PECC International Project: *Energy Transition 2013-2014*

June 24-25, 2014 | Santiago, Chile

An overview of the best suitable locations for marine renewable energy (MRE) development in the PECC economies given local constraints and opportunities: 'The best locations worldwide'

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Laboratoire Comportement des Structures en Mer

What are :
'The best locations worldwide' ?

No definite answer
but
a combination of items to address
and some possible tracks

Best locations = Combination of

Resource availability versus **Loads on structures**

Energy use at short distance
or
Energy transport on long distance

Grid connection and energy storage

Industry and transport infrastructures :
shipyards, harbours,…

Facilities and associated manpower
(training and **education)**
Installation
Operation and **maintenance**
Dismantling
Monitoring

Environmental and **Social acceptability**

Resource and loads

addressed during

PECC Seminar 2 on Marine Resources: Oceans as a Source of Renewable Energy

Wind

Currents

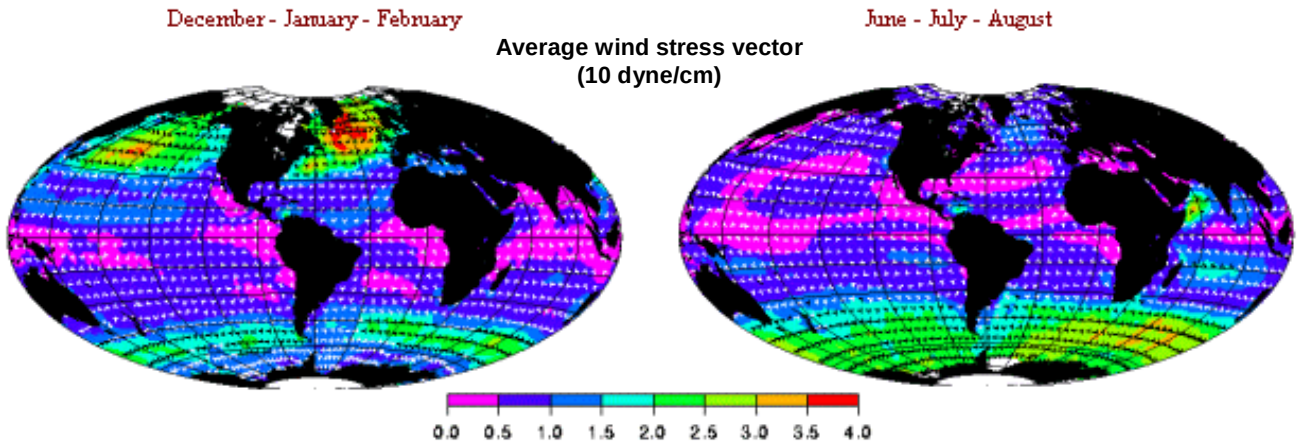
Waves

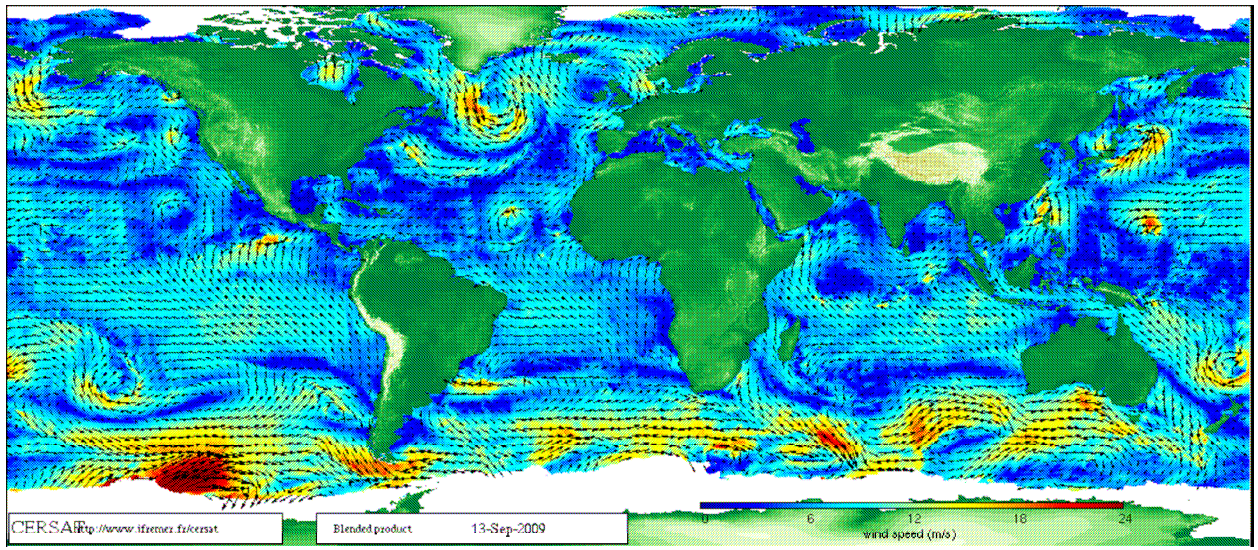
Thermal

+ Biomass + Salinity gradient

Wind energy

Wind energy is an intermittent resource.
Short term meteorological prediction are improving.
Yearly tendencies are available from large scale observations.



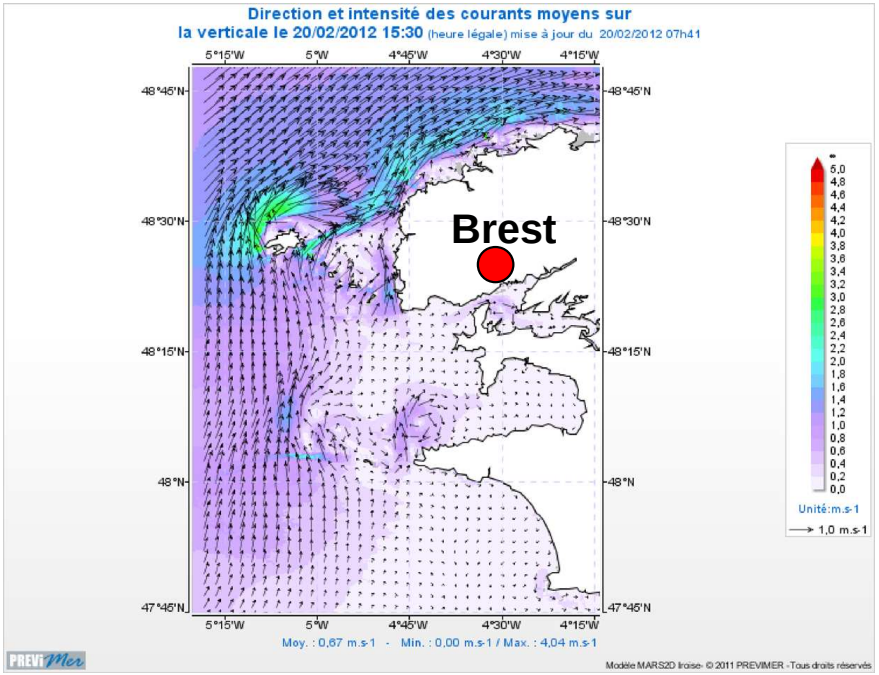


Ifremer-CERSAT

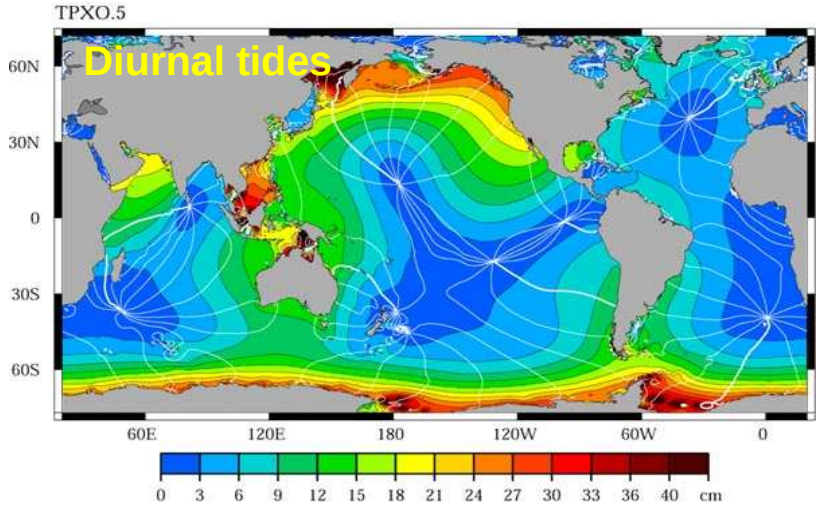
Tidal and current energy

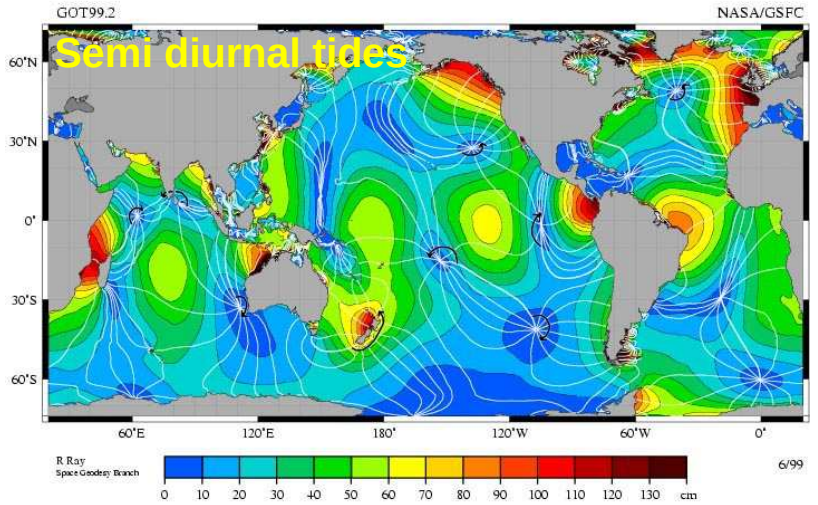
The resource is predictable.
The tidal height and current speed can be computed at a given place and at a given time.

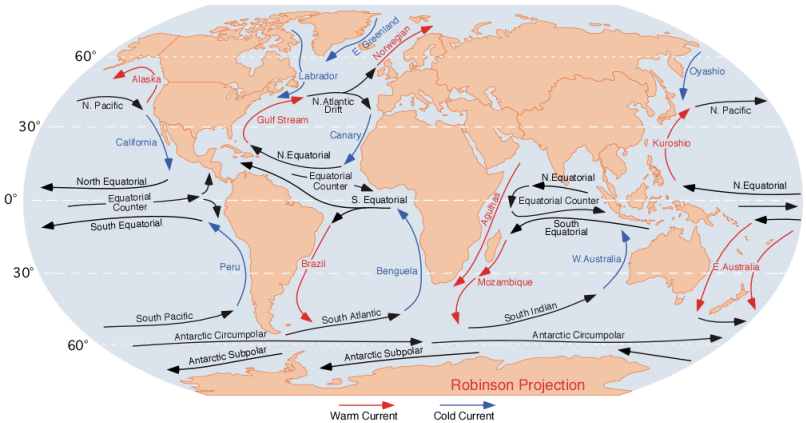
Example of numerical prediction :
Mer d'Iroise, France
www.previmer.org/previsions/courants



Coastal currents







Ocean currents

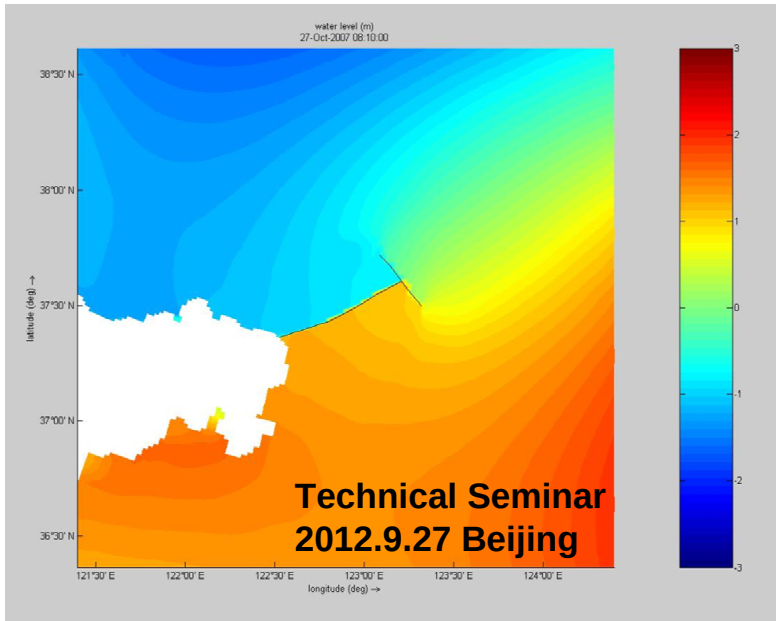
Tidal and current energy

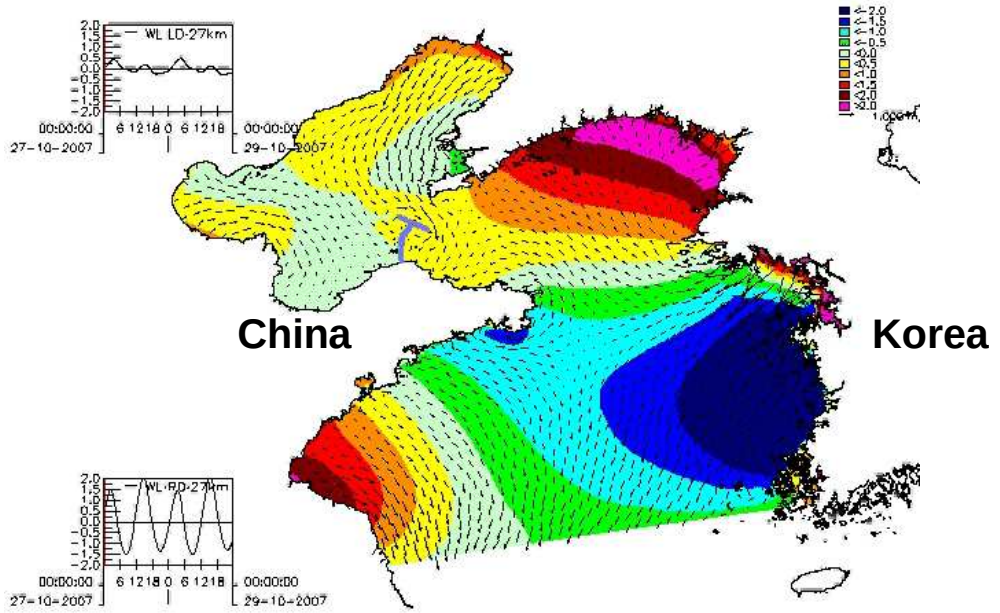
Some hot points :

- Bay of Fundy (Canada)
- French UK Channel
- Estuaries worldwide

A new concept :

- Dynamic Tidal Power www.powerdtp.nl
  - Supported by UNIDO United Nations Industrial Development Organization
- Refined studies in China : Shandong case

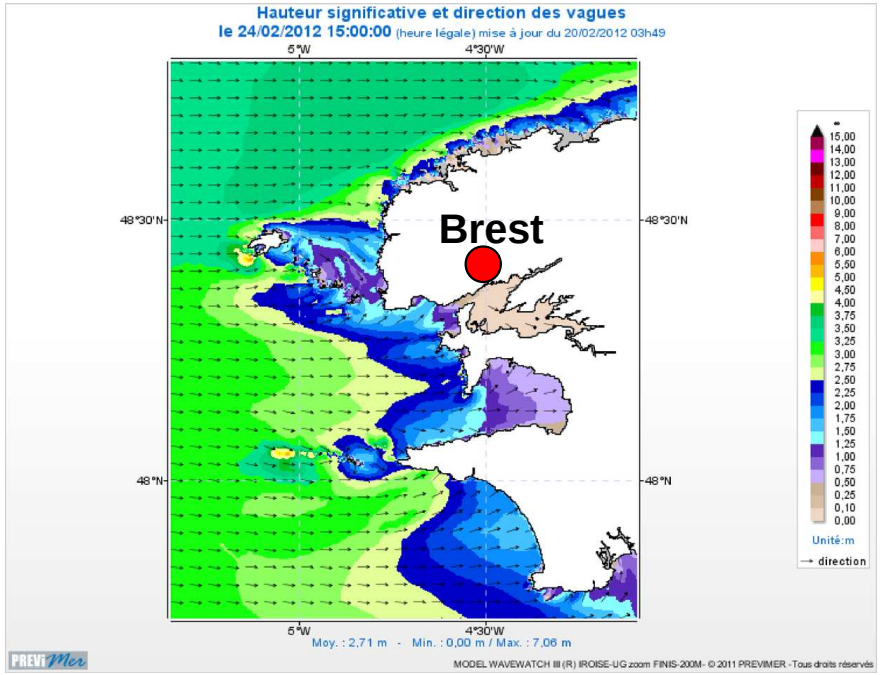




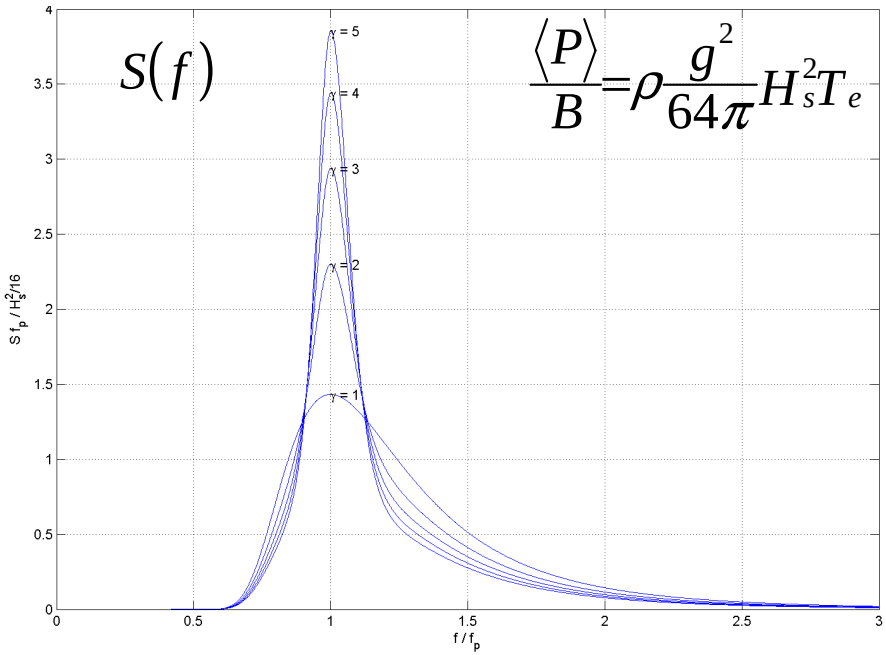
Wave energy

Wind energy is an intermittent resource, related to the far wind generation (swell) and close wind generation (wind seas), characterised by statistics and probability of occurrence of waves spectra, and recorded in waves atlas.

Example of numerical prediction :
Mer d'Iroise, France
www.previmer.org/previsions/vagues

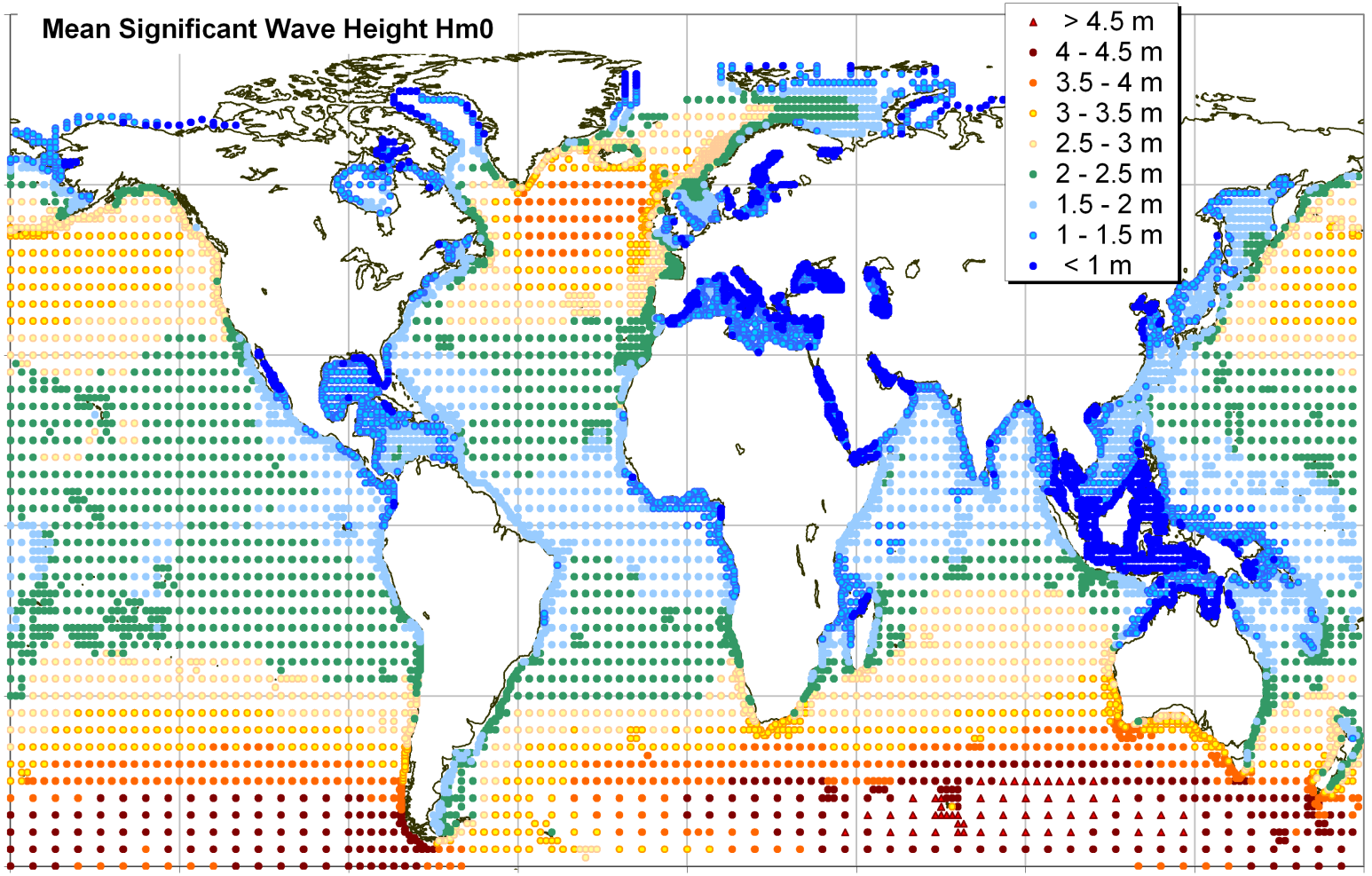


Example of an analytical form of wave spectra :
JONSWAP (*JOint North Sea WAve Project)*



Wave energy

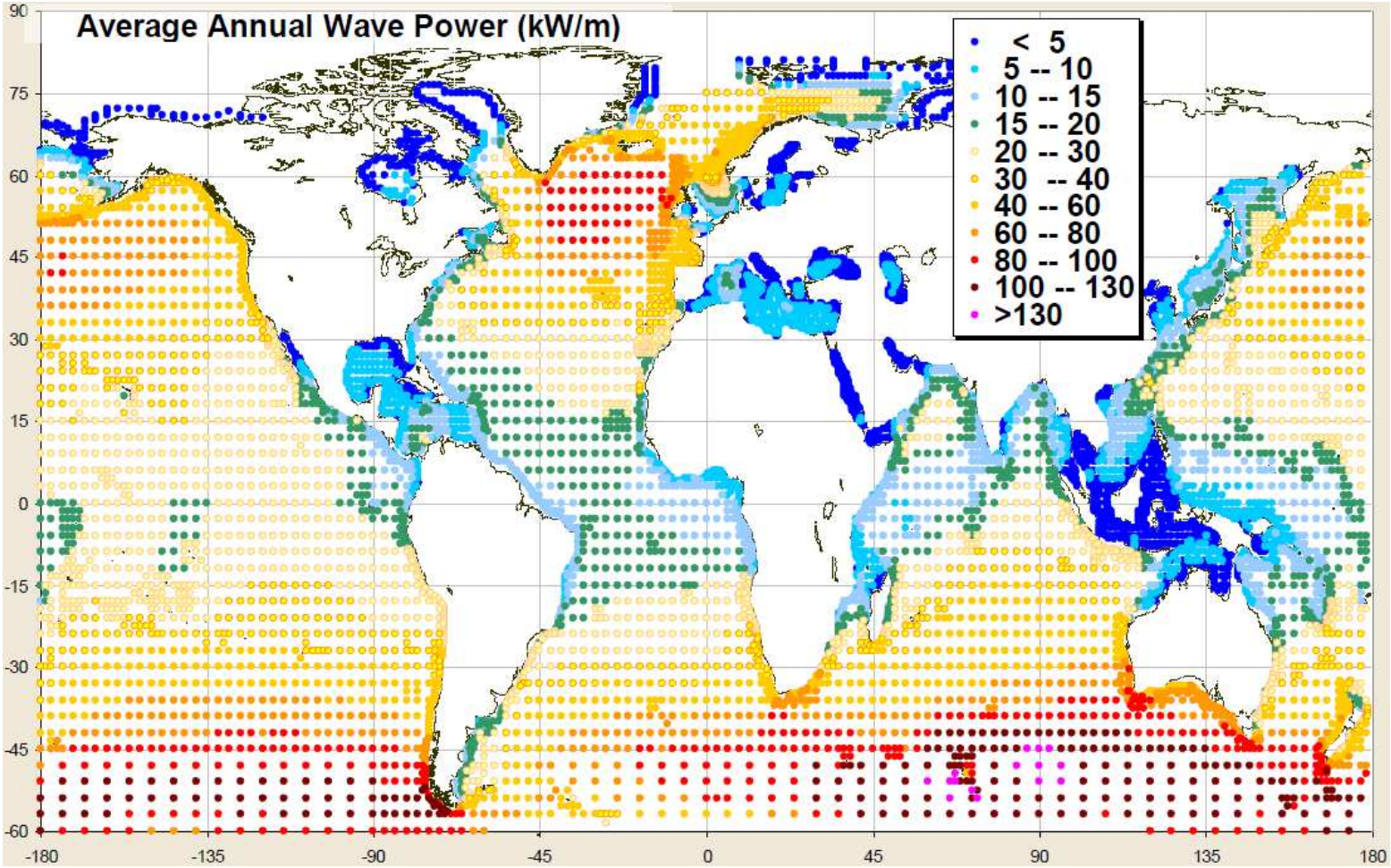
Wave significant height (m) : yearly mean average



Source : Fugro Oceanor

Wave energy

Wave energy per front meter (kW/m) : yearly mean average



Source : Fugro Oceanor

Wave energy resource assessment

Case of the French coasts

Study by E. Boudière, Ch. Maisondieu et al Christophe.Maisondieu@ifremer.fr

A suitable metocean hindcast database for the design of Marine energy converters. Edwige Boudière, Christophe Maisondieu, Fabrice Ardhuin, Mickaël Accensi, Lucia Pineau-Guillou, Jérémy Lepesqueur
International Journal of Marine Energy 3–4 (2013) e40–e52

Numerical modelling : HOMERE database

Hydrodynamics Ocean-Meteorology and Marine Renewable Energies

Based on www.previmer.fr (currents, level)

- **WAVEWATCH III (waves)**
- **NCEP (wind)**
- **SHOM (bathymetry)**

19 years period from 1994 to 2012

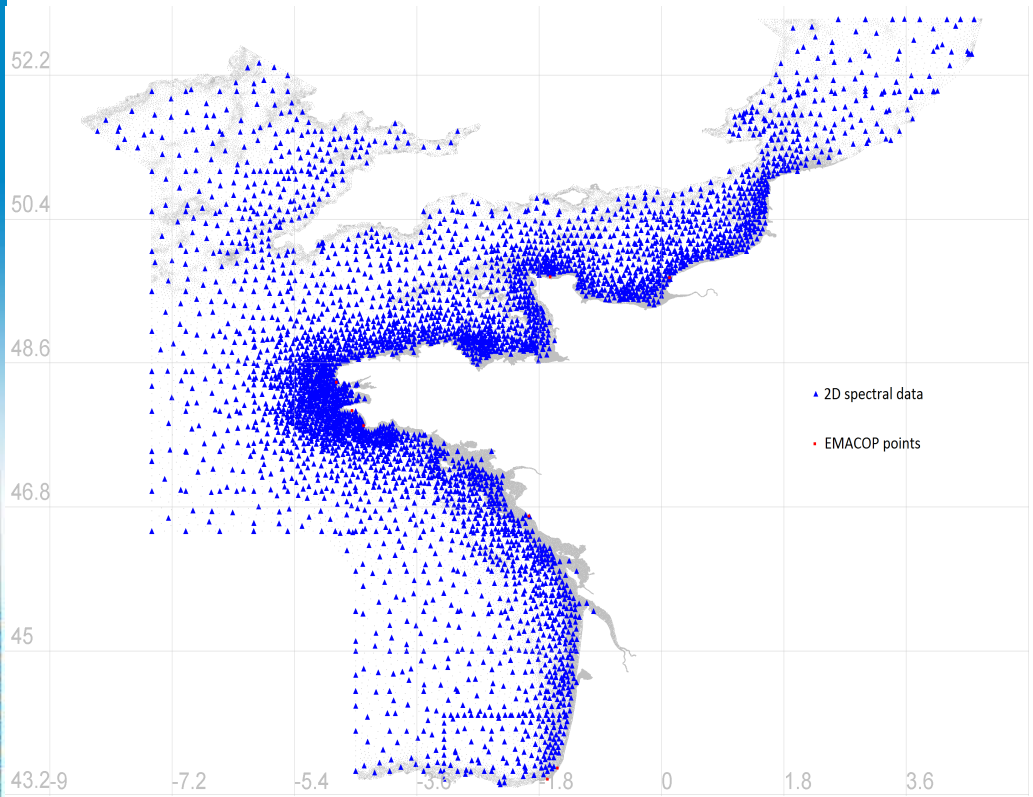
Product :
http://www.previmer.org/produits/rejeu_d_etats_de_mer_homere
User guide :
http://www.previmer.org/content/download/9626/50964/file/HOMERE_NGUG-v3_notice_v1_Publique.pdf

Wave energy resource assessment

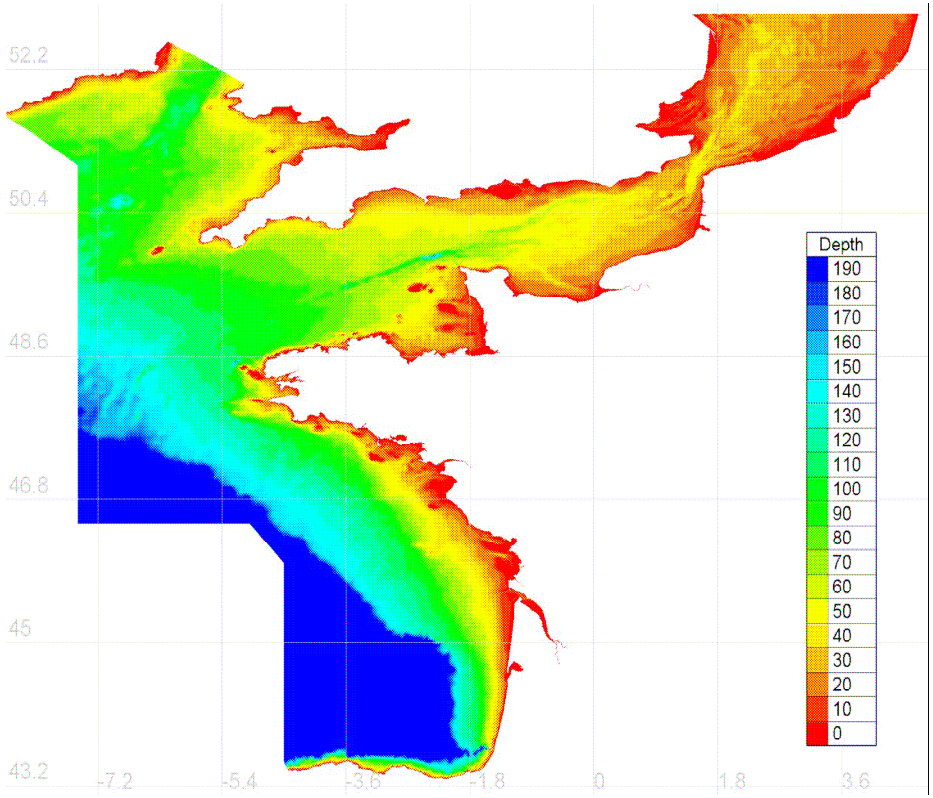
Case of the French coasts

Numerical modelling

Mesh for results display



Bathymetry

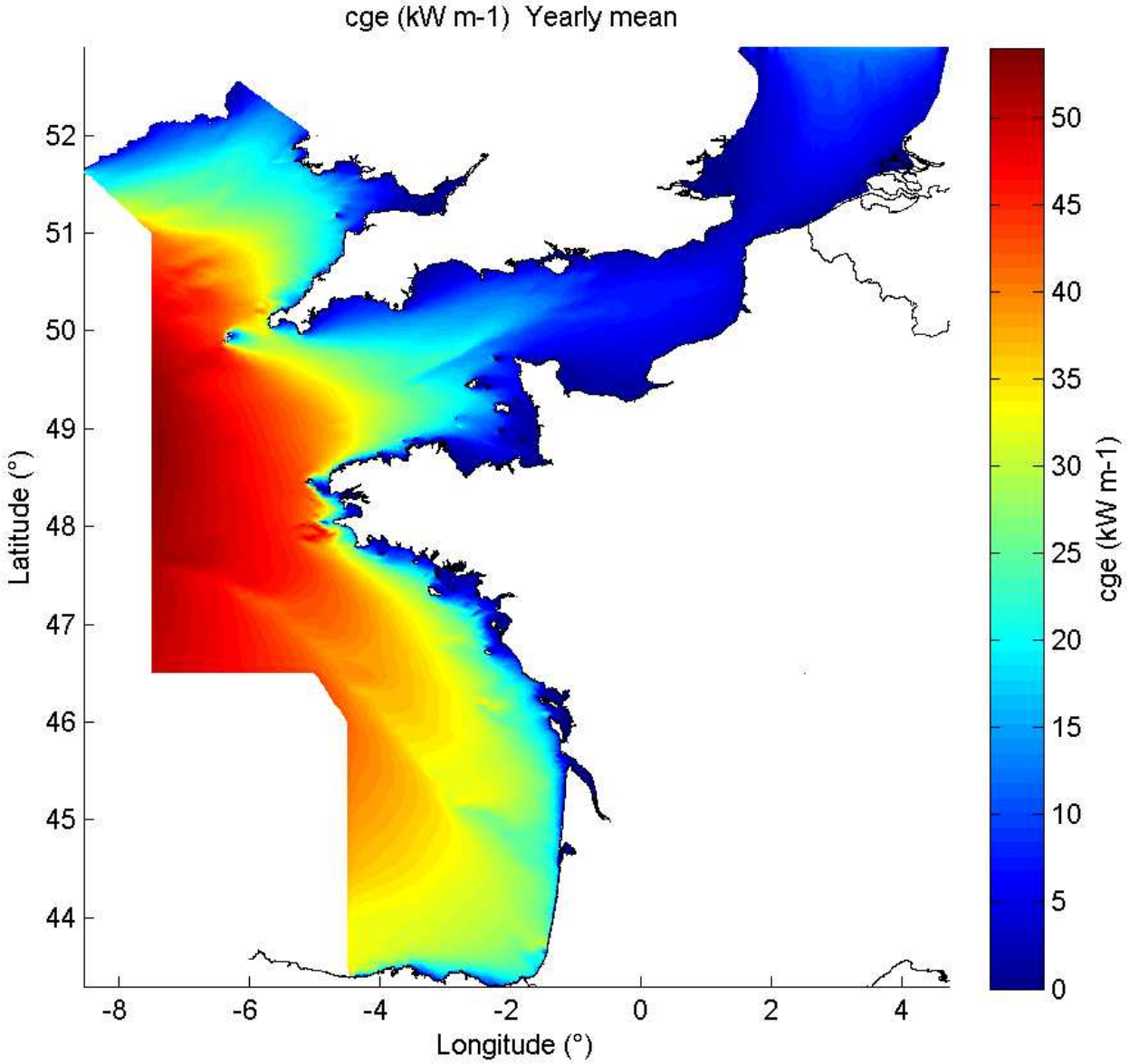


Wave energy resource assessment

Case of the French coasts

Numerical modelling

Wave energy per front meter (kW/m)



Wave energy resource assessment

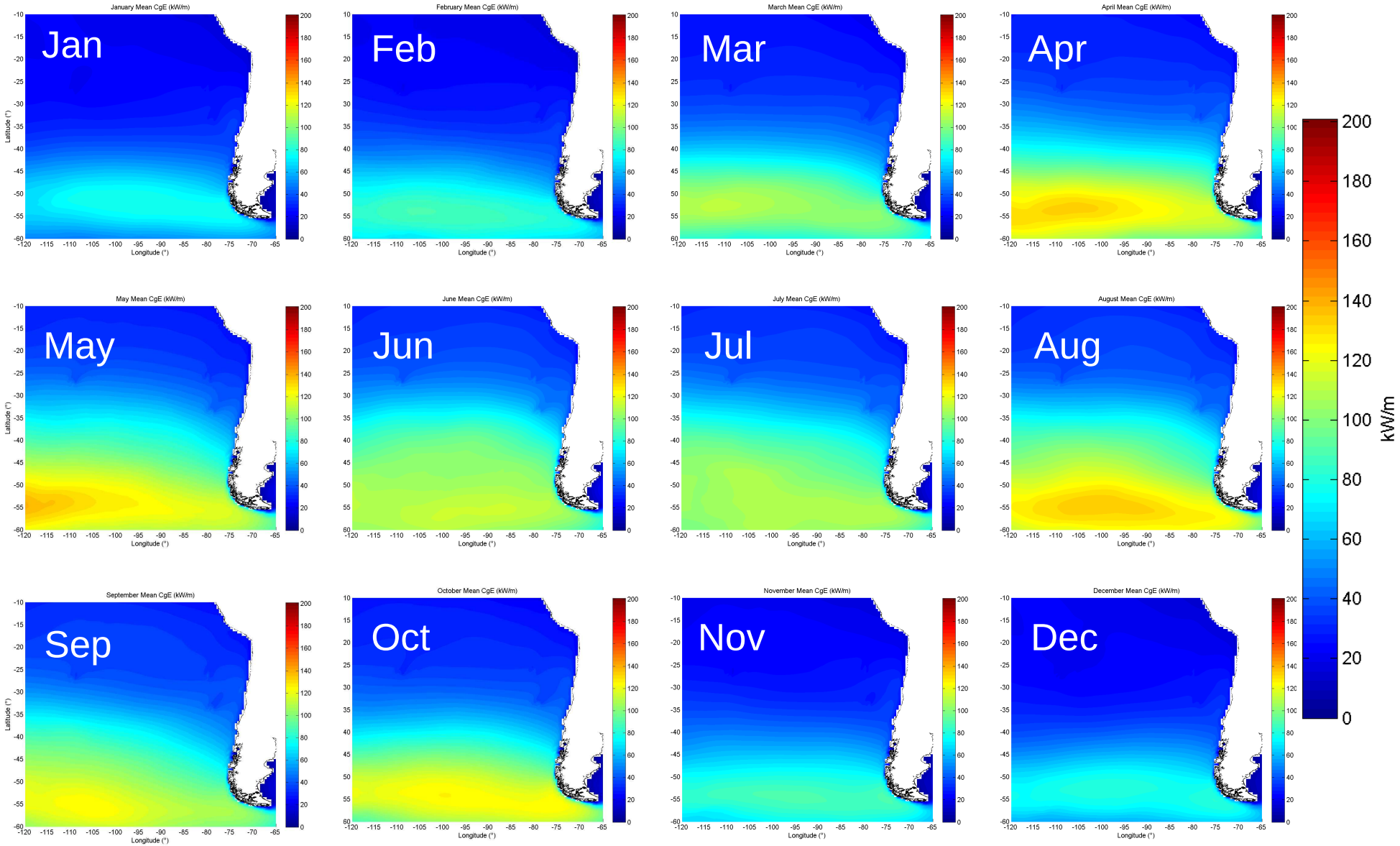
Case of the Chilean coasts

Study by Ch. Maisondieu Christophe.Maisondieu@ifremer.fr

13 years period from 1999 to 2012

Wave energy resource assessment

Case of the Chilean coasts



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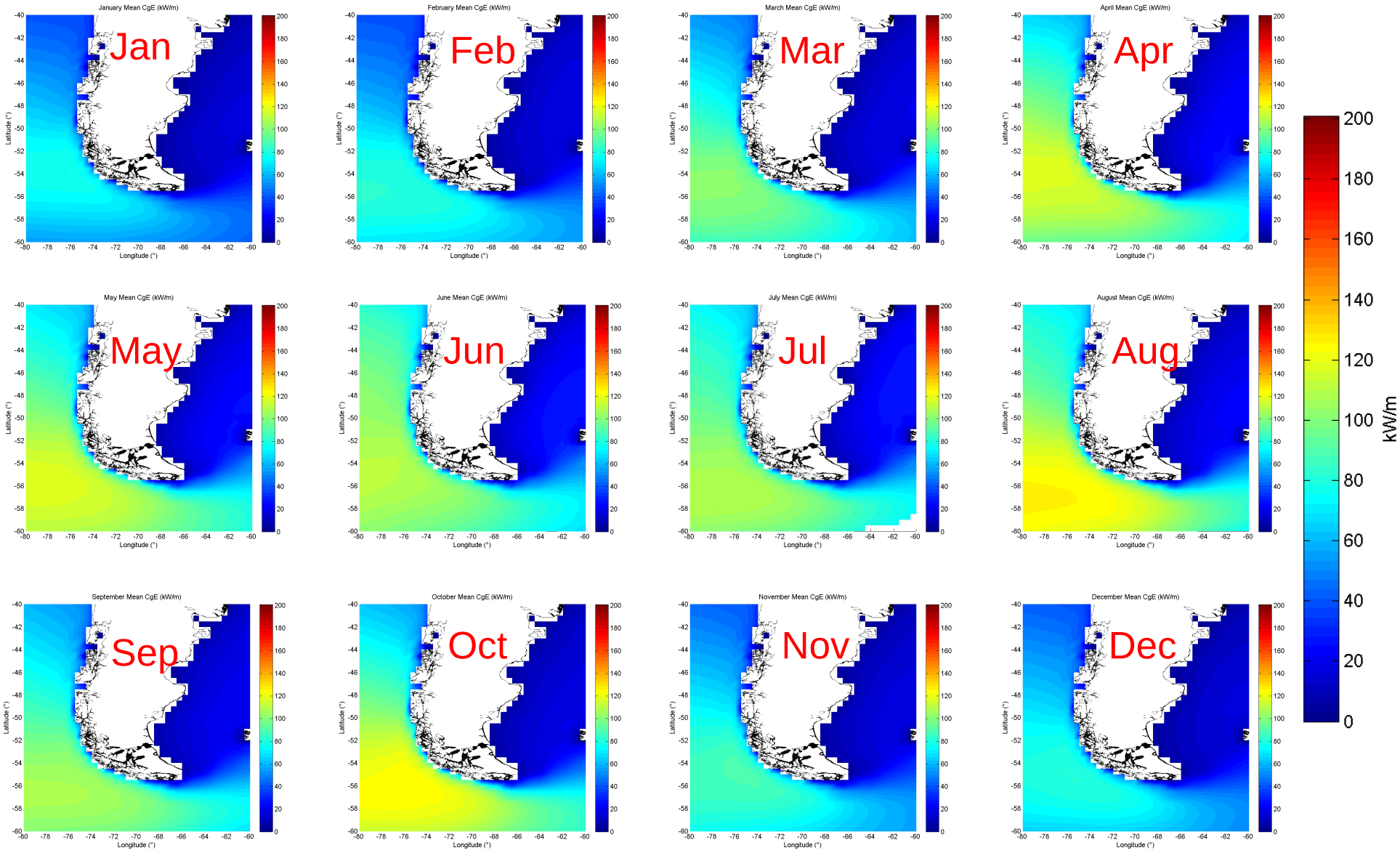
Wave energy resource assessment

Case of the southern Chilean coasts



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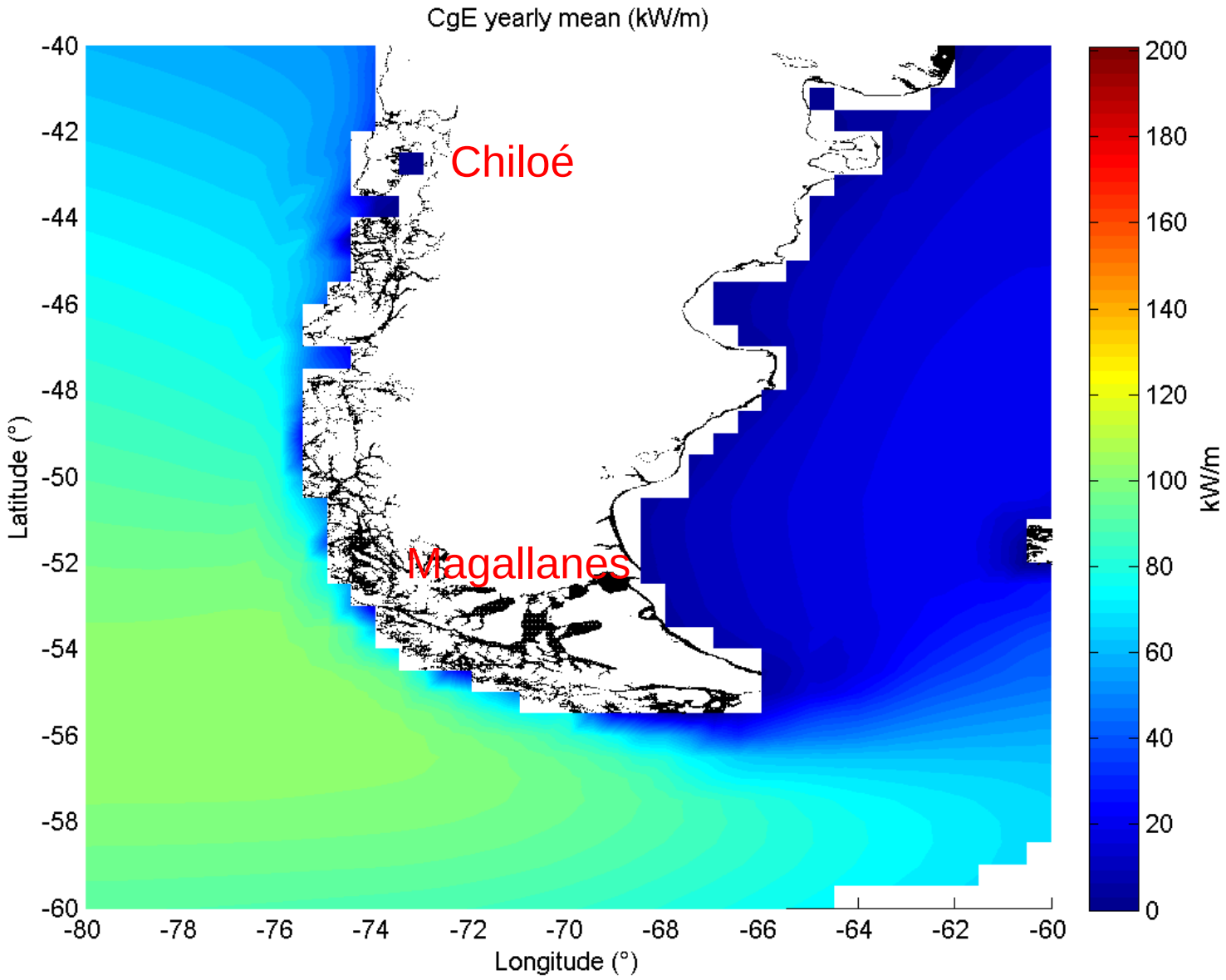
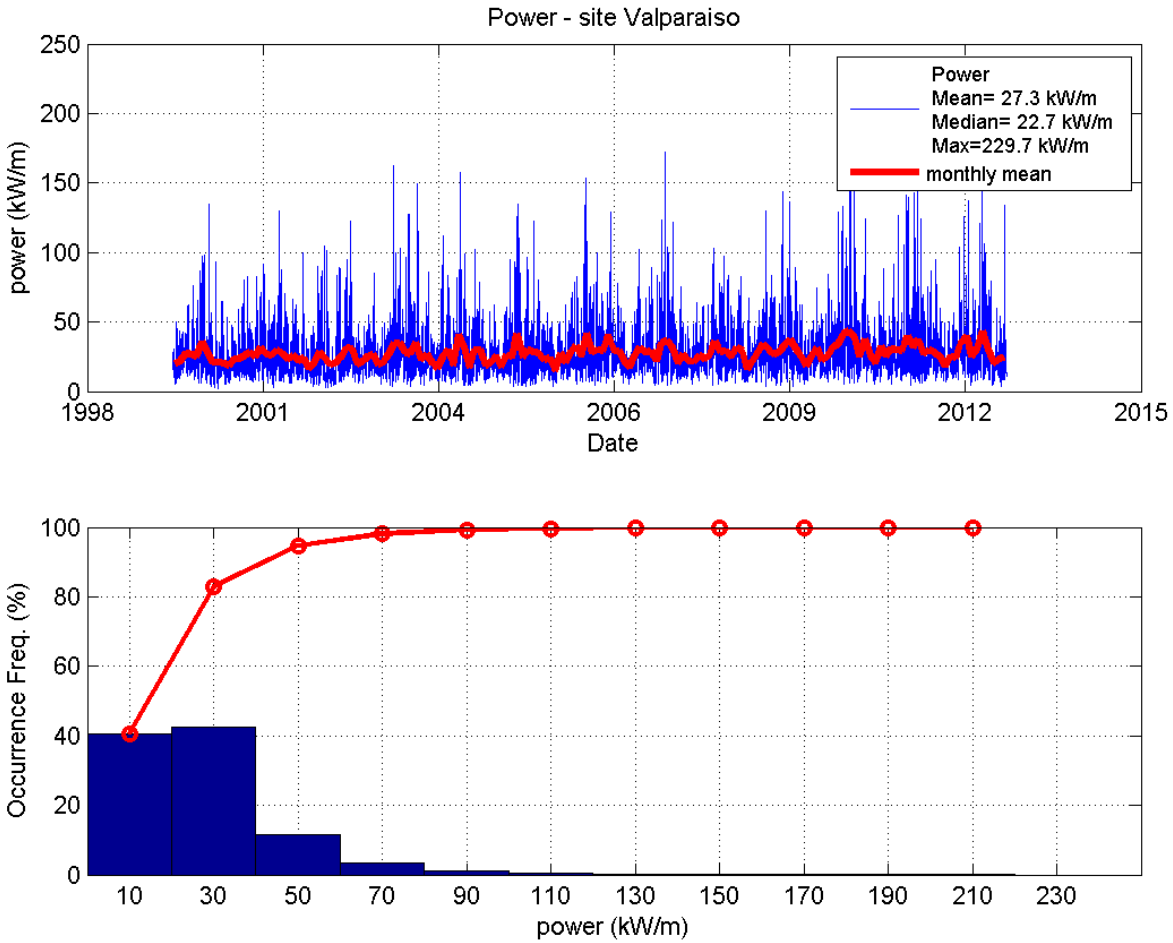
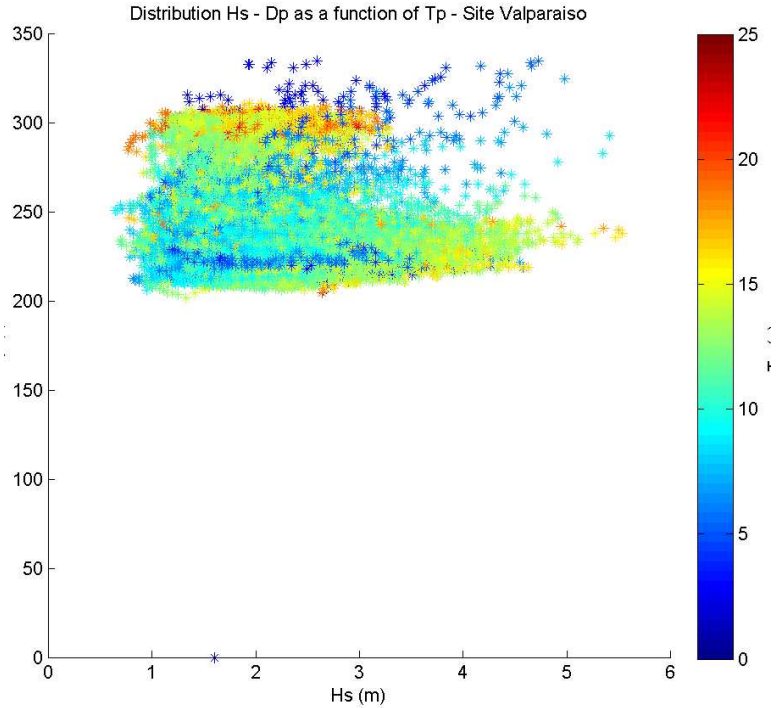
Case of the southern Chilean coasts



Wave energy resource assessment

Case of the Chilean coasts : Valparaiso





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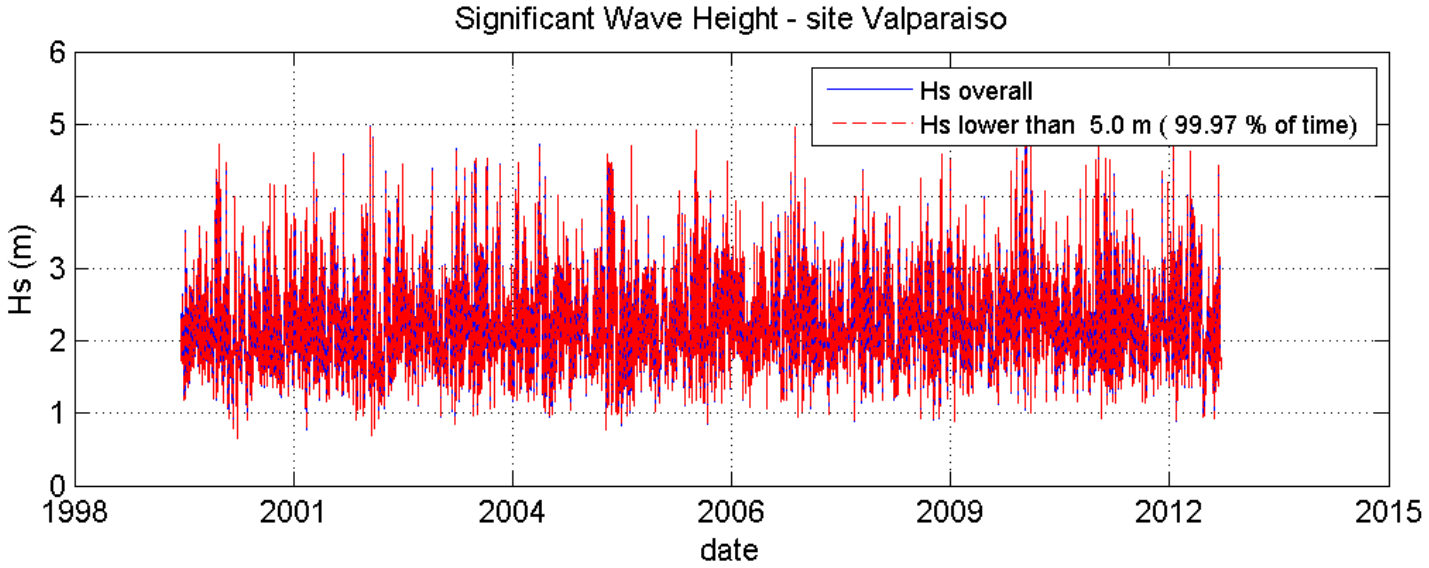
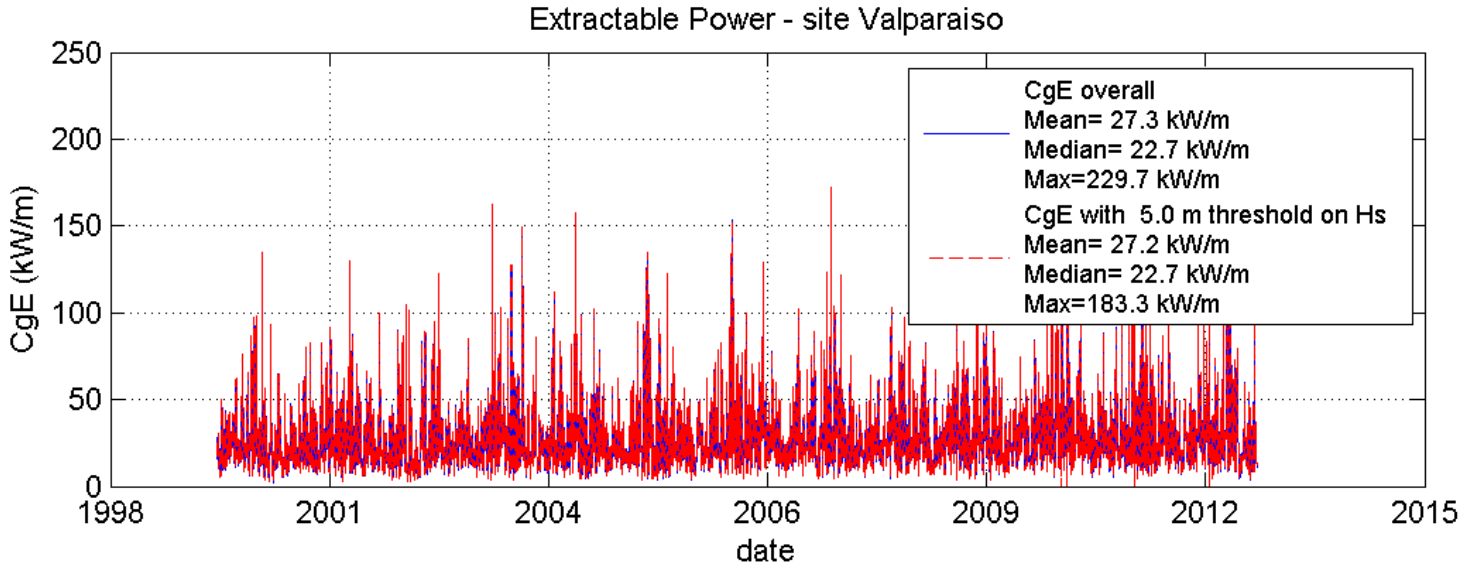
Wave energy resource assessment

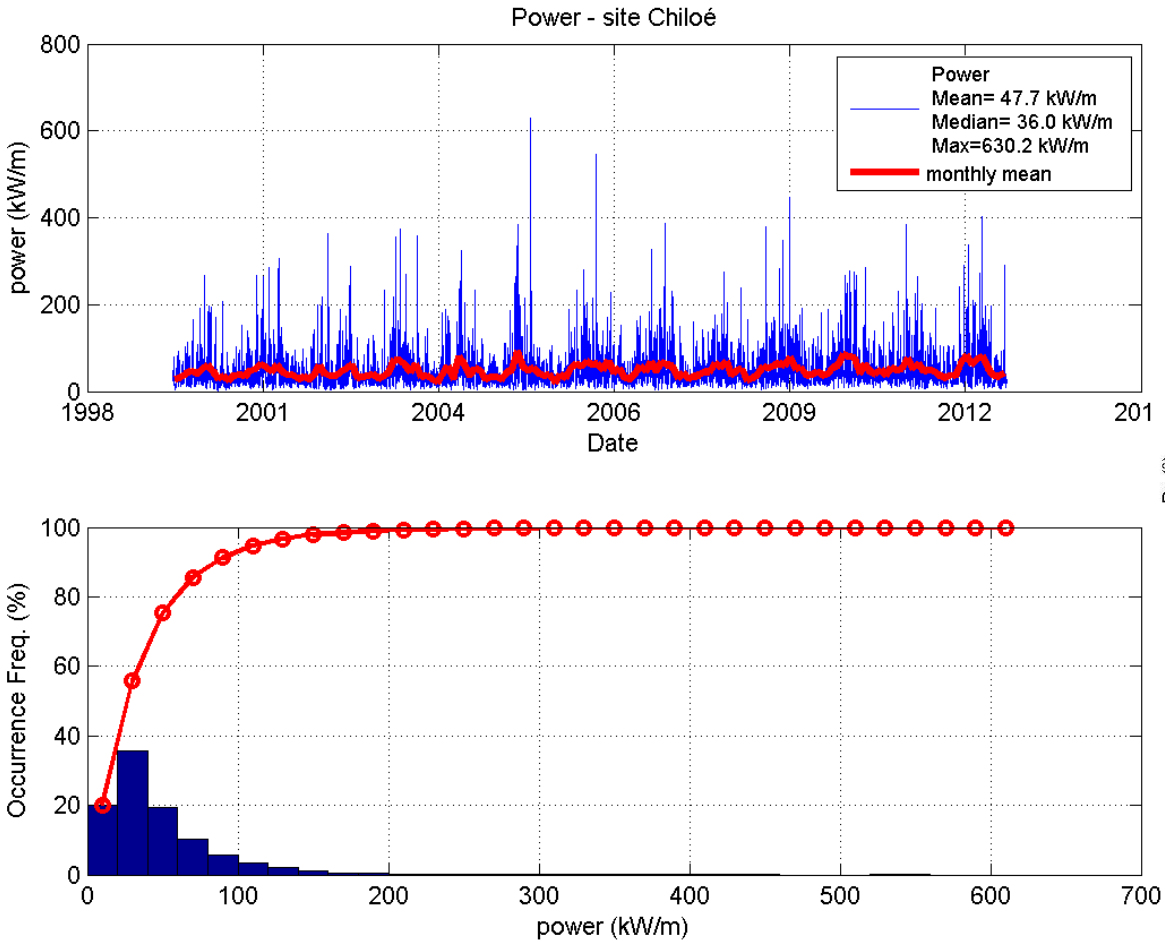
Case of the Chilean coasts : Valparaiso

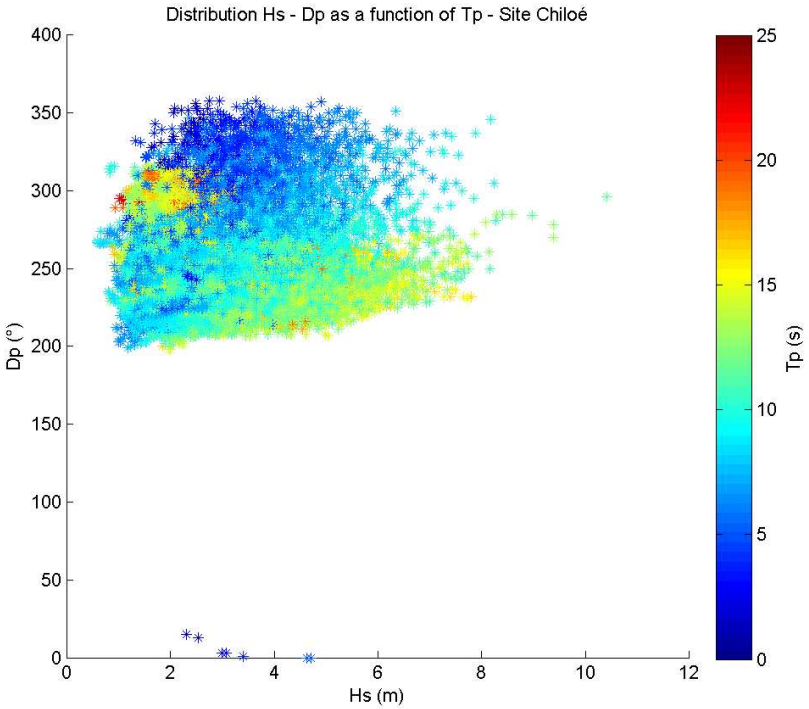




Wave energy resource assessment

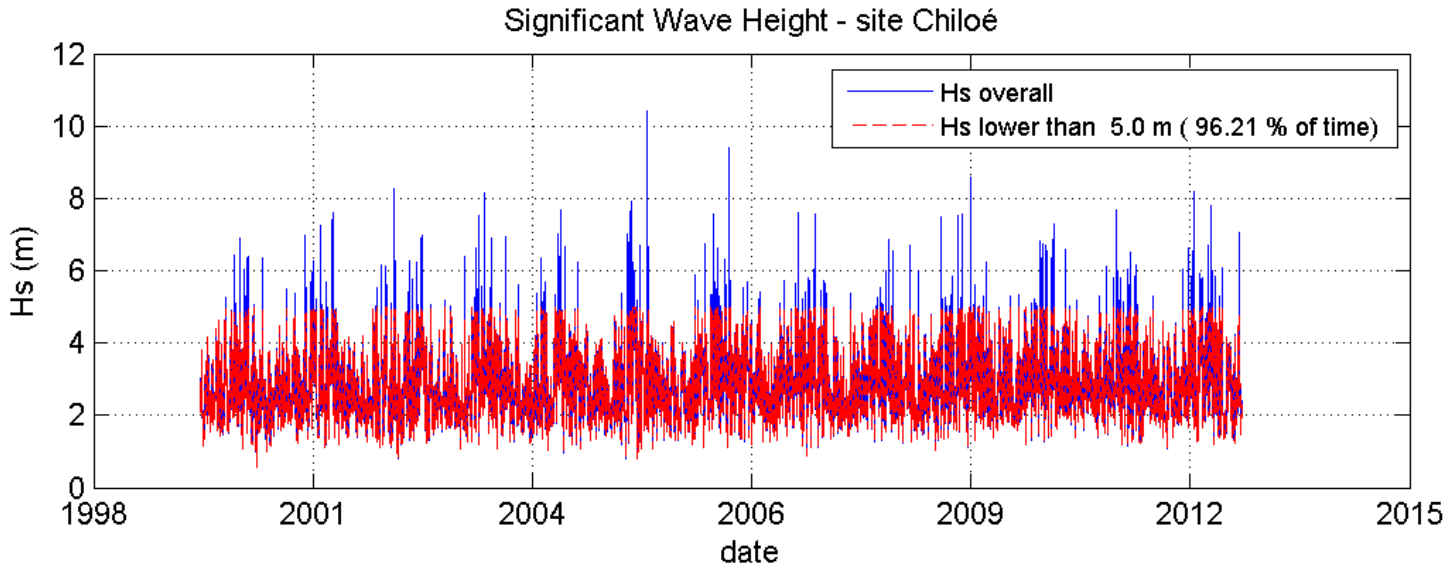
Case of the Chilean coasts : Chiloé

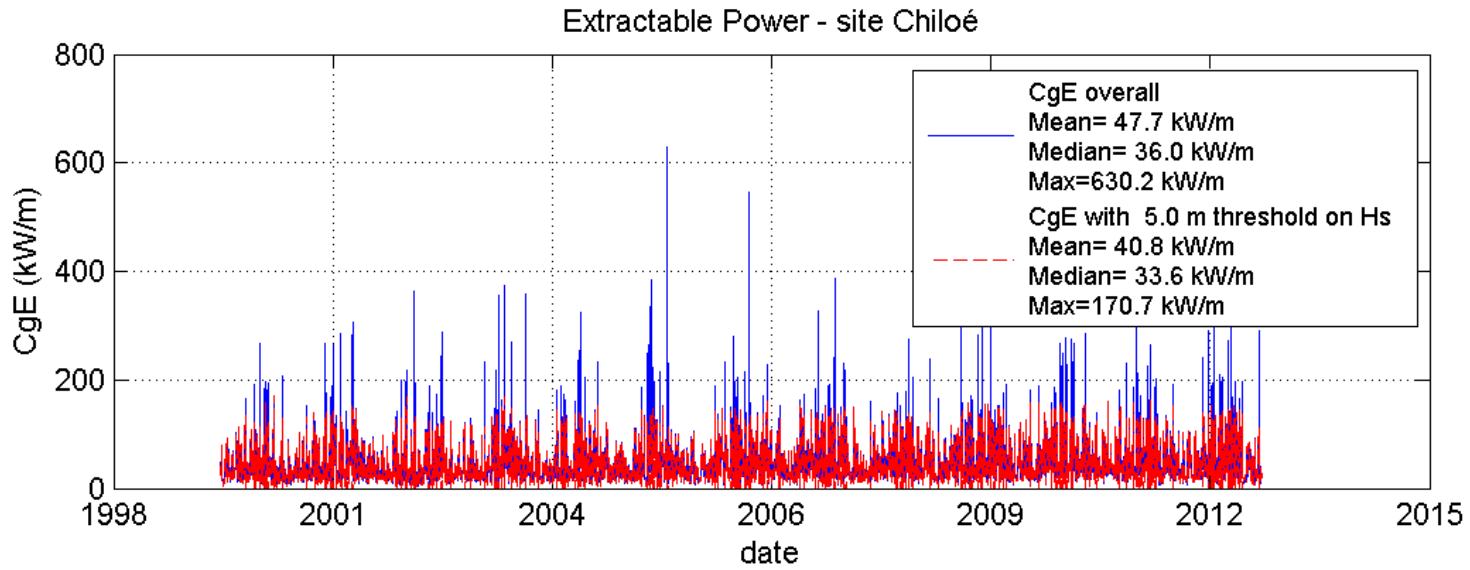




Wave energy resource assessment

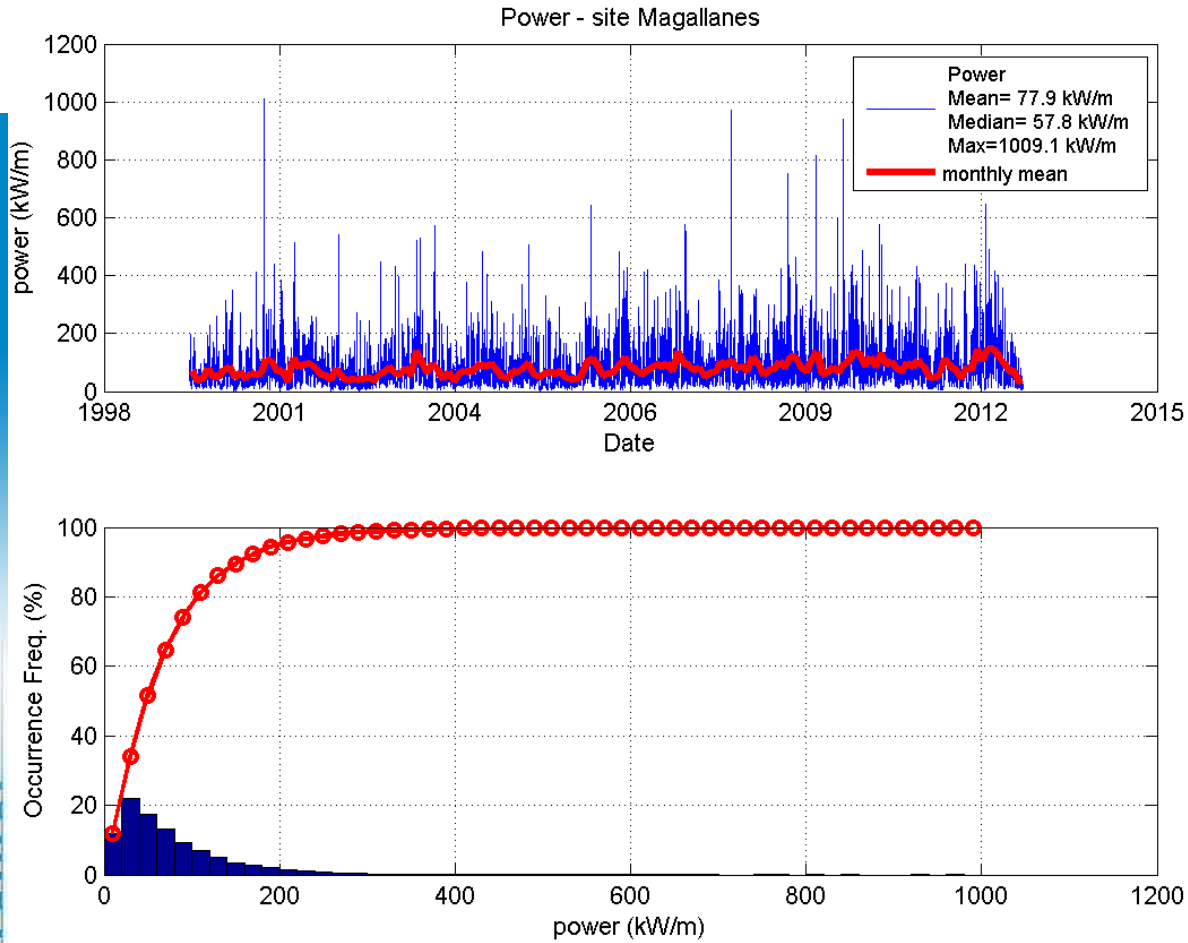
Case of the Chilean coasts : Chiloé

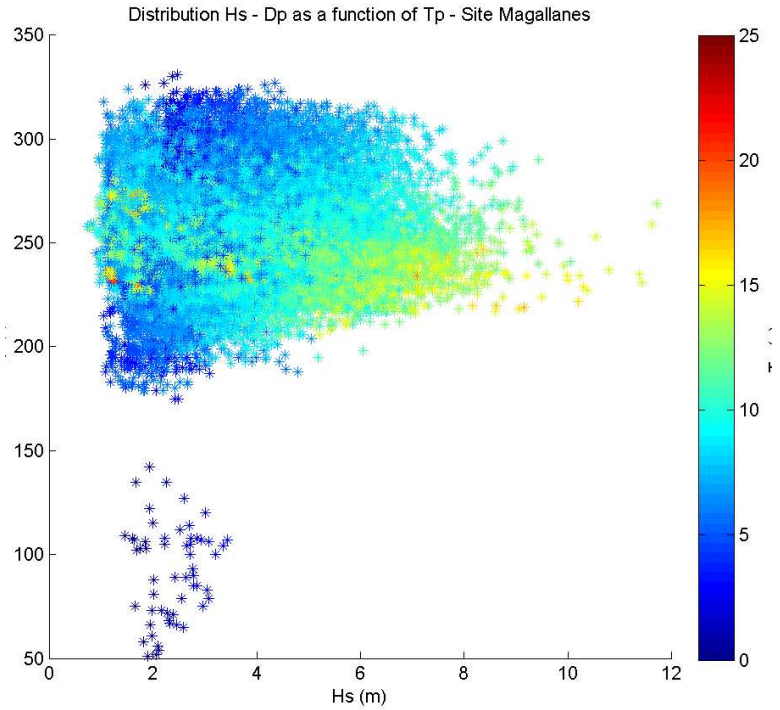




Wave energy resource assessment

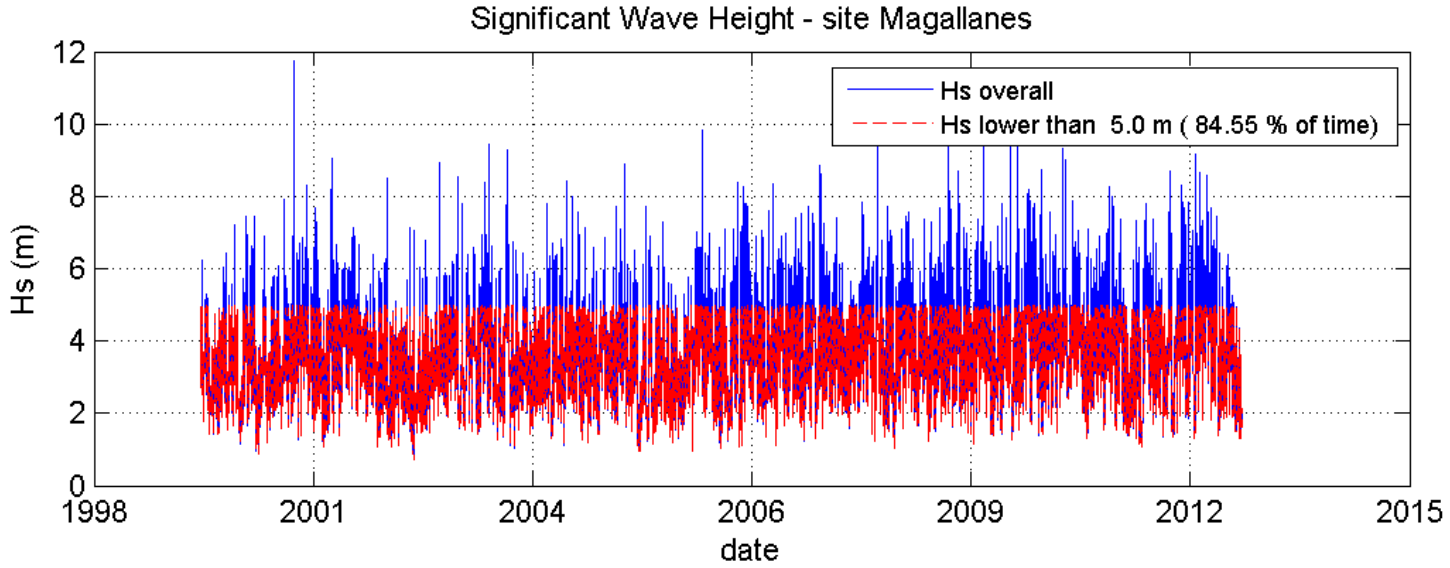
Case of the Chilean coasts : Magallanes

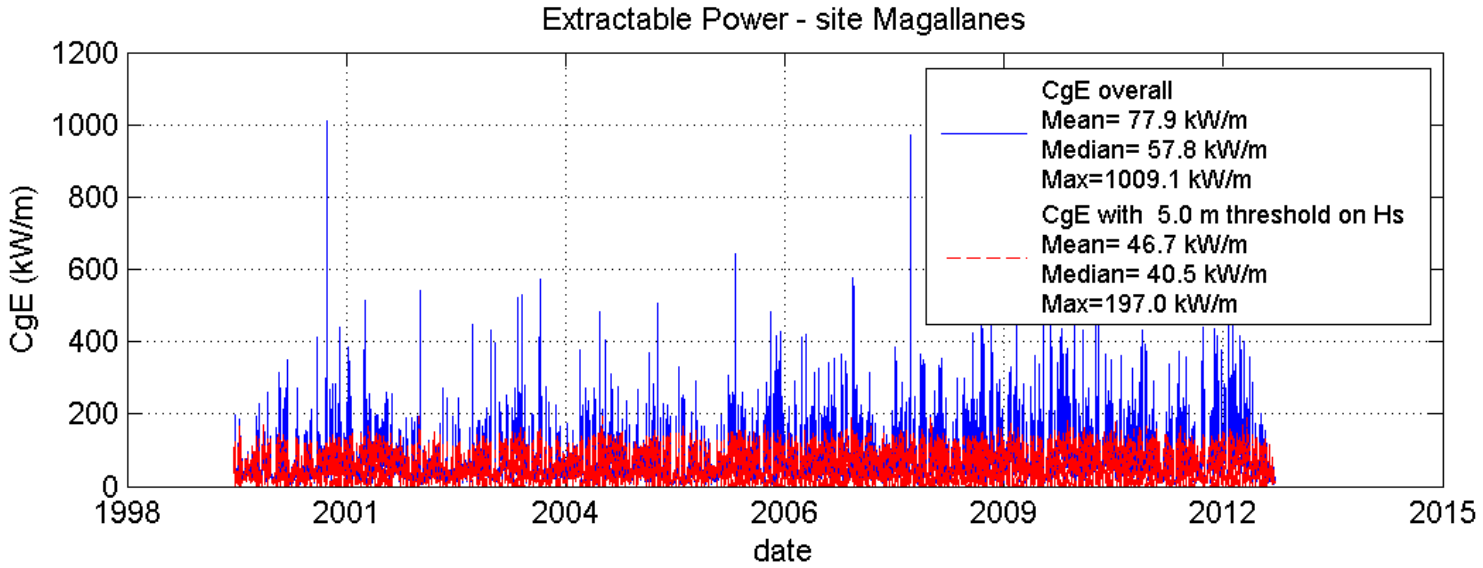




Wave energy resource assessment

Case of the Chilean coasts : Magallanes





Wave energy resource assessment

Case of the Chilean coasts :

Valparaiso : 27 kW/m yearly average

Low to medium rate of wave energy,

suitable for wind energy ?

Chiloe : 48 kW/m yearly average

Environmental aspects

Grid connection

Magallanes : 78 kW/m yearly average

Low population density and high energy level

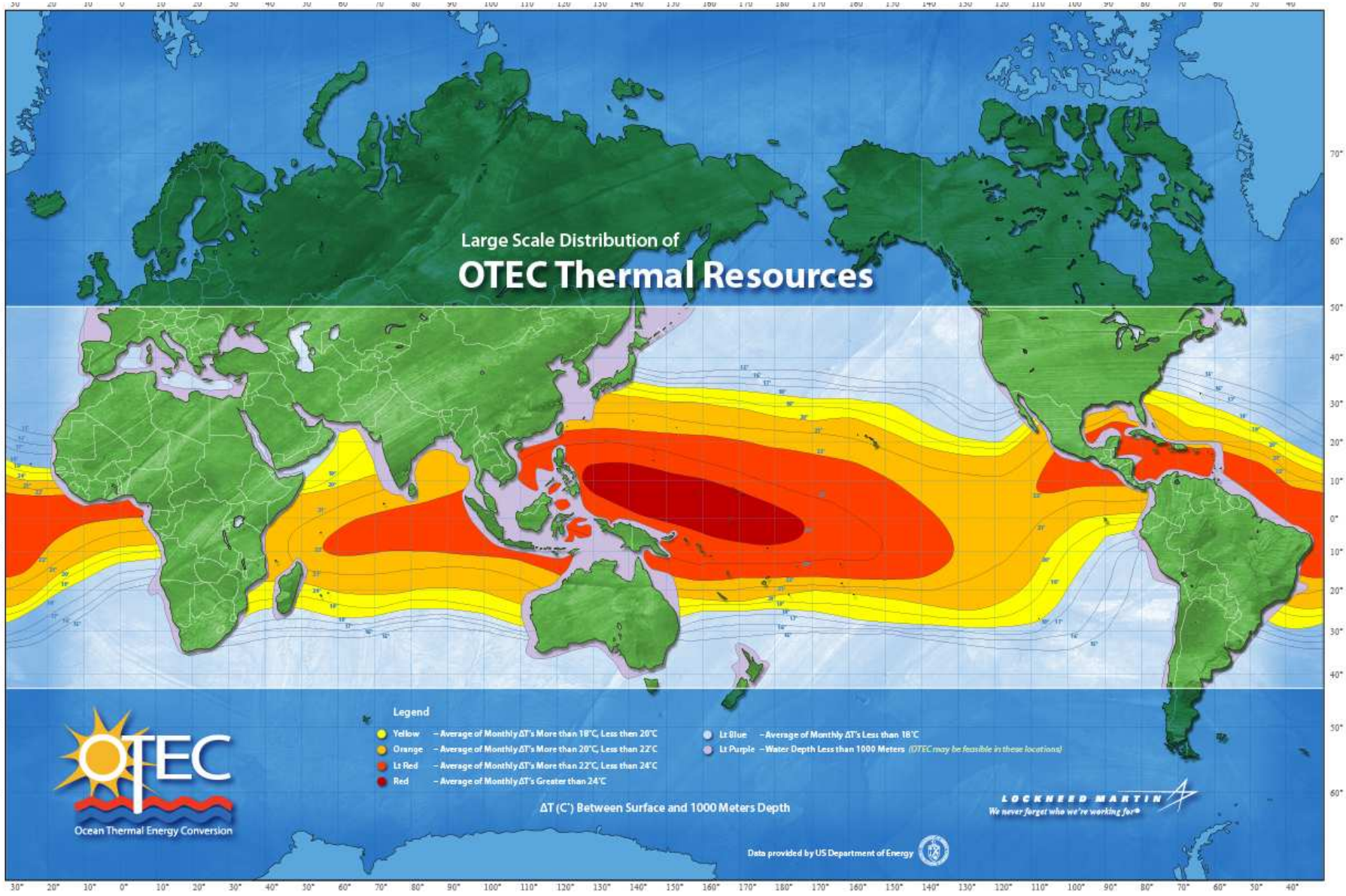
Energy transport

Grid connection

Survivability of structures

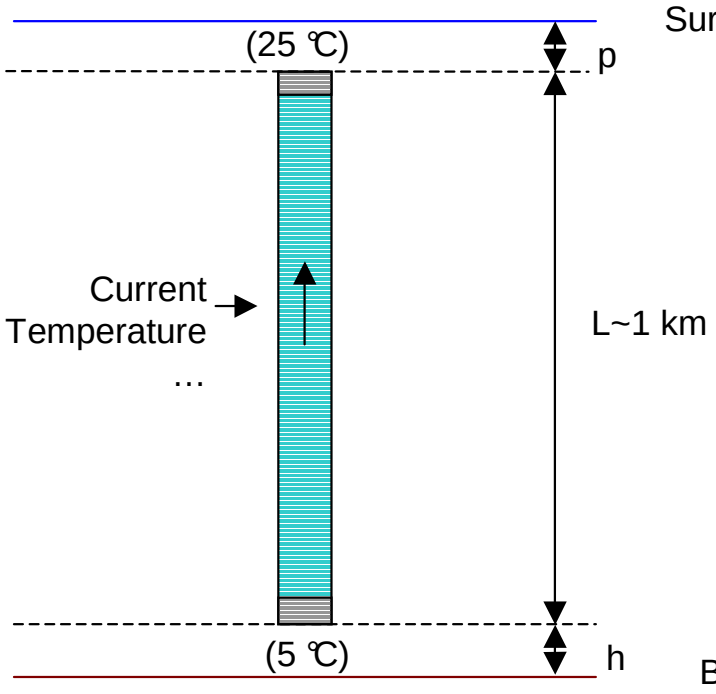
Ocean Thermal Energy Conversion

Inter tropical zone



Ocean Thermal Energy Conversion

Inter tropical zone



Technological barriers : **cold water pipe, heat exchanger, sea keeping**
costs (5 à 10 MW , 200 M€ ?)
energy transport on long distances (Hydrogen ?)

Other applications : SWAC Sea Water Air Conditioning in hot areas

Ocean Thermal Energy Conversion

Inter tropical zone

High energy potential

Today : high price level

Today : suitable for islands with highest population

Very low population density in smaller Pacific islands

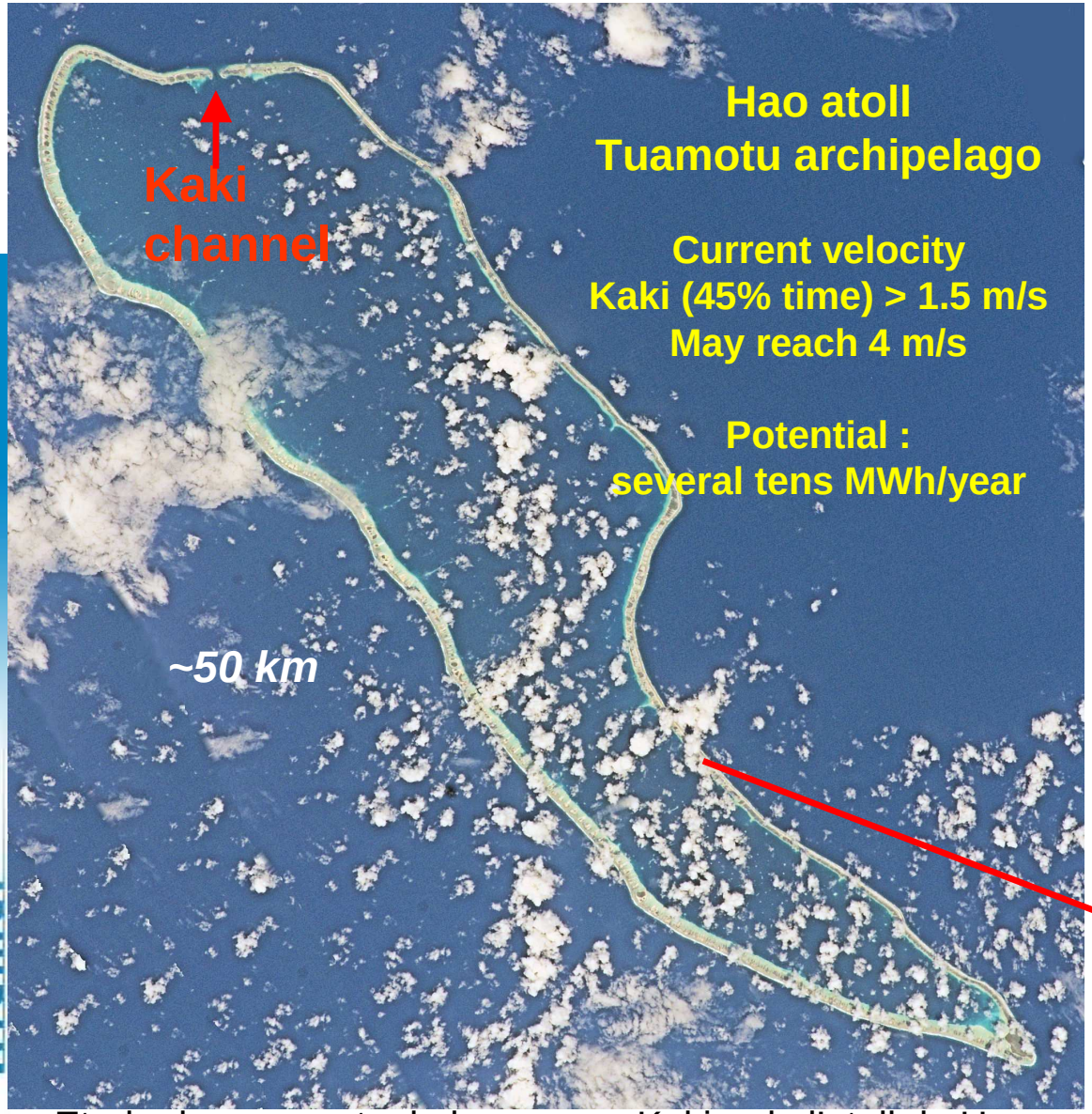
In case of high level energy production :

Export energy production (hydrogen ?)

Combine with new harbours

and with maritime transport

Waves and current energy : Atoll case

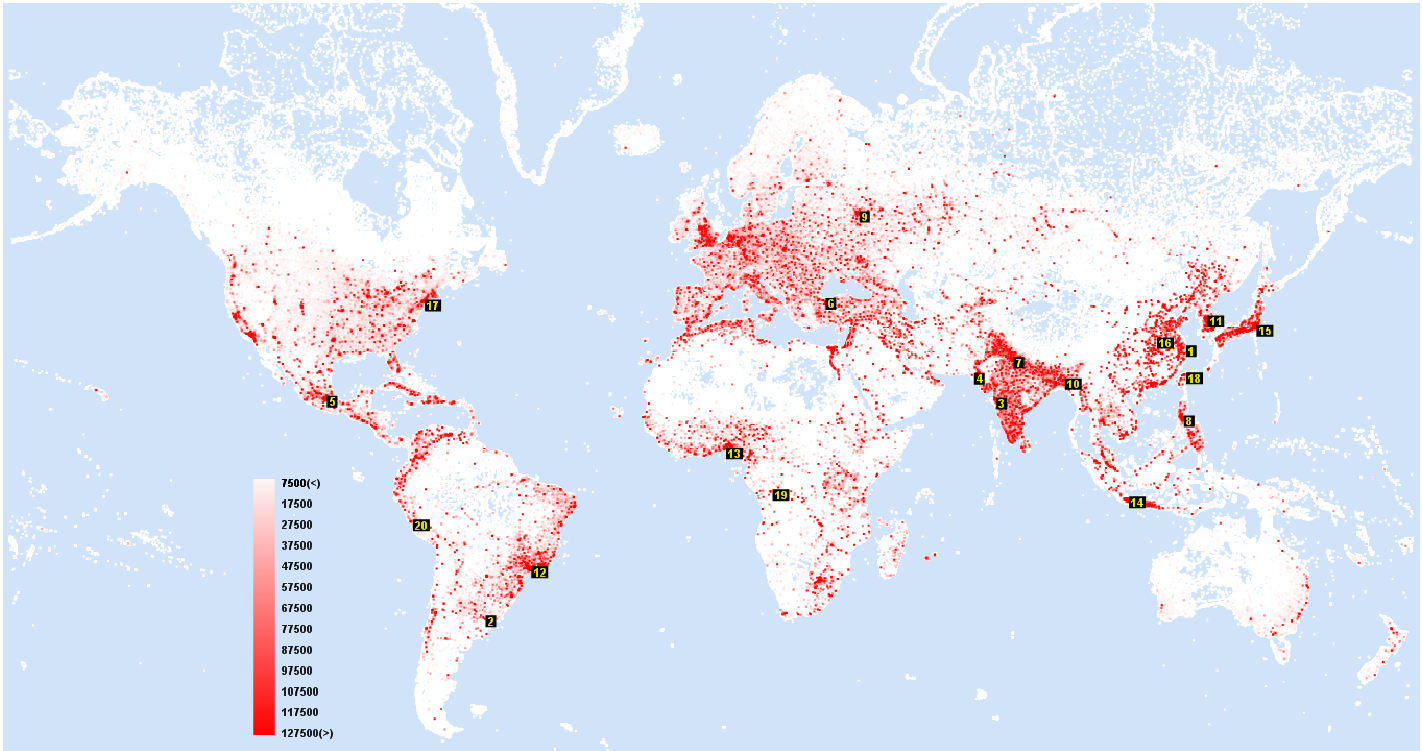


Atoll lagoon flushing mechanism : combination of tidal effect and wave breaking on the barrier and currents through the hoas.

Possible exploitation :
- **main channel current**
- **hoas currents**

Etude des courants de la passe « Kaki » de l'atoll de Hao
Evaluation du gisement hydrolien
Ifremer - Auteurs : Damien MARIGLIANO, Marc TAQUET

Population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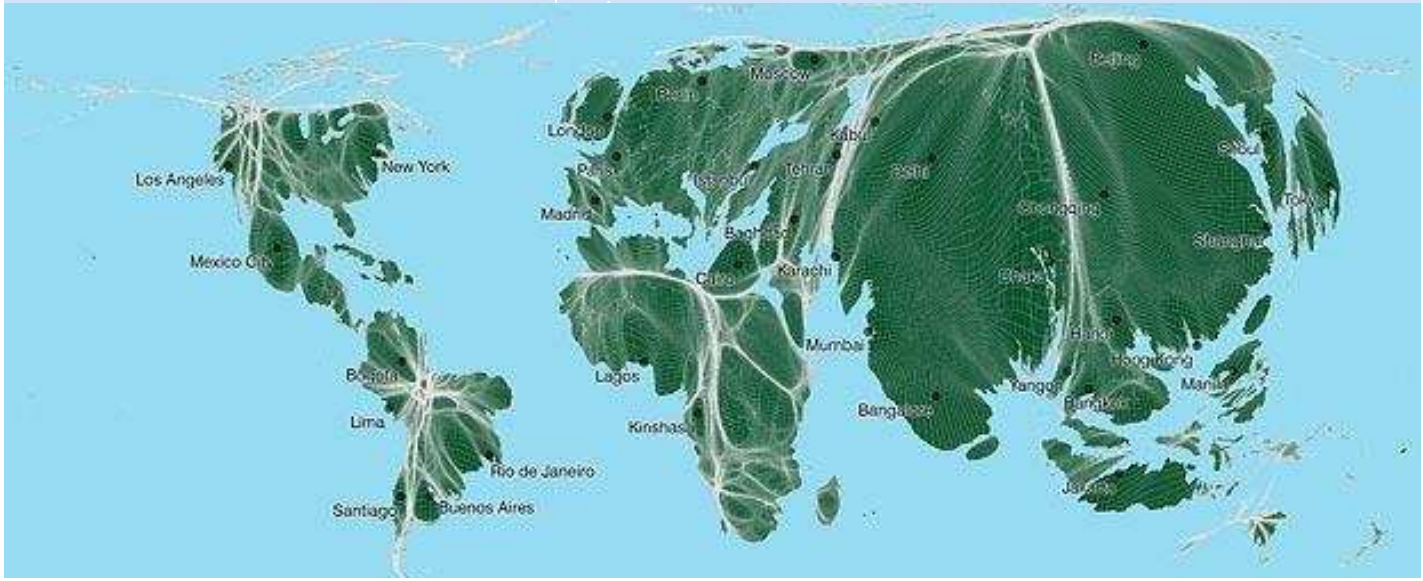
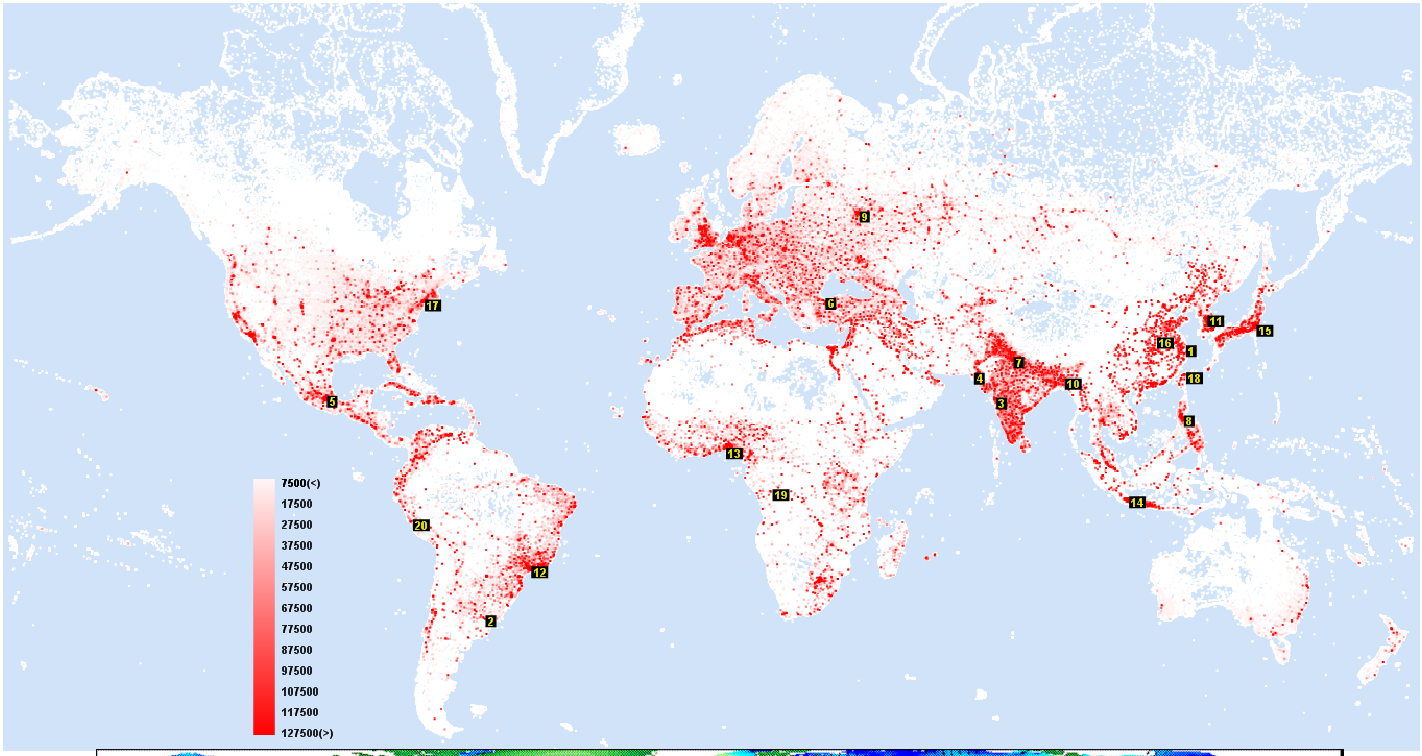
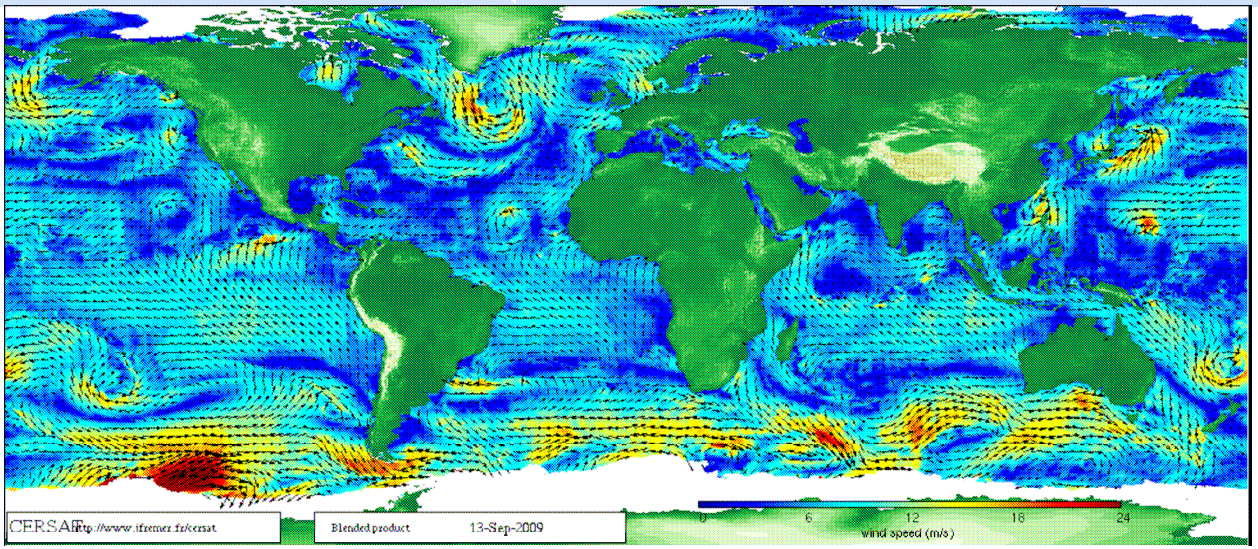
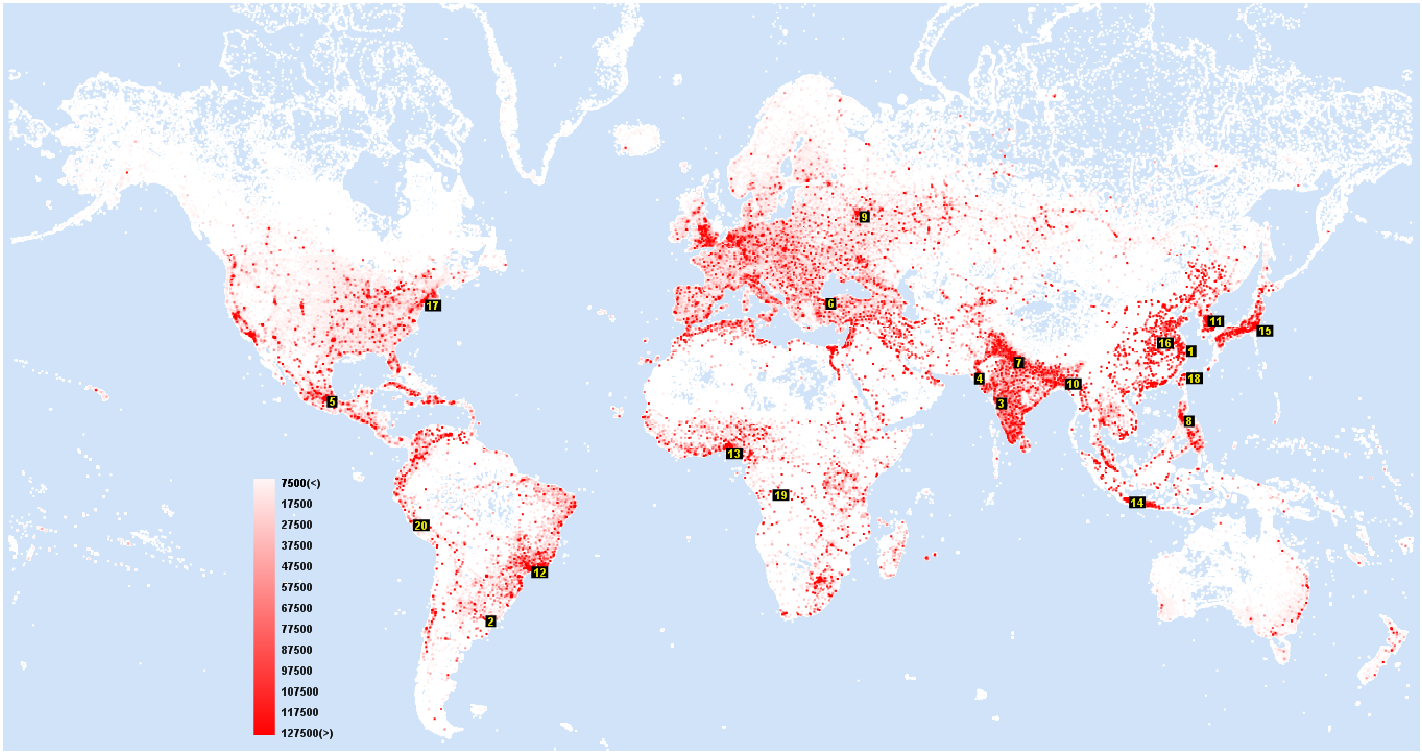

Los Angeles
New York
Mexico City
Bogotá
Lima
Rio de Janeiro
Santiago
Buenos Aires
Lagos
Kinshasa
Mumbai
Karachi
Tehran
Moscow
London
Madrid
Beijing
Shanghai
Tokyo
Jakarta

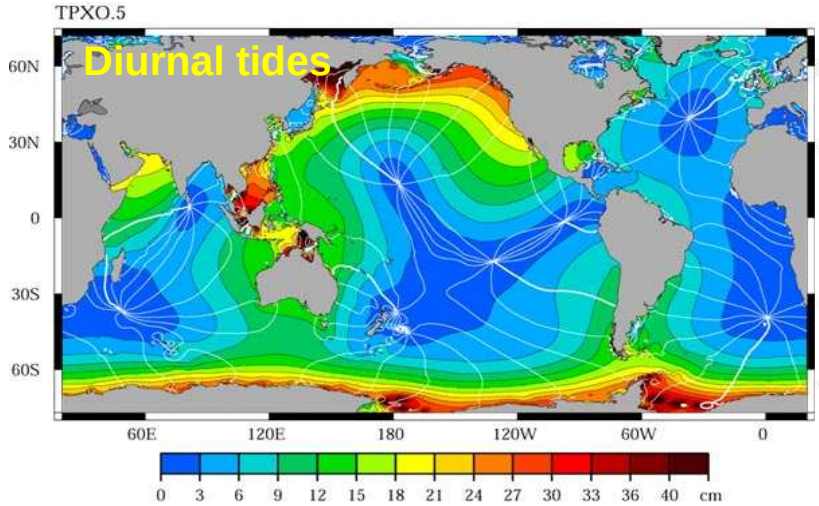
Population - Wind energy

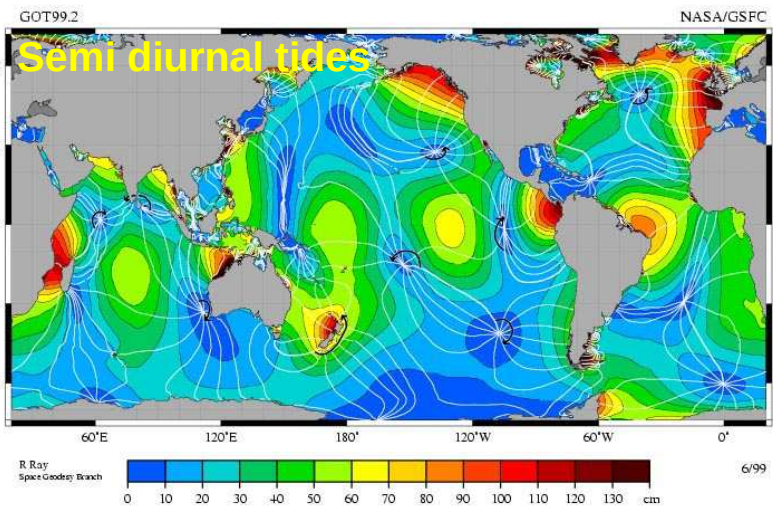




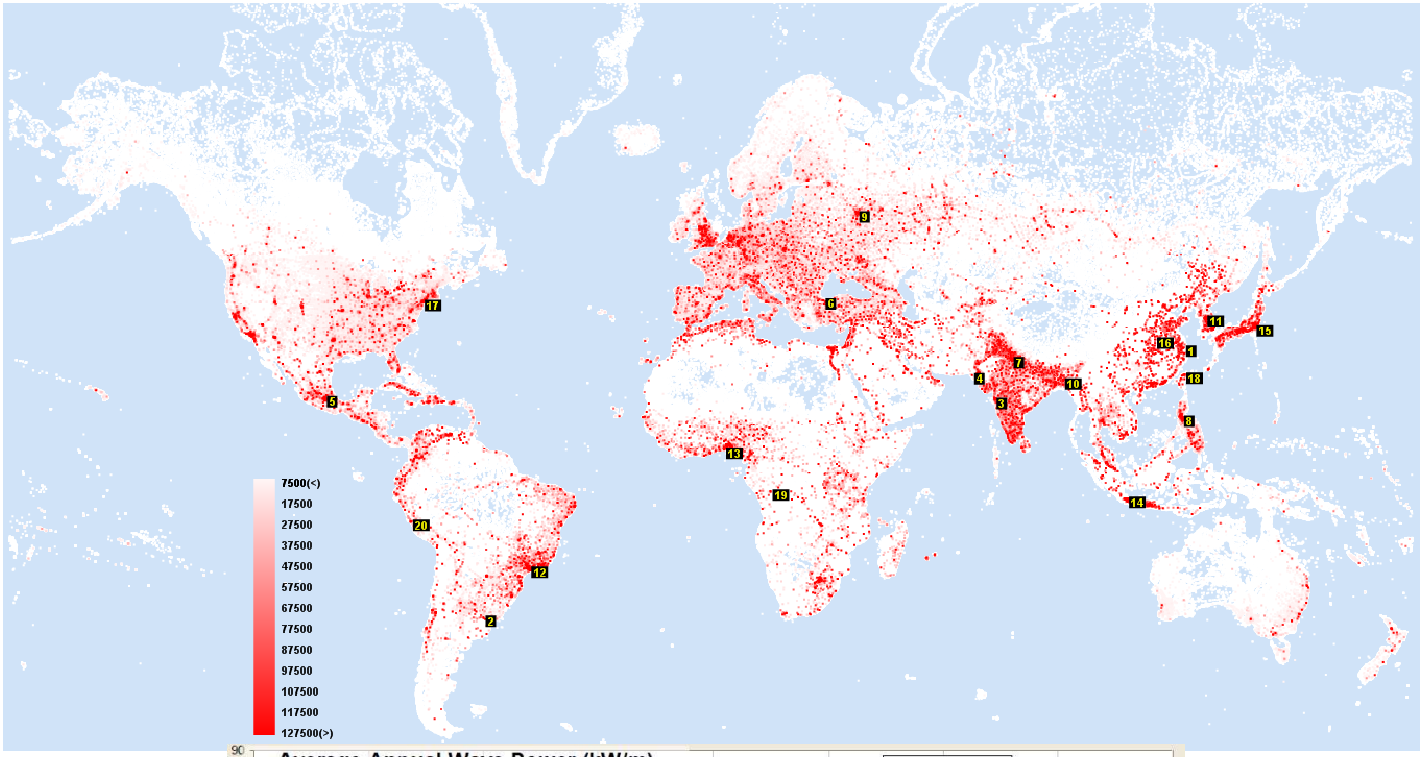
Population – Marine currents energy

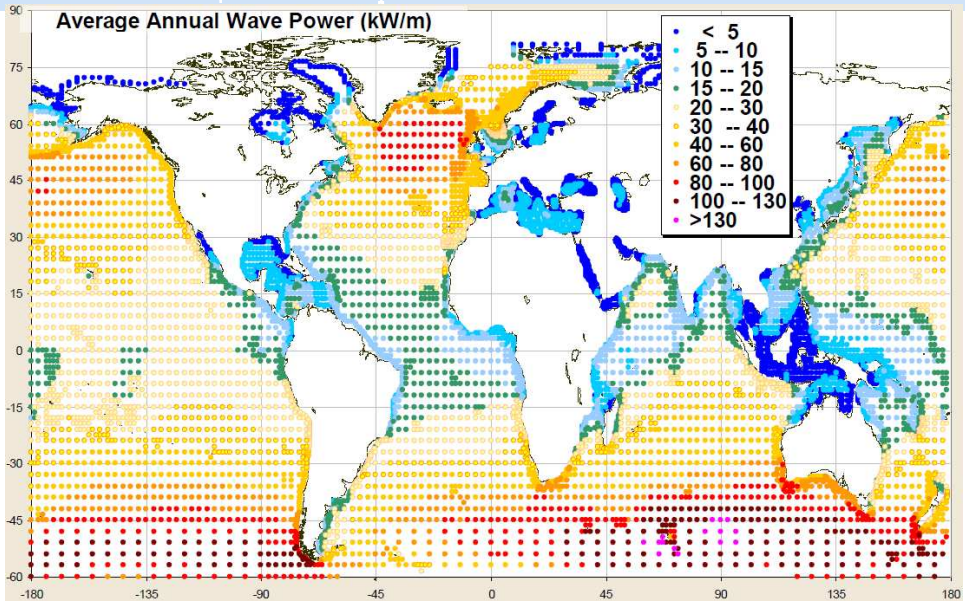




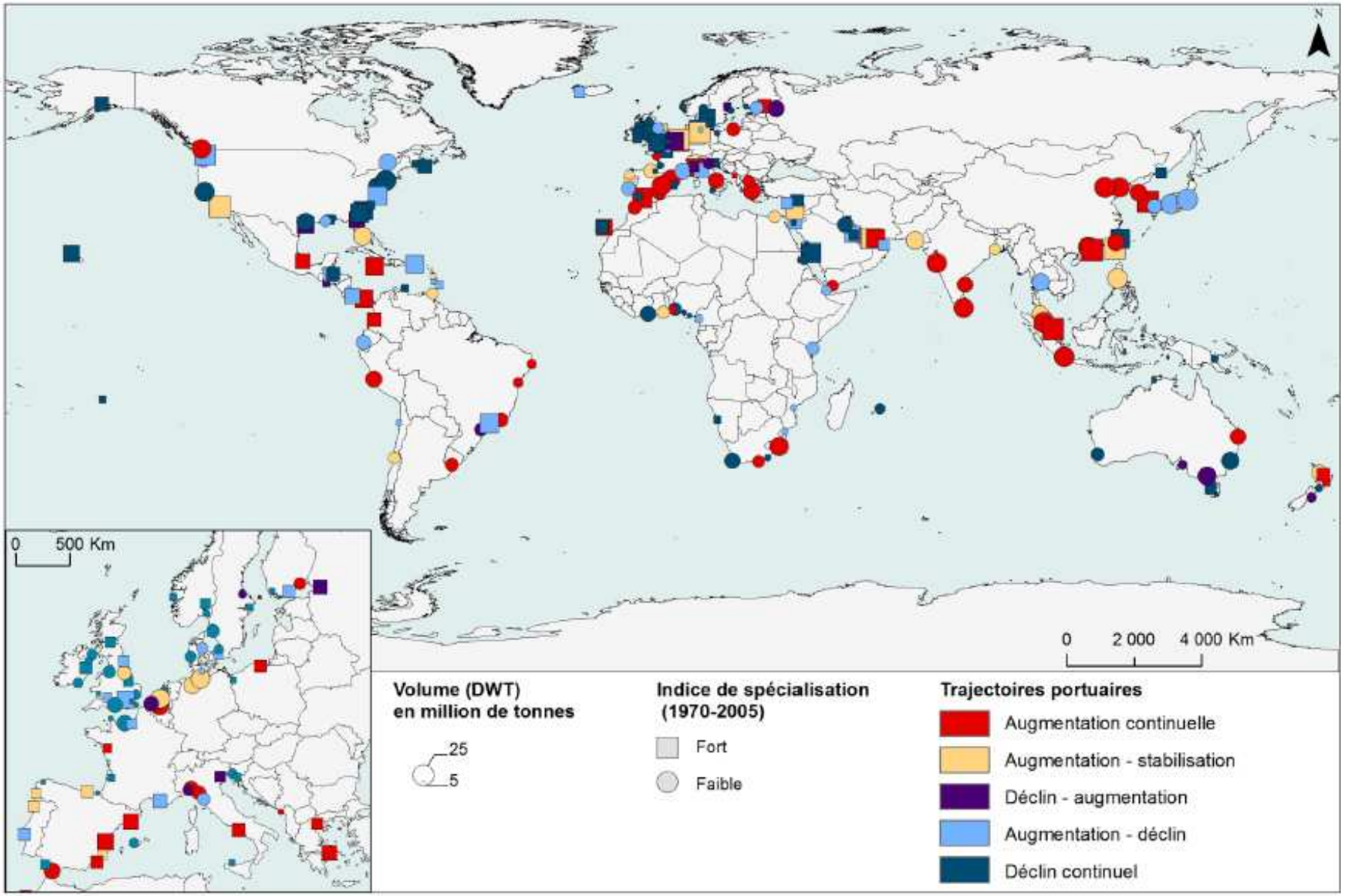


Population – Wave energy



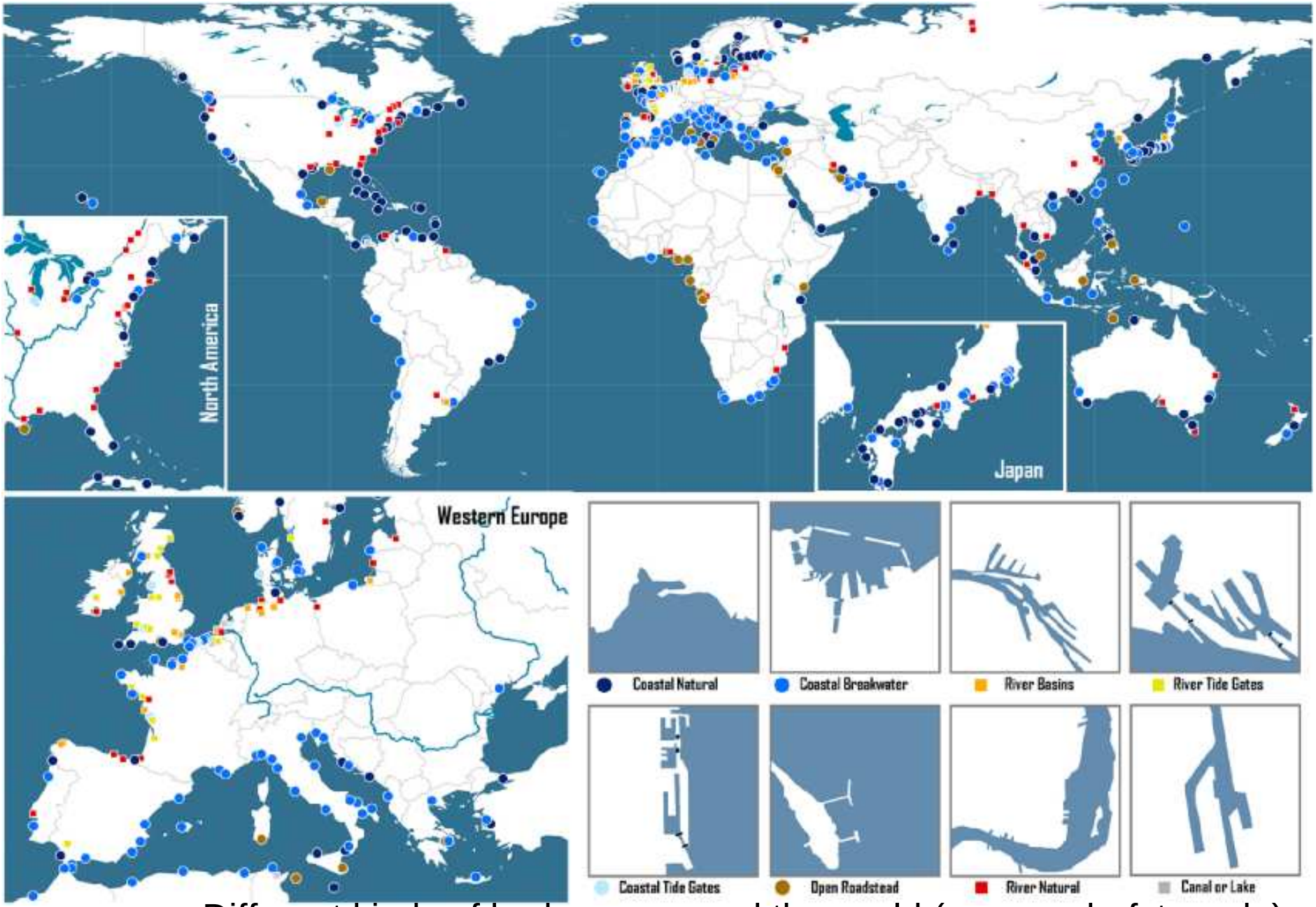


Infrastructures : harbours



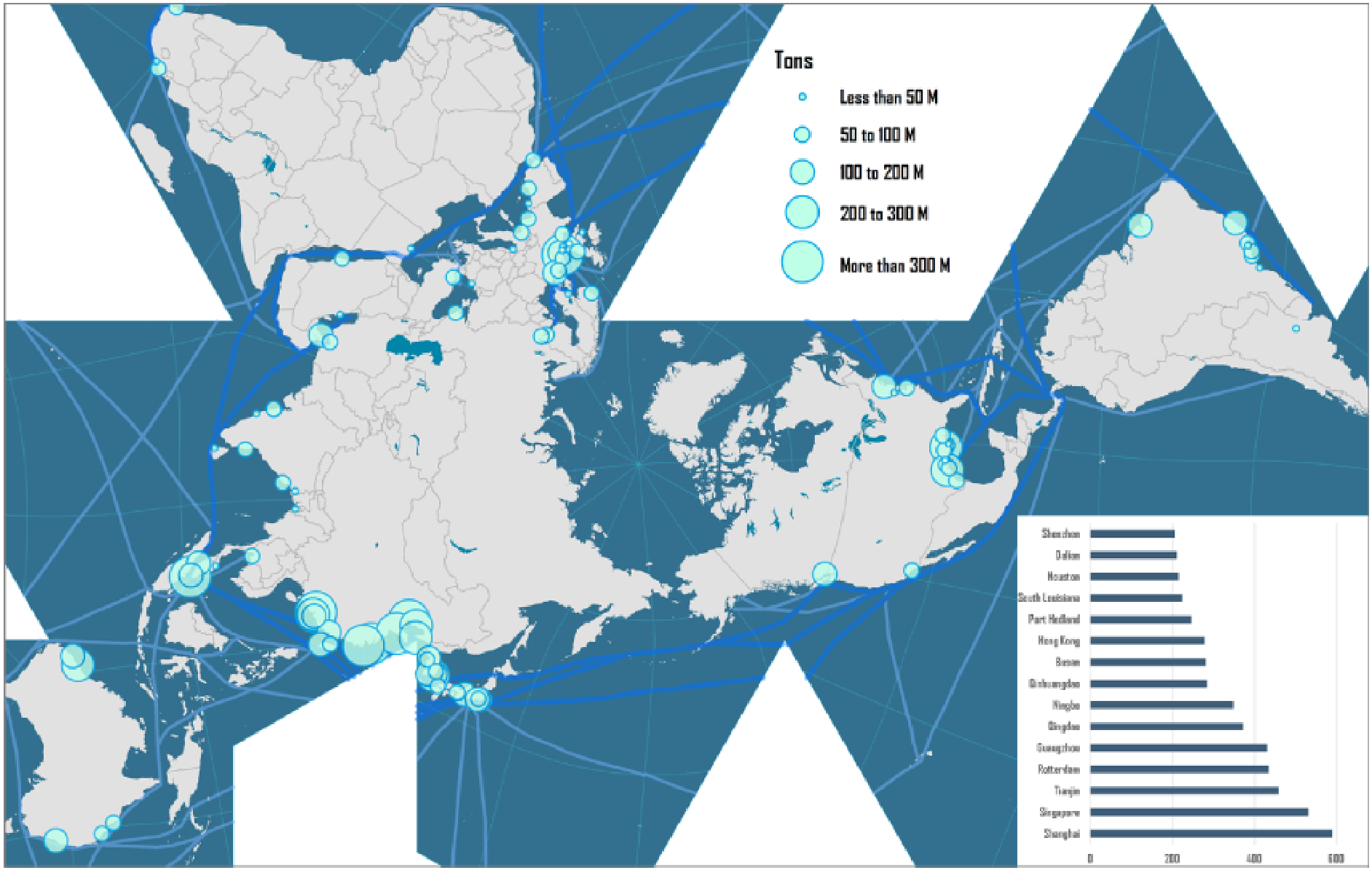
Expanse or decline of harbours (source : Ducruet 2011)

Infrastructures : harbours and maritime transport



Different kinds of harbours around the world (source : hofstra.edu)

Infrastructures : harbours and maritime transport

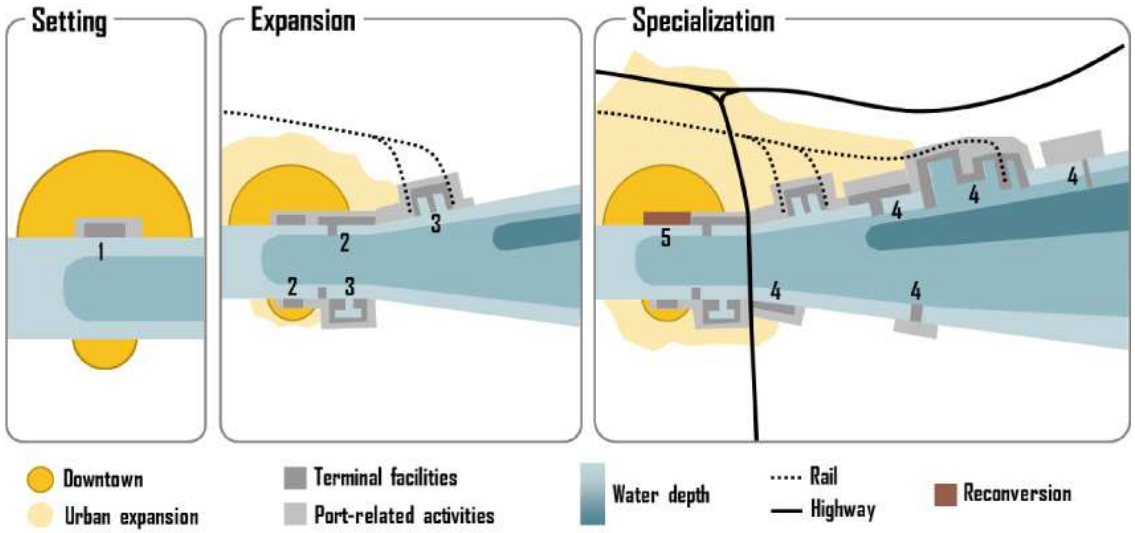


Main maritime transport network (source : hofstra.edu)

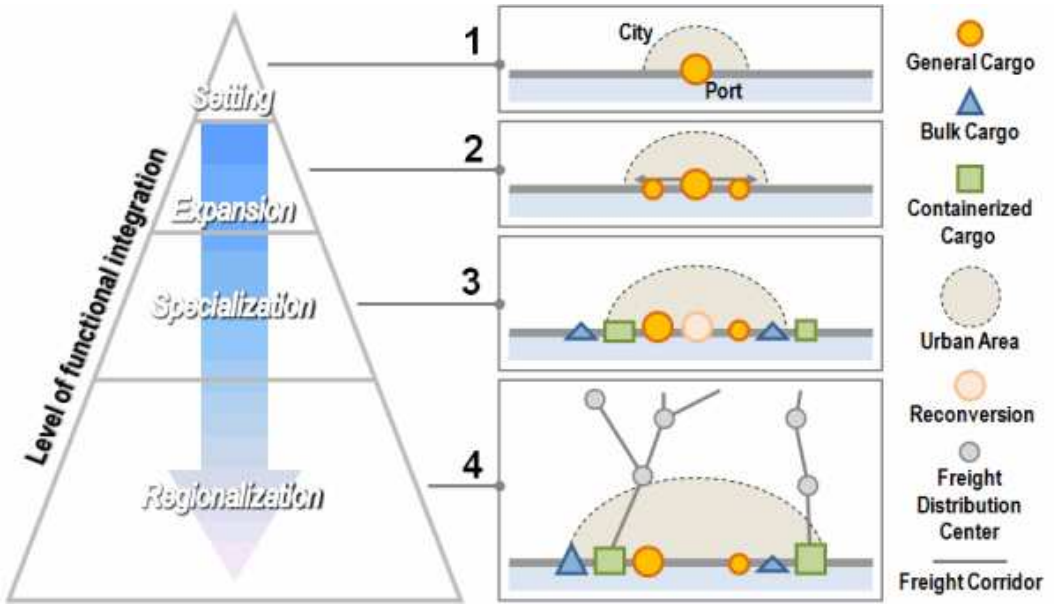
Infrastructures : harbours

The “Anyport” model

(Bird 1963 revised by various authors, eg Ducruet 2011)



Bird’s Anyport model can be broken down into three distinct stages : setting, expansion and specialization
Source: Bird, 1963



An adapted version of Anyport model including stage 4 – Regionalisation
Source: Notteboom & Rodrigue, 2005

Infrastructures : harbours and maritime transport

Could harbours and maritime transport include Marine Renewable Energy ?

- MRE as an energy source for harbours from harbours
  (see French EMACOP project
  Energie Marine Côtière et Portuaire
  Coastal and harbours Marine Energy)

- MRE as an energy source for maritime transport including new “fuel” (Hydrogen, Marine Biomass)

Conclusion on 'The best locations worldwide'

Marine Renewable Energies =
Multidisciplinary field for research and development

Benefit from public-private collaboration (universities, industry,…).
Need for skilled manpower.

Benefit from existing infrastructures (harbours, maritime transport, shipyards,…) and should impulse their development.

Places with high level population and medium to high energy resource level play an essential role.

Places with low level population and high energy resource level need for innovative energy storage and transformation and transport methods.

Consider scattered habitats with reduced energy requirements.

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Thank you for your attention

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