Hydrologic application and assessment of remotely sensed high-resolution precipitation products over cold-mountainous regions

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Introduction/Motivation

Mountainous regions often experience snowfall, frozen ground, and orographically-induced precipitation that complicate the retrieval of precipitation from remote sensing. This study assesses the efficacy of several HRPPs in the San Joaquin-Sacramento basins of the Sierra Nevada range in California, USA, which provides water for some of the richest farmlands in the U.S. and world, and is a critical source of drinking water. Most of the annual precipitation in this region falls during the winter season in the form of extreme rain or snowfall, often brought by atmospheric rivers.

Objective:

The purpose of this manuscript is to investigate (1) how satellite precipitation products perform over a number of representative sub-basins in the study region that experience a diverse range of snowfall-to-total precipitation ratios, (2) how the observed differences in the HRPPs impact the simulation of streamflow, and (3) what causes discrepancies between ground and satellite estimates of precipitation. The analysis of streamflow also provides a secondary check for assessing the precipitation products through comparison with streamflow observations at the basin outlets. By extension, the outcome of this study can shed light on the performance and the level of maturity of HRPPs for hydrometeorological applications in mountainous basins, where ground observation of precipitation is sparse or non-existent. This effort builds upon the longstanding precipitation validation program of the International Precipitation Working Group (IPWG) (Ebert et al., 2007). The IPWG has the role of leadership for the Group on Earth Observations (GEO) precipitation subtask (Kucera and Lapeta 2013). It also sets the stage for the implementation of newly designed HRPPs that will be available in the GPM era such as the Integrated Multi-satellitE Retrievals for GPM (IMERG; Huffman et al. 2013).

Study area, hydrologic model, and datasets

Geographical locations of 22 studied sub-basins in the Sacramento-San Joaquin, California region, are shown on Figure 1 with the topography map in the background. The basins were selected based on the size (larger than 1000 km²) and availability of uninterrupted streamflow observations at the outlet, eventually drained into Sacramento and San Joaquin valleys. The basins span a range of elevations (from ~150 m to ~3000 m above sea-level) and ratios of annual snowfall to total precipitation (from 0 to more than 40%). The Variable Infiltration Capacity (VIC) hydrological model was used to simulate streamflow at daily time scales. VIC is a widely used semi-distributed hydrologic model that has been successfully applied over numerous areas.

Concluding remarks:

- Currently precipitation retrieval technique faces major difficulties in retrieving snowfall and warm rainfall (see Behrangi et al. 2012). Precipitation over frozen land is also challenging and at the present time results in missing data in microwave precipitation products, especially from microwave imagers, negatively impacting HRPPs.
- Precipitation retrievals from microwave sounder and infrared data can produce more reasonable precipitation estimates over the studied region, but the indirect infrared techniques often show poor detection skill and microwave sounding in dry atmosphere remains challenging.
- As precipitation is the major forcing for hydrologic simulations, the observed errors are well propagated and manifested in simulated streamflows (Figs. 6-8) that can negatively impact several applications such as water resources management and flood control. The high similarity between precipitation and streamflow errors suggests that significant improvement in streamflow simulation is possible if high-quality HRPPs are obtained.

References: