Global Precipitation Diurnal Variations Depicted in the Observations and Reanalyses

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Objective:

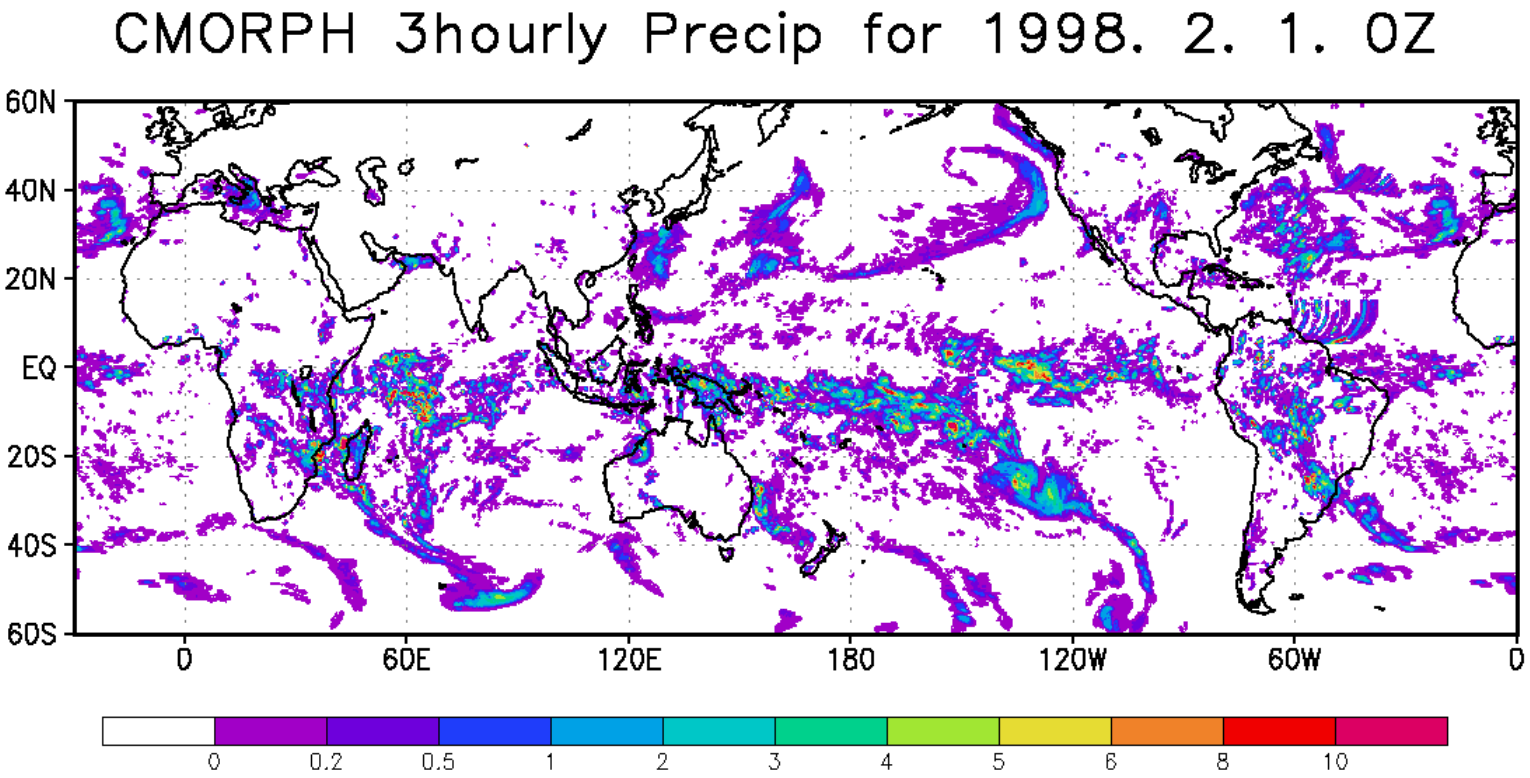
- To examine diurnal cycle of precipitation over the globe as depicted in the state-of-the-art high-resolution observations and reanalyses

  - Observations:
    - Bias-Corrected CMORPH satellite precipitation estimates

  - Reanalyses
    - CFS Reanalysis (T382; hourly)
    - MERRA (2/3^{o}lon x 0.5^{o}lat; hourly)
    - ERA-Interim (1.5^{o}lat/lon; 6-hourly)

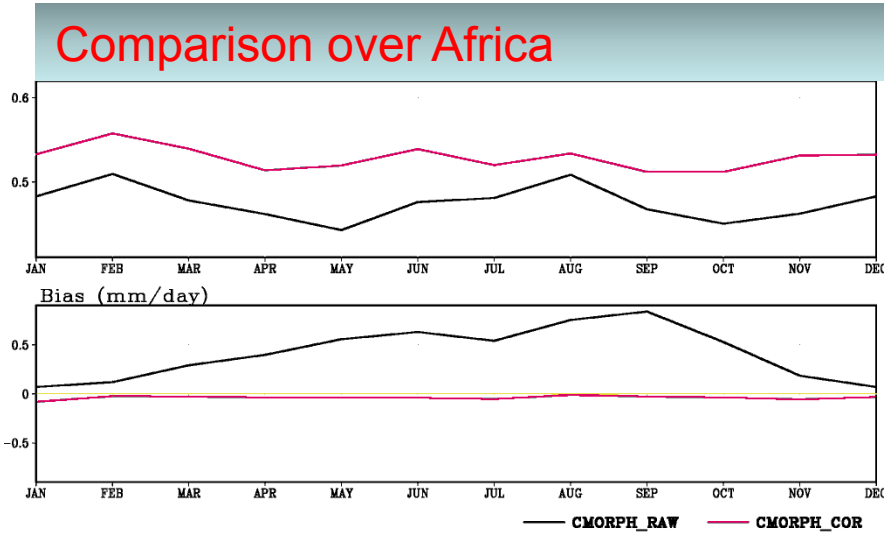
Bias-Corrected CMORPH [1]

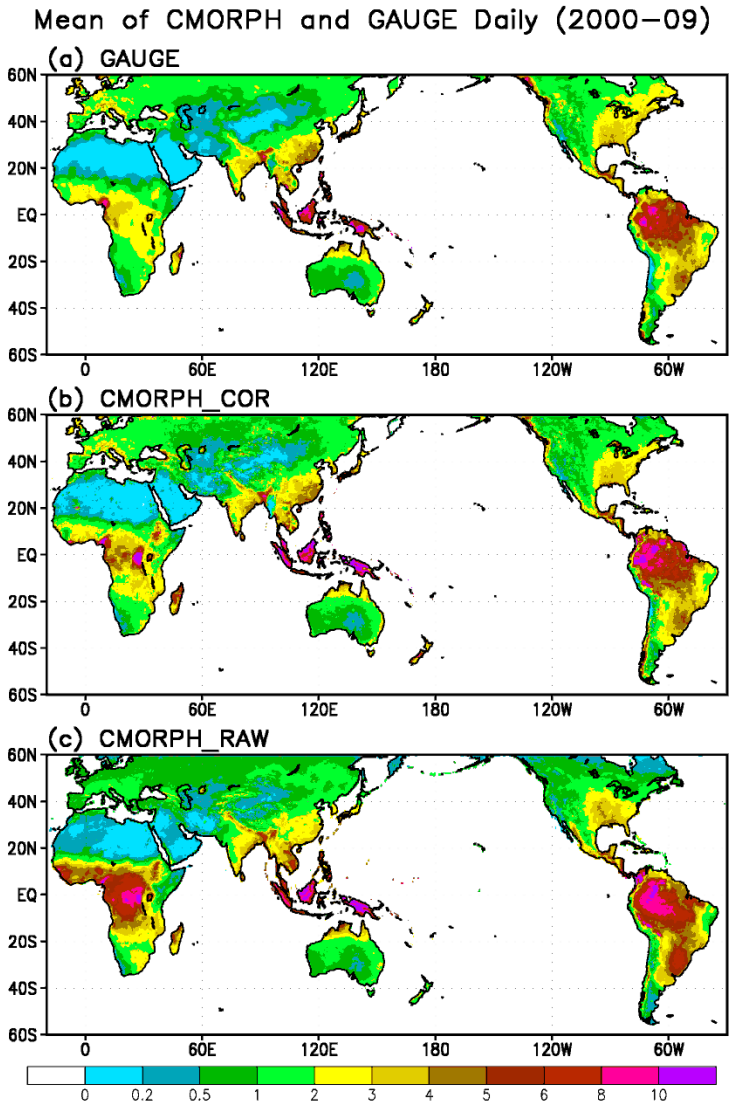
- CMORPH
  - High-res global precipitation estimates by integrating information from multiple satellite platforms
  - 8kmx8km; globe (60°S-60°N)
  - 30-min; from 1998 to the present
- Bias Correction for CMORPH
  - Over land: PDF matching against daily gauge analysis
  - Over ocean: Calibration against a long-term coarser resolution record



Bias-Corrected CMORPH [2]

- 2000-2009 annual mean
- Large-scale bias corrected

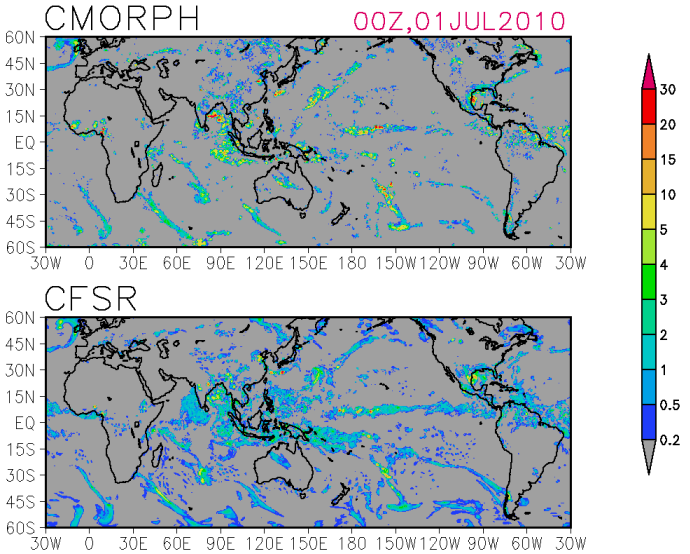


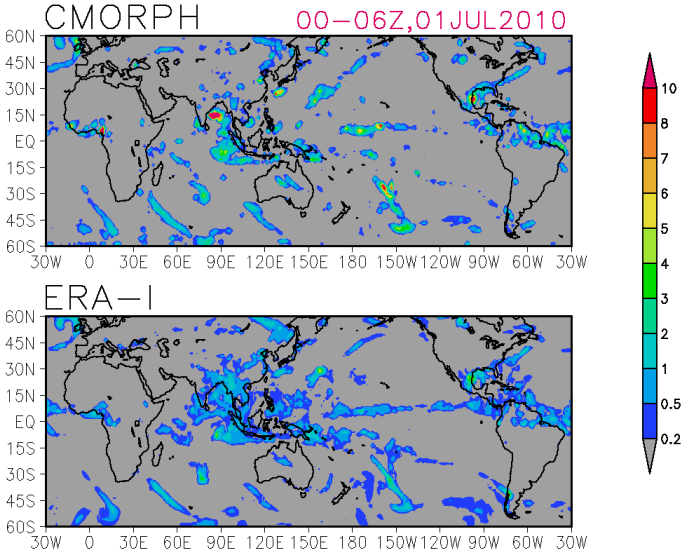


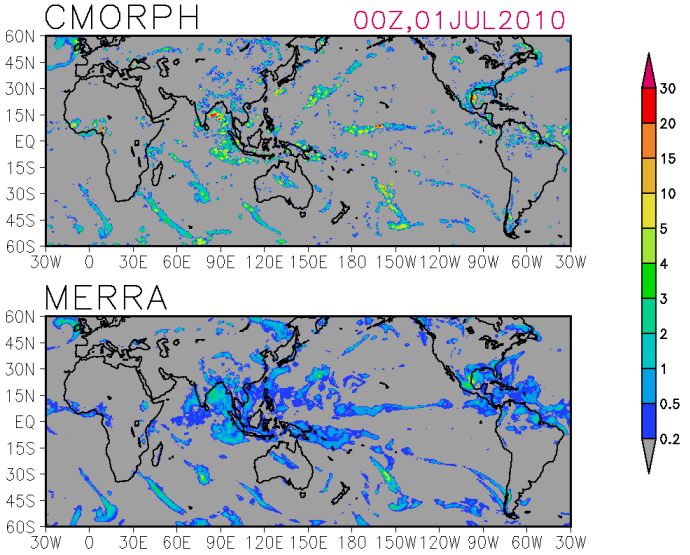
Global Precipitation [1]

Hourly / 6-Hourly Fields

- Hi-res CMORPH integrated to model time/space resolution for the comparison here
- The three reanalyses capture large-scale structure quite well
- Under-/over-estimate strong/weak precipitation
- Raining area too wider
- CFSR closer to observations



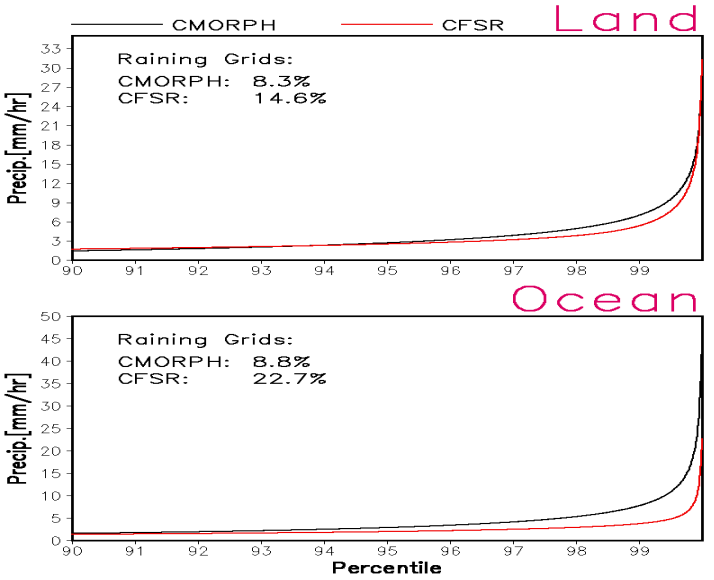


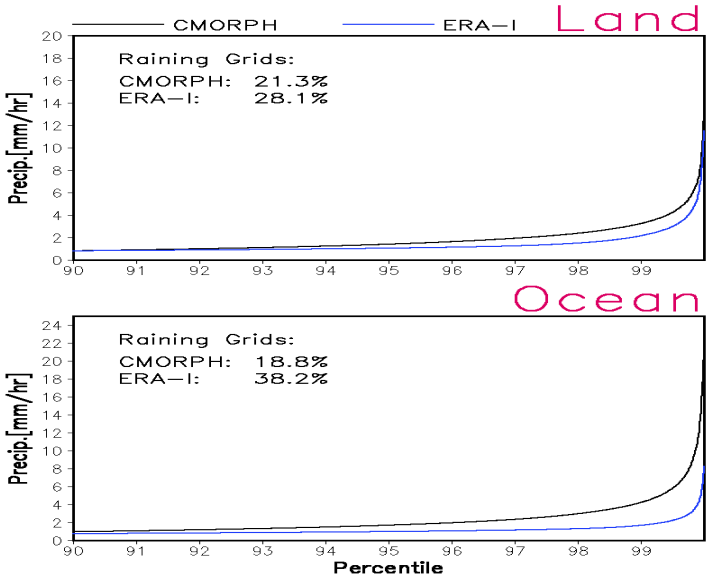


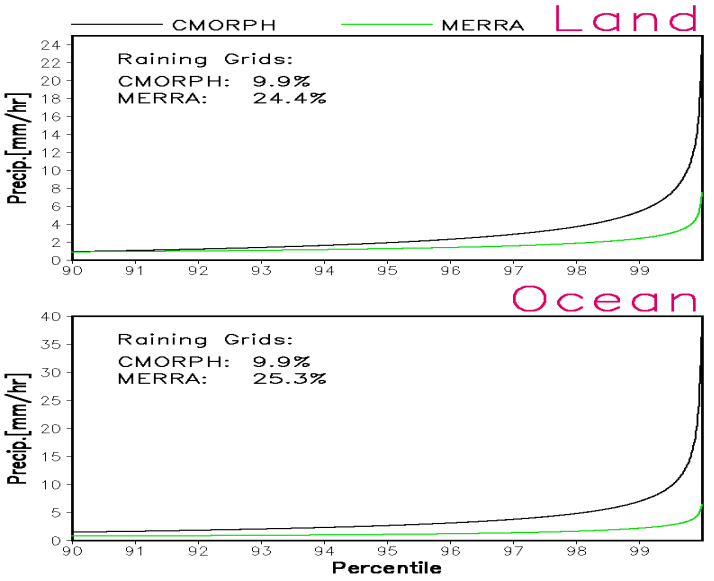
Global Precipitation [2]

Hourly / 6-Hourly Precip PDF

- Percentile precipitation intensity at the original model resolution computed using data for July 2010
- The three reanalyses generate wider raining areas than the observation
- Under-/over-estimate strong/weak precipitation



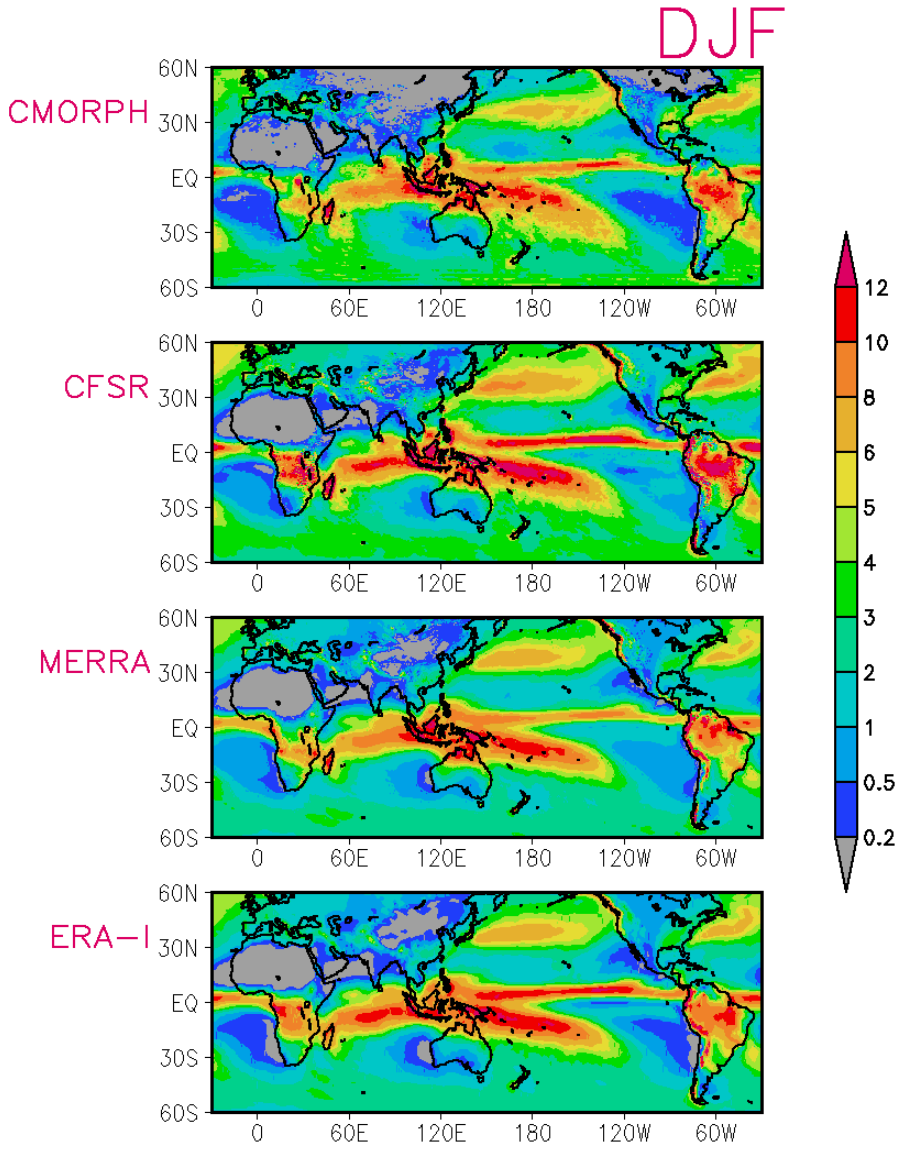




Global Precipitation [3]

DJF Mean

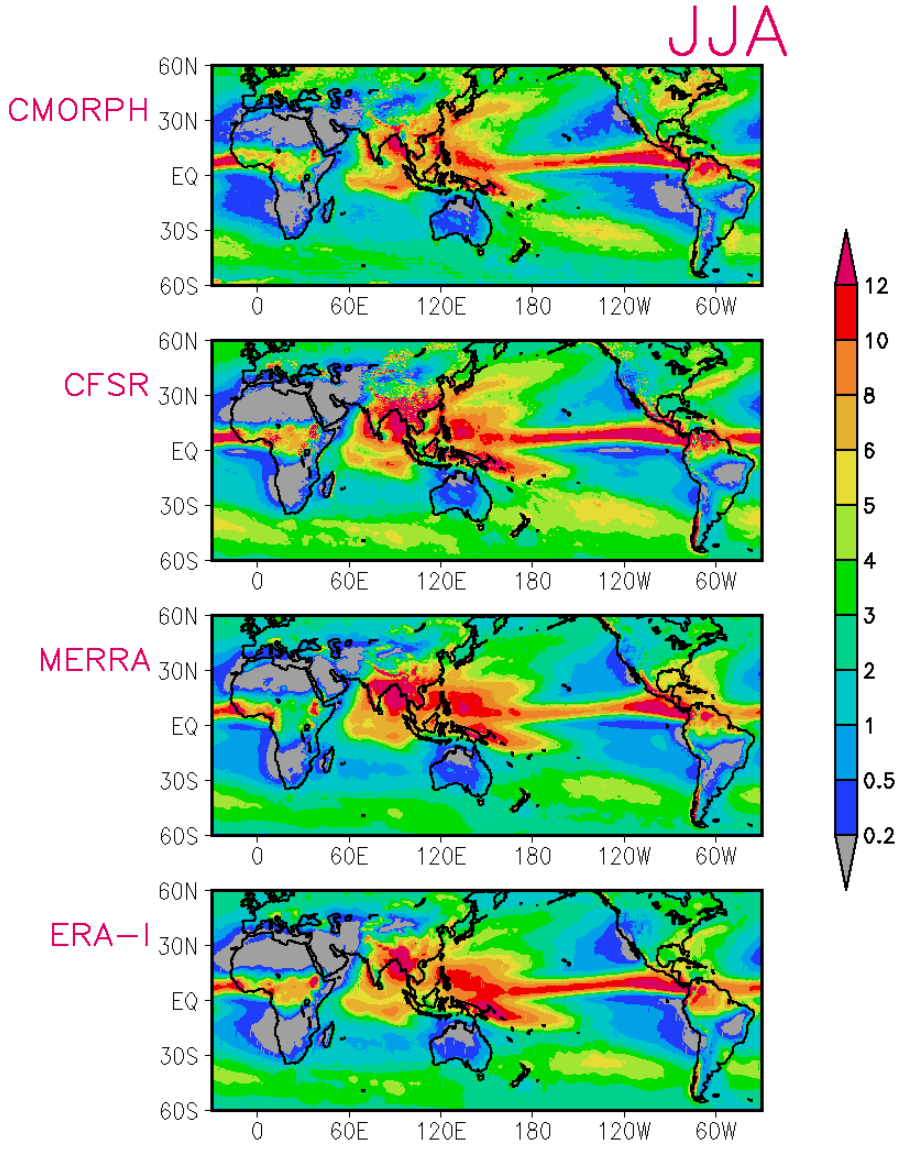
- DJF Mean for 1998 – 2010
- Very close agreement with the observation in spatial distribution patterns
- Larger oceanic precipitation, especially in CFSR and ERA-I
- CMORPH precipitation too small over land during winter caused by inability of satellite observations to pick up snowfall
- Precipitation in reanalyses larger than observations over most tropical land areas



Global Precipitation [4]

JJA Mean

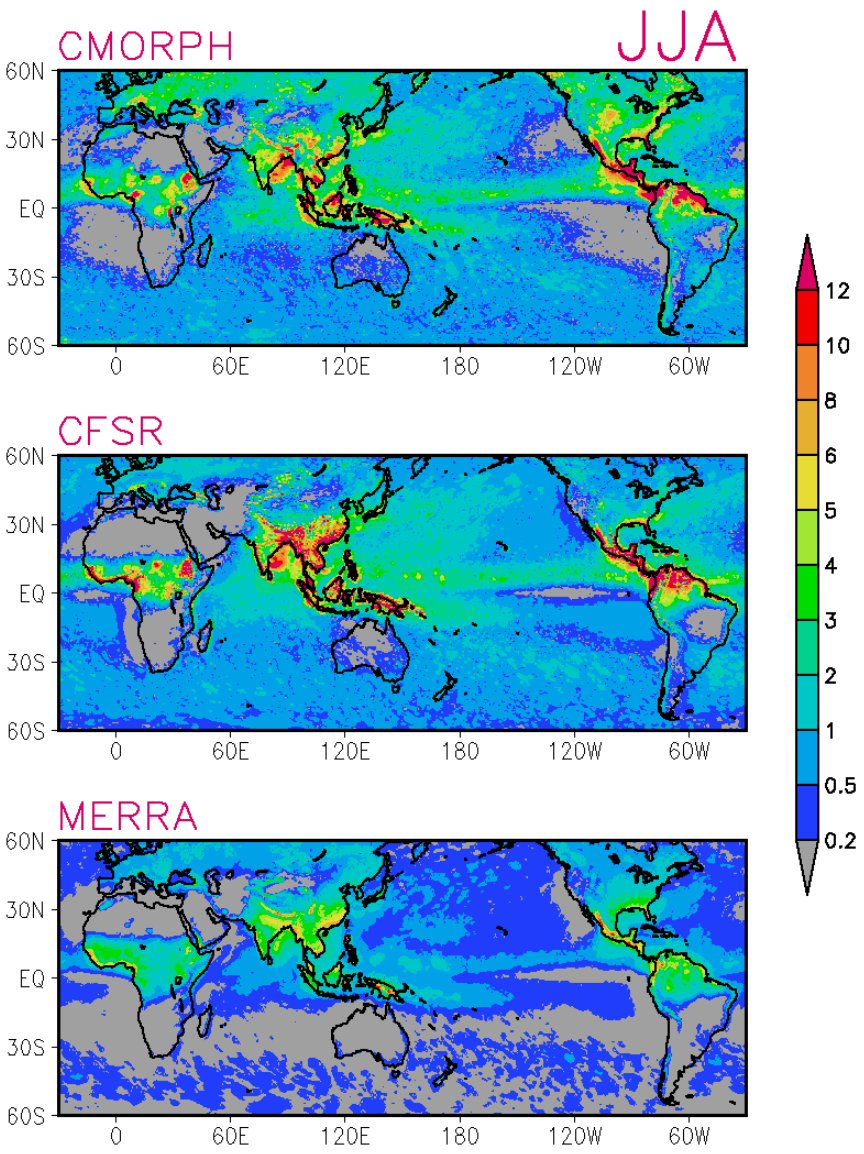
- JJA Mean for 1998 – 2010
- Spatial pattern of precipitation, especially that associated with topography, well reproduced by the reanalyses
- Larger oceanic precipitation in CFSR and ERA-I
- Weaker precipitation over mid-latitude compared to the CMORPH
- Heavier rainfall over Maritime-continent



Diurnal Cycle [1]

JJA Diurnal Amplitude

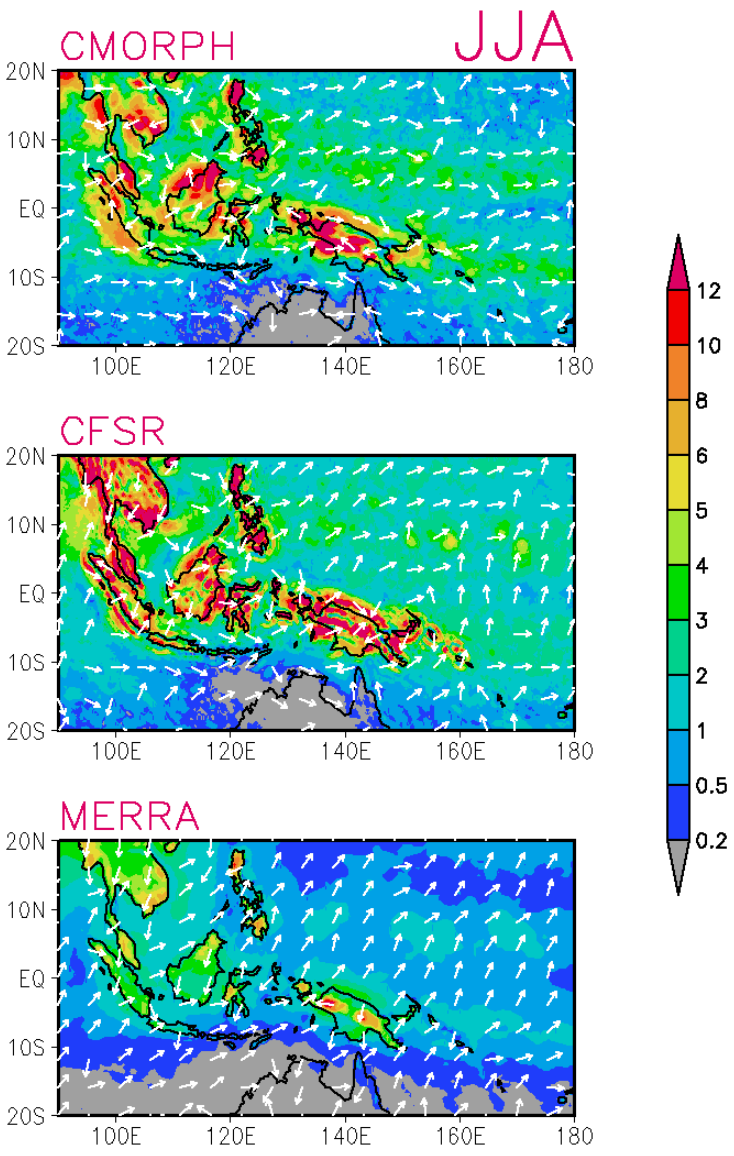
- Standard deviation of 24 hourly means for 1998-2010 (mm/day)
- Diurnal amplitude in CFSR has very similar patterns with that in the observations but presents smaller / larger magnitude over ocean, extra-tropical land / tropical land
- Diurnal amplitude in MERRA is generally smaller than that in the observations over tropics and extra-tropics in northern hemisphere and is almost diminished over extra-tropics in the southern hemisphere



Diurnal Cycle [2]

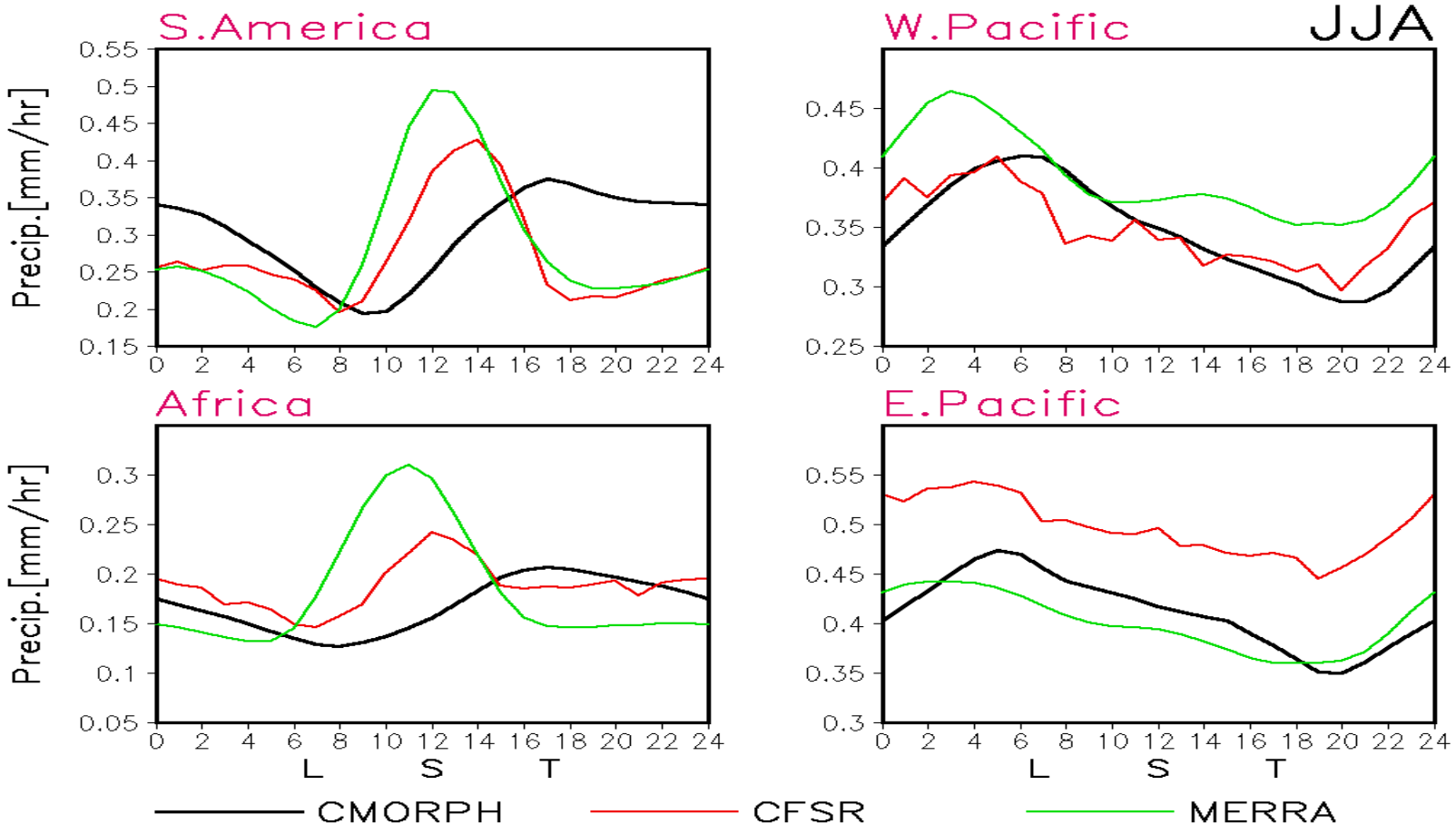
Maritime-Continent

- Amplitude (mm/day) color shading
- Timing (LST) of maximum hourly precipitation arrow
  (N=00; E=06; S=12; W=18)
- Spatial pattern of amplitude in association with land / sea contrasts
- CFSR shows minimum amplitude over ocean along coast lines (not seen in the observations and MERRA)
- Phase in general agreement with observations



Diurnal Cycle [3]

Over Four Selected Tropical Regions

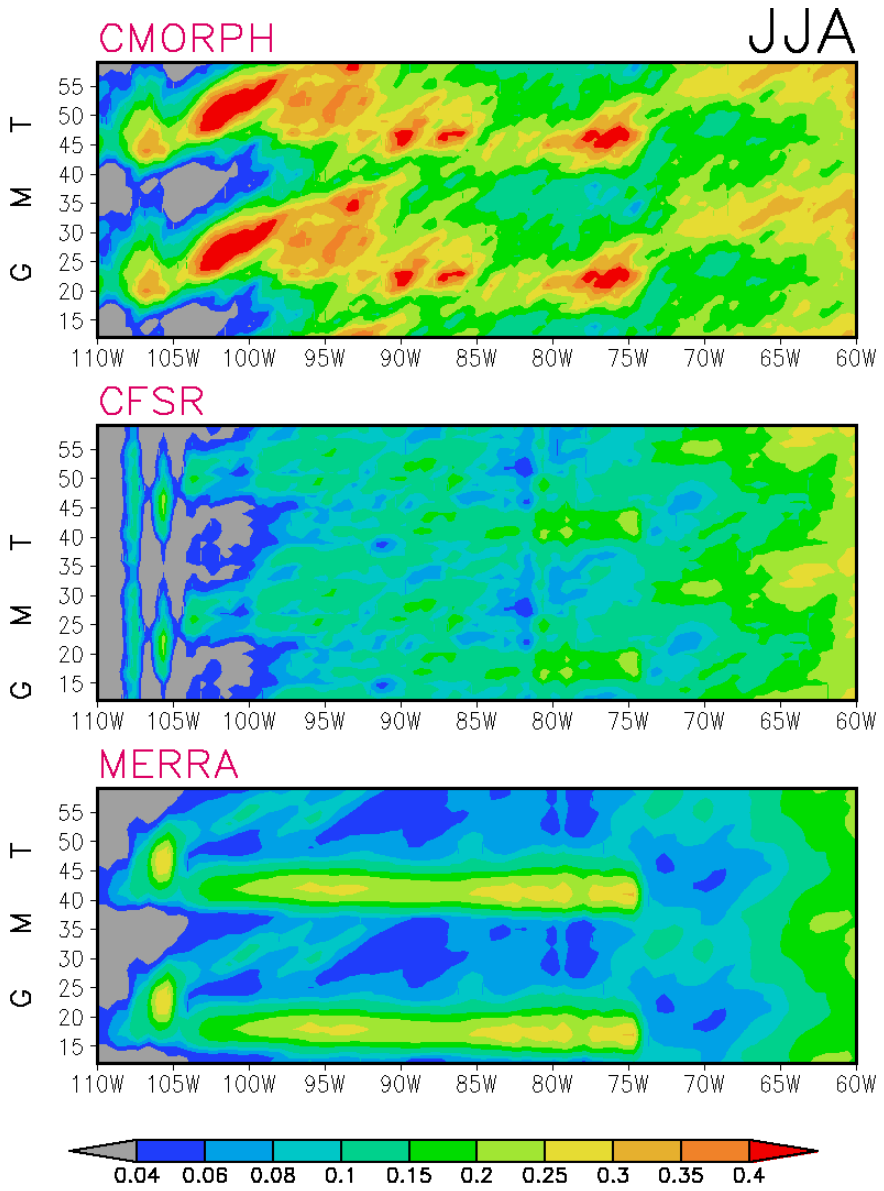


- Peak in the reanalyses comes earlier
- Amplitude in the reanalyses is larger / smaller over tropical land / ocean

Diurnal Cycle [4]

Evolution over CONUS

- Longitude section (X-axis) of diurnal evolution (Y-axis) along 40°N over CONUS
- Diurnal cycle (Y-axis) repeated twice
- Precipitation starts from the eastern Rocky around early afternoon (20GMT), propagating eastward and reaching 90°W late afternoon the next day
- Diurnal cycle over land east of 90°W presents fixed phase, opposite to that of precipitation over the nearby ocean
- Neither CFSR nor MERRA captures this diurnal variation patterns very well



Summary

- The three sets of high-resolution reanalyses are capable of depicting detailed structures of global precipitation
- The reanalyses tend to under-/over-estimate strong / weak precipitation, generating wider raining areas than observations
- Diurnal cycle of precipitation is reasonably well reproduced by the CFSR, with stronger / weaker amplitude over tropical land / ocean and a peak time 2-5 hours earlier
- The MERRA is capable of generating reasonable diurnal cycle over tropics but failed to capture the diurnal variations over southern hemisphere extra-tropical ocean
- Neither reanalyses succeeded in simulating diurnal variations over CONUS