Main outcomes of the CoSMOS/NAFE campaign for the validation of the SMOS soil moisture retrieval algorithm

Kauzar Saleh Contell, Yann H. Kerr, Gilles Boulet, Maria-José Escorihuela, Philippe Maisongrande, Philippe Richaume, Patricia de Rosnay, Jean-Pierre Wigneron, Ernesto Lopez-Baeza, Jennifer Grant, et al.

The CoSMOS/NAFE campaign for the validation of the SMOS retrieval algorithm over land

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S. Delwart, M.J. Escorihuela, P. Maisongrande, G. Boulet
and the CoSMOS/NAFE team**

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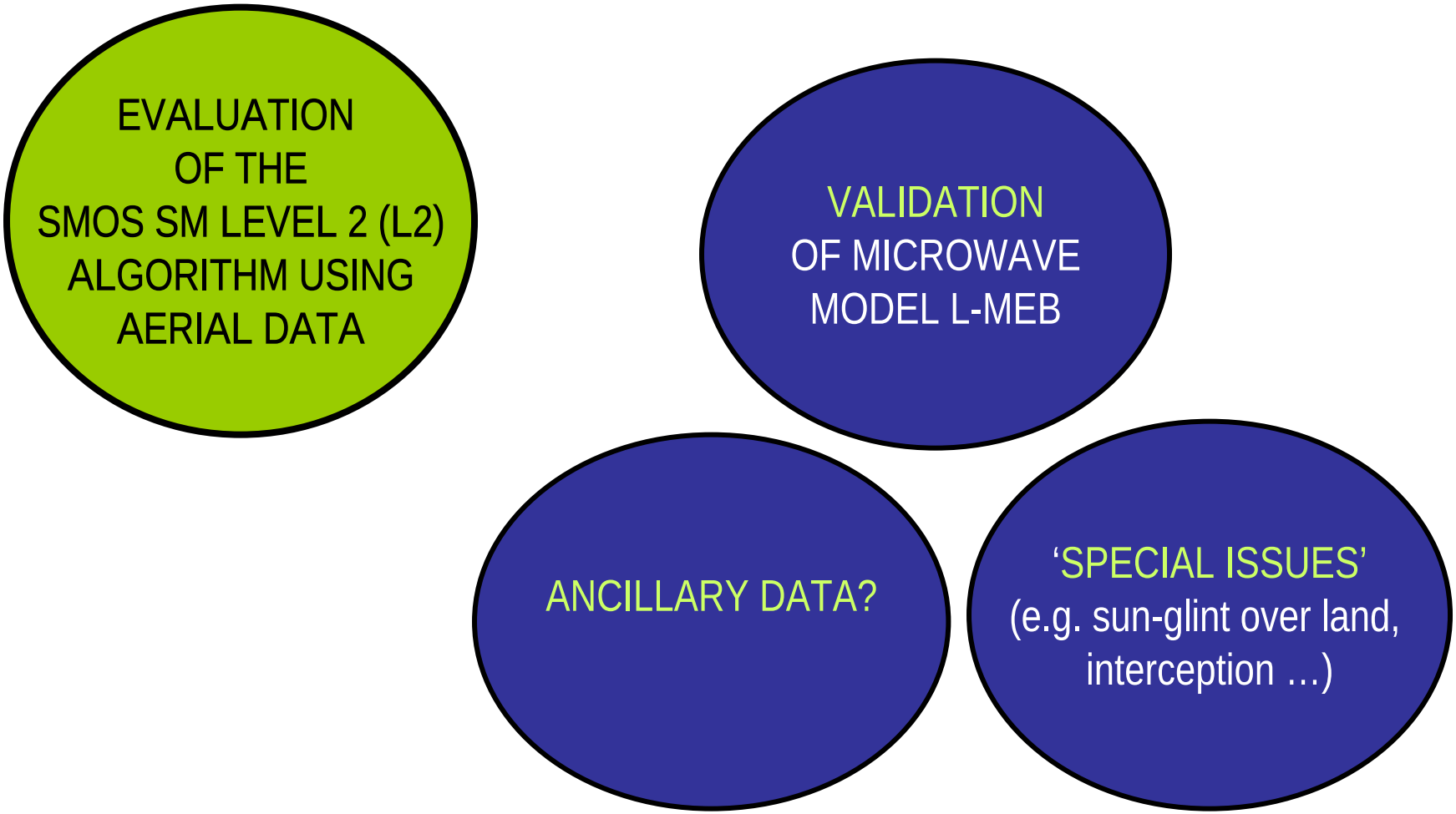
1/ ESA CoSMOS study (2007-2008): Overview



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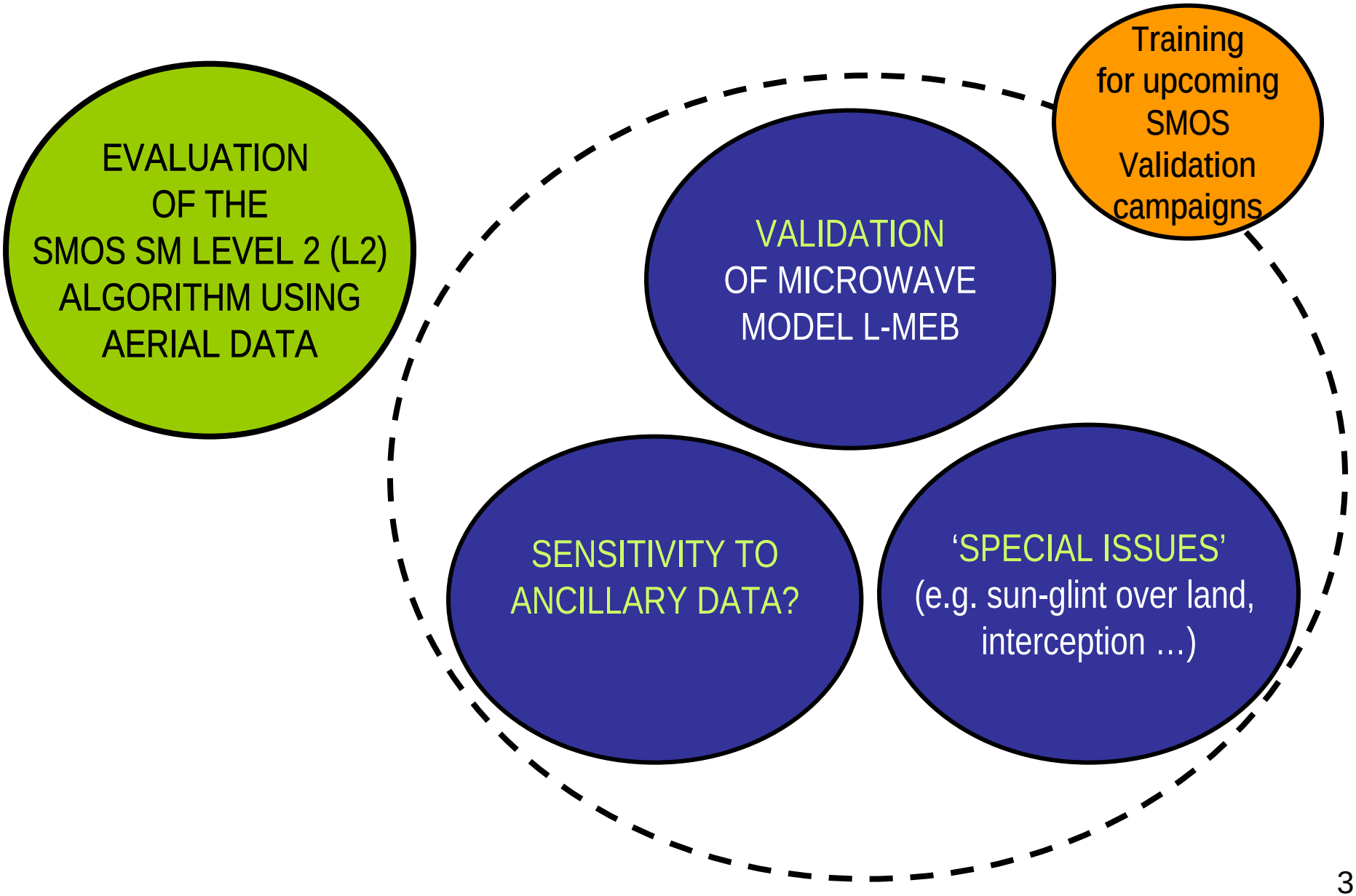
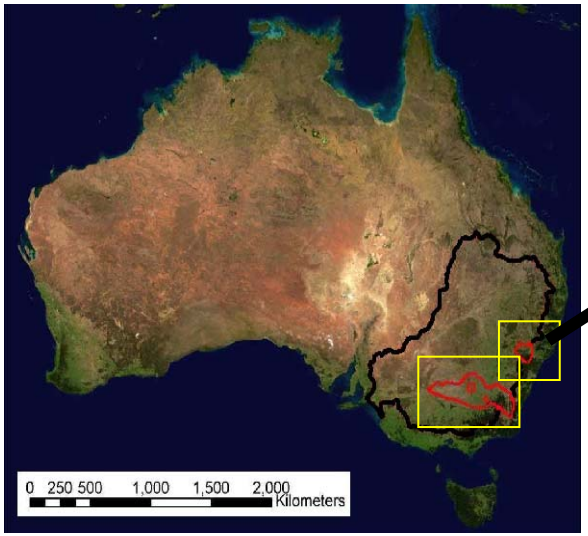


1/ CoSMOS-NAFE Experiment: Overview & objectives

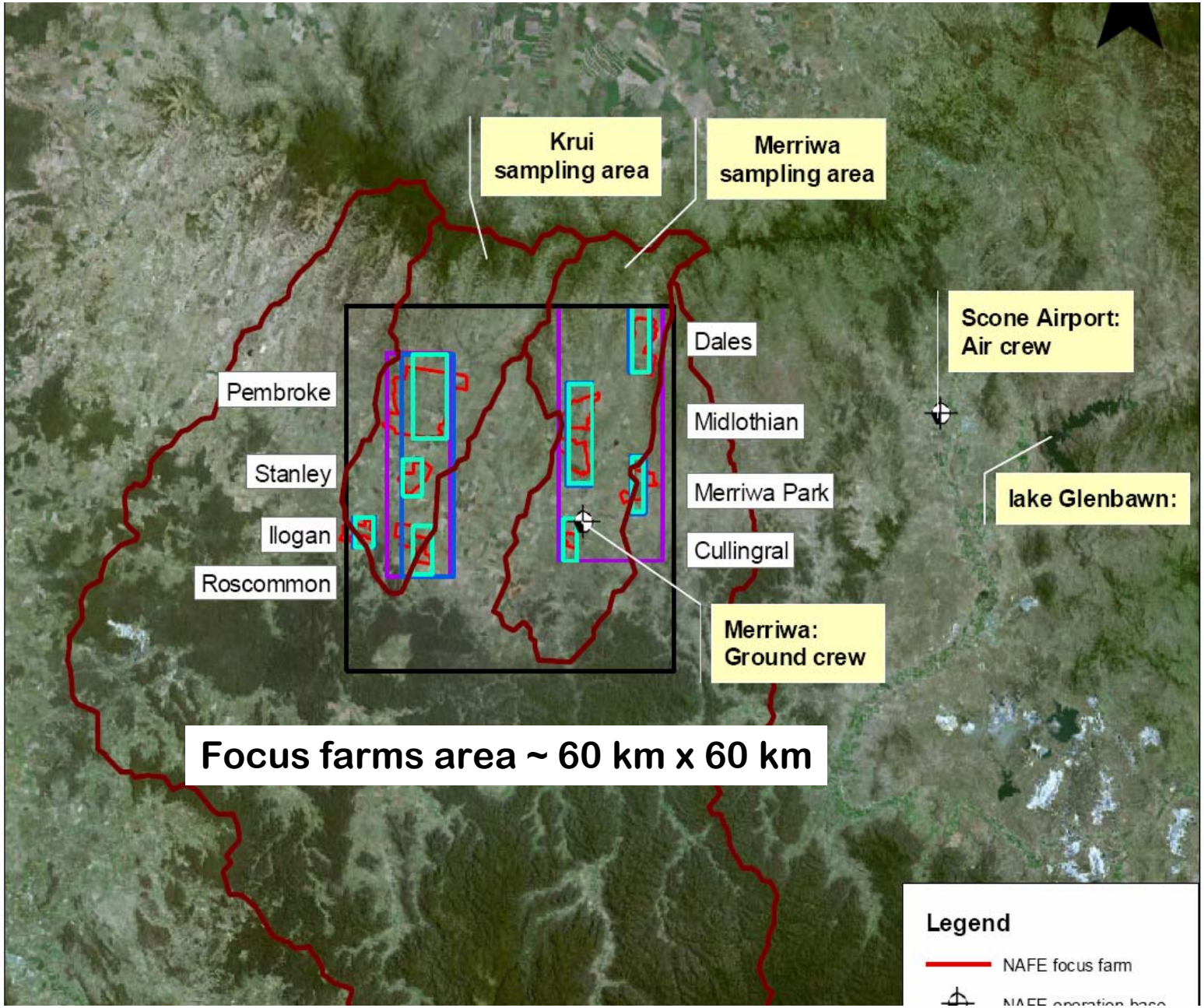


Goulburn River catchment

6-week campaign

2 L-band sensors onboard two aircrafts (2 week overlap)
Focus area: ~60 km x 60 km farming area

Collaboration between NAFE experiment (University of Melbourne), researchers from Europe, US and Australia, ESA


Krui sampling area
Merriwa sampling area
Scone Airport: Air crew
Dales
Pembroke
Midlothian
Stanley
Merriwa Park
lake Glenbawn:
Ilogan
Cullingral
Roscommon
Merriwa: Ground crew
Focus farms area ~ 60 km x 60 km
Legend
NAFE focus farm

CROP AREAS

VWC: 0.3-2.7 kgm-2

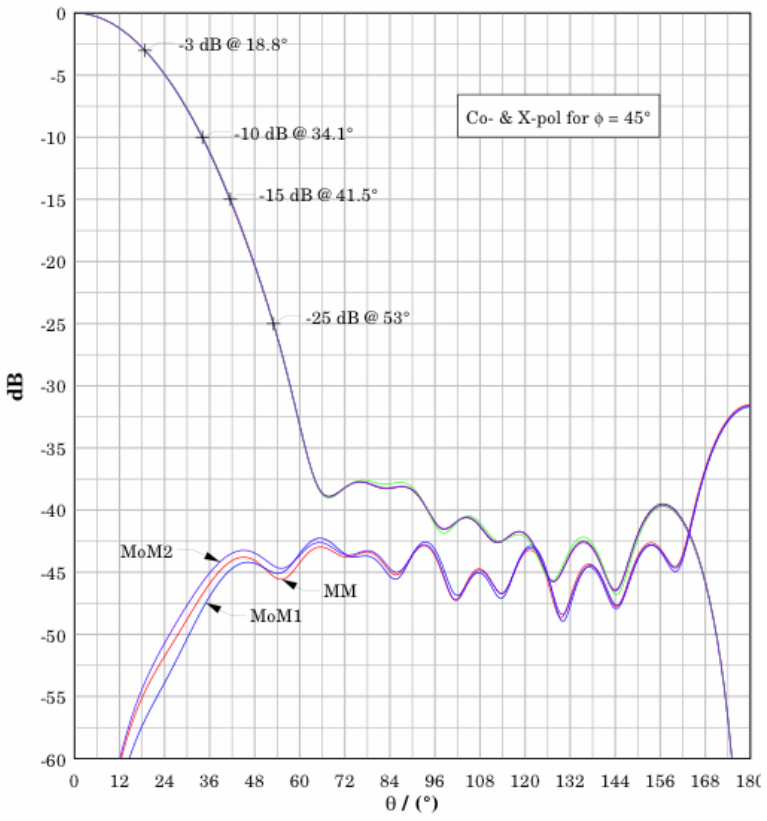
GRAZING AREAS

VWC: 0.1-1 kgm-2

2/ Instruments

a) ESA flights- EMIRAD

EMIRAD POLARIMETRIC RADIOMETER (TUD) onboard Aero Commander 500S

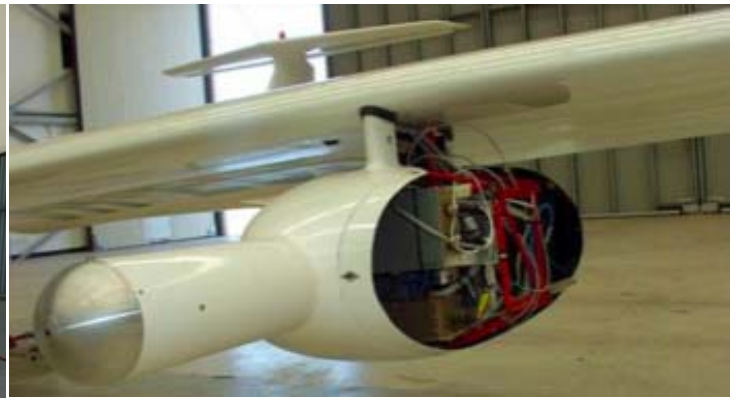


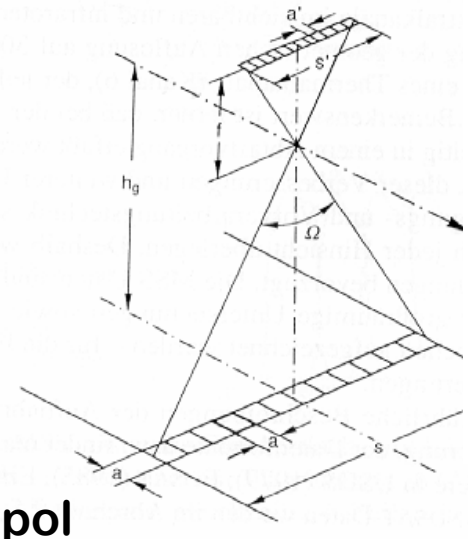
Full-Stokes
IR Radiometer onboard

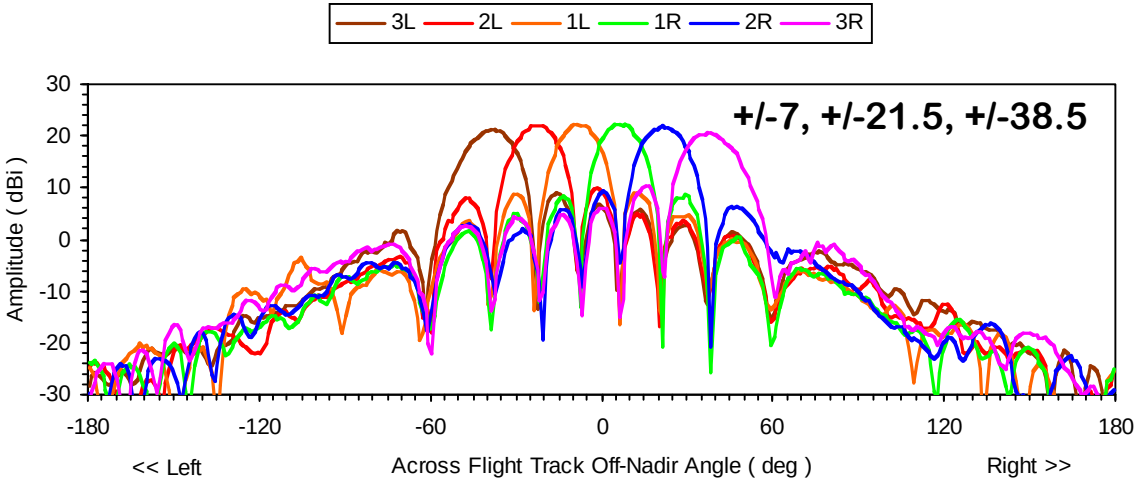
2/ Instruments

b) NAFE flights- PLMR

PLMR RADIOMETER (UM) onboard Diamond Eco-Dimona motor glider

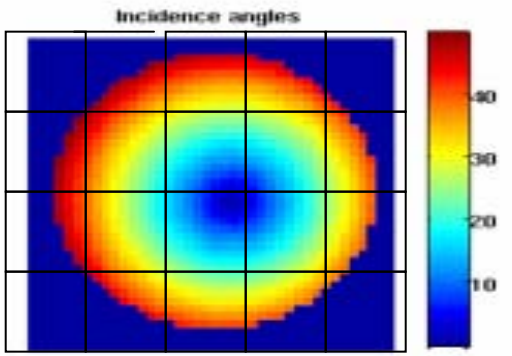


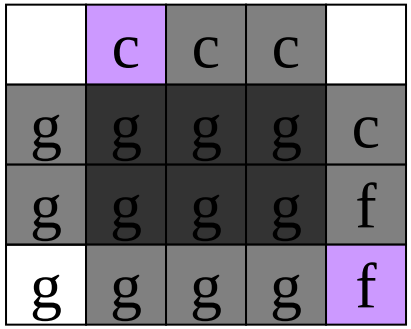


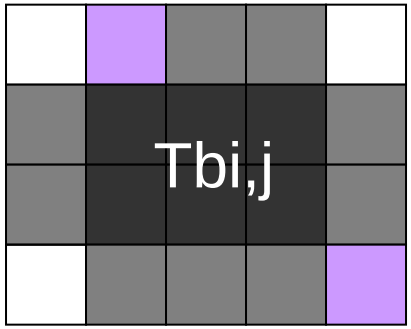


H & V pol

3/ L-band data processing







1

Antenna projected onto the surface

f(aircraft attitude, antenna orientation, no slopes)

2

Land-use from Landsat classif.

(e.g. crop,grass,forest)

+

Ancillary surface data

3

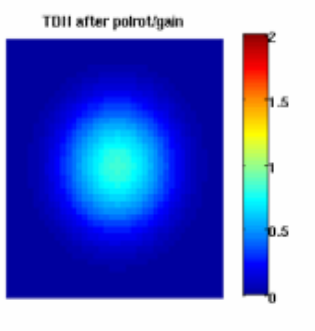
Simulated Tbi,j using SMOS BBs

4

Transportation of simulated Stokes vector to antenna level

5

Weighting by antenna gain & integration

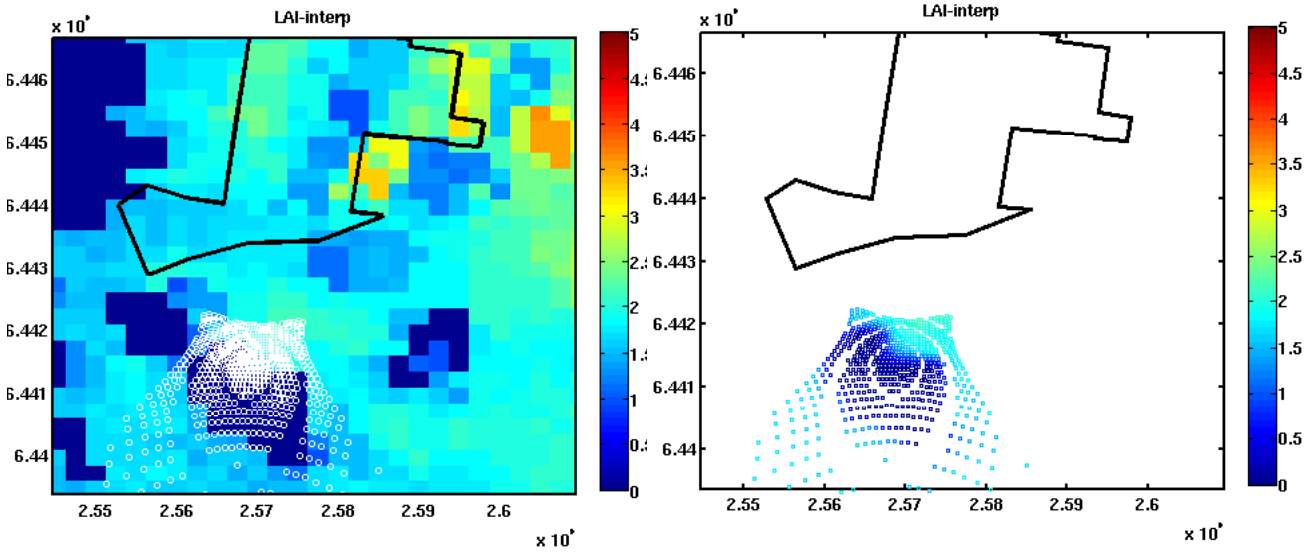


6

Comparison to measured Stokes and retrievals

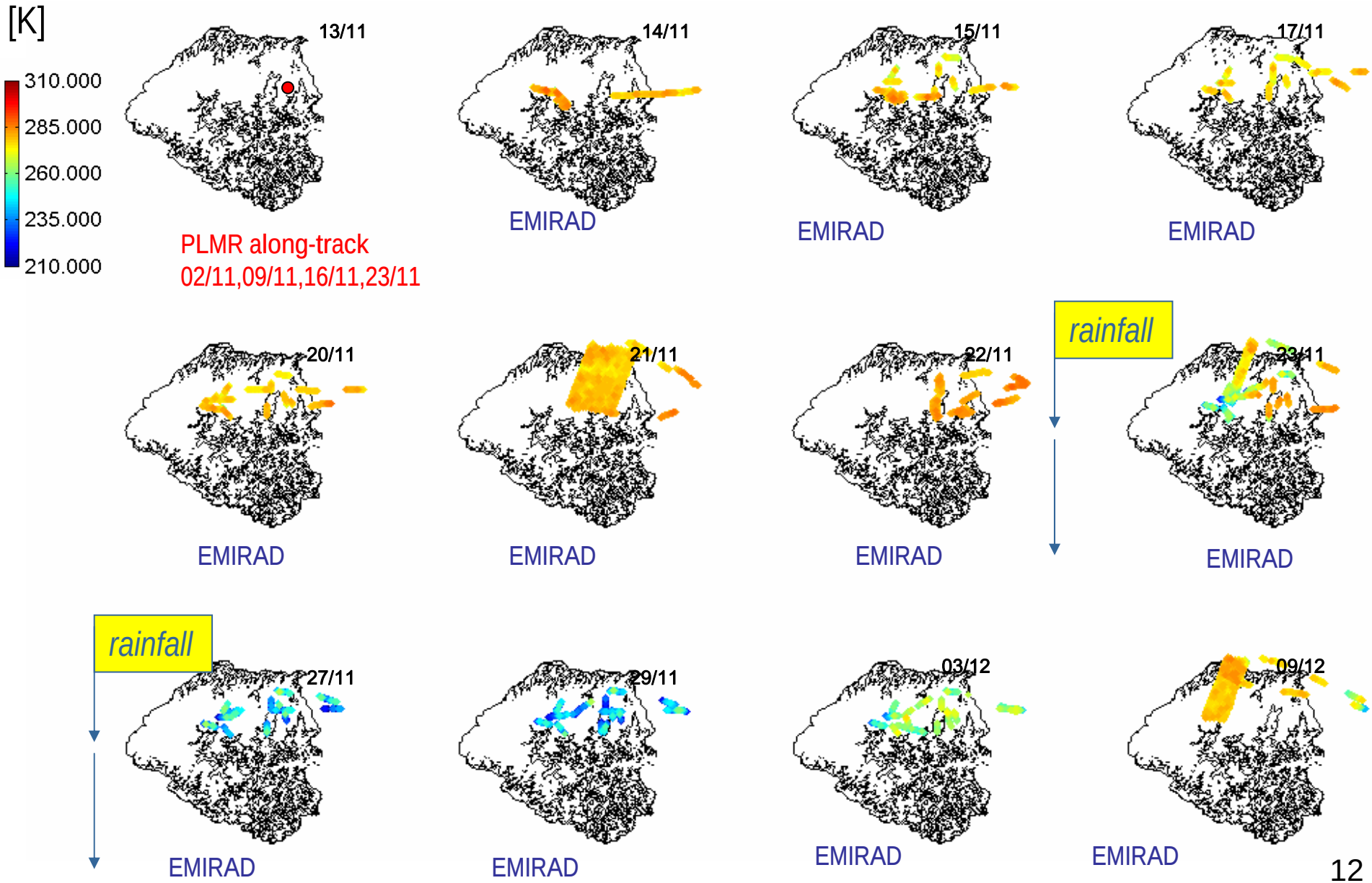
3/ L-band data processing

Large aperture : 3dB area up to ~1 km (off-nadir)



Simulations of TB and retrievals take into account antenna pattern and observed surface

4/ L-BAND measurements



4/ L-BAND measurements

nadir

Surface conditions	TBnadir [K]	IRT [K]	Emissivity	ΔSM (station)
Grass & dry soil- STAN	265 (3)	289 (1.0)	0.92 (0.01)	0.30 m3m-3
Grass & wet soil- STAN	221 (11)	284 (0.5)	0.78 (0.04)	
Crop & dry soil- MP	265(3)	288 (0.3)	0.92 (0.01)	0.25 m3m-3
Crop & wet soil -MP	219 (8)	286 (0.3)	0.76 (0.03)	

40 deg

Surface conditions	TV-40 [K]	IRT [K]	Emissivity	ΔSM (station)
Grass & dry soil- STAN	273 (2)	289 (1.0)	0.94 (0.01)	0.30 m3m-3
Grass & wet soil- STAN	237(11)	284 (0.5)	0.83 (0.04)	
Crop & dry soil- MP	273(2)	288 (0.3)	0.95 (0.01)	0.25 m3m-3
Crop & wet soil -MP	235 (6)	286 (0.3)	0.82 (0.02)	

EMIRAD

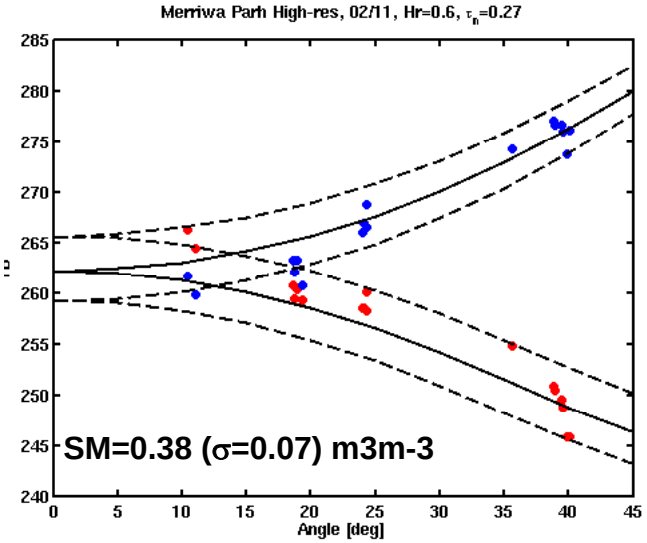
-Dry to wet soil ΔTB~40 K at nadir (for ΔSM~ 0.3 m3m-3)
-Low angular variation in TB between Nadir and 40 deg
ΔTBv < 5-10 K for dry soil, ΔTBv < 15-20 K for wet soil
-Rather stable TB measurements across the farm for dry soil

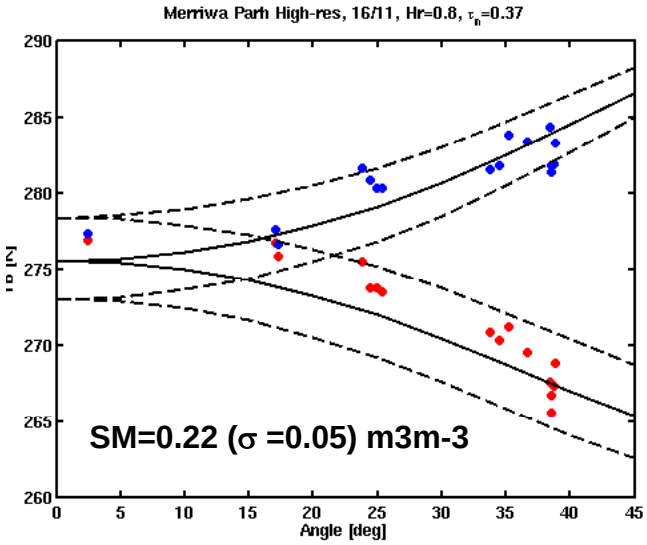
PLMR Along track

5/ Modelling

What do L-MEB simulations indicate?

High-res area





Wheat, Clay-loam

Day/Farm	SM [m3m-3]	T_sfce	τ_nadir	Hr	RMSE [K]	R2
02/11-MP	0.38	302	0.27	0.56	2.1	0.96
09/11-MP	0.41	303	0.25	0.64	2.6	0.96
16/11-MP	0.22	296	0.37	0.76	1.2	0.98
23/11-MP	0.14	304	0.29	0.51	2.9	0.94
18/11-CU	0.07	304	0.22	0.63	0.9	0.99

PLMR Along track

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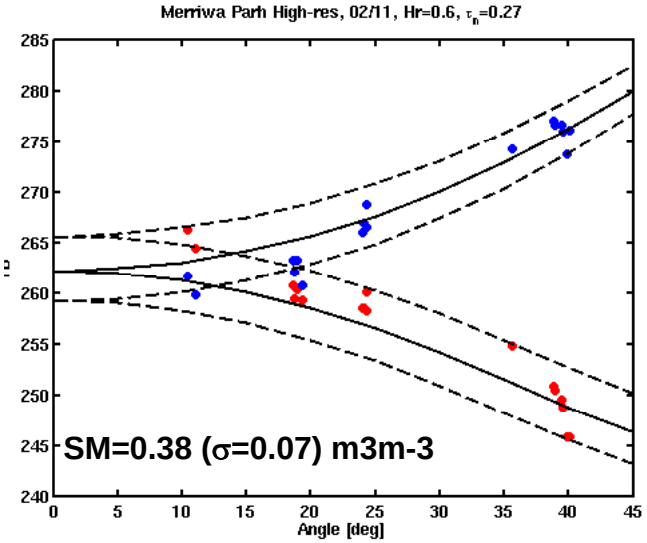

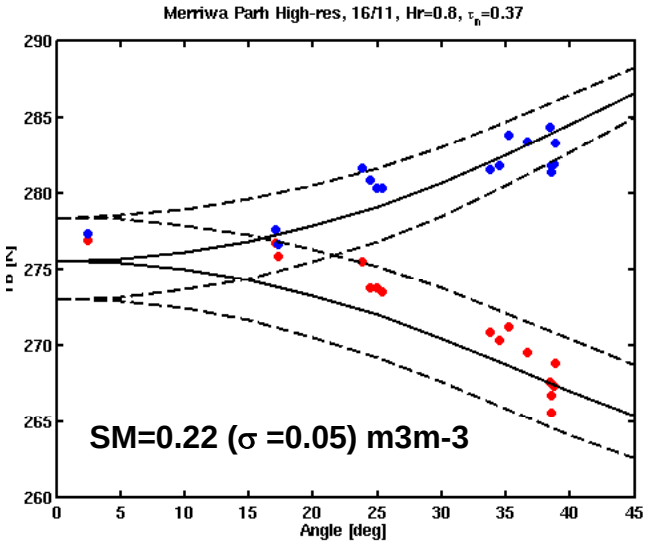

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5/ Modelling

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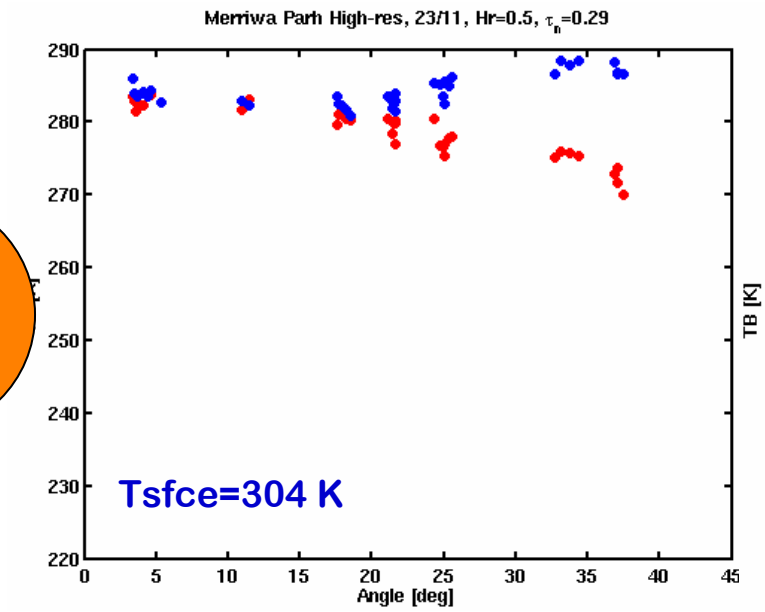
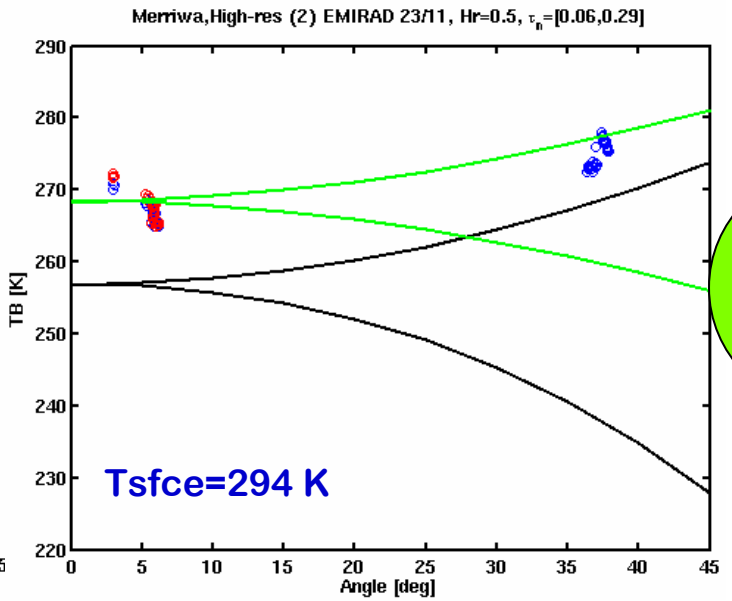
PLMR Along track





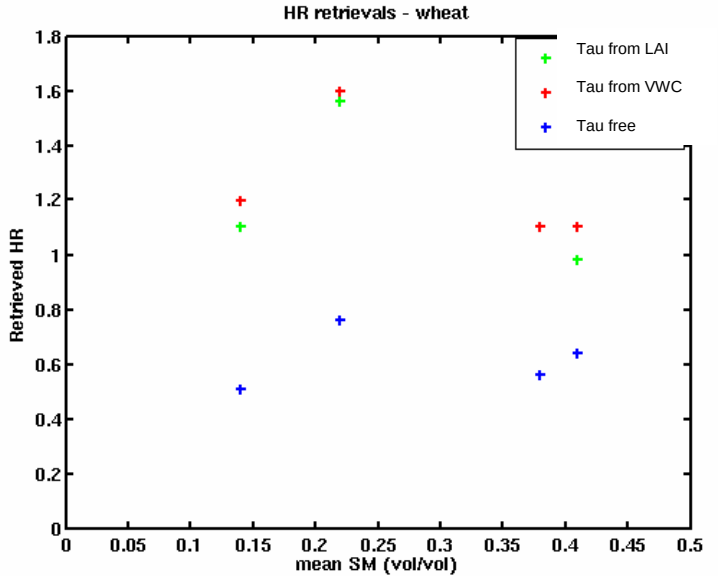
EMIRAD Along track

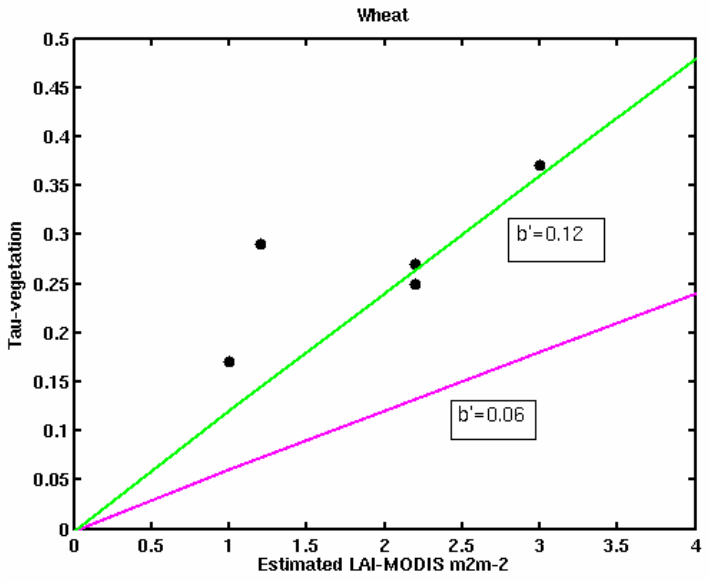
EMIRAD and PLMR over the same wheat area on the same day
- Dry soil
(green, TB from Hr and τ_n from PLMR)
(black, same but for τ_n = 0.06*LAI)

PLMR Along track

5/ Modelling

What do L-MEB simulations indicate?





$\Gamma = \Gamma^{*} \exp(-Hr/\cos^{Np}(\theta))$

HR~0.6, ploughed soil, Clay-loam, black basalts

- Literature: crops Hr=[0.1-0.7]
- Sensitivity of HR to dielectric model
- No clear sensitivity of HR to SM

Explore next if default b'(LAI) too low for wheat?

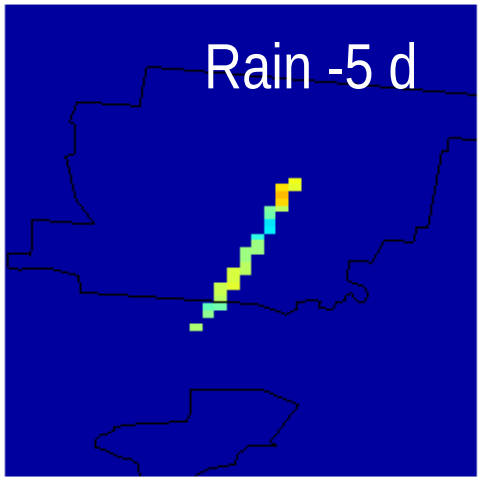
$b' = \tau_n / LAI$

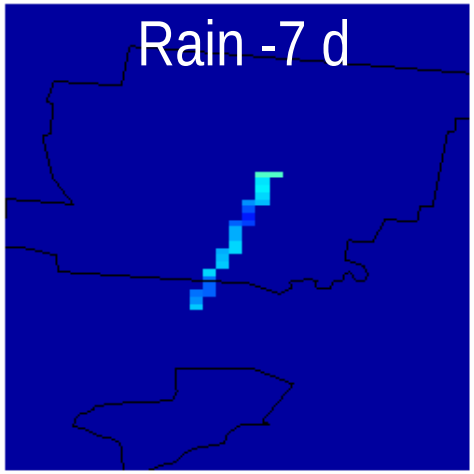
- Field VWC & b=0.08 --> τ_n wheat [0.05-0.1]

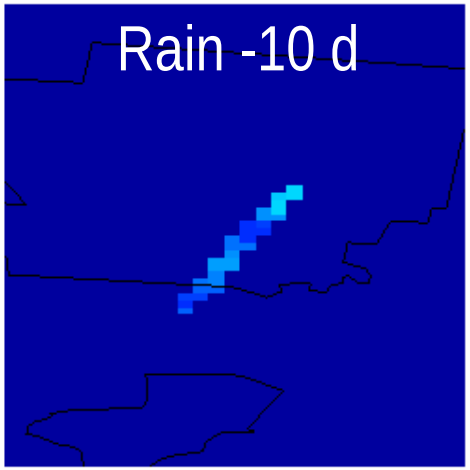
6/SM Retrievals

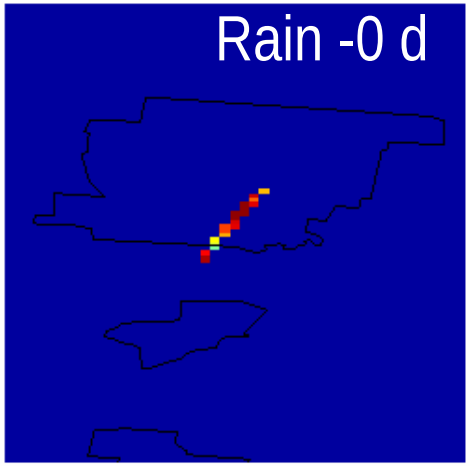
EMIRAD Along track

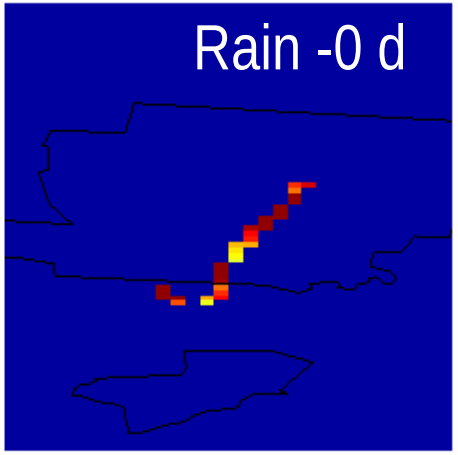
Retrieved SM 250-m (all points)- PEMBROKE 15/11, 17/11, 20/11, 27/11, 29/11, 0312

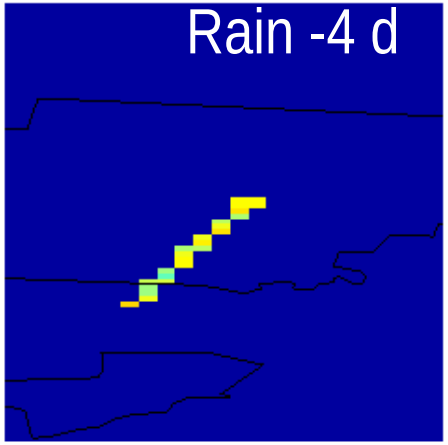


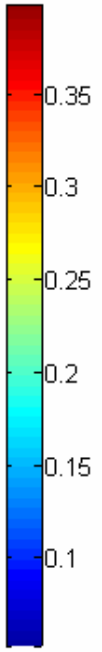












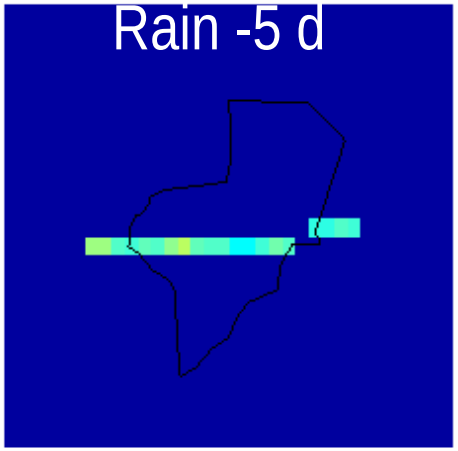
CROPS Clay, HR=1

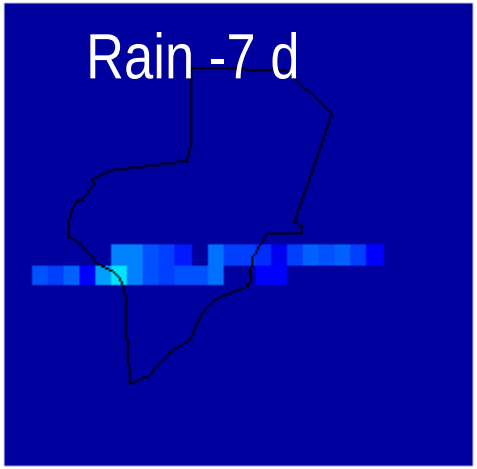
ΔSM_station ~ 0.3 m3m-3

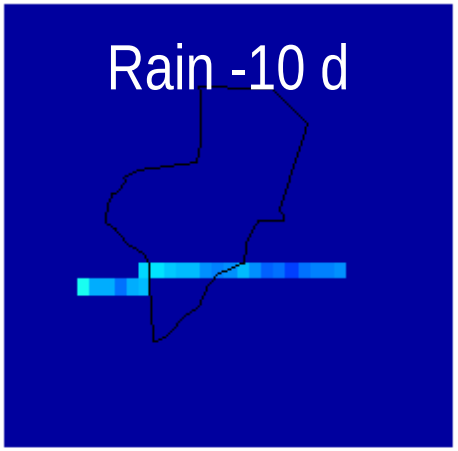
6/ SM Retrievals

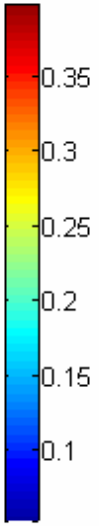
EMIRAD Along track

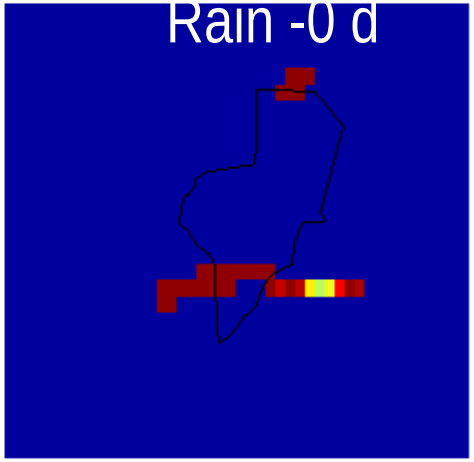
RETRIEVED SM-250M (all points)- ILLOGAN 15/11,17/11,20/11,27/11,29/11,03/12

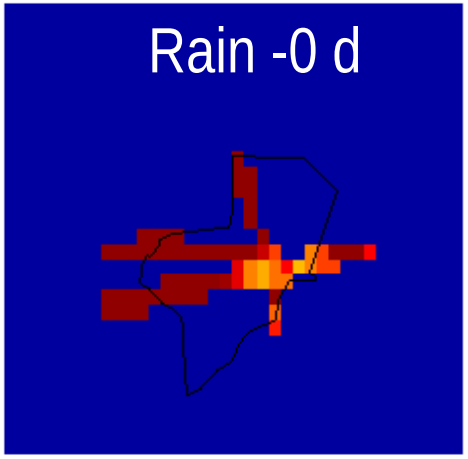


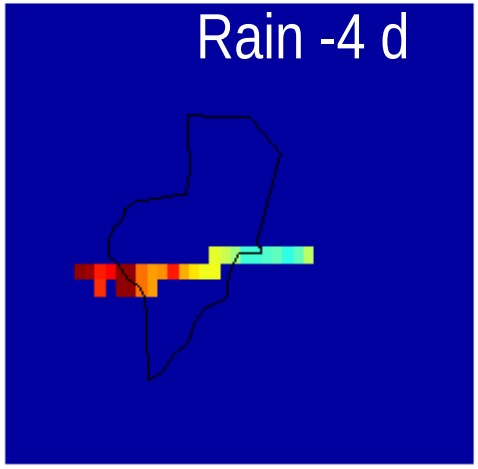












Silt-loam,crops , HR=1

ΔSM_station ~ 0.3 m3m-3

7/ Conclusions

i) L-band processing 'close' to the SMOS L2 approach (aggregated TBs within the antenna pattern, SMOS BBs)

- Basis for upcoming airborne campaigns over land

ii) The CoSMOS study is now in the algorithm validation phase

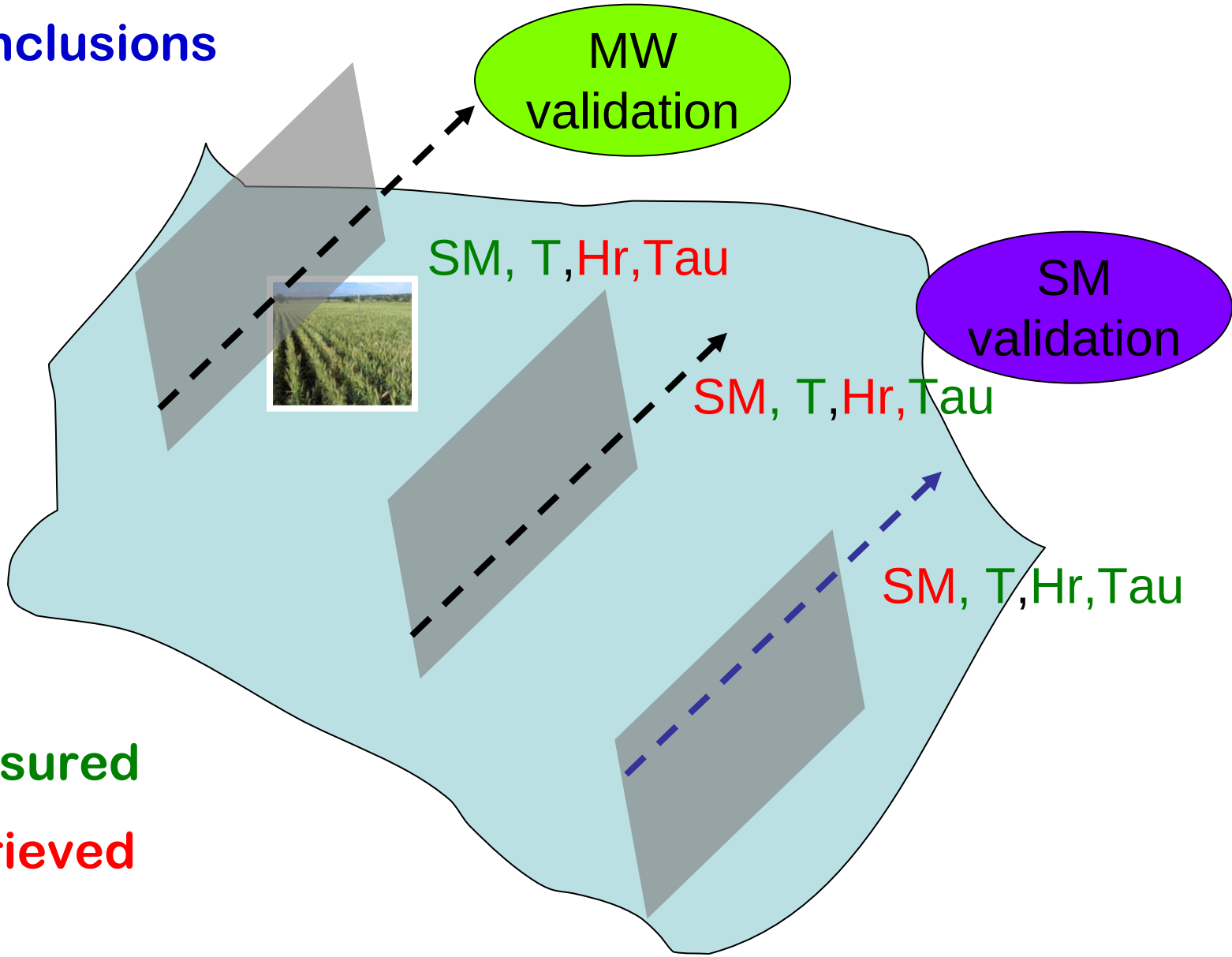
- Focus on small areas with dense sampling to characterise vegetation and soil emission, next step is moving to the farm scale

iii) Both PLMR and EMIRAD data produce a TB signature that requires large Hr

- Hr is usually fitted in experiments, how do we fit it globally?
- Hr = f(land use, soil type, std)

iii) Once roughness is fitted, changes in the retrieved and measured SM are comparable

7/ Conclusions



Measured

Retrieved

4/ Modelling

What do L-MEB simulations indicate?

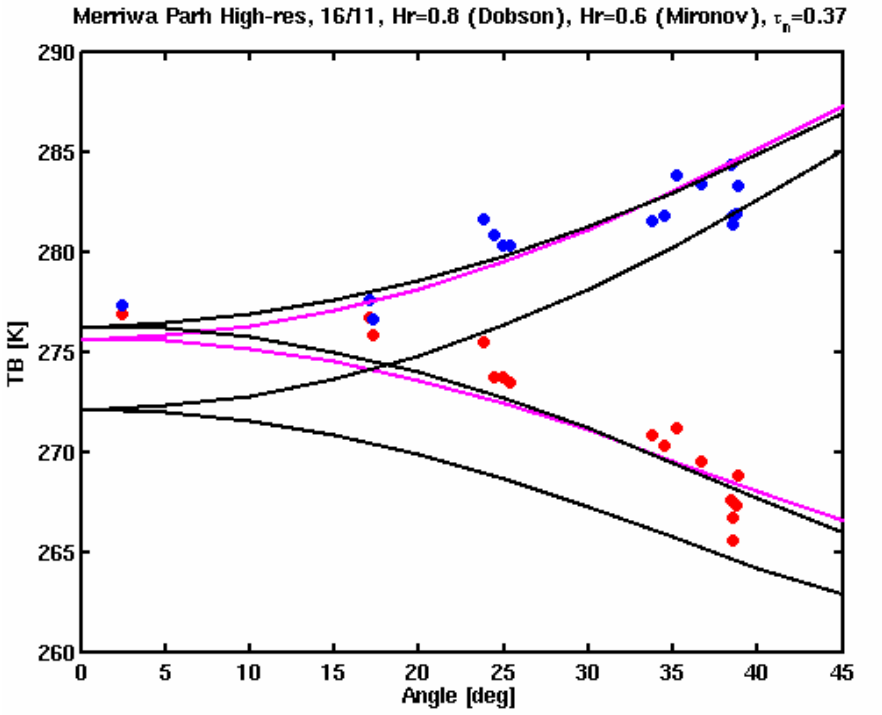


Table 5.8 Dielectric properties of some rock families reported in the literature

Solid rocks	Freq. (GHz)	ε'	ε''	References
Granites	0.45	5.47	0.08	Campbell and Ulrichs (1969)
(average values)	35	5.31	0.1	Campbell and Ulrichs (1969)
	170	5.31	0.197	Thomas (2004)
Basalts	0.45	7.79	0.2	Campbell and Ulrichs (1969)
(average values)	35	7.36	0.41	Campbell and Ulrichs (1969)
	170	7.67	0.45	Thomas (2004)
Carbonates	0.2	8.9	0.2	Thomas (2004)
(average values)	35	7.76	0.24	Thomas (2004)
	110	8.12	0.1	Thomas (2004)
	170	7.68	0.11	Thomas (2004)
Andesite	0.45	5.1	0.02	Campbell and Ulrichs (1969)
	35	5.0	0.07	Campbell and Ulrichs (1969)

Mean HR=0.6, ploughed soil, 70% clay, black basalts

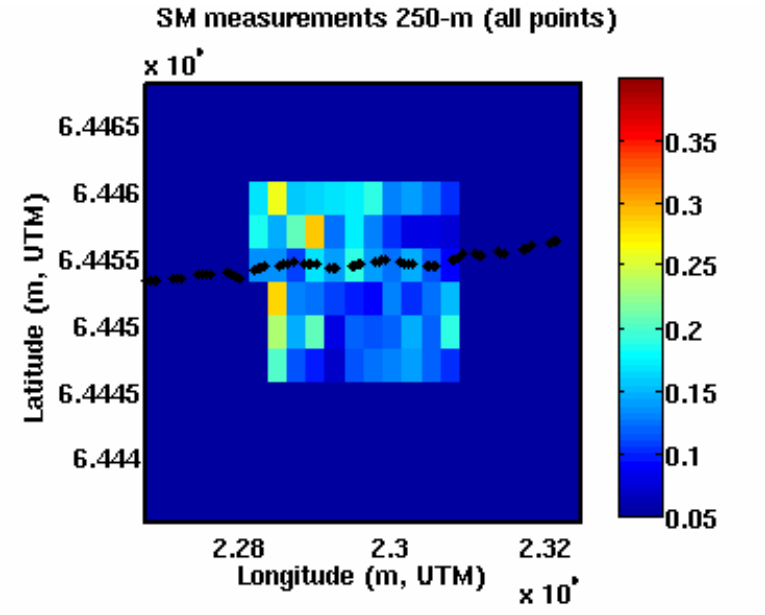
Literature: crops Hr=[0.1-0.7]

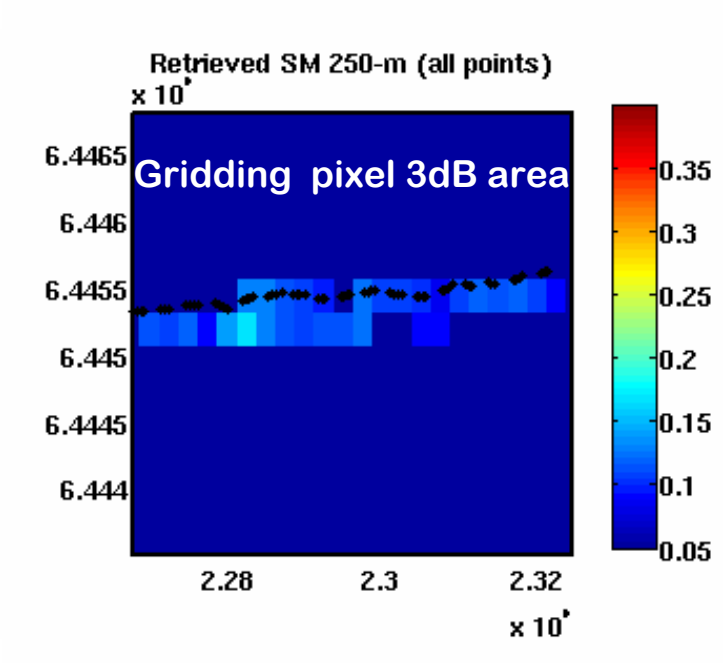
Field WC & b=0.08 --> Hr~1, higher TB error

3/ L-band data processing

Zone 2. Farm scale

Scattered SM data





Cell-to-cell comparisons between surface data and L-band retrievals
e.g. comparisons to SM when available
e.g. LAI and retrieved optical depth

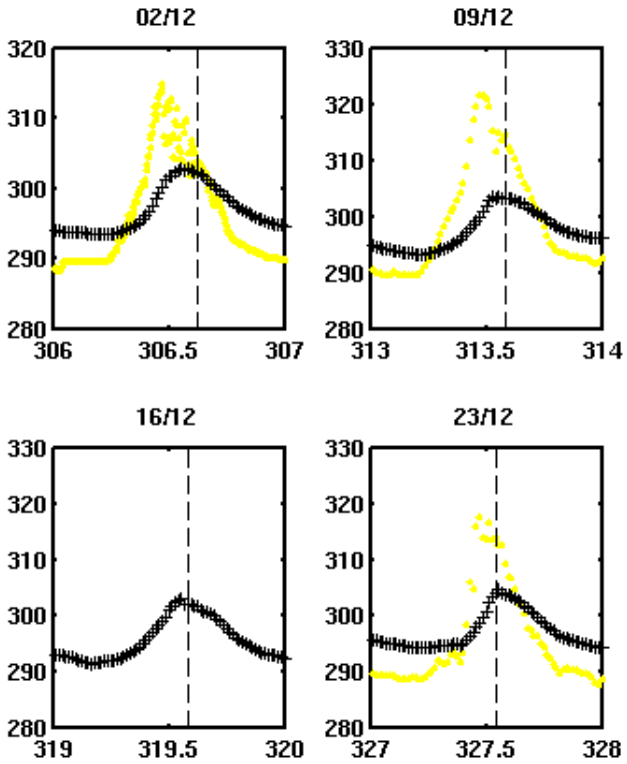


Figure 6b. Temperatures at Merriwa Park: Yellow: IR station (when available), Black: surface 2.5 cm, Dotted line: Flights PLMR

2/ Summary of acquired data- L-BAND

(EMIRAD AND PLMR ALONG-TRACK)

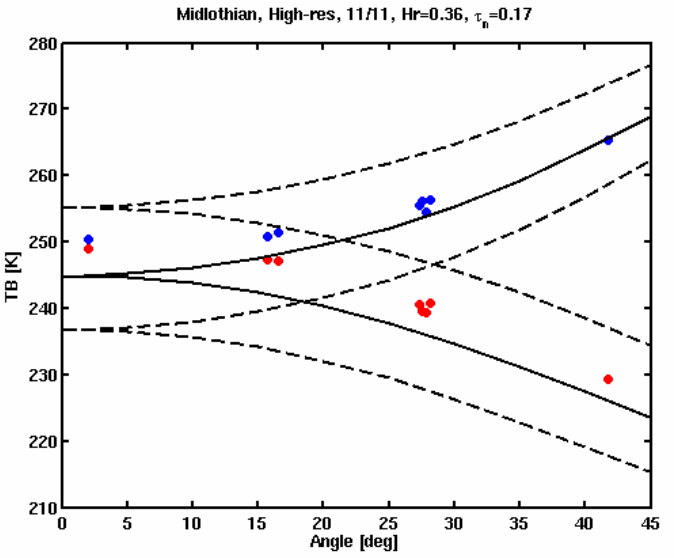
RADIOMETRIC MEASUREMENTS: EMIRAD 900 S / PLMR along-track PLMR-AT / ... SM intensive samling/ M SM regional sampling

DoE	KRUI CATCHMENT FARMS				MERRIWA CATCHMENT FARMS			
	PEMBROKE	STANLEY	ILLOGAN	ROSCOMMON	DALES	MIDLOTHIAN	MERRIWA	CULLINGRAL
02/11							PLMR-AT ...	
09/11							PLMR-AT ...	
11/11						PLMR-AT ...		
14/11			900 M wat	900 M water				
15/11	900 S	900 S	900 S part	900 M glint	900 S	900 S	900 S	900 S
16/11	-	-	-	-		o	PLMR-AT ...	
17/11	900 S	900 S	900 S	900 S	900 S	900 S	900 S	900 S
18/11	-	-	-	-	o	o		PLMR-AT ...
19/11	-	-	-	-	-	-	-	-
20/11	900 S	900 S	900 S	900 S	900 S	900 S (south)	900 S	900 S
21/11					2300 scal	2300 scal		2300 M scal
22/11	o			o		800-900 M water	-	800-900 M water
23/11	900 S, 2300 M scal (part)	900 S, 2300 M scal (part)	900 S	900	900 S	900 S (north)	900 S PLMR-AT ...	900 S
24/11								
25/11								
26/11	-	-	-	-	-	-	-	-
27/11	900 S	900 S	900 S	900 S	6000 S	900 S (north)	900 S	900 S
28/11								
29/11	900 S	900 S	900 S (north)	900 S (north of)	900 S	900 S	900 S	900 S
30/11	-	-	-	-	-	-	-	-
01/12	-	-	-	-	-	-	-	-
02/12	-	-	-	-	-	-	-	-
03/12	900 S	900 S	900 S	900 S	900 S	900 S	900 S	900 S
04/12	-	-	-	-	-	-	-	-
05/12	-	-	-	-	-	-	-	-
06/12								
07/12	-	-	-	-	-	-	-	-
08/12	-	-	-	-	-	-	-	-
09/12	2300 M scal	2300 M scal			1300 S			

5/ Modelling

What do L-MEB simulations indicate?

High-res area



PLMR -along-track high-res area

Grass, clay

Day/Farm	SM [m3m-3]	T_sfce	τ_nadir	Hr	RMSE [K]	R2
11/11-MD	0.32	303	0.17	0.36	1.5	0.99