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Air pollution research report 83

# European Conference on Aviation, Atmosphere and Climate (AAC)

*Proceedings of an International Conference*

Friedrichshafen, Germany, 30 June to 3 July 2003



*Edited by*

Robert Sausen, Christine Fichter and Georgios Amanatidis



The photograph for the AAC-Logo was provided by C. König ([www.bvbk.de](http://www.bvbk.de)).

## Foreword

The "European Conference on Aviation, Atmosphere and Climate (AAC)" in Friedrichshafen (Lake Constance, Germany) 2003 was initiated by the European Commission, Directorate General Research. The conference was organised with the objective of updating our knowledge on the atmospheric impact of aviation, four years after the publication of the 1999 IPCC Special Report "Aviation and the Global Atmosphere" and three years after the European workshop "Aviation, Aerosols, Contrails and Cirrus Clouds (A<sup>2</sup>C<sup>3</sup>)" in Seeheim, Germany.

During the recent years many European projects (e.g. AEROCHEM-2, TRADEOFF, PARTEMIS, MOZAIC, AERO2K, SCENIC, INCA) and many national projects have been devoted to increase our knowledge with respect to the topic of the AAC conference. Significant scientific progress has been achieved: the aviation impact on the atmospheric concentrations of ozone and methane and their uncertainties have been better quantified; a consistent quantification of the radiative forcing from linear contrails has been provided; the interaction between aerosols emitted by aircraft and clouds is now better understood; first quantitative estimates of the radiative forcing from contrail cirrus are now available; and we learned about mitigation of aircraft effects on climate.

Despite the progress made, many open questions remain. For instance, how large is the radiative forcing index for aviation, now that first estimates of the effect from contrail cirrus are available? How large is the aviation impact on atmosphere and climate compared with other modes of transport?

115 participants attended the AAC conference and there were 50 oral and 27 poster presentations. Extended abstracts of most of the presentations are included in this book of proceedings. Many of the papers will be revised and after peer review be published in a special issue of the journal *Meteorologische Zeitschrift*.

I am confident that the outcome of this conference will be useful for scientific community and other stakeholders. Sincere thanks are due to my colleagues G. Amanatidis, C. Fichter and R. Sausen for organising this important event.

Anver Ghazi  
Head, Global Change Unit  
Research DG, European Commission  
Brussels

## **Programme Committee**

Prof. Robert Sausen (chair), Deutsches DLR - Oberpfaffenhofen, Germany  
Dr. Georgios Amanatidis, European Commission, Brussels, Belgium  
Winfried Dewes, DLR-Buro Brussels, Co-ordinator AERONET, Belgium  
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Dr. Helen Rogers, University of Cambridge, Cambridge, United Kingdom  
Dr. Claudia Stubenrauch, Laboratoire de Meteorologie Dynamique, France

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## Conference Agenda

### Sunday, 29.06.2003

18:00 – 20:00 Registration

### Monday, 30.06.2003

09:00 Registration

10:00 Sausen, R: Welcome and Information

#### **Engine emissions and plume processes (1)**

**Chair: Paul Madden**

10:20 Gleitsmann G, Somnitz H, Zellner R: Novel rates of OH induced sulfur oxidation implications to the plume chemistry of jet aircraft

10:40 Wahl C, Kapernaum M, Krüger V, Rainer P, Aigner M: Determination of soot mass fraction soot density and soot fractal character in flame exhaust gases

11:00 *Coffee break*

11:20 Anderson B E, Winstead E L, Hudgins C H, Branham S, Plant J V, Thornhill K L: Overview of results from the NASA experiment to characterize aircraft volatile aerosol and trace species emissions (EXCAVATE)

12:00 Miake-Lye R C, Zaccardi V: SAE E-31 committee on aircraft exhaust emission measurements and an aerospace information report on the measurement of non-volatile Particle Emissions

12:20 Sorokin A, Katragkou E, Arnold F, Busen R, Schumann U: SO<sub>3</sub> and H<sub>2</sub>SO<sub>4</sub> in exhaust of an aircraft engine: Measurements and implications for fuel sulfur conversion to S(VI) and SO<sub>3</sub> to H<sub>2</sub>SO<sub>4</sub>

12:40 *Lunch break*

#### **Engine emissions and plume processes (2)**

**Chair: Ulrich Schumann**

14:00 Schumann U: Welcome, Aeronautic Research at DLR

Ghazi A: Welcome, Perspective EU, Environment and Aviation

14:40 Petzold A, Wilson C W, Arnold F, Baltensperger U, Fiebig M, Fritzsche L, Giebl H, Gysel M, Hitzenberger R, Hurley C D, Katragkou E, Kurtenbach R, Madden P, Nyeki S, Puxbaum H, Schumann U, Stein C, Vrhoticky S, Wahl C, Wiesen P: Particle emissions from aircraft engines - An overview of the european project PARTEMIS

15:20 Kurtenbach R, Kapernaum M, Lörzer J, Niedojadlo A, Petrea M, Wahl C, Wiesen P: Emission of non-methane volatile organic compounds (NMVOCs) from a jet engine combustor and a Hot End Simulator (HES) during the PARTEMIS project

15:40 Goos E, Braun-Unkhoff M, Slavinskaya N, Frank P: Modeling of soot precursor formation in laminar premixed flames with C1- C2- and C6-Fuels

16:00 *Coffee break*

#### **Engine emissions and plume processes (3)**

**Chair: Karlheinz Haag**

16:20 Lee D S, Sun C-G, Cooper M, Snape C, Wilson C: Stable carbon isotope signatures of aircraft particles

16:40 Vancassel X, Sorokin A, Mirabel P: Modelling of volatile particles during PARTEMIS

- 17:00 Garnier F, Ferreira-Gago C, Brasseur A L, Uthéza F, Paoli R, Cuenot B: Growing and dispersion of particles in a turbulent exhaust plume
- 17:20 Plumb I, Randeniya L, Vohralik P, Baughcum S L: The effect of plume processes on aircraft impact
- 17:40 Wilson, C W: Aviation fuels - Where are we going and why?
- 18:00 *Break*
- 19:00 *Ice-breaking reception in the Zeppelin museum*

## **Tuesday, 01.07.2003**

### **Transport and impact on chemical composition (1)**

**Chair: David S. Lee**

- 09:00 Crowther R, Law K, Pyle J, Nedelec P, Smit H, Volz-Thomas, A: NO<sub>y</sub> in the UT/LS: A source attribution study utilising MOZAIC measurements
- 09:20 Isaksen I S A: The TRADEOFF project: Goals and achievements
- 09:50 Brunner D, Staehelin J, Hauglustaine D, Jourdain L, Rogers H L, Koehler M O, Pyle J A, Berntsen T K, Gauss M, Meijer E, van Velthoven P, Grewe V, Sausen R, Pitari G, Mancini E, Isaksen I S A: On the quality of chemistry-transport simulations in the upper troposphere/lower stratosphere region
- 10:10 Grewe V: Lightning NO<sub>x</sub> emissions and the impact on the effect of aircraft emissions - Results from the EU-project TRADEOFF
- 10:30 *Coffee break*

### **Transport and impact on chemical composition (2)**

**Chair: Georgios Amanatidis**

- 10:50 Hauglustaine D, Stordal F, Myhre G, Gauss M, Berntsen T, Isaksen I: Impact of present-day and future subsonic aircraft emissions on tropospheric ozone and associated radiative forcing of climate
- 11:10 Gauss M, Köhler M, Grewe V: Impact of aircraft NO<sub>x</sub> emissions: Effects of changing the flight altitude
- 11:30 Meijer E, Van Velthoven P, Bregman B, Seger A, Brunner D: Improved mass fluxes in a global chemistry-transport model: implications for upper tropospheric chemistry
- 11:50 Rodriguez J M, Logan J A, Rotman D A, Bergmann D, Baughcum S L, Friedl R R, Anderson D E: Activities of NASA's Global Modeling Initiative (GMI) in the assessment of subsonic aircraft impact
- 12:30 *Lunch break*

### **Transport and impact on chemical composition (3)**

**Chair: Ivar Isaksen**

- 13:50 Wuebbles D J, Dutta Mayurakshi P, Kenneth O, Baughcum S L: Parametric study of potential effects of aircraft emissions on stratospheric ozone
- 14:10 Baughcum S, Plumb I, Vohralik P: Stratospheric ozone sensitivity to aircraft cruise altitudes and NO<sub>x</sub> emissions
- 14:30 Stubenrauch C: Introduction to Poster Session 1
- 14:55 *Poster Session 1 (Engine emissions and plume processes, Transport and impact on chemical composition)*

- 17:20 Brennkmeijer C, Slemr F, Zahn A, Fischer H, Hermann M, Heintzenberg J, Schlager H, Ziereis H: Investigating the global atmosphere by using commercial aircraft: CARIBIC and MOZAIC
- 17:40 Gossling S: The importance of aviation for tourism: Status and trends
- 18:00 *end of sessions*

### **Wednesday, 02.07.2003**

#### **Transport and impact on chemical composition (4)**

**Chair: Philippe Mirabel**

- 09:00 Dessens O, Rogers H, Pyle J, all SCENIC-project members: The SCENIC project: presentation and first results
- 09:20 Pitari G, Mancini E, Rogers H, Dessens O, Isaksen I, Rognerud B: A 3D model intercomparison of the effects of future supersonic aircraft on the chemical composition of the stratosphere

#### **Particles and clouds (1)**

**Chair: Philippe Mirabel**

- 09:40 Kärcher B, Schumann U, Aigner M, Schurath U, Schrems O, Sausen R, Kruse H, Schiller C, Borrmann S, Arnold F, Feichter J, Lohmann U, Ström J, Rother T, Brinkop S, Busen R, Flentje H, Gierens K, Graf J, Haag W, Hendricks J, Mannstein H, Petzold A, Wendling P, Frank P, Gerlinger P, Noll B, Stricker W, Wahl C, Möhler O, Schaefers S, Stetzer S, Immler F, Döpelheuer A, Krämer M, Mangold A, Wollny A, Schneider J, Wilhelm S, Aufmhoff H, Timmreck C: Particles and cirrus clouds (PAZI) - Overview of results 2000-2003
- 10:20 *Coffee break*
- 10:40 Arnold F: Upper tropospheric aerosol formation inside and outside aircraft wakes: new findings from mass spectrometric measurements of gaseous and ionic aerosol precursors and very small aerosols
- 11:10 Baumgardner D, Kok G, Raga G, Diskin G, Sachse G: Single particle black carbon measurements in the UT/LS
- 11:30 Suzanne J, Ferry D, Popovicheva O B, Shonija N K: Ice-nucleating ability of soot particles in UT/LS
- 11:50 Möhler O, Schnaiter M, Wagner R, Schurath U, Mangold A, Krämer M: Experimental investigation of homogeneous and heterogeneous freezing processes at simulated UTLS conditions
- 12:10 Monier M, Wobrock W, Flossmann A: Detailed modelling of cirrus cloud - An intercomparison of different approaches for homogeneous nucleation

12:30 *Lunch break*

#### **Particles and clouds (2)**

**Chair: Corinne Marizy**

- 13:50 Friedl R, WB-57 CRYSTAL-FACE science team: Overview of contrail and cirrus cloud measurements from the WB-57 aircraft in the CRYSTAL-FACE mission
- 14:10 Minnis P, Garber D P, Nguyen L, Duda D P, Palikonda R: Simulation of contrail coverage over the USA missed during the air traffic shutdown
- 14:40 Duda D P, Minnis P, Costulis P K, Palikonda R: CONUS contrail frequency estimated from RUC and flight track data
- 15:00 Danilin M Y, Baughcum S L, Read W G: Contrail properties derived from UARS MLS measurements

- 15:20 *Poster Session 2 (Particles and Clouds, Mitigation)*
- 16:30 Mannstein H: Observations of contrails and cirrus over Europe
- 17:00 Zerefos C, Eleftheratos K, Zanis P, Balis D, Stordal F, Myhre G: Updated perturbations on cirrus and contrail cirrus
- 17:20 Penner J, Liu X: Potential alteration of ice clouds by aircraft soot
- 17:40 *Break*
- 19:30 *boarding: Ship Cruise on Lake Constance with Dinner*

### **Thursday, 03.07.2003**

#### **Particles and clouds (3)**

**Chair: Winfried Dewes**

- 09:00 Hendricks J, Kärcher B, Döpelheuer A, Feichter J, Lohmann U: Potential impact of aviation-induced black carbon on cirrus clouds: Global model studies with the ECHAM GCM
- 09:20 Marquart S, Ponater M, Mager F, Sausen R: Future development of contrail cover optical depth and radiative forcing: Impacts of increasing air traffic and climate change
- 09:40 Guldberg A: A studie of contrails in a general circulation model
- 10:00 *Coffee break*

#### **Mitigation**

**Chair: Winfried Dewes**

- 10:20 Ponater M, Marquart S, Ström L, Sausen R, Gierens K, Hüttig G: On the potential of the cryoplane option to reduce aircraft climate impact
- 10:40 Lee D S, Sausen R, Marquart S, Fichter C, Norman P: Tradeoffs in contrail and CO<sub>2</sub> radiative forcing by altered cruise altitudes
- 11:00 Noland R, Toumi R, Williams V: Policies for mitigating contrail formation from aircraft
- 11:20 Green, J: Greener by Design
- 11:50 *Lunch break*

#### **Summary and Outlook**

**Chair: Robert Sausen**

- 13:30 Schumann, U: What did we learn?
- 14:10 Discussion
- 14:40 Sausen, R.: Homework and Good Bye
- 15:00 *end of conference*

### **Poster Sessions**

#### **1. Engine Emissions and Plume Processes/Transport and Impact on Chemical Composition**

Hitzenberger R, Giebl H, Petzold A, Gysel M, Nyeki S, Weingartner E, Baltensperger U, Wilson C W: CCN activation of jet engine combustion particles during PARTEMIS

Worsnop D R, Miake-Lye R, Boudries H, Wormhoudt J, Anderson B: Gas and aerosol chemistry of commercial aircraft emissions measured in the NASA EXCAVATE experiment

Katragkou E, Wilhelm S, Arnold F, Wilson C W: Sulfur (VI) in the simulated internal flow of an aircraft gas turbine engine: first measurements during the PARTEMIS project

- Fiebig M, Fritzsche L, Stein C, Nyeki S, Petzold A: Emission of volatile and non-volatile ultrafine particles from a combustion source during PARTEMIS
- Sorokin A, Vancassel X, Mirabel P: Kinetics of binary nucleation in aircraft exhaust plume
- Garber D P, Minnis P, Costulis P K: A USA commercial flight track database for upper tropospheric aircraft emission studies
- Hayashi S, Yamada, H, Takazawa K, Makida M, Kurosawa Y: Interaction of NO and ice crystals produced from combustion generated water vapor in a simulated jet engine exhaust gas plume
- Geigle K P, Schneider-Kühnle Y, Krüger V, Tsurikov M, Lücknerath R, Braun-Unkloff M, Slavinskaya N, Frank P, Stricker W, Aigner M: Validation of the kinetic soot model: An experimental and theoretical study on soot formation using LII and shifted vibrational CARS
- Gysel M, Nyeki S, Weingartner E, Baltensperger U, Giebl H, Hitzenberger R, Petzold A, Wilson C W: Jet engine combustion particle hygroscopicity under subsaturated conditions during PARTEMIS
- Bukovnik M, Kalivoda M: AvioMEET inventory tool and its applications
- Leigh P, MacKenzie R, Borrmann S: Air parcel trajectories in the south european UTLS: implications for the impact of air traffic emissions
- Gauss M, Isaksen I, Lee D: The impact of aircraft on the chemical composition of the atmosphere and options for reducing the impact A 3D CTM model study
- Köhler M O, Rogers H L, Pyle J A: Modelling the impact of subsonic aircraft emissions on ozone
- Krämer M, Beuermann J, Schiller C, Grimm F, Arnold F, Peter T, Meilinger S, Meier A, Hendricks J, Petzold A, Schlager H: Uptake of nitric acid in cirrus clouds
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## **Extended Abstracts**

