Evaluation of Quantitative Precipitation Estimation (QPE) in Complex Terrain

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Quantitative Precipitation Estimation (QPE) is extremely challenging in regions of complex terrain due to a combination of issues related to sampling. In particular, radar beams are often blocked or scan above the liquid precipitation zone while rain gauge density is often too low to properly characterize the spatial distribution of precipitation. Due to poor radar coverage, rain gauge networks are used by the National Weather Service (NWS) River Forecast Centers as the principal source for QPE across the western U.S. However, there has been little evaluation to determine the relative performance of gauge-only, radar, and blended radar-gauge QPE products in the western U.S.

The National Water Center (NWC) is intended to develop and provide new-generation and interoperable water information and services in support of the NWS, and other NOAA and federal agencies. To support the need for stream flow forecasts from the NWC, River Forecast Centers (RFCs) and other federal agencies, the best possible QPE is needed to serve as input forcing for hydrologic models to produce accurate and timely stream flow forecasts. Therefore, QPE evaluations are needed to determine the relative merits of different algorithms and sensors as well as to develop uncertainty estimates for QPE products.

In this study, an evaluation of radar-only, merged radar-gauge, and gauge-only QPE products is performed on precipitation events occurring in the Russian-Napa River basin in northern California using independent data sets, including rain gauge data from the NOAA Hydrometeorology Testbed (HMT). The evaluation is performed with the Multi-sensor Precipitation Estimator (MPE) and National Mosaic and Multi-sensor QPE (NMQ) algorithms, using a retrospective case study approach. The retrospective analyses allow for sensitivity tests using different gauge and radar input.

Keywords: precipitation, streamflow, radar, rain gauge

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Water Management Applications of Advanced Precipitation Products

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Advanced precipitation sensors and numerical models track storms as they occur and forecast the likelihood of heavy rain for time frames ranging from 1 to 8 hours, 1 day, and extended outlooks out to 3 to 7 days. Forecast skill decreases at the extended time frames but the outlooks have been shown to provide “situational awareness” which aids in preparation for flood mitigation and water supply operations. In California the California-Nevada River Forecast Centers and local Weather Forecast Offices provide precipitation products that are widely used to support water management and flood response activities of various kinds. The Hydrometeorology Testbed (HMT) program is being conducted to help advance the science of precipitation tracking and forecasting in support of the NWS. HMT high-resolution products have found applications for other non-federal water management activities as well.
This presentation will describe water management applications of HMT advanced precipitation products pertinent to the Bay-Delta region. Two case examples will be highlighted, 1) reservoir operations for flood control and water supply, and 2) urban storm water management.
Application of advanced precipitation products in support of reservoir operations is a focus of the Sonoma County Water Agency. Examples include: a) interfacing the high-resolution QPE products with a distributed hydrologic model for the Russian-Napa watersheds, b) providing early warning of in-coming storms for flood preparedness and water supply storage operations.
For the storm water case, San Francisco wastewater engineers are examining a plan to deploy high resolution gap-filling radars looking off shore to obtain longer lead times on approaching storms. A 4 to 8 hour lead time would provide opportunity to optimize storm water capture and treatment operations, and minimize combined sewer overflows into the Bay.

Keywords: advanced precipitation products, reservoir operations, urban storm water, combined sewer

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A 21st-Century Observing Network for California

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During northern hemisphere winters, the western coast of North America is battered by land falling, extra tropical storms. The impact of these storms is a paramount concern to California, where aging water supply and flood protection infrastructures are being challenged by the effects of age, increased standards for urban flood protection, and projected climate change impacts. In addition, there is a built-in conflict between providing flood protection and the other functions of major water storage facilities in California: water supply, water quality, hydropower generation, water temperature and flow for at risk species, and recreation. In order to improve reservoir management and meet the increasing demands on water, improved forecasts of precipitation, especially during extreme events, will be required. In this paper we describe how the California Department of Water Resources is addressing their most important and costliest environmental issue (too much or too little water), in part, by partnering with the NOAA Earth System Research Laboratory and Scripps Institution of Oceanography to develop and implement a 21st-century observing, modeling, display, and decision support system to improve NOAA's ability to forecast, detect, and monitor wintertime extreme events. With better confidence in the forecasts of these events, water managers can make improved decisions with increased lead time, which ultimately will benefit Bay-Delta management and provide ecosystem sustainability for at risk species across California.

Keywords: observations, extreme events, precipitation, forecasting, floods, water management

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Estimating Basin Drainage Characteristics Using Spatially and Temporally Limited Soil Moisture Observations

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The NOAA Hydrometeorological Testbed Program (HMT) began deploying soil moisture observing stations in the North Fork (NF) of the American River Basin and the Russian River Basin in 2002. Currently there are seven stations in the Russian and nine in the NF American. The HMT program has begun using these soil moisture observations to validate both conceptual stream flow and full physics land surface models. The spatial variability of precipitation, soil properties, and land use limits our ability to interpret in-situ soil moisture measurements.

In our presentation we will examine a method for estimating basin drainage characteristics by combining data obtained from HMT soil moisture stations over four years with soil survey data taken in the NF American basin. The American River is a major tributary of the Sacramento River and understanding how this sub-basin responds to precipitation events is of interest to numerous agencies including the National Weather Service, Army Corps of Engineers, and the California Department of Water Resources.

Research recently completed in the NF American indicates that the geological origins of the soils in the basin play a primary role in how the upper and lower portions of the basin drain. Preliminary results suggest that only two to five years of direct soil moisture sampling may be needed to characterize basin response to precipitation.

Keywords: Soil Moisture, Flood Forecasting, Evapotranspiration

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Pacific Atmospheric Rivers: Impacts on Extreme Rainfall, Flooding and Water Supply in California

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Atmospheric Rivers (ARs) are long, narrow regions in the atmosphere (>2000 km and<1000 km, respectively) that are responsible for most of the horizontal water vapor transport outside of the tropics. ARs translate with extra tropical cyclones and number four to six in the mid-latitudes at any given time. Zhu and Newell (1998) found that most of the water vapor was transported in relatively narrow regions of the atmosphere (over 90% of the transport occurred typically in these 4-6 long, narrow regions roughly 400 km wide), and coined the term atmospheric river. ARs are found in both the Atlantic and Pacific Basins of the northern and southern hemispheres. Pacific Atmospheric Rivers are key phenomena that are highly correlated to extreme precipitation and winter floods along the West Coast of the US (Ralph et al. 2006; Neiman et al. 2008; Leung and Qian2009; Smith et al. 2010; Ralph et al. 2010). They also contribute 30 to 40 % of the annual rainfall and up to 50 to 60% of the annual stream flow along the West Coast (Dettinger, et al, 2011).
ARs can lead to flooding in higher altitude, inland mountain watersheds because they are accompanied by anomalously high freezing levels, which combined with the orographically enhanced precipitation exacerbate the flood threat. At the highest elevations, ARs contribute significantly to snowpack replenishment (Guan et al. 2010), which, in turn, provides much-needed water to area reservoirs during the snowmelt season.

This talk will focus on the key physical processes that form ARs in the North Pacific Basin, as well as our current capabilities to forecast these phenomena impacting northern and central California with sufficient lead-time to manage reservoir operations to conserve water supplies while still protecting downstream human, biological/ecological, and material assets. A decade of research from NOAA's Hydrometeorological Testbed contributed to these results.

Keywords: Flooding, Water Supply, Reservoir Management Forecasting

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