ABSTRACT

For the definition of the Earth Explorer Land Surface Processes and Interactions Mission (LSPIM), multi-sensor hyper-spectral data were acquired by different airborne and ground-based systems during the 1999 DAISEX campaign (Digital Airborne Imaging Spectrometer Experiment). Airborne instruments included the DAIS7915 and HYMAP which acquired data simultaneously with POLDER and LEANDRE.

It is the purpose of this experiment to evidence the feasibility of quantitatively retrieving geophysical variables by controlling atmospheric effects and analysing at the same time possible additional information present in directional anisotropy (BRDF).

Two test sites were used during DAISEX '99, a site close to Colmar, France, and an agricultural site Barrax, close to Albacete, Spain. Barrax is also one of the LSPIM key-experimental sites, a selection of about 100 globally distributed sites representing major ecosystems. Within LSPIM it is proposed to study these sites in detail for land surface process modelling and up-scaling from regional to global.

It is the intention of this paper to outline the scientific objectives and to demonstrate first results of the DAISEX'99 campaign.

INTRODUCTION

To better understand and predict processes occurring in the different ecosystems estimates of process driving variables are needed. The 'Living Planet Programme' of the European's Space Agency (ESA) is aiming on advancing understanding of these processes [1]. The capability to observe the Earth with a range of instruments providing different spatial, radiometric, spectral, temporal and angular resolution is expected to result in major advances for monitoring and management.

One of the elements of the 'Living Planet Programme' is the Earth Explorer Missions. Earth Explorers are research and demonstration missions. There are two classes of Earth Explorers, namely, Explorer Core missions, larger missions led by ESA, and Explorer Opportunity missions, smaller and more flexible mission, not necessarily led by ESA.

One of the four Earth Explorer Core Missions subject to a Phase A study, was the LSPIM [2]. The main scientific objective of the mission is to increase the understanding of land surface processes and interactions with the atmosphere. To fulfill the mission objectives a hyperspectral imager covering the visible, near infrared, short-wave infrared and thermal infrared (VNIR/SWIR/TIR) spectral range was proposed.

Following a user consultation meeting held in Granada, Spain, in October 1999, LSPIM was not selected as one of the first Earth Explorers but was assessed as being of very high scientific merit [3]. Currently it is planned to propose a land mission with similar but more focused objectives for the next call for Earth Explorers.

DAISEX '99

In the framework of the Earth Observation Preparatory Programme ESA carries out various airborne campaigns to support the development of geo/biophysical retrieval algorithms, calibration and validation and simulation for future spaceborne Earth observation missions.

The Digital Airborne Imaging Spectrometer Experiment (DAISEX) provides airborne hyperspectral measurements over land to demonstrate the retrieval of variables as required for the LSPIM. The experiment includes intensive field work, providing in-situ measurements of various variables for calibration and validation purposes [4].

The main scientific objective of the DAISEX '99 campaign is to demonstrate the retrieval of bio/geophysical variables from angular hyperspectral measurements such as the leaf area index (LAI), biomass, leaf water content, canopy height,
chlorophyll content, etc. Since an accurate calibration and atmospheric correction is essential to quantitatively retrieve these variables, in-situ atmospheric measurements needed for atmospheric corrections were performed in addition to field measurements for calibration and retrieval validation.

THE BARRAX TEST SITE

One of the sites selected for the 1999 campaign, was the Barrax site, an agricultural test site located close to the town of Albacete, Spain. The Barrax site was formerly used in international programmes such EFEDA which includes the exploitation of a range of airborne instruments e.g. AVIRIS and AIRSAR. It is a well described site. Detailed thematic maps and a long history of data are available. In addition two permanent meteorological stations are located in the area recording continuously data on fluxes of energy and water. Fields are permanently monitored by the School of Agronomical Engineering of the University of Castilla-LaMancha. The campaign in Barrax was organised by the University of Valencia, Spain.

An additional advantage of the Barrax site is its topography and geomorphology. The Barrax site is relatively flat, which eases the required pre-processing to correct geometric and radiometric distortions due to viewing geometry and exposition which is needed for the analysis of multi-angular observations.

THE DAISEX'99 INSTRUMENTATION

The core instruments for the DAISEX'99 campaign are the Digital Airborne Imaging Spectrometer (DAIS) and the High Resolution Imaging Spectrometer HYMAP, operating simultaneously from the same aircraft, a DO-228 operated by DLR.

DAIS is a re-furbished GER-II instrument (originally built by the GER Corporation). It was modified in cooperation of EC JRC and DLR to increase performances. For specifications of the DAIS79-15 please consult http://www.op.dlr.de/DAIS/. The instrument has been flown in Europe since 1995 on a number of different research and commercial projects.

HYMAP is an Australian instrument, build by Integrated Spectronics PtyLtd., using latest technology and thus, provides increased performances in particular for the SWIR signal to noise ratio (see http://www.intspec.com/ for details).

Data have been acquired under different observation geometries by crossing flight lines enabling investigations on BRDF characteristics.

The simultaneous operation of the two instruments offers the unique opportunity for intercomparison. In addition to this, data acquired by DAIS are complementing HYMAP data covering the SWIR-1 and TIR spectral range (see Fig. 1).

In the frame of an EC funded project, the French ARAT aircraft, equipped with the LEANDRE instrument for atmospheric measurement and the POLDER imaging radiometer, for angular measurements, could be exploited at the same time and operated strictly simultaneously with DAIS and HYMAP. This enables to acquire a complimentary data sets never was done before. HYMAP (VNIR, SWIR-2 component), DAIS (SWIR-1, TIR component), POLDER (angular component) data enables to simulate an instruments as proposed by LSPIM whereas the instruments onboard ARAT provides a 3D characterisation of the atmosphere during the time of the overflight.

Field measurements involved a suite of instruments operated by different research groups. The direct and diffuse solar irradiation was measured with high spectral resolution (6nm) for atmospherically characterisation. Further, in-situ aerosol characterisation was performed by a particle counter and nephelometer onboard ARAT enabling to estimate aerosol extinction profiles. Reflectance measurements were mainly acquired for two reasons: a.) reflectance measurements of relative homogeneous targets for system calibration purposes and b.) reflectance measurements to radiometrically characterise principal soils and vegetation. Latter was also performed under different viewing geometries exploiting a field goniometer. Fig. 2 shows the Swiss goniometer used for BRDF measurements, as operated during the DAISEX'99 campaign. All field measurements were georeferenced by the support of GPS instruments for later integration into a GIS system. Further detailed mapping included crop identification, phenological status description and soil roughness measurements. Soil and crop samples were collected for following laboratory analysis of the soil mineral composition and the biochemicals. Validation measurements included LAI,

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\text{Figure 1: Spectral resolution of DAIS79-15 in comparison to HYMAP.}
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fPAR, chlorophyll content, surface temperature, surface emissivity and evapotranspiration.

**Figure 2:** The Swiss field goniometer FIGOS in Barrax

Furthermore, in-situ radiosonde measurement were performed to obtain profiles of temperature, ozone, pressure and humidity up to an altitude of 30 km. These measurements are used to constrain the atmospheric transfer code for atmospherically corrections. Radiosounding was supported by the Spanish National Institute of Meteorology, Madrid, Spain.

**FIRST RESULTS**

Pre-processing included radiometric, geometric (parametric) and atmospheric correction, carried out by the DLR. First results are given in Fig. 3. HYMAP data acquired in Barrax during DAISEX'99 with a spatial resolution of about 6m x 6m are shown. The image is a 'true-colour' composite using bands 3,9,18 for red, green and blue, respectively. For visualisation purposes the image was enhanced using standard image processing tools. Irrigated field patterns of different sizes (circled objects) are shown in the image. Different tones of green indicate different types and growing stages of vegetation and crops. Brownish to greyish colours show sparsely vegetated fields and bare soils. Gravel roads are exposed as white lineaments.

Data acquired during the DAISEX '99 campaign show for the first time the 'hot spot' in hyper-spectral data cubes. The 'hot spot' is the increased reflectance which can be observed when the target is observed in the same direction as illuminated by the sun. In the image the line of the hot-spot can be seen as a horizontal line in the upper part of the image.

**OUTLOOK**

Data acquired during the DAISEX'99 campaign are currently being further analysed and validated. In particular validation of higher level products accounting for different viewing and illumination geometry will be analysed. This is planned to be performed by comparing measured and modelled BRDF, to use the BRDF in order to increase retrieval accuracy e.g. by normalisation techniques or by accounting for it e.g. by inverting a full radiative transfer code.

Results of the DAISEX '99 campaign will be aggregated into process models describing the vegetation growth and energy/water balance over time. This will demonstrate the feasibility of a future land mission aiming at advancing knowledge on land surface processes and interactions.

**REFERENCES**