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Quantification of intra-plot variability of vine water status using Sentinel-2 : case study of two Belgian vineyards

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For decades, vines have been grown in dry regions, as the plant has to grow under water deficit to produce quality wines. Due in part to climate change, vine cultivation is developing in historically cooler and more humid regions. In addition to climate, soil and plant material are the terroir factors that most influence the water status of the vine, and conditions can be different within the same vineyard plot, implying heterogeneous vineyard management to achieve optimal wine quality.

The objective of this study is to explore the potential of Sentinel-2 to characterize the intra-plot variability of vine water status and its evolution through time.

Two Belgian vineyards, with high soil water availability intra-plot variation and different grape varieties, were selected. Both vineyards have grass in the inter-row and the spatial distributions of soil depth and soil water holding capacity (WHC) were measured. A cumulative drought index (DI_{cum}) was also estimated for each plot.

Four years (2018, 2019, 2020 and 2021) of Sentinel-2 images of these two Belgian vineyards were analyzed. Several spectral indices, based on the blue, red, NIR and SWIR bands on a 10 x 10 m² grid, were calculated and compared to quantify the evolution of the water status of the vine, as a function of the weather conditions (DI_{cum}), the grape variety and the WHC. Predawn leaf water potential (Ψ_{pd}) measurements were collected *in situ* at different dates during dry periods in order to compare them with the remote sensing indices.

We observed that spectral indices and the WHC were better correlated when the water conditions were the most constraining for the vine (e.g. $R^2 = 0.72$ on 16/08/18 for NDWI/EVI), i.e. when DI_{cum} is lowest. Edaphic heterogeneity is therefore better captured by spectral indices when conditions are dry for the vine. The spectral indices have a low value when the WHC is low, and *vice versa*. The spectral index NDWI/EVI quantifies the water status of the vine better than the NDWI, when comparing linear regressions between the two spectral indices and the Ψ_{pd} measured in the field ($R^2 = 0.67$ for NDWI/EVI; $R^2 = 0.64$ for NDWI).

In conclusion, the NDWI/EVI spectral index, measured from the Sentinel-2 bands, is promising for quantifying the spatial distribution of vine water status on a regular basis at the plot scale.