

# HYDRO-CLIMATIC DRIVERS OF SAR BACKSCATTER IN VINEYARDS TO SUPPORT AGRICULTURAL STATISTICS

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## Objective

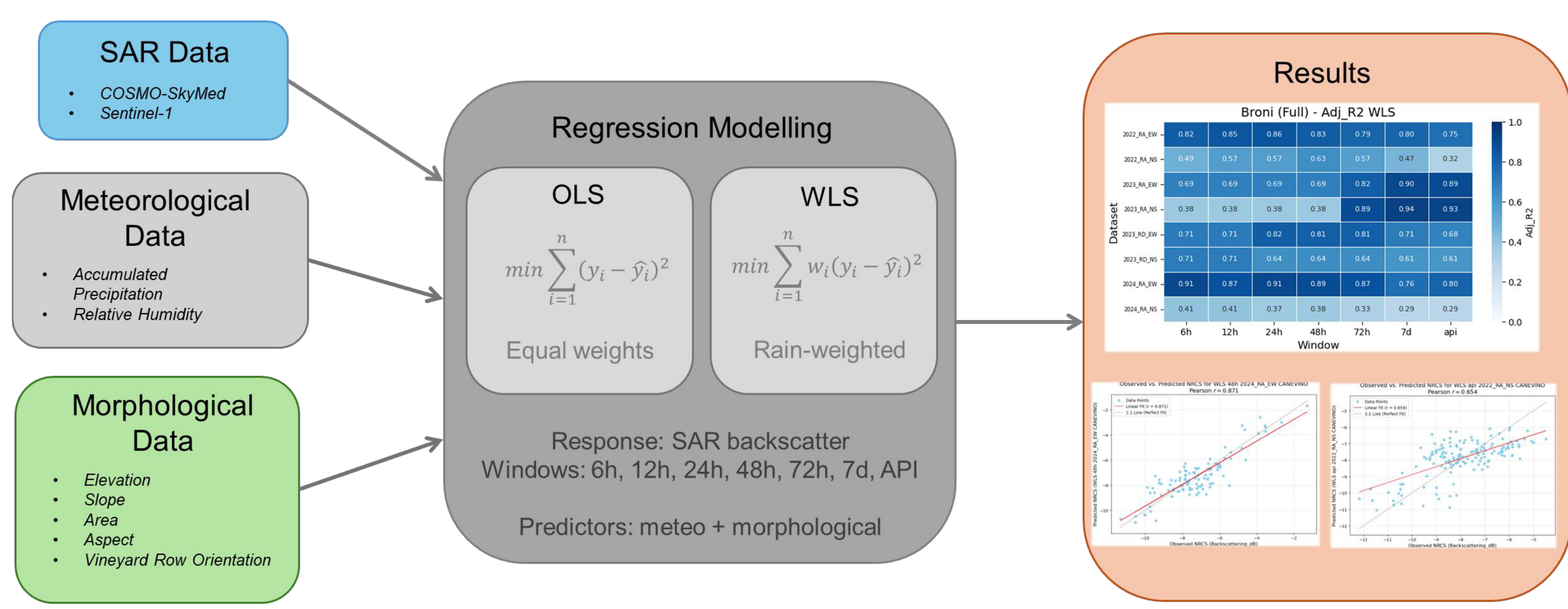
The aim of this study is to assess the capability of morphological and hydrometeorological parameters to estimate SAR backscatter variability in vineyards, focusing on their statistical relationship with canopy moisture and structure.

## Overview

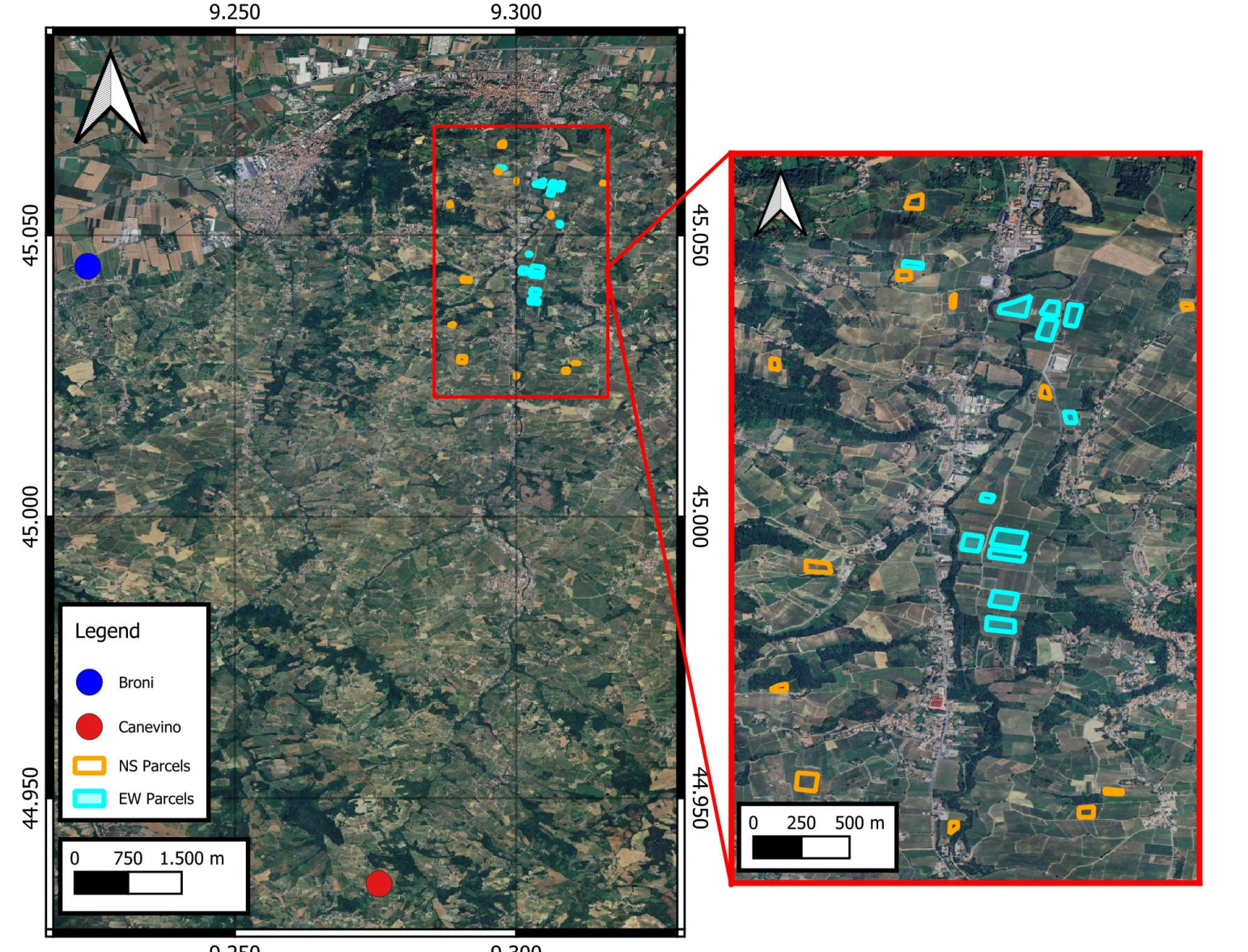
While remote sensing has been widely employed to investigate vineyard phenology [1], current approaches rely predominantly on optical data and UAV platforms. These methods are limited by weather conditions and often lack the structural sensitivity required for robust biomass estimation [2]. This study addresses this gap by exploring the potential of Synthetic Aperture Radar (SAR) technology as a tool for assessing vineyard vulnerability and structural response to environmental stressors. The analysis focuses on the Oltrepò Pavese winemaking region of northern Italy, where climate change has become a challenging factor. We posit that precise knowledge of vineyard biomass is not only relevant for carbon sink quantification but is also a key indicator of the crop's capability to withstand increasingly warm and dry conditions.

## Data & Methodology

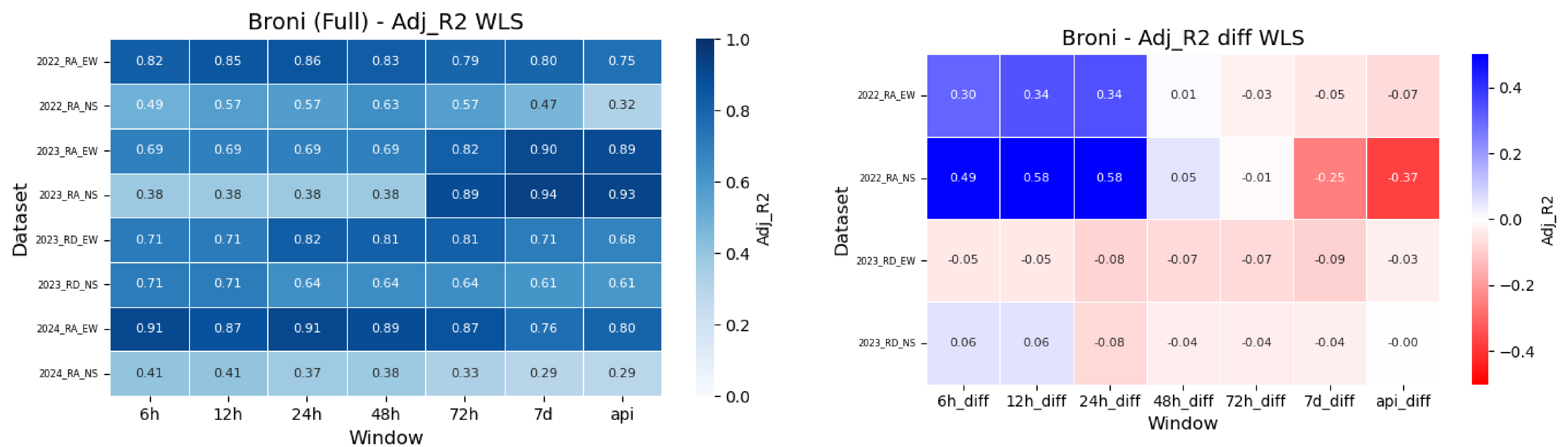
<b>Study Area</b>	Oltrepò Pavese, northern Italy
<b>Vine Parcels</b>	24 selected parcels: • 12 East–West (EW) row orientation • 12 North–South (NS) row orientation
<b>SAR Data</b>	<b>Sentinel-1</b> : VV, VH polarization — ascending orbit (RA, 17:15); descending orbit (RD, 05:35) <b>COSMO-SkyMed</b> : HH polarization — ascending orbit (RA, 04:50); descending orbit (RD, 17:20)
<b>Meteorological Data</b>	ARPA Lombardia weather stations: • Broni: closer to the parcels, different agroclimatic characteristics • Canevino: farther from the parcels, similar agroclimatic characteristics
<b>Morphological Data</b>	Derived from Copernicus DEM GLO-30 (Global 30 m Digital Elevation Model), processed in Google Earth Engine



This research analyses the complex interaction between vegetation structure and meteorological hazards, specifically focusing on the influence of accumulated rainfall and dew formation on radar backscatter. Building on previous, multi-sensor SAR observation of vineyards [3] we present a simple linear regression modelling framework. Three input data streams are combined: SAR backscatter time series, meteorological variables, and morphological parcel descriptors. Ordinary Least Squares (OLS) and Weighted Least Squares (WLS) models are compared, with WLS assigning higher importance to observations coinciding with rainfall events. Model performance is evaluated across seven temporal windows of antecedent rainfall, ranging from 6 hours to a cumulative API-based index, to assess the sensitivity of radar backscatter to precipitation at different timescales. To evaluate the impact of dew, an analysis on dew-free subsets was performed, retaining only satellite acquisitions unaffected by dew deposition.



## Results



Results suggest the WLS models outperform OLS models, regardless of the sensor. CSK X-band backscatter integrates rainfall over a broad range of temporal windows (adj.  $R^2$  up to 0.94), while Sentinel-1 C-band is more sensitive to intermediate timescales (24h, 48h), consistent with C-band's deeper canopy penetration and greater sensitivity to soil moisture accumulation following rainfall. EW-oriented parcels show significantly higher performance compared to NS (adj.  $R^2 \geq 0.61$  for EW vs.  $\leq 0.41$  for NS), supporting the assumption that parcel geometry influences radar backscattering. Regarding dew, early morning acquisitions systematically capture canopy wetness (adj.  $R^2$  difference up to +0.58), suggesting that dew has a significant impact on the SAR signal. Results are consistent across both weather stations, suggesting limited sensitivity to the choice of meteorological data source for this case study.

## Conclusion

The study develops linear regression models to estimate the influence of meteorological and morphological drivers on SAR backscatter in a viticultural environment. The models successfully capture the primary determinants of backscatter variability. Future studies will aim to enhance the vineyard statistics evolution through mixed-effects models and the integration of additional biophysical parameters, as well as contributions from other optical and radar sources. This work highlights the potential of SAR-derived modelling as a driver for agricultural statistics, helping seasonal monitoring and management of vineyards.

## Bibliography

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- [2] Weiss, M., Jacob, F., & Duveiller, G. (2020). Remote sensing for agricultural applications: A meta-review. *Remote Sensing of Environment*, 236, 111402.
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