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Interactive
Comment

Interactive comment on "Surface circulation and upwelling patterns around Sri Lanka" *by* A. de Vos et al.

Anonymous Referee #1

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Recommendation Major revision / resubmit. This paper discusses the oceanic circulation around Sri Lanka, and the processes that control the upwelling that generally occurs along Sri Lankan Southern coast. In particular, this paper suggests that wind-driven offshore flow is not the only process that contributes to the upwelling there, but that interactions between the South Monsoon Current and topography also induce divergence and upwelling. This discussion is motivated by the aggregation of blue whales in this region during the South East monsoon. While I think that the subject of the paper is interesting, I have several objections (detailed below) to its publication in Biogeosciences (at least in its current form): 1) does the topica of the paper really fits in this journal?; 2) I think that the paper does not convincingly demonstrate some of the mechanisms it hypothetizes and 3) I think that the paper could be re-organized in order to become clearer. I detail this issues below. I however found promise in this work, and encourage the authors to work on a revised version and re-submit it to this or another forum.

General comments Is Biogeosciences a good forum for this paper? This is really for the editor to answer this question. The paper is motivated by the aggregation of Blue Wahels south of Sri Lanka during the NE monsoon, and discusses surface chlorophyll maps, but the actual topic of the paper are a description of the circulation around Sri Lanka and of the upwelling processes at its Southern Coast, i.e. this paper is mostly concerned with ocean dynamics and circulation. Probably that Journal of Geophysical Research-Oceans would be a more suitable forum for this paper. I found a lot of the discussions in this paper rather qualitative. For example, a lot of the discussions are based on snapshots of the simulation, so that one does not get a feeling of how these snapshots are representative of variability on the longer term (which is inherently due to the short duration of the simulations analysed here: one year, which is not enough in my opinion to discuss the seasonal cycle and its intraseasonal variability). Also the validations that are presented are very qualitative, while some data are available to perform more quantitative validations (e.g. gridded sea level data, TMI or AVHRR SST data, etc, see suggestions below). In addition, I found that a lot of the statements in the paper were not supported by the analyses that are presented. For example, does the sensitivity experiment with varying wind strength really demonstrate that the Sri Lanka dome is the effect of a recirculation in the Lee of the Island (see detailed comments)? Is the idealized experiment with wind forcing of differing intensities on both side of Sri Lanka representative of actual wind fluctuations in nature, and how do you explain dynamically the results of that experiment (see detailed comments)? In general, I feel that more in-depth analyses are needed to back up the hypotheses that are presented in the paper. Finally, I also think that the paper could be re-arranged to ease its reading. For example the motivation of the paper (aggregation of blue whales) should be explained and detailed from the very start. Some of the theoretical background that is presented in the discussion section could be very useful in the introduction, so that the reader now what's the general idea of the paper from the beginning. My impression is that it would be easier to follow that way.

In general qualitative (snapshots of single events, rather than composites, or time series to get a better handle on the temporal variability) and descriptive, without dynamical explanations.

Detailed comments P14954: the abstract is long and not very synthetic. Try to shorten it. L20-22: isn't always upwelling due to flow convergence / divergence? L23-27: this is not obvious to me. Why would the intensification of the flow to the east shift the convergence to the west? Last point: from the abstract, one wonders if this paper really belongs to Biogeosciences: it is mostly concerned with circulation modelling around Sri Lanka, with only color of the sea and blue whales aggregation briefly mentioned. P14955, L11-12: if you focus on the wind pattern, the SW monsoon is rather May to September and the NW from November to March. L23-26: why? Upwelling occurs quite close to the equator in the Peru coastal upwelling system. P14956: L25-27. Is it useful to mention SLP? And the tides on p 14957? P14957, L13: 1 Sv=103 m3s-1. P14960, L5-32: One important characteristic of the Northern Indian Ocean variability at intraseasonal (e.g. Vialard et al. GRL 2009), seasonal (e.g. McCreary et al. Prog. Oceanogr. 1993) and interannual timescales, is the propagation of siganls around the Bay of Bangal and southern tip of India under the form of coastal Kelvin waves. This remote forcing for example contributes non negligibly to seasonal variations of the EICC. Similarly, the southern boundary of you domain is also strongly connected to the equatorial circulation. Because your regional domain solution is going to be strongly constrained by the HYCOM boundary conditions, one would like to see a few basic validations of that solution, for example to gridded sea level products. I would also like to hear more details about the surface forcing of you model: to you directly specify heat, momentum and freshwater fluxes from ERA-I, or does the model compute them using a bulk formula, with near-surface air temperature, humidity and winds and downward radiative fluxes specified? Another important issue is the model bathyùetry. For example did you close the channel between India and Sri Lanka in your model? Available navigation charts in this region show extremely shallow waters that block the flow between India and Sri Lanka almost entirely. Section 2.3.1: I don't find this section very useful. A lot of the discussions in this paper are related to large and meso scale variability, so what is the need to discuss tides in details? Section 2.3.2, L8-9: not so clear from the figure I have: it is difficult to see the red and baclk vectors. Maybe plot less vectors for the model and bigger vectors. Otherwise, I think this is a nice validation. I don't think that ship drift climatologies (Mariano et al. 1995 USCG Report CG-D-34-95) would be very helpful. On the other hand, geostrophic currents derived from altimetry (e.g ; the AVISO merged gridded product for absolute currents available from http://www.aviso.oceanobs.com/index.php?id=1271) may be another useful data source to validate your modelled circulation against (in particular because you could compare the observations and model for the same dates). Section 2.3.3: Colour of the sea pictures are only available when the sky is relatively free from clouds: AVHRR 4 km resolution SST images are hence probably also available for those dates (http://data.nodc.noaa.gov/pathfinder/Version5.2/). Using such images, you can provide a more quantitative assessment of the model (mean bias, correlation with observations, etc...) than you currently do through a single example. Section 3.1. In what is this a "result"? This section rather describes the monsoonal forcing of the model and these figures could have been incorporated in the introduction, for example, when discussing the wind patterns over Sri Lanka. Section 3.2.1: since you discuss the influence of the circulation on the SCC field, you could maybe overlay the surface circulation from your model on the SCC climatology maps. I think that a lot of the circulation patterns that are discussed in the text are not really obvious from the SCC map (eg is it so easy to distinguish an open ocean upwelling from the offshore advection of SCC from a costal upwelling region ?): the discussion here is very qualitative. L20: 2700 km??? The full extent of the hovmoeller is about 700 km only! I guess that you mean 270 km. P14966, L9-10: how do you compute this value exactly (over which depth and which latitude range do you integrate, at which longitude ?). Please be more accurate. The paper of Durand et al. (JGR, 2009) provides a state-of-the art

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description of alongshore currents at two points along the coast of Sri Lanka that may be useful here. P14967, L5-6: well, the divergence of the surface flow also provides an indication of regions of upwelling. You could have added that information. Figure 11 also shows an obvious influence of topography, with a strong divergence of the surface circulation at the edge of the shelf that extends south of Sri Lanka, and upwelled waters that occupy most of the shelf. The details of the circulation that result in this distribution would have been interesting to discuss. L9-10: it would have been nice to show time series of the SST in selected boxes to illustrate those seasonal / sporadic SST upwellings. A situation map with the standard deviation of the SST would also maybe help locating the main upwelling areas. L15-17: The mean wind pattern during that season is indeed not favourable to upwelling, but did you investigate the wind variability associated with the snapshots of figure 11? L20-22: you would need to perform an heat budget within the mixed layer to be able to demonstrate that lateral advection in the mixed layer also contributes to the cooling. P14968, L1-3: I don't really get the point here. Is your point that the wind does not change so much between July and August but that there is a significant change in the position of the upwelling? Or that the upwelling can be the result of the blocking of monsoon current by Sri Lanka (and that this current is not the result of local winds only)? Because another possible explanation is that, at the seasonal timescale, this upwelling is indeed wind-forced, but that it si modulated by meso-scale variability or by equatorial waves (intraseasonal equatorial Rossby waves or mixed gravity waves can significantly modulate the surface circulation close to 6°N). P14968, section 3.3: this intraseasonal variability is interesting. Can it be related to the passage of a (remotely forced) coastal Kelvin Wave as those described in e.g. Vialard et al. (GRL, 2009)? Or is it related to local intraseasonal wind variations (see several papers by Rao et al. on that topic (e.g. their 2006 paper in GRL and references therein). You could look at wind variations for that event and other events (for example using a composite analysis, or simple indices). P14968 bottom and 14969 top: a longer simulation would allow to characterize that type of variability better. Is it an hydrodynamic instability that creates rings over the mean current? The

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Interactive Discussion

Discussion Paper

effect of wind-forced equatorial waves? Of coastal Kelvin waves coming from the Bay of Bengal? P14969, L10-21: I quite like the sensitivity experiments here, but the type of wind stress perturbations that are applied are poorly justified. The only season when mean wind flows southward along both coasts is the winter monsoon. And even for that season, can you pove that the main pattern of wind perturbations correspond to southward winds of varying intensities along both coasts? Finally, the reason why the upwelling sets on the side of the weakest wind perturbation is not explained here (and the explanation is not obvious to me). P14970, L1-17: in what does this experiment demonstrate that the SL dome is due to a recirculation of the current in the lee of Sri Lanka? A more convincing experiment would be to suppress Sri Lanka and see if the recirculation disappears. But the current experiment can be interpreted in many different ways. P14970, L24-25: you show comparisons of the model SST with SCC but not with observed SST, so you can't really say that here. P14971, L1-8: you speak about the model as if it was ground truth, while it is not even validated quantitatively in terms of the transports it simulates. P14971 bottom and top of 14972: many readers won't be familiar with those scaling arguments. If you want to use them, you need to introduce and explain them in more details. Also explain how you chose the scaling values U, L and Kh for both seasons. And again, the SL dome is quite possibly created by a recirculation of SMC in the lee of Sri Lanka, but I don't think that your experiments demonstrate it. 014973, top: it would be more convincing to show this for an average over the entire SWM rather than just a snapshot. I guess that the point here is that classical coastal upwelling dynamics (alongshore wind stress and offshore transport) are not the only source of divergence and upwelling, but that the interaction between an incoming current (the SMC) and the island is as well. This point is actually further explained on page 14974: I think it would have been nice to state all of this motivation as an introduction to the study, because it would help the reader to understand your hypotheses better all along the text. P14975: L11: you did not demonstrate that the transport was more realistic than previous estimates. L12-15: I do not think that you have demonstrated this either (although I agree that this explanation sounds sensible).

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L23-26: it is not obvious to me that your idealized experiments correspond to actual patterns of wind variations on both side of the Island.

Figures The axis labels on almost all figures are too small to be read properly. Try to be more consistent in your figure choices (e.g. use same layout for figs 7 and 8, use same months for figs 7_8 and 10). Fig3 can be improved (bigger label on axes, short title that gives variable and data, e.g. "SST, 19th June 2013" Fig4: the caption says "Roms currents in blue" but they are in black. It is quite difficult to judge the quality of ROMS simulation from this plot. Fig 5: add some bathymetry contrours on figure 5b (some current features are obviously topography-driven). Fig6: Are the red curves and dots needed on that figure? Say that 0° is northward. Fig 9: indicate the averaging box for that plot one one of the other figures (e.g. fig 8). Figs 7, 8, 10: it bould be better to make consistent choices for the months displayed in all those figures, and maybe to plot SCC & the modelled circulation on the same plot. If just plot 4 panels (say SE monsoon / NW monsoon and transitions) you can have all the info (wind forcing / modelled circulation + observed SCC) on the same page. Fig 10: you should plot the actual model coastline on this plot, not the coastline from your visualization software. Fig 11: again, the labels are small, and you should maybe plot one vector in 4 and bigger vectors, for an improved readability. Fig 16: there must be a mistake in the caption. I imagine that the simulation with the Coriolis effect included is the one on the right, not on the left.

Interactive comment on Biogeosciences Discuss., 10, 14953, 2013.

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