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HYPERHEALTH - Environmental impact assessment on human health: advanced methods for hyperspectral data exploitation

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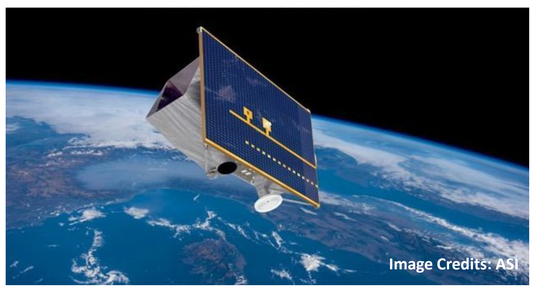
HYPERHEALTH Project



PRISMA (Hyperspectral PRecursor of the Application Mission) is an Italian Space Agency Earth observation satellite with innovative electro-optical instrumentation which combines a hyperspectral sensor with a medium-resolution panchromatic camera. The system is able to provide a unique information contribution for different applications thanks to its high spectral and spatial resolution.

The **HYPERHEALTH** project aims to develop a system for the assessment of the conditions of human activity in the open air and the value of high spectral resolution hyperspectral data typical of PRISMA records is critical to the development of the methodologies proposed in the project.

The project aims to exploit the information extracted from PRISMA hyperspectral images and integrate them with images and data from other satellite missions and with data collected with ground-based instruments.

Such a system would provide an essential tool for the assessment of health risk factors due to the presence in the air of excessive humidity, carbon dioxide or other gases and particles (pollen, allergens) or the excessive intensity of solar UV radiation.
The risk assessment is aimed at all persons who are exposed to the above agents i.e., those engaged in outdoor activities both work and recreational. This tool would provide useful information in the process of defining the regulations and ordinances of the institutions responsible for protecting the citizen's health, but could also lead, through the development of dedicated 'app', to recommend individual criteria of behavior in the conduct of outdoor activities.

The Project objectives are aimed at the characterization of the environment for human health and may have important implications on many topics of interest: Air Quality, Natural and Man-Made Hazards, Ecosystem Structure & Composition, Vegetation & Forestry.

The HYPERHEALTH Project will allow an immediate use of the results through the realization of prototype services (i.e. web, app) that can represent and establish the basis for the development of new types of personal health care services.

Project Mission

The project aims to develop innovative methodologies for estimating atmospheric constituents (H_2O, CO_2, O_3), identifying surfaces containing potentially allergenic plant species, and monitoring the flowering and pollen release period. The estimates of these quantities at the surface are an important indicator for calculating the risk factor for human breathing. The data resulting from the analysis of PRISMA hyperspectral images will be combined with those provided by other missions and in situ sensors (POLLnet, Sentinel, 5p, CAMS, SEVIR etc) in order to complete the information system for health risk assessment related to outdoor activities.
HYPERHEALTH also aims to exploit the DREAM (Dust REgional Atmospherical Model) model used the prediction and modeling of dust in the atmosphere.

Geophysical or environmental parameters generated through the proposed techniques	Products Products used for estimation
Allergenic plant species identification maps	▪ PRISMA: L1, L2d-2c ▪ Sentinel 2: L2A
Classification maps of the vegetation status of plant species (flowering, etc.)	▪ PRISMA: L1, L2c ▪ Sentinel 2: L2A
Concentration maps of CO_2, H_2O, O_3	▪ PRISMA: L1, L2c ▪ Copernicus
Estimation of the albedo of surfaces on the UV spectral bands	▪ PRISMA: L2d

The table summarizes the parameters generated through the proposed methodology in relation to the products used.

The cross-platform information set would be integrated to derive maps of atmospheric constituents at the surface, maps of allergens in addition to maps of solar UV irradiance. These maps will be used to derive a more generic and possibly interactive health risk map.

The project is organized into the following research activities:

- Development of innovative methods based on *machine learning* approaches for estimating atmospheric constituents from PRISMA data.
- Development of innovative methods based on machine learning approaches and forward modelling techniques for allergenic plant species identification from PRISMA data.
- Development of methods for extrapolation of albedo data from PRISMA data for analysis of solar UV radiation reflected from the ground.
- Development of methods for fusion/integration of data at different spatial/temporal scales to improve the analysis capabilities of systems that are currently in use.
- Analysis and testing of appropriate system evaluation/validation methods.

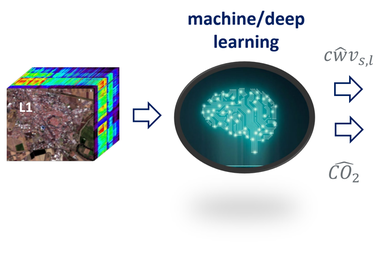
Project Outputs

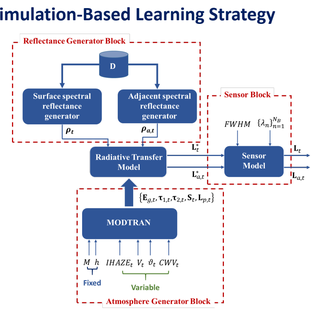
Atmospheric Constituent Estimation

The use of hyperspectral data makes it possible to obtain pixel-by-pixel, i.e., spatially resolved, and large-scale estimates of the constituents of interest. It allows for freedom from the presence and deployment of ground-based meteorological stations. The spectral bands of the sensor adopted by the PRISMA mission provide sufficient information (in terms of spectral resolution, number of contiguous spectral channels, and spectral range extension) for estimating the columnar content of water vapor and CO_2 and possibly other constituents.

The project aims to analyze and develop:

- *Deep Neural Network* architectures for estimating the columnar contribution of water vapor, CO_2 and from PRISMA data.
- A *Simulator* of training data in addition to the definition of learning strategies.



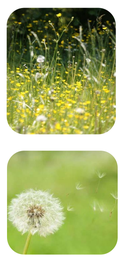


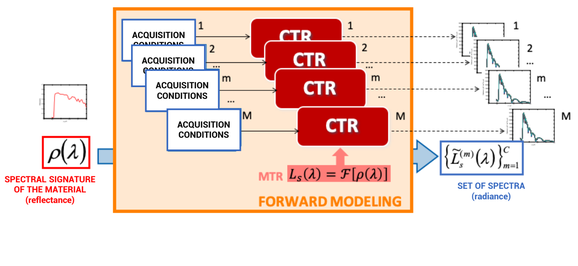
Allergens Monitoring

PRISMA hyperspectral data are essential for monitoring flowering and pollen status in vegetation. One or more types of specific allergenic species (i.e., grasses, pinaceae, salicaceae, etc.) will be chosen as case studies in the project according to the availability of PRISMA data and ground truth data

The project aims to analyze and develop:

- *GLRT-based* algorithms for material detection starting from reflectance images.
- *Kernel-based* machine learning algorithms for material identification from satellite reflectance images.
- Identification algorithms based on *forward modeling* approach starting from satellite radiance images.
- Development of *context-based* methodology that integrates atmospheric contributions.



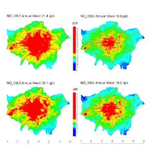


Data Fusion and Risk Monitoring

Multi-source integration will be carried out using methodologies for spatial realignment of data from the different sources and using forecasting methodologies (based on methods for predictive calculation of parameters) so as to obtain for the different parameters a congruent representation for service purposes.

The project would develop a prototype service that would be developed from the infrastructure to date used by *siHealth* to deliver the services/products (smartphone apps or web portals) based *on HappySun8* technology.

The service will exploit personal data of registered users such as gender, age, presence of respiratory diseases, allergies, and skin type which will be cross-referenced with parameters obtained from the other sources (satellite and point) and prediction models used. User-specific risk maps will then be produced.


Risk Maps


Web&App Services

Healtcare Info.

Partnership

Funding institution for the "PRISMA SCIENCE" call DC-UOT-2019-061.