Greek forest fires in summer 2007 as observed from MERIS and SCIAMACHY

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Introduction

During summer 2007 a forested area of about 70,000 ha was destroyed on the Peleponnes. The fire fronts were extending over more than 160 km and impacting the health of thousands of people. Trajectory analyses show that the observed smoke and trace gas plumes in the vicinity of the southern parts of the Mediterranean sea originated from the fires over the Peleponnes. Local anthropogenic or biogenic emissions are not to be expected over the open sea.
The primary aim of this study, concentrating on the episode between 24 to 27 of August 2007 (intense fire periode, see Fig. 1), is the evaluation of the fire events regarding climate and pollution relevant atmospheric parameters, such as enhanced trace gas concentration and aerosol impacts. Since direct observations within the plumes are mostly not available the synergistic use of remotely sensed data from satellite based observations by the (MERIS), MEdium Resolution Imaging Spectrometer and SCIAMACHY (The SCanning Imaging Absorption SpectroMeter for Atmospheric CHartographY) (Bovensmann et al., 1999, Gottwald et al., 2006) both on board of ENVISAT as well as forward trajectory analyses and chemical box model BRAPHO (BRemens Atmospheric PHOchemical model, Meyer-Arnek et al., 2005) calculations have been used to derive enhancement of atmospheric pollution parameters and to quantify the effects for further modelling.

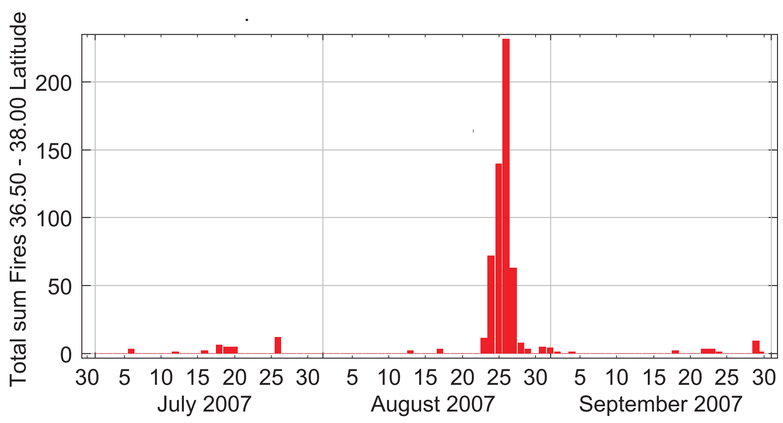

Fig. 1. Time series of MODIS Terra fire counts from July to September 2007 over the Peleponnes.

Results

In this study the plume location as seen in satellite measurements shows the best match to the output of the trajectory analysis in a height of 2 to 4 km (see Fig. 2). We assume a well mixed layer of aerosols and trace gases in this height and clean air conditions above and below this layer.
MERIS observations reveal that particles displaying an Ångstroem α > 1.3 and large aerosol optical thickness (AOT) are present for several locations for the 26th of August 2007. As follows a decrease of temperature below this layer is estimated. From Moderate-resolution Imaging Spectroradiometer (MODIS) fire count data it can be seen that an area of 8,000 km² was burning over a time period of 4-5 days during August 2007. The values of AOT obtained from MERIS observations, retrieved using BAER (Bremen AErosol Retrieval, v. Hoynigen-Huene et al., 2007), show an increase up to 1.2 (see Fig. 2d) and its pattern is following the calculated trajectories (see Fig. 2b).
Estimations of radiative forcing have been made using radiative modelling of daily averaged down- and up-welling radiation flux densities for the corresponding latitude zone by a radiative transfer program based on Nakajima el a., 1988. The averaged absorbed short wave radiation flux densities by the plumes reach for the observed AOT of 0.8 to 1.0 values of -16 to -18 W/m² for the down-welling flux at the ground. Assuming, that this flux is absorbed within the fire plume (height extension of 2 km) a heating rate within the plume of 1.4 up to 1.8K per day is obtained. For the average AOT of 0.6 we obtain a reduced flux density of -13 W/m² and a heating rate 1.2 k/day.

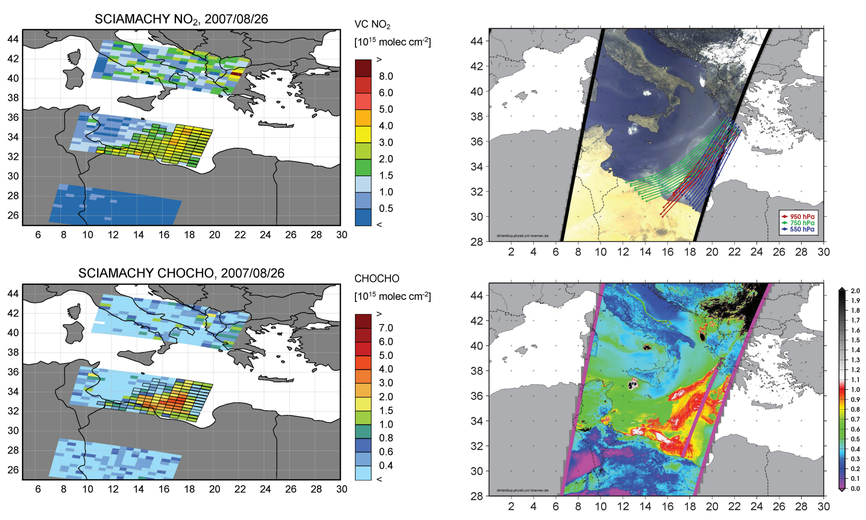

Fig. 2. The transport of air masses calculated with Traj.x overlayed on MERIS RGB image (b), as well as AOT from MERIS (d), NO_2 (a) and CHOCHO (c) from SCIAMACHY on August 26 2007.

Further the retrievals of AOT have been used for the estimation of the concentration of PM10 as described in v. Hoynigen-Huene et al., 2008. PM10 concentrations of 150 - 180 µg/m³ have been obtained for conditions within the thick fire plumes (exceeding the limit of European Union (EU) and World Health Organization (WHO) of an daily average of 50 µg/m³). Wide areas according to the high AOT values are covered with PM10 concentrations of about 100 µg/m³. For comparison, the estimates for unaffected cloud free regions are within 29 and 40 µg/m³.

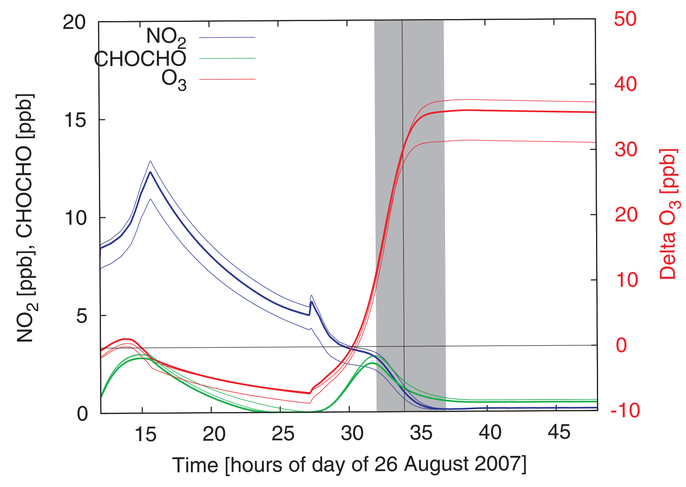

Fig. 3. Model output for the trace gases NO_2, CHOCHO and O_3, grey coloured is the overpass time of ENVISAT.

Retrieved maximum columns of NO_2 of $5*10^{15}$ molec/cm² (1.1 ppb) and CHOCHO of $6*10^{15}$ molec/cm² (1.4 ppb) from SCIAMACHY coincide well with the AOT maximum when regarding their geographical positions and extensions. This is an increase by a factor of 12 respectively by factor 30 when comparing to background conditions. From the calculation of the Lagrangian boxmodel BRAPHO (Meyer-Arnek et al., 2005) an O_3 increase at SCIAMACHY overcrossing time of 30 ppb (depending on the initialisation) was determined (see Fig. 3, one day after their release over the Peleponnes); from model results a mixing ratio of 13.5 ppb of NO_x and of 0.8 ppb of CHOCHO in the presence of a 2 ppb loading of hydrocarbons can be calculated near the fire. The here measured values are below the prescriptive limits for both trace gases. Nevertheless an increase as described above for NO_2 (small compared to the Indoneasian fires 1997, (Ladstätter-Weißenmayer et al., 2005) and for CHOCHO should not be neglected.

Conclusions

This case study shows the influence of polluted air masses due to biomass burning, no other sources like e.g. urban pollution or biogenic emissions have to be considered. An increase of AOT up to 1.2 from MERIS was seen whereas the average value was 0.6. As follows a reduced flux density of 13 W/m² and a heating rate of 1.2K/day were obtained. Within the plume the obtained concentrations of PM10 (150-180 µg/m³ ± 70 µg/m³) were above the limit of European Union (EU) and World Health Organisation (WHO). Near the fire mixing ratios of 13.5 NO_x, of 0.8 ppb CHOCHO in the presence of 2 ppb hydrocarbons and an increase of tropospheric O_3 of 30 ppb were calculated from model output. Although the prescriptive limits were not exceeded the impact of this fire event should not be neglected.

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Acknowledgements

Parts of this work have been funded by the University of Bremen, Germany, the DLR/DARA, the European Community, and the European Space Agency (ESA).We would like to thank National Aeronautics and Space Administration (NASA) for providing the MODIS data.

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