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A global insight into the seasonal and spatial distribution of wind and waves

Executive Summary

Where can surfers, windsurfers and sailors find desired wind and wave conditions during the year? A general trend for such conditions can be inferred from atmospheric and oceanographic reanalysis data of previous years. We developed a data processing and visualization tool that enables users to globally identify prior wind and wave conditions on a monthly resolution. This tool helps water sports enthusiasts to quickly determine travel destinations which most likely meet their desired meteorological and oceanographic conditions.

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Introduction

Surfers and windsurfers travel the globe on their search for perfect swell and wind conditions. Sailors and the marine industry are interested in spatial patterns of global winds and storms. The goal of this project is to be able to quickly evaluate the spatial and temporal distribution of relevant parameters like wave height, wave period, wind speed, wind direction, and sea surface temperature of the past. What is of great interest for advance planning of any trip or cruise depending on these meteorological and oceanographic parameters is their frequency and strength of occurrence during the year around the globe. Therefore a main focus is put on the monthly consistency, an indicator for the chances of occurrence of a parameter with a certain magnitude. Evaluating the consistency of the past should give an idea of e.g. how often winds occur with a certain strength or direction, or e.g. how often do wave heights and wave periods with a certain magnitude occur in any month. With the help of the presented tool one is able to quickly grasp seasonal trends and general conditions during the year to know when to go where to find sought conditions.

1. Data

The global wave and wind data is obtained from ERA-Interim, one of the latest global atmospheric and oceanographic reanalysis data sets. It is produced by the European Centre for Medium-Range Weather Forecasts (ECMWF; [1]). Parameters used for the study are significant wave height, mean wave direction (mwd; measured from true north), mean wave period (mwp), peak wave period (pp1d), mean wind speed at 10 m (ws), mean wind direction at 10 m (mdwi; measured from true north), and sea surface temperature (sst). All data is available on a grid covering the whole globe with the size of 0.75° × 0.75° (approximately 80 km × 80 km) with a temporal resolution of 6 hours from 1979 onward. The data for the time period from 1979 until end of 2016 (37 years) is extracted. Further details on the parameters can be found on the parameter database[1] from the ECMWF.

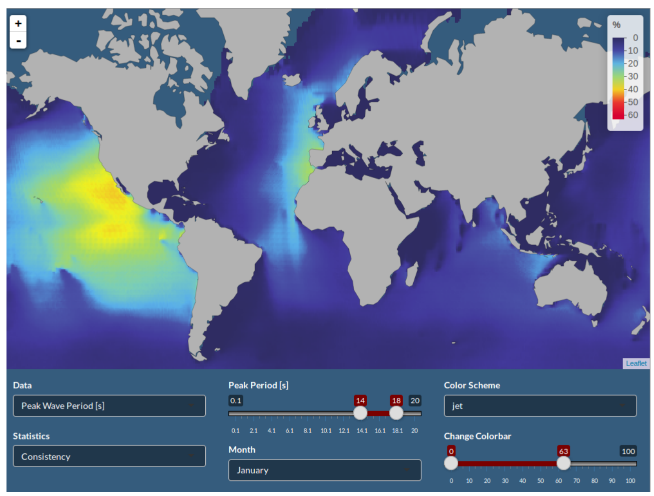

Figure 1. Consistency: peak wave period (14 - 18 s) for January.

2. Method

To gain insights into the seasonal distribution of each parameter the data is divided into 12 samples, each representing one month. We then want to estimate the fraction of the sample falling into a corresponding range, what we refer to as consistency. Therefore the empirical cumulative distribution function (ecdf) is calculated. The obtained ecdf is interpolated at query points with spacing 0.1 for swh [m], mwp [s], ws [m], pp1d [s], with spacing 0.2 for swh [ft], with spacing 0.4 for ws [kn] and with spacing 1 for mwd [°] and mdwi [°]. This is done to be able to evaluate the value of the ecdf at points other than the original data. The fraction f of the

[1] http://apps.ecmwf.int/codes/grib/param-db

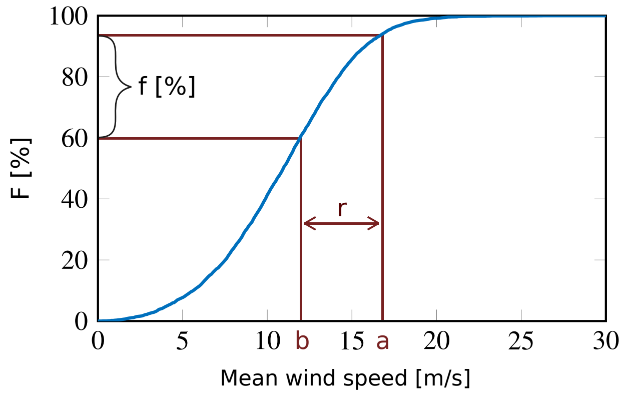

Figure 2. Interpolated ecdf (blue line) of ws-sample in April for a grid point in the North Atlantic. The indicated value f represents the consistency for the range r.

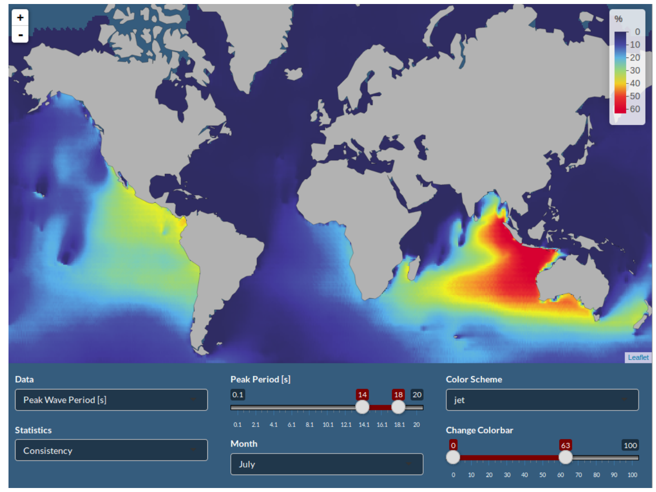

Figure 3. Consistency: peak wave period (14 - 18 s) for July.

sample falling between two points, namely in the range (r) between a and b (Figure 2), where $a > b$ is then estimated with

$$f = F(a) - F(b) \quad (1)$$

where F() is the value of the ecdf. For a given month, f is seen as a measure of the consistency. The dominant wind and wave direction in any month are assessed by evaluating the most frequent occurring value of each grid point's data. The monthly plots of these two parameters are smoothed using a mean filter over a rectangle of 3×3 grid points. Additional statistical parameters like the 37 year monthly maxima, minima, and mean are calculated for each grid point. Grid points for which the sample contains equal values in more than 95% of the cases are seen as unreliable data and are skipped from the analysis.
One has to point out that our method does not take climate phenomena like e.g. El Niño / La Niña or a changing climate into account.

3. Visualization

The tool used to conduct the visualization is the shiny package [2] in the *R* framework. The user is allowed to select the sample of interest for any month. Beside the consistency we visualize the 37 year mean, maxima, and minima for each month. As an example we show the consistency for the peak wave period ranging from 14 - 18 s for January (Figure 1) and July (Figure 3). One can quickly grasp when and where the chances of finding the sought conditions are higher. The chances for high period swell to occur in July in Europe are close to zero, whereas Indonesia and Australia are the most consistent places to go. This pattern is reversed during January when the most consistent places to go are at the Atlantic Coast in Western Europe and Northern Africa or the Pacific coast in America. Nevertheless, one sees that the chances are about 20 % lower finding sought conditions in these regions during that time.

References

[1] P. Berrisford and Coauthors. The ERA-Interim Archive Version 2.0. *ERA Report Series*, (1):23 pp, November 2011.

[2] RStudio, Inc. *Easy web applications in R.*, 2017. URL: `http://www.rstudio.com/shiny/`.