

HICO Data User's Proposal

Using HICO data for the preparation of the future satellite mission EnMAP

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Abstract

The Earth Observation Centre (EOC) of the German Aerospace Center (DLR) is responsible for the establishment of the ground segment of the future German hyperspectral satellite mission EnMAP (Environmental Mapping and Analysis Program). The EOC has long lasting experiences with air- and spaceborne acquisition, processing, and analysis of hyperspectral image data. EnMAP covers the spectrum from 420 nm to 2450 nm with a spectral resolution of at least 10 nm and a spatial resolution of 30 m × 30 m with a swath width of 30 km. To achieve high-quality and consistent data with respect to the same and other missions, extensive calibration and validation activities are foreseen during the five years of mission operations. With the availability of HICO, we propose to assess the quality of the output data delivered by the EnMAP processing chain on HICO hyperspectral satellite data prior to EnMAP launch in 2015. Expected outcomes include a direct comparison with in situ data sets from oceanic towers (AERONET-OC), ground truth campaigns and, if possible, ongoing airborne (HySpex) datasets over selected test sites on water and on land.

Statement of work

The main objective of this study is to test and to evaluate the EnMAP processing chain using HICO hyperspectral data. The foreseen standard products of the EnMAP processing chain include radiometric, geometric, and atmospheric correction. A clear advantage in using HICO for testing the processing chain is the unique opportunity to have real hyperspectral satellite data with specifications comparable to EnMAP VNIR sensor requirements.

A brief summary of the most relevant tasks when using HICO data include:

1. Detection of data artefacts
2. Ortho-rectification
3. Automated atmospheric correction
4. Assessing quality of processed data on water and land
5. Intercomparison of atmospheric correction using different software.

Project description

Background

The EOC of the German Aerospace Centre (DLR) has long lasting experiences in the fields of the airborne hyperspectral sensor operation, pre-processing and analysis of hyperspectral imagery. Jointly with the German Space Operations Centre it is responsible for the establishment of the ground segment for the future German hyperspectral satellite mission EnMAP (Environmental Mapping and Analysis Program) (Rossner et al. 2009; Storch et al. 2009) (www.enmap.org).

EnMAP (Environmental Mapping and Analysis Program) is a German built hyperspectral space sensor scheduled for launch in 2015. EnMAP will measure in the 420-2450 nm spectral range at a varying spectral sampling interval of 6.5-10 nm. Images will cover 30 km × 30 km areas at an approximate ground sampling distance of 30 m.

The EnMAP satellite will be operated on a sun-synchronous orbit at 643 km altitude to observe any location on the globe under defined illumination conditions featuring a global revisit capability of 21 days under a quasi-nadir observation. EnMAP has an across-track tilt capability of ± 30° enabling a revisit time of four days. The hyperspectral instrument (HSI) will be realized by Kayser-Threde GmbH as a pushbroom imaging spectrometer (Stuffler et al. 2007).

EnMAP is conceived as a science and research mission and a pathfinder to evolve towards an operational/ commercial service. The primary and immediate targets are the science community with

its specific needs for research and development and the value adding companies offering information of great interest and use by public commercial sectors.

During the five years of mission operations, which are planned to start in 2015, EnMAP will provide information about the status of different ecosystems and their response to natural or man-made changes of the environment, which will be evaluated by an international user community of science and industry coordinated by the GeoForschungsZentrum Potsdam as the mission principal investigator. To meet these objectives a team of value adders and scientific partners jointly investigated the mission characteristics.

Project Goals

In this study our objectives are to take advantage of the high spatial and spectral resolution of Hyperspectral Imager for the Coastal Ocean (HICO) data to test and validate the pre-processing chain, which is currently under development for EnMAP. HICO, together with HYPERION, are currently the only available spaceborne instruments meeting the spatial and spectral resolution required for testing the processing chain for the EnMAP satellite.

Our primary goal is to provide efficient and high-level products to the EnMAP user based on a fully automated processing chain (including geometric and/or atmospheric correction). A sound and intensive testing of the processing tools is absolutely essential. The use of existing hyperspectral data would optimise and facilitate these efforts and give the unique opportunity to exchange knowledge and experience as well as compare recent outcomes with other scientists.

The design of the EnMAP processing chain is based on the experience with a fully automated and ISO 9001-2000 certified processing chain for airborne hyperspectral data (Bachmann et al. 2007) as well as processing chains for spaceborne optical data (Schwind et al. 2009). Similar to these processor chains, the newly developed EnMAP processors will include system calibration, parametric geo-coding, atmospheric correction, and assessment of data quality (Müller et al. 2010).

Proposed Study Sites

Our idea is to work with HICO data and use proposed test sites (see Table 1) in combination with data from oceanographic towers (AERONET-OC) (Zibordi et al. 2009) and/or with regular ground campaigns to test and validate our remote sensing pre-processing products for a variety of applications on water and on land.

Table 1: Location of proposed study sites (and center coordinates [Lat, Lon], ordered by priority)

	<i>Site</i>		<i>Lat ° N</i>	<i>Lon ° E</i>
1	Aqua Alta Tower, Italy	Coast Colour Site 3	45.314	12.508
2	Lake Ammersee, Germany		48.031	11.186
3	Lucinda Jetty, Australia	Coast Colour Site 12	-18.520	146.386
4	Witbank, South Africa		- 25.848	29.178
5	München, Germany		48.139	11.580
6	Barrax, Spain		39.060	-2.019

The proposed data acquisition would be calibrated L1b format in addition to atmospherically corrected L2a format, if available. We are interested in historical and ongoing data collections.

We request access to HICO data to complete the following specific objectives:

1. Detection and –if possible- correction of data artefacts in calibrated at-sensor radiance data
2. Ortho-rectification of data
3. Automated atmospheric correction which includes water vapour and aerosol retrieval
 - a. Over land using ATCOR software
 - b. Over water using MIP software
4. Assessing quality of processed data on water and land
5. Intercomparison of atmospheric correction using different software (Tafkaa, ATCOR, MIP), including in-situ data (AERONET-OC, ongoing ground campaigns)

Biographical sketch and available facilities

Personnel

Martin Bachmann is head of Applied Spectroscopy Group at DLR. He is a scientist who focuses his research interest on hyperspectral pre-processing and calibration of airborne and spaceborne hyperspectral remote sensing data (Bachmann et al. 2009). He leads the work package on 'Data Quality Control' within the EnMAP Ground Segment. The image processing is in collaboration with Rudolf Richter (DLR), the developer of the ATCOR model (Richter 1996, 1998, 2008, 2011). Thomas Heege is director of the company EoMAP GmbH & Co KG and is specialised in coastal and inland water monitoring services using Modular Inversion Program (MIP) software (www.eomap.de). Peter Gege has extensive expertise in water optical modelling and developed the Water Colour Simulator (WASI) (Gege 2004, Gege and Pinnel 2011). Nicole Pinnel works in the EnMAP Ground Segment as application support and is experienced in shallow water applications. Uta Heiden is Application Support Manager coordinating EnMAP science user. The Applied Spectroscopy Group has significant experience in hyperspectral data analysis and airborne hyperspectral campaigns (OPAIRS).

Available Facilities

The EOC at DLR in Oberpfaffenhofen, Germany, has a history of over 12 years operating hyperspectral instruments in Europe such as HyMAP and ROSIS. It will operate the airborne hyperspectral sensors HySpex VNIR-1600 und HySpex SWIR-320m starting 2012. The two HySpex sensors are pushbroom type instruments and cover the complete reflective spectral range from 400-2500 nm with a maximal spatial resolution of 50 cm (VNIR) (<http://www.hyspex.no/>).

The EOC has computer workstations for image processing using IDL/ENVI software and a wide variety of field and laboratory spectrometers for oceanic measurements (e.g. TriOS RAMSES-ACC-VIS, ASD FieldSpec Pro FR, Solar Light Microtops-II sun photometer and ozonometer, Varian Cary-1, Perkin-Elmer Lambda 1050). The group has long term experience in acquisition and operation of airborne flight campaigns (OPAIRS).

The EnMAP image processing on land will be performed with the **ATCOR** (atmospheric correction) code (e.g. Richter 1996; 1998, 2008, 2011). ATCOR accounts for flat and rugged terrain, and includes haze/cirrus detection and removal algorithms. Output products will be the ground reflectance cube, maps of the aerosol optical thickness and atmospheric water vapour, and masks of land, water, haze, cloud, and snow. A different strategy is employed for water applications exploiting the spectral properties of water, using the **MIP** (Modular Inversion Program) (Heege et al. 2005), which combines the finite element method with the MODTRAN4 atmospheric model and the multi-component water model. Output products are the water reflectance cube, water constituents, the aerosol optical thickness map, and updates of masks of land, water, haze and cloud.

The Water Colour Simulator (**WASI**) by Peter Gege (Gege 2004) is a software tool developed for modeling and analysing optical in situ measurements in aquatic environments. WASI can be used to simulate (by forward calculation) and analyse (by inverse modeling) spectral measurements using well-established analytical models.

Output and deliverables

1. The primary anticipated outputs from this proposed effort would be a comparison of HICO and EnMAP data processing, focusing primarily on atmospheric correction as a test data set for further improvement of automated processing.
2. Yearly participation in HICO data team meeting

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