Research Project

The Far-infrared-Outgoing-Radiation Understanding and Monitoring (FORUM) mission has been recently selected by ESA as one of the two candidates for the Earth Explorer 9 mission program and is currently undergoing the industrial and scientific Phase-A study (2018-19). FORUM will measure the Earth's top-of-atmosphere emission spectrum from 100 to 1600 cm-1 (nominal resolution of 0.3 cm-1), thus filling the observational gap across the so-called far-infrared (100-667 cm-1) where the exiting radiance is highly sensible to upper tropospheric water vapor and cirrus clouds.

The Physics and Astronomy Dep. of the University of Bologna is deeply involved in the FORUM Phase-A activities, especially those concerning ice clouds studies. The focus of the studies is on the characterization of clouds radiative features, the sensitivity analysis that are introductory to the core of the project that is the implementation and application of cloud identification/classification algorithms and cloud properties retrieval techniques exploiting the far infrared information content.

It is co-responsibility of the Physics and Astronomy Dep. of the University of Bologna (in collaboration with DEIMOS Space and CNR) to contribute in the scene definition and generation and in the development of the retrieval products of an End-to-end simulator for the FORUM mission (project E2EFORUM). The End-to-end is a tool which simulates the end-to-end performance of a mission, i.e. from the observed (earth/atmosphere) scene or phenomena to the retrieved parameters. E2E simulators are used during phase A to support activities like: performance consolidation on mission level, quantification of trade-offs impact on the mission product, early preparation of user community for mission exploitation.

Within the FORUM phase-A activities, the Physics and Astronomy Dep. of the University of Bologna also participates to the analysis of airborne interferometric data in the mid and far infrared part of the spectrum (project EXPRO) in collaboration Imperial College (UK). In particular, the goal is the application of machine learning algorithm to upwelling high spectral resolution data in the infrared for the cloud identification and classification.

Activity Plan

The activities cover multiple work packages of the E2EFORUM and EXPRO projects. The candidate will work in a UNIX environment and will be able to implement software codes in MATLAB, C and Fortran programming languages. The main tasks are related to:

E2EFORUM project
Algorithm specification and justification. The physical and mathematical backgrounds are collected in the ATBD module. The activity will require the production of documentation containing:

- Description of the physical problem and of the available algorithms or methods and applicability.
- Detailed description of the physics and of the numerical implementation when innovative methods or algorithms are accounted for. Short description and detailed references of the physics and of the numerical implementation of methodologies derived from literature.
- Estimation of the effect of possible parameterizations and/or physical and mathematical simplification
- Examples (Tables, graphs and diagrams).

Once the draft versions are collected a work of text homogenization and consistency will be performed.
Input scenes definition and generation and Scene Generator for FORUM end-to-end simulator

- Selection of key geophysical parameters of the atmosphere and surface Definition of input scenes.
- Definition of a reference database for climate model atmospheric profiles, emissivity and clouds parameters. Definition of the data formats.
- Implementation of software tools for the Scenes configuration (a line-by-line multiple scattering forward model, for clear and cloudy atmosphere, able to simulate upwelling radiance at high spectral resolution
- Define cloud properties (by use of external routines) from single scattering single particle ice crystal databases (P. Yang) or from water and ice index of refraction in case of water or mixed phases (Mie solution).
- In case of non-homogeneous Scenes, multiple runs of the RT code is required to produce the observed radiance and the functionality will be implemented.

EXPRO project

A machine learning algorithm (based on Support Vector Machine or on Principal Component Analysis) will be implemented in order to ingest TAFTS and ARIES data to classify clear and cloudy spectra.

- A trade-off of the available tools will be performed;
- the selected code will be adapted to the sensor's optical features and to the observing geometry;
- synthetic datasets will be created by the use of a line-by-line multiple scattering routine to train the code for identification and classification;
- classification code will be applied to high spectral resolution data (test set);
- performances will be evaluated by exploiting ancillary information and independent observations;
- a distributional approach will be possibly applied to whole test set in order to improve the code performances (by estimating the D Ashman parameter).