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Spatial distribution of $\Delta^{14}CO_2$ across Eurasia: measurements from the TROICA-8 expedition

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Abstract. Because fossil fuel derived CO_2 is the only source of atmospheric CO_2 that is devoid of ^{14}C, atmospheric measurements of $\Delta^{14}CO_2$ can be used to constrain fossil fuel emission estimates at local and regional scales. However, at the continental scale, uncertainties in atmospheric transport and other sources of variability in $\Delta^{14}CO_2$ may influence the fossil fuel detection capability. We present a set of $\Delta^{14}CO_2$ observations from the train-based TROICA-8 expedition across Eurasia in March–April 2004. Local perturbations in $\Delta^{14}CO_2$ are caused by easily identifiable sources from nuclear reactors and localized pollution events. The remaining data show an increase in $\Delta^{14}CO_2$ from Western Russia (40° E) to Eastern Siberia (120° E), consistent with depletion in $^{14}CO_2$ caused by fossil fuel CO_2 emissions in heavily populated Europe, and gradual dispersion of the fossil fuel plume across Northern Asia.

Other trace gas species which may be correlated with fossil fuel CO_2 emissions, including carbon monoxide, sulphur hexafluoride, and perchloroethylene, were also measured and the results compared with the $\Delta^{14}CO_2$ measurements. The sulphur hexafluoride longitudinal gradient is not significant relative to the measurement uncertainty. Carbon monoxide and perchloroethylene show large-scale trends of enriched values in Western Russia and decreasing values in Eastern Siberia, consistent with fossil fuel emissions, but exhibit significant spatial variability, especially near their primary sources in Western Russia.

The clean air $\Delta^{14}CO_2$ observations are compared with simulated spatial gradients from the TM5 atmospheric transport model. We show that the change in $\Delta^{14}CO_2$ across the TROICA transect is due almost entirely to emissions of fossil fuel CO_2, but that the magnitude of this $\Delta^{14}CO_2$ gradient is relatively insensitive to modest uncertainties in the fossil fuel flux. In contrast, the $\Delta^{14}CO_2$ gradient is more sensitive to the modeled representation of vertical mixing, suggesting that $\Delta^{14}CO_2$ may be a useful tracer for training mixing in atmospheric transport models.

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