Measurements with a CHM-15k ceilometer at the Alpine station of Aosta, Italy: first results and new insights on pollution dynamics

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Aerosol monitoring is particularly important at mountain sites:

- aerosol can have a large impact on the fragile mountain environment and climate (e.g. on glaciers) and on the visual quality of the landscape;
- mountain stations represent the ideal background sites to study long-range transports episodes and long-term aerosol trends. From this perspective, the Alps environment is unique, being a cross between continental Europe and the Mediterranean basin.

INSTRUMENTATION AT THE AOSTA SOLAR OBSERVATORY

Figure 1: Lufft CHM-15k Nimbus ceilometer.

A new CHM-15k ceilometer (Fig.1) was installed in April 2015 at the solar observatory of the Environmental Protection Agency (ARPA) of the Aosta Valley (45.74°N, 7.36°E, 560 m a.s.l.). The instrument is an automatic laser radar (Lidar) operating at 1064 nm and capable of mapping the vertical profile of aerosols and clouds up to the tropopause. The location is in a semi-rural context, just out-of-town, slightly influenced by anthropogenic activity. The site is in a large valley floor with a wide field of view.

Several instruments to measure the solar irradiance (ultraviolet broadband radiometers, double-monochromator spectroradiometer, pyranometer), infrared irradiance (pyrgeometer), trace gases (MkIV Brewer spectrophotometer) and aerosol properties (POM-02 sun-sky photometer) are already operating at the same site (Fig. 2).

The ceilometer will complement the current instrumentation providing semi-quantitative information about the clouds/aerosol vertical profiles and possbile depositions to the ground (e.g. Saharan dust). Also, it will be beneficial to retrieve the mixing layer height and the top of the temperature inversion, both important parameters to understand the concentrations of pollutants at the surface and their short- and long-term variations

Figure 2: instrumentation at the solar observatory at ARPA.

The institute is also in charge of the Regional Air Quality Network: the PM concentrations are measured in the stations of Aosta (urban site) and Donnas (rural site) (Fig. 3) with an OPSIS SM200 particulate monitor.

Figure 3: map of Aosta Valley and PM measurement sites.

FIRST CASE STUDIES

Although the lidar has been operating only for a few months, the analysis of the backscattered signal already provided unexpected results that deserve much interest.

11-13 May 2015

In a first case study, we observe the usual daily evolution of the mixing layer centered at noon of the first day; a likely episode of advection during the afternoon; a Saharan dust advection late in the afternoon on the second day (Fig. 4).

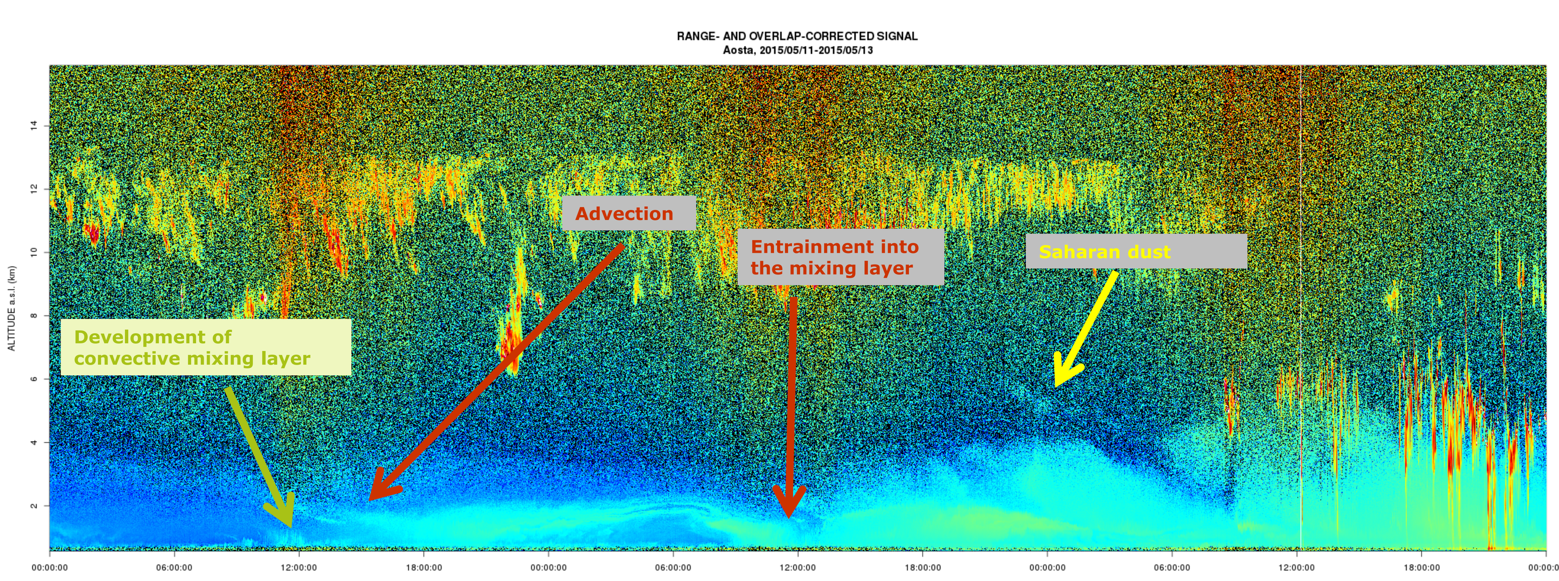

Figure 4: ceilometer backscattered signal (range and overlap corrected), 11-13 May 2015.

During the period, the surface winds came from East during the day (Fig. 5), as a consequence of the breeze circulation from the plain to the mountain in Spring and Summer in clear-sky days with weak synoptic circulation.

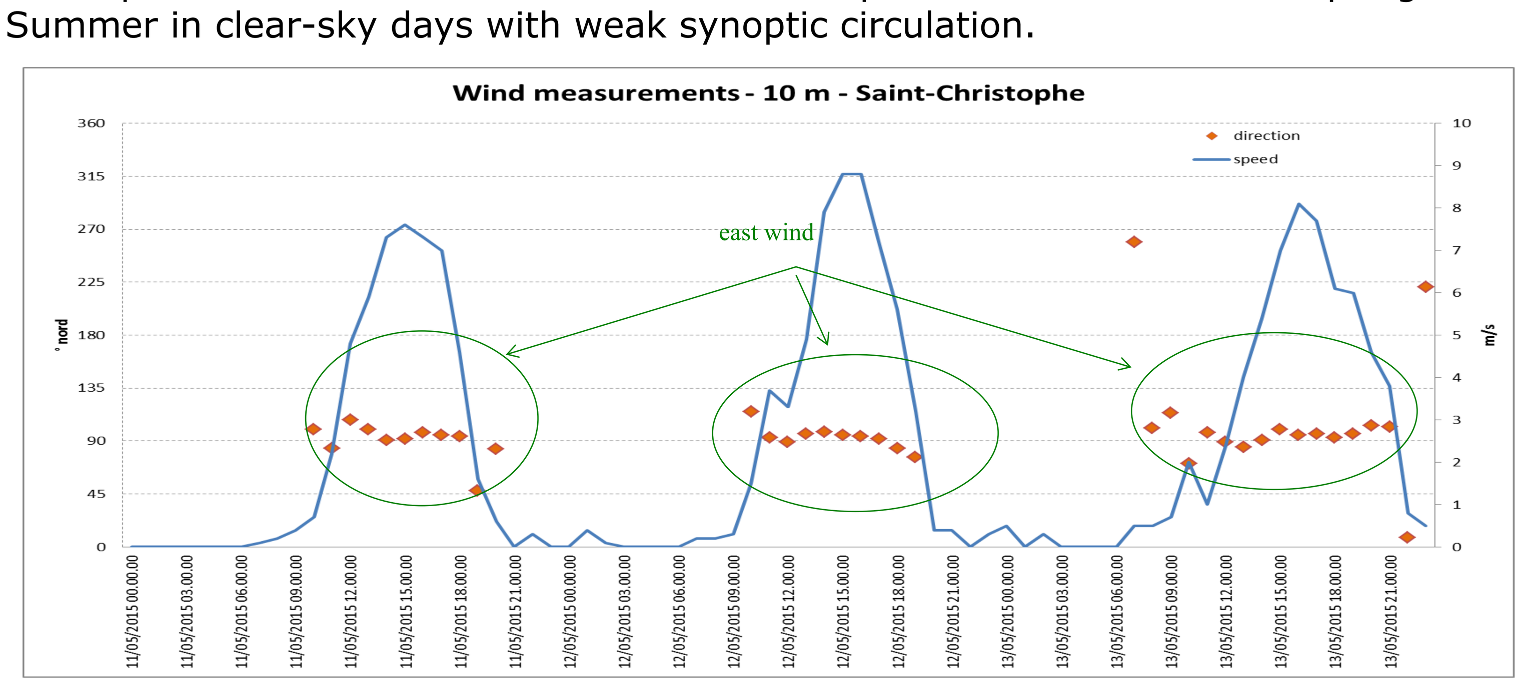

Figure 5: chart of the surface wind measurements (direction on the left axis and speed on the right axis) in Saint-Christophe 11-13 May 2015

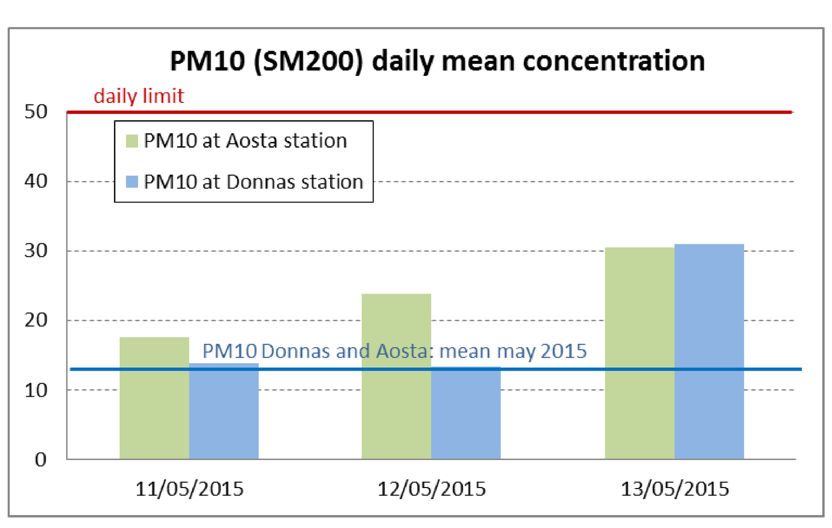

Figure 6: PM10 concentration levels in Aosta and Donnas 11-13 May 2015

A look at the PM10 concentration levels (Fig. 6):

11/05 – typical average concentrations in Aosta and Donnas;
12/05 – the concentration increases in Aosta;
13/05: the level is twice as much as the mean in Aosta and in Donnas. Such high levels in both stations suggest that some sources of aerosol have reached the Aosta Valley (Saharan dust advection)

3-6 June 2015

In a second case study, we observe the same configuration for several consecutive days, likely advections from East as a consequence of the breeze circulation.

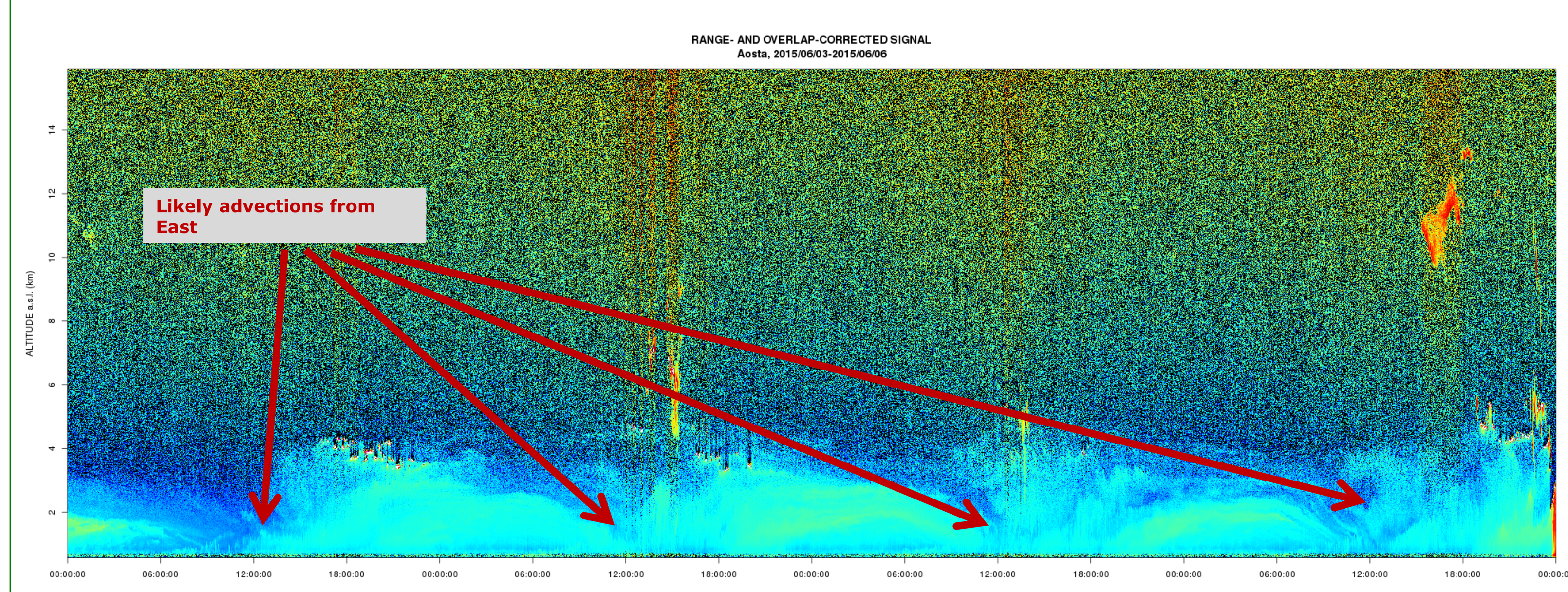

Figure 7: ceilometer backscattered signal (range and overlap corrected), 3-6 June 2015.

On these days, the surface winds follow the typical evolution of the breeze circulation: an increase of the wind speed during the warmest hours with a rotation of the wind direction from East.

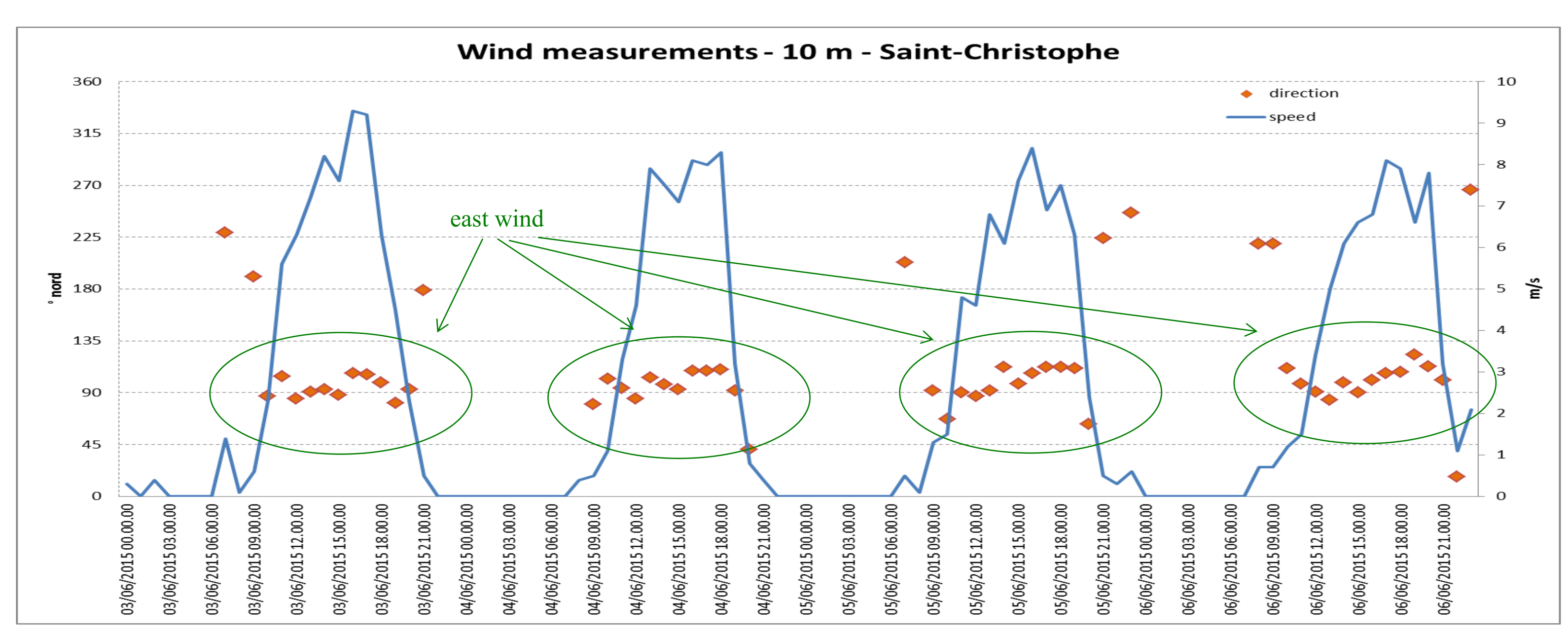

Figure 8: chart of the surface wind measurements (direction on the left axis and speed on the right axis) in Saint-Christophe 3-6 June 2015.

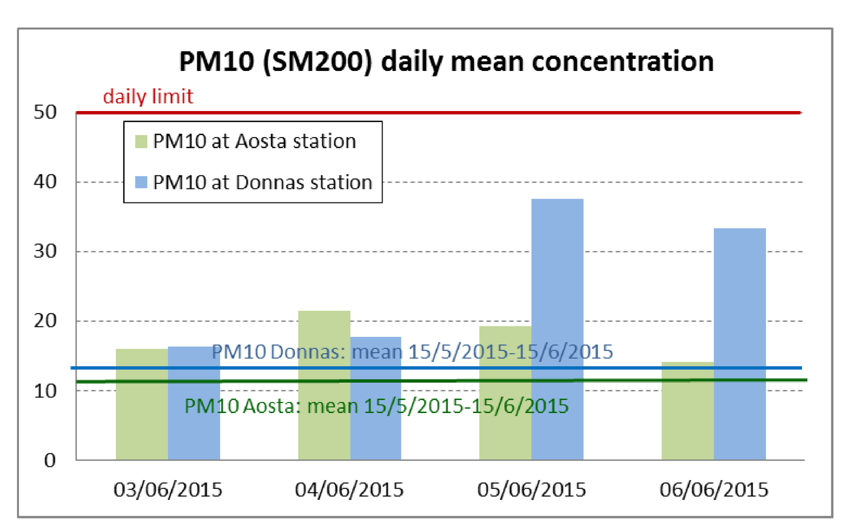

Figure 9: PM10 concentration levels in Aosta and Donnas 3-6 June 2015

The PM10 concentration levels in Aosta were higher than the mean of the period 15 May-15 June. The levels increased on the last two days in the station of Donnas (Fig. 9).

FUTURE RESEARCH

Due to technical reasons, no overlap between the measurements by the sunphotometer and the lidar was possible so far. We plan to correlate the retrieval of the column aerosol properties from the photometer with the vertical profile of the backscatter obtained by the ceilometer, a first step towards retrieving an aerosol extinction profile.

Moreover, wind profiles from meteorological models will be useful to understand the dynamics and vertical extent of the breezes and shed some light on the mechanisms of the pollution transport. Large tilting of the ceilometer will be carefully evaluated to reduce the minimum overlap height and monitor the lowest atmospheric layers. Finally, automated classification schemes and algorithms for the retrieval of cloud and aerosol layers heights will be adopted.

In the near future, collaboration and data sharing with ISAC-CNR is scheduled to foster the development of an Italian network of ceilometers.

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