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TAKING THE PULSE OF OUR PLANET FROM SPACE

EUMETSAT ECMWF EUSPA

Remote sensing of soil moisture for agricultural areas using combined high-resolution C-band Sentinel-1 and L-band ALOS-2 SAR timeseries

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Soil moisture is a key parameter within agricultural production and scientific research, but high-resolution data is still challenging.

SAR satellite missions provide continuous temporal and spatial high-resolution monitoring of earth surface on a global scale

→ **Development of an applicable and robust workflow for soil moisture estimation from SAR data**

→ **AssimEO project: Assimilation of EO data into the CLM-ParFlow hydrological model**

Study Area

Location: Sergezia farm in the Cervaro Basin
North-West part of Puglia region, Southern Italy

Climate: Semiarid Mediterranean
hot and dry summers and short and temperate winters (550 mm/a)

Size: ~ 4 km²
mainly cropped with cereals and pastures
Sandy clay loam soil texture

Soil moisture monitoring network:
11 stations with EM50 datalogger (15 min)
Two 5TM and two 10HS probes installed horizontally at 2.5 cm,10 cm, 20 cm and 40 cm depths, measuring m_v

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SAR data

Sentinel-1 A/B:

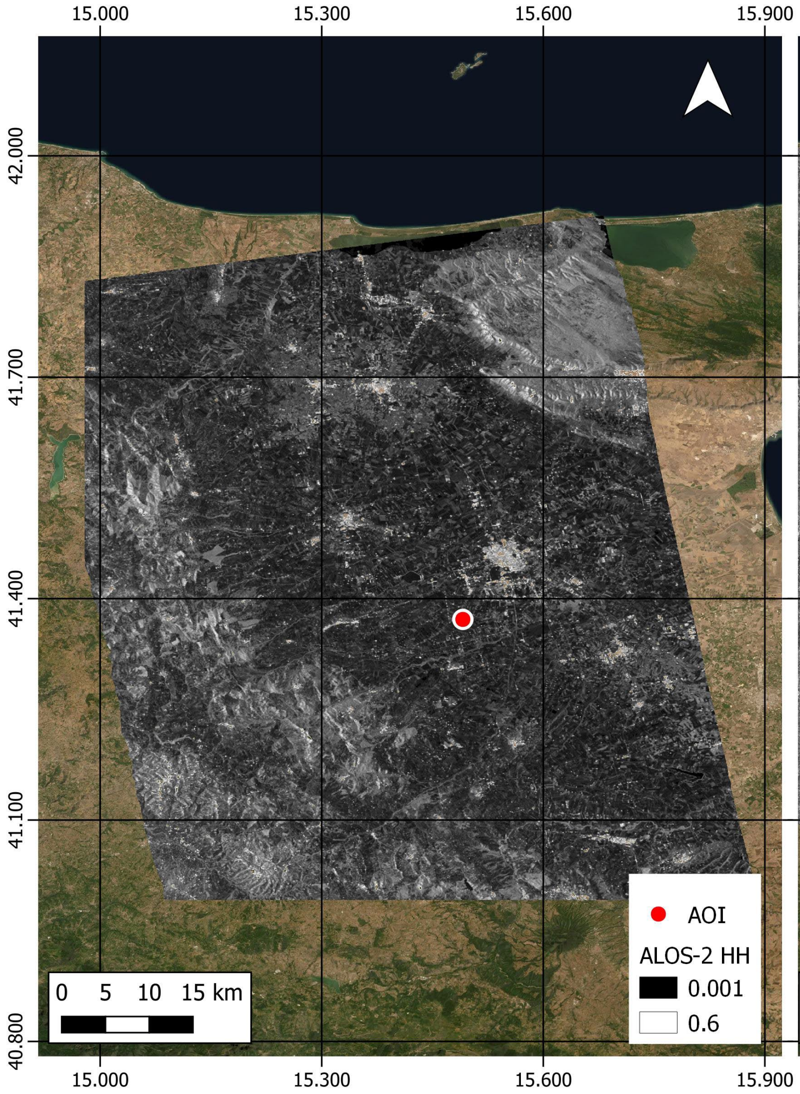
- C-band (5400 MHz)
- VV/VH dual-polarization

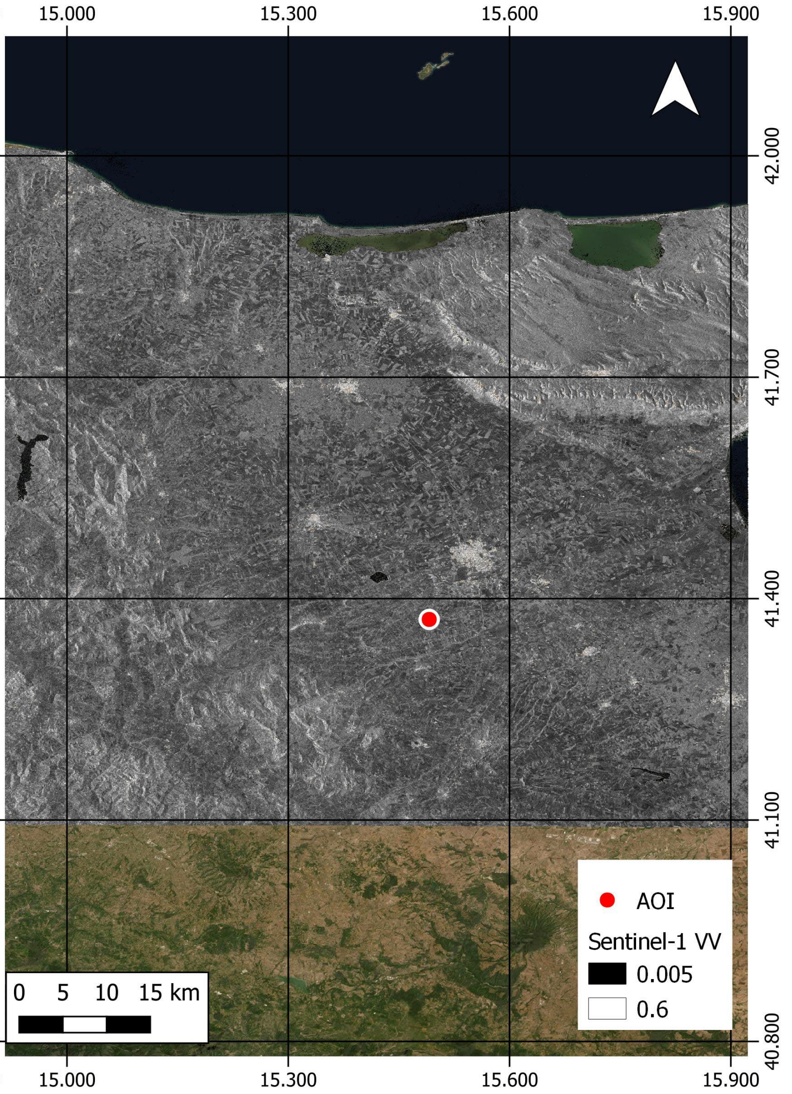
→ **Higher temporal resolution, but sensitive to vegetation**

ALOS-2:

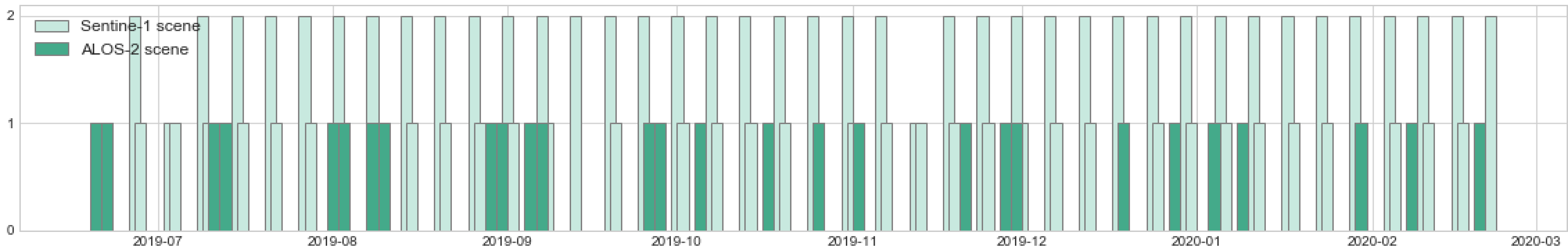
- L-band (1257.5 MHz)
- HH/HV dual-polarization

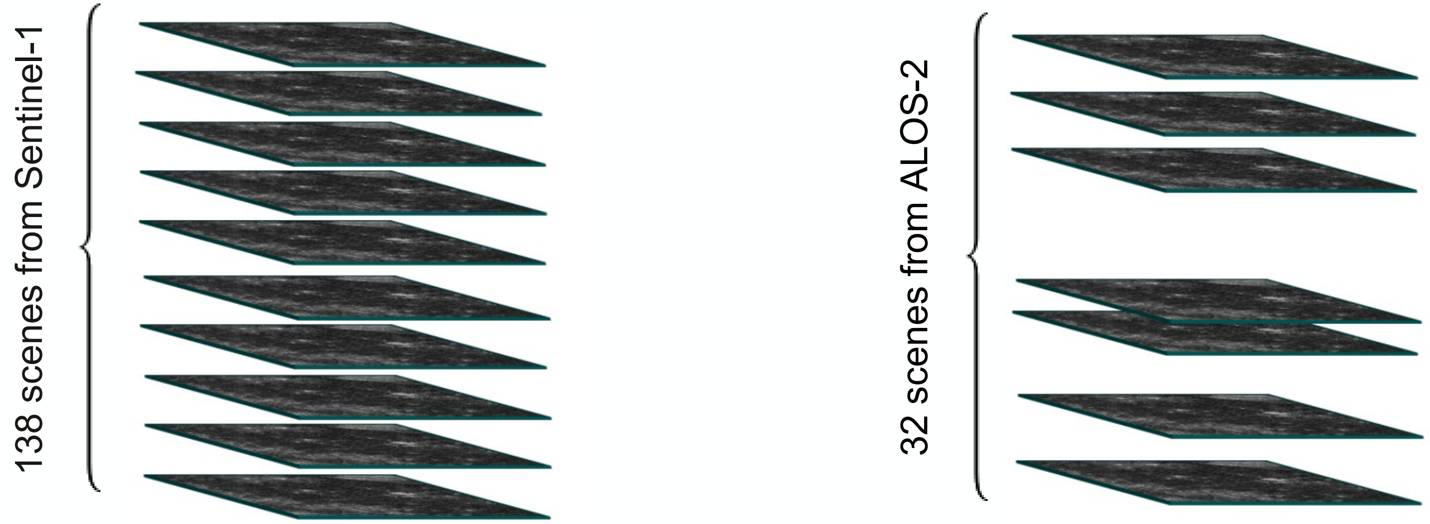
→ **Lower temporal resolution, but insensitive to agricultural vegetation**





Temporal resolution





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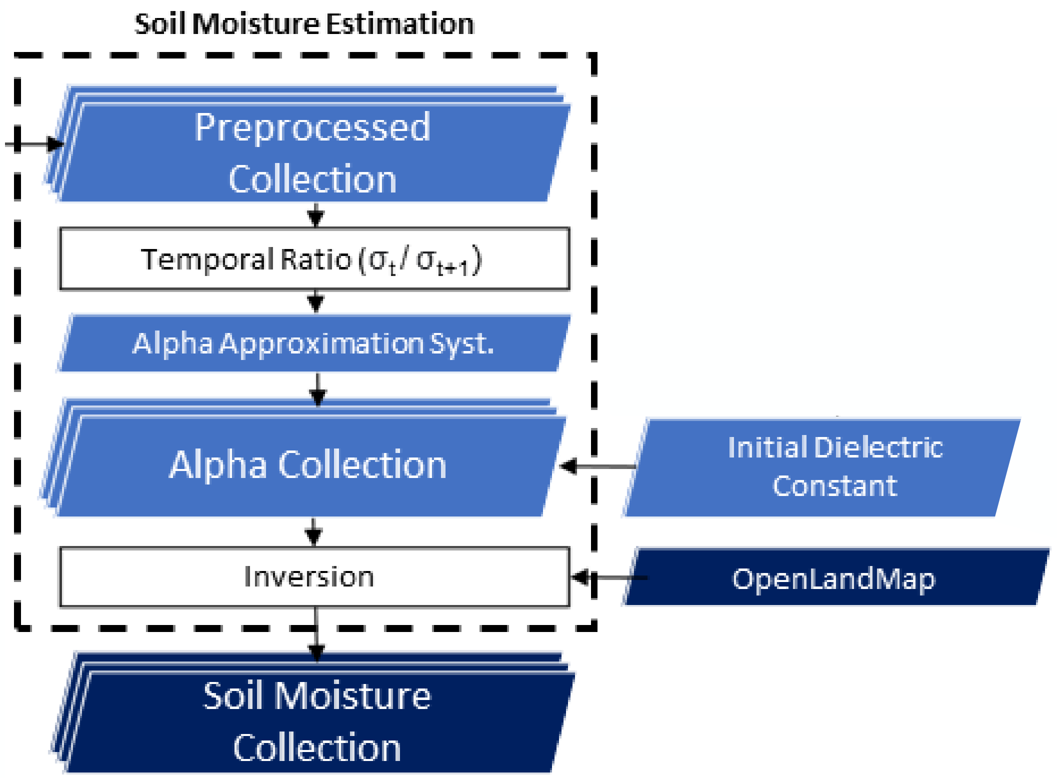
Short term change detection

Basic principle: Between two consecutive SAR observations, change in backscattering signal is caused by a change in dielectric constant and incidence angle as other surface parameters do not change considerably within short time interval

$$\left(\frac{\sigma_0^{(2)}}{\sigma_0^{(1)}}\right) \approx \left|\frac{\alpha_{PP}^{(2)}(\varepsilon^{(2)},\theta)}{\alpha_{PP}^{(1)}(\varepsilon^{(1)},\theta)}\right|^2 \qquad |\alpha_{VV}(\varepsilon,\theta)| = \left|\frac{(\varepsilon-1)\left(sin^2\theta - \varepsilon(1+sin^2\theta)\right)}{\left(\varepsilon\cos\theta + \sqrt{\varepsilon - sin^2\theta}\right)^2}\right|$$

→ **Underdetermined linear equation system**



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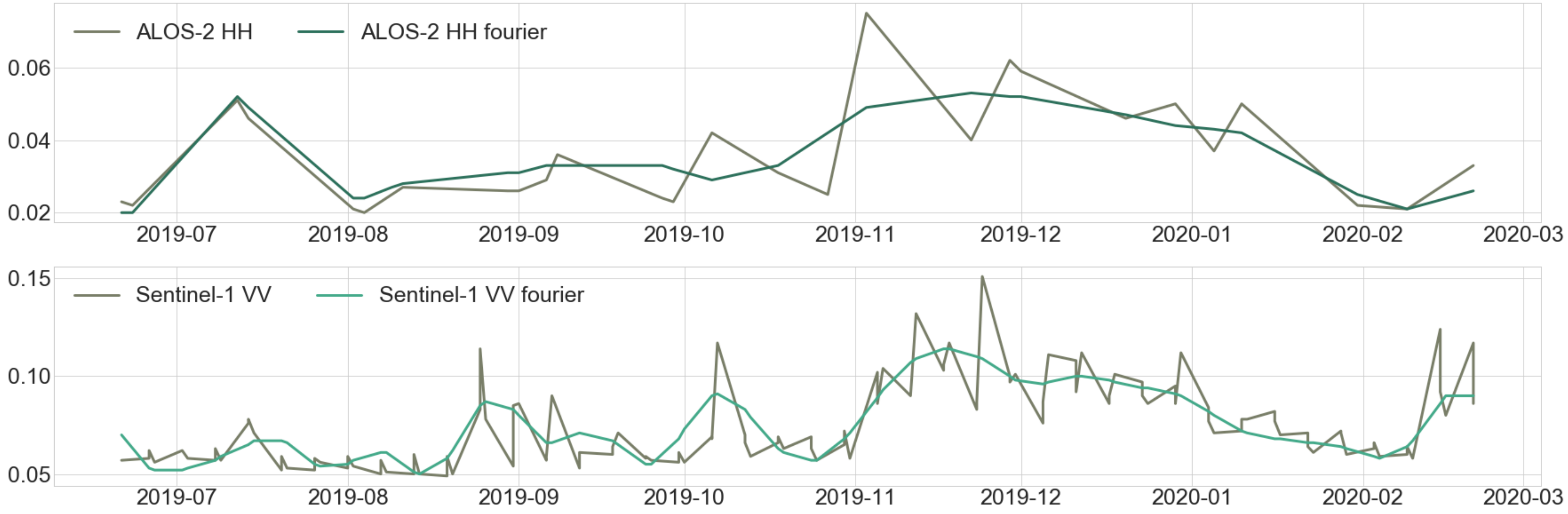
Reducing incidence angle effect:

- Incidence angle normalization to reference angle
- Fourier series transformation, excluding frequencies lower than orbit revisit time



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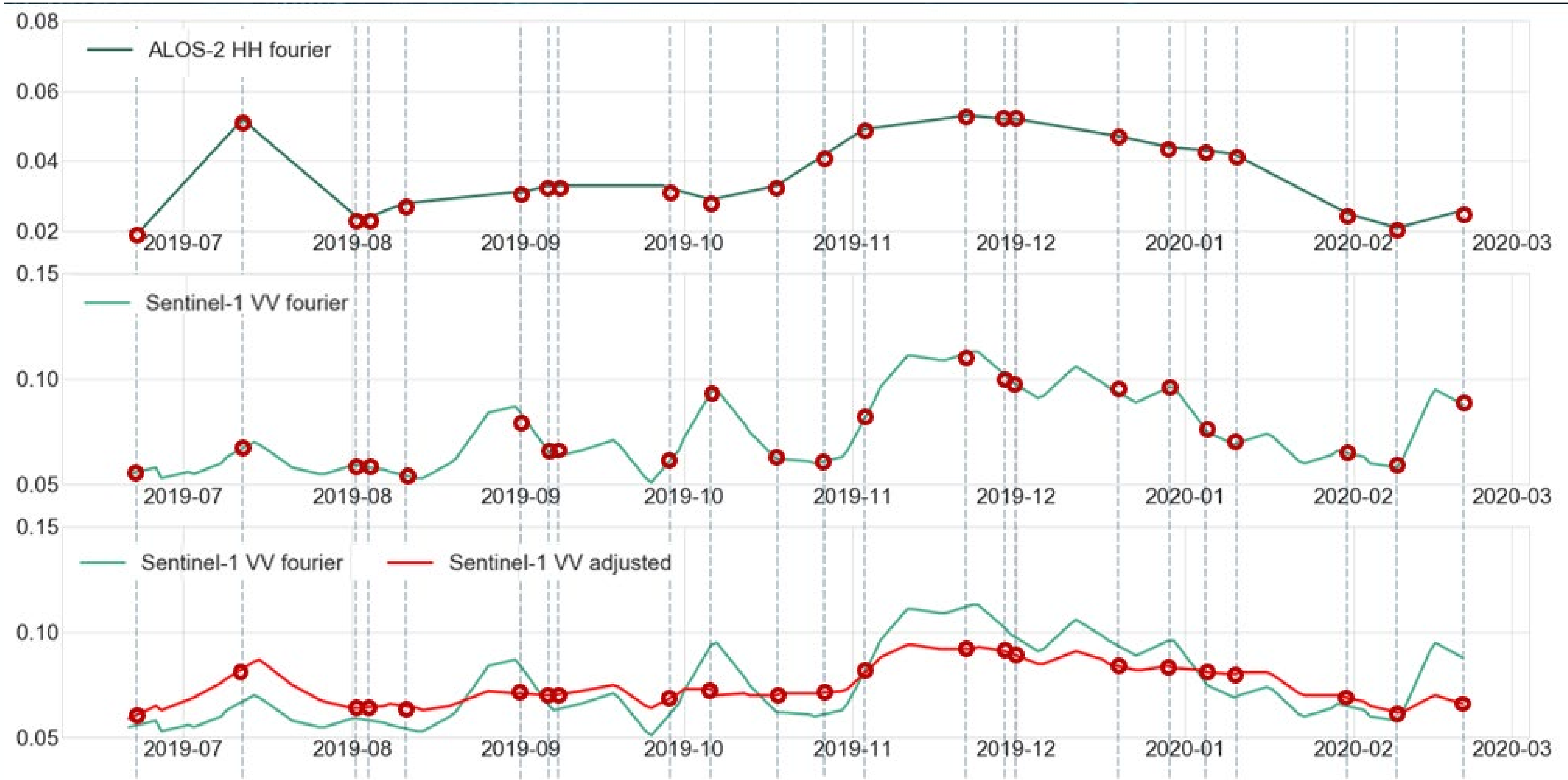
Combining C- and L-band timeseries:

- Changes in L-band are less affected by vegetational influence and serve as “reference” points
- Between L-band acquisitions, C-band timeseries are stretched to match the observed L-band scenes
- Stretched timeseries is shifted to match observed C-band mean value



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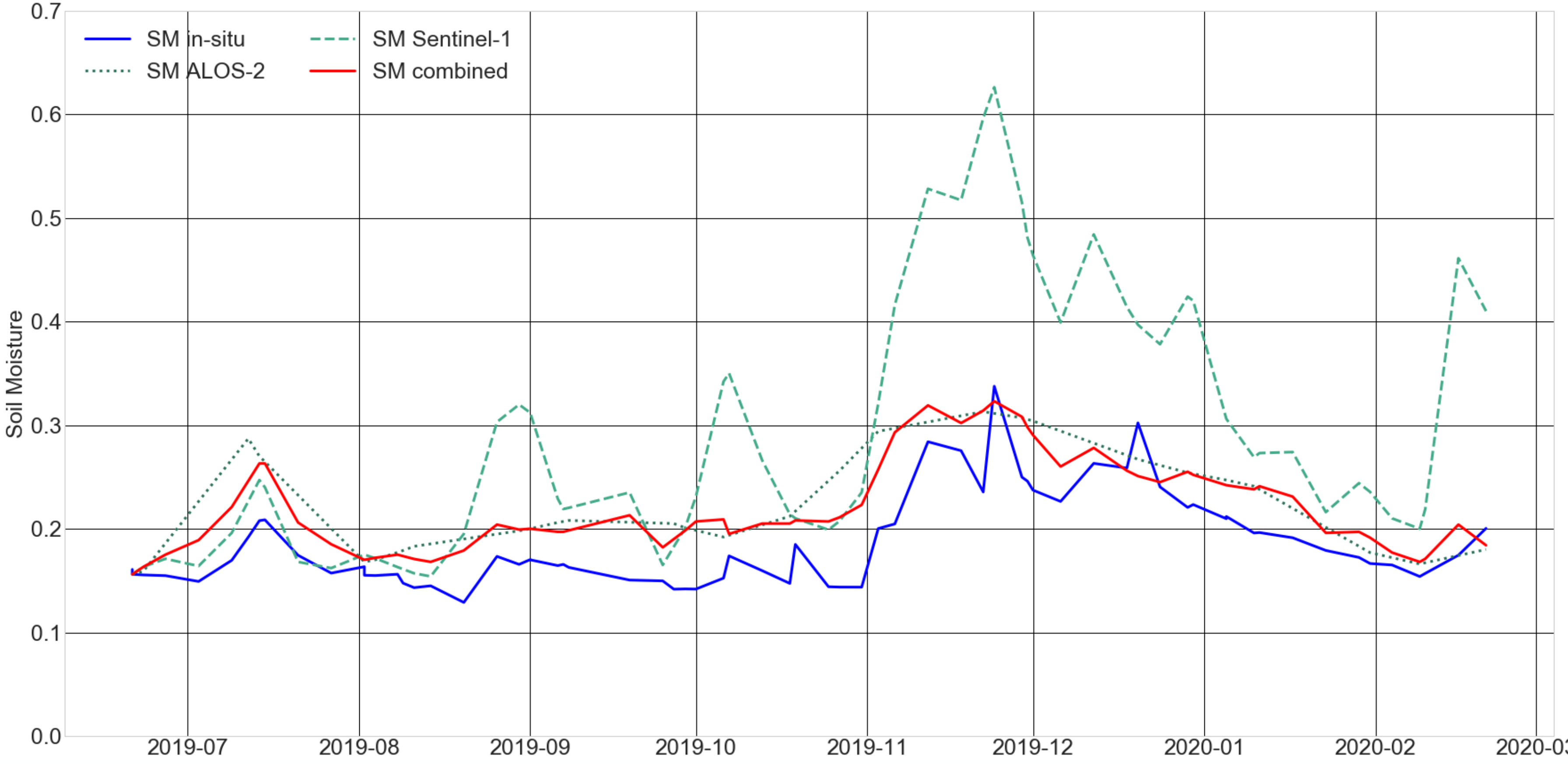
Comparison between C-band, L-band and combined soil moisture estimation

- Soil moisture estimation from Alos-2 matches in-situ measured soil moisture better in absolute terms, but sparse temporal resolution leads to lack of correlation
- Soil moisture estimation from Sentinel-1 has higher correlation but also higher absolute error
- Soil moisture estimation from both C- and L-band combines higher correlation and lower absolute error



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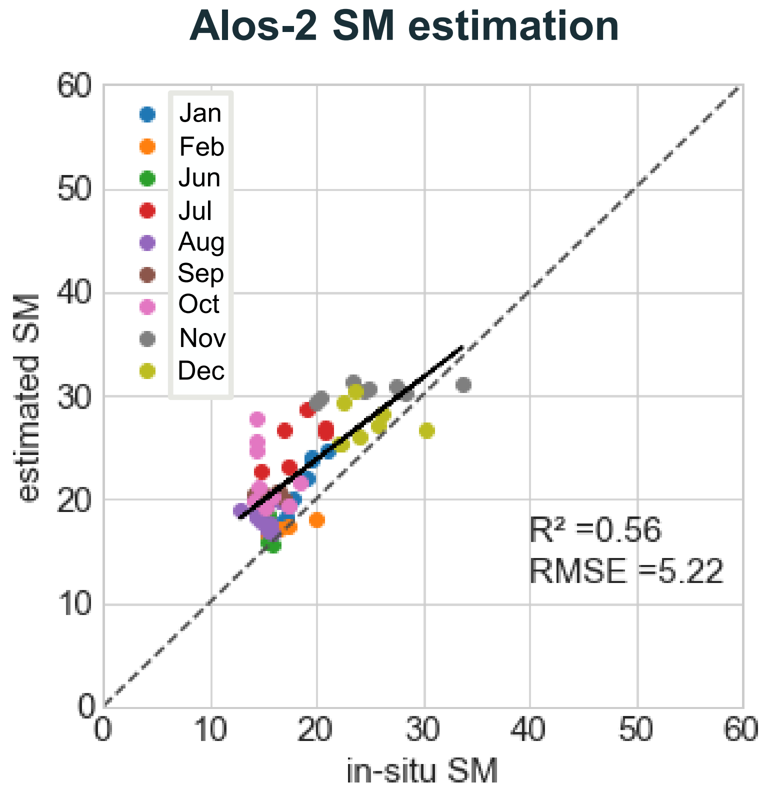

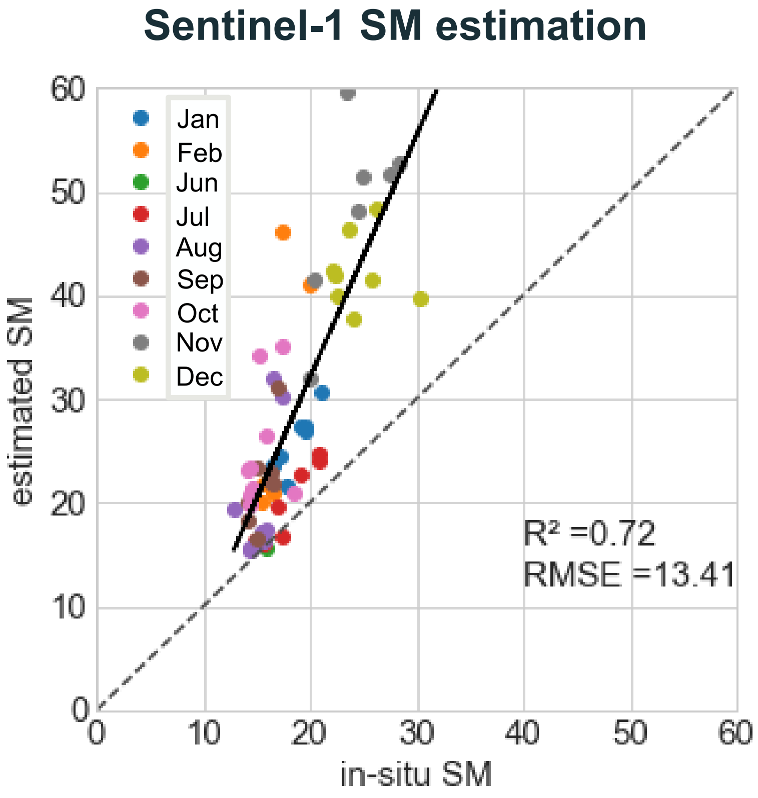

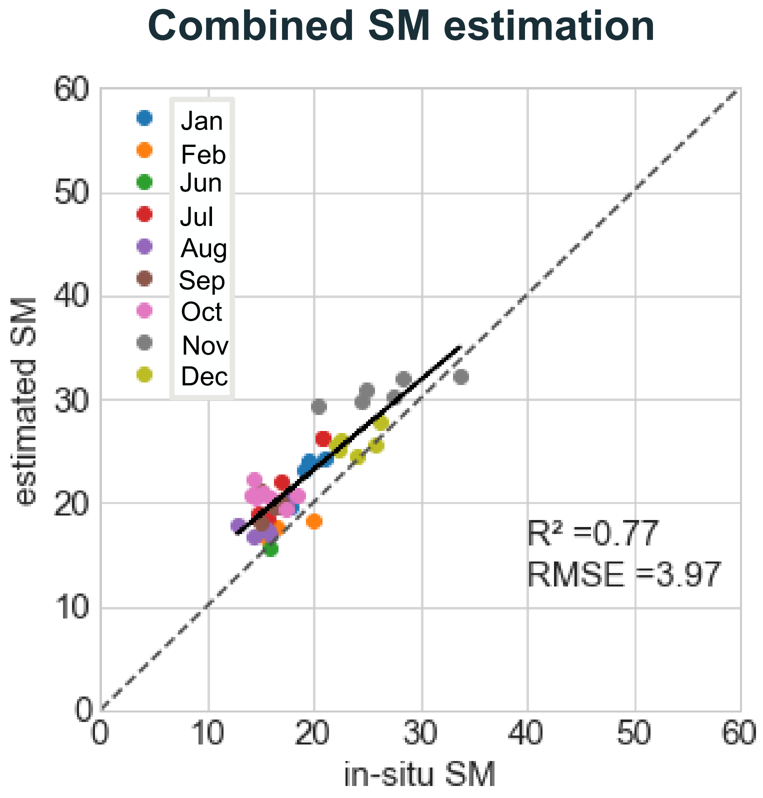

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Conclusion & Outlook

- Taking advantage of high temporal resolution from Sentinel-1 and vegetation insensitivity from ALOS-2 increase correlation and reduce RMSE of soil moisture estimation
- For wheat, temporal resolution of 2-3 weeks of Alos-2 is sufficient to level out vegetational bias of C-band timeseries
- Examine C- and L-band combination for different crop types (e.g. sugar beet, potatoes, maize), especially under dense vegetation conditions
- Matching backscatter changes between low and high temporal resolution timeseries

Questions?

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