Biogeosciences

Discussions

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Interactive comment on "Physical control of the interannual variations of the winter chlorophyll bloom in the northern Arabian Sea" *by* M. G. Keerthi et al.

Anonymous Referee #1

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General Comments:

The Arabian Sea is one of the most productive regions of the world oceans which experiences phytoplankton blooms during boreal summer and winter. Both these blooms are reasonably well characterized and the physics controlling them are reasonably well studied. However, what is still largely least explored is the inter-annual variability of the summer as well as the winter blooms. The major reason why it has not yet been adequately addressed is the limitation in long time-series data. It is in this context that the present study assumes importance.

The present paper addresses the inter-annual variability of the winter chlorophyll bloom in the northern Arabian Sea (NAS) using both observation and simulations from a

coupled biophysical ocean model. Towards the observational data, the authors used satellite-derived chlorophyll pigment concentrations, and Argo-derived mixed layer and thermocline depths. Using these, the authors aim at "better understanding the inter-annual variability of the NAS winter bloom" (lines 15).

The central theme of the study is the processes that leads to the phytoplankton bloom in NAS during winter and to ascertain whether the process suggested by Prasanna Kumar et al. (2001) or that by Wiggert et al. (2002) explains the bloom. The authors conclude that the winter blooms are strongly tied to mixed layer depth and the resulting modulation of nutrient entrainment into the mixed layer, a result similar to that of Prasanna Kumar et al. (2001). The inter-annual variability of NAS winter bloom amplitudes are controlled by the variation in the net heat flux at the air-sea interface, which in turn controls the MLD and nutrient entrainment.

It is a well written manuscript and should be published, in my opinion, but only after consideration of some of the comments listed below.

Major concerns: 1. What is the basis on which the authors use the months from January to April to define winter? This is not true in the case of the Arabian Sea and hence not acceptable. Let me explain.

Based on the mean seasonal cycle of net heat flux both from observation as well as model presented in Figure 6 (c & f), the ocean looses heat from November until February. From March onwards the ocean starts gaining the heat and the net heat flux remains positive until October. Note that in April ocean gains heat as much as 100 w/m2 indicating the warming of the ocean rather than the prevalence of winter conditions. So from the net heat flux point of view November to February defines the winter condition.

Similarly, the mean seasonal cycle of surface chlorophyll from observation and model in figure 6 (a &d)) shows an increase from November, peaks in February and returns to the November value by March.

In view of the above, November until March could be considered as winter while dealing with chlorophyll response in the box under study.

2. It has been shown in recent years that episodic dust storms that occur during winter are important in driving the interannual variability of chlorophyll in the Arabian Sea through the atmospheric input of nutrients, especially iron. See for example the studies of Wiggert and Murtugudde (2007), Patra et al (2007), Naqvi et al (2010) and Banerjee and Prasanna Kumar (2014). The authors need to at least address the role of dust-induced Fe input in driving the inter-annual variability of chlorophyll in their study region.

Minor concerns:

3. Page 7 Line 15 " The simulation captures the surface chlorophyll seasonal cycle in the NAS. . ..."

While it is so during winter (even in winter note that the model SChl does not capture the increase from November to January seen in the observation), the model completely misses the declining SChl trend from July to August. Instead model depicts the continuation of monotonic increase from May to August.

Authors need to point this out while discussing the simulation results. 4. Page 8 lines 7-9 "The figure illustrates that the observed interannual SChl. . .."

The authors need to explain in the text/discussion what the inverse relationship between SChla and MLDa during 2003 & 2005 means.

5. Page 9 lines 2-3 "As a result, the mixed layer nitrate. . ..."

Though the MLD nitrate concentration during 2008 Feb is double than that of 2007, the Chlorophyll did not show a commensurate increase. The authors need to explain this in the discussion in the of Redfield ratio and carbon fixation.