GeoSphere Austria

Austrian Wind Atlas: Validation of wind speed in a diverse landscape

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Overiew

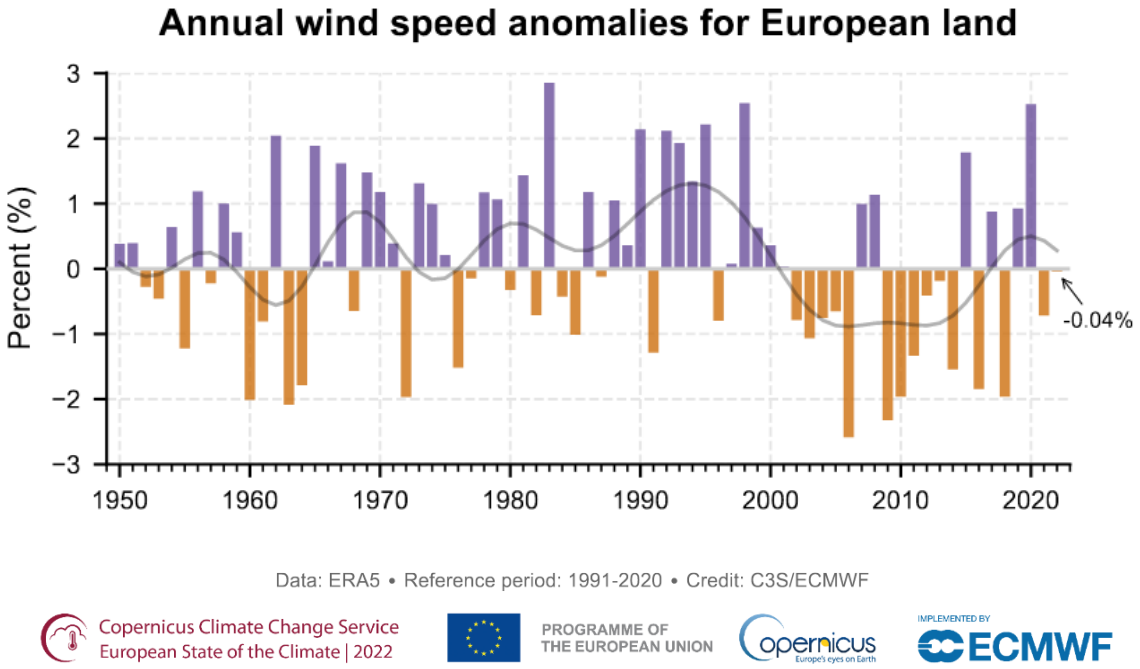
- Motivation
- Station data
- Methods
- Preliminary results
- Conclusion and next steps

Motivation

Past

http://s0.geograph.org.uk/geophotos/02/57/05/2570527_eea1b3ec.jpg

Present

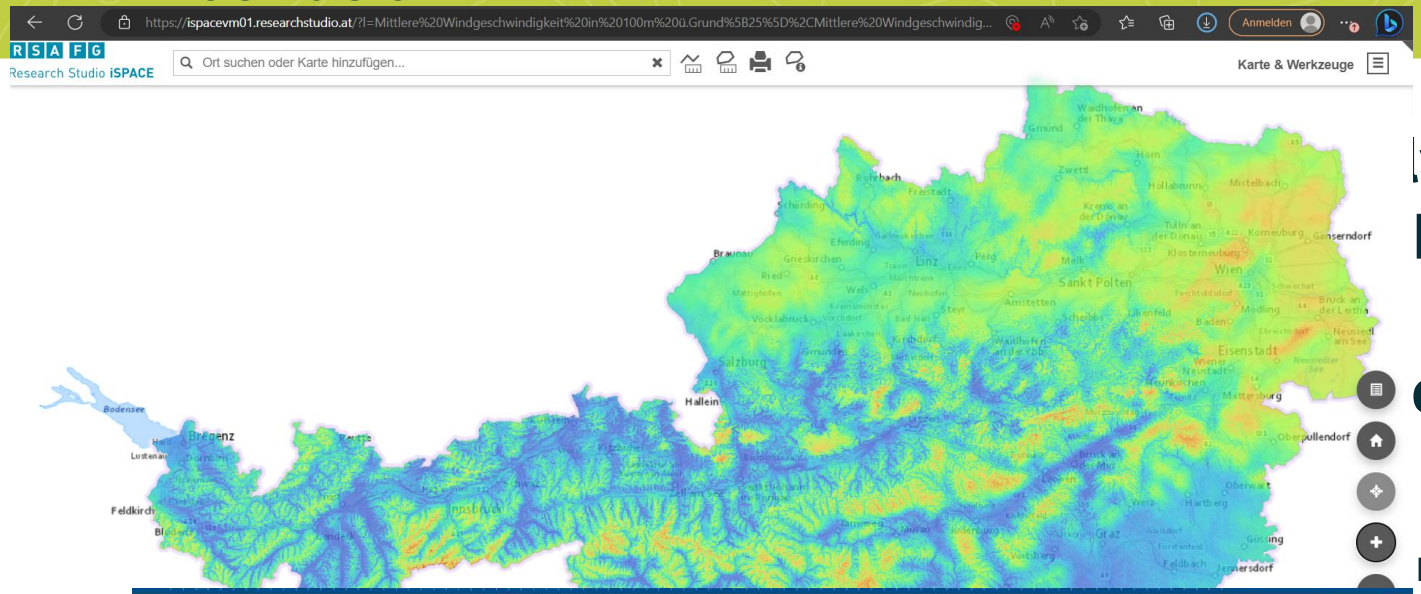


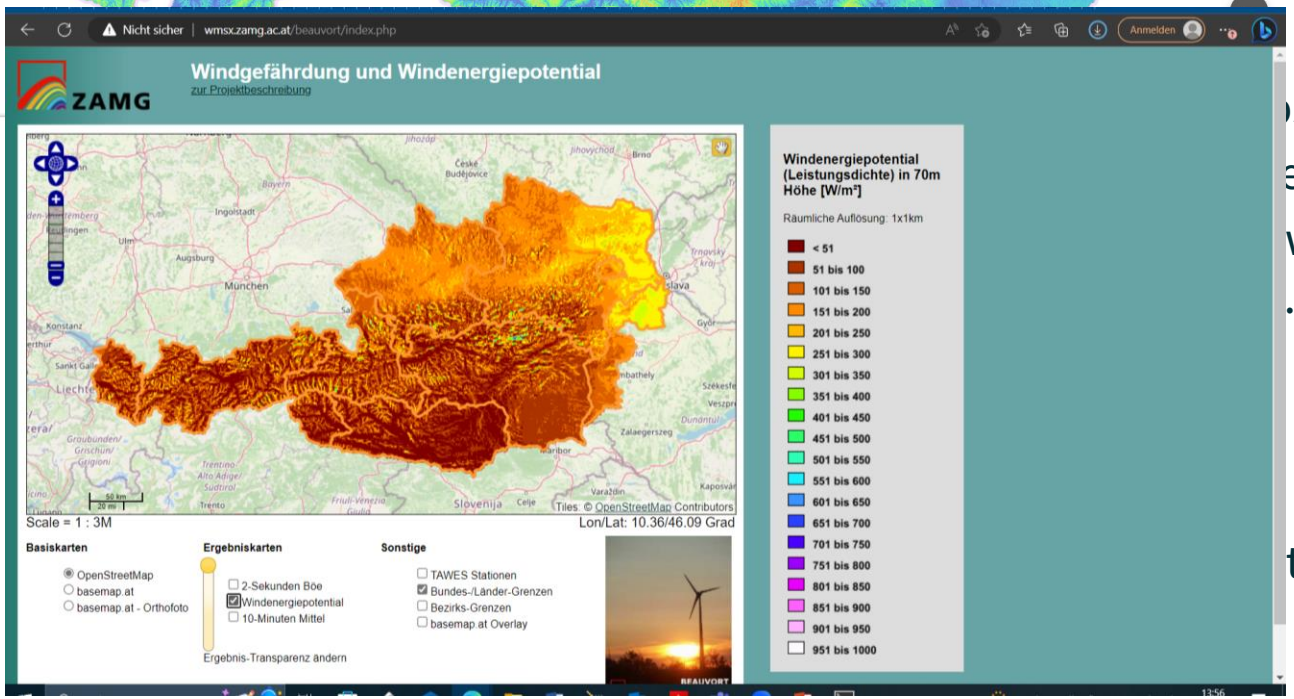
Future

?

Wind in future climate

Motivation





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downscaling / super-resolution

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wind climate for
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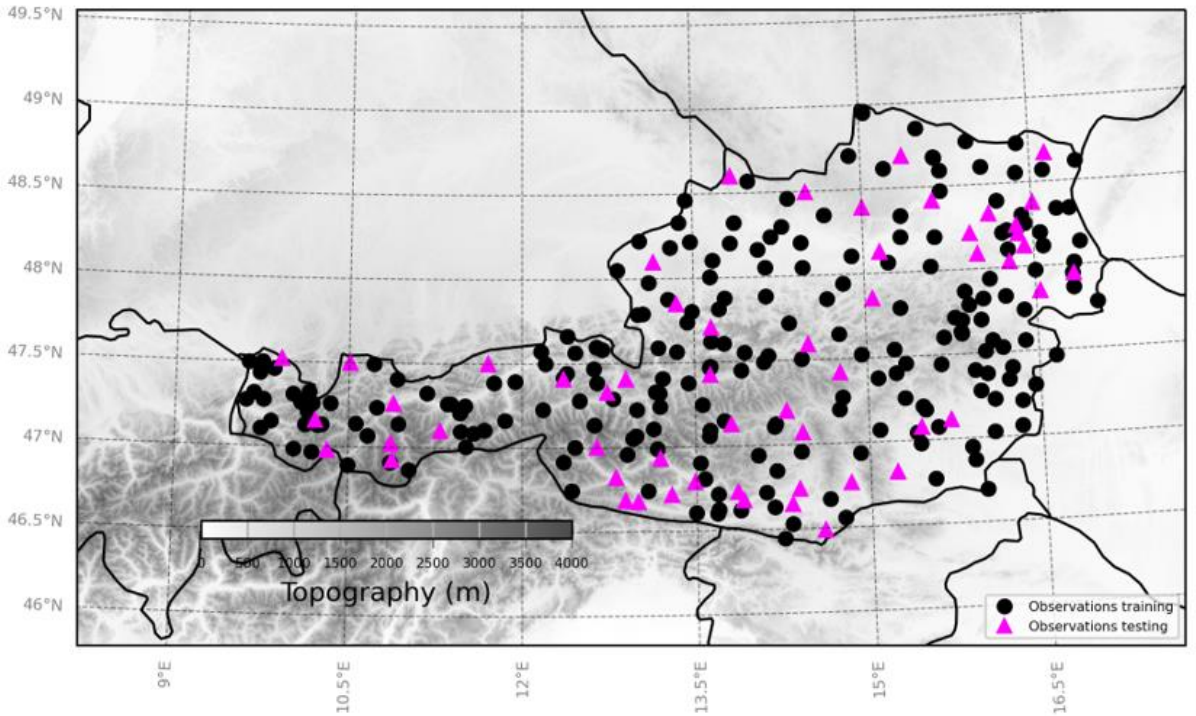
Station data

An experimental setup ...

- ~ 250 measurments sites
- Selection of sites based on previous internal project
  - Covering time period 2006 to 2022 (16 years)
  - Data is quality controlled but not for conciseness in terms of availability
  - Sub-setting to a random 85%/15%-selection of sites below/above 1000 m altitude
  - Remaining non-used sites are used in verification process
  - Additional sub-setting within the methods for 12 sites



- Ongoing: Improvement of considered station network by extending number of sites and investigating temporal homogeneity

GeoSphere Austria

BAMLSS - A Lego Toolbox for Flexible Bayesian Regression (and Beyond)

- BAMLSS: Bayesian Additive Models for Location, Scale, and Shape
- BAMLSS offers a variety of Bayesian regression models implementations with flexible plug and play approaches for regression terms and modular combinations of fitting algorithms.
- Here, we use the **GAM** (generalized additive regression model), principle similar to GAM/GLM regression kriging

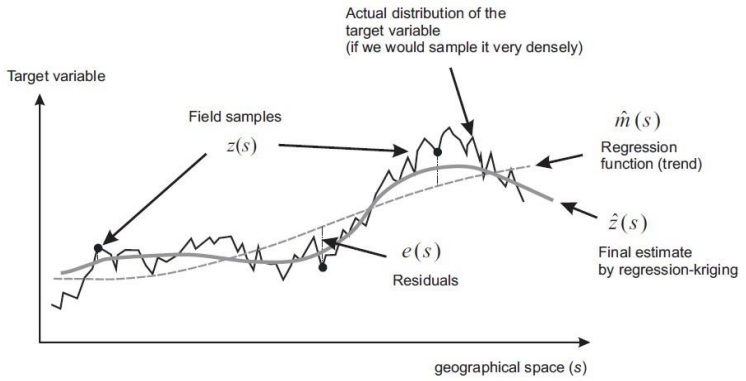
- Two very simple baseline approaches, fitted and predicted for every hour of the day separately (=> no globally pre-trained model used):
  - **Approach 1**: station and topography based, uses current station observations of wind speed and site metadata, predicted on the grid using:

$$ff \sim s(lat, lon) + alt, \text{ sigma~1}$$

  - **Approach 2**: uses station observations of wind speed, site metadata, and the ERA5 10m wind speed at the location site for fitting, ERA5 field and topography for prediction/interpolation.

$$ff \sim s(lat, lon) + alt + ERA5\_WS10, \text{ sigma~1}$$

GAM and GLM regression kriging



- Regression kriging (RK) combines regression of dependent variable (wind speed here) and auxiliary / predictive variables (e.g., topography, lat,lon) with kriging of regression residuals.
- Deterministic and stochastic components can be modelled separately.
- Deterministic residuals are interpolated with kriging and added back to the trend
- Two models used: **GAM** (Generalized Additive Model) and **GLM** (Generalized Linear Model)
- Ordinary kriging combined with GAM/GLM residuals is used for interpolation
- Setup similar to BAMLSS-ERA5 with some slight differences in the equations

All methods use "operational" mode:
fitting on wind speed of the selected time stamp and "predicting" using only the features.

Pre-trained leave-one-out mode will be investigated once we have a concise data set.

INCA (Integrated Nowcasting through Comprehensive Analysis)

- INCA: multi-parameter numerical analysis, nowcasting and short-term forecasting system (Haiden et al. 2011) with a spatial resolution of 1 x 1 km
- Statistical-dynamical downscaling of NWP fields for, originally, nowcasting and medium-range prediction.
- Also being used for downscaling of reanalysis data or subseasonal to seasonal predictions.
- Needs:
  - Pre-processed background NWP fields (surface and some vertical levels), in our case ERA5 wind speed, topography
  - Observations
  - Target topography/domain/CRS

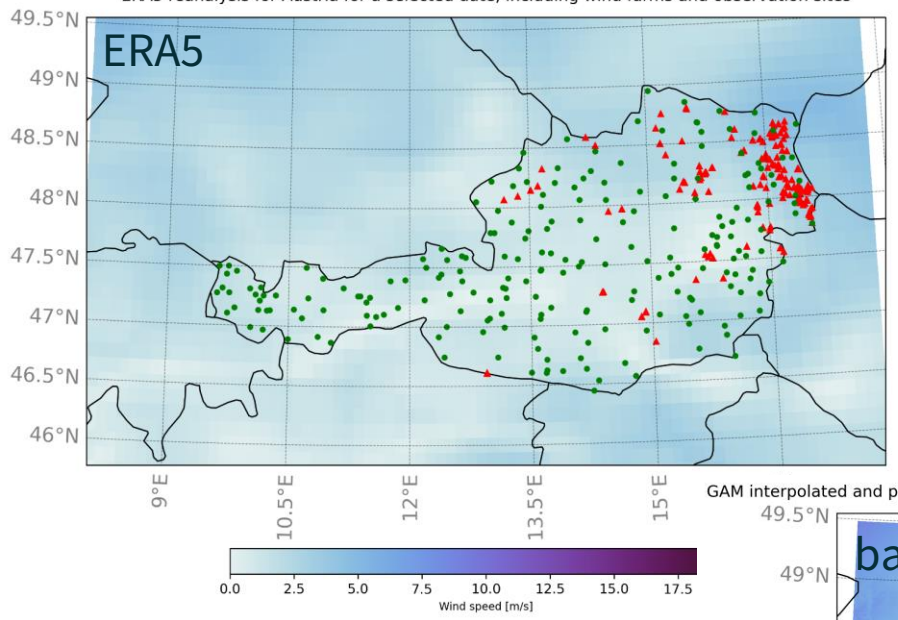
Unfortunatly, pre-processing of NWP fields had a small bug, need to re-run these experiments

Haiden T, Kann A, Wittmann C, Pistotnik G, Bica B, Gruber C. 2011. The Integrated Nowcasting through Comprehensive Analysis (INCA) System and Its Validation over the Eastern Alpine Region. Weather and Forecasting, 26/2, 166-183, doi: 10.1175/2010WAF2222451.1

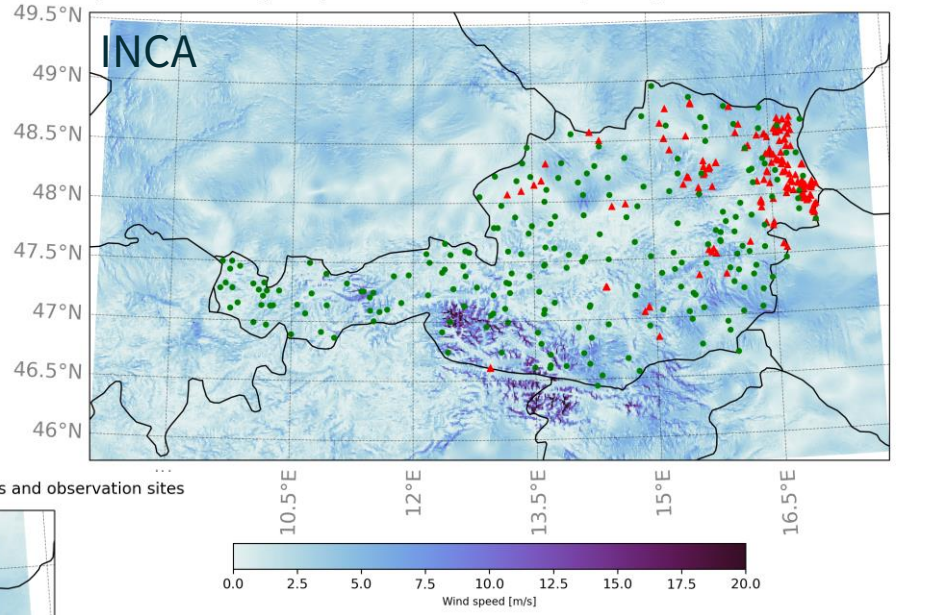
Preliminary results – use case

June 12, 2018 (15 UTC)

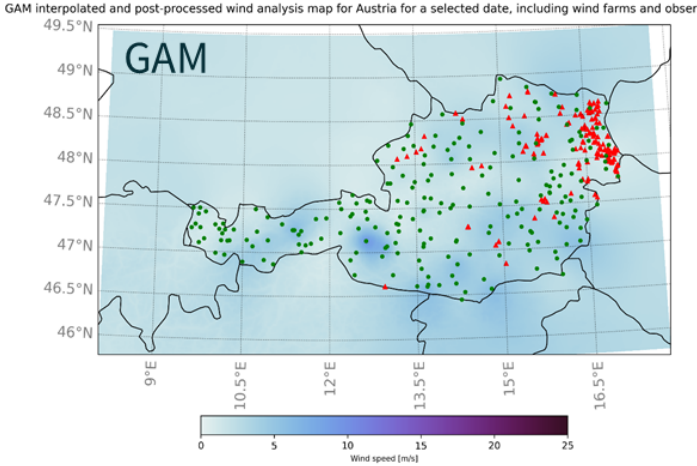
ERA5 reanalysis for Austria for a selected date, including wind farms and observation sites



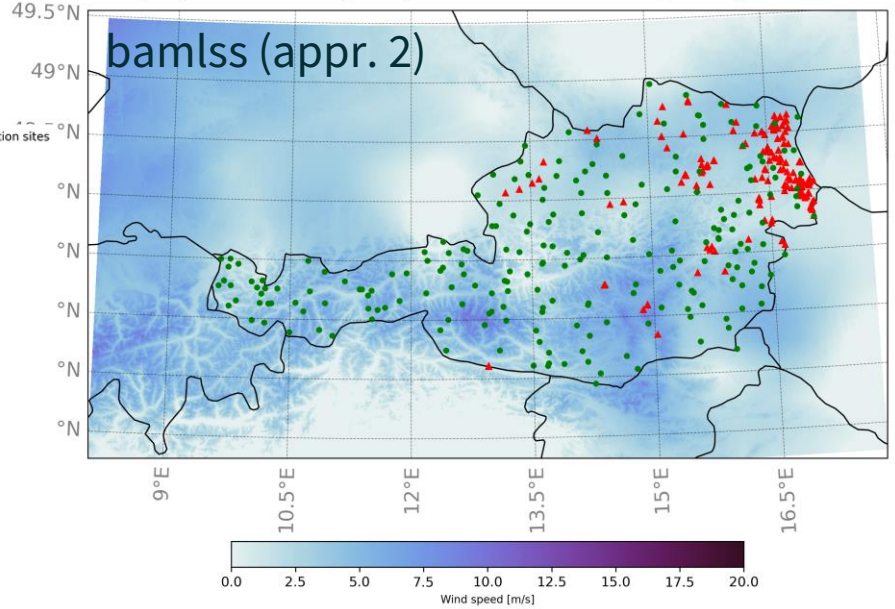
INCA operational wind analysis map for Austria for a selected date, including wind farms and observation sites



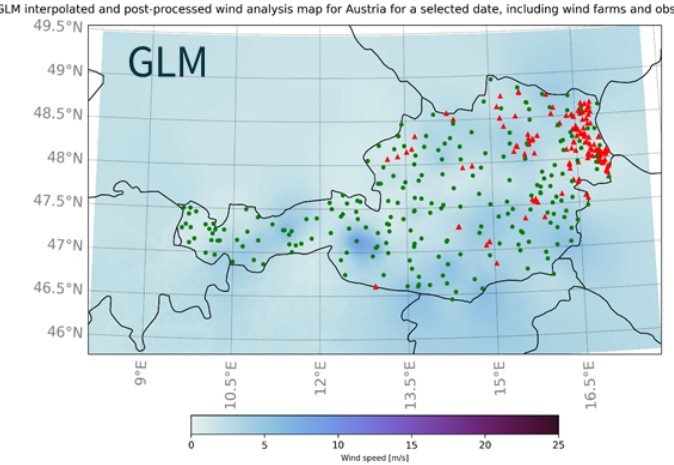
GAM interpolated and post-processed wind analysis map for Austria for a selected date, including wind farms and observation sites



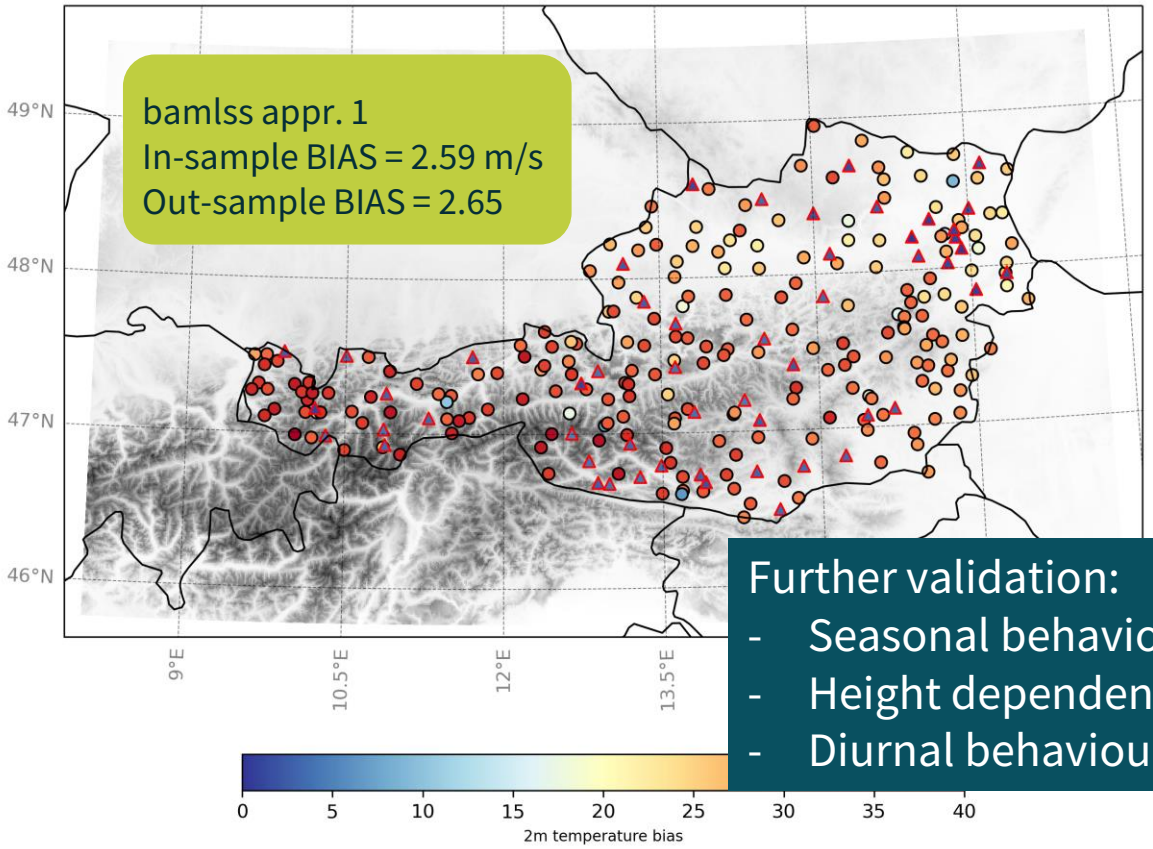
GAM interpolated and post-processed wind analysis map for Austria for a selected date, including wind farms and observation sites

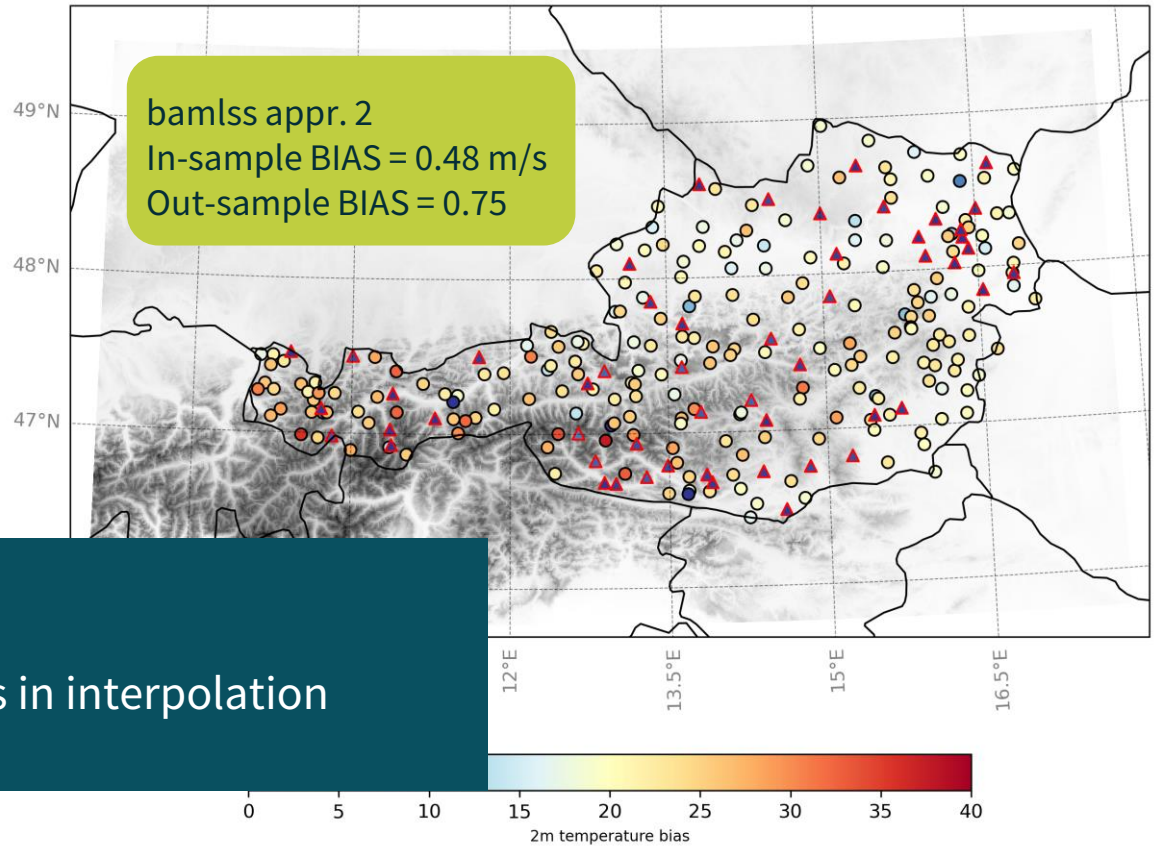


GLM interpolated and post-processed wind analysis map for Austria for a selected date, including wind farms and observation sites



Preliminary results – validation against observations





Further validation:
- Seasonal behaviour
- Height dependencies in interpolation
- Diurnal behaviour

Roughness length calculations for extrapolation

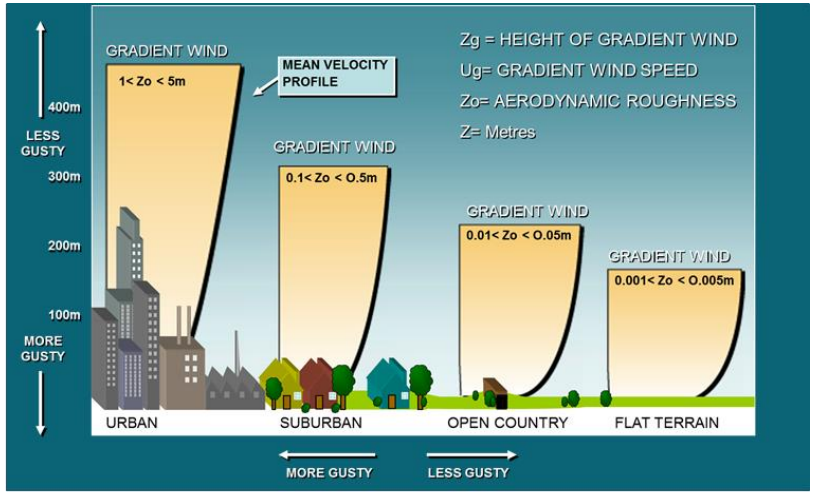
$$z0 = z \exp\left(-C * k * \left(\frac{v}{Sigma_v}\right)\right)$$

Motivation

- Not for all sites a roughness lengths is available in the metadata
- If available: Only one value but seasonal changes and different behaviour per wind direction sector are present

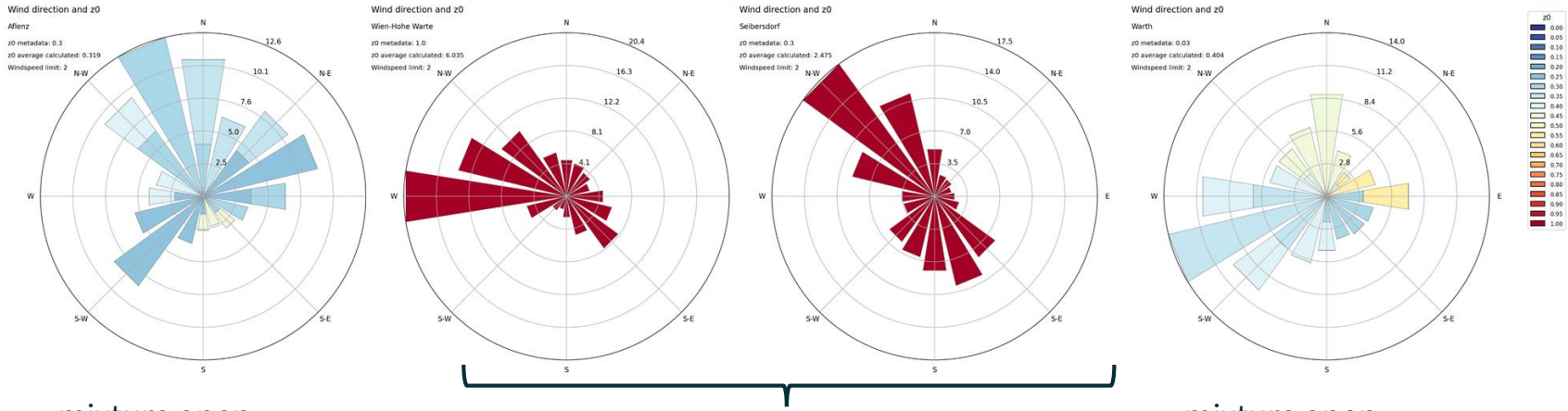
Open questions:

- What do use for "first shot" extrapolation of wind analysis maps if we want to include as much information and detail as possible?
- How well does the above equ. perform in z0 calculation compared to wind atlas values?
- Can we safely use this? What else could we use / look into? Do we miss important pieces here?



https://cppwind.com/wind-profile-characterization/

$\bar{v} \geq 2$ m/s



mixture open country/village/rural

urban, z0 in metadata not correct!

mixture open country/village/rural

Conclusion

- Using only station data can result in not so accurate interpolation of the data when using "operational" mode
- Adding reanalysis information does improve the results
- We still use a very simplistic baseline, feature engineering adding non-linear features can be of additional benefit
- Uncertainty estimation needs to be added not only via using a set of methodologies but also in the underlying data

Next steps

- Adaption of considered station network (concise data set)
- Improvement of extrapolation to different heights
- Validation with external data (met mast data, measurements from other station networks)
- Application and usage as ground truth in climate model downscaling

https://lawinenwarndienst.blogspot.com

In a nutshell …

- **Motivation:** Investigation of wind resources in Austria in future climate
- **Problem:** Lack of gridded wind speed analyses for the past years with a spatial resolution of 1 x 1 km
- **Approach:** Interpolation of wind speed observations with statistical (GAM) and statistical-dynamical (INCA) approaches
- **(Preliminary) results:** Technical requirements are met, scientific evaluation still ongoing
- **Outlook:** Downscaling of climate models using newly generated historic wind speed dataset

THANK YOU!

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