Are model-data differences in the Indo-Asian monsoon due to model or data biases?

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Abstract: Precipitation difference between atmospheric general circulation models (AGCMs) and observational data sets (GPCP, TRMM and CMAP) continually persist over Southern Asia. It has been hypothesized that high-resolution modeling is key to reducing biases such as over estimated orographic precipitation over the Himalayan front, Bay of Bengal and Arabian Sea. Here we compared a suite of high to low-resolution simulations (~0.25° to ~ 2.0°) using Community Earth System Model version 1.0 (CESM1). This study show that these features are consistent across the range of resolutions. Finally, we compared our high-resolution simulation to various observational data sets and compared observation versus observation to discuss the implication of data versus model accuracy.

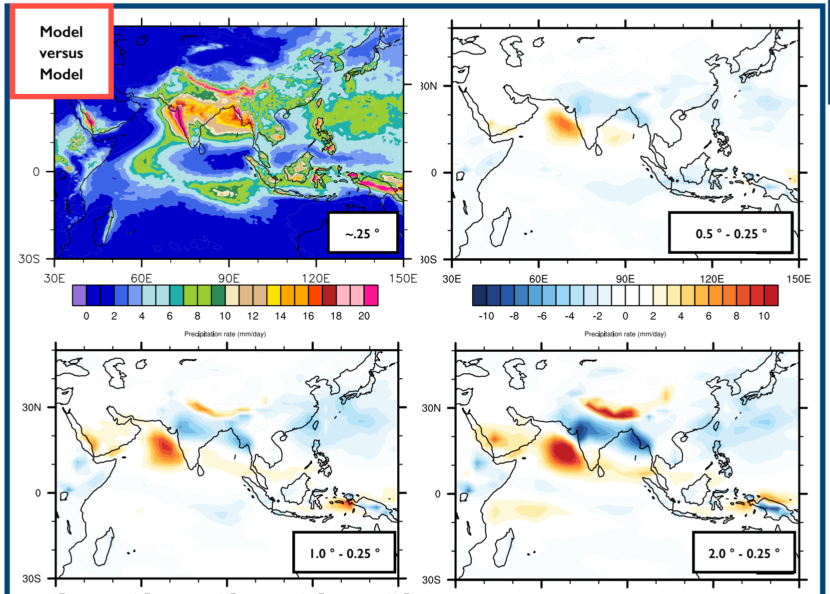

Figure 1: Modern climate simulations, illustrating Asian monsoon precipitation over 30 E-150 E with black outlines representing continents. Color contour plot on the top left illustrates high resolution simulation (0.25°) with precipitation rate in color. The rest of the color contour plots shows precipitation anomaly between different model resolution (converted to a 2° resolution). The top is the difference between 0.50° and 0.25° resolution. The middle plot is the difference between 1.0° and 0.25° resolution. Lastly, the lower plot represents the difference between the 2.0° and 0.25° resolution simulation.

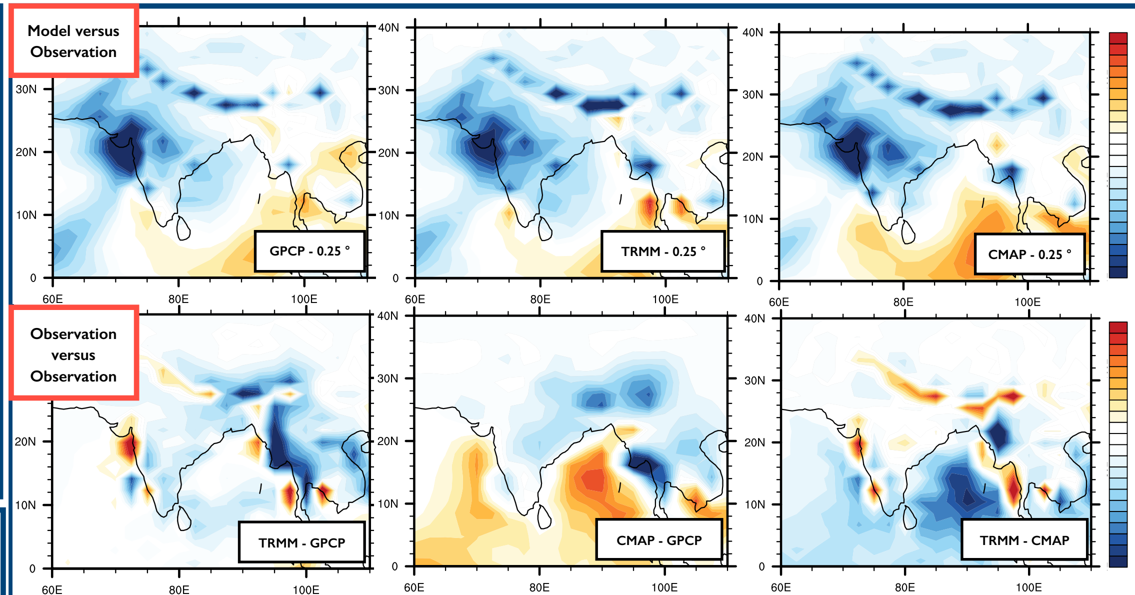

Figure 2: Color contour plot of precipitation rate over the South Asian Monsoon region. Top three panel are observation plotted against our high resolution model (0.25°) converted to a 2.0° resolution model (see methods for regridding specifics). The lower three panel shows observations plotted against other observations. The observations used for this analysis are Global Precipitation Climatology Project (GPCP), Tropical Rainfall Measuring Mission (TRMM) and CPC Merge Analysis of Precipitation (CMAP). For more information about the data sets please see the method section.

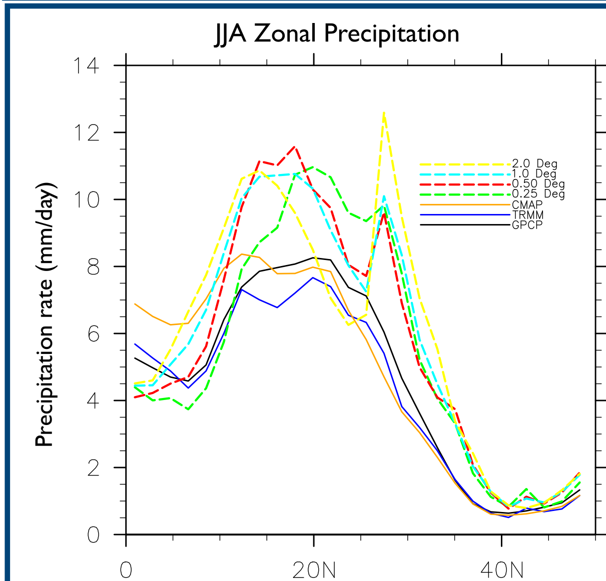

Figure 3: Zonal average of JJA precipitation confined over longitudes 60E-110E.

Summary Points:

1. Increasing model resolution show a decrease in precipitation over the Himalayan front and Arabian Sea. However, this is then compensated by an increase in precipitation over Central India and Northern section of the Bay of Bengal.

2. There are large discrepancies between observed precipitation which suggest the need to better constrain observational data sets.

3. Lastly, current General Circulation Models (GCMS) show positive precipitation bias over Asian monsoonal region (Bollasina and Ming 2012) and here we show increasing model resolution can aid some but nonetheless cannot fully resolve all precipitation differences between model and observation.

Citation:

1. Bollasina, M. a., & Ming, Y. (2012). The general circulation model precipitation bias over the southwestern equatorial Indian Ocean and its implications for simulating the South Asian monsoon. *Climate Dynamics*, *40*(3-4),

2. Zhang, G. J., & McFarlane, N. a. 1995: Sensitivity of climate simulations to the parameterization of cumulus convection in the Canadian climate centre general circulation model. *Atmosphere-Ocean*, *33*(3), 407–446.

Methods: The primary model used for this project was CESM version 1.0.5 with CAM4 AGCM (Zang and McFarlane 1995). We utilized the fixed sea surface temperature model configuration, We ran a total of four resolution simulations from 0.25° to 2.0°. The simulations used modern boundary conditions and were continuously ran for10 plus years, with the last10 years were used as our averaged climatology. We then used NCL's ESMF regridding tool in conservative or bilinear interpolation method to match our lowest resolution model (2.0°). The observational data sets were linearly interpolated using NCL's linint2_Wrap tool. This study used three modern precipitation observations, GPCP, CMAP, and TRMM. The GPCP data set consist of both ground observation, geostationary satellite and low orbit infrared, passive microwave merged to create 2.0° monthly climatologies from years 1979 to present. The CMAP data sets consists of monthly average precipitation values from1979 to 2014, obtained from five different satellites (GPI, OPI, SSM/I scattering, SSM/I emission and MSU), blended with NCEP/NCAR Reanalysis Precipitation values. The TRMM is a precipitation product with the data set compiled and supplied by Earth Observation Research Center and Japan Aero space Agency created as 0.5° monthly climatologies (for more information about please see TRMM 3A25G1).

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- CMAP Precipitation data provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their Web site at http://www.esrl.noaa.gov/psd/
- Tropical Rainfall Measuring Mission (TRMM). The algorithms were developed by the TRMM Science Team. The data were processed by the TRMM Science Data and Information System (TSDIS) and the TRMM office; they are archived and distributed by the Goddard Distributed Active Archive Center.
- GPCP Precipitation data provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their Web site at http://www.esrl.noaa.gov/psd/