MONASH University

Engineering

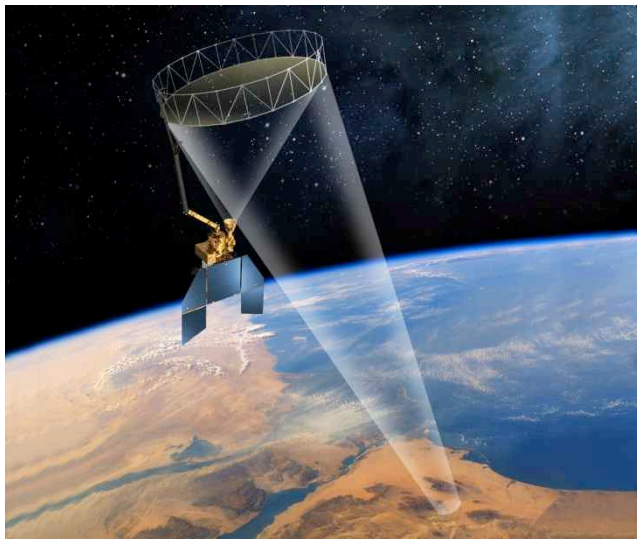
The Soil Moisture Active Passive Experiments: SMAPEx

***J. P. Walker*[1], *X. Wu*[1], *Y. Gao*[1], *A. Monerris*[1], *R. Panciera*[2], *T. Jackson*[3], *P. O'Neil*[4], *N. Das*[5], *D. Gray*[6], *and D. Ryu*[7]**

[1]Department of Civil Engineering, Monash University, Australia
[2]Cooperative Research Centre for Spatial Information, University of Melbourne, Australia
[3]United States Department of Agriculture (USDA), USA
[4]NASA/Goddard Space Flight Center, USA
[5]NASA/JPL, USA
[6]Department of Electrical and Electronic Engineering, University of Adelaide, Australia
[7]Department of Infrastructure Engineering, University of Melbourne, Australia

Acknowledgement: Australian Research Council DP0984586, LE0453434 and LE0882509

The Soil Moisture Active Passive mission



SMAP Specifications

Launch: NASA, 2014

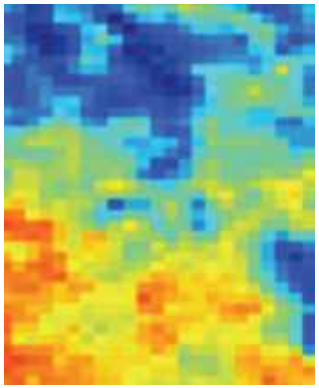
Frequency band: L-band

Incidence angle: 40˚

Azimuth direction: conically-scanning antenna

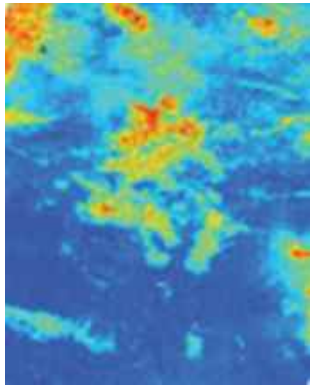
Resolution: Soil Moisture ~9km -- 36km radiometer + 3km radar

Repeat: 2-3 days



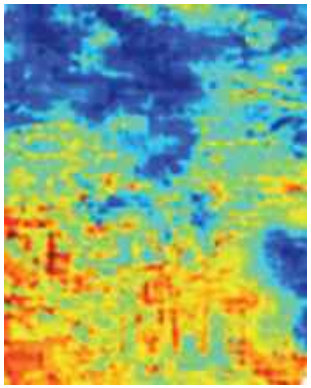
Radiometer observation ~36km

+



Radar observation ~3km

=



Downscaled product ~9km

Algorithms

Active Passive Retrieval and Downscaling

Objectives

1. Radar-only soil moisture retrieval (3km)

   Verify baseline algorithms proposed for SMAP

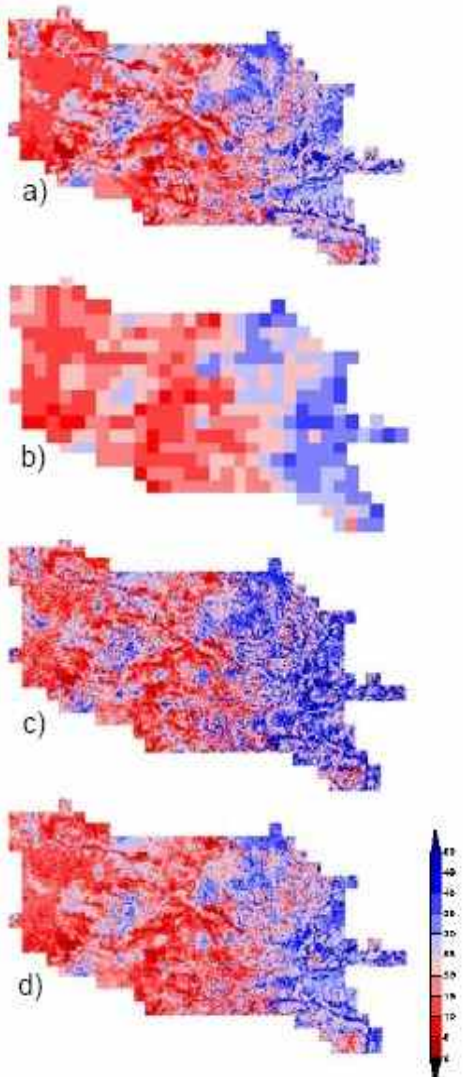
2. Radiometer-only soil moisture retrieval (36km)

   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 (9km)

   Use the high resolution (3km) but noisy SMAP radar observations to downscale the accurate but low resolution (36km) radiometer footprint

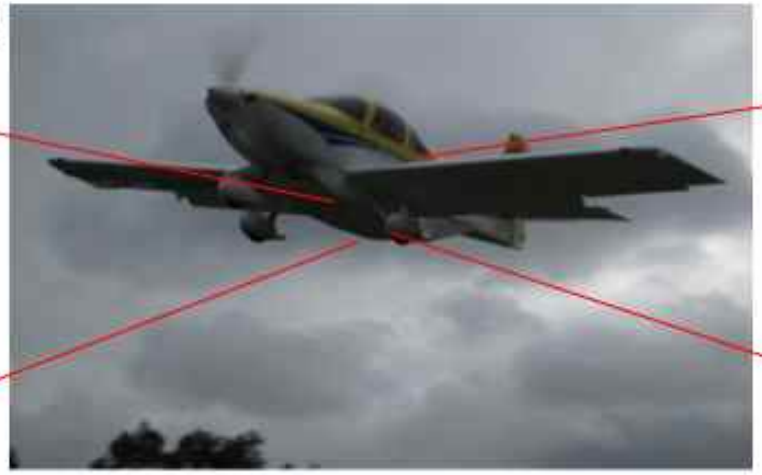
DP0984586



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).

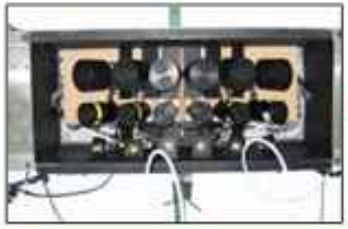
Airborne simulator

L-band radiometer (PLMR)



L-band radar (PLIS)

6 x Vis/NIR/SWIR/TIR



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: 8 ×8 patch array

LE0453434

PLIS: Polarimetric L-band Imaging SAR

Frequency/bandwidth:1.26GHz/30MHz

Polarisations: VV, VH, HV and HH

Resolution: ~10m

Inc. angles 15º -45º on both sides of aircraft

Antenna type: 2x2 patch array

LE0882509

Motivation

Pre-launch active-passive algorithm validation largely based on synthetic studies & few airborne data sets

TEST DATA

Datasets:

T_B at 36km

& σ° at 3km

Downscaled product:

T_B/SM at 9km

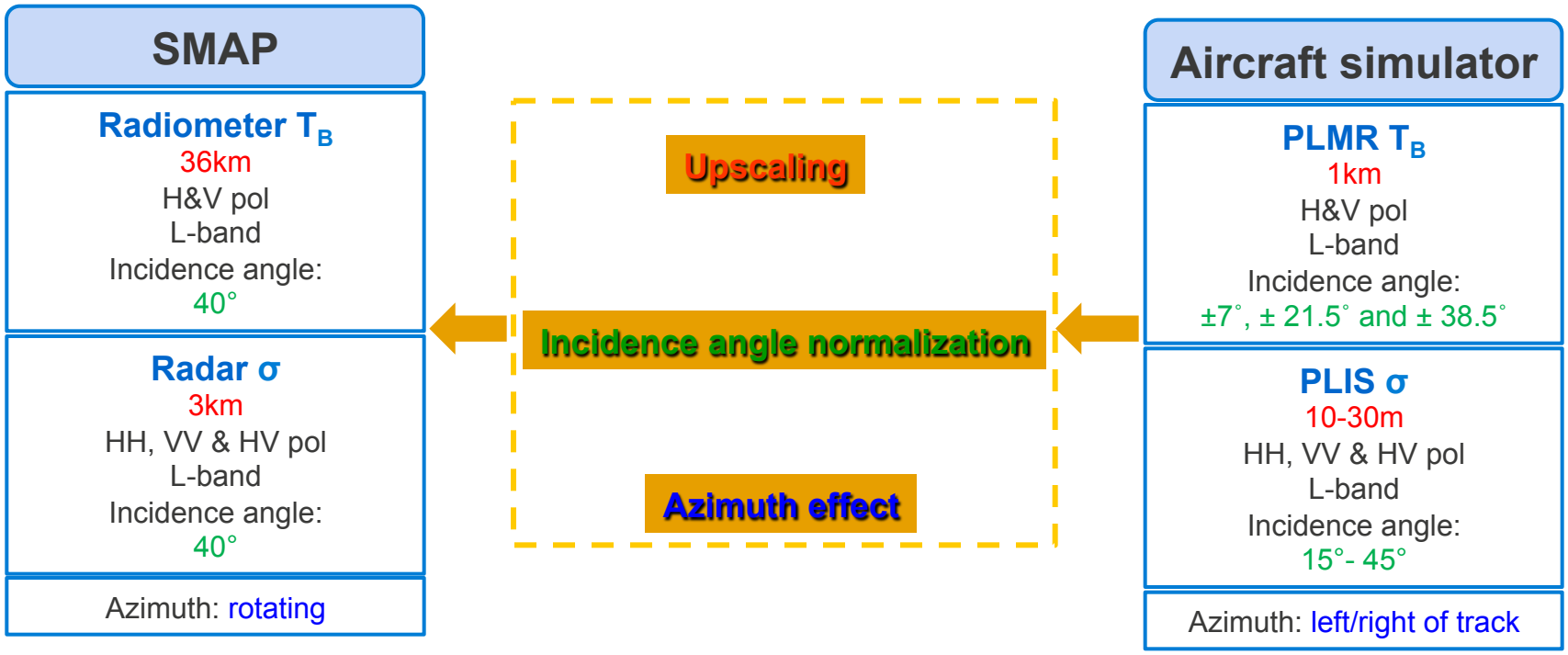
EVALUATION DATA

Reference dataset:

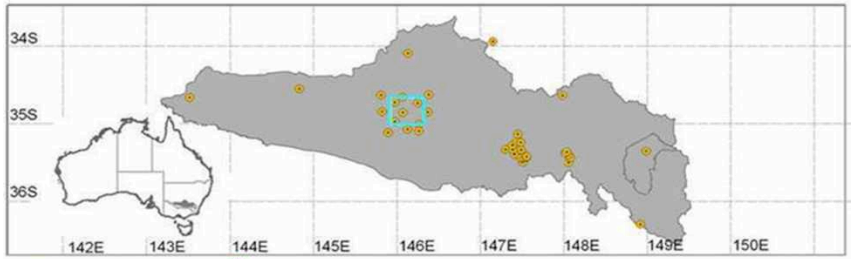
T_B/SM at 1km

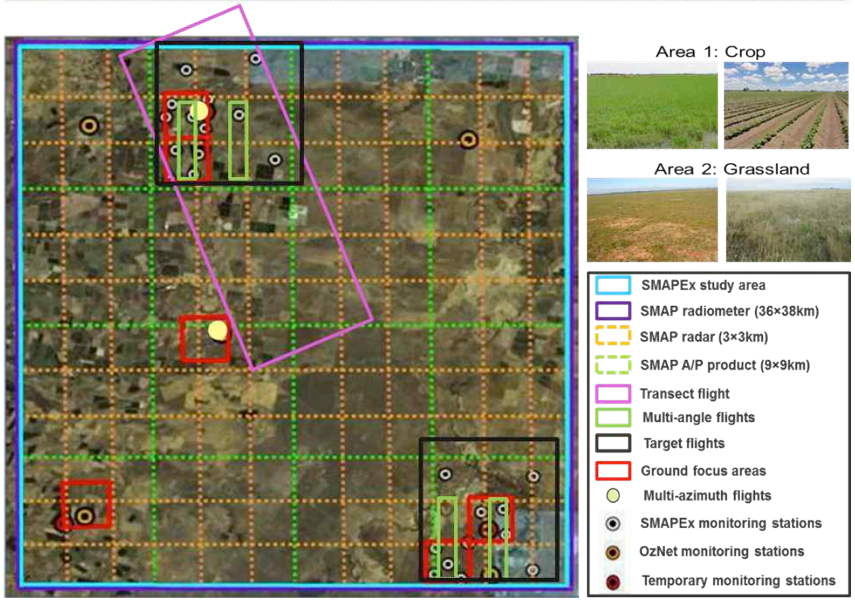
SMAP Data Simulation

Simulation of SMAP data



Study site





Flights

Regional flight, Target flights, Transect flight;

Multi-angle flights and multi-azimuth flights

Soil Moisture Active Passive Experiments (SMAPEx)

Location: Yanco, Murrumbidgee Catchment, NSW;

Field campaigns: SMAPEx-1 (5th-10th July 2010)

SMAPEx-2 (4th-8th Dec 2010)

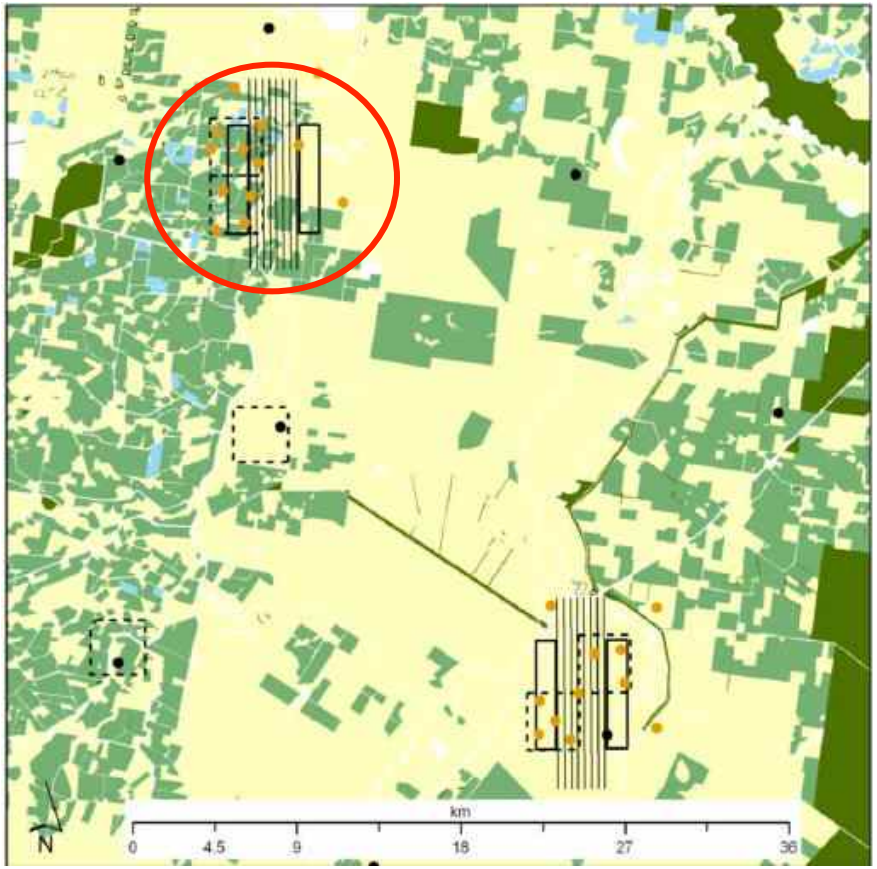
SMAPEx-3 (5th-23rd Sept 2011)

Ground sampling

Soil moisture; and

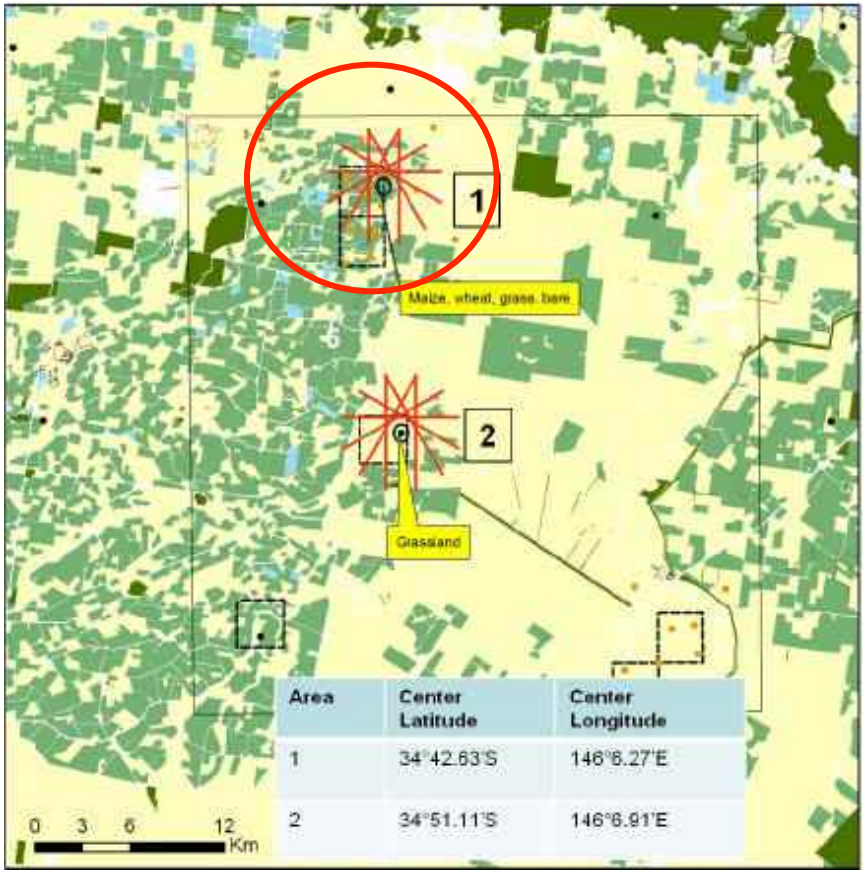
vegetation

Target flights



Multi-angle flights

at 3,000m altitude



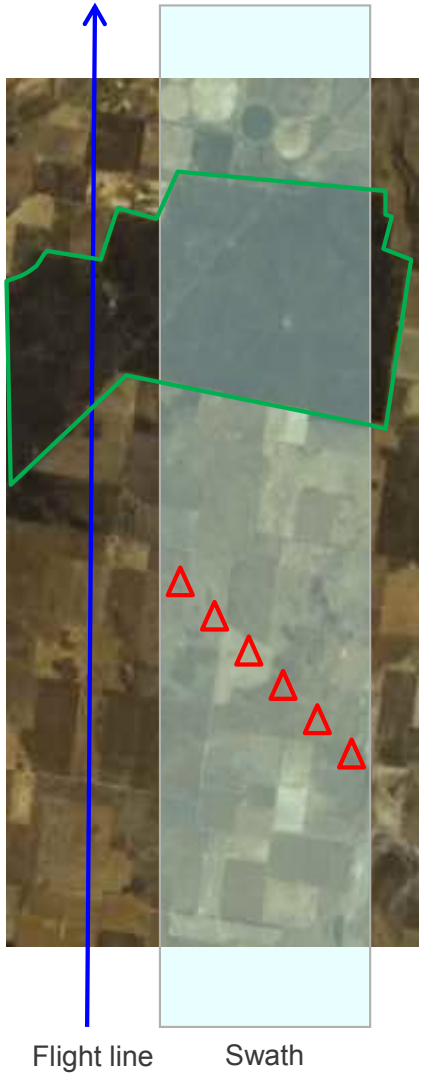
Area	Center Latitude	Center Longitude
1	34°42.63'S	146°6.27'E
2	34°51.11'S	146°6.91'E

Multi-azimuth and multi-resolution flights

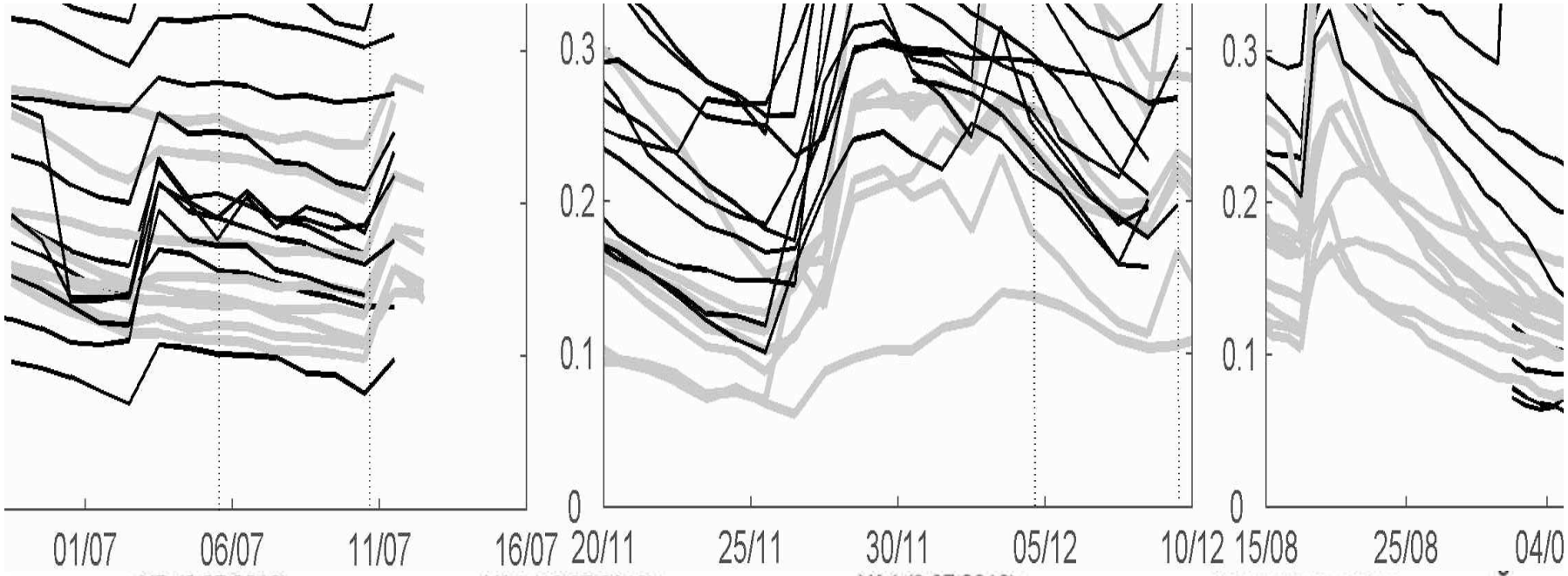
both at 1,500m altitude

Calibration

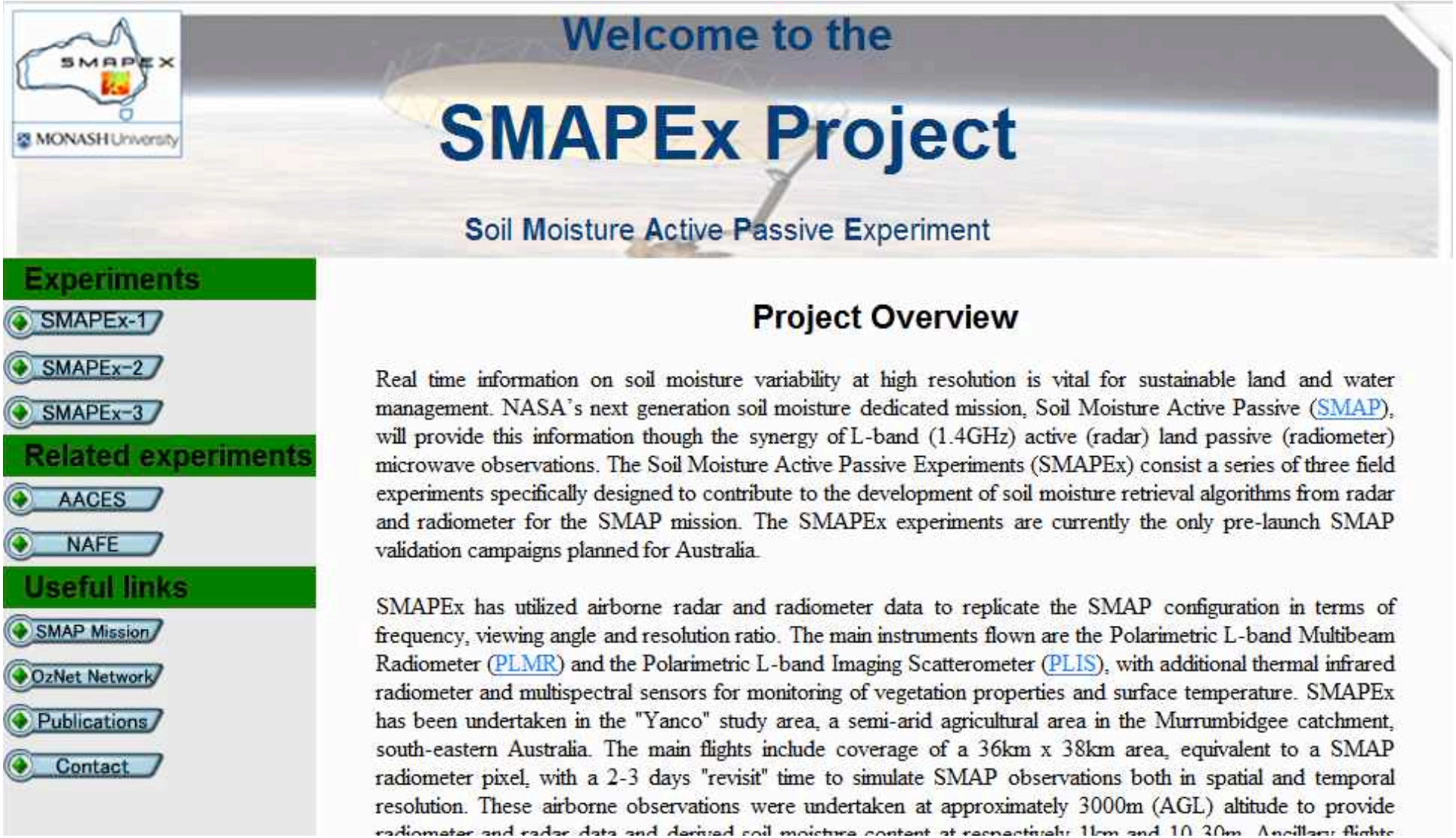
- A single set of calibration solutions for PLIS have been derived for each campaign based on daily calibration flights
- Absolute calibration accuracy for PLIS based on the PRCs from SMAPEx-3 is ~0.93dB
- Relative calibration (start and end of the flight) accuracy for PLIS is ~0.8dB
- The calibration procedure for PLMR is mature and is accurate to ~2K



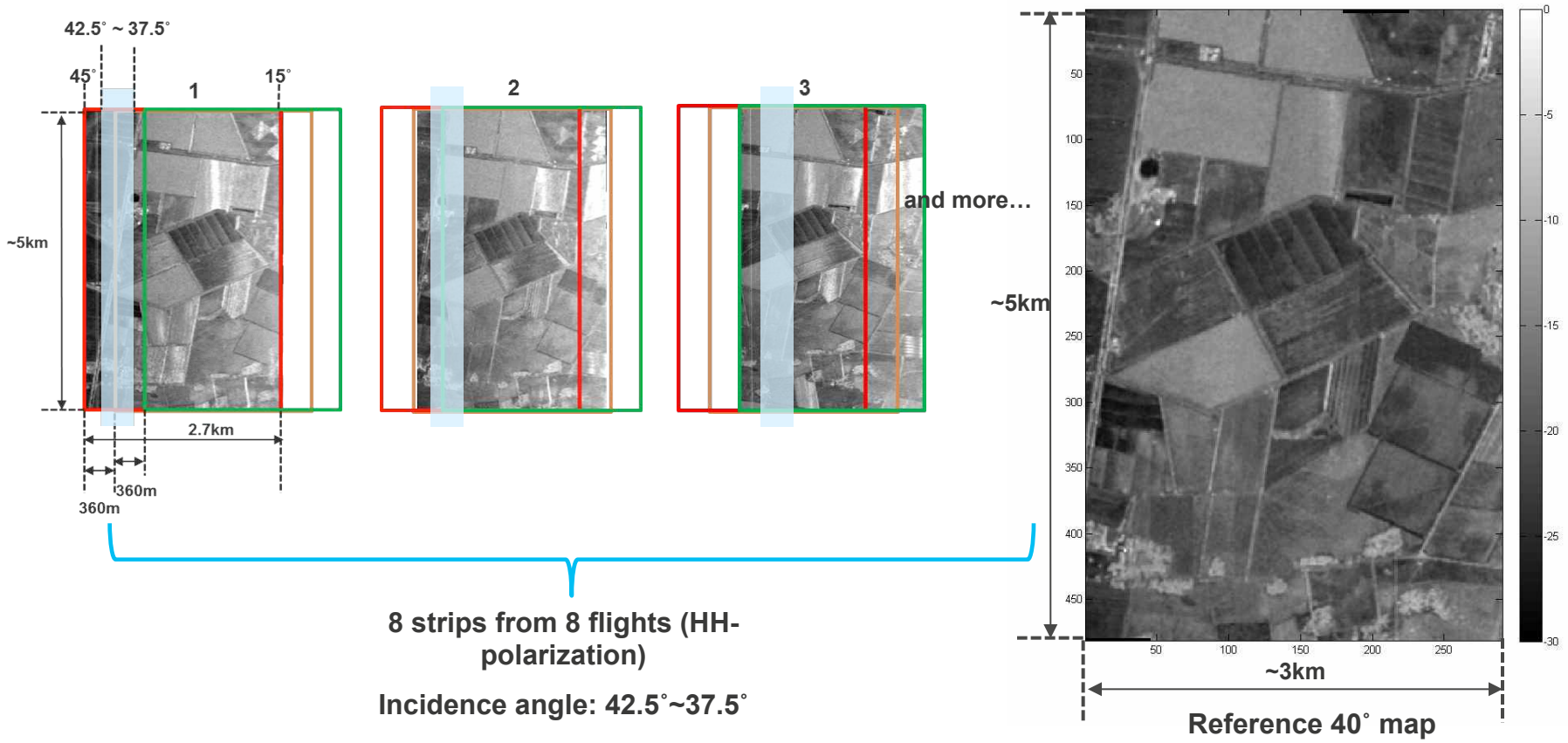
Ground soil moisture



www.smapex.monas.edu.au



Normalization to 40˚ for PLIS

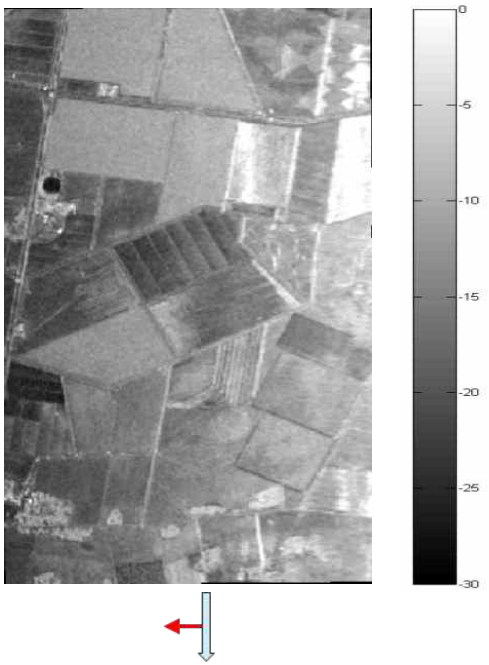


8 strips from 8 flights (HH-polarization)

Incidence angle: 42.5˚~37.5˚

Normalization to 40˚ for PLIS

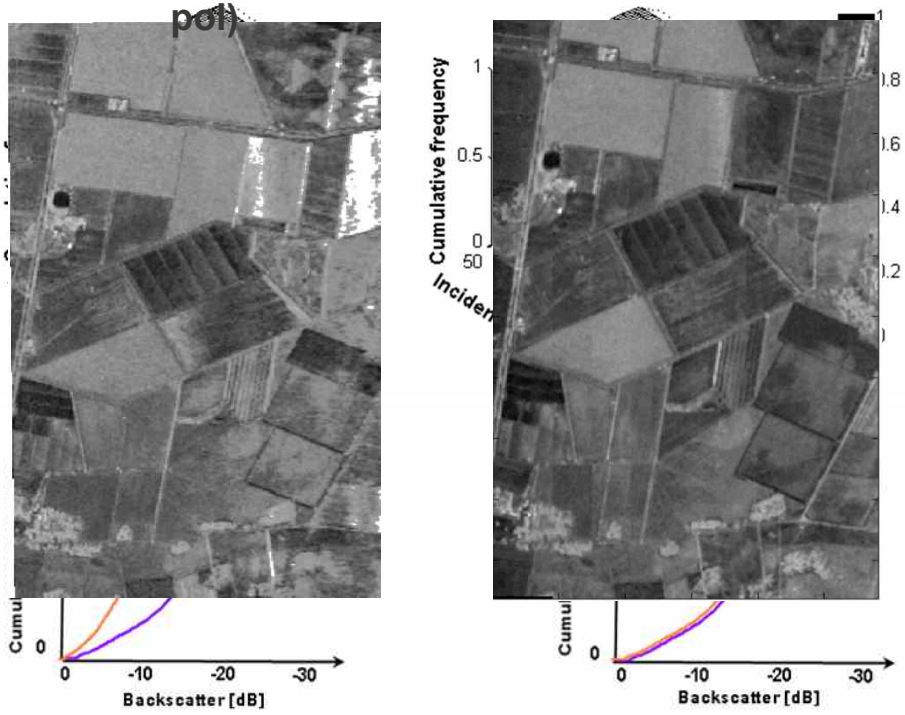
Original flight (HH-pol)



Normalized flight (HH-pol)

CDF method

Reference (HH-pol)

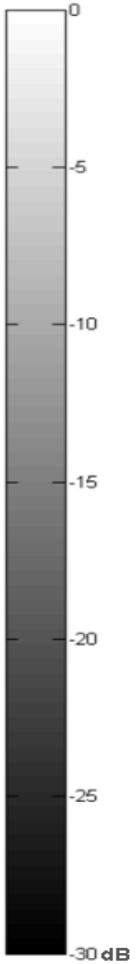


Note: The CDFs used in this study are from small sample sizes. Results may be improved by using a larger sample of data.

Normalization to 40˚ for PLIS

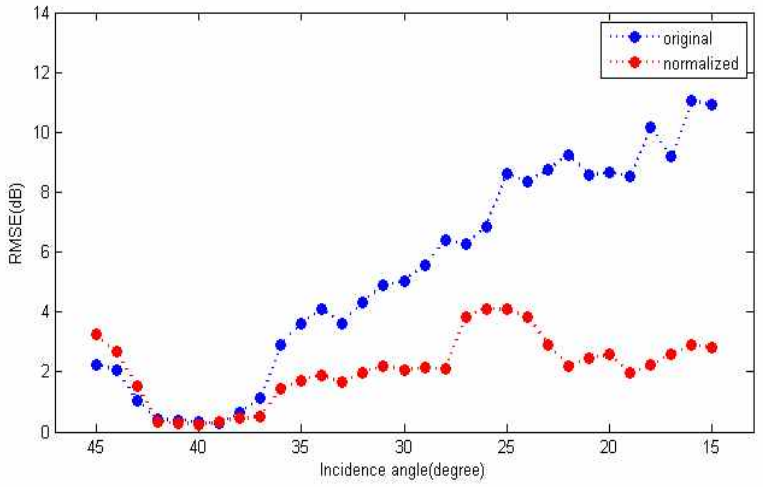
Normalized flight (HH-

10m p

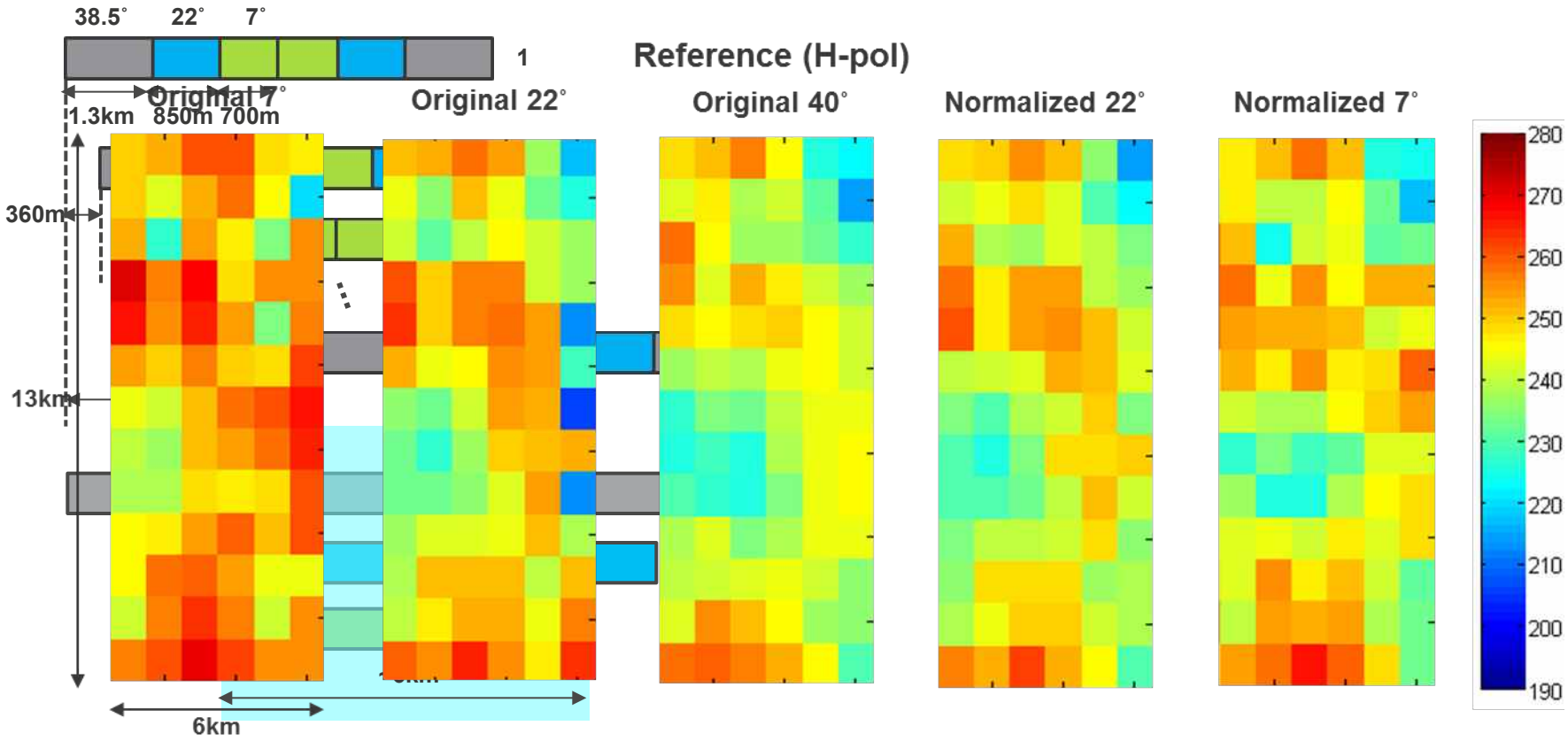


RMSE (dB)	10m
Original	5.7
Normalized	3.7

RMSE vs Angle (1˚ /

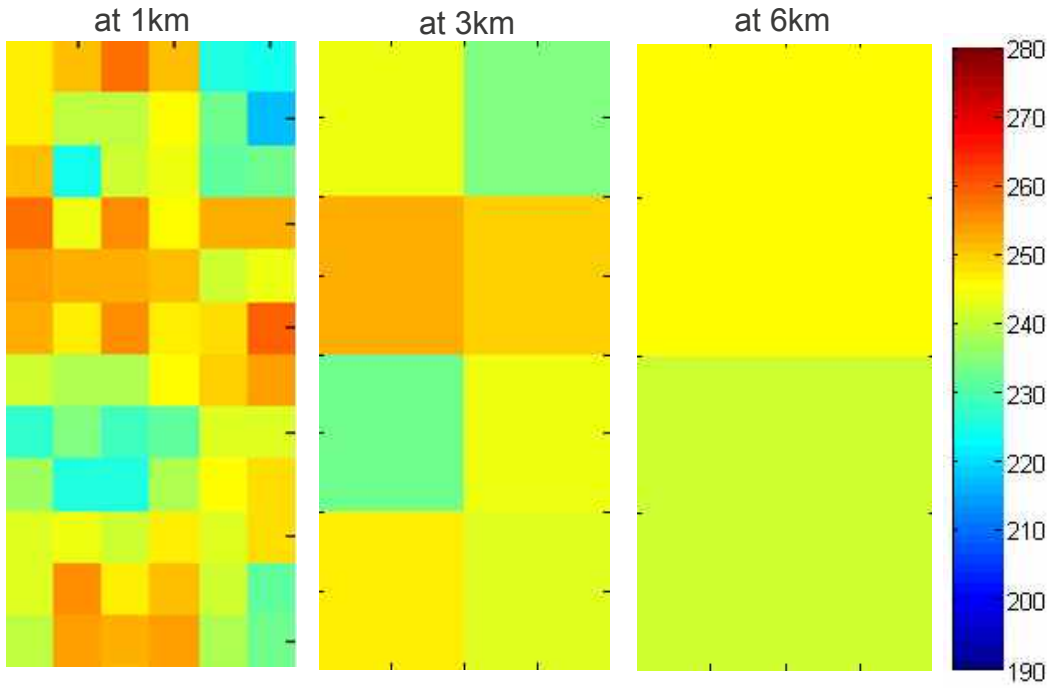


Normalization to 40˚ for PLMR



Normalization to 40˚ for PLMR

Normalized flight (7˚, H-pol)



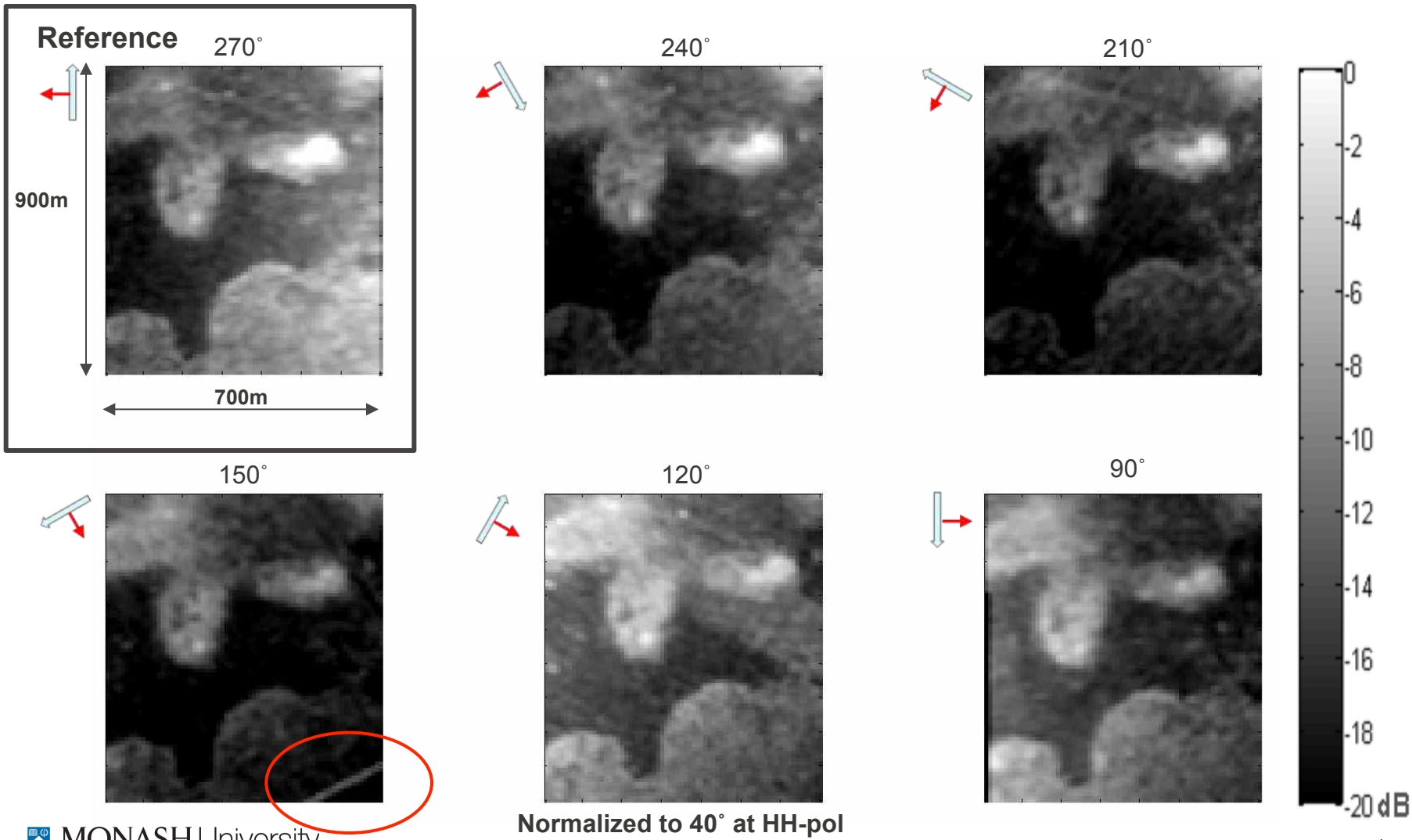
Normalized flight -- 7˚

RMSE(K)	1km	3km	6km
Original	13.7	12.6	11.2
Normalized	7.4	5.7	3.0

Normalized flight -- 22˚

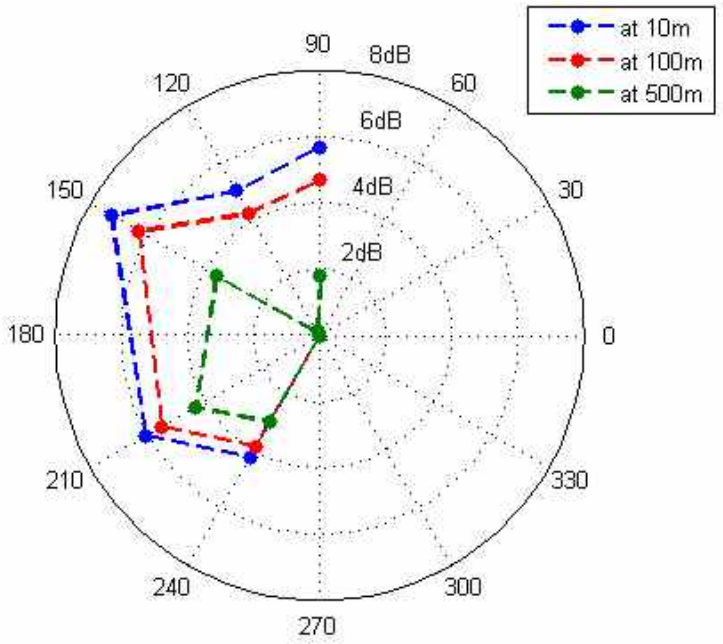
RMSE (K)	1km	3km	6km
Original	11.6	7.2	6.6
Normalized	6.7	4.0	2.9

Azimuth effect for PLIS

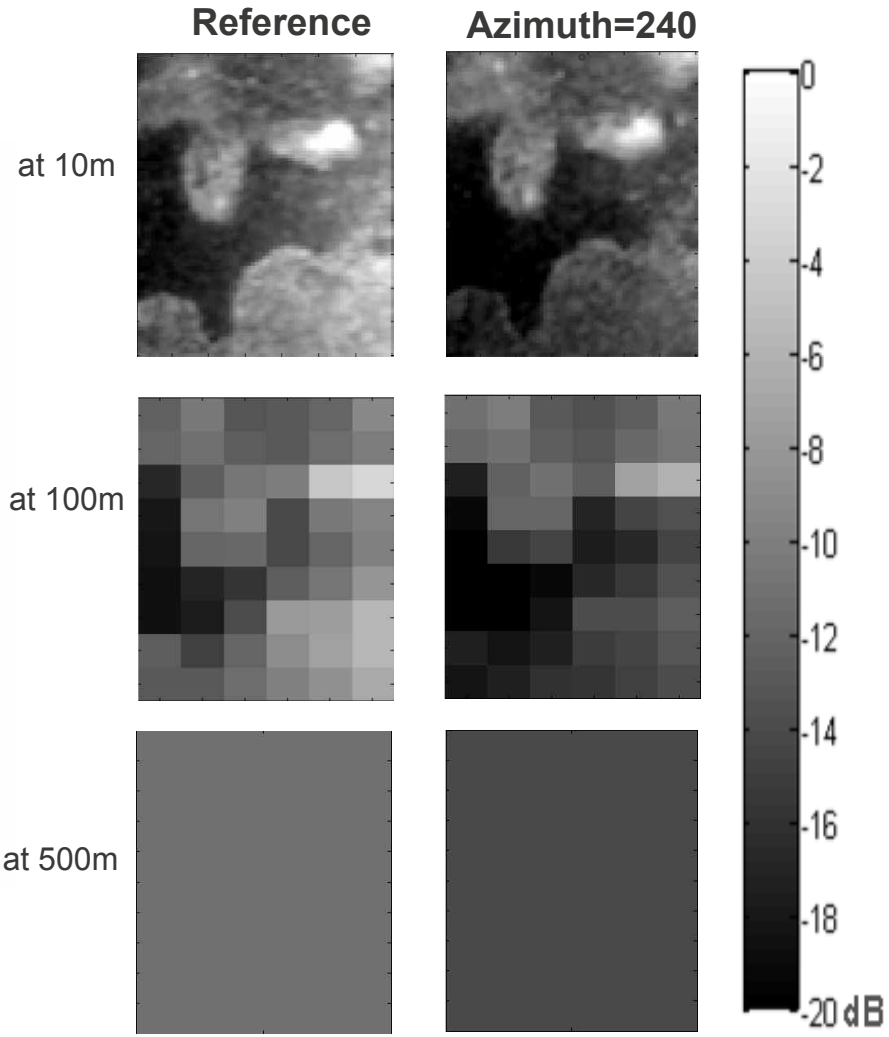


Normalized to 40˚ at HH-pol

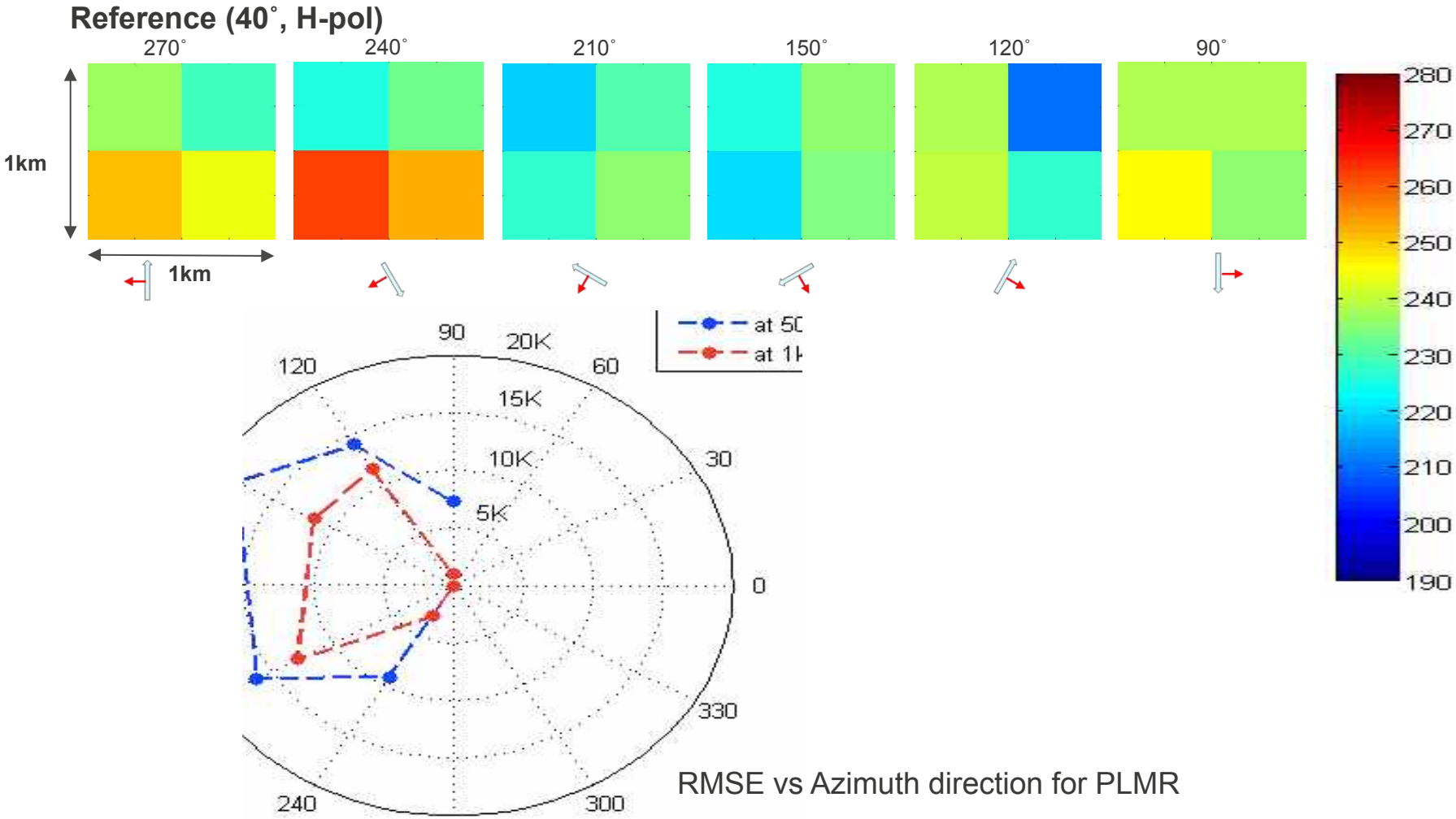
Azimuth effect for PLIS



RMSE vs Azimuth direction for PLIS

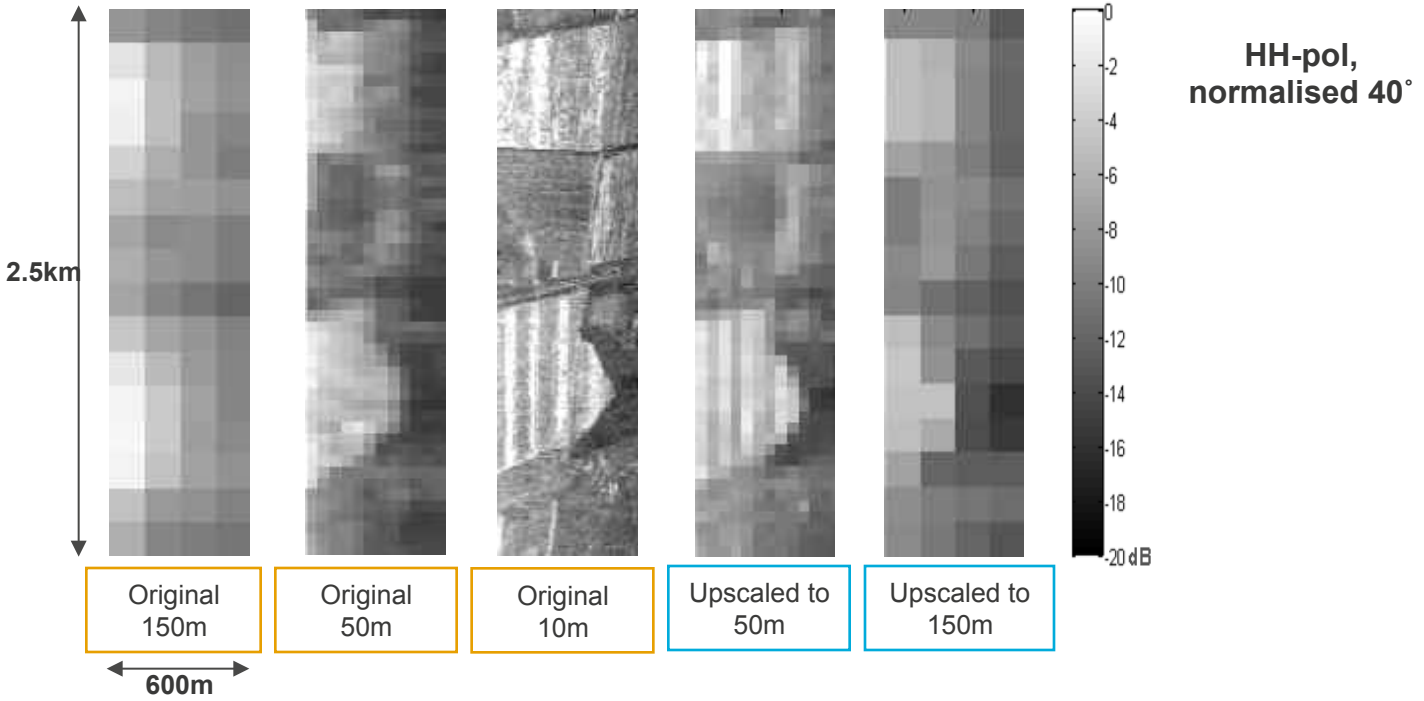


Azimuth effect for PLMR



RMSE vs Azimuth direction for PLMR

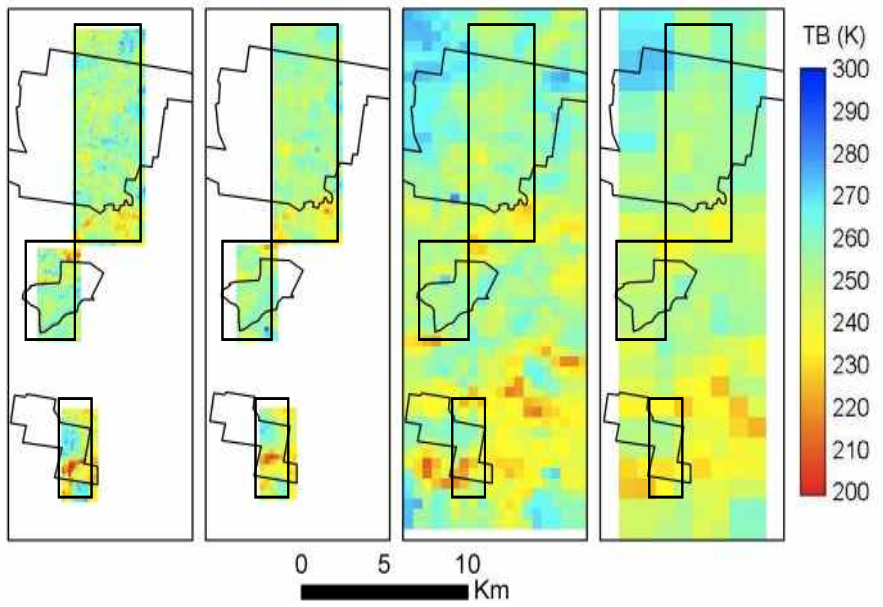
Upscaling for PLIS

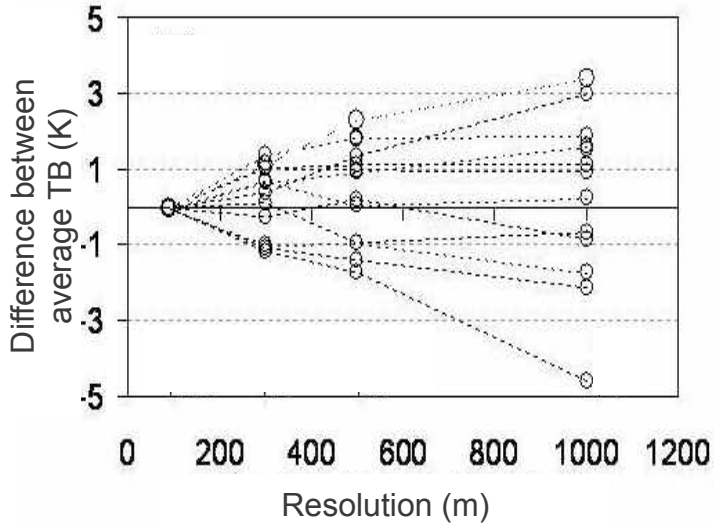


	50m	150m
RMSE (dB) of upscaling	4.0	2.1

	10m	100m	500m
RMSE (dB) of normalisation	3.7	2.0	1.8

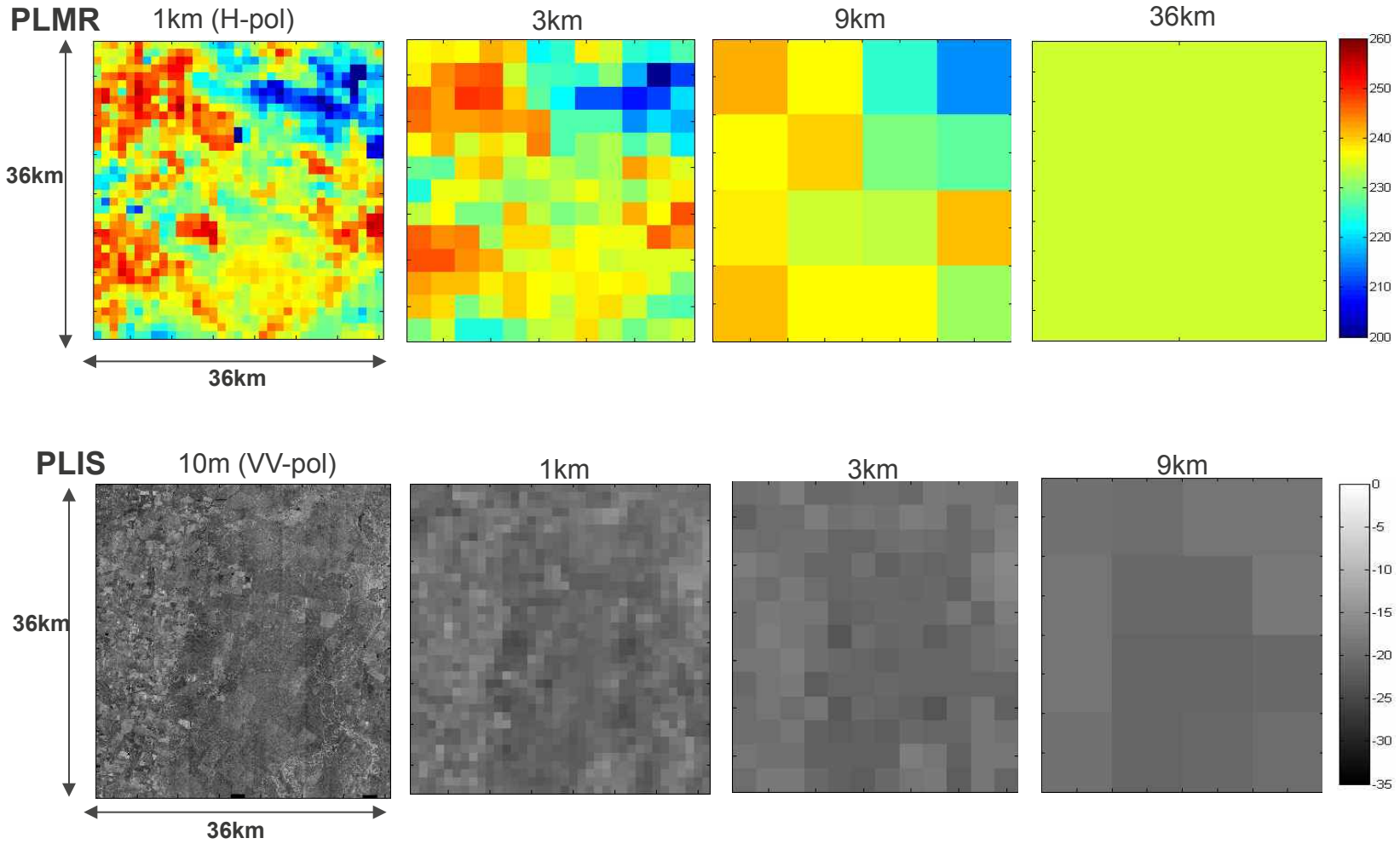
Upscaling for PLMR





Panciera, Walker et al. (2009), RSE

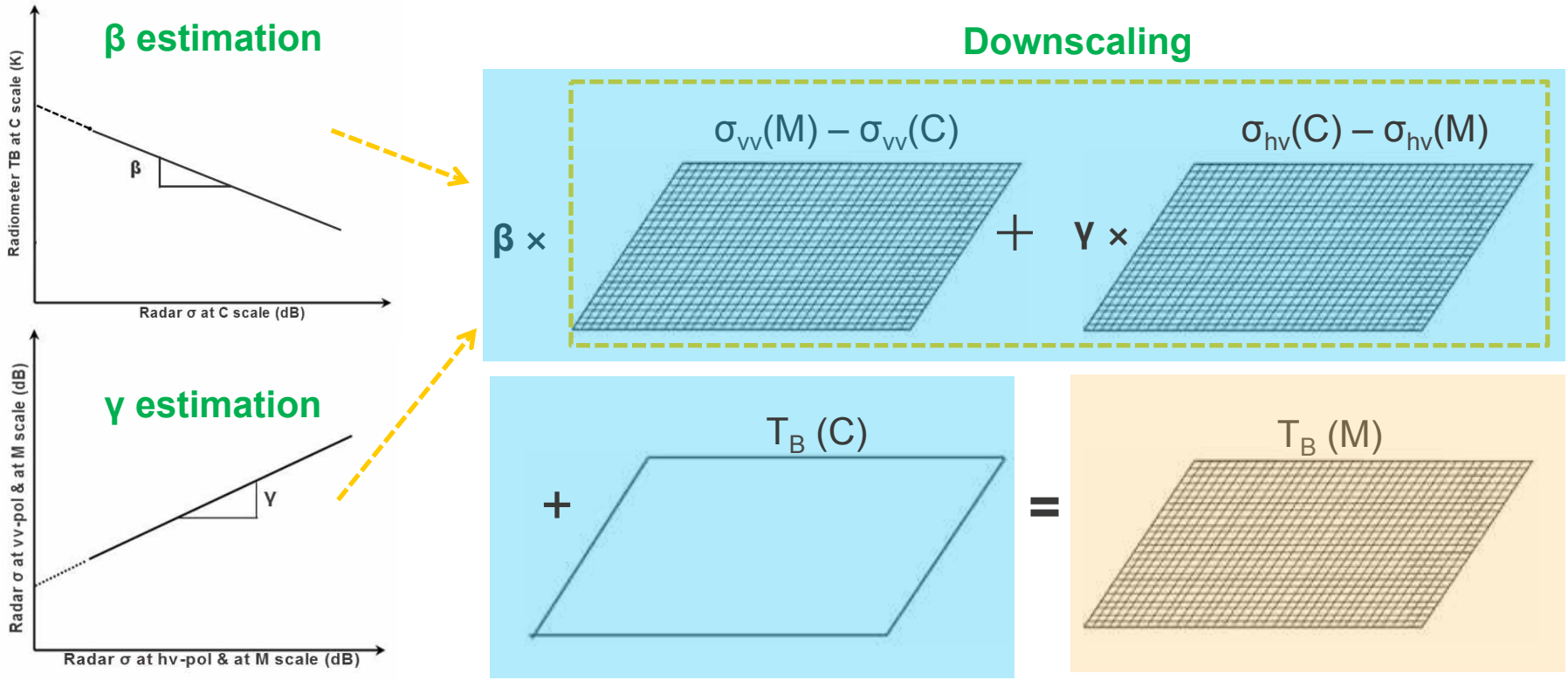
Example of simulated data



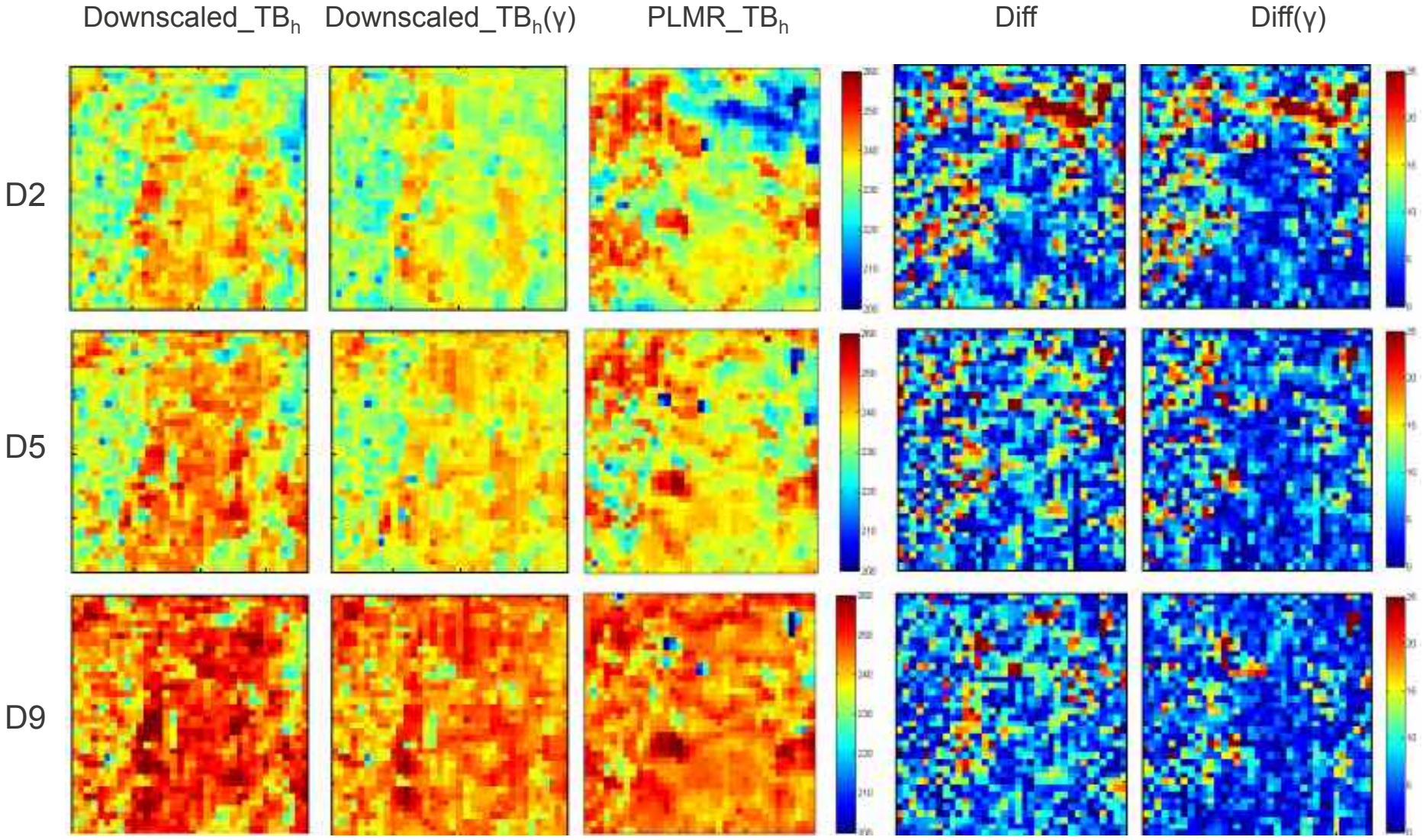
(Data collected on 7th Sept. 2011)

Baseline downscaling algorithm for SMAP

- Near-linear relationship between Radar backscatter and Brightness Temperature (ATBD, algorithm for SMAP mission)



See Poster by Wu et al. tomorrow

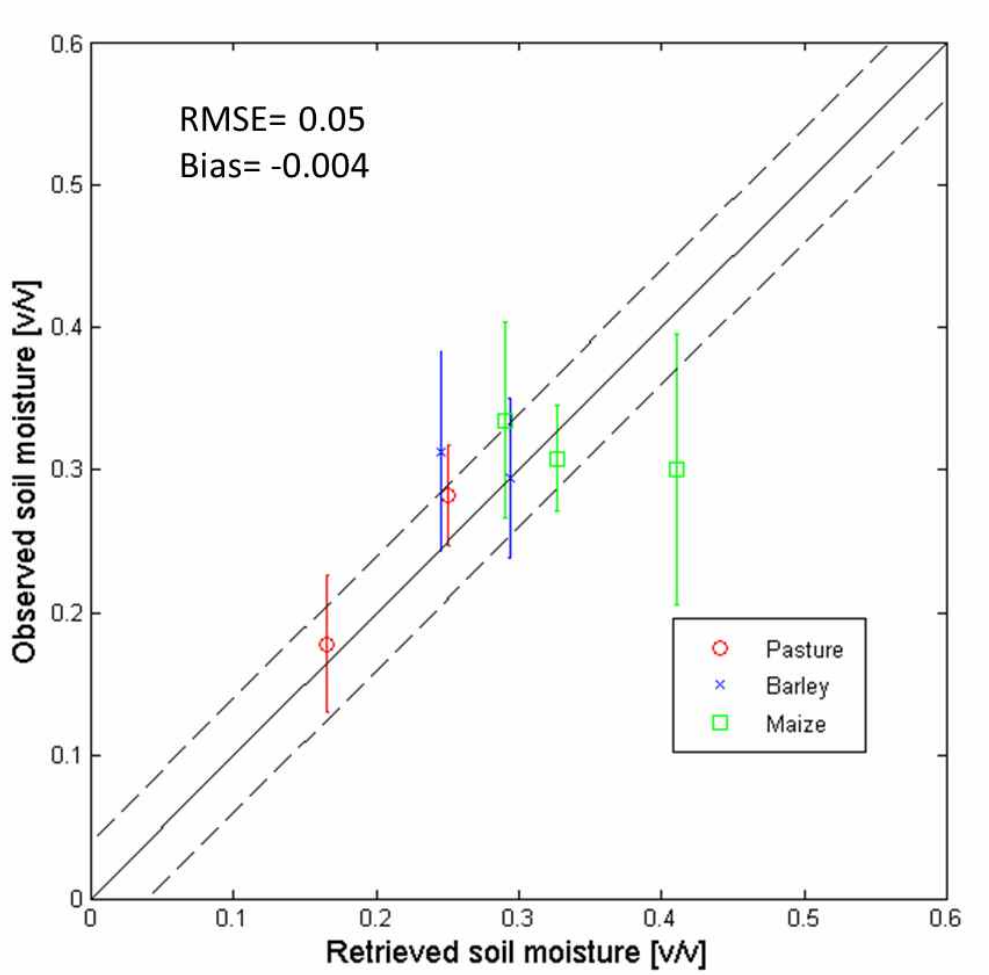

Downscaled_TB$_h$
Downscaled_TB$_h$(γ)
PLMR_TB$_h$
Diff
Diff(γ)
D2
D5
D9

Active-passive downscaling results

	D2		D5		D9		Average	
Pol.	H	V	H	V	H	V	H	V
1km	12.2	9.6	10.8	8.3	10.3	7.8	11.1	8.5
	11.4	9.4	9.6	8.0	8.6	7.2	9.8	8.2
3km	9.4	7.4	7.1	5.3	6.4	4.5	7.6	5.7
	9.0	7.3	6.5	5.2	5.2	4.3	6.9	5.6
9km	6.7	5.8	4.3	3.3	3.5	2.3	4.8	3.8
	7.1	6.3	4.0	3.3	2.5	1.9	4.5	3.8

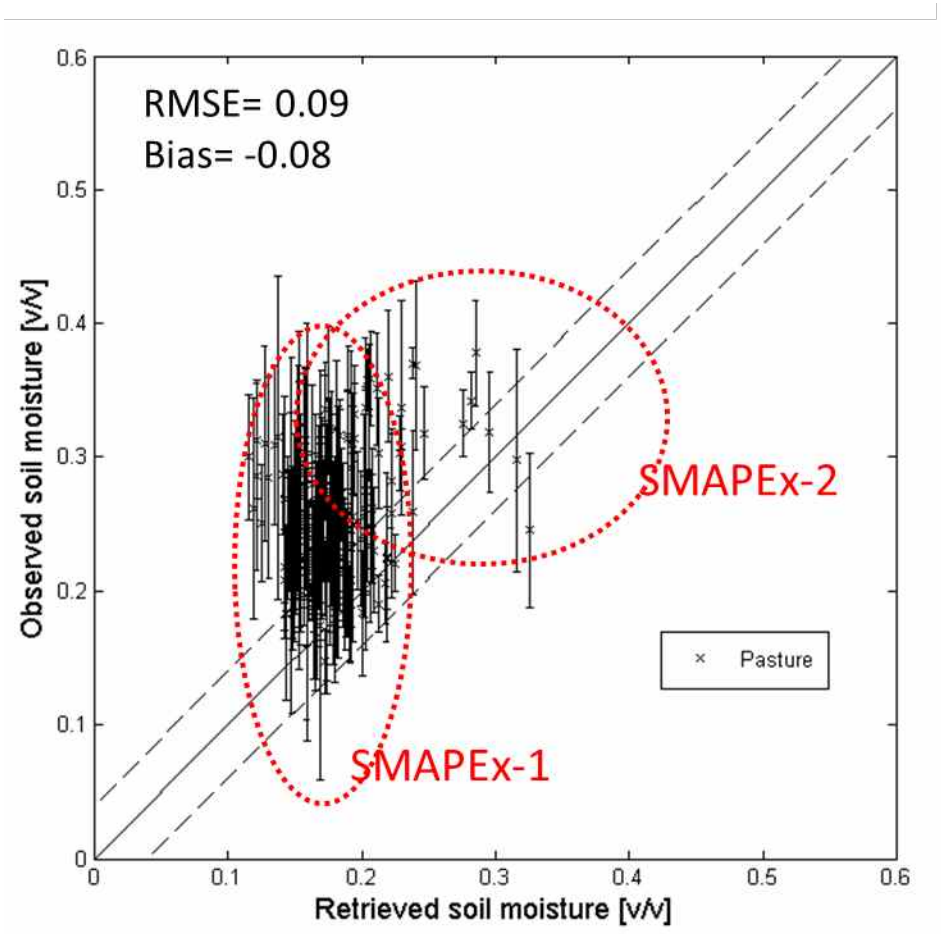
- Results on V-pol are better than H-pol
- Improvement by including vegetation conditions

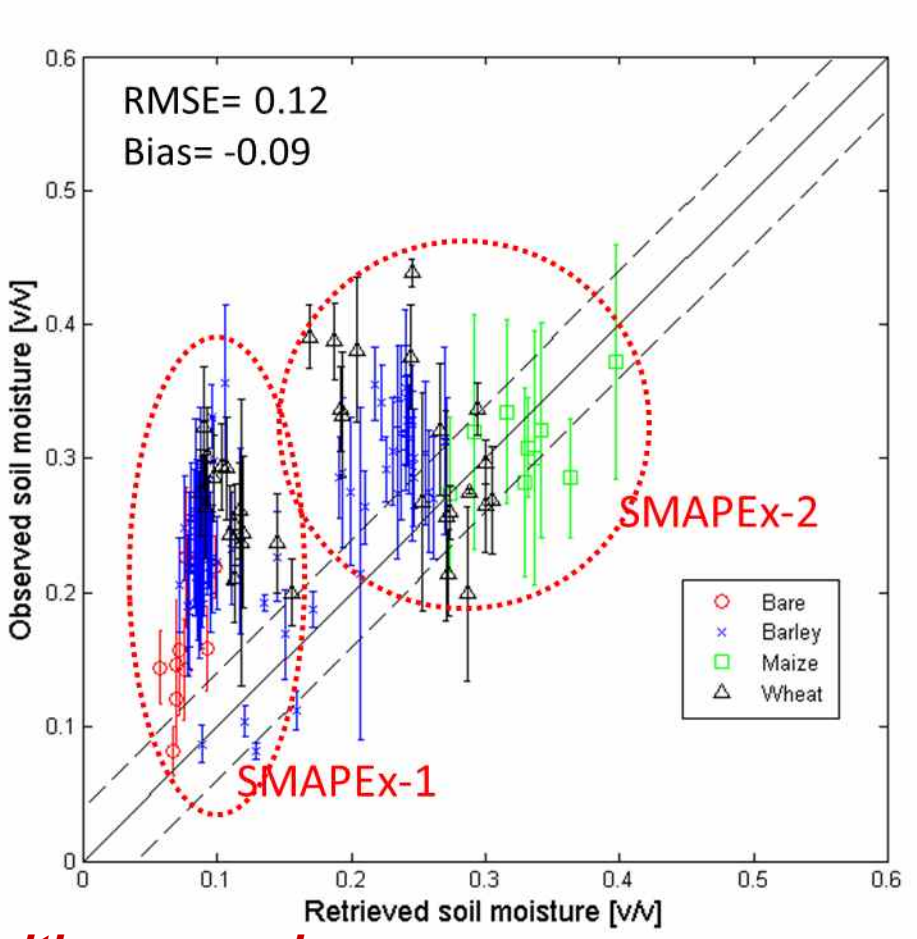
Passive microwave soil moisture retrieval



- SMAPEx-1 and SMAPEx-2 target pixels (100m)
- Retrieval using default model parameters
- Pixels with VWC sampled at exactly the same location

Passive microwave soil moisture retrieval



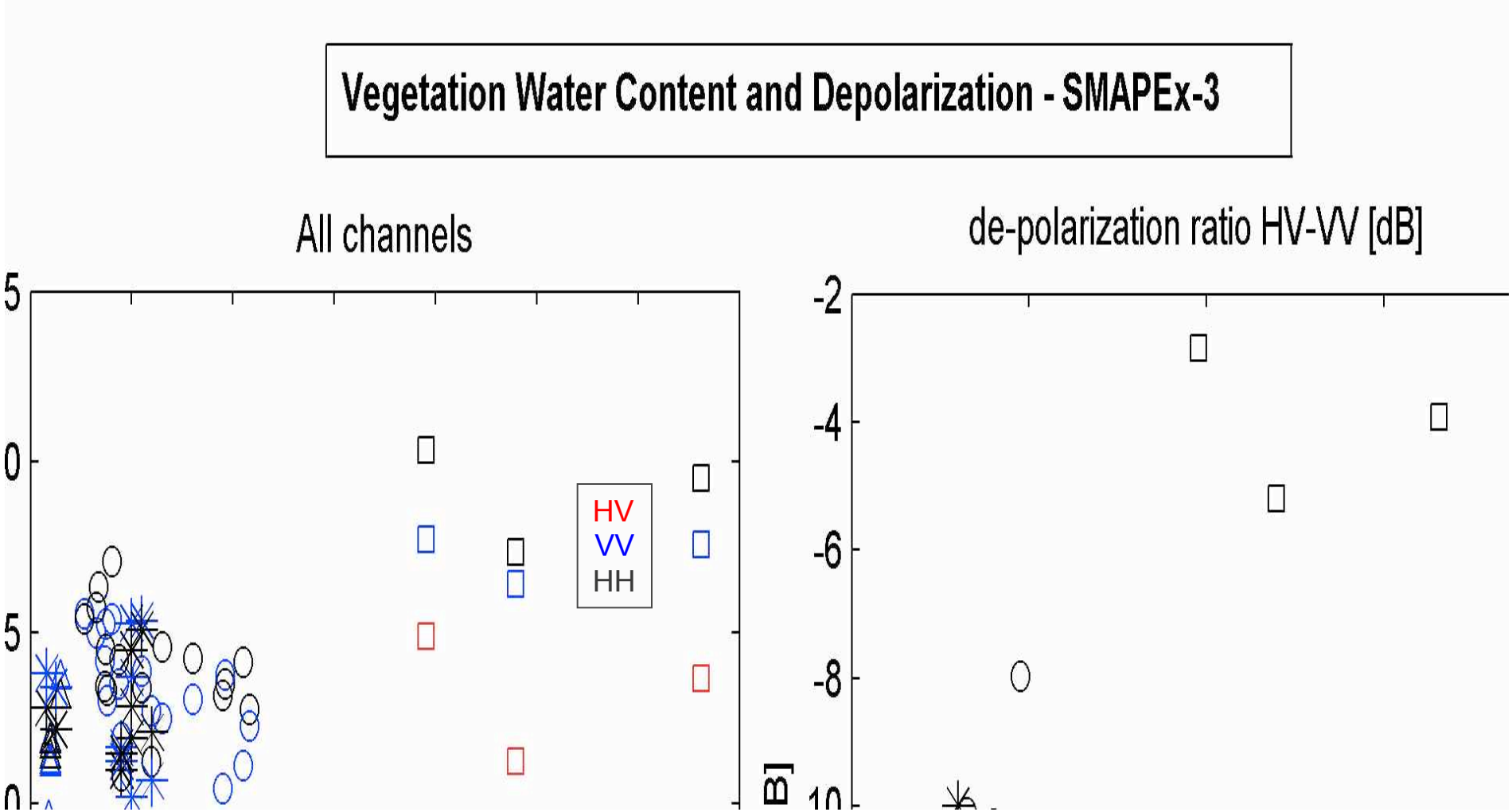


Pasture

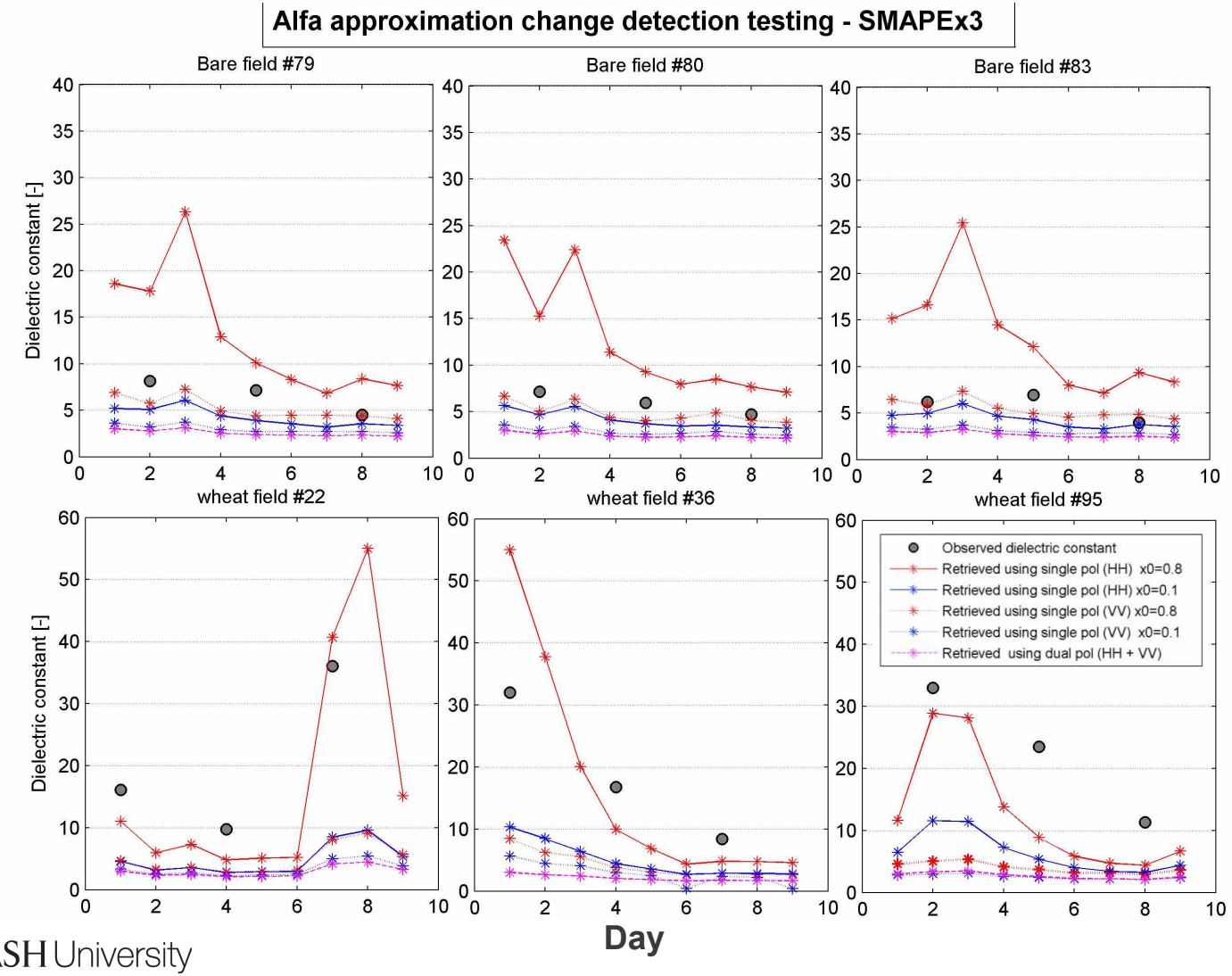
All pixels, with averaged VWC for each type of land cover

Croplands

Active microwave VWC retrieval



Active microwave soil moisture retrieval



Future work

- Try and eliminate any angle normalisation contributions to the azimuth and scaling results and assess georegistration contributions
- Undertake soil moisture retrievals from 1km PLMR (passive only), validated with higher resolution PLMR data and ground observations, for evaluation of SMAP soil moisture retrieval algorithms based on simulated SMAP data
- Testing of SMAP default radiometer parameters
- Testing of SMAP radar baseline algorithms
- Testing of alternate active-passive downscaling algorithms; there is about 4K downscaling error in the current baseline algorithm

IGARSS 2013
21-26 July 2013
MELBOURNE
INTERNATIONAL GEOSCIENCE AND REMOTE SENSING SYMPOSIUM

IEEE

GRSS

WELCOME TO MELBOURNE, AUSTRALIA

for

IEEE IGARSS 2013

21 – 26 July 2013

www.igarss2013.org