Marine Renewable Energy Resources Atlas for Western Iberia

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1 MARETEC - Instituto Superior Técnico - Universidade de Lisboa

2 LAMTec-ID - University of Azores

3 Action Modulers, Consulting and Technology

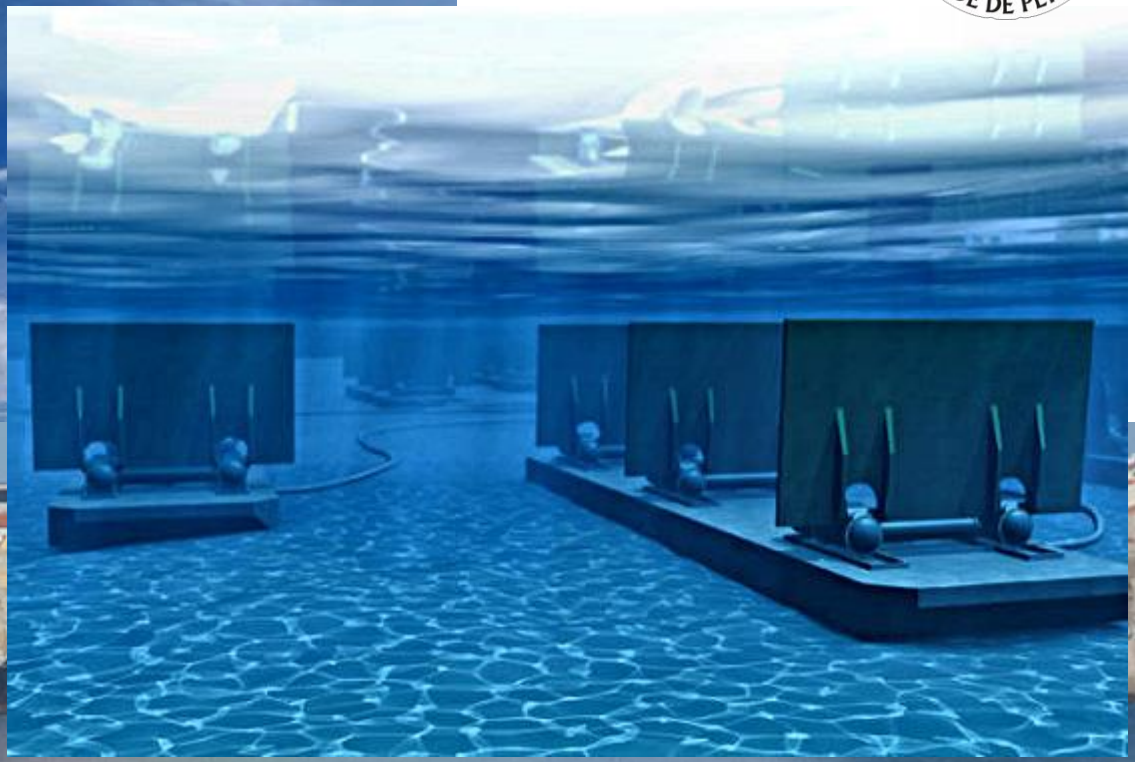
4.as Jornadas de Engenharia Hidrográfica| Lisbon| Portugal| 21, 22 & 23 June 2016

Investing in our common future

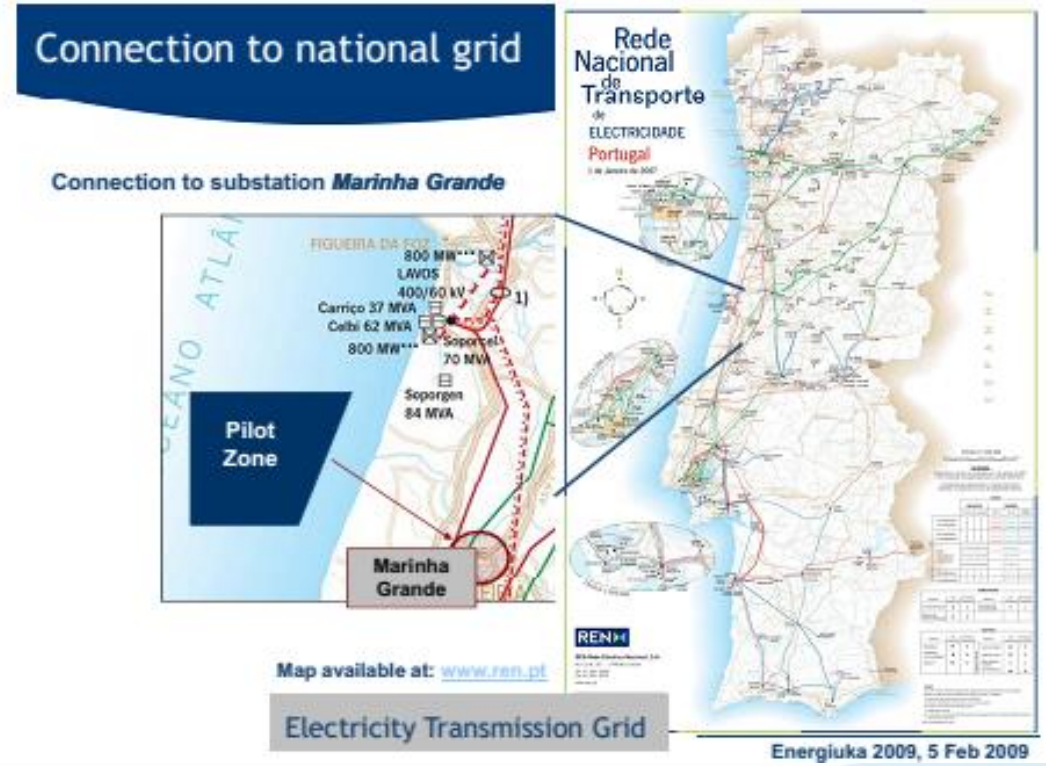
ERDF

City of Nazaré

City of Peniche



Marine renewables in Portugal



ocean plug
portuguese pilot zone

WavEC
Offshore Renewables

ATLANTIC AREA
ESPACIO ATLÁNTICO
ESPACE ATLANTIQUE
ESPAÇO ATLÂNTICO

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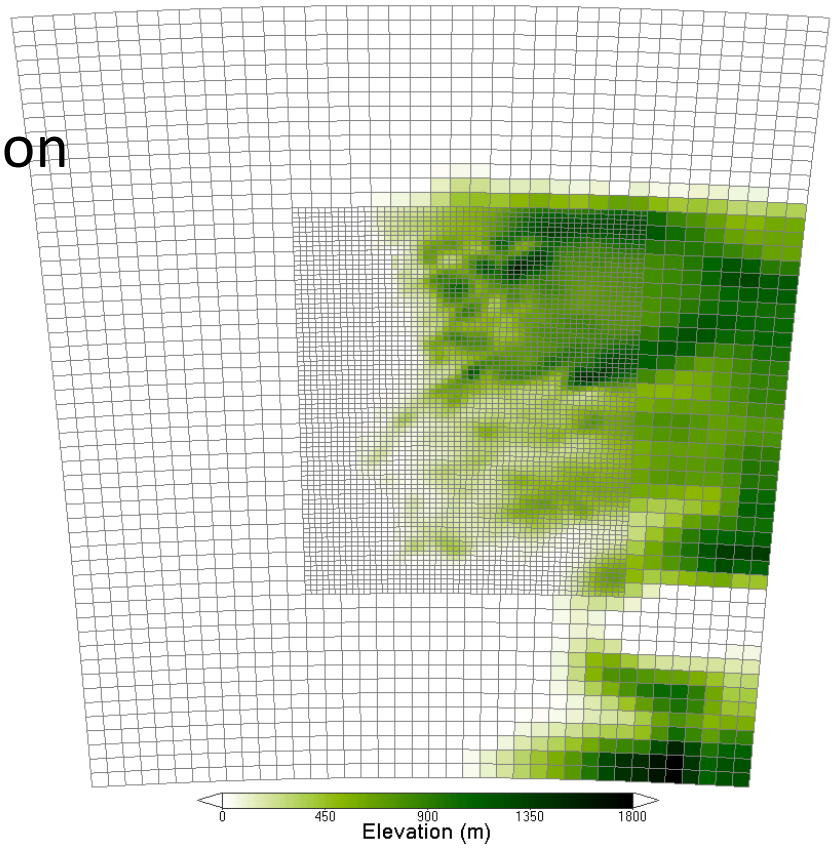
Wind Energy Estimation

- Two domains with horizontal resolution
- of 27 km and 9 km respectively
- Implemented by the MARETEC meteorological group http://meteo.tecnico.ulisboa.pt
- Analysed period: Jun 2009-Jun 2015



Wind Energy conversion

- Wind modulus transposed to 100 m height (hub height):

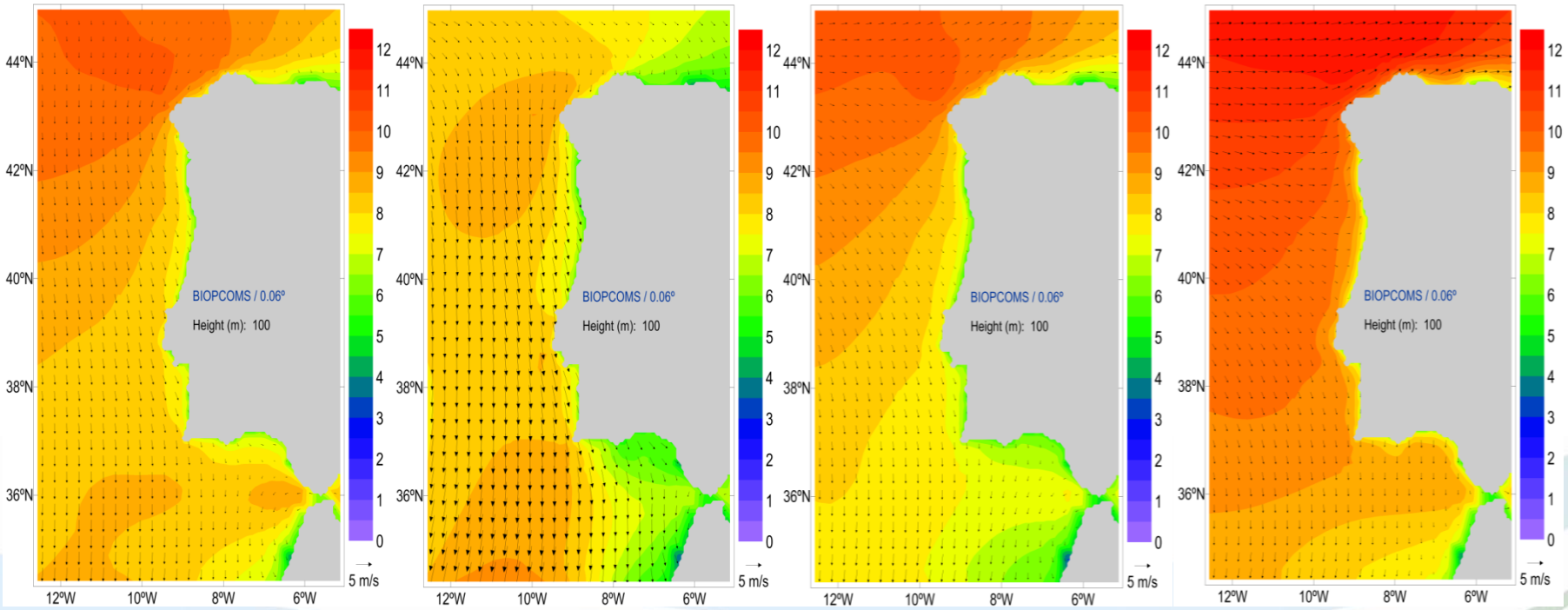
$$u_{100}=u_{10}(100/10)^{0.11}$$

- Power density (P_{wind}) per m^2 of rotor swept area can be obtained by applying the following formula:

$$Pwind= 1/2\rho|U|^3$$

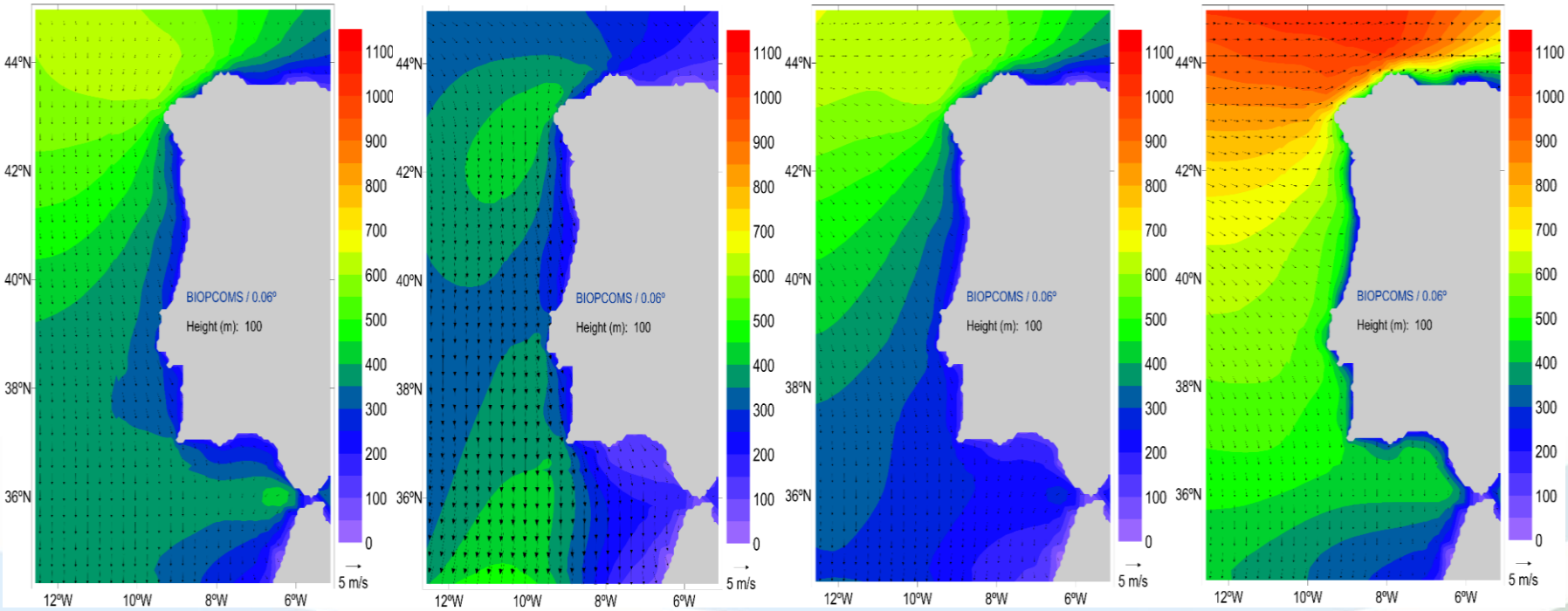
ρ is the air density, 1.225 kg/m^3 , and |U| is the wind speed modulus

Wind Intensity Seasonality at 100 m



SPRING SUMMER AUTUMN WINTER

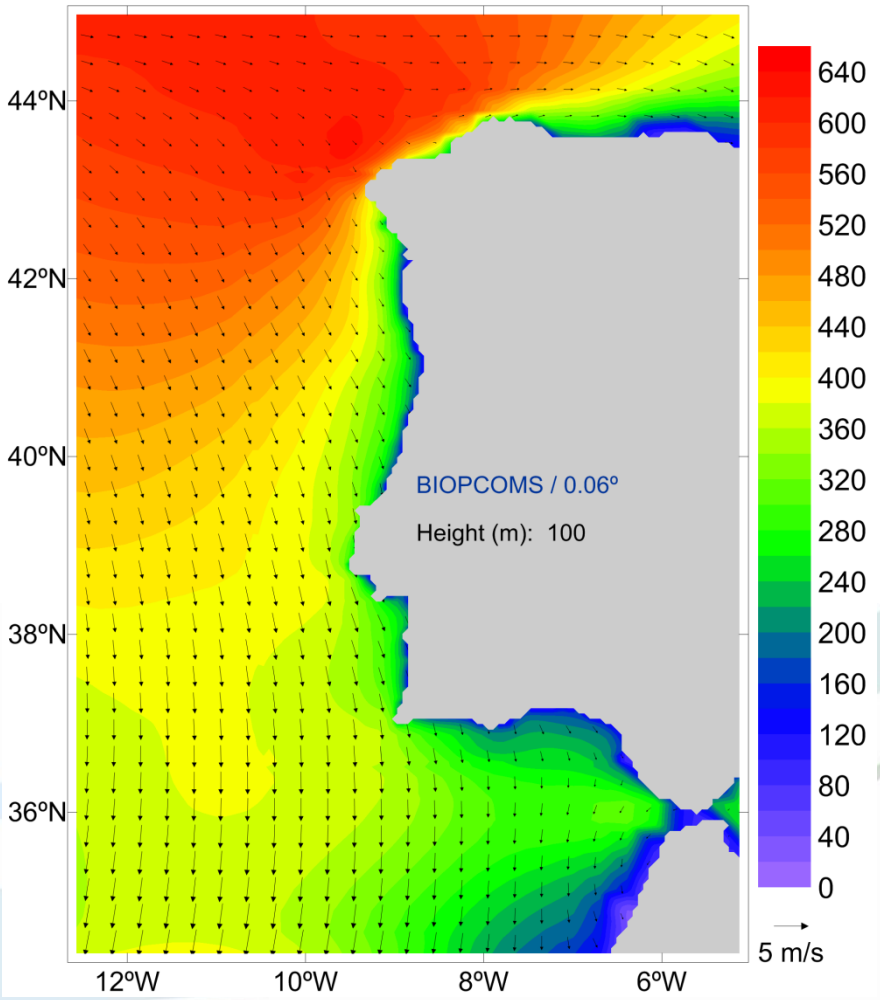
Wind Power Seasonality in Wm^{-2}



SPRING SUMMER AUTUMN WINTER

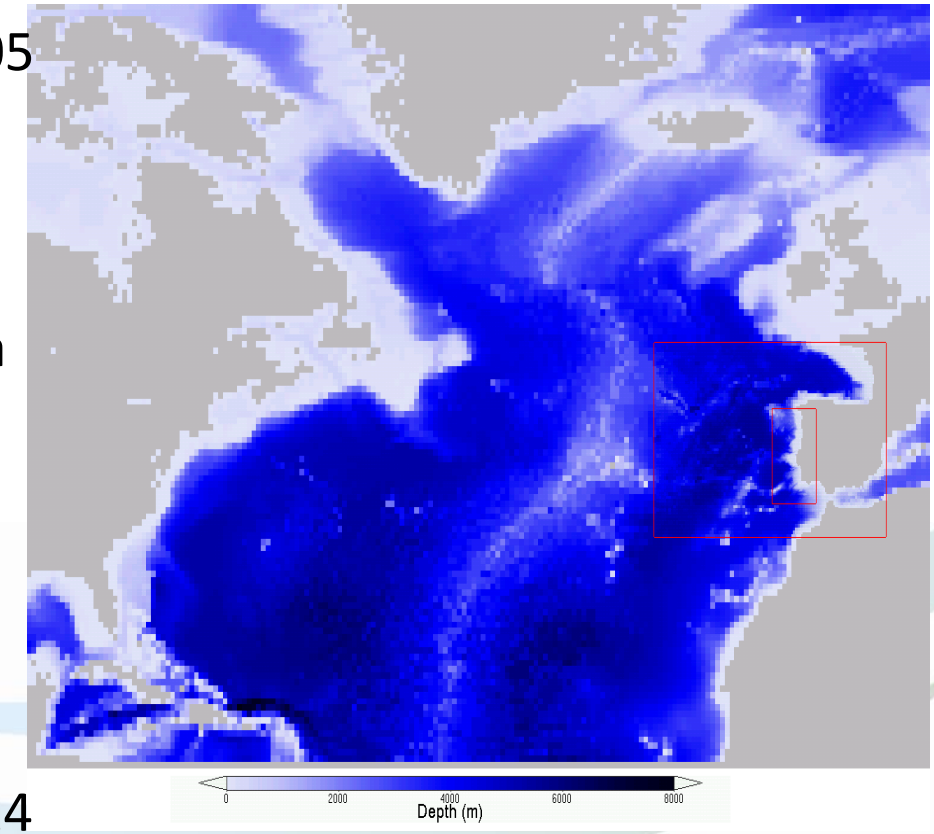
Wind Energy Summary

- Wind power gradient from North to South in Western Iberia
- Maximum values found in the Galicia region in Spain and decreasing landwards.
- In Portugal the resource appears to be relatively constant along its Western coast
- Sheltered coasts in the Algarve region present the lowest values.
- Annual values above 200 Wm^{-2} found relatively close to the western coasts.



Wave Energy Estimation

- 3 nested levels with increasing horizontal resolution 0.5, 0.25 and 0.05 degrees
- Bathymetry from EMODnet Hydrography portal completed by the 30” resolution global bathymetry data SRTM30_PLUS
- Period analysed: 2000-2010
- Forced by NCEP FNL Operational Model Global Tropospheric Analyses with 1 degree of horizontal resolution
- NOAA WAVEWATCH III (R) Model V3.14



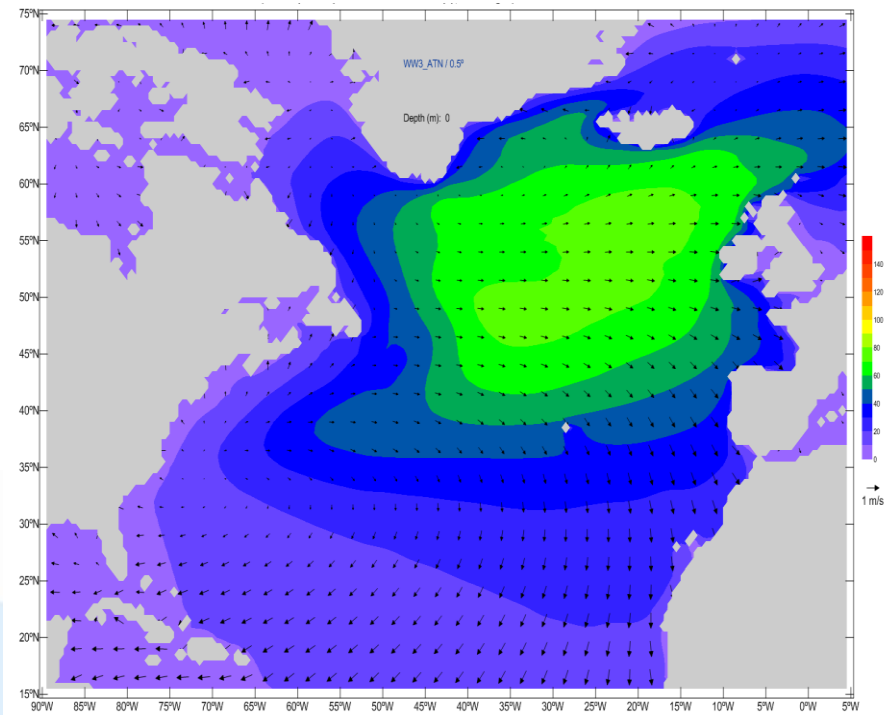
Wave Energy conversion

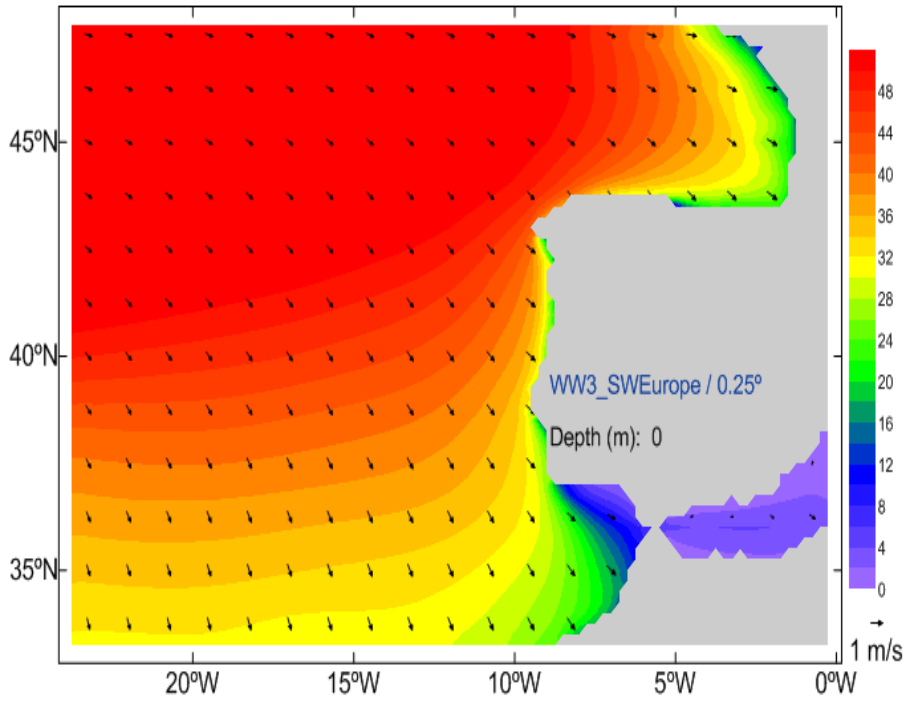
- Wave power (P) was estimated using the formula for deep water, where water depth is larger than half the wavelength:

$$P = 0.49 * Hs^2 * Tm$$

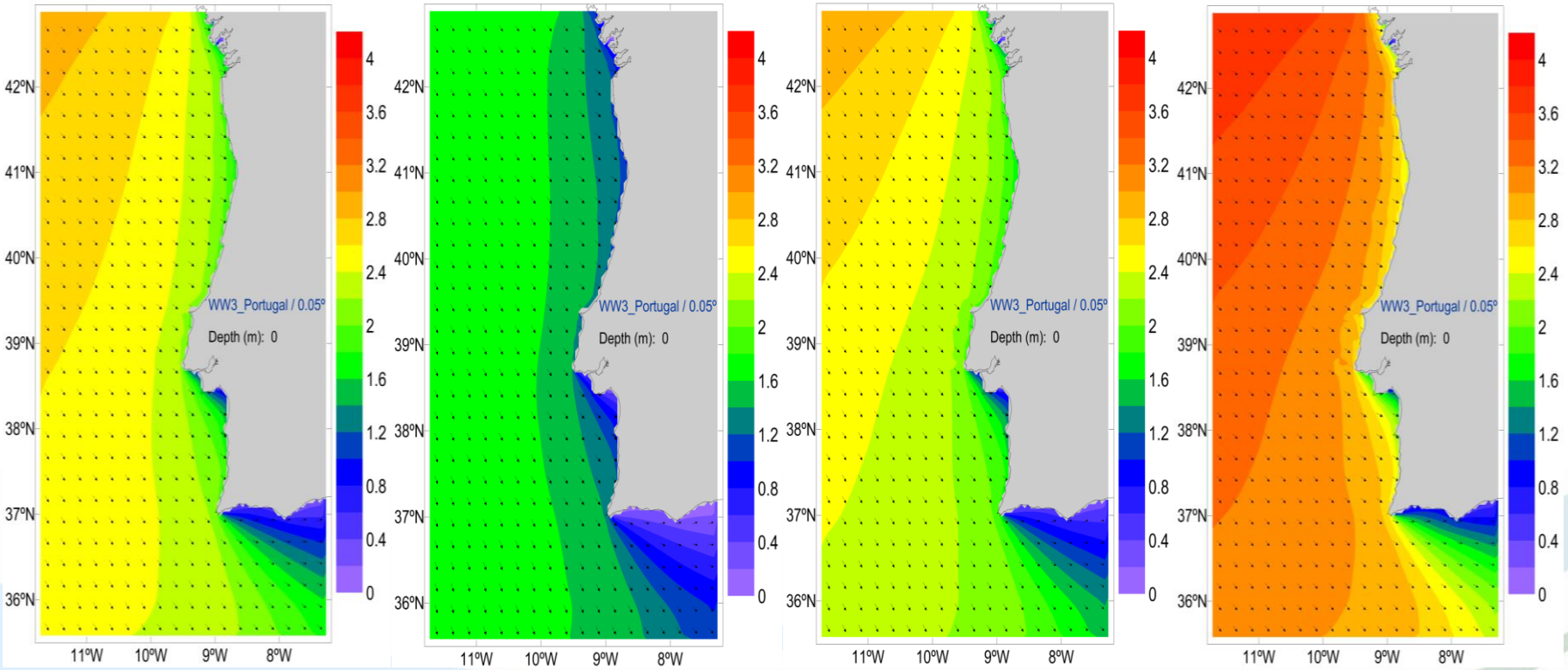
- Hs is the Significant Wave Height and Tm is the wave average period, obtaining kilowatts (kW) per meter of wavefront length.

WW III 10 years average
Wave Power



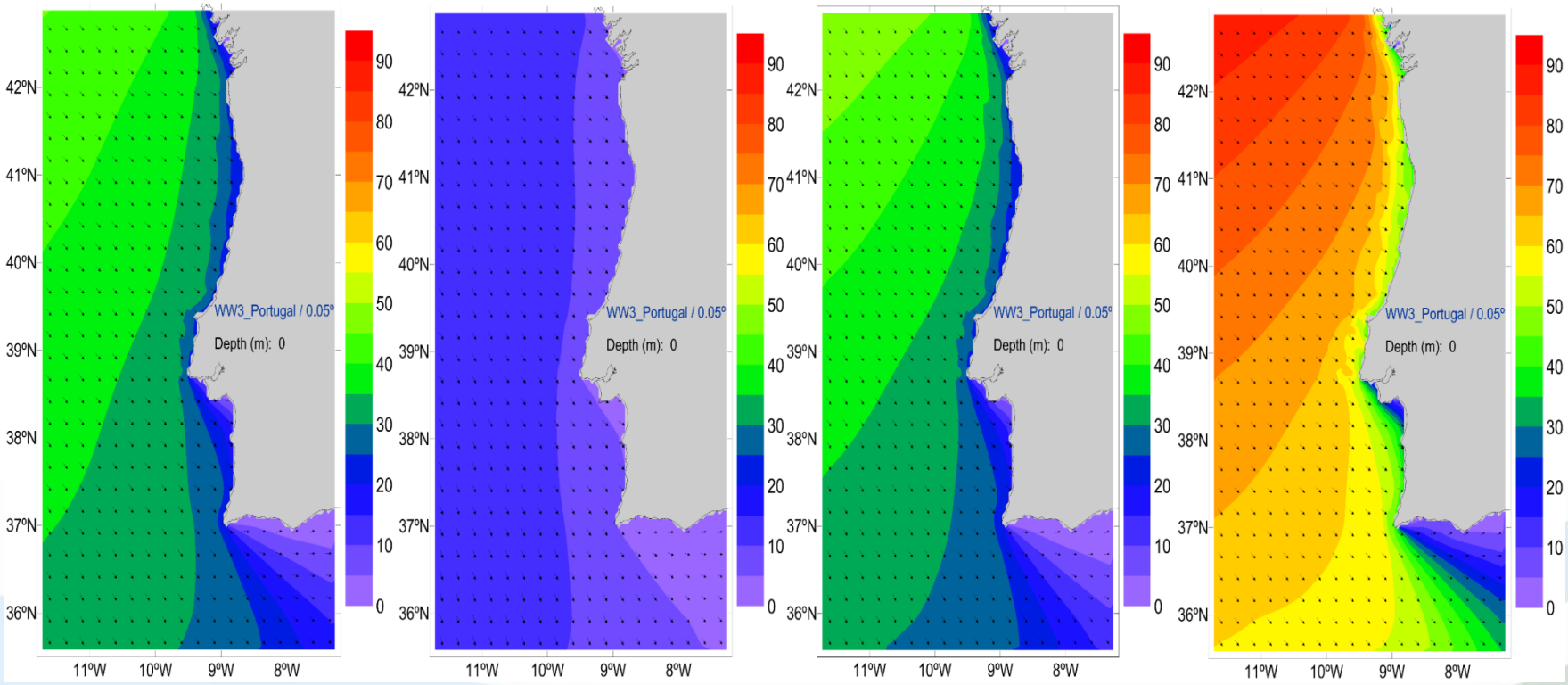


Significant Wave Height in m



SPRING SUMMER AUTUMN WINTER

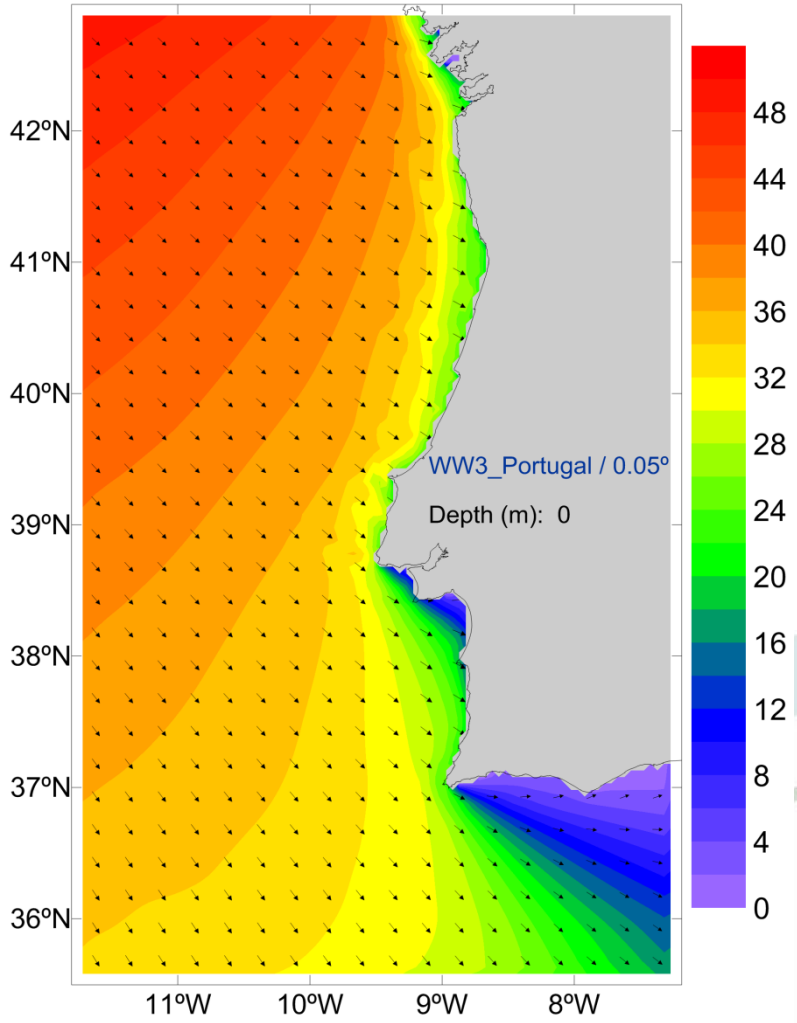
Wave Power Seasonality in kWm^{-1}



SPRING SUMMER AUTUMN WINTER

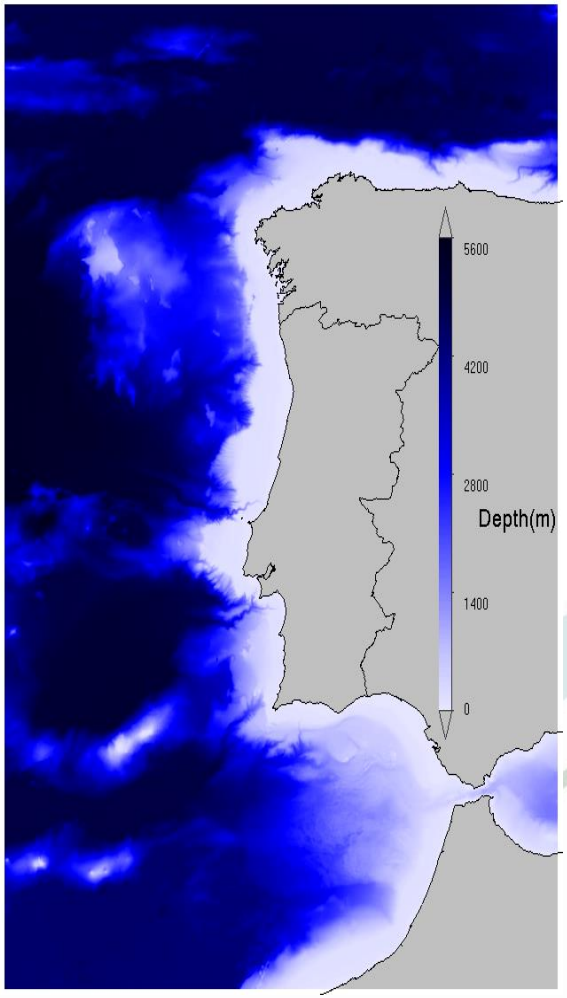
Wave Energy Summary

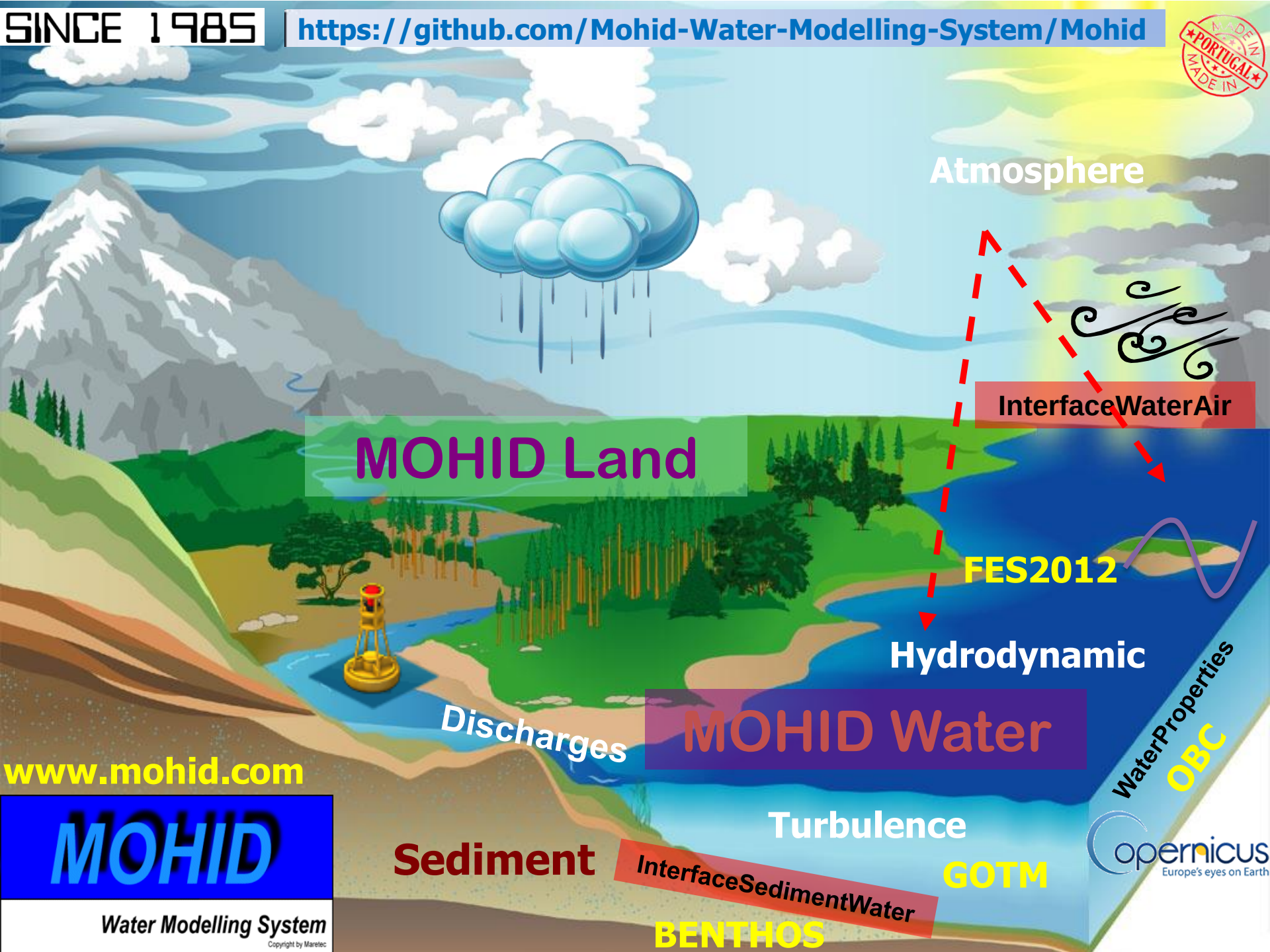
- Wave power distribution shows a clear gradient with a NW-SE orientation
- Maximum values around 50 kWm^{-1} found in the open ocean off the Northern coast while minimum values are located in the areas sheltered by geographic features from this direction i.e. the Tagus and Sado estuarine mouths and the Algarve southern coast
- On average the Portuguese coastal area has a wave power around 30 kWm^{-1} though this value would present a strong seasonality.
- Wave density power present a strong seasonality, maximum are obtained during the winter period and minimum during summer periods



Tidal Energy Estimation

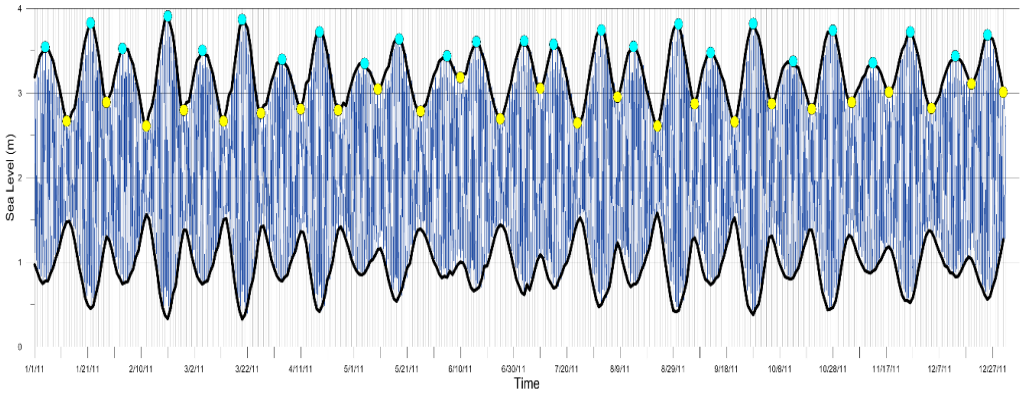
- Domains: 2D West Iberia domain with 0.015° horizontal resolution
- Period analysed : year 2011
- Mohid Water Model (www.mohid.com)
- Forced with the FES2012 global tide model

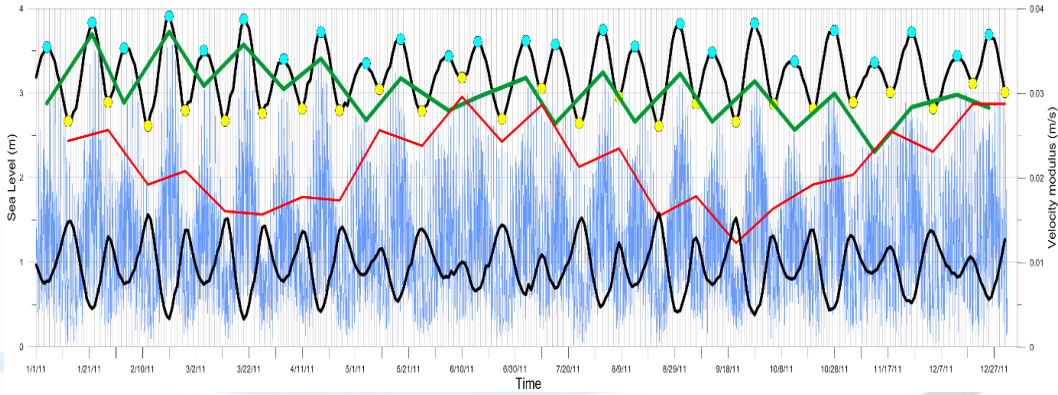



SINCE 1985
https://github.com/Mohid-Water-Modelling-System/Mohid
MADE IN PORTUGAL
Atmosphere
InterfaceWaterAir
MOHID Land
FES2012
Hydrodynamic
Discharges
MOHID Water
WaterProperties
OBC
www.mohid.com
MOHID
Water Modelling System
Copyright by Maretec
Turbulence
GOTM
Sediment
InterfaceSedimentWater
BENTHOS
opernicus
Europe's eyes on Earth

Water level and currents analysis

- Interesting parameters are the maximum velocity during neap and spring tides.
- Developing methods for identifying the maximum for each spring and neap tide and searching for the associated maximum velocity.



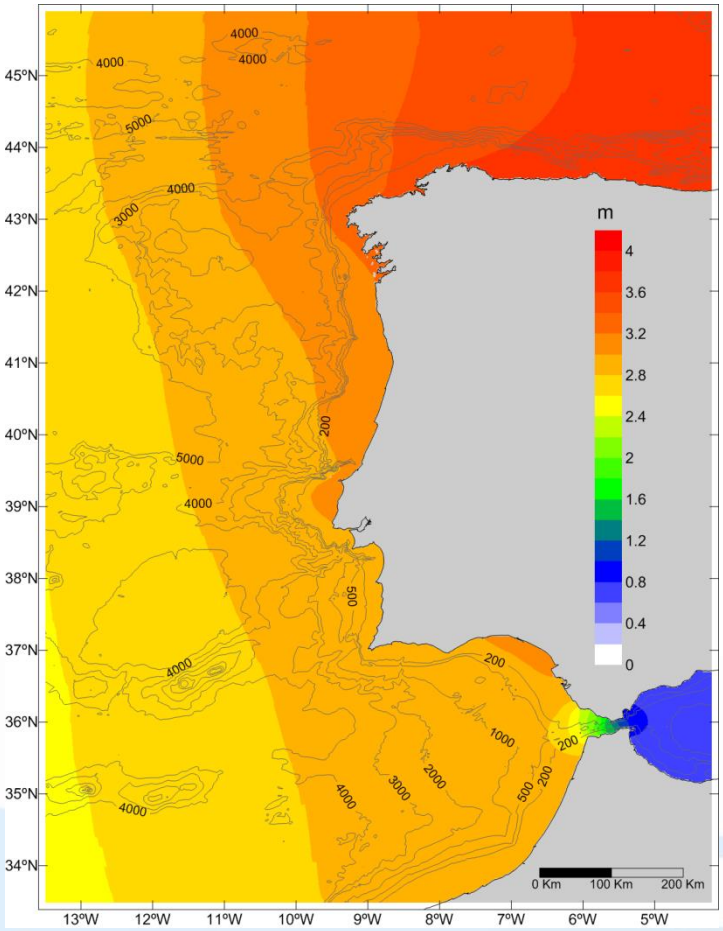


MONICAN01 example:

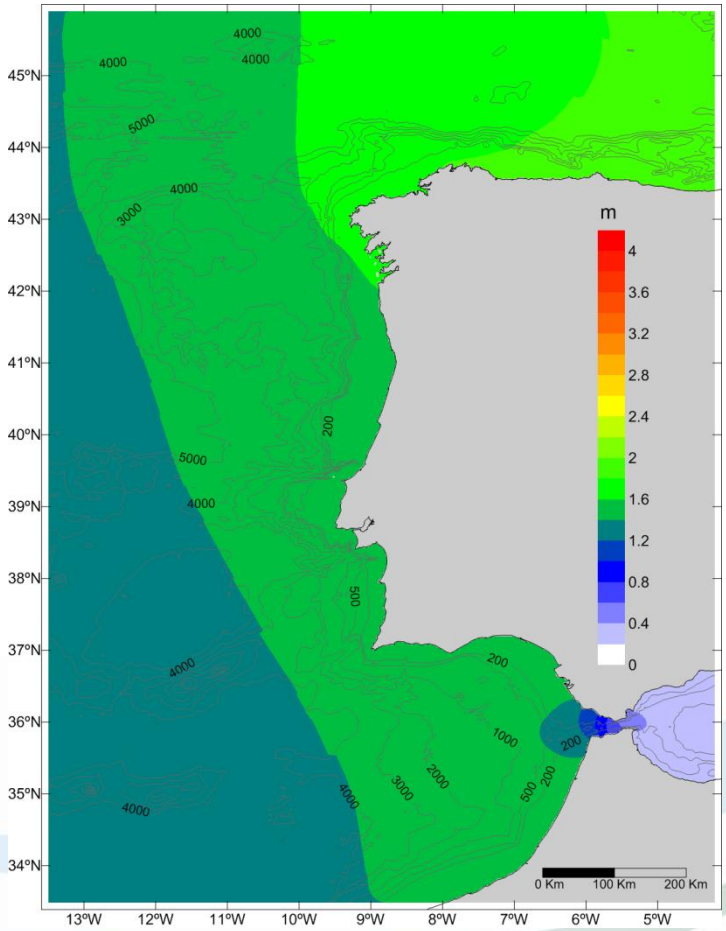
-top: water levels with spring and neap maximum

-bottom: maximum currents and levels envelope

Mean Tidal Range

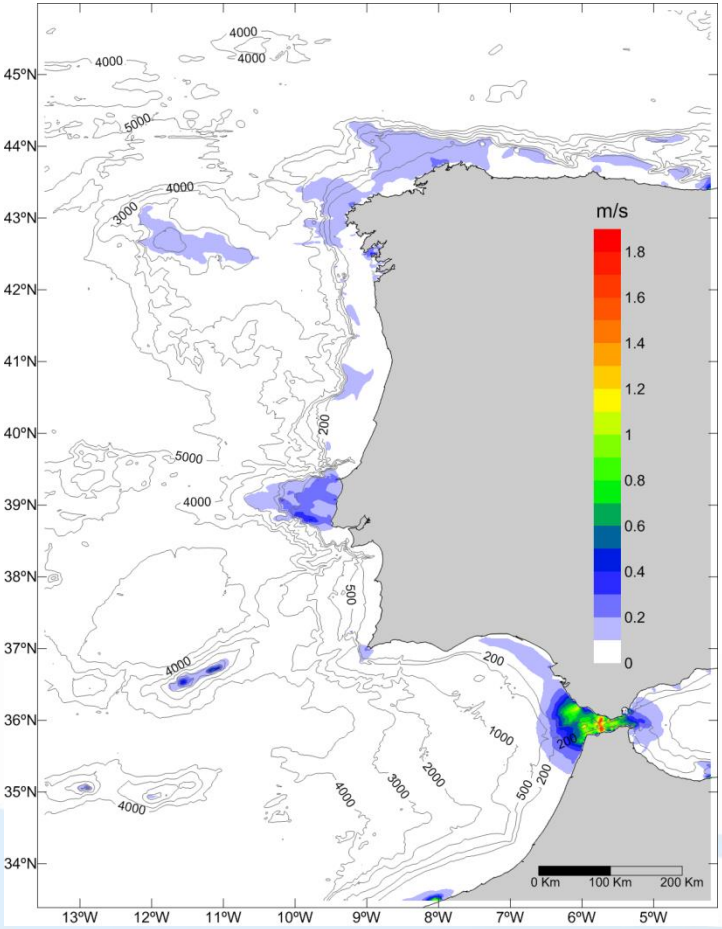


Spring Tide

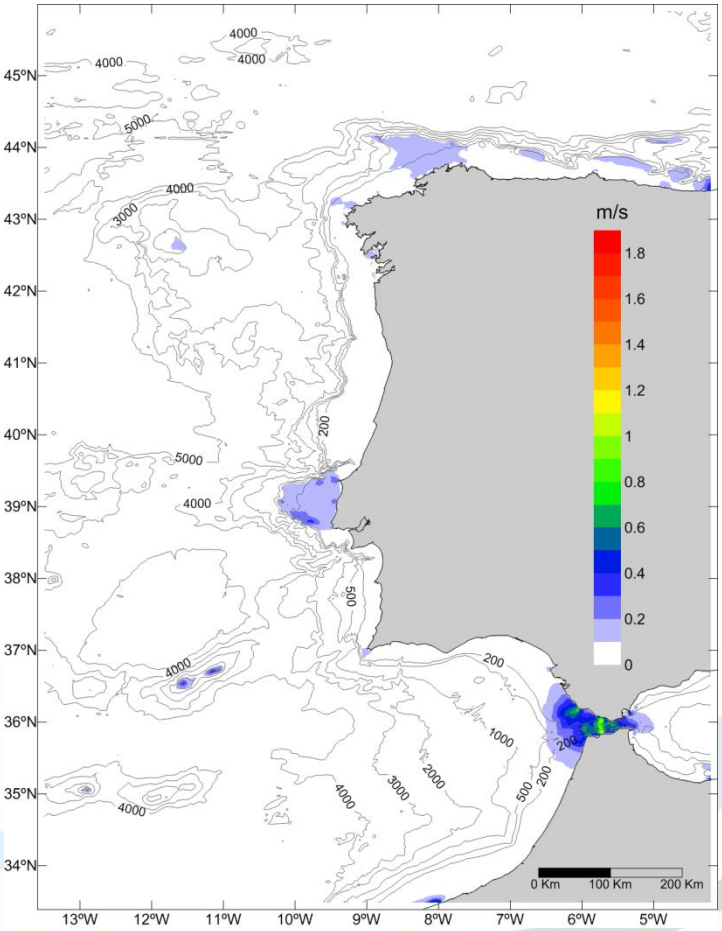


Neap Tide

Mean Peak Velocities

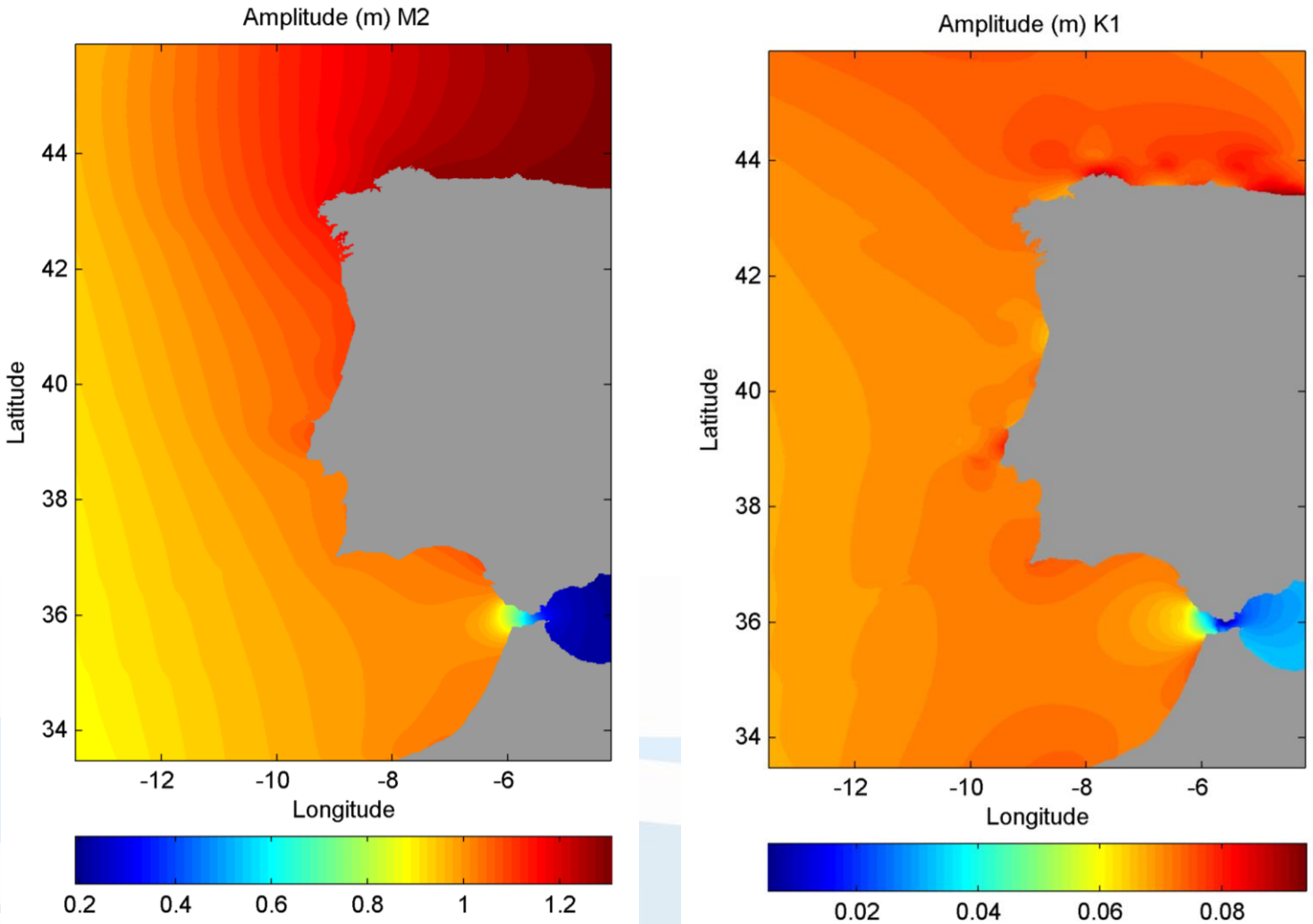


Spring Tide



Neap Tide

Harmonic analysis



Tidal Energy conversion

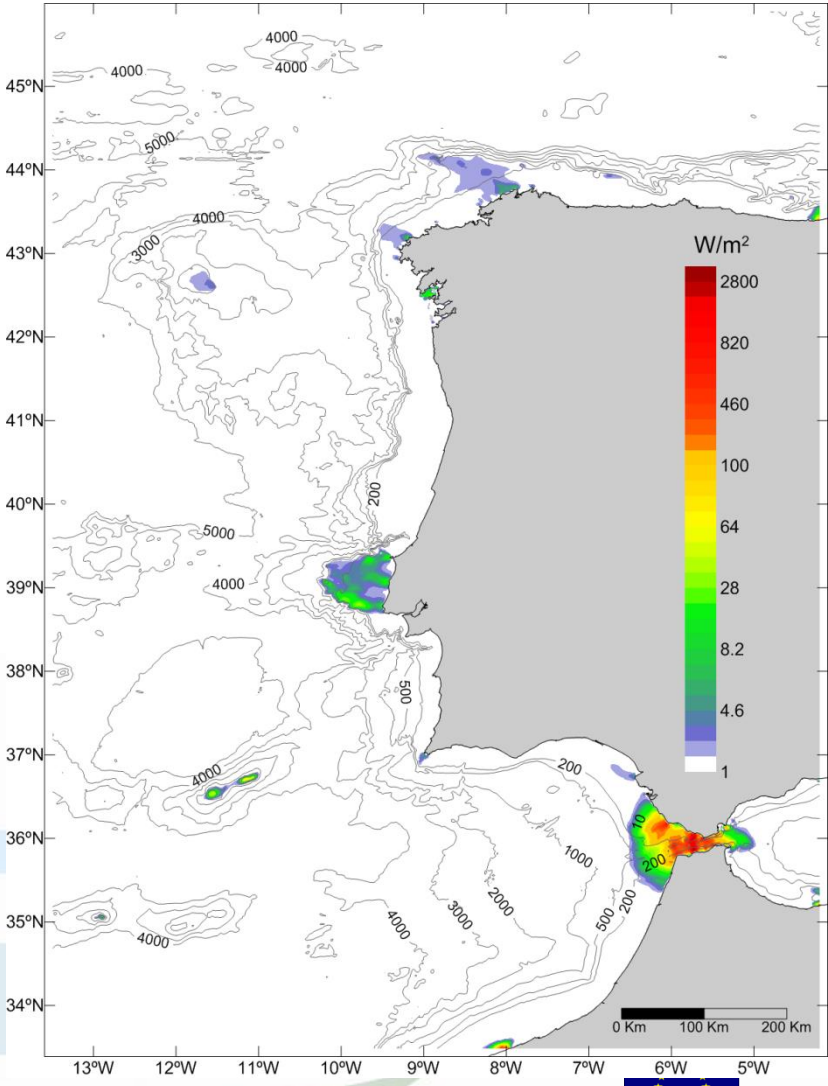
- Power potential by square metre cross-sectional area was obtained by using the following formula :

$$P = 1/2\rho|U|^3$$

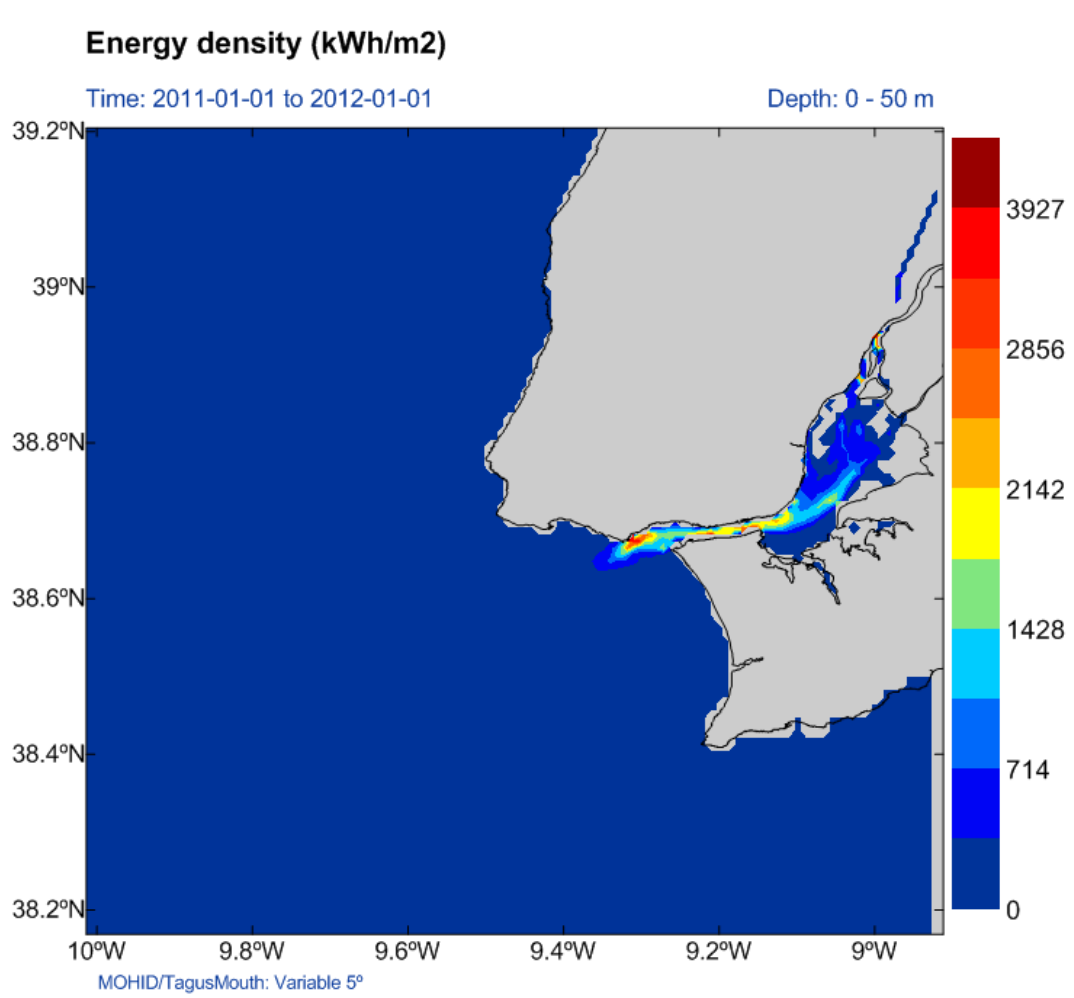
ρ is the water density ρ is the density of water, 1027 kg/m^3, and U is the instantaneous current velocity (m/s).

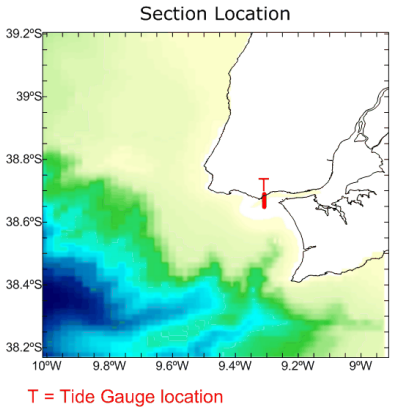
Tidal Power Summary

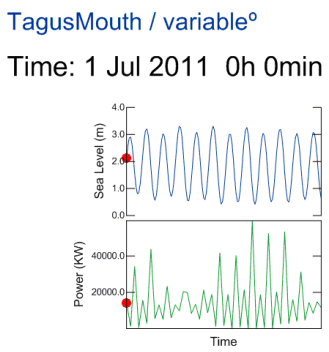
- Mean Spring tidal power. Values are represented in logarithmic scale.
- In general the obtained tidal energy values are very low when compared to some locations in the UK coast with areas with power higher than 20 kWm^{-2}.
- Modelling results reflect some of the circulation features present in Western Iberia as the Strait of Gibraltar circulation, the submarine mountains signal and the currents occurring in the Tagus Plateau in central Portugal.

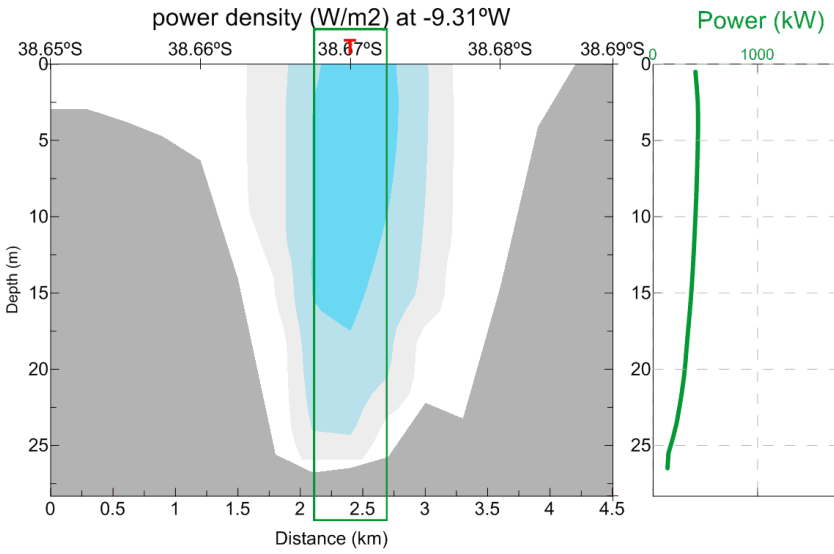


TagusMouth domain

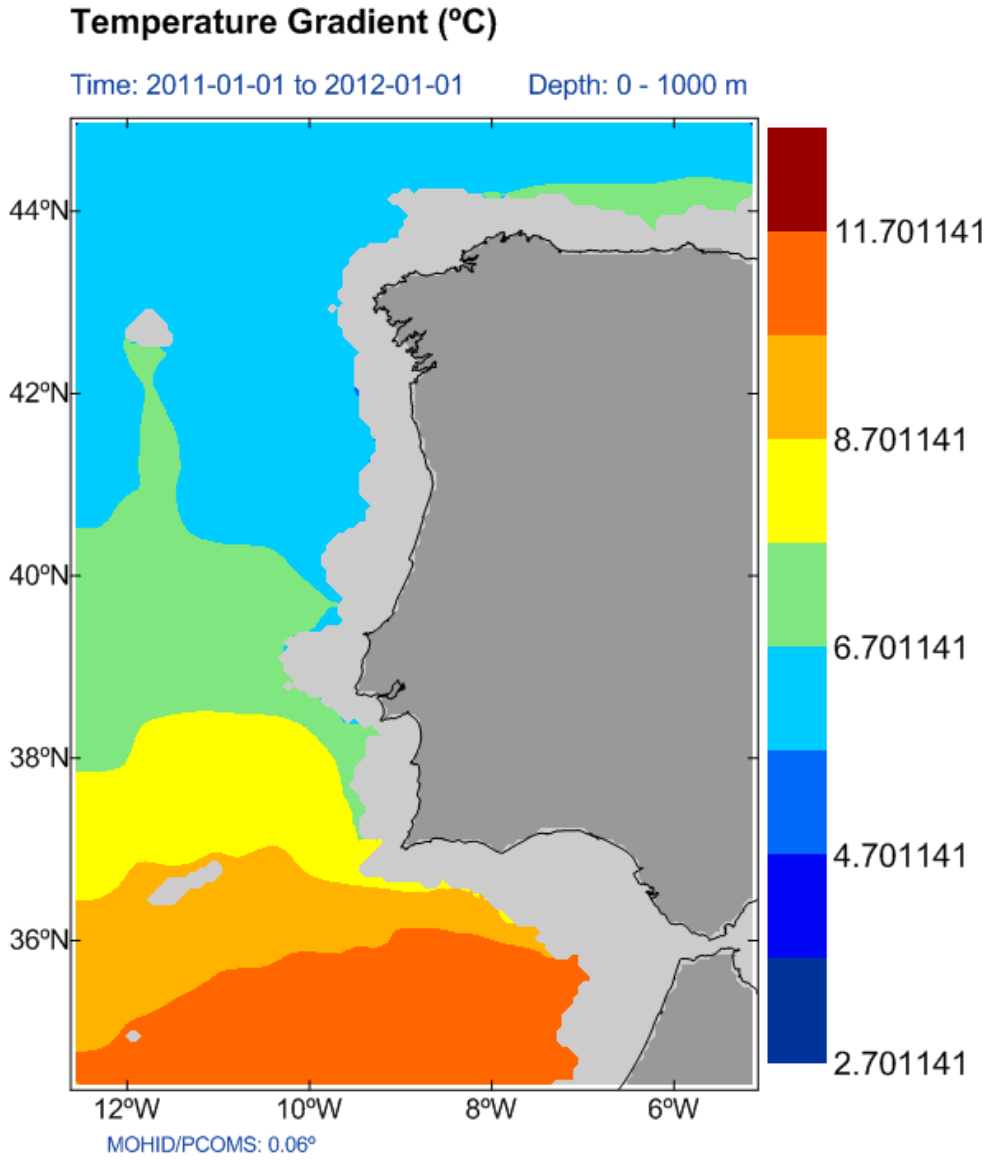


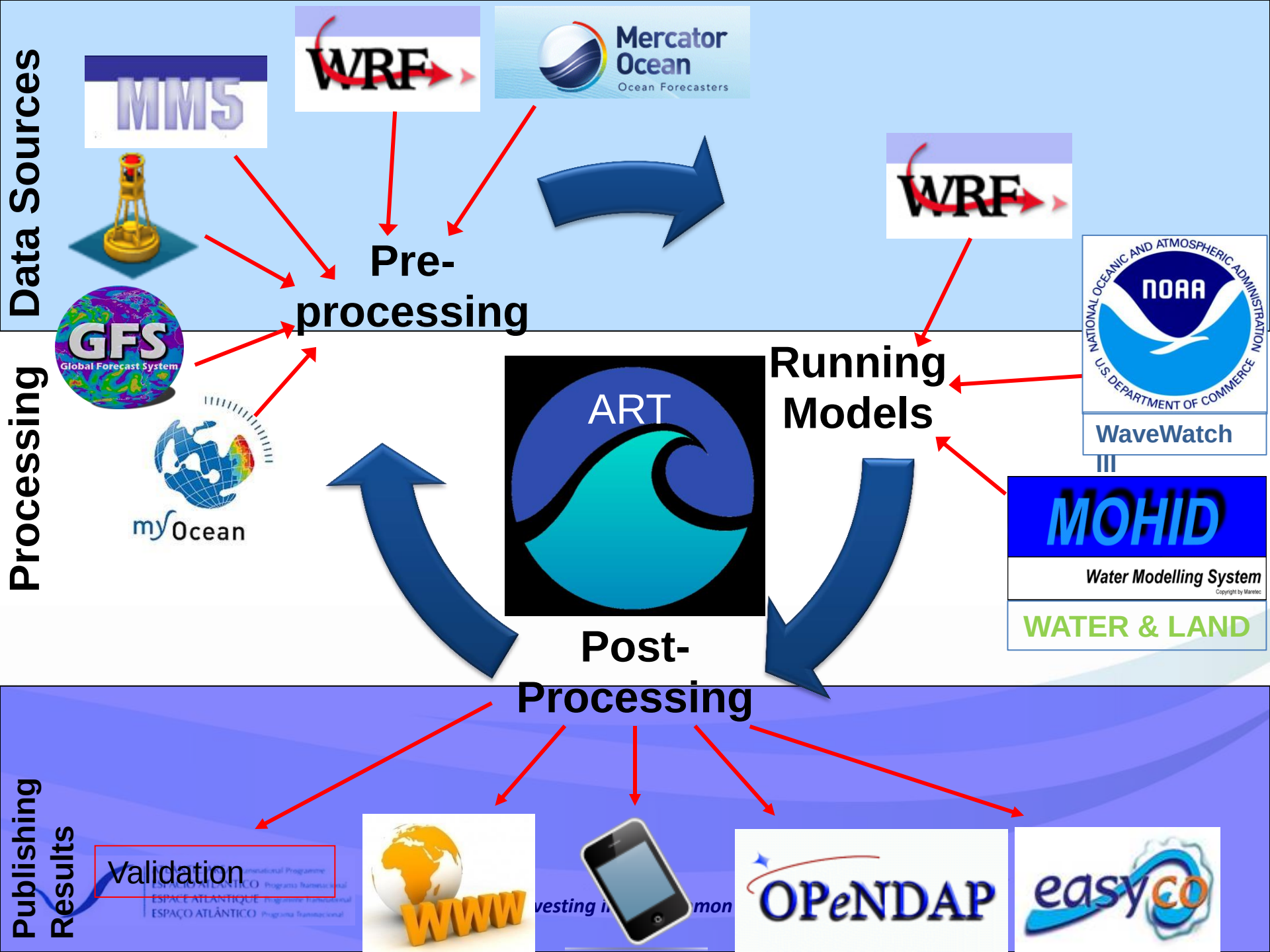






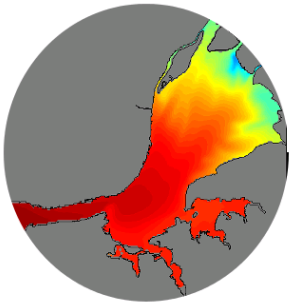
OTEC Energy


Temperature Gradient (ºC)
Time: 2011-01-01 to 2012-01-01
Depth: 0 - 1000 m
44ºN
42ºN
40ºN
38ºN
36ºN
12ºW
10ºW
8ºW
6ºW
11.701141
8.701141
6.701141
4.701141
2.701141
MOHID/PCOMS: 0.06º


Data Sources
MM5
WRF
Mercator Ocean
Ocean Forecasters
Pre-processing
WRF
GFS
Global Forecast System
myOcean
Processing
ART
Running Models
NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE
WaveWatch III
MOHID
Water Modelling System
WATER & LAND
Post-Processing
Publishing Results
Validation
WWW
OPeNDAP
easyco

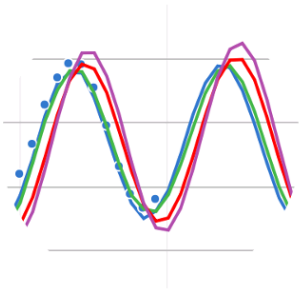
New webpage
http://forecast.maretec.org

MARETEC
MARINE ENVIRONMENT & TECHNOLOGY CENTER



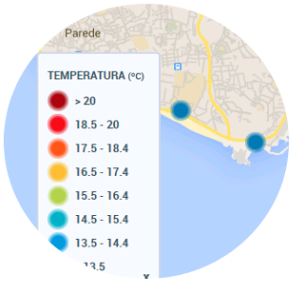
Modelling Maps

Graphic representation of the modelling results and forecasts



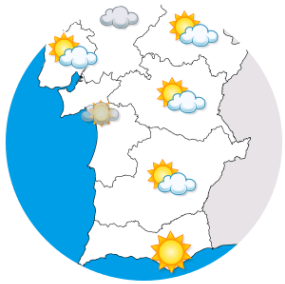
Modelling Charts

Chart representation of the modelling results, forecasts and observations.



Beach Forecasts

Maretec beach portal including comprehensive information of the sea conditions



Weather Forecast

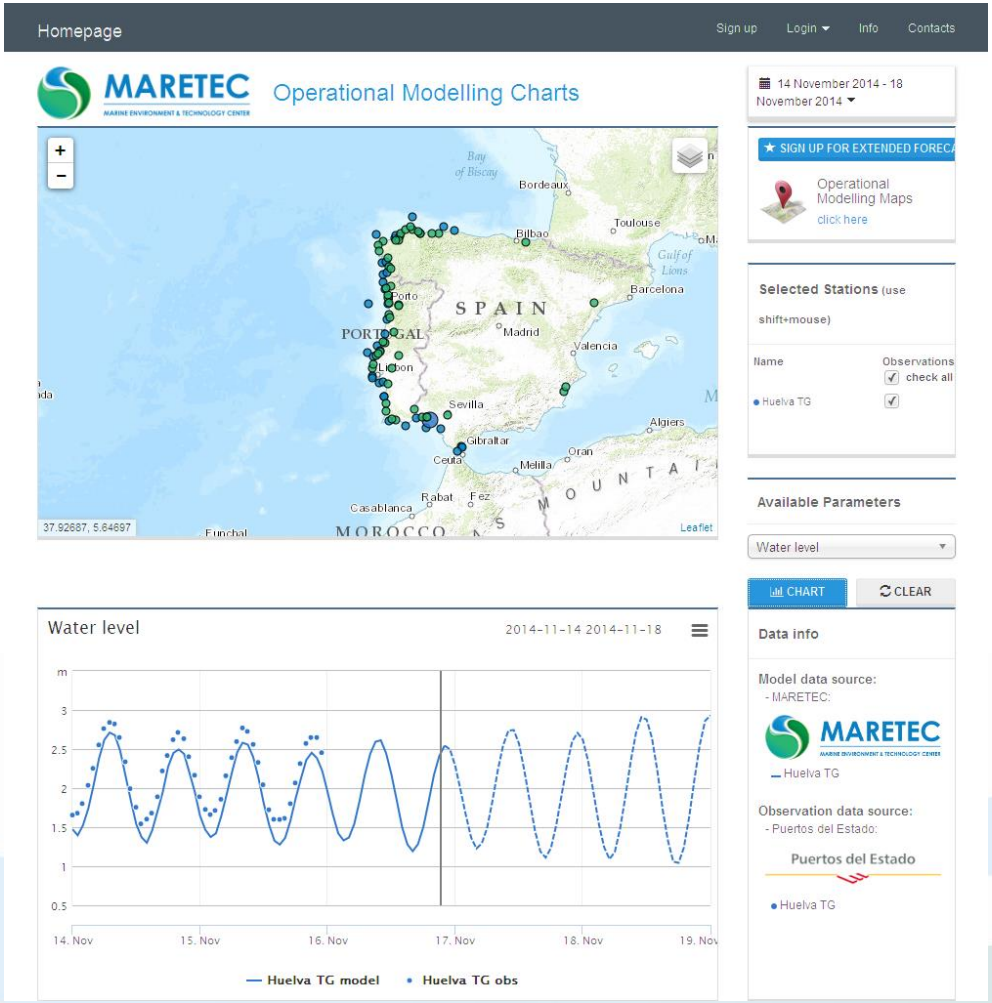
7 day weather forecast for Portugal Continental

OPERATIONAL MODELS

MARETEC - Operational Modelling

HTTP://FORECAST.MARETEC.ORG/

WebGIS Interface



Pilot Zone

http://www.oceanplug.pt

ocean plug

portuguese pilot zone

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contacts PT EN search

METEO

TEMPERATURE (ºC) 7
HUMIDITY (%) 100
PRESSURE (MBAR) 1015.92
WIND SPEED (KM/H) 11.27
UV INDEX 1
DATE Thu, 26 Mar 2015 9:00 am WET

WAVE FORECAST

WAVE POWER (KW/M) 16.37
PEAK PERIOD (S) 11.36
PEAK DIRECTION (º) 325.00
MEAN WAVE DIRECTION (º) 327.00
MEAN WAVE PERIOD (S) 6.66
SIGNIFICANT WAVE HEIGHT (M) 2.24
DATE Thu, 26 Mar 2015 9:00

Source and additional information:
MARETEC/IST +

Oceanplug Expedition:

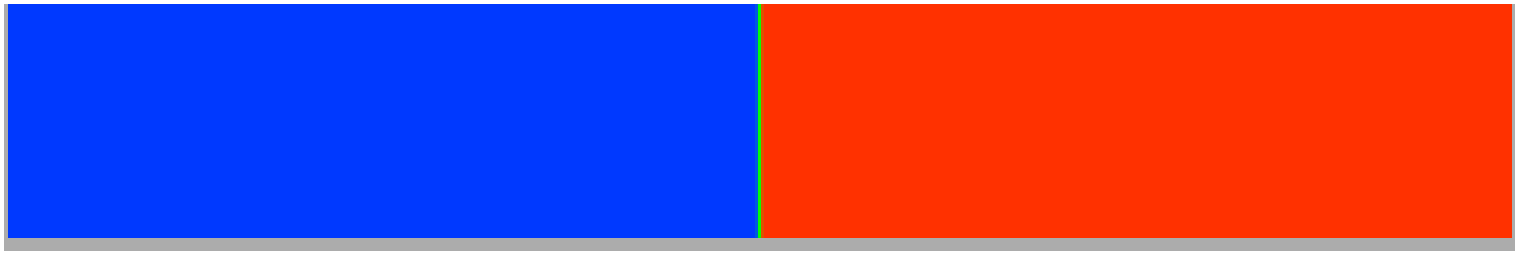
Highlights

- This Atlas allow to better plan, design and manage deployments of energy extracting devices and perform safer operations at sea due to numerical model forecasts.
- Full report location available in this conference proceedings.
- The operational models allow to plan your O&M activities with 7 days in advance and alert of extreme weather and ocean conditions.
- Easy to visualize and access through WebGIS.
- Technology validated and available for any location.
- The present methodology is able to provide gapless data of metocean conditions and to produce forecasts and to complete observation systems.

Highlights

- The developed methodology is generic and could be set for any region using open source data and models and it has already been applied to several coastal areas in the Portuguese coasts.
- This methodology could aid in decision making at several levels: MRE O&M, managing MRE devices, disaster and risk management, etc.

- Muito obrigado pela sua atenção!!
- Thank you very much for your attention!!



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