Eurasian winter snow variability in the future warming scenarios of CCSM4/CMIP5

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1. Introduction

A large fraction of the Eurasian continent is covered with snow during the winter months. Seasonal snow cover over Eurasia is a highly variable component of the global system and has been recognized as an important factor affecting climate variability in the following seasons both locally and in remote regions (Bamzai and Shukla, 1999; Cohen et al. 2012; Wu et al., 2014). The observed trend in the Eurasian snow cover extent (SCE) shows marked seasonal and spatial differences; spring (fall) SCE reveals diminishing (increasing) trend (Yeo et al. 2017). CMIP5 multi-model ensemble confirms widespread reduction of Northern Hemisphere (NH) spring SCE over the 21st century due to climate change, though with considerable inter-model scatter (Collins et al. 2013). In light of the larger sensitivity of NH SCE to climate change (Collins et al. 2013), the present study is focused on the Eurasian winter snow (EWS) variability in a projected future warming, using the 20th century historical and 21st century future projections of three Representative Concentration Pathways (RCP) by the CCSM4 model from the fifth Coupled Model Intercomparison Project (CMIP5; Taylor et al., 2012). The CCSM4 model is chosen due to reasonable simulation of EWS climatology compared to the observation (Prabhu and Mandke, 2019), along with its high horizontal resolution (1.2^0E x 0.9^0N).

2. Data

Monthly mean snowfall flux data of CCSM4 model for the Reference Period (1850-2005; RP) of the 20th century historical and three RCP scenarios (2.6, 4.5 and 8.5) for the period (2006-2100) of the 21st century from CMIP5 (http://www-pcmdi.llnl.gov), is used.

3. Results

The interannual variability (IAV) (vertical color bars), trend (dashed black line) overlaid by the decadal variability (color shading) of winter snowfall flux averaged over Eurasian region (50- 70°N; 20-140°E) in historical and three RCP simulations of CCSM4 model from CMIP5 are depicted in Figures 1a, 1b, 1c, and 1d respectively. The averaged conditions from December through March of the following year (DJFM) are chosen as representative of the winter season due to prevalence of maximum snow over Eurasia during DJFM in the annual cycle (Prabhu and Mandke, 2019). The target Eurasian region is selected because it is one of the main snow cover areas and also winter/spring snow over this region exert strong influence on the All-India summer monsoon rainfall (Yim et al., 2010). A trend of EWS in historical and three RCPs is declining with the largest downward trend in RCP8.5 and a relatively very weak trend in RCP2.6. IAV of EWS during RP is dominated by positive (negative) anomalies before (after) 1970's. This results in prevalence of weak positive (strong negative) conditions before (after) 1970s in the decadal variability of EWS during RP. The EWS variability (IAV and decadal) in RCP2.6 do not agree with RCP4.5 and RCP8.5 with regard to timing of the positive/negative anomalies. The time series of EWS in RCP4.5 displays similarity in its long-term behavior to RCP8.6, although the amplitude of anomalies (IAV and decadal) is higher in RCP8.6. The decadal variability of EWS in RCP2.6 is characterized by positive anomalies from 2006 till early 2030s and later near normal or negative conditions, still its amplitude is small. The positive phase of decadal variability persisted from 2006 till mid-2050s and thereafter is negative in both RCP4.5 and RCP8.6. As the results of the present study are based on the simulations of a single model, detailed analysis with CMIP6 multi-model ensemble future climate change simulations would provide possible extension of this work.

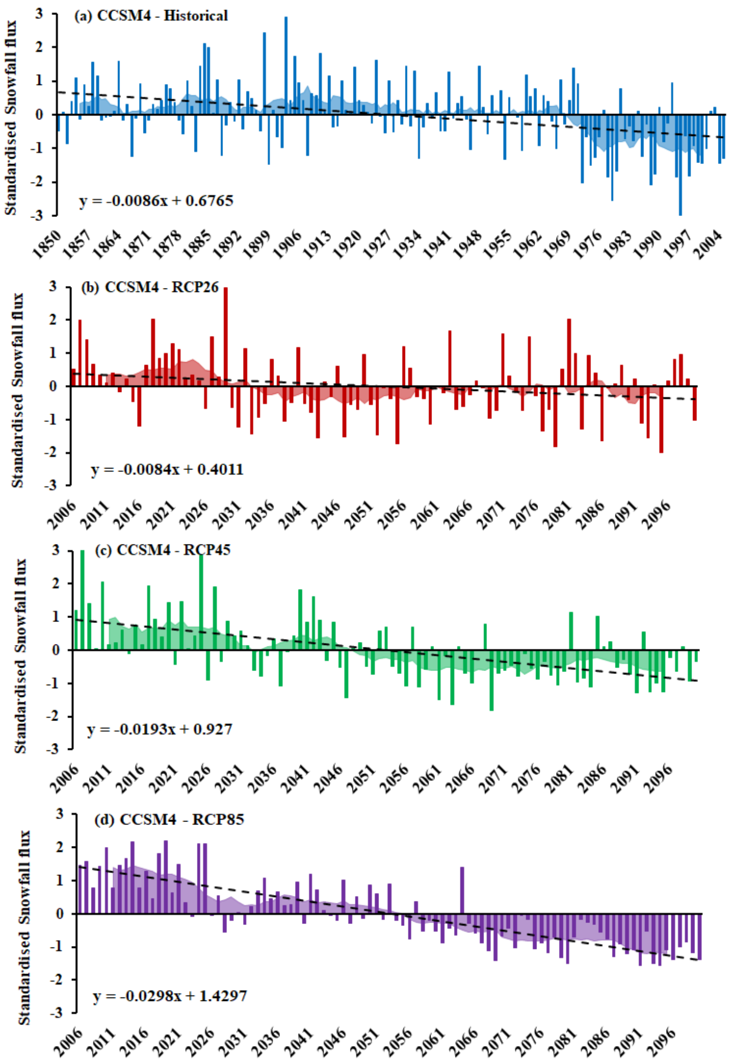

Figure 1: Variability of winter snow averaged over Eurasia (50-70°N, 20-140°E) simulated by CCSM4/CMIP5 model. Vertical color bars (year-to-year variations); Color shading (decadal variability); Black dashed line (trend) (a) Historical run (b) RCP2.6 (c) RCP4.5 (d) RCP8.5

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