The Sonnblick Mountain Observatory - a platform to validate hemispheric-scale emissions

Gerhard Wotawa, August Kaiser, Helfried Scheifinger and Bernhard Niedermoser

Zentralanstalt fuer Meteorologie und Geodynamik (ZAMG), Vienna, Austria

1. Introduction

At the Mount Sonnblick Observatory site (Figure 1), various atmospheric trace gases (O_3, CO, CO_2, SO_2, NO_y,), particles and radioactive substances are measured on a routine basis. These substances are transported towards the samplers over ranges of a few dozens to several thousands of kilometres. Volcanic ash from Iceland, desert dust from the Sahara, radionuclides from the Fukushima accident, air pollution from Europe as well as the United States, and last but not least ozone from the stratosphere has been detected in the past. To track back the substances, the routine calculation of Source Receptor Sensitivity (SRS) Fields using the Lagrangian Particle Diffusion Model (LPDM) FLEXPART in backward mode is performed. The SRS fields, calculated every three hours, are used for the interpretation of the trace gas and particle measurements.

Figure 1: At an altitute of 3106 m asl, ZAMG operates the highest permanently staffed summit observatory in the world – since 1886

2. Source-receptor relationship

To describe the possible area of origin for trace gases and aerosols measured at Mt. Sonnblick, the established concept of the source-receptor relationship is employed (Wotawa et. al.., 2003). Let us consider the concentration c of one specific substance measured at the summit location during a certain time interval Δt. Then, c (g m^{-3}) can be simply expressed as the product of a spatio-temporal source field S (g) and a corresponding source–receptor sensitivity (SRS) field M (m^{-3}) at discrete locations (i,j) and time intervals n as follows:

$$c = S_{ijn} \cdot M_{ijn}$$

SRS fields are specific for the measurement (place, time) as well as for the measured substance (deposition, decay,…).

3. Calculation of SRS Fields

SRS Fields can be calculated using a Lagrangian Particle Diffusion Model (LPDM) backward in time. For Mount Sonnblick and other summit locations of the WMO Global Atmosphere Watch (GAW) program, ZAMG calculates these fields every three hours using the LPDM FLEXPART (http://www.flexpart.eu/; Stohl et al. 1998, 2005) version 8 in backtracking mode. Deposition is currently not considered. The SRS fields, together with trajectories are used regularly to interpret measurements.

4. Saharan dust episodes

Dessert dust episodes from the Sahara region are regularly encountered in the Alpine region, sometimes visible for weeks due to the sand-like colour of the snow. During a strong episode beginning of May 2013, the SRS fields clearly show that air masses from Northern Africa were transported to Mount Sonnblick (Figure 2). A particularly strong episode occurred in spring 2014, causing health-concerns over good parts of Europe. Also in this case, SRS fields worked well to identify the area of origin of the air masses.

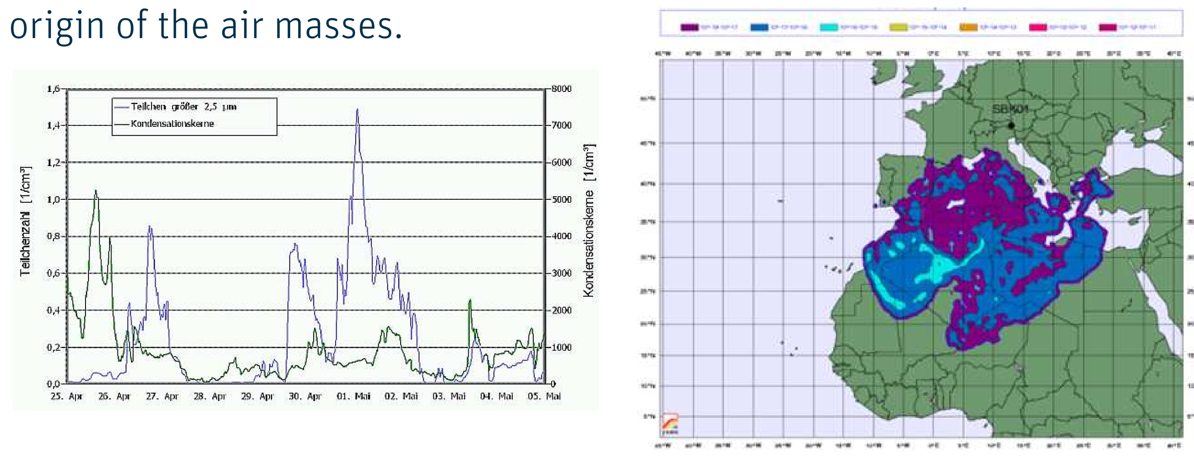

Figure 2: Detection of dessert dust aerosols at Sonnblick around May 1st, 2013, and the associated SRS field 5 days prior, showing the source area in the Sahara

5. Stratospheric intrusions

In April 2013, an ozone peak above the regulatory threshold was measured at the observatory. SRS fields showed the stratospheric origin of the respective air masses (see Figure 3).

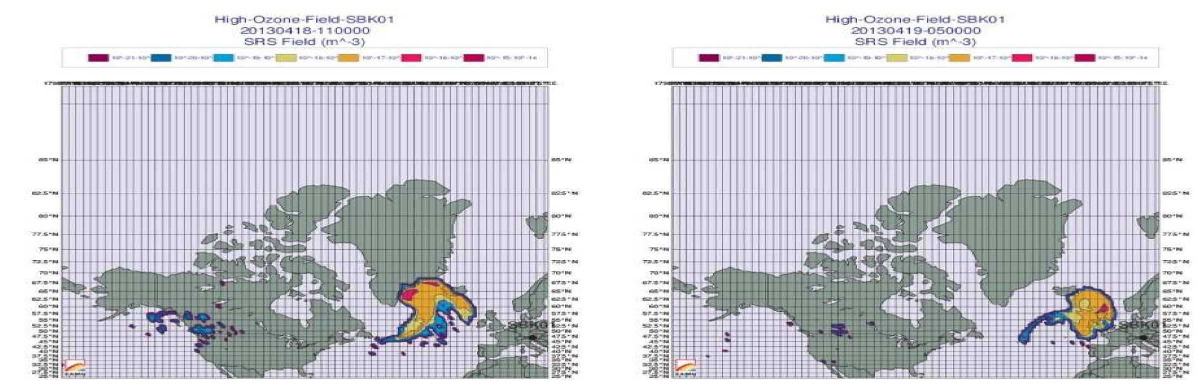

Figure 3: SRS fields in the 10-11 km height interval, 27 and 24 hours before the ozone episode

6. Statistical source analysis

SRS fields are not only used to investigate single events. Like the method of trajectory statistics, they can be utilized to explore the importance of possible source regions statistically. There are some methods available, for example the source correlation method, showing the variance of the measurement time series explained by all possible emission grid points, or the SRS statistics which investigates residence-time weighted concentration values on the same grid. These methods are applied to trace gases monitored, for example CO or NO_y). Especially in wintertime, the high-emission regions in north-western Europe become visible (Figure 4).

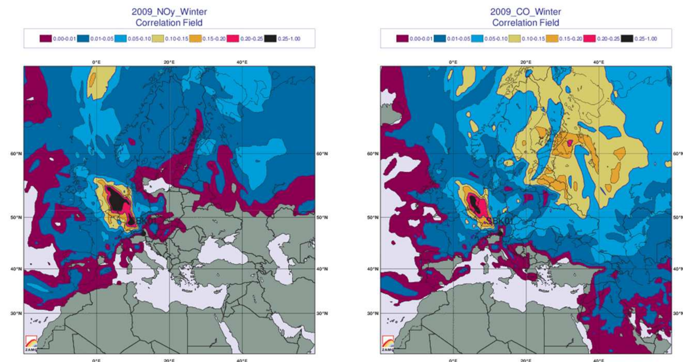

Figure 4: Source correlation analysis for NO_y and CO for the year 2009 in wintertime, based on a statistical evaluation of SRS fields

Literature

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ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Central Institute for Meteorology and Geodynamics, Division for Data, Methods and Modelling, Hohe Warte 38,
A-1190 Vienna, Austria Telephone: +43 1 36026 2002 - Facsimile: +43 1 3691233 – E-mail Address: Gerhard.Wotawa@zamg.ac.at