Seasonal climate prediction: a new management tool for the wind energy sector

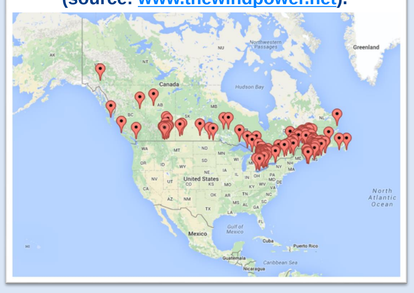
Verónica Torralba, Francisco J. Doblas-Reyes, Isadora Jiménez, Nube González, Albert Soret and Melanie Davis

Barcelona Supercomputing Center (BSC), Catalan Institute of Climate Science (IC3), Institució Catalana de Recerca i Estudis Avançats (ICREA)

Aim of the study

- Accurate forecasts of wind speeds are key for the decision-making processes for the wind energy users. In monthly to decadal time scales current energy practices assume that future will be a repetition of the retrospective climatology.
- The available seasonal predictions can provide an additional value for wind energy applications, especially the management of power production plants. However, the application of the seasonal predictions is limited because this information is hard to understand and apply.
- This work aims to investigate the use of probabilistic seasonal climate predictions to inform wind energy users.
- A region of Canada with an exceptional wind energy development [112.5º-113.2ºW, 53.3º-51.0ºN] is used to illustrate the performance of the predictions. ECMWF System 4 10-m wind speed seasonal predictions in December-January-February have been used. Prediction start date is 1st of November for the period of 1981-2013. ERA-Interim wind speeds have been used for validation.

Map of wind farms in Canada
(source: www.thewindpower.net).



Methodological comparison: Canada wind farm case study

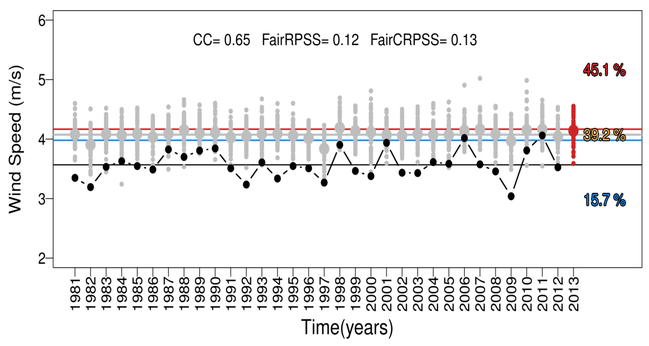
Skill Scores inform users about the performance of the forecast. Skill scores above 0 are better than the climatology forecast; equal to 0 make no improvement and below 0 the prediction is unskillful. (CC=Correlation Coefficient; FRPSS =Fair Ranked Probability skill score; Fair CRPSS=Fair Continuous Ranked Probability Skill Score).

Rank histograms show if the forecasts are statistically consistent with the observations (i.e. they have the same probability distribution). When the and the rank histogram is homogeneously populated it is statistically consistent and needs no calibration. This happens when the rank histogram is homogeneously populated.

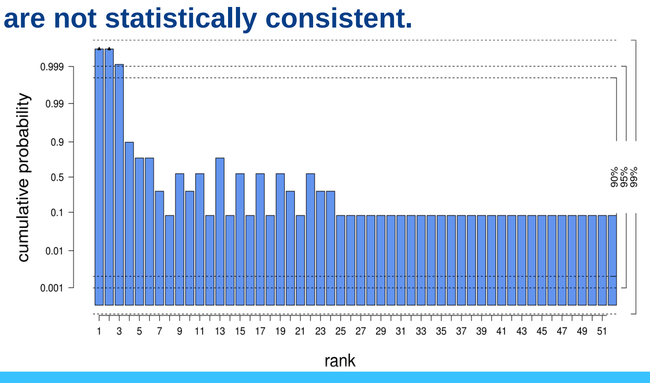
Reliability diagrams provide a visual assessment of the forecast reliability. A perfectly reliable forecast should draw a line as closely as possible to the diagonal. Right panels show sharpness diagrams for three events: above-normal wind speeds (red line), normal wind speeds (orange) and below-normal wind speeds (blue).

Uncorrected

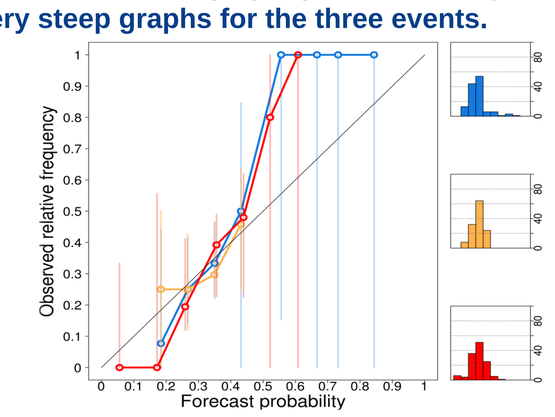
Differences between the hindcast mean and the reference mean indicates that the forecasts of wind speeds are affected by a bias.



The most populated lowest ranks evidence the presence of a cold bias in the forecasts, which are not statistically consistent.



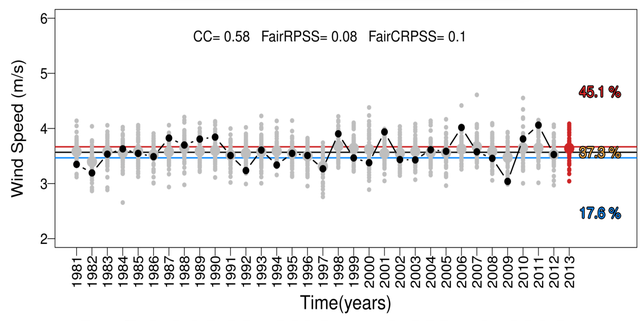
The forecast displays poor reliability with very steep graphs for the three events.

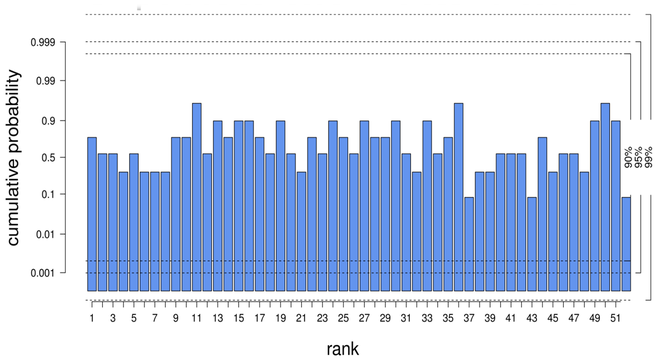


The wind speed forecasts require a post-processing stage to correct their deficiencies. Two different approaches are applied and compared

Simple bias correction

$$w_{ij} = (x_{ij} - \bar{x})\frac{\sigma_{ref}}{\sigma_e} + \bar{o}$$

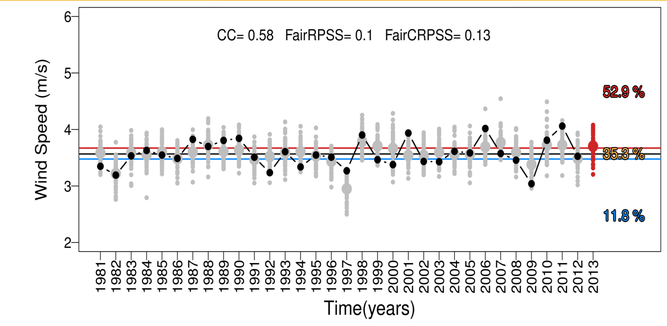


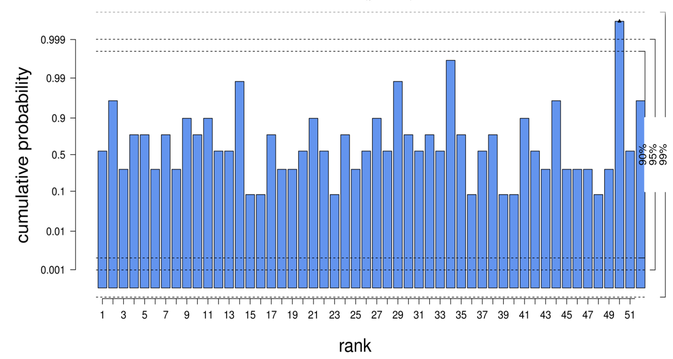


- The **probabilities in each category differ** for post-processed forecasts because the terciles and the ensemble members change when both methods are applied.
- The **skill scores also vary showing a decrease** related due to the uncertainty introduced in the estimation of the statistical parameters of the corrections.
- The bias corrected and calibrated forecasts show more homogeneously populated ranks than for the uncorrected. This change in the shape of the rank histograms show the **improvement in the statistical consistency** of the forecasts.
- The **calibration method**, which corrects the ensemble spread, **provides more reliable forecasts** than the simple bias correction technique. Because its points lie closer to the diagonal.
- The above normal category shows a slope close to one and the sharpness diagram is more homogeneously populated which indicates the **increase in the reliability to predict above normal wind speeds**.

Calibration

$$w_{ij} = \alpha x_i + \beta z_{ij}$$





Conclusions

- Although the post-processing decreases the skill of the forecasts, these techniques are essential for the seasonal forecasts to be usable.
- Post-processing methods produce forecast with more robust statistical properties, with a remarkable increase of reliability, a critical aspect from the user perspective.
- The region of Canada has positive skill therefore seasonal forecasts have added value compared to the use of retrospective climatology.

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