**Atmospheric
Chemistry
and Physics
Discussions**

Interactive comment on "Spatial distribution of $\Delta^{14}CO_2$ across Eurasia: measurements from the TROICA-8 expedition" *by* J. C. Turnbull et al.

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Interactive Discussion

Discussion Paper

Review of Turnbull et al., *Spatial distribution of $\Delta^{14}CO_2$ across Eurasia: Measurements from the TROICA-8 expedition*

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19 August 2008

The abundance of the trace isotope carbon-14 is a very useful indicator of carbon transport in the atmosphere and ocean, and in particular has the potential to uniquely trace the movement and dispersal of carbon dioxide generated during fossil fuel burning, as shown e.g. in Turnbull et al., GRL, 2006. However, the ambient few permil differences in $^{14}C/^{12}C$ ratio are at the limit of measurement precision, making detecting and quantifying these abundance differences quite difficult. The current paper reports on observations of $^{14}C/^{12}C$ ratio in carbon dioxide in air samples collected along the Trans-Siberian railway, and compares these with modeled carbon dioxide production, uptake and transport. The expectation is for an 8 permil east-west gradient in $^{14}C/^{12}C$ ratio across Russia; while the measurements are noisy, removing some outliers based on reasonable criteria yields a qualitatively similar trend, and the difference between the modeled and measured gradient can plausibly be attributed to slow (vertical or horizontal) mixing in the atmospheric transport model as compared with reality, a tendency also independently suggested by persistent model underestimates of the amplitude of the seasonal cycle in column carbon dioxide abundance. Measurements of atmo-

spheric carbon-14 are scarce, and the work presented here is a welcome addition, particularly because a multitude of other trace species were measured in the same campaign. The modeling presented is well conceived and usefully compared with the measurements. While this is fundamentally a worthy paper, the presentation can be improved. My comments and suggestions are as follows:

1. 15209:14-26 *The initially very large disequilibrium between the oceans (and to a lesser extent, the terrestrial biosphere) dominated the secular decrease (and seasonal change) in $\Delta^{14}CO_2$ until the mid-1980s, causing annual decreases in $\Delta^{14}CO_2$ of up to 100 permil* - There's probably a better way to word this. The hemispheric-scale decline rate in atmospheric $\Delta^{14}CO_2$ actually reached a maximum of $\sim$80 permil per year in 1964/5 and was less than 10 permil per year by the mid-1980s. Further, Randerson et al. (GBC, 2002, cf. Figures 5 and 6 there) suggest that exchange with the stratosphere was initially the main driver of the seasonal cycle in tropospheric $\Delta^{14}CO_2$, far outweighing air-sea exchange or land respiration.

2. 15214:12 *net oceanic fluxes derived from ΔpCO_2 (Takahashi et al., 2002)* - With which assumptions about the gas exchange rate?

3. 15214:18-19 *extrapolating the emission pattern up to 2004* - Is this a linear extrapolation of the 1995-2000 trend, or holding constant the 2000 pattern?

4. 15214:22 Where did the value of $^{14}CO_{2bg}$ in Equation 1 come from?

5. 15214:24 What is a "$^{14}CO_2$ value"? Did you transport $^{14}CO_2$ mixing ratio, $\Delta^{14}CO_2$ anomalies, or something else?

6. 15216:25-27 *Net $^{14}CO_2$ fluxes into and out of the biosphere and ocean, and autotrophic respiration are not included because $\Delta^{14}CO_2$ accounts for natural*

fractionation (Stuiver and Polach, 1977) and these fluxes are therefore all neces-sarily zero. - This is not quite the right reason. For example, the main reason for neglecting the influence of autotrophic respiration flux on atmospheric $\Delta^{14}CO_2$ is the assumption that almost all the respired carbon was fixed in the past few months, and therefore has essentially the same $\Delta^{14}C$ level as the current atmosphere.

7. Please include a data table similar to that in Turnbull et al., JGR, 2007 with the sampling time and location, measured $\Delta^{14}CO_2$, flags, and any other relevant information.

8. 15218:5 *predominantly producing* ^{14}C *as* $^{14}CH_4$ - Add something like: "which becomes well-mixed in the atmosphere by the time it oxidizes to $^{14}CO_2$"

9. 15218:16 *These flagged samples are excluded from further analysis.* - Can you include the exact criteria (e.g. proximity of back-trajectory to a nuclear power plant by a certain time) for excluding samples as unrepresentative on this basis?

10. 15221:11ff *The observations suggest...* - How is this inferred? Be more specific.

11. 15222:11 *but is heavily influenced by a single outlier* - What is the influence? Is the correlation significant without the outlier?

12. 15223:8 *The westernmost sample...* - How far from Moscow is this sample actually?

13. 15223:26-27 *Increasing the global fossil fuel CO$_2$ emissions by 10% increased the modeled west-east gradient by only 0.2 permil in each model scenario.* - I don't see how this can be right, given that the modeled east-west gradient attributable to fossil-fuel burning is 8 permil (Figure 7, or 5 permil just across Siberia) and that the gradient should scale linearly with emissions (assuming that the distribution is held constant)

Minor typography:

1. 15209:3 *mean lifetime=8 267 y (Godwin, 1962)* - enclose in parentheses; also, elsewhere you use the abbreviation yr, so be consistent

2. 15213:17 *Single sample uncertainties-range* - delete hyphen

3. 15213:22 *1.34, note* - semicolon rather than comma

4. 15215:9 *which is then convolved with the atmospheric $\Delta^{14}CO_2$ history, to give the $\Delta^{14}CO_2$ of the respiratory flux* - delete comma

5. 15215:13 *the disequilibrium which when multiplied* - insert comma before "which"

6. 15216:17 *Krol et al. (2004)* - should be 2005 according to the reference list; also at 15217:7

7. 15219:8 μ *mol* - no space

8. 15219:29 *solid points, each point* - semicolon rather than comma

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