The Prisma Hyperspectral Mission

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Abstract. The aim of the paper is to provide an overview of the PRISMA (PRecursore IperSpettrale della Missione Applicativa) mission and the related scientific foreseen applications. The mission development program is in actually in the C phase and it is completely funded by ASI. PRISMA is an earth observation system with innovative electro-optical instrumentation which combines an hyperspectral sensor with a panchromatic, medium-resolution camera, capitalising ASI investments in the field of "small missions" (e.g. AGILE), hyperspectral payloads (e.g. Hypseo, Joint Hyperspectral Mission/JHM), satellite platforms (MITA/PRIMA) and centres for tracking and remote sensed data processing centres (COSMO-SkyMed and CNM – Multi-mission National Centre). The user segment offers a full range of mission products comprising the following level 0, 1 and 2 products, for both hyperspectral and panchromatic data: within this framework, five scientific studies have been started to undertake research on some specific hyperspectral applicative themes and procedures for the processing of hyperspectral data.

Keywords. Hyperspectral payload, data and applications.

1. Introduction

The PRISMA program is aimed to the development, qualification, launch of a space mission based on an advanced hyperspectral sensor and his pre-operations via the companion mission control and data processing ground segment. The project, which is a follow-on of previous concept studies (Hypseo A/B phase, JHM A phase) started in 2007 with ASI and contractor (a consortium of Italian industries) signature of the formal agreements and is now close to the completion of the design (C-phase end) with a launch foreseen for 2017.

2. The PRISMA Italian Hyperspectral Mission

2.1. Mission description

The mission foreseen a single satellite embarking a state-of-the-art hyperspectral and panchromatic payload which, thanks to the Low Earth, Sun Synchronous orbit placement, is able to acquire images with a worldwide coverage in a "user driven" targeting mode fashion, with a maximum 7 days re-look and a 14 days end-to-end response times[1]. Global performances (optimized in a specific area covering the whole European and Mediterranean region) foreseen a daily imaged area exceeding 100,000 km^2 with the generation (archiving, cataloguing, cloud cover assessment and quicklooks) and distribution of all the data downlinked per day, plus the processing of at least 30 hyperspectral scenes (30 km by 30 km each) to level 2d (geocoded over terrain).

The core of the mission is a HYP/PAN instrument, combination of an hyperspectral camera working in the spectral range 0.4 - 2.5 µm (VNIR and SWIR channels, overlapped between 920nm and 1010nm in order to assure an optimal reconstruction of the spectral signature of each observed pixel) and a panchromatic camera working in the spectral range 0.4 - 0.7 µm. The average spectral resolution is less than 10nm on the entire spectral range allowing the generation of more than 200 spectral bands spectrally placed with a ±0.1 nm accuracy, with a nominal orbit HYP GSD of 30m

(5m for the PAN). PRISMA shall be capable to acquire up to 200 km of along-track length in each acquisition with enough system resources support to extend such figure to 1800 km, even if the standard images will be square tiles 30 by 30 km (i.e. the HYP/PAN swath size). Their geographical placement will be known with a 1 km accuracy during the programming of the acquisitions (i.e. at sensor pointing level) and with a 0.5 GSD accuracy (90% radial error) at terrain geocoded processing level (geocoding registration accuracy, with the availability of a Level-2 DEM). PRISMA MTF at the Nyquist frequency will be larger than 0.3 for the two hyperspectral channels and larger than 0.2 for the panchromatic camera. The SNR will be better than 200:1 on 1000 ÷ 1750 nm range, than 100:1 on 1950 ÷ 2350 nm, than 240:1 on PAN, with an absolute radiometric accuracy better than 5% with 12 bits quantized data. The system will be available 95% of any 1 month period with a probability of maintaining his specification better than 0.7 at end of life (5 years for the satellite and 10 years for the product and data archive).

The ground segment concept is based on the separation and differentiation of the functions needed to support the mission between a Monitoring & Control (M&C) center and a image data reception, processing and user interface centers, geographically distributed in two Italian sites: Fucino station for the first and Matera for the latter. A image data simulator tool is included in the system, with benefits both for the system (e.g. processing algorithms tuning) as well as for user community (disseminate mission products well before the availability of true mission data).

In order to verify that the high quality performances are reached after the mission commissioning completion and maintained during the whole mission lifetime, a dedicated Calibration and Validation Working Group has been setup. The capacity to detect and measure the environment's changes through remote sensed data and the dedicated applications exploiting such data is strongly linked to the true quality and accuracy of the space sensed images, the long term stability of such quality playing a key role. In such field the user needs range from overall consistency (terminology, traceability with international standards, measurement techniques, just to name few) to data reliability, data access availability and data quality stability over time. The objectives of such group, thanks to their composition (scientists independent by the industrial developers of the system and ASI personnel) are hence the supervision of the system calibration and validation program, with a critical evaluation of the approach, procedures and results foreseen in it.

Such group will guarantee the adoption of internationally recognized standards in hyperspectral data calibration (correction of the mission data inaccuracies coming from radiometric, geometric and spectral errors) and validation (measurement and verification of the data quality) ensuring the release of high accurate products.

PRISMA, being focused on the needs of the Italian institutional and research entities, is aimed to the generation of an entire line of products ranging from the Level-0 data up to the fully calibrated Level-2 geocoded images, in order to feed (but not limiting to) selected scientific applications (including those described in next sections): quality and protection of the environment, sustainable development, climate change, and so on.

The Data Policy being currently drafted foreseen a free access to data during the first year in which the experimental developments will have the higher priority in the usage of the system resources. Some fees could be required in sequent years, e.g. to cover part of the operative costs. Even if the mission core is the demonstration of the capabilities of an advanced HYP/PAN instrument, commercial usage of mission data is currently foreseen.

2.2. Space segment

The payload

The core of the PRISMA mission is the Hyperspectral instrument based on a pushbroom scanning technique. It is made up of Hyperspectral imager, composed by two imaging spectrometers (one for the VNIR and one for the SWIR spectral range) able to take images in a continuum of spectral bands ranging from 400 to 2500 nm and a Panchromatic camera (400 to 700 nm). The dispersive elements for the Hyperspectral imager are prisms.

As it is shown in the next block diagram, the Instrument is composed of two units: the Hyperspectral/PAN Optical Head and the Main Electronics box (ME) dedicated to control the Instrument and to forming and handling of the bit stream representing the spectral images, up to the interface with the S/C transmitter.

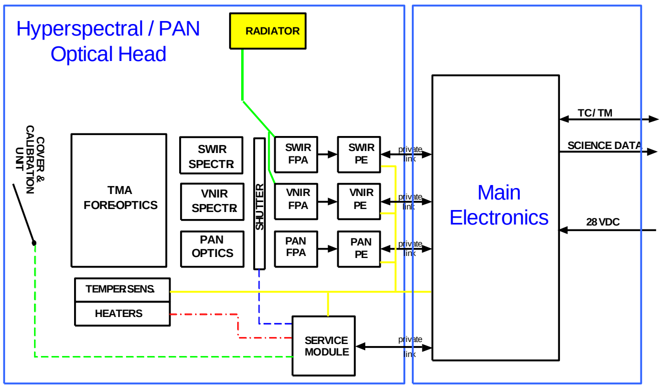

Figure 1. PRISMA Instrument block diagram

The Optical Head collects the radiation impinging by a common telescope, spill some of it in the PAN Channel and the remaining (divided by a beam splitter and dispersed by the two spectrometers) in Focal Plane Arrays (FPA).

The optical system consists of a common telescope, two imaging spectrometers (operating in VNIR and SWIR bands) and a panchromatic camera. In next figure is shown the optical scheme of the system.

The prism system on which the spectrometer is based has an high efficiency and a low polarization sensitivity, allowing to reduce the instrument mass and size and some criticalities for the optics design.

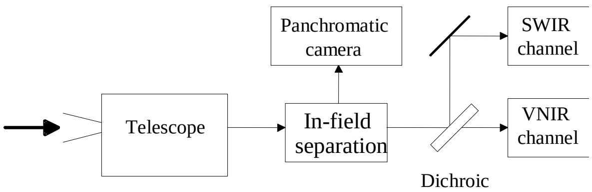

Figure 2. Block diagram of optics

The configuration was studied in order to match a detector with a pixel size of 30 µm for both VNIR and SWIR channels, and 6.5 µm for the PAN. The detection chain involves three focal planes which are physically accommodated on the optical bench.

The telescope consists of a Three Mirrors Anastigmatic (TMA) configuration that assures excellent optical quality with a minimum number of optical elements. This solution is very compact and without obstruction, and as it is shown in next figure is constituted by three aspherical mirrors. The entrance pupil diameter choice allows the system to meet high Signal-to-Noise Ratio (SNR) considering an overall 10% degradation at EOL, while keeping a F# such to achieve high geometrical performances (in terms of smile, keystone, co-registration). Moreover, with this design choice it is possible to reduce the Instrument volume and mass, the mirrors material cost and manufacturing times.

A slit common to VNIR and SWIR spectrometers, whose fields of view coincide, is placed on the telescope focal plane. The separation between VNIR and SWIR is realized by a dichroic plate to improve co-registration features.

The spectrometer design is based on a refractive prism solution optimized for each band which allows a much higher efficiency and lower polarization sensitivity than those achievable with gratings. In this way it was possible to maximize the SNR with a relatively small clear entrance pupil diameter for the telescope, with evident advantage in sizing the whole instrument. The spectral dispersion is achieved by prisms placed in parallel beams designed to achieve the required high optical quality, in terms of Point Spread Function (PSF), Smile and Keystone effects.

The panchromatic channel is obtained separating the main beam coming from the TMA telescope by an in-field separation technique implemented by a second slit parallel to the spectrometer. The PAN image is obtained using a three mirrors optical relay that is diffraction limited for wavelengths greater than 400 nm.

Due to the demanding requirements on the radiometric accuracy an in-flight internal calibration unit (ICU) has been designed so to allow operations of absolute and relative radiometric calibration and spectral calibration. The ICU utilizes a very compact optical path able to image Sun light, through a dedicated solar entrance port, over an internal diffuser, seen during calibration activity by the primary mirror of TMA telescope. The calibration unit comprises solar port cover mechanism, filters and spectral lamps. The Dark calibration is implemented by means of a light-weight shutter placed in front of the optical slit.

<u>The Satellite</u>

The PRISMA platform will provide all the functionalities to guarantee the operation of the Satellite and in particular it is in charge to provide to the PRISMA payload the required services for its operation. It represents a significant evolution of the MITA/AGILE platform. In particular it will include an enhanced attitude control system with pointing agility, a propulsion subsystem for orbit control and final disposal, and a power control electronics that makes maximum use of the competences in this domain at national level.

The on board operative and control functions of the satellite are performed by the On Board Data Handling (OBDH) Subsystem, which is in charge of on board telemetry and telecommand management, ground generated commands execution, Attitude and Orbit Control Subsystem (AOCS) control, power management, monitoring of main platform house-keeping (H/K) parameters, payload monitoring and image downloading during ground contacts.

The S band Telemetry/Telecommand (TM/TC) subsystem carries out the telecommunications tasks. It is composed of two transmitters, two receivers and three antennas, managed in order to guarantee global coverage with every attitude condition.

The Payload Data Handling & Transmission (PDHT), very similar to those embarked on the COSMO-SkyMed constellation, includes all the necessary functions to interface different sources at different data rate, for the Payload data acquisition, data storage, downlink data formatting, encryption and RF transmission (X-Band communication equipment) to Ground Stations. His main feature is a multimode capability allowing not only data storage on the on-board solid-state mass memory or data transmission to earth, but storage of a new images while simultaneously downlinking previously acquired image and ancillary data to earth, in the so called store & dump modality. Data confidentiality protection can be enforced using commercial grade encryption on the downlinked data stream.

2.3. Ground segment

The PRISMA Ground Segment key aspects deals with the monitoring and control of the mission as well as reception, processing, archiving and dissemination of the mission products.

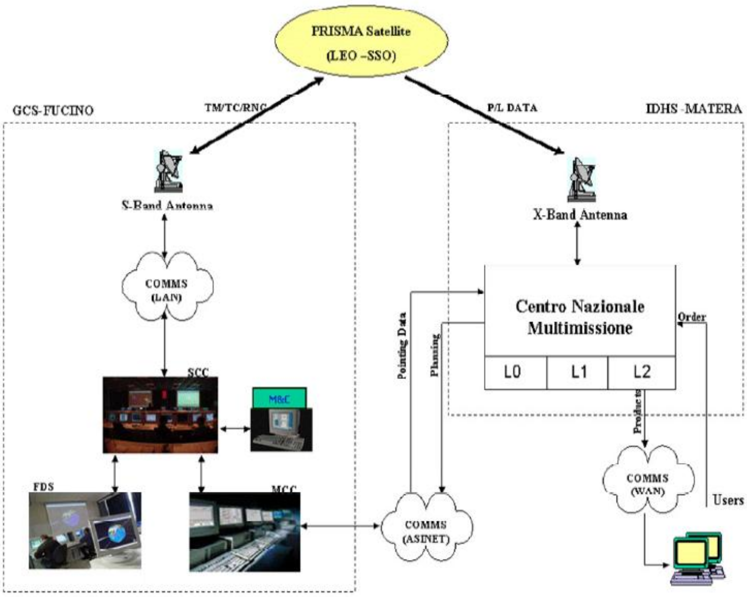

Figure 3. The Ground segment centres

The rationales on which such component has been developed includes the following aspects:

- improve the Italian capabilities and know-how about the handling and processing of the hyperspectral data and promote the development of new applicative products based upon the hyperspectral remote sensing techniques
- facilitate the integration between earth observation data coming from different missions and based on different technologies (e.g. SAR-HYP using COSMO-SkyMed) and to increase the national capabilities in remote sensing data exploitation
- pursue the evolution and customization of ASI existing ground segment infrastructures developed in the frame of different programs, enhancing, consolidating and re-using them for various missions

The Ground Segment is based on a two centers architecture:

- the Satellite and Mission Control Centre (located at Fucino station), evolution and customization of the existing Mission Control Centre and devoted to the mission and satellite control (including flight dynamics)
- the Matera IDHS (Image Data Handling System) based on the reuse and improvement of the existing "Centro Nazionale Multimissione", dedicated to remote sensing data acquisition, processing, archiving and distribution, as well as to the PRISMA users interfacing and support

During the PRISMA missions, the two centers will work in close coordination (with operations sized on 2-shift/day, 7 day/week) exchanging data such as satellite tracking information (based upon orbit determination data) and payload observations planning (based upon the users' orders) to be uploaded to the satellite.

<u>Mission Ground Segment (MGS)</u>

This part of the Ground Segment shall be devoted to the control of the spacecraft and the payload (Mission Control Centre – MCC). MCC is composed by the SCS (Satellite Control System, devoted to telemetry acquisition from TT&C ground station, TM processing and archiving, subsystems and payload health monitoring, telecommand preparation), the FDS (Flight Dynamic System, devoted to orbit and attitude determination and prediction) and by the TT&C system (which is the RF interface between the spacecraft and the Ground Segment). The functions of the MCC range from geometric feasibility analysis of the user's acquisition requests, generation of a conflict-free acquisition plan based on the priorities assigned to the requests and translation into the commands to be transmitted to the spacecraft via the SCS and TT&C systems.

Image Data Handling System (IDHS)

The development of the data processing section of the GS has been guided by the concept of Users support. PRISMA Users, organized into various classes (e.g. institutional, scientific, commercial, organizations, members of the CALVAL Working Group, etc) are allowed to execute the full range of operation needed to obtain a space sensed earth image. The user operation sequence starts from system access by mean of a web-based portal, continue with products catalogue browsing and a new acquisition programming and ends with image downloading from the user data repository. Such chain is supported by:

- an interoperable catalogue of the archived Level-0 products, their quicklook images and associated metadata, allowing users to browse existing data performing complex queries based on space, time, allowed cloud coverage
- functions and services assisting users in the creation of new acquisition requests, selecting a valid space, time, acquisition constraints / parameters set characterizing the desired earth portion image
- fully automated payload data downlink and process into Level-0, Level-1 or Level-2 products, including the retrieval of all the support data (e.g. Digital Elevation Models, Calibration data, Atmospheric models, Ground Control Points, etc)
- users feedback about the success / failure / delay of their acquisition or data processing requests
- users general assistance (trouble ticketing in case of anomalies of the system, system documentation access, etc)

PRISMA Products

The products foreseen in the PRISMA mission belongs to a full range line, with levels spanning from 0 (corresponding to raw data) to 2D (corresponding to reflectance and radiance geocoded over terrain):

- Level 0 products: HYP and PAN reformatted instrument data packets with appended metadata, including ancillary data and file formatting information)
- Level 1 product: HYP and PAN calibrated Top of Atmosphere Radiance - TOA including Cloud Mask, Sun-glint Mask, General Classification Mask and Characterization and Calibration Data
- Level 2 products: HYP and PAN radiance and at ground reflectance products, geocoded and non geocoded
    - Level 2b: Geolocated at Ground Radiance Product (obtained by applying atmospheric correction)
    - Level 2c: Geolocated At-surface Reflectance Product (obtained by applying atmospheric correction, processed optionally using Ground Control Points - GCP), Aerosol Characterization Product (VNIR, to provide aerosol optical thickness and Angstrom

exponent maps, with appended geolocation coefficients), Water Vapor Map Product (only HYP), Cloud Characterization Product
- Level 2d: HYP and PAN geocoded at-surface Reflectance Product

The Hierarchical Data Format (HDF5) adopted for PRISMA products is a standard data storage format allowing easy sharing of self-describing files across heterogeneous platforms (a powerful capability that allows to reads files generated on different machine architectures). With this format, even a complicated data set, such as a multidimensional array of numbers along with the information needed to data understanding (metadata) is kept within a single file, with contents organized using the well-known principles of object-oriented programming (hierarchical structured information object).

3. PRISMA on-going scientific studies and future applications

The applications domain of national interest identified for the mission can summarized in the following list:

- Detailed mapping of land cover and agricultural landscapes;
- Risk Management Support & Hazard monitoring (fires, landslides, volcanic and seismic risk);
- Quality of inland waters;
- Coastal zones and Mediterranean sea;
- Carbon cycle monitoring;
- Urban functional areas mapping and monitoring;
- Atmospheric turbidity: optical and spectral characterization;
- Land surface hydrology and water management;
- Security;
- Desertification.

PRISMA will primary cover focus on the Euro-Mediterranean Regions, therefore the scientific applications will be aimed to study the most relevant Earth processes in Europe and Mediterranean areas. To consolidate the PRISMA science team and a number of applications, ASI sent out a call for proposal in 2009 to support scientific studies. The five projects started in 2011 and are planned for 4 years.

3.1. Development of algorithms and Products for agriculture and land monitoring applications for supporting the PRISMA missioN - SAP4PRISMA- (to be realized by IMAA CNR) [2]

The general objective of the project is the development of algorithms for PRISMA hyperspectral data processing for mature value added earth observation products.

The project is based on different research activities focused on the consolidation, with respect to the PRISMA sensor characteristics, of the methodological issues for retrieving geophysical and agro-environmental parameters to be used as inputs into physically based models trying to better understand Earth’s surface processes and start the development of innovative complex products (e.g., nitrate leaching, land degradation and fuel maps, etc.).

To achieve these specific objectives, the project focuses also to data quality and pre-processing chain. In particular noise and dimension reduction, atmospheric correction, cloud masking and classification methods that are fundamental and preparatory to ensure the full exploitation of the PRISMA performances for obtaining consistent and innovative products.

On the topic of the applicative products, that are value added hyperspectral products the project focuses on:

- land degradation and vegetation status,
- products development for agricultural areas,
- management and monitoring of natural and induced hazards

Regarding the land degradation application, at present we are focusing on the soil compartment. Hybrid classification techniques were selected for mapping areas affected by processes of erosion and indices for the characterization of the level of degradation of soils and surface texture (DSLI, GSI index).

As regards natural vegetation, procedures and indexes were selected for the characterization of the parameters associated with the level of coverage, conditions of stress, species composition, and degree of patchiness (LSMA, CAI, Landscape Metrics.

Regarding the agricultural applications, the activities started by analyzing the bare soil properties on plowed agricultural fields images acquired by CHRIS-PROBA (ESA) and MIVIS hyperspectral sensors. Systematic sampling of the main soil properties (i.e. granulometric composition, organic matter and electrical conductivity) and agricultural crops were performed on a test site. These data were used as input in the PLSR statistical model and so far, the best results were obtained for the estimation of the soil clay content.

Regarding the application of PRISMA for the management and monitoring of natural and anthropogenic hazards, we focus on the assessment of the damage severity and mainly on the effects of fire in vegetated areas interested by a fire. Moreover, project goal is to develop an index that, in the presence of an area where the vegetation index shows a sharp decline, is able to understand the causes that may not necessarily be linked to the occurrence of a fire (e.g., oil spills, etc.). As for the limited availability of hyperspectral satellite images of burned areas, it is difficult to check the index we introduced.

The SAP4PRISMA team involved:

- Istituto di Metodologie per l'Analisi Ambientale (IMAA) CNR project coordinator
- Università di Pisa, Dipartimento di Ingegneria della Informazione Elettronica, Informatica, Telecomunicazioni
- Istituto per le Applicazioni del Calcolo "Mauro Picone"(IAC) CNR
- Università degli Studi della Tuscia - Dipartimento di Produzione Vegetale
- Università degli Studi di Roma La Sapienza - Centro di Ricerca Progetto San Marco

3.2. Synergistic use of PRISMA products with high resolution meteorological and chemical simulations and their validation using ground- and satellite-based observations - PRIMES (to be realized by CETEMPS)

PRIMES project has two main objectives: (1) the study of the effect of land-use changes and urban texture on local meteorology and air quality, and (2) the study of the feedbacks between atmospheric aerosol and clouds. The satellite products implemented and used concern mainly the characterization (1) of the physical properties of soils, and (2) of the aerosol burden and chemical composition. The satellite-derived products take advantage and are infused into a state-of-art atmospheric model that simulates the relevant meteorological, chemical and radiative processes of the troposphere in an interactive way (WRF/Chem)[3],[4].

The satellite-derived soil product integrates high spatial resolution information from hyperspectral measurements (30 m) into the European CORINE land cover database, with a special attention to Italian major urban centres whose extension is corrected with updated EO observations. Moreover, the spectral coverage is exploited to estimate several physical properties of the soils, i.e.

broad-band albedo, vegetation cover, soil moisture availability, thermal emissivity and roughness height. The latter information is put in correspondence with CORINE land-use classes and then implemented into the atmospheric model, which is subsequently used to evaluate the effect of land-use changes and urban canopy on the meteorological and chemical simulated fields[5].

The other EO products concern the aerosol content of the atmosphere and also include the synergy between retrieval algorithms and atmospheric models. A first product is an improved retrieval of the aerosol optical depth (AOD) at high resolution. Location- and time-specific vertically and chemically resolved aerosol scene simulated with the atmospheric model[6] is provided as a-priori to the aerosol retrieval algorithm, in order to better constrain the AOD and possibly other aerosol properties such as the size. Another product focuses on the exploitation of the hyperspectral features to attempt a characterization of the aerosol chemical composition, especially on the distinction between inorganic and organic fractions. The latter fraction of aerosol are the most abundant and the most uncertain in current models and are expected to play a significant role in both air quality and climate change issues. An important topic is the role that different aerosol types play in providing cloud condensation nuclei (CCN) that determine the microphysical properties of clouds, and thus their radiative properties, lifetime, and precipitation behaviour. The combination of high-spatial resolution observations of aerosol and cloud properties from satellite and the coupled model WRF/Chem provides a potentially very interesting testbed on our current knowledge of aerosol-clouds interactions.

3.3. Hyperspectral system analysis for integrated geophysical applications – ASI-AGI (to be realized by INGV)

In the last decades the technological development of “imaging spectrometers” both on airborne and spaceborne platforms has increased the scientific interest of image spectroscopy for a number of applications and in particular in Geophysics with regards of interaction between Earth interior surface and surface-atmosphere phenomena.

ASI-AGI (**A**nalisi **S**istemi **I**perspettrali per le **A**pplicazioni **G**eofisiche **I**ntegrate) is part of the selected projects. The ASI-AGI project focus on geophysical and geological applications. It has the following main objectives:

- Improving the scientific understanding of natural phenomena and in particular geophysical phenomena: volcanic activity and tectonic processes, forest fires[7];
- development of innovative techniques based on image spectroscopy and focused on the PRISMA system characteristics that operates an hyperspectral camera and a panchromatic camera.

ASI-AGI project is organized in tasks and focuses on the objectives listed below:

- Optimize the hyperspectral and panchromatic contribute to study geophysical phenomena
- Consolidate the use of hyperspectral data in a number of geophysical applications by developing specific algorithms: surface characterizations, spectral feature of fire, temperature and emissivity during the eruptive phase, study of volcanic gas emission
- Develop a PRISMA data simulator to test the specific algorithms during the developing phases of the PRISMA mission
- Improve the atmospheric correction procedures for hyperspectral data to achieve more precise estimation of the ground radiance and reflectance
- Organize CAL/VAL(calibration/validation) activities including the definition of a vicarious test site in Algeria
- Support the Italian Space Agency to verify the scientific and technical requirements of the PRISMA mission

The ASI-AGI project team is composed by the following institutions:

- Istituto Nazionale di Geofisica e Vulcanologia (INGV), project coordinator
- Dipartimento di Ingegneria Meccanica e Civile dell'Università degli Studi di Modena e Reggio Emilia (DIMEC)
- Centro di Geomorfologia Integrata per l'Area del Mediterraneo (CGIAM).

3.4. Advanced methods for analysis, integration and optimization of level 1 and level 2 PRISMA products – OPTIMA (to be realized by IFAC CNR)[8]

The main goal of the OPTIMA project is to increase and to strengthen the applications of PRISMA mission by the implementation of advanced methodology for the analysis, the integration and the optimization of level 1 and 2 products. All OPTIMA activities give rise to the development of algorithms devoted to the processing of the data acquired by the payloads of the PRISMA mission.

The implementation of image enhancement, image restoration and data fusion algorithms takes advantage from the system configuration in which the hyperspectral sensor and the panchromatic camera are fed by the same optical system.

The OPTIMA project is comprehensive of the data simulation, data quality, data optimization, data processing and integration, evaluation of some applications. When possible, the developed algorithms employ high speed autonomous procedures for the elaboration of the acquired images.

To assess the performances of the algorithms and products developed for PRISMA mission, a sensor data simulator is developed. Starting from the image generation on the basis of cartographic data and a data base of reflectance spectra of observed targets, the image simulation takes into account both the acquisition geometry and the atmospheric parameters affecting the acquisitions. The obtained at-sensor radiance data are converted into digital numbers raw data simulating the instrumental characteristics.

Noise modeling and spatial and spectral characteristics assessment are the main tasks implemented for data quality analysis, as well as advanced techniques for radiometric and atmospheric corrections are developed to retry the at-ground spectral reflectance maps.

Some algorithms for data fusion, feature extraction, unmixing, enhancement and restoration are implemented to exploit the PRISMA mission potentialities. The potentialities of the mission in monitoring some environmental process and disaster through the estimation of surface humidity and the analysis of burned area are investigated.

To fully exploit the potentialities of the PRISMA mission some calibration and validation activities are considered on the basis of the experience gained in previous space hyperspectral missions (HYPERION and CHRIS) utilizing the CAL/VAL test site managed by CNR-IFAC and located inside the Regional Park of San Rossore (Pisa).

3.5. Coasts and Lake Assessment and Monitoring by PRISMA HYperspectral Mission – CLAMPHYM (to be realized by ISMAR CNR).

The CLAM-PHYM (Coasts and Lake Assessment and Monitoring by PRISMA HYperspectral Mission) project aims to verify the capability of PRISMA hyperspectral sensor (in terms of spatial, temporal and spectral resolution) for useful applications on coastal and inland waters[9], [10].

The project is divided into two stages in which different issues are addressed. During the 1st stage, the project has been focused on a preliminary version of algorithms and products, mostly based on field measurements and PRISMA-like data with the aim of evaluating and improving available processing methodologies. The 2nd stage is planned for testing and validating final products and defining robust algorithms for PRISMA data. This phase of the project will provide value-added products for environmental monitoring and ecological assessment of test site quality status, according to the requirements of different stakeholders.

The CLAM-PHYM products consist in water quality products, which are derived from water reflectance with the application of semi-empirical and semi-analytical algorithms. The water quality products include Chlorophyll-a concentration, Total Suspended Matter concentration, Yellow substance concentration, in optically deep waters and optically shallow waters. In the latter, different albedos of substrate are provided (i.e., submerged vegetation). A physic-based approach is used for obtaining water reflectance from “at sensor” radiance with the removal of atmospheric, adjacency and sun-glint effects. The role of the aerosol characterization on the accuracy of the atmospheric correction over water target is specifically investigated for PRISMA hyperspectral data.

The test sites include several Italian coastal and inland areas, characterized by different environmental issues and requirements, in order to approach their inherent optical variability with adequate methodologies. Lakes with different trophic states (oligo-, meso- and eutrophic) with respect to seasonal ecological successions, abundance of submerged vegetation; coastal areas affected by terrestrial input and oceanic circulation, which alternate clear, turbid and productive waters; transitional waters (i.e., lagoons and estuaries) characterized by local morphologic peculiarities and controlled by tide and climate. Moreover, the presence of anthropogenic activities (e.g. changes in land use, sewage discharge, aquaculture industry, port activities), which increases the system variability. These factors influence the optical conditions and require regional site-specific parameterization for solving their complexity though remote sensing techniques.

For both semi-empirical and analytical techniques, we need to characterize site-specific optical properties variability, both spatially and temporally and a parameterization based on in situ measurements is required. During the CLAM-PHYM project, several surveys have been carried out in the test sites, in order to gather data for calibrating a bio-optical model and for evaluating the derived products, including water reflectance and water quality parameters. Biogeochemical concentrations and key water optical parameters were sampled, in order to define the inherent and apparent optical properties of the water column. During the fieldworks, a special attention was oriented to improve specific procedures and protocols, as well as to define optimal instrumentation asset for the achievement of project aims.

The CLAMPHYM team involved is composed by:

- Istituto di Scienze Marine (ISMAR), CNR
- Istituto sull’Inquinamento Atmosferico (IIA) CNR
- Istituto per il Rilevamento Elettromagnetico dell’Ambiente (IREA),CNR

4. Conclusions

The PRISMA mission, initially conceived as a test bench for the Italian technologies in hyperspectral space sensors, is receiving an increasing interest from the user community, aware of the developments since the “PRISMA: verso le applicazioni della missione iperspettrale nazionale” workshop, held in Matera during April 2009. The scientific projects discussed in this paper are only a first step towards the full exploitation of the mission outcomes which will enable not only the scientific and commercial exploitation of the related data and services (a fundamental asset in the ASI strategy for environment and climatic monitoring via space sensing missions) but will also support ASI international cooperation in the field, as witnessed by the Italy-Israel Spaceborne Hyperspectral Applicative Land And Ocean Mission (SHALOM) or the national flagship OPSIS mission, an Earth Observation satellite mission equipped with a Very High Resolution Optical Camera, both currently in an initial study phase.

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