EGU General Assembly
26/05/22

LANDWISE NFM

University of Reading

Monitoring Relative Surface Soil Moisture Using Sentinel-1 Across the River Thames Catchment

Dr. Will Maslanka, Prof. Keith Morrison, Dr. Kevin White, Prof. Anne Verhoef, Prof. Joanna Clark

W. Maslanka et al., "Retrieval of Sub-Kilometric Relative Surface Soil Moisture with Sentinel-1 Utilizing Different Backscatter Normalisation Factors" *IEEE Trans. Geosci. Remote Sens.*

UKRI Natural Environment Research Council

Sharing is encouraged

Context

- **Soil Moisture (SM) is valuable for agricultural and hydrometeorological processes.**
  - Essential Climate Variables by the Global Climate Observing System
- **SM is also vital for inferring the effectiveness of land- and soil-management based Natural Flood Management**
  - Soils ability to store precipitation before it enters the watercourse
- **Ability to observe SM over range of scales (catchment to field) is vital to assess the impact on SM from other variables**
  - Geology, Soil Type, Crop Management, Land Use

Method

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

$$rSSM(t) = \frac{\sigma^\circ(\vartheta, t) - \sigma^\circ{}_d(\vartheta)}{\sigma^\circ{}_w(\vartheta) - \sigma^\circ{}_d(\vartheta)} \quad \text{where} \quad \sigma^\circ(\vartheta, t) = \sigma^\circ(\theta, t) - \beta(\theta - \vartheta)$$

- **Backscatter is sensitive to many individual, highly variable features**

Concerning Vegetation	Concerning Soils
Vegetation Water Content	Soil Roughness
Crop Row Orientation	Tillage
Size	Soil Moisture
Crop Density	
Wind Bending	

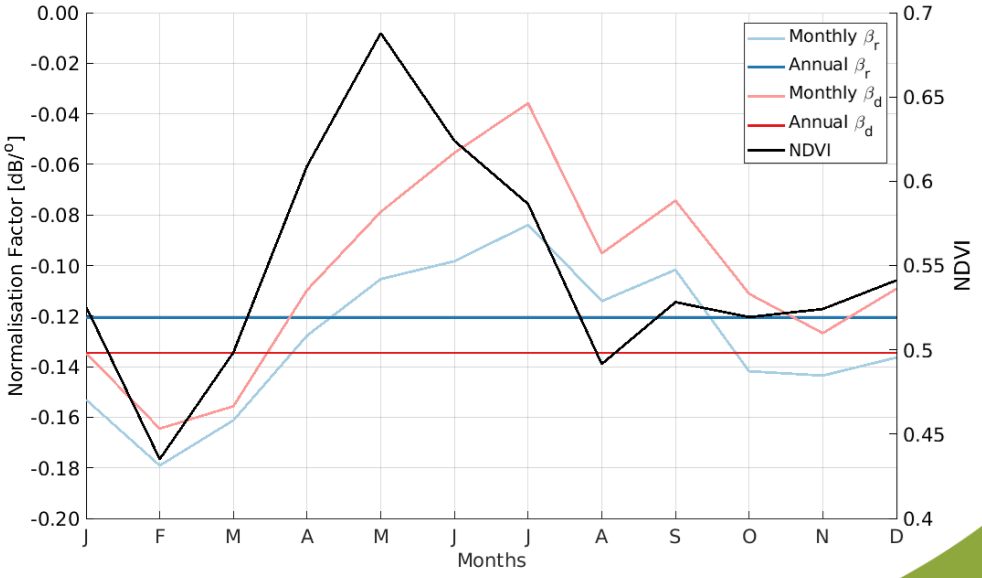
- Can mitigate a lot via spatial averaging, and normalisation, via normalisation parameter $\boldsymbol{\beta}$
- Assuming surface roughness and vegetation do not change in time*

[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

Normalisation

- **Two different normalisation methods used**
  - Traditional “Direct Regression Slope” Method
  - Complex “Multiple Regression Slope” Method
  - Both slopes calculated at Traditional Annual and Monthly timescales

- **Seasonal Cycle Present**
  - Peak in Early Summer
  - Trough in Late Winter
  - Clear impact of Harvest in August
  - Not captured with Annual Factors

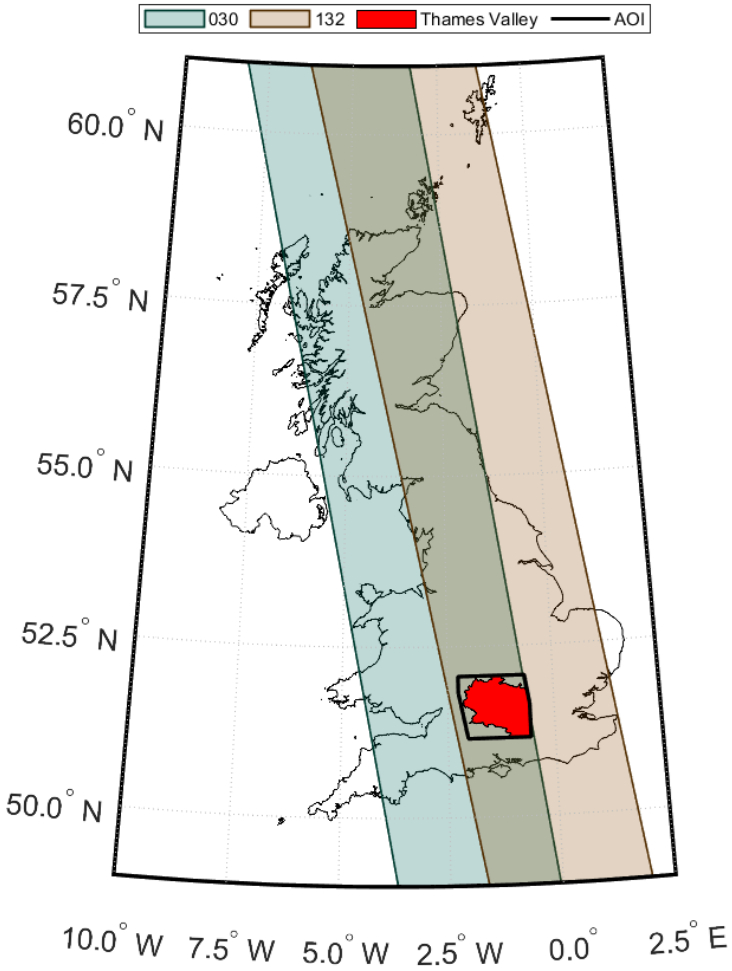


NDVI data from Copernicus Global Land Service

Data Used

- **Sentinel-1**
  - Level 1 IWGRDH (VV)
  - October 2015 – September 2021
  - Ascending Orbits
    - **Relative Orbits 030 and 132**

- **COSMOS-UK Network**
  - 3 sites
    - **Chimney Meadows (CHIMN)**
    - **Sheepdrove (SHEEP)**
    - **Waddesdon (WADDN)**
  - January 2016 – December 2019
  - Volumetric Water Content
    - **Normalised**
  - Precipitation



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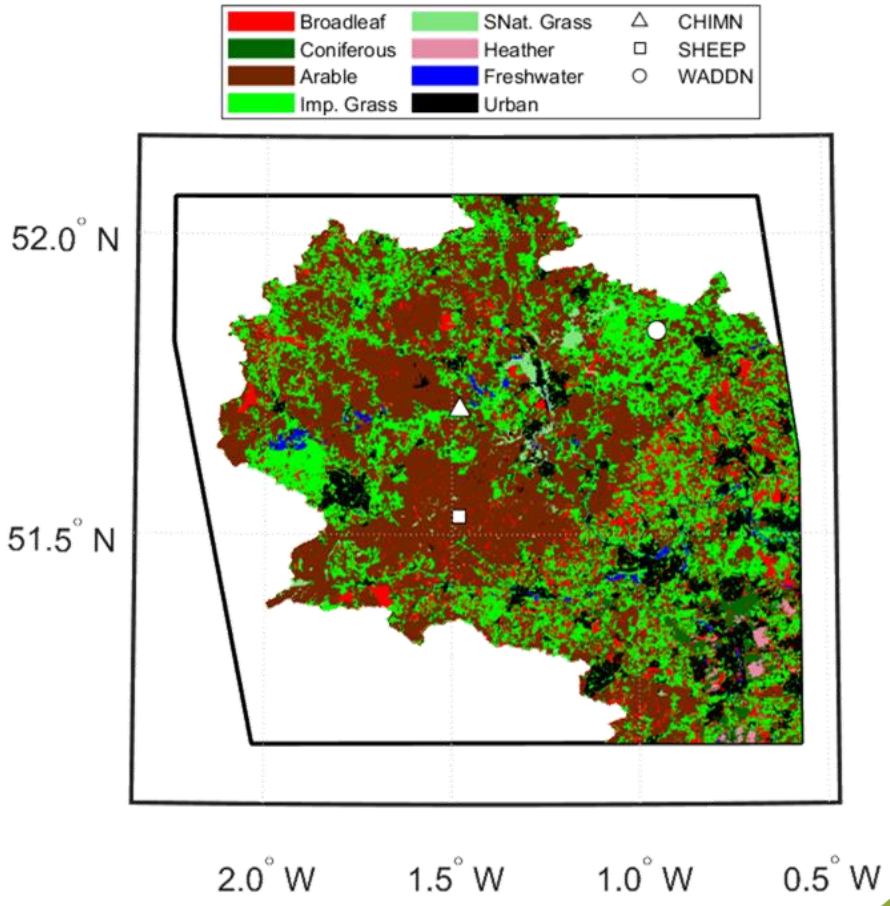
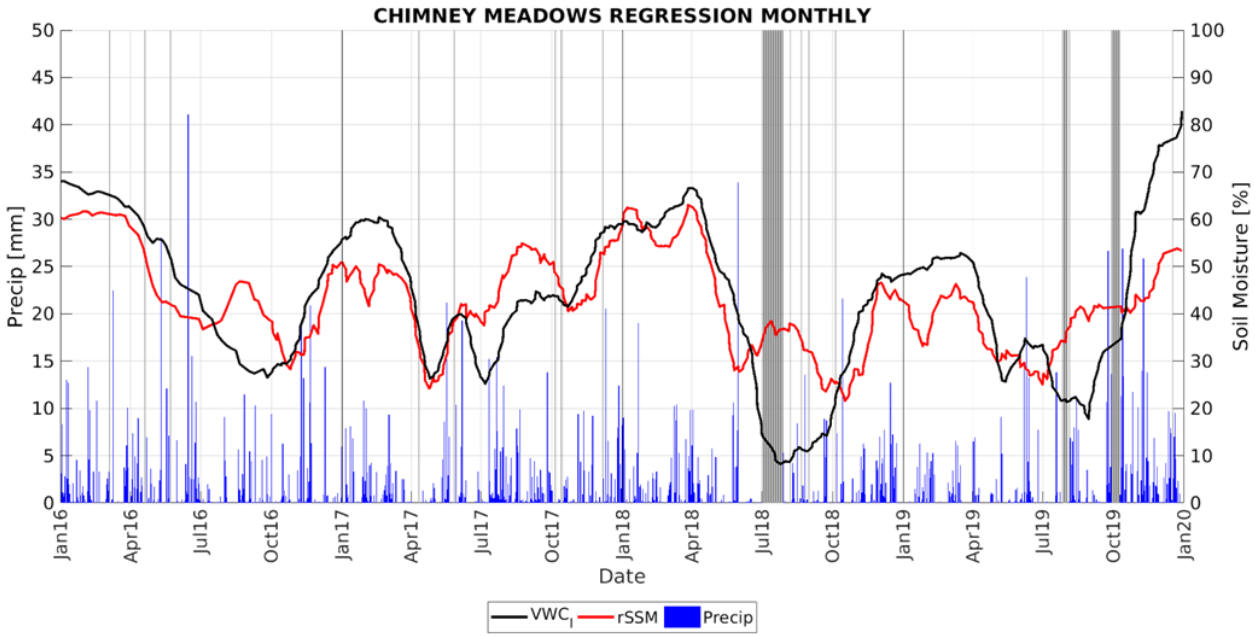
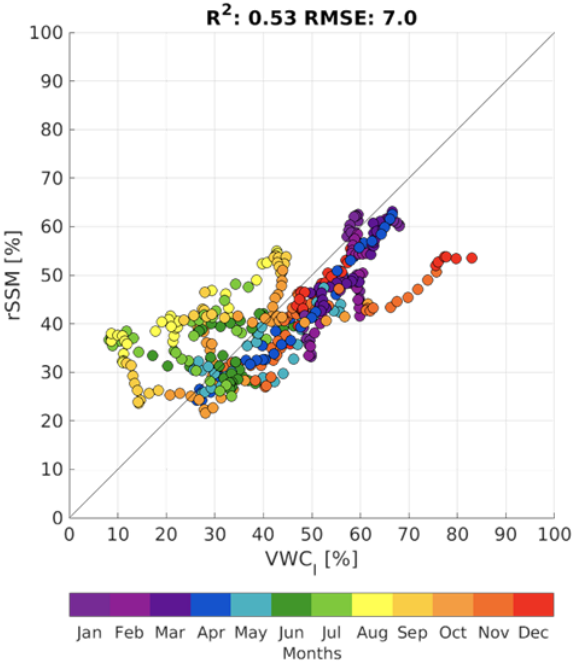


Centre of Ecology and Hydrology, Land Cover Model 2018

Comparison with COSMOS-UK (CHIMN – 100m)





- **General Trend in good agreement**
  - Overestimation during late summer (July – October)
  - Measurement depths different (Surface / ~15 cm)
  - 14-orbit moving average applied to remove noise

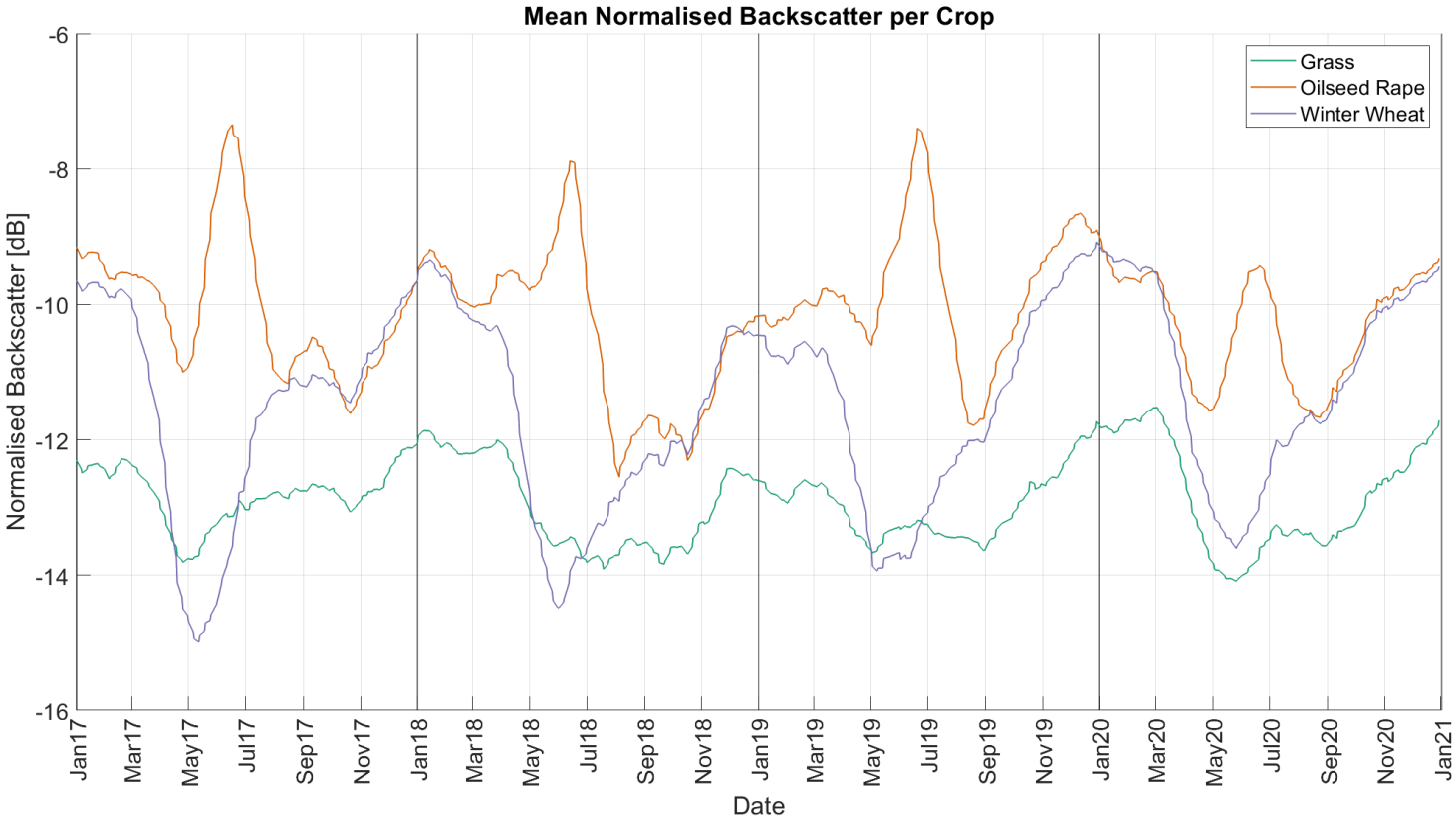
Comparison with COSMOS-UK (CHIMN)

100m	RMSE	R2
Ann-Dir	6.6%	0.58
Mon-Dir	7.2%	0.48
Ann-Reg	6.7%	0.58
Mon-Reg	7.0%	0.53

Mon-Reg	RMSE	R2
1000m	12.1%	0.29
500m	12.0%	0.21
250m	8.2%	0.41
100m	6.6%	0.58

- **Normalisation Factor**
  - Comparable uncertainties regardless of combination used
  - Annual normalisation factors perform the best, they don't take variation in slope into account.
- **Spatial Averaging**
  - Finer Spatial Averaging performs best
  - Expected, as comparing with *in-situ sensor*
    - **Coarser Spatial Averaging includes ground not covered by *in-situ sensor*.**

Overestimation in Arable



- **Oilseed rape incorrectly identifies Summer as "wet"**
  - Summer peak in backscatter due to plant/pod geometry
  - Centre of Ecology and Hydrology, Land Cover Model plus Crops 2018

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Future Work

- Using rSSM time series, will compare:
  - Land-use (Arable vs. Grassland)
  - Land-management (Crop type comparison)
  - Soil-type (Dominant Soils in the Thames Valley)
  - Anecdotal Evidence (Common areas of high rSSM)

- Thank you for listening!

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https://landwise-nfm.org/

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