Experiment Plan
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Content

1 Overview and Objectives

The Soil Moisture Active Passive Experiment 2 (SMAPEx-2) is the second of a series of field experiments conducted in the Yanco study area (NSW) which started with SMAPEx-1 on 5-10 July, 2010. SMAPEx will comprise of four campaigns across a one year timeframe. This document outlines the airborne and related ground monitoring during the second campaign (SMAPEx-2), which will be conducted between 4-8 December, 2010.

The objective of this project is to develop algorithms and techniques to estimate near-surface soil moisture from the future Soil Moisture Active Passive (SMAP) mission from the National Aeronautics and Space Administration (NASA). This will involve collecting airborne prototype SMAP data together with ground observations of soil moisture and ancillary data during four Soil Moisture Active Passive Experiments (SMAPEx).

Although plans for SMAP-dedicated airborne campaigns are undergoing at NASA, the SMAPEx campaigns are the first such campaigns worldwide specifically addressing SMAP scientific requirements. Therefore SMAPEx represent a significant contribution to the limited heritage of airborne experiments which included both active and passive observations, essentially the passive/active L-band/S-band sensor (PALS) flights undertaken as part of the Southern Great Plains experiment in 1999 (SGP99), the Soil Moisture Experiment in 2002 (SMEX02) and the recent cloud and land surface interaction campaign (CLASIC) conducted in Oklahoma in 2007 (http://hydrolab.arsusda.gov).

The SMAPEx campaigns have been made possible through infrastructure (LE0453434, LE0882509) and research (DP0984586) funding from the Australian Research Council. Initial campaigns, setup, and maintenance of the study catchment were funded by research grants (DP0343778 and DP0557543) from the Australian Research Council, and the CRC for Catchment Hydrology. SMAPEx also relies upon the collaboration of a large number of scientists from throughout Australia and around the world, and in particular of key personnel from the SMAP team which provided significant contribution to the campaign's design.

1.1 Overview

Accurate knowledge of spatial and temporal variation in soil moisture at high resolution is critical for achieving sustainable land and water management, and for improved climate change prediction and flood forecasting. Such data are essential for efficient irrigation scheduling and cropping practices, accurate initialisation of climate prediction models, and setting the correct antecedent moisture conditions in flood forecasting models. The fundamental limitation is that spatial and temporal variation in soil moisture is not well known or easy to measure, particularly at high resolution over large areas. Remote sensing provides an ideal tool to map soil moisture globally and with high temporal frequency. Over the past two decades there have been numerous ground, air- and space-borne near-surface soil moisture (top 5cm) remote sensing studies, using thermal infrared (surface temperature) and microwave (passive and active) electromagnetic radiation. Of these, microwave is the most promising approach due to its all weather capability and direct relationship with soil moisture through the soil dielectric constant. Whilst active (radar) microwave sensing at L-band (~1.4GHz) has shown some positive results, passive (radiometer) microwave measurements at L-band are least affected by land surface roughness and vegetation cover. Consequently ESA will launch the Soil Moisture and Ocean Salinity (SMOS) satellite in October this year, being the first-ever dedicated soil moisture mission that is based on L-band passive microwave radiometry. However, space-borne passive microwave data at L-band suffers from being a low resolution measurement, on the order of 40km. While this spatial resolution is appropriate for some broad scale applications, it is not useful for small scale applications such as on-farm water management, flood prediction, or meso-scale climate and weather prediction. Thus methods need to be developed for reducing these large scale measurements to smaller scale.

To address the requirement for higher resolution soil moisture data, NASA has proposed the Soil Moisture Active Passive (SMAP) mission. SMAP will carry an innovative active and passive microwave sensing system, including an L-band radar and L-band radiometer, The basis for SMAP is that the high resolution (3km) but noisy soil moisture data from the radar and the more accurate but low resolution (40km) soil moisture data from the radiometer will be used synergistically to produce a high accuracy and improved spatial resolution (10km) soil moisture product with high temporal frequency. The SMAP sensing configuration will overcome the limitations due to coarse spatial resolution currently affecting pure passive microwave platforms such as the Soil Moisture and Ocean Salinity (SMOS) and the Advanced Microwave Scanning Radiometer (AMSR-E), as well as the limitations due to low signal-to-noise ratio of pure active system such as the Advanced Synthetic Aperture Radar (ASAR) and the Phased Array type L-band Synthetic Aperture Radar (PALSAR).

In preparation for SMAP launch (currently planned for 2014), suitable algorithms and techniques need to be developed and validated to ensure that an accurate, high resolution soil moisture product from SMAP radar and radiometer data can be produced. To this end, it is essential that field campaigns with coordinated satellite, airborne and ground-based data collection be undertaken, giving careful consideration to the diverse data requirements for the range of scientific questions to be addressed. The SMAPEx campaigns described in this document have been specifically designed to address these scientific requirements. SMAPEx stem from the availability of a new airborne remote sensing capability which allows us to have the only sensor combination world-wide able to undertake high resolution active and passive microwave remote sensing at L-band with resolution ratios, incidence angles and polarisations replicate to those expected from SMAP. The facility includes the Polarimetric L-band Multibeam Radiometer (PLMR) and the Polarimetric L-band Imaging Scatterometer (PLIS) which, when used together on the same aircraft allow simulation of the SMAP data with passive microwave footprints at 1km and active microwave footprints at 10m resolution when flown at a flying height of 3000m. All other existing active-passive capabilities currently provide only active-passive data for the same footprint resolution.

1.2 Objectives

The main objective of SMAPEx-2 is to collect airborne active and passive microwave data which are scaled replicate of the data which will be collected by SMAP, supported by ground observations of soil moisture and ancillary data needed for development and validation of algorithms to estimate soil moisture from future SMAP data. Algorithms for soil moisture retrieval from passive microwave observations (radiometer brightness temperatures) are fairly mature for bare and vegetated surfaces. However, some open questions still remain on suitable methods to estimate the contribution of Vegetation Water Content (VWC) and surface roughness to the microwave signal. Moreover, ways of mitigating the impact of land surface heterogeneity within the SMAP radiometer pixel (40km) on the soil moisture retrieval accuracy from passive microwave data needs to be developed. Conversely, soil moisture retrievals from active microwave observations (radar backscatter coefficients), which are influenced to a greater extent by vegetation scattering, have been so far limited to predominantly bare soil conditions or vegetation cover with VWC less than about 0.5–1kg/m^2. Several theoretical models have been proposed to model the vegetation effects for more severe vegetation conditions. However, such formulations are still to be properly incorporated in soil moisture retrieval algorithms and require extensive testing with field data.

Lastly, techniques to efficiently merge active and passive microwave observations having different resolutions to obtain accurate soil moisture information at 10km resolution need to be developed and tested.

Specifically the SMAPEx-2 data set will aim at:

1. Testing of existing soil moisture retrieval algorithms for bare and vegetated surfaces from radar backscatter coefficients;

2. Development and testing of techniques to improve the soil moisture retrieval from the radiometer brightness temperatures using information on the surface conditions (VWC and surface roughness) extracted from the radar backscatter coefficients; and

3. Development and testing of techniques to downscale the coarse-resolution soil moisture retrieval from the radiometer brightness temperatures using the fine-resolution radar backscatter coefficients.

1.3 General Approach

SMAPEx will comprise four, one-week long airborne campaigns in the Yanco study area within the Murrumbidgee catchment (see Figure 1-1), in south-eastern Australia. The first campaign (SMAPEx-1), was conducted in the austral winter between 5-10 July, 2010. The second campaign, described in this document, will take place in the austral summer between 4-8 December, 2010. The four campaigns are planned to span across a one year timeframe (one within each season), to encompass seasonal variation in soil moisture condition as well as vegetation growth stage. Moreover, a one-week time window was selected to widen the range of soil wetness conditions encountered through capturing wetting or drying cycles associated to rainfall events.

The primary aircraft instruments will be the Polarimetric L-band Multibeam Radiometer (PLMR), used in across-track configuration (pushbroom) to map the surface with three

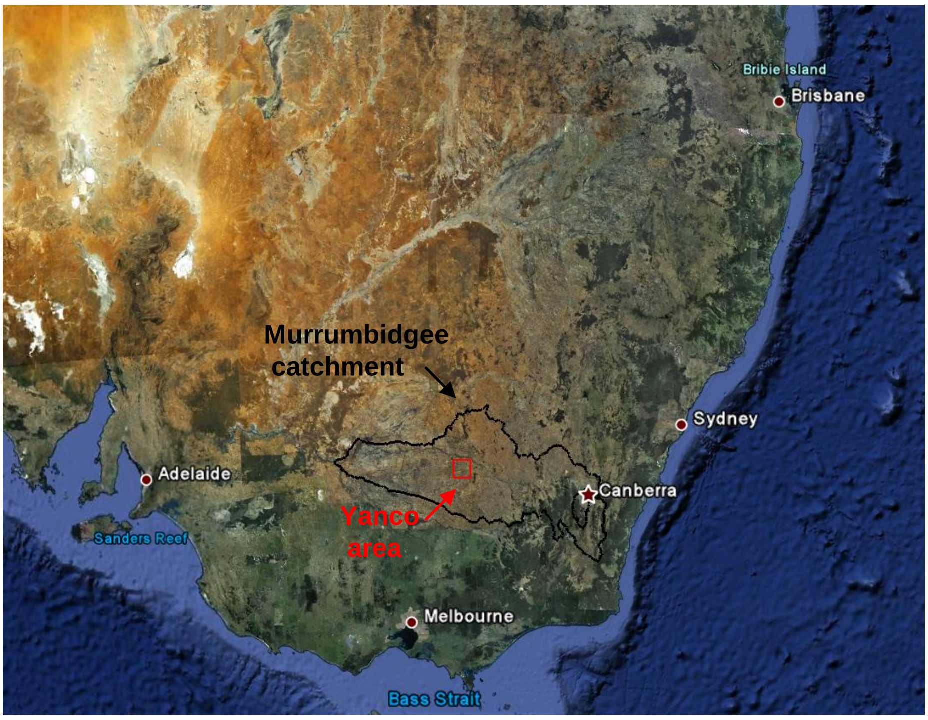


Figure 1-1. Location of the SMAPEx study area within the Murrumbidgee catchment.

viewing angles (±7°, ±21.5° and ±38.5°) to each side of the flight direction, achieving a swath width of about 6 km, and the Polarimetric L-band Imaging Scatterometer (PLIS), with two antennas used to measure the surface backscatter to each side of the flight direction between 15° and 45° angle. The flight lines have been designed so that full PLMR and PLIS coverage of the study area is guaranteed. All flights will be operated out of the Narrandera airport, while the ground crew will be accommodated at the Yanco Agricultural Institute and will drive daily to the ground sampling areas (see Figure 1-2).

Data collected in each campaign will consist of:

(i.) airborne L-band active and passive microwave observations, together with ancillary visible, thermal infrared, infrared, near-infrared and shortwave infrared;

(ii.) continuous near-surface (top 5cm) soil moisture and soil temperature monitoring at 29 permanent stations across the study area. Of these stations, 5 will also provide profile (0-100cm) soil moisture and soil temperature data; and

(iii.) additional intensive measurements of near-surface (top 5cm) soil moisture spatial distribution, vegetation biomass, water content and reflectances and surface roughness across 6, 2.8km x 3.1km focus areas.

The airborne and ground monitoring strategy will follow a "nested grids" approach based on the future SMAP grids (see Figure 1-2). Airborne data will be collected on alternate days over an area equivalent to a future SMAP radiometer pixel (SMAP L1C_TB product, 40km x 40km nominal resolution) and two sub-areas equivalent to a SMAP downscaled soil moisture

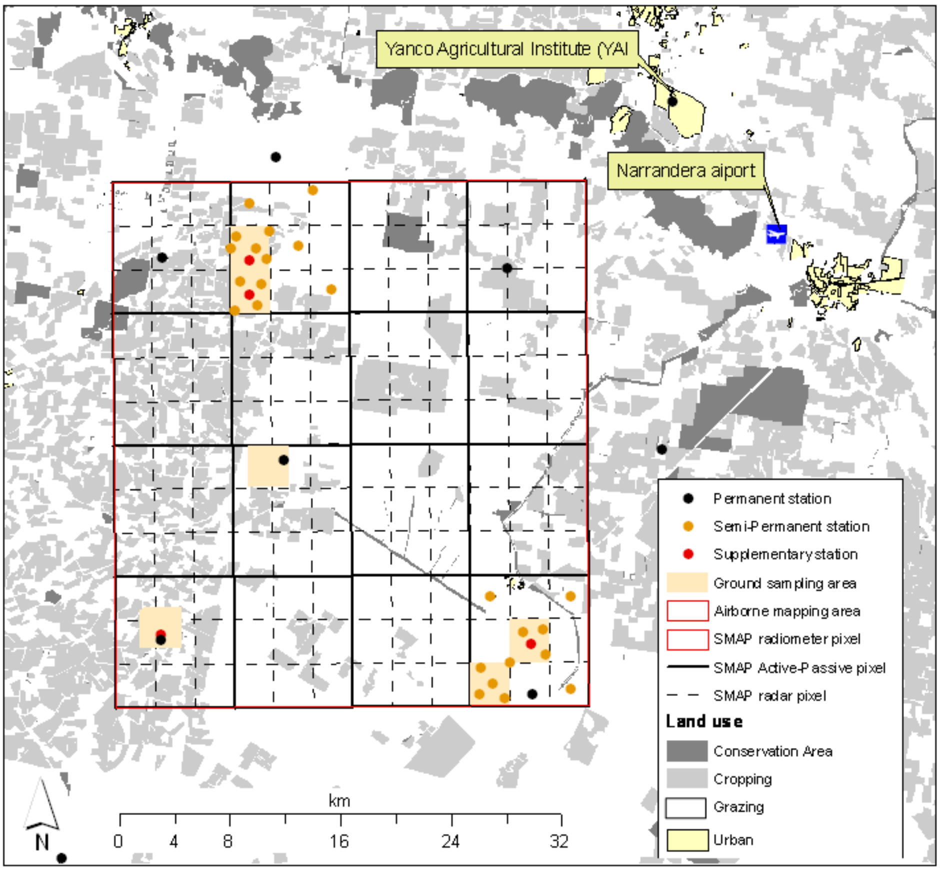


Figure 1-2. Overview of the SMAPEx-2 experiment. The map shows the area covered by airborne mapping (red rectangle), the ground soil moisture networks (colored dots) and ground sampling focus areas and the Future SMAP grids.

product (SMAP L3_SM_A/P product, 9km x 9km). Continuous ground monitoring permanent monitoring sites will cover the entire SMAP radiometer pixel, but with denser network in the two sub-areas, while spatial monitoring will concentrate on 6 focus areas equivalent to a SMAP radar pixel (L1C_HiRes product, 3km x 3km). This design will allow simulating SMAP prototype data over the Yanco study area by aggregation of the airborne observations to SMAP radiometer and radar resolutions, as well as detailed ground truthing of the airborne data at all the resolutions of the SMAP products.

The approach described was defined based on the predicted Earth Fixed grid where all SMAP products will be projected. The Earth Fixed grid is an Equal-Area Scalable Earth (EASE) Grid with several advantages (easy implementation, suitability for mosaicking) which, however, come at the cost of a certain level of distortion, depending on latitude. The actual pixel size of all SMAP products varies with latitude, corresponding to the nominal resolutions only at latitudes +/- 30º. As a result of this, at the latitudes of the Yanco study area a SMAP radiometer pixel corresponds to a rectangle of 34km x 38km against the 40km x 40km nominal resolution. The other SMAP products grids present similar distortion, with a radar pixel corresponding to a 2.8km x 3.1km rectangle and the merged active and passive soil moisture product pixel to a 8.5km x 9.4km rectangle. The airborne monitoring during SMAPEx was designed to match the effective resolutions of the SMAP products, rather than the nominal ones, this way guaranteeing consistency of the data collected with of the future SMAP data in the area. Moreover, the area covered by airborne monitoring was shifted southward with respect to the predicted SMAP grid in order to cover the region south-west of Yanco where the pre-existing monitoring network is denser. The southward shift was equivalent to one full SMAP merged active and passive soil moisture product pixel (9.4km), so as to keep a high level of consistency between the SMAP grids simulated with SMAPEx data and the future SMAP grids.

2 Relevant Satellite Observing Systems

Satellite observing systems of relevance for soil moisture remote sensing are listed below. While passive and active microwave sensors are able to provide direct estimates of near-surface soil moisture, optical data can be used in synergy for direct soil moisture retrieval and/or downscaling.

2.1 Microwave Sensors

2.1.1 Soil Moisture Active Passive (SMAP)

SMAP (http://smap.jpl.nasa.gov) is NASA‟s soil moisture mission, and will use a combined radiometer and high-resolution radar to provide a soil moisture product at better than 10km resolution. Additionally, it will provide information on freeze-thaw state. SMAP will consist of a combined radar and radiometer system operating at 1.26GHz (with VV, HH, and HV polarisations) and 1.41GHz (H, V and U polarisations), respectively. The radar and radiometer of SMAP will share the aperture of a single feed horn and reflector, which will rotate conically about the nadir axis to form a constant incidence angle with the surface of 39.3º. Radar acquisition will be at 1km resolution (and averaged to 3km) with coincident 40km radiometer measurements across a 1,000km wide swath. Due to the peculiarities of radar measurement, no high resolution radar data will be obtained within the 300km band of the swath centred on the nadir track. The SMAPEx airborne facility will closely simulate SMAP viewing configuration using The Polarimetric L-band Multibeam Radiometer (PLMR) and the Polarimetric L-band Imaging Scatterometer (PLIS) (see section 3). SMAP is currently scheduled for launch in 2014.

2.1.2 Aquarius

Aquarius (http://aquarius.gsfc.nasa.gov) is also an L-band microwave satellite, but it is designed specifically for measuring the global sea surface salinity. However, it can also be used for soil moisture retrieval, but with a much lower spatial resolution (150km) than SMOS, and with a longer repeat time (8 days). The science instruments will include a set of three L-band radiometers and an L-band scatterometer (to correct for the ocean's surface roughness), meaning that it can also be used to explore active-passive retrieval of soil moisture. This mission is currently scheduled to launch in 2011 with a 3-year lifetime. Consequently, it is likely that the later SMAPEx campaigns can be scheduled to coincide with overpasses by Aquarius.

2.1.3 Soil Moisture and Ocean Salinity (SMOS)

The SMOS (http://www.esa.int/esaLP/LPsmos.html) satellite was launched on 2 November 2009, making it the first satellite to provide continuous multi angular L-band (1.4 GHz) radiometric measurements over the globe. Over continental surfaces, SMOS provides near-surface soil moisture data at ~50km resolution with a repeat cycle of 2-3 days. The payload is a 2D interferometer yielding a range of incidence angles from 0° to 55° at both V and H polarisations, and a 1,000km swath width. Its multi-incidence angle capability is expected to assist in determining ancillary data requirements such as vegetation attenuation. This satellite has a 6:00am/pm equator overpass time (6:00am local solar time at ascending node). Due to the synthetic aperture approach of this satellite, brightness temperature observations will be processed onto a fixed hexagonal grid with an approximately 12km node separation. While the actual footprint size will vary according to position in the swath, incidence angle, etc, it will be approximately 42km diameter on average. Campaigns for validation of SMOS retrieval algorithms are the focus of a separate project, the Australian Airborne Cal/val Experiments for SMOS (AACES). SMOS data for the SMAPEx campaigns will be available through a CAT-1 ESA proposal.

2.1.4 Phased Array type L-band Synthetic Aperture Radar (PALSAR)

The PALSAR (http://www.eorc.jaxa.jp/ALOS/about/palsar.htm) is an active microwave sensor aboard the Advance Land Observing Satellite (ALOS, www.nasda.go.jp/projects/sat/alos/index_e.html). The sensor operates at L-band with HH and VV polarisation (HV and VH polarisations are optional). The sensor is beam steerable in elevation and the ScanSAR mode, which allows obtaining a wider swath than conventional SARs. ALOS was launched in 2004 into a sun-synchronous orbit at the altitude of 700km, providing a spatial resolution of 20m for the fine resolution mode (swath width of 70km) and 100m for the ScanSAR mode (swath width of 360km). The repeat cycle is 46 days and the local time at descending node is about 10:30am. A request for PALSAR data has been submitted to ALOS by a SMAPEx team member (Tom Jackson).

2.1.5 Advanced Microwave Scanning Radiometers (AMSR-E & AMSR-2)

The AMSR-E (http://www.ghcc.msfc.nasa.gov/AMSR/) sensor is a passive microwave radiometer operating at 6 frequencies ranging from 6.925 to 89.0GHz. Both horizontally and vertically polarized radiation are measured at each frequency with an incidence angle of 55°. The ground spatial resolution at nadir is 75km × 45km for the 6.925GHz channel (C-band). The AMSR-E is one of six sensors onboard Aqua, which was launched in 2002. It has a 1:30am/pm equator crossing orbit with 1-2 day repeat coverage. Several surface soil moisture products are available globally. AMSR-E brightness temperature data can be downloaded free of charge from the NSIDC web site (http://nsidc.org/data/amsre/order.html) or other Distributed Active Archive Center (DAAC). While the current AMSR sensor continues to outlive its expected lifetime, a follow-on mission is planned by JAXA for the near future, the AMSR-2 sensor onboard the Global Change Observation Mission – Water (GCOM-W, http://www.jaxa.jp/projects/sat/gcom_w/index_e.html), scheduled for lunch in 2011.

2.1.6 Advanced Synthetic Aperture Radar (ASAR)

The ASAR (http://envisat.esa.int/instruments/asar/) instrument is operating at C-band and provides both continuity to the ERS-1 and ERS-2 mission SARs and next generation capabilities in terms of coverage, range of incidence angles, polarisation, and modes of operation. The resulting improvements in image and wave mode beam elevation steerage allow the selection of different swaths, providing swath coverage more than 400km wide using ScanSAR techniques. ScanSAR is a Synthetic Aperture Radar (SAR) technique that combines large-area coverage and short revisit periods with a degraded spatial resolution compared to conventional SAR imaging modes. ASAR can provide a range of incidence angles ranging from 15° to 45° and can operate in alternating polarisation mode, providing two polarisation combinations (VV and HH, HH and HV, or VV and VH). The ASAR is onboard the EnviSat satellite, which was launched into a sun synchronous orbit in March 2002. The exact repeat cycle for a specific scene and sensor configuration is 35 days. ASAR data for the SMAPEx campaigns will be available through a CAT-1 ESA proposal.

2.1.7 Advanced SCATterometer (ASCAT)

The ASCAT (http://www.esa.int/esaME/ascat.html), operating at C-band, provides continuity to the ERS-1 and ERS-2 scatterometers. The ASCAT is onboard the Metop satellite, which was launched into a sun synchronous orbit on 19 October 2006 and has been operational since May 2007. ASCAT operates at a frequency of 5.255GHz in vertical polarization. Its use of six antennas allows the simultaneous coverage of two swaths on either side of the satellite ground track, allowing for much greater coverage then its predecessors. It takes about 2 days to map the entire globe. A 50km resolution soil moisture product is now operational from ASCAT, available from EUMETSAT (http://www.eumetsat.int/).

2.1.8 Windsat

WindSat (http://www.nrl.navy.mil/WindSat/) is a multi-frequency polarimetric microwave radiometer with similar frequencies to the AMSR-E sensor, with the addition of full polarisation for 10.7, 18.7 and 37.0GHz channels and the lack of an 89.0GHz channel. Developed by the Naval Research Laboratory, it is one of the two primary instruments on the Coriolis satellite launched on 6 January 2003. WindSat is continuing to outlive its three year design life, with data free of charge to scientists from http://www.cpi.com/twiki/bin/view/WindSat/WebHome.

2.1.9 COnstellation of small Satellites for the Mediterranean basin Observation (COSMO-SkyMed)

COSMO-SkyMed (http://www.cosmo-skymed.it/en/index.htm) is a constellation composed of four satellites equipped with Synthetic Aperture Radar operating at X-band operated by the Italian Space Agency (Agenzia Spaziale Italiana). The first satellite of COSMO-SkyMed constellation has been launched on June 2007. The constellation consists of 4 medium-size satellites, each one equipped with a microwave high-resolution synthetic aperture radar (SAR) operating in X-band, having ~600 km single side access ground area, orbiting in a sun-synchronous orbit at ~620km height over the Earth surface, with the capability to change attitude in order to acquire images at both right and left side of the satellite ground track (nominal acquisition is right looking mode). The spatial resolution ranges from 1m for the spotlight images to 100m in ScanSAR mode. COSMO-SkyMEd data for the SMAPEx-2 campaign will be provided by the “Consiglio Nazionale della Ricerca” (,National Research Council, CNR), Italy.

2.2 Optical Sensors

2.2.1 Advanced Along Track Scanning Radiometer (AATSR)

AATSR (http://envisat.esa.int/instruments/aatsr/) is the most recent in a series of instruments designed primarily to measure Sea Surface Temperature (SST), following on from ATSR-1 and ATSR-2 on board ERS-1 and ERS-2. AATSR data have a resolution of 1 km at nadir, and are derived from measurements of reflected and emitted radiation taken at the following wavelengths: 0.55 µm, 0.66 µm, 0.87 µm, 1.6 µm, 3.7 µm, 11 µm and 12 µm. These can also be used to obtain Land surface temperature at a spatial resolution of 1km x 1km over a swath of 500km. AATSR data for the SMAPEx campaigns will be available through a CAT-1 ESA proposal.

2.2.2 Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)

ASTER (http://asterweb.jpl.nasa.gov/) provides high resolution visible (15m), near infrared (30m) and thermal infrared (90m) data on request. ASTER is onboard Terra and has a swath width of about 60km. ASTER is being used to obtain detailed maps of land surface temperature, reflectance and elevation.

2.2.3 Advanced Visible and Near Infrared Radiometer type 2 (AVNIR-2)

AVNIR-2 (http://www.eorc.jaxa.jp/ALOS/about/avnir2.htm) is a visible and near infrared radiometer onboard ALOS. AVNIR-2 is a successor to AVNIR that was onboard the ADvanced Earth Observing Satellite (ADEOS), which was launched in August 1996. Its instantaneous field-of-view is the main improvement over AVNIR. AVNIR-2 also provides 10m spatial resolution images, an improvement over the 16m resolution of AVNIR in the multi-spectral region. Improved CCD detectors (AVNIR has 5,000 pixels per CCD; AVNIR-2 7,000 pixels per CCD) and electronics enable this higher resolution. The pointing angle of AVNIR-2 is +44° and -44°. AVNIR-2 data for the SMAPEx campaigns will be provided by the "Consiglio Nazionale della Ricerca" (National Research Council, CNR), Italy.

2.2.4 Compact High Resolution Imaging Spectrometer (CHRIS)

CHRIS (www.chris-proba.org.uk) provides remotely-sensed multi-angle data at high spatial resolution and in superspectral/hyperspectral wavelengths. The instrument has a spectral range of 415-1050 nm, and provides observations at 19 spectral bands simultaneously with a spatial resolution of 20m at nadir and a swath width of 14km. CHRIS is on board ESA's PRoject for On-Board Autonomy (PROBA). The PROBA satellite is on a sun-synchronous elliptical polar orbit since 2001 at a mean altitude of about 600km.

2.2.5 Landsat

Landsat (http://landsat.usgs.gov/http://landsat7.usgs.gov/programdesc.html) satellites collect data in the visible (30m), panchromatic (15m), mid infrared (30m) and thermal infrared (60 to 120m) regions of the electromagnetic spectrum. These data have an approximately 16 day repeat cycle with a 10:00am equator crossing time. This data is particularly valuable in land cover and vegetation parameter mapping. Due to an instrument malfunction onboard Landsat 7 in May 2003, the Enhanced Thematic Mapper Plus (ETM+) is now only able to provide useful image data within the central ~20km of the swath. As Landsat 5 Thematic Mapper is still in operation it is being increasingly relied upon. The approximate scene size is 170 × 183 km. A December 2012 launch date was recently confirmed for the Landsat Data Continuity Mission (LDCM). Landsat 5 and 7 imagery can be purchased from Geoscience Australia (http://www.ga.gov.au/remote-sensing/get-satellite-imagery-data/ordering/pricing/index.jsp)

2.2.6 Medium Resolution Imaging Spectrometer (MERIS)

MERIS is one of the sensors onboard the Environmental Satellite (ENVISAT) of the European Space Agency (http://envisat.esa.int/instruments/meris/MERIS), launched on the 1st March 2002 aboard into a sun-synchronous polar orbit at a height of 790 km (±10 km). MERIS is designed so that it can acquire data over the Earth in the solar reflective spectral range (390 to 1040 nm), using 15 bands selectable across the range. The instrument's 68.5° field of view around nadir covers a swath width of 1150 km at a resolution of 260m x 300m. MERIS data for the SMAPEx campaigns will be provided by the "Consiglio Nazionale della Ricerca" (National Research Council, CNR), Italy.

2.2.7 MODerate resolution Imaging Spectroradiometer (MODIS)

The MODIS (http://modis.gsfc.nasa.gov) instrument is a highly sensitive radiometer operating in 36 spectral bands ranging from 0.4µm to 14.4µm. Two bands are imaged at a nominal resolution of 250m at nadir, five bands at 500m, and the remaining 29 bands at 1km. MODIS is operating onboard Terra and Aqua. Terra was launched in December 1999 and Aqua in May 2002. A ±55° scanning pattern at 705km altitude achieves a 2,330km swath that provides global coverage every one to two days. Aqua has a 1:30am/pm equator crossing time while Terra has a 10:30am/pm equator crossing time, meaning that MODIS data is typically available on a daily basis. MODIS data are free of charge and can be accessed online at http://lpdaac.usgs.gov/main.asp.

In general, the range of surface temperature values is dependent on the time of acquisition, and is greater for Aqua. The downscaling approaches based on optical data requires a strong coupling between surface temperature and surface soil moisture, which commonly occurs in areas where surface evaporation is not energy limited and when solar radiation is relatively high (usually between 11am and 3pm). Therefore MODIS on Aqua (1:30pm) is more relevant than MODIS on Terra for downscaling purposes.

2.2.8 MTSAT-1R

The Multi-functional Transport Satellite (MTSAT) series fulfils a meteorological function for the Japan Meteorological Agency and an aviation control function for the Civil Aviation Bureau of the Ministry of Land, Infrastructure and Transport. The MTSAT series (http://www.jma.go.jp/jma/jma-eng/satellite/index.html) succeeds the Geostationary Meteorological Satellite (GMS) series as the next generation of satellites covering East Asia and the Western Pacific. This series provides imagery for the Southern Hemisphere every 30 minutes at 4km resolution in contrast to the previous hourly rate, enabling the Japan Meteorological Agency to more closely monitor typhoon and cloud movement. The MTSAT series carries a new imager with a new infrared channel (IR4) in addition to the four channels (VIS, IR1, IR2 and IR3) of the GMS-5.

3 Airborne Observing Systems

Airborne measurements will be made using a small single engine aircraft, including the PLMR radiometer, The PLIS radar, thermal infrared, and multi-spectral sensing instruments. This infrastructure will allow passive microwave (~1km), land surface skin temperature (~20m and 1km) and vegetation index (~1km) observations to be made across large areas.

The aircraft (Figure 2-1) can carry a typical science payload of up to 250kg (120kg for maximum range) with cruising speed of 150-270km/h and range of 9hrs with reserve (5hrs for maximum payload). The aircraft ceiling is 3000m or up to 6000m with breathing oxygen equipment, under day/night VFR or IFR conditions. The aircraft can easily accommodate two crew; pilot/scientist plus scientist.

Aircraft instruments are typically installed in an underbelly pod or in the wingtips. Aircraft navigation for science is undertaken using a GPS driven 3-axis autopilot together with a cockpit computer display that shows aircraft position relative to planned flight lines using the OziExplorer software. The aircraft also has an OXTS (Oxford Technical Solutions) Inertial plus GPS system (two antennae on the fuselage) for position (georeferencing) and attitude (pitch, roll and heading) interpretation of the data. When combined with measurements from a base station, the RT3003 can give a positional accuracy of 2cm, roll and pitch accuracy of 0.03° and heading accuracy of 0.1°. Without a base station the positional accuracy is degraded to about 1.5m (www.oxts.com).

3.1 L-band Microwave Sensors

3.1.1 Passive: Polarimetric L-band Multibeam Radiometer (PLMR)

The PLMR (Figure 2-3) measures both V and H polarisations using a single receiver with polarisation switch at incidence angles +/–7°, +/–21.5° and +/–38.5° in either across track (pushbroom) or along track configurations. In the normal pushbroom configuration the 3dB beamwidth is 17° along track and 14° across track resulting in an overall 90° across track

Figure 3-1. Experimental aircraft showing a wingtip installation in the left inset, and the cockpit with cockpit computer display in the right inset.

Figure 3-2. View of PLMR with the cover off.

field of view. The instrument has a frequency of 1.413GHz and bandwidth of 24MHz, with specified NEDT and accuracy better than 1K for an integration time of 0.5s, and 1K repeatability over 4 hours. It weighs 46kg and has a size of 91.5cm × 91.5cm × 17.25cm.

3.1.2 Active: Polarimetric L-band Imaging Scatterometer (PLIS)

The PLIS is an L-band radar which can measure the surface backscatters at HH, HV, VH and VV polarisations (see Figure 3-3). The PLIS is composed of two main 2x2 patch array antennas tilted at an angle of 30º from the horizontal to either side of the aircraft to obtain pushbroom imagery over a cross track swath of +/-45 degrees. Both antennas are able to transmit and receive at V and H polarisation. Additional secondary antennas can be deployed for interferometry (not used during SMAPEx). The antenna's two way 6-dB beamwidth is of 51 degrees, and the antenna gain is 9 dBi +/-2 dB. In the cross-track direction, the antenna gain is within 2.5 dB of the maximum gain between 15° and 45°. The PLIS has an output frequency of 1.245-1.275 GHz with a peak transmit power of 20W. The instrument can radiate with a pulse repetition frequency of up to 20kHz with pulse width of 100ns to 10µs. The minimum detectable Normalized Radar Cross Section is of -45 dB m^2/m^2 for the main antenna. Each antenna has a size of 28.7cm x 28.7cm x 4.4cm and weights 3.5Kg.

3.1.3 Thermal Infrared Sensors

During flight there will be six thermal infrared radiometers together with a thermal imager (Figure 3-4). The thermal imager is a FLIR ThermaCam S60 with spectral range 7.5 to 13m, accuracy +/–2°C or +/–2% of reading and thermal sensitivity of 0.08°C. It has an 80° × 60° FOV lens with 1.3mrad IFOV, resulting in approximately 20m data from a 3000m flying height. The thermal imager looks very similar to a digital video camera, with a weight of 2kg and size of 10cm × 12cm × 22cm, without the 80° FOV lens fitted.

The thermal infrared radiometers are the 8.0 to 14.0m Everest Interscience 3800ZL (see www.everestinterscience.com) with 15° FOV and 0-5V output (-40°C to 100°C). The six radiometers are installed at the same incidence angles as PLMR so as to give coincident

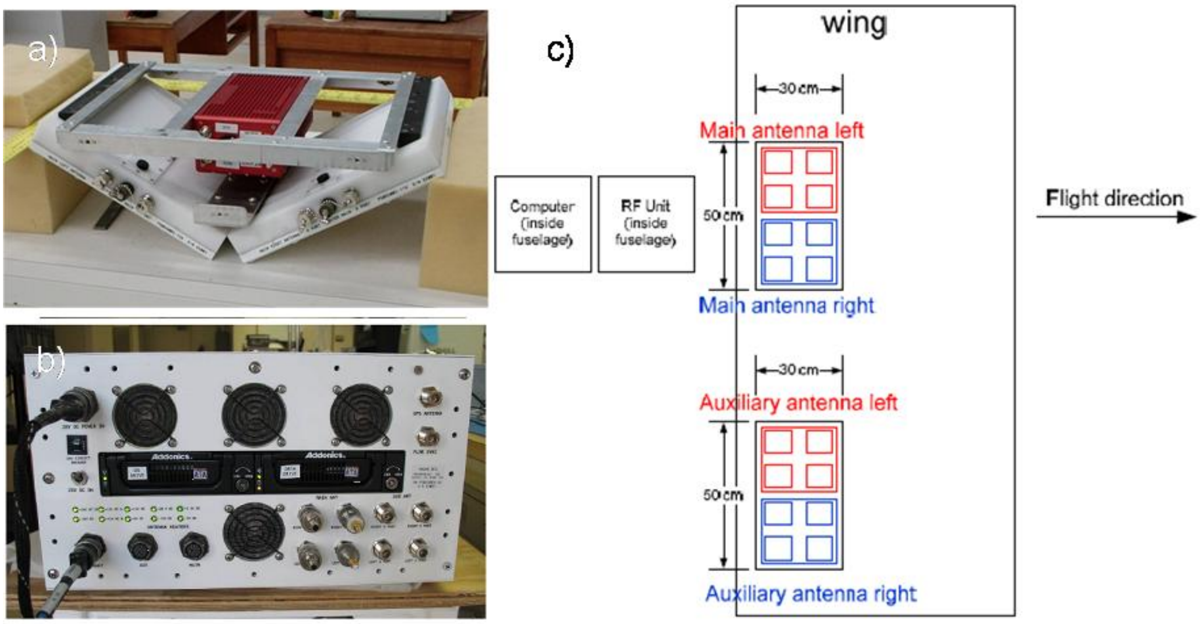


Figure 3-3. View of PLIS antennas (a), RF unit (b) and aircraft configuration (c).

Figure 3-4. Thermal imager (left) without the 80° FOV lens attached and thermal infrared radiometers (right).

footprints with the PLMR observations. The nominal relationship between voltage and temperature is given by the manufacturer as V = 1.42857 + (0.03571428*T).

3.2 Multi-Spectral Sensors

The multispectral measurements are made using an array of 15° FOV Skye 4-channel sensors (Figure 3-5), each with 0-5V signal output (http://www.skyeinstruments.com). When installed these sensors are configured in a similar way to the Everest thermal infrared radiometers (Figure 3-4), such that the six downward looking sensors have the same incidence angle and footprints as for the six PLMR beams. However, to correct for incident radiation, an upward looking sensor with cosine diffuser is also installed. Each sensor weighs approximately 400g and has a size of 8.2cm × 4.4cm without the cosine diffuser or field of view collar attached. Two arrays of 4 channel sensors are installed, with the following (matched) spectral bands:

Figure 3-5. Multi-spectral sensors; downward looking sensor without the field of view collar attached (left) and upward looking sensor with cosine diffuser fitted (right).

Sensor VIS/NIR (SKR 1850A)

Channel 1	MODIS Band 1	620 – 670nm
Channel 2	MODIS Band 2	841 – 876nm
Channel 3	MODIS Band 3	459 – 479nm
Channel 4	MODIS Band 4	545 – 565nm

Sensor SWIR (SKR 1870A)

Channel 1	MODIS Band 6	1628 – 1652nm
Channel 2		2026 – 2036nm
Channel 3	MODIS Band 7	2105 – 2155nm
Channel 4		4 2206 – 2216nm

3.3 Visible Sensors

A high resolution digital SLR camera, a digital video camera, and a Pika-II hyperspectral camera are available to the campaign (Figure 3-6). The digital camera is a Canon EOS-1Ds Mark III that provides 21MegaPixel full frame images. It has a 24mm (23°) to 105mm (84°) variable zoom lens. The digital video camera is a JVC GZ-HD5 with 1920 × 1080 (2.1 MegaPixel) resolution and 10× optical zoom. Also available is a HD-6600PRO58 wide angle conversion lens to provide full swath coverage of PLMR.

The Pika-II is a compact low-cost hyperspectral imaging spectrometer manufactured by Resonon, Inc (see http://www.resonon.com). It acquires data between 400 nm and 900nm at a

Figure 3-6. Canon EOS-1DS Mark 3 (left), video camera (centre) and Pika II (right).

spectral resolution of 2.1nm. Across track field of view is ~53° using the current Schneider Cinegon 1.8/4.8mm compact lens, with 640 cross-track pixels. It weighs approximately 1kg and has a size of 10cm × 16.5cm × 7cm.

4 Study Area

SMAPEx-2 will be undertaken in the Yanco intensive study area located in the Murrumbidgee Catchment (see Figure 1-1), New South Wales. The Yanco study area is a semi-arid agricultural and grazing area which has been monitored for remote sensing purposes since 2001 (www.oznet.unimelb.edu.au), as well as being the focus of the National Airborne Field Experiment 2006 (NAFE'06, www.nafe.unimelb.edu.au) dedicated to algorithm development studies for the SMOS mission. It therefore constitutes a very suitable study site in terms of background knowledge and data sets, scientific requirements, and logistics.

4.1 Murrumbidgee Catchment

The Murrumbidgee is a 100,000 km2 catchment located in southeast of Australia with latitude ranging from 33S to 37S and a longitude from 143E to 150E. There is significant spatial variability in climate (alpine to semi-arid), soils, vegetation and land use (see Figure 4-2). The catchment topography with elevation varying from 50m in the west of the catchment to in excess of 2000m in the east. Climate variations are primarily associated with elevation, varying from semi-arid in the west, where the average annual precipitation is 300mm, to temperate in the east, where average annual precipitation reaches 1900mm in the Snowy Mountains. The evapotranspiration (ET) is about the same as precipitation in the west but represents only half of the precipitation in the east.

Soils in the Murrumbidgee vary from sandy to clayey, with the western plains being dominated by finer-textured soils and the eastern half of the catchment being dominated by medium-to-coarse textured soils. Landuse in the catchment is predominantly agricultural with exception of steeper parts of the catchment, which are a mixture of native eucalypt forests and exotic forestry plantations. Agricultural land use varies greatly in intensity and includes pastoral, more intensive grazing, broad-acre cropping, and intensive agriculture in irrigation

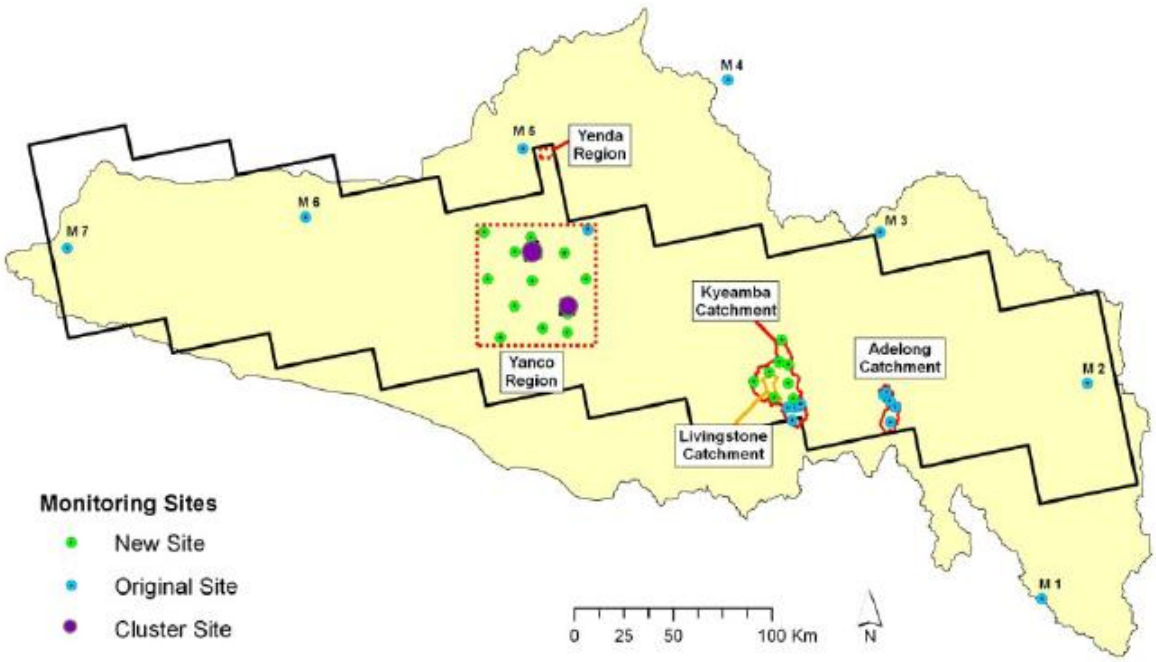


Figure 4-1. Overview of the Murrumbidgee River catchment, soil moisture monitoring sites and the Yanco study area focus of SMAPEx. Also shown in black are the flight boxes to be monitored by the AACES campaigns

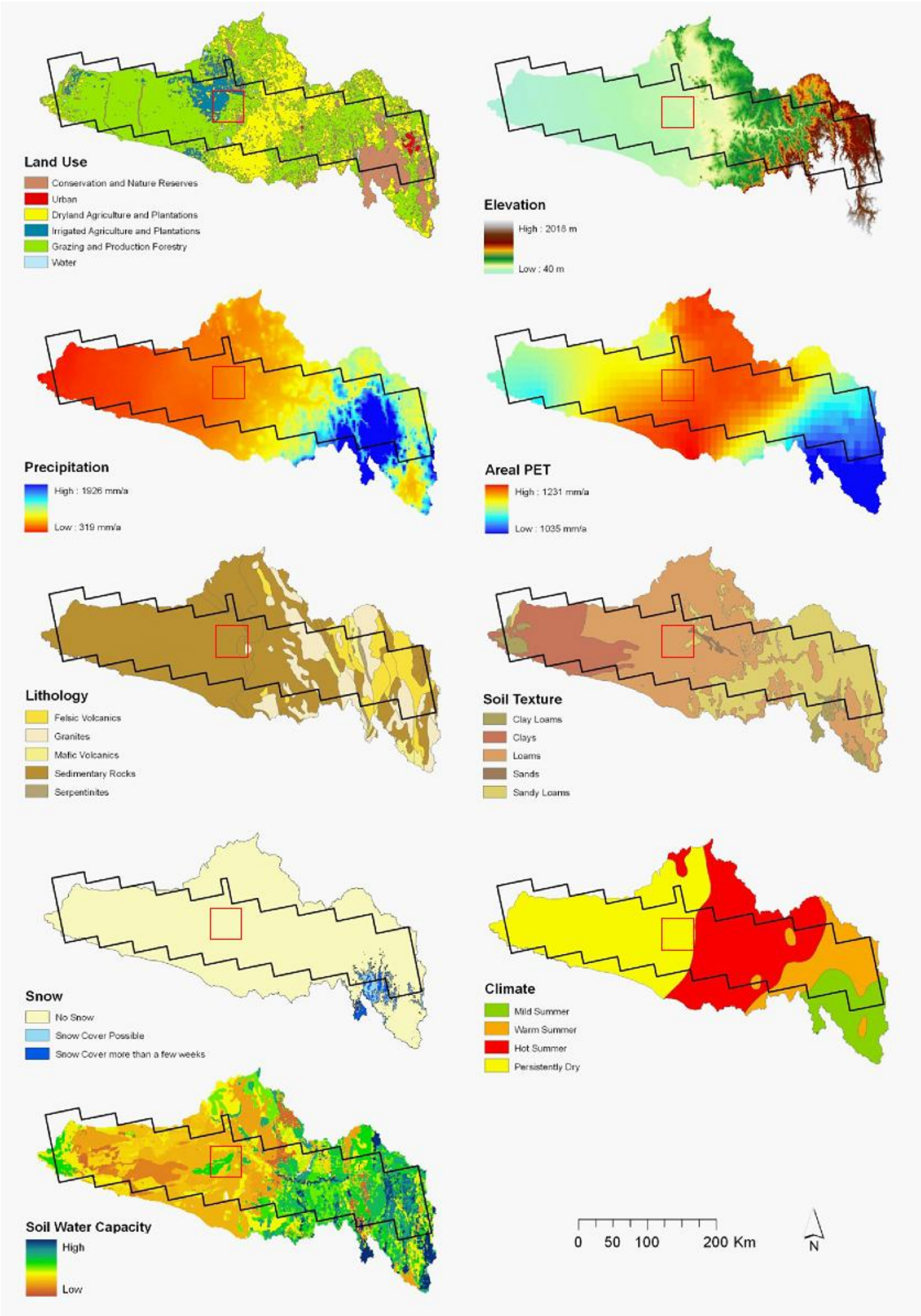


Figure 4-2. Climatic, soil and land use diversity across the Murrumbidgee catchment. Overlain is the outline of the SMAPEx-2 Yanco study area (red). Also shown in black are the flight boxes to be monitored by the AACES campaigns (data sources: Australian Bureau of Meteorology, Australian Bureau of Rural Science, and Geoscience Australia).

areas along the mid-lower Murrumbidgee. The Murrumbidgee catchment is equipped with a wide-ranging soil moisture monitoring network (OzNet) which was established in 2001 and upgraded with 20 additional sites in 2003 (http://www.civenv.unimelb.edu.au/oznet/mdbdata/mdbdata.html) and an additional 24 surface soil moisture only probes in 2009 in the Yanco region. At present, the network consists in total of 38 continuously operating soil moisture profile stations (excluding the additional surface soil moisture stations recently installed) distributed across the whole catchment (see Figure 4-1), with three focus areas (Yanco, Kyeamba and Adelong) comprising about two-third of the existing monitoring sites.

4.2 Yanco Region Description

The Yanco area is a 60km by 60km area located in the western flat plains of the Murrumbidgee catchment where the topography is flat with very few geological outcroppings. Soil types are predominantly clays, red brown earths, transitional red brown earth, sands over clay, and deep sands. According to the Digital Atlas of Australian Soils, dominant soil is characterised by "plains with domes, lunettes, and swampy depressions, and divided by continuous or discontinuous low river ridges associated with prior stream systems--the whole traversed by present stream valleys; layered soil or sedimentary materials common at fairly shallow depths: chief soils are hard alkaline red soils, grey and brown cracking clays".

The area covered by SMAPEx-2 airborne mapping will be a 34km by 38km rectangle within the Yanco area (145° 50'E to 146° 21'E in longitude and 34° 40'S to 35° 0'S in latitude, see Figure 4-3) Approximately one third of the SMAPEx study area is irrigated. The Coleambally Irrigation Area (CIA) is a flat agricultural area of approximately 95,000 hectares (ha) that contains more than 500 farms. Figure 4-3 illustrates the extension of the CIA within the SMAPEx study area, as well as the farm boundaries. The principal summer crops grown in the CIA are rice, corn, and soybeans, while winter crops include wheat, barley, oats, and canola. Rice crops are usually flooded in November by about 30cm of irrigation water. However, due to the ongoing draught summer cropping in 2009 was generally very limited and few rice crops were planted (source: Coleambally Irrigation Annual Compliance Report, 2009). The average CIA cropping areas for 2009 are listed in Figure 4-4.

4.3 Soil Moisture Network Description

4.3.1 OzNet Permanent Network

Each soil moisture site of the Murrumbidgee monitoring network measures the soil moisture at 0-30cm, 30-60cm and 60-90cm with water content reflectometers (Campbell Scientific). Detailed information about the instruments installed, as well as the data archive can be found at http://www.civenv.unimelb.edu.au/oznet/mdbdata/mdbdata.html. Reflectometers consist of a printed circuit board connected to two parallel stainless steel rods that act as wave guides. They measure the travel time of an output pulse to estimate changes in the bulk soil dielectric constant. The period is converted to volumetric water content with a calibration equation parameterised with soil type and soil temperature. Such sensors operate in a lower range of frequencies (10-100 MHz) than Time Domain Reflectometers TDR (700- 1000 MHz).

Soil moisture sites also monitor continuously precipitation (using the tipping bucket raingauge TB4-L) and soil temperature. Moreover Time Domain Reflectometry (TDR) sensors are installed and are monitored when sites are visited to provide additional calibration information and ongoing checks on the reflectometers. All the stations except for one in

Figure 4-3. The Yanco site is a 60km box with approximately one third of irrigated area (Coleambally Irrigation Area). The six ground sampling areas of SMAPEx and the soil moisture monitoring networks are indicated

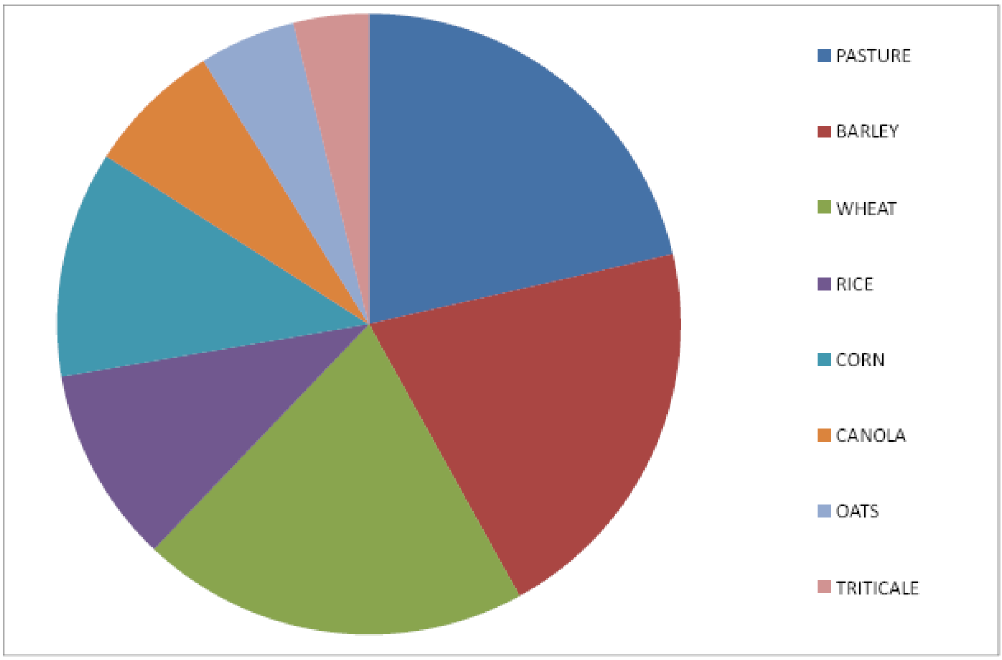


Figure 4-4. Proportions of total irrigated area sown to various crops within the CIA (source: Coleambally Irrigation Annual Compliance Report, 2009).

Yanco and seven stations in Kyeamba were installed throughout late 2003 and early 2004 (new sites) while the eighteen other stations have operated since late 2001 (original sites). Figure 4-5 illustrates the differences between the original and new sites. The original sites use the Water content reflectometer CS615 (Campbell, http://www.campbellsci.com/cs615-l) while the new sites use the updated version CS616 (Campbell, http://www.campbellsci.com/cs616-l), which operates at a somewhat higher measurement frequency (175MHz compared with 44MHz). The original sites monitor soil temperature and soil suction (in the 60-600kPa range) at the midpoint of the four layers 0- 7cm, 0-30cm, 30-60cm and 60-90cm, whereas the new sites only monitor 15cm soil temperature from T-107 thermistors (Campbell, http://www.campbellsci.com/107-l). All new sites have been upgraded since April 2006 to include a 0-5cm soil moisture from a HydraProbe (Stevens Water; http://www.stevenswater.com/catalog/stevensProduct.aspx?SKU='70030'), 2.5cm soil

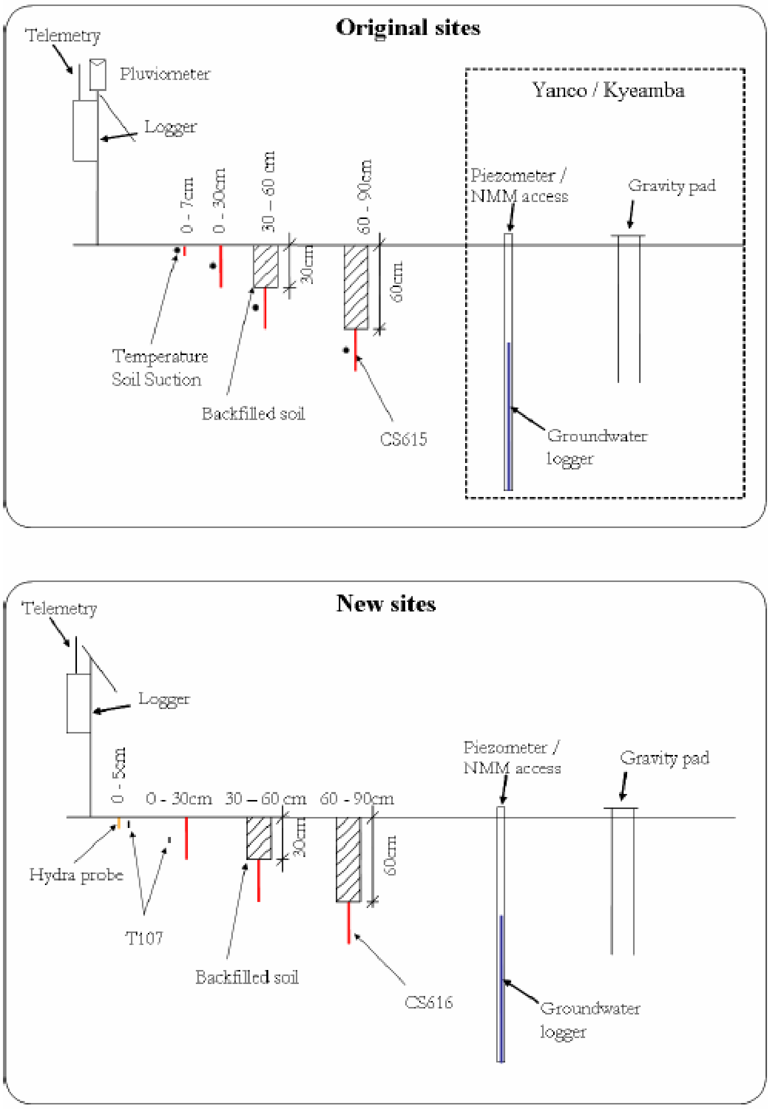


Figure 4-5. Typical equipment at the original (2001) and new (2004) soil moisture sites in the Murrumbidgee catchment. Each site provides continuous data of rainfall, soil moisture at 0- 5cm (or 0-7cm), 0-30cm, 30-60cm and 60-90cm and soil temperature and accommodates periodic measurements of gravity, groundwater and TDR soil moisture measurements.

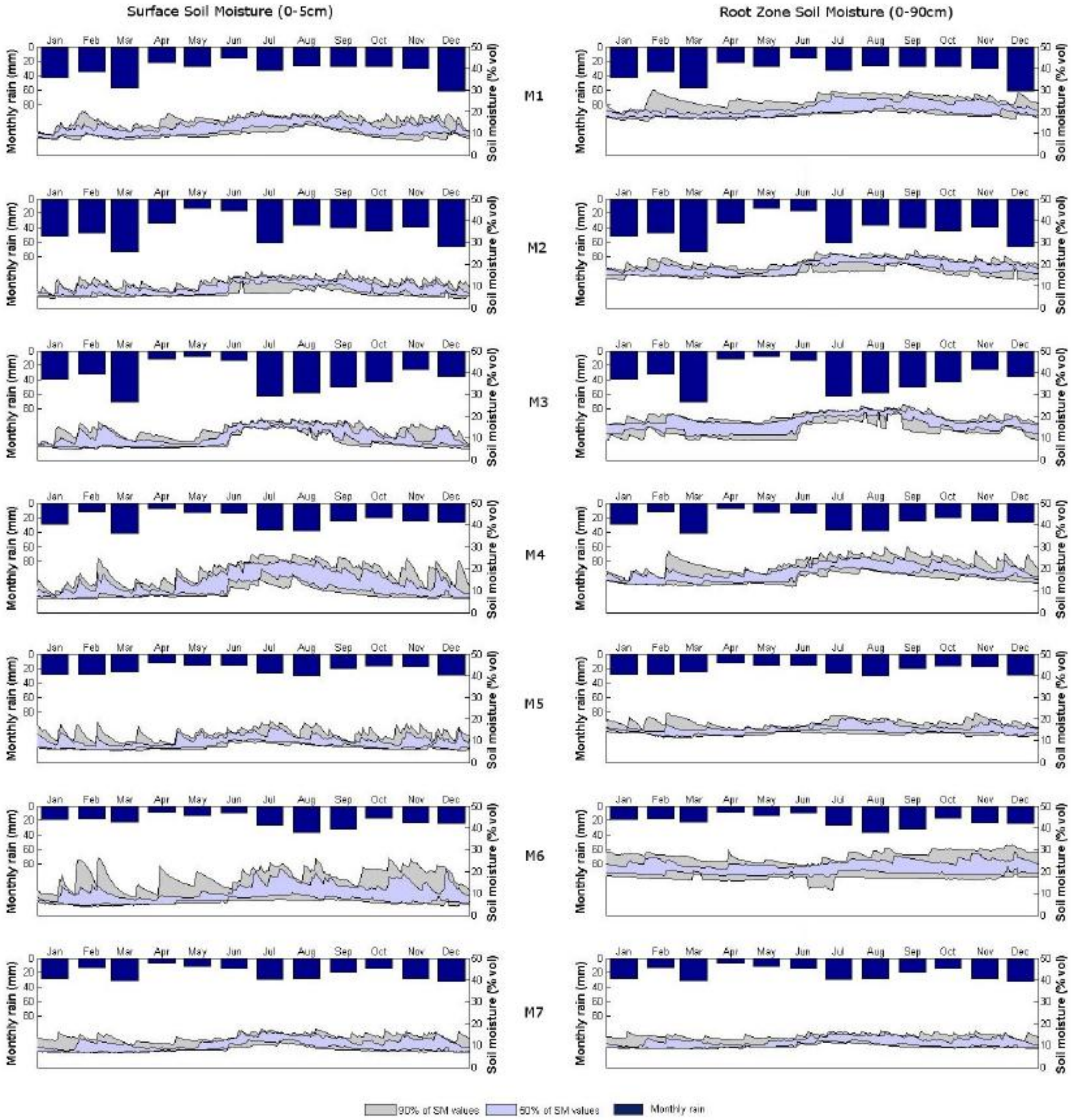


Figure 4-6. Monthly average precipitation and soil moisture variability (left: surface soil moisture 0-5cm; right: root zone soil moisture 0-90cm) across the Murrumbidgee catchment based on data derived from the Murrumbidgee monitoring network stations M1-M7. The shaded areas show the 50 and 90 percentile limits.

temperature from thermistors (Campbell Scientific model T-107) and telemetry.

Sensor response to soil moisture varies with salinity, density, soil type and temperature, so a site-specific sensor calibration is being undertaken using both laboratory and field measurements. The on-site calibration consists of comparing reflectometer measurements with both field gravimetric samples and occasional TDR readings. As the CS615 and CS616 sensors are particularly sensitive to soil temperature fluctuations the T-107 temperature sensors were installed to provide a continuous record of soil temperature at midway along the reflectometers. Deeper temperatures are assumed to have the same characteristics across the Yanco and Kyeamba sites and are therefore estimated from detailed soil temperature profile measurements made at the original soil moisture sites.

Table 4-1. Characteristics of the OzNet soil moisture stations in the SMAPEx study area

ID	Latitude	Longitude	Elevation (m)	Land use
Y4	34° 43.17’S	146° 1.2’E	130.0	Wet land cropping
Y5	34° 43.7’S	146° 17.59’E	136.0	Dry land cropping
Y7	34° 51.11’S	146° 6.92’E	128.0	Native pasture, grazing
Y9	34° 58.07’S	146° 0.98’E	122.0	Dry and wet land cropping
Y10	35° 0.32’S	146° 18.59’E	119.0	Native pasture, grazing

Figure 4-6 shows the seasonal variability of rainfall and soil moisture conditions across the entire catchment captured by seven of the monitoring sites. The surface soil moisture within the top 5cm varies significantly between the different sites resulting in a range of about 0.05-0.25m^3/m^3 (using the upper and lower limit defined by 50% and 90% respectively based on all observations collected within the past eight years). Note that moisture conditions are typically slightly wetter during winter (July-August), which dries over the following months towards the driest conditions typically in autumn (April-June). Comparable seasonal variations are recorded for the root zone soil moisture. The site closer to the SMAPEx study area is M5 (see Figure 4-1).

The 13 OzNet soil moisture monitoring sites in the Yanco area are all new sites installed throughout late 2003 and early 2004, and they are located in a grid-based pattern within the 60 km by 60 km area allowing for measurement of the sub-grid variability of remote sensed observations such as near-surface soil moisture from AMSR and SMOS. 5 of these sites fall within the area covered by the SMAPEx airborne coverage (see Figure 4-3)

The five sites are evenly divided between the 3 main land uses in the region—irrigated cropping (including the major rice growing region of the Coleambally Irrigation Area), dryland cropping (typically wheat and fallow), and grazing (typically perennial grass type vegetation). The characteristics of the OzNet soil moisture stations in the SMAPEx study area are listed in Table 4-1.

4.3.2 SMAPEx Semi-permanent Network

24 additional soil moisture sites were installed in late 2009 to support the SMAPEx experiment. These will continuously monitoring soil moisture at 0-5cm with a HydraProbe and soil temperature at 1, 2.5 and 5cm depths (Unidata® 6507A/10 Sensors). Figure 4-7 illustrates schematically the layout of the semi-permanent stations. The 24 sites will be concentrated on two 9km x 9km focus areas within the radiometer pixel (areas YA and YB), corresponding to two pixels of the SMAP grid at which the active and passive soil moisture product (SMAP L3_SM_A/P product) will be produced. Finally, 10 of the sites within areas YA and YB will be concentrated on two “sub-areas” of 2.8km x 3.1km (at least 4 stations in each sub-area), corresponding to two SMAP radar pixels. Figure 4-7 shows a schematic of the installation, while Figure 4-8 shows the locations of the SMAPEx semi-permanent sites within the study area.

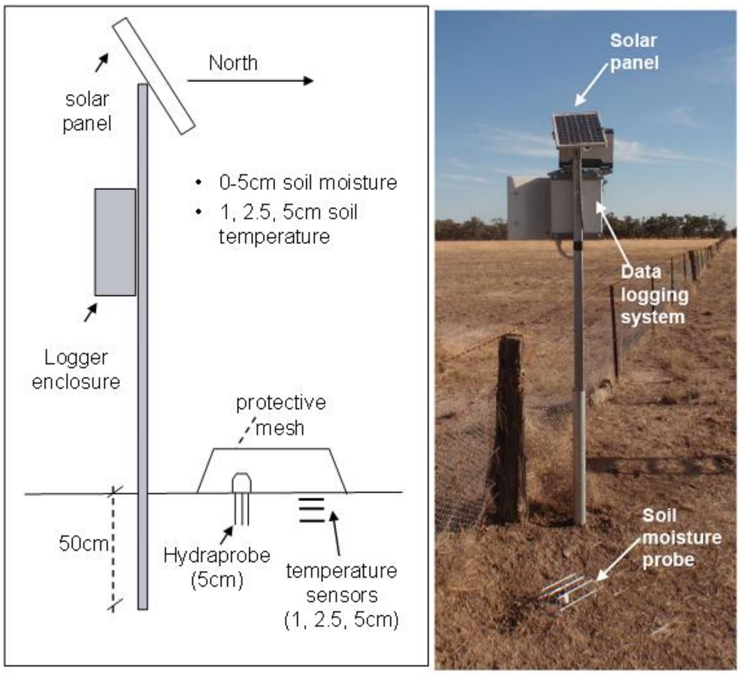


Figure 4-7. Schematic layout of the additional SMAPEx monitoring site and photo of site YA5.

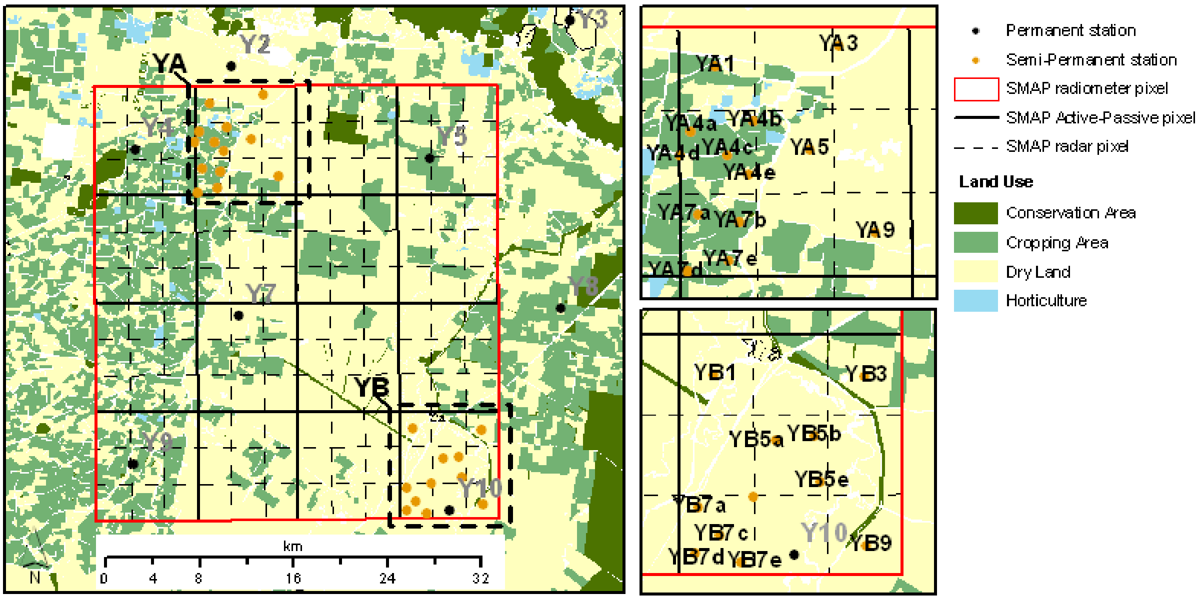


Figure 4-8. Layout of the SMAPEx semi-permanent soil moisture network in the study area.

The sites were installed so as to monitor a variety of land cover conditions in the area as comprehensive of the study area conditions as possible. Table 4-1 lists the main characteristics of the SMAPEx semi-permanent sites. The network is equally distributed between irrigated cropping land (occupying approximately 1/3 of the SMAPEx study area, and grazing dry land.

The SMAPEx semi-permanent network will operate throughout the SMAPEx project (2010-2012). Further operation beyond 2012 is subjected to additional funding.

Table 4-2. Characteristics of the SMAPEx semi-permanent monitoring sites. NOTE: the crop types listed are those observed at the time of installation, between August-December 2009 and depend on the water allocations. The list will be updated with the actual ground conditions in a supplement to the present document.

Area ID	Latitude	Longitude	Landuse	Vegetation Type	Irrigated
YA1	146.0897	-34.68425	Cropping	Stubble	Possibly
YA3	146.1397	-34.677153	Grazing	Perennial grass	No
YA4a	146.07937	-34.706005	Cropping	Barley	Yes
YA4b	146.10529	-34.703062	Cropping	Stubble	Yes
YA4c	146.09425	-34.714213	Cropping	Wheat	Yes
YA4d	146.07506	-34.714202	Cropping	Wheat	Yes
YA4e	146.10297	-34.721393	Grazing	Perennial grass	No
YA5	146.12771	-34.712858	Grazing	Perennial grass	No
YA7a	146.08197	-34.735208	Cropping	Wheat	Yes
YA7b	146.09867	-34.737835	Cropping	Stubble	Possibly
YA7d	146.07777	-34.7544	Cropping	Stubble	Unlikely
YA7e	146.09493	-34.750728	Grazing	Perennial grass	No
YA9	146.15364	-34.741377	Grazing	Perennial grass	No
YB1	146.27654	-34.941243	Grazing	Perennial grass	No
YB3	146.34015	-34.942698	Cropping	Wheat	No
YB5a	146.30262	-34.965268	Grazing	Perennial grass	No
YB5b	146.31843	-34.963373	Grazing	Perennial grass	No
YB7b/YB5d	146.29299	-34.984833	Grazing	Perennial grass	No
YB5e	146.32052	-34.979712	Grazing	Perennial grass	No
YB7a	146.26941	-34.988457	Grazing	Perennial grass	No
YB7c	146.27852	-34.998378	Grazing	Perennial grass	No
YB7d	146.26853	-35.00497	Grazing	Perennial grass	No
YB7e	146.28805	-35.007732	Grazing	Perennial grass	No
YB9	146.33978	-35.002167	Grazing	Perennial grass	No

5 Air Monitoring

The PLMR, PLIS and supporting instruments (thermal radiometers and multispectral radiometers) will be flown onboard a high performance single engine aircraft to collect airborne data across the SMAPEx study area every day during five days. A total of 25 mission hours have been estimated for a single campaign.

Two main types of flights will be conducted during SMAPEx-2 to serve the main scientific objectives of the project (see Table 5-1):

1. **Regional flights** (section 5.2) will provide prototype SMAP radar and radiometer data over an area equivalent to a SMAP pixel, for development of active and passive microwave retrieval algorithms and techniques to downscaling the passive microwave information using the high-resolution active microwave data;
2. **Target flights** (section 5.3) will provide high resolution radar and radiometer data over two focus areas, for development of radar-only soil moisture retrieval and comparison of active and passive soil moisture signatures;

Four types of additional flights will also be performed with specific objectives:

1. **Multi-angle flights** (section 5.4) will provide radar and radiometer data at multiple incidence angle over two focus areas;
2. **PALSAR transect** (section 5.3), will provide data over a focus transect for cross-comparison of the airborne active microwave data of PLIS with those of the PALSAR sensor onboard ALOS.
3. **Azimuth flights (section 5.6):** will collect PLIS radar observations of small areas at a variety of azimuth viewing angles;
4. **Belvedere orchard flights (section 5.7):** will collect high resolution radar and radiometer observations over a large orchard plantation.

Table 5-1. Summary of SMAPEx flight types

Flight Type	Objectives	Coverage	Ground Resolution	Altitude (AGL)
Regional Flights	* Active/Passive retrieval * Downscaling	34km x 38km	1km PLMR 10m-30m PLIS^{+}	10,000ft
Target Flights	* Radar-only retrieval * Comparison active and passive	8.5km x 9.5km	100m PLMR 10m-30m PLIS^{+}	1,000ft
PALSAR Transect	* Comparison of PLIS and PALSAR backscatters	8 x 22km	1km PLMR 10m-30m PLIS^{+}	10,000ft
Multi-angle Flights	* Effect of incidence angle on active and passive obs.	2 strips of 1km x 6km each	1km PLMR 10m-30m PLIS^{+}	10,000ft
Multi-azimuth flights	* Effect of azimuth view angle on PLIS radar observations	2 areas of 1km x 1km	500m PLMR 10m-30m PLIS^{+}	5,000ft
Orchard flights	* high resolution radar and radiometer data of ocrhard	1.3km x 3.5km	100m PLMR 10m-30m PLIS^{+}	1,000ft

$^{+}$ *PLIS resolution varies between 10m (45°) and 30m (15°)*

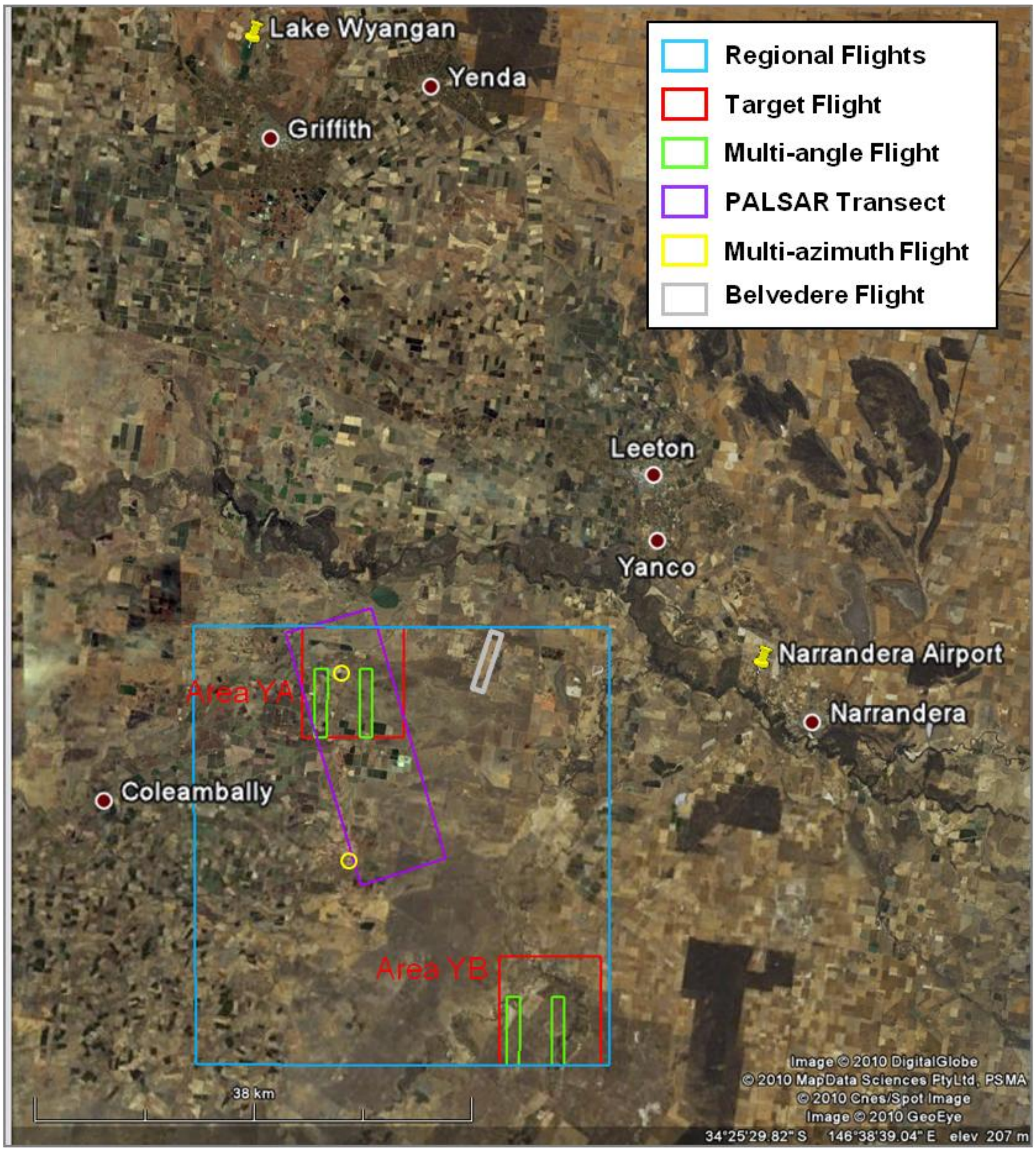


Figure 5-1. Schematic of SMAPEx-2 airborne monitoring approach.

All flights will be preceded and followed by specific low altitude passes of Lake Wyangan for in-flight calibration of the PLMR (section 5.8). An exception to this rule will the transect flights. In-flight calibration of the PLIS will also be performed (see section 0). An overview of the planned flight coverage is given in Figure 5-1. For detailed flight line coordinates see Appendix C.

All flights will be operated out of the Narrandera airport. The ferry flights to and from the airport were designed such that the aircraft will pass over at least one permanent monitoring station before and after covering the monitored area. This will allow identifying any changes in microwave emission between the start and the end of each flight associated to diurnal soil temperature variation rather than soil moisture changes. A partial repeat of the first flight line will also be performed at the end of the main flights (Regional and Target) to check for temporal changes in brightness temperatures during the airborne monitoring. The criteria followed to design the flight lines are explained in the following section, after which each flight type is described in detail.

5.1 Flight Line Rationale

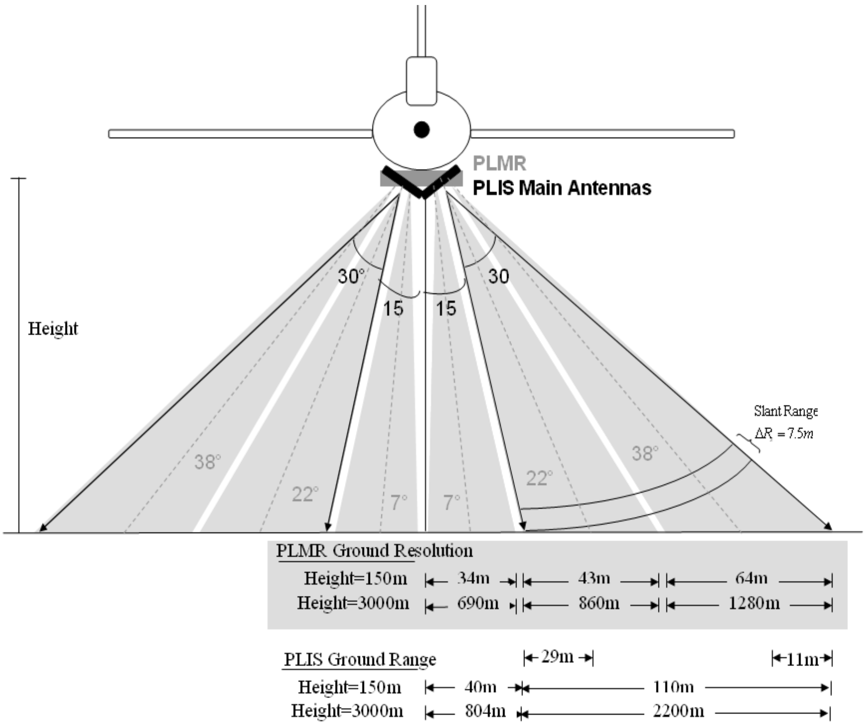


Figure 5-2. PLMR and PLIS viewing configuration on the RV-10 aircraft.

Most flights (except multi-azimuth) will be conducted along parallel flight lines, with flight line distance designed to allow full coverage of PLMR, PLIS and supporting instruments. Regional and target flights will be flown along north-south oriented flight lines, while transect flights will be flown with flight lines matching PALSAR equatorial inclination (98º), to avoid differences in azimuth viewing angle to affect the comparison between PLIS and PALSAR observations. Each flight line was extended of 2km outside the monitored area at both ends to ensure the aircraft has a stable attitude over the area monitored. The median surface elevation under the flight routes was used to determine the optimum flying altitude across the monitored area to maintain the target spatial resolution of airborne data.

The flight pattern for all flight types was largely determined by the viewing configuration of the PLMR and the PLIS as installed on the RV-10 aircraft. This is illustrated in Figure 5-2.

The PLIS will be installed under the RV10 fuselage, behind the PLMR. Since PLIS antennas radiate mainly between 15°-45° from nadir, at 10,000ft flying height this configuration will provide PLIS data over a swath of 2.2km on each side of the aircraft. The central portion of the PLIS swath between +15° and -15° about nadir (approximately 1,6km from 10,000ft flying height) will not provide useful data due to the elevated ground return. PLMR will observe the ground with six across-track beams (+/–7°, +/–21.5° and +/–38.5° with 14° across-track beamwidth), providing a swath of 6km from 10,000ft flying height, equivalent to total PLIS swath, with pixels of approximately 1km size. The viewing configuration for the reflectance and thermal radiometer sensors are the same as that of the PLMR.

The flight patterns were planned according to the following general criteria:

- Ensure full coverage of PLIS and PLMR data for the entire the study area;
- Flight line separation was set so as to guarantee either (i) coverage of the central portion of the swath where PLIS data are affected by the ground return, or (ii) overlap of the PLMR outer beams, whichever is smaller;
- Allow either (i) full auto-pilot control during the flight, in which case the 180° turns between adjacent flight lines must be wider than 2km or (ii) full manual control, in which case no restriction applies to the width of the 180° turns.

- In the case of multi-angle flight and PALSAR transect, the flight line separation was set so as to obtain PLIS data at the desired incidence angle.

These criteria resulted in variable flight lines separation and routes for each flight type, which are detailed in the following sections.

5.2 Regional Flights

Regional flights will be the core component of the SMAPEx-2 experiments. These will map a 34km by 38km area, correspondent to a SMAP radiometer pixel. The flying altitude will be of 10,000ft AGL, yielding active microwave observations at approximately 10m-30m spatial resolution (depending on the position within the PLIS swath) and passive microwave, supporting thermal infrared and spectral observations at 1km resolution. Such altitude was chosen to allow coverage of the entire study area in a timely fashion without compromising the functionality of the airborne instruments and aircraft system which is a risk at altitudes higher than 10,000ft AGL. Aggregation of the active and passive microwave data collected during Regional flights to the resolution of the EASE SMAP grids will provide prototype SMAP data for development and testing of (i) techniques for joint active and passive soil moisture retrieval development and (ii) techniques to downscale the coarse-resolution soil moisture retrieval from SMAP passive microwave observations using the fine-resolution active data. Regional monitoring will be repeated 3 times during each campaign (Monday, Wednesday and Friday), closely replicating SMAP revisit time (~3 days globally). It is expected that this approach will provide prototype SMAP data covering at least on wetting or drying cycle of the study area associated to rainfall events to further widen the range of conditions observed across seasons.

The flying altitude above sea level will be of 10,400ft, which results from flying above the median elevation of the terrain in the Yanco study area (128m). Given the small relief in the area (33m) the variation in ground spatial resolution for PLMR and supporting instrument due to variation in terrain elevation will not be appreciable. Regional flights will timed so that data acquisition will start at least 45min after sunrise (i.e., 5:54am EDT). This time was selected to ensure reliability of the vegetation reflectance data from the Skye sensors. Figure 5-3 gives an overview of the regional flight lines and coverage, while detailed flight line coordinates are given in Appendix C. The flight line pattern for regional flights will be of 10 flight lines off 42km length, with flight line separation of alternatively 2km and 5km, resulting in a swath overlap of, respectively, 67% and 18% for both PLMR and PLIS. The flight line pattern is schematically shown inFigure 5-4.

5.3 Target flights

Target flights will have the primary objective of providing active microwave data for testing of existing soil moisture retrieval algorithms for bare and vegetated surfaces from radar backscatters, as well as providing high resolution data over a heavily monitored area for investigating how different land surface factors affect active and passive microwave observations. Target flights will map one 8.5km x 9.5km sub-areas (Yanco A, "YA" area) from 1,000ft AGL flying altitude, collecting active microwave observations at approximately 10m-30m spatial resolution and passive microwave, supporting thermal infrared and spectral observations at 100m resolution. Such altitude was chosen to obtain high resolution PLMR data while ensuring sufficient re-sampling of PLMR and PLIS footprints at the sampling rate set in the instruments. The area will be covered on one occasion (December 5). The area are equivalent in size to one pixel of the future SMAP downscaled soil moisture product

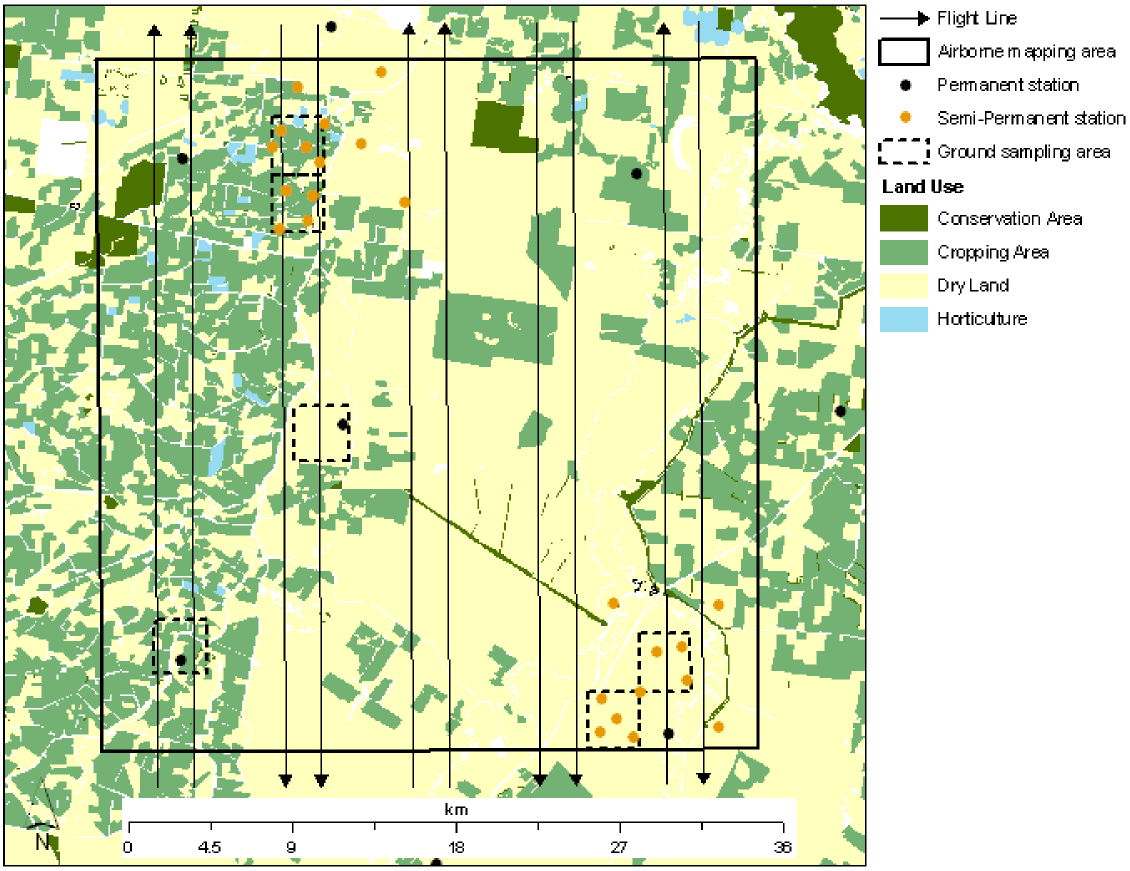


Figure 5-3. Overview of SMAPEx-2 regional flights. Also indicated are the ground monitoring network and sampling areas.

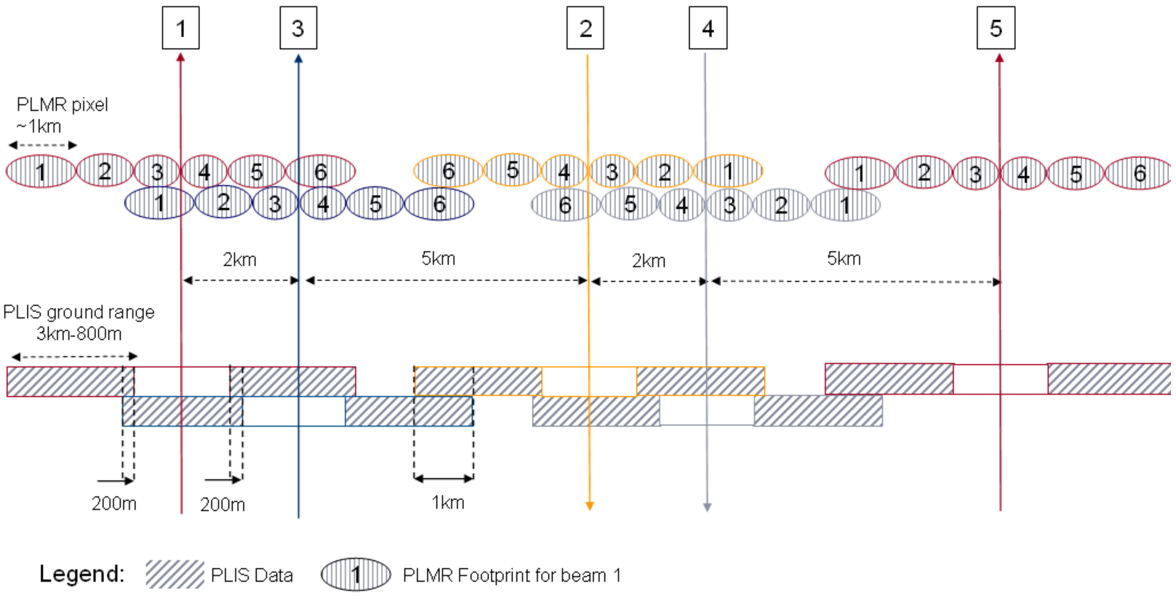


Figure 5-4. Flight line pattern and PLIS/PLMR overlap diagram for SMAPEx regional flights. Different flight lines are indicated by different colors.

Figure 5-5. Overview of SMAPEx-2 target flights. Also indicated are the ground monitoring network and sampling areas.

(L3_SM_A/P product, 9km x 9km) and is heavily monitored 13 permanent monitoring stations. Figure 5-5 gives an overview of the target flight lines and coverage, while detailed flight line coordinates are given in Appendix C. Note that the "YB" area indicated in the figure, although part of the SMAPEx general strategy, will not be covered by target flights during SMAPEx-2 due to extended flooding

The flying altitude above sea level will be of 1,400ft for both YA and YB areas, resulting from flying above the median elevation of the terrain in the areas (132m for YA and 123m for YB). Target flights will be conducted over a 3.6 hours time window with departure from the airport timed so that data acquisition will start 45min after sunrise (happening at 5:54am EDT). This time was selected to ensure reliability of the vegetation reflectance data from the Skye sensors and to minimize the perturbation on the L-band signal due to differences between air, vegetation and soil temperature (which are almost in equilibrium around sunrise), which affect the soil moisture retrieval from passive microwave data.

The flight line pattern for target flights resulting from the criteria discussed in section 5.1 is that of 25 flight lines of 13.5km length, with flight line separation of alternatively 200m and 500m, resulting in a swath overlap of, respectively, 67% and 18% for both PLMR and PLIS. The flight line pattern is schematically shown in Figure 5-6.

5.4 Multi-angle Flights

In order to closely replicate SMAP data, every portion of the study area should be observed at the same incidence and azimuth view angle. However, this cannot be achieved with an

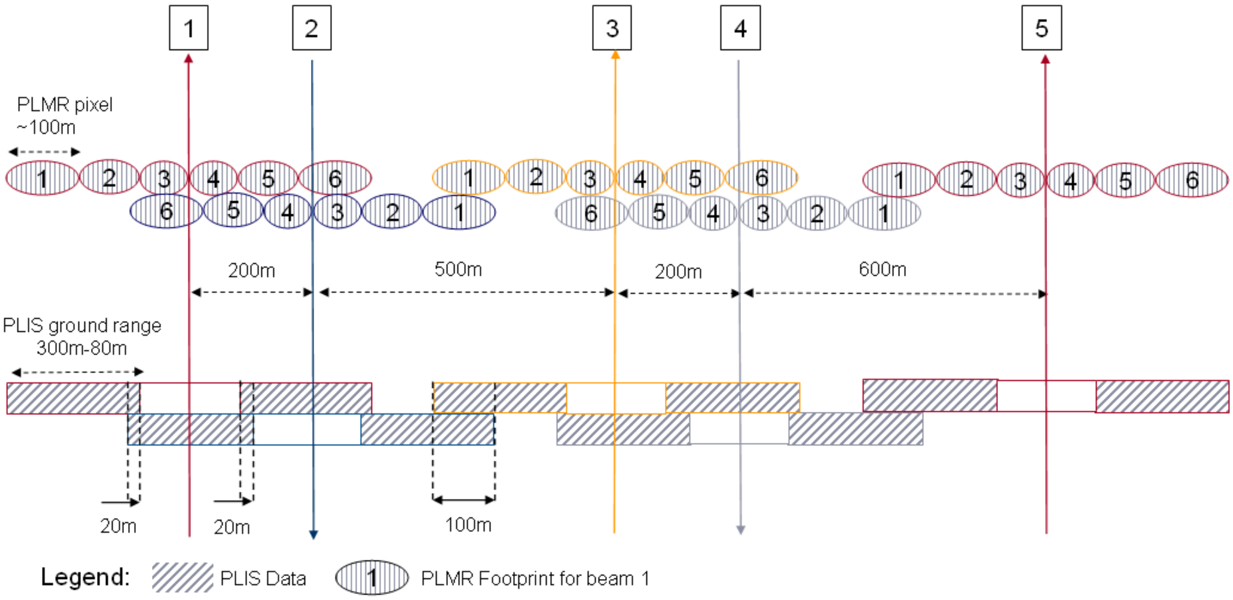


Figure 5-6. Flight line pattern and PLIS/PLMR overlap diagram for SMAPEx target flights. Different flight lines are indicated by different colors.

airborne instrument over an area as large as the SMAPEx study area. Multi-angle flights were therefore designed to provide data for characterizing the variation of radar backscatter measured by PLIS with incidence angle and. To this end, multi-angle flights will cover portions of areas YA and YB so that the same ground locations are observed by PLIS at a variety of incidence angles. The flying altitude will be 10,000ft (AGL) to collect multi-angle active microwave observations at approximately 10m-30m spatial resolution and passive microwave, supporting thermal infrared and spectral observations at 1km resolution.

The flight line pattern will be of 8 parallel flight lines, each 10.5km in length, separated of 360m. Given that the relationship between incidence angle range and ground range for PLIS is non linear, obtaining multi-angle PLIS data of the same ground locations at a fixed incidence angle step would require variable flight line separation, which is considered not practical. Therefore, the flight line separation of 360m was chosen as that equivalent to a variation of incidence angle of 5° at the center of the PLIS swath. This configuration will provide PLIS multi-angle data over 2 ground strips of 1km x 6km in size at the range of angles shown in Table 5-2, with minimal deviation from the nominal 5° incidence angle step. The flight lines will be covered consecutively from west to east. Figure 5-7 gives an overview of the multi-angle flight lines and coverage, while detailed flight line coordinates are given in Appendix C.

Table 5-2 Range of incidence angles at which concurrent PLIS observations will be collected during SMAPEx multi-angle flights

Mean Incidence Angle	43°	39°	35°	30°	24°	18°
Extremes	41.3°-45°	41.3°-37.1°	37.1°-32.4°	32.4°-27.1°	27.2°-21.3°	21.3°-15.0°
Angle range	3.7°	4.2°	4.7°	5.3°	5.8°	6.3°

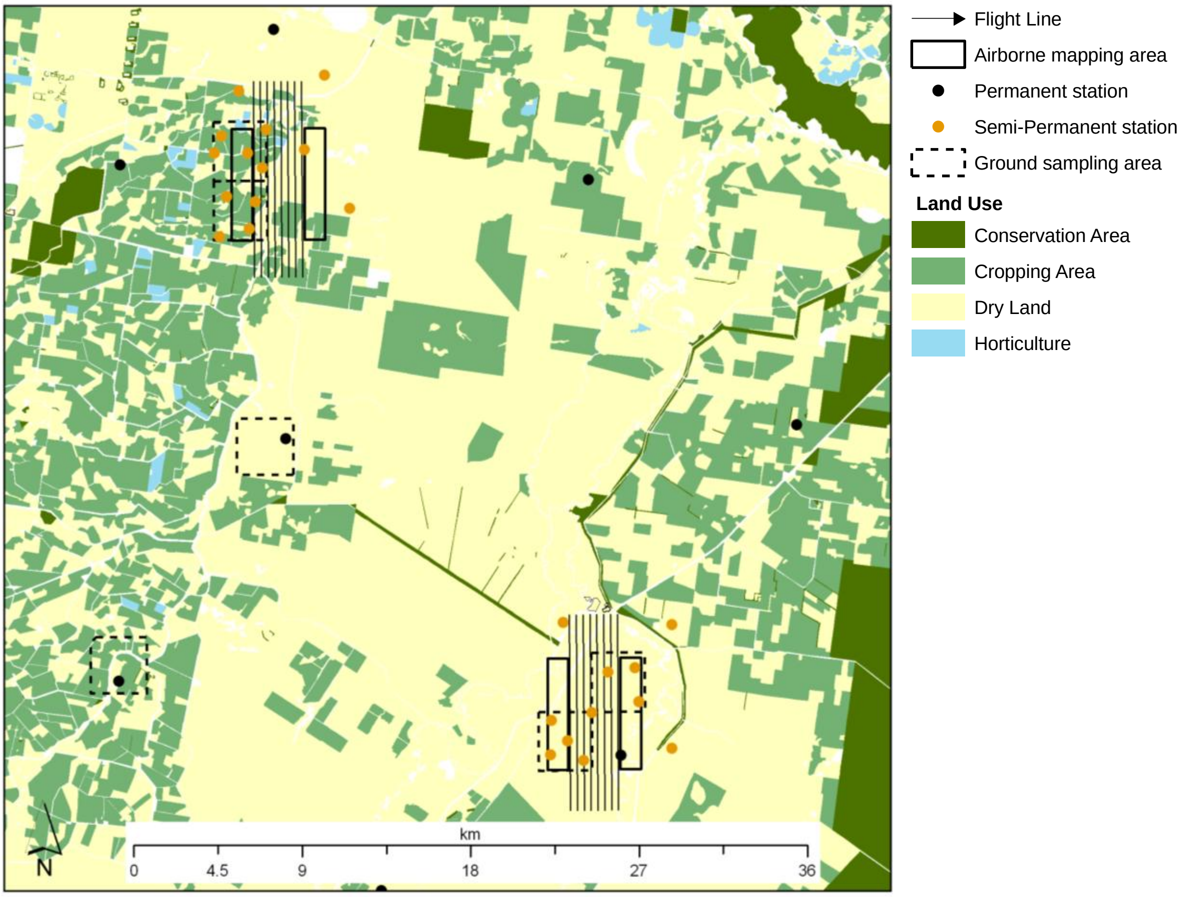


Figure 5-7. Overview of SMAPEx multi-angle flights. Also indicated are the ground monitoring network and sampling areas.

5.5 Transect Flights

Transect flights will be undertaken concurrently with the overpass of the ALOS platform. This will allow cross-comparison of the airborne active microwave data of PLIS with those of the PALSAR sensor onboard ALOS. Ideally, transect flights will be timed to match as much as possible (logistics permitting) PALSAR local overpass time for ascending orbits (24:30 EDT, 13:30 UTC), which are the passes where PALSAR sensor acquisitions are favoured in the ALOS acquisition strategy over the optical instruments also onboard ALOS. However, due to restrictions with night-time flying, the PALSAR transect will be anticipated. Due to limitation on the total campaign flight time, transect flights will cover only a 8km x 22km section of the study area from 10,000ft AGL flying altitude (10,400ft ASL), collecting active microwave observations at approximately 10m-30m spatial resolution. However, the focus area was selected to cover both cropping areas and grazing land, land covers representative of the SMAPEx study area.

The transect flight lines were designed to match as closely as possible the PALSAR viewing configuration in Fine Beam mode (Inclination: 98°, Incidence angle: 34°). Therefore, the flight line separation (685m) was chosen to provide continuous PLIS data at incidence angles between 30°-40°, with 100m overlap between adjacent 30°-40° data strips. Figure 5-8 gives an overview of the transect flight lines and coverage, while detailed flight line coordinates are given in Appendix C. The flight lines will be covered consecutively from west to east. Due to limitations in night-time flying altitude, no overpasses of Lake Wyangan for PLMR calibration will be performed for transect flights.

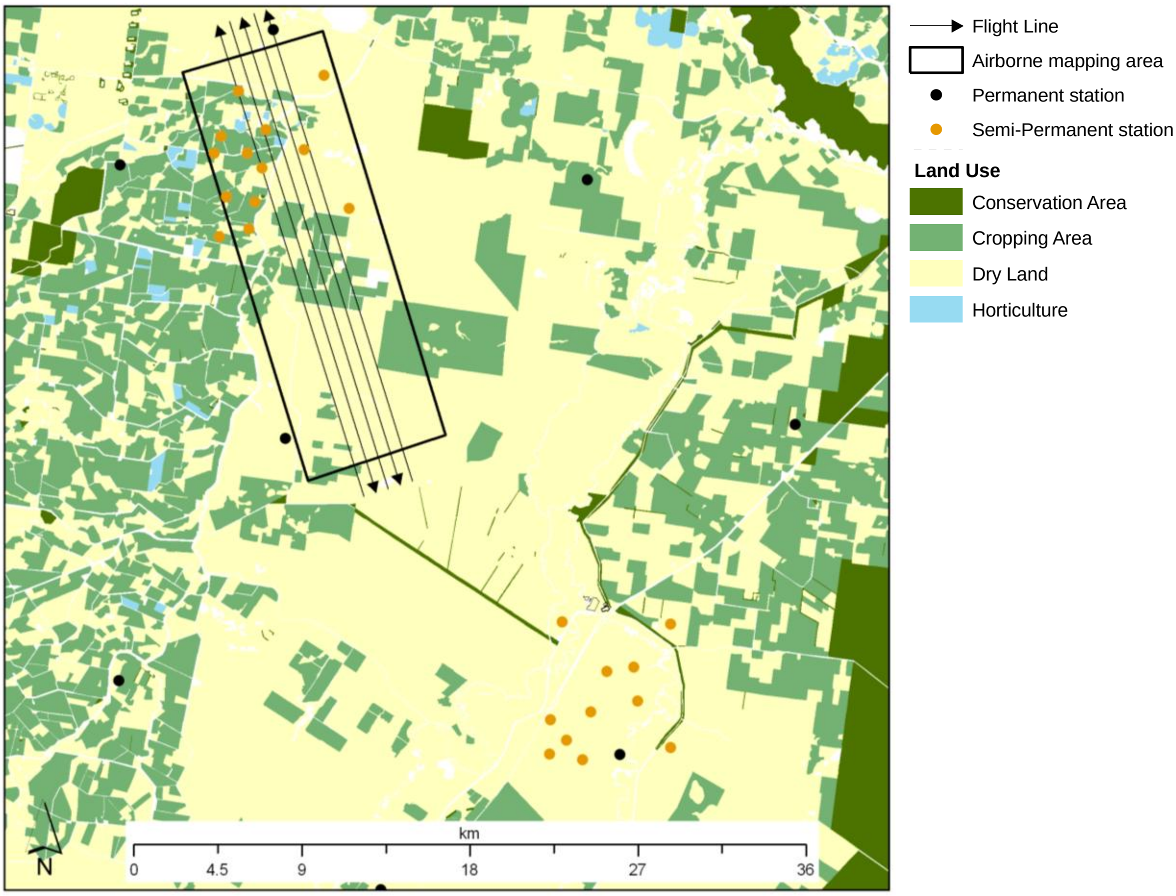


Figure 5-8. Overview of SMAPEx PALSAR transect flights. Also indicated is the ground monitoring network (Ground sampling areas not indicated since there won't be any ground sampling during transect flight due to night time flying).

5.6 Azimuth Flights

SMAP will make use of a rotating antenna mesh to provide radar observations over the entire swath. Therefore, it will be important to understand the effect of the azimuth viewing angle on the power backscatter by the land surface. To this end, PLIS will be flown to observe a two focus areas from different azimuth view angles (0°-180° with 30° increments). Flights will be performed at low altitude (5,000ft AGL, 5,400 ASL) in order to maximize the sensitivity of the PLIS radar to changes in backscatter due to the azimuth view angle. The ground spatial resolution for active microwave observations will be approximately 10m-30m. Azimuth flights will be undertaken one occasion during SMAPEx-2. The target areas will be one uniform grassland site and a heterogeneous site comprised of a mix of crop (maize and wheat), native pasture and bare soil wit crop rows. This will allow investigation of the effect of azimuth view angle on a variety of land cover types. The ground area where observations will be collected at multiple azimuth angles will be approximately a circle of radio 500m.

Figure 5-9 gives an overview of the azimuth flight lines and coverage, together with the center coordinates of the multi-azimuth focus areas, while detailed flight line coordinates are given in Appendix C.

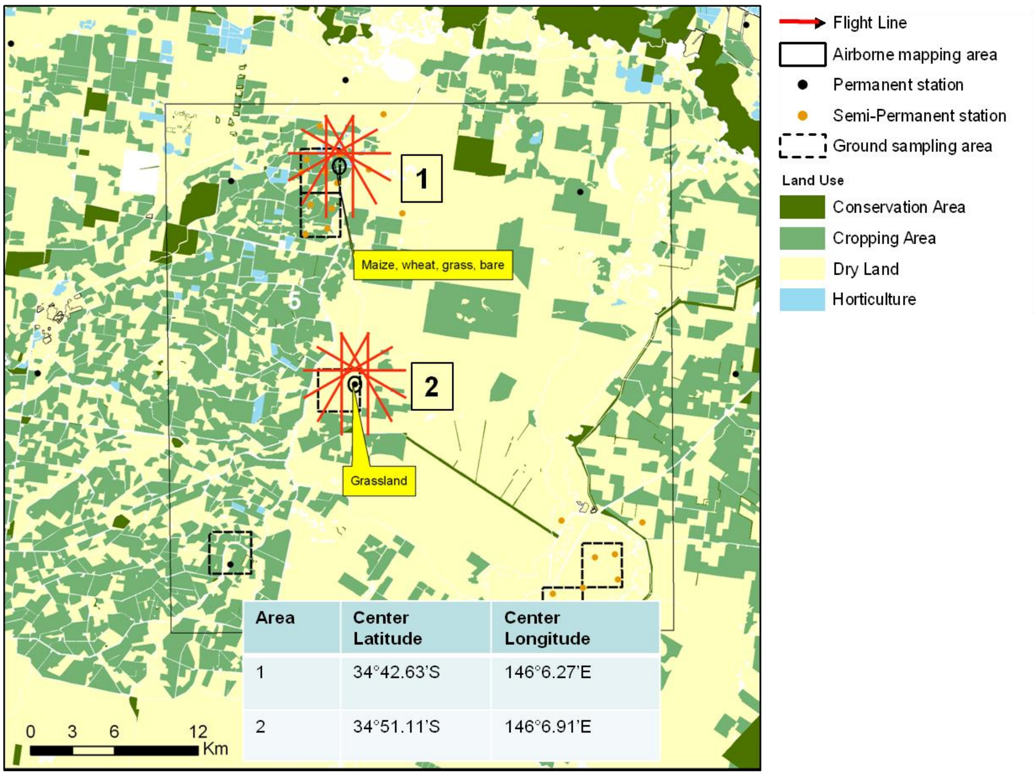


Figure 5-9. Overview of the SMAPEx-2 multi-azimuth flights. Also indicated is the ground monitoring network

5.7 Belvedere Orchard Flight

A specific flight will be conducted on one occasion to collect high resolution (1200m for the PLMR and 10m for the PLIS) over an extensive Orchard located at the Belvedere farming complex . This flight will be conducted on the same day as Target flights on area YA (December 5) given the similar altitude.

Figure 5-10 gives an overview of the flight lines of the Belvedere orchard, together with the coordinates of the airborne coverage corners. Detailed flight line coordinates are given in Appendix C.

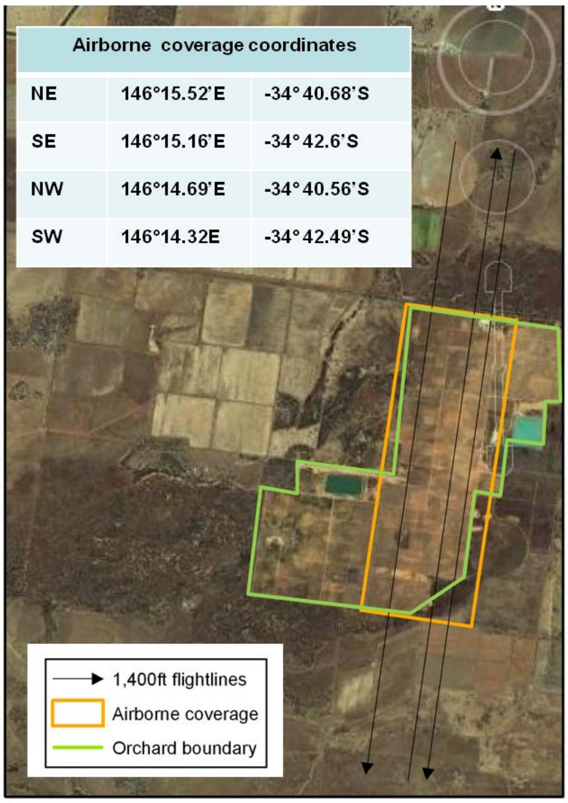


Figure 5-10 Overview of the SMAPEx-2 high-resolution flight over the Belvedere orchard.

5.8 PLMR Calibration

The normal operating procedure for PLMR is to perform a "warm" and "cold" calibration before, during and after each flight. The before and after flight calibrations are achieved by removing PLMR from the aircraft and making brightness temperature measurements of a calibration target and the sky (see Figure 5-11). The in-flight calibration is accomplished by

Figure 5-11. Upper left: undertaking a sky cold point calibration with PLMR; upper right: undertaking a warm point calibration with the calibration box shown in the inset; lower left: the buoy used to monitor water temperature and salinity; lower right: undertaking a boat transect of water salinity and temperature.

measuring the brightness temperature of the sky during a series of steep turns (if possible) and of a water body. Lake Wyangan will be used as a cold target for in-flight calibration of PLMR (see Figure 5-1).

Given the relatively small size of the water storages, PLMR will be flown at the lowest permissible altitude (500ft) so as the swath of the instrument (300m at 500ft) will be entirely included within the lake boundary along a distance of around 1km. Calibration flights are illustrated in Figure 5-12.

Ground requirements for over-water flights include monitoring of the water temperature and salinity within the top 1cm layer of water. Both quantities will be monitored continuously during the campaign using a UNIDATA 6536B® temperature and salinity sensor connected to a logger, located at 146° 1.32’E and 34° 13.14’S at Lake Wyangan. Furthermore, transects of water temperature and salinity in the top 1cm layer will be undertaken

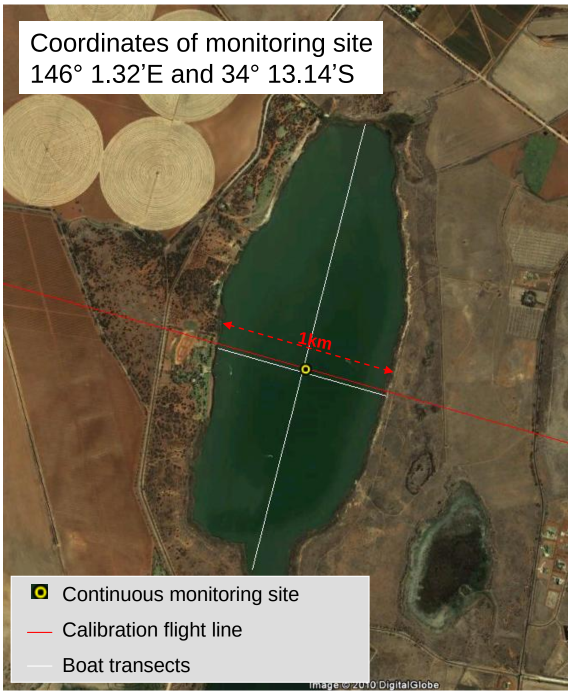


Figure 5-12. Calibration flight (red line) and boat transects (white lines) over Lake Wyangan

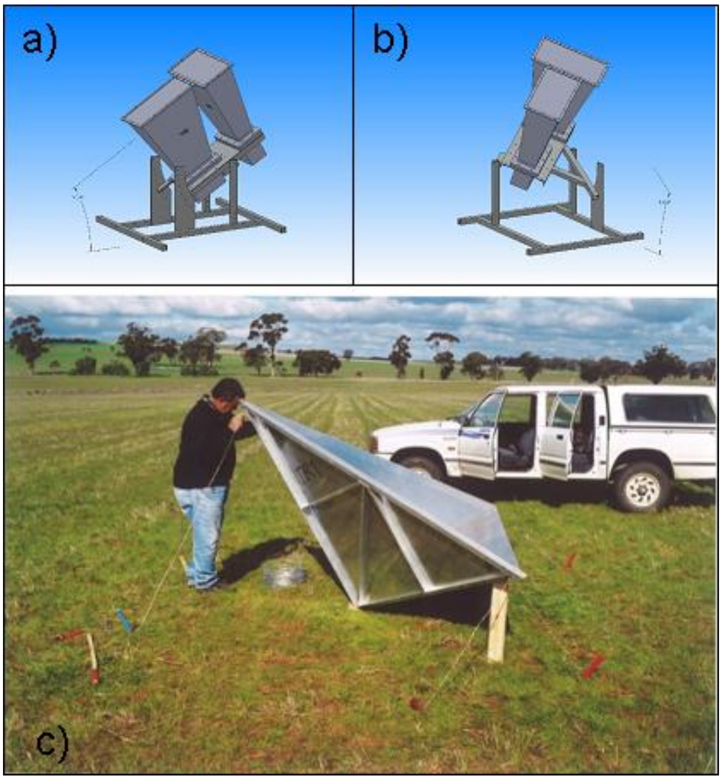


Figure 5-13. Polarimetric Active Radar Calibrators #1 and #2 (a), #3 (b) and Passive Radar Calibrator (c)

with a handheld temperature and salinity meter (Hydralab Quanta®) at the start and end of the week, coincident with regional flights (see Figure 5-13). This will involve making north-south and east-west transects at 100m spacing centred on the monitoring station. The purpose of these measurements is to check for spatial variability. Rodger Young will be responsible person for these measurements.

5.9 PLIS Calibration

Calibration of PLIS will be performed using three triangular trihedral passive radar calibrators (PRCs) and three Polarimetric Active Radar Calibrators (PARCs).

5.9.1 Polarimetric Active Radar Calibrators (PARCs)

The PARCs are high radar-cross-section transponder with a known scattering matrix (see Figure 5-13). PARCs detect the incident microwave energy radiated by the PLIS and then transmit back to the radar an amplified signal at a known level and equivalent radar cross-section. These can be used to calibrate the PLIS radar by employing a set of three PARCs, with one aligned to receive vertical polarization and re-transmit horizontal polarization (PARC #1), a second aligned to receive horizontal polarization and re-transmit vertical polarization (PARC #2), and a third aligned to receive 45° linear polarization and re-transmit - 45° linear polarization (PARC #3).

During SMAPEx-2, the PARCs will be located in an open, flat area within the Narrandera Airpot (see Figure 5-14). Calibration of PLIS will be performed along a "calibration circuit" consisting of 3 overpasses of the PARCs (runs 1, 2 and 3). In order to be clearly distinguishable in the radar images the three PARCs will aligned at 45° with respect to the

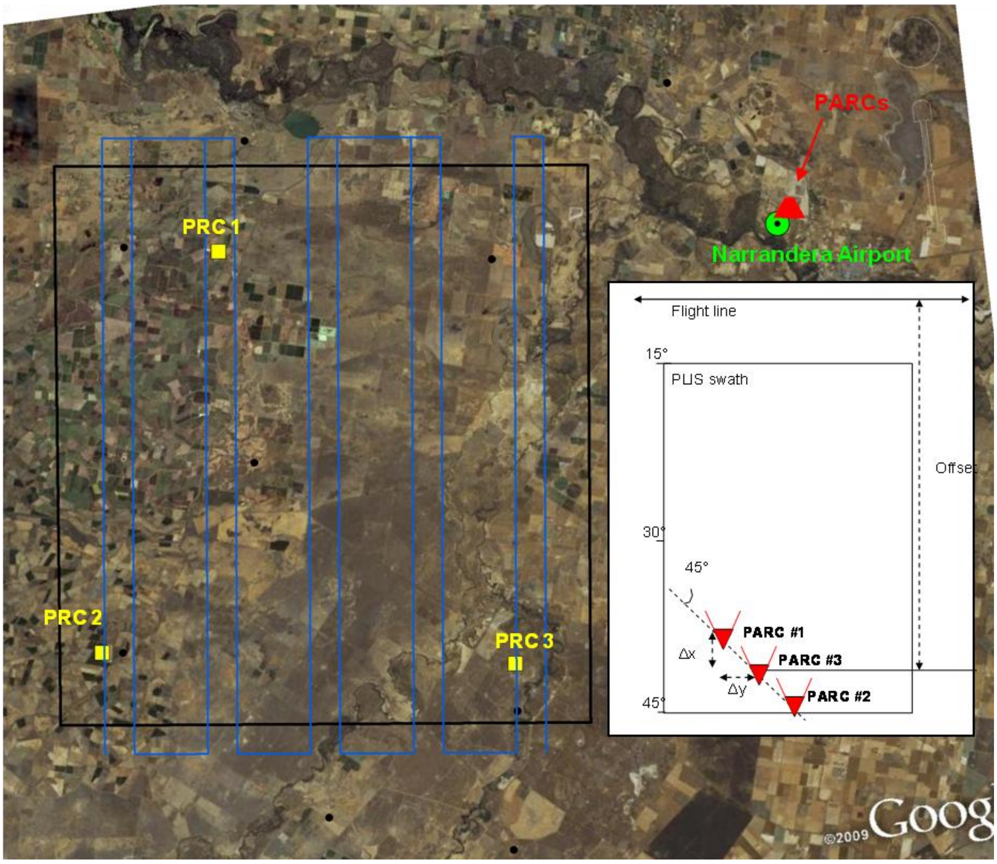


Figure 5-14. Locations of PARCs (red triangle) and PRCs (yellow square) in the SMAPEx study area (black outline) and location relative to the regional flight lines (blue lines). The inset shows the PARCs configuration (Offsets and values of Δx and Δy for each calibration run are detailed in Table 5-3)

Table 5-3. PLIS calibration circuits. For each run the offset the flight line with respect to the location of the centre PARC (# 3) is indicated, as well as the which PARCs (# 1, 2 or 3) will fall within the 15°-45° PLIS swath.

Calibration Type	Altitude (ft AGL)	PARCS Δx, Δy	Run 1 (inner swath)		Run 2 (center swath)		Run 3 (outer swath)	
			Offset*	PARCS	Offset*	PARCS	Offset*	PARCS
Regional	10,000	200m, 200m	1000	1,2,3	1700	1,2,3	2800	1,2,3
Target	1,000	100m, 100m	80	2,3	180	1,2,3	300	1,3

**The offset zero datum is the location of PARC type 3*

calibration flight lines, in the order type 1, type 3 and type 2 going outward in the PLIS swath (see inset in Figure 5-14). All PARCs will be oriented at 30° incidence angle, corresponding to the PLIS incidence angle at the center of the swath. Each overpass will be offset with respect to the PARCs so that these fall towards the outer edge (45° incidence angle), in the center (30°) or towards the inner edge (15°) of the PLIS swath in respectively run 1, run 2 and run 3, in order to verify the radar performance across the entire swath and at both polarizations. Detailed characteristics of the calibration circuit are given in Table 5-3, while flight line coordinates are given in Appendix C. Each flight line will be repeated in both directions to calibrate both left and right antenna of the PLIS. The aircraft altitude will depend on the altitude of the scientific flight to be undertaken on the day. On regional monitoring days, calibration will be performed at 10,000ft altitude (AGL). On target monitoring days, the altitude will be 1,000ft (AGL). On target monitoring days only certain PARCs will be visible by the radar on each run, due to the narrow PLIS swath from 1,000ft flying height (220m), and the need to maintain the PARCs separated of at least 100m to be distinguishable in the range profile, (this is indicated in Table 5-3). The PARC's coordinates The exact PARC's coordinates will be communicated in an addendum to this document.

Due to flight time restrictions, the calibration circuit will be generally undertaken only at the end of the airborne monitoring. However, on one day (first regional monitoring day, December 4) PLIS calibration will be undertaken both at the beginning and at the end of the airborne monitoring to check for calibration drift during flight.

5.9.2 Passive Radar Calibrators (PRCs)

The PRCs are metallic corner reflectors (see Figure 5-13) capable of reflecting the incident microwave energy radiated by the PLIS back to the radar. Due to the limited scattering of the incident radiation, they can be used as a point of spatial reference in the radar image. The triangular trihedral configuration ensures a good reflection over a range of angles about bore sight (the angle of view at which they appear symmetrical, 66° from nadir).

The three PRCs will be deployed across the 34km x 38km SMAPEx study area to check for the stability of PLIS calibration during flights. The exact locations will be chosen so that PLIS calibration can be checked: (i) at the beginning, middle and end of the data acquisition window (ii) over three different land cover types. Each PRCs will be located as close as possible to the center of the PLIS swath (30° incidence angle), so that the aircraft will be aligned with the PRCs boresight (36° from nadir), therefore maximizing the reflection of the PLIS incidence microwave radiation back to the radar. This means the PRCs will have an approximate offset with respect to the flight lines of 1700m for 10,000ft flying altitude (regional) and 170m for 1,000ft flights (target). The actual locations of the PRCs will be decided depending on the ground conditions at the time of the campaign and might be subjected to logistic constraints. The proposed locations for the PRCs are those from the SMAPEx-1 campaign, shown in Figure 5-14. The actual PRC's coordinates will depend on the land cover conditions and will be communicated in an addendum to this document

5.10 Flight Time Calculations

In order to provide an estimate of the total flight time, climb/turn and cruise speeds of the aircraft were assumed to be 110kts and 140Kts, respectively. The climb rate was assumed to be 300ft/min and the time to descend from maximum altitude to ground level was set to a minimum of 10min. To account for turns, the flight lines were extended 2km beyond the measurement area to ensure aircraft attitude stability over the data acquisition area. Turning times was set to 1min, 2min and 3min for flight separation of respectively 2km, 5km and 7km (regional flights), after the analysis of actual aircraft data from previous NAFE campaigns. For flight line separations smaller than 2km (target, multi-angle and transect flights), a turning time of 2min was accounted for to allow for a dumb-bell turn. A 10min buffer was also added to the flight time to account for arrival and departure manoeuvres (taxi etc.). The estimated times for each flight type are given in Table 5-4.

5.11 Flight Schedule

SMAPEx-2 flights will be undertaken every day for 5 days (see flight schedule in Table 5-4). regional flights will be conducted every other day (December 4,6 and 8) for a total of 3 regional monitoring, to provide prototype SMAP data over an area the size of a SMAP radiometer footprint, with near-daily repeat time, for development and testing of joint active and passive microwave soil moisture retrieval and downscaling techniques. During the days not covered by regional flights (December 5 and 7), the other flight types will be conducted (PALSAR transect, multi-angle, multi-azimuth and orchard flights).

On December 5 target flight over area YA will be conducted to provide high-resolution radar and radiometer data over for development of radar-only soil moisture retrieval and comparison of active and passive soil moisture signatures.

On December 7, transect, multi-angle and multi-azimuth flights will be conducted. Multi-angle flights have the objective of investigate the effect of incidence and azimuth view angles on the radar backscatter which might affect the prototype SMAP data obtained during regional flights. Since extensive multi-angle flights were already conducted during the SMAPEx-1 campaign, during SMAPEx-2 these will be repeated only on one occasion (see Table 5-4), A secondary objective of SMAPEx-2 is to compare ALOS PALSAR and PLIS backscatters for verification of PLIS performance. The SMAPEx-2 transect flight will therefore made to coincide as much as possible, given logistical constraints, with the ascending PALSAR overpass in Fine Beam mode closest to the campaign dates (7/12/2010 13:45 UTC). Fine Beam mode was chosen since the incidence angle (34.3°) closely matches that SMAP (40°) incidence angle.

Low-altitude PLMR calibration flights over Lake Wyangan will be performed right after take-off and prior to landing on each monitoring day (with the exception of transect flight of December 7, when no in-flight PLMR calibration will be performed due to restrictions on night time flying altitude). The PLIS calibration circuit will also be performed prior to landing at the end of the daily monitoring. The order in which PLMR and PLIS calibration will be performed will be dictated by the altitude of the flight conducted on the day. After high altitude flights (10,000ft), high-altitude PLIS calibration will be undertaken before low-altitude PLMR calibration and landing. After low-altitude flights (1,000ft), PLMR calibration will precede PLIS calibration and then landing. One occasion (December 4) PLIS calibration will be undertaken both after take-off and before landing, to check for PLIS calibration drift in flight.

Table 5-4. SMAPEx-2 flight schedule and flight sequence for each flight (M= Mapping, PC=PLMR calibration. LC=PLIS calibration, TO=Take-off, LA=Landing)

Date/Time (UTC)	Date/Time (EDT)	Flight Type	Duration (hrs)	Flight sequence
3/12/2010 22:00	4/12/2010 8:00	Regional	4.6	TO – PC – LC – M – LC – PC – LA
4/12/2010 22:00	5/12/2010 8:00	Target YA	4.0	TO – PC – M – PC – LC – LA
5/12/2010 22:00	6/12/2010 8:00	Regional	4.3	TO – PC– M – LC– PC – LA
6/12/2010 22:00	7/12/2010 8:00	Multi-angle	1.9	TO – PC– M
7/12/2010 0:00	7/12/2010 10:00	Multi-azimuth	3.2	– M – PC – LA
7/12/2010 11:40	7/12/2010 21:40	Transect	1.9	TO– M – LC – LA
7/12/2010 22:00	8/12/2010 8:00	Regional	4.3	TO – PC – M – LC– PC – LA
		Total campaign	**24.2**	

6 Ground Monitoring

This chapter should be read in conjunction with Chapter 6.4.7 where ground sampling protocols are presented, and Chapter 8 where logistics are discussed. Ground monitoring for the SMAPEx campaigns was designed with the two-fold objective of (i) validating the aircraft radiometer and radar observation and (ii) providing supporting ground data for the prototype SMAP data that will be created by aggregation of aircraft data at the spatial resolutions of the future SMAP products (36x38km for the radiometer-only retrieval, 8.5km x 9.4km for the merged active and passive retrieval and 2.8km x 3.1km for the radar-only retrieval). In addition to the network of continuous soil moisture monitoring stations (permanent and semi-permanent) described in section 4.3, the ground monitoring component of the SMAPEx campaigns will focus on six focus areas equivalent to six SMAP radar pixels. Within each area, ground monitoring will include:

1. Supplementary monitoring stations;
2. Intensive spatial monitoring of the top 5cm soil moisture; and
3. Intensive spatial monitoring of supporting data (land cover, soil surface roughness and soil gravimetric samples).

It is important to note that, to facilitate comparison with satellite observations of the study area, some data set will be recorded using Coordinated Universal Time (*UTC*) as reference; these will be the time-varying data for which an exact temporal synchronization is crucial (aircraft data, continuous monitoring stations and HDAS spatial measurements). All the remaning data set will be recorded in local time for simplicity, i.e., Australian Eastern Standard Time (EST, UTC+10 hours) or Eastern Daylight Time (EDT, UTC+11 hours), depending on the period. For the SMAPEx-2 period, the local time will be EDT.

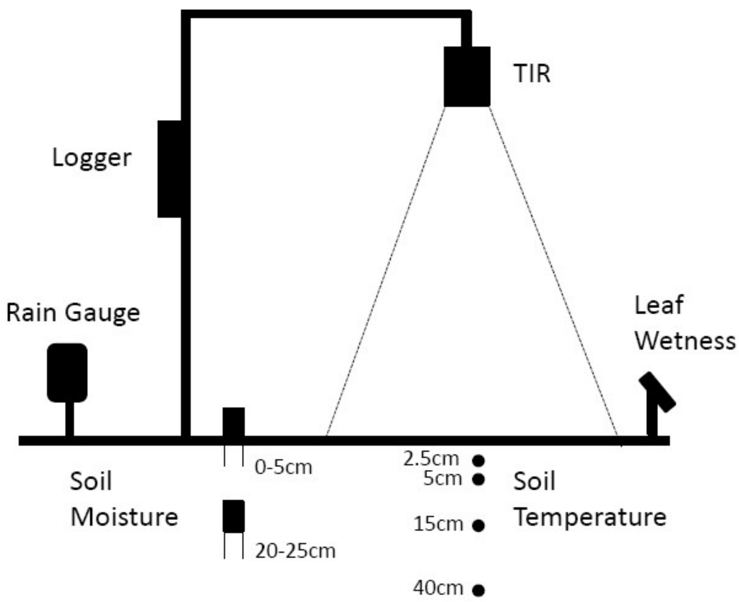


Figure 6-1. .Schematic of the temporary monitoring station.

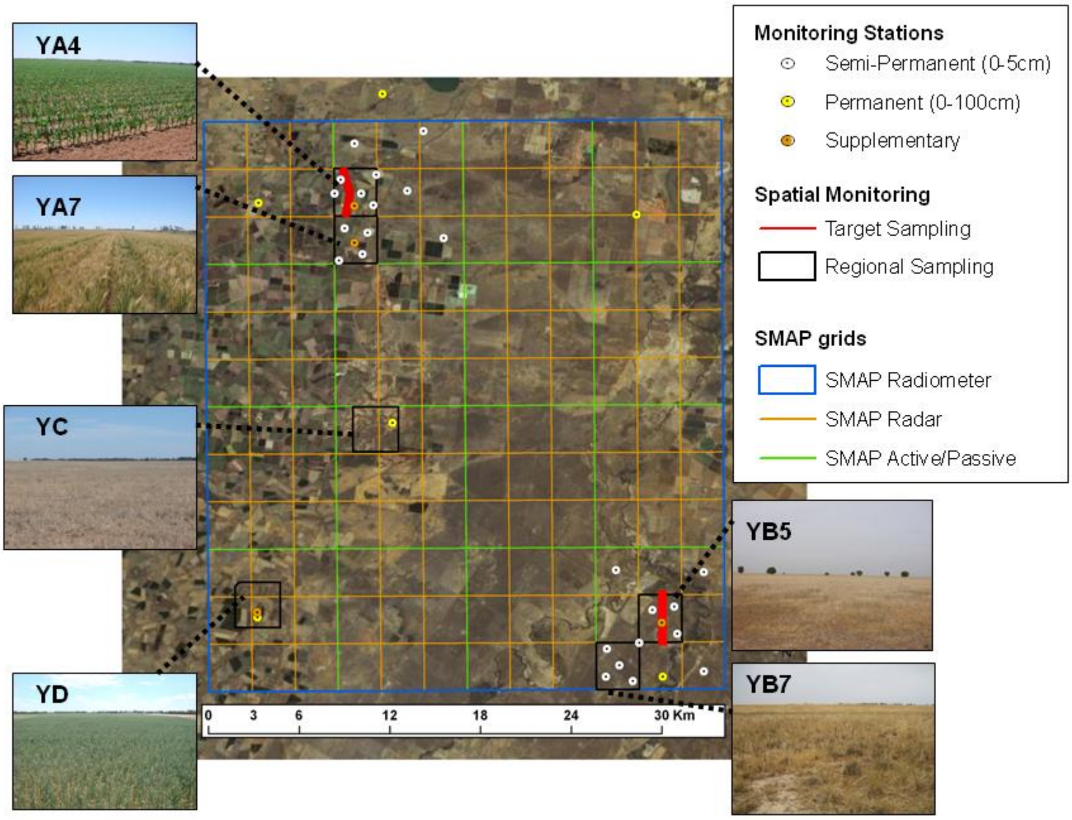


Figure 6-3. Overview of SMAPEx-2 ground sampling areas with photographs.

6.1 Supplementary Monitoring Stations

Permanent monitoring stations will be supplemented by four identical temporary monitoring stations at each focus farm. These short-term monitoring stations will be instrumented with a raingauge, thermal infrared sensor (2 Thermalerrt Tx and 2 Apogee sensors), leaf wetness sensor (MEA LWS v1.1), two soil moisture sensors (Delta-T Thetaprobes; 0-6cm and 23-29cm) and four soil temperature sensors (MEA6507A; 2.5cm, 5cm, 15cm and 40cm depth) in order to provide time series data during the sampling period (Figure 6-1).

Such measurements will be used for identifying the presence or absence of dew, and verifying the assumptions that i) effective temperature has not changed throughout the course of the aircraft measurements; ii) vegetation and soil temperature are in equilibrium; and iii) soil moisture has not changed significantly during ground sampling. The supplementary stations will be distributed across the study area to monitor vegetation and soil temperature in representative areas on the basis of dominant vegetation type(s). This however means that the locations will depend on the cropping conditions at the time of the campaign as well as be subjected to logistical constraints. The proposed locations of supplementary monitoring stations and the vegetation type covered are indicated in Figure 6-2, The actual locations will be communicated in an addendum to this document. Supplementary monitoring station data will be recorded in UTC time reference.

6.2 Spatial Soil Moisture Sampling

During SMAPEx-2 intensive spatial ground sampling will focus on six, 2.8km x 3.1km focus areas (hereby referred to as "focus areas") distributed across the simulated SMAP radiometer pixel (see Table 6-2). The ground sampling areas overlap with six future SMAP radar pixels and were selected to cover the representative land cover conditions within the study area. Figure 6-3 gives an overview of the locations of the focus areas in relation to the future SMAP grids. The characteristics of the focus areas are listed in Table 6-2. While most focus areas exactly match the future SMAP radar grid, in some cases (YC and YD, see Figure 6-3) the focus areas are slightly shifted with respect to the grid due to property access issues.

Soil moisture will be monitored daily at the focus areas using the Hydraprobe Data Acquisition System (HDAS). Two soil sampling patterns will be in order to provide ground data suitable to each flight's characteristics and scientific objectives:

1. "Regional sampling" on days when regional flights are planned;
2. "Target sampling" days when target or PALSAR transect flights are planned

Table 6-1 indicates the ground sampling schedule, while specific sampling patterns for regional and target flight day are described in the next sections. Spatial soil moisture data will be recorded in UTC time reference.

Table 6-2. Characteristics of the SMAPEx-2 ground sampling areas. Soil texture data are derived from *soil particle analysis of 0-30cm gravimetric samples or **CSIRO, Digital Atlas of Australian Soils (1991)

Area Code	Land Use	Vegetation Type (s)	Mean Elevation	Soil texture (%C/%Si/%S)
YA4	Irrigated cropping (90%); Grazing (10%)	wheat, barley, maize, oats rice, improved pasture	131m	Clay loam (31/48/20)*
YA7	Irrigated cropping (90%); Grazing (10%)	Wheat, oats, rice; improved pasture	130m	Clay loam (31/48/20)*
YC	Grazing (100%)	Native or improved pasture	127m	Silty clay loam (39/43/17)*
YD	Irrigated cropping (10%); Pasture (90%)	Maize, wheat , rice, oats improved pasture	132m	Loam (23/47/29)*
YB5	Grazing (100%)	Native or improved pasture	122m	Loam (N/A)**
YB7	Grazing (100%)	Native or improved pasture	123m	Loams (N/A)**

Table 6-1. Airborne and Ground Sampling Schedule (Sampling areas are shown in Figure 6-3). Prefix [c] indicates mostly cropping area while [g] stands for mostly grazing area

	4/12	5/12	6/12	7/12	8/12
Airborne	Regional	Target Area YA	Regional	PALSAR transect	Regional
Soil Moisture Sampling	YA4[c] YB5[g]	Transect YA4[c]	YD[c] YC[g]	Transect YA4[c]	YA7[c] YB7[g]
Vegetation Sampling	YA4[c]	YA4[c]	YD[g] YC[g]	YA7[c]	YB5[g] YB7[g]

6.2.1 Regional Sampling

During each of the three regional flight days, two focus areas will be sampled in rotation, one of which will be characterised by cropping land use and the other by grazing. Each 2.8km x 3.1km focus area will be monitored using a north-south oriented regular grid of sampling

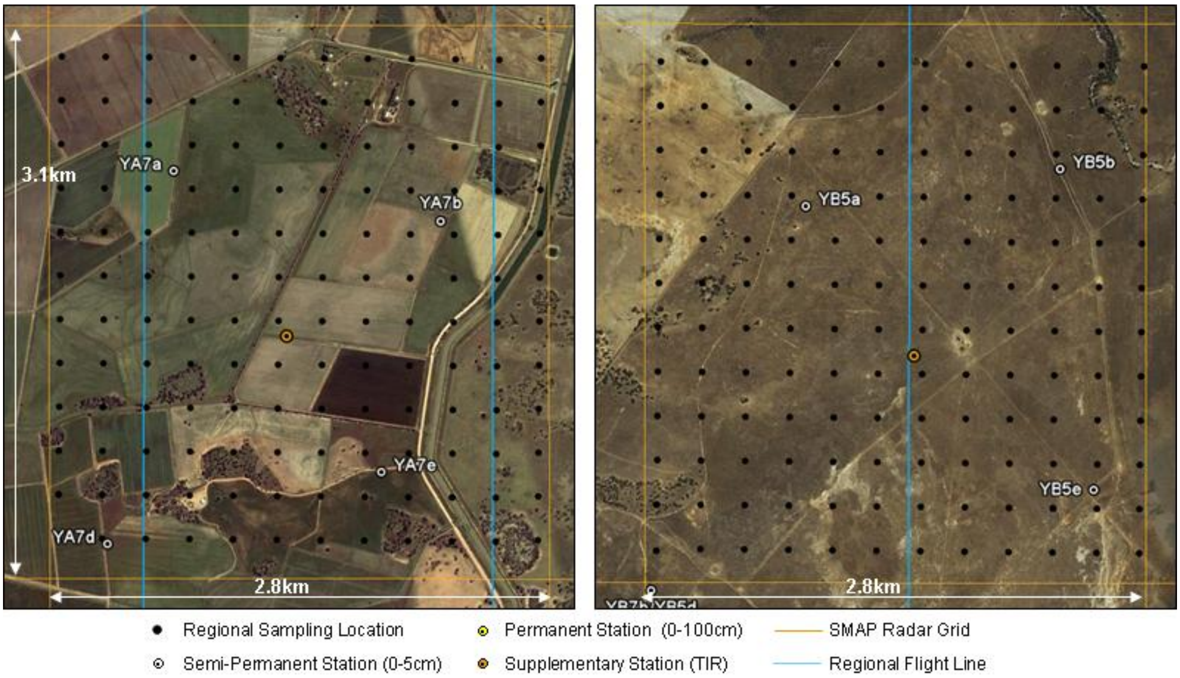


Figure 6-4. Locations of the spatial soil moisture sampling sites during regional days at focus areas YA4 (mostly cropped, left panel) and YB7 (at grazing, right panel).

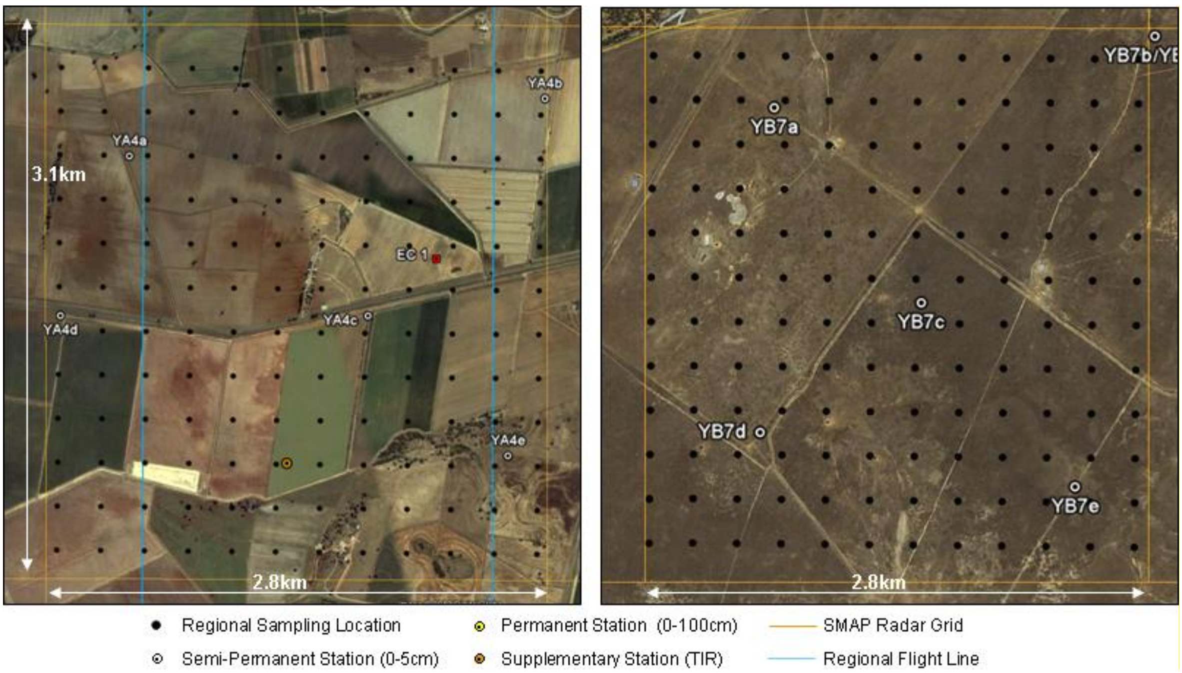


Figure 6-5. Locations of the spatial soil moisture sampling sites during regional days at focus areas YA4 (mostly cropped, left panel) and YB7 (at grazing, right panel).

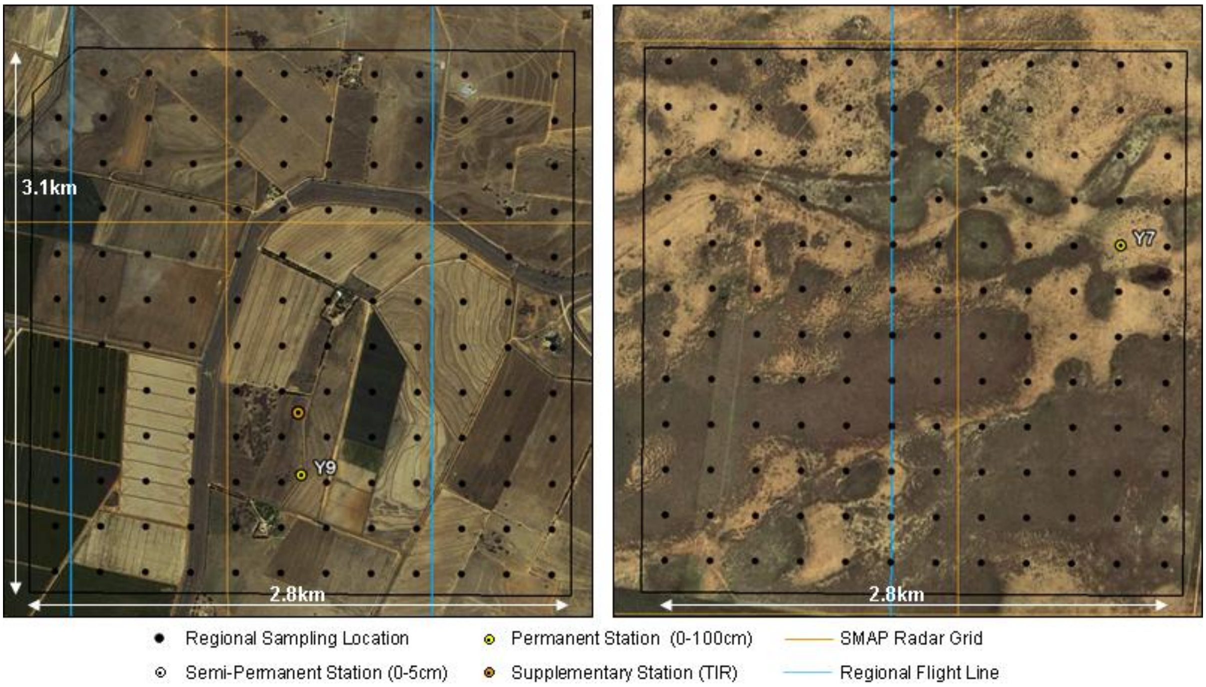


Figure 6-6. Locations of the spatial soil moisture sampling sites during regional days at focus areas YA4 (mostly cropped, left panel) and YB7 (at grazing, right panel)

Figure 6-7. Locations of the spatial soil moisture sampling sites during target days at focus areas YA4

locations at 250m spacing. This will provide detailed spatial soil moisture information for 2 prototype SMAP pixels on each day. The choice of pairing one cropping and one grazing area on each regional day aims at ensuring that a wide as possible range of soil moisture conditions are encountered for both land cover types. Local scale (1m) soil moisture variation will be accounted for by taking three surface soil moisture measurements within a radius of 1m at each sampling location. This will allow the effect of random errors in local scale soil moisture measurements to be minimised. Figure 6-5, Figure 6-4 and Figure 6-6 show the soil moisture sampling locations during regional monitoring days at all six focus areas (see Table 6-1). The coordinates of the focus area boundaries are shown in Appendix H.

6.2.2 Target Sampling

During the target flights, more detailed soil moisture measurements will be undertaken to support the high resolution radar (10m) and radiometer (100m) observations collected by the aircraft over the focus area YA.

Target sampling will include taking measurements along 10, 3km long and 50m-spacedtransects oriented along the Target flight lines. Along each transect, sampling locations will be spaced of 50m. As per the Regional sampling, local scale (1m) soil moisture variation will be accounted for by taking three surface soil moisture measurements within a radius of 1m at each sampling location. Figure 6-7 show the soil moisture sampling locations during target day at focus areas YA4. Target sampling will be repeated on the same day when the PALSAR transect flight is planned, in order to provide ground sampling data for PALSAR soil moisture retrieval.

6.3 Spatial Vegetation Monitoring

The vegetation water content (VWC, g of water per m^2) is a crucial parameter for modeling both the land surface emission and backscatter at L-band, and will be derived from destructive biomass samples taken at several sampling locations across the study area. Moreover, surface spectral reflectance data is valuable in developing methods to estimate the vegetation water content and other canopy variables. Ground-based spectral observations taken concurrently with biomass sampling will provide data to develop relationships between vegetation reflectance and plant properties, which will in turn be used for larger scale mapping of vegetation properties using aircraft and satellite spectral observations. In addition, reflectance measurements made concurrent with MODIS overpasses will allow the validation of MODIS reflectance estimates based upon correction algorithms. During SMAPEx, MultiSpectral Radiometer (MSR) developed by CROPSCAN (http://www.cropscan.com) will be used. Note that MSR bands will coincide with the MODIS instruments. Leaf area will be measured with a LAI-2000. Spatial vegetation data will be recorded in local time reference.

The objective of the vegetation monitoring is to characterise the individual 2.8km x 3.1km focus areas so as to describe all dominant vegetation types at various stages of maturity and vegetation water content. The best way to achieve this will be left to the vegetation team. However, following are some recommendations of the general approach to be followed. Full details on sampling procedures at each sampling location are then given in section 7.3.

- The vegetation sampling strategy will be based on the assumption that the changes in vegetation (biomass, VWC and plant structure) during the duration of the field campaign will be negligible.

- Vegetation samples for biomass, vegetation water content, surface reflectance and LAI measurements will be collected daily at the 2.8km x 3.1km focus areas;

- Vegetation sampling will largely follow the sampling schedule of the soil moisture monitoring (see Table 6-1). However, since cropping areas (YA4, YA7 and YD) are expected to present a large variety of vegetation types and growth stages to be sampled, as opposed to the more uniform dryland areas (YB5, YB7 and YC), the

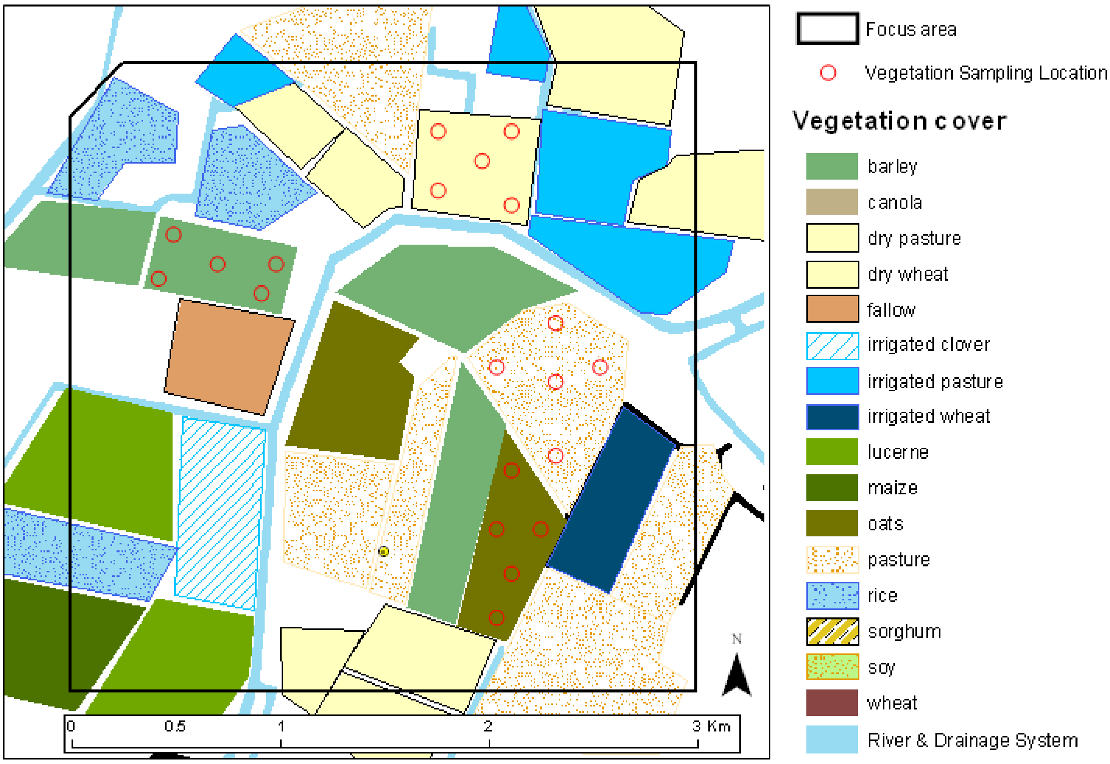


Figure 6-8. Schematic of vegetation sampling strategy for one example focus area (vegetation cover data from November 2006).

former will be strictly sampled when coincident aircraft spectral observation of the area are scheduled;

- Within each focus area, the 4 major vegetation types will be monitored. In the eventuality that different growth stages of the same vegetation type existed within the sampling area, they will be independently sampled;

- Each major vegetation types (or growth stages of the same vegetation type) will be characterised by making measurements at a minimum of 5 sampling locations distributed within homogeneous crops/paddocks. Figure 6-8 illustrates the rationale of the vegetation sampling locations for an example 2.8km x 3.1km sampling area;

- Additional vegetation sampling should be performed outside the focus areas when a major vegetation type observed within the SMAPEx study area is not represented in these;

- All vegetation measurements should be made between 10am and 2pm eastern standard time to optimise the ground spectral observations;

- To assist with interpolation of vegetation water content information and derivation of a land cover map of the region, the vegetation type and vegetation canopy height will be recorded for each vegetation type sampled. In the case of crops, additional information on row spacing, plant spacing and row direction (azimuth angle) will be recorded.

6.4 Supporting Data

In addition to soil moisture and vegetation spatial measurements, the ground teams will be in charge of collecting a range of supporting data, which are needed as input of the soil moisture retrieval algorithms: Such data include

1. Land cover type;
2. Soil roughness measurements;
3. Vegetation canopy height;
4. Visual observation of dew presence and characteristics;
5. Gravimetric soil moisture samples, and
6. Soil texture samples.
7. Standing water mapping.

Land cover type, vegetation canopy height and visual observations of dew presence will be electronically recorded in the HDAS systems at each location where soil moisture measurements are taken. Soil roughness and soil gravimetric and textural samples will be instead sampled only at certain selected locations. Further details on this supporting data are included Supporting data will be recorded in local time reference.

6.4.1 Land cover classification

Land cover information can be used to support the interpretation of remotely sensed data in various ways. In particular, it has been used to interpolate vegetation water content information. It is therefore important to characterise the main land cover types in the study area at the time of the campaign, to help deriving a land cover map from satellites like LandSat through supervised classification. Land cover will be characterised by visual observation and electronically recorded in the HDAS systems, assigning every sample location to one of the predefined subclasses. Photographs of the typical vegetation types found in the catchment are included in Figure 6-9 which may be a useful reference for identifying the vegetation types encountered in the focus areas.

6.4.2 Soil Surface Roughness

Soil surface roughness affects both the radiometric and radar observations. Radar observations can, in certain conditions, be more sensitive to surface roughness than soil moisture itself due to the increase scattering of the incoming radiation. Moreover, surface roughness affects the radiometric observations by effectively increasing the surface area of electromagnetic wave emission. Its effect on observations at L-band frequency has been shown to be difficult to quantify, and therefore it is crucial to characterise the spatial variation of this parameter across the different land cover types. During SMAPEx-2 surface roughness will be characterized at 3 locations within each major land cover type in the focus areas. At each of the 3 locations two, 3m-long surface profiles will be recorded, one oriented parallel to the look direction of the PLIS radar (East-west)and one perpendicular to it (North-south). Given the similar, land cover-based sampling approach adopted for both surface roughness

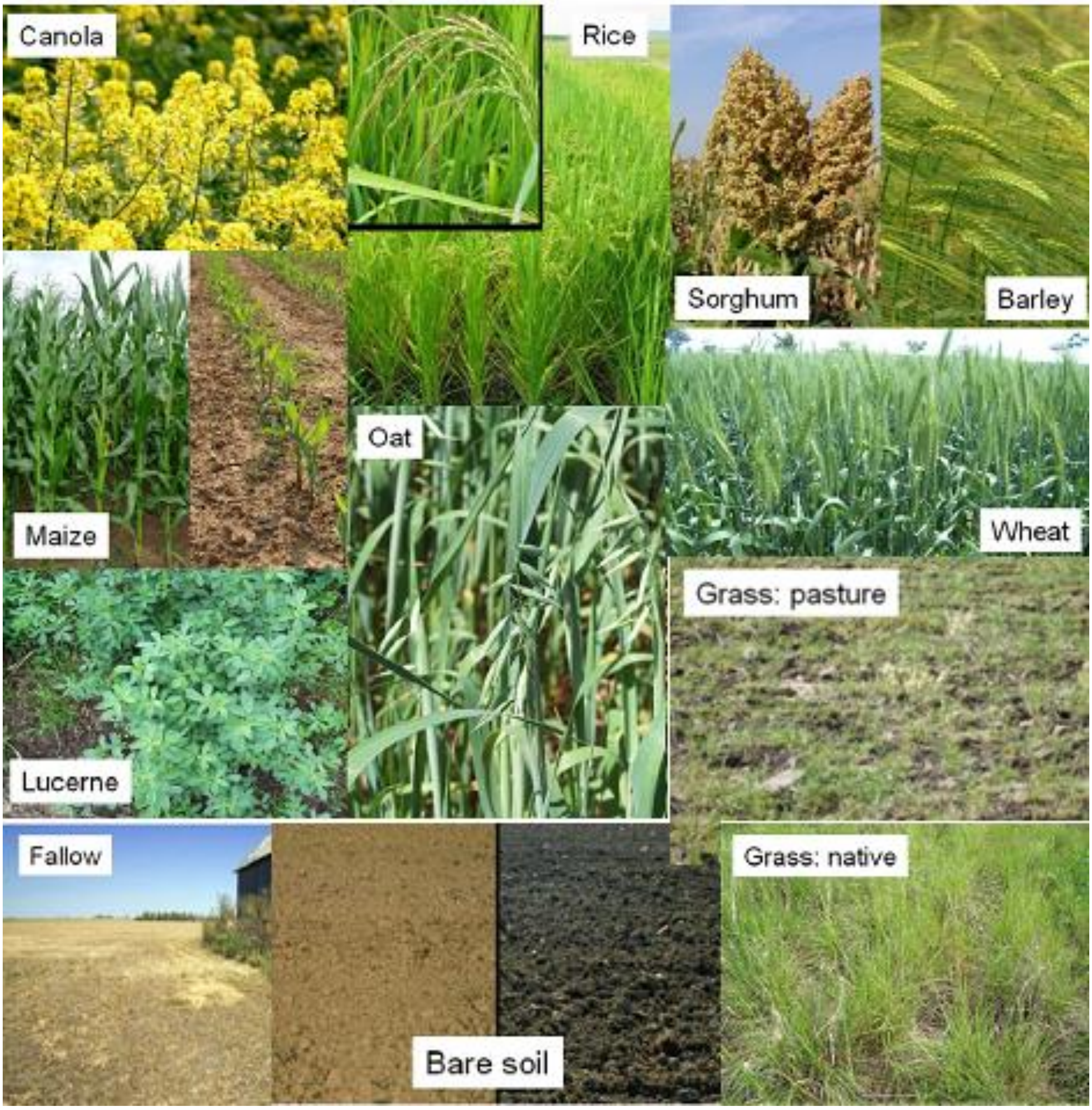


Figure 6-9. Photos of expected vegetation types within the focus farms highlighting features that will be useful for identification.

and vegetation properties, the vegetation sampling team will be in charge of the surface roughness measurements. Further details on procedure for roughness measurements with the pin profiler are included in section 7.5 where measurement protocols are presented.

Note that roughness measurements do not need to be made coincident with PLMR and PLIS overpass, since the roughness is expected to be fairly constant in time, so they may be made on the preceding/following day(s) that what planned to minimise workload during intensive monitoring activities.

6.4.3 Canopy height

Information on canopy height can also be used to interpolate vegetation water content information. In particular, it gives an estimate of vegetation biomass and/or crop maturity. Consequently, canopy height will be estimated to the nearest decimetre and electronically

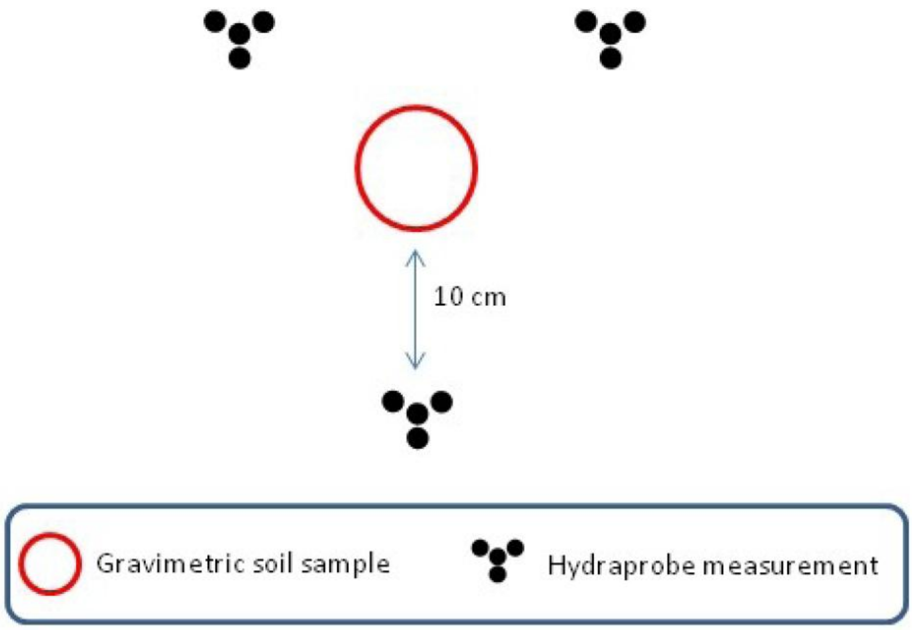


Figure 6-10. A minimum of three Hydraprobe measurements should be made in a radius of 10 cm around the gravimetric soil sample.

recorded in the HDAS systems. To this end, height reference marks with 10cm precision will be provided on the HDAS vertical pole.

6.4.4 Dew

The presence of dew on vegetation is likely to affect the passive microwave observation made in the early hours of the morning and subsequent retrieval of soil moisture. In order to support the leaf wetness measurements made by the supplementary monitoring stations, the soil moisture sampling team will be required to make a visual estimate of the leaf wetness conditions during the early hours of the day and record them in the HDAS systems to assist with the interpretation of both PLMR and PLIS data. These measurements only need be recorded until the dew has dried off.

6.4.5 Gravimetric Soil Samples

While a generic calibration equation has been derived for the conversion of Hydraprobe voltage readings into a soil moisture value ({Merlin, 2007 #37}), this equation should be confirmed for the specific soil types and soil moisture conditions encountered on the focus areas. Consequently, this equation will be evaluated from a comparison of Hydraprobe readings with gravimetric measurements.

Volumetric soil samples will be collected for each focus area with the gravimetric water content computed from the weight of a known soil sample volume before and after drying. The team leader of each ground sampling team will be in charge of collecting the gravimetric samples. Preferably, the Hydraprobe readings are made in the sample being taken. If this proves not to be possible due to moist soil sticking to the probe, a minimum of 3 Hydraprobe readings should be made at not more that 10cm from the soil sample (see Figure 6-10). The objective of the sampling will be to represent the range of soil types and soil moisture conditions encountered in each focus area. The best way to achieve this will be left to the ground sampling teams. However, following are some recommendations of the general approach to be followed. Full details on sampling procedures at each sampling location are given in section 7.3.1:

- At least one gravimetric sample will be collected for each soil type at each of three wetness levels encountered in the focus area. These wetness level are wet (HDAS reading above $0.35m^3/m^3$), intermediate (HDAS reading between $0.15\text{-}0.35m^3/m^3$) and dry (Hydraprobe reading below $0.15m^3/m^3$)

- For every focus area a minimum of 3 soil samples will be collected;

6.4.6 Soil Textural Properties

Information on soil textural properties is very important for modeling soil microwave emission, as it strongly affects the dielectric behavior of the soil. Moreover, the information from available soil texture maps is typically poor. Consequently, soil gravimetric samples will be archived for later laboratory soil textural analysis determination of fraction of sand, clay and silt if required

6.4.7 Standing Water Mapping

One of the objectives of the SMAP radar is that of provide a map of the water bodies boundaries within the SMAP radiometer pixel, so as to filter the confounding water emission from the soil signal for passive microwave retrieval purposes. During SMAPEx-2, one day will be dedicated to the precise GPS mapping of the boundaries of areas with standing water in the study area (mainly flooded rice paddocks and inundated areas) in order to provide ground validation data for the radar estimates of water bodies boundaries.

7 Ground Sampling Protocols

Field work during SMAPEx-2 will consist of collecting data in the Yanco Region and archiving the information collected during the sampling days. Most of the data collected on the ground will be assisted by the Hydraprobe Data Acquisition System (HDAS). The HDAS system will be used both to store the observations and to visualize the real-time position via a GPS receiver and GIS software.

The ground crew will be comprised of three teams (A, B and C, see Table 8-1 for composition of the teams). Team A and B will be mainly responsible for the soil moisture sampling using the HDAS system and will also collect soil gravimetric samples, with Team A also responsible for the mapping of standing water areas. Team C will mainly take care of the vegetation sampling and the surface roughness sampling. A list of team participants is included in Chapter 8 together with a daily work schedule.

The campaign is comprised of 5 sampling days. On the three regional days, both team A and B will work independently on the two assigned focus areas, accordingly to the sampling schedule shown in Table F-1 of Appendix F. On the target day (December 5) as well as on the days where PALSAR transect will be conducted (December 7), Teams A and B will work in parallel on the same focus areas YA4. A measurement grid will be uploaded on the HDAS screen to improve the accuracy and efficiency of the ground sampling; see also guidelines on farm mobility in Chapter 8. The soil moisture measurements will take place along 250m spaced regular grids (on regional days), and along 10 parallel transects each 50m apart and 3km in length, with sampling locations spaced of 50m (on transect days). Soil moisture sampling will involve navigating from one predefined location to the other and taking a series of 3 measurements at the predefined sampling locations. Sampling will be assisted by use of a GPS receiver (in-built in the HDAS), which displays the real-time position on the HDAS screen that shows the predefined locations. Once the sampling site has been located, the ground measurements of soil moisture and related meta data (presence of dew, vegetation height and type) are automatically stored into a GIS file on the HDAS storage card; Detailed training on how to use to HDAS system will be given in the day prior to the beginning of the sampling (for training times and locations see section 8.6). See also see Appendix B for more details on how to use the HDAS. Gravimetric samples will be collected along the same grids and transects, with position and other pertinent information stored in the HDAS system while vegetation and surface roughness sampling locations will be established by the leader of Team C depending on the actual conditions.

Coincident with soil moisture sampling activities, the vegetation team C will sample vegetation and surface roughness independently form the other two teams and according to the schedule in Table F-1 of Appendix F. Between 10am and 2pm (EDT) is the optimal time for spectral measurements, so this time will be dedicated to vegetation destruction sampling and coincident spectral sampling. The remainder of the day will be used by the vegetation team for surface roughness sampling.

At the end of each day, all teams will independently return to the Yanco Agricultural institute for soil and vegetation sample weighting in the laboratory and data downloading and archiving. The GIS files stored in the HDAS systems will be downloaded on a laptop computer, the soil gravimetric and vegetation samples will be weighed for wet weight and put in the ovens to dry overnight and the samples left from the day before will be weighed for dry weight. Moreover, the filled forms with vegetation, soil gravimetric and surface roughness sampling data will be entered in an excel spreadsheet **Team leaders will be responsible to coordinate these operations for each respective team and to ensure all data are properly**

downloaded and archive. Please Table F-2 in Appendix F for detailed tasks of each team.

This Chapter describes the protocols that will be used for the soil moisture and vegetation sampling in order to assure consistency in collecting, processing and archiving the collected data. Measurement record forms are provided in Appendix G for logging data other than the HDAS measurements.

7.1 General Guidance

Sampling activities are scheduled every, but may be postponed by the ground crew coordinator if it is raining or very likely to rain, there are severe weather warnings, or some other logistic issue arises. In this case the remaining campaign schedule may be revised.

Each team will make use of a campaign vehicle to access the farms. The soil moisture teams will walk along pre-established grids and transects in the focus area to take HDAS readings on the soil moisture sampling grid. They will be dropped off at a location in the focus areas strategically selected and agreed by all team members and will return to that location for pick up at the end of the sampling. The vegetation team will drive across the focus areas to undertake their sampling activities, walking to sampling points where driving is not feasible or practical; only qualified personnel are permitted to drive the 4WDs across the farms.

Some general guidance is as follows:

- Leave all gates as you find them!! (i.e., open if you found it open, closed if you found it closed);
- When sampling on cropped areas, always move through a field along the row direction to avoid impact on the canopy;
- Do not drive on farm tracks if the soil is too wet, because this will mess up the track;
- Do not drive through crops;
- When sampling on regular grids, as in regional days, try to first cover all the points falling within a paddock (area enclosed by a fence) where you currently are. When you covered all points, move to the next paddock;]
- PROTECT YOURSELF FROM THE SUN AND DIHYDRATION! It is recommended that you bring with you at least 2 litres of water, since you'll be sampling for the entire day, possibly under the sun. Each team will be assigned a water Jerry can of 25 litres You should remember to also wear a hat, sturdy shoes (above ankle), and long, thick pants to avoid snake bites.
- All farmers in the area are aware of our presence on their property during the campaign. However, if anyone questions your presence, politely answer identifying yourself as a scientist working on a University of Melbourne soil moisture study with satellites. If you encounter any difficulties just leave and report the problem to the ground crew leader. A copy of the campaign flyer distributed to farmers is included in Appendix H to assist you should this situation arise;
- Count your paces and note your direction. This helps greatly in locating sample points and gives you something to do while walking;

- Although gravimetric and vegetation sampling are destructive, try to minimize your impact by filling holes and minimizing disturbance to surrounding vegetation. Leave nothing behind!

- Please be considerate of the landowners and our hosts. Don't block roads, gates, and driveways. Keep sites, labs and work areas clean of trash and dirt;

- Beware of the possible presence of stock in the sampling areas;

- Watch your driving speed, especially when entering towns (town speed limits are typically 50km/h and highway speeds 100km/h). Be courteous on dirt and gravel roads, lower speed means less dust and stone;

- Drive carefully and maintain a low speed (~5 km/h) when going through tall grass fields. Hidden boulders, trunks or holes are always a danger. Also check for vegetation accumulation on the radiator;

- When parking in tall grass for prolonged periods of time, turn off the engine. Only diesel vehicles should be used in paddocks as catalytic converters can be a fire hazard.

- Some of the sampling sites may have livestock. Please be considerate towards the cattle and do not try to scare them away;

- For your own security, carry a mobile phone, a UHF radio or a Walkie-Talkie. Check the mobile phone coverage over your sampling area and be aware of the local UHF security frequencies (if relevant) as well as the team frequency (typically channel 38);

- In case of breakdown of any part of the sampling equipment, report as soon as practical to the team leader (not later than the end of the day!).

7.2 Soil Moisture Sampling

Soil moisture sampling teams are in charge of collecting (see also Appendix F for detailed team tasks sheet):

- 0-5cm soil moisture data using the HDAS instrument at each sampling location (minimum of 3 independent measurements per site) with coordinates automatically given by the HDAS system;

- Information about land use, vegetation type, canopy height and presence of dew at each sampling location (only required once per site);

- GPS location at each sampling location;

- Additionally, team leaders are in charge of collecting soil gravimetric samples.

The HDAS measurements will be made on regular grids of 250m x 250m spacing (regional days) or along transects each 50m (target days). The planned sampling locations for each focus area will be loaded onto the HDAS, and visible with the ArcPad GIS software. Sampling involves navigating along the sampling transect through the use of the GPS in-built in the GETAC, which displays the real-time position on the same ArcPad screen. Once the

GPS cursor is located at the predefined sampling point, HDAS measurements can be made and stored in the GETAC.

The information about vegetation type, canopy height and presence of dew will be stored in the HDAS by prompting the values into forms, following the Hydraprobe readings. For further details on the HDAS operation see Appendix B.

7.2.1 Field equipment

Each soil moisture team will be equipped with the items listed below:

- 1 4WD vehicle;
- 1 hardcopy of the workplan;
- 1, 25litres water Jerry can
- 1 UHF radio or satellite phone
- 1 first aid kit
- 1 first aid book
- 1 sunscreen bottle
- 1 gravimetric sampling kit

The gravimetric sample kit will be assigned to the team leader, who is responsible for collecting the soil gravimetric samples. Each individual in the team will be equipped with the items listed below:

- 1 HDAS system
- 1 hardcopy of each focus area map with the sampling grids and useful topographic information
- 1 mosquito net
- 1 walkie-Talkie
- 1 fieldbook and pens. The field book is to be used for comments and must be returned at the end of the campaign.

Each person will be individually responsible for the use and care of their assigned equipment throughout the campaign, and must report any damage to the group leader immediately so that actions can be taken to repair or substitute the damaged item. Each person is also responsible for putting the GETAC unit to recharge each day and downloading/uploading their own GETAC data (see also Appendix F for detailed team tasks sheet). **Each team member will be assigned their own HDAS system and will stick to it during the campaign. Please do not interchange equipment without prior discussion with the team leader.**

7.2.2 Hydra probe Data Acquisition System (HDAS)

Step-by-step information on the operation of the HDAS system, including files upload and download, sampling commands and troubleshooting is included in Appendix B.

Each HDAS system is composed of:

- 1 GETAC unit (with ID marked)
- 1 HDAS battery
- 1 GETAC pencil
- 1 power cable
- 1 USB download cable
- 1 pole (with ID marked)
- 1 Hydraprobe

The GETAC unit has been programmed to automatically read the Hydraprobe at the desired sampling location when a specific command is sent from the GETAC screen, and store the probe readings in a file together with the GPS coordinates provided by the GPS in-built in the GETAC unit. This is achieved with the "ArcPad" software, a geographic information system for handheld devices. The ArcPad program stores the readings of the probe with the coordinates given by the GPS. All the necessary commands will be given through the ArcPad screen, with basically no need to access any ArcPad menu items. On the ArcPad screen there will be 5 visible layers:

- Boundaries of the daily sampling area;
- Main roads (paved and unpaved);
- Properties and lot boundaries;
- Property main entrance;
- Locations of known gates and canal bridges;
- Irrigation canals;
- Grid of planned sampling locations
- Grid of actual sampling locations: this is the file that will be edited every time a soil moisture reading is taken.
- GPS position indicator;
- background Googlearth image;

It is important to check daily BEFORE sampling starts that the GETAC time is set to the correct UTC time as the time information will be used to interpret the data. Additionally,

it is necessary to recharge each GETAC after each sampling day, in order to avoid any malfunctions.

At each sampling location the following information will be selected from pre-defined drop down lists, in addition to a free-form comment if desired. The vegetation **canopy height** is selected from a list with 10cm increments up to a maximum height of 1.5m, while vegetation type and dew amount selected from the lists below:

Vegetation Type (dryland, irrigated:drip, irrigated:spray, irrigated:flood)

bare soil

fallow

grass: native

grass: pasture

crop: barley

crop: canola

crop: lucerne

crop: maize

crop: oats

crop: rice

crop: sorghum

crop: soybean

crop: wheat

crop: other

orchard

vineyard

woodland: open

woodland: closed

water body

building

other

Dew Amount

none

small droplets

medium droplets

large droplets

film

7.3 Vegetation Sampling

The vegetation sampling team (Team C) is in charge of collecting (see also Appendix F for detailed team tasks sheet):

- Vegetation and litter destructive samples
- Vegetation canopy reflectance measurements
- Vegetation canopy LAI measurements
- Information about vegetation type, canopy height, crop row spacing and direction
- GPS location of the actual vegetation sampling site

Vegetation teams are additionally in charge of collecting soil roughness measurements. The vegetation team will be equipped with a GETAC unit in order to navigate through the focus areas using GPS positioning like for the sampling teams. The GETAC will contain information on main roads, properties and lot boundaries and Irrigation canal to aid the navigation and selection of the sampling locations.

Roughness measurements will also be made at 3 locations within each major land cover type in the focus areas. To facilitate the roughness sampling, it is recommended to take those measurements near the vegetation sampling areas.

7.3.1 Field Equipment

The vegetation team will be equipped with the items listed below:

- 1 4WD vehicle;
- 1 hardcopy of the workplan
- 1 hardcopy of each focus area map with the sampling grids and useful topographic information
- 1 GETAC
- 1 CROPSCAN device
- 1 LAI-2000 device
- 1 vegetation destructive sampling kit
- 1 surface roughness sampling kit
- 1 satellite phone
- 5 field books
- Pens, permanent markers
- 1, 25litres water Jerry can

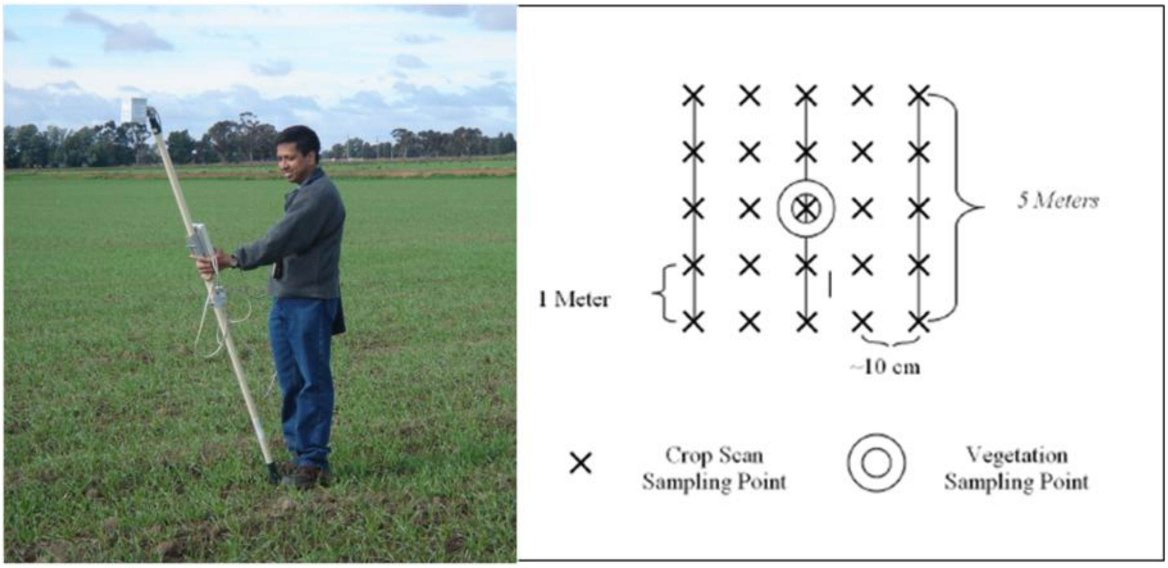


Figure 7-1. The CROPSCAN Multispectral Radiometer (MSR, left panel, Size is 8cm x 8cm x 10 cm), and Illustration of the surface reflectance protocol (right panel).

- 1 first aid kit
- 1 first aid book
- 1 sunscreen bottle
- 5 pair of gloves

7.3.2 Surface reflectance Observations

The CROPSCAN is an inexpensive instrument that has up-and-down-looking detectors and the ability to measure reflected sunlight at different wavelengths. The basic instrument is shown in Figure 7-1. The CROPSCAN multispectral radiometer systems consist of a radiometer, data logger controller (DLC) or A/D converter, terminal, telescoping support pole, connecting cables and operating software. The radiometer uses silicon or germanium photodiodes as light transducers. Matched sets of the transducers with filters to select wavelength bands are oriented in the radiometer housing to measure incident and reflected irradiation. Filters of wavelengths from 450 up to 1720 nm are available. For SMAPEx-2 a MSR16R unit will be used with the set of bands indicated in Table 7-1. These bands coincide with channels of the MODIS instruments. Channels were chosen to provide NDVI as well as a variety of vegetation water content indices under consideration.

Reflectance data will be collected for each vegetation sampling location (Figure 7-1), just prior to vegetation removal using the following sampling scheme. Making sure that the radiometer is well above the plant canopy, take a reading every meter for 5 meters. Repeat, for a total of 5 replications located 1 meter or 1 row apart. See Appendix D for detailed instructions on how to operate the CROPSCAN.

Figure 7-2. The LAI-2000 instrument.

Table 7-1. CROPSCAN vs. MODIS and Skye sensors bands

MODIS		SKYE SENSORS	CROPSCAN
Band	**Bandwidth**	**Bandwidth**	**Band (Bandwidth)**
1	620 - 670	620-670	650nm (40nm)
2	841 - 876	841 - 876	850nm (40nm)
3	459 - 479	459 - 479	470nm (10nm)
4	545 - 565	545 - 565	550nm (40nm)
5	1230 - 1250	-	1240nm (12nm)
6	1628 - 1652	1628 - 1652	1640nm (16nm)
7	2105 - 2155	2105 - 2155	
		2026 - 2036	710nm (12nm)
		2026 - 2216	970nm (10nm)

7.3.3 Leaf Area Index Observations

The LAI-2000 (see Figure 7-2) will be set to average 4 points into a single value so one observation is taken above the canopy and 4 beneath the canopy; in the row, ¼ of the way across the row, ½ of the way across the row and ¾ of the way across the row. This gives a good spatial average for row crops of partial cover. For grasses, weeds and non-row crops, five sets of measurements (each set consisting of 1 above the canopy and 4 beneath the canopy) will be made. These should be made just before taking the biomass sample. For short vegetation, LAI will be derived from the destruction samples as described below.

If the sun is shining, the observer needs to stand with their back to the sun and put a black lens cap that blocks ¼ of the sensor view in place and positioned so the **sun and the observer are never in the view of the sensor**. The observer should always note if the sun was obscured during the measurement, whether the sky is overcast or partly cloudy with the sun behind the clouds. If no shadows could be seen during the measurement, then the measurement is marked “cloudy”, if shadows could be seen during the measurement then the measurement is marked “sunny”. Conditions should not change from cloudy to sunny or sunny to cloudy in the middle of measurements for a sample location. Also, it is important to check the LAI-2000 internal clock each day to verify they are recording in GMT. See Appendix C for detailed instructions on how to operate the LAI-2000.

Additionally, the vegetation samples taken within the 50cm × 50cm quadrant will be passed through a leaf area scanner, to determine the full leaf area for the sample. These data can then be used to compare the observed and measured leaf area indices.

7.3.4 Vegetation Destructive Samples

At least five vegetation samples concurrently with reflectance/leaf area index observations will be taken for each major vegetation type across the focus area per day, making sure that all significant vegetation types and growth stages encountered across the farm are included. These vegetation samples will be weighed at sample check-in on return to the operations base, and then left in oven overnight for drying.

Note: Vegetation sample should only be taken after the spectral and LAI measurements have been made.

Vegetation destructive sampling kit

- GETAC unit
- 0.5m × 0.5m quadrant to obtain vegetation samples
- vegetation clipper
- scissors
- gloves
- paper bags for temporary storage (pre-drying) – small
- paper bags for temporary storage (pre-drying) – large
- plastic bags for long term storage (post-drying)
- rubber bands
- permanent markers
- Vegetation sample recording form

Vegetation destructive sampling protocol

The procedure for vegetation biomass sampling is as follows:

1. Note on the vegetation sampling form the type of vegetation to be sampled (e.g. crop, native grass, improved pasture) using the predefined list in the HDAS, its height and row spacing and direction if relevant.
2. Randomly place the 0.5 m × 0.5 m quadrant on the ground within area to be sampled
3. Record sample location with GPS and sample location reference number in GETAC

4. Label paper bag provided using a permanent marker with the following information: Area_ID / DD Month YYYY / Sample_ID and time at which the sample was taken. Take photo of area to be sampled prior to removal of vegetation

5. Remove all aboveground biomass within the 0.5 m × 0.5 m quadrant using vegetation clipper, scissors, knife, etc. provided – use whatever tool works best on the vegetation in that particular field. There should be no condensed water on the surface of the vegetation before it is cut and removed – if there is water from dew or intercepted rainfall, either wait until the vegetation is dry to take the sample or blot the vegetation dry before removing it from the soil.

6. Place vegetation sample into labeled paper bag

7. Fold over top of paper bag multiple times to seal and place this bag immediately into a plastic trash bag to ensure that no moisture is lost; loosely knot the plastic bag before moving on to next sampling location in the same field

8. Take photo of sample plot following removal of aboveground biomass. [so there is a before and after photo]

9. Fill up the vegetation sampling form with all the required information (A copy of the vegetation sampling form is given in Appendix G)

10. Move to next sampling location in the same field. If they fit, you can put all paper bags w/samples from the same field into the same plastic trash bag. Once finished in a field, tightly knot or seal the plastic bag for the ride back to the lab.

It is the responsibility of team C to deliver the vegetation samples to the operations base at the end of the day for determination of wet and dry weight (see laboratory procedures in section 7.6.1)

7.4 Soil Gravimetric Measurements

At least 3 soil samples should be collected per day in each focus area. It will be the responsibility of the team leader to collect these samples, making sure that sure that all soil types and the complete range of soil moisture encountered on the focus area are included. These gravimetric soil samples will be weighed at sample check-in on return to the operations base.

Gravimetric soil moisture sampling kit

- sampling ring (approximately 7.5cm diameter and 5cm depth)
- hammer and metal base
- garden trowel
- blade
- spatula
- gloves
- plastic bags

- rubber bands
- carton tags
- permanent markers
- Soil sample recording form

Gravimetric soil moisture sampling protocol

1. Take a minimum of 3 soil moisture readings with the Hydraprobe immediately adjacent to the soil to be sampled, plus 1 reading in the soil sample if conditions permit**. Indicate the gravimetric sample ID in page 3 "Other" of the HDAS screen. The ID will be the same for the 3 measurements taken adjacent to the soil sample and will correspond to the ID indicated on the sample bag**
2. Remove vegetation and litter.
3. Place the ring on the ground
4. Put the metal base horizontal on top of the ring and use the hammer to insert the ring in the ground, until its upper edge is level with the ground surface.
5. Use the garden trowel to dig away the soil at the side of the ring. The hole should reach the bottom of the ring (5cm) and should be sufficiently large to fit the spatula in
6. Use the spatula to cut the 0-5cm soil sample at the bottom of the ring
7. Place the 0-5cm soil sample in the plastic bag ensuring that no soil is lost
8. Write Area_ID / TEAM ID/ DD-MM-YY / Sample_ID on the provided carton tag and place it in the bag.
9. Seal the bag with the rubber band provided, then place this bag into a second bag and seal the second bag.
10. Label the internal plastic bag as Area_ID / TEAM ID/ DD-MM-YY / Sample_ID.

7.5 Surface Roughness Measurements

The vegetation team will be responsible for the surface roughness measurements. Three surface roughness measurements will be made within each major land cover type present in each focus area. Each measurement will consist of two, 3m-long profiles, one oriented parallel to the look direction of the PLIS radar (East-west)and one perpendicular to it (North-south). The exact location of the 3 profilers is left to the vegetation team. The 3 measurements should cover the variability of surface conditions observed within the land cover patch of interest.

Surface roughness sampling kit

- GETAC unit
- pin profiler

- level
- field book
- pencil
- roughness sampling recording form
- digital camera
- compass
- marker

Surface roughness sampling protocol

Soil roughness measurements will be made using a 1m long drop pin profiler with a pin separation of 5mm. Photos of the pin profile will be taken at each sampling locations and the images will be then post-processed to extract the roughness profiles and roughness statistics. At each soil roughness sampling location, 3 lots of consecutive readings (to simulate a 3m long profile) will be performed in North-South and East-West orientations, respectively. A 3m profile has been shown to provide stable correlation lengths in previous campaigns.

1. Note in the roughness sampling form the time and date, the Sample ID, the local time, the focus area ID, the coordinates (from GPS), the land cover type, the vegetation type, the row direction (if crops), the orientation of the roughness measurements (N-S or E-W determined using the compass) as well as the name of the person sampling.

2. Select an area for a 3-m roughness transect (N-S or E-W). Assure that the sun will be at your back when taking roughness photos. Position the profiler behind and parallel to the transect.

3. Place the roughness profiler vertically above the first 1m of the desired transect (the right one, defined from perspective of photograph), avoiding stepping over the area chosen for the remaining 2m profile

4. Use the compass to align the profiler exactly N-S or E-W depending on the transect Clear vegetation if necessary from the proposed transect.

5. Release the profiler legs using the controls at the back of the profiler. Position the level on top of the profiler and level the profiler horizontally using the controls.

6. When the profiler is horizontal, extend the lateral legs to sustain the profiler.

7. Mark the position of the profiler left foot on the side of the pin profiler adjacent to the next meter of the desired transect, using a stick or mark position BEHIND the profiler (left and right defined from perspective of photograph)

8. Release the pins. Make sure that all the profiler pins touch the soil surface. The pins MUST NOT be inserted into the ground or be resting on top of vegetation.

9. Extend the camera bar and position the camera, making sure the lens plane is parallel to the profiler board.

10. Take a photograph (# 1) of the profiler clearly showing the level of all pins. Note the photo identification number in the roughness sampling form.

11. After retracting the camera bar and the lateral legs, lift the profiler and move it to behind and parallel to the transects

12. Lean the profiler on its back, retract the pins and block them using the bottom enclosure

13. Shift the profiler over 1 m so that its right foot is now in front of the marker which was used to flag the profiler left foot. (left and right defined from perspective of photograph).

14. Repeat procedure in Step #3-12 above to take photograph #2.

15. Repeat steps #13-14 for photograph #3 of the transect. Note that the 3 photographs for the 3-m transect are always taken left to right (as you face the profiler with the camera).

16. Repeat steps #1-15 for the 3,1-m long profilers in the perpendicular direction.

NOTE: this protocol should produce 2 continuous 3m-long profiles (without gaps between photographs #1and #2, and between photographs #2 and #3)

7.6 Laboratory Procedures

Laboratory work for soil gravimetric samples and vegetation water and vegetation biomass determination will be conducted by the team leaders at the Yanco Agricultural Institute facilities, where ovens etc are readily available. The laboratory procedures for each of these sample measurements are summarised below.

7.6.1 Biomass and Vegetation Water Content Determination

All vegetation samples are processed to obtain a wet and dry weight. Vegetation samples will be processed at the YAI, where a large electronic balance and large dehydrators (max 70 degrees) will be available. It is the responsibility of team C to deliver the vegetation samples to the operations base at the end of the day, wet weight, oven-dry and dry weight the samples. All the information will have to be recorded in the Vegetation_Drying.xls (one form per day, see templates in Appendix G).

The procedure for determining the wet weight is as follows:

Wet Weight Procedure

1. Turn on electronic balance.

2. Tare.

3. Remove paper bags with vegetation for a given field from the plastic trash bag. Note any excessive condensation on the inside of the plastic trash bag and record this on the vegetation drying form.

4. Record wet weight (sample + bag) of each paper bag with veg on the vegetation drying form. Record wet weight (sample + bag) in the computer excel vegetation drying form.

5. Put the sample + bag in the oven for drying. Try to keep all bags for a given field on the same shelf in the oven. Note the time that the bags were placed in the oven on the drying form (see procedure below).

Drying Procedure

1. Place the samples in the dehydrator to dry at 65°Cand leave it to dry until a constant weight is reached (typically 2-3 days depending on how wet the vegetation is to start with – very dense wet vegetation could take longer to dry). Record the location of the sample in the dehydrator (dehydrator ID and shelf ID) together with date and time on the vegetation drying form when you start and end the drying.

2. Dry samples in oven at 65° C until constant weight is reached (typically 2-3 days).

3. Turn on balance.

4. Tare.

5. Remove samples from dehydrator one at the time, close the dehydrator and put samples immediately on the electronic scale.

6. Record dry weight (sample + bag) on the vegetation drying form

NOTE: once out of the dehydrator, the vegetation sample will absorb moisture from the air surprisingly quickly. It is recommended that the dry weight is recorded within not longer than 10 seconds from removing the sample from the oven.

Taring of paper bags

At some point during the field experiment (preferably at the beginning), weigh a reasonable number (20-30) of dry new paper bags under normal room conditions, place in the ovens at the vegetation drying temperature (usually 65 deg C), and weigh again (taking them out of the oven one at a time) after 2-3 days of drying. The difference between the average before-drying weight of a bag and the after-drying weight of a bag is the amount of weight lost by the bags themselves during the oven drying process. This value needs to be considered in converting the wet & dry weights of the vegetation into an estimate of vegetation water content (VWC).

7.6.2 Gravimetric Soil Moisture Determination

All gravimetric samples are processed to obtain a wet and dry weight. Gravimetric samples will be processed at the YAI, where an electronic balance and an oven will be available. It is the responsibility of each team leader to deliver the gravimetric samples to the operations base at the end of the day, wet weight, oven-dry and dry weight the samples. All the information will have to be recorded in the Gravimetric_Drying.xls (one form per day, see templates in Appendix G).

Wet Weight determination

1. Turn on balance.

2. Tare.
3. Record wet weight (sample+bags+rubber bands) into the gravimetric drying form
4. Record bags and rubber bands weight into the gravimetric drying form
5. Record alluminium tray weight on the gravimetric drying form.
6. label the alluminium tray uniquely based on the sample ID using a permanent marker
7. Place the used bags in order. The labeled bags will be used for permanently storing the samples after the drying procedure is finished.

Dry Weight determination

7. Place the samples in the oven to dry at 105°C for 24 hours. Record the date and time (local) on the gravimetric drying form when you start and end the drying.
8. Turn on balance.
9. Tare.
10. Remove samples from oven one at the time, close the oven and put samples immediately on the electronic scale. These samples will be hot! Use the gloves provided.
11. Record dry weight (sample + tray) on the gravimetric drying form
12. Return soil into the original plastic bag, close bag with a rubber band and store samples

The dry/wet weight data of soil samples and their associated sample ID will be stored in an excel worksheet named Desktop/SMAPEx-#\Ground_Data\DD-MM-YY\Area_ID\Gravimetric\TEAM_$\Gravimetric.xls where # is the identification number of the campaign, DD is day, MM is month, YY is the year (**Please note: date/time must be local**), $ is the team identification letter (A or B) and Area_ID is the focus area identification code (see Table Table 6-2).

7.7 Data Archiving Procedures

All the data collected during the daily sampling will be saved onto two field laptops which will be available at the operation base. The exact location of the laptops will be communicated during training. Each team (A and B) will use one laptop for data downloading and archiving. Team C will archive data independently. The data archived will be backed up daily on an external hard drive and CD/DVD. The general data structures for the SMAPEx-2 ground as well as airborne data are shown in Figure 7-3. It is the responsibility of each team member to download and properly archive the data collected with their HDAS system following the procedures outlined below. **Data must be downloaded and archived right the end of the sampling, upon returning to the Yanco Agricultural Institute. Moreover, the sampling grids for the following day will be loaded.**

It is the responsibility of each team leader to make sure that every team members has downloaded the data collected onto the field laptop. It is the responsibility of the ground crew leader to back up daily on external hard drive and CD/DVD.

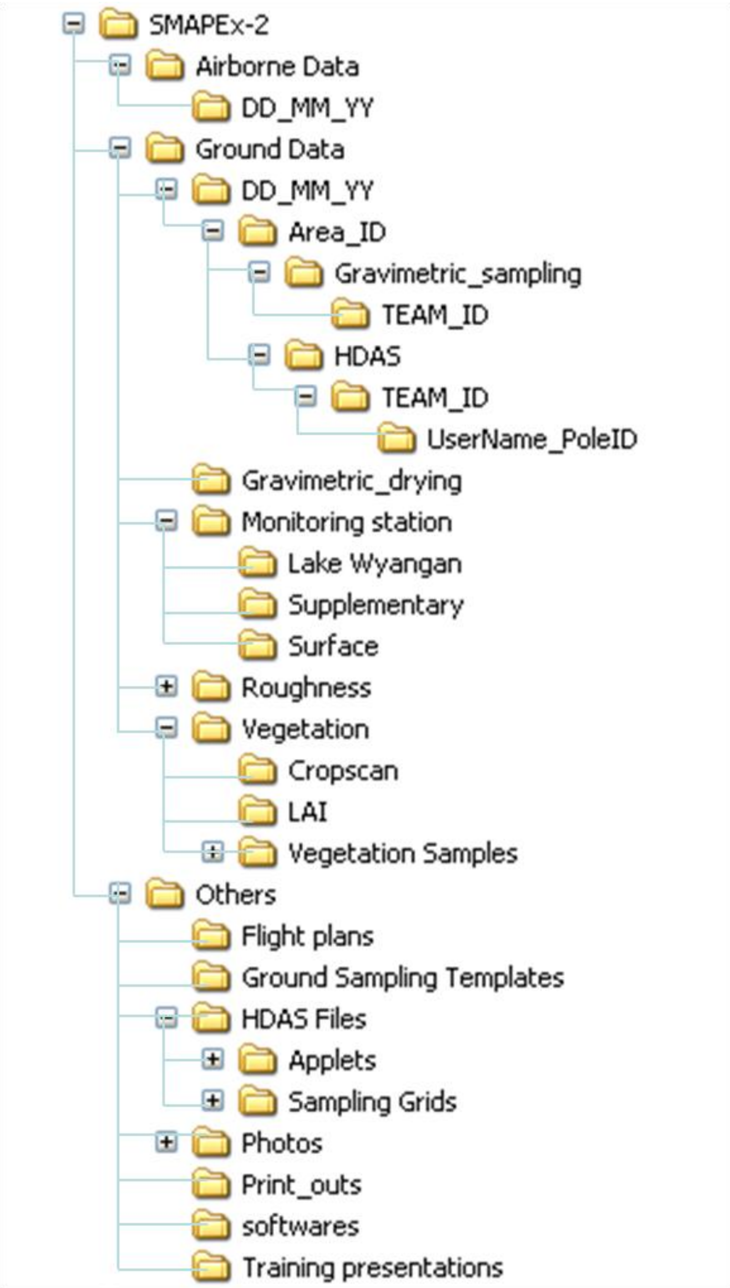


Figure 7-3 Tree diagram of the general SMAPEx-2 file structure.

Downloading and Archiving HDAS Data

This section explains how to save the data collected in the field to the data archive in the field laptop (if the operating system on the laptop is Windows XP, Microsoft ActiveSync will have to be installed to follow the steps)

- Connect the GETAC unit to the field laptop using the GETAC USB cable
- The GETAC unit will be added as a new drive in the "My Computer" (same as for a normal USB pen)
- Click on the drive icon in the windows explorer

- Navigate in the GETAC file system to the folder names “SD Card” in the root directory

- Copy and paste all the files with root name “hydra” or “hydraGRID” (extensions .dbf, .shb, .shx, .prj and .apl)

- Past the files into the folder on the field laptop named “Desktop/SMAPEx-#\Ground_Data\DD-MM-YY\Area_ID\HDAS\TEAM_$\UserName_PoleID” where # is the identification number of the campaign, DD is day, MM is month, YY is the year, Area_ID is the focus area identification code (see Table Table 6-2), $ is the team identification letter (A or B), UserName is the Family name of the team member whose HDAS is being downloaded and PoleID is the ID of the HDAS system being downloaded.

- **Make a backup of the HDAS data as follows:** Once the files have been properly saved on the laptop, go to folder “SD Card” on the GETAC unit, make a copy of the folder “SD Card” and rename the copied folder as “DD-MM-YY _UserName_PoleID

- Finally, empty the content of the folder “SD Card” by deleting all the files with prefix “hydra” or “hydraGRID”

Step-by-step information on the operation of the HDAS system, including files upload and download, sampling commands and troubleshooting is included in 0.

Uploading the HDAS Sampling Grids.

At the end of each day and after having downloaded and archived the HDAS data collected, each team members must load onto their GETAC the sampling grids for the day after. The sampling grids (and ancillary data for better visualization on the GETAC) will be stored in the folder “Desktop/SMAPEx-#\Ancillary Data\HDAS Files\Sampling grids\” where # is the identification number of the campaign. Two types of sampling grids will be available, one for regional sampling days and one for target days (folders “\Regional” and “\Target”). Note that on PALSAR transect day (December 7), Target days sampling grids will have to be uploaded. Team members should determine the type of sampling (regional or target) which will be performed the following day (by asking the team leader or consulting the schedule in Appendix F) and load the relevant folder “regional” or “target”. To load the folder to the GETAC, copy and past the folder “regional” or “target” into a location on the GETAC system.

To load the sampling grids, just use the “open map” command in ArcPad and load either “Regional.apm” or “Target.apm” files. This will visualize all the sampling grids onto the GETAC screen. **NOTE: the data collected during the day (**“hydra” or “hydraGRID” shapefiles) **will be always saved into the GETAC “SD Card” folder, regardless of where you upload the sampling grids**.

Archiving soil roughness data

Soil roughness data will be archived both in hardcopy and electronically:

- The roughness sampling form will be submitted to the ground crew leader at the end of the sampling day.

- The data from the form will be entered at the end of the day in the Roughness.xls and stored in data laptop in the Excel worksheet named "Desktop/SMAPEx-#\Ground_Data\DD-MM-YY\ Area_ID\Roughness\Roughness.xls" where # is the identification number of the campaign, DD is day, MM is month, YY is the year and Area_ID is the focus area identification code (see Table Table 6-2). This data must be typed up at the end of the sampling day or at latest the subsequent day. The photos must also be stored in the same directory as the xls file, renamed as Roughness_DD-MM-YY_#.jpg where # is the photo identification number provided by the camera and crossed-referenced in the hardcopy form,

8 Logistics

SMAPEx-2 activities will be supported by a ground crew, aircraft crew and support crew. The aircraft activities will be conducted from the Narrandera Airport, while the ground and support crew will be based at the Yanco Agricultural Institute (YAI), which will provide lab space and equipment for pre-sampling and post-sampling operations. One of the ground crew members, Rodger Young, will be dedicated to instrument repair and general technical support. Breakdowns and instrument faults must be reported to him at the end of each day. The HDAS data and ground samples will be archived according to the instruction in this work plan promptly at the end of each sampling day, either directly or via your team leader, so he can further process the data and samples, thus ensuring the early availability of quality data at the end of the campaign.

8.1 Teams

Ground crew sampling operations will be undertaken by 3 teams acting independently, each coordinated by a team leader (see Table 8-1 for composition of the teams). Two of the ground teams (Team “A” and “B”) will be responsible for soil moisture monitoring using the HDAS system, while Team “C” will be responsible for vegetation and surface roughness sampling (see team tasks in Appendix F). Each of the two ground soil moisture teams have been assigned three of the six focus areas across the SMAPEx study area which they will sample during regional sampling days. Table 8-1 indicates the composition of each team and the focus areas assigned to each group. The aircraft crew will operate from the Narrandera airport and be coordinated by Jeff Walker. Those people supporting the aircraft component are indicated in Table 8-2. There are also a few support people, and these are indicated in Table 8-3. Contact details for all participants are given in Chapter 9.

8.2 Operation Base

The Yanco Agricultural Institute (YAI, http://www.agric.nsw.gov.au/reader/yanco) is a 825 hectare campus located at Yanco, in the Murrumbidgee Irrigation Area. The centre is just 10 minutes drive from downtown busy Leeton, and 20 minutes drive from the town of Narrandera, junction of the Sturt and Newell Highways (see location in Figure 8-2). YAI shares the site and resources with Murrumbidgee Rural Studies Centre (MRSC, http://www.mrsc.nsw.edu.au), formerly known as Murrumbidgee College of Agriculture. Both MRSC and YAI are run by the NSW Department of Primary Industries (NSW DPI). A map of the YAI and the facilities available to SMAPEx-2 participants is provided in Figure 8-1.

During SMAPEx-2, the YAI will make available two lab spaces with all the equipment needed for pre-sampling and post-sampling operations (see N19 and N22 in Figure 8-1), including scales for sample weighing, ovens for drying soil and plant samples, and a storage space for processed samples and field equipment (see N20 in Figure 8-1),. It will be the responsibility of each team to make sure instruments and tools are stored properly overnight.

Facilities available during the SMAPEx-2 campaign include: lab space, storage shed, two types of accommodation and a conference room. Air crew will also be based in YAI and operate the RV10 aircraft out of the Narrandera Airport.

Table 8-1. SMAPEx-2 ground crew. [FA] first aid person

Team	Team Leader	Vehicle	Focus Areas	Team Members	Tasks*
A	Rocco Panciera	Rental 4WD (Melbourne Univ.)	YA4,YA7,YD	Rocco Panciera[(FA)]	Soil moisture (HDAS) Soil gravimetric samples
				Maria Piles	Soil moisture (HDAS)
				Muzaffar Ahmad	Soil moisture (HDAS)
				Giuseppe Satalino	Soil moisture (HDAS)
				Fedra Mendez	Soil moisture (HDAS)
B	Dongryeol Ryu	Rental Ute 4WD	YB5,YB7,YC	Dongryeol Ryu[(FA)]	Soil moisture (HDAS) Soil gravimetric samples
				Lucheng Huang	Soil moisture (HDAS)
				Perrine Hamel	Soil moisture (HDAS)
				Rob Pipunic	Soil moisture (HDAS)
				Chris Rudiger	Soil moisture (HDAS)
C	Lynn McKee	Rental 4WD	YA4,YA7,YD, YB5,YB7,YC	Lynn McKee	Roughness
				John Prueger	Vegetation destructive sampling
				Seungbum Kim	Vegetation relfectance
				Mehmet Kurum	Vegetation LAI

Table 8-2. SMAPEx-2 aircraft crew

Person	Tasks	Vehicle
Jeff Walker	Aircrew coordinator	Economy rental 1
Jon Johanson	Pilot[FA]	
Heath Yardley	PLIS support	

Table 8-3. SMAPEx-2 support crew

Person	Tasks	Vehicle
Rodger Young	Equipment maintenance PARCs deployment Lake transects	Economy rental 2

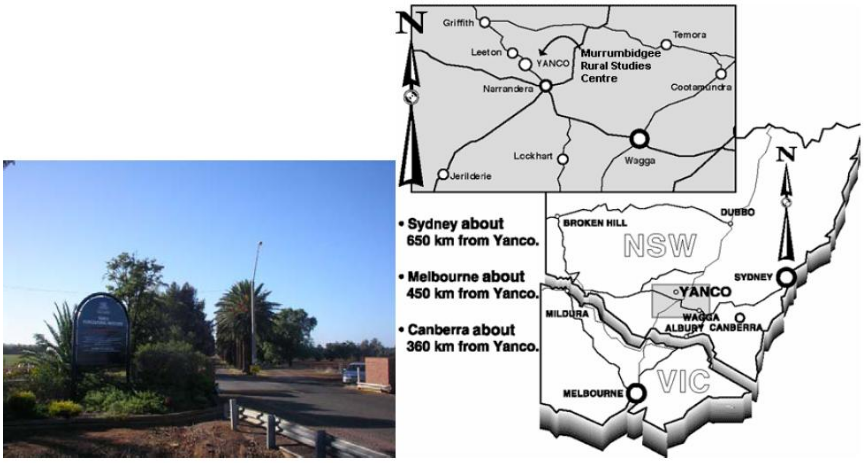


Figure 8-2. Location of the YAI at Yanco.

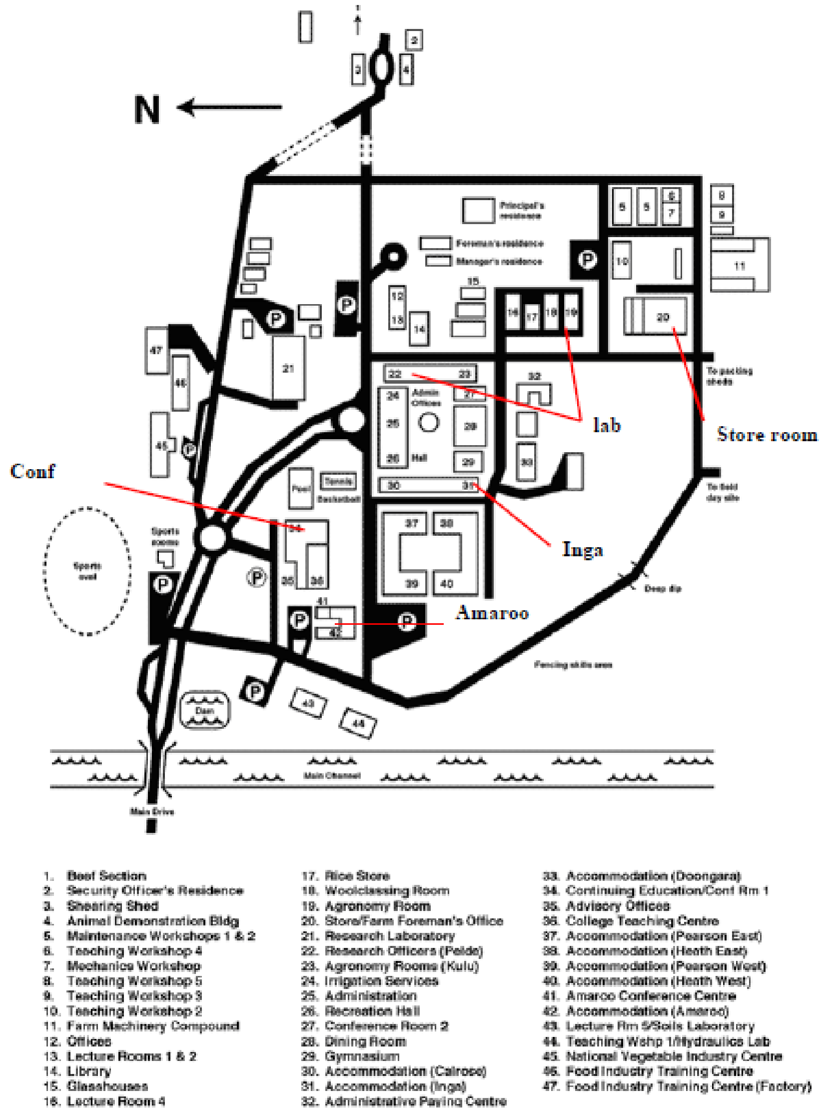


Figure 8-1. Map of the Yanco Agricultural Institute

Table 8-4. Accomodation logistics for SMAPEx-2 participants

Person	Funding Organization	Location	Check-in	Check-out
Rocco Panciera	UoM	Inga	26/11//2010	10/12/2010
Rodger Young	UoM	Inga	26/11//2010	13/12/2010
Maria Piles	UoM	Inga	26/11//2010	13/12/2010
Giuseppe Satalino	CNR, Italy	Inga	2/12/2010	9/12/2010
Fedra Mendez	External	Inga	2/12/2010	9/12/2010
Dongryeol Ryu	UoM	Inga	2/12/2010	9/12/2010
Muzaffar Ahmad	Monash Uni	Inga	2/12/2010	9/12/2010
Lucheng Huang	Monash Uni	Inga	2/12/2010	9/12/2010
Perrine Hamel	Monash Uni	Inga	2/12/2010	9/12/2010
Rob Pipunic	UoM	Inga	2/12/2010	9/12/2010
Chris Rudiger	Monash Uni	Inga	2/12/2010	9/12/2010
Lynn McKee	USDA	Inga	2/12/2010	9/12/2010
John Prueger	USDA	Inga	2/12/2010	9/12/2010
Seungbum Kim	JPL	Inga	2/12/2010	9/12/2010
Mehmet Kurum	Goddard	Inga	2/12/2010	9/12/2010
Jon Johanson	External	Inga	2/12/2010	9/12/2010
Jeff Walker	Monash Uni	Inga	2/12/2010	9/12/2010
Heath Yardley	Univ of Adelaide	Carlose	2/12/2010	9/12/2010

8.3 Accommodation

Accomodation costs will be fully covered by the SMAPEx project for the members of the air crew and the ground Teams A and B. Two types of accommodation are available for SMAPEx-2 participants: motel-style and a bunk house at MRSC.

Amaroo' motel-style accommodation

Amaroo, meaning ‘a quiet place’, features 15 bed and breakfast (continental) motel-style rooms (see N42 in Figure 8-1). Each room has a queen bed and a single bed, ensuite, TV, toaster, tea and coffee making facilities, bar fridge, and heating and cooling and wi-fi internet access. The motel rooms are organised around a central courtyard connected to the conference facility. Price is $82.50/night/person for single room and $105/night/room for double room (incl. breakfast).

'Inga' Bunk house accommodation

Inga has 14 double rooms and one single room (see N31 in Figure 8-1). Rooms have a double bunk, wardrobe and desk. Linen and towels are provided. The bunk house has a kitchen with microwave, toaster, kettle and fridge. Barbecue facilities are available on site by request. A free laundry, lounge room and shared single-sex bathroom facilities are also featured. Cost is $35/night/person (+$5.50 for breakfast). It **may be necessary to share a room, depending on final numbers.** Accommodation details for all participants are listed in Table 8-4.

8.4 Meals

Meal costs will be fully covered by the SMAPEx project for the members of the air crew and the ground Teams A and B. If you wish to supplement the meal choices provided depending on your appetite and dietary requirements, it is recommended to do this on the evening before each sampling day at the Leeton supermarket.

<u>Breakfast:</u> a variety of breakfast choices (cereals, milk, toasts, jams) will be made available in the Inga kitchen.

<u>Lunch:</u> no facilities will be open in time on sampling days for buying lunch prior to departure for the field. Moreover, there are typically no facilities near to the sampling areas themselves for buying lunches, nor are you likely to pass any shops on the way to your sampling site. Therefore a variety of supplies for packet-lunches top be carried in the field will be pre-purchase from the supermarket by Rodger young and made available in the Inga kitchen. Each participant will need to make his/her own lunch in the morning (or night before if you are not a morning person) prior to leaving for the field.

<u>Dinner:</u> apart from the supermarket (if you wish to cook your own meal in the Inga kitchen), you will be able to purchase a meal from a nearby restaurant or hotel. When at YIA the only options for dinner are to drive into Yanco (2km), Leeton (5km) or Narrandera (20km).

8.5 Internet

Internet access will be available to SMAPEx-2 participants when at MRSC (see N36 in Figure 8-1). An office with internet access will be available with key access for the participants. A password for login on these computers is provided in the room.

8.6 Daily Activities

Field work during SMAPEx-2 will consist of collecting data in the Yanco Region and archiving the information collected during the sampling days. Table 8-6 illustrates the campaign schedule.

Daily schedule during sampling days will is shown Table 8-5. At the end of the day, each team member will need to coordinate with their team leader (as relevant) to:

- download their HDAS data and have it checked for completeness;
- upload the sampling grids for the following sampling day;
- check-in their gravimetric samples and any associated information (see section 0); samples must be weighed, details entered on the excel form provided(see Appendix G);

Table 8-6. SMAPEx-2 schedule

Date	Time	Location	Activity	Coordinator
December 2	8:30~13:30	-	Travel Melbourne-Yanco	D. Ryu
	13:30-14:30	Leeton	Lunch	D. Ryu
	14:30-15:00	YAI	Check in at YAI	R.Panciera
	15:00-17:30	YAI, Computer Room	Training session 1	R. Panciera
December 3	8:30-10:30	YAI, Computer Room	Training session 2	R. Panciera
	10:30-17:00	Focus Areas	Survey of Focus Areas	R.Panciera
December 4	All day Sampling			
December 5	All day Sampling			
December 6	All day Sampling			
December 7	All day Sampling			
December 8	All day Sampling			
December 9	8:30~13:30	-	Travel Yanco-Melbourne	D. Ryu

Table 8-5. SMAPEx-2 sampling day schedule.

Time	Activity
7:30~8:00	Gathering of the teams at the laboratory Review of the activity of the day on the notice board Preparation of the instruments for the sampling
8:00	Teams departure for the sampling location
8:00-9:00 (approx.)	Travel to the focus areas
9:00-16:30pm	Sampling operations
16:30-17:30	Travel to the YAI
17:30-18:30	Teams return to the lab Report to the project leaders Data downloading on the computers Soil and vegetation samples check in Recharge of electronic devices Refuel vehicles
19:30	Dinner and free time

- check-in their roughness data (**only Team C**); must be typed in the excel form provided;
- check-in all vegetation samples , spectral measurement and LAI information (**only Team C**); samples must be weighed and details entered on the excel form provided (see example in Appendix G);
- check-in the instruments used, ensuring ALL electronic devices are recharged overnight and any repairs needed reported to BOTH your team leader and Rodger Young (do not wait until the next sampling day!!), and
- ensure all electronic devices are put to recharge (GETAC, HDAS batteries, UHF radios).

Team leaders will in turn report to Rodger Young for technical/equipment repairs, and to Rocco Panciera for general updates etc. Team leaders will also be responsible for confirming ALL data is appropriately recorded/archived at the end of each sampling day:

8.7 Training sessions

A 2-day training session has been scheduled to ensure all SMAPEx-2 participants are familiar with the project objectives, the sampling strategy and the use of all the instruments involved in the sampling. The training session is scheduled for 2/3 December 2010. The training session will be held in the computer room of the YAI on 2 December and 3 December morning (see N36 in Figure 8-1) with all the participants, and by teams at the respective farms on 3 December afternoon, with the schedule and activities indicated in Table 8-7.

Training sessions will cover:

- Overview of the campaign logistics, ground sampling and flight schedule,
- End-of-day data download and housekeeping procedures;
- Overview of the “code of conduct” on farms, first aid, driving on unsealed farm tracks,
- Use of the University of Melbourne Hydraprobe Data Aquistion System (HDAS),
- Vegetation height estimation,
- Vegetation type recognition,
- Dew amount recognition,

As vegetation sampling activities will be undertaken by well trained NASA personnel, and gravimetric samples by the team leaders, no dedicated training sessions are scheduled for the vegetation and gravimetric sampling will be undertaken.

8.8 Farm Access and Mobility

Farms will be accessed regularly for the ground sampling operations. Transport from the ground operations base to the farm (and in some case across the farm) for sampling will be done using the team 4WD vehicle. Please note that 4WD driving on off-road areas and farm tracks can lead to injury and death, and therefore requires extreme attention and care and

Table 8-7. SMAPEx-2 training schedule and activities.

Date	Time	Location	Activity	Coordinator
December 2	15:00-15:30	YAI, Computer room	Presentation: SMAPEx-2 Introduction	J. Walker
	15:30-16:00	YAI, Computer room	Presentation: SMAPEx-2 Logistics and safety	R. Panciera
	16:00-17:00	YAI, Computer room	Presentation: SMAPEx-2 Sampling Strategy	R. Panciera
	17:00-17:30	YAI, Computer room	Post-work day check-in & downloads	R. Panciera
December 3	8:30-9:30	YAI, Computer room	Presentation: HDAS Overview	R. Panciera
	9:30-10:30	YAI	Training: HDAS Practice (all)	R. Panciera
	10:30-17:00	Focus Areas	Training: Survey of Focus Areas	R.Panciera D. Ryu

should only be undertaken after appropriate training. Driving through cultivated areas should be avoided at all times, due to the serious damage the transit could cause to crops. As there will be poor or no mobile phone coverage at many farms, each team member will be issued with a small UHF radio for team communication, as an additional security measure. These have a range of 3-4km and a channel for communication will be announced at the training session.

The sampling locations have been organised so that only reasonably accessible areas will be the object of the sampling.

"Regional" sampling days

During regional sampling days, a 2.8km x 3.1km area will be sampled over a regular grid of sampling locations, spaced of 250m. It is left to the team leader to agree a sampling strategy with the team members. However, it is recommended to follow this guidlines:

- Sampling will be undertaken in pairs, for safety reasons;
- Before starting the sampling, the team should agree and identify clearly on the map a meeting point and a meeting time where to gather at the end of the sampling. **NOTE: the UHF radio provided and mobile phones might not always be effective due to various factors, so it is important that each team member is able to locate the meeting point on the map and return to it.**
- At the beginning of the sampling, Team leaders will define a sampling approach with the team members. Each pair of team members will be assigned a number of sections of the 2.8km x 3.1km area, and will be solely responsible for sampling the entire section. Each section will be identified on the hardcopy maps provided using clearly visible features, such as irrigation canals, paddock fences, roads. The sections should be defined and agreed to avoid having two groups accidentally sampling the same location at different times during the day.

- Each group should then identify an access point to their section from the main roads. The team leader will then drive the team members to their access location. The team leader will then leave the car at the agreed meeting point and start its own sampling;

- It is highly recommended that each group of 2 samples their own section by “area” rather than by “line”, i.e., once you enter an area delimited by a fence, canal or road, sample all the locations falling within the delimited area along transects, keeping your group mate always in sight, and then move to an adjacent area.

- When sampling on cropped areas, always move through a field along the row direction to avoid impact on the canopy;

“Regional” sampling days

During target sampling days, Team A and B will work together to cover 10, 3km long transects, spaced of 50m, and sampling will be conducted at 50m-spaced locations. Each soil moisture team member will choose one of the 10 soil moisture transects. Starting from one end, the 10 soil moisture team members should proceed “side-by-side” from one end of the transect to the other. It is recommended that team members keep their two adjacent team mates in sight at all times to ensure their safety; stay at least in pairs. Try and team up with someone that has a similar pace to you. It is also recommended that all team members have a mobile phone to facilitate communication with each other in case of emergency and for logistics reasons.

It is the responsibility of the team leader to ensure that all points have been measured at the end of each day prior to leaving the field. Following are some recommendations to make the sampling as uniform and consistent as possible between different farms, different days, and different participants:

- Use the GPS as a guide rather than the sole means of navigation. Calibrate your step and pace out the distance between sampling points; allow more steps when going up hill and less when coming down. This will help minimise “chasing” the GPS position which is only accurate to about 20m.

- Take the samples at the location indicated on the screen map: exception to this rule might be the case of a sampling point falling within an undesirable location which might create local soil moisture conditions not representative of the site (e.g. an isolated tree in a vast short grass area, or in a creek bed). In this case, shift the sampling far enough to capture the average site conditions (up to 25m).

Remember that AACES activities are allowed by the property owners on the basis that no damage will be caused to the properties. In particular:

- Use gates when transiting between paddocks. The location of (some) gates etc are identified on the maps in Appendix H. Leave all gates as you find them!! (i.e., open if you found it open, closed if you found it closed);

- When you open a gate, SHUT IT immediately after you crossed the fence and make sure that the locking system is securely positioned.

- In the case of heavy rain, stop sampling and wait for better weather conditions. If rain appears to “set-in”, return to the operations base.

- Be aware of the presence of stock on most of the farms during the sampling activities. Most of the animals are harmless cows and sheep, which will generally keep their distance unless they are being hand fed, in which case they may be a nuisance but not dangerous.

Detailed maps of the focus areas are provided in Appendix H. Hardcopy of these maps will be provided to each team member and will be part of the personal equipment during sampling.

8.9 Communication

Communication between team members, teams and experiment coordinators is essential both from a logistic and safety point of view. In every team there will be at least one mobile phone with the team leader. Moreover, each team member will have a hand-held UHF radio on a pre agreed channel; normally channel 38. Additionally, working together as a team, or at least in pairs, will ensure that contact within the individual team members is maintained. Ensure that each team member can be accounted for each half an hour. If a team member cannot be accounted for, search initiation should be immediate. On most farms the mobile phone coverage is extensive, while on some it is poor, and thus use of UHF radio, visual contact, and other means of communication (satellite phone) will be more important.

8.10 Safety

There are a number of potential hazards in doing field work. Common sense can avoid most problems. However, the following has some good suggestions. Full details on risk assessment for this field work can be found in Appendix J. Remember to:

- Always work in teams of two
- Carry a phone and/or UHF radio
- Know where you are. Keep track of your position on the provided farm map.
- Do not approach, touch or eat any unidentified objects in the field.
- Dress correctly; long pants, long sleeves, hiking boots, hat etc
- Use sunscreen.
- Carry plenty of water for hydration.
- Notify your teammate and supervisors of any pre-existing conditions or allergies before going into the field.
- Beware of harvesting machinery. When sampling on crop, always make sure your presence is noted and watch out for moving harvesting machines.
- Beware of snakes. Always wear sturdy hiking boots and long work pants to avoid penetrating bites. Refer to http://www.australianfauna.com/australiansnakes.php for detailed info about the most common of Australian snake species. Treat all Australian snakes as potentially deadly. In 99.9% of all encounters, the snake will try to avoid any human contact. For detailed information on how to avoid a snake bite and how to treat a person who has been bitten, see Appendix J.

- Do not run through high grass or uneven ground to avoid injuries.

- The temperature used for the soil drying ovens is 105C. Touching the metal sample cans or the inside of the oven may result in burns. Use the safety gloves provided when placing cans in or removing cans from a hot oven. Vegetation drying is conducted at lower temperatures that pose no hazard.

8.11 Travel Logistics

8.11.1 Getting there

In terms of booking flights etc, international participants should fly into Melbourne (or Sydney). To travel to Yanco there are for options below:

- get a lift to Yanco on the "Melbourne shuttle" -- see below,

- get a connecting flight to Narrandera with Regional Express (REX), where there will be somebody waiting to pick you up and take you to Yanco which is ~10min drive away (please give your arrival details if that is the case) or

- if you are planning to have a rental car for your own purposes, arrange to pick it up in Sydney or Melbourne and drive direct to Yanco/Leeton (~5-7hrs; some people may want to car pool and do this); see detailed driving directions below. You may also wish to take a connecting flight to Canberra (~4hrs from Yanco) with Qantas, Virginblue or Jetstar, or to Wagga Wagga (~1hr from Yanco) with REX.

NOTE 1: Please allow a few extra days on the end of the campaign in case of rescheduling due to rainfall on sampling days or other logistical problems.

NOTE 2: All ground crew are expected to attend the extensive training sessions on December 2 and 3.

The travel itinerary and detailed driving instructions from Melbourne, Sydney, Canberra and Wagga Wagga to Yanco can be found on googlemaps.

Melbourne Shuttle

A "Melbourne shuttle" will be organized to transport all participants of Team A and B from Melbourne to Yanco on December 2 (departure will be in the morning; details TBD) and return to Melbourne on December 9 (arrival sometime in the afternoon). The "Melbourne shuttle" will be organized by Dongryeol Ryu and will consist of 3 vehicles. Details on seat allocations are TBD and will be announced prior to December 2.

8.11.2 Getting to the farms

Each ground sampling team will each use their vehicle (Table 8-1) to drive to the focus areas in the morning and return to the YAI at the end of the sampling. The team leaders will be the designated drivers and will have knowledge of the routes to/from the focus areas to the YAI. However, driving directions from the YAI to the focus areas are provided in Appendix H.

9 Contacts

9.1 Primary

The primary contacts for the SMAPEx-2 project are:

Professor Jeffrey Walker
Phone: 03 99059681
Mobile: 0413 023 915
Email: jeff.walker@monash.edu

Department of Civil Engineering,
Monash University
Clayton, Victoria 3800, Australia

Dr. Rocco panciera
Phone: 03 8344 6529
Mobile: 0431 688 696
Email: panr@unimelb.edu.au

Dept. of Civil and Environmental
Engineering, The University of Melbourne
Parkville, Victoria 3010.Australia

The satellite phone numbers are: +61 147 168 758 and 0011 872 761 151 283 (those are only used for emergencies, for calls, please contact the participants via the hotel in the evening).

9.2 Field Work

A list of contacts for key personnel during the campaign is provided below:

Person	Organization	Function	Phone Number
Panciera, Rocco	Univ. of Melbourne	Ground crew coordinator, Team A coordinator	0431 688 696
Walker, Jeff	Monash University	Air crew coordinator	0413 023 915
Young, Rodger	Univ. of Melbourne	Technical support	0417 504 593
Ryu, Dongryeol	Univ. of Melbourne	Team B coordinator	0403 257 335
Lynn McKee	NASA	Team C coordinator	0424 125 035
Field satellite phone		Field support	0417168758

9.3 Emergency

Emergency number in Australia 000

NSW Poisons information centre 131 126

Leeton District Hospital

Address: Cnr Wade and Palm Avenue,

Leeton, NSW, 2705

Phone: (02) 6953 1111

Narrandera District Hospital

Address: Cnr Douglas and Adams Streets

Narrandera, NSW 2700, Ph: (02) 6959 1166

9.4 Farmers

Focus Area	Farmer Name (Farm Nr.)	Home Phone	Mobile Phone
YA4	John Wallace (4)	02 6954 1220	0428 696 330
	Greg Kelly (6,7,13,14)	02 6954 1212	0427 541 217
	Keith Burge (3)	02 6954 1204	0428 541 104
	Ian Scifleet (5)	02 6954 1504	N/A
YA7	Adrian Hay (15,16,25)	N/A	0427 541 256
	Lance Harland (17)	02 6954 1261	N/A
YB5	Wayne Durnan	02 6959 7466	0407 275 534
YB7	Wayne Durnan	02 6959 7466	0407 275 534
YC	Adrian Hay	N/A	0427 541 256
YD	Franck McKersie (606)	02 6954 8566	N/A
	Danny Graham (551)	02 6954 8551	0427 548 545
	Lawrence Graham (552)	02 6964 6403	0448 368 527
	Rodney Foster (554)	02 6954 8322	0428 948 322
	Ross McIntyre (607)	02 6954 8514	0428 548 500
	Craig Perkins (615)	02 6954 8520	0407 274 110

9.5 Accomodation and Logistics

Yanco Agricultural Institute (YAI)

Mail: Narrandera Road

PBM

Yanco NSW 2703 Australia

Contact person: George Stevens

Phone: (02) 69512652

Fax: (02) 6955 7580

Email: georges.stevens@dpi.nsw.gov.au

Web: http://www.dpi.nsw.gov.au

The YAI facilities (lab space and equipment)

Contact person: Geoff Beecher

Research Agronomist

NSW Dept Primary Industries

Yanco Agricultural Institute

YANCO NSW 2703

Ph 0269512725

Fx 0269557580

Murrumbidgee Rural Studies Centre (MRSC)

Mail: Murrumbidgee Rural Studies Centre

PMB

YANCO NSW 2703 Australia

Phone: 1800 628 422 (From overseas: +61 2 6951 2696)

Fax: (02) 6951 2620

Email: mrsc@dpi.nsw.gov.au

Accommodation in the MRSC

Contact person: Kellie Goring

Phone: (02) 69 512 775

Fax: (02) 69 512 620

Email: kellie.goring@dpi.nsw.gov.au

Leeton Heritage Motor Inn

Contact person: Evelyn Vogt

Address: 439 Yanco Avenue, Leeton, NSW 2705

Phone: (02) 6953 4100

Fax: (02) 6953 3445

Off Road Rentals

1370 North Road

Huntingdale VIC 3166

Phone (03) 9543 7111

Fax (03) 9562 9205

Email: manager@offroadrentals.com.au

Web: http://www.offroadrentals.com.au/

Appendix A. Equipment List

Item	Quantity	
Yanco base		
Gel cell battery charger	2	
Power board	5	
HDAS battery charger	5	
Star pickets with flag for PARCs locations	6	
Big water-proof tarps to cover PARCs	3	
RS232 download cable	1	
Laptop	4	
Hard drive for ground data	2	
Backup dvds	50	
Color printer	1	
Scales	2	
Weight recording forms	1	
Laptop projector	1	
White board	1	
Ovens	1	
Alluminium trays	2	
Extension leads	150	
White board markers		
Vegetation + grav samples storage boxes		
Team equipment (2 x soil moisture teams)		
	per team	**total**
Mosquito nets	5	10
Gloves pair	1	2
Two-way UHF Radio	1	2
Walkie-talkie	5	10
Gravimetric sampling kit	1	2
HDAS	5	10
25 litres water Jerry can	1	2
Sunscreen Bottle	1	2
first aid kit	1	2
first aid book	1	2
Field book	5	10
SMAPEx workplan	1	2
Hardcopy locus area maps	5	10
Pens		
Team equipment (1 x vegetation team)		
Vegetation sampling kit	1	
Mosquito nets	5	
Gloves pair	2	
Two-way UHF Radio	1	
25 litres water Jerry can	1	
Sunscreen Bottle	1	
First aid kit	1	
First aid book	1	
Pens	5	
Field book	5	
SMAPEx workplan	1	
Hardcopy focus area maps	5	
Hardcopy whole area map	1	
Satellite phone	1	

HDAS (12 x)	
GETAC	12
Poles	12
Batteries	12
GETAC power cable	12
GETAC download cable	12

Gravimetric Sampling Kits (2 x)		
	per kit	total
Soil sample ring (5cm)	5	10
Garden trowel	1	2
Blade	1	2
Spatula	1	2
Hammer	1	2
Metal base for hammering rings	1	2
Plastic bags (SMALL)	80	160
Rubber bands	80	160
Paper tags (to label samples inside bags)	40	80
Print out of soil recording form	5	
Pens		
Markers		

Vegetation sampling kits (1 x)	
GETAC unit	1
Large vegetation clipper	1
Small vegetation clipper	1
Scissors	1
Quadrant	1
Serrated Knife	1
Box of Large Trash Bags	240
Compass	1
Meter Sticks	1
Back Pack (to carry equipment)	1
CROPSCAN	1
LAI2000	1
Print-out of Vegetation recording form	5
Paper Bags with flat bottoms	
Package of pencils	
Permanent Markers	

Surface Roughness Sampling (1 x)	
GETAC unit	1
Pin profiler	1
Level	2
Field book	1
roughness sampling recording form	80
Digital camera	1
Compass	1
Wooden blocks	4
Markers	

Appendix B. Operating the HDAS

HDAS Quick Instruction!

1. HDAS set up

- Connect the GETAC unit to the field laptop using the GETAC USB cable (if the operating system on the laptop is Windows XP, Microsoft ActiveSync will have to be installed to follow these steps)
- The GETAC unit will be added as a new drive in the "My Computer" (same as for a normal USB pen)
- Click on the drive icon in the windows explorer
- Copy and paste all the files provided in the HDAS software package ("Applets folder") to the GETAC subdirectory "My Mobile Device\Program Files\ArcPad\Applets". These files are required to display the HDAS custom toolbar and perform the hydraprobe reading commands.
- Create a folder named "SD Card" in the device root folder "\". This is the folder where the files with the point recorded ("hydra" and hydraGRID") will be saved by the software.
- Copy and paste the Arcpad layers (or map files) you want to have as a background on the ArcPad screen into a folder of your choice
- If it is the first time the unit is being used goto "Start" (see Figure 1) → "Settings" → "System" → "GPS" → set GPS program port to COM8

2. Hydra Probe

- Make sure that the power cable (black socket) is connected to the battery
- Make sure that the connection cable (gray socket) is connected and screwed to the bottom port of the GETAC
- Check Hydra Probe sensors prongs regularly to see if they are straight and not broken! Clean the sensor prongs after each measurement!

3. ArcPad

- Tap on start icon to see the menu. Tap on ArcPad 7.1.1 icon to open the program (see figure 1).
- If there is no ArcPad 7.1.1 icon in the menu, go to Programs and load the software from there.
- Press the "add layers" icon to load the Arcpad layers (or map files) you want to have as a background on the ArcPad screen

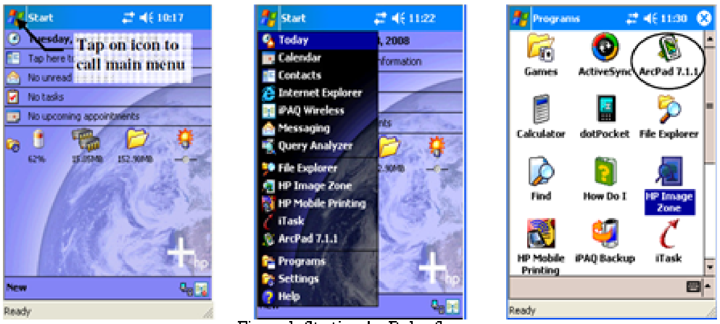


Figure 1. Starting ArcPad software

- Tap the icon in the second toolbar to activate the HDAS file system

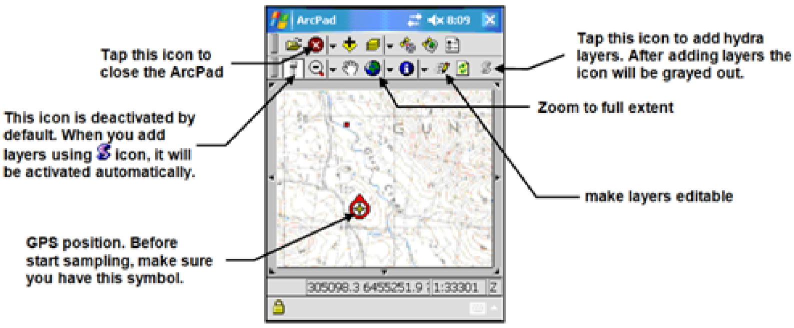


Figure 3. Customised toolbars for HDAS in ArcPad

- Wait for the "Hydra Files loaded successfully" message window and hit the OK button.
- The first icon in the second (HDAS) toolbar should now be active. This means HDAS is ready to take a reading.
- The general commands of ArcPad are illustrated below in Figure 3

- The Symbol indicates your GPS position is lost or is not accurate. **You need to wait until you have a fixed position (symbol) before sampling.**
- If you don't have a fixed position symbol, check that the GPS is activated by pressing the GPS icon . If the GPS icon is active but you still have the symbol , you will have to wait until the GPS established a fixed position .
- Before taking a reading tap on the hydraprobe icon to prepare the HydraProbe for reading (unless the hydraprobe icon is already active).
- Put the Hydra Probe into the ground at the sampling point, tap wherever within the map area of the screen (**don't tap on the toolbars**) and wait for a few seconds (**NOTE: the exact point on the map area where you tap does not matter, since the coordinates will be taken from the GPS**).
- Tapping on touch screen will start a few seconds event procedure that will communicate with the Hydra Probe and GPS to gather both position and soil moisture related data.
- After a few seconds, a form with collected data will appear in the screen.
- Fill out each of the pages in the form as described in figure 4.

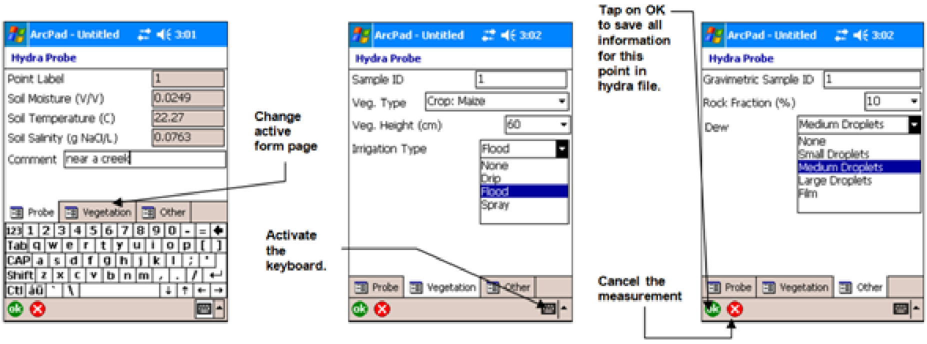


Figure 4. HDAS data entry pages with instructions

- press the ok icon to save the point or press the red cross icon to delete the point
- to check the data you have saved at a particular point, activate the information icon and tap on the desired point

4. Troubleshooting

- "Error 55: Your connection to GPS has not been established". This means that the wrong communication port is set for the GPS. To correct problem, from the desktop "Start" (see Figure 1) → "Settings" → "System" → "GPS" → set GPS program port to COM8. Then go back to ArcPad.
- "Hydra Probe Reading Error: Check connection cable between GETAC and Hydra Probe.". Make sure that the connection cable (gray socket) is connected and screwed to the bottom port of the GETAC
- In case the GETAC freezes for a long time, reboot the GETAC by pressing and holding the power button (bottom right button in the GETAC keypad).

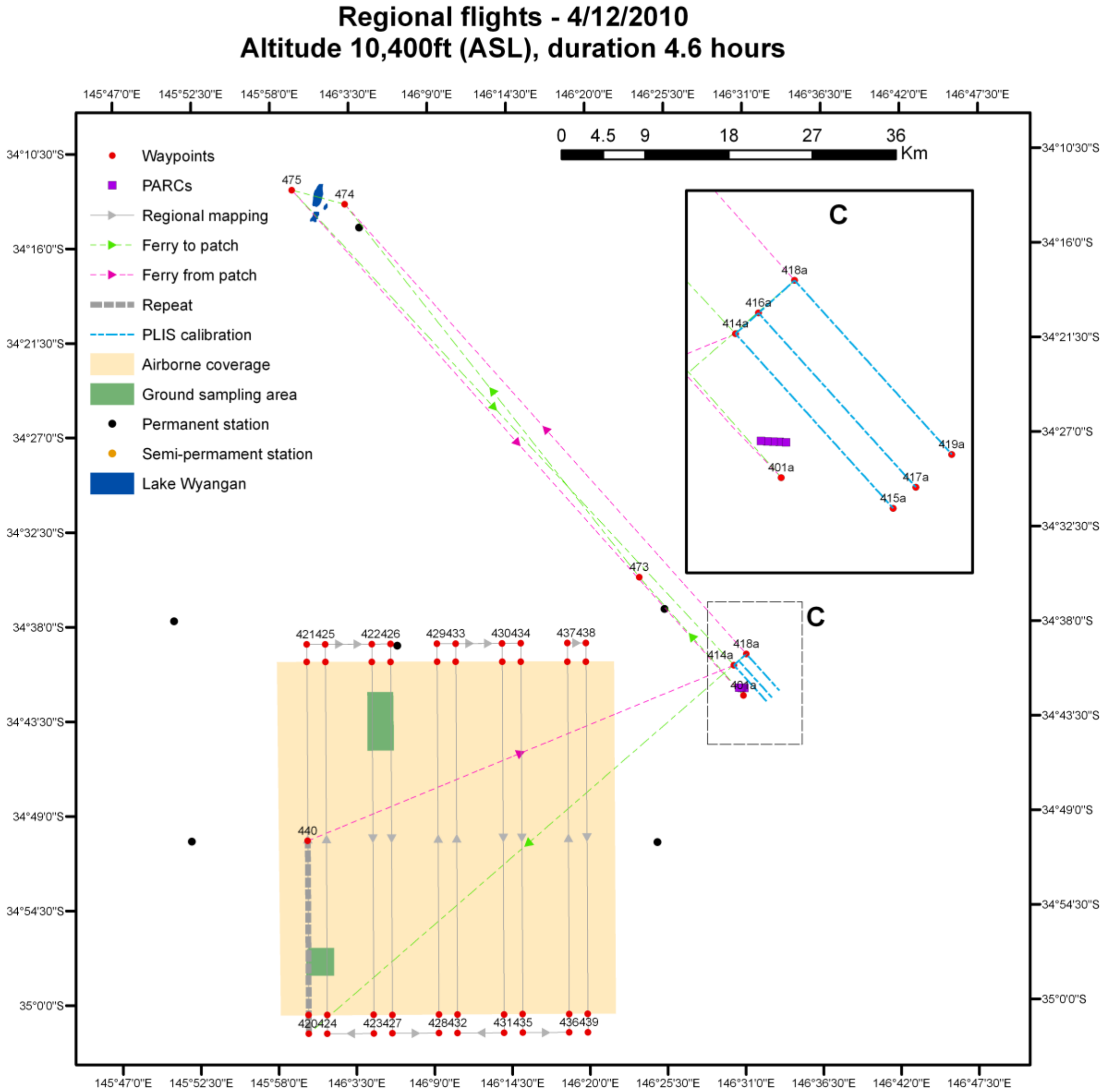
5. Data downlading

This section explaines how to save the data collected in the field to the data archive in the field laptop (if the operating system on the laptop is Windows XP, Microsoft ActiveSync will have to be installed to follow these steps)
- Connect the GETAC unit to the field laptop using the GETAC USB cable
- The GETAC unit will be added as a new drive in the "My Computer" (same as for a normal USB pen)
- Click on the drive icon in the windows explorer
- Navigate in the GETAC file system to the folder names "SD Card" in the root directory
- Copy and paste all the files with root name "hydra" or "hydraGRID" (extensions .dbf, .shb, .shx, .prj and .apl)
- Past the files into the desired folder on the field laptop
- empty the folder of the "SD Card" folder by deleting all "hydra" and hydraGRID" shapefiles.

6. Checking out

- Disconnect the GETAC from the laptop
- Put the GETAC to recharge overnight using the GETAC power cable
- Turn off the GETAC by pressing and holding the power button (bottom right button in the GETAC keypad).
- Return all GETAC components (GETA unit, power cable, USB cable, pencil) to the boxes with the same label.

Appendix C. Flight Line Coordinates

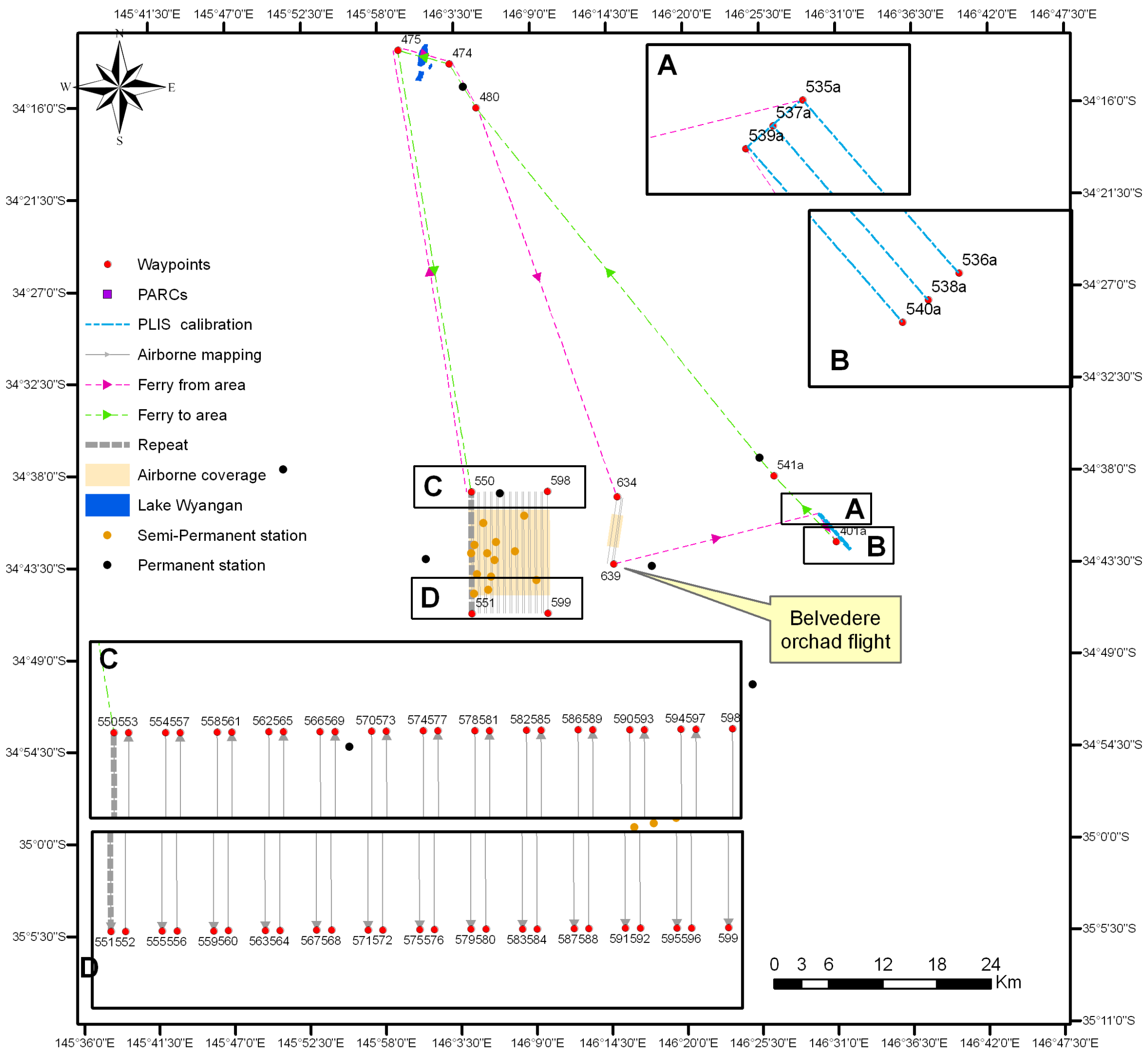


Regional Flights – 04/12/2010
Altitude 10,400ft (ASL) and duration 4.6 hours

Point ID	Longitude	Latitude	Point ID	Longitude	Latitude
401a	146° 30.953' E	34° 42.3' S	429	146° 9.411' E	34° 39.18' S
414a	146° 30.286' E	34° 40.538' S	430	146° 13.994' E	34° 39.19' S
415a	146° 32.608' E	34° 42.682' S	431	146° 13.928' E	35° 1.83' S
416a	146° 30.627' E	34° 40.286' S	432	146° 10.639' E	35° 1.822' S
417a	146° 32.947' E	34° 42.427' S	433	146° 10.72' E	34° 39.183' S
418a	146° 31.164' E	34° 39.889' S	434	146° 15.304' E	34° 39.192' S
419a	146° 33.48' E	34° 42.026' S	435	146° 15.243' E	35° 1.832' S
420	146° 0.116' E	35° 1.789' S	436	146° 18.532' E	35° 1.838' S
421	146° 0.245' E	34° 39.15' S	437	146° 18.577' E	34° 39.198' S
422	146° 4.828' E	34° 39.166' S	438	146° 19.887' E	34° 39.199' S
423	146° 4.72' E	35° 1.805' S	439	146° 19.847' E	35° 1.839' S
424	146° 1.431' E	35° 1.794' S	440	146° 0.18' E	34° 50.574' S
425	146° 1.555' E	34° 39.155' S	473	146° 23.676' E	34° 35.392' S
426	146° 6.137' E	34° 39.17' S	474	146° 3.205' E	34° 13.577' S
427	146° 6.035' E	35° 1.81' S	475	145° 59.512' E	34° 12.728' S
428	146° 9.324' E	35° 1.819' S			

Route:401a, 473, 474**, (500ft→)**,475 **(500ft↑10,400ft)**, 414a**(10,400ft→)**, 415a, 414a, 416a, 417a, 416a, 418a,419a,418a,420,421,422,423,424,425,426,427,428,429,430,431,432,433,434,435,436,437,438,439,420,440, 414a, 415a, 414a,416a, 417a, 416a, 418a, 419a,418a**(10,400ft↓500ft)**,474**(500ft→)**,475,473,401a

Target flights - 5/12/2010
Altitude 1,400ft (ASL), duration 3.7 hours

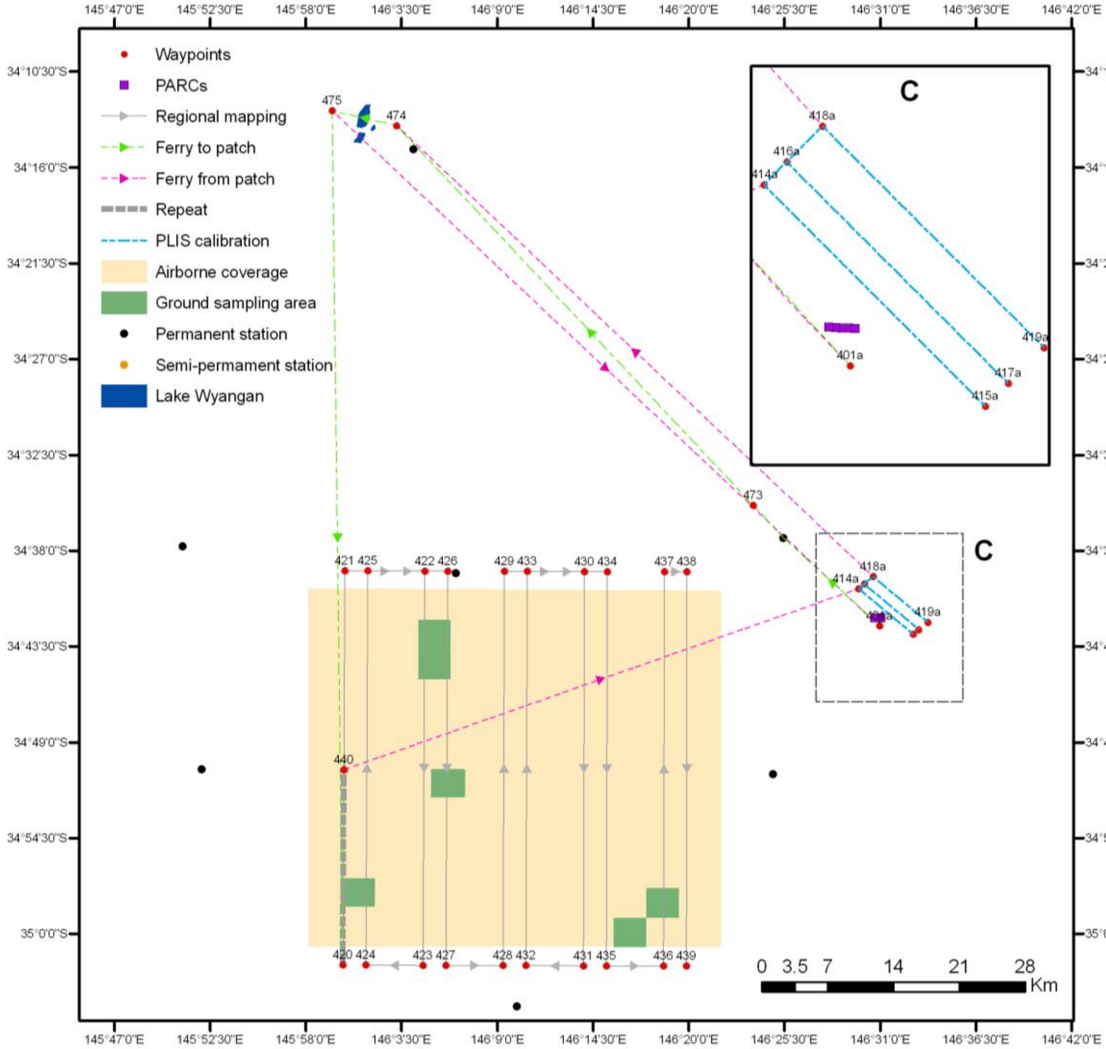


Target Flight – 5/12/2010
Altitude 1,400ft and duration 3.7hrs

Point ID	Longitude	Latitude	Point ID	Longitude	Latitude
401a	146° 30.953' E	34° 42.3' S	638	146° 15.518' E	34° 39.599' S
474	146° 3.205' E	34° 13.577' S	639	146° 14.811' E	34° 43.556' S
475	145° 59.512' E	34° 12.728' S	569	146° 6.486' E	34° 39.172' S
480	146° 5.109' E	34° 16.197' S	570	146° 6.814' E	34° 39.172' S
550	146° 4.522' E	34° 39.166' S	571	146° 6.79' E	34° 46.46' S
535a	146° 29.771' E	34° 40.585' S	572	146° 6.921' E	34° 46.461' S
536a	146° 32.051' E	34° 42.766' S	573	146° 6.945' E	34° 39.173' S
537a	146° 29.711' E	34° 40.628' S	574	146° 7.272' E	34° 39.173' S
538a	146° 31.992' E	34° 42.809' S	575	146° 7.249' E	34° 46.461' S
539a	146° 29.657' E	34° 40.665' S	576	146° 7.38' E	34° 46.462' S
540a	146° 31.942' E	34° 42.844' S	577	146° 7.403' E	34° 39.174' S
541a	146° 26.441' E	34° 38.338' S	578	146° 7.73' E	34° 39.174' S
551	146° 4.495' E	34° 46.455' S	579	146° 7.708' E	34° 46.462' S
552	146° 4.626' E	34° 46.455' S	580	146° 7.839' E	34° 46.463' S
553	146° 4.653' E	34° 39.167' S	581	146° 7.861' E	34° 39.174' S
554	146° 4.98' E	34° 39.168' S	582	146° 8.188' E	34° 39.175' S
555	146° 4.954' E	34° 46.456' S	583	146° 8.167' E	34° 46.463' S
556	146° 5.085' E	34° 46.457' S	584	146° 8.298' E	34° 46.464' S
557	146° 5.111' E	34° 39.168' S	585	146° 8.319' E	34° 39.175' S
558	146° 5.439' E	34° 39.169' S	586	146° 8.647' E	34° 39.176' S
559	146° 5.413' E	34° 46.457' S	587	146° 8.626' E	34° 46.464' S
560	146° 5.544' E	34° 46.458' S	588	146° 8.757' E	34° 46.465' S
561	146° 5.57' E	34° 39.169' S	589	146° 8.778' E	34° 39.176' S
562	146° 5.897' E	34° 39.17' S	590	146° 9.105' E	34° 39.177' S
563	146° 5.872' E	34° 46.458' S	591	146° 9.085' E	34° 46.465' S
564	146° 6.003' E	34° 46.459' S	592	146° 9.216' E	34° 46.466' S
565	146° 6.028' E	34° 39.17' S	593	146° 9.236' E	34° 39.177' S
566	146° 6.355' E	34° 39.171' S	594	146° 9.563' E	34° 39.177' S
567	146° 6.331' E	34° 46.459' S	595	146° 9.544' E	34° 46.466' S
568	146° 6.462' E	34° 46.46' S	596	146° 9.675' E	34° 46.466' S
634	146° 15.065' E	34° 39.543' S	597	146° 9.694' E	34° 39.178' S
635	146° 14.348' E	34° 43.52' S	598	146° 10.022' E	34° 39.178' S
636	146° 14.669' E	34° 43.564' S	599	146° 10.003' E	34° 46.467' S
637	146° 15.389' E	34° 39.583' S			

Route:401a**,** 541a**,** 480, 474**(500ft→),**475 **(500ft↑1,400ft)**,550(**1,400ft→) ,**551 ,552 ,553 ,554 ,555 ,556 ,557,558,559,560,561,562,563,564,565,566,567,568,569,570,571,572,573,574,575,576,577,578,579,580,581,582,583,584,585,586,587,588,589,590,591,592,593,594,595,596,597,598,599,551,550(**1,400ft↓500ft),**475(**500ft→)**,474,480, (**500ft↑1,400ft)** , 634**(1,400ft→),** 635,636,637,638,639, (**1,400ft↓)** 535a,536a,535a,537a,538a,537a,539a,540a,539a, 401a

Regional flights - 6/12/2010 & 8/12/2010
Altitude 10,400ft (ASL), duration 4.3 hours

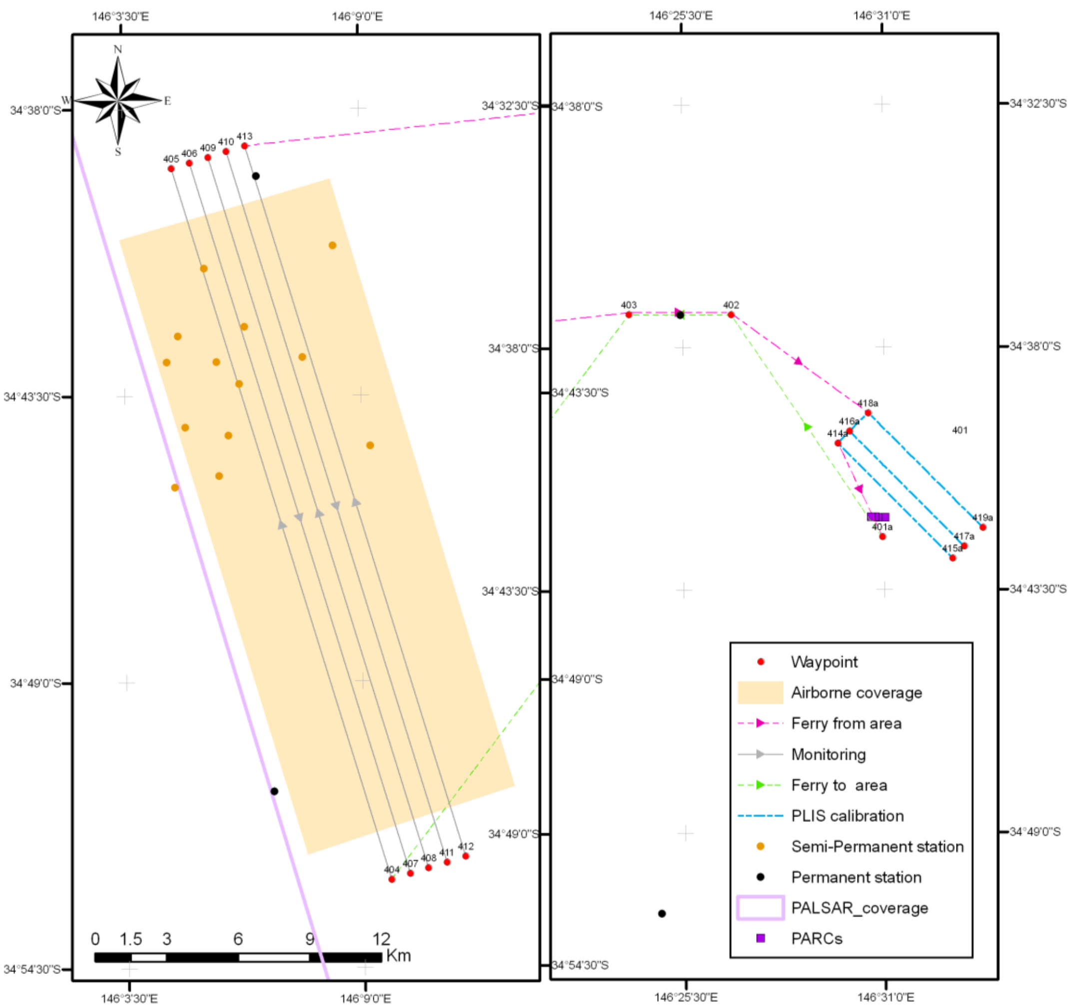


Regional Flights – 06/12/2010 & 08/12/2010
Altitude 10,400ft (ASL) and duration 4.6 hours

Point ID	Longitude	Latitude	Point ID	Longitude	Latitude
401a	146° 30.953' E	34° 42.3' S	429	146° 9.411' E	34° 39.18' S
414a	146° 30.286' E	34° 40.538' S	430	146° 13.994' E	34° 39.19' S
415a	146° 32.608' E	34° 42.682' S	431	146° 13.928' E	35° 1.83' S
416a	146° 30.627' E	34° 40.286' S	432	146° 10.639' E	35° 1.822' S
417a	146° 32.947' E	34° 42.427' S	433	146° 10.72' E	34° 39.183' S
418a	146° 31.164' E	34° 39.889' S	434	146° 15.304' E	34° 39.192' S
419a	146° 33.48' E	34° 42.026' S	435	146° 15.243' E	35° 1.832' S
420	146° 0.116' E	35° 1.789' S	436	146° 18.532' E	35° 1.838' S
421	146° 0.245' E	34° 39.15' S	437	146° 18.577' E	34° 39.198' S
422	146° 4.828' E	34° 39.166' S	438	146° 19.887' E	34° 39.199' S
423	146° 4.72' E	35° 1.805' S	439	146° 19.847' E	35° 1.839' S
424	146° 1.431' E	35° 1.794' S	440	146° 0.18' E	34° 50.574' S
425	146° 1.555' E	34° 39.155' S	473	146° 23.676' E	34° 35.392' S
426	146° 6.137' E	34° 39.17' S	474	146° 3.205' E	34° 13.577' S
427	146° 6.035' E	35° 1.81' S	475	145° 59.512' E	34° 12.728' S
428	146° 9.324' E	35° 1.819' S			

Route:401a, 473, 474**, (500ft→)**,475 **(500ft↑10,400ft)**, 420,421,422,423,424,425,426,427,428,429,430,431,432,433,434,435,436,437,438,439,420,440,414a, 415a, 414a,416a, 417a, 416a, 418a, 419a,418a**(10,400ft↓500ft)**,474**(500ft→)**,475,473,401a

PALSAR Transect - 7/12/2010
Altitude 10,400ft (ASL), duration 1.9 hours



Point ID	Longitude	Latitude	Point ID	Longitude	Latitude
401a	146° 30.953' E	34° 42.3' S	411	146° 10.929' E	34° 52.492' S
402	146° 26.829' E	34° 37.255' S	412	146° 11.359' E	34° 52.385' S
403	146° 24.022' E	34° 37.241' S	413	146° 6.352' E	34° 38.706' S
404	146° 9.637' E	34° 52.814' S	414a	146° 29.741' E	34° 40.172' S
405	146° 4.635' E	34° 39.134' S	415a	146° 32.875' E	34° 42.786' S
406	146° 5.064' E	34° 39.027' S	416a	146° 30.066' E	34° 39.906' S
407	146° 10.068' E	34° 52.707' S	417a	146° 33.201' E	34° 42.52' S
408	146° 10.498' E	34° 52.6' S	418a	146° 30.578' E	34° 39.487' S
409	146° 5.494' E	34° 38.92' S	419a	146° 33.713' E	34° 42.101' S
410	146° 5.923' E	34° 38.813' S			
Route: 401a, 402, 403, 404**(10,400→),** 405, 406, 407, 408, 409, 410, 411, 412, 413, 403, 402, 418a, 419a, 418a, 416a, 417a, 416a, 414a, 415a, 414a, (**10,400ft↓G)** 401 a					

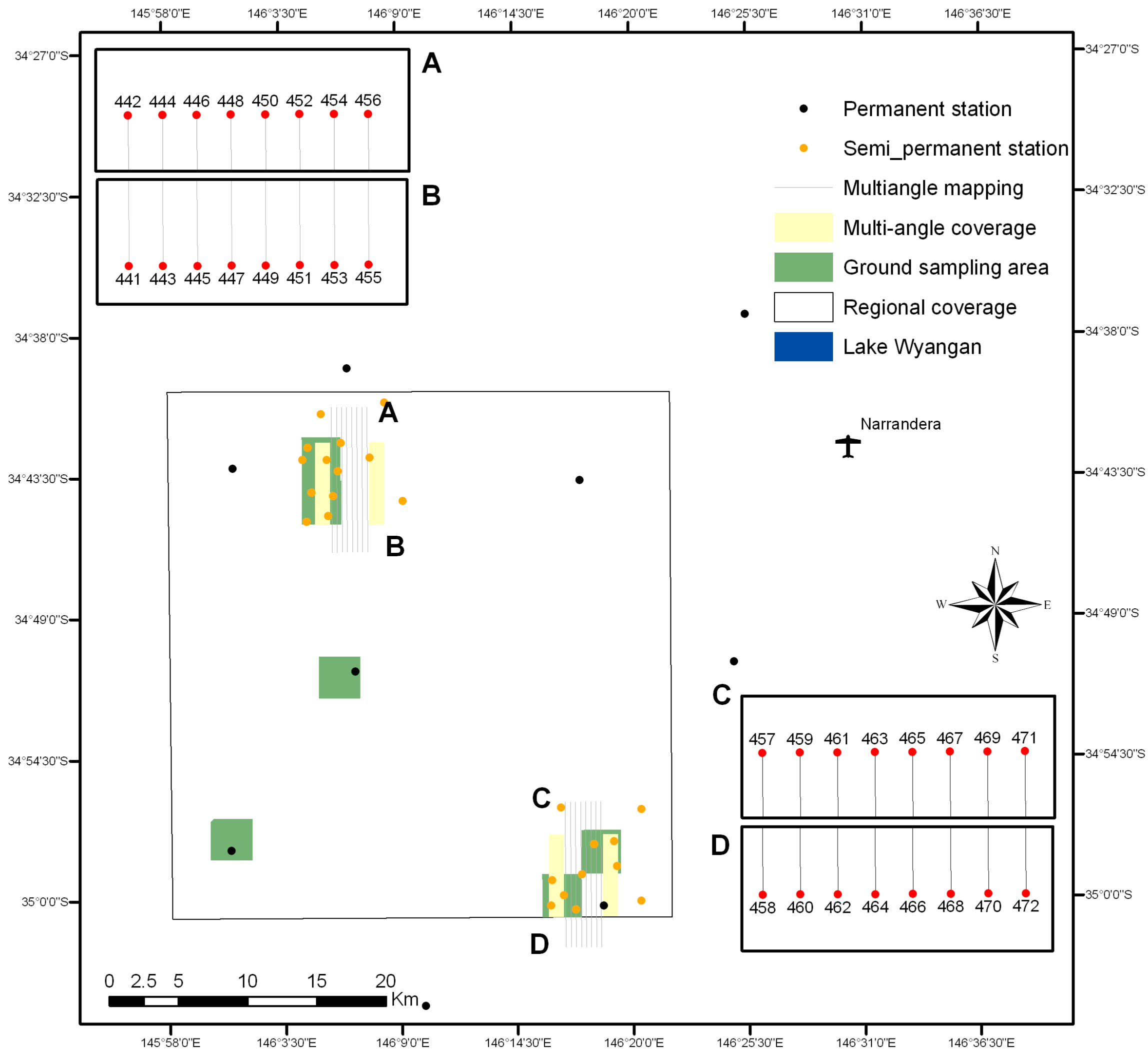
Multi-angle and Multi-azimuth Flight
Altitude 10,400ft (ASL), duration 5.1 hours

Point ID	Longitude	Latitude	Point ID	Longitude	Latitude
PLMR calibration					
401a	146° 30.953' E	34° 42.3' S	475	145° 59.512' E	34° 12.728' S
474	146° 3.205' E	34° 13.577' S	473	146° 23.676' E	34° 35.392' S
Multi-angle Routes, Altitude 10,400ft (ASL), duration 1.2hrs					
441	146° 5.857' E	34° 46.458' S	457	146° 16.799' E	34° 56.249' S
442	146° 5.877' E	34° 40.785' S	458	146° 16.791' E	35° 1.922' S
443	146° 6.097' E	34° 46.458' S	459	146° 17.039' E	34° 56.249' S
444	146° 6.116' E	34° 40.786' S	460	146° 17.032' E	35° 1.922' S
445	146° 6.337' E	34° 46.459' S	461	146° 17.28' E	34° 56.249' S
446	146° 6.356' E	34° 40.786' S	462	146° 17.273' E	35° 1.922' S
447	146° 6.577' E	34° 46.459' S	463	146° 17.52' E	34° 56.25' S
448	146° 6.596' E	34° 40.787' S	464	146° 17.514' E	35° 1.922' S
449	146° 6.817' E	34° 46.46' S	465	146° 17.761' E	34° 56.25' S
450	146° 6.835' E	34° 40.787' S	466	146° 17.754' E	35° 1.922' S
451	146° 7.057' E	34° 46.46' S	467	146° 18.001' E	34° 56.25' S
452	146° 7.075' E	34° 40.788' S	468	146° 17.995' E	35° 1.923' S
453	146° 7.297' E	34° 46.461' S	469	146° 18.241' E	34° 56.25' S
454	146° 7.315' E	34° 40.788' S	470	146° 18.236' E	35° 1.923' S
455	146° 7.537' E	34° 46.462' S	471	146° 18.482' E	34° 56.25' S
456	146° 7.555' E	34° 40.789' S	472	146° 18.476' E	35° 1.923' S
Multi-azimuth Routes, Altitude 5,400ft (ASL), duration 2.6hrs					
608	146° 2.311' E	34° 42.506' S	621	146° 7.521' E	34° 53.073' S
609	146° 2.298' E	34° 43.621' S	622	146° 8.91' E	34° 49.572' S
610	146° 3.061' E	34° 44.475' S	623	146° 6.309' E	34° 49.173' S
611	146° 4.163' E	34° 44.998' S	624	146° 6.273' E	34° 53.043' S
612	146° 5.409' E	34° 45.028' S	625	146° 5.168' E	34° 52.521' S
613	146° 6.529' E	34° 44.512' S	626	146° 4.417' E	34° 50.552' S
614	146° 7.28' E	34° 43.643' S	627	146° 5.089' E	34° 49.6' S
615	146° 7.403' E	34° 42.549' S	628	146° 7.562' E	34° 49.182' S
616	146° 6.798' E	34° 41.527' S	629	146° 9.394' E	34° 51.688' S
617	146° 5.451' E	34° 41.137' S	630	146° 9.517' E	34° 50.594' S
618	146° 4.2' E	34° 41.127' S	631	146° 4.405' E	34° 51.667' S
619	146° 2.982' E	34° 41.555' S	632	146° 8.643' E	34° 52.557' S

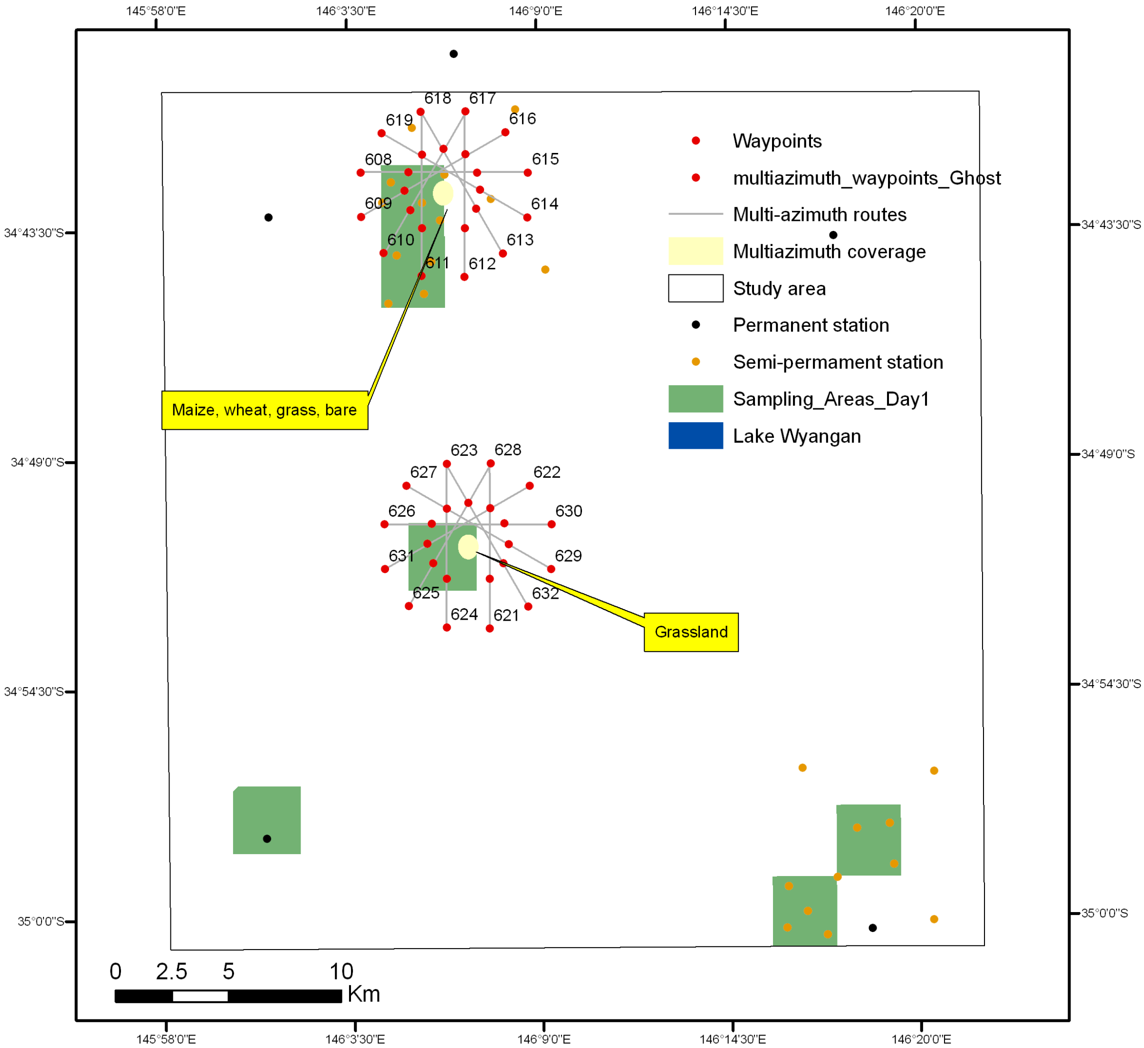
Route: 401a, 473, 474**, (500ft→)**,475**(500ft↑5,400ft)**, **Multi-azimuth (Jeff and Jon to fill)**

(5000ft ↑10,400ft→), 441(**10,400ft→)**, 442,444,443,445,446,448,447,449,450,452, 451 453,454,456, 455, 457,458,460,459,461,462,464,463,465,466,468,467,469,470,472,471 (**10,400ft↓500ft)**, 475**(500ft→),** 474, 473, 401a

Multi-angle routes
Altitude 10,400ft (ASL), duration 1.2 hours



Multi-azimuth Routes
Altitude 5,400ft (ASL), duration 2.6 hours



Appendix D. Operating the CROPSCAN MSR16R

In the field the radiometer is held level by the support pole above the crop canopy. The diameter of the field of view is one half of the height of the radiometer above the canopy. It is assumed that the irradiance flux density incident on the top of the radiometer (upward facing side) is identical to the flux density incident on the target surface. The data acquisition program included with the system facilitates digitizing the voltages and recording percent reflectance for each of the selected wavelengths. The program also allows for averaging multiple samples. Ancillary data such as plot number, time, level of incident radiation and temperature within the radiometer may be recorded with each scan.

Each scan, triggered by a manual switch or by pressing the space key on a terminal or PC, takes about 2 to 4 seconds. An audible beep indicates the beginning of a scan, two beeps indicate the end of scan and 3 beeps indicate the data is recorded in RAM. Data recorded in the RAM file are identified by location, experiment number and date.

The design of the radiometer allows for near simultaneous inputs of voltages representing incident as well as reflected irradiation. This feature permits accurate measurement of reflectance from crop canopies when sun angles or light conditions are less than ideal. Useful measurements of percent reflectance may even be obtained during cloudy conditions. This is a very useful feature, especially when traveling to a remote research site only to find the sun obscured by clouds.

Three methods of calibration are supported for the MSR16R systems.

2-point Up/Down - Uses a diffusing opal glass (included), alternately held over the up and down sensors facing the same incident irradiation to calibrate the up and down sensors relative to each other (http://www.cropscan.com/2ptupdn.html).

Advantages:

- Quick and easy.
- Less equipment required.
- Radiometer may then be used in cloudy or less than ideal sunlight conditions.
- Recalibration required only a couple times per season.
- Assumed radiometer is to be used where radiance flux density is the same between that striking the top surface of the radiometer and that striking the target area, as outside in direct sunlight.

White Standard Up & Down - Uses a white card with known spectral reflectance to calibrate the up and down sensors relative to each other.

Advantages:

- Provides a more lambertian reflective surface for calibrating the longer wavelength (above about 1200 nm) down sensors than does the opal glass diffuser of the 2-point method.
- Radiometer may then be used in cloudy or less than ideal sunlight conditions.
- Recalibration required only a couple times per season.
- Assumed radiometer is to be used where radiance flux density is the same between that striking the top surface of the radiometer and that striking the target area, as outside in direct sunlight.

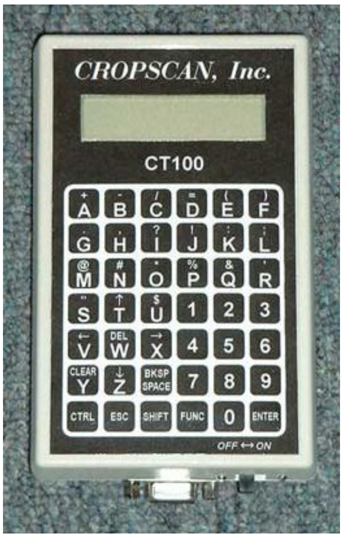


Figure D- 1. CT100 hand terminal.

White Standard Down Only - Uses a white card with known spectral reflectance with which to compare down sensor readings.

Advantages:

- Only down sensors required, saving cost of purchasing up sensors.
- Best method for radiometer use in greenhouse, under forest canopy or whenever irradiance flux density is different between that striking the top of the radiometer and that striking the target area.

Disadvantages:

- White card must be carried in field and recalibration readings must be taken periodically to compensate for sun angle changes.
- Less convenient and takes time away from field readings.
- Readings cannot be made in cloudy or less than ideal sunlight conditions, because of
- likely irradiance change from time of white card reading to time of sample area reading.

There are six major items you need in the field -

- MSR16 (radiometer itself)
- Data Logger Controller & Cable Adapter Box (carried in the shoulder pack, earphones are to hear beeps)
- CT100 (hand terminal, connected to the DLC with a serial cable)
- Calibration stand and opal glass plate
- Memory cards
- Extension pole (with spirit level adjusted so that the top surface of the radiometer and the spirit level are par level)

Set Up

- Mount the radiometer pole bracket on the pole and attach the radiometer.
- Mount the spirit level attachment to the pole at a convenient viewing position.
- Lean the pole against a support and adjust the radiometer so that the top surface of it is level
- Adjust the spirit level to center the bubble (this will insure that the top surface of the radiometer and the spirit level are par level)
- Attach the 9ft cable MSR87C-9 to the radiometer and to the rear of the MSR Cable Adapter Box (CAB)
- Connect ribbon cables IOARC-6 and IODRC-6 from the front of the CAB to the front of the Data Logger Controller (DLC)
- Plug the cable CT9M9M-5 into the RS232 connectors of the CT100 and the DLC (the DLC and CAB may now be placed in the shoulder pack for easy

Figure D- 2. Data logger controller & cable adapter box

carrying)

- Mount the CT100 on the pole at a convenient position
- Adjust the radiometer to a suitable height over the target (the diameter of the field of view is one half the height of the radiometer over the target)

ConFig. MSR

- Perform once at the beginning of the experiment, or if the system completely loses power
- Switch the CT100 power to on
- Press ENTER 3 times to get into main menu
- At Command * Press 2 then ENTER to get to the ReconFig. MSR menu
- At Command * Press 1 then ENTER, input the correct date, Press ENTER
- At Command * Press 2 then ENTER, input the correct time, Press ENTER
- At Command * Press 3 then ENTER, input the number of sub samples/plot (5), Press ENTER
- At Command * Press 6 then ENTER, input a 2 or 3 character name for your sampling location (ex OS for Oklahoma South), Press ENTER; input the latitude for your location, Press ENTER; input the longitude for your location, Press ENTER
- At Command * Press 9 then ENTER, input the GMT difference, Press ENTER
- At Command * Press M then ENTER until you return to the main menu

Calibration

- We are using the 2-point up/down calibration method
- Calibrate everyday before you begin to take readings
- Switch the CT100 power to on
- Press ENTER 3 times to get into main menu
- At Command * Press 2 then ENTER to get to the ReconFig. MSR menu
- At Command * Press 11 then ENTER to get to the Calibration menu
- At Command * Press 3 then ENTER to get to the Recalibration menu
- At Command * Press 2 then ENTER for the 2-point up/down calibration
- Remove the radiometer from the pole bracket and place on the black side of the calibration stand, point the top surface about 45° away from the sun, press SPACE to initiate the scan (1 beep indicates the start of the scan, 2 beeps indicate the end of the scan, and 3 beeps indicate the data was stored)
- Place the separate opal glass plate on top of the upper surface and press SPACE to initiate scan
- Turn the radiometer over and place it back in the calibration stand, cover it with the separate opal glass plate and press SPACE to initiate scan
- CT100 will acknowledge that the recalibration was stored
- At Command * Press M then ENTER until you return to the main menu
- Return the radiometer to the pole bracket
- Store configuration onto the memory card

Memory Card Usage

- Switch the CT100 power to on
- Press ENTER 3 times to get into main menu
- At Command * Press 7 then ENTER to get to the Memory Card Operations menu

- Memory Card Operations menu is:
    1. Display directory
    2. Store data to memory card (use to save data in the field)
    3. Load data from memory card (use first to download data from memory card)
    4. Save program/configuration to card (use to save after calibrating)
    5. Load program/configuration from card (use when DLC loses power)
    6. Battery check

    M. Main menu
- There are 2 memory cards, 64K for storing the program/configuration and 256 for storing data in the field

Taking Readings in the Field

- Switch the CT100 power to on
- Press ENTER 3 times to get into main menu
- At Command * Press 2 then ENTER to get to the ReconFig. MSR menu
- At Command * Press 5 then ENTER, input your plot ID (numbers 1-999 only), Press ENTER
- Press M to return to the MSR main menu
- At Command * Press 8 then ENTER to get to the MSR program
- Press ENTER to continue or M to return to the MSR main menu
- Enter beginning plot number, ENTER
- Enter the ending plot number, ENTER, record plot numbers and field ID in field
- notebook
- Adjust the radiometer to a suitable height (about 2 meters) over the target, point the radiometer towards the sun, center the bubble in the center of the spirit level and make sure that there are no shadows in the sampling area
- Do not take measurements if IRR < 300
- Initiate a scan by pushing SPACE, the message ‘scanning’ will appear on the screen and a beep will be heard
- When the scan is complete (about 2 seconds) ‘**’ will be displayed and 2 beeps will be heard
- Now, you can move to the next area
- 3 Beeps will be heard when the data has been stored
- Press SPACE to start next scan, R to repeat scan, P to repeat plot, S to suspend/sleep, M to return to the MSR main menu, W to scan white standard, and D to scan Dark reading
- When you are done scanning at that field location, press M to return to the MSR main menu, then press 10 to put the DLC

Appendix E. Operating the LAI-2000

Plug the sensor cord into the port labelled “X” and tighten the two screws.

Place a black view-cap over the lens that blocks 1/4 of the sensor view; that 1/4 that contains the operator. Place a piece of tape on the view cap and body of the sensor so if the cap comes loose it will not be lost.

Turn on the logger with the “**ON**” key (The unit is turned off by pressing “**FCT**”, "**0**" , "**9**".)

Clear the memory of the logger

- Press “FILE”
- Use “↑” to place “Clear Ram” on the top line of display
- Press “ENTER”
- Press “↑” to change “NO” to “YES”
- Press “ENTER”

General items

When changing something on the display, get desired menu item on the top line of display and then it can be edited.

Use the “↑” and “↓” to move items through the menu and the “**ENTER**” key usually causes the item to be entered into the logger.

When entering letters, look for the desired letter on the keys and if they are on the lower part of the key just press the key for the letter; if the desired letter is on the upper part of the key then press the “↑” and then the key to get that letter.

Press “**BREAK**” anytime to return to the monitor display that contains time, file number or sensor readings on one of the five rings that are sensed by the LAI-2000.

Do not take data with the LAI-2000 if the sensor outputs are less than 1.0 for readings above the canopy.

To Begin

- Press “SETUP”
- Use “↑” to get “XCAL” on the top line of the display and press “ENTER”
- Following XS/N is the serial number of the sensor unit, enter appropriate number
- Check or put appropriate cal numbers from LICOR cal sheet into the 5 entries.
- Final press of “ENTER” returns you to “XCAL”
- Use “↑” to get to “RESOLUTION”
- Set it to “HIGH”
- Use “↑” to get to “CLOCK”
- Update the clock (set to local time using 24 hr format)
- Press “OPER”
- Use “↑” to get “SET OP MODE” on top line of display
- Choose “MODE=1 SENSOR X”
- Enter “↑”, “↓”, “↓”, “↓”, “↓” in “SEQ”
- Enter "1" in “REPS”
- Use “↑” to get to “SET PROMPTS”

- Put “SITE” in first prompt
- Put “LOC” in second prompt 144
- Use “↑” to get to “BAD READING”
- Choose "A/B=1"
- Press “BREAK”
- Display will contain the two monitor lines

Use “↑” and “↓” to control what is displayed on the top line in the monitor mode, time, file number or sensor ring output 1 through 5 for the X sensor. (If FI is selected, then the file number is displayed)

Use the “→” and “←” to control what is displayed on the bottom line of the monitor mode, time, file number or sensor ring output 1 through 5 for the X sensor. (If X2 is selected, then ring #2 output is displayed)

Press “**LOG”** to begin collecting data

Type in the response to the first prompt (if “**ENTER**” is pressed the same entry is kept in response to the prompt).

Type in the response to the second prompt (if “**ENTER**” is pressed the same entry is kept in response to the prompt).

Place the sensor head in the appropriate position above the canopy, level the sensor and press the black log button on the handle of the sensor (a beep will be heard when the black button is pushed). Hold the sensor level until the second beep is heard.

For grasslands:

1. Place the sensor head in the appropriate position above the canopy, level the sensor and press the black log button on the handle of the sensor (a beep will be heard when the black button is pushed). Hold the sensor level until the second beep is heard.

2. Place the sensor below the plant canopy in one corner of your sampling area level the sensor and press the black log button on the sensor handle and keep level until the second beep.

3. Repeat for the other 3 corners

Repeat steps 1-3 so that you have a total of 5 sets of measurements.

For Row crops:

1. Place the sensor head in the appropriate position above the canopy, level the sensor and press the black log button on the handle of the sensor (a beep will be heard when the black button is pushed). Hold the sensor level until the second beep is heard.

2. Place the sensor below the canopy in the row of plants, level the sensor and press the black log button on the sensor handle and keep level until the second beep.

3. Place the sensor one-quarter (1/4) of the way across the row and record data again.

4. Place the sensor one-half (1/2) of the way across the row and record data again.

5. Place the sensor three-quarters (3/4) of the way across the row and record data again.

Repeat steps 1-5 so that you have a total of 5 sets of measurements.

The logger will compute LAI and other values automatically. Using the "↑" you can view the value of the LAI.

NOTE: You will record the "SITE" and "LOC" along with the LAI value on a data sheet.

The LAI-2000 is now ready for measuring the LAI at another location. Begin by pressing "**LOG**" twice. The file number will automatically increment. When data collection is complete, turn off the logger by pressing "**FCT**", "**0**", "**9**". The data will be dumped onto a laptop back at the Field Headquarters.

Downloading LAI-2000 files to a PC Using HyperTerminal

Before beginning use functions 21 (memory status) and 27 (view) to determine which files you want to download. Make a note of their numbers.

1. Connect wire from LAI-2000 (25pin) to PC port (9 pin).
2. Run HyperTerminal on the PC (Start | Programs | Accessories | Communications |HyperTerminal | LAI2000.ht)
3. On the LAI-2000, go to function 31 (config i/o) and conFig. I/O options. Baud=4800, data bits=8, parity=none, xon/xoff=no.
4. On the LAI-2000, go to function 33 (set format) and setup format options. First we use Spdsheet and take the default for FMT.
5. In HyperTerminal go to Transfer | Capture text. Choose a path and filename (LAIMMDDFL.SPR, where MM is month, DD is day, FL is first and last initials of user and SPR for spreadsheet data files) to store the LAI data. Hit Start. HyperTerminal is now waiting to receive data from the LAI-2000.
6. On the LAI-2000, go to function 32 (print) and print the files. „Print‟ means send them to the PC. You will be asked which file sequence you want. Eg. Print files from:1 thru:25 will print all files numbered 1-25. Others will not be downloaded.
7. Once you hit enter in function 32, lines of text data will be sent to HyperTerminal. The LAI-2000 readout will say „Printing file 1, 2, etc‟. Check the window in HyperTerminal to ensure the data is flowing to the PC. This may take a few minutes, wait until all the desired files have been sent.
8. In HyperTerminal go to Transfer | Capture text | Stop.
9. On the LAI-2000, go to function 33 (set format) and setup format options. Now set to Standard, Print Obs = yes
10. In HyperTerminal go to Transfer | Capture text Choose a path and filename (LAIDDMMFL.STD, where DD is day, MM is month, FL is first and last initials of user and STD for standard data files) to store the LAI data. Hit Start. HyperTerminal is now waiting to receive data from the LAI-2000.

11. On the LAI-2000, go to function 32 (print) and print the files. „Print“ means send them to the PC. You will be asked which file sequence you want. Eg. Print files from: 1 thru 25 will print all files numbered 1-25. Others will not be downloaded.

12. In HyperTerminal go to Transfer | Capture text | Stop.

13. Using a text editor (like notepad) on the PC, open and check that all the LAI data has been stored in the text file specified in step 3. Make a back up of this file according to the archiving instructions later in this chapter.

14. Once you are sure the LAI values look reasonable and are stored in a text file on the PC, use function 22 on the LAI-2000 to delete files on the LAI-2000 and free up its storage space.

Note: The above instructions assume that HyperTerminal has been configured to interface with the LAI-2000, i.e. the file LAI2k.ht exists. If not, follow these instructions to set it up.

1. Run HyperTerminal on the PC (Start | Programs | Accessories | Communications | HyperTerminal | Hypertrm

2. Pick a name for the connection and choose the icon you want. Whatever you pick will appear as a choice in the HyperTerminal folder in the start menu later. Hit OK.

3. Connect using com1 or com2. Choose which is your com port, hit OK. Setup Port settings as follows: Bits per second = 4800, Data Bits = 8, Parity = none, Stop bits = 1, Flow control = Hardware. Say OK.

4. Make sure the wire is connected to the LAI-2000 and the PC and proceed with step 3 in the download instructions above. When finished and leaving HyperTerminal you will be prompted to save this connection.

Appendix F. Team Task Sheets

Table F- 1. Team focus area schedule. $^{+}$ **2 people to do inundation areas mapping**

Date (Monitoring type)	04/12/2010 (Regional)	05/12/2010 (Target)	06/12/2010 (Regional)	07/12/2010 (Target)	08/12/2010 (Regional)
TEAM A	YA4	Transect YA4	YD	Transect YA4^{+}	YA7
TEAM B	YB5	Transect YA4	YC	Transect YA4	YB7
TEAM C	YA4	YA4	YD, YC	YA7	YB5,YB7

Table F- 2. Soil moisture sampling task sheet; Regional monitoring

Measurement	Extent	Point Spacing	Nr. of Samples	Person Responsible
HDAS	2.8km x 3.1km	250m	3 per point	All team members
Land Use	2.8km x 3.1km	250m	3 per point	All team members
Vegetation Type	2.8km x 3.1km	250m	3 per point	All team members
Vegetation Height	2.8km x 3.1km	250m	3 per point	All team members
Presence of Dew	2.8km x 3.1km	250m	3 per point	All team members
Gravimetric Soil Samples	2.8km x 3.1km	variable	Min. 3 per focus area	Team leader

Table F- 3. Soil moisture sampling task sheet; Target monitoring

Measurement	Extent	Point Spacing	Nr. of Samples	Person Responsible
HDAS	3km transect	50m	3 per point	All team members
Land Use	3km transect	50m	3 per point	All team members
Vegetation Type	3km transect	50m	3 per point	All team members
Vegetation Height	3km transect	50m	3 per point	All team members
Presence of Dew	3km transect	50m	3 per point	All team members
Gravimetric Soil Samples	3km transect	variable	Min. 3 per focus area	Team leaders

Table F- 4. Vegetation sampling task sheet

Measurement	Extent	Point Spacing	Nr. of Samples	Person Responsible
Vegetation destructive sample	3km x 3km area	variable	5 per vegetation type	All team members
LAI	3km x 3km area	variable	5 per vegetation type	All team members
CROPSCAN	3km x 3km area	variable	5 per vegetation type	All team members
Surface roughness	3km x 3km area	variable	3 per surface type	All team members
Vegetation Height	3km x 3km area	variable	5 per vegetation type	All team members
Row crop spacing	3km x 3km area	variable	5 per vegetation type	All team members
Row crop direction	3km x 3km area	variable	5 per vegetation type	All team members

Appendix G. Sampling Forms

The following tables are the pro-forma sheets to be used for vegetation water content, gravimetric sampling and surface roughness.

Vegetation sampling form

Local Date:					Focus Area					Team:			
Sample ID	Local Time (HH:MM)	Coordinate		Vegetation Type	Canopy Height (cm)	Row Spacing	Plant spacing	Row Direction	Number of Rows	Wet Weight before drying(g)	Dry Weight after drying (g)	Tare (g)	VWC (Kg/m^2)
		Lat.	Long.										
	:												
	:												
	:												
	:												
	:												
	:												
	:												
	:												
	:												
	:												
	:												

Comments: 4. Label paper bag as Area_ID / DD Month YYYY / Sample_ID and time

Vegetation sample drying form

Local Date:	
Person making entry	

Sample ID	Oven ID		Weight before drying (g)				Oven In & Out Date (DD/MM/YY) and Time (HH:MM)				Weight after drying (g)	
	Oven #	Shelf #	Bag + Wet Sample	Bag #	Scale #	Tare (g)	Date in Oven	Starting time	Date out of oven	Ending time	Bag + dry samplem(g)	Tare (g)
							/ /	:	/ /	:		
							/ /	:	/ /	:		
							/ /	:	/ /	:		
							/ /	:	/ /	:		
							/ /	:	/ /	:		
							/ /	:	/ /	:		
							/ /	:	/ /	:		
							/ /	:	/ /	:		
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							/ /	:	/ /	:		
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							/ /	:	/ /	:		
							/ /	:	/ /	:		
							/ /	:	/ /	:		
							/ /	:	/ /	:		

Comments:

Gravimetric soil moisture sample drying form

Local Date	DD / MM / YY	Focus Area ID:		Team ID.:	

Sample ID	Pre-Weighing (g)		Weight before drying (g)			Drying Date (DD/MM/YY) and Time (HH:MM)					Weight after drying (g)	
	Wet Sample + Bags	Operator Name	Wet Sample + Bags	Bags	Tray	Starting date	Starting time	Operator Name	Ending date	Ending time	Tray + dry sample	Operator Name
						/ /	:		/ /	:		
						/ /	:		/ /	:		
						/ /	:		/ /	:		
						/ /	:		/ /	:		
						/ /	:		/ /	:		
						/ /	:		/ /	:		
						/ /	:		/ /	:		
						/ /	:		/ /	:		
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						/ /	:		/ /	:		
						/ /	:		/ /	:		
						/ /	:		/ /	:		
						/ /	:		/ /	:		
						/ /	:		/ /	:		
						/ /	:		/ /	:		
						/ /	:		/ /	:		
						/ /	:		/ /	:		

Comments:

Surface Roughness Sampling Form

Local Date:			Focus Area ID		Name of Person		Team ID					
Sample ID	Local Time:	GPS Latitude	GPS Longitude	Land Cover*	Vegetation Type*	Row Direction**	Photo ID					
							N-S-1	N-S-2	N-S-3	E-W-1	E-W-2	E-W-3

*Select from the GETA list
**express in degrees from North clockwise

Appendix H. Focus Areas Maps and Directions

Following are the driving instructions to get from the Yanco Agricultural Institute to all the six SMAPEx focus areas:

Focus Area YA4 – Approx. driving time (30min)

1. From The YAI, turn right on irrigation way and immediately left on Euroley Rd.
2. After approx. 8km turn right left into Uroly Rd
3. After approx 5kmturn right into Sturt Hwy (20)
4. Continue on Sturt Hwy for approx. 20km
5. After you crossed the Coleambally Main Canal, turn left into Main Canal Rd.
6. After approx 7km turn left into Wallace Rd.
7. YA4 lays west of Main Canal Rd. Wallace Rd crosses YA4 at middle latitude

Focus Area YA7 – Approx. driving time (30min)

1. As per YA4 (point 1-5)
2. YA7 lays west of Main Canal Rd., 1.5km south of Wallace Rd until Eulo Rd.

Focus Area YC – Approx. driving time (45min)

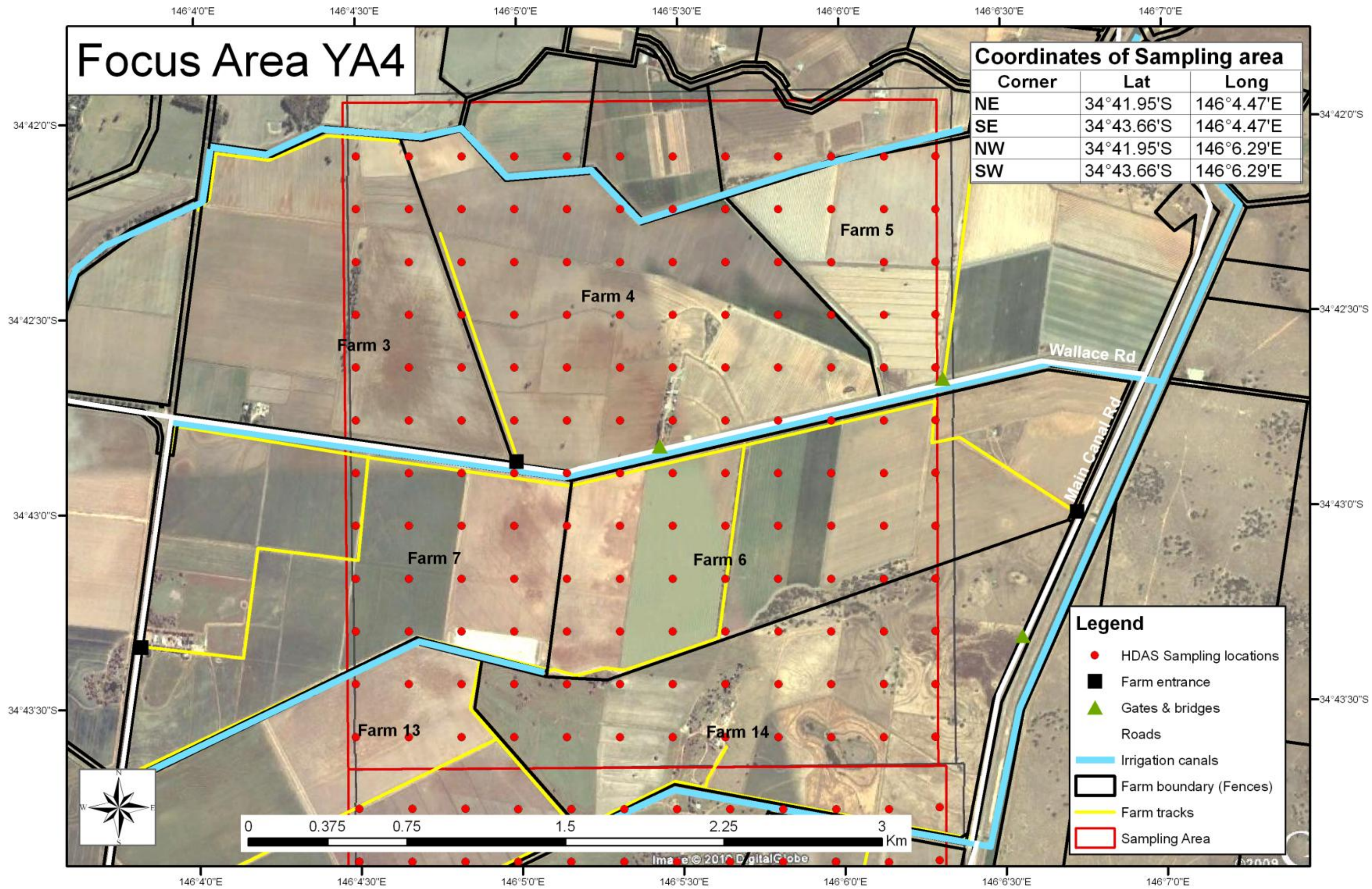
3. As per YA4 (point 1-5)
4. Continue south on Main Canal Rd past Wallace Rd.
5. Turn left into unpaved Morundah Rd. (or Old Morundah Rd.)
6. YC lays west of Morundah Rd., after approx. 8km from Main Canal Rd.

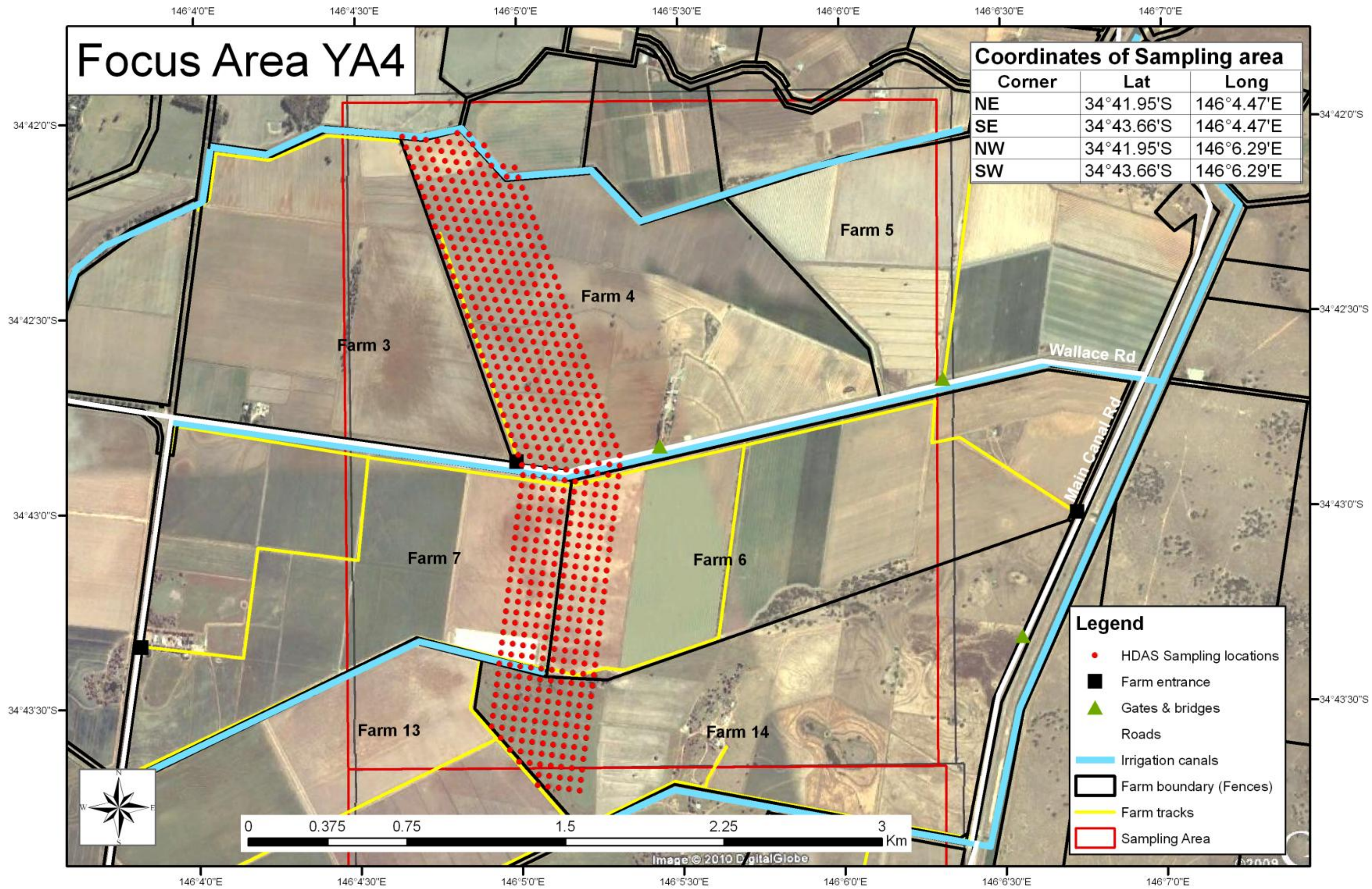
Focus Area YD – Approx. driving time (50min)

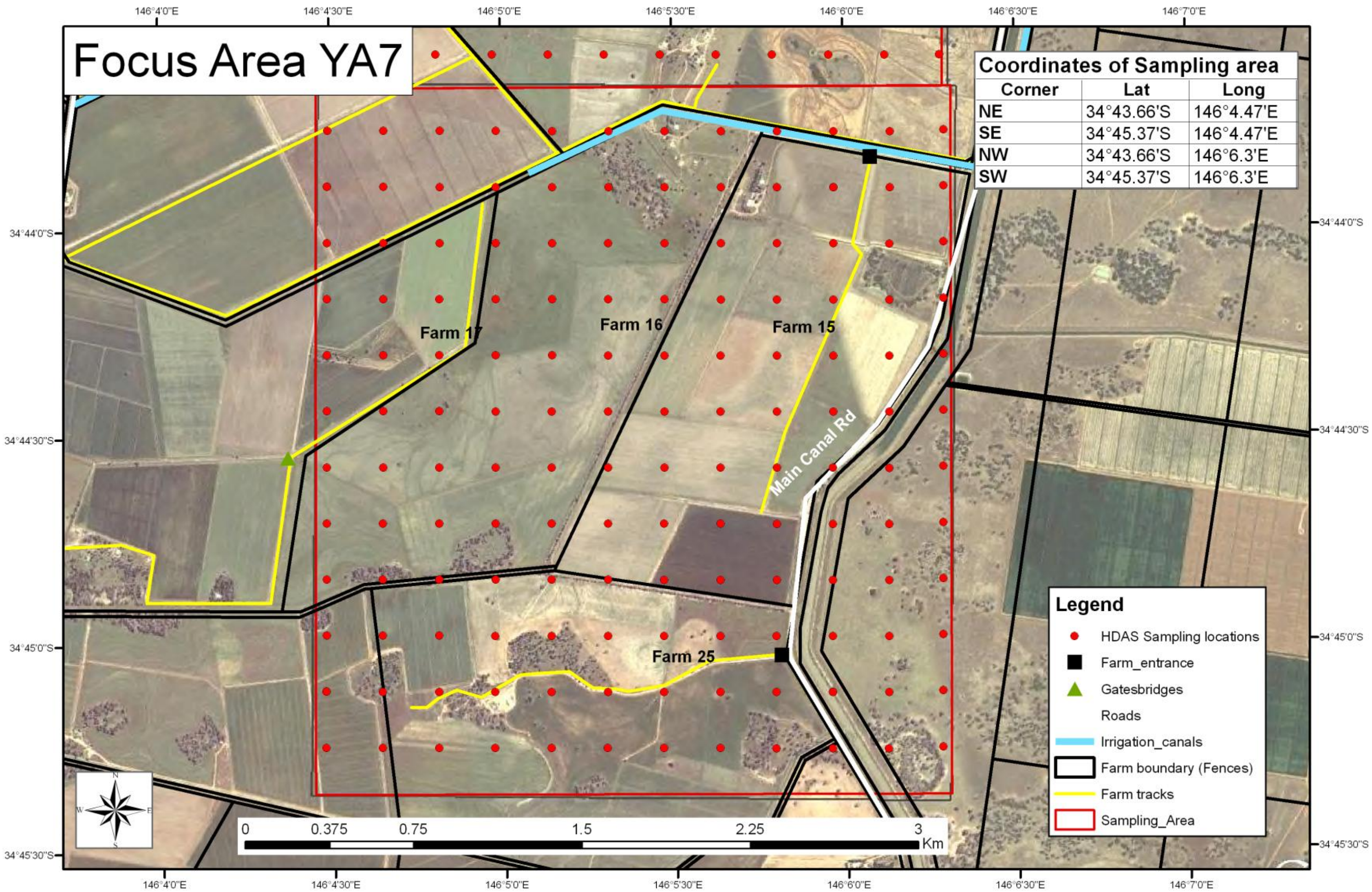
1. As per YA4 (point 1-5)
2. Continue south on Main Canal Rd past Wallace Rd.
3. After approx. 30km, pass Yamma Rd. and continue on Main Canal Rd., which turns into Gilber Rd.
4. After approx 7km, Gilber Rd. veers toward west (leaving Glenn Rd to the left) and enters YD from east.

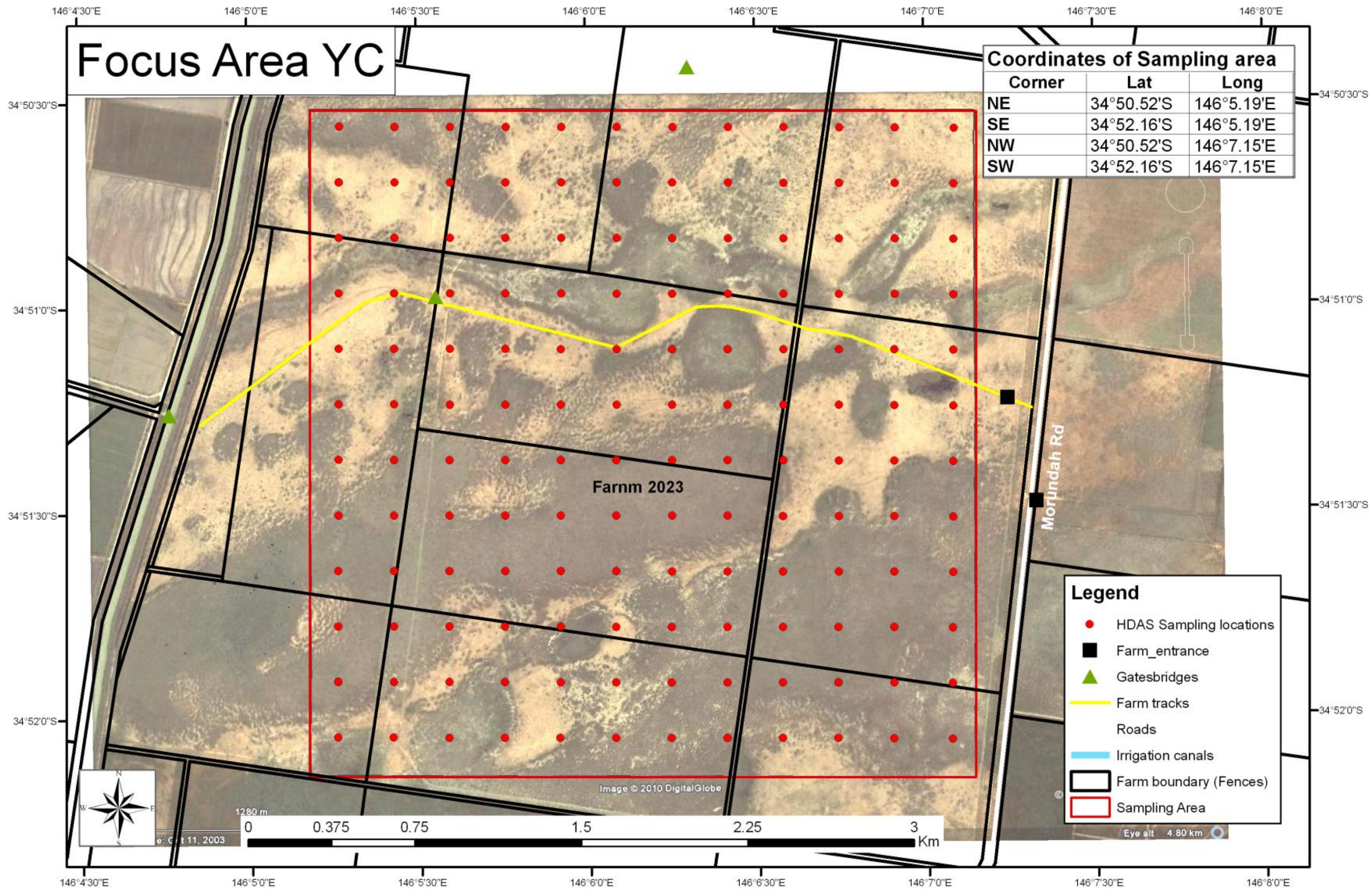
Focus Area YB7 and YB5 – Approx. driving time (60min)

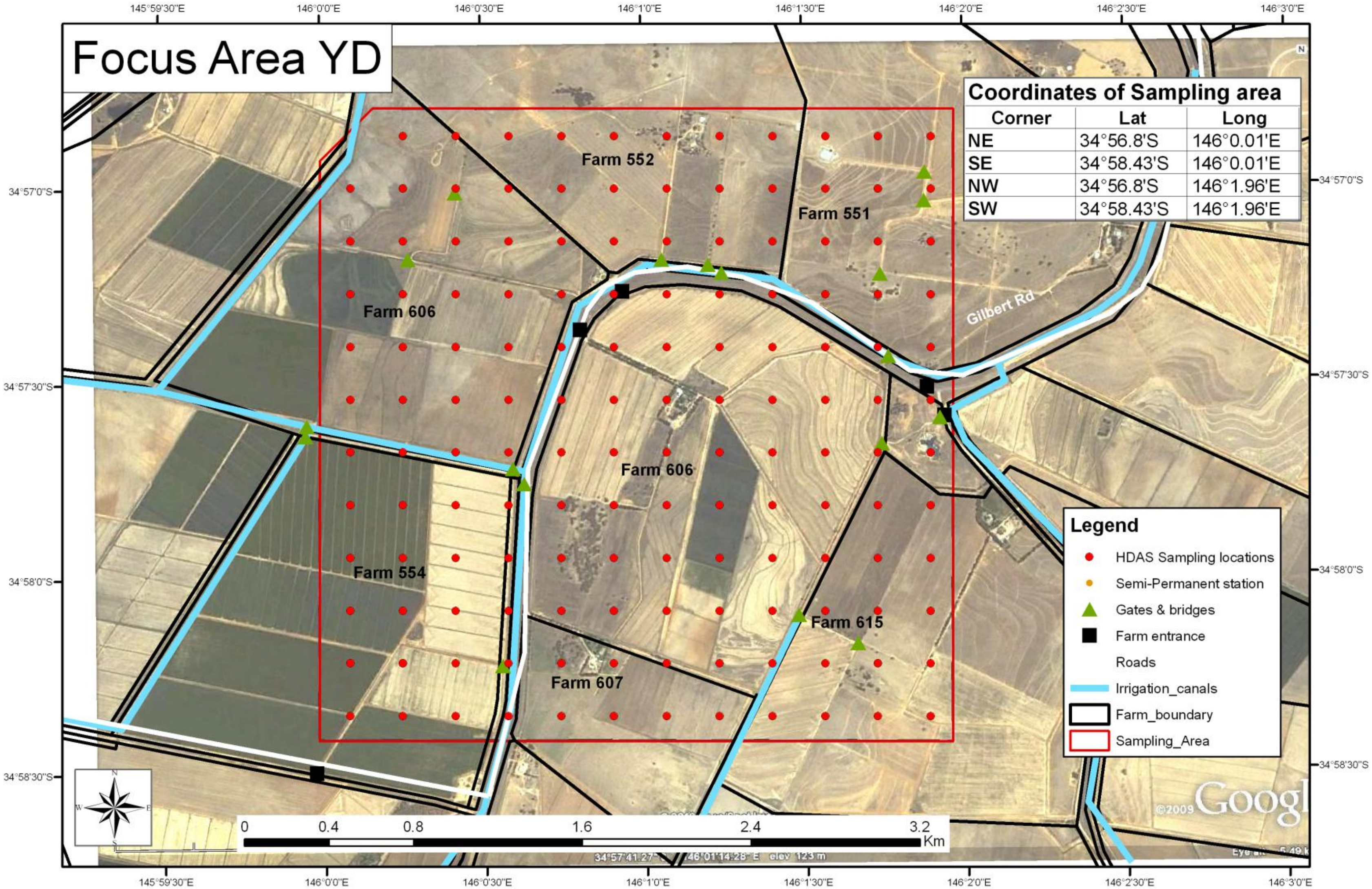
1. From The YAI, turn left on irrigation way towards Narrandera.
2. Once reached Narrandera (approx. 25km), turn right on Newel Highway
3. Continue on Newell Highway for approx.35km until reaching the little town of Morundah (notice big silos on the right side of the Rd.)
4. 100m before Morundah, turn left into Urana Morundah Rd.
5. After approx. 15km, look to the right of the road for sign “The Overflow”
6. At the overflow, turn right onto unpaved road with gate.
7. Go through gate (close it behind you!) and follow unpaved road over bridge.
8. Go through Stockyards keeping right next to the river
9. For YB7, turn left at next gate after stockyards and continue westward on track for 2km, entering YB7 from east. For YB5, go straight at next gate after stockyard and follow the track along the river, entering YB5 from south


Focus Area YA4
Coordinates of Sampling area
Corner Lat Long
NE 34°41.95'S 146°4.47'E
SE 34°43.66'S 146°4.47'E
NW 34°41.95'S 146°6.29'E
SW 34°43.66'S 146°6.29'E
146°4'0"E
146°4'30"E
146°5'0"E
146°5'30"E
146°6'0"E
146°6'30"E
146°7'0"E
34°42'0"S
34°42'30"S
34°43'0"S
34°43'30"S
Farm 3
Farm 4
Farm 5
Farm 6
Farm 7
Farm 13
Farm 14
Wallace Rd
Main Canal Rd
Legend
HDAS Sampling locations
Farm entrance
Gates & bridges
Roads
Irrigation canals
Farm boundary (Fences)
Farm tracks
Sampling Area
0 0.375 0.75 1.5 2.25 3
Km

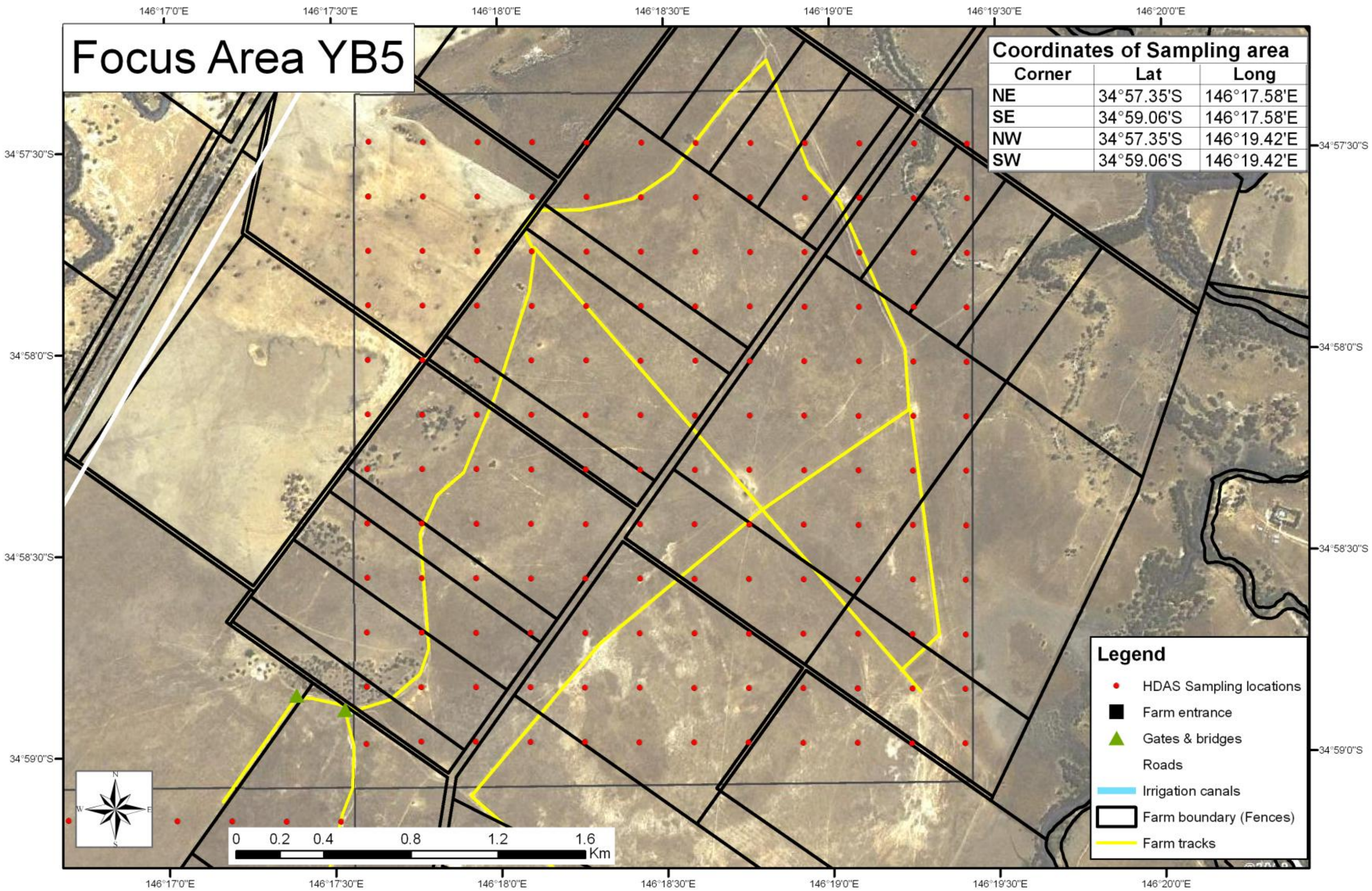

Focus Area YA4
Coordinates of Sampling area
Corner Lat Long
NE 34°41.95'S 146°4.47'E
SE 34°43.66'S 146°4.47'E
NW 34°41.95'S 146°6.29'E
SW 34°43.66'S 146°6.29'E
Farm 3
Farm 4
Farm 5
Farm 6
Farm 7
Farm 13
Farm 14
Wallace Rd
Main Canal Rd
Legend
HDAS Sampling locations
Farm entrance
Gates & bridges
Roads
Irrigation canals
Farm boundary (Fences)
Farm tracks
Sampling Area
0 0.375 0.75 1.5 2.25 3
Km
Image © 2010 DigitalGlobe
146°4'0"E
146°4'30"E
146°5'0"E
146°5'30"E
146°6'0"E
146°6'30"E
146°7'0"E
34°42'0"S
34°42'30"S
34°43'0"S
34°43'30"S

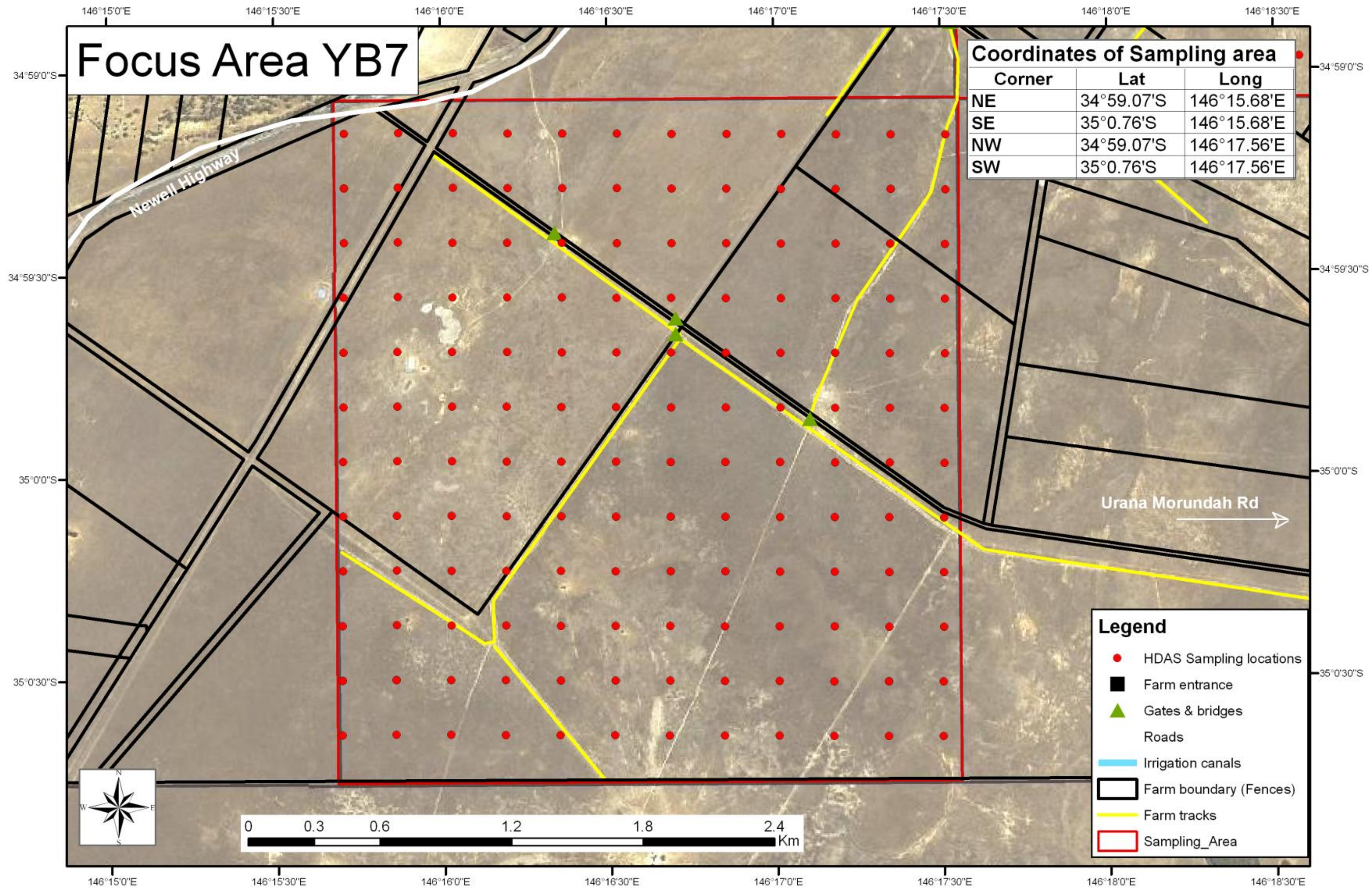

Focus Area YA7
Coordinates of Sampling area
Corner | Lat | Long
NE | 34°43.66'S | 146°4.47'E
SE | 34°45.37'S | 146°4.47'E
NW | 34°43.66'S | 146°6.3'E
SW | 34°45.37'S | 146°6.3'E
Farm 17
Farm 16
Farm 15
Farm 25
Main Canal Rd
Legend
HDAS Sampling locations
Farm_entrance
Gatesbridges
Roads
Irrigation_canals
Farm boundary (Fences)
Farm tracks
Sampling_Area
0 0.375 0.75 1.5 2.25 3 Km
146°4'0"E 146°4'30"E 146°5'0"E 146°5'30"E 146°6'0"E 146°6'30"E 146°7'0"E
34°44'0"S 34°44'30"S 34°45'0"S 34°45'30"S


Focus Area YC
Coordinates of Sampling area
Corner | Lat | Long
NE | 34°50.52'S | 146°5.19'E
SE | 34°52.16'S | 146°5.19'E
NW | 34°50.52'S | 146°7.15'E
SW | 34°52.16'S | 146°7.15'E
Farnm 2023
Morundah Rd
Legend
HDAS Sampling locations
Farm_entrance
Gatesbridges
Farm tracks
Roads
Irrigation canals
Farm boundary (Fences)
Sampling Area
0 0.375 0.75 1.5 2.25 3 Km
Image © 2010 DigitalGlobe
Eye alt 4.80 km
146°4'30"E
146°5'0"E
146°5'30"E
146°6'0"E
146°6'30"E
146°7'0"E
146°7'30"E
146°8'0"E
34°50'30"S
34°51'0"S
34°51'30"S
34°52'0"S



Focus Area YD
Coordinates of Sampling area
Corner | Lat | Long
NE | 34°56.8'S | 146°0.01'E
SE | 34°58.43'S | 146°0.01'E
NW | 34°56.8'S | 146°1.96'E
SW | 34°58.43'S | 146°1.96'E
Farm 552
Farm 551
Farm 606
Farm 606
Farm 554
Farm 607
Farm 615
Gilbert Rd
Legend
HDAS Sampling locations
Semi-Permanent station
Gates & bridges
Farm entrance
Roads
Irrigation_canals
Farm_boundary
Sampling_Area
0 0.4 0.8 1.6 2.4 3.2 Km
145°59'30"E
146°0'0"E
146°0'30"E
146°1'0"E
146°1'30"E
146°2'0"E
146°2'30"E
146°3'0"E
34°57'0"S
34°57'30"S
34°58'0"S
34°58'30"S
©2009 Google


Focus Area YB5
Coordinates of Sampling area
Corner | Lat | Long
NE | 34°57.35'S | 146°17.58'E
SE | 34°59.06'S | 146°17.58'E
NW | 34°57.35'S | 146°19.42'E
SW | 34°59.06'S | 146°19.42'E
Legend
HDAS Sampling locations
Farm entrance
Gates & bridges
Roads
Irrigation canals
Farm boundary (Fences)
Farm tracks
0 0.2 0.4 0.8 1.2 1.6 Km
146°17'0"E
146°17'30"E
146°18'0"E
146°18'30"E
146°19'0"E
146°19'30"E
146°20'0"E
34°57'30"S
34°58'0"S
34°58'30"S
34°59'0"S



Focus Area YB7
Coordinates of Sampling area
Corner Lat Long
NE 34°59.07'S 146°15.68'E
SE 35°0.76'S 146°15.68'E
NW 34°59.07'S 146°17.56'E
SW 35°0.76'S 146°17.56'E
Newell Highway
Urana Morundah Rd
Legend
HDAS Sampling locations
Farm entrance
Gates & bridges
Roads
Irrigation canals
Farm boundary (Fences)
Farm tracks
Sampling_Area
0 0.3 0.6 1.2 1.8 2.4 Km
146°15'0"E
146°15'30"E
146°16'0"E
146°16'30"E
146°17'0"E
146°17'30"E
146°18'0"E
146°18'30"E
34°59'0"S
34°59'30"S
35°0'0"S
35°0'30"S

Appendix I. SMAPEx Flyer

THE UNIVERSITY OF MELBOURNE

MONASH University

High-resolution Soil Moisture Measurement from Space

In 2013 NASA will launch a new satellite which will provide soil moisture measurements at unprecedented resolution (approximately 3km) for all Australia. In order to validate the soil moisture information provided by the NASA satellite, researchers at the University of Melbourne are planning to undertake an experiment in the Yanco area, and your farm has been selected as a ground validation sites of interest. The availability of soil moisture information at 3km resolution will have important implications in water resources management. It will allow better knowledge of the soil moisture distribution across farms and improved prediction of water availability and consequently will provide farmers with the ability to make better decisions for managing their water resources.

Fig. 1. Location of the Study Area (blue) and ground sampling areas (white) in the Colleambally district.

In order to make sure that the soil moisture information provided by the NASA satellite is accurate over Australia, researchers at the University of Melbourne are planning to make aircraft measurements of the surface soil moisture with instruments similar to those that will be onboard the satellites in the Yanco area. This is necessary to test this new measuring system in preparation of the future satellite data. Aircraft measurements will be supported by ground measurement of the surface soil moisture content in carefully selected areas, together with a small number of soil and vegetation samples.

A total of four aircraft campaigns are envisaged over the next two years, covering the complete range of soil moisture and vegetation conditions experienced in the Yanco area. Airborne and ground measurements will be made across a 40km x 40km area including the Colleambally irrigation district and surrounding areas (Fig. 1). In return for granting us the access to your farm, you will have access to all the data collected in the campaigns. More importantly, you will contribute to the development of leading-edge technology needed in Australia to achieve a sustainable and efficienct use of our natural resources.

The ground measurements undertaken on your farm will be completed by a small team of researcher in a few days for each campaign. In addition, we would like to install an additional 5 small semi-permanent monitoring stations on your farm to supplement the existing soil moisture stations we have operated since 2004, providing us with spatial information on soil moisture. Further details of the measurements to be made are given below for your information.

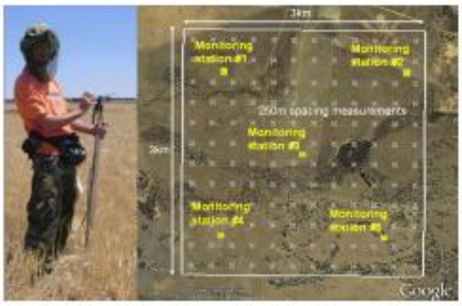


Fig. 2. Field technician with soil moisture probe and typical soil moisture sampling across a farm.

Ground Measurements of Surface Soil Moisture

This is the primary measurement we would like to make on your farm. It involves use of a non-destructive soil moisture probe, having four 5cm long tines that are stuck in the ground and measured using some electrical circuitry. No soil will be removed during this measurement. Using an integrated GPS, the field technicians will navigate to predefined sampling points at 250m spacing, covering a squared area of 3km x 3km size (Fig. 2).

Fig. 3. Typical vegetation sampling within a 40cm x40cm area and example of non-destructive spectral measurements

Vegetation Sampling

Vegetation sampling is required to determine the vegetation water content of the plants in order to estimate soil moisture from the aircraft and satellite. Assuming that vegetation conditions are relatively uniform across the sampling area, only five sampling locations will be required for each campaign. Both non destructive spectral measurements and complete removal of vegetation to ground level from within a 40cm x 40cm area (Fig. 3) will be required at each location. This will allow calibration of the spectral data for estimating the vegetation water content at other locations.

Semi-permanent Monitoring Stations

The semi-permanent monitoring stations will include a soil moisture sensor at the soil surface and three small soil temperature sensors at three depths of 1, 2.5 and 5cm (Fig. 4). The five stations will be uniformly distributed across the 3km x 3km sampling area. We hope to have these stations installed by September 2009, and keep them operating until at least after the satellite launch in 2013. Each station will occupy a minimal space, consisting of a small (10cm x 30cm) metallic mesh sitting on the ground to protect the sensors and a 3m high pole where the data logging system and solar panel will be mounted. The pole will be inserted 0.5m into the ground.

General Note on Property Access

Permission to access your property for these campaigns will be treated with the utmost respect, minimising any impact on the soil and vegetation. You will recall that our team undertook a similar ground monitoring campaign in your farm during the National Airborne Field Experiment 2006 (NAFE'06) and we hope to continue our good working relationship into the future. Moreover, all participants are intimately aware of the requirements for a good collaboration with local property owners and will be closely monitored during the planned campaign activities.

Fig. 4. Set up of a typical semi-permanent station

Contact Details

If you have further questions, please don't hesitate to contact us:

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(Project Leader)
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Email: jeff.walker@eng.monash.edu.au

Dr. Rocco Panciera – The University of Melbourne
(Project Co-ordinator)
Ph: 03 8344 7560
Email: panr@unimelb.edu.au

Appendix J. Safety

Field Work Safety Form

Safety Briefing – Surveying Fieldwork

Please ensure all necessary paperwork has been completed prior to commencing the Fieldwork.

- EHS Field Work Form
- Off Campus Medical Questionnaire
- Risk Assessment

FIELDWORK SAFETY BRIEFINGS SHOULD BE CONDUCTED ON-SITE AND HELD DAILY TO ENSURE IMPORTANT INFORMATION CONCERNING EHS IS COMMUNICATED AND UNDERSTOOD BY ALL FIELDWORK PARTICIPANTS.

1. All Fieldwork participants should ensure an 'In case of Emergency' (ICE) number is stored in their mobile phone. (Name: ICE, Number: (Area Code) (Phone Number)
2. All participants should have access to a mobile phone. If a member of the group does not have a mobile phone then a 'buddy system' should be established.
3. Any participant who requires medication as declared on their Off Campus Medical Questionnaire, must ensure that they have sufficient amounts for the duration of the trip.
4. All Fieldwork participants must ensure that they have appropriate Personal Protective Equipment (as identified on the Risk Assessment)
5. All Participants should make themselves aware of the exact location (Street name, nearest cross-road, suburb etc) at which they are working each day. You will need this information if you have the need to contact any of the Emergency Services.
6. A First Aid procedure should be in place. If a First Aid Officer is unavailable to attend the trip then alternative arrangements such as, familiarizing yourself with the local medical facilities, is vital.
7. Continuous communication shall be established at all times of the Fieldwork. This can be verbal/visual – staying within sight and hearing distance of the group or via communication devices – mobile phones, 2-way radios etc. Alternative arrangements can be set up if appropriate.
8. If an incident occurs, all participants must take the following action:
   a. Assess the medical requirements
   b. If serious, call the emergency services (000 or 112 from mobile phones) for assistance
   c. Notify the individual's contact person (their ICE contact)
   d. Complete an S3 Incident report as soon as possible
   e. Notify the Supervisor of the Incident as soon as possible
10. If a dangerous situation (natural disaster, personal threat, animal presence) occurs and you believe you need to evacuate the area, take the following action:
    a. Remove any persons from immediate danger
    b. Notify all members of the group for the need to leave the area
    c. Contain or eliminate the problem, if possible
    d. Evacuate yourself and others if you cannot contain the problem
11. Remember to adopt safe work practices and look out for each other
12. All participants are responsible for their own health and safety and that of others who may be affected by their conduct, including members of the public.
13. If there is something you are not sure of, seek clarification from your Supervisor before commencing the task
14. Do not operate/use equipment that you are not familiar with
15. Ensure appropriate clothing is worn AT ALL TIMES when required, this includes, enclosed footwear, High-visibility vests, sunscreen, hats, long sleeved, long legged clothing etc.
16. Ensure water and snacks are available at all times
17. Conduct regular rest breaks
18. Report any unsafe conditions or hazards to your Fieldwork Supervisor
19. Treat all other members of Fieldwork with respect and courtesy
20. Clean up after yourselves – leave the Fieldwork environment in the same (or better) condition than when you arrived.
21. Notify all members of any planned rest breaks or lunch breaks and where your meeting spot is, i.e. the car, the café etc
22. Work hard and have fun!

University of Melbourne Risk Assessment Form

can save data typed into this form.

THE UNIVERSITY OF MELBOURNE

GENERAL RISK ASSESSMENT FORM : 3 VARIABLE

STEP 1 – ENTER INFORMATION ABOUT THE ACTIVITY/TASK, ITS LOCATION AND THE PEOPLE COMPLETING THE RISK ASSESSMENT | RA NO. (IF USED):

Location name:	Building No.:	Date:	Assessed by:	Health & Safety Rep.:
Yanco, NSW, Australia		16-Jun-2010	Dr. Dongryeol Ryu	

Description of Activity/Task:

Sampling soil and measuring soil dielectric conductivity using a portable electronic device in crop fields and pastures.

Workplace conditions (Describe layout and physical conditions - including access and egress)

Open paddocks in farm, access through gates

List systems of work for the Activity/Task: • Training procedure • Inspections • SOPs	Half-day training of sampling and securing safety is planned prior to field works.
Is there past experience with the Activity/Task that may assist in the assessment? • Existing controls • SOPs • Standards • Industry standards • Incidents & near-hits • Legislation & Codes • Training • Incident Investigation • Uni guidance material	Similar activities have been conducted in large groups before in the same area. Close investigation of possible risks was made during the past field campaigns and safety training was delivered to the participants each time.

FOR REFERENCE: THREE VARIABLE RISK CALCULATOR – when completing Step 2, refer to the variable definitions, then use the risk score calculator to calculate the risk score

(1) Definition of Exposure Variable

Exposure	E
Continuously or many times daily.	10
Frequently: Approximately once daily.	6
Occasionally: Once a week to once a month.	3
Infrequent: Once a month to once a year.	2
Rare: Has been known to occur.	1
Very rare: Not known to have occurred.	0.5

(2) Definition of Likelihood Variable

Likelihood	L
Almost certain: The most likely outcome if the event occurs.	10
Likely: Not unusual, perhaps 50-50 chance.	6
Unusual but possible: (e.g. 1 in 10).	3
Remotely possible: A possible coincidence (e.g. 1 in 100).	1
Conceivable: Has never happened in years of exposure but is possible (e.g. 1 in 1,000).	0.5
Practically impossible: Not to knowledge ever happened anywhere (e.g. 1 in 10,000).	0. 1

(3) Definition of Consequences Variable

Consequences	C
Catastrophe: Multiple fatalities, permanent extensive environmental damage.	100
Disaster: Fatality, permanent local, damage to environment	50
Very serious: Permanent disability/ill health, non-permanent environmental damage.	25
Serious: Non-permanent injury or ill health. Adverse effect on environment	15
Important: Medical attention needed, off-site emission but no damage.	5
Noticeable: Minor cuts and bruises or sickness, small loss of containment, no off-site consequences.	1

(4) Risk Score Calculator

Risk Score = E x L X C

Risk Score	Risk Rating
> 600	Very High
300 - 599	High
90 - 299	Medium
< 90	Low

www.pb.unimelb.edu.au/ehs/ GENERAL RISK ASSESSMENT FORM: 3 VARIABLE 1

Date: 17-Jun-2010 Version: 1 Authorised by: Stephen Beard Next Review: 01-Jan-2011

STEP 2 – IDENTIFY HAZARDS AND ASSOCIATED RISK RATINGS AND CONTROLS

For each of the following prompts:

- **Check the box** for each hazard that may potentially exist for the activity/task;
- Determine and record a **risk rating** by with reference to the Three Variable Risk Calculator overleaf;
- In the **comments** box, describe when and where the hazard is present;
- Specify the risk **control type** from the Hierarchy of Control at right, for each current or proposed risk control;
- Provide a **control description** for each current or proposed risk control.

Hierarchy of Control (Control Type)

El - Elimination
S – Substitution
En – Engineering Is- Isolation G- Guarding
A – Administrative T- Training In- Inspection
P – PPE

Activity/Task Hazard Identification	Risk Score	Comments (when and where hazard is present)	Control Type	Control Description (Current & Proposed)
Is there potential for? ☐ Being cut or stabbed ☐ Struck, crushed or entangled ☐ Electric shock ☑ Manualhandling/ergonomics ☐ Infectious agents or materials ☐ Vibration ☑ Other factors – specify: Wild animals (snakes and spiders)	3x2x5=30 (Low)	Lifting heavy weights	T T/P	* Share loads with others * Bend knees
Workplace Conditions Hazard Identification				
Is there potential for? ☐ Extremes of temperature ☐ High wind or humidity ☐ Inadequate light ☐ Dusts, fumes or vapours ☑ Exposure to UV or other radiation ☐ Emergency situations ☑ Other factors – specify: Wild animals (snakes and spiders)	10x2x5=100 (Medium) 3x1x25=75 (Low)	Participants can be exposed to UV for a prolonged period Wild animals with a potential danger by venom can be encountered during the activity	T/P T/P	*Training about how to protect from UV is delivered, and the use of sun cream, hat, and other gear is advised. *Training on how to cope with the encounter with wild animals are delivered and participants are strongly advised to wear sturdy shoes and outfit to protect them
Environmental AspectsHazard Identification				
Is there potential for? ☐ Energy consumption ☐ Nuisance noise ☐ Dust ☐ Water consumption ☐ Hazardous waste ☐ Hazardous emissions ☐ Other factors – specify:				

STEP 3 – COMPLETE THE IMPLEMENTATION OR ESCALATION PLAN

Determine the person responsible for deciding upon and implementing the proposed controls. Obtain the authorisation of the Management Representative.
Ensure the HSR (if applicable) has been consulted. Ensure the person(s) performing the Activity/Task have been consulted.

Person Responsible or Escalated to	Dr. Dongryeol Ryu	**Controls due date**	11-Jul-2010
Signature of Management Representative		**Date**	
Signature of HSR		**Date**	
Signature of person performing Activity/Task		**Date**	

For use in conjunction with *Environment, Health & Safety Manual 3.1.New. Risk Management.*
For further information, refer to http://www.pb.unimelb.edu.au/ehs/riskmanagement/ or contact your EHS Adviser/Manager in the EHS Unit.

www.pb.unimelb.edu.au/ehs/ GENERAL RISK ASSESSMENT FORM: 3 VARIABLE 2

Date: 17-Jun-2010 Version: 1 Authorised by: Stephen Beard Next Review: 01-Jan-2011

Template date: 18 May 2009 **Version**: 1.3 **Authorised by**: General Manager, Environment, Health & Safety **Next Review**: 6 May 2012 © The University of Melbourne – Uncontrolled when printed.

Extra writing room - use this page to enter extended comments or descriptions
Workplace Conditions Hazard Identification: Dehydration during the outdoor activity / 10x2x3=60 (Low) / Participants can suffer from dehydration during the field sampling / (T/P) Potential danger of dehydration is noticed during the pre-campaign training and participants are advised to carry at least 1 litre of water per 2 hours of field activity.

How to Prevent Snake Bites Guidelines

- Step 1

Prior to your hike, familiarize yourself with the local species of snakes: knowing their habits and habitats may help you avoid coming into contact with them unexpectedly. Plan your route in advance and let someone know where you will be located in case of an emergency.

- Step 2

For your hike, wear heavy, knee-high socks, high-top boots, and long pants tucked into your shoes. Stay on the trail, if one is available and keep out of tall grass unless you wear thick leather boots, chaps or gaiters. Walk around logs or large stones, instead of stepping over them.

- Step 3

During your hike, bang a walking stick against the ground. The vibrations will coax the snake out of your path. Take special care not to reach or step into places that you cannot see and be especially careful when climbing rocks, whose crevices may house quiet, venomous tenants.

- Step 4

If you come across a snake, stay as far away from it as possible. at least six feet or more than the snake's body length. If you find yourself close to a snake, take at least two giant steps back. Leave the snake alone as they can strike much faster and farther than most people think. Stay away even from dead snakes because their reflexes can still cause a bite for an hour after death.

- Step 5

When you make camp, do so on open ground. Check the area for likely hiding places such as rock piles, holes or empty burrows. And don't collect firewood (especially after dark) with your bare hands; instead, break a piece away from the pile with a long stick. Each night, zip your tent firmly closed and ensure that your sleeping bags are snake-free before entering them.

Read more: How to Prevent Snakebites While Hiking | eHow.com
http://www.ehow.com/how_2279574_prevent-snakebites-hiking.html#ixzz0rRUq1Qjk

http://www.ehow.com/how_2282699_prevent-snakebites-camping.html

Snake Bites First Aid Instructions

First in First Aid

St John

SNAKE BITES

MANAGING A SNAKE BITE

1) Check for signs of life:
- if casualty is unconscious, follow DRABCD (Danger, Response, Airway, Breathing, CPR, Defibrillation).

2) Calm casualty.

3) Apply pressure immobilisation bandage:
- apply a firm roller bandage starting just above the fingers or toes and moving up the limb as far as can be reached
- the bandage needs to be very firm.

4) Immobilise casualty:
- apply a splint to immobilise the bitten limb
- check circulation in fingers or toes
- ensure casualty doesn't move.

5) Call 000 for an ambulance.

SIGNS & SYMPTOMS

- puncture marks
- nausea, vomiting, diarrhoea
- headache
- double or blurred vision
- breathing difficulties
- drowsiness, giddiness
- pain or tightness in chest or abdomen
- respiratory weakness or arrest.

WARNING

Do not wash venom off the skin as retained venom will assist identification.

Do not cut bitten area or try to suck venom out of the wound.

Do not use a constrictive bandage (i.e. arterial tourniquet).

Do not try and catch the snake.

*Carry the **Bites and Stings** first aid kit with you when camping or bushwalking. Call St John on 1300 360 455 for further information about the full range of first aid kits.*

For more information on St John first aid training and kits, visit www.stjohn.org.au or call Toll free 1300 360 455.