Scientific Publishing with pdfLaTeX

Activities of the *Copernicus* Society

Patrick W Daly *Arne K Richter*

Introduction

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The goal of the publishing house ***Copernicus***, serving primarily scientific, non-profit associations, is *free-to-read and free-to-publish* for the electronic versions of all scientific publications.

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- Universal Text Formatting Software
  - Instead of using additional software components, such as QuarkXpress or In-Design, one can use LaTeX directly for formatting any typeset/composed and edited article in the required document class and layout.

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  - or offset printing machines (computer-to-plate technology).

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- While transforming an article in *Word* into PDF can be cumbersome, even leading to server deformations of figures, pdfLaTeX supports this in a straight forward way.

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This reduces the overall production time for a scientific article by a factor of 5-10 over other typesetting, formatting and printing procedures, reducing the overall production costs considerably.

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- The entire management of more than 15,000 abstracts submitted to the Joint EGS-AGU-EUG Assembly 2003 could be handled by only 1.75 ***Copernicus*** staff members in less than a week's time.

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The two most important ones are

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- It takes 4-10 times longer to edit a well-sized document in *Word* rather than in LaTeX with the editing software developed by ***Copernicus*** based on pdfLaTeX.

LaTeX-to-HTML

- For the scientific associations and learned societies using ***Copernicus*** as their back-office, ***Copernicus*** has compiled a *Central Online + Open-access Library* (COOL) for their publications, including a reference library and an online reference catalogue.

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Established by the Councils of the
European Geophysical Society (EGS) ***and***
European Union of Geosciences (EUG)
on 7 September 2002

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- Committees
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Meetings

- General Assemblies
  - General Information
  - EGU 2004
  - Previous Assemblies
  - Future Assemblies
- Topical Conferences
  - General Information & List of Topical Conferences
- Short Course
  - General Information & List of Short Courses
- Sponsored & other forthcoming Meetings
  - Meeting Calendar
  - Co-Sponsoring Request Forum

Publications

- General Information

- Newsletter - the eggs
- Geophysical Research Abstracts
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CLUSTER/RAPID PARTICLE DISTRIBUTIONS FROM TAIL CROSSING OF 2001 AUG 22

P. W. Daly (1), U. Mall (1), J. F. Fennell (2), R. Friedel (3), C. H. Perry(4)

(1) Max-Planck-Institut für Aeronomie, Lindau, Germany, (2) Aerospace Corporation, Los Angeles, USA, (3) Los Alamos National Lab, Los Alamos, USA, (4) Rutherford Appleton Lab,UK (contact email daly@linmpi.mpg.de)

On August 22, 2001, the Cluster spacecraft crossed the magnetotail, observing several examples of plasma flow reversals, and flux ropes. The RAPID energetic particle spectrometer (electrons >20 keV, ions >30 keV) was in a particularly opportune state for observing 3-D ion distributions. We present RAPID data from these events from 4 spacecraft, illustrating how a 3-D interpretation of the temporal changes may be accomplished.

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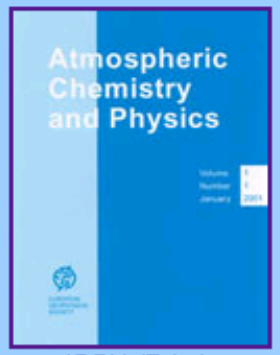

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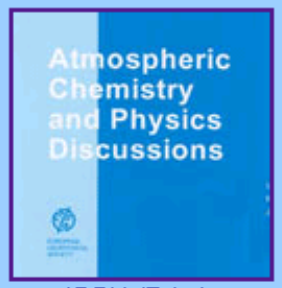

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- **foster scientific discussion;**
- **enhance the effectiveness and transparency of scientific quality control;**
- **enable rapid publication;**
- **make scientific publications freely accessible.**

In the first stage, papers that pass a rapid access peer-review are immediately published on the *Atmospheric Chemistry and Physics Discussions* (ACPD) website. They are then subject to interactive public discussion, during which the referees' comments (anonymous or attributed), additional short comments by other members of the scientific community (attributed) and the authors' replies are also published in ACPD. In the second stage, the peer-review process is completed and final revised papers are published in ACP. To ensure publication precedence for authors, and to provide a lasting record of scientific discussion, ACPD and ACP are both ISSN-registered, permanently archived and fully citable. For more information see About ACP and FAQs.

General Information

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- Publication Statistics
- Publicity and Background Information
- Site Index

Publications (Search, Browse, Download)

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- *Atmospheric Chemistry and Physics Discussions* (ACPD)

ACP - Manuscript preparation: Technical instructions for LaTeX

Please use the ACP LaTeX macro package to prepare your manuscript as described below. The package contains example files that can be run directly with LaTeX. In addition, there is a template file that contains an empty framework into which you can enter your own text. You can download the whole package here as a **zip** or **tar.gz** archive.

- **example1.tex** is for articles without any figures.
- **example2.tex** and **template.tex** are for articles with included figures. This template will be suitable for most authors. To include graphics, the standard LaTeX package "graphicx" is used. Vector graphics (graphs etc.) should be provided in encapsulated postscript (eps) or pdf format. Photos and drawings should be in png, jpg, or pdf format.

The other files in the package are needed by LaTeX but you will not have to edit them yourself.

First steps

After installing a working LaTeX distribution you will be able to run LaTeX by typing "pdflatex example1.tex" in the appropriate directory from the prompt. This will produce a pdf-file of your manuscript (example1.pdf) which can be viewed using Adobe Acrobat Reader. example1.tex is an example file provided by the EGS to introduce you to the style for ACP (see below). If you want to make changes to example1.tex open it in your favorite text editor (Emacs, Notepad, or WinEdt etc.). Now you can add extra text, formulas etc. Afterwards save the file, run "pdflatex example1.tex" again and you will be able to look at the changes in the new file example1.pdf.

Authors who wish to use LaTeX but are not familiar with it should first read the "Getting started with LaTeX" or the "Not so Short Introduction to LaTeX2e".

Hints for experienced LaTeX users

- If you are familiar with BibTeX, you can use egs.bst from the package. It will sort your bibliography entries alphabetically and produce the correct layout of the list of references. Don't forget to submit your *.bbl file when you use BibTeX.
- Very detailed information about the inclusion of graphics into LaTeX can be found in the article "Using Imported Graphics in LaTeX2e".
- The EGS office will use the program pdfLaTeX (which is included in recent LaTeX distributions) to convert your manuscript into pdf. If your LaTeX code runs through "regular" LaTeX2e without any errors, you can assume that the production of the pdf file will cause no problems.

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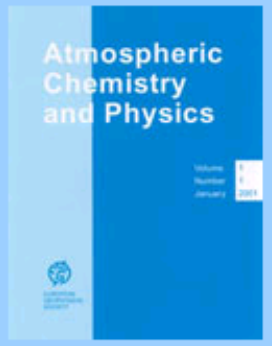

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Recent Final Revised Papers

The final revised papers published in *Atmospheric Chemistry and Physics* (ACP) have emerged from a two-stage process of peer-review and public discussion in *Atmospheric Chemistry and Physics Discussions* (ACPD), the discussion forum and first publication stage of ACP. For each paper the original version and its interactive discussion including referees' comments and authors' replies are directly accessible via the link "Discussion Paper". For more information see the ACP Homepage. In case of problems with online viewing, download the PDF file and open it with Acrobat Reader Version 4 or higher.

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Volume 3 (Atmos. Chem. Phys., 3, 2003)			
Ice condensation on sulfuric acid tetrahydrate: Implications for polar stratospheric ice clouds T. J. Fortin, K. Drdla, L. T. Iraci, and M. A. Tolbert	987-997	09.07.2003	Abstract (HTML, 5 KB) Full Text (PDF, 1631 KB) Discussion Paper (ACPD)
Rapid intercontinental air pollution transport associated with a	969-985	09.07.2003	Abstract (HTML, 5 KB)

Accounting for local meteorological effects in the ozone time-series of Lovozero (Kola Peninsula) O. A. Tarasova and A. Yu. Karpetchko	941-949	07.07.2003	Abstract (HTML, 5 KB) Full Text (PDF, 532 KB) Discussion Paper (ACPD)
Ground-based PTR-MS measurements of reactive organic compounds during the MINOS campaign in Crete, July–August 2001 G. Salisbury, J. Williams, R. Holzinger, V. Gros, N. Mihalopoulos, M. Vrekoussis, R. Sarda-Estève, H. Berresheim, R. von Kuhlmann, M. Lawrence, and J. Lelieveld	925-940	03.07.2003	Abstract (HTML, 5 KB) Full Text (PDF, 936 KB) Discussion Paper (ACPD)
A novel model to predict the physical state of atmospheric $H_2SO_4/NH_3/H_2O$ aerosol particles C. A. Colberg, B. P. Luo, H. Wernli, T. Koop, and Th. Peter	909-924	02.07.2003	Abstract (HTML, 5 KB) Full Text (PDF, 3218 KB) Discussion Paper (ACPD)
Global distribution of tropospheric ozone from satellite measurements using the empirically corrected tropospheric ozone residual technique: Identification of the regional aspects of air pollution J. Fishman, A. E. Wozniak, and J. K. Creilson	893-907	02.07.2003	Abstract (HTML, 5 KB) Full Text (PDF, 2628 KB) Discussion Paper (ACPD)
Dependence of solar radiative forcing of forest fire aerosol on ageing and state of mixture M. Fiebig, A. Stohl, M. Wendisch, S. Eckhardt, and A. Petzold	881-891	30.06.2003	Abstract (HTML, 5 KB) Full Text (PDF, 487 KB) Discussion Paper (ACPD)
Long term measurements of submicrometer urban aerosols: statistical analysis for correlations with meteorological conditions and trace gases B. Wehner and A. Wiedensohler	867-879	24.06.2003	Abstract (HTML, 5 KB) Full Text (PDF, 430 KB) Discussion Paper (ACPD)
Commentary on "Homogeneous nucleation of NAD and NAT in liquid	863-865	24.06.2003	Abstract (HTML, 5 KB)

Atmospheric Chemistry and Physics (ACP): Abstracts

Atmos. Chem. Phys., 3, 909, 2003

A novel model to predict the physical state of atmospheric $H_2SO_4/NH_3/H_2O$ aerosol particles

C. A. Colberg, B. P. Luo, H. Wernli, T. Koop, and Th. Peter

The physical state of the tropospheric aerosol is largely unknown despite its importance for cloud formation and for the aerosol's radiative properties. Here we use detailed microphysical laboratory measurements to perform a systematic global modelling study of the physical state of the $H_2SO_4/NH_3/H_2O$ aerosol, which constitutes an important class of aerosols in the free troposphere. The Aerosol Physical State Model (APSM) developed here is based on Lagrangian trajectories computed from ECMWF (European Centre for Medium Range Weather Forecasts) analyses, taking full account of the deliquescence/efflorescence hysteresis. As input APSM requires three data sets: (i) deliquescence and efflorescence relative humidities from laboratory measurements, (ii) ammonia-to-sulfate ratios (ASR) calculated by a global circulation model, and (iii) relative humidities determined from the ECMWF analyses. APSM results indicate that globally averaged a significant fraction (17-57%) of the ammoniated sulfate aerosol particles contain solids with the ratio of solid-containing to purely liquid particles increasing with altitude (between 2 and 10 km). In our calculations the most abundant solid is letovicite, $(NH_4)_3H(SO_4)_2$, while there is only little ammonium sulfate, $(NH_4)_2SO_4$. Since ammonium bisulfate, NH_4HSO_4, does not nucleate homogeneously, it can only form via heterogeneous crystallization. As the ammonia-to-sulfate ratios of the atmospheric $H_2SO_4/NH_3/H_2O$ aerosol usually do not correspond to the stoichiometries of known crystalline substances, all solids are expected to occur in mixed-phase aerosol particles. This work highlights the potential importance of letovicite, whose role as cloud condensation nucleus (CCN) and as scatterer of solar radiation remains to be scrutinized.

Back to ACP Homepage

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Atmospheric Chemistry and Physics

A novel model to predict the physical state of atmospheric $H_2SO_4/NH_3/H_2O$ aerosol particles

C. A. Colberg, B. P. Luo, H. Wernli, T. Koop, and Th. Peter

Institute for Atmospheric and Climate Science, Swiss Federal Institute of Technology, Zürich, Switzerland

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Abstract. The physical state of the tropospheric aerosol is largely unknown despite its importance for cloud formation and for the aerosol's radiative properties. Here we use detailed microphysical laboratory measurements to perform a systematic global modelling study of the physical state of the $H_2SO_4/NH_3/H_2O$ aerosol, which constitutes an important class of aerosols in the free troposphere. The Aerosol Physical State Model (APSM) developed here is based on Lagrangian trajectories computed from ECMWF (European Centre for Medium Range Weather Forecasts) analyses, taking full account of the deliquescence/efflorescence hysteresis. As input APSM requires three data sets: (i) deliquescence and efflorescence relative humidities from laboratory measurements, (ii) ammonia-to-sulfate ratios (ASR) calculated by a global circulation model, and (iii) relative humidities determined from the ECMWF analyses. APSM results indicate that globally averaged a significant fraction (17–57%) of the ammoniated sulfate aerosol particles contain solids with the ratio of solid-containing to purely liquid particles increasing with altitude (between 2 and 10 km). In our calculations the most abundant solid is letovicite, $(NH_4)_3H(SO_4)_2$, while there is only little ammonium sulfate, $(NH_4)_2SO_4$. Since ammonium bisulfate, NH_4HSO_4, does not nucleate homogeneously, it can only form via heterogeneous crystallization. As the ammonia-to-sulfate ratios of the atmospheric $H_2SO_4/NH_3/H_2O$ aerosol usually do not correspond to the stoichiometries of known crystalline substances, all solids are expected to occur in mixed-phase aerosol particles. This work highlights the potential importance of letovicite, whose role as cloud condensation nucleus (CCN) and as scatterer of solar radiation remains to be scrutinized.

Correspondence to: C. A. Colberg
(christina.colberg@jethz.ch)

1 Introduction

Aerosol particles in the atmosphere affect the radiative balance of the Earth through light scattering and absorption. Besides this direct climatic effect, aerosol particles contribute also indirectly - as cloud precursors - to the terrestrial radiation budget. Neither the direct nor the indirect effects are quantitatively well characterized, leading to large uncertainties in the global mean radiative forcing caused by aerosol particles, which may counteract the forcing by greenhouse gases to a large degree (IPCC, 2001).

The direct forcing by partially ammoniated aqueous sulfuric acid particles, has been investigated in a number of studies (Charlson et al., 1991; Kiehl and Briegleb, 1993; Pilinis et al., 1995; Nemesure et al., 1995; Kiehl et al., 2000; Adams et al., 2001; Metzger et al., 2002). The presence of sulfate in aerosol particles covers the range between sulfuric acid H_2SO_4 and ammonium sulfate $(NH_4)_2SO_4$ with intermediate compounds depending on the availability of gaseous ammonia to neutralize the sulfuric acid originating from the oxidation of sulfur dioxide (IPCC, 2001). As these particles enhance the Earth's albedo, their direct effect results in a net cooling. However, the level of confidence in the quantification of this effect is low (IPCC, 2001) due to the variety of sizes, shapes and refractive indices of sulfate aerosol particles. Their radiative effect depends sensitively on the relative humidity (RH), because particle growth due to water uptake, and hence light scattering, is not linear in RH (Pilinis et al., 1995; Nemesure et al., 1995). The water content further depends on the degree of neutralization of the sulfate particles by ammonia (Adams et al., 1999). More importantly, partial neutralization by NH_3 makes the droplets susceptible to partial crystallization, producing solid ammonium sulfate $(NH_4)_2SO_4$, ammonium bisulfate NH_4HSO_4, or letovicite $(NH_4)_3H(SO_4)_2$, with ammonium-to-sulfate-ratios ASR = 2.0, 1.5, and 1.0, respectively. If the provided RH drops sufficiently low, the crystalline forms are

Atmospheric Chemistry and Physics Discussions (ACPD): Discussion Paper 2/2449

Publication Date	*Title, Authors, Reference*	*Online Access*
16.12.2002	**A novel model to predict the physical state of atmospheric $H_2SO_4/NH_3/H_2O$ aerosol particles** C. A. Colberg, B. P. Luo, H. Wernli, T. Koop, and Th. Peter Atmos. Chem. Phys. Discuss., 2, 2449-2487, 2002	Abstract (HTML, 4 KB) Full Text Online Version (PDF, 3830 KB) Full Text Print Version (PDF, 3574 KB) Interactive Discussion

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Atmospheric Chemistry and Physics Discussions

A novel model to predict the physical state of atmospheric $H_2SO_4/NH_3/H_2O$ aerosol particles

C. A. Colberg, B. P. Luo, H. Wernli, T. Koop, and Th. Peter

Institute for Atmospheric and Climate Science, Swiss Federal Institute of Technology, Zürich, Switzerland

Received: 14 November 2002 – Accepted: 21 November 2002 – Published: 16 December 2002

Correspondence to: C. A. Colberg (christina.colberg@ethz.ch)

Abstract

The physical state of tropospheric aerosol particles is largely unknown despite its importance for cloud formation and for the aerosols' radiative properties. Here we show the first systematic global modelling study of the physical state of the $H_2SO_4/NH_3/H_2O$ aerosol, which constitutes an important class of aerosols in the free troposphere. The Aerosol Physical State Model (APSM) developed here is based on Lagrangian trajectories computed from ECMWF (European Centre for Medium Range Weather Forecasts) analyses, taking full account of the deliquescence/efflorescence hysteresis. As input APSM requires three data sets: (i) deliquescence and efflorescence relative humidities from laboratory measurements, (ii) ammonia-to-sulfate ratios (ASR) calculated by a global circulation model, and (iii) relative humidities determined from the ECMWF analyses. APSM results indicate that globally averaged a significant fraction (17–57%) of the ammoniated sulfate aerosol particles contain solids with the ratio of solid-containing to purely liquid particles increasing with altitude (between 2 and 10 km). In our calculations the most abundant solid is letovicite, $(NH_4)_3H(SO_4)_2$, while there is only little ammonium sulfate, $(NH_4)_2SO_4$. Since ammonium bisulfate, NH_4HSO_4, does not nucleate homogeneously, it can only form via heterogeneous crystallization. As the ammonia-to-sulfate ratios of the atmospheric aerosol usually do not correspond to the stoichiometries of known crystalline substances, all solids are expected to occur in mixed-phase aerosol particles. This work highlights the global importance of letovicite, whose role as cloud condensation nucleus (CCN) and as scatterer of solar radiation remains to be scrutinized.

1. Introduction

Aerosol particles in the atmosphere affect the radiative balance of the Earth through light scattering and absorption. Besides this direct climatic effect, aerosol particles contribute also indirectly as cloud precursors to the terrestrial radiation budget. Neither

ACPD
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Physical state model of $H_2SO_4/NH_3/H_2O$-aerosols

C. A. Colberg et al.

the direct nor the indirect effects are quantitatively well characterized, leading to large uncertainties in the global mean radiative forcing caused by aerosol particles, which may counteract the forcing by greenhouse gases to a large degree (IPCC, 2001).

The direct forcing by "sulfate aerosols", a commonly used abbreviation for partially ammoniated aqueous sulfuric acid particles, has been investigated in a number of studies (Charlson et al., 1991; Kiehl and Briegleb, 1993; Pilinis et al., 1995; Nemesure et al., 1995; Kiehl et al., 2000; Adams et al., 2001). The presence of sulfate in aerosol particles covers the range between sulfuric acid H_2SO_4 and ammonium sulfate $(NH_4)_2SO_4$ with intermediate compounds depending on the availability of gaseous ammonia to neutralize the sulfuric acid originating from the oxidation of sulfur dioxide (IPCC, 2001).

As these particles enhance the Earth's albedo, their direct effect results in a net cooling. However, the level of confidence in the quantification of this effect is low (IPCC, 2001) due to the variety of sizes, shapes and refractive indices of sulfate aerosol particles. Their radiative forcing depends sensitively on the relative humidity (RH), because particle growth due to water uptake, and hence light scattering, is not linear in RH (Pilinis et al., 1995; Nemesure et al., 1995). The water content further depends on the degree of neutralization of the sulfate particles by ammonia (Adams et al., 1999). More importantly, partial neutralization by NH_3 makes the droplets amenable to partial crystallization, producing solid ammonium sulfate $(NH_4)_2SO_4$, ammonium bisulfate NH_4HSO_4, or letovicite $(NH_4)_3H(SO_4)_2$, with ammonium-to-sulfate-ratios ASR = 2.0, 1.5, and 1.0, respectively. Provided RH drops sufficiently low, the crystalline forms are thermodynamically favored (Clegg et al., 1998) and droplets may effloresce, depending on the ASR and temperature.

The optical properties of aerosol particles can change remarkably upon crystallization (Tang and Munkelwitz, 1991, 1994). However, as the stoichiometry of the droplets is unlikely to correspond precisely to ASR = 2.0, 1.5 and 1.0, the particles will develop mixed solid/liquid or mixed solid/solid phases, and radiative forcing estimations become even more complex.

In order to estimate the occurrence of solid-containing phases in the

$H_2SO_4/NH_3/H_2O$ aerosol system it is insufficient to know the ambient RH and the ASR at a given point in time, but the time history of the investigated air parcel needs to be known in order to account for the deliquescence/efflorescence hysteresis effect. For example, aqueous ammonium sulfate is saturated with respect to its crystalline phase at 82.8% RH at 250 K (Clegg et al., 1998; Onasch et al., 1999; Cziczo and Abbatt, 1999), whereas laboratory studies show that homogeneous crystallization of droplets does not occur before RH drops to about 72.7% (Onasch et al., 1999). Conversely, solid ammonium sulfate does not deliquesce at RH lower than 82.8%. Therefore, in the range 72.7% < RH < 82.8% the physical state of such a particle in the atmosphere depends on its RH history which can be assessed only from Lagrangian air parcel trajectories.

In a general circulation model assessment of the sensitivity of direct climate forcing to hysteresis in anthropogenic sulfate aerosol particles Boucher and Anderson (1995) show that solid $(NH_4)_2SO_4$ particles have a 20% lower global cooling effect than if they remained liquid. Radiative transfer (Julian day 180, at 12 pm and at 0°×0° by Martin (2000, unpublished results) indicate, depending on the Earth's underlying reflexivity, differences in forcings of +3.81 to −0.91 Wm^{-2} when the aerosol is crystalline rather than aqueous in an atmospheric column at 80% RH.

The physical state of aerosol particles is also important for their ability to act as cloud condensation nuclei (CCN) and has been discussed in the context of cirrus cloud formation (Martin, 1998; Bertram et al., 2000; Zuberi et al., 2001). Although the ice nucleation process largely determines the microphysical properties of cirrus clouds and therefore their climate forcing potential (DeMott et al., 2001), the exact role of aerosol particles in cirrus formation remains unclear (Martin, 2000). This also illustrates the need for a detailed microphysical investigation of the physical state of atmospheric aerosol particles.

Ammonia and sulfate are known for a long time to be components of the atmospheric aerosol particles, and their importance is also corroborated by recent studies (Li et al., 1997; Talbot et al., 1998; Dibb et al., 1999; Liu et al., 2000; Chow et al., 1999). Of

course, tropospheric aerosol particles are not only a mixture of $H_2SO_4/NH_3/H_2O$, but may also contain nitrate, sea salt, organic compounds and elemental carbon. Their composition varies widely with geographical location and altitude (Seinfeld and Pandis, 1998). Recent time of flight mass spectrometry measurements of single atmospheric aerosol particles by Noble and Prather (1996), Murphy et al. (1998) and Hald et al. (2002) highlight the importance of organics and elemental carbon besides water soluble inorganic compounds. In this sense, the restriction of the present study to the subclass $H_2SO_4/NH_3/H_2O$ represents only a first step towards a comprehensive modelling of the physical state of tropospheric aerosol particles.

Despite the importance for the Earth's radiation balance, there is a lack in our understanding of the physical state of atmospheric aerosol particles, and also in particular of the $H_2SO_4/NH_3/H_2O$ class investigated here. This lack in knowledge is due to the difficulty of field measurements having to determine the physical state of individual particles in the sub-micron range simultaneously with RH and ASR measurements (the latter from a single particle composition measurement). In the free troposphere such simultaneous measurements of single aerosol particles have not been performed to date. However, there are some field measurements of the physical state of boundary layer aerosol particles, which show that supersaturated particles exist, even at low RH (McMurry and Stolzenburg, 1989; Rood et al., 1989; Shaw and Rood, 1990; McMurry et al., 1996). In principle, atmospheric aerosol particles can remain liquid or crystallize homogeneously or heterogeneously depending on their chemical composition. At present, it is not clear which are the most important mechanisms (Martin, 2000).

The goal of this work is to apply state-of-the-art laboratory data on the homogeneous efflorescence and deliquescence of the $H_2SO_4/NH_3/H_2O$ aerosol system to the atmosphere in order to predict, for the first time, the physical state of this aerosol class globally. For this purpose we use trajectories derived from ECMWF analyses. As input parameters we use global RH-fields, also from the ECMWF analyses, and ASR data from a GCM-study by Adams et al. (1999). RH values are then tracked along trajectories.

2 Methodology

2.1 Input parameters

The process that dry solid crystals stay dry upon humidification but take up water spontaneously above a certain RH to form an aqueous solution is called deliquescence, and the corresponding RH value thermodynamically required for this to happen is called deliquescence relative humidity (DRH). The inverse process of solidification is called efflorescence and, in contrast to deliquescence, is not thermodynamically determined but is a kinetic phenomenon, which requires supersaturation. The RH value typically required for solidification is called efflorescence relative humidity (ERH). Because DRH > ERH, there is a deliquescence/efflorescence-hysteresis. In case DRH and ERH are known functions of temperature (T) and ASR, and provided that 3-dimensional atmospheric fields of ASR and RH values are available, the physical state of an aerosol of a given composition can be predicted from air parcel trajectory analysis.

For $H_2SO_4/NH_3/H_2O$ aerosol particles our Aerosol Physical State Model combines the 3-D time-dependent input fields $ASR(x, y, z, t)$, $RH(x, y, z, t)$ and $T(x, y, z, t)$, and tracks $ERH(T, ASR)$ and $DRH(T, ASR)$ time-dependently along trajectories.

2.1.1 Efflorescence and deliquescence relative humidities (ERH and DRH)

For DRH we use the thermodynamic model of the $H_2SO_4/NH_3/H_2O$ system by Clegg et al. (1998), which has been verified by a number of laboratory studies (Yao et al., 1999; Chelf and Martin, 1999; Koop et al., 1999; Cziczo and Abbatt, 1999; Onasch et al., 1999). For efflorescence we assume crystallization to occur via homogeneous nucleation in the APSM. This allows us to obtain a lower bound for the formation of solid-containing particles. Although heterogeneous nuclei occur quite frequently in the atmosphere (Martin, 2000) their influence on atmospheric nucleation processes is still uncertain.

The limited data available in the literature on low temperature ERH are restricted

Date

16.12.2002

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Atmos. Chem. Phys. Discuss., 2, 2449-2487, 2002

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AC S904 : 'Response to Scot T. Martin's Com...' , Christina Colberg, 22.01.2003, 17:57

RC S1018 : 'Referee comments' , Anonymous Referee #1, 10.02.2003, 17:29
——**AC** S1063 : 'Reply to Referee 1' , Christina Colberg, 07.03.2003, 13:41

RC S1022 : 'Review' , Swen Metzger, 10.02.2003, 17:53

Atmos. Chem. Phys. Discuss., 2, S798–S801, 2002
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Atmospheric Chemistry and Physics Discussions

ACPD
2, S798–S801, 2002

Interactive Comment

Interactive comment on "A novel model to predict the physical state of atmospheric $H_2SO_4/NH_3/H_2O$ aerosol particles" *by* C. A. Colberg et al.

S. Martin

smartin@deas.harvard.edu

Received and published: 30 December 2002

Comment offered by Scot T. Martin, Harvard University, December 29, 2002

This manuscript provides a state-of-the-art treatment of the assessment of the phase (including aqueous state and crystalline ammonium sulfate, letovicite, and ammonium bisulfate) of atmospheric particles with (NH4)2SO4-H2SO4-H2O chemistry. A major emphasis of the work is to employ trajectories (numbering in excess of 10000) to provide time histories of temperature and relative humidity, which is the first effort ever to assess hysteresis effects of tropospheric particles on a global basis. I offer comments and questions below that I hope will aid the authors to further improve their excellent manuscript.

I believe the authors have done an excellent job in offering creative ground-breaking

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Role of NO_3 radical in oxidation processes in the eastern Mediterranean troposphere during the MINOS campaign
M. Vrekoussis, M. Kanakidou, N. Mihalopoulos, P. J. Crutzen, J. Lelieveld, D. Perner, H. Berresheim, and E. Baboukas
Atmos. Chem. Phys. Discuss., 3, 3135-3169, 2003

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Atmos. Chem. Phys. Discuss., 3, 3135-3169, 2003

Role of NO_3 radical in oxidation processes in the eastern Mediterranean troposphere during the MINOS campaign

M. Vrekoussis, M. Kanakidou, N. Mihalopoulos, P. J. Crutzen, J. Lelieveld, D. Perner, H. Berresheim, and E. Baboukas

During the MINOS campaign (28 July-18 August 2001) nitrate (NO_3) radical was measured at Finokalia, on the north coast of Crete in South-East Europe using a long path (10.4 km) Differential Optical Absorption Spectroscopy instrument (DOAS). Hydroxyl (OH) radical was also measured by a Chemical Ionization Mass-Spectrometer (Berresheim et al., this issue). These datasets represent the first simultaneous measurements of OH and NO_3 radicals in the area. NO_3 radical concentrations ranged from less than $3 \cdot 10^7$ up to $9 \cdot 10^8$ radical$\cdot$cm^{-3} with an average value of $1.1 \cdot 10^8$ radical$\cdot$cm^{-3}.

The observed NO_3 mixing ratios are analyzed on the basis of the corresponding meteorological data and the volatile organic compound (VOC) observations simultaneously obtained at Finokalia station. The importance of the NO_3 radical relatively to that of OH in the dimethylsulfide (DMS) and nitrate cycles is also investigated. The observed NO_3 levels clearly regulate the diurnal variation of DMS. NO_3 and N_2O_5 reactions account for about 21% of the total nitrate ($HNO_{3(g)} + NO^-_{3(part)}$) production.

Back to ACP Homepage

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Atmospheric Chemistry and Physics Discussions

Role of NO_3 radical in oxidation processes in the eastern Mediterranean troposphere during the MINOS campaign

M. Vrekoussis[1], M. Kanakidou[1], N. Mihalopoulos[1], P. J. Crutzen[2], J. Lelieveld[2], D. Perner[2], H. Berresheim[3], and E. Baboukas[2]

[1]Environmental Chemical Processes Laboratory, Department of Chemistry, University of Crete, P.O. Box 1470, 71409 Heraklion, Greece
[2]Max-Planck-Institut für Chemie, Abt. Luftchemie, Mainz, Germany
[3]Deutscher Wetterdienst, Meteorologisches Observatorium, DWD, Germany

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Correspondence to: M. Kanakidou (mariak@chemistry.uoc.gr)

Atmospheric Chemistry and Physics Discussions (ACPD): Interactive Discussion

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19.06.2003	**Role of NO_3 radical in oxidation processes in the eastern Mediterranean troposphere during the MINOS campaign** M. Vrekoussis, M. Kanakidou, N. Mihalopoulos, P. J. Crutzen, J. Lelieveld, D. Perner, H. Berresheim, and E. Baboukas *Atmos. Chem. Phys. Discuss.*, 3, 3135-3169, 2003	Abstract (HTML, 4 KB) Full Text Online Version (PDF, 1181 KB) Full Text Print Version (PDF, 1017 KB)

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This is an \emph{excellent} paper. The value of $\int_0^\infty \beta^2 dx$ is well
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Atmospheric Chemistry and Physics Discussions: Submission of Short Comments

Discussion paper:
Role of NO_3 radical in oxidation processes in the eastern Mediterranean troposphere during the MINOS campaign
M. Vrekoussis, M. Kanakidou, N. Mihalopoulos, P. J. Crutzen, J. Lelieveld, D. Perner, H. Berresheim, and E. Baboukas
Atmos. Chem. Phys. Discuss., 3, 3135-3169, 2003

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Atmos. Chem. Phys. Discuss., 3, S1–S1, 2003
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Atmospheric Chemistry and Physics Discussions

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3, S1–S1, 2003

Interactive Comment

Interactive comment on "Role of NO_3 radical in oxidation processes in the eastern Mediterranean troposphere during the MINOS campaign" *by* M. Vrekoussis et al.

P. Daly

DALY@LINMPI.MPG.DE

Received and published: 10 July 2003

This is an *excellent* paper. The value of $\int_0^\infty \beta^2 dx$ is well evaluated.

Interactive comment on Atmos. Chem. Phys. Discuss., 3, 3135, 2003.


13
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13
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