



RESOURCECODE

MARINE DATA TOOLBOX

EWTEC Side Event

Matt Storey

European Marine Energy Centre

06.09.2021



THE UNIVERSITY
of EDINBURGH



Agenda

- RESOURCECODE project general presentation - Matt Storey, EMEC (10 mins)
- RESOURCECODE Marine Data Toolbox presentation - Nicolas Raillard, IFREMER (15 mins)
- RESOURCECODE hindcast database, Mickaël Accensi, IFREMER (15 mins)
- RESOURCECODE Marine Data Toolbox demo, Nicolas Raillard, IFREMER (20 mins)
- Q&A (30 mins)

RESOURCECODE OVERVIEW & OBJECTIVES

The aim of RESOURCECODE is to create an integrated marine data toolbox that will enable developers of ocean energy devices and arrays, and their suppliers, to make optimised technical and commercial decisions.

The project brings together an international consortium of businesses and Marine Renewable Energy (MRE) test sites supported by established academic partners that seek to increase the competitiveness of wave and tidal energy across Europe.



The RESOURCECODE Consortium

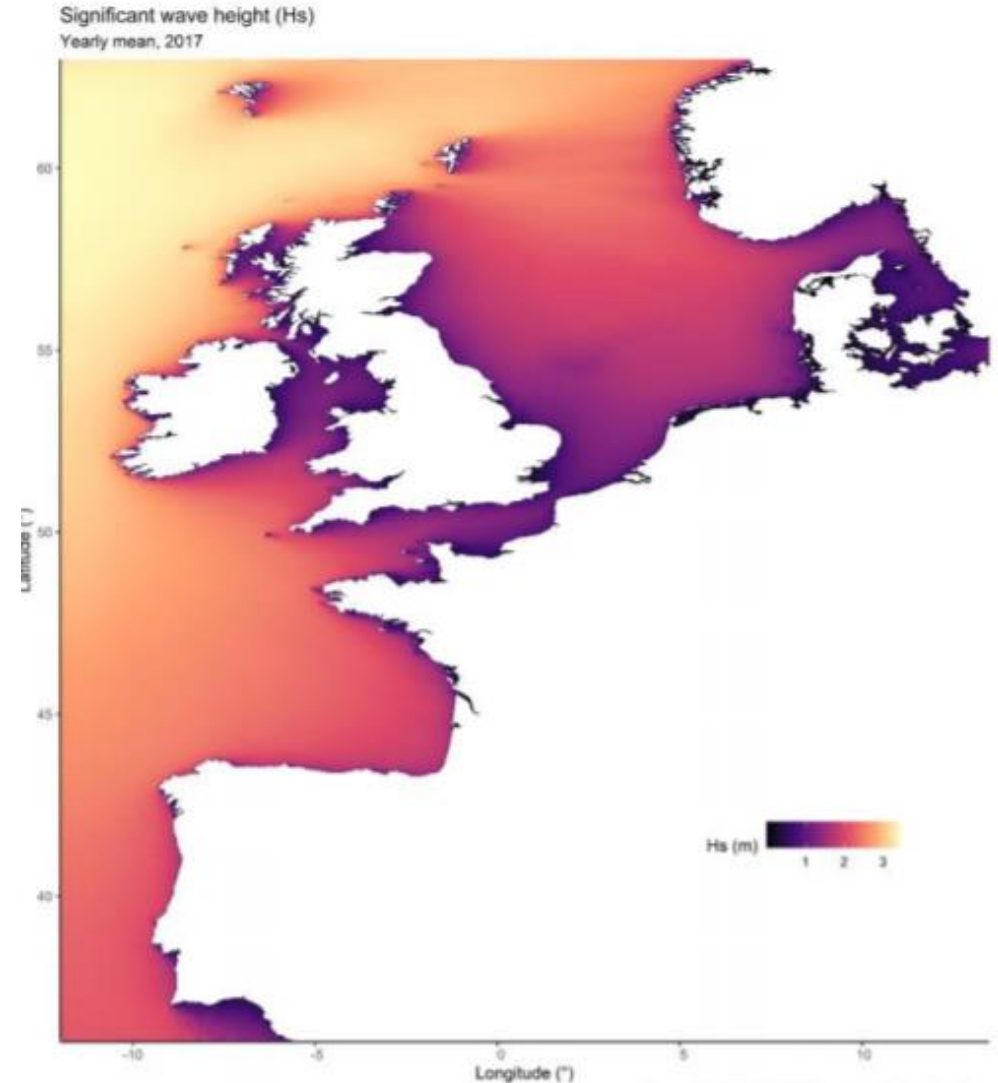
The RESOURCECODE consortium draws upon academic and technical expertise from across Europe with universities, industry leaders and test centers represented. The project is lead by the European Marine Energy Centre (EMEC).



The RESOURCECODE Deliverables

The RESOURCECODE project has two high value, technical deliverables combined tools, resources and data sources

- A calibrated, verified, hindcast dataset on a flexible mesh providing comprehensive wave data across Western Europe
- An “all in one” easy-to-use Toolbox, linked to the data set, allowing for quick and easy calculations
- Aimed at developers, academics and technical specialists across the industry



Outcomes for the industry

The RESOURCECODE project adds value across the wave energy industry through trusted, useable hindcast data and toolbox, increasing confidence and lowering barriers to entry

- **Open source:** Public access to an extensive wave dataset for Northwest Europe.
- **Cost:** Reduce design and development costs for the marine renewable sector.
- **Reliability:** Reduce uncertainty in expected environmental conditions and de-risk investment in future technology designs.
- **Quality:** Providing reliable, traceable, validated data to support high caliber marine engineering development.
- **Knowledge:** Bringing together academic expertise, research test centres and industry leaders.

The RESOURCECODE next steps

Case trial

The RESOURCECODE Team intends to run more in detail, functionality and useability trials of data set and tool box with key users. We would be delighted for any users who wish to volunteer to take part, and shall be keeping our website updated with all the information and how to take part.



<https://www.resourcecode.info>

Up next

Learn about the hindcast data set.....



RESOURCECODE

MARINE DATA TOOLBOX

Marine Data Toolbox

Nicolas Railard

IFREMER

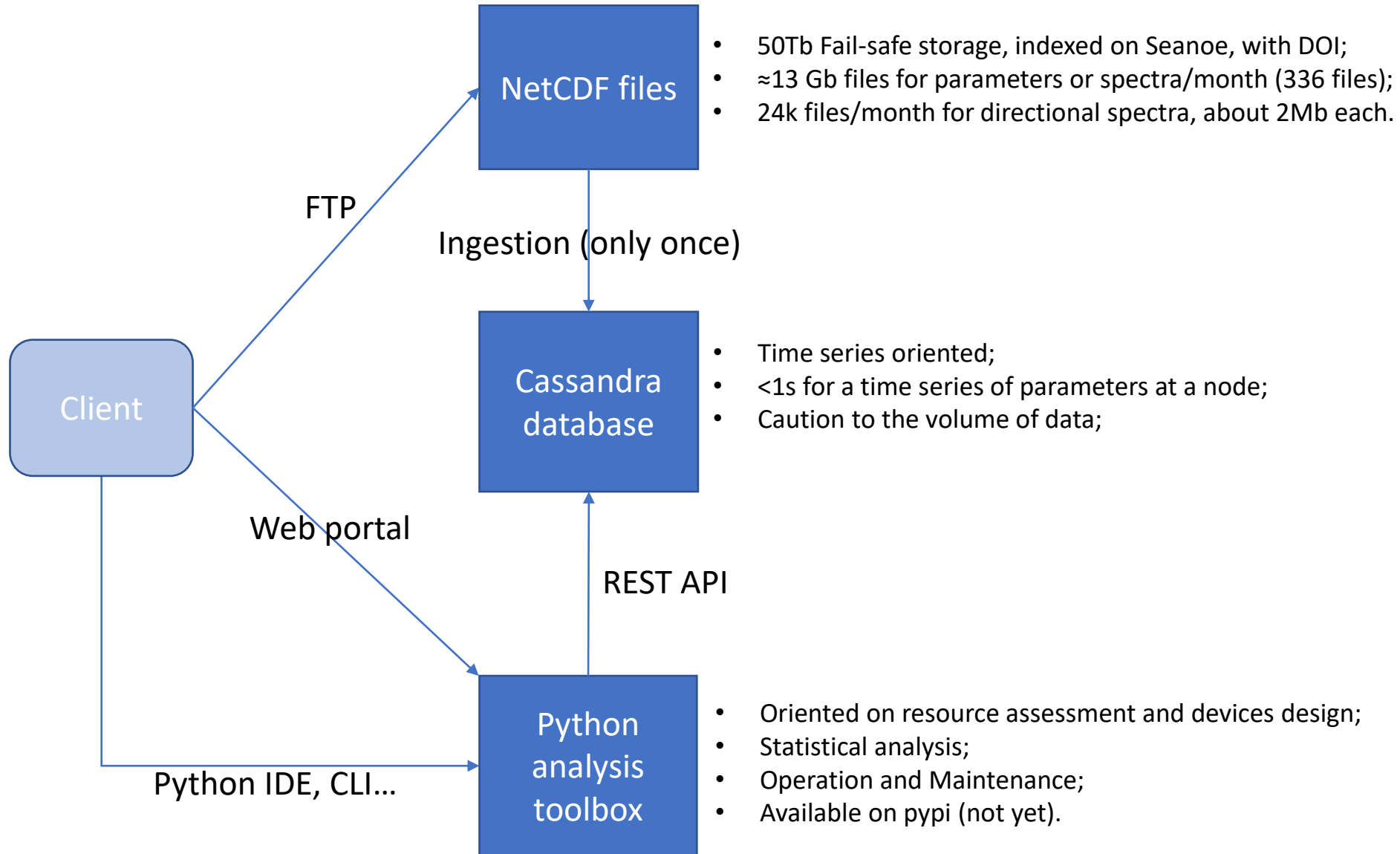
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Outline

- 1.Objectives of the Toolbox
- 2.Web portal for data access
- 3.Toolbox for statistical analysis

Objectives of the Toolbox:

- Provide an easy and quick access to the datasets
 - Dedicated web portal for user-friendly extraction and simple statistics
 - Fast extraction process based on a time-series oriented storage (Cassandra database)
- **Provide developers with support tools for online analysis:**
 - Global statistics;
 - Resource assessment and extremes;
 - Producibile assessment;
 - Operation and Maintenance

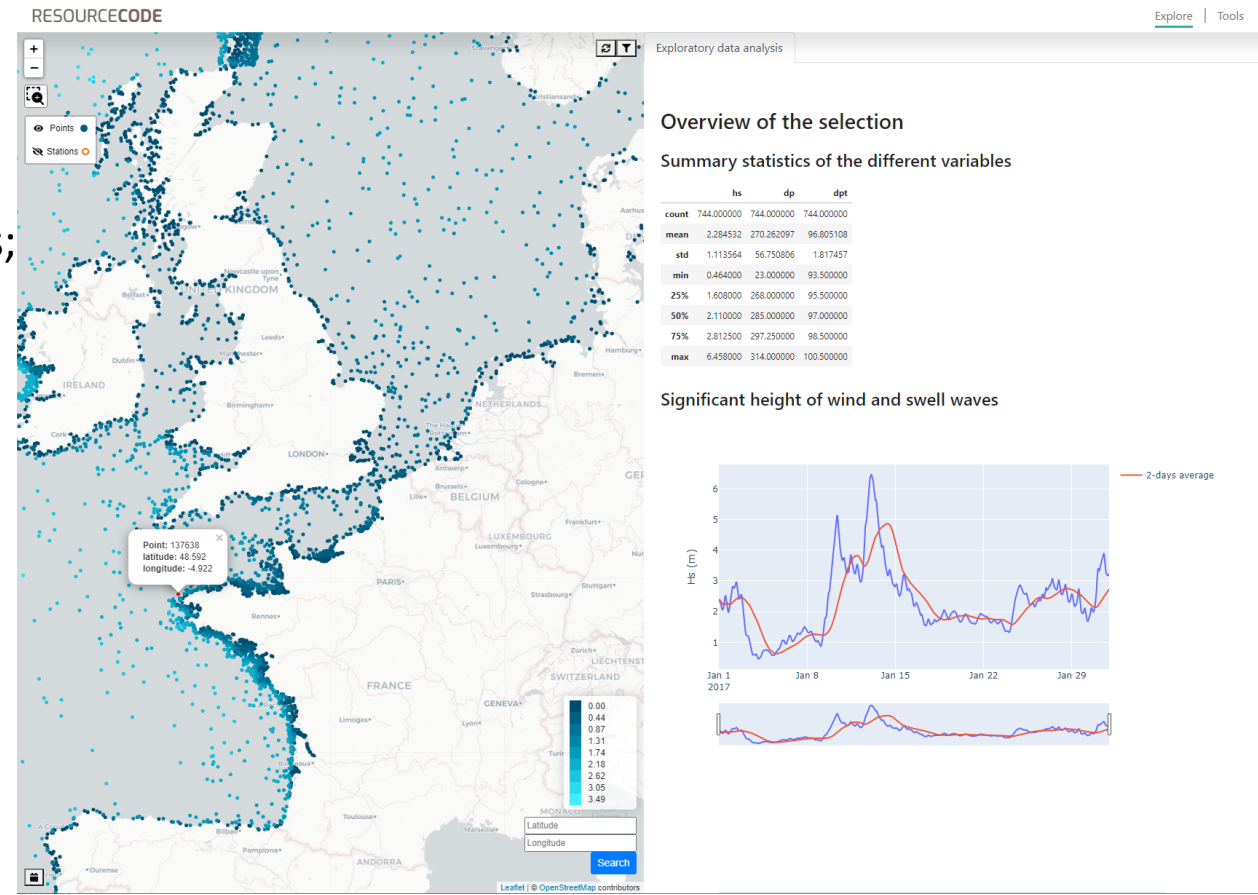


Dedicated website: resourcecode.ifremer.fr

- Contains project presentation and news;
- Provides a dynamical interface to retrieve data;
- Some use-case will be provided:
 - Statistical summaries;
 - Extreme value analysis and environmental contours;
 - Weather windows
 - Estimation of the energy producible by a WEC

Python toolbox

- Data extraction
- Utility functions: Get the closest point in the mesh, conversion from/to zonal/meridional components...
- Extreme value modelling;
- Weather windows (model based and empirical);
- Producibile estimation
- Validation against in-situ data



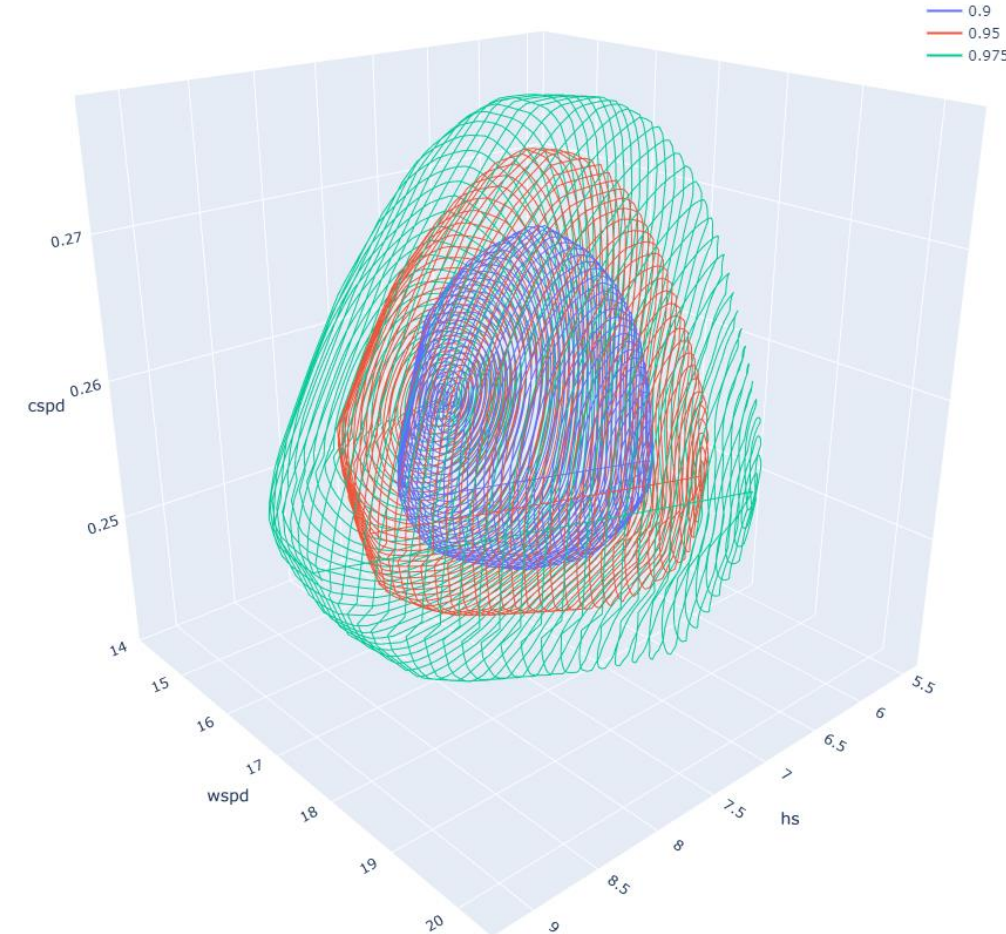
Data extraction and utility functions

- Node selection from coordinates;
- Full computational grid and coastlines included as data;
- Full list of nodes with full 2D spectrum;
- List of available variables, names and units;
- Set of utility functions:
 - Conversion of zonal and meridional velocity components to magnitude and direction according to meteorological convention
 - Sea-state parameters from 1D and 2D spectrum;
 - JONSWAP spectrum from H_s , T_p ;

Extreme values modeling

Methodology based on [1] :

- Classical 1D Peaks Over Threshold for marginal distributions;
- Several dependance models:
 - Gaussian copula;
 - Censored Gaussian copula (fitted only on tails);
 - Conditionnal Extremes (Heffernan & Tawn model [2])
- Environmental Contour: hypersphere where the N-year return level is located
 - Estimated in the Physical Space using Huseby approach [1]

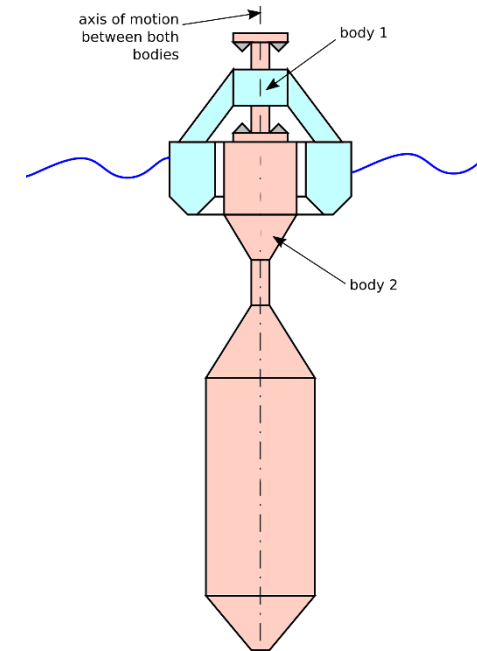
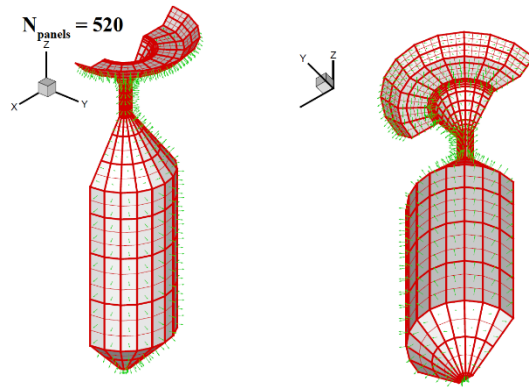


[1] Raillard Nicolas, Prevosto Marc, Pineau H. (2019). **3-D environmental extreme value models for the tension in a mooring line of a semi-submersible**. *Ocean Engineering*, 184, 23-31. <https://doi.org/10.1016/j.oceaneng.2019.05.016>

[2] J.E. Heffernan, J.A. Tawn (2004). **A conditional approach for multivariate extreme values**, *Journal of the Royal Statistical Society Series B: Stat. Methodol.*, 66 (3), 497-530. [10.1111/j.1467-9868.2004.02050.x](https://doi.org/10.1111/j.1467-9868.2004.02050.x)

WEC PRODUCTION ESTIMATES

- Device considered: generic WaveBob



WEC numerical model underlying assumptions

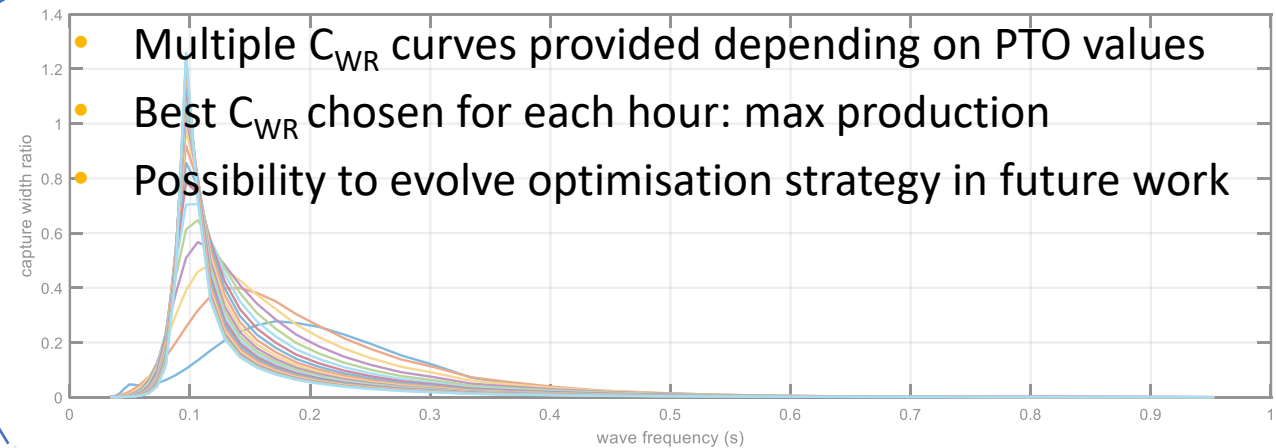
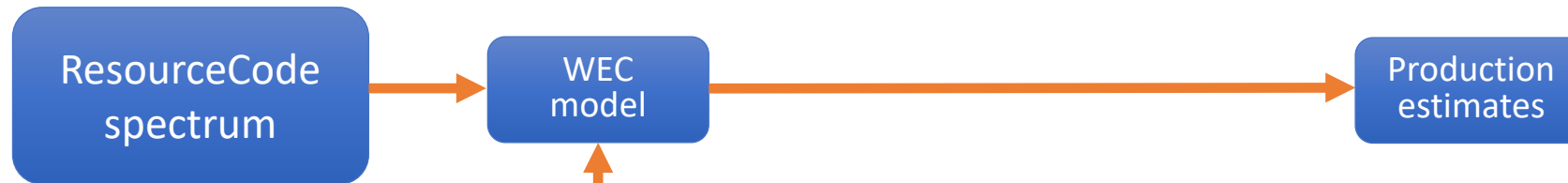
- > Linear potential flow theory in frequency domain
- > Variable linear damping PTO
- > Infinite water depth

Toolbox functionalities for producible estimation

- Inputs needed: capture width and PTO damping (WEC dependant)
- Optimization can be carried on the spectrum and sea-state parameters time series

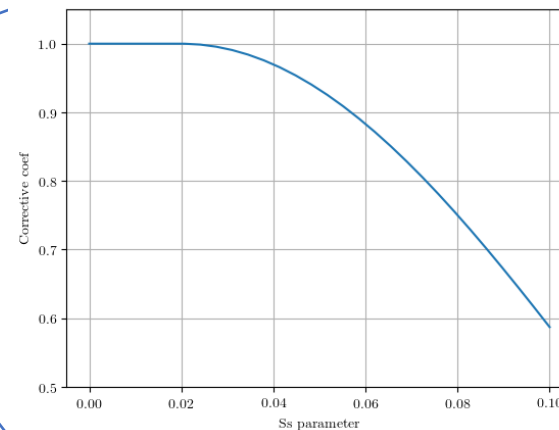
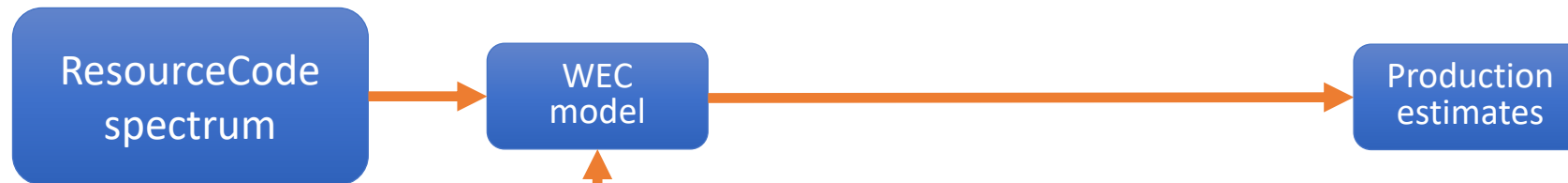
Production estimates computation principle

> On an hourly basis



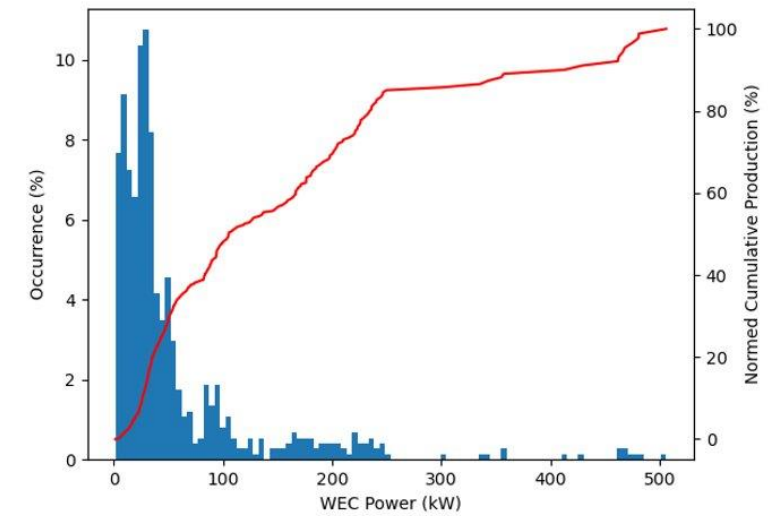
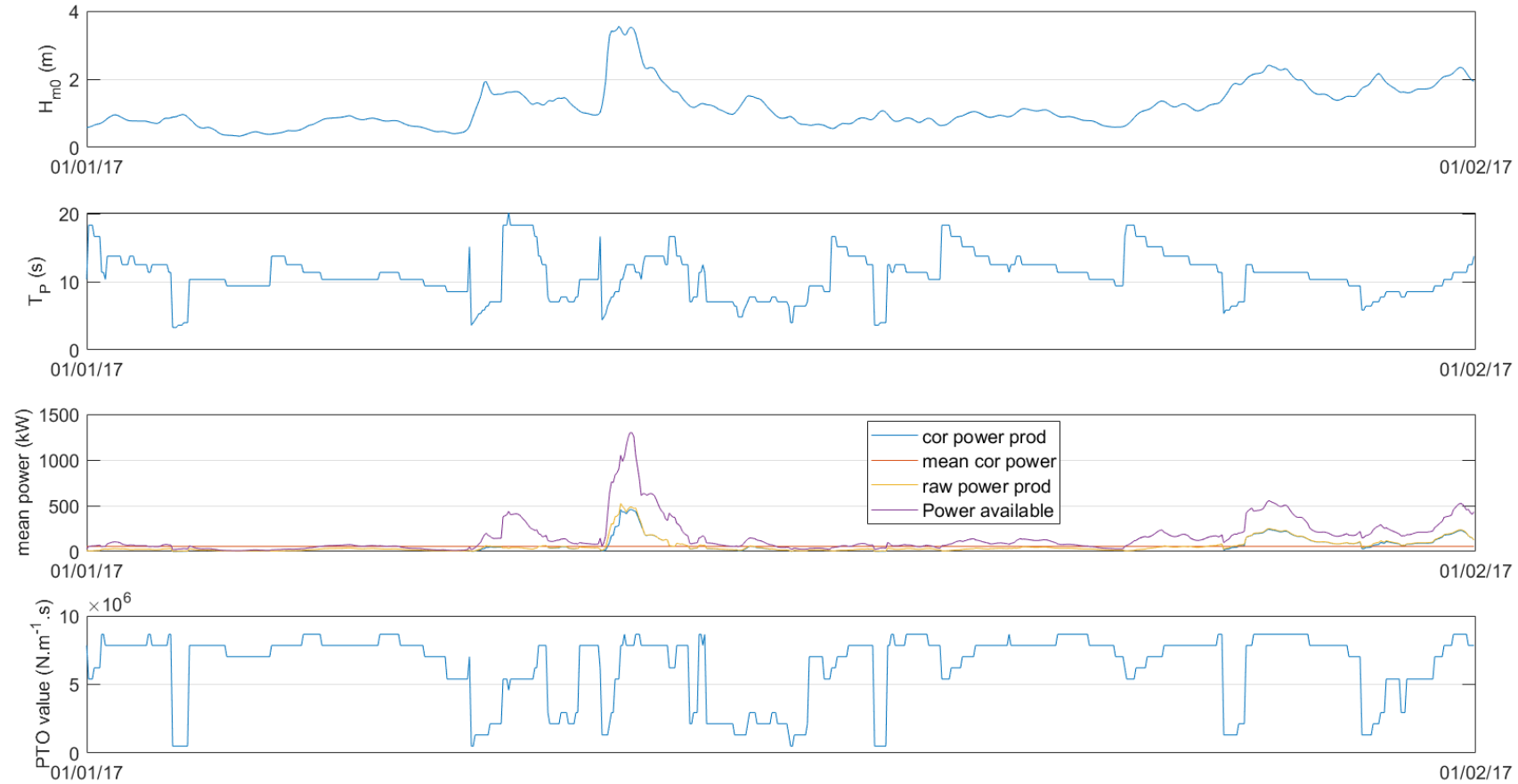
Production estimates computation principle

> On an hourly basis



Performance decrement for steeper sea state to consider potential non linearities:
→ Estimated power is decreased as a function of sea state steepness

Outputs



Weather windows

For a given location, compute weather windows and waiting time given operational constraints :

- Model based [1,2]
 - Hypothesis: 2- or 3-parameters Weibull distribution for H_s , triangular storms. Analytical formulas can be given
 - Only available for constraints on H_s
- Empirical
 - Counts the weather windows and waiting time
 - Constraint on H_s and T_p

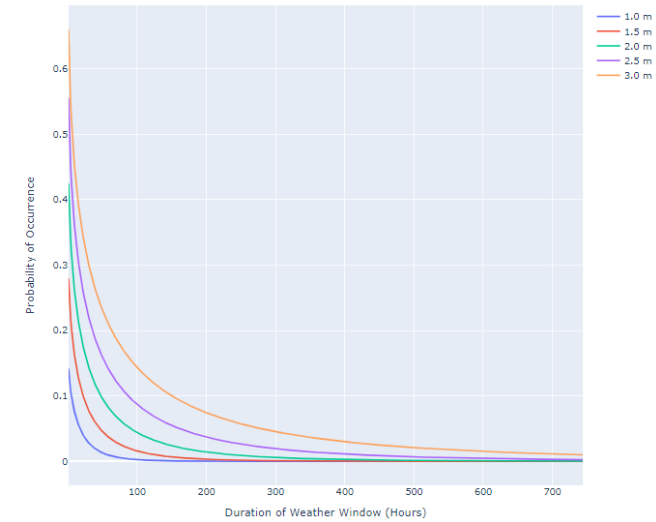
[1] EQUIMAR Deliverable D7.4.1 « Procedures for Estimating Site Accessibility and Appraisal of Implications of Site Accessibility » (2010), T. Stallard, University of Manchester, UK J-F. Dhedin, Sylvain Saviot and Carlos Noguera Electricité de France, France)

[2] Walker RT, Johanning L, Parkinson R. (2011) Weather Windows for Device Deployment at UK test Site: Availability and Cost Implications, European Wave and Tidal Energy Conference, Southampton, EWTEC2011.

Probability of Occurrence

month_name

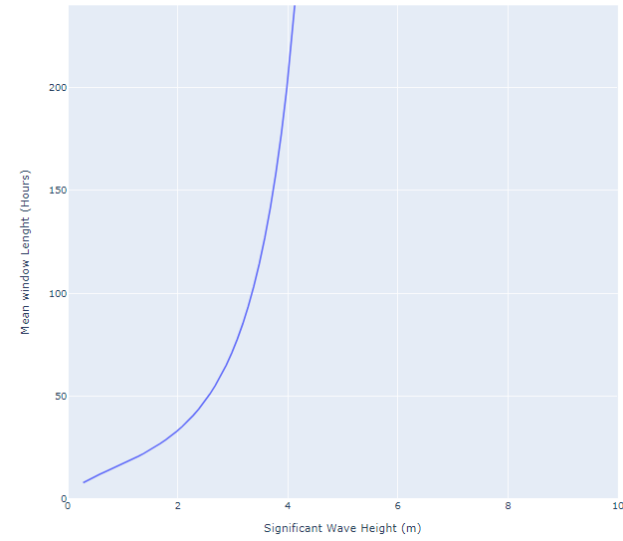
Probability of Occurrence – January



Mean Window Length

month_name

Mean window Length – January

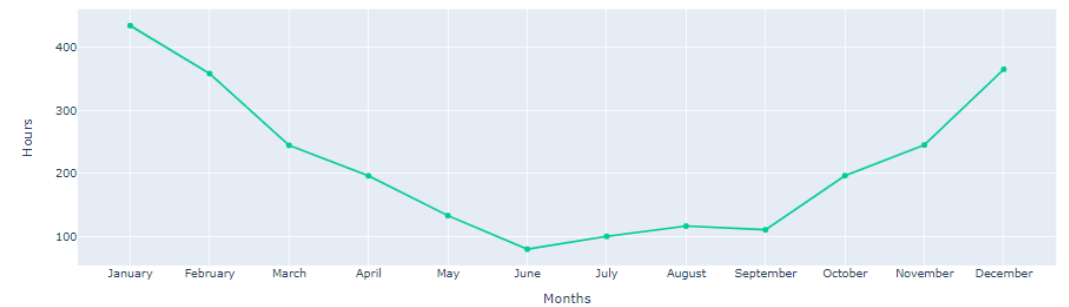
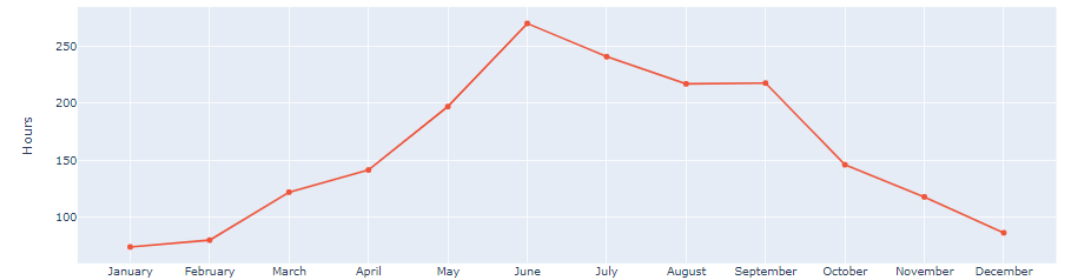
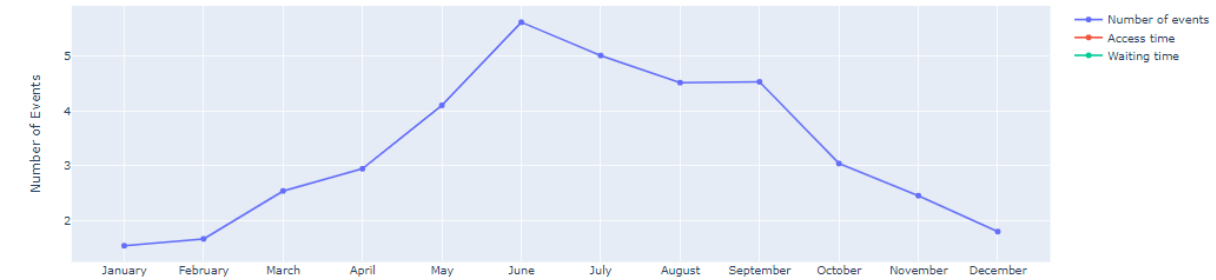


Monthly evolution of number of events

time

hs

Weibull 3p fit – Hs = 2m, 48 hours window



A set of python-based software tools have been developed for validation of the RSCD WW3 model against archived *in situ* buoy data; it is assumed that the buoy data are in a standardised format (as used by CMEMS).

The tools are modularised and the methods have been generalised so that the tools can be adapted for the validation of other models and/or using alternate observation data sets.

The model and buoy data are loaded into class structures that have embedded functions for basic interrogation and extraction of data. There are a set of separate modules that contain standard functions for time data conversions, file manipulation, geometry, wave spectra, and graphics.

The validation process is separated into two parts:

1. Matching observation data to model locations data – this builds an on-the-fly SQLite database for the search.
2. Calculation and collation of validation statistics for every buoy match found.

To extend the tools to other models and data sets, new classes for the models or data need to be written, but these can inherit existing classes and the relevant methods overridden to suit the new data.

These software tools will be made available at the end of the project in the form of an open-source installable python package, with examples of how to construct processing scripts using the tools, and a basic user manual.

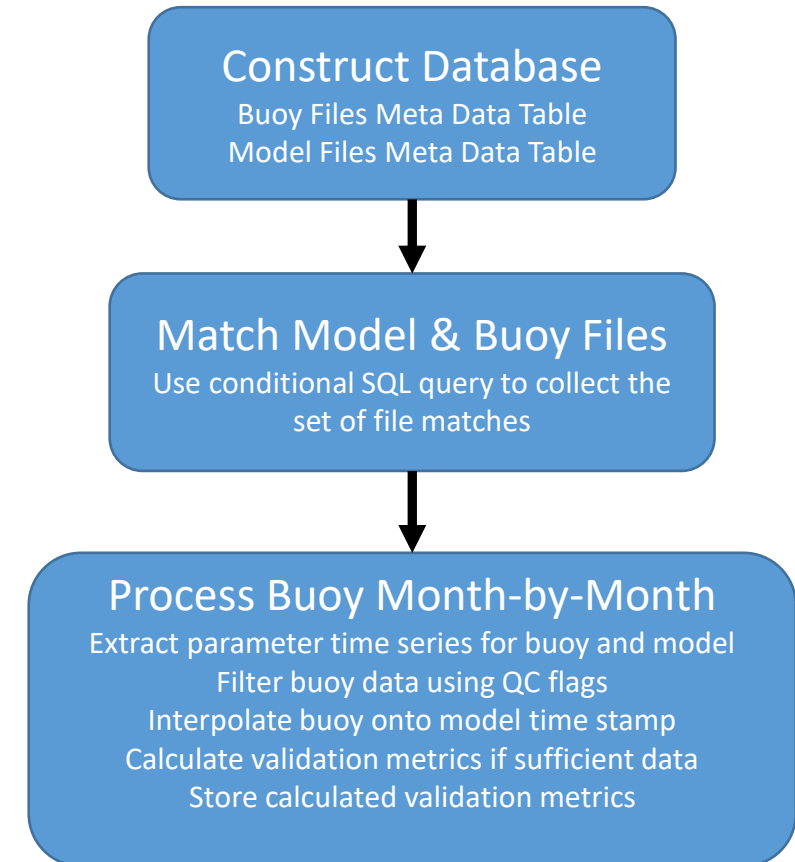
Data processing scripts constructed using the UEDIN toolbox

Batch jobs generated to process every buoy matched to a model node.

Output:

1. Text file with tabulated results for every buoy and every parameter, each table contains values for each available month.
2. Matlab format binary equivalents to tabulated data.
3. Matlab format binary of cleaned time series data used to generate validation metrics.

Post-processing is applied to the binary data to construct global statistics, monthly statistics, buoy statistics, etc.





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Hindcast database

Mickaël Accensi

IFREMER

06.09.2021

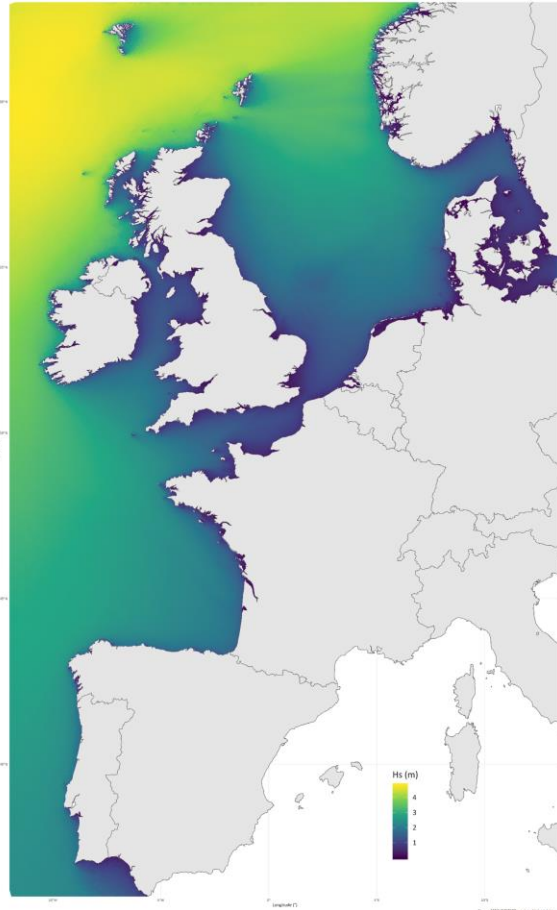


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Summary Information

- Hindcast from 1994 to 2020
- Covers European Shelf from Gibraltar to Faroe island



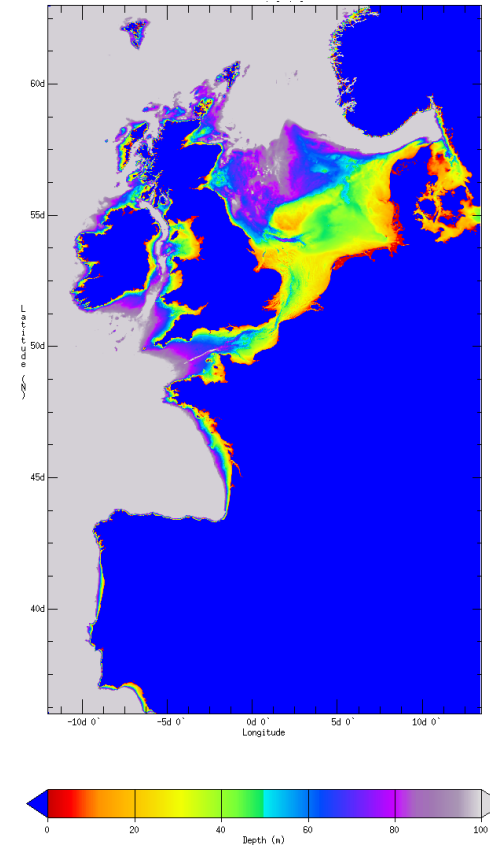
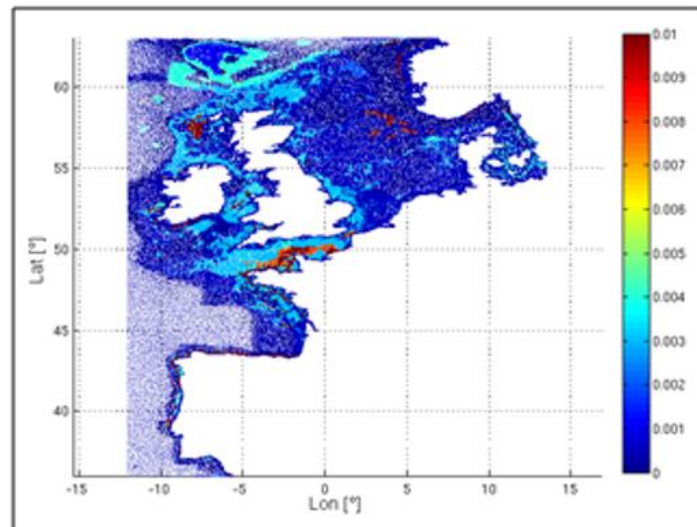
Mean Hs during 2017

Summary Information

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Bathymetry and sediment

- EMODnet2016 (200m) and HOMONIM (100m) for French Shelf
- OpenStreetMap for coastline contours
- EMODnet and SHOM sediment map for grain size classification



Summary Information

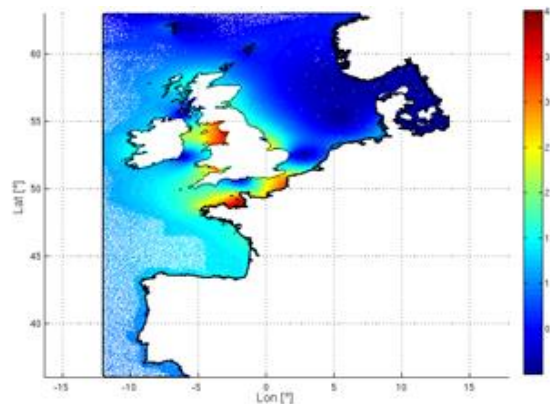
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Currents and water level

- IFREMER Tidal Atlas (from 250m to 2km)
- FES2014 native mesh, regridded at 450m for South Portugal
- updated every 30min at each node



M2 amplitudes interpolated into mesh nodes



IFREMER tidal atlas domains with resolutions about 250m (coastal), 700m (France) and 2km (NE Atlantique)
Red dots represent the domain open boundaries

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Wind

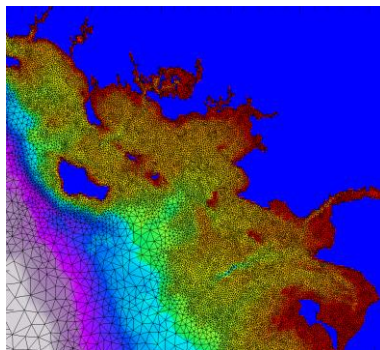
- ERA-5 global hindcast (0.25° - hourly)
- Bias-corrected for extreme wind

Currents and water level

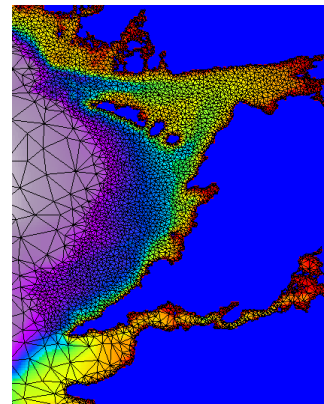
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Waves

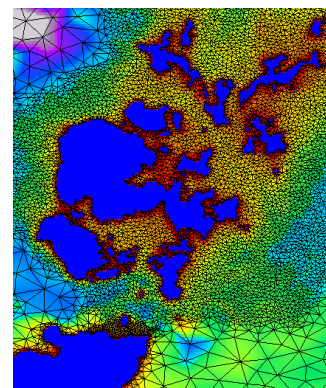
- WAVEWATCH-III v7.08, parametrisation T475 (Alday et. Al 2021)
- 36 directional bins (10°) and 36 frequencies (from 1s to 29s)
- grid resolution between 200m and 10km with +330k nodes
- Open boundary forced by global model (0.5°) directional spectra



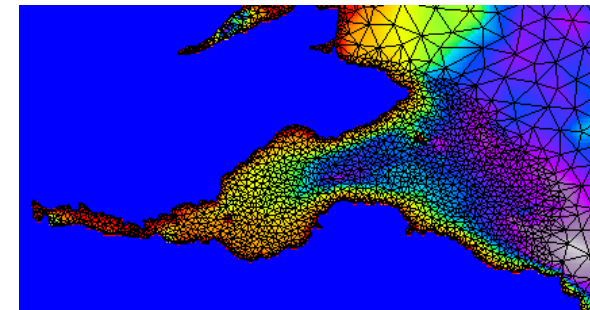
Croisic



Galway



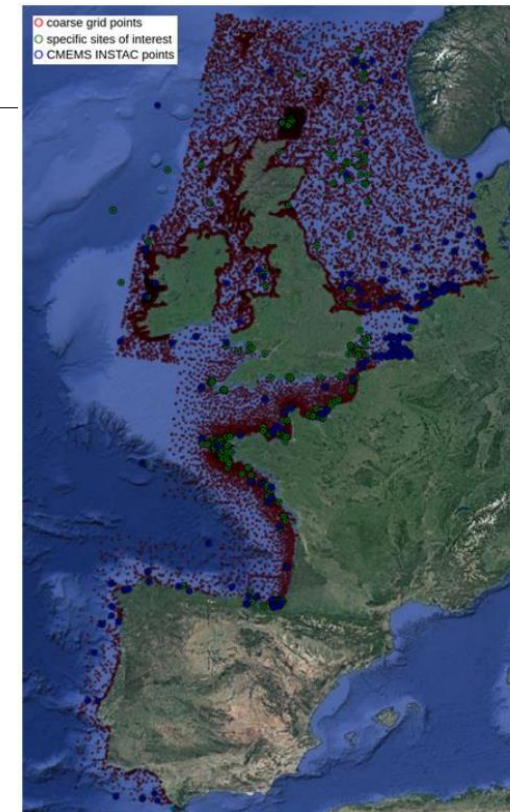
Orkneys



Edinburgh

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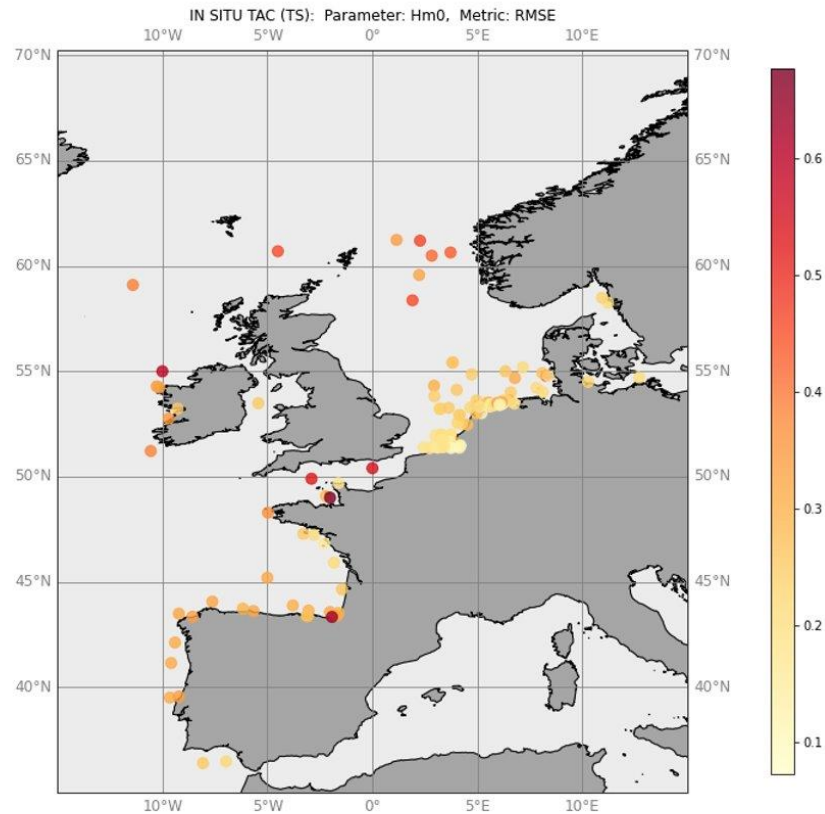
Global Parameters

39 parameters:

- Sea-state: H_s , T_p , Energy flux C_gE , T_e ...
- Output from spectral partitioning;
- Forcings: wind, water levels...

1D and 2D Spectra

- Each grid node for 1D spectra
- > 24,000 output points for 2D spectra
- 36x36 directional spectra at each time step (hourly)

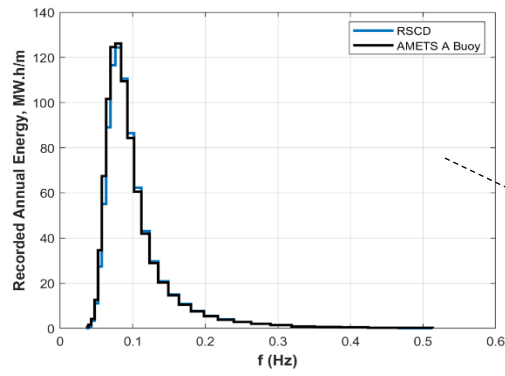


Validation Statistics

Parameter	R (%)	NMB (%)	NRMSE (%)	SI (%)
Hm0	93 +/- 9	1 +/- 20	22 +/- 23	17 +/- 13
Tp	62 +/- 19	3 +/- 16	28 +/- 17	24 +/- 12
Tm02	81 +/- 18	6 +/- 9	15 +/- 7	11 +/- 5
Direction	71 +/- 16	-1 +/- 4	14 +/- 7	13 +/- 8
Spreading	30 +/- 21	19 +/- 29	52 +/- 19	43 +/- 29

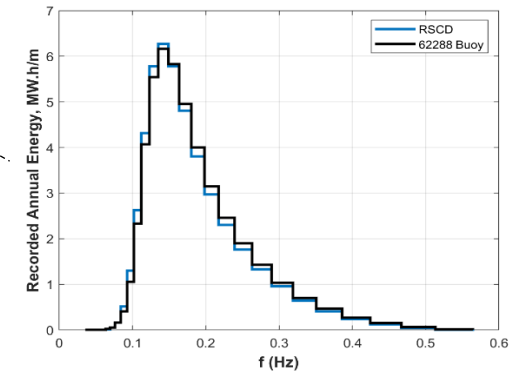
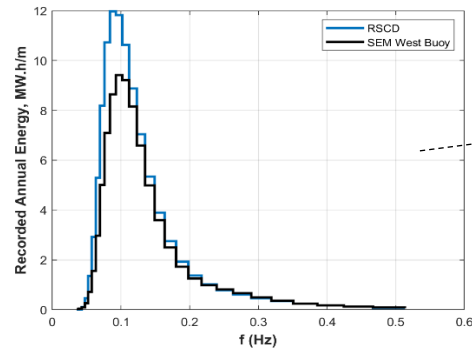
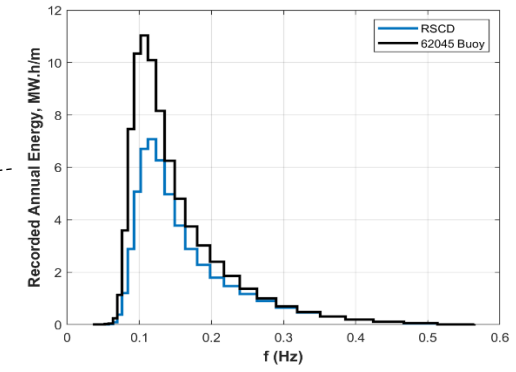
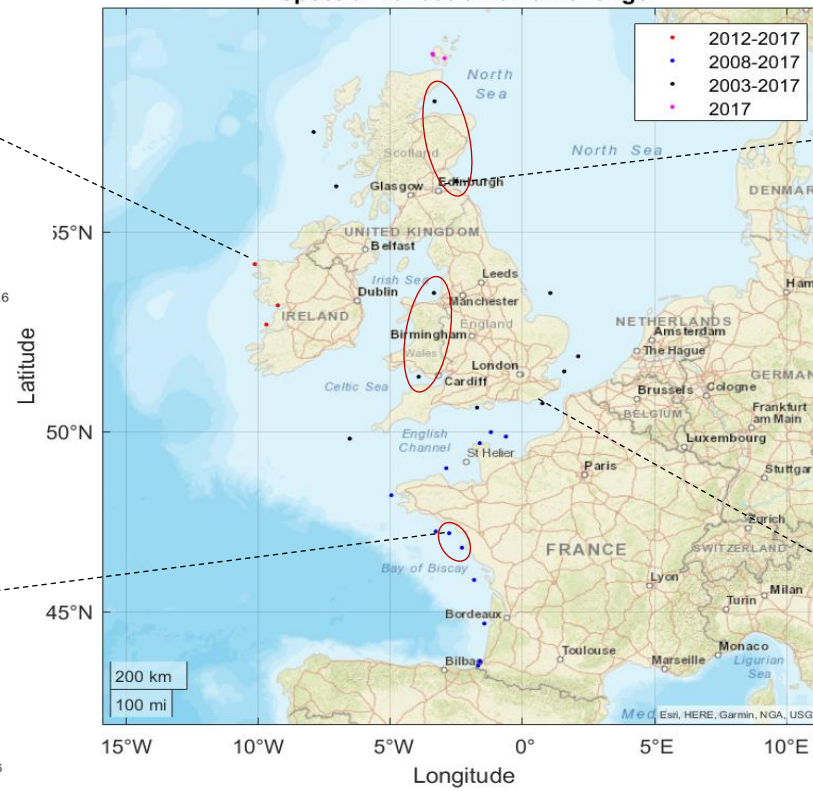
Number of Parameter Samples

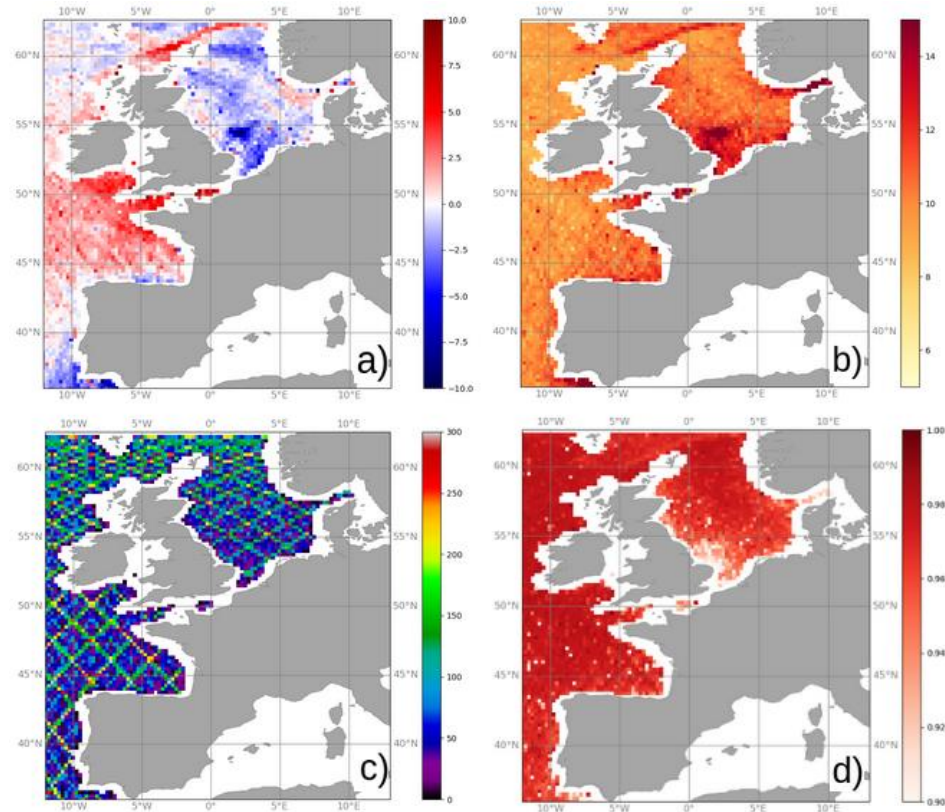
Parameter	Number of Buoys	Number of Samples
Hm0	107	10085
Tp	98	8098
Tm02	60	5901
Direction	38	4055
Spreading	18	1469



2013

Spectral Validation on time range

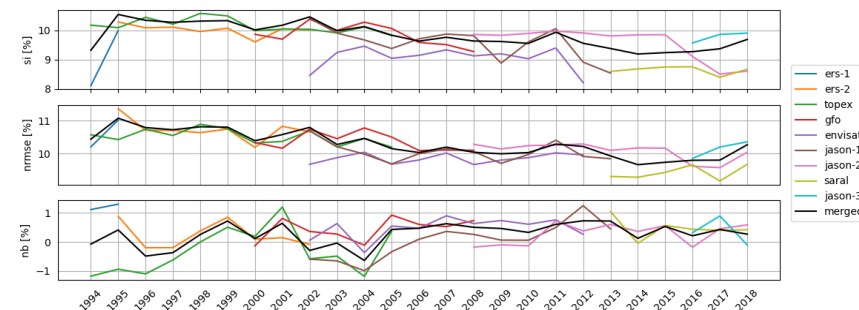




Yearly validation criteria averaged over 1994-2018.
a) NB; b) NRMSE; c) matches-up; d) R

OVERALL STATISTICS PER ALTIMETER

Satellite	Covered period	B (m)	NB (%)	RMSE (m)	NRMSE (%)	SI (%)	R (%)
ERS-1	1994-1995	0.021	1.20	0.300	10.61	9.05	93.87
TOPEX	1994-2005	-0.013	-0.32	0.325	10.52	10.16	97.11
ERS-2	1995-2002	0.004	0.23	0.308	10.73	10.03	96.08
GFO	2000-2008	0.008	0.44	0.315	10.37	9.85	96.96
JASON-1	2002-2013	0.001	0.04	0.307	10.06	9.56	96.90
ENVISAT	2002-2012	0.011	0.47	0.292	9.86	9.06	96.11
JASON-2	2008-2018	0.011	0.28	0.308	10.08	9.56	96.92
SARAL	2013-2018	0.015	0.47	0.279	9.42	8.64	97.03
JASON-3	2016-2018	0.014	0.37	0.292	10.14	9.78	97.16
MERGED	1994-2018	0.007	0.26	0.307	10.30	9.82	96.80



Overall timeseries of SI, NRMSE and NB



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Marine Data Toolbox demo

Nicolas Raillard

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Questions

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Thank you slide

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