# Identifying And Mapping Soils From Remote Sensing Hyperspectral Sensors With fCover

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EnMAP

Supported by:
Federal Ministry for Economic Affairs and Climate Action
on the basis of a decision by the German Bundestag

## Introduction

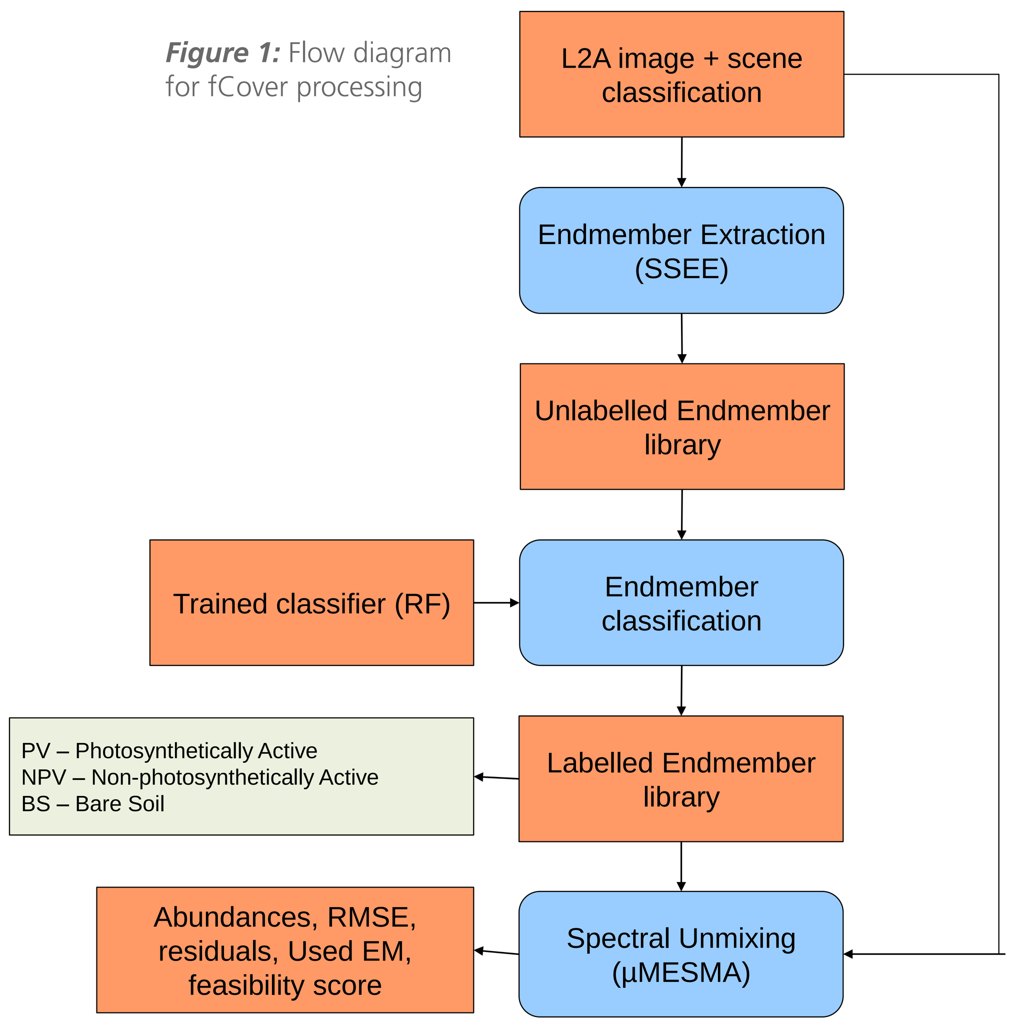
- Identifying pure soil spectra from remote sensing images is vital for:
  - mapping soil parameters (soil organic carbon, soil mineral composition)
  - assessing soil health
  - integrating into soil models.
- However, pixels are often large and a mixture of soil and vegetation.
- A clear strategy is required to disentangle spectral signals of soil, photosynthetically active vegetation (PV) and non-photosynthetically active vegetation (NPV)
- Hyperspectral images are required to distinguish between these different classes, taking advantage of well resolved spectral features (incl. ligno-cellulose absorption feature at ~2100 nm, clay absorptions at ~2200 nm)
- Hyperspectral sensors are becoming more abundant: DESIS, PRISMA, HISUI, EnMAP, CHIME, SBG, HySpex, AVIRIS-NG.

## fCover Processor

To find pure soil spectra, a fractional vegetation cover processor (fCover) is used to calculate per pixel soil abundances (Figure 1).

1. Identify pure spectra (vegetation and soil) from the image using a spatial-spectral endmember extraction method and compile these into an endmember library.
2. Label each endmember as PV, NPV or bare soil with a Random Forest classifier.
3. Using a MESMA unmixing approach, treat each pixel in the original image as a linear combination of one PV spectrum, one NPV spectrum and one soil spectrum from the labelled endmember library. An additional component for shade is also considered and the results are optionally normalised to sum to one. The weights on each component correspond to the abundance of each class.
   Expected accuracies (expressed as abundance RMSE) shown in Figure 2.
4. Use the abundance value derived for the soil class to identify pixels of relatively pure bare soil.

*Figure 1:* Flow diagram for fCover processing



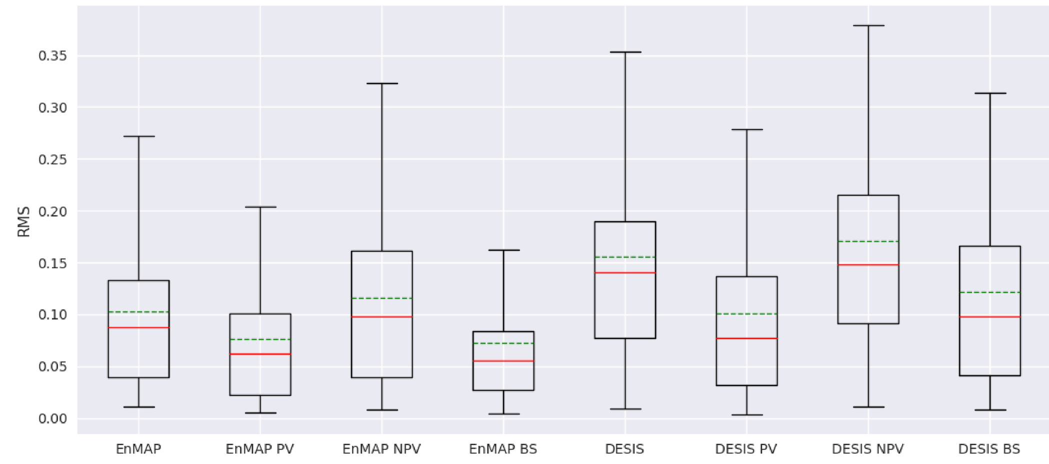




*Figure 2:* Abundance error estimation (as RMSE) for fCover results at PRISMA/EnMAP resolution (450-2500 nm) and DESIS resolution (450-1000 nm) based on a synthetic study. The RMSEs are derived for all classes and for each individual class.

## Camarena, Spain

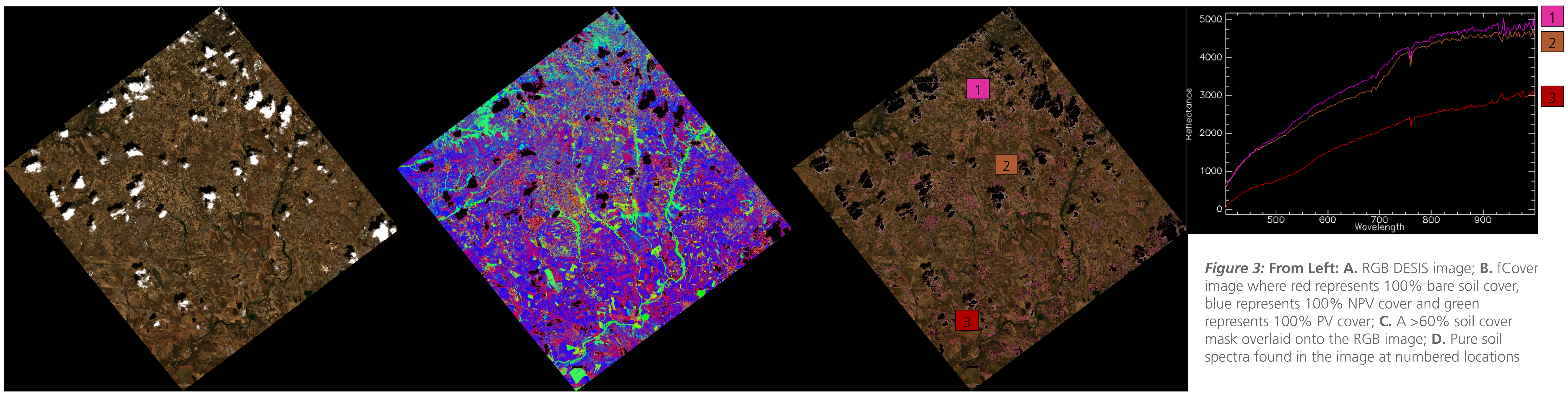



*Figure 3:* **From Left: A.** RGB DESIS image; **B.** fCover image where red represents 100% bare soil cover, blue represents 100% NPV cover and green represents 100% PV cover; **C.** A >60% soil cover mask overlaid onto the RGB image; **D.** Pure soil spectra found in the image at numbered locations

The first study uses observations of Camarena, central Spain from the spaceborne system DESIS. Camarena is a rainfed agricultural area covering about 75 km² in a semi-arid climate (Figure 3A). The results of the fCover processing show a dry region with widespread areas of NPV (shown in blue in Figure 3B). There are few pure soil pixels – the masking applied in Figure 3C is a result of thresholding with soil abundances greater than 60%. Three examples of these pure soil spectra are given in Figure 3D at the numbered locations.

## Central Israel

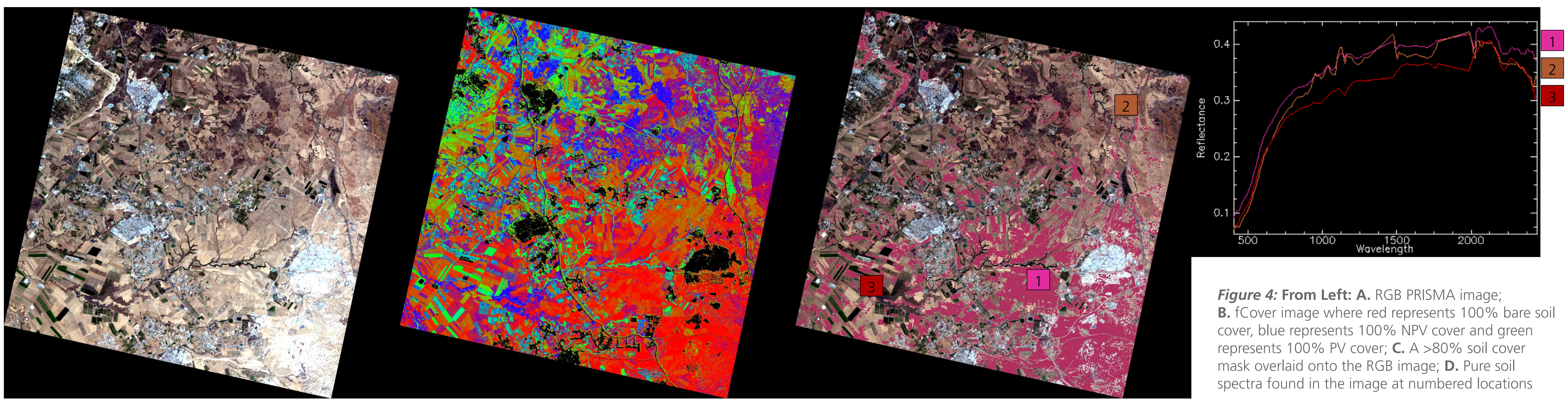



*Figure 4:* **From Left: A.** RGB PRISMA image; **B.** fCover image where red represents 100% bare soil cover, blue represents 100% NPV cover and green represents 100% PV cover; **C.** A >80% soil cover mask overlaid onto the RGB image; **D.** Pure soil spectra found in the image at numbered locations

The second case study covers a 900 km² area in central Israel with spaceborne data from PRISMA (Figure 4A). The observation includes agricultural and urban areas as well as expanses of bare soil. With fCover (Figure 4B), a large area of soil shown in red is identifiable in the bottom right corner of the image. The masking applied in Figure 4C denotes areas where the soil abundance was found to be greater than 80%. Three of these pure soil spectra are shown in Figure 4D from the numbered locations.

### References

- Bachmann, Martin et al. (2009) *Increasing and evaluating the reliability of multiple endmember spectral mixture analysis (MESMA).* 6th EARSeL-SIG-IS, 16.-18. März 2009, Tel Aviv, Israel.
- Bayer, Anita et al. (2016) *Combining Field and Imaging Spectroscopy to Map Soil Organic Carbon in a Semiarid Environment.* IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 9 (9), Seiten 3997-4010. IEEE - Institute of Electrical and Electronics Engineers.
- Marshall, David et al. (2021) *An automated operational processor for the determination of fractional vegetation cover from DESIS observations*. 1st DESIS User Workshop
- Rogge, Derek et al. (2012) *Spatial Sub-Sampling Using Local Endmembers for Adapting OSP and SSEE for Large-Scale Hyperspectral Surveys.* IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 5 (1), Seiten 183-195. IEEE - Institute of Electrical and Electronics Engineers.

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