Downscaled Winter Warming over the Western Himalaya of India

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Abstract—*Mountains and Polar Regions are the most vulnerable zones under the context of global warming due to its wide range of ice and glacier coverage, which is highly sensitive to temperature rise. Recently several studies highlighted that the rate of warming over mountains is approximately three times larger than global warming rate. An attempt has been taken to assess past and future winter warming over the complex topographic area; the Western Himalaya region (WHR) of India, using the monthly temperature data for the period of 1969-2009 from the India Meteorological Department (IMD), in addition to the simulations of the Global Climate Model (GCMs) from the Coupled Model Intercomparison Project, Phase-5 (CMIP5). Sixteen numbers of available station data indicated an amplified higher winter warming of 1.41^{O}C for the period of 1969-2009 compared to global warming of 0.85^{o}C during 1850-2012. In general all the CMIP5 GCMs are able to capture the observed warming trends adequately but the inter-annual variability and magnitudes were not well captured. This is because the observed rainfall is highly influenced by the local scale complex climatic features, which is unable to capture by the coarser scale GCMs. Future warming is constructed for each station using Multi Model Ensemble of 34 GCMs (MME34) for four available Representation Concentration Pathways (RCPs) of CMIP5 simulations. Downscaled winter warming for some selected stations namely Srinagar, Manali and Dheradun indicated rapid increasing trends of 4.5 – 7.5 ^{O}C and 1.1 – 5.6 ^{O}C and 1.2 – 6.1^{o}C respectively as per the lowest forcing of RCP2.6 to the highest forcing of RCP8.5 at the end of 21st century. It is interesting to be noted that the downscaled temperature change is comparatively higher than the trends obtained from the raw GCMs without downscaling. In general uncertainty of future projection is gradually increases from RCP2.6 to RCP8.5.*

Keywords*: WHR, Winter warming, CMIP5, MME34 and RCPs*