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Ocean Science Discussions

Interactive comment on "Effects of the 2003 European heatwave on the Central Mediterranean Sea surface layer: a numerical simulation" *by* A. Olita et al.

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The authors would like to thank the two anonymous Referees for their constructive comments which will contribute to the substantial improvement of the paper. In the sections below we would attempt to reply to each general and specific comment of the two referees.

1 Reply to Anonymous Referee 1

General Comments

General Comment 1.1 - ".... the analysis of the ocean response needs to be significantly expanded. For example, they apply the Fourier and wavelet analyses to the simulated SST only...."

Response 1.1 - We agree with the Referee that the section of the analysis of the ocean response is too limited. We already performed wavelet analysis also on satellite SST then founding a very good agreement with the spectrum of the model SST. We will insert this analysis (and figure) in the revised version of the paper. We will also expand the discussion of ocean response and insert a comparison with in situ data.

Comment 1.2 - "Figure 13 supposedly shows the SST time series and the model - observed differences for the entire period, but it is not at all clear if these curves relate to a specific point or if they are some type of model domain average."

Response 1.2 - Figure 13 shows the domain averages of the satellite and model SST fields. We will specify this better in the revision.

Comment 1.3 - "It is also not clear why they chose to use SST data from NASA-JPL (as noted in the acknowledgements) rather than the SST analyses that are available through MFSTEP"

Response 1.3 - Concerning the NASA-JPL vs MFSTEP SST sat dataset, we choose the former for some reasons:

- MFSTEP SST data have been already assimilated (using the SOFA assimilation scheme) by the coarse resolution model (OGCM-MFSPP; Pinardi and Masetti, 2000; Demirov and Pinardi, 2002) for the surface heat flux correction (Pinardi et al., 2003). For this reason in several MFS meetings has been suggested, for better comparisons, not to use MFS data but coming from different databases; - better resolution (1/24° instead of 1/16°); - availability of monthly fields entirely covering the 5 years (2000-2004) of simulation.

Comment 2.1 - "The other major difficulty with the experimental setup is to blindly use

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the ECMWF operational atmospheric analyses...snip...they must carefully check the source and validity of the atmospheric forcing fields for their intended purpose. They should ideally have used the fields from the reanalysis (e.g., ERA-40), or if not, they must convince the reader that the fields that they used do not suffer from the above-mentioned problems."

Response 2.1 - Although the point underlined by the Referee might actually be a problem (that we can mention on the paper), we used the 6-hours ECMWF analyses fields because the coarse resolution operational model MFSPP-OGCM version SYS3, used to drive our regional model at the lateral open boundaries, is forced by the same ECMWF analyses fields. Moreover the re-analyses (ERA-15 and ERA-40), actually, do not entirely cover the period of simulation.

Comment 2.2 - "An additional crucial point that they must clarify regarding their choice of surface flux boundary conditions is the addition of the “correction terms” in the heat flux (Eq. 3) and the freshwater (or salinity) flux (Eq. 5). These flux correction terms were added in MFSPP during multi-year, climatological, perpetual year simulations in order to guarantee the correct long-term heat and salt budgets of the simulated Mediterranean Sea. In this paper, however, the authors are interested in a particular case of interannual variability. Therefore they must provide some evaluation of the magnitude of these correction terms as compared to the anomalous 2003 forcing that is the focus of this paper."

Response 2.2 - Experiments with lower (and zero) values of the relaxation terms have been performed in order to attempt to better reproduce the variability of temperature (whose agreement with remotely-sensed SST shows a weak decrease during summer 2003). Running these experiments, although the heatwave event seemed to be well reproduced (however worse than with the settings used in our paper), the rest of the time series actually show unrealistic values. So, in agreement with Zavatarelli et al. 2002, we choose to set these values as in the mentioned paper. We will include these comments and a plot showing the time series without "relaxation term" in the next

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revised version of the paper.

Comment 2.3 - "Finally it is not clear which OGCM data they used for the lateral boundary conditions...."

Response 2.3 - The OGCM version we used is based on MOM (1/8°). The model is a modified version of MOM1.1 and the assimilation engine is SOFA (System for Ocean Forecast and Analysis) described by De Mey and Benkiran (2002). Both SLA (Sea Level Anomaly) and XBT are assimilated starting from September 1999 to the current week. SST from satellite is also assimilated as a heat flux correction term. The correction of this type (OGCM 1/16°) will be produced in the revised version of the paper.

Specific Comments

About section 2.1.2 we included the constraint to conserve the coarse resolution mass flux on the high resolution model. We totally agree with the anonymous referee 1 about the other specific comments and notes. Changes will be produced in the revision.

2 Reply to Anonymous Referee 2

General comments

"I have had some difficulties in reading this paper because it's not clear what is its aim. Is it a study on the effects of the 2003 heat-wave on the surface ocean? Is it a test on a high resolution circulation model when extreme events occur? Is it an investigation on the anomalous sea surface warming during 2003 summer? The title suggests that the goal is to investigate the effects of the 2003 European heatwave on the Mediterranean Sea surface layer by means of a numerical simulation. ...snip... However, in my opinion, this work is not a good test of an high resolution model circulation in a critical region

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under significant variations of the atmospheric forcing because the tests are few and incomplete ...snip... Thus, in order to improve their paper, I suggest that the Authors focus better the subject and enlarge the comparison with the observations."

Response to General Comments

Actually our major aim is to explore, mainly using a numerical tool, the effects of the heatwave on the Central Mediterranean Sea. Only a secondary aim is to test the response of SCRM to particular atmospheric conditions. We will better focus the subject of the paper by modifying the introduction and reducing the section of the atmospheric forcing analysis. We will better support our observations on the effects of the heatwave enlarging the comparison with measurements, also including CTD and XBT data.

Specific Comments

Comment 1 - "The results obtained by the model show SST anomalies and modifications in the circulation of the sub-surface currents as well as in the coastal upwelling. However, these results are questionable because they are not well supported. Particularly, the skill of the model under this extreme condition has to be demonstrated. On the contrary, notwithstanding in the Introduction the Authors write that in situ measurements will be used, any test is performed on the layers below the surface and the only validation is a comparison between the computed SST and the monthly mean AVHRR Ocean Pathfinder SST data. This is insufficient for validating the model and its outcomes when extreme events occur, especially because the Authors use in their analysis the computed daily values."

Response to Comment 1 - In order to better validate the model and to demonstrate the skill of the model under extreme conditions we will perform a comparison with in situ data for thr period of simulation, with special care to the data included in summer 2003.

Comment 2 - "Furthermore, although the agreement between the computed and the satellite monthly mean SST is generally good, the results of this comparison shows that

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the model skill decreases during the period affected by the heat-wave. The Authors suggest that this could be due to the relaxation term in the computation of the heat fluxes, but they do not support this conclusion with any effective arguments."

Response to Comment 2 - Please, see above Response 2.2 to referee 1.

Comment 3 - "The obtained disagreement may be not particularly significant from a numerical point of view, but it becomes important if we want to use this model to analyse the effects due to the 2003 heat-wave because it indicates that the used parameterizations might be not able to correctly simulate the phenomenology under this specific condition. Thus, having doubts on the model performances when the heat-wave occurs and lacking any reference to, or comparison with, in situ observations, the conclusions obtained for the sub-surface layers during 2003 summer are questionable."

Response to Comment 3 - Actually, the lack of comparison with in situ observations constitutes the main problem we will attempt to solve in our revision, in order to assess the performance of the model under "normal" as well as "extreme" conditions. However we think that the model with the used parameterization, despite the reduction of agreement with SST data during the heat wave event, is able to well reproduce the anomalous conditions in the time-frequency domain at least. The CWT analysis of the remotely-sensed SST will enable us to compare the spectra of simulated and measured temperatures.

Comment 4 - "Additionally, the interannual variability of the surface atmospheric and sea parameters is analysed by using an approach based on a joint use of FT and CWT analysis. This method is the most interesting aspect of the paper. Nevertheless, the time series are too short for a significant study of the inter-annual variability. Analogously for what concerns the analysis on the heat fluxes variability."

Response to Comment 4 - The problem underlined by the Referee on the length of the studied period was aim of discussion at the start of the work. For this reason we checked how other authors (e.g. Oddo P, Pinardi N, Zavatarelli M. , 2005, A numerical

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study of the interannual variability of the Adriatic Sea (2000-2002). Sci Total Environ. 2005 Dec 15;353(1-3):39-56. Epub 2005 Oct 27) approached the problem. Then the fact that the aim of this paper is to study the effects on the sea of an already known atmospheric anomalous event, and secondly to show how the model answers to atmospheric extreme events, has induced us to think that a 5 years period, almost centred in the months of interest, might constitute a sufficient time window to locate this event in time-frequency domain.

We agree with anonymous Referee 2 also for minor comments. Changes will be produced in our revision.

Interactive comment on Ocean Sci. Discuss., 3, 85, 2006.