

BlueMath

A Collaborative Open-Source Repository for Statistical Analysis and Fast, Efficient Hydrodynamic Emulators of Coastal Climate Hazards

Laura Cagigal, Javier Tausía, Fernando Mendez, Valvanuz Fernandez-Quiruelas, Gabriel Bellido, Etienne Faugere, Jennifer Montaña, Jared Ortiz-Angulo, Alba Ricondo, Pablo Alonso-Alguacil, Beatriz Perez-Diaz, Mirian Jimenez-Tobio, Paula Camus, Sonia Castanedo, Jose A. A. Antolinez

Coastal Hazards



Available tools



Environmental Modelling & Software

Volume 165, July 2023, 105712

CCdownscaling: A Python package for multivariable statistical climate model downscaling

Andrew D. Polasky¹

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<https://doi.org/10.1016>



Computers & Geosciences

Volume 162, May 2022, 105098

APPMAR 1.0: A Python application for downloading and analyzing of III® wave and wind data

German Rivillas-Ospina^a , Diego Casas^b, Mauro Antonio Marianella Bolívar^d, Gabriel Ruiz^e, Roberto Guerrero^d, José M. Hernández Milton Guerrero^c, Karina Díaz^d, Roberto del Río^c, Erick Campos^c

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<https://doi.org/10.1016/j.jageo.2022.105098>



CoastSeg: an accessible and extendable hub for satellite-derived-shoreline (SDS) detection and mapping

Sharon Fitzpatrick¹ , Daniel Buscombe¹ , Jonathan A. Warrick² , Mark A. Lundine

¹ Contracted to California, Unit Cruz, California Australia

DOI: 10.21105/joss.06683



Environmental Modelling & Software

Volume 122, December 2019, 104528

CoastSat: A Google Earth Engine-enabled Python toolkit to extract shorelines from publicly available satellite imagery

Kilian Vos^a , Kristen D. Splinter, Mitchell D. Harley, Joshua A. Simmons, Ian L. Turner



Environmental Modelling & Software

Volume 178, July 2024, 106076

PyCoSMoS: An advanced toolbox for simulating real-world hydroclimatic data

Cappelli Francesco^a , Simon Michael Papalexioy^b , Yannis Markonis^c , Salvatore Grimaldi^a

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Motivation

Only 11% of the
analyzed papers
provided code

Jansen et al., 2020

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Jansen et al., 2020

70% of the
researchers failed to
reproduce published
research

Baker, 2016

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More than 50%
failed to reproduce
their own
experiments

Baker, 2016

Motivation

Only 11% of the analyzed papers provided code

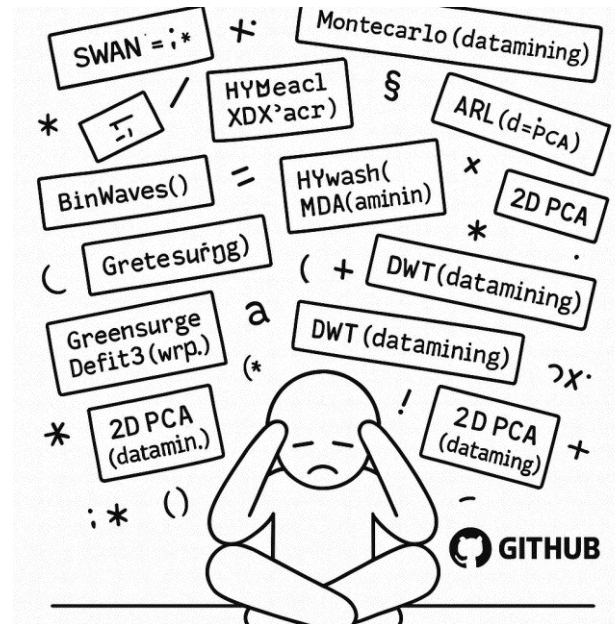
Jansen et al., 2020

70% of the researchers failed to reproduce published research

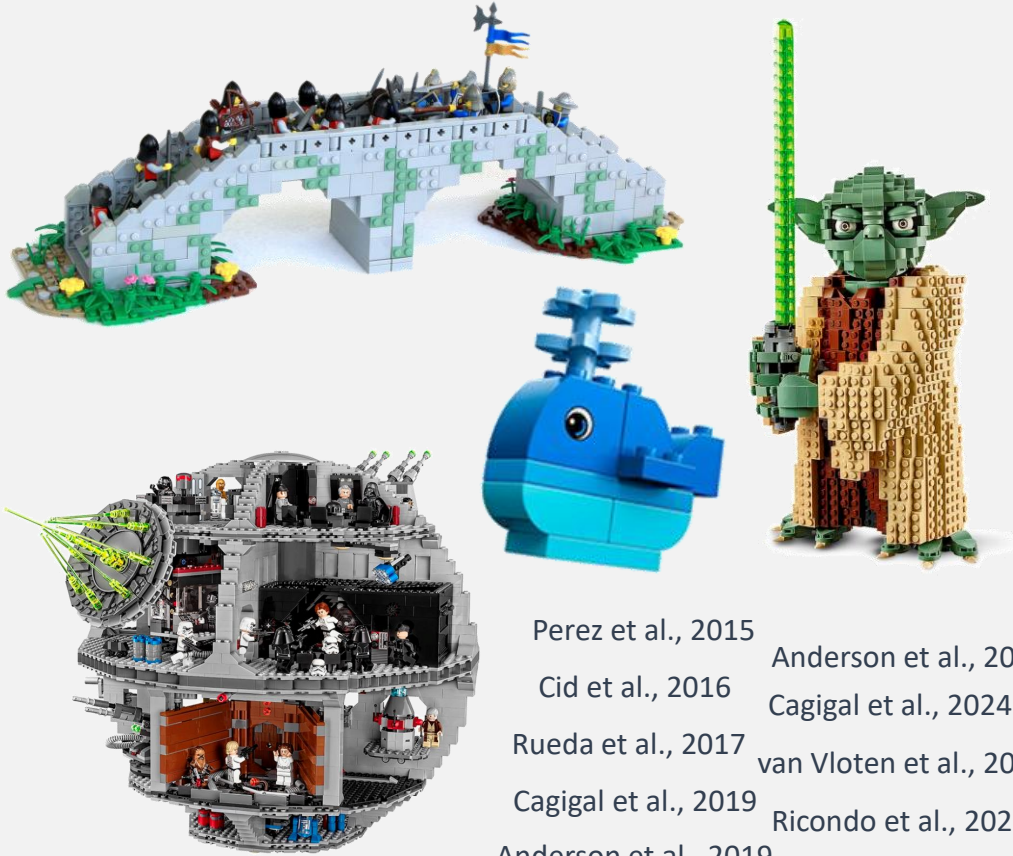
More than 50% failed to reproduce their own experiments

Baker, 2016

Research progress slows down,
as integrating **new methodologies** into an existing framework requires significant **time and effort**



Projects and Publications

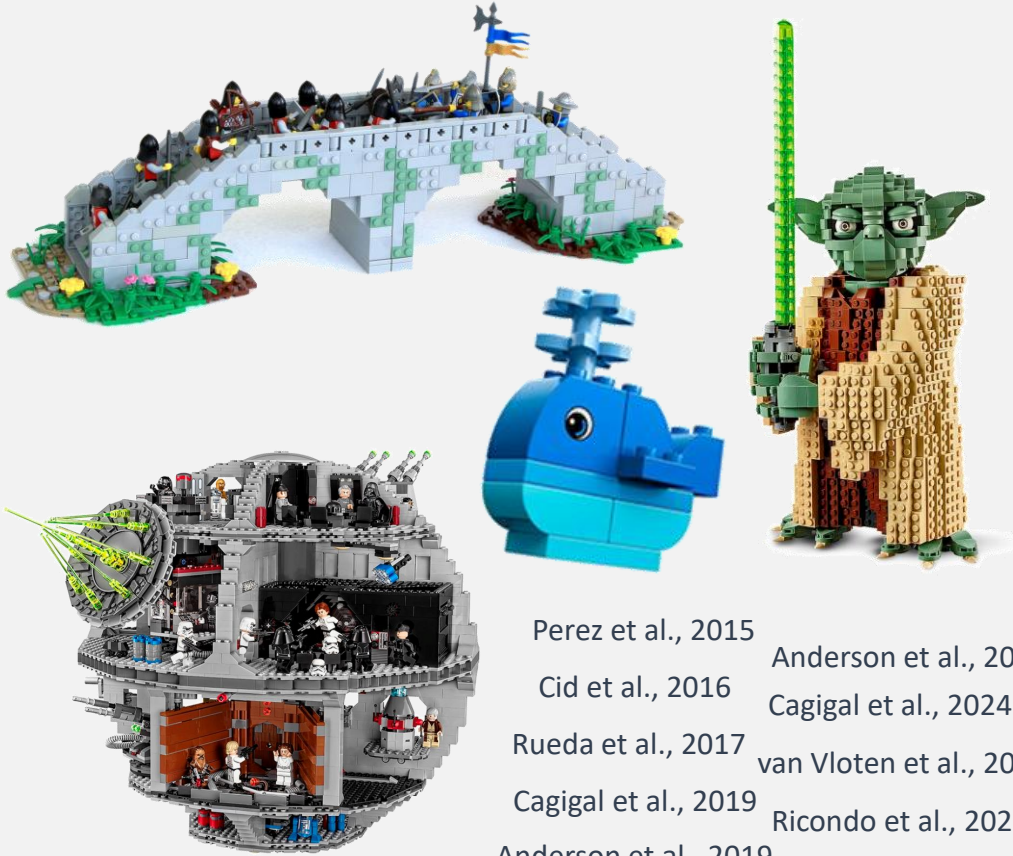


Perez et al., 2015	Anderson et al., 2021
Cid et al., 2016	Cagigal et al., 2024
Rueda et al., 2017	van Vloten et al., 2023
Cagigal et al., 2019	Ricondo et al., 2023
Anderson et al., 2019	Ricondo et al., 2024

Projects and Publications

1

Identify individual pieces



Perez et al., 2015	Anderson et al., 2021
Cid et al., 2016	Cagigal et al., 2024
Rueda et al., 2017	van Vloten et al., 2023
Cagigal et al., 2019	Ricondo et al., 2023
Anderson et al., 2019	Ricondo et al., 2024

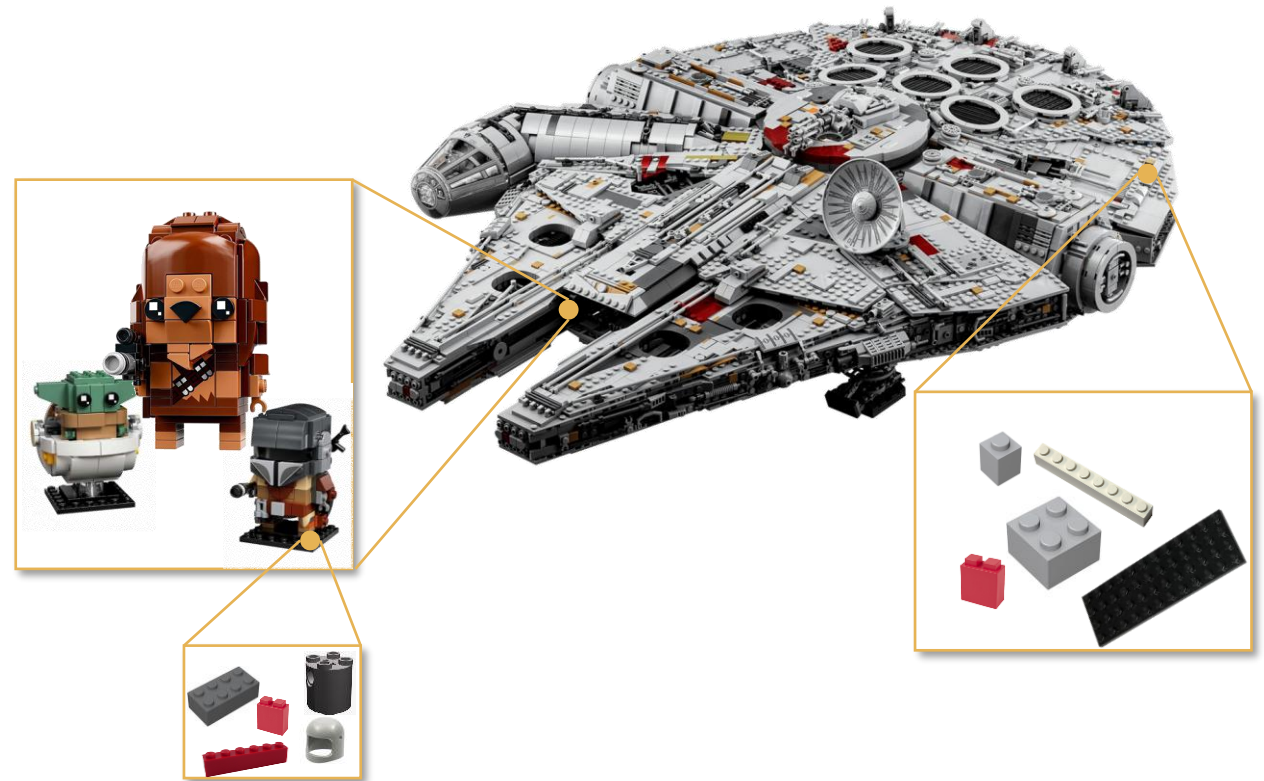


Projects and Publications

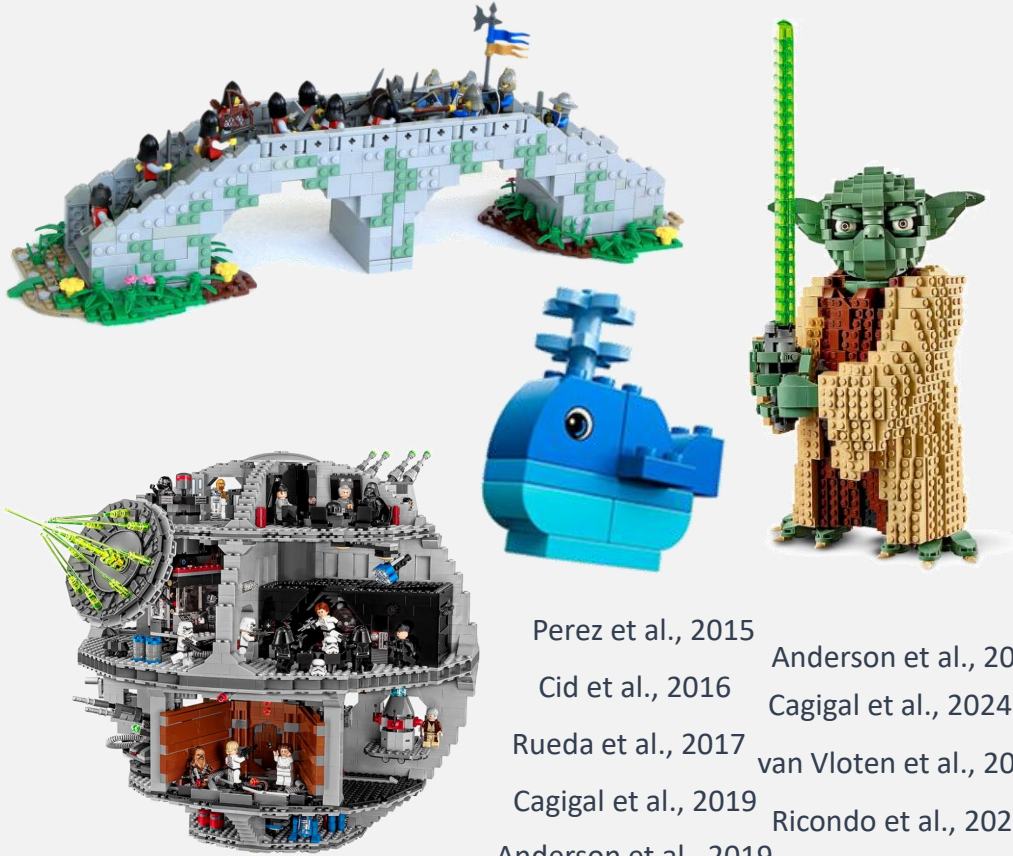


Perez et al., 2015	Anderson et al., 2021
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Cagigal et al., 2019	Ricondo et al., 2023
Anderson et al., 2019	Ricondo et al., 2024

1 Identify individual pieces



Projects and Publications

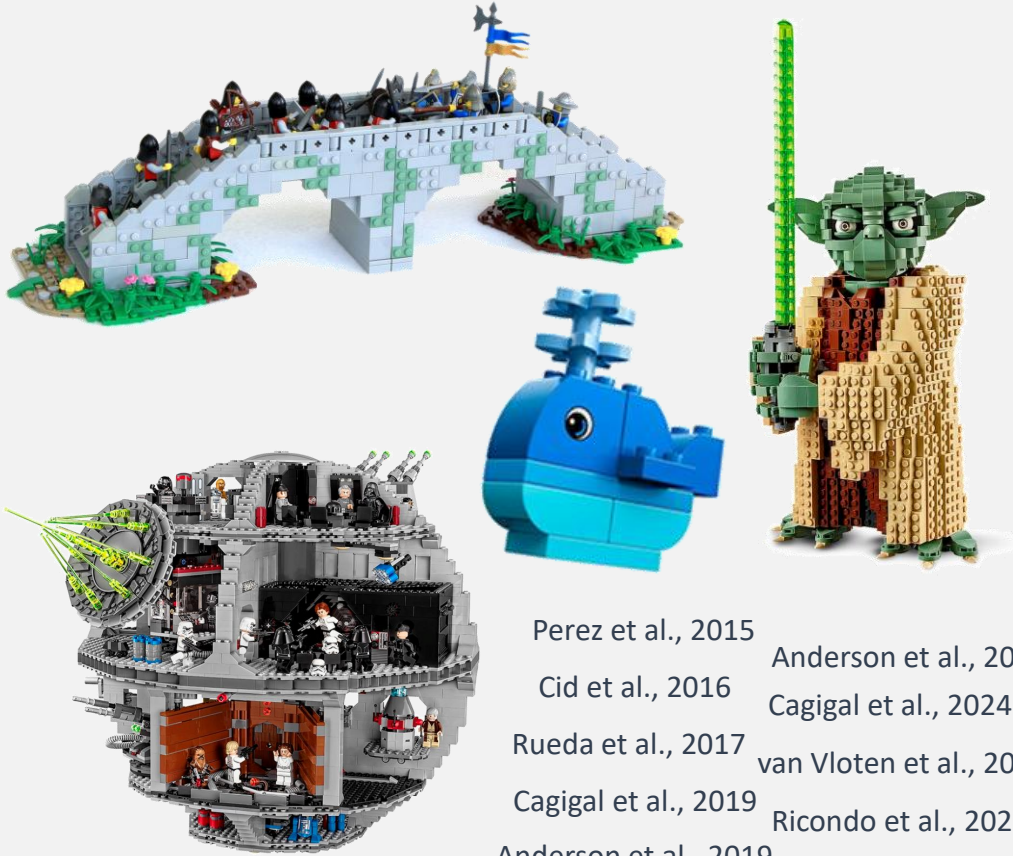


Perez et al., 2015	Anderson et al., 2021
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Cagigal et al., 2019	Ricondo et al., 2023
Anderson et al., 2019	Ricondo et al., 2024

2 Organize pieces



Projects and Publications



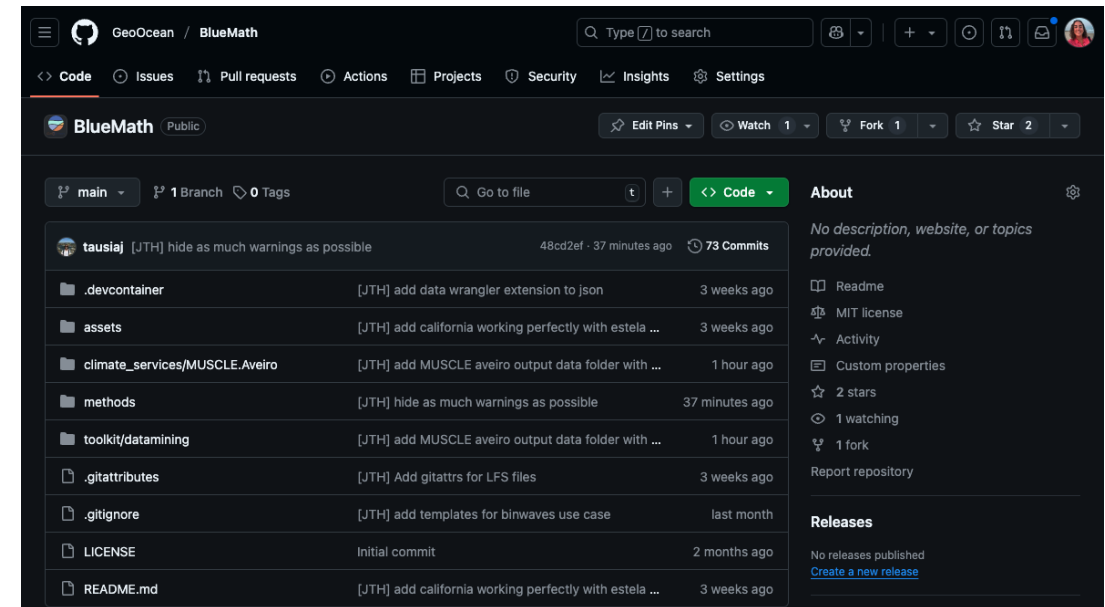
Perez et al., 2015
Anderson et al., 2021
Cid et al., 2016
Cagigal et al., 2024
Rueda et al., 2017
van Vloten et al., 2023
Cagigal et al., 2019
Ricondo et al., 2023
Anderson et al., 2019
Ricondo et al., 2024

3

Create an open-source code repository



<https://github.com/GeoOcean/BlueMath>

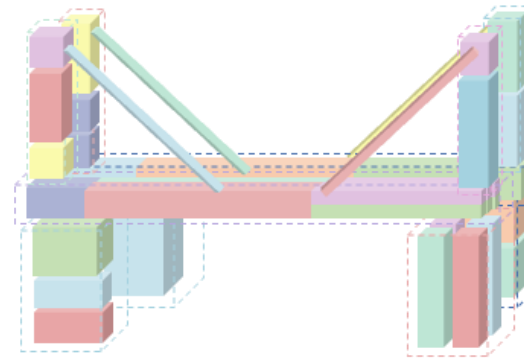




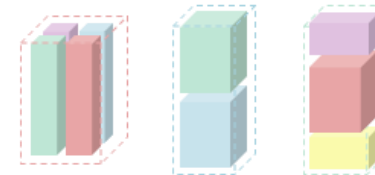
BlueMath



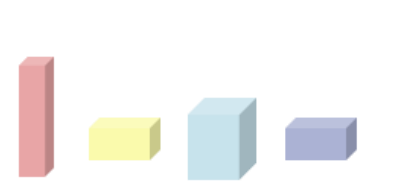
Climate Services



Methods



Toolkit

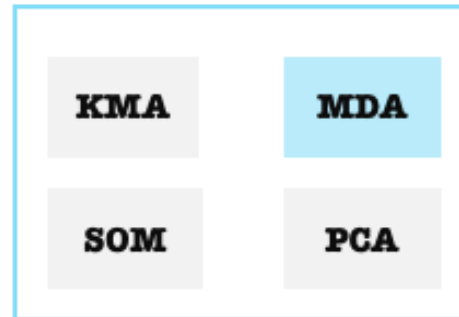




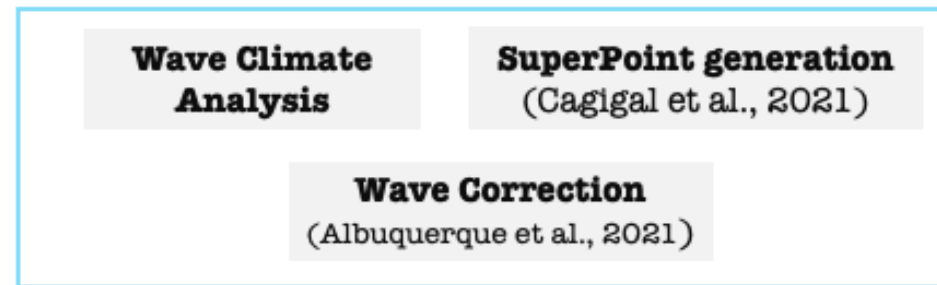
Toolkit



Datamining



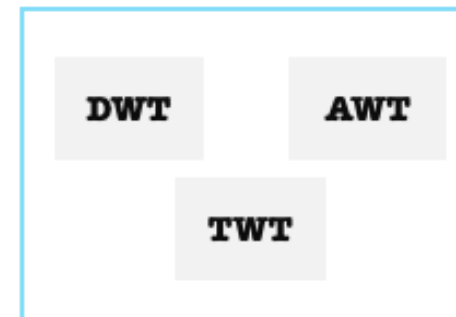
Waves



Wrappers



Predictor





Toolkit



UC

Universidad
de Cantabria



Geomatics and Ocean
Engineering Group
UNIVERSIDAD DE CANTABRIA

MDA

Maximum Dissimilarity Algorithm

The screenshot displays a JupyterLab environment with a dark theme. The left sidebar shows a file explorer with a tree structure under 'BLUEMATH [CODESPACES: F...]'. The main area is titled 'Comparison MDA vs KMeans' and contains two code cells. The first cell, labeled '[2]', shows the import of various libraries including numpy, pandas, xarray, and specific modules from the 'bluemath.tk.datamining' package. The second cell, labeled '[3]', shows the loading of a dataset from a local path using xarray. The bottom status bar indicates the user is in a 'bash' terminal session within a 'codespaces' environment.

```
[2] toolkit > datamining > MDA_vs_KMeans.Aveiro.ipynb > M+ Comparison MDA vs KMeans
+ Código + Markdown | ▶ Ejecutar todo | ✖ Borrar todas las salidas | Esquema ... Detectando Kernels

Comparison MDA vs KMeans

import numpy as np
import pandas as pd
import xarray as xr
from bluemath.tk.datamining.mda import MDA
from bluemath.tk.datamining.kma import KMA
from bluemath.tk.datamining.lhs import LHS

from utils.plotting import plot_variable_combinations

[3]

Load Dataset

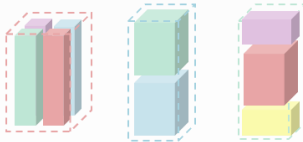
data = (
    xr.open_dataset("/workspaces/BlueMath/climate_services/MUSCLE.Aveiro/data/era5_aveiro.nc")
    .rename({"sw_h": "Hs", "pp1d": "Tp", "mwd": "Dir"})
    .to_dataframe()
    .iloc[:10, :]
    .reset_index()
    .drop(columns=["latitude", "longitude", "time"])
)
```

PROBLEMAS 6 SALIDA CONSOLA DE DEPURACIÓN TERMINAL PUERTOS 1 JUPYTER

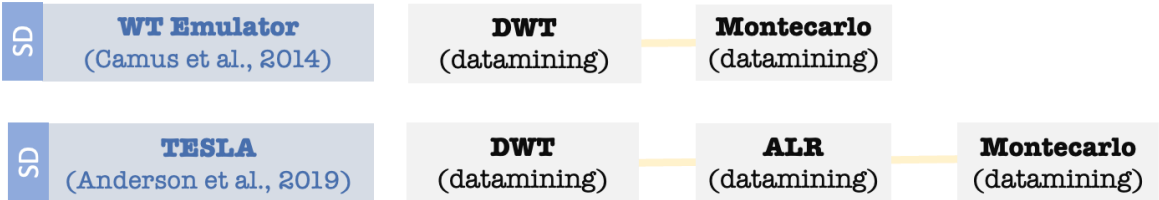
bash [root@codespaces-3b176a BlueMath]#



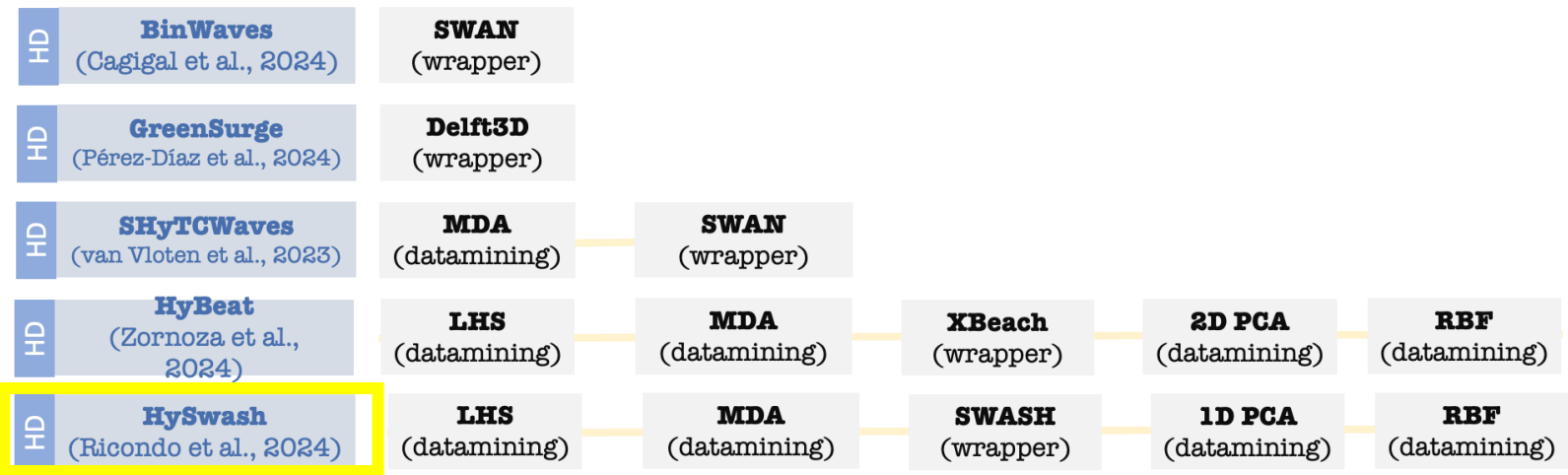
Methods

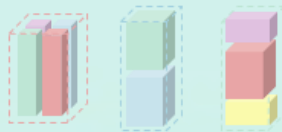


Statistical Downscaling



Hybrid Downscaling



**HySwash**

Ricondo et al., 2024

Hybrid modelling of wave runup and setup

BlueMath [Codespaces: fictional winner]

EXPLORADOR

- BLUEMATH [CODESPACES: FICTIONAL WINNER]
 - .devcontainer
 - assets
 - climate_services
 - methods
 - hybrid_downscaling
 - additive/BinWaves
 - metamodels/HySwash
 - assets
 - templates
 - utils
 - HySwash.Veggy.ipynb
 - HySwash.Veggy.RunUp.ipynb
 - statistical_downscaling
 - toolkit/datamining
 - utils
 - MDA_RBF.Aveiro.ipynb
 - MDA_RBF.ipynb
 - MDA_vs_KMeans.Aveiro.ipynb
 - MDA_vs_KMeans.ipynb
 - .gitattributes
 - .gitignore
 - LICENSE
 - README.md

ESQUEMA

LÍNEA DE TIEMPO

HySwash: A hybrid method for nearshore wave processes

LHS

LATIN HYPERCUBE SAMPLING
Sampling Technique of Nearshore Wave Conditions
(N cases) ($H_s, H_s/L_0, WL$)

MDA

MAXIMUM DISSIMILARITY ALGORITHM
Clustering Algorithm (selection of M cases)

SWASH

1D Numerical Simulation
 $R_{2\%}, \bar{\eta}, H_{rms}$
 H_{ss}, H_{ig}, H_{vlf}

from input to multiple spatial outputs

from input to singular output

PCA

PRINCIPAL COMPONENT ANALYSIS
Dimensionality Reduction

RBF

RADIAL BASIS FUNCTIONS
Interpolation Algorithm

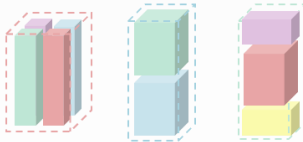
Reconstruction of surf-zone hydrodynamics

PROBLEMAS 8 SALIDA CONSOLA DE DEPURACIÓN TERMINAL PUERTOS 2 JUPYTER

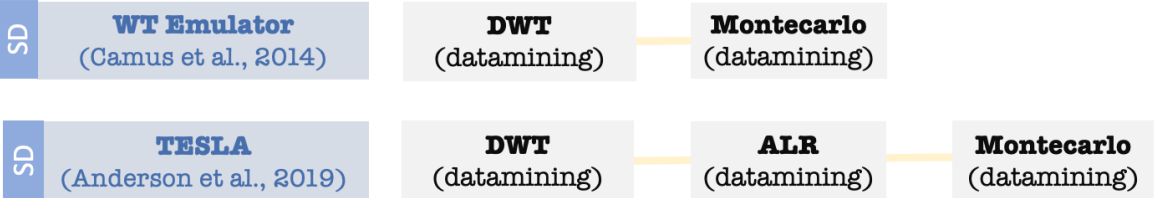
[root@codespaces-3b176a BlueMath]#



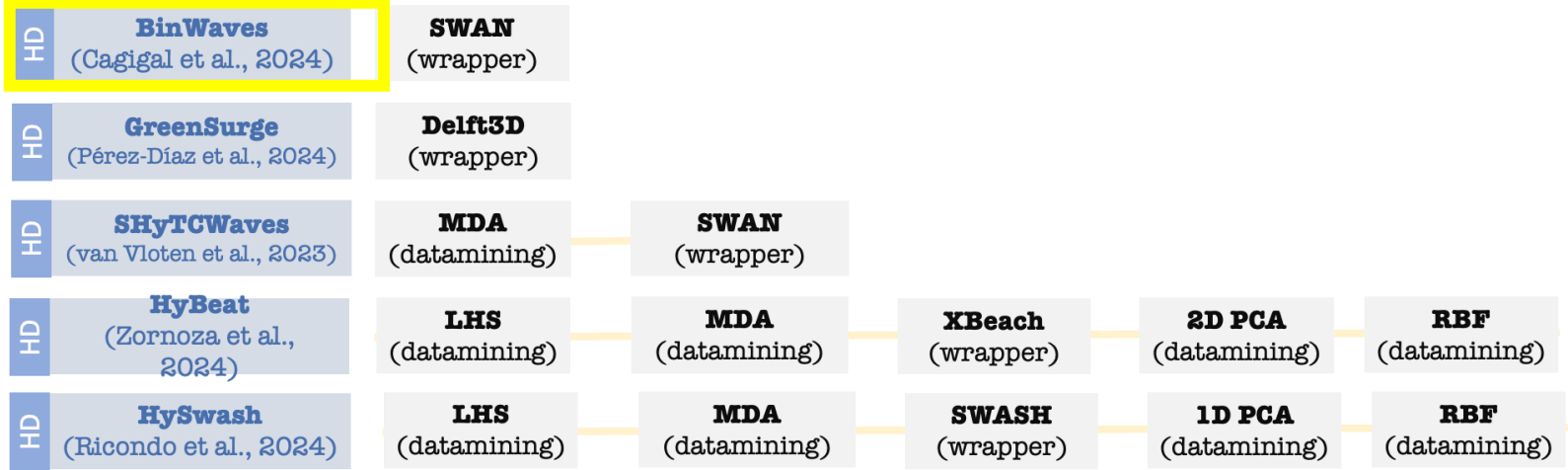
Methods



Statistical Downscaling

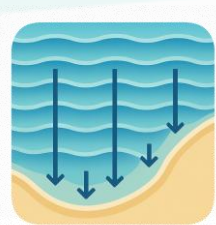
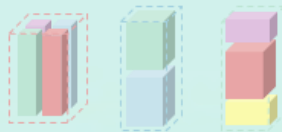


Hybrid Downscaling





Methods



BinWaves
Cagigal et al., 2024

Additive hybrid modelling of wave propagation

BlueMath [Codespaces: studios space spork]

EXPLORADOR

- BLUEMATH [CODESPACES: STUDI...
- > .devcontainer
- > assets
- > climate_services
- > methods
 - > dynamical_downscaling
 - > hybrid_downscaling
 - > additive
 - > BinWaves
 - > CAN_cases
 - > logs
 - > outputs
 - > templates
 - > utils
 - BinWaves_Propag... M
 - BinWaves_Reconstructi...
 - BinWaves_Validation.ip...
 - > GreenSurge
 - > metamodels
 - > statistical_downscaling
 - > toolkit
 - > .gitattributes
 - > .gitignore
 - > LICENSE
 - > README.md
- ESQUEMA
- LÍNEA DE TIEMPO

[Vista previa] README.md

BinWaves_Propagation.ipynb M X BinWaves_Reconstruction.ipynb BinWaves_Validation.ipynb

generar + Código + Markdown ▶ Ejecutar todo ↺ Reiniciar ⌵ Borrar todas las salidas 🔗 Ver datos 📄 Jupyter Variables 📄 Esquema ...

base (Python 3.12.9)

BinWaves example in Cantabria (Propagation)

In this notebook:

Here is where the construction of the library of pre-run cases for all the monochromatic wave systems is made.

Steps:

- Generates wave conditions for all given frequencies and directions.
- Generates SWAN cases and runs them.
- Extracts SWAN cases and saves output.
- Plots the library for all the cases and some larger example ones.

Generate computational bathymetry

```
[1] import xarray as xr

bathy = -(
    xr.open_dataset("outputs/bathymetry_100m.nc")
    .rename({"cx": "lon", "cy": "lat"})
    .transpose("lat", "lon")
    .isel(lon=slice(50, 500, 10), lat=slice(0, 350, 10))
    .sortby("lat", ascending=False)
```

PROBLEMAS SALIDA CONSOLA DE DEPURACIÓN **TERMINAL** PUERTOS 2 JUPYTER

bash + ▾ 🗑️ ... ^ ×

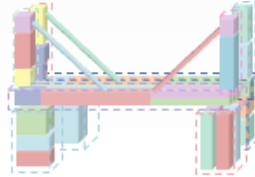
[root@codespaces-0c0918 BlueMath]#

Visual Studio Code

Climate services



Climate Services



Wave Forecast System



Data Download

Wave Correction
(Albuquerque et al., 2021)

SuperPoint generation
(Cagigal et al., 2021)

HD

BinWaves
(Cagigal et al., 2024)

HD

HyBeat
(Zornoza et al., 2024)

TC Forecast System



TC Data Download

HD **SHyTCWaves**
(van Vloten et al., 2023)

SuperPoint generation
(Cagigal et al., 2021)

HD

BinWaves
(Cagigal et al., 2024)

HD

HyBeat
(Zornoza et al., 2024)

TC Risk Assessment



Data Download

SD **TESLA**
(Anderson et al., 2019)

HD **SHyTCWaves**
(van Vloten et al., 2023)

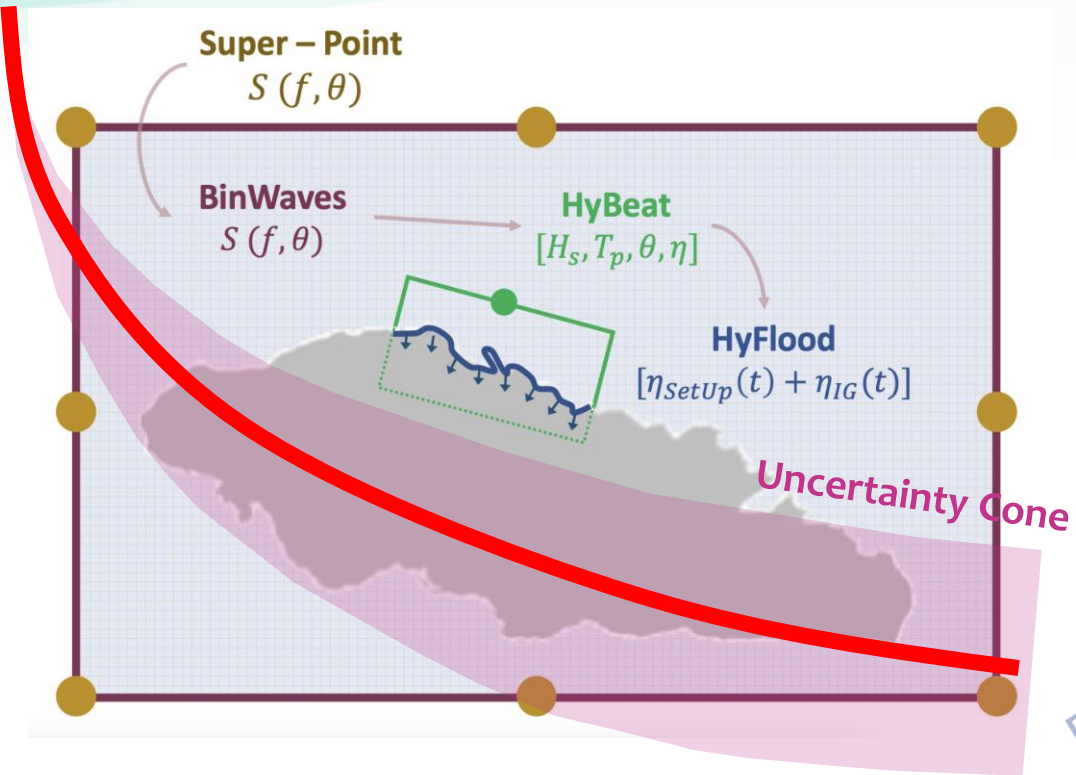
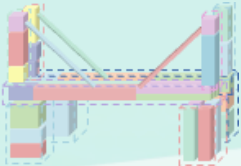
SuperPoint generation
(Cagigal et al., 2021)

HD

BinWaves
(Cagigal et al., 2024)

HD

HyBeat
(Zornoza et al., 2024)



Example for building a TC Forecast System

HIGH
RESOLUTION
WAVES

WAVE
RUNUP

HySwash

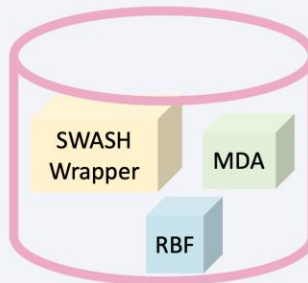
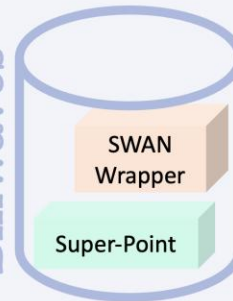
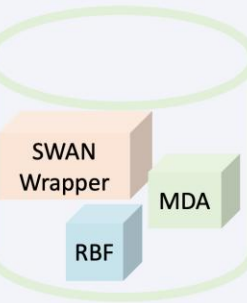
BinWaves

REGIONAL
WAVES

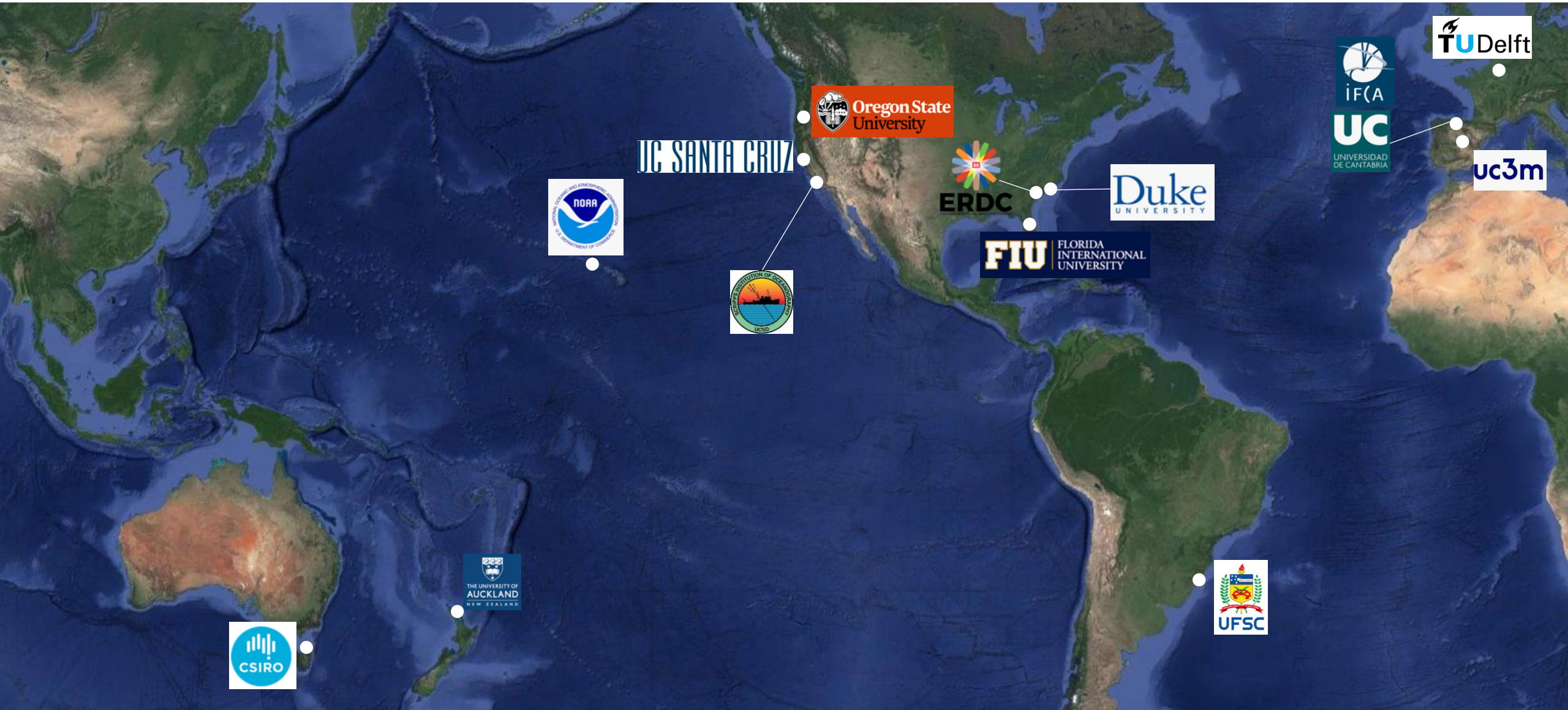
SHyTCWaves

TC FORECAST
DOWNLOADER

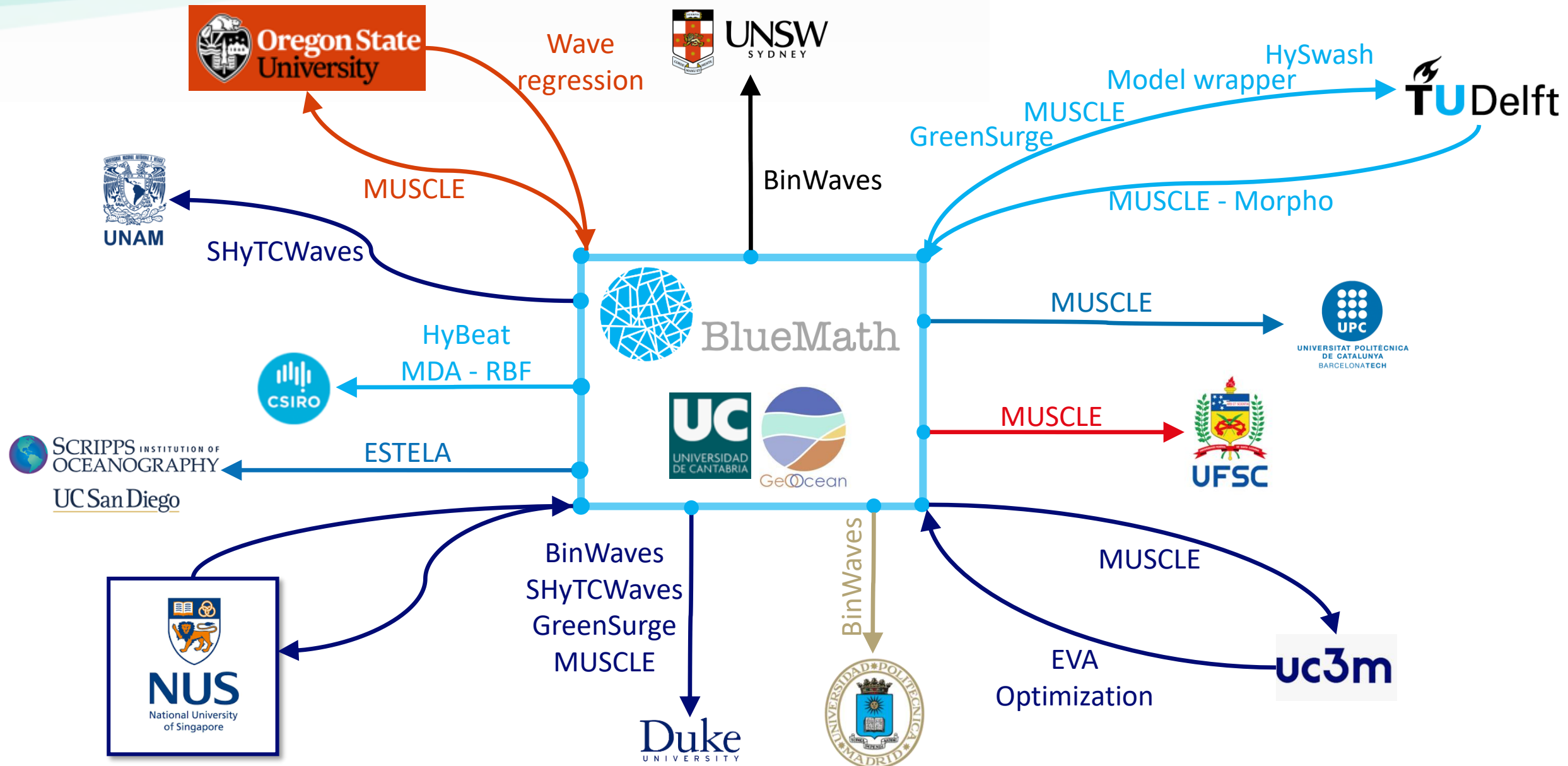
TRACK
INFORMATION



Ongoing collaborations



Users and code providers



Courses



WDWE conference,
Hong Kong



Coastal Dynamics,
Aveiro, Portugal



41st IAHR World
Congress, Singapore



RCEM, Barcelona,
Spain

March 2025

June 2025

June 2025

October 2025

December 2024

April 2025

June 2025

September 2025

UFSC, Brazil



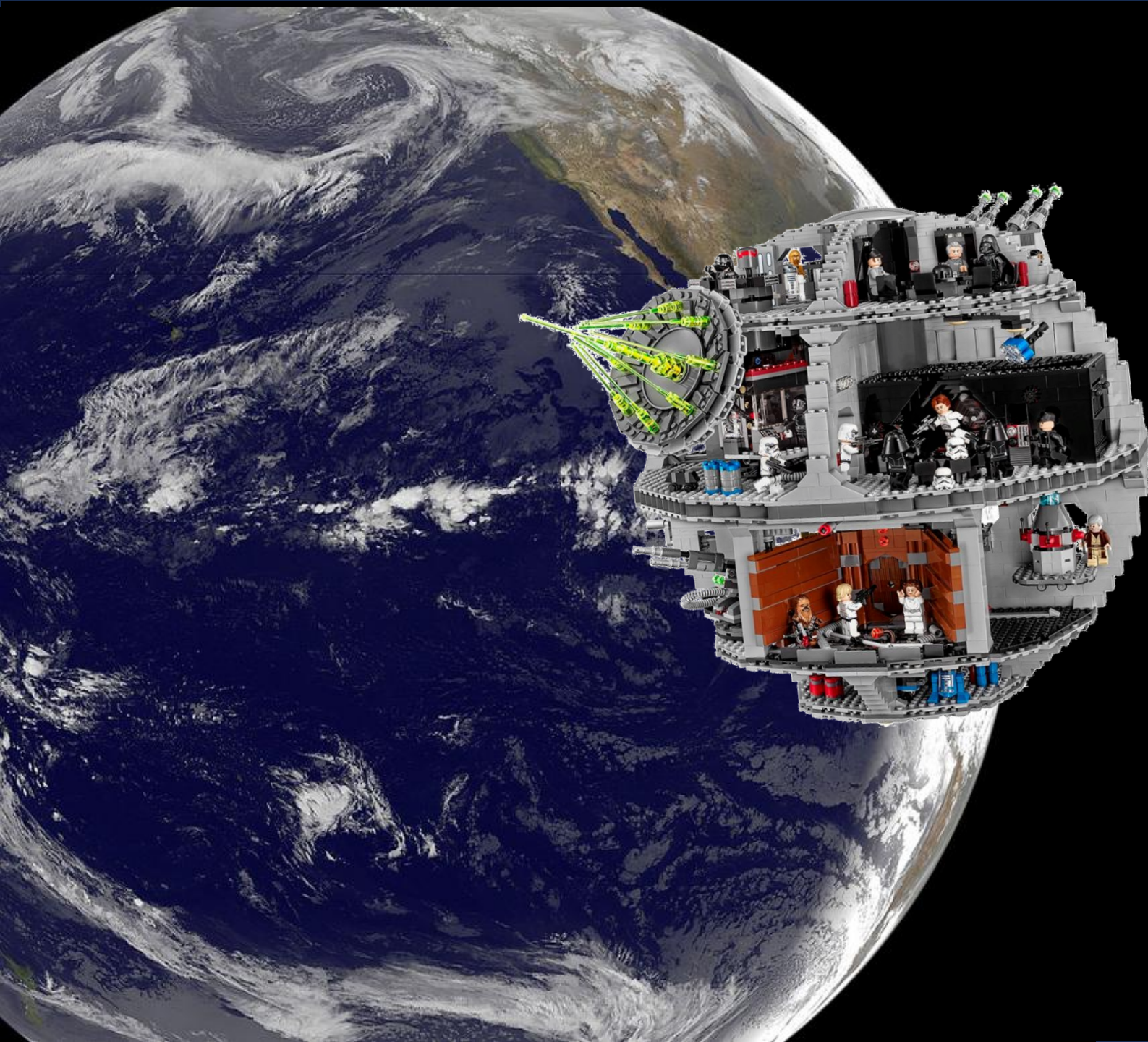
DigiShape,
Netherlands



NUS, Singapore



Water Week, Cairo, Egypt



Thank you

laura.cagigal@unican.es

BlueMath Repo



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