We thank the anonymous referee #2 for his/her comprehensive review and detailed suggestions. These suggestions help us to present our results more clearly.

Referee: The authors lay out three goals on page 3500. The first goal was to improve upon previous inversion studies. This paper did not present why it provides a unique analysis of CO_2 fluxes relative to other studies. Are the choices of prior fluxes significantly different from or better than those used in other inversion studies (specifically the BEPS ecosystem exchange and the ocean flux model)? Are the mechanics of the inversion different than previous studies? Moreover, the authors never presented the inverted fluxes relative to the prior fluxes, so as a reader, I was left with small understanding of how the inversion impacted these priors. It seems that the biospheric prior fluxes already vary interannually based on LAI data and NCEP meteorology. How much of the interannual variability in the inverted fluxes owes to the GLOBALVIEW CO_2 and how much owes to the adaptive prior fluxes?

Author: *We improved our previous inversion study by considering the diurnal variations in the surface CO2 flux and the atmospheric boundary layer dynamics in order to use more observations from continental sites to better constrain the* CO_2 *flux from the earth surface, especially from the land surface. Consequently our inverted fluxes could better reflect the responses of terrestrial ecosystems to important climate events that happened in recent years. Some of the unique results that we derived through inversion are consistent with our understanding of terrestrial ecosystem processes. For instance, the large annual sink in Europe in 2002, is mainly caused by negative flux anomalies outside the growing season.*

We choose these two prior fluxes based on the fact they provide seasonally and diurnally (for land) variable fluxes from process-based models and these could help consider both the seasonal and diurnal rectifier effects in our inversion. Those land and ocean surface flux estimates, such as CASA flux (Randerson et al., 1997) and ocean flux by Takahashi et al. (2009), which were often used in other inversions, however, could not satisfy our requirements. We emphasize the diurnal variation in the prior ecosystem exchange and in the atmospheric transport model we used because we can only optimize a monthly flux (seasonal cycle) in each region and cannot optimize the diurnal cycle to reflect the large diurnal concentration variations over continental regions especially during the growing season.
As mentioned on page 3502, we use a neutralized annual terrestrial flux at each grid, so the interannual variation of the inverted fluxes (excluding the emission from fossil fuel, and biomass burning emissions) over land surface is mainly a consequence of the GLOBALVIEW CO2.

Referee: Goal (2) was subjugated to goal (3), when it seemed that the authors could have used their results first to understand fluxes at larger scales and then addressed smaller scale IAV. Presumably the trends at large scales are more robust than those in the smaller regions. I am not convinced that the regional interpretation necessary to achieve goal (3) has the implications asserted by the authors. The authors have not indicated that there are not significant covariations in the inverted regional fluxes, particularly those in the small North American regions. Still, I would be curious as to how the posterior minus prior fluxes look in the smaller regions versus the larger ones, and how the interannual variability scales with region size and with posterior minus prior fluxes. If the North American regions are aggregated, does the IAV become comparable in size to that of Europe?

Author: *Our second goal is using the inverted land and ocean surface fluxes to locate the main contributor (ocean or land, northern land or tropical land, etc.) to the interannual variability of the global CO_2 flux. The third goal is using the anomalies of climatic conditions to interpret the anomalies of our inverted fluxes, and through this process to observe whether the inverted fluxes could reflect the 'likely' state or the 'likely' variability of the regional terrestrial carbon exchange. We set our goal 3 based on the assumption that the climatic conditions could greatly affect the terrestrial ecosystem carbon balance. Though we recognized that doing such an interpretation is not a complete validation of our flux estimates, we still believe that it 'could help us, at least partially, evaluate our inversion results' (Page 3514), as 'estimated carbon fluxes at the regional scale cannot be validated through direct measurements' (Page 3514) and through other methods effectively. We'll rewrite our goal 3 to precisely reflect this point.*

As the terrestrial ecosystems and their relationships with climatic variations are so complicated and nonlinear, and the existence of uncertainties, only some of the significant variations in small regions can be well explained with the anomalies of climatic conditions.

You are right that trends at larger scales (aggregated from smaller regions) are more robust than those in the smaller regions, and we actually aggregated all 30 North America regions into 2 large ones in Fig. 4 (C) to show their IAVs. We'll change the size of the figure, figure caption in our revision to make it friendlier to the readers. If the North American regions are aggregated, the IAV for the 6-year is only 0.41Pg C, much smaller than that of Europe (0.85 Pg C) and the reasons for this large IAV are given on Page 3512.

Following your suggestion, we will use two large aggregated regions (NA-N (Regions 1-17), NA-S (Regions 18-30) in North America to discuss the covariation between inverted carbon fluxes and climatic conditions.

Fig 1 shows the prior and posterior for Europe, regions 15 and 27. It is obvious that CO_2 observations exert quite strong influences on the inferred seasonal fluxes in both large and small regions.

Referee: The authors could focus on making the language in the paper more concise and more precise. For instance, the last paragraph on page 3499 contains true statements, but I had trouble determining how they applied to this study. Likewise, on page 3500, the authors state that "consequently, this climate-carbon cycle interaction results in a positive feedback and an addition of atmospheric CO2 that ranges between 20 and 220 ppm by 2100 from different models", but the authors never specify the forcing associated with these changes. The vague language becomes a problem when the authors discuss their methodology. More details on the methodology and data are necessary to properly interpret the results.

With regard to the inversion setup, the authors appear only to use GLOBALVIEW CO2 where actual data has been collected. Still, these data have been smoothed and gap filled. What would the results look like with actual observations? I did not understand how the _const values were determined in the model setup. I would also like more details regarding the weighting for data at several levels within a grid box. It seems that the vertical profile information should provide more information, not less. Data from within the free troposphere should, for instance, provide constraints on the fluxes well upstream, while data at the boundary layer reflect more local fluxes. To underweight multiple observations within a gridbox, rather than to use them to constrain fluxes at different lengthscales, seems to underutilize available information.

Author: *We'll try to make our language more precise in the revision. We'll rewrite the last paragraph on page 3499 to to make it clear that a transport model with diurnally variable biosphere fluxes and planetary boundary layer dynamics is needed to minimize the biases. We will also delete the less relevant discussion on page 3500.*

To answer what kind of observation data should be used in an inversion, we need to consider the spatial and temporal resolutions of both the atmospheric transport model and the inversion. We discuss the representation problem in our response to the other reviewer's comments. Using actual observations is excellent for high resolution modeling. However, we have to do similar data processing before we can use them in our monthly inversion. GlobalView CO_2 *data have been successfully used in similar inversions (Gurney et al., 2008; Rayner et al., 2008).*

As there is no objective approach to determine the model-data mismatch, the constant portion used in our approach is designed to reflect the systematic error for each category of sites. However, this is also a 'subjective choices' (Peters et al., 2005) based on our modeling experience. The reasonability of model-data mismatch and the a priori uncertainty is examined by a χ^2 *test.*

You are right. Multiple CO_2 *observations at different height levels at one geographical location could provide much useful information for inversion, but have not been used in many inversions. To use them, we need to consider how well we can simulate the vertical profile of the* CO_2 *mixing ratio in the transport model and how well we understand the covariation of observation-model mismatches between different levels. Before we can give positive answers to both of these questions, the available information can be hardly fully utilized in an inversion. So our strategy is to use these observations, but underweight their influence before an effective approach is available to define the vertical covariances.*

Referee: The figures in the paper require major revision. Figures 6-9 have very small text, similar colors representing different years, and the timeseries are difficult to interpret owing to many lines on each graph. Many of the anomalies seem to oscillate on a monthly basis. Perhaps binning the data by seasons would eliminate some of the noise and clarify the points the authors are trying to make. In any case more attention needs to be given to visual representation of the data. Figure 4 also had a lot of data presented in a practically illegible manner yet still didn't address how different the flux estimates were from the prior.

Author: *We will revise Figures 6-9 according to your suggestion by binning the data by seasons. In this way the noises could be reduced and the figures could be more readable and easy to interpret. As we will bin the 12 months into 4 seasons (Jan-Mar, Apr-Jun, Jul-Sep, and Oct-Dec), sometime we still need to refer to a specific month that are not shown in the figures. We will enlarge Fig 4 in our revision. As the prior flux is yearly balanced, so the flux estimates shown in Figure 4 is also the difference from the prior.*

Referee: Minor points
Page 3507, the paragraph beginning at 20: all of a sudden, the fossil and biomass burning fluxes are summed with the land biosphere exchange.

This is done to support figure 3, but it does make it confusing when the term land fluxes sometimes include fossil and biomass, and sometimes only terrestrial exchange. It would be better to keep the terminology consistent throughout.

Author: *We will use a term 'budget' instead of 'flux' to include the fossil, biomass burning fluxes, and the land biosphere exchange over the land surface, and to include fossil fuel emission, and ocean uptake over ocean surface. We'll be more careful to keep the terminology consistent in our revision.*

Referee: Page 3511, line 21: based on my knowledge of the scientific discussion regarding the Amazon green-up, it seems disingenuous to say that the issue has been reconciled by Samanta. Rather, this seems like an area of active research.

Author: *We are not experts in this area, and it is not our main concern, so we'll remove this sentence in our revision.*

Referee: Typographical and grammatical issues
p3449 line 1: distributions should be distribution
p 3449 line 4 dataset should be datasets
p 3502 line 4 GLOBAVIEW should be GLOBALVIEW
p 3502 line 15 CIDAC should be CDIAC
p 3590 line 9, accents are wrong in Le Quérép 3507 line 26 summaries should be summarizes
p 3509 line 26: Freasdale should presumably be Fraserdale

Author: *We will make corrections accordingly in our revision.*

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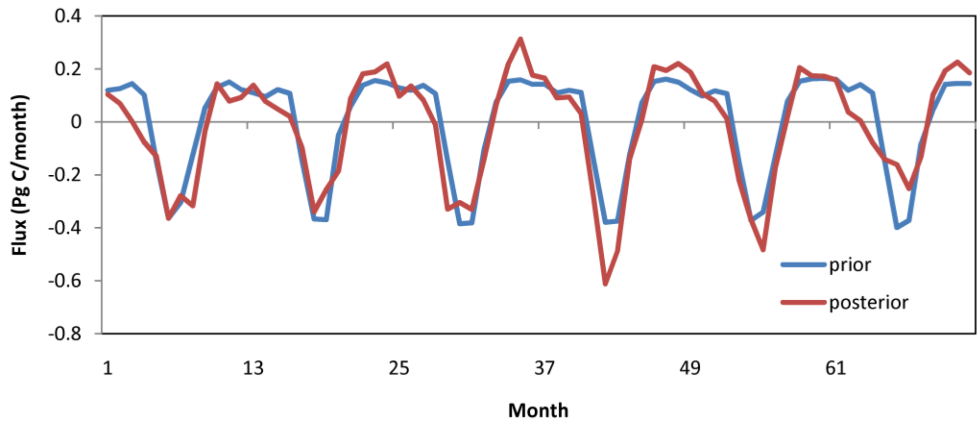
a



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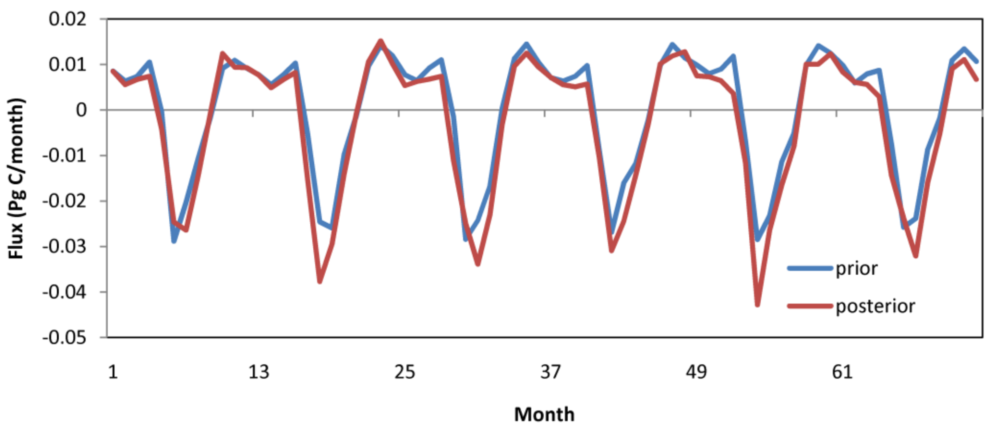

c

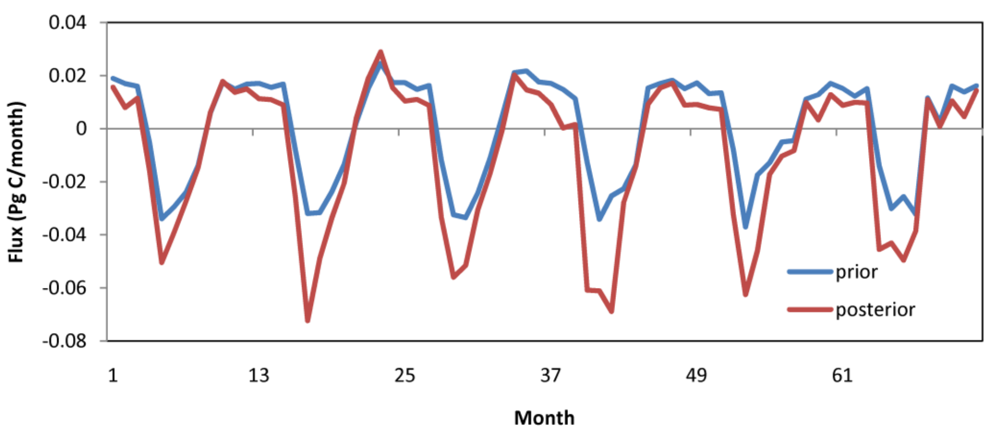

***Figure 1**. The prior and posterior flux estimates of 3 land regions, (a) Region 39 (Europe), (b) Region 15 (NA), and (c) Region 27 (NA).*