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Characterization of the physical properties of industrial plume aerosols from PRISMA hyperspectral images.

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According to the European Environmental Agency, industrial fine particles emissions have represented respectively 15% and 6.5% of PM10 and PM2.5 emissions in Europe between 2013 and 2018. Stack emissions are a significant contributor to the atmospheric PM burden. Satellite imagery is a proven technique for stack plume detection although the quantitative retrieval of aerosol properties within the plume remains a challenge. We propose a new method to detect stack plume aerosol properties from hyperspectral satellite imagery.

PRISMA (PRecursore IperSpettrale della Missione Applicativa) is a medium-resolution (30 m) hyperspectral imaging mission launched in 2019 and carrying a camera with 239 spectral channels between 0.4 and 2.5 µm. Additionally to PRISMA data, SENTINEL-2/MSI observations within a few days delay from PRISMA acquisition are used in the proposed method to better constrain the surface reflectance conditions over the targeted scenes.

Three industrial sites have been observed: a coal-fired power plant in Kendal, South Africa (on 25/09/2021), a steel plant in Wuhan, China (on 24/03/2021), and gas flaring at a gas extraction site in Hassi Messaoud, Algeria (on 09/07/2021).The Sentinel-2 acquisitions are set to the PRISMA spectral resolution thanks to a fusion method called the Coupled Non-Negative Matrix Factorisation (Yokoya et al., TGRS, 2011).

Then, the aerosol optical depth and the particulate radius are retrieved using an optimal estimation method (Calassou et al., RS, 2020). The retrieved radii range from 0.15 to 0.3 µm with an uncertainty of 5 to 20 nm for the flare emission, from 0.3 to 0.7 µm with an uncertainty of 15 to 40 nm for the steel site emission and from 0.4 to 1.25 µm with an uncertainty of 0.05 to 0.2 µm for the coal plant. The retrieved AOTs vary from 0.2 to 1 for the flaring site, from 0.5 to 3.4 for the steel site plume and from 0.6 to 2.45 for the coal plant emission. The retrieved aerosol radii are of the same order of magnitude as literature data for the flares, while retrieved radii for the coal plant and the steel site are higher due to the potential contribution of a coarse aerosol mode than is not accounted for in the procedure.

The proposed case studies demonstrate the ability of a coupled hyper/moderate spectral satellite imagery for stack plume analysis and open a way to estimate particulate flux emission from stack using space remote sensing.