Instrument Data quality Evaluation and Analysis Service (IDEAS)

Field Campaign Report Speulderbos Cal/Val Site

Project Reference	Sensor Performance, Product and Algorithms: Maintenance and Operations of the Earth Observation Payload Data System (IDEAS)
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Contents

List of Abbreviations

DHP .... Digital Hemispherical Photography

IML .... In-situ Monitoring Lidar

L7 .... Landsat 7

L8 .... Landsat 8

LAI .... Leaf Area Index

PAI .... Plant Area Index

TLS .... Terrestrial Laser Scanner

S2 .... Sentinel-2

UAV .... Unmanned Aerial Vehicle

1. Introduction

1.1. Purpose of the Document

This document describes the field campaign in Speulderbos forest (The Netherlands), including instrumentation, sampling design, and achieved temporal data coverage and quality.

1.2. Background

The purpose of the field campaign was to collect a data set of forest structural variables during the leaf senescence phase in autumn 2015. Sampling this time period allows to capture the widest possible range of forest foliage coverage conditions for the given forest.

2. Site Description

The campaign was conducted in the Speulderbos forest in the province of Gelderland, Netherlands, close to the city of Garderen (N 52° 15”, E 5° 42”). The focus area in this campaign is a stand dominated by European Beech (*Fagus sylvatica*) with occasional Pedunculate oak (*Quercus robur*), Sessile oak (*Quercus petraea*) and few European Holly (*Ilex aquifolium*) in the understorey. Japanese Larch (*Larix kaempferi*) makes up an enclosed parcel within the Beech-Oak dominated areas.

According to the Dutch National Forest Service (Staadsbosbeheer) the stand dates back to 1835 and is therefore one of the oldest beech forest stands in the Netherlands. This shows in the general appearance of the stand with its cleared understorey due to the suppression of the beech. Speulderbos is part of the global ForestGEO network of large-scale forest-dynamics plots (http://www.ctfs.si.edu/site/Speulderbos). Principal investigators are Dr. Jan den Ouden (Jan.denouden@wur.nl) and Dr. Patrick Jansen (Patrick.Jansen@wur.nl).

The choice of Speulderbos as the site for this campaign had several advantages: first, the area provided a relatively large homogenous forest coverage. Second, it was easily accessible by car for repeated measurements. Third, in an earlier campaign the stand has been equipped with wooden poles that have been geolocated with land surveying techniques with centimetre accuracy (Figure 1). This makes it easier to co-reference ground, air- and space-borne observations.

Additionally, a scaffold tower equipped to measure CO_2 eddy covariance and other meteorological variables is situated in a Douglas fir (*Pseudotsuga menziesii*) stand ca. 500 m west of the focus area of this campaign (Figure 1, Weligepolage, Gieske, & Su (2013)). This was used to mount the above canopy reference devices of the PASTIS sensors (Section 3).

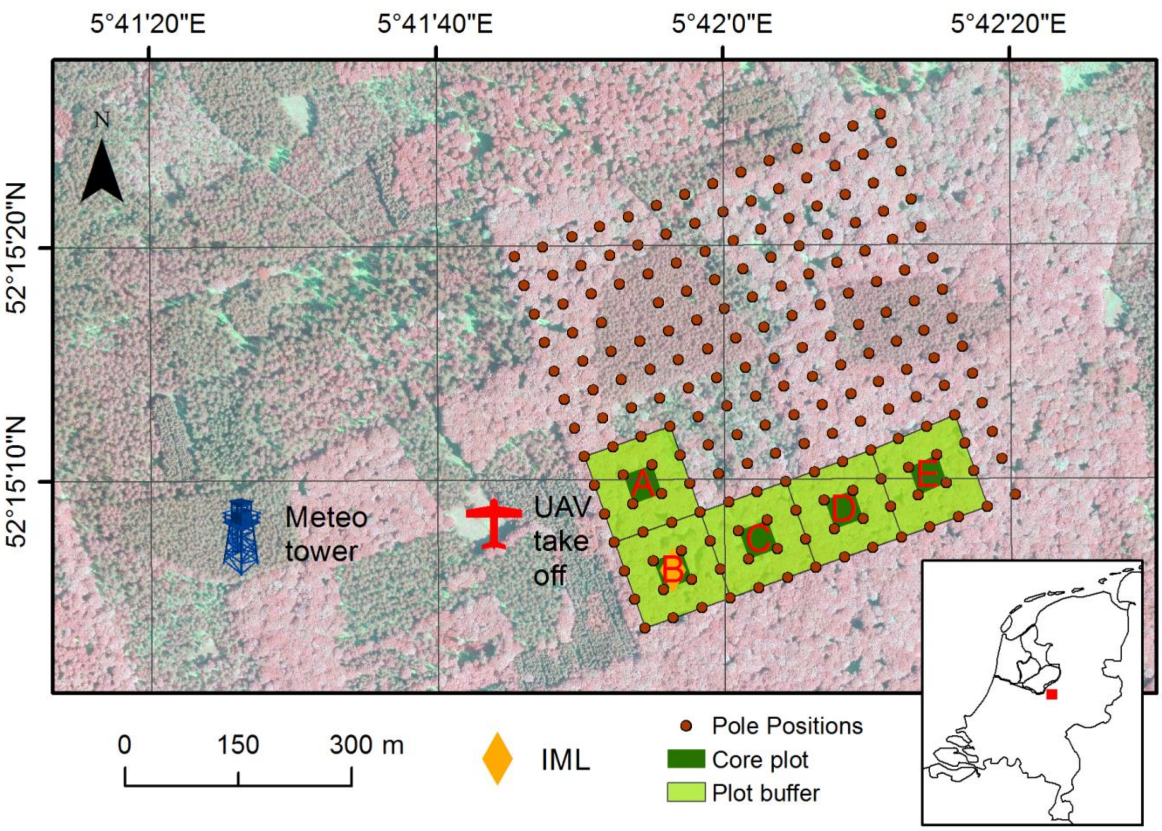

Figure 1: Speulderbos site map (background from airborne surveying 2013)

3. Instrumentation and Sampling Design

This campaign made use of a palette of ground-based, air- and space borne instruments. A common nomenclature was used for the ground instruments to describe their location within the single plots A to E (Figure 2). Only in plot D a fallen tree with its branches prevented the establishment of the location d3. This sampling grid was nested into the larger grid of geolocated wooden poles (Figure 1), so that the four corner locations (a1, a3, a7, a9) represent pole locations, and a1 the SW, a3 the SE, a7 the NW and a9 the NE directed pole in each plot.

Digital Hemispherical Photographs (**DHP**) were acquired with a Nikon D7000 digital camera with a Sigma 4.5 mm F2.8 lens fisheye lens. Images were taken at all plot locations within the plots and at low sun angles, mostly during dawn, to avoid 'burning out' of canopy edges. The camera was mounted on a tripod and levelled with a bubble level attached to the camera flash socket. The lens was fixed to 1.30 m above ground. The images were recorded in the camera specific raw format with 14 bit image depth to preserve the sensor's maximum dynamic range.

Terrestrial laser scans (**TLS**) were acquired with a Riegl VZ-400 laser scanner (www.wageningenur.nl/lidar) at locations a5 and b1 to b4 according to the set up described in Calders et al. (2015). The plots were equipped with cylindrical reflectors to allow linking scans from all five positions in a plot together. Data takes with these two manual ground based systems (DHP and TLS) were conducted on a weekly basis while avoiding unfavourable weather conditions for TLS (rain, strong wind). The takes started in October and lasted until the third week of November.

The In-situ Monitoring Lidar (**IML**) system VEGNET (Culvenor, Newnham, Mellor, Sims, & Haywood, 2014) was placed on a tripod in the centre of plot B next to location a5 and connected to a 80 W solar panel to recharge the internal batteries. The prism at the sensor head was fixed at 1.45 m above ground. The instrument was surrounded with a mesh wire fence to protect it against wild boars. It was programmed to take one measurement per night.

In total 12 Autonomous light sensors for PAI continuous monitoring (**PASTIS**, Lecerf et al. (2010)) were placed in plot A, B and C: in plot A and B at all four c locations and in plot C at c2, c3, and c4. They were mounted on iron poles so that the sensors were at 1.30 m above ground. The six single sensors of each instrument were pointing to NW, NE, E, W, SW and SE. The PASTIS 57 were programmed to make one measurement each 2 min. Two reference instruments, which were of identical design as the below canopy instruments, were attached on top of the scaffold tower to measure above canopy incoming pseudo-radiance.

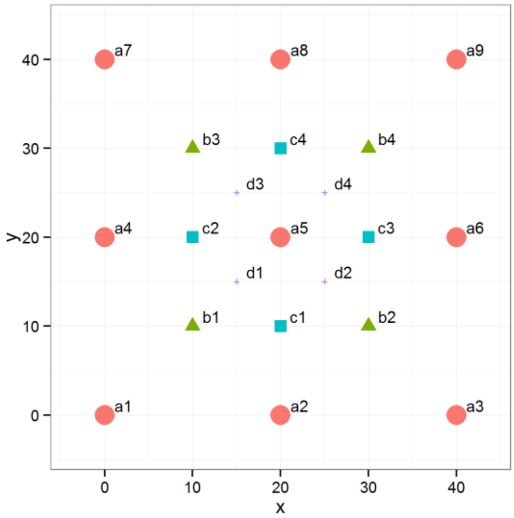

Figure 2: Sampling design nomenclature (axes in m)

For acquisition of airborne super-spectral images the Unmanned Aerial Vehicle (**UAV**) Altura PRO AT8 multicopter (www.wageningenur.nl/uarsf) equipped with a Rikola Hyperspectral Camera (Rikola Ltd., Oulu, Finland) was aimed to be flown weekly. The Rikola spectral bands were adjusted to simulate Sentinel-2 VIS/NIR bands 1 to 9. The UAV was flown at an approximate height of 100 m above ground in three flight lines covering plot A and B.

Satellite overpasses for monitoring missions have been calculated based on initial known overpasses and the revisit time of 16 days (**Landsat**) and 10 days (**Sentinel-2**). Figure 3 gives an overview of the overpass times, which are potential observations depending on cloudiness on the particular dates.

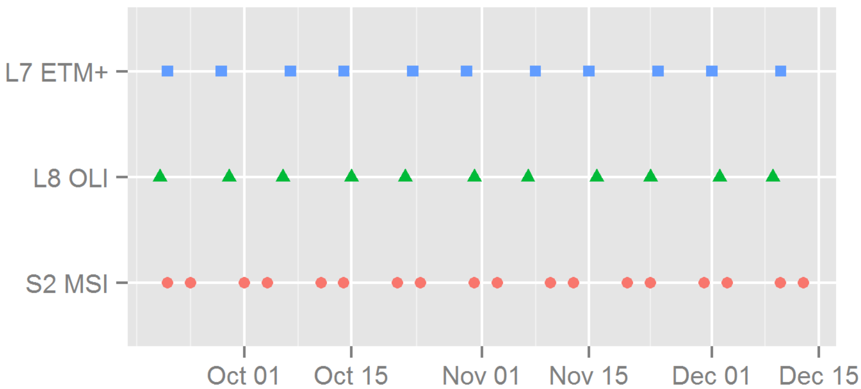

Figure 3: Satellite overpass schedule for Speulderbos

4. Acquired Data and Quality

Actual success in data acquisition was mostly influenced by weather conditions. This was especially true for the UAV, which cannot operate at wind speeds > 5 m/s. Additionally, scattered clouds strongly impact the quality of the resulting images. In case of the TLS and IML wind and rain do not hamper the acquisition itself, but reduce the data quality. The PASTIS is very robust in respect to acquisition conditions, but their influence on the data quality has not been systematically assessed yet. Figure 4 displays the time line of successful ground and airborne data takes.

The UAV was actually flown 6 times in total. However, image data from 2 flights was corrupted due to an internal error in the camera, which is known to the camera manufacturer. The camera will be send for maintenance to update the camera firmware and prevent these cases in the future. The IML experienced problems during acquisition which were most likely caused by condensation at the bottom surface of the prism in the sensor head. This results in unusable data for the time of the campaign.

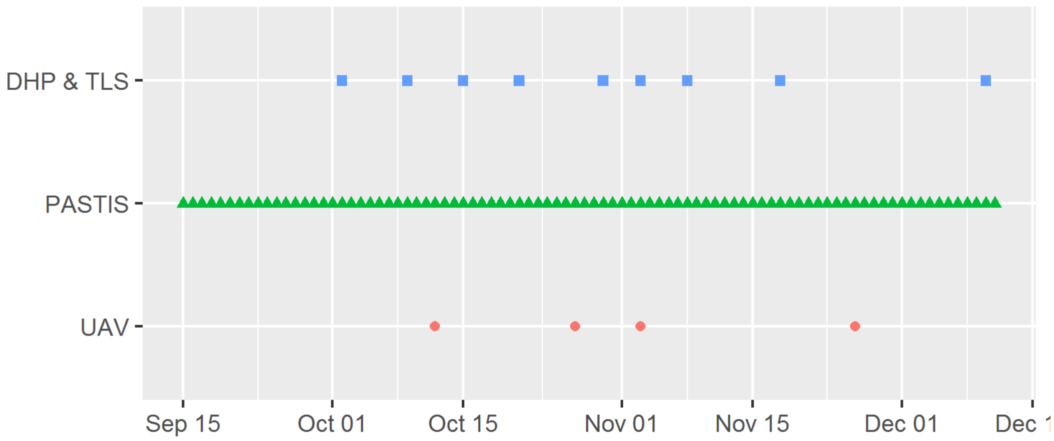

Figure 4: Successful ground and airborne data takes

Also Landsat and Sentinel-2 observations were influenced by weather conditions, especially cloud cover. A preliminary inspection of quicklook images on the USGS Earth Explorer (http://earthexplorer.usgs.gov) for Speulderbos revealed that most of the potential observations are most probably affected by clouds (Figure 5). A similar assessment for Sentinel-2 scenes on the Sentinel Scientific Data Hub (https://scihub.copernicus.eu) resulted showed no better results. However, the Sentinel Hub did not contain all acquired scenes at the moment of inspection. Only products sensed after November 28, 2015 were available. Products prior to that date will be processed in the future.

Apart from these restrictions, Landsat 8 Thermal Infrared Sensor (TIRS) showed anomalous behaviour on November 1, 2015 (http://landsat.usgs.gov/mission_headlines2015.php). This does not affect OLI data, but standardized processing to bottom of atmosphere (BOA) reflectance factors of scenes acquired thereafter, which includes cloud detection based on the thermal infrared information, is suspended until at least February 2016. A possible way to derive BOA reflectance factors will be empirical line correction with quasi-stable landmarks like inland dunes and concreted areas.

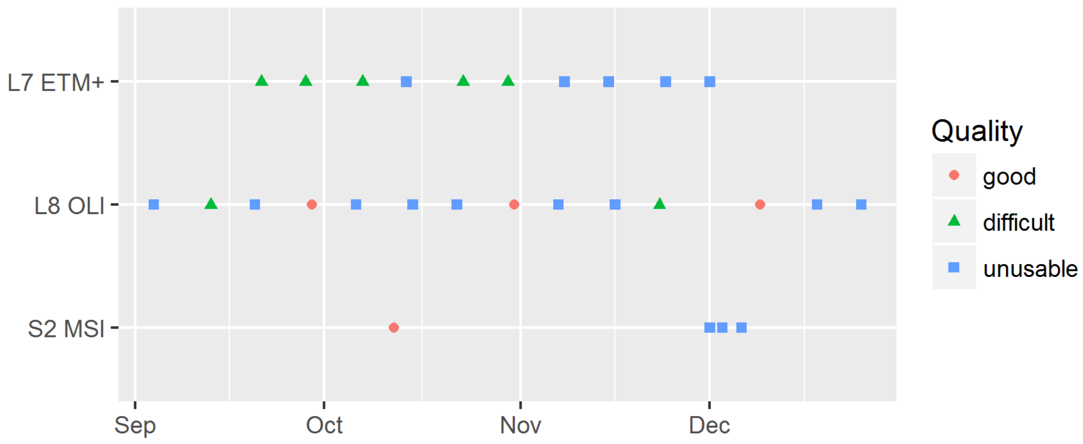

Figure 5: Estimated cloud situation over Speulderbos during satellite acquisitions

5. Conclusions

With the 2015 Speulderbos autumn field campaign a data set based on diverse ground- and airborne sensors has been collected. Some instruments (TLS, PASTIS57) proved very robust, while others suffered from environmental conditions (VEGNET, Landsat). Especially frequent cloud cover in November over the Netherlands challenges the capabilities of satellite sensors operating in VIS/NIR to monitor autumn leaf senescence. The UAV based monitoring approach allowed flexible field visits to avoid unfavourable cloud conditions.

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