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Ocean Science Discussions

Interactive comment on "Submesoscale CO_2 variability across an upwelling front off Peru" *by* Eike E. Köhn et al.

Anonymous Referee #1

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Kohn et al. observe and address the drivers of CO2 flux variability at small time (hours) and space (km) scales off coastal Peru. Eastern boundary upwelling zones such as this region can be a large source of CO2 to the atmosphere, so understanding the mechanisms that drive CO2 flux from these regions is critical to reducing the uncertainty in the global carbon cycle.

This paper provides an important contribution to understanding the driving mechanisms of CO2 flux from eastern boundary upwelling zones, and I recommend publication in Ocean Sciences after the authors consider some comments below on methodology clarity and how these results relate to other modeling and observational work.

Major comments:

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1) Comparison to studies at broader time and space scales: Most observational- and modeling-based studies of CO2 flux do not constrain the influence of submesoscale processes as done here by Kohn et al. In order to make a stronger connection to existing research and provide valuable insight for future studies, this manuscript would benefit from additional analyses that link small to broader scale processes. For example, Kohn et al. compare their observations to the observations presented by Friederich et al. (2008) for the month of February (in section 6). What is the seasonal context for this comparison, i.e., how does February compare to the range of seasonal patterns in CO2 flux and wind forcing in this region? Are submesoscale processes more dominant during certain times of year or certain phases of ENSO? In addition, there have been more recent assessments of broad-scale CO2 flux (Landschützer et al., 2014) that likely utilize more recent underway observations off coastal Peru (Bakker et al., 2014). How do these compare to Friederich et al. and the results presented here? Finally, are there lessons learned as a result of this research on submesoscale processes that may be useful to improving observational design and model parameterizations?

2) Methodology: Further clarification is needed to better understand the experimental design. The beginning of section 2 Data and methods requires a description of the location and timing of field work. This could be addressed by simply moving existing text from the introduction (page 2 lines 21-22) and the results (page 7 lines 2-12). Transects A-C and how they relate to zonal transects 3-7 and cross-frontal transects 1-17) also needs better explanation. Is it possible to show and label all transects in Figures 2 and/or 5 so the reader can better understand how these two figures relate? Transects B and C are mentioned in Fig 2 caption but are not labeled within the figure.

Minor comments/edits:

Page 1 line 5: Here and at key points throughout it would be useful to mention the direction (N-E-S-W) of downfrontal, along-frontal, etc winds.

Page 2 lines 3-5: Some rephrasing necessary here. Processes *are* difficult to ob-

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serve? By "their importance" do you mean submesoscale processes or models? Do you mean altering, not alterating?

Page 5 section 2.2: What is the estimated uncertainty in fCO2 measurements and resulting CO2 flux? How does using mean salinity during the field study impact the fCO2 uncertainty?

Figure 4: Be consistent in presenting units (e.g., either kg-1 or /kg). State in the caption what the contour lines represent.

Page 7 line 4: Does Feb 16 10:00-15:00 represent the main experiment or the CTD transect?

Figure 5 caption: In panel (e) clarify that velocities are represented by lines and vorticity by circles.

Page 10 line 6: Spell out local time or define acronym.

Page 10 line 25: Is a comma meant after anomalies?

Page 11 line 2: Present consistent # of significant digits.

Page 12 line 8: The weakening of the front is not caused by Ekman transport as demonstrated by what?

Figure 9 caption: Is the uncertainty range represented by the shaded areas around the lines? Add "(green)" after introducing Rb ratio. Why are the Rb ratio errors omitted? Also, consider defining the Rb ratio before presenting Fig 9.

Figure 10 caption: Explain what 200 and 8.7 km represents in panel (a).

Page 17 line 12: Development misspelled.

Page 18 lines 16-17: Wouldn't the difference between delta pCO2 and fCO2 be insignificant compared to measurement uncertainty?

Page 18 line 22: How much does the parameterization of Friederich et al. overestimate

CO2 flux compared to the parameterization used here?

Page 21 line 2: Rephrase "responsible for fast the observed changes"

References:

Bakker, D.C.E., Pfeil, B., Smith, K., Hankin, S., Olsen, A., Alin, S.R., Cosca, C., Harasawa, S., Kozyr, A., Nojiri, Y., O'Brien, K.M., Schuster, U., Telszewski, M., Tilbrook, B., Wada, C., Akl, J., Barbero, L., Bates, N.R., Boutin, J., Bozec, Y., Cai, W.-J., Castle, R.D., Chavez, F.P., Chen, L., Chierici, M., Currie, K., de Baar, H.J.W., Evans, W., Feely, R.A., Fransson, A., Gao, Z., Hales, B., Hardman-Mountford, N.J., Hoppema, M., Huang, W.-J., Hunt, C.W., Huss, B., Ichikawa, T., Johannessen, T., Jones, E.M., Jones, S.D., Jutterstrom, S., Kitidis, V., Koertzinger, A., Landschuetzer, P., Lauvset, S.K., Lefevre, N., Manke, A.B., Mathis, J.T., Merlivat, L., Metzl, N., Murata, A., Newberger, T., Omar, A.M., Ono, T., Park, G.-H., Paterson, K., Pierrot, D., Rios, A.F., Sabine, C.L., Saito, S., Salisbury, J., Sarma, V.V.S.S., Schlitzer, R., Sieger, R., Skjelvan, I., Steinhoff, T., Sullivan, K.F., Sun, H., Sutton, A.J., Suzuki, T., Sweeney, C., Takahashi, T., Tjiputra, J., Tsurushima, N., van Heuven, S.M.A.C., Vandemark, D., Vlahos, P., Wallace, D.W.R., Wanninkhof, R., Watson, A.J. (2014) An update to the Surface Ocean CO2 Atlas (SOCAT version 2). Earth System Science Data 6, 69-90.

Friederich, G.E., Ledesma, J., Ulloa, O., Chavez, F.P. (2008) Air–sea carbon dioxide fluxes in the coastal southeastern tropical Pacific. Progress In Oceanography 79, 156-166.

Landschützer, P., Gruber, N., Bakker, D.C.E., Schuster, U. (2014) Recent variability of the global ocean carbon sink. Global Biogeochemical Cycles, 2014GB004853.

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