SMAPEX-3

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Addendum to "The Third Soil Moisture Active Passive Experiment Workplan"

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CONTENT

1. SUMMARY

This document contains the addendum to the SMAPEx-3 experiment workplan. Any aspect not mentioned here is to be assumed unchanged from the original document (Monerris et al., 2011).

The SMAPEx-3 experiment was conducted from 5-23 September, 2011. A total of 60hrs of scientific flights were conducted, with concurrent ground sampling occurring on all days. Airborne radar and radiometer data were collected three times per week (9 flights in total), typically a day or two apart between flights. Airborne LIDAR and hyperspectral measurements were acquired twice during the campaign (see Table 2-1 for schedule). Moderate rainfall (35mm) was experienced in the study area the week before the experiment started, while some showers (up to 4mm) were registered during the first week. This lead to soil moisture values varying from 2-32m^3/m^3 in grazing areas and from 3-46m^3/m^3 in crops across the three weeks of experiment.

2. AIR MONITORING

Air monitoring was undertaken largely as outlined in the experiment plan, with the exception of some dates that were switched due to expected poor weather. The updated schedule for the scientific flights is shown in Table 2-1. Changes with respect to Table 5-3 from the workplan are highlighted in bold blue characters.

Table 2-1. SMAPEx-3 flights schedule (R = Regional, T = Target LIDAR/VNIR, CR = COSMOS Rover). Changes with respect to Table 5-3 from the workplan are highlighted in bold blue characters.

Flight ID	Date (AEST)	Observations
R01	5/09/2011	Run over PARCs only at the start due to parachute operations in the airport
T01	5/09/2011	
T02	6/09/2011	
R02	**7/09/2011**	Order of PARCs reversed. VNIR and SWIR not connected
R03	**10/09/2011**	Early flight due to expected poor weather (starts 5am, ends 10:30am AEST). Lake Wyangan calibration not done at start due to early departure. PARCs calibration flight at the end done in reverse direction
CR01	**13/09/2011**	COSMOS Rover over YC
R04	13/09/2011	
R05	**15/09/2011**	

R06	18/09/2011	Some of the PRCs had been knocked down and their tilt/orientation was not correct during the flight (see Table 8-1). Aerial photos taken
R07	19/09/2011	Lake Wyangan calibration not done at start due to early departure. PRCs tilt still incorrect flight (see Table 8-1). PRCs fixed after the flight
R08	21/09/2011	Some of the PRCs had been knocked down again, and were not fixed till after the flights (see Table 8-1)
CR02	**21/09/2011**	COSMOS Rover transect
T03	**22/09/2011**	
R09	23/09/2011	PRCs OK during flight but the car may be near PRC#5 at the end. Aerial photos taken

3. SUPPLEMENTARY MONITORING STATIONS

Four supplementary monitoring stations were deployed during SMAPEx-3. Their coordinates and the land cover conditions during the experiment are listed in Table 3-1. A summary of the sensors installed at each station and the data availability is given in Table 3-2. Photos of the two of the stations are shown in Figure 3-1. Note that the loggers from the supplementary stations were set to UTC time.

(a) YS1 (b) YS2

Figure 3-1. Picture of two of the supplementary stations deployed during SMAPEx-3.

Table 3-1. Coordinates and land cover conditions of the supplementary monitoring stations during SMAPEx-3.

Station ID	Latitude	Longitude	Land cover
YS1	34°58'06.198S	146°01'29.772E	Canola
YS2	34°58'34.614S	146°18'29.73E	Grassland
YS3	34°42'59.106S	146°05'08.016E	Wheat
YS3	34°43'24.348S	146°05'18.606E	Fallow

Table 3-2. Sensors and data availability of the supplementary monitoring stations during SMAPEx-3.

Station ID	Sensors	Data availability (AEST)
YS1	1x Thermal infrared (Apogee)	01/09-30/09
	2x Thetaprobes (0-6 and 23-29cm)	01/09-30/09
	4x soil temperature (2.5, 5, 15, 40cm)	01/09-30/09
	1x Rain gauge	01/09-30/09
	1x Leaf wetness	13/09-30/09
YS2	1x Thermal infrared (Apogee)	09/09-08/11
	2x Thetaprobes (0-6 and 23-29cm)	09/09-08/11
	4x soil temperature (2.5, 5, 15, 40cm)	09/09-08/11
	1x Rain gauge	09/09-08/11
	1x Leaf wetness	13/09-08/11
YS3	1x Thermal infrared (Apogee)	04/09-29/09
	2x Thetaprobes (0-6 and 23-29cm)	04/09-29/09
	4x soil temperature (2.5, 5, 15, 40cm)	04/09-29/09
	1x Rain gauge	04/09-29/09
	1x Leaf wetness	13/09-29/09
YS4	1x Thermal infrared (Apogee)	05/09-10/11
	2x Thetaprobes (0-6 and 23-29cm)	05/09-10/11
	4x soil temperature (2.5, 5, 15, 40cm)	05/09-10/11
	1x Rain gauge	05/09-10/11
	1x Leaf wetness	13/09-10/11

4. SMAPEX SEMI-PERMANENT NETWORK

Table 4-1 updates Table 4-2 of the experiment plan for the 24 soil moisture sites in terms of land use and vegetation type observed during SMAPEx-3. Data availability for the campaign period is also shown. Note that YA1 and YA7 had been removed by the farmers and were re-installed in a different paddock, close to their original location.

Table 4-1. Characteristics of the SMAPEx semi-permanent monitoring sites during SMAPEx-3. Changes with respect to Table 4-2 in the work plan are highlighted in bold blue colour.

Station ID	Longitude	Latitude	Land Use	Vegetation Type	Irrigated	Data availability (UTC)	Comments
YA1	**146.0855**	**-34.6889**	Fallow	Stubble	No	03/09-24/09	
YA3	146.1397	-34.677153	Grazing	Perennial grass	No	03/09-24/09	
YA4a	146.07937	-34.706005	Cropping	**Wheat**	Yes	04/09-24/09	
YA4b	146.10529	-34.703062	Cropping	**Bare**	Yes	03/09-24/09	
YA4c	146.09425	-34.714213	Cropping	**Bare (corn planted)**	Yes	07/09-23/09	
YA4d	146.07506	-34.714202	Cropping	**Wheat**	Yes	03/09-24/09	
YA4e	146.10297	-34.721393	Grazing	Perennial grass	No	03/09-24/09	No soil moisture data available since that date 22/09
YA5	146.12771	-34.712858	Grazing	Perennial grass	No	03/09-24/09	
YA7a	**146.0802**	**-34.7326**	Cropping	**Bare (cotton planted)**	Yes	03/09-24/09	
YA7b	146.09867	-34.737835	Cropping	**Bare (cotton planted)**	Yes	03/09-24/09	
YA7d	146.07777	-34.7544	**Cropping**	**Wheat**	**Yes**	03/09-24/09	
YA7e	146.09493	-34.750728	**Cropping**	**Wheat**	**Yes**	03/09-24/09	Some faulty readings of T2
YA9	146.15364	-34.741377	Grazing	Perennial grass	No	03/09-24/09	
YB1	146.27654	-34.941243	Grazing	Perennial grass	No	03/09-24/09	
YB3	146.34015	-34.942698	**Fallow**	**Stubble**	No	03/09-16/09	Data missing since 16/09 due to problems with battery power supply
YB5a	146.30262	-34.965268	Grazing	Perennial grass	No	03/09-24/09	
YB5b	146.31843	-34.963373	Grazing	Perennial grass	No	03/09-24/09	
YB7b/YB5d	146.29299	-34.984833	Grazing	Perennial grass	No	03/09-24/09	
YB5e	146.32052	-34.979712	Grazing	Perennial grass	No	03/09-24/09	
YB7a	146.26941	-34.988457	Grazing	Perennial grass	No	03/09-24/09	
YB7c	146.27852	-34.998378	Grazing	Perennial grass	No	03/09-24/09	Faulty readings of T3 from 4/09 to 14/09
YB7d	146.26853	-35.00497	Grazing	Perennial grass	No	03/09-24/09	
YB7e	146.28805	-35.007732	Grazing	Perennial grass	No	03/09-24/09	
YB9	146.33978	-35.002167	Grazing	Perennial grass	No	No data	Logger malfunction

5. VEGETATION SAMPLING

The vegetation sampling schedule was modified from that outlined in the work plan taking into account the predominant vegetation types present in the experiment site during SMAPEx-3. The resulting schedule is shown in Table 5-1. Each vegetation measurement comprises of: 1x destructive sample + 5x LAI readings + 25x CROPSCAN readings + canopy height and crop row spacing and direction observations where applicable.

Table 5-1. Vegetation sampling schedule during SMAPEx-3.

Area ID	Date (AEST)	Vegetation type	Nr. measurements
YA7	06/09	Wheat	8
	13/09		8
	19/09		8
	06/09	Bare	2
	13/09		2
	19/09		2
YA4	04/09	Barley	5
	12/09		5
	18/09		5
	22/09		3
	05/09	Wheat	6
	12/09		6
	18/09		6
	22/09		3
	05/09	Bare	2
	12/09		2
	18/09		2
	05/09	Linseed	1
	12/09		1
	18/09		1
	22/09		3
	05/09	Pasture	4
	12/09		4
	18/09		4
YD	07/09	Lucerne	3
	14/09		3
	20/09		3
	07/09	Pasture	4
	14/09		4
	20/09		4

	07/09	Wheat	4
	14/09		4
	20/09		4
	07/09	Canola	3
	14/09		3
	20/09		3
YB5	08/09	Pasture	5
	15/09		5
	21/09		5
YB7	10/09	Pasture	5
	15/09		5
	21/09		5
YC	08/09	Pasture	5
	13/09		5
	21/09		5
Forest	08/09	Forest	2
	15/09		2
	21/09		2

6. SURFACE ROUGHNESS SAMPLING

The existence of a Team dedicated only to soil surface roughness sampling significantly increased the number of sites measured during SMAPEx-3 with respect to the previous two experiments. A summary of the schedule for surface roughness sampling is provided in Table 6-1. Note that each measurement comprised two 3m-long profiles, one oriented East-West and the other North-South.

Table 6-1. Summary of surface roughness sampling during SMAPEx-3.

Focus area	Land cover	Date sampling (AEST)	Nr. measurements
YA7	Savannah	08/09	3
	Wheat	08/09	6
	Wheat	22/09	2
	Bare	12/09	6
	Bare	20/09	1
	Fallow	22/09	1
YA4	Fallow	04/09	3
	Fallow	06/09	6
	Fallow	20/09	1
	Fallow	22/09	1
	Wheat	06/09	6

	Wheat	22/09	1
	Bare	08/09	3
	Bare	20/09	1
	Bare	22/09	2
	Pasture	08/09	3
YD	Canola	09/12	3
	Bare	22/09	4
	Pasture	22/09	1
YB5	Pasture	14/09	5
YB7	Pasture	14/09	3
YC	Pasture	14/09	3
Forest	Forest	20/09	8

7. INTENSIVE VEGETATION SAMPLING

CROPS INTENSIVE MONITORING

Table 7-1 shows the classification of agricultural crops by scattering mechanism during SMAPEx-3. The vegetation type selected as representative of each group has been highlighted in bold characters.

The main changes to the intensive vegetation sampling protocols were:

- No 'Group 2' scattering type paddock was sampled as corn had not been planted yet at the time of the experiment. Instead, two wheat paddocks ad different growth stages were monitored to characterize wheat plant geometry over a wider range of growth stages. Moreover, an additional savannah site was sampled on one occasion. Table 7-1 updates Table 7-2 from the workplan.
- The sampling protocol for 'Group 4' pasture was changed.

FIELD SAMPLING PROTOCOL

The location of the 10 focus sites on the paddock were preloaded on a hand-held PC.

1. Record in the form the Date, paddock ID, Person recording;
2. Navigate to first location and record in the form the area ID (Date/paddock ID/Area1,…,10);
3. Take 3 HDAS soil moisture reading within a 1m x 1m area and record on the form;
4. Identify the dominant species (e.g., different types of grass / crop plants etc...) and record on the form with Species ID and description. Then for each species record the following set of measurements:

Table 7-1. *C*lassification of agricultural crops by scattering mechanism during SMAPEx-3. In bold the vegetation type selected as representative of each group.

Scattering type	Crops	Dates monitored
Group 1: Vertically oriented thin scatterers - high density	**Wheat tall (height range)** **Wheat short (height range)** Lynseed	**Sept 6, 12, 20**
Group 3: Horizontally oriented scatterers	**Canola** Lucerne	**Sept 8, 14, 22**
Group 4: Variable scatterers orientation- low density	**Pasture** Fallow	**Sept 8, 14, 22**
Group 5: Savannah	**Savannah**	**Sept 12**
Group 2: Vertically oriented thick scatterers - significant stem return	~~**Corn**~~ **(not planted yet)**	

- **Crops**

1. Record row orientation, row spacing, species % cover and nr of plants per meter square on one row using the 50cm x 50cm quadrangle and record in the form;
2. Select one random plant from the area;
3. Take two photos of the plant standing with the background of the white cardboard (one north-south and one east-west) and one of the overall site conditions and record the photo ID on the form;
4. Without removing or disturbing the plant, take measurements of plant height, stalk length (between upper and lower node), stalk diameter (bottom, mid and top most node), stalk angle with respect to nadir in both north-south and east-west direction (at the base) and leaves angle (3 leaves, one at bottom, one middle and one top of the plant, each measured at the bole, the leaf midpoint, and the leaf tip);
5. In the case in which the main stalk splits into separate branches, record the angle from nadir of 3 randomly selected branches;
6. Remove the plant, remove all leaves from the stalk and set 3 random leaves aside;
7. Measure length, width and thickness of each leaf and record;

8. Put all leaves from the plant into a paper bag. Label a small paper bag as Date/paddock_ID/Species_ID/leaves. NOTE: All the leaves from a particular species on a paddock can go in this same paper bag;
9. Store stalk it in a separate big paper bag and label it Date/paddock ID/Species ID/ Stalk. All the stalks from a paddock will go in this same paper bag;
10. Seal both paper bags into plastic bags and seal with a rubber band.

- **Pasture**

1. Record species % cover;
2. Count nr of stalks per meter square using the 50cm x 50cm (when the plant density is high making the count unfeasible, provide an estimate of the nr of stalks as accurate as possible). If the stalks are organized in clumps, the total count can be obtained by counting the stalks in a representative clumps and multiplying by the nr of clumps within the 50cm x 50cm area (times 4);
3. Select one representative grass clump from the 50cm x 50cm area;
4. Take two photos of the clump standing with the background of the white cardboard (one north-south and one east-west) and record the photo ID on the form;
5. Measure and record on form the clump maximum height and sizes on two perpendicular directions (if the stalks are not organized in clumps, only record height);
6. Measure and record on form the diameters of 3 randomly selected stalks;
7. Measure and record on form the angle from nadir of 10 randomly selected stalks;
8. Cut all the biomass within the 50cm x 50cm quadrangle and store into a paper bag labelled Date/paddock_ID/Area_ID/Species_ID for vegetation water content determination. NOTE: One bag for each species present in the 50cm x 50cm area;
9. Seal the paper bag into plastic bags and seal with a rubber band.

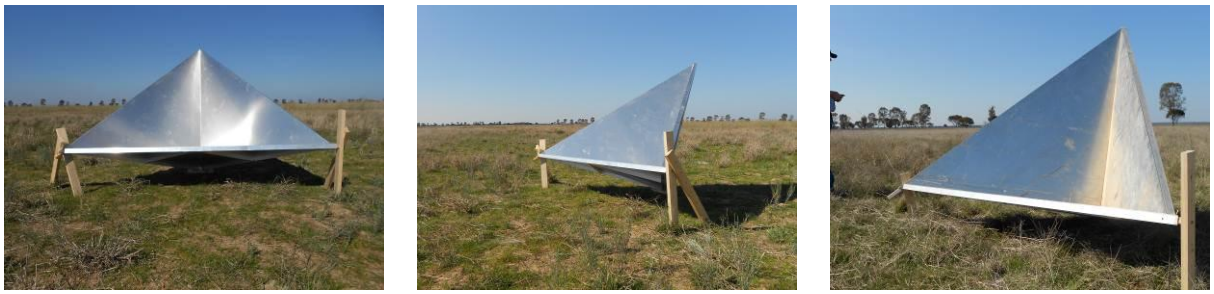
FOREST INTENSIVE MONITORING

The main changes in the forest intensive monitoring with respect to the workplan are the following:

- **Tree inventory**

1. Only trees with a diameter at breast height (DBH) > 5 were sampled. The rest were counted for and their average height visually estimated. Tree height was measured from one position only.
2. Leaf area index estimation: The sampling protocol was only followed in site #1 since it was found to be inappropriate once in the field. Five photos instead of one were taken at each plot. Fish-eye camera photos of diagonal transect were only taken in site #1.

(a) PRC#1 (b) PRC#2 (c) PRC#3



(d) PRC#4 (e) PRC#5 (f) PRC#6

Figure 8-1. The six PRCs deployed during SMAPEx-3.

- **Understory water content estimation**: few understory samples were collected (only in 2 sites for the last two weeks). There was only one type of understory in the forest site (grass).

8. PASSIVE RADAR CALIBRATORS

Six passive radar calibrators (PRC) were installed in a grazing paddock near the south-eastern corner of YB7. The location and tilt angle of each PRC is listed in Table 8-1. Even though the PRC were periodically checked, some of them were found knocked down by animal stock during our visits. Thus, their orientation and tilt was not correct during some of the flights. Details are provided in Table 8-1. Some photos of the PRCs are shown in Figure 8-1.

Table 8-1. PRC location and tilt angle during SMAPEx-3.

	Lat	Long	Tilt (deg)	Comments
PRC#1	-35	146.3416	37	• 12/09: Checked and OK • 18/09: Knocked down by cows. Temporarily fixed by Team B • 19/09: Fixed in the afternoon • 23/09: Knocked down again. Fixed before the Regional flights, but set to a 39° tilt
PRC#2	-35.0022	146.3441	33	• 12/09: Checked and OK • 18/09: Knocked down by cows. Temporarily fixed by Team B • 19/09: Fixed in the afternoon • 23/09: Checked and OK
PRC#3	-35.0042	146.3468	28	• 12/09: Checked and OK • 18/09: Checked and OK • 19/09: Checked and OK • 23/09: Knocked down. Fixed before the Regional flights, but set to a 31.5° tilt
PRC#4	-35.0068	146.3496	25	• 12/09: Checked and OK • 18/09: Checked and OK • 19/09: Checked and OK • 23/09: Checked and OK
PRC#5	-35.0105	146.3536	20	• 12/09: Checked and OK • 18/09: Knocked down by cows. Temporarily fixed by Team B to a 26° tilt • 19/09: Fixed in the afternoon to correct tilt • 23/09: Checked and OK
PRC#6	-35.0134	146.3580	15	• 12/09: Checked and OK • 18/09: Knocked down by cows. Team B left it flat on the ground with the correct orientation • 19/09: Fixed in the afternoon • 23/09: Checked and OK

Table 9-1. Time reference used for different SMAPEx-3 datasets. UTC=Coordinated Universal Time; AEST=Australian Easter Standard Time (UTC+10 hours).

Data set	Time reference
Airborne data	UTC
HDAS systems	UTC
SMAPEx semi-permanent network	UTC
SMAPEx supplementary network	UTC
OzNet Permanent Network	AEST
Soil gravimetric samples	AEST
Vegetation samples, LAI and reflectance	AEST
Surface roughness measurements	AEST
Intensive vegetation sampling	AEST

9. TIME REFERENCE

Not all data were recorded in UTC time during SMAPEx-3. Some datasets were recorded in local time (Australian Eastern Standard Time, AEST, being UTC+10 hours) for consistency with daily activities. Table 9-1 lists the time reference used for each SMAPEx-3 dataset.

10. REFERENCES

[1] A. Monerris, J.P. Walker, R. Panciera, T.J. Jackson, M. Tanase, D. Gray and D. Ryu (2011). The Third Soil Moisture Active Passive Experiment Workplan. Available online at: http://www.smapex.monash.edu.au/Data/SMAPEx-3/SMAPEx-3 Workplan.pdf