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Wave model downscaling for coastal applications

Nikolay Valchev (1), Georgi Davidan (2), Ekaterina Trifonova (1), and Nataliya Andreeva (1)

(1) Institute of Oceanology, Coastal Zone Dynamics, Varna, Bulgaria (valchev@io-bas.bg), (2) A.P. Karpinsky All-Russian Institute of Geological Research, St. Petersburg, Russian Federation

Downscaling is a suitable technique for obtaining high-resolution estimates from relatively coarse-resolution global models. Dynamical and statistical downscaling has been applied to the multidecadal simulations of ocean waves. Even as large-scale variability might be plausibly estimated from these simulations, their value for the small scale applications such as design of coastal protection structures and coastal risk assessment is limited due to their relatively coarse spatial and temporal resolutions. Another advantage of the high resolution wave modeling is that it accounts for shallow water effects. Therefore, it can be used for both wave forecasting at specific coastal locations and engineering applications that require knowledge about extreme wave statistics at or near the coastal facilities.
In the present study downscaling is applied to both ECMWF and NCEP/NCAR global reanalysis of atmospheric pressure over the Black Sea with 2.5 degrees spatial resolution. A simplified regional atmospheric model is employed for calculation of the surface wind field at 0.5 degrees resolution that serves as forcing for the wave models. Further, a high-resolution nested WAM/SWAN wave model suite of nested wave models is applied for spatial downscaling. It aims at resolving the wave conditions in a limited area at the close proximity to the shore. The pilot site is located in the northern part the Bulgarian Black Sea shore.
The system involves the WAM wave model adapted for basin scale simulation at 0.5 degrees spatial resolution. The WAM output for significant wave height, mean wave period and mean angle of wave approach is used in terms of external boundary conditions for the SWAN wave model, which is set up for the western Black Sea shelf at 4km resolution. The same model set up on about 400m resolution is nested to the first SWAN run. In this case the SWAN 2D spectral output provides boundary conditions for the high-resolution model run.
The models are implemented for a couple of storms occurred in 2009 as well as for a reconstructed past extreme storm. The system is validated against ADCP-born wave directional measurements. The SWAN model correlates well with measurements but slightly underestimates the wave height mostly due to coarse resolution of wind forcing.
Presently, the results obtained for the study site feed up morphological models used for estimation of morphological changes such as sea bed and beach erosion. The system is targeted at regions where local wave growth and transformation rate differ from the offshore locations often used to estimate the near shore wave parameters. This includes areas with complicated bathymetry such as bays that endure a greater extent of human impact.