# Multi-sensor correction of Sentinel-2 LAI for pasture biomass estimation in Northern Apennine grasslands

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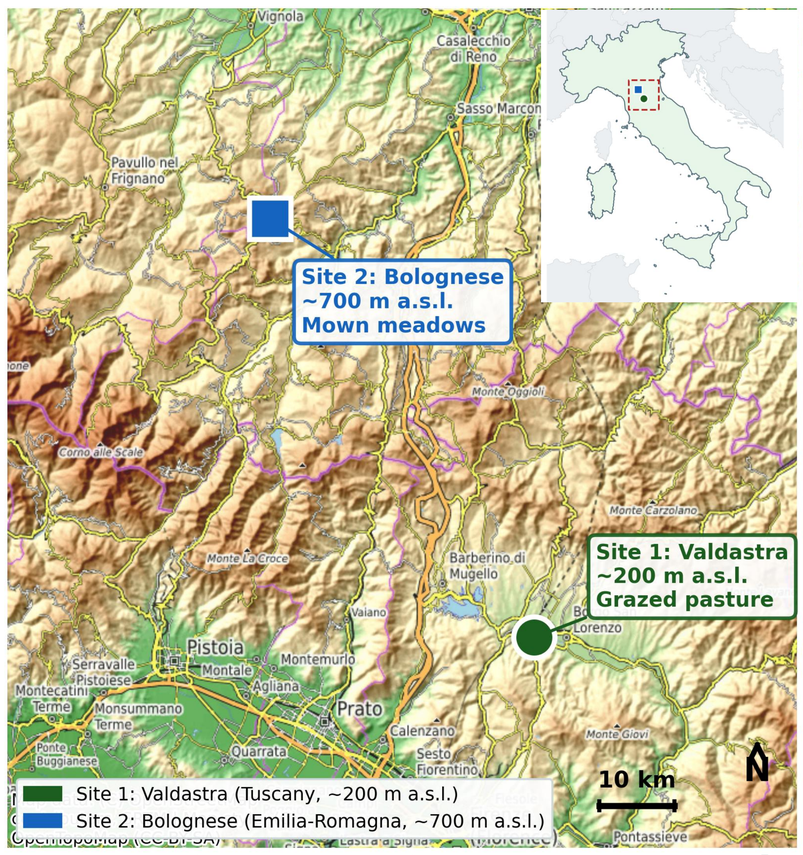
## Introduction

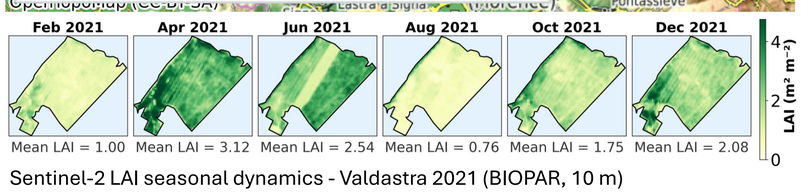
Pasture above-ground biomass (AGB) is a key variable for precision grazing management in mountain areas. AGB is commonly estimated from Sentinel-2 (S-2) **Leaf Area Index (LAI)**, but S-2 LAI products are strongly affected by **phenological state**, **cloud cover**, and **topography**, limiting their reliability as AGB proxies. **Weather**- and **multi-sensor-based corrections** offer a promising avenue to improve S-2 LAI performance by accounting for vegetation physiological state.

### Aims

- Develop and evaluate weather- and multi-sensor-based **corrections for S-2 LAI**
- Assess performance across two **contrasting grassland system**s at different elevations
- Provide a corrected LAI product to support **operational grazing management**

## Study area




Sentinel-2 LAI seasonal dynamics - Valdastra 2021 (BIOPAR, 10 m)

## Methods

### Inputs

**Sentinel-2 LAI (BIOPAR)** | **Sentinel-1 VH Channel** | **ERA5 CHIRPS CFSV2**

### Physiologically-informed correction approaches

- **TBC: Temperature-based Correction**
- **LF: Liebig Factor**
- **VPI: Vegetation Physiological Index**

### LAI Correction Formulae

$$\mathrm{LAI}_{corr} = \mathrm{LAI}_{S2} \times \mathrm{COEF}_B \times \mathrm{Factor}$$

*Where Factor is one of:*

**TBC:** $$\mathrm{T}_{factor} = \exp\left(-\frac{(T - T_{OPT})^2}{2\,\sigma^2}\right)$$

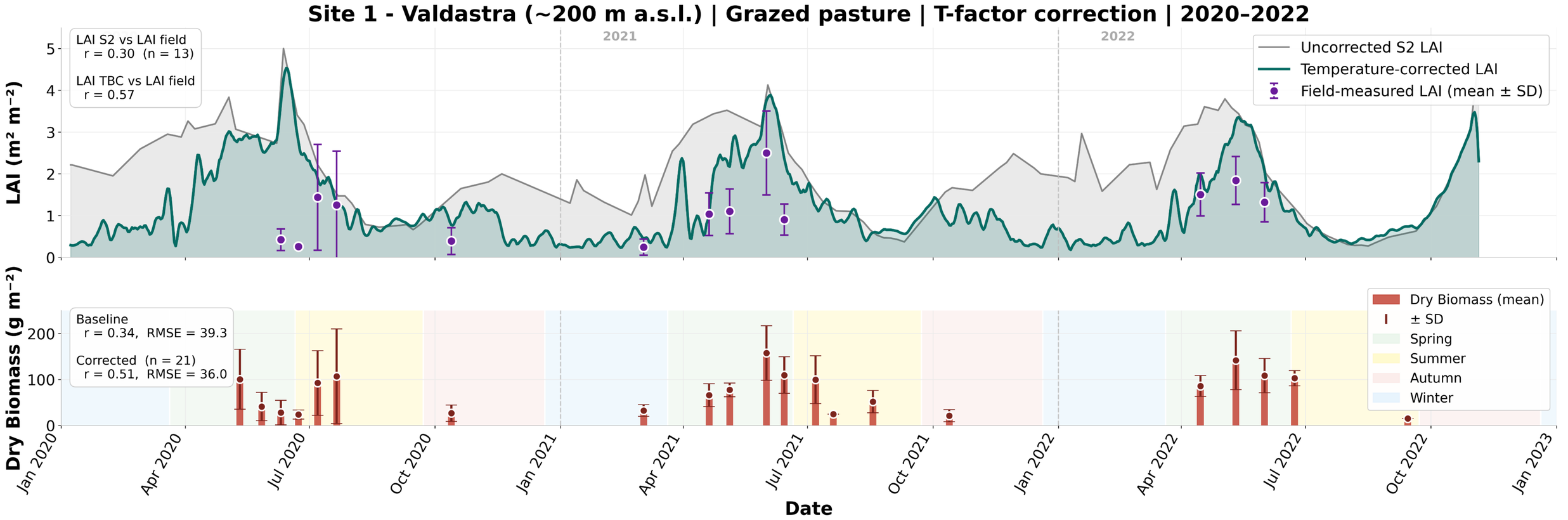
**LF:** $$Liebig = \min(T_{factor},\ P_{factor})$$

**VPI:** $$\mathrm{VPI} = 0.30 \cdot T_{factor} + 0.10 \cdot S_{factor} + 0.40 \cdot SAR_{factor} + 0.20 \cdot Liebig$$

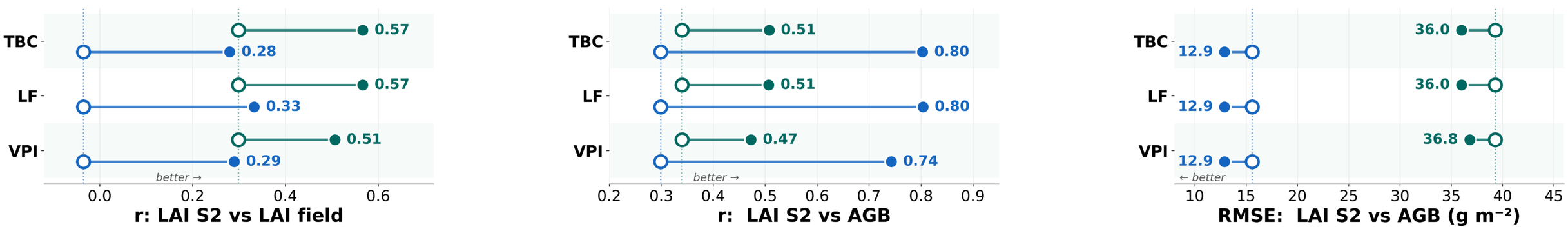
$\mathrm{COEF}_B$: scaling coefficient calibrated against field-measured LAI (Site 1: $\mathrm{COEF}_B = 0.6$; Site 2: $\mathrm{COEF}_B = 0.7$)

## Results

**Site 1 - Valdastra (~200 m a.s.l.) | Grazed pasture | T-factor correction | 2020–2022**




### Correction Performance: Baseline (○) vs Corrected (●)




● Site 1 - Valdastra (~200 m a.s.l.) ● Site 2 - Bolognese (~700 m a.s.l.) ○ = Baseline ● = Corrected

## Conclusion

- **Weather-based corrections** substantially improve S-2 LAI reliability for AGB estimation at both sites
- **Site-specific calibration** of T_opt and COEF_B is essential, a single parameterisation is insufficient across contrasting elevations
- **TBC** and **LF** perform equally well at the mown meadow site, outperforming VPI
- Results **support optimal stocking rate** and grazing timing decisions in pastoral systems of the **Northern Apennines**

## Next steps

- **A distance-adaptive updating scheme** showed promising preliminary results and will be further evaluated across sites and years (Site 1: r = 0.672, RMSE = 30.9 g $m^{-2}$, Δr = +0.15 vs simple correction)
- Integration of corrected LAI into the **GRASSVISTOCK** process-based growth model for operational biomass forecasting
- Extension to additional sites and years to assess spatial **transferability** across contrasting Apennine grassland types

## Bibliography

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