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Numerical simulation of upwelling with a coupled Atmosphere-Ocean mesoscale model

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In order to study the interactions between the sea breeze and the coastal upwelling, the use of a coupled ocean/atmospheric model is required. This model must have a very good temporal and spatial resolution, to be able to realistically reproduce the upwelling regime and the sea breeze, over a limited area of the Atlantic Ocean, between SW Europe and Africa near the entrance to the Mediterranean Sea. Two mesoscale models were coupled: an atmospheric model and an ocean model. The coupled parameters are: the sea surface temperature, computed by the ocean model, and wind, rainfall, short and long wave radiation, specific humidity and temperature of the air at two meters, computed by the atmospheric model.

1. Introduction

Coastal upwelling is an interaction process between the ocean and the atmosphere, with important impacts on the local weather and climate. The western coast of the Iberian Peninsula is a well known upwelling region due to the establishment of a well defined northerly wind regime (the “Nortada”), associated with the joint action of the Azores High and the Thermal Low that typically develops in central Iberian Peninsula during summer.

The *Nortada* induces, by Ekman effect, a superficial westward ocean current, which, by continuity, leads to upwelling of deep cold waters near the coast. The rising cold waters are rich in nutrients, causing a great impact in the Portuguese economy, due to the renewal of the fishery resource stocks.

The decrease of the sea surface temperature caused by the upwelling tends to locally amplify the sea breeze and to create a positive feedback: the upwelling intensifies the sea breeze which tends to intensify the forcing wind. But, on the other hand, the sea breeze tends to reduce the air temperature in the coastal region, by cold air advection, which can lead to a negative feedback.

2. Model Coupling

The MM5 and HYCOM domains are co-located, with a coarse domain resolution of about 27 km, and a nested domain of 9 km on a Mercator projection. To keep the coupling process between MM5 and HYCOM as simple as possible, and to avoid the need to merge these two rather complex models, the atmosphere and ocean models are run in parallel, HYCOM lagging MM5 by one hour. This approach takes advantage of the much slower evolution of the oceanic variables, and will be justified by the results.

The SST response is very good, comparing with satellite and in-situ data. There are also significant improvements in the dynamical fields associated with upwelling.

On the other hand, the SST pattern produced by the uncoupled model is totally unrealistic. The uncoupled model is totally incapable of reproducing upwelling.