

AOT40 ESTIMATE AND MAPPING

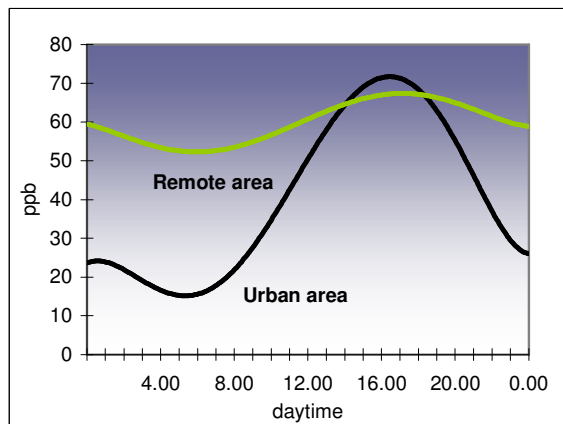
The problem

Passive samplers provide a low-cost alternative for the monitoring of ozone on a weekly basis. The samplers require no power, have a simple deployment system, and take only a few minutes each week to exchange samplers. They can be used to determine trends (long term measurements), getting base-line conditions, and for mapping concentration distributions of ozone over space.

As they provide mean weekly concentration data they cannot be used to calculate AOT40 (Accumulated dose over a threshold of 40 ppb), the European legislation key indicator for vegetation protection, which requires for its calculation hourly concentration data.

AOT40 is defined as the sum of the differences between the hourly mean ozone concentration (in ppb) and 40 ppb for each hour when the concentration exceeds 40 ppb, accumulated during daylight hours.

Ozone is known to have a particular distribution during daylight hours due to the emission rates of precursor and sunlight (energy) availability. Daytime distribution profile may be very different between urban and remote areas. In addition ozone in mountainous areas shows also an elevation dependent relationship due to the stronger sunshine and to the decreasing importance of depletion processes related to the low NO emissions.



Based on a study based on ca. 100 continuous monitoring stations Loibl et al. (1994) describe ozone concentration distribution as a function of the relative elevation (hr) of a site and daytime hours. Relative elevation consists of the difference between absolute elevation minus elevation of the lowest point within a 5 km radius. This function dependence is given by

$$O_3(h_r(x, y), t) = (a_1 + a_2 e^{-(t-a_3)^2 a_4}) x \ln \left(\frac{h_r(x, y)}{100} + \frac{b_1 t^2 + b_2 t + b_3}{b_4 t^2 + b_5 t + 10,000} e^{-b_6 t} \right)$$

where:

hr = relative elevation (m)

t = time of the day (in 0.1 h between 0.0 e 24.0)

a e b x = fitting coefficients

Based on this function a procedure to estimate AOT40 and to map the exposition index has been developed.

The method

Input data: passive sampler mean weekly concentrations (May - July, or April – September)
Digital terrain model (DTM)

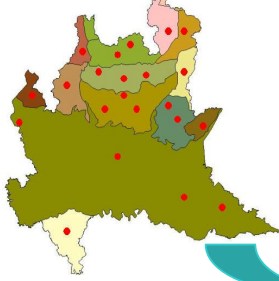
Once passive sampler weekly data are available, they are synchronized to avoid differences in starting and ending time of the sampling periods. This is done by a simple Access application which compares two series of data, the theoretical exposition series of 168 h and the real one and adjusts the latter. Nine possible cases are considered and corrected. After defining the semivariogram and kriging coefficients, data of each week are interpolated.

In order to map AOT40 over the vegetative period relative elevation (hr) values for the area considered from a digital terrain model (DTM) are calculated. Typical spatial resolution of a DTM are 1 x 1 km, 0.5x0.5 or 250 x 250 m. For each grid cell the difference between the absolute elevation minus the elevation of the lowest grid cell within a radius of 5 km are determined. This is done automatically and produces a new grid file of relative elevation data.

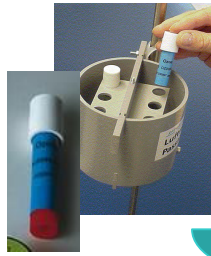
The Loibl function is applied to each cell. Ozone concentrations are calculate with a time resolution of 0.1 h. data are processed to obtain the mean weekly concentrations for each cell with the same starting time used for the passive samplers. The daily ozone distribution is then adjusted on a weekly basis using the passive sampler data (from the interpolated data set), in order to obtain new “corrected” weekly means equal to the passive measurements. Daily concentration distributions are than available for each grid cell. Concentration data between 10.00 and 20.00 (local time) are extracted and the threshold 40 ppb is subtracted. Negative data are set to “0”. The sum of the data exceeding 40 ppb is the AOT40. Mapping spatial resolution is the same of the DTM.

Attalea

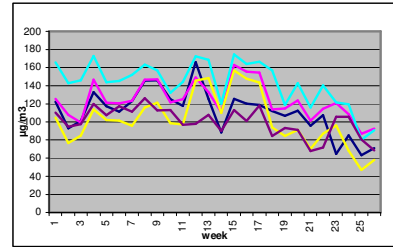
Passive sampler network



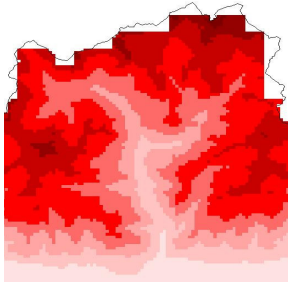
Passive sampler (PS) measurements



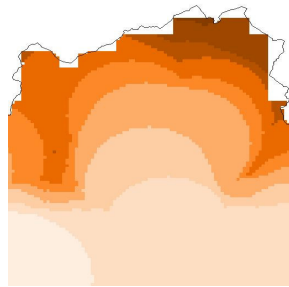
Mean weekly concentrations



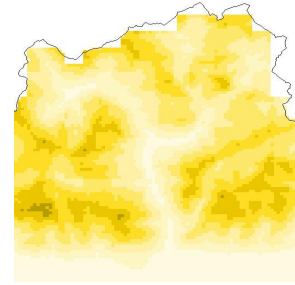
Digital terrain model



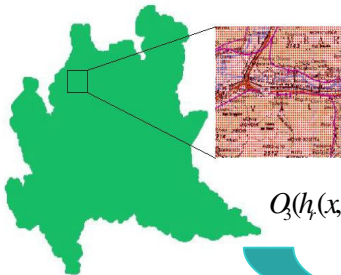
Extraction procedure



Relative elevation map



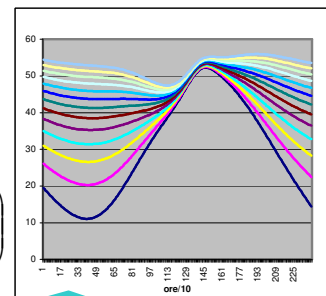
Digital terrain model - Grid



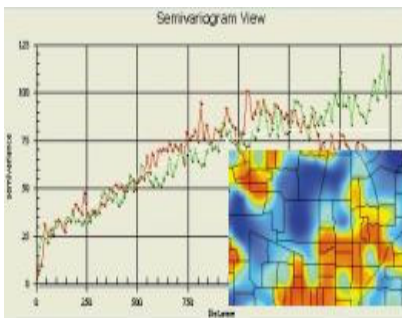
“Standard ozone” calculation

$$O_3(h(x,y),t) = (a_1 + a_2 e^{-(t-a_3)^2 a_4}) \times \ln \left(\frac{h_r(x,y) + \frac{b_1 t^2 + b_2 t + b_3}{b_4 t^2 + b_5 t + 10000}}{100} e^{-t/h} \right)$$

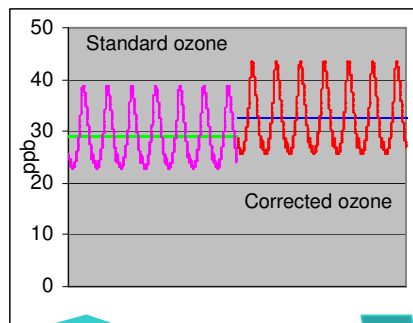
Standard ozone profiles



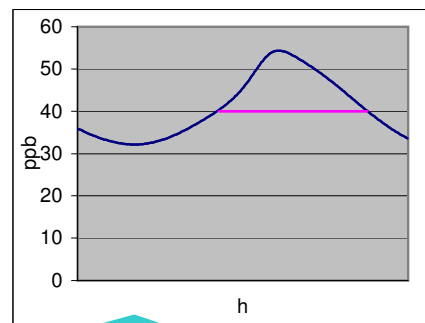
PS data Interpolation (Kriging)



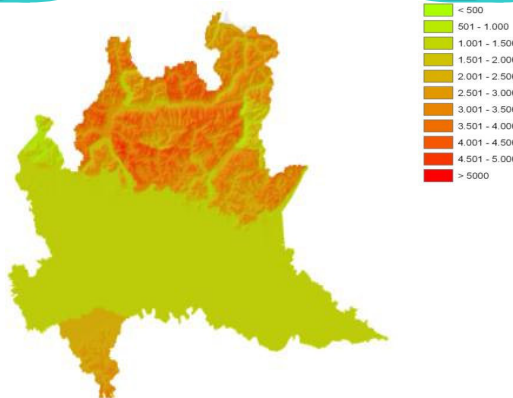
Standard ozone correction



AOT40 extraction

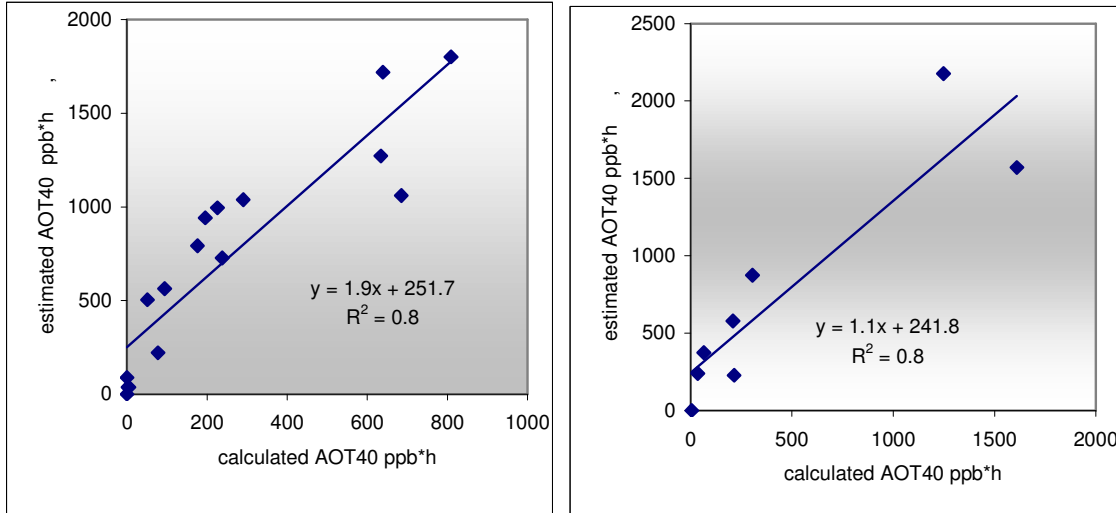


AOT40 Mapping



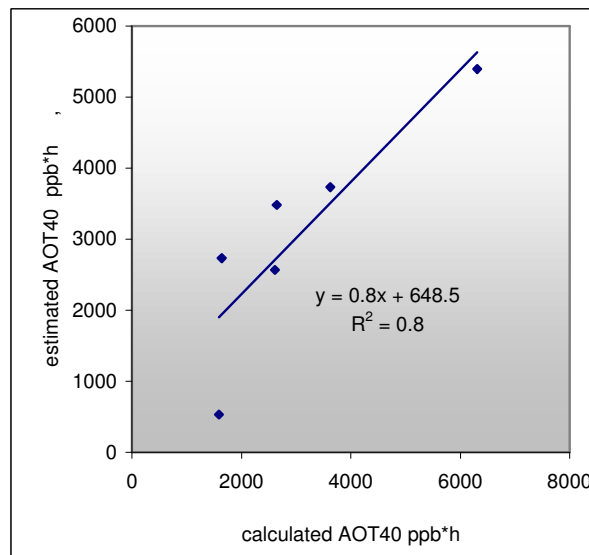
Validation

AOT40 derived from continuous ozone measurements (calculated AOT40) were compared with data from the modelling approach and co-located passive samplers (estimated AOT40). Calculated and estimated AOT40 values show no statistically significant differences.



Correlation analysis between estimated AOT40 and calculated AOT40i at a mountainous site (Val Masino, Lombardy, Italy) in 2005 and 2006

In plain areas the estimated AOT40 is overestimated but the correlation is statistically significant ($R^2 = 0.8$), probably due to the effects of nitrogen oxides sources. A correction with nitrogen oxides data may provide more precise data.



Correlation analysis between estimated AOT40 (monthly means) and calculated AOT40i at the JRC, Isrpa, Italy in 2004.