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Method Comparison for Extreme Wave Analysis on the Italian coasts

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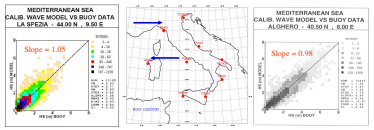
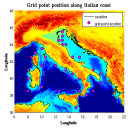
Data calibration

1 – **Satellite data validation:** comparison buoy vs. satellite → 2 – **Calibration of model data:** comparison model vs. satellite → 3 – **Creation of timeseries in crucial points:** from June 1992 to july 2002

4 – **Correlation calibrated model vs. observations:** validation of procedure ← 5 – **Statistic determination of climate:** one and two-variate statistics analysis ← 6 – **Extention of timeseries to 40 years:** database from ERA40

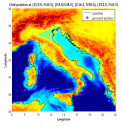


A multivariate statistics analysis has been carried out for 30 geographical points. Points have been selected in order to characterize the physiographic units of the Italian coasts and seas and to define the corresponding offshore wave climate.

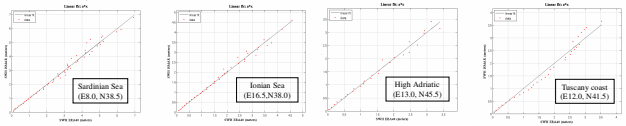


The extreme weather events might become relevant as their mean frequency increases over a period (e.g. >10 years) engendering climate and morphological changes of the Italian coasts and seas.

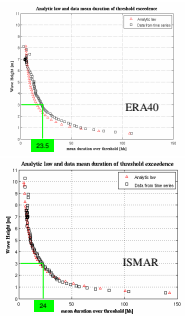
For each analyzed point and over a time-interval of 42 years (from 1958 to 1999) the output fields of the model WAM-ERA40 have been conveniently calibrated starting from the common 8-years data period (1992-1999):



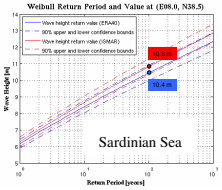
There's a good correlation between ISMAR and ERA40 calibrated datasets. Correlations refers to points shown below:



Data comparison for the cumulative and mean (Mathiesen, 1993) persistence [hh] of the sea states over threshold :



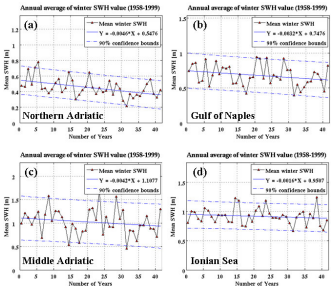
During the 8-years superposition period the calibrated ERA40 and the ISMAR data are well consistent as for the persistence over threshold (left side) as for the return periods and values (below).



Methodology

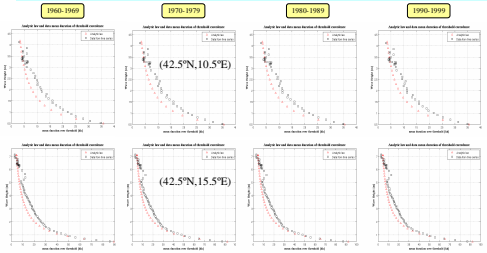
For each analyzed point with the calibrated ERA40 data the followings values have been obtained:

•Annual and seasonal mean values of significant wave height of the whole (*dependent*) dataset [m].



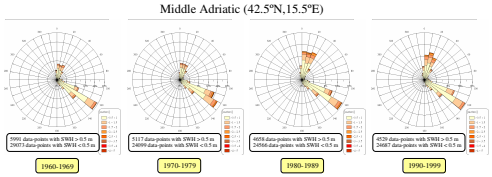
From 1958 to 1999, graphics show the mean trend of the winter averaged significant wave height (SWH), i.e. the averaged wave heights from December to February.
The linear fit shows an overall slightly negative trend, especially in Northern and middle Adriatic Sea.

•Decadal cumulative and mean (Mathiesen, 1993) persistence [hh] of the sea states over threshold.



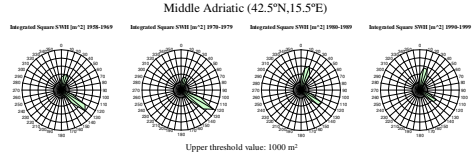
The red curve depicts a theoretically found parametric model for the estimation of duration statistics for SWH. Use of the model requires information both on the distribution and the average absolute rate of change of the SWH. The model provides fairly accurate estimates of mean duration of exceedance of a threshold level.

•Directional distribution of the wave events shown for each decade.



Panels show all wave events with height > 0.5 m for each decade in the period 1960-1999. Main incoming directions in the Adriatic Sea are those of *Bora* (NE) and *Sirocco* (SE).

•Directional distribution of the wave energy (H^2_s cumulated value for each directional sector).



Panels show the cumulated wave energy for unit period of corresponding waves shown above. Main incoming directions in the Adriatic Sea are those of *Bora* (NE) and *Sirocco* (SE).

•Computation of the return time [years] and value [m] of the extreme wave events by using two diverse methods: *peak over threshold* (Goda, 1997) and *r-largest annual maxima* (Smith, 1987).

Extreme events

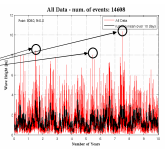
Are all those events that lie at the *extremes* of climatologic distributions. All events whose (*small*) probability to occur over a certain "risk" threshold can be described by a cumulated probability distribution. Are examples the extremes of timeseries of precipitation, flood, wind speed, significant wave height, temperature, etc…

Two methods have been used to process the wave data:

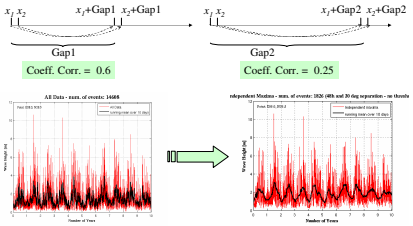
•*r-largest annual maxima* is based on the first *r*-maxima of each year within the wave height dataset;

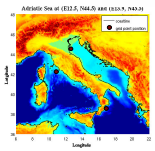
•*peak over threshold* (POT) method, i.e. all the independent wave-events whose value is larger than a fixed threshold.

Each dataset obtained by both methods must contain only events with property of mutual statistical independence. The *r*-method assures by definition the independence condition if maxima are not selected within the same storm.

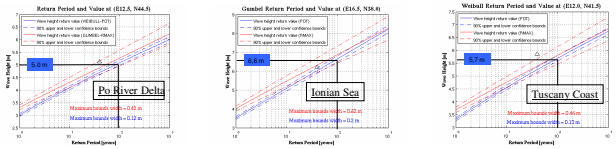


Conversely the POT method must apply on a user-selected independent dataset:





Solid blue and red lines show for each year the Return Value [m] starting from the first year y_0, i.e. the begin of the ERA40 timeseries, to y_0 + 1000. The red line represents the *r*-method; The blue line shows the value obtained using the POT method. The two methods converge for increasing return periods.



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