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AI-driven analysis of multi-resolution Earth Observation data for vineyard disease pressure and crop water demand

In this abstract, we present a multi-scale framework that combines satellite and aerial imagery with machine-learning models to support advanced decision-making in Mediterranean agriculture, with a focus on vineyards. The work brings together two complementary application domains: early detection of vine diseases and irrigation management based on crop evapotranspiration (ETc).

Within the PERBACCO project, we conduct high-resolution airborne surveys over thousand hectares of vineyards to detect grapevine diseases, such as Flavescence Dorée and other grapevine yellows, through a RGB-based spectral indices analysis. These maps provide field-level labels to train a convolutional neural network on commercial high-resolution satellite data, including Pléiades and Pléiades Neo. The model ingests pan-sharpened image chips and derived vegetation indices to perform binary classification of vineyard parcels, distinguishing healthy from anomalous canopies across the Emilia-Romagna region.

In parallel with the SEMAFORO project, we integrate in-field measurements from weather stations and soil moisture probes with optical and radar data from open Copernicus missions and other sources. Multi-temporal patches derived from Sentinel-2 optical bands, Sentinel-1 SAR polarisations and a digital elevation model are used to drive a geospatial foundation model that estimates weekly crop evapotranspiration at parcel scale. The satellite-based estimates are trained against sensor-derived ETc and compared with operational services. The model reproduces the expected seasonal dynamics of water use across multiple farms and crops in Sicily and remains consistent with ground-based ETc envelopes, indicating that Earth Observation-only ETc can support the design of simple, rule-based irrigation policies and quantify potential water savings without dense sensor networks.

Taken together, these studies show how the joint use of public and commercial imagery, ranging from decametric Sentinel-2 to sub-metric Pléiades and aerial data, can underpin a coherent pipeline for monitoring both disease pressure and water demand in vineyards. The approach is designed to scale to larger regions using High Performance Computing resources, paving the way for operational services that deliver timely, spatially explicit information to growers and water managers.

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Authors: TRICOMI, Alessia Rita (Istituto Nazionale di Fisica Nucleare (Sezione di Catania) & Dipartimento

di Fisica e Astronomia, Università di Catania & Centro Siciliano di Fisica Nucleare e Struttura della Materia); Dr SABISTER, Francesco (Centro Siciliano di Fisica Nucleare e Struttura della Materia (CSFNSM)); HASNAIN, Ghulam (Dipartimento di Fisica e Scienze della Terra, Università di Ferrara & Istituto Nazionale di Fisica Nucleare (Sezione di Ferrara) & Università degli Studi di Trento/Università degli Studi di Ferrara - CUP E66E24000190005); ANASTASI, Gioacchino Alex (Dipartimento di Fisica e Astronomia, Università di Catania & INFN Catania); PIPARO, Giuseppe (Istituto Nazionale di Fisica Nucleare (Sezione di Catania)); ELEK, Nedime Irem (Dipartimento di Fisica e Scienze della Terra, Università di Ferrara & Istituto Nazionale di Fisica Nucleare (Sezione di Ferrara)); STRATI, Virginia (Dipartimento di Fisica e Scienze della Terra, Università di Ferrara & Istituto Nazionale di Fisica Nucleare (Sezione di Ferrara))

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