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RESOURCECODE: A Python package for statistical analysis of sea-state hindcast data

Nicolas Raillard[1¶], Christophe Maisondieu[1], David Darbynian[2], Gregory Payne*[3], and Louis Papillon[4]

1 Ifremer, RDT, F-29280 Plouzané, France **2** EMEC, Orkney, UK **3** LHEEA, Ecole Centrale de Nantes and CNRS (UMR6598), 1 rue de la Noë, 44300 Nantes, France **4** Innosea, Nantes, France ¶ Corresponding author

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Software

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Summary

The resourcecode Marine Data Toolbox is a python package developed within the **ResourceCODE** project, to facilitate the access to a recently developed Metocean hindcast database (Accensi et al., 2021), and to a set of state-of-the-art methods for data analysis. This toolbox provides developers with a set of standard functions for resource assessment and operations planning. The advanced statistical modelling tools provided together with the embedded high resolution wave hindcast database provide the developers with a set of standard functions for resource assessment, extreme values modelling and operations and maintenance planning. Suitable for users not familiar with netCDF files handling or statistical analysis development, it is however designed to fulfil expert metocean analysis requirements. The advanced statistical modelling tools provided allow the developers of Offshore Renewable Energy (**ORE**) devices to conduct the necessary assessments to reduce uncertainty in expected environmental conditions, and de-risk investment in future technology design.

Statement of Need

The resourcecode python package allows to retrieve and analyse time series of Metocean parameters and spectra extracted from the companion hindcast database. This database consists in a high-resolution unstructured grid with more than 300 000 nodes, spanning from the South of Spain to the Faeroe Islands and from the Western Irish continental shelf to the Baltic Sea. At each node, 39 wave parameters and frequency spectra are available with a hourly time-step. Directional spectra are also available, on a coarser grid over the area covered. This data has been extensively validated against both in-situ and satellite remote sensing data (Accensi et al., 2021). However, this database is very large (more than 50Tb) and can not easily be downloaded by the end users. The resourcecode python package objectives are twofold: preparing data harvesting from the database, which is often one of the most time-consuming steps, and providing the user with unified, state-of-the-art methods for analysing the data extracted. The analysis tools offer different capabilities, such as resource assessment, optimisation of the design of ORE devices and the planning of Operation and Maintenance (O&M) tasks.

Key Features of the resourcecode python package

resourcecode provides a wrapper for easy fetching of data from the **ResourceCODE** database, by calling the Cassandra API. The database itself represents more than 50Tb of data, preventing

*Present address: Farwind Energy, 1 rue de la Noë, 44300, Nantes, France standard user to download it as a whole. Hence, this toolbox is intended to provide access to time series of sea-state parameters, as simply as the following code snippet:

```
import resourcecode
client = resourcecode.Client()
data = client.get_dataframe_from_criteria(
    """
{
    ”node”: 134939,
    ”parameter”: [”hs”,”fp”,”dp”,”cge”]
}
"""
)
```

In the example above, we used `resourcecode` to fetch data from node *134939*, for the entire time period, and for some parameters: significant wave height H_s, peak wave frequency f_p, Mean direction at peak frequency D_p and Wave Energy Flux CgE. The `resourcecode` package will automatically construct the proper Cassandra request and will process the data internally to output a **pandas** data frame (McKinney (2010)) workable in-memory.

The different tasks that can be handled via this package, both for data management and statistical modelling include :

- Data management:
  - Extraction of sea-state parameters from Cassandra web-service;
  - Accessing database configuration:
    * nodes location and spectral data availability;
    * coastlines, islands ans mesh triangles;
    * bathymetry and bottom roughness;
    * List of output variables;
  - Easy to use **pandas** data frame (filtering,aggregating,...);
  - Data conversion:
    * Directional spectra $\rightarrow$ Frequency spectra $\rightarrow$ Sea-state parameters;
    * Zonal/Meridional components to Intensity/Direction.
- Statistical modelling:
  - Environmental conditions assessment;
  - Extreme values modelling;
  - 2D and 3D environmental contours (as in Raillard, Prevosto, & Pineau (2019)).
- Weather windows for O&M:
  - Model based (as in Walker, van Nieuwkoop-McCall, Johanning, & Parkinson (2013));
  - Empirical estimates.
- WEC energy production estimates:
  - A WEC case study is included, extensible with user-provided characteristics;
  - PTO optimization (as in Payne, Babarit, Pascal, & Perignon (2021)).

Companion web Portal

The toolbox is associated to a Web Portal[1] for exploring the data and accessing some simplified use-cases, dynamically rendered and based on the possibilities offered by the toolbox.

For instance, users can identify and select a specific location on a dynamical map on which all the nodes of the computational grid as well as the nodes of the 2D spectra coarser grid are plotted (see Figure 1, left plot). They can either click on the node to select it or enter its coordinates. They can also specify the start and end dates of the data subset to be extracted.

[1]https://resourcecode.ifremer.fr/

The node selected by the user along with the period specified can be directly specified by an url[2].

Once a node is selected, the user is offered several tools for analysing the data available at the selected location. These tools are developed on top of the python package and allow for several statistical characterization of the selected site: summary statistics; time series visualization; bivariate statistics; wind and wave roses plotting.

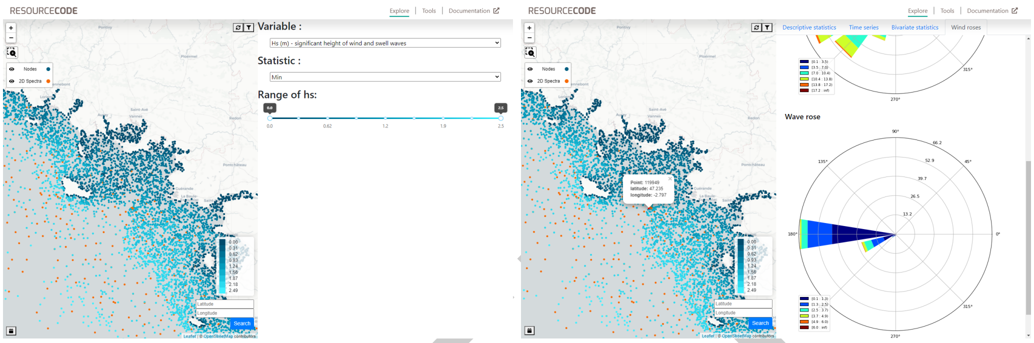

Figure 1: Left: Map for location selection. Right: Available previews.

Conclusion

The `resourcecode` package is offering to the met-ocean engineering community a tool to access seamlessly a large and comprehensive dataset that have been proven to be a reference for sea-states hindcasting. Along with the dataset, the functionalities offered by the toolbox permit to foster the development of OREs. For a complete list of available features, the reader can access to the package documentation at https://resourcecode.gitlab-pages.ifremer.fr/resourcecode/.

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