**Atmospheric
Chemistry
and Physics
Discussions**

The Mt Cimone, Italy, free tropospheric campaign: principal characteristics of the gaseous and aerosol composition from European pollution, Mediterranean influences and during African dust events

Y. Balkanski[1], S. E. Bauer[1], R. van Dingenen[2], P. Bonasoni[3], M. Schulz[1],
H. Fischer[4], G. P. Gobbi[5], M. Hanke[6], D. Hauglustaine[1], J. P. Putaud[2], A. Stohl[7],
and F. Raes[2]

[1]Laboratoire des Sciences du Climat et de l'Environnement, 91190 Gif-sur-Yvette Cedex, France
[2]Joint Research Center, 21020 Ispra, Italy
[3]CNR ISAC, via Gobetti, 40129 Bologna, Italy
[4]Max Planck Institute for Chemistry, POB 3060, 55020 Mainz, Germany
[5]CNR, Via Fosso del Cavaliere, 00133 Rome, Italy
[6]Max Planck Institute for Nuclear Physics, POB 103980, 69029 Heidelberg, Germany
[7]Technical University of Munich, 85354 Freising-Weihenstephan, Germany

Correspondence to: Y. Balkanski (balkansk@lsce.saclay.cea.fr)

Title Page

Abstract | Introduction

Conclusions | References

Tables | Figures

◀ | ▶|

◀ | ▶

Back | Close

Full Screen / Esc

Print Version

Interactive Discussion

© EGU 2003

Abstract

A 5 weeks experiment (1 June to 5 July 2000) took place at a mountain site, Mt Cimone (44°11′ N, 10°42′ E, 2165 m a.s.l.), that is representative of Southern Europe background conditions. During this field campaign, a comprehensive characterisation

5 of trace gases and radicals, involved in the production and destruction of O_3, as well as of chemical, physical and optical properties of the aerosol was done. Atmospheric gases and aerosols were measured continuously over the 5 weeks period, in order to characterize their background concentrations in the free troposphere and their respective differences in air containing dust aerosols advected from Africa. Due to its location

10 and elevation, Mt Cimone gets free tropospheric air both from the Mediterranean and from the Po Valley, which makes it an invaluable place to study gas/aerosol interactions.

A global chemical model coupled to a GCM was used to simulate based upon ECMWF reanalysis the ozone over the region during the period of the field study. The heterogeneous reactions of O_3, N_2O_5, HNO_3 and NO_3 were accounted for. We esti-

15 mate that during the field campaign, the effect of heterogeous reactions was to reduce by 8 to 10% the ozone concentration at MTC in cases when air had passed over the Mediterranean Sea. When air was coming from the Atlantic or continental Europe, the reduction of ozone is still 4%. This reduction is mostly due to the large uptake of HNO_3 and is the the topic of ongoing work to assess how it affects the global cycle of O_3 and

20 the global nitrogen budget.

1. Introduction

Dust provides surfaces for the gases to condense or be absorbed on. Numerous authors have reported observations of low ozone/high dust occurrences (Prospero et al., 1995; Dentener et al., 1996; Bonasoni et al., 1998; de Reus et al., 2000). Bonasoni et

25 al. (1998) report concurrent measurements of dust and ozone at the Mt Cimone site over the March 1991 to December 1994 period. Dust reaching the site was identified

The Mt Cimone, Italy, campaign: gaseous and aerosol composition

Y. Balkanski et al.

Title Page

Abstract	Introduction
Conclusions	References
Tables	Figures

◄◄   ►►

◄   ►

Back   Close

Full Screen / Esc

Print Version

Interactive Discussion

by the colorimetric Munsell soil-colour chart analysis. In 14 out of 20 events when dust reached the site in appreciable amounts, concurrent ozone measurements revealed ozone decreases when the dust-loaded air reached the site. In 3 of the remaining 6 cases, no significant O_3 variation was detected, and in the other 3 cases ozone in-creased. De Reus et al. (2000) analysed simultaneous airborne observations of dust aerosol and ozone acquired on 8 July over the North Atlantic as part of the ACE 2 experiment. The dust layer span from 2.5 to 5.5 km altitude and O_3 concentrations were measured as consistently lower in the dust layer compared to the altitudes above 5.5 km. The authors, using a box model which includes non methane hydrocarbon chemistry, estimated a corresponding O_3 loss of 4 ppbV per day. Although a reac-tion involving metal ions has been proposed to be responsible for the loss in ozone, the chemical reactions responsible for a possible ozone reduction remain to be identified in the laboratory. Observational data of NO_3^- and nss-Ca^{2+} indicate that high concentra-tion of nitrate can be associated with calcium (Hirai et al. 1991; Prospero et al., 1995; Fig. 2a in Dentener et al., 1996). During events of significant dust transport across the tropical Atlantic region, nitrate was found on the coarse mode of dust particles, sug-gesting its formation from nitrogen species on the dust particles (Prospero et al., 1995; Horai et al., 1993). In addition, Putaud et al. (this issue) show that nitrate is found on the coarse fraction of the aerosol and its formation is limited by ammonia availability. Fewer studies have tried to quantify the proportion of dust grains actually coated by nitrate or sulfate. Parungo et al. (1995) used transmission electron microscopy and report that 40% of the particles captured over the China Sea region in the Asian out-flow were covered by sulphate. Despite these reports, measurements are too limited to determine whether reactions involving SO_2, H_2O_2, N_2O_5, HNO_3 and O_3 are taking place on the dust. This lack of observational evidence and of a mechanism to describe this gas/aerosol interactions motivated the pursuit of the MINATROC project, funded by the European Commission. Its goal is to document through laboratory, field and modelling work the heterogeneous processes occurring on dust. Two field campaigns are part of the project, of which the first one took place at Mt Cimone from 1 June to 5

July 2000. Its aim was to fully characterize the gas as well as the aerosol species with a complete set of measurements in order to identify heterogeneous reactions on dust. Additionally, optical characterisations of the aerosols encountered during the campaign were made. The campaign was set up to bring together simultaneous gas and aerosol measurements in conditions when air devoid or laden with mineral dust reaches Southern Europe. These contrasted situations should allow for a quantification of the role of mineral dust in tropospheric chemistry.

Dry deposition of O_3 on bare soil and sand suggests that uptake on dust is possible. Measurements of the accommodation coefficient of ozone on dust confirm this (Hanisch and Crowley, 2002a). Further evidence gathered in laboratory studies shows that HNO_3 uptake by dust surfaces is very efficient (Hanisch and Crowley, 2001a; Hanisch et al., 2001b). The uptake of SO_2 on $CaCO_3$ has also been measured using a low pressure Teflon coated reactor (Adams et al., 2002).

These studies raise the following questions: Why are O_3 concentrations low in the presence of dust? Is it due to air advected from O_3-poor regions, or, are these low concentrations of O_3 on dust due to heterogeneous reactions directly on the surface, to decreased photochemical production in the presence of dust clouds or limited O_3 production due to low NO_x availability? This paper attempts to answer the first question: are the ozone concentrations low due to advection from O_3-poor regions before reaching Mt Cimone? A companion paper will address the role of heterogeneous reactions on ozone concentrations over the Mediterranean and Southern Europe.

In Sect. 1, we first review the measurements made in the course of the campaign. In Sect. 2, we distinguish the different influences at the site and propose a classification of the different air parcels encountered at the Mt Cimone station. The discussion in Sect. 3 is based on ozone concentrations simulated either by accounting for homogeneous chemistry alone either with heterogeneous reactions included. Finally, the ozone concentrations are analysed from the point of view of the region over which the air parcel spent the most recent days of 5-day back trajectories.

Title Page

Abstract | Introduction

Conclusions | References

Tables | Figures

◀ | ▶

◀ | ▶

Back | Close

Full Screen / Esc

Print Version

Interactive Discussion

2. Description of the gas, aerosol and meteorological measurements made at Mt Cimone, Italy

Mt Cimone (44°11′ N, 10°42′ E) is a Global Atmospheric Watch site (GAW), where background air pollution is monitored. The station is located on the highest peak of the Northern Apennine chain at 2165 m a.s.l.. It is surrounded by a free horizon with the Mediterranean Basin on the South and Southwest side and overlooks the Po Valley on the North and Northeast side. Surface O_3, CO_2 and particulate matter are routinely monitored at the site, respectively since 1979 and 1991. In most conditions, air sampled at Mt Cimone is representative of free tropospheric air, but daytime summer measurements are affected by upslope winds, which occasionally deliver polluted air from the Po Valley to the site. During the campaign from 1 June to 5 July 2000, in-situ physical, chemical and radiative properties of the Mediterranean "free" troposphere were analyzed both during and without Saharan dust intrusions. The campaign at Monte Cimone (MTC), originally planned to last 4 weeks was extended by a 5th week since no significant dust event had been observed during the first four weeks, but the meteorological forecast was favorable for the 5th week. The elevation of the site (2165 m a.s.l.) provided an opportunity rarely taken before to study the remote troposphere over periods of several weeks. The diurnal variations of NO_y, NO_x, O_3, RO_x, CO, formaldehyde and VOCs unraveled that O_3 was produced in this environment with little local pollution (see Fischer et al., 2002; Hanke et al., 2002). Table 1 indicates the instruments deployed and the measurements made during the campaign. The aerosol physical and chemical properties were identified through the following measurements (van Dingenen et al.; Putaud et al.; Gobbi et al., this issue):

– Number size distributions from Differential Mobility Analyzer (6–600 nm).

– Number distributions from Optical Particle Counter (0.3–10 μm).

– Total number, surface area, volume concentration derived from DMA and OPC data.

  – High time resolution ionic composition in fine fraction ($< 1\,\mu$m).

  – Aerosol chemistry from impactor samples (of which OC/EC analysed at JRC).

  – Aerosol absorption coefficient and equivalent black carbon concentration.

  – Aerosol hygroscopicity at 90% RH.

5 – Refractory aerosol size distributions.

The chemical composition of the aerosol was analysed by measuring on-line concentrations of the main ions (Na^+, NH_4^+, K^+, Mg^{2+}, Ca^{2+}, Cl^-, NO_3^-, SO_4^{2-}) present in the submicron aerosol fraction. Sampling was done with 15 min time intervals using a wet aerosol denuder steam jet aerosol collector combination. The detection limits for
10 the setup is better than $0.1\,\mu$g m^{-3}. For most of the campaign time, just NH_4^+, NO_3^-, and SO_4^{2-} were detected with significant concentrations (see Putaud et al., this issue). The displacement of NO_3^- from the submicronic mode in the absence of dust, to the super micronic mode in the presence of dust is indicative of an efficient uptake of HNO_3 on the dust surface. By opposition, Putaud et al., report could not detect any interaction
15 with SO_2 during the dust episode.

3. Identification of dust events and ozone concentrations during the campaign

Gobbi et al. (this issue) report profiles of aerosol extinction, depolarisation, surface area and volume retrieved by the LIDAR during the MTC campaign. Furthermore, the authors attempted a closure analysis on the same quantities using aerosol size distri-
20 butions observed by the DMA and OPC instruments . During the 1–30 June period, no significant dust event was observed at the elevation of the site although the LIDAR evidenced 5 instances indicated in Fig. 1 when dust layers appeared aloft. Therefore, a large part of this data can be considered representative of continental background conditions. In only 1 case out of 5, from 2–4 July 2000, did the dust layers extend

The Mt Cimone, Italy, campaign: gaseous and aerosol composition

Y. Balkanski et al.

down to the altitude of the Mt Cimone Observatory. This allowed for a full chemical characterization of the air mass. The arrival of the dust cloud at the site was clearly indicated by the OPC data where a significant increase in coarse aerosol number and volume was observed (Fig. 1). Although this last dust event was not particularly strong,

5 a maximum of 3.2 particles/cm^3 (size > 1 mm) and a simultaneous O_3 decrease was detected during the dust transport episode. A marked influence of Saharan dust on the HNO_3 concentration could be registered (Hanke et al., 2002) during the dust intrusion of 3–4 July: at the onset of the dust event in the early morning of 3 July, the HNO_3 concentration started to decrease continuously and reached its minimum in the early

10 morning of the next day. After a short period of passing clouds and slight rain around noon of 4 July, HNO_3 recovered again. In contrast, SO_2 does not show such a clear influence of dust. Both aerosol scattering and absorption coefficients are not significantly altered during the dust event. These parameters are dominated by the sub-micrometer aerosol (continental background) which is mixed with the dust.

15 3.1. The LMDZ-INCA model

LMDZ-INCA is composed of a chemical model (INCA: Interactions with Chemistry and Aerosols) which is embedded into a General Circulation Model (GCM) developed by the Laboratoire de Mtorologie Dynamique. INCA treats the emissions, photochemical transformations and deposition of chemical tracers interactively in the GCM. We used

20 a reasonably high resolution for a global model, 160×98 (2.25× 1.84° in respectively longitude and latitude) with 19 σ-p hybrid vertical levels. The model is run in a nudged mode by relaxing the wind components to the corresponding ECMWF analysis. In this way the meteorological fields of the model are consistent with the actual meteorological conditions at the time of the sampling. The chemistry version used is based upon the

25 implementation of a methane oxidation scheme to calculate interactively tropospheric ozone and OH. Emissions and chemistry of CH_4, CO, and NO_x are included. Typically this version includes 43 tracers and roughly 100 photochemical reactions and several aerosol types including dust are included with a spectral scheme to represent

The Mt Cimone, Italy, campaign: gaseous and aerosol composition

Y. Balkanski et al.

size distribution. Different aerosol components are included in the model, in particular, seasalt, dust, sulfate and carbonaceous aerosols are explicitly resolved and we account for their solubility. The heterogeneous reactions of O_3, N_2O_5, HNO_3 and NO_3 on dust were included. The accomodation coefficient for these reactions were cho-
sen based upon laboratory studies that were performed within the MINATROC project (Hanisch and Crowley, 2001a; 2001b; 2002a and 2002b), respectively 1.e-5, 0.02 to 3.e-3 depending on relative humidity, 0.1 and 3.e-3. Note that the reaction of NO_3 on dust has not been measured in the laboratory to our knowledge.

3.2. Summertime ozone features simulated over the region

The features of the ozone distribution are dominated in June by a maximum over Central Europe that extends to the Middle East region. Monthly mean ozone concentrations at the elevation of MTC (780 mb) show a maximum over the region that covers the Middle East and parts of Central Europe (Fig. 2). The strong summertime O_3 maximum over the Middle East region has been first documented by Li et al. (2001). Three sites,
Tel-Aviv, Dubai and Teheran, showed a pronounced maximum ozone concentration in the free troposphere. Simulated vertical profiles of ozone agreed well with measurements from the MOZAIC program aboard commercial aircraft (Marenco et al., 1998; Stohl et al., 2001). The maximum was attributed to a complex coupling between dynamical and chemical processes. During summer, ozone produced over the region
experiences large scale subsidence which participates in the observed maximum. The position of this summertime maximum is best defined in the model at 400 mb (upper panel of Fig. 2 and Fig. 1 of Li et al., 2001). Other contributions to this feature of the ozone distribution were identified by Li et al. (2001) by switching off the main sources of O_3 precursors. Model results showed that sources from Europe and North Amer-
ica supply 4 to 12 ppbv of 400 hPa O_3 in the northern part of the Middle East region whereas Asian sources contribute to more than 8 ppbV of ozone over its southern part. This ozone maximum is also simulated with the LMDZ-INCA model. In both months, June and July, O_3 precursors produced over Western and Central Europe create rela-

tively strong North-South and East-West gradients across the Mediterranean Sea (see Fig. 2, lower panel). Over the African continent, the East-West ozone concentration gradient reflects the circulation of air from the South of the ozone maximum located over the Middle East to the African region. In addition, ozone precursors from Europe
5 are transported over the Eastern Mediterranean region.

Air mass back trajectories arriving at the site were analysed to study whether changes in gas/aerosol concentrations and composition were attributable to the emissions over a wide geographical region. These trajectories were computed using the FLEXTRA model (Stohl et al., 1995). Following the study of Bonasoni et al. (2000) for Mt Cimone,
10 six regions were identified as having different signatures (see Fig. 3). These regions are: North-West Europe (NW-EUR), Atlantic-West Europe (ATL/W-EUR), Eastern Europe (E-EUR), the Mediterranean region (MED), Africa (AFR) and Arctic (ARC). Back trajectories were assigned to one of these regions based upon where the air parcel spent most of its time before its arrival at MTC (Fig. 3). Hence a trajectory is chosen
15 to be from a given sector based upon air mass characteristics of the region during its transit to the receptor site, as in the study of Pochanart et al. (2001) who showed that gases and aerosol properties strongly depend on the number of days a parcel spends over a given source region.

4. Discussion of the ozone concentrations at Mt Cimone

20 The ozone field shown on Fig. 2 (bottom panel) for June indicates that the main gradients for ozone across the Mediterranean Region are a North-South and an East-West gradient. The ozone time series at MTC during the period 1 June–5 July 2000 is presented in Fig. 4 together with the concentrations simulated by the LMDZ-INCA model with the assumption of homogeneous chemistry alone (top panel) and the heteroge-
25 neous reactions listed above included (bottom panel). The whole period can be divided into 5 phases where the station received different air mass influences:

- 1–5 June is characterised by high ozone concentrations (62 to 75 ppbV) with back trajectories coming from W-EUR, NW-EUR and on 5 June from E-EUR.

- The next period spans 10 days from 6–15 June and is dominated by influences coming from the MED region with boundary layer air arriving at the site as indicated by the number of Aitken nuclei.

- A period of 3 days (16–18 June) follows, when air coming from NW-EUR and E-EUR brings about high ozone concentrations (64 to 68 ppbV). For all three periods presented so far, simulated ozone concentrations agree very well with the measured ones and the heterogeneous reactions are not important.

- The next and longest period spans from 19–30 June. Very low ozone concentrations occur in 2 instances: on 19 June and for 2 consecutive days, 25 and 26 June. On the first instance air coming from the Arctic brings about low ozone concentration, this situation is not reproduced by the model. On 25–26 June, the air is advected from the boundary layer over W-EUR with remarquably low concentrations (50-51 ppbV) which is captured by the simulation.

- Finally, the last period (1–5 July) which includes the dust episode recorded at Mt Cimone, is characterised by air masses coming from the Mediterranean and African regions. This is when the influence of the heterogeneous reactions is most clear. The model reproduces well both the decline and the recovery in ozone concentrations and overpredicts slightly the dip in daily mean concentrations that accompany the dust on 3 and 4 July (Fig. 4).

To find out whether the low ozone concentrations that are observed together with dust events are attributable to the photochemical regime over the regions of dust production rather than to heterogeneous processes on the surface of dust, we examined ozone concentrations along the computed back trajectories arriving at MTC. We used 5 days back trajectories that were computed every 3 h. At each grid box location along the back trajectory, daily mean ozone concentrations simulated by LMDZ-INCA were

Title Page

Abstract | Introduction

Conclusions | References

Tables | Figures

◀ | ▶

◀ | ▶

Back | Close

Full Screen / Esc

Print Version

Interactive Discussion

recorded. Figure 5 presents the O_3 concentrations at the time of arrival and for each of the 5 days preceding the arrival at MTC in the case ran with homogeneous chemistry. The influence of the origin of the air masses on ozone concentrations can be grouped into two categories. For air masses originating from NW-EUR, W-EUR and E-EUR the averaged ozone concentration measured at MTC over the period is 60 ppbV (resp. from 61 to 67 ppbV in the model). In the 24-h before the arrival of the air mass at MTC the averaged simulated ozone concentrations only differ by 1 to 5 ppbV (Table 2). The concentrations averaged over 24-h periods from day 2 to 5 of along the back trajectories are indicated in Table 2. Air masses originating either the MED and AFR regions arrive at MTC with lower ozone concentrations than from any european sector. Measured averaged ozone concentrations are 57 and 56 ppbV, respectively for Mediterranean and Africa sectors. The simulated ozone concentrations for the same regions are 61 and 57 ppbV, respectively (Table 2). The comparison of the concentrations between the simulation with homogeneous reactions and heterogeneous reactions permits to quantify the effect of these reactions (Table 2). For air coming from the MED and AFR regions, the ozone concentrations at MTC, indicative of free tropospheric air, are reduced respectively by 5 and 6 ppbV (respectively 8 and 10%) due to heterogeneous chemistry. The uptkake of HNO_3 onto mineral dust is important since a change in NO_y will influence both O_3 and NO_x concentrations. The measurements of uptake coefficients of HNO_3 on $CaCO_3$ and mineral dust using a Knudsen reactor have lead to large differences: Underwood et al. (2001) reported a γ of approximately 10^{-5}, whereas Hanisch et al. (2001b) measured an accomodation coefficient of 10^{-1}. Working with an aerosol flow reactor that allows to mimick better the flow of HNO_3 than in the case of the Knudsen reactor, (Hanisch and Crowley, 2002) using genuine Saharan dust found an accomodation of 0.1 equal to the one deduced from their Knudsen reactor experiments. This very fast uptake of HNO_3 on dust is consistent with the very steep decrease in concentration that Hanke et al. report in this issue.

Title Page

Abstract   Introduction

Conclusions   References

Tables   Figures

◄◄   ►►

◄   ►

Back   Close

Full Screen / Esc

Print Version

Interactive Discussion

5. Conclusions

In conclusion, an unprecedented, high quality data set has been obtained for the period 1 June–5 July 2000, characteristic of both continental background conditions as well as a moderate dust episode. A comprehensive dataset on aerosol as well as gas phase properties is available for process studies as well as for model validation.

A global chemical model coupled to a GCM was used to simulate based upon ECMWF reanalysis the ozone over the region during the period of the field study. The ozone concentrations over Southern Europe and the Mediterranean region are dominated over the summer by a maximum over Central Europe and the Middle East region.

Daily mean ozone concentrations at Mt Cimone are 4 ppbV lower when air is advected from the Mediterranean Basin or Africa rather than when air was advected from Europe.

The effect of heterogeneous chemistry estimated using accomodation coefficient reported by the latest laboratory studies is to reduce by 8 to 10% the ozone concentration at MTC in cases when air had passed over the Mediterranean Sea. When air was coming from the Atlantic or continental Europe, the reduction of ozone is still 4%. This reduction which is partly due to the large uptake of HNO_3, is the the topic of ongoing work to assess its effect on O_3 and NO_x on the global scale.

References

Adams, J. R. and Cox, P: Griffiths and D. Stewart, Reactive uptake of gases on mineral aerosols, in Proceedings of the 27th General Assembly of the European Geophysical Society, 21–26 April 2002, Nice, France, Geophysical Research Abstract, 4, 2002.

The Mt Cimone, Italy, campaign: gaseous and aerosol composition

Y. Balkanski et al.

Title Page	
Abstract	Introduction
Conclusions	References
Tables	Figures
◄◄	►►
◄	►
Back	Close

Full Screen / Esc

Print Version

Interactive Discussion

© EGU 2003

Bauer S., Balkanski, Y., Schulz, M., Hauglustaine D., and Dentener, F.: Heterogeneous chemistry on mineral dust aerosol surfaces: Influence on the global tropospheric ozone chemistry, to be submitted to J. Geophys. Res., 2003.

Bonasoni P., Bonafé, U., Colombo, T., Santaguida, R., Lenaz, R., and Tesi, G.: Effect of dust transport on trace gases concentration, in: XVIII Quade. Ozone Symp., l'Aquila, Italy, 12–21 September 1996, Bojkov, Visconti (Eds.), 323–326, 1998.

Bonasoni P., Stohl , A., Cristoganelli, P., Calzolari, F., and Colombo, T.: Bakground ozone vriations at Mt Cimone Station, Atmospheric Environment, 34, 5183–5189, 2000.

Bonasoni, P., Cristofanelli, P., Calzolari, F., Bonafé, U., Evangelisti, F., Van Dingenen, R., Colombo, T., and Balkanski, Y.: Aerosol and ozone correlation during the dust transport episodes of the summer-autumn 2000 period, this issue.

Dentener F. J., Carmichael, G. R., Zhang, Y., Lelieveld, J., and Crutzen, P. J.: Role of mineral dust as a reactive surface in the global troposphere, J. Geophys. Res., 101, 22 869–22 889, 1996.

de Reus, M., Dentener, F., Thomas, A., Borrmann, S., Ström, J., and Lelieveld, J.: Airborne observations of dust aerosol over the North Atlantic Ocean during ACE2: Indications for heterogeneous ozone destruction, J. Geohpys. Res., 105, D12, 15 263–15 275, 2000.

Fischer, H., Kormann, R., Klüpfel, T., Gurk, Ch., Königstedt, R., Parchatka, U., Mühle, J., Rhee, T. S., Brenninkmeijer, C. A. M., Bonasoni, P., and Stohl, A.: Ozone production and trace gas correlations during the June 2000 MINATROC intensive measurement campaign at Mt. Cimone, Atmos. Chem. Phys. Discuss., 2, 1509–1543, 2002.

Gobbi, G. P., Barnaba, F., Van Dingenen, R., Putaud, J. P., Mircea, M., and M. C. Facchini: Lidar and in situ observations of continental and saharan aerosol: closure analysis of particles optical and physical properties, this issue.

Gobbi, G. P., Barnaba, F., Giorgi R., and Santacasa, A.: Altitude-resolved properties of a Saharan dust event over the Mediterranean, Atmospheric Environment, 34, 5119–5127, 2000.

Hanisch, F. and Crowley, J. N.: Heterogeneous reactivity of gaseous nitric acid on Al_2O_3, $CaCO_3$, and atmospheric dust samples: A Knudsen cell study, J. Phys. Chem., 105, 3096–3106, 2001a.

Hanisch, F. and Crowley, J. N.: The heterogeneous reactivity of gaseous nitric acid on authentic mineral dust samples, and on individual mineral and clay mineral components, Phys. Chem. Phys., 3, 2474–2482, 2001b.

Hanisch, F. and Crowley, J. N.: Ozone decomposition on Saharan dust: an experimental inves-

tigation, Atmos. Chem. Phys. Discuss., 2, 1809–1845, 2002a.

Hanisch, F. and Crowley, J. N.: Heterogeneous reactivity of NO and HNO_3 on mineral dust in the presence of ozone, submitted to Phys. Chem. Phys., 2002b.

Hanke M., Umann, B., Uecker, J., Arnold, F., and Bunz, H.: Atmospheric measurements of gas-phase HNO_3 and SO_2 using chemical ionization mass spectrometry during the minatroc field campaign 2000 on Monte Cimone, Atmos. Chem. Phys. Discuss., 2, 2209–2258, 2002.

Hirai E., Miyazaki, M., Chohji, T., Lee, M., Kitamura, M., and Yagamuchi, K.: Effect of Kosa aerosol on inorganic ion components in rainwater collected in cicum-pan-Japan-Sea area, Proceeding of the 2nd IUAOOA Regional conference on Air Pollution, Seoul, Korea, Korea Air Research Association, 27–34, 1991.

Horai, S., Minari, I., and Migita, Y.: Aerosols Composition In Kagoshima in the Annual Report of the Kagoshima Prefectural Institute, 9, 1993.

Li, Q., Jacob, D. J., Logan, J. A., Bey, I., Yantosca, R. M., Liu, H., Martin, R. V., Fiore, A. M., Field, B. D., and Duncan, B. N.: A trosposperic maximum ozone over the Middle East, Geophys. Res. Let., 28, 3235–3238, 2001.

Marenco, A., Thouret, V., Nédélec, P., et al.: Measurement of ozone and water vapor by Airbus in-servive aircraft: The MOZAIC airborne program, An overview, J. Geophys. Res., 103, 25 631–25 642, 1998.

Parungo, F., Kim, Y., Zhu, C.-J., et al.: Asian dust storms and their effects on radiation and climate, STC Rep. 2906, (available from Science and Technology Coporation, 101 Research Drive, Hampon, VA. 23666, USA), 1995.

Pochanart, P., Akimoto, H., Maksyutov, S., and Staehelin, J.: Surface ozone at the Swiss Alpine site Arosa: the hemispheric background and the influence of large-scale anthropogenic emissions, Atmospheric Environment, 35, 5553–5566, 2001.

Prospero, J. M., Schmidtt, R., Cuevas, E., Savoie, D. L., Graustein, W. C., Turekian, K. K., Volz-Thomas, A., Dias, A., Oltmas, S. J., and Levy II, H.: Temporal variability of summer-time ozone and aerosols in the free troposphere over the eastern North Atlantic, Geoph. Res. Let., 22, 2925–2928, 1995.

Putaud J. P., van Dingenen, R., Dell'Acqua, A., Matta, E., Decesari, S., Facchini, M. C., and Fuzzi, S.: Size-segregated aerosol mass closure and chemical composition in Monte Cimone (I) during Minatroc, this issue.

Stohl, A., Wotawa, G., Seibert, P., and Kromp-Kolb, H.: Interpolation errors in wind fields as a function of spatial and temporal resolution and their impact on different types of kinematic

The Mt Cimone, Italy, campaign: gaseous and aerosol composition

Y. Balkanski et al.

Title Page

Abstract	Introduction
Conclusions	References
Tables	Figures

◄◄ ►►

◄ ►

Back Close

Full Screen / Esc

Print Version

Interactive Discussion

trajectories, J. Appl. Meteorology, 34, 2149–2165, 1995.

Stohl, A., James, P., Forster, C., Spichtinger, N., Marenco, A., Thouret, V., and Smit, H. G. J.: An extension of Measurements of Ozone and Water Vapor by Airbus In-service Aircraft (MOZAIC) ozone climatologies using trajectory statistics, J. Geophys. Res., 106, 27 757– 27 768, 2001.

Underwood, G. M., Li, P., Al-Abadleh, H., and Grassian, V. H.: A Knudsen Cell Study of the Heterogeneous Reactivity of Nitric Acid on Oxide and Mineral Dust Particles, Journal of Physical Chemistry A, 105, 6609–6620, 2001.

Van Dingenen, R., Putaud, J.-P., and Raes, F.: Physical aerosol properties and their relation to air mass origin at Monte Cimone (Italy) during the first MINATROC campaign, this issue.

The Mt Cimone, Italy, campaign: gaseous and aerosol composition

Y. Balkanski et al.

Title Page

Abstract | Introduction

Conclusions | References

Tables | Figures

◄ | ►

◄ | ►

Back | Close

Full Screen / Esc

Print Version

Interactive Discussion

The Mt Cimone, Italy, campaign: gaseous and aerosol composition

Y. Balkanski et al.

Title Page

Abstract | Introduction

Conclusions | References

Tables | Figures

◄◄ | ►►

◄ | ►

Back | Close

Full Screen / Esc

Print Version

Interactive Discussion

© EGU 2003

Table 1. Overview of instrumentation and methods deployed during the Monte Cimone campaign (to be continued on next pages)

Parameter	Instrument/method	Partner
Gas phase chemistry		
HO_2 and $\sum RO_2$	ROXMAS	MPIK Heidelberg
SO_2 and HNO_3	CIMS	MPIK Heidelberg
SO_2 and HNO_3	Wet annular denuder + IC	JRC Ispra
O_3	UV absorption	CNR-ISAO, MPIK Heidelberg
CO_2	ULTRAMAT-5E Siemens NDIR	CNR-ISAO+AM CAMM
NO_2, HCHO, $H_2O_2^{(*)}$	TDLAS	MPI Mainz
$NO^{(*)}$	Chemiluminescence detector (CLD)	MPI Mainz
$NO_y^{(*)}$	Catalytic converter + CLD	MPI Mainz
CO	GC + FID	MPI Mainz, CNR-ISAO
RO_x	peroxy radical chemical amplifier	MPI Mainz
NMVOC[#]	Canister sampling + off-line analysis	MPI Mainz
$J(O^1D)^{(*)}$	up-and downward radiation flux in the UV-B range	MPI Mainz

[*] Not available during the dust event.
[#] Ethane, ethene, propane, propene, iso-butane, butane, acetylene, trans-2-butene, 1-butene, iso-butene, cis-2-butene, 2-methylbutane, pentane, propine, 1,3-butadiene, trans-2-pentene, cis-2-pentene, cyclohexane, 2-methylpentane, 3-methylpentane, hexane, isoprene, heptane, benzene, toluene, sulfur hexafluoride, carbon dioxide, methane, nitrous oxide.

The Mt Cimone, Italy, campaign: gaseous and aerosol composition

Y. Balkanski et al.

Table 1. Continued.

Parameter	Instrument/method	Partner
Aerosol chemistry		
Water soluble inorganic + water soluble organic content + EC + gravimetric mass (12 h time resolution)	5 stage impactor, double substrate. Analysis with IC, Total Organic Carbon analyzer, speciation of WSOC by HNMR	CNR-ISAO
Major ions (15 min time resolution)	Steam jet aerosol collector + IC on-line (fine/coarse fraction), artefact-free	JRC Ispra
Major ions (12 h time resolution)	Fine/coarse fraction on whatman filter, IC off-line	JRC Ispra
Total organic carbon and EC (12 h time resolution)	Fine/coarse fraction on quartz filter + evolved gas analysis	JRC Ispra
Elemental composition/ mineralogy (12 h time resolution)	High-volume samples (PM10) on whatman, analysis by WHICH TECHNIQUE	JRC Ispra + CNRS Paris
Aerosol physical properties		
Number concentration >15 nm	Condensation nuclei Counter	JRC Ispra + CNR-ISAO
Number size distribution (6–600 nm) (5 min time resolution)	Differential Mobility Analyzer (DMA)	JRC Ispra
Number size distribution (300 nm –10 μm) (1 min time resolution)	Optical particle Counter (OPC)	JRC Ispra
Aerosol volatility (6–600 nm) (5 min time resolution)	DMA + thermodenuder at 300° C	JRC Ispra
Aerosol hygroscopicity (10–200 nm)	Humidity Tandem DMA	JRC Ispra

The Mt Cimone, Italy, campaign: gaseous and aerosol composition

Y. Balkanski et al.

Title Page

Abstract	Introduction
Conclusions	References
Tables	Figures

Table 1. Continued.

Parameter	Instrument/method	Partner
Aerosol optical properties		
In-situ scatter coefficient	White light nephelometer	CNRS Paris
In-situ light absorption coefficient	Aethalometer	JRC Ispra
Vertical profile of backscatter ratio and depolarisation ratio (profile includes measurement station altitude)	VELIS LIDAR	CNR-IFA Roma
Aerosol optical depth	multi-band sunphotometers (CIMEL)	CNR-IFA Roma
Meteorological parameters		
T, RH, Pressure, wind direction and wind speed		CNR-ISAO
10-days back trajectories analysis	FLEXTRA model	CNR-ISAO
Forecasts and analysis		
Meteorological	BOLAM model, ISAO METEOSAT IR, VIS, WV maps	Facilities at the Monte Cimone station provided by CNR-ISAO through URL connection.
6 days 3D-back trajectories	HYSPLIT model, NOAA ARL	
Dust load, surface concentration forecasts	DREAM model, Uni. Malta	
Dust optical depth	NAAPS model, NRL Monterey	
Radiosondes	Uni. Wyoming	

Back

Close

Full Screen / Esc

Print Version

Interactive Discussion

© EGU 2003

Table 2. Ozone concentrations (ppbV) along air masses coming from the different wind sectors defined in the text. For columns 5 trough 9, the concentrations in parenthesis for the run with homogeneous chemistry only and numbers without parenthesis are for the simulation including heterogeneous reactions with O_3, N_2O_5, HNO_3 and NO_3

| REGION	# trajectories	% of all trajectories	Measured daily O_3 (ppbV) at Mt Cimone	Simulated daily ozone at Mt Cimone	Simulated ozone averaged for 24 h before its arrival at Mt Cimone	Idem but between 24 and 48 h before air mass arrives at Mt Cimone	Idem but between 48 and 72 h before air mass arrives at Mt Cimone	Idem but between 72 and 96 h before air mass arrives at the station	Idem but between 96 and 120 h before air mass arrives at the station
NW-EUR	34	13	60	65 (68)	62 (65)	51 (54)	49 (52)	49 (51)	50 (52)
W-EUR	61	24	60	66 (69)	61 (64)	54 (58)	54 (57)	54 (57)	56 (58)
E-EUR	39	15	60	68 (71)	67 (70)	62 (66)	60 (65)	62 (66)	61 (65)
MED	88	34	56	61 (66)	59 (64)	56 (61)	57 (60)	57 (61)	58 (62)
AFR	26	10	57	57 (63)	56 (62)	53 (59)	54 (58)	54 (59)	55 (61)
No Class	11	4	64	71 (73)	67 (70)	59 (62)	54 (58)	51 (53)	65 (57)
All Cases	259	100	59	64 (68)	61 (65)	56 (60)	56 (59)	56 (59)	57 (60)

Fig. 1. Number concentration of aerosol particles with diameter > 1 μm and surface ozone concentration for the period 1 June–5 July 2000 at Mt Cimone, Italy. The periods when dust layers were detected by the LIDAR are indicated by the shaded grey and yellow. The yellow shading indicates the only period when both significant dust amounts were measured by the optical particle counter at the Observatory and dust layers were detected by the LIDAR. Dust layers were identified through the measure of the depolarization ratio (indicative of the asymmetry of the particle).

The Mt Cimone, Italy, campaign: gaseous and aerosol composition

Y. Balkanski et al.
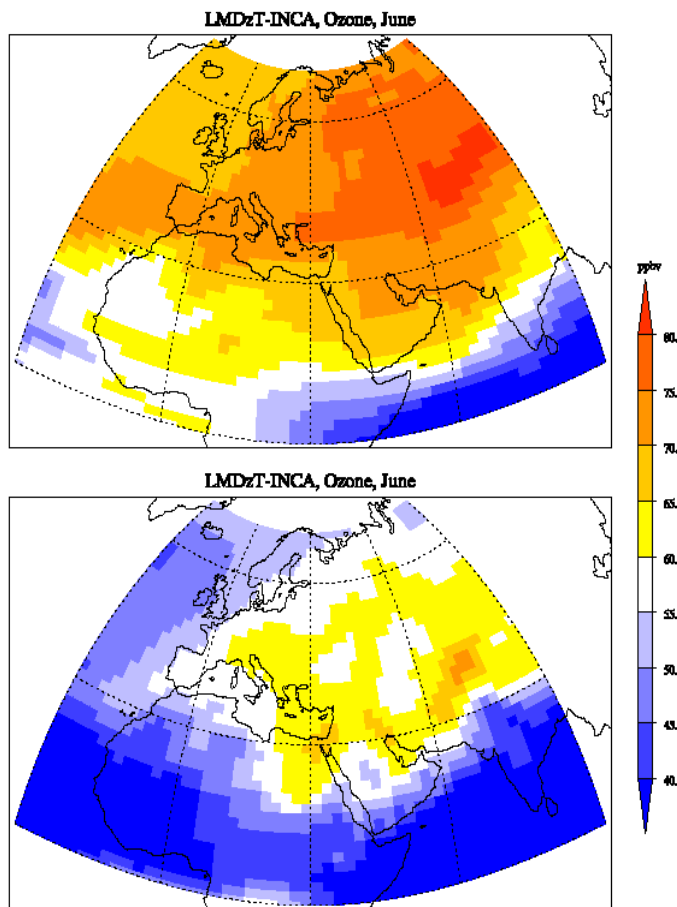
Fig. 2. June monthly mean ozone concentrations in ppbV at 400mb (Upper panel) and 780 mb (lower panel) simulated by the LMDZ-INCA model.
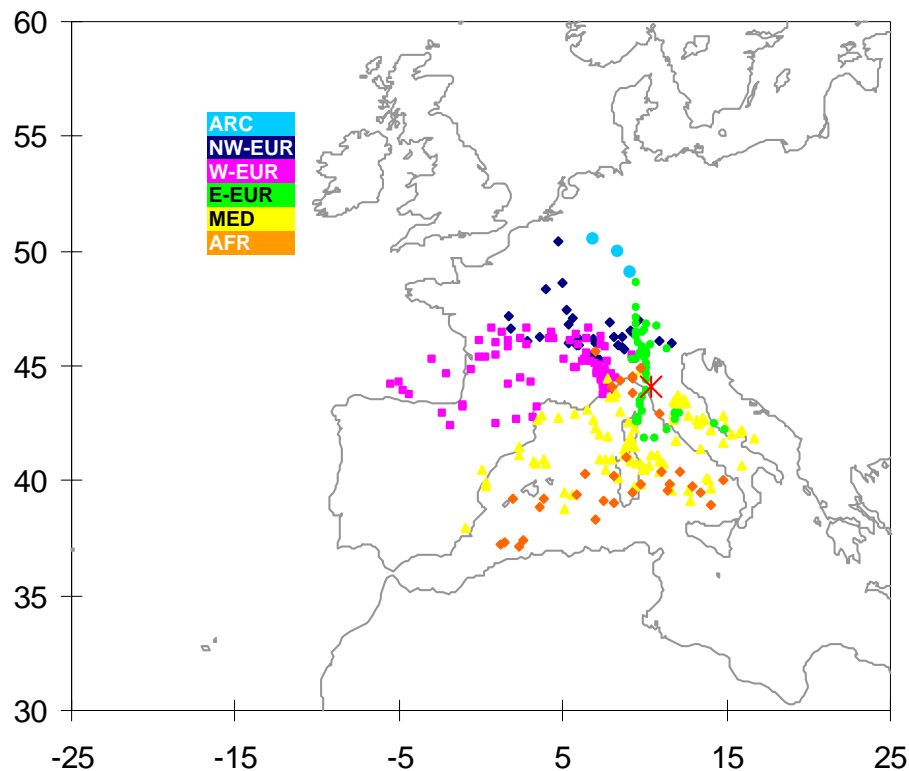
Fig. 3. Average position of the air mass associated to each trajectory. The coordinates of these points were obtained using a weight factor averaged along the trajectory. The weight factor is 1 at the time of arrival at MTC, and decays with 4%/backward per hour along the trajectory. This yields weight factors of 0.38, 0.14 and 0.05, respectively for 1, 2 and 3 days backward. By plotting these average positions on a map, one gets an idea of the "zone" contributing to the air mass properties before arriving at MTC.

The Mt Cimone, Italy, campaign: gaseous and aerosol composition

Y. Balkanski et al.

Title Page

Abstract | Introduction

Conclusions | References

Tables | Figures

◀ | ▶|

◀ | ▶

Back | Close

Full Screen / Esc

Print Version

Interactive Discussion
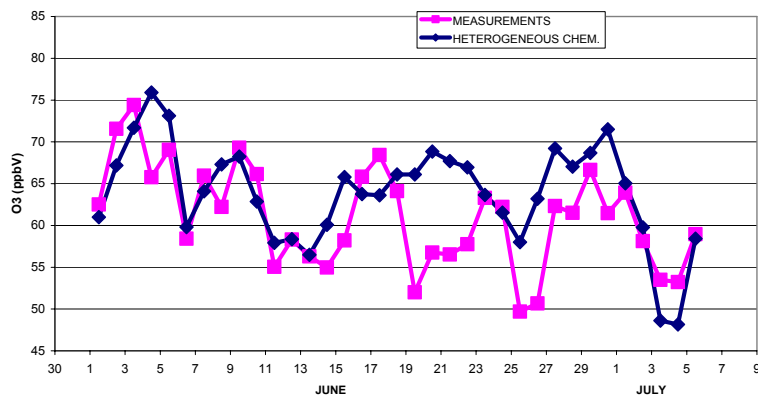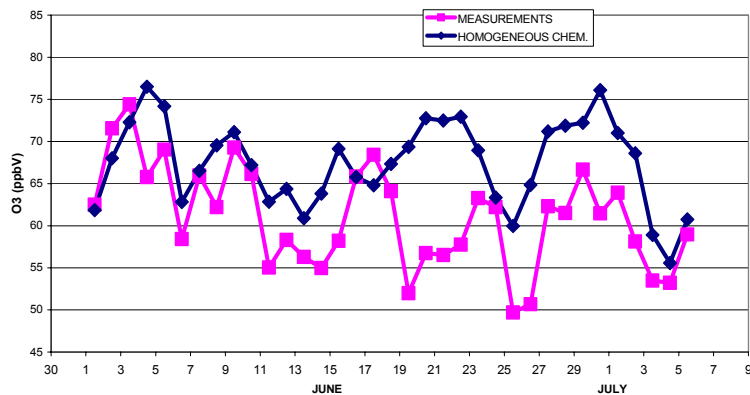
Fig. 4. Time series of daily mean ozone concentrations at Mt Cimone. The squares represent the measured concentrations (ppbV) while the diamonds are the ozone concentrations simulated by the LMDZ-INCA model. Ozone measurements were taken by P. Bonasoni from CNR-ISAC, Bologna.
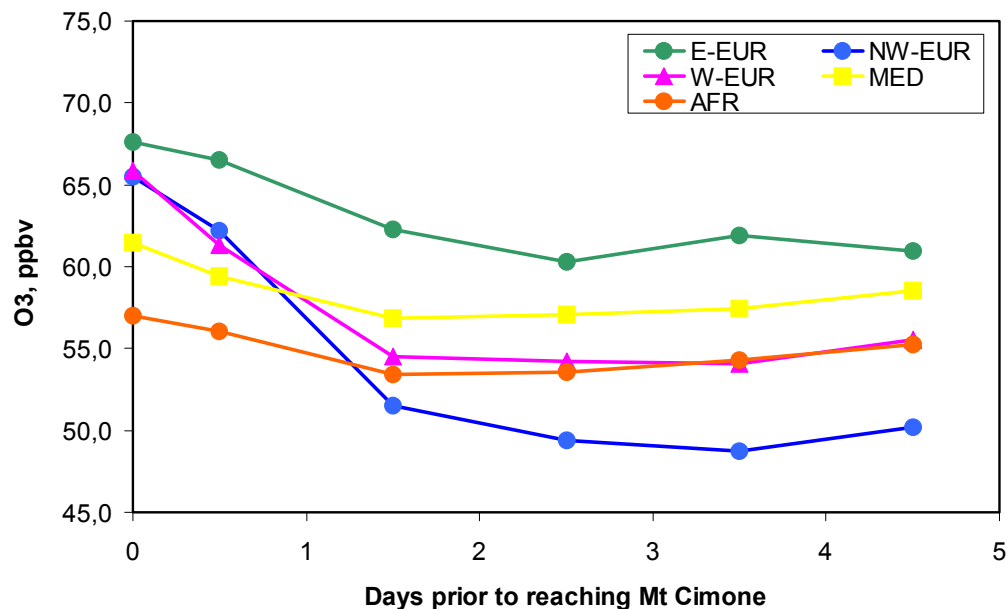
Fig. 5. Simulated mean ozone concentrations along the back trajectories arriving at Mt Cimone, respectively, 12, 36, 60, 84 and 108 h prior to the arrival time at the site.