

## ***Interactive comment on “Sea–air CO<sub>2</sub> fluxes in the Indian Ocean between 1990 and 2009” by V. V. S. S. Sarma et al.***

**V. V. S. S. Sarma et al.**

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Interactive comment on “Sea–air CO<sub>2</sub> fluxes in the Indian Ocean between 1990 and 2009” by V. V. S. S. Sarma et al.

Anonymous Referee #2 Received and published: 6 September 2013

General Comments:

In this paper Sarma et al. describe a comparative study of annual, seasonal and inter-annual CO<sub>2</sub> flux variability for the Indian Ocean derived from interpolated observations, ocean biogeochemical models and atmospheric and ocean inversions. These comparisons are made over the entire Indian Ocean and also for specific subregions.

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The introduction to this paper provides a good overview of previously published estimates of CO<sub>2</sub> fluxes for the Indian Ocean, commenting on the agreement (or lack of agreement) between them, and the strengths and weaknesses of the various methods that have been employed.

The primary conclusion of this paper is very encouraging, i.e., that there is remarkably good overall agreement between the CO<sub>2</sub> flux estimates derived from different methods for the entire basin, albeit with some significant regional and seasonal discrepancies. The latter are discussed extensively and insights are provided into why these discrepancies arise. This is a well-written paper that will very likely become a benchmark for studies of CO<sub>2</sub> flux variability in the Indian Ocean for many years to come. I recommend publication with only minor revision as specified below.

Response: Thank you very much for your appreciation.

Specific Comments and Technical Corrections:

Page 10762, Line 1: Should read “: : of [the] globe: : :”

Response: Corrected in the text to be published in BG.

Page 10762, Line 21: Should read “receives [a] significant amount: : :”

Response: Corrected in the text to be published in BG.

Page 10763, Line 17: Poorly sampled with respect to CO<sub>2</sub>, or in general? Please reword to clarify. Response: Corrected in the text to be published in BG.

Page 10764, Line 1: Modify punctuation as follows: “: : who, using underway pCO<sub>2</sub> data, estimated: : :” Response: Corrected in the text to be published in BG.

Page 10764, Line 15: The Indian Ocean Dipole Zonal Mode (IODZM) is now almost universally referred to as just the Indian Ocean Dipole (IOD).

Response: We have now used only IOD in the entire manuscript to be published in BG

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Page 10764, Line 26: No need to redefine the IOD acronym here. It is defined in line 15.

Response: Corrected in the text to be published in BG.

Page 10765, Line 2: Should read “: : in [the] Arabian Sea: : :”

Response: Corrected in the text to be published in BG.

10765, Line 23: Change to “Because of the paucity of sampling in this important region, interpolated: : :”

Response: Corrected in the text to be published in BG.

Page 10766, Fig. 1: Need to add latitudes and longitudes to the axes.

Response: Figure 1 has been redrawn illustrating the major circulation, labeling latitude and longitudes, and atmospheric stations – as given below.

“Figure 1: Sub-regions of the Indian Ocean (30°N-44°S, red and blue combined) used in this paper: North Indian Ocean (blue), South Indian Ocean (red). The water column circulation pattern is also given. East India Coastal Current (EICC), West India Coastal Current (WICC), Somali Current (SC), South Equatorial Counter Current (SECC), East African Coastal Current (EACC), North East Madagascar Current (NEMC), South East Madagascar Current (SEMC), South Equatorial Current (SEC), South Java Current (JC) and Leeuwin Current (LC). The currents shown in dashed line represents during boreal winter and these currents flow opposite direction during boreal summer. Overlain also is the network of atmospheric observations of CO<sub>2</sub> - Cape Rama, India (CRI), Mount Kenya (MKN), Bukit Koto Tabang (BKT), Seychelles (SEY), Tromelin Island (TRM), Cape Point (CPT), Amsterdam Island (AMS), Cape Grim Observatory (CGO), Crozet Island (CRZ). The colour of the dot indicates how many inversions used data from that location (black: all or almost all inversions, dark grey: around half the inversions, light grey: one or two inversions). We note that the temporal period over which the atmospheric data was collected is not the same for all the stations”.

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Page 10766, Line 8: Need to include latitude range for the southern portion of the northern Indian Ocean.

Response: It is added in the text to be published in BG.

Page 10766, Lines 3-9: The authors should say something about the basis for dividing up the basin into these specific broad latitudinal zones for calculating CO<sub>2</sub> fluxes. Although this becomes obvious further on (i.e., based upon where the annual observed CO<sub>2</sub> fluxes switch from positive to negative at 18 degrees S), it seems rather arbitrary at this point in the manuscript.

Response: We have now added now the following reference where it was explained about reason behind the division at 18°S:

These regions were defined based on regions used in the ocean inversions (Mikaloff Fletcher et al., 2006).

Page 10766, Line 12-13: Should read “: : which [includes] datasets from: : :”

Response: Corrected in the text to be published in BG.

Page 10766, Line 22: Should read “: : variability a challenge: : :”

Response: Corrected in the text to be published in BG.

Page 10766, Line 23: Should read “: : 3 million measurements of: : :” Response: Corrected in the text to be published in BG.

Page 10773, Line 21: Overestimated is one word.

Response: Corrected in the text to be published in BG.

Page 10774, Line 23: Should read “: : except [the] tropical Indian Ocean: : :”

Response: Corrected in the text to be published in BG.

Page 10777: There do not appear to be any references to Fig. 5.

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Response: It was referred in page 10773: Line 2.

Page 10778, Line 19: Should refer to Fig. 9 rather than Fig. 7.

Response: Corrected in the text to be published in BG.

Page 10779, 1st paragraph: Switching back and forth between boreal and austral is confusing. Please choose one or the other reference frame and use it exclusively.

Response: As much of the Indian Ocean is in the Southern Hemisphere we have defined the text in terms of austral summer and winter exclusively in the text to be submitted to BG

Page 10779: Fig. 10 needs a color key of some kind that specifies which inversion models are represented by each colored line.

Response: We have now given color scale in the revised plot.

Page 10780, Line 5: I think this should say “: : a strong [negative] sea-air CO<sub>2</sub> flux: :”

Response: Corrected in the text to be published in BG.

Page 10780, Lines 22-25: This sentence seems to contradict itself, first stating that simulated pCO<sub>2</sub> values were higher than observations by 10 uatm during all seasons (which, by the way, they are not as they switch from about 10 uatm higher to 10 uatm lower seasonally), then stating that the difference is only present during the Austral Summer. Also need to add Figure references here so that the reader knows exactly which Figures are being referred to.

Response We have clarified the text to say:

Overall, OBGMs simulated pCO<sub>2</sub> values higher than observations by up to 10 uatm during the Austral Summer, and lower by up to 15 uatm during the austral winter. However if we compare only the response in the well-sampled regions (i.e. the South-

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west Indian Ocean; Figure 2), this difference is only present during the Austral Summer (Fig. 8) with OBGMs capturing the Austral Winter response (not shown).

Page 10781, Line 7: Should read “: : additionally, given the fact that: : :” Response: Corrected in the text to be published in BG.

Page 10782, Line 4: Should read “: : also [to] have: : :” Response: Corrected in the text to be published in BG.

Page 10782, Line 29: This sentence isn't right “: : with strong positive sea-air anomalies are simulated: : :”

Response: This has been corrected, the sentence now states:

“Simulated IAV appears to show good correlation with the strong IOD event in 1997-1998, with strong positive sea-air anomalies simulated in OBGMs and inversions, and low observed biological production (Wigget et al., 2002)”.

Page 10783, Line 20: Should be “IODZM”, but switch all to IOD as suggested above.

Response: Corrected in the text to be published in BG.

Page 10785, Line 17: Should read “: : driven [by] poor simulations: : :” Response: Corrected in the text to be published in BG.

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Interactive comment on Biogeosciences Discuss., 10, 10759, 2013.

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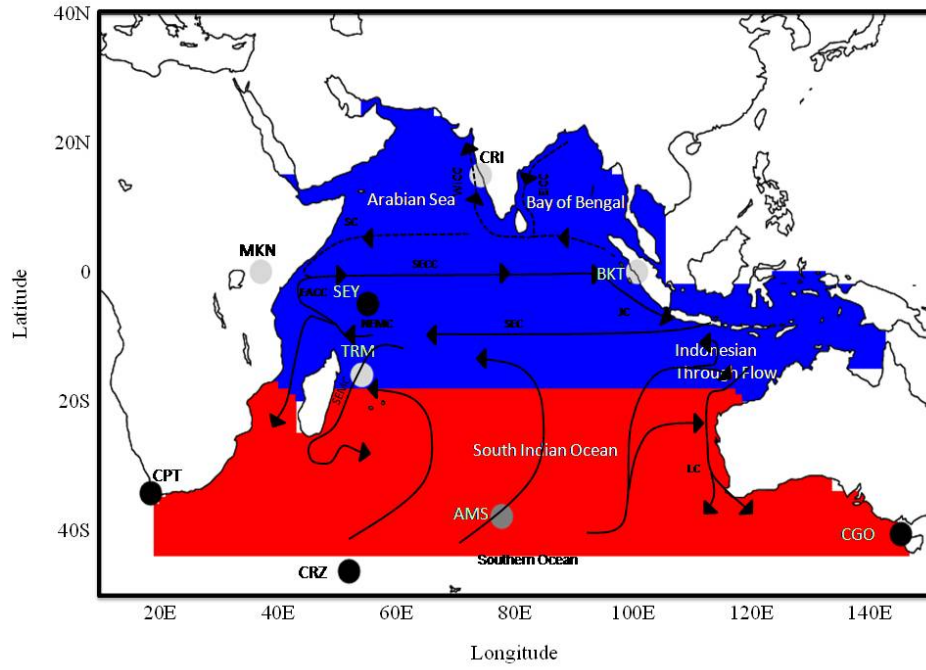


Fig. 1.

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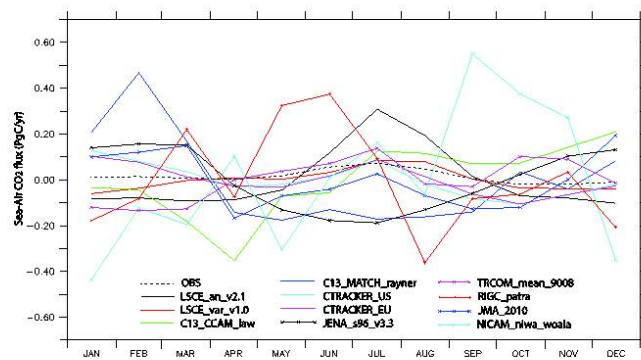


Fig. 2.

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