Mitigation of model-data differences over the Indo-Asian monsoon region using high-resolution modeling

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Support for this project was provided by NH EPSCoR with support from the National Science Foundation's Research Infrastructure Improvement Award # EPS 1101245.

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Abstract: In order to produce more precise downscaled boundary conditions for regional climate models, it is critical to resolve model-data mismatch. This study looks at how general circulation models (GCMs) over estimate precipitation rates over the Indo-Asian monsoon (IAM) region or more specifically how GCMs produces excessive orographic precipitation near topography such as the Himalayan Mountains. Here we used a suite of high to low-resolution simulations (~0.25 to ~ 2.0) using Community Climate System Model with Atmospheric GCM, Community Atmospheric Model version 4 (CAM4) (CCSM4) and compared our results to observational data set, Global Precipitation Climatology Project (GPCP). We show that precipitation biases are mitigated as you increase model resolution. However, despite model improvements, some of these biases continually persist. Comparisons between reanalysis products (MERRA, CFSR, and JRA55) suggest that strong orographic precipitation over this region suffers from excessive total diabatic heating (Q) forming near topography. We find that enhancing model grid-resolution has the potential to mitigate the Q bias. However, parameterization of convection will nevertheless result in producing a systematic monsoonal circulation that consistently has a hardwired precipitation distribution.

Precipitation Anomaly

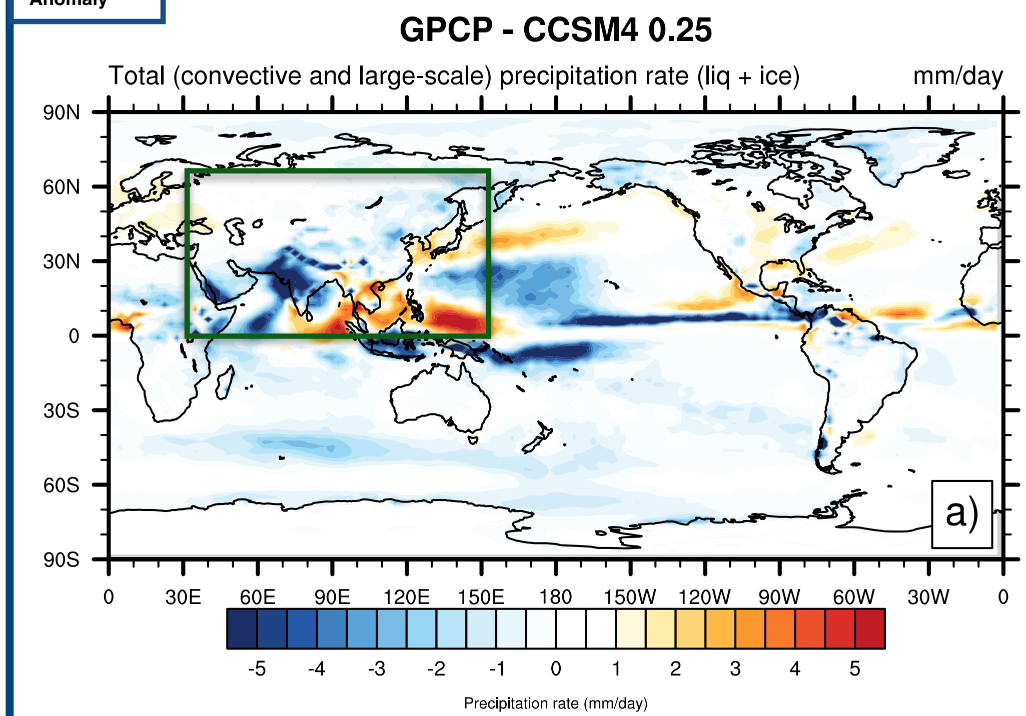


Figure 1: Modern climate simulations, illustrating anomaly of summer (June, July and August) global precipitation between Global Precipitation Climatology Project (GPCP) and Community Climate System version 4 (CCSM4) with black outlines representing continents. The green box represent the Asian Monsoon region which we focus on the green panel above.

Precipitation Diabatic Heating

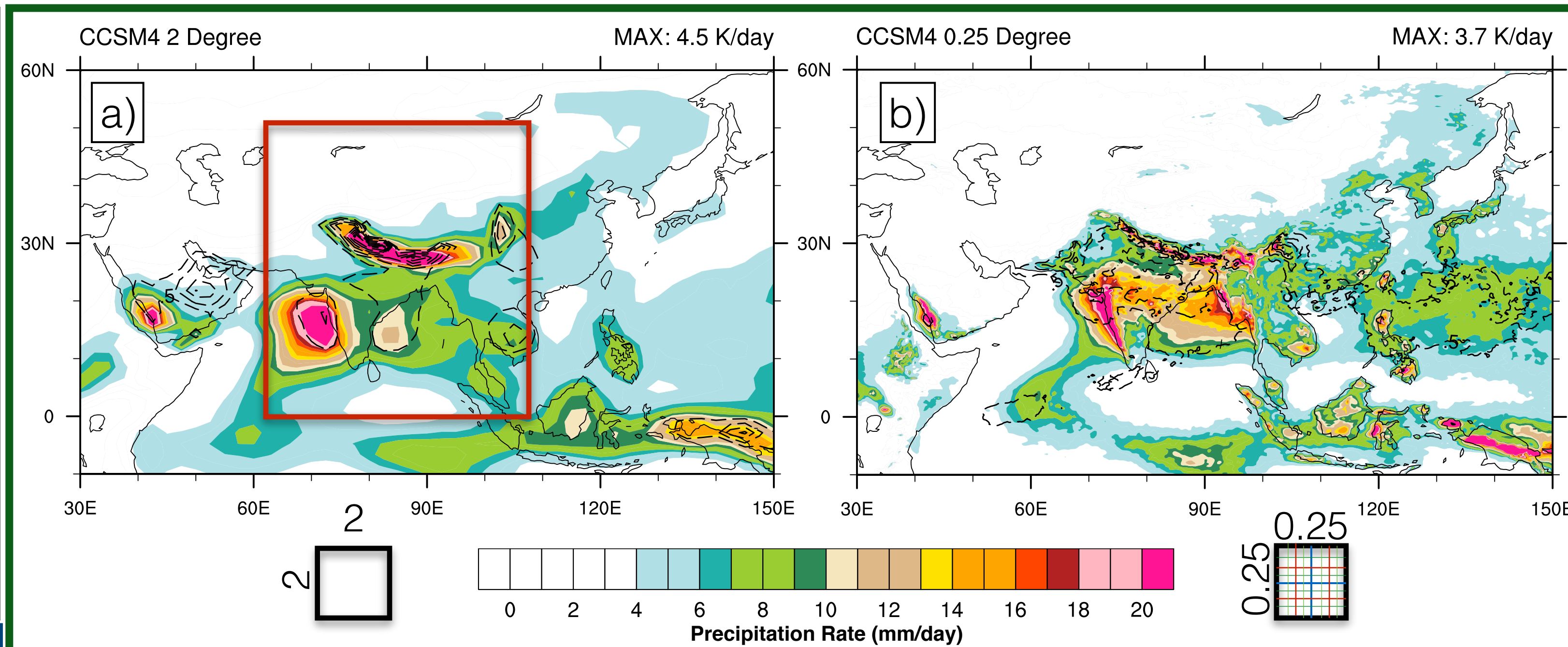
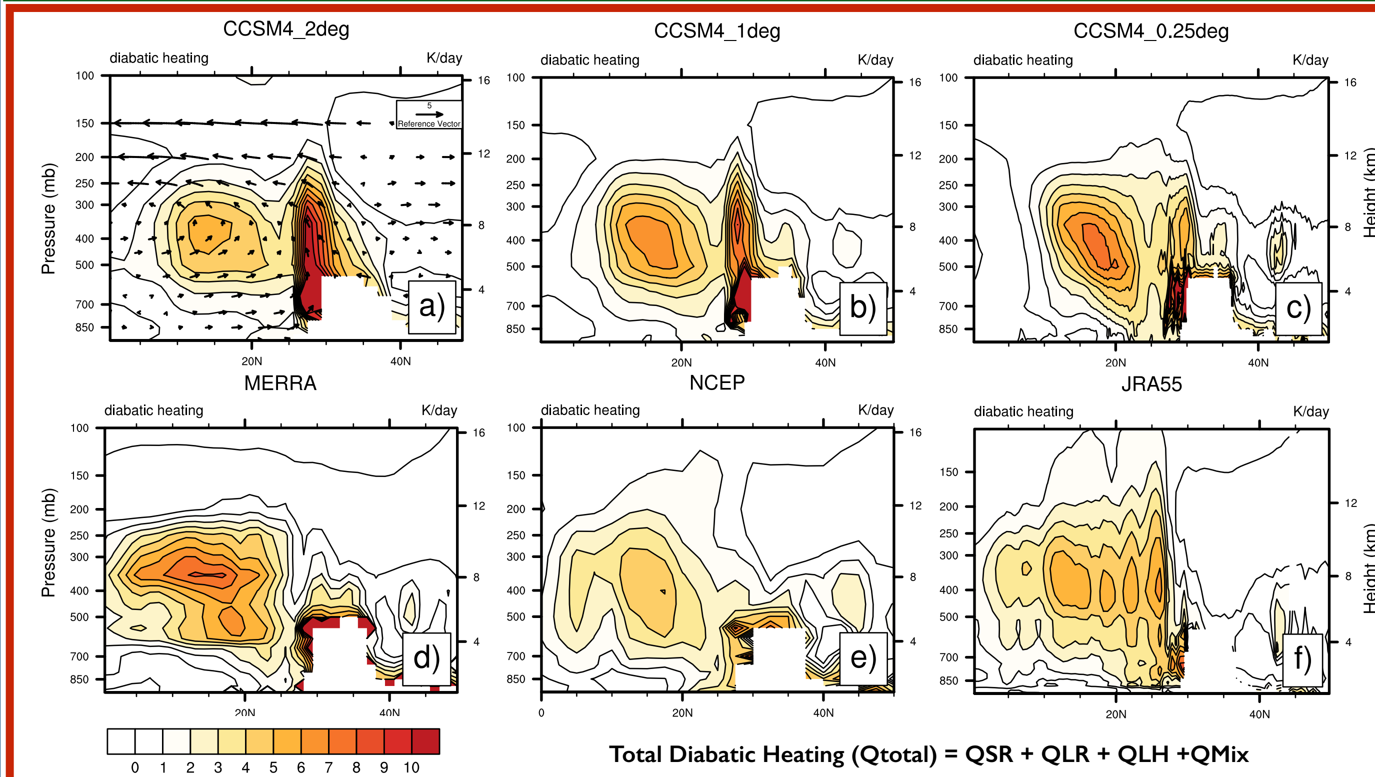


Figure 2: Color contour map of JJA precipitation rate distribution over Asia, overlain with dashed contour lines of vertically integrated (1000-100 mb) diabatic heating. Dashed contour is from 0.5-5.0 in increments of 0.5. **a** represents our 2 degree simulation and **b** is our 0.25 degree simulation. The red box on plot **a** represents the area we focus on below.

Total Diabatic Heating



Total Diabatic Heating (Qtotal) = QSR + QLR + QLH +QMix

Figure 3 shows the zonal average of total diabatic heating over Southern Asia during summer months June, July and August, averaged over 80E-90E and displaying latitude from 0-50N. **a, b, and c** shows CCSM4 simulations in 2, 1, and 0.25 resolution. **d, e, and f** illustrates reanalysis products MERRA, NCEP CFSR, and JRA55. The white region near the surface represents the Himalayan-Tibetan mountains.

Methods: The primary model used for this project was CCSM version 1.0.5 with CAM4 AGCM and utilizes deep convection parameterization (Zang and McFarlane 1995). We utilized the fixed sea surface temperature model configuration. We ran a total of three resolution simulations from 0.25° to 2.0°. The simulations used modern boundary conditions and were continuously ran for15 plus years, with the last10 years were used as our averaged climatology. We then used NCL's ESMF regridding tool in bilinear interpolation method to match our lowest resolution model (2.0°). The observational precipitation data set (GPCP) were linearly interpolated using NCL's linint2_Wrap tool. 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. To compare modeled diabatic heating profile with observations, we used reanalysis data-products Modern Era Retrospective-analysis for Research and Applications (MERRA), National Center for Environmental Prediction (NCEP) Climate Forecast System Reanalysis (CFSR), and Japanese 55-year Reanalysis (JRA55). The MERRA is a product of NASA's GCM, Goddard Earth Observing System, Data Assimilation System version 5 (GOES-5 DAS). It is on a 1.25 latitude-longitude resolution. The NCEP CFSR was designed as a global coupled atmosphere-ocean-land surface-sea ice system that includes conventional and satellite observations. It is a monthly mean (4 per day) of 6-hour average forecast on a grid resolution. The JRA-55 is the second Japanese global atmosphereic reanalysis product and have been found to improve deficiencis found in JRA-25. It is a monthly mean product with a horizontal spatial grid resolution of 1.25. All three data products have a temporal climatology from 1979 to present.

Acknowledgments & Citations

- National Science Foundation Grant OCE-0902882 and EAR-1049921
- National Center for Atmospheric Research, Community Earth System Model
- NCAR command Language and NCO
- Purdue Research Computing
- Climate dynamics prediction Laboratory (Aaron Goldner. Jon Buzan, Srinath Krishnan and Nicholas Herold)
- University of New Hampshire, Institute of Earth Ocean Space
- UNH EPSCoR Project for funding my travel.
- CISL Research Data Archived http://rda.ucar.edu/datasets/

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