Using GEFS ensemble forecasts for decision making in reservoir management in California

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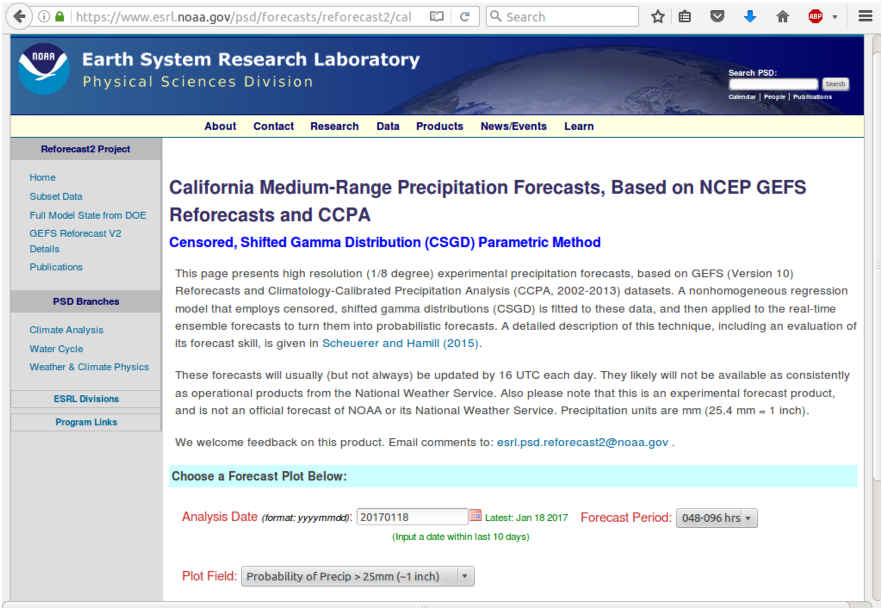
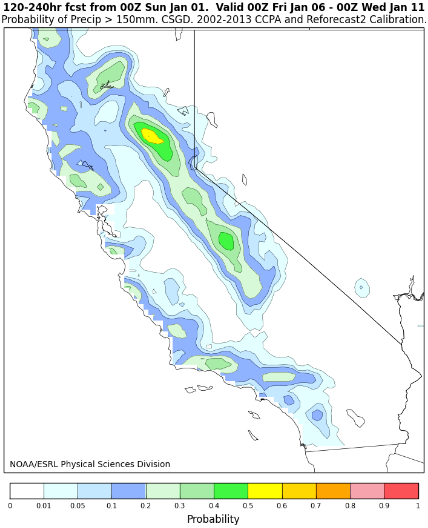
PSD's experimental forecast web product for California



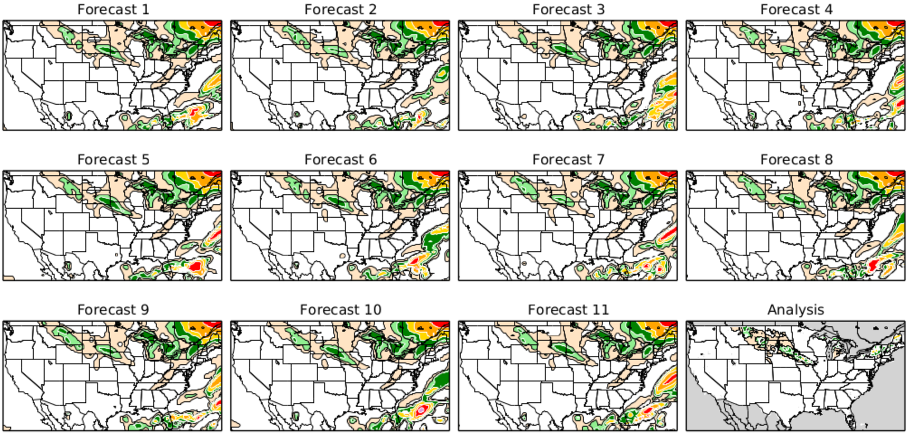
Probability of $\geq$ 6" precipitation, 00Z Jan 6 - 00Z Jan 11

Initialization time 00Z Jan 1, day 6-10 precipitation forecast.

This lead time is of particular interest in the context of FIRO.



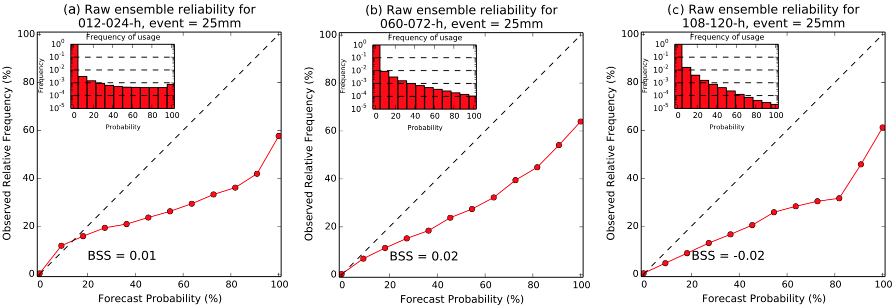
How do we get there?



GEFS ensemble forecast (lead time 12h - 24h) and climatology corrected analysis of 12h precipitation accumulations on 20 January 2013.

Post-processing of ensemble forecasts for precipitation

Quantiles and probabilities of threshold exceedance derived from the raw ensemble directly are often unreliable (biases, insufficient representation of uncertainty, etc.)



Statistical post-processing methods use forecast-observation pairs from the past to identify and correct those shortcomings.

Data used for our experimental web products

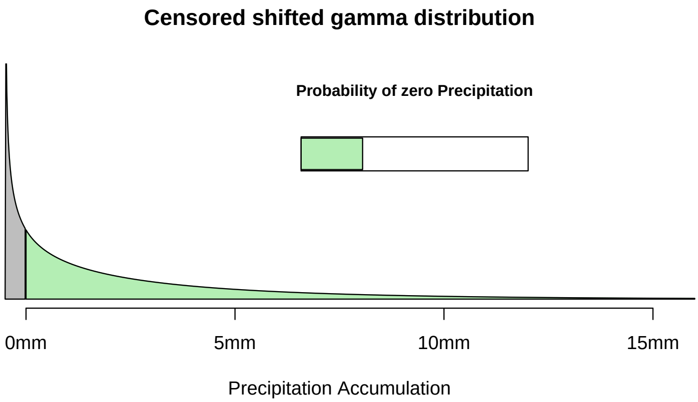
The 2nd generation GEFS reforecast data set (Hamill et al., 2012) is the backbone of our experimental web products and associated research. It contains GEFS version 10 ensemble forecasts for a period from January 1985 to present, initialized at UTC 0000 and consisting of 11 members.

Climatology corrected precipitation analyses (Hou et al., 2012) over the conterminous U.S. on a grid with $1/8^\circ$ horizontal resolution are used as the 'truth' against which those forecasts are calibrated and verified.

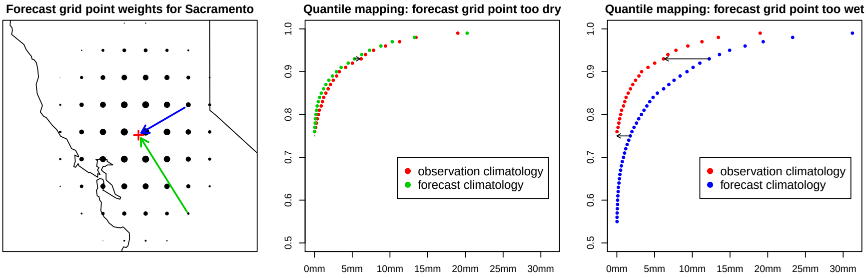
The probabilistic forecasts made available through our experimental web products are based on the Censored Shifted Gamma Distribution (CSGD) post-processing methodology proposed by (Scheuerer and Hamill, 2015) and explained on the following slides.

A distribution family for precipitation

We model precipitation accumulations by censored, shifted gamma distributions (CSGDs):



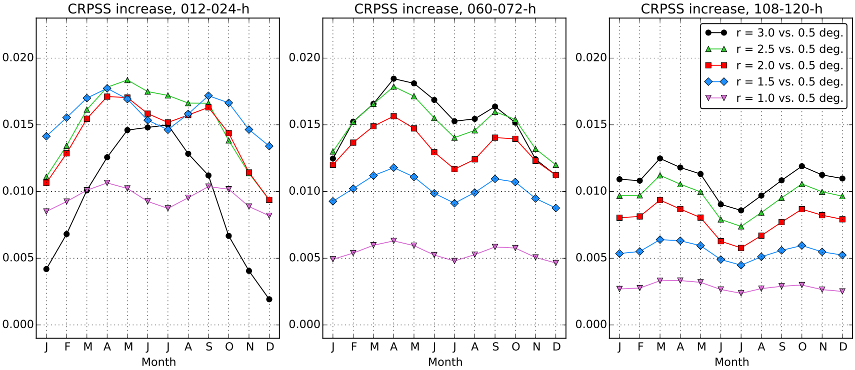
Accounting for displacement errors



Our method accounts for displacement errors by considering ensemble forecasts in a larger neighborhood of the analysis grid point of interest (here: Sacramento, red cross).

To address the issue of different climatologies within that neighborhood, quantile mapping is used to homogenize the forecasts before further processing them.

Impact of neighborhood size



Increase of continous ranked probability skill scores (CRPSSs) for different neighborhood sizes, relative a neighborhood radius of $r = 0.5$ degrees.

Results are for 12-h precipitation accumulations, cross-validated over the years 2000 to 2013, and averaged over all 1/8 degree CCPA grid points within the CONUS.

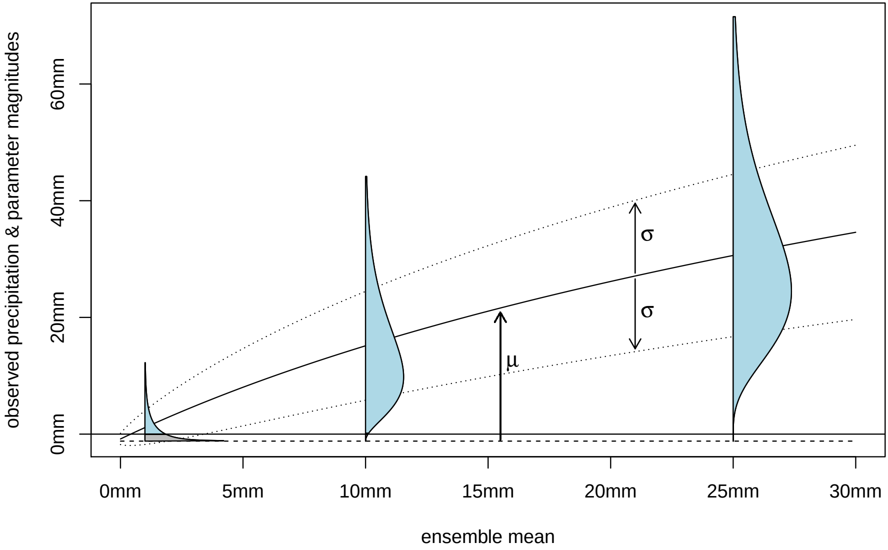
Statistics of quantile-mapped ensemble forecasts

Denote by $\tilde{f}_{xk}$ the quantile-mapped precipitation forecast of member k at forecast grid point x. For prediction at s we consider the following ensemble statistics:

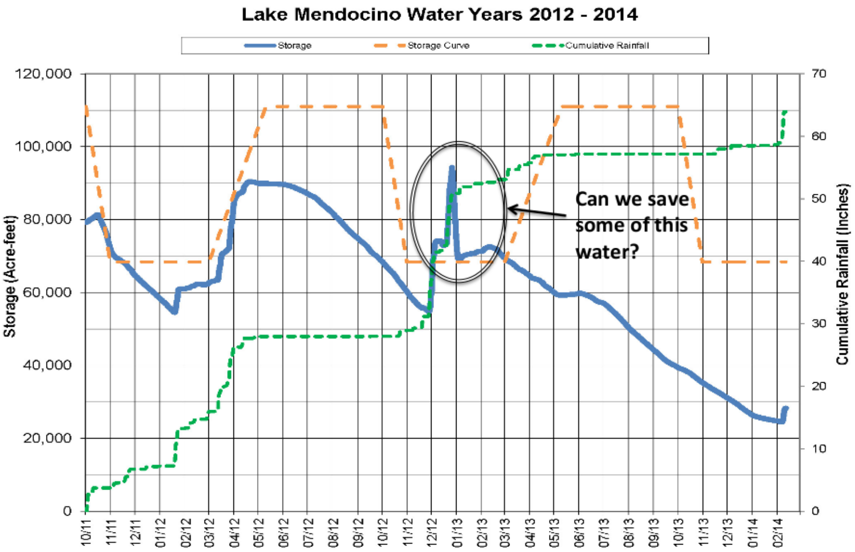
- $\mathrm{POP}_{f,s} := \frac{1}{m} \sum_{k=1}^{m} \sum_{x \in N(s)} w_{sx} \, \mathbf{1}_{\{\tilde{f}_{xk} > 0\}}$
- $\overline{f}_s := \frac{1}{m} \sum_{k=1}^{m} \sum_{x \in N(s)} w_{sx} \, \tilde{f}_{xk}$
- $\mathrm{MD}_{f,s} := \frac{1}{m^2} \sum_{k,k'=1}^{m} \sum_{x,x' \in N(s)} w_{sx} w_{sx'} \left| \tilde{f}_{xk} - \tilde{f}_{x'k} \right|$

where $N(s)$ is the set of forecast grid points in the neighborhood of s and w_{sx} is the weight associated with this grid point.

Heteroscedastic regression model



Application in the FIRO context



Application in the FIRO context

Could the probabilistic forecasts of our experimental web product be used to inform reservoir operations?

For example, if a very low chance of extreme precipitation is forecast, could water be kept in the reservoir even if water levels already exceed the storage curve?

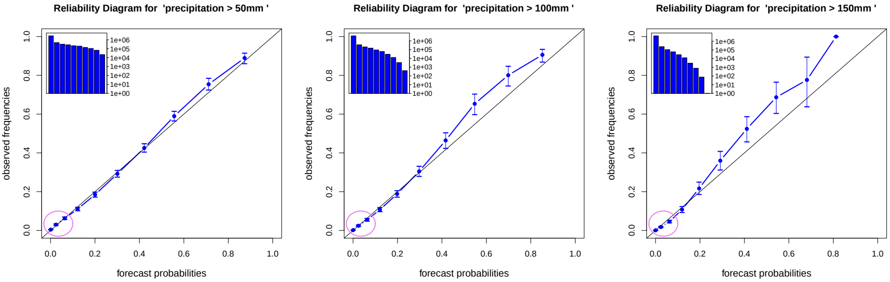
In order to be useful for decision making, probability forecasts must be

- reliable, i.e. if a 10% chance of exceeding a threshold is forecast, the threshold should be exceeded in about 10% of all such forecast cases
- sufficiently discriminative, i.e. if the threshold is exceeded the forecast probability of exceedance should be as high as possible, otherwise as low as possible

Forecast reliability

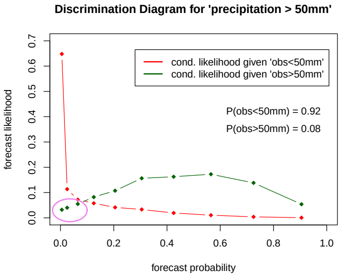
A verification study was conducted

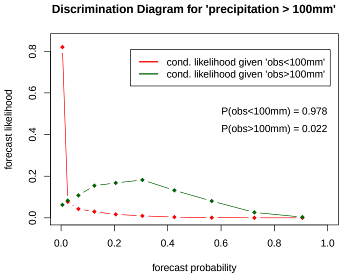
- using all CCPA grid points within Northern and Central California
- cross validating the cool seasons 2002/2003 to 2015/2016

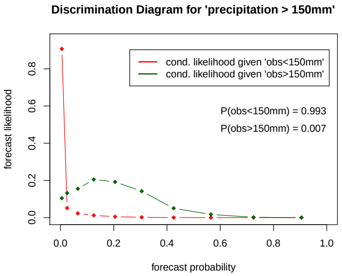


The experimental forecast product has a tendency to underforecast when high probabilities are issued, but is reliable for the low probabilities that are relevant for decision making.

Discrimination ability



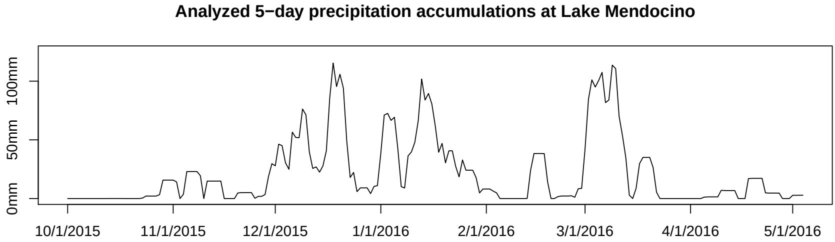


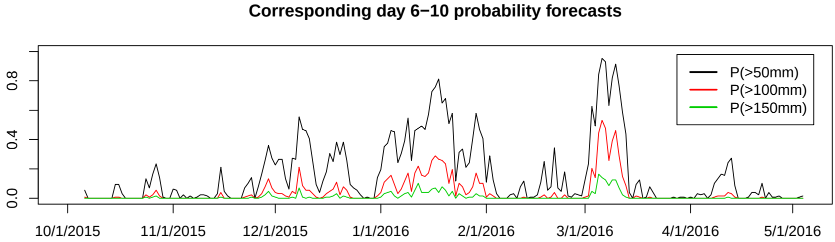


The probability forecasts are able to discriminate exceedance and non-exceedance.

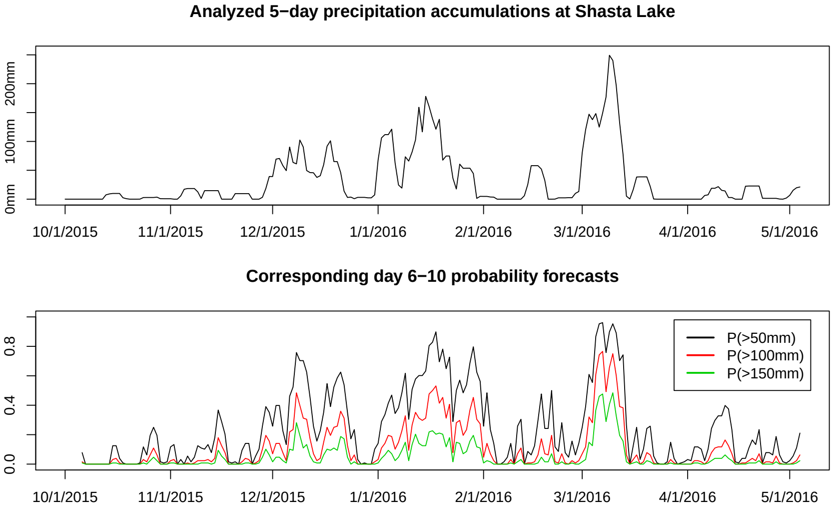
Due to the large uncertainty at lead time 6-10 days, however, there are a number of exceedance cases where low exceedance probabilities are issued.

Case Study: Lake Mendocino, 2015/2016 cool season





Case Study: Shasta Lake, 2015/2016 cool season



Summary and Discussion

- Statistical post-processing of the GEFS ensemble forecast can generate probabilistic forecast that can be used for decision making
- Currently, uncertainty at 6-10 days lead time is still large; as a result, even a reliable probabilistic forecast product will not always issue high exceedance probabilities when an extreme event occurs
- Probabilistic framework gives decision makers the freedom to manage risks by selecting the probabilities at which action is taken

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Thanks for listening!

References I

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