Measuring Soil Moisture from Satellites

Work Package 3: Make measurements from remote sensing data using models

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Outline of the talk

Refresher of Radar Remote Sensing

Soil Moisture Across the Thames Valley Area of Interest (AOI)

**Verification of Soil Moisture Patterns**

Comparisons of…
- Different Land Uses
- Different Crop Types
- Impact of Soil Associations

Radar Remote Sensing (1/2)

ESA **Sentinel-1** Satellite Constellation

- Sentinel-1A and Sentinel-1B
- Strict 6 day repeating cycle (175 orbits)
- October 2015 – September 2021
- Focusing on two ascending orbits
  - 030 and 132
- Dependable viewing geometry and spatial coverage over the Thames Valley Area of Interest (AOI)

- Raw resolution 20x22m
  - Not suitable for soil moisture observations
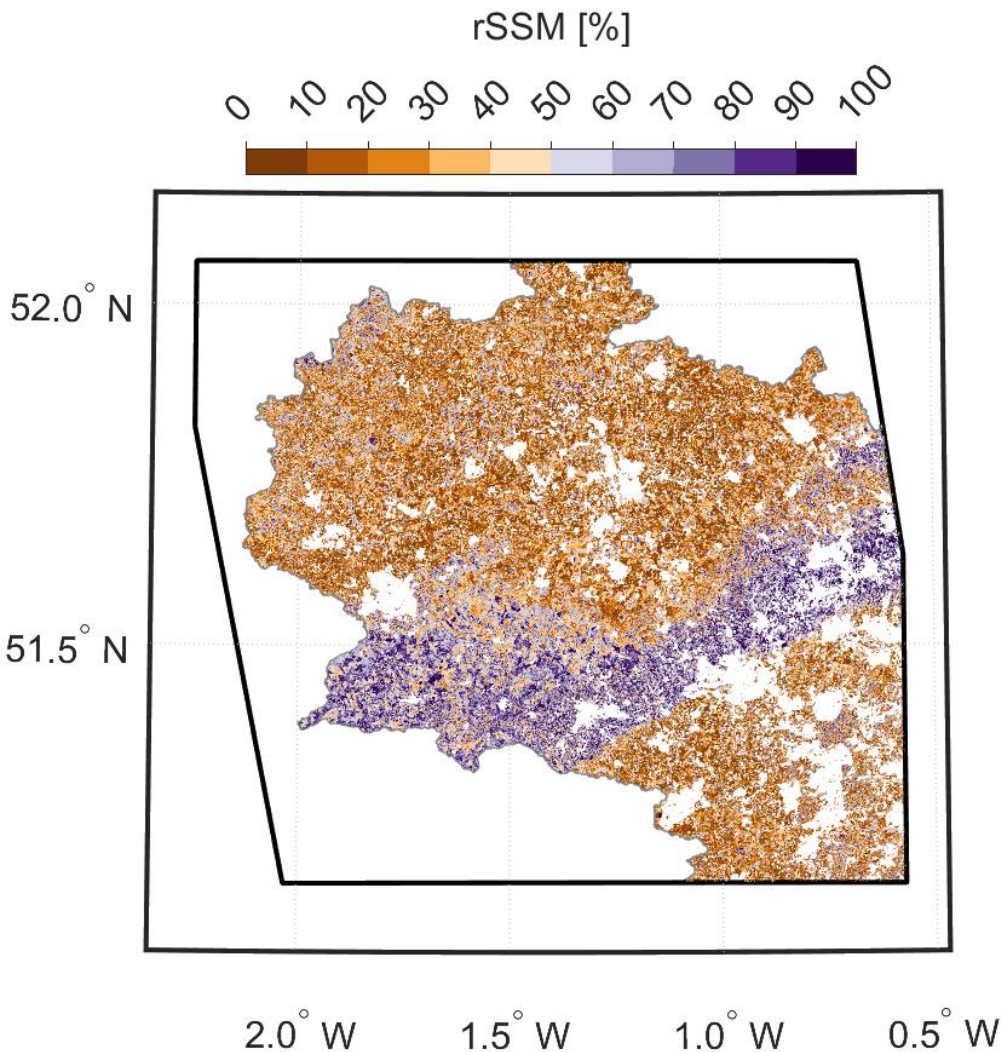 - Spatial averaging of pixels
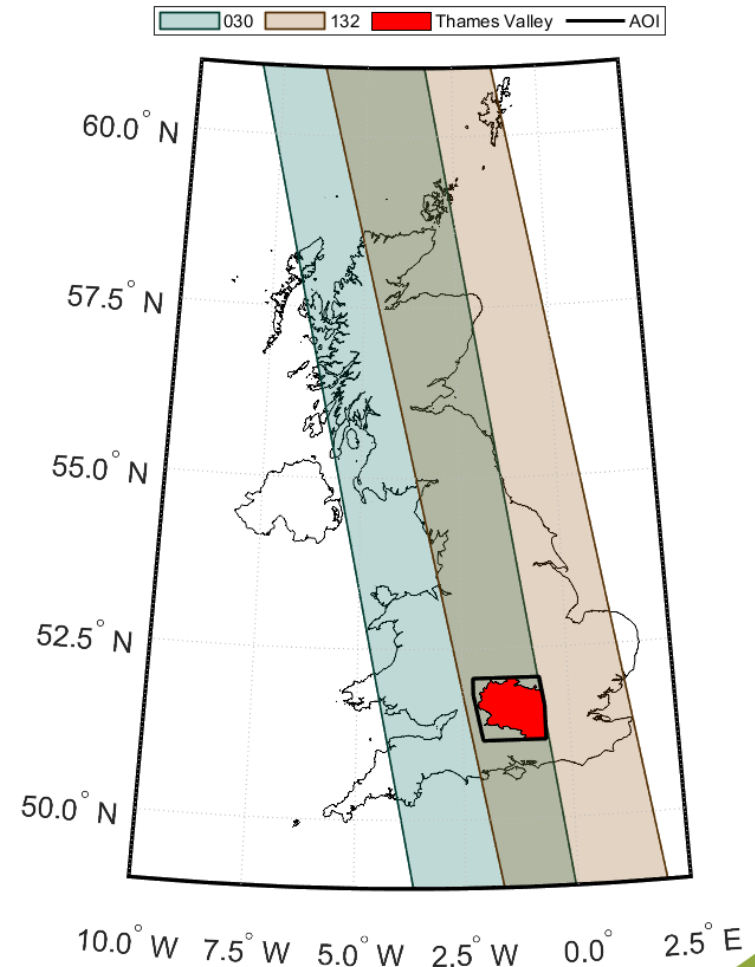
Radar Remote Sensing (2/2)

Using TU-Wien Change Detection Model[1] to calculate relative Surface Soil Moisture (rSSM) over the Thames Valley, UK.

Normalised Backscatter for orbit "t" [dB]

Relative Surface Soil Moisture for orbit "t" [%]

Dry threshold in the timeseries [dB]

$$rSSM(t) = \frac{\sigma°(\theta, t) - \sigma°_d(\theta)}{\sigma°_w(\theta) - \sigma°_d(\theta)}$$

Wet threshold in the timeseries [dB]

[1] W. Wagner et al., 1999: "A method for estimating soil moisture from ERS Scatterometer and soil data", *Remote Sens. Environ.* 70(2) pp 191-207

What does this look like? (1/2)

rSSM [%]

0 10 20 30 40 50 60 70 80 90 100

52.0° N

51.5° N

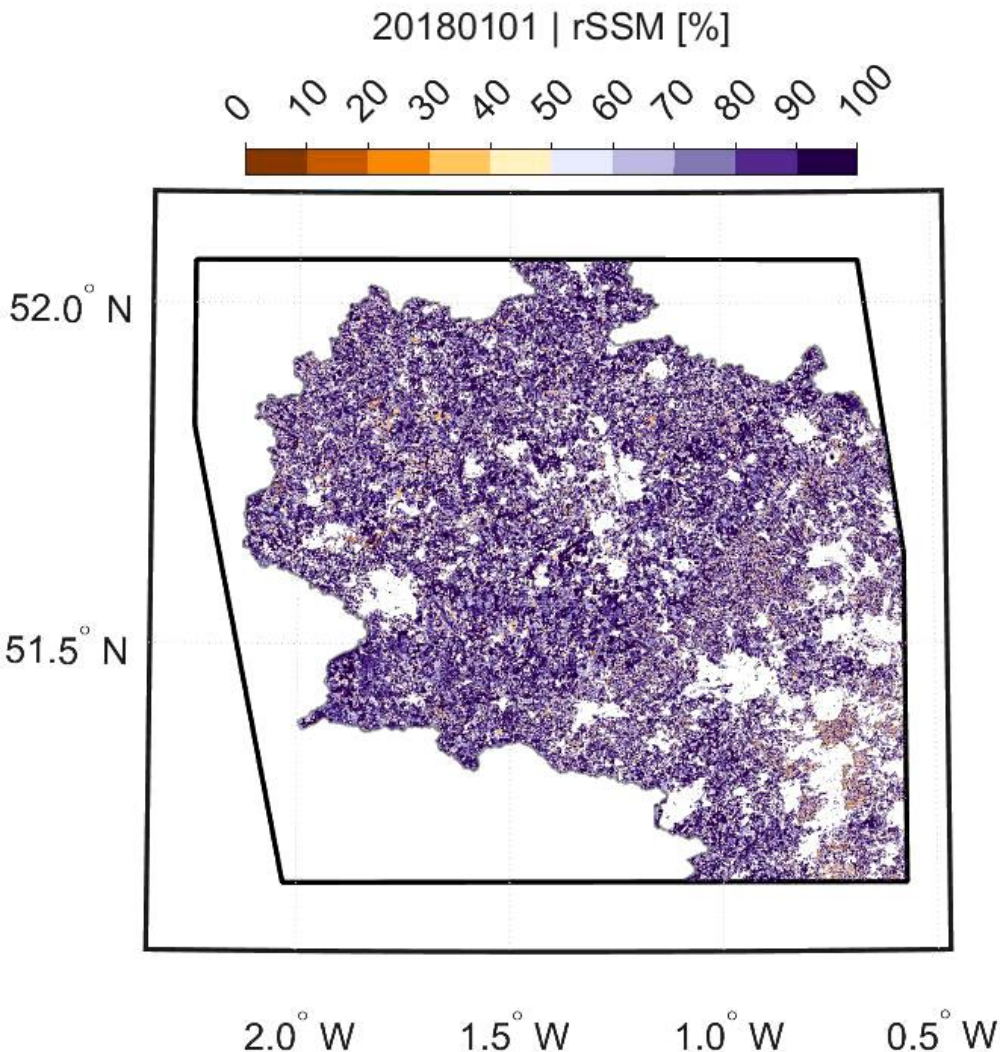2.0° W   1.5° W   1.0° W   0.5° W

Showing the backscatter data for 11th September 2018

Calculate the dry threshold from the entire timeseries

Calculate the wet threshold from the entire timeseries

From that, calculate rSSM for 11th September 2018

What does this look like? (2/2)
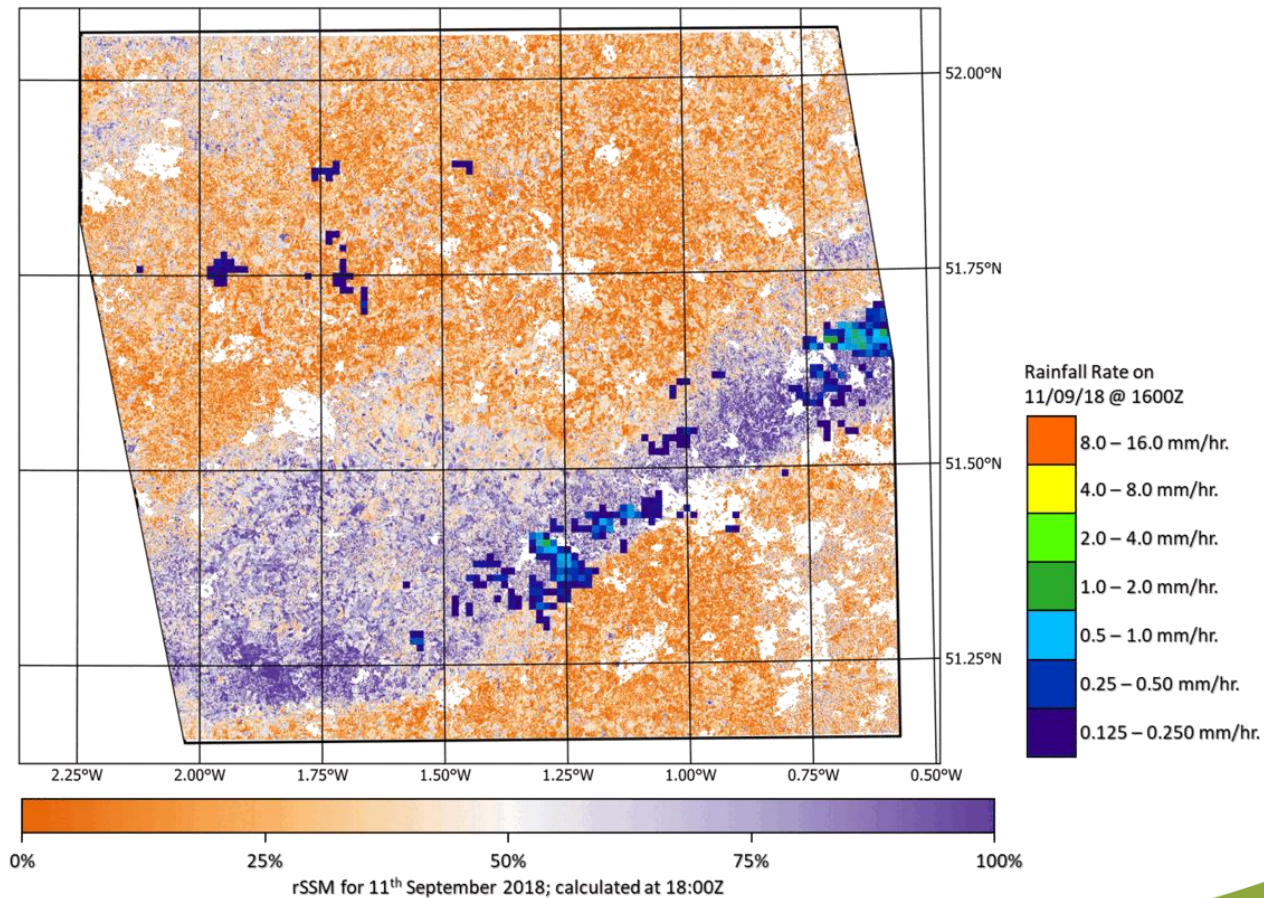

20180101 | rSSM [%]

2018 relative Surface Soil Moisture

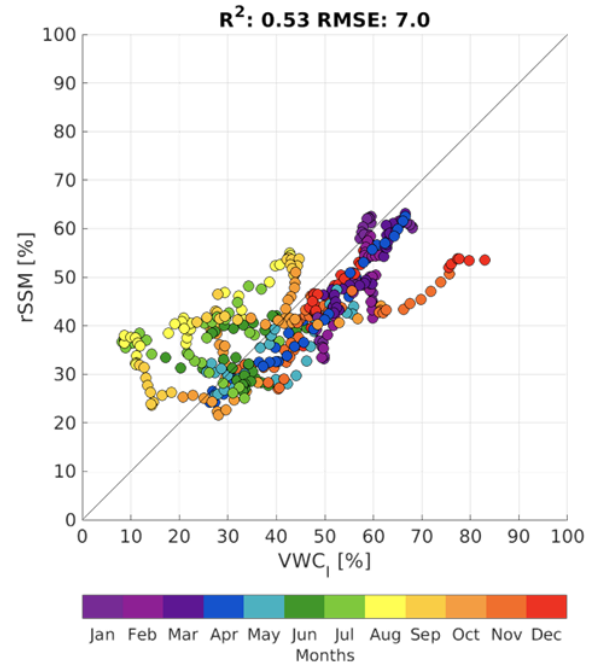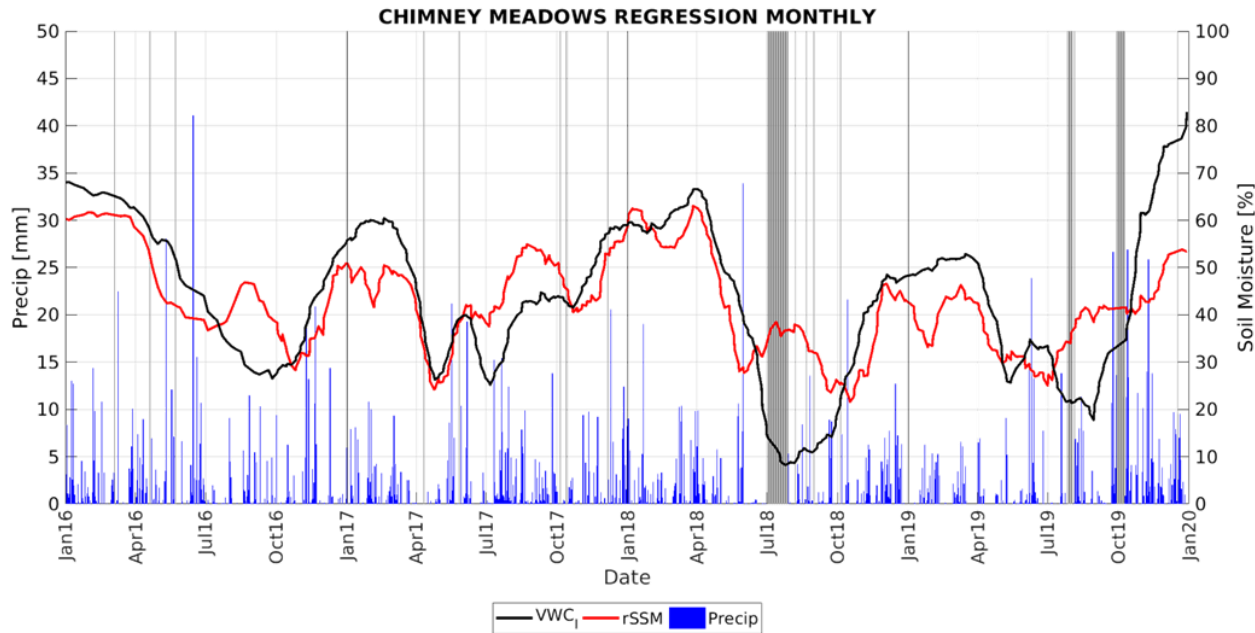General Wetting during the winter months, with a drier summer

Some individual fields showing very wet in June*

Verification 1 - Rainfall

UK Met Office Rainfall – 16:00 – 18:00

Sentinel-1 Orbit time ~ 18:00

Rainfall Rate on
11/09/18 @ 1600Z

8.0 – 16.0 mm/hr.
4.0 – 8.0 mm/hr.
2.0 – 4.0 mm/hr.
1.0 – 2.0 mm/hr.
0.5 – 1.0 mm/hr.
0.25 – 0.50 mm/hr.
0.125 – 0.250 mm/hr.

0%   25%   50%   75%   100%

rSSM for 11th September 2018; calculated at 18:00Z

Verification 2 – COSMOS-UK

CHIMNEY MEADOWS REGRESSION MONTHLY

R^2: 0.53 RMSE: 7.0

COSMOS-UK – Chimney Meadows
- General Trend in good agreement
- Overestimation during late summer
  - Due to vegetation growth and different measurement depths.
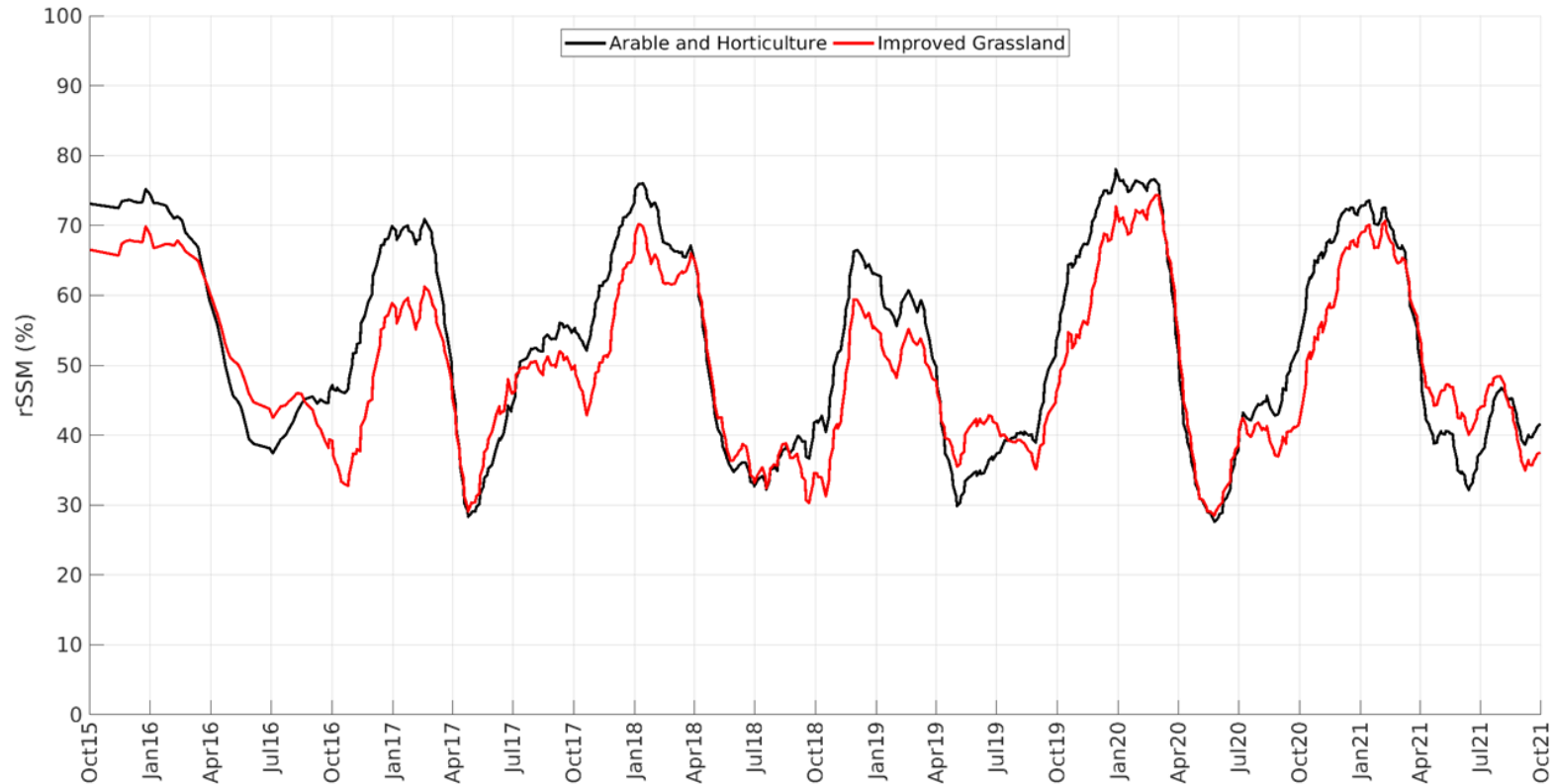
Comparison 1– Land Use
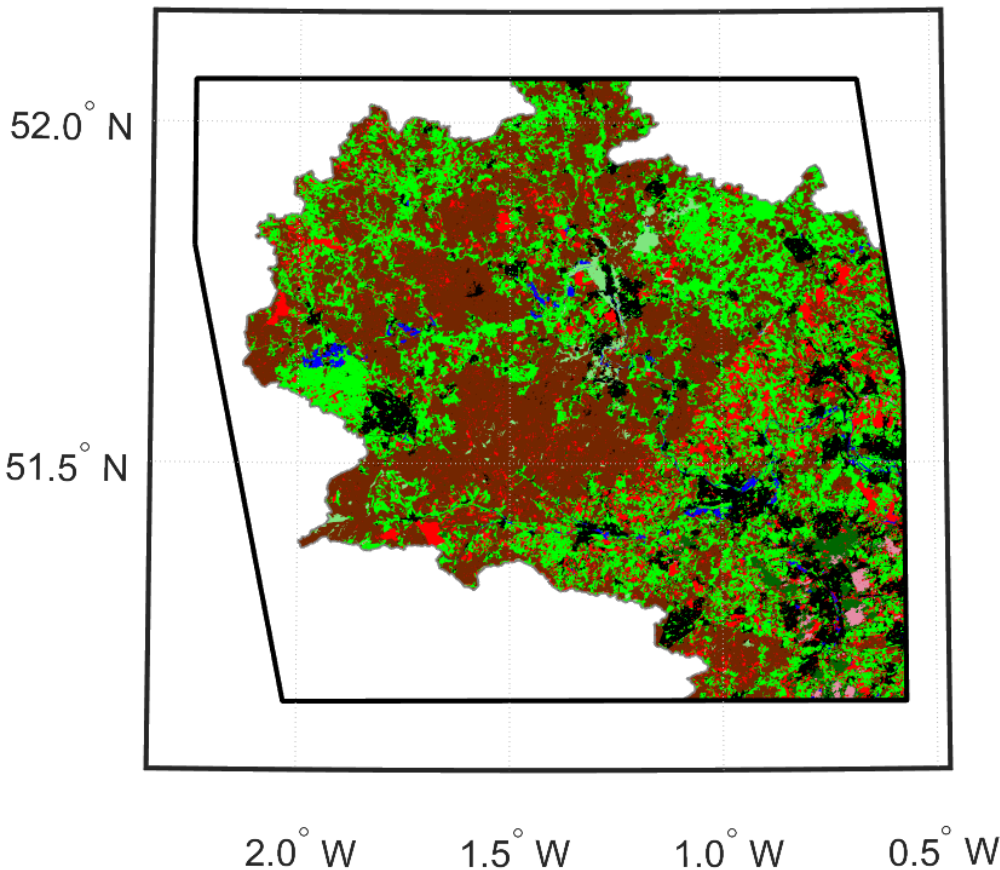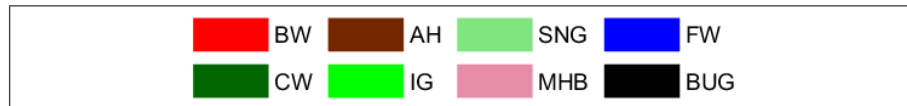
Can compare rSSM signal for different land uses

UK CEH Land Cover Model 2018

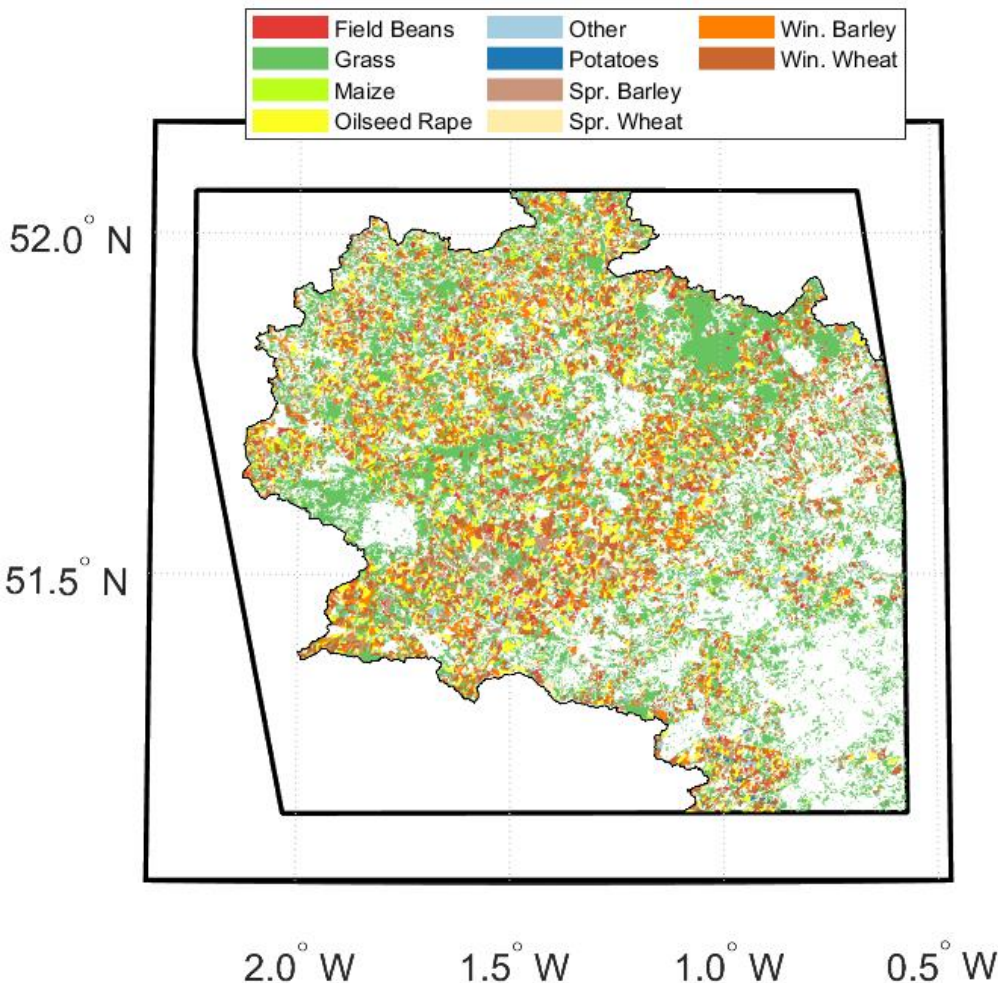Main comparison is between Arable and Horticulture (AH) and Improved Grassland (IG)

rSSM signal over forested areas (Broadleaf [BW] and Coniferous [CW]) is noisy, due to tree interference

Comparison 1– Land Use

AH tends to have higher rSSM over the winter than IG

Both see impacts of vegetation over the summer months
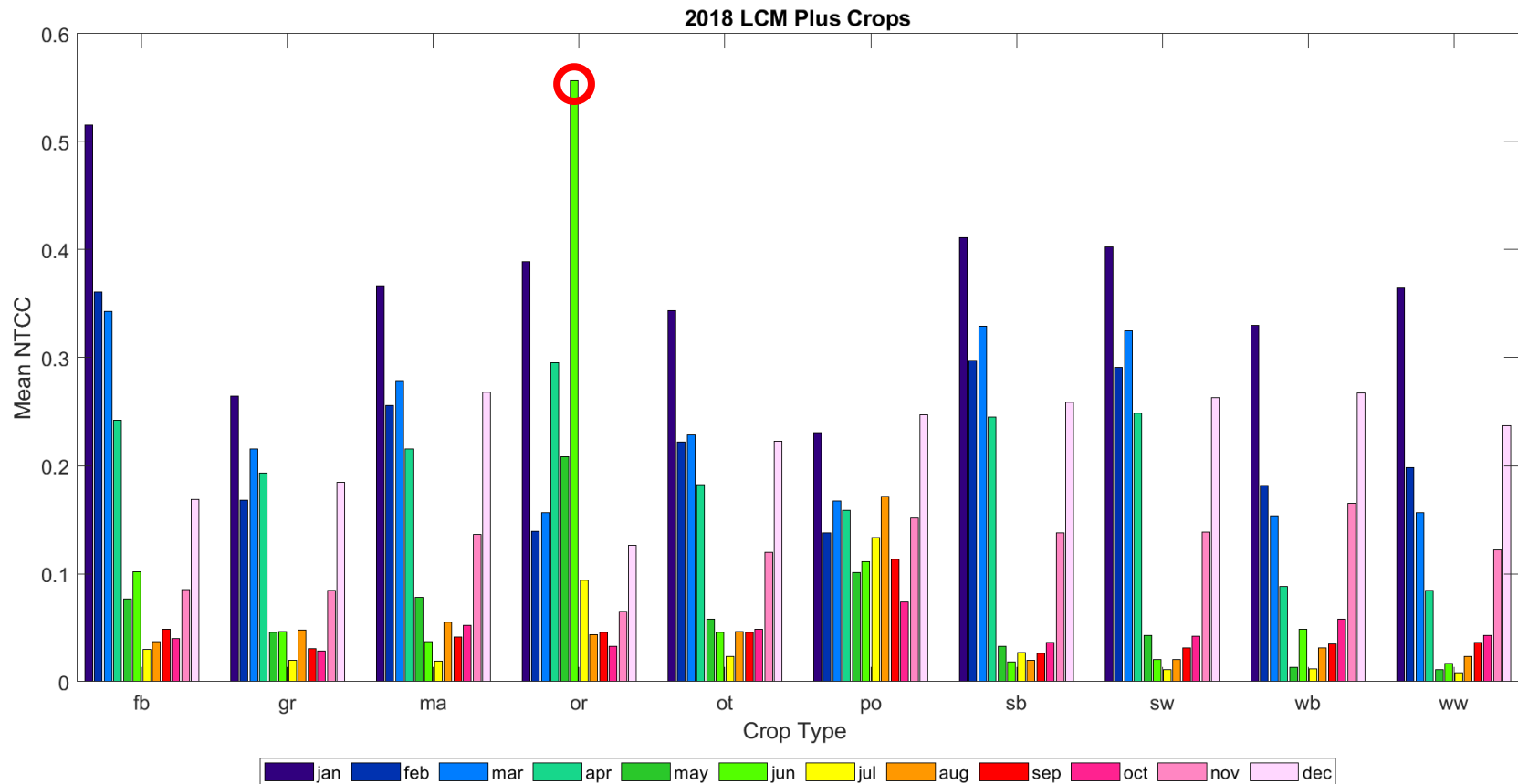
Comparison 2– Crop Type

Exploring crop differences further

UK CEH Land Cover Model plus Crops 2018

Can look at the number of times a crop plot breaches a threshold (>85% rSSM)
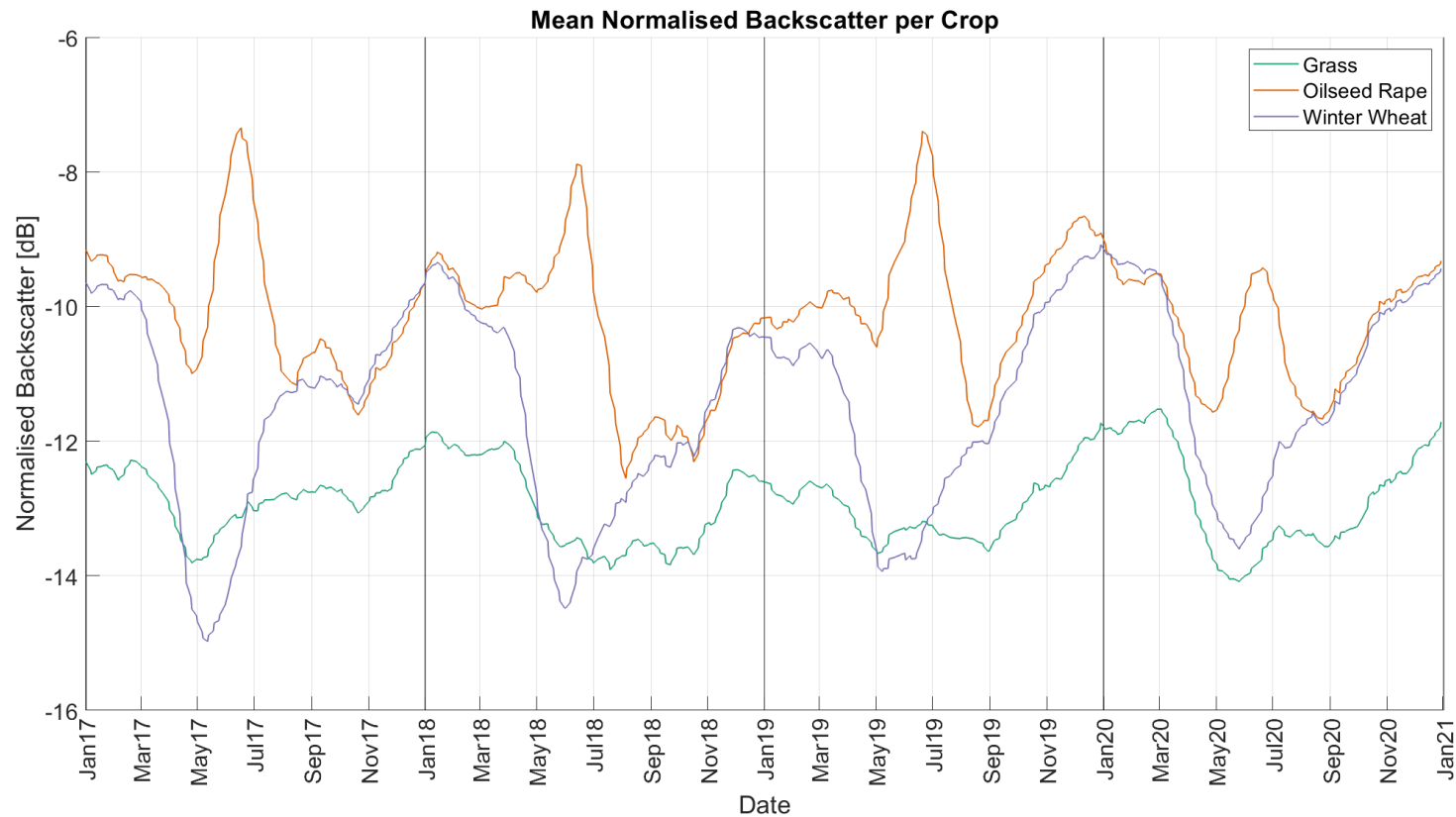
- Normalised Threshold Crossing Count (NTCC)

Comparison 2– Crop Type - NTCC
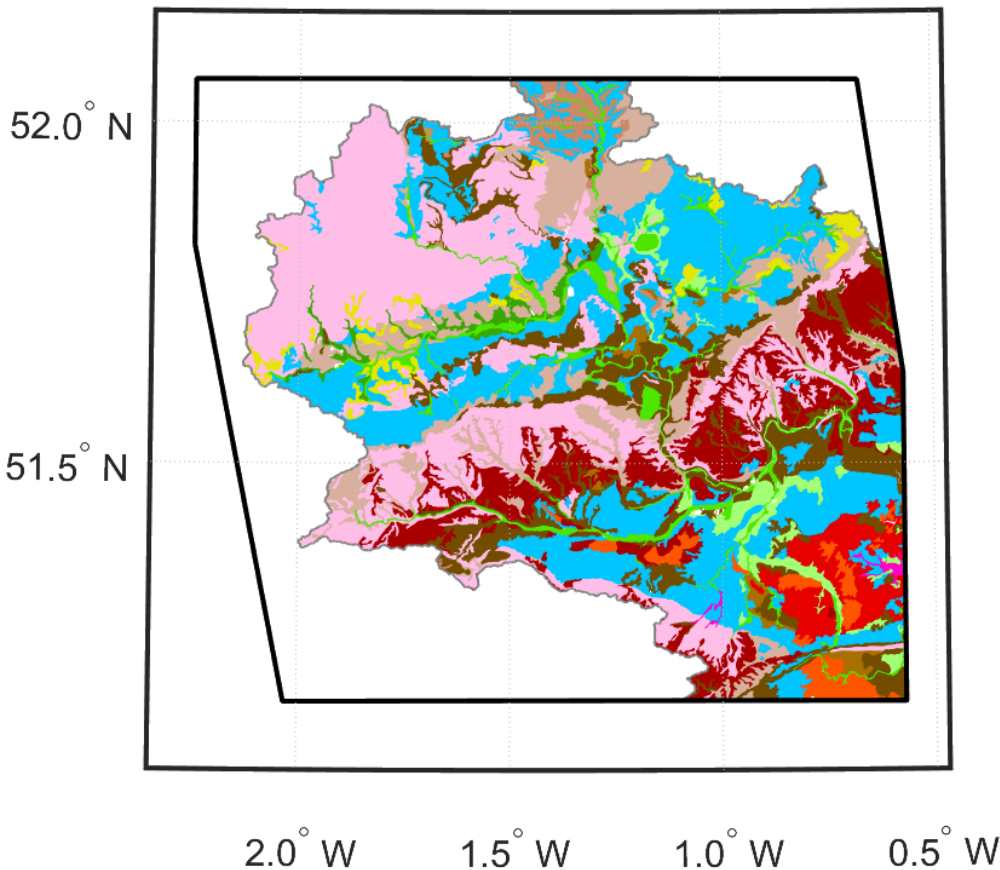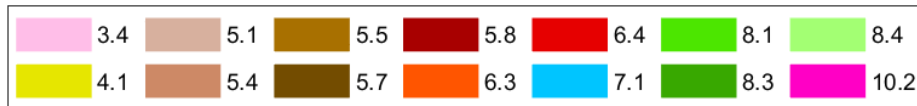

2018 LCM Plus Crops

Wetter in the winter / Drier in the summer
* Oilseed Rape?

Comparison 2– Crop Type - Backscatter

Mean Normalised Backscatter per Crop

- **Oilseed rape incorrectly identifies Summer as "wet"**
  - Summer peak in backscatter due to plant/pod geometry
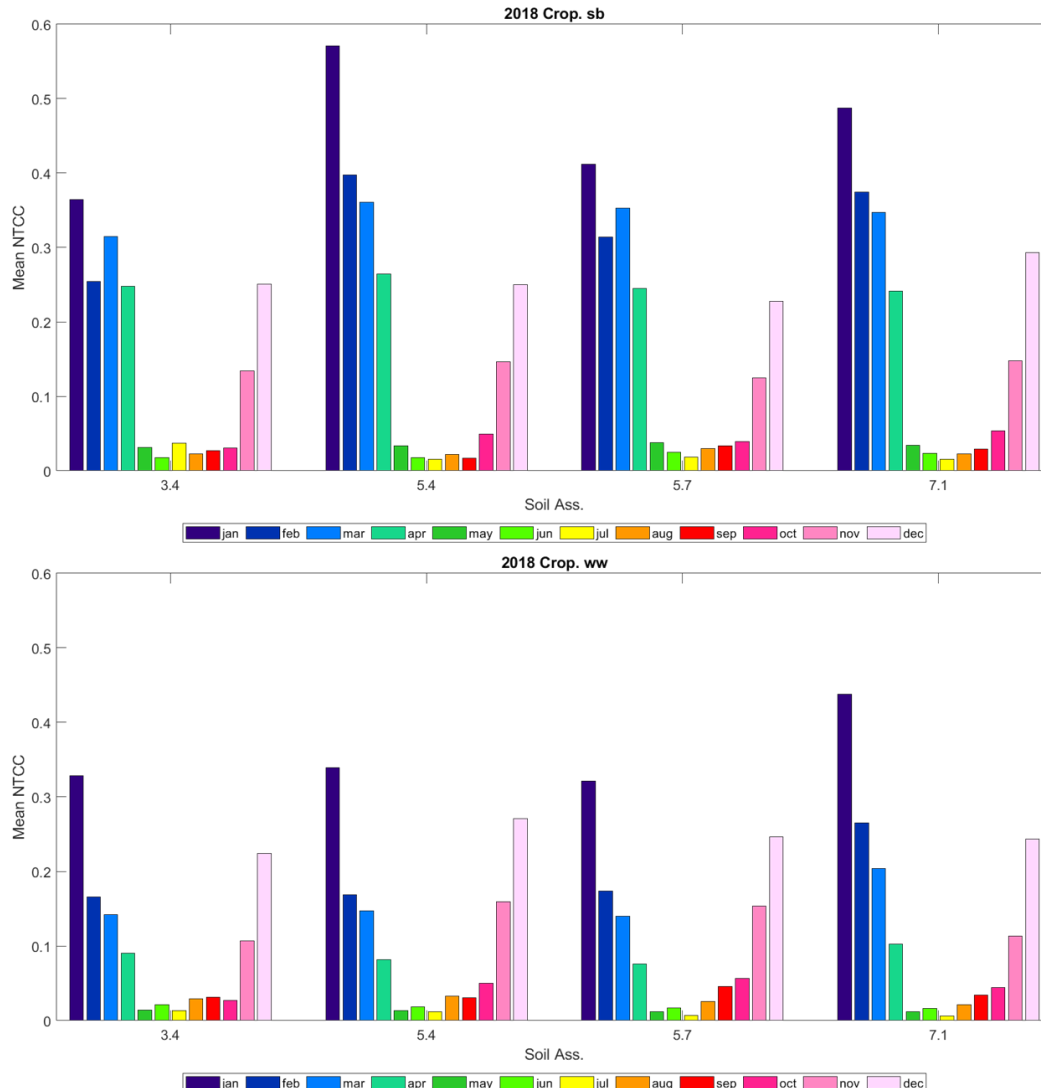
Comparison 3– Crop and Soil Type

Introduce Soil influences

Cranfield NATMAP Soil Associations

Focus on 4 Soil Groups
- 3.4 – Rendzinas
  - calcareous soils over chalk limestone
- 5.4 – Brown Earths
  - loamy or loamy not over clayey soils
- 5.7 – Argillic Brown Earths
  - loamy or loamy over clayey soils
- 7.1 – Stagnogley Soils
  - Seasonally waterlogged

Comparison 3– Crop and Soil Type

Comments:
- Grass wetter in Late Spring
- W. Wheat wetter in Winter
- OSR produces false positive in June

- 7.1 soils wetter in Winter (more obvious in W. Wheat)
- 3.4 soils tend to be drier than other soils

- S. Barley on 5.4 (brown earths) wetter over the winter than other soil types

Summary

- Developed relative Surface Soil Moisture (rSSM) product for Thames Valley

- Verified with two external datasets

- Briefly shown impacts of land use / crop type / soils on rSSM

- Thank you for listening!

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🌐 https://landwise-nfm.org/

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