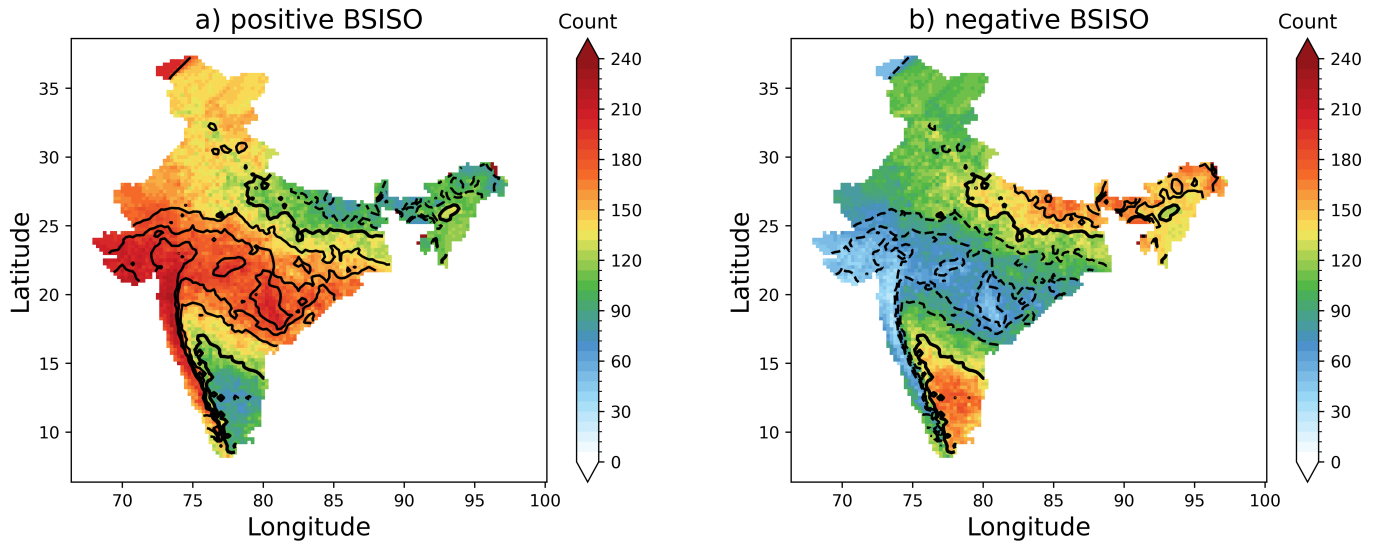


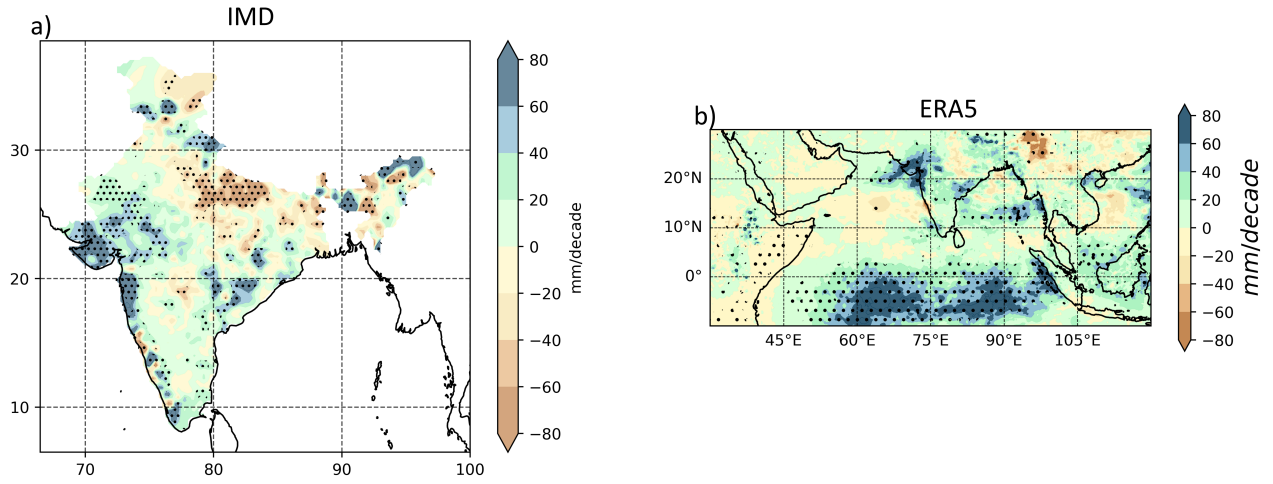
Supplementary material for Energetic constraints
on BSISO-driven extreme Rainfall Intensification
over India in the recent Decades

Aditya Kottapalli, Vinayachandran PN

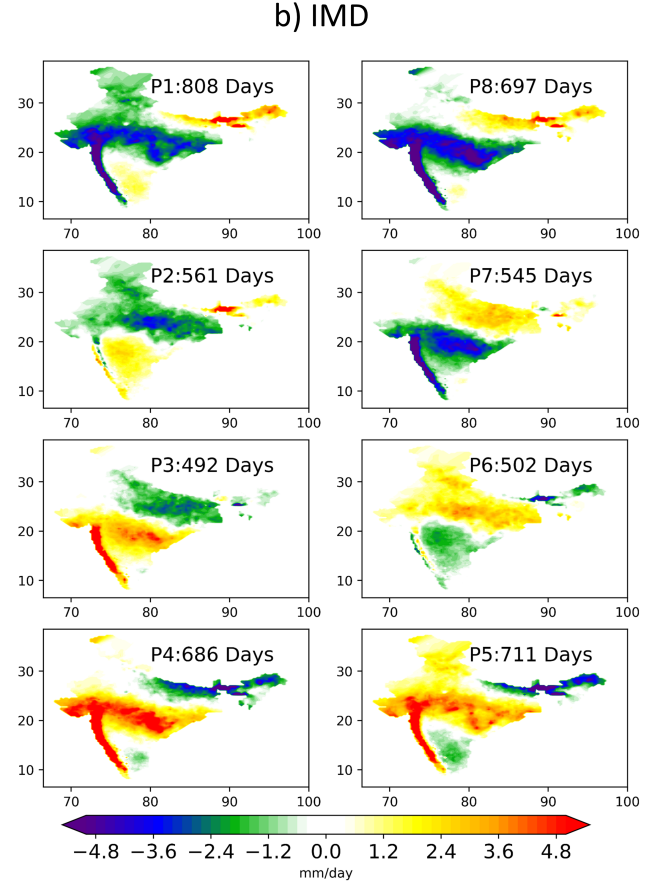
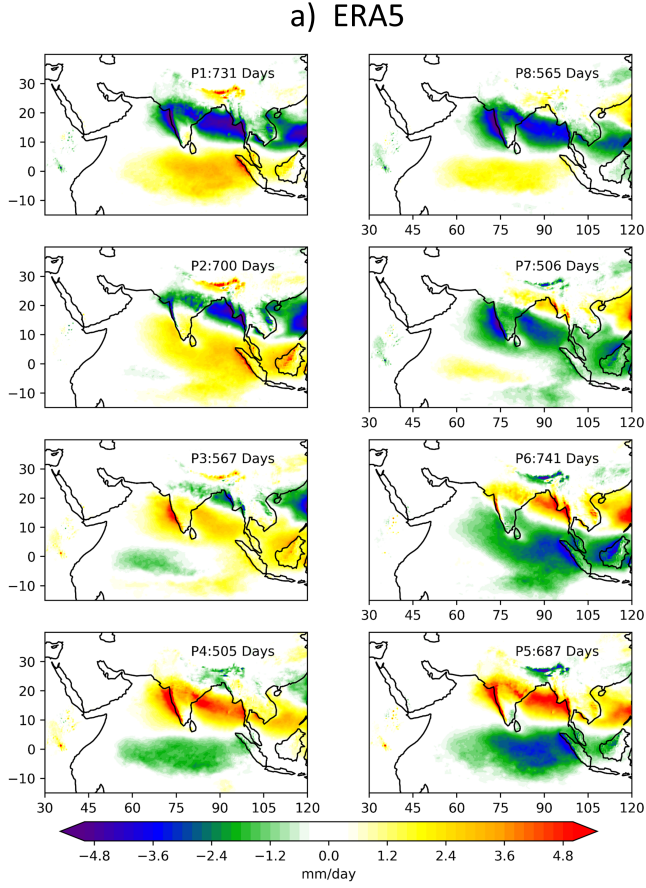
Supplementary Figures



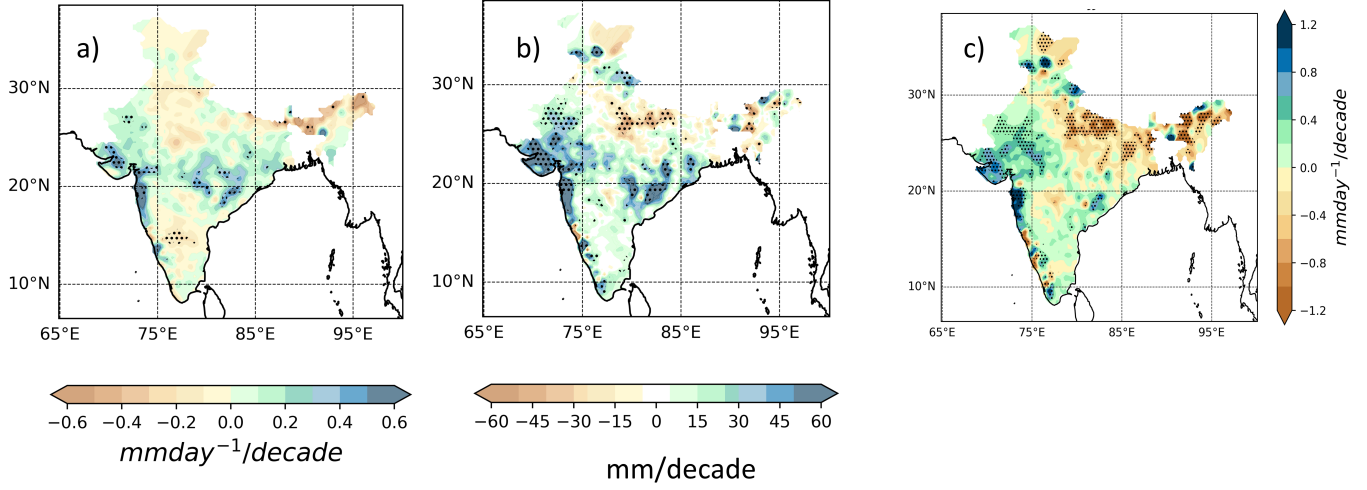
Supplementary Figure. 1: Same as figure 1 in the main manuscript, but with rainfall from IMD Data



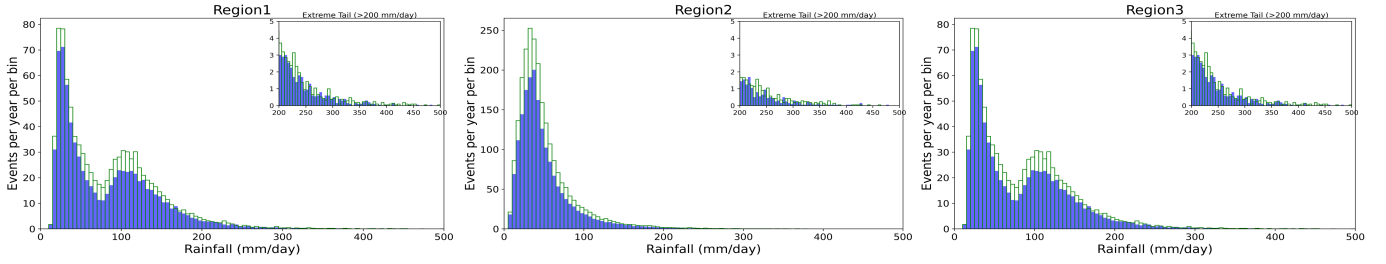
Supplementary Figure. 2: Trend in the accumulation due to extremes crossing 95 percentile at each grid point during JJAS in a) IMD data and b) ERA5 data. Unlike Figure. 2b in the original manuscript, the rainfall is not conditioned on the BSISO active phases here.



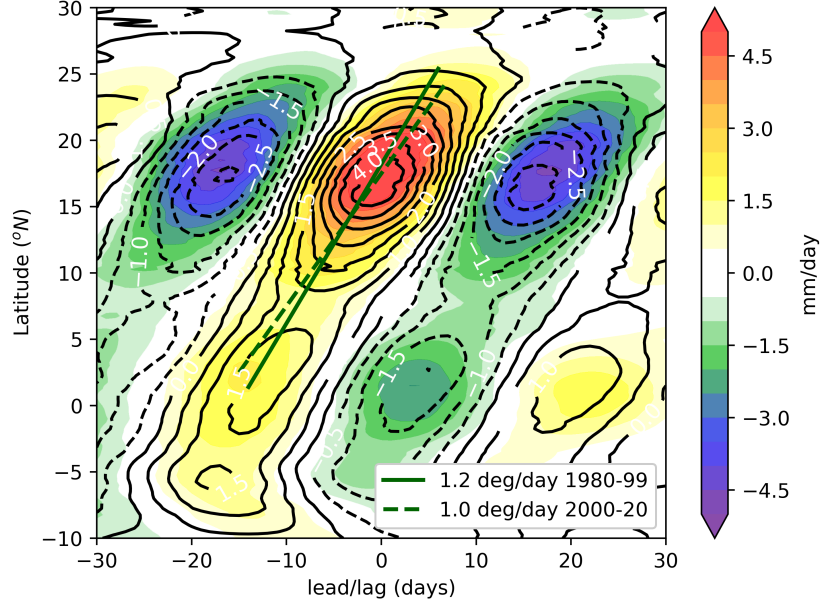
Supplementary Figure. 3: Phase plot showing the phases of the BSISO in the ERA5 data (a) and IMD rainfall data (b). Refer to the methods section in the main manuscript to understand how phase composites are constructed. The phases and corresponding numbers of days for each phase are printed in each panel for both ERA5 and IMD data.



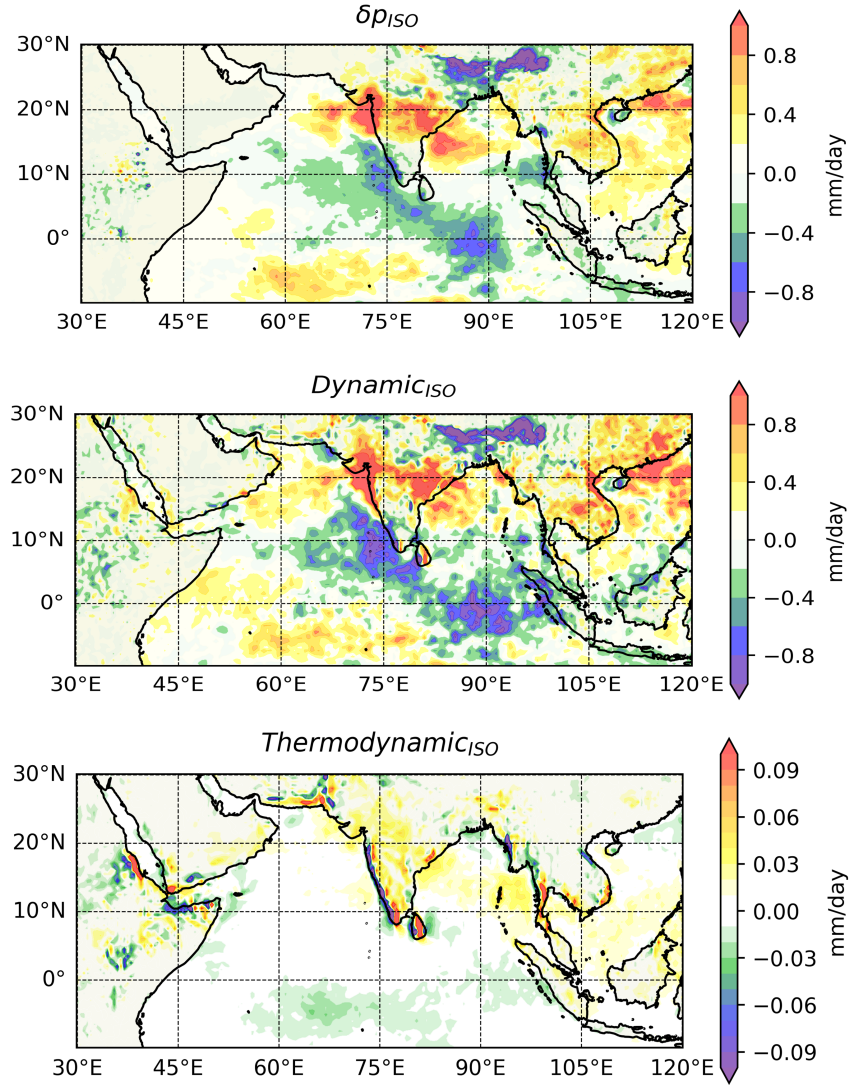
Supplementary Figure. 4: Same as figure 2 in the main manuscript, but with rainfall from IMD data.



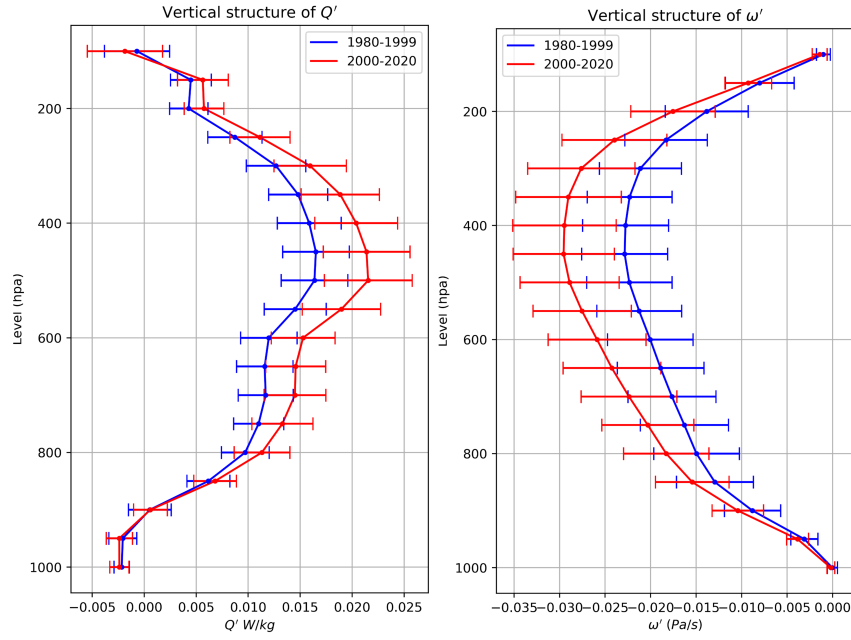
Supplementary Figure. 5: Same as figure 3 in the main manuscript, but with rainfall from IMD data. Regions are as defined in the main manuscript.



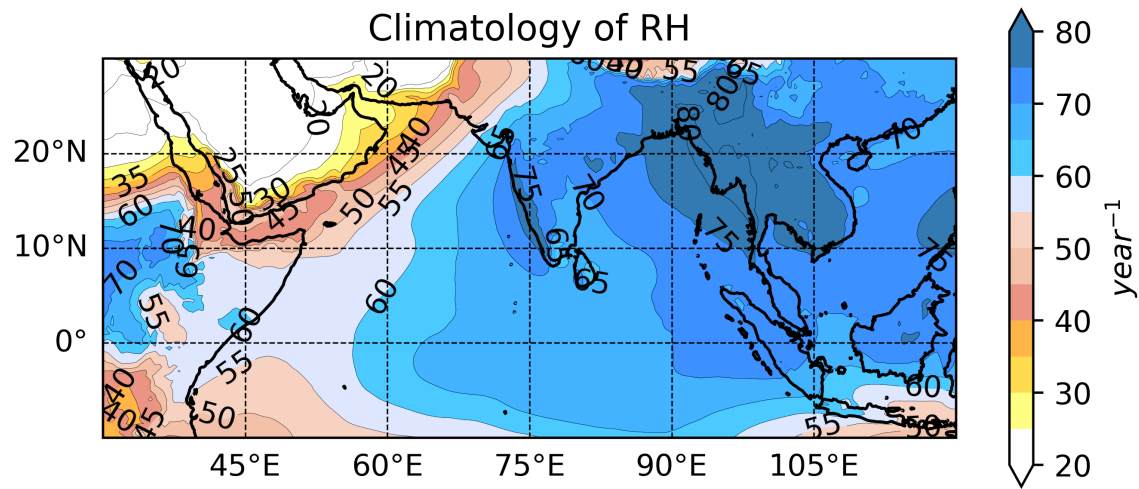
Supplementary Figure. 6: Latitude-time Hovmöller plot for showing the BISO propagation during the 2000-2020 epoch (shading) and the 1980-1999 epoch (shading). The solid green (dashed green) line shows the speed of propagation during the 1980-1999 (2000-2020) epoch. The speed of propagation is given by the slope of the line that has the maximum rain accumulation (See the section on calculating the speed of propagation below).



Supplementary Figure. 7: Change in the BSISO filtered precipitation during active phases of BSISO between the two epochs (a), change explained by the dynamic (term 1 in equation 6 of the main manuscript, b) and change explained by the thermodynamic term (term 2 in equation 6 of the main manuscript, c)



Supplementary Figure. 8: Vertical structure of diabatic heating (Q') (left) and vertical pressure velocity (ω') (right), over central India during the active phase of BSISO, defined as the number of days BSISO crosses $0.5SD$ over central India. The blue curve represents the average for 1980-1999, and the red curve represents the average for 2000-2020. The error bars denote a 95% confidence interval for the mean.



Supplementary Figure. 9: The JJAS Climatology of Column Saturation factor (RH). The saturation factor is calculated as $RH = \frac{\langle q \rangle}{\langle q_s \rangle}$. Where q is the specific humidity and q_s is the saturation specific humidity calculated as $q_s = 6.11 \exp\left(\frac{17.67T}{243.5+T}\right)$ following Bolton(1980)

Calculating the speed of propagation

The speed of propagation is calculated as the speed at which maximum rainfall accumulation happens in the Hovmöller plot. To do this, we follow the following algorithm

Algorithm 1 Calculating the speed of propagation

Step 1: Plot the Hovmöller plot.

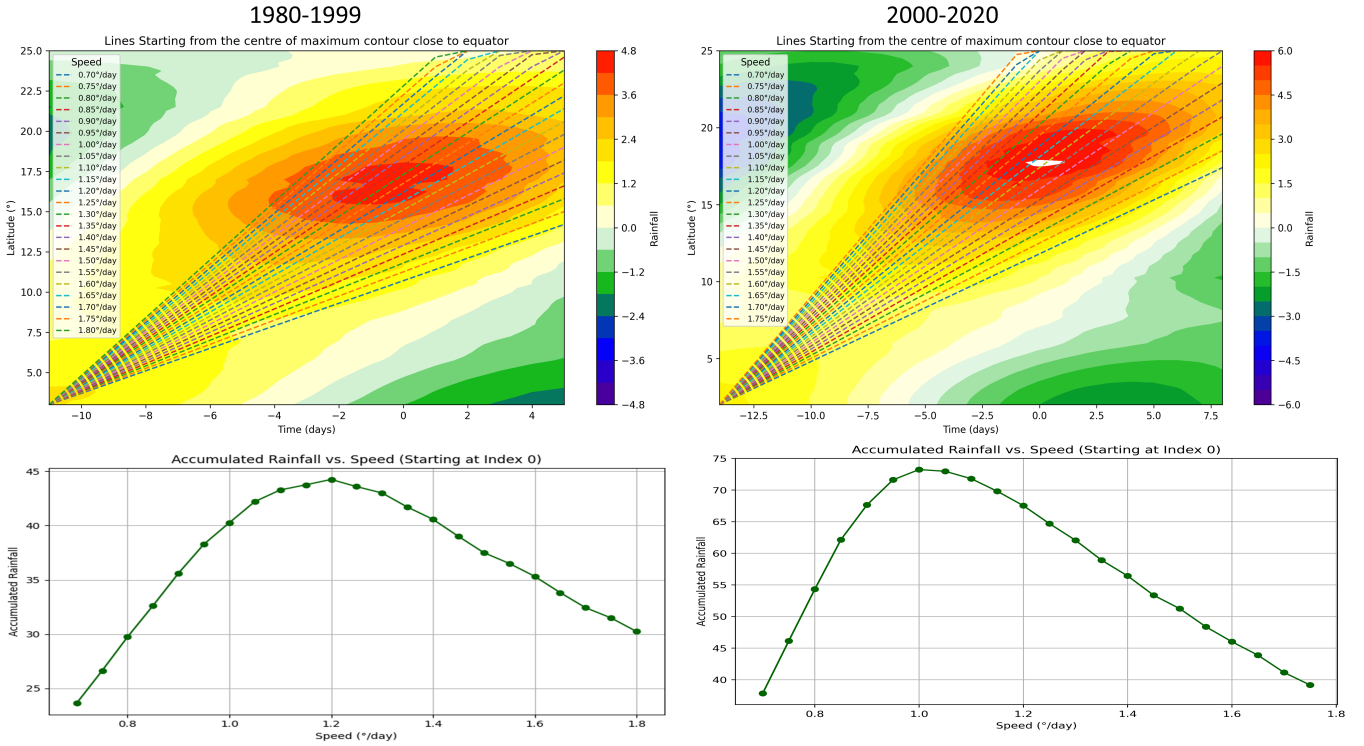
Step 2: Plot the lines with the speed of propagation ranging from 0.7 deg/day to 1.8 deg/day .

Step 3: Calculate the rainfall accumulation at each speed of propagation from 0.7 deg/day to 1.8 deg/day .

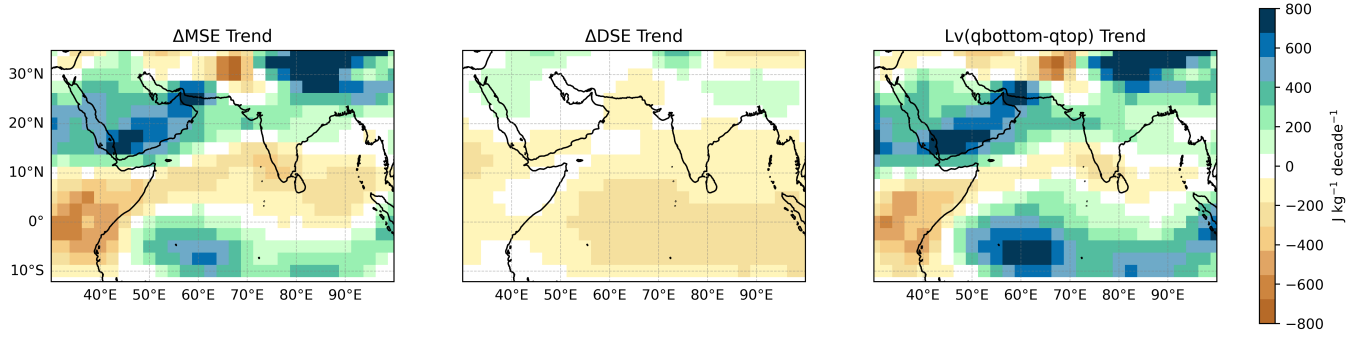
Step 4: Pick the speed that has the maximum accumulated rainfall.

Step 5: Repeat steps 1 to 4 for the next epoch in question.

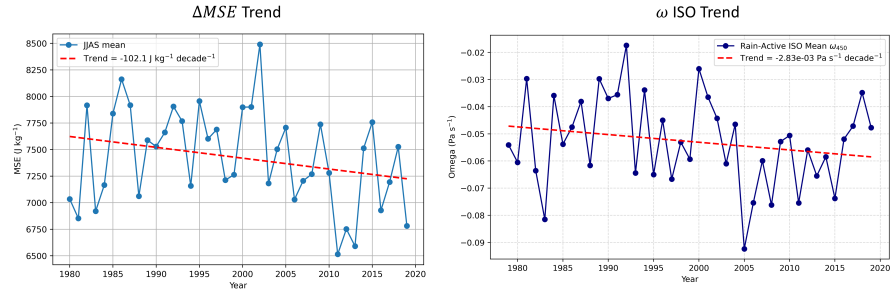
Figure 10 illustrates the implementation of the algorithm for both epochs.



Supplementary Figure. 10: Figure illustrating the implementation of the algorithm 1 for both epochs we examined.



Supplementary Figure. 11: Same as Fig. 6 in the main manuscript but with NCEP DOE2 Reanalysis



Supplementary Figure. 12: Same as Fig. 6 in the main manuscript but with NCEP DOE2 Reanalysis