CHANGE NOTES

GENERAL TEXT

* Consistently used “anomalies” instead of using both “residuals” and “anomalies.”
* Fixed areas where paragraphs started with long descriptions of figures and changed to more attention-grabbing topic sentences.

INTRODUCTION

* Significantly change introduction to shift focus to large scale modes of variability and their influence on CO2 fluxes

METHODS

* Added model details to methods section, clarification of what CESM-LENS does better than a pre-industrial control run, clarification on generating anomalies.
* Added subsection discussing climate indices.

MODEL EVALUATION

* Added discussion of seasonal cycle (with reference to new figure)

FIGURES

* Added plot assessing the seasonal cycle of CO2 flux in CESM-LENS as well as the number of observations informing the SOM-FFN

TABLES

* Split the trend component in Table 1 into contemporary, natural, and anthropogenic

COMPOSITE ANALYSIS

**California (NPGO):**

More associated with offshore/gyre dynamics.

Increased nearshore upwelling of enriched subsurface DIC is compensated for by biological uptake.

Offshore uptake is driven by advection of cold subpolar waters with enriched DIC and little biological activity.

**California (PDO):**

**Humboldt (ENSO):**

**Canary (NAO):**

RESPONSES

METHODS

**Nicolas Gruber**: A few more details would be helpful here. Which version of CESM was used. What were the parameter values for BEC, etc? I found it a bit frustrating that there is only a limited amount of traceability in CESM-BEC across versions. This should be alleviated at least here. A simple table in the appendix would suffice.

**Riley Brady:** Added version of CESM1 and some discussion of BEC with citations to two studies with in-depth descriptions of BEC in CESM1.

**Nicolas Gruber:**I suggest to reformulate. You can assess the controls on air-sea flux variability also by single runs. Thus, please be more specific about what advantages the use of a LE has.

**Riley Brady:** Added to methods section. This includes confident removal of the forced signal (generation of purely internally driven anomalies), the addition of anthropogenic CO2, and climate change driven modifications to ocean dynamics and the frequency and magnitude of large scale climate variability.

**michael.jacox:**This is super far offshore to be looking at EBUS dynamics. 800 km offshore will still be influenced by upwelling somewhat through lateral advection, but the vast majority of these regions, maybe 80-90% are not characterized by upwelling. More on this later.

MODEL EVALUATION

**michael.jacox**: It would be worth commenting on the lack of nearshore estimates in SOM-FFN. The strongest outgassing in CESM occurs next to the coast where there is no SOM-FFN output. If you applied the SOM-FFN mask to CESM, this comparison would look a lot better.

**Riley Brady:** Added comment on the lack of nearshore estimates. **May still add the SOM-FFN mask to CESM.**

**michael.jacox:** Not quite clear what this means? SOM-FFN is filling in these regions based on data from far away?

**Riley Brady:** Edited for clarity and added figure that shows number of observations. See Figure 1 of (Landschützer et al. 2014). The HumCS is generally informed by the tropical Pacific, but sections of the CanCS and BenCS and informed by subtropical gyres.

**michael.jacox:** how big are the SST biases in other EBUS?

RESULTS

Internal Variability in Upwelling Systems

**Nicolas Gruber:**How did you make this attribution? It is quite certainly correct, but you should state the basis for this argument. I my suspicion is right, then you used the long-term trend of the ensemble mean to establish the contribution of anthropogenic CO2. This is only approximately correct, since this trend includes also climate-change driven trends in the fluxes of natural and anthropogenic CO2. Please explain.

**Riley Brady:** You are correct that it was the long-term trend of the ensemble mean (clarified in text). The long-term trend toward a greater sink in the contemporary carbon flux is almost entirely driven by anthropogenic carbon in CESM (this is tested by computing the linear trend for contemporary flux, natural flux, and anthropogenic flux). These values have been separated in Table 1.

**Nicolas Gruber:** This needs to be explained better. How was this component (anthropogenic CO2) diagnosed?

**Riley Brady:** This description was added to the methods section.

**michael.jacox:** The gray shading is actually the internal variability plus the seasonal cycle. I suggest changing the figure and/or text as sometimes you talk about the internal variability, seasonal cycle, and anthropogenic trend as separate components, but in Fig. 3 all three components share signal (i.e., you can't add them together to get the full signal).

**Riley Brady:** This was more of a design choice since the black ensemble mean line overlays the gray shading and thus any of the gray showing is due to internal variability. I’ve changed the caption to the figure to explicitly denote that the gray shading shares signal.

**Nicolas Gruber:** The total variability includes also the forced component, no? Or are you referring here to the variability of the residual fluxes? Please specify. But the residual fluxes don't vary seasonally, do they?

**Nicolas Gruber:** You need here a better transition. So far, you have established the importance of internal variability, but you have not provided any evidence why we should focus on the (inter annual) variability associated with major climate modes. A spectral analysis or some other form of timescale separation could help here.

California Current

**michael.jacox:** Can you back this up? Spatial correlation of this pattern with PDO, ENSO, and NPGO patterns?

**Nicolas Gruber:** Does this mean that the NPGO explains ~24% of the total variance?

**Riley Brady:** Approximately, yes. The CESM-LENS does a surprisingly good job at representing the NPGO. See DiLorenzo and Manuta 2016 (DOI: 10.1038/NCLIMATE3082) Figure 6. The observed NPGO explains 20% of SST variance, while CESM-LENS explains 22% for the ensemble mean.

**michael.jacox:**I assume by uniform here you mean "single-signed". But it's definitely not uniform. In fact, in the main upwelling region (central/northern California within a couple hundred km of the coast), the correlation is near zero. Later, upwelling is implicated in the patterns found here, but there if you focused on the upwelling region (as you do in Fig. 6 for PDO), you'd find virtually no correlation with NPGO. This is an important issue as it looks like the dynamics you're capturing in the regional averages are more associated with he offshore/gyre dynamics than the coastal upwelling.