ECHO

Emission and CHemical Transformation of Biogenic Volatile Organic Compounds:

Investigations in and Above a Mixed Forest Stand

A project of the german Atmospheric-Research-Program 2000

Partners

- Prof. Dr. R. Koppmann, Fachbereich Mathematik und Naturwissenschaften, Bergische Universität Wuppertal, Koordinator
- Prof. J. Kesselmeier, Max-Planck-Institut für Chemie, Mainz
- Dr. T. Hoffmann, Institut für Spektrochemie, Dortmund
- Prof. M. Schatzmann, Meteorologisches Institut Hamburg, Universität Hamburg

Aims of the project

Forests are complex sources of biogenic volatile organic compounds (VOC) in the planetary boundary layer. Previous studies estimate that global emissions of biogenic VOC are in the range of 490 Tg C/year to 1150 Tg C/year and thus a factor of 5 to 10 higher than anthropogenic emissions. Therefore, biogenic VOC contribute significantly to the formation of photo-oxidants in the troposphere. Due to fast vertical transport processes, they may even have an impact on the chemistry of the upper troposphere. Recent airborne measurements show surprisingly high mixing ratios of reactive compounds such as acetone, formaldehyde, methanol, hydrogen peroxide and organic hydroperoxides. These compounds are believed to originate from primary biogenic emissions or to be oxidation products of biogenic VOC.

All together, the impact of biogenic VOC on tropospheric photochemistry, air quality, and the formation of secondary products affecting our climate on a regional and global scale are far from being understood. A considerable lack of knowledge exists concerning a typical forest stand as a net source of reactive trace compounds, the amount of primary emitted VOC which are transported directly into the PBL, and the amount of VOC which are chemically processed within the canopy, the products of which are transported into the PBL. The gas phase chemistry above the canopy which is driven by high concentrations of reactive precursor compounds and high UV radiation is also not yet understood. The goal of the proposed project is to investigate these questions to improve our understanding of biosphere-atmosphere interactions and effects on the planetary boundary layer. This will be achieved by the investigation of the following themes:

1. Sources of reactive trace gases in a mixed forest stand: Emission rates of VOC from the trees will be investigated as well as the role of the soil as a source and sink of reactive trace compounds.
2. The forest stand as a chemical reactor: Chemical processes and formation of oxidation products of VOC (secondary VOC, photo-oxidants, organic aerosols) inside the forest stand will be studied.
3. The forest stand as a source of biogenic VOC and their oxidation products: The emission of trace compounds (primary emitted VOC, oxidation products, photo-oxidants, aerosols) from the canopy to the planetary boundary layer will be investigated. The net fuxes of these compounds will be quantified.
4. Atmospheric chemistry above the canopy: Chemical processes above the canopy, the influence of the emission of reactive compounds on these processes, and the formation of oxidation products will be investigated. Of primary interest is the influence of the vertical distribution of different trace gases on the chemical processing and the formation of photo-oxidants.

Contributions of the partners

- In the subproject proposed by the **Research Centre Jülich** the emissions of volatile organic compounds (VOC) from the different tree species at the field site (Stetternicher Forest, Jülich, Germany) will be measured. In parallel, experiments in plant chambers under defined conditions will be done in order to quantify the primary emissions of these compounds. In addition, their uptake by the plants will be investigated. The objective of these experiments is making emission algorithms available for later modelling. In two intensive field campaigns it will be investigated with which oxidizing agents (OH, HO_2, NO_3, O_3) VOC react predominantly in the canopy and to what extent photochemistry or night time chemistry (e.g. ozonolysis and reactions with NO_3) contribute to the oxidation of VOC. For this purpose it is planned for the first time to measure the concentration of radicals (OH, HO_2, RO_2, NO_3), a large set of trace gases (VOC, CO, O_3, NOx, organic nitrates), and meteorological parameters at different heights in and above the forest stand.
  In order to quantify the photochemical activity in the forest stand, for the first time the solar actinic flux in the visible and ultraviolet will be measured spectrally resolved to derive photolysis frequencies of relevant radical precursors (O_3, NO_2, peroxides, oxygenated VOC). The chemical processing of the trace gas mixtures observed in the forest stand will be simulated in the atmosphere simulation chamber SAPHIR under controlled conditions. In the simulation experiments the same trace gases and parameters are measured as in the field experiments under application of the same equipment. This enables on the one hand the detailed study of the chemical processes under exclusion of transport processes and on the other hand sensitivity studies by direct modification of individual chemical parameters. The observations of the field experiments and of the simulation experiments will be compared further with chemical box model calculations. With the combination of field and simulation experiments it will be tried to quantify the chemical processing of the VOC, the photo-oxidant formation in the forest and the radical balance.

- The **Max Planck Institute for Chemistry** will investigate the release of VOC and NO_x species as well as their fate within the atmosphere. Gaseous and reactive compounds, once emitted, are not easily quantified within the atmosphere as they underlie fast oxidative transformation processes. Quite often the products are unknown and/or end up within or on particles. Therefore, to quantify the total VOCs we will combine different investigation

and techniques with enclosure methods to perform analyses on the leaf and branch level as well as with mesoscalic integration by micrometeorological methods. Such a combination will give access to primary emissions and secondary fluxes. This work will be closely coupled to the investigations of processes of air chemistry (radical chemistry) and aerosols as planned within the Joint project. An interpretation of the influence of VOC onto the oxidation capacity of the atmosphere is impossible without knowing the NO_x-concentrations or the biogenic NO source strength of the soil, respectively. Complementing the studies of primary emissions and of VOC fluxes we will therefore perform intensive investigations of the biogenic NO-release from forest soils as well as of the vertical distribution of NO_x and its turbulent transport within and above the forest.
The combination of the different techniques and procedures for the determination of primary emissions, atmospheric concentrations and the fluxes will allow a better interpretation of biogenic emissions and their influence on the atmosphere. A high time resolution (1/s) of a new measuring technique for VOCs, the AP-CIMS technique, will provide accurate diurnal patterns and will give access to the short time variations of primary emissions. Furthermore, measuring organic acids will contribute to the understanding of the production processes and compositions of secondary organic aerosol. Quantification of biogenic NO-Emission, the understanding of the production controls (soil moisture and temperature, composition), the knowledge of the vertical NO_x-distribution and transport within and above the forest will build up a fundamental understanding of the oxidation processes, to which VOCs, radicals and NO_x are contributing in a very complex manner. Hence, measuring the primary emissions of trace gases and their fluxes will help to produce a budget in order to verify the physical and chemical transformation processes within and above the forest and the amount and quality of the trace compounds released into the background atmosphere in reality.

- The role of **ISAS Dortmund** within the overall project is focused on the investigation of the atmospheric degradation of the reactive natural VOCs in connection with their potential to form aerosols. Although the aerosol formation potential of biogenic VOCs as a consequence of the gas-to-particle conversion of their oxidation products is a well known phenomenon, detailed investigations in the field are lacking. The studies realised up to now concentrated essentially on the determination of the aerosol yields of biogenic and anthropogenic VOCs and the identification of gas and particle phase oxidation products in laboratory studies, indicating that the amount of organic aerosol formed strongly depends on the initial oxidation step (OH, NO_3 or O_3) as well as the temperature.
Unfortunately, field studies considering these processes and therefore a validation of the lab results are rare, especially in anthropogenically influenced regions with a high variation of the actual NO_x and ozone concentrations which affect the routes to the formation of low volatile species. Therefore, the attempt to close the mass balance of tropospheric organic compounds still fails due to a missing understanding of the processes. In order to answer these questions, the following measurements are planned:

1. Gradient measurements of biogenic VOCs and some of their oxidation products above a mixed forest in the vicinity of Jülich.
2. Time resolved chemical characterisation of the organic particle phase, especially focusing on secondary organic aerosol components.

- The **Meteorological Institute Hamburg of the University of Hamburg** will deliver new information on vertical transport phenomena in the lower layers of the Troposphere. The

horizontal and vertical transport of tracers above a biogenic area source (finite forest area) will be modelled in a large boundary layer wind tunnel. Systematic investigations consisting of detailed high resolution flow and dispersion measurements will be carried out to extend the field data and to quantify reliability and representativeness of corresponding field measurements in space and time.

The project directly contributes to quality assurance of field data and their enhancement in terms of extending the database for situations that could not be measured in full scale. Field and laboratory data together will lead to a high quality data set for model validation purposes. The sub-project is part of the project cluster ECHO which aims on a better understanding of the role of a forest stand as a complex source of volatile organic compounds on the climate system. The specific objectives of our sub-project are

1. support in effective planning of the field measurements done by the FZ Jülich group (repeating specific aspects of the field experiments in the new boundary layer wind tunnel, optimising and validating the location of sampling points for field measurements in terms of reliability of the results and their representativeness in space and time for different wind directions/wind speeds)
2. complementing field data with additional laboratory data for adjacent emission situations not captured during field data campaigns (extending the database by adding data for additional wind directions, different emission characteristics, measuring horizontal and vertical transport of momentum and species above the emitting area)
3. quantifying the variability of field data due to the variation of boundary conditions (quantifying the reliability of field data which is required for comparing the field data with results from numerical dispersion modelling)
4. compiling an extensive and completely documented set of reference data consisting of field data and high quality laboratory data. Publication of all results in an electronic database as well as in reviewed journals.

Proposed Measurements

Measurand	Measurement Instrumentation	Institution	Working Group
Emissions from plants	Enclosures, adsorption tubes GC-MS	ICG-II	Dr. Koppmann
Vertical distribution of VOC and oxidation products	on-line GC-MS	ICG-II	Dr. Koppmann
Soil emissions of VOC	Enclosures, adsorption tubes, GC-MS	ICG-II	Dr. Koppmann
Vertical distribution of HO_x-radicals	Laser-induced fluorescence	ICG-II	Dr. Hofzumahaus Dr. Holland
Measurement of photolysis frequencies	Spectral radiometer, filter radiometer	ICG-II	Dr. Hofzumahaus
Vertical distribution of peroxi radicals and NO_3	Matrix-Isolation-Electron-Spin-Resonance	ICG-II	Dr. Mihelcic
Meteorological parameters	Meteorological tower, different masts in the forest stand	S	Dr. Knaps
Tracerexperiments	SF_6-Monitor and GC-ECD	S	Dipl.-Met. Möllmann-Coers
Emission and uptake of VOC by plants	Plant chambers, on-line GC-MS	ICG-III	Dr. Wildt
Simulation experiments	Atmospheric simulation chamber SAPHIR	ICG-II	Prof. Dr. Wahner
Plant emissions	Enclosures, adsorption tubes GC-MS	MPI	Prof. Kesselmeier
VOC fluxes	Eddy Covariance, CIMS	MPI	Prof. Kesselmeier
Physiological parameters of the plants	Measurements of CO_2, H_2O	MPI	Prof. Kesselmeier
VOC fluxes	Relaxed Eddy Accumulation	MPI	Prof. Kesselmeier
Vertical distribution of NO_x and Ozon	Chemiluminescence	MPI	Prof. Meixner
Soil emissions of NO	Automatic incubation system	MPI	Prof. Meixner
VOC and oxidation products in the gas phase	adsorptive preconcentration, thermo desorption/GC/MS	ISAS	Dr. Hoffmann
Particle bound VOC oxidation products	Filter/Impactor sampling followed by derivatisation/GC/MS resp. Micro-HPLC/MS	ISAS	Dr. Hoffmann
EC/OC-matter of the particle phase	Sampling with quartz filters	ISAS	Dr. Hoffmann

Measurand	Measurement Instrumentation	Institution	Working Group
Optimization of the field site in the wind tunnel	Wind tunnel	UHH	Prof. Schatzmann Dr. Leitl
Quantification of the variability of the field data	Wind tunnel	UHH	Prof. Schatzmann Dr. Leitl

Publications

FINAL REPORT

Emission and chemical transformation of biogenic volatile organic compounds (ECHO) – Investigations in and above a mixed forest stand

R. Koppmann, J. Kesselmeier, F. X. Meixner, M. Schatzmann, B. Leitl, T. Hoffmann, R. Dlugi, M. Zelger, J. Kleffmann, A. Neftel, J. Dommen, C. Thomas, T. Trautmann, B. Neininger, Emission and chemical transformation of biogenic volatile organic compounds (ECHO) - Investigations in and above a mixed forest stand, in: Results of the German Atmospheric Research Programme - AFO 2000, ed. by R. Winkler, pp. 29-39, Federal Ministry of Education and Research, Publications Division, Bonn, Berlin 2005.

Annual Reports

Overview (PDF-Format)

FZJ (PDF-Format)
"Emission and CHemical Transformation of biogenic volatile Organic Compounds - Investigations in and above a Mixed Forest Stand (ECHO)"

MPI (PDF-Format)
"Simultaneous measurements of primary emission rates and fluxes of Volatile Organic Compounds (VOC) and nitrogen oxides (NOx) within and above canopy stands."

ISAS (PDF-Format)
"Field Studies for the Chemical Characterization of Tropospheric Organic Aerosol Particles"

UHH (PDF-Format)
"Wind tunnel study on the effects of horizontally inhomogeneous biogenic emission sources on the results of field measurements"

ANNUAL REPORTS 2002

FZJ (PDF-Format)
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UHH (PDF-Format)
"Wind tunnel study on the effects of horizontally inhomogeneous biogenic emission sources on the results of field measurements"

Peer reviewed journals

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KARL, M., T. BRAUERS, H. P. DORN, F. HOLLAND, M. KOMENDA, D. POPPE, F. ROHRER, L. RUPP, A. SCHAUB, AND A. WAHNER, Kinetic study of the OH-isoprene and O3-isoprene reaction in the atmosphere simulation chamber SAPHIR, *Geophys. Res. Lett.*, **31**, L05117, doi:101029/2003GL019189, 2004.

KLEFFMANN, J., R. GAVRILOAIEI, A. HOFZUMAHAUS, F. HOLLAND, R. KOPPMANN, L. RUPP, E. SCHLOSSER, M. SIESE, A. WAHNER, Daytime formation of nitrous acid: A major source of OH radicals in a forest, submitted to *Geophys. Res. Lett.*, 2004.

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NEUBERT, C., Charakterisierung eines Proton-Transfer-Reaktions-Massenspektrometers für Messungen flüchtiger organischer Verbindungen, Fachhochschule Aachen, Abteilung Jülich, 2004.

OTTO, S., Modellierung des eindimensionalen Strahlungstransports in hochreichender Vegetation mit Zweistrom-Methoden, Universität Leipzig, 2003.

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PhD Theses

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DINDORF, T., Biosphere-Atmosphere Exchange of nonmethane organic carbon, Fachbereich Biologie, Universität Mainz, in preparation.

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Conference Contributions

1. C. Ammann, C. Spirig, A. Neftel, A. Schaub, M. Komenda, The use of proton transfer mass spectrometry to characterize VOC concentrations within a deciduous forest, EGS-AGU-EUG Joint Assembly, Nizza, Frankreich, 6.-11. April 2003

2. C. Ammann, C. Spirig, A. Neftel, W. Grabmer, J. Beauchamp, A. Hansel, A. Wisthaler, A. Schaub, J. Dommen, A. Thielmann

Evaluation of multi-component VOC eddy covariance measurements over an inhomogeneous forest canopy
Gordon Research Conference on Biogenic Hydrocarbons & The Atmosphere, 1.-8. Mai 2004, Il Ciocco, Italien

3. S. Aubrun, B. Leitl, M. Schatzmann
Physical modelling of biogenic emissions from a forest area
EUROTRAC 2 Symposium 2002, Garmisch-Partenkirchen, 11.-15. März 2002

4. S. Aubrun, B. Leitl, M. Schatzmann, R. Koppmann
Footprint Experiments in a model of a complex forest stand (ECHO site)
AGU Fall Meeting, San Francisco, USA, 8.-12. Dezember 2003

5. S. Aubrun, B. Leitl and M. Schatzmann
Physical modelling of the transport of biogenic emissions in and above a finite forest area
1st EGS-AGU-EUG Joint Assembly, 06 - 11 April 2003, Nizza, Frankreich

6. S. Aubrun, B. Leitl and M. Schatzmann
The transport of biogenic emissions in and above a finite forest area
International workshop on Physical Modelling of Flow and Dispersion Phenomena, 3-5 September 2003, Prato, Italien

7. S. Aubrun, B. Leitl, M. Schatzmann, R. Koppmann
Footprint Experiments in a model of a complex forest stand (ECHO site)
AGU Fall Meeting, 8. - 12. Dezember 2003, San Francisco, USA

8. S. Aubrun, B. Leitl, M. Schatzmann, R. Koppmann
Physical modelling of the vertical transport of biogenic emissions above a complex forest stand (ECHO site)
EGU - 1st General Assembly, 25.-30. April 2004, Nizza, Frankreich

9. T. Brauers, B. Bohn, D. Brüning, H. P. Dorn, F. Holland, F J. Johnen, R. Koppmann, F. Rohrer, L. Rupp, S. Rodriguez Bares, R. Tillmann, A. Wahner
The atmosphere simulation chamber SAPHIR: A tool for the investigation of photochemistry
102. Hauptversammlung der Deutschen Bunsen-Gesellschaft für Physikalische Chemie e.V., Kiel, 29. - 31. Mai 2003

10. T. Dindorf, U. Kuhn, S. Rottenberger, T. Biesenthal, A. Wolf, S. Muth, G. Schebeske, R. Gabriel, K. Bode, L. Schäfer, M. Staudt, C. Gerlach, E.M. Jork and J. Kesselmeier
Bidirectional exchange of oxygenated volatile organic compounds between plants and the atmosphere: A synopsis of field and laboratory studies
Deutsche Botanikertagung, 22.-27. September 2002, Freiburg

11. T. Dindorf, U. Kuhn, C. Ammann, C. Holzke, A. Thielmann, S. Ausma, L. Lehmann, G. Schebeske, C. Tritsch, M. Scheibe, C. Thomas, F. Meixner, E. Branceleoni, M. Frattoni, A. Neftel, P. Ciccioli, R. Koppmann, J. Kesselmeier
Biogenic VOC Exchange in a Mixed Forest Stand during the ECHO Field Campaign 2002
Gordon Research Conference on Biogenic Hydrocarbons & The Atmosphere, 1.-6. September 2002, Oxford, Großbritannien

12. T. Dindorf, T., Kuhn, U., Dindorf, W., Ammann, C., Chaparro, G., Knothe, N., Steindel, F., Tritsch, C., Scheibe, M., Brancaleoni, E., Frattoni, M., Ciccioli, P., and Kesselmeier, J.
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13. R. Dlugi, M. Zelger, M. Berger
    Effects of chemical reactions, clouds and convective precipitation on BVOC-emissions
    AGU Spring Meeting, Washington D.C., USA, 28. - 31. Mai 2002

14. R. Dlugi, M. Berger, M. Zelger, S. Rube
    Micrometeorological influences on mass transfer of BVOC's at the canopy-atmosphere interface
    AGU Fall Meeting, San Francisco, USA, 6. - 10. Dezember 2002

15. A. Folkers, R. Koppmann, J. Wildt
    Direct emission of methyvinylketone from Birch (betula pendula)
    AGU Fall Meeting, San Francisco, USA, 6. - 10. Dezember 2002

16. T. Hoffmann, J. Warnke, R. Bandur, S. Besche, B. Papke
    Emission and CHemical Tranformation of Biogenic Volatile Organic Compounds: Field studies on the chemical characterisation of tropospheric organic aerosols
    AFO 2000 Statusseminar, Schliersee, 7.- 9. Oktober 2002

17. A. Hofzumahaus, M. Siese, L. Rupp, J. Kleffmann, D. Mihelcic, F. Holland, E. Schlosser, H. Rongen
    HOx Radical Measurement during the ECHO Campaign 2003
    AGU Fall Meeting, San Francisco, USA, 8. - 12. Dezember 2003

18. C. Holzke, T. Hoffmann, R. Koppmann
    Diurnal and seasonal variation of terpene emissions from plants
    Jahrestagung der FESPP (Federation of European Societies of Plant Physiology),
    1.- 6. September 2002, Heraklion, Griechenland

19. C. Holzke, R. Koppmann
    Seasonality of Plant Terpene Emissions in a Deciduous Forest
    EGS-AGU-EUG Joint Assembly, Nizza, Frankreich, 6. - 11. April 2003

20. C. Holzke, R. Koppmann
    Terpene emissions from e deciduous forest - Variation of compound composition and emission rates
    AGU Fall Meeting, San Francisco, USA, 8. - 12. Dezember 2003

21. C. Holzke, C. Ammann, R. Bandur, J. Beauchamp, P. Ciccioli, T. Dindorf, J. Dommen, A. Folkers, M. Graus, A. Hansel, T. Hoffmann, T. Mentel, A. Neftel, C. Neubert, J. Kesselmeier, E. Kleist, N. Knothe, M. Komenda, R. Koppmann, U. Kuhn, A. Schaub, C. Spirig, R. Tillmann, J. Warnke, J. Wildt, A. Wisthaler
    Description and Results of VOC Intercomparison Experiments
    during the ECHO Project
    Frühjahrstagung der Deutschen Physikalischen Gesellschaft, München, 23.-25. März 2004

22. J. Kesselmeier, U. Kuhn, S. Rottenberger, T. Dindorf
    About the Complexity of the Exchange of Oxygenated Volatile Organic Compounds Between Vegetation and the Atmosphere
    Fall Meeting of the American Geophysical Union (AGU), San Francisco, USA, 5.-11. Dezember 2002

23. M. Komenda and the ECHO Team
    Overview of the ECHO Project: Emissions and Chemical Transformation of Biogenic Volatile Organic Compounds - Investigation in and above a Mixed Forest Stand
    EGS-AGU-EUG Joint Assembly, Nizza, Frankreich, 6. - 11. April 2003

24. M. Komenda and the ECHO Team
    Investigations of the Isoprene Oxidation at Ambient Concentrations inside the Atmosphere Simulation Chamber SAPHIR
    EGS-AGU-EUG Joint Assembly, Nizza, Frankreich, 6. - 11. April 2003

25. G. A. Kirkman, Ammann, C., Meixner, F.X.
    Surface boundary layer exchange of nitric oxide, nitrogen dioxide, and ozone over a Brazilian pasture
    American Meteorological Society's 15th Symposium on Boundary Layers and Turbulence, 15-19 July 2002, Wageningen, The Netherlands

26. M. Komenda, A. Schaub, and R. Koppmann
    Measurements of isoprene, methyl vinyl ketone, and methacrolein in and above a forest canopy during ECHO
    Gordon Research Conference on Biogenic Hydrocarbons & The Atmosphere, 1. - 6. September 2002, Oxford, Großbritannien

27. M. Komenda, A. Schaub, R. Koppmann
    Measurements of Isoprene, Methyl Vinyl Ketone, and Metacrolein in and above a Forest Canopy During ECHO
    10th Scientific Conference or the International Association of Atmospheric Sciences (IAMAS) Commission for Atmospheric Chemistry and Global Pollution and 7th Scientific Conference of the International Global Atmospheric Chemistry Project (IGAC), 18.-25. September 2002, Heraklion, Griechenland

28. M. Komenda and the ECHO-Team
    Emission and Chemical Transformation of Biogenic Volatile Organic Compounds - Investigations in and above a Mixed Forest Stand (ECHO)
    AFO 2000 Statusseminar, Schliersee, 7. - 9. Okotober 2002

29. M. Komenda and the ECHO Team
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    EGS-AGU-EUG Joint Assembly, Nizza, Frankreich, 6. - 11. April 2003

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    Investigations of the Isoprene Oxidation at Ambient Concentrations inside the Atmosphere Simulation Chamber SAPHIR
    EGS-AGU-EUG Joint Assembly, Nizza, Frankreich, 6. - 11. April 2003

31. R. Koppmann, T. Hoffmann, J. Kesselmeier, M. Schatzmann
    Emission and Chemical Transformation of Biogenic Volatile Organic Compounds (ECHO)
    EUROTRAC 2 Symposium 2002, 11.-15. März 2002, Garmisch-Partenkirchen

32. R. Koppmann, T. Hoffmann, J. Kesselmeier, M. Schatzmann
    Emission and Chemical Transformation of Biogenic Volatile Organic Compounds (ECHO)
    XXVII General Assembly of the European Geophysical Society, 21. - 26. April 2002, Nizza, Frankreich

33. R. Koppmann, F. Fiedler
    Earth surface-atmosphere interactions
    EGS-AGU-EUG Joint Assembly, Nizza, Frankreich, 6. - 11. April 2003

34. R. Koppmann, T. Hoffmann, J. Kesselmeier, M. Schatzmann
    Emission and Chemical Transformation of Biogenic Volatile Organic Compounds (ECHO)
    10th Scientific Conference or the International Association of Atmospheric Sciences (IAMAS) Commission for Atmospheric Chemistry and Global Pollution and 7th Scientific Conference of the International Global Atmospheric Chemistry Project (IGAC), 18.-25. September 2002, Heraklion, Griechenland

35. R. Koppmann and the ECHO-Team
    Emission and Chemical Transformation of Biogenic Volatile Organic Compounds - Investigations in and above a Mixed Forest Stand (ECHO): An Overview
    AFO 2000 Statusseminar, Schliersee, 7. - 9. Okotober 2002

36. R. Koppmann and the ECHO-Team
    Emission and Chemical Transformation of Biogenic Volatile Organic Compounds - Investigations in and above a Mixed Forest Stand (ECHO): Contribution of the Participating Research Groups
    AFO 2000 Statusseminar, Schliersee, 7. - 9. Okotober 2002

37. R. Koppmann, FZJ ECHO Team, J. Kesselmeier, F. X. Meixner, MPI ECHO Team, J. Warnke, T. Hoffmann, S. Aubrun, B. Leitl, M. Schatzmann, R. Dlugi, M. Zelger, J. Kleffmann, A. Neftel, A. Hansel, C. Thomas, B. Neininger
    Emission and chemical transformation of biogenic volatile organic compounds (ECHO) - Investigation in and above a mixed forest stand: An overview
    AGU Fall Meeting, San Francisco, USA, 8. - 12. Dezember 2003

38. R. Koppmann, D. Brüning, M. Komenda, F. Rohrer, A. Schaub
    Measurements of isoprene and its oxidation products during two years of the ECHO project
    EGU - 1st General Assembly, Nizza, Frankreich, 25.-30. April 2004

39. Kramm, G., Meixner, F.X.
    Segregation effects and their impact on chemical transformation rates and vertical fluxes of atmospheric trace constituents
    AGU Spring Meeting, , Washington, D.C., USA, 29. - 31. Mai 2002

40. G. Kramm, R. Dlugi, P. Werle
    Evaluation of conditional sampling techniques for measuring vertical fluxes of chemically reactive trace constituents
    AGU Spring Meeting, , Washington, D.C., USA, 29. - 31. Mai 2002

41. L. Lehmann, Meixner, F.X.
    Simultaneous measurements of concentration profiles of NO, N_2O, CO_2, CH_4 and ^{222}Rn in a forest soil in central Europe
    AGU Fall Meeting, San Francisco, USA, 8. - 12. Dezember 2003

42. Meixner, F.X., Ammann, C., Gatti, L.V., Gut, A., Kirkman, G.A., Rummel, U.
    Fluxes of nitrogen oxides and ozone over contrasting ecoysystems: An example from Rondônia, Brazil
    American Geophysical Union Spring Meeting, 29-31 May 2002, Washington, D.C., U.S.A.

43. Meixner, F.X., Ammann, A., Rummel, U., Gut, A., Andreae, M.O.
    The rain forest canopy reduction effect on NOx emissions
    7th Scientific Conference of the International Global Atmospheric Chemistry Project (IGAC), 22 September 2002, Creta Maris, Hersonissos, Crete, Greece

44. Meixner, F.X., Gut, A., van Dijk, S.M., Rummel, U., Ammann, C., Biogenic soil emission of nitric oxide from the rainforest floor: Five different methods applied
    EGS-AGU-EUG Joint Assembly, Nizza, Frankreich, 6. - 11. April 2003

45. B. Mittermaier, D. Klemp
    Speciated analysis of biogenic VOCs during the ECHo campaign
    EGU - 1st General Assembly, 25.-30. April 2004, Nizza, Frankreich

46. N. Mölders, D. Hinneburg, R. Dlugi, M. Zelger
    A parameterization for modeling dry deposition of reactive trace species in complex terrain
    AGU Spring Meeting, Washington D.C., USA, 28.- 31. Mai 2002

47. A. Neftel, C. Ammann, C., A. Schaub, M. Komenda, R. Koppmann, A. Wisthaler, A. Hansel
    The use of Proton Transfer Mass Spectrometry to measure ambient VOC concentrations
    Gordon Research Conference on Biogenic Hydrocarbons & The Atmosphere, 1. - 6. September 2002, Oxford, Großbritannien

48. S. Rodiguez Bares, T. Brauers, A. Hofzumahaus, F. Holland, F. Rohrer, R. Koppmann, L. Rupp, R. Tillmann, A. Wahner
    Investigation of the Ozonolysis of a Series of Alkenes in the Atmosphere Simulation Chamber SAPHIR
    EGS-AGU-EUG Joint Assembly, Nizza, Frankreich, 6. - 11. April 2003

49. Rummel, U., Ammann, C., Meixner, F.X., Characterizing turbulent trace gas exchange above a dense tropical rain forest using wavelet and surface renewal analysis, American Meteorological Society's 15th Symposium on Boundary Layers and Turbulence, 15-19 July 2002, Wageningen, The Netherlands

50. L. Rupp, M. Siese, J. Kleffmann, T. Gavrilolai, A. Hofzumahaus, E. Schlosser, F. Holland
    HOx- und HONO-Konzentrationen in und über einem Mischwaldbestand - Ergebnisse der ECHO Feldmesskampagne 2003
    Frühjahrstagung der Deutschen Physikalischen Gesellschaft, München, 23.-25. März 2004

51. A. Schaub, M. Komenda, and R. Koppmann
    Description of the ECHO field site: Ecosystem compartments of a mixed deciduous forest and their implication for atmospheric chemistry

Gordon Research Conference on Biogenic Hydrocarbons & The Atmosphere, 1. - 6. September 2002, Oxford, Großbritannien

52. A. Schaub, M. Komenda, C. Holzke, R. Koppmann
Vertical distribution of isoprene and its oxidation products in a mixed forest stand during the ECHO campaign in summer 2002
Botaniker-Tagung, 22.-27. September 2002, Freiburg

53. A. Schaub, M. Komenda, R. Koppmann
Measurement of isoprene and its oxidation products in a mixed decidious forest - first results of the ECHO-campaign
EGS-AGU-EUG Joint Assembly, Nizza, Frankreich, 6. - 11. April 2003

54. A. Schaub, M. Komenda, R. Koppmann
Photochemistry in a mixed diciduous forest: First results of the measurements of isoprene and its oxidation products during two years of the ECHO project
AGU Fall Meeting, San Francisco, USA, 8. - 12. Dezember 2003

55. G. Spindler, Ashuri, F., Brüggemann, E., Grüner, A., Herrmann, H., Meixner, F.X., Trebs, I., Long-term study of the atmosphere-biosphere exchange of reactive reduced and oxidized N-species at the Melpitz site (Germany), 7th Scientific Conference of the International Global Atmospheric Chemistry Project (IGAC), 18-25 September 2002, Creta Maris, Hersonissos, Crete, Greece

56. I. Schlüter, R. Koppmann, K. H. Schlünzen
Simulation des Transports biogener Emissionen in und über einem Waldbestand mit einem mikroskaligen Modell
Deutsch-Österreichisch-Schweizerische Meteorologen-Tagung, Karlsruhe, 7. - 10. September 2004

57. C. Spirig, A. Neftel, C. Ammann, W. Grabmer, J. Beauchamp, A. Hansel, A. Wisthaler, A. Schaub, J. Dommen, A. Thielmann
Flux and profile measurements of VOCs by PTR-MS at a deciduous forest site
EGU - 1st General Assembly, Nizza, Frankreich, 25.-30. April 2004

58. C. Spirig, A. Neftel, C. Ammann, J. Dommen, J. Wildt
Biogenic VOC fluxes during the ECHO 2003 Intensive campaign
Gordon Research Conference on Biogenic Hydrocarbons & The Atmosphere, Il Ciocco, Italien, 1.-8. Mai, 2004

59. A. Thielmann, Chaparro, G., Kuhn, U., Dindorf, T., Lehmann, L., Kortner, M., Tritsch, C., Kesselmeier, J., Meixner, F.
Uptake of Nitrogen Dioxide by Quercus robur - is There a Compensation Point?
AGU Fall Meeting, San Francisco, USA, 8. - 12. Dezember 2003

60. C. Thomas, J.-C. Mayer, F.X. Meixner, T. Foken
Detection of coherent structures in high frequent time series of a monostatic Sodar-Rass system
12th International Symposium on Acoustic Remote Sensing, British Antarctic Survey, Cambridge, UK, 11. - 16. Juli 2004

61. J. Warnke, T. Kühn , R. Bandur, T. Hoffmann (2002): Capillary-HPLC-ESI-MS/MS-Analysis of Acidic Compounds in Tropospheric Aerosols, European Conference of Analytical Chemistry (Euroanalysis), Dortmund (Germany) 8-13 September 2002

62. J. Warnke, B. Papke, T. Kühn , R. Bandur, T. Hoffmann (2002): Chemical Characterisation of Organic Aerosol Particles by LC/MS, Atmospheric chemistry within the Earth System: from regional pollution to global change. IGAC-CACGP Scientific Conference, Crete (Greece) 18-25 September 2002

63. R. Winkler, H. Zock, R. Koppmann
    The German Atmospheric Research Programme of the Federal Ministry of Education and Research (AFO 2000)
    XXVII General Assembly of the European Geophysical Society, 21. - 26. April 2002, Nizza, Frankreich

64. J. Warnke, T. Kühn , R. Bandur, T. Hoffmann
    Capillary-HPLC-ESI-MS/MS-Analysis of Acidic Compounds in Tropospheric Aerosols, European Conference of Analytical Chemistry (Euroanalysis)
    Dortmund, 8 - 13 September 2002

65. J. Warnke, B. Papke, T. Kühn , R. Bandur, T. Hoffmann
    Chemical Characterisation of Organic Aerosol Particles by LC/MS, Atmospheric chemistry within the Earth System: from regional pollution to global change
    IGAC-CACGP Scientific Conference, Crete (Greece) 18-25 September 2002

66. T. Hoffmann, J. Warnke, R. Bandur, S. Besche, B. Papke
    Emission and CHemical Tranformation of Biogenic Volatile Organic Compounds: Field studies on the chemical characterisation of tropospheric organic aerosols
    AFO 2000 Statusseminar, Schliersee, 7.- 9. Oktober 2002

67. J. Warnke, R. Bandur, T. Kühn, T. Hoffmann
    Identifizierung und Quantifizierung von sauren Monoterpen-Oxidationsprodukten im atmosphärischen Aerosol mittels Kapillar-HPLC-ESI-MS/MS
    36. Diskussionstagung der DGMS, Münster, 9. - 12. März 2003

68. J. Warnke, R. Bandur, and T. Hoffmann
    Characterisation of boreal forest aerosols by HPLC/MS
    European Aerosol Conference EAC 03, Madrid, Spain, August 31 - September 5, 2003

69. J. Warnke, R. Bandur, A. Grundmann, T. Kühn, T. Hoffmann
    Quantification of biogenic tracer compounds in organic aerosol particles by LC/MS in Central Europe
    European Geoscience Union, 1st General Assembly, Nice, France, April 25-30, 2004

SELECTED PRESENTATIONS OF THE ECHO PROJECT

AFO 2000 Abschlusssymposium, Bad Tölz, 22.-24. März 2004 - Poster

Emission and CHemical Transformation of Biogenic Volatile Organic Compounds - Investigations in and above a Mixed Forest Stand (ECHO): An Overview

Ralf Koppmann and the ECHO-Team
JPEG Preview (117kB), PDF Format (~1,6MB)

Emission and CHemical Transformation of Biogenic Volatile Organic Compounds - Investigations in and above a Mixed Forest Stand (ECHO)
Ralf Koppmann and the ECHO-Team
JPEG Preview (131kB), PDF Format (~1,6MB)

Emission and CHemical Transformation of Biogenic Volatile Organic Compounds - Investigations in and above a Mixed Forest Stand (ECHO): Contribution of the Participating Research Groups
Ralf Koppmann and the ECHO Team
JPEG Preview (124kB), PDF Format (~1,7MB)

Emission and CHemical Transformation of Biogenic Volatile Organic Compounds (ECHO): Investigations of primary emissions and fluxes of volatile organic compounds (VOC) and nitrogen oxides (NOx) within and above vegetations stands
Jürgen Kesselmeier; Franz X. Meixner, and the ECHO Team
JPEG Preview (131kB), PDF Format (~1,5MB)

Emission and CHemical Transformation of Biogenic Volatile Organic Compounds (ECHO): Field studies on the chemical characterisation of tropospheric organic aerosols
Thorsten Hoffmann, Rolf Bandur, Susanne Besche, Anke Grundmann, Thorsten Kühn, Björn Papke, Jörg Warnke, Ralph Dlugi, Michael Zelger
JPEG Preview (116kB), PDF Format (~1,4MB)

Emission and CHemical Transformation of Biogenic Volatile Organic Compounds (ECHO): Wind Tunnel Experiments
Sandrine Aubrun; Bernd Leitl, Michael Schatzmann
JPEG Preview (129kB), PDF Format (~1,7MB)

AFO 2000 Abschlusssymposium, Bad Tölz, 22.-24. März 2004 - Talks

Emission and CHemical Transformation of Biogenic Volatile Organic Compounds (ECHO): Quantitative Beschreibung der Nettoemissionen reaktiver Spurengase aus einem Mischwaldbestand in die Troposphäre
Ralf Koppmann
Download ZIP file (~2,0MB), PDF Format (~3,7MB)

AFO-DEKLIM - Übergreifende Fragen
Ralf Koppmann
Download ZIP file (953kB), PDF Format (~1,2MB)

AFO 2000 Statusseminar, Schliersee, 7.-10. Oktober 2002 - Poster

Emission and CHemical Transformation of Biogenic Volatile Organic Compounds - Investigations in and above a Mixed Forest Stand (ECHO): An Overview
Ralf Koppmann and the ECHO-Team
JPEG Preview (126kB), PDF Format (~32MB)

Emission and CHemical Transformation of Biogenic Volatile Organic Compounds - Investigations in and above a Mixed Forest Stand (ECHO)
Michael Komenda and the ECHO-Team
JPEG Preview (124kB), PDF Format (~10MB)

Emission and CHemical Transformation of Biogenic Volatile Organic Compounds - Investigations in and above a Mixed Forest Stand (ECHO): Contribution of the Participating Research Groups
Ralf Koppmann and the ECHO Team
JPEG Preview (132kB), PDF Format (~13MB)

Emission and CHemical Transformation of Biogenic Volatile Organic Compounds (ECHO): Combined studies of primary emissions and fluxes of volatile organic compounds (VOC) and nitrogen oxides (NOx) within and above vegetation
Jürgen Kesselmeier; Franz X. Meixner, and the ECHO Team
JPEG Preview (134kB), PDF Format (~17MB)

Emission and CHemical Transformation of Biogenic Volatile Organic Compounds (ECHO): Field studies on the chemical characterisation of tropospheric organic aerosols
Thorsten Hoffmann; Jörg Warnke, Rolf Bandur
JPEG Preview (121kB), PDF Format (~10MB)

Emission and CHemical Transformation of Biogenic Volatile Organic Compounds (ECHO): Wind Tunnel Experiments
Sandrine Aubrun; Bernd Leitl, Michael Schatzmann
JPEG Preview (139kB), PDF Format (~58MB)

7th Scientific Conference of the International Global Atmospheric Chemistry Project (IGAC)

September 18.-25. 2002, Crete - Poster

Measurements of isoprene, methyl vinyl ketone, and methacrolein in and above a forest canopy during ECHO
M. Komenda, A. Schaub, and R. Koppmann
JPEG Preview (217kB), PDF Format (~1,7MB)
Emission and CHemical Transformation of Biogenic Volatile Organic Compounds - ECHO
R. Koppmann, T. Hoffmann, J. Kesselmeier, and M. Schatzmann
JPEG Preview (173kB), PDF Format (~22MB)

Gordon Research Conference on Biogenic Hydrocarbons & The Atmosphere 2002

1. - 6. September 2002, Oxford, Großbritannien - Poster

Measurements of isoprene, methyl vinyl ketone, and methacrolein in and above a forest canopy during *ECHO*

M. Komenda, A. Schaub, and R. Koppmann
PDF-Format, ~3,4 MB

Description of the ECHO-Fiels site: Ecosystem compartments of a mixed decidious forest andtheir implication for atmospheric chemistry *ECHO*
A. Schaub, M. Komenda, and R. Koppmann
PDF-Format, ~3,4 MB

Biogenic VOC exchange in a mixed forest stand during the *ECHO* field campaign 2002
Tamara Dindorf et al.
PDF-Format, 680 kB

The use of Proton Transfer Mass Spectrometry to measure ambient VOC concentrations
Albrecht Neftel et al.
PDF-Format, 532 kB

EUROTRAC 2 Symposium 2002, 11.-15. März 2002, Garmisch-Partenkirchen - Poster

Physical Modelling of Biogenic Emissions from a Forest Area
S. Aubrun, B. Leitl, M. Schatzmann
PDF-Format, ~3,8 MB / download ZIP-Format ~2,8 MB

Emission and CHemical Transformation of Biogenic Volatile Organic Compounds - ECHO
R. Koppmann, T. Hoffmann, J. Kesselmeier, and M. Schatzmann
PDF-Format, ~1 MB / download ZIP-Format ~800 kB

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AFO2000-Newsletter No. 5, Dezember 2003