Sentinel-1 SAR data to visualize the growth dynamic in cropland

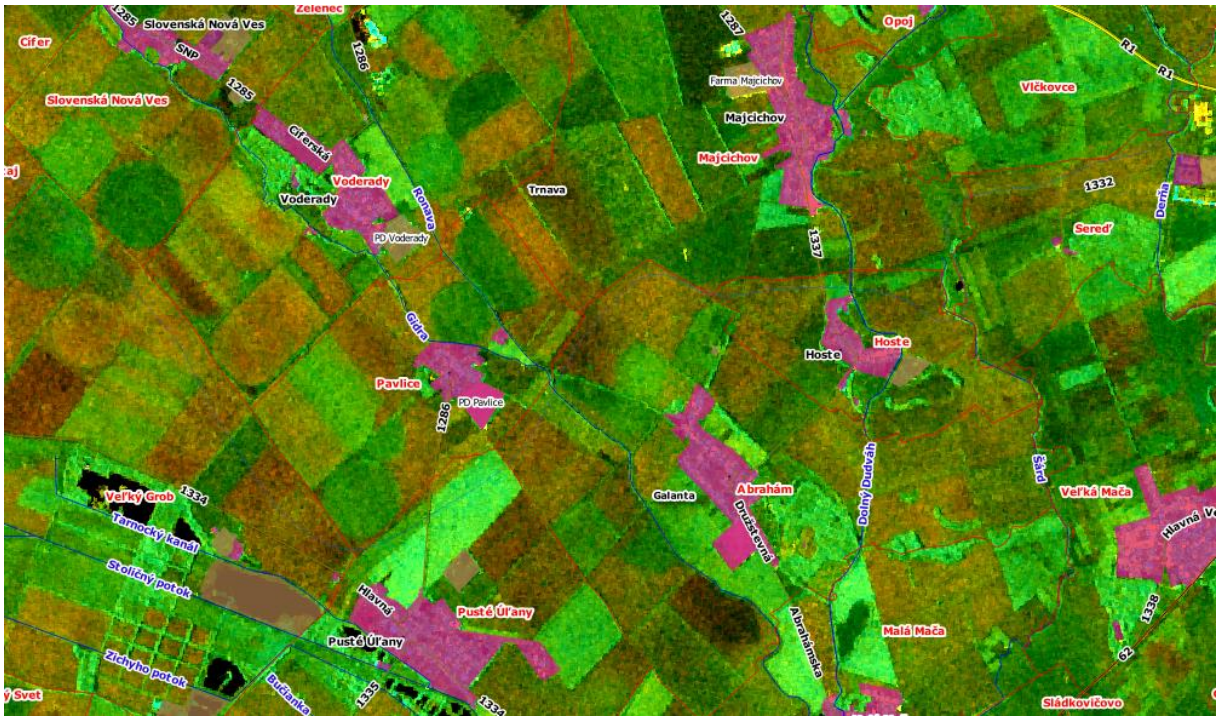
In farming and especially precision farming we have a technology driven crop production. But still crop development follows natural processes, which vary due to weather conditions and site-specific circumstances. We can support with remote sensing to monitor crop development and assist farmers with actual data from their cropland.

When we talk about crop-growth we are looking at the development of fresh biomass.
SAR (synthetic aperture radar) measures the structure and humidity and can be seen as a proxy for fresh biomass. Such sensors are mounted on the two Sentinel-1 satellites, which are operated by ESA (European Space Agency). The data is world-wide available and can be downloaded free of charge.

Since SAR (synthetic aperture radar) is independent from atmospheric disturbances, it is ideal for time-series analysis and change detection. The active sensor delivers a constantly reliable measurement and acquires data each time from the same angle with the same energy.
This means, that the changes in values are changes of biomass development on cropland.
This enables us to generate high quality map products for crop monitoring over the entire season.

The following images show four different map products from Sentinel-1 SAR data.
Those are a pseudo-true **Color Composite**, which is a RGB image composed from three layers from one single date. The **ESVI** (enhanced SAR Vegetation Index), which is a proxy for fresh biomass.
The **GCB** (Gradual Change of Biomass), which is derived from two succeeding ESVI.
And **EVO** (Evolution), which is again a RGB derived from three succeeding ESVI.

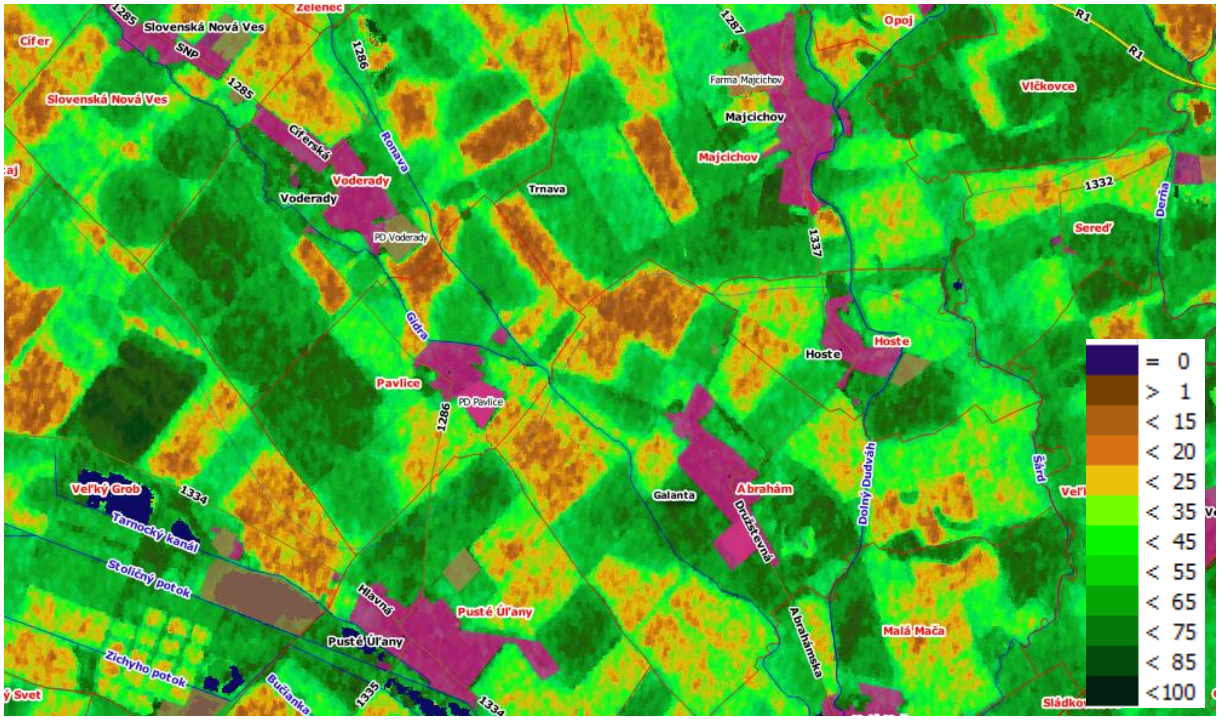
The area for this case study is in the south-west of Slovakia and the observation took place in August 2022. Winter crops were already harvested and the summer crops are grown up.



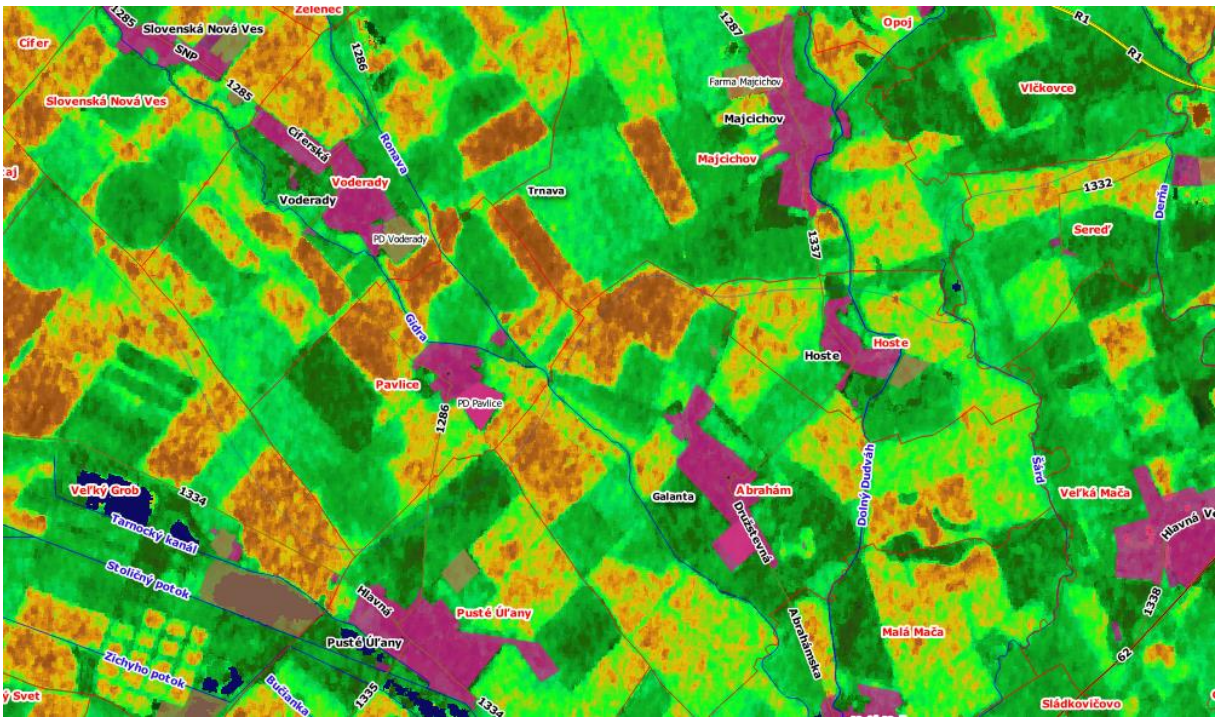
The image shows a single-date Color Composite from August 29, 2022 derived from Sentinel-1 SAR data. You see the different plots and some soil bound structures within the plots. Some plots have a bright green color, which represents high values of fresh biomass. Plots that appear in brown color show bare soil or in this case plots which were harvested and are covered with dry plant residues.

The map product has a high spectral contrast and gives an overview over the spatial variability of crop development. It helps to detect anomalies within single plots.

The next example is an ESVI (enhanced SAR Vegetation Index) which represents the fresh biomass content in a scale from 0-100. The legend definition is valid over all crop-types and seasons. It cannot be transferred directly into to/ha. But it can be seen as a proxy for LAI (Leaf Area Index), which is a biophysical parameter for yield modelling. The image below is the ESVI from August 5, 2022

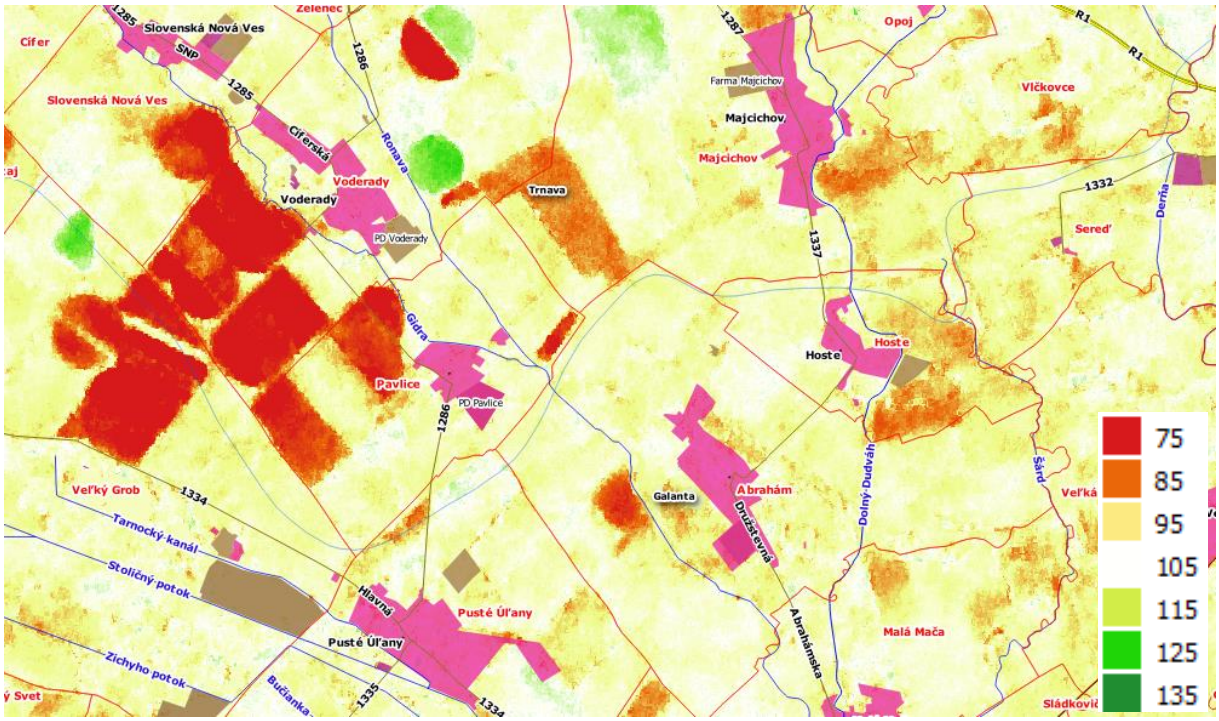


Followed by the ESVI 12 days later. August 17, 2022



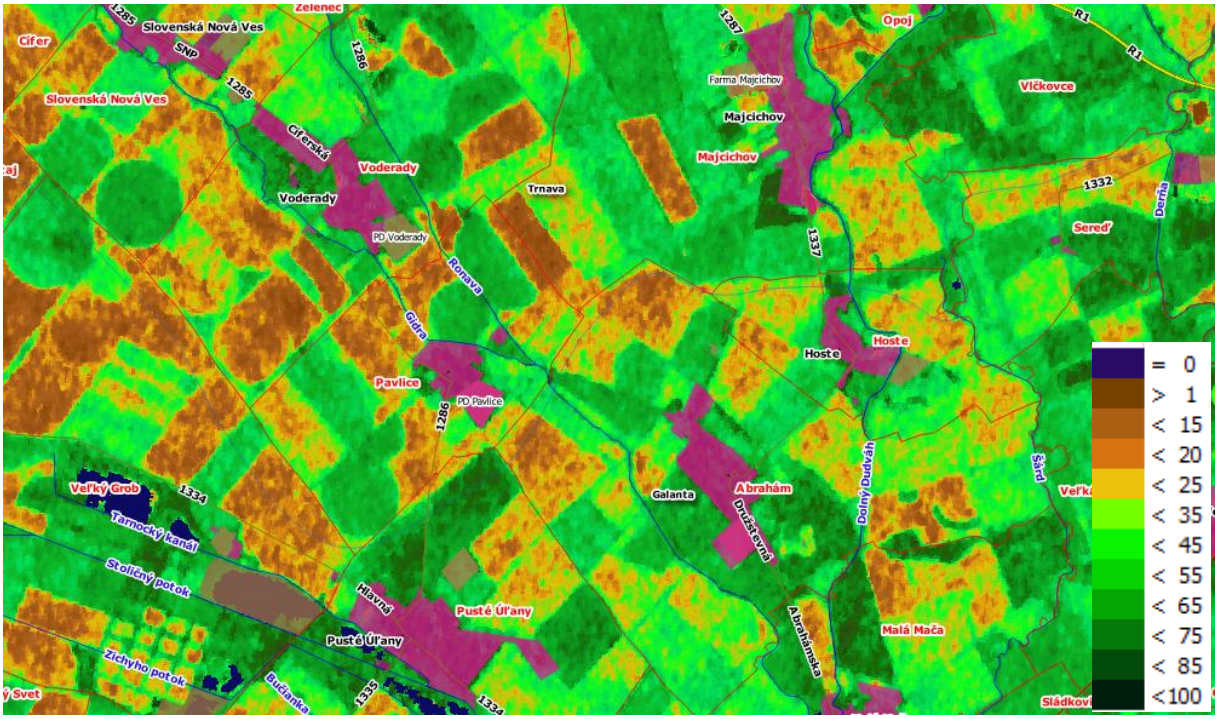
The legend covers the whole range of vegetation in green colors. Slight differences appear more or less in the same color and are not easy to differentiate in this map product.
Nevertheless the values can be statistically analyzed and can be compared with other plots of the same crop type or cross seasonal. A higher spectral contrast you will see in the next example.

We can use ESVI of two succeeding acquisitions and set them into relation, in order to show the Gradual Change of Biomass and put it in a higher contrast. Red colors show a decrease and green colors show an increase of ESVI values. The GCB from August 17, 2022 shows the change between the actual and previous acquisition.

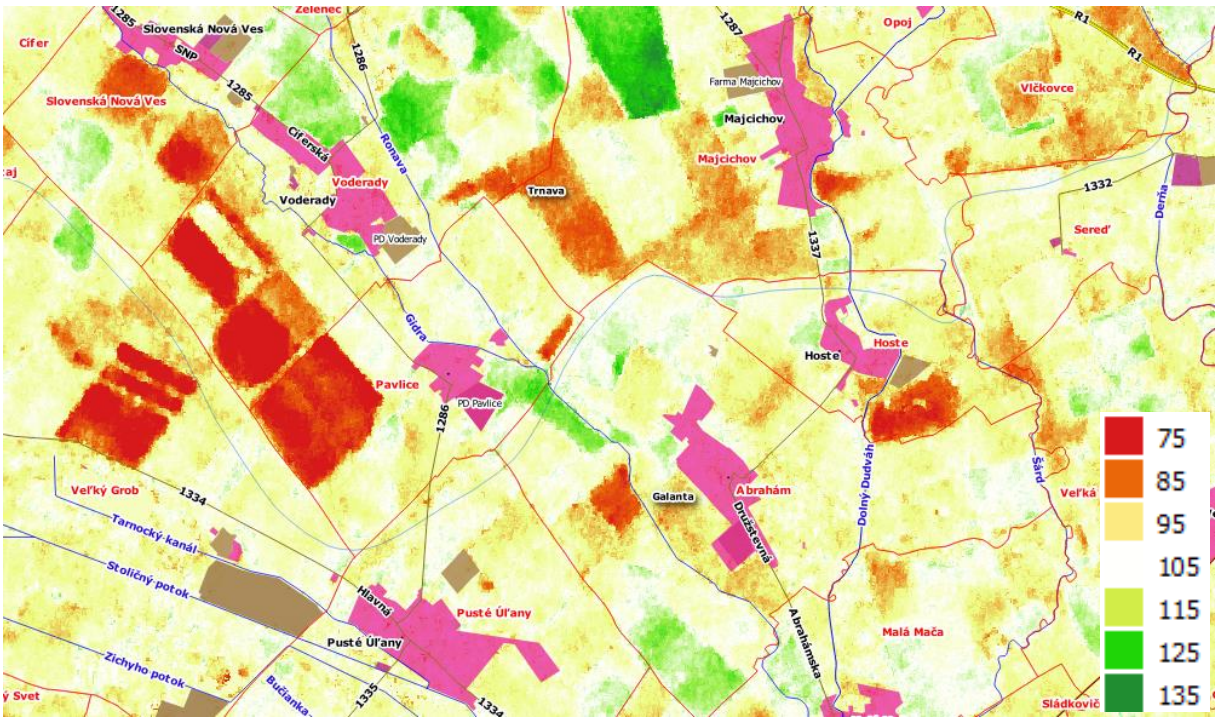


We calculate the difference between 2 succeeding datasets and add the value 100 to have integer values. A value of 75 shows a decrease of 25 ESVI units. This is a substantial reduction in ESVI units.

The next image is the ESVI from August 29, 2022.
We can again observe slight changes in crop growth compared to the ESVI from August 17, 2022.



The next image represents the GCB from August 29, 2022. We see the change between the actual and previous acquisition and observe that some plots have a significant reduction for the second time. But it is the relative change of ESVI units and not the absolute value.



Below we see the map product Evolution, which combines three succeeding ESVI into a RGB image. In grey-white color we see permanent high values over the whole period. Those are normally forests. In black we see inland water bodies and bare soil, where the bare soil condition persists over the past 24 days. In green we see an increase of values. In bright green the increase is on a high level. In dark green the increase is on a low level. In pink we see a decrease of the values. Again bright color means that the decrease is on a high level and dark color means, that the decrease is on a low level.

These four map products can assist farmers in better understand the actual growing processes on their cropland and help them to pass better management decisions in order to save input costs, achieve higher yields and work more sustainable.