INFERRING VEGETATION MEMORY FROM REMOTE SENSING DATA USING NOVEL CLIMATE RECONSTRUCTION PRODUCTS

M.Sc. Thesis Defense

UNIVERSITETET I BERGEN

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Ecological and Environmental Change Research Group
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What is Vegetation Memory?

Vegetation Memory is the effect of **antecedent ecosystem/environmental anomalies** on **current vegetation performance**[1].

Components of Memory:[2]

1. *Intrinsic Memory* (e.g. antecedent vegetation characteristics)[2,3]
2. *Extrinsic Memory* (antecedent climate characteristics)[2–4]

Explaining Memory:

1. *Causal pathways* remain poorly understood[5]
2. Expressions of *Plant Function* as a possible solution

Can we **distinguish** between **intrinsic** and **extrinsic** memory effects?

What **biological traits cause** areas to exert **intrinsic** and **extrinsic memory**?

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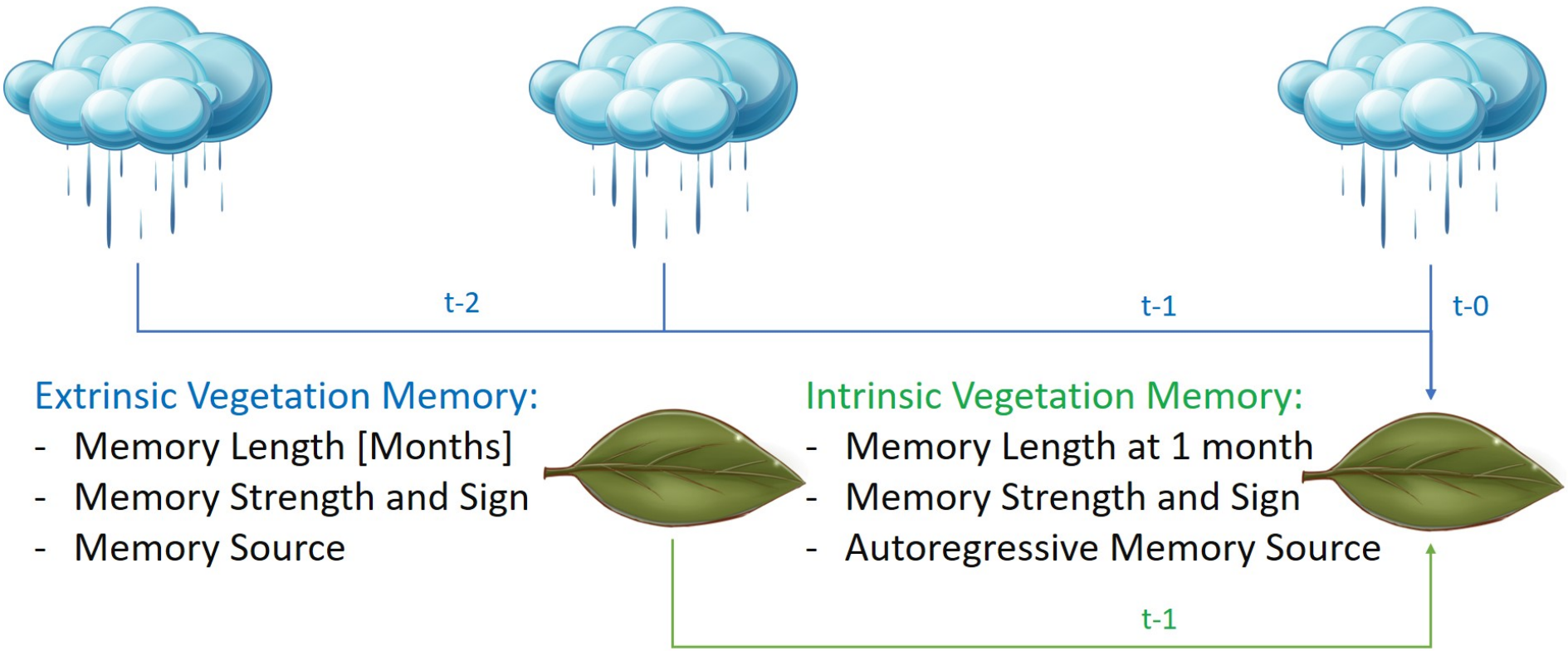
Intrinsic vs. Extrinsic Memory Components



→ Big emphasis on **dryland regions** due to demonstrated vegetation memory effects[1,3,4,6], and the strong dependence of dryland vegetation on local water regimes[5]

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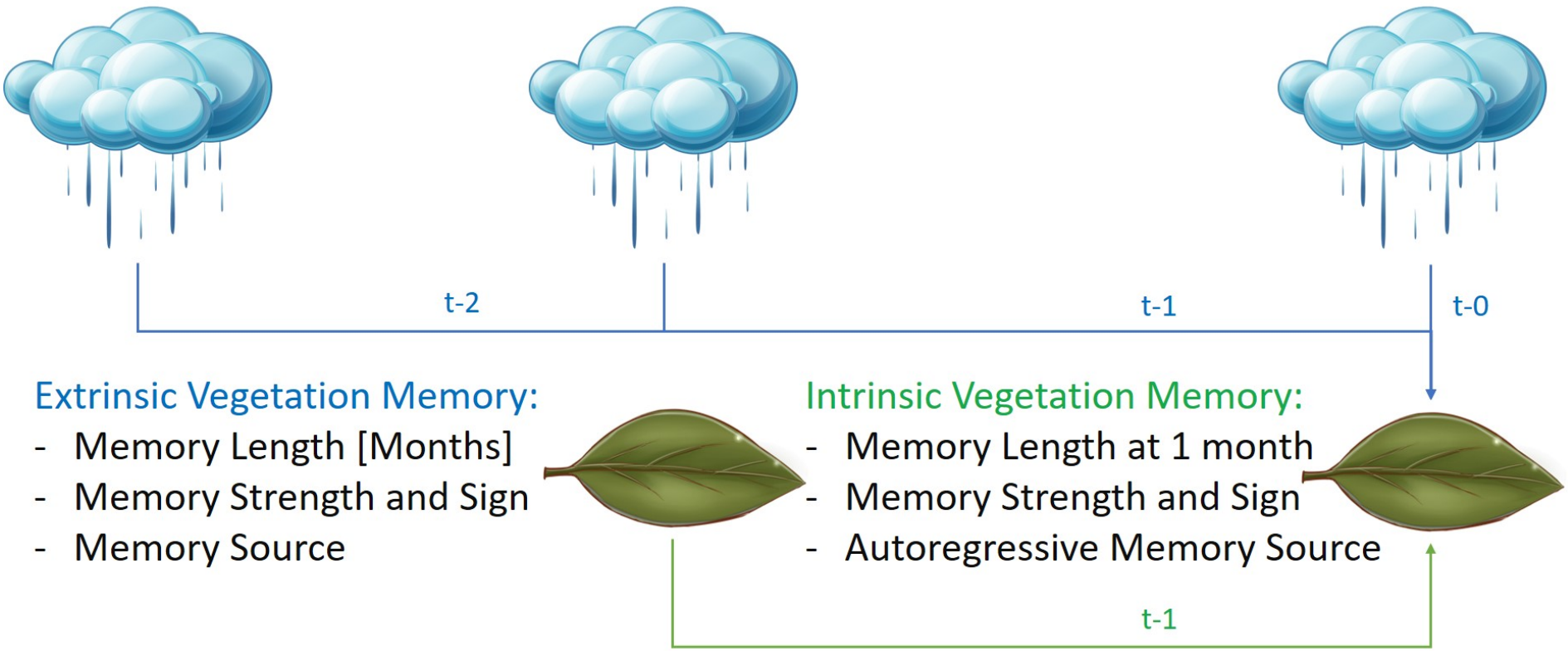

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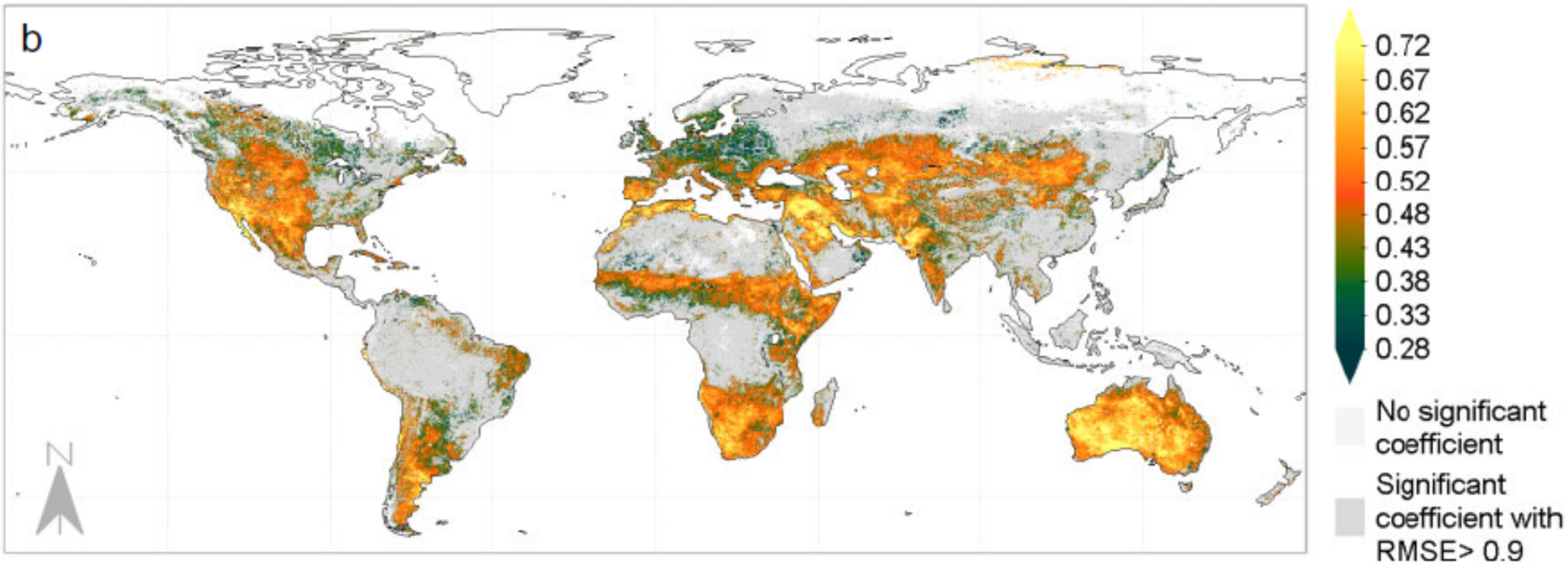

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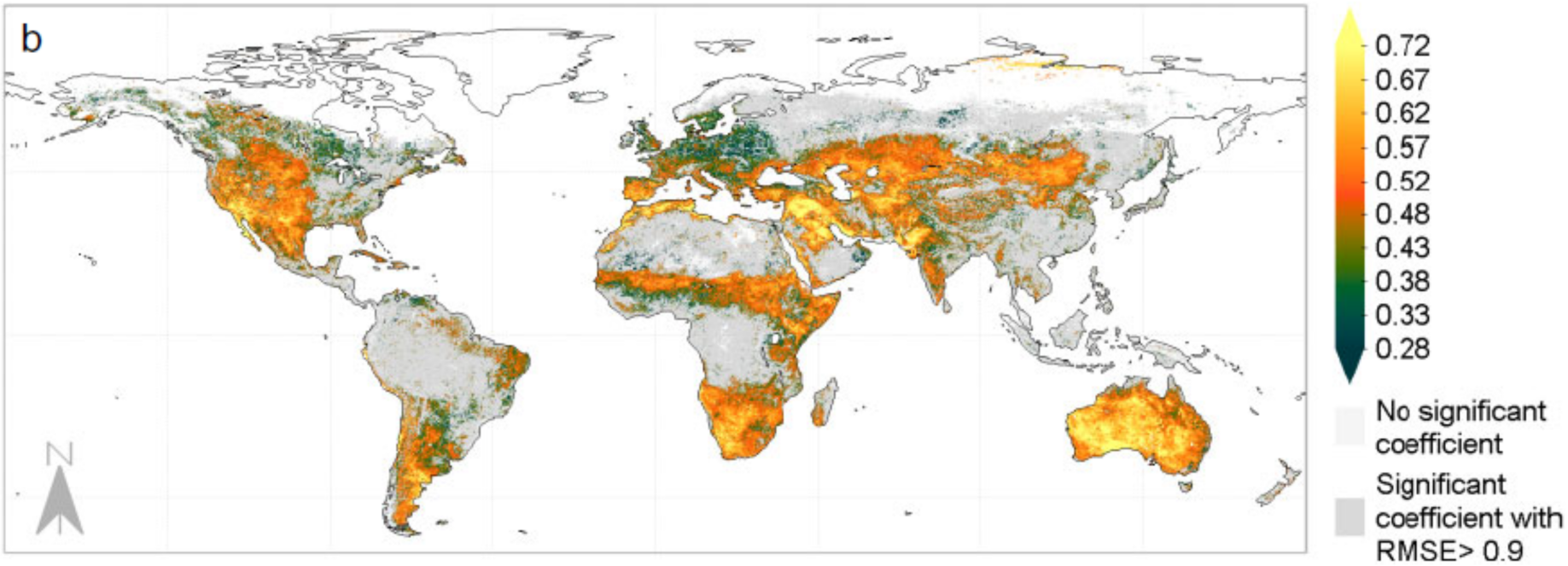

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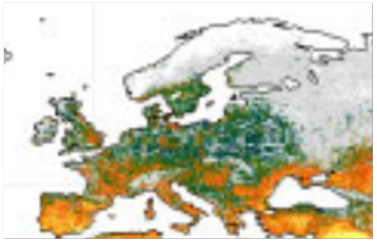
Study Regions

The Iberian Region

Intrinsic Memory



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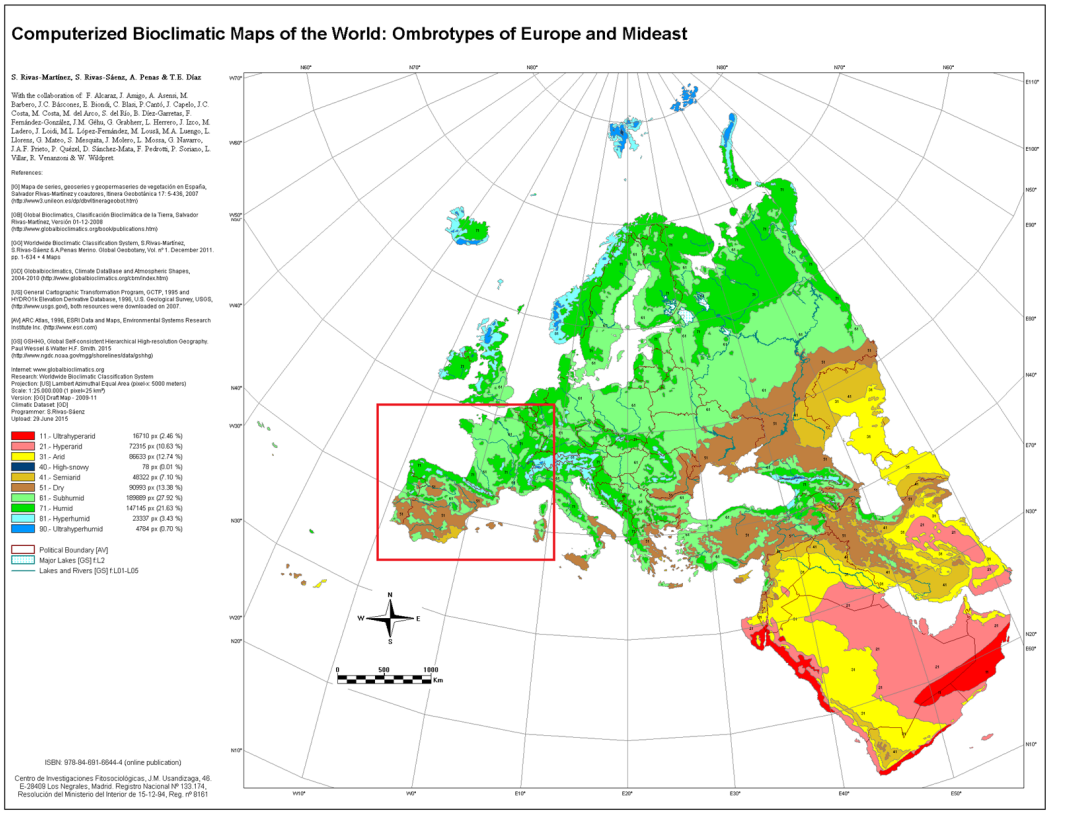
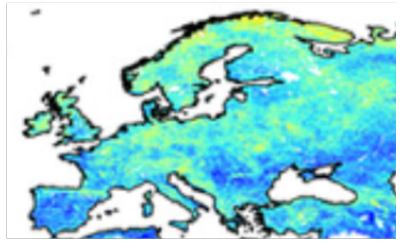


Water Memory



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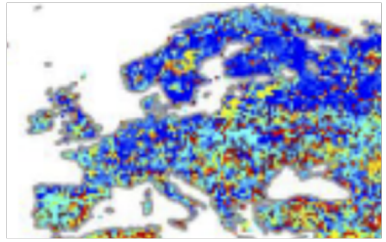
Water Memory Length



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- Caatinga, Brazil
- Australia
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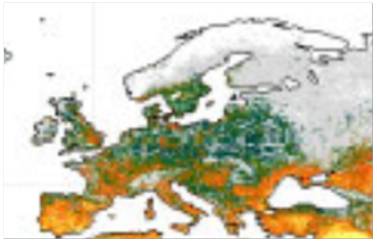

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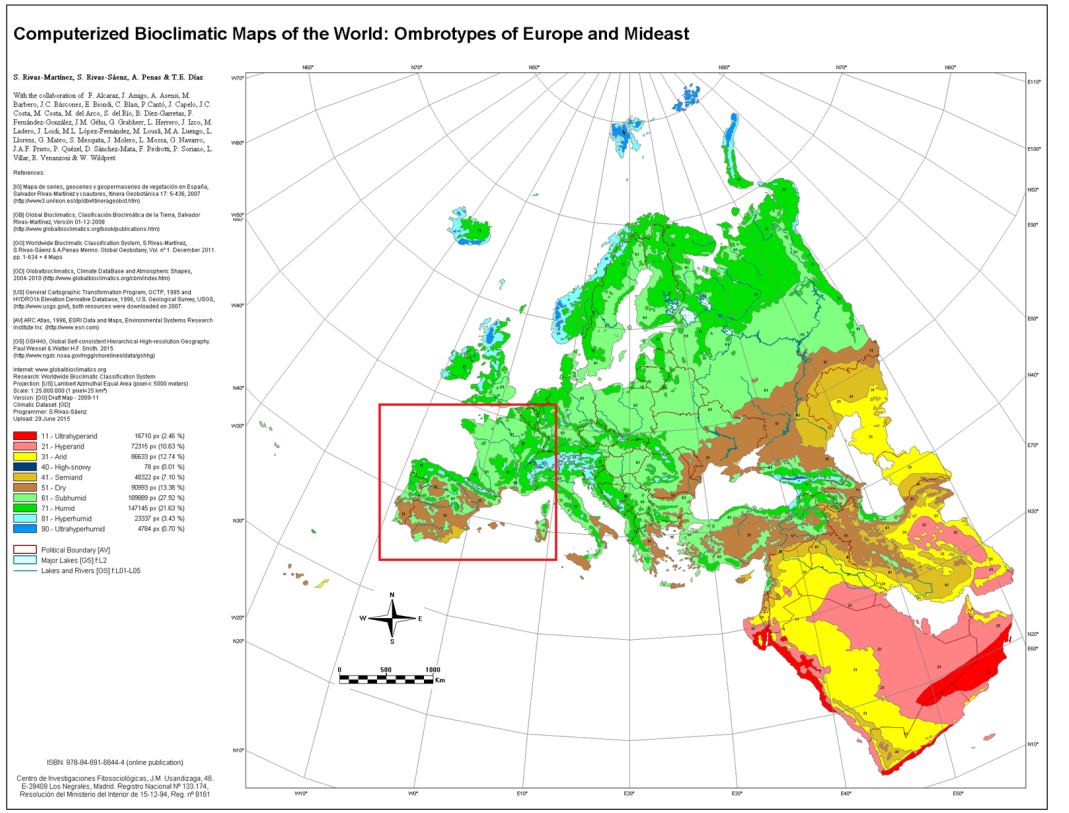

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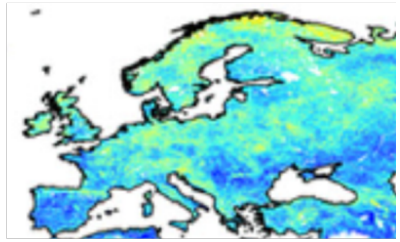

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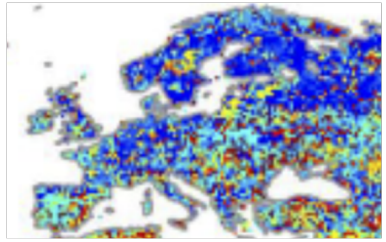

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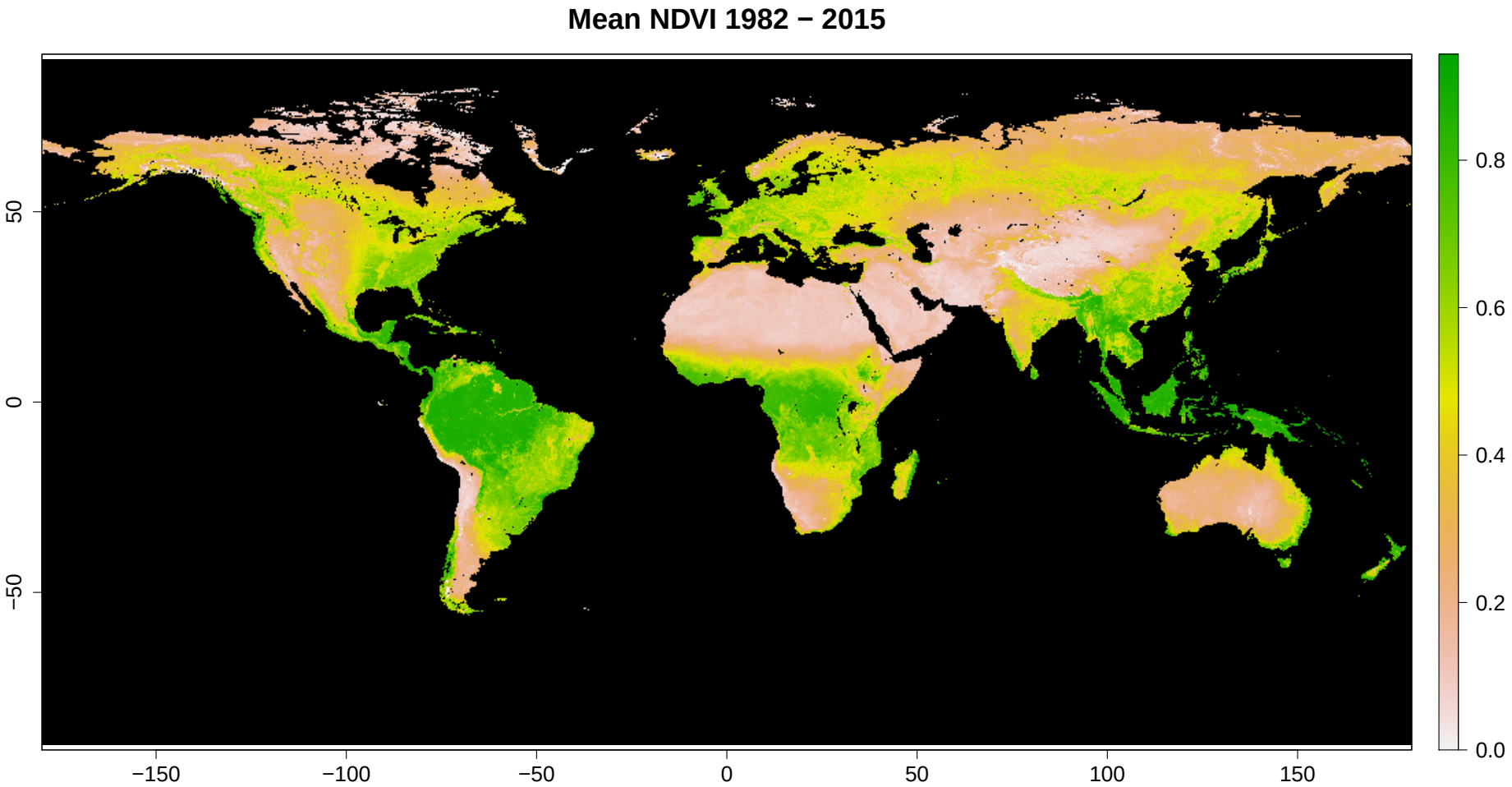
Normalised Difference Vegetation Index (NDVI)

- *Biological Relevance:* Proxy of biomass and vegetation cover
- *Comparability:* Has been used in other studies of vegetation memory



ERA5 & Climate Variables

- **Why:**
  - Applicable globally
  - Gap-less time series
  - More sophisticated approach than previously utilised:
    - Worldclim - Superior Temporal Resolution (superior resolving of climate extremes)
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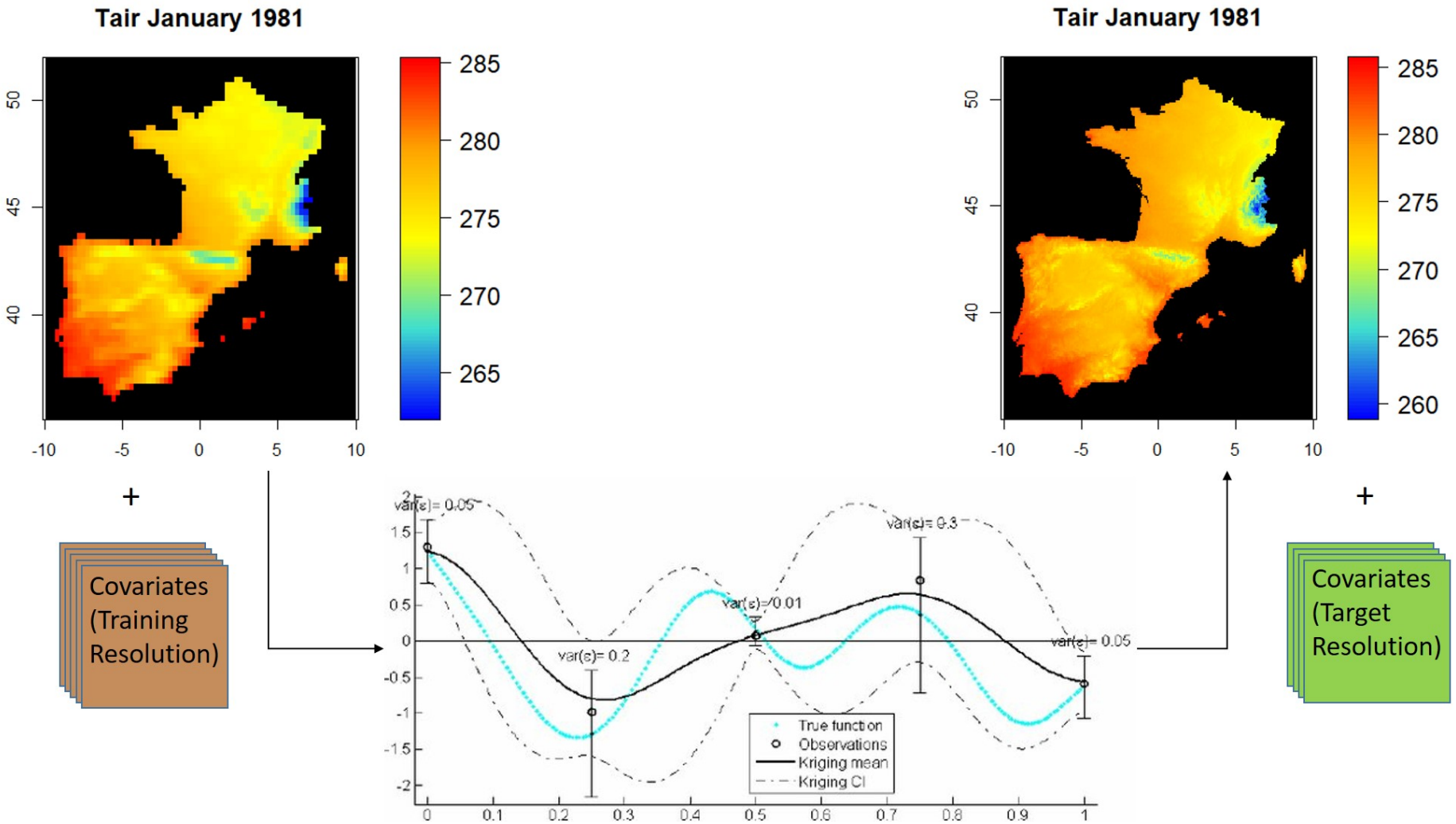
- **Air Temperature** - $Tair$
  - *Why:* Temperature drives plant physiology and drives levels of aridity[3,7].
  - *How:* As one single layer (2m above ground)

Kriging


Tair January 1981
285
280
275
270
265
50
45
40
-10
-5
0
5
10
+
Covariates (Training Resolution)
var(ε)= 0.05
var(ε)= 0.2
var(ε)= 0.01
var(ε)= 0.3
var(ε)= 0.05
True function
Observations
Kriging mean
Kriging CI
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285
280
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COMPADRE Data

Life History Traits (LHTs)

- **Why:**
  - *Biological Relevance:* Indices of plant behaviour through time
  - *Comparability:* Capture much of natural life strategy variation[9]
- **Core Measures:**
  - *Fast-Slow Continuum (FSC):* Capture over 60% of the variation in plant life history strategies
    - FSC-1: Life History Speed
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Pixel-Wise Model Building

- Linear detrending
- Z-Scores:

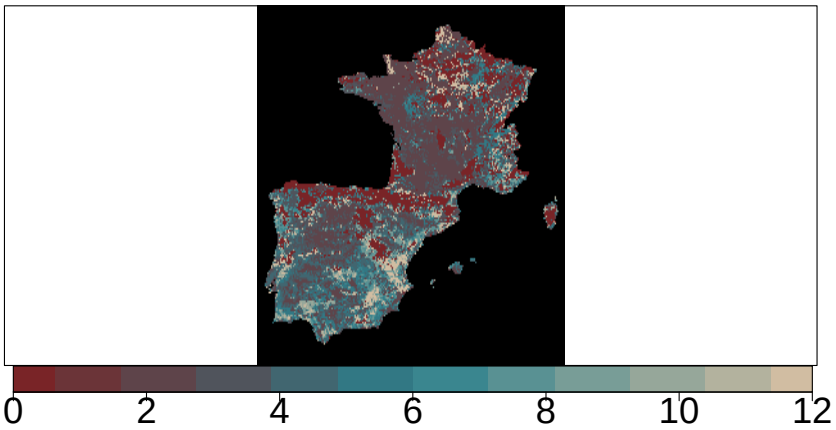
$$Anomaly_i = \frac{Detrended_i - \overline{Detrended_{month}}}{SD_{Detrended,month}} \quad (1)$$

- Calculate:
  - $t-1$ lag for NDVI
  - Cummulative lags for $Qsoil$ data
- Set NDVI anomalies to 'NA' in months for which $Thresholds_i < 0.1$ with $Thresholds_i = \overline{Raw_{NDVI,month}}$
- PCA regression and model selection:

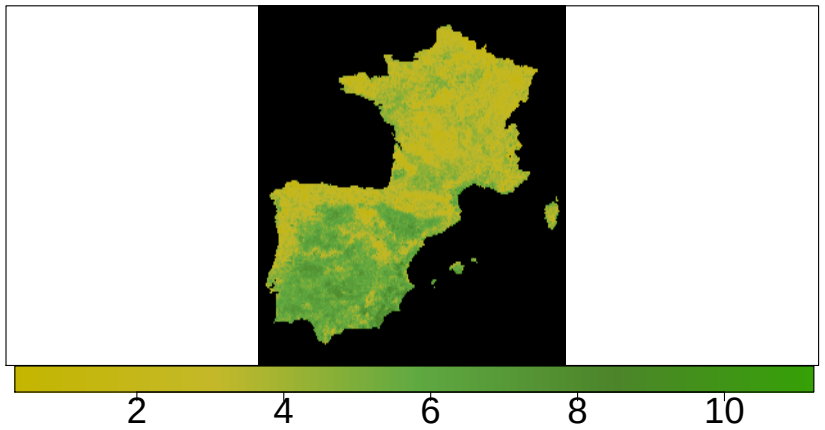
$$NDVI_t = \beta_{t-1} * NDVI_{[t-1]} + \beta_{Qsoil} * Qsoil_{k;m} + \beta_{Tair} * Tair_t \quad (2)$$

Vegetation Memory Coefficients

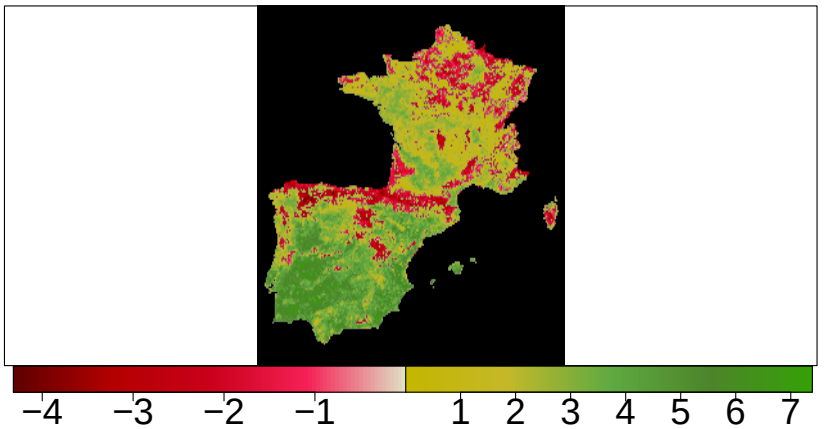
Soil Memory Lag



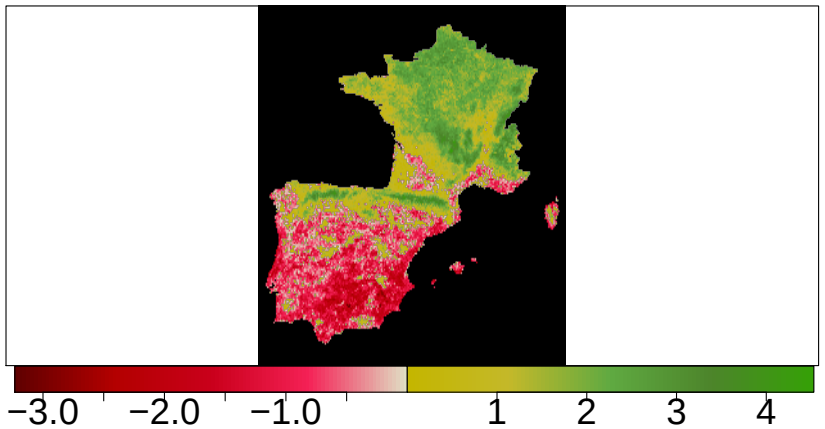
NDVI [t−1]



Soil Moisture (0−7cm)



Air Temperature



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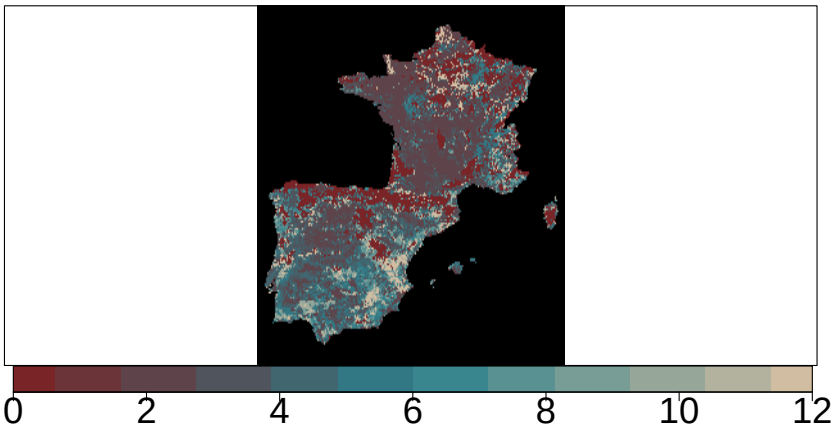

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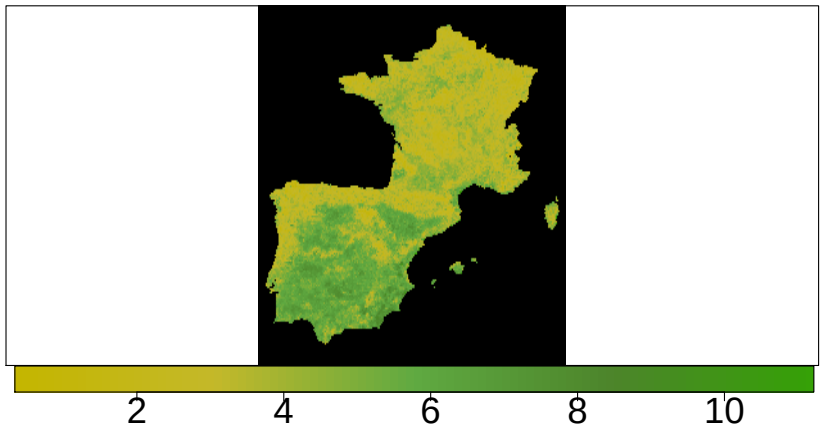

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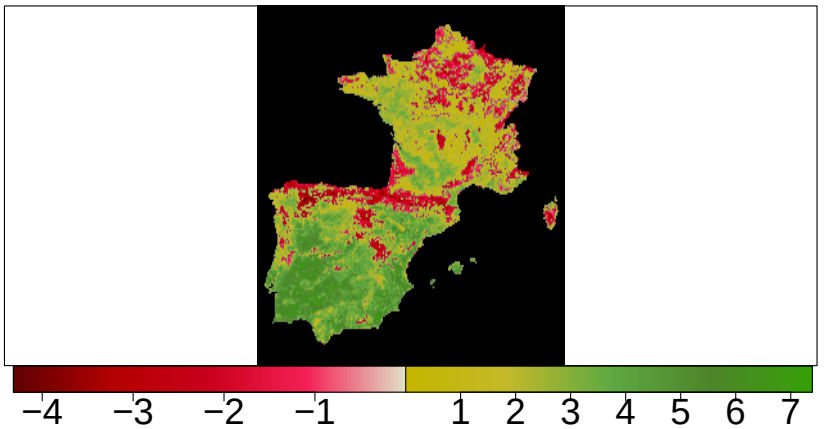

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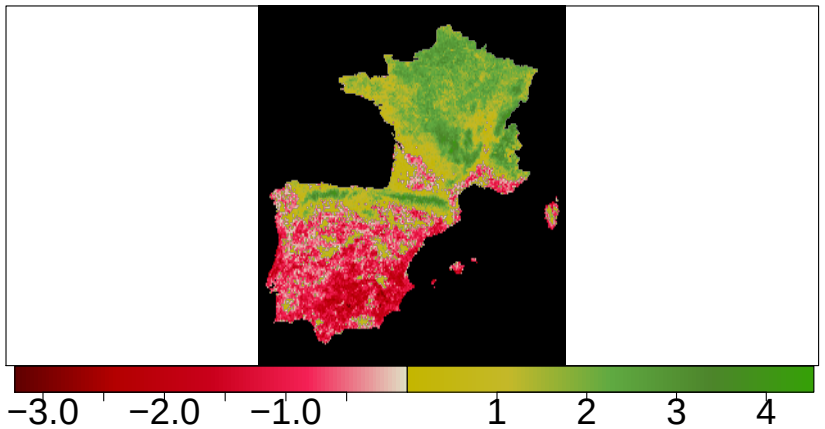

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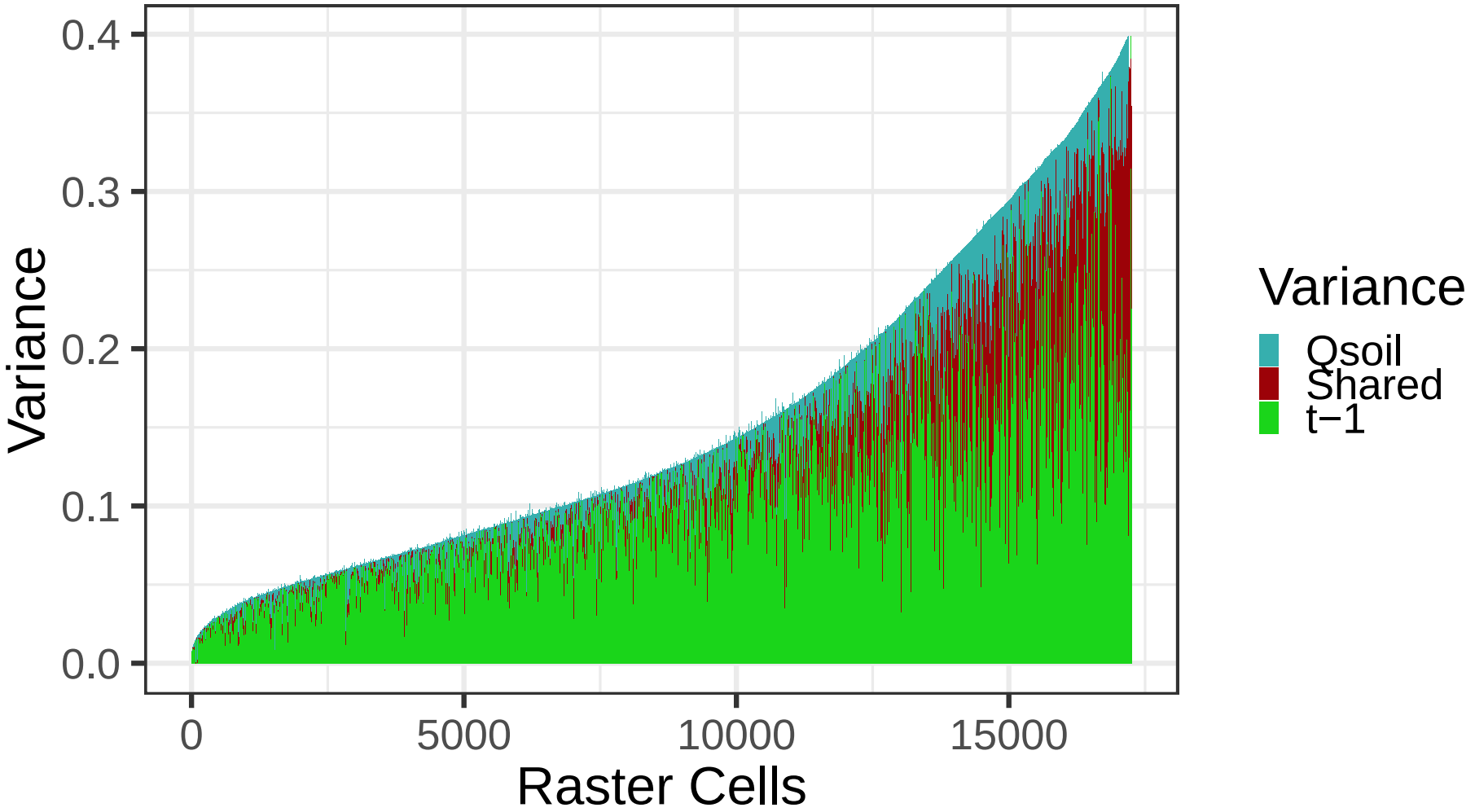
Distinguishing Intrinsic and Extrinsic Memory

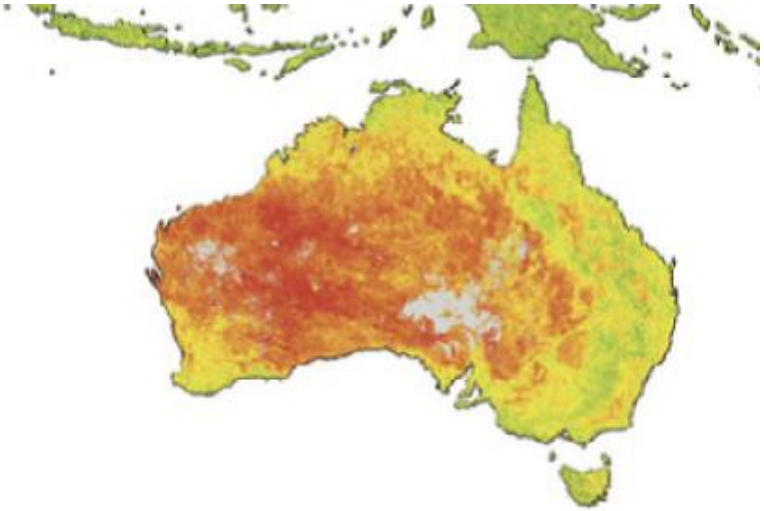
Qsoil1 is the **most informative** of the **soil moisture** layers!



Identifying Underlying Extrinsic Patterns I

Uniform $NDVI[t-1]$ **effect** across Australia **contrasts** with **other studies**.

Intrinsic Memory by Seddon et al.[6]:



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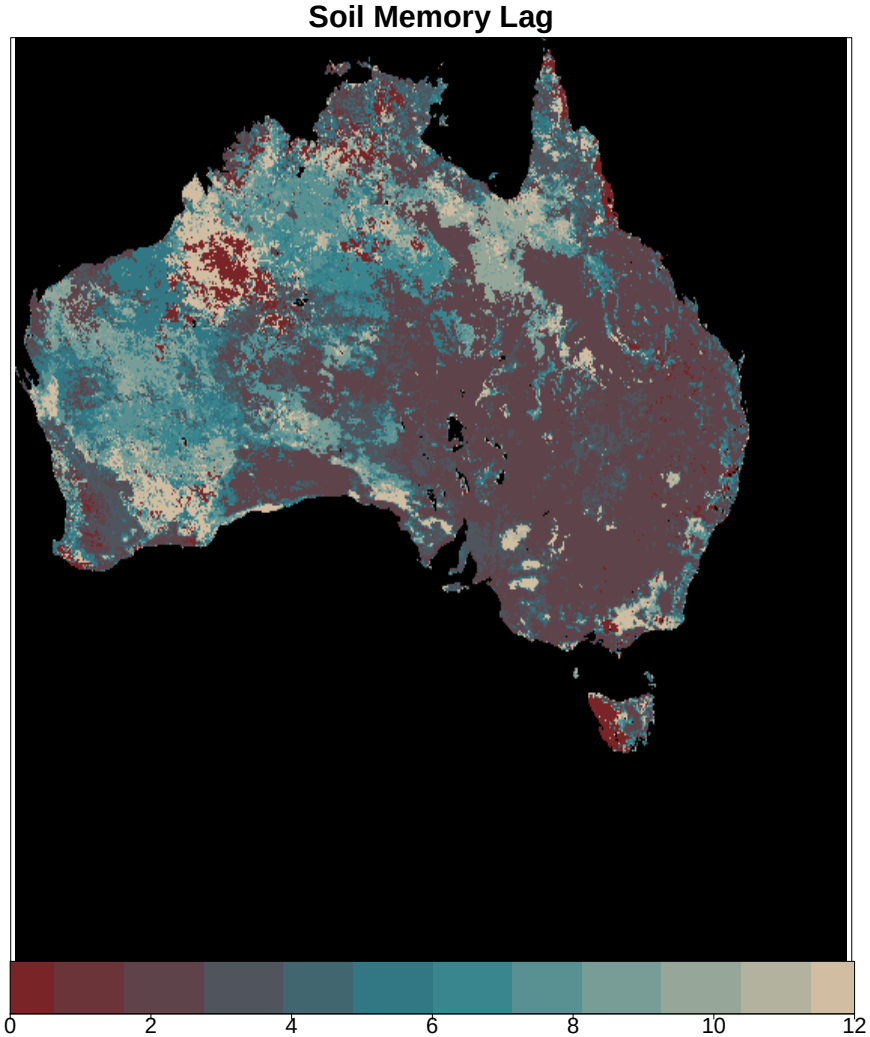

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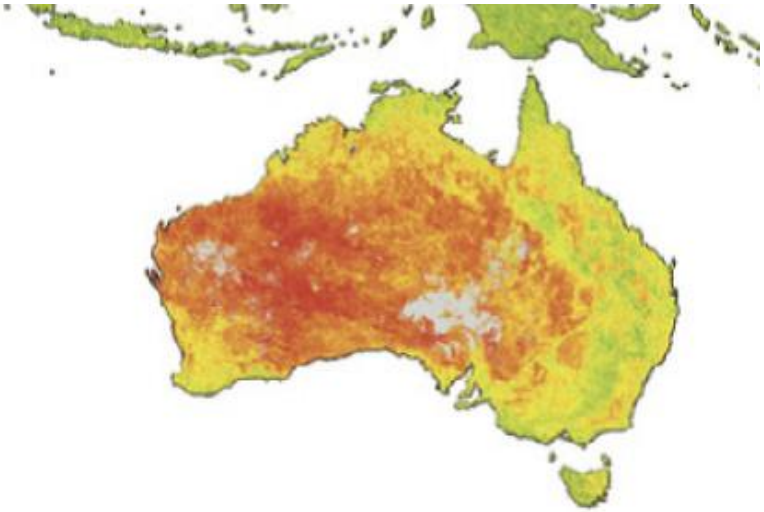

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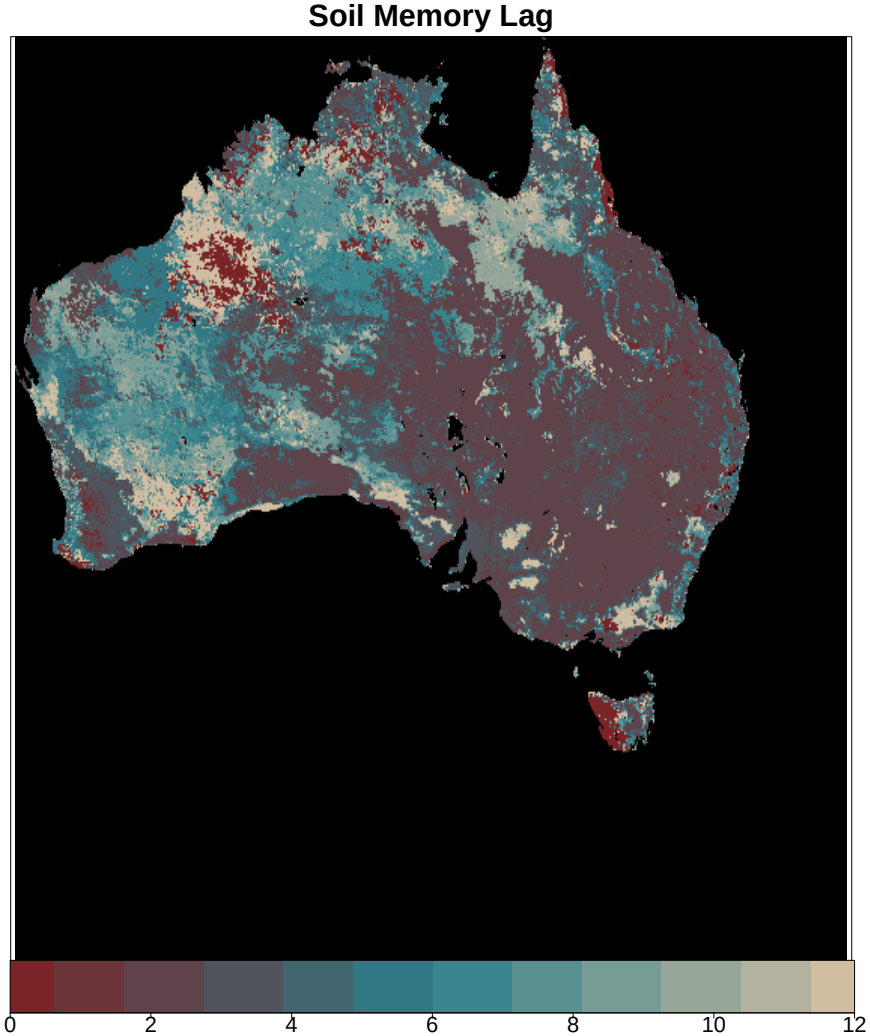

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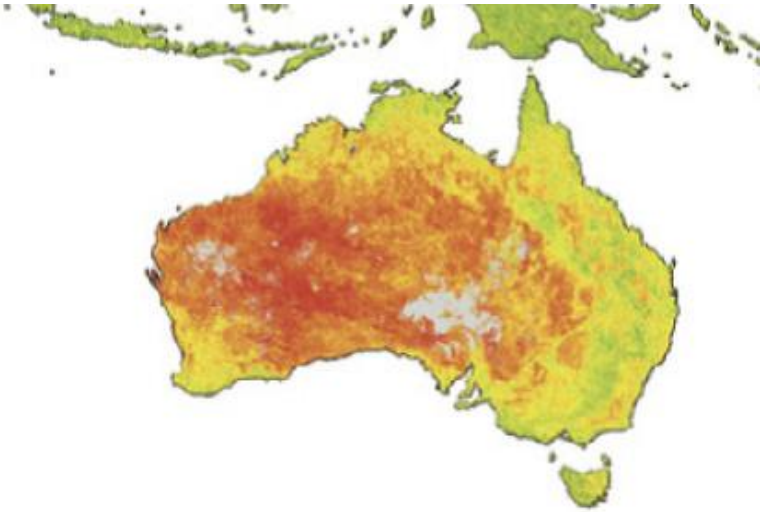
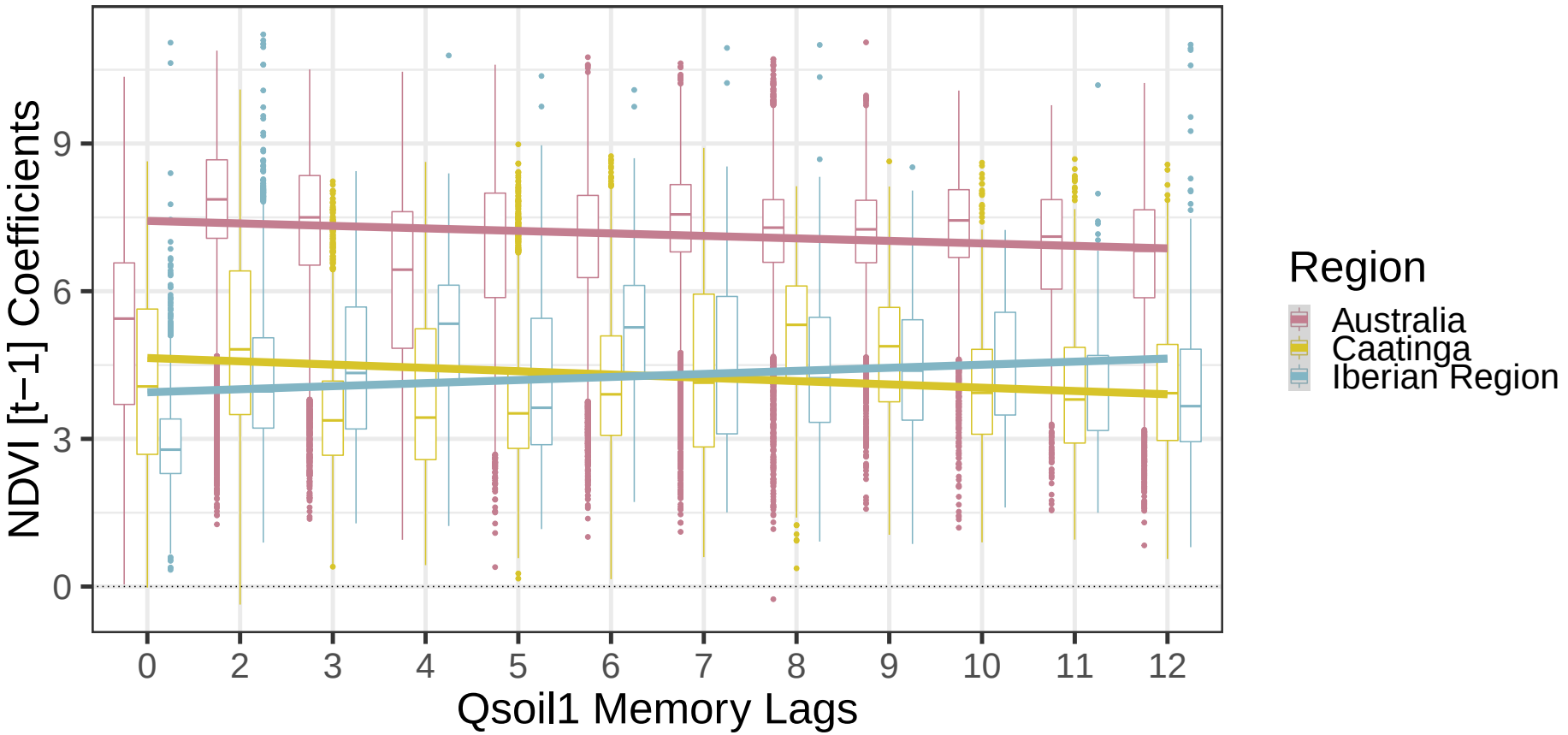


Previous $t-1$ variation can be **understood through extrinsic vegetation memory**.

Vegetation Memory Adaptation



Relationship of $t-1$ coefficient and extrinsic vegetation memory length is not uniform within or between study regions.

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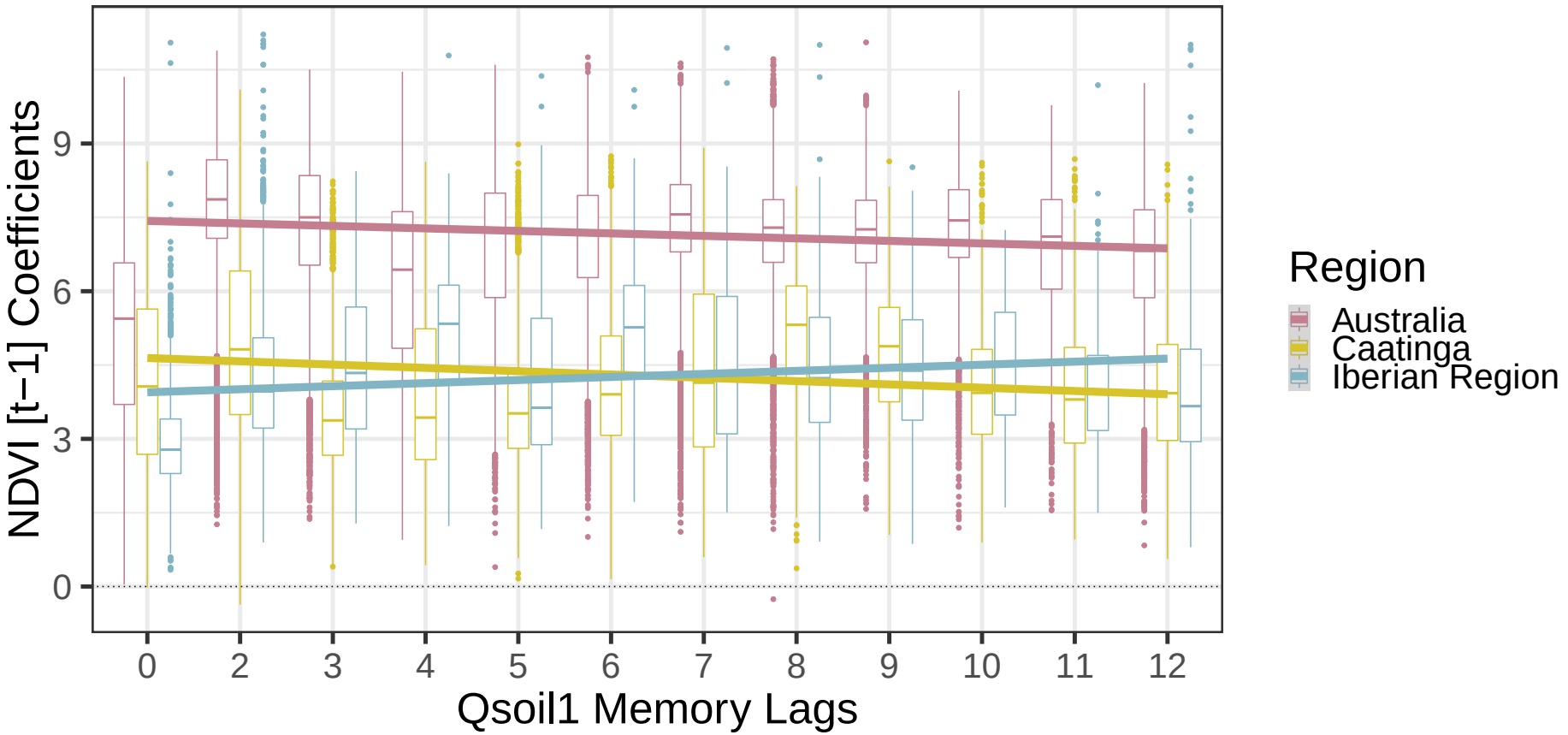

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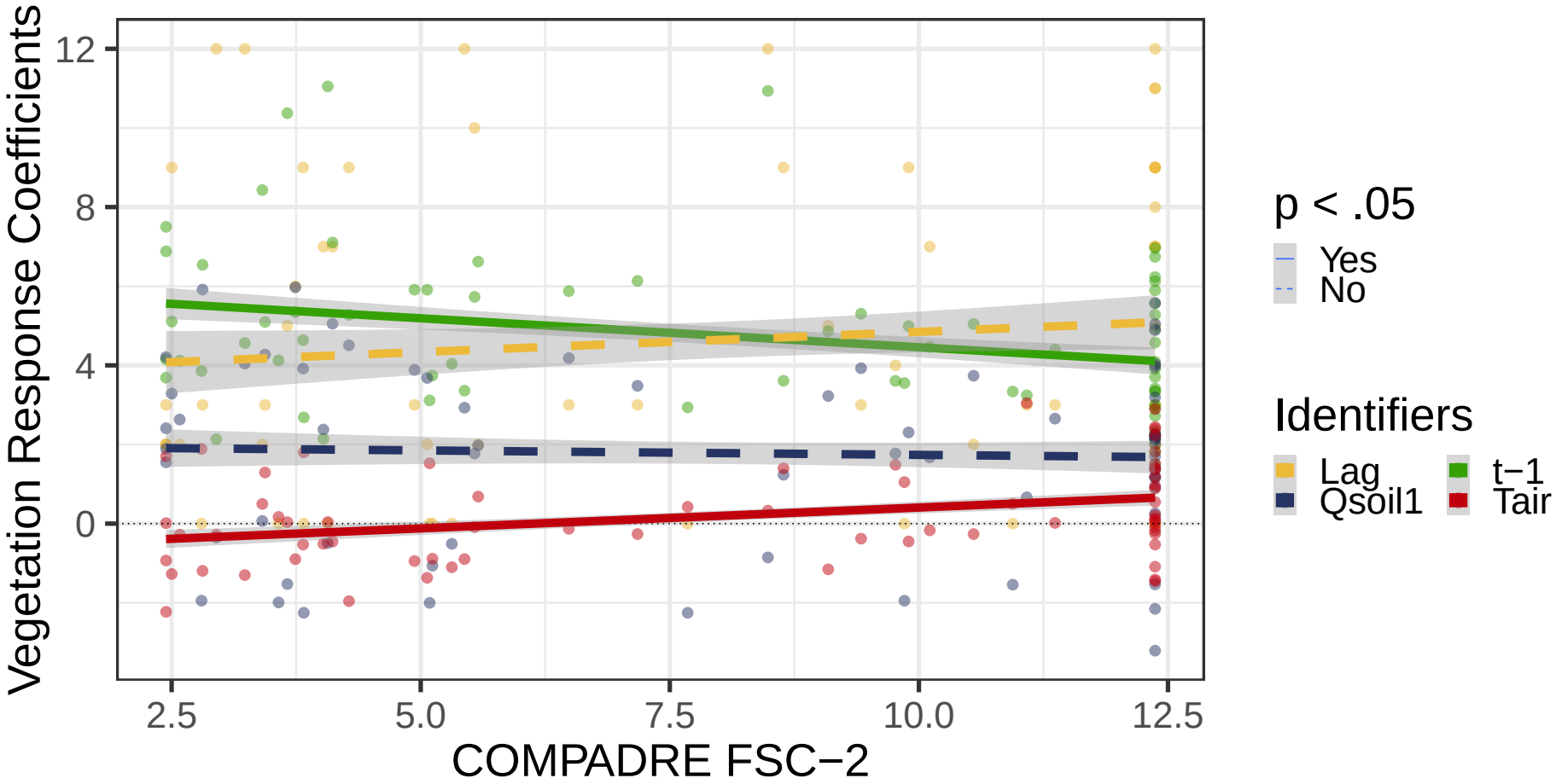
Plant Function I

Linking **plant functional traits** and vegetation memory proved **non-conclusive** but **life history traits** showed **interesting patterns**:



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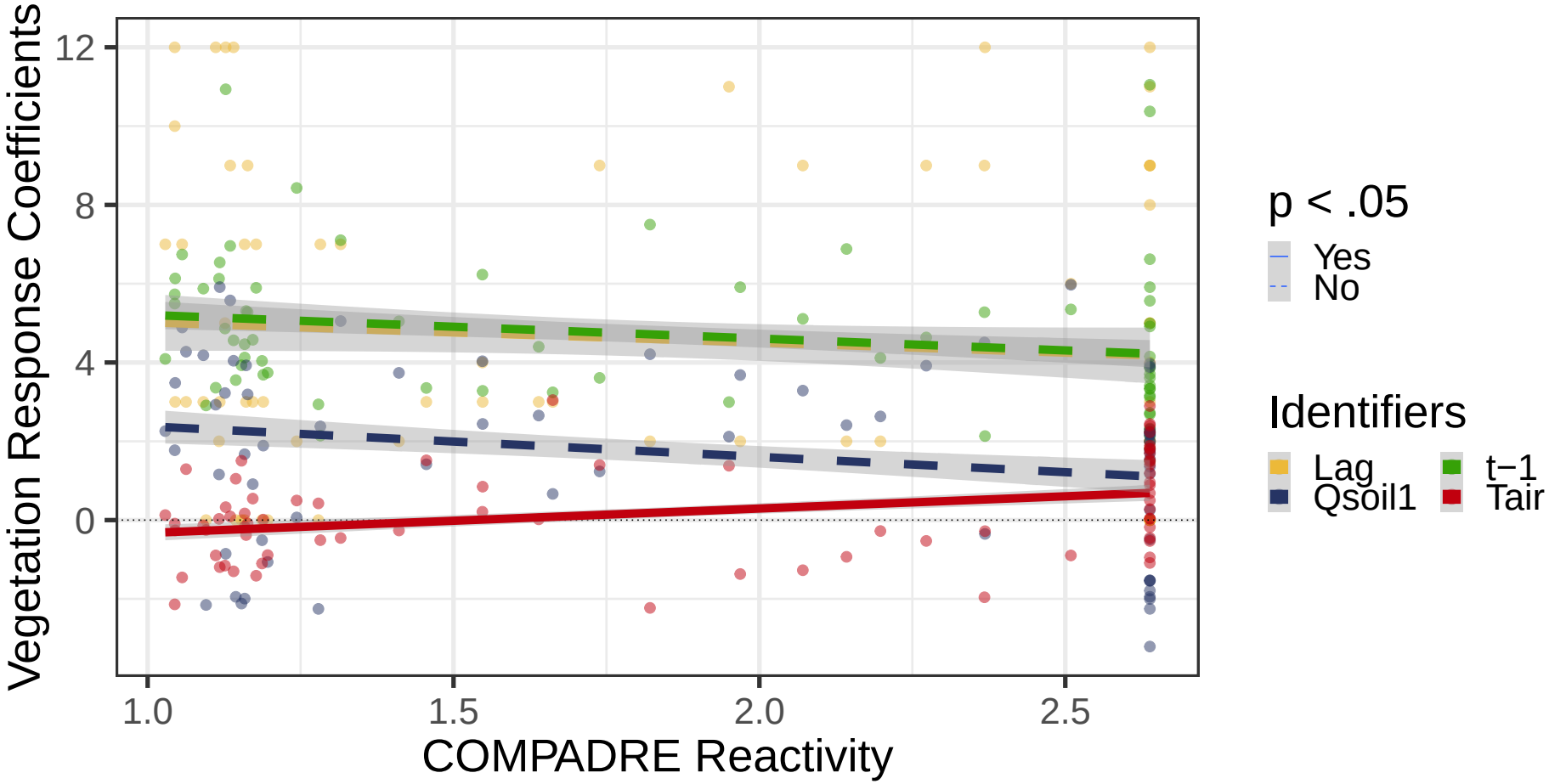

Some LHTs can be linked to some vegetation memory characteristics.

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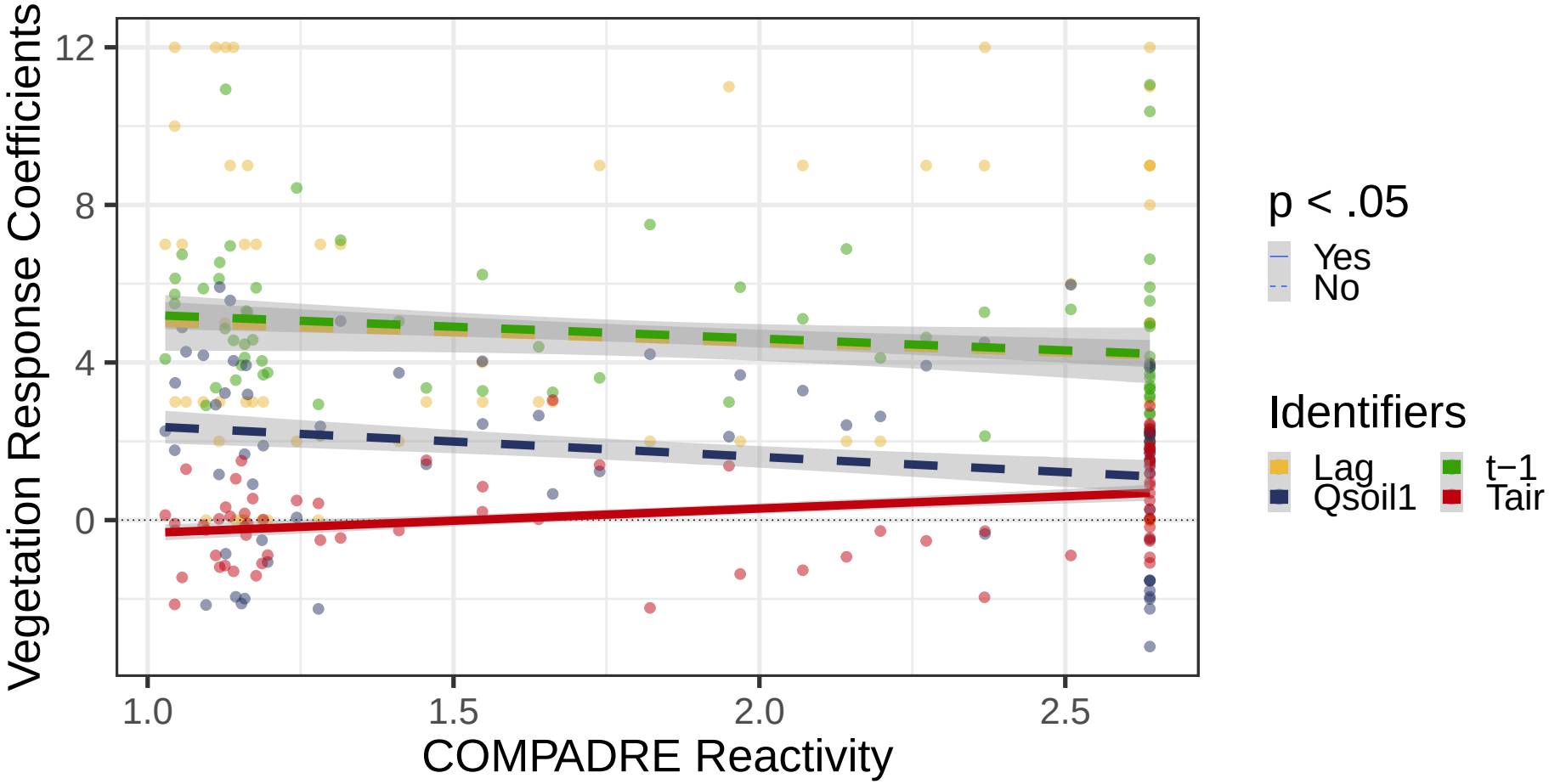

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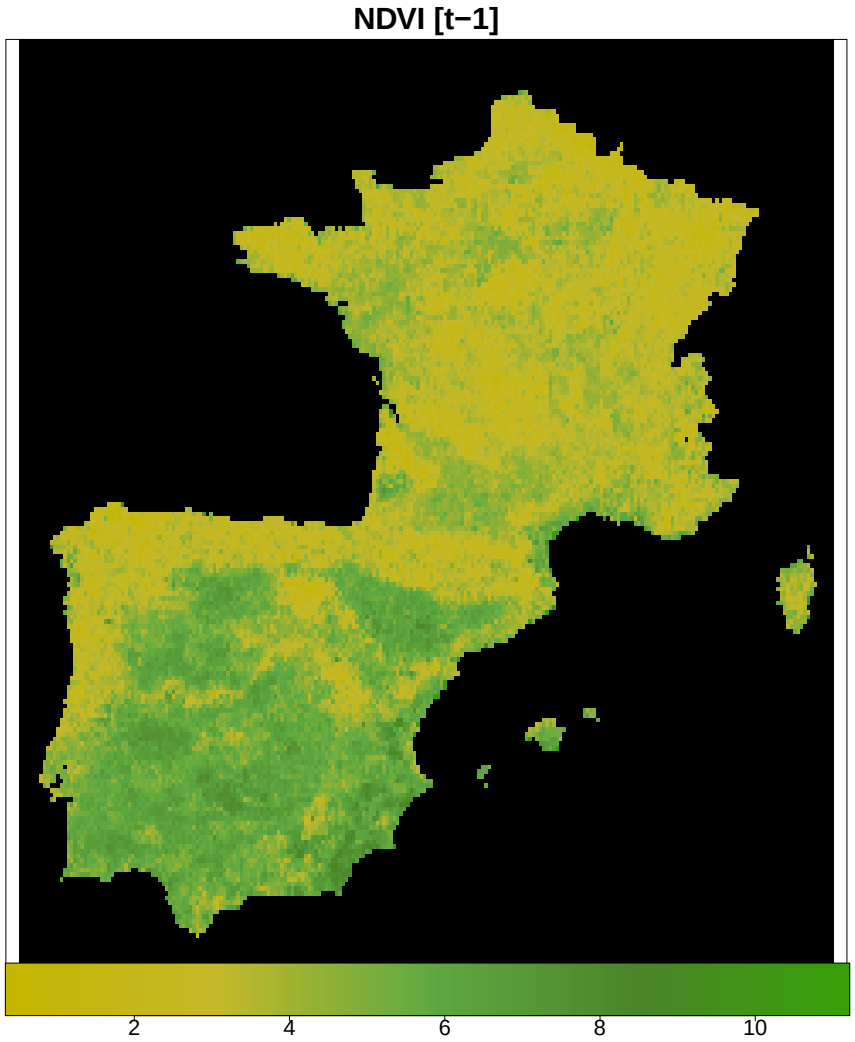

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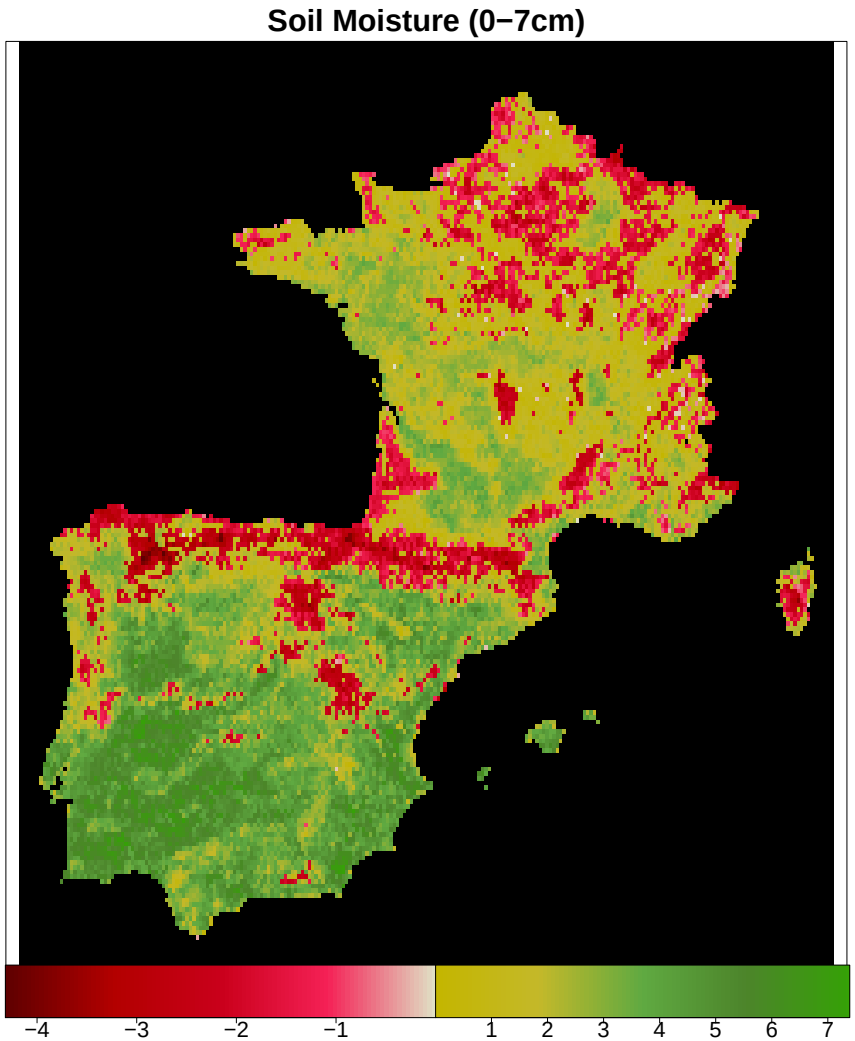
1. Intrinsic vegetation memory as a proxy for engineering resilience may be an oversimplification.



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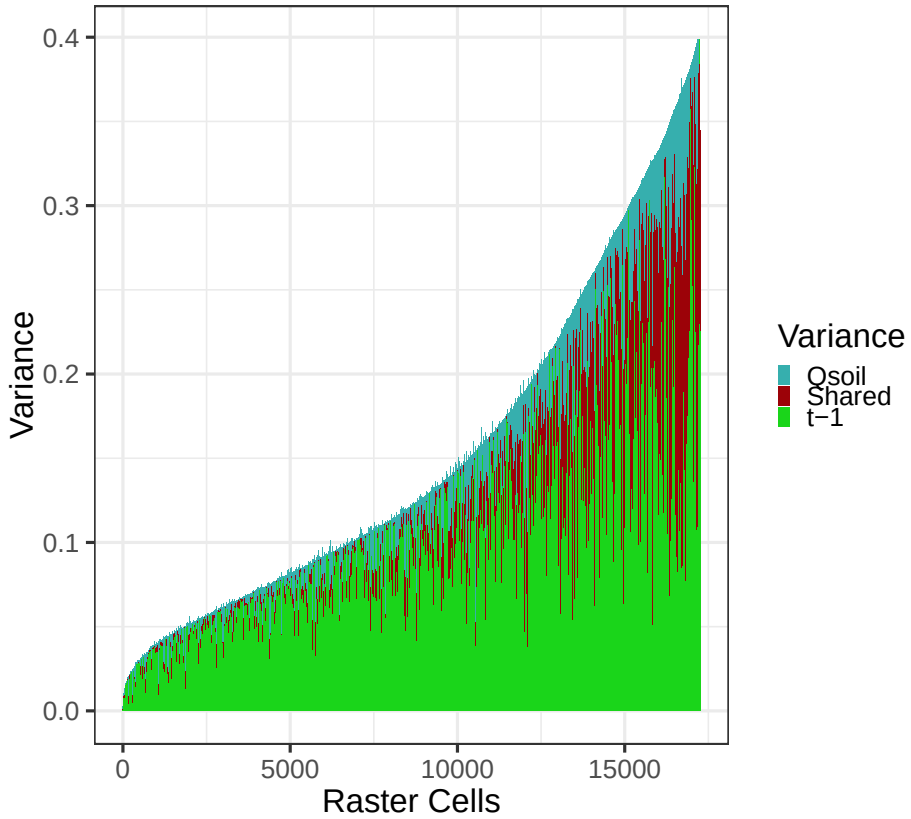

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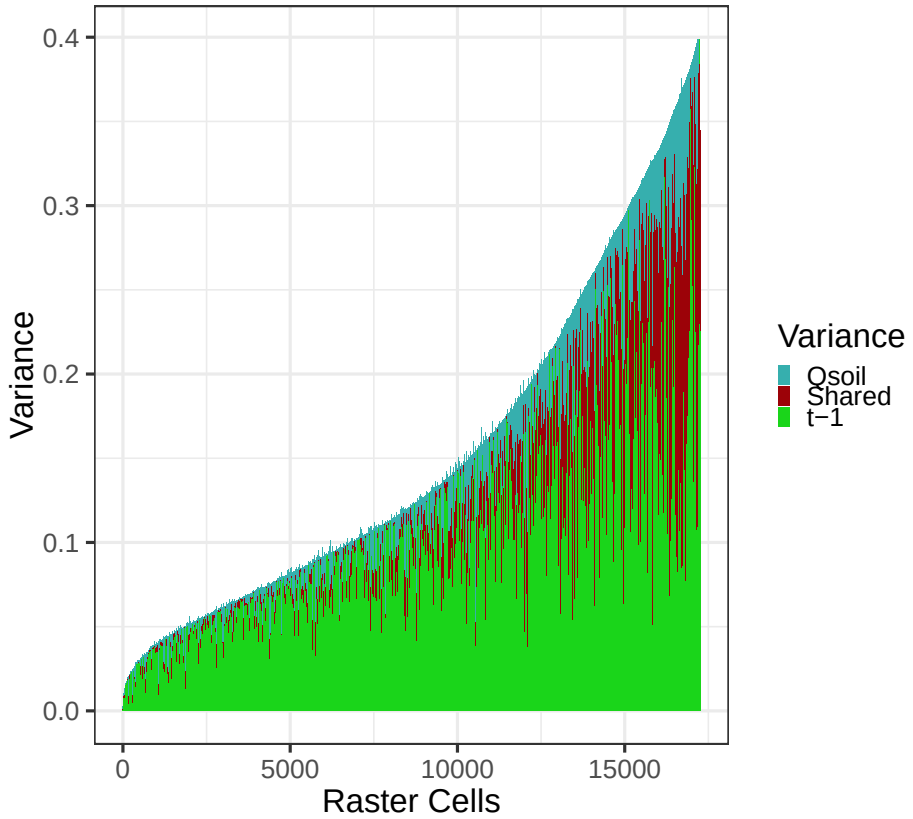

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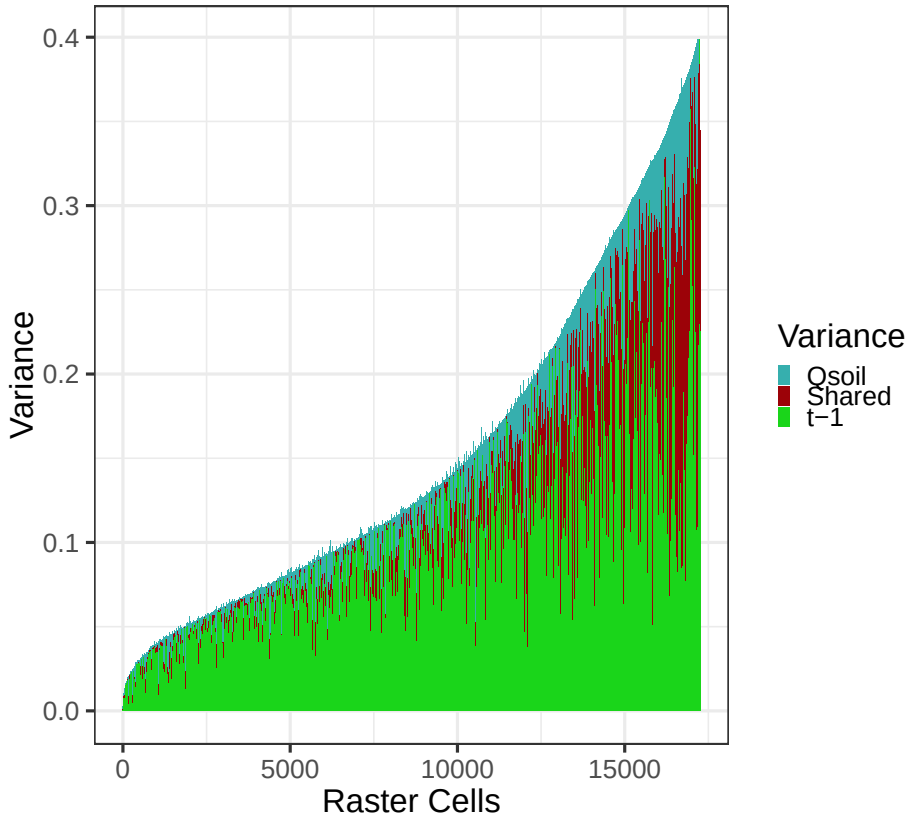

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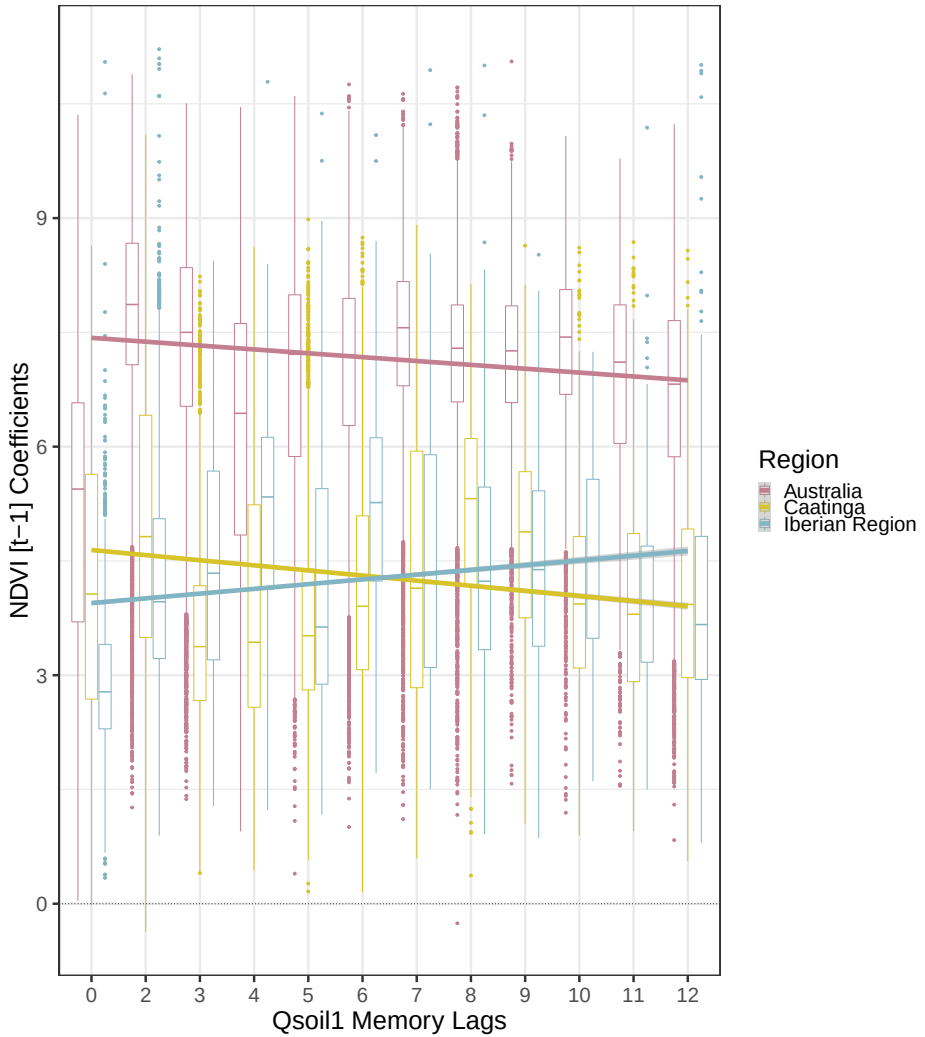

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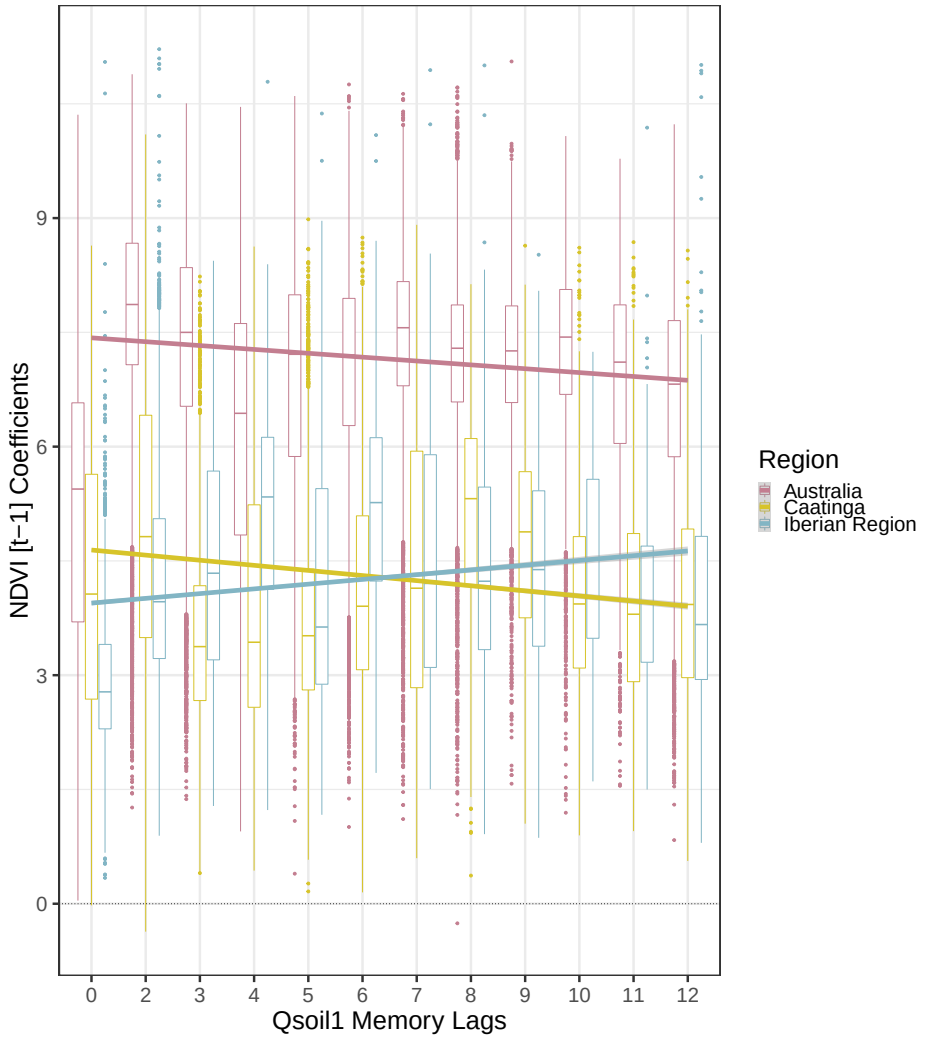

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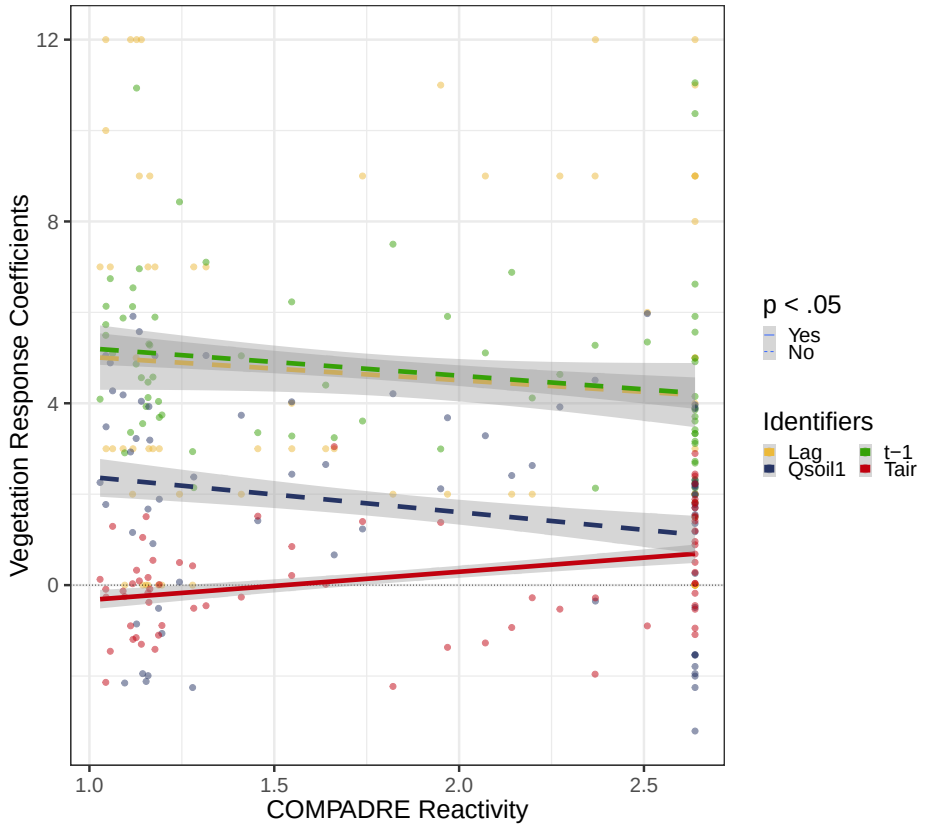

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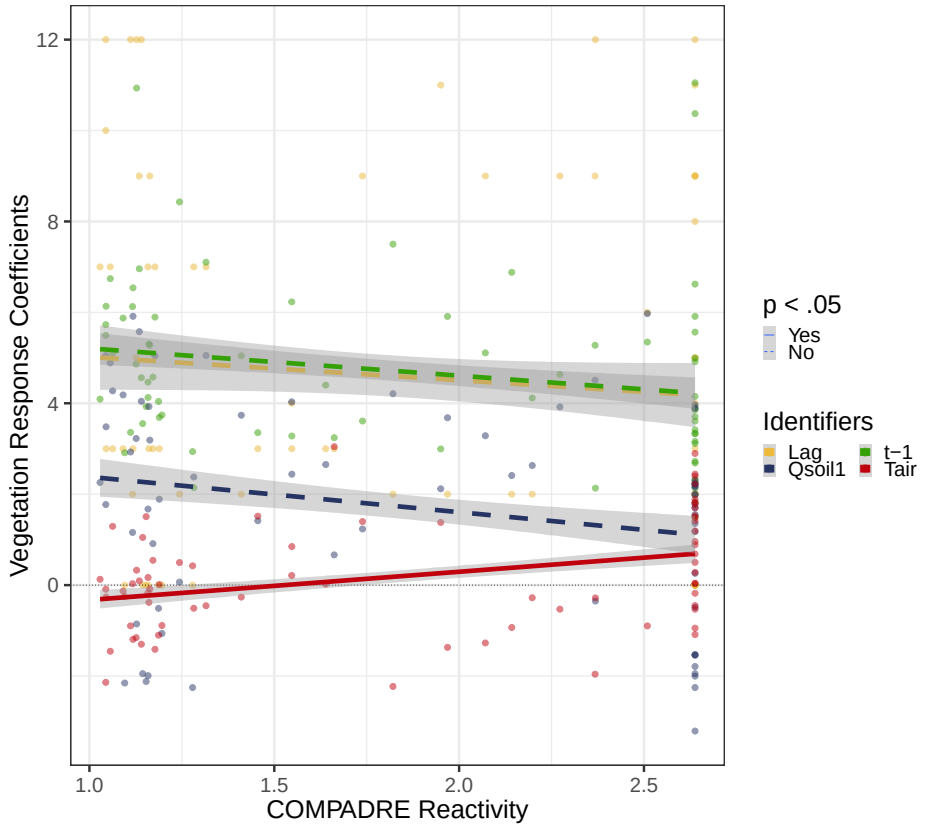

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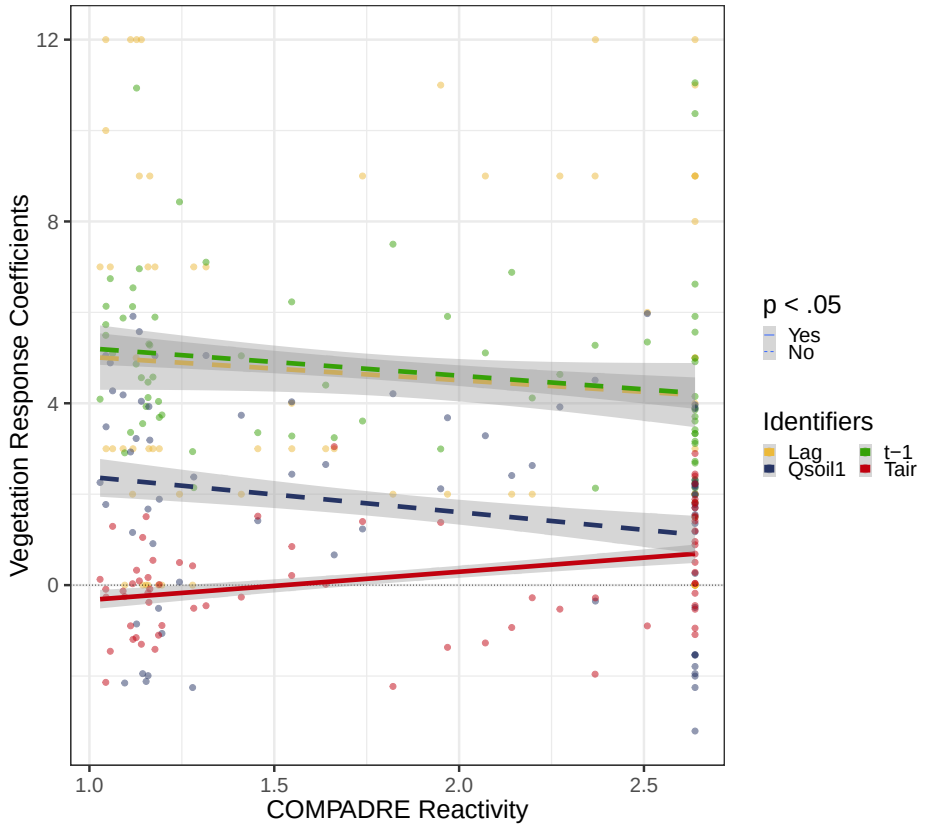

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1. In which ways does vegetation react to anomalies of other climatic factors?
2. How robust are my findings when applied to non-dryland regions?
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