"Visibility" at the Italian natural parks: preliminary data from the first-ever pilot project by ENEA and CUFAA

Ettore Petralia[1], Teresa La Torretta[1], Milena Stracquadanio[1], Antonella Malaguti[1], Giuseppe Cremona[1], Giancarlo Papitto[2], Cristiana Cocciufa[2], Maurizio Gualtieri[3] & Antonio Piersanti[1]*

[1] ENEA – SSPT-MET-INAT, Italian National Agency for New Technologies, Energy and Sustainable Economic Development – Atmospheric Pollution Laboratory, 40129 - Bologna

[2] CUFAA – Forest, Environmental and Agri-food Units Command of the Carabinieri, 00187 - Roma

[3] Department of Earth and Environmental Sciences, University of Milano-Bicocca, 20126 - Milano

[*] Corresponding author. Tel: +39 051 6098132, E-mail: ettore.petralia@enea.it

THE PROJECT "VISIBILITY"

"Visibility" is meant as the greatest distance at which an observer can see a distant object in contrast with the horizon and, when referred to a landscape, it depends on the optical characteristics of the atmosphere, which are also linked to the presence of gaseous or particulate pollutants that contribute to generating haze that obstructs clear vision. The visibility is therefore a useful indicator of air quality in natural areas with a significant naturalistic, ecological or attractiveness vocation such as the National Parks. In these areas the possibility of enjoying a clear panorama immersed in a natural landscape represents a precious recreational value, a *de facto* ecosystem service. The Italian Constitution itself (Article 9) and several Italian laws point at preserving the nature and the landscape.

OBJECTIVE. The goal is to employ the American protocol I.M.PRO.V.E. (Interagency Monitoring of PROtected Visual Environment) based on the algorithm developed by Malm et al (1994) [1] for the quantification of the coefficient B_{ext} (light extinction, equation (a)) as a function of different chemical-physical parameters associated with compounds in the particulate and gaseous phase of both anthropic and natural origin.

$$B_{ext} \approx 2.2 * f_S(RH) * [\text{Small Ammonium Sulfate}] + 4.8 * f_L(RH) * [\text{Large Ammonium Sulfate}] + 2.4 * f_S(RH) * [\text{Small Ammonium Nitrate}] + 5.1 * f_L(RH) * [\text{Large Ammonium Nitrate}] * 2.8 * [\text{Small Organic Mass}] + 6.1 * [\text{Large Organic Mass}] + 10 * [\text{Elemental Carbon}] + 1 * [\text{Fine Soil}] + 1.7 * f_{SS}(RH) * [\text{Sea Salt}] + 0.6 * [\text{Coarse Mass}] + \text{Rayleigh Scattering (Site Specific)} + 0.33 * [NO_2\ (ppb)] \quad \text{(a)}$$

[1] Spatial and seasonal trends in particle concentration and optical extinction in the United States. J. Geophys. Res. 99: 1347–1370. 1994

EXPERIMENTAL MEASURES. During spring-summer 2021 and winter 2021/2022, 24-hours samples were collected, with a frequency of one every three days. The following chemical species and components were characterized and quantified (μg/m^3) according to equation (a):
PM_{10}, $PM_{2.5}$, water soluble anions and cations[2], Elemental and Organic Carbon[3], metals and trace elements[4] and NO_2 (concentration quantified in ppb with a dedicated monitor).

Fig. 3 Daily measures of the different sources affecting air quality characterized according to the equation (a). The chemical species underlying this sources (see notes [2], [3] and [4]) were used to determine the B_{ext} parameter. The daily value were used to calculate the B_{ext} parameter during each day and to correlate the obtained value to actual pictures giving evidence of the real possibility to distinguish the Circeo promontory (examples in Fig 4)

[2] Sulphates, Nitrates and Ammonium for Secondary inorganics pollutants, or Chloride to calculate the marine – Sea salt spray aerosol concentration
[3] Tracer of organic emissions from both natural sources or anthropogenic sources such as combustion
[4] Al, Ti, Si, Ca and Fe, necessary for calculating Fine soil particles component

THE PILOT SITE. The first site study to apply the *Visibility* approach in Europe, is the Circeo National Park (LT). The measuring instruments are located near the Lago dei Monaci site. The identified site is far from local sources of pollutant emissions, is characterized by good local ventilation and faces a site of high naturalistic interest, namely the Circeo promontory.

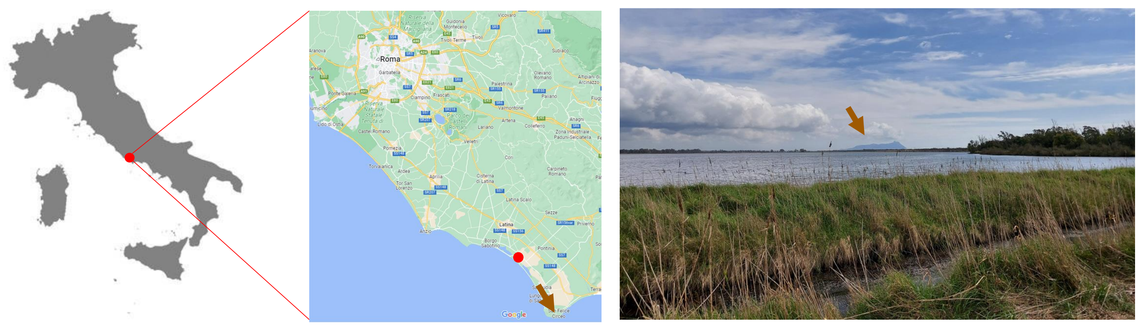

Fig. 1 Sampling site near the Lago dei Monaci and view of the Circeo promontory from the sampling area (distance ≈ 20Km). Brown arrows: the Circeo Mount, focus point of the photocamera)

THE *VISIBILITY* SAMPLING CABINET. The cabinet developed for *Visibility* is equipped with two FAI Hydra dual-channel samplers for atmospheric particulate matter sampling, an analyzer for NO_x, a camera for image acquisition (pointed towards Monte Circeo, necessary for the definition of long-distance optical visibility) and a weather station for the collection of local meteorological data (in particular, relative humidity is one of the factors required for calculating the visibility coefficient).

Fig. 2 The Visibility cabinet near the Lago dei Monaci, drone view and focus on the sampling lines for particulate matter and the meteorological measurements

THE "VISIBILITY INDEX". A first visibility index (B_{ext}) was calculated (according to equation (a)) and preliminary results show that an increasing B_{ext} effectively corresponds to a decreasing optical visibility at long distance. The parameters that seem to contribute the most to reduce the visibility and hence to the increase of B_{ext} are the secondary inorganic species (Ammonium Sulphate and Ammonium Nitrate) closely linked to atmospheric humidity.

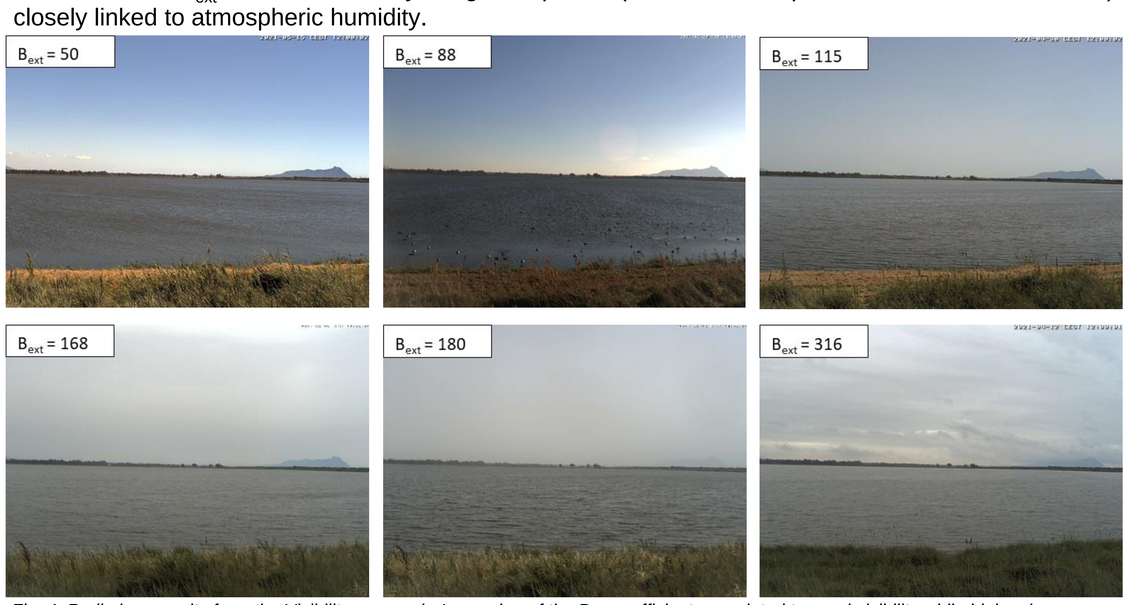

Fig. 4. Preliminar results from the Visibility approach. Low value of the B_{ext} coefficient are related to good visibility while high values correlate to scarce or reduced visibility of the Circeo promontory.