Development of a wind energy climate service based on seasonal climate predictions

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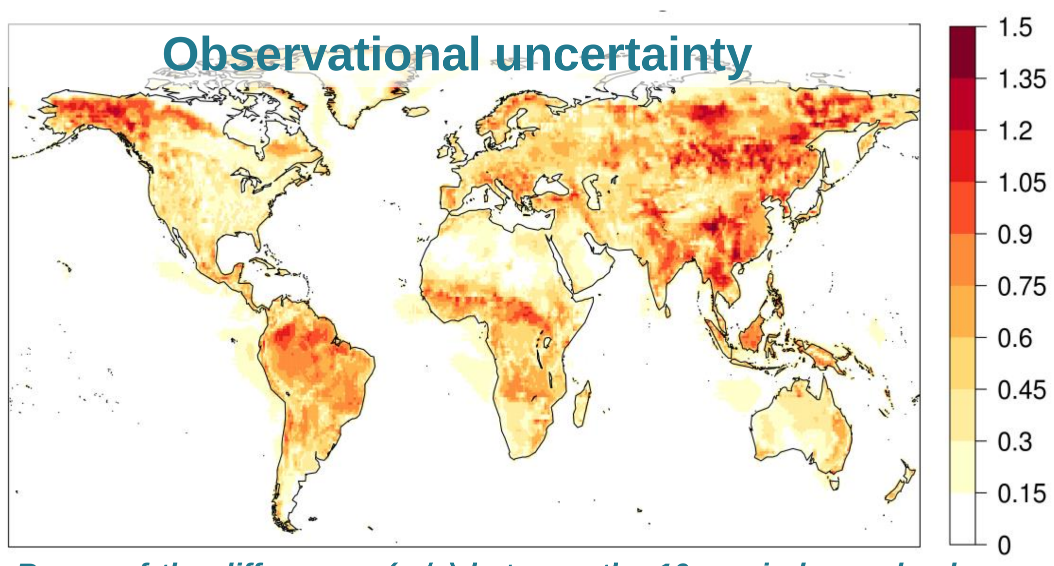
Development of a wind energy climate service

Climate information

The large amount of information that arises from the climate is hard to understand and in most cases wind energy users are not able to incorporate it in their daily activities. The main goal of this work is the creation of tailored climate information that can be afterwards used as a tool to inform wind energy users with greater accuracy than their current approaches.

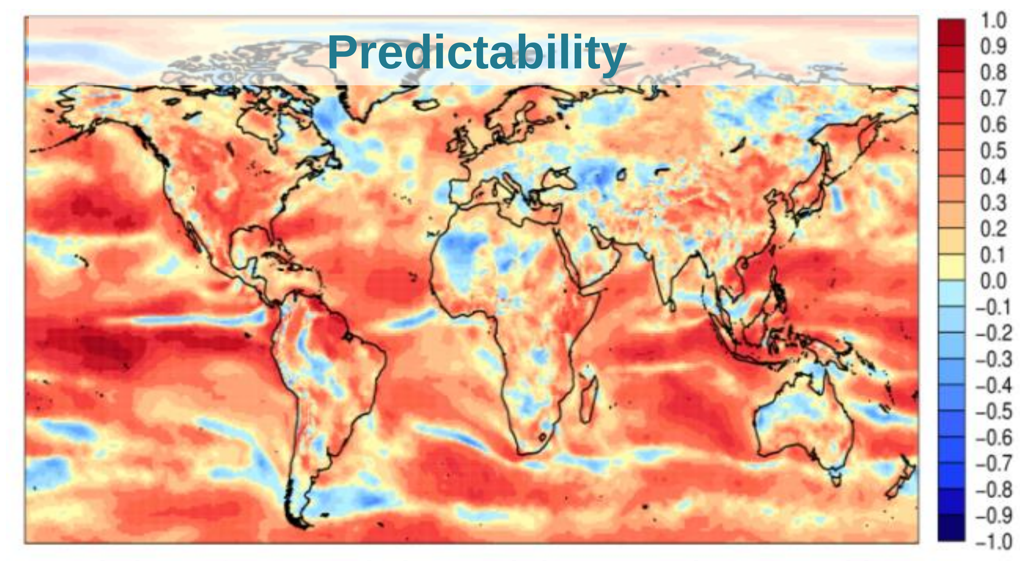
1 Wind speed assessment

Wind energy users can not use the outputs of the global climate models directly because they require an evaluation and interpretation of the forecast quality



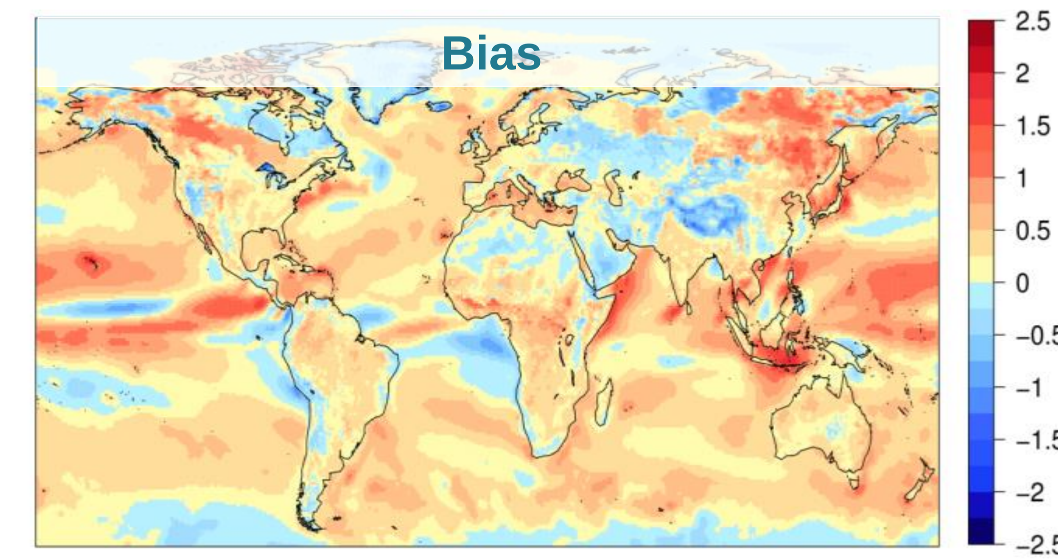
Range of the differences (m/s) between the 10-m wind speed values produced by ERA-Interim, MERRA and JRA-55. in DJF.

Verification of seasonal forecasts against different reanalyses might have slightly different results related with the reanalyses uncertainty.



Correlation of 10-m wind speed between the ensemble mean forecasts from ECMWF S4 and ERA-Interim reanalysis in DJF

Key regions for the wind industry as North America, Northeast Brazil, North Sea and Eastern China display potential skill.

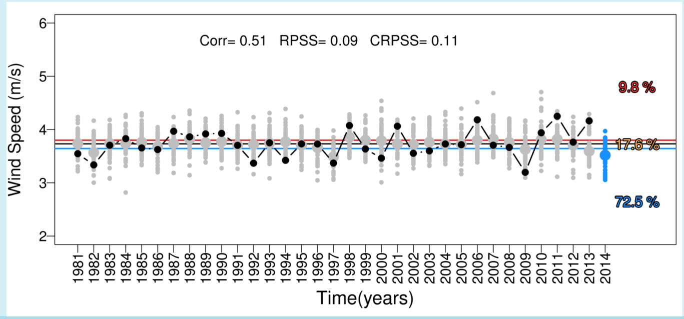
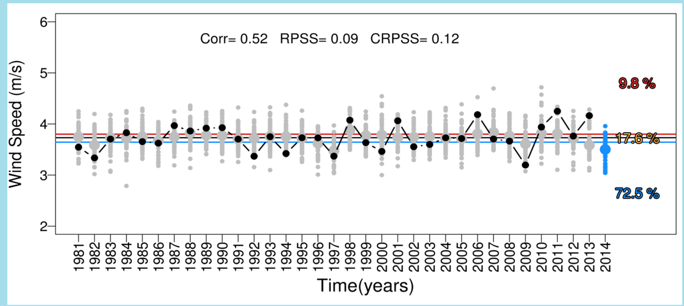
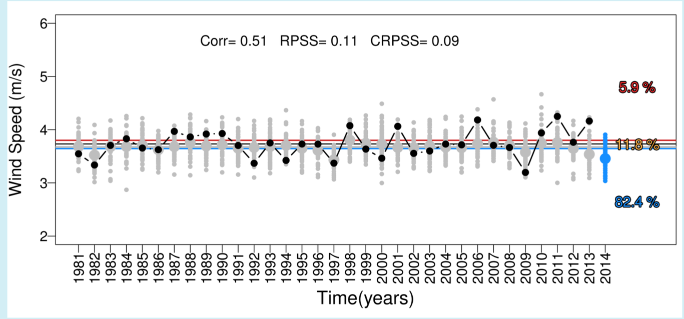


Bias for 10-m wind speed between the seasonal forecasts from ECMWF S4 and ERA-Interim reanalysis in winter (DJF)

Biases resulting from the prediction system inability to perfectly reproduce the climate variability should be corrected in order to produce usable climate information.

2 Bias adjustments

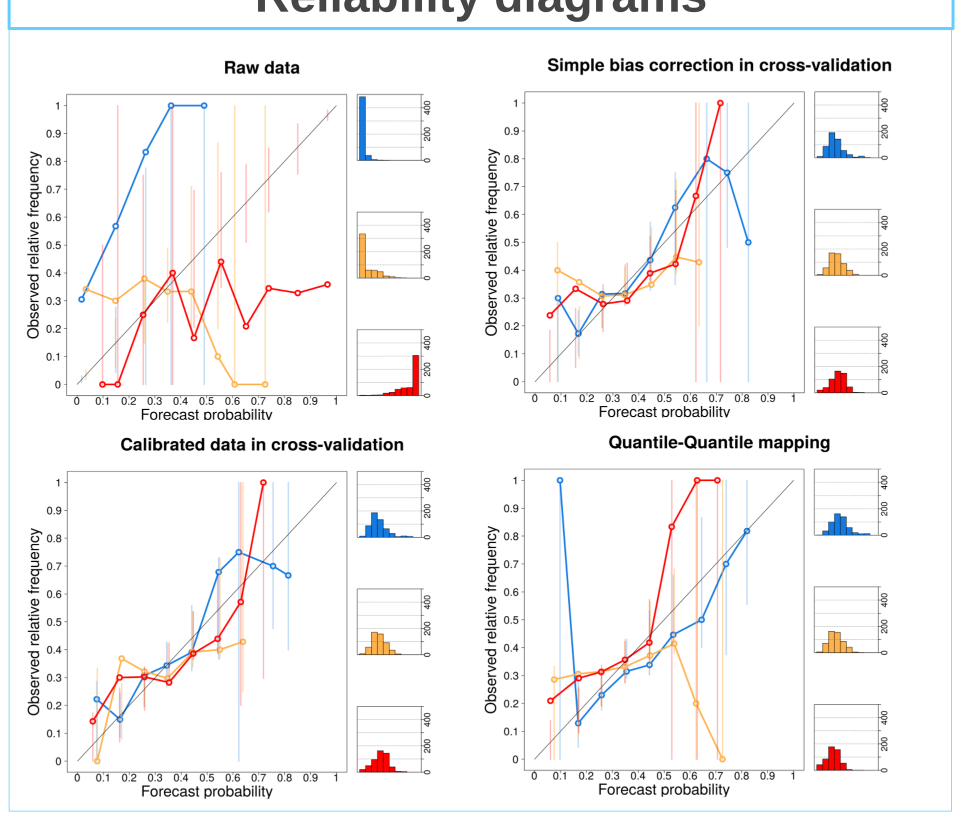
Different methods of bias-correction have been used to produce forecasts with improved statistical properties

Method	Equation	Description	Result
Simple bias correction	$y_{j,i} = (x_{ij} - \overline{x})\frac{\sigma_{ref}}{\sigma_e} + \overline{o}$	Based on the assumption that both the reference and forecasted distribution are well approximated by a Gaussian distribution.	
Calibration method	$y_{j,i} = \alpha x_i + \beta z_{ij}$	The variance inflation modifies the predictions to have the same interannual variance as the reference dataset and corrects the ensemble spread to obtain more reliable probabilities.	
Quantile mapping	$y_{j,i} = (ecdf^{ref})^{-1} ecdf^{mod}(x_{ij})$	Each forecast is assigned to the quantile of the forecast climatology it corresponds, and then the forecast value is changed by the observed value in the same quantile of the of the observational climatology.	

3 Forecast quality assessment

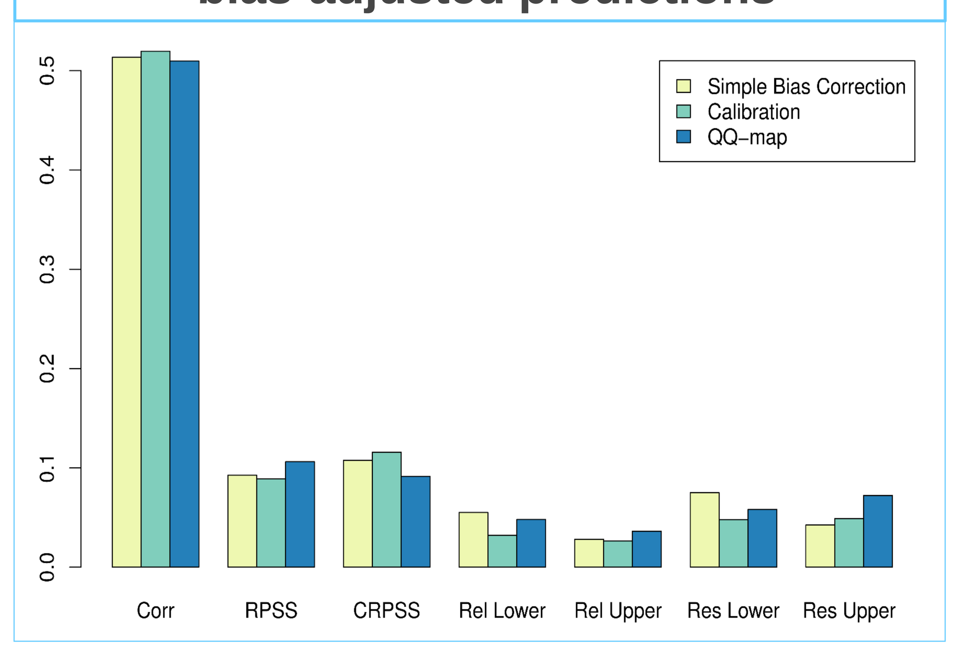
The impact of the bias-adjustments on the forecast quality has been explored by several scoring measures

Reliability diagrams



- Raw forecasts display poor reliability.
- Corrected forecasts display improved reliability with more points falling along the diagonal and more homogeneously populated sharpness diagrams.
- Calibrated forecasts show slopes closer to one.

Comparison of scores for different bias-adjusted predictions

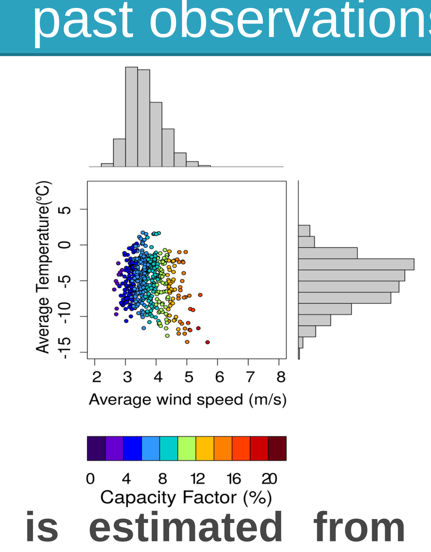


Calibration method produces the best CRPSS and reliability for the below-normal category and above normal category, however the forecasts corrected with the quantile mapping method produce higher RPSS.

4 Transfer model

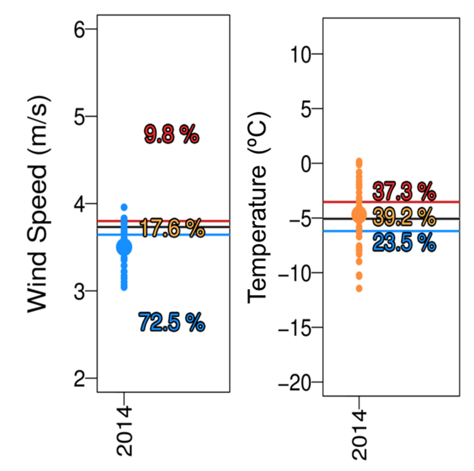
Capacity factor (CF) is widely used indicator for the wind energy users. Predictions of CF are not produced by the climate models and it should be computed from climate variables

CF based on past observations



CF is estimated from ERA-Interim 10-m wind speed and 2-m temperature in DJF (1981-2013). This CF is used as a reference. The methodology followed is further described in MacLeod et al. (2015)

Bias corrected seasonal forecasts



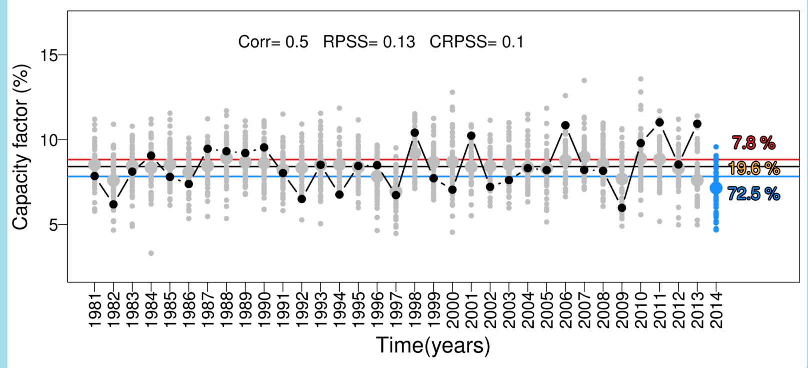
Bias corrected wind speed (WS) and temperature (T) are calculated and used as input in the regression model.

Multivariate linear regression model

CF (WS,T) = A WS + B T + C

- Past observations of CF, WS and T are fitted to a multivariate regression and the coefficients A, B and C are obtained.
- Probabilistic seasonal predictions of WS and T are fitted to the regression together with the coefficients A, B, C.
- The regression is applied in leave-one-out cross-validation mode.

Probabilistic seasonal forecasts of CF



The transfer model generates bias corrected probabilistic forecasts of capacity factor. The estimated CF predictions show positive skill. This illustrates the potential added value of these forecasts compared to the climatology.

Wind energy decisions

Climate predictions tailored to the wind energy sector represent an innovation to better understand the future variability of wind energy resources. These predictions can improve decision making processes related with: maintenance works, the matching of supply with demand and the reduction of financial penalties for incorrect wind power predictions.