EAGLE 2006

EAGLE Netherlands Multi-purpose, Multi-Angle and Multi-sensor In-situ, Airborne and Space Borne Campaigns over Grassland and Forest

Campaign objectives - Complementary to AGRISAR2006 which addresses agricultural fields

CAMPAIGN PLAN

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1. Introduction

1.1 Campaign overview

The understanding of bio-geophysical parameter retrieval from multi-parameter optical and SAR data as well as the direct modelling of the underlying physical processes in forests and grassland remain challenging due to lack of appropriate observation data. In EAGLE2006 we propose to perform an intensive filed campaign using different airborne sensors - one radar, one optical sensor, one imaging microwave radiometer, and one flux airplane - for data acquisition and to collect extensive ground measurements simultaneously over one grassland (Cabauw) and two forest sites (Loobos & Speulderbos), in additional to acquisition of multi-angle and multi-sensor satellite data. Such a data set up is not available currently and is urgently needed for the development and validation of models and inversion algorithms for quantitative surface parameter estimation and process studies.

The understanding and quantification of bio-geophysical parameters of different vegetated surfaces is essential in the development of validated, global, interactive Earth system models for the prediction of global change accurately enough to assist policy makers in making sound decisions concerning the planning, sustainable use and management as well as conservation of water resources and environment. Multi-sensor remote sensing monitoring (using radar & optical data) are essential for the development and validation of models and retrieval algorithms for the above stated purposes.

The EAGLE2006 activities are planned over central parts of the Netherlands (the grassland site at Cabauw and two forest sites at Loobos & Speulderbos; with yearly precipitation around 750 mm and yearly average temperature about 10° Celsius) from the 8th of June until the 2nd of July 2006, with a focus on the period June 8th until June 18.

EAGLE2006 is originated from the combination of a number of initiatives coming under different funding:

1. Field activities in the framework of the EU GMES project EAGLE
2. Field activities in the framework of the EcoRTM Project, funded by the Dutch National Science Foundation (NWO)
3. Field activities in the framework of the ESA SMOS-CalVal Project (ID: 3269)
4. Field activities in the framework of the ESA-EUMETSAT EPS/MetOp Project (ID: 3055)
5. Field activities in the framework of the ESA-MOST Dragon drought monitoring project (ID: 2608)
6. Field activities in the framework of the national project BSIK-ME2
7. ESA Campaigns (SPARC04, Sen2Flex2005, AGRISAR2006)
8. Other national projects

The objectives of the EAGLE2006 campaign are closely related to the objectives of previous and current ESA Campaigns (SPARC04, Sen2Flex2005 and especially AGRISAR2006).

One important objective of the proposed campaign is to build up a data base for the investigation and validation of the retrieval of bio-geophysical parameters, obtained at different radar frequencies (X-, C- and L-Band) and at hyperspectral optical and thermal bands acquired over vegetated fields (forest and grassland).

All activities are related to algorithm development for future satellite missions such as Sentinels (discussed below) and for satellite validations for CHRIS, MODIS and MERIS data, with activities also related to AATSR and ASTER thermal data validation, as well as the ASAR sensor on board ESA's Envisat platform and those on EPS/MetOp and SMOS. Most of the activities to be performed in the campaign are highly relevant for EAGLE, but also issues related to retrieval of biophysical parameters from CHRIS and MERIS as well as AATSR and ASTER data will be of particular relevance, while scaling issues and complementary between these (covering only local sites) and global sensors such as MERIS/SEVIRI, EPS/MetOP and SMOS are also key elements.

1.2 GMES - Sentinel Missions Technical Requirements

Apart from delivering answers to scientific questions, the proposed campaign aims *to serve the programmatic elements of ESA* with valuable information to support ongoing and further decision-making for future missions. Several programmatic elements of ESA have been identified which will considerably benefit from the proposed campaign.

The next generation of ESA Earth Observation satellites include a series of 'Sentinel Missions' to be developed and operated with the framework of GMES (Global Monitoring for Environment and Security). These will include SAR and Optical satellites with new imaging configurations and spectral bands, and much improved capabilities for frequent repeat coverage.

Plans for the first of the Sentinel Missions have recently been announced, and industrial studies are being initiated:

- Sentinel-1: C-band SAR system (2 satellite operation)
- Sentinel-2: High Resolution Optical Imager (without TIR) + IR
- Sentinel-3: Low Resolution Optical Imager (with TIR) + Altimeter

Sentinel-1 is an imaging radar mission at C-band which will provide continuity of data for existing user services. It is envisaged as a 2 satellite system, providing daily SAR coverage of Europe and other parts of the world above 45 degrees N&S latitude. The technical concept currently under study includes the following capabilities:

- Repeat cycle: 10 -12 days
- Four modes: StripMap (high resolution), Interferometric Wide Swath, Extra Wide Swath (low resolution), Wave Mode
- Swath Width: 80km (SM), 240km (IW), 400km (EW), 20km x 20km (WM)
- Polarisation: VV+VH or HH+HV (all modes)

Sentinel-2 is a high resolution imaging mission for terrestrial applications providing continuity with Landsat and SPOT type measurements (including VEGETATION). Global land imaging with a 1 – 2 day repeat is envisaged, with around 8 narrow spectral bands and a panchromatic channel. Provisional specifications are as follows:

- Repeat cycle: 7 days
- Spectral Bands: Between 6 and 18 (VNIR-SWIR), plus 1 Panchromatic
- Spatial resolution: 10 – 30 m (VNIR – SWIR), 5 or 10m (PAN)
- Swath: > or = 200km
- Absolute radiometric accuracy: 3%
- Inter- band calibration: 5%
- Geo-location accuracy: 1 pixel (without ground control points)

The EAGLE2006 campaign will collect in-situ and airborne SAR and optical measurements in support of decisions on satellite instrument configurations for the first Sentinel Missions, as well as providing an important database for the study of longer term mission concepts.

1.3 Campaign objectives

The general purposes of the campaigns are:

1. Acquisition of simultaneous multi-angular and multi-sensor (from visible to microwave domain) data over a grassland and a forest
2. Advancement of process understanding in description of radiative and turbulent processes in land-atmosphere interactions
3. Validation of primary bio-geophysical parameters derived from satellite data using in-situ and airborne data
4. Improvement of soil moisture retrieval accuracy by synergy of multi-angular (L-band) SMOS and multi-angular C-band SAR/Optical-thermal observations.
5. Development of operational algorithms to extract land surface parameters and heat fluxes from the future EPS/MetOp mission
6. Development of physically based drought monitoring and prediction method (Hydro-climatologic modeling) on the basis of EPS/MetOp observations

In particular, the EAGLE2006 campaign is required to address important specific programmatic needs of Sentinel-1 and -2:

- To assess the impact of Sentinel-1 and Sentinel-2 sensor and mission characteristics for land applications (land use mapping, parameter retrieval) over forest and grassland
- To provide a basis for the quantitative assessment of sensor or mission trade-off studies, e.g. spatial and radiometric resolution
- Simulate Sentinel-1 and Sentinel-2 image products over the land (forest and grassland)

In the context of Sentinel-1, EAGLE2006 aims primarily at the investigation of radar signatures over forest and grassland simultaneously which is currently not addressed. An important dataset of coordinated in-situ and airborne SAR measurements will be collected which will provide support both to studies of the Sentinel-1 technical concept, as well as contributing to studies of future mission concepts involving parameter retrieval at L-band.

As part of the refinement and verification of the Sentinel-1 technical concept, EAGLE2006 data will be used for the assessment of land use classification using the proposed nominal operating configuration (i.e. IW mode, VV + HH polarisation plus co-polarisation). Simulation of Sentinel-1 image products is planned.

By including an optical data acquisition component, the campaign also aims to provide feedback on key issues relating to definition of the ESA Sentinel-2 multi-spectral mission requirements. Attention focuses on the investigation of the optimum position and width of spectral bands for land cover/change classification and retrieval of bio-geophysical parameters (e.g. improved surface classification, quantitative assessment of vegetation status – forest and grassland). The imaging spectrometer data acquired as part of EAGLE2006 will be used to simulate Sentinel-2 L1b products using the proposed different configurations, and to investigate compatibility with the envisaged L2/L3 products.

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1.5 Overview of airborne, satellite and in-situ sensors

AHS
INTA will be in charge of the AHS flights, with final confirmation of aircraft availability depending on activities and weather conditions in the AGRISAR2006 Campaign. The sensor to be used is INTA-AHS 80 Airborne Hyperspectral Scanner (AHS). As soon as INTA has fulfilled their duties over Germany, we have disposal of the INTA team until 15 June. Ideally we would like them to fly on the three days of CHRIS overpasses around 15 June.

ESAR
Ideally, we would like to have a similar agreement with the DLR-HR operated SAR system. Preferably we'd like them to fly on 15 June, where we will have the CHRIS-PROBA overpass, but also two ASAR observations (one around 10:00 UTC and another around 21:20 UTC). Subject to weather constraints, 3 flights in the period of 15-18 would be feasible.

CHRIS-PROBA
The field activities will take place in the period 8 – 18 June 2006 over the central part of The Netherlands. Central focus point in the campaign over grassland and forest will be the CHRIS-PROBA overpass on 15 June, which will serve as the main golden day. Preferably we would like the satellite to be programmed such that we have an additional series of images the day before and the day after, i.e. 14 and 16 of June. Furthermore we have requested MERIS full resolution, AATSR and ASAR

observations for the entire period. Details on overpass times and dates are given below.

The PROBA satellite was launched in a special orbit that makes possible to have coverage over a given site for 2 or 3 consecutive days, and then several days in between where access to the site is not possible due to the orbital coverage. Each orbit provides 5 images with different view angles (-55°, -36°, 0°, +36°, +55° along-track zenith angles).
Overpass times and relevant angles (solar angles are averages for the sites, azimuth is defined South zero and East positive) for the days during the campaign are listed below. Focus however will be on the 14 and 15 June overpasses. The reason for the selection of focusing on days 14 and 15 June to carry out the campaign is the coincidence with two consecutive days of CHRIS/PROBA and AATSR overpasses. Since most of the other planned activities are somehow flexible in dates (continuous satellite overpasses) the particular orbit of PROBA is the driver in choosing the preferable dates for the campaign.

Date	Time	Min. Satellite Zenith	Solar Azimuth	Solar Zenith
06-06-06	10:55:00		19	31
14-06-06	?		?	?
15-06-06	10:59:30		18	30
23-06-06	10:53:00		22	30
02-07-06	10:57:30		21	30

The plan is to get a multi-angular reference dataset with 10 angles (5 angles along each of the 2 different orbits) and 62 spectral channels per angle during this intensive campaign.

MERIS/AATSR
For MERIS it is possible to get Full Resolution data for almost every second day during the campaign, from 8 until 18 June. This also holds true for AATSR imagery, if also night images are considered relevant.

ASTER/MODIS
MODIS is available in principle twice daily during the entire campaign, morning overpass times (TERRA platform) are a few minutes around 10:50:00 AM (UTC), whereas afternoon overpass times are around 01:50:00 PM (UTC). However, since the MODIS imagery has a very large ground coverage (reason for having an "overpass" every day), and thus a wide scan angle the spatial resolution is not constant for all days. Best results are obtained at nadir overpasses, which are the same dates as the ASTER overpasses, Table 7.

SEVIRI
SEVIRI data will be recorded by the ITC MSG receiving station continuously at 15 min interval in the complete campaign period, 8 June 2 - July.

In-situ measurements
Concerning atmospheric measurements, the combination of LIDAR, sunphotometers and high spectral resolution sky radiance measurements will be taken from the Cabauw site and will allow addressing such issues as:

1. Aerosols optical thickness retrievals with different methods and techniques, and
2. Atmospheric correction of the satellite data.

Radiometric measurements at the leaf and canopy levels will be performed by using the several available radiometers with different fields of view and different setups. A number of radiometers will participate in the campaign, some of them mounted on the goniometer, with angular FOV ranging from 1 to 25 degrees.

If extremely bad weather conditions develop during the planned focus period 8-18 June, a backup solution is considered around the 22 till 24 of June, when CHRIS/PROBA (23 June), AATSR (24 June) and ASTER (22 June) overpasses may be obtained.

ALOS PALSAR
PALSAR data might be acquired at 7, 12 and 19/06/06. Since ALOS is still in the Commissioning Phase until end of October 2006 and the offline data delivery to ESA will start end of June only it is uncertain if any data will be acquired over the area of interest.

1.6 Schedule Overview

An overall timetable for image acquisition and the involvement of the different field teams is provided below.

Table 1. Measurement schedule in EAGLE2006 Campaign

Topic\Week	23	24	25	26
Month	June-July 2006			
Days	08-11.06	12-18.06	19-25.06	26.06-02.07.
Grassland (Cabauw)				
Loobos				
Speulderbos				
DLR (ESAR)		ESAR		
INTA (AHS)		AHS		
Satellite sensors (CHRIS/PROBA, ASTER/MODIS, MERIS/AATSR/ASAR, SEVIRI)	X	X	X	X
ITC	I/C	I/C	I/C	I/C

University of Valencia	I	I	I	I
LSIIT, Strasbourg	I	I	I	I
NLR		I		
WUR/Alterra	C	C/(FX)	C	C
WUR/METAIR	C	C	C	C
KNMI	C	C	C	C
RIVM	C	C	C	C
MIRAMAP	M	M	M	M

(ESAR: DLR X, C, L band SAR;
AHS: INTA Airborne Hyperspectral Scanner;
X: Satellite Observation;
I: Intensive in-situ measurements;
C: Continuous observation
FX: Flux airplane;
M: MIRAMAP X, C, L band imaging radiometer)

2 Campaign sites

Simultaneous measurements will take place at three sites:

Cabauw, grassland, 51°58′00″ N, 04°54′00″ E, -0.7 m. a.m.s.l.
Loobos, forest, 52°10′02.8″ N, 05°44′38″ E, 52 m. a.m.s.l.
Speulderbos, forest, 52°15′08.1″ N, 05°41′25.8″ E, 52 m. a.m.s.l.

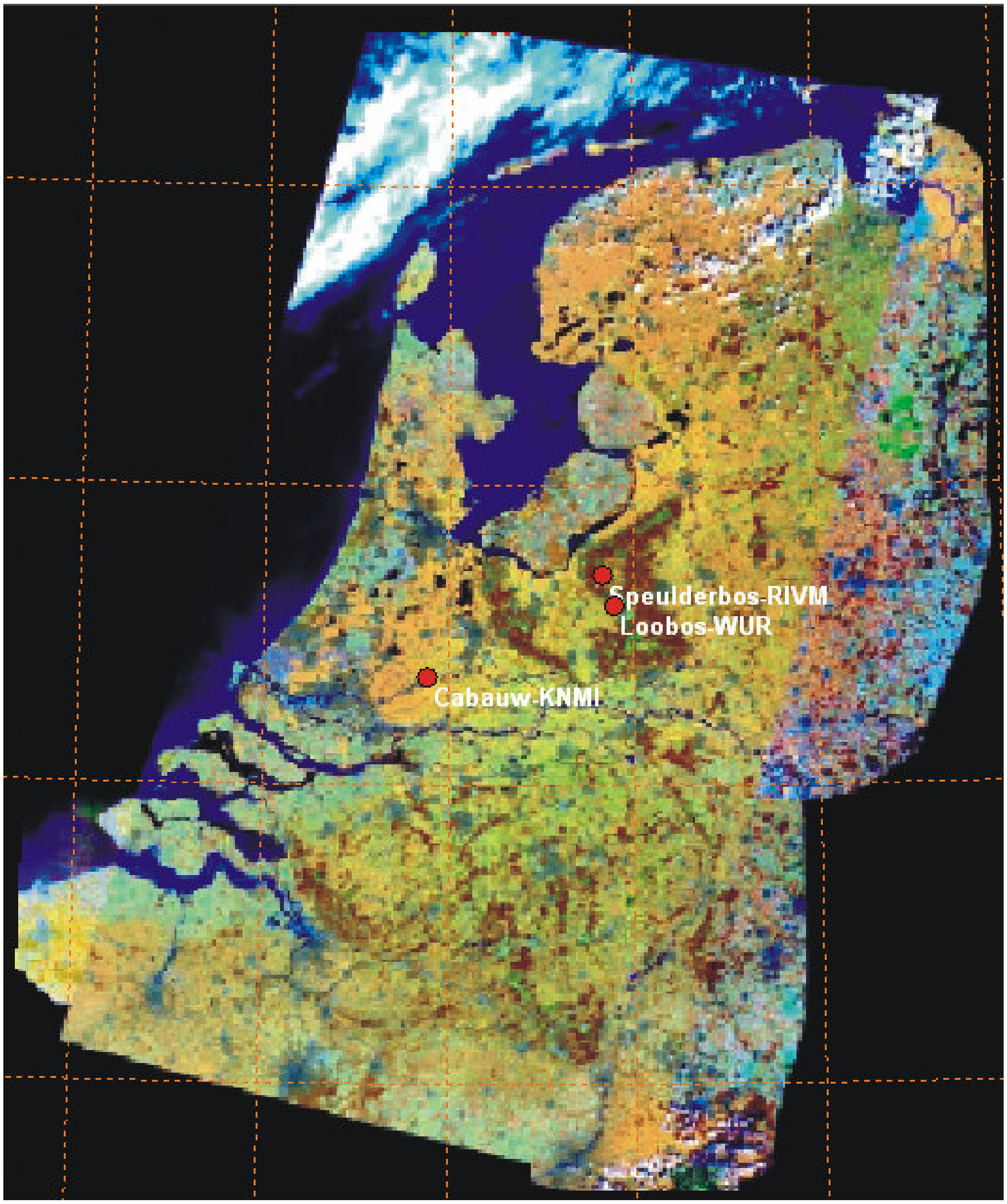


Figure 1. Overview of the study area on a resampled (1000 m) Landsat-TM false color composite of the Netherlands; red dots indicate sites described in the text.

2.1 Cabauw

The Cabauw site is located approximately at the central western part of the Netherlands near the village of Cabauw. In 1972 at Cabauw a 213 m high mast was built by the Koninklijk Nederlands Meteorologisch Instituut (KNMI). This tower was built to establish relations between the state of the atmospheric boundary layer (ABL), land surface conditions and the general weather situation for all seasons. The Cabauw mast is located in a polder 0.7 m below average sea level.

Figure 2. The 213 meter high Cabauw tower as seen during different weather conditions.

The instruments are mounted on a 213 m tower placed in an extensive grassland area. In the immediate surroundings of the tower (corresponding to an area of 1 ha) the grass is kept at a height of 8 cm by frequent mowing. Apart from scattered villages, roads and trees the landscape within a radius of at least 20 km consist of flat grassland. Approximately 1.5 km south of the tower runs the river Lek, which is one of the main branches of Rhine. The river is a few hundred meters broad. The water holding capacity of the soil at the site is high, the soil being fine grained with a high content of organic matter. The ground water level in the whole catchment area, within which the field tower is located, is artificially managed through narrow, parallel ditches spaced 40 m apart from each other. The water level in the ditches is always kept at 40 cm below the surface level maintaining the level of the ground water table near the surface. Due to the rich supply of water and the fine grained soil, the evaporative fraction rarely falls below 0.6.

More detailed info is provided in (Ulden & Wieringa, 1996).

An overview of recorded data is provided on the web at:
http://www.knmi.nl/kodac/ground_based_observations_climate/cabauw.html

2.2 Loobos

The Loobos site is located two kilometers south-west of the village Kootwijk. Continuous micrometeorological measurements are carried out since 1997 at a height of 23 m above the surface. In a radius of 500 m 89% of the vegetation consists of pine trees, with an average height of about 16 meter, 3.5% is open vegetation e.g. heather and the remainder is a mixture of coniferous and deciduous trees.

Figure 3. The Loobos forest (left panel) and the ALTERRA flux tower (right panel)

Some more detailed information is available from the ALTERRA research web-site at: http://www.loobos.alterra.nl

2.3 Speulderbos

The Speulderbos site, operated by the National Institute for Public Health and the Environment (RIVM), is located approximately 60 km northeast from Cabauw within a large forested area in the Netherlands. The tower is placed within a dense 2.5 ha Douglas fir stand planted in 1962. The tree density is 785 trees per hectare and the tree height in 1995 was approximately 22 m, which has grown till 32 meter in 2006! The tower, which is currently not used for operational measurements, is 46 meter high and has power until a height of 34 m. The single-sided leaf area index varies between 8 and 11 throughout the year. The surrounding forest stands have typical dimensions of a few hectares and varying tree heights. Dominant species in the neighbourhood of the Douglas fir stand are Japanese Lark, Beech, Scotch Pine and Hemlock. At a distance of 1.5 km east from the tower the forest is bordered by a large heather area. In all other directions the vegetation consists of forest at distances of several kilometers. The topography is slightly undulating with height variations of 10 to 20 m within distances of 1 km.

Figure 4. Forester tower site at Drie, Speulderbos (upper panels) and the RIVM tower site (lower panels), where the lower right panel shows a view from the top (46 m) of the tower in the direction of the forester tower.

Another tower, currently used by foresters, in the area is located in Drie at about 2 km distance at 52°15’54.8” N latitude and 5°40’39.4” E longitude. A Large Aperture Scintillometer (LAS) will be installed between this and the previous tower to obtain spatial average sensible heat fluxes.

3 Satellite data acquisitions

3.1 CHRIS-PROBA acquisitions

CHRIS (Compact High Resolution Imaging Spectrometer) is a physically compact payload as its name implies (weighing under 15 kg) and operates in the 'push-broom' mode. Its main applications will be in environmental monitoring, forestry inventory and precision farming.

From a 600 km orbit, CHRIS can image the Earth in a 14 km swath with a spatial resolution of 18 m (this is somewhat variable as the altitude varies around the orbit). Using PROBA's agile steering capabilities in along and across track directions enables observation of selectable targets well outside the nominal field of view of 1.3°. Images will generally be acquired in sets of 5, these being taken at along track angles of ± 55 degrees, ± 36 degrees, and as close to nadir as possible (Figure 5).

CHRIS operates over the visible/near infrared band from 400 nm to 1050 nm and can operate in 63 spectral bands at a spatial resolution of 36m, or with 18 bands at full spatial resolution. Spectral sampling varies from 2-3 nm at the blue end of the spectrum, to about 12 nm at 1050nm. Sampling is about 7nm near the red edge (~690-740nm). The instrument is very flexible and different sets of bands can be used for different applications.

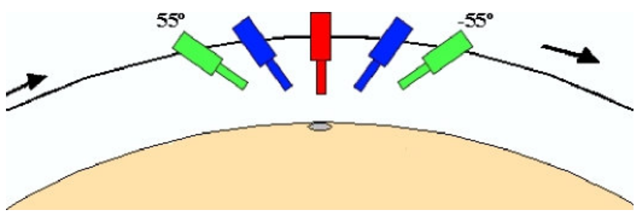


Figure 6. Illustration of how CHRIS can hold a target in view by using PROBA's pitch control

Table 2. Key characteristics of CHRIS-PROBA

Spatial sampling interval	18 m on ground at nadir
Image area	14 x 14 km^2 (748 x 748 pixels)
Number of images	Nominally 5 downloads at 4 different view angles
Data per image (14 x 14 km^2)	131 MegaBytes
Spectral range	410 to 1050 nm
Number of spectral bands	19 bands at 18 m resolution, 63 bands at 36 m resolution
Spectral resolution	1.3 nm @ 410 nm to 12 nm @ 1050 nm (variable across the spectrum)
Programmable operation:	
Across pixel size	18 m or 36 m
Along pixel size	At finest 18 m but can be made coarser by changing integration time

Spectral	Variable bandwidth and band location
Digitisation	12 bits
Signal-to-noise-ratio	200 @ a target albedo of 0.2

In the following table the foreseen acquisition characteristics for the current campaign are shown for both overpasses.

Table 3. Focus days of CHRIS-PROBA acquisition programmed during the EAGLE Campaign

FZA	Date	Time	Min. Satellite Zenith	Solar azimuth	Solar zenith
+55	14-06-06				
+36	14-06-06				
0	14-06-06				
-36	14-06-06				
-55	14-06-06				
+55	15-06-06	10:57:30		18	30
+36	15-06-06	10:58:30		18	30
0	15-06-06	10:59:30		18	30
-36	15-06-06	11:00:30		18	30
-55	15-06-06	11:01:30		18	30

3.2 MERIS acquisitions

The MERIS sensor is a programmable, medium-spectral resolution, imaging spectrometer operating in the solar reflective spectral range installed on board of ESA’s Earth Observation satellite ENVISAT. Fifteen spectral bands can be selected by ground command, each of which has a programmable width and a programmable location in the 390 nm to 1040 nm spectral range.
The instrument scans the Earth's surface by the so-called 'push broom' method. CCDs arrays provide spatial sampling in the across track direction, while the satellite's motion provides scanning in the along-track direction. MERIS is designed so that it can acquire data over the Earth whenever illumination conditions are suitable. The instrument's 68.5^{o} field of view around nadir covers a swath width of 1150 km. This wide field of view is shared between five identical optical modules arranged in a fan shape configuration. In the calibration mode, correction parameters such as offset and gain are generated, which are then used to correct the recorded spectra. This correction can be carried out either on board or on the ground. The Earth is imaged with a spatial resolution of 300 m (at nadir). This resolution is reduced to 1200 m by the on board combination of four adjacent samples across track over four successive lines.

The scene is imaged simultaneously across the entire spectral range, through a dispersing system, onto the CCD array. Signals read out from the CCD pass through several processing steps in order to achieve the required image quality. These CCD processing tasks include dumping of spectral information from unwanted bands, and spectral integration to obtain the required bandwidth. On-board analogue electronics perform

pre-amplification of the signal and correlated double sampling and gain adjustment before digitisation. The on-board digital electronics has three major functions: it completes the spectral integration, performs offset and gain corrections in full processed mode, and creates the reduced resolution data when required. The calibration of MERIS is performed at the orbital south pole, where the calibration diffuser is illuminated by the sun by rotating a calibration mechanism.
The engineering requirements on the instrument, which have been derived from the ENVISAT mission requirements, are provided in Table 4.

Table 4. Key characteristics of MERIS

Spectral range	390 nm to 1040 nm
Spectral resolution	1.8 nm
Band transmission capability	Up to 15 spectral bands, programmable in position and width
Band-to-band registration	Less than 0.1 pixel
Band-centre knowledge accuracy	Less than 1 nm
Polarisation sensitività	Less than 0.3 %
Radiometric accuracy	Less than 2% of detected signal, relative to sun
Band-to-band accuracy	Less than 0.1%
Dynamic range	Up to albedo 1.0
Field of view	68.5°
Spatial resolution	300 m at nadir

For the current campaign the following overpasses and characteristics are foreseen:

Table 5. MERIS acquisition programmed during the EAGLE2006 Campaign

Orbit	Frame	Date	DOY	Time	Solar azimuth	Solar zenith
22335	237	08-06-2006	159	10:15:30	36	33
22364	266	10-06-2006	161	10:52:22	21	30
22378	280	11-06-2006	162	10:21:11	34	33
22421	323	14-06-2006	165	10:26:52	32	32
22435	337	15-06-2006	166	09:55:34	44	35
22464	366	17-06-2006	168	10:32:32	31	32
22478	380	18-06-2006	169	10:01:16	43	34

3.3 MODIS acquisitions

The Moderate Resolution Imaging Spectroradiometer (MODIS) is a key instrument aboard the Terra (EOS AM) and Aqua (EOS PM) satellites. Terra's orbit around the Earth is timed so that it passes from north to south across the equator in the morning, while Aqua passes south to north over the equator in the afternoon. Terra MODIS and Aqua MODIS are viewing the entire Earth's surface every 1 to 2 days, acquiring data in 36 spectral bands, or groups of wavelengths (see MODIS Technical Specifications). These data will improve our understanding of global dynamics and processes occurring on the land, in the oceans, and in the lower atmosphere. MODIS is playing a vital role in the development of validated, global, interactive Earth system models able to predict global change accurately enough to assist policy makers in making sound decisions concerning the protection of our environment.

The MODIS instrument provides high radiometric sensitivity (12 bit) in 36 spectral bands ranging in wavelength from 0.4 µm to 14.4 µm. The responses are custom tailored to the individual needs of the user community and provide exceptionally low out-of-band response. Two bands are imaged at a nominal resolution of 250 m at nadir, with five bands at 500 m, and the remaining 29 bands at 1 km. A ±55-degree scanning pattern at the EOS orbit of 705 km achieves a 2,330-km swath and provides global coverage every one to two days. The Scan Mirror Assembly uses a continuously rotating double-sided scan mirror to scan ±55-degrees and is driven by a motor encoder built to operate at 100 percent duty cycle throughout the 6-year instrument design life. The optical system consists of a two-mirror off-axis afocal telescope, which directs energy to four refractive objective assemblies; one for each of the VIS, NIR, SWIR/MWIR and LWIR spectral regions to cover a total spectral range of 0.4 to 14.4 µm. A high performance passive radiative cooler provides cooling to 83K for the 20 infrared spectral bands on two HgCdTe Focal Plane Assemblies (FPAs). Novel photodiode-silicon readout technology for the visible and near infrared provide unsurpassed quantum efficiency and low-noise readout with exceptional dynamic range. Analog programmable gain and offset and FPA clock and bias electronics are located near the FPAs in two dedicated electronics modules, the Space-viewing Analog Module (SAM) and the Forward-viewing Analog Module (FAM). A third module, the Main Electronics Module (MEM) provides power, control systems, command and telemetry, and calibration electronics. The system also includes four on-board calibrators as well as a view to space: a Solar Diffuser (SD), a v-groove Blackbody (BB), a Spectroradiometric calibration assembly (SRCA), and a Solar Diffuser Stability Monitor (SDSM).

Table 6. MODIS technical specifications

Orbit	705 km altitude, sun-synchronous, near-polar, circular
Descending node (TERRA)	10:30 am
Ascending node (AQUA)	1:30 pm
Scan rate	20.3 rpm, cross track
Swath dimensions	2330 km (cross track) by 10 km (along track at nadir)
Telescope	17.78 cm diam. Off-axis, afocal (collimated), with intermediate field stop
Size	1.0 x 1.6 x 1.0 m
Weight	228.7 kg
Power	162.5 W (single orbit average)

Data rate	10.6 Mbps (peak daytime); 6.1 Mbps (orbital average)
Quantization	12 bits
Spatial resolution	250 m (bands 1-2), 500 m (bands 3-7), 1000 m (bands 8-36)

The first MODIS Flight Instrument, ProtoFlight Model or PFM, is integrated on the Terra (EOS AM-1) spacecraft. Terra was successfully launched on 18 December 1999. The second MODIS flight instrument, Flight Model 1 or FM1, is integrated on the Aqua (EOS PM-1) spacecraft; it was successfully launched on 4 May 2002. These MODIS instruments will offer an unprecedented look at terrestrial, atmospheric, and ocean phenomenology for a wide and diverse community of users throughout the world.

3.4 AATSR acquisitions

The AATSR (Advanced Along Track Scanning Radiometer) instrument is an imaging radiometer primarily designed to measure global Sea Surface Temperature (SST) to the high levels of accuracy and stability required for climate research and modelling. Like its predecessors, ATSR 1 & 2 it will also produce high quality visible and thermal images. AATSR is the third in the ATSR series, and is a payload instrument on ESA's ENVISAT-1 polar orbiting mission. It is primarily funded by the UK Department of Environment, Transport and the Regions (DETR) with contributions from the Natural Environment Research Council and from Australia. On behalf of the DETR, the Principal Investigator is Professor David Llewellyn Jones of the University of Leicester.

The first ATSR instrument, ATSR-1, was launched on board the European Space Agency's (ESA) European Remote Sensing Satellite (ERS-1) in July 1991, as part of their Earth Observation Programme. An enhanced version of ATSR, ATSR-2, was successfully launched on board ESA's ERS-2 spacecraft on 21 April 1995. ATSR-2 is equipped with additional visible channels for vegetation monitoring. The AATSR (Advanced Along Track Scanning Radiometer) instrument has been successfully launched on board the ENVISAT spacecraft on 1 March 2002 at 01:07 GMT from the Kourou spaceport in French Guiana

AATSR has the same signal channels and embodies exactly the same viewing principle as ATSR-2. These are: thermal channels at 3.7, 10.8, and 12 microns wavelength; and reflected visible/near infrared channels at 0.555, 0.659, 0.865, and 1.61 microns wavelength. The main objective of AATSR is to contribute to the long-term climate record of global Sea Surface Temperature by extending the current ATSR-1 and -2 global data-sets well into the next decade. This could eventually provide the climate research community with uniformly high quality global SST data over a period of 12-15 years (depending on the lifetime of AATSR).

Like its predecessors, ATSR-1 and ATSR-2, AATSR carries on-board calibration systems for the thermal channels, using two black bodies, viewed every scan, and for the visible channels a sample of solar radiation scattered from a diffuser plate is viewed once per orbit. Unlike ATSR-2 it maintains full digitisation of all channels all the time and has no limited-data-rate operating modes.

The AATSR instrument, in contrast to its predecessors (funded by SERC/NERC), is primarily funded by the DETR's Global Atmosphere Division, in order to complete a data-set of accurate global SST, lasting over ten years, which will contribute to the Climate Record and help provide quantitative assessments of possible climate change. The DETR is funding AATSR as a potential operational user of the data - the first environment ministry in Europe to take such a step - as part of a UK Government drive to direct the development and deployment of Earth Observation satellite missions more specifically towards the requirements of end-users of the data.

Like the predecessors onboard the ERS-1/2 (ATSR-1/2), AATSR can provide observations of the surface reflectance spectra in the visible and surface emission spectra in the thermal part of the electromagnetic spectrum, and observes the earth' surface at two viewing angles; at nadir and at a 55 degrees forward looking view. The resolution of the forward and nadir looking channels are approximately 2.0 and 1.0 km, respectively. The combination of optical and thermal observations provided by the AATSR sensor is especially appropriate for the application of remote sensing based energy budget modeling approaches. In addition, AATSR's dual angle configuration allows the potential extraction of component vegetation and soil temperatures.

Table 7. AATSR acquisition programmed during the EAGLE Campaign

Orbit	Frame	Date	DOY	Time
22335	237	08-06-2006	159	10:15:43
22356	258	09-06-2006	160	21:07:22
22378	280	11-06-2006	162	10:21:24
22413	315	13-06-2006	164	20:41:49
22421	323	14-06-2006	165	10:27:05
22456	358	16-06-2006	167	20:47:29
22464	366	17-06-2006	168	10:32:45

3.5 ASTER acquisitions

The ASTER images (which consists of 2 level 1B scenes) of Figure 6 were acquired on 30/03/04 over the Central part of The Netherlands EAGLE test site at 10:45 UTC.

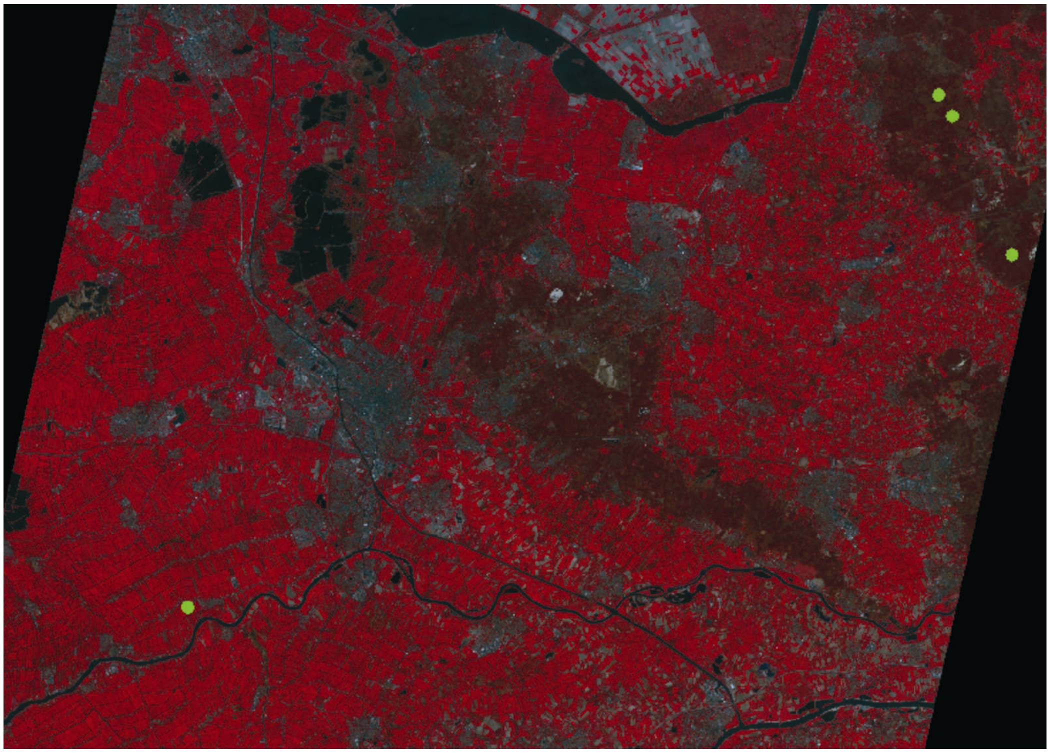


Figure 7. Aster composite acquired on 30-march-2004, at 10:45 UTC over the EAGLE test sites.

ASTER products are provided in hierarchical data format (HDF), and are defined by level:

Level 1B: at-sensor radiance (geometric and radiometric coefficients applied)
Level 2 (AST09): at-surface radiance in the VNIR and SWIR regions
Level 2 (AST09T): at-surface radiance in the TIR region
Level 2 (AST08): land surface temperature (obtained with the TES algorithm)
Level 2 (AST05): land surface emissivity (obtained with the TES algorithm)

Table 8. ASTER acquisitions (also yield the highest MODIS resolution) during EAGLE 2006.

Date	Time
06-06-06	12:56:29
15-06-06	12:50:00
22-06-06	12:56:00
01-07-06	12:50:00
17-07-06	12:49:29
24-07-06	12:55:2

3.6 ASAR acquisitions

The ASAR sensor on board of the Envisat platform, operates at C-band, ensuring continuity with the image mode (SAR) and the wave mode of the ERS-1/2 AMI. It features enhanced capability in terms of coverage, range of incidence angles, polarisation, and modes of operation. This enhanced capability is provided by significant differences in the instrument design: a full active array antenna equipped with distributed transmit/receive modules which provides distinct transmit and receive beams, a digital waveform generation for pulse "chirp" generation, a block adaptive quantisation scheme, and a ScanSAR mode of operation by beam scanning in elevation. The Advanced SAR is built up on the experience gained with the ERS-1/2 active microwave instrument (AMI) to continue and extend Earth observation with SAR. Compared to ERS AMI, ASAR is a significantly advanced instrument employing a number of new technological developments which allow extended performance. The replacement of the centralized high-power amplifier combined with the passive waveguide slot array antenna of the AMI by an active phased array antenna system using distributed elements is the most challenging development. The resulting improvements in image and wave mode beam elevation steerage allow the selection of different swaths, providing a swath coverage of over 400-km wide using ScanSAR techniques. In alternating polarisation mode, transmit and receive polarisation can be selected allowing scenes to be imaged simultaneously in two polarisations.

The ERS high resolution products PRI, SLC, and GEC will be continued for image mode, and generated for alternating polarisation mode on user request. The wave mode products are continued and their quality improved thanks to cross spectra algorithms.

Table 9. ASAR acquisitions during EAGLE2006.

Orbit	Frame	Date	DOY	Time (UTC)	Direction
22349	251	09-06-2006	160	09:45:00	D
22356	258	09-06-2006	160	21:08:00	A
22392	294	12-06-2006	163	09:50:45	D
22435	337	15-06-2006	166	09:56:25	D
22442	344	15-06-2006	166	21:19:20	A
22478	380	18-06-2006	169	10:02:10	D
22485	387	18-06-2006	169	21:25:05	A

3.7 SEVIRI acquisitions

The images are received as a series of wavelet compressed segments (e.g. 8 segments for bands 1-11 and 24 segments for band 12, the High Resolution Visible, HRV). There are also Epilogue (*.epi) and Prologue files (*.pro) which contain important information with regard to the SEVIRI settings. These epilogues and prologue files are in binary format but not compressed. The compressed segment files are in fact made up of two parts: first, a header which contains information with regard to coordinates and radiometric settings and which is not compressed, and second the actual wavelet compressed image segment.

After decompression, the segments have to be combined and provided with a coordinate and a georeference system. After that, radiometric calibration coefficients have to be used to transform the two-byte per integer pixel values into radiances. For bands 1 to 3, radiances can be converted into TOA albedo and the thermal bands 4 to 11, radiances can also be converted into brightness (TOA) temperature.

Table 10. SEVIRI radiometric specifications.

Channel	Spectral bandwidth (μm)	Central wavelength (μm)	In-flight radiometric noise results
HRV	Broad band – 0.6 to 0.9		2.84 (1.20) at 0.28% MDR
VIS 0.6	0.56 to 0.71	0.6	159 (10.1) at 1% MDR
VIS 0.8	0.74 to 0.88	0.8	53 (7.28) at 1% MDR
NIR1.6	1.50 to 1.78	1.6	10 (3.00) at 1% MDR
IR 3.9	3.48 to 4.36	3.9	0.105 K (0.35) at 300 K
WV 6.2	5.35 to 7.15	6.2	0.05 K (0.75) at 250 K
WV 7.3	6.85 to 7.85	7.3	0.060 K (0.75) at 250 K
IR 8.7	8.30 to 9.10	8.7	0.07 K (0.28) at 300 K
IR 9.7	9.38 to 9.94	9.7	0.11 K (1.50) at 255 K
IR10.8	9.80 to 11.80	10.8	0.074 K (0.25) at 300 K
IR12.0	11.00 to 13.00	12.0	0.11 K (0.37) at 300 K
IR13.4	12.40 to 14.40	13.4	0.295 K (1.80) at 270 K

The SEVIRI radiometric characteristics are displayed in Table 9. The noise is expressed in Signal to Noise Ratio (SNR) at a referenced target for the solar channels (MDR standing for Maximum of the Dynamic Range) and in Kelvin for the IR channels at a referenced source brightness temperature (Noise Equivalent Temperature difference or NEdT). The specified radiometric SNR or NEdT is the one between parentheses.

3.8 ALOS PALSAR acquisitions

The Phased Array type L-band Synthetic Aperture Radar (PALSAR) is an active microwave sensor using L-band frequency to achieve cloud-free and day-and-night land observation. It provides higher performance than theJERS-1's synthetic aperture radar (SAR). Fine resolution in a conventional mode, but PALSAR will have another advantageous observation mode. ScanSAR, which will enable us to acquire a 250 to 350km width of SAR images (depending on the number of scans) at the expense of spatial resolution. This swath is three to five times wider than conventional SAR images. The development of the PALSAR is a joint project between JAXA and the Japan Resources Observation System Organization (JAROS).

Table 11. ALOS PALSAR specifications.

Mode	Fine		ScanSAR	Polarimetric (Experimental mode)*1
Center Frequency	1270 MHz(L-band)			
Chirp Bandwidth	28MHz	14MHz	14MHz,28MHz	14MHz
Polarization	HH or VV	HH+HV or VV+VH	HH or VV	HH+HV+VH+VV
Incident angle	8 to 60deg.	8 to 60deg.	18 to 43deg.	8 to 30deg.
Range Resolution	7 to 44m	14 to 88m	100m (multi look)	24 to 89m
Observation Swath	40 to 70km	40 to 70km	250 to 350km	20 to 65km
Bit Length	5 bits	5 bits	5 bits	3 or 5bits
Data rate	240Mbps	240Mbps	120Mbps,240Mbps	240Mbps
NE sigma zero *2	< -23dB (Swath Width 70km) < -25dB (Swath Width 60km)		< -25dB	< -29dB
S/A *2,*3	> 16dB (Swath Width 70km) > 21dB (Swath Width 60km)		> 21dB	> 19dB
Radiometric accuracy	scene: 1dB / orbit: 1.5 dB			

4 Airborne data acquisitions

4.1 Flight line coordinates

To plan the flight coordinates we will use the overlap between the ASTER image (Figure 6) and the most likely expected area to be included in all the views for the different CHRIS/PROBA acquisitions during the campaign.

The flights ideally should take place between the 8 and 18 June 2006, at the same time as the CHRIS/PROBA acquisitions (14-15 June). The flights will be both parallel to the principal plane (in the sun direction), in order to reduce angular effects in the images, as well as perpendicular to the principal plane, to observe the angular effects. Figure 8 shows the AHS flight configuration for the Cabauw and Speulderbos and Loobos sites corresponding to 15 June. Simultaneously a CHRIS-PROBA image is taken and flight lines are such that is flown parallel and perpendicular to the principal plane. Altitude is 3200 ft, such that ground coverage is 3200 ft (about 2 km) as well and resolution is 2.5 m (AHS sensor).

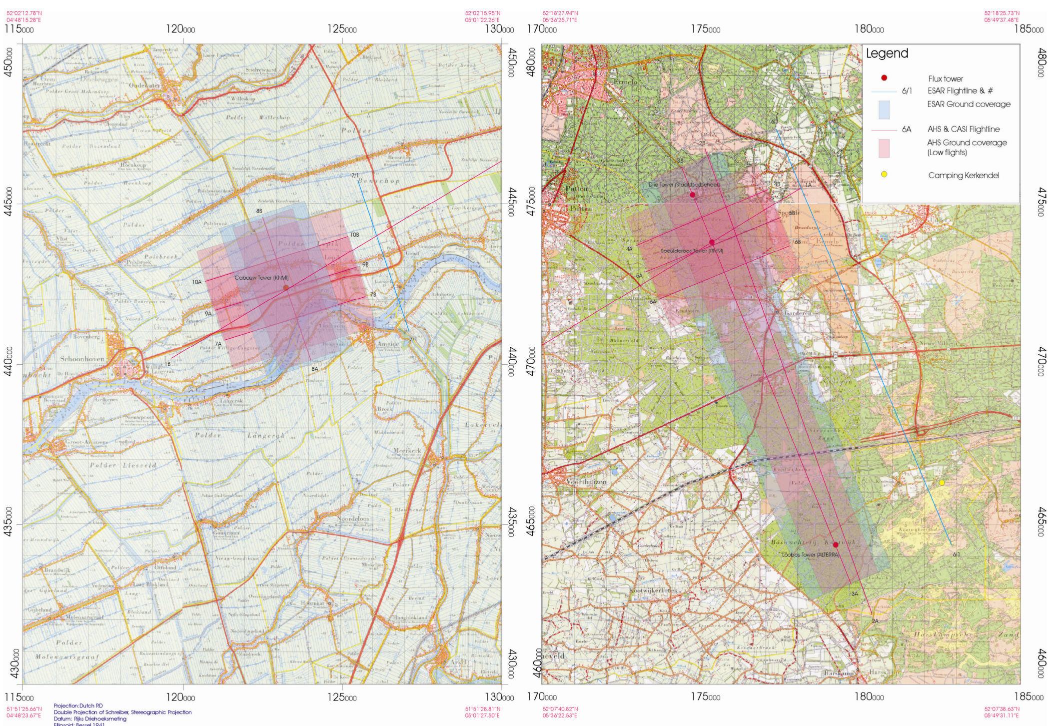


Figure 8. Flight configuration for the Cabauw site (left panel) and Speulderbos and Loobos site (right panel) corresponding to 15 June, for both the INTA (red) as well as the DLR flights (blue).

4.2 INTA Airborne Hyperspectral System (AHS)

The AHS is an imaging 80-band line-scanner radiometer, built by Sensytech Inc (currently Argon ST, and formerly Daedalus inc.) and purchased by INTA in 2003. AHS is based on previous airborne hyperspectral scanners, such as the MIVIS (Multispectral Infrared and Visible Imaging Spectrometer) and MAS (MODIS Airborne Simulator).

The instrument has been installed in the INTA´s aircraft (CASA C-212), and integrated with an INS/GPS POS-AV 410 from Applanix.

The AHS was first flown by INTA in September 2003. During 2004 the instrument was validated during a number of flight campaigns which included extensive ground surveys (SPARC-2004 and others). It has been fully operational from the beginning of 2005.

It has a design which has very distinct spectral performances depending on the spectral range considered. In the VIS/NIR range, bands are relatively broad (28-30 nm): the coverage is continuous from 0.43 up to 1.0 microns. In the SWIR range, there is an isolated band at 1.6, useful to simulate the corresponding band found in a number of satellite missions. Next, there are a number of continuous, fairly narrow bands (13 nm) between 2.0 and 2.5 microns, which are well suited for soil/geologic studies. In the MIR and TIR ranges, spectral resolution is again high (30 to 50 nm), and the atmospheric windows (3 to 5 microns and 8 to 13 microns) are fully covered.

AHS-INTA will be operated onboard a CASA aircraft (Figure 9).

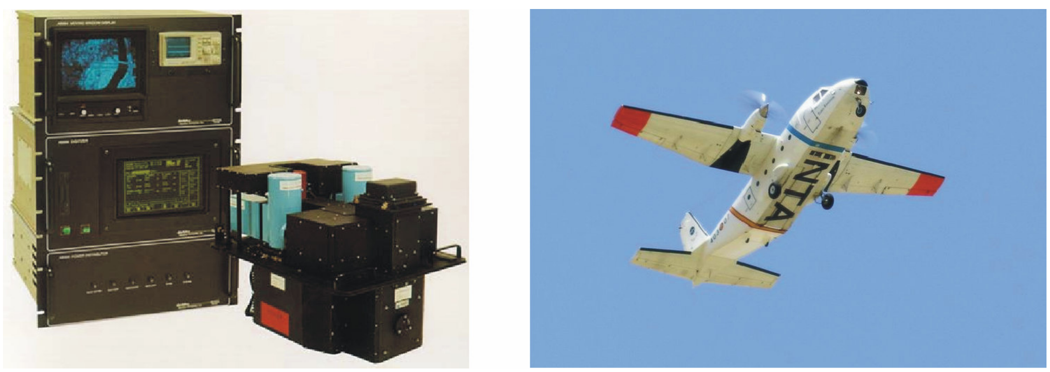


Figure 9. AHS sensor and INTA plane

4.2.1 AHS characteristics

The main characteristics of AHS are:
- Optical design: scan mirror plus reflective optics with a single IFOV determining field stop.
- FOV (Field Of View) / IFOV (Instantaneous Field Of View): 90º / 2.5 mrad.
- GSD (Ground Sampling Distance): 2.1 mrad (0.12 degrees).
- Scan rates: 6.25, 12.5, 18.75, 25, 31.25 and 35 r.p.s., providing GSD's from 7 to 2.5 m@72ms^{-1}
- Digitization precision: 12 bits to sample the analog signal, with gain level from x0.25 to x10.
- Samples per scan line: 750 pixels/line.

- Reference sources: two controllable thermal black bodies within the field of view, set to a temperature range from -15ºC to +25ºC with respect to scan heat sink temperature.
- Spectrometer: four dichroic filters to split radiation in four optical ports, and diffraction gratings within each port.
- Detectors: Si array for VIS/NIR port; InGaAs, InSb and MCT arrays, cooled in N_2 dewars, for SWIR, MIR and TIR ports.
- Spectral bands: continuous coverage in four spectral regions + one single band at 1.5 micrometers, as shown in table 4.1.
- Data recording media: Removable SCSI magnetic hard disks.

Table 10. AHS spectral configuration

Optical Port	Detector	Number of Bands	Spectral Range	Band Width Δλ (FWHM)	λ/Δλ (minimum)
Port 1 – VNIR	Si - not cooled	20	442 to 1 019 nm	27-30 nm	≈ 17
Port 2A – SWIR	InGaAs - cooled	1	1 491 to 1 650 nm	159 nm	≈ 10
Port 2 – SWIR	InSb – LN2 cooled	42	2024 to 2498 nm	12-13 nm	≈ 156
Port 3 – MWIR	InSb – LN2 cooled	7	3030 to 5410 nm	260-420 nm	≈ 9
Port 4 - LWIR	HgCdTe– LN2 cooled	10	7950 to 13700 nm	400-550 nm	≈ 17

The spectral bands in the narrower ports (Port 1 and Port 2) have a gaussian distribution with FWHM equal to bandpeak-to-bandpeak spacing, as assumed by processing tools (typically ENVI). Bands in the thermal ports (3 and 4) are also well approximated by the gaussian curve, but their broader size would require the use of the spectral responsitivity for detailed analysis. Band AHS-21 (port 2A) is the less regular one, and band center, peak response and FWHM have a singular relation.

Table 11. AHS technical specifications

FOV	90º		
IFOV	2.5 mrad		
GFOV	2 ÷ 6 m at 140 kt cruise speed		
Scan rate	6.25, 12.5, 18.75, 25, 31.25, 35 rps		
Quantization	12 bits		
Sampling	750 samples per line		
Pixel size	2.5 m @ 3200 ft Above Ground Level		
Calibration	Black body thermal reference		
Spectral characteristics:	80 bands in 5 ports:		
Optical ports	Number of bands	Spectral region	Band width
VIS	20	430 to 1030 nm	30 nm
NIR	1	1.550 to 1.750 μm	200 nm
SWIR	42	1.994 to 2.540 μm	13 nm
MWIR	7	3.3 to 5.4 μm	300 nm
LWIR	10	8.20 to 12.7 μm	400 nm

4.2.2 Optical flight tracks

The optical surveys to carry out during the EAGLE2006 measurement period will aim to provide at least two hyperspectral coverages of the test site area shown in Figure 8).

4.2.3 AHS Operating Modes

AHS operating modes are presented in the Table 12. For EAGLE2006 surveys, two AHS modes of operation are proposed, (in green colour in the table), providing imagery at 2.5 m and 7 m at nadir pixel size (TBC) in 80 spectral bands spread along VNIR, SWIR, MIR and TIR spectral regions.

Table 12. Summary of AHS Operating Modes (@ Ground Speed=72 ms-1) (In green colour those proposed for EAGLE2006)

Scan rate (rps)	GS(Kts)	AAT(m)	AAT(ft)	GIFOV (m)	Swath (m)
6,25	140	5491	18010	13,73	10982
12,5	140	2745	9005	6,86	5491
18,7	140	1835	6020	4,59	3670
25	140	1373	4503	3,43	2745
31,2	140	1100	3608	2,75	2200
35	140	981	3216	2,45	1961

4.2.4 AHS Data Processing

Table 13 provides a list of the standard products produced by INTA.

Table 13. INTA AHS standard data products

IDENTIFICATION	RADIOMETRIC CORRECTION	GEOMETRIC CORRECTION
L0 / L1a raw data	No process	No process
L1b At-sensor radiance	From ND to Ls using test bench + Labsphere data for VIS-NIR-SWIR and sensor black-bodies for TIR bands.	No process
L1c Geo-referenced at-sensor radiance	From ND to Ls using test bench + Labsphere data for VIS-NIR-SWIR and sensor black-bodies for TIR bands.	Direct geo-referencing using PARGE©
L2a Geo-referenced reflectance & apparent temper.	From Ls to ρ using MODTRAN©	Direct geo-referencing using PARGE©

For EAGLE2006 it is planned to deliver the following products:

1) AHS L1a images: raw data in ENVI format.
2) AHS L1b images: at-sensor radiance, in nW/(cm2 sr nm).
3) AHS L1c images: georeferenced at-sensor radiance, in nW/(cm2 sr nm).
4) AHS L2a images: georeferenced reflectance (-) and apparent temperature (K)

Table 14. INTA AHS data specifications

Port	Radiometric resolution	Radiometric accuracy
1 (VIS/NIR)	NedL< 0.25 w/(m2 sr um) (in 90% of the bands) *NedL = stdev NDbb in image*	< 2% (at sensor radiance)
2 (SWIR) (including AHS21)	NedL< 0.4 w/(m2 sr um) (in 90% of the bands) *NedL = stdev NDbb in image*	< 5% (at sensor radiance)
3 (MIR)	N/A	N/A
4 (TIR)	NedT < 0.33 ºC in at least 5 bands *NedL = stdev NDbb for a 32 lines moving window in datafile*	< 0.5ºC (at sensor apparent temperature)

No radiometric or spectral specification is given for Port 3 (3 to 5 micrometers)

Two separate files per scene, ENVI format, with filenames:
AHS_YYMMDD_ZONEX_PNNHD_L10020_PT12.raw / .hdr (Port 1 & 2)
AHS_YYMMDD_ZONEX_PNNHD_L00120_PT34.raw / .hdr (Port 3 & 4)
(example AHS 050510_INTA1_P01AD_L10020_PT12.raw)

5) Applanix AV410 attitude and position per scanline computed by POSPAC, in ZI-Imaging format, cartographic system UTM, datum WGS84; orthometric height computed with POSPAC using EGM96.

Attitude and position data accuracy < 1 pixel.
One file per scene, with filename:
POS_YYMMDDZONEX_PNNHD.txt
(example POS_050510_INTA1_P01AD.txt)

6) Image Geometry Files (IGM), describing the ground UTM position of each imaged pixel, in ENVI format.

There will be an IGM file for each scene (the same IGM file is used for PT12 and PT34 files). *The IGM files are used in ENVI to generate georeferenced products from L1b data using GLT or SuperGLT tools.*

7) Auxiliary files
7.1) A text file containing radiometric performance (NedL/NedT and SNR) and calibration coefficients (slope, gain and offset per scene and per spectral band).
7.2) AHS system specifications document .

8) Reports
Metadata for the AHS image files: one XML file per scene and processing level, INTA profile (according to ISO19115:2003)
No metadata will be provided for the Applanix data or the auxiliary files.

9) Delivery Schedule
Products will be delivered 4 weeks after reception of raw data.
All data products will be delivered via ftp and/or a portable USB hard drive.

4.3 DLR E-SAR

4.3.1 E-SAR System

DLR-HR operates the experimental multi-frequency, multi-polarisation Synthetic Aperture Radar (SAR) system E-SAR onboard a Do228 aircraft. E-SAR features across track SAR interferometry capabilities at X-band (VV polarisation). Single channel operation in X-band takes place with VV and HH polarisations switched from pass to pass. C-Band data can be acquired either in single channel mode (VV, HH polarisations, pass to pass) or in dual-channel mode with combinations of VV/VH and HH/HV polarisations switched from pass to pass. Fully polarimetric data acquisition is possible in L- and P-bands only. Technical specifications for each of the RF bands are shown in Table 15). The SAR processing ground segment, adapted to E-SAR data at DLR-HR, includes operational modules for DEM generation and geo-coding amongst others. The data products fulfill high quality standards in terms of calibration and geometric accuracy. Aircraft navigation and SAR motion compensation are based on a modern combined DGPS/INS system.

Table 15. E-SAR Technical Parameters

RF-Band	X Band	C Band	L Band	P Band
RF-centre frequency	9.6 GHz	5.3 GHz	1.3 GHz	350 MHz
Transmit peak power	2.5 kW	750 W	400 W	1000 W
Receiver noise figure	4.0 dB	4.0 dB	8.5 dB	6.0 dB
Antenna gain	17.5 dB	17 dB	15 dB	10 dB
Azimuth beamwidth	17°	17°	18°	30°
Elevation beamwidth	30°	33°	35°	40°
Antenna Polarisation	H and V	H and V	H and V	H and V
Aquisision Mode	single pol	dual pol	quad pol.	quad pol.
IF-centre frequency	300 MHz	300 MHz	300 MHz	300 MHz
Max. Signal bandwidth	100 MHz	100 MHz	100 MHz	100 MHz
System bandwidth	120 MHz	120 MHz	100 MHz	100 MHz

The aircraft Do 228 is operated by the DLR’s flight operation institute; they are contributing with the full maintenance of the aircraft, with pilots and one technician. The incidence angle range for all frequencies is ranging between 25 and 55 degrees.

4.3.2 Flight Tracks

Two Radar flight tracks have been defined which cover the selected sites (Figure 8). The flights with all radar operating configurations around 15 June will be feasible. No flights are planned for other period due to the constraints in budget and the expected stable phonological conditions over the selected period in the summer months (maintained grassland and forests).

4.3.3 Operating Modes

For the EAGLE2006 campaign it is intended to fly the following configurations.

Frequency	Polarisation	Passes	Remarks
X-band DEM	VV	1	1.7m (single pass baseline)
X-band	HH / VV	2	Coregistered
C-band	Dual	2	Coregistered
L-band	quad	1	Coregistered

The X-band DEM mode will be flown just once for the preparation of a detailed DEM.

In the flight, all segments will be covered. (i.e. 2 passes of each flight).

4.3.4 Data Processing

E-SAR processing is described herein as subsequent steps with well-defined interfaces, most of which are fully automated. The procedure is divided into the following functional blocks:

- Track-point generation
- Transcription
- Survey-Processing
- Navigation Data Processing
- Tie-point Data Processing (i.e. Corner Reflector Positions)
- Generation of Processing-Setup-Table (Excel-Sheet)
- Full Performance SAR Processing
- Archiving
- Delivery

The Microwaves and Radar Institute will provide the following Radar data products:

Radar Geometry Image Products (RGI)

- Multilook (slant & ground range) & SLC data
- L- & P-band full polarimetric, C-band 2xdual polarimetric, X-band VV-pol.

Geocoded Terrain Corrected Products (GTC)

- WGS-84, UTM projection, zone 50
- Horizontal posting: 2 m
- Incl. DEM (except MAWAS) & Incidence angle map

Geocoded Digital Elevation Products (DEM)

- For each segment with 2m posting (used as input for GTC)
- Mosaic for complete test-site with 5m posting

Repeat-pass interferometric products

- Master & Slave data sets as RGI products
- Including resampled SLC data of slave
- With coherence, interferometric phase, tracks & kz-matrix

Radar data products will be provided to the campaign participants successively after each campaign, except the RGI products.

4.4 MIRAMAP L-band Microwave radiometer

MIRAMAP is a private earth observation company providing an affordable collection, processing and management solution to measure the water situation from the air with Airborne Passive Microwave Radiometry. This technology is capable of quickly producing soil moisture maps of the upper ground layers and in certain conditions to produce depth to water table maps down to several meters of large areas at a time.

The XCL-band Microwave radiometers are used with different wavelengths, parameter models and processing software. The end product is a geo-referenced map that clearly shows potential problem areas. This digital map can be used in combination with existing or concurrently collected digital photography, lidar elevation data and thermal infrared imagery for many different applications.

Passive microwave and thermal infrared observations will be made during flights that will be carried out this summer in part of the EAGLE2006 test area (the Langebroekwetering area, which consists of 15 fixed level drainage areas, in which the surface water and shallow groundwater level is controlled by the waterboard) as part of a project run by the "Waterboard Hoogheemraadschap De Stichtse Rijnlanden" in combination with several other parties (Wageningen University and Research Centre, TNO, Utrecht University, Free University Amsterdam, Rijkswaterstaat and the University of Gent). Emphasis in the current project will be on nowcasting of hydrological variables such as specific discharge, shallow ground water levels and soil moisture content, in combination with re-analysis with a primary focus on the water balance components.

Due to a delay in the airplane for the installation of the XCL-band radiometers, MiraMap will provide, install and operate a twin-beam L-band radiometer system that continuously collects Brightness Temperature data from a static tower location. The system will be mounted on a tower at Cabauw, Loobos or Speulderbos and will be operational for about three weeks in June 2006. The technical system specifications are given below.

Parameter	Value
Band	L (twin-beam)
Frequency	1.4 GHz
Polarization	H
Sensitivity	1 K
Absolute accuracy	± 5K
3-dB Beam width	25°
Integration time	about 200 ms
Data rate	≤ 1 Hz
Band width	60 MHz
Elevation	15°
Size antenna array	60 x 70 x 20 cm^3
Proposed mounting angle	10-30°
Footprint size at H (m)	2 * H (m)

This specific L-band sensor was designed for airborne operations, so for this project it has to be altered (special mount, weather proof, power adaptation, etc.). A Data Acquisition System controls the sensor, writes the data to a removable memory card and is connected to a GPS receiver for positioning and timing information.

The deliverables are raw Brightness Temperature data in Kelvin with location and time stamps. The estimated data delivery is less than one week after system removal.

4.5 ISAFoM-CNR Flux airplane

ISAFoM-CNR is currently operating a flux airplane (the Sky Arrow ERA of Figure 9) which will be operating during the EAGLE 2006 campaign. Onboard there will also an altimeter for the measurement of regional roughness.

Figure 9. Flux airplane with instruments mounted on board

The purpose of using these airborne flux measurements here is to develop alternatives to ground-based measurements in order to obtain information required to predict the effects of soil and land use on the surface energy balance and the water balance. Satellite-based algorithms have been developed via flux measurements from an aircraft to estimate vegetation and soil conditions on a regional scale. The purpose of these flights will be to make measurements in the boundary layer of the fluxes of sensible and latent heat, momentum, and carbon dioxide, plus supporting meteorological parameters such as temperature, humidity, wind speed, and wind direction. Aircraft position, heading, and altitude will also be recorded, as also several radiometric observations for use in interpretation of the data. The aircraft allows steady flight trajectories at low airspeed down to levels less than 10 m above the ground. The aircraft is instrumented to measure the contribution of flux densities of momentum, sensible and latent heat, and CO2.

All the flux measurements will be obtained with the eddy-correlation method, wherein the aircraft is equipped with an inertial platform, accelerometers, and a gust probe for measurement of earth-relative gusts in the x, y, and z directions. Gusts in these dimensions are then correlated with each other for momentum fluxes and with fluctuations in other variables to obtain the various scalar fluxes, such as temperature (for sensible heat flux) and water vapor mixing ratio (for latent heat flux).

5 Ground thermal infrared radiometric measurements

5.1 Instrumentation

The following instruments will be employed during the campaign by the Global Change Unit of the Faculty of Thermodynamics from the University of Valencia:

CIMEL 312-1 radiometer

The CIMEL CE-312-1 is a radiance-based thermal-infrared radiometer composed of two major components: an optical head containing the detector and optics, and the electronic unit that performs the data storage. The detector includes one broad-band filter, 8-13 µm, and three narrower filters, 8.2 – 9.2 µm, 10.5 – 11.5 µm and 11.5 – 12.5 µm. An external temperature probe can be added by the user into the control unit. It allows collecting the temperature of an external blackbody especially for the estimation of absolute emissivity. A set of different scenarios is available to collect data depending on the user desires.

CIMEL 312-2 ASTER radiometer

The CIMEL CE-312-2 ASTER is a radiance-based thermal-infrared radiometer composed of two major components: an optical head containing the detector and optics, and the electronic unit that performs the data storage. The detector includes 6 bands, a wide one, 8-13 µm, and five narrower filters, 8.1 – 8.5 µm, 8.5 – 8.9 µm, 8.9 – 9.3 µm, 10.3 – 11 µm and 11 – 11.7 µm. An external temperature probe can be added by the user into the control unit. It allows collecting the temperature of an external blackbody especially for the estimation of absolute emissivity. A set of different scenarios is available to collect data depending on the user desires.

EVEREST 3000.4ZLC Infrared temperature transducer

The Everest thermometer, model 3000.4ZLC single band 8 – 14 µm collect the infrared radiation from the sample converting it into electrical signal. With the suitable calibration process, the electrical signal is converted to a signal in terms of temperature. It is scaled from – 40°C to 100°C with a resolution of 0.1 K, an accuracy of ±0.5 K and a repeatability of ±0.1K. The Field of View -FOV- is 4°. It has an adjustable emissivity equal to unity. The output signal is in mV (10 mV/°), and the power requirements is 5V to 26V DC. Power supply was provided by an auxiliary Einhell power station.

RAYTEK ST8 Infrared radiometer

A portable RAYTEK, model ST8 single band 8–14 µm, with a FOV of 8 degrees, and with adjustable emissivity operation mode will be used. It ranges up to 100°C with a sensitivity of 0.1 K and an accuracy of 0.5K. It has a laser beam that helps to locate the target for the measurements.

RAYTEK Thermalert MID radiometers

The Raytek Thermalert MID radiometer is an infrared sensor with a single band 8–14 µm, with a FOV of 20 degrees, and with adjustable emissivity operation mode. It ranges up to 600°C with a sensitivity of 0.1 K and an accuracy of 0.5K.

Thermocouple Type K.
The water and surface temperature will be measured with different thermocouples with error lower than 0.1 °C.

EVEREST 1000 calibration source
A calibration source EVEREST model 1000 will be used to calibrate the radiometers. Its operating range is from 0°C to 60°C, with a resolution of 0.1K, with an absolute accuracy of 0.3 K over entire range.

LICOR LI-1000 Dataloggers
Four different Licor LI-1000 dataloggers will be used to store data from both radiometers and thermocouples.

5.2 Measurement plan

A set of thermal radiometric measurements will be carried out in the framework of the EAGLE2006 experimental field campaign. The retrieval of bio-geophysical parameters such as land surface emissivity and temperature is the main aim of these measurements, which will take place over several land cover units mainly at the Cabauw and Speulderbos test sites. To this end, radiometric measurements will be carried out in the thermal infrared region with various instruments that include fixed FOV and single band or multi bands radiometers. In addition, a thermocouple for thermometric temperatures measurements and black bodies (calibration sources) for calibration purposes will be used.

Therefore, the experimental work of the Global Change Unit of the University of Valencia will be the measurement of thermal radiometric temperatures, emissivities, atmospheric radiances, air temperature, temperature transects and angular measurements within the site area. Transects will be performed concurrently to the flight/satellite overpasses. Transects will be carried out taking temperatures measurements with different field radiometers (CIMEL, RAYTEK and EVEREST), at regular steps (3 meters) or fixed in characteristic areas.

TBD:
All days, brightness temperature transects simultaneously with flight/satellite overpasses will be carried out.

6 Surface energy budget measurements

6.1 Introduction

In order to advance our understanding of land-atmosphere exchanges of water and heat in space and time over heterogeneous land surfaces, in-situ measurements of these exchanges as well as the thermal dynamic states of the atmosphere, soil and vegetation will be carried out over several representative land cover units in the area. Since turbulent fluxes occur from scales of an air molecule to regional scale characterized by synoptic circulation and are influenced by both internal biophysical characteristics of the soil and vegetation and external forcing (e.g. solar radiation and wind), the measurements of these fluxes are most challenging over heterogeneous terrain. Because the terrain heterogeneity in addition to the organized patterns and circulations of turbulent fluxes also causes secondary effects either in terms of surface geometrical conditions (roughness) or thermal dynamic conditions (dryness or wetness) that may cause local circulation of turbulent fluxes, a number of ground based instruments will be employed for a complete observation and understanding of these turbulent fluxes in space and time.

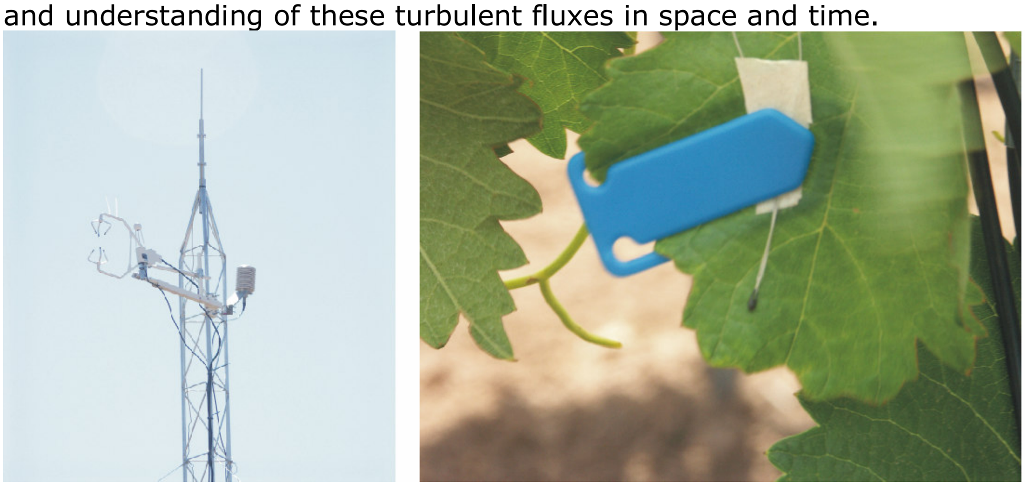


Figure 10. Eddy correlation system (left) and example of component temperature monitoring (right)

The two towers at the Speulderbos site will be employed for setting up a Large Aperture Scintillometer (LAS) by the WUR Meteorology and Air Quality Group. In addition, on one of the towers an eddy correlation system (by the ITC) will be installed, as well as a standard meteo-station, including a Kipp and Zoonen CNR1 radiometer. A mobile scintillometer, Figure 11, will be employed over several characteristic land cover units to monitor the individual components of the energy and water flux exchanged over different surfaces at other EAGLE2006 test sites. When these measurements are combined with airborne and satellite data (such as the AHS, CHRIS-PROBA and possibly AATSR), detailed quantification of the characteristics of turbulent fluxes over different surfaces at different scales becomes possible.

Figure 11. Mobile LAS system

Knowledge of the heat transfer is essential in understanding the exchanges of water vapour and energy between a canopy and the surrounding atmosphere. Heat flux estimations over homogeneous areas have been achieved by the use of relatively simple models. The architecture of most vegetation canopies however leads to a complex three-dimensional exchange of heat requiring directional temperature measurements of the different canopy components. Therefore an automated directional acquisition system, or goniometer, will be employed for these directional measurements with different sensors, such as thermal cameras and spectrometers (TBD). Concurrent to the goniometer measurements the temperatures of different land surface components are monitored. These different components can be divided into 4 pairs (shadowed versus sunlit, leaves versus soil, high versus low leaves, young versus old leaves). This leads to eight canopy component temperatures and two soil component temperatures that will be monitored at the Cabauw test site, in order to be implemented into a virtual canopy model for the simulation of directional temperatures.

6.2 Measurement plan

The following measurements will be carried out by the ITC team at the KNMI Cabauw site during the entire campaign:

- Component temperatures (Instruments: thermo-couples and goniometer)
- Directional reflectance and temperature (Instruments: goniometer & add. Sensors, details Table 11)

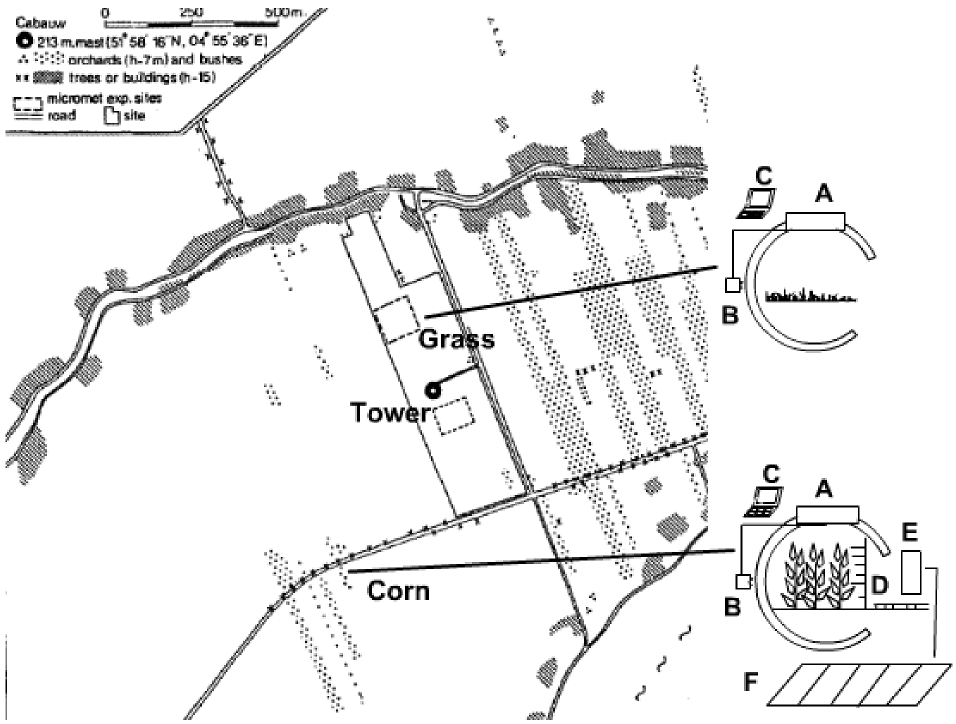


Figure 12. Setup of the instrument in the Cabauw field site, courtesy (Ulden & Wieringa, 1996). The denomination of the letters is given in Table 11.

Table 11. Sensor installation at the Cabauw site. Note [1]: To be borrowed from UV, if possible. Note [2]: To be borrowed from LSIIT, if possible.

Symbol	Description	Name	#
A	Goniometer	ADAS	1
B	Instruments to be attached to A	Several, see below	6
C	Control box + laptop	-	3
D	Component temperature	NTC 833ET	14
E	Logger	C23x	1
F	Solar panels	-	1
Instruments to be attached to A;			
	Thermal imager (low resolution)	Irisys 1011	
	Thermal imager (low resolution)	TH9100 PRO[1]	
	Thermal radiometer (single band)	Everest 3000	
	Thermal radiometer (ASTER bands)	Cimel312[2]	
	Spectrometer	ASD	
	Digital camera	Canon	

The following measurements will be carried out at the Speulderbos RIVM site:

- Radiation flux: Short & long wave incoming and outgoing radiation (Instruments: Kipp and Zoonen CNR1)
- Conduction: Soil heat fluxes (Instruments: HFP01 soil heat flux plates and soil thermistors)
- Sensible heat fluxes (Instrument: Kipp and Zoonen LAS)
- Sensible and latent heat fluxes (Instruments: CSAT sonic anemometer)
- Carbon fluxes (Instrument: Licor)
- Directional reflectance and temperature (Instruments: several handheld sensors)
- Air temperature and wind speed profile in the canopy air space (Instruments: A100L2, W200P)
- Wind speed, air temperature and humidity in the ASL and PBL (via KNMI radiosounding at Cabauw)
- Atmospheric pressure (routine measurements at Cabauw)

Measurement details (sensors and elevation) are provided in Figure 13 and Table 12:

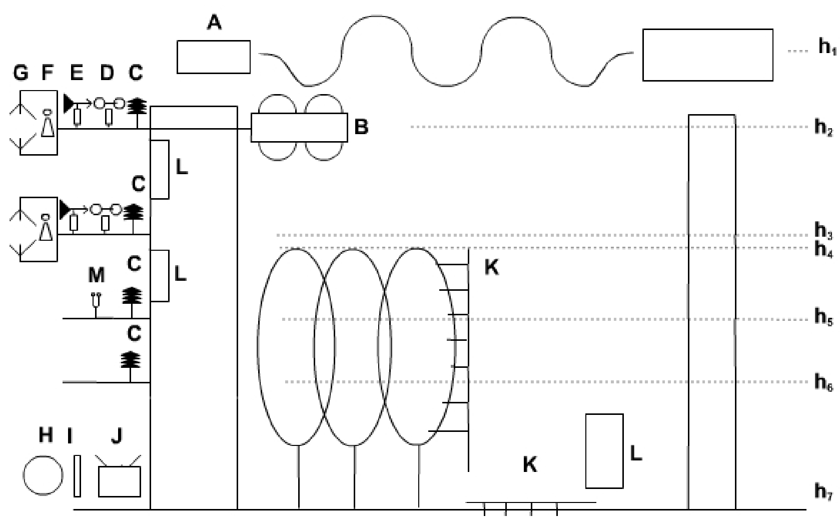


Figure 13. Setup of the instrumentation in the Speulderbos field site; Nomenclature of the symbols and heights used are provided in Table 12.

Table 12. Sensor installation heights at the Speulderbos site. Note [1]: 4 temperature probes means 2 pairs at 2 different depths. Note [2]: 22x canopy component, means 10 heights at both old and young leaves plus 2 soil temperatures.

Symbol	Description	Device name	#	Height
A	Scintillometer	LAS_1423	1	H_1
B	Net Radiation	CNR1	1	H_2
C	Humidity and Air Temperature	hmp45	4	H_2,H_3,H_5,H_6
D	Wind Anemometer	A100R	2	H_2, H_3
E	Wind Direction	W200p	2	H_2, H_3

F	CO_2 / H_2O	LICOR-7500	2	H_2, H_3
G	Sonic Anemometer	CSAT3	2	H_2, H_3
H	Soil Heat Flux	HFP01	4	H_7
I	Soil Temperature	107	4[1]	H_7
J	Rain gauge	52202	1	H_7
K	Canopy Component Temperature	NTC 833ET	22[2]	H_5-H_3
L	Loggers	C23X	2	--
		C5000	1	--
		Multiplexer	1	--
M	Pressure sensor		1	H_5
Symbol	Height/Depth	Explanation		
H_1	46m	Top of the Tower		
H_2	42m	10m over Top Canopy		
H_3	37m	05m over Top Canopy		
H_4	32m	Top Canopy		
H_5	22m	2/3 Top Canopy		
H_6	11m	1/3 Top Canopy		
H_7	0m till -0.5m	Depth of soil heat flux plates and temperature probes		

Furthermore a mobile LAS system will be employed for characterizing sensible heat flux exchange over several land cover units in the Speulderbos and Loobos test site areas during the entire campaign.

7 Ground hyperspectral, biophysical and soil moisture measurements

7.1 Sampling items

At each site detailed measurements will be conducted for hyperspectral, biophysical and soil moisture measurements, including

In-situ hyperspectra

- ASD hyperspectral measurements (different surface types and components of trees)
- BRDF of different tree canopies

Vegetation

- type
- height
- leaf dimensions
- azimuthal canopy distribution
- vertical density distribution
- LAI
- LIDF
- local and regional fractional coverage
- Biomass (parameters for allometric equations = DBH, total height, height to first branch for trees)
- Wet/Dry Biomass
- Plant water content
- Roughness

Soil

- Texture
- Bulk density
- Soil mositure
- Roughness

Water

- ASD hyperspectral measurements
- Total Suspended Matter,
- Water Surface Temperature
- Chlorophyll-a
- Transparency

LAI

1. Method 1
   - LAI-2000
2. Method 2
   - Hemispherical (Fish-eye lens) photographs
   - WinPhot 5.0 software (Ter Steege, 1996) used to estimate Leaf Area Index (http://www.bio.uu.nl/~herba/Guyana/winphot/wp_index.htm)

Roughness - Near Sensing Camera Field Equipment (NESCAFE)

This is a close range remote sensing technique for measurement of surface roughness - DEM's of ca. 10 x 10 m, with pixels of ca. 2 cm.

The needed equipments are fishing rod, camera, wider angle view lens, Controlling Cable (Draadontspanner), Plastic caps for setting GCPs, Water-leveling instrument (for measurements of GCPs) or DGPS.

Table 13. Camera specification

	Analog SLR+17mm
FOV horiz	93
Coverage with 4m alt: (m)	8.4*5.6
Resolution	5600*3600
Resolution in MP	20
Pixel size on ground (cm)	0.151
Processing costs	Film processing + scanning time
Equipment costs Euro:	700+700

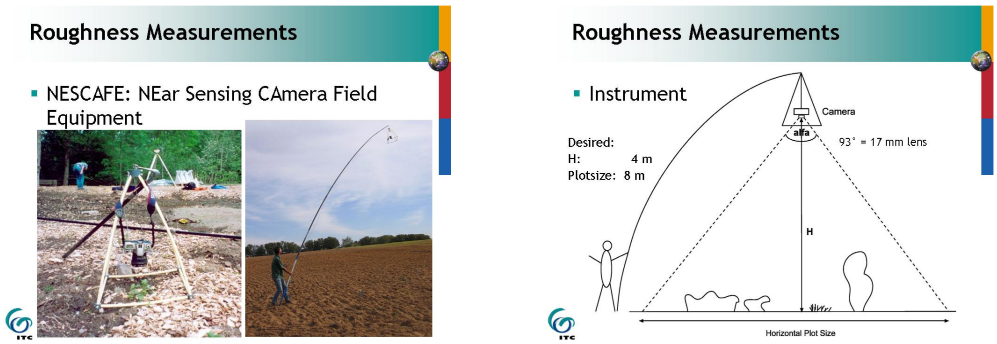
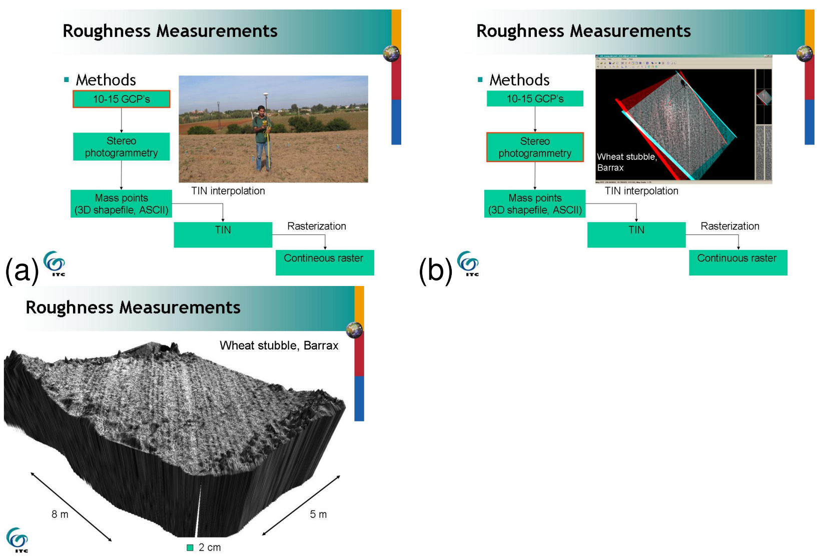


Figure 14. NESCAFE overview (left), and measurement principle (right)



(c)

Figure 15. Examples of NESCAFE derived roughness (a) reference DGPS points, (b) generation of target DEM, (c) final DEM and derived roughness

7.2 Measurements overview

Bio-physical Parameter	Method/instruments	Sampling	Derived values
In-situ hyperspectra			
Hyperspectra	ASD	Different surfaces, different components of trees	Individual spectra
Hyperspectra	ASD	Different surfaces, different components of	Individual spectra

		trees	
BRDF	ASD, Crane	Selected trees with accessible road conditions	BRDFs of canopies

Vegetation			
Type			Description per plot
Height	Ruler altimetry		average Average/st.dev.
leaf dimensions	Ruler		average
azimuthal canopy distribution	Hymispheric photograph		Average/st.dev.
vertical density distribution	Vertical laser scanning		Speulderbos RIVM tower
LAI	1. LAI 2000 Li-COR 2. hemispheric fisheye camera	10 measurements per field	Average/st.dev.
LIDF	3-D reconstruction of laser scanning		
local fractional coverage (density)	Counting the plants per m2 (maize)		
Regional fractional coverage		Derivative from high resolution images	
Biomass	(parameters for allometric equations = DBH, total height, height to first branch for trees)	TBD	Representative values (average)
Wet/Dry Biomass	Cutting 1 m2 (grass) gravimetric measurement before and after oven drying at 70 °C	10 sampling units per field/ 2 samples per sampling unit	Average/st.dev.
Plant water content	Derived from wet/dry biomass	As above	Average/st.dev.
Roughness (low vegetation)	NESCAFE technique		Average/st.dev.
Roughness (forest)	Altimetry (NESCAFE technique – local roughness)	Airborne coverage	Average/st.dev.

Soil			
Texture	Laboratory measurements (soil maps)	-42 soil rings - 2 shoves - 3 GPSs - flags for marking points of measurements - GPS Station	
Soil bulk density	Volumetric measurement using cylinder. 0-5cm sample, 0-10cm sample.	See above	Averages/st.dev. 0-5cm and 0-10cm
Gravimetric soil moisture	Gravimetric measurement 0-5cm sample, 0-10cm sample. Weighting before and after oven drying at 105ºC.	10 sampling units per field (or per moisture region as indicated on site)	Averages 0-5cm and 0-10cm for each sampling field
Volumetric soil moisture	1. Derivation from gravimetric soil moisture and bulk density. 0-5cm sample, 0-10cm sample. Oven drying at 105ºC.	As above	Averages 0-5cm and 0-10cm for each sampling field
Volumetric soil moisture	3 hydra probes 6 theta probes	As above	Averages 0-5 cm for each sampling field
Soil roughness	NESCAFE technique	10 measurements per field	Averages/st.dev. (RMS height/correlation length)

Water			
hyperspectra	ASD/GER spectroradiometers	Selected water bodies (cross sections)	
Total Suspended Matter	Lab analysis of water samples	Selected water bodies	
Water Surface Temperature	NTC/thermal couples	Selected water bodies	
Chlorophyll-a	Lab analysis of water samples	Selected water	

		bodies	
Transparency	Secci disk	Selected water bodies	

8 Existing meteorological measurements

In the study area, at both the grassland- (Cabauw) and forest-site (Loobos) existing stations are operationally monitoring numerous meteorological parameters, which will be made available to the participants for the duration of the campaign:

Cabauw, 51°58'00" North, 04°54'00" East
Loobos, 52°10'03" North, 05°44'38" East

The following measurements are available from each station.

Cabauw, tower data and surface flux data, observations every 10 minutes of:

Tower	*Parameter*	Surface	Parameter
	Clearsky shortwave downward radiation (model)		Available energy
	Short wave downward radiation at 1.5m		heat fluxes
	Short wave upward radiation at 1.5m		Co2 flux
	Long wave downward radiation at 1.5m		friction velocity
	Long wave upward radiation at 1.5m		Rotor
	Rain amount AWS		Inclino meters
	Rain duration AWS		Psychrometer
	Surface pressure AWS		Psychrometer difference
	Wind speed at 200 m selected and corrected		XLAS heat flux
	Wind speed at 140 m selected and corrected		Cn2 structure parameter
	Wind speed at 80 m selected and corrected		XLAS
	Wind speed at 40 m selected and corrected		XLASD
	Wind speed at 20 m selected and corrected		Soil temperature
	Wind speed at 10 m selected and corrected		Soil heat flux
	Wind direction at 200 m selected and corrected		Groundwater level
	Wind direction at 140 m selected and corrected		Heimann surface temperatures
	Wind direction at 80 m selected and corrected		Heimann sky temperatures
	Wind direction at 40 m selected and corrected		Heimann thermostat

	Wind direction at 20 m selected and corrected		Temperature fluxes
	Wind direction at 10 m selected and corrected		Humidity fluxes
	Temperature at 2 m		CO2 fluxes
	Dew point at 2 m		Momentum fluxes
	Potential temperature at 200 m reduced to surface pres.		Licor IFM flux comparison
	Potential temperature at 140 m reduced to surface pres.		Licor H2O
	Potential temperature at 080 m reduced to surface pres.		
	Potential temperature at 040 m reduced to surface pres.		
	Potential temperature at 020 m reduced to surface pres.		
	Potential temperature at 010 m reduced to surface pres.		
	Potential temperature at 002 m reduced to surface pres.		
	Dew point at 200 m		
	Dew point at 140 m		
	Dew point at 80 m		
	Dew point at 40 m		
	Dew point at 20 m		
	Dew point at 10 m		
	Dew point at 2 m		
	Temperature at 200 m		
	Dew point at 200 m		

Loobos, observations of:

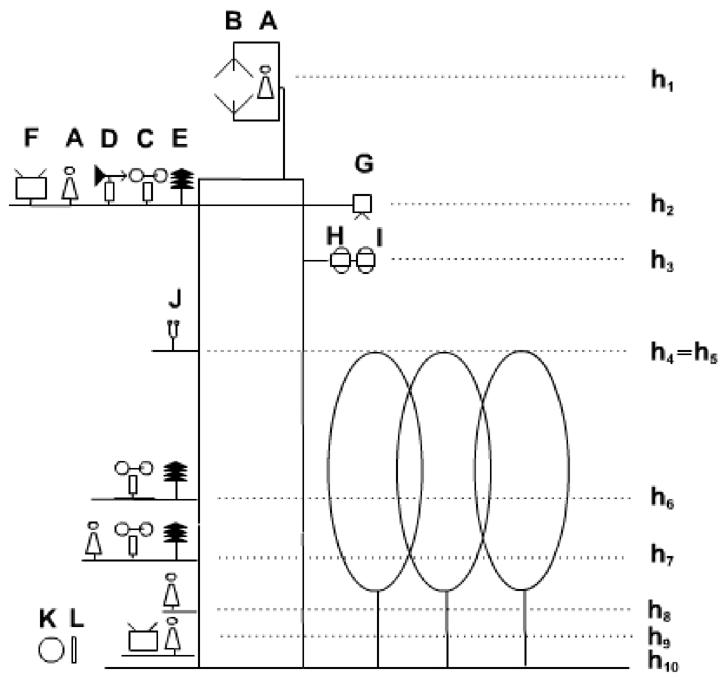


Figure 14. Setup of the instrumentation at the Loobos site; Nomenclature of the symbols and heights used are provided in the Table below.

	Parameter	*#*	*Height meter a.g.l*	*Instrument*
B	Turbulence components	1	26.0	Windmaster
A	Virtual temperature	1	26.0	Windmaster
B	CO2/Specific humidity fluctuations	1	26.0	LI-7500
H	Incoming/outgoing short wave radiation	1	21.9	CM21
I	Incoming/outgoing long wave radiation	1	21.9	CG1
I	Temperature long wave radiation sensors	1	21.9	PT100
G	Photosynthetically active radiation	1	24.5	LI-190SZ
E	Air temperature	3	23.5, 7.5, 5.0	HMP35A
J	Air pressure	1	15.0	PTB101C
E	Relative humidity	3	23.5, 7.5, 5.0	HMP35A
C	Wind speed	3	24.4, 7.5, 5.0	A101ML
D	Wind direction	1	24.0	W200P
A	CO2/H2O-concentration	5	24.4, 7.5, 5.0, 2.5, 0.4	CIRAS-SC
F	Precipitation	2	23.8 (tower), 0.4 (open field)	ARG100
F	Throughfall	1	1.0	IMAG
K	Soil heat flux	1	-0.1	PU43T

L	Soil moisture/ temperature	5	-0.03, -0.10, -0.25, -0.75, -2.00	Mux
-	Groundwater level (filter depth)	2	-6.5, -4.8	-

9 Overview airborne and spaceborne measurements during EAGLE 2006

Activities over the Cabauw (C), Loobos (L) and Speulderbos (S) sites are as follows*:

Date	Sensor	Time (UTC)		Site
		Start	End	
Thursday 08-Jun-'06	CHRIS-PROBA			
	MERIS	10:15:30	10:17:11	C, L, S
	MODIS			
	AATSR	10:15:43	10:16:58	C, L, S
	AHS			
Friday 09-Jun-'06	CHRIS-PROBA			
	MODIS			
	AATSR	21:07:22	21:08:37	C, L, S
	ASAR			
	AHS			
Saturday 10-Jun-'06	CHRIS-PROBA			
	MERIS	10:52:22	10:54:03	C, L, S
	MODIS			
	AHS			
Sunday 11-Jun-'06	CHRIS-PROBA			
	MERIS	10:21:11	10:22:52	C, L, S
	MODIS			
	AATSR	10:21:24	10:22:39	C, L, S
	AHS			
Monday 12-Jun-'06	CHRIS-PROBA			
	ASAR			
	MODIS			
	AHS			
Tuesday 13-Jun-'06	CHRIS-PROBA			
	MODIS			
	AATSR	20:41:49	20:43:04	C, L, S

	AHS			
Wednesday 14-Jun-'06	CHRIS-PROBA			
	MERIS	10:26:52	10:28:33	C, L, S
	MODIS			
	AATSR	10:27:05	10:28:20	C, L, S
	AHS			
Thursday 15-Jun-'06	CHRIS-PROBA	10:59:00		C
	MERIS	09:55:34	09:57:15	C, L, S
	MODIS			
	ASAR			
	ASTER	10:50:00	10:50:30	C, L, S
	AHS			
Friday 16-Jun-'06	CHRIS-PROBA			
	MODIS			
	AATSR	20:47:29	20:48:44	C, L, S
	AHS			
Saturday 17-Jun-'06	CHRIS-PROBA			
	MERIS	10:32:32	10:34:13	C, L, S
	MODIS			
	AATSR	10:32:45	10:34:00	C, L, S
	AHS			
Sunday 18-Jun-'06	CHRIS-PROBA			
	MERIS	10:01:16	10:02:57	C, L, S
	MODIS			
	ASAR			
	AHS			

* Please note that SEVIRI scans are made of the entire area every 15 minutes.

10 Overview ground measurements during EAGLE 2006

Activities at the Cabauw (C), Loobos (L) and Speulderbos (S) sites are as follows*:

Date	Institute	Activity	Time (UTC)	Site
Thursday 08-Jun-'06	WUR-Meteo	LAS	Continuous	S
	ITC	EC & Meteo +	Continuous	S
	UV	BTT	Continuous	-
	ITC	Gonio & Comp.Temp.	-	C
	ITC & UV	LAS-mobile & Emissivity	-	-
Friday 09-Jun-'06	WUR-Meteo	LAS	Continuous	S
	ITC	EC & Meteo +	Continuous	S
	UV	BTT	Continuous	-
	ITC	Gonio & Comp.Temp.	-	C
	ITC & UV	LAS-mobile & Emissivity	-	-
Saturday 10-Jun-'06	WUR-Meteo	LAS	Continuous	S
	ITC	EC & Meteo +	Continuous	S
	UV	BTT	Continuous	-
	ITC	Gonio & Comp.Temp.	-	C
	ITC & UV	LAS-mobile & Emissivity	-	-
Sunday 11-Jun-'06	WUR-Meteo	LAS	Continuous	S
	ITC	EC & Meteo +	Continuous	S
	UV	BTT	Continuous	-
	ITC	Gonio & Comp.Temp.	-	C
	ITC & UV	LAS-mobile & Emissivity	-	-
Monday 12-Jun-'06	WUR-Meteo	LAS	Continuous	S
	ITC	EC & Meteo +	Continuous	S
	UV	BTT	Continuous	-
	ITC	Gonio & Comp.Temp.	-	C

	ITC & UV	LAS-mobile & Emissivity	-	-
Tuesday 13-Jun-'06	WUR-Meteo	LAS	Continuous	S
	ITC	EC & Meteo +	Continuous	S
	UV	BTT	Continuous	-
	ITC	Gonio & Comp.Temp.	-	C
	ITC & UV	LAS-mobile & Emissivity	-	-
Wednesday 14-Jun-'06	WUR-Meteo	LAS	Continuous	S
	ITC	EC & Meteo +	Continuous	S
	UV	BTT	Continuous	-
	ITC	Gonio & Comp.Temp.	-	C
	ITC & UV	LAS-mobile & Emissivity	-	-
Thursday 15-Jun-'06	WUR-Meteo	LAS	Continuous	S
	ITC	EC & Meteo +	Continuous	S
	UV	BTT	Continuous	-
	ITC	Gonio & Comp.Temp.	-	C
	ITC & UV	LAS-mobile & Emissivity	-	-
	UV	CIMEL-ASTER	11:50:00	-
Friday 16-Jun-'06	WUR-Meteo	LAS	Continuous	S
	ITC	EC & Meteo +	Continuous	S
	UV	BTT	Continuous	-
	ITC	Gonio & Comp.Temp.	-	C
	ITC & UV	LAS-mobile & Emissivity	-	-
Saturday 17-Jun-'06	WUR-Meteo	LAS	Continuous	S
	ITC	EC & Meteo +	Continuous	S
	UV	BTT	Continuous	-
	ITC	Gonio & Comp.Temp.	-	C
	ITC & UV	LAS-mobile & Emissivity	-	-
Sunday 18-	WUR-Meteo	LAS	Continuous	S

Jun-'06	ITC	EC & Meteo +	Continuous	S
	UV	BTT	Continuous	-
	ITC	Gonio & Comp.Temp.	-	C
	ITC & UV	LAS-mobile & Emissivity	-	-

* Please note that – indicates that timing or site is flexible and BTT represents Brightness Temperature Transect measurement.

11 Data delivery and management

(Data base management - Remco Dost)
(Coordination airborne data - Wim Timmermans)

Each ground team is responsible for timely processing of in-situ measurements in accordance with the following schedule.

- quick products (raw data and documentation, Level 1A), immediately after each measurement data or period;
- processed data (corrected and calibrated measurements – Level 1B); TBD according to processing requests but before progress meeting;
- derived geophysical parameters (Level 2), before final EAGLE2006 meeting.

10.1 Campaign Documents and Information

An ftp server has been established to provide the latest documents and information about the campaign.

Server details are:
ftp.itc.nl
Login name: ftpguest
Password: ftp4you

10.2 Data Distribution

Mechanisms for the distribution of image and ground data are currently under review, with details to be provided in the next update of the campaign plan.

12 Flight Operations

12.1 Airports

12.2 Air traffic control (ATC) and Flight Restrictions

12.3 Arrangements for Special Permission to be Obtained for INTA aircraft

12.4 Weather Forecast Arrangements

12.5 Briefing Procedure and Communication with Field Teams

12.6 Communication with Field Teams

The result of the daily briefings will be passed on to the involved teams by ITC.

12.7 Contact Details

For flight facilities please contact: See paragraph 11.

13 Accommodation at EAGLE 2006

Several accommodation possibilities exist in the study area, most of them in the Eastern (forest) part, due to high tourist activity. Due to major uncertainties in the planning of the campaign, so far no final bookings have been made. However to ensure some back-up accommodation (high tourist activity in this season) one reservation is made for the entire period (8^{th} of June until 2^{nd} of July) for a 4-person chalet (max number of persons is 6) at:

Landgoed Kerkendel
Kerkendelweg 49
3775 KM, Kootwijk
Tel: +31-(0)577-456224 (Willeke Jansen)
Email: kerkendel@kerkendel.nl
Web-page: http://www.kerkendel.nl/

At this site also a garage is at our disposal where sheltered (electronic) assembling can take place and power is available.

Basic hotel rooms are available at:

Hotel 't Hilletje
De Brink 5
3775 KP, Kootwijk
Tel: +31-(0)577-456581
Prices: 30 € p.p. incl. Breakfast, Double room.
Facilities: Shared shower and toilet, TV.

Hotel-Café-Restaurant Hoog Soeren
Hoog Soeren 15
7346 AB Hoog Soeren
Tel.: +31-(0)55 5191231/ Fax : +31-(0)55 5191450
E-mail: Hoog-Soeren@hetnet.nl
Web-page: http://www.hotelhoogsoeren.nl/
Prices: 40 € p.p. incl. Breakfast, Double room
Facilities: Bathroom, shower, toilet, TV.

More comfortable rooms at:

Bilderberg Hotel 't Speulderbos ****
Speulderbosweg 54
3886 AP, Garderen
Tel.: +31-(0)577-46.15.46 / Fax.: +31-(0)577-46.11.24
E-mail: midden-veluwe.reservation@bilderberg.nl
Web-page: http://www.bilderberg.nl/speulderbos/
Prices: 140 € p.p. incl. Buffet breakfast, Single room
Facilities: Basically: all…

References.

Ulden A. P. V. & Wieringa J. (1996) Atmospheric boundary layer research at Cabauw. *Boundary-Layer Meteorology* 78, 39-69.