



Koninklijk Meteorologisch Instituut

Institut Royal Météorologique

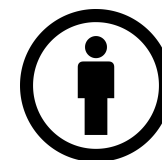
Königliche Meteorologische Institut

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Statistical post-processing of ensemble forecasts at the Belgian met service

Jonathan Demaeyer, Bert Van Schaeybroeck & Stéphane Vannitsem

vEGU 21, 28 April 2021, 09:21 CEST



- Introduction
- Operational Implementation
- Example of forecasts
- Scores
- Wind gust forecasts
- Conclusion & Outlook

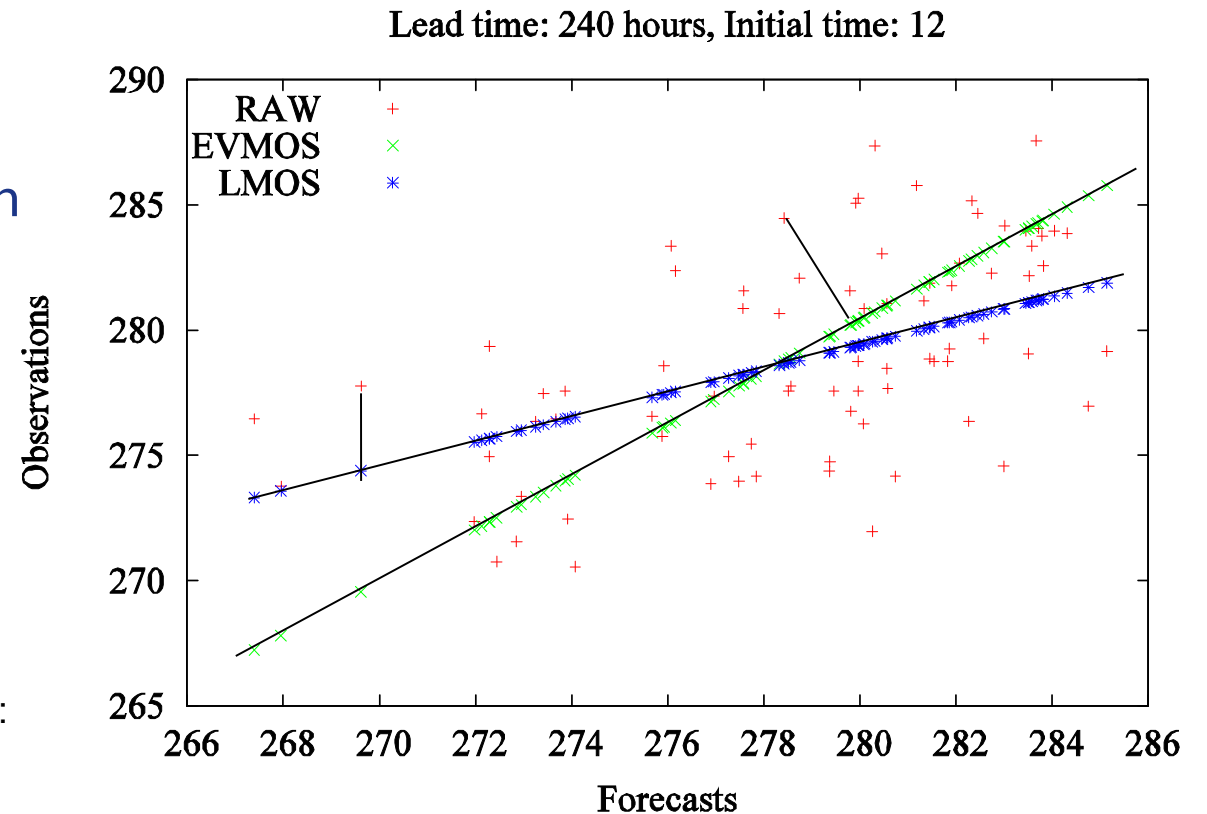
Statistical Postprocessing

- Statistical postprocessing of forecasts to improve their quality based on information gathered from past forecasts and observations.
- Ensemble forecasts: Calibration of the ensemble forecasts
- Member-by-member correction of the ECMWF ensemble raw forecasts:

~ Van Schaeybroeck & Vannitsem, Ensemble post-processing using member-by-member approaches: theoretical aspects. QJRMS 2015.

~ Vannitsem & Hagedorn, Ensemble forecast post-processing over Belgium: comparison of deterministic-like and ensemble regression methods. Meteorological Applications 2011.

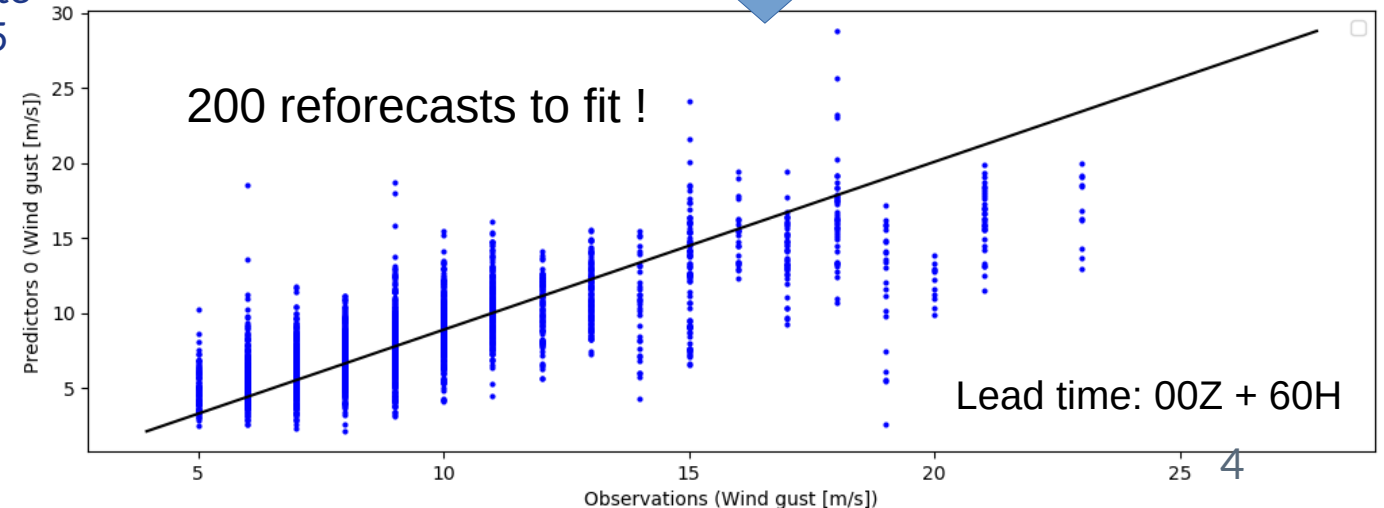
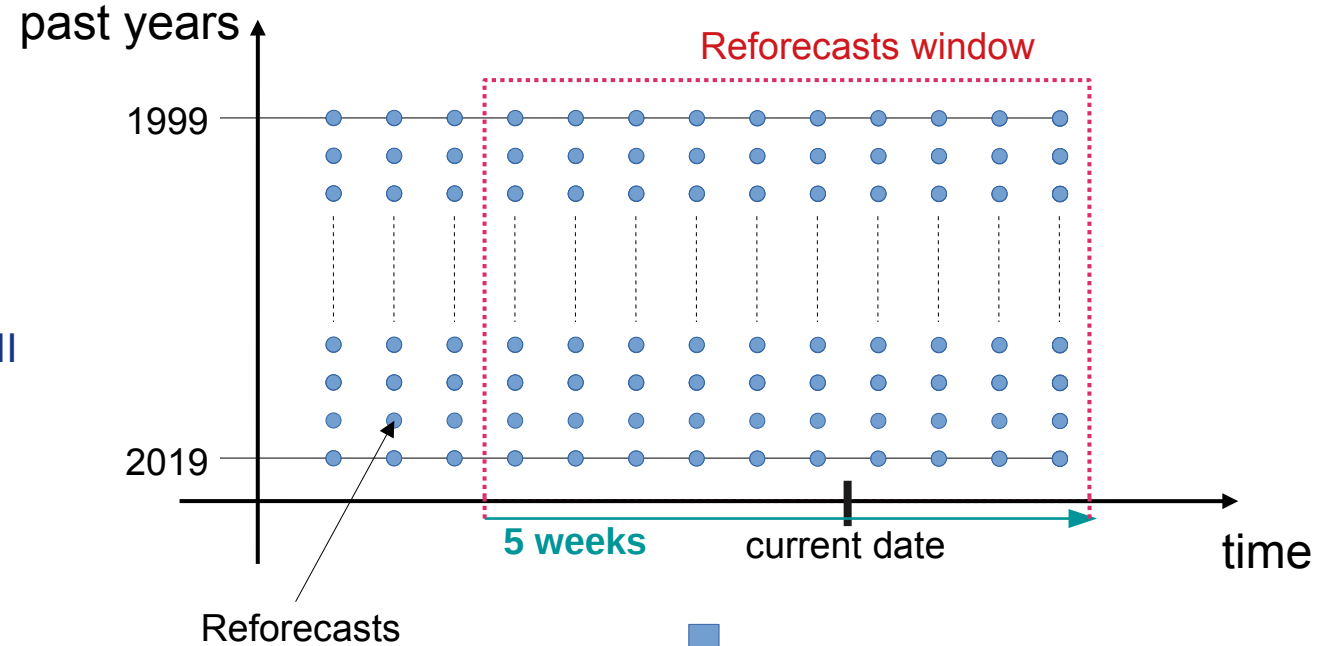
- Optimizes the CRPS
- Preserves time- and space-correlations !



Vannitsem QJRMS 2009

Operational Implementation

- **Pairing ECMWF forecasts and observations over 20 years in the past:**
 - Homogeneous past forecasts (no bias)
 - Use of reforecasts (hindcasts)
 - Compare with observations at the 11 “canonical” RMI stations
- **For each reforecast date, “only” 20 reforecasts to fit at each lead time**
 - not enough points to fit!
- Solution: A sliding window around the current date including 10 reforecast dates corresponding to 5 weeks
 - 200 reforecasts to fit.
- Update of the window and the fit (training) 2 times a week.





Operational Implementation

Docker App Flowchart

3 main parts :

- Window Data
- Training
- Postprocessing

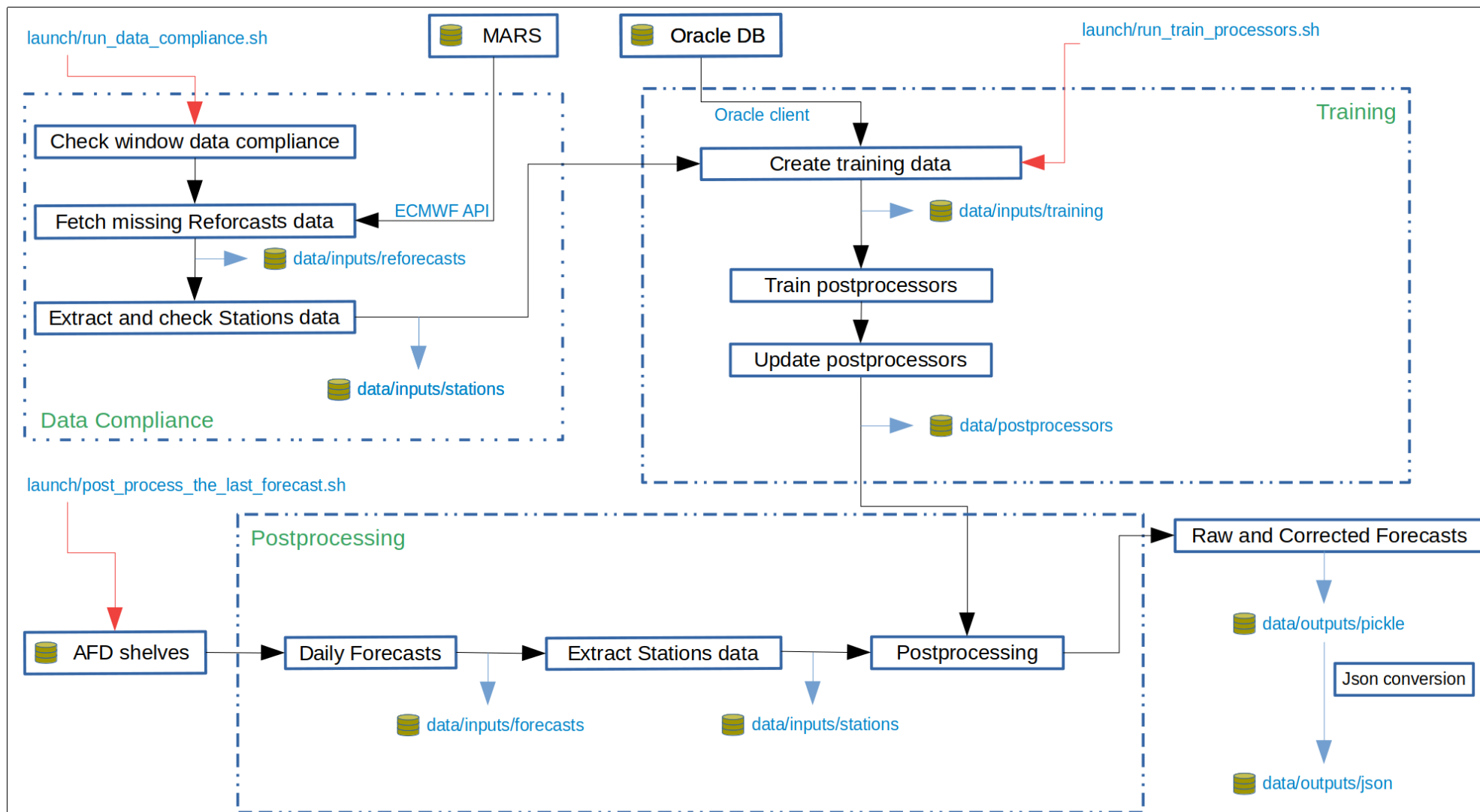
Integrally written in Python

App core is a new postprocessing package:

- Pythie
- Just published on GitHub:

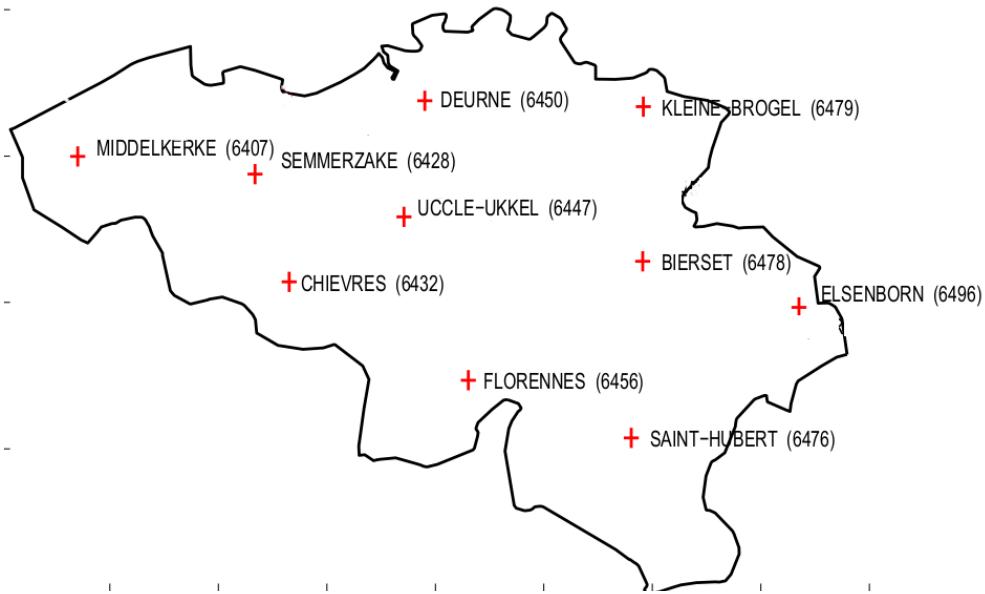
<https://github.com/Climdyn/pythie>

- See slide 12 for more details



Practical Details

- **Variables concerned**
 - 2m Temperature
 - Tmin
 - Tmax
 - Wind gust
- **Where**
 - 11 stations over Belgium
 - Stations defining regional climate
- **Lead time**
 - 0 → 15 days



Status

- **Pre-operational setup**
 - Docker app developed with a python library for ensemble postprocessing (still under development).
 - Pre-operational Docker currently still running continuously (beta-test)
 - Will continue to run for the next 2 years to accumulate statistics and as a backup
- **Operational docker**
 - Running since mid-July 2020
 - Update of the window and the fit (training) 2 times a week.
 - Postprocess everyday the ECMWF midnight run and fill the RMI database with the results which are then communicated to the forecasters.

Examples of Forecasts

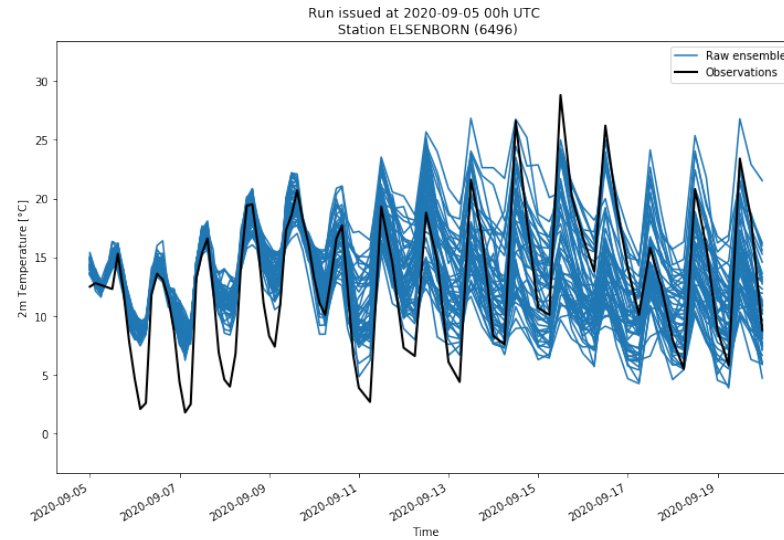
Forecasts PP

Example here:

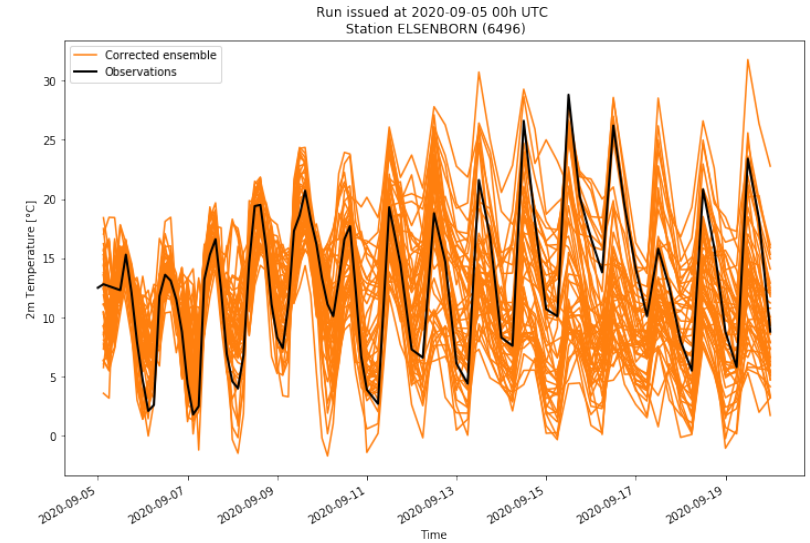
- Elsenborn
- 2m Temperature

Details:

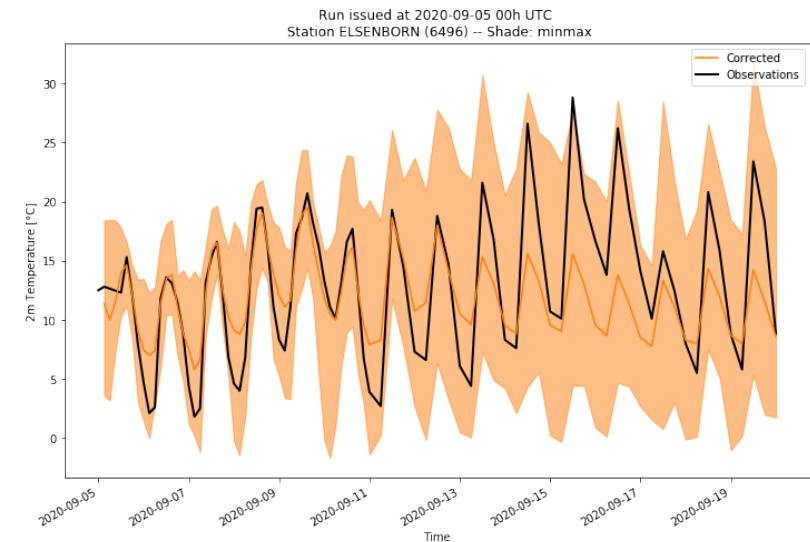
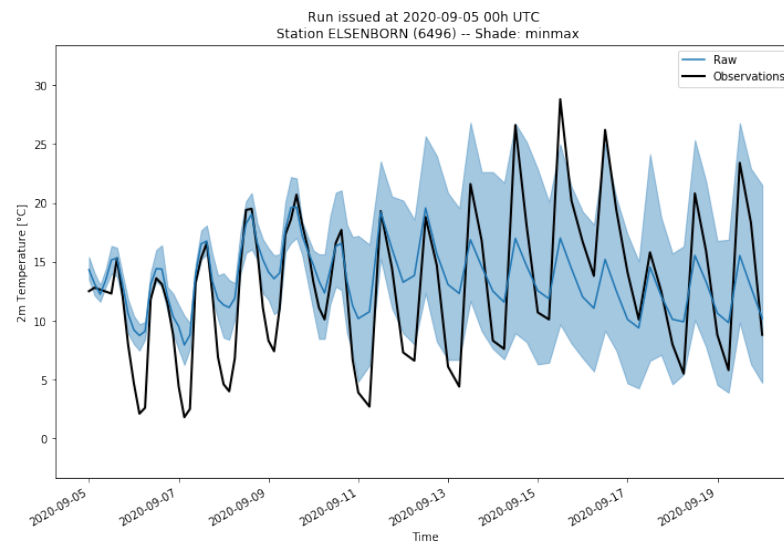
- Ensemble PP
- Member-by-Member
- Compatible with probabilistic forecasting



Postprocessing



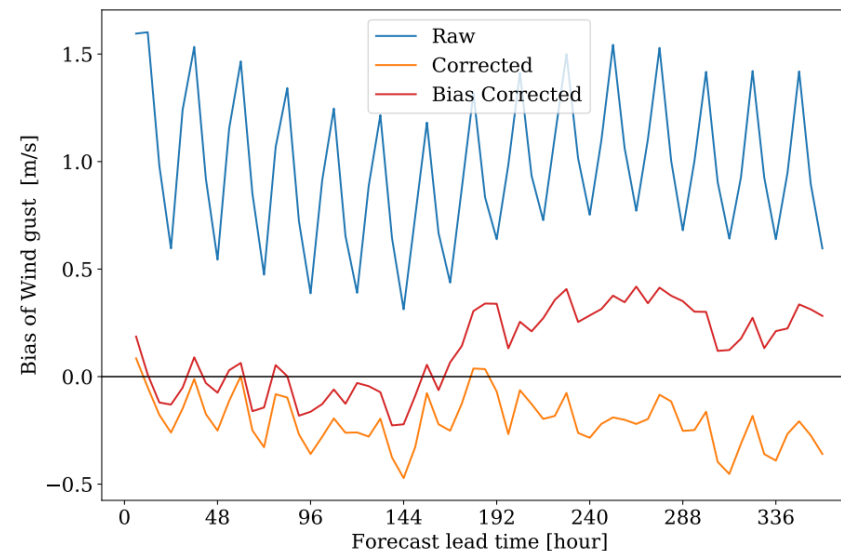
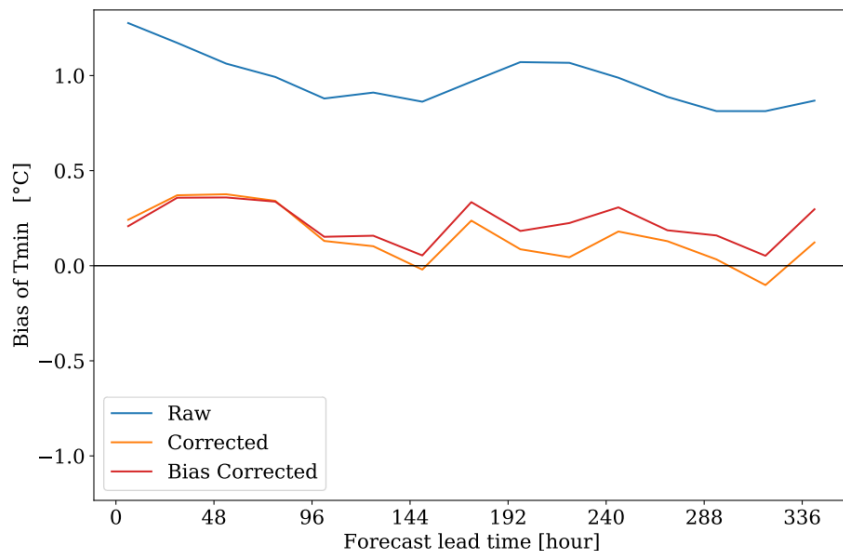
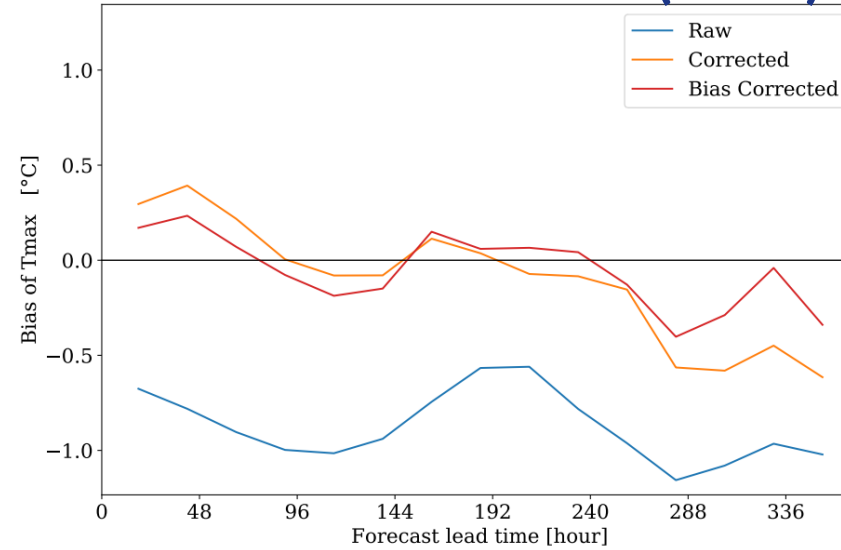
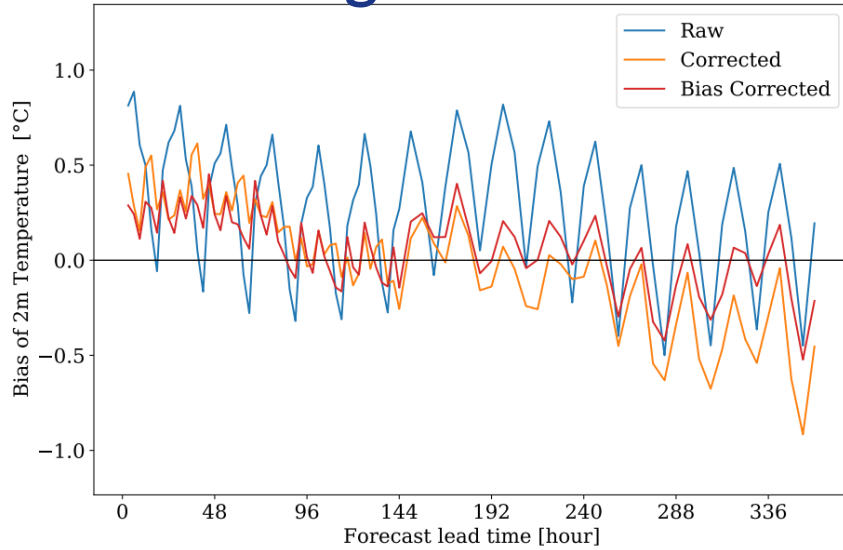
Ensemble mean
Ensemble minmax



Details:

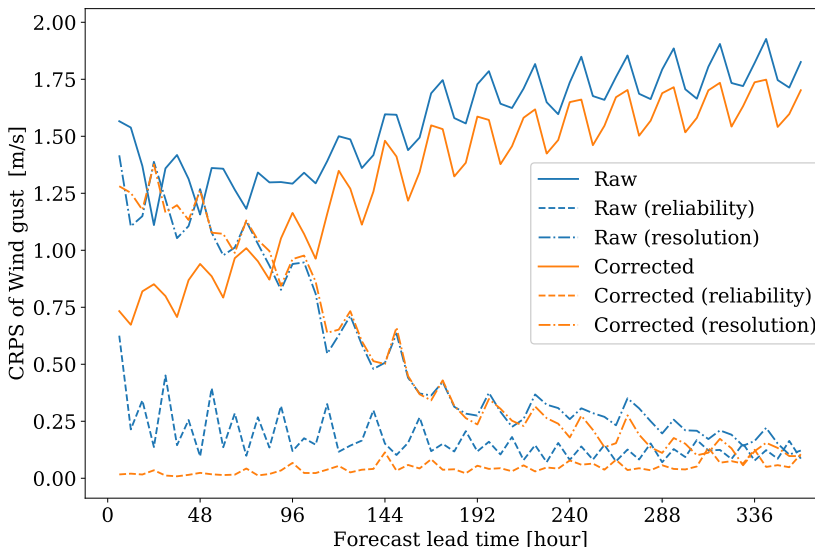
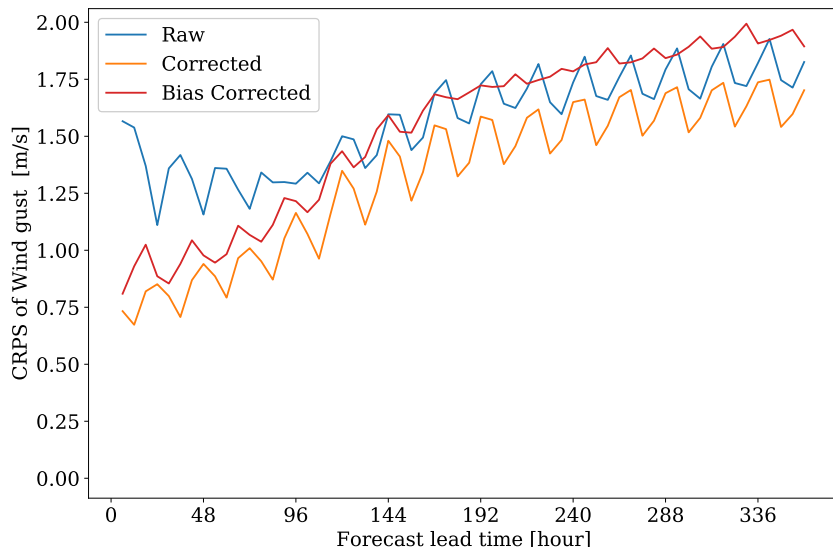
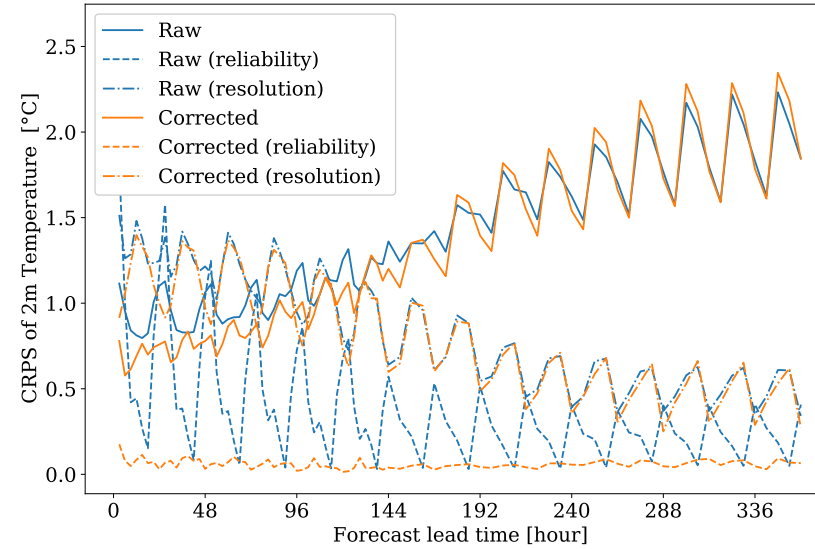
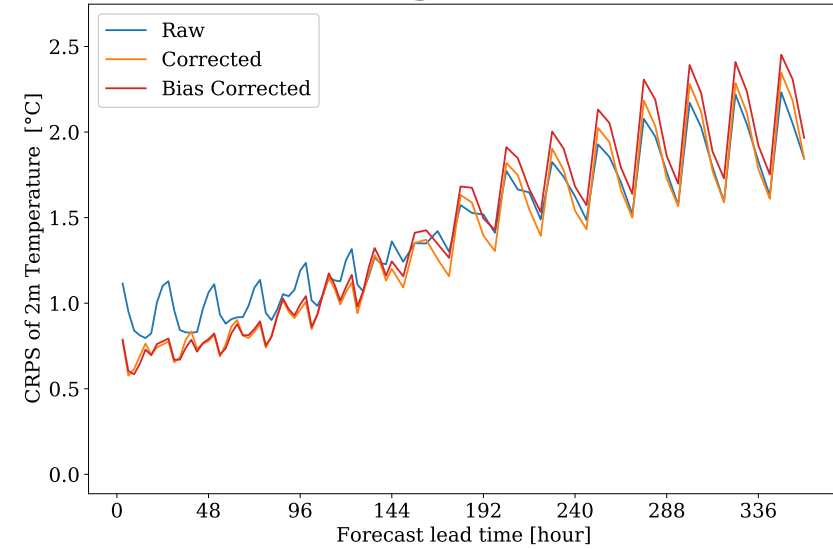
- 2t and wind 3 hrly then 6 hrly after 144 hrs
- Tmin btw 18:00-6:00
- Tmax btw 6:00-18:00
- Raw = ECMWF forecast input of MBM PP
- Corrected = Output of MBM PP
- Bias Corrected = Bias correction alone

Bias averaged over all 11 stations and 2020 Summer (JJAS)



Scores: CRPS of 2t and wind

CRPS averaged over all 11 stations and 2020 Summer (JJAS)



Details:

- Right panels: CRPS scores (lower = better)
- Left panels: Reliability, resolution and uncertainty decomposition of the MBM PP CRPS
- Tmin btw 18:00-6:00
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$$CRPS = REL - RES + UNC$$

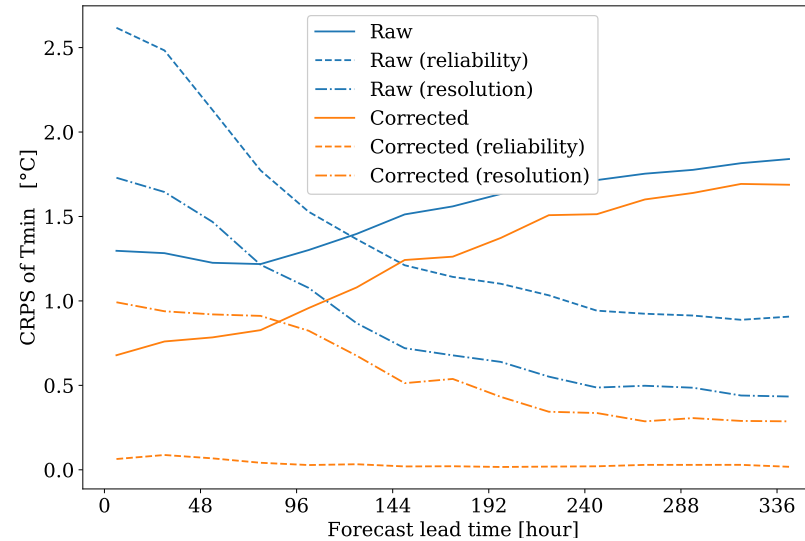
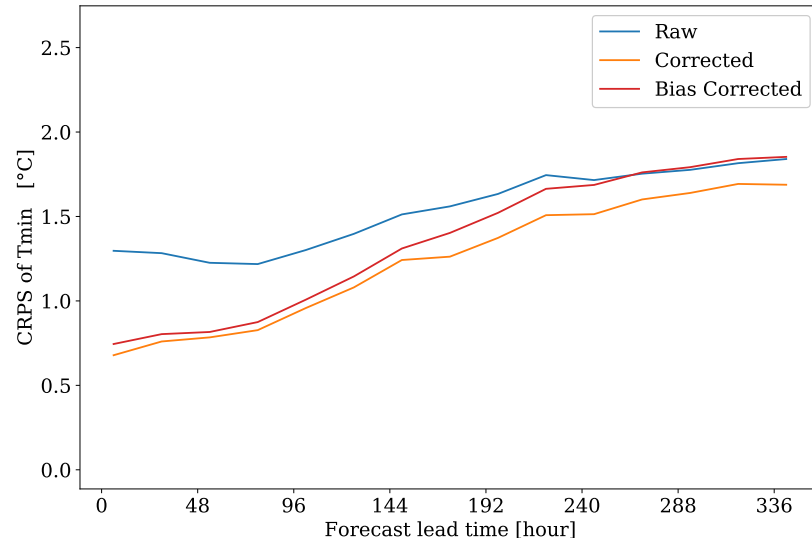
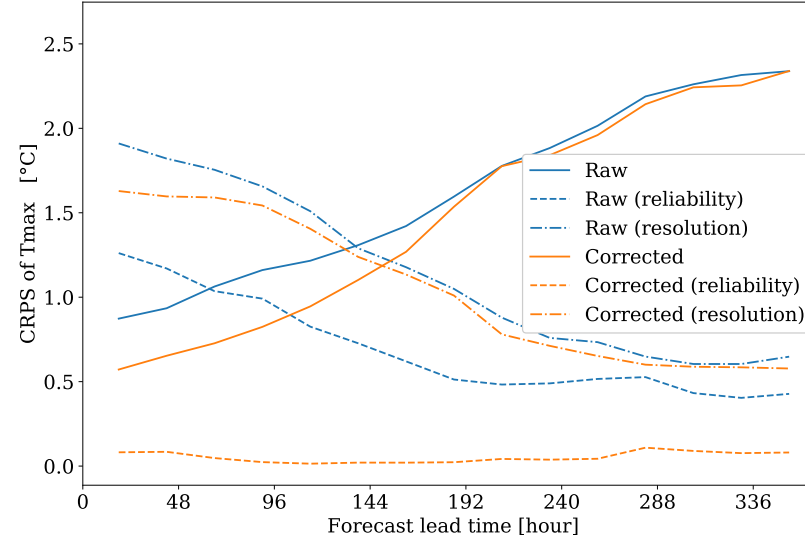
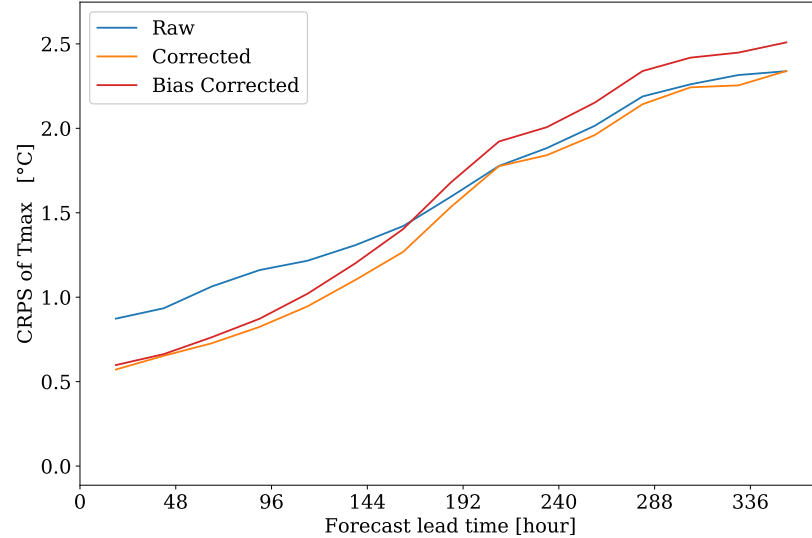
- The forecast are the better when:
 - the smaller the reliability value is
 - the bigger the resolution is.
- The ensemble system has positive resolution if it performs better than the climatological probabilistic forecast.
- The uncertainty is the potential reliability for a forecast system based on the sample climatology.
- See also Hersbach, Weather and Forecasting , 2000.

Scores: CRPS of Tmin and max

Details:

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CRPS averaged over all 11 stations and 2020 Summer (JJAS)

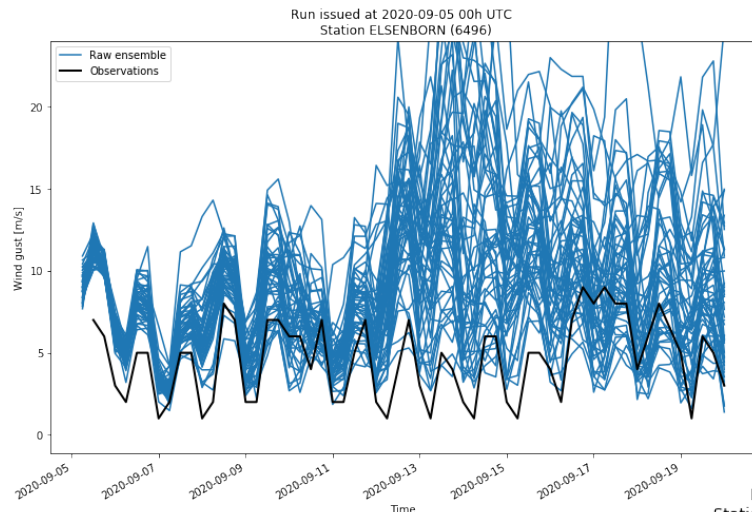


$$CRPS = REL - RES + UNC$$

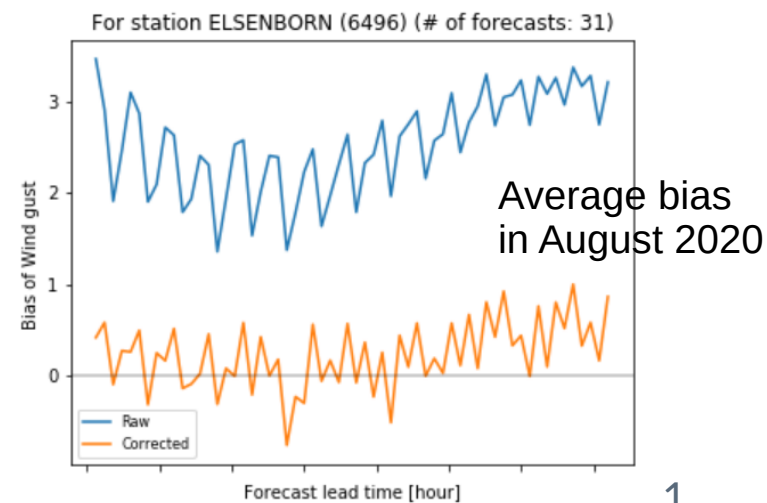
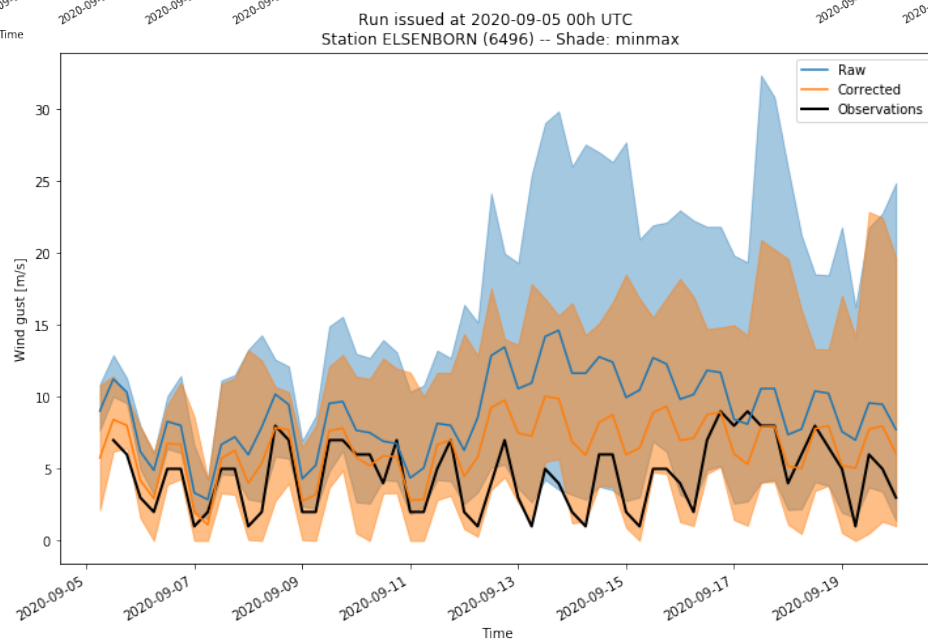
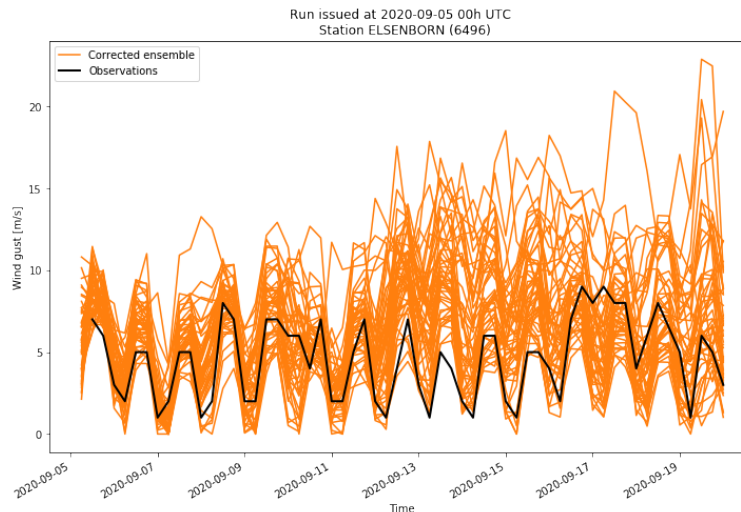
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Example of a wind gust corrected forecast

Bias in Elsenborn station



Postprocessing



Development of the core postprocessing package:

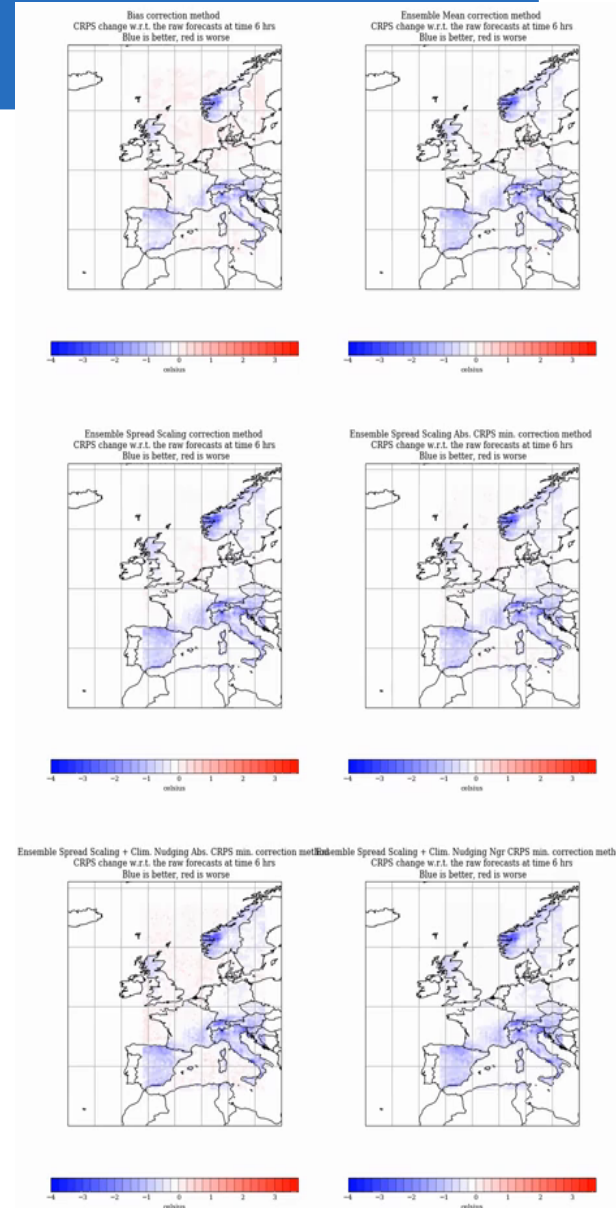
Github: <https://github.com/Climdyn/pythie>

- Pythie is a Python package to postprocess weather forecasts.
- The data model of Pythie is flexible and allows one to postprocess both station points and gridded data forecasts.
- Presently, it contains a MBM modules: a module to make member-by-member ensemble forecasts postprocessing based on past (re)forecasts.
- This module implements the methods described in: Van Schaeybroeck & Vannitsem, QJRM, 2015.
- Other modules with other methods and better interfaces with existing libraries are planned in the future (help welcome ;-).
- Pythie comes with an online documentation containing examples:

<https://pythie.readthedocs.io/>

Example of gridded forecast postprocessing:
Show the CRPS difference between postprocessed and raw ensemble forecasts. Blue is better. (Click on the video to play)

Data sources: ECMWF reforecasts and Copernicus ERA5



Conclusions

- RMI MOS PP scores indicate it is effective
- Usage and impact still to be assessed
- Huge potential in probabilistic forecast (quantiles, cost model, etc...)
- Publication of these results in the 2020-2021 ECMWF Winter newsletter:

<https://www.ecmwf.int/en/newsletter/166/meteorology/statistical-post-processing-ensemble-forecasts-belgian-met-service>

Outlook

- Correction of the ECMWF noon forecast
- Addition of other predictors than the variable itself
- MOS PP on the grid with Pythie

THANK YOU

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