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Using Sentinel-1 and -2 satellite time series to monitor crop phenology at the parcel level

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Phenology can contribute to many scientific disciplines from climate change, biodiversity, agriculture and forestry to human health. The knowledge of timing of phenological events and their variability can provide valuable data for agriculture. Accurate and timely information on the dates of specific stages of crop development is needed for various applications including crop yield forecasting. Despite the proven capabilities of Sentinel satellites for crop mapping and estimating phenology, they have not yet been applied effectively for tracking crop development across large areas.

A methodology is proposed to systematically identify phenology phases from time series generated by the Copernicus Sentinel-1 (S1) and Sentinel-2 (S2) sensors. This is done by linking specific agricultural-parcel temporal S1 and S2 signatures to phenology observations representative for 5-km buffers around the 6573 Deutscher Wetterdienst (DWD) stations spatially distributed across Germany. First, a S1-based 10-m crop type classification was made around each DWD station trained with LUCAS (Land Cover and Land Use Area frame Survey) 2018 data which allowed identifying parcels as well as crop types. Second, the average crop specific S1 (VV and VH) and S2 (NDVI) temporal signal is extracted for each DWD station and the correlation between the DWD BBCH event and characteristic behaviour in the satellite signals such as dips or peaks is systematically assessed for each crop.

This approach identified the unique and crop-specific temporal signatures of S1 and S2 associated with specific phenology events such as emergence, flowering or ripening. We further discuss the potential and limitations of S1 and S2 to extract this type of information. These temporal S1 and S2 signatures can contribute to a digital reference library that could be used to monitor crop phenology operationally for parcels across the globe. Moreover, it unveils the potential of S1 and S2 to study detailed spatial and temporal gradient of crop phenology in the light of climate change.