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Interactive comment on “Eddy Surface properties and propagation at Southern Hemisphere western boundary current systems” by G. S. Pilo et al.

Anonymous Referee #1

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This manuscript analyzes a satellite altimetry derived global eddy data base with the aim of characterizing the mean lifetimes, radius, rotational speed and propagation in the neighborhood of the Southern Hemisphere western boundary currents. Though the scope of the analysis is straightforward and the manuscript is well organized and generally well written, there are several issues that require a more in-depth analysis as indicated below. Though there are parts of the analysis that justify its publication in Ocean Science I cannot recommend acceptance until the authors address the following issues.

General comments

The study must include distributions of sea surface height variance or eddy kinetic energy as well as eddy density in the three WBCs. These distributions are important

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to evaluate the results because, as illustrated by existing eddy energy and/or SSH variance distributions, and as briefly explained below, the selected regions are very heterogeneous. Thus, one wonders to what extent are the statistics representative of specific sub-regions where eddy properties are so distinct.

The study refers to the eddy direction of propagation in all three WBCs but the only supporting evidence is presented in the AC (Fig 2c). The observations that most eddies of the western BC system propagate southward, but some eddies propagate northward (p. 142, line 15) must be documented. The authors go on referring to coastal trapped waves with phase speeds 3-fold larger than the eddy propagation speeds and that it is unclear whether the northward propagating eddies are advected by the Malvinas Current. What is clear is that the issue demands a more in-depth analysis. It is also relevant that south of about 40°S the western slope of the Argentine basin presents very low eddy kinetic energy ($\sim 10 \text{ cm}^2/\text{s}^2$) and rms sea surface height ($<4 \text{ cm}$) (Goni et al., JGR, C10037, 2011; Saraceno and Provost, DSR, 62-69, 2012), indicating small mesoscale variability and presumably very few eddies. Likewise, it is stated that EAC eddies propagate southward (p.143), but no evidence is presented to support this observation. Thus, the study lacks a quantitative measure of eddy propagation. An analysis similar to Fu's (GRL, L14610, 2006 and Fu, JGR, C11017, 2009) seems suitable. In fact, the later reference is relevant to the eddy propagation in all three regions and must be carefully considered in the discussion. The need for a more quantitative measure of the eddy density and pathways is clear when considering AC eddies penetrating westward beyond Walvis Ridge, and EAC eddies into the Great Australian Bight. Neither of these eddy paths seem statistically relevant, compared to the large eddy densities observed both, upstream within the WBC, nor farther downstream, after the WBCs deflect towards the interior.

Inspection of Figs. 2, 3 and 4 indicates that eddies do not form nor drift over the continental shelves. There are a number of dynamical reasons for this, but why is this particular behavior pointed out in the EAC eddies (p. 143) and not in the AC and BC

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systems?

It appears that class intervals for amplitude, rotation speed and radius are 1cm, 2cm/s and 2km, respectively. You must explain how were these values selected. The spatial resolution of satellite altimetry, even with multi-mission data, is too gross to justify the 2km radius binning. Perhaps this is why those histograms are considerably noisier. Also note the % of observations is about half of those for speed and amplitude.

The poleward extensions of WBCs are characterized by some of the sharpest SST fronts in the world ocean. Eddies formed in the southwest corner of the subtropical gyres (in the SH) are therefore expected to present strong SST signals. It was therefore rather disappointing to see "surface properties" did not include SST anomalies. In addition to SST anomalies these data would provide independent information on the eddy radius at better space-time resolution than the original SSH data.

I am not a marine geologist but something seems wrong in the bottom topography. In p. 142, line 3 the authors state: "It flows around the Zapiola Rise, a bathymetric feature of 2000 m in the centre of the 4000m basin (45° W, 45° S; Fig. 1b)." This gives the impression that the rise is about 2000 m higher than the surrounding waters, which are 4000 m deep. However, available bathymetric maps and data bases show that the Argentine Basin is mostly deeper than 5000 m around the Zapiola Rise, and that the rise itself is only about 1000 m shallower than the abyssal plane, which is ~ 6000 m deep, and 500 m shallower than the waters farther east (e.g. Fig. 2 in Saunders and King, JPO, 1942-1958, 1993). The gray shading in Fig. 2b indicates the rise is shallower than 3500 m, whereas it should be around 4900 m! The error does not appear to have an impact on the AC and EAC regions, but this needs to be carefully checked in all figures that present a bottom topography background. In addition, according to Exon et al. (Austr. J. Earth Sci., 561-577, 1997) the names of the bathymetric features south of Australia are incorrect, the feature labeled as Tasman Plateau is the South Tasman Rise and the feature labeled Tasman Rise is the East Tasman Plateau.

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In the Discussion the authors point out that EAC eddies are also derived from the Coral Sea, which is clear from the eddy tracks in Fig. 4. However, the study of Everett et al. shows that both, cyclonic and anticyclonic eddies are a lot more frequent south of 32–33°S. This suggests that eddy shedding near the EAC retroflexion is a more significant eddy source. This could be tested quantitatively based on the analysis of eddy density distributions suggested earlier.

The authors claim that the eddies that cross south of Tasmania may "...act on heat and biogeochemical budgets between different oceanic regions." Given that only very few eddies were observed in a 20 year period, I wonder how significant these fluxes are. It seems that eddy fluxes must be more relevant within the Tasman Sea. A combination of maps of eddy density and eddy kinetic energy would be more useful in this regard than just the trajectories.

It is argued that AC and EAC System eddies present smaller amplitudes because they live longer than BC eddies. To test this hypothesis the authors must determine the statistics of young AC and EAC eddies and compare them with those of BC eddies.

Last but not least, in the summary section the authors state that Agulhas rings propagate into the Atlantic "along the expected path between 20–30° S". I wonder why is this path expected? Interestingly, the band of high SSH variability extending from the Agulhas Retroflexion maximum into the subtropical South Atlantic, is clearly located south of 30° S (e.g. Fu, GRL, 2006). However, the results presented here show that west of 10°W all AC eddies follow paths to the north of that high variability band. Thus, the high EKE band does not match the AC eddy path. Given the small number of eddies observed in a 20 year period this is not too surprising, but it also warns us about the interpretation of SSH variability distributions and Agulhas eddies. The authors should delve deeper in these issues as the results perhaps are not "as expected" as they may first appear.

Specific Comments

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Page 137, line 23, “Hall_and Lutjeharms, 2011”, insert blank Line 26, “has not been fully reported.” too vague. If there are previous reports, what are their main conclusions? Line 30, “These early studies were based on data with reduced temporal and spatial resolution. . .”

Page 138, line 15, “Here, we qualify AC, BC and EAC System eddies based on their surface properties, and investigate eddy propagation and lifetime.” Spell out the surface properties being analyzed. Line 18, “ presented here help. . .” delete “s” Line 19, “Identifying eddies’ propagation patterns allows us to establish monitoring programs.” First identify the propagation patterns and then be specific, what kind of monitoring programs? For what purpose?

Page 139, lines 13-17 indicate the selected regions in Fig 1.

Page 140, line 3, unclear what the authors mean by “particularity”, is it inaccuracies? Why are these more relevant in the regions of interest? line 4-5, Detection inaccuracies may lead to premature dissipation but also to late detection and, more importantly, tagging of “old” eddies as new ones.

Page 141, line 11, are 3.8 and 4 km/day significantly different? Line 12, why is the propagation of a higher number of anticyclonic rings beyond the AC system expected? Line 21, it is very difficult to observe the eddy deflection in the Agulhas Plateau in Fig. 2, perhaps using bold lines for selected trajectories would help.

Page 142, line 15: “Despite most eddies of the BC System eddies in the basin’s western domain propagate. . .” line 18: “ intraseasonal”

Page 143, line 5: “ Regardless of their origin, . . .”

Page 144, lines 6-9: Statements such as “ . . . cyclonic eddies spin faster than anticyclonic eddies” and “. . . cyclonic eddies also having larger mean amplitude than anticyclonic ones” must be supported by a significance test.

Page 146, line 9: “. . . to a smaller extent.” line 16: isopycnals line 17: the vertical scale

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of eddies can be estimated from hydrographic data.

Figure 5: The labels in y-axes are misleading. They appear to be % of observations. If that is the case this needs to be stated in the figure caption, and the Amplitude (cm), Rotation Speed (cm/s) and Radius (km) labels should be moved to the x-axes.

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