

Short-term Ensemble Prototype at the CNRFC

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Ensemble Challenges



- Appropriately integrate the uncertainty introduced from model, data, and human sources.

OBSERVATIONS

precipitation
air temperature
streamflow

MODEL STATES

snow
soil moisture
basin routing

MODELLING SYSTEM

simplifications
temporal issues
scale issues

???

MODEL PARAMS

snow
soil moisture
basin routing

HUMAN INPUT

education
training
experience
mental state

FORECASTS

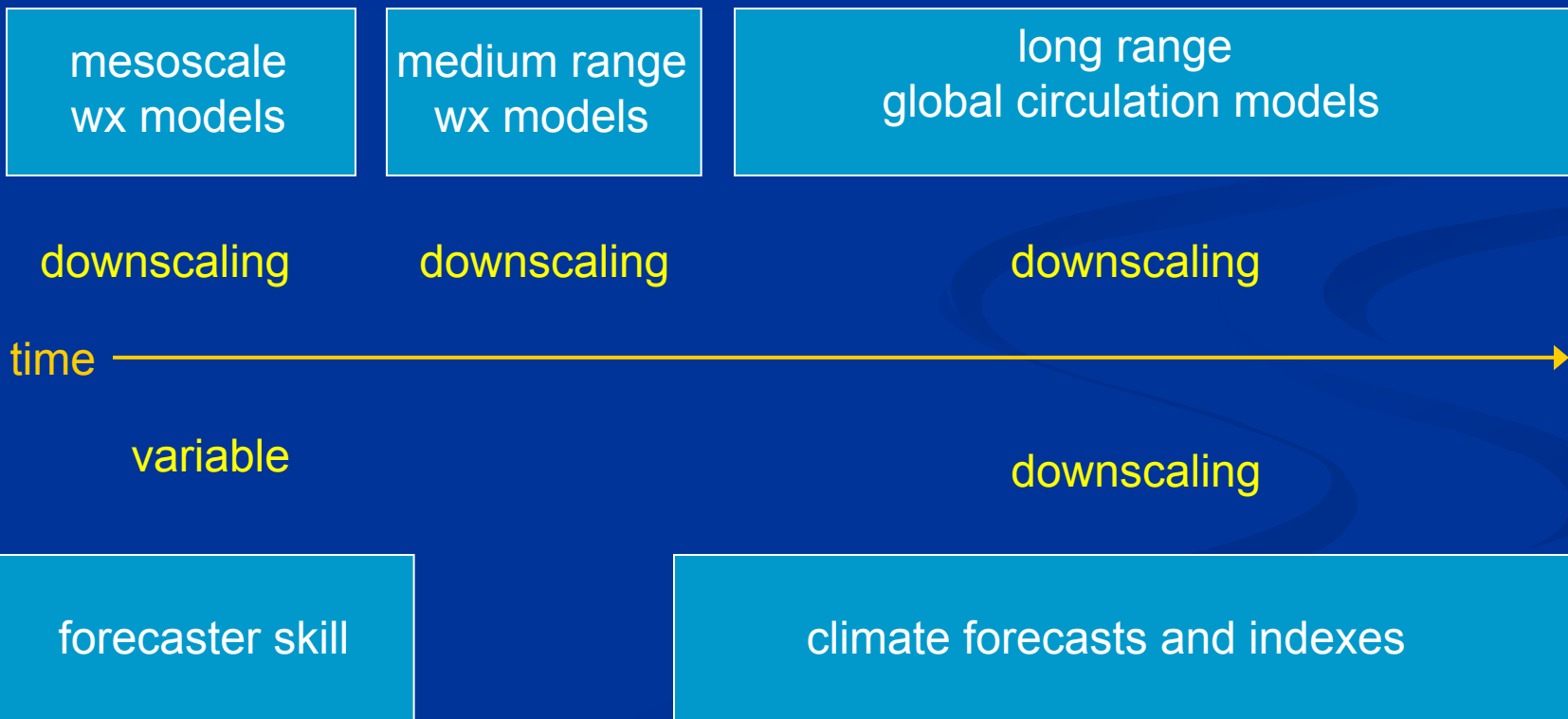
precipitation
air temperature
regulation



Ensemble Challenges



- Mesh ensemble forcing from short, medium, and long range techniques.

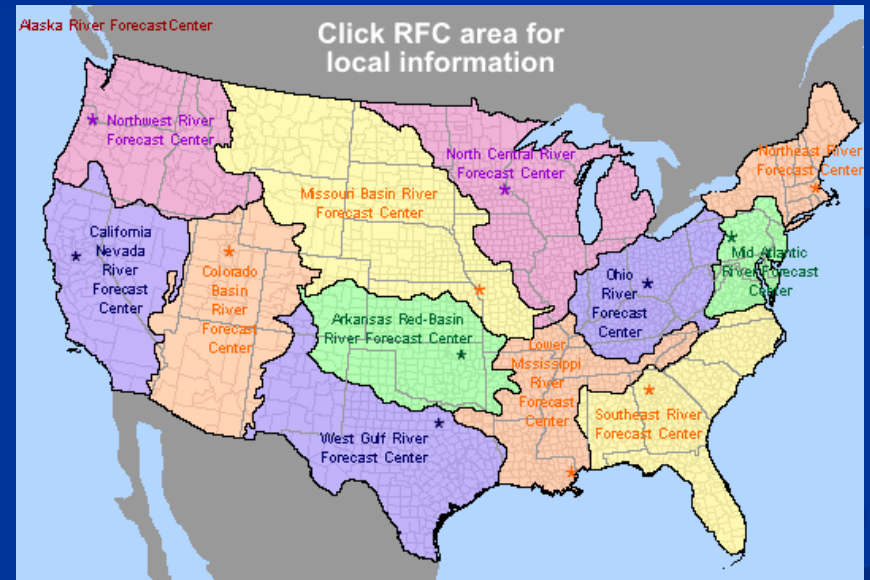
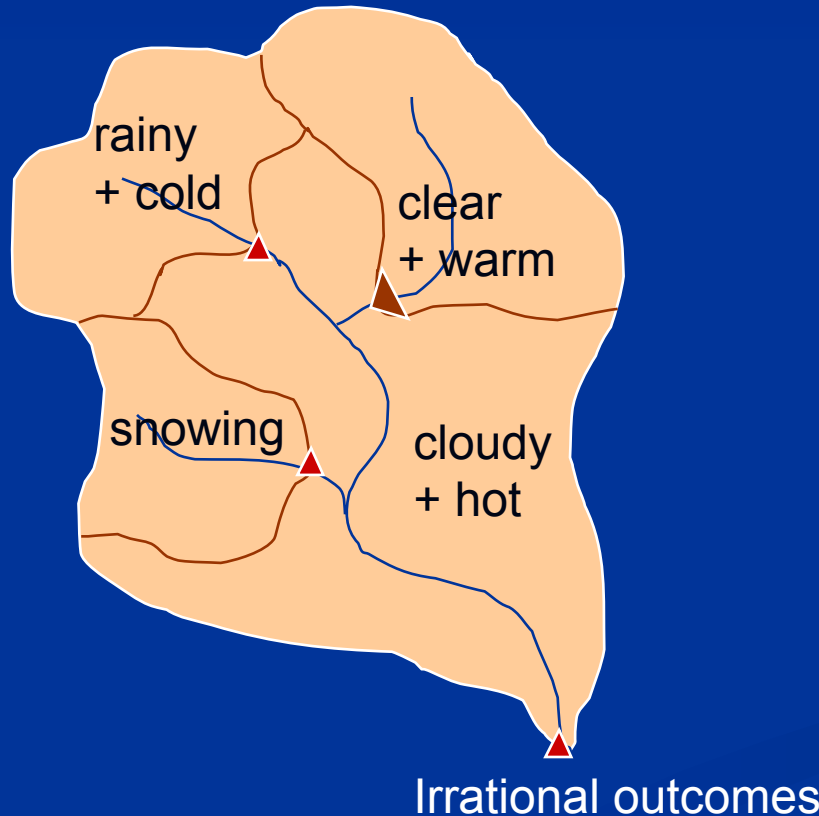




Ensemble Challenges



- Maintain spatial and temporal relationships across very large areas.





Ensemble Challenges



- Include forecaster skill in short-term inputs (QPF, temperature, etc.)



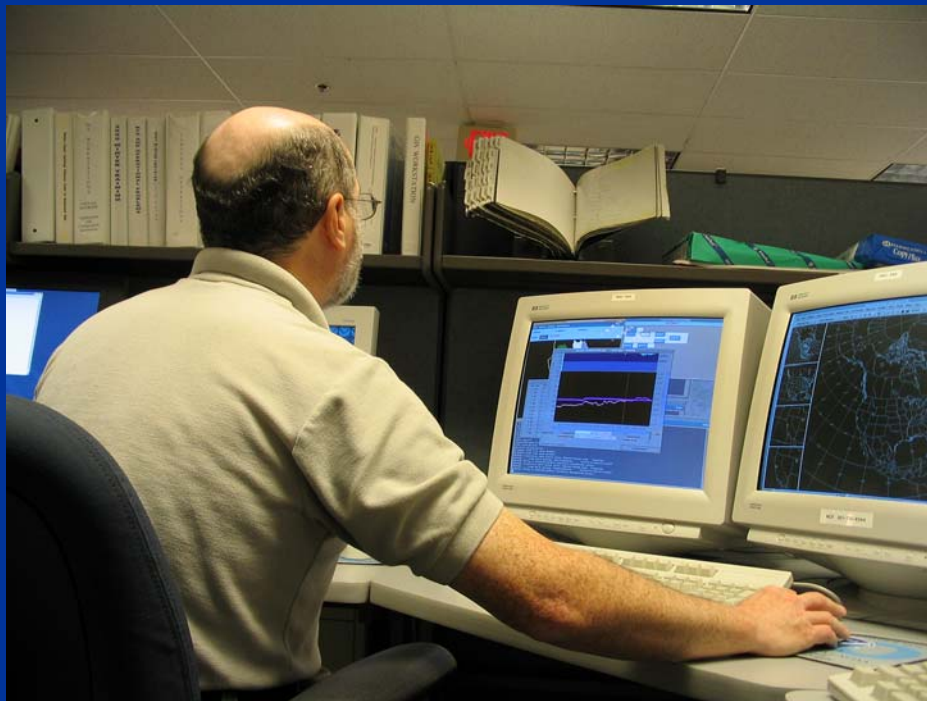
- Forecasters add value to short-term QPF.
 - HPC adds value to models
 - RFC adds value to HPC



Ensemble Challenges



- Include forecaster guidance of hydrologic model operation



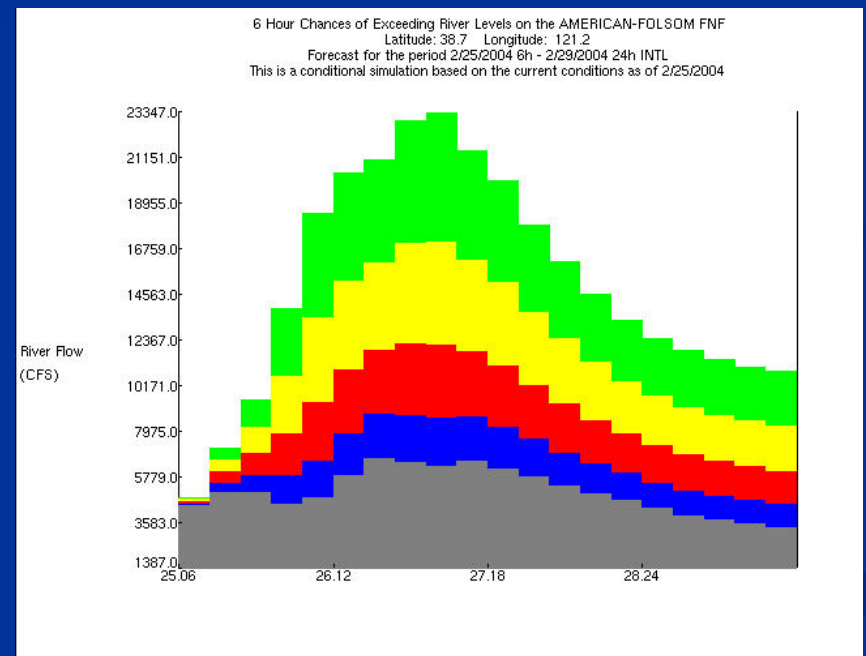
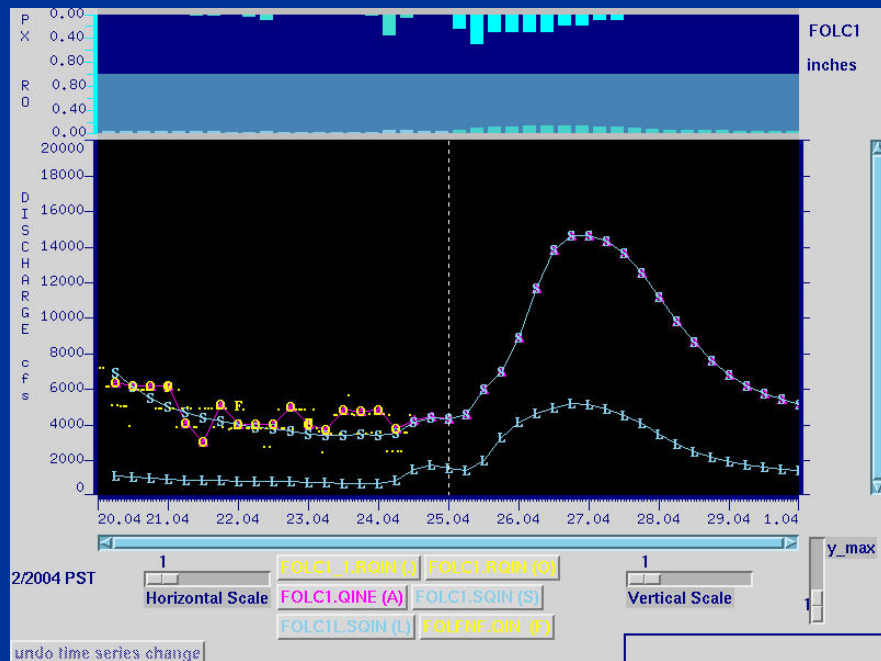
- Hydrologic models require on-going tuning.
- Forecasters commonly adjust or influence raw model output.



Ensemble Challenges



- Maintain coherence between deterministic and ensemble forecasts





Short-term Ensemble Prototype



- 5 day Precipitation and temperature ensembles
- Based on operational deterministic precipitation and temperature forecasts
- Uses forecast (skill) and watershed climatology



Eureka!!!



Dirac e delta fn.

pdf

$P_0 \cdot \delta(0)$

$(1-B) f_c(p|p>0)$

Weibull

σ_{pc}

μ_{pc}

$F(v)$

cdf

$F_x(x)$

$F_y(y)$

$v = G^{-1}(G(v)) = G^{-1}(F_y(y))$

$G(v) = F_y(y)$; $y = F_y^{-1}(G(v))$

$x \rightarrow u \Rightarrow F_{vu}(v|u) = F_{yx}(y|x)$

$v|u(\pi) = F_{vu}^{-1}(\pi) = F_{yx}^{-1}(y|x)$

$G(v|u(\pi)) = G(F_{vu}^{-1}(\pi))$

$y|x = F_y^{-1}(G(v|u(\pi))) = F_y^{-1}(G(F_{vu}^{-1}(\pi)))$

$\pi = F_x(y|x)$

$f_{xy}(x,y) = f_{vu}(v|u) \cdot f_x(u)$

$f_{xy}(x,y) = f_{yx}(y|x) \cdot f_x(x)$

$\lambda = x_{aug}$

$\sigma = x_{std}$

$\lambda + \frac{\sigma^2}{2} + \frac{\sigma^4}{24} + \dots = 1$

$\lambda = \alpha + \beta u$

$\sigma = \gamma u$

$\sigma^2 = \gamma^2 u^2$

y_1

y_2

y_3

y_4

y_5

y_6

y_7

y_8

y_9

y_{10}

y_{11}

y_{12}

y_{13}

y_{14}

y_{15}

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y_{95}

y_{96}

y_{97}

y_{98}

y_{99}

y_{100}

$x \rightarrow F_x \rightarrow F(v) = G(v) \rightarrow \text{Prob} \rightarrow \pi \rightarrow u$

MA7/1 Oct 60 - Sept 79

5 years AMPC recd # days

2003 E Sierra, Humboldt 17

2004 N Coast, Ross Mt 31

2005 Central Coast, San Gil 31

2006 Up + Low San 32

2007 Up + Low San 3, San Delta 48



Ensemble Challenges



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Temperature Ensembles



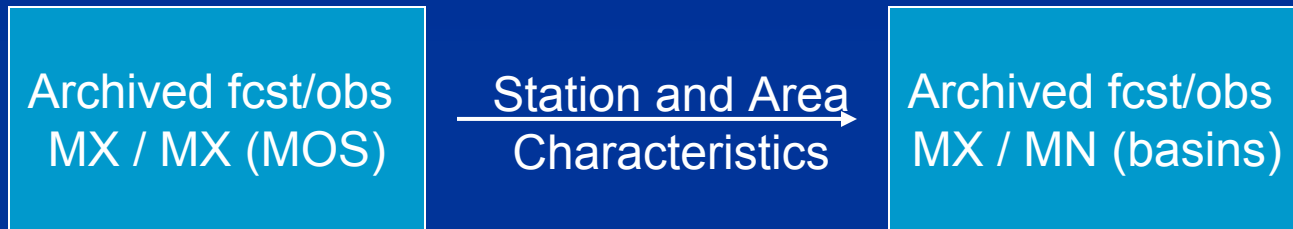
- **Have**
 - Archived (6yrs) MAX/MIN temperature forecasts for MOS locations.
 - Archived (6yrs) Observed MAX/MIN temperatures for MOS locations.
 - Calibration (~40yrs) MATs for each basin.
 - Station and Area characteristics.
 - Forecast MAX MIN temperatures for MOS locations (next 7days).
- **Need**
 - 6 hr MAT ensembles for basins for the next 20 periods (120 hrs).



Temperature Ensembles



- Translate archived forecast and observed MX/MN values from MOS locations to basins.

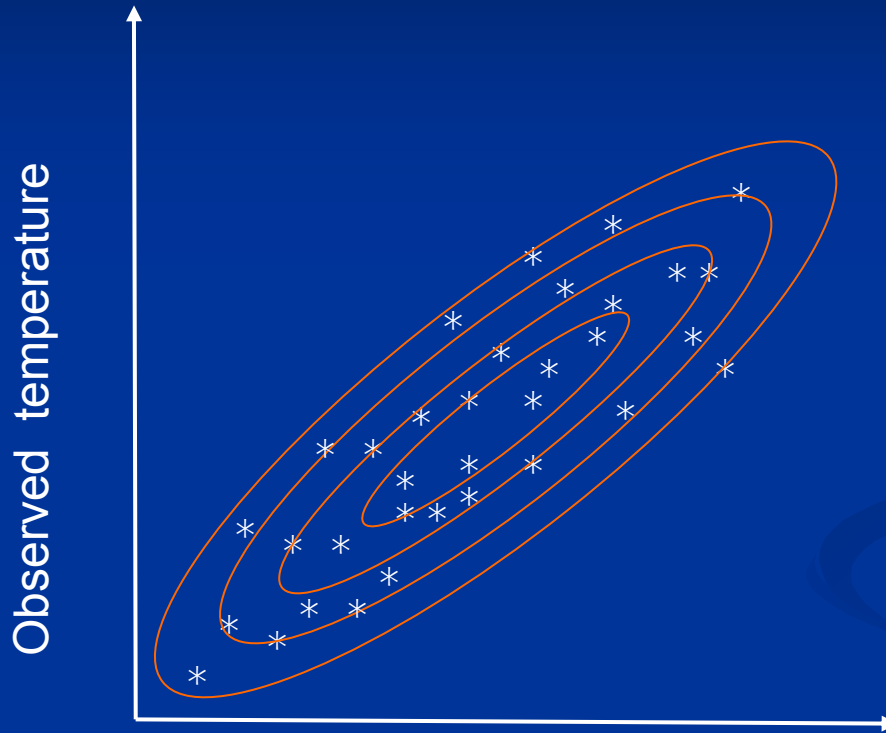
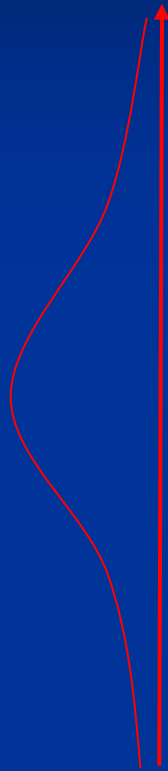


- Create calibration period MX/MN “observations” for basins by running MAT preprocessor backwards.

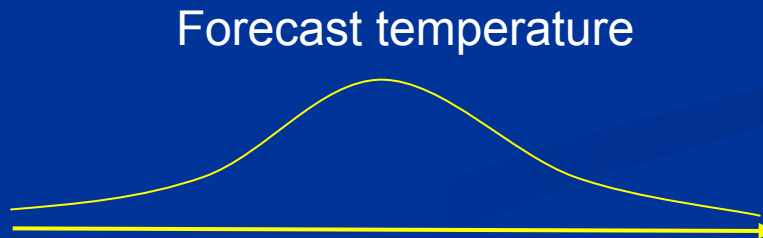




Joint Distribution

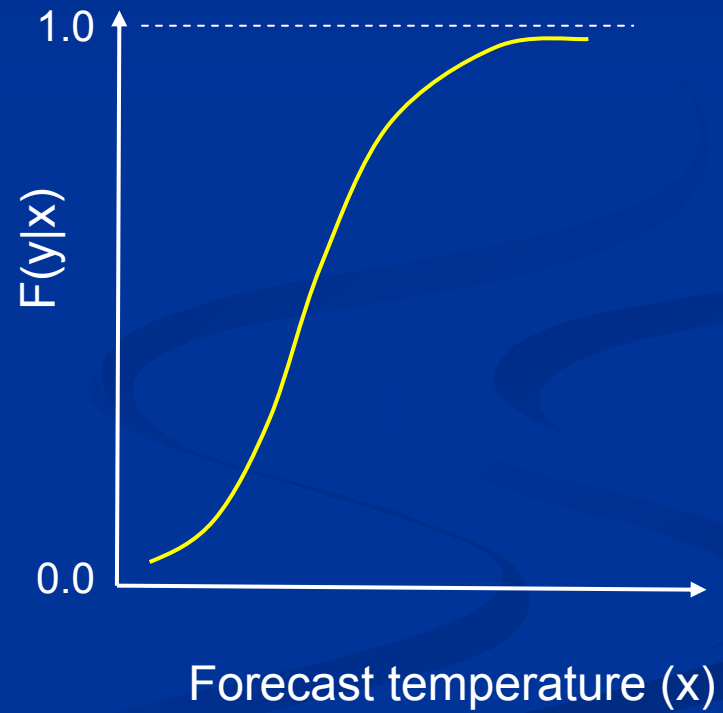
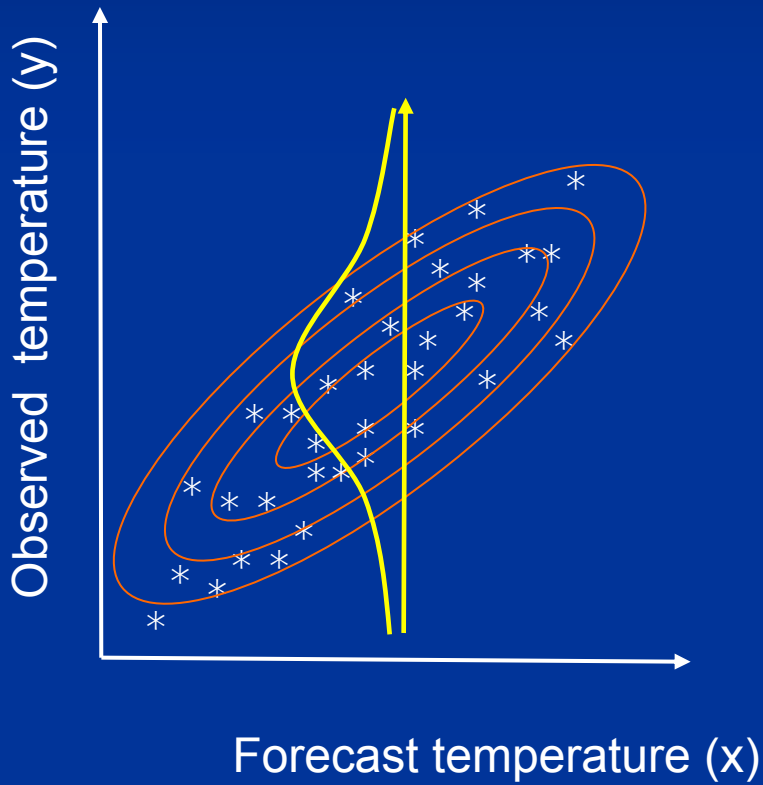


- Developed for:
 - Max and Min
 - Each lead time
 - Each period
 - Monthly (90 day window)



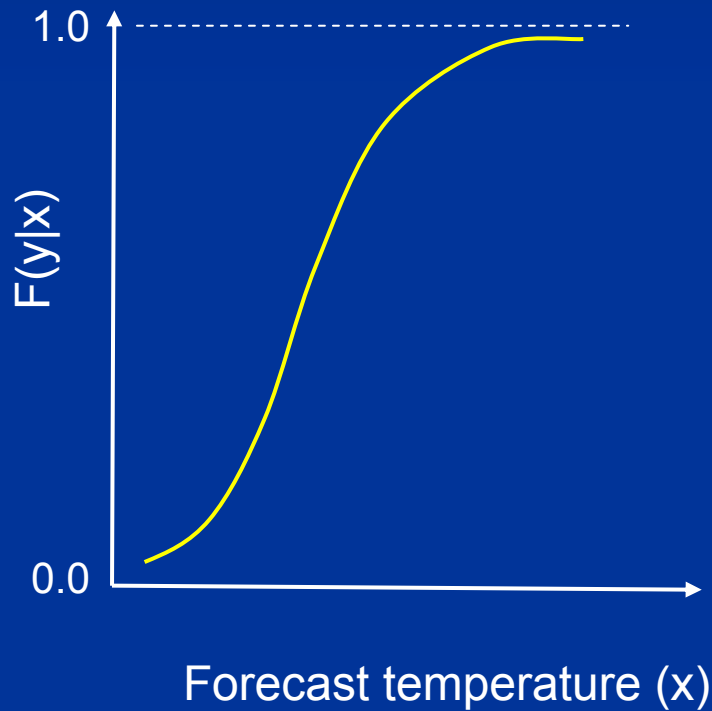


CDF of observed | forecast





Create Max / Min Ensembles



- Sample $F(y|x)$
 - 1/nth intervals
 - integrate within range
- Place into ensembles
 - Schaake Shuffle



Temperature Ensembles



- Create temperature ensembles by running max and min ensembles through the MAT preprocessor.

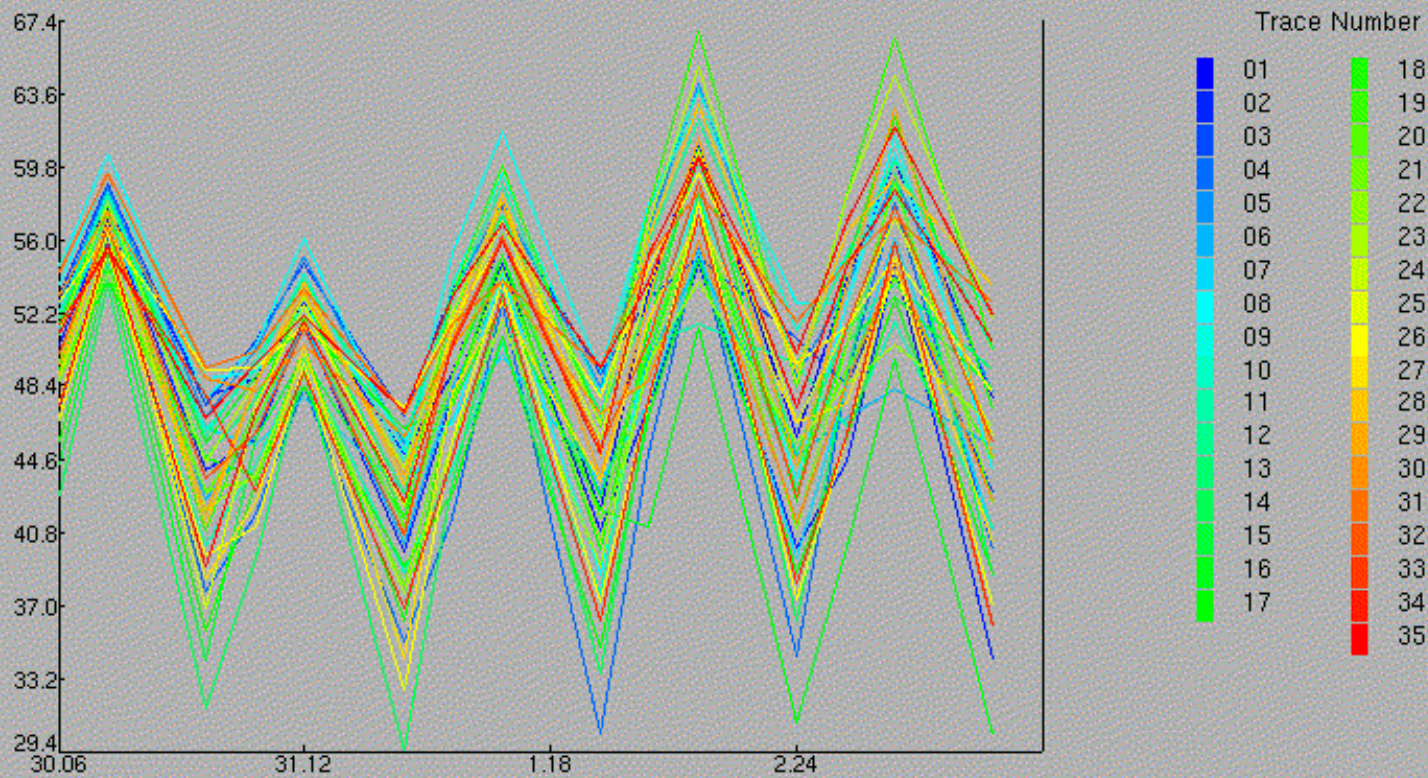




6 Hour Temperature - Ensembles

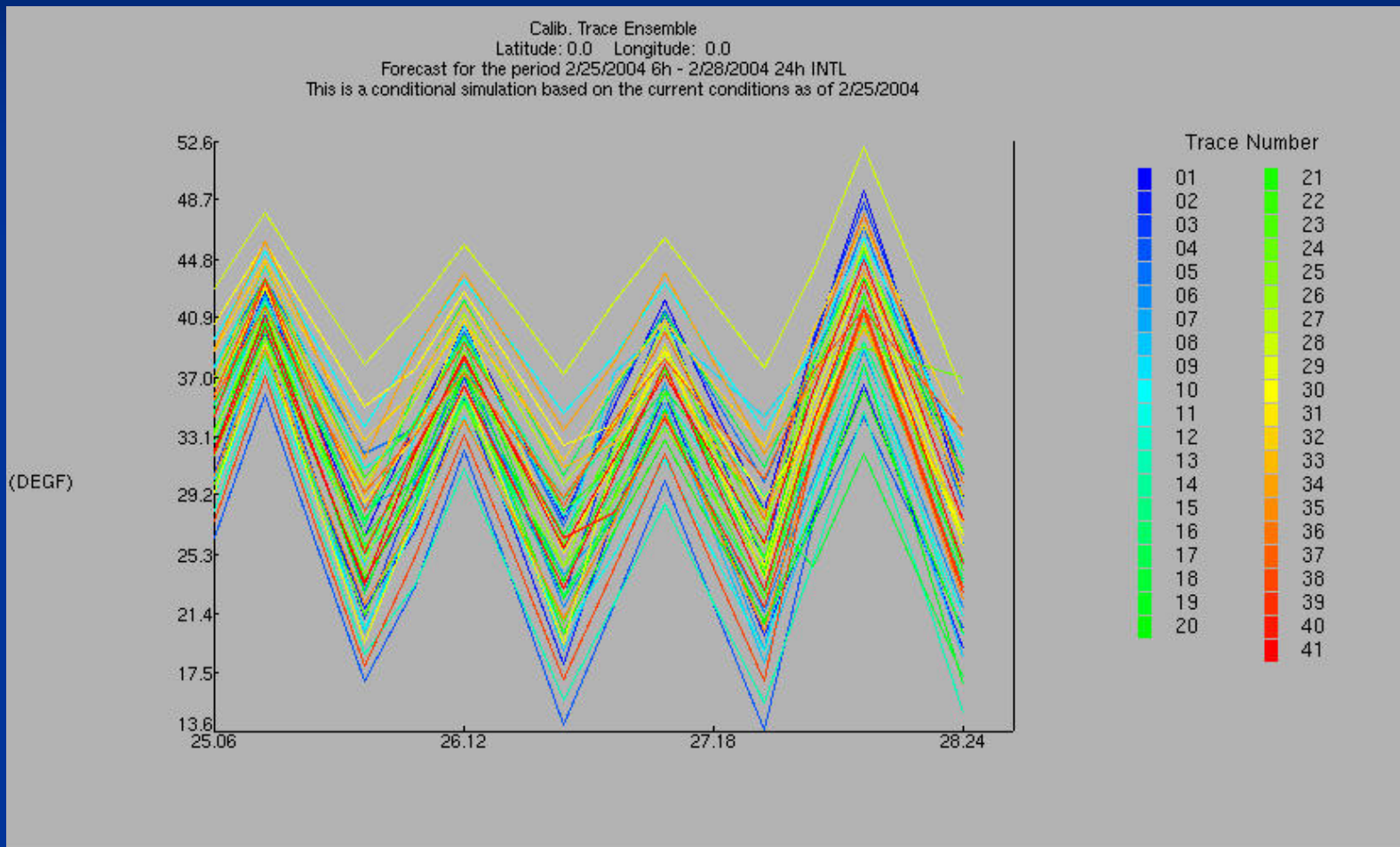
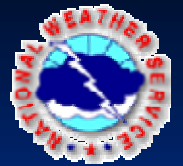


Calib. Trace Ensemble
Latitude: 0.0 Longitude: 0.0
Forecast for the period 10/30/2003 6h - 11/3/2003 24h INTL
This is a conditional simulation based on the current conditions as of 10/30/2003



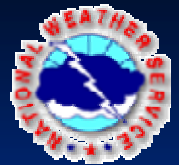


5 day temperature ensembles

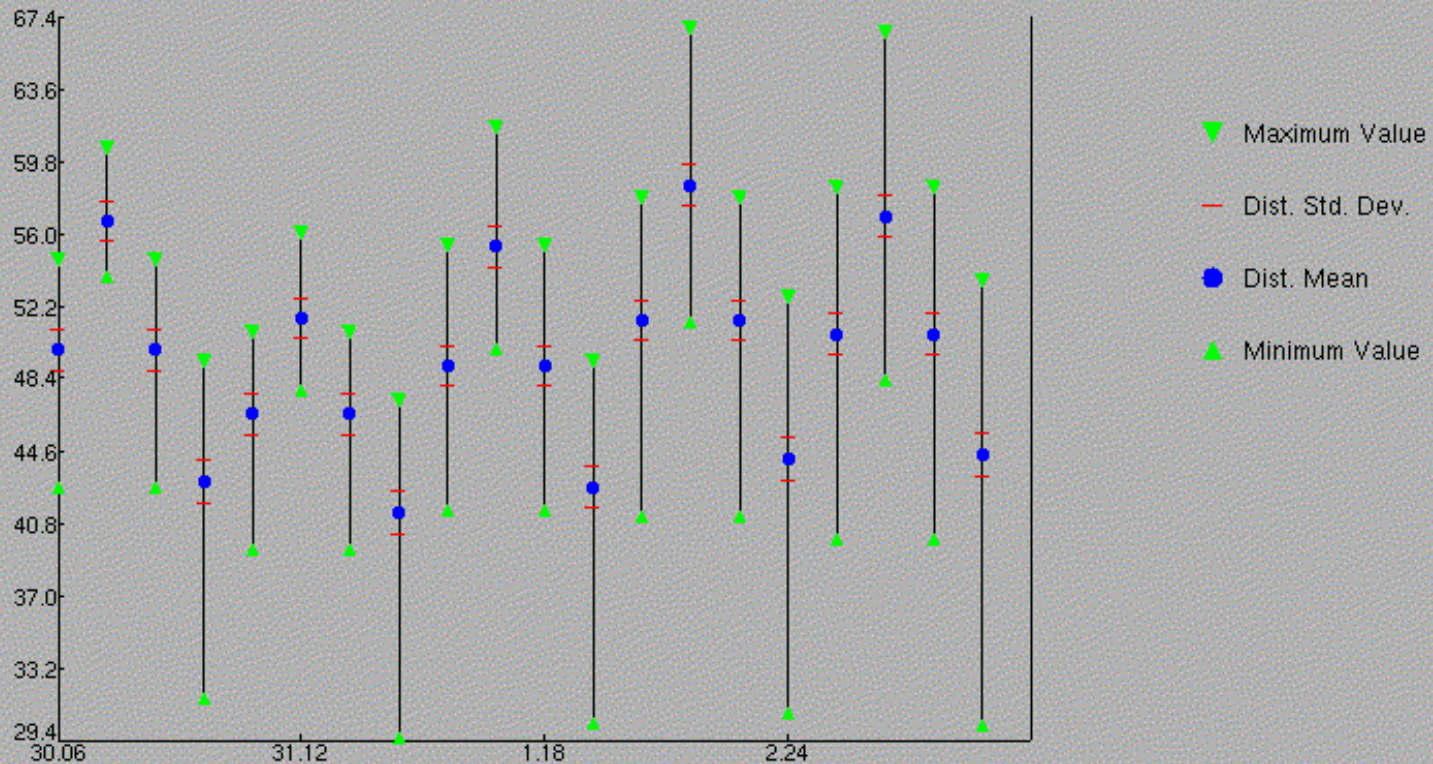




6 Hour Temperatures Expected Values



Calib. Expected Value
Latitude: 0.0 Longitude: 0.0
Forecast for the period 10/30/2003 6h - 11/3/2003 24h INTL
This is a conditional simulation based on the current conditions as of 10/30/2003



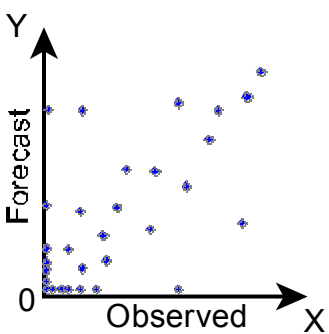


Precipitation Ensembles (not quite so simple!)



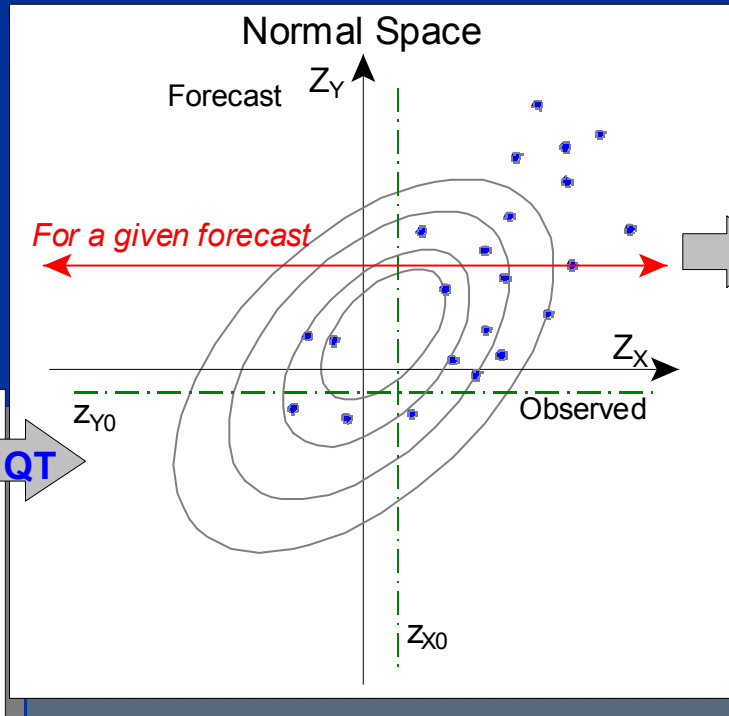
No assumption of normality for observed & forecast distributions

Archived data

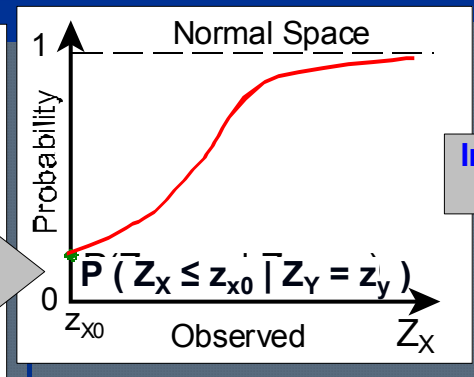


NQT

Joint distribution



Conditional Distribution

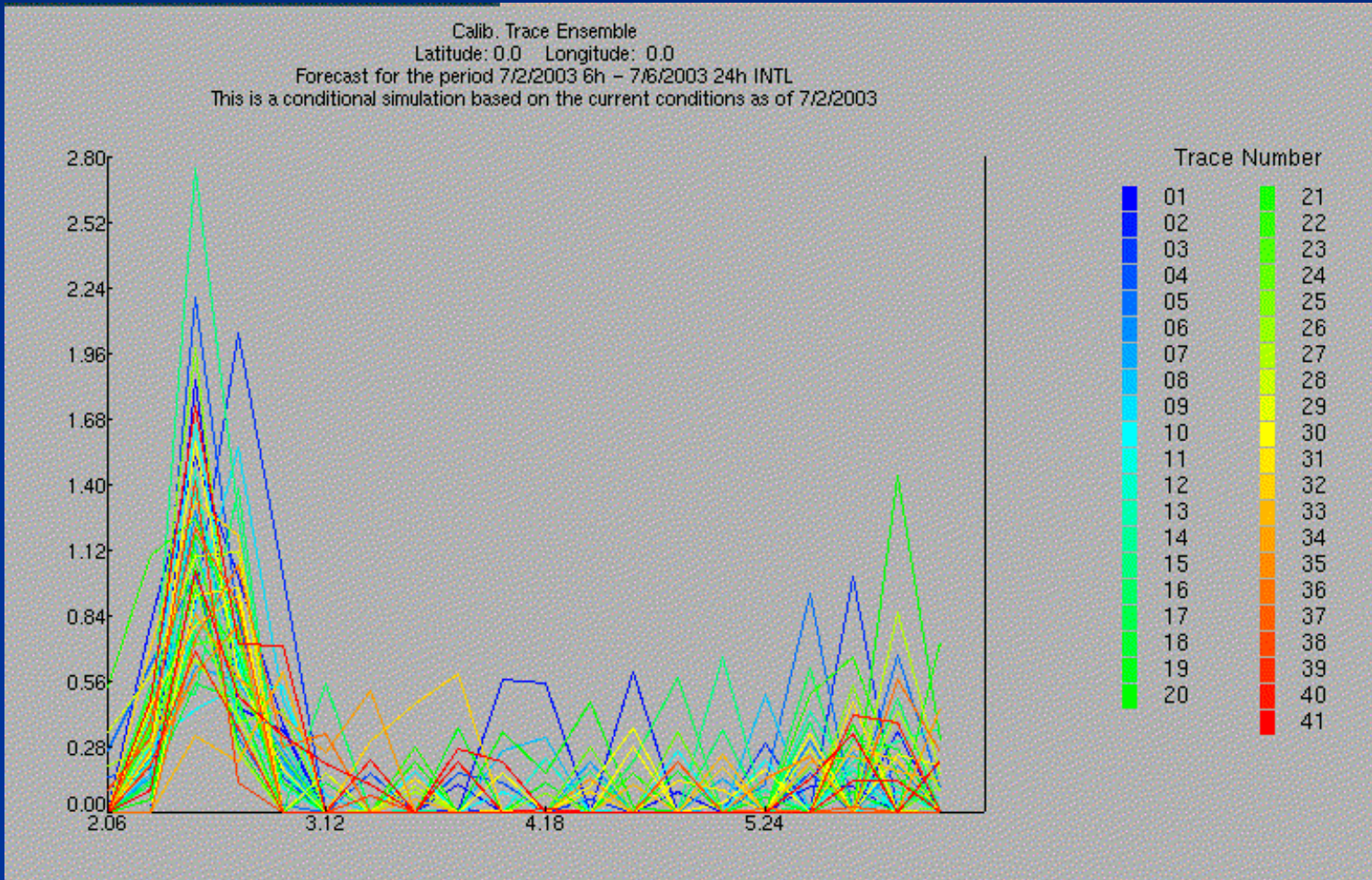


Inverse NQT

PQPF given a QPF

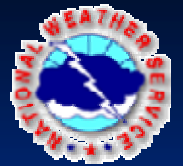


6 Hour Precipitation - Ensembles

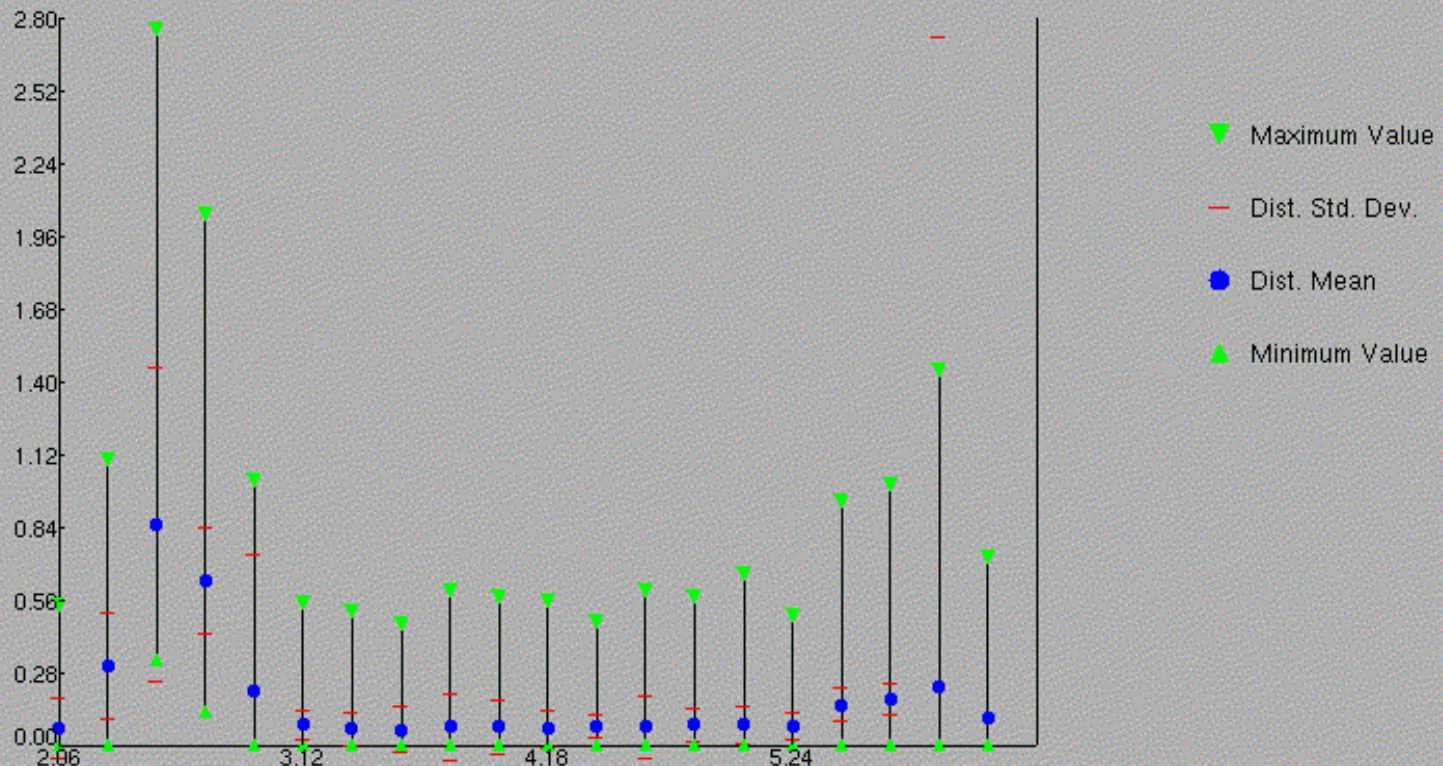




6 Hour Precipitation Expected Values



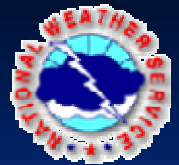
Calib. Expected Value
Latitude: 0.0 Longitude: 0.0
Forecast for the period 7/2/2003 6h - 7/6/2003 24h INTL
This is a conditional simulation based on the current conditions as of 7/2/2003



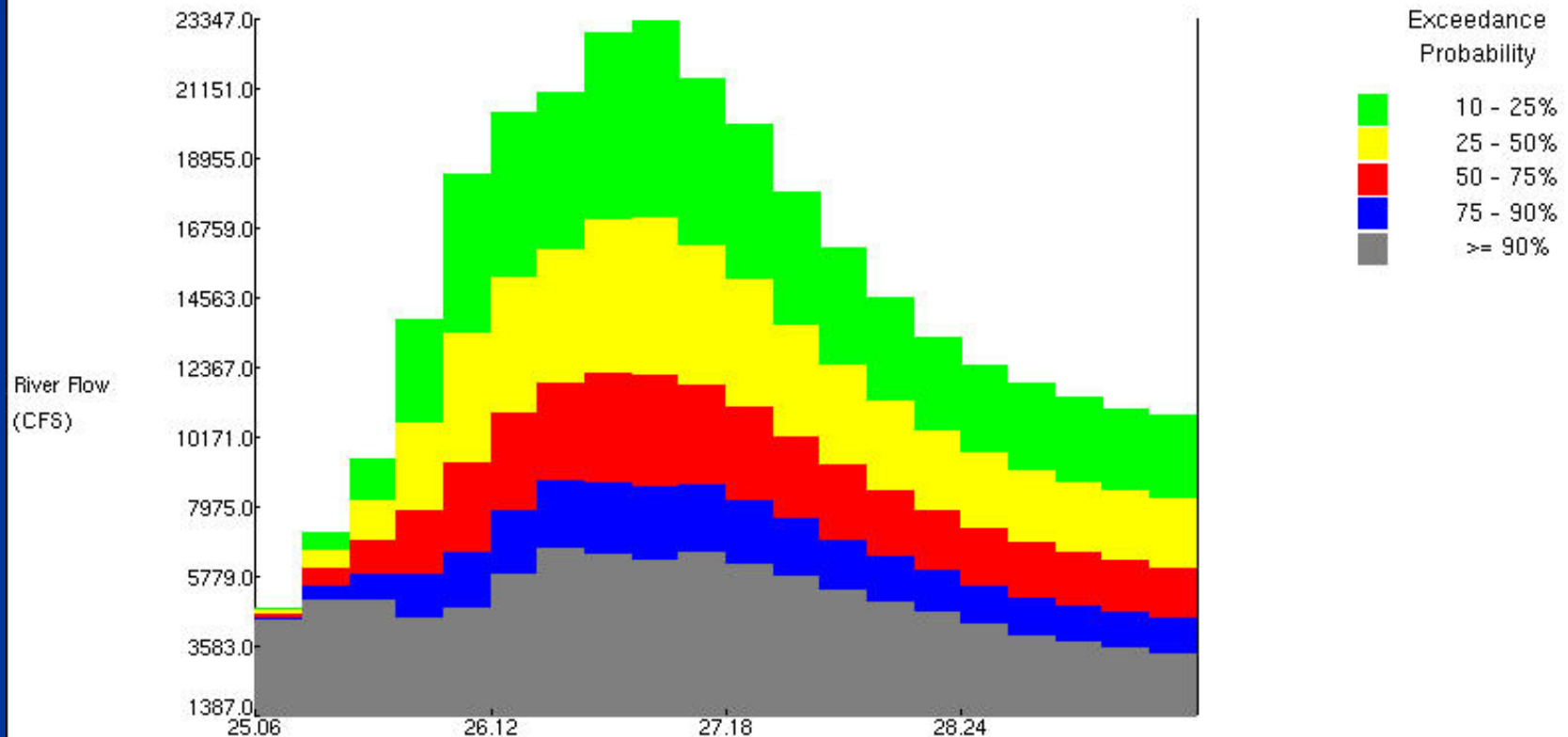
5.12, 2.30



American River – 5 day ESP



6 Hour Chances of Exceeding River Levels on the AMERICAN-FOLSOM FNF
Latitude: 38.7 Longitude: 121.2
Forecast for the period 2/25/2004 6h - 2/29/2004 24h INTL
This is a conditional simulation based on the current conditions as of 2/25/2004





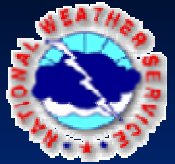
Obvious Next Steps



- Implement in more active (coastal) watersheds.
- Validate outcomes.
 - Are the distributions reasonable (accurate)?
 - More experience.
 - Retrospective analysis needed.
- Update statistics with additional forecasts and observations.



Concerns



- We're only dealing with the future forcing.
 - Need to include (approximate) other sources of uncertainty (model, data, etc.)
- Ensemble mean is always less than QPF when $QPF > \text{climatology}$ and $\text{skill} < 1.0$
 - QPF is not biased...
 - Will this create a bias?
 - Too conservative?
 - Lots to learn here!
- Major effort to really systematize this into actual operational context.
 - Lets get started!



Thank You