Leveraging EnMAP for building soil reflectance composites with Sentinel-2

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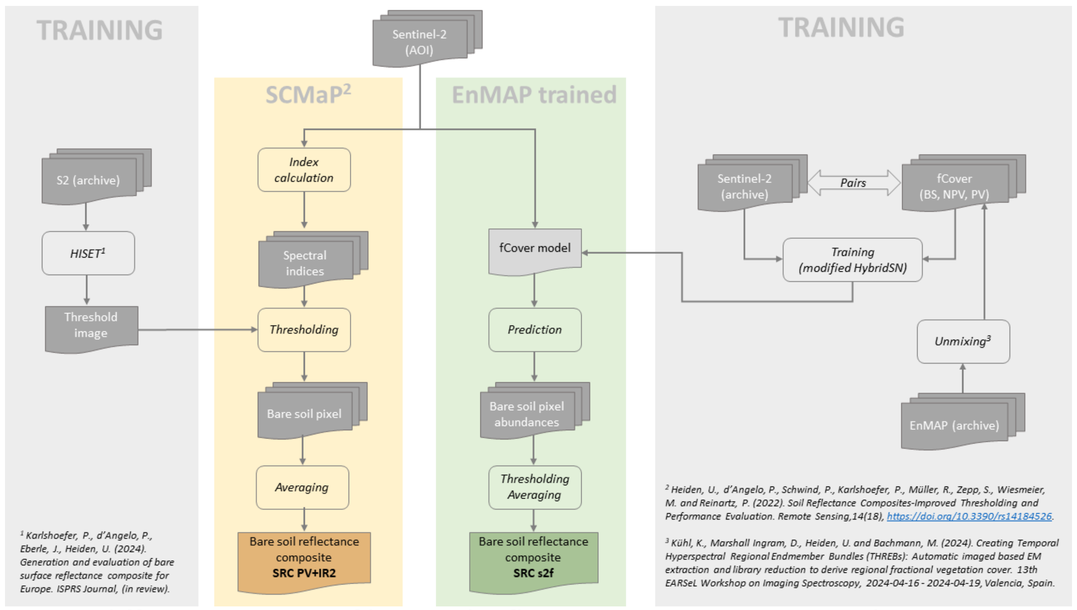
EO-based bare soil reflectance composites (SRC) are essential:

- for large scale soil parameter analysis,
- to differentiate agricultural areas with tillage (conventional) and with reduced or no-tillage (conservation) and
- to evaluate the impact of soil erosion processes.

https://www.biosphaerenreservat-rhoen.de/service/newsarchiv/detailseite/140-teilnehmende-bei-biosphaerentagung-zum-thema-klimaanpassung-und-klimaschutz#&gid=lightbox-group-2242&pid=0

https://www.bauernzeitung.ch/dossier/pflanzen/bodenschonende-verfahren-im-ueberblick-399738

Impact of bare soil and dry vegetation on erosion processes (reference: see photograph)



Testing different concepts of bare soil reflectance compositing using the SCMaProcessor and the fCover processor developed at DLR.

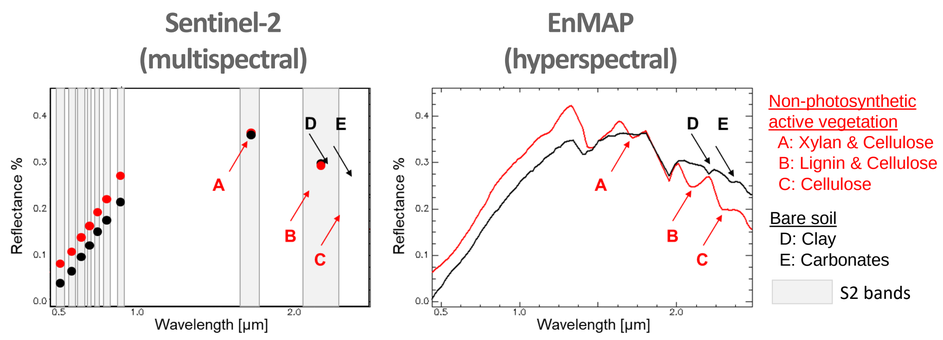
Test site – Sentinel-2 31UFS (Belgium)

Google Earth image

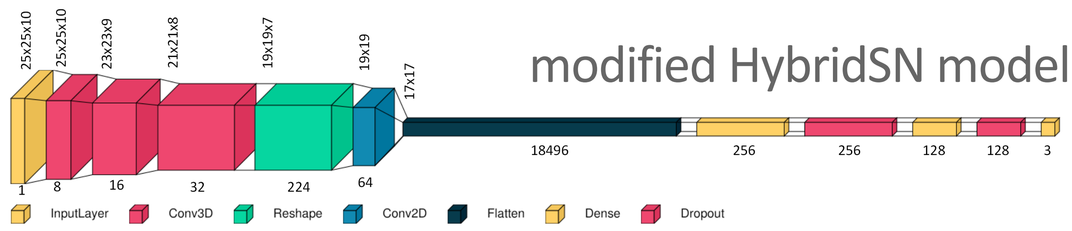
The test area is covered by the UTM tile 31UFS covering the area South-East of Leuven (Belgium). It is dominated by agriculture and shows a mixture of pastures and crops. The results below are shown for a subset of the 31UFS tile, the statistics are calculated for the complete tile.

Pros and cons of hyperspectral image data

A commonly used technique to generate SRCs are to utilize spectral indices applied to multispectral image archives (e.g. Sentinel-2). However, the reduced spectral resolution of Sentinel-2 does not allow for a clear separation between dry vegetation (NPV) and bare soil (BS) but ensures a large coverage and frequent observations.

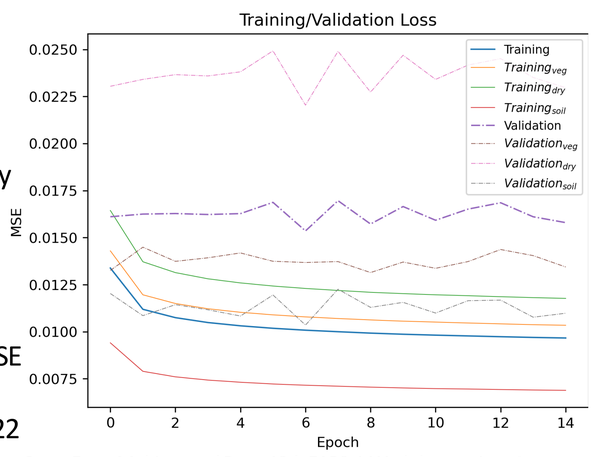


Hyperspectral EnMAP data allows for a spectroscopy based separation of NPV and BS on a sub-pixel level but lacks at coverage and frequent observations. In this study, **we leverage the growing hyperspectral archive of EnMAP** to predict bare soil abundances with Sentinel-2 data stacks to build improved bare soil reflectance composites (flowchart left). We trained a modified HybridSN model with Sentinel-2 L2A scenes paired with EnMAP-based abundance maps of bare soil (BS), dry (NPV) and green vegetation (PV) of the same day and area.



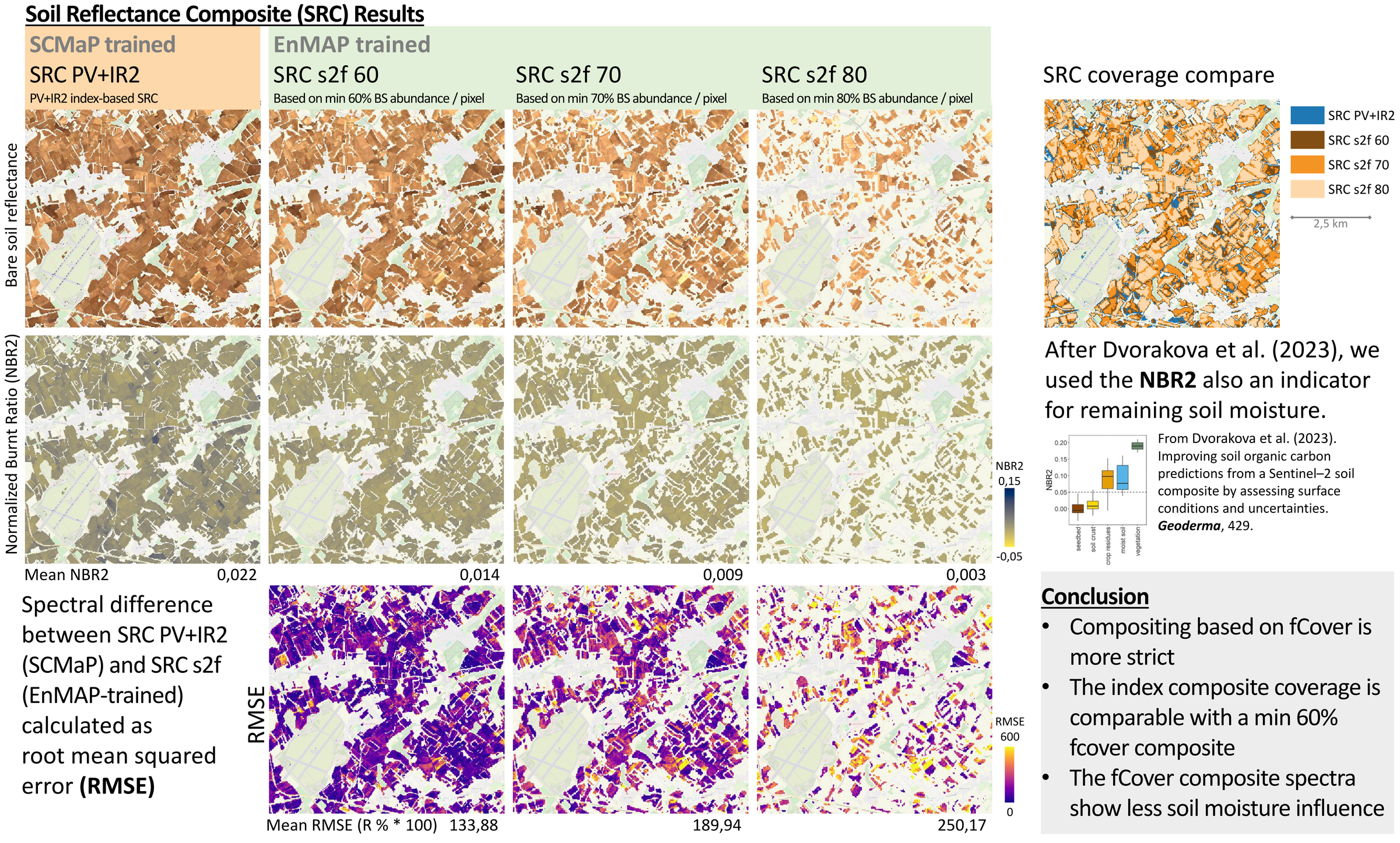
The model is trained with 61 S2-EnMAP$_{fcover}$ maps. 55 pairs are used for training[4]:

- (30.579.104 patches with size 25x25x10; randomly flipping training patches in X/Y to prevent overfitting
- Trained on single NVIDIA GeForce RTX 2080 Ti
- Training for 15 epochs (1 epoch =157 minutes)
- Min. validation loss achieved at epoch 7: 0.015 MSE
- The mean squared error (MSE) for sample fCover predictions in mid Europe range from 0.025 – 0.022



[4]Schwind, P. et al. (2024). Using Deep Learning To Generate Fractional Vegetation Cover From Multispectral Data. 13th EARSeL Workshop on Imaging Spectroscopy, 2024-04-16 - 2024-04-19, Valencia, Spain.

Soil Reflectance Composite (SRC) Results



Spectral difference between SRC PV+IR2 (SCMaP) and SRC s2f (EnMAP-trained) calculated as root mean squared error **(RMSE)**

SRC coverage compare

After Dvorakova et al. (2023), we used the **NBR2** also an indicator for remaining soil moisture.

From Dvorakova et al. (2023). Improving soil organic carbon predictions from a Sentinel–2 soil composite by assessing surface conditions and uncertainties. ***Geoderma***, 429.

Conclusion

- Compositing based on fCover is more strict
- The index composite coverage is comparable with a min 60% fcover composite
- The fCover composite spectra show less soil moisture influence