

NOAA Office of Hydrologic Development
Annual Progress Report

Project Title : Improving operational streamflow forecasts in the Colorado River Basin

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Name of PI : Andrew G. Slater

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PI's Institution: CIRES/NSIDC, University of Colorado, Boulder, CO, 80309-0449

Dear Dr. Restrepo,

I wish to request the continuation of the no-cost extension funding for our project as we have on-going research that builds upon our prior efforts. Our goal of understanding all areas of uncertainty in the hydrologic modeling process has already investigated the issues associated with input uncertainty via model forcing ensemble generation methods (Clark and Slater, 2006), the prospects of improving initial conditions uncertainty via data assimilation (Slater and Clark, 2006; Clark et al., 2006) as well as the problems associated with parameter uncertainty (Clark and Vrugt, 2006).

We have continued our efforts to understand uncertainty within the hydrologic modeling context by delving into matters associated with model structural uncertainty and parameter uncertainty. We have tackled this problem on two fronts; one regarding the soil model component (Clark et al., 2007) of a model and the other regarding the snow model component (Slater et al., 2007). The ability to quantify model uncertainty is an important step towards being able to implement a truly objective data assimilation system; currently, the model uncertainty portion of assimilation systems is generally specified or tuned.

For exploring the issue of functional behavior and the ability to identify model parameters of soil runoff models, a series of models was developed in which the models shared as many parameters as possible. The four basic structures were founded on the philosophy underpinning of several existing models (SAC-SMA, TopModel, PRMS and VIC). Understanding and isolating the impacts of model structure is an extremely challenging problem given the vast number of potentially confounding structural and parameter interactions. It was found that across all models as a whole, parameters were actually poorly identifiable and even applying different objective functions did not solve the problem. Conversely, parameters could be identified as important for each of the individual model structures, suggesting that the generation of a priori parameters is a model specific problem.

In a similar fashion to assessing uncertainty in the soil models, we have developed a hierarchical snow model that is based in principal upon the NWS module SNOW-17, which is a degree day model. In our implementation we have ensured that snow processes can be added or removed without significantly impacting other sections of the model. This provides us with the ability to investigate the appropriate complexity for a snow model given the other uncertainties within the forecast system. Examples of processes that can be included in the model are seasonal amplitudes of melt factors, cold content of the snowpack, sub-basin snow distribution and separate parameterizations for rain-on-snow events. Preliminary simulations at individual SNOTEL stations have shown that calibrated models with more process representation will more often than not give a better result in terms of SWE than simple models when forced with unbiased but degraded inputs; however results are not always consistent with the more complex model sometimes producing a worse result. A further step has been taken by implementing a

full surface energy balance snow model for use as a comparison. This is an ongoing effort than has applications to many regions in the Western US.

Participation and contribution to the NOAA-OHD based project, DMIP2, has also been a priority. We have collected and processed all available data surrounding the two western basins chosen DMIP2. The HRAP-grid data developed by NOAA/NWS/OHD for these two basins have been both spatially and temporally interpolated to ensure completeness for modeling purposes over the DMIP period of 1987-2002; we have subsequently shared this product with other DMIP participants such as the USGS and DHI in Denmark. To supplement this data and utilize alternative observational sources, we have gathered data from the cooperative observer network stations, the SNOTEL network, the PRISM (Parameter-elevation Regressions on Independent Slopes Model) datasets and the NOHRSC-SNODAS forcing data. We have applied and developed methods such as adaptive polynomial regression and direct kriging to compile a continuous data stream from 1987 through to the end of 2006; extending the use of the data through to the NASA-EOS satellite era, for example, see Figures 1 & 2. We have already performed preliminary simulations of streamflow over the Carson basin using the TopNET model as well as “off-line” simulations using just the snow model component. Numerous remote sensing (e.g. MODIS, IMS) and derived products (e.g. SNODAS) are being applied to the validation process. The DMIP2 basins will provide an ideal test-bed for our snow model complexity work and fosters a continuing interaction with NOAA-OHD.

Yours sincerely,



Andrew G. Slater

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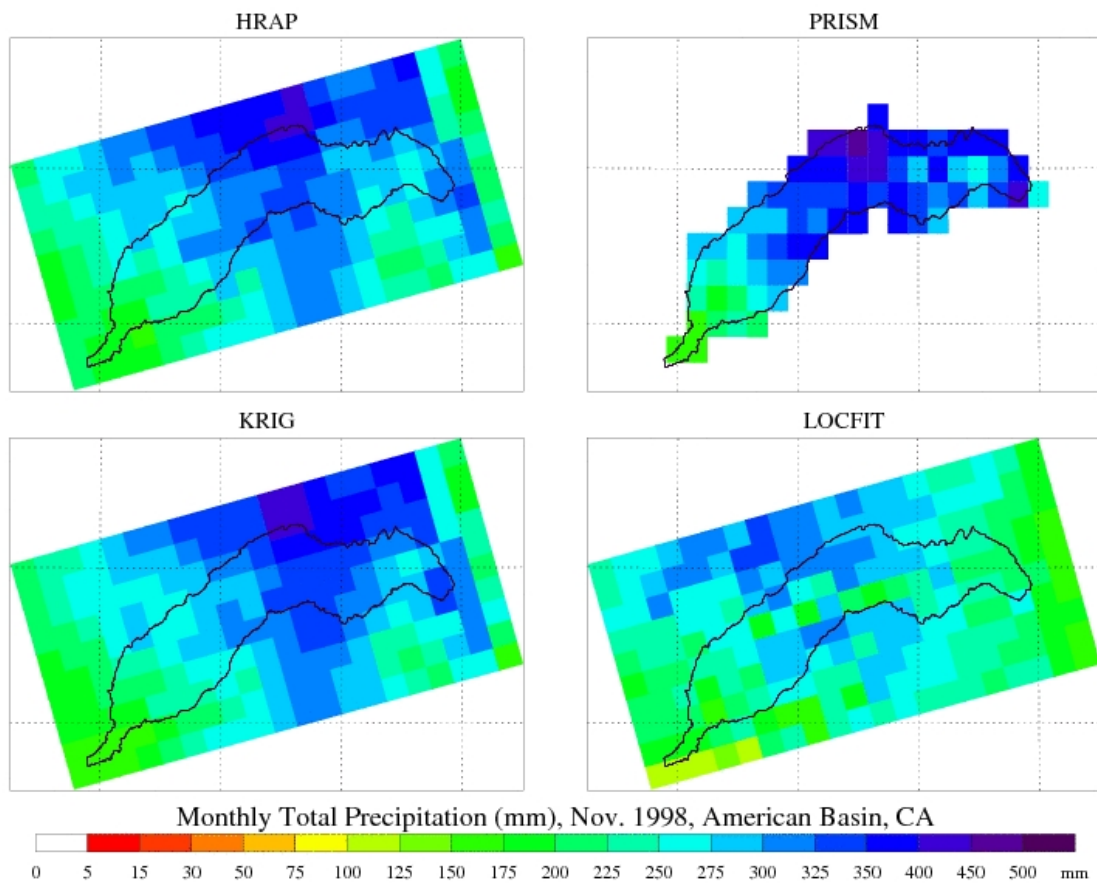


Figure 1: Monthly total precipitation for the American River basin for November 1998. Several different methods of deriving grid-based precipitation are shown here. The HRAP data was compiled by NOAA/NWS/OHD for use in the DMIP2 experiments. PRISM is a long running data stream developed at Oregon State University. We developed the KRIG method for the purposes of extending the HRAP data beyond 2002; the method performs direct kriging between station data (COOP and SNOTEL) and the grid boxes using covariance relationships based on historical data. The LOCFIT method uses an adaptive-order local polynomial regression approach to interpolate station data to the desired grid but does not use any historical relationships.

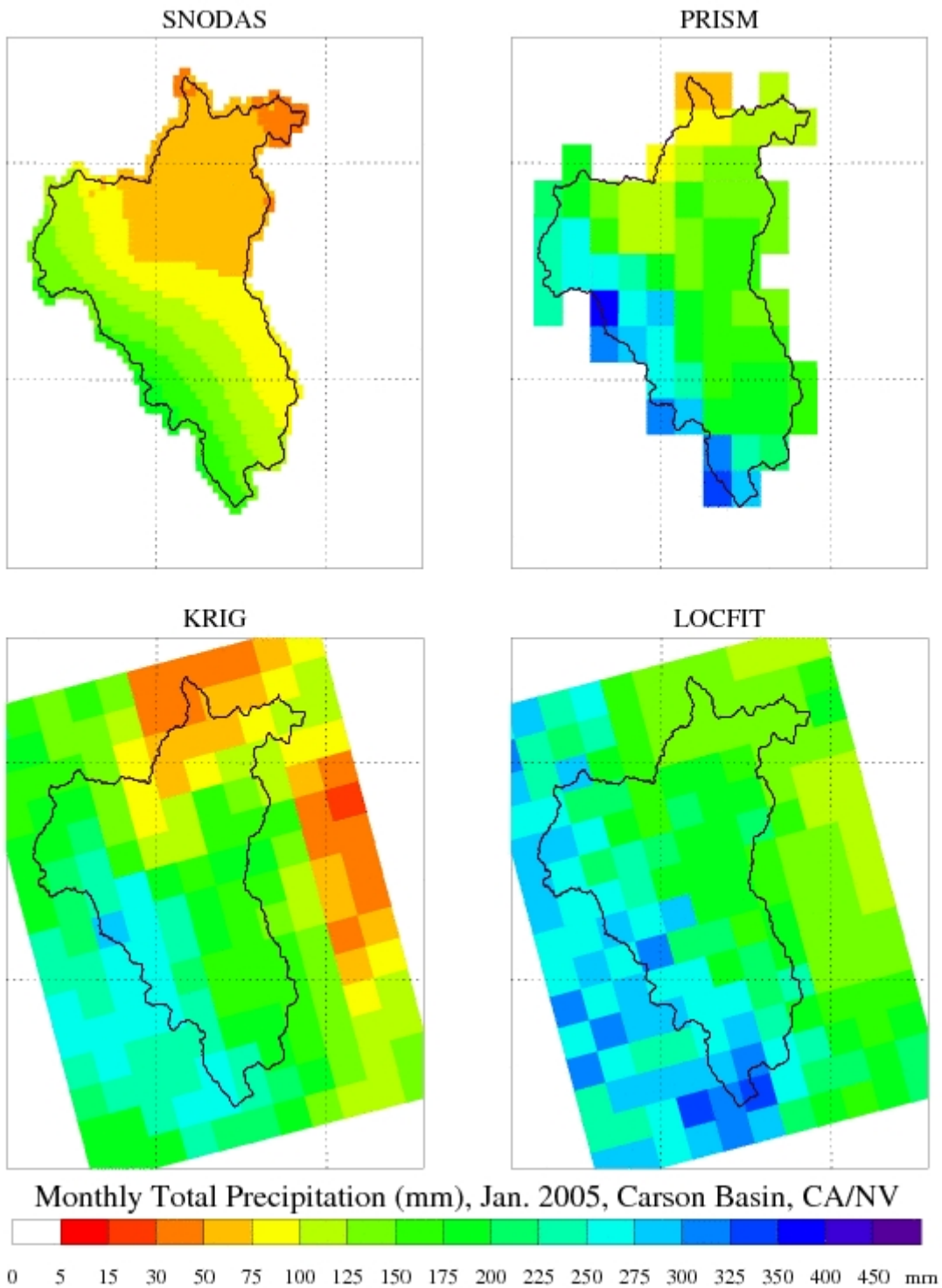


Figure 2: Similar to Figure 1 but for the Carson Basin. The data compiled by NOAA/NWS/OHD is not available beyond 2002. The NOAA/NWS/NOHRSC SNODAS product became available as of Oct 2003. Here we show the precipitation used by SNODAS compared to the other station-based methods.