Analysis of long range air pollutant transport using trajectory residence time statistics.

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1.1. Abstract

There is a wealth of experience with trajectories and their application for various studies mostly dealing with air pollution problems. Trajectories have been applied to define air pollution source regions and calculate the dispersion of pollutants (Stohl, 1996 and 1998; Stohl and Trickl, 1999; Kaiser, 2000 and Kaiser et al., 2001). In this paper, trajectory residence time analysis is used to study long range transboundary air pollutant transport towards the two alpine measurement sites Hoher Sonnblick, 3105 m, and Zöbelboden, 899 m.

2. The air pollutant measuerment sites

The Sonnblick Observatory is situated at the peak of the Hoher Sonnblick, 3105 m, at the main ridge of the Alps. The air pollutant measurements are a contribution to the Global Atmosphere Watch Programme (GAW) of the World Meteorological Organization (WMO). Zöbelboden (899 m) is situated at the Reichraminger Hintergebirge, 42 km south of Linz, between the valleys of the Enns and the Steyr. Both stations are remote from local emission sources and are thus most appropriate to study the influence of long range air pollutant transport on the background air pollutant concentration in the Alps.

The study focuses on nitrogen dioxide, sulfur dioxide and ozone measured during the year 2000.

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3. Back trajectory residence time analysis

Three dimensional back trajectories are calculated with the FLEXTRA trajectory model and released at each measurement site each 3 hours in a height of 100 m above the model topography. The trajectories are based on the ECMWF wind fields with a horizontal resolution of 1° x 1° and 60 vertical layers up to the upper model limit (0 hPa), respectively 12 vertical layers up to 850 hPa (approx. 1500 m a.s.l.). The model domain used in this study spans from 90°W to 90°E and from 18°N to 90°N.

For trajectory residence time analysis, a grid is used with a resolution of 0,5° x 0,5° and 250 m heigth intervals. The time (hours) the trajectories spend in each grid square is added up and weighted with the measured air pollutant concentration to study the geographical origin of the polluted air masses.

Due to the fact, that the topography of the Alps is highly complex, the relatively coarse ECMWF wind fields are scaled down with the MM5 model up to a horizontal resolution of 3 km x 3 km for some selected episodes. Special emphasis will be put on the effects of the downscaling on the reliability of the trajectories.

4. Long range air pollutant transport

The results of the trajectory residence time analysis will be presented. A first assessment shows the prealpine region north of the Alps to be a relevant source of air with relatively high nitrogen dioxide and sulfur dioxide concentration. During winter, these air masses are relatively ozone-poor due to ozone depletion by nitrogen monoxide in the boundary layer and only small photocemical ozone production. High ozone concentration during winter is connected with air that subsides from high elevation down to the stations connected with foehn in the case of the lower station Zöbelboden (north of the main ridge of the Alps) and stratospheric intrusions at the high elevated site Sonnblick. During summer, transport of nitrogen dioxide- and sulfur dioxide-rich air from the prealpine region north of the Alps is connected with relatively high ozone concentration at Zöbelboden due to photochemical ozone production. Air flow from regions south of the Alps also shows relatively high ozone concentration. Especially for Sonnblick, the Po basin is an important ozone source.

Sulfur dioxide has a relatively long lifetime, therefore regions more remote to the Alps also play an important role: The region north east from Austria (Czech Republic – Hungaria) and even emissions from Slovenia cause elevated sulfur dioxide concentration at Zöbelboden.

5. References

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