The Network for Calibration and Validation in Earth Observation (NCAVEO) 2006 Field Campaign

Milton, E.J. and the NCAVEO Partnership[1]

School of Geography, University of Southampton
Contact details: ncaveo@soton.ac.uk

Abstract

This paper describes a remote sensing field campaign undertaken by the Network for Calibration and Validation in Earth Observation (NCAVEO) in southern England in June 2006. The aims of the campaign were: (a) to gain experience in the collection and use of field data to validate radiance and reflectance products from airborne and satellite sensors; (b) to share best practice on the validation of leaf-area index (LAI) estimates derived from satellite sensor data; and (c) to assemble a quality controlled, multi-scale, multi-sensor data set for algorithm development and testing. Data specifically to support the campaign experiments were acquired by CHRIS/Proba, SPOT and three satellites in the DMC constellation. Three aircraft fitted with hyperspectral sensors, LiDAR and high performance digital survey cameras were flown over the test area. Several field teams made measurements on the ground, and many data sets were acquired near-simultaneously so as to allow direct inter-comparison. The data may be accessed via the NERC EO Data Centre and potential uses are many and varied, including research, education and training on the physical basis of remote sensing (e.g. sensor and instrument calibration); image understanding (e.g. up- and down-scaling); and remote sensing applications (e.g. land cover mapping, forest survey, river habitat survey, LAI estimation, policy-related issues).

Keywords: *NCAVEO, calibration, validation, field experiment, data archive, Chilbolton*

1. Introduction

In June 2006, the NERC-funded 'Network for Calibration and Validation in Earth Observation' (NCAVEO) organised a community-led field campaign in southern Hampshire, UK. The campaign involved 37 scientists from 22 UK and international organisations (academia, industry and government)[1] as well as 16 other interested parties from government, industry and the local community. International support for the experiment included the collection of data from seven EO satellites operated by ESA, NASA, CNES, SSTL, China, Algeria, and Nigeria. Three aircraft fitted with hyperspectral sensors, LiDAR and high performance digital survey cameras were flown over the site, acquiring multi-scale, multi-sensor data from a core area 54 km^2 in size (Figure 1). Several field teams made measurements on the ground, and many data sets were acquired near-simultaneously so as to allow direct inter-comparison.

The campaign had three main aims:

- To gain experience in the collection and use of field data to validate radiance and reflectance products from airborne and satellite sensors;
- To share best practice on the validation of leaf-area index (LAI) estimates derived from satellite sensor data;
- To assemble a quality controlled, multi-scale, multi-sensor data set for algorithm development and testing.

The site chosen was centred on the Science and Technology Facilities Council (STFC) Chilbolton Facility for Atmospheric and Radio Research (CFARR), approximately 25 km north of Southampton (Figure 1). The CFARR provided state-of-the-art instruments for measuring atmospheric properties, together with on-

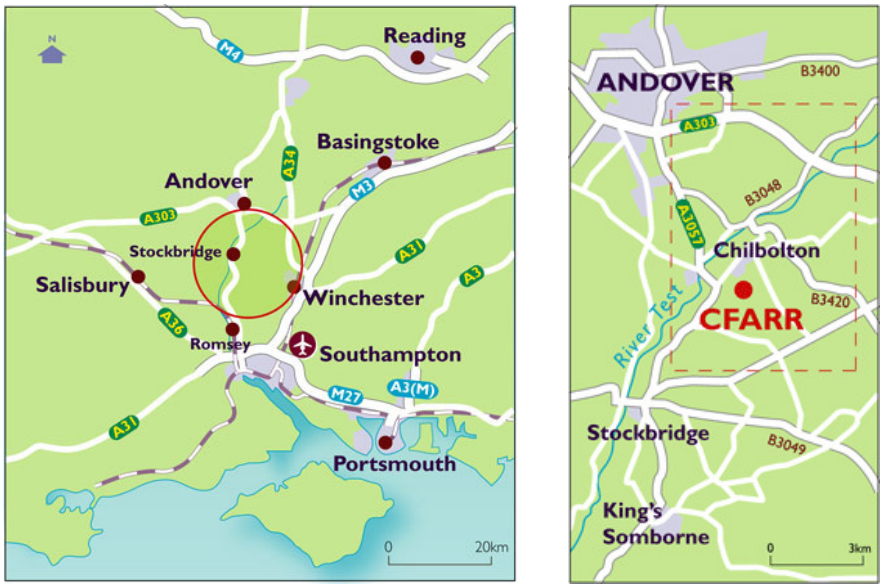
[1] http://www.ncaveo.ac.uk/NFC06_participants.pdf

site workshops and meeting space. The area around the facility contains many of the land cover types present in southern England, including arable fields, improved grassland, urban, woodland, rural villages and transportation infrastructure, as well as designated habitats including river channel vegetation, grassland, and associated wetland communities of national ecological importance (DEFRA, 2008).

2. Methodology

Planning for the experiment began in December 2005, and once the necessary permissions from landowners had been secured, a land cover map of the area was prepared based on farm plans and field survey. An announcment was made to invite participation from the remote sensing community and a meeting was held in April 2006 to plan the experiment.

A window of three weeks in June was identified as the optimum period for the experiment, taking into account knowledge of the crop calendar, the probability of good weather and the availability of staff, aircraft and ground instruments. Within this three-week window, the overpass dates of the satellites defined several days when participants were asked to be on standby for simultaneous field data collection. Arrangements were made to accommodate those scientists not local to the area in the village of Stockbridge, a few kilometres from the field site. Most visiting scientists stayed for 2- 3 days during the field campaign.



(a) (b)

Figure 1: *(a) location of the study area in southern England (b) the area studied in detail (dashed line).*

A reconniassance visit was arranged for 12th May 2006, and this was very important in identifying those sites to be measured on the ground, and to discuss the method of sampling. These decisions were informed by aerial photography of the area provided by Infoterra Ltd, one of the partners in NCAVEO. Following this meeting rectangular plots were marked out with coloured flags in each of the fields to be sampled, and a GPS survey of the field sites was undertaken in advance of the main experiment.

3. Data

The study focused on an area 9 km north-south by 6 km east-west, the south-west corner being defined by Ordnance Survey grid reference SU 370360. The main crops in the area were winter wheat, winter barley, winter oats, spring barley and oilseed rape. Several fields were under grass, either set-aside, permanent pasture or cultivated leys. Harewood Forest, north of the River Test was surveyed in August 2007 and a map of the dominant species in each forest compartment produced. It comprises conifer plantations and areas of broadleaf woodland, and is criss-crossed with access tracks. Large parts of the floodplain of the River Test were formerly managed as water meadows, a traditional method of grassland management in which parcels of land were seasonally flooded by water flowing through a system of diversionary channels and sluices. Two areas of semi-natural wet grassland remain, Chilbolton Cow Common and Bransbury Common, the latter having protected status as a Site of Special Scientific Interest (SSSI).

A summary of the data collected is presented in Tables 1 and 2, and a full report of the campaign can be obtained by registering on the NCAVEO website: http://www.ncaveo.ac.uk.

3.1 Remotely sensed data

	Sensor	Date acquired[2]	Operator	Spectral region[3] No. of bands / Pixel size	Summary of data and pre-processing
1	CHRIS/Proba	17/06/06	SSTL/ESA	VNIR 62 bands / 34 m	Multiple view angle superspectral data. Registered to the British National Grid using ground control points.
2	UK-DMC	17/06/06	SSTL	VNIR 3 bands / 32 m	Wide swath multispectral data. UK-DMC has an estimated radiometric accuracy of ±5%, AlSat and Nigeria-Sat have been cross-calibrated with UK-DMC using an image-based method.
3	AlSat	14/07/06	SSTL	VNIR 3 bands / 32 m	
4	Nigeria-Sat	13/06/06	SSTL	VNIR 3 bands / 32 m	
5	SPOT-5 HRG	10/06/06	CNES	VNIR/SWIR 4 bands /10 m/20 m	Registered to the British National Grid using ground control points.
6	CASI-2™	17/06/06	NERC	VNIR 15 bands / 2.5 m	Nine flightlines acquired using an Itres Instruments Compact Airborne Spectrographic Imager. Registered to the British National Grid using data from on-board sensors.
7	CASI-3™	17/06/06	EA	VNIR 32 bands / 1 m	Nine flightlines acquired using an Itres Instruments Compact Airborne Spectrographic Imager. Registered to the British National Grid using data from on-board sensors.
8	Specim AISA Eagle™	17/06/06	NERC	VNIR 244 bands / 1 m	Nine flightlines acquired. Registered to the British National Grid using data from on-board sensors.
9	Rollei AIC Modular LS™ digital camera	17/06/06	EA	RGB 3 bands / 1 m	Nine flightlines acquired. Registered to the British National Grid using data from on-board sensors.
10	Integraph Z/I Imaging DMC™	09/06/06	OS	VNIR 4 bands / 60 cm	Digital Mapping Camera. Orthorectified to the British National Grid using photogrammetric methods. 84 images acquired with 60% overlap along track.
11	Optech ALTM 2033™ LiDAR	17/06/06	EA	1064 nm 1m	2km x 2km tiles of digital terrain model and digital surface model. First and last pulse returns were recorded, using an approximate pulse spacing of 1-2 metres.

Table 1: *Principal remotely sensed data sets acquired*

3.2 Ground data and sampling scheme

3.2.1 Biophysical data

Non-destructive optical methods were used to make leaf area index (LAI) measurements using two Li-Cor LAI-2000™ plant canopy analysers and two Delta-T SunScan™ canopy gap fraction measurement devices. In the wheat, barley and oats fields, five points were located in a die pattern within each field, and these were taken to define centre point of 10 m long transects, within which both the spectral and biophysical measurements were made every 1 m. The extent of the rectangular sample area within the crop was defined by the 'reach' of the various instruments, and was approximately one metre. The SunScan was much faster to use in the field, so additional measurements were made in each field by extrapolating the sampling by a further 10 m at either end of the central 10 m transect. At each of the LAI-2000 sample points downward-looking hemispherical photographs were also acquired to provide more information on canopy structure.

3.2.2 Spectral data

A temporary radiometric calibration laboratory was established at CFARR to provide traceability to the UK national standards. A transportable integrating sphere (TSARS) was used for for radiance calibration (Pegrum et al. 2004). A total of 10 field spectroradiometers were calibrated to radiance and had their wavelength calibration checked during the campaign, and the reflectance factor of several Spectralon™ calibration panels was measured. Three teams measured atmospheric data during the period of aircraft and

[2] Dates are expressed as DD/MM/YY
[3] VNIR = Visible & Near IR; SWIR = Short-wave IR, RGB = Visible wavelengths only.

satellite overpasses, and a further four teams collected spectral data from the sample fields and a number of ground calibration targets.

	Variable	Date of survey	Summary of data and pre-processing
1	Land cover	April/May 2006	Complete coverage of the test area 9km x 6km and sampled observations from a co-located 60 km x 60 km area as part of the CEH Land Cover 2007 Pilot Project.
2	Leaf Area Index (barley, oats, wheat & oilseed rape)	June 2006	50 LAI-2000 measurements per field, 150 SunScan measurements per field.
3	Vegetation canopy structure	June 2006	Several upward and downward looking hemispherical photographs from the sample fields and Harewood Forest.
4	Leaf chlorophyll content	June 2006	Ten replicates at each of 20 random locations in the spring barley field.
5	Water depth (River Test)	16/06/06	Measurements at selected point locations. River bed material type also noted.
6	Aerosol Optical Thickness (AOT) and total atmospheric water vapour	17/06/06	Measurements every 15 minutes from two Cimel CE318-2™ sun photometers, one of which is part of AERONET, and every 5 minutes from three Microtops™ II sun photometers.
7	Atmospheric water vapour profile	16/06/06	UV Raman LiDAR located at CFARR.
8	Sky spectral irradiance distribution	17/06/06	Sampling interval 18° in zenith and 30° in azimuth. Frequent sets of measurements made during the period of RS data collection (VNIR).
9	Proportion of direct-to-diffuse sky irradiance	17/06/06	Measurements every minute using a Delta-T BF2™ sunshine sensor.
10	Hemispherical-conical reflectance factor (HCRF)	17/06/06	Measurements of an asphalt ground calibration target every 30 s using a dual-beam GER1500 spectroradiometer (VNIR).
11	HCRF	17/06/06	Measurements of a concrete ground calibration target every minute using a single-beam GER3700 spectroradiometer (VNIR/SWIR).
12	HCRF	17/06/06	Reflectance of white, grey and black artificial targets 6 m x 6 m in size placed on the ground at the CFARR site (VNIR).
13	HCRF	15/06/06 to 18/06/06	Reflectance of the crop at each of the LAI-2000 sample points, made using two ASD FieldSpec Pro™ spectroradiometers operated in single beam mode (VNIR/SWIR).
14	HCRF	18/06/06	Reflectance of bare soil within one of the fields sampled (Brockley), made using an ASD FieldSpec Pro™ spectroradiometer operated in single beam mode (VNIR/SWIR).

Table 2: *Principal ground data sets collected during the campaign*

4. Dissemination of the data set

Data from the field campaign will be distributed via the NERC Earth Observation Data Centre (NEODC), which also maintains the full archive of data collected. The complete NCAVEO Field Campaign data archive is over 150 GB in size. Each instrument dataset has a Principal Investigator, responsible for the integrity of the data, for any updates and for the associated metadata. Access to the data has been restricted to participants of the experiment during data collection and for an intial period until September 2008, after which they become publicly available. During the period May 2006 - June 2007, a total of 21 users downloaded 250GB (4751 files) from the NCAVEO field experiment archive. Metadata have been produced and made available for discovery through the NERC DataGrid discovery gateway and other environmental data portals.

Acknowledgements – *We are grateful to NERC for funding the NCAVEO knowledge exchange network and to the many organisations which supported the field campaign, either financially or by the provision of data and staff time. We are especially grateful to the staff of the STFC CFARR for hosting the campaign, and to the local landowners in the Test valley who allowed access on to their land.*

5. References

DEFRA, 2008. The Environmentally Sensitive Areas (ESA) of the Test Valley. http://www.defra.gov.uk/erdp/schemes/esas/stage2/test.htm (accessed 10/7/08).

PEGRUM, H., WOOLLIAMS, E., FOX, N., RIEL, L. V., OTTER, G. AND KOWALEWSKI, M., 2004. *Calibration of the NPL Transfer Standard Absolute Radiance Source (TSARS) and its use with GOME 2 - FM3 Spectral Radiance measurements*. 11th International Symposium on Remote Sensing, Sensors, Systems, and Next-Generation Satellites VIII, Maspalomas, Spain.