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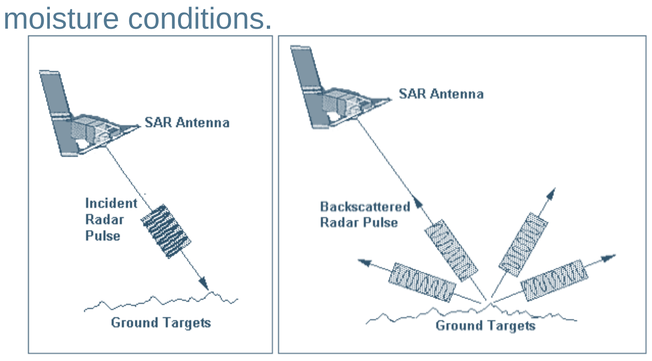
Sentinel-1 high resolution soil moisture data: a case study in Southeast Luxembourg

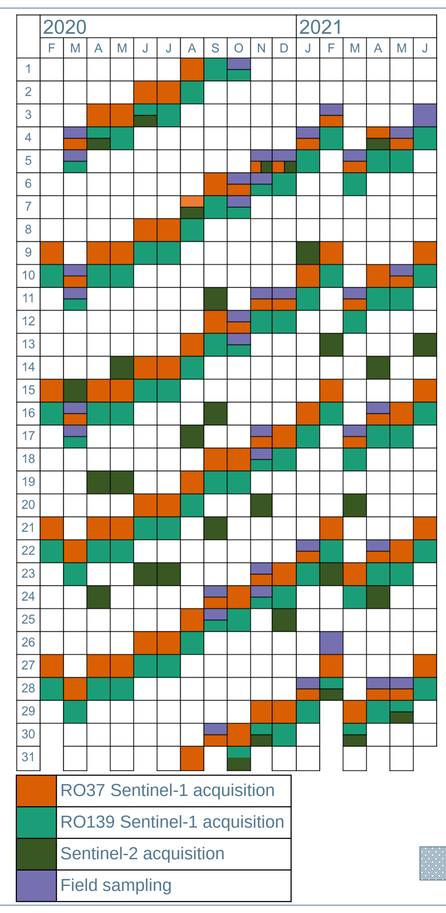
Background

- **High resolution** soil moisture data would be a valuable addition for monitoring soil moisture and vegetation drought status
- Remotely sensed soil moisture data has a large **spatial coverage** and can be assimilated in hydro-meteorological models directly
- **Active microwave** measurements are characterized by a high spatial resolution
- Here we set up a high resolution **field campaign** to test the accuracy of SAR soil moisture data at different high resolutions.
- We **hypothesise** that even native resolution SAR data contains relevant information on sub-field soil moisture conditions.



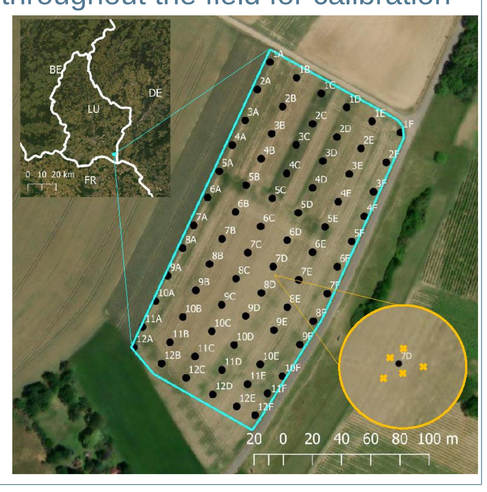
Satellite data

- Sentinel-1 L1 HR IW GRD VV and VH data.
- 2 orbits: 37 (LIA = 33.2°) and 139 (LIA = 42.1°)
- Preprocessing in ENVI SARscape
  - import, geocode, radiometric calibration at 20x20m² on the WGS84/UTM 32N coordinate system
- Sentinel-2 L2 optical data for NDVI, processed in SNAP 7.0
- MULESME soil moisture retrieval algorithm (Pulvirenti et al., 2018)
  - Assumes roughness is constant over 5 images
  - Oh forward model in a look-up table
  - Filters on PWC (NDVI), σ^0, LC, slope



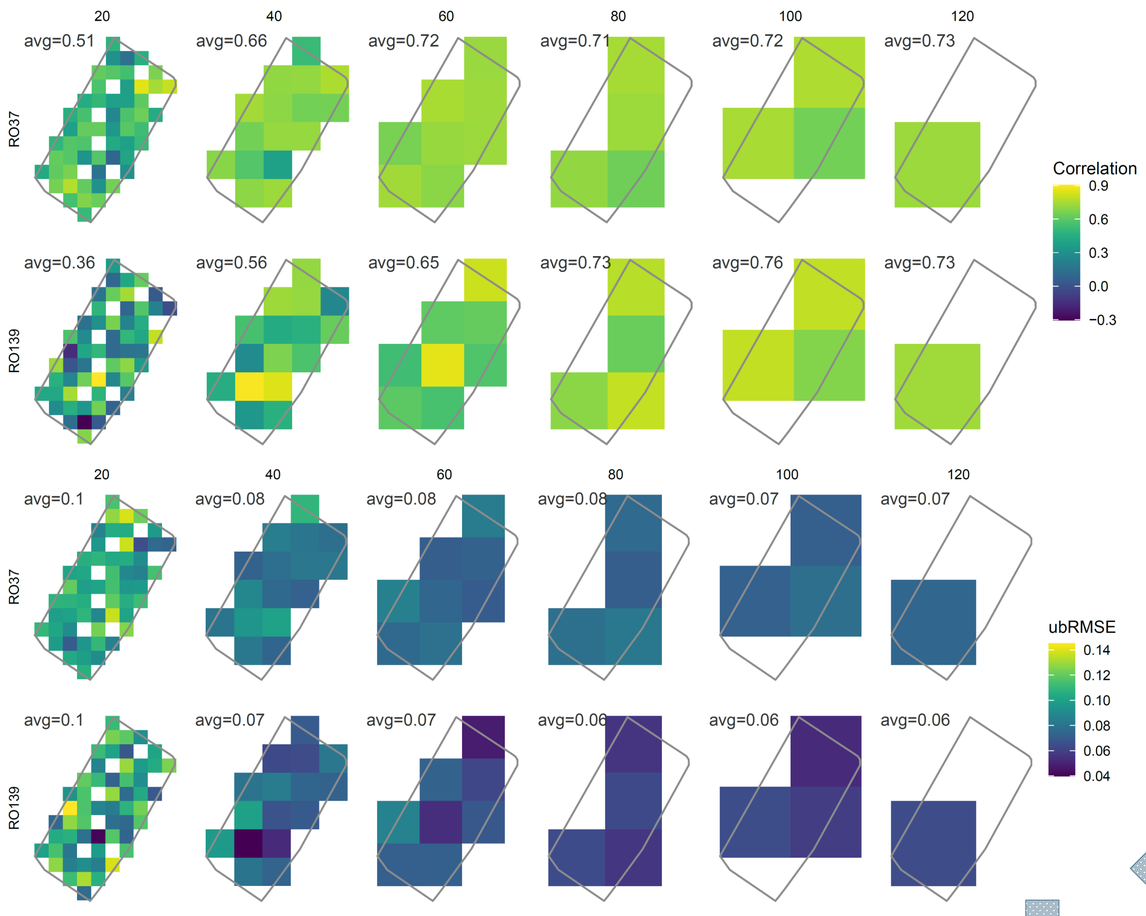
Field campaign

- Agricultural field (110 x 250 m) in SE Luxembourg (Elvange)
- Moderate climate
- 9 m elevation difference N-S
- Vegetation state varying
  - Bare soil, winter wheat growing season
- 38 measurement days
- 5 TDR samples per sampling location
  - FieldScout TDR 350 with 1.5-inch pins
- 12 gravimetric samples throughout the field for calibration



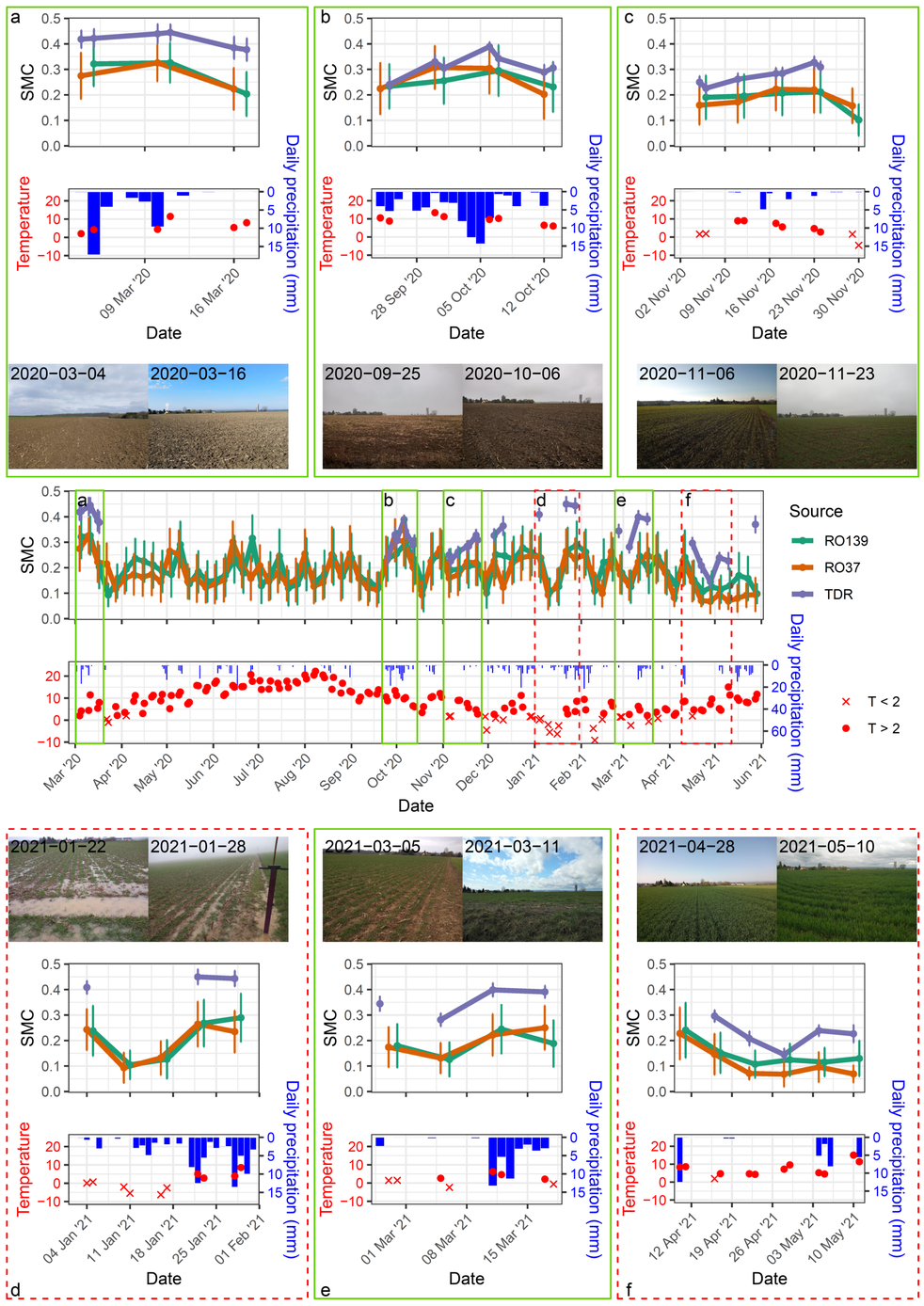
Temporal metrics

- At high resolutions, temporal correlation is higher in the RO37 data than in the RO139, but at low resolutions, temporal correlation is higher in the RO139 data. Correlation barely improves after 60 m and does not increase above 0.7
- Unbiased RMSE is spatially variable at high resolution and decreases at lower resolutions. No substantial differences between the two orbits exist



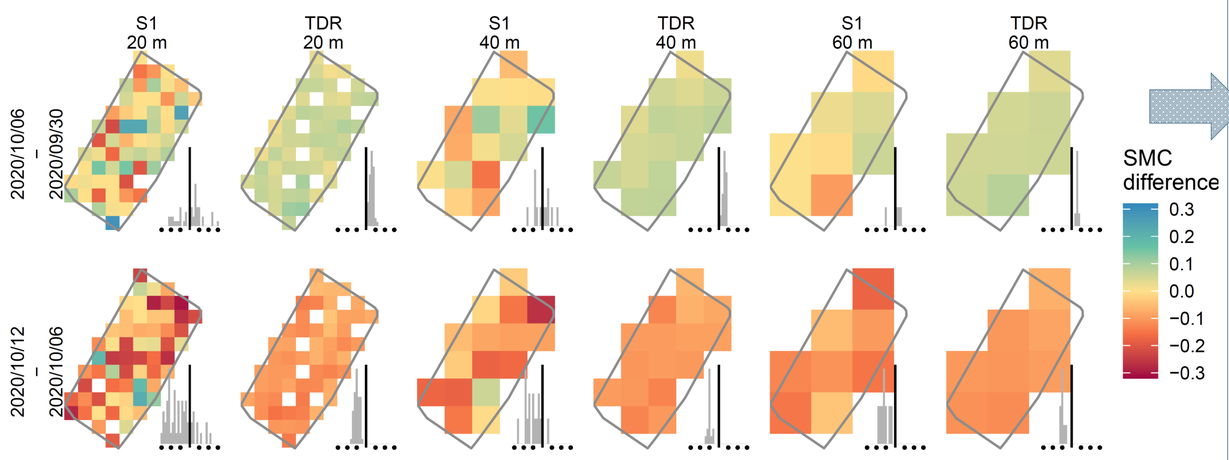
Time series

- A bias between field and satellite data exists
- The impact of precipitation and temperature is clearly visible in soil moisture conditions
- Differences in performance are observed for different field conditions (a-f)



Case study

- Soil moisture changes are visible in both field and satellite data
- Sub-field variation in high resolution field data is not that obvious in the satellite data, confirming a low spatial correlation
- Trends in spatially aggregated field data are visible in satellite data
- The difference between field and satellite data seems to stem mostly from the bias.



Conclusions

- Temporal sub-field soil moisture variability could be retrieved accurately
- The spatial correlation was limited by the absence of large sub-field soil moisture variability.
- The optimal spatial resolution is 60x60 m² with a temporal correlation of 0.72
- The spatial correlation was limited by the absence of large sub-field soil moisture variability

In short…

- A satellite soil moisture dataset was derived from 20x20m² resolution S1 backscatter data
- A field dataset was collected on 38 days in southeastern Luxembourg
- The datasets were compared using the Pearson correlation and the unbiased RMSE

References

Pulvirenti, L. et al., 'A Surface Soil Moisture Mapping Service at National (Italian) Scale Based on Sentinel-1 Data', Environmental Modelling & Software 102 (2018): 13–28, https://doi.org/10.1016/j.envsoft.2017.12.022.

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