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Ocean Science Discussions

Interactive comment on ""Scale oriented" embedded modeling of the North-Western Mediterranean in the frame of MFSTEP" *by* C. Estournel et al.

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Letter to Referee 1

Comment: The validation must be carried out to the coastal level. The validation of a three-level system (basin-regional-coastal) could reveal important information. I recommend the validation to be performed at the coastal level as well.

Answer: We are really sorry but for technical reasons, it was not possible to satisfy this comment. We had to implement the operational system on a new computer and then only the regional model simulations were done. It was then not possible to do the validation with the coastal model as the simulations we had with this model were too old. To make the paper more coherent, we have removed all references to the coastal

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model.

Question: The spatial behaviour of the regional and coastal model is ignored.Validation and comparison on the spatial frame will contribute to the discussion of the forecasting system performance

Answer : We agree that this comparison constitutes an improvement. A section was added at the end of section 3.1 (see below). Moreover this section has been coupled with a spatial comparison of the wind fields used by the OGCM and the regional model. This latter comparison was added as an answer to a further comment of the reviewer: -in page 160 line 19 explain- (this point is discussed later). The two points allowed an interesting discussion on the origin of some differences on the currents. Besides the analysis of the regional model behaviour based on spatial averages, it is interesting to consider the localization of the differences between the regional model and the GCM. A typical example is presented on Figure 7 showing the 30m depth current calculated by both models on 17 November 2004 during the strong wind period of Figure 6. The main tendency for the open sea is that the regional model currents are often narrower and slightly stronger than those of the GCM. Important differences appear on the shelf: first an intrusion of the Northern current on the shelf at the eastern entrance of the Gulf of Lion (around 5°20E). This mechanism was observed in a large number of situations (Gatti, 2008). The resolution of the model is probably crucial to capture this process. The second point is the circulation in the western part of the Gulf of Lion which is anticyclonic in the GCM (northward current along the coast) and opposite in the regional model (southward current fed by a strong intrusion of the Northern current around 4°E). These differences are related to the wind fields used by both models (Figure 6). In the GCM (Figure 6b), the wind maximum is not sticked to the west coast resulting in a negative wind curl southwest of this wind channel creating the anticyclonic circulation. In the regional model, the wind field (Figure 6a) is dominated by a positive wind curl northeast of the wind maximum inducing the cyclonic circulation.

Question: The absence of any description of the GCM forecasting system makes the

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validation, comparison between models and processes described difficult for the reader to follow and understand. In he list of papers submitted in the special issue, there is a paper submitted by the GCM group that should be included in the reference. Furthermore, a short description of the GCM system in the present manuscript will greatly improve the overall discussion.

Answer: We have first added a sentence about the forecasting system model in section 2.4:

The regional model is initialized and forced at its boundaries by the general circulation model (GCM) OPA implemented at the 1/16° horizontal resolution (Tonani et al., 2008).

A few paragraphs later, we have added details about the functioning of the system:

The GCM delivers each week analyses for the previous fifteen days and ten days of forecast (Tonani et al., 2007). The meteorological ALADIN model delivers analyses for the previous seven days and a 5-day forecast. As soon as these products are available on ftp sites, the regional forecast can start (figure 2). First the pre-modeling corresponding to the hindcast of the previous seven days is done using analyzed atmospheric fluxes, GCM analysis as initial condition and forcing along its open boundaries and, when available, in-situ observations for river discharges. Then, the same numerical run is pursued during 5 days in forecasting mode, based on forcing by atmospheric and GCM forecasts. This 12-day modeling procedure is repeated every week. In order to clearly evaluate the quality of such forecasts during the 6-month TOP of the MFSTEP, a similar regional modeling was conducted in which only analyses were used for atmospheric, oceanic and river forcing. This hindcast modeling identical to the forecast modeling during the first seven days of pre-modeling has been used as a reference to evaluate the quality of the five-day forecasts. Figure 2 presenting the regional forecasting system has been added.

Question. the discussion of particular processes in section 4 is too much

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Answer: We have removed the section on the Rhone river freshwater dispersion.

Comments The paper needs editing, especially in the abstract and introduction. The abstract should be extended and give more information on the modeling system, the period of forecasting, the forecasting length, the overall validation and the performance related to specific processes and areas in the system. The abstract was extended to give more information as requested.

Paragraphs 3 and 4 of the introduction need to be rewritten since in the present form the meaning of what the authors want to state is rather vague and confusing Paragraph 3 was removed and the two following paragraphs were improved.

Question: Page 159 the authors state -we can globally notice that the obtained large scale currents are rather similar. This should be shown (not only the averaging over the forecasting day)-

A figure (Fig.4 has been added to show the large scale currents are very similar in GCM and regional systems: Figure 4 presenting the large scale currents at 100m on January 18th 2005 at the end of a hindcast period shows that spatial structures are also the same at large scale.

Question: in page 160 explain the differences in meteorological forcing. In section 3.2 same.

A typical example of the impact of the meteorological model resolution on the wind field in this region dominated by continental winds submitted to orographic effects is shown (new figure 6) and discussed: A comparison has been made between the wind stress calculated on one hand by the regional model using the Aladin model at the horizontal resolution of 0.1° and on the other hand by the GCM using the ECMWF forcing at about 0.5°. A period of 9 days (11-19 November 2004) characterized by strong wind blowing offshore has been chosen (Figure 6). Although maximal values and general patterns are similar for both fields, some differences appear that can be related to the

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representation of orography. Compared to ECMWF, the Aladin model produces local winds which are more channeled in the valleys (see the Ebro valley in Spain, the region of Genoa or the Arno valley) while the reduction of the flow is also more important downstream of mountains. Large differences can be noticed on the west coast of the Gulf of Lion where the Tramontana wind from Aladin blocked by the Pyrenees blows eastward inland (not shown on the figure) and then turns southward at the extremity of the Pyrenees as observed during the PYREX experiment (Georgelin and Richard, 1996) while this diversion of the flow is not so clear from the ECMWF forcing. These orographic effects result in enhanced wind curls which are able to generate temporary eddies on the shelf (Estournel et al., 2003) or vertical velocities offshore. Section 3.2 was not modified as we insist on the very low differences between surface fields from the forecasts and the hindcasts.

Question: Page 162 lines 3-9, the conclusion should be better clarified taking into account that the GCM system includes SST assimilation

Answer: We added more details about the possible origin of the SST bias of the regional model by discussing about the differences between the GCM and the regional model including turbulence scheme, atmospheric forcing and data assimilation.

Question: Page 163 first paragraph, you should include the GCM performance and the initialization fields

Answer: it has been done and considerations on the role of SST assimilation in the GCM have been added.

Question: A paragraph should be included in the concluding remarks section, stating the overall performance, issues open to discussion and improvement and accumulated knowledge during the forecasting activities

Answer: this was done by giving some insights about the performance of the system, possible improvements and the interest of the specific high resolution and high

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frequency meteorological forcing.

Bad wording was corrected.

Letter to Referee 2

Question: Scale oriented is never really defined until perhaps the middle paragraph of page 170. It should be defined in the Introduction.

Answer: This point has been clarified in the introduction by adding a sentence: The objective of scale oriented modelling is to explicitly model the linear and non-linear interactions of a large variety of processes occurring in a given range of space and time scales whereas, for long, process oriented modeling has focused on a limited number of processes neglecting their interactions with their dynamical environment.

Question: Page 150-151 : As in most coastal models, a sigma coordinate system provides a realistic representation of the bathymetry. I m not sure exactly what was meant here. Sigma coordinate models require a certain amount of smoothing of bathymetry to avoid pathologies associated with a steep bottom, and this smoothing makes for a somewhat unrealistic bathymetry. Isn t the advantage of sigma coordinates for coastal modelling more in the enhanced resolution of shallow near-coastal flow? How much smoothing is applied to the bathymetry?

Answer: This point was clarified. First we explain that the bathymetry was built with a high resolution data base which includes several data inside each model grid cell. A Laplacian filter was then used to remove the 2Dx signal of the bathymetry to avoid the growth of small numerical modes in the simulations. The impact of the filter on larger length scales is small owing to the high spatial resolution of our grid, allowing a faithful representation of the continental shelf break slope. Further in the text, we discuss the classical shortcomings of the sigma coordinate especially the truncation of the pressure gradient related to the sigma levels slope which often leads modellers to smooth the bathymetry : On the other hand, the sigma coordinate is known to present

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some serious shortcomings. Among them, the accuracy of the pressure gradient is probably the most well known with the so called truncation error problem related to the sigma levels slope. Another shortcoming of the sigma system concerns the possible lack of vertical resolution in deep sea areas, or alternatively, an excessive number of vertical levels in shallow areas consequently leading to a drastic reduction of the time step in order to ensure numerical stability. Many authors have proposed compromises to reduce those drawbacks. A common way to improve the accuracy of the pressure gradient force is to smooth the model bathymetry

After describing our hybrid coordinate system s-step, we added the following sentence: Thus, the s-step system offers the advantage of improving the pressure gradient force accuracy without employing the classical technique of smoothing the bathymetry.

Question: Pages 154-155 : I would prefer to see the description of surface conditions summarized here with details moved to an appendix

- Done

Question: Page 161: why is temperature poorly affected by river discharges?

Answer: The contrast between river and sea temperatures is of a few degrees while the salinity contrast is about 38. This contrast explains why the rivers have a limited influence on the sea temperature. This point was detailed in the text: Temperature, which is less affected than salinity by river discharges due to the temperature contrast between river and sea lower than the salinity contrast, shows a steep increase of its rms errors during the very first day.

Question: Figure 5 clearly shows that 60 to 65 %of the discrepancies between forecasts and observations are associated to a negative bias. Is this really obvious from figure 5 (I don t see it but it is possible that I have missed the obvious)?

Answer: We have improved the figure caption by replacing upper and lower panel by solid and dashed lines which describe better the figure: Figure 5: rms error (solid line)

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and bias (dashed line) of the regional model with respect to satellite SST. We hope that it is now clearer. The bias curves are negative and looks like a mirror of the rms curve even if the bias value is less important than the rms. We can conclude that a large part of the rms error can be attributed to a negative bias.

Minor issues have been addressed Here we consider some particular remarks:

Question: Section 2.4 Is the coastal model grid a subdivision of the regional model grid? Are the two bathymetries closely related?

Answer: Reviewer 1 asked to do the validation at the level of the coastal model but unfortunately, due to technical problems, it was not possible. To be more coherent, we removed all references to the coastal model in the new version. However, the answer to your question was : the coastal grid was not built from the regional one. Both were built by averaging the bathymetry points available on each grid cell or by interpolation when no data was available.

Page 158 previsibility was replaced by predictability

Page 158: It is stated that the model is forced at its free surface by analyzed atmospheric fluxes, along its open boundaries by GCM analyses but then the hindcast is described as driven only by analyses for atmospheric, oceanic and river forcing. I assume this means the GCM component of forcing is dropped, although it was just refereed to as an analysis? This point should be clarified

Answer: Each weekly 5-day forecast is preceded by a 7-day hindcast (the pre-modeling period whose objective is to develop small scale features). The hindcast is forced by (GCM and meteorological) analyses while the forecast is forced by (GCM and meteorological) forecasts. At the end of the six-month of the forecasting exercise, it was decided in order to evaluate the forecasts, to perform again the 12-day simulations but forced from the beginning to the end by analyses (these simulations are referred to hindcasts and they constitute our reference run). We have clarified this section as

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follows: As soon as these products are available on ftp sites, the regional forecast can start (Figure 2). First the pre-modeling corresponding to the hindcast of the previous seven days is done using analyzed atmospheric fluxes, GCM analysis as initial condition and forcing along its open boundaries and, when available, in-situ observations for river discharges. Then, the same numerical run is pursued during 5 days in forecasting mode, based on forcing by atmospheric and GCM forecasts. This 12-day modeling procedure is repeated every week. In order to clearly evaluate the quality of such forecasts during the 6-month TOP of the MFSTEP, a similar regional modeling was conducted in which only analyses were used for atmospheric, oceanic and river forcing. This hindcast modeling identical to the forecast modeling during the first seven days of pre-modeling has been used as a reference to evaluate the quality of the five-day forecasts.

Page 166 : canalized was replaced by channeled

Interactive comment on Ocean Sci. Discuss., 4, 145, 2007.