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Biogeosciences Discussions

Interactive comment on "Air–Sea Fluxes of Greenhouse Gases and Oxygen in the Northern Benguela Current Region During Upwelling Events" *by* Eric J. Morgan et al.

Anonymous Referee #1

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Morgan et al. present an evaluation of using ground-based measurements of gas concentrations to estimate air-sea gas fluxes in coastal waters off the northern Benguela upwelling region. This approach can provide greater resolution than ship-based sampling during upwelling events, and thus represents a valuable tool for monitoring air-sea gas flux in coastal upwelling areas, which are important sites for emitting greenhouse gases such as N2O and CH4 to the atmosphere, but may be subject to seasonal and short term variability that may be missed by infrequent ship-based sampling efforts. The authors validate their method by comparing ground-based flux estimates to those estimated from ship-based sampling, which is an important step. The manuscript goes on to discuss the sources of variability and error in their data, and ways in which data

must be filtered to minimize error. The authors ultimately suggest that tower-based flux montoring systems should be widely adopted to measure air-sea flux in eastern boundary upwelling systems. This work thus represents an important contribution to coastal marine air-sea flux studies, and should be published with minor revisions. The presentation quality and writing is excellent, and I have only a few minor comments/questions that need to be addressed (see below). While I agree that this presents an important contribution and should be widely adopted, I can't help but struggle with the fact that the towers only appear to be used to estimate fluxes during upwelling events, and may be being under-utilized. Could the authors briefly discuss other potential benefits of these towers? E.g. could they be used to measure downward fluxes as well? Or perhaps measuring land-air fluxes? These towers might also naturally be compatible with eddy-covariance flux estimates.

Specific Comments:

Page 2, Line 32 – can you give the approximate frequency at which measurements were taken? What standards were used, and how frequently the instruments were calibrated?

Page 3, line 4 – perhaps include a brief explanation for presenting atmospheric oxygen relative to N2? What is this correcting for?

Page 3, line 7 – remove one of the 'as' (there are two in a row)

Page 3 line 16 – Why not include areas further off-shelf? Perhaps a justification for selecting these boundaries would be helpful? i.e. it's upstream of your tower in the direction of prevailing winds during upwelling? Or perhaps it's based on SST anomalies during upwelling events?

Page 3, line 19 – how were wind-speeds and SSTs determined? Update: I see this is discussed in the subsequent section. It's nice to understand where the data come from before you explain how the data was used, so I suggest moving the discussion on

Remote Sensing Data ahead of this section. But this is only a suggestion.

Page 3 – line 19-25 – I understand that you chose the upwelling thresholds by visually inspecting the data, but perhaps you could clarify how 'extreme' the thresholds you chose were relative to the standard deviation from your smoothed SST or windspeed curves? Or perhaps you could state how many upwelling events were flagged during this step before filtering them further based on the SST, atmospheric data, backtrajectories of winds, and CO concentration?

Page 5 section 2.4. I'm curious about the dilution factor calculation – q. This seems straightforward, but I'm sure there are complications that may be being glossed over, and I have a few questions that I feel should be addressed in the text. How many sets of data points from the ship and tower were used to derive the average q? What is meant by 'filtered to exclude for poor agreement between CO2 and CH4'? and what percentage of the potentially viable measurements were excluded from the average because of this? And finally, how does the q you derived compare with other estimates?

Page 8 line 32 to end of para – you suggest that upwelling fluxes probably account for the majority of the mean annual flux (as reported by others). Can you support this claim by calculating how many upwelling events similar to the ones you observed (i.e. flux density x duration of UW event) would be needed to account for the annual flux assuming the fluxes the rest of the year were net-zero?

Page 9 line 3-6 – Good! I was wondering about how different O2 /N2 vs. APO would be. Thank you for including this. . . , but where are the actual comparison between dO2/N2 and APO shown? There isn't a reference to a figure or table here, nor a slope and r2 value, or even a mean difference between the two.

Page 9 line 10 – can you include the range here as well? It would be useful to know the maximum flux density you measured to compare with the others' estimates mentioned later in the paragraph. Figure 1 – can you please show the locations of Walvis Bay and Luderitz on the maps, since you refer to them in the text?

Page 9 line 25 – what were the dissolved CH4 concentrations in the upper 15m during this cruise? How do they compare with the other concentration values reported in the same paragraph?

Page 10, line 1 and 2. This sentence seems to contradict the second sentence of the paragraph, which states you observed elevated CH4 mixing ratios. Something is unclear here.

Page 10, line 18 – 'likely a result of warming temperatures that would reduce their solubility' are you suggesting the only reason the gases evaded to the atmosphere was warming? This implies CH4 and CO2 weren't supersaturated before the water warmed up. . .is that true? More likely the net evasion was enhanced by warming, except for O2.

Conclusion – Might be worth emphasizing the fact that your tower method is capable of measuring methane flux associated with both bubble flux and diffusion, which can't be said of ship-based measurements.

As previously mentioned, I agreed that a network of these towers would be great, but it might be easier to sell the idea of a network of these towers by mentioning the other potential uses of these towers. E.g. can you not estimate air-sea fluxes during downwelling events? What about land-air fluxes when winds from the east? You already mentioned the filtering for biomass burning based on CO, so surely there is some value here as well?

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