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Discussions

Interactive comment on "Sedimentary and atmospheric sources of iron around South Georgia, Southern Ocean: a modelling perspective" *by* I. Borrione et al.

Anonymous Referee #1

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This paper describes the application of regional hydrodynamic and biogeochemical models to the study of iron sources at South Georgia. It concludes that shallow sediments are the dominant source, with atmospheric dust deposition having very little effect on iron concentrations and subsequent chorophyll a concentrations. Although the comparison with the limited iron data is quite good, I have some concerns regarding the design and implementation of the models that need to be addressed before this paper is suitable for publication.

Specific comments

1) Bathymetry: Looking at a map of South Georgia, it is clear that the near-coast

bathymetry is very steep, and the bays have a deep, fjord-like bathymetry. There are no extensive shallow areas and the 50m contour appears to be at most about 5km from the coastline. With a model resolution of around 11 km, I am very surprised that you have cells with the shallow depth ranges you quote in table 1. How realistic is your model bathymetry? If the model bathymetry is unrealistically shallow, the conclusions of your study may be invalid. Please comment on this.

2) Lack of freshwater: The lack of coastal freshwater in the model is a concern. As you discuss on p. 10835-10836, glacial sources of iron could be significant, but you do not identify it as a 'main' source and do not attempt to quantify its possible impact. Coastal freshwater inputs will also have an important influence on seasonal stratification and water column stability, and hence vertical mixing. Please comment on this.

3) Local dust source: You do not consider the potential contribution of local dust from South Georgia in your model. During strong wind events, a significant amount of red dust, rich in iron, is observed to blow off the island, and this could be a far more significant source than Patagonia.

4) Physical oceanography: The description of the general oceanography of the region needs rewriting as at present it is not entirely accurate. In particular, the following need correcting:

p.10813, lines 8-14: The SACCF flows around the southern South Georgia shelf, not along it. The meander in the SACCF is not the cause of downstream waters being transported to the north and northwest. The shelf waters at South Georgia are strongly influenced by local processes, and can be very different to the surrounding oceanic waters, with the latter dominated by the properties of the ACC.

p. 10821-10823, section 4.1: The ACC is characterised by strong fronts (e.g. as depicted in figure 1) and this section should include reference to the fronts, instead of 'branches' or 'currents' of the ACC.

p. 10821, line 27: I would be wary of using the word 'join' in regard to the oceanic flows as it implies strong diapycnal mixing across fronts.

p. 10821, line 25: A significant portion of the flow appears to go north and then east. Please reflect this in your description.

p. 10822, lines 13 and 28: please use 'through' instead of 'across' for flows through passages.

p. 10822, line 24: The strongest flows from altimetry are around the shelf edge and not along the shelf (which is expected from bathymetric steering of the SACCF). Please correct this. Note also that flows on the shelf from satellite altimetry should be treated with caution due to significant errors in such regions. This latter point is also of relevance for the discussion on p. 10825, lines 9-19 and should be considered.

5) Representation of iron: Given the emphasis on sedimentary sources of iron in the paper, the model representation of iron fluxes from sediments needs to be more fully described. Specifically:

p. 10816, line 28: How did you adapt the denitrification model described by Middelburg et al. to dFe fluxes?

p. 10818, line 1: Why did you choose the value of 1 μmol dFe m-2day-1? Was this based on data? What is the relevance of the 2 μmol dFe m-2day-1 from the Moore & Braucher modeling study? It appears that your choice of this parameter value is based on previous modeling studies. How well does it relate to values from field data, and how sensitive are the model results to variations in the parameter (within observed ranges)?

p. 10817, line 2: How realistic is it to use depth as a proxy for sediment oxygenation? Does the way this is approximated strongly influence the depth/iron relationship predicted by the model (and detailed in Table 1)? How sensitive is the model to this approximation?

6) Model configuration:

p. 10815, line 12: What do you mean by coastline-following curvilinear coordinates?

p. 10817, line 24: As you're interested in sediment fluxes of iron, why did you not increase the near-bed resolution as well?

p. 10817, line 27: Please explain the nature of the 'r-parameter'. How sensitive is the model to the choice of this parameter?

p. 10818: The description of the model forcing is confusing, in particular regarding the temporal resolutions of the datasets. Specifically:

lines 2-7: Over what period did you obtain SODA data? Were these averaged to create a climatology?

lines 7, 10 & 12: what is the resolution of the 'climatology'? Are they monthly means?

line 10: '2000-2007' time-period. What is the relevance of this time period? How does it compare to the time periods used to construct the other climatological forcing data?

line 17: What is the temporal resolution of the WOA climatology?

line 19: What is the temporal resolution of the ORCA2 model output?

p. 10818, line 23: Why did you run for an additional 10 years if the model was already at quasi-equilibrium? Why not just use the following year?

p. 10818, line 26: Why was the iron source only modified in the last 3 years and not throughout the model run? Similarly, why did you choose to modify it for 3 years? Did it make much difference if you modified it for longer?

General question: What is the timestep of the coupled ROMS_AGRIF-PISCES model? Assuming it's much shorter than the climatological forcing, how did you deal with the difference in temporal resolution?

7) Other general issues

p. 10813, line 16: The previous sentence only discusses Si, not other macronutrients. Why are ALL macronutrients at excess concentrations?

p. 10814, line 8: You should mention other sources here, including upwelling at the shelf edge, freshwater sources at the coast and local dust from South Georgia itself.

p. 10815, line 1: '...main sources...'. In my opinion, you are neglecting some potentially very important local sources and can therefore not identify the main sources with your model, only which of shelf sediments or dust is the more important. Similarly, p. 10821, line 15, you cannot say that you're identifying the principal sources if you're neglecting important local sources. Similarly, p. 10830, line 27: you should not refer to 'two main iron sources' if you haven't considered all possible sources.

p. 10819, lines 3-5: Did you consider any deeper depth bands, which might reveal upwelling of iron from the shelf-edge, for example?

p. 10819, line 17: Why did you choose the period 2006-2011 for construction of the climatology? I believe the data are available for a longer time period (from 2003 for January and February).

p. 10819, line 24; p. 10820, line 10, p. 10825, line 20: Why did you choose 2011 to compare with the model? As the model is a climatology and not appropriate to any specific year, would it not make more sense to compare with climatological data?

p. 10820, line 1: The ability of the model to predict the vertical water column structure is also important. For example, vertical stratification would suppress vertical mixing of iron from sediments. How well does the model simulate the observed vertical water column structure on the South Georgia shelf?

p. 10820, line 14: Over what temporal period are the data averaged? Can you include a measure of variance associated with the mean values on figure 5?

p. 10821, lines 8-13: This section would be more appropriate in the model description.

p. 10823, line 15: Minimum values are observed in late austral summer (not early).

p. 10823-10824, section 4.2: How are the SD and SE calculated, in particular the model values? Why do you use '$\sim$' and not '$=$'? Is it appropriate to quote errors to 2 decimal places?

p. 10826, line 7: The model bloom to the N and NE of South Georgia is consistently further south than observed. Why is this?

Figure 6: The model predicts high chlorophyll a values on the northeast shelf, which are not seen in the MODIS images. What might cause this discrepancy?

p. 10827, line 24: Are you sure you mean 'relative variability'? You appear to be comparing absolute values.

p. 10828, line 2: Do you mean 'modeled', not 'measured'?

p. 10828, lines 25-29: Looking at the flows and iron distributions, it is hard to tell how much of the 'second' iron plume is actually iron that has exited the shelf to the northwest and then turned eastward. Are you able to discriminate between these two possible pathways?

p. 10831, line 13: What proportion of the shelf is represented by each depth band? For example, if the 25-30m band includes only 1 model grid cell, whilst the 5-10m band has 5 cells, it would not be surprising that the 5-10m band has a bigger influence on simulated iron. Can you include some information on the geographical area represented by each depth band?

Figure 10: I don't think this figure is necessary.

Technical corrections

I would suggest that this paper be edited by a native English speaker to correct the grammatical errors that appear throughout the paper.

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