Hydrologic Ensemble Forecasts
(Ensemble Streamflow Prediction – ESP)

USBR Drought Workshop

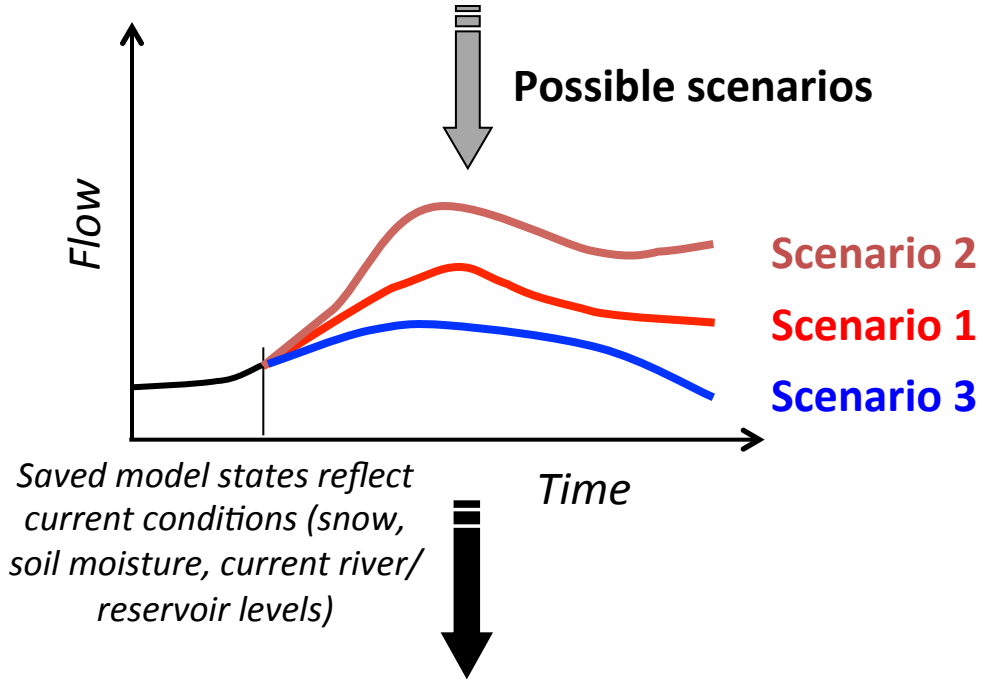
November 6, 2012

Outline

- Ensemble Streamflow Prediction (ESP) 101
- Coming soon: Hydrologic Ensemble Forecast System (HEFS)
- CBRFC/CU ensemble project update

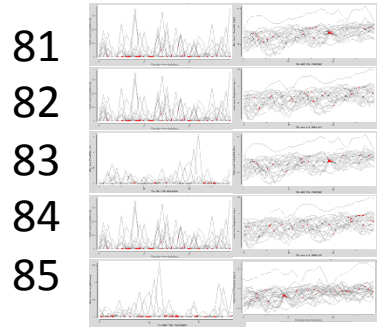
ESP Technique

Multiple streamflow scenarios with historic meteorological or forecast weather/climatic data



Results used in statistical analysis to produce forecasts with probabilistic values

Historical time series of precipitation and temperature



CBRFC: Currently using water years 1981-2010

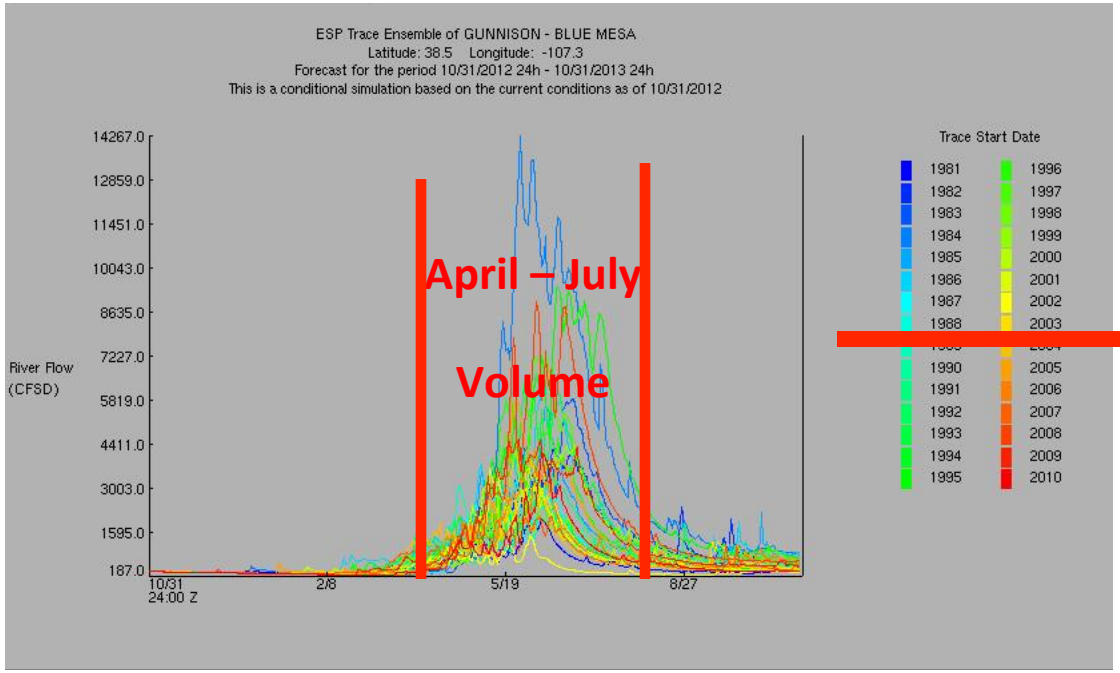
Can also include forecast precipitation and temperature.

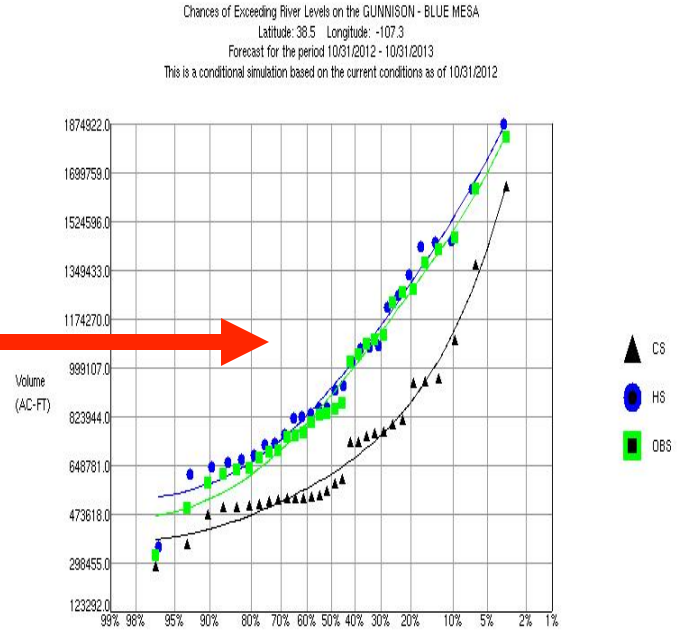
CBRFC:

- *Use 10 days of forecast max/min temperatures.*
- *Two runs –*
  - *5 days of forecast precipitation*
  - *0 days of forecast precipitation*

More information available from COMET: www.meted.ucar.edu/hydro/ESP/Intro/

Ensemble Streamflow Prediction (ESP)

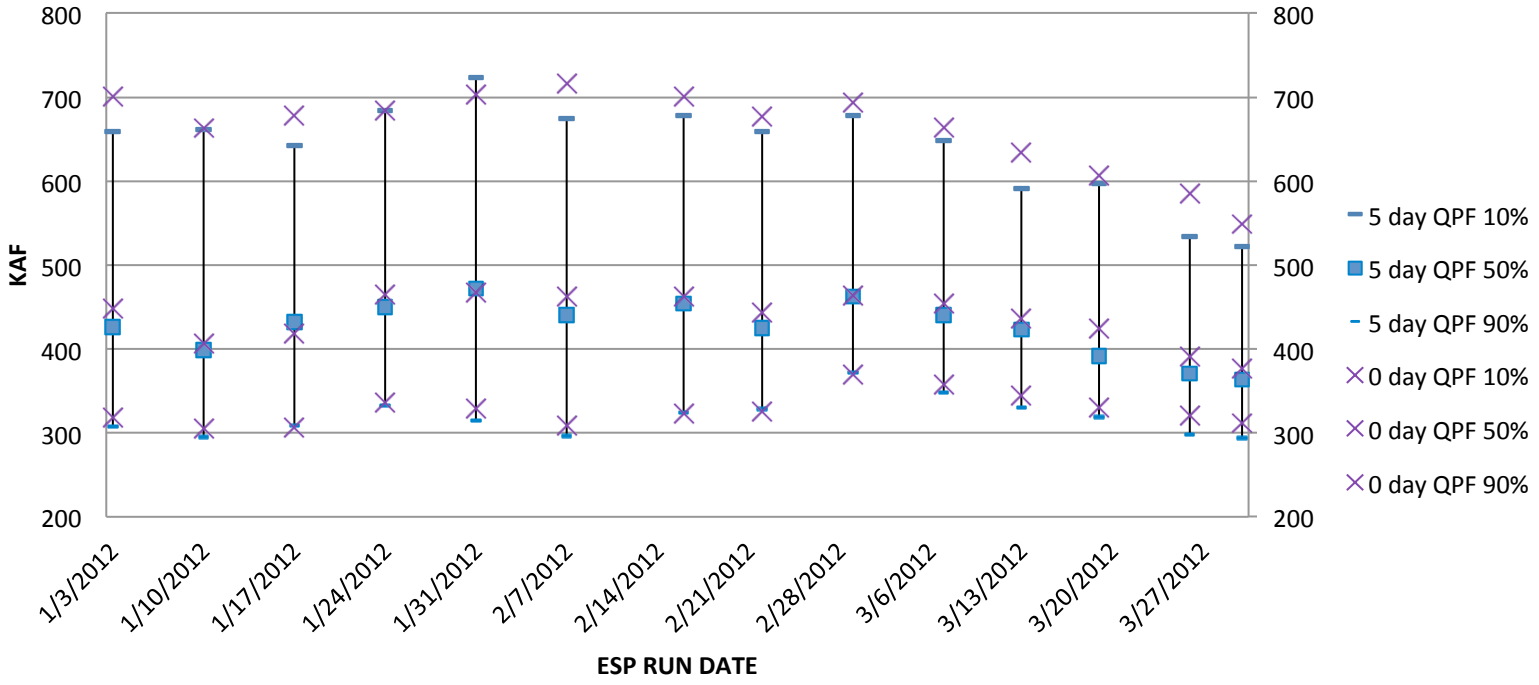




1. Select a forecast window
2. Select a forecast variable
3. Model derives a distribution function
4. 50% exceedance value = most probable forecast
5. Also use 10%/90% levels

# Exceedance Probabilities	Conditional Simulation	Historical Simulation	Historical Observed
0.900	417330.156	581462.500	525460.000
0.750	493856.750	699928.938	659224.812
0.700	517683.500	741569.312	705094.750
0.600	565268.875	829048.438	799524.375
0.500	616216.625	923809.188	898919.562
0.400	676330.375	1029094.688	1006031.062
0.300	755745.938	1151067.250	1126296.500
0.250	808794.500	1222083.250	1194804.500
0.100	1123002.375	1534576.375	1490881.125

Gunnison - Blue Mesa
Apr-Jul ESP Volumes



ESP 'Modes'

UNREGULATED

(Water Supply Volume Forecasts)

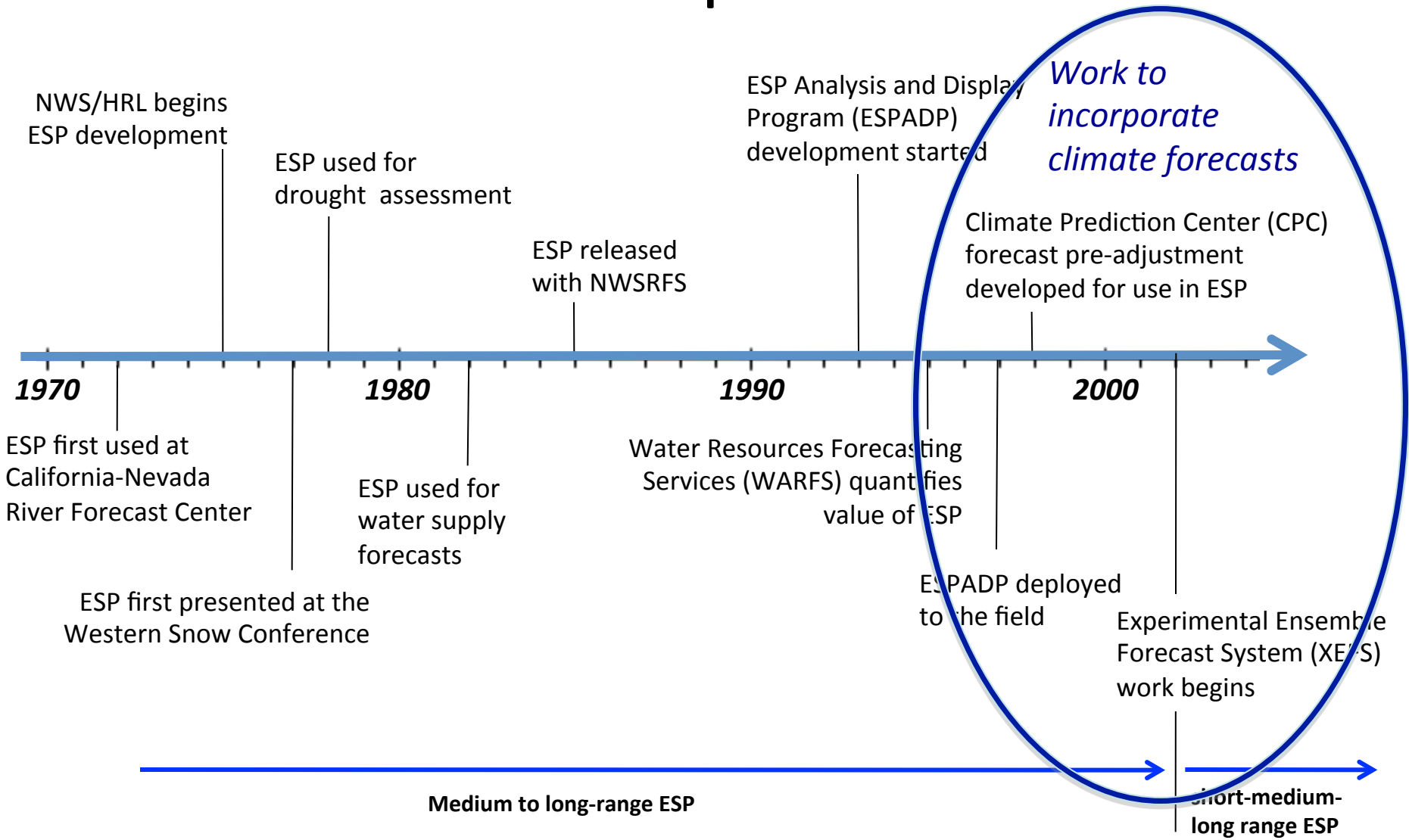
- Not what will be observed in the rivers.
- No diversions (for places we have historical/real time measurements).
  - Trans-basin diversions.
- No water held by reservoirs (passes through).
- Consumptive Use operation still in effect.

REGULATED

(Peak Flow Forecasts)

- Observed mean daily peak.
- Historical diversion data used in calculation of each year's hydrograph.
- Reservoirs operated based on a set of 'rules'.
  - Time of year or elevation.
- Similar to daily forecast methodology.

Historic development of ESP

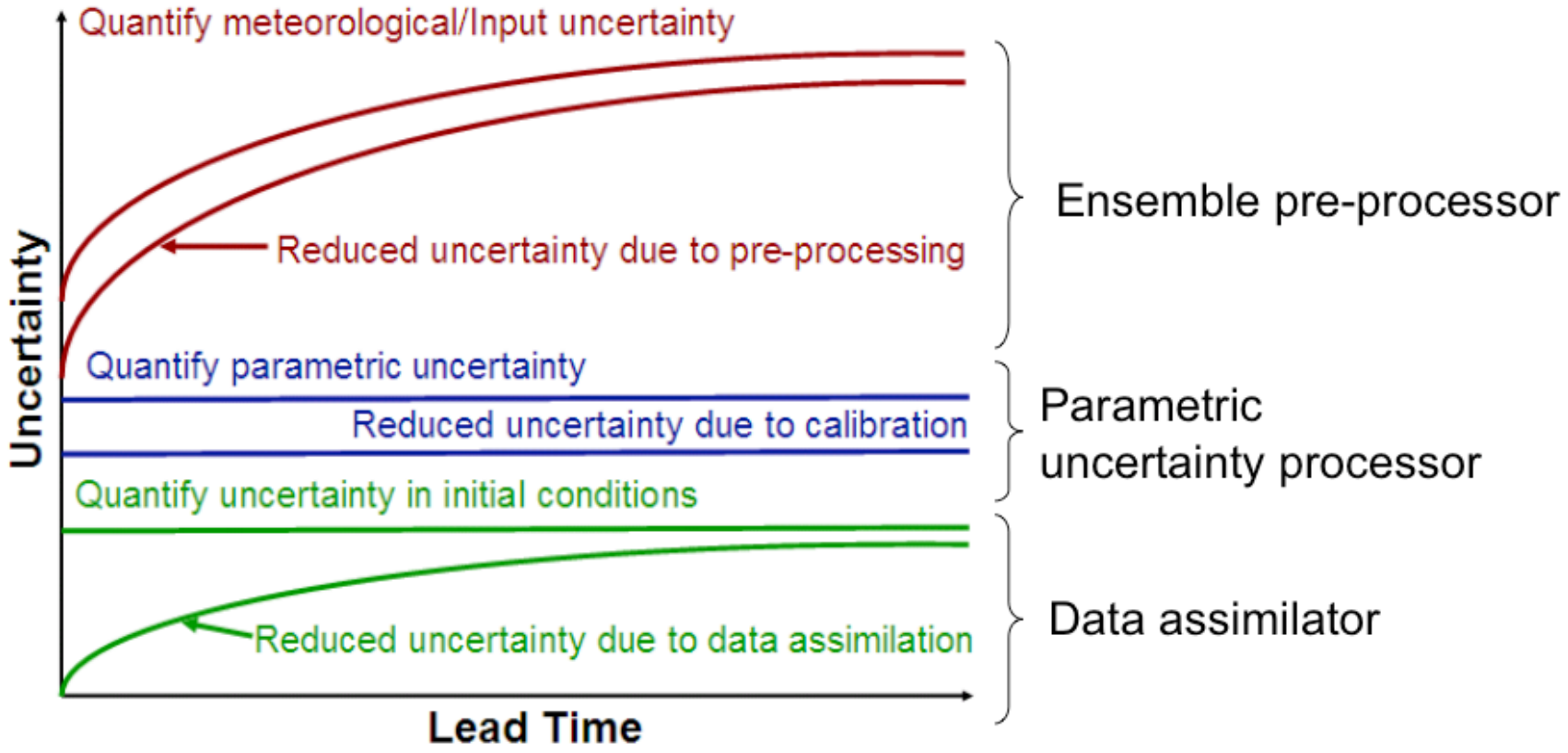


Info Western Snow Conference paper, 1977

HEFS

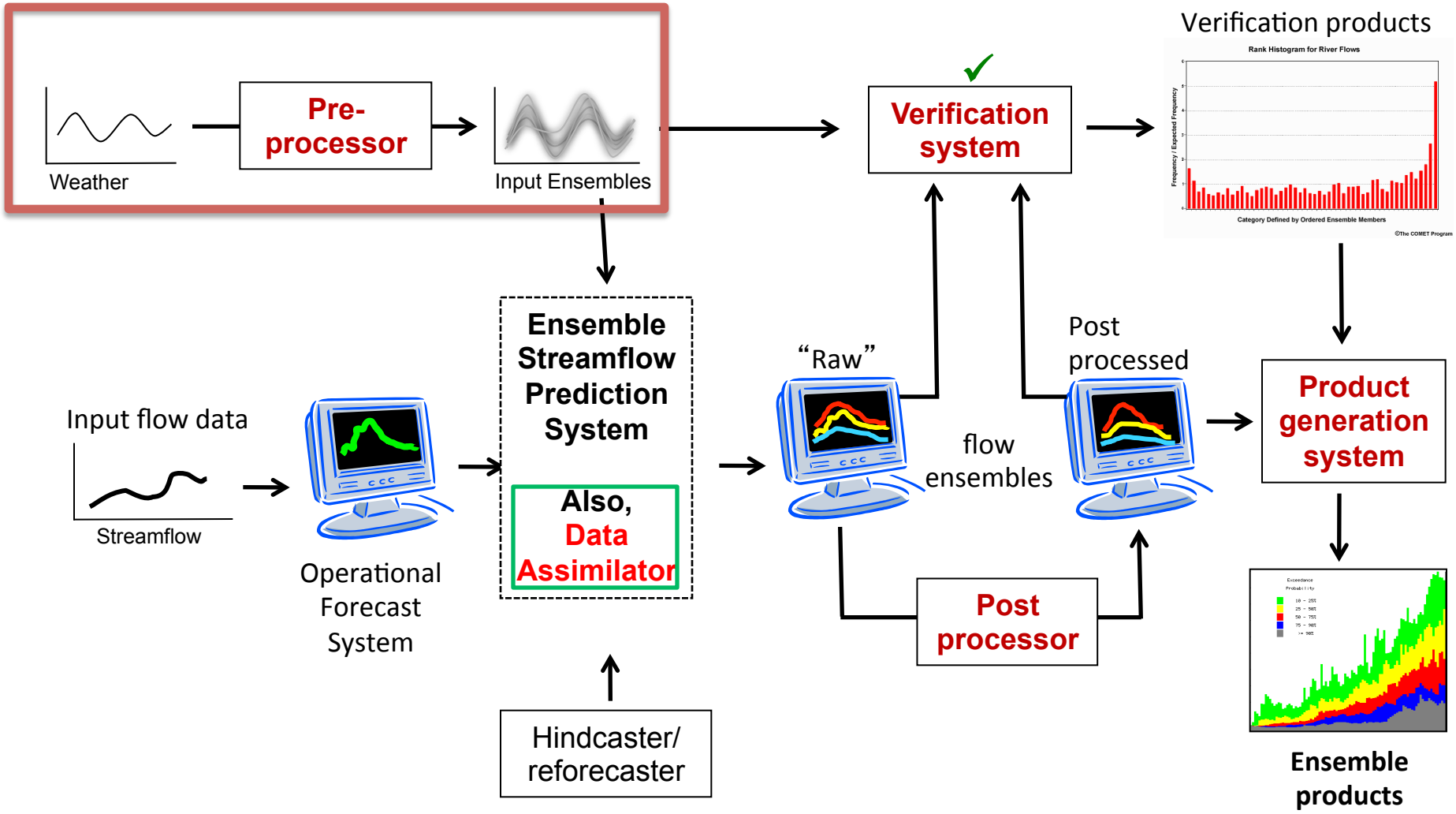
- Motivations:
  - Quantify and reduce uncertainties in ESP due to:
    - Future weather and climate
    - Calibration
    - Initial conditions
  - Provide unbiased and skillful forecast ensembles to stakeholders and NWS hydrologic forecast products
  - Generate reforecast dataset consistent with real time forecasts

Uncertainties in Hydrologic Forecast

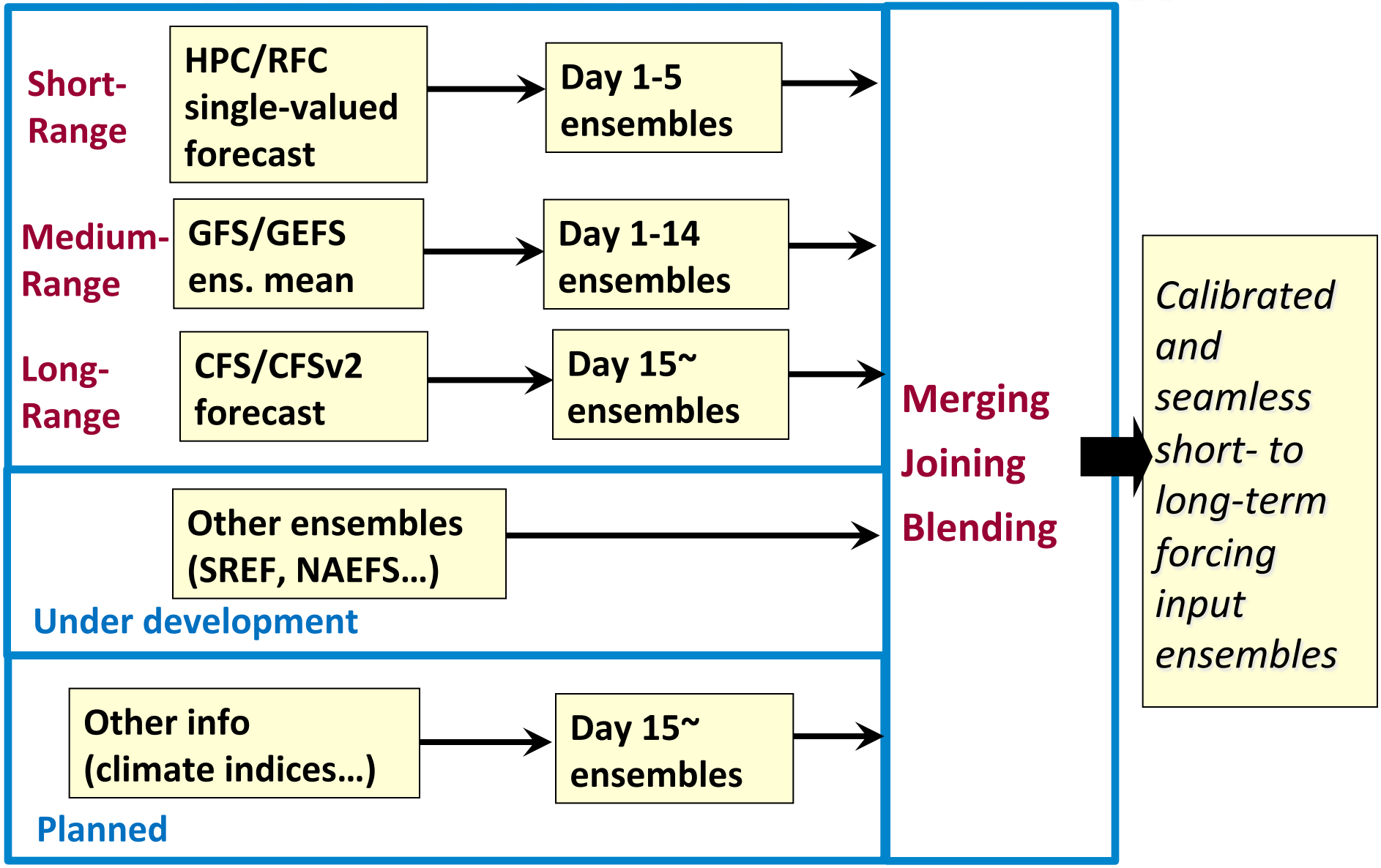


Flow regulations: A large challenge

An ESP Upgrade: The NWS Hydrologic Ensemble Forecast Service (HEFS)

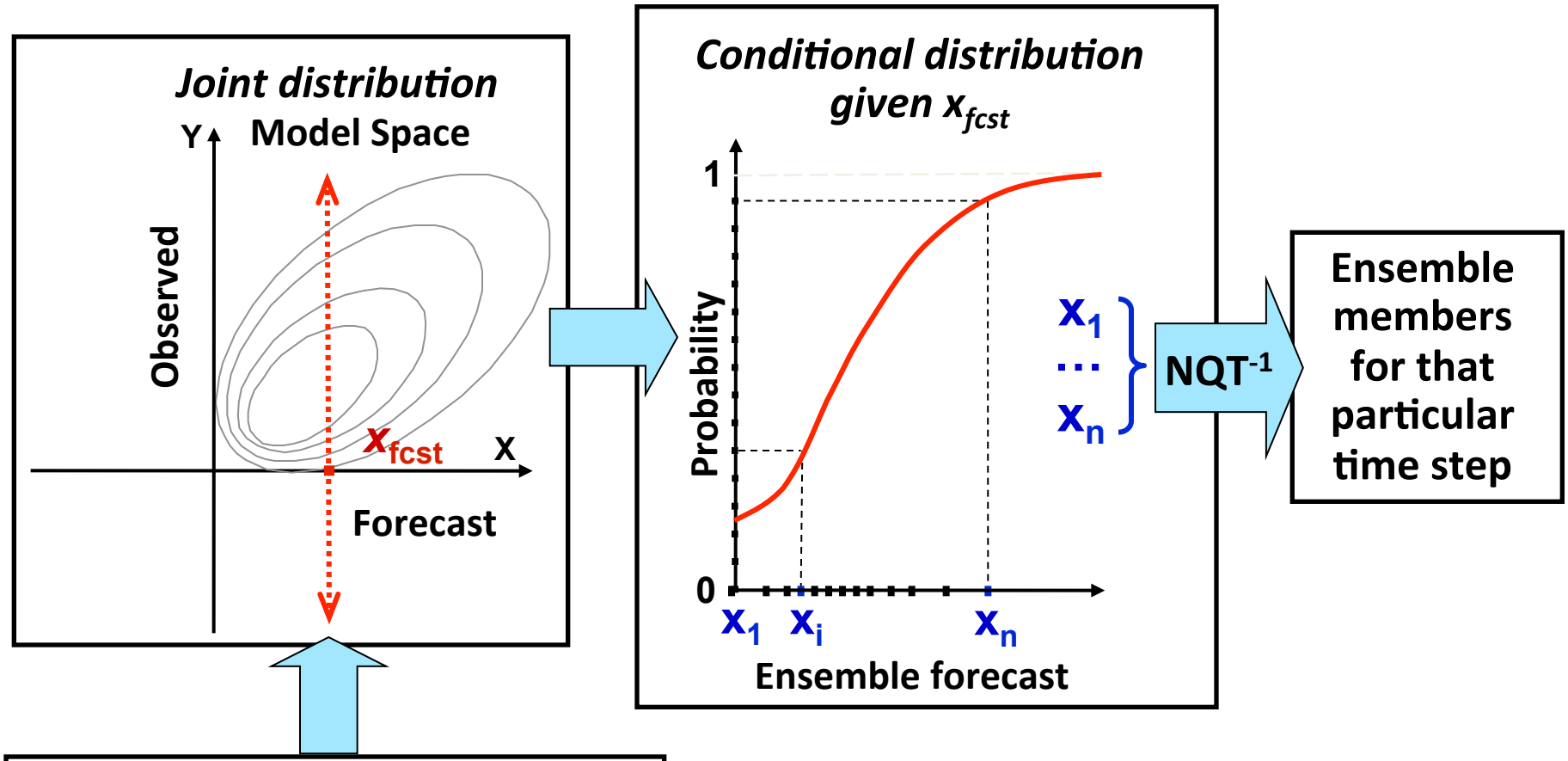


Atmospheric Ensemble Processor: current & new forecast sources



Atmospheric Pre-Processor: ensemble generation (1)

In real-time, given single-valued forecast, generate ensemble traces from the conditional distribution for each lead time



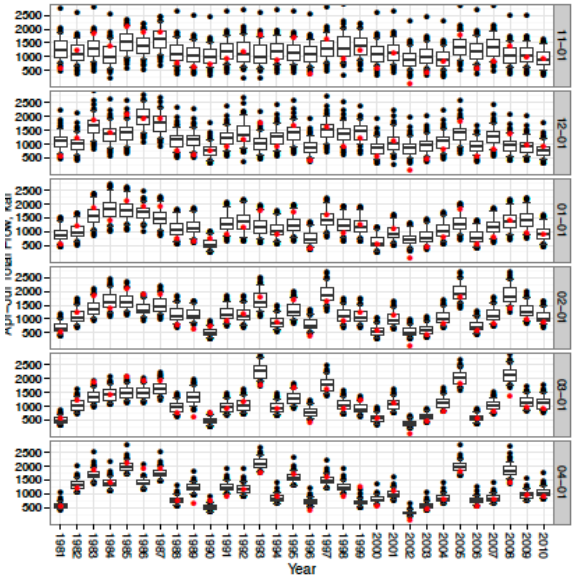
Schaake et al. (2007), Wu et al. (2011)

CBRFC HEFS Timetable Goals

- HEFS products will start to roll out during the Water Year 2013 season
- Dolores was selected as our test basin and will be completed first
- San Juan basin is next to support project with CU/USBR
- Bear and Six Creek basins next to support SARP project
- Full CBRFC implementation by Water Year 2014

CU/CBRFC Ensemble Project

- Project Goals:
  - Generate ensemble inputs for ESP using climate forecasts through weather generator method
  - Increase number of ensemble members to improve resolution in tails of distribution
- Personnel:
  - Balaji Rajagopalan (CU)
  - Kevin Werner, John Lhotak, Michelle Stokes (CBRFC)
  - Edie Zagona (CADSWES)



(b) WG output as traces: 90 traces

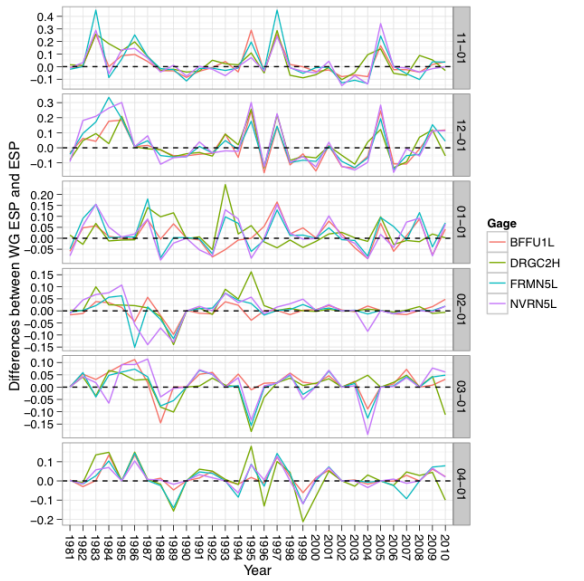
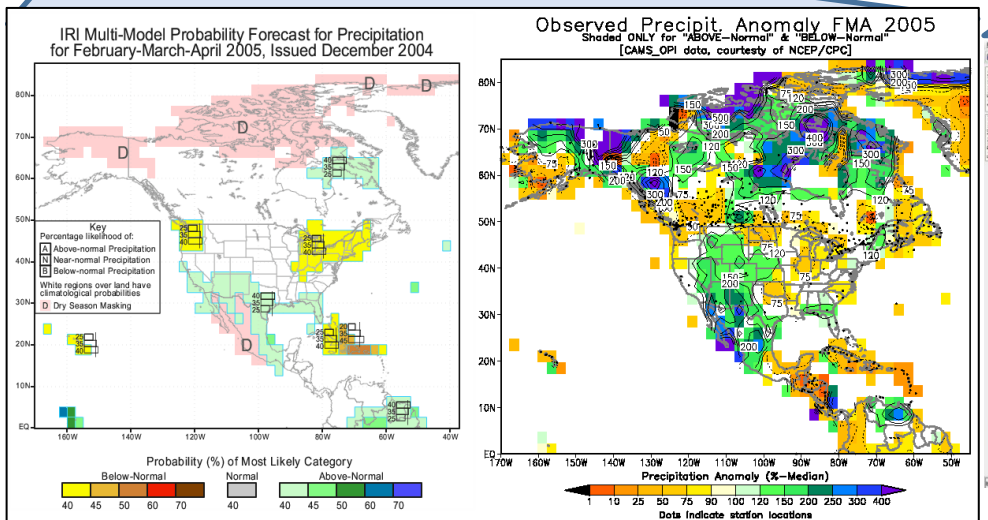
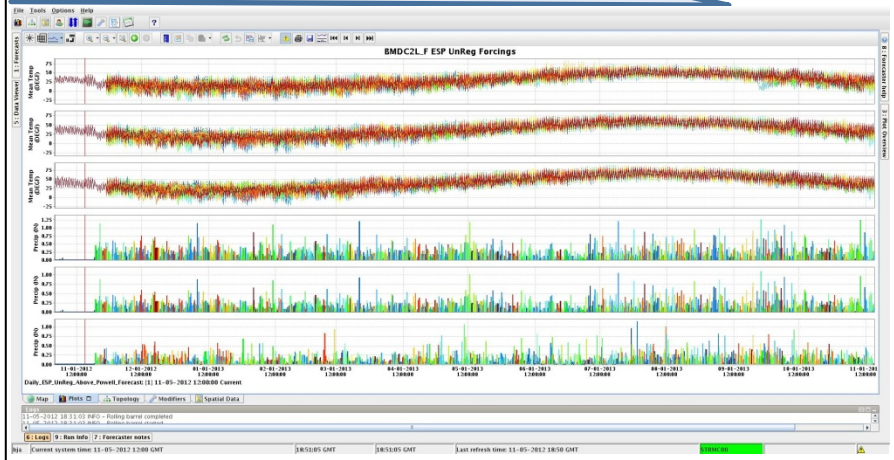


Figure: RPSS differences: positive values denote improvement with WG ESP

Climate Forecast → Weather Generator → ESP/CHPS → Improvement of Skill





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