Hydrological post-processing of streamflow forecasts issued from multimodel ensemble prediction systems

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FloodNet, June 27th 2017

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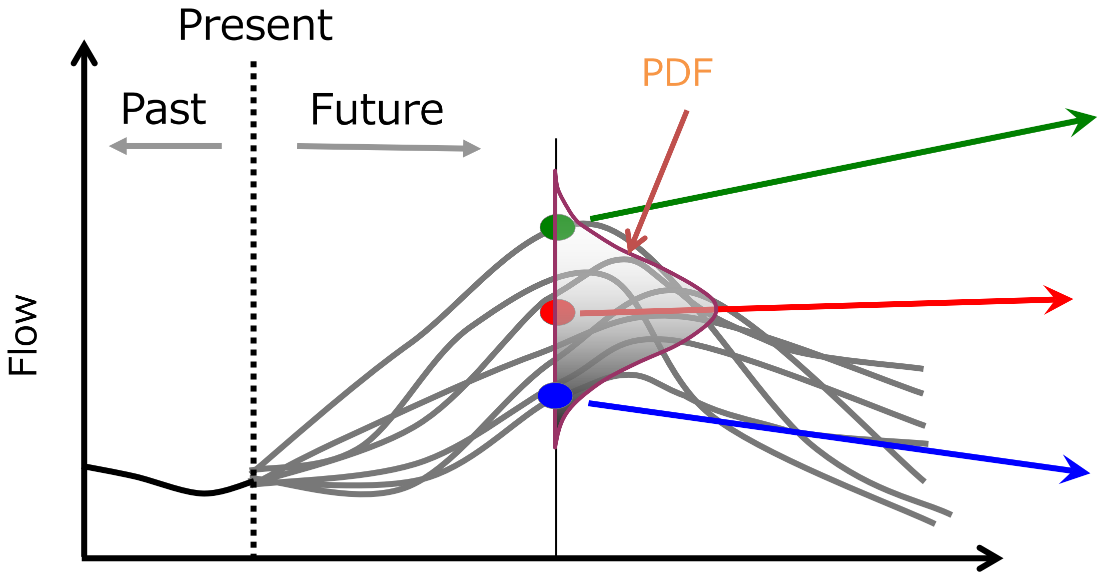
Hydrological Ensemble Prediction



Saved model states reflecting current conditions

Low chance of this level flow or higher

Medium chance of this level flow or higher

High chance of this level flow or higher

Adapted from COMET Module

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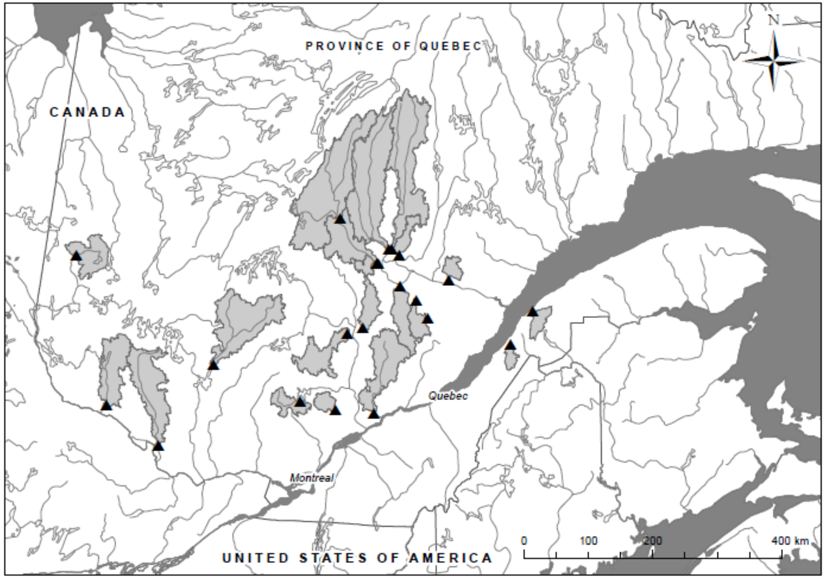
The Experiment



Thiboult et al. 2015

Meteorology
- 50 members

Initial conditions
- 50 *EnKF* members

Structural
- 20 daily lumped models

50,000 members

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Managing Uncertainty

Table 1. Description of the forecasting systems

Systems	A	B	C	D	E	F	G	H
Multimodel					■	■	■	■
EnKF			■	■			■	■
Met. ensemble		■		■		■		■
Nb of members	(20×)1	(20×)50	(20×)50	(20×)2500	20	1000	1000	50 000

Structural Uncertainty
Meteorological Uncertainty
Initial Condition Uncertainty

Thiboult et al. 2015

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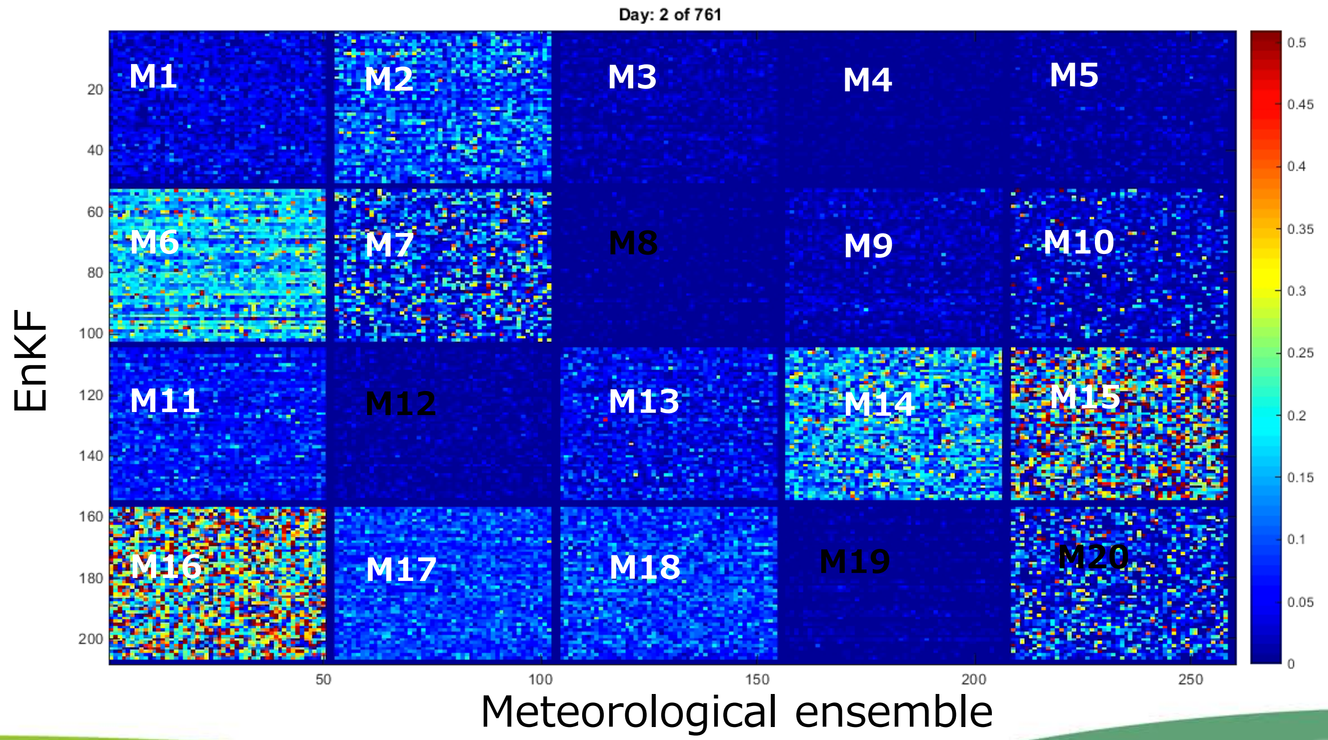
Visualization



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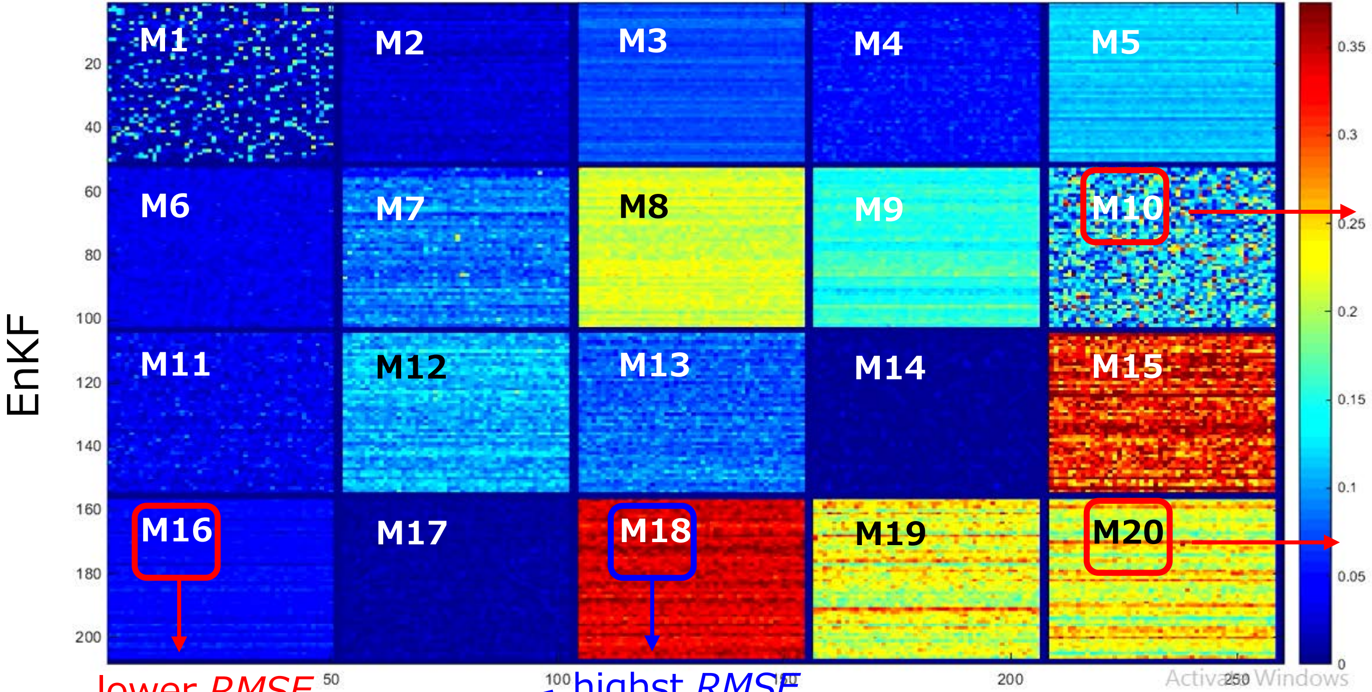
Visualization



combined uncertainty

initial condition uncertainty

lower *RMSE*

highst *RMSE*

Meteorological ensemble

structural uncertainty

Activate Windows

Research objective

Could we search for specific weights for each model?

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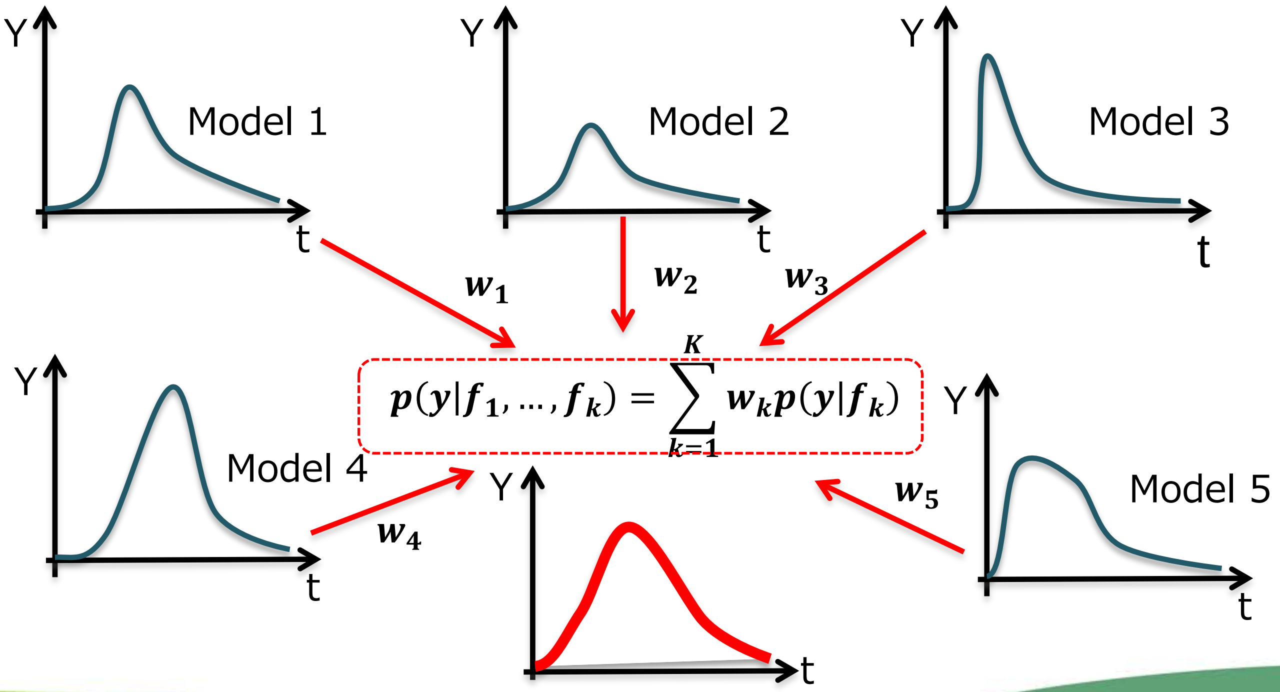
Bayesian model averaging (BMA)



$$p(y|f_1, \dots, f_k) = \sum_{k=1}^{K} w_k p(y|f_k)$$

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Bayesian model averaging (BMA)

$$p(y|f_1, \dots, f_k) = \sum_{k=1}^{K} p(f_k) \cdot p(y|f_k) = \sum_{k=1}^{K} w_k \cdot p(y|f_k)$$

where, y is the streamflow observation;

f_k is *the* forecast from model (member) *k*,

$p(f_k)$ is the posterior probability of the model prediction f_k.
Besides, it is usually replaced by a weight w_k that represents the credibility of model *k*.

$p(y|f_k)$ is the predictive probability density function (PDF) of streamflow observation according to model *k*.

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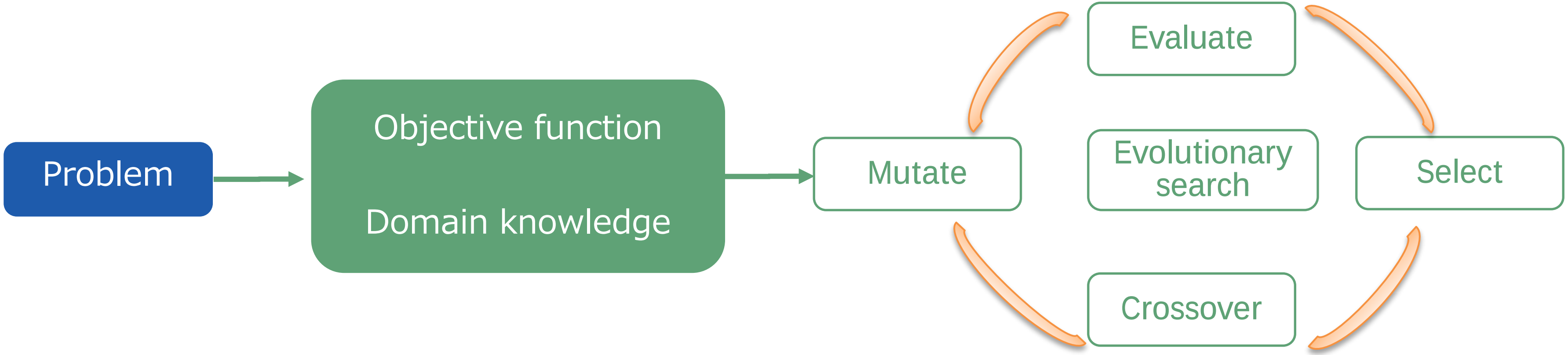
Multiobjective genetic algorithm: NSGA-II

NSGA-II is a nondominated sorting-based multiobjective genetic algorithm. (Kalyanmoy Deb., 2002)



The process of searching for the optimal solution from a set of candidates to the problem of interest based on the certain *performance criteria* (objective function).

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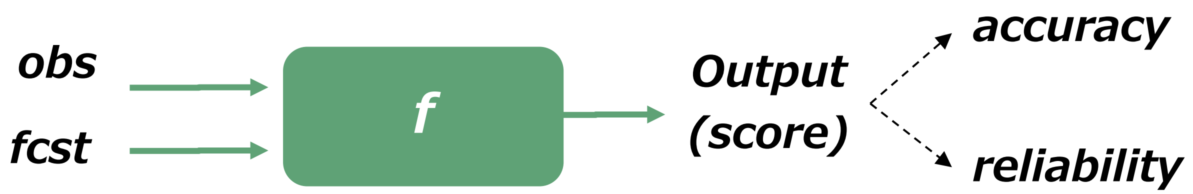
Multiobjective genetic algorithm: NSGA-II

Objective functions for optimization (performance criteria):

1. The Kling-Gupta efficiency (Gupta et al., 2009)
2. Normalized reliability deviation score (NRD′, in %) (Fortin et al., 2014)



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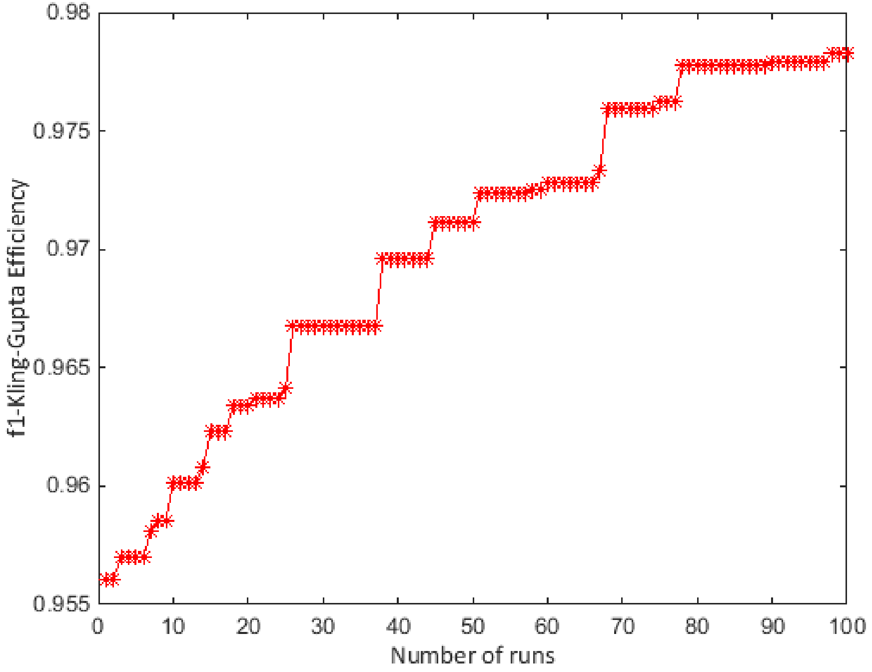
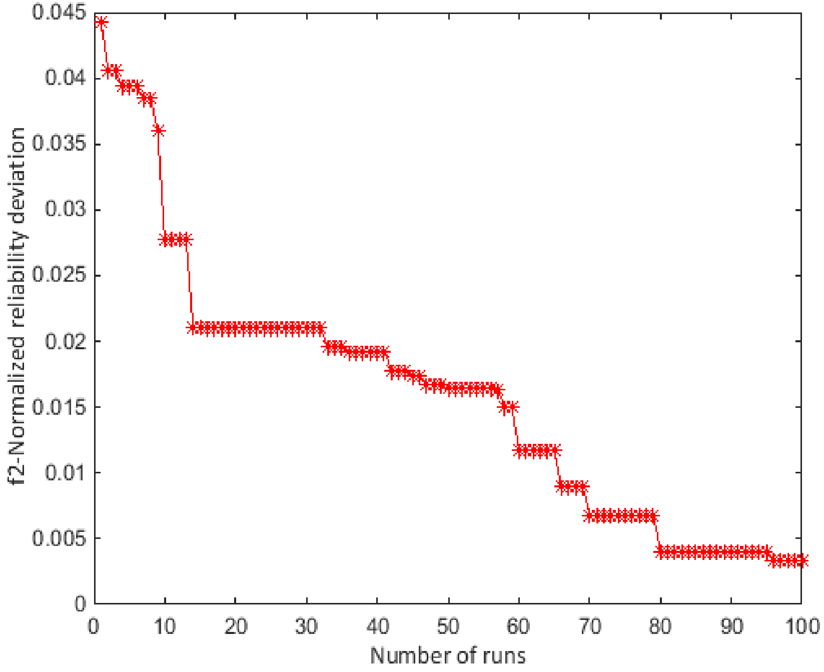
NSGA-II pareto fronts





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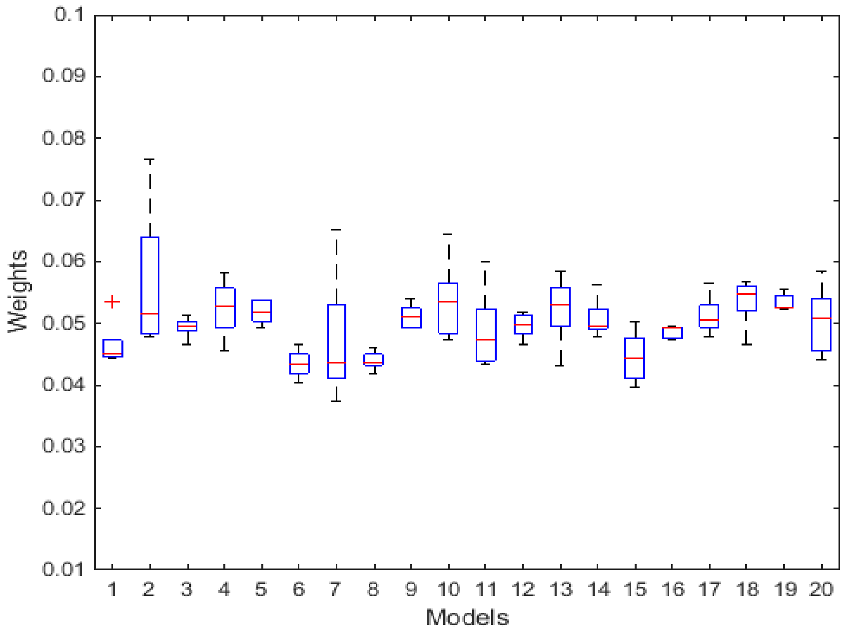
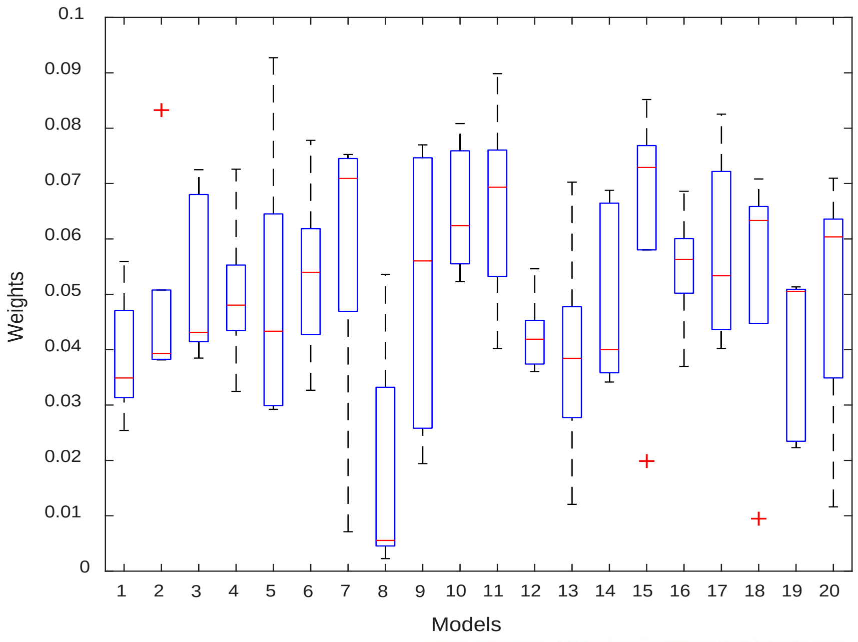
Comparison of weights of *system E*

BMA



NSGA-II



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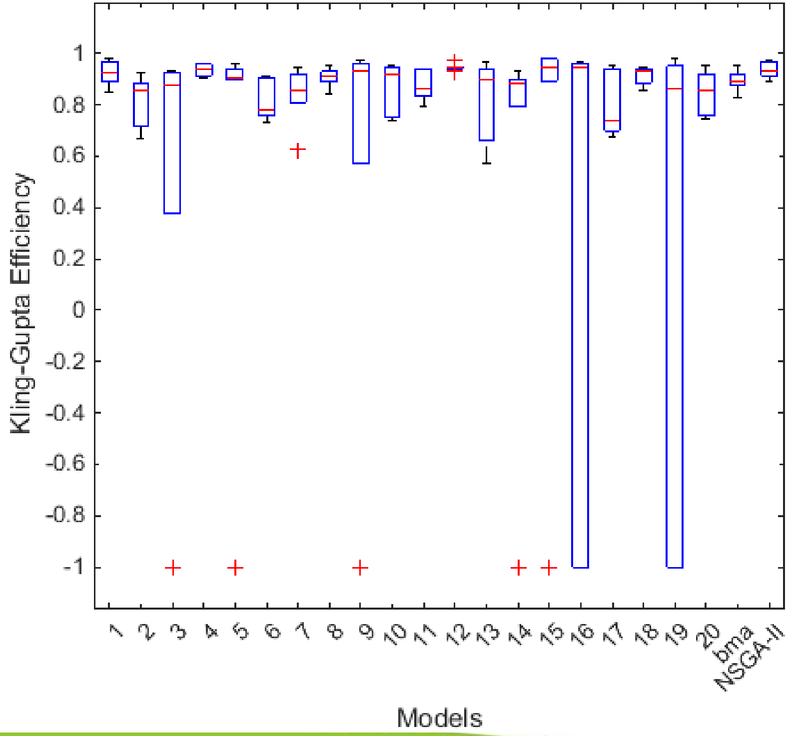
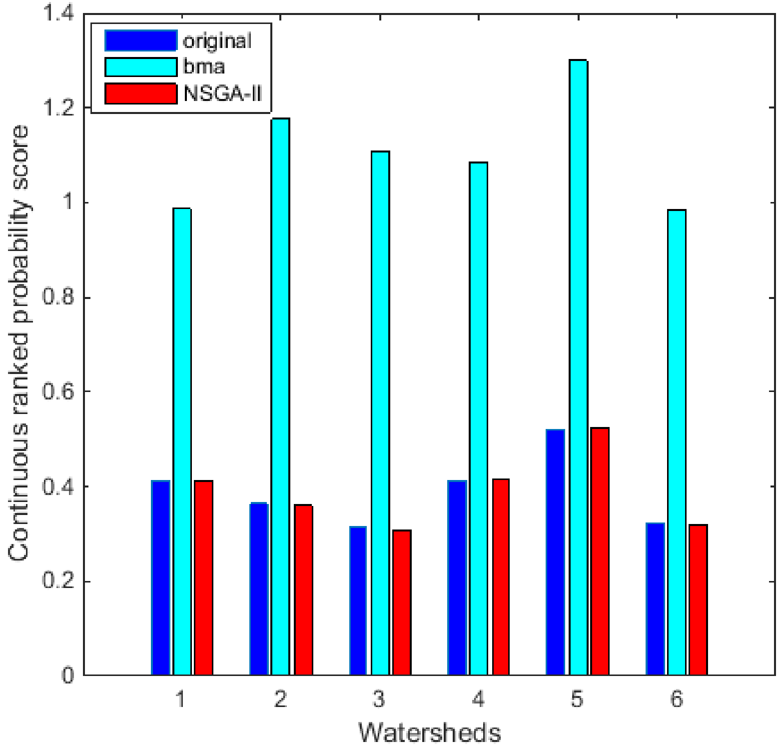
Comparison of accuracy verification results of *system E*

(Watershed #1-#6, Horizon 1)





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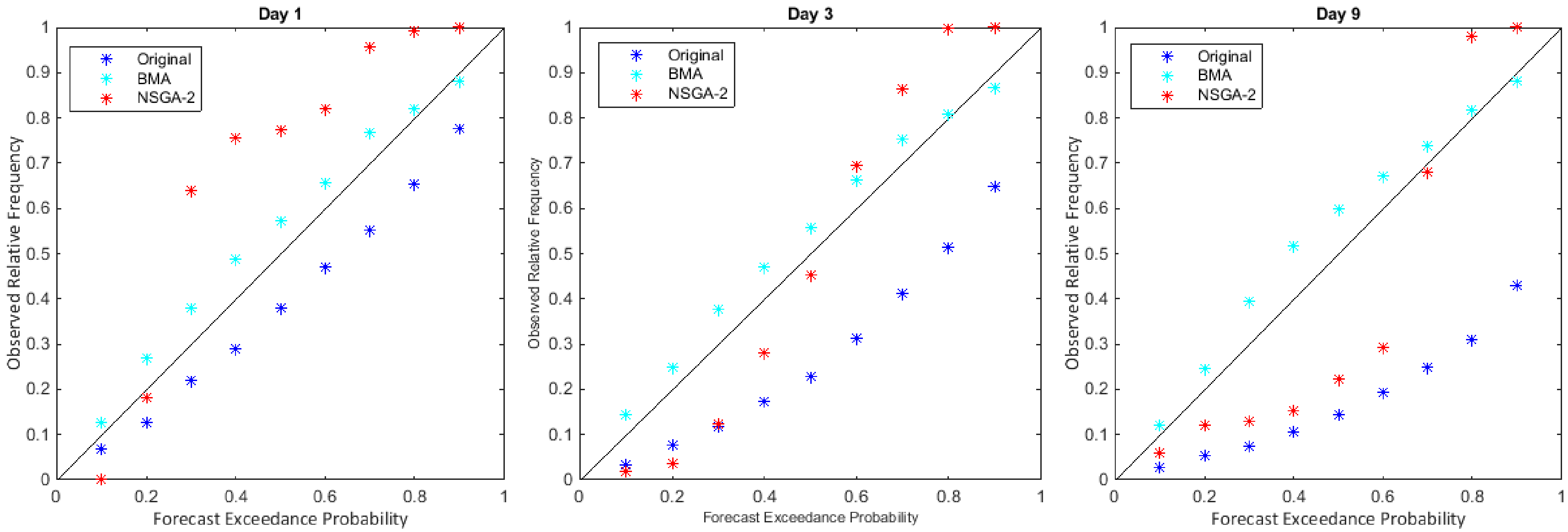
Comparison of reliability verification of *systmes E, F, G, H*

(Watershed #1 Trois Pistoles)

System E: Structural Uncertainty



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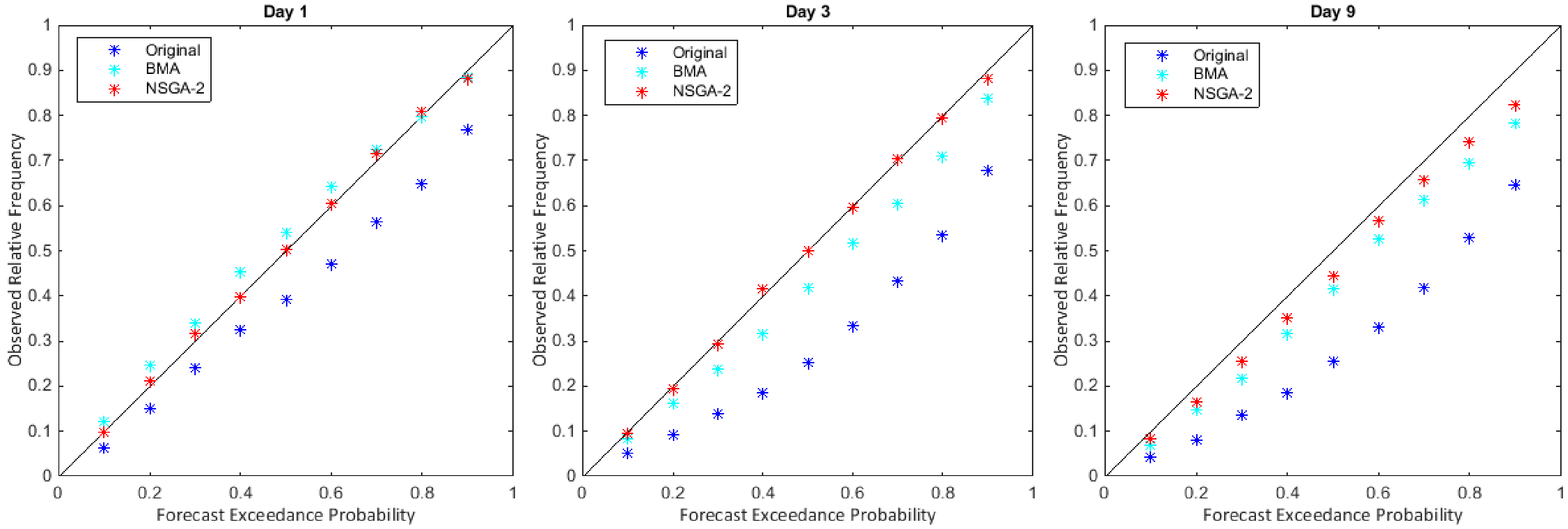
Comparition of Reliability verification of *systmes E, F, G, H*

(Watershed #1 Trois Pistoles)

System F: Meteorological Uncertainty



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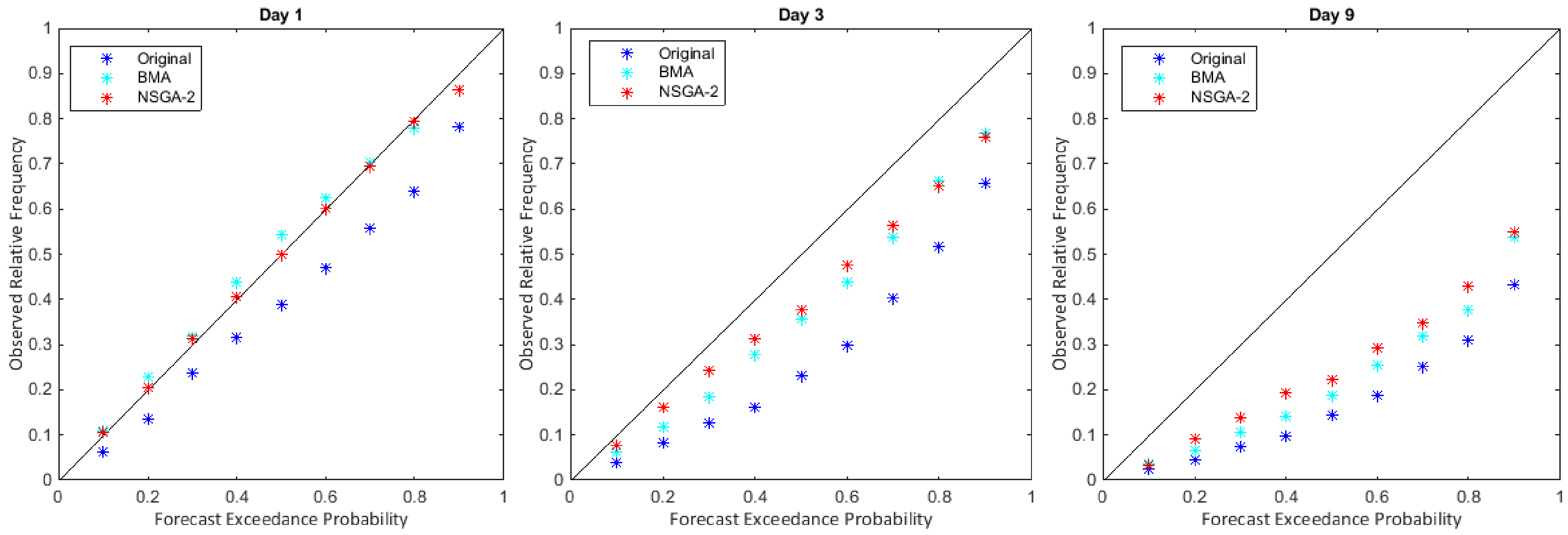
Comparition of Reliability verification of *systmes E, F, G, H*

(Watershed #1 Trois Pistoles)

System G: Initial Conditions Uncertainty



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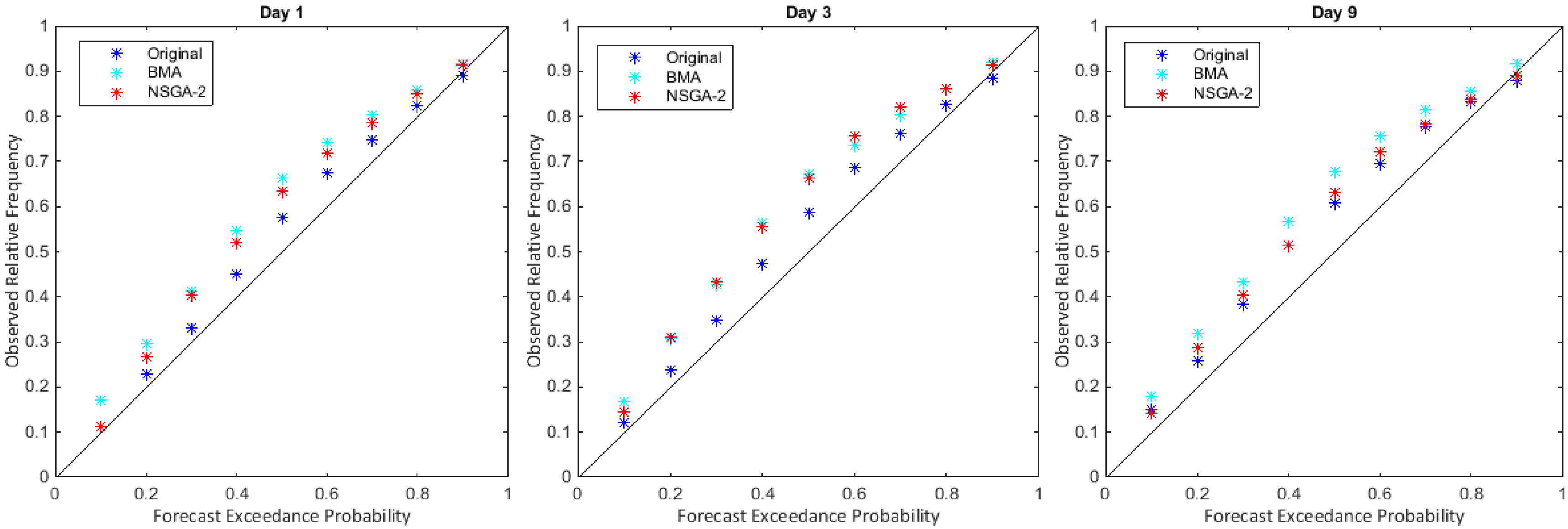
Comparition of Reliability verification of *systmes E, F, G, H*

(Watershed #1 Trois Pistoles)

System H: Combined Uncertainty



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Thank you!

Merci beaucoup!

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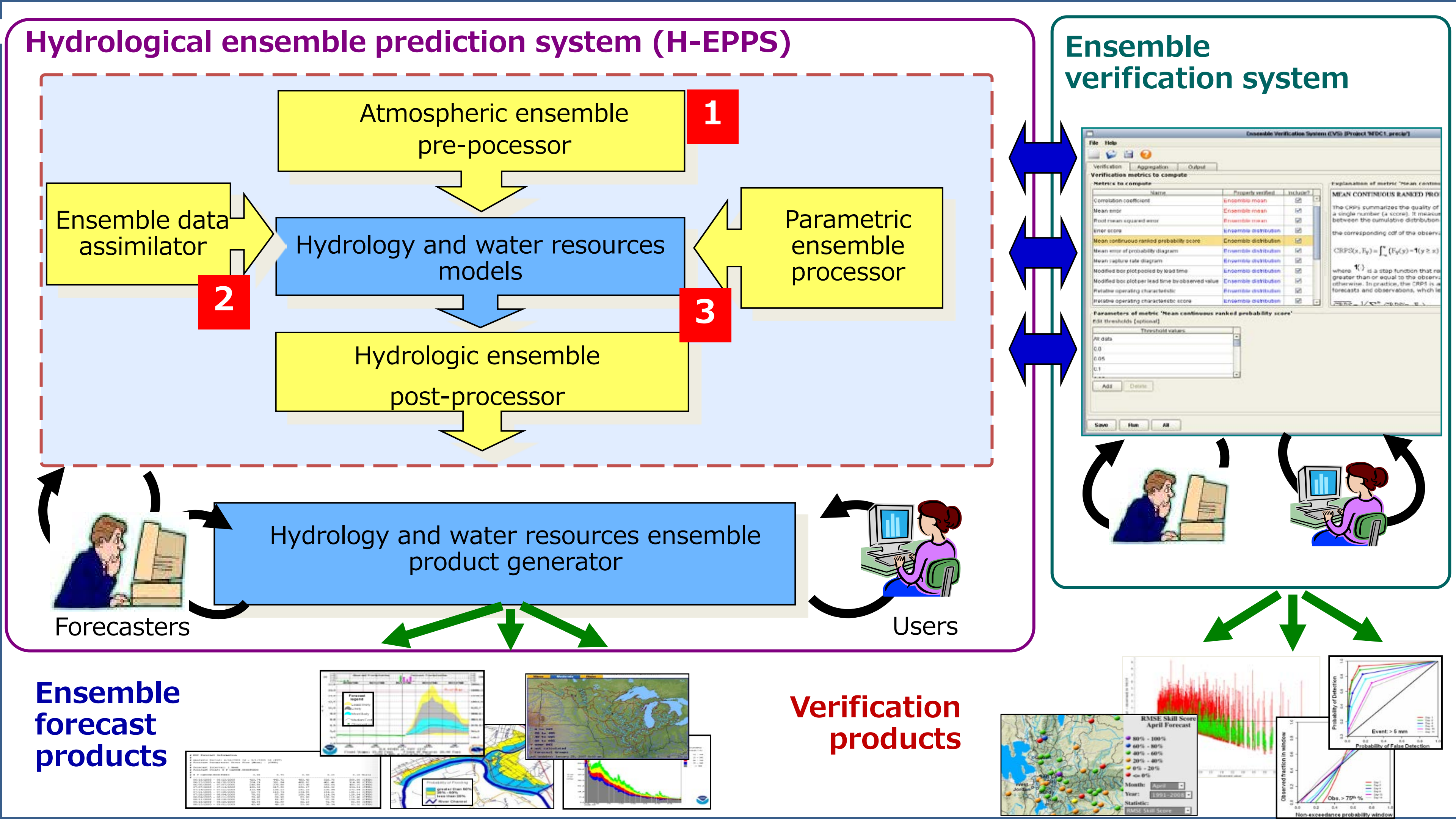
Hydrological ensemble prediction system (H-EPPS)
Atmospheric ensemble pre-processor
1
Ensemble data assimilator
2
Hydrology and water resources models
Parametric ensemble processor
3
Hydrologic ensemble post-processor
Hydrology and water resources ensemble product generator
Forecasters
Users
Ensemble verification system
Ensemble forecast products
Verification products

The Kling-Gupta efiiciency

The Kling-Gupta efiiciency (Gupta et al., 2009)

This performance criteria was used to assess the model performance comprehensively.

$$KGE = 1 - ED$$

$$ED = \sqrt{(r-1)^2 + (\alpha - 1)^2 + (\beta - 1)^2}$$

$$\alpha = {}^{\sigma_S}/_{\sigma_0} \qquad \beta = {}^{\mu_S}/_{\mu_0}$$

Where *ED* is the Euclidian distance from the ideal point, *r* is the correlation coeffcient between the simulations and the observations. μ_0 and σ_0 are the mean and standard deviation of the observations, μ_s and σ_s are the mean and standard deviation of the simulations,α is a measure of the relative variability in the simulated and observed values, and β is the ratio of the mean values of simulations and observations.

Without any simulation errors, the values of the three components are, *r*=1, α=1 and β=1. In this condition, *KGE* value is 1.

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The Kling-Gupta efficiency (*KGE*)

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$$KGE = 1 - ED$$

$$ED = \sqrt{(r-1)^2 + (\alpha - 1)^2 + (\beta - 1)^2}$$

$$\alpha = {}^{\sigma_S}/_{\sigma_0} \qquad \beta = {}^{\mu_S}/_{\mu_0}$$

Without any simulation errors, the values of the three components are, r=1, α=1 and β=1. In this condition, *KGE* value is 1.

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Normalized reliability deviation score (*NRD'*)

Normalized reliability deviation score (Fortin et al., 2014, Abaza et al., 2015)

This performance criteria was used to assess reliability of ensemble prediction.

$$NRD' = 100 \times \frac{RMSE - \sigma}{RMSE}$$

$$RMSE = \sqrt{\frac{1}{M}\sum_{t=1}^{M}\left(Q_{ens,t} - Q_{obs,t}\right)^2}$$

$$\sigma = \sqrt{\frac{1}{M}\sum_{t=1}^{M}\frac{1}{N-1}\sum_{i=1}^{N}\left(Q_{sim,i,t} - \overline{Q_{ens,t}}\right)^2}$$

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