# Ensemble Forecasting Lab Activities

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- Introduction and Ensemble Activities
- Ensemble Pre-Processor Methodology
- Ensemble Pre-Processor Status by Component
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  - *Calibration*
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  - *Papers*
- ESP system
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  - *Future ESP System: VAR, Processors for other uncertainties*
  - *Verification*
  - *Architecture*
- Conclusion

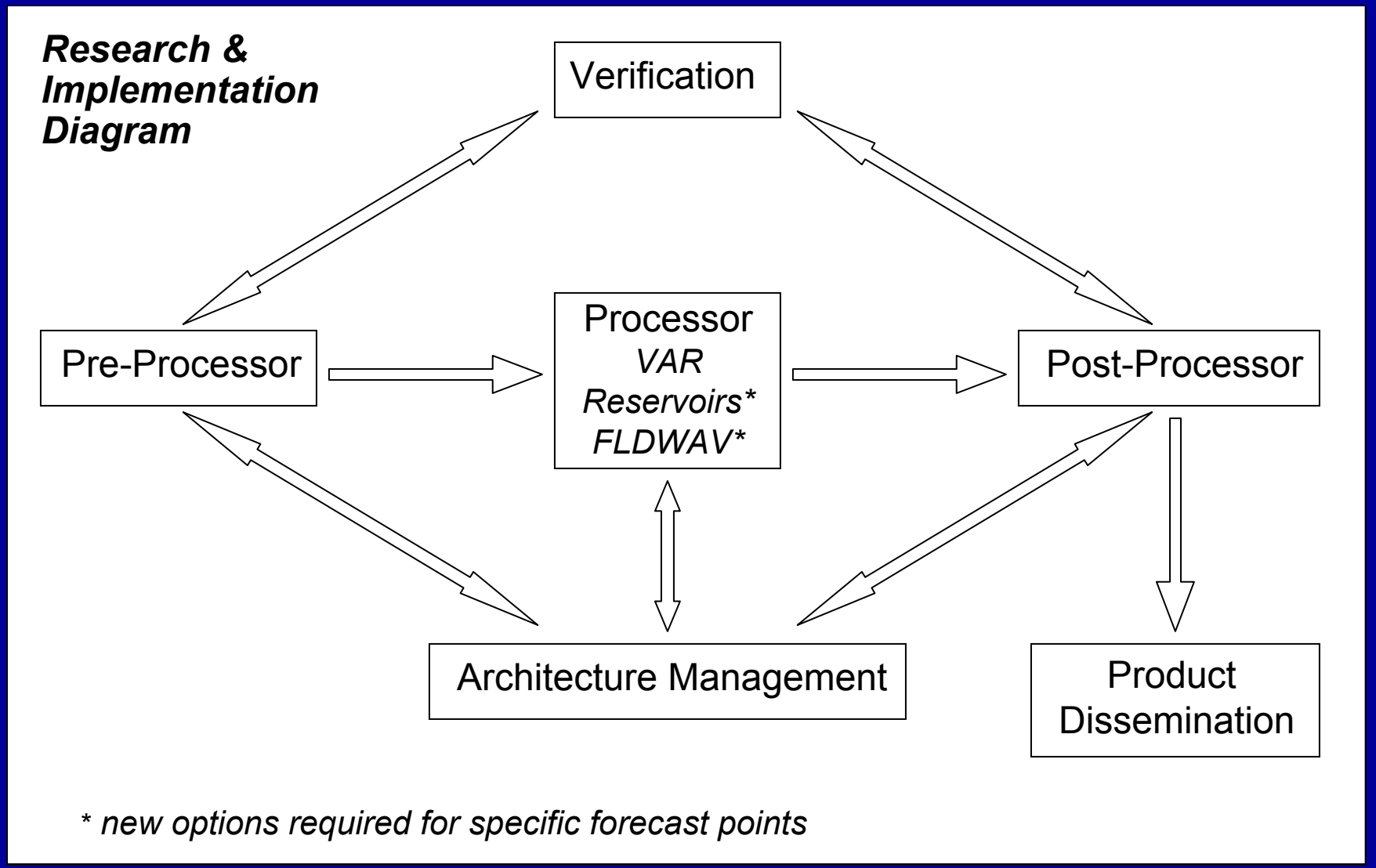
# Introduction

- **Main goal of ensemble activities:**
  - ***Seamless and consistent probabilistic forecasts for all lead times***
  - ***Accounts for both meteorological and hydrologic uncertainties***
  - ***Verify ESP performance in both space and time***

- **The time scale is currently tied to the lead times of available meteorological forecasts:**
  - ***1 to 5 days: short term***
  - ***6 to 14 days: medium range***
  - ***Two weeks and beyond: long range***

# Ensemble Activities

- **Main activities for the whole ESP system**



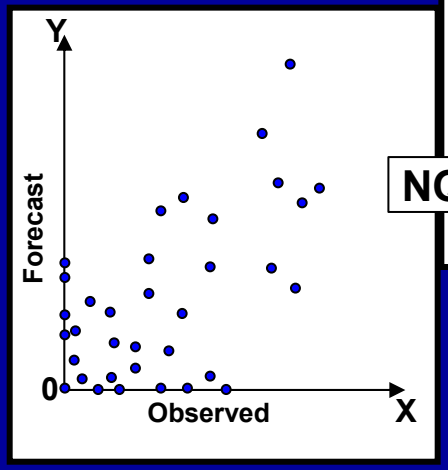
# Ensemble Pre-Processor Methodology

**1. Short-Term Calibration: at each time step for the whole year, compute the parameters of the joint distribution of observed and forecast precipitation/temperature values**

***Example for PQPF/PQTF***

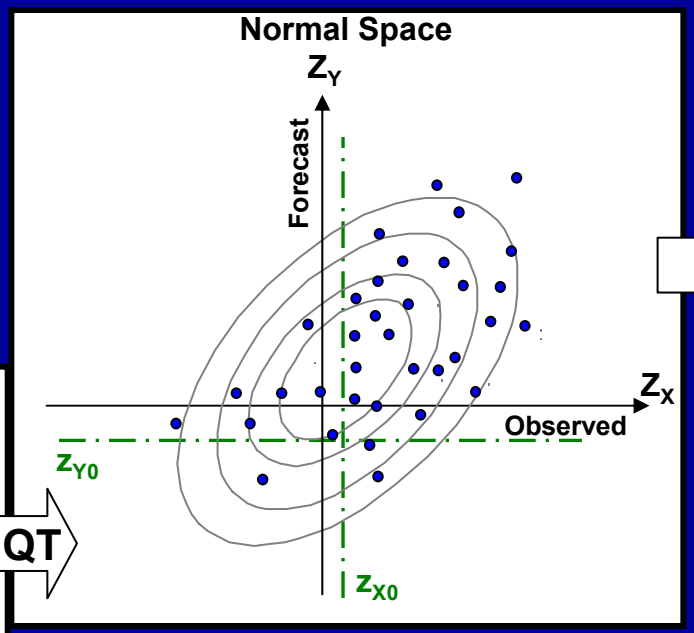
***No assumption of normality for observed and forecast distributions***

***Archived data***




NQT

***Joint distribution***

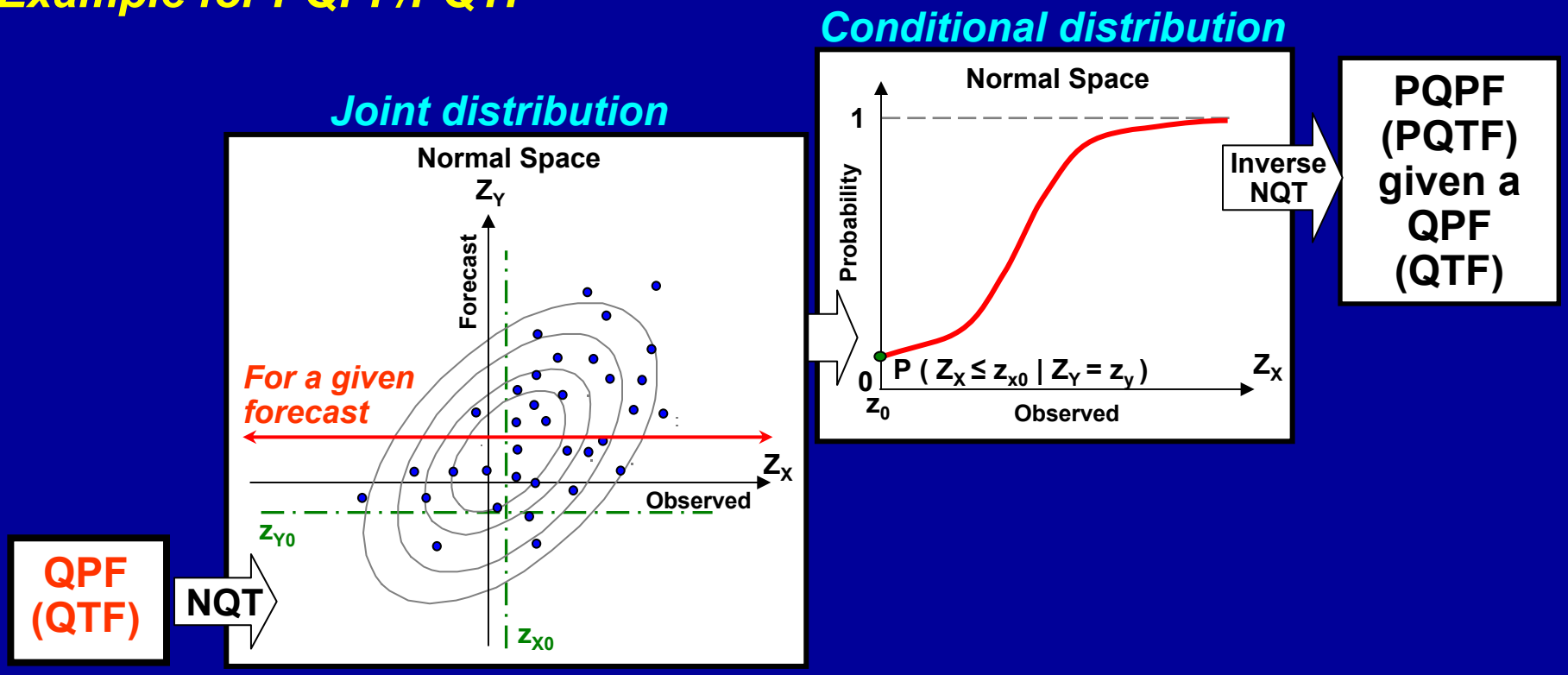



***Short Term Parameters that describe the joint distribution***

# Ensemble Pre-Processor Methodology

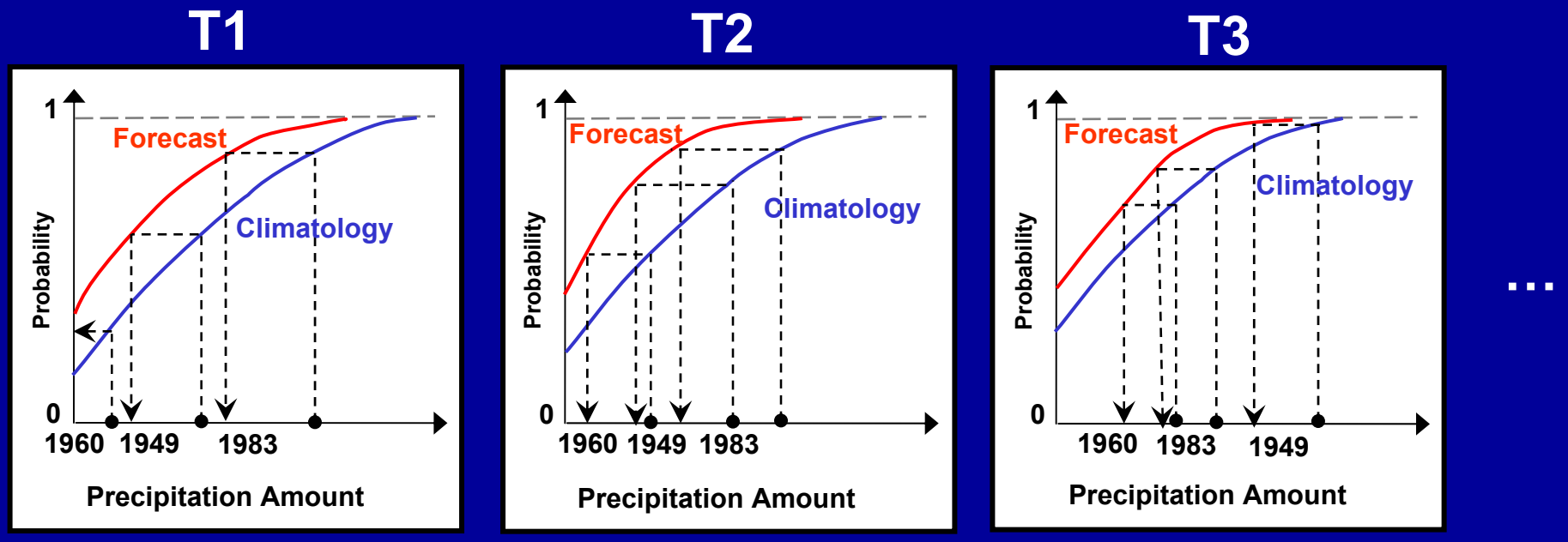
**2. Generate Short-Term PQPF/PQTF Distribution: at each time step for the forecast period, compute the parameters of the conditional distribution of future precipitation/temperature values**

***Example for PQPF/PQTF***



# Ensemble Pre-Processor Methodology

**3. Short-Term Distribution Mapping: at each time step of the forecast period, generate ensemble points given the conditional distribution of future precipitation/temperature from climatology time series**

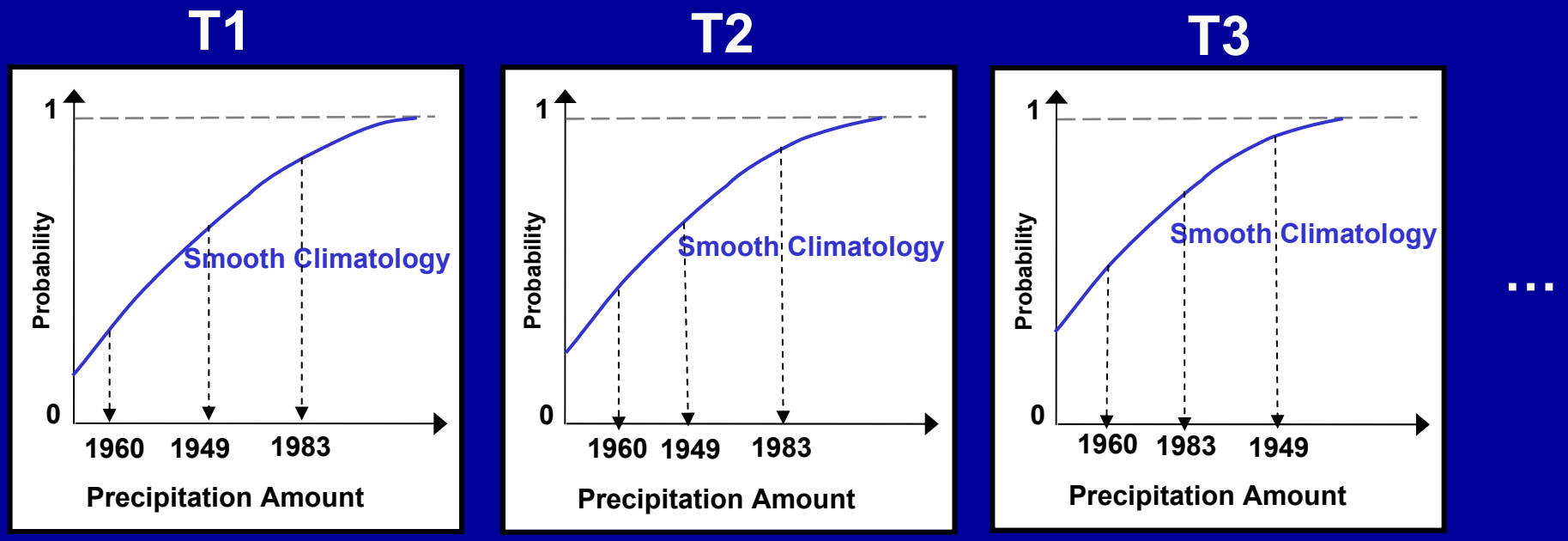



**Ensemble points incorporate the skill of the single value forecast**

**Space-time properties are similar to the historical events properties**

# Ensemble Pre-Processor Methodology

**4. Distribution Mapping if no QPF/QTF Forecast: at each time step of the forecast period, use the smoothed climatology distribution of historical precipitation/temperature and distribution mapping to generate ensembles**




**Space-time properties are similar to the historical events properties**

# Ensemble Pre-Processor Methodology

5. Climate adjustments: integrates days 1-365 meteorological forecasts/climate outlooks from NCEP/CPC. The pre-processor adjusts smoothed historical mean areal precipitation (MAP) and temperature (MAT) time series with respect to the current meteorological forecasts/climate outlooks.

*Pre-processor will only do climate adjustments if no QPF/QTF forecast

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# Pre-Processor Status: Ensemble Generation

- **Delivered enhancements (04/19/04 delivery)**
  - ***Create one unified pre-processor***
  - ***Allow non 12Z forecasts***
  - ***Extend the QPF from the control file***
- **Future enhancements**
  - ***Allow ingestion of NetCDF data***
  - ***Modify the 6-10 day temperature adjustments. Add the 8-14 day temperature and precipitation adjustments***
  - ***Compute short term temperature ensembles more efficiently (remove redundant NQT)***
  - ***Add Forecaster Control***
  - ***Enhance the short term procedure to use the CPC precipitation forecasts for days 2-5 if no RFC forecast is available***
  - ***Enhance the short term procedure to use the CPC precipitation and temperature forecasts for days 6-14 if no RFC forecast is available***

# Pre-Processor Status: Calibration

- **Delivered enhancements (Dec. 03 delivery)**
  - *Three RFCs are using Linux parameters*
- **Future Enhancements**
  - ***Update parameters***
  - *Combine ens_pre_cp and ens_pre_cp2 into one operationally robust calibration program*
  - *Estimate parameters for days 1-5 from CPC forecasts for ABRFC and MARFC, compare to parameters derived from RFC archive*
  - *Enhance operational calibration program to include the short term calibration procedures*

# Pre-Processor Status: Evaluation

- **Current enhancements:**
  - *Created a research evaluation prototype to evaluate the goodness of fit of the model by comparing a simulated joint distribution with the real forecast-observation distribution*
- **Future Enhancements:**
  - *Add a bivariate normality test to the evaluation prototype*
  - *Provide analysis to test cases for three RFCs for days 1-5 precipitation and temperature*
  - *Develop a checking technique for the estimate of rho*

# Pre-Processor Status: Verification

- **Current enhancements:**
  - ***Created a verification developmental prototype that aims at assessing the quality of days 1-5 precipitation and temperature ensembles***
    - **Includes the ensemble generation component to simulate ensembles**
    - **Output: ~20 statistics including Nash-Sutcliffe Efficiency, Brier Skill Score, and Heidke Skill Score**
- **Future Enhancements:**
  - ***Integrate other verification statistics (Talagrand diagram, discrimination diagram)***
  - ***Extend lead times***

# Pre-Processor Status: Product Analysis & Display

- **ESPADP**
  - ***Delivered Enhancements (04/19/04 delivery)***
    - **ESPADP can read in the "PQPT/PQTF" output data cards**
    - **Fixed the "OBSOverlayPRD" and "OverlayPRD" feature**
  - ***Future Enhancements***
    - **???**

# Pre-Processor Status: Papers

- Paper 1: motivation for a new methodology
- Paper 2: presentation of the short-term ensemble pre-processor with example of results for daily precipitation and temperature ensembles at CNRFC
- Paper 3: results from applying the short-term ensemble pre-processor at ABRFC, CNRFC and MARFC

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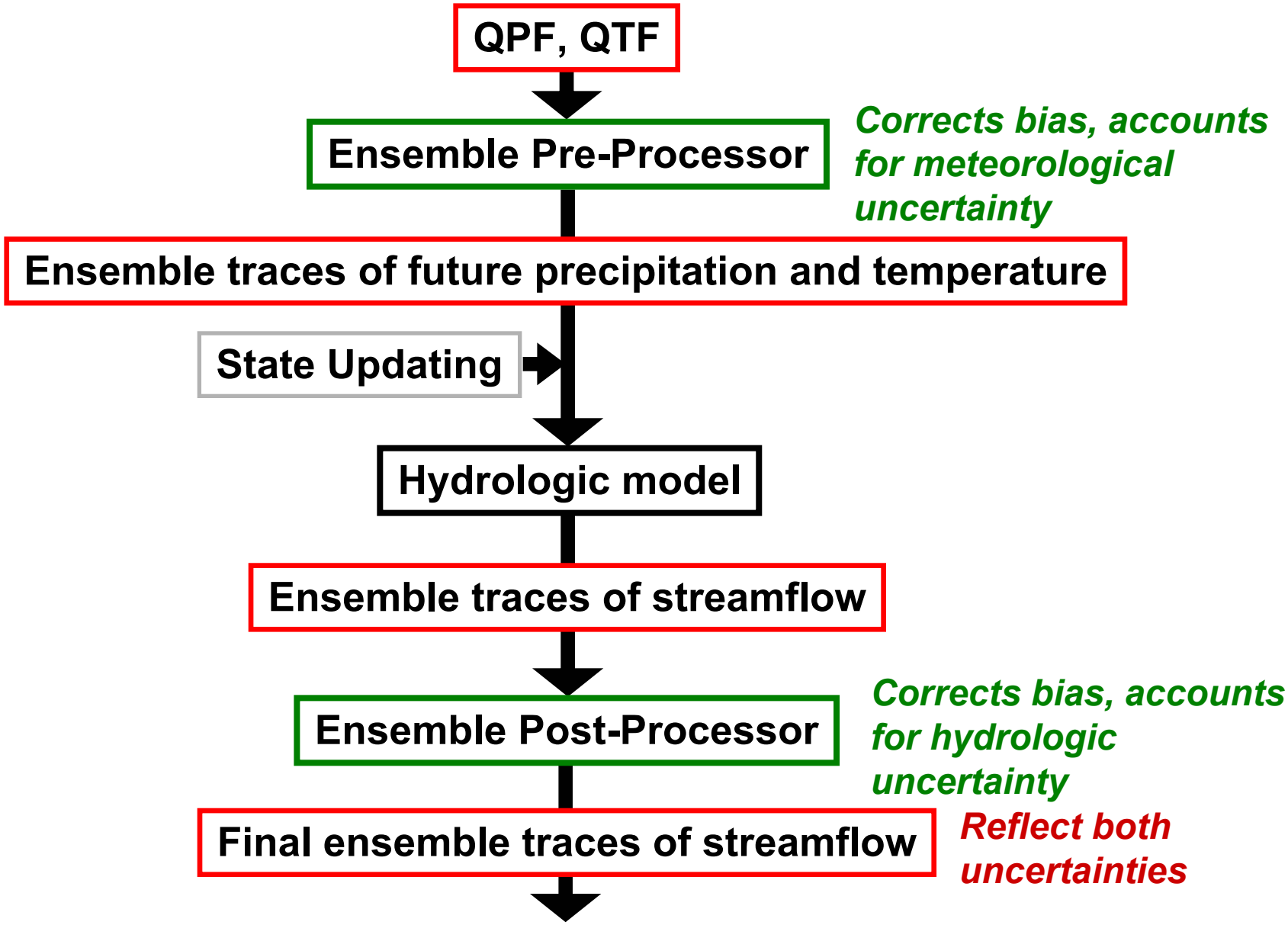
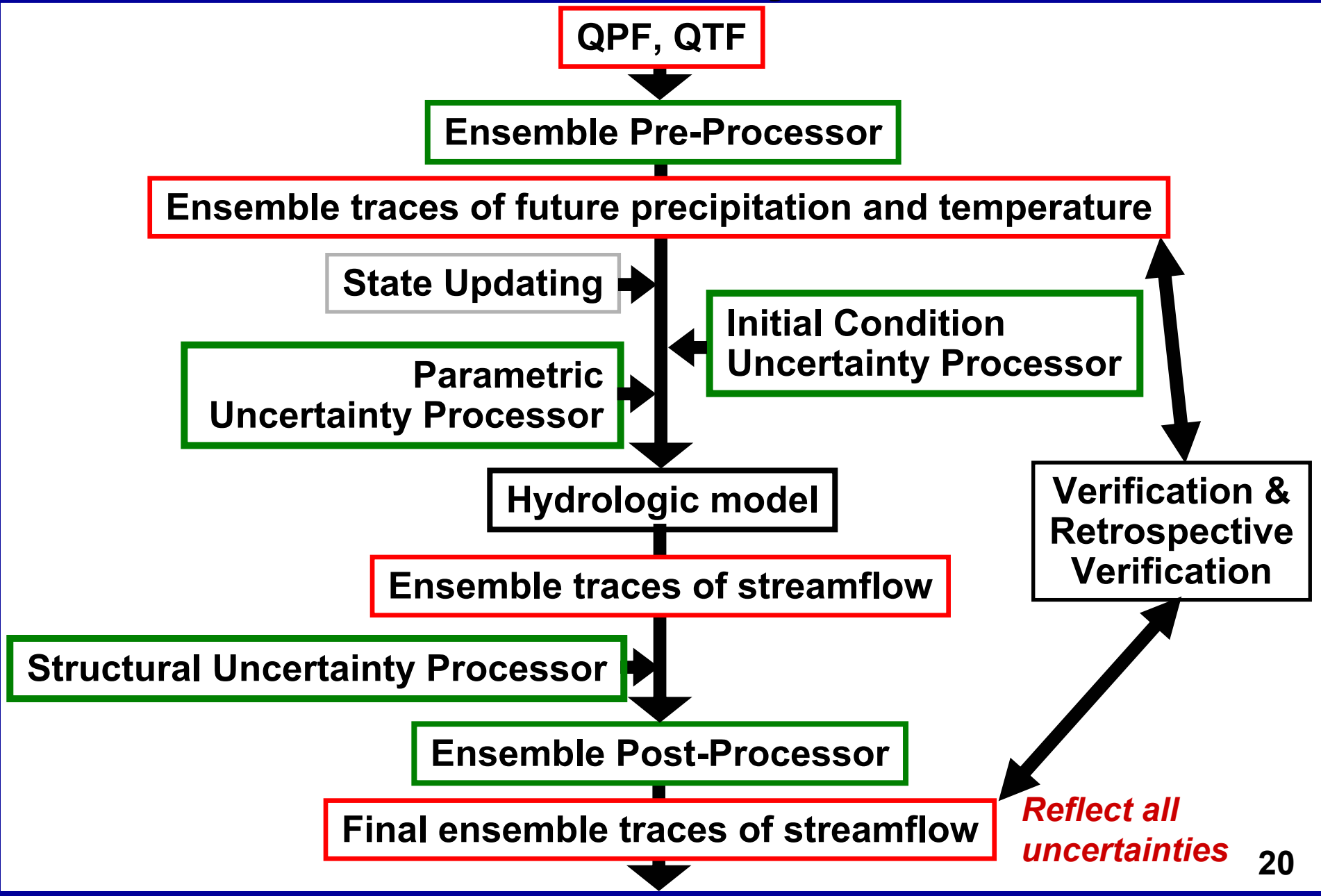
# Current ESP System



# Current ESP System: State Updating & Post-Processor

- **SS-SAC (State-Space Sacramento Model): updates state variables through data simulation using latest observed streamflow**
  - ***Requires to re-calibrate Sacramento Model parameters and to estimate uncertainty of inputs, state variables and parameters***
- **Post-Processor: accounts for all hydrologic uncertainties collectively**
  - ***Parametric uncertainty & structural uncertainty in hydrologic model, as well as model initial conditions uncertainty***
  - ***Corrects for systematic model biases***

# Future ESP System



# Future ESP System: Individual Uncertainty Processors

- **Goal: to explicitly account for individual sources of hydrologic uncertainties**
- **Initial Conditions Uncertainty Processor (VAR Project): to reduce and to quantify uncertainty in the initial conditions and to effect automatic run-time modification**
  - ***Variational assimilation-based technique assimilates streamflow observations at the headwater basin outlet, potential evaporation and precipitation in real time***
- **Parametric Uncertainty Processor: to capture propagation of long-memory errors and extremely nonlinear errors and to simplify post-processing**
- **Structural Uncertainty Processor**

# Future ESP System: Verification

- **Package to quantify quality of input & output ensembles**
- **Retrospective verification based on a retrospective simulation of ESP system**
  - ***Ensembles of Precipitation, Temperature, & Streamflow***
  - ***Needs to integrate the Ensemble Pre-Processor and Post-Processor***
- **ESP Verification System (ESPVS) currently under redevelopment**
  - ***Based on Franz and Sorooshian (2002) and others***
  - ***Includes Ranked Probability Score (RPS), Ranked Probability Skill Score (RPSS), discrimination diagram, & reliability diagram***

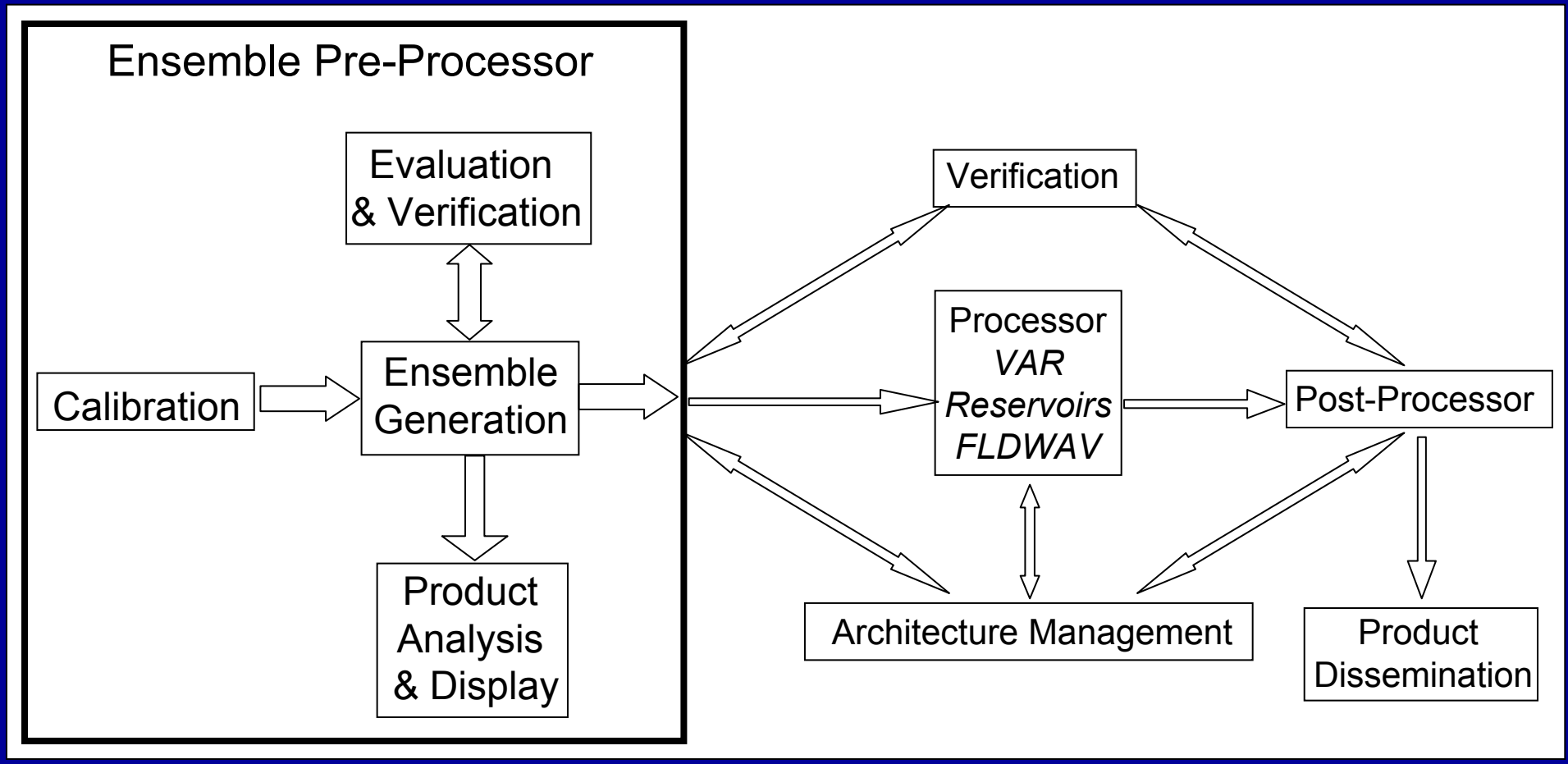
# Future ESP System: Architecture

- **Follow a structured development process**
  - ***Develop Use Cases to help discover system requirements***
  - ***Document requirements to ensure more useable and maintainable software***
- **Focus on services based architecture to permit faster science infusion**
  - ***http://www.nws.noaa.gov/ohd/hrl/hseb/hseb_pdf_links.htm***
  - ***Communication between modules with XML***

# HEPEX
# Hydrologic Ensemble Prediction Experiment

- **Goal**
  - *Develop "engineering quality" hydrologic ensemble prediction procedures for time scales (flash-flood to 1-yr) and space scales (1-km to continental)*
- **Organization**
  - *IAHS (PUB), GEWEX (WRAP), WMO*
- **Initial Workshop: ECMWF, March 2004**
  - *Develop science plan*

# Conclusion


Ensemble Pre-Processor
Evaluation & Verification
Calibration
Ensemble Generation
Product Analysis & Display
Verification
Processor
VAR
Reservoirs
FLDWAV
Post-Processor
Architecture Management
Product Dissemination