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Operational setup

Past configuration:
- **ALADIN-HRDA**: 2km, 32 levels, dynamical adaptation (DA) of wind; 72h fcst.; ICs/LBCs: ALADIN-HR4; 4 runs per day

Current operational model configurations:
- **ALADIN-HR40**: Δx=4 km; 480x432x73; CY43T2; HYD dyn.; t=150 s;ALARO-1 phy.; IC: CANARI + 3DVar (3h-cycle, ENS B); 72h fcst.; LBC:IFS-3h (6-h lagged), 4 runs per day

- **ALADIN-HR20**: Δx=2 km; 450x450x87; CY43T2; NH dyn.; DFI ini.; t=60 s;ALARO-1 phy.; 72h fcst.; IC: ALADIN-HR40; LBC: IFS 1-h (6-h lagged); 4runs per day

- **HRAN**: Analog-based method - a statistical post-processing method that finds analogous situations in the previous (training) period and using a similarity metric predicts values that are observed under a "very similar" forecast; predictor weight optimization and statistical correction for rare events are used

Verification of ALADIN wind speed forecasts: HR20 vs. HRDA

- The ALADIN-HRDA configuration was replaced by the ALADIN-HR20 configuration, and the maximum 10 m wind speed for the time period 2021-2022 of both configurations was compared.

- The configurations have a similar spatial distribution over continental Croatia. ALADIN-HR20 gives higher maximum wind speeds over the coastal region of Croatia, especially over a wider area under the Velebit mountains, where storm and violent storm wind speed categories occur (**Fig. 1**).

- ALADIN-HR20 forecasts the strongest wind speed category (>32.7 m/s) over a much smaller area and in a different location than ALADIN-HRDA, which corresponds better with observations.
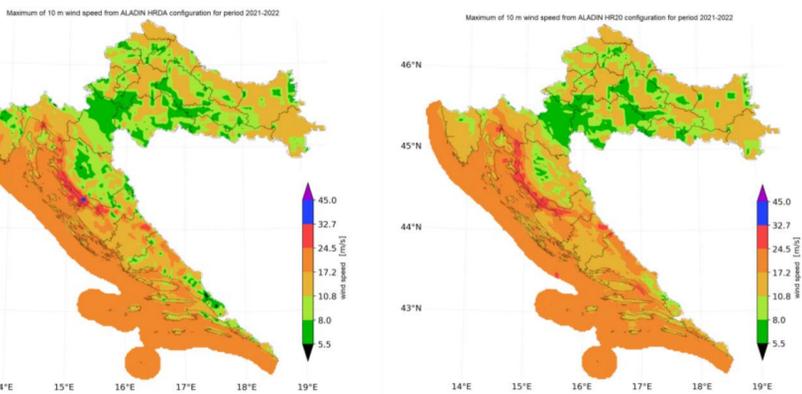

Figure 1. Spatial distribution of maximum 10 m wind speeds for ALADIN-HRDA (left) and ALADIN-HR20 (right) for time period 2021 -2022 within Croatian borders

Neighborhood Ensemble altitude Correction (NEA)

- Novel approach for temperature postprocessing without using any observations.

- **NEA** involves finding the closest model point to the **Location of Interest** (**LoI**), forming a neighborhood ensemble, calculating the temperature lapse rate through linear regression of neighboring points' altitude and temperature, and applying this lapse rate to all neighboring points to obtain altitude-corrected temperatures. The ensemble mean of these corrected temperatures forms the final forecast (**Fig. 2**), accounting for model uncertainty due to the inability to resolve all processes at the model grid size scale.
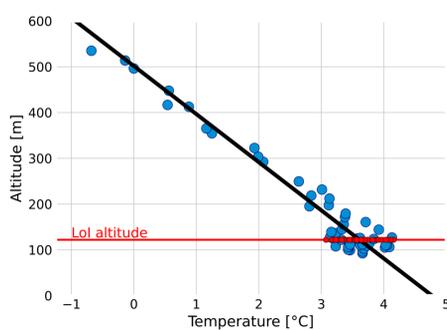

Figure 2. Example of a linear regression between temperature and altitude of model grid points (blue dots). Model grid points with altitude-corrected temperatures are shown in red.
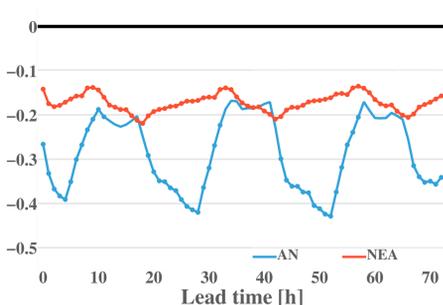

Figure 3. RMSE of AN and NEA relative to nearest point for the verification period. Forecast ranges with statistically significant differences are marked with bullets. Statistical significance for NEA is calculated against NP, and for AN against NEA.

- The method was thoroughly tested and validated using a one-year period and 36 surface stations in Croatia. Results are encouraging and show an **increase in forecast accuracy of about 10%** on average when compared to the default method of using the nearest model land point (**Fig. 3**).

- NEA's performance is comparable to advanced analog-based method (**Fig. 3**), especially during daytime, making it a robust solution for diverse terrains and operational settings.

Universal Thermal Climate Index - UTCI

- Examined the relationship of the Universal Thermal Climate Index (UTCI) mortality caused by thermal strain in Croatia → from measurements on 4 stations for period 2006-2022

- For cold/hot conditions calculated the UTCI index values [°C] below/above which averaged difference of relative mortality from expected mortality is increased and statically significant on a level of significance of 0.05 :

  - Cold conditions- UTCI is in moderate stress category for all stations – lowest values for mountain station Gospić, highest for maritime stations Dubrovnik

  - Hot conditions: UTCI is in strong heat category for maritime stations Dubrovnik (highest values) and Split-Marjan and in moderate stress categories for continental station Zagreb-Maksimir and mountain Gospić (lowest values) (**Fig 4.**)

Figure 4. UTCI values [°C] below (blue) and above (orange and red) which averaged difference of relative mortality from expected mortality is increased and statically significant on a level of significance of 0.05 at 4 stations in Croatia over period 2006-2022.

Destination Earth - DestinE

Synthetic vs. wind farm data

- Synthetic wind speed data at hub height was compared with measurements from one coastal wind farm in Croatia. Also, a post-processing of the wind speed forecasts at the location of the wind turbines was carried out using the analog method.

- Since the synthetic wind generally has a higher RMSE than HR20 (the NWP tuned for winds across the Croatian domain) (**Fig 5.**), post-processing forecasts that use synthetic wind show comparable performance or underperform compared to NWP. Expectedly, post-processing forecasts that use measurements from the wind turbines have the lowest errors.
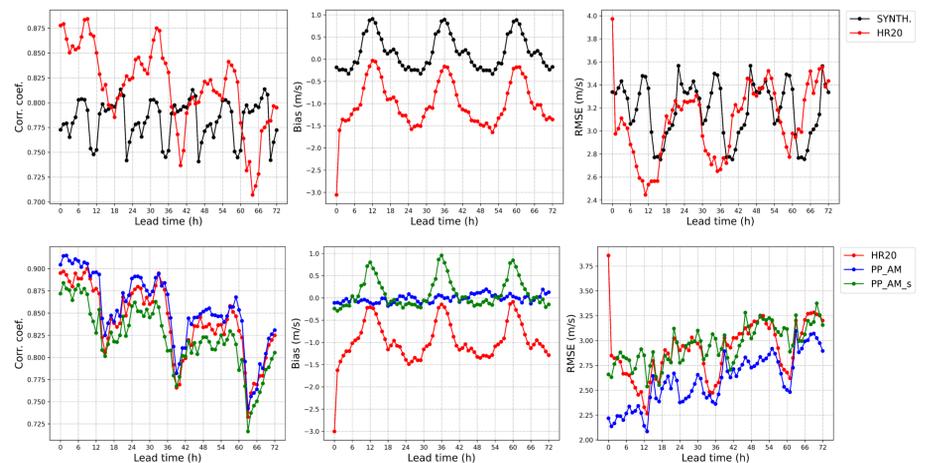

Figure 5. Correlation coefficient, bias and RMSE per lead time; SYNTH. - synthetic wind speed, PP_AM - post-processing forecasts that use measurements from the wind turbines, PP_AM_s - post-processing forecasts that use synthetic wind speed

Two 2D analog-based approaches

- To improve the 2-m temperature forecast, two distinct 2D analog-based post-processing approaches were compared: **Point-by-Point** and **Field-wise** methods.

- The Point-by-Point method treats each grid point as an independent location, and the distance metric is calculated for each forecast lead time; the Field-wise approach does the same, but then averages the calculated metric over an entire field to select the best match, rather than selecting it for each grid point separately.
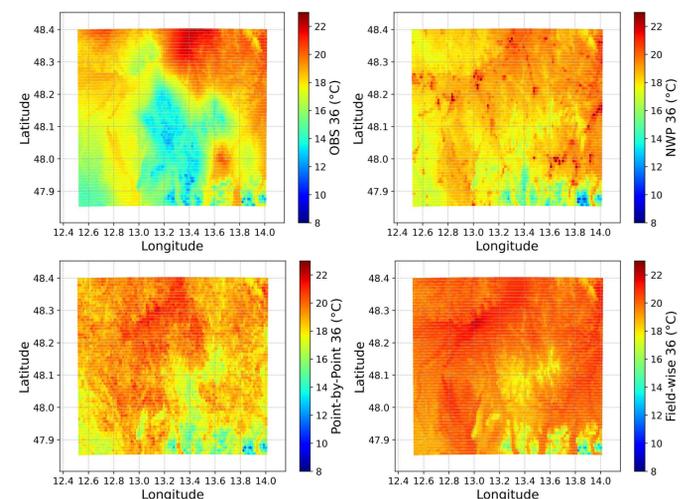

Figure 6. The temperature observations (upper left), hyper-resolution raw NWP (upper right), post-processed Point-by-Point (lower left), and post-processed Field-wise (lower right) temperature forecasts at lead time 36h for the high-precipitation event in the middle of the Austrian domain on 12th May 2016.

- AROME hyper-resolution hindcasts' 2-m temperature and wind speed were used as predictors and the training dataset consisted of 60 events. The "ground-truth" consisted of gridded INCA analysis fields.

- As can be seen in the results (**Fig. 6**) for the high-precipitation event in Austria on May 12th, 2016, **the point-by-point method outperforms Field-wise method**. The point-by-point method is comparable to the raw NWP field.