

Spatial features of snow over Eurasia and precipitation over India in the warming scenarios:

CCSM4 model projections from CMIP5

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Introduction

Multimodel projections indicate significant decrease in snow water equivalent for most of the regions of the Northern hemisphere (Shi and Wang, 2015) and an increase in the mean precipitation over South Asian summer monsoon region in greenhouse gases induced warmer climate during the 21st century relative to the present (Wang et al. 2020). However, there is little agreement between models in projections of snow (Collins et al. 2013) and regional precipitation throughout vast areas of the tropics (Rowell 2012). Linkage between Eurasian snow in the preceding season and Indian summer monsoon rainfall (ISMR) has been extensively documented (Kripalani and Kulkarni, 1999). Understanding how the spatial features of Eurasian snow and ISMR may change in the future remains a grand challenge. In this study, we provide insights into the spatial characteristics of projected changes in winter snow over Eurasia and summer monsoon precipitation (SMP) over India for the 21st century under three different Representative Concentration Pathways (RCP) scenarios of CCSM4 model from Coupled Model Intercomparison Project phase 5 (CMIP5; Taylor et al., 2012).

Data

Monthly mean precipitation and snowfall flux of CCSM4 model for the reference period (1975-2005; RP) of 20th century historical and three RCP scenarios namely RCP2.6, 4.5 8.5 from CMIP5 (<http://www-pcmdi.llnl.gov>) are used. The future change in three RCPs for the period 2020-2100 of 21st century is evaluated over two sub-periods separately: an early-to-middle (2020-2050; EMP) and late period (2070-2100; LP).

Results

Projected spatial changes in winter snowfall flux (WSF) over Eurasia during EMP relative to RP in CCSM4 model from CMIP5 are shown for RCPs 2.6, 4.5 and 8.5 in figures 1a, 1b, and 1c respectively. Similar projected spatial changes in SMP over India are shown in figures 1d, 1e and 1f respectively for three RCPs. Likewise, projected spatial changes in WSF over Eurasia and SMP over India are analyzed for three RCPs (figure 2 [a-e]) during LP. The model projects significant decreases in WSF during the EMP over region encompassing northwestern Eurasia extending southeastward to 90°E, in RCP 8.5, whereas decrease is confined to very small pockets from west to central Eurasia in RCPs 2.6 and 4.5. The only region with projected increase in WSF is north-central and north-eastern Eurasia in RCP2.6, which reduces in spatial extent from RCPs 4.5 to 8.5. Spatial features of projected WSF during LP (Fig 2(a-c)) are mostly analogous to EMP (Fig. 1(a-c)), but with larger spatial extent of reduction in WSF. Also, the magnitude and spatial spread of projected decrease in WSF during LP exhibit gradual increase from RCPs 2.6 to 8.5 (Figure 2(a-c)), as evident over whole of west and central Eurasia in RCP8.5 (Fig. 2c). Significant increase in WSF during LP over small portion of extreme northeastern Eurasia in RCP2.6 displays steady growth in its spatial expanse from RCPs 2.6 to 8.5 (Fig. 2(a-c)).

Significant increase in SMP during EMP relative to RP in CCSM4 model is projected over northeast, west and southeast peninsular India in RCP 2.6 (Fig. 1d), with further increase in its spatial spread from RCPs 2.6 to 8.5 (Fig. 1(d-f)). Projected spatial characteristics of SMP during LP (Fig 2(d-f)) are mostly analogous to that during EMP (Fig. 1(d-f)). Projected changes in WSF and SMP in CCSM4/CMIP5 model in the present study are in consensus with the earlier studies mentioned in introduction.

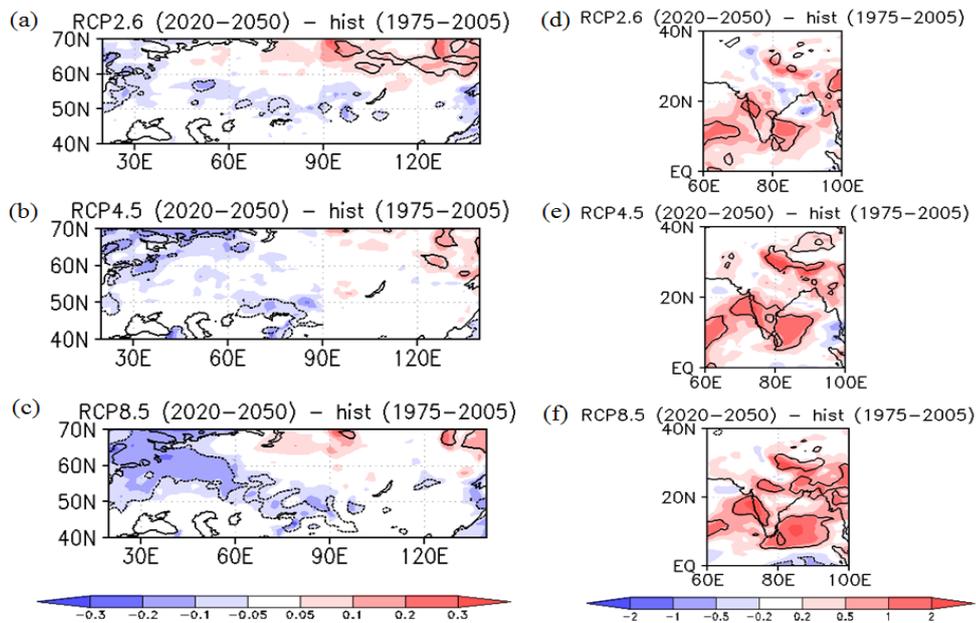


Fig. 1: Projected change in WSF (mm day^{-1}) over Eurasia (a-c) and SMP (mm day^{-1}) over India (d-f) for three RCPs by CCSM4 model from CMIP5 during EMP relative to RP. Black solid contour indicates statistical significance at 95% level.

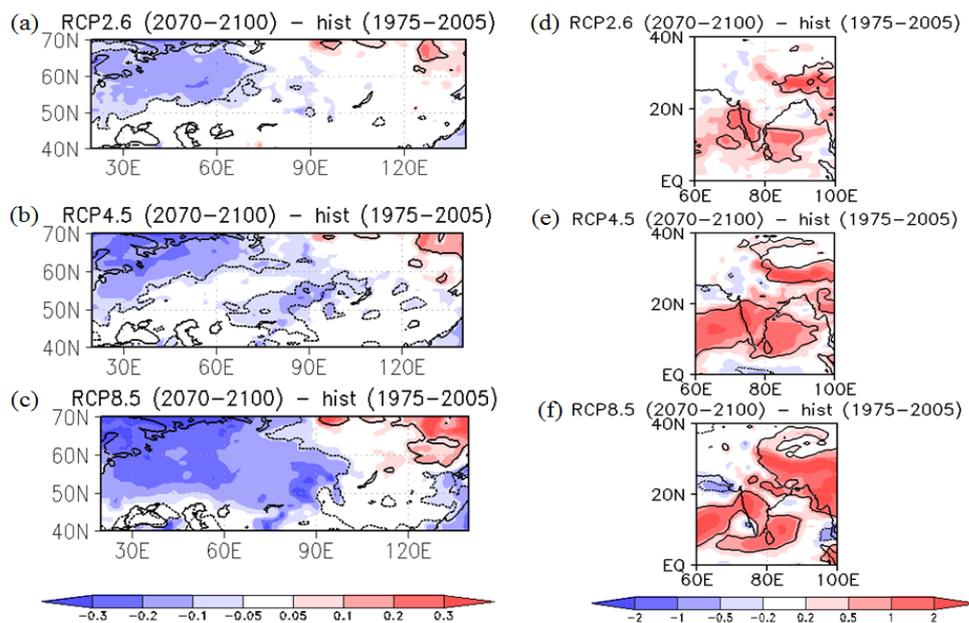


Fig. 2 (a-f): Same as in Figure 1 (a-f) except during LP relative to RP

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