Initial Results of Calibrating the Baron LIS-NOAH-V2 Fully Distributed Hydrological Modeling System for the DMIP Elk River Basin

J.N. McHenry(1) , Dave Gochis(2), David Yates(2), and Carlie Coats(1)
1. Baron Advanced Meteorological Systems, Raleigh, NC (e-mail: john.mchenry@baronams.com), 2. National Center for Atmospheric Research, Boulder, CO

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1. The DEStructive WATers Abatement and Control of Water Disasters (DESWAT) Project:

The DEStructive WATer Abatement and Control of Water Disasters Project is a multi-institution effort to supply the Romanian National Institute of Hydrology and Water Management (INHGA) with state-of-science improvements to precipitation and stream-gauge measurement systems as well as implement a comprehensive operational hydrologic forecast modeling system, including lumped, distributed, and FFG style models.

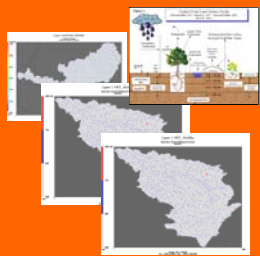
Motivation:

• Destructive floods continue cause loss of life and property in the country of Romania. A series of massive floods caused extensive property damage and loss of life in 2005. In 2007, flooding left 130 villages without power, and farms throughout the country's north and east were inundated. In July of 2008, five people died in flooding and heavy rains in areas bordering Ukraine.

• DESWAT will enable INHGA to fully track, assess, predict, and warn the population in time to significantly reduce the impact of flooding caused by Romania's unique geography, climate, and river system.

The Land-Information-System NOAH-Distributed Version 2 Model (LN2)

The LN2 represents a merger of the NASA Land-Information System (Peters-Lidard et al, 2007) and the NOAH-distributed land-surface-overland-flow model (Gochis and Chen et al, 2003) with explicit channel-routing, baseflow, and lake/reservoir sub-models. Both BAMS and NCAR scientists have contributed substantially to the overall parallel developments of versions running at NCAR and at BAMS.



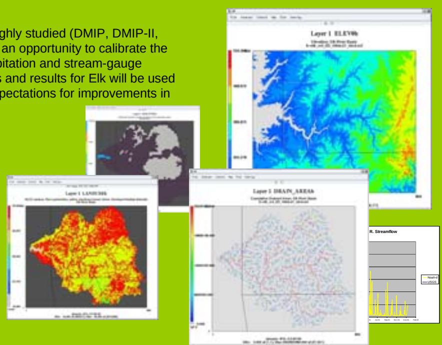
2. Elk River Basin (US): Benchmark Calibration

The Elk River Basin in the US:

The Elk River Basin in the US is thoroughly studied (DMIP, DMIP-II, Smith et al., 2004) and thus represents an opportunity to calibrate the LN2 model using quality-assured precipitation and stream-gauge measurements. The calibration process and results for Elk will be used to refine techniques and set realistic expectations for improvements in selected Romanian basins.

Datasets:

- GIS data: soils (USGS), land-use/land-cover (NLCD) and topographic (30-meter) were used to provide LSM and routing model foundational parameters
- Input precipitation was acquired from the DMIP-II repository (radar based)
- Temperatures, winds, and other meteorological variables were acquired from the NNRP (NCDC) dataset and downscaled.



3. Calibration Strategy

Three-Phase Calibration:

- LN2 is being calibrated following a division of the major process components of the model: (1) land-surface (LSM), (2) baseflow discharge (Bucket model), and (3) channel flow (Diffusive-wave, Levelpool, Weir, Orifice).
- The initial calibration has focused on the LSM and baseflow models, with tuning of the channel Manning's "N" and geometry in process as of this writing.
- A combination of manual, expert-based tuning and non-linear optimization-based calibration with the PEST package is being employed.
- Techniques and learning in Elk will be applied to the 25 Elk River-sized catchments that are to be calibrated in Romania

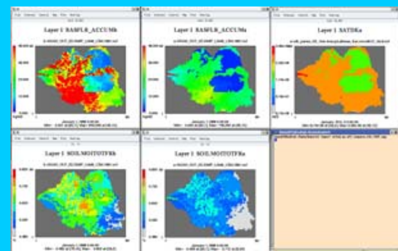
Calibration Period:

- For the Elk, a three year land-surface/overland-routing spin-up was done for the period 1997-1999. Following that, a calibration/validation period consisting of the years 2000-2005 (with specific targeted internal periods for calibration of channel parameters) is chosen.
- In Romania, the period 2000-2005 is selected, with the second half of 2005 as the primary validation period.

4a. Preliminary Studies: Land-Surface Model

NOAH vs. NOAH-D:

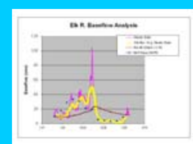
- In typical land-surface applications, an LSM is run without overland flow routing (terrain driven routing).
- Question: Can adequate spin-up of soil-moisture be obtained without overland-flow turned on, thus saving significant computing time?
- Results: soil climatology is much wetter w/ ovlnd flow turned on and it cycles water into the bucket more efficiently -- by at least a mean factor of 2.



The response is clearly non-linear and heavily dependent on SATDK. *Left hand top/bottom w/ overland routing on; right hand w/ LSM only, and far right showing SATDK map.* Nominal REFKDT = 1.5 and SLOPE = .1

4b. Preliminary Studies: Baseflow Discharge

- Monthly USGS/PART-estimated values of baseflow for 1999 for the Elk. R. and two solutions from Noah-D: (1) a simple steady-state or 'pass-through' solution where all deep soil drainage is converted directly to baseflow and there is no storage in the bucket (the flashier of the two); (2) uses parameters estimated from theoretical max baseflow input conditions (accum of saturated free-drainage conditions for 10 days over the entire basin) and a minimum baseflow from USGS analysis.



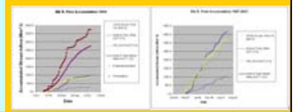
- Result: clear differences in the phase of both Noah-D solutions and the values estimated by the USGS/PART model. 30day moving average of the steady-state solution is plotted for reference. Strong phase lag suggests that subsurface processes are highly complex and possibly influenced by forcing beyond the basin boundary.

5. Initial Calibration Results

5a. Land-Surface including infiltration factor, drainage-to-base-flow overland roughness.

ERROR SCORES (Volume accumulation) :

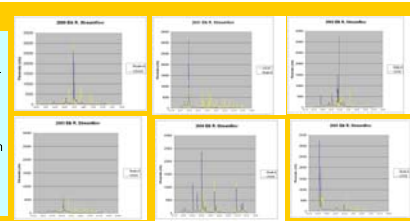
Correlation Coefficient	> .95
RMSE	250.0 mm**3
MAE	213.5 mm*3
Final Accumulation Error	434.8 mm*3
% Accumulation error	13.4%
Baseflow Frac (Basef Indx)	71.3%
USGS PART Baseflow Indx	61.8%



- 1997-1999 multi-year calibration of infiltration and terrain runoff parameters
- Multi-year stream-flow partitioning also reveals a dominant influence of base-flow contributions though model somewhat overestimates base-flow fraction (Noah-d 71.3% vs. 61.8% from USGS PART model) Model maintains excellent correl. with USGS flow although there is a positive bias in total runoff ~13%
- Components of water balance for 1999 suggest an annual runoff fraction (Q/P) of approximately 0.25, with ET being dominant sink for moisture

5b. 2001 – 2005 Continuous Stream-flow Analysis (Base Run)

- Comparison of USGS Elk R. at Tiff City vs. Noah-d hourly flows
- Un-calibrated Channel Flow using results of volume calibration above
- NASH-Sutcliff: 0.54 for Year 2000



- Modeled stream-flow hydrographs appear too responsive to input forcing though several of the largest events are under-estimated
- Hydrograph recession in model is currently too fast
- Combined with the previous slides these results suggest while the long-term water balance of the model in terms of runoff production is reasonable, further calibration of base-flow discharge model and channel routing parameters is required

6. Conclusions and Next Steps

1. Complete the Elk River calibration focusing on base-flow and channel routing parameters using PEST and manual expertise. Document improvements due to calibration.
2. Calibrate 20-25 carefully selected sub-basins in Romania, starting with the Arges Basin:
   - Run initial 2000-2005 test run w/ full routing; analyze to ensure model gives reasonable un-calibrated results [no problems with input forcing data or DEM].
   - Run hydrograph separation on 2000-2005 stream-gauge observations (USGS "PART" model).
   - Tune (1) infiltration factor; (2) runoff-to-base-flow-slope; and (3) overland roughness using LN2-PEST and/or manual expertise. Result: calibrated values for REFKDT, OVLROUGH, and SLOPEFAC
   - Tune (4a) bucket model coefficient, (4b) exponent, and (4c) initial starting bucket water level for base-flow volume/timing against observed base-flow using LN2-PEST
   - Tune Manning's N using LN2-PEST and produce modified Manning's N power law consistent w/ tuning.
   - Conduct Model verification run and obtain statistical measures of improvement