Date: 27.03.2020

An ACTRIS-Italy contribution to atmospheric monitoring during the COVID-19 lockdown.

At the time of writing, about one billion people in the world are confined to their home as a measure taken by governments to confine the SARS-CoV-2 virus contagion. Whatever will be the duration and the immediate regional and global aftermaths of the lockdown, these are also exceptionally times for understanding the human impact on the Earth system. The large reduction of anthropogenic emissions resulting from the lockdown will provide a real-world quasi-experiment of unprecedented importance (much greater than the 2008 Beijing Olympic Games[1]) about the impact of human activities on air quality and atmospheric composition.

Recent reports from ESA and NASA showing remote sensing observations of priority pollutants over China and Italy indicate that the effects of the lockdown on air quality has already become apparent[2,3]. According to first analyses, surface concentration of NO_2 have decreased in north Italy of about 10% per week during the last four or five weeks[4,5]. The concentrations of another major air pollutant, the particulate matter (PM10 and PM2.5), have declined too but with large day-to-day variations: after two weeks of lockdown and large reductions in traffic activity in north Italy, PM10 levels above the threshold of 50 $\mu g\ m^{-3}$ are still recorded in several cities of the Po Valley.

Particulate matter exhibits indeed a large diversity of sources, atmospheric transformations and transport patterns which cannot be fully traced by regulatory air quality monitoring. Probing the complexity of the meteorological and chemical processes linking emissions to concentrations is one of the targets of ACTRIS (https://www.actris.eu/). *ACTRIS*[6] *(Aerosol, Clouds and Trace Gases Research Infrastructure) is a pan-European initiative consolidating actions amongst European partners producing high-quality observations of aerosols, clouds and trace gases. ACTRIS provides 4D-variability of clouds and of the physical, optical and chemical properties of short-lived atmospheric species, from the surface throughout the troposphere to the stratosphere, with the required level of precision, coherence and integration.*

The Italian component of the distributed research infrastructure ACTRIS (ACTRIS-IT) is based on a number of different facilities distributed throughout the national territory including observational sites with multi-parameter instrumentation, laboratories and experimental simulation chambers. It strongly contributes to the implementation of the ACTRIS Lidar Calibration Centre, the ACTRIS Data Centre and the ACTRIS Head Office.

The main facility operative within ACTRIS in Northern Italy is “Monte Cimone – Po Valley observatory” (CMN-PV). It is a distributed infrastructure including the GAW and ICOS station of Monte Cimone (http://www.isac.cnr.it/cimone/) in the northern Apennines, and the two stations of San Pietro Capofiume and Bologna in the south sector of the Po Valley. It is a unique observatory for providing parallel measurements of atmospheric composition at different altitudes and urbanization contexts in the same geographical area. Preliminary measurements at Monte Cimone (2165 m a. s. l.) show reduced submicron

aerosol concentrations compared to 2019 (Fig. 1). If confirmed, a negative anomaly with respect to the climatology will proof that the abatement of anthropogenic emissions caused by the lockdown are affecting the composition of the background atmosphere in this region of the world.

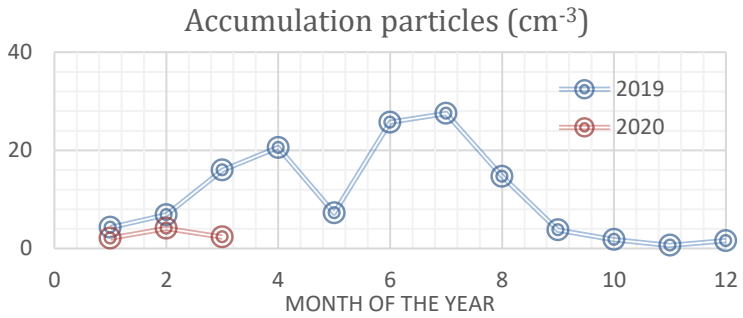

Fig. 1. Monthly mean concentrations of accumulation-mode aerosol at Monte Cimone in 2019 and early 2020 (update March 20th).

At the low altitude sites of the observatory (Bologna and San Pietro Capofume), advanced aerosol measurements are set up during intensive observation periods. Currently, a state-of-the-art high-resolution aerosol time-of-flight mass spectrometer (HR-ToF-AMS) is being operated in Bologna (Fig. 2). The instrument provides real-time submicron aerosol chemical composition measurements providing unparalleled detail on the time-resolved PM source contributions including traffic, residential combustion and secondary formation. First observations during the lockdown show that the concentrations of several particulate anthropogenic pollutants – like ammonium nitrate – are still very dynamic in the Po Valley, with a large variability induced by meteorological factors. Accounting for such effects provides baseline knowledge for quantifying the impact of emission changes on PM concentration levels.

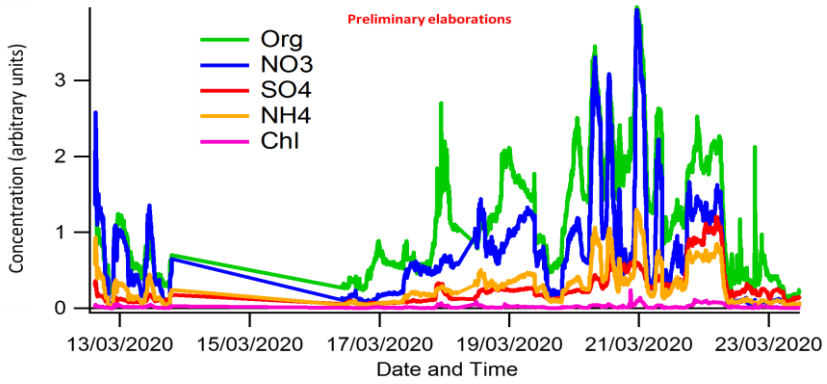

Fig. 2 Time series of the non-refractory chemical components of sub-micrometer aerosol measured by the HR-ToF-AMS in Bologna (preliminary data for the third week of March 2020). “Org”: organic matter; “NO3”: nitrate; “SO4”: sulfate; “NH4”: ammonium; “Chl”: chloride.

Further advanced aerosol observations, including multichannel aerosol size and mobility distributions measurements, are being set up in collaboration with the University of Modena, Helsinki and of Eastern Finland. International scientific networks are of great importance for the empowerment of regional monitoring networks for priority scientific objectives. Thanks to ACTRIS and parallel ESFRI platforms like ICOS, CNR was able to maintain efficient collaborations across the EU frame programmes with institutions like FMI, CNRS and various top EU universities. The established scientific collaborations between CNR and other partners with the EU institutions responsible for satellite Earth observations (EUMETSAT, ASI) will enable to benchmark remote-sensed air quality parameters with the advanced in situ ground measurements carried out by ACTRIS for a more quantitative assessment of the impact of emissions on

concentrations and exposure. In these extraordinary times, scientific research must take a pro-active role to achieve quantitative information on the human impact on the environment, as such information will be key for governance in the upcoming years.

References:

[1] Rich et al., Association between changes in air pollution levels during the Beijing Olympics and biomarkers of inflammation and thrombosis in healthy young adults, JAMA, 307(19), 2068–2078, 2012.

[2] https://www.youtube.com/watch?v=ARpxtAKsORw&feature=emb_title.

[3] https://earthobservatory.nasa.gov/images/146362/airborne-nitrogen-dioxide-plummets-over-china.

[4]https://atmosphere.copernicus.eu/air-quality-information-confirms-reduced-activity-levels-due-lockdown-italy

[5]https://public.wmo.int/en/media/news/economic-slowdown-result-of-covid-no-substitute-climate-action

[6]https://www.youtube.com/watch?v=03pELRVn7qI

Acknowledgements:

Stefano Decesari, Angela Marinoni, Paolo Bonasoni, Paolo Cristofanelli, Matteo Rinaldi and Maurizio Busetto of the CNR Institute of Atmospheric Sciences and Climate (ISAC) provided the data and contributed to this report