EO-based Grassland Production Index (GPI) for estimating drought related yield losses: development in mountainous environment and current challenges

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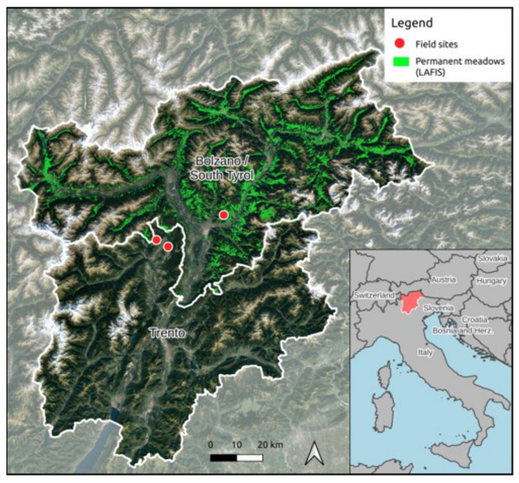
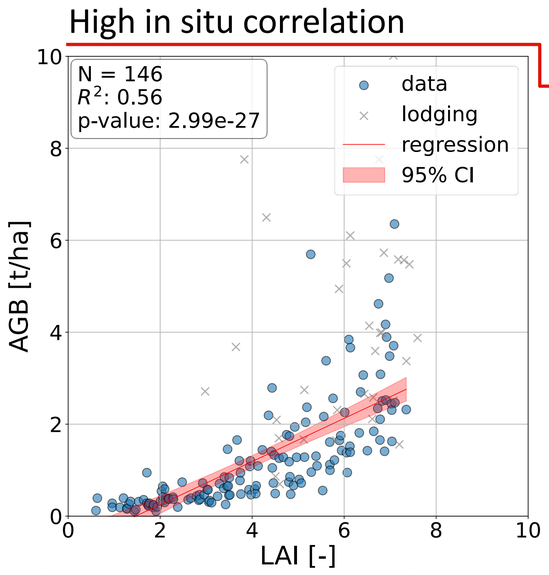
Motivation, GPI definition and validation

Grasslands have a **crucial role** in **alpine ecosystem** regulation, forage production, recreative activities, covering **70%** of South Tyrolean **agricultural areas**.

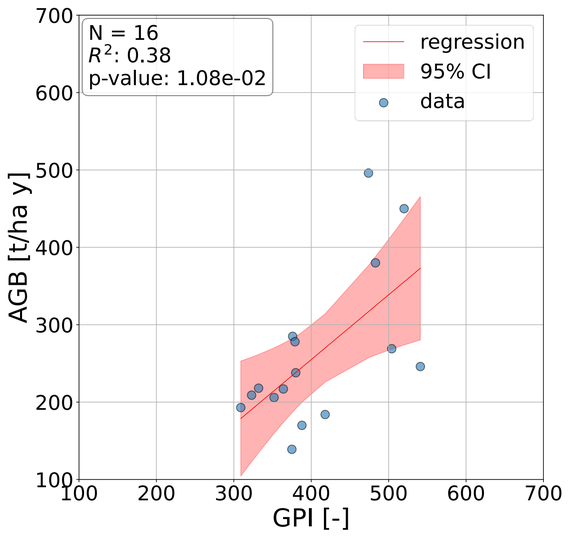
Robust in situ **data collection** for training and validation purposes (**2023-2024**) over **8 parcels**
- Leaf Area Index (**LAI**)
- Above Ground Biomass (**AGB**)



High in situ correlation

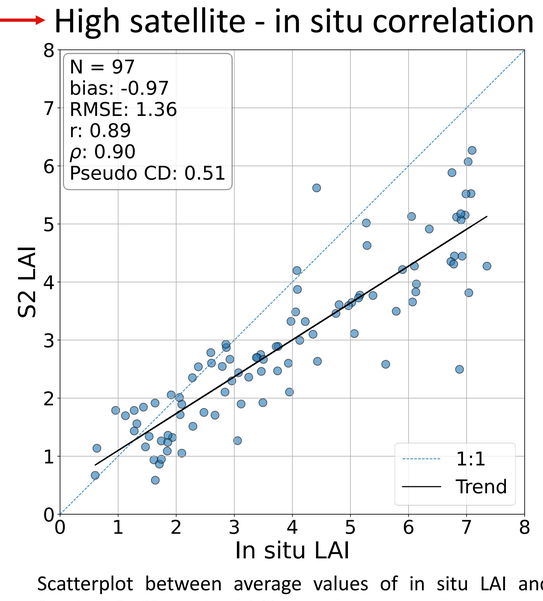


Scatterplot between average values of AGB and LAI over the parcels for the years 2023, 2024. Data associated with lodging events are excluded from the dataset.



Scatterplot between cumulated GPI and AGB over the parcels for the years 2023, 2024. Daily time series obtained with linear interpolation are used for cumulating the parameters over the agricultural season depending on each parcel's elevation.

High satellite - in situ correlation



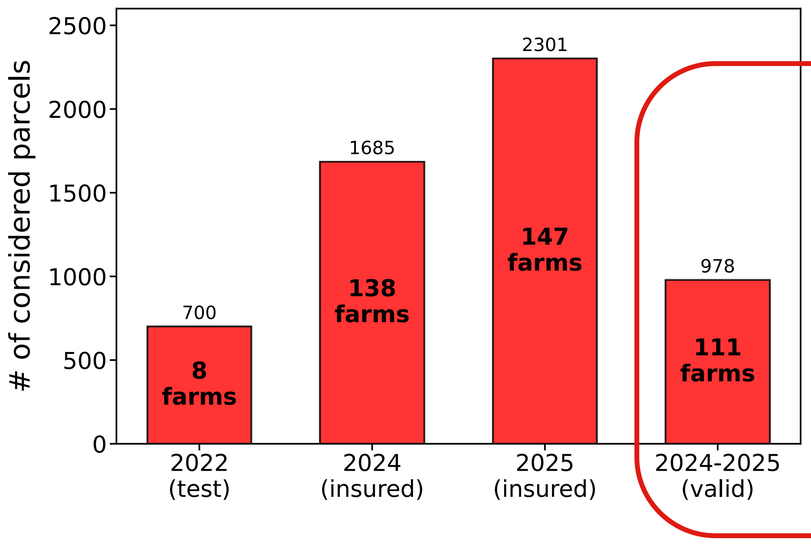
Scatterplot between average values of in situ LAI and Sentinel-2 (S2) derived LAI over the parcels for the years 2023, 2024. S2 LAI is computed from SL2P hybrid physical and Machine Learning (ML) algorithm with 10 m resolution. Data associated with lodging events are excluded from the dataset.

GPI definition (Castelli et al., 2023): cumulated sum over the agricultural season (Start, End Of Season) of the **daily** product between LAI and a meteorological derived Coefficient of Water Stress (CWS, Roumiguié et al., 2016).

$$GPI_n = \sum_{i=SOS}^{i=EOS} (LAI_{grassland\ i} \times CWS)$$

GPI validation

Index-based insurance against drought



Parcel validity due to: size, land cover type and variation over time

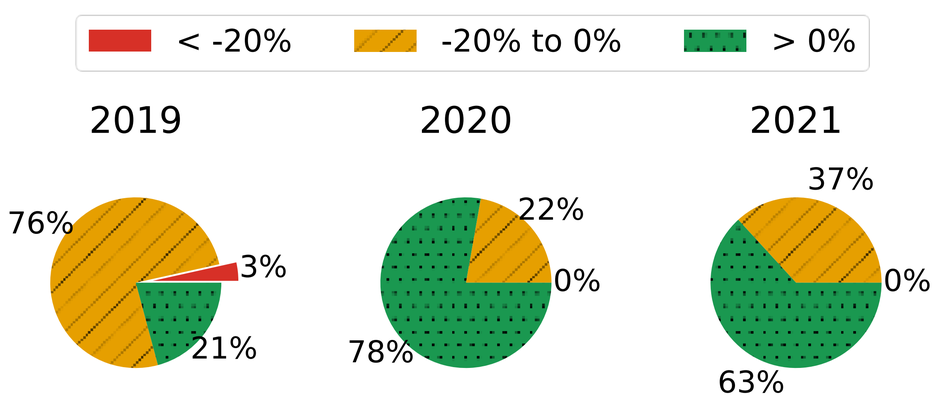
Dataset: valid parcels insured both during 2024 and 2025

Reference time frame for yield variation (ΔGPI) calculation: 2019-2025

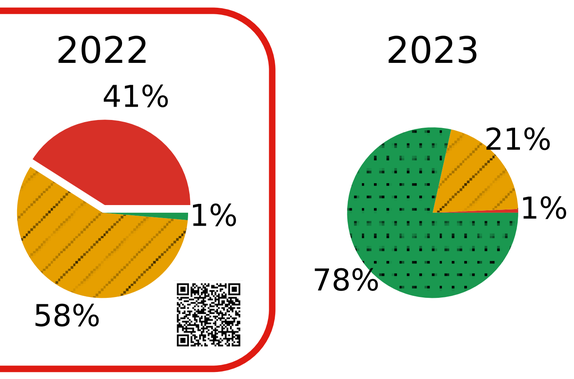
$$\Delta GPI_n = \frac{GPI_n}{Olympic\ average(GPI_{2019}; \ldots; GPI_{2025})}$$

Yield variation (ΔGPI) of classes of parcels of the same farm within the same municipality from 2019 to 2025

Reimbursement eligibility based on **exceedance** of **< -20%** variation over a class

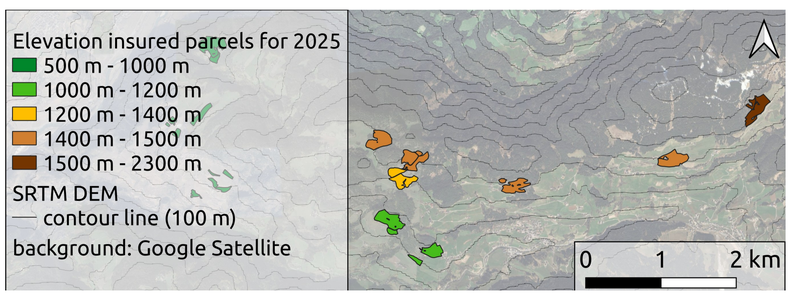


GPI identified 41% of classes with yield variation < -20%, in agreement with the severity of the impact ID 42768 reported in the European Drought Impact Database



GPI intercepts interannual variability of grassland **yield caused** by agricultural **drought** events

Challenges of complex terrain



Altitudinal belts: elevation dependent length of agricultural season

Extremely **high cloud coverage:** no availability of Sentinel-2 optical data

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Optical and SAR data fusion

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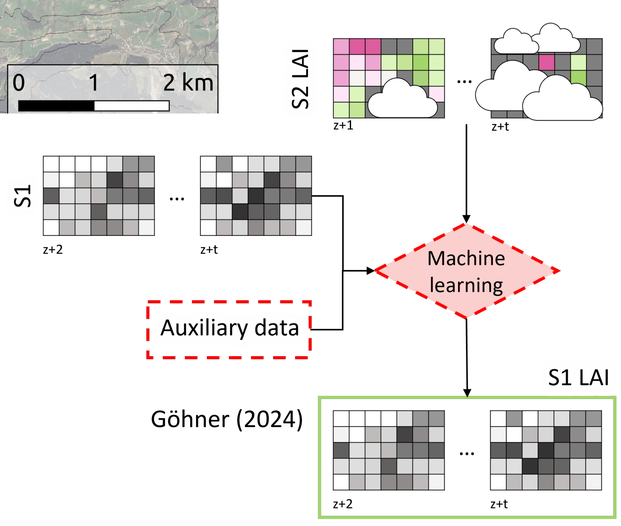
Complex terrain: geometric and radiometric effects on SAR data



References and funding

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