

# **Short-term streamflow prediction for a small Midwestern watershed**

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# *Introduction*

**This is a cooperative effort between ISU and Des Moines Weather Forecast Office (DMX) using the Ames watershed as a test basin.**

## **Two main objectives:**

- test the feasibility of using the USACE HEC-HMS model for operational flood prediction**
- test research-stage hourly PQPF for improved lead-time for flood prediction**

## **Motivation:**

**DMX streamflow forecasting tools are currently limited to**

**1) Site Specific Model: developed for small headwater basins (<200 sq. miles), not accurate when initial soil conditions are dry**

**2) Flood Forecast Guidance: developed as a one time step, seldom updated**

**Lack of confidence in RFC forecasts by local communities**

# Approach

*...to conduct a collaborative experiment to expedite integration of new tools into operations*

## 1. Retrospective Analysis

- Update and calibrate the HEC-HMS model for current land use
- Verify model for basin hydrology
- Develop guidance for model use
- Test QPF for past events

## 2. Real-time analysis

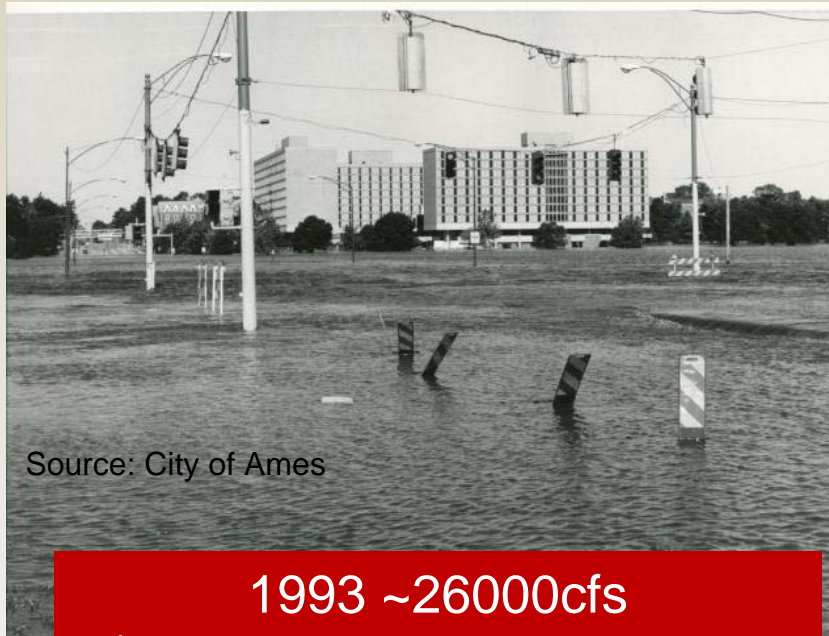
- Once calibrated, HEC-HMS will be delivered to DMX
- DMX and ISU will run HEC-HMS in real-time as events occur
- Forecast and model application methodology will be developed

This talk presents preliminary results for a flood event that occurred April 24-26, 2007



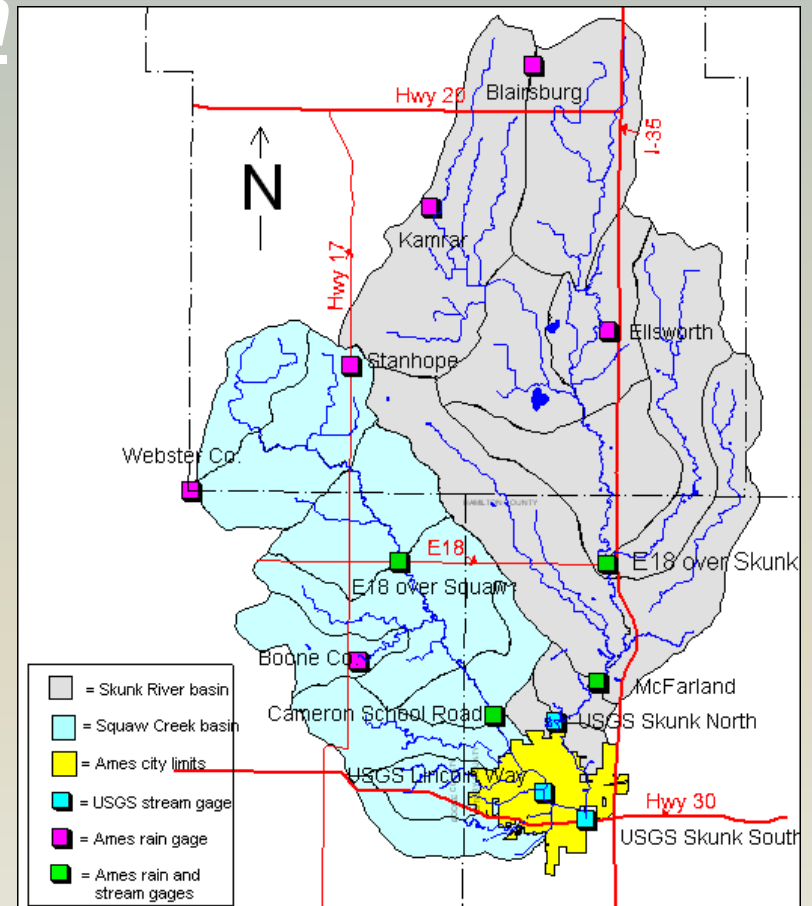
## Study Basin

- Drainage Area: 556mi<sup>2</sup> (1440km<sup>2</sup>)
- Mostly agricultural, some wooded & urban
- Average slope: ~1% or less
- Average annual rainfall: 30-35" (75-89cm)
- Mean flow 434cfs



Source: City of Ames

1993 ~26000cfs  
\$10 million in economic loss



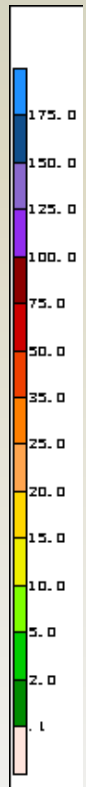
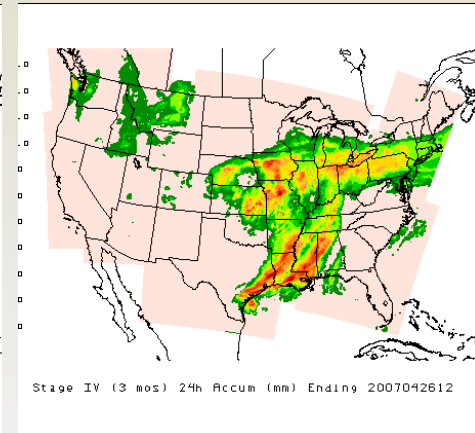
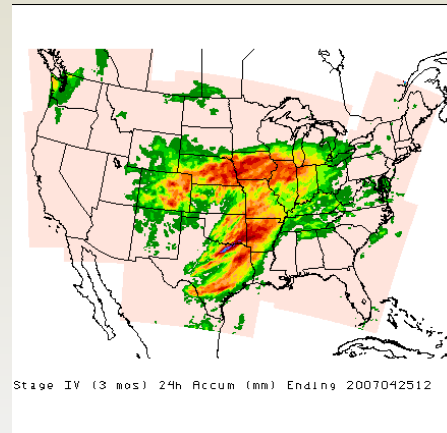
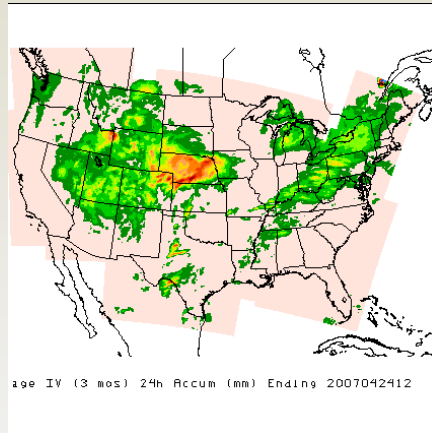
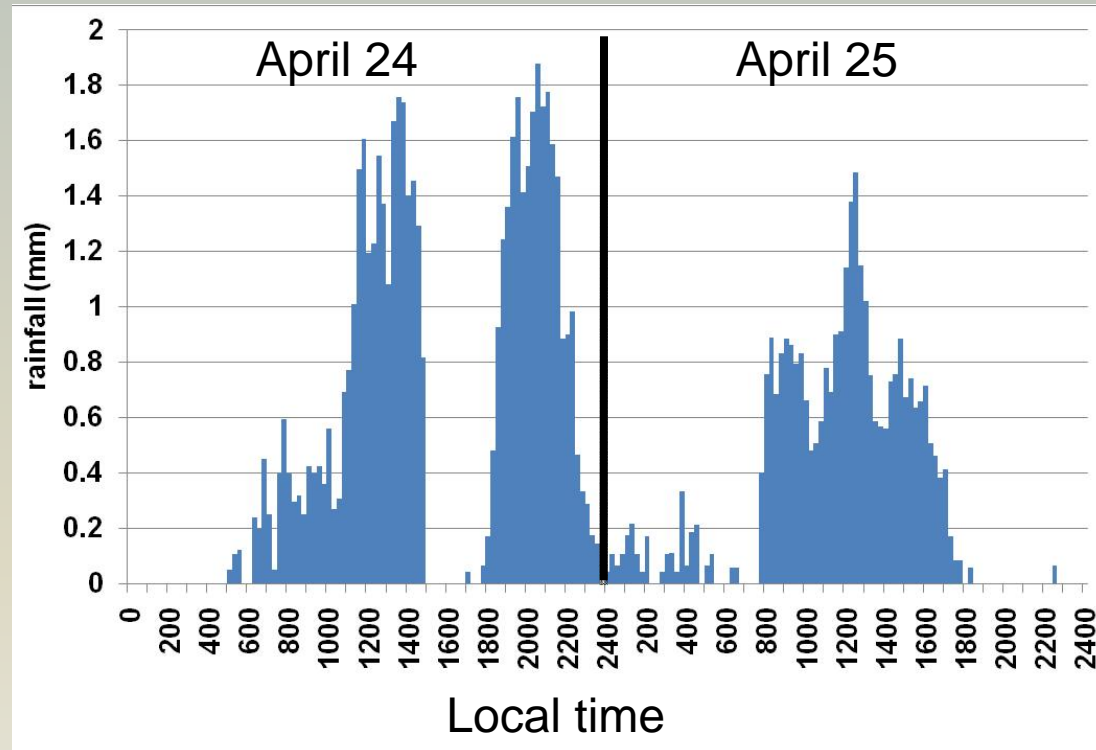
1993 event prompted City to initiate its own flood watch program

- HEC-HMS model
- ALERT system

# Test case: April 24-25, 2007 event

Beginning morning  
of April 24<sup>th</sup> ...

36 hours of near  
continuous rain  
3.34 in. (85 mm)

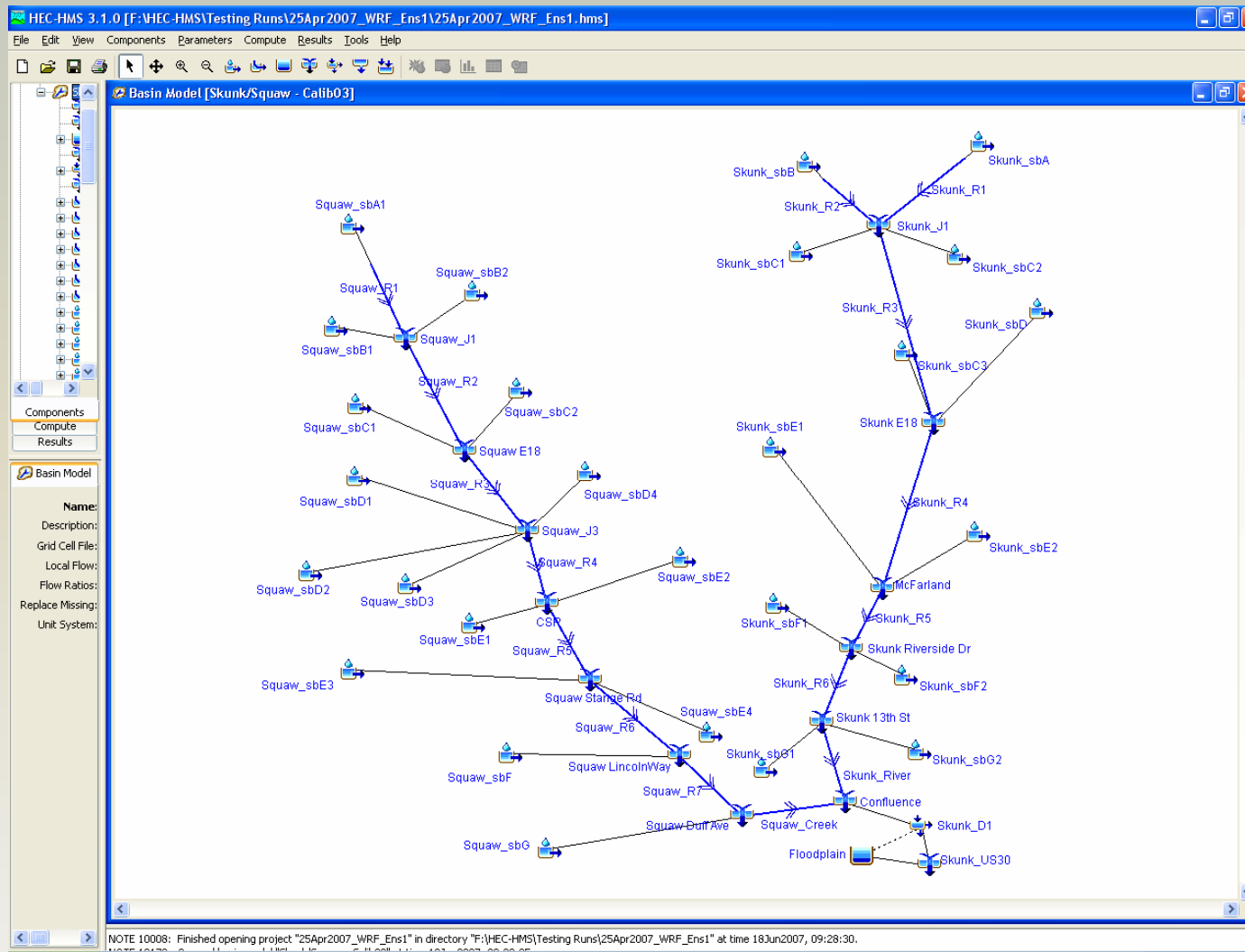


- Peak discharge 12,000 cfs (approx. 10-12 year event)
- Considered minor to moderate flooding



Photos from the Ames Tribune

# HEC-HMS Model Calibration



- Event only

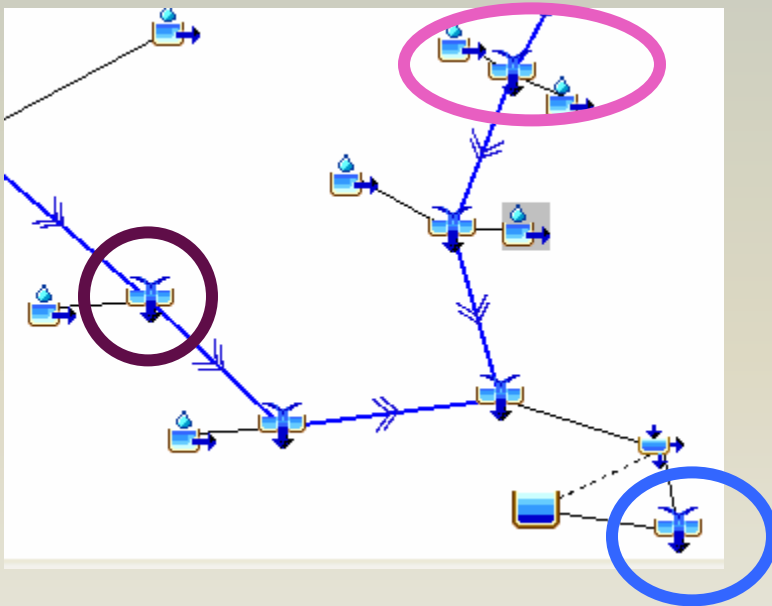
- 30 minute time step

- Runoff: SCS curve number

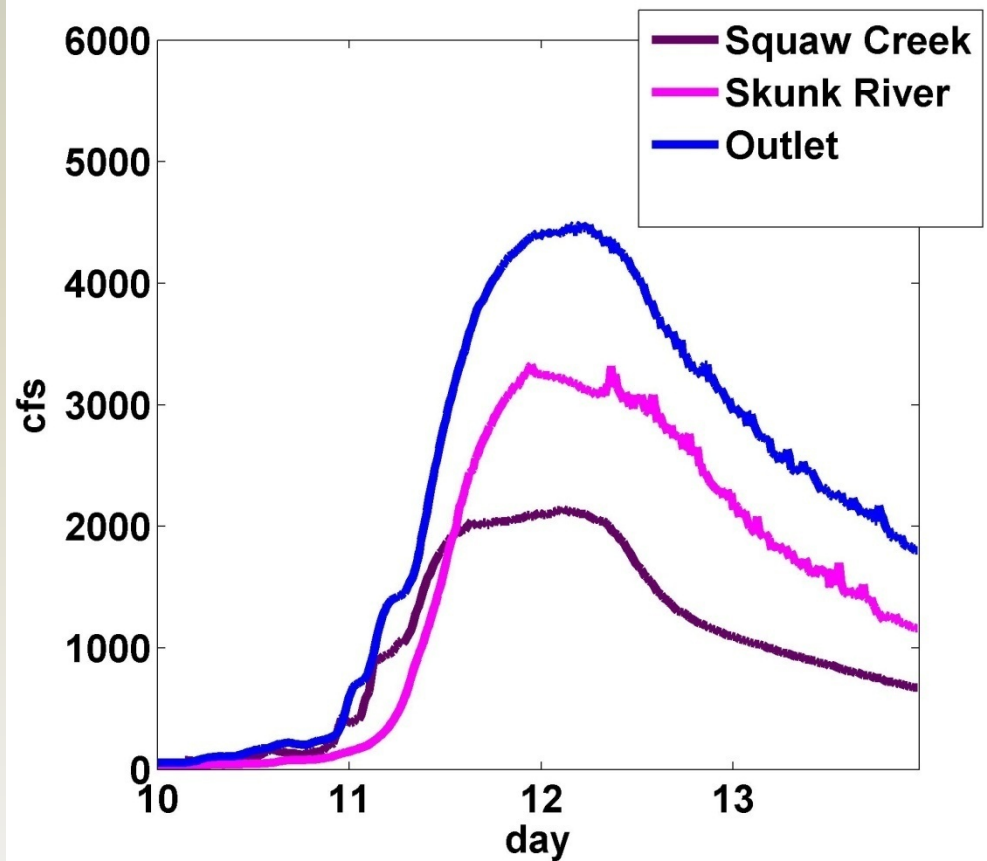
- Routing: Muskingum

- 2 years of ALERT data available

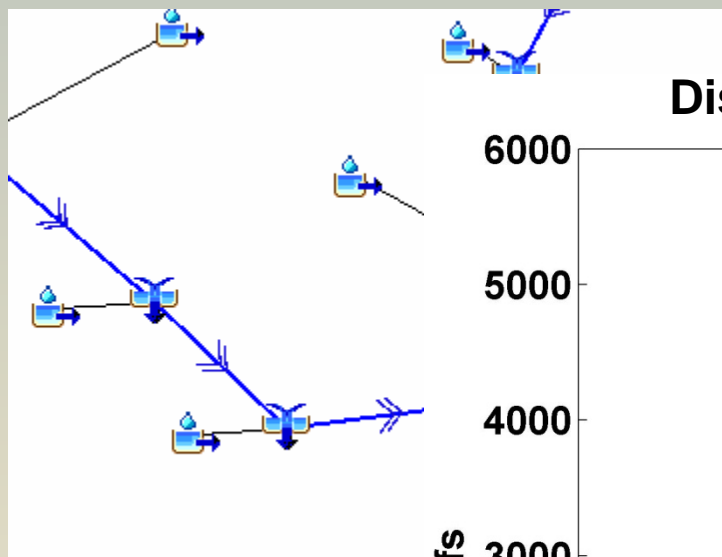
# *The water balance*



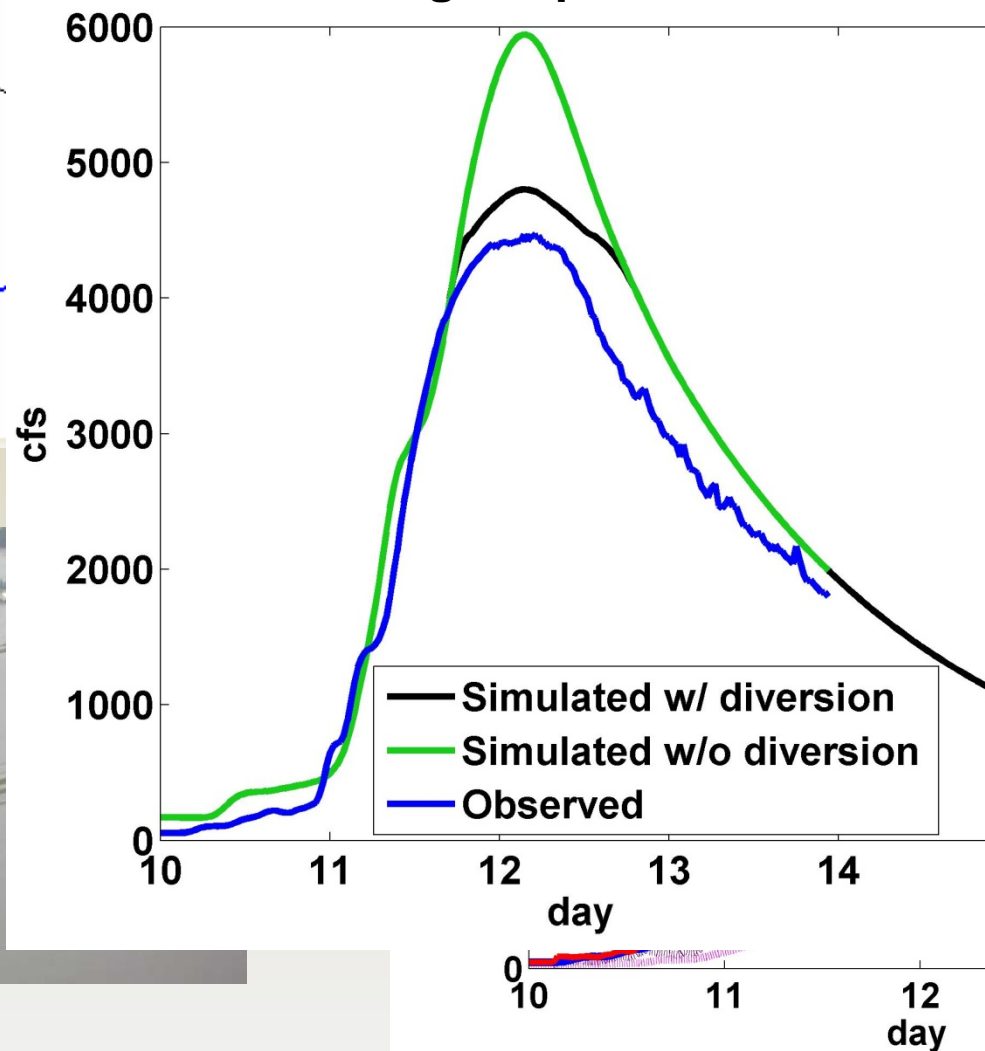
**Observed Discharge (cfs)  
September 10-13, 2006**



# Accounting for surface storage

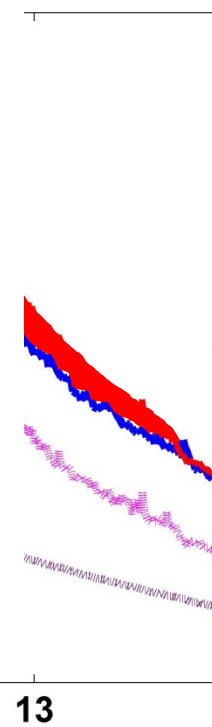


Discharge September 10-14



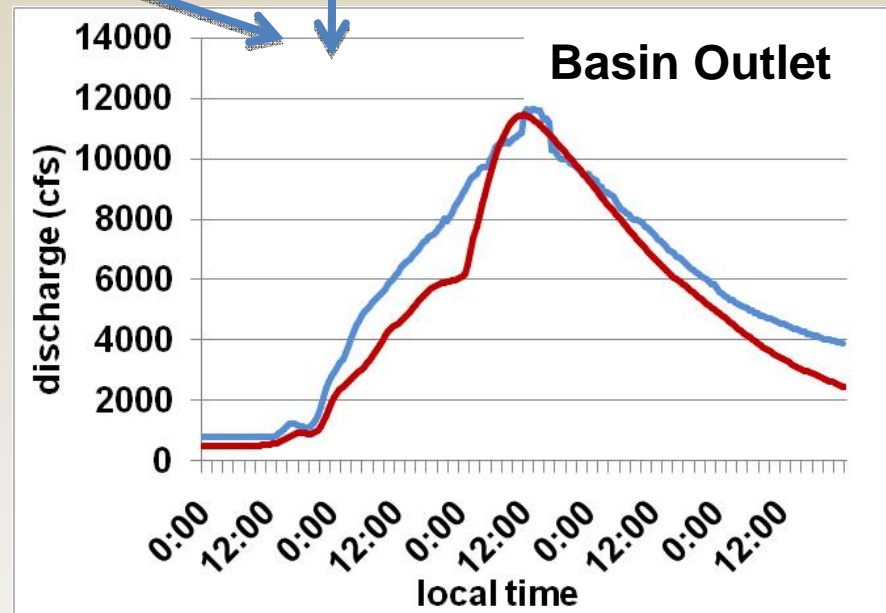
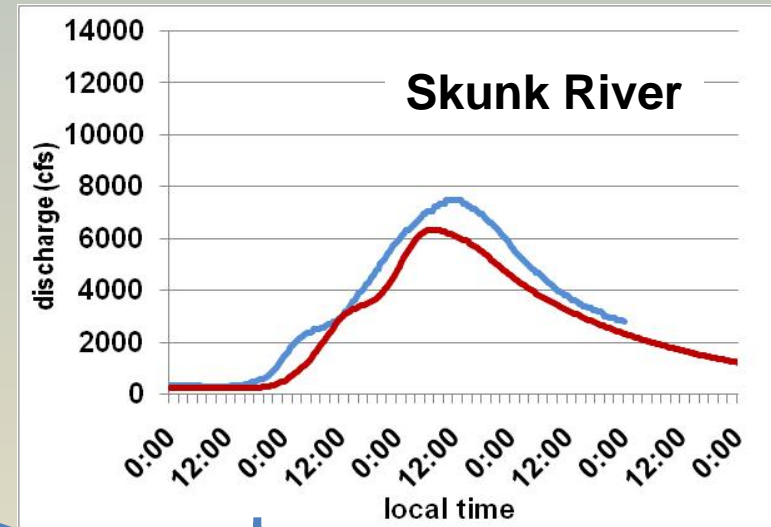
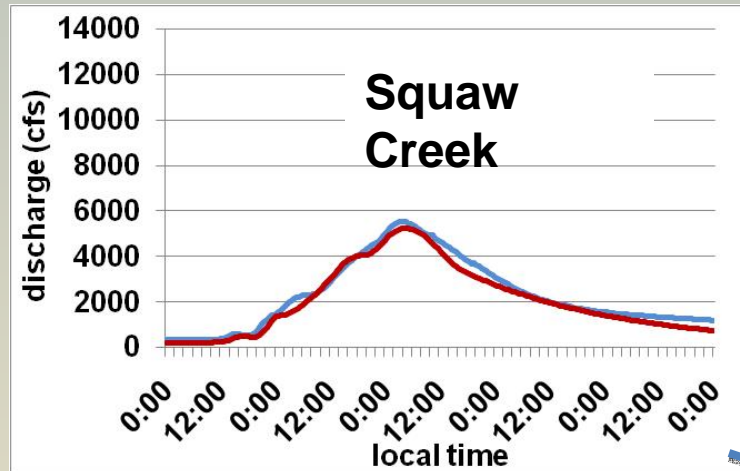
Skunk

September 10-14



# HEC-HMS April 24<sup>th</sup>-28<sup>th</sup>

— Observed  
— Simulated



## Peak discharge

	error	bias
Squaw	-200 cfs	-2%
Skunk	1140 cfs	17%
Outlet	-303 cfs	-5%

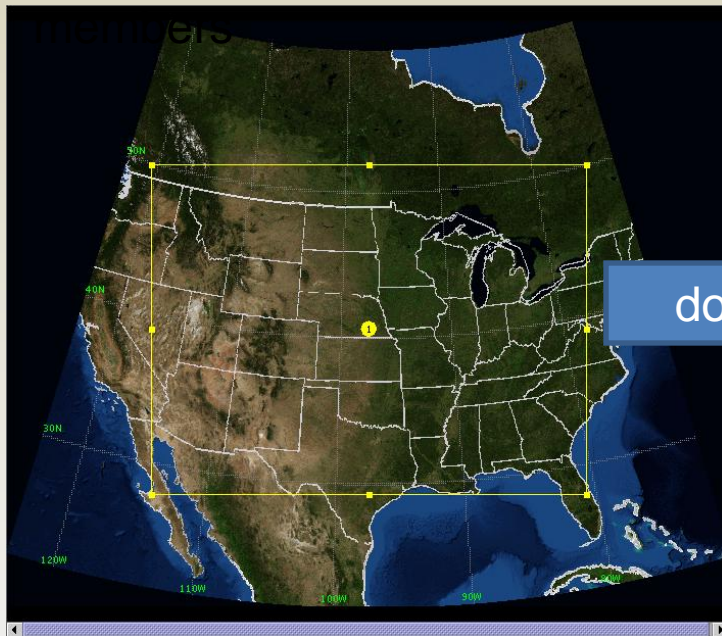
# *Preliminary results*

- HEC-HMS simulations thus far are satisfactory
- Curve numbers:
  - Have to be adjusted for current conditions (some guess work involved)
    - Seasonal land cover (agriculture)
    - Antecedent moisture conditions
    - Simulation highly sensitive to small changes in CN
    - Can reliable look-up tables be developed to allow easy operational application and limit ad hoc model initialization?
- Ability to “follow” water downstream assists in calibration and understanding basin hydrology
- HEC-HMS bugs
  - Randomly loses data and changes units
    - Reduces confidence

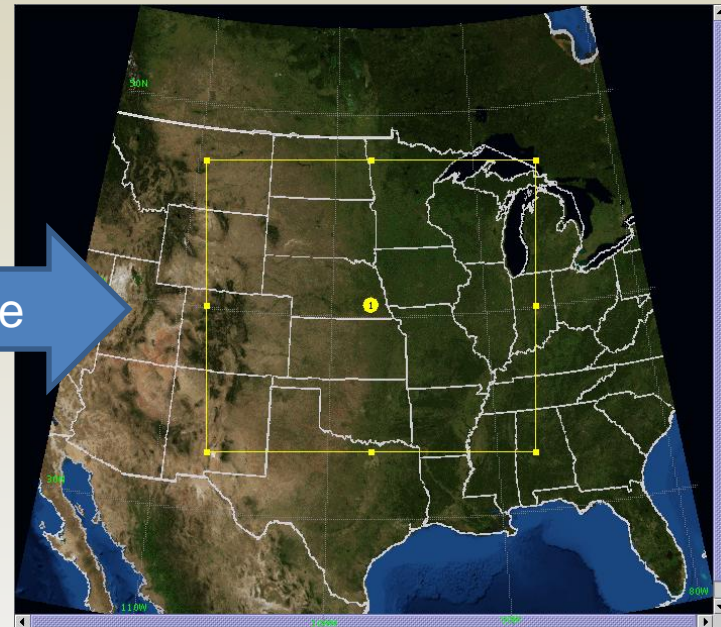
# Testing hourly QPF

- Most flash flood predictions are based on precipitation that has already fallen. Longer outlooks use 6-hr QPF.
- 1-hour QPF may provide early warning of impending floods in basins that respond faster than 6-hours or require modeling at shorter timesteps

Most recent version of WRF,  
run at 20-km grid spacing, 16



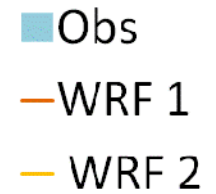
4 versions downscaled to 4-km to  
create finer-scale ensemble



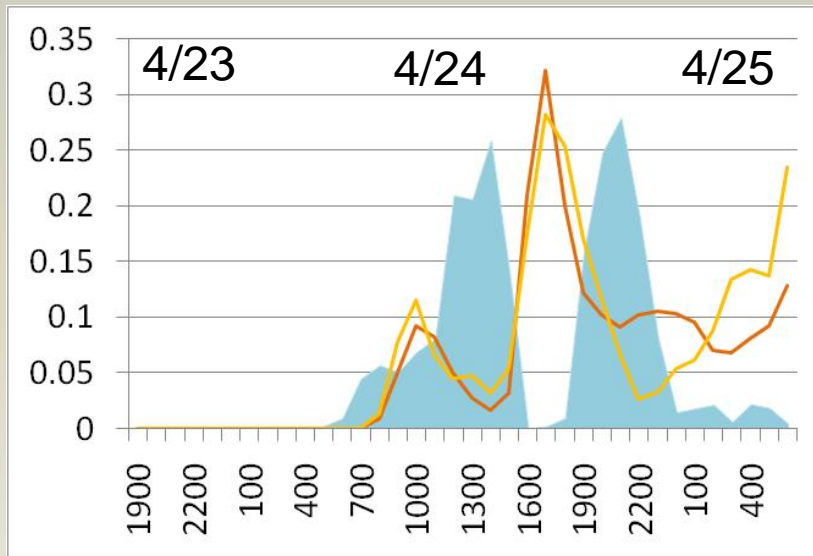
downscale

Forecasts courtesy of Adam Clark

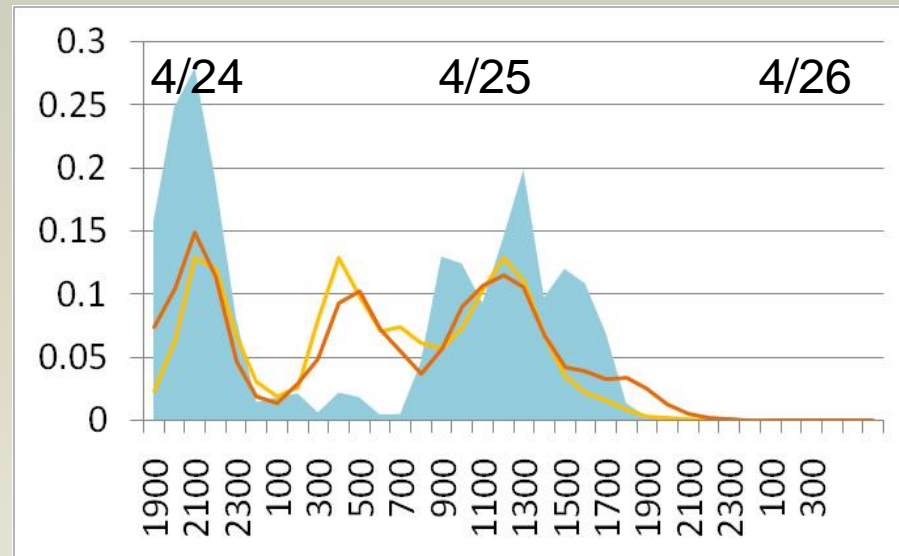
# QPF



**Precipitation Forecast 1: Initialized**  
April 24<sup>th</sup> 00 UTC (April 23<sup>rd</sup> 7pm local)



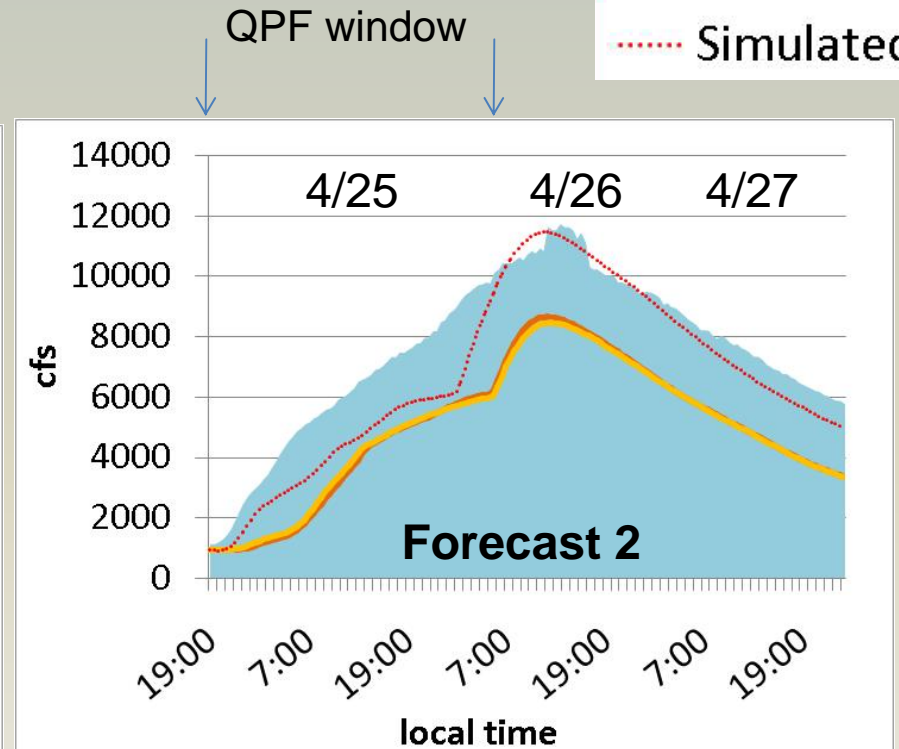
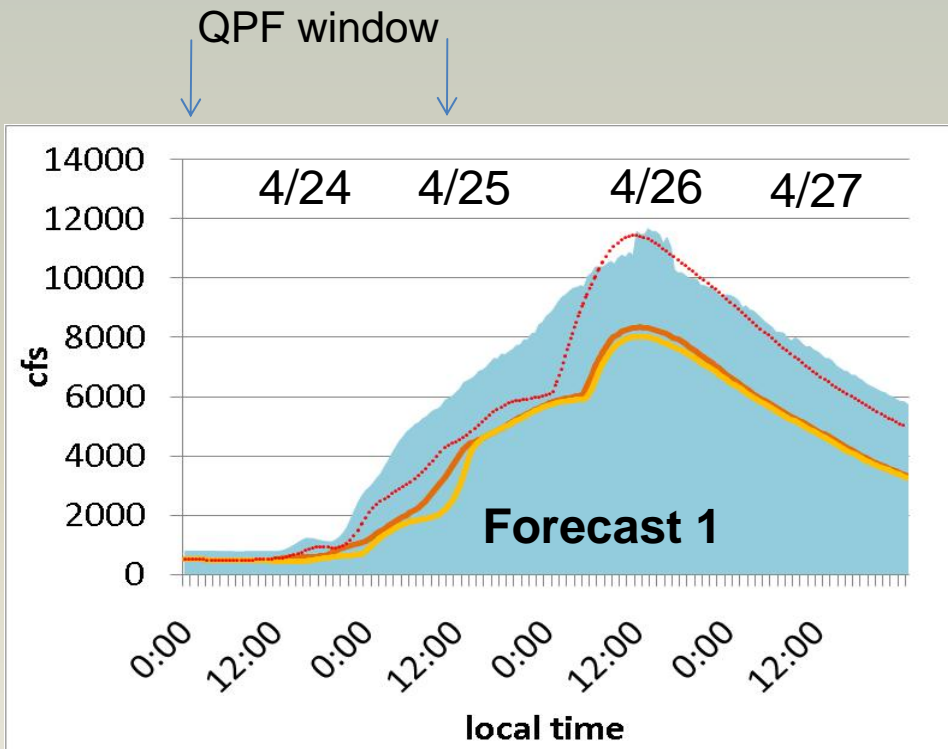
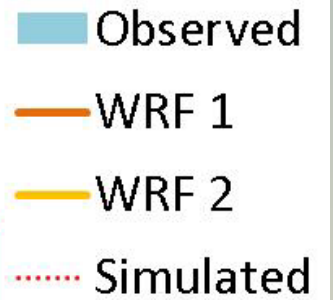
**Precipitation Forecast 2: Initialized April**  
25<sup>th</sup> 00 UTC (April 24<sup>rd</sup> 7pm local)



## Total rainfall

	1 <sup>st</sup> 36 hr period	2 <sup>nd</sup> 36 hr period
Obs	55.9 mm	56.13 mm
WRF 1	57.2 mm	40.9 mm
WRF 2	62.5 mm	43.2 mm

# Discharge forecast



## Peak discharge

	1 <sup>st</sup> 36 hr period	2 <sup>nd</sup> 36 hr period
Obs	11,700 cfs	11,700 cfs
WRF 1	8341 cfs	8647 cfs
WRF 2	8037 cfs	8444 cfs

# *RFC forecast*

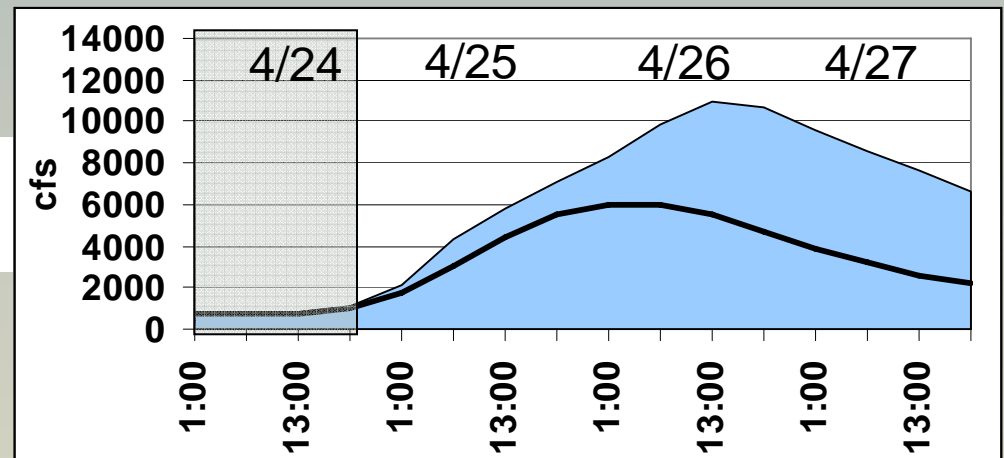
**observed**  
 **RFC predicted**

Uses SACSMA model:  
continuous model, 6-  
hour timestep, lumped

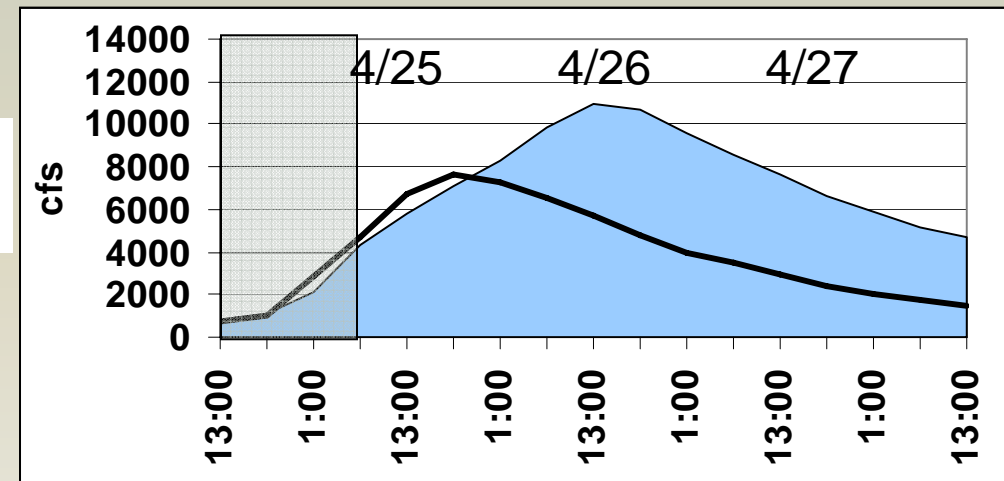
- Forecasts missed magnitude and timing of peak

error	Discharge (cfs)	Stage (ft)
4/24 8pm	5000	2.45
4/25 8am	3000	1.35
4/25 8pm	2000	.75

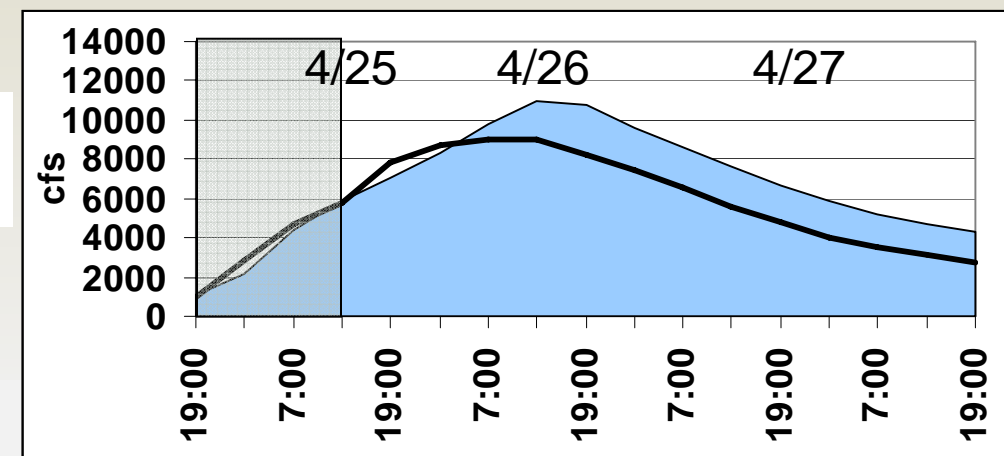
April 24<sup>th</sup>,  
8pm



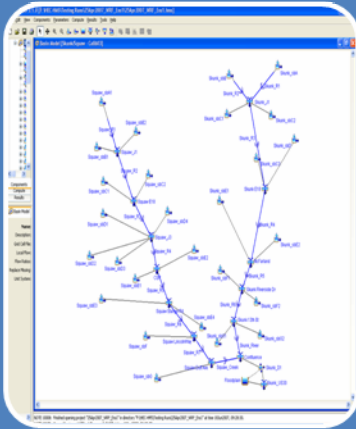
April 25<sup>th</sup>,  
8am



April 25<sup>th</sup>,  
4pm

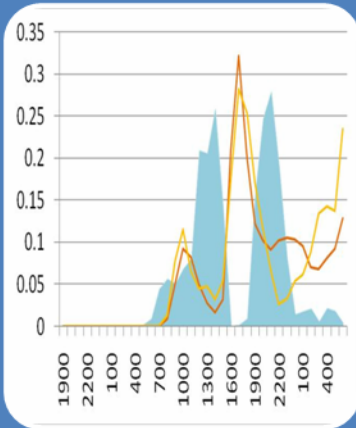


# Future work



## Modeling

- Determine feasibility and advantage of running model at WFO through real-time experiment
- Test HEC-HMS in gridded application which is more compatible with forecasts, Stage IV data, etc (Will an external data base fix the lost data problem?)
- Compare HEC-HMS to SAC-SMA at 1-hour time step
- Test on other basins in region with less data



## QPF

- Compare 16 member ensemble WRF run at 20-km grid-spacing to 4 member ensemble WRF run at 4km
- Test sampling schemes to account for spatial and temporal uncertainty