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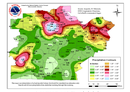
in cooperation with Kentucky Division of Water

Tanja N. Williamson, Kenneth R. Odom, Chuck J. Taylor, Jeremy K. Newson

WATER - A water-assessment decision tool for environmental regulators

The value of WATER - a Water Assessment Tool for Environmental Resources

Precipitation Record or Forecast



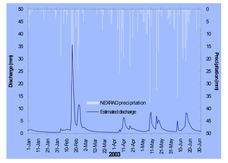
August 4th, 2009
Louisville Flood Event

Long-Term Flow Record

Nutrient Loads

Eco Flows

Hydrograph



Water Budget

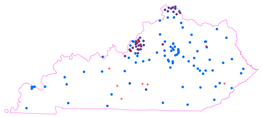
Water Allocation Decisions

Flood Forecast

Disaster Preparedness

Streamflow estimates for Kentucky

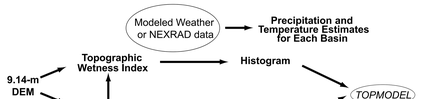
monitoring sites distributed unevenly throughout Commonwealth
- 121 streamflow
- 44 water quality sites



Planning for weather events
- floods
- droughts
- climate change

Extending water-quality data
- nutrient loads
- low-flow for habitats

Source Data



DATA SOURCES
- KY Dam Safety Commission
- Soil Survey Geographic Data
- TR55 Impervious Erosion Curve
- National Land Cover Data 2001
- KY Pollutant Discharge Elimination System
- KY Division of Water
- NOAA NWS

Site ID
Area
Total cells
Lake Area
Uplake Area
Soil Characteristics
Root Zone
Stream cells
Latitude
Impervious Area
Withdrawals
Discharges

Calibrate and Validate: Compare modelled data to USGS streamflow gage data at monitored sites

For more information, please contact:

Tanja N. Williamson, Ph.D. — tnwillia@usgs.gov
Hydrologist — 502-493-1934
Kentucky Water Science Center
U.S. Geological Survey — http://ky.water.usgs.gov/

The Hydrologic Model - TOPMODEL

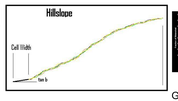
TOPography-based hydrologic MODEL

Developed by Beven and Kirkby (1979)

Fundamental Assumptions
- steady-state recharge
- hydraulic gradient ≈ surface slope
- Ksat ↓ with depth

Uses the Topographic Wetness Index to model landscape:

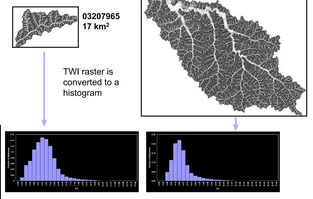
$$TWI = \ln\left(\frac{upslope\ contributing\ area}{\tan\ slope}\right)$$



High TWI → High potential for saturation

Low TWI → Low potential for saturation

Quasi-distributed Approach

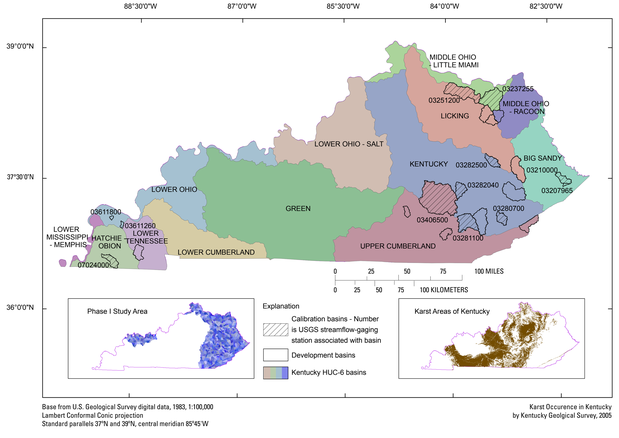


Grid cells with the same TWI are hydrologically similar

A saturation deficit (S) is then calculated for each bin of TWI values:

$$S_x = \bar{S} + m(TWI - TWI_x) \qquad m = \frac{porosity - \theta_K}{f} \qquad f = \frac{\ln(Ksat\ surface\ /\ Ksat\ bottom)}{soil\ \ thickness}$$

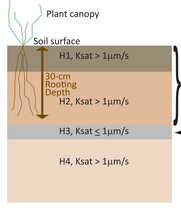
where x is local conditions and ***m*** is a ***scaling parameter*** that controls the range of saturation deficit.



Soil Characteristics

Required for TOPMODEL
- saturated hydraulic conductivity
- field capacity
- porosity
- plant-available water
- thickness

Queried from SSURGO
- removed layers with very-low to moderate Ksat
- compared to bounding layers
- averaged data
  - thickness weighted
  - component weighted



Portion of soil for which Ksat > 1 µm
- layers involved in daily hydrologic processes
- used to calculate required soil parameters.

This layer would not be included in the soil-parameter calculations.

In 8 percent of the soil components, a bounded layer with Ksat > 1 µm/s was included in the soil-parameter calculations.

Importance of the Scaling Factor *m*

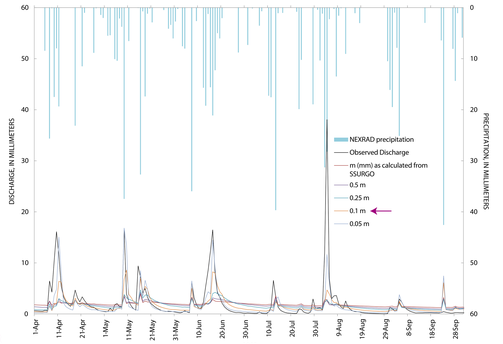
As ***m*** increases:
- variability in S ↑
- effect of topography ↑
- hydraulic gradient ↑
- peak flows ↓

m can be calculated from SSURGO data

m is scale dependant (Brassington and Richards, 1998)

0.1 x ***m*** calculated from SSURGO is best for these basins
- accurately represents baseflow
- preserves event peaks in hydrograph

This adjustment was applied uniformly to all basins, but ***there was no site-specific optimization***.

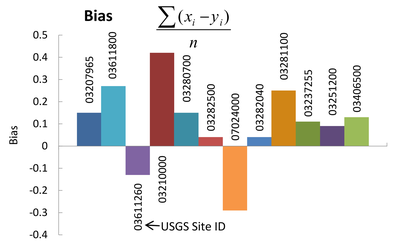


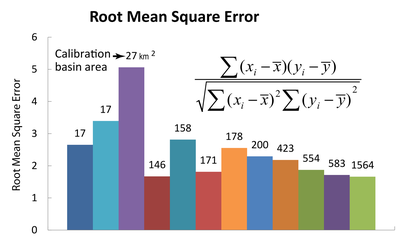
Validation of WATER output

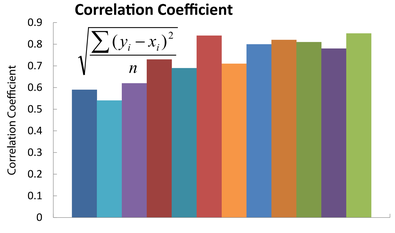
Model output was statistically evaluated for a period of 2119 days
- 12 basins
- January 2001 - August 2006

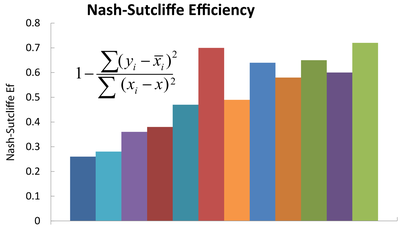
Final model parameters (discussed at left) were chosen based on:
- simulation of hydrograph (example shown above)
- consistency of multiple statistics at calibration basins

The positive Nash-Sutcliffe values indicate that the model is accurate
- a negative value indicates that mean observed streamflow ($\bar{x}$) is a better indicator than the model
- a positive value indicates that the model (y_i) is a better indicator than the $\bar{x}$
- a value of 1 indicates that the model (y_i) perfectly simulates observed streamflow (x_i)







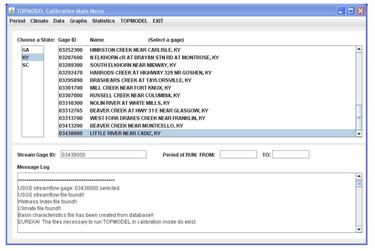


Using WATER

Data processing and validation for WATER was done with a JAVA encapsulated Fortran version of TOPMODEL.
- data stored in an MS Access database
- basin characteristics means sampled using ArcMap
- individual characteristics could be changed using the "Basin Characteristics"

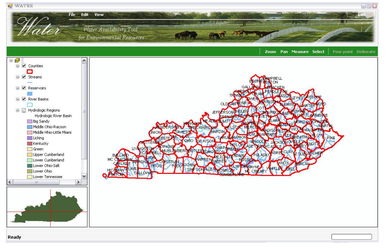
Model output was over-written the next time the tool was used.

This form of the tool used pre-delineated basins:



WATER now uses .NET code in a Virtual Basic environment
- data are stored as rasters
- basin is delineated from a selected pour point

This "point and click" environment allows users to
- assess various sizes of basins
- store model runs (both input and output)



References and Citations

Beven, K. J. and Kirkby, M. J. 1979. A physically based, variable contributing area model of basin hydrology. Hydrological Sciences Bulletin, v. 24, pp. 43-69.

Brassington, J. and Richards, K. 1998. Interactions between model predictions, parameters and DTM scales for TOPMODEL. Computers and Geosciences, v.24, p.299-314.

For a complete discussion of WATER, please see:
Williamson and others, 2009, The Water Availability Tool for Environmental Resources (WATER): a water-budget modeling approach for managing water supply resources in non-karst areas of Kentucky (Phase I) - data processing and model structure documentation. USGS Scientific Investigations Report 2009-in press.