In answer to reviewers' comments on the BGD paper: New insights of $fCO_2$ variability in the tropical eastern Pacific Ocean using SMOS SSS

We would like to thank both the anonymous reviewer and Rik Wanninkhof for the time put into reviewing this paper. We appreciated the comments and suggestions to improve the quality of the submission, and have worked to correct the issues highlighted within the original BGD article.

**In answer to anonymous reviewer Number one:**

1) **In order to allow a more robust comparison of the results of this work versus previous studies using different methods, the authors should provide additional background on the look-up-table (LUT) method. Has the LUT method been described previously? If so, provide references. What SSS/SST-based algorithms result from this method for predicting pCO2 in the three distinct water masses shown in Fig 2? These relationships could be embedded in Fig 2 or presented in a separate table**

**Response:**

The LUT method has not been previously used within the oceanic $pCO_2$/$fCO_2$ field, however, it is used extensively in other fields (such as net primary productivity and gross primary productivity estimates from satellite, e.g. Zhao et al. 2006). The original manuscript was missing this description, so we have added this information.

As each cell within the LUT is fully independent of each other cell, the LUT method does not feature a single algorithm but rather a collection of $fCO_2$ descriptions distributed across TS space. To illustrate this, figure 5A shows $fCO_2$ within TS space, both highlighting the three watermasses and their respective $fCO_2$ values. We have added this information to the figure caption, and modified the text accordingly:

**Modified text (P10, L322):**

As the variance between individual $fCO_2$ observations occupying the same location within T S space is low (Fig 5B) we use a look-up-table (LUT) to describe $fCO_2$ as a function of T and S. This LUT technique, although not previously used to estimate oceanic $fCO_2$, has proven useful for estimating net primary productivity using satellite observations (Zhao et al. 2006). The LUT in this study uses a mesh of equal sized bins within T-S space. Observations of $fCO_2$ within these discrete TS bins are collected, and an average $fCO_2$ within TS space calculated. As each bin is fully independent of neighbouring bins, non-linear and/or skewed $fCO_2$ distributions within TS space can be accounted for, and hence an improved synthetic fCO2 product, with a lower root-mean-squared-error (RMSE) attained compared to using an alternative linear statistical description, such as a basic linear fit.

**Modified figure caption (Fig. 5):**

A, fCO2 (color) as in the Look Up Table derived from the position of ETPO SOCAT $fCO_2$

measurements within T S space.

B the root mean squared error of the LUT –$fCO_2$ observations, showing the variance between $fCO_2$ observed within the same TS space.

C the number of LDEO measurements per 0.1psu x 0.1°C salinity/ temperature bins that went into generating the LUT

> **It would also be informative to include a comparison of ETPO-wide flux estimates derived from this work and the work of Takahashi, Ishii, Landschutzer, etc in section 4.3. While the main focus of the Brown et al. analysis is fine-scale variability, annual pCO2 and flux estimates are also presented, and it would be useful to understand how the different methods compare in predicting overall annual flux from this region as well.**

**Response:**

We agree that is would be useful to discuss the numerical results reported in other papers (when these numbers are available- Landschutzer et al. and Ishii et al. do not have tabulated results for the ETPO, and Cosca et al. does not fully overlap the study region). Therefore, we have added a comparison with Takahashi's results to the paper, based on the supplementary data associated with Takahashi et al. 2009. Additionally, fluxes and $\Delta pCO_2$ from Takahashi et al. 2009 have now been added to the supplementary table 1.

**Modified text (P16 L502):**

Of these three studies, only Takahashi et al. (2009) provides a dataset of calculated $\Delta pCO_2$ that includes the ETPO region, thus allowing direct comparison with our calculations. Collocating the $\Delta pCO_2$ results from Takahashi et al. (2009) within the ETPO regions defined in Fig. 1, the Gulfs of Techuantepec, Papagayo, Panama and the Offshore region featured values of +28.9, +54.1, +17.1 and +19.5 µatm respectively (Table. 1). This suggests that the Takahashi et al. (2009) study differentiates the low $\Delta pCO_2$ Panama Gulf region from the higher values observed in the Gulfs of Tehuantepec and Papagayo. The resolution used in Takahashi's study is too coarse to identify any mesoscale features (such as upwelling), or interannual variability within the region. However, we find that the average $\Delta pCO_2$ from Takahashi et al. (2009) of 29.1 µatm was within the error limits of this study (Table 1).

Applying the same windspeed product, and gas transfer parametrisation used in this study to the ETPO $\Delta pCO_2$ values from Takahashi et al. (2009), we find that all regions are net outgassing, with the Gulf of Papagayo dominant within the ETPO (table 1). The ingassing observed within the Gulf of Panama for our study is not replicated in Takahashi et al. 2009.

**Modified table 1:**

Table 1. Annual averaged values for each region, as reported in figure 8 and average values from Takahashi et al. 2009.

| Date/ Location | Δ fCO2 (µatm) | Δ fCO2 error (µatm) | CO2 Flux (mmol $m^{-2}$ $d^{-1}$) | CO2 Flux error (+/- mmol $m^{-2}$ $d^{-1}$) | Mean Wind ($ms^{-2}$) | Salinity | Temp (oC) |
|---|---|---|---|---|---|---|---|
| 2010-11 ETPO | 37.92 | 17.47 | 1.52 | 0.34 | 4.81 | 33.3 | 27.9 |
| 2010-11 OS | 38.24 | 19.58 | 1.60 | 0.39 | 5.18 | 33.2 | 27.7 |
| 2010-11 Panama | 0.73 | 12.85 | -0.18 | 0.08 | 4.57 | 28.3 | 27.4 |
| 2010-11 Papagayo | 40.22 | 20.68 | 0.93 | 0.29 | 4.17 | 33.7 | 28.2 |
| 2010-11 Tehuantepec | 36.70 | 18.90 | 1.55 | 0.37 | 3.72 | 33.6 | 29 |
| 2011-12 ETPO | 36.85 | 18.53 | 1.53 | 0.35 | 4.59 | 33.3 | 27.9 |
| 2011-12 OS | 35.42 | 17.35 | 1.57 | 0.34 | 4.97 | 33.1 | 27.7 |
| 2011-12 Panama | 0.02 | 13.04 | -0.19 | 0.08 | 4.02 | 28.4 | 27.5 |
| 2011-12 Papagayo | 41.96 | 19.92 | 1.07 | 0.25 | 4.01 | 33.7 | 27.9 |
| 2011-12 Tehuantepec | 38.74 | 19.93 | 1.62 | 0.40 | 3.90 | 33.7 | 28.4 |
| 2012-13 ETPO | 34.18 | 16.35 | 1.39 | 0.32 | 4.88 | 33.2 | 28.6 |
| 2012-13 OS | 33.72 | 16.87 | 1.48 | 0.31 | 5.11 | 33 | 28.3 |
| 2012-13 Panama | -1.11 | 13.06 | -0.10 | 0.08 | 3.92 | 28.7 | 27.3 |
| 2012-13 Papagayo | 39.96 | 19.28 | 1.05 | 0.25 | 4.49 | 33.6 | 28.5 |
| 2012-13 Tehuantepec | 30.59 | 17.09 | 1.49 | 0.37 | 4.08 | 33.6 | 29.3 |
| 2013-14 ETPO | 35.86 | 17.56 | 1.50 | 0.34 | 4.67 | 33.3 | 28 |
| 2013-14 OS | 34.53 | 16.66 | 1.61 | 0.36 | 5.09 | 33 | 27.8 |
| 2013-14 Panama | 1.73 | 13.54 | 0.13 | 0.06 | 3.88 | 27.5 | 27.7 |
| 2013-14 Papagayo | 43.98 | 20.05 | 1.12 | 0.25 | 4.15 | 33.7 | 28 |
| 2013-14 Tehuantepec | 35.20 | 17.70 | 1.55 | 0.34 | 3.92 | 33.7 | 28.6 |
| Average ETPO | 36.21 | 17.48 | 1.49 | 0.34 | 4.74 | 33.3 | 28.1 |
| Average OS | 35.48 | 17.62 | 1.57 | 0.35 | 5.09 | 33.1 | 27.9 |
| Average Panama | 0.34 | 13.87 | -0.09 | 0.08 | 4.10 | 28.2 | 27.5 |
| Average Papagayo | 41.53 | 19.98 | 1.04 | 0.26 | 4.21 | 33.7 | 28.2 |
| Average Tehuantepec | 35.31 | 18.40 | 1.55 | 0.37 | 3.91 | 33.7 | 28.8 |
| Takahashi 2009ETPO | 29.09 | N/A | 0.78 | N/A | 4.74 | 33.3 | 28.2 |
| Takahashi 2009. OS | 19.53 | N/A | 0.65 | N/A | 5.09 | 33.0 | 27.9 |
| Takahashi 2009. Pan | 17.08 | N/A | 0.54 | N/A | 4.10 | 28.2 | 27.5 |
| Takahashi 2009. Pap | 54.12 | N/A | 1.83 | N/A | 4.21 | 33.7 | 28.1 |
| Takahashi 2009. Tec | 28.88 | N/A | 0.71 | N/A | 3.91 | 33.7 | 28.8 |

2) **Similarly, while the difference between fCO2 and pCO2 will not impact the main conclusions on the influences of physical drivers on surface ocean pCO2 in the ETPO and how those compare between subregions, it will impact the absolute values of annual pCO2 and flux estimates presented in this manuscript and the authors' ability to compare to previous papers. This is important considering the community's goal of constraining regional fluxes to 0.2 Pg C year-1 (Bender et al. 2002, A Large Scale Carbon Observing Plan: In Situ Oceans and Atmosphere). If using pCO2, the authors should consider converting SOCAT fCO2 to pCO2. In addition, are Mauna Loa atmospheric observations used to calculate air-sea flux? If so, the authors could be introducing considerable errors by applying higher-latitude atmospheric CO2 to a lowerlatitude region with less seasonal atmospheric CO2 variation. The authors should use the GLOBALVIEW-CO2 marine boundary layer product for weekly atmospheric values at a latitude more appropriate for this tropical region.**

**Response:**

We agree that when using $fCO_2$/ $pCO_2$, the same unit should be used for both air and oceanic values in order to calculate Δ $fCO_2$/ $pCO_2$ and resulting air-sea fluxes (this was not done in the original submission.) Reviewing published work, it would seem illogical to convert the fugacity measure (as reported within the SOCAT database) into a partial-pressure value. Therefore, we have elected to use $fCO_2$ throughout the paper, and thus recalculate the LDEO data (which is natively in $pCO_{2ocean}$ format) into $fCO_{2\ ocean}$. Furthermore, atmospheric $fCO_{2air}$ (rather than $pCO_{2air}$) is now calculated from observations of $xCO_{2air}$, and used throughout this paper. This is explained in section 2.1.

Additionally, we note that $\Delta pCO_2$ ($pCO_{2ocean}$ - $pCO_{2air}$) and $\Delta fCO_2$ ($fCO_{2ocean}$ - $fCO_{2air}$) would be almost identical, assuming that the temperature of the air and ocean at the boundary layer is the same. Therefore direct intercomparison of air-sea carbon dioxide exchanges calculated from $fCO_2$ or $pCO_2$ based studies (e.g. Takahashi et al. 2009) is possible.

We confirm that the Mauna Loa xCO2 product was used for the original submission. Although the modelled GLOBAL-VIEW-CO2 product does not extend past 2013, GLOBALVIEW includes a dataset from the Scripps CO2 program, from Fanning Island (3.5° N, 159° W, 1974- present, P.I. R Keeling), which is closer in latitude to the study region, and thus we use this data product in the revised paper.

**Modified text (P5, L168):**

…weekly dry-air $CO_2$ mole fractions ($xCO_2$) measured at Fanning Island (3.5° N, 159° W)

**Page 4598 line 13: define ITCZ**

**Modified text:**

Intertropical Tropical Convergence Zone (ITCZ)

**Page 4601 lines 12-14: What is the estimated uncertainty associated with the SMOS SSS? And lines 17-19: How about the uncertainty in OSTIA SST?**

**Response:**

Answered below for Rik Wanninkhof's review

**Page 4603 line 9: provide reference Page 4603 line 17: provide longitudes for this region**

**Response:**

These longitudes have been provided

**Page 4603 lines 16-21: Consider also including comparisons to Ishii et al. 2014 and Landschutzer et al. 2014 (cited later in section 4.3) and the following: Cosca, C. E., R. A. Feely, J. Boutin, J. Etcheto, M. J. McPhaden, F. P. Chavez, and P. G. Strutton (2003), Seasonal and interannual CO2 fluxes for the central and eastern equatorial Pacific Ocean as determined from fCO2-SST relationships, Journal of Geophysical Research: Oceans, 108(C8), 3278. Feely, R. A., T. Takahashi, R. Wanninkhof, M. J. McPhaden, C. E. Cosca, S. C. Sutherland, and M.-E. Carr (2006), Decadal variability of the air-sea CO2 fluxes in the equatorial Pacific Ocean, J. Geophys. Res., 111.**

**Response:**

These papers are useful background, and we have now referred to these papers in discussion elsewhere in the manuscript. The Takahashi et al. 2009 paper includes data from Feely et al. 2006 to determine the annual increase in oceanic $pCO_2$ due to increased atmospheric $xCO_2$, and arguably provides a more complete synopsis of mean rate of change in surface water $pCO_2$ for the Pacific. Therefore kept the reference to the Takahashi paper within this sub-section.

**Page 4608 line 1: also shown in Fig 8**

**Modified text:**

Fig. 7 and 8

**Page 4611 section 4.3: What about comparisons to Cosca et al. 2003 and Feely et al. 2006?**

**Response:**

The spatial coverage of these papers does not extend into any of the three main gulfs of the ETPO, so we are not able to compare fluxes directly. However, we have now discussed both papers in section 1

**Modified text (P3 L106):**

Therefore, in order to achieve improved spatial coverage, a frequently used solution is to fit data-driven diagnostic models (e.g. Cosca et al. 2003; Feely et al. 2006; Park et al. 2010;

Rödenbeck et al., 2013). These models use observed correlations between ~~physical~~ ocean properties and the $pCO_2$ observed under these conditions. In addition, statistical criteria based on the surface ocean observations (for example, satellite imagery) and/ or neural networks have been used to identify biogeochemical provinces in order to improve the accuracy of the extrapolated field (Boutin et al. 1999; ; Landschützer et al., 2014). Although the quality of these extrapolation methods have been refined over the past few years, in part due to the increasing number of in situ measurements, the interannual variability of the global air-sea $CO_2$ flux obtained using different data-driven methods still substantially differ, and further work is required to unify our estimates and improve understanding of this air-sea flux.

**Page 4611 line 24: change Sampling though to Sampling through**

**Response:**

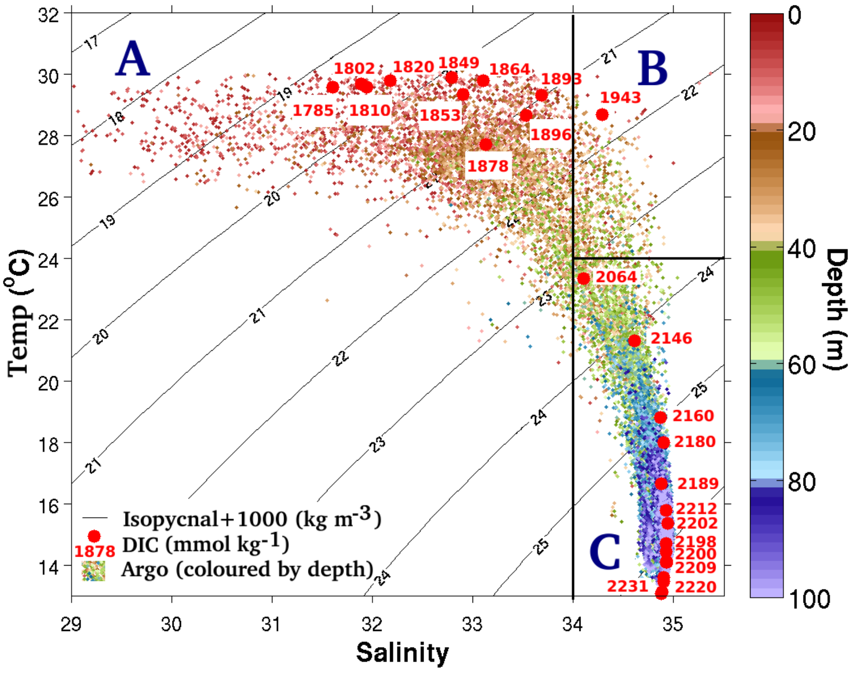
Corrected

**Figure 2: consider adding a box around the A, B, and C regions to clarify the extent of those water masses**

**Response:**

This suggestion improves the clarity of the diagram, so it has been added.

**Modified Figure (2):**



**Figures 7 and 8: clarify in the figure legends that this is LUT-derived pCO2**

**Response:**

This suggestion has been implemented.

**Modified Figure caption:**

Figure 7.

July 2010- June 2014 average SSS, SST, LUT derived $fCO_2$ , air sea fluxes and wind vectors for the ETPO, split bimonthly (Jan+Feb, Mar+Apr, May+Jun, Jul+Aug, Sep+Oct, Nov+Dec).

Figure 8.

Upper: Yearly average SSS, SST LUT derived $\Delta fCO_2$ , air sea fluxes and wind vectors for the ETPO for July to June 2010+2011, 2011+2012, 2012+2013 and 2013+2014.

Lower: The continuous LUT derived $fCO_2$ fluxes from the entire ETPO (red line), the Gulfs of Tehuantepec (purple), Papagayo (blue), Panama (green) and the South Equatorial Current (black).

---

**In answer to Rik Wanninkhov:**

1. **There should be a more comprehensive assessment of how well the synthetic "LUT" pCO2 (from SSS and SST plus look up table) compares with observations. Since the pCO2 and remotely sensed SSS &SST observations only overlap for 2010 and 2011, some discussion need to focus on how well the static relationships used in the LUT (Figures 2 and 4) work when using [adjusted] historical pCO2 data and recent SSS and SST. Also it should be noted that the DIC data are from 1995.**

**Response:**

Indeed, the lack of temporal overlap between SOCAT (/ LDEO) and the SMOS observation period (July 2010-present) makes extensive direct intercomparison difficult, as there are but a handful of cruises during this period, and most of these are within the same north-westerly shipping lane. However we acknowledge that additional assessment can be undertaken. Rik Wanninkhof's suggestions 1,2,3,4 and 9 are interrelated, therefore we have made two areas of improvements to the manuscript.

Synthetic fCO2 vs observed fCO2

Firstly, figure 6 indicates how the LUT performs when forced with the entire available historic LDEO T,S dataset within this region (1991-2013). T and S data, and compares this to the actual $fCO_2$ recorded. We have improved this comparison by:

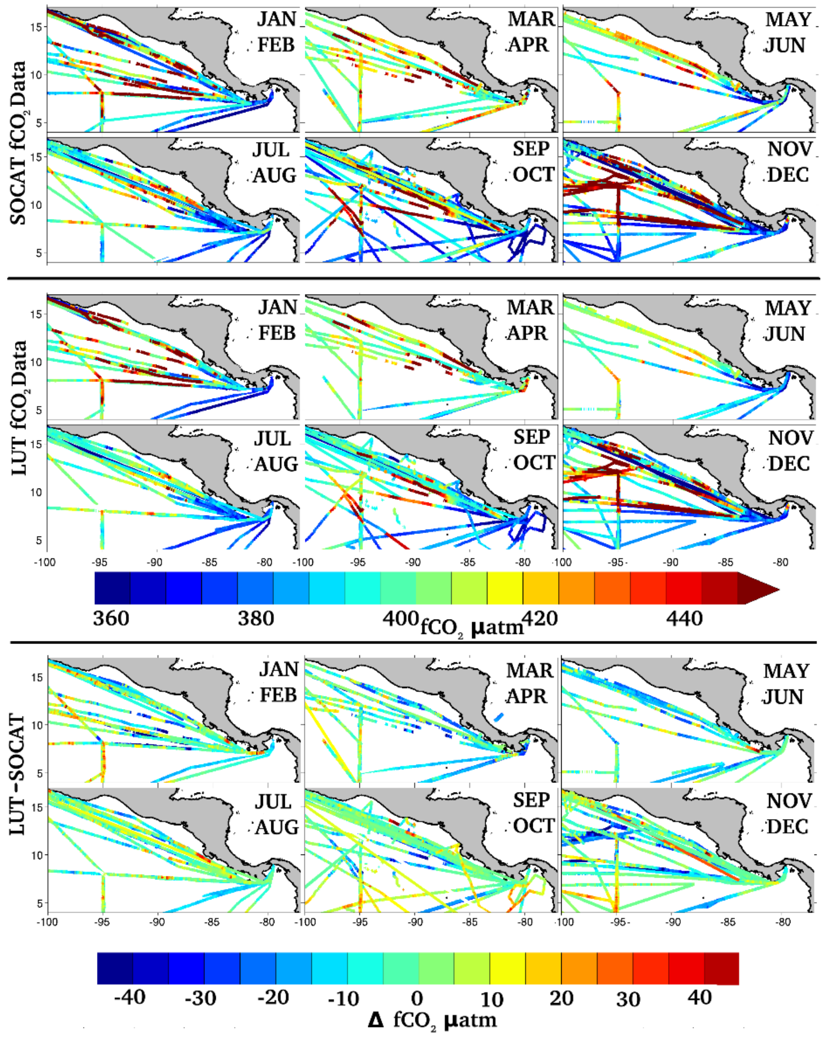
1. Modifying figure 6 to also include the difference between the measures of fCO2 (Observed fCO2 – synthetic fCO2), as recommended by Rik under suggestion 9.
2. Adding further text within section 3.1, as discussed in answer to reviewer one.

Satellite SST/ SSS vs in-situ TSG/ Argo TS

We have also generated a new figure (supplementary figure 1) that compares SMOS to match-ups within the SOCAT SST/SSS and Argo near surface profiles datasets. Additional discussion is also made.

Additionally, the age of the DIC observations has now been stated within the text.

**Modified Figure (6):**



**2. The SMOS product and uncertainty in SSS from SMOS needs to be better described particularly the fidelity of the 0.25 degree data in light of the comment running average over 100_100km2 (page 4601 line 7).**

**Response:**

The noise on individual SMOS SSS at roughly 43km resolution is significant (upto 0.6psu in tropical/subtropical regions). In order to reduce this noise to 0.2-0.3, it is convenient to average SSS over typically 100km and one month (as described in Boutin et al. 2013). Given the higher spatial resolution of SMOS SSS, the SMOS L3 data product is sampled using 100km running averages over a 0.25 degree grid, in order to smooth spikiness.

> A comprehensive comparison along the cruise track with the 5 cruises in the 2010 and 2011 time frame is warranted.

We have implemented this suggestion, and supplemented the sparse TSG data from SOCAT with TS data from Argo floats, as demonstrated in supplementary figure 1. The rmse difference between SMOS SSS averaged over 100km and punctual SSS is 0.24psu; this includes natural variability within 100km not described per Argo plus SMOS SSS uncertainty. We now make reference to the paper of Delcroix et al. (2005) that discusses the intrinsic variability within SSS across various length scales finding that in about 20% of the case SSS variability within 100 km is 0.1.

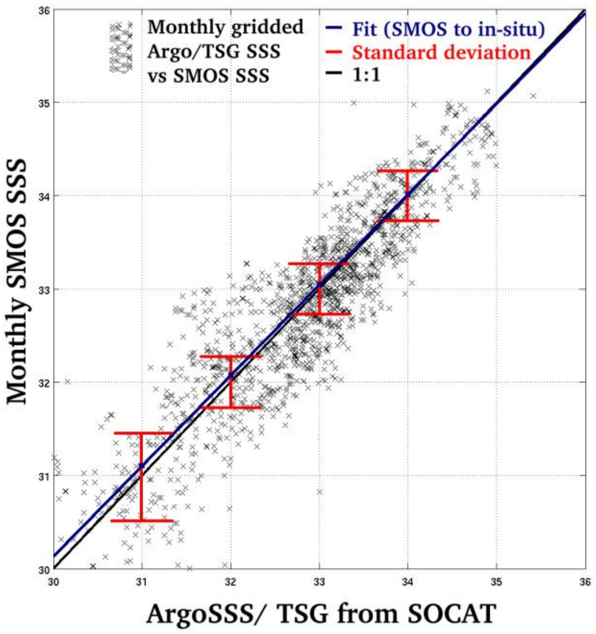
**Modified text (P6 L213):**

Analysing the accuracy of the SMOS product, using in-situ point observations of SSS can be completed using both SOCAT SSS data (where the salinity is derived from ship mounted thermosalinograph-TSG), and Argo profiles made within the region (S Fig. 1). Binning all Argo and TSG near surface salinity data (that overlaps the SMOS observational period) into the same monthly, 0.25 degree structure as the SMOS monthly 0.25 ˚ product enables direct comparison. It is found that the RMSE between SMOS and these binned in-situ data is 0.24 psu, with a minimal offset (of 0.04 psu, S Fig. 1). This variability is a function of both the intrinsic variability of SSS within the EPTO (for example, caused by localised rainfall, riverine outflow, upwelling events that may occur within each SMOS observational pixel), and a measurement error made in the SMOS data. Estimates of this intrinsic variability within the tropics is 0.1 psu, but in certain regions (such as the western warmpool and ETPO) may feature variabilities of 0.4 psu or higher (Delcroix et al. 2005). We suggest that this is a satisfactory noise to signal ratio, given that the region features SSS variability of upto 8 psu (Fig. 2).

**Additional Figure:**

Supplementary Figure 1.

Monthly 0.25 degree SMOS SSS matchups with near surface Argo and SOCAT TSG data (that have been binned into the same monthly/ 0.25 degree grid as the SMOS SSS data). The red error bars indicate the standard deviation in 1psu bins, the blue line is a linear regression between the two SSS datasets.



**3. The uncertainties in the fluxes need to be provided. 4. There is discussion about the effect of rainfall on pCO2 but there is no mention of the effect of rainfall on the gas transfer velocity (and thus flux). In this region with high rainfall this could be significant. (see e.g. Komori et al. 2007 where the Panama basin shows a large rain induced enhancement of k: Komori, S., Takagaki, N., Saiki, R., Suzuki, N., Tanno, K., 2007. The effect of raindrops on interfacial turbulence and air-water gas transfer, in: Garbe, C.S., Handler, R.A., Jähne, B. (Eds.), Transport at the air-sea interface: measurements, models and parameterizations. Springer Berlin, pp. 169-179.)**

**Response:**

Uncertainties calculated using a quadratic deviation technique have been added to the manuscript, and table 1, where the deviation within the LUT and the error on SMOS observations is described.

The issue of rainfall is challenging as transfer velocity under rainfall is poorly known, and there is not enough information available to quantify it. Referencing the text of Garbe et al. 2014, “rain event are episodic and rain rates are variable... Modelling studies using relationships derived in the laboratory shows that the effect of rain on air-sea C02 exchange is insignificant on a global scale, but could be important on regional scales (Komori et al. 2007; Turk et al. 2010). However, those studies made simple assumptions that remain to be tested...Field experiments should be conducted in areas likely to be impacted by rain”

**Modified text (P6 L191):**

We do not take into account influences of rainfall on k, although rainfall has been observed to enhance gas transfer velocities in laboratory experiments (see a review in Garbe et al., 2014). However, more research need to be perform to end up with a relationship between k and rainfall validated over the open ocean. Hence, in our study, we do not take into account the influence of rain on k. The effect on our estimates of air-sea $CO_2$ fluxes are expected to be limited for two reasons: 1) the role rainfall is to reduce DIC, thus bringing ΔfCO2 closer to atmospheric equilibrium, 2) rainfall is a very intermittent process and the effect of rainfall on k is likely to last for a much shorter duration than the rain induced dilution of DIC at the ocean surface.

**Modified text (P11 L370):**

In order to calculate the uncertainty of the carbon dioxide flux determined using LUT derived synthetic fCO2, we consider three sources of error:

The observational $fCO_2$ variance within each cell of the LUT: $E(fCO_{2LUT})$.

The measurement error of the OSTIA SST product (of 0.57° C, Donlon et al. 2010), and the relationship between fCO2 and temperature within the LUT.

The measurement error of the SMOS SST (of 0.24 psu), and the relationship between fCO2 and salinity within the LUT.

Initially, $\Delta fCO2_{error}$ on each individual LUT based observation is calculated using a mean squared error technique:

$$\Delta fCO2_{error} = \sqrt{\left[E(sss)\bullet\frac{dfCO2}{dsss}\right]^2 + \left[E(sst)\bullet\frac{fCO2}{dsst}\right]^2 + \left[E(fCO2LUT)\right]^2} \qquad (4)$$

Here, the variance on the LUT (an average of 16.8 µatm per LUT cell) is the first order control on $\Delta fCO2_{error}$. Error arising from SST and SSS uncertainties and the influence these have on $\Delta fCO_2$, of ~0.4 and 0.5 µatm respectively, are an order of magnitude smaller than the variance within on the LUT.

The error on the $CO_2$ flux is calculated using

$$flux_{error} = \sqrt{\sum_{i=1}^{npixels}\left(K_i \cdot \Delta fCO2_{error_i} \cdot S_i\right)^2} \qquad (5)$$

where $K_i$, $\Delta p\_error_i$ and $S_i$ are the $CO_2$ exchange coefficient, the error on $\Delta fCO_2$ and the surface in a given observational pixel respectively. These errors are reported in Table 1. Additionally, we note that in addition to these uncertainties, the gas transfer velocity parametrisation is estimated to feature an uncertainty of approximately 20%, however gauging the exact uncertainty requires in-situ observations, of the type described by Wanninkhof (2014.)

**5. As mentioned by reviewer 1. While interchanging fCO2 and pCO2 will likely not effect the results to any degree, it comes across as a bit sloppy mixing these parameters, and the correction is straightforward to apply.**

**Response:**

Corrected, with $fCO_2$ used throughout the paper.

**6. The pCO2 data accessed through SOCAT primarily comes from a few investigators (Nojiri, Takahashi & Feely). Acknowledging them by name in the acknowledgments (or offering co-authorship) would be appropriate.**

**Response:**

We have now acknowledged their efforts within the paper.

**Modified acknowledgements:**

We thank one anonymous reviewer and Rik Wanninkhof for their insightful reviews.

The research leading to these results was aided by the LOCEAN team

Xiaobin Yin and Nicolas Martin, and supported through the EU FP7project CARBOCHANGE Changes in carbon uptake and emissions by oceans in a changing climate which received funding from the European Commission's Seventh Framework Programme under grant agreement no. 264879 and the SMOS+SOS STSE project funded by ESA .

We would also like to thank all of the contributors to SOCAT and LDEO of $fCO_2$/ $pCO_2$ observations within the Pacific Ocean, specifically Yukihiro Nojiri, Taro Takahashi and Richard Feely who contributed greatly within this region.

**7. I believe the region labelled the South Equatorial Current is incorrect. In the Eastern Equatorial Pacific the SEC is South of the Equator. Moreover in "Wikipedia" the SEC is defined as South of 5 N.**

**Response:**

We agree that the designation of this region could lead to confusion, and it has been renamed accordingly

**8. 4600 line 5: WOCE data available from http://woceatlas.ucsd.edu/, I do not believe the Atlas provides data. The right access point is CCHDO.**

**Response:**

The correct WOCE access point has been added to the text

**Modified text (P 5, L167):**

WOCE data available from http://cchdo.ucsd.edu/

**9. Figure 6 bottom panel: It would be more illustrative if the bottom panels showed the difference between SOCAT and LUT data.**

**Response:**

As discussed above, this suggestion has been followed, and the figure amended accordingly.