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GeoSphere Austria

Challenges in S2S post-processing: data pre-processing, methods, verification

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Outline

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- Motivation
- Challenges
- Our current solutions in post-processing and downscaling S2S
- Planed next stepst and outlook

Motivation

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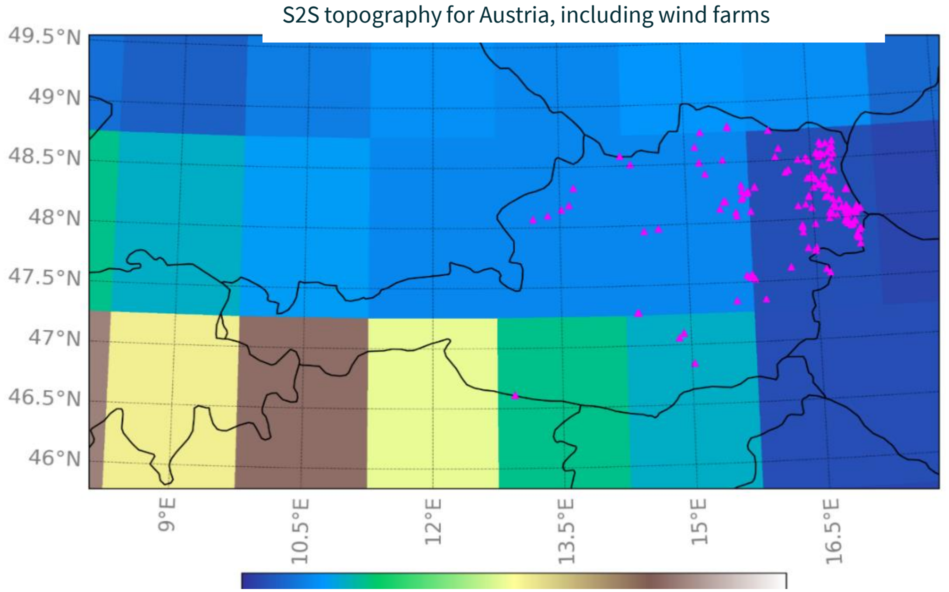
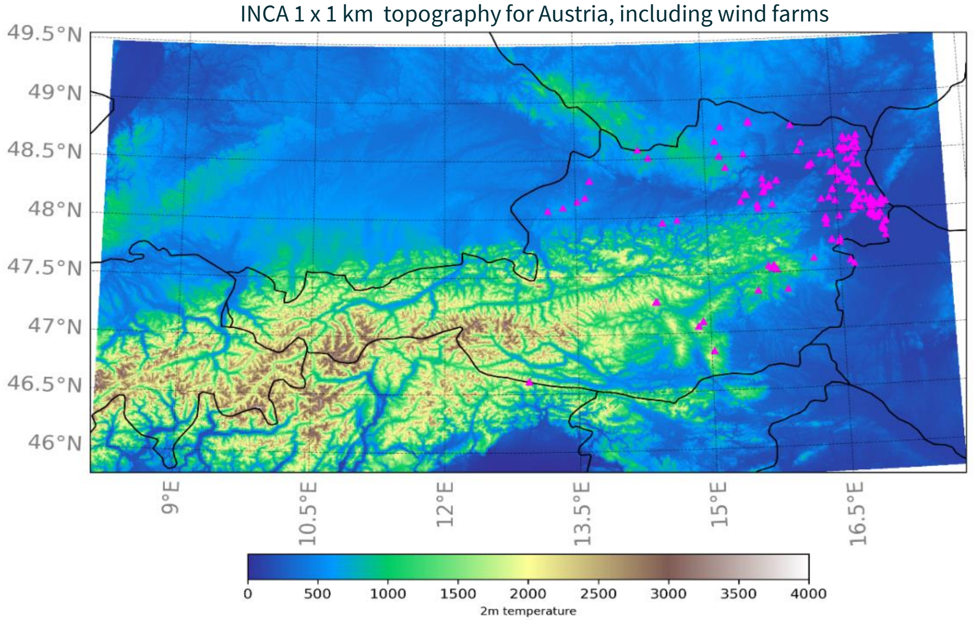
- Significant advances in S2S + seasonal prediction of NWPs
- Advantage of S2S (or extended range) data: multi-model ensembles
- Renewables need <u>high-quality meteorological forecasts </u>for managing <u>across all timescales</u>

BUT S2S DATA COMES NOT WITHOUT <u>ISSUES</u>:

- High **computational costs** (RAM/storage/ensembles)
  → **limitations in resolution** (spatial/temporal) even for original extended range products
- Often **insufficient for small scale renewable** production sites/wind farms/pv/small hydro power catchments, especially in rugged terrain
- Needed are **targeted forecasts** : wind speed, temperature (heating degree days, etc), precipitation (# consecutive days precip), wind (drought,…) …

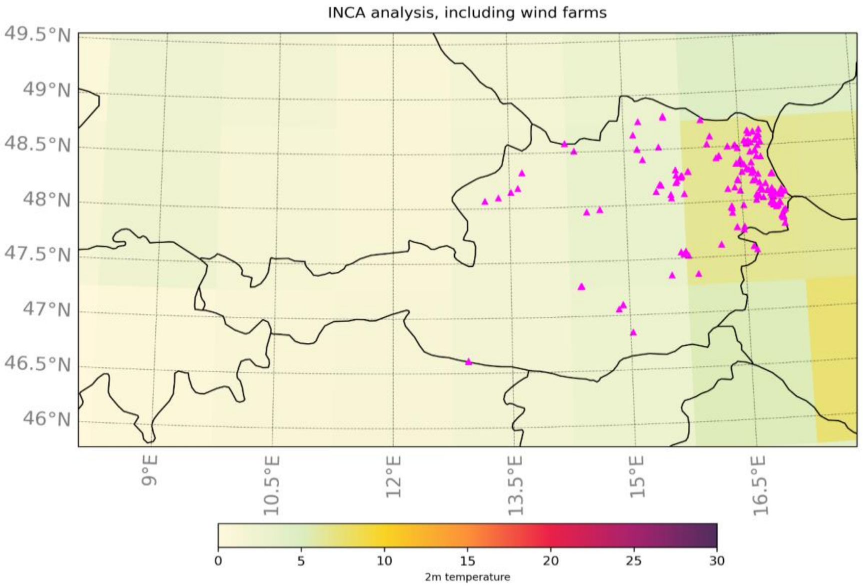
→ aim to overcome **challenges** in **S2S downscaling** + **post-processing**

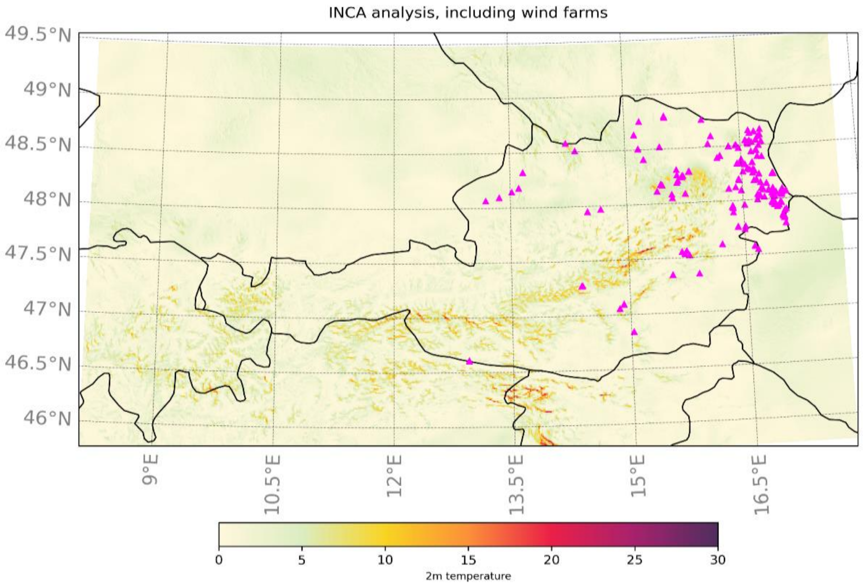


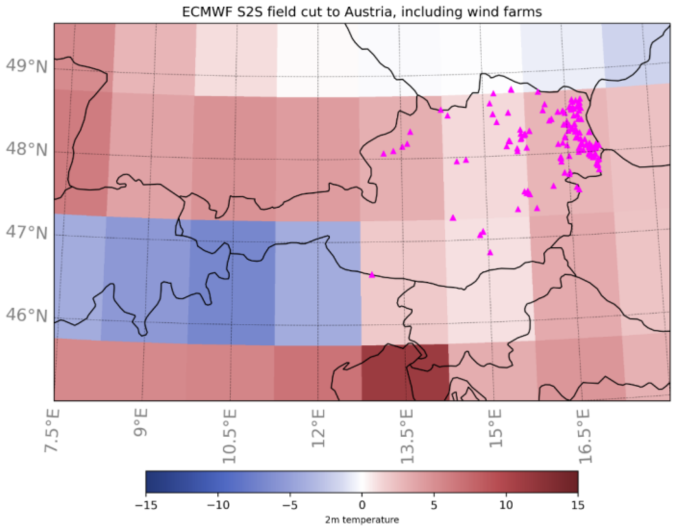


Motivation

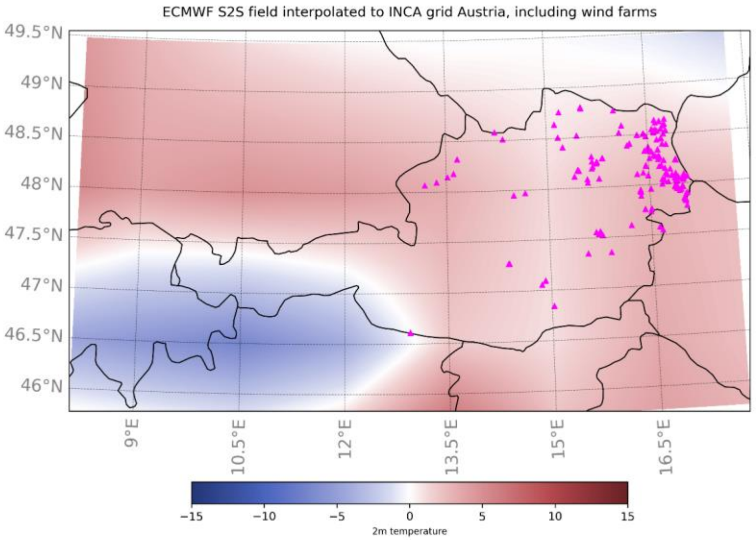
Example temperature and wind representation for a +8 day forecast







TO INCA GRID



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Challenges in post-processing S2S for renewables

Our **aim** in renewables:

- **S2S initiative**: spatial resolution of 1.5° in spatial and approx. 6-hourly temporal resolution.

  small side comment:

  for operational purposes one would rather switch to the extended range forecasts due to availability in time
- **Need to post-process + downscale** as not being sufficient for **small scale renewable** production sites

We face different **challenges** in **S2S downscaling** + **post-processing:**

- Appropriate **communication** to the **end-user/costumer** on the forecast products and their skills
- **Interpretability** and **uncertainty** of obtained results
- **Implementation issues** when starting these timescales:
  - Technical issues in accessing resources, data, code-portability
  - Which parameters to focus in long forecast horizons
  - Identifying most effective methods to use on long forecast time-horizon and suitable for renewables
  - operationalization

End user communication

Build **user awarness** – how does one use and interpret obtained forecast products?

- How do extended range / S2S /seasonal forecasts behave, what is their general idea, aim and what can a user or what can media/the general public expect (still it is often not clear enough that it is not a weather forecast). Provide easy understandable guidelines (similar to IPCC summary reports?)
- Appropriate communication to the end-user/costumer on the forecast products is neeeded.
- The end users needs to be educated about uncertainty and useability of a forecast product.

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End user communication

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- A…
- T…

Feedback loop for post-processing, workshop/close collaboration with users :

- Do end users see the **benefit** with current state of **post-processing** compared to raw S2S/extended range?
- Different **use cases** as in short-range can help discussing usefulness for our implementations + user needs.
- We need to consider which **parameters** the end user needs most in **longer time-scales**.
- **Heating/cooling forecasts/wind drought** in long time ranges also significant for renewable energies/evaluating wind fields

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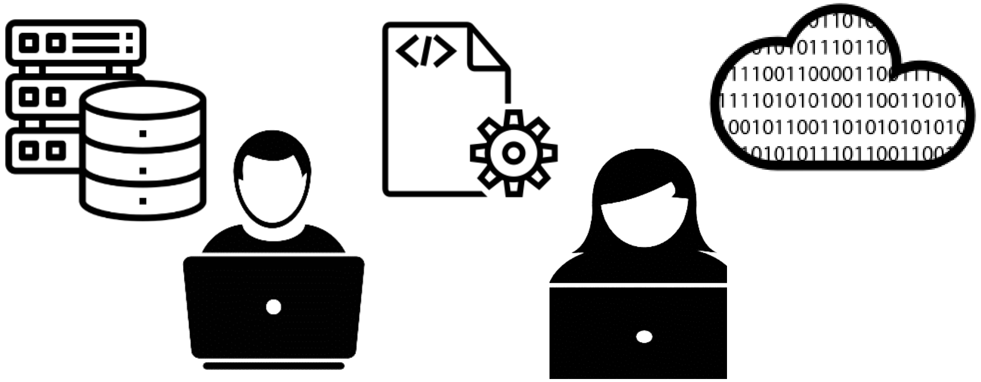
Interpretability and uncertainty of results

Explain results - How can one interpret forecast results with varying degree of **uncertainty**?

- The process of downscaling and long forecasting horizons gives a higher degree of uncertainty
- Effectiveness of one appraoch can vary with the **weather situation, local optimization**, and **quality of input data**
- Uncertainty modeled by **ensemble forecast, spread, mean** – needs to be communicated
- **AI** tends to **smoothen results** and needs lot of **tuning**, but can be difficult in complex situations
- Hard to improve S2S/extended range forecasts compared to climatology (ECMWF S2S data is an interpolated product of the higher resolved extended range forecast) → **interpretation** of results with respect to **climatology**

Implementation issues in the S2S range



Build new **S2S ready Forecast Products** – how do we implement and optimize to renewables?

- Finding a **starting point** for a implementation that is feasable for resources and interpretable
- Usage of **existing code** comes with issues in documentation, reproduction, and code-portability to different computing environments
- In implementation and operationalization often **technical issues** occur in accessing **resources/memory/data**
- In long forecast horizons, which **parameters/transformation** (input + output) to focus on with limited resource?
- Identifying most effective **methods** to use on **long** forecast **time-horizon** and **suitable for renewables**
- Often exceptionally **long time-series** may be needed for training (e.g.: EPISODES in generating analogs)
- Overcome issues with **operationalization** (e.g.: switch to extended range ecmwf forecast)

Current approaches to s2S in Austia

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In **Austria** we worked on **in gridded S2S forecast/downscalling** for the :

Domain: INCA domain: **1 km grid (401x701)**

Lead: **+1, +2, ..., +46 days** ahead, providing **daily** forecasts

Targets: Forecasts first focusing on simpler parameters as **temperature/T2m**, extend to **precipitation**, ….

Input: ECMWF s2s, INCA analysis (inc. computed anomalies, climatologies, etc)

Starting point was the **s2sChallenge** winner‘s code (https://s2s-ai-challenge.github.io/):

Freely available code of participants, however implementation often comes with technical difficulties/lack of documentation/dependencies on certain IT infrastructure/data

Modify/Set up Simple **models**:

RF (by gridpoint), **MLP** (by gridpoint), **UNET**, **Episodes**, **SAMOS**

Current **issues** to be solved:

Data and processing issues: **Data availabiltity** (energy provider/DSO; operational inputs), **ressources**

Finalization of all missing simulations / rerunning faulty simulations

Input data size for the different models: need large domain and some parameters, reforecasts, etc.

Outlook and Next steps in Austria

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Challenges in S2S forecasts need to be considered by **developers** and **end-users**.

Operationalization requires different data and constant access to computing resources. Is our post-processing approach better than climatology and input by S2S in praxis?

Adding **parameters** needed for a **full power system model chain** (e.g. for Calliope) to the downscaling (wind speed, surface pressure, ssrd)

Semi-operational implementation: changes at ECMWF with June affecting semi-operational implementation: decision right now not to change our current setup (bi-weekly, 10 – 50 member as they are exchangeable)

Downscaling to **power grid nodes**/ many local nets in alpine area (e.g.: Mürztalernetz),
but accessing sufficient data from DSO* still difficult…

Extension to day and week values (here, APG provides us with data 15 min. updated)

*) Distribution System Operators (DSO): entities distributing/managing energy from generation sources to final consumers.

QUESTIONS?

Post-processing
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References

Sha, Y., D. J. Gagne II, G. West, and R. Stull, 2020a: Deep-learning-based gridded downscaling of surface meteorological variables in complex terrain. Part I: Daily maximum and minimum 2-m temperature. J. Appl. Meteor. Climatol., 59, 2057–2073, https://doi.org/10.1175/JAMC-D-20-0057.1.

Sha, Y., D. J. Gagne II, G. West, and R. Stull, 2020b: Deep-learning-based gridded downscaling of surface meteorological variables in complex terrain. Part II: Daily precipitation. J. Appl. Meteor. Climatol., 59, 2075–2092, https://doi.org/10.1175/JAMC-D-20-0058.1.

Scheepens, D. R., Schicker, I., Hlaváčková-Schindler, K., and Plant, C.: An adapted deep convolutional RNN model for spatio-temporal prediction of wind speed extremes in the short-to-medium range for wind energy applications, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2022-599, 2022.

Dan, Y., Zhao, Y., Li, X. *et al.* Generative adversarial networks (GAN) based efficient sampling of chemical composition space for inverse design of inorganic materials. *npj Comput Mater* **6**, 84 (2020). https://doi.org/10.1038/s41524-020-00352-0

Miralles, O., D. Steinfeld, O. Martius, and A. C. Davison, 2022: Downscaling of Historical Wind Fields over Switzerland Using Generative Adversarial Networks. *Artif. Intell. Earth Syst.*, **1**, e220018, https://doi.org/10.1175/AIES-D-22-0018.1.