Determinants of woody cover in a major island in the Mediterranean basin

Sara Simona Cipolla and Nicola Montaldo
, Department DICAAR- Environmental, Civil Engineering and Architecture, University of Cagliari, Via Marengo, 2 - 09123 Cagliari – ITALY- saras.cipolla@unica.it

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Background

Mediterranean forests are an important regional asset, but they are currently subject to threats driven mainly by **climate change** and **increasing demography**.

Drought is currently shaping the structure of Mediterranean Forests.

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Marganai Forest (Sardinia-Italy)

23/09/2017

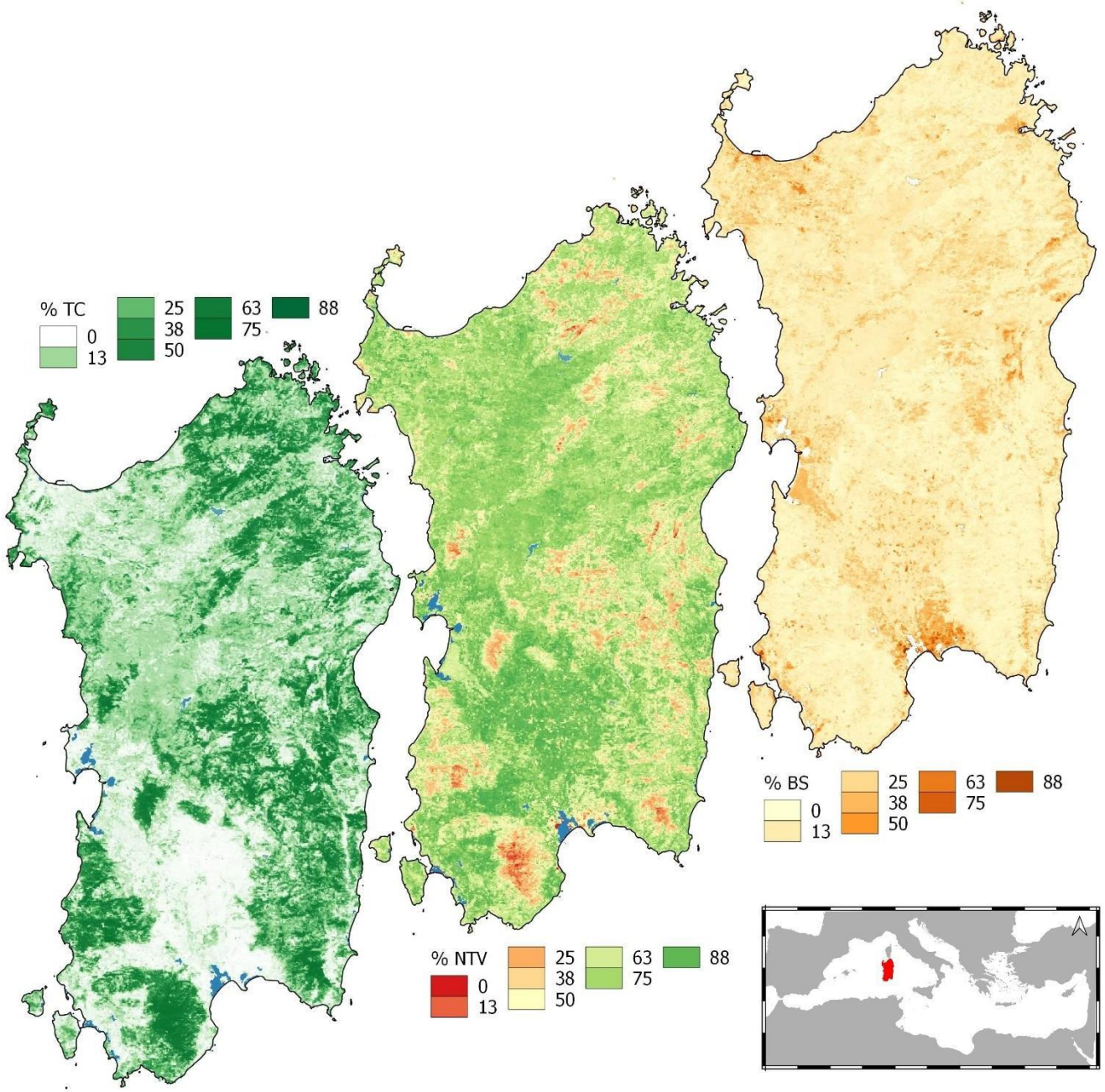
CRITICAL ZONE OBSERVATORIES : RESEARCH AND APPLICATIONS

METHODS

Evaluation of long-term trends for:

- **Tree Cover Percentage:** yearly product (2000-2020) from **MOD44B** Version 6 Vegetation Continuous Fields (VCF);
- **Precipitation:** daily precipitation (1922-2019) from Sardinian rain gauge stations;
- **Air temperature**: ERA 5 reanalysis dataset from 1980-2019 (monthly);
- **Vapor pressure deficit:** 1980-2019 monthly from ERA5 dataset analysis;

Time series were statistically analyzed on an annual and seasonal base. Trends were estimated using the ***Mann-Kendall non- parametric test*** (*Kendall, 1938*), while the slope of linear trend has been estimated with the ***Theil-Sen method*** (*Sen, 1968; Theil, 1992*)

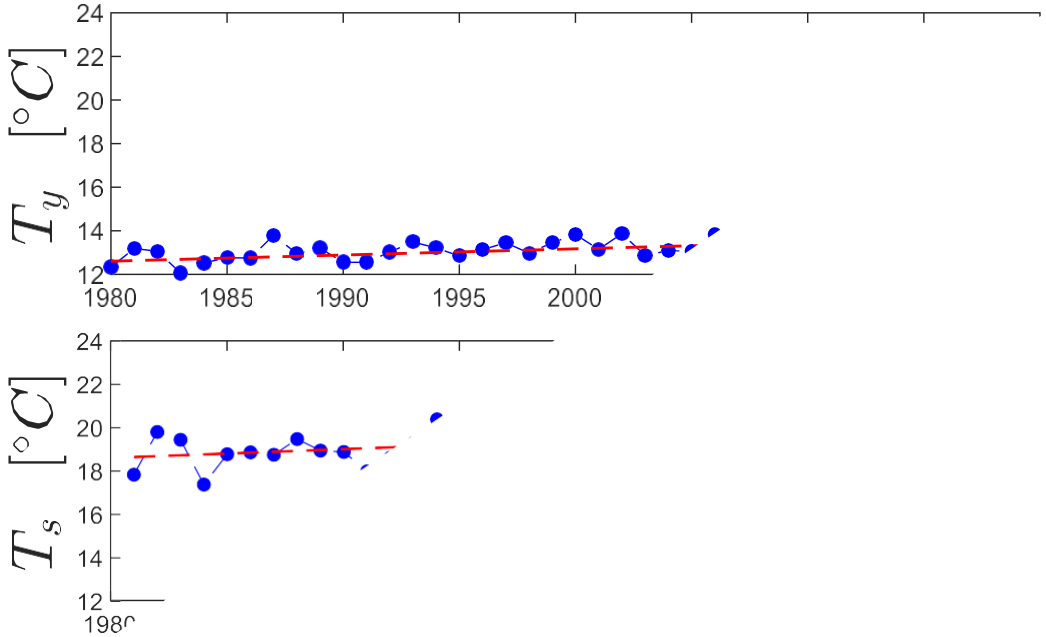


CRITICAL ZONE OBSERVATORIES : RESEARCH AND APPLICATIONS

TERENO
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

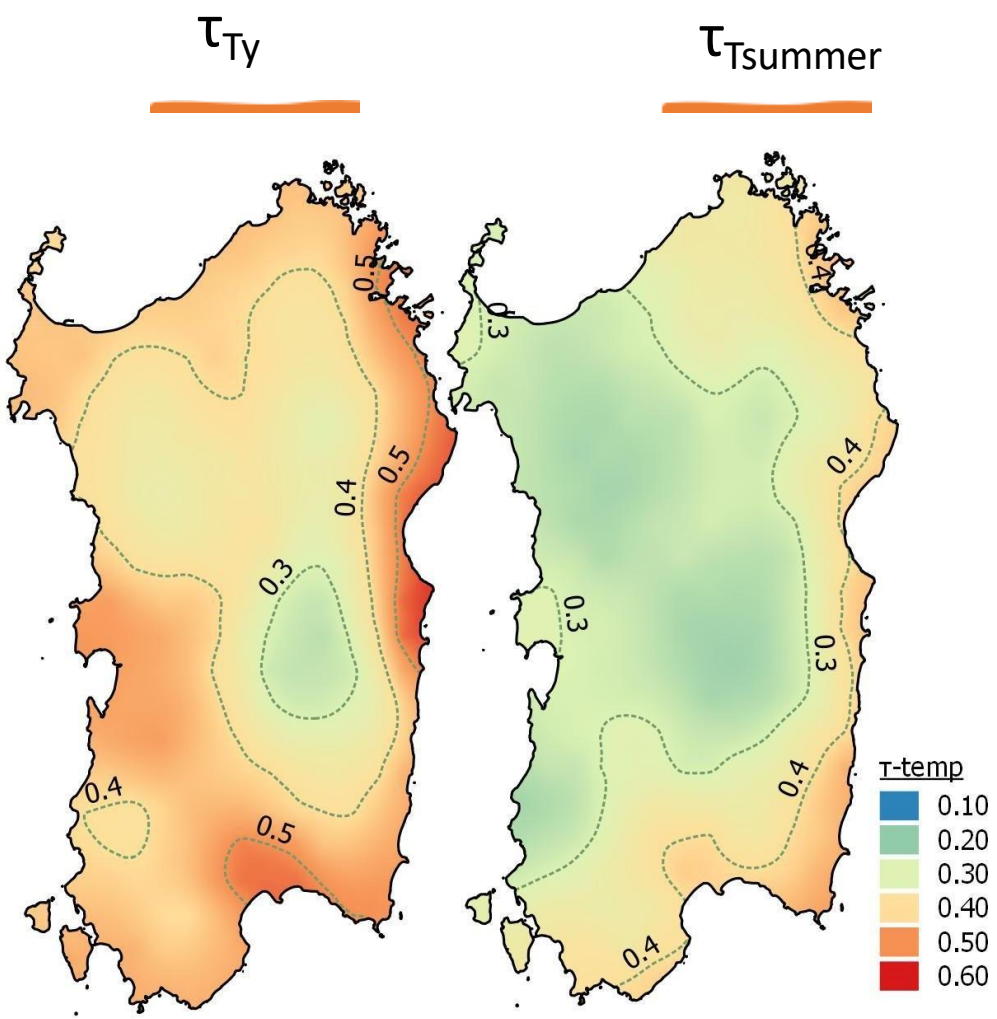
Air temperature

Monthly near surface air temperature data from the ERA5 reanalysis dataset for the 40-year period 1980–2019 period were used to evaluate more recent trend in air temperature and to calculate the vapour pressure deficit over time.



τ_{Ty}= 0.44
p_{value}= <0.005
β_{Ty}= 0.028 °C/y

τ_{Ts}= 0.37
p-value= <0.005
β_{Ts} = 0.038 °C/y



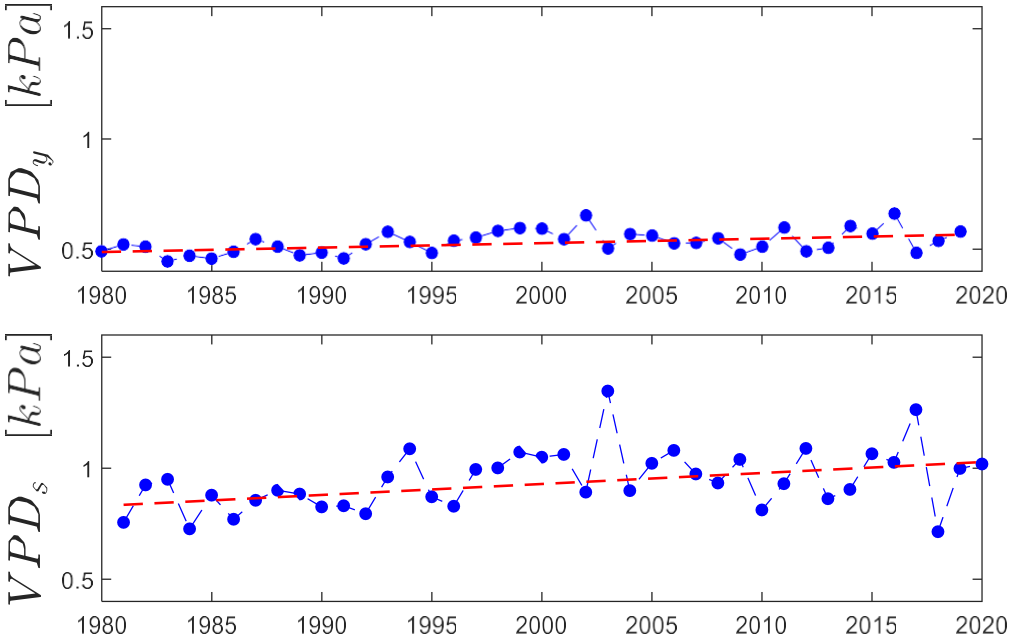
τ values (ordinary kriging model, linear semi-variogram)

Vapor pressure deficit

VPD is the difference (deficit) between the amount of moisture in the air and how much moisture the air can hold when it is saturated. VPD has been calculated by using the ERA5 monthly near surface air temperature (T) and dew point (Td), from the following equation (*Barkhordarian et al., 2019*):

$$VPD = c_1 * \exp\left(\frac{c_2 * T}{c_3 + T}\right) - c_1 * \exp\left(\frac{c_2 * Td}{c_3 + Td}\right)$$

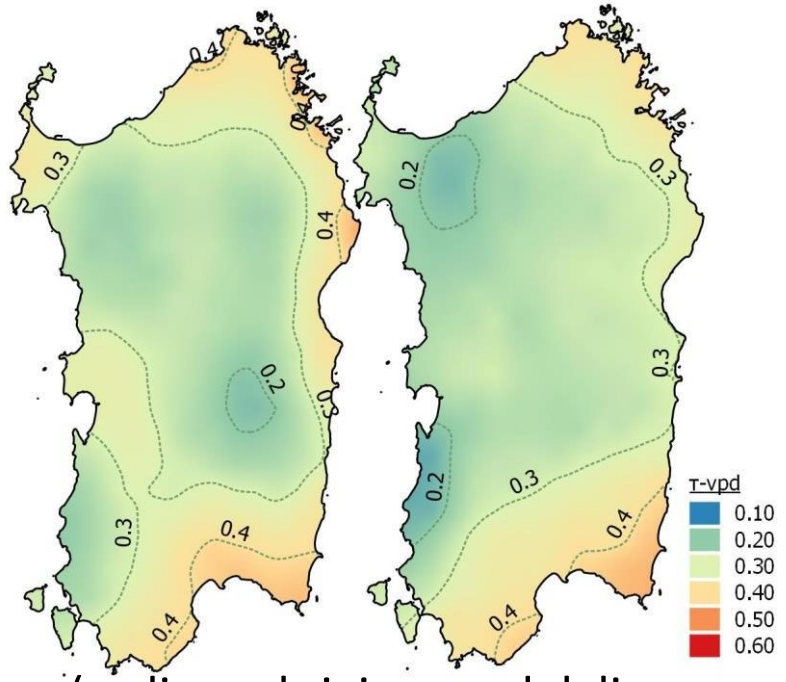
c_1=0.611 Kpa, c_2=17.5, c_3=240.978°C.



τ_{VPDy}= 0.32
p_{value}= <0.05
β_{VPDy}= 0.002 kPa/y

τ_{VPDs}= 0.30
p-value= <0.05
β_{VPDs} = 0.004 kPa/y

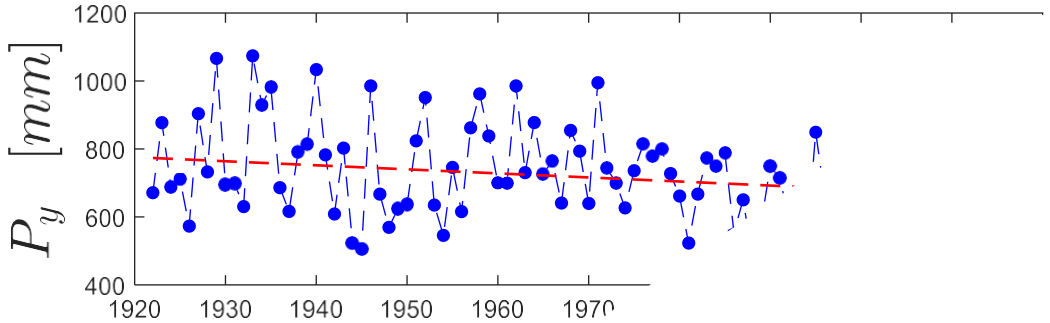
τ_{VPDy} $\tau_{VPDsummer}$



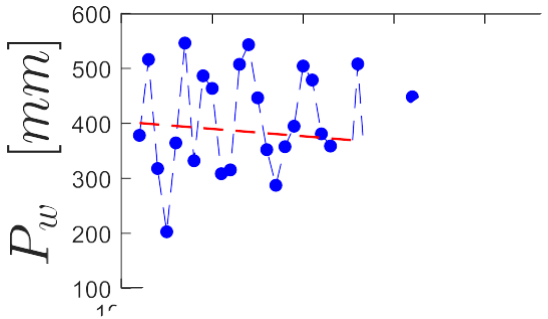
τ values (ordinary kriging model, linear semi-variogram)

Precipitation 1/2

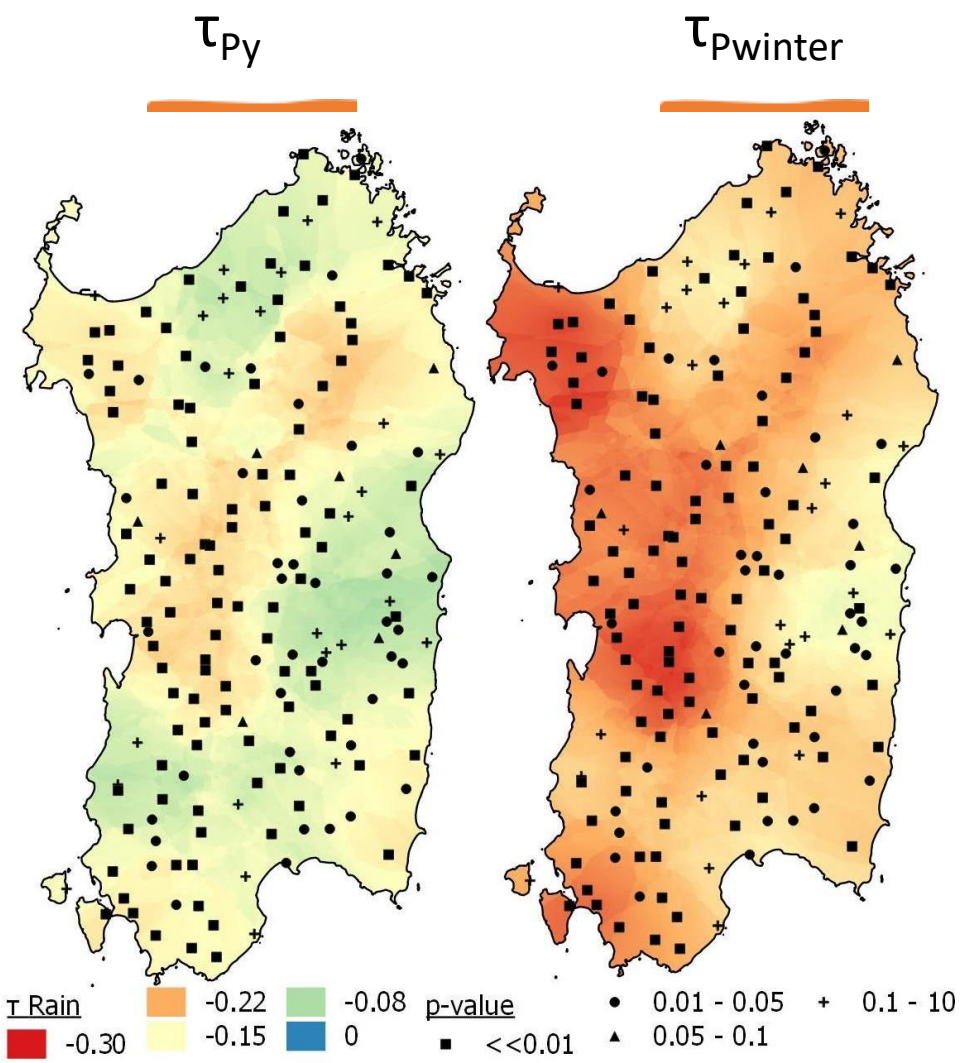
The statistical analysis of precipitation has been done by analysing data coming from 179 rain-gauge stations for the period 1922-2018. Selected rain gauge have at least 60 complete years of data.



τ_{Py}= -0.14
p_{value}= 0.03
β_{Py}-1.2 mm/y



τ_{Pw}= -0.23
p-value= <0.005
β_{Pw} = -1.33 mm/y



τ values (ordinary kriging model, linear semi-variogram)

Precipitation 2/2

Many studies demonstrates that when Mean Annual Precipitation (MAP) falls below 700 mm, the upper bound of the percentage of tree cover may mainly be limited by water availability *(Sankaran et al. 2008)*.

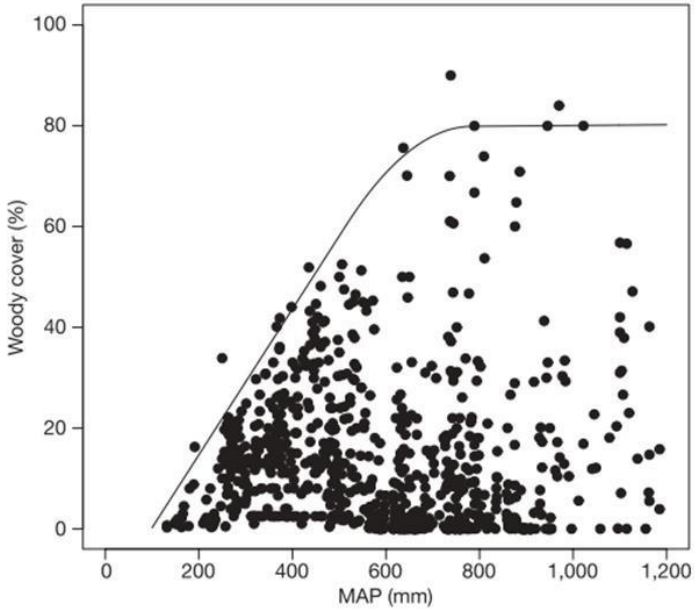
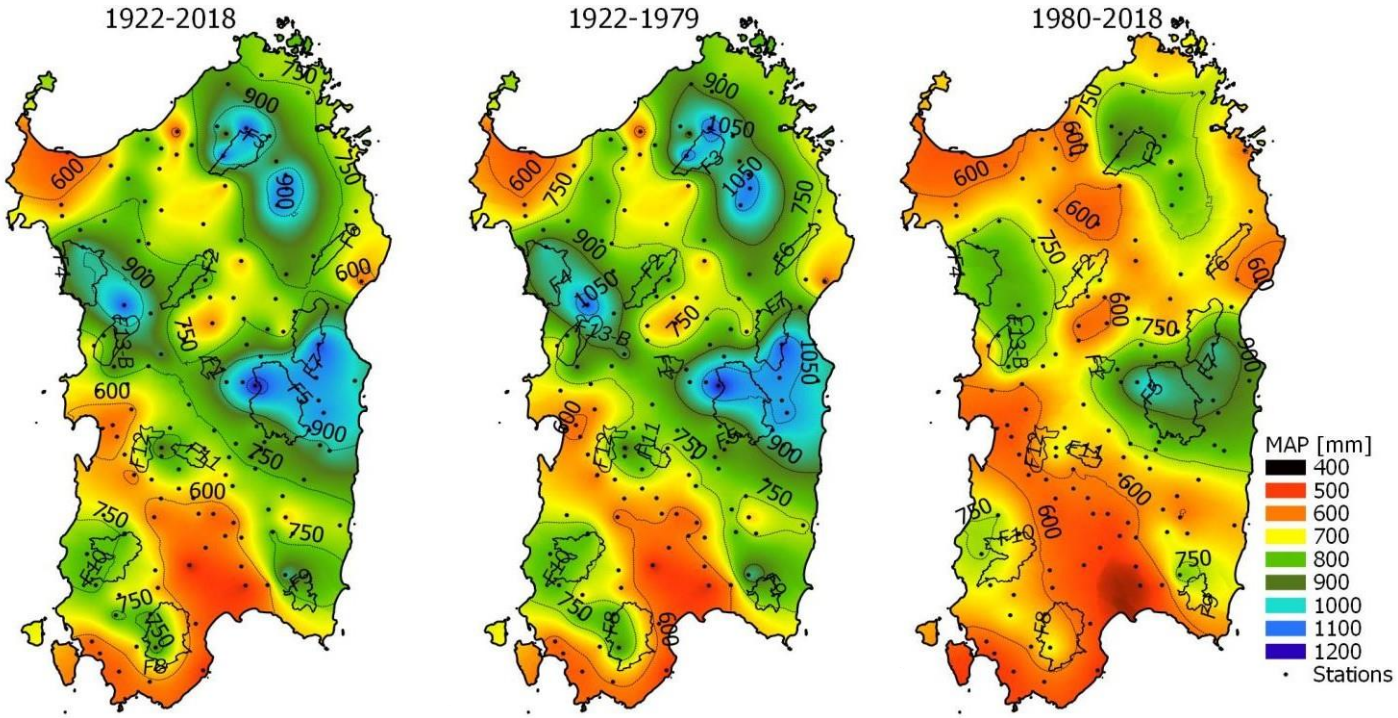


Figure 1 | Change in woody cover of African savannas as a function of MAP. Maximum tree cover is represented by using a 99th quantile piece-

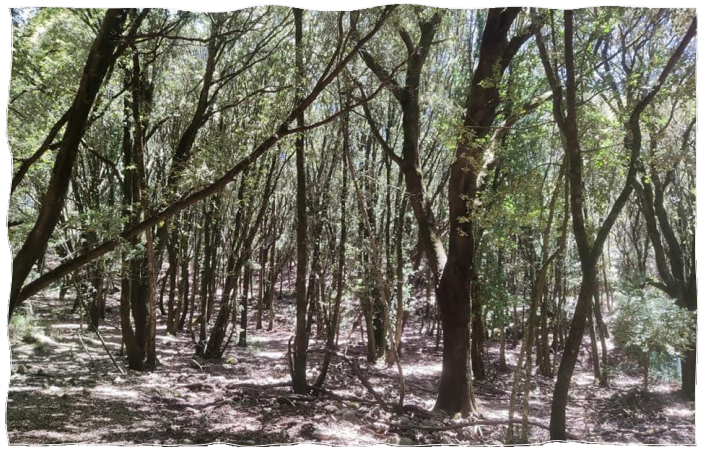


MAP [mm/y]	< 600	600< MAP < 700	> 700
1922-1980	9%	17%	74%
1980-2018	22%	40%	38%

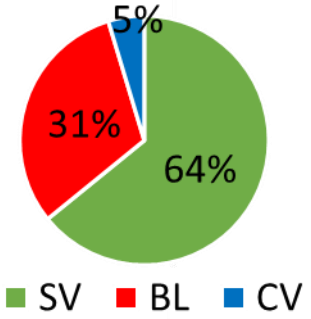
Land Cover

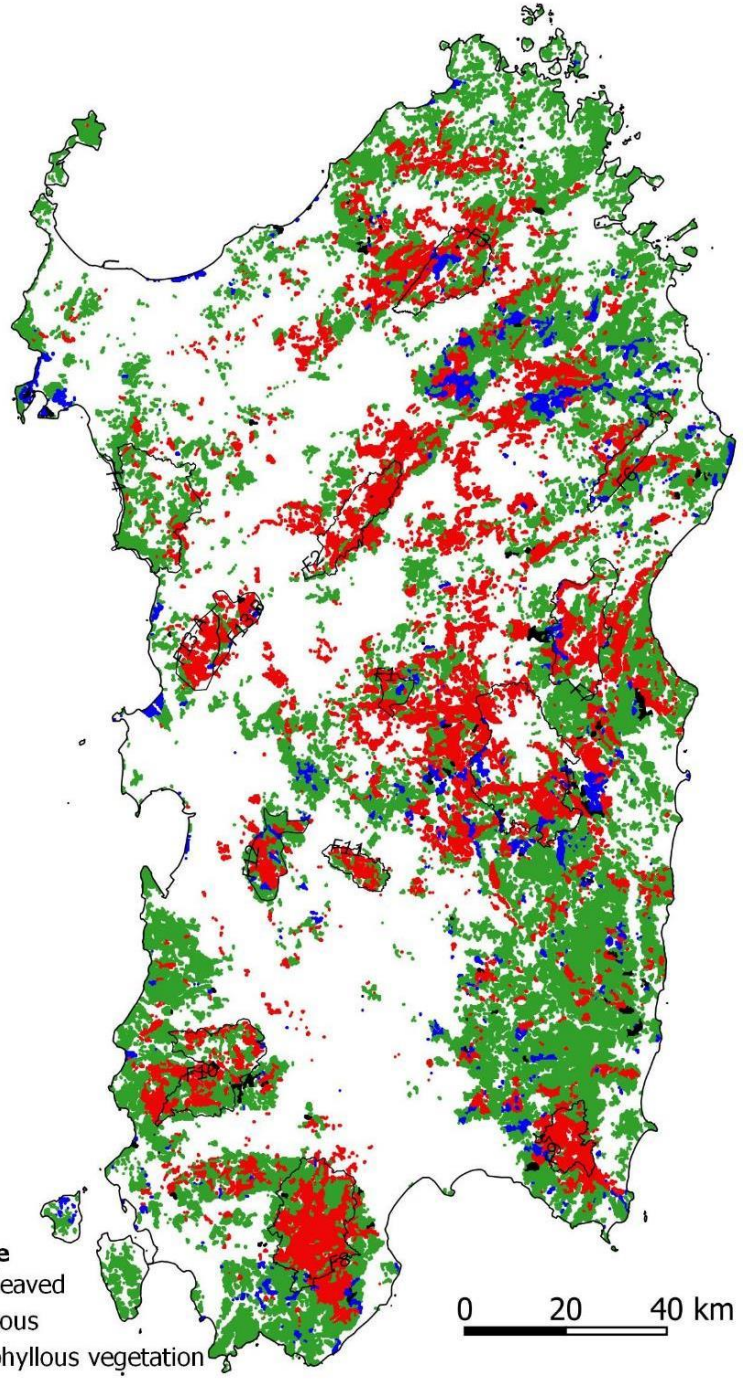
Sardinia's wildlands have been selected based on the Corine Land Cover (CLC) classification of year 2018.
Observing plots were identified by using the following procedure:

1. Creation of a regular grid (250 m) that coincides with the mesh of the raster of the MODIS VCF product;
2. Selection of plots with a homogeneous land use falling in the Broad leaved (BL), Coniferous (CV) and Sclerophyllous (SV) vegetation categories;
3. Elimination of all areas affected by fire during the period 2005–2019



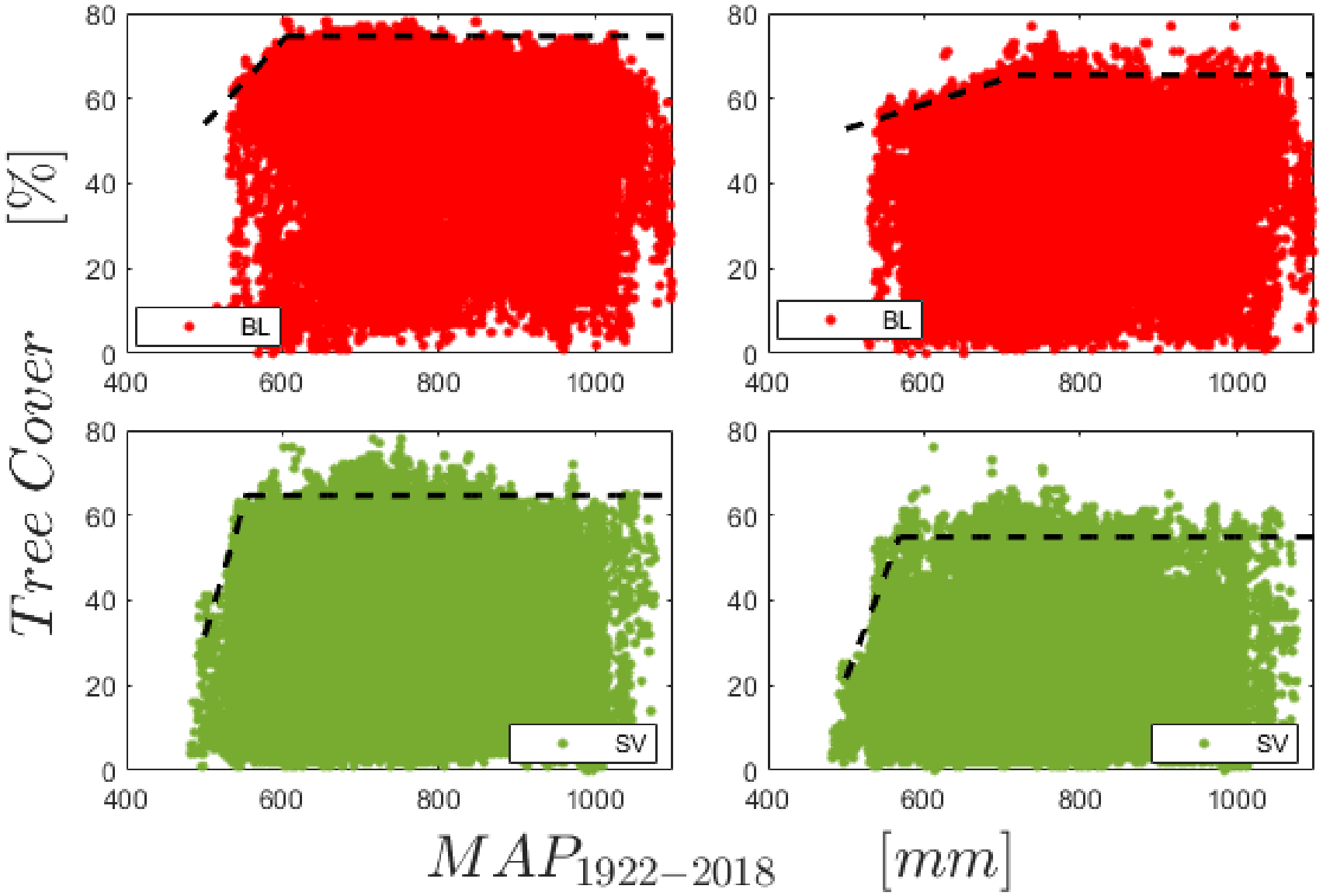
A total of **169.000** plots were sampled across the study area, corresponding of about the **30% of the entire island**.





Relationship between MODIS tree cover (TC) and $MAP_{1922\text{-}2018}$

Maximum tree cover (Max_{TC}) is represented by using a 99th quantile piece-wise linear regression.



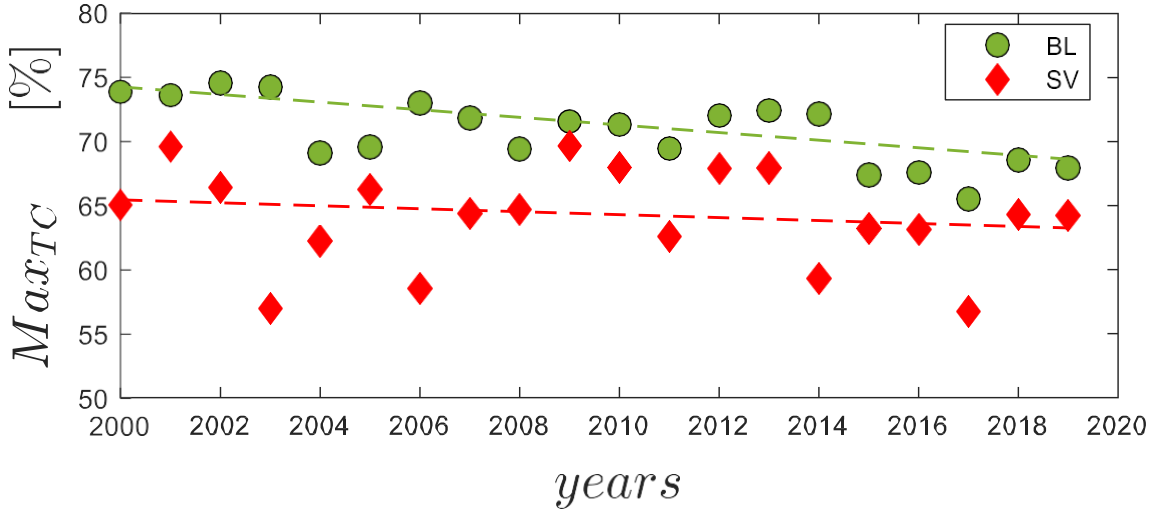
Results 2/4

Maximum tree cover of **broad-leaved vegetation**:

- τ_{MAX_TC} = **-0.49**
- p_{value}<0.005
- β_{MAX_TC} = -0.3 %/y

Maximum tree cover of **Sclerophyllous vegetation**:

- τ_{MAX_TC} = -0.14
- p_{value}= 0.38
- β_{MAX_TC} = -0.11%/y



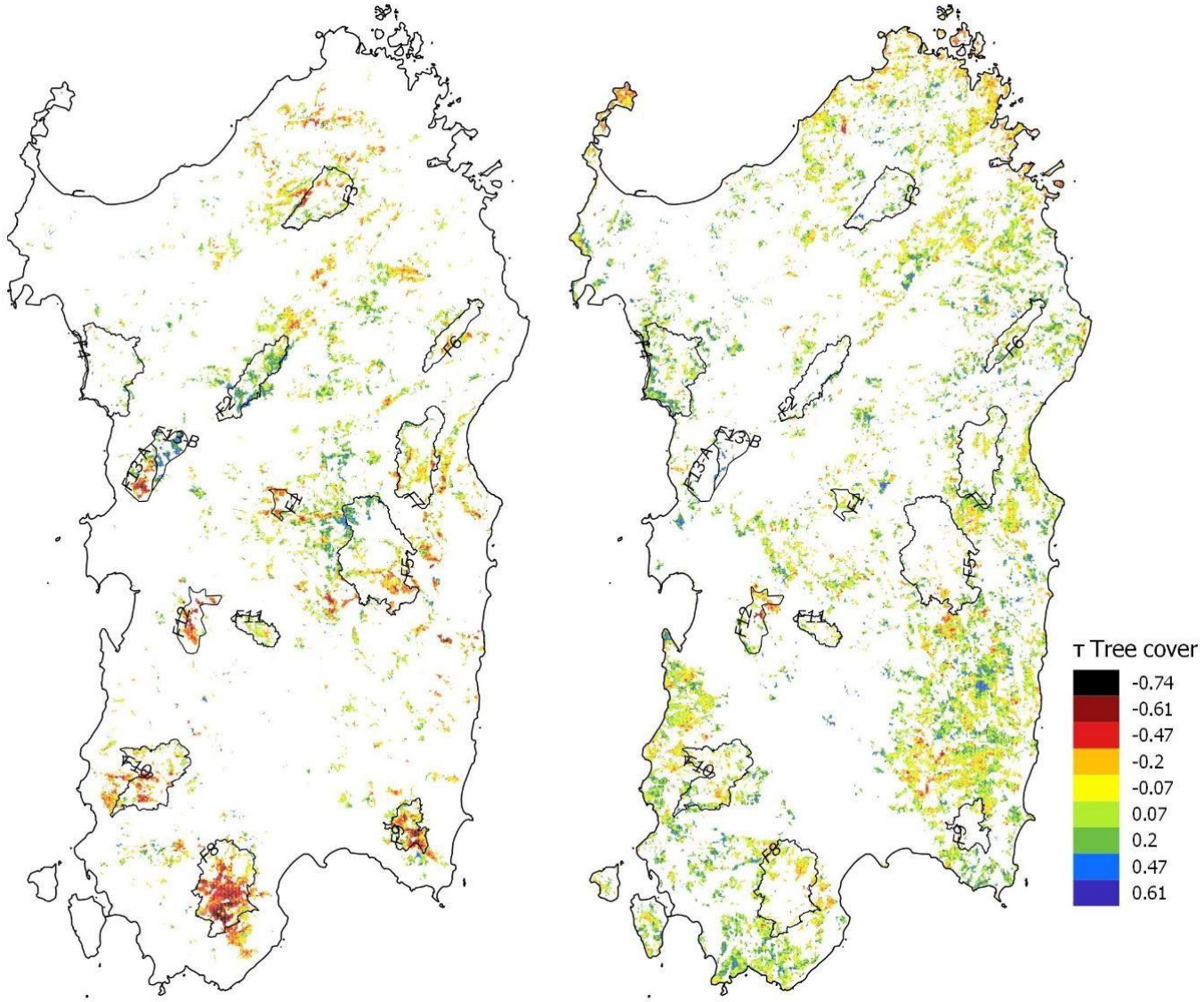
Results 3/4

TREE COVER

Analysis at the observing plot scale

- The **58.07** % of the observing plots show no trend in tree cover;
- The **30.8 %** of the observing plots show a **positive** trend in tree cover;
- The **11.1 %** of the observing plots a **negative** in tree cover;

The **70.5%** of the plots that shows a significant **negative trend in T**C (β mean slope of -0.72 %TC*y^{-1}) are classified as **broad -leaved forest** and are mainly located in the **southern part of the island.**



Broad-leaved vegetation

Sclerophyllous vegetation

Results 4/4

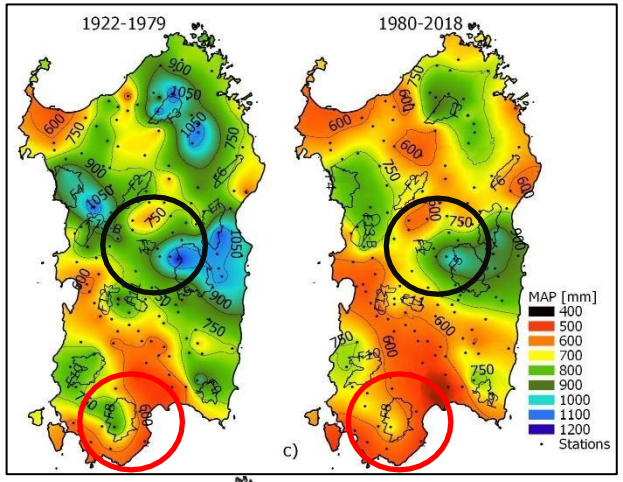
BROAD-LEAVED VEGETATION

Analysis at the observing plot scale

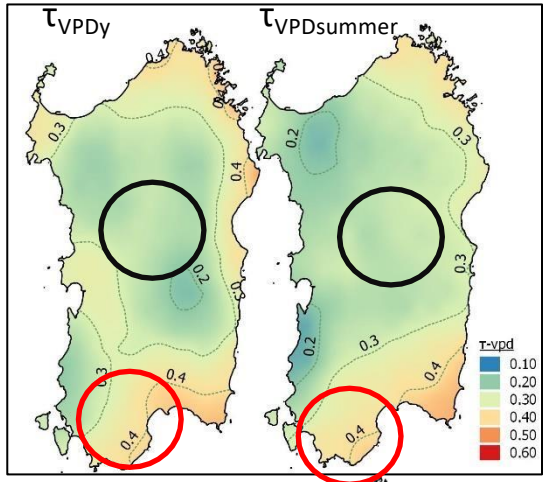
- **Negative** trend in **TC** is countered by an **increase** in vegetation with a height of less than 5m (**NTC).**

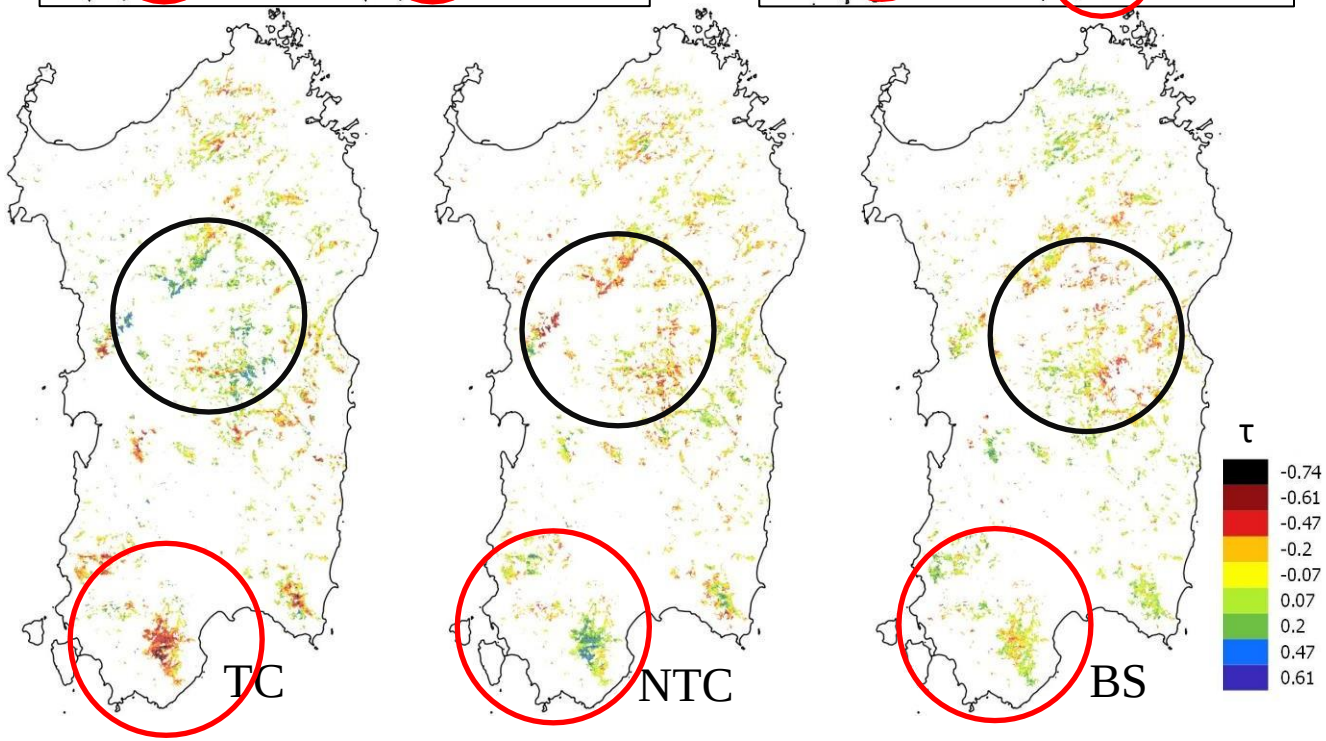
- A positive trend in TC is countered by a decrease in NTC. This particularly happens in areas where the water availability is not a limiting factor and the rise in temperatures (especially the minimum) leads to an improvement in the growing conditions.

Mean Annual Precipitation



Vapor pressure deficit



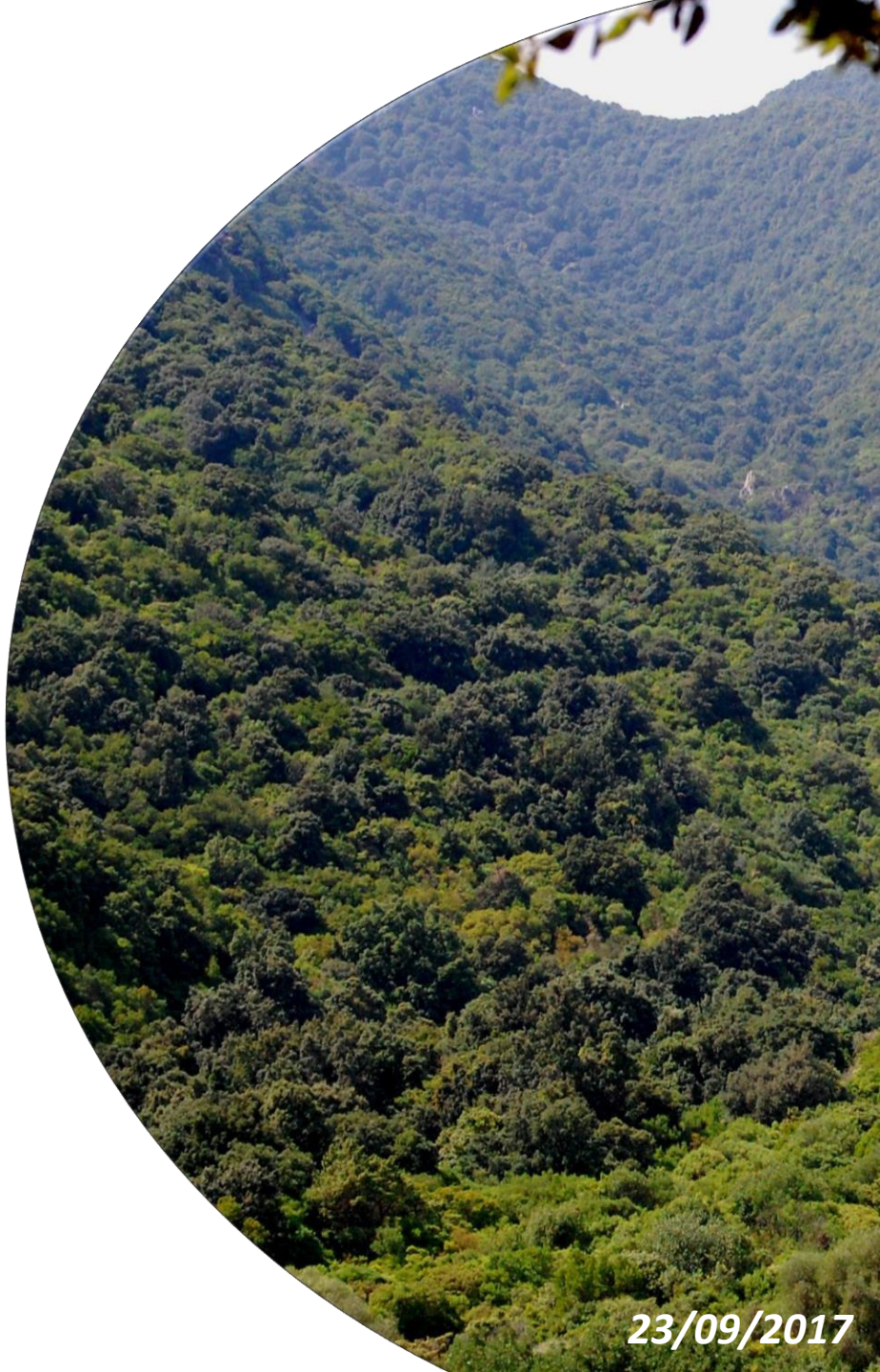


Conclusion

- MOD44B dataset has been used to estimate the long-term trend of tree cover over Sardinia's island. The complementary spatial and temporal analysis of hydrological variables allowed us to determine which factors most influence tree cover.

- Results shows that in the last 40 years Sardinia has experienced a simultaneous increase in air temperatures and VPD combined with reductions in both total precipitation and winter precipitation, and that the areas with **$MAP_{1980\text{-}2018}$ lower than 700 mm have become the 61.5 % of the entire island**.

- In the presence of a decreasing trend in precipitation opposed to an increasing trend in VPD, the broad-leaved forests respond by reducing the TC and increasing the NTC, on the contrary, under the same conditions, Sclerophyllous vegetation show an increase in TC and a decrease in NTC.



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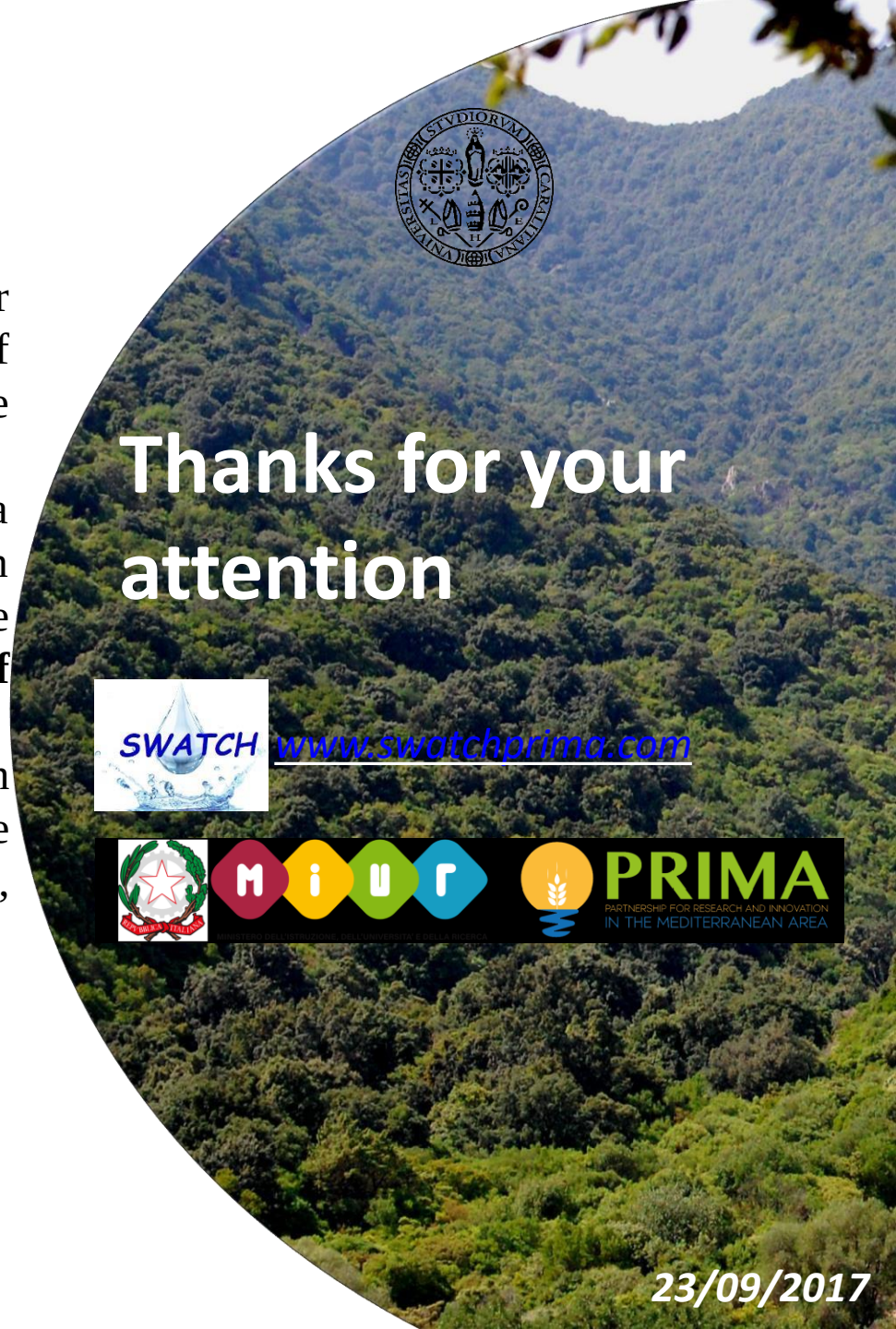

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