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
University of Bergen

05/07/2019

Outline

What is this?

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 Functional* 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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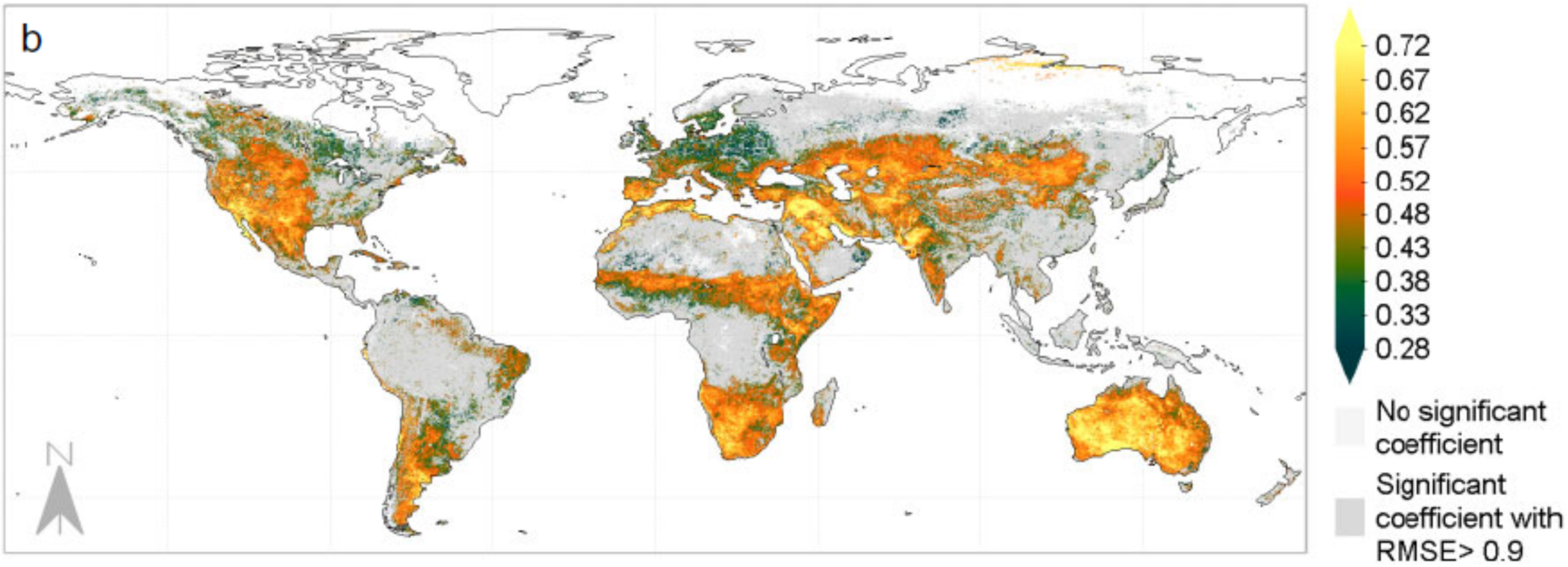
Vegetation Memory proposed to be a *proxy* of **engineering resilience in ecosystems** (*high memory* $\sim$ *low resilience*)[3].



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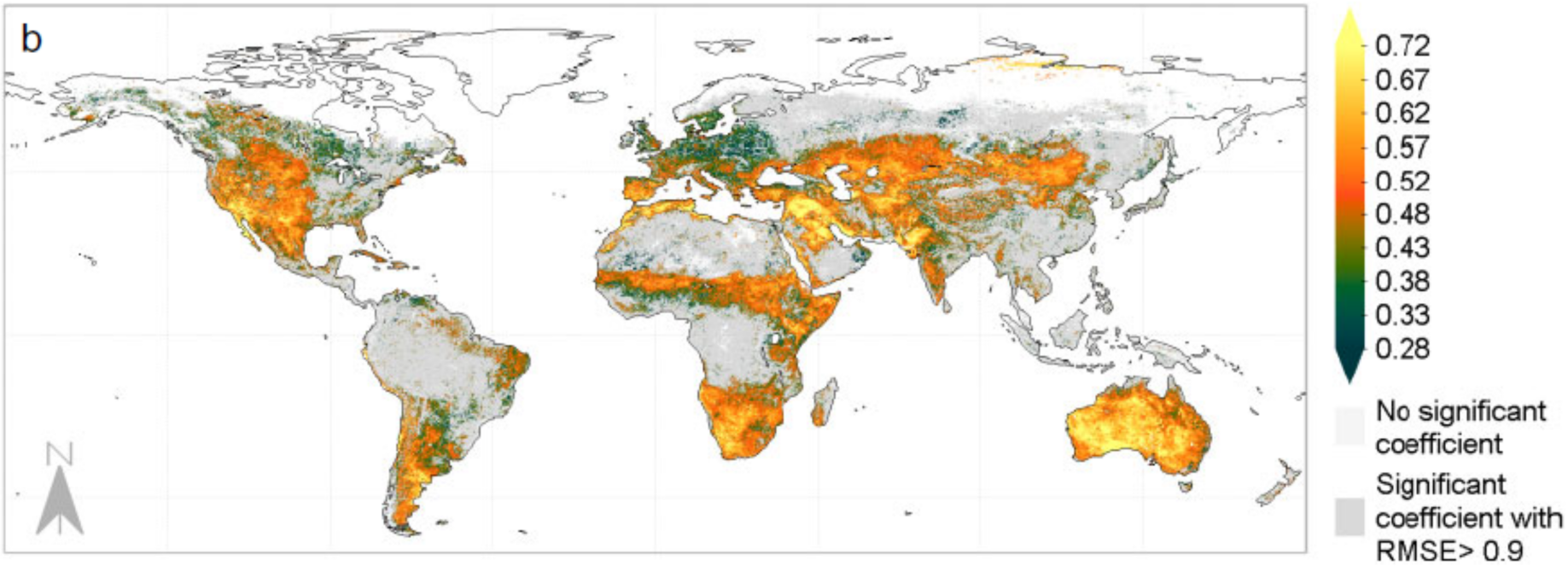

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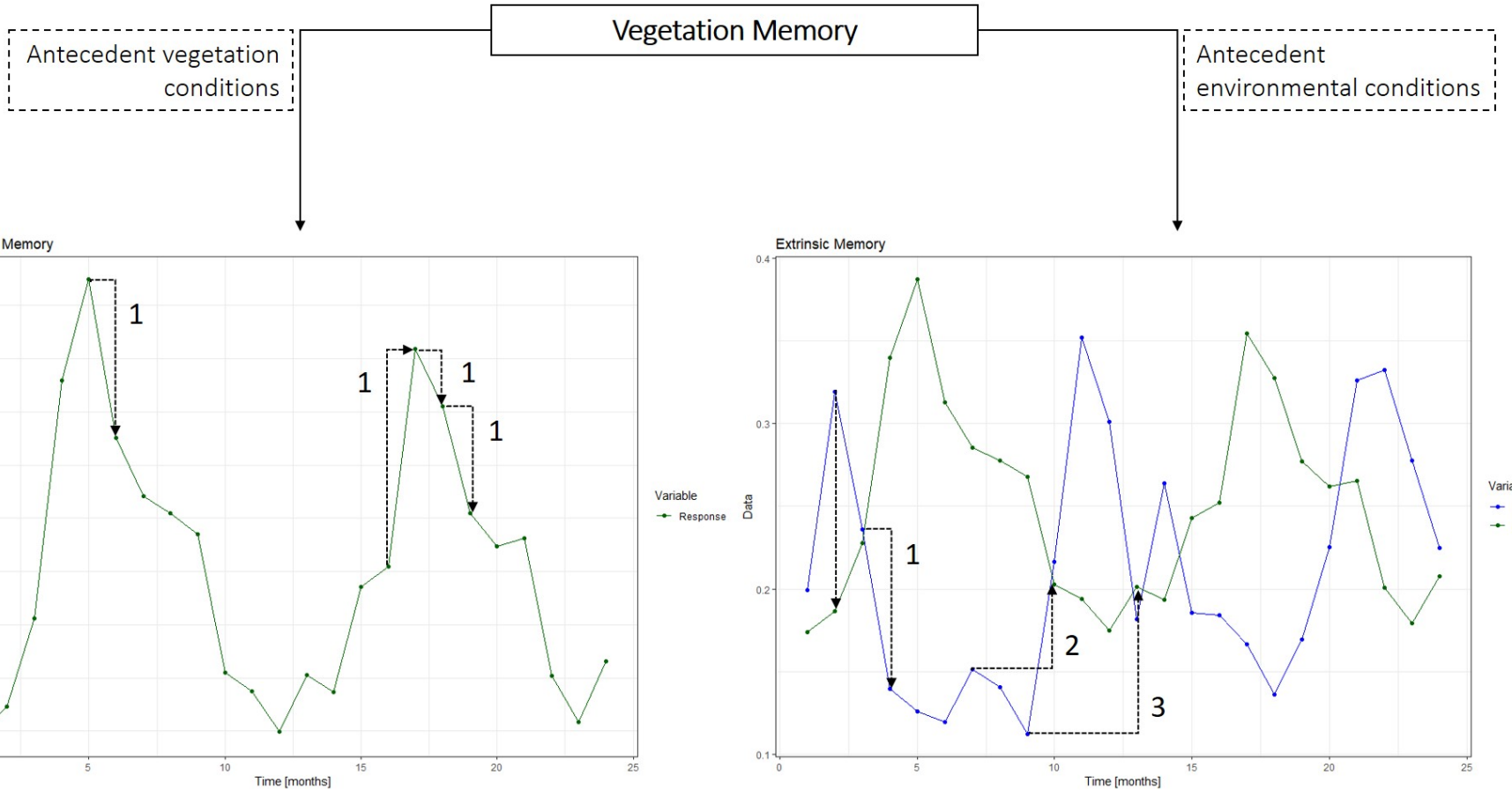
Intrinsic vs. Extrinsic Memory Components



→ 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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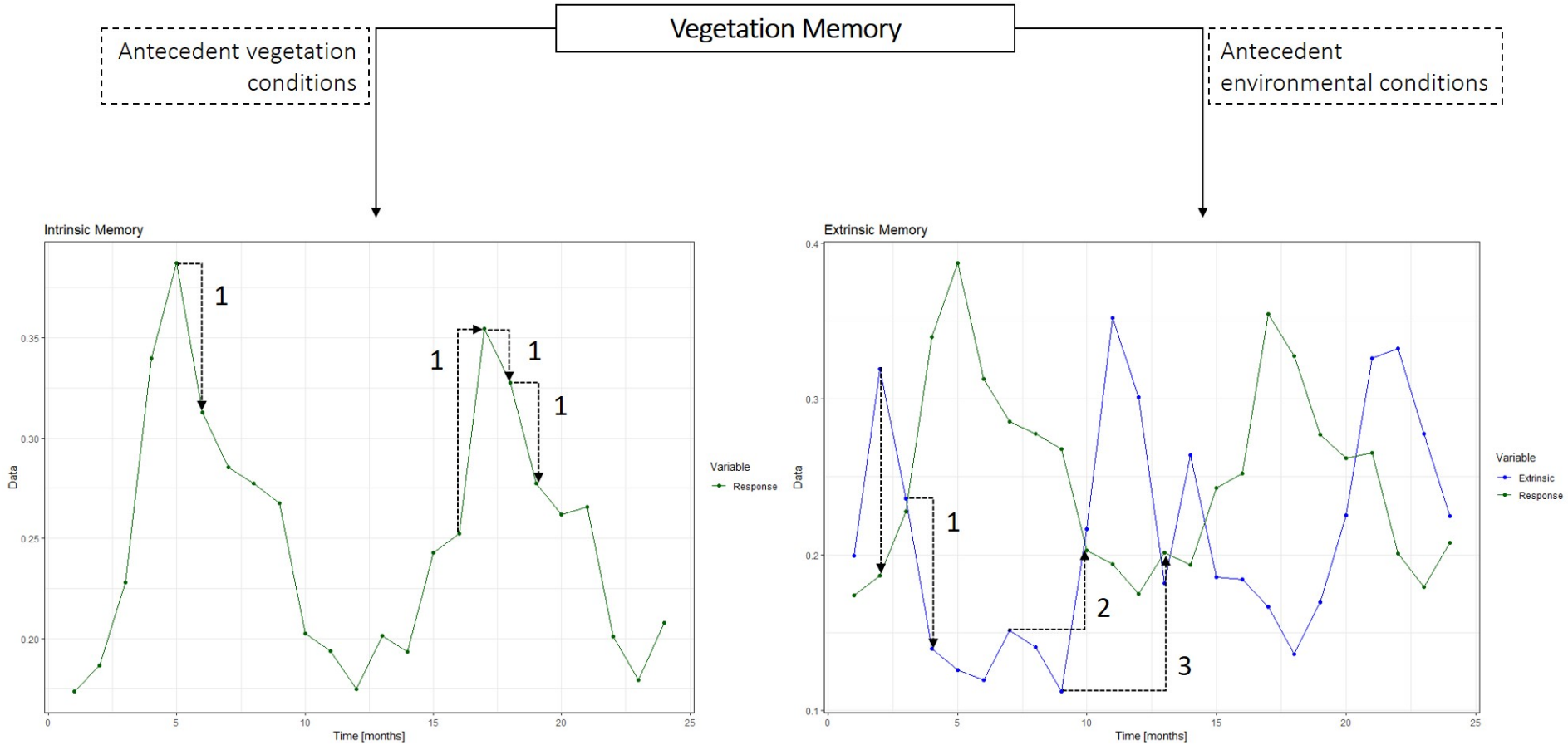

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The Iberian Region

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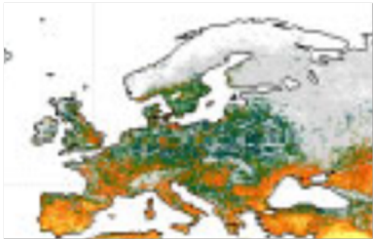

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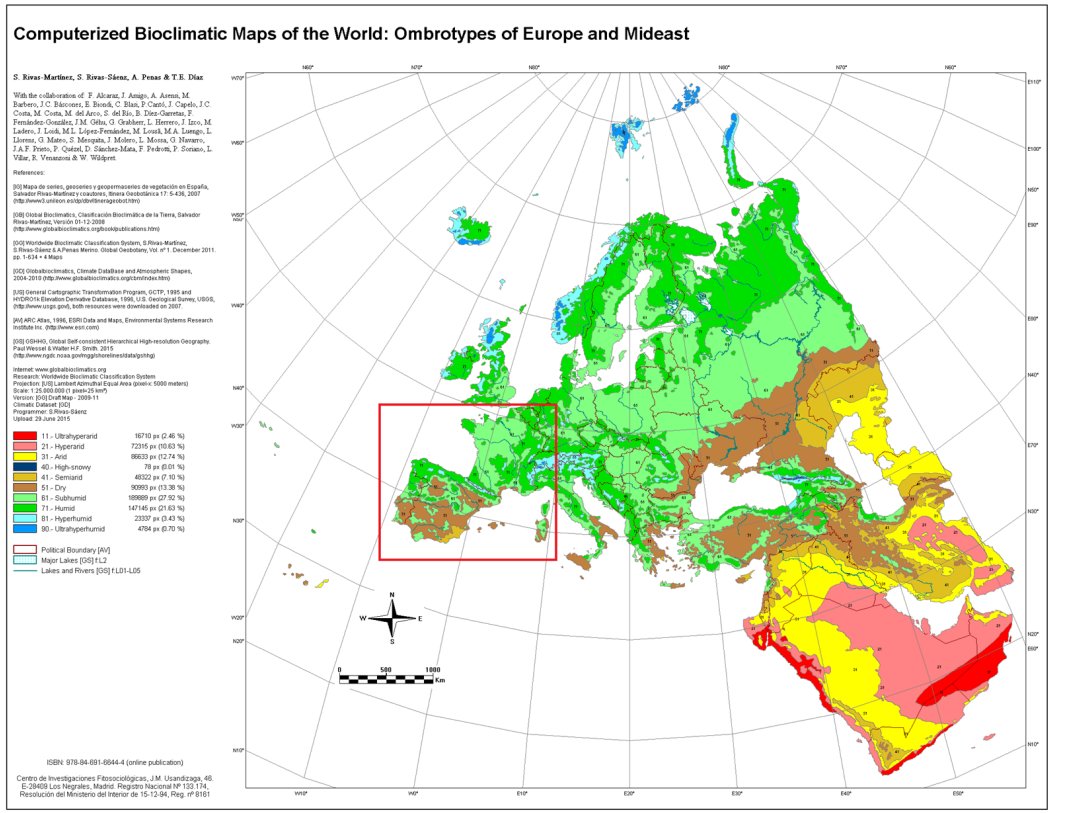

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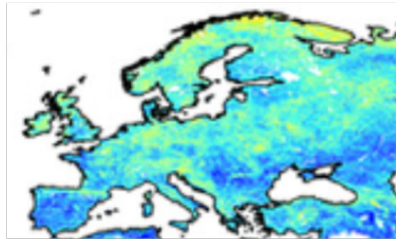

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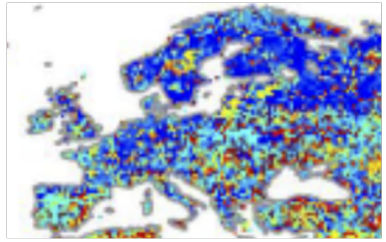

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Additional Study Regions:

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- Australia
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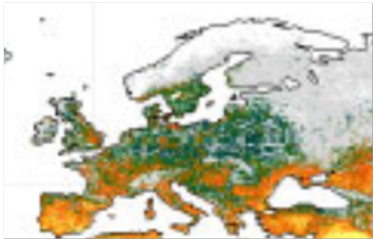

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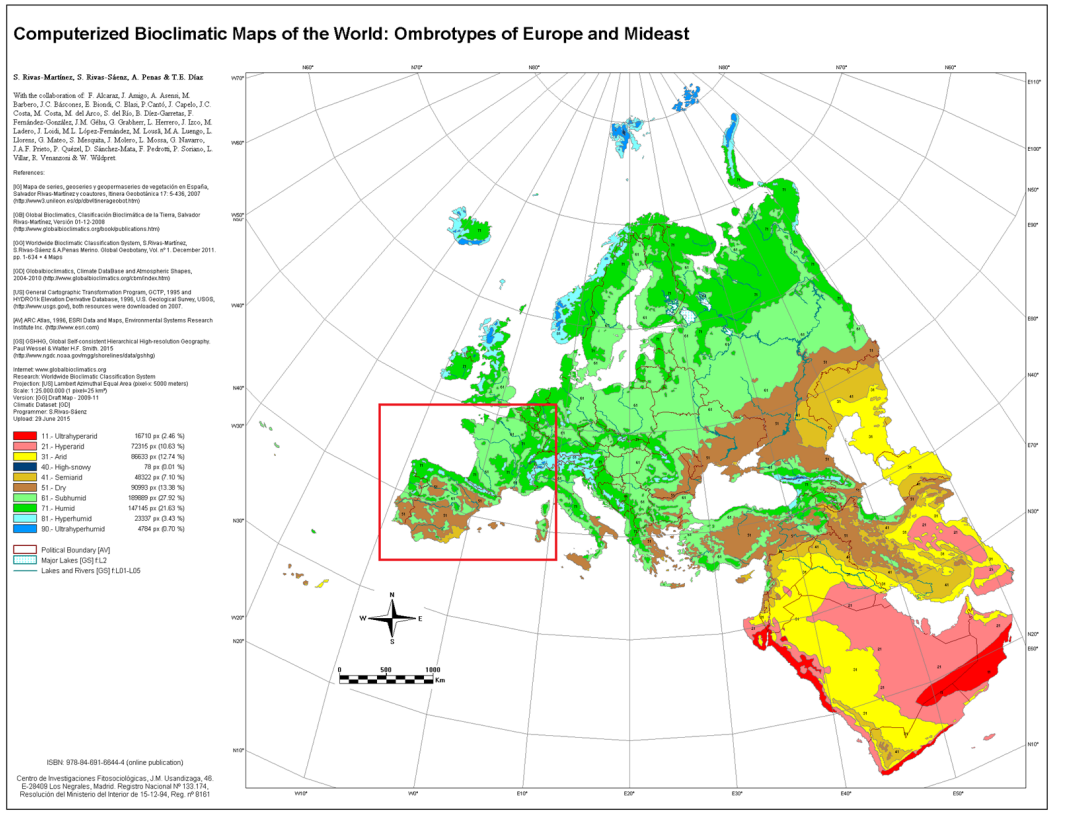

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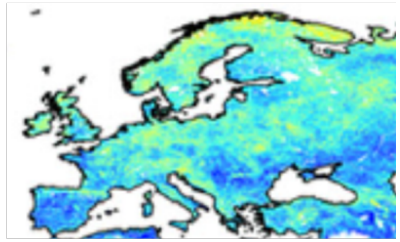

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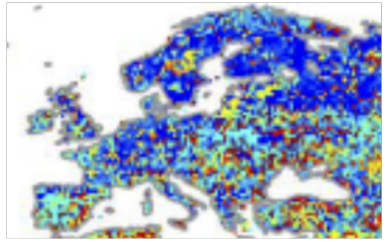

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We are using the **GIMMS NDVI3g** (v.1).

$$NDVI = \frac{\rho_{\text{NIR}} - \rho_{\text{RED}}}{\rho_{\text{NIR}} + \rho_{\text{RED}}} \tag{1}$$

- **Why:**
  - *Biological Relevance:* Proxy of biomass and vegetation cover
  - *Comparability:* Has been used in other studies of vegetation memory
- **Core Characteristics:**
  - *Resolution:* $0.083^\circ \sim 9.27km \times 9.27km$
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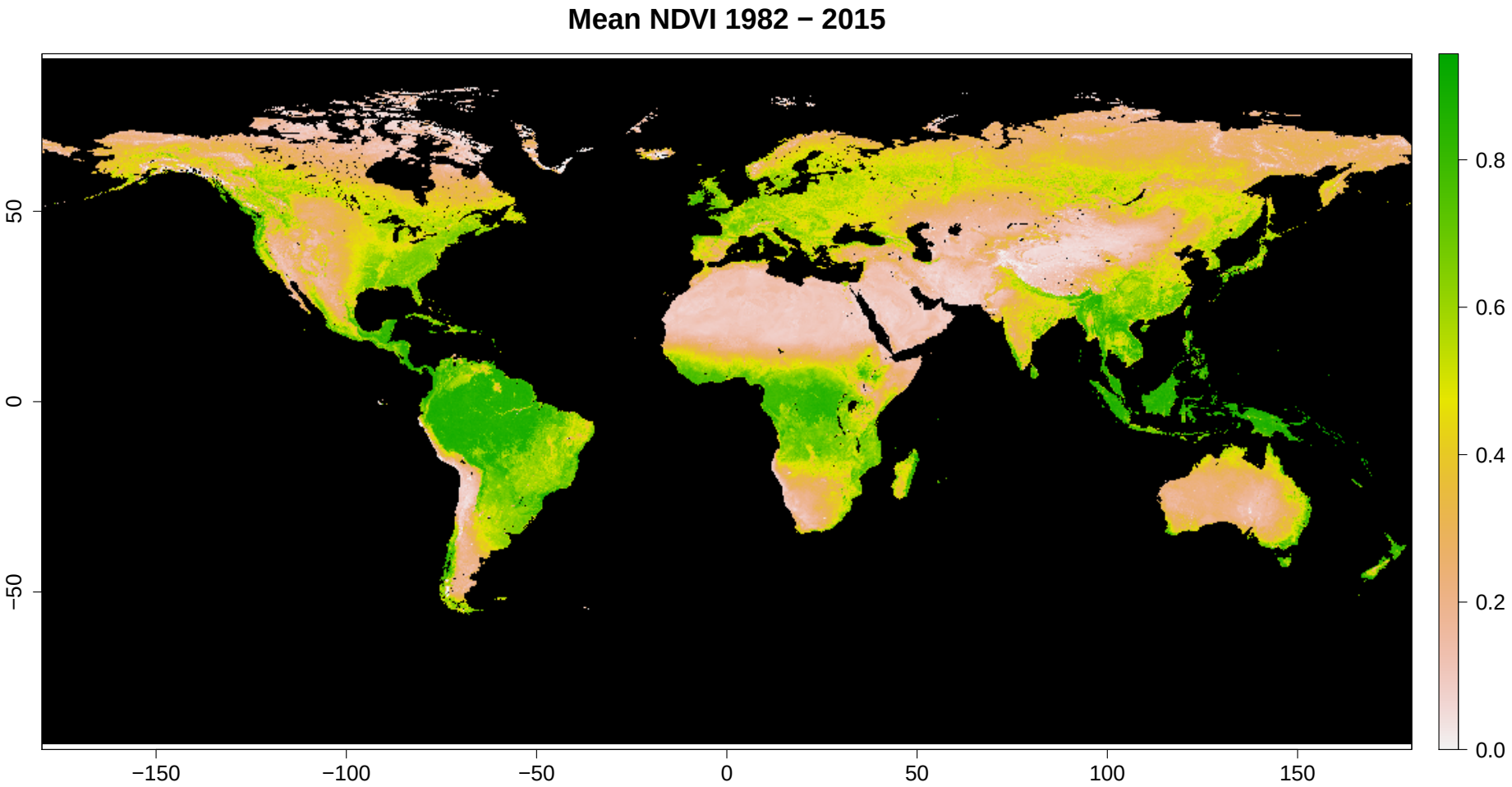

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We are using the **ERA5** Data Set[7,8].

- **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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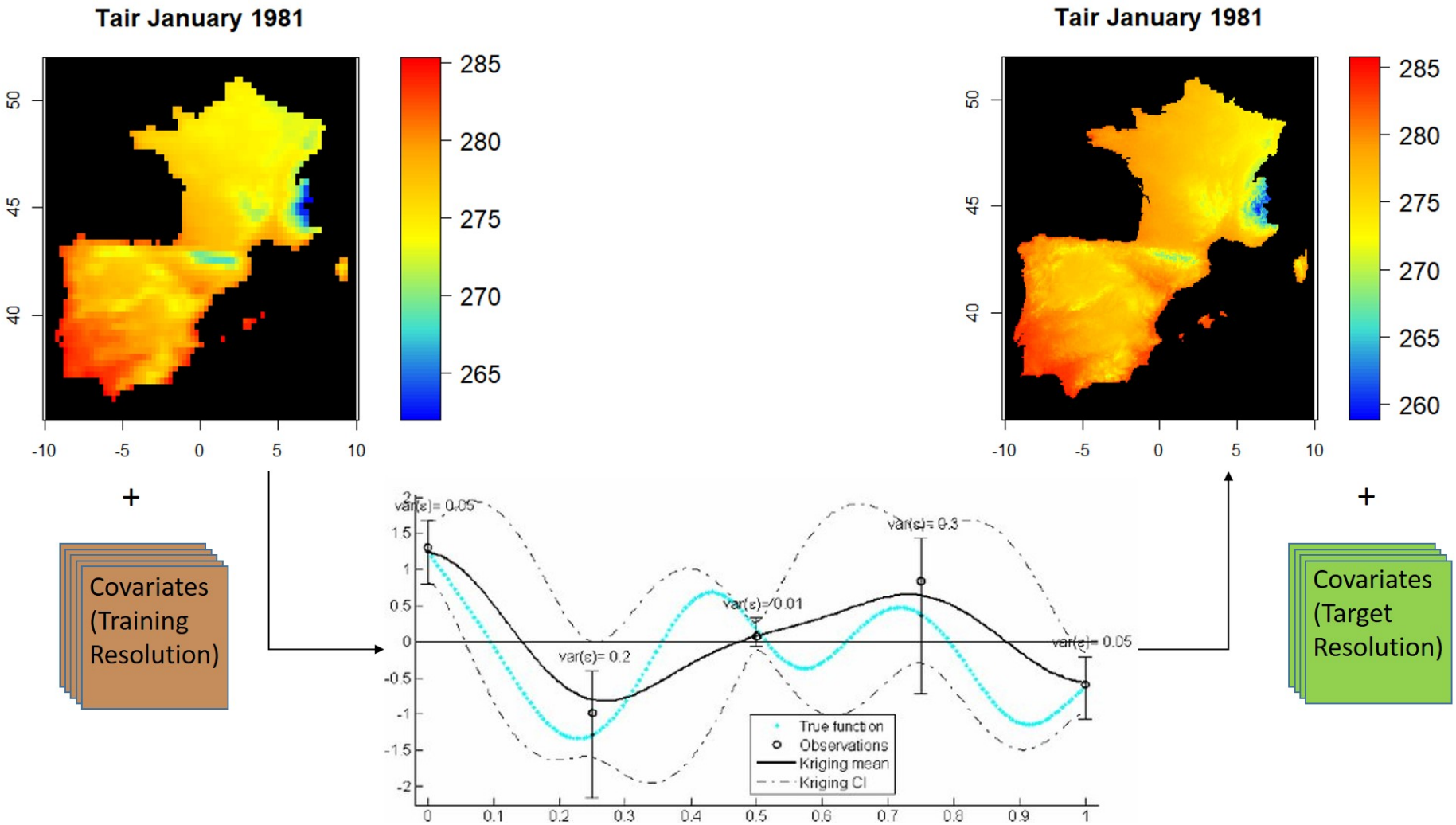
  - *Why:* Temperature drives plant physiology and drives levels of aridity[3,9].
  - *How:* As one single layer (2m above ground)

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
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True function
Observations
Kriging mean
Kriging CI
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Plant Functional Traits (PFTs)

- **Why:**
  - *Biological Relevance:* Snapshots of functional reality
  - *Comparability:* Have widely been used in functional ecology[11,12]
- **Core Measures:**
  - *Vegetative Height:* Ability to pre-empt light
  - *Leaf Nitrogen Content:* Measure of photosynthetic potential and nitrogen acquisition

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- **Why:**
  - *Biological Relevance:* Indices of plant behaviour through time
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  - *Fast-Slow Continuum (FSC):* Capture over 60% of the variation in plant life history strategies
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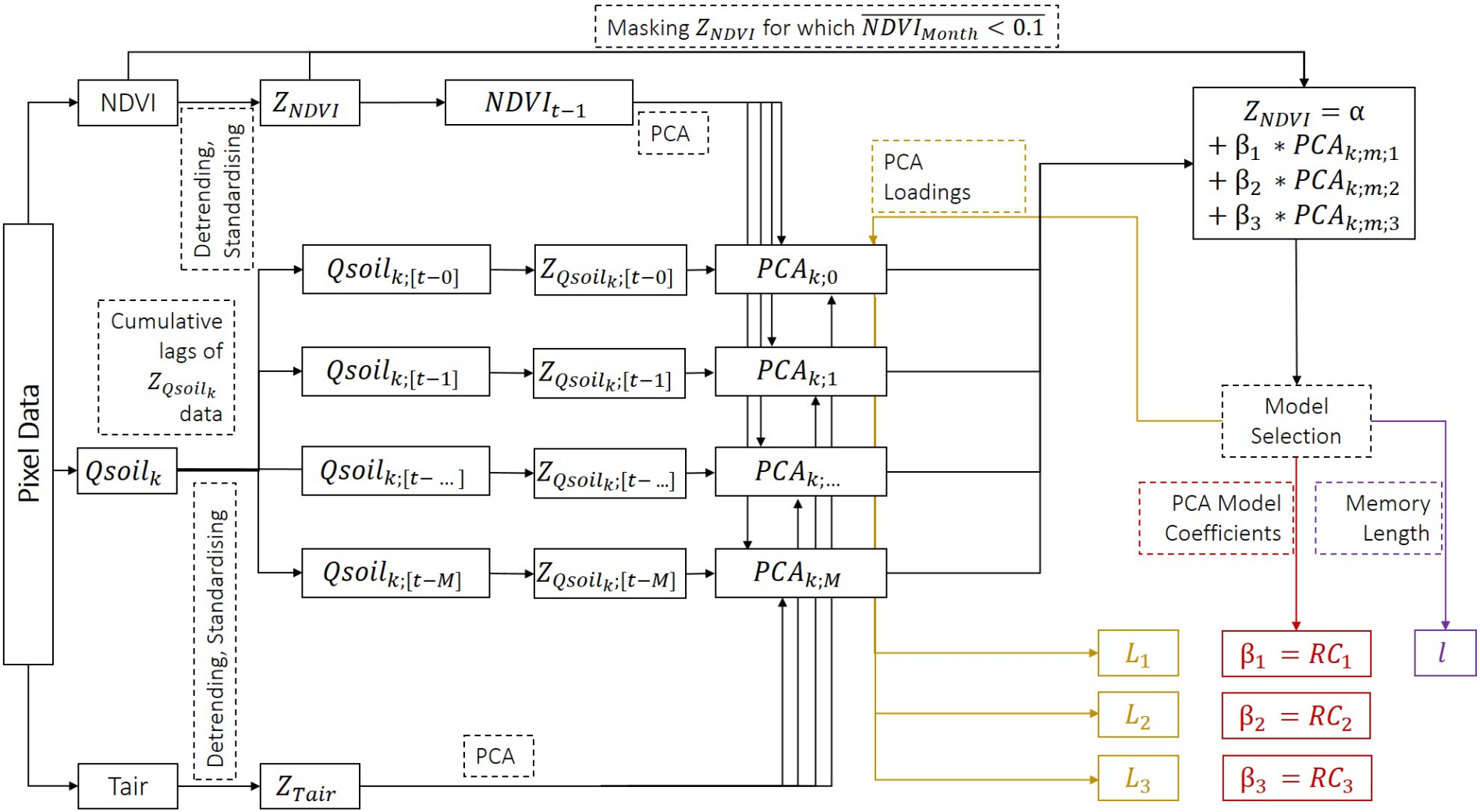
Pixyel-Wise Model Building



PCA Regression

Model Formula: $NDVI_t = PC_1 + PC_2 + PC_3$

$NDVI_t$ .... NDVI anomaly at month t
PC_1 .... First principal component
PC_2 .... Second principal component
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	PC1	PC2	PC3
$NDVI_{t-1}$	2.5	-1.14	1.95
$Qsoil_{1;6}$	2.6	-0.73	-2.03
$Tair$	-1.6	-3.00	-0.25
Model Coefficients	**1.77**	**-0.50**	**0.71**

Loadings

$$C_p = \sum_{i=1}^{3} (L_{p;i} * RC_i)$$

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i .... Principal component counter
$L_{p;i}$ .... Loading of variable p on principal component i
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Σ

Model Comparisons:

- *Which variable exerts the greatest influence on vegetation anomalies?*
- *Which soil moisture layer is the most biologically influential?*

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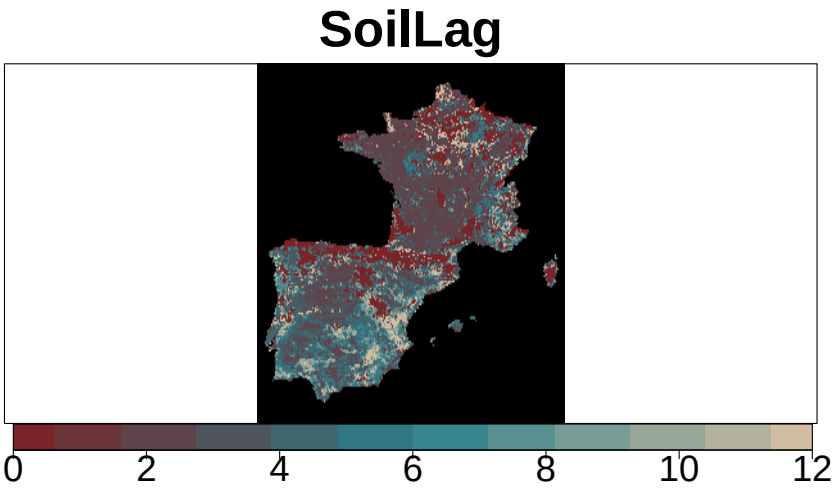

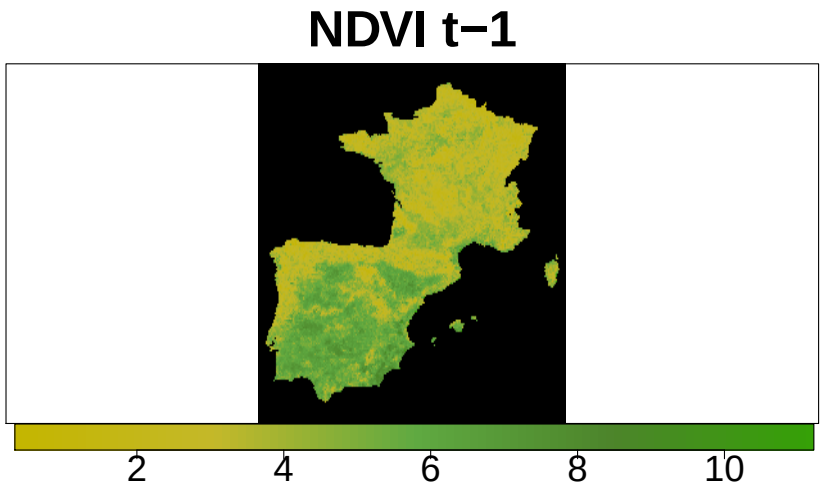

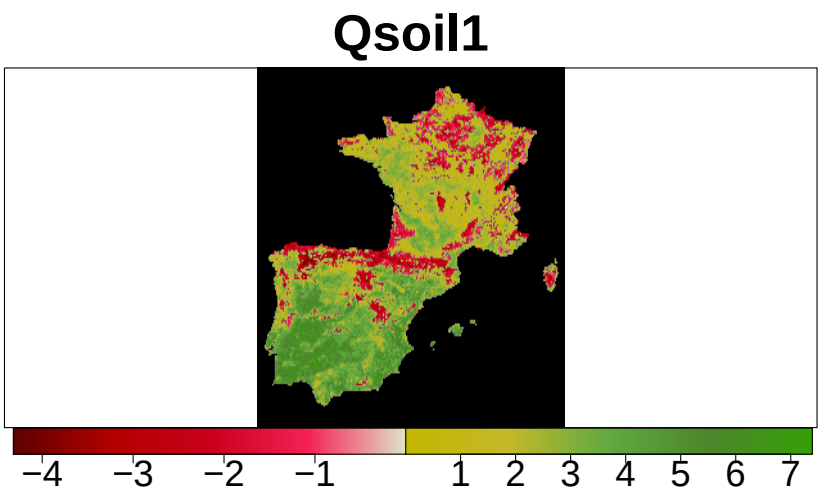

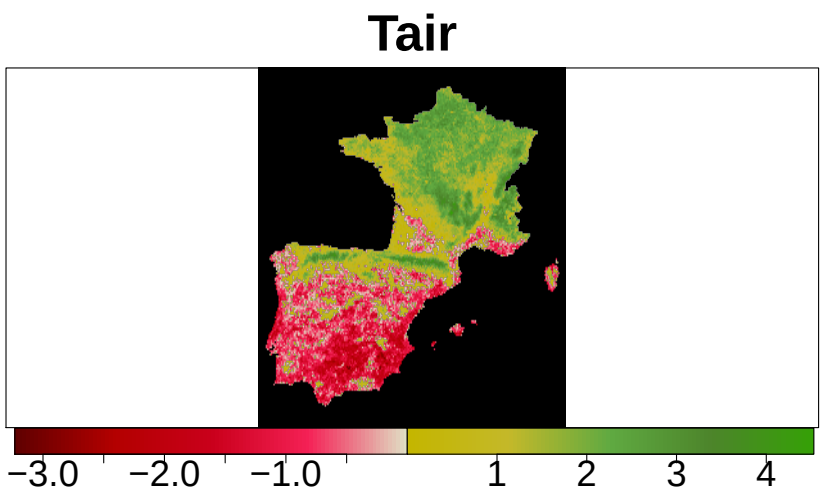

→ Is **intrinsic** memory really *intrinsic*?

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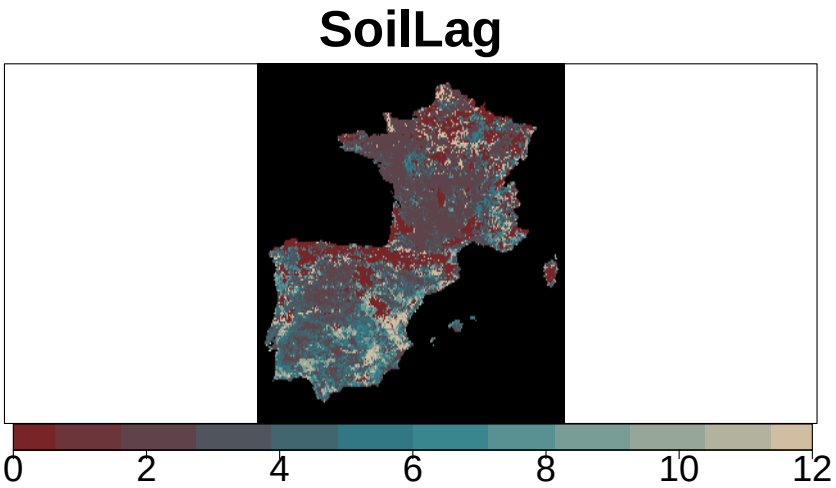
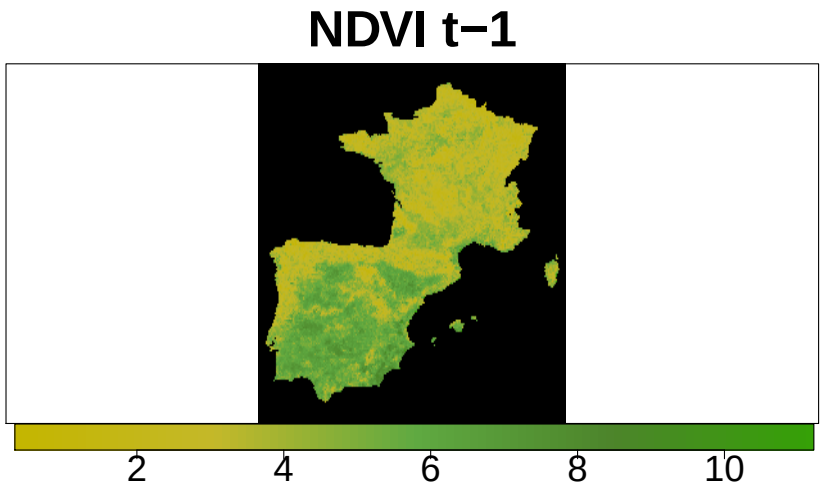
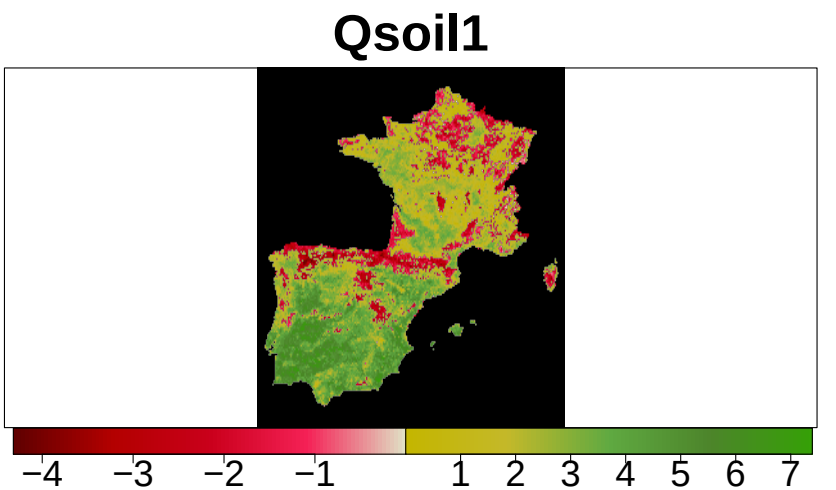
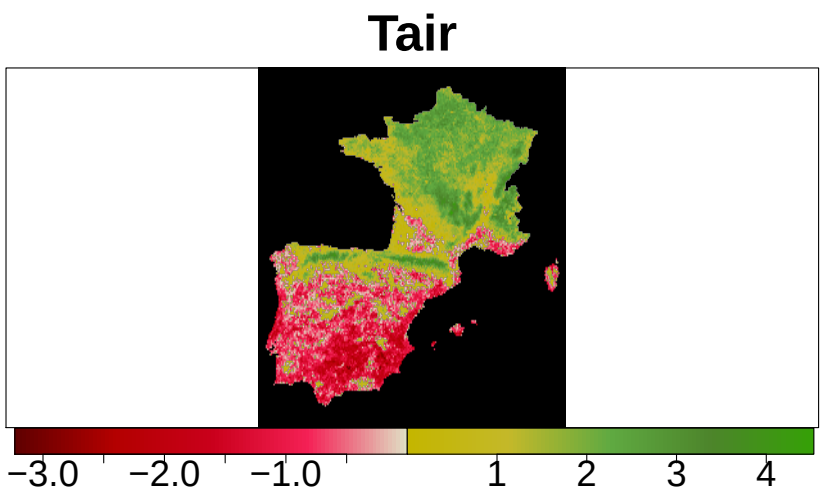




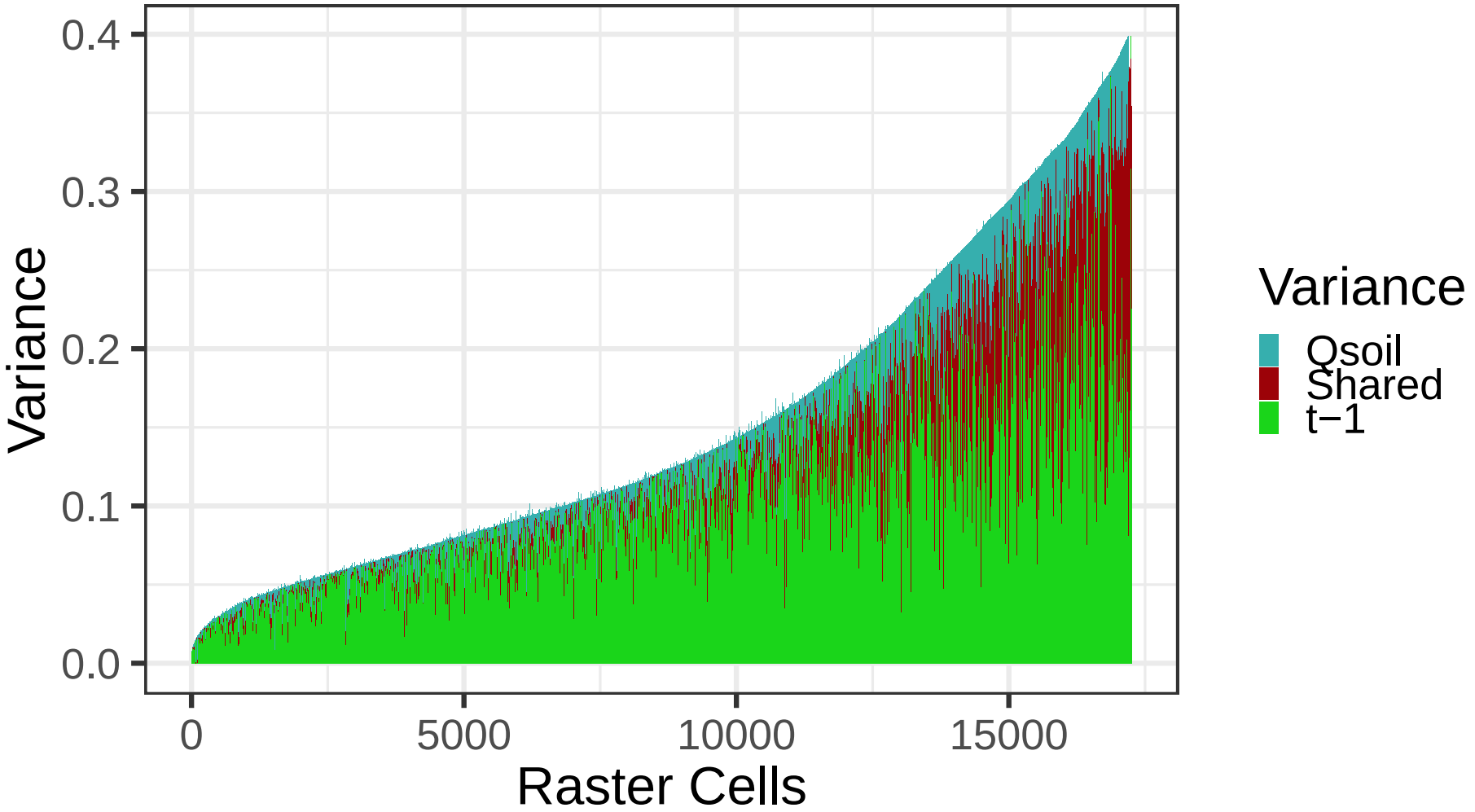




→ Is **intrinsic** memory really *intrinsic*?

Distinguishing Intrinsic and Extrinsic Memory

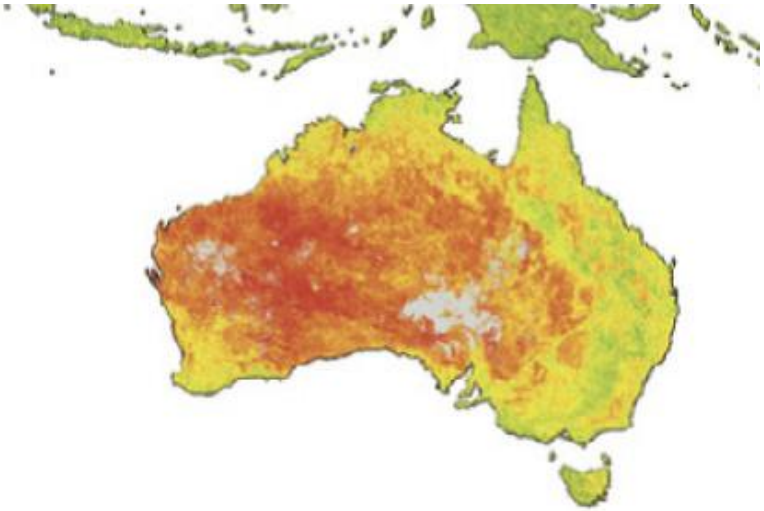
Qsoil1 is the **most informative** of the **soil moisture** layers!



Identifying Underlying Extrinsic Patterns I

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

Intrinsic Memory by Seddon et al.[6]:



Identifying Underlying Extrinsic Patterns II

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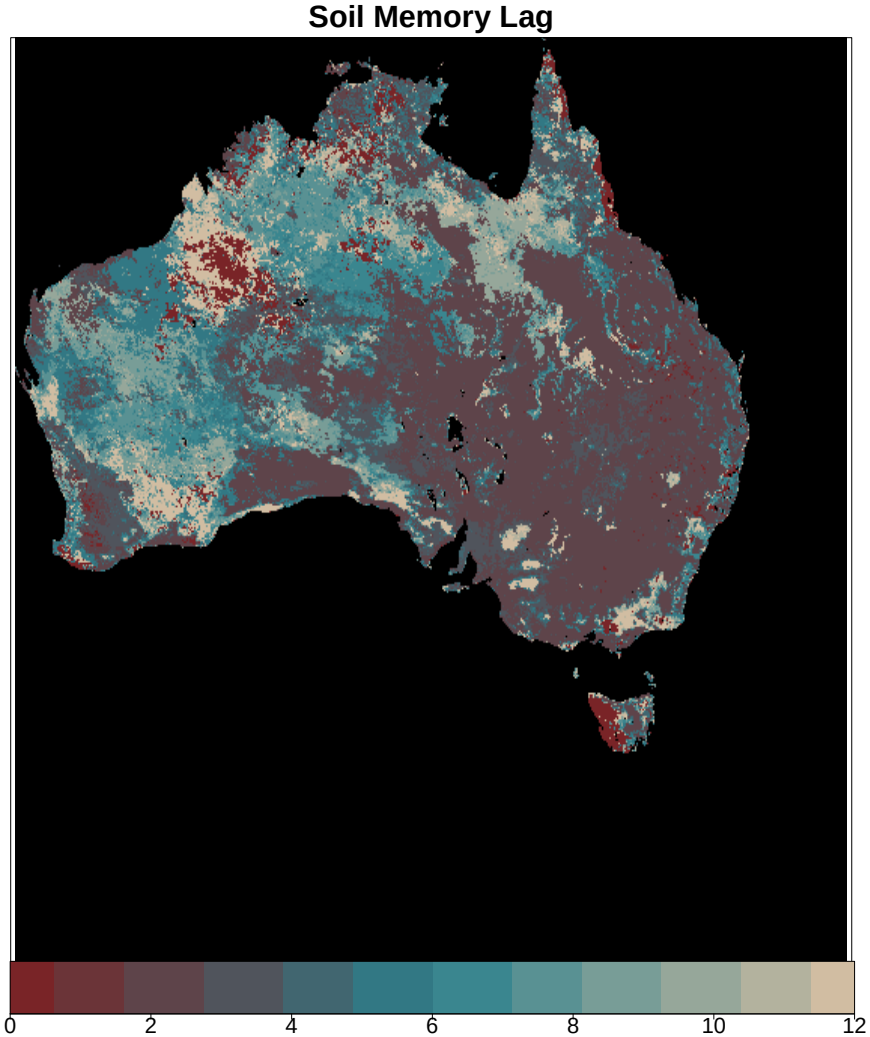

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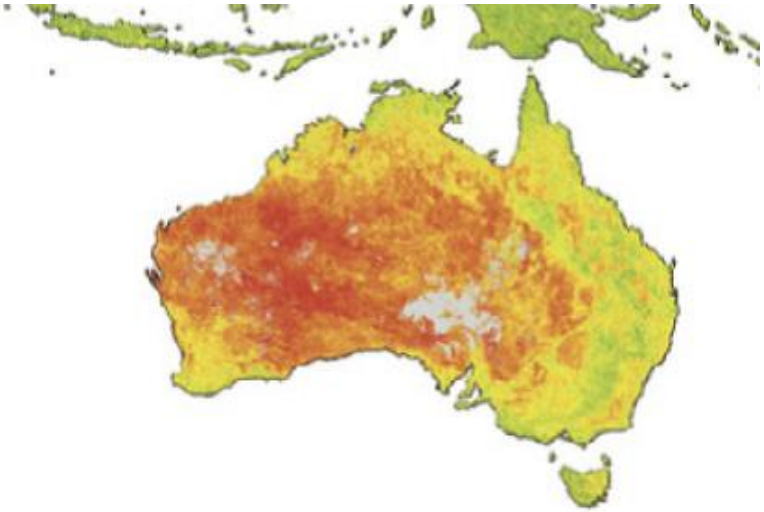

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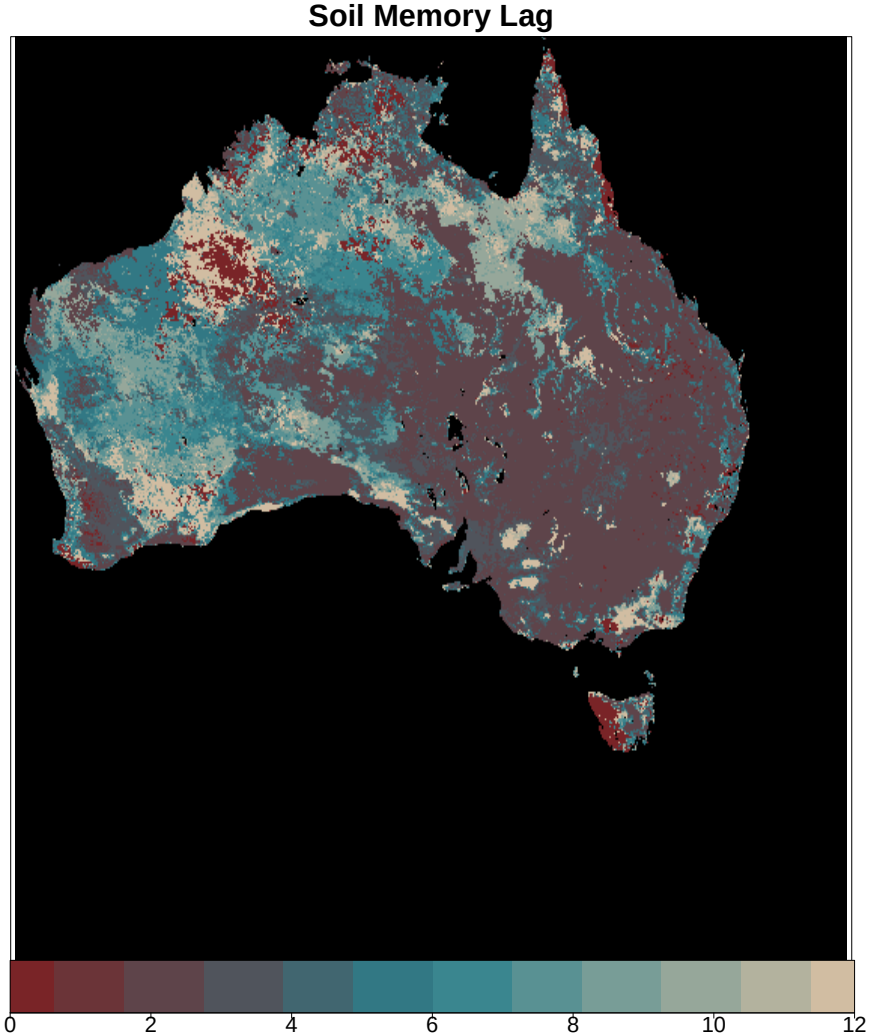

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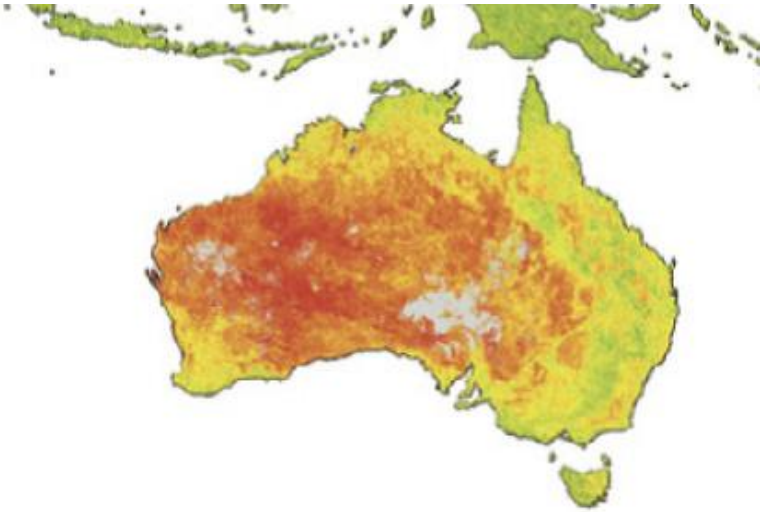
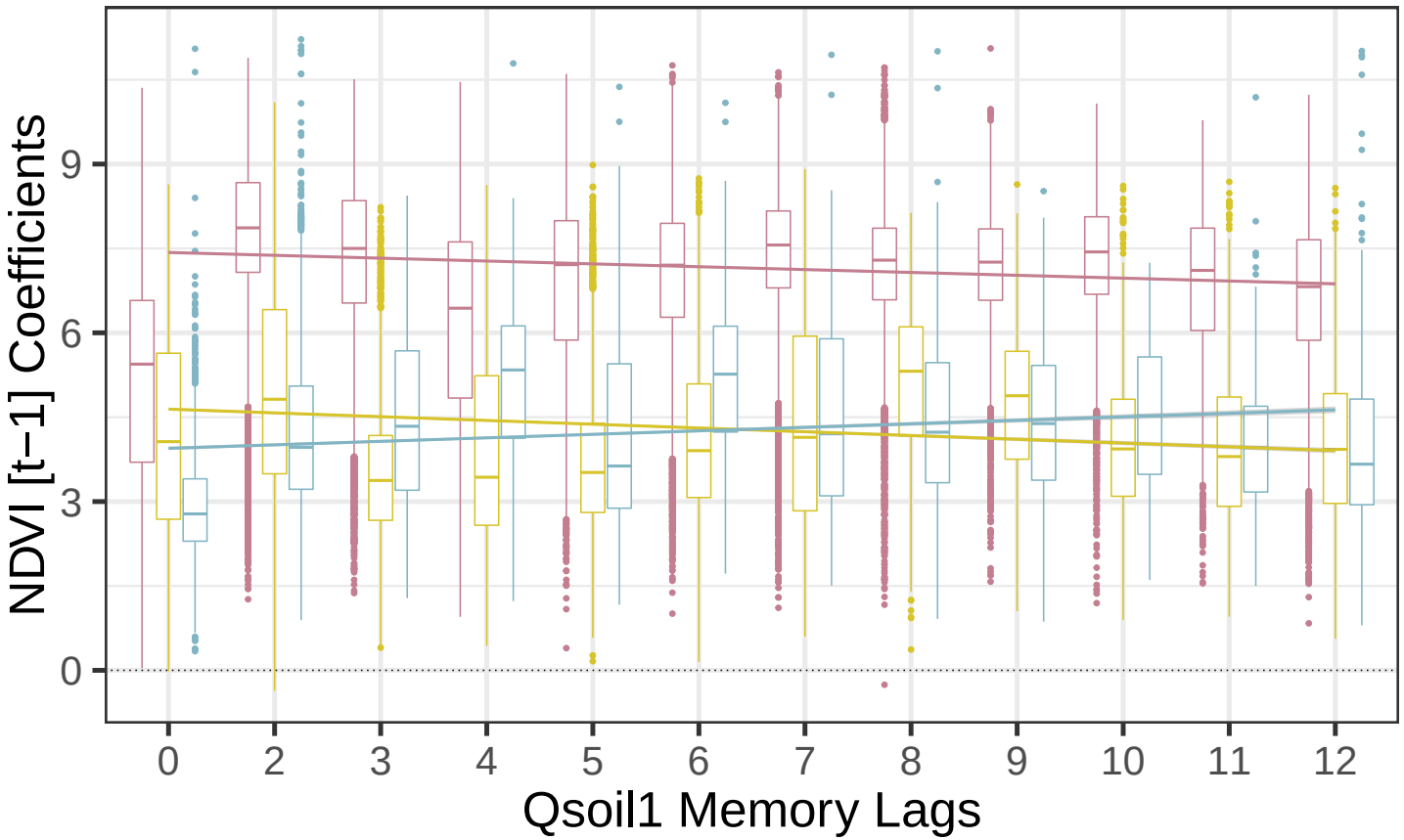


Previous $t-1$ variation can be **understood through extrinsic vegetation memory**.

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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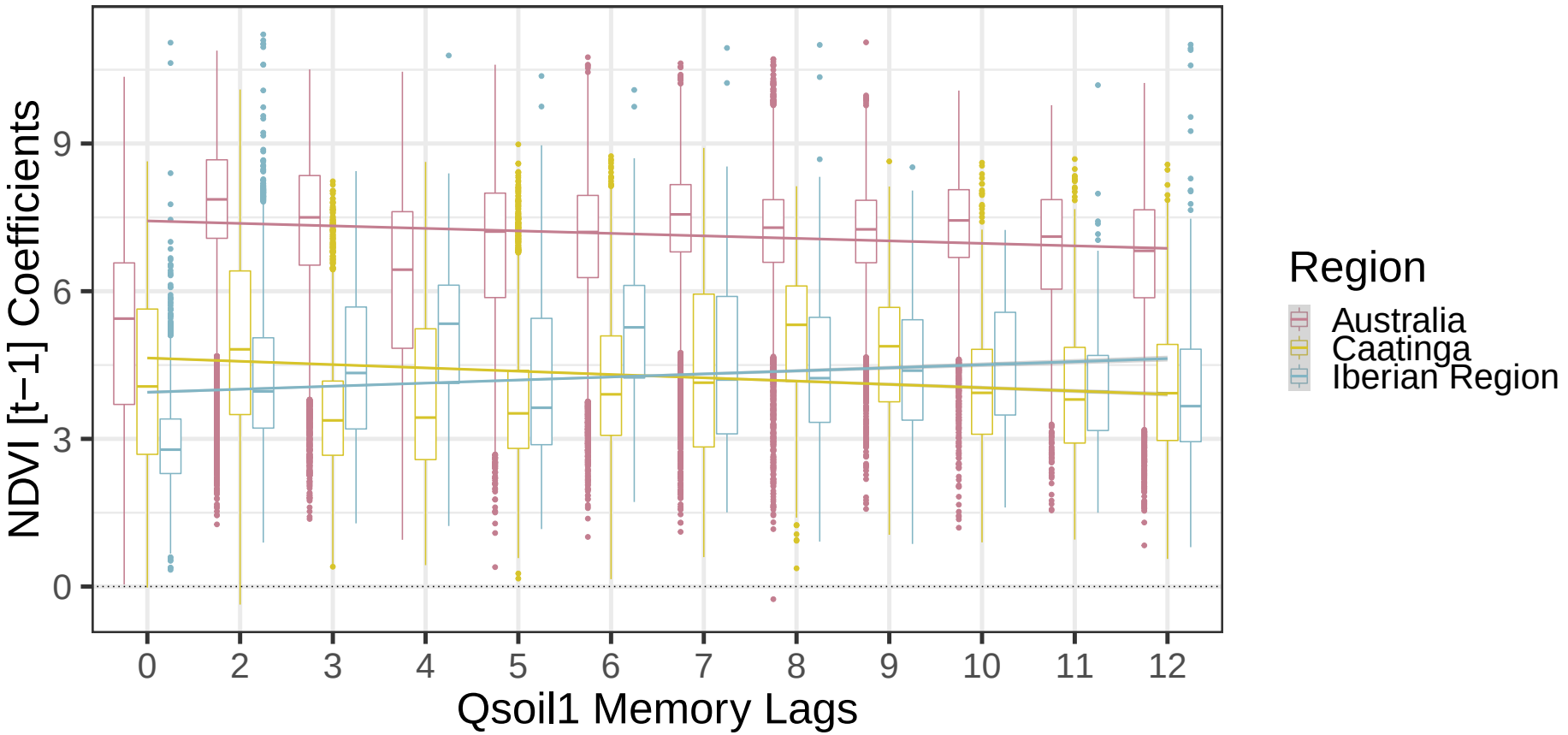
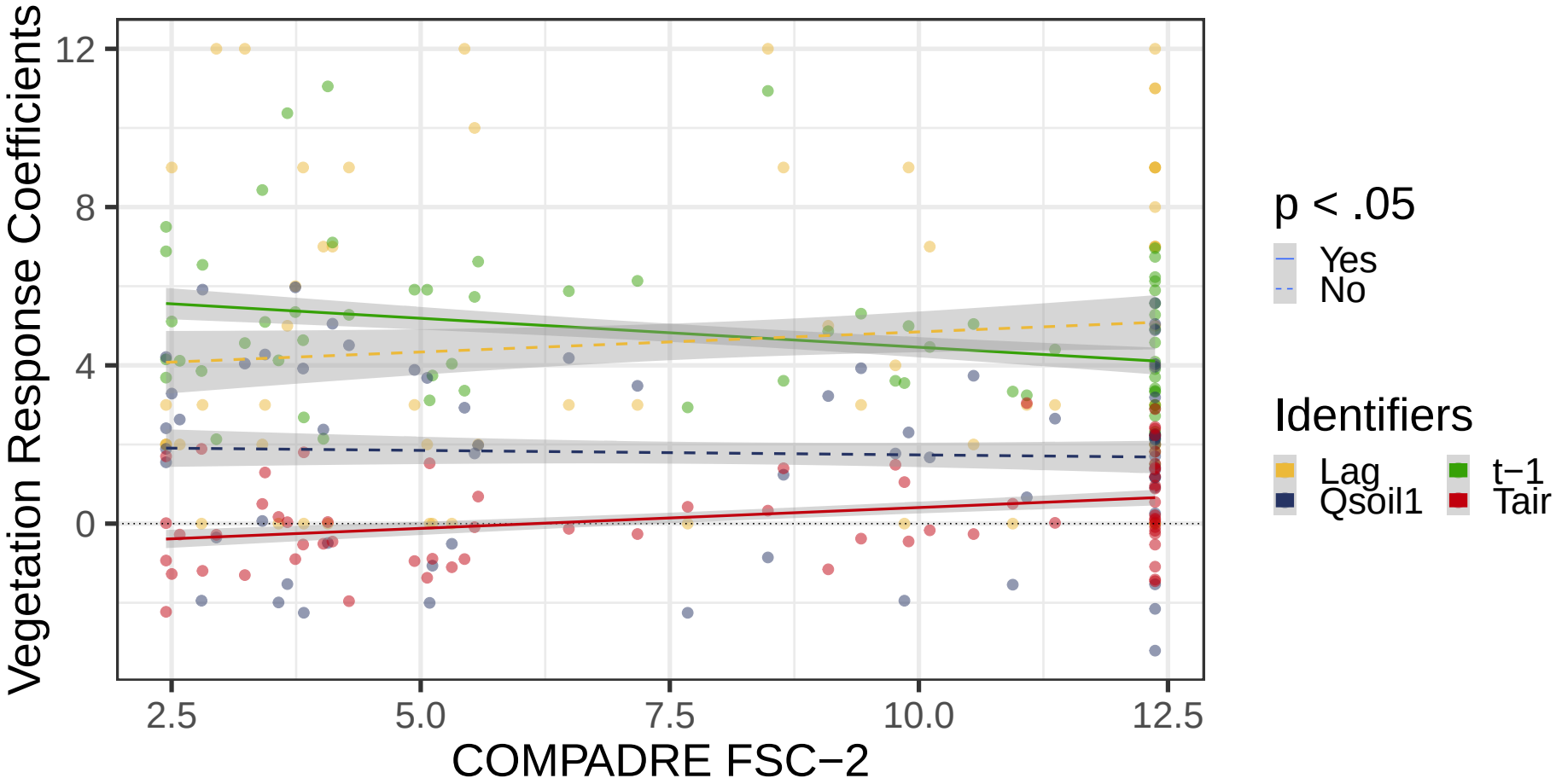


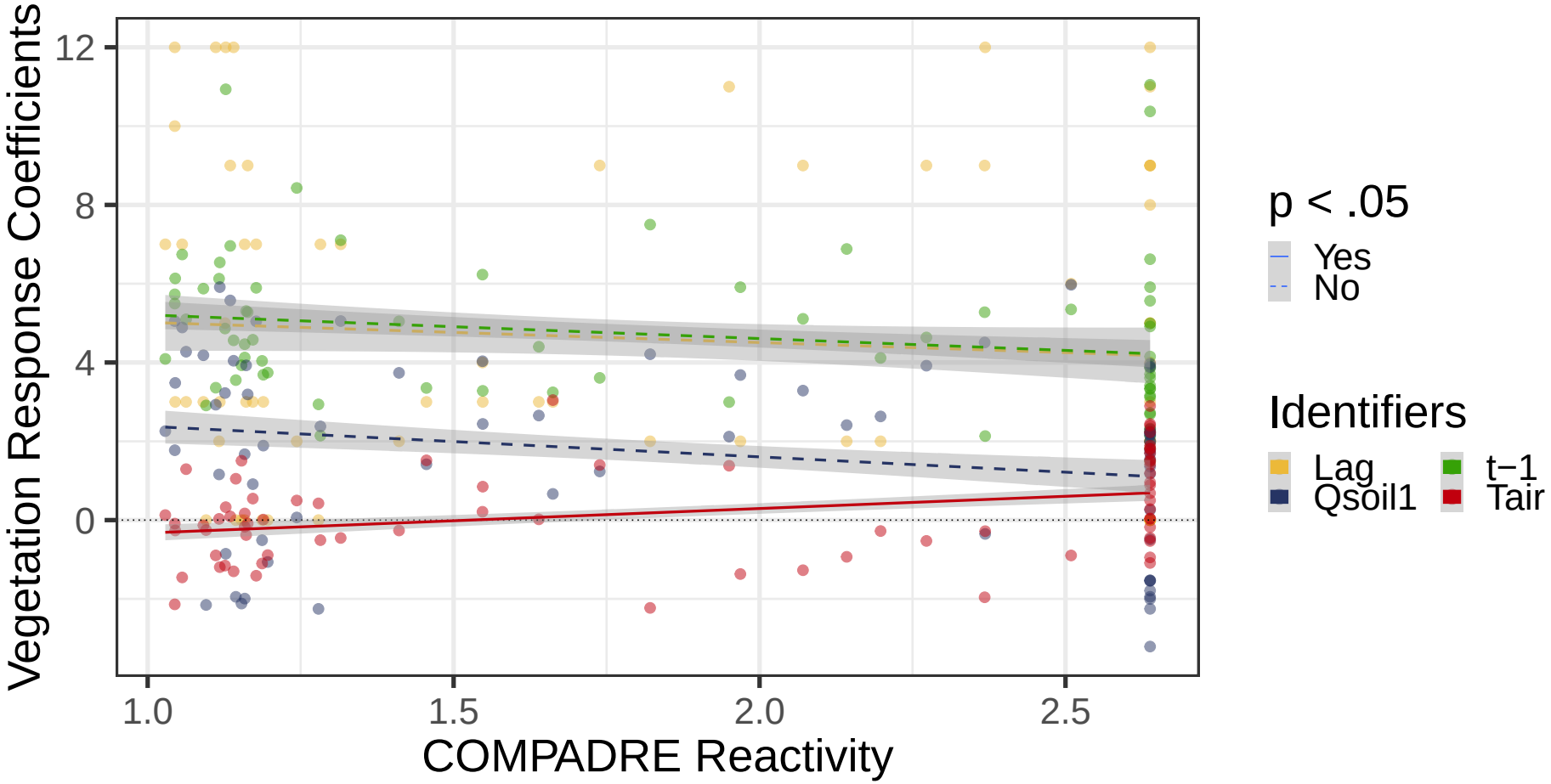
Relationship of $t-1$ coefficient and extrinsic vegetation memory length is not uniform within or between study regions.

Plant Function I

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

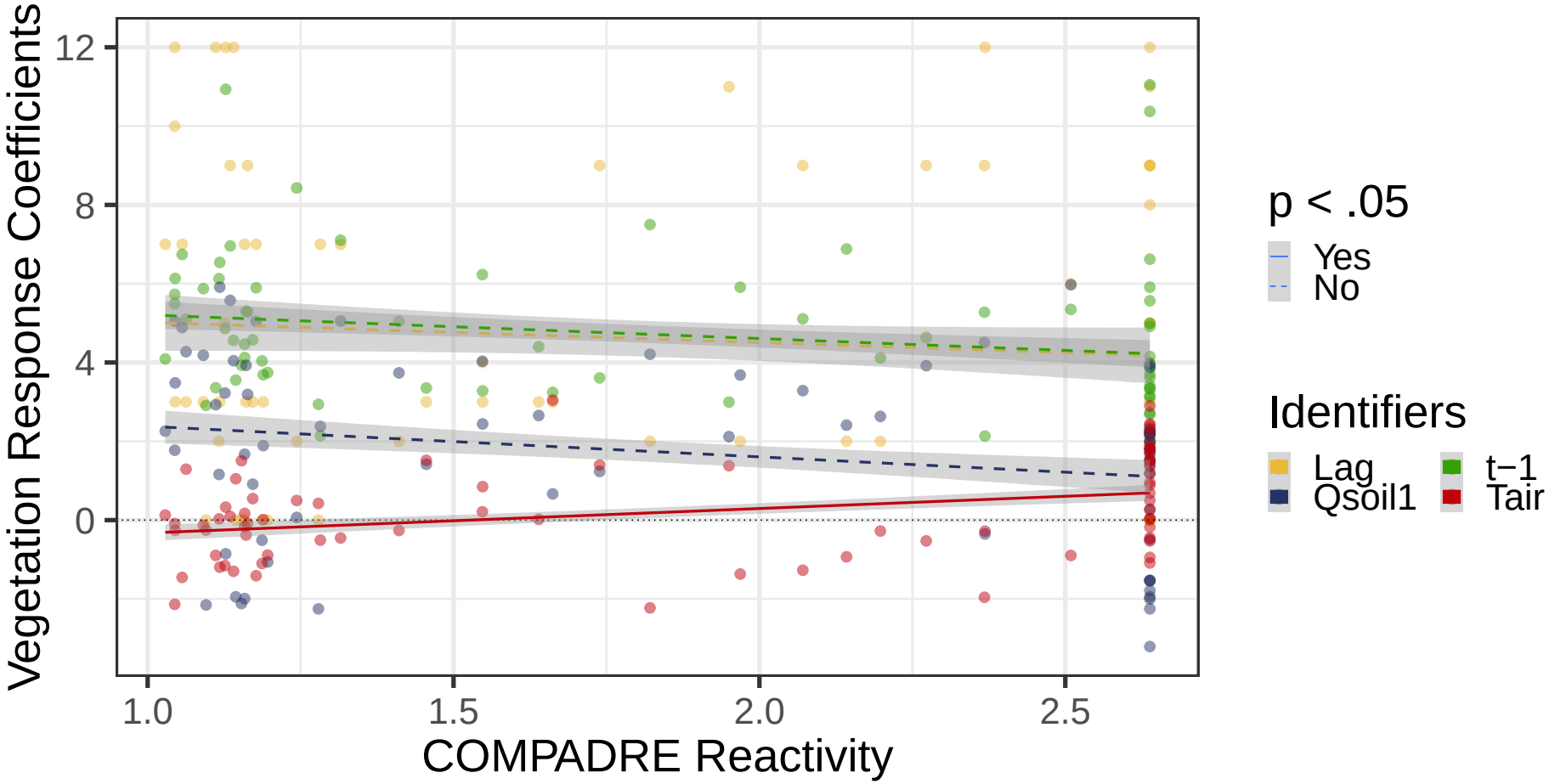


Plant Function II



Some LHTs can be linked to some vegetation memory characteristics,

Plant Function II



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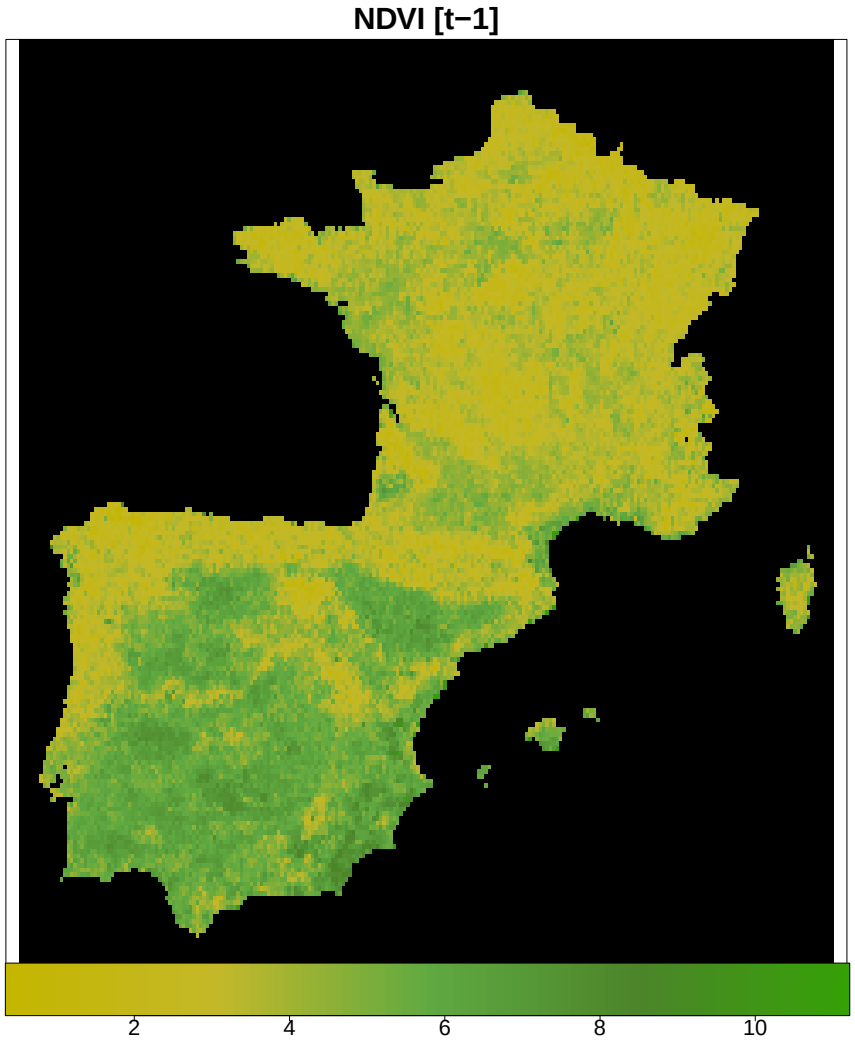
Outline

Conclusion

Summary:

Extrinsic memory should not be neglected in favour of intrinsic memory.



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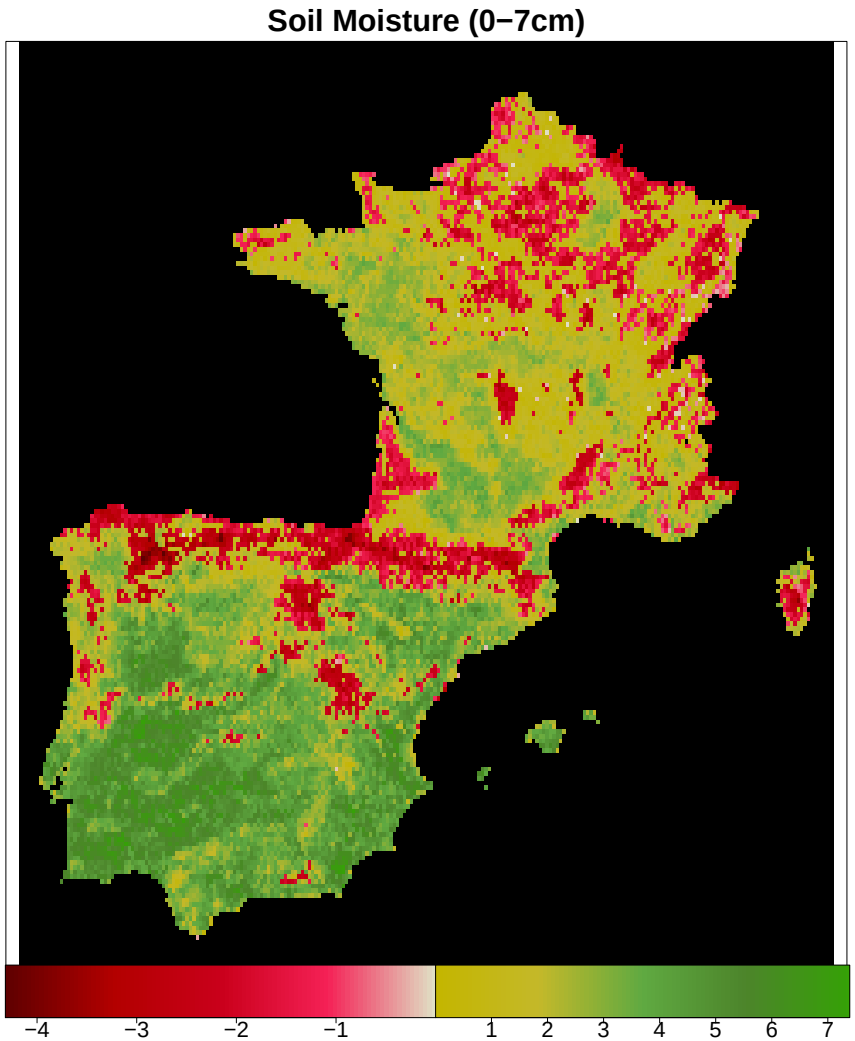
1. Intrinsic vegetation memory as a proxy for engineering resilience may be an oversimplification.



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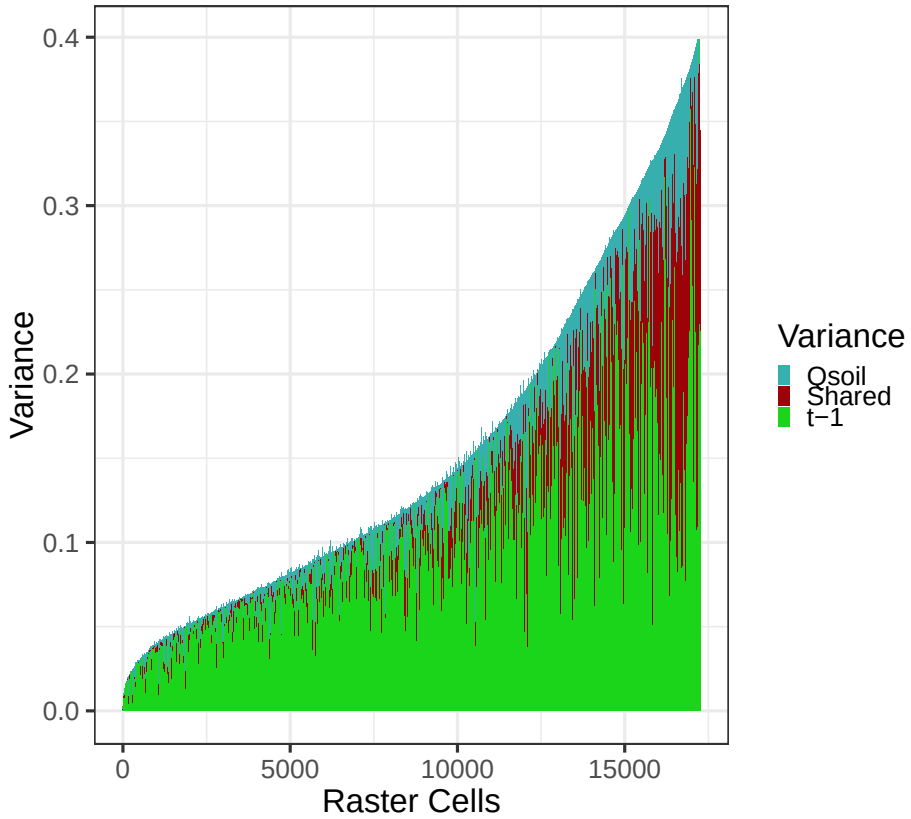

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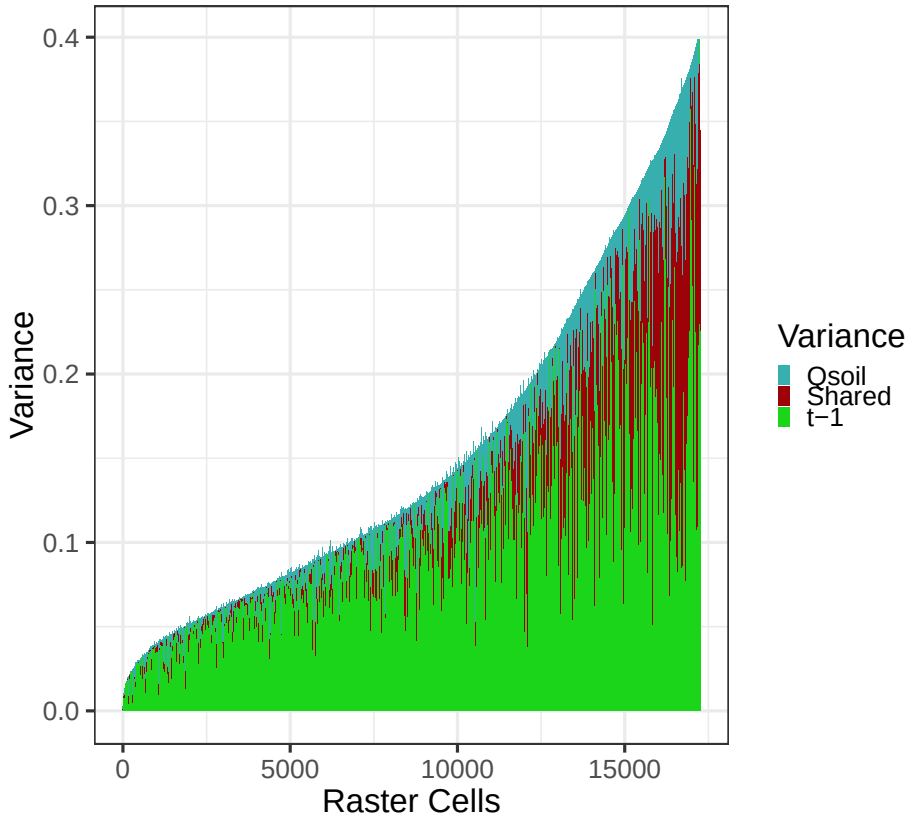

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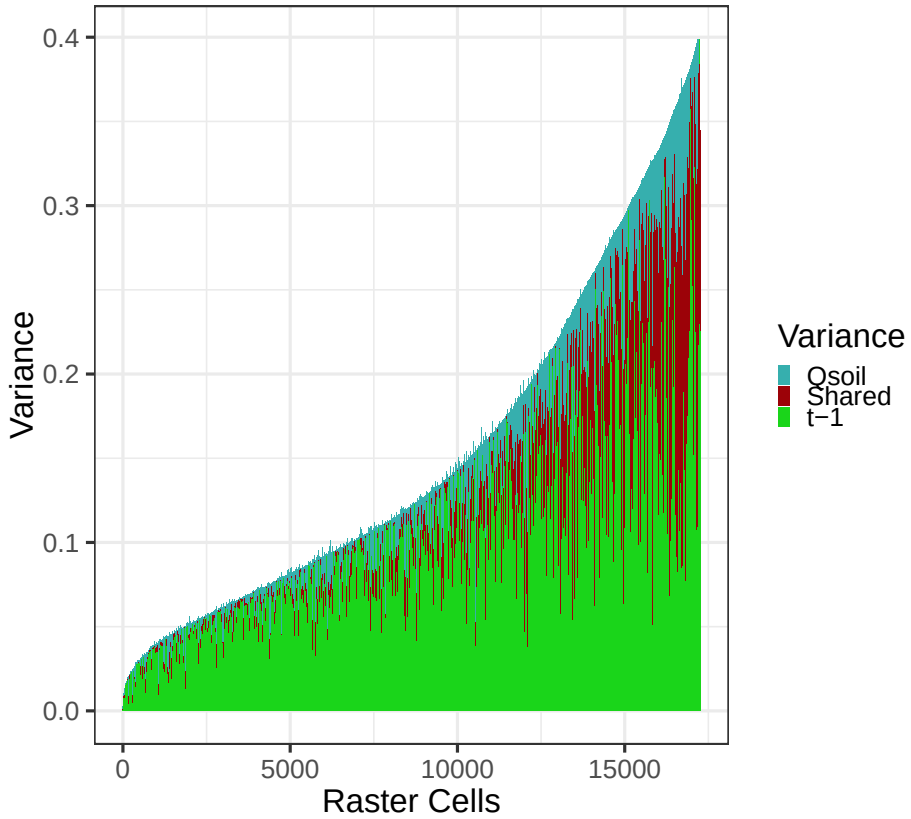

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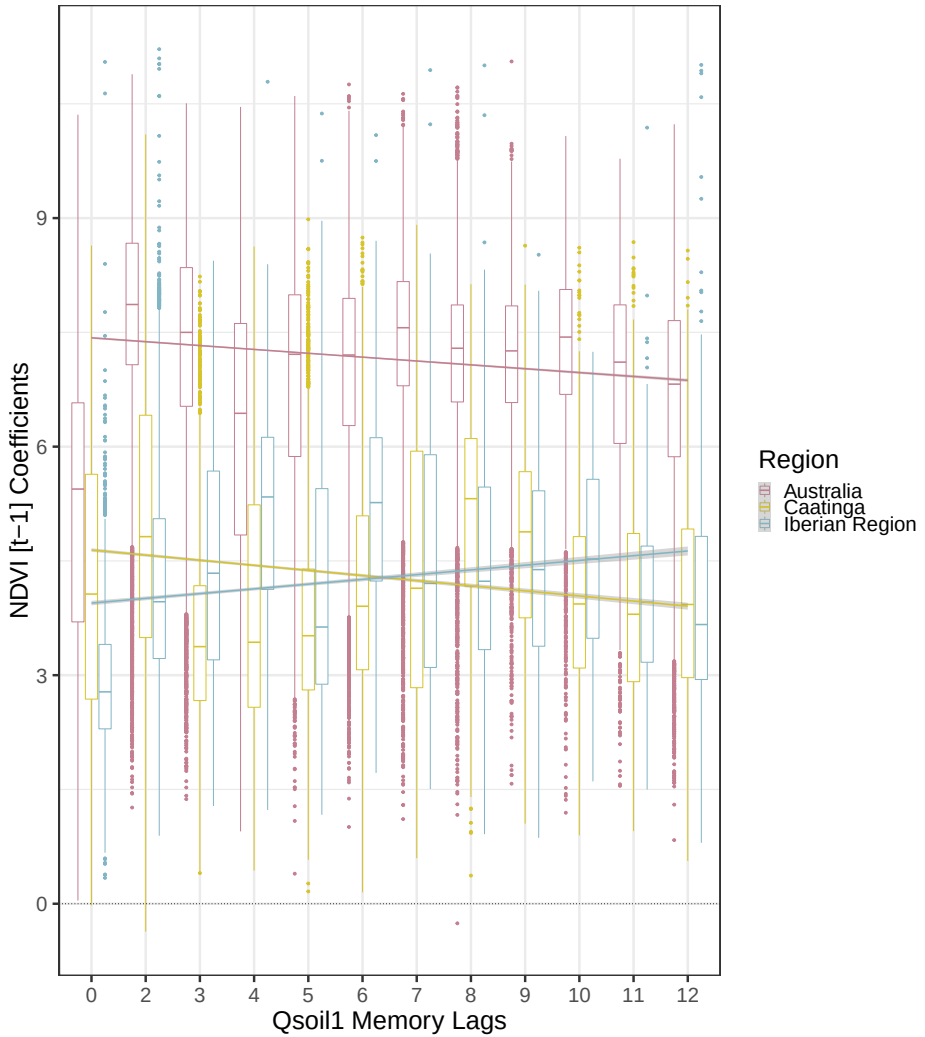

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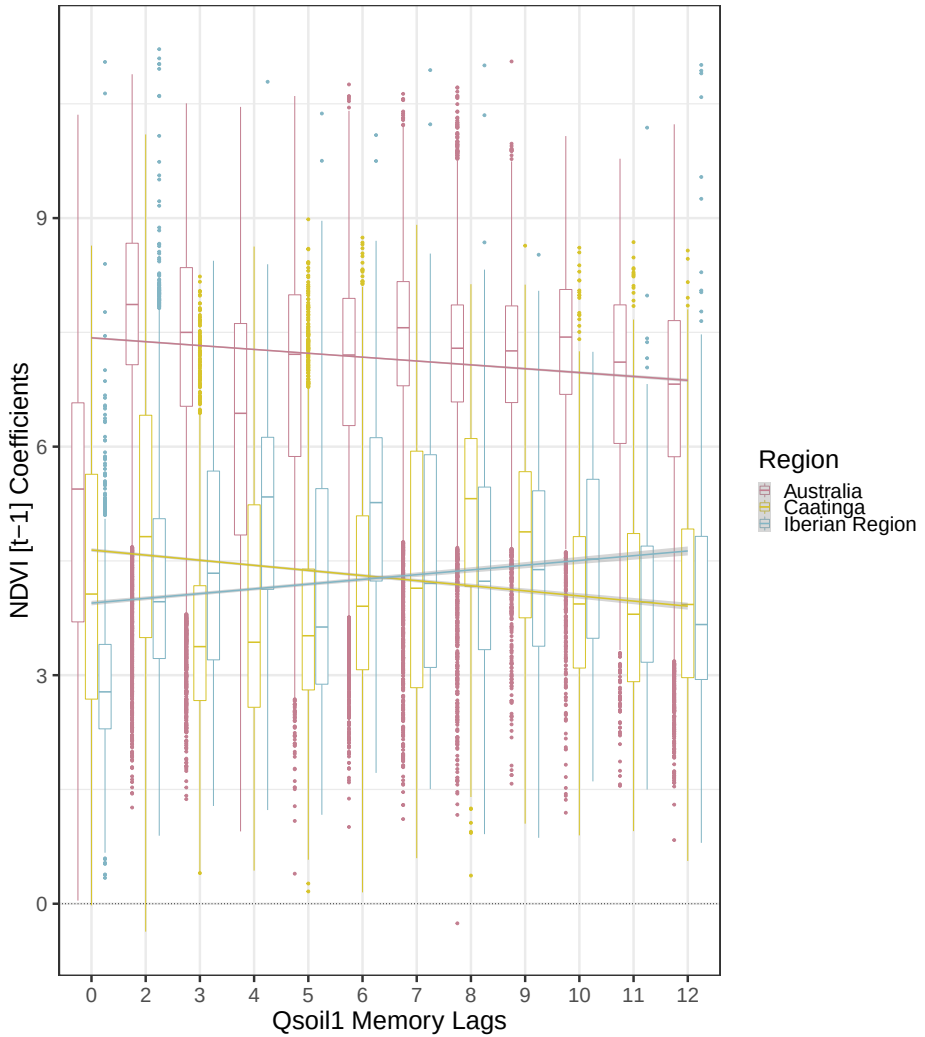

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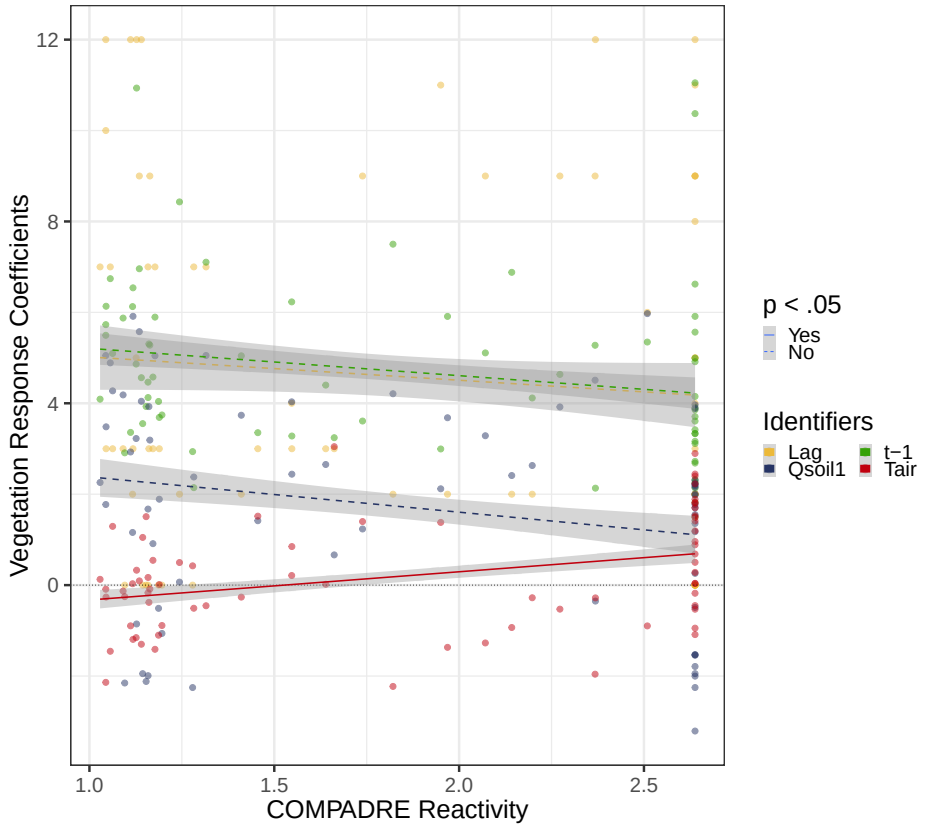

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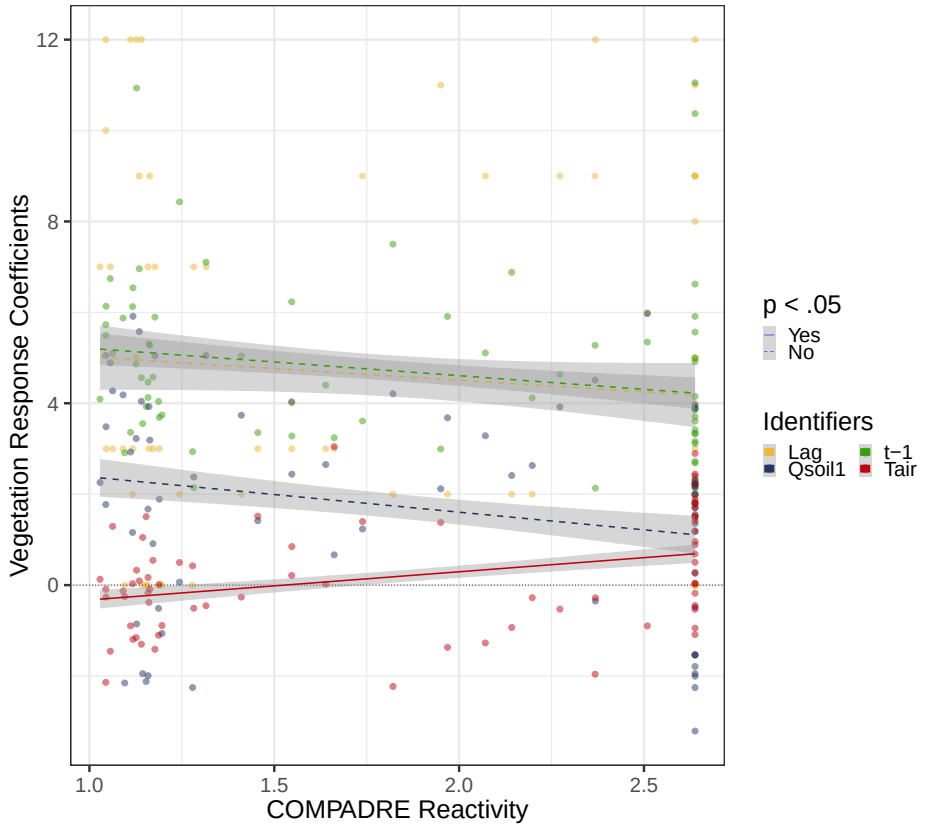

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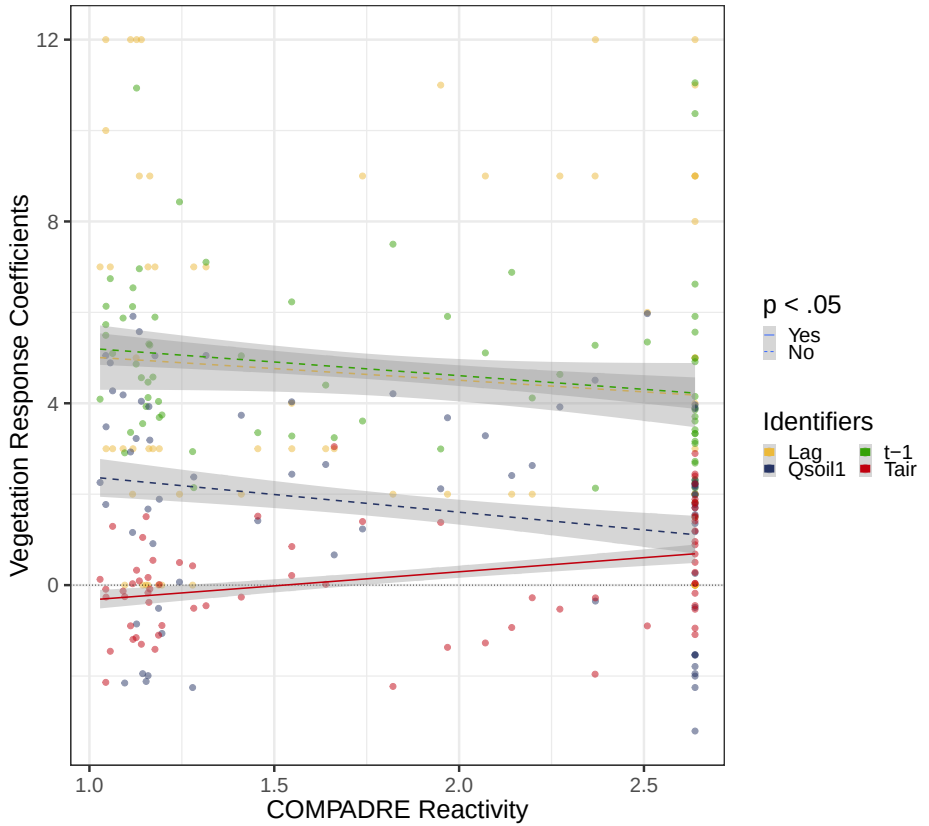

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