Regional-scale river modeling using thousands of mapped rivers, off-the-shelf runoff products and hundreds of stream flow gages

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OBJECTIVES

The mapped rivers and streams of the United States are available in a Geographic Information System dataset called **NHDPlus**.

The United States Geological Survey (**USGS**) measures stream flow at about twenty thousand gauges which locations are known exactly on NHDPlus rivers.

The Routing Application for Parallel computatIon of Discharge (**RAPID**, David et al. 2011) is a river network model that can run on NHDPlus if given inflow to rivers from runoff.

The second version of the North American Land Data Assimilation System (**NLDAS2**, Xia et al. 2011) provides runoff estimates from four land surface models over the continent.

The goal of this study is to combine RAPID with NLDAS2 runoff to compute stream flow in all NHDPlus "blue lines" of the Texas Gulf Coast Hydrologic Region (NHDPlus Region 12) during 2000-2007. We also use a locally calibrated land surface model called Noah-MP for comparison purposes.

RESEARCH QUESTIONS

What are the advantages and drawbacks of using "blue line" river networks?

Is the quality of continental-scale runoff datasets from land surface models sufficient for regional- to continental-scale river flow computations using mapped rivers? Where can runoff computations be improved?

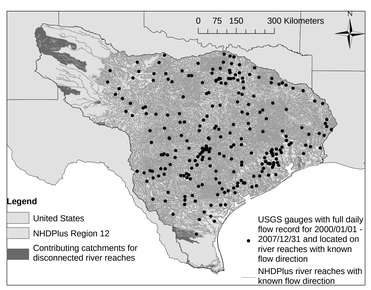
Is a locally-calibrated runoff dataset much more advantageous than national products?

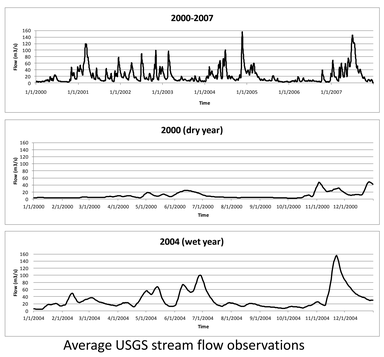
Should one use all available gauging stations to train a river model?

Should river model parameters be adapted to each runoff dataset?

Does it make a difference to increase the spatial variability of river model parameters based on available high-resolution "blue line" data such as flow velocity?

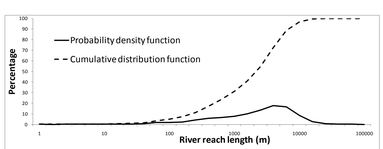
STUDY DOMAIN - SPATIAL/TEMPORAL RANGE

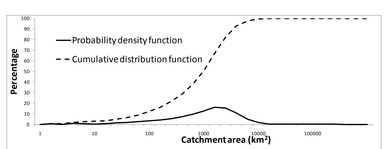




Average USGS stream flow observations

The NHDPlus Region 12 covers an area of 465,000 km^2 and contains approximately 68,000 connected river reaches. The USGS National Water Information System has 248 gauges with full daily record during 2000-2007. 2000 was the driest year and 2004 was the wettest year.

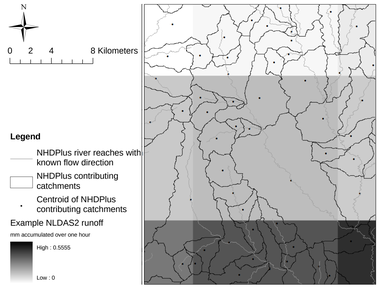


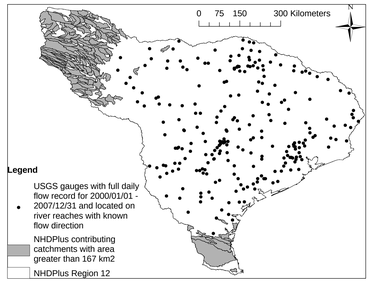


The reaches with known flow direction range in length from 1 - 68,514 m (median 2,191 m, average 3,002 m).

The catchments range in area from 0.001 – 7404.142 km^2 (median 3.070 km^2 , average 6.856 km^2).

FROM NLDAS2 RUNOFF TO NHDPLUS RIVERS

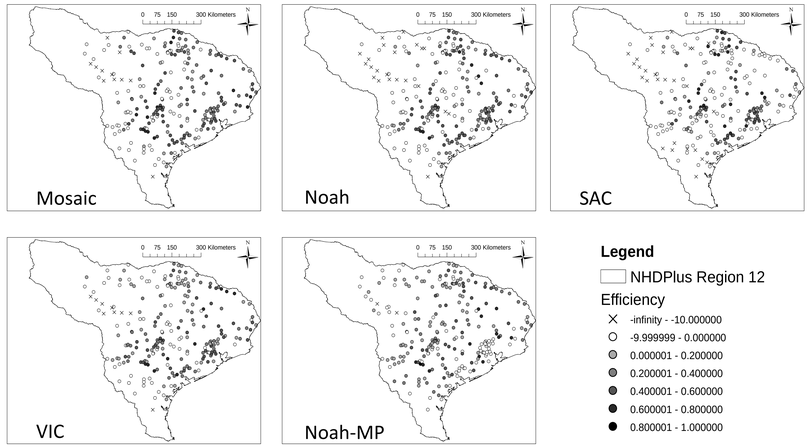




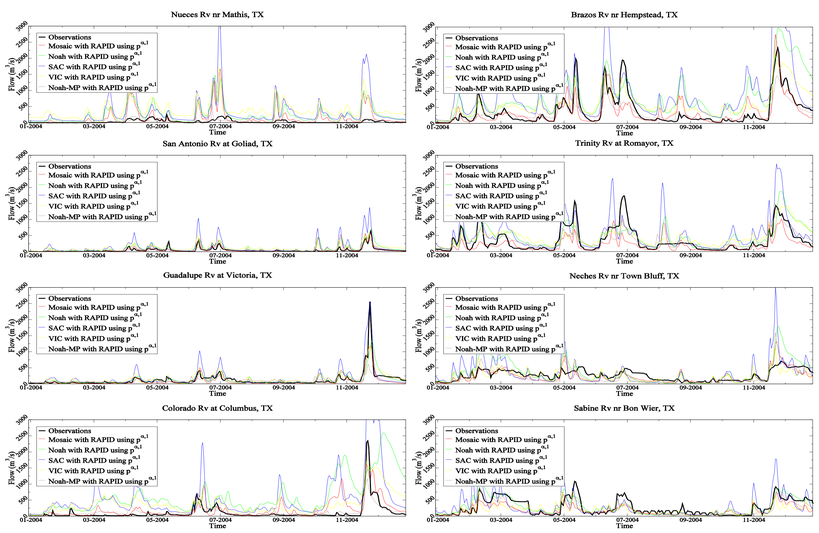
The conceptual translation between surface and subsurface runoff from NLDAS2 and water inflow to NHDPlus rivers is non-trivial. We use the runoff value at catchment centroids associated to catchment areas.

Large catchments are located at the northwest and south of the domain where the lack of routing processes between land and rivers in RAPID may be an issue.

STREAM FLOW AMONG RUNOFF DATASETS

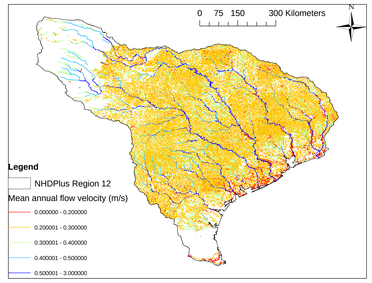


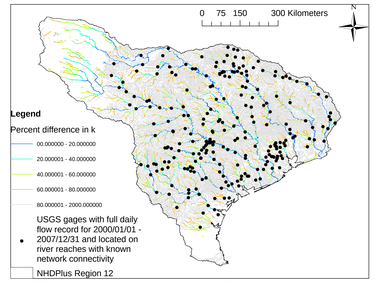
Map of Nash-Sutcliffe efficiency



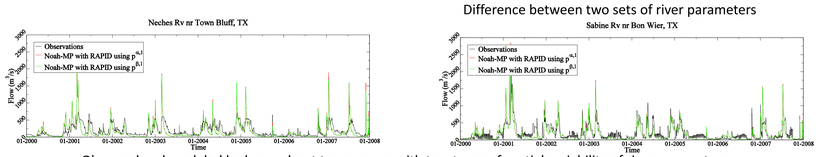
Observed and modeled stream flow downstream of the 8 biggest basins

RIVER MODEL PARAMETERS BASED ON LENGTH



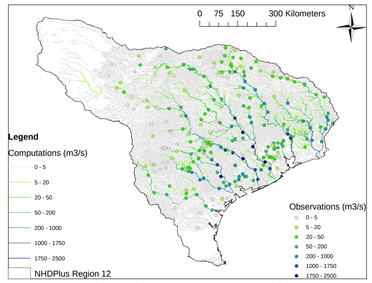


Difference between two sets of river parameters

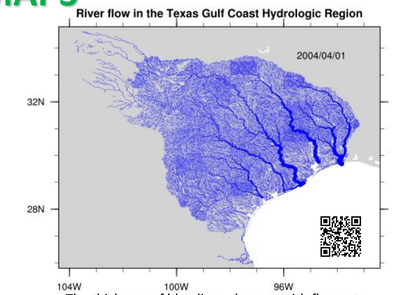


Observed and modeled hydrographs at two gauges, with two types of spatial variability of river parameters

SYNOPTIC RIVER FLOW MAPS



Comparison of daily observed and computed flow for 2004/11/24



The thickness of blue lines changes with flow rate

CONCLUSIONS

Despite initial difficulties in the determination of water inflow from NLDAS2 to NHDPlus rivers, the "blue line" approach is advantageous partly because hundreds of gauges are easily located on river networks and used throughout basins. Such use of a large number of gauges allows for new investigations related to the analysis of river flow computations and to the optimization of river model parameters.

With the exception of large outliers at a few gauges, the best NLDAS2 runoff products (VIC and Mosaic) perform similarly to the calibrated Noah-MP.

Such outliers prevent the successful optimization of river model parameters but a careful selection of what stations to use for optimization allows overcoming this difficulty.

While river model parameters determined separately for each runoff dataset allow best results, a single set of parameters is sufficient to assess the relative quality of runoff datasets.

The detailed NHDPlus description of river reaches also allows enhancement of model computations through increase in spatial variability of model parameters, although such improvements may not be statistically significant.

References

David, C. H., S. Hong and Z.-L. Yang, Regional-scale river flow modeling using off-the-shelf runoff products, thousands of mapped rivers and hundreds of stream flow gauges, (in preparation).

David, C. H., D. R. Maidment, G.-Y. Niu, Z.-L. Yang, F. Habets and V. Eijkhout, (2011) River network routing on the NHDPlus dataset, Journal of Hydrometeorology, DOI: 10.1175/2011JHM1345.1

Hong, S., and Z.-L. Yang (2011), Assessing Noah-MP Hydrological Simulations Over Small River Basins in Texas, US, (in preparation).

Niu, G.-Y., Z.-L. Yang, K. E. Mitchell, F. Chen, M. B. Ek, M. Barlage, A. Kumar, K. Manning, D. Niyogi, E. Rosero, M. Tewari, and Y.-L. Xia, 2011: The community Noah land surface model with multiparameterization options (Noah-MP): 1. Model description and evaluation with local-scale measurements, J. Geophys. Res., 116, D12109, doi:10.1029/2010JD015139.

Xia, Y., K. Mitchell, M. Ek, B. Cosgrove, J. Sheffield, L. Luo, C. Alonge, H. Wei, J. Meng, B. Livneh, Q. Duan, Lohmann, D., (2011), Continental-Scale Water and Energy Flux Analysis and Validation for the North-American Land Data Assimilation System Project Phase 2 (NLDAS-2),Part 2: Validation of Model-Simulated Streamflow. J. Geophys. Res. (in review).

Yang, Z.-L., G.-Y. Niu, K. E. Mitchell, F. Chen, M. B. Ek, M. Barlage, L. Longuevergne, K. Manning, D. Niyogi, M. Tewari, and Y.-L. Xia, 2011: The community Noah land surface model with multiparameterization options (Noah-MP): 2. Evaluation over global river basins, J. Geophys. Res., 116, D12110, doi:10.1029/2010JD015140.

Acknowledgments

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