

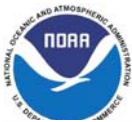


# Data Assimilator for Research Distributed Hydrologic Model (DA for RDHM)

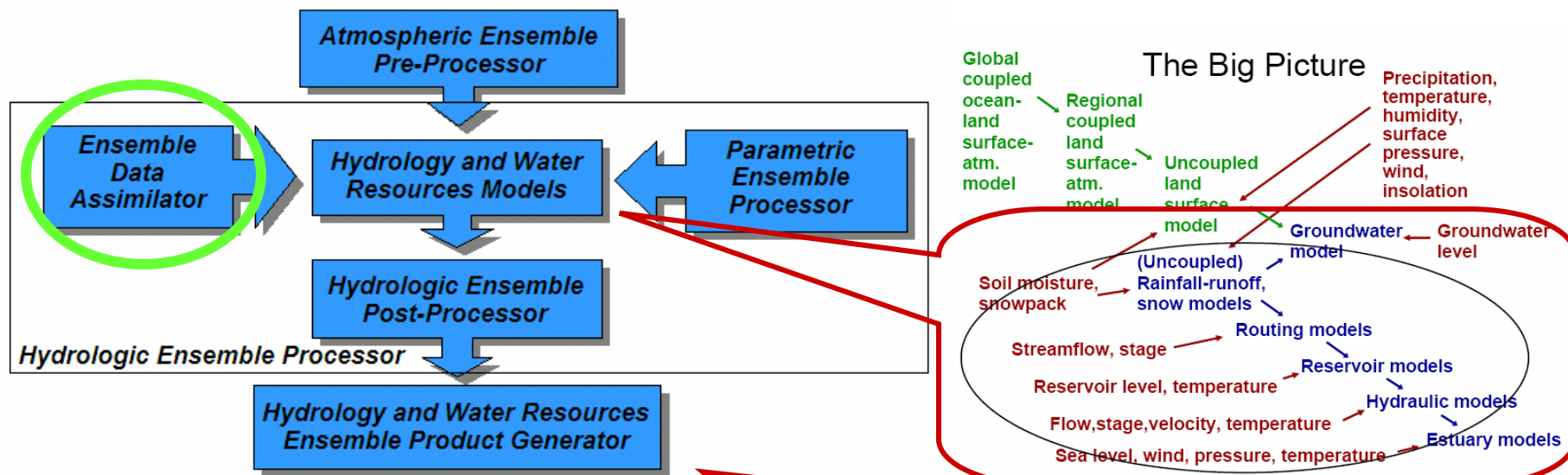
D.-J. Seo<sup>1,2</sup>, Victor Koren<sup>1</sup>, Haksu Lee<sup>1,2</sup>

<sup>1</sup>Hydrologic Science and Modeling Branch  
Hydrology Laboratory  
Office of Hydrologic Development  
NOAA/National Weather Service

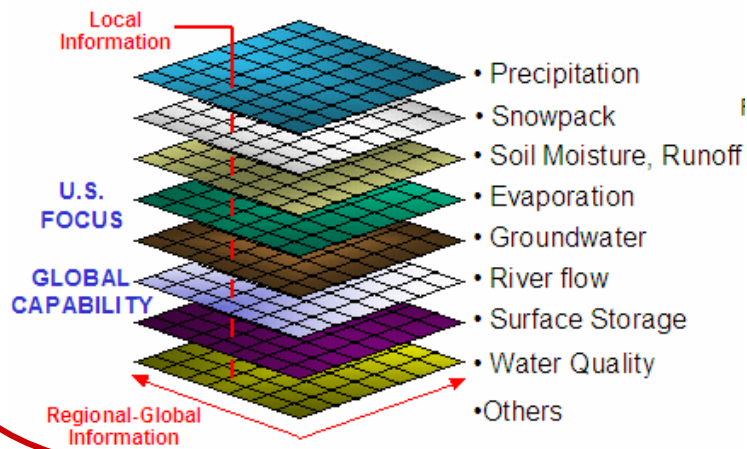
<sup>2</sup>University Corporation for Atmospheric Research



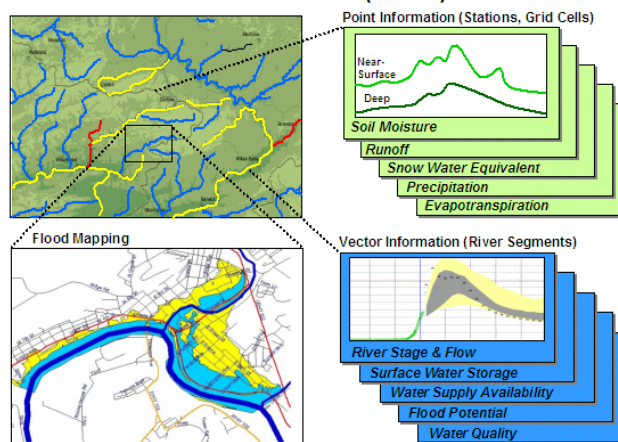
# Vision for Ensemble & DA



a) NWS-NDFD High-Resolution Gridded Water Resources Product Suite (WRPS)



b) NWS-NDFD High-Resolution Geospatial Water Resources Product Suite (WRPS)



**Improved accuracy, Reliable uncertainty estimates, Benefit-cost effectiveness maximized**



# FY06 Activities

- Funded by the Climate Prediction Program for the Americas (CPPA) of the NOAA Climate Program Office (NCPO)
- Developed a prototype 4-Dimensional Variational Assimilator (4DVAR) for distributed SAC and kinematic wave routing models in RDHM
- Carried out testing and preliminary evaluation (see Appendix H in Folder “dj” at [http://www.weather.gov/ohd\\_files/quickpost/index.php](http://www.weather.gov/ohd_files/quickpost/index.php) )



# How does it work?

Adjust model states, observed precipitation and PE, and model errors so that the model-simulated flow is sufficiently close to the observed

$$\begin{aligned}
 \text{Minimize } J_k = & \frac{1}{2} [\mathbf{Z}_q - \mathbf{H}_{qq}(\mathbf{X}_{s,k-l}, \mathbf{X}_p, \mathbf{X}_e, \mathbf{X}_w)]^T \mathbf{R}_{qq}^{-1} \\
 & [\mathbf{Z}_q - \mathbf{H}_{qq}(\mathbf{X}_{s,k-l}, \mathbf{X}_p, \mathbf{X}_e, \mathbf{X}_w)] \\
 & + \frac{1}{2} [\mathbf{Z}_p - \mathbf{H}_{pp}\mathbf{X}_p]^T \mathbf{R}_{pp}^{-1} [\mathbf{Z}_p - \mathbf{H}_{pp}\mathbf{X}_p] \\
 & + \frac{1}{2} [\mathbf{Z}_e - \mathbf{H}_{ee}\mathbf{X}_e]^T \mathbf{R}_{ee}^{-1} [\mathbf{Z}_e - \mathbf{H}_{ee}\mathbf{X}_e] \\
 & + \frac{1}{2} [\mathbf{Z}_w - \mathbf{H}_{ww}\mathbf{X}_w]^T \mathbf{R}_{ww}^{-1} [\mathbf{Z}_w - \mathbf{H}_{ww}\mathbf{X}_w] \\
 & + \frac{1}{2} [\mathbf{Z}_b - \mathbf{H}_{bb}\mathbf{X}_{s,k-l}]^T \mathbf{R}_{bb}^{-1} [\mathbf{Z}_b - \mathbf{H}_{bb}\mathbf{X}_{s,k-l}]
 \end{aligned}$$

$$\text{subject to } \mathbf{X}_{s,j} = \mathbf{F}(\mathbf{X}_{s,j-1}, \mathbf{X}_{p,j}, \mathbf{X}_{e,j}, \mathbf{X}_{w,j}), \quad j = k-l+1, \dots, k$$

$$\mathbf{X}_{s,j}^{\min} \leq \mathbf{X}_{s,j} \leq \mathbf{X}_{s,j}^{\max}, \quad j = k-l+1, \dots, k$$

How good is my streamflow data?

How good is my rainfall data?

How good is my potential evaporation (PE) data?

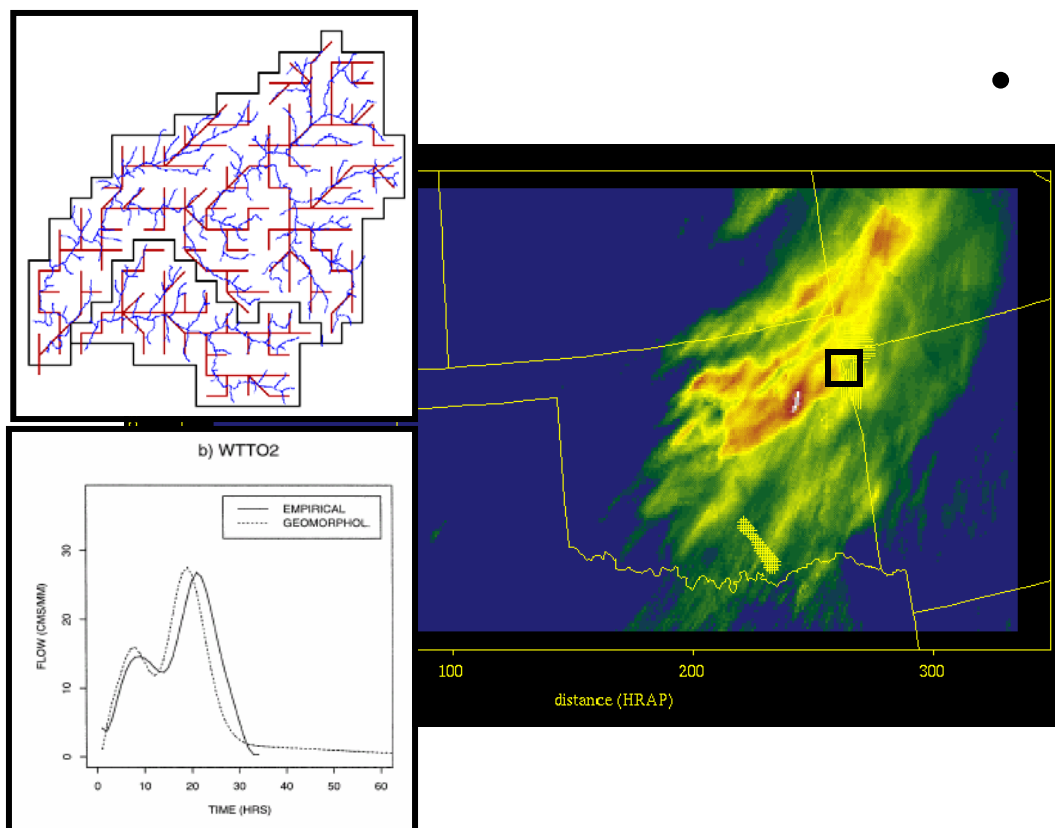
How good is my model?

What do I know about the model soil moisture states?

Whatever adjustments I am making must honor the model dynamics

The adjustments must be within physically-realistic bounds

# An example – ABRFC/WTTO2



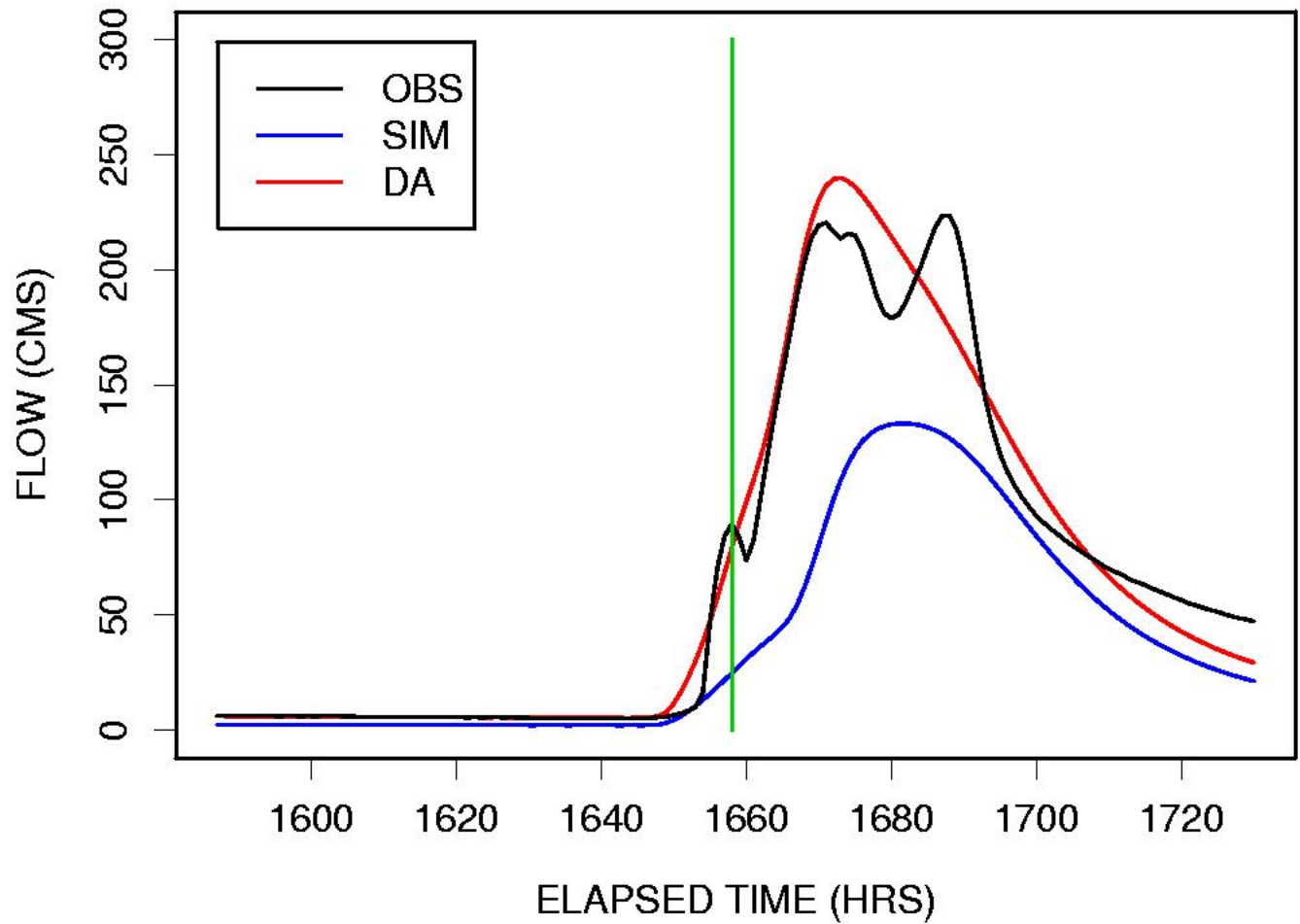
hydrograph

sac states

soil water

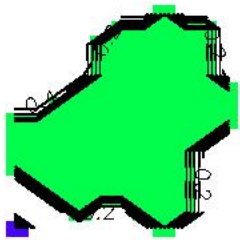
- Why WTTO2?
  - Leverage DMIP I & II
  - Interior stream gauges
    - Verification of assimilating outlet streamflow observations for monitoring and prediction of flow at interior points
    - Evaluation of assimilating additional streamflow observations at interior locations
  - Two major tributaries (bi-modal UH)
  - Assimilation of outlet flow only poses an “under-determined” problem
  - Offers an extremely stringent test for DA

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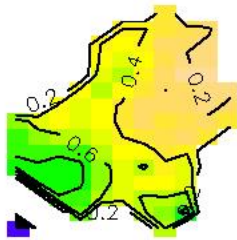




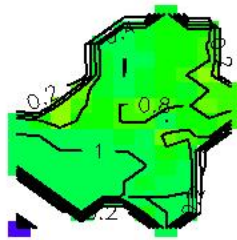
UZZTWC (w/o DA)



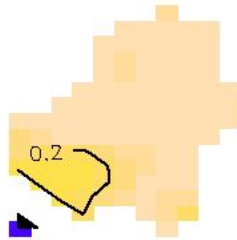
UZZFWC (w/o DA)



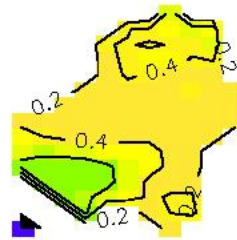
LZZTWC (w/o DA)



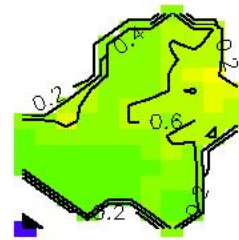
LZZFSC (w/o DA)



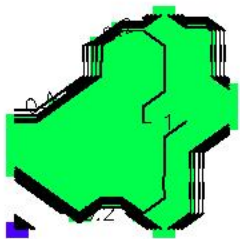
LZZFPC (w/o DA)



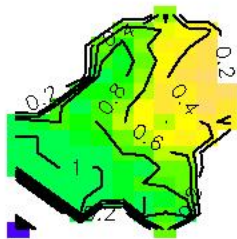
ADIMC (w/o DA)



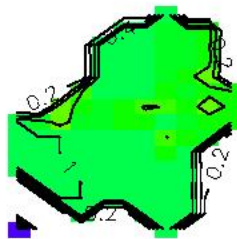
UZZTWC (w/ DA)



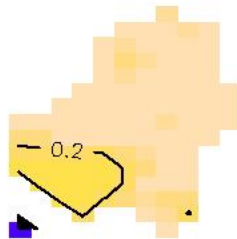
UZZFWC (w/ DA)



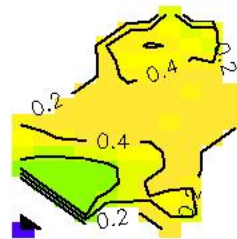
LZZTWC (w/ DA)



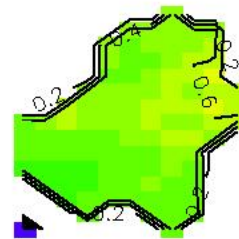
LZZFSC (w/ DA)



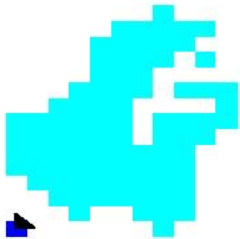
LZZFPC (w/ DA)



ADIMC (w/ DA)



HSLOPE (w/o DA)



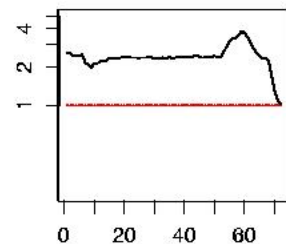
CHANNEL (w/o DA)



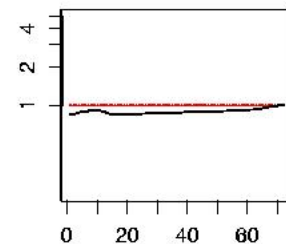
PRECIP (w/o DA)



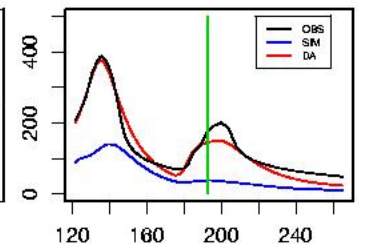
BIAS IN PRECIP



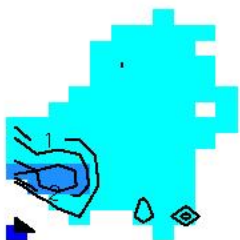
BIAS IN PE



OUTLET STREAMFLOW (CMS)



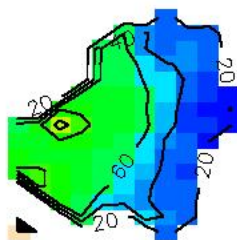
HSLOPE (w/ DA)



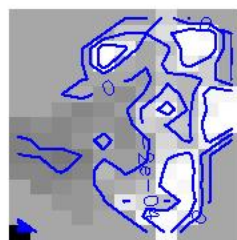
CHANNEL (w/ DA)



PRECIP (w/ DA)



BIAS IN SURF RUNOFF

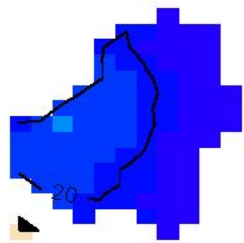


BIAS IN GW RUNOFF

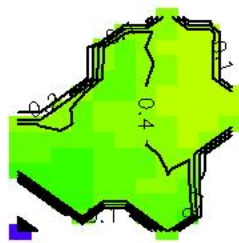


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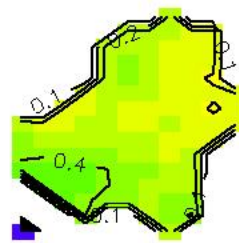
PRECIP (w/o DA)



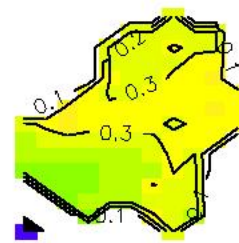
SWC 5cm (w/o DA)



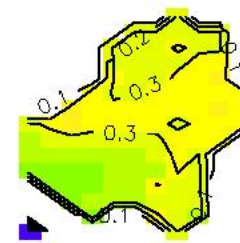
SWC 25cm (w/o DA)



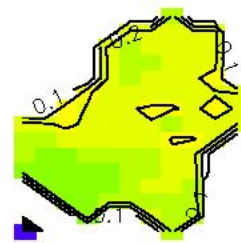
SWC 60cm (w/o DA)



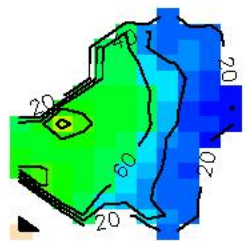
SWC 75cm (w/o DA)



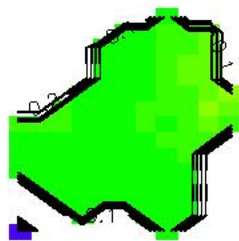
SWC 1m (w/o DA)



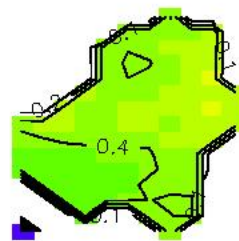
PRECIP (w/ DA)



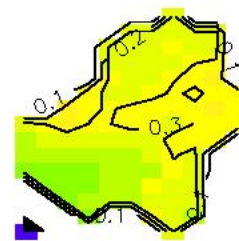
SWC 5cm (w/ DA)



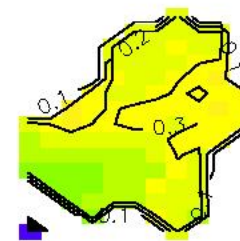
SWC 25cm (w/ DA)



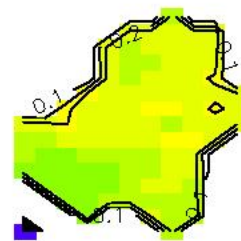
SWC 50cm (w/ DA)



SWC 75cm (w/ DA)



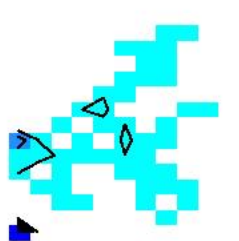
SWC 1m (w/ DA)



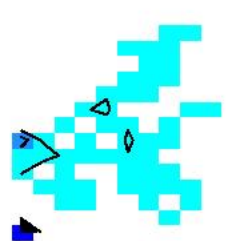
HSLOPE (w/o DA)



CHANNEL (w/o DA)



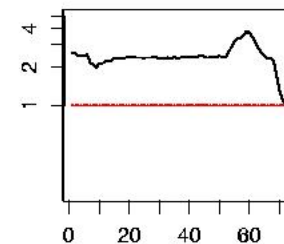
CHANNEL (w/o DA)



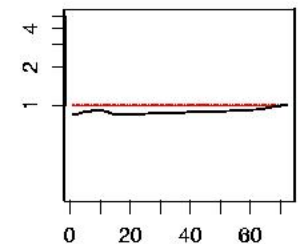
CHANNEL (w/o DA)



BIAS IN PRECIP



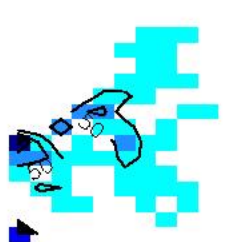
BIAS IN PE



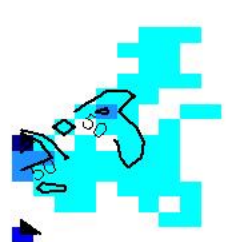
HSLOPE (w/ DA)



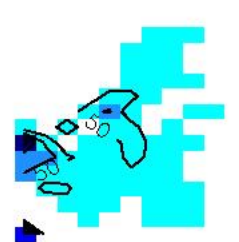
CHANNEL (w/ DA)



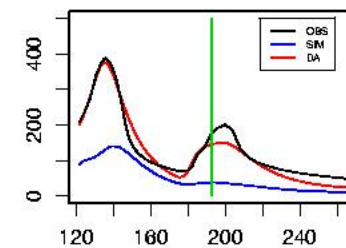
CHANNEL (w/ DA)



CHANNEL (w/ DA)



OUTLET STREAMFLOW (CMS)



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# FY07 Activities

- Continue R&D of the prototype (CPPA funding anticipated)
  - Assimilation of soil moisture data
  - Development of Maximum Likelihood Ensemble Filter-like technique to update uncertainty
- Work toward experimental operation (pending availability of AHPS funding)



Thank you