Atmospheric Chemistry and Physics
An Interactive Open Access Journal of the European Geosciences Union

Atmos. Chem. Phys., 7, 2855-2879, 2007
www.atmos-chem-phys.net/7/2855/2007/

Isoprene and monoterpene fluxes from Central Amazonian rainforest inferred from tower-based and airborne measurements, and implications on the atmospheric chemistry and the local carbon budget

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Abstract. We estimated the isoprene and monoterpene source strengths of a pristine tropical forest north of Manaus in the central Amazon Basin using three different micrometeorological flux measurement approaches. During the early dry season campaign of the Cooperative LBA Airborne Regional Experiment (LBA-CLAIRE-2001), a tower-based surface layer gradient (SLG) technique was applied simultaneously with a relaxed eddy accumulation (REA) system. Airborne measurements of vertical profiles within and above the convective boundary layer (CBL) were used to estimate fluxes on a landscape scale by application of the mixed layer gradient (MLG) technique. The mean daytime fluxes of organic carbon measured by REA were 2.1 mg C m^{-2} h^{-1} for isoprene, 0.20 mg C m^{-2} h^{-1} for α-pinene, and 0.39 mg C m^{-2} h^{-1} for the sum of monoterpenes. These values are in reasonable agreement with fluxes determined with the SLG approach, which exhibited a higher scatter, as expected for the complex terrain investigated. The observed VOC fluxes are in good agreement with simulations using a single-column chemistry and climate model (SCM).

In contrast, the model-derived mixing ratios of VOCs were by far higher than observed, indicating that chemical processes may not be adequately represented in the model. The observed vertical gradients of isoprene and its primary degradation products methyl vinyl ketone (MVK) and methacrolein (MACR) suggest that the oxidation capacity in the tropical CBL is much higher than previously assumed. A simple chemical kinetics model

was used to infer OH radical concentrations from the vertical gradients of (MVK+MACR)/isoprene. The estimated range of OH concentrations during the daytime was $3–8\times10^6$ molecules cm^{-3}, i.e., an order of magnitude higher than is estimated for the tropical CBL by current state-of-the-art atmospheric chemistry and transport models. The remarkably high OH concentrations were also supported by results of a simple budget analysis, based on the flux-to-lifetime relationship of isoprene within the CBL. Furthermore, VOC fluxes determined with the airborne MLG approach were only in reasonable agreement with those of the tower-based REA and SLG approaches after correction for chemical decay by OH radicals, applying a best estimate OH concentration of 5.5×10^6 molecules cm^{-3}. The SCM model calculations support relatively high OH concentration estimates after specifically being constrained by the mixing ratios of chemical constituents observed during the campaign.

The relevance of the VOC fluxes for the local carbon budget of the tropical rainforest site during the measurements campaign was assessed by comparison with the concurrent CO_2 fluxes, estimated by three different methods (eddy correlation, Lagrangian dispersion, and mass budget approach). Depending on the CO_2 flux estimate, 1–6% or more of the carbon gained by net ecosystem productivity appeared to be re-emitted through VOC emissions.

Final Revised Paper (PDF, 1257 KB) Discussion Paper (ACPD)

Citation: Kuhn, U., Andreae, M. O., Ammann, C., Araújo, A. C., Brancaleoni, E., Ciccioli, P., Dindorf, T., Frattoni, M., Gatti, L. V., Ganzeveld, L., Kruijt, B., Lelieveld, J., Lloyd, J., Meixner, F. X., Nobre, A. D., Pöschl, U., Spirig, C., Stefani, P., Thielmann, A., Valentini, R., and Kesselmeier, J.: Isoprene and monoterpene fluxes from Central Amazonian rainforest inferred from tower-based and airborne measurements, and implications on the atmospheric chemistry and the local carbon budget, Atmos. Chem. Phys., 7, 2855-2879, 2007. Bibtex EndNote Reference Manager