3 KM SIMULATIONS WIND RESULTS – 2012 VS. 2008

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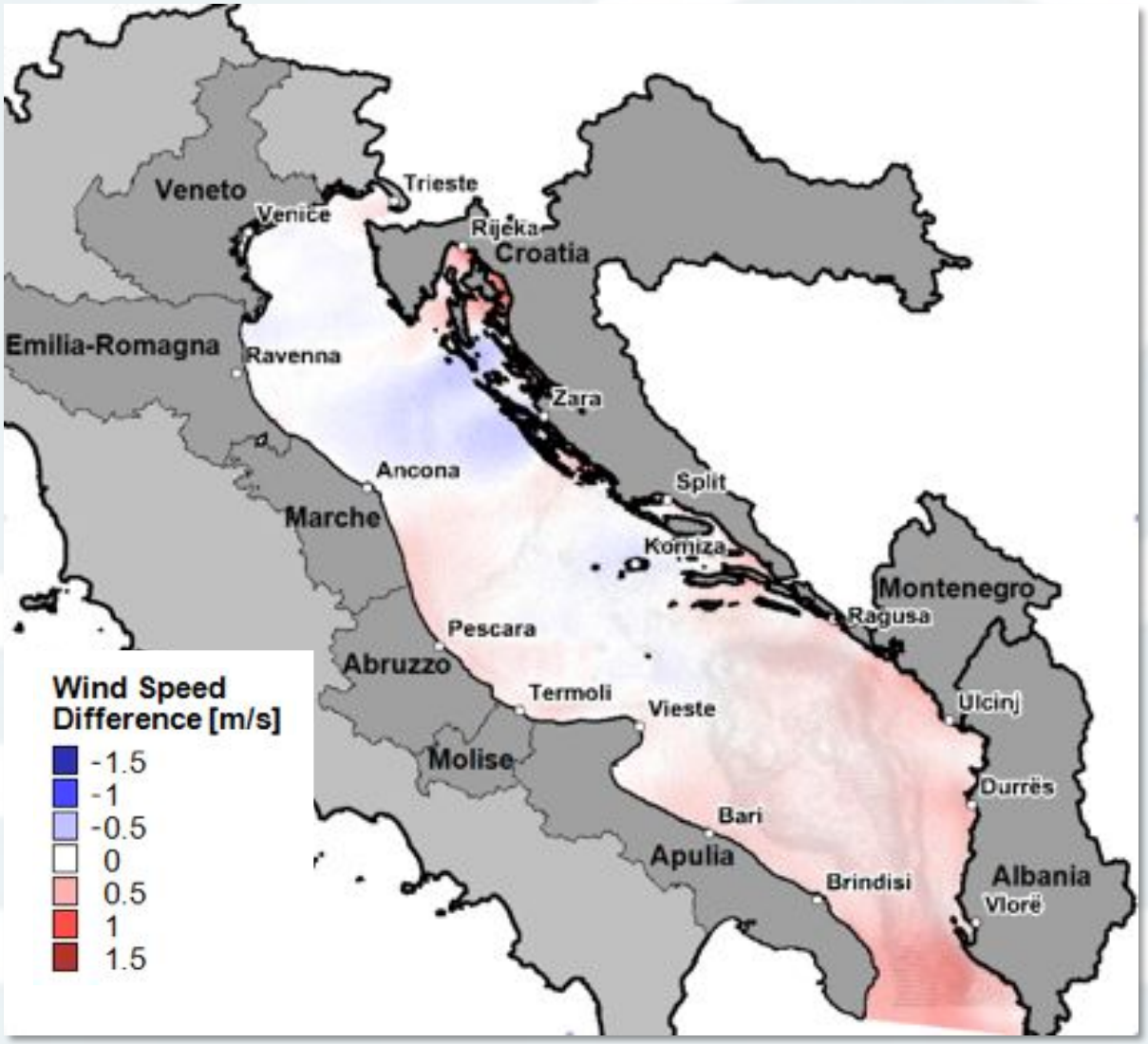
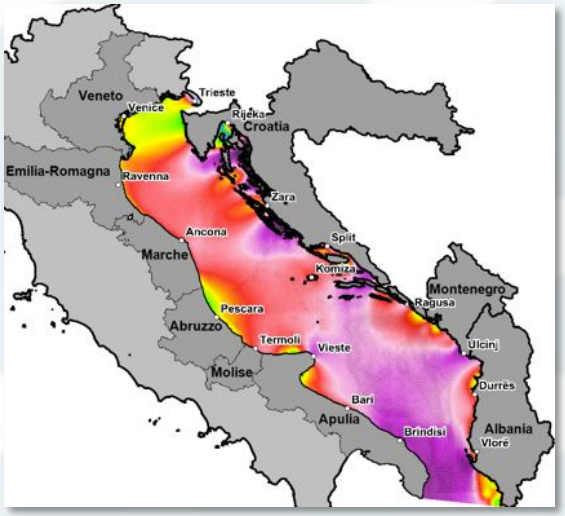
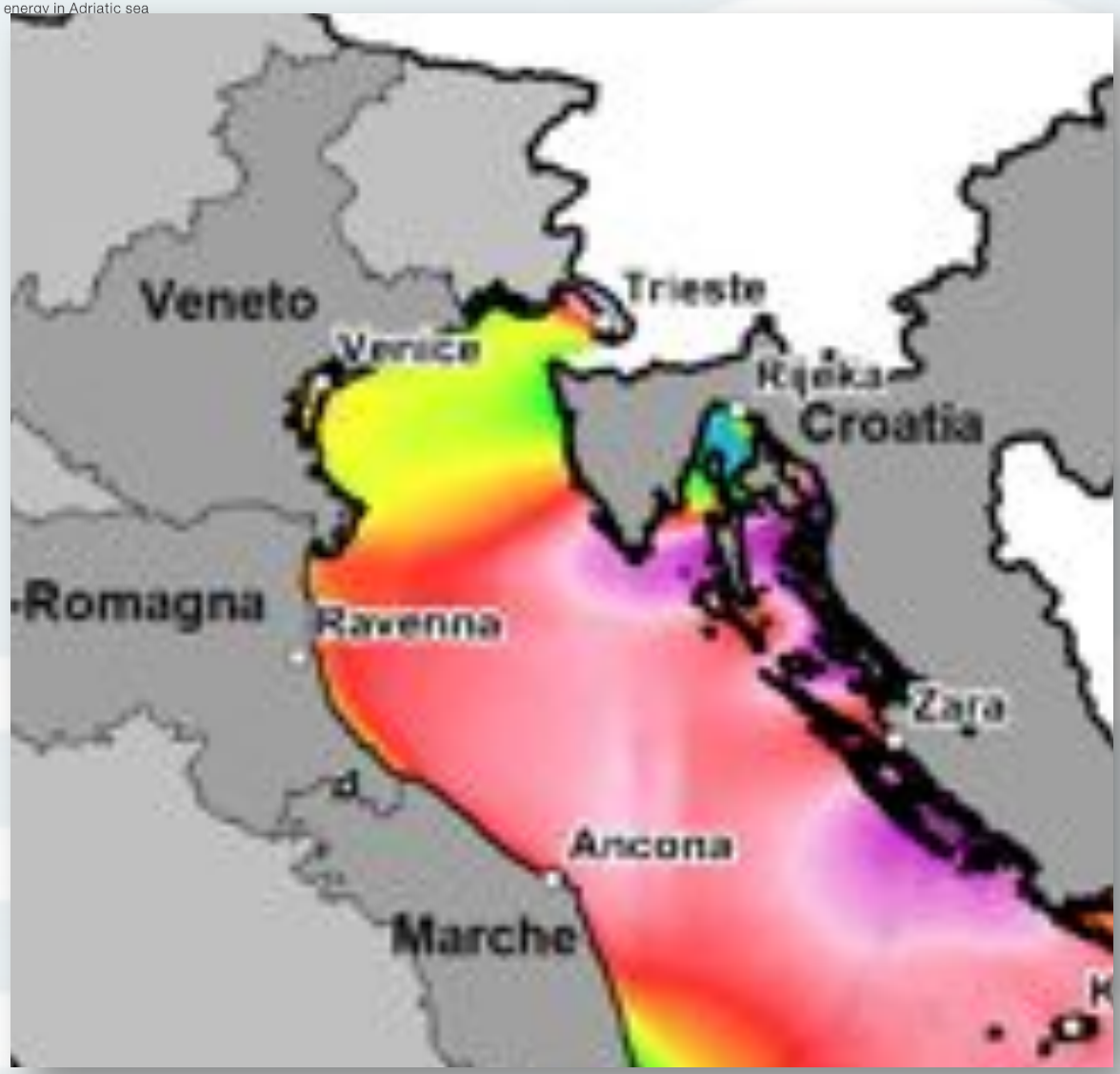


Year 2012 Height 90 [m] a.s.l.



3 KM SIMULATIONS WIND RESULTS - 2008



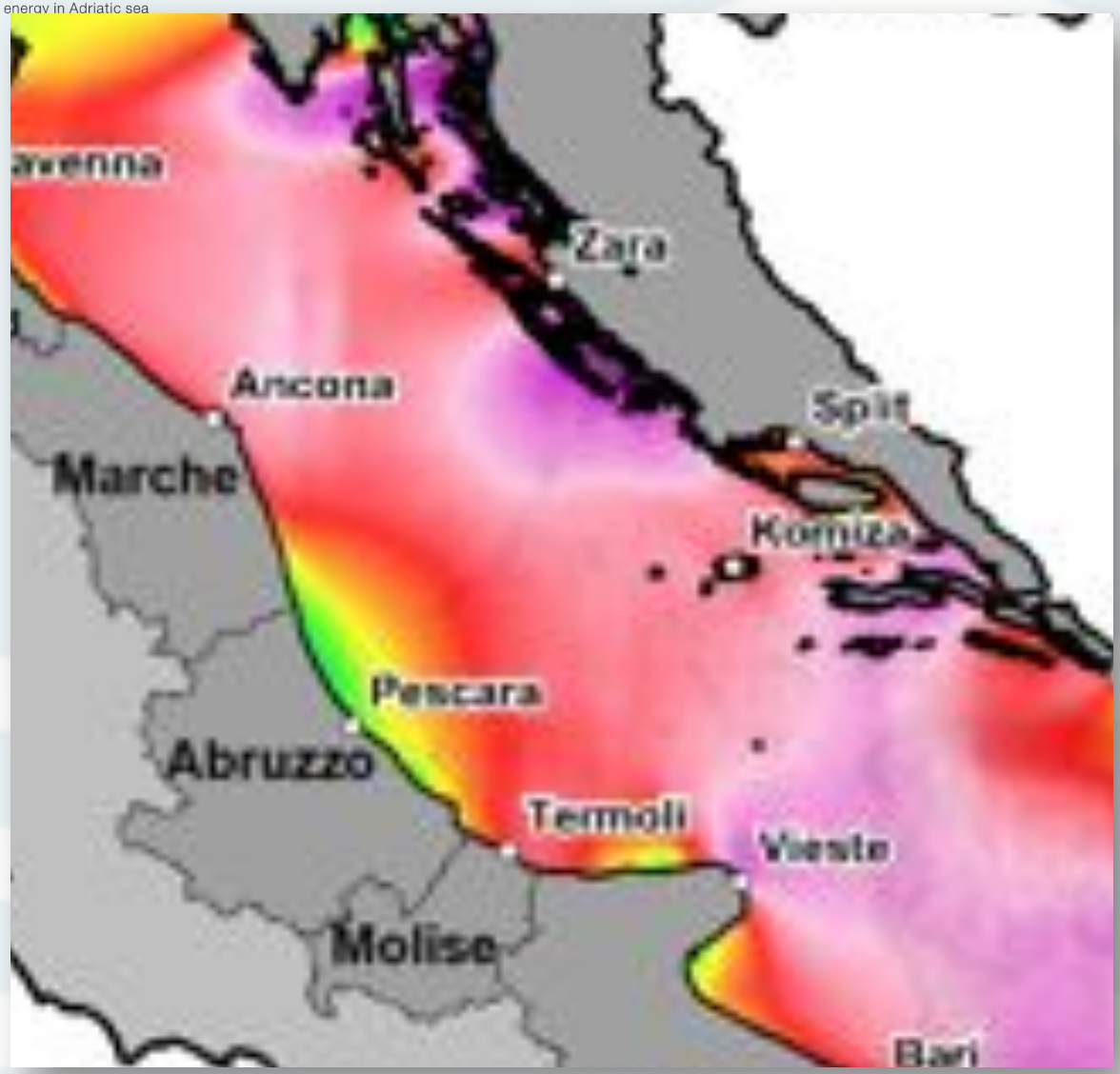
WIND SPEED [m/s]

- 8
- 7
- 6.5
- 6
- 5.5
- 5
- 4.5
- 4
- 3.5
- 3

Year 2008 Height 90 [m] a.s.l.

The sea area in front of the Veneto region shows lower wind velocities with respect to the other Adriatic Basin zones. An interesting velocity may be observed just before Trieste. Mean wind speed increases at lower latitudes, particularly for the Croatian island's areas, where velocities greater than 7 [m/s] was found.

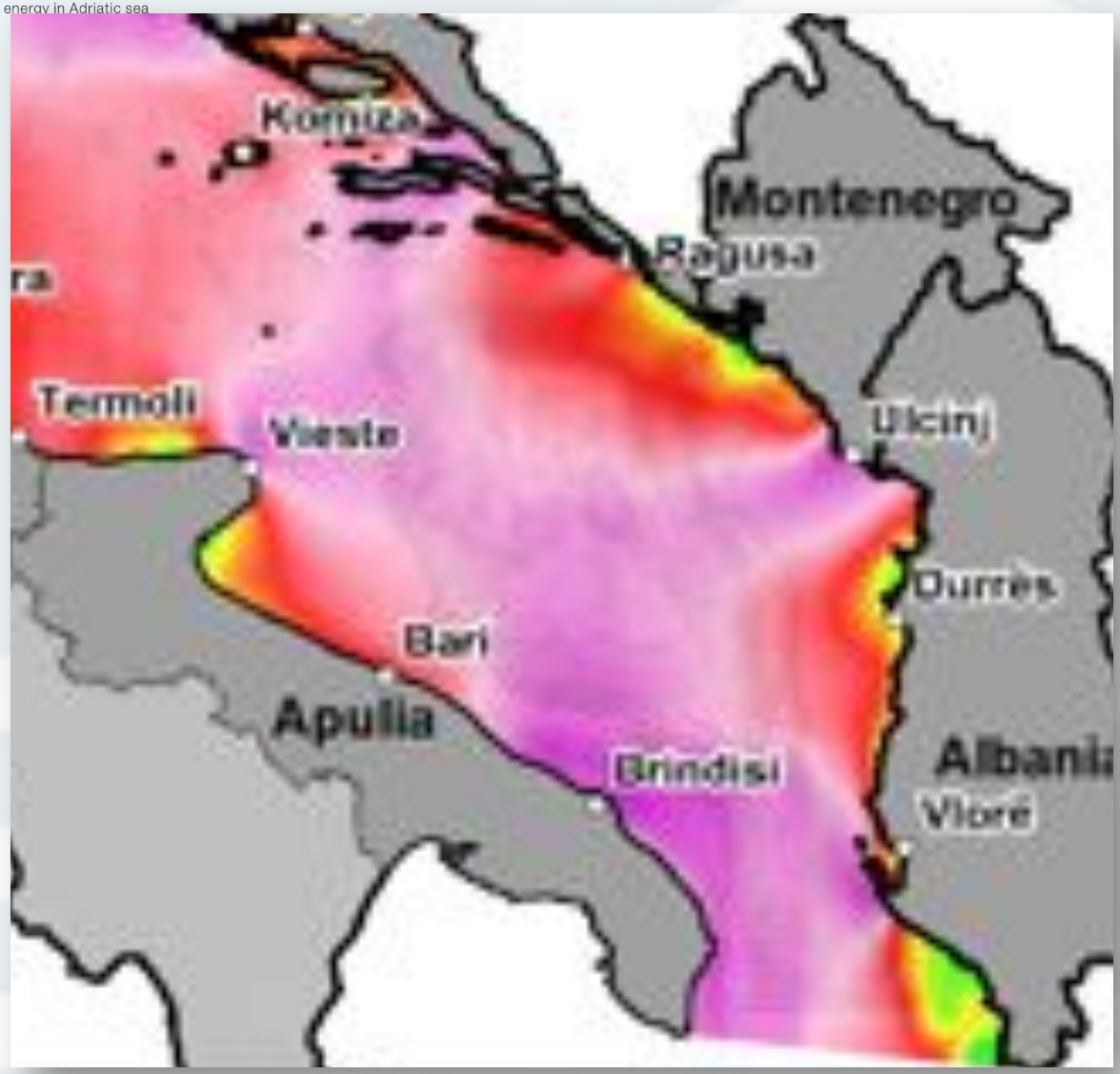
3 KM SIMULATIONS WIND RESULTS - 2008



Year
2008
Height
90 [m] a.s.l.

A wind velocity decrease may be observed for the coastal areas in front of South Marche and North Abruzzo, while an interesting wind speed is revealed in front of Molise coastal line. South Croatian islands also show an interesting average wind speed to be deeper analysed with finer resolutions.

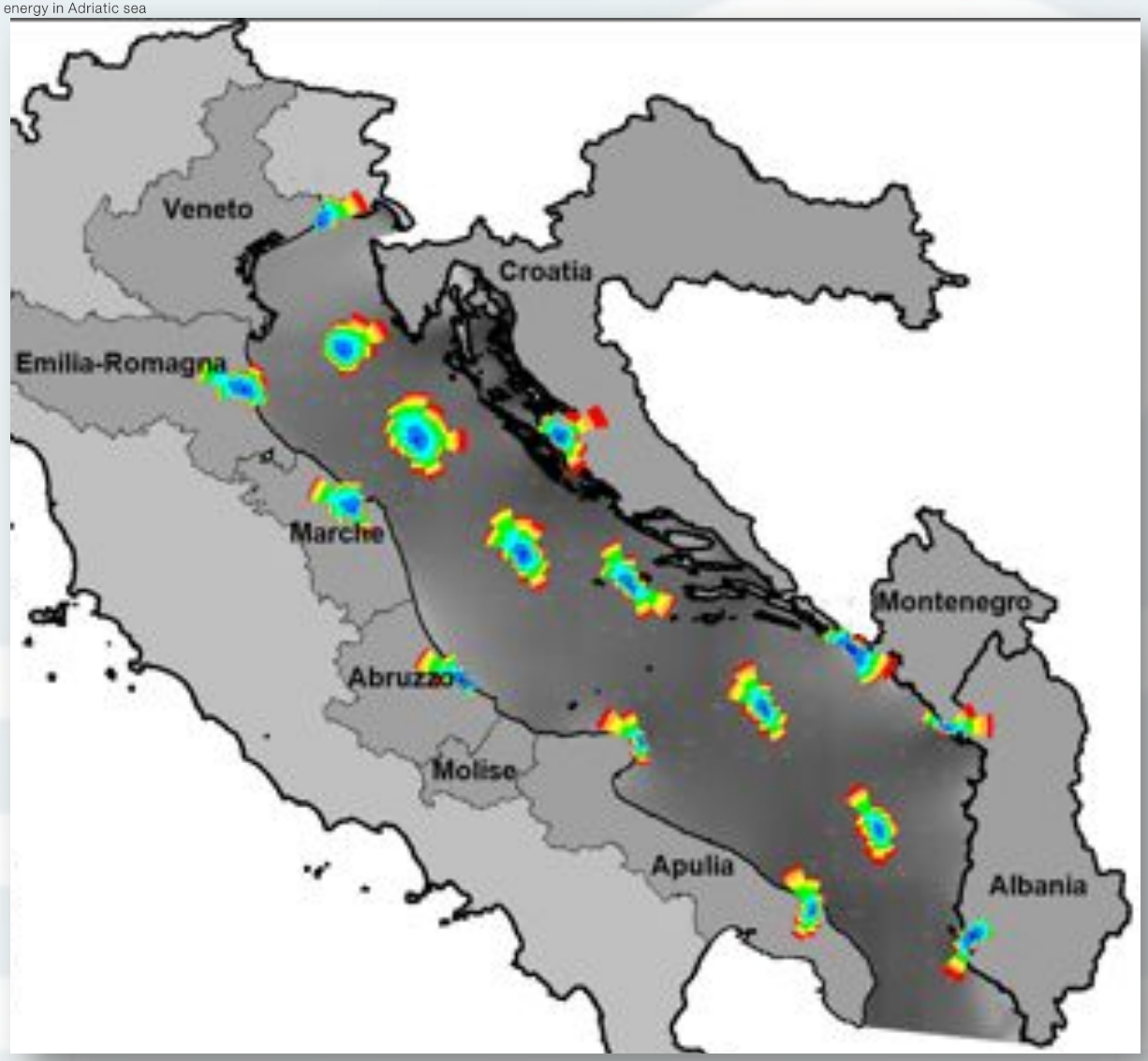
3 KM SIMULATIONS WIND RESULTS - 2008

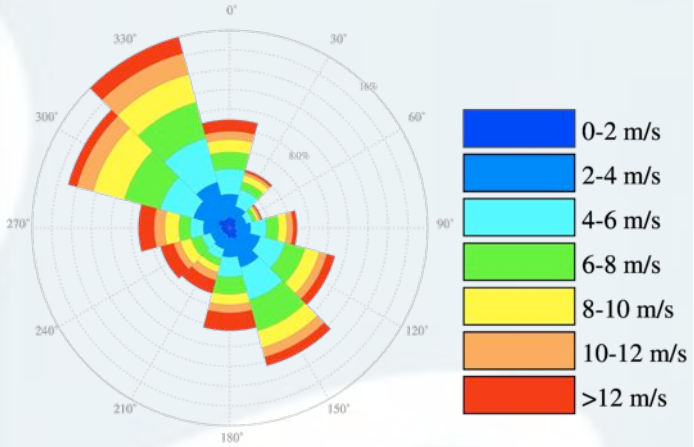


Year
2008
Height
90 [m] a.s.l.

The south part of the Adriatic Basin is doubtless the more interesting area with respect to the average wind speed. Velocities greater than 7 [m/s] may be observed both for Apulia, South Montenegro and North and South Albania .

3 KM SIMULATIONS WIND RESULTS - 2008





Annual wind roses show a NNW-SSE directionality in the south Adriatic Basin while an omnidirectional behaviour may be observed at higher latitudes. Wind roses near coastal line show instead different occurrences due to interactions with the local terrain conformation.

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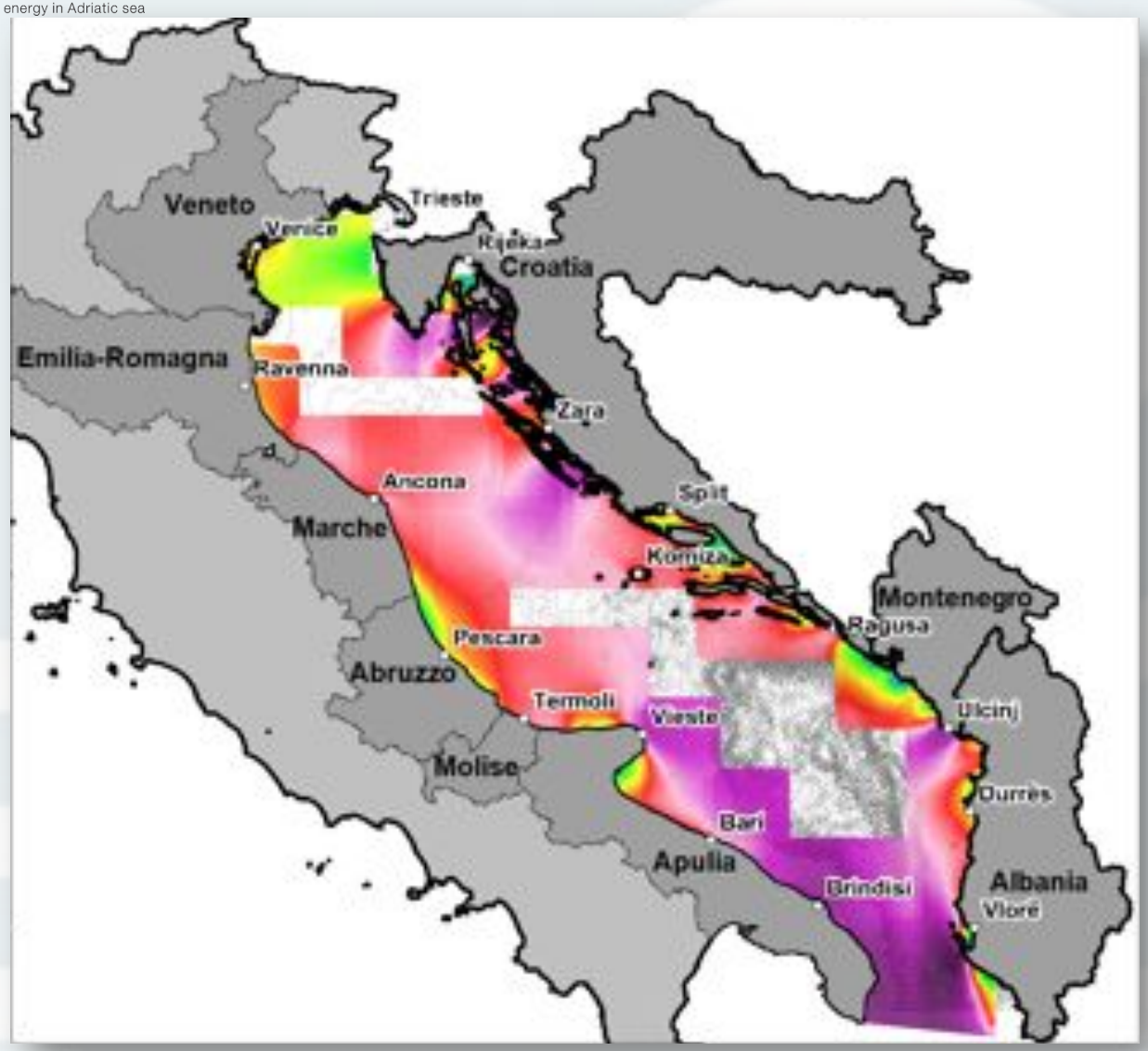
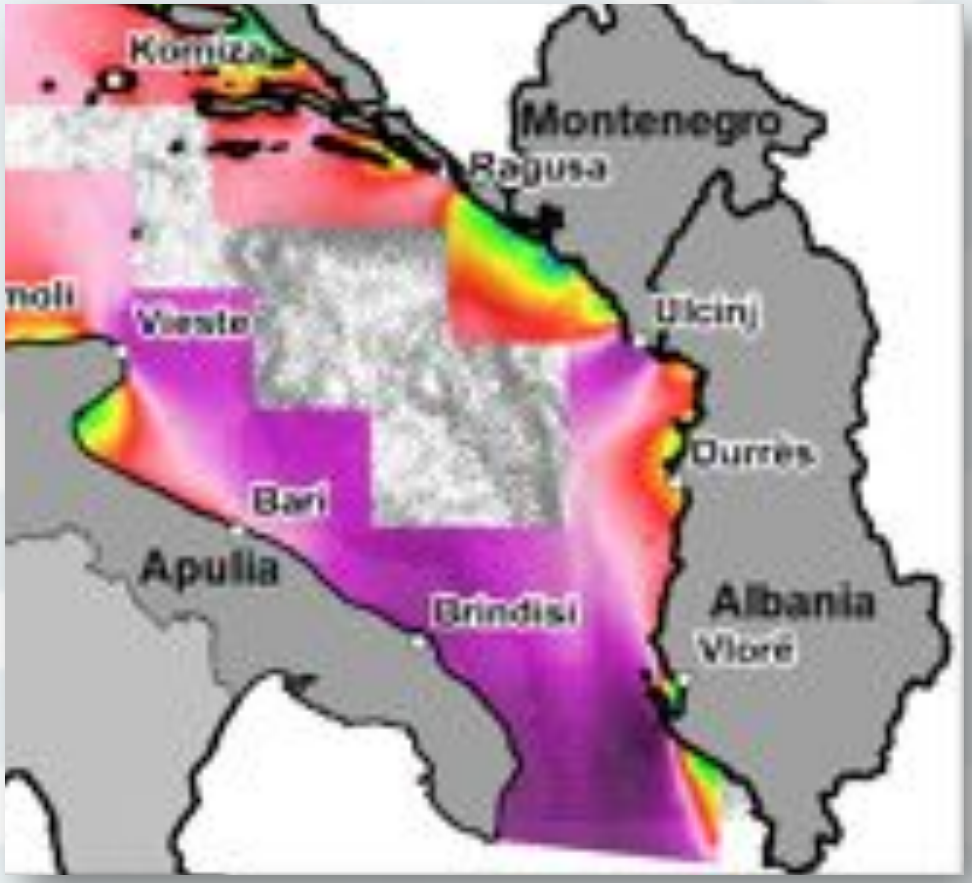
1 KM SIMULATIONS WIND RESULTS - 2010

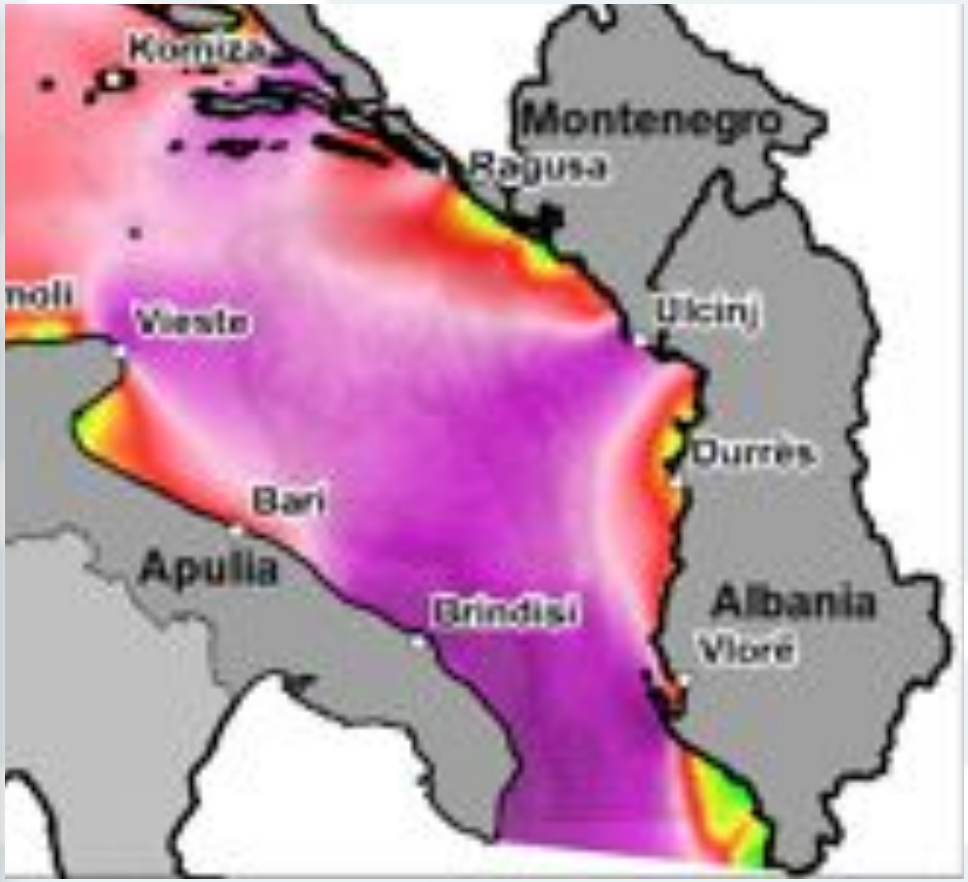


Numerical simulations with an horizontal spatial resolution of 1 [km] show the same trends revealed by the 3 [km] results, although a more detailed definition is observed near coastal lines, especially for islands areas like the ones present in Croatia country.

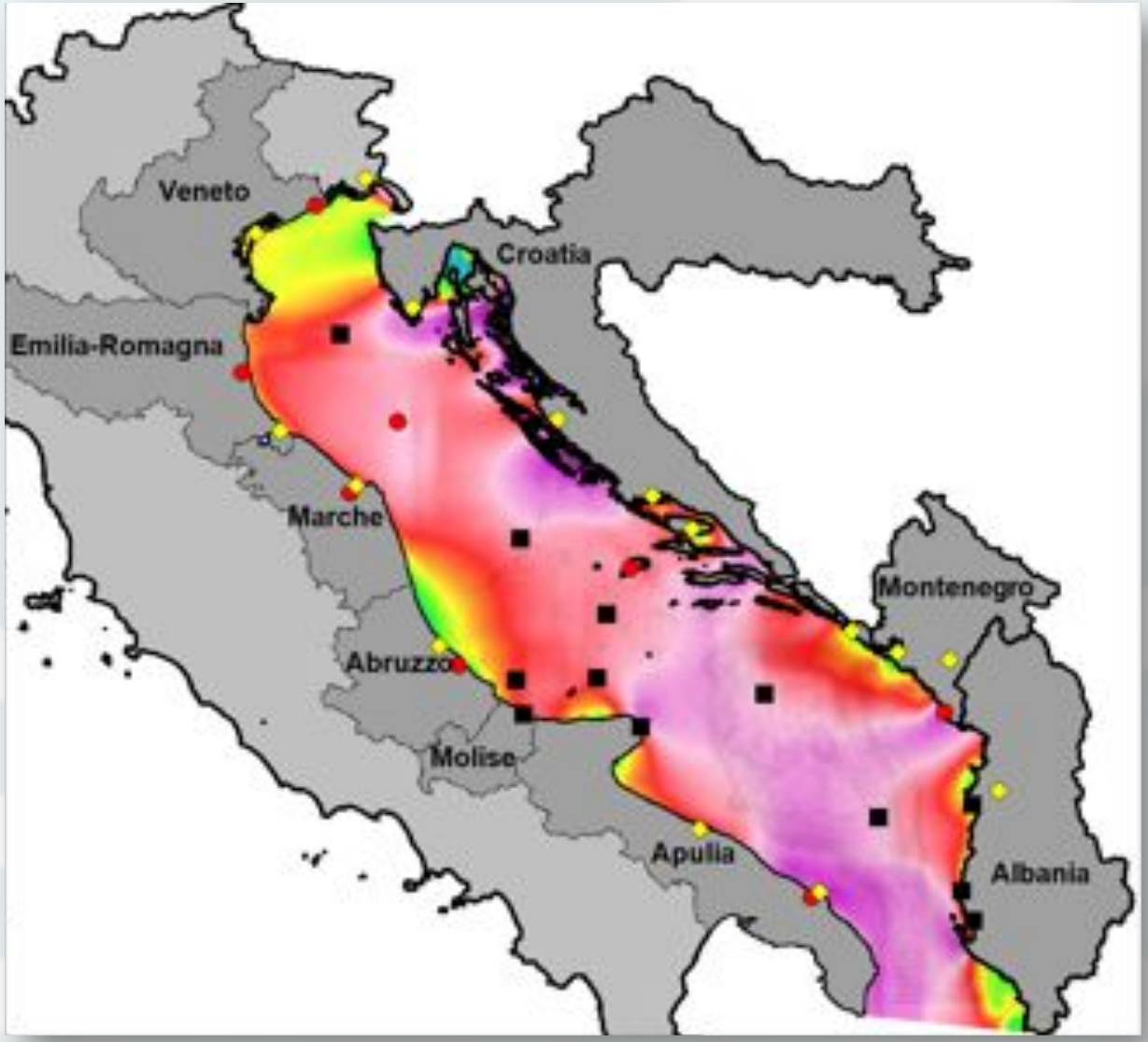
1 KM VS. 3 KM SIMULATIONS WIND RESULTS - 2010

Improving the horizontal resolution up to 1 [km] allow to better define local wind resources expecially with respect to terrain conformation just behind the coastal lines.





VIRTUAL METEO MAST NETWORK

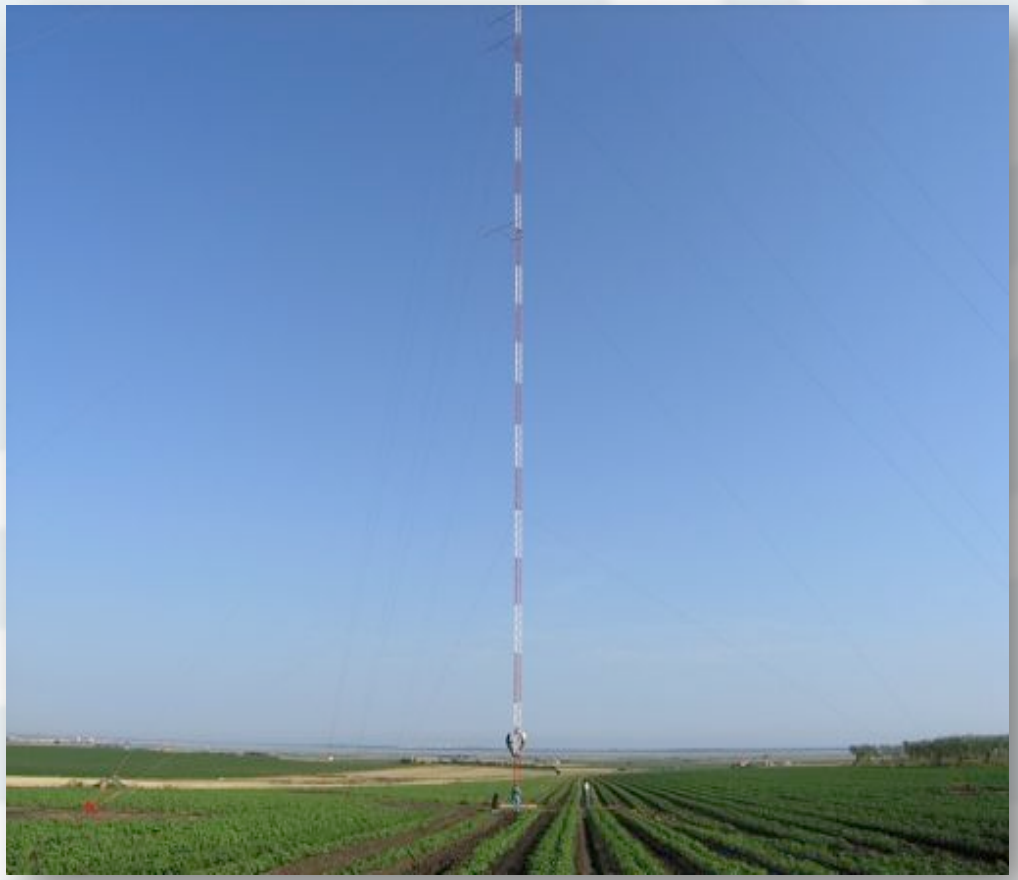


POWERED MAST
SAMPLE MAST
AFIS (*)

Several Virtual Meteo Mast was extracted in significant point over the Adriatic Basin so to analyze in a detailed way the wind behavior. Direct comparisons with experimental data becoming from Powered partners and Powered sponsors was carried out.

ON-SHORE WIND RESULTS COMPARISONS

WPD-Powered Sponsor Mast



Lattice Tower: 100 [m] height
Four Measurement Planes: 40[m], 60[m], 80[m] and 100[m];
Speed Sensors: 4 NRG#40C, 1THIES;
Direction Sensors: 2 NRG#200P

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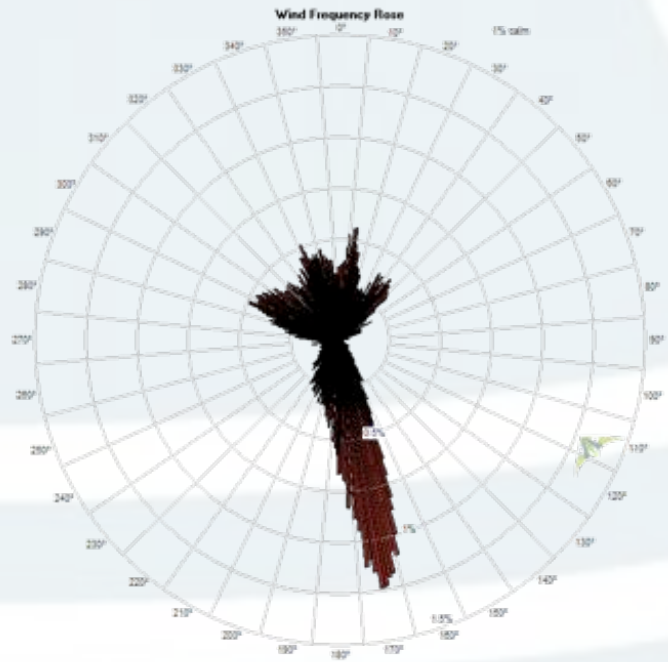
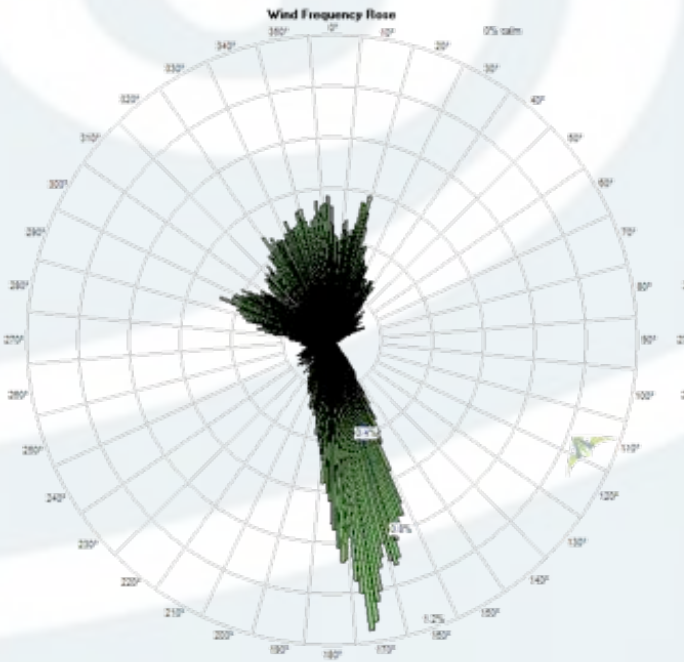
ON-SHORE WIND RESULTS COMPARISONS

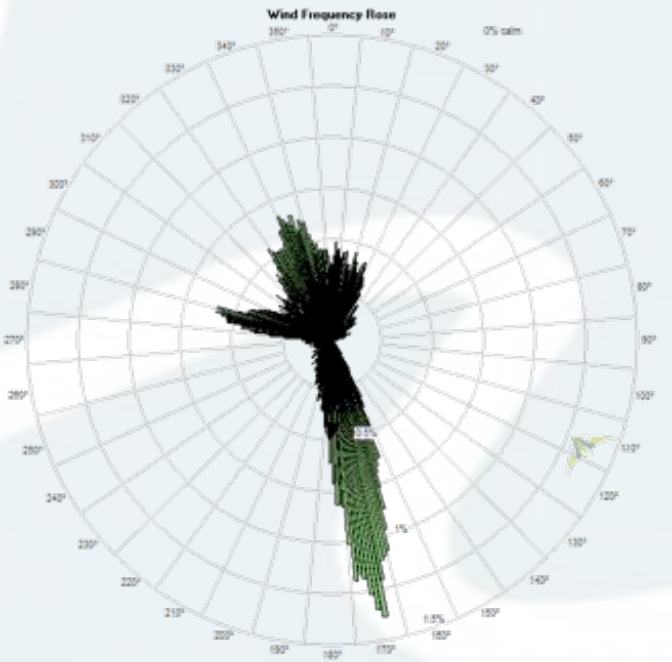
A comparison among experimental results and numerical results, obtained with different horizontal resolutions, show a good agreement with a clear identification of the most relevant wind direction.



Annual Directional Occurrences
Experimental Results
Wind Rose @ 58 [m]



Annual Directional Occurrences
P3 Numerical Results
Wind Rose @ 51 [m]



Annual Directional Occurrences
P1 Numerical Results
Wind Rose @ 51 [m]

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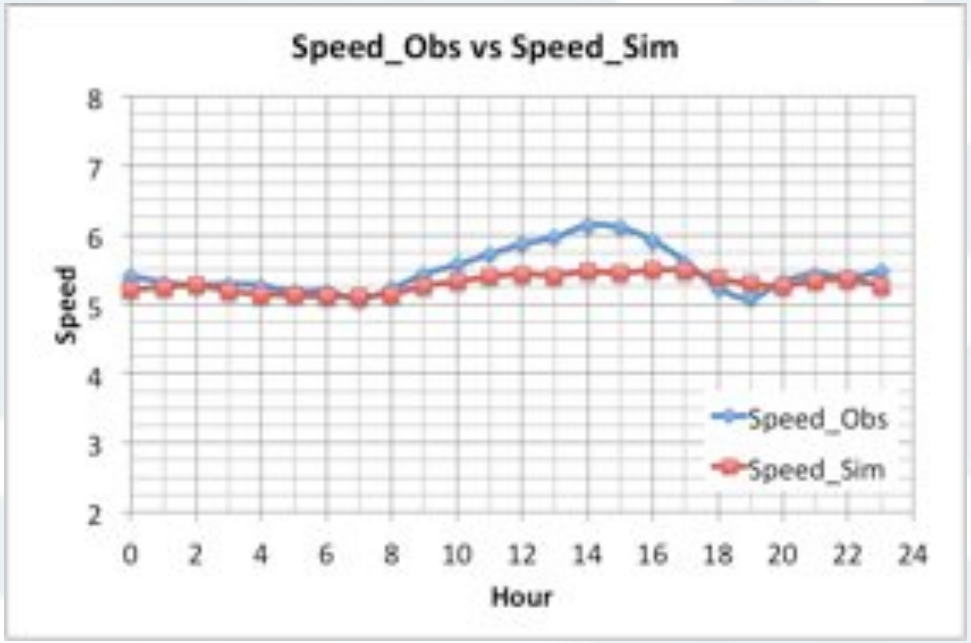
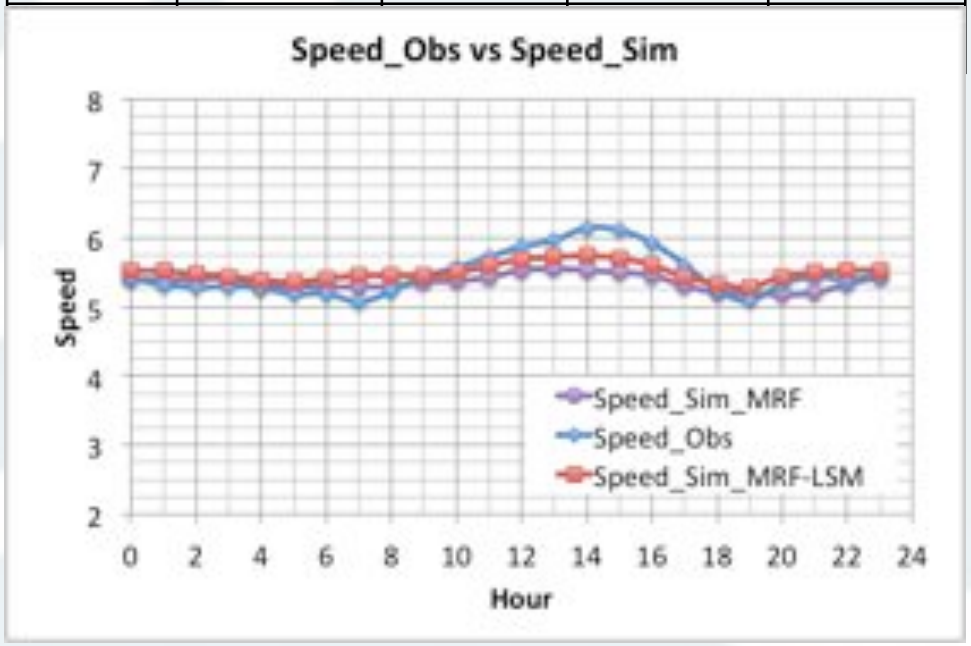
ON-SHORE WIND RESULTS COMPARISONS

<Vobs>	<Vsim>	Bias	Bias%	Bias°
5.48	5.30	-0.18	-3.29%	10.66



Annual Mean Diurnal – Exp. Vs. P3
Wind Speed Profile @ 40 [m]

<Vobs>	<Vsim>	Bias	Bias%	Bias°
5.48	5.36	-0.12	-2.18%	6.87



Annual Mean Diurnal – Exp. Vs. P1
Wind Speed Profile @ 40 [m]

$$Bias\% = \frac{\langle V_{sim} \rangle - \langle V_{obs} \rangle}{\langle V_{obs} \rangle}$$

MRF: Medium Range Forecast;
LSM: Land Surface Model

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ON-SHORE WIND RESULTS COMPARISONS

<Vobs>	<Vsim>	Bias	Bias%	Bias°
5.48	5.30	-0.18	-3.29%	10.66

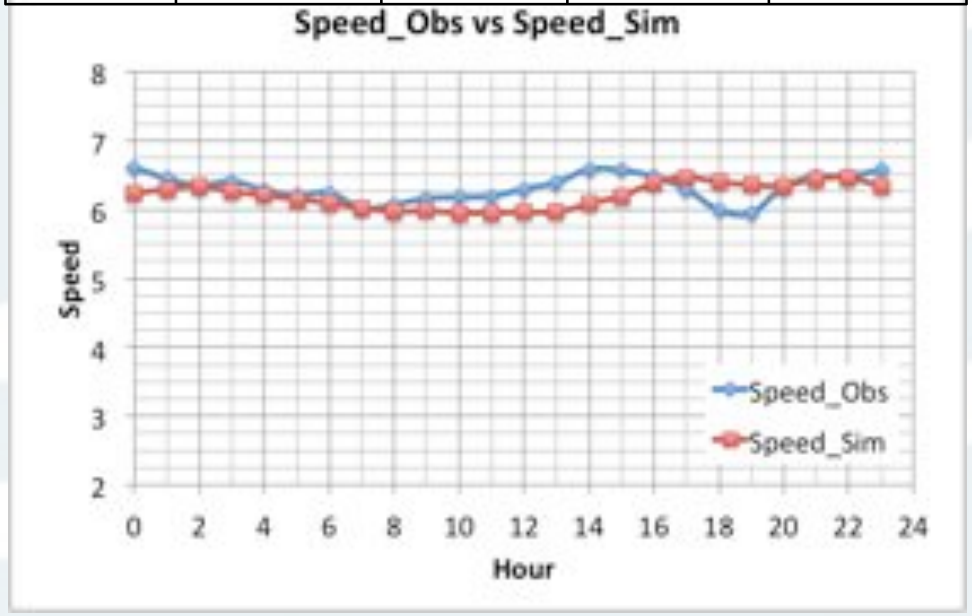
Monthly Mean – Exp. Vs. P3
Wind Speed Profile @ 40 [m]

<Vobs>	<Vsim>	Bias	Bias%	Bias°
5.48	5.36	-0.12	-2.18%	6.87
5.48	5.50	0.02	0.36%	6.88

Monthly Mean – Exp. Vs. P1
Wind Speed Profile @ 40 [m]

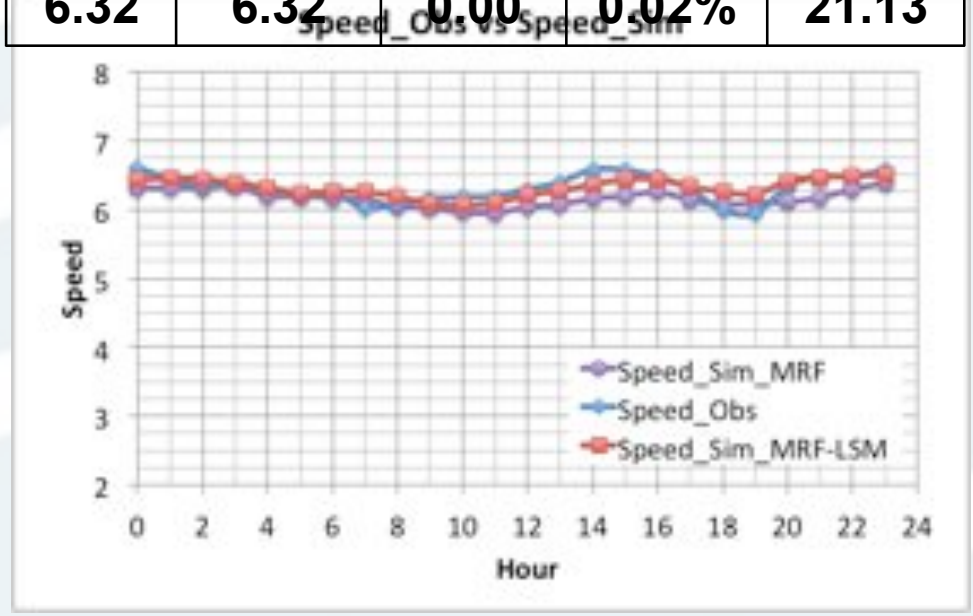
ON-SHORE WIND RESULTS COMPARISONS

<Vobs>	<Vsim>	Bias	Bias%	Bias°
6.32	6.20	-0.11	-1.80%	24.08



Annual Mean Diurnal – Exp. Vs. P3
Wind Speed Profile @ 100 [m]

<Vobs>	<Vsim>	Bias	Bias%	Bias°
6.32	6.16	-0.15	-2.42%	20.85
6.32	6.32	0.00	0.02%	21.13



Annual Mean Diurnal – Exp. Vs. P1
Wind Speed Profile @ 100 [m]

ON-SHORE WIND RESULTS COMPARISONS

<Vobs>	<Vsim>	Bias	Bias%	Bias°
6.32	6.20	-0.11	-1.80%	24.08

Monthly Mean – Exp. Vs. P3
Wind Speed Profile @ 100 [m]

<Vobs>	<Vsim>	Bias	Bias%	Bias°
6.32	6.16	-0.15	-2.42%	20.85
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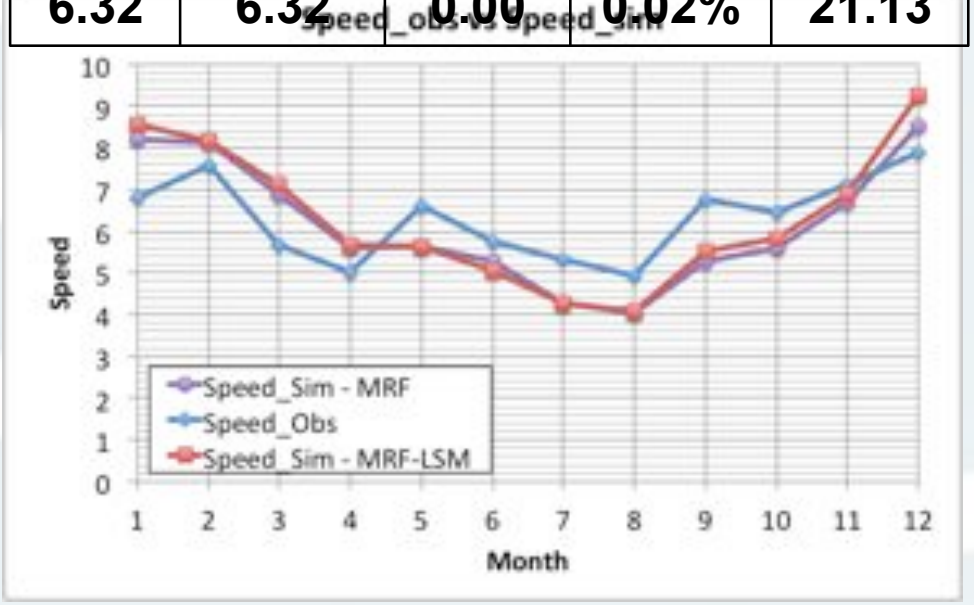
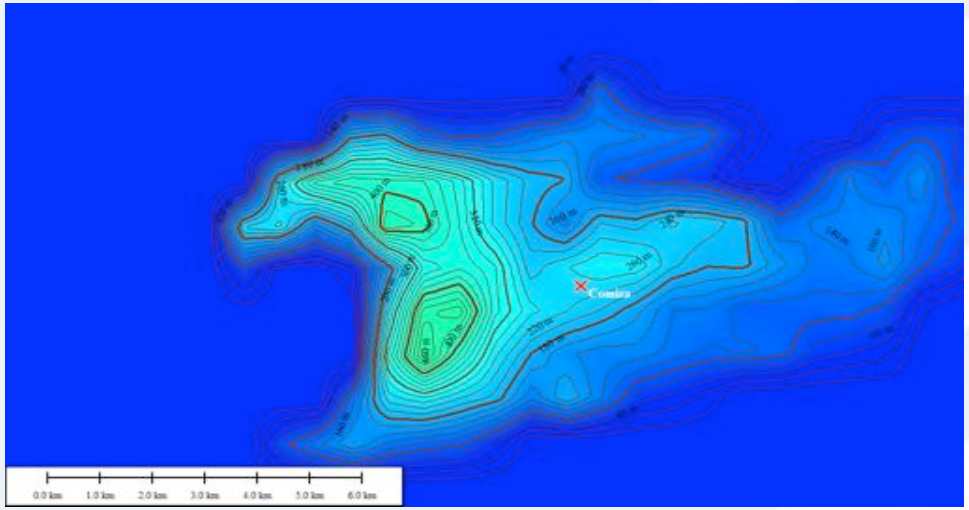
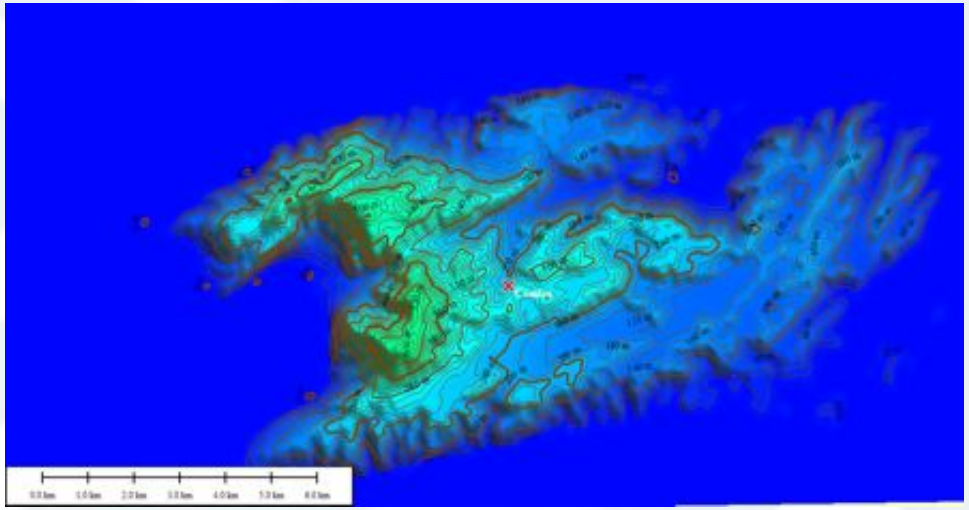


Monthly Mean – Exp. Vs. P1
Wind Speed Profile @ 100 [m]

COMPLEX AREAS WIND ASSESSMENT

Horizontal Terrain Grid Resolution:



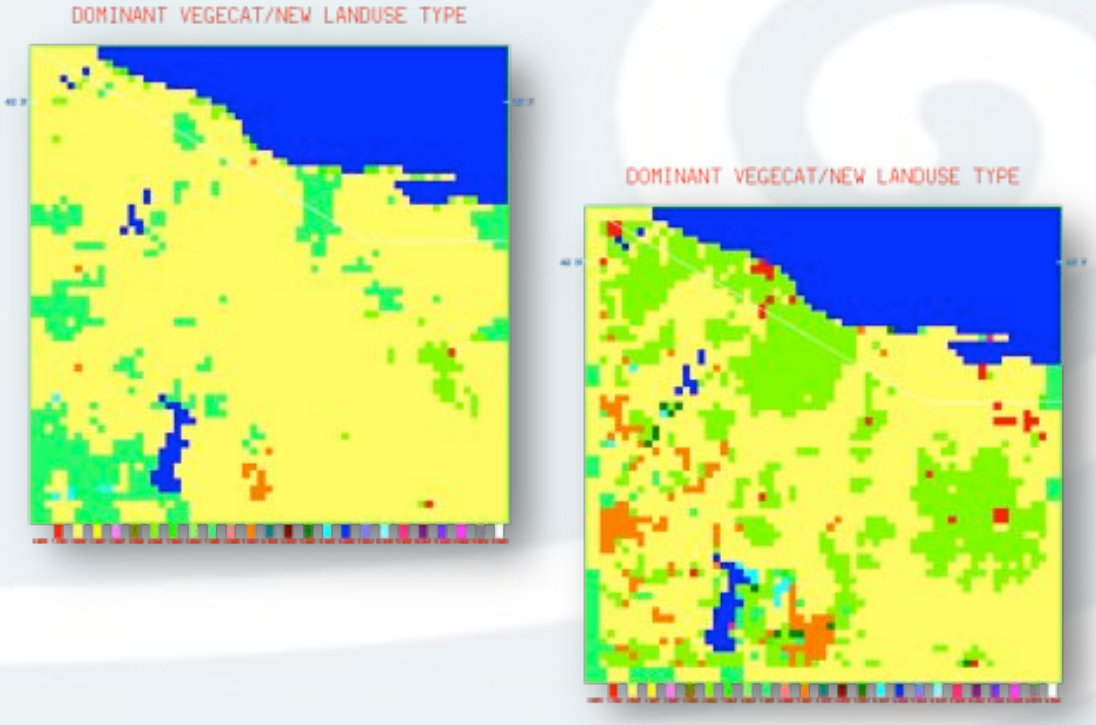


By improving the grid resolution up to about 200 m is possible to better describe both effects of very complex terrains and also areas devoted to mini wind turbines as city ports. Figures reports an example of very complex terrain for the island of Komiza, one of the project partner, that is correctly described only improving the terrain resolution.

In order to use this very high resolution in the MM5 mesoscale model, was rewritten its TERRAIN module so to be able to ingest SRTM 3'' (~ 90m) data. This new version was just tested in very complex terrain areas.

COMPLEX AREAS WIND ASSESSMENT

Horizontal Land Use Grid Resolution:



Another approach to better describe the surface boundary layer energy exchanges and the wind-land interactions is to improve the land use resolution by using the Corine database (100m step size); in this way it is possible to better describe the terrain roughness, that directly modify the wind speed profile, but also the soil categories that influence the energy exchange between terrain and lower part of the boundary layer. In order to use this new database in the MM5 mesoscale model, was rewritten another section of the TERRAIN module. For an area as the Marina di Ravenna Port, it is very important to describe the land use categories for the 5th (200m step size) and 4th (600 m step size) domains but it is also necessary to finely describe the coast lines with an accurate terrain resolution.

NEAR-SHORE WIND ASSESSMENT – RAVENNA PORT

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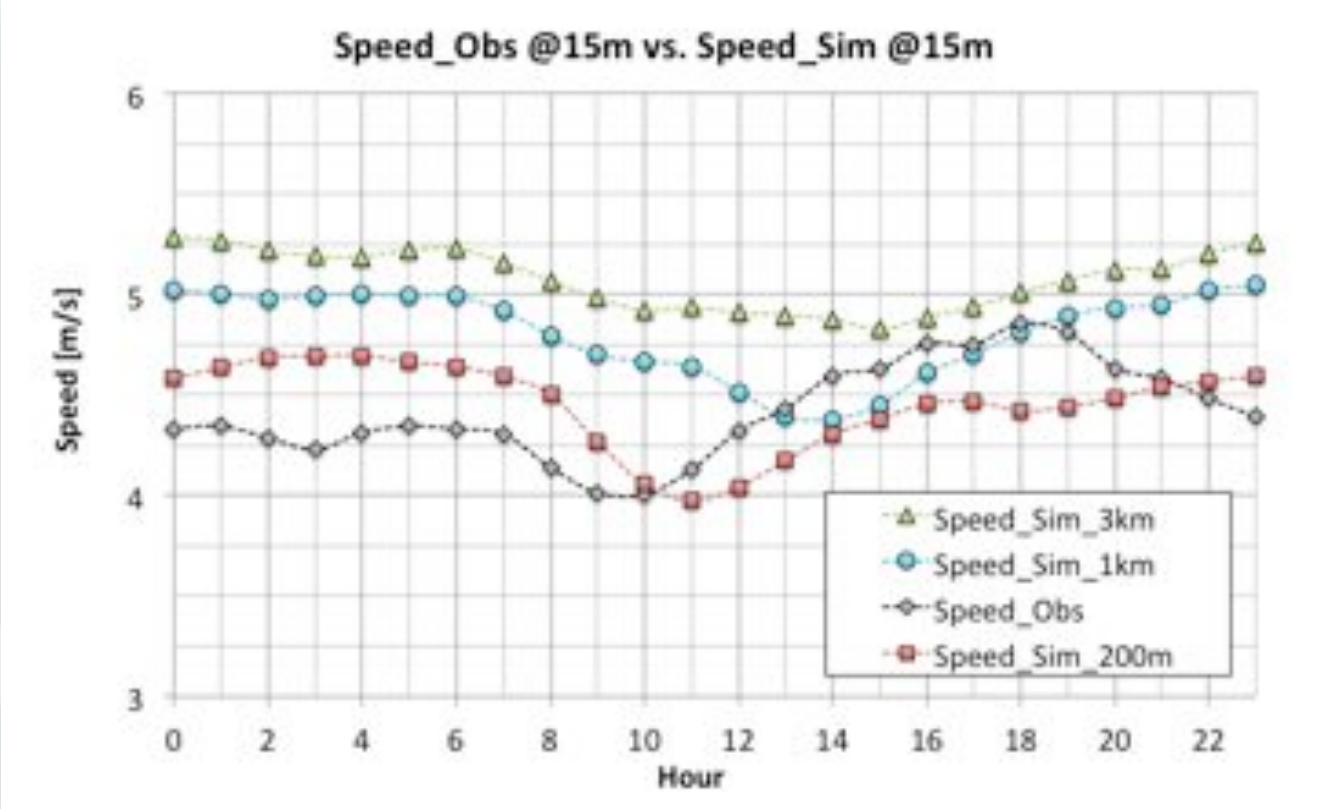
$$Bias\% = \frac{\langle VV_{simobs} \rangle 2 \langle \quad \rangle}{\langle V_{obs} \rangle}$$



	MM5 PBL-BK Res. 200m			MM5 PBL-MRF Res. 1km			MM5 PBL-MRF Res. 3km		
<Vobs>	<Vsim>	Bias	Bias%	<Vsim>	Bias	Bias%	<Vsim>	Bias	Bias%
4.42	4.45	0.04	0.80%	4.81	0.39	8.71%	5.07	0.65	14.72%

By increasing the MM5 horizontal terrain resolution it is possible to better describe the speed increase typical of the middle hours of the day. By combining the resolution increase with a PBL scheme that offer greater abilities to simulate these phenomena, is possible to follow in a more realistic way the real wind speed trend.

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POWERED METEOROLOGICAL NETWORK

SHORT PERIOD FORECASTING (IN PROGRESS)

FDDA TECHNIQUE (FOUR DIMENSION DATA ASSIMILATION)

USING LOGGED DATA FROM THE P.O.W.E.R.E.D METEOROLOGICAL NETWORK ON MM5 MODEL

GFS (Global Forecasting System) meteo data processed by REGRID

Observational Data from the POWERED meteorological network

MM5 short–term forecasting on mesoscale area. Coarse Domain area (2400x2400 km²)

Useful monitoring the crossing of meteorological fronts on Adriatic Basin

GFS (Global Forecasting System) meteo data processed by REGRID

Observational Data from a POWERED single tower . High time resolution.

Microscale reosolution MM5 forecast. Coarse Domain area(1000x1000 km²)

Useful monitoring the area of interest near the weather station

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ARTIFICIAL NEURAL NETWORK SOLUTION

OUTPUT	Implementation of a short – term wind forecasting system

COUPLING THE MM5 METEOROLOGICAL MODEL WITH AN ARTIFICIAL NEURAL NETWORK (ANN) BASED APPROACH: AN HIBRYD SYSTEM FOR SHORT – TERM WIND FORECASTS

- DEVELOPMENT OF AN HYBRID APPROACH FOR SHORT TERM WIND FORECASTING

FULLY AUTOMATED SYSTEM

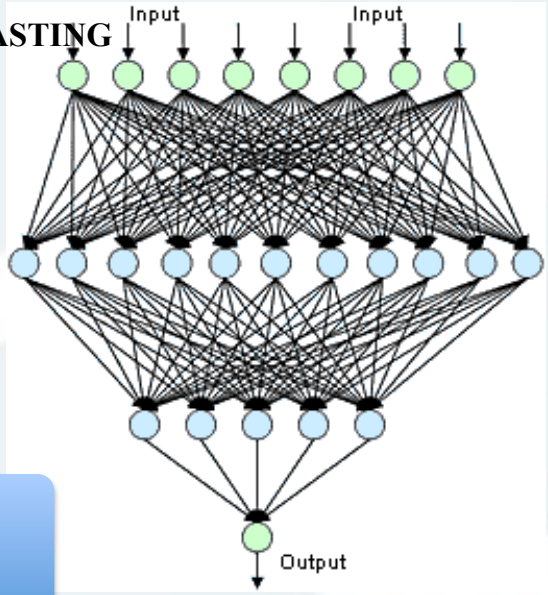
GFS (Global Forecasting System) meteo data download

MM5 short – term forecasting (24 – 48 h)

MM5 forecast post – processing

ANN forecast correction (P.O.W.E.R.E.D. anemometric network)

Sketch of an ANN



CORRECTION OF MM5 NATIVE FORECAST BY MEANS OF A PREVIOUSLY TRAINED ANN: DELIVERING OF THE FINAL SHORT-TERM WIND FORECAST.