



VAR Update

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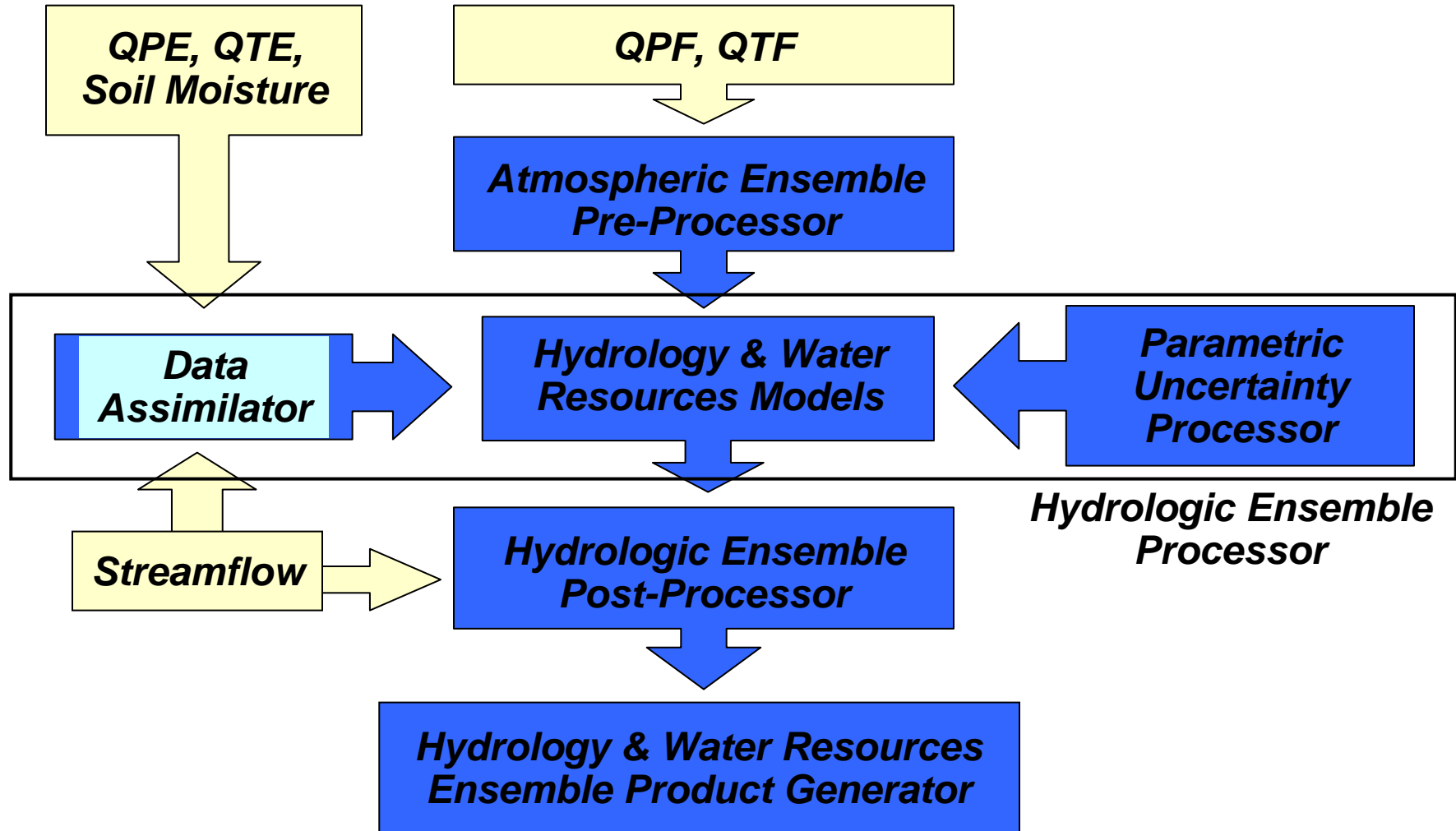
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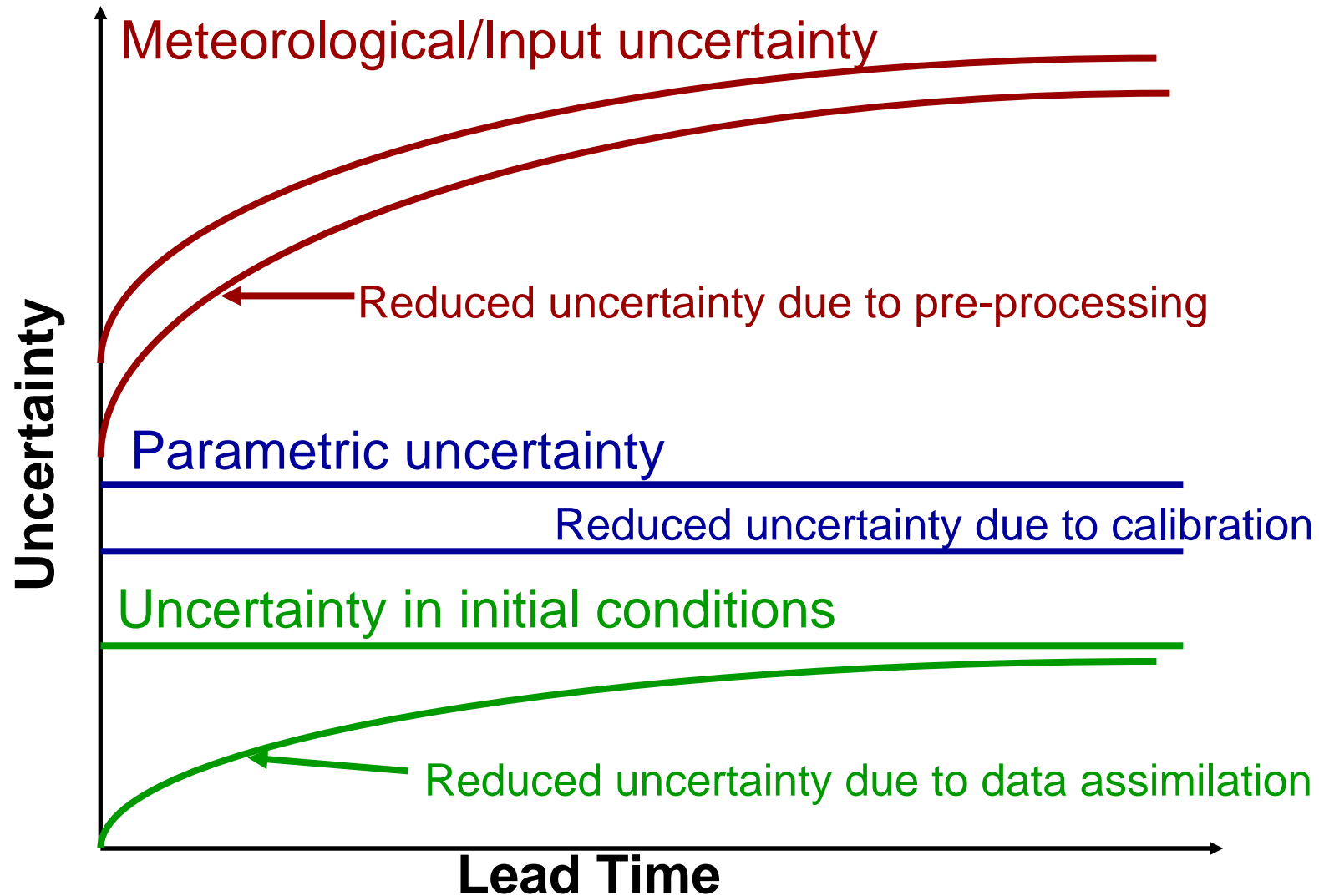


Elements of a Hydrologic Ensemble Prediction System





Uncertainties in Hydrologic Forecast





FY06 Activities

- Funded by CPPA
- Continued experimental operation of prototype VAR at WGRFC
- Carried out comparative evaluation of prototype VAR
- Summarized in Seo et al. (manuscript in internal review for submission to ASCE J. Hydrol. Eng., an earlier version is available as Appendix G in Folder “dj” at http://www.weather.gov/ohd_files/quickpost/index.php)



How does VAR work?

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

$$\begin{aligned}
 \text{Minimize } J_k &= \frac{1}{2} \sigma_q^{-2} [Z_{q,k} - H_{qq}(\mathbf{X}_{s,k-l}, X_p, X_e, X_w)]^2 && \text{How good is my streamflow data?} \\
 &+ \frac{1}{2} \sigma_p^{-2} \left[\sum_{j=k-l+1}^k Z_{p,k-l+j}^2 \right] (1 - X_p)^2 && \text{How good is my rainfall data?} \\
 &+ \frac{1}{2} \sigma_e^{-2} \left[\sum_{j=k-l+1}^k Z_{e,k-l+j}^2 \right] (1 - X_e)^2 && \text{How good is my potential evaporation (PE) data?} \\
 &+ \frac{1}{2} \sigma_w^{-2} X_w^2 && \text{How good is my model?}
 \end{aligned}$$

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

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

Whatever adjustments I may be making must follow the model dynamics

The adjustments must be within the model-physical limits

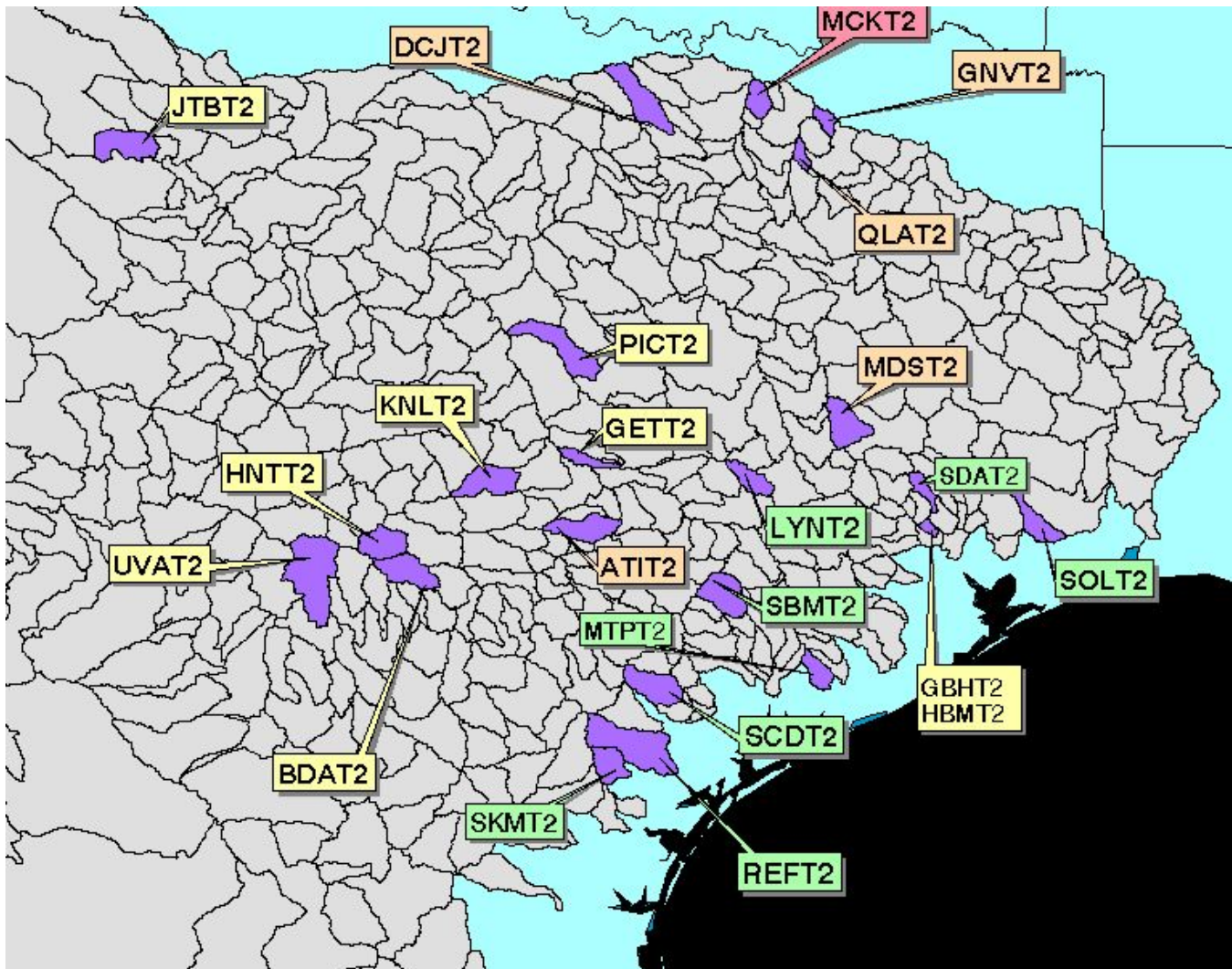


Comparative evaluation

- The evaluation period was from July 1, 2005, through July 31, 2006.
- 23 headwater basins in TX (22 in the evaluation)
- Adjustment factors to MAPX and climatological PE, estimation optimization of unit hydrograph, and local optimization of SAC parameters for 1-hr timestep were made using AB_OPT.
- VAR updated the model states every hour, whereas forecaster MOD updated the model states once every day or less frequently.
- 7 different forecasts and simulations were intercompared pairwise.
- Verification statistics were calculated for high (85th-percentile or higher), low (below 85th-percentile) and for all observed flows.
- Basin-specific verification statistics were aggregated over multiple basins according to the basin response time:
 - Fast (time-to-peak less than 12 hrs, 12 basins)
 - Intermediate (time-to-peak between 12 and 24 hrs, 8 basins)
 - Slow (time-to-peak greater than 24 hrs, 2 basins)
- The following 6 slides are excerpted from Appendix G in Folder “dj” at http://www.weather.gov/ohd_files/quickpost/index.php



Study Basins



No	Basin	Area (km ²)	T _p (hrs)
1	ATIT2	844	9
2	BDAT2	870	9
3	DCJT2	1039	6
4	GBHT2	137	5
5	GETT2	334	10
6	GNVT2	212	16
7	HBMT2	246	3
8	HNTT2	769	3
9	JTBT2	945	9
10	KNLT2	904	7
11	LYNT2	508	18
12	MCKT2	427	14
13	MDST2	870	21
14	MTPT2	435	17
15	PICT2	1178	6
16	QLAT2	197	12
17	REFT2	1787	39
18	SBMT2	896	26
19	SCDT2	932	14
20	SDAT2	285	17
21	SKMT2	640	12
22	SOLT2	1746	24
23	UVAT2	1981	13



Table 2. Types of forecasts and simulations of river stage intercompared

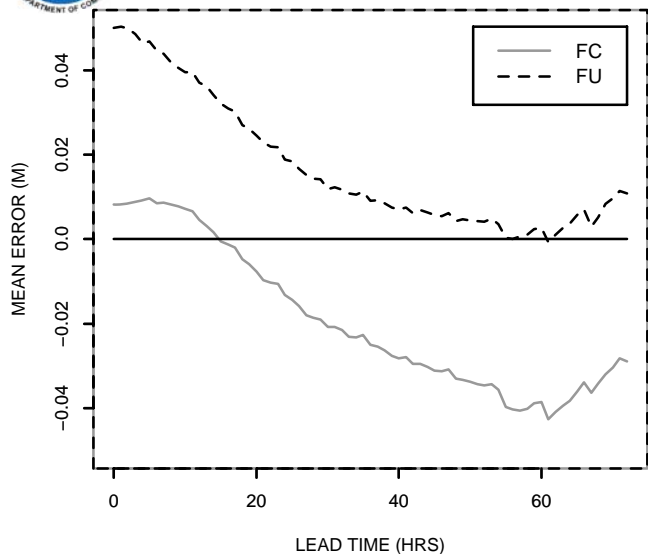
Forecast type	Timestep (hr)	Explanation
FA	1	VAR-aided SAC-UH forecast
FC	1	MOD ^a -aided SAC-UH forecast
FD	6	MOD ^a -aided SAC-UH forecast with Adjust-Q ^b
FQ	1	Raw SAC-UH simulation
FU	1	Raw SAC-UH forecast
FW	1	MOD ^a -aided SAC-UH simulation
FX	6	MOD ^a -aided SAC-UH simulation

^a Run-time modification by human forecaster.

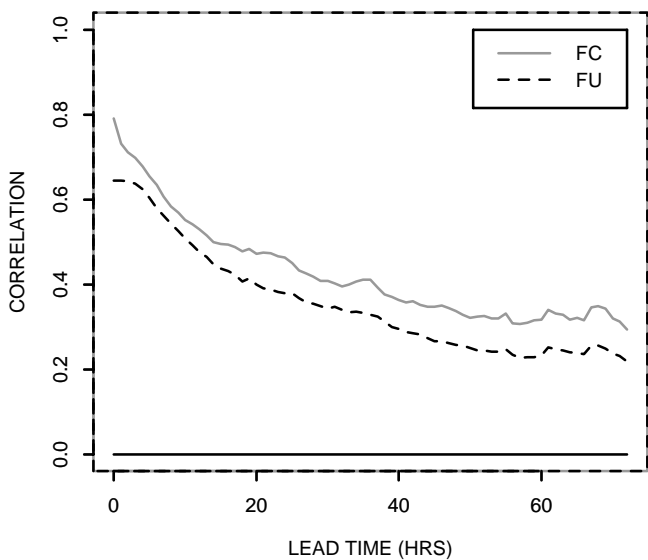
^b Weighted interpolation of flow between the model forecast and the observations over a time window such that the model forecast matches the observed over very short lead times and remains unchanged over long lead times.



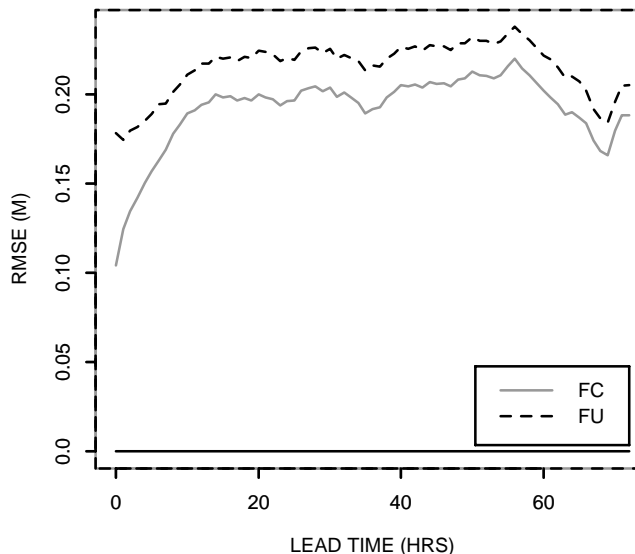
Tp <= 12 (HRS), ALL STAGES



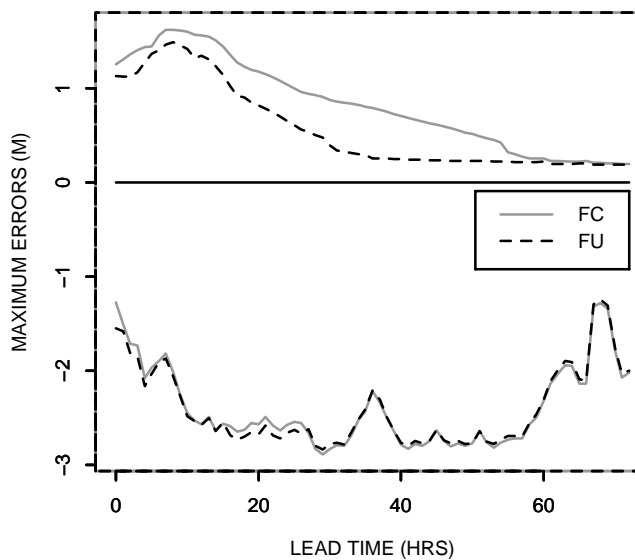
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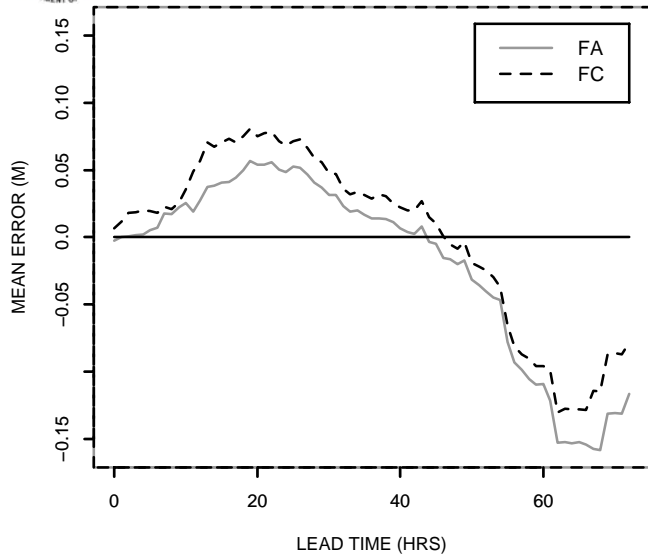


FC (solid line):
MOD-aided SAC-
UH forecast

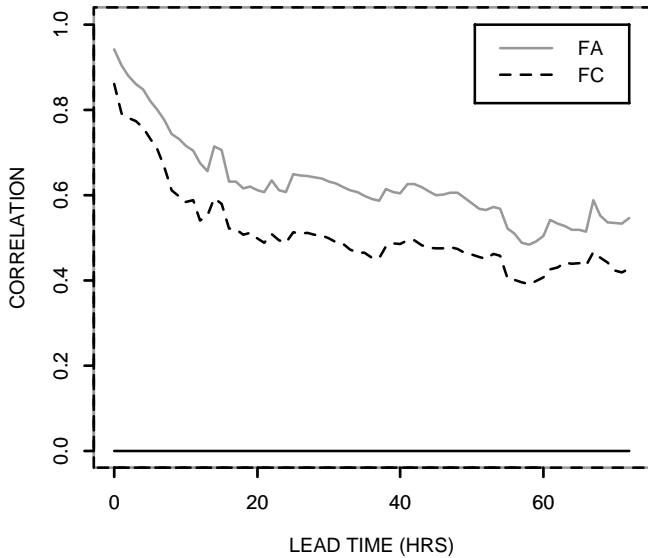
FU (dashed line):
Raw SAC-UH
forecast



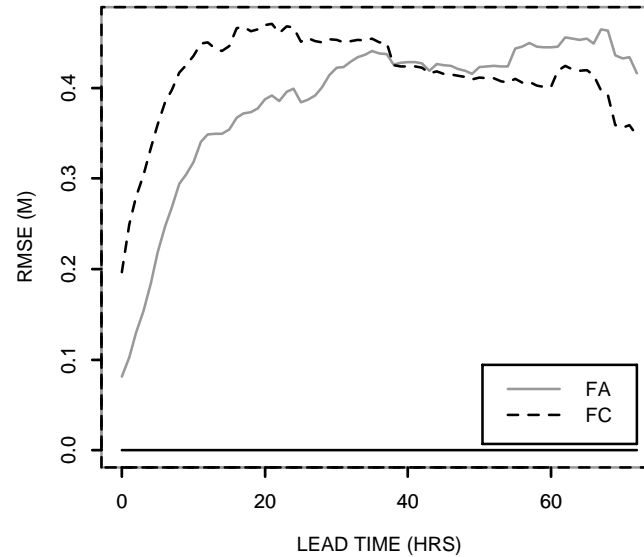
12 < Tp <= 24 (HRS), HIGH STAGES



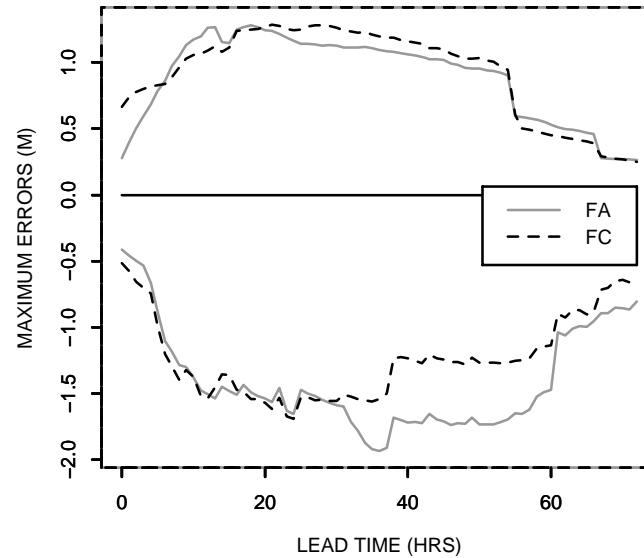
12 < Tp <= 24 (HRS), HIGH STAGES



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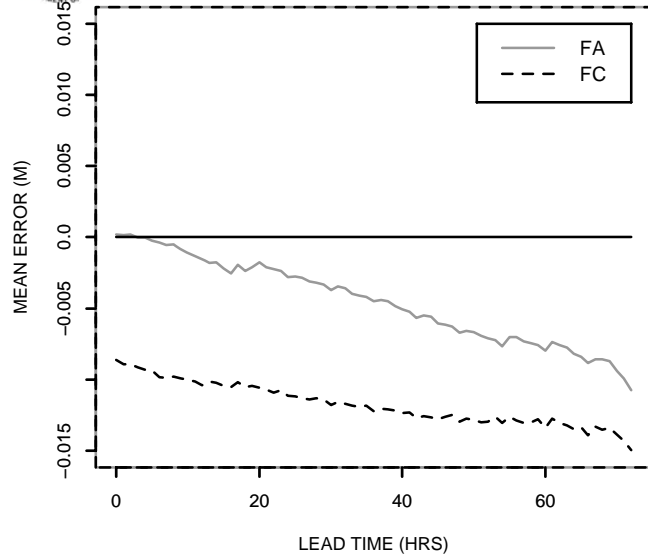


FA (solid line):
VAR-aided SAC-
UH forecast

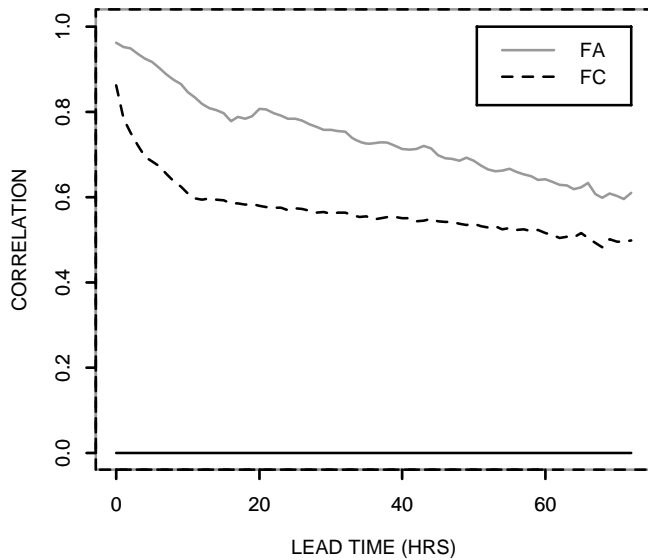
FC (dashed line):
MOD-aided SAC-
UH forecast



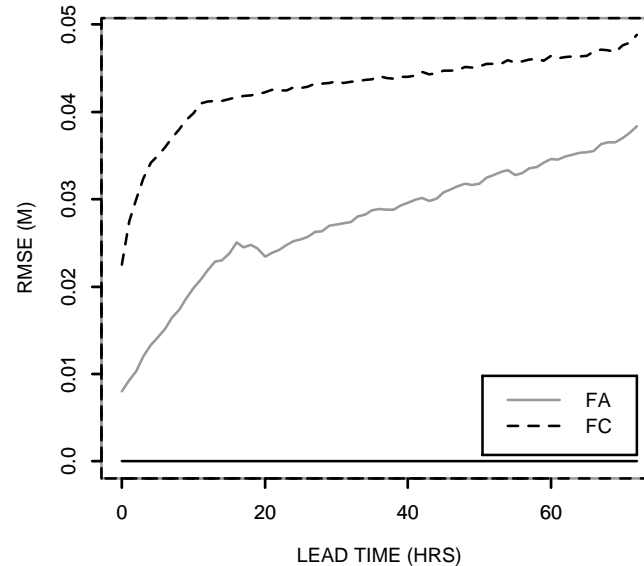
12 < Tp <= 24 (HRS), LOW STAGES



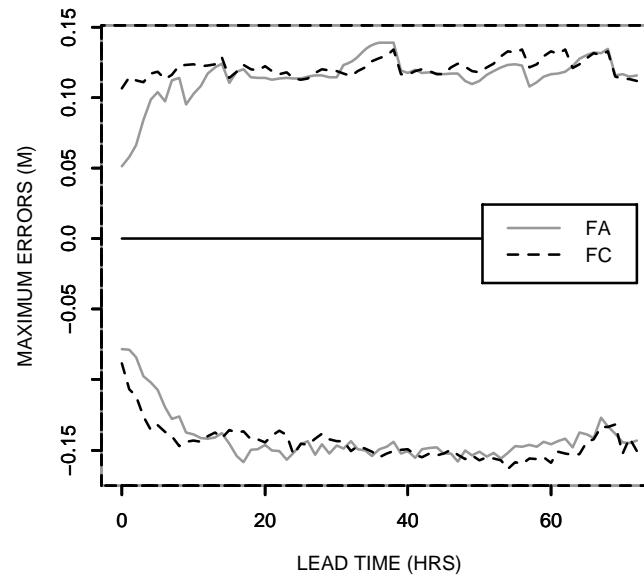
12 < Tp <= 24 (HRS), LOW STAGES



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12 < Tp <= 24 (HRS), LOW STAGES

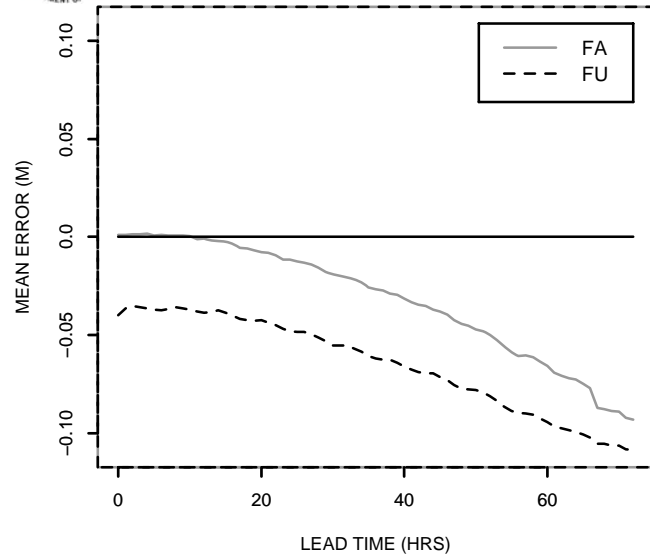


FA (solid line):
VAR-aided SAC-
UH forecast

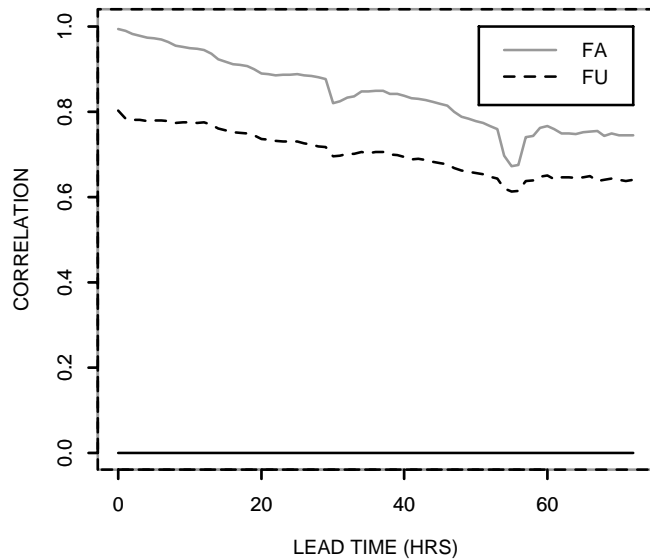
FC (dashed line):
MOD-aided SAC-
UH forecast



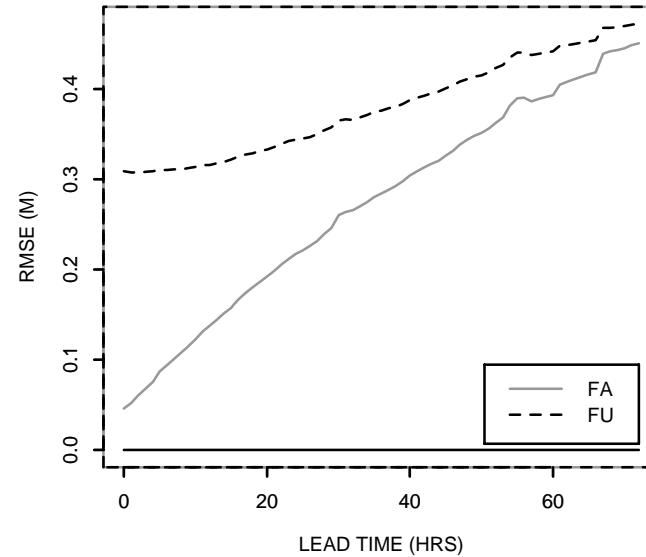
Tp > 24 (HRS), ALL STAGES



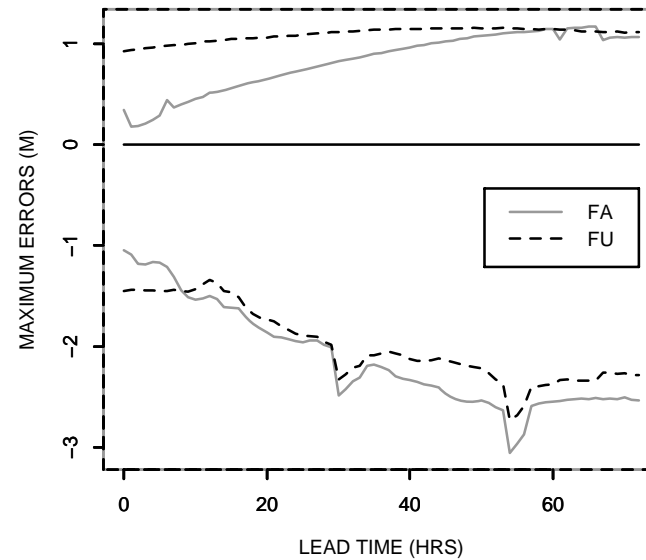
Tp > 24 (HRS), ALL STAGES



Tp > 24 (HRS), ALL STAGES



Tp > 24 (HRS), ALL STAGES



FA (solid line):
VAR-aided SAC-
UH forecast

FU (dashed line):
Raw SAC-UH
forecast



FY07 Activities

- AHPS funding anticipated to enhance data assimilation capabilities for lumped SAC-UH
 - Continue experimental operation of prototype VAR at WGRFC
 - Enhance prototype VAR to work at 6- or 3-hr timestep
 - Begin development of an ensemble DA capability that builds on the prototype VAR
- Prototype VAR to be implemented in the Gulf Coast Region as a part of Site-Specific (funded by Hurricane Supplemental)



Thank you