

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

- 1** Background
 - Motivation
 - Concept
- 2** Allocating and Preparing Data
 - Vegetation Data
 - Climate Data
 - Plant Functional Data
- 3** Delineating Vegetation Memory
- 4** Results
 - Coefficients of Vegetation Memory
 - Regional Aspects of Vegetation Memory
 - Functional Aspects to Vegetation Memory
- 5** Conclusion

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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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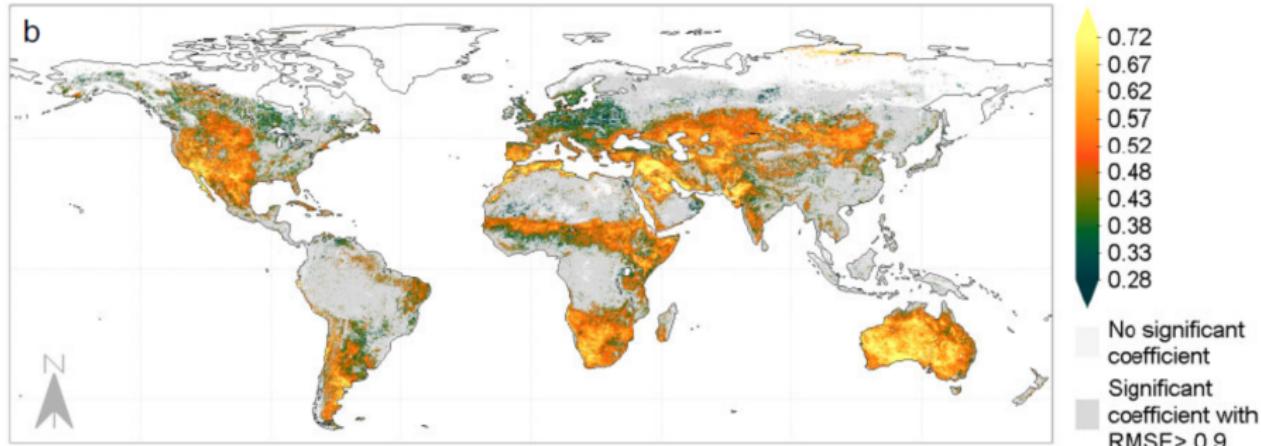
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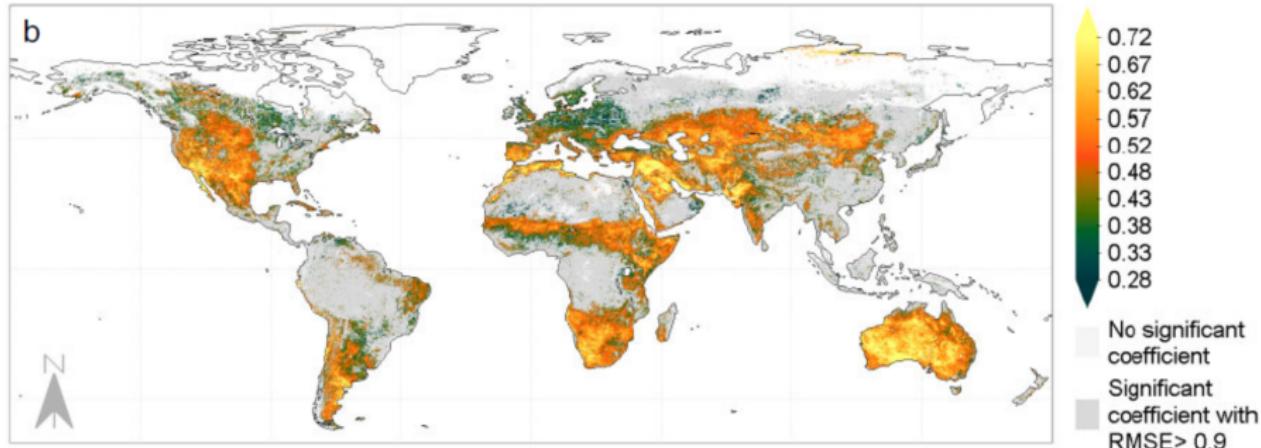
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How valid is this assumption?

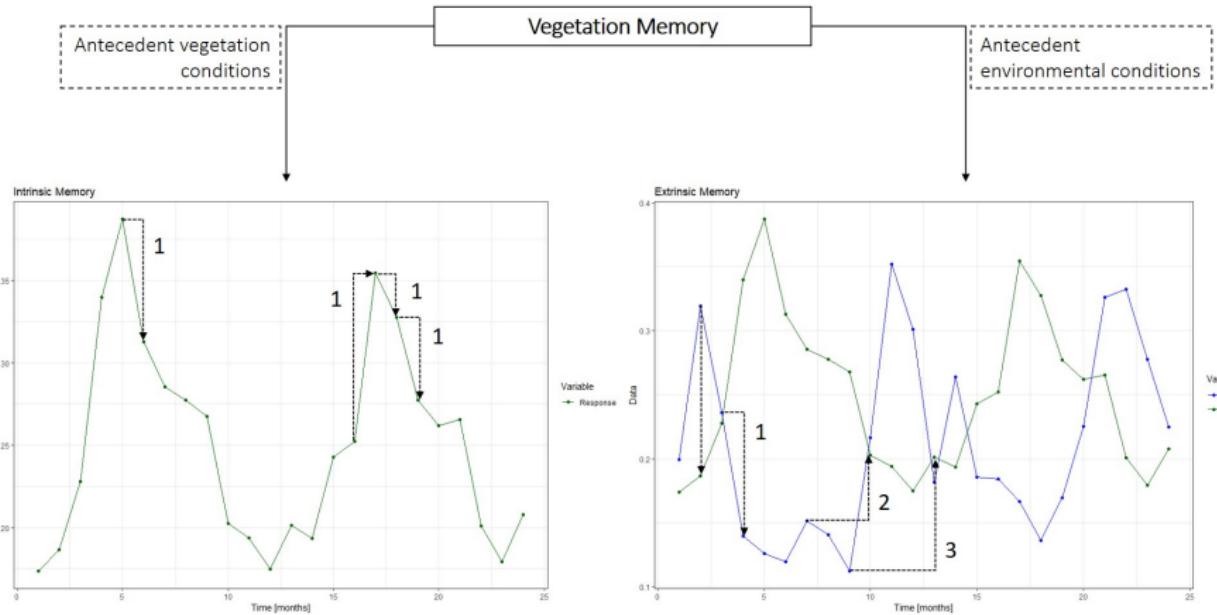
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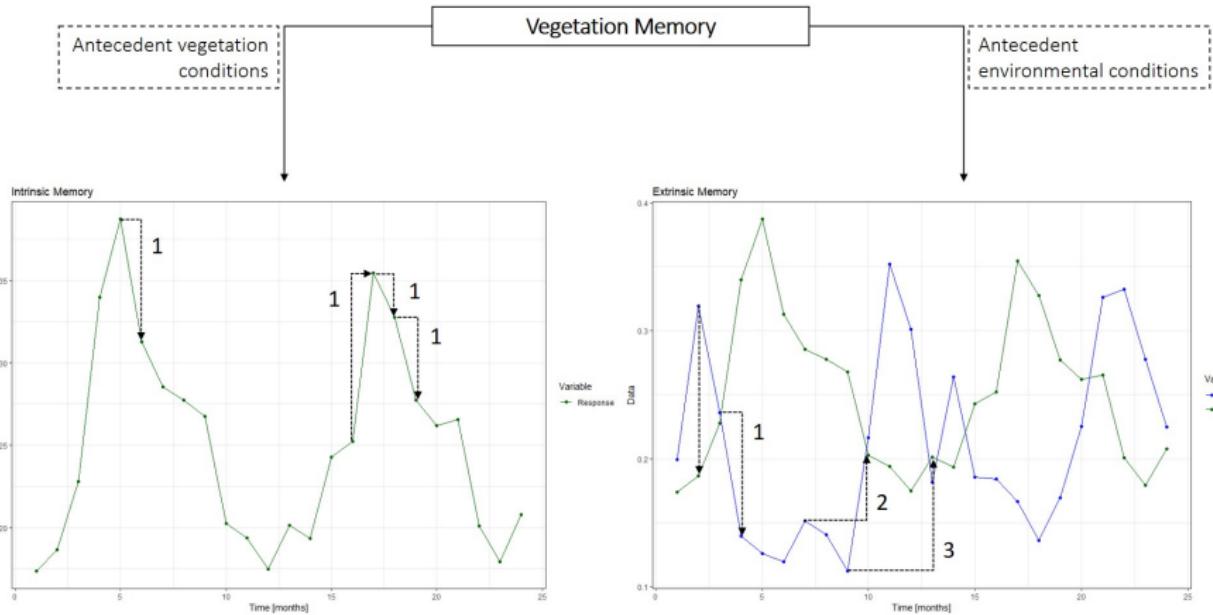
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Intrinsic vs. Extrinsic Memory Components



→ 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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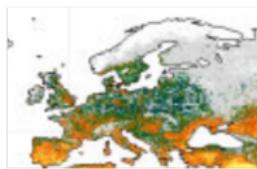


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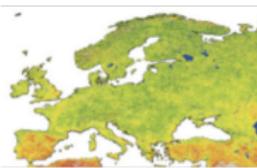
The Iberian Region

Intrinsic Memory



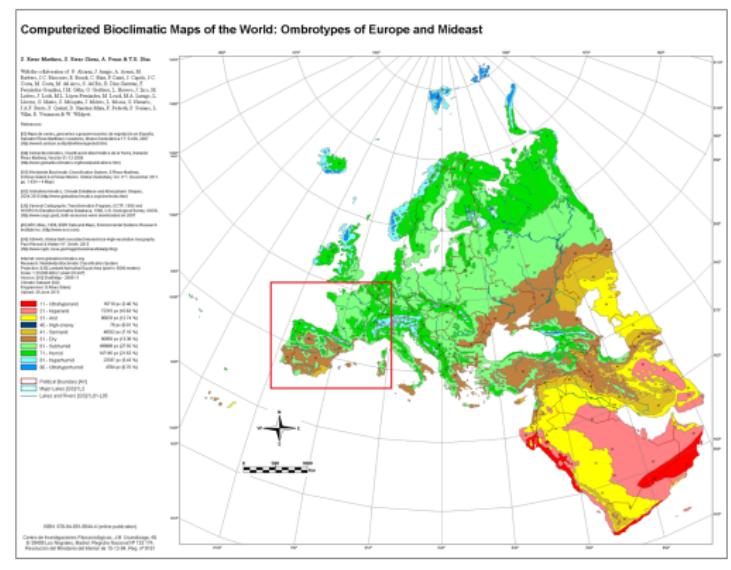
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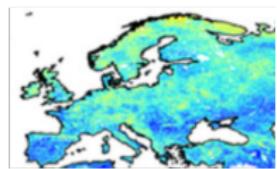


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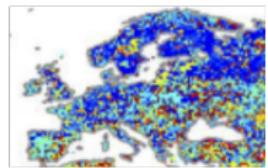


Water Memory



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Additional Study Regions:

■ Caatinga, Brazil

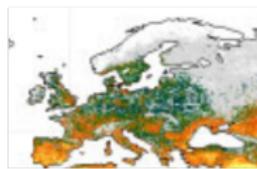
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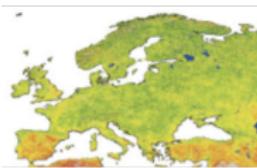
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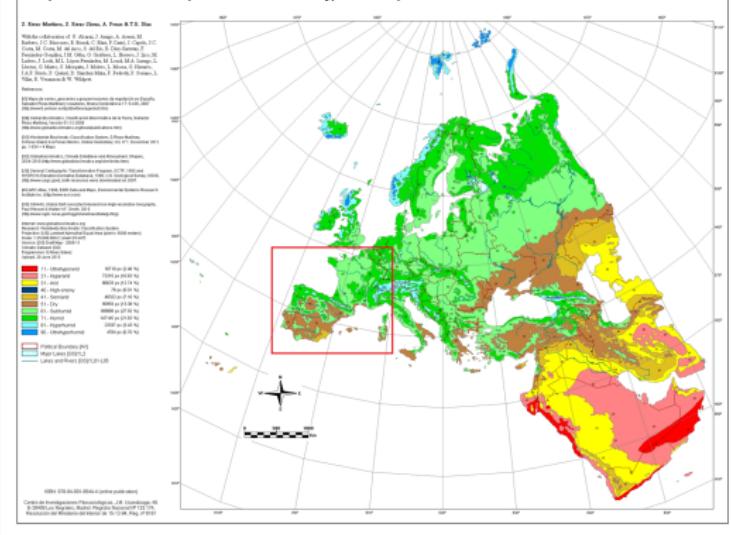
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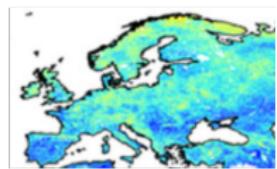


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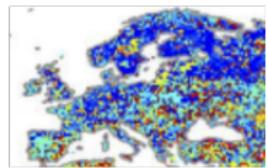


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Normalised Difference Vegetation Index (NDVI)

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

$$NDVI = \frac{\rho_{NIR} - \rho_{RED}}{\rho_{NIR} + \rho_{RED}} \quad (1)$$

■ Why:

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

■ Core Characteristics:

- *Resolution*: $0.083^\circ \sim 9.27\text{km} \times 9.27\text{km}$
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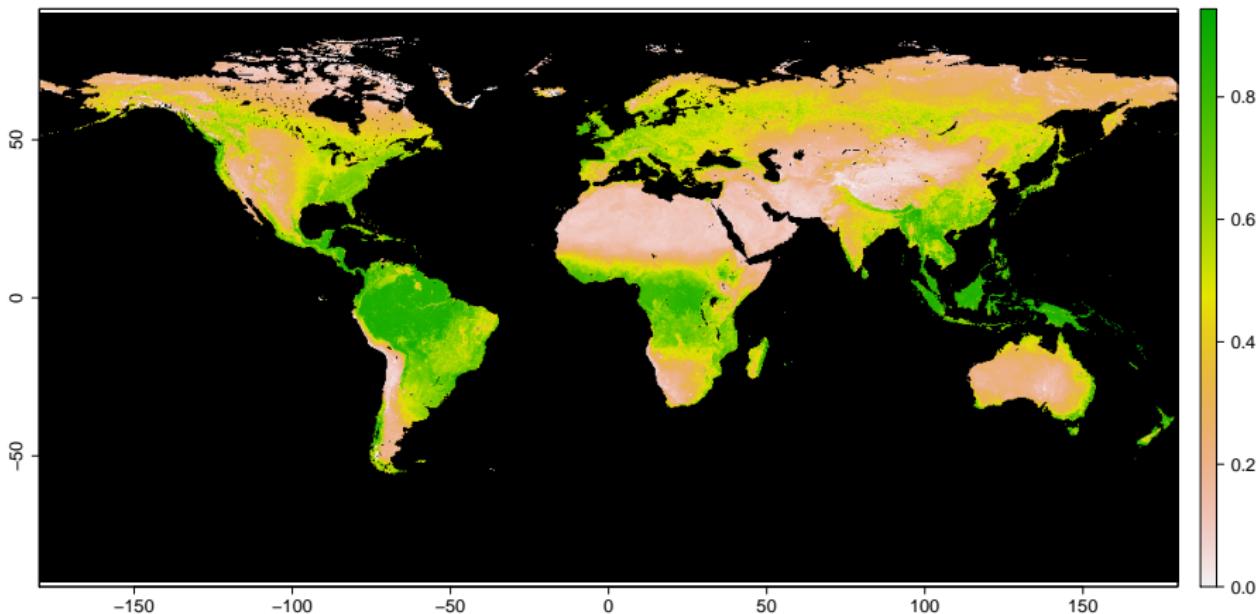
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Monthly Composites

Mean NDVI 1982 – 2015



ERA5 & Variables I

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

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- Applicable globally
- Gap-less time series
- More sophisticated approach than previously utilised:
 - Worldclim - Superior Temporal Resolution (superior resolving of climate extremes)
 - CRU - Superior Spatial Resolution
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- *Why:* Soil moisture effects on vegetation may indicate if/how the local ecosystem may deal with drought stress^[5,9,10].
- *How:* as different layers of depth
 - Q_{soil} - 0-7cm layer
 - Q_{soil2} - 7-28cm layer
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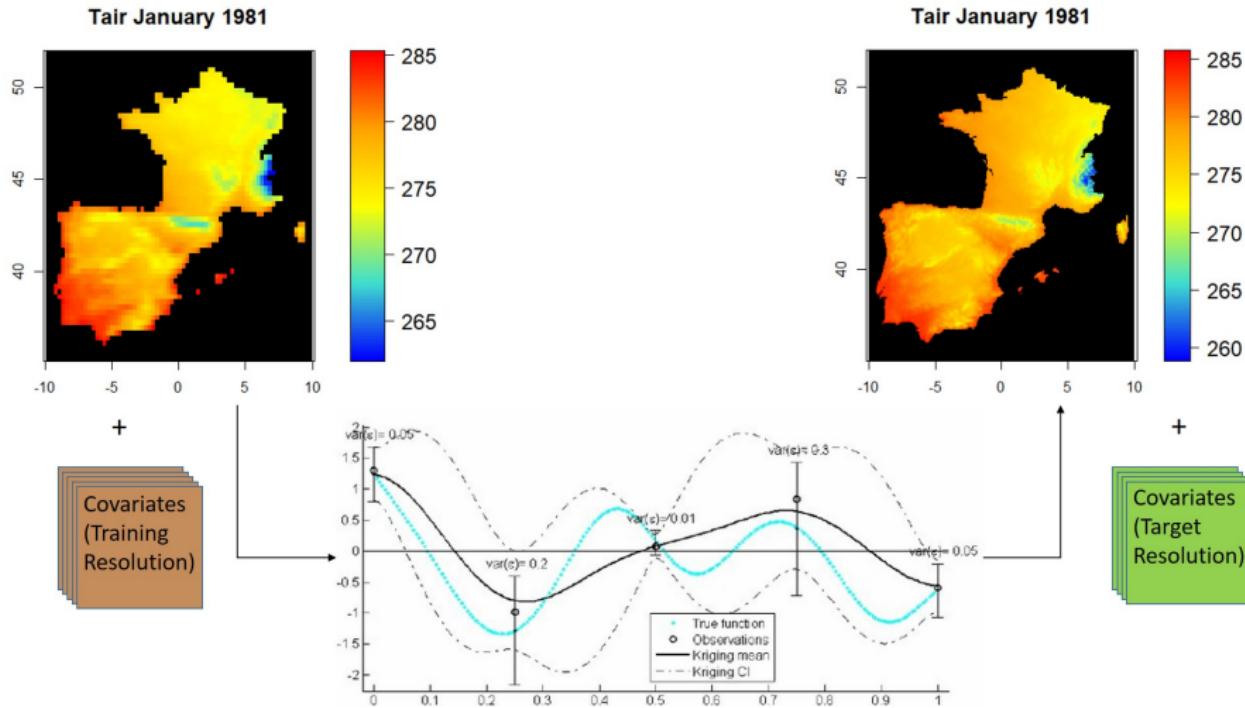
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- *Why:* Temperature drives plant physiology and drives levels of aridity^[3,9].
- *How:* As one single layer (2m above ground)

Kriging



Plant Functional Data

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

Life History Traits (LHTs)

■ Why:

- *Biological Relevance*: Indices of plant behaviour through time
- *Comparability*: Capture much of natural life strategy variation^[13]

■ 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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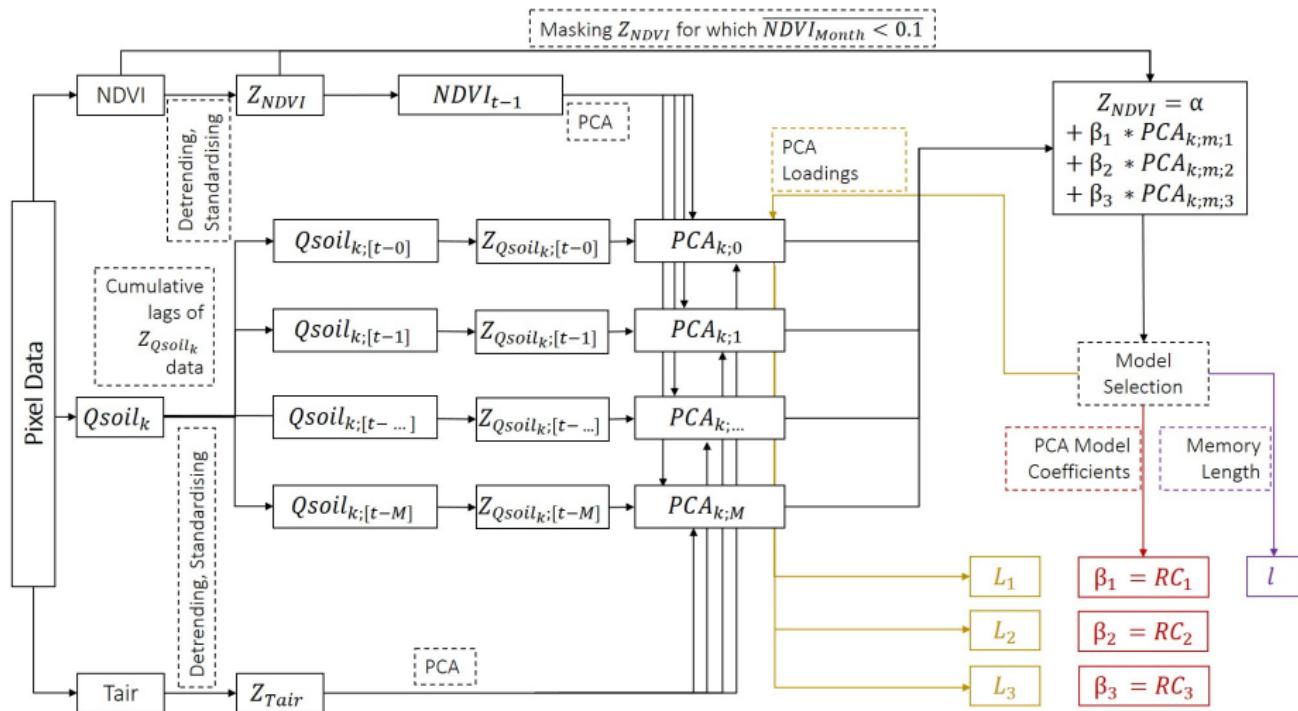
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Pixyel-Wise Model Building



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

PC_3 Third principal component

	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

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

C_p Coefficient of variable p

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$L_{p;i}$ Loading of variable p on principal component i

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- Which variable exerts the greatest influence on vegetation anomalies?
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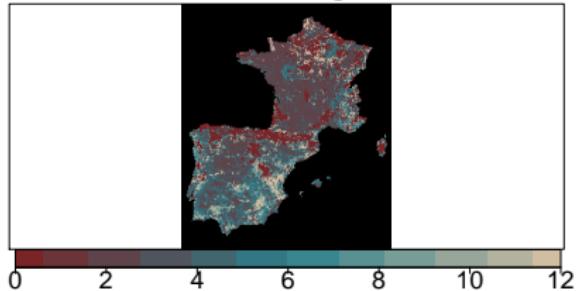
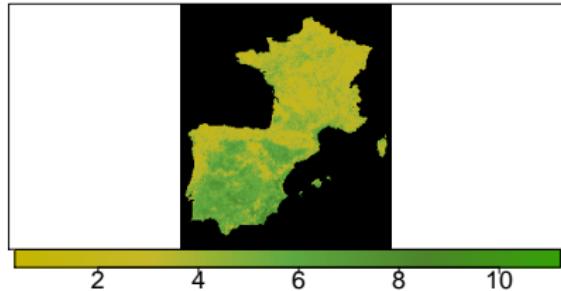
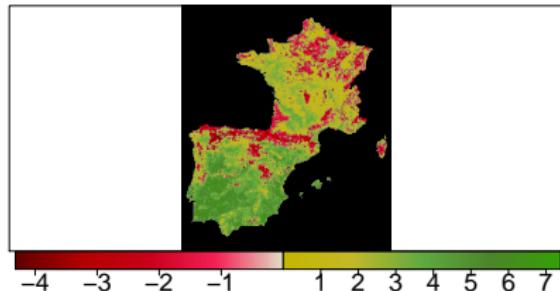
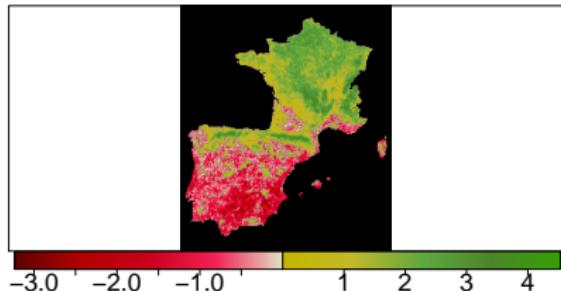
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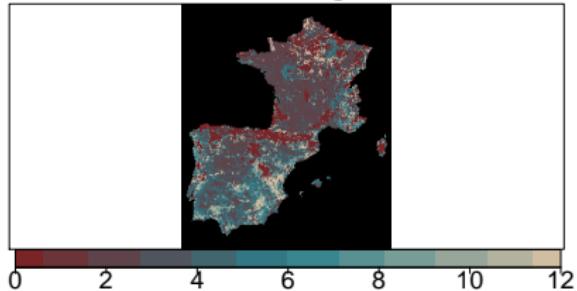
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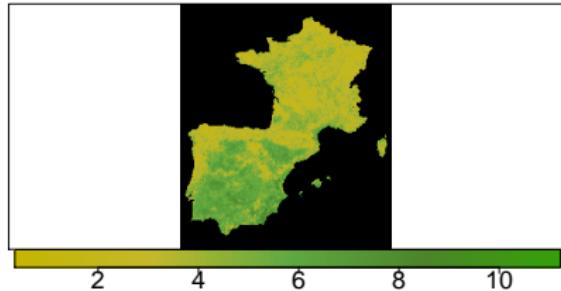
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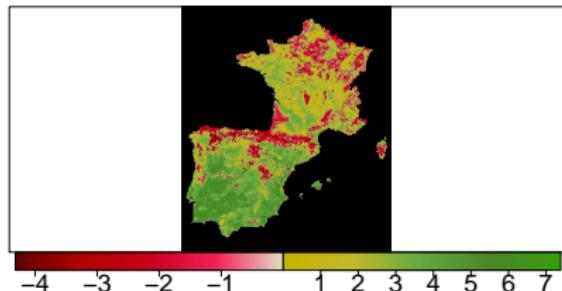
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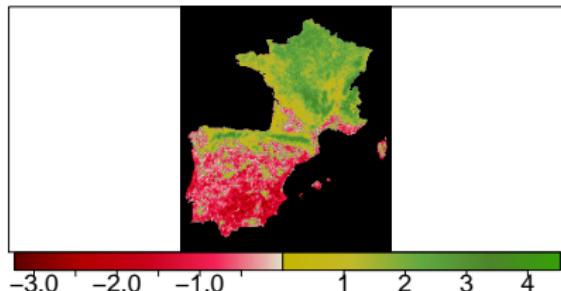
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Qsoil1



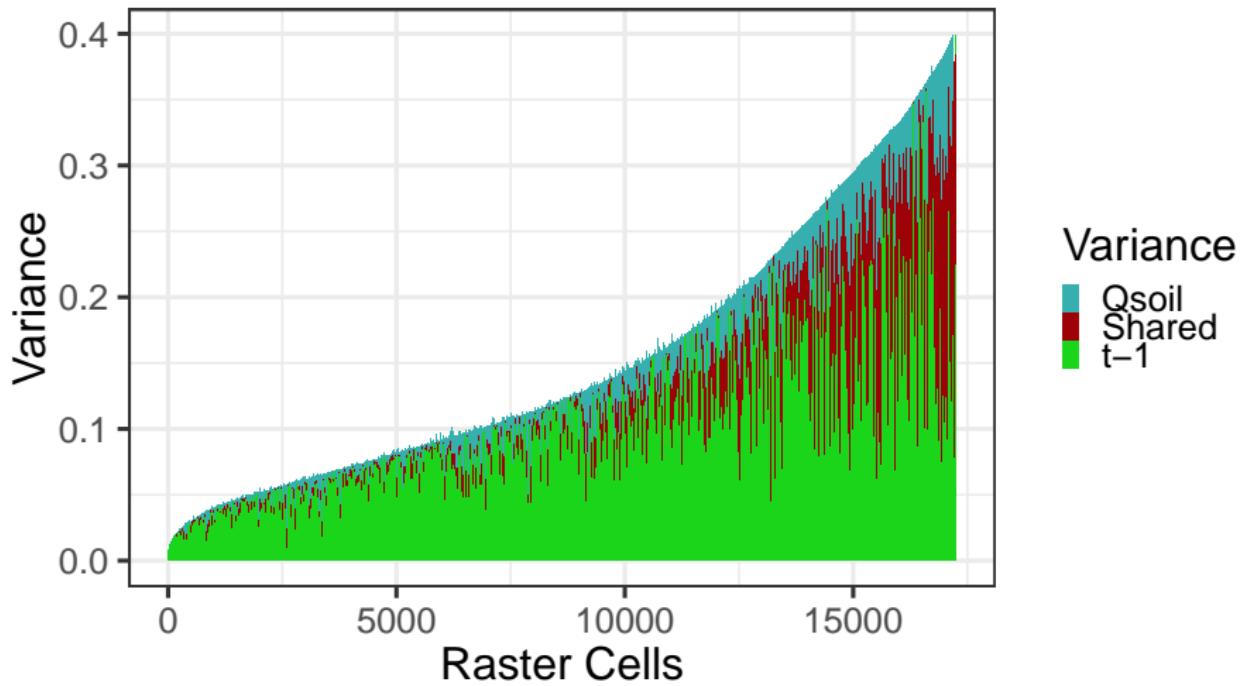
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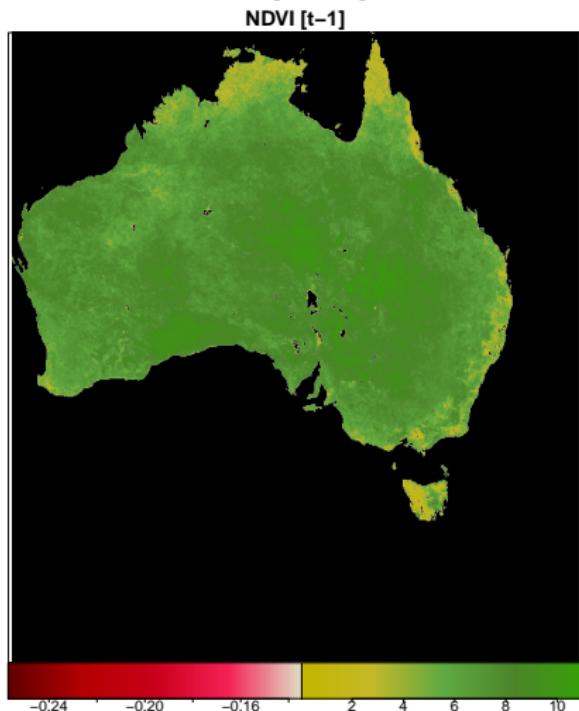
Distinguishing Intrinsic and Extrinsic Memory

Qsoil1 is the most informative of the soil moisture layers!

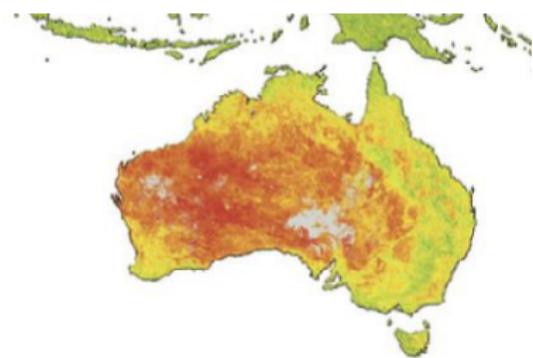


Identifying Underlying Extrinsic Patterns I

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

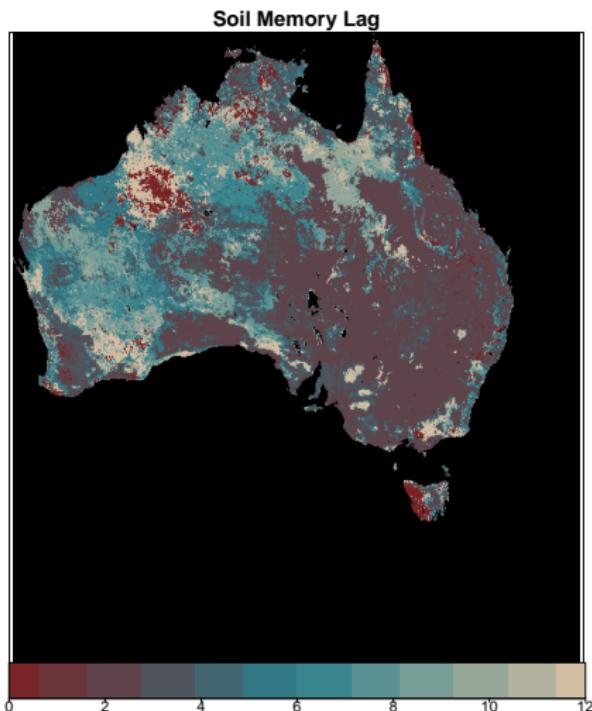


Intrinsic Memory by Seddon et al.^[6]:

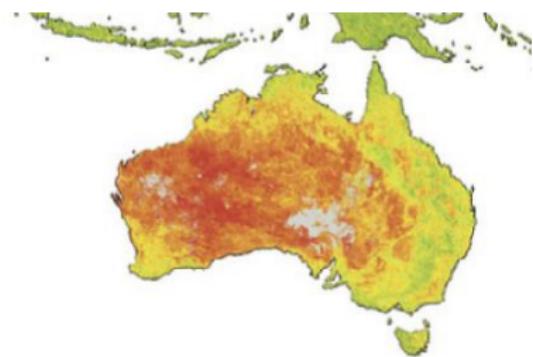


Identifying Underlying Extrinsic Patterns II

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

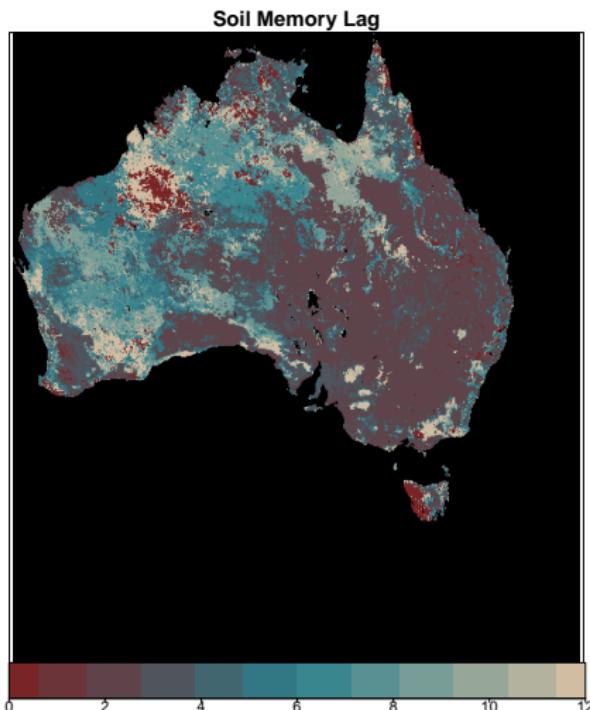


Intrinsic Memory by Seddon et al.^[6]:

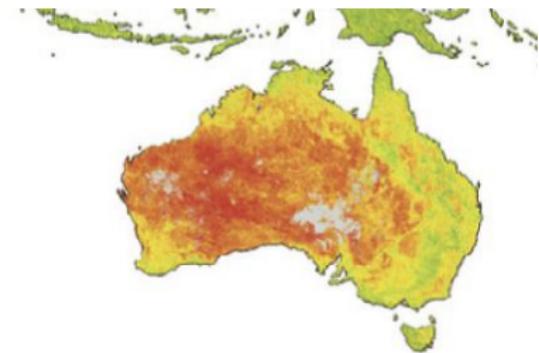


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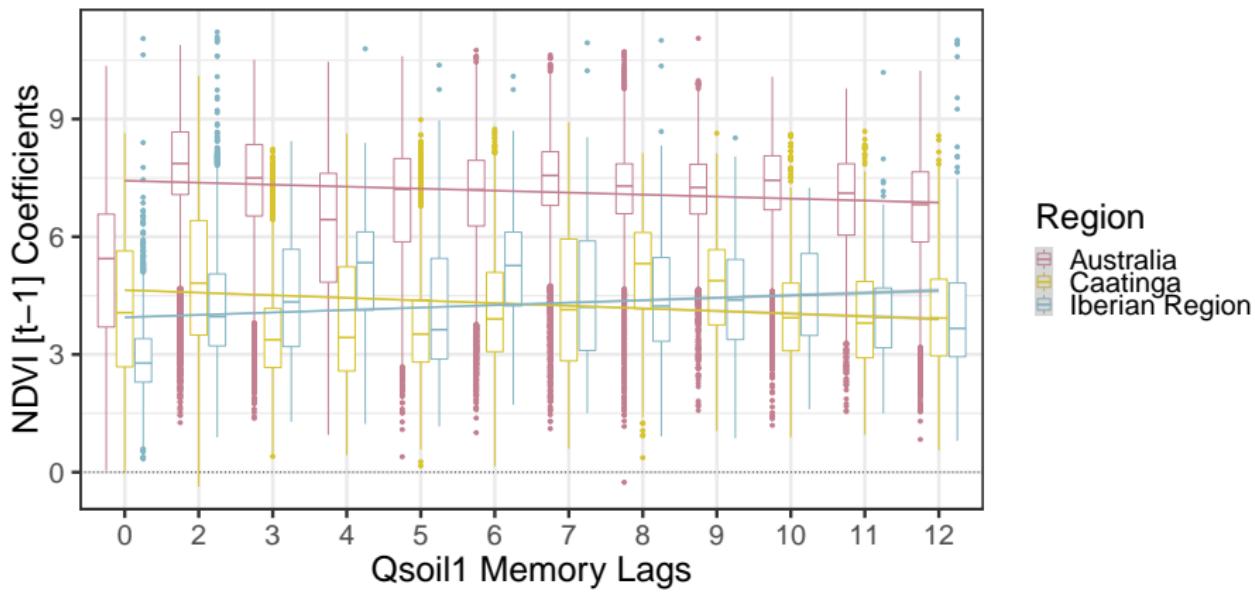


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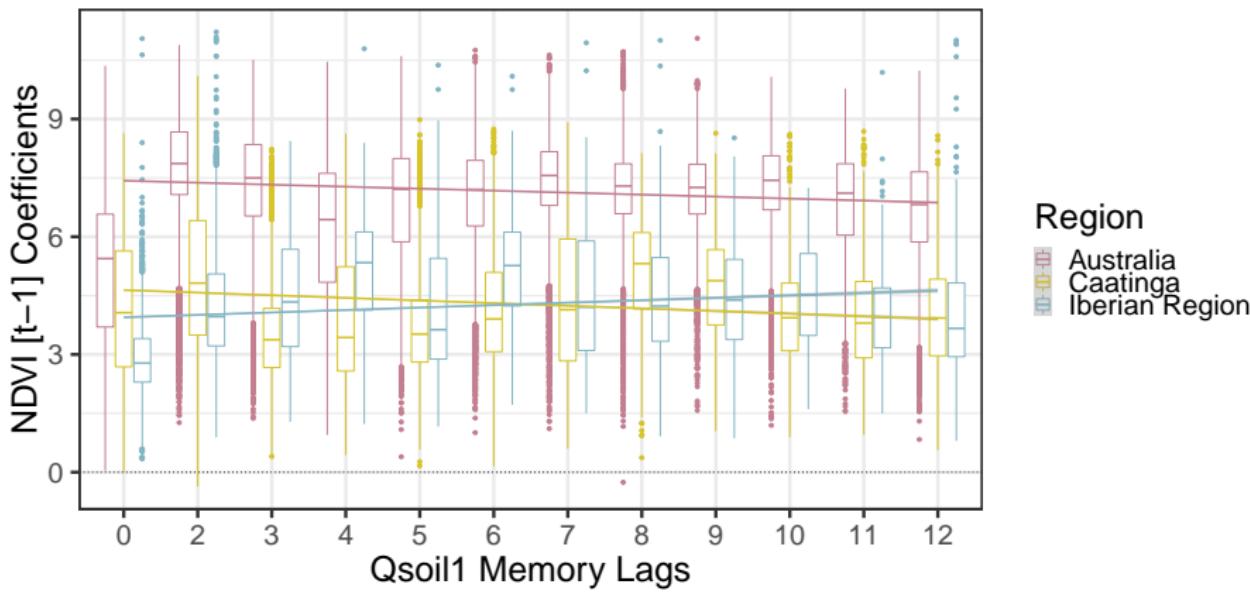
Previous $t - 1$ variation can
be understood through
extrinsic vegetation memory.

Vegetation Memory Adaptation



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

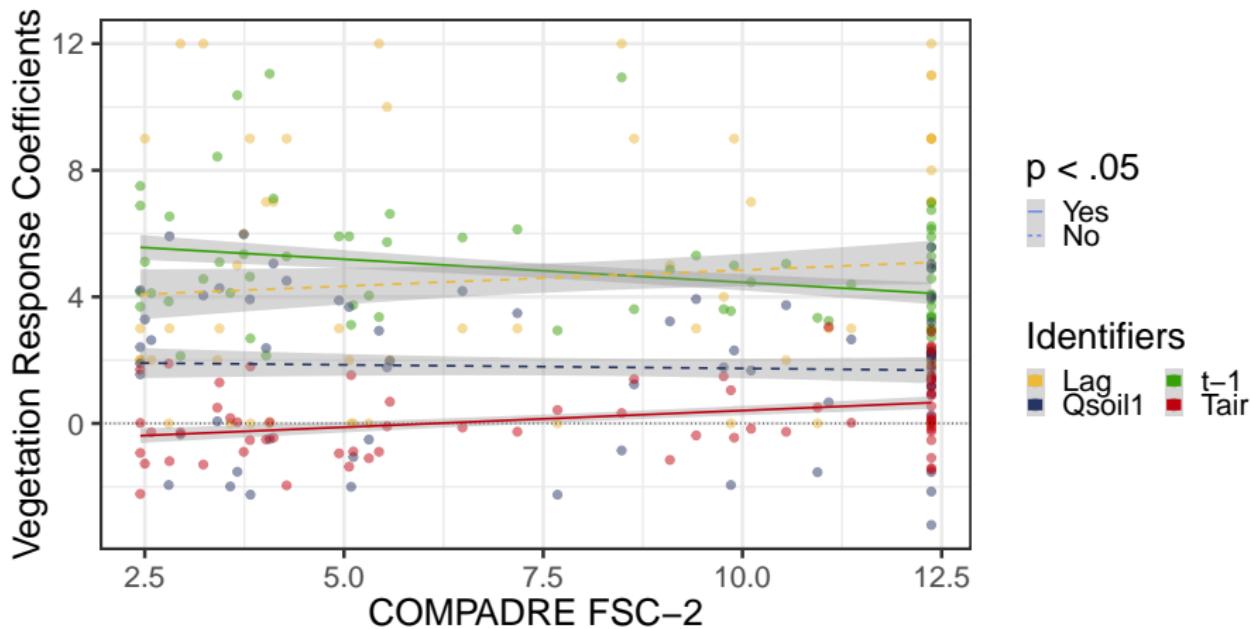
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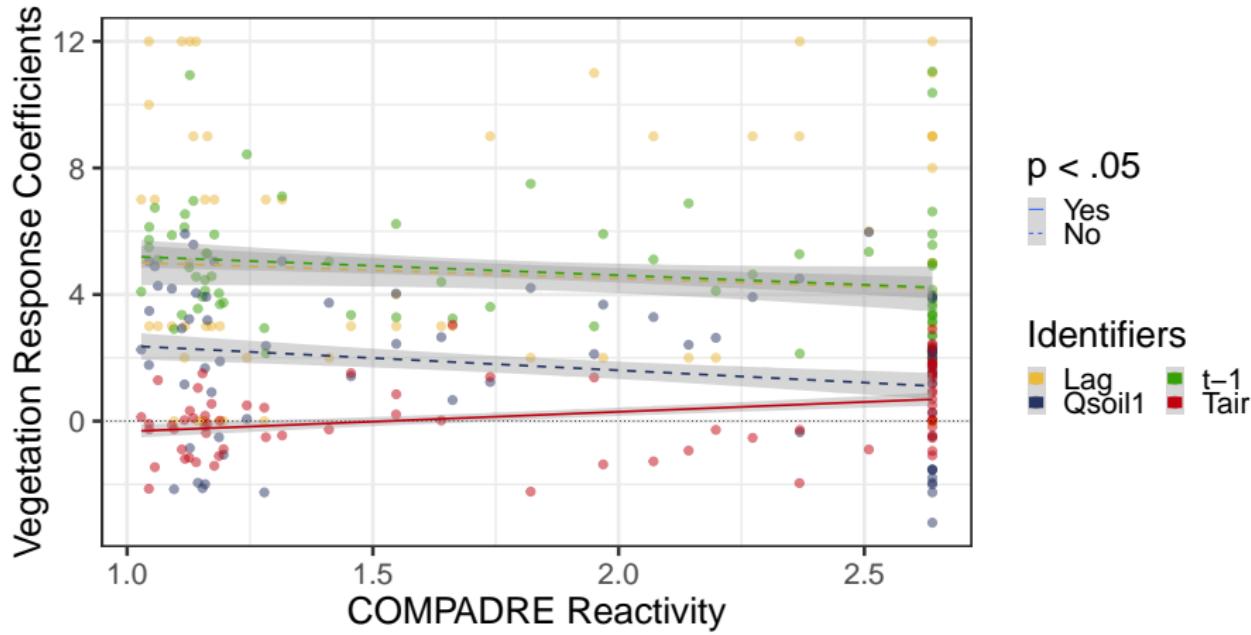
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Plant Function I

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

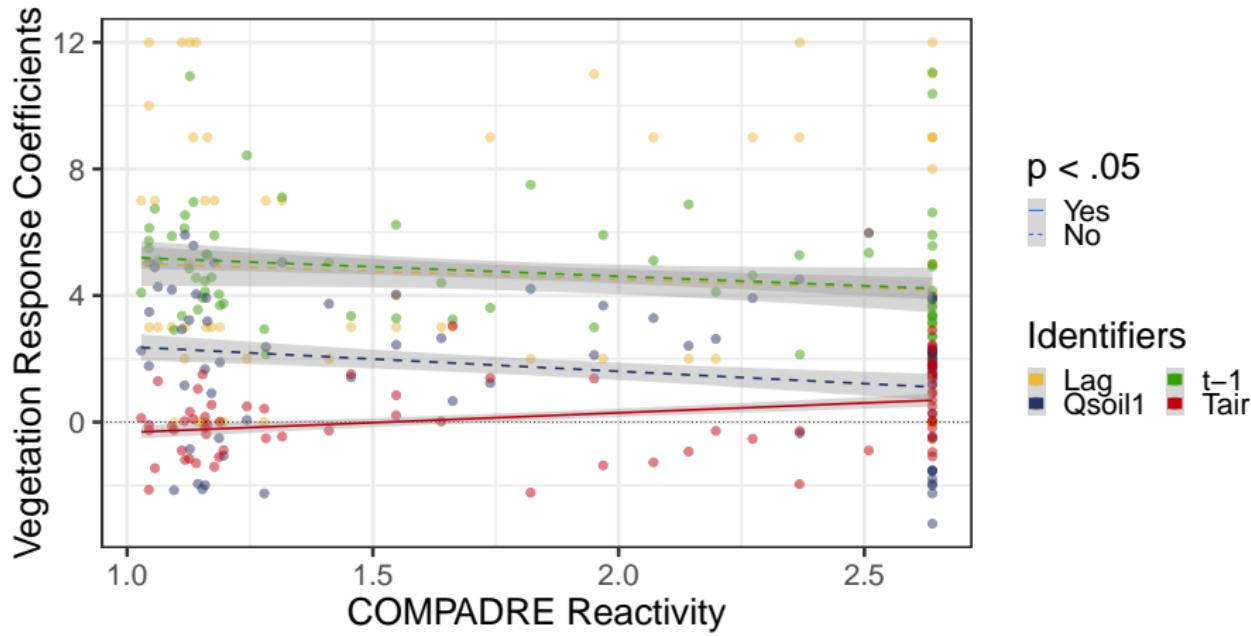


Plant Function II



Some LHTs can be linked to some vegetation memory characteristics,

Plant Function II



$p < .05$
Yes
No

Identifiers
Lag $t-1$
Qsoil1 Tair

Some LHTs can be linked to some vegetation memory characteristics,

Outline

1 Background

- Motivation
- Concept

2 Allocating and Preparing Data

- Vegetation Data
- Climate Data
- Plant Functional Data

3 Delineating Vegetation Memory

4 Results

- Coefficients of Vegetation Memory
- Regional Aspects of Vegetation Memory
- Functional Aspects to Vegetation Memory

5 Conclusion

Conclusion

Summary:

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

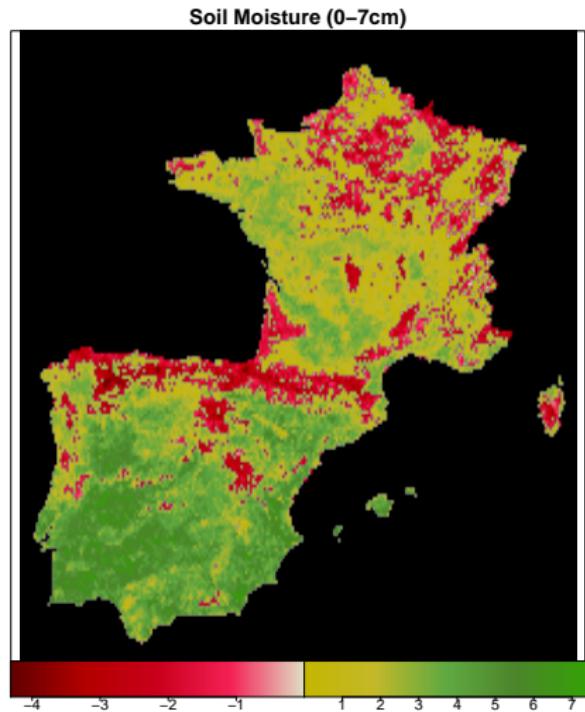


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Extrinsic memory should not be neglected in favour of intrinsic memory.

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

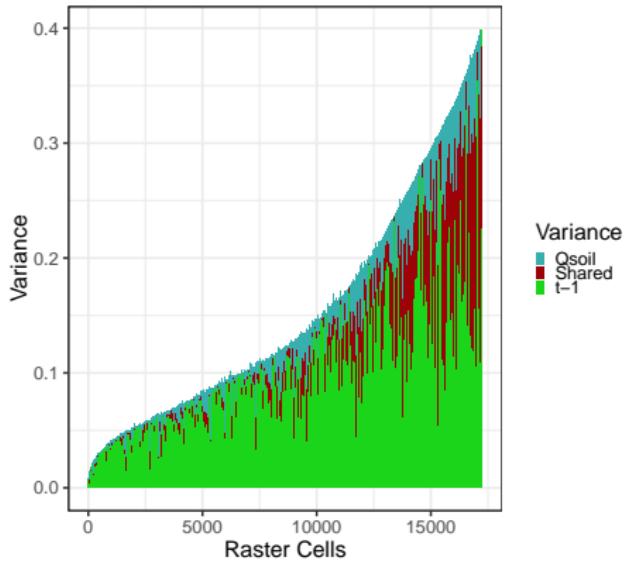


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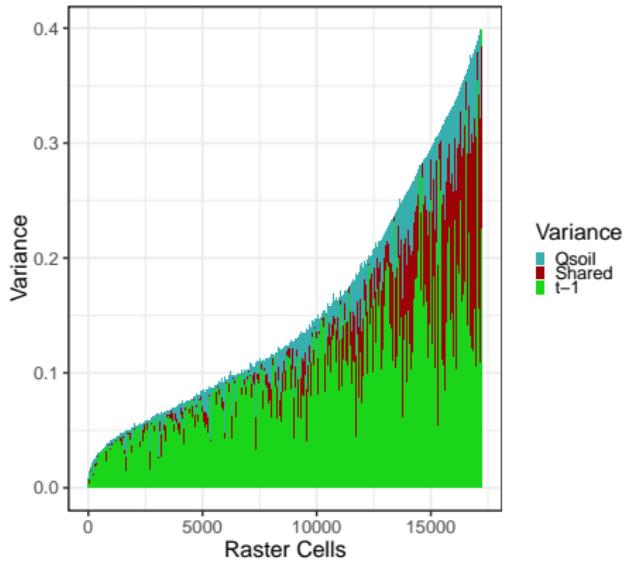


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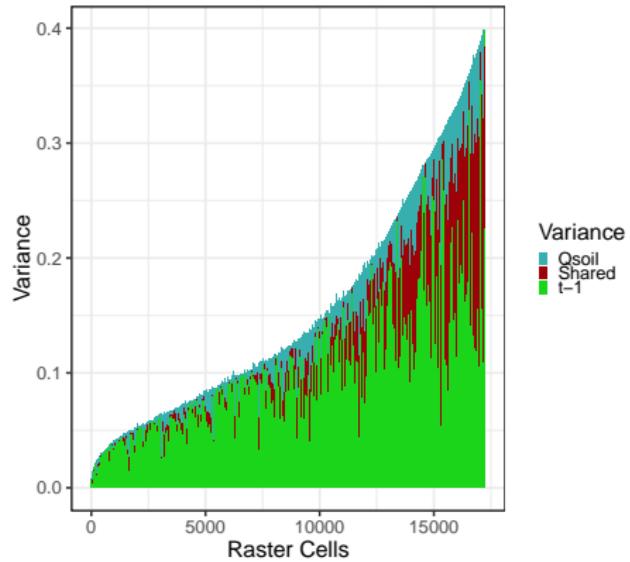


Distinguishing intrinsic and extrinsic memory components remains challenging.

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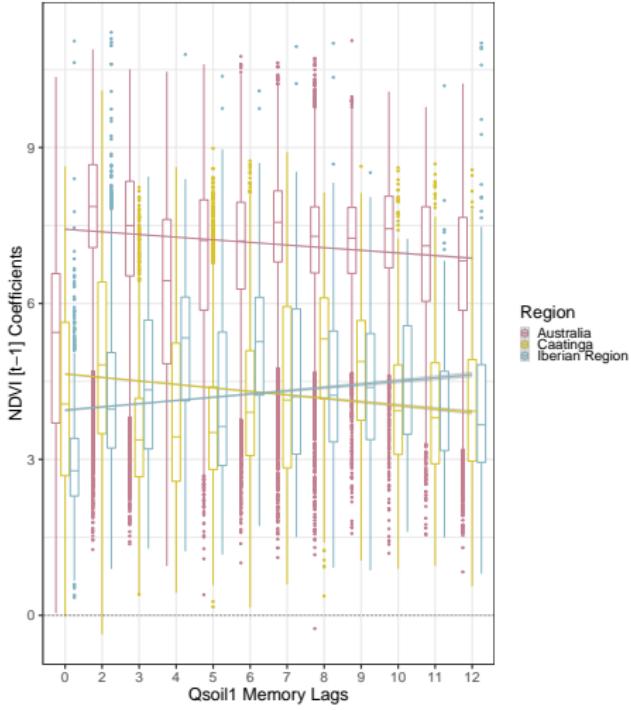
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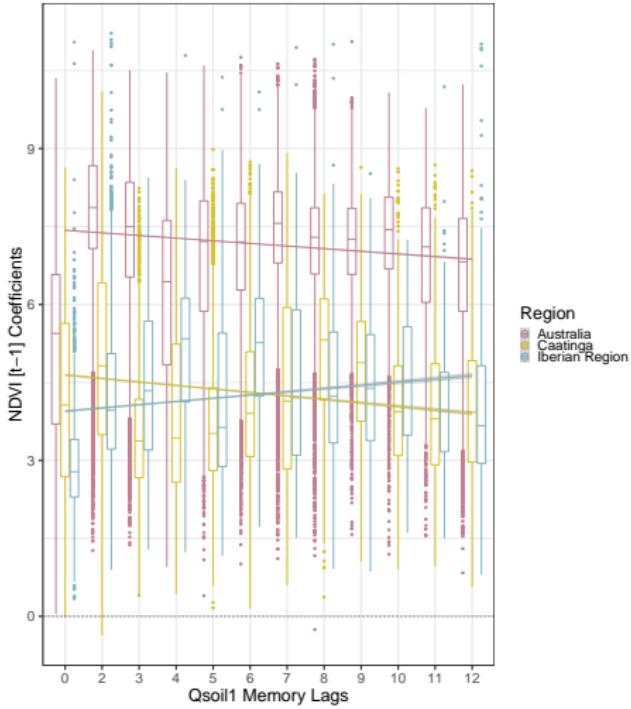
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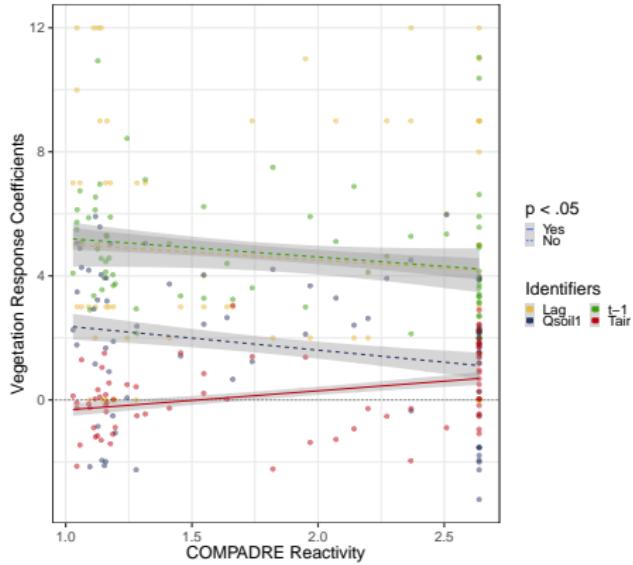


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Some measures of life history strategies are related to vegetation memory characteristics.

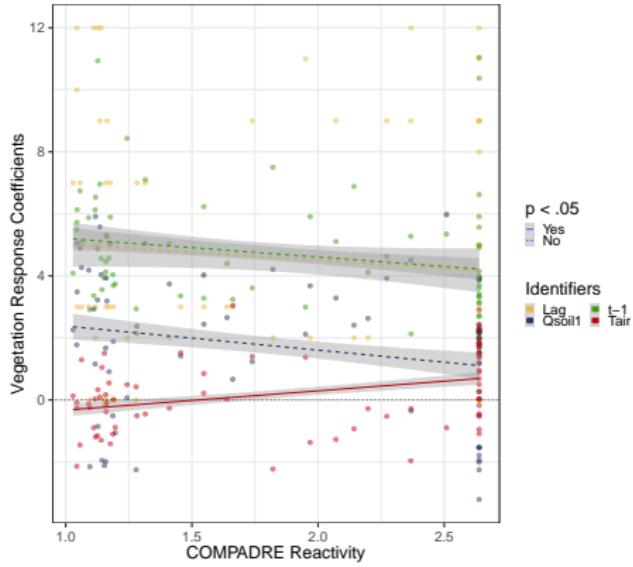


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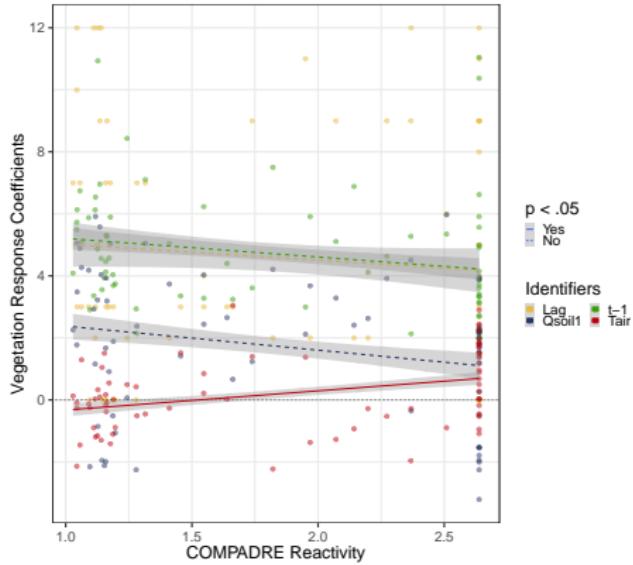


Challenging to establish direct proxies of either intrinsic or extrinsic vegetation memory components.

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Future Directions:

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- 3 Analyse changes in vegetation memory over time
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