Metocean Engine: Developing Open-Access Tools for In-Depth Metocean Analysis

https://github.com/MET-OM/metocean-api

https://github.com/MET-OM/metocean-stats

Konstantinos Christakos[1,2], Jan-Victor Björkqvist[1], Dung M. Nguyen[1], Clio Michel[1], Birgitte Furevik[1,3]

[1] Norwegian Meteorological Institute (MET Norway), Norway

[2] Norwegian University of Science and Technology, Norway

[3] Bergen Offshore Wind Centre (BOW), University of Bergen,Norway

Open-source Python Tool: Metocean Engine

Analysis of metocean (**met**eorological and **ocean**ographic) conditions is essential to the design of **marine structures**, the **marine operations**, and the **wind and wave energy resource assessments**. This work presents the development of an open-source Python tool, called **Metocean Engine**, that aims to automate the metocean reporting based on the open-access NORA3 hindcast [1,2] by MET Norway and ERA5 [3] by ECMWF. It has two components: i) **metocean-api** that contains functions to extract time series in a csv-format and ii) **metocean-stats** that creates a variety of detailed metocean statistics.

metocean-api

Installation using conda:

```
conda install conda-forge::metocean-api
```

The time series (ts) object is initialized with the following command:

```
from metocean_api import ts
df_ts = ts.TimeSeries(lon=3.73, lat=64.6,
                      start_time='1990-01-01',
                      end_time  ='2020-12-31' ,
                     product='NORA3_wind_wave')
```

Several options for **product** are available:

- For wind NORA3 hourly data in 10, 20, 50, 100, 250, 500, 750m (Nordic Area): product=**'NORA3_wind_sub'**
- For atmospheric (pressure,temperature,precipitation,humidity, radiation) NORA3 hourly surface data (Nordic Area): product=**'NORA3_atm_sub'**
- For SST and atmospheric (wind, temperature, relative humidity) NORA3 3-hourly data in 50, 100, 150, 200, 300m (Nordic Area): product=**'NORA3_atm3hr_sub'**
- For wave NORA3 sub data (Nordic Seas): product=**'NORA3_wave_sub'**
- For combined wind and wave NORA3 sub data (Nordic Seas): product=**'NORA3_wind_wave'**
- For wave NORA3 data (Nordic Seas + Arctic): product=**'NORA3_wave'**
- For sea level NORA3 data (Nordic Seas): product=**'NORA3_stormsurge'**
- For coastal wave NORA3 data: product=**'NORAC_wave'**
- For global reananalysis ERA5 (wind and waves): product=**'ERA5'**

  The user needs to install the *CDS API key* according to https://cds.climate.copernicus.eu/api-how-to ,

  Dataset: https://doi.org/10.24381/cds.adbb2d47

Import data from server to **ts-object** and save it as csv:

```
df_ts.import_data(save_csv=True)
```

time	wind_speed_10m	wind_direction_10m	wind_speed_20m	wind_direction_20m	wind_speed_50m	wind_direction_50m	wind_speed_100m	wind_direction_100m
1990-01-01 00:00:00	4.45	145.2	4.55	145.2	4.73	145.2	4.84	145.1
1990-01-01 01:00:00	6.24	153.5	6.37	154.0	6.7	154.2	6.92	154.3
1990-01-01 02:00:00	6.02	158.0	6.1	158.5	6.39	159.0	6.55	159.4
1990-01-01 03:00:00	5.72	177.8	5.86	178.1	6.05	178.1	6.16	177.8
1990-01-01 04:00:00	5.72	187.8	5.81	188.0	5.94	187.6	6.01	186.9
1990-01-01 05:00:00	5.5	200.6	5.58	200.9	5.7	200.8	5.77	200.6
1990-01-01 06:00:00	6.07	205.3	6.19	205.5	6.33	205.4	6.39	205.2
1990-01-01 07:00:00	5.95	202.9	6.05	202.9	6.17	202.9	6.22	202.7
1990-01-01 08:00:00	5.61	199.9	5.69	199.7	5.87	199.7	5.92	199.4
1990-01-01 09:00:00	5.17	192.7	5.28	192.5	5.43	192.6	5.49	192.7
1990-01-01 10:00:00	4.88	187.5	4.94	187.5	5.04	187.8	5.1	188.1
1990-01-01 11:00:00	4.65	187.1	4.69	187.3	4.8	187.8	4.9	188.7
1990-01-01 12:00:00	4.25	183.7	4.3	183.8	4.42	184.5	4.49	185.4
1990-01-01 13:00:00	4.65	183.2	4.72	183.3	4.84	183.9	4.9	184.4
1990-01-01 14:00:00	4.88	186.2	4.99	186.5	5.11	186.7	5.17	186.9
1990-01-01 15:00:00	5.47	183.3	5.57	183.3	5.68	183.6	5.72	183.7
1990-01-01 16:00:00	5.56	182.6	5.65	182.7	5.77	183.0	5.82	183.2
1990-01-01 17:00:00	5.51	181.3	5.62	181.4	5.74	181.7	5.79	181.9
1990-01-01 18:00:00	5.33	179.5	5.42	179.5	5.52	179.7	5.57	179.9
1990-01-01 19:00:00	5.35	178.7	5.43	178.6	5.53	178.8	5.58	179.0
1990-01-01 20:00:00	5.46	177.3	5.55	177.3	5.65	177.5	5.7	177.7
1990-01-01 21:00:00	6.05	181.6	6.16	181.8	6.3	182.0	6.37	182.3
1990-01-01 22:00:00	6.0	184.4	6.09	184.4	6.23	184.7	6.3	185.0
1990-01-01 23:00:00	5.63	186.1	5.72	186.1	5.84	186.4	5.9	186.7
1990-01-02 00:00:00	4.92	185.4	4.99	185.3	5.09	185.6	5.13	185.8
1990-01-02 01:00:00	4.64	180.5	4.71	180.7	4.8	180.9	4.85	181.3

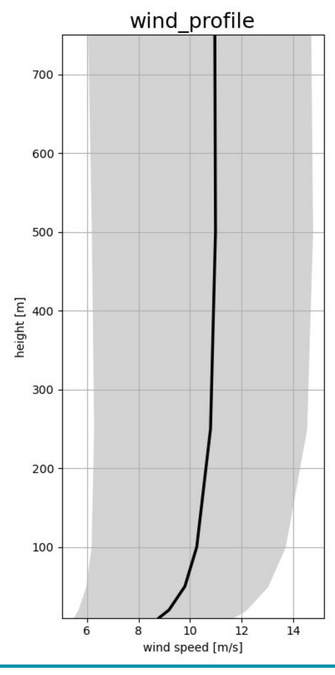
metocean-stats

Installation using conda:

```
conda install conda-forge::metocean-stats
```

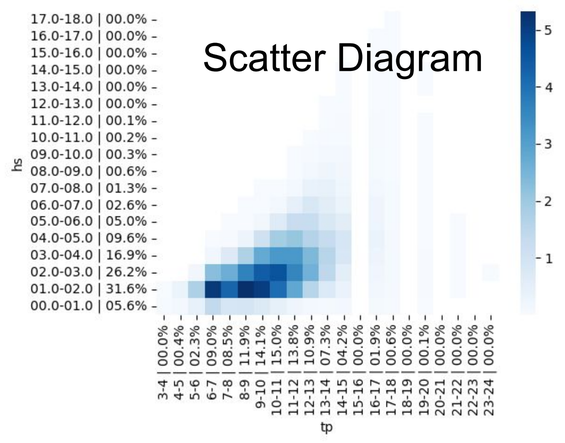
Wind Profile Statistics

```
from metocean_stats.stats import profile_stats

mean_prof = profile_stats.mean_profile(data = ds.data, vars =
            ['wind_speed_10m','wind_speed_20m','wind_speed_50m',
             'wind_speed_100m','wind_speed_250m','wind_speed_500m',
             'wind_speed_750m'],
            height_levels=[10,20,50,100,250,500,750],
            perc=[25,75],
            output_file='wind_profile.png')
```



General Statistics

```
from metocean_stats.stats import general_stats

general_stats.scatter_diagram(data=ts.data,
                              var1='hs', step_var1=1,
                              var2='tp', step_var2=1,
                              output_file='scatter_diagram.png')
```




```
general_stats.table_monthly_percentile(data=ts.data,
var='hs',output_file='hs_perc.csv')
```

Month	5\%	50\%	Mean	95\%	99\%
jan	1.9	3.8	4.2	7.7	10.2
feb	1.8	3.7	4	7.3	9.6
mar	1.5	3.2	3.6	6.7	9
apr	1.1	2.4	2.6	4.9	6.8
may	0.9	1.8	2	3.6	4.8
jun	0.8	1.6	1.7	3.2	4.4
jul	0.7	1.4	1.6	3	3.7
aug	0.8	1.6	1.7	3.3	4.4
sep	1	2.2	2.5	4.9	6.5
oct	1.3	2.7	3	5.6	7.5
nov	1.4	3.1	3.4	6.6	8.6
dec	1.7	3.6	3.9	7.3	9.7
Annual	1.7	3.6	3.9	7.3	9.7

```
general_stats.table_monthly_min_mean_max(data=ts.data,var='hs',
output_file='hs_min_mean_max.csv')
```

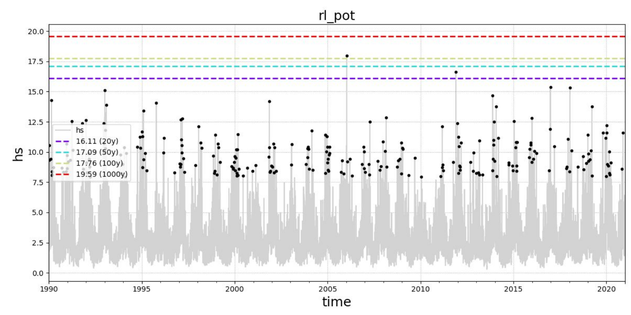
Month	Minimum	Mean	Maximum
jan	5.75	10.4	17.97
feb	4.43	9.6	14.28
mar	4.6	9.4	13.76
apr	3.56	6.6	12.5
may	3.38	5	8.1
jun	2.58	4.4	8.75
jul	2.42	3.7	6.16
aug	2.87	4.6	7.34
sep	3.22	6.7	9.63
oct	4.06	7.8	14.05
nov	4.36	9	16.63
dec	5.65	9.5	15.37
Annual Max.	7.93	12.7	17.97

```
general_stats.table_var_sorted_by_hs(data=ts.data,var='tp',
var_hs='hs',output_file='tp_sorted_by_hs.csv')
```

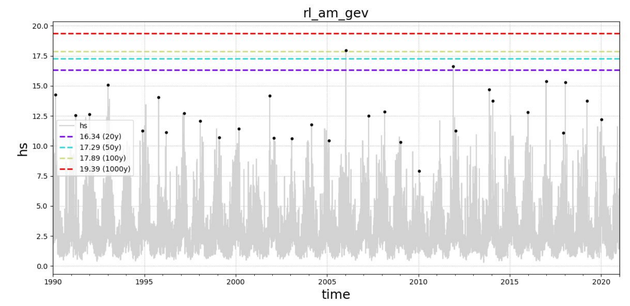
Hs	Entries	Min	5\%	Mean	95\%	Max
0-1	15217	3.2	5.7	8.4	13.5	19.8
1-2	85838	3.6	5.7	8.9	12.3	21.8
2-3	71225	5.2	6.9	9.9	13.5	23.9
3-4	45819	6.3	8.4	10.9	14.9	21.8
4-5	26011	6.9	9.2	11.7	14.9	21.8
5-6	13564	7.6	10.2	12.4	16.4	21.8
6-7	7003	8.4	11.2	13.1	16.4	19.8
7-8	3629	9.2	11.2	13.6	16.4	19.8
8-9	1749	11.2	12.3	13.9	16.4	19.8
9-10	850	11.2	12.3	14.5	18.0	19.8
10-11	429	12.3	13.5	15.3	18.0	19.8
11-12	208	13.5	13.5	15.7	18.0	19.8
12-13	109	13.5	14.9	15.8	18.0	18.0
13-14	49	14.9	14.9	16.5	19.1	19.8
14-15	27	14.9	15.3	17.1	18.0	19.8
15-16	19	16.4	16.4	17.4	18.0	18.0
16-17	3	16.4	16.5	17.4	18.0	18.0
17-18	3	18.0	18.0	18.0	18.0	18.0
18-19	0	-	-	-	-	-
0-19	271752	3.2	6.3	10.2	14.9	23.9

Extreme Statistics

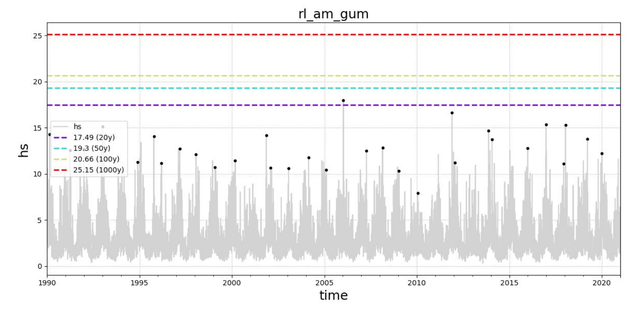
```
from metocean_stats.stats import extreme_stats

extreme_stats.return_levels_pot(data=ds.data, var='hs',
         periods=[20,50,100,1000],
         output_file='rl_POT.png')
```



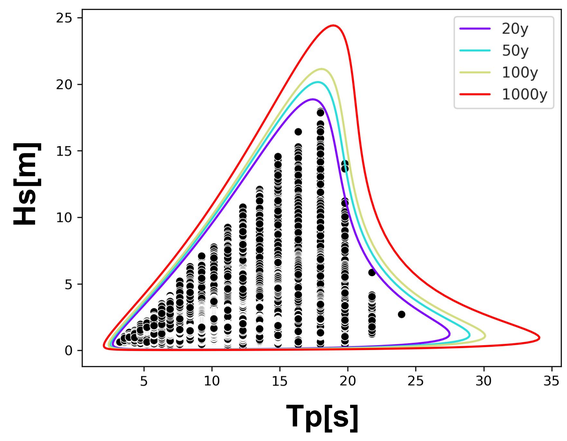

```
extreme_stats.return_levels_annual_max(data=ds.data,var='hs',
periods=[20,50,100,1000],method='GEV',output_file='rl_GEV.png')
```




```
extreme_stats.return_levels_annual_max(data=ds.data,var='hs',peri
ods=[20,50,100,1000],method='GUM',output_file='rl_GUM.png')
```




```
extreme_stats.plot_joint_2D_contour(data=ds.data,var1='hs',
var2='tp',periods=[20,50,100,1000],output_file='joint2D.png')
```



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2. Breivik, Ø., Carrasco, A., Haakenstad, H., Aarnes, O. J., Behrens, A., Bidlot, J.-R., Björkqvist, J.-V., Bohlinger, P., Furevik, B. R., Staneva, J., and Reistad, M.(2022). The impact of a reduced high-wind Charnock parameter on wave growth with application to the North Sea, the Norwegian Sea, and the Arctic Ocean. Journal of Geophysical Research: Oceans, 127, e2021JC018196. https://doi.org/10.1029/2021JC018196
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Norwegian Meteorological Institute

NTNU Norwegian University of Science and Technology