Water Availability and Use Science Program
Streamflow estimation: FY 2016 End-of-Year Report
October 28, 2016

(1) PROJECT ACCOMPLISHMENTS/CONTRIBUTIONS (FY 2016)

The streamflow estimation project is tasked with characterizing historical streamflow in the U.S. The team has largely focused on developing deterministic and statistical models of streamflow discharge for the nation. Estimates of historical streamflow from this project are intended to represent natural or rural (non-irrigated) conditions. A much smaller effort focused on trends in past streamflow is also underway.

The Precipitation Runoff Modeling System (PRMS) is a deterministic, numerical model of streamflow generation processes that has been developed and enhanced by USGS over many years. Setup of the PRMS and other similar models can be a very time-consuming process. In FY2016, a default national setup was developed, with improved initial parameters based on research conducted over the year. In addition, strategies for calibration and regionalization of model parameters to improve model performance in ungaged areas, where direct calibration is impossible, were tested with success. This work included a study of the sensitivity of processes modeled in PRMS to different parameters. These methods were first tested using the monthly water balance model, for computational efficiency. The calibration and regionalization methods will be used in FY2017 to develop a calibrated national model for CONUS, for which results will be published. Other work to improve model documentation and usability was also completed.

Statistical methods can also be used to estimate streamflow at ungaged locations. Here again, improvements to a “default” model for the nation were developed and tested. This included methods for improving estimation of flow duration curves, one of the building blocks used in statistical estimation of streamflow. Kriging is another statistical method for estimating time series of flows (see Farmer 2016 and Pugiliese et al. 2016). It has been shown to provide good results , except at extreme high flows or low flows, where it is biased. Methods for correcting that bias were developed during this year. Papers describing these improvements to statistical models of streamflow are being drafted. These improved methods will inform National-scale implementation for CONUS in FY2017.

The combination of statistical and deterministic modeling was also tested this year. Proof of concept simulations show that using statistical modeling results to calibrate PRMS in otherwise ungaged areas is as effective as other methods for regionalizing parameters. A paper presenting these results will be drafted and released in FY2017.

The modeling team also published a paper (see below: Archfield and others, 2015) describing the ways in which continental-scale modeling can benefit from the strengths in various modeling communities – ranging from catchment modeling (typically used for water management applications) to land surface modeling (typically used as the lower boundary of GCMs) to global water security modeling.

Finally, a small amount of funds was put forward to begin investigating trends in streamflow, with an initial focus on peak flows. A paper (Archfield et al. 2016) showing that changes in small, frequent peaks do not mirror changes in large, rare peaks was published. This paper was included in the daily DOI report to the White House on 9/28 and was reported on by Reuters.

(2) PROJECT WORKPLAN AND BUDGET FOR FY 2017

An 18-page workplan and accompanying budget were submitted separately.

(3) NOTEWORTHY COLLABORATIONS, MEETINGS, TECHNICAL TRANSFER ACTIVITIES, SPIN-OFF PROJECT DEVELOPMENTS, AND ACKNOWLEDGEMENTS

Improvements in the default PRMS parameterization makes the model increasingly useful for other modeling teams. Jacob LaFontaine handles requests from users who would like to use portions of the national model as their initial modeling setup for smaller geographical areas within the U.S. Other related work by the MOWS group includes stream temperature modeling, glacier runoff modeling, and SW-GW interactions via the GSFLOW model.

The MOWS group presented a series of papers at the AWRA spring specialty conference on Water, Energy, and Environment in Anchorage, Alaska.

Members of the flow estimation team contributed to the special session on Water Census at the AWRA GIS specialty conference. (organized by Dave Blodgett)

The flow estimation team initiated communications with NCAR researchers on possible collaborations. NCAR researchers include those developing the NWM. One focus of discussions has been model evaluation tools, which will be a thrust in FY2017.

The flow estimation team is continuing collaboration with the Powell Center research group. The group has written a proposal for NSF PIRE funding for continued work on continental scale modeling.

Building on the specific flow modeling work of the Water Census, William Farmer was lead author of a paper describing the benefits of incorporating stochastic elements in model outputs.

In part due to Water Census investments in trends analysis, the USGS secured funds for a cooperative project with FHWA on peak flow trends. This project provides 1.8M in funding over 3 years to study peak flow trends throughout the nation and to research methods for incorporating potential change in peak flow frequency estimation.

(4) Report Products, Bibliographic Update, Data Releases

In addition to the papers listed below, numerous presentations were also made at scientific conferences. Other papers are in preparation, but not listed here.

<u>Reports and papers in review or published this FY:</u>

Regan, R.S., Niswonger, R.G., Markstrom, S.L., and Barlow, P.M., 2015, Documentation of a restart option for the U.S. Geological Survey coupled groundwater and surface-water flow (GSFLOW) model: U.S. Geological Survey Techniques and Methods, book 6, chap. D3, 19 p., http://dx.doi.org/10.3133/tm6D3.

Bock, A. R., L. E. Hay, G. J. McCabe, S. L. Markstrom, and R. D. Atkinson, 2016. Parameter regionalization of a monthly water balance model for the conterminous United States. Hydrology and Earth System Sciences. doi: http://www.hydrol-earth-syst-sci.net/20/2861/2016/hess-20-2861-2016.pdf

Viger, Roland J., Alan Rea, Jeffrey D. Simley, and Karen M. Hanson, 2016. NHDPlusHR: A National Geospatial Framework for Surface-Water Information. Journal of the American Water Resources Association (JAWRA) 52(4):901–905.DOI: 10.1111/1752-1688.12429

Van Beusekom, A. E., and R. J. Viger (2016), A Glacier Runoff Extension to the Precipitation Runoff Modeling System, J. Geophys. Res. Earth Surf., 121, doi:10.1002/2015JF003789.

Fulton, J.W., Risser, D.W., Regan, R.S., Walker, J.F., Hunt, R.J., Niswonger, R.G., Hoffman, S.A., and Markstrom, S.L., 2015, Water-budgets and recharge-area simulations for the Spring Creek and Nittany Creek Basins and parts of the Spruce Creek Basin, Centre and Huntingdon Counties, Pennsylvania, Water Years 2000–06: U.S. Geological Survey Scientific Investigations Report 2015–5073, 86 p, http://dx.doi.org/10.3133/sir20155073.

Roland J. Viger, David Bjerklie, Lauren E. Hay, Steven L. Markstrom, (**submitted to Hyd Pro**), Spatially-distributed Estimation of Groundwater Flux Rates. Hydrological Processes.

Regan, RS and JH LaFontaine, PRMS Enhancements – Dynamic parameters; water-use; routing with lakes; depression storage; I/O options (**in review as USGS OFR**)

Regan, RS and JH LaFontaine, Documentation of New Dynamic Parameter and Water-Use Input and Summary Output Modules and Updates to Routing of Streamflow with On-channel Lakes, Surface-Depression Storage Simulation, and Use of Initial Conditions within the Precipitation Runoff Modeling System (PRMS): **in USGS review**, USGS SIR

Farmer, W. H.: Ordinary kriging as a tool to estimate historical daily streamflow records, Hydrol. Earth Syst. Sci., 20, 2721-2735, doi:10.5194/hess-20-2721-2016, 2016.

Pugliese, A., W. H. Farmer, A. Castellarin, S. A. Archfield, R. M. Vogel, Regional flow duration curves: Geostatistical techniques versus multivariate regression, Advances in Water Resources, Volume 96, October 2016, Pages 11-22, http://dx.doi.org/10.1016/j.advwatres.2016.06.008.

Farmer, W. H., and R. M. Vogel (2016), On the deterministic and stochastic use of hydrologic models, Water Resour. Res., 52, 5619–5633, doi:10.1002/2016WR019129.

Archfield, S.A., Clark, M.P., Arheimer, B., Hay, L.E., McMillan, H., Kiang, J.E., Seibert, J., Hakala, K., Bock, A., Wagener, T., Farmer, W.H., Andreassian, V., Attinger, S., Viglione, A., Knight, R., Markstrom, S., and Over, T.M., 2015, Accelerating advances in continental domain hydrologic modeling, Water Resources Research, http://dx.doi.org/10.1002/2015WR017498.

Archfield, S. A., R. M. Hirsch, A. Viglione, and G. Blöschl (2016), Fragmented patterns of flood change across the United States, Geophys. Res. Lett., 43, 10,232–10,239, doi:10.1002/2016GL070590.

(5) PROJECT TEAM DIRECTORY -

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Statistical flow estimation and trends analysis

Note that the Modeling of Watershed Systems (MOWS) group is integral to this project but is not funded directly by Water Census. The group includes Lauren Hay, Steve Markstrom, Steve Regan, Roland Viger. Lauren hays is the lead for the PRMS work on this project and is the only one on the MOWS group listed above.

The team will be expanding considerably in FY2017.

(6) PHOTOS, ANIMATIONS, AND GRAPHICS –

Please contact Julie Kiang if you are looking for a graphic to illustrate a specific concept or result.