

*Anonymous Referee #1:*

*This manuscript by Gille et al. provides an overview of large scale wind stress curl fields and SST and some analysis of wind stress, upwelling, mixing and SST. Though there are limited contributions to novel science and methods, the manuscript is an essential part of physical background and forcing mechanisms in the Kerguelen Islands and its vicinity and necessary information needed for the KEOPS 2 project. I recommend this manuscript for publication on BGD. Here are some specific comments:*

Thanks to the reviewer for a supportive and helpful review. Here we have responded to each of the comments.

*1) Abstract: "... High wind speeds typically correlate with cold sea surface temperatures, implying that wind mixing leads to enhanced vertical mixing. Negative windstress curl also correlates with cold SSTs, implying that Ekman pumping can further enhance upwelling, and coupling between winds and SSTs associated with mesoscale eddies can locally modulate the wind-stress curl..." This is a general concept and not necessarily included in the abstract while it is difficult to understand from this abstract what detailed studies conducted in this manuscript. There is a need of outline what this manuscript studied and conclusions.*

The abstract has been revised to better indicate the contributions provided by this paper. The sentences highlighted by the reviewer have been revised to emphasize that these findings are demonstrated in our calculations:

Results show that in the Kerguelen region, cold SSTs correlate with high wind speeds, implying that wind-mixing leads to enhanced vertical mixing. Cold SSTs also correlate with negative wind-stress curl, implying that Ekman pumping can further enhance upwelling.

We've also edited the final portion of the abstract to provide more information about our findings regarding the wind-stress curl dipole in the wind shadow of Kerguelen and the wind-induced upwelling during the KEOPS-2 field program. The abstract now concludes:

Kerguelen has a significant wind shadow on its downwind side, which changes position depending on the prevailing wind and which generates a wind-stress curl dipole that shifts location depending on wind direction. This leads to locally enhanced Ekman pumping for a few hundred kilometres downstream of the Kerguelen Plateau; Chl-a values tend to be more elevated in places where wind-stress curl induces Ekman upwelling occurs than in locations of downwelling. During the October-November 2011 KEOPS-2 field program, wind conditions were fairly typical for the region, with enhanced Ekman upwelling expected to the north of the Kerguelen Islands.

*2) Introduction: In the first paragraph, a better literature review is needed such as the papers by Measures et al (2010) on iron source and transport in the Drake Passage, by Hopkinson et al (2007, 2013) on iron limitation and enhancement on primary production, Park et al (2008) on vertical*

*mixing of iron, van Beek et al (2008), Charette et al (2008) and Dulaiova et al (2009) on iron source and horizontal/vertical transport. The literature provides a useful background information for the study in this manuscript.*

We've added references to Hopkinson et al. (2007), Charette et al. (2007), van Beek et al. (2008), Blain et al. (2008), Park et al. (2008a), Park et al. (2008b), Dulaiova et al. (2009), and Measures et al. (2012). (In the "Web of Science" we did not find a 2008 paper by Charette et al or a 2010 paper by Measures et al, so if the reviewer had specific publications in mind, we would be grateful for full reference information.) We have also expanded and clarified some of the discussion of KEOPS-1 results and have added references to the new KEOPS-2 findings. Since the paper has been submitted to a special collection associated with KEOPS-2, other papers in the same volume will provide more thorough literature review covering the biological and chemical aspects of the project so we have aimed to focus the introduction primarily on the physical processes that control iron availability.

*3) Page 8375, last paragraph: "... While wind-driven upwelling appears to play a central role in determining variability... " Suggest changing "central role" to "one of key roles" because there are many other important processes such as wind mixing as discussed, and upwelling associated with fronts and eddies.*

This is a good point. We've changed the wording to say "wind-driven upwelling appears to help determine variability ..." This seemed to be a concise way to express the point raised by the reviewer.

*4) Page 8378, line 1: "... Fig. 1f shows mean SST from ..." Suggest changing to "Mean SST from ... is shown in Fig. 1f." This suggestion is also applied to other "Fig. xx shows ..." in this manuscript.* Where possible, we have tried to avoid passive voice constructions, as they make English-language text difficult to read. Instead we have merged this sentence with the subsequent sentence to read, "For October-November 2011, when the KEOPS-2 field program took place, SSTs from WindSat are used (Figure 1f)."

We have made similar modifications in reference several other figures.

- For Figure 2a: "We correlate wind speed and SST (Figure 2a), using the method of partial correlations to control for the impact of surface heat fluxes (Baba et al., 2004)."
- For Figure 4: "More than 50% of the time, winds are from the west or west-northwest (Figure 4), giving rise to the distinct pattern of negative wind-stress curl to the northeast of the Kerguelen Island,...."
- For Figure 6a (now 7a): "A rose histogram for wind direction for October-November, 2011 (Figure 7a) indicates that the prevailing wind directions during KEOPS-2 were consistent with prevailing wind directions shown in Figure 4 for the 2002-2009 time period."
- For Figure 7b: "The time-mean wind-stress curl for October-November, 2011 (Figure 7b) is consistent with historical trends and indicates negative wind-stress curl, so upwelling favorable conditions, to the northeast of Kerguelen."

5) Page 8378, the 2nd paragraph: *"... Sea surface geostrophic velocity anomalies (relative to a temporal mean from 1992-1999) were produced by the SSALTO/DUACS project, which computes them based on a multi-satellite altimeter product ..."* I have some difficulty to understand what is the definition of "which." Do you mean *"... Sea surface geostrophic velocity anomalies (relative to a temporal mean from 1992-1999) were produced by the SSALTO/DUACS project based on a multi-satellite altimeter product?"*

This is a good suggestion. We've made the change.

6) *Methodology*: Reading through this section, my comments are (1) most of information is well developed and used in the past so that they just need to be mentioned with citations, (2) the justification using these variables based on previous studies by others should be mentioned in the Introduction recognizing their original contributions, and then validated these variables in the Discussion section, and (3) because the methodology will be relative short, the data and methods can be combined into one section.

We have shortened the methodology section to three relatively concise paragraphs. After some discussion, we have concluded that we would prefer to retain the methodology section heading, since we feel that this is helpful to readers, and that readers should be able to reconstruct the core details of the approach without needing to track down additional literature. This is particularly important for this paper, since the methodology is drawn from the physical oceanography literature and may be unfamiliar to readers of *Biogeosciences*.

7) *Results*: Though I am in favor to mix results from the study, validation of results, discussions and comparisons to literatures in one section, there is a need of a clear pattern for a reader to follow. If it is getting too difficult, the traditional separation between results, discussion and summary is a better way to organize the manuscript. I am not against the current way to organize this section which the authors decided to take. But I do suggest having a clear organization from results, comparison to others and hypotheses based on results. For example, in Page 8380 Section 4.1, the first paragraph starts from a literature review, and then followed by discussions on Figure 2. It is difficult to understand if the results in Figure 2 supports the results from literature, or they agree/disagree to each other.

The Results section has been revised to focus first on the results and then on the interpretation, as suggested by the reviewer. The opening paragraph of the section now reads:

We correlate wind speed and SST (Figure 2a), using the method of partial correlations to control for the impact of surface heat fluxes (Baba et al., 2004). Through most of the Southern Ocean, in year-round data high wind speeds correlate with cold SSTs, implying that wind-induced mixing deepens the mixed layer and brings cold water and nutrients to the surface (Kahru et al., 2010), and during spring and summer this can promote phytoplankton growth (Carranza and Gille, 2014). (In winter and early spring when stratification is low, high winds can deepen the mixed layer and move phytoplankton out of the euphotic zone, resulting in low Chl-a (Kahru et al., 2010), but the focus of this study is on spring and summer.) As hypothesized, wind speed and SST are negatively correlated (blue) almost everywhere, except in some locations to the north of Kerguelen. Positive correlations (red) fall along the Subantarctic Front and Polar Front

of the ACC, which represent the primary axes of the current; here changes in SST can feedback on the winds. This positive correlation associated with the mesoscale vanishes when we high-pass filter the data to consider synoptic storm effects (Carranza and Gille, 2014), implying that large-scale storms suppress eddy feedback effects.

Similarly we have revised discussions of the other figures presented in section 4.1 to focus first on showing the results and then on interpreting them.

*8) Summary and Discussions: There are significant discussions in the Results section on variations of stress curls and correlations. But the discussions on the comparison of this work with results from other studies are quite weak. There are a series of studies done by Park et al on small-large circulation patterns and mixing, and by McCartney and Donohue (2007) on large circulation. There are significant similar patterns in results between this and those studies.*

Thank you for these suggestions. We have revised the discussion to provide further context based on prior studies. In doing this, we have read a number of the suggested Park et al papers, which have proved extremely useful in providing context for these results. The McCartney and Donohue (2007) paper is interesting but we did not readily see how to incorporate it into this discussion, since McCartney and Donohue focus largely on bottom water, which is likely deeper than the shelf waters that influence productivity in this region, and they do not consider wind forcing or nutrients. However, in the final two papers of the Summary section, we have added references to a number of the KEOPS-1 and KEOPS-2 studies of this region.