Modeling Streamflow Using Gauge-Only Versus Radar-Derived Rainfall

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Background & Goals
- Precipitation comparisons between gauge-derived Thiessen polygons and radar-derived grid cells have been made over several Florida basins (VanCleve and Fuelberg, 2007).
- This study seeks to understand the sensitivity of a hydrologic model to two different multisensor forms of input data as well as gauge-derived data alone.
- Determine the spatial scale of precipitation data necessary for various modeling tasks

Data & Methodology
- Streamflow was simulated by the WAM hydrologic model
- Model setup parameters were held constant while the type of rainfall input was altered in each run.
- Daily flow at the USGS stream gauge on the Santa Fe River at Worthington Springs (02321500) is used as the observed truth for comparison with the WAM simulated flows.
- Our Area of Interest (AOI) is the area contributing to the flow at the Worthington Springs gauge site (all reaches upstream). This AOI was chosen because the WAM model was thought to contain little unknown hydrological or outside influences.

Watershed Assessment Model (WAM)
- Description and figures taken from:
- Developed by Soil & Water Engineering Technology, Inc. (SWET) to simulate the primary physical processes important for watershed hydrologic and pollutant transport.
- GIS-based coverages include: land use, soils, topography, hydrography, basin and sub-basin boundaries, point sources/service areas, climate data, land use/plants description files.
- Model is based on a grid cell representation of the watershed, which allows the identification of surface and ground water flow and concentrations for each cell. The model “routes” the surface water and groundwater through the cells to assess the flow and pollutant levels throughout the watershed.
- Simulates hydrology of the watershed using other imbedded models including GLEAMS, EAAmod (WAM manual contains references).
- Dynamic routing technique is based on Manning’s flow equation. Attenuation is calculated using the flow rate, characteristics of the flow path, and the distance of travel.

Rain Gauge-Derived Input
- Input to WAM is from hourly rain gauge data of the Suwannee River Water Management District (SUW) and the National Climatic Data Center (NCDC)
- Data were quality-controlled by Florida State University (FSU) using a rigorous scheme described by Marzen and Fuelberg (2005).
- WAM interprets precipitation amounts over the basin using Thiessen polygons of all gauges influencing the AOI (see figure above center)
- Hourly gauge data were summed to daily amounts, and if missing, were filled with the value from the closest neighboring gauge

Radar-Derived Input
- Input to WAM is from the historical database (1996-2006) created at FSU which combines hourly rain gauge data with radar-derived hourly Digital Precipitation Arrays provided by the NWS Southeast River Forecast Center
- Rain gauge data are from the Florida Water Management Districts and NCDC and then quality-controlled by FSU as described above
- FSU’s product is created using a version of the NWS Multi-sensor Precipitation Estimator (MPE) code and placed on the Hydrologic Rainfall Analysis Project (HRAP) - 4x4 km grid (see figure above center)
- Hourly HRAP cell values are summed to daily values, with missing data left as zeroes in WAM (neighbor fill schemes would be processor and memory intensive)

Background & Goals
- Hydrographs show that all three WAM runs often miss event features, miscalculating peaks and overestimating low flow periods
- Difference (simulated - obs) hydrographs show that both gauge-derived and radar-derived model runs underestimate most often in 2005 (also seen in 2003). Radar-derived model runs in these years also produce their greatest negative mean differences.

2002 & 2005 Flow Statistics
- Both radar-derived WAM runs show improved standard deviation of differences over the gauge-derived run
- Correlations between measured data and the full MPE run always are superior to the Thiessen run (similar to trends found in other years)

Additional Considerations
- SWET recently has noted that important hydrography could be added to the model setup for improved flow simulations.
- The MPE-SUW model run was performed with limited gauge data and without adjusting MPE parameters that account for radar biases and other factors. Thus, the full MPE model run should be considered the typical radar-derived dataset to be used in a hydrology model.
- Missing HRAP cells could be filled with neighboring cells (as is done with Thiessen polygons) to possibly further improve the radar-derived simulations.

Conclusions
- The different rainfall inputs to WAM significantly change the output streamflow values
- No simulations exactly match observed values. However, the highest-resolution radar-derived data generally produce the best statistical agreement. Even during years when radar-derived data give the greatest annual underestimate, the radar-derived data correlate best with observed streamflow.
- Despite possible WAM inadequacies, radar-derived data provide improved correlations
- WAM and its sub-models require daily rainfall data that do not take advantage of MPE’s hourly output.

Research in Progress
- Subdivide flow statistics by wet and dry seasons
- Create rainfall maps associated with major streamflow events and address the possible impacts of missing rainfall data
- Results from other stream gauge sites (AOIs) will be shown in future publications

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References