Figures

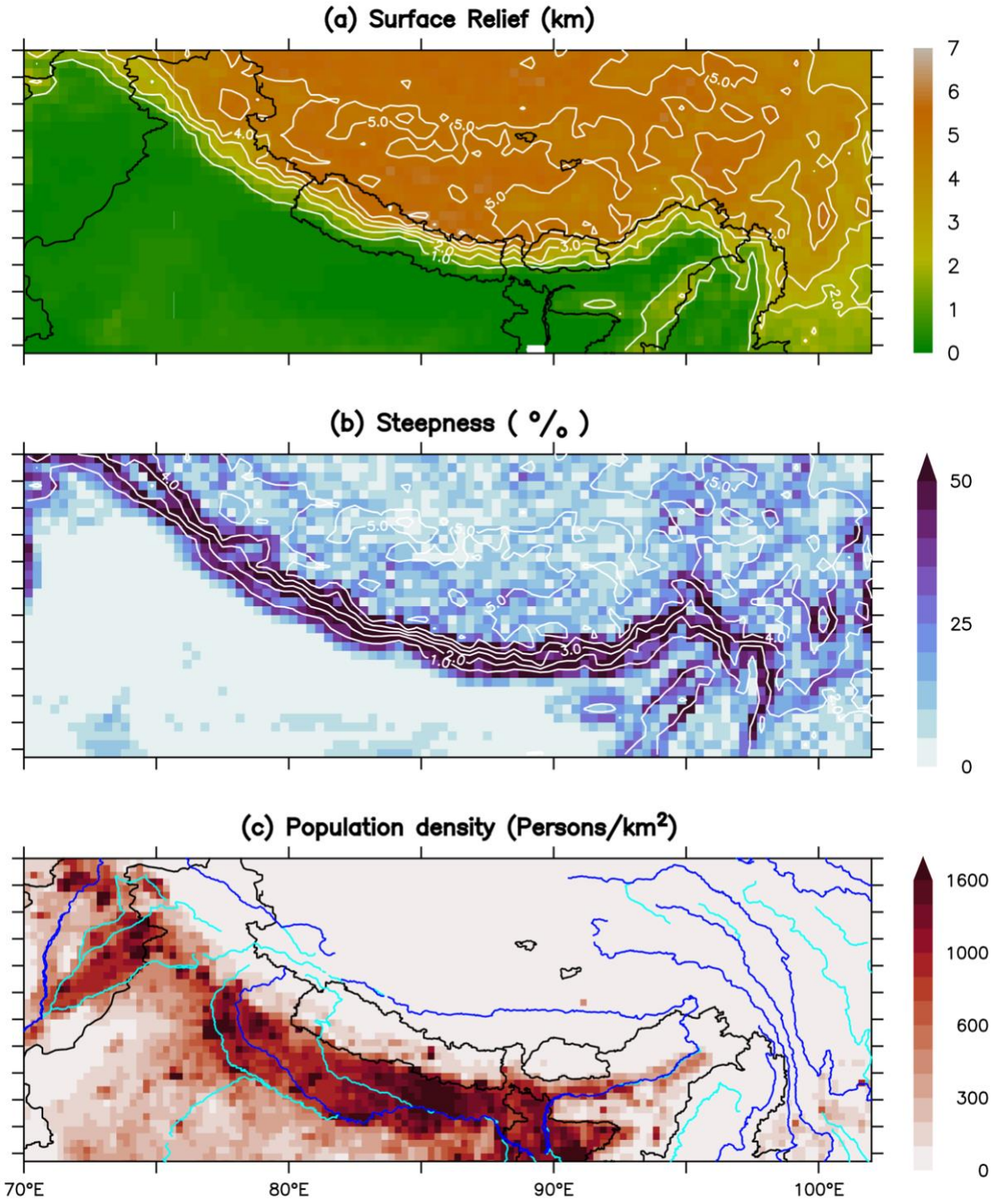

Figure 1. Topographic elevation and demography of the Himalayan region. (a) shaded surface relief (Topography surface of the Earth data at five-minute grid resolution; https://www.ngdc.noaa.gov/mgg/global/etopo5.HTML) with overlayed national borders in black

color and surface relief contour intervals of 1km in white color. (b) Shaded steepness estimated using the slope raster method with surface relief contour intervals of 1km in white color. (c) The shaded population density map highlights the exposed population in 2020 (gridded population of the world version 4 (GPWv4) population density; https://sedac.ciesin.columbia.edu/data/set/gpw-v4-population-density-rev11) overlayed national borders in black color and river system in blue and cyan color.

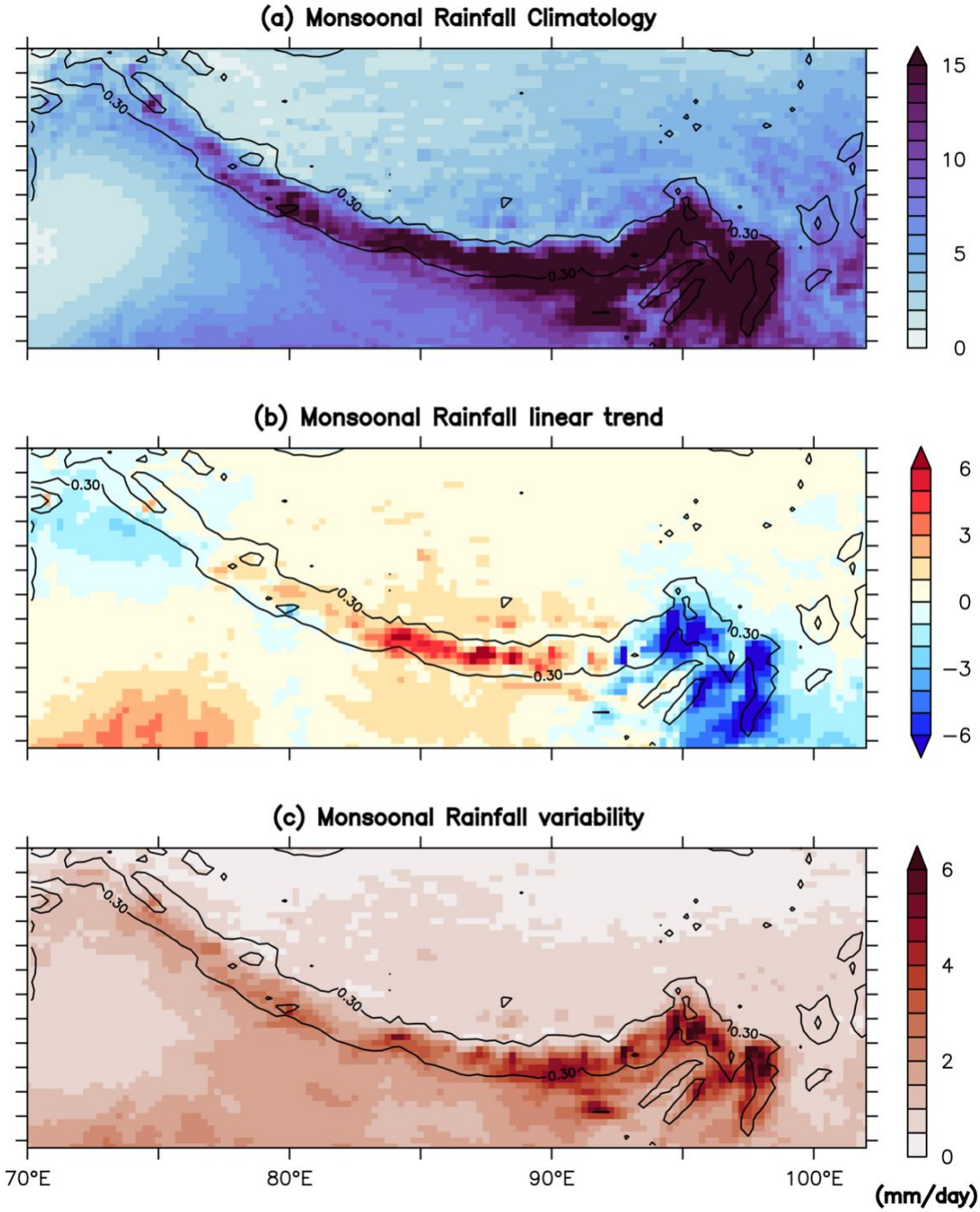

Figure 2. Monsoon seasonal rainfall features over the Himalayan foothills in the last 43 years. (a) Shaded mean rainfall climatology in Himalaya, (b) Shaded trend in rainfall estimated by linear regression method. (c) Shaded rainfall variability in the last 43 years. Here, overlayed white color contours represent regions with elevation steepness higher than 30%.

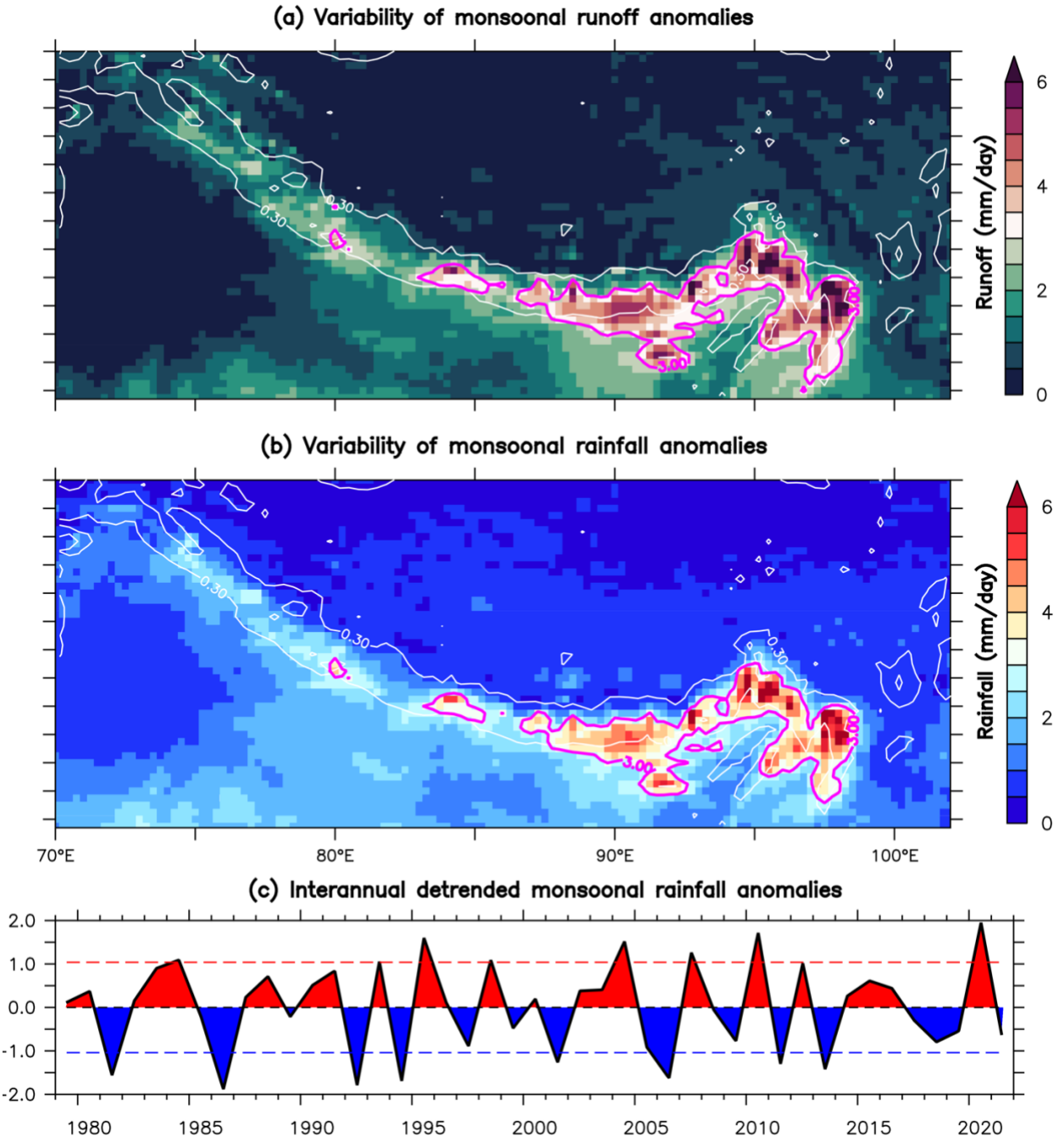

Figure 3. Interannual variability of the Himalayan hydroclimate. (a) Shaded surface relief using the etopo5 dataset with overlayed national borders in black color, river system in blue and cyan color, (b) Interannual amplitude of rainfall anomalies during the last 43 years (1979-2021) from ERA5(Hersbach et al., 2020) (The fifth generation ECMWF reanalysis; https://cds.climate.copernicus.eu/cdsapp#!/home) reanalysis dataset with white contours represent steep topography and black contours denote regions with associated variance more than 3 mm/day consider as high amplitude, and (c) Time series of the linearly detrended monsoonal rainfall

anomalies illustrated in plot, those are normalized with associated multi-year standard deviation. Shaded red (blue) indicates extreme wet (dry) monsoon years. Here we have considered years greater than the multi-year standard deviation (dashed line) of rainfall anomalies for further composite analysis.

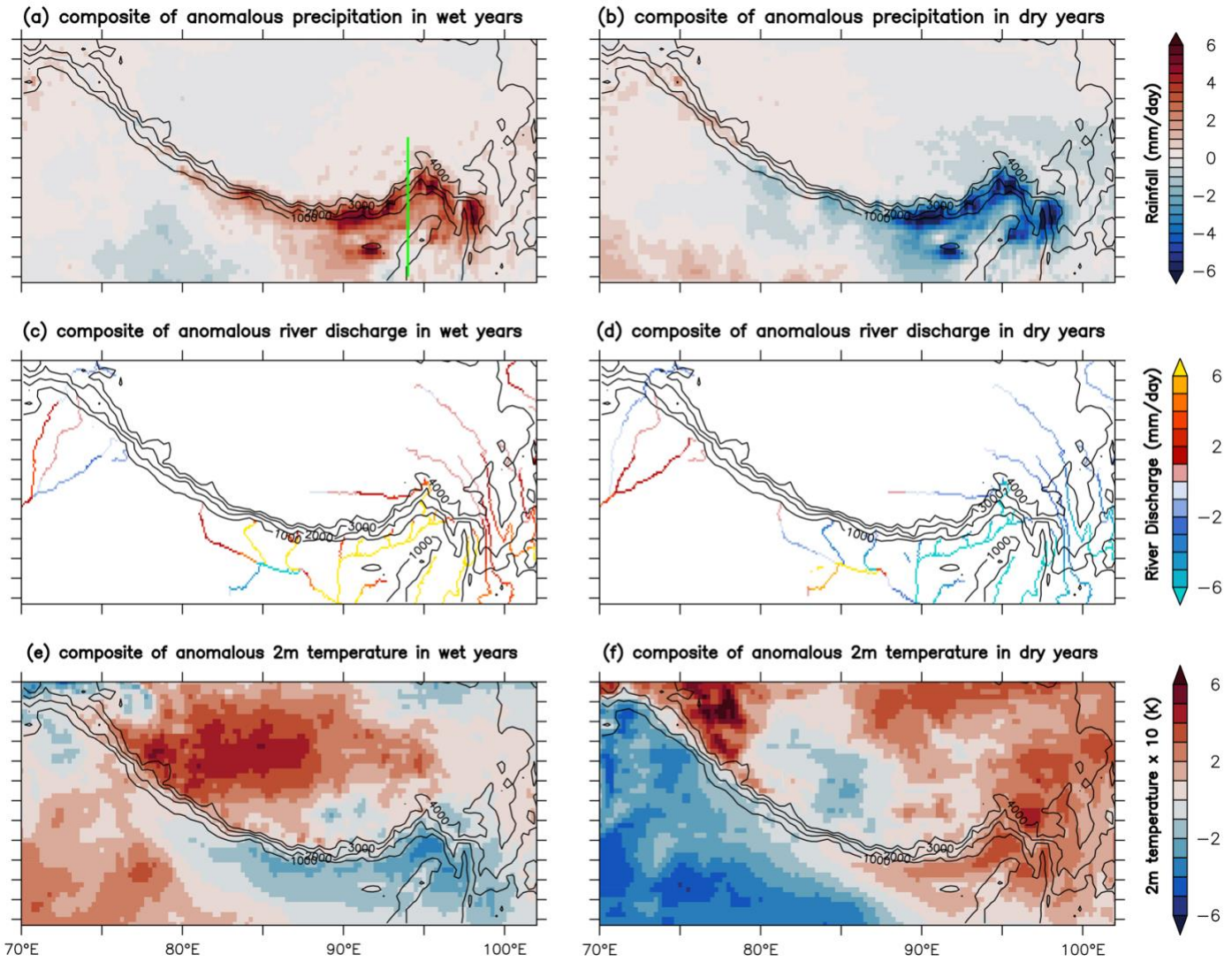

Figure 4. Composite analysis for monsoonal hydroclimate during 1979–2021. (a) Composite map of rainfall anomalies for wet years and (c) dry monsoon years using ERA5(Hersbach et al., 2020) dataset. (c) Composite map of mean river discharge anomalies for wet and (d) dry years using GloFAS-ERA5(Harrigan et al., 2020) (The GloFAS-ERA5 operational global river discharge dataset obtained from https://cds.climate.copernicus.eu/cdsapp#!/dataset/cems-glofas-historical?tab=form) reanalysis). (e) Composite map of 2 m air temperature anomalies for wet and (f) dry years, multiply by 10 factor. Here black contour represents surface relief intervals from 4000 to 1000 m.

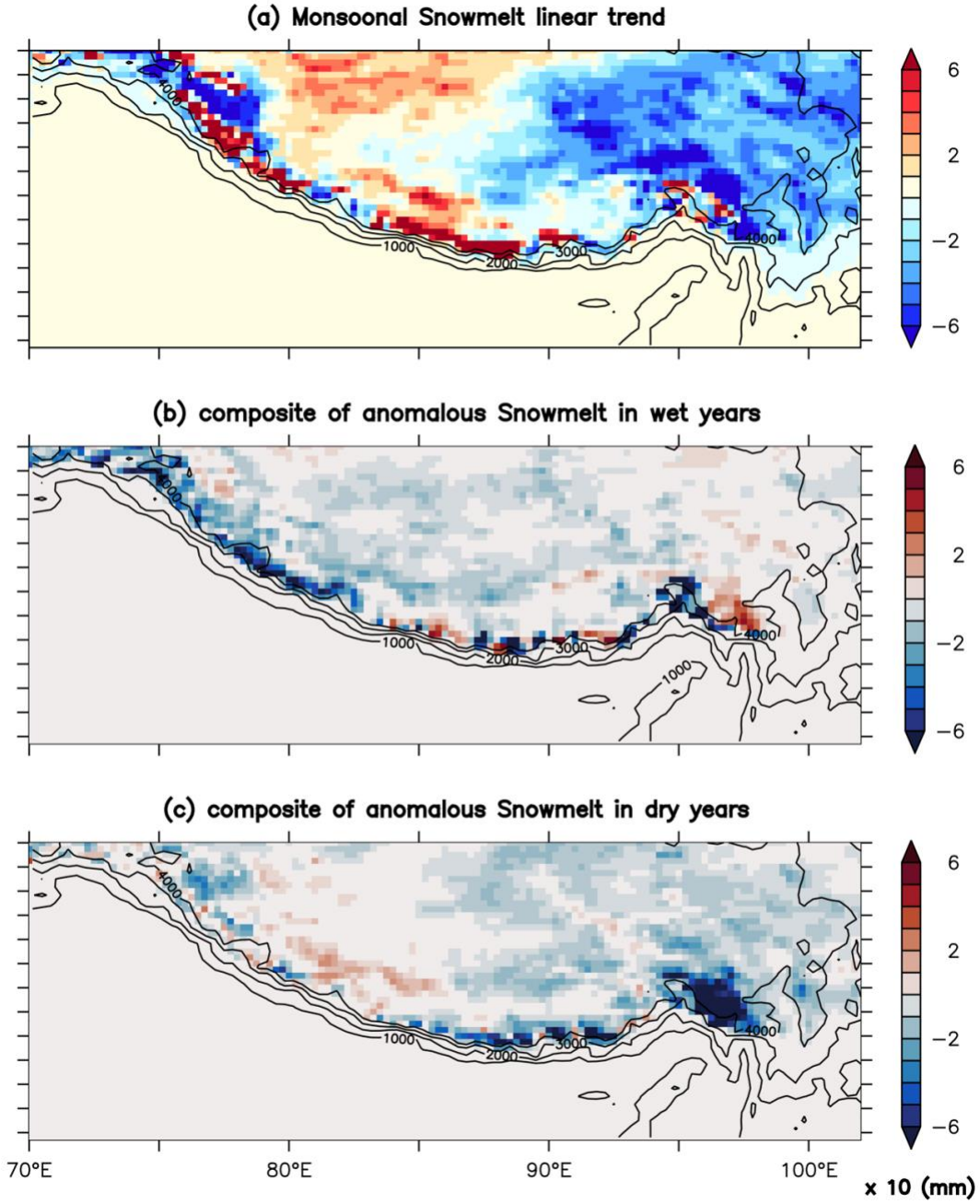

Figure 5. Composite map of snowmelt anomalies for wet and dry monsoon years. Shaded snowmelt (multiplied by 10) with surface relief contour intervals of 1km and white contour intervals denotes steepness. (a) Shaded trend in snowmelt estimated by linear regression method, (b) Composite map of anomalous snowmelt for wet years and and (c) dry monsoon years.

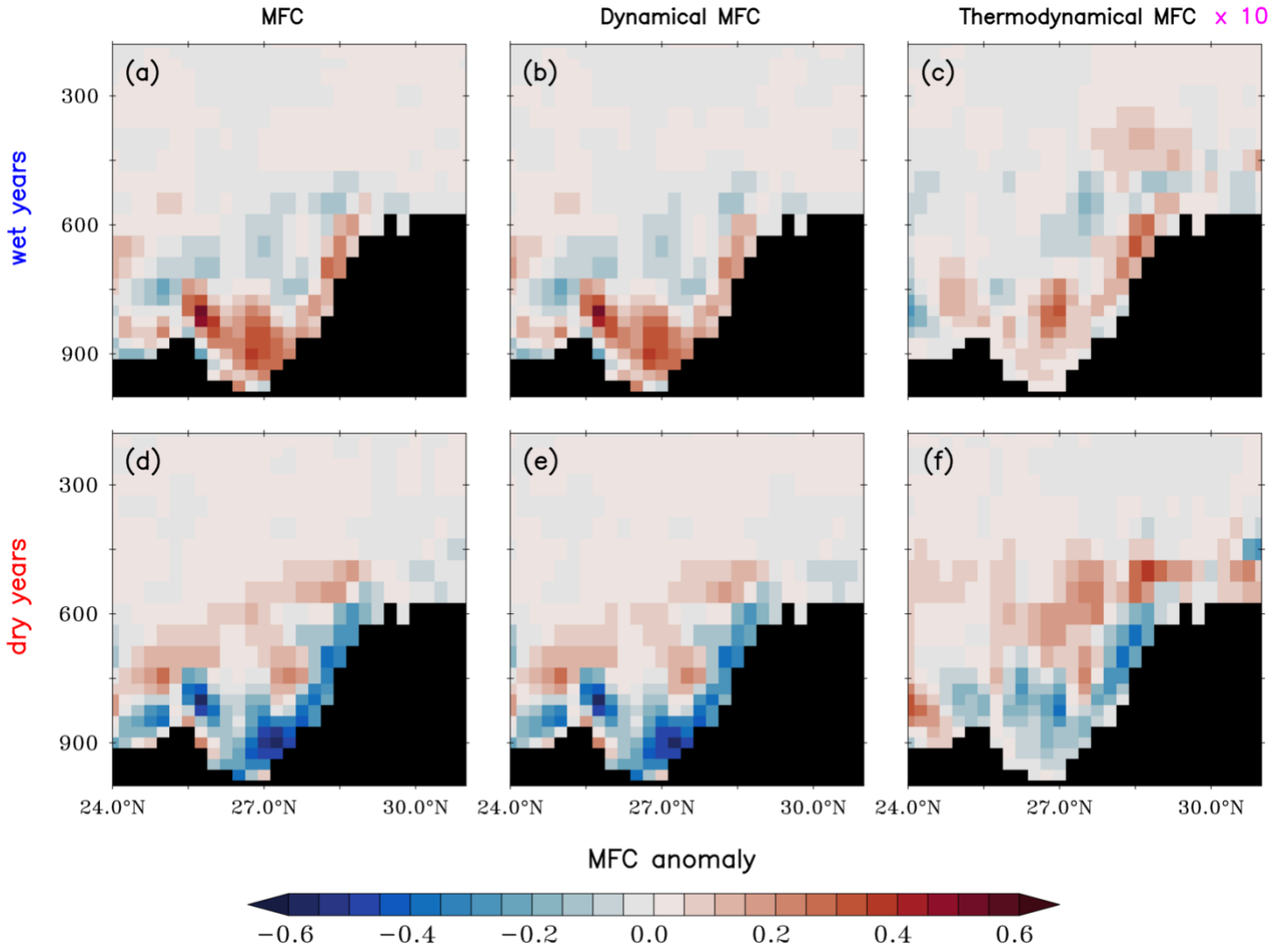

Figure 6. Anomalous moisture flux convergence for composite wet and dry monsoons. Cross section taken over the green line represented in Fig 4 (a) where shaded quantities are moisture flux convergence, dynamical moisture flux convergence, and thermodynamical moisture flux convergence. (a)-(c) for composite wet years, and (b)-(f) for dry years respectively. Where thermodynamical moisture flux convergence is is multiplied by 10. Here, elevation topography regions are masked by black color.

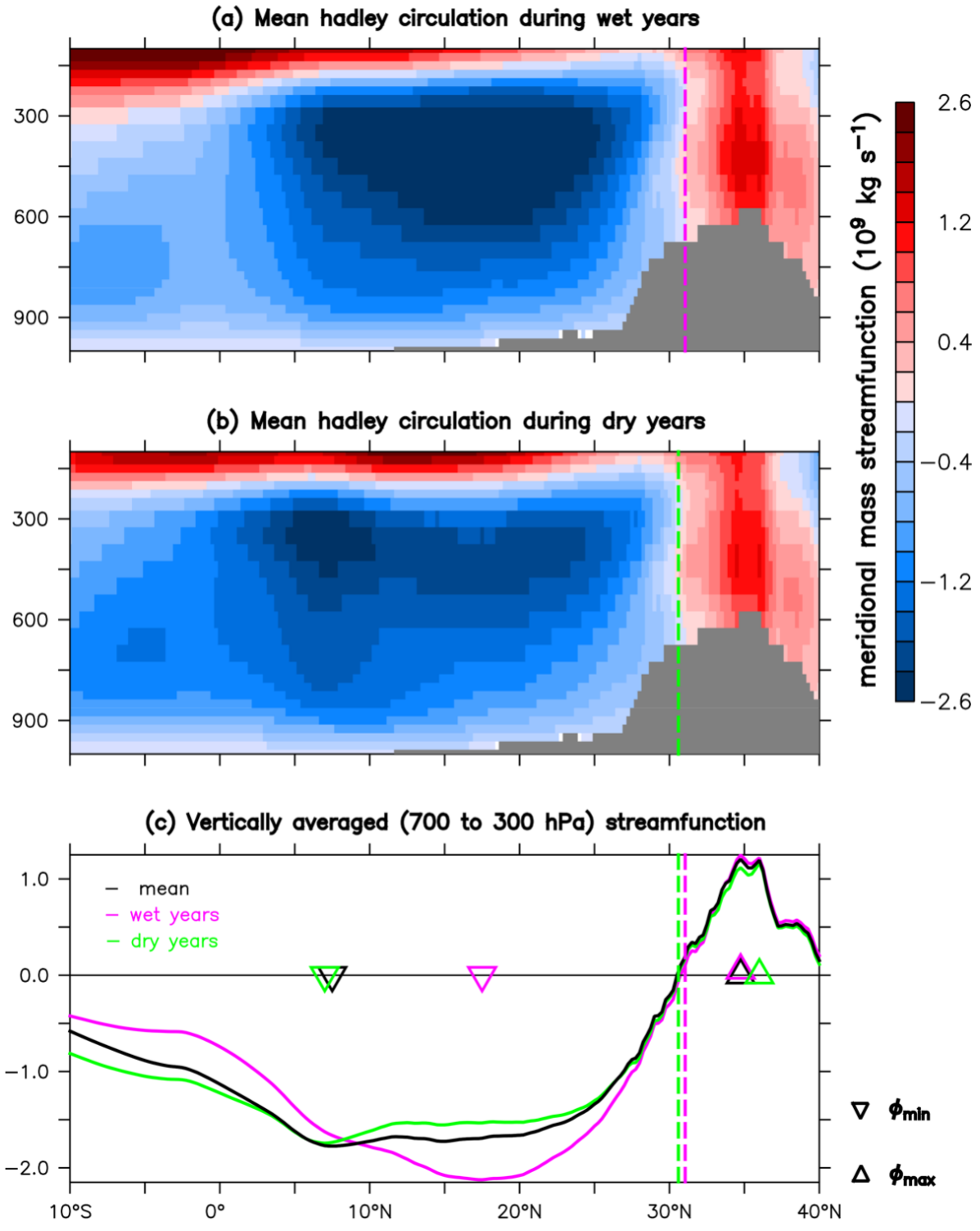

Figure 7. Mean local Hadley circulation in wet and dry monsoon years. Zonal mean meridional Mass stream function averaged over 70°E to 102°E represents local monsoonal circulation (a) for composite wet year and (b) for dry year respectively. A negative (Positive) values of streamfunction indicates counterclockwise (clockwise) circulation. Here, the elevation topography

(averaged over 70°E to 102°E) regions are masked by grey color. (c) Vertically averaged (from 700 hPa to 300 hPa) zonal mean meridional streamfunction. The dashed line shows the location of ITCZ; Maxima and minima latitudinal points are represented with upper and lower empty triangles, respectively.

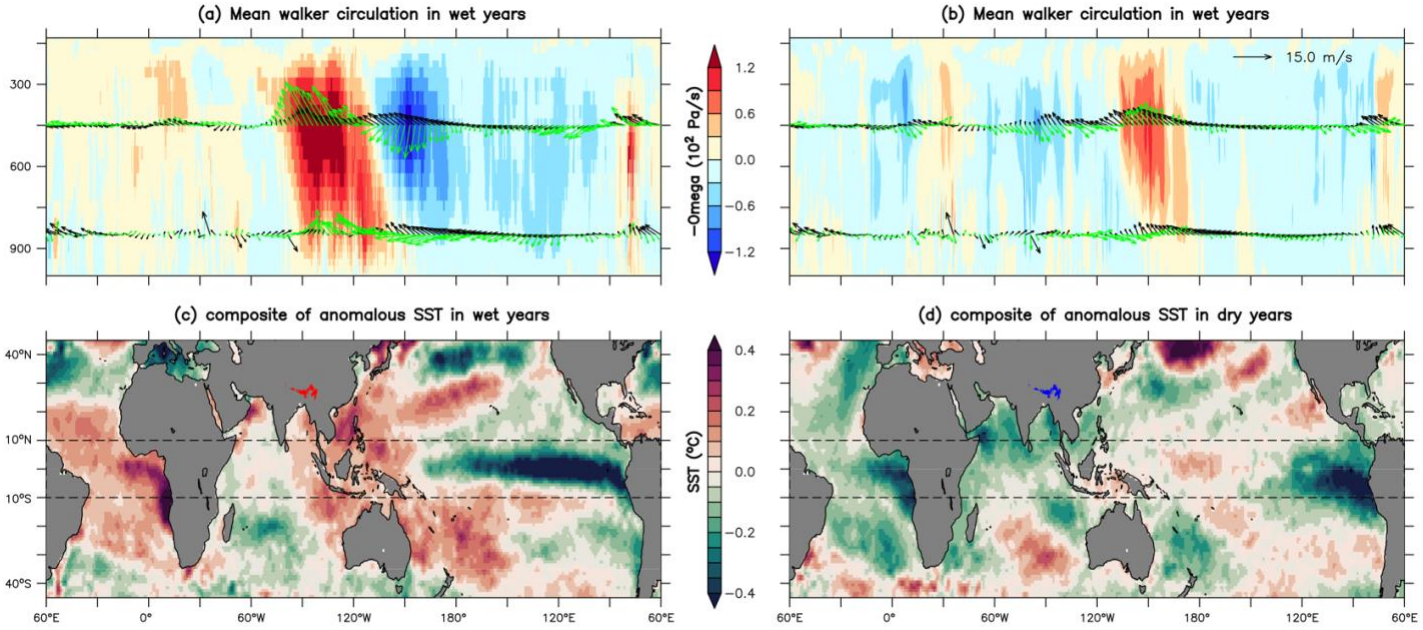

Figure 8. Mean global Walker circulation in wet and dry monsoon years with their composite SST anomalies. Anomalous omega (multiplied by −100) averaged over 10°S–10°N is shaded (a) for a composite wet year and (b) for a dry year, respectively. The black vector represented the composite climatology of wind vectors, while the green vectors showed anomalous wind vectors (multiplied by 10). SST anomalies (c) for wet and (d) dry years using HadSST. Here, the dashed line shows the region consider for Walker circulation.