The Australian
SMAPEX and Core Validation Site

Jeffrey Walker, Rocco Panciera, Dongryeol Ryu, Douglas Gray, Thomas Jackson
Objectives

1. Radar-only soil moisture retrieval (3km)
   Verify baseline algorithms proposed for SMAP

2. Radiometer-only soil moisture retrieval (40km)
   Use the SMAP radar information on surface roughness and vegetation structure (3km) to aid the soil moisture retrieval from the SMAP radiometer (40km)

3. Active Passive soil moisture product (10km)
   Use the high resolution (3km) but noisy SMAP radar observations to downscale the accurate but low resolution (40km) radiometer footprint

Simulated fields of a) 3km truth soil moisture and retrieved soil moisture for b) 40km passive microwave observations, c) 3km radar observations and d) 3km merged passive microwave and radar observations (Zhan et al., 2006).
The airborne SMAP simulator

**PLMR:**
**Polarimetric L-band Multibeam Radiometer**
- Frequency/bandwidth: 1.413GHz/24MHz
- Polarisations: V and H
- Resolution: ~1km at 10,000ft flying height,
- Incidence angles: +/- 7°, +/-21.5°, +/- 38.5° across track
- Antenna type: 8x8 patch array

**PLIS:**
**Polarimetric L-band Imaging SAR:**
- Frequency/bandwidth: 1.26GHz/30MHz
- Polarisations: VV, VH, HV and HH
- Resolution: ~10m
- Incidence angles 15° - 45° on both sides of aircraft
- Antenna type: 2x2 patch array
The SMAP test-bed (core validation site)

SM sites
- 0-5cm
- 0-90cm only

SMAP grids
- L3_SM_40km
- L3_HiRes
- L3_AP_SM

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Monitoring network

Permanent sites

Semi-Permanent sites
SMAPEx: The concept

Study Area:
One SMAP radiometer pixel (34km x 38km) with 29 monitoring sites

Focus areas YA & YB:
Two SMAP active passive product pixels (~9km x 9km) with 13 monitoring sites ea.

Ground Sampling:
Six SMAP radar pixels (~3km x 3km)
Campaign strategy
### Seasonal cycle

#### Soil Moisture

- **SMAPEX-1**: July 5-10
- **SMAPEX-2**: December 4-8

<table>
<thead>
<tr>
<th>Crop</th>
<th>Stage</th>
<th>Sowing</th>
<th>Planting</th>
<th>Stages</th>
<th>Harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Barley</td>
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<td>Oats</td>
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<tr>
<td>Rice</td>
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<tr>
<td>Maize</td>
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</tr>
<tr>
<td>Canola</td>
<td></td>
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</tr>
<tr>
<td>Cotton</td>
<td></td>
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</tr>
</tbody>
</table>
## SMAPEX monitoring strategy

### Flight Description

<table>
<thead>
<tr>
<th>Flight Type</th>
<th>Aim</th>
<th>Altitude (AGL)</th>
<th>Coverage</th>
<th>Ground Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional</td>
<td>Active/Passive retrieval</td>
<td>10,000ft</td>
<td>36km x 38km</td>
<td>1km (P)/10m (A)</td>
</tr>
<tr>
<td>Multi-angle</td>
<td>Effect of incidence and azimuth angle on radar</td>
<td>10,000ft</td>
<td>1km x 6km (2 strips)</td>
<td>1km (P)/10m (A)</td>
</tr>
<tr>
<td>PALSAR Transect</td>
<td>Comparison PLIS vs PALSAR</td>
<td>10,000ft</td>
<td>8km x 22km</td>
<td>1km (P)/10m (A)</td>
</tr>
<tr>
<td>Target</td>
<td>Radar algorithm development</td>
<td>1000ft</td>
<td>9km x 9km</td>
<td>100m (P)/10m (A)</td>
</tr>
</tbody>
</table>

### Weekly Flight Schedule

<table>
<thead>
<tr>
<th>Flight Type</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional</td>
<td>7.30-10.20*</td>
<td>7.30-10.20*</td>
<td>7.30-10.20*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transect</td>
<td>21.40-23.20</td>
<td></td>
<td>AREA YB</td>
<td>7.30-11.10*</td>
<td>AREA YA</td>
<td></td>
</tr>
</tbody>
</table>

*PALSAR overpass at 10:30pm of Monday (Exact day of PALSAR transect flight will change for each campaign accordingly to PALSAR overpass)

* Sunrise at 7.24am (EDT), start mapping at 8.15am (i.e., 45min after sunrise for Skye data reliability)
SMAPEx monitoring strategy

Ground validation data

- Continuous soil moisture at 29 sites
- Continuous TIR/soil temperature at 4 sites
- Six 3km x 3km focus areas
  > Soil moisture @ 250m spacing (Regional days)
  > Soil moisture @ 50m spacing (Target days)
  > Vegetation biomass, water content, LAI, reflectance @ 5 sites per dominant vegetation type
  > Surface roughness @ 3 sites per dominant vegetation type
Supplementary data

- Supplementary Station
- Soil Gravimetric Samples
- Surface Roughness
Ground validation data

HDAS
- soil moisture
- vegetation type
- vegetation height
- dew amount

Vegetation
- water content
- biomass type
- LAI
- spectral
- crop row spacing/orientation
SMAPEX-1

SMAPEX monitoring network

Average soil moisture ± Standard deviation

Daily Rainfall (mm)

0-5cm Soil Moisture (%w/w)

SMAPEX-1

Bare soil

Fallow

Maize

Wheat

Canola

Lucerne

Native pasture

Improved pasture

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SMAPEx-2

Extensive flooding

Flooded areas

SMAPEx Monitoring Network

Daily Rainfall

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### SMAPEX-2: vegetation sampling

<table>
<thead>
<tr>
<th>Crop</th>
<th>VWC (Kg/m²)</th>
<th>Plant Height (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize-tall</td>
<td>3.95</td>
<td>170.0</td>
</tr>
<tr>
<td>Maize- short</td>
<td>1.38</td>
<td>89.6</td>
</tr>
<tr>
<td>Pasture-West</td>
<td>1.16</td>
<td>112.5</td>
</tr>
<tr>
<td>Straw</td>
<td>1.11</td>
<td>9</td>
</tr>
<tr>
<td>Rice</td>
<td>0.77</td>
<td>31.0</td>
</tr>
<tr>
<td>Wheat</td>
<td>0.36</td>
<td>85.6</td>
</tr>
<tr>
<td>Barley</td>
<td>0.24</td>
<td>42.6</td>
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<tr>
<td>Oats</td>
<td>0.23</td>
<td>53.3</td>
</tr>
<tr>
<td>Cotton</td>
<td>0.21</td>
<td>16.8</td>
</tr>
<tr>
<td>Pasture</td>
<td>1.63</td>
<td>140.0</td>
</tr>
<tr>
<td>Pasture-East</td>
<td>0.71</td>
<td>55.0</td>
</tr>
<tr>
<td>Pasture-West</td>
<td>0.38</td>
<td>62.5</td>
</tr>
<tr>
<td>Pasture</td>
<td>0.19</td>
<td>100.0</td>
</tr>
<tr>
<td>Pasture</td>
<td>0.15</td>
<td>93.0</td>
</tr>
<tr>
<td>Pasture-East</td>
<td>0.02</td>
<td>42.5</td>
</tr>
</tbody>
</table>
Regional flights

PLMR

SMAPEX-1

July 6
Tb-H

Tb-V

July 8

July 10

Tb-H

Tb-V

36 km

38 km

SMAPEX-2

Dec 4
Tb-H

Tb-V

Dec 6

Dec 8

Tb-H [K]

Tb-V [K]
Target flights

PLMR

**SMAPEX-1**

July 7 Tb-H  Tb-V

July 9

**SMAPEX-2**

Dec 5

CANCELLED
Other airborne data

PLIS, SMAPEX-1, July 5
- SAR focused
- Georegistered
- Non calibrated
- Different polarisation combinations for RGB bands

VIS/NIR/SWIR, SMAPEX-2, Dec 5
Example PLIS data: SMAPEEx-1

Left Side VV

Left Side HH

dR = 6.0m
dAz = 4.2m

Left Side VH

Left Side HV
SMAPEX-1: soil moisture data

250m Sampling

6/07

50m Sampling

7/07

8/07

9/07

10/07

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SMAPEx-2: soil moisture data

250m Sampling

50m Sampling

Standing water

YB7 non accessible

rain @ 12:00

0 - 0.05
0.05 - 0.10
0.10 - 0.15
0.15 - 0.20
0.20 - 0.25
0.25 - 0.30
0.30 - 0.35
0.35 - 0.40
0.40 - 0.45
0.45 - 0.50
0.50 - 0.55

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### Supplementary data

#### Vegetation destructive sample, LAI, reflectances

<table>
<thead>
<tr>
<th>Vegetation type</th>
<th>Nr. of Samples</th>
<th>SMAPEX-1</th>
<th>SMAPEX-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley</td>
<td>3</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>1</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Oats</td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Pasture</td>
<td>10</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Maize</td>
<td>3</td>
<td>510(st)+7(leaf)</td>
<td></td>
</tr>
<tr>
<td>Canola</td>
<td>3</td>
<td></td>
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</tr>
<tr>
<td>Lucerne</td>
<td>4</td>
<td></td>
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</tr>
<tr>
<td>Cotton</td>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Rice</td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Straw</td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Cereal grain</td>
<td>4</td>
<td></td>
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</tr>
<tr>
<td>Bare Soil</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fallow</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mix wheat/fallow</td>
<td>1</td>
<td></td>
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</tr>
</tbody>
</table>

1x vegetation = 1x destructive sample + 5x LAI + 25x reflectance

#### Surface roughness

<table>
<thead>
<tr>
<th>Vegetation type</th>
<th>Nr. of Samples</th>
<th>SMAPEX-1</th>
<th>SMAPEX-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley</td>
<td>3</td>
<td>3</td>
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</tr>
<tr>
<td>Wheat</td>
<td>1</td>
<td>5</td>
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</tr>
<tr>
<td>Oats</td>
<td>4</td>
<td>2</td>
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</tr>
<tr>
<td>Pasture</td>
<td>10</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Maize</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Canola</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lucerne</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cotton</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cereal grain</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lucerne/grass</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bare Soil</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fallow</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mix wheat/fallow</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1x roughness = 3x 1-m profile (N-S) + 3x 1-m profile (E-W)
SMAPEx-2: additional data

Multi-azimuth flights

- Radar scaling overpasses
  - Effect of resolution on radar obs.
  - Multi-resolution radar images (5m, 50m, 150m)

- Ground mapping of standing water
  - Retrieval of standing water in satellite footprints
  - 9 inundated areas boundaries mapped using GPS tracking
  - Extension: 10m²– 0.2km²

<table>
<thead>
<tr>
<th>Area</th>
<th>Center Latitude</th>
<th>Center Longitude</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>34°42.83'S</td>
<td>146°8.27'E</td>
</tr>
<tr>
<td></td>
<td>34°51.11'S</td>
<td>146°6.91'E</td>
</tr>
</tbody>
</table>
Welcome to the
SMAPEX Project
Soil Moisture Active Passive Experiment

PLEASE NOTE: Site under construction

Project Overview

Real time information on soil moisture variability at high resolution is vital for sustainable land and water management. NASA’s next generation soil moisture dedicated mission, the Soil Moisture Active Passive (SMAP), will provide this information through the synergy of L-band (1.4GHz) active (radar) and passive (radiometer) microwave observations. The Soil Moisture Active Passive Experiments (SMAPEX) consist of 4, 1-week long field experiments specifically designed to contribute to the development of soil moisture retrieval algorithms from radar and radiometer for the SMAP mission. The SMAPEX experiments are currently the only SMAP validation campaigns planned for Australia.

SMAPEX will utilize airborne radar and radiometer data replicating the SMAP configuration in terms of frequency, viewing angle and resolution ratio. The main instruments flown are the Polarmetric L-band Multichannel Radiometer (PLMR) and the polarimetric L-band Imaging Scatterometer (PLIS), as well as a thermal infrared radiometer and multispectral sensor for vegetation properties and temperature measurements. SMAPEX will be undertaken in the ‘Yanco’ study area, a semi-arid agricultural area in the Murrumbidgee catchment, south-eastern Australia. The main flights will include coverage of a 36km x 36km area, equivalent to a SMAP radiometer pixel, with 2 days ‘revival’ time to simulate SMAP observations both in spatial and temporal resolution. These airborne observations will be undertaken at an approximately 3000m (AGL) altitude to provide radiometer and radar data and derived soil moisture content at respectively 1km and 10-20m. Ancillary flights will include lower altitude flights over target areas and other flights of limited coverage to investigate radar specific issues.

Concurrently with each flight, supporting ground data on soil moisture, vegetation properties, soil temperature and surface roughness will be collected at six intensive measurement sites. Moreover, an existing OzNet site...
SMAPEX-3

• Focus on change detection techniques
  3-weeks campaign to capture crop growth phase
  regional monitoring with 2-3 days “revisit”

Radar soil moisture retrieval (Superscience)
  detailed vegetation structure sampling
  additional soil moisture sampling
  monitoring of forest (airborne soil moisture & vegetation)
  airborne LIDAR and hyperspectral for validation of radar
  retrieval of vegetation parameters

• Tentative dates: 2-26 Sept 11----- volunteers welcome!
Participants: SMAPEX-1

AIR CREW
Jeff Walker (Monash Uni)
Jon Johannson
Heath Yardley (Adelaide Uni)

VEGETATION SAMPLING
Peggy O’Neill (GSFC)
Alicia Joseph (GSFC)
Rajat Blindlish (USDA)
Susie Chai

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Rocco Panciera (Melbourne Uni)
James Yates (Monash Uni)
Kung Khin loh (Monash Uni)
Wenshen Wong (Monash Uni)
Anna Balenzano (CNR, Italy)
Mohan Yellishetty (Monash Uni)
Wen Ooi (Monash Uni)
Sheen Chua (Monash Uni)
Chin Cheong (Monash Uni)
Rodger Young (Melbourne Uni)
Andreas Collander (JPL)

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Participants: SMAPEX-2

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Heath Yardley (Adelaide Uni)

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John Prueger (USDA)
Seungbum Kim (JPL)
Mehmet Kurum (GSFC)

SOIL MOISTURE SAMPLING
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Lucheng Huang (Monash Uni)
Giuseppe Satalino (CNR, Italy)
Perrine Hamel (Monash Uni)
Rocco Panciera (Melbourne Uni)
Maria Piles (Melbourne Uni)
Chris Rudiger (Monash Uni)
Fedra Mendez
Muzaffar Ahmad (Melbourne Uni)
Rodger Young (Melbourne Uni)