Using Copernicus Atmosphere Monitoring Services to map natural areas at risk due to poor air quality

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The effects of poor air quality on vegetation are dependent on both pollutant and vegetation type and include reduced growth rate, increased vulnerability to external stresses (e.g., drought, diseases) and reduced flower numbers. An extensive overview of the effects of air pollution on vegetation can be found in Weber et al., 1994[1].

Reference levels for vegetation exposure to air pollution are reported in the guide on mapping critical levels on vegetation[2] of the International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops (ICP Vegetation), which is part of the Working Group on Effects (WGE) under the Convention on Long-range Transboundary Air Pollution (LRTAP) of the UNECE. Critical levels are defined as "concentration, cumulative exposure or cumulative stomatal flux of atmospheric pollutants above which direct adverse effects on sensitive vegetation may occur according to present knowledge"[2]. For the purpose of this project, the effects on vegetation of Sulphur dioxide (SO_2), Nitrogen oxides (NO_X) and Ozone (O_3) are analyzed. The critical levels considered are those reported in the aforementioned guide and also included in the EU Ambient Air Quality Directive[3]. For SO_2 the critical levels are based on the annual mean concentration or the winter half-year mean and are dependent on the vegetation type. The critical levels for NO_X are set for both short- and long-term exposure, but only the latter are used because the long-term effects are considered to be more important. For O_3 two type of indicators are available, one based on the cumulative stomatal flux (POD), the other on the cumulative exposure to ozone concentration (AOT40). The metrics based on the stomatal flux are preferred, but since there is a need for further local meteorological variables, only the metric based on cumulative exposure is used. The AOT40 is defined as the difference between the hourly mean and a threshold of 40 ppb during daylight and over the growing season.

The reference year for this study is 2019 since 2021 and 2020 are not representative because of the temporary decrease in emission caused by the COVID-19 pandemic.

In this proposed project I will use the Copernicus Atmospheric Monitoring Service (CAMS) ensemble air quality model estimation to compute the impact indicators for vegetation health due to NO_X, SO_2 and O_3 concentrations over Europe. Then I will proceed to overlap the high impact areas with the Copernicus CORINE LAND COVER to identify natural areas where AQ indicators for vegetation are exceeded. Finally, values for specific vegetation indexes (e.g., NDVI) will be analyzed in order to compare the health of vegetation among natural areas differently affected by poor air quality.

[1] Weber, J., D. Tingey, AND C. Andersen. PLANT RESPONSE TO AIR POLLUTION. U.S. EPA.
[2] Alonso, R.; et al. III. MAPPING CRITICAL LEVELS FOR VEGETATION; 2017.
[3] EEA Air quality in Europe - 2020 report.