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POST-DOCTORATE PROPOSAL

Title : **Monitoring soil contamination by specific-species identification and diversity assessment based on multi-scale (from in-situ to satellite) optical remote sensing**

Reference : **PDOC-DOTA-2023-06**
(to be recalled in all correspondence)

Start of contract: 2024

Application deadline: Until fulfilled

Duration: 36 months

Keywords:

Optical remote sensing, machine learning, vegetation, bio-chemical and physical traits, species-specific, soil contamination, phytostabilisation, multi-(hyper-)spectral technologies, multi-scale platforms (satellite, airborne, UAV, and in-situ sensors)

Profile and skills required:

Formation: PhD discipline related to the project's scope, such as optical remote sensing, signal / image processing, applied mathematics, terrestrial ecosystems

Skills: strong remote sensing data processing knowledge from terrestrial/proximal or Unmanned Aerial Vehicles or aerial or satellite platforms, python programming experience, possibly GIS (Geographic Information System) and experimental field measurement skills, knowledge of the English language

Presentation of the post-doctoral project, context and objective:

TMEs (Trace Metal Element), released by various anthropic activities like agricultural, mining, smelting or other industrial activities, can lead to persistent pollution in soil even after the cessation of operations. The environment is then exposed to the transfer and dissemination of TMEs causing water and soil contamination and loss of biodiversity. Vegetation mapping and monitoring in development on polluted soils (or nearby) are of interest to provide information on the results of rehabilitation or to detect and control residual contaminants through modification of physiological activities (revealed e.g. by pigment concentrations, biomass) (Slonecker et al. 2010, Lassale et al. 2019, Malabad et al. 2022, Béraud et al. 2023), species-specific identification (Gimenez et al. 2022) or biodiversity change (Song et al. 2020). Therefore, monitoring soil TMEs on large scale for various land covers is of great interest and can be achieved by passive optical remote sensing. Hyperspectral imagery and multispectral temporal series have been widely used to assess vegetation traits and species/genus/assemblage classification. More recently, these technics are used to map variables characterizing the contamination (vegetation traits, soil composition) (Ong et al. 2019, Song et al. 2020, Lassalle et al. 2019, Lassalle et al. 2021, Fabre et al. 2020, Gimenez et al. 2022, Béraud et al. 2023). The retrieval of TME impacts on vegetation by optical remote sensing data remains challenging (species-dependent according to their sensitivity to particular TMEs, TME effects combined with other natural or environmental stressors of greater impact…) and site-specific (Wang et al. 2018).

The objective of this post-doctorate is to provide performant and robust method by means of multi-scales optical remote sensing data processed by AI technics to map species and diversity at local and regional scales in various polluted contexts (agricultural, mining, post-mining, industrial areas). Then, these maps will be correlated to foliar and soil TME contents to retrieve indicators characterizing a contamination at local scale. To reach this objective, the candidate will work on optical remote sensing of terrestrial ecosystems by means of a range of technologies and platforms, including hyperspectral and/or multispectral multitemporal sensor on-board satellite (PRISMA, EnMAP, Sentinel-2), hyperspectral camera on-board aircraft, multispectral camera on-board drone and hyperspectral in-situ sensors. These multi-scale data will be used in synergy at various stages: model calibration, data fusion and validation. The most suitable strategy to exploit multi-scale data to improve the quality of the provided classification and prediction maps and assess performance will be studied.

The project phases will be the following:

- Spectral signature library build and processing: the candidate will participate to the definition of a standardized procedure to build a spectral library based on in-field and laboratory measurements and will measure soil and vegetation spectral responses on 7 study sites. The in-situ experiments will be synchronized with drone/aircraft flights for 3 sites. The spectral analysis will lead to the identification, for major species, of sensitive vegetation traits (biophysical, biochemical properties) to soil contamination that can be related to spectral signatures (Béraud et al. 2022). This library will be included in a scalable GIS platform and exploited as training and validation database,

- Image preprocessing : satellite image collection definition (available image selection, temporal series construction), radiometric and geometric correction analysis, multi-scale image registration (Brigot et al. 2016),
- Species and diversity map supply for 3 sites (mining and agricultural areas): supervised classification methods based on machine learning algorithms will be applied to airborne hyperspectral images (metric spatial resolution) (Erudel et al., 2017, Gimenez et al., 2022). The multispectral images acquired from drone platform providing fine-scale analyze (centimetric spatial resolution) will be used firstly to build the training and validation database and calibrate supervised classification models. Various strategies could be tested: GIS construction by photointerpretation, metric assessment (e.g. spectral indices) or supervised or unsupervised classification. Secondly, the hyperspectral features will be completed by the drone fine-scale features (textural or morphological features, LAI-Leaf Area Index…) to fully increase the classification input data.
- Up-scaling to satellite level over all the sites: the species/genus/assemblage of species and diversity maps will be provided with a decametric spatial resolution (from 10 to 30 m). These maps will allow analyzing spatial or temporal patterns at larger areas. The contribution of data acquired at smaller scales (airborne, UAV) will be studied as previously mentioned.
- Experiment feedback: the most performant and robust strategy (machine learning algorithm, scale of observation…) to map and predict will be defined, the correlation between vegetation maps and foliar and soil metal contents will be analyzed.

This work will contribute to set up the appropriate experiment and methodology to monitor polluted soils.

This post-doctorate proposal is in the framework of the EDAPHOS R&I project as part of the "Soil Health and Food" mission in the context of the EU Soil Strategy 2030 (Horizon Europe Call). EDAPHOS aims to implement innovative nature-based technologies for monitoring polluted soils and remediation to accelerate their reclamation. The candidate will work in close collaboration with University of Bourgogne Franche Comté (FR, coordinator) / University of Franche Comté (FR) and 11 other partners in the European consortium (DE, ES, FR, GR, IT, PL).

Candidates should have:

- Less than 3 years after their PhD degree,
- Obtained outstanding academic results and have experience with academic publishing;
- Proven interest and experience in image processing, remote sensing, and environment.

Application materials include:

- a letter of motivation,
- an academic CV, including a publication list,
- contact details of an academic referee.

The Postdoctoral project supervisor has relevant expertise in hyperspectral and multispectral image processing, species classification, data fusion, machine learning algorithms and soil contamination contexts.

References:

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External collaborations:

University of Bourgogne Franche Comté / University of Franche Comté and CSIC, CRES, UNIBO, GIG, A21, INERIS

Host laboratory at ONERA:

Department : Optics and Associated Techniques

Location (ONERA center): Toulouse

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