Interactive comment on "Air–sea CO$_2$ fluxes and the controls on ocean surface pCO$_2$ variability in coastal and open-ocean southwestern Atlantic Ocean: a modeling study" *by* R. Arruda et al.

R. Arruda et al.

cadoarruda@gmail.com

C4633

Point-by-Point reply to referee 1

24 August 2015

We would like to thank the referee for the careful review of our manuscript. Your comments were taken into careful consideration. Here, a point-by-point reply together with the latest changes on the manuscript is presented. We hope that the changes adequately address the reviewer's comments and that the new version is suitable for publication in Biogeosciences.

- **Comment 1** – As stated above, I do not know the statistical indicators used by the authors, and these are not used in any biogeochemical modelling studies I am aware of. In addition, from the way they are used here, it appears that they provide only a very coarse qualitative assessment of model performance. Thus, I find these indices of no value here and would suggest to replace them with a Taylor diagram, which is more quantitative and would greatly facilitate the comparison with other modelling studies.

- **Reply to comment 1** – We added the equations and more detail about the statistical indicators (ME, CF and PB). We also added a new figure with a Taylor diagram

C4634

that is consistent with the Model Efficiency (ME) indicator. This diagram shows a good correlation in the northernmost area (A1), while the areas to the South (A2 and A3) are not correlated with the observations. This may be explained by the higher eddy variability in these areas, as shown in the EKE map (Fig 4a), and thus higher expected pCO2 variability. Another factor may be the limited number of observations in these areas.

Texts changed: L225-236:

"model efficiency $ME = 1 - (\Sigma(O - M)^2)/(\Sigma(O - \bar{O})^2)$ (Nash and Sutcliffe, 1970), cost function $CF = (\Sigma \mid M - O \mid)/(n\sigma_o)$ (Ospar et al., 1998) and percentage of bias $PB =\mid (\Sigma(O - M).100)/\Sigma O \mid$ (Allen et al., 2007), where M stands for modeled pCO_2 and O for observations from SOCAT database, n is the number of observations and σ_o is the standard deviation of all observations."

"ME relates model error with observational variability, CF is the ratio of mean absolute error to standard deviation of observations, and PB is the bias normalized by the observations (Dabrowski et al., 2014; Stow et al., 2009). Basically if $ME > 0.5$, $CF < 1$ and $PB < 20$, indicate that the model is "good/reasonable "when comparing to observations. If $ME < 0.2$, $CF > 3$ and $PB > 40$ the model is classified as "poor/bad "."

Texts added: L256-261:

"The Taylor diagram is consistent with the model efficiency (ME) estimate, showing good/reasonable results in A1, with a correlation of 0.8, and poor results in A2 and A3, with negative correlations (Fig.5). Only in A1, the correlation was found to be statistically significant. Aside from greater pCO_2 variability in these regions, the poor results found in A2 and A3 could also be due to the paucity of the observational data both in space and time."

- **Comment 2** – The authors describe several processes lacking in their model, e.g.,

rivers and tides (p. 7374 bottom to p. 7375 top). While I have no problem accepting this decision, I found the discussion somewhat confusing. On p. 7375, l. 8, it says that the "model re- sults should nit be significantly affected ..." but in the next sentence: "These processes will be implemented in future studies." This does not make sense to me: either these processes are (expected to be) important, then the authors should discuss the reasons why they expect that these processes do not strongly affect their present conclusions, or they are not important, then there is no reason to include them in future studies. For example, on p. 73887, l. 10, an expectation is expressed that including tides and rivers could help "diminishing the biases in the southernmost and La Plata regions", which seems to contradict the above statement. This should be resolved in a revised manuscript.

- **Reply to comment 2** – It is known that these processes are locally important in controlling mixing and stratification, with likely impacts on pCO2. But the extent to which regional pCO2 is affected is not established, requiring a separate study, which we leave for the future. Turbulent mixing due to tides is mostly important in the inner shelves of Patagonia. In contrast, the South and Southeastern Brazilian shelves have a micro-tidal regime. Therefore we expect this process to not significantly effect pCO2 in these regions. Riverine inputs are mostly important in the La Plata region, since it is the major river in our study area, but not elsewhere. Therefore, we expect that the overall large scale pCO2 distribution of the model will not depend substantially on these local processes. These processes should be included in studies with a more regional emphasis. In response, we added some explanation into the text arguing for why these processes are not considered in our study and what the potential implications of this limitation might be.

Texts changed:L105

"Even though some processes as river runoff and tides are locally relevant (i.e.,

la Plata River, and Patagonia shelf), we are not considering them in the present study (see conclusions section)." ... "These shortcomings may effect the results in some regions, but it is unlikely that they will affect the overall pCO_2 results in the wider domain."

Moved paragraph to conclusions section L466:
"Our model does not include river inputs of carbon, which are known to be an important factor regulating pCO_2 (Bauer et al., 2013). The lack of tides may adversely affect our model results in the inner shelf of Patagonia, where tidal amplitudes reach up to 12 meters at some points (Kantha et al., 1995; Saraceno et al., 2010) and tidal fronts are known to impact oceanic pCO_2 (Bianchi et al., 2005)."
And added: L451:
"In future regional studies focused on the Patagonia shelf, tides and river run-off should be included."

- **Comment 3** – Some minor problems: P. 7374, l. 21 "(CESM) climatological model product": a reference should be provided for this product.
  On the ocean -> In the ocean (several places)
  The axis and tick labels in all figures are much too small and should be increased to the font size of the main text.

- **Reply to comment 3** – Added reference to (CESM) climatological model product "(Moore et al., 2013)". Corrected text to "In the ocean" throughout the manuscript. Increased axis and tick label in all figures.