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Interactive comment on “Chlorophyll signatures and nutrient cycles in the Mediterranean Sea: a model sensitivity study to nitrogen and phosphorus atmospheric inputs” by M. Pacciaroni and G. Crispi

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Author comments to Referee #1 General comments regarding Biogeosciences Discussions, 4, 909-959, 2007: "Chlorophyll signatures and nutrient cycles in the Mediterranean Sea: a model sensitivity study to nitrogen and phosphorus atmospheric inputs" by M. Pacciaroni and G. Crispi. We report after all R1 the Referee's comments, and ours after AC; the revised text is reported between asterisks.

General comments

R1-Pacciaroni and Crispi describe a coupled physical-biological modeling study of the

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Mediterranean Sea, focusing on impacts of atmospheric deposition of nitrogen and phosphorus. The physical model is a Mediterranean implementation of POM. The biological model is a relatively simple NPZD type of formulation, that includes large and small phytoplankton size classes and also N and P cycling and limitations. The authors argue that the model captures major aspects of the observed temporal and spatial chlorophyll variability, and therefore provides a means of assessing how atmospheric deposition likely impacts the system. My overall impression of this study is that it is a potentially important contribution to our general understanding of the impact of atmospheric nutrient inputs on the Mediterranean Sea. The model reveals how these inputs influence chlorophyll concentrations in both the eastern and western regions of the Mediterranean and also how phytoplankton size structure (ultraplankton versus netplankton) might be differently impacted in oligotrophic versus more eutrophic waters. These demonstrated influences are probably robust. However, my confidence in the model results are significantly compromised by the fact the model fails to reproduce some major features of the observed chlorophyll variability. This failure is most apparent in the comparison between modeled and observed vertical sections (Figures 6 - 9), where the observed deep chlorophyll maximum variability departs substantially from the model. For example, in the E-W transect (Figure 6) along the western half of the section the model generates a strong shoaling of the DCM that is not apparent in the observations, and also in a N-S transect (Figure 8) in the western basin where the observed deep chlorophyll maximum is consistently 50 meters deeper than observed. In addition, there are disturbing differences between the modeled and observed variability (e.g., Figure 9), where the model appears to be generating much more spatial variability in the integrated chlorophyll than observed.-

AC-The discussion of the modelling approach is done in the text mainly discussing the equations, so it is rather difficult to show the rationale of this approach. We touch here briefly the points discussed separately for giving assessment and discussion. The two considered nutrients, nitrogen and phosphorus, do not exclude the importance of other as silicate, iron or others; they are considered in this framework as the only nutrients

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because there is wide consensus that limit the primary production. In some place it can be limiting the first or in some seasons the other, anyway the nitrogen and phosphorus cycles should be studied at the same time in the Mediterranean. Another point is the role of the fluxes at Gibraltar and at Sicily, when a general overview of the oligotrophic processes is depicted as in the introduction. The western basin concentrations in the deeper layers are proportional to the western and to all the external loads. The second estimates, that at Sicily, impacts the deeper layer of the Eastern Mediterranean after taking account in a rather complicated manner of all the external inputs and also of the biological sources. These estimations are a strong point in favour of using this model, taking into account the different dynamics of the nitrogen and of the phosphorus cycles depending on their different remineralization rates and ecological behaviours in the two subbasins. The third point is that we focus on the sensitivity analysis of three different atmospheric depositions of nutrients, given to the system as nitrates and phosphates. The system can react in different way, but it reacts to the external inputs, while the physics is maintained always the same. There is no feedback of the nutrient cycles to the physics. Eastern and western basins are selected for the clear differences of their behaviour, differences well described in terms of averages, of seasonal biomass, and of surface chlorophyll. Nonlinearity in the overall response describes a particular response situation. The revised text improves the analysis of the results for the transects, taking also into account chemical fields and potential density. The interpolation on the Mediterranean grid of VIM for chlorophyll is a field of comparison of our results, but considering in addition the MEDAR raw data for the averages over specific areas of the Western and the Eastern Mediterranean.-

R1-The authors provide some explanations for these discrepancies, related mostly to potential problems with the data (i.e., sparse data and seasonal bias), but as it stands these comparisons give the strong impression that there are some substantial errors in the physical solution (e.g., poor representation of the pycnocline depth and therefore nutricline depth and the deep chlorophyll maximum). But it is not possible to assess how good the physical solution is because no information is given on the physical

solution, i.e., no plots of the temperature, salinity or density fields relative to observed patterns on these same sections, or on any other sections. So my first and probably most significant recommendation is that the authors need to go back and validate the physical solution at some level to make sure that it is not the route cause of these discrepancies, and report on this to some degree in this paper.-

AC-We confirm the explanation for the western basin contained in the previous revision. Anyway we follow the Referee #1 considerations about the importance of the physics, which is the same for the three simulations in terms of different atmospheric inputs, in the forcing of the internal variabilities of the ecosystem. In the 34 N transect, we decided to describe the model results in terms of density, plotting also the variability in depth for recovering the pycnocline. The five regions, also considered in terms of MEDAR data, are from east to west: Sicily Channel, southern Ionian Sea, Cretan Passage, southern Levantine Basin, southeastern Levantine Basin. The density profiles are also shown, here from north to south, in the three western areas containing the meridional transect in the Western Mediterranean: in the Gulf of Lions, in the Algero-Provençal Basin and in the eastern Algerian Sea.-

R1-I am also concerned about the lack of statistical analysis. The authors validate the model using a lot of spatially and temporally averaged quantities, and they discuss differences between the model runs and differences between the model results and the observations, but no confidence intervals are calculated. It is therefore impossible to assess the significance of these differences. Confidence intervals should be calculated for all of the tabular mean values reported (e.g., tables 4-9). I fear the authors may find that the variability is large and that the differences reported are not statistically significant.-

AC-The 95% confidence intervals are calculated in Table 5 considering the anomalies from three years of the averaged chlorophyll values at surface. The errors are relatively small without overlapping, however in two cases are they are larger with some overlapping: GARUN and AVRUN in the western basin. We cannot use the same

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methods for VIM and CZCS, because there is only one data for grid-point, while we have three monthly averages from the model; on the other hand to evaluate the statistics with all the points would cover the statistics with the spatial variability of the surface chlorophyll.-

R1-Finally, another significant concern I have about this paper is the complete lack of validation data on nutrient distributions (i.e., DIN and DIP) and also primary and secondary production. There must be historical data and transects in the Mediterranean that can be used for comparison with the model. It is particularly crucial to assess whether or not the DIN and DIP concentrations in surface waters and at depth are correct and determine how well the model reproduces the vertical position of the nutricline. Validating these fields will very likely shed some light on the discrepancies in the chlorophyll fields described above. And at least some tabular comparisons of modeled versus observed primary production rate should be included.-

AC-The nitrates and phosphate distributions are considered in five regions from east to west containing the zonal transect in the Eastern Mediterranean: top down, Sicily Channel, southern Ionian Sea, Cretan Passage, southern Levantine Basin, south-eastern Levantine Basin. Discrepancies between the model and the chemical data are present in the western side of the basin in Sicily Channel and in the Ionian Sea. These profiles are introduced after the behaviour of the chlorophyll in the 34 N transect. The same chemical vertical profiles are shown in the three western areas containing the meridional transect in the Western Mediterranean from north to south: top down, Gulf of Lions, Algero-Provencal Basin, eastern Algerian Sea. An overestimation of the model's results with respect to the MEDAR data, similar to that previously seen in the Sicily Channel and the Ionian Sea, is recognizable. Overall primary production estimates are reported in the revised text.-

R1-Finally, the sentence structure in this paper is awkward in many places. I have pointed out some of these problems in my specific comments, but there are many other places in the paper where rewriting is needed. This manuscript should be given

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a very thorough editing to correct these kinds of problems before it is published. See also my specific comments below.-

AC-The revised text is carefully edited, considering the following specific points.-

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BGD

4, S1027–S1032, 2007

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