Ensemble Forecasting OHD Activities

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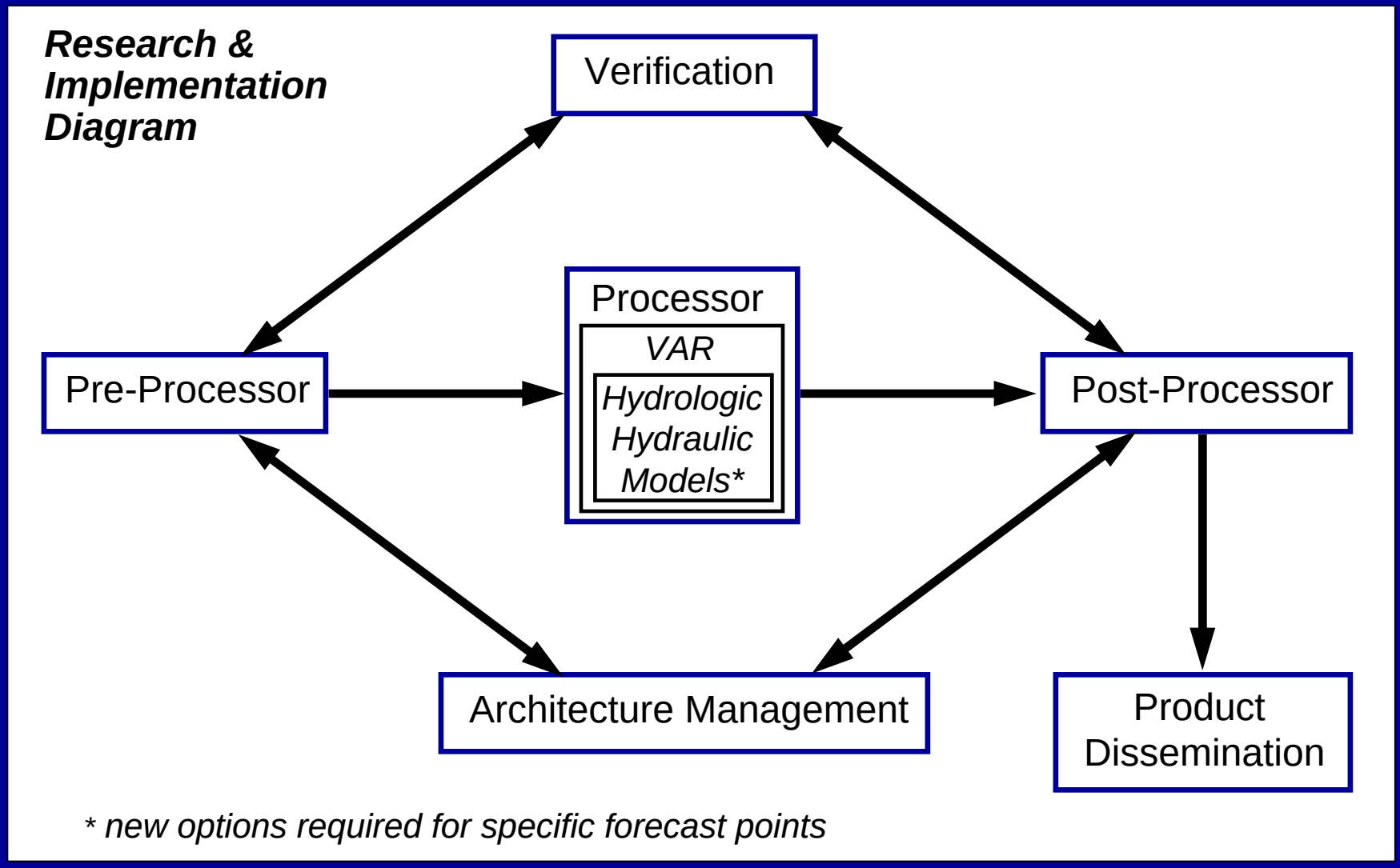
Introduction

- **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 methodology 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**

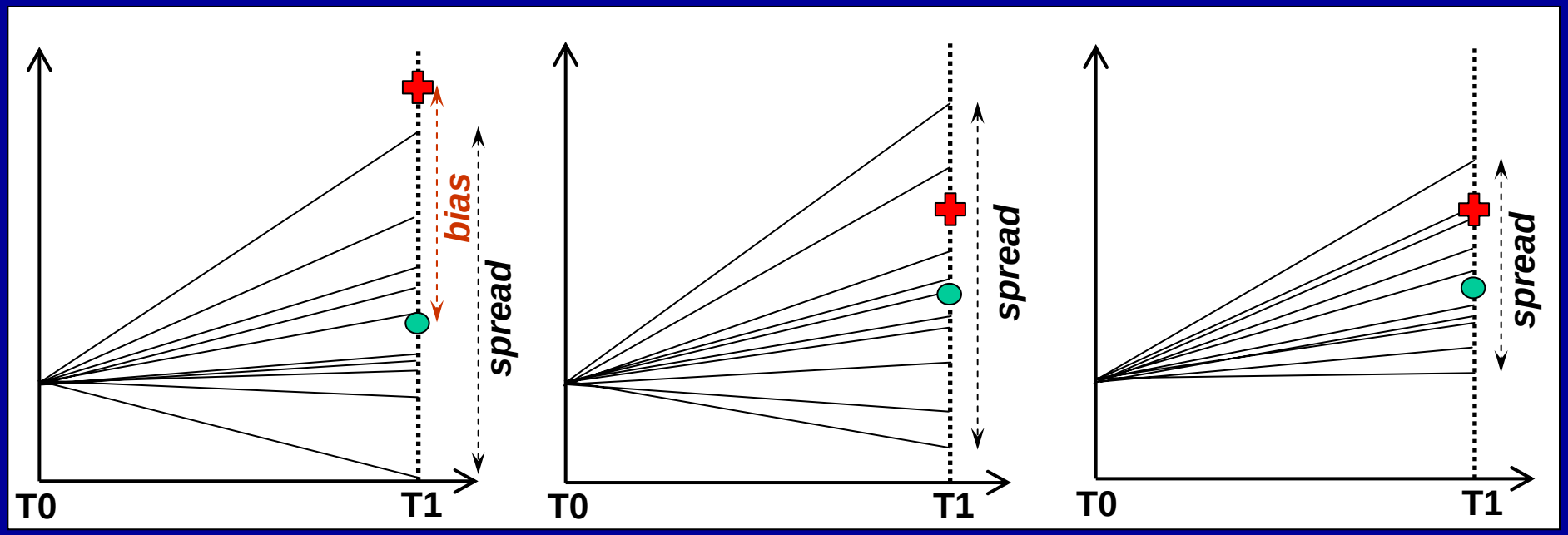


Goals

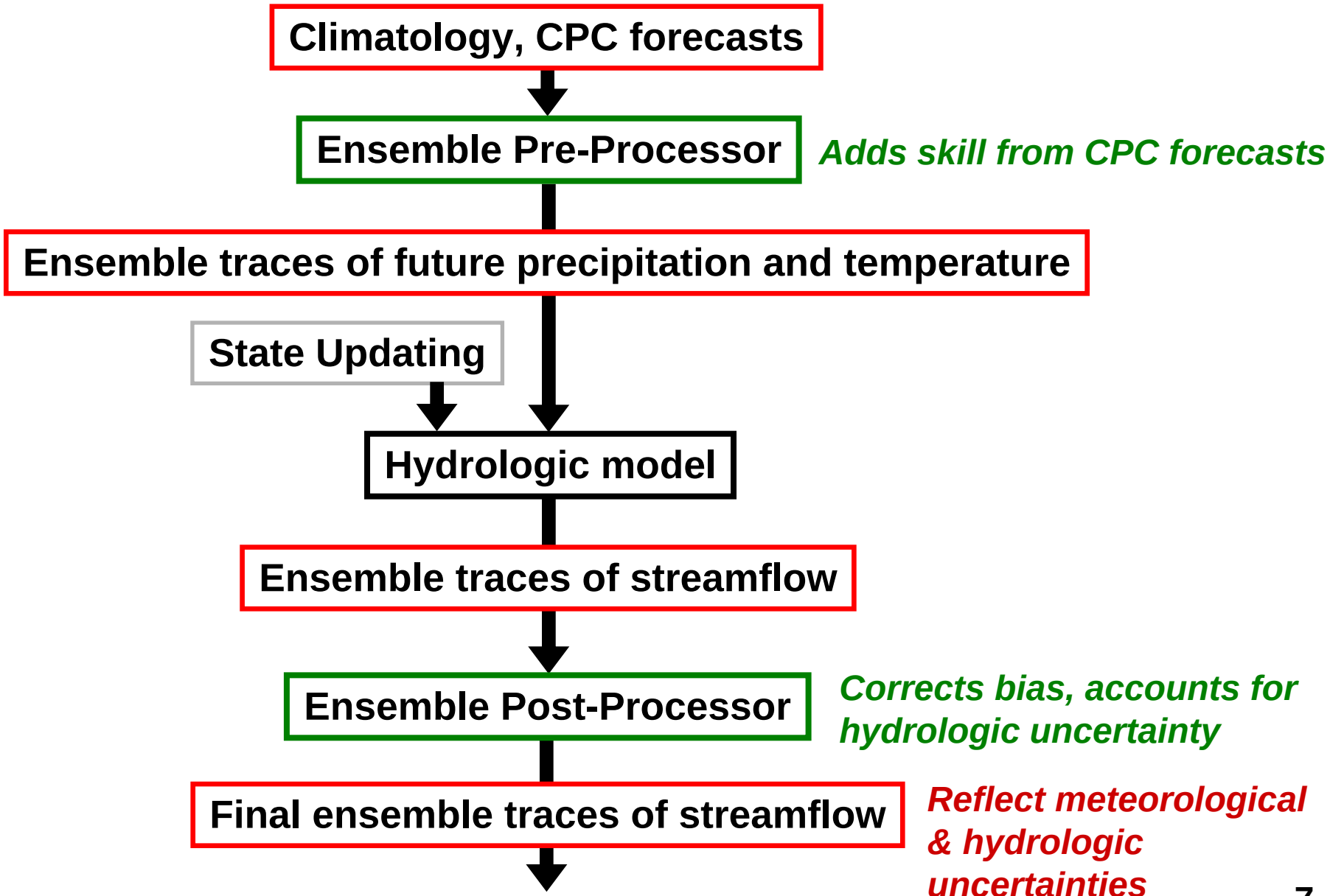
- **Ensemble inputs for ESP:**
  - ***4 forcing inputs: precipitation, temperature, potential evaporation, freezing level***
  - ***For each RFC sub-basin and all lead times (1 hr to 1 yr)***
- **Ensemble outputs from ESP: streamflow ensembles**
- **Verification information for all ensemble forecasts**

Goals

- **Ensemble characteristics:**
  - ***Unbiased***
  - ***Reliable: forecast probabilities correctly reflect future uncertainty***
  - ***Resolution: reduced spread***



Current ESP System



Current ESP System: Ensemble Pre-Processor

- **Ensemble Pre-Processor adds skill by integrating meteorological forecasts/climate outlooks from NCEP/CPC**
- **Limitations:**
  - ***Climate time series too noisy and too sparse***
  - ***Needs to integrate other available meteorological forecasts (deterministic, atmospheric model forecasts)***
  - ***Global and regional ensembles not reliable enough to be used directly***
- **Priority: precipitation and temperature ensembles**

Current ESP System: Ensemble Pre-Processor

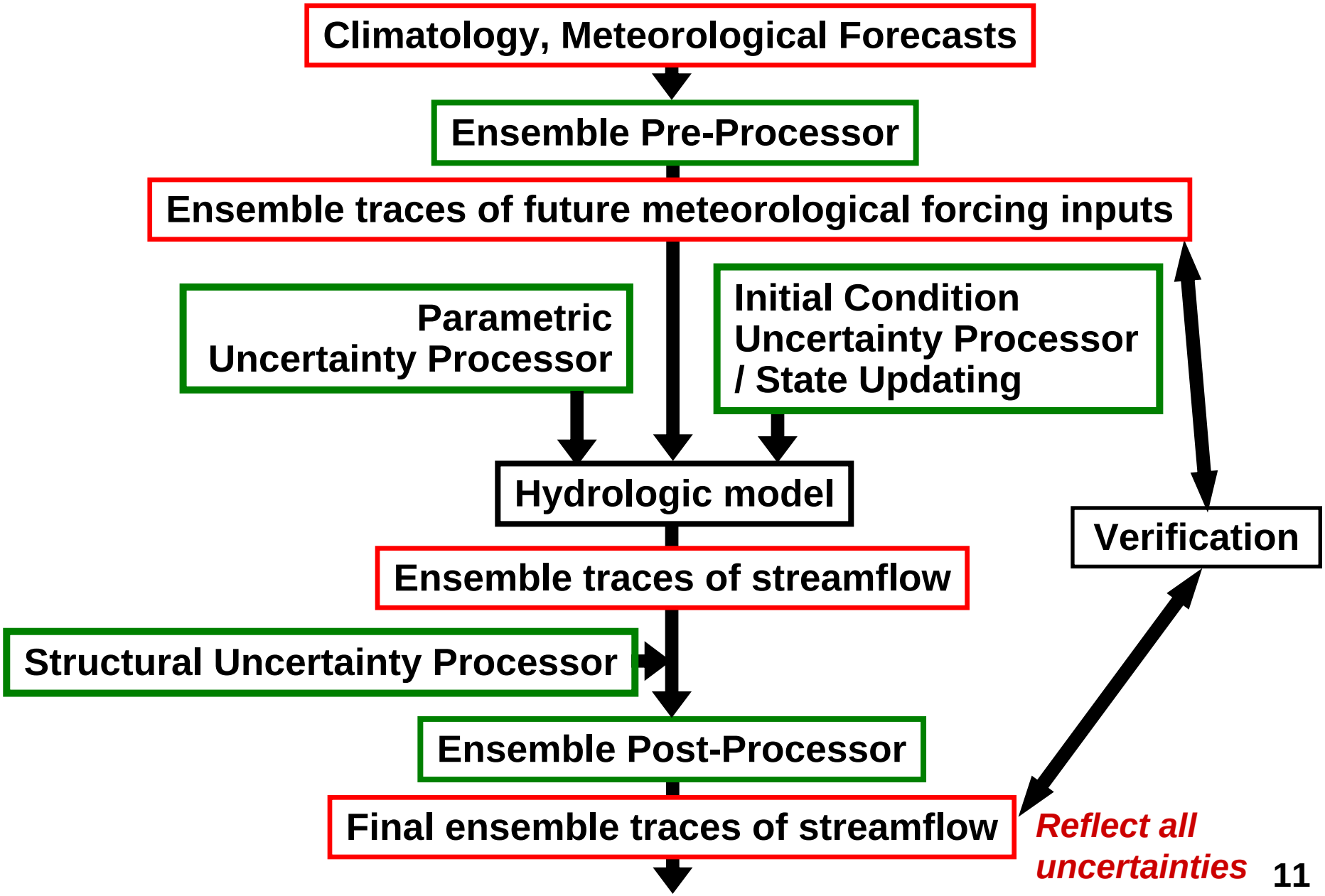
- **Goal of current enhancements: correct bias and account for meteorological uncertainty**

- **Different processes under development:**
  - ***Short-term ensembles based on available QPF and QTF***
  - ***Global and regional model ensembles***
  - ***Climatology smoothing and adjustment***

Current ESP System: Ensemble Post-Processor

- **Ensemble Post-Processor corrects bias and accounts for all hydrologic uncertainties collectively:**
  - ***Model initial conditions uncertainty, parametric uncertainty & structural uncertainty in hydrologic model***
- **Fully automated calibration component**
- **Paper with MARFC experiments**
  (DJ Seo et al, Journal of Hydrology, under review)
- **Limitations**
  - ***Little experience***
  - ***Not compatible with mods***
  - ***Effects of temporal disaggregation not well understood***

Future ESP System



Future ESP System: Ensemble Pre-Processor

- Merge the different procedures for all lead times
- Enhance short to long range ensembles: space-time aggregation-disaggregation issues
- Improve calibration and assess data requirements
- Develop a unified calibration prototype
- Integrate forecaster control and confidence factor
- …
- Integrate distributed modeling into ESP

Future ESP System: Hydrologic Uncertainty Processors

- **Develop various processors to explicitly account for individual sources of hydrologic uncertainties and simplify post-processing**
  - ***Initial Conditions Uncertainty Processor (VAR Project):*** *to reduce and to quantify uncertainty in the initial conditions and to effect automatic run-time modification*
  - ***Parametric Uncertainty Processor:*** *to capture propagation of long-memory errors and extremely nonlinear errors*
  - ***Structural Uncertainty Processor:*** *to account for model structure errors*
- **Develop ensemble data assimilation**
- **Integrate distributed modeling into ESP**

Future ESP System: Ensemble Post-Processor

- Further evaluate the post-processor
- Test other approaches
- Demonstrate the usefulness of post-processor in an end-user point of view
- Improve the post-processor robustness and parameter estimation, and assess data requirements
- …
- Integrate distributed modeling into ESP

Future ESP System: ESP Verification System (ESPVS)

- **Develop a package to quantify quality of input & output ensembles including new diagnostic measures**
- **Retrospective verification based on a retrospective simulation of ESP system (ESPTSG)**
  - ***Ensembles of Precipitation, Temperature, & Streamflow***
  - ***Needs to integrate all the uncertainties processors***
- **Statistic package (ProbVS) currently under redevelopment:**
  - ***Currently tested at CBRFC***
  - ***Needs to develop user-friendly verification information***

Future ESP System: Architecture

- Archive data for calibration and verification
- Standardize data management & delivery
- 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*

Future ESP System: Product Dissemination

- Generate useful products for all end-users
- Probabilistic ensemble forecasts require new end-products to be defined and delivered
- Training is needed for forecasters and end-users

Conclusions

- Many tasks to perform: with current level of resources, progress is slow
- An ensemble strategic plan is needed to prioritize tasks and to determine resources for all ensemble activities

Thank You

Summary: OHD Ensemble Projects

- **Ensemble Pre-Processor:**
  - ***PQPF - PQTF ensemble project (including verification)***
  - ***Global and regional ensembles***
- **Hydrologic Uncertainty Processors: VAR project**
- **Ensemble Post-Processor: proposal under development**
- **Verification: ESPVS (including retrospective verification)**
- **Architecture**
- **Product Dissemination: AHPS web page development**