Role of Solar Activity in Enhancing the Prediction Skill of Indian Monsoon on Seasonal to Decadal Time Scale

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The role of the Sun in changing our weather and climate has been a debated issue in the scientific community for many decades. Still, it is not certain how much the Sun has contributed to altering the Earth's climate. This is partly due to the confounding effects of volcanic eruptions which, by chance, happened mostly during times of low solar activity. In this study, we undertake another effort towards understanding the role of the Sun in changing or varying the Earth's climate on seasonal to decadal time scale. We focus on effects of varying solar activity on All Indian Summer Monsoon Rainfall (AISMR) and try to investigate how much the prediction of AISMR on a seasonal to decadal time scale can be improved by considering the solar irradiance variability in climate models. Atmosphere Ocean Chemistry Climate Model (AOCCM) simulations with SOCOL-MPIOM along with observational datasets have been used to investigate the influence of the Sun on AISMR. Four different sets of transient simulations from 1600-2000 including all major forcings, carried out in the framework of the SNF project FUPSOL I, have been analysed (L1, L2, M1 and M2 simulations of [1]). The simulations differ in solar forcing and initial conditions. In all model simulations, solar irradiance reconstructions by [2] have been used, with strong Shapiro forcing (6 W/m^2 mean TSI amplitude) in the L1 and L2 runs, and medium Shapiro forcing (3 W/m^2 mean TSI amplitude) in the M1 and M2 runs. Runs with indices 1 and 2 have different initial ocean conditions. In a first part, we have validated SOCOL-MPIOM for AISMR with respect to various observational datasets (Twentieth Century Reanalysis, 20CR, 1901-2000, [3]; Global Precipitation Climatology Center, GPCC, 1901-2000, [4]; Monsoon Asia Drought Atlas, 1600-2000, [5]). Figure 1 shows the difference of the FUPSOL ensemble simulations (mean of L1, L2, M1 and M2) relative to GPCC and 20CR. From Figure 1 it is clear that the model simulates the monsoon season climatology of AISMR reasonably well for most parts of the Indian sub-continent, whereas large differences are found over the mountaineous regions of the Western Ghats, the Himalayans, and the coastal ranges in Myanmar and between India and Myanmar due to low spatial resolution of the model (3.75°×3.75°). Figure 2 shows a comparison of the observed (GPCC) and simulated (FUPSOL) annual cycle of AISMR. The model annual cycle for AISMR exhibits an RMS error of 0.60 mm/day relative to GPCC. Furthermore, we have validated the relationships of AISMR with ENSO and AMO with the HadISST [6] and Kaplan SST [7] datasets. The model shows a correlation coefficient (CC) of -0.51 between AISMR and the Niño3 index which is close to the observed correlation (-0.42) during the period 1901-2000. [8] found a CC of 0.50 between decadal AISMR anomalies and a decadal AMO index for 20th century. Our model is in agreement with a CC of 0.41. Further, in our analysis we have found strong statistical evidence of the influence of solar activity on AMO and AISMR. We have found highly statistically significant evidence that North Atlantic SSTs are positively correlated with TSI on annual (CC 0.46), decadal (CC 0.55) and multidecadal time scales (CC 0.42) during the period 1600-2000. Also AMO influences the Niño3 and AISMR. We have calculated Spearman's CCs, and Spearmans partial CCs, using multiple liner regression technique, between AMO & TSI, AMO & Niño3, AMO & AISMR, AISMR & TSI, and Niño3 & TSI while controlling or partialling out the the effects of external factors/variables such as CO2, Tropospheric Aerosol Optical Detpth (AOD), Stratospheric AOD etc. Our analysis indicates that there is no direct influence of TSI on Niño3 and AISMR. The influece of TSI on Niño3 and AISMR comes into effect through AMO which subsequently modulates Niño3 and AISMR. In a second part, we explore the possible solar link with AISMR for the entire simulated period (1600-2000 AD). The behavior of AISMR during the Maunder and Dalton Minima will be compared with the current warming period. The influence of the Quasi-Biennial Oscillation on AISMR will also be investigated.

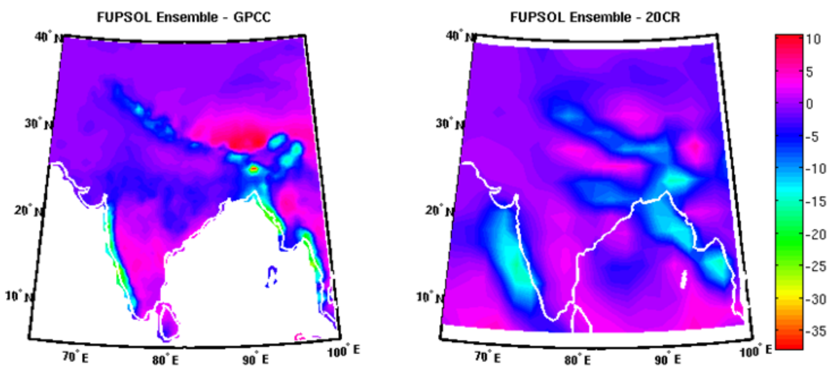

Figure 1. Difference of the FUPSOL ensemble simulations with GPCC (right) and 20CR (left).

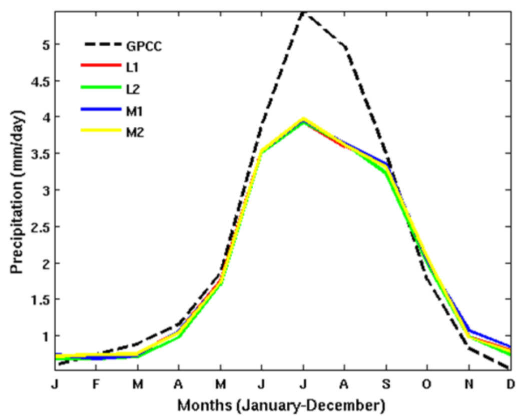

Figure 2. Comparison of the observed (GPCC) and simulated (FUPSOL) annual cycle of AISMR.

References

1. S. Muthers, J. G. Anet, A. Stenke *et al.*, The coupled atmosphere-chemistry-ocean model SOCOL-MPIOM, *Geosci. Dev. Discuss* **7**, 3014 (2014), 10.5194/gmdd-7-3013
2. A. I. Shapiro, W. Schmutz, E. Rozanov *et al.*, A new approach to the long term reconstruction of the solar irradiance leads to large historical solar forcing, *Astron. Astrophys.* **529(A67)**, 3023 (2011), 10.1051/0004-6361/201016173
3. G. P. Compo, J. S. Whitaker, P. D. Sardeshmukh *et al.*, The Twentieth Century Reanalysis Project, *Quarterly J. Roy. Meteorol. Soc.* **137**, 1(2011), 10.1002/qj.776
4. U. Schneider, A. Becker, P. Finger *et al.*, GPCC full data reanalysis version 6.0 at 0.5°: monthly land-surface precipitation from rain-gauges built on GTS-based and historic data, 2011, *10.5676/DWD_GPCC/FD_M_V6_050*
5. E. R. Cook, K. J. Anchukaitis, B. M. Buckley *et al.*, Asian monsoon failure and megadrought during the last millenium, *Science* **328(5977)**, 486 (2010), 10.1126/science.1185188
6. N. A. Rayner, D. E. Parker, E. B. Horton *et al.*, Global analyses of sea surface temperature, sea ice, and night marine air temperature since the late nineteenth century, *J. Geophys. Res.* **108(D14)**, 4407 (2003), 10.1029/2002JD002670
7. A. Kaplan, M. Cane, Y. Kushnir *et al.*, Analyses of global sea surface temperature 1856-1991, *Journal of Geophysical Research* **103**, 18,567(1998)
8. K. J. Manish, A. C. Pandey, Trend and spectral analysis of rainfall over India during 1901-2000, *Journal of Geophysical Research* **116**, 1 (2011), 10.1029/2010JD014966