Wind-Wave energy potential over the Greek seas

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Abstract

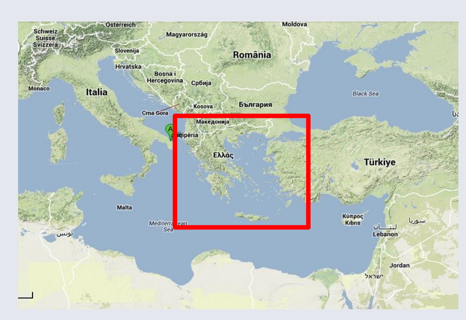
The **renewable energy resources** are on the top of environmental issues. More specifically, wind and wave energy seems to be promising solutions for coastal and island countries, like *Greece*.

In this study, results of a project in which an integrated, high resolution system is developed for quantifying and monitoring the energy potential from wind and sea waves in the region of Eastern Mediterranean Sea, with special emphasis to the Greek area, are presented.

The models for the estimation of the energy potential, from wind and waves over sea areas, are discussed. Moreover, atmospheric (WRF) and sea wave (WAM) numerical models, used for the simulation of the environmental parameters that directly affect the wind-wave energy potential, will be evaluated. Then, high resolution maps for the coastal and offshore areas of Greece will be produced, in which sea wave and wind climatological characteristics, as well as the relevant distribution of the wave energy potential will be monitoring.

Objectives-area of study

- Develop and employ advanced numerical models and statistical tools
- Allocate the areas of increased interest for wave energy applications around the Greek peninsula



Methods-models

The atmospheric system SKIRON

- SKIRON has been developed at the University of Athens, by the Atmospheric Modeling and Weather Forecasting Group, based on the Eta/NCEP model.
- Is a full physics non-hydrostatic model with sophisticated convective, turbulence and surface energy budget scheme
- Horizontal Resolution 0.05 x 0.05
- 45 vertical levels up to 50hPa
- Initial and boundary conditions: High-resolution reanalysis (15 x 15 Km)

Wave Model WAM

- ECMWF version of WAM model (Komen et al., 1994, Bidlot J. et al., 2007).
- It is a third generation wave model, which computes spectra of random short-crested wind-generated waves.
- It is the first model that solves the complete action density equation, including non-linear wave-wave interactions.
- WAM is mainly used for offshore deep water simulations but the new shallow water scheme of the latest version seems to provide new potential for near-shore modeling too.

WAM setup:

- East Mediterranean (30N – 41N, 15E – 37E)
- Horizontal Resolution: 0.05x0.05 degrees
- Spectrum discretization 25 frequencies x 24 directions

The available (theoretical) potential for Wind Energy Power is estimated as

$$P_{wi} = \frac{1}{2}\rho v^3 \quad [W]$$

where ρ stands for the air density and v for the wind speed.

The Wave Energy Power density potential for the area of study is estimated by

$$P_w = pg\int_0^{2\pi}\int_0^{\infty} f^{-1}E(f,\theta)dfd\theta = \frac{pg^2}{64\pi}\mathrm{H}_s^2 T_e \qquad [W/m]$$

where
$E(f,\theta)$ is the 2-dimensional wave spectrum,
H_s the significant wave height and
Te the mean energy wave period.

Statistical tools:

The following statistical indices have been used for the analysis of the modelled data of power and environmental parameters obtained in the framework of the two projects

- Mean Value: $\mu = \frac{1}{N}\sum_{i=1}^{N} x(i)$, N denoting the sample size
- Standard deviation: $\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(x(i)-\mu\right)^2}$, a typical variation index
- Kurtosis: $g_2 = \dfrac{\frac{1}{N}\sum_{i=1}^{N}\left(x(i)-\mu\right)^4}{\sigma^4} - 3$, the fourth moment of the data under study, that gives a measure of the "peakedness" of the probability distribution and the impact of possible extreme values.

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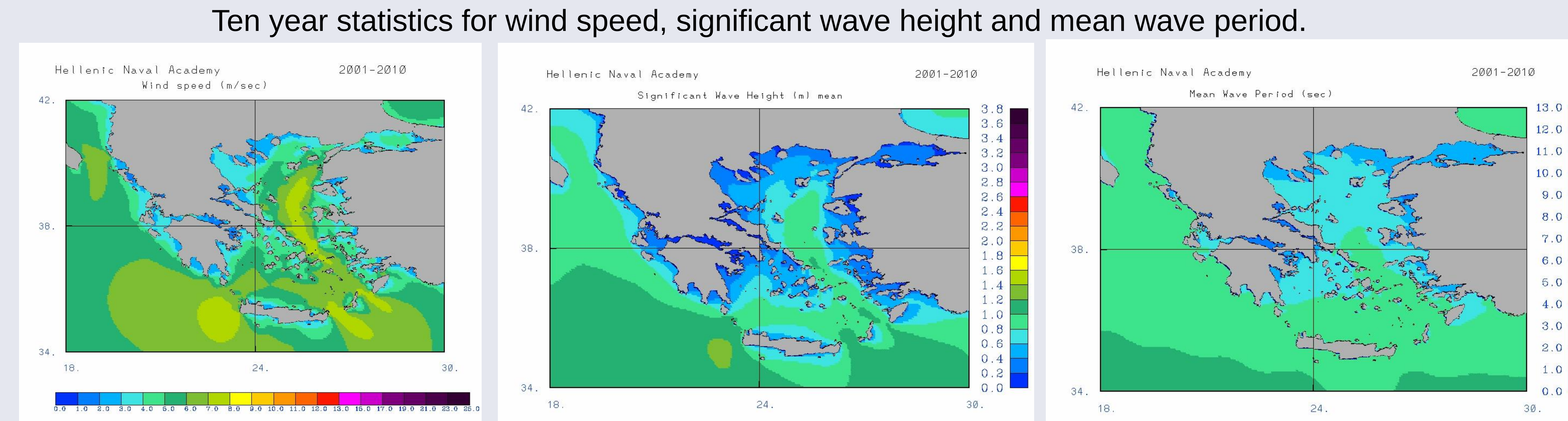
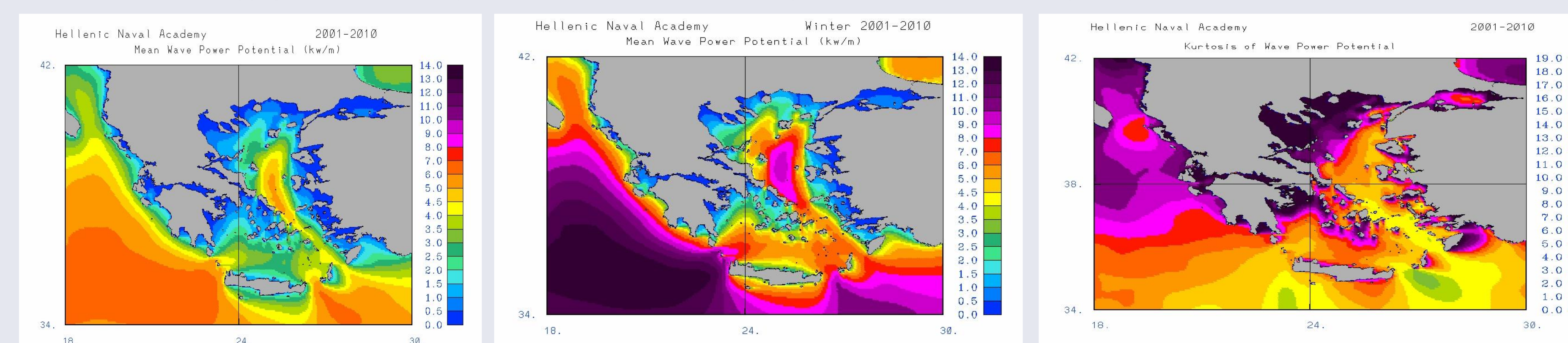
Results

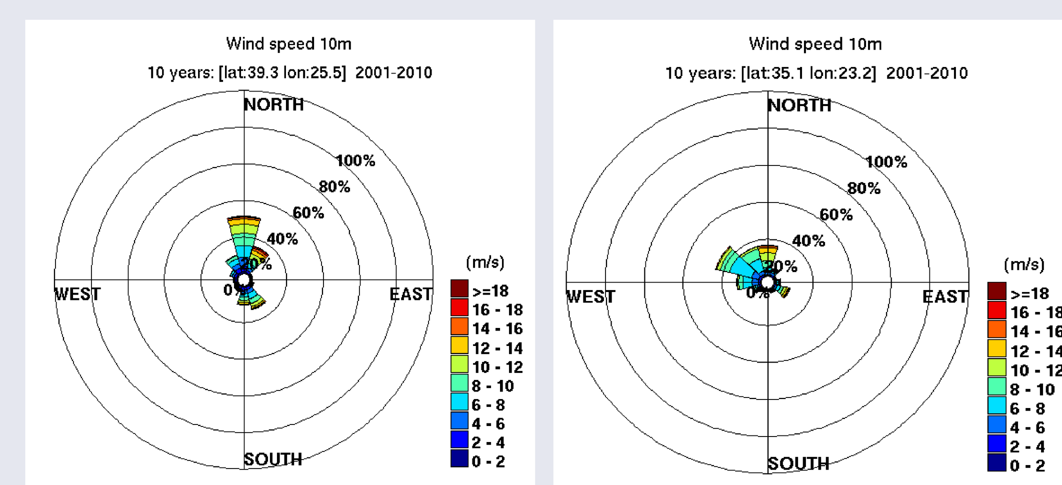
Ten year statistics for wind speed, significant wave height and mean wave period.



Wave energy potential: ten year mean, winter of ten years mean and ten year kurtosis.



Wind roses for two points over north and southwest Aegean Sea

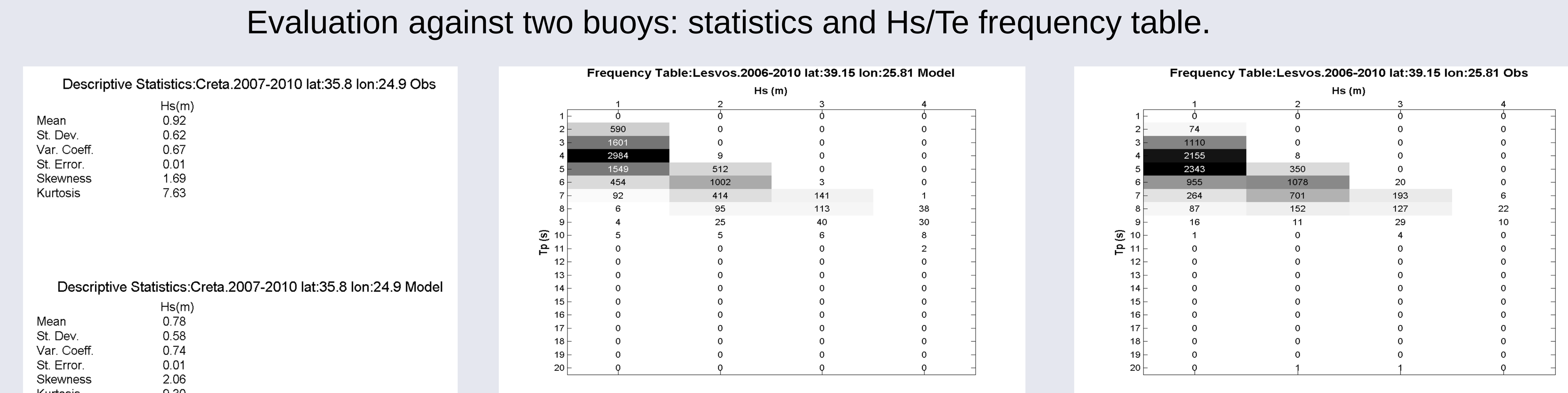


Comments:

1. Wind intensity is maximizing in a tunnel crossing Aegean Sea from northeast to southeast parts, as well as west and east of Crete.
2. Significant wave height is affected more than the swell part of waves, coming from the central and south Mediterranean Sea.
3. The same reason is affecting the mean wave period.
4. Wave energy potential is showing interesting values up to 7 kW/m in the southwest parts and across the Aegean tunnel mentioned above.
5. Winter time is giving considerable potential, rising to 14 kW/m.

6. But kurtosis map shows the dependence from high values in the northern parts of the study area.

Evaluation against two buoys: statistics and Hs/Te frequency table.



The evaluation was performed against two buoys, one in the north Aegean Sea and the second in the south part of Aegean.

- It shows an underestimation of the significant wave height (swh) in the south part.
- The Hs/Te (swh/mean wave period) frequency tables for the model results and the relevant measurement show very good agreement in the distribution.
- The calculation of the wave energy potential is credible.

Conclusions

The Greek sea area is having interesting points for exploitation of wind and wave energy potential.

- Atmospheric and wave models can simulate accurately the weather conditions in these areas with the proper configuration.
- The primary areas of interest for wind is the Aegean Sea tunnel and the areas west and east of Crete.
- For the wave, primary role is having the swell part, so more availability of energy exists in the southwest parts.
- The wave power potential in these areas is more stable because of the high wave periods prevailing there.
- The dependence on extreme weather events, as well as the distribution of each parameter affects the energy potential should be studied in more detail.
- The relevant technology for the exploitation of the energy potential has to advance in order to minimize the cost of such constructions.

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