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Probabilistic power ramp forecasts using multivariate Gaussian regression

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Motivation

Power ramps

Sudden changes in power caused by fluctuating wind speeds.

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Probabilistic forecasts

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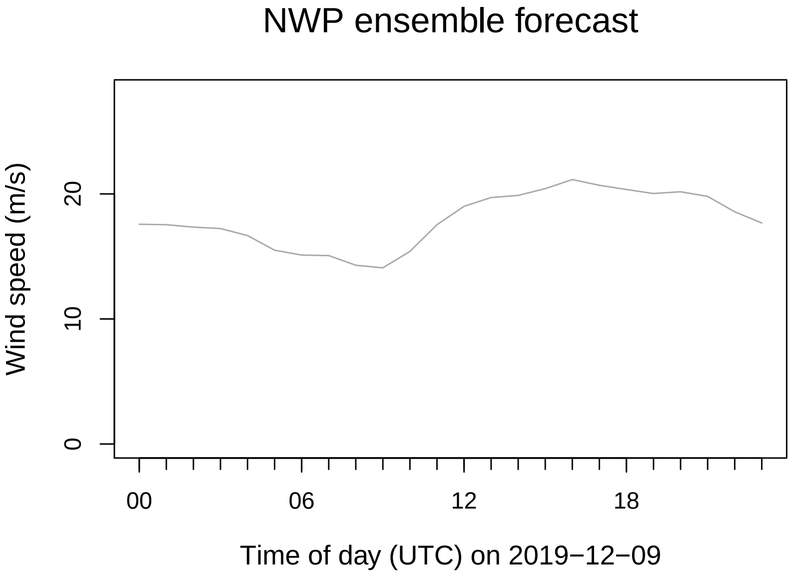
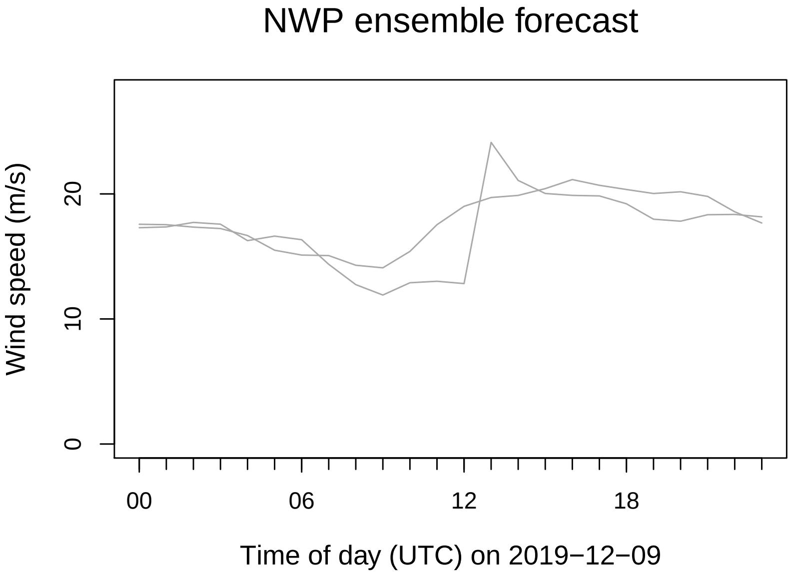
Multivariate Gaussian regression
Models the next day's hourly wind speeds by a multivariate Gaussian distribution

$$(\mathtt{obs}_{+24\mathrm{h}}, \ldots, \mathtt{obs}_{+47\mathrm{h}}) \sim \mathcal{MVN}(\mu, \Sigma),$$

estimated conditionally on a numerical weather prediction ensemble.


NWP ensemble forecast
Wind speed (m/s)
0
10
20
00
06
12
18
Time of day (UTC) on 2019−12−09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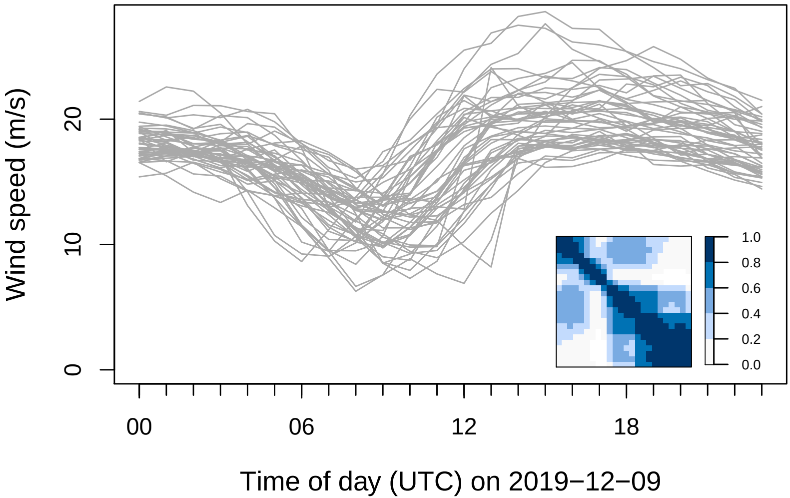
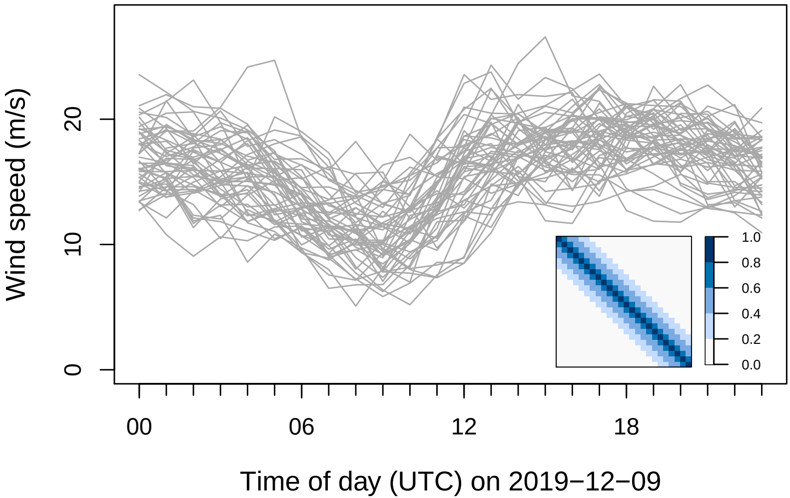
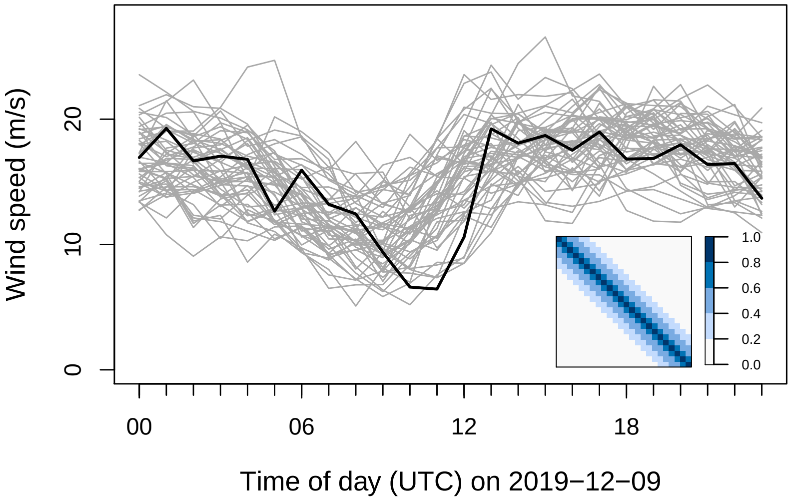


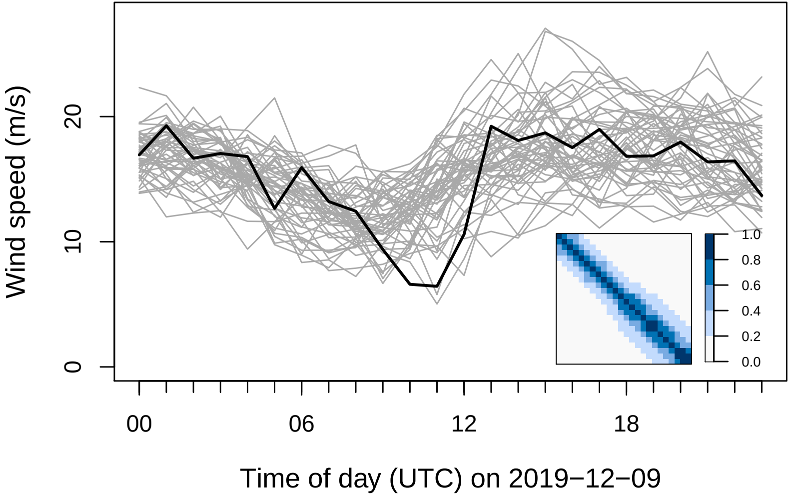
Multivariate Gaussian regression (AR−1)



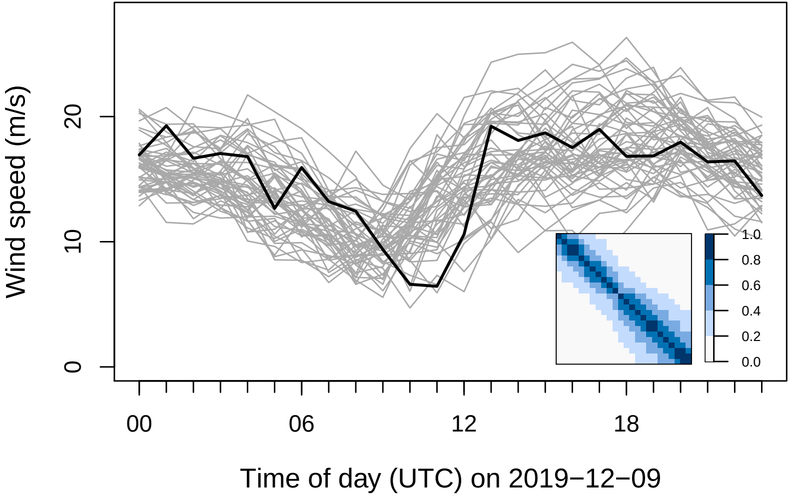
Multivariate Gaussian regression (AR−1)



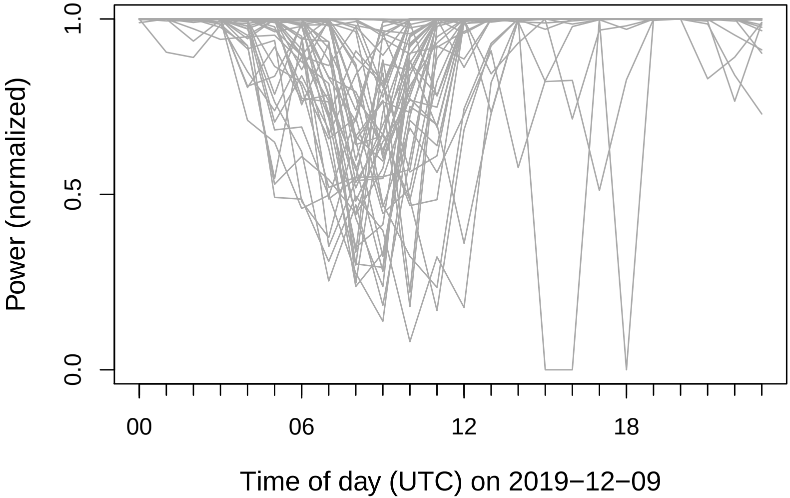
Multivariate Gaussian regression (AD−1)



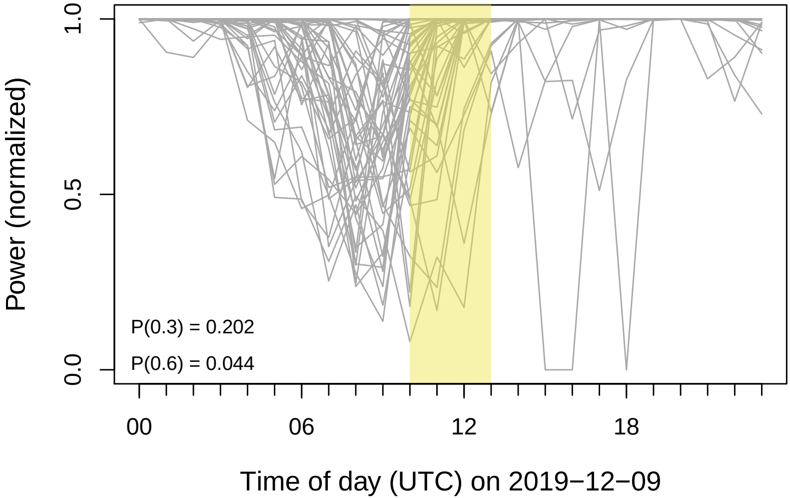
Multivariate Gaussian regression (AD−2)

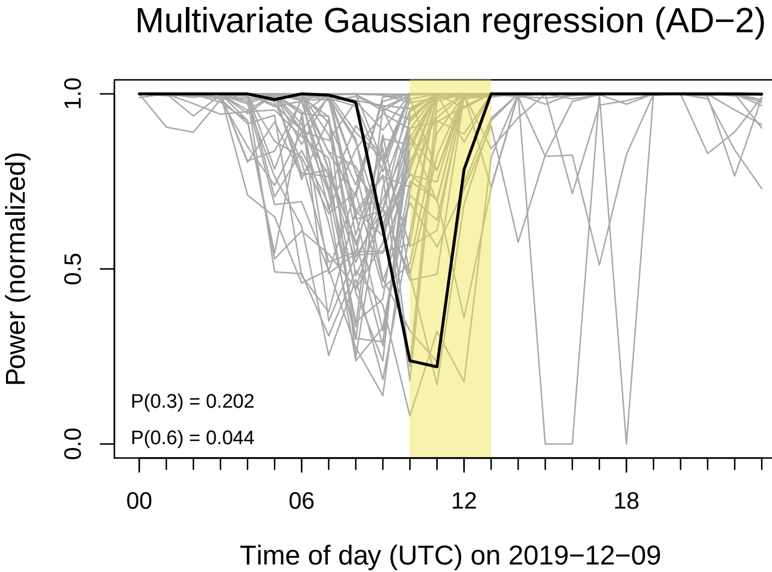


Multivariate Gaussian regression (AD−2)



Multivariate Gaussian regression (AD−2)




Multivariate Gaussian regression (AD−2)
Power (normalized)
1.0
0.5
0.0
P(0.3) = 0.202
P(0.6) = 0.044
00
06
12
18
Time of day (UTC) on 2019−12−09

Summary

Multivariate Gaussian regression with AR-1 outperforms more flexible AD-1 or AD-2 models and state-of-the-art reference methods.

Major advantages of the regression for multivariate postprocessing:

1. Forecasts are joint distributions $\rightarrow$ simulate large ensembles.
2. Multivariate dependencies are parameterized and explicitly modeled rather than adopted directly from the ensemble, observations, or forecast errors.

References

Thomas Muschinski, Georg J Mayr, Thorsten Simon, Nikolaus Umlauf, and Achim Zeileis (2022). "Cholesky-based multivariate Gaussian regression". In: *Econometrics and Statistics*, 2452-3062, doi:10.1016/j.ecosta.2022.03.001.

Recently submitted to *Wind Energy Science*:
"Predicting power ramps from joint distributions of future wind speeds".

This presentation participates in OSPP

EGU

Outstanding Student & PhD candidate Presentation contest