Vertical profiles of aerosol physico-chemical and optical properties measured along Italy over basin valleys

L. Ferrero[1]; D. Cappelletti[2]; M. Petitta[3]; F. Scardazza[2]; M. Castelli[3]; B. Moroni[2]; G. Sangiorgi[1]; M.G. Perrone[1] and E. Bolzacchini[1]

[(1)]Centro di Ricerca POLARIS, DISAT, Università di Milano-Bicocca, Piazza della Scienza 1, 20126, Milano.
[(2)]Dipartimento di Ingegneria, Università di Perugia, Via G. Duranti 93, 06125 Perugia.
[(3)]EURAC Institute for Applied Remote Sensing, Viale Druso 1, 39100, Bolzano, Italy

Introduction

Aerosols physico-chemical and optical properties are fundamental for remote sensing applications (Wang et al., 2010; Di Nicolantonio et al., 2009) as well as for climate change (IPCC, 2007; Kaufman et al., 2002); their 3D knowledge, especially along the whole atmospheric column is required (Levy et al., 2007; Wang et al., 2010).

Sampling sites

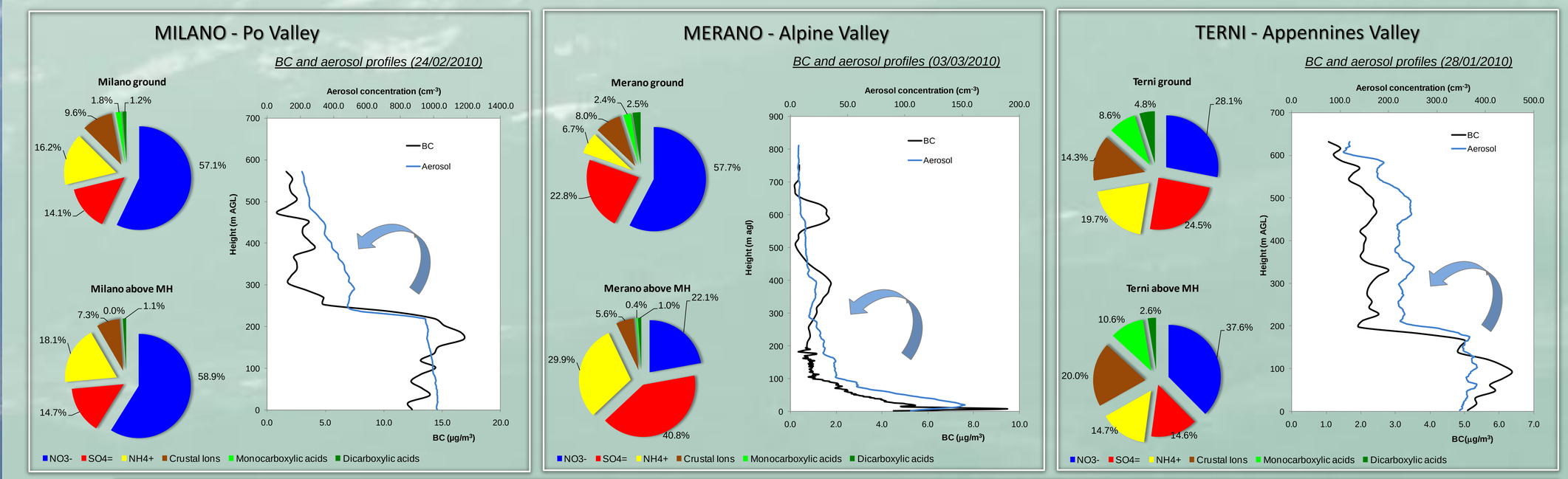
Vertical profiles of aerosol properties were conducted in:
1) Milano (Po Valley);
2) Merano (Alpine Valley);
3) Terni (Appennines Valley);
during January-March 2010 period.

Instrumentation

silica gel *met. station*

A tethered balloon was fitted with an instrumentation package consisting of:
1) a tandem-OPC system (2 OPCs GRIMM *1.107*; 31 size classes between 0.25 to 32 µm: one dried, the other one at ambient RH);
2) a novel micro-Aethalometer (AE51, Magee Scientific);
3) a miniaturized cascade impactor (Sioutas SKC with 2 impaction stages: <1 µm, >1 µm);
4) a metorological station.

Black Carbon (BC) and Inorganic ions along the vertical profiles



BC profiles clearly **identified the mixing height (MH)**, which was characterized by a strong vertical concentration gradient. The **BC fraction of aerosol volume fell to 50-70% above the MH**, compared to ground-level data, so that primary particles emitted by combustion sources showed a strongest vertical gradient than aerosol itself. This caused a change in the optical absorption properties of the aerosol at different heights thus changing the Single Scattering Albedo (SSA). Ionic fraction showed a similar composition to that measured at ground over Milano and Terni (polluted urban and industrial urban sites) were a substantial residual layer is present. Over Merano, aerosol has chemical properties more close to that found in continental remote sites.

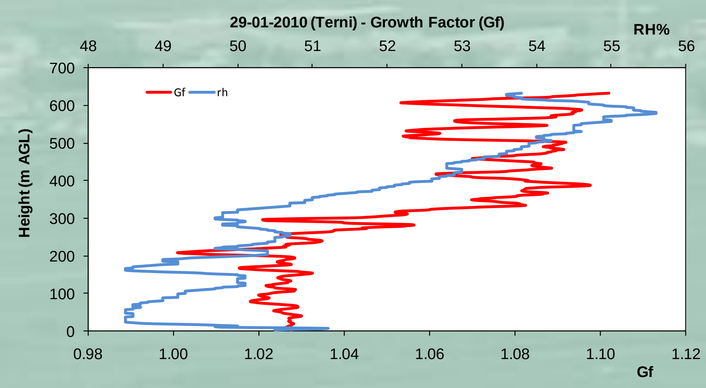
Hygroscopicity along the vertical profiles

Aerosol humidographs along height were determined using the **OPCs tandem system** following the method reported in Snider et al. (2008):

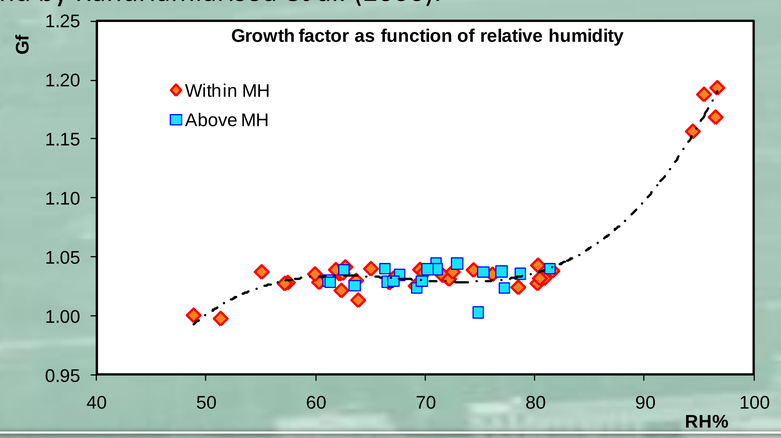
$$\left(\frac{dN_d}{d\log_{10} D_d}\right) = \alpha_d \cdot D_d^{-\beta} \quad \Leftrightarrow \quad \left(\frac{dN_w}{d\log_{10} D_w}\right) = \alpha_w \cdot D_w^{-\beta}$$

OPC_{dry} $Gf = (\alpha_w/\alpha_d)^{(1/\beta)}$ OPC_{wet}

Hygroscopic growth (Gf) was found to be not uniform along the vertical profiles: simple parameterizations of Gf along the atmospheric column in remote sensing applications can be a source of uncertainty in the results.



The behaviour of the Gf as a function of the relative humidity along vertical profiles showed results are in accordance with those reported by Snider et al. (2008) and by Randriamiarisoa et al. (2006).



Optical properties calculations

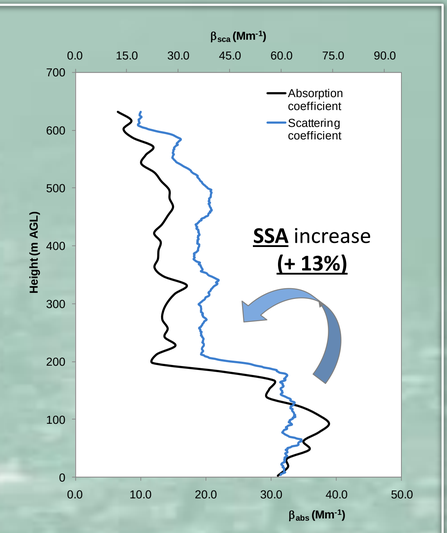
The chemical speciation allowed to estimate an aerosol refractive index with the Effective Medium Approximation:

$$\frac{\varepsilon_{eff} - \varepsilon_h}{\varepsilon_{eff} + 2\varepsilon_h} = \sum_{i=1}^{n} f_i \frac{\varepsilon_i - \varepsilon_h}{\varepsilon_i + 2\varepsilon_h}$$

i.e. for Milano (at 880 nm): 1.484+0.039i within MH amd 1.465+0.025i above the MH.

Aerosol scattering properties along height were calculated from OPC data using a Mie code (Bohren and Huffman, 1983) and absorption from the micro-Aethalometer using its compensation factor C=2.05 (Ferrero et al., 2011):

$$b_{abs} = \left[\frac{A \cdot \Delta ATN}{100Q \cdot \Delta t}\right] \cdot \left[\frac{1}{C \cdot R(ATN)}\right]$$



Constant values of absorption coefficient were found **above the MH (5-20%; 2-15 Mm^{-1})** of those measured within the mixing layer. **SSA increased due to a reduction of BC.**

Summary

In summary, changes in aerosol physico-chemical properties affected optical behaviour along height. SSA was found higher above the MH due to a reduction in the absorbing BC aerosol along height.
Also aerosol hygroscopic growth changed along the profile; thus simple parameterizations of Gf along the atmospheric column based on ground level RH in remote sensing applications can be a source of uncertainty in the results.
Vertical profiles are necessary to understand aerosol properties along height to improve satellite algorothms.

Aknowledgement

Project SATMAP, Provincia di Milano, fondazione CARIT di Terni e Narni, Provincia Autonoma di Bolzano - Alto Adige, Agenzia provinciale per l'ambiente - Laboratorio di chimica fisica.