NASA Science Mission Directorate
Earth Science Division
Applied Sciences Program

Advancing Water Supply Forecasts in the Colorado River Basin for Improved Decision Making

Jay Day

NASA Water Resources PI Meeting
April 26-28, 2016

Statement of challenges / need

- To improve water supply forecasting in an area with high spatial variability in the snow accumulation and ablation process

Opportunity

- To leverage improved models, new data sources, and advanced data assimilation techniques to provide more skillful water supply forecasts with uncertainty estimates to water managers to support risk-based decision making

Advancing Water Supply Forecasts in the Colorado River Basin for Improved Decision Making

Current partners

Role	Name(s)	Affiliation
Co-I	Christian Kummerow	Colorado State University, Cooperative Institute for Research in the Atmosphere (CIRA)
Co-I	David Tarboton	Utah State University
Partner	Colorado Basin River Forecast Center	National Weather Service, NOAA

User community

Role	Organization Name	Organization Type
End-user	Denver Water	Public Water Utility
End-user	Dolores Water Conservancy District	Water Conservancy District

Riverside team

Shaun Carney, Paul Micheletty, Gi-Hyeon Park, Jon Quebbeman, Abby Watson

Partner communities you / your project could engage in the future

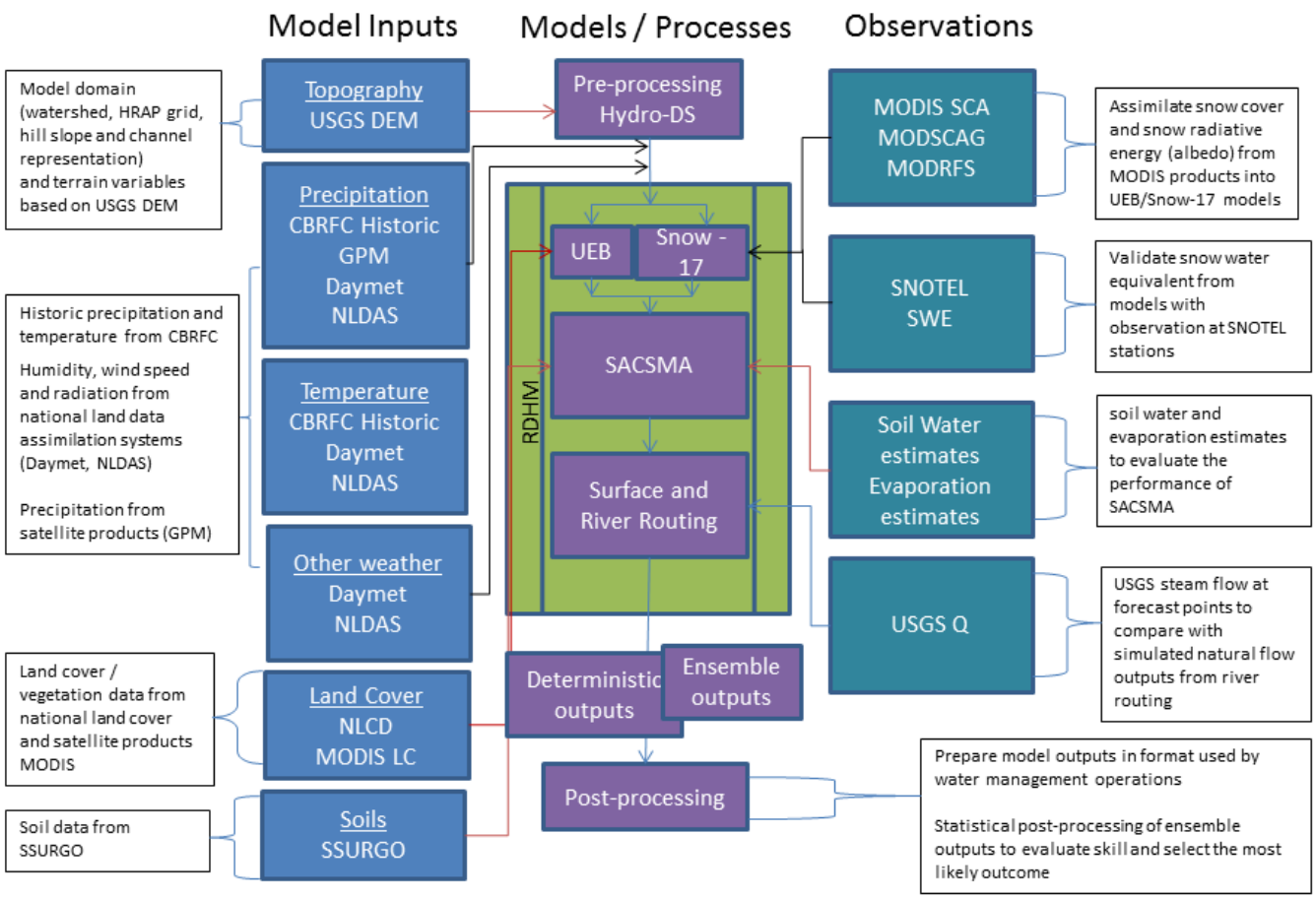
- Bureau of Reclamation
- Other municipalities
- State Department of Water Resources
- Other river districts
- Irrigation companies
- Other river basins

Key datasets, models, scientific, technical tools

- GPM, SNOTEL, MODSCAG, MODDRFS, NLDAS, Daymet, Airborne Snow Observatory
- Utah Energy Balance (UEB) model, NWS Research Distributed Hydrologic Model (RDHM) with SNOW-17 and Sacramento models
- Community Hydrologic Prediction System (CHPS), Ensemble Kalman Filtering, Non-dominated Sorting Genetic Algorithm (NSGA II)

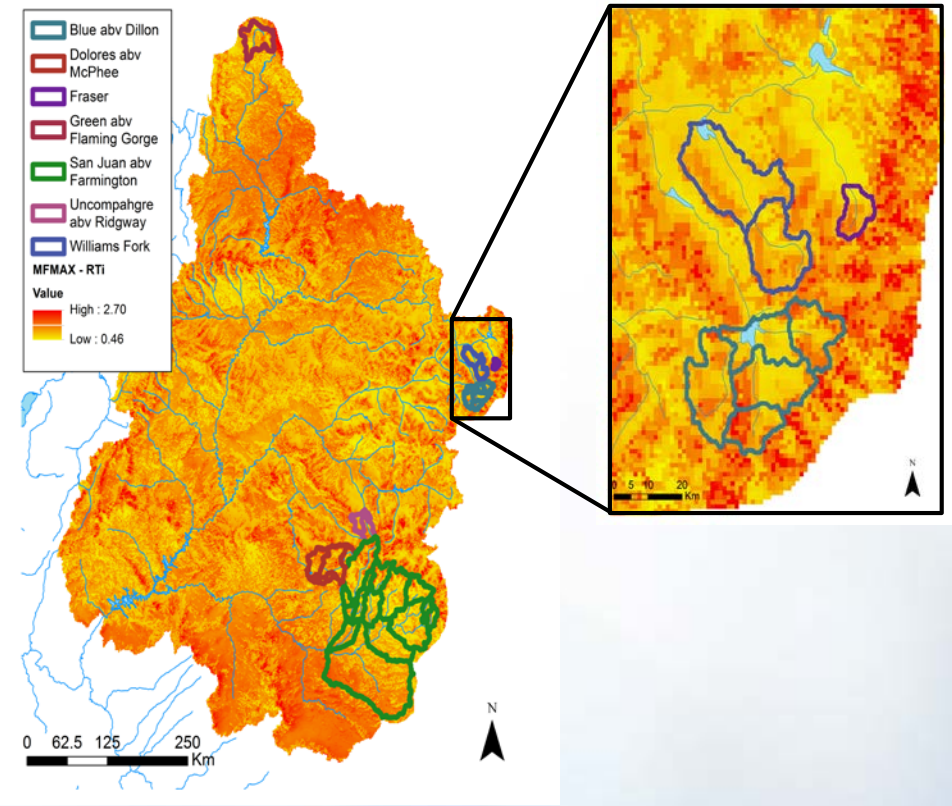
Approach

Data and model workflow



Approach

- Provide ensemble forecast products to capture forecast uncertainty
- Generate reforecasts to assess forecast skill and reliability
- Work with decision makers to leverage probabilistic water supply forecasts



Impacts (achieved and anticipated)

- Improved Operational Water Supply Forecasts
  - Regionally Calibrated Satellite Precipitation Estimates
  - Distributed Hydrologic Modeling
  - Energy Balance Snow Model Evaluation
  - Snow Data Assimilation

- Improved Water Management Decision Making
  - Skillful Forecasts with Uncertainty Estimates
  - Reforecasts for Verification and Development of System Operating Rules

Transition Strategy

- Make CBRFC a Partner
  - Leverage local knowledge
  - Collect constant feedback
  - Shared ownership

- Work Closely with Water Managers
  - Understand system/tradeoffs/decision making process
  - Demonstrate value of the forecasts

Lessons Learned

Importance of Communication

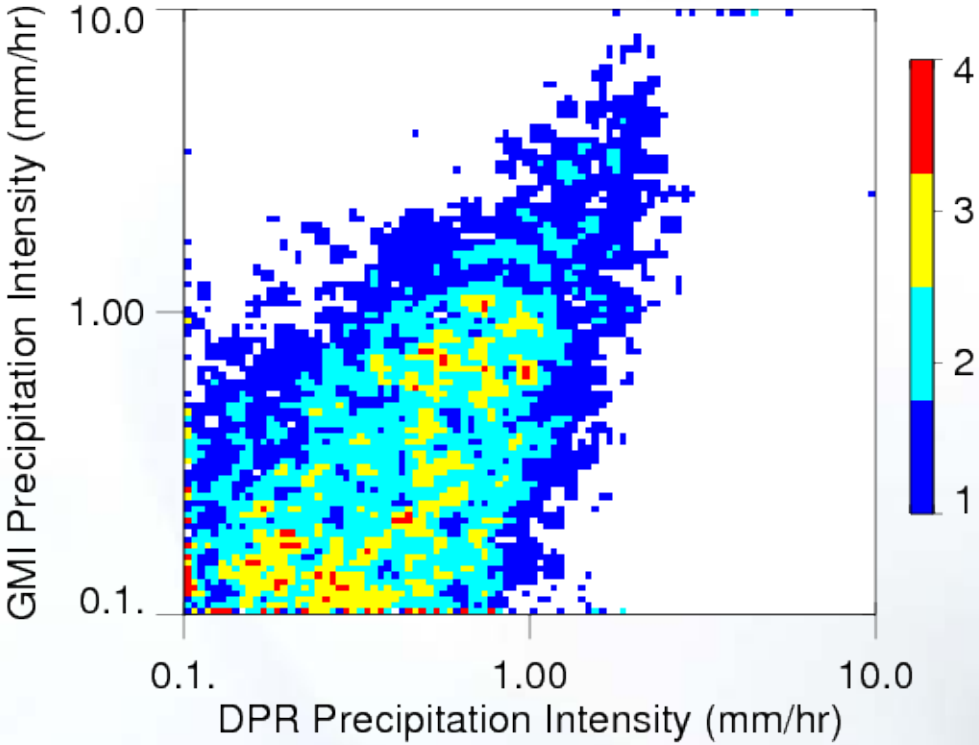
- Project team members
- Users

Highlight:

- The GMI precipitation product, after removing biases, reproduces the instantaneous surface precipitation field similar to the GPM radar measurements.

Relevance:

- The highly-correlated precipitation intensities from the two sensors solidifies the the superiority of using a customized precipitation database in accurately retrieving the regional precipitation information.



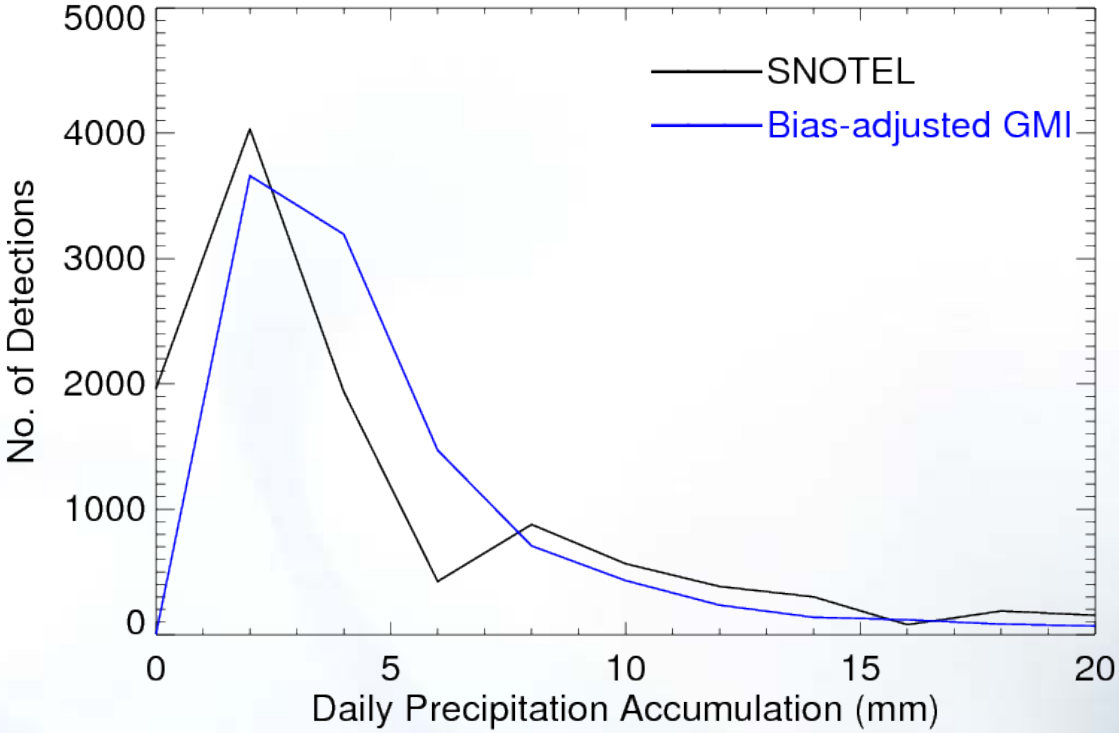
Two-dimensional density plot of the collocated bias-adjusted GMI and DPR at the similar spatial resolutions, where the colorbar indicates the number of the collocated observations falling into the same precipitation intensity bin. The data period starts in October 1st, 2014, and lasts for seven months.

Highlight:

- After adjusting the relative biases with respect to the SNOTEL climatology, our customized GMI precipitation algorithm is seen to retrieve a very comparable probability distribution function to the in-situ observations.

Relevance:

- The consistency of the two probability distribution functions verifies the capabilities of the preliminary precipitation retrieval algorithm. The algorithm, with the upcoming modifications during the first quarter in Year 2, will then be applied to the remaining GPM constellation satellites to create a high-time-resolution precipitation product over the CRB.



The probability distribution functions of daily precipitation accumulation from SNOTEL and the bias-adjusted GMI over the same 0.25° grid box.

Advancing Water Supply Forecasts in the Colorado River Basin for Improved Decision Making

Highlight:

Preliminary model outputs for the first test watershed, Animas above Durango, CO. Simulated snow water equivalent (SWE) from the Utah Energy Balance (UEB) at a grid cell containing the Cascade SNOTEL station compares well to the observed SWE at the SNOTEL station (top figure).

Relevance:

These comparisons are a first step in evaluating whether the physically based UEB snowmelt component leads to better water supply forecasts and can be operationalized within the National Weather Service forecasting platform.

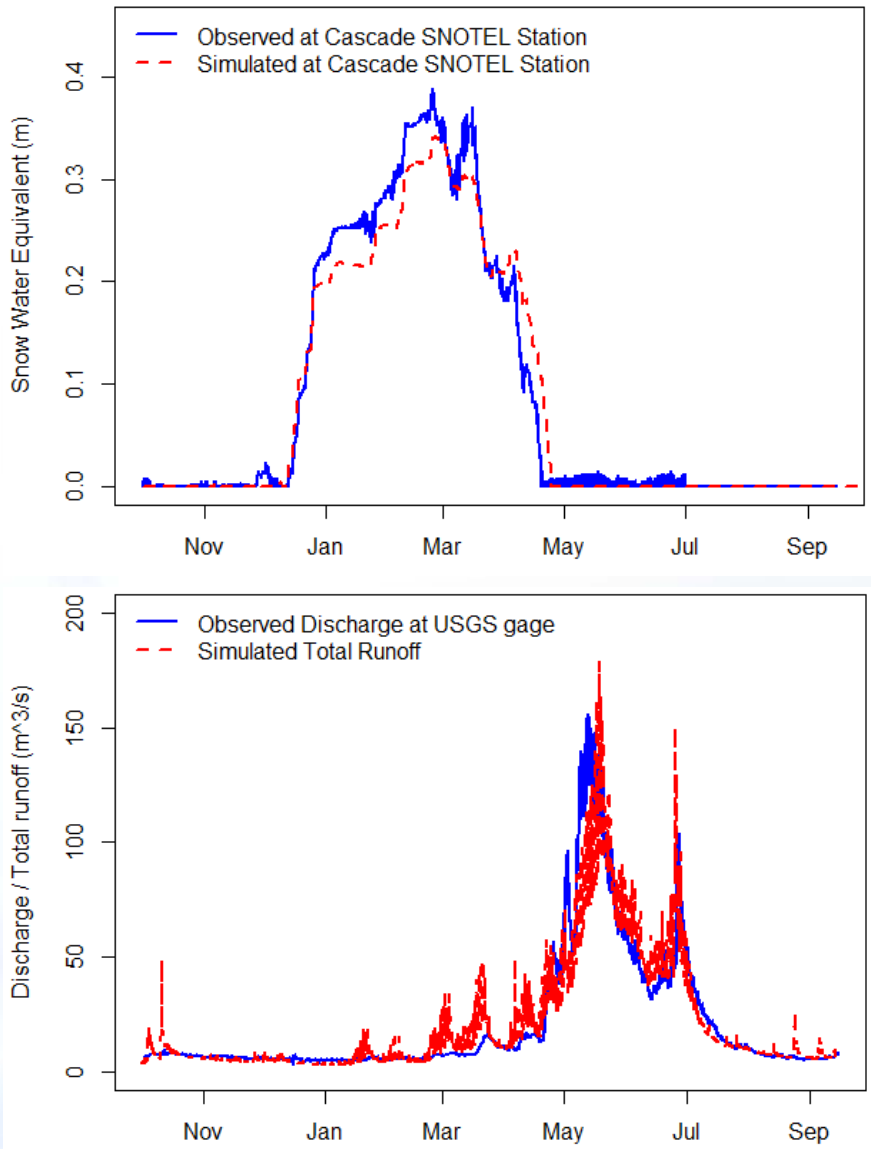


Figure 3: UEB snow water equivalent (SWE) and SAC-SMA total runoff for the first test watershed (Animas above Durango) for the water year 2009.

Advancing Water Supply Forecasts in the Colorado River Basin for Improved Decision Making

Highlight:

Riverside is investigating the use of an innovative approach to hydrologic model calibration:

- Multiple objective functions that capture hydrograph fit and expert knowledge to maintain realism
- Automatic calibration algorithms and weighted solution selections

Relevance:

Hydrologic model calibration and validation are critical steps to ensuring accurate and credible forecasts.

The framework is designed for automated parameter optimization, but it provides detailed information to assist in evaluation of non-dominated parameter sets.

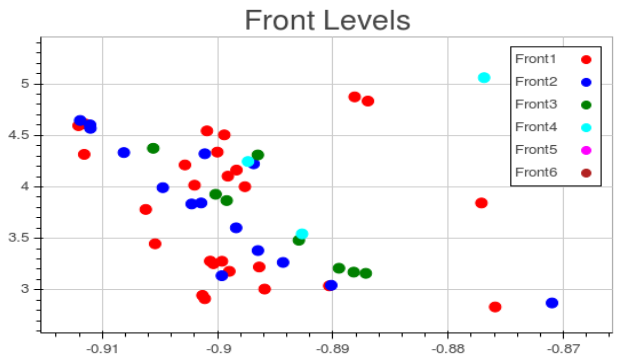


Figure 1(a): Multiple Pareto Fronts shown for two objective functions

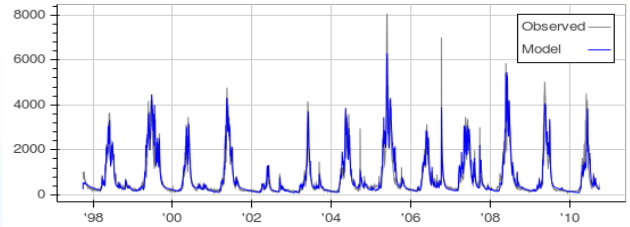


Figure 2(b): Hydrograph shown for one non-dominated parameter set

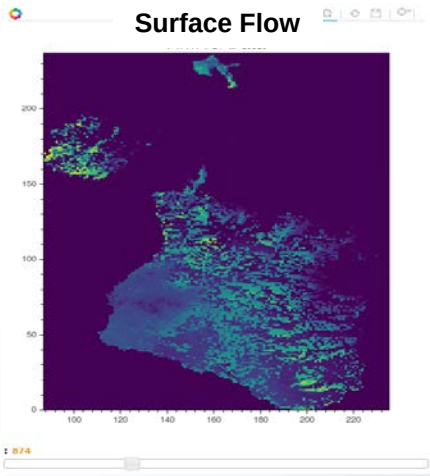


Figure 2(c): Spatial Visualization of model simulated state for one time step. Slider bar allows user to view across multiple time steps.

Thank you

jay.day@riverside.com