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Interactive comment on "A Joint Global Carbon Inversion System Using Both CO_2 and CO_2 Atmospheric Concentration Data" *by* Jing M. Chen et al.

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This manuscript presents an interesting approach for using 13CO2 data as extra constraints for top-down flux inversions based on in-situ surface CO2 data. This approach has taken into account spatial variation of isotropic discrimination and disequilibrium by using a terrestrial biosphere model and an ocean model to simulate the discrimination rates. The manuscript is well written, and their results are interesting. It should be published after minor revision. Answer: Thank you for your positive comments and the penetrating comments below which indicate that you have understood our methodology and analyzed our results carefully. Your expert views are much appreciated.

Major comments: My major concern is that the uncertainties in model simulation of Dj and Ci (Eqs. 6 and 8) have been properly taken into account in the flux inversions.

1. Ideally Dj should be part of the state vector, with prior estimates taken from the biospheric or oceanic model simulation. Treating Dj as a single fixed value could result in artificially enlarging the impacts of 13CO2 data, as well as distorting the spatial distribution of the posterior fluxes.

Answer: We agree that Dj would ideally be part of the state vector if its uncertainty is to be fully considered for its influence on CO2 inversion. The same can be said to other isotopic parameters, such as disequilibrium coefficients over land and ocean. To include all these as state variables, our inversion system would have to be much too big to be manageable. In order to keep our system simple and practically useful, we have followed the strategy to estimate these isotopic parameters as accurately as possible and used them as input and not to be adjusted in the inversion system. We also felt that the amount of C13 data is still limited, and we cannot be overly ambitious to do too much with the data. If we are not limited by computing resources, we may even opt for higher spatial and temporal resolutions rather than adding more state variables.

2. The observation errors for 13CO2 should also be enlarged to account for possible modelling errors (Eq.10). Actually it is a bit surprising that the uncertainties for both land and oceanic fluxes inferred from 13CO2 data only (Table 6) are smaller than those directly based on surface CO2 data (Table 3), considering that they have fewer sites.

Answer: We completely agree and this is also implied by the other reviewer Peter Rayner. We will rerun our inversion for all scenarios and the resulting uncertainties in the CO2 flux as shown in Tables 3 and 6 may change in the right direction.

3. In the joint inversion, the observation error correlation between CO2 and 13CO2 data, (for example, due to the common model transport errors) has not been taken into account.

Answer: In our joint inversion system, the transport error is not included in the covariance matrix, similar to many other systems. To do this properly, we need to run multiple transport models, and this would be the next step.

Minor comments: 1. Line 17, Page 4 ': : :60 months' The time period 2000-2004 could be mentioned here.

Answer: Yes, we will do.

2. Eq. 9, Page 7: It would be helpful if the authors can add some discussions on temporal variation of Dj in the following sections.

Answer: Yes, we will do.

3. Line 1, Page 13: 'A transport-only : : :' What is the spatial resolution of TM5 ?

Answer: The spatial resolution of TM5 is 6x4 degrees for the globe and 3x2 degrees for North America. The atmosphere is divided vertically into 25 layers with 5 layers in the planetary boundary layer. We will add these details to the manuscript.

4. Line 34: 'equal the sum of : : :' Uncertainty of (ab) usually is not equal to such a simple linear sum.

Answer: We agree that in this case (P18L34), the total uncertainty should equal to the square root of the sum of the two variances. We will recalculate the total uncertainty of the terms involved.

5. Figure 13. I only see blue solid line (instead of the green one in the caption). Also, it seems that over Northern hemisphere, the posterior model CO2 concentrations have a larger seasonal cycle than the GV data. What is the reason?

Answer: The solid line was indeed blue rather than black (a mistake in the caption). Over some stations in the Northern hemisphere, the posterior CO2 concentrations have a larger seasonal cycle that the observation. This is likely due the remainder influence of the prior CO2 flux which might have respiratory fluxes too large in the

winter. However, we cannot rule out the influences of transport errors and the site representativeness. We will add some discussion to this effect.

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