Session: C15 Poster: T86A

Impacts of atmospheric river landfalls on the cold season hydrology in California

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Impacts of atmospheric river (AR) landfall events along the California coast on the cold season (Oct-Mar) hydrology in California have been investigated for the 10 water year (WY) period 2001-2010 using the CPC precipitation analysis, regional climate modeling, SWE assimilation, and air-parcel trajectory analysis in conjunction with the IWV fields from satellite-retrievals and reanalysis. An inventory of AR landfalls along the California coast has been developed on the basis of the IWV retrievals from SSM/I and SSMIS and the ERA-Interim reanalysis. ARs are defined in the satellite images by 'narrow plumes of SSM/I PWV with values >2 cm that are >2000-km long and <1000-km wide' (Neiman et al. 2008). A total of 95 AR landfalls along the coast of California are identified for the 10 WYs. The satellite-based AR landfalls are further refined into the northern and southern California coasts using the ERA-Interim IWV fields. The CPC analysis shows that 10-30% of the cold season precipitation in California occurs during AR landfalls. The amount and intensity of precipitation during AR landfalls are generally larger on the northern California region than the south. The number of AR landfalls and the cold-season precipitation totals in the Sierra Nevada region are only marginally correlated; however, AR landfalls are clearly related with the occurrence of heavy precipitation events, especially in the northern Sierra Nevada region. The freezing-level altitudes are higher for AR storms than non-AR storms by over 260m indicating warmer low-tropospheric conditions during AR storms. The fine-resolution SWE assimilation also shows that AR landfalls are generally related with the occurrence of heavy snowpack increases in the Sierra Nevada region above 1500m. The air-parcel trajectory study in conjunction with a k-mean clustering analysis, shows that the trajectories arriving in the central Sierra Nevada are categorized into four groups characterized by clearly distinct atmospheric circulations over the Eastern Pacific and precipitation in California. It is also found that all AR landfall cases fall into a trajectory group with southwesterly paths. Upper air circulations and PV fields associated with the trajectory group will also be presented. Regional climate modeling using WRF simulates important features in the observed seasonal and AR-related precipitation during the 10 cold seasons, at least qualitatively. The daily spatial pattern correlations in PWV and upper-air fields between the model simulation and ERA-Interim reanalysis show that the model drift is minimal, if any, for the all 10 cold seasons. The simulation also simulates well the spatial variations in the observed precipitation, especially the north-south gradients in the totals and intensities of the precipitation during AR landfalls. The most noticeable model errors in the cold season are the general overestimation of precipitation especially in the northern California region and general underestimation of SWE. The simulated daily precipitation in the Sierra Nevada agrees well with observations despite the fact that heavy precipitation frequencies are overestimated for both the northern and southern Sierra Nevada. The evaluation of the simulation suggests that the WRF model possesses useful skill level for investigating the AR-related winter precipitation in California.