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Coupling of WRF meteorological model to WAM spectral wave model through sea surface roughness at the Balearic Sea: impact on wind and wave forecasts

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Meteorological models, like WRF, usually describe the earth surface characteristics by tables that are function of land-use. The roughness length (z_0) is an example of such approach. However, over sea z_0 is modeled by the Charnock (1955) relation, linking the surface friction velocity u_*^2 with the roughness length z_0 of turbulent air flow,

$$z_0 = \frac{\alpha}{g} u_*^2$$

The Charnock coefficient α may be considered a measure of roughness. For the sea surface, WRF considers a constant roughness $\alpha = 0.0185$. However, there is evidence that sea surface roughness should depend on wave energy (Donelan, 1982). Spectral wave models like WAM, model the evolution and propagation of wave energy as a function of wind, and include a richer sea surface roughness description. Coupling WRF and WAM is thus a common way to improve the sea surface roughness description of WRF. WAM is a third generation wave model, solving the equation of advection of wave energy subject to input/output terms of: wind growth, energy dissipation and resonant non-linear wave-wave interactions. Third generation models work on the spectral domain. WAM considers the Charnock coefficient α a complex yet known function of the total wind input term, which depends on the wind velocity and on the Charnock coefficient again. This is solved iteratively (Janssen et al., 1990).

Coupling of meteorological and wave models through a common Charnock coefficient is operationally done in medium-range met forecasting systems (e.g., at ECMWF) though the impact of coupling for smaller domains is not yet clearly assessed (Warner et al, 2010). It is unclear to which extent the additional effort of coupling improves the local wind and wave fields, in comparison to the effects of other factors, like e.g. a better bathymetry and relief resolution, or a better circulation information which might have its influence on local-scale meteorological processes (local wind jets, local convection, daily marine wind regimes, etc.).

This work, within the scope of the 7th EU FP Project FIELD_AC, assesses the impact of coupling WAM and WRF on wind and wave forecasts on the Balearic Sea, and compares it with other possible improvements, like using available high-resolution circulation information from MyOcean GMES core services, or assimilating altimeter data on the Western Mediterranean. This is done in an ordered fashion following statistical design rules, which allows to extract main effects of each of the factors considered (coupling, better circulation information, data assimilation following Lionello et al., 1992) as well as two-factor interactions. Moreover, the statistical significance of these improvements can be tested in the future, though this requires maximum likelihood ratio tests with correlated data.

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