Summary

Excessive tropospheric ozone concentrations are not only harmful for human health but also have detrimental effects on plants. Current practice is to assess O_3 exposure based on the AOT40 (Accumulated Ozone exposure over a Threshold of 40 ppb) which has been defined in the European Air Quality Directive 2008/50/EG, as the sum of hourly O_3 concentrations above a threshold of 40 ppb, from 8 to 2h during the growing season. This indicator is presently being used in MINA-plan 4 (2011-2015) to monitor the evolution of the risk for O_3 damage to vegetation in Flanders. The European long term objective is 3000 ppb.h (= 6000 (µg/m³).h), the critical level for O_3 damage to sensitive crops and natural vegetation.

Ozone effects are however primarily related to the amount of O_3 effectively entering the plant which is only a fraction of the surrounding atmospheric O_3 concentration. O_3 uptake is controlled by the degree of opening of the leaf stomata (stomatal conductance), that also regulate CO_2 and H_2O exchange. This mechanism allows the plant to adapt the degree of transpiration and photosynthetic activity to changes in environmental conditions. Consequently, also O_3 uptake is dependent upon climatic changes (temperature, air and soil moisture, irradiance …) and plant-specific characteristics (number of stomata, phenology …).

To obtain better estimates of O_3 damage, in the last 10 years a lot of effort has gone to the development of methods for the estimation of O_3 uptake by plants and to obtain reliable dose-response relations based on the O_3 flux. This has resulted in a new indicator for estimating the O_3 impact on yield and biomass accumulation of crops, forest trees and grassland: the Phytotoxic Ozone Dose POD_Y (mmol O_3 m^{-2} plant leaf area), which is the sum of the hourly stomatal O_3 flux over a threshold of Y nmol O_3 m^{-2} s^{-1} accumulated during daylight hours over the appropriate time-window.

This work is a continuation of the literature and feasibility study (Deutsch and Vandermeiren, 2013) that investigated how POD_Y could be calculated for Flanders. A first part describes the processing of the necessary input data being both meteorological data as well as the ozone concentration and soil and vegetation characteristics. The meteorological input data is based on the ECMWF data which are interpolated to the grid of the RIO concentration maps using the CHIMERE pre-processing tool. The RIO grid was also combined with the soil texture map used in the ECMWF meteorology and maps containing the fields for the different vegetation types considered in the POD_Y calculation as well as the different regions that have to be distinguished in the output resulting in a data set containing the combinations of vegetation-soil-meteorology-region for which a POD_Y calculation is required.

The report furthermore describes how based on the DO_3SE module of the European air quality model EMEP that can be used for an area-wide calculation of POD_Y a new program code was developed that reads these input data sets to calculate POD_Y for a user specified vegetation type for those fields that are covered with the vegetation type. The different user configuration files that are read by the code are described. The new model code was tested by comparing the model results to the results of the EMEP model. Also the effect of water stress and the choice of the input for the photosynthetic active radiation was assessed. Finally for the different vegetation types POD_Y values were calculated and visualised as maps and for wheat and potatoes further processed to estimate the yield loss based on dose response-relations for POD_Y that can be found in literature.