# SPECIAL PROJECT FINAL REPORT

All the following mandatory information needs to be provided.

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|---|---|
| **Project Title:** | WRF-based high resolution numerical weather simulations to update the new Italian Wind Atlas |
| **Computer Project Account:** | spitsper |
| **Start Year - End Year :** | 2024 - 2024 |
| **Principal Investigator(s)** | Simone Sperati |
| **Affiliation/Address:** | Ricerca sul Sistema Energetico (RSE) SpA |
| **Other Researchers (Name/Affiliation):** | Davide Airoldi (RSE SpA) |

The following should cover the entire project duration.

## Summary of project objectives

(10 lines max)

The aim of the project was to extend the dynamically downscaled 5-year period of the new Italian Wind Atlas AEOLIAN beyond 2019 using the WRF model. The extension by dynamical downscaling of the ERA5 global fields allows capturing the atmospheric dynamics, benefiting of the availability of 10-m wind measurements by the Italian regional weather services.

## Summary of problems encountered

(If you encountered any problems of a more technical nature, please describe them here.)

No problems were encountered during the project.

## Experience with the Special Project framework

(Please let us know about your experience with administrative aspects like the application procedure, progress reporting etc.)

The application procedure went smooth and allowed us to quickly benefit of the ECMWF computational resources. The ECMWF AC cluster is reliable and fast, and also compilation of codes (e.g., WRF v3.9) went smooth.

## Summary of results

(This section should comprise up to 10 pages, reflecting the complexity and duration of the project, and can be replaced by a short summary plus an existing scientific report on the project.)

The objectives of the activity concerned the temporal extension of the Italian Wind Atlas AEOLIAN [1] beyond 2019, in order to cover the most recent years and have an updated description of the wind conditions over Italy. Unlike the extension in the past, for which it was used the Analog Ensemble (AnEn) technique described in [1][3], to update the dataset it was chosen to conduct numerical simulations with the WRF model [3] as already done for the period 2015-2019. In this way it is possible to benefit from the observation stations available, as well as the entire set of meteorological variables output from the model, possibly usable for other purposes.
Figure 1 shows the computational domain of the numerical simulations conducted with WRF, with a 1.33 km pitch grid centered on Italy inserted into a looser grid with a resolution of 4 km. The external and internal grids are made up of 520x520 and 837x1029 grid points respectively, and the internal one constitutes the area covered by AEOLIAN. The temporal resolution is equal to 1 h.

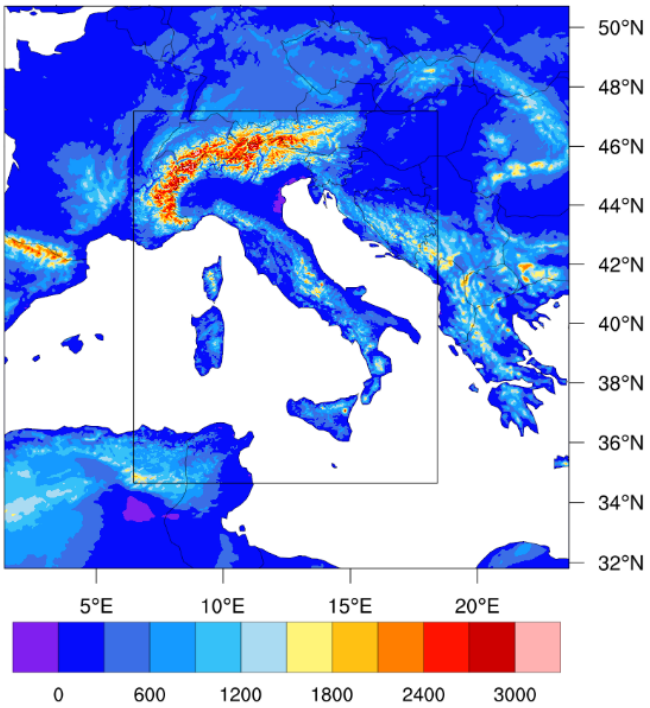

Figure 1 Computational domain of the WRF simulations.

The late special project request of 45 million core hours allowed simulating the years 2020 and 2021, maintaining the same WRF configuration already used. Following the simulations, comparisons were conducted to verify any deviations in the average wind fields. Specifically, the average data at 50, 100 and 150 m of the period 2015-2019 were compared with those of the period 2015-2021, obtaining the maps of the differences reported in Figure 2, Figure 3 and Figure 4, respectively.

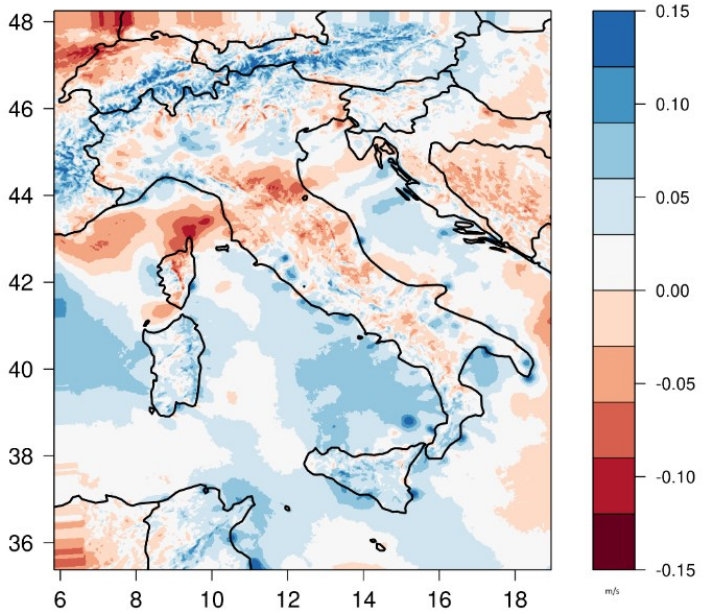


Figure 2 Map of differences (in m/s) between the average of the period 2015-2019 and the average of the period 2015-2021 at 50 m.

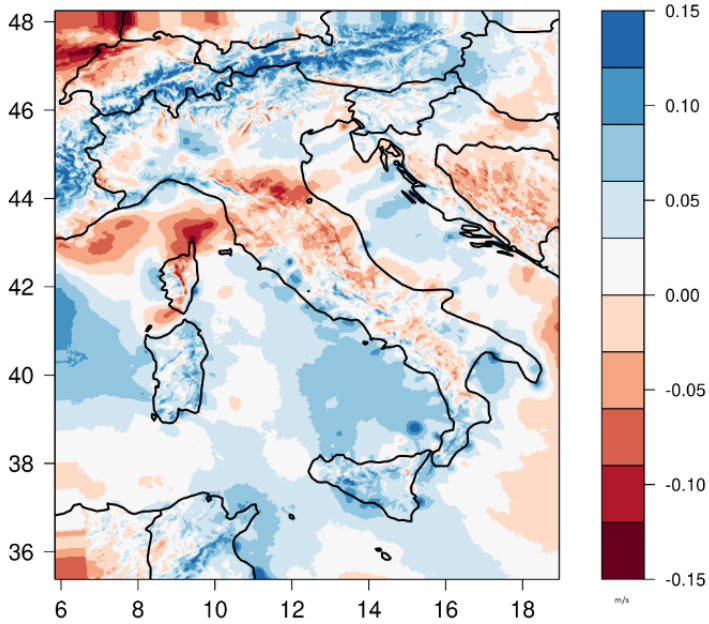


Figure 3 Map of differences (in m/s) between the average of the period 2015-2019 and the average of the period 2015-2021 at 100 m.

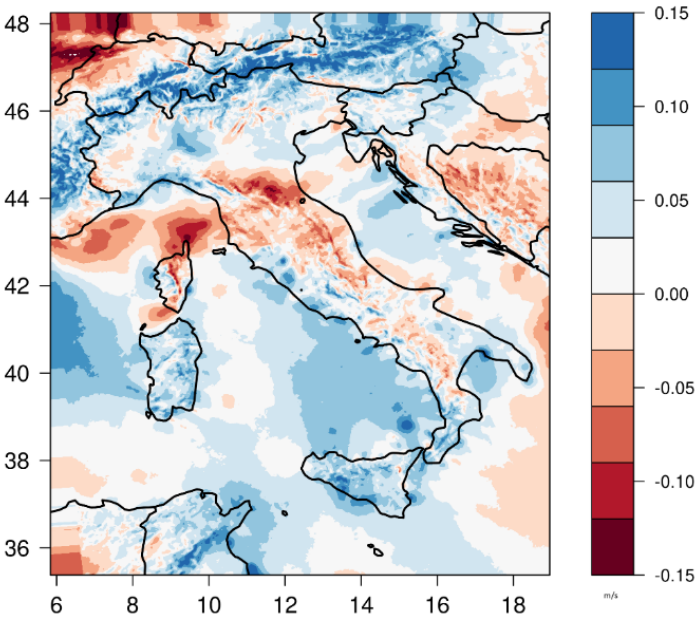

Figure 4 Map of differences (in m/s) between the average of the period 2015-2019 and the average of the period 2015-2021 at 150 m.

The maps generally highlight a slight positive deviation in the Alpine areas, on the major islands and marine areas, where the average calculated over 7 years is slightly lower than that calculated over 5 years, and negative along the Apennine ridge, much of Tuscany, on Corsica and in the Ligurian Sea, indicating slightly higher values in 2020 and 2021 which they therefore influenced the average. In any case, it should be noted that the deviations are limited at 0.15 m/s in both directions. Specifically, the data shows maximum positive differences around 0.2 m/s and negative around -0.15 m/s. For viewing convenience and to emphasize the differences in the same way, a symmetrical scale with a maximum of 0.15 m/s was imposed on the maps. We note how the differences intensify as the quota considered increases, showing the highest deviation values in the 150 m map of Figure 4.

1. Sperati S, Alessandrini S, D'Amico F, et al. A new Wind Atlas to support the expansion of the Italian wind power fleet. Wind Energy. 2024; 27(3): 298-316. doi:10.1002/we.2890.
2. Delle Monache, L., Eckel, F.A., Rife, D.L., Nagarajan, B., Searight, K. Probabilistic weather prediction with an analog ensemble. Mon Weather Rev. 2013;141(10):3498-3516. doi:10.1175/mwr-d-12-00281.1
3. Skamarock, W., Klemp, J., Dudhia, J. A description of the Advanced Research WRF Version 3. Tech. Note NCAR/;475;2008.

## List of publications/reports from the project with complete references

Airoldi D., Sperati S. AEOLIAN: nuove funzionalità Web e aggiornamento temporale dei dati. 2024. RSE technical report, 24011095, Milano (IT).

## Future plans

(Please let us know of any imminent plans regarding a continuation of this research activity, in particular if they are linked to another/new Special Project.)

Future plans regard continuing the extension of the dataset to update the atlas with the most recent years with the same dynamical downscaling approach already used, as described in the project request spitsper 2025.