Multi-frequency Radiometers Field Campaigns

The multi-frequency radiometers field campaigns comprise of two one-day campaigns across an approximately two or three weeks' timeframe. The overall objective of this campaign is to develop algorithms and techniques to retrieve soil profile using K-, L- and P-band radiometers, and to downscale L- or P-band brightness temperature observations and/or soil moisture products using K-band radiometers. The field campaigns involve collecting airborne radiometer data together with ground observations of soil moisture, vegetation water content, soil surface roughness and ancillary data for a diverse range of conditions.

1. **Aircraft facilities**

i) Aircraft.

Fig. 1. Aircraft for remote sensing experiments, showing a wingtip installation in the left inset, and the cockpit with cockpit computer display in the right inset.

ii) Polarimetric P-band Multibeam Radiometer (PPMR)

This passive microwave radiometer at P-band (742-752 MHz) provides brightness temperature in vertical and horizontal polarization from four beams, and is expected to provide accurate soil moisture information over a deeper layer of soil (the top ~15cm) that closely relates to crop and pasture growth.

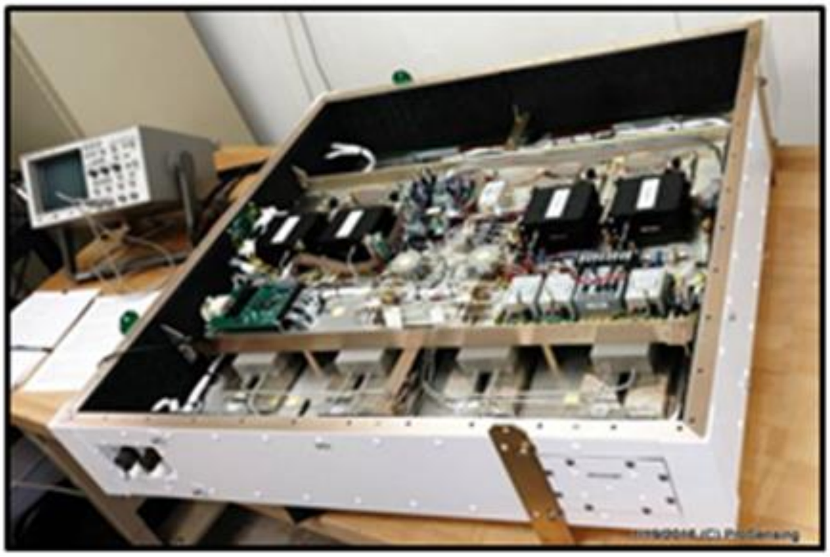


Fig. 2. Polarimetric P-band Multibeam Radiometer

iii) Polarimetric L-band Multibeam Radiometer (PLMR)

PLMR is a compact L-band (1400-1426 MHz) imaging radiometer that generates push-broom images of scene brightness temperature in vertical and horizontal polarization from six beams. It has been used to extract ocean surface salinity and top 5cm soil moisture from the measured brightness temperature data.

Fig. 3. Polarimetric L-band Multibeam Radiometer

iv) Polarimetric K-band Scanning Radiometer (PKSR)

This passive microwave radiometer has a reflector and programmable motor system, being able to coaxially scan with a narrow beam. The RF front end can be swapped between Ku-band (18.7 GHz) and Ka-band (36.5 GHz). It is expected to provide soil moisture at a higher resolution.

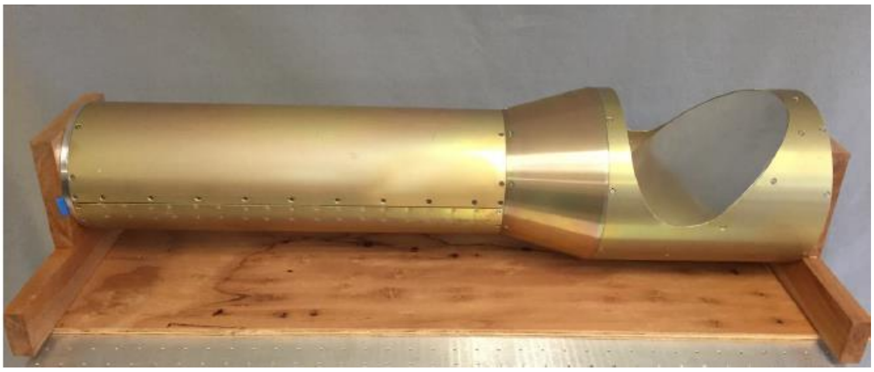


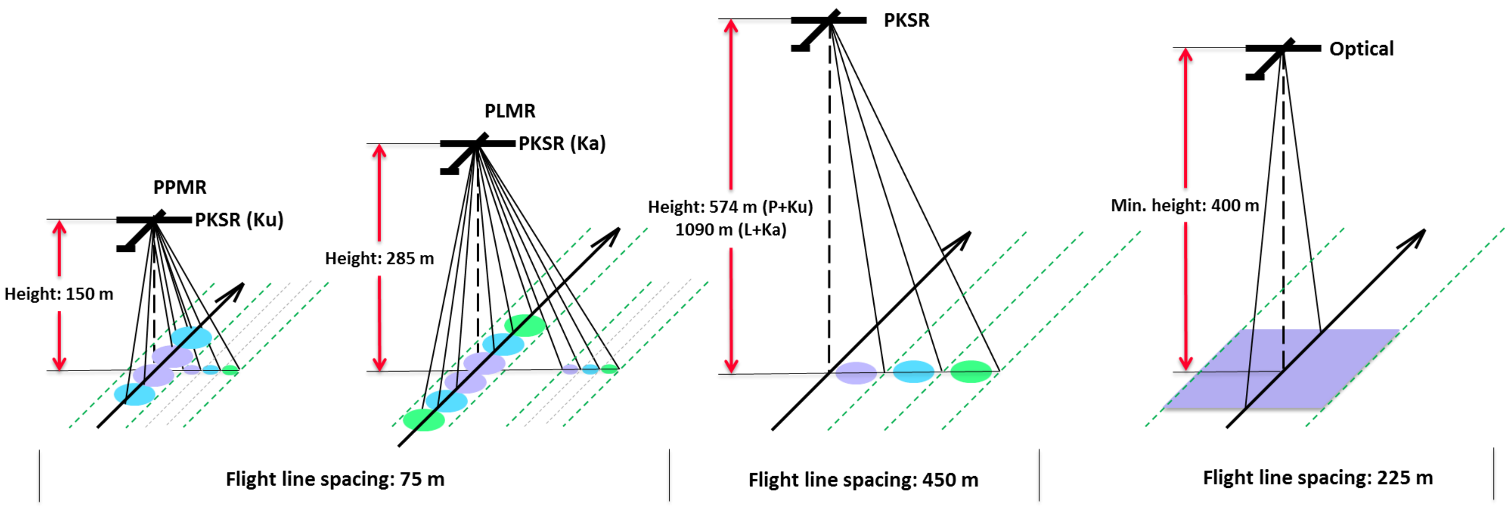
Fig. 4. Polarimetric K-band Scanning Radiometer

v) Optical cameras
The optical cameras, including a high resolution digital SLR camera, a digital video camera and FLIR A65, are used to provide high resolution NIR, RGB and TIR images respectively.

Fig. 5. Canon EOS-1DS Mark 3 (left: Red / Green / Blue), Canon EOS-5D Mark 3 camera (centre: Red+Near InfraRed / Green+NIR/ NIR), and FLIR A65 thermal infrared camera (right: 7.5–13 µm).

2. Flight and ground sampling design

1) Flight design (altitudes are AGL)



- PPMR and PLMR will be configured in multi-angle flight mode, in order to collect data for multi-angular retrieval. Being limited by the minimum flight height of 150m AGL (160m ASL), the PPMR and PLMR spatial resolution of 75 m will be achieved.

- On each day, two flights will be conducted over the study area (Fig. 6):
    i) Flight 1 with P-band + Ku-band. This flight will start with an altitude of 150m AGL; after fly 12 lines (the black lines in Fig. 6) over the entire study area it will ascend to 574 m AGL and then fly along 2 lines (the red lines in Fig. 6). At this higher altitude, the optical data will also be collected.
    ii) Flight 2 with L-band + Ka-band. This flight will start with an altitude of 285m AGL; after fly 12 lines (the black lines in Fig. 6) over the entire study area it will ascend to 1090m AGL and then fly along 2 lines (the red lines in Fig. 6). At this higher altitude, the optical data will also be collected.
- The flights with lower altitudes (150m AGL for flight 1 and 285m AGL for flight 2) have the same spacing of 75m; those with higher altitudes (574m AGL for flight 1 and 1090m AGL for flight 2) will have a spacing of 450m.
- Each flight will start from the Tyabb airport in the southeast of Victoria (Fig. 7), then go towards the study area. At the end it will fly over a waterbody. The distance between Tyabb airport and the study area is ~40km.
- Detailed configuration for each flight is listed in Table 1, including the altitude, resolution, scan angles and integration time.
- Expected flight duration: 1.5 hours for each flight; therefore ~3 hours for each day.
- Expected flight date: 25 Oct and 4 Nov (weather permitting), in austal spring. It is expected to experience a decrease of soil moisture and increase of vegetation biomass during the short experiment.

2) Ground sampling design

- Soil moisture sampling: will be conducted concurrently with flights, using the Hydraprobe Data Acquisition System (HDAS), at a spacing of 75m, as shown in Fig. 6. A more intensive soil moisture sampling will also be conducted at a spacing of 25m under two flight lines (as shown in Fig. 6).
- Vegetation sampling: will cover representative selection of paddocks shown in Fig. 8. Two vegetation samples for biomass and vegetation water content will be collected per representative paddock.
- Roughness sampling: will be conducted two locations at each paddock with stations using roughness profiler. At each of the locations two 3m-long surface profiles will be recorded in orthogonal direction, perpendicular to row direction.
- Ground samplings (soil moisture, vegetation and roughness): will be repeated at approximately same locations for each campaign.

- Monitoring stations: are installed in each paddock shown in Fig. 8 to monitor real-time soil moisture and surface temperature.
- Expected crop types: as shown in Fig. 8, this study area consists of a range of vegetation types, e.g. fallow, pasture and wheat. There is also some vegetable and pasture in the flight area but outside the ground sampling area.

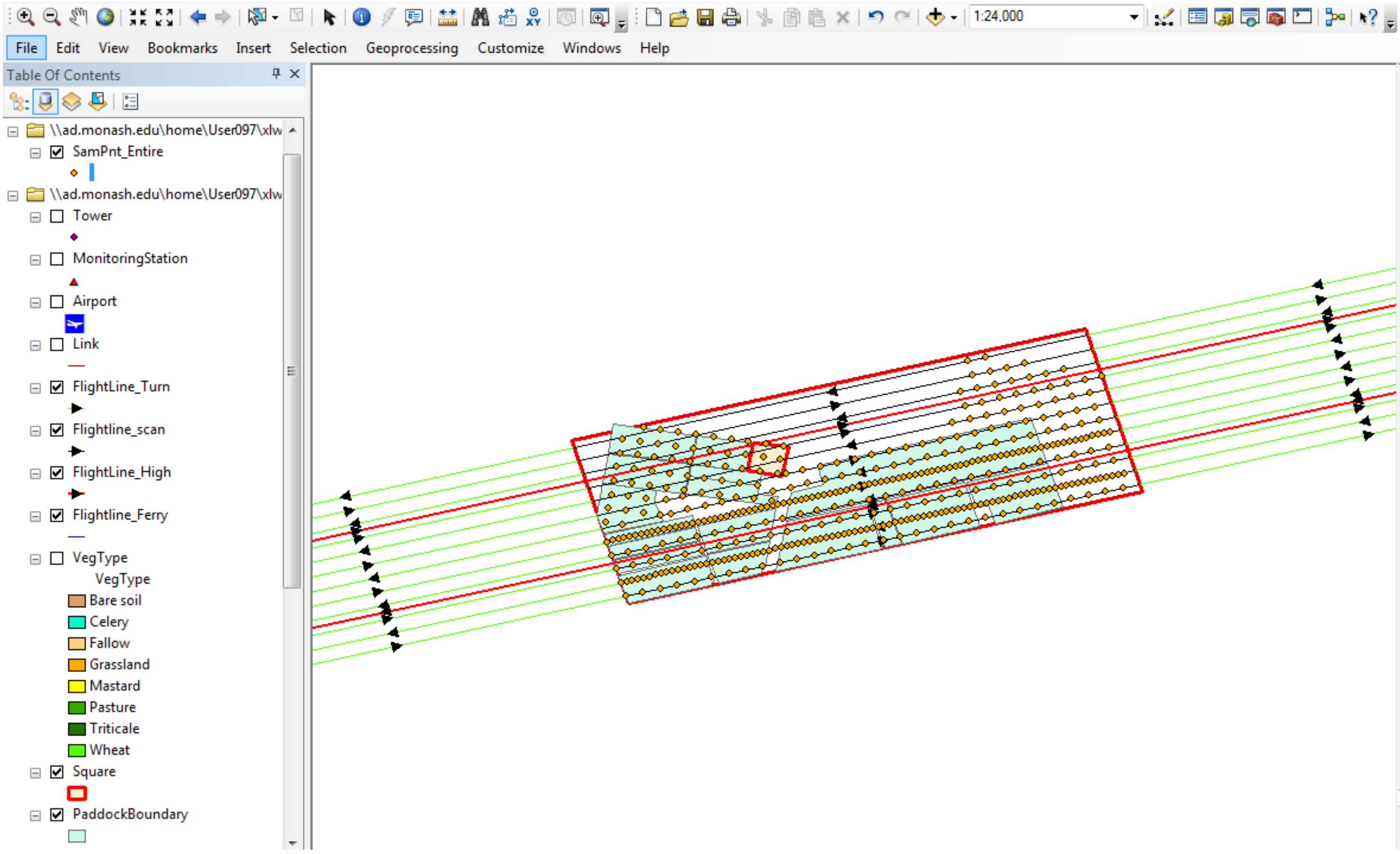


Fig. 6. Flight lines (black for lower altitudes, red for higher altitudes and green for turnning) and ground soil moisture sampling points (orange points)

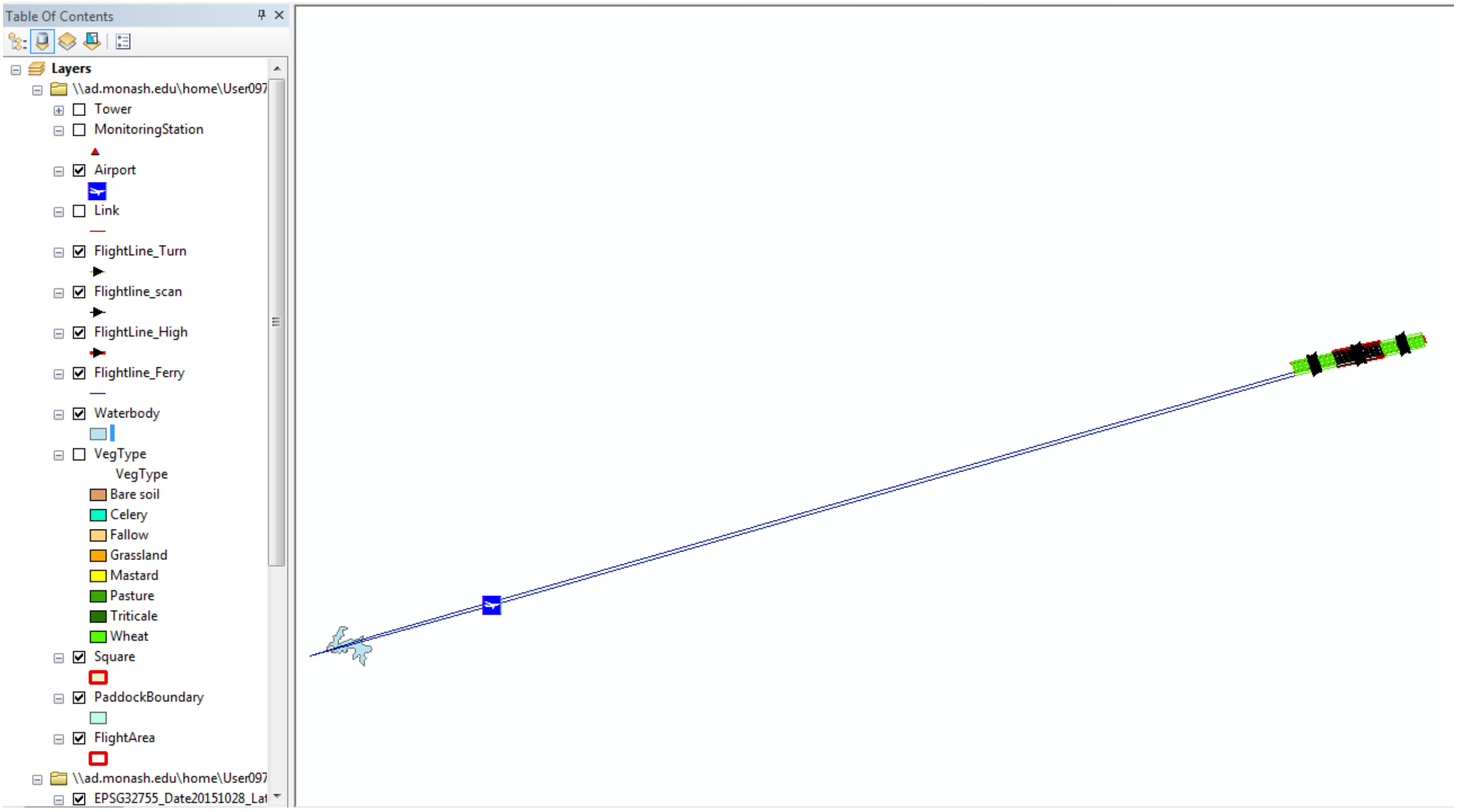


Fig. 7. Locations of flight area, flight starting points (from Tyabb airport) and location of the waterbody.

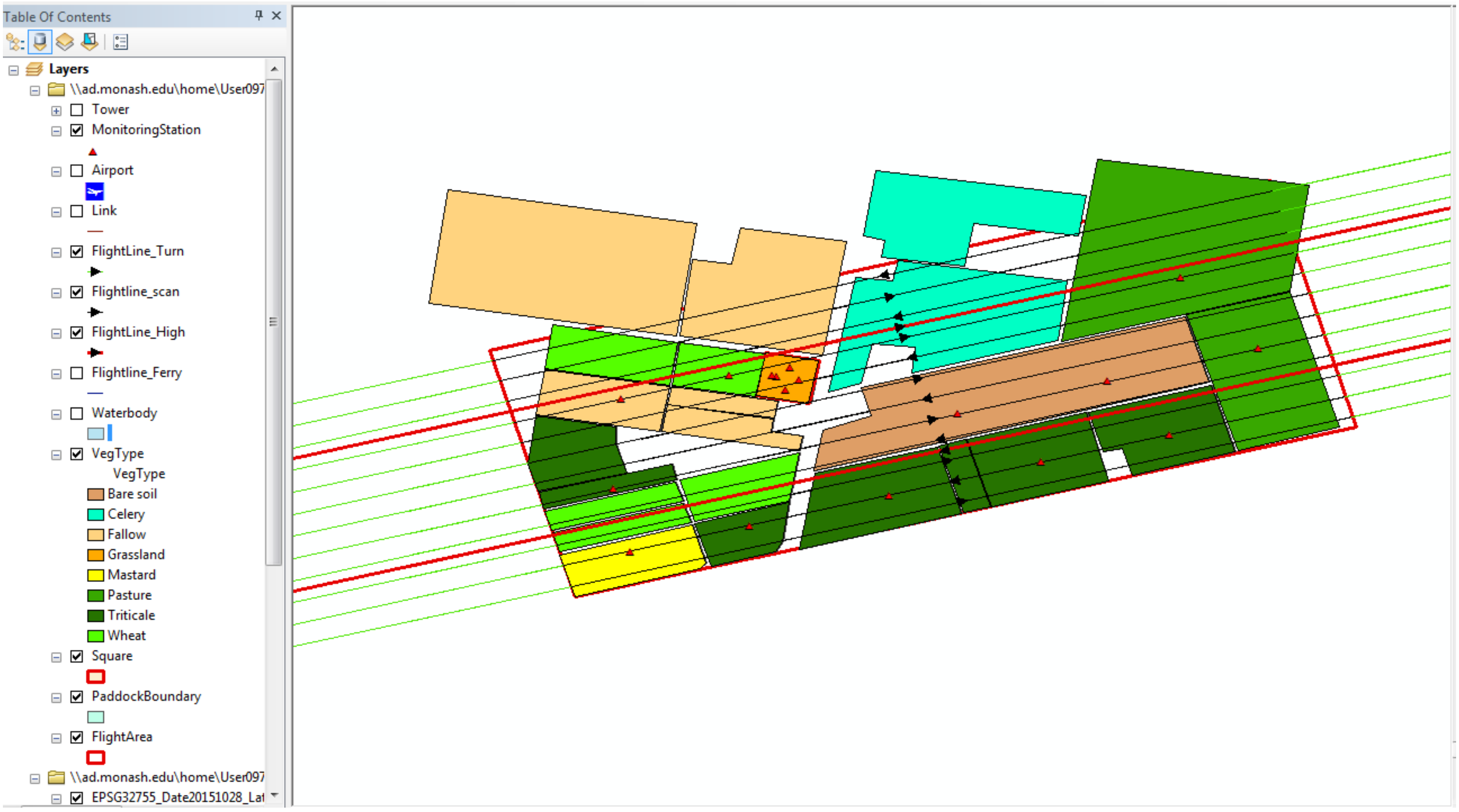


Fig. 8. Vegetation types for each paddock in the study area. Vegetation sampling will be performed in each paddock. Also shown is the location for the stations (in red triangle)

Table 1. Configuration for each flight (ground speed: 230km/h = 64m/s = 125knot)

<table>
<tr><th rowspan="2">Flight</th><th rowspan="2">Mode</th><th colspan="2">Altitude
(above sea level)*</th><th rowspan="2">Resolution
(m)</th><th rowspan="2">Scan angles
for K-band
(˚C)</th><th rowspan="2">No. of
lines</th><th rowspan="2">Integration
time
(ms)</th></tr>
<tr><th>in meter</th><th>in feet</th></tr>
<tr><td rowspan="4">P+Ku
(+Optical*)</td><td rowspan="2">Low</td><td rowspan="2">170</td><td rowspan="2">560</td><td>25 (Ku)</td><td rowspan="2">19.6, 28.2, 35.5</td><td rowspan="2">12</td><td rowspan="2">50</td></tr>
<tr><td>75 (P)</td></tr>
<tr><td rowspan="2">High</td><td rowspan="2">594</td><td rowspan="2">1950</td><td>75 (Ku)</td><td rowspan="2">3.7, 11, 18</td><td rowspan="2">2</td><td rowspan="2">50</td></tr>
<tr><td>308(P)</td></tr>
<tr><td rowspan="4">L+Ka
(+Optical*)</td><td rowspan="2">Low</td><td rowspan="2">305</td><td rowspan="2">1000</td><td>25(Ka)</td><td rowspan="2">23.7, 27.8, 31.6</td><td rowspan="2">12</td><td rowspan="2">50</td></tr>
<tr><td>75(L)</td></tr>
<tr><td rowspan="2">High</td><td rowspan="2">1110</td><td rowspan="2">3640</td><td>75(Ka)</td><td rowspan="2">2, 6, 9.8</td><td rowspan="2">2</td><td rowspan="2">50</td></tr>
<tr><td>288(L)</td></tr>
</table>

*20m added to convert AGL to ASL.

*Optical flight only operates at the “High” altitudes, being 1950ft and 3640ft.