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Source apportionment of $PM_{2.5}$ in a major city in an Alpine valley during the cold season: the effects of atmospheric dispersion and inversion dynamics

Mauro Masiol[1], Gianni Formenton[2], Flavia Visin[1], Alessandro Bonetto[1], Manuela Rovea[2], Silvia Ficotto[2], Elisa Danesin[1], Tommaso Toffanin[1], Anita Maggiulli[1], Maria Battistel[1], Giovanna Mazzi[1], Andrea Gambaro[1], Rossano Piazza[1], and Philip K. Hopke[3,4]

[1]Dept. Environmental Sciences, Informatics and Statistics, Università Ca' Foscari Venezia, Via Torino 155, 30172 Mestre (VE), Italy

[2]ARPAV - Regional Agency for Environmental Protection and Prevention of Veneto, via Lissa 6 30174 Mestre (VE), Italy

[3]Dept. Public Health Sciences, University of Rochester Medical Center, Rochester, NY, 14642, United States

[4]Institute for a Sustainable Environment, Clarkson University, Potsdam, NY, 13699, United States

Urban areas in mountain environments are generally located on valley floors surrounded by slopes, where mountain orography drives peculiar meteorology and atmospheric circulation. Also, persistent inversion dynamics may occur strongly affecting air pollution. This study characterised the $PM_{2.5}$ pollution in a major city located in an Alpine valley (Belluno, Northeastern Italy) during the cold season (Autumn-Winter). Major aerosol species (elemental and organic carbon, major inorganic ions) and minor/trace elements conventionally used as tracers for source apportionment were analysed, including oxalate and specific $PM_{2.5}$-bound tracers for biomass burning (K^+, levoglucosan, mannosan, galactosan) and for primary biogenic organic aerosol (arabitol, mannitol, glucose). The major aerosol components are reconstructed through mass closure, while the major sources are identified through positive matrix factorization and a series of post-processing tools. Results indicate that biomass burning, mostly emitted by residential wood combustion for domestic heating, is the major $PM_{2.5}$ source (52% $PM_{2.5}$ mass concentration), followed by secondary aerosol, biogenic aerosol, traffic, and dust resuspension. The source contributions are therefore handled by accounting for the local meteorology. Insights on the dispersion or buildup of $PM_{2.5}$ sources were then investigated by dispersion normalization. In addition, the possible effects of persistent thermal inversion events occurring across the Alpine valley are evaluated by assessing the inversion strength from temperature profiles measured from multiple ground-based weather stations at different elevations with respect to the air quality sampling station. Data analysed in this study reflects typical autumn/winter air pollution in a major Alpine valley. Significantly higher concentrations are recorded in colder months, i.e., when the newly proposed maximum daily concentrations for $PM_{2.5}$ (25 μg m^{-3} not to be exceeded more than 18 times per calendar year, according to the Proposal for a Directive COM(2022) 542 final/2, 2022/0347(COD)) or the newest WHO air quality guidelines are frequently breached, posing serious concerns for meeting the forthcoming European air quality standard for $PM_{2.5}$. Beyond the indication of which emission sources require further mitigation actions, this study also analyses the potential effects

of local meteorology on $PM_{2.5}$ pollution and air mass transport from the nearby Po Valley. This study is supported by the project iNEST (Interconnected North-Est Innovation Ecosystem) funded by the European Union Next-Generation EU.