Off-shore wind potential in Cyprus: Towards an integrated representative geospatial database

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Introduction

Cyprus' energy balance today depends to a large extent on imports of petroleum products for energy production. This has an impact on both the economy and the environment of the island. The contribution of renewable energy sources (RES) in Cyprus, although exhibiting considerable potential, still remains limited. Specifically, renewable energy sources today account for less than 9% of the country's total gross energy consumption.

This work contributes to the study of the off-shore wind power being present the island. It focuses on the creation of an integrated geospatial database for the study of wind characteristics above the coasts and offshore of Cyprus using measurements from meteorological stations, data from the European database with horizontal analysis 25x25 *km*, and 24-hour forecasts from the Open Skiron meteorological model in 5x5 *km* spatial resolution. In particular, the analysis take advantage of wind measurement from meteorological stations in coastal Cyprus areas (fig. 1), as well as information on wind values from forecasting models and databases (fig. 1) to record an initial reference distribution in space and time.

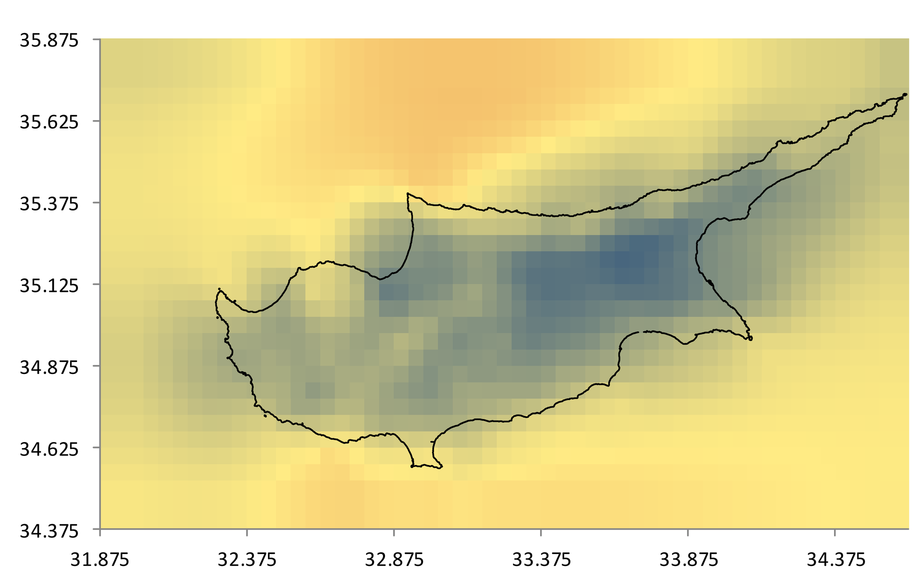

Figure 1. Area of application and positions of the meteorological stations.

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Re-analysis data ERA5/ECMWF

One of the main sources of information are the re-analysis wind data obtained from ERA5/ECMWF. The data covers the period from 2000 – present on an hourly basis with a horizontal resolution of 25x25 *km* (72 grid points within the analysis area), at 10 *m* AGL as shown in the figures below. The typical average speed is about 4.5 *m/s* above the sea and 2 *m/s* above continental areas. The southern coastal parts appear slightly more windy compared to the rest areas.

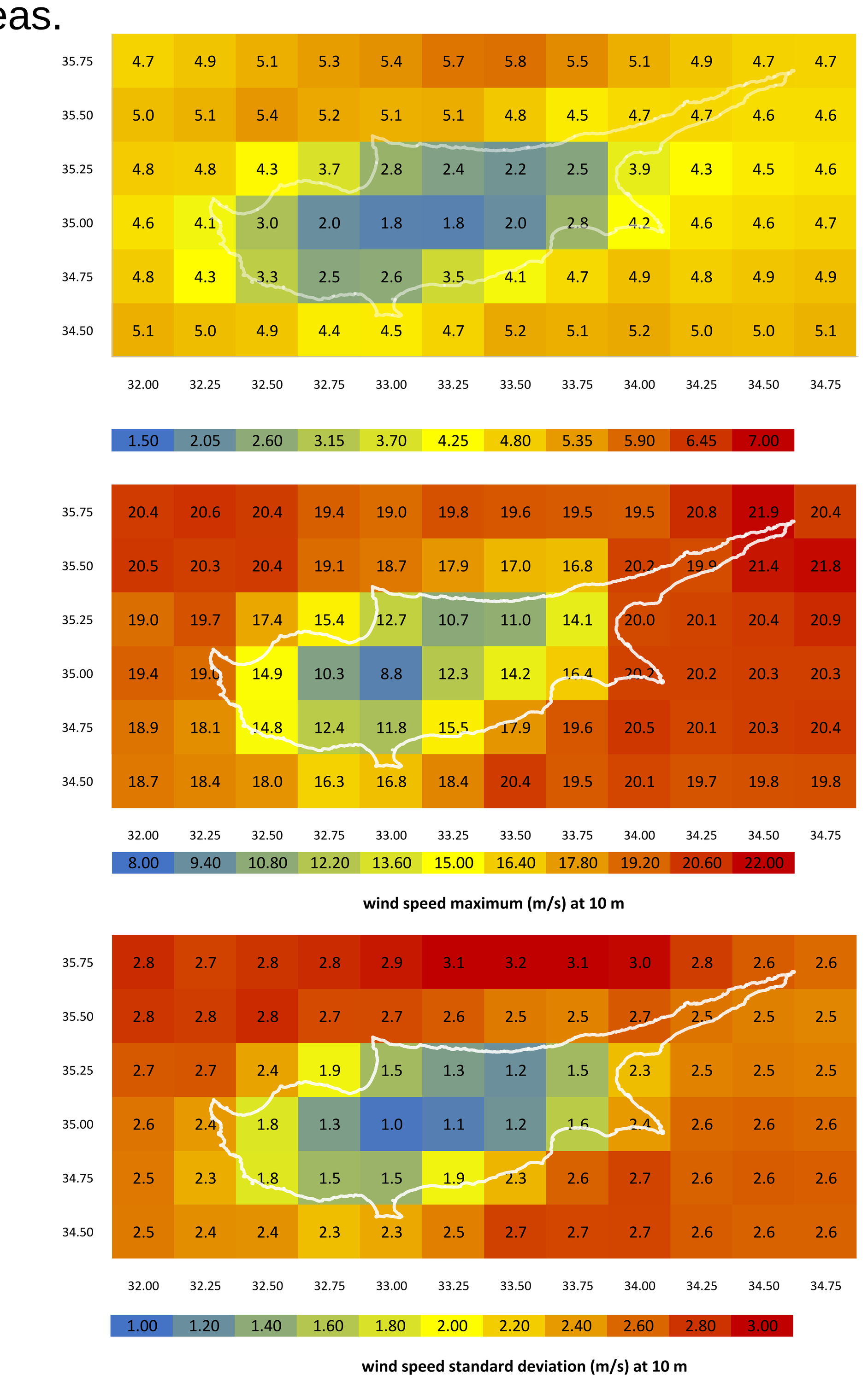

Figure 2. Average, maximum, and standard deviation of the wind speed (m/s) in the area of Cyprus based on the hourly data of ECMWF (re-analysis data) with a spatial analysis of 25 km x 25 km.

The standard deviation of the wind speed is about half the average value and the maxima about 10 *m/s* above the land and 20 *m/s* above the sea. In fact, Cyprus is located in the eastern Mediterranean between latitudes of 34.6º and 35.6º north, and longitudes of 32º and 34.5º east. During the rainy season (November to March) Cyprus is frequently suffered by depressions moving eastwards across the Mediterranean Sea, in addition to troughs that extend from the continental depression commonly centered over Asia during the dry season. Prevailing winds in Cyprus are mostly low to medium in speed; very strong winds (wind speeds faster than 34 knots) are rare, mainly seen in windward areas.

General comparisons with data from the Open Skiron

In the figures below we compare basic statistics of the wind speed as obtained from the 24 *h* forecasts of the Open-Skiron meteorological model for the year 2017. Open-Skiron operates on 5 *km* resolution and results have been scaled to 25 km for the needs of the present comparison.

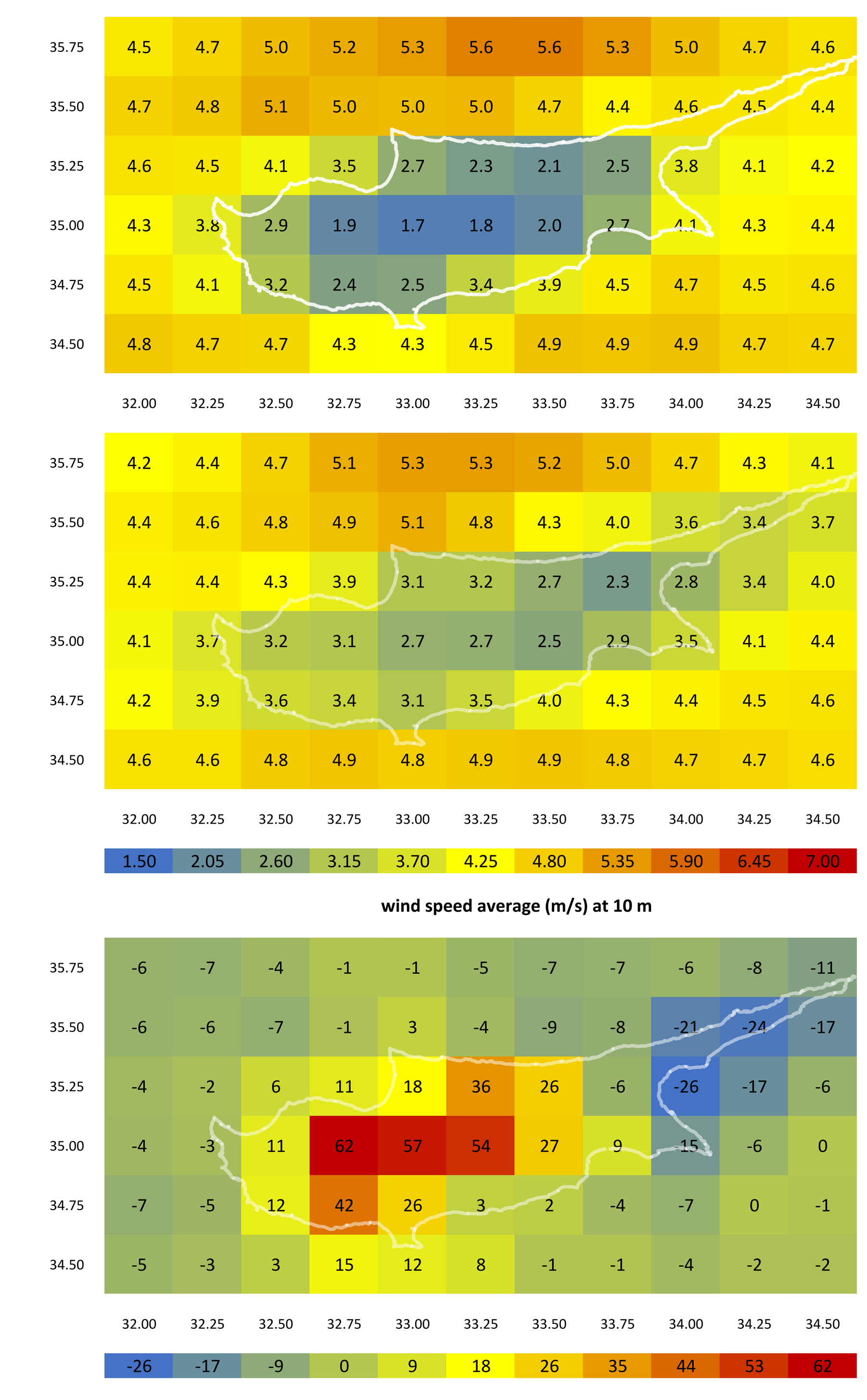

Figure 3. Comparison between mean wind speed for 2017, as obtained by ECWMF re-analysis data and Open-Skiron forecasts.

Regarding the mean wind speed over the sea, the meteorological model provides fair predictions, estimating 5 to 10% lower speed values, except for the east coast where the model underestimates the speed up to 20% compared to the re-analysis data. In contrast to ECWMF estimations of higher values at the North part of the sea region than the South Part, Open-Skiron reveals a more uniform behavior. However, much larger discrepancies are observed over the land. Actually, an inverse behavior is observed, in which the general circulation is very high above the land and mildly weaken above the sea. This picture has to be further tested using meteorological observations in the future.

Comparison with meteorological measurements

Comparisons with in-situ wind measurements by the Cyprus meteorological service exhibits a reasonable agreement in some cases, given the low spatial resolution of the modeled data.

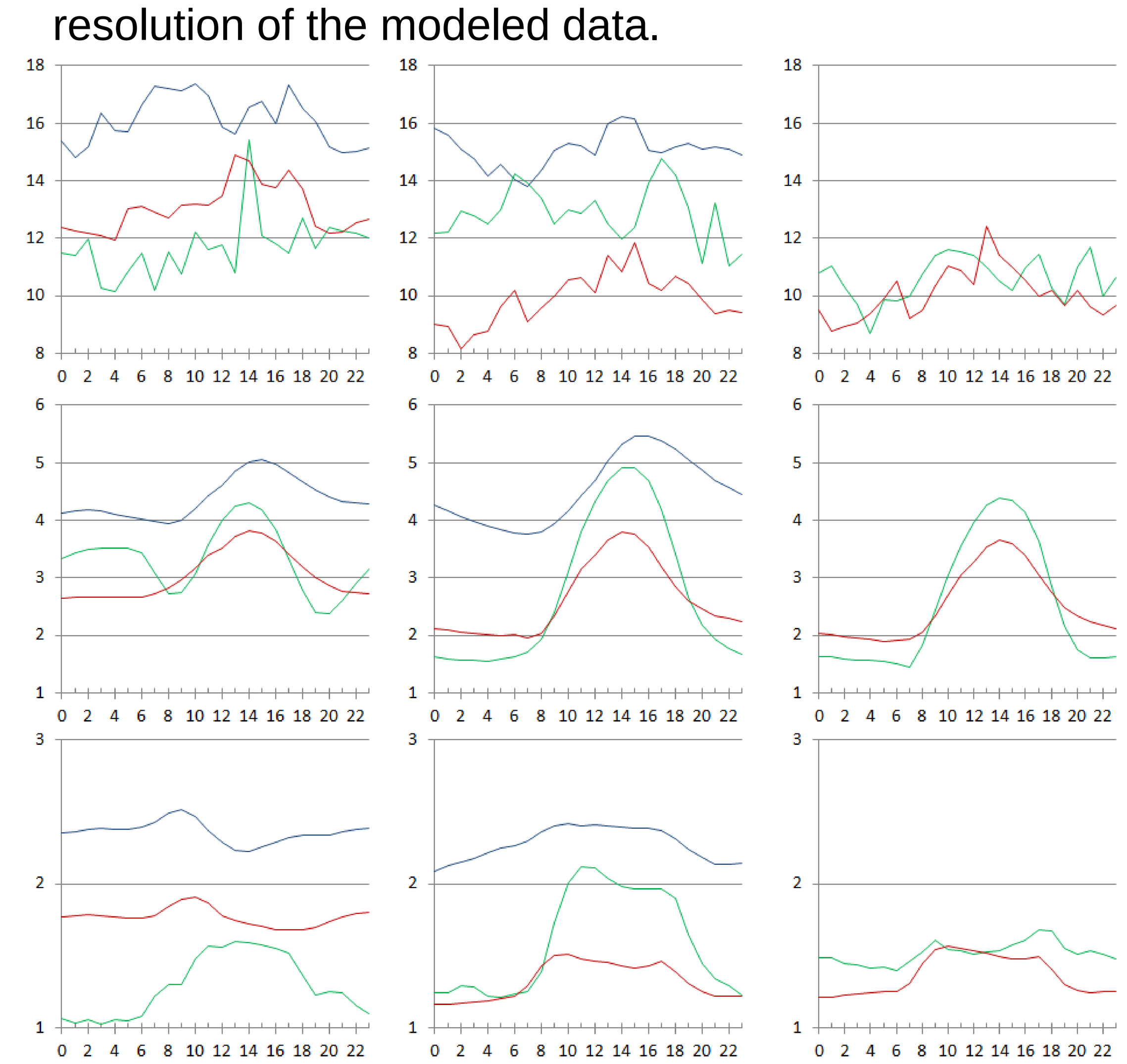

Figure 4. Hourly maximum, average and standard deviation of the wind speed (m/s) (top to bottom) for the period 2002-2008, obtained from three meteorological stations (green curves) and the ECWMF. With red curves the closest gird point over land and with blue curves the closest sea grid point.

Actual Weibull distributions reveal an intermediate behavior between modelled sea and land points.

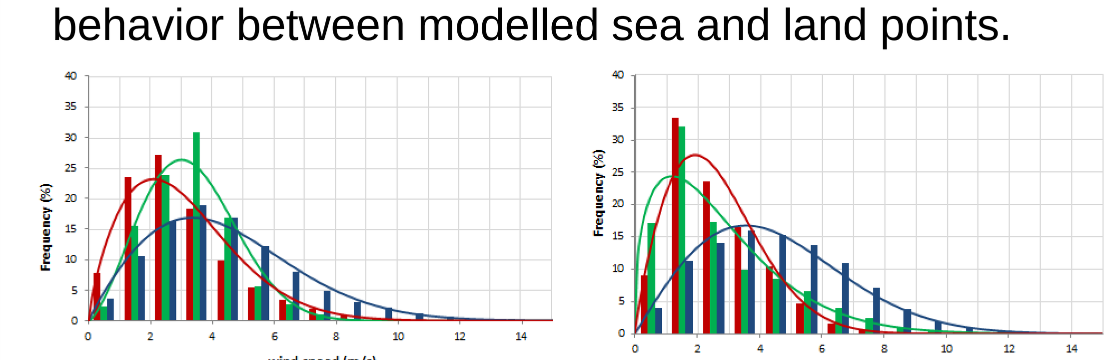

Figure 5. Comparisons of the Weibull distributions of two coastal –stations (green curves) with the closest land (red curves) and sea (blue curves) grid point for 25km resolution.

Conclusions

- ➡ ECMWF re-analysis data show reasonable agreement with forecasts of Open-Skiron and meteorological stations in some cases
- ➡ Increasing the resolution through the use of the 5 *km* analysis data will provide more detailed information in the future
- ➡ The inclusion of the in-situ measurements will be extrapolated using flow models and used to increase the accuracy of the picture.

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