GPM Satellite Radar Observations of Precipitation Mechanisms in Atmospheric Rivers

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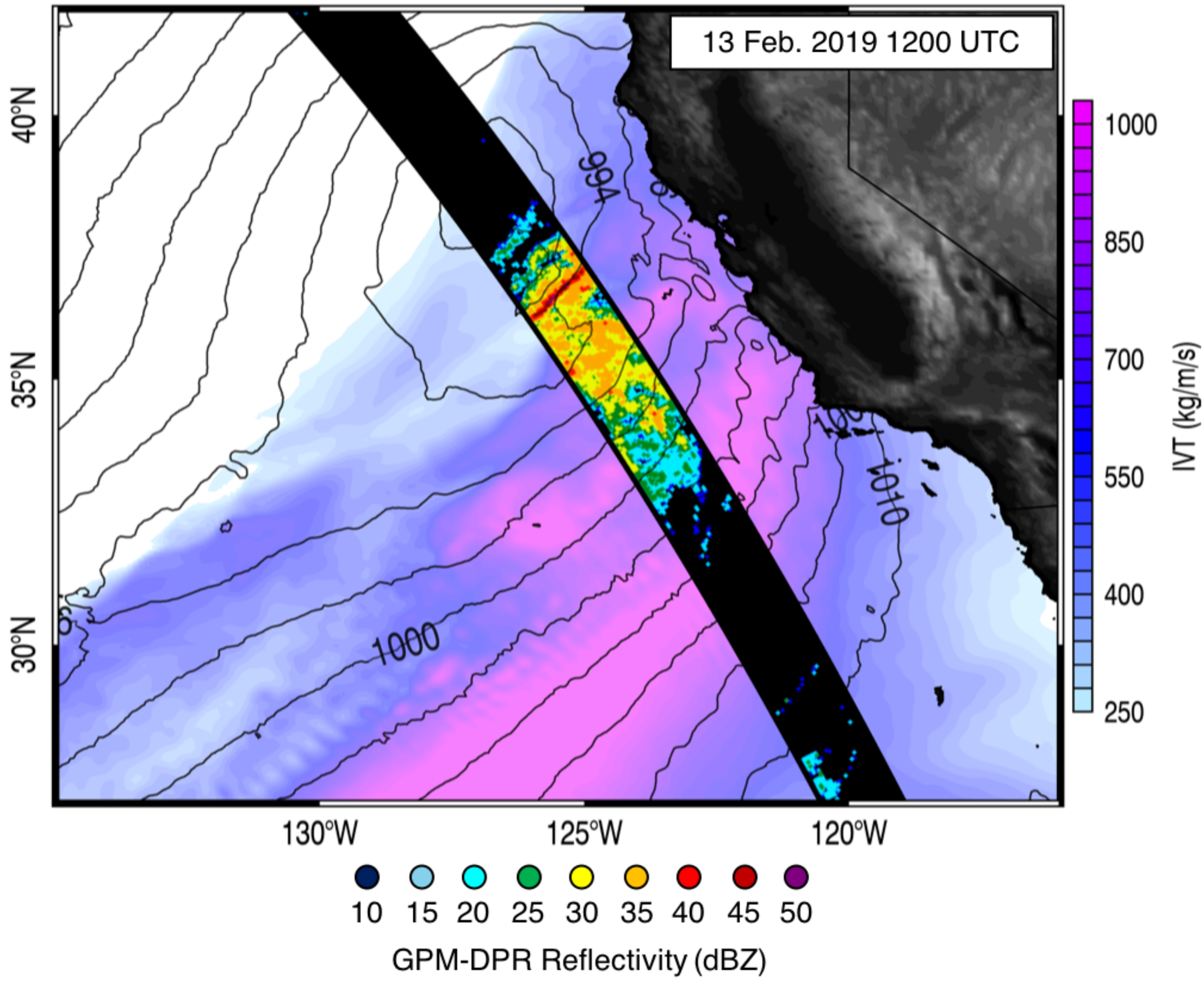
Atmospheric rivers (AR) account for more than 90% of the total meridional water vapor flux in mid-latitudes, and 25-50% of annual precipitation in the coastal western United States. Despite numerous studies identifying the importance of ARs, the evolution of their water vapor fluxes is difficult to investigate given the challenges of observing and modeling the frequency, location and intensity of precipitation processes within ARs over the ocean. In this study, satellite radar reflectivity profiles from the Global Precipitation Measurement Dual-Frequency Precipitation Radar (GPM-DPR) are used to evaluate the precipitation characteristics of ARs over the northeast Pacific Ocean. Transects of 192 ARs with GPM-DPR-measured precipitation, occurring between 2014 and 2018, exhibited both abundant stratiform and convective precipitation. The primary mechanism that generated precipitation across these AR transects upstream of the warm-conveyor belt was forced ascent in the vicinity of a cold front, which occurred preferentially in frontogenetic conditions. Additionally, despite low or no convective available potential energy in most transects, convective precipitation was frequently observed over the moist-neutral low-level jet in an environment with high wind shear. An evaluation of satellite-observed precipitation mechanisms against reanalyses indicates that although these mesoscale processes are not absent from global scale models, their representation of resultant precipitation is frequently in error. The weather research and forecasting model is used to further demonstrate that simulating these observed precipitation processes and subsequent latent heat release is important for representing the evolution of an impactful AR. This investigation highlights a potential source of error in the representation of AR evolution in global-scale models, which translates to uncertainty in forecasting their impacts upon landfall in the western U.S.

Keywords: GPM-DPR , Precipitation Processes, Atmospheric River, Mesoscale Meteorology



WRF-simulated integrated water vapor transport at the time of a GPM overpass during extreme atmospheric river conditions over California on 13 February 2019. A narrow band of intense GPM-DPR reflectivity was observed at 1km elevation along the northern edge of the landfalling atmospheric river (37°N, 126°W). Latent heating associated with this precipitation feature was an important factor in the development of a mesoscale frontal wave that affected the overall event intensity, duration and predictability.