We thank Dr. Krakauer for his thoughtful and constructive comments and helpful suggestions.

Referee: This study uses monthly-mean CO_2 concentration measurements from a small number of sites to infer the global distribution of CO_2 sources and sinks at coarse resolution, using new compilations of fossil fuel burning and biomass burning emissions as auxiliary data. The results and their possible implications for biosphere response to climate are interesting, but the authors need to provide more details about their methodology in order for readers to understand what its uncertainties are and how much confidence should be placed in the reconstructions of the location and interannual variability of fluxes.
1) The authors correctly state that "large diurnal variations of PBL at continental sites could have caused large diurnal variations of CO_2 concentration and hence can produce substantial biases in the inversion result if a transport model is used without considering the diurnal variations". They need to provide more detail on how they overcome this when they are using monthly CO_2 concentrations from GLOBALVIEW. In theory this is feasible because GLOBALVIEW provides the fraction of contributing observations collected during each hour of the day, but even weighting by this distribution will miss synoptic-scale fluctuations in CO_2 concentrations, as well as the impact of sampling preferentially by wind direction or other criteria intended to limit "local influences".

Author: *We considered the diurnal variations to improve CO_2 flux inferred from atmospheric CO_2 concentration observations in monthly time step, and at a spatial resolution with 50 regions globally, and 30 of them in North America. Our modeling experiments demonstrated considering the diurnal variations in the surface CO_2 flux and the atmospheric boundary layer dynamics significantly affect the inverted surface fluxes over land regions. We will include more detail of the methodology in our revision.*

The representation problem of observations exists in almost all of the global atmospheric inversions, including those using real time observations. The spatial resolutions of these models are in the magnitude of degrees, and the time-steps of meteorology used to drive the atmospheric transport model are usually 6 hours. Even though the model time steps are much shorter, the simulated CO_2 concentrations still cannot represent the real time, local observations. The temporal-spatial resolution in our inversion limits our ability to consider the 'synoptic-scale fluctuations in CO_2 concentrations' and the 'local influences' explicitly. These influences may partially be reflected in the weighting average of the transport (observation) matrix statistically, the rest part that cannot be represented in our method become part of the data-model mismatch (observation uncertainty) as described on page 3503. Regional models like STILT (Lin, 2003) may capture more local characteristics, but it is not an ideal tool for a global application.

Referee: 2) Along the same lines, what do they do about sites for which there is no data for a given month, and the GLOBALVIEW value is entirely extrapolated? If stations with no observations during part of the period were included in the inversion, it could play havoc with their attempted localizations of interannual variability; if they were included only for months when some threshold frequency of observations was reached, the changing observing network again raises the question of whether seen is real.

Author: *We did not use the extrapolated CO_2 concentration data in our CO_2 concentration. We included those monthly average data only when 4 weekly data are all available.*
An inverse problem is usually ill-posed or underdetermined, so it does not have a unique solution. An inversion approach is used to find the most likely state (in our case, CO_2 flux) that is consistent with all of the available observations (CO_2 observations). The quantity (as many as 12181 monthly CO_2 concentration data from 210 sites are used in this study) and quality of CO_2 observations determine the posterior uncertainty of the inferred CO_2 flux. The Bayesian synthesis inversion method we used also considers prior knowledge about the state (CO_2 flux) in the second term of the cost function. When the observations are not complete, 'such prior knowledge can be thought as a virtual measurement, as, like a real measurement, it provides us with an estimate of some function of the state, together with a measure of the accuracy of the estimate, albeit usually rather a poor one' (Rodgers, 2002). For terrestrial ecosystems we used the simulation result from BEPS, a terrestrial ecosystem model, as the a priori to further constrain our inversion to avoid the possible 'havoc' solution. Though Bayesian inversion is a helpful approach to update our prior estimate using observations, we are aware that the posterior uncertainties brought by the imperfect measurements and the inferred seasonal and interannual variations are also accompanied with their uncertainties. Your question 'whether the interannual variability seen is real' is also our concern in the paper, and that is why we have a long regional analyses rather than a statistical one. We have tried to answer this very same question through examining if the inferred variations (seasonal, interannual) could be explained by the monthly climatic conditions and their anomalies in terms of complying with our understanding of terrestrial ecosystem processes.

Referee: 3) Uncertainties such as 0.25 Pg C/y for the northern land sink are difficult to credit. The quoted 6% uncertainty in fossil fuel emissions, assuming 5 Pg C/y from northern land regions, would by itself lead to a 0.30 Pg C/y uncertainty in the sink even if the gross flux were perfectly known. Even assuming that the estimated fluxes are computed from reasonable estimates of the concentration and prior flux uncertainties, they do not include transport model error and thus are valid only for an imaginary perfect model. With results from the Transcom intercomparisons available, there is no reason not to include estimated transport uncertainty as part of the posterior flux uncertainty (the transport error could also be estimated from an ensemble of basis functions generated by the same model but driven with different reanalysis fields); the uncertainty as presented is misleading.

Author: *Fig 3 (Page 3530) could be used to intuitively describe the allocation of uncertainties in our paper. Theoretically we can only calculate one uncertainty for one region in an atmospheric inversion. The land region in Fig 3, for example, is shown as a source of 6.25 Pg C/y with an uncertainty 0.49 Pg C/y, and this source is further allocated to fossil fuels burning, biomass burning, and biosphere uptake, but no further uncertainty was assigned to each of them.*

In reality, as summarised in IPCC FAR (2007) 'Fossil fuel emissions are generally considered perfectly known in inversions, so that their effect can be easily modelled and subtracted from atmospheric CO_2 data to solve for regional land-atmosphere and ocean-atmosphere fluxes'. We followed suit in our inversion. We quoted the 6% uncertainty in fossil fuel emissions to show that the a priori uncertainty (2.0 Pg C/y) we used could adequately cover the possible uncertainties *aroused from the components including fossil fuel emissions, and to notify our reader that the fossil fuel emission is not perfect.*

The uncertainty of 0.25 Pg C/y for Northern land is then the uncertainty of the total flux (fossil fuel burning, biomass burning, and biosphere uptake), theoretically, and also used as the uncertainty for the land sink as used in most of the atmospheric inversion papers.

The uncertainty of the total flux could be smaller than that of a component because of the cancelation effect of certain positive and negative biases among components.

In our inversion, we use a part of the model-data mismatch (observation uncertainty) to represent the model uncertainty and that is finally transformed as one part of the posterior uncertainty.

Using an ensemble of atmospheric transport models could possibly but not necessarily improve an inversion (Stephens et al., 2007). TM5, the transport model we used, is one of the models that produced the least bias in Stephens et al.'s comparison. According to existing comparisons (Baker et al., 2006), transport models can make considerable differences in the inverted carbon flux. The differences are mostly in the absolute flux values for a given region, but the pattern of the seasonal and inter-annual variation patterns similar if adequate measurements are used, such as Europe. We will add this point in our revision.

Referee: 4) The analysis of drought impacts on regional carbon fluxes is potentially the most novel part of this work but is limited to qualitative comparisons between time series in a few regions. The authors might consider some statistical testing of this relationship, along the lines of what was done by Schwalm et al. ("Assimilation exceeds respiration sensitivity to drought: A FLUXNET synthesis", GCB, 2010) for carbon fluxes measured from towers, and perhaps comparing their inversion with the eddy covariance results.

Author: *As stated in the introduction we made our effort to explain the inverted regional fluxes and their anomalies in terms of monthly climatic conditions and their anomalies to observe whether our inverted results reflect the likely state of the regional terrestrial carbon exchange, mostly its likely variability with variation of climatic conditions.*

Dr. Krakauer's suggestions to analyze the drought impact on regional carbon flux are very constructive. As the terrestrial ecosystems are very complicated, there are many relationships (including time-delay effect) to explore. It is not easy to include them in this paper within a certain number of pages. We did a full set of statistical analysis on how the terrestrial carbon cycle responds to the variabilities of climatic conditions based on the inferred fluxes in a separate paper (Deng & Chen, to be submitted).

To directly compare carbon measurement with fluxnet is not feasible. We did a comparison of our inverted CO_2 *flux with an independent flux field over temperate North America derived from site-level eddy covariance flux data and wall-to-wall satellite data from Moderate Resolution Imaging Spectroradiometer (MODIS) (Xiao et al., 2008) in another paper where forest stand age information is included in an inversion (Deng et al., submitted).*

Referee: 5) Figures 6-9, showing a profusion of time series, are cumbersome to interpret. I suggest replacing them with simpler versions and/or a graphic that provides some sort of global perspective on the argued connection between drought and reduced carbon uptake.

Author: *To make it easy to read and interpret, we will follow anonymous referee #2's suggestion to bin 12 months into 4 seasons (Jan-Mar, Apr-Jun, Jul-Sep, and Oct-Dec) and redo these figure and analysis in our revision.*

Referee: 6) The study period is inconsistently given as 2001-2007 or 2002-2007; please clarify.

Author: *We use CO_2 concentration observations from 2001-2007 to infer CO_2 fluxes from 2002 to 2007. The first year data are used to stabilize our inversion.*

Referee: 7) Typographic:
Eq. 1: should be Q^{-1}
3501 l. 17: a priori *estimate*
3502 l. 4: GLOBALVIEW
3502 l. 12: *basis* regions
3502 l. 14: carbontracker.noaa.gov
3504 l. 16: at the upper bound

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

References

Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Climate Change 2007: The Physical Science Basis, Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Rodgers, C.D.: Inverse methods for atmospheric sounding: Theory and Practice, Series on Atmospheric, Oceanic and Planetary Physics – Vol. 2, World Scientific, 2000

Baker, D. F., Law, R. M., Gurney, K. R., Rayner, P., Peylin, P., Denning, A. S., Bousquet, P., Bruhwiler, L., Chen, Y. H., Ciais, P., Fung, I. Y., Heimann, M., John, J., Maki, T., Maksyutov, S., Masarie, K., Prather, M., Pak, B., Taguchi, S., and Zhu, Z.: TransCom 3 inversion intercomparison: Impact of transport model errors on the interannual variability of regional CO_2 fluxes, 1988-2003, Global Biogeochem. Cycles, 20, GB1002, 2006.

Lin, J. C.: A near-field tool for simulating the upstream influence of atmospheric observations: The Stochastic Time-Inverted Lagrangian Transport (STILT) model, Journal of Geophysical Research, 108, ACH 2-1-ACH 2-17, 10.1029/2002jd003161, 2003.

Stephens, B. B., Gurney, K. R., Tans, P. P., Sweeney, C., Peters, W., Bruhwiler, L., Ciais, P., Ramonet, M., Bousquet, P., Nakazawa, T., Aoki, S., Machida, T., Inoue, G., Vinnichenko, N., Lloyd, J., Jordan, A., Heimann, M., Shibistova, O., Langenfelds, R. L., Steele, L. P., Francey, R. J., and Denning, A. S.: Weak Northern and Strong Tropical Land Carbon Uptake from Vertical Profiles of Atmospheric CO_2, Science, 316, 1732-1735, 10.1126/science.1137004, 2007.

Xiao, J., Zhuang, Q., Baldocchi, D. D., Law, B. E., Richardson, A. D., Chen, J., Oren, R., Starr, G., Noormets, A., Ma, S., Verma, S. B., Wharton, S., Wofsy, S. C., Bolstad, P. V., Burns, S. P., Cook, D. R., Curtis, P. S., Drake, B. G., Falk, M., Fischer, M. L., Foster, D. R., Gu, L., Hadley, J. L., Hollinger, D. Y., Katul, G. G., Litvak, M., Martin, T. A., Matamala, R., McNulty, S., Meyers, T. P., Monson, R. K., Munger, J. W., Oechel, W. C., Paw U, K. T., Schmid, H. P., Scott, R. L., Sun, G., Suyker, A. E., and Torn, M. S.: Estimation of net ecosystem carbon exchange for the conterminous United States by combining MODIS and AmeriFlux data, Agricultural and Forest Meteorology, 148, 1827-1847, 2008.