Smart Control of the Climate Resilience in European Coastal Cities

Webinar

From Global to Local scale Wave Simulations

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11:00 a.m.- 12:00 p.m. (CET)

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Storm surges

Ocean waves can cause destruction, coastal erosion, and contribute to coastal flooding

Liguria - 6 November 2000

Liguria - 3 November 2023

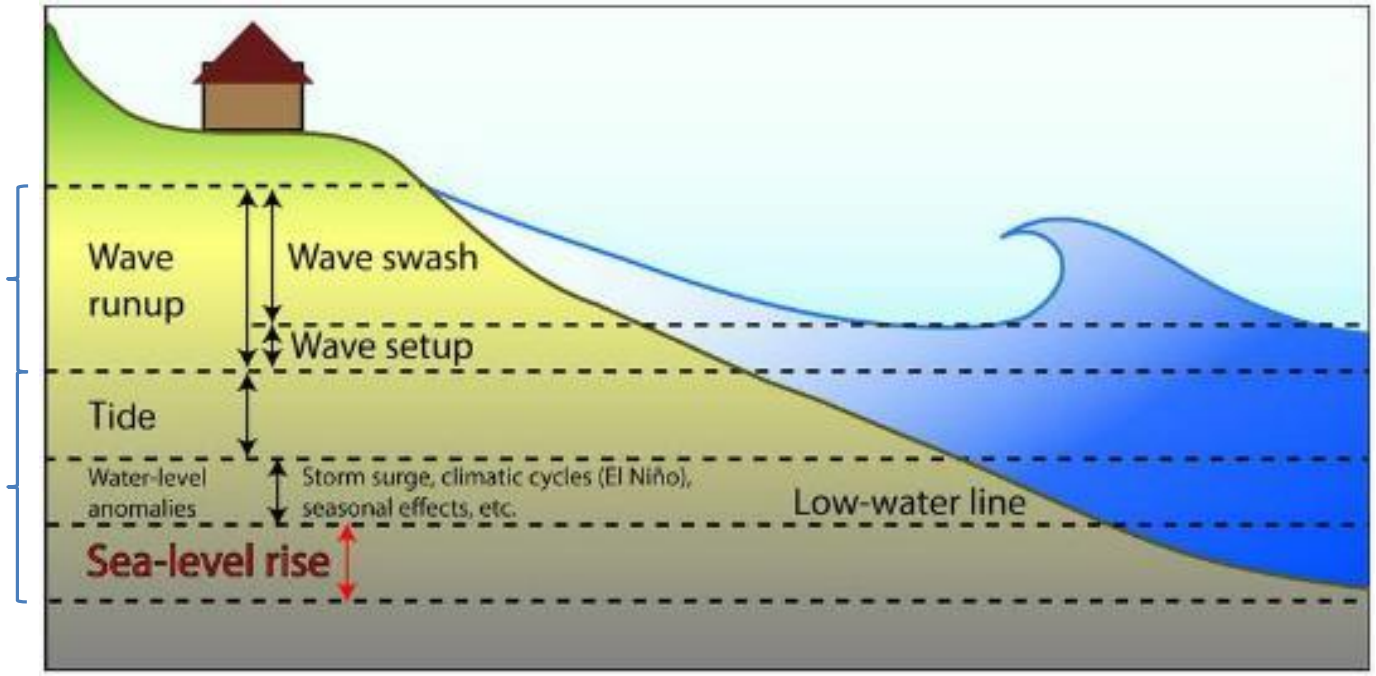
Toscana – 2 December 2023

Storm surge modeling

- A number of different factors contribute to the storm surge
- Different kind of models are needed

Nearshore wave models

Sea level models



usgs.gov

Focus on

Offshore wave models

Wind wave formation

The ocean waves of interest to us are the so-called wind waves, the result of the interaction between water and atmosphere.

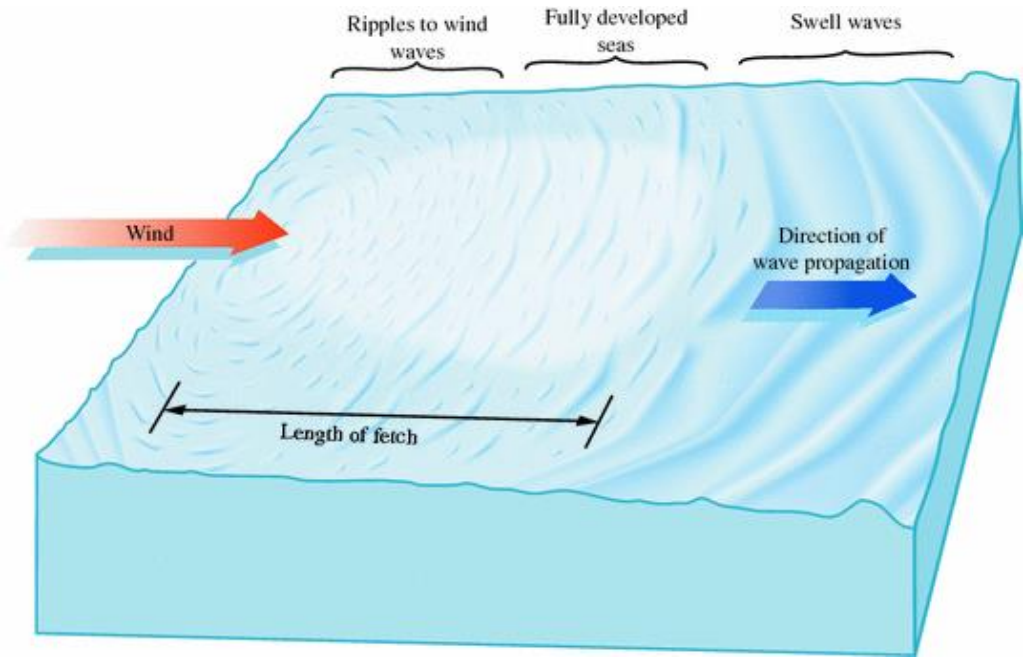
When the wind starts to blow, waves of a few millimeters are formed (capillary waves, or ripples), which stop if the wind stops.

If the wind continues to blow, the capillary waves grow to become gravity waves, which do not die out immediately when the wind stops. They can propagate and become swell waves.

The height of the wind wave in deep water depends on wind intensity, persistence, and fetch.

The fetch is the length of sea area over which the wind has blown without obstructions. The longer the fetch, the more energetic the waves will be.

Moreover, ocean waves are affected by dissipation and wave-wave interactions.



Garrison, T.S., 2010

Numerical wave models

Third generation models (1990 -):

Phase average models that solve the spectral action balance equation with with forcing terms that take into account wind interaction, dissipation, and nonlinear wave-wave interactions

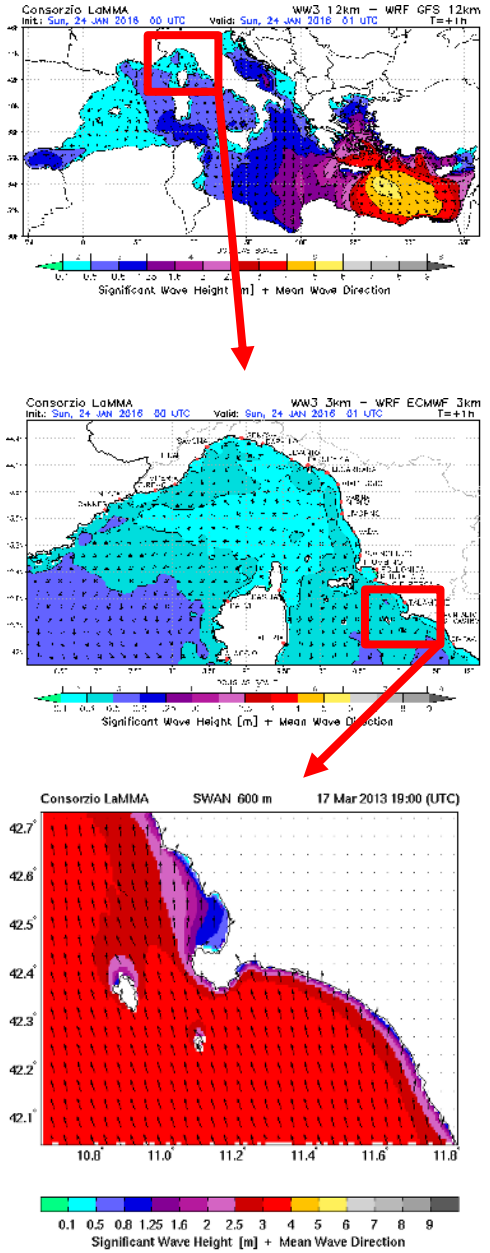
$$\frac{\partial}{\partial t}N + \frac{\partial}{\partial x}c_x N + \frac{\partial}{\partial y}c_y N + \frac{\partial}{\partial \sigma}c_\sigma N + \frac{\partial}{\partial \theta}c_\theta N = \frac{S_{in} + S_{ds} + S_{nl}}{\sigma}$$

Spectral action balance equation

WAM (1994), WAVEWATCH III (1997), SWAN (1999)

The differential equations can be solved numerically by discretization on a grid of points.

Different scales, from global to regional, can be resolved by nesting regular grids with narrow domains and higher resolutions



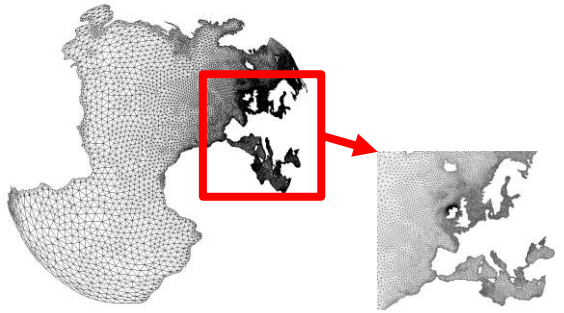
Numerical wave models: WaveWatch III

The numerical wave model used in SCORE is WAVEWATCH III, a third generation wave model developed at NOAA (latest released on March 2019): https://polar.ncep.noaa.gov/waves/wavewatch/

The code must be installed and compiled on a UNIX/Linux platform.

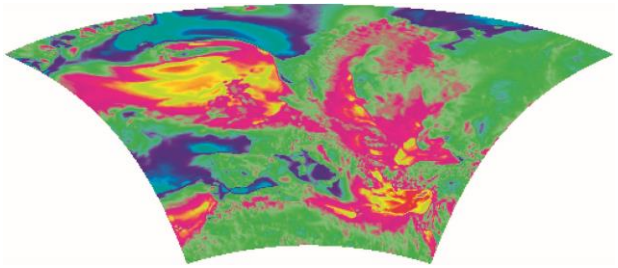
Setting up grid and forcing files:

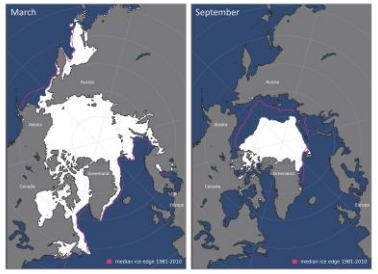
A unstructured WWIII computational grid can be generated by using free code like Gmsh (https://gmsh.info/), coastline data (e.g. GSHHS, OpenStreetMap), and bathymetry (e.g. EMODnet, GEBCO)



Input forcing fields (from MEDCORDEX or EUROCORDEX)

- **Near-Surface Wind components (uas, vas)**
- **Sea Ice Area Fraction (sic)**





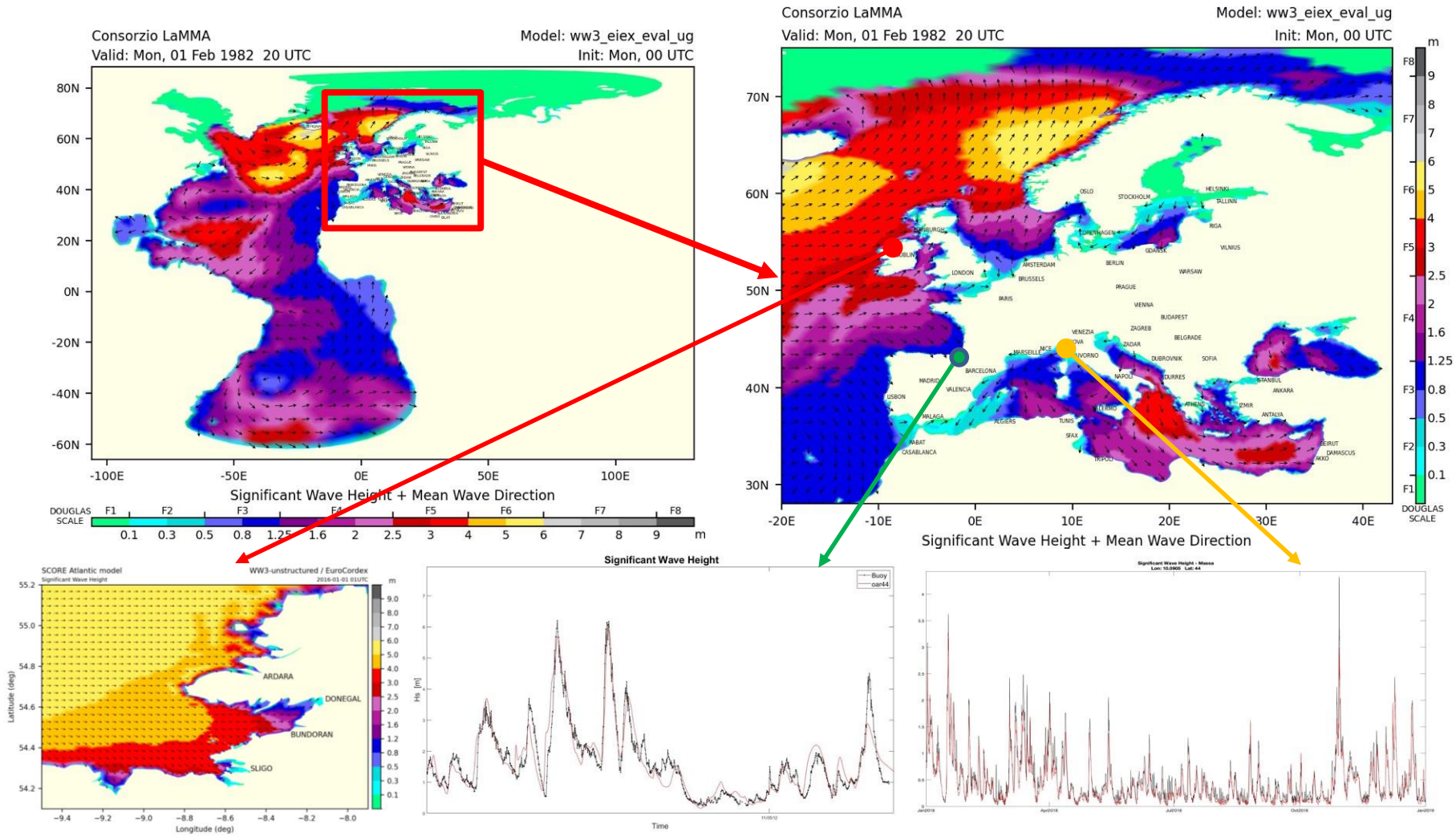
score

Numerical wave models: WaveWatch III

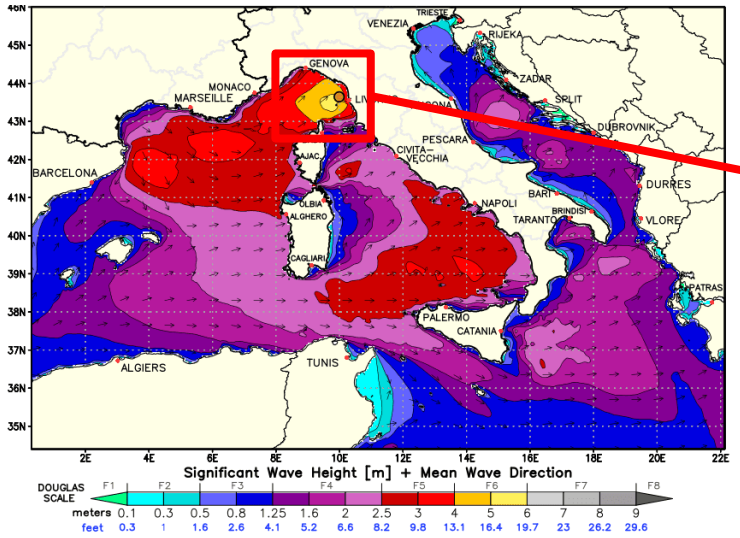
Setting up a simulation run (main steps):

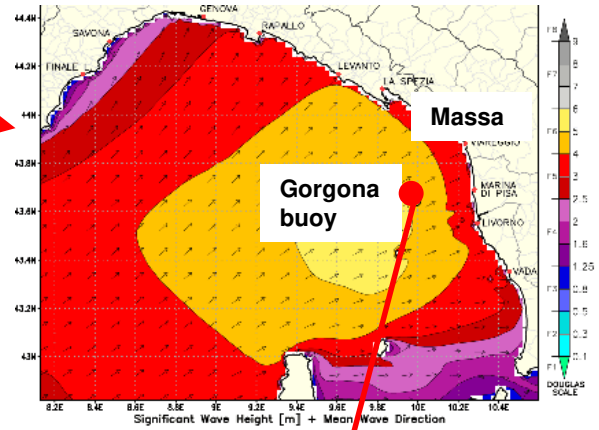
- Edit grid preprocessor input file ww3_grid.inp and process .msh file by ww3_grid
- Edit wind and ice preprocessor input files ww3_prnc.inp and process NetCDF forcing files by ww3_prnc
- Edit model configuration in shel input file ww3_shel.inp and run model simulation by ww3_shel
- Edit point or grid output post-processing input files, ww3_ounp.inp, and ww3_ounf.inp, and extract point or grid data into NetCDF files by ww3_ounp, and ww3_ounf, respectively

EuroCordex study case in SCORE



MedCordex study case in SCORE – Massa (Italy)





Gorgona buoy comparison