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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 #2

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General Comments:

The study, using multiple datasets and a model, examines the processes related to the interannual variability of winter chlorophyll in the northern Arabian Sea. The Arabian Sea, especially the coastal-open ocean upwelling regions are subjected to an interplay of oceanic processes, such as coastal upwelling, Ekman pumping, mixing, entrainment and lateral/vertical advection (Vialard et al 2012). Other than these physical processes, changes in light penetration and nutrient supply also regulate the chlorophyll content in this basin. Hence it is an interesting task to investigate the biophysical interactions over this region, which result in the observed chlorophyll variations. However, other than presenting several correlation analyses between the mixed layer depth and

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chlorophyll variations, the study does not delve in depth into the processes governing the chlorophyll changes. The paper is neatly written but it is difficult for the reviewer to comprehend what the prime objectives of the study are, or if there is anything novel in the results. Due to these shortcomings, and as detailed below, I do not recommend the manuscript for publication at its current state.

Specific Comments:

1. The study revolves around a hypothesis put forward by Wiggert et al (2002) that the interannual variations of chlorophyll intensity is regulated by diurnal mixing. The current study, using correlation analyses, points out that the winter chlorophyll variability is tied to the mixed layer depth anomalies, which are associated with the surface heat flux anomalies. However, this factor has already been pointed by studies like Prasanna Kumar et al (2002), where they point out that surface cooling (due to evaporation) in the northern Arabian Sea, combined with reduced incoming solar radiation and high salinity, drives convective mixing, resulting in the upward transport of nutrients in the mixed layer. Similar to the current study, this study also compares two anomalous years and describe the processes involved.

2. Also, apart from the correlation analyses between mixed layer depth (and nutrients) and chlorophyll concentrations, the manuscript does not examine how the oceanic processes such as the Ekman pumping, offshore advection etc plays a role on the interannual variability. Also, to counter the study by Wiggert et al (2002), the current study does not examine the contributions due to diurnal mixing. In fact, it is not clear to me where Wiggert et al (2012) says that mixed layer variations are not important in controlling the chlorophyll concentrations – though the study says that diurnal changes of mixed layer are important.

3. Page 10, Line 10 says the MLD deepening is controlled by convective overturning, which in turn is controlled by surface heat fluxes. It is not clear to me how the cause and effect is separated here. Surface net heat flux is inversely proportional to the mixed

layer depth. Hence it is not surprising as in Fig.10 that they show a good correlation.

4. Page 12, Line 20 suggests that the interannual variations in the surface flux are modulated by ENSO (strong correlations). The connection with ENSO was shown by Murtuggude et al (1999), which examined the chlorophyll changes in the Indian Ocean with respect to the 1997-1998 El Niño and the 1998 La Niña. The El Niño – La Niña episodes were accompanied by changes in chlorophyll over the Arabian Sea, with low Chl concentrations during the El Niño period, followed by anomalously high concentrations during the La Niña episode. These changes were attributed to local ocean-atmospheric dynamics linked to the shifts in the Walker circulation.

On a similar case, the authors compare 2007 and 2008 MLD and chlorophyll. 2006/7 was a weak El Niño year and 2007/8 was a La Niña year, which is clearly reflected in the Chl anomalies, with the former resulting in negative anomalies and the latter in positive anomalies. Going by correlations as in the current study, I can say that ENSO is a major component in driving both the surface flux and chlorophyll anomalies in the Arabian Sea, on interannual timescales.

5. Also, how do the changes in Eurasian winds (Page 13, Line 8, Goes et al 2005) compare with the ENSO impact? Are the winds increasing, and do they have an impact on the Chl in the Arabian Sea? If so, how does it ride on the interannual variability imposed by ENSO?

References:

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