

Report as of FY2006 for 2006PA66B: "Functional Classification of Susquehanna River Basin Watersheds in an Uncertainty Framework"

Publications

- Book Chapters:
 - Yadav, Maitreya, Thorsten Wagener, and Hoshin V. Gupta. (2006). Regionalization of dynamic watershed behavior. In Andreassian, Vazken, N. Chahinian, Alan Hall, Charles Perrin, John Schaake (eds.), Large sample basin experiments for hydrological model parameterization. Results of the Model Parameter Estimation Experiment (MOPEX) Paris (2004) and Foz de Iguacu (2005) workshops. IAHS Redbook Publ. no. 307.
 - Wagener, Thorsten, Patrick Reed, Kathryn Van Werkhoven, Yong Tang, and Zhenxing Zang. (2007). Identification and evaluation of complex environmental systems models using global sensitivity analysis and evolutionary multiobjective optimization. In *Advances in Hydroinformatics* (in review).
- Articles in Refereed Scientific Journals:
 - Yadav, Maitreya, Thorsten Wagener, and Hoshin Gupta. (2007). Regionalization of constraints on expected watershed response behavior for improved predictions in ungauged basins. *Advances in Water Resources* 30, 1756-1774.
 - Zhang, Zhenxing, Thorsten Wagener, and Patrick Reed. (2007). Ensemble streamflow predictions in ungauged basins combining hydrologic indices regionalization and multiobjective calibration. *Water Resources Research* (in preparation).
- Dissertations:
 - Yadav, Maitreya. (2006). Regionalization of dynamic watershed behavior. MS Dissertation, Department of Civil and Environmental Engineering, Pennsylvania State University, University Park, PA, 95.

Report Follows

PRINCIPAL FINDINGS AND SIGNIFICANCE

Summary

Rainfall-runoff models are standard tools for hydrologic analysis. These models are used for applications such as water resources studies and flood forecasting, or in support of ecological studies. Available watershed models range from parsimonious-lumped to complex distributed physically based representations. A problem common to all such models is that they all require some degree of parameter calibration to achieve reliable predictions, in which process the model parameters are adjusted (manually or automatically) until the observed and simulated watershed responses match as closely as possible. Even physically based models usually require some degree of calibration since it is difficult to estimate values for all of the parameters through field measurements. This occurs because the scale of measurement is usually smaller than the effective scale at which the model parameters are applied. Problems in hydrologic modeling are accentuated further when it comes to prediction in ungauged or altered (e.g. land use) basins, where sufficiently long streamflow time series for parameter estimation via calibration are typically not available.

Approaches to modeling the continuous hydrologic response of ungauged basins use observable physical characteristics of watersheds to either directly infer values for the parameters of hydrologic models, or to establish regression relationships between watershed structure and model parameters. Both these approaches still have widely discussed limitations, including impacts of model structural uncertainty. In this paper we introduce an alternative, model independent, approach to streamflow prediction in ungauged basins based on empirical evidence of relationships between watershed structure, climate and watershed response behavior. Instead of directly estimating values for model parameters, different hydrologic response behaviors of the watershed, quantified through model independent streamflow indices, are estimated and subsequently regionalized in an uncertainty framework. This results in expected ranges of streamflow indices in ungauged watersheds.

A pilot study using 30 UK watersheds distributed throughout England and Wales shows how this regionalized information can be used to constrain ensemble predictions of any model at ungauged sites. It was found that high pulse count, runoff ratio and the slope of the flow duration curve provided strong regionalizable constraints while still allowing for reliable predictions, i.e. most of the observed flow was captured by the ensemble. The dominant physical characteristics are climate (wetness index, P/PE), watershed topography (slope, DPSBAR) and subsurface geology and soils (base-flow index, BFIHOST). Using too many dynamical characteristics simultaneously often resulted in a rejection of all models. This new approach provided sharp and reliable predictions of continuous streamflow at the ungauged sites tested. In general, the approach yielded very promising results and has several advantages compared to the common regionalization of models.

The main advantages of this new approach to ensemble predictions in ungauged basins are that it (1) is applicable to any hydrologic model (lumped or distributed), (2) is not impacted by problems of parameter calibration or model structural error, (3) does not try to establish relationships between conceptual (effective) model parameters and watershed characteristics, and (4) yields increased understanding about the controls on watershed response behavior at the scale of interest, which could guide an improved approach to watershed classification.

STUDENTS SUPPORTED

Maitryea Yadav, Civil and Environmental Engineering, Graduate Spring 2006 with MS
Yaoling Bai, Civil and Environmental Engineering, PhD Student since Fall 2006

PRESENTATIONS AND OTHER INFORMATION TRANSFER ACTIVITIES

Conference Presentations

- Wagener, T., Reed, P., Werkhoven, K. van and Tang, Y. 2007. Identification and evaluation of complex environmental systems models using global sensitivity analysis and evolutionary multiobjective optimization. International Workshop on Advances in Hydroinformatics (HIW07), Niagara Falls, Canada, June 4-7th 2007. – Planned (Invited Keynote)
- Wagener, T. 2006. Catchment classification and hydrologic similarity. Hydroecological Landscapes and Processes (HELP) Workshop – “Expert Workshop on Watershed Characterization Schemes for Canadian Forests”, 9-11th November 2006, The University of Western Ontario, London, Ontario, CA. (Invited Plenary Speaker)
- Wagener, T. 2006. Towards an uncertainty framework for PUB. USA PUB Workshop, 16-19th October 2006, Oregon State University, Corvallis, Oregon, USA. (Invited Talk)
- Wagener, T., Yadav, M., and Gupta, H. 2006. Hydrologic ensemble predictions in ungauged basins. 2nd International Symposium on Quantitative Precipitation Forecasting and Hydrology, 4th-8th June 2006, Boulder, CO. (Invited Talk)
- Yadav, M, Wagener, T. and Gupta, H.V. 2006. Regionalization of dynamic watershed response behavior. *Eos Trans. AGU*, 87(36), Jt. Assem. Suppl., Abstract H23D-15. (Poster)

Invited Seminars

- Wagener, T. 2007. Catchment classification, hydrologic similarity and predictions in ungauged basins. Department of Geography, University of British Columbia, Canada.
- Wagener, T. 2007. Catchment classification, hydrologic similarity and predictions in ungauged basins. Department of Civil and Environmental Engineering, University of Washington, Seattle, USA.
- Wagener, T. 2007. Catchment classification, hydrologic similarity and predictions in ungauged basins. 3TIER Environmental Forecasting, Seattle, Washington, USA.
- Wagener, T. 2006. Hydrologic model identification under uncertainty in gauged and ungauged catchments. Graduate School of Environmental Studies, Tohoku University, Japan.
- Wagener, T. 2006. Catchment classification and hydrologic similarity. Cooperative Wetlands Center, Pennsylvania State University, USA.
- Wagener, T. 2006. Catchment classification, hydrologic similarity and predictions in ungauged basins. Department of Land Resources and Environmental Sciences, Montana State University, Bozeman, MT, USA.
- Wagener, T., Duffy, C., Reed, P., Tang, Y., Goodwin, K. and Yadav, M. 2006. Advancing hydrologic ensemble forecasting using distributed watershed models. National Weather Service - Hydrology Laboratory, Washington D.C., USA. (Combined presentation by all authors)
- Gupta, H.V., Wagener, T., *Yilmaz, K. and *Yadav, M. 2006. Improved Distributed Watershed Modeling in Gauged and Ungauged Basins using the HL-RMS System. National Weather Service - Hydrology Laboratory, Washington D.C., USA.

AWARDS

ADDITIONAL FUNDING ACQUIRED USING USGS GRANT AS SEED MONEY