EVALUATION OF CONTINENTAL-SCALE ENSEMBLE HYDROLOGICAL FORECASTS FROM ENVIRONMENT AND CLIMATE CHANGE CANADA (ECCC): A COMPARISON WITH FORECASTS FROM THE GLOBAL FLOOD AWARENESS SYSTEM (GLOFAS)

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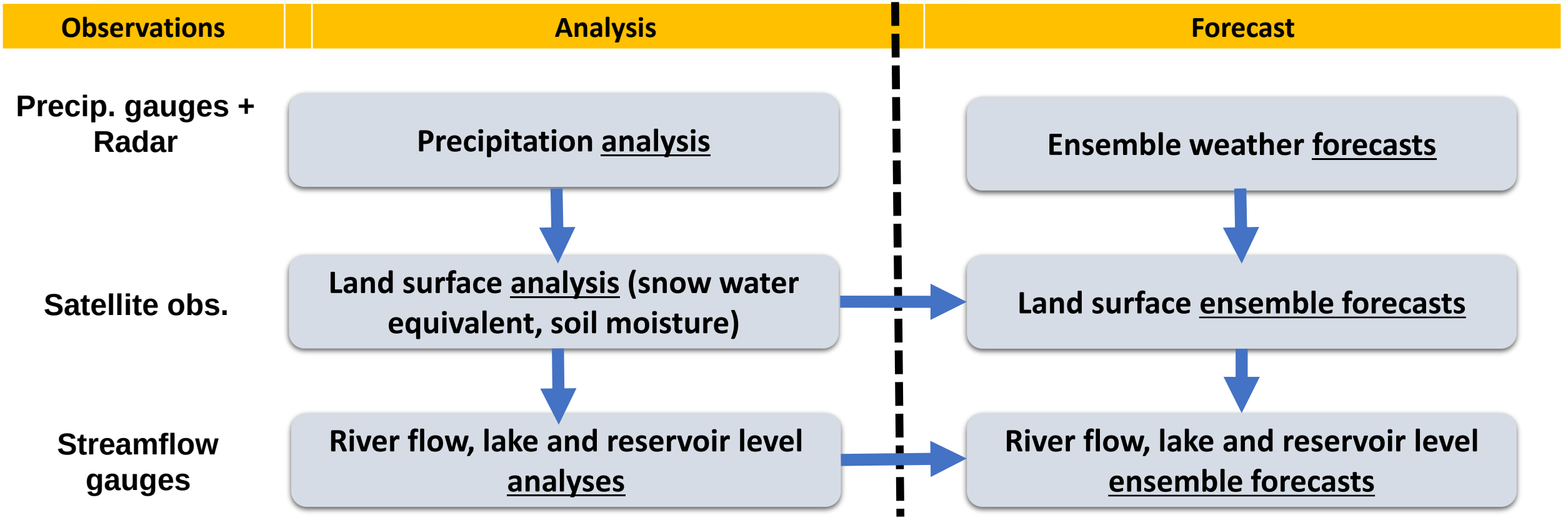
Presentation outline

- Overview of the National Surface and River Prediction System (NSRPS)
- Experiment details
- Comparison of NSRPS against persistence
- Comparison of NSRPS against climatology
- Comparison of NSRPS against GLOFAS v3
- Conclusions and future work

The National Surface and River Prediction System (NSRPS)

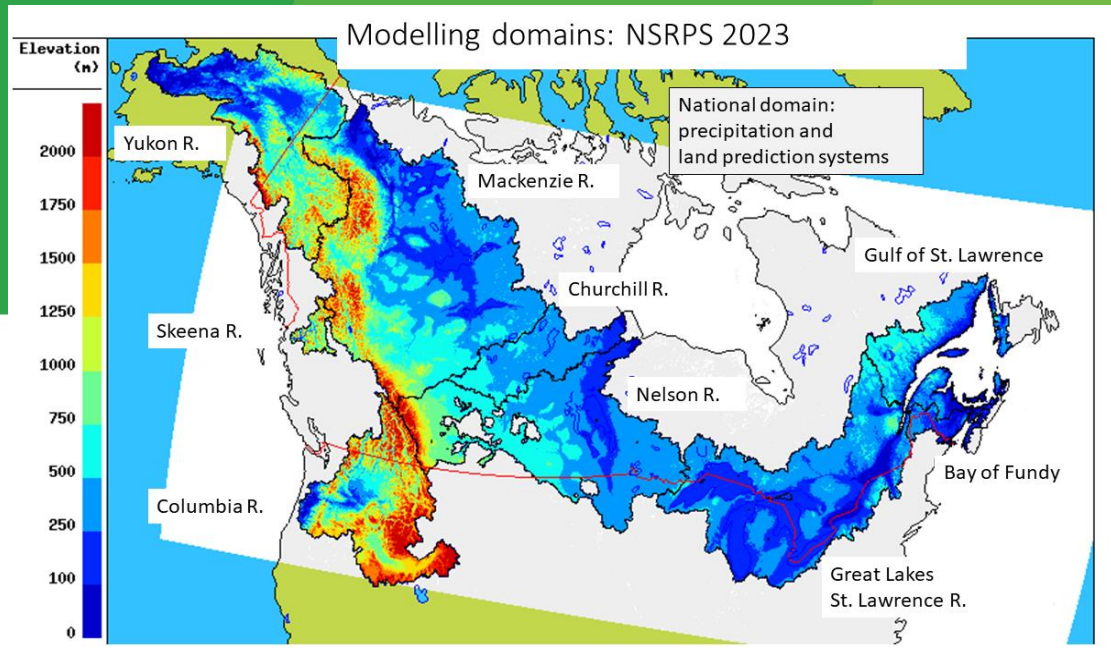
An integrated system of physically-coherent land surface and hydrologic products

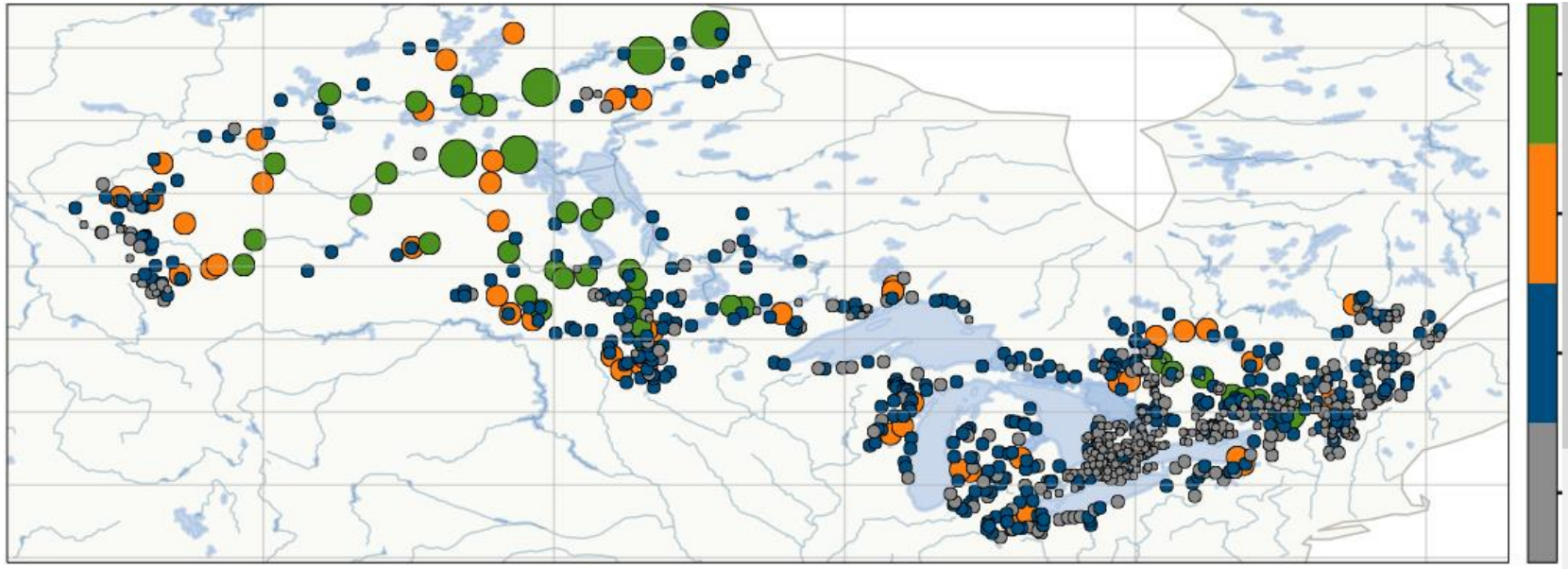


NSRPS experiment details

- 16-day forecasts
- emitted twice-daily
- February 13, 2022 – December 16, 2022
- Variable evaluated: mean daily specific flow (Q/DA, $mm.day^{-1}$)
- Scores: KGE, pBIAS, nNSE, CRPS = CRPS_rel + CRPS_pot

770 stations across the Churchill, Nelson, and Great-Lakes watersheds





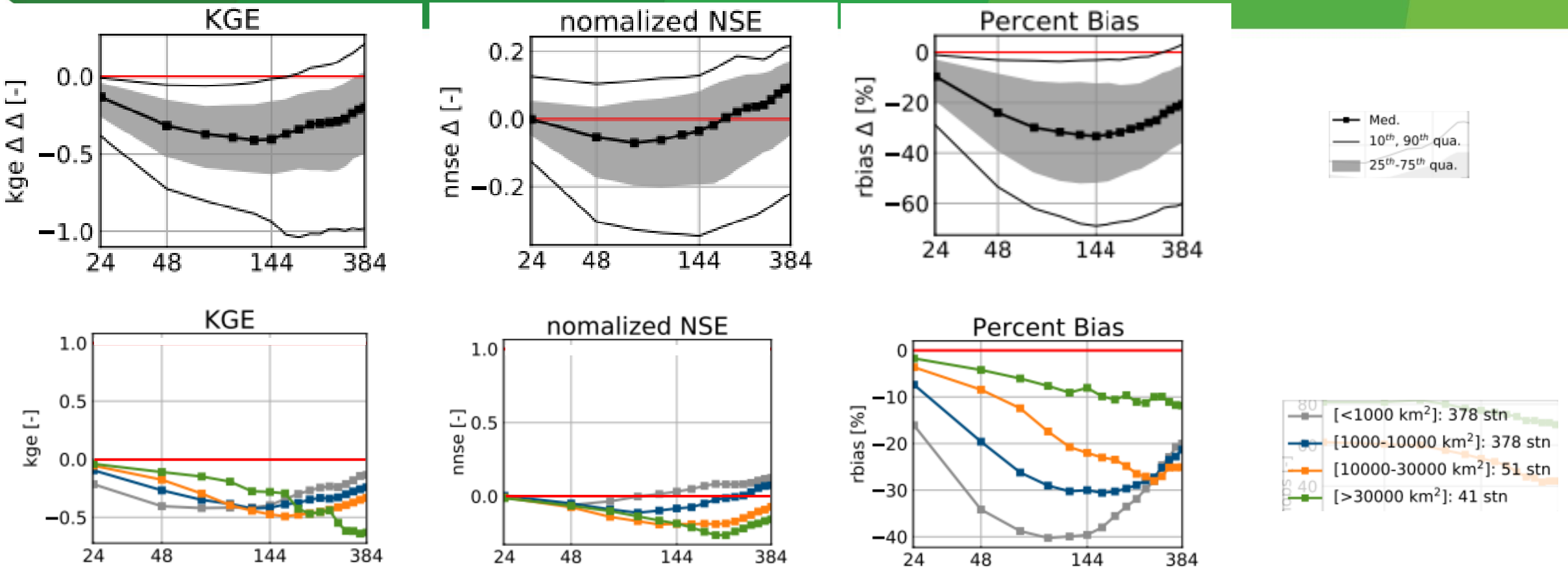
Drainage Area (DA) classes

30·000 km^2

10·000 km^2

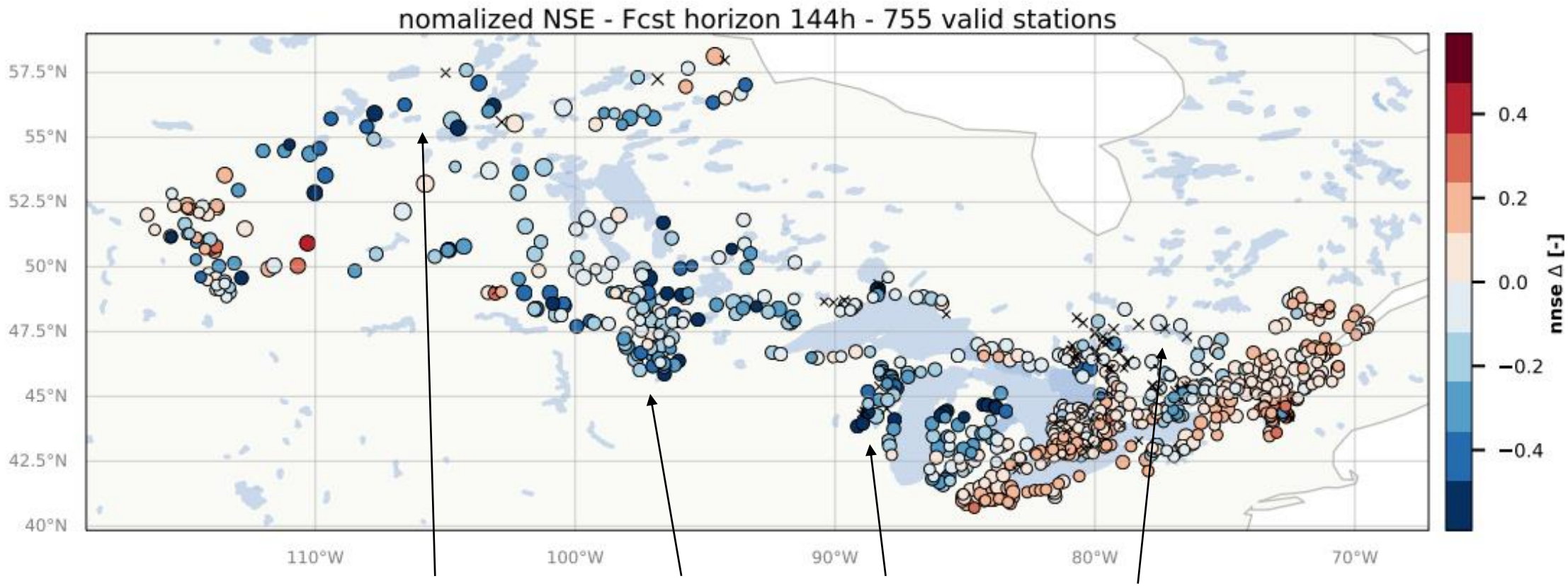
1000 km^2

NSRPS trimmed mean vs. persistence: scores across stations vs. lead-time



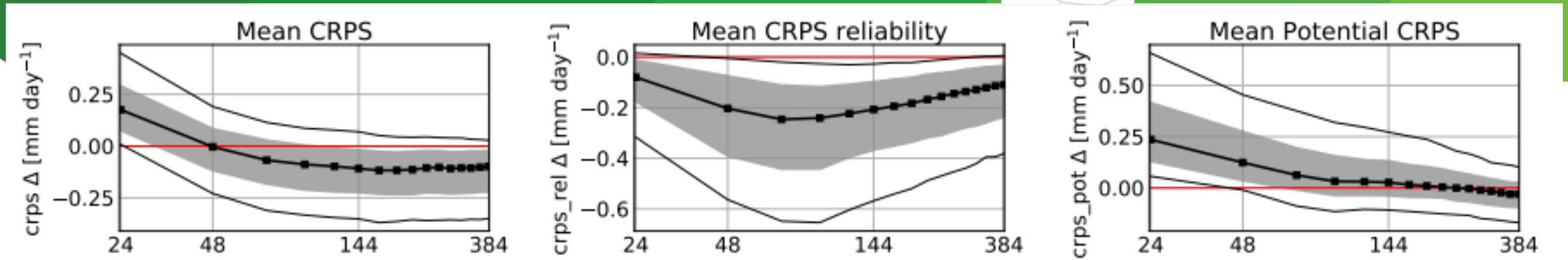
Generally worst than persistence in terms of Bias, but can be better in terms of dynamics (correlation, variability)

NSRPS trimmed mean vs persistence; spring 2022; lead-time 6 days. Map of normalized NSE

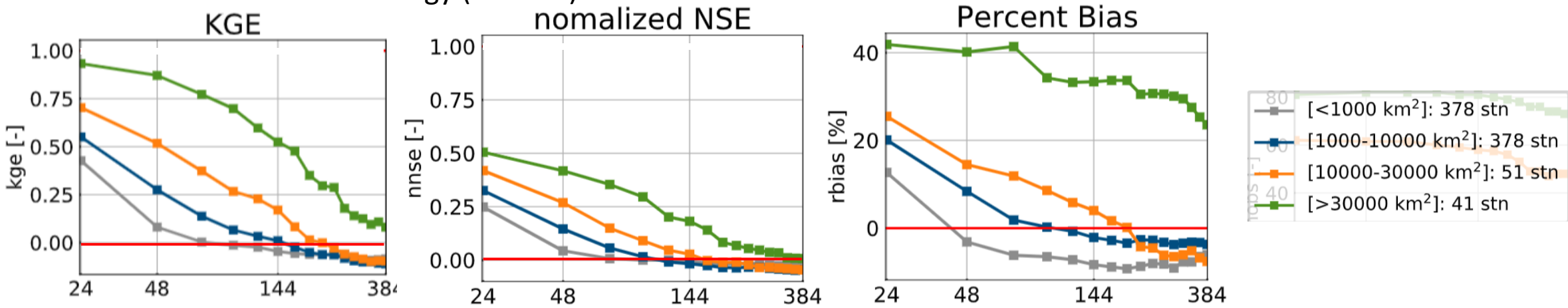


Still worst than persistence mainly for large watersheds and in areas with strong bias issues: basin of Lake Michigan, prairie potholes region, and areas with underestimation of solid precip. in Precip. analysis

NSRPS vs. climatology



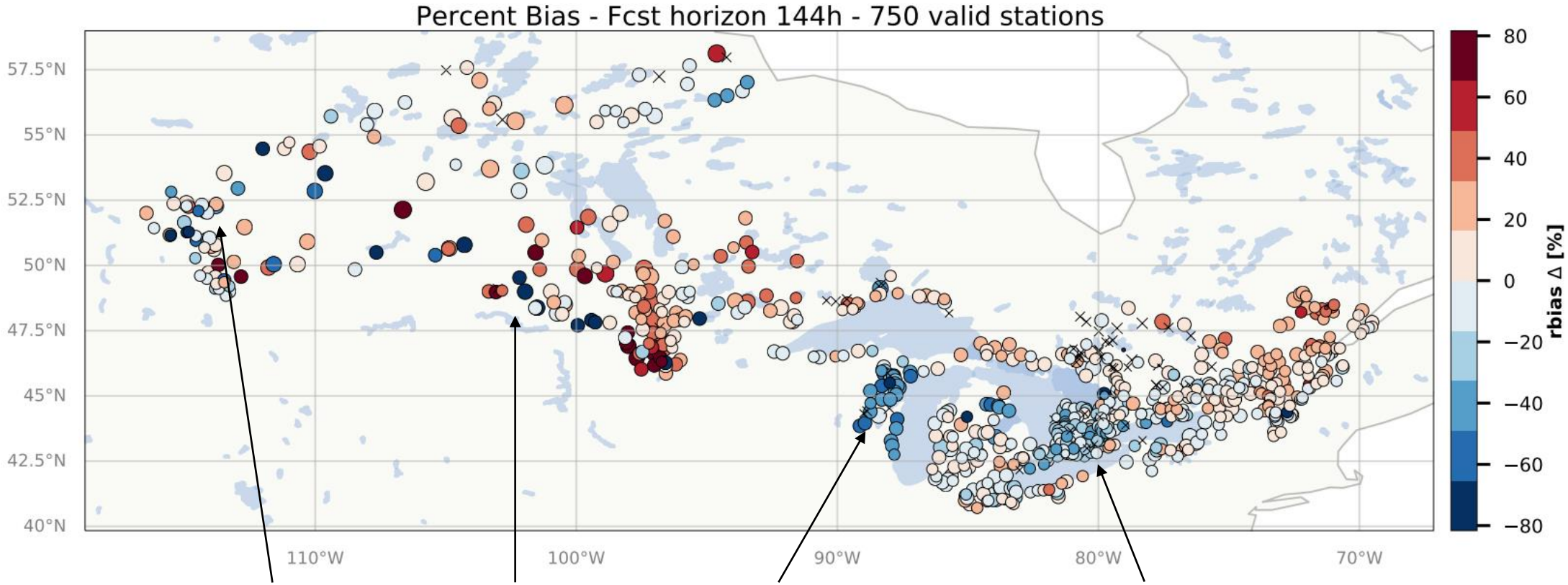
NSRPS trimmed mean vs. climatology (median)



NSRPS mean generally better than the climatology until about 6 days of lead-time, but depends on catchment size

Bias issues!

NSRPS trimmed mean vs climato; spring 2022; lead-time 6 days. Map of percent bias



Already worst than climatology mainly in small basins and areas with strong biases: agricultural areas (around Lake Erie), basin of Lake Michigan, Rockies (spring freshet of 2022 overestimated), prairie potholes region

Comparison of NSRPS (2022 operational version) and GLOFAS v3

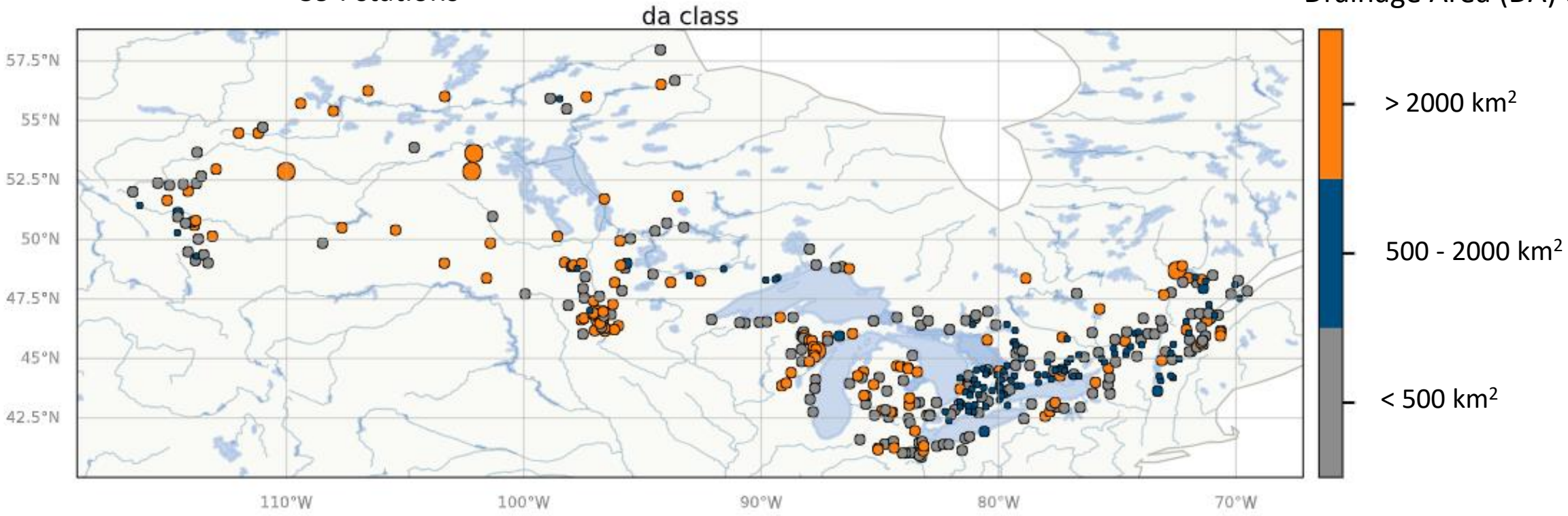
NSRPS (2022)	GloFAS v.3
• Based on GEM-Hydro	• Based on LISFLOOD
• **Resolution: ~ 2.5 km / 1 km**	• Resolution: ~ 10 km
• 16-day forecasts, 32 days 1/week	• **30-day forecasts refreshed daily**
• Regional coverage	• **Global coverage**
• 20 ensemble members	• **50 ensemble members**
• *Spread comes from uncertainty in weather forecasts only*	• *Spread comes from uncertainty in weather forecasts only*
• Current operational version is uncalibrated (calibrated model not yet in operations)	• **Current operational version is calibrated at some locations (32 locations with watersheds > 6500 km²)**
• **Assimilation of precipitation, snow cover and streamflow observations**	• Relies on ERA-5 precipitation for initial conditions

NSRPS vs. GLOFAS v3: Evaluation Dataset

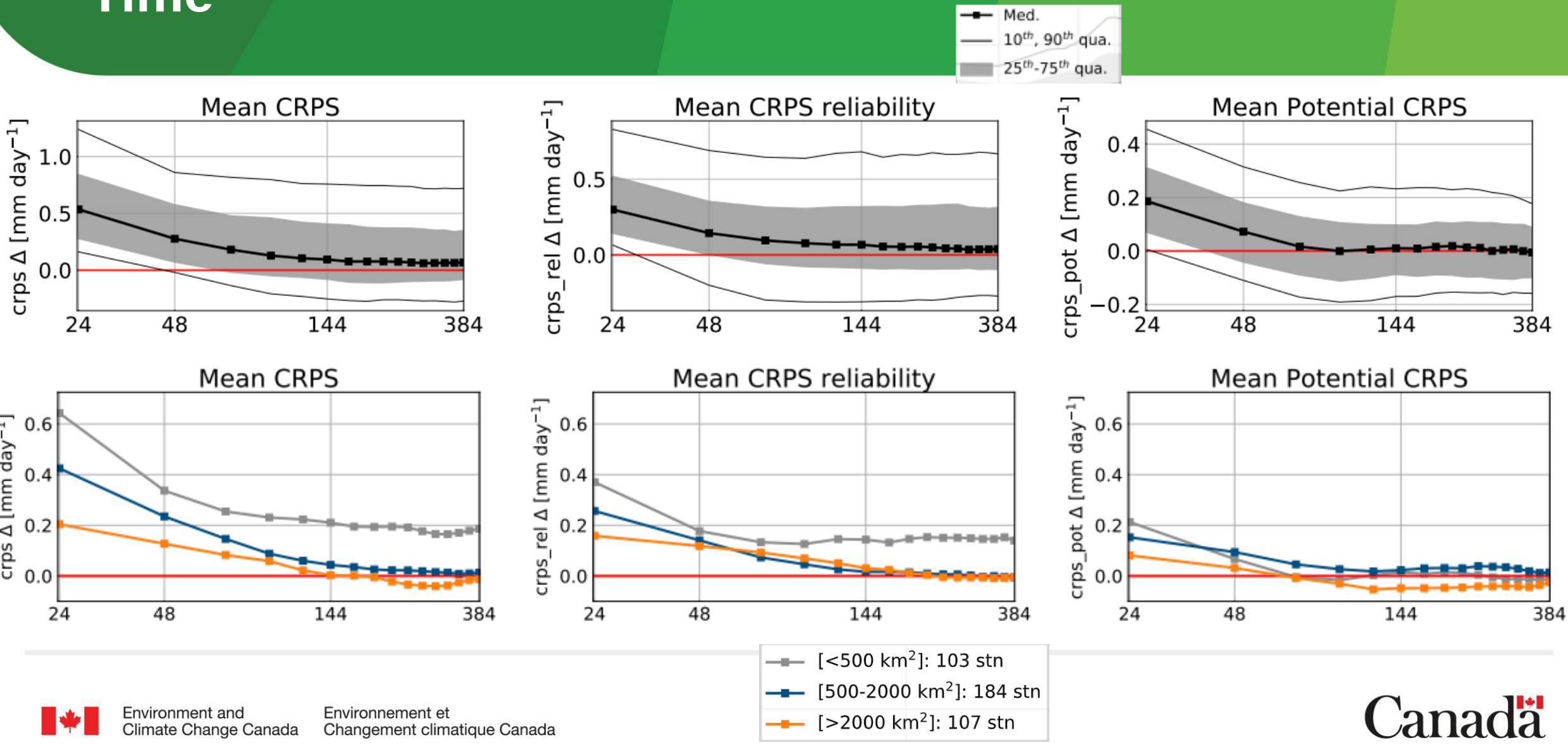
Data from GLOFAS version 3; version 4 has been released from then

394 stations

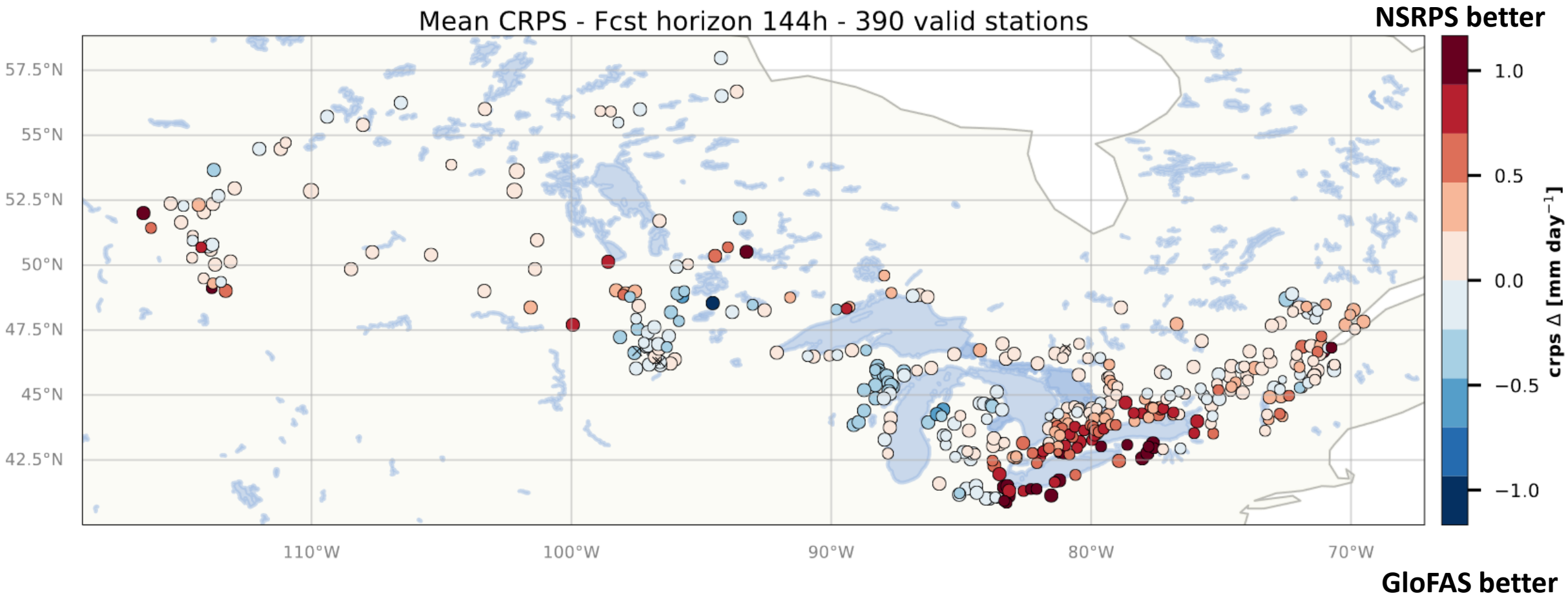
Drainage Area (DA) classes



NSRPS vs. GLOFAS v3: Difference in scores vs Lead Time



NSRPS vs. GLOFAS v3: map of mean CRPS Differences for lead-time 6 days



Conclusions / future work

- NSRPS performance varies strongly in space: areas with strong bias issues
- NSRPS comparison against persistence and climatology depends strongly on catchment size
- NSRPS generally better than GLOFAS v3 for short lead-times and small basins: effect of flow assimilation, resolution, … ?
- NSRPS strongly underdispersed (not shown)
- Need to improve the strong biases of NSRPS: add missing processes, post-process and combine forecasts of different systems! See Fortin et al. (2023)
- Compare / merge NSRPS forecasts to/with GLOFAS v4.

References

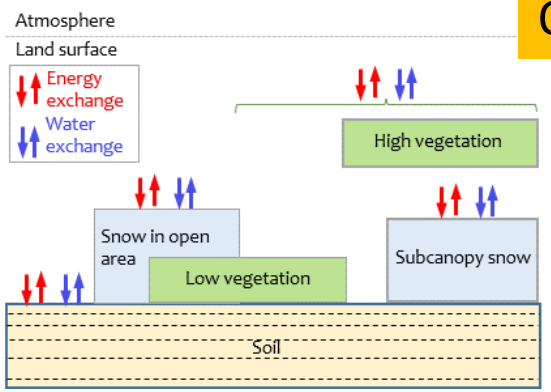
- Fortin, V., Innocenti, S., Gaborit, É., Durnford, D., Keita, S., Bruxer, J., ... & Gervasi, N. (2023). *Evaluation of continental-scale ensemble hydrological forecasts from Environment and Climate Change Canada: a comparison with forecasts from the Global Flood Awareness System (GloFAS)* (No. EGU23-2950). Copernicus Meetings.

Supplementary material

The GEM-Hydro model (model inside NSRPS)

GEM-Hydro = GEM-Surf (Bernier et al. 2011)+ Watroute (Kouwen, 2010)

One-way coupling between the Surface and Routing components

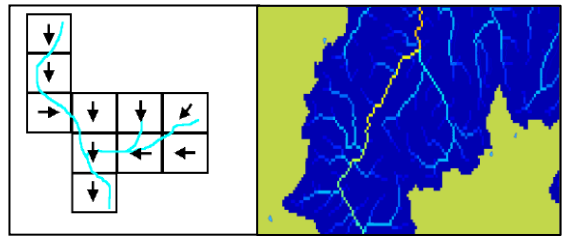


courtesy of G. Leonardini

Land: SVS
1-D fluxes

Alavi et al. (2016)
Leonardini et al. (2020, 2021)

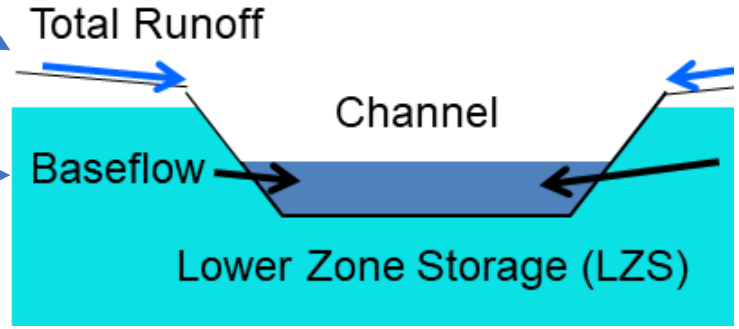
Flow direction grids (1km)



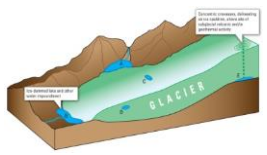
Total surface runoff

Soil drainage

1-D Hydraulic routing



Water surfaces/Ice over water



Glaciers
(Image source: USGS)

Urban Areas
(Image source: r-city.fr)

Natural lakes and regulated reservoirs can be explicitly represented

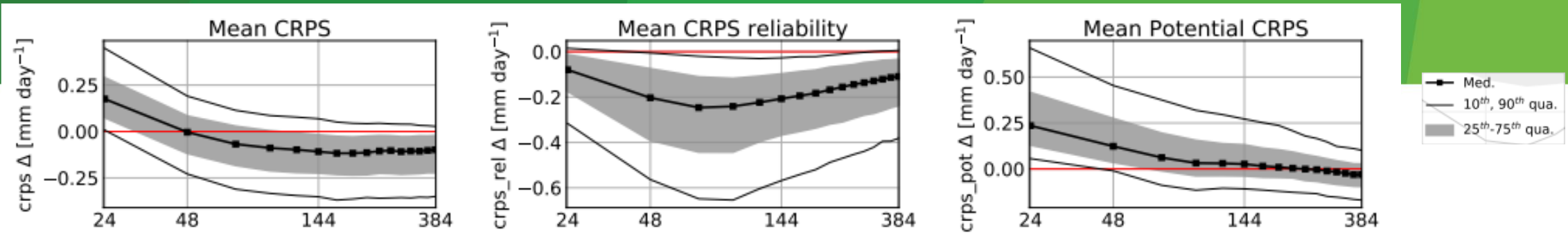
Verification metrics

- **Variables that are scored:**
  - mean daily specific flow (Q/DA)
- **Scores:**
  - Continuous Ranked Probability Score and its decomposition into reliability and potential components

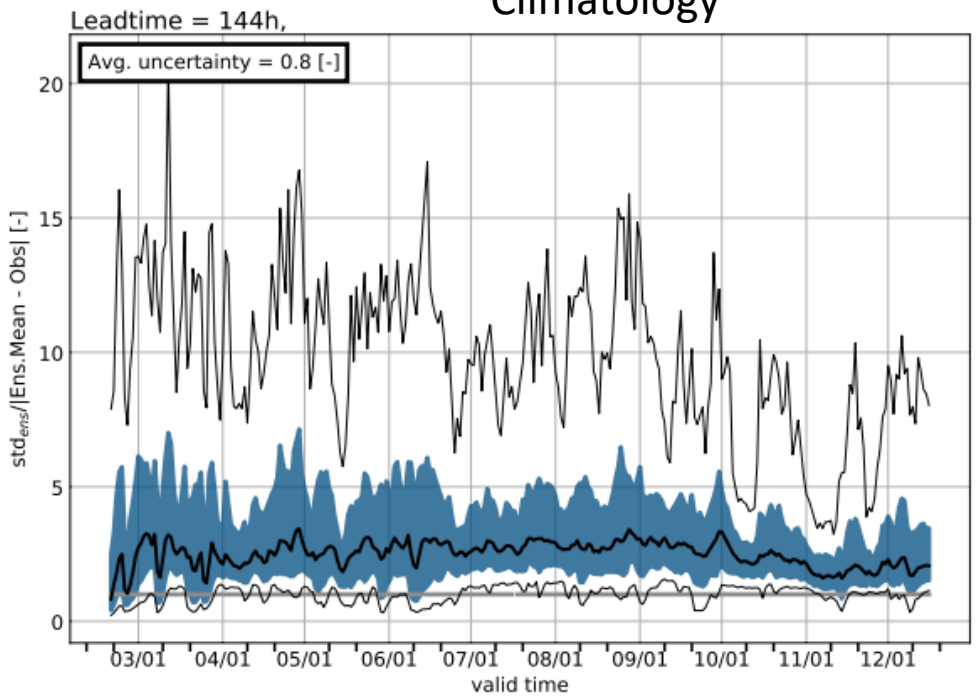
$$\mathrm{CRPS}(F, y) = \int_{-\infty}^{\infty} \{F(u) - H(u - y)\}^2 \, \mathrm{d}u \qquad \overline{\mathrm{CRPS}} = \overline{\mathrm{Rel}} + \overline{\mathrm{Pot}}, \qquad \overline{\mathrm{Rel}} = \sum_s \bar{g}_s \left(\bar{o}_s - \frac{s}{S} \right)^2$$

  - KGE, percent bias and normalized NSE of the ensemble (trimmed) mean
  - Normalized NSE: $nNSE = \frac{1}{2 - NSE}$ (nNSE is rescaled between 0 and 1)
- **Differences between these scores for the two systems**

NSRPS vs. climatology

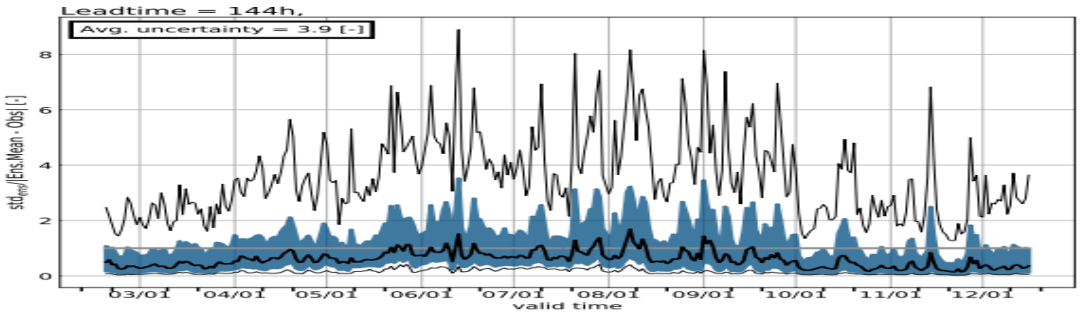


Climatology



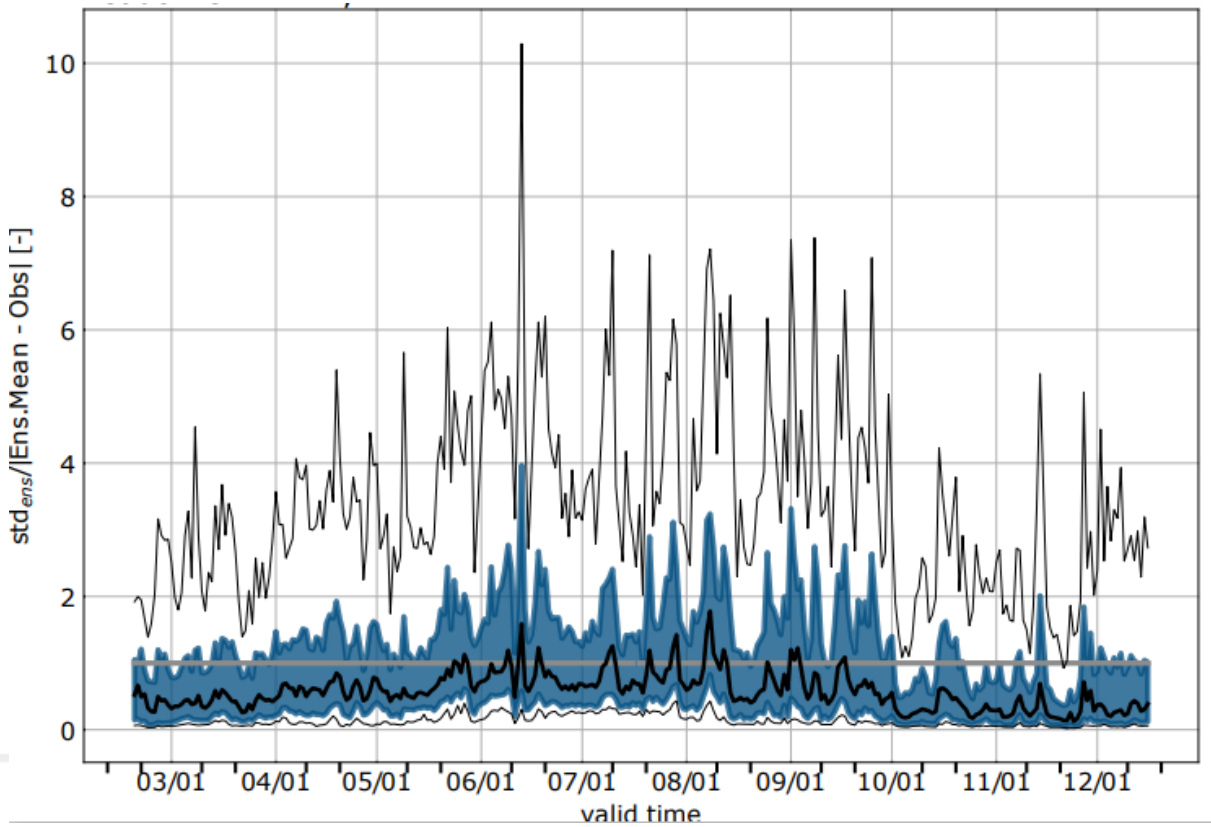
Median > 1 : Ensemble is overdispersive
Median < 1 : Ensemble is underdispersive

NSRPS



Dispersion of ensemble on Day 6

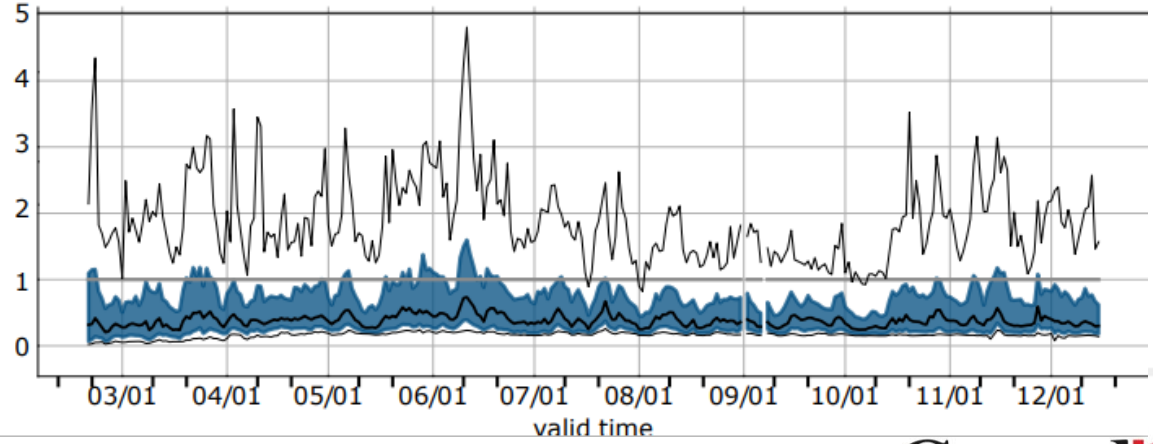
NSRPS/EHPS



GloFAS

Graphs show, for each date, the distribution across watersheds of the ratio between the standard deviation of the ensemble members divided by the absolute error associated with the ensemble mean

Median > 1 : Ensemble is overdispersive
Median < 1 : Ensemble is underdispersive



Example forecast hydrographs for station 061901 (Ashuapmushuan, flowing into Lake Saint-Jean)