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A model study of stomatal uptake of ozone in a costal Mediterranean maquis ecosystem

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Increased tropospheric background concentration of ozone due to increased emissions of ozone precursor gasses over the past century have reached values of which adverse effects on vegetation can be expected. These effects include reduced biodiversity in some areas, as a result to ozone-sensitivity differences across plant species, economic loss due to reduced crop yield, and may in some cases affect food security in areas of high food demand due to high population growth rates in the future decades. Estimate of the total stomatal dose of ozone to the vegetation, needed to quantify the damage of ozone to plants, requires calculation of the stomatal flux of ozone from the ambient air into the vegetation.

Uptake of ozone in plants has been studied in the Eulerian non-hydrostatic WRF-Chem model (Weather Research and Forecasting model with chemistry). This model is extensively used for atmospheric research, and consists of a dynamical part which is fully coupled with a chemistry module. In this study, WRF-Chem version 3.2 has been used with the RADM2 chemistry scheme. The model was run for two separate periods during the summer 2007 in order to compare results with measurements made in Castelportziano, outside Rome, Italy, in order to assess the performance of the model. The site is located in a Mediterranean maquis ecosystem. The two periods of May 20-26 and June 22-28 were selected by the availability and quality of measured data for comparison. Various horizontal resolutions have been used, down to 1km x 1km. Dry deposition of ozone is based on a scheme formulated by Weseley, in which the stomatal uptake is regulated by temperature and photosynthetic active radiation (PAR). The ozone chemistry and the meteorology (e.g. temperature and radiation) are coupled on-line in the model.

The modelled stomatal flux is compared to the flux derived from measurements for the daytime hours. The second of the two simulated periods was characterized by a lower measured stomatal flux, caused by overall dryer conditions at the measuring site, reducing the rate of evapotranspiration substantially and thereby also uptake of ozone. To account for the evaporative power of the atmosphere on the stomatal conductance, water vapor pressure deficit (VPD) was taken into account in adopting a Jarvis type approach, introducing a functions reducing the stomatal ozone uptake. Two different VPD functions were used, one based on instantaneous VPD and one on VPD accumulated over the day. Introducing the reduction in ozone uptake due to VPD improved the model results in comparison with the measurements. The VPD effect was only included in an off-line mode, but will later be included in on-line calculations.