NEXRAD Data (Radar-Based MPEs) Application to Runoff Routing Using a Hybrid Hydrologic Model (Distributed-Clark)

Younghyun Cho[1, 2], Bernard A. Engel[1]

[1]Department of Agricultural and Biological Engineering, Purdue University, West Lafayette, IN, 47907, [2]K-water (Korea Water Resources Corporation), Daejeon, Korea (the Republic of)

Email: yhcho@purdue.edu

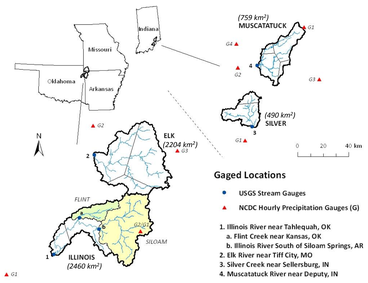
Introduction

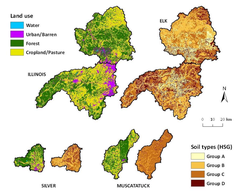
NEXRAD data (radar-based MPEs) applicability and performance of a **hydrologic model for runoff routing** using these data were explored.

- **A GIS-based automation tool for NEXRAD data processing** to create regular grid based spatiotemporally varied rainfall data, particularly using Stage IV composite product (Lin and Mitchell, 2005), was developed and a simple hydrological modeling approach, **a GIS-based hybrid hydrologic model (Distributed-Clark)** (Cho et al., 2015), was introduced to use NEXRAD precipitation estimates for storm event flow prediction in a GIS platform.
- Application results for spatially distributed radar-based rainfall and spatially averaged gauged data were investigated with comparisons of model performance against observed streamflow.

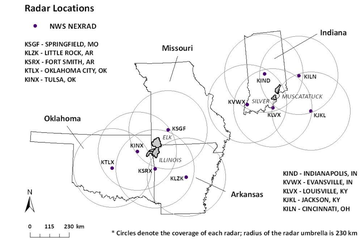
Study Area and Data

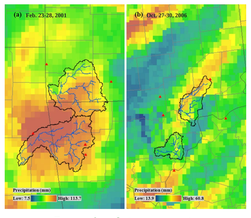
- ***Study Watersheds***





<Land use and soil>





<Example of storm events>

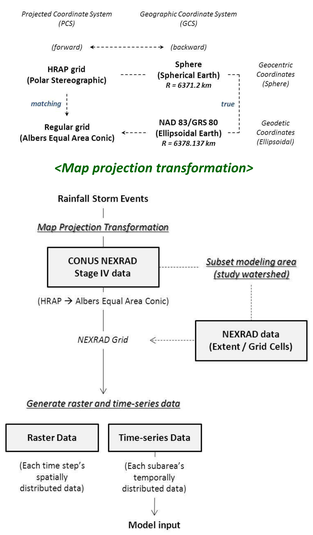
* 24 events (6 events for each watershed) from 1998 to 2007 were selected for hydrological modeling using NEXRAD data (NCEP Stage IV)

- ***Data Sources***

- *USGS National Map (nationamap.gov)*: DEM, NLCD 2011, and NHD
- *USGS NWIS (waterdata.usgs.gov/nwis)*: Streamflow (hourly) data and gage information
- *USDA WSS (websoilsurvey.sc.egov.usda.gov)*: SURRGO
- *NOAA (noaa.gov) NCDC/HDSC*: Rainfall (hourly) data and gage information/PF estimates
- *NCAR/UCAR EOL (data.eol.ucar.edu)*: NEXRAD NCEP Stage IV (GRIB format, hourly)

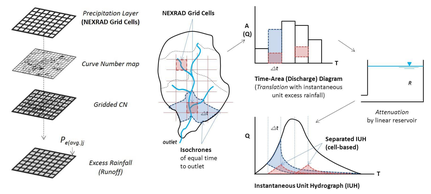
Model Description

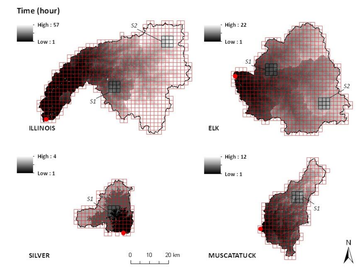
- ***NEXRAD Data Processing Tool***



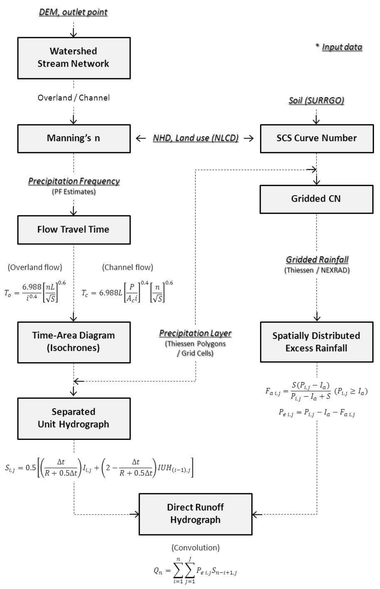
<Overall procedures: NEXRAD data processing>

- ***Hybrid Hydrologic Model (Distributed-Clark)***





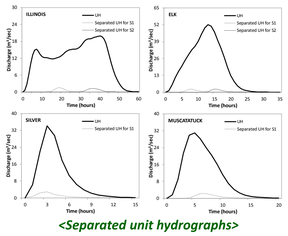
<Flow travel time map; Isochrones>



<Overall procedures: Distributed-Clark Development>

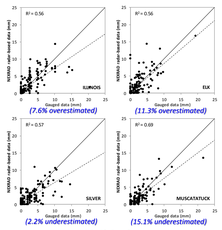
Results

- ***Distributed-Clark***

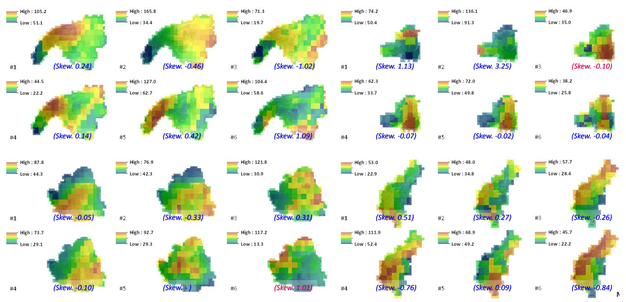


<Separated unit hydrographs>

- ***NEXRAD Data***



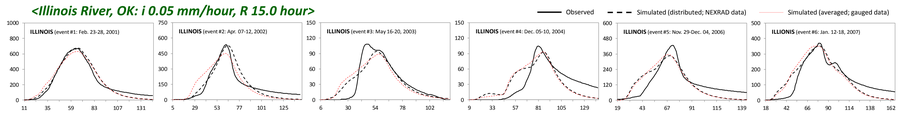
<Validation>



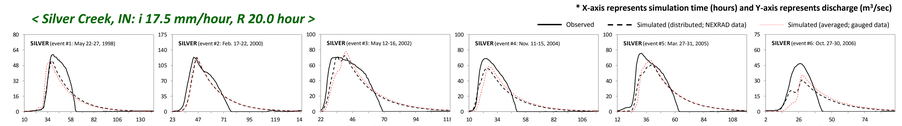
<Spatial variability: Rainfall amounts in grid cells are varied for each event; max. 782.3% to min. 85.1%>

- ***Model Performance***

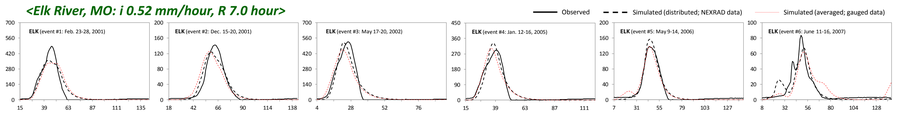
<Illinois River, OK: i 0.05 mm/hour, R 15.0 hour>



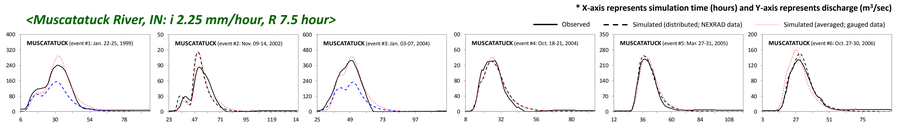
< Silver Creek, IN: i 17.5 mm/hour, R 20.0 hour >



<Elk River, MO: i 0.52 mm/hour, R 7.0 hour>



<Muscatatuck River, IN: i 2.25 mm/hour, R 7.5 hour>



Discussion (Summary)

- In **Distributed-Clark** (a hybrid hydrologic model; lumped conceptual and distributed feature), the **SCS CN** approach (gridded CN) estimated spatially distributed excess rainfall (NEXRAD data) and GIS-derived time-area diagram (isochrones) based a set of **separated unit hydrographs** are utilized to convolute a **direct runoff hydrograph**.
- NEXRAD & spatial data processing and model execution can be performed by **Python script tools** (developed) in a GIS platform.
- Correlations (**0.56** to **0.69**) and underestimated trends in higher values in NEXRAD data validation were found compared with gauged rainfall, and significant differences (**7.6** and **11.3%** overestimated; **2.2** and **15.1%** underestimated) between the amounts of rainfall were found; these and spatial variability can **affect** the **model performance** in hydrologic simulation.
- Model case studies of single storm event application for four river basins using spatially distributed NEXRAD precipitation data demonstrate:
  - ✓ **Relatively good fit** (direct runoff; E_{NS} **0.85**, R^2 **0.89**, and ***PBIAS*** **3.92%**) against observed flow data,
  - ✓ **Slightly better fit** (direct runoff; increases in E_{NS} **of 3.0%** and R^2 **of 6.0%**) in comparison with the outputs of spatially averaged gauged rainfall data simulations.

Conclusion

- With **Distributed-Clark**, which is a relatively simple technique to implement spatially distributed rainfall-runoff routing, **NEXRAD data** show more **appropriate** simulation results than gauged rainfall for **storm event flow prediction**; but NEXRAD product quality issues may result in poor model performance.

References

- Cho, Y., B. A. Engel, and V. M. Merwade, 2015: Development and evaluation of a GIS-based hybrid hydrologic model for spatially distributed rainfall-runoff routing. *Environ. Model. Softw.*, **in process**.
- Lin, Y., K. E. Mitchell, 2005: The NCEP Stage II/IV hourly precipitation analysis: development and applications. *19th Conference on Hydrology*, San Diego, CA, Amer. Meteor. Soc., Paper 1.2.

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