Assessment of GCM-based Rainfall Simulations for the Austral-Indonesian Region

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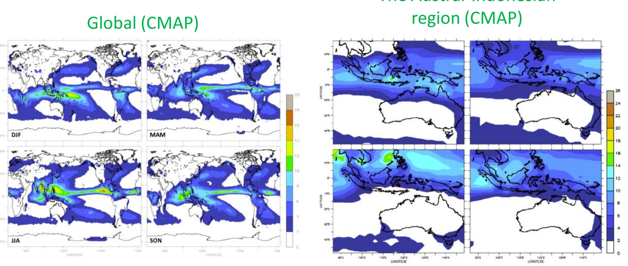
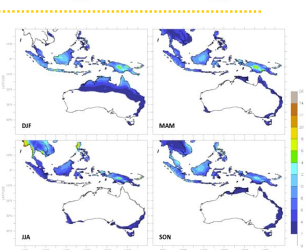
Introduction

This study presents model evaluation of 20th century rainfall simulation for a region known to pose challenges for climate models in simulating Intertropical Convergence Zone (ITCZ), monsoon circulation and the effect of topography. Previous generation of GCM-based rainfall simulations are found to have problems and difficulties in simulating large-scale convection near the equatorial Western Pacific and the complexity of the monsoon circulations (1,2), the representation of the ITCZ (3,4,5,6), the simulation of rainfall distribution and intensity (7,8) and the fine-scale topographic features of Indonesia (6). Therefore, assessment of the newest generation of GCMs in simulating basic features of historical rainfall in the Austral-Indonesian region is important. It aids the confidence of future climate scenarios derived from coarse resolution models for one of the most populated regions of the world where economic prosperity is closely linked with climate variability.

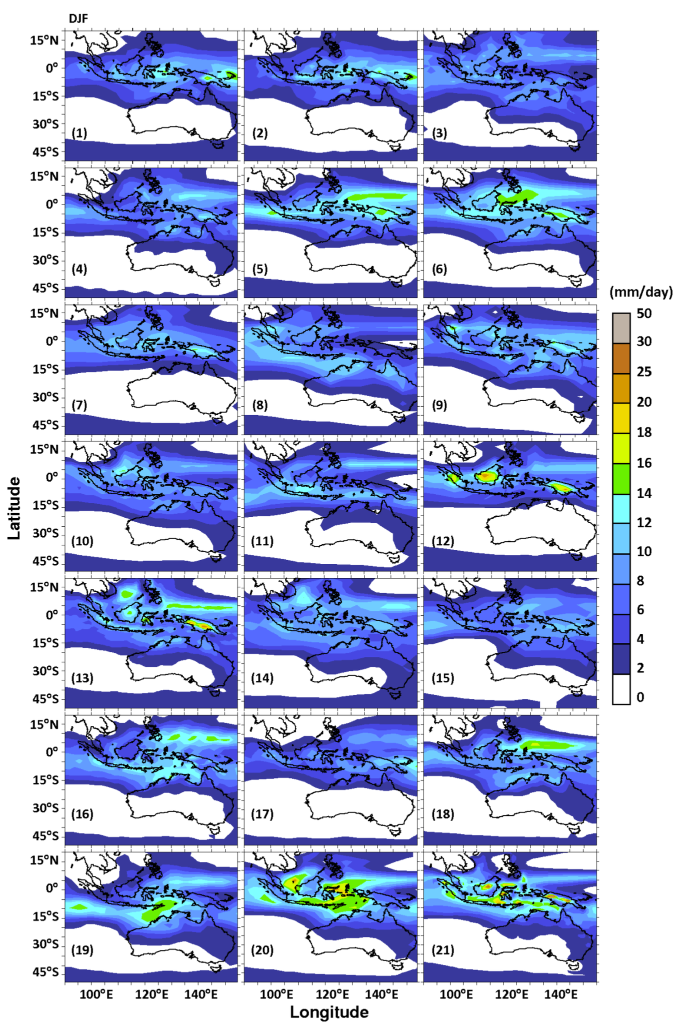


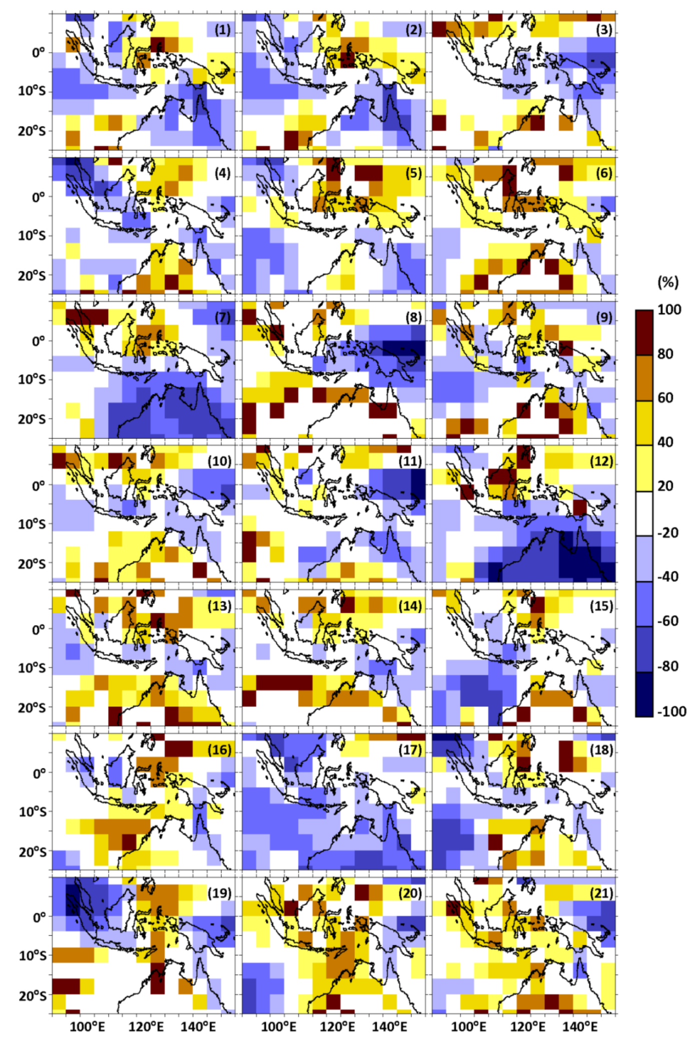


The Austral-Indonesian region (CRU TS2.1)

Seasonal patterns of terrestrial rainfall climatology from CMAP and CRU TS2.1 observational datasets (1979-99 periods)

Summer rainfall climatology (1979-99 periods) from 21 GCMs. Note: other seasons are not shown.





Summer rainfall climatology differences between modelled rainfall from 21 GCMs with CMAP observed data. The approach from previous study (15) is followed to adjust the grid into the coarsest resolution (5°x4 ° longitude-latitude). Note: other seasons are not shown.

- Cumulative Absolute Difference (CAD)
  - from seasonal rainfall series (CAD_S):

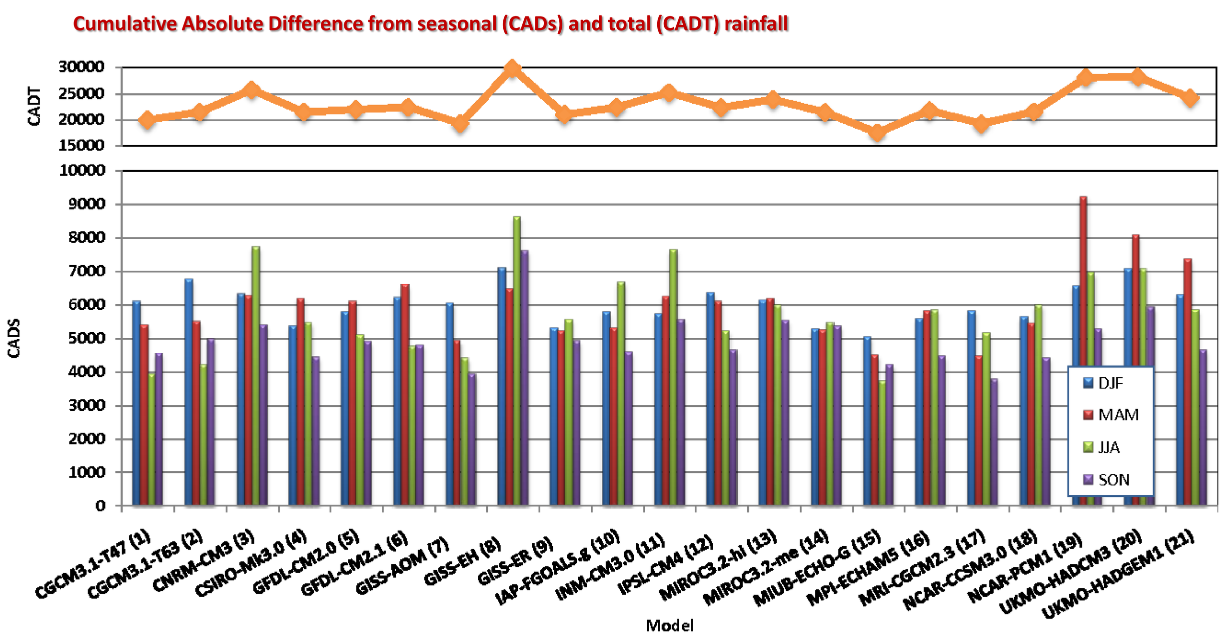
$$CADs_k = \sum_{i}^{m}\sum_{j}^{n} AD_{ij} \qquad \text{Equation (1)}$$

  - total of all-seasons (CAD_T):

$$CAD_T = \sum_{k=1}^{s} CADs_k \qquad \text{Equation (2)}$$

CADs = seasonal absolute cumulative difference between simulated and observed seasonal rainfall (AD) time series from year i *at terrestrial and ocean grid point* j; i = *1979,1980,…,m=1999 and* j = 1,2,3,…,n=104.

CAD_T = Total CADs at all season k; k = 1(djf), 2(mam), 3(jja), s=4(son)

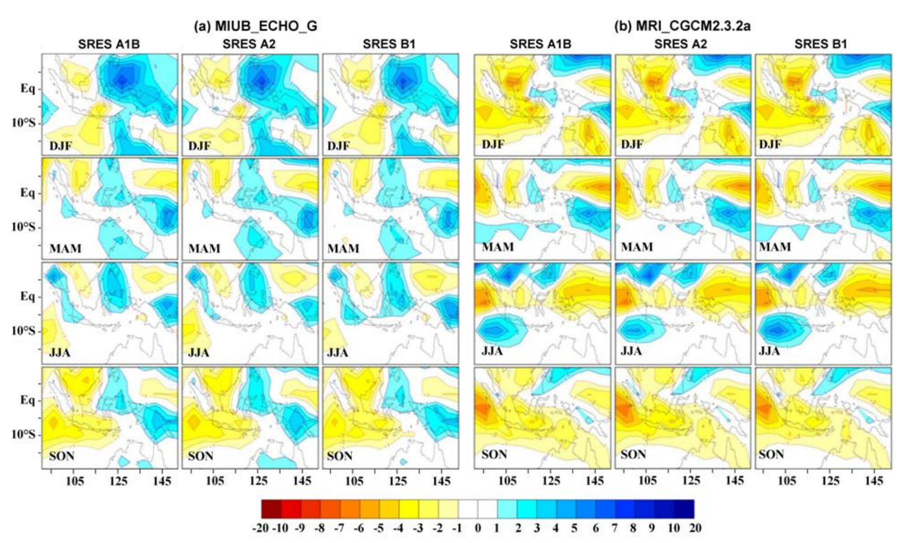


Data and Methods

Ensemble runs of monthly historical and future rainfall data simulated by climate models used in the the fourth assessment report (9) were assessed for the Austral-Indonesian region. Those data are compared with observed data from the Climate Prediction Centre Merge Analysis of Precipitation (CMAP) (10,11) and from the Climate Research Unit dataset namely CRU TS2.1 (12).

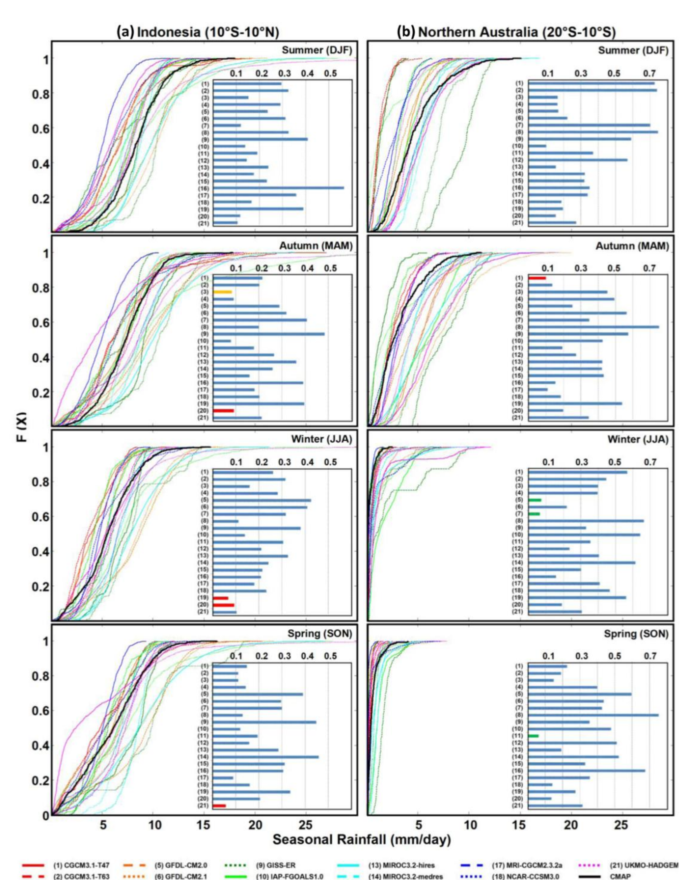
Basic features of seasonal rainfall are examined in this study. We assessed seasonal time series and climatology of the 20th century rainfall simulations by calculating departures from observed rainfall. To rank the models, cumulative absolute difference (CAD) calculated for each season (CADS) and all seasons rainfall series (CADT) were introduced. A small CAD value indicates a better model performance. We also assessed projected future rainfall from the selected best performing model based on the ranking result. The evaluation includes three Special Report on Emissions Scenarios (SRES) scenarios (i.e., SRES A1B, A2 and B1) used in the IPCC AR4.

Additionally for the land only (terrestrial) rainfall assessment, we calculated the differences and developed a quantitative assessment tool based on cumulative distribution function (CDF) and Kolmogorov-Smirnov (KS) tests (13,14).



Climatology differences between projected future rainfall (2081-2100 periods) from two models; (a) MIUB_ECHO_G and (b) MRI_CGCM2.3.2a compared with observed rainfall data (1979-1999 periods). Contour interval is 1 mm/day and zero value is omitted.

The empirical CDFs of seasonal terrestrial rainfall for 1979-1999, (a) Indonesia and (b) northern Australia. Bar graphs show the KS-stat between modelled and observed data. Red, orange and green bars show no significant differences based on KS test at the 99%, 95% and 90% confidence levels. Numbers in the figure are consistently used to refer the model names.



Summary

Our assessment shows considerable discrepancies between observed and simulated rainfall amongst the 21 models. Generally, the representation of rainfall is better for northern Australia during seasonally dry periods (Austral winter and spring). More than half of the models reproduce unrealistic rainfall distributions, particularly due to overestimation of rainfall in the Indonesian region.

The CADS shows that MIUB-ECHO-G model has the lowest deviation from recorded seasonal rainfall in summer and winter, while MRI-CGCM2.3.2a performs best during transition periods in autumn and spring. The late 21st century rainfall assessments of these two models indicate considerable rainfall changes particularly over Indonesia for all seasons. Rainfall projections for northern Australia, however, show little changes in rainfall patterns. Structural differences between these two models and other GCMs need to be investigated to pinpoint the physical causes of differences in performance.

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