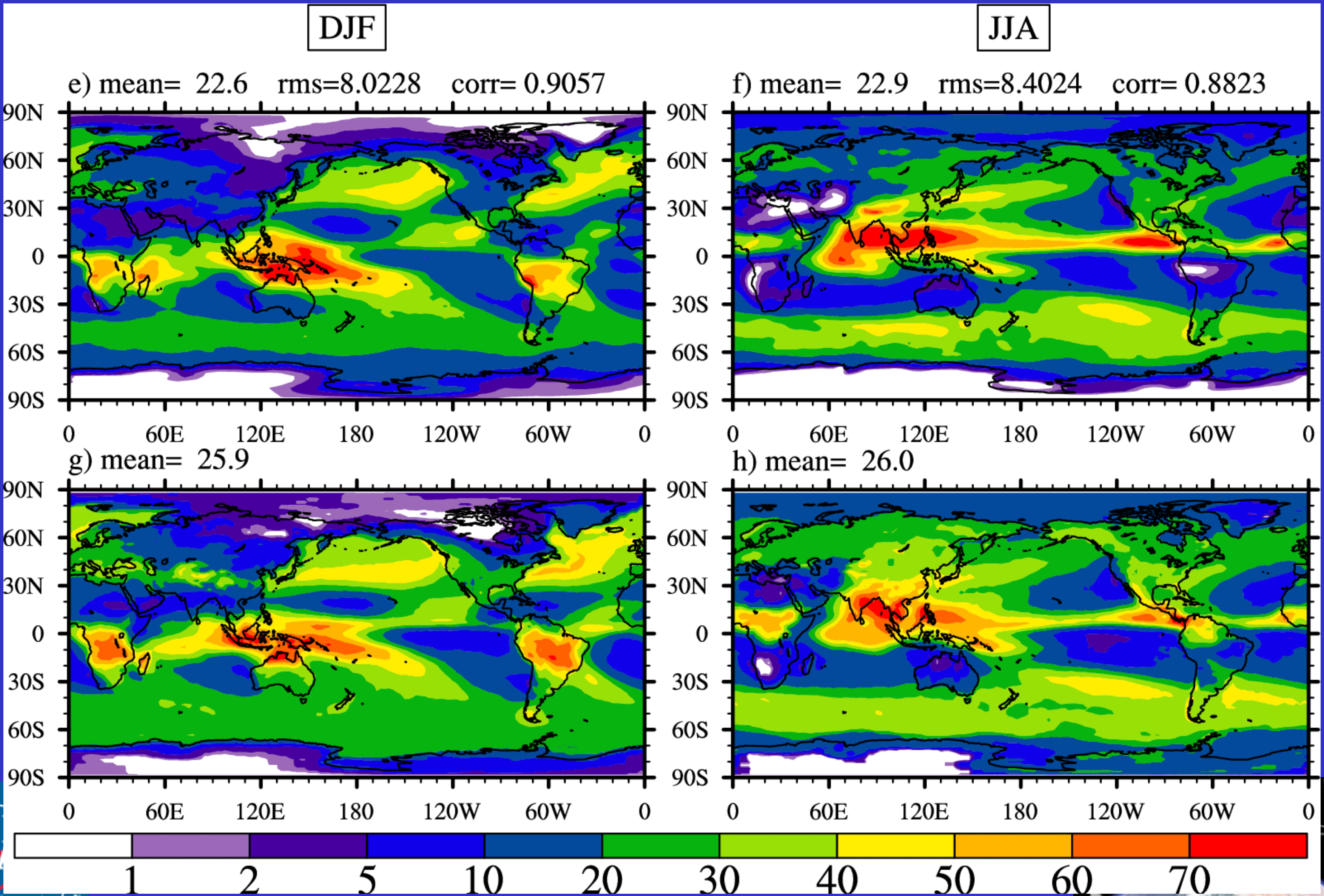
- Move your eyelids up & down: top panel for MMF, bottom panel for EBAF
- Global means, correlations and root-mean-square (RMS) errors



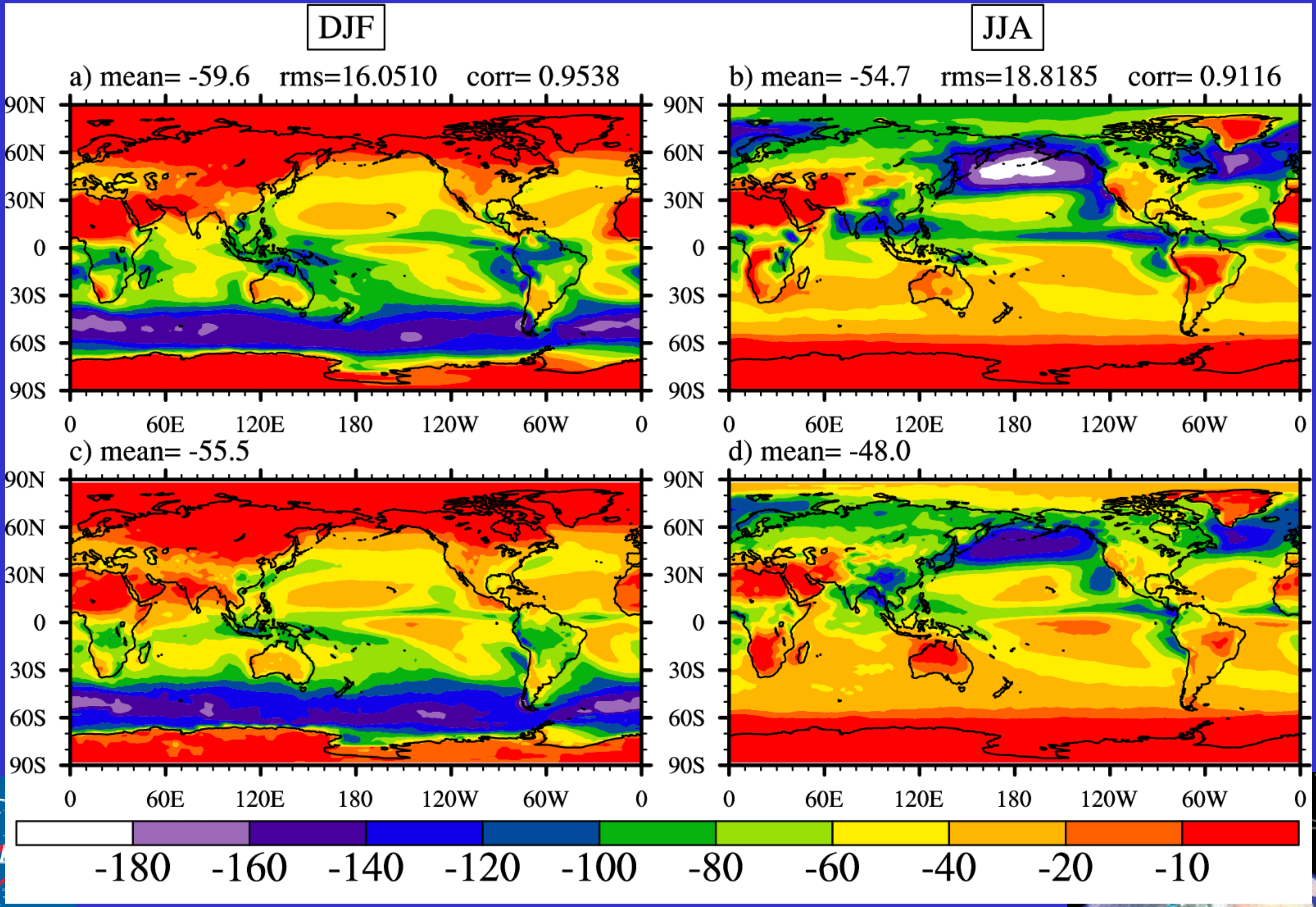
SW cloud radiative effect @ TOA



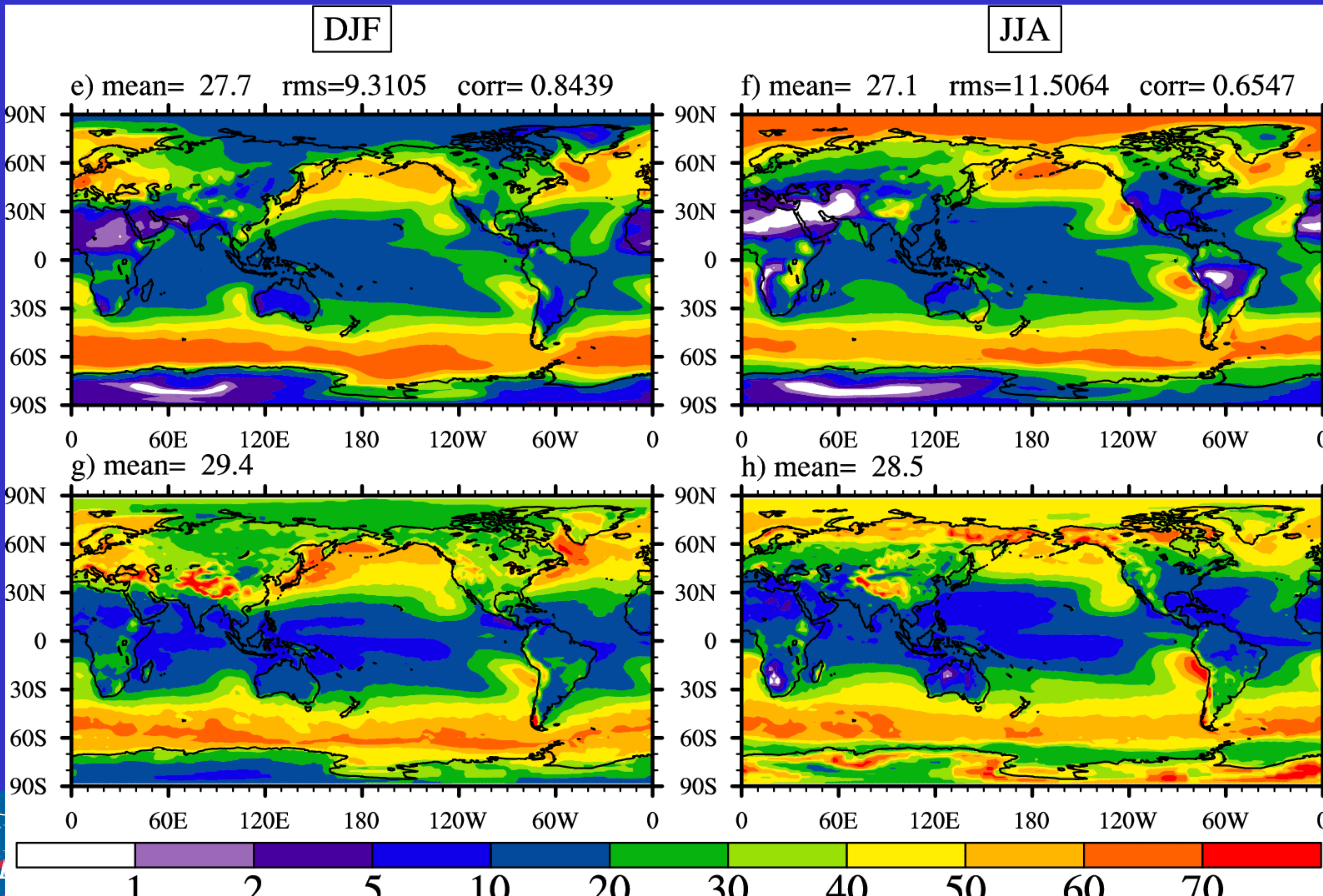
LW cloud radiative effect @ TOA



SW cloud radiative effect @ surface



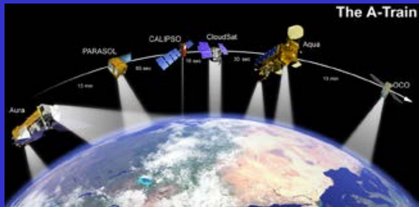
LW cloud radiative effect @ surface



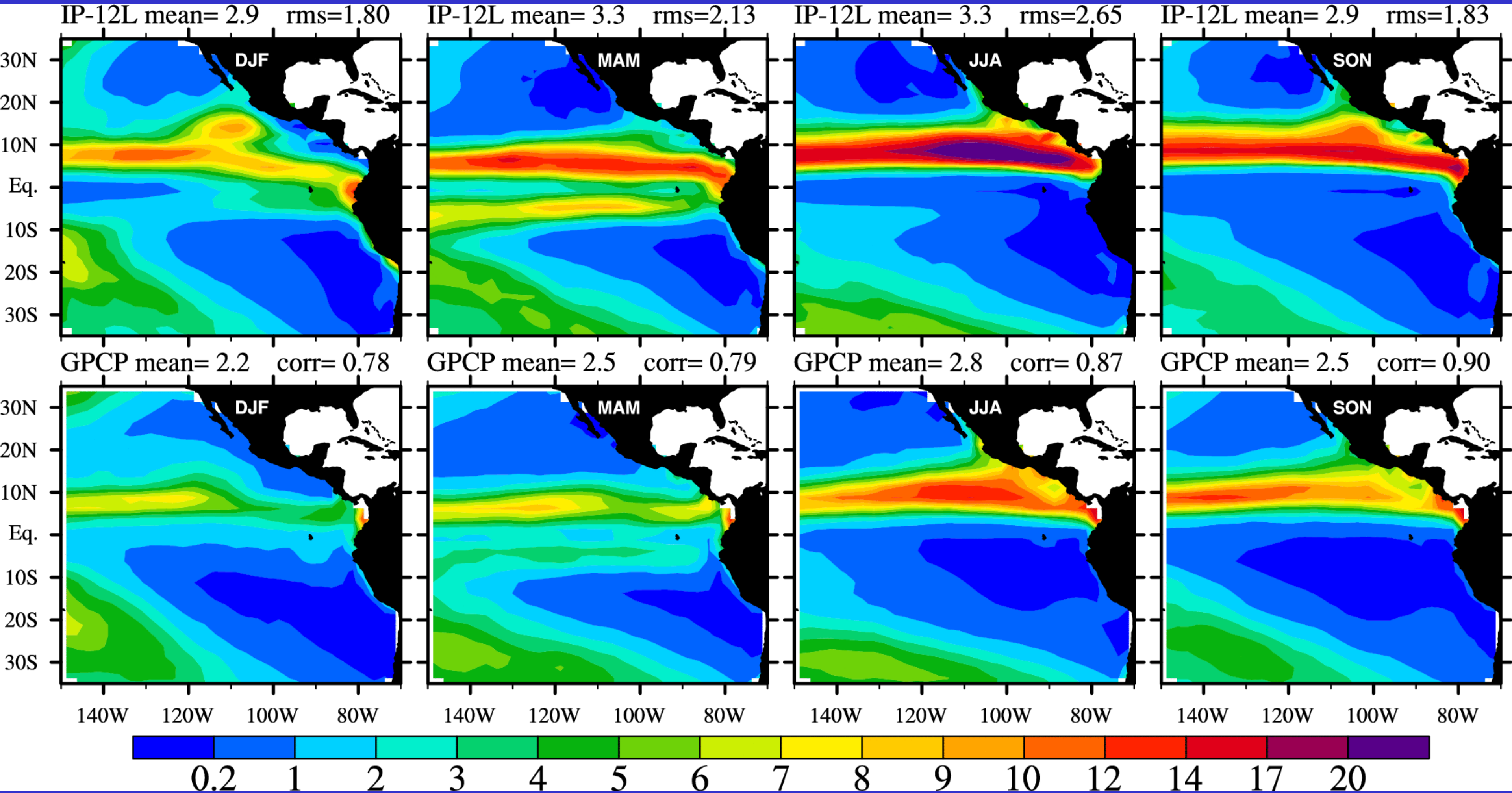
The Eastern Pacific Seasonal Cycle

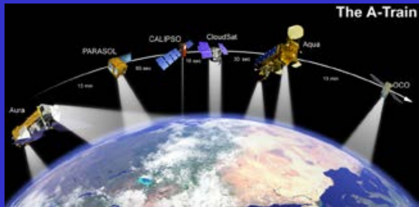
- All four seasons (DJF, MAM, JJA, and SON)
- Precipitation observations: Global Precipitation Climatology Project (GPCP; Adler et al. 2003)
- Low-level cloud amount: CloudSat, CALIPSO, CERES and MODIS merged data (C3M; Kato et al. 2010, 2011)
- Cloud radiative effects at the TOA and surface: CERES EBAF version 2.6 (TOA) and surface EBAF2.6

- MMF simulation, top panel; Observations, bottom panel.
- Domain means, correlation and root-mean-square (RMS) errors

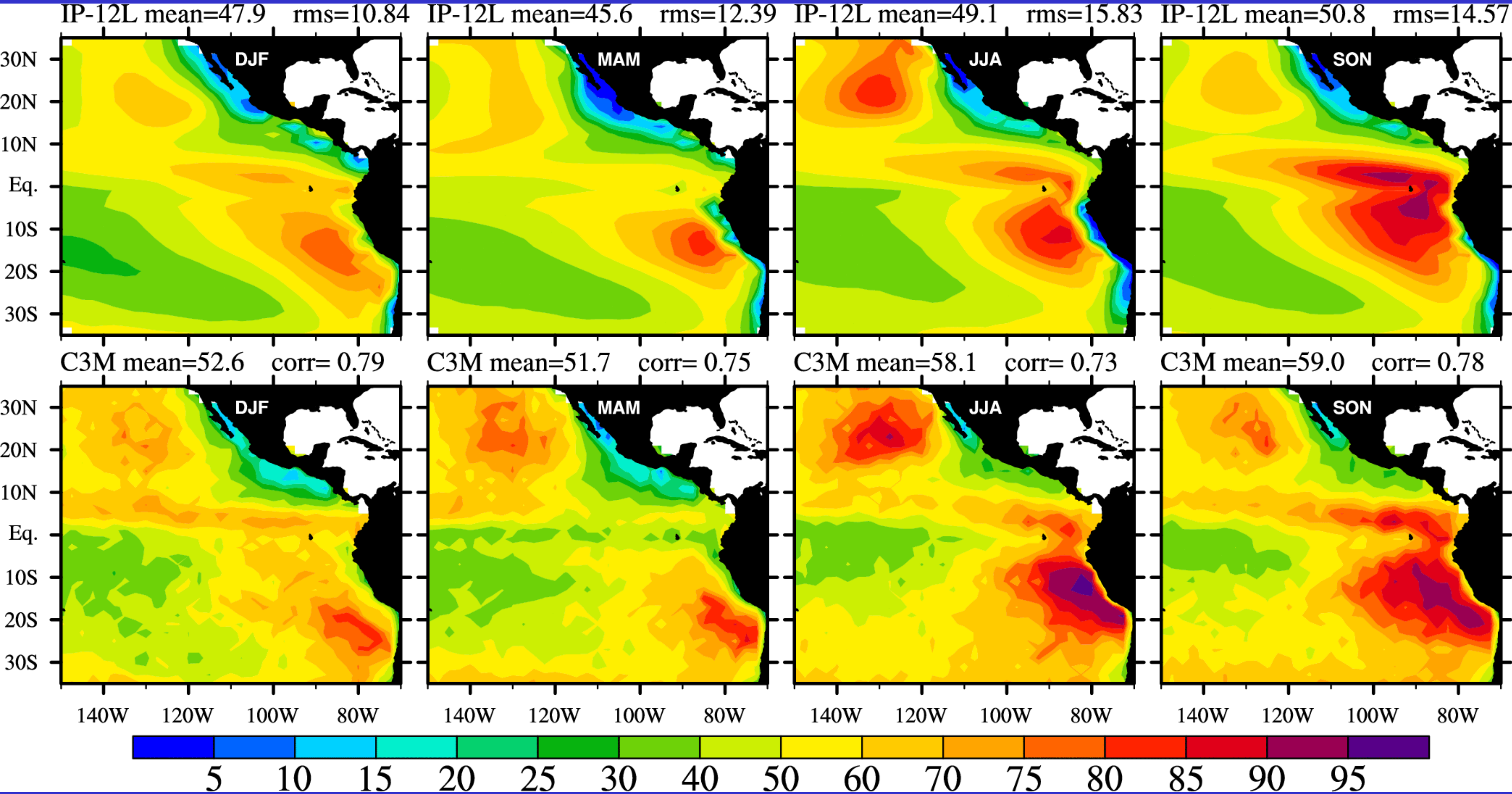


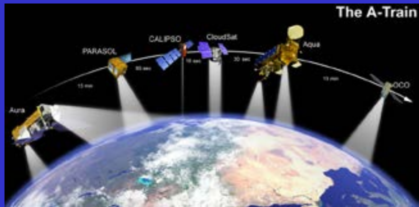
E. Pac. surface precipitation, MMF v GPCP



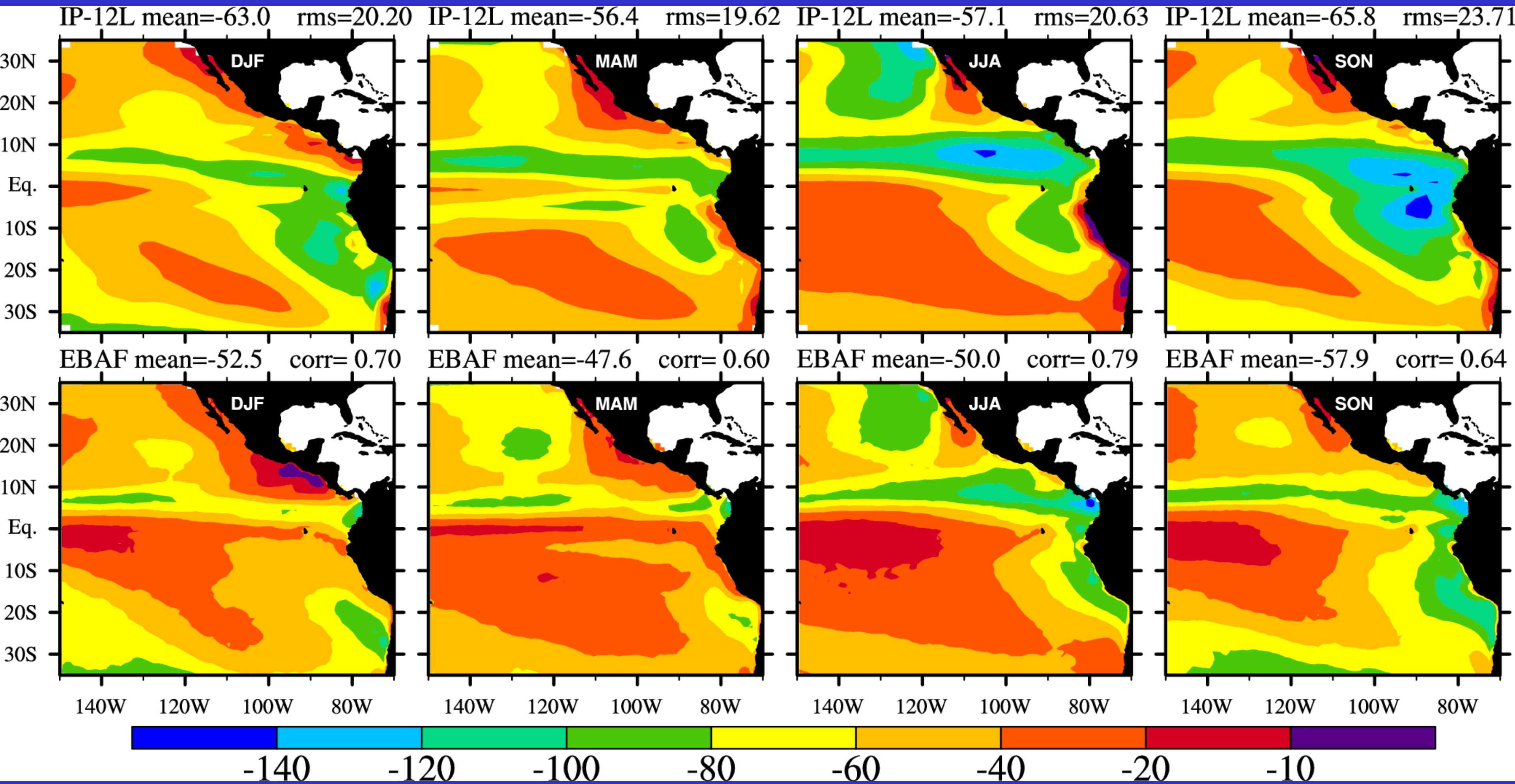


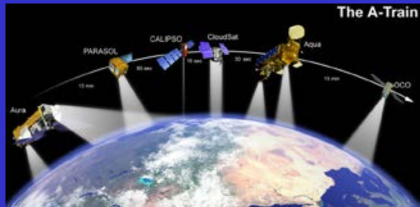
E. Pac. low cloud amount, MMF vs. C3M



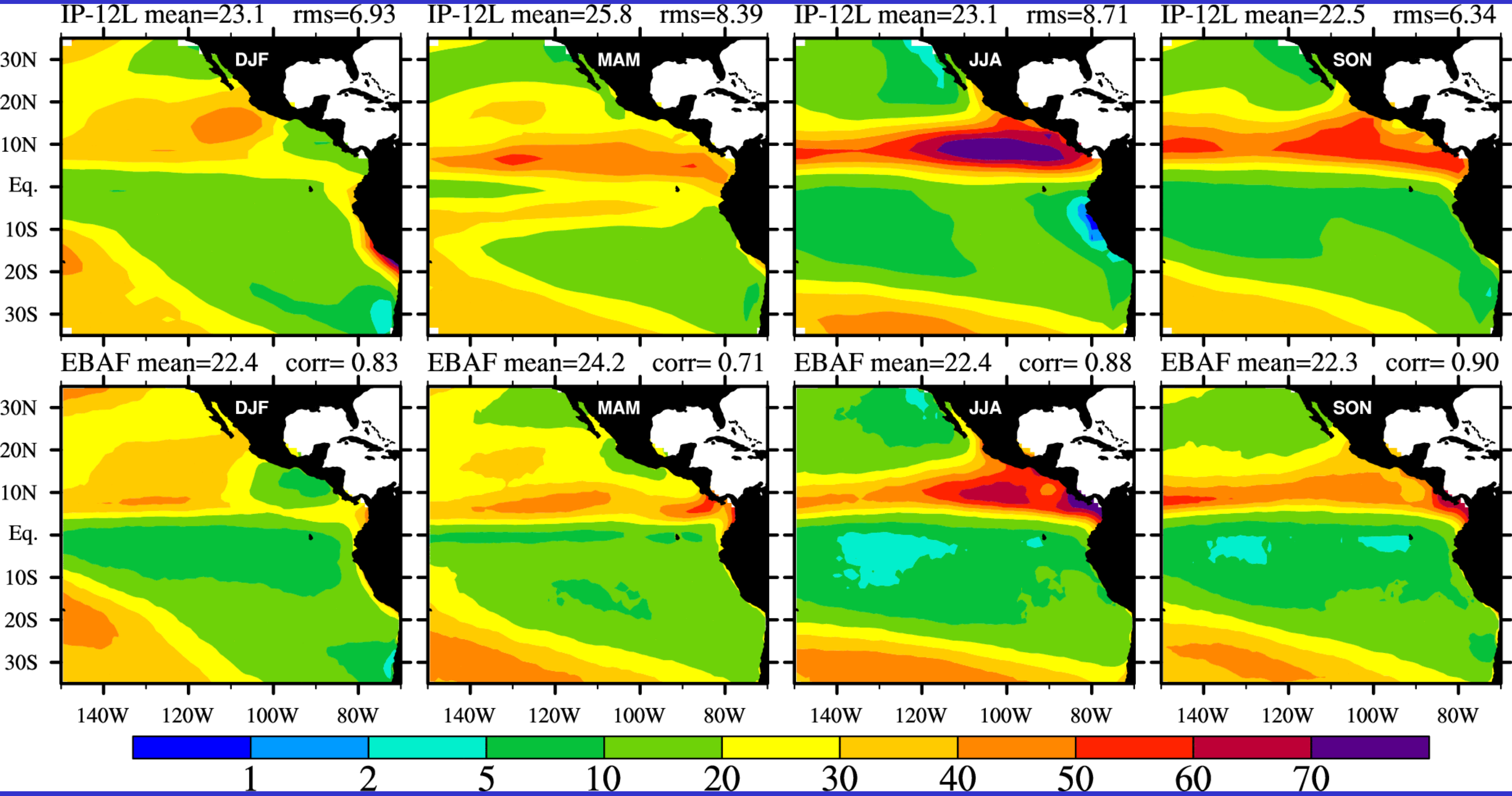


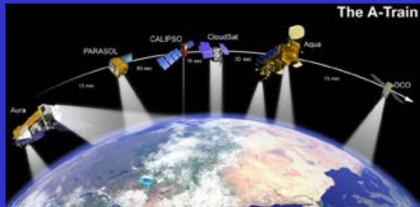
E. Pac. SW cloud radiative effect @ TOA



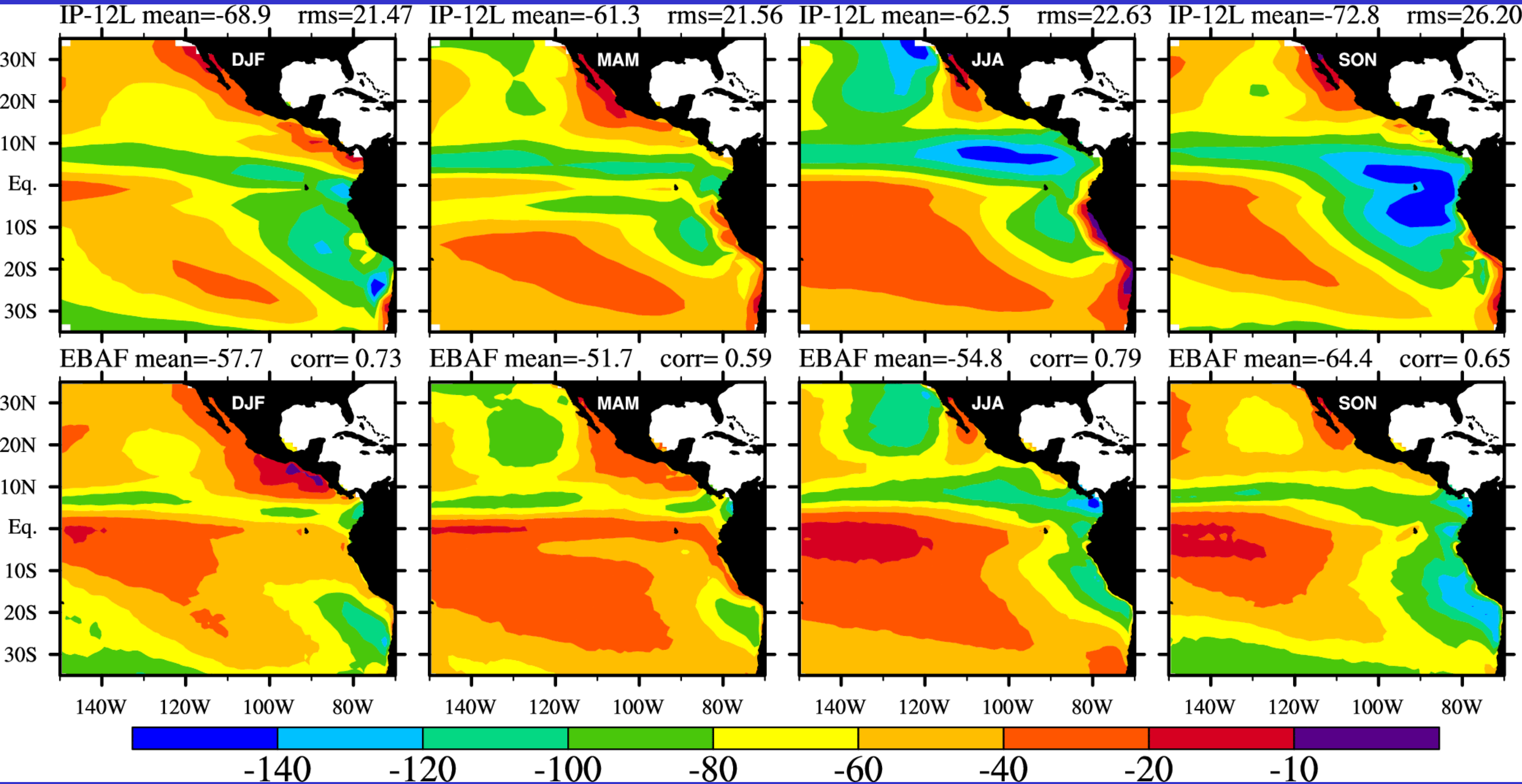


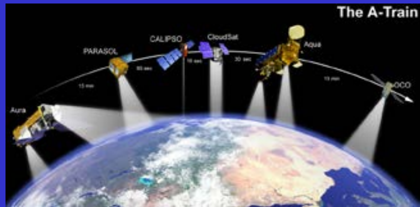
E. Pac. LW cloud radiative effect @ TOA



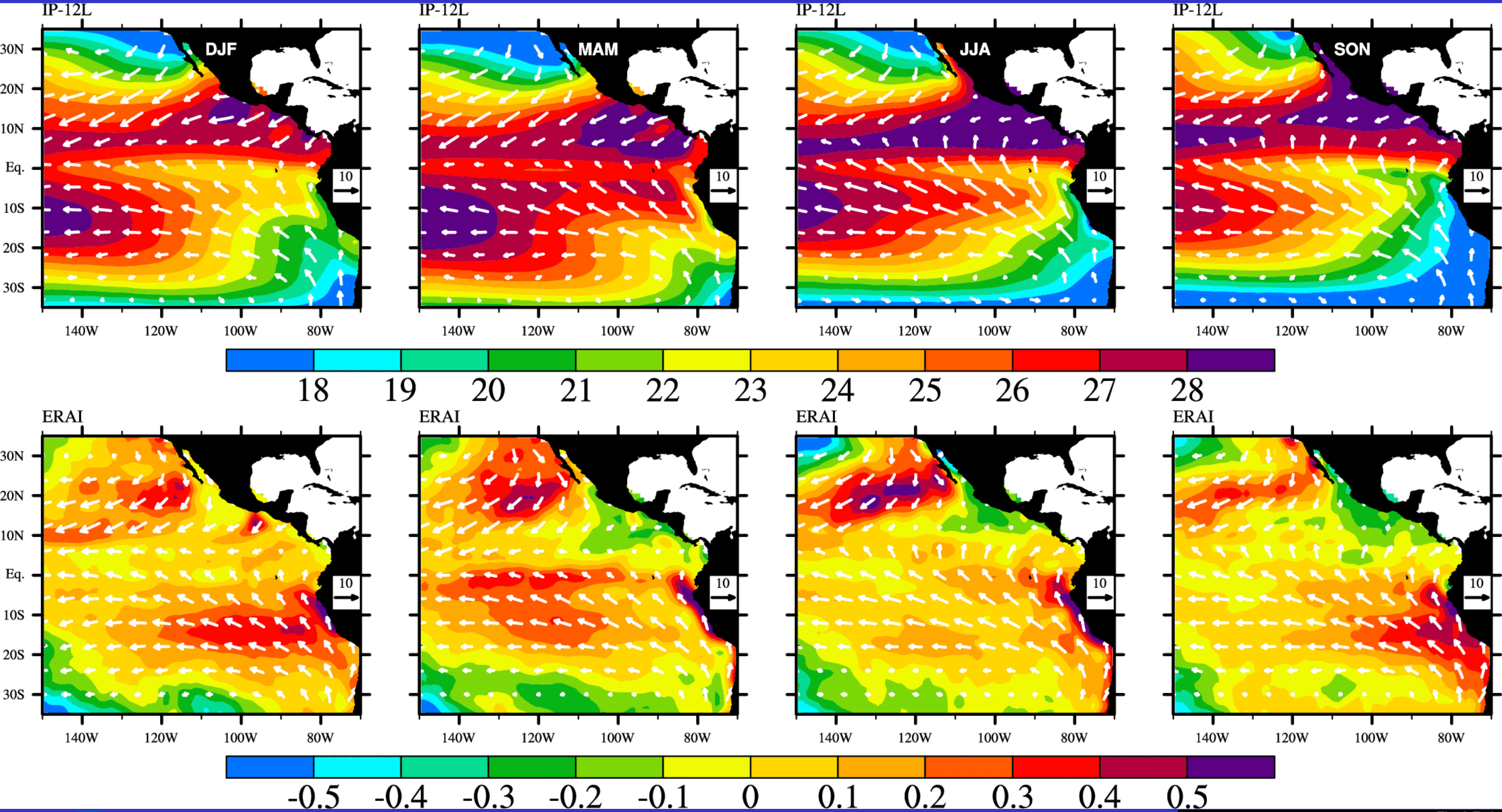


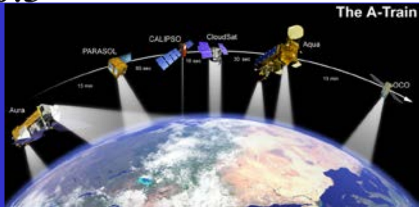
E. Pac. SW cloud radia. effect @ surface



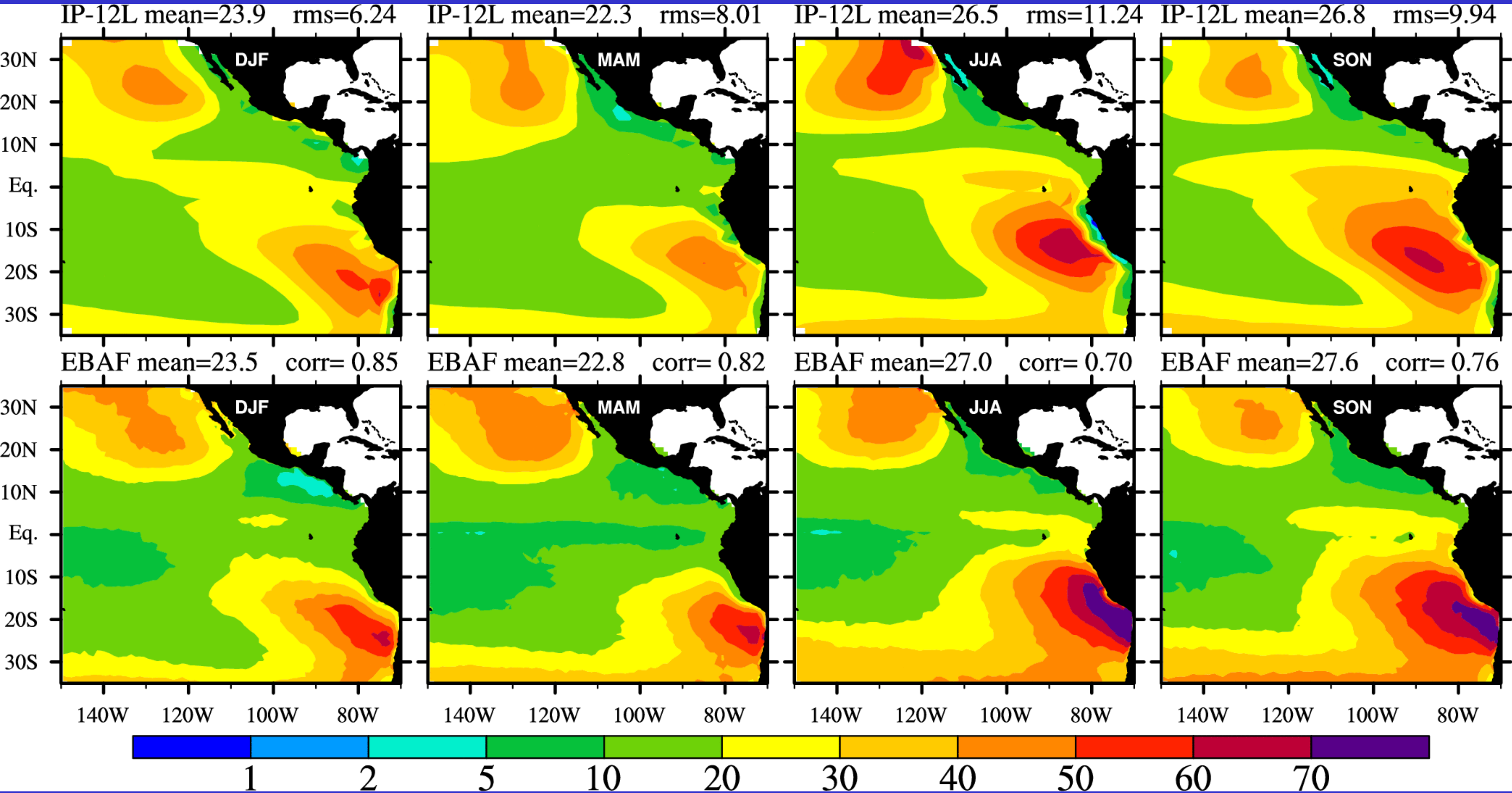


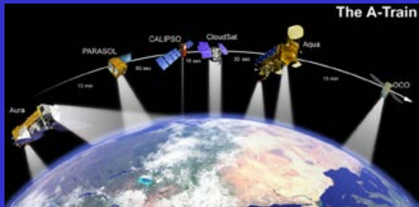
Wind, SST and SST difference





E. Pac. LW cloud radia. effect @ surface





Summary and conclusions

- The MMF climate simulation has biases that are comparable to (slightly smaller) CMIP3 and CMIP5 ensembles; but it reduces regional biases associated with low-level clouds.
- The seasonal climatology agrees with both TOA EBAF and surface EBAF very well, but noticeable differences exist in the high latitudes when compared to surface EBAF-beta.
- The seasonal cycle of the eastern Pacific is rather well simulated, except for the exact locations of low-level clouds in the southeastern Pacific and overestimated intensity of deep convection.