

Assessing climate change impacts on holm oak forest combining Copernicus data and high-resolution satellite imagery on Mediterranean areas

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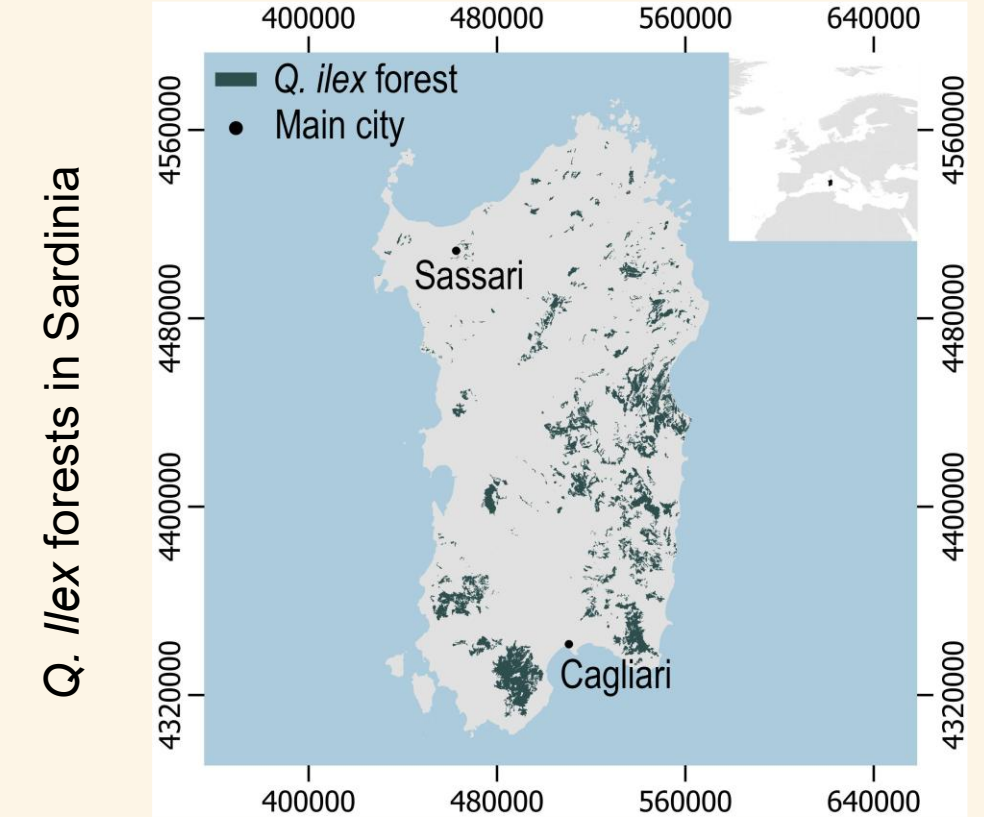
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1. INTRODUCTION

Forests are crucial for biodiversity, biogeochemical regulation, and human well-being (Shvidenko et al. 2005).
 Forests have the potential to mitigate global climate change by serving as relevant carbon stock (Pan et al. 2011).
 Climate change increased tree mortality through drought, heat stress, wildfires and insect attacks (Anderegg et al. 2015).
 Mediterranean summer temperatures exceeded natural variability with unprecedented anomalies (Tejedor et al. 2024).
 In August/September 2024, a widespread holm oaks crown desiccation (*Quercus ilex* forest) was observed in Sardinia.

Examples of holm oaks mortality (*Q. ilex* forest) occurred in Sardinia



2. AIMS

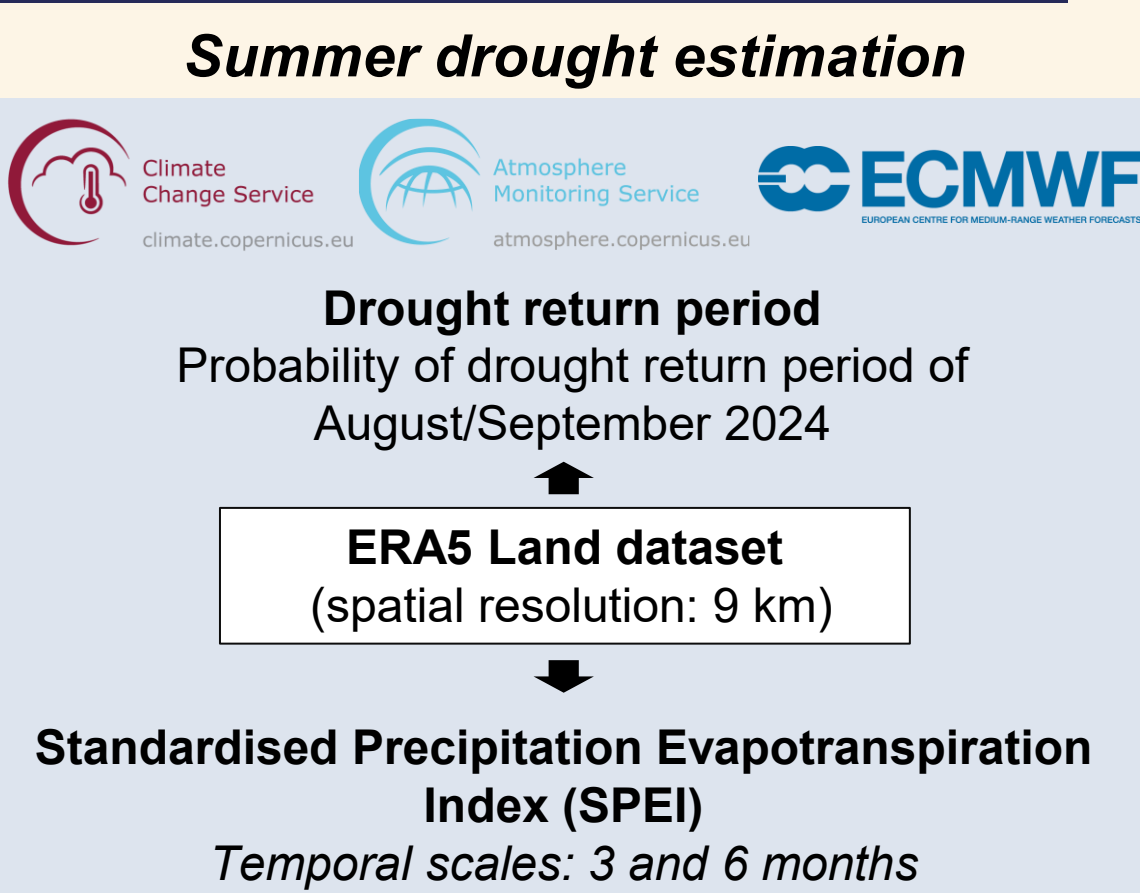
This study investigates the use of Remote Sensing data to assess the impact of recent prolonged droughts on the productivity of Mediterranean holm oak forests in Sardinia, Italy. In particular:

- Analysing the drought intensity during the peak of *Q. ilex* forest productivity (April-September);
- Optimizing spectral productivity indices and thresholds for multi-scale satellite-based drought impact detection;
- Estimating the relationship between productivity decrease and drought intensity on *Q. ilex* forest of Sardinia;
- Disentangling the role of abiotic factors on the drought impacts of *Q. ilex* forest.

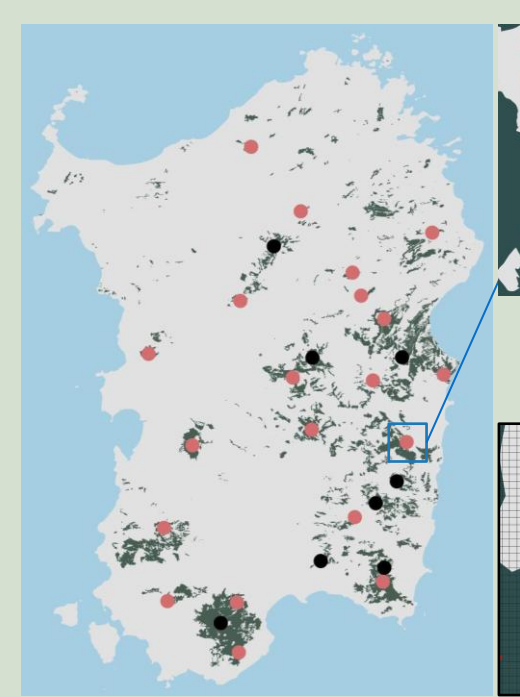


3. MATERIALS AND METHODS

Assessing of drought effect



- Visual-interpretation of RGB Planet imagery (spatial resolution 3m)
 - August/September 2024
 - 28 random *Q. ilex* forests
 - 70% training for models
 - 30% accuracy for models
 - 2 km buffer area
 - Grid co-register with Sentinel-2
 - 1% random points to assess the drought effects



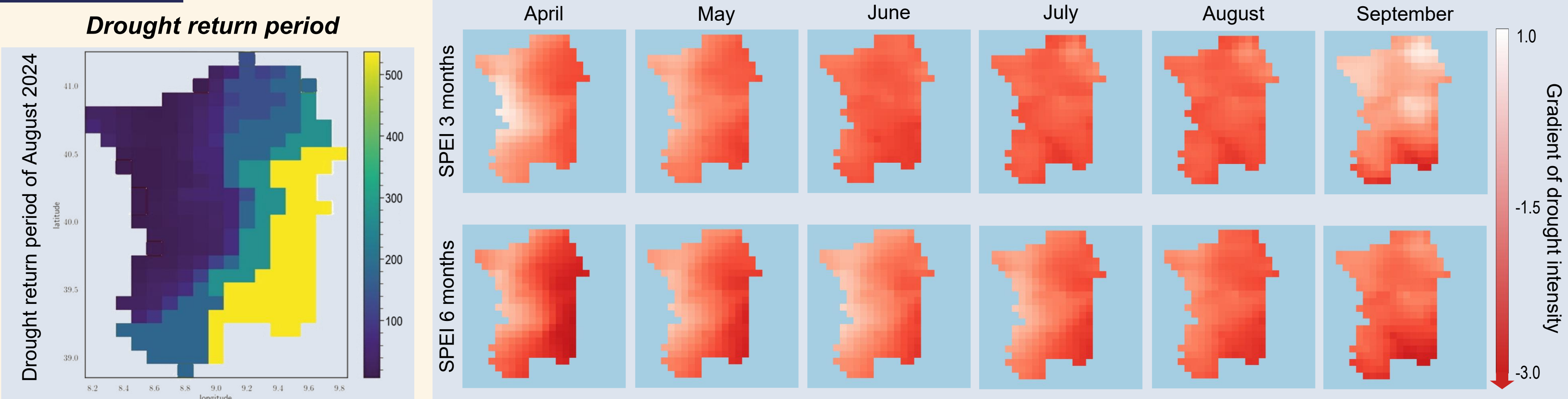
- Sentinel-2-based drought impact modeling (spatial resolution 10 m)
 - Spectral productivity indices (VI): NDVI / EVI / MSAVI2
 - Dataset Sentinel-2 images (cloud < 10%)
Before: September 2023 — After: August 2024
 - Drought effects: $\Delta VI = (VI_{2023} - VI_{2024}) / VI_{2023}$
 - Identification threshold values:
 - GLM formula: Visual-interpretation ~ ΔVI
 - Threshold: Sensitivity=Specificity / Max Sens. + Specific. / Max Kappa

Modeling effects of drought event

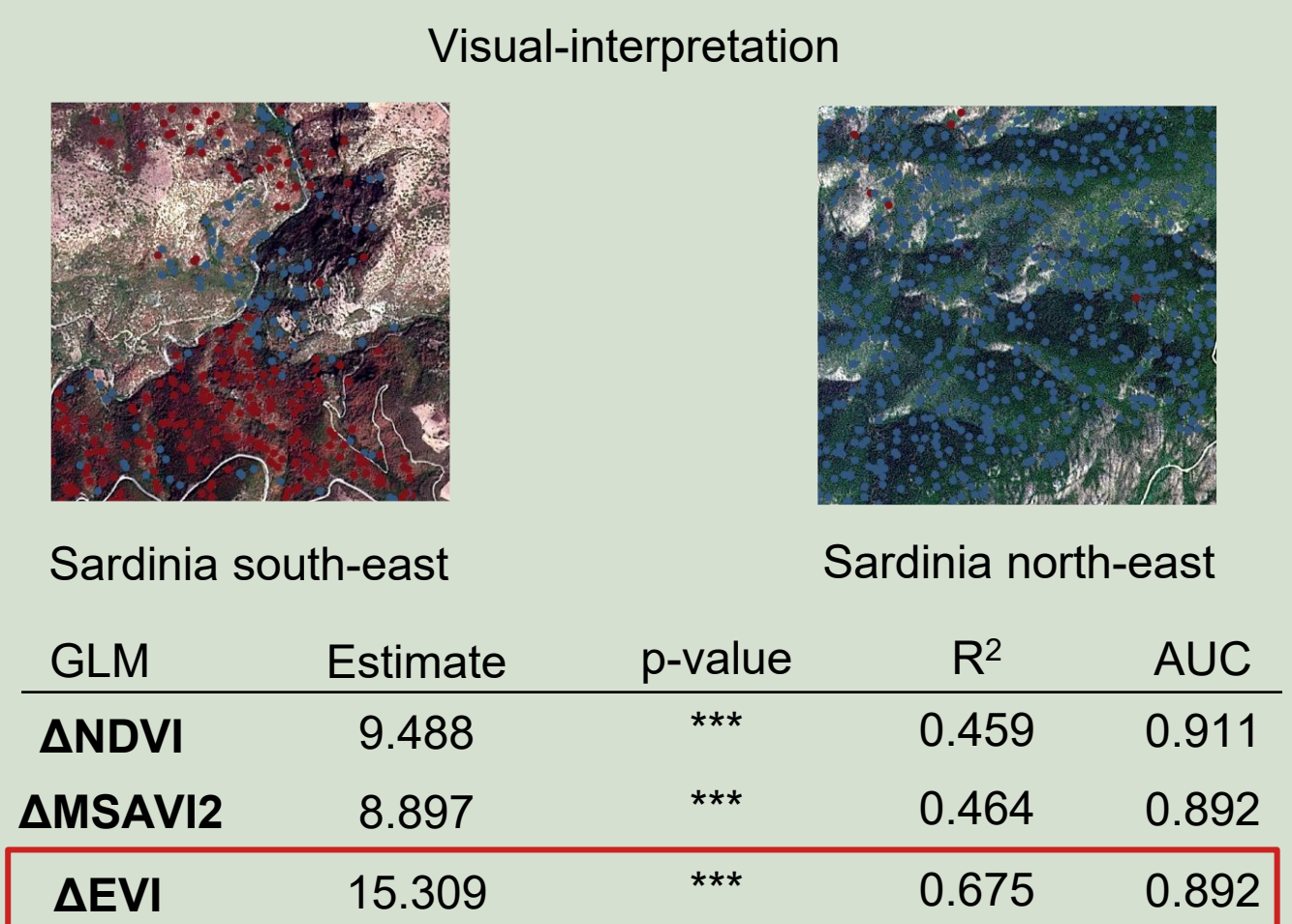
- Prediction of most accuracy GLM;
 - Compute % of impacted pixels within ERA5 grid;
 - Drought variables: SPEI 3 — SPEI 6 months;
 - Random Forest (RF) regressions, formula:
% of Impact ~ Monthly SPEI 3;
% of Impact ~ Monthly SPEI 6;
- Abiotic drivers of drought response**
- Prediction of most accuracy GLM;
 - Variables: altitude, slope, aspect, land form, river distance, Brightness index (BI);
 - Random Forest binomial regressions, formula:
Impact/No Impact ~ Altitude + Slope + Aspect + Land Form + River Distance + BI.

4. RESULTS

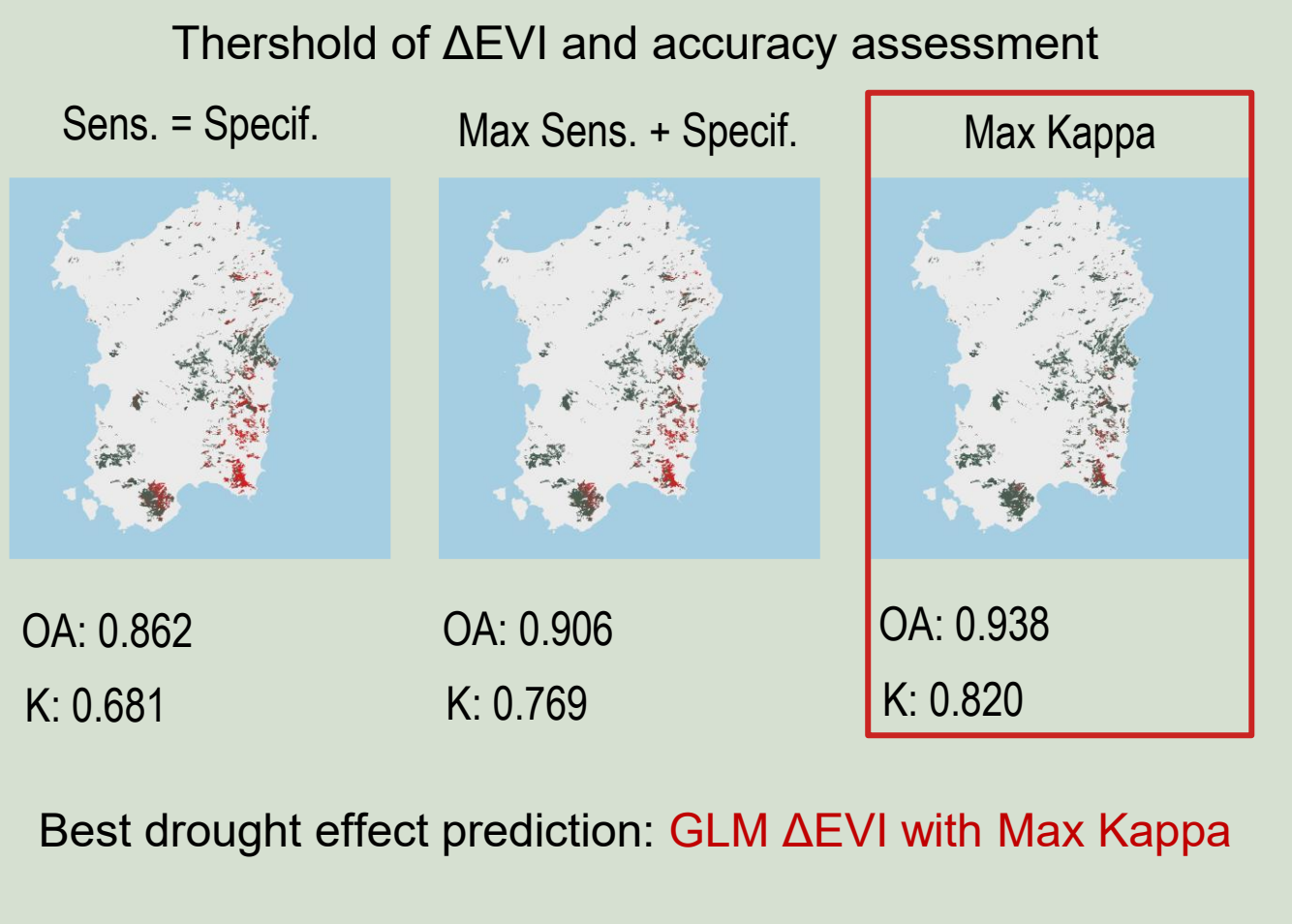
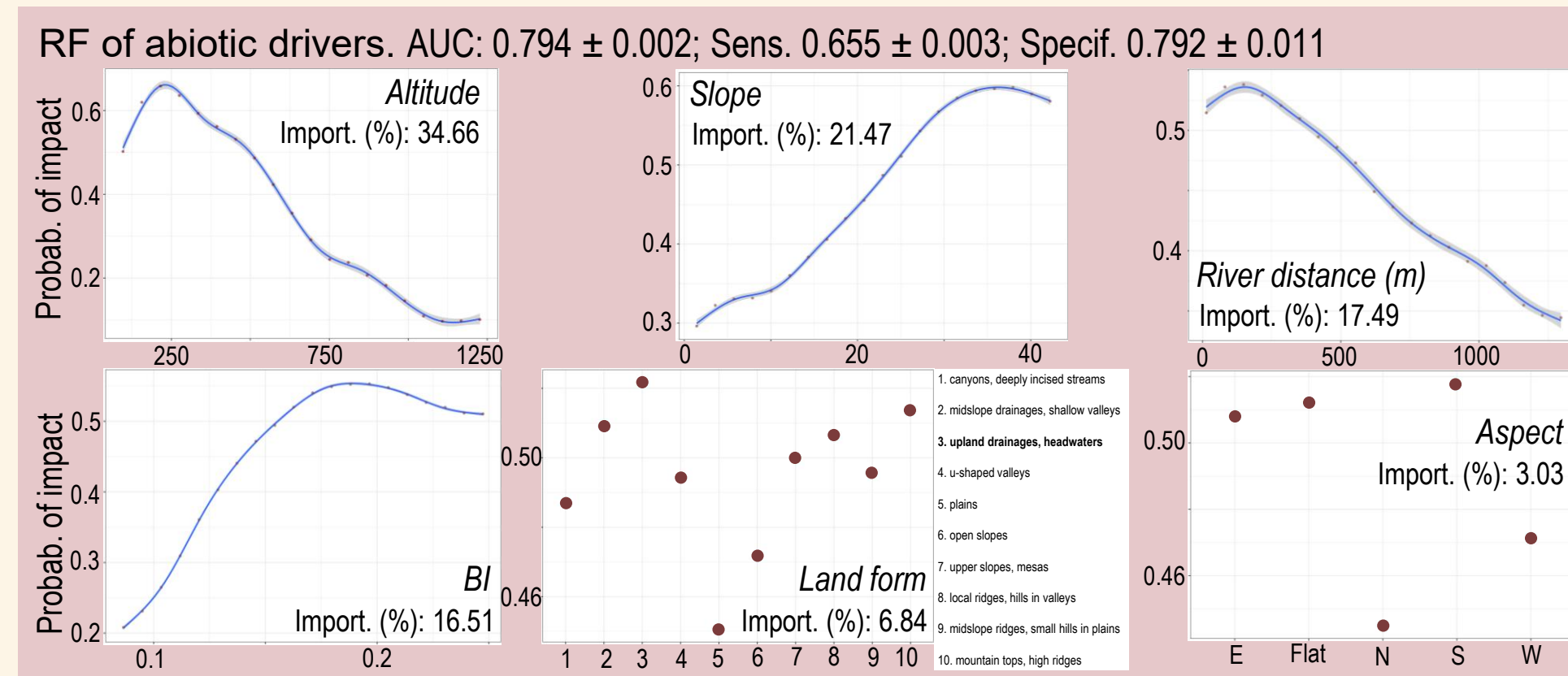
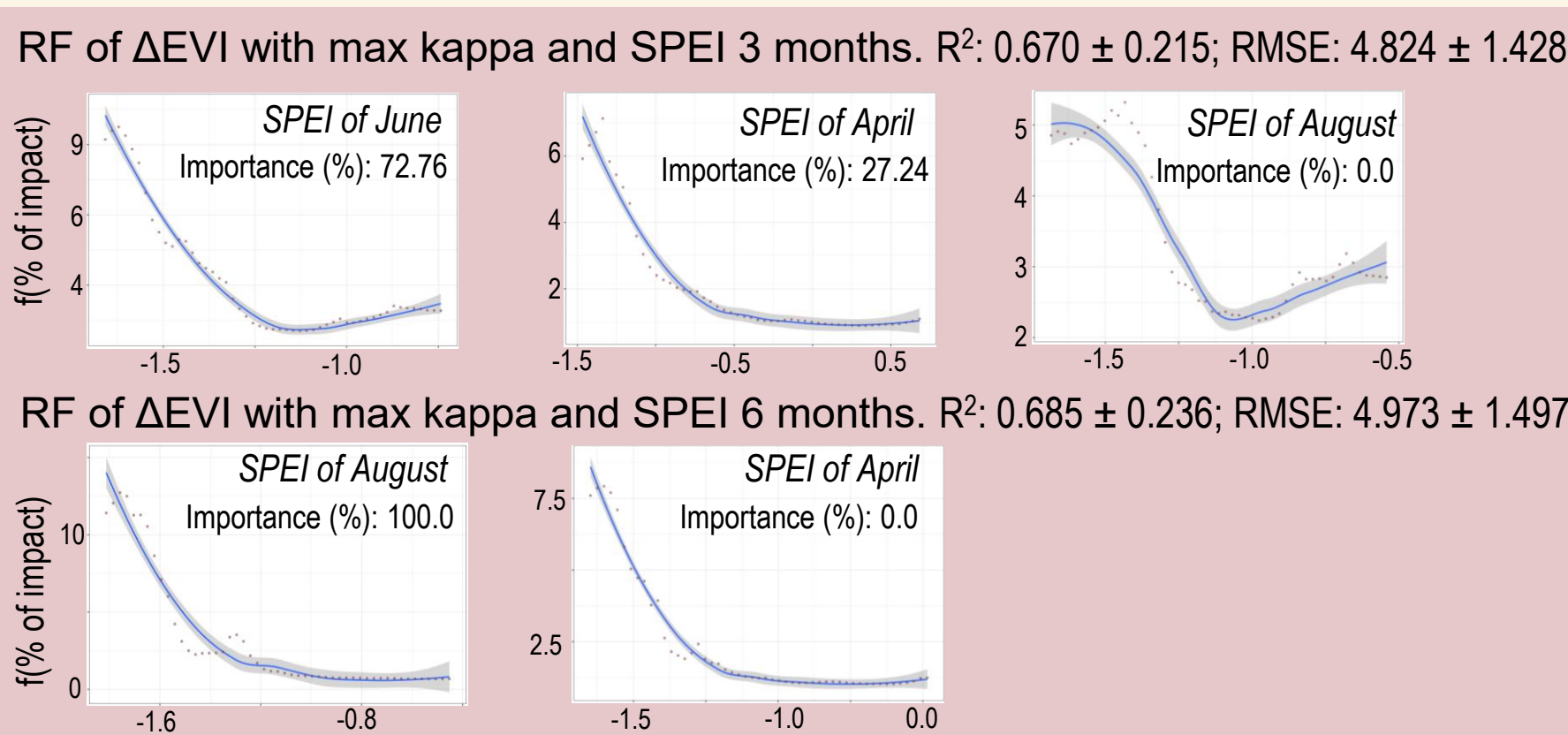
Multi-temporal drought intensity



Prediction and threshold of drought effect



Relationship between drought and productivity decrease



5. DISCUSSION AND CONCLUSION

- ✓ Drought return period results confirmed extremeness of the 2024 summer drought in Sardinia, specially in the South-east of island.
- ✓ SPEI index at 3 and 6 months highlighted a gradient of drought from south-east to north-west in Sardinia.
- ✓ RGB PlanetScope combined with multispectral Sentinel-2 imagery detected the drought effects on *Q. ilex* forest with very high accuracy assessment.
- ✓ EVI showed the higher accuracy performance to model and predict *Q. ilex* forest impacted or non-impacted by drought period in Sardinia.
- ✓ A prolonged winter–spring–early summer drought was strongly associated with the decrease of productivity of *Q. ilex* forests.
- ✓ Drought impacts were strongest on *Q. ilex* in low-elevation, high slope, near rivers, within canopy gaps, south-facing sites, and in upland drainage/headwater landforms.

