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Moisture recycling over the Iberian Peninsula. The impact of 3DVAR data assimilation

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RATIONALE

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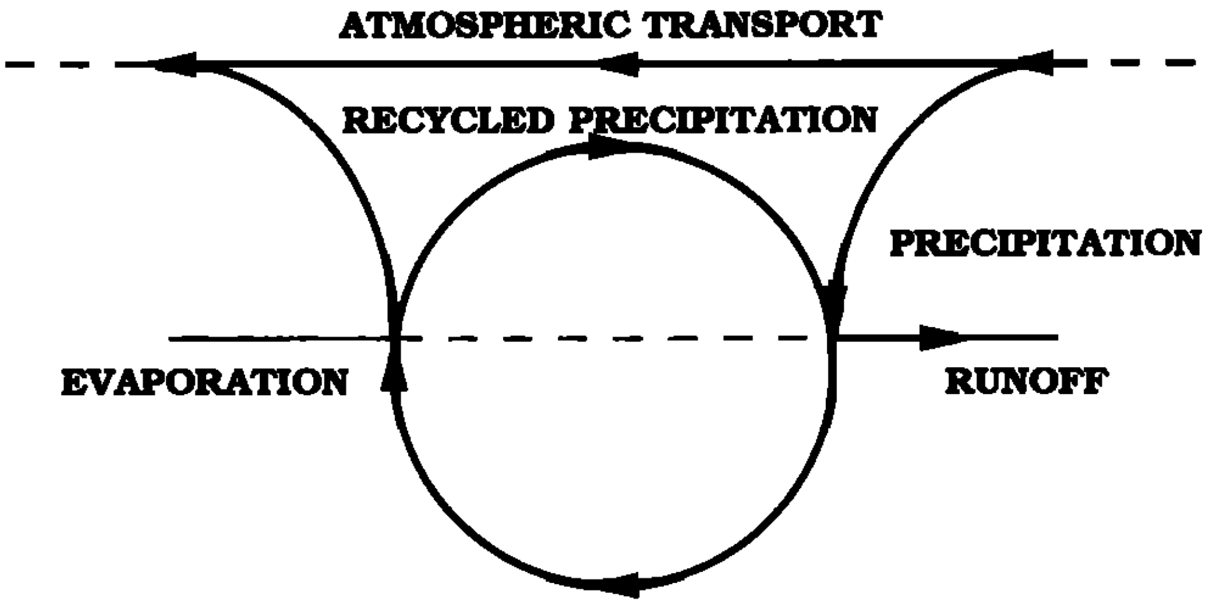

Adapted from: Eltahir and Bras (1996)

- **Moisture recycling** is defined as the fraction of precipitation over a delimited region that comes from the evaporation over that region.

- Its importance lies in the fact that it is an approximated measurement of a regional feedback between the atmosphere and the surface.

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Objectives:

- Estimate the spatio-temporal distribution of moisture recycling over the Iberian Peninsula.
- Evaluate the impact of the use of 3DVAR data assimilation during the model run.

To do so:

- Check differences between WRF experiments:
  - Annual Cycle
  - Seasonal Patterns
- Cross-Correlation Function (CCF) based analysis.

MODEL AND EXPERIMENTAL DESIGN

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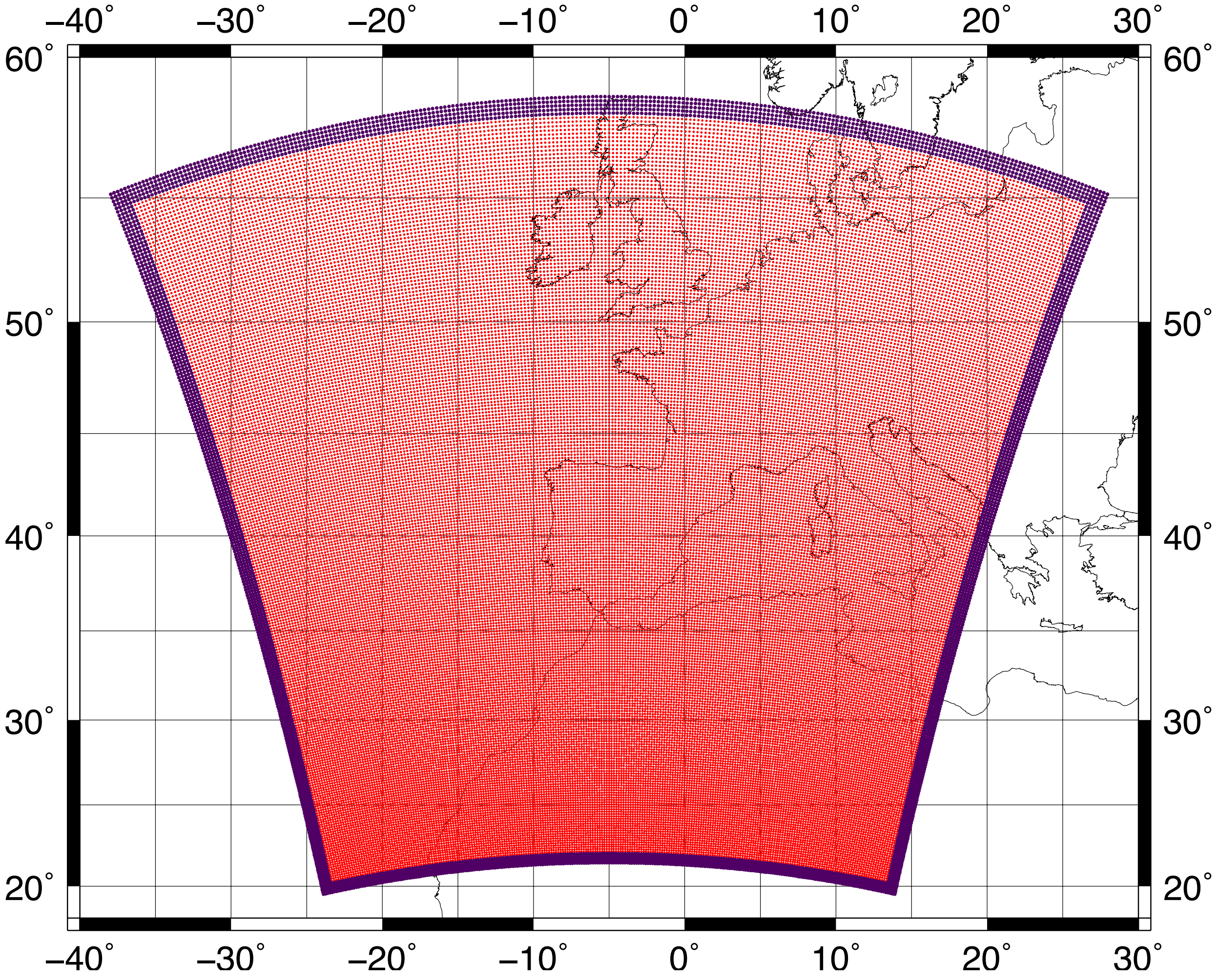

WRF v3.6.1:

- Nested in ERA-Interim.
- 15x15 km horizontal resolution.
- 51 vertical levels up to 20 hPa.
- Period: 2009-2014; 2009 only for spin-up.
- 3DVAR data assimilation at 00, 06, 12 and 18UTC.

2 Experiments:

- Without data assimilation: NO DA - Exp N.
- With data assimilation: DA - Exp D.

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Definition of Moisture Recycling:

Based on the definition by Eltahir and Bras in 1994:

Month — Normalized Precip — Moisture Recycling

$$[\rho](k) = \sum_{i,j} p(i,j,k)\,\rho(i,j,k)$$

Integrating over the entire area:

$$[\rho](t)\;[P](t)\cdot \not{A} = [\rho P](t)\cdot \not{A}$$

Applying Reynolds decomposition:

$$[P\rho] \;=\; \left[([P]+P^*)([\rho]+\rho^*)\right] \;=\; [P][\rho]+[P^*\rho^*]$$

Our spatial average of **moisture recycling definition**:

$$[\rho](t) = \frac{1}{[P]}\left([P\rho] - [P^*\rho^*]\right)$$

Covariance of spatial anomalies

RESULTS Annual Cycle

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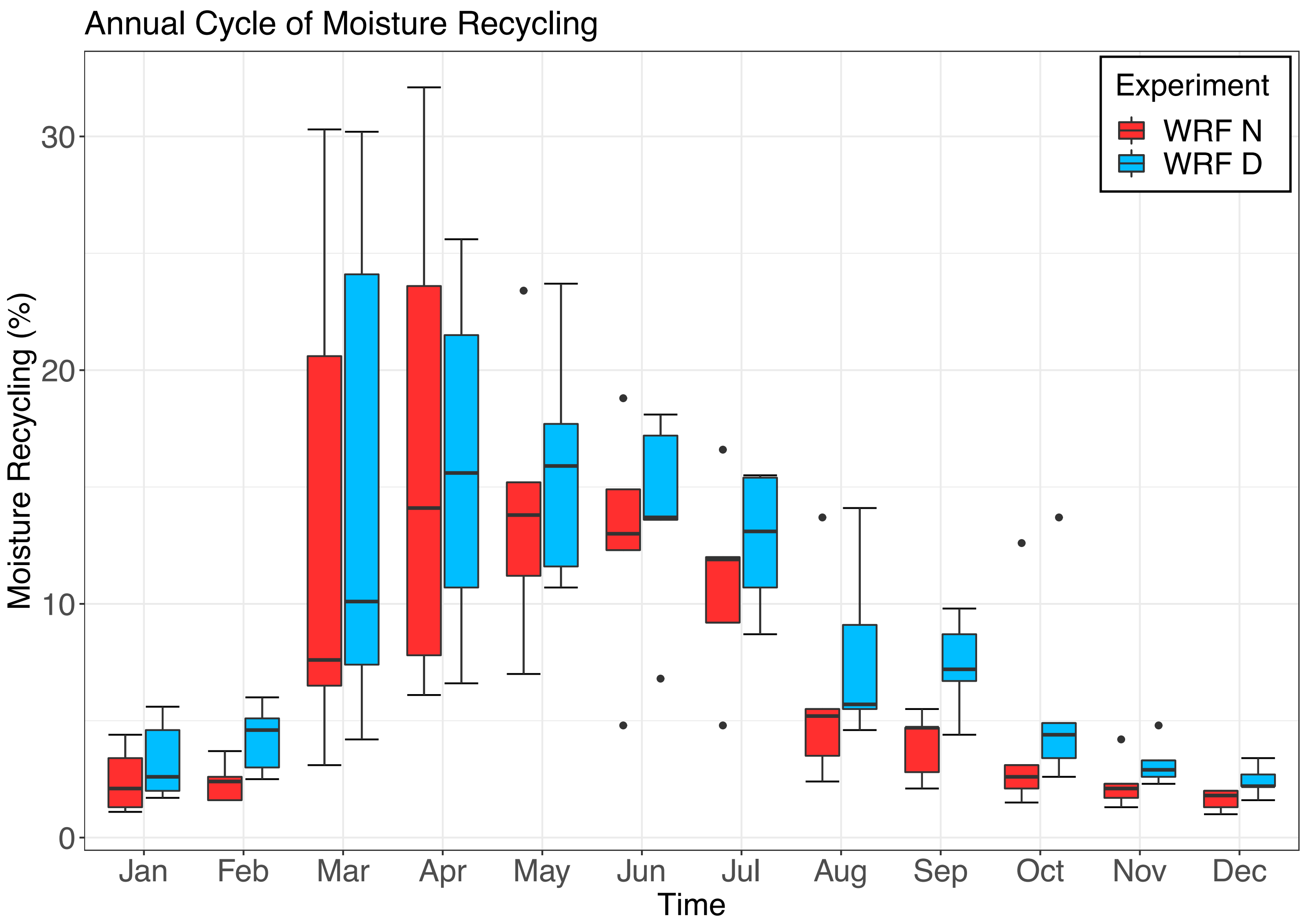

Two different regimes:

- Nov-Feb: Recycling is limited.
- Mar-Aug: Remarkable values.
- Larger variability in Spring.

Differences between experiments:

- During Summer and Autumn.
- **Smaller values for N (No DA)**
  - **Dryer soil**

RESULTS Annual Cycle

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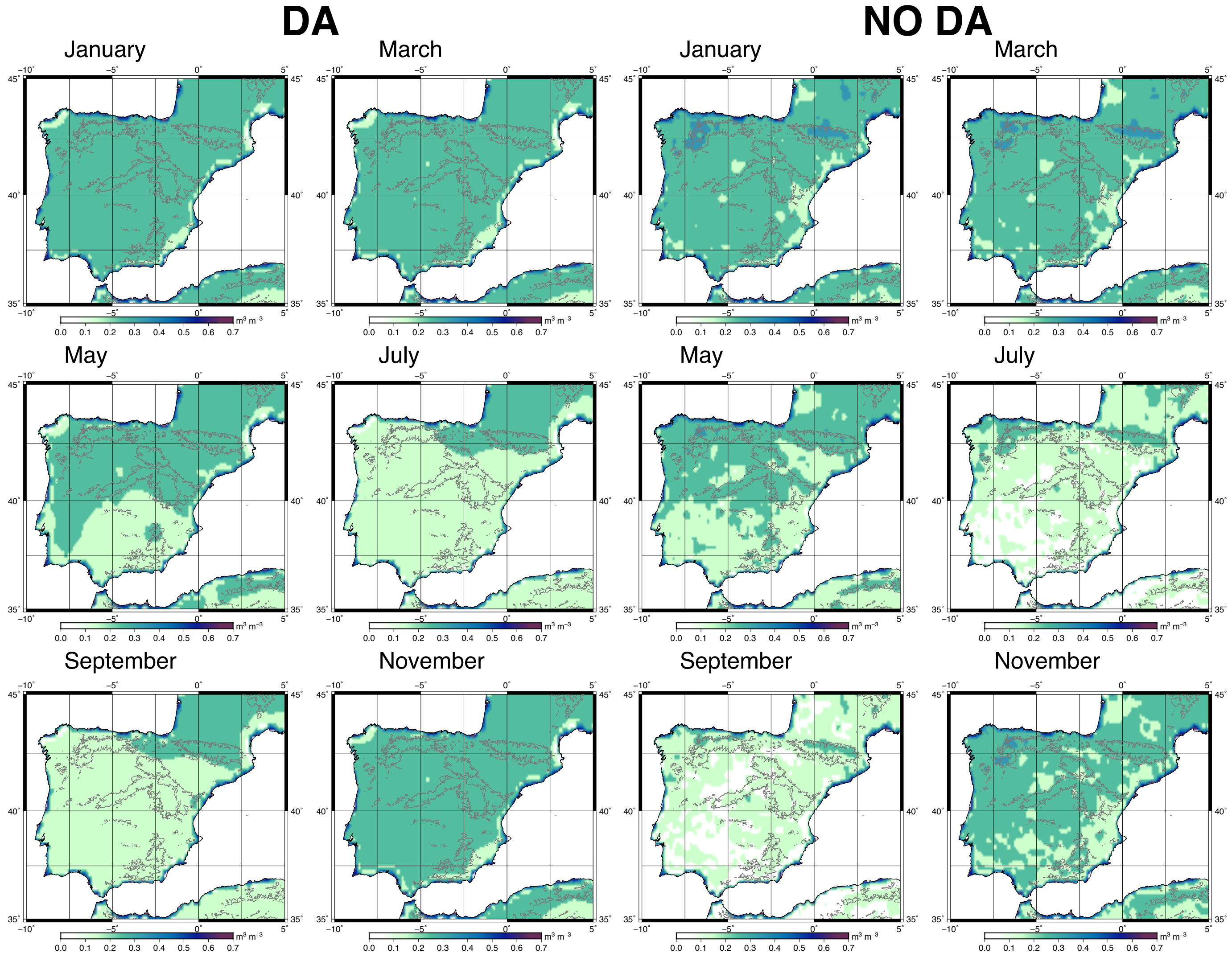

Soil Moisture Content:

- Differences in Summer and Autumn.
- Smaller values for N (No DA)
  - Dryer soil
  - DA corrects that bias

RESULTS Seasonal Patterns

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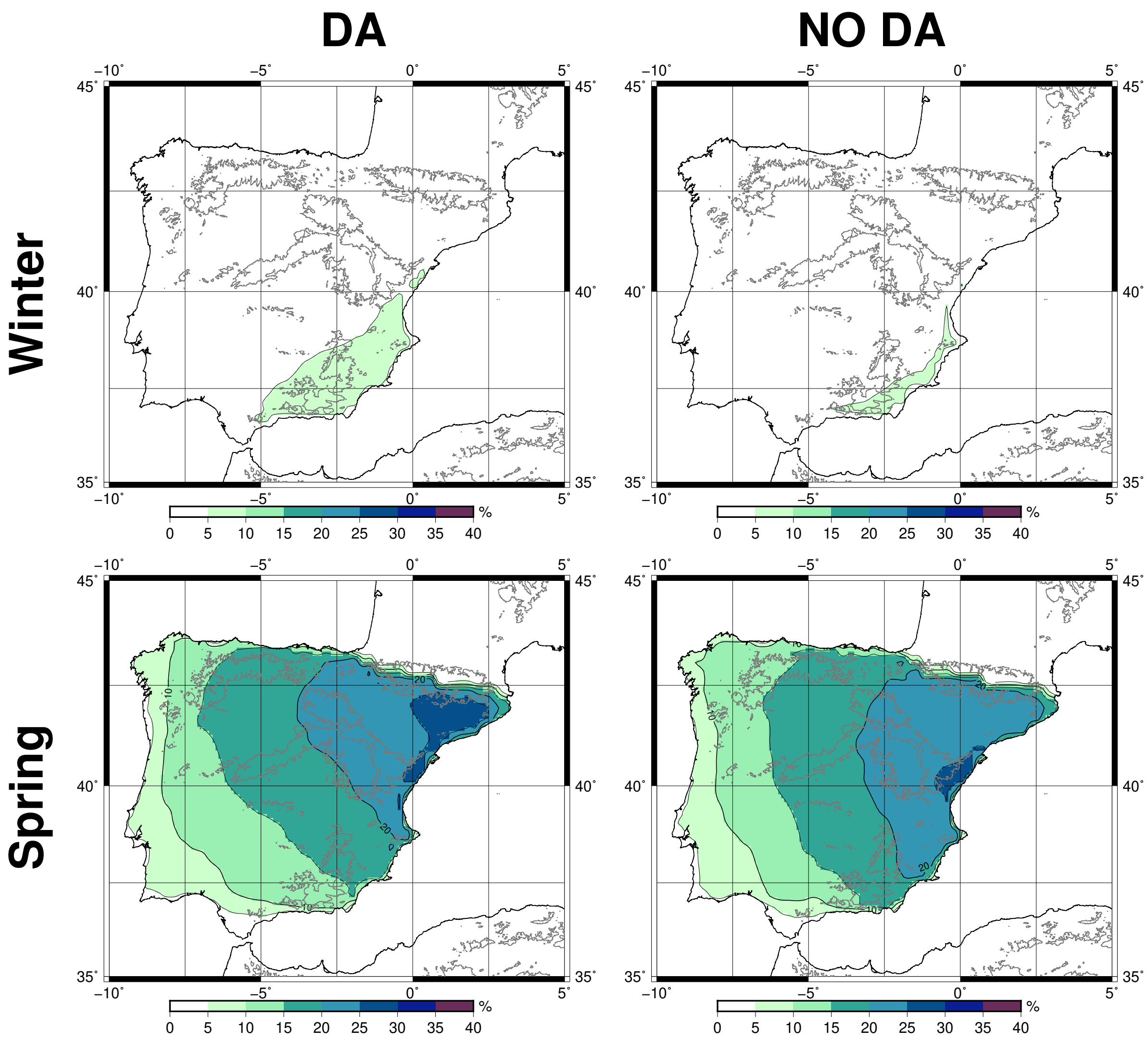
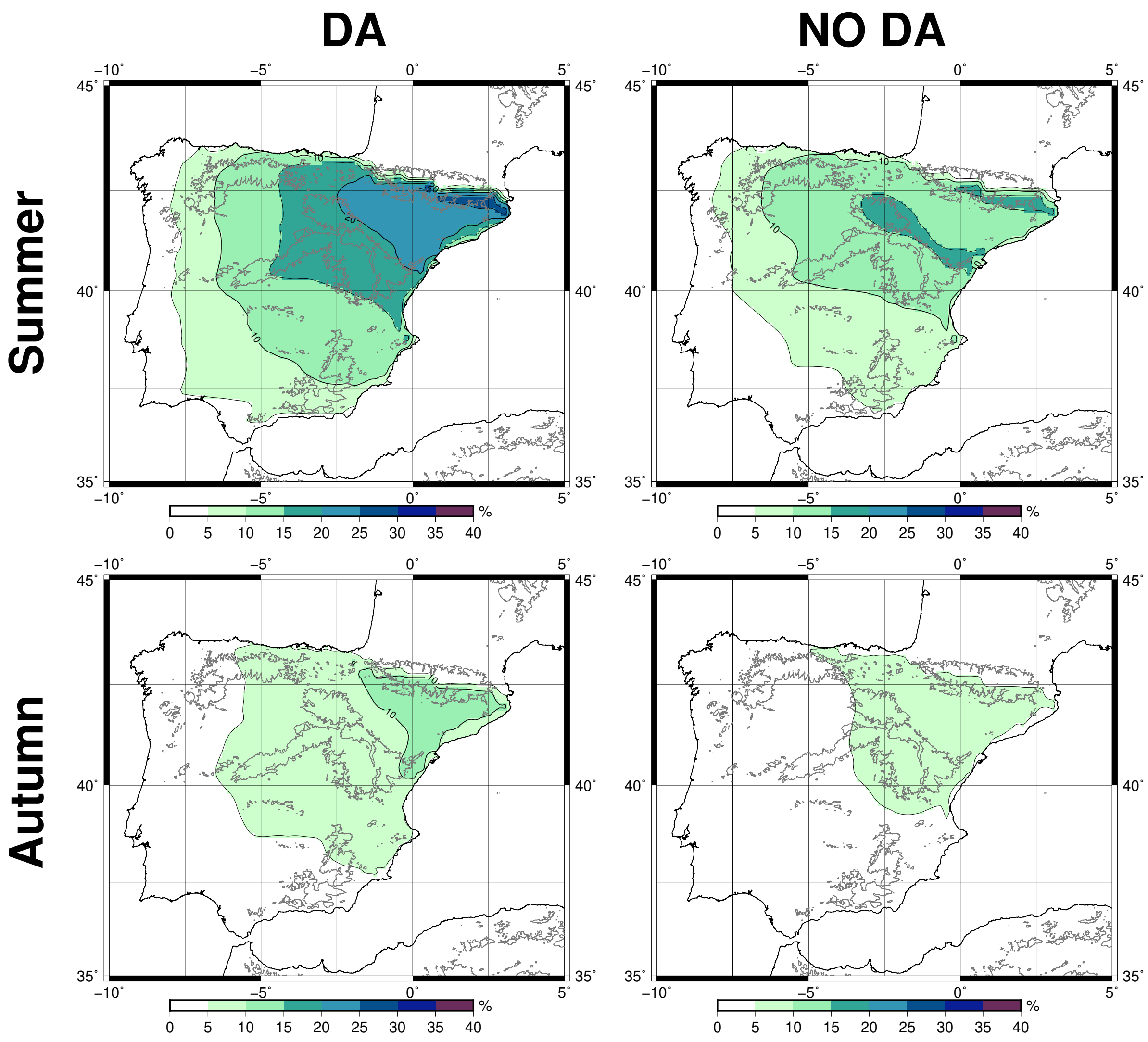


- Only in the southeastern corner of the IP.
- Small values in most regions of the IP (below 5%).

➡ Weak Surface-Atmosphere coupling, as the IP is dominated by large moisture influx from large-scale systems.

- Strongest Surface-Atmosphere coupling in Spring.
- Different location of the maximum due to:
  - More precipitation in the NE corner in NO DA.
  - Drier soil towards the end of spring in NO DA.

RESULTS Seasonal Patterns



- Season with greatest differences.
- DA: Similar pattern to Spring but the maximum located over the Pyrenees.
- NO DA: Recycling important in the southern rims of Ebro basin and the Pyrenees.
- Differences due to soil moisture content only.

- Transition season.
- Smaller values in NO DA due to:
  - More precipitation in the northern part in NO DA.
  - Drier soil in NO DA.

RESULTS Extended Time Series Analysis

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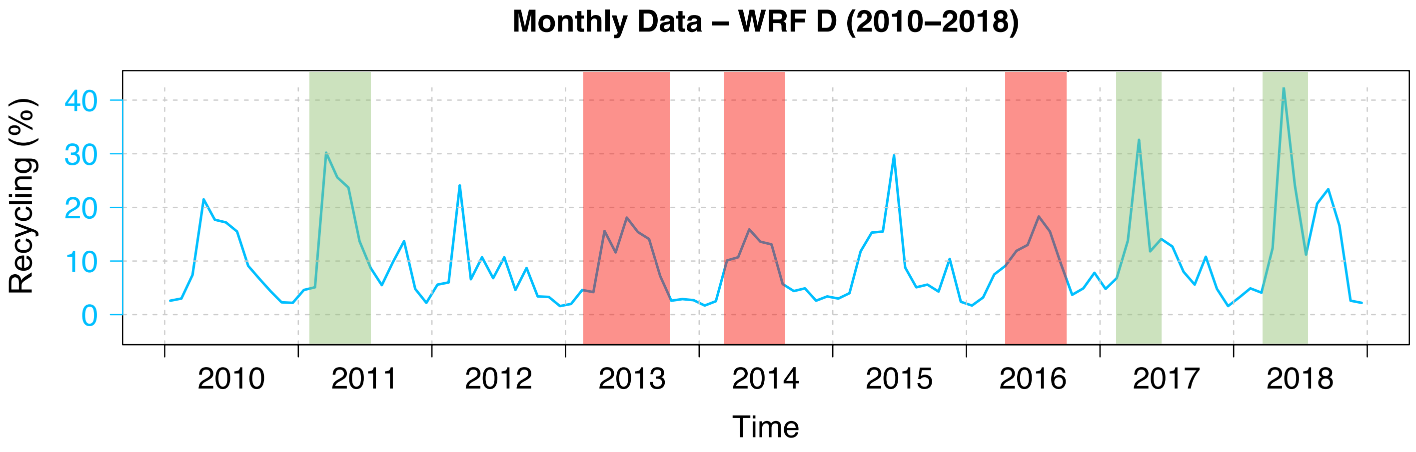
DA experiment extended until 2018 because:

- Able to correct the bias in soil moisture.
- Reproduces the spatial and temporal evolution of water balance variables (Ulazia et al. 2017; González-Rojí et al. 2018).



High heterogeneity in Moisture Recycling

- Some years present recycling above 30%.
- Absent of maximum and values below 20% during the entire year

RESULTS Extended Time Series Analysis

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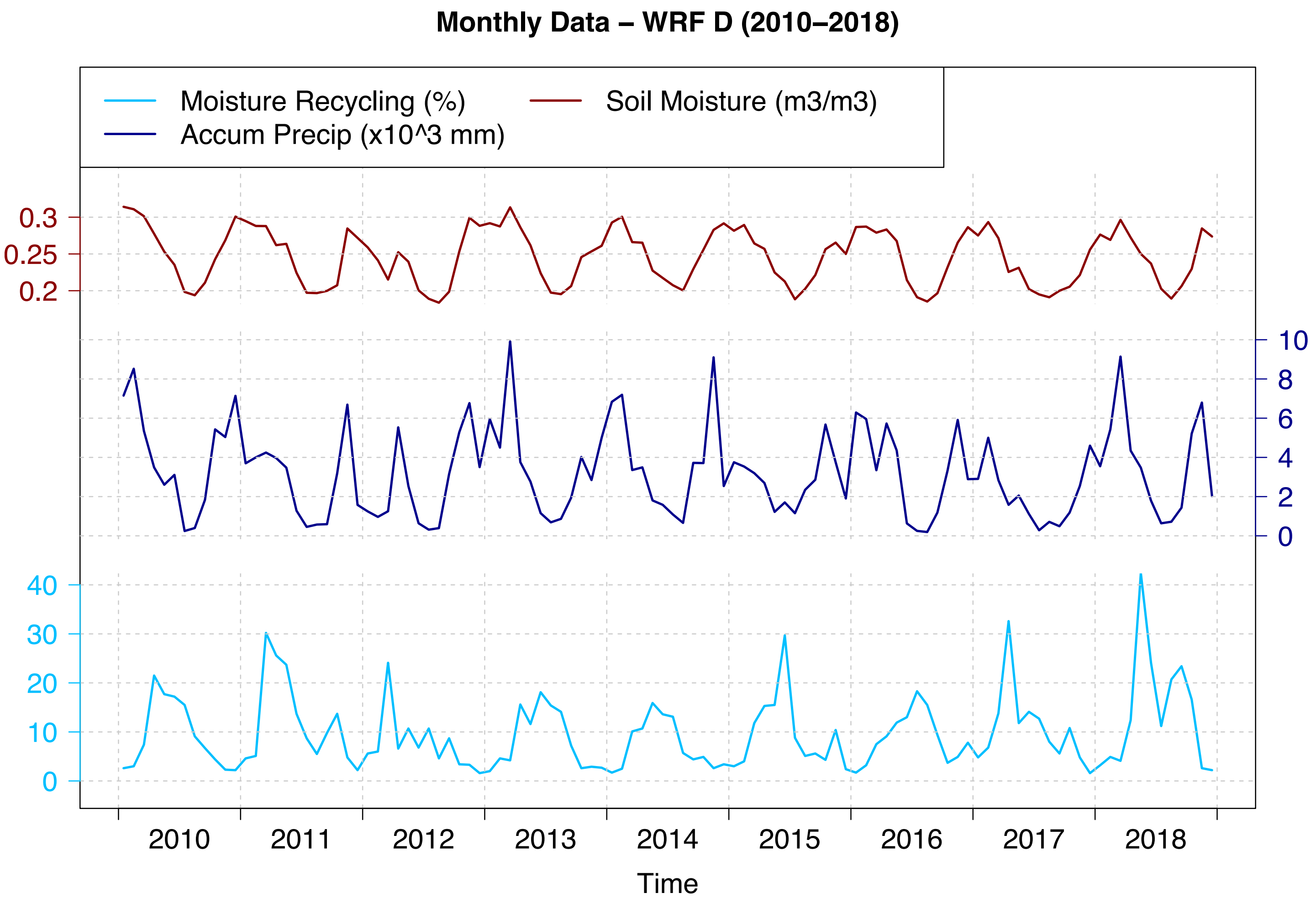

But how is Precip related to Moisture Recycling and Soil Moisture?

→ Cross-Correlation Function (CCF) based analysis.

RESULTS CCF Analysis

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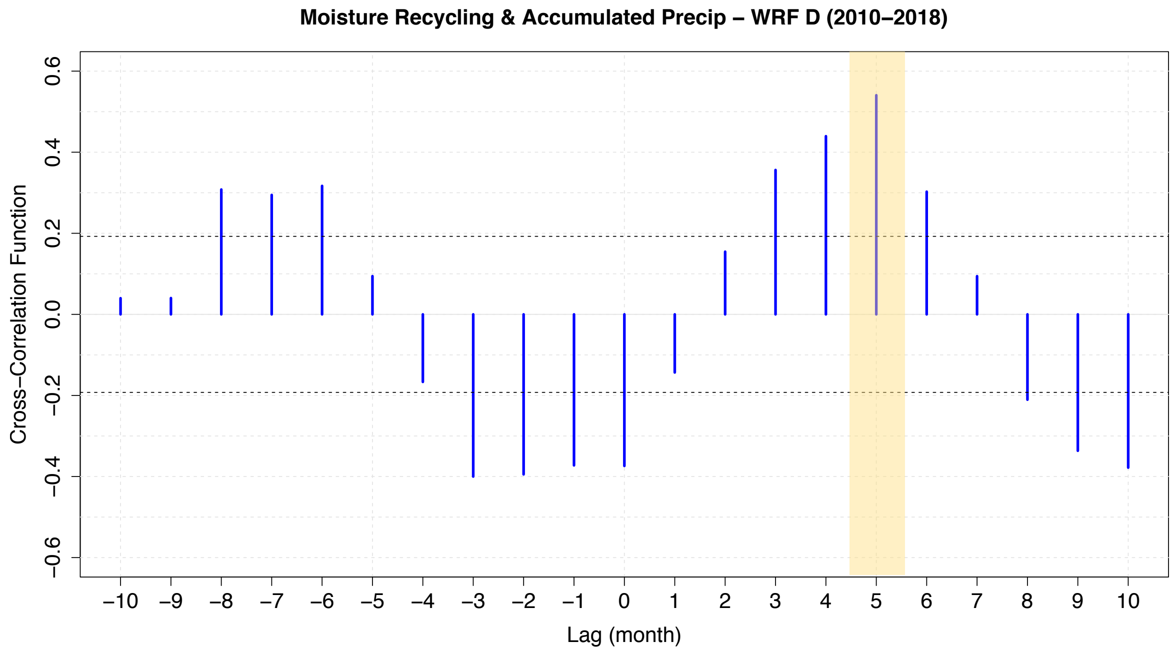

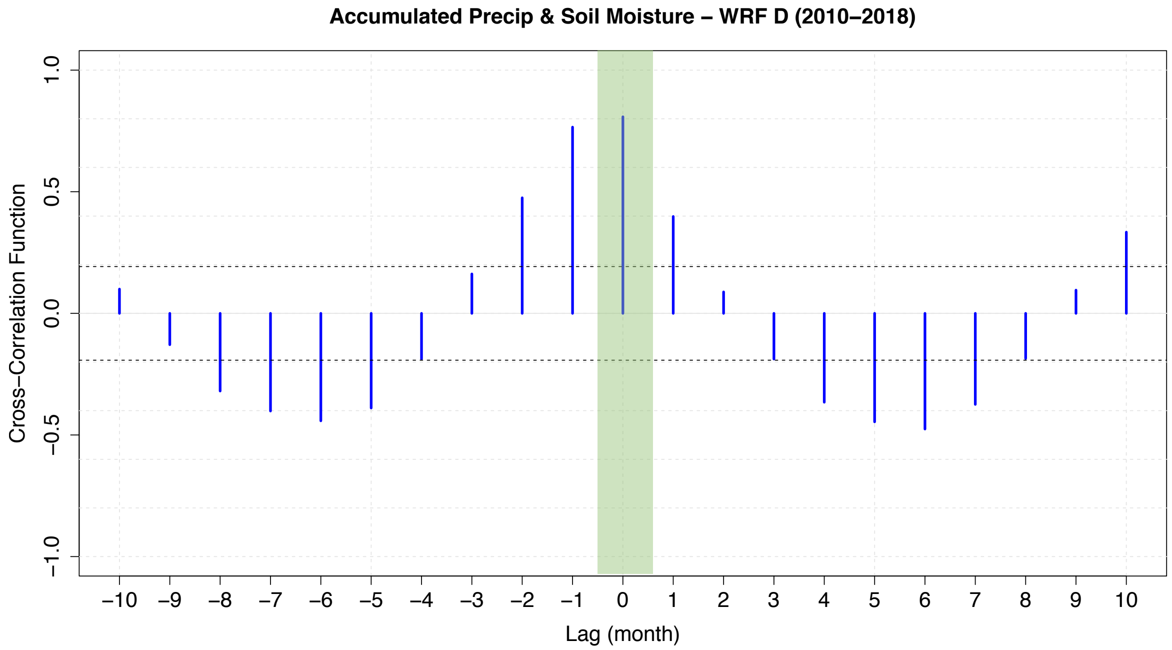

- Recycling achieves high values 5 months later than the maximum of precipitation over the IP.

- The lag corresponding to the highest value is at 0 months. Soil Moisture and Precip are synchronized.

CONCLUSIONS

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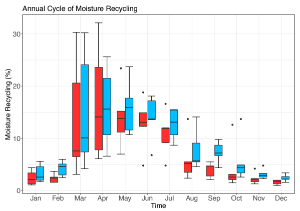
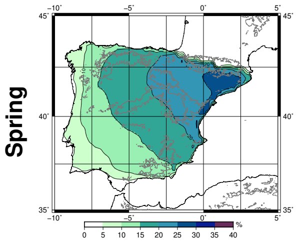
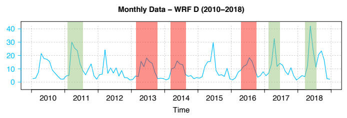


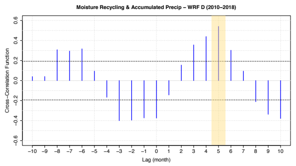
Two different regimes over the IP: Lowest values from Nov. to Feb. (~ 3%); Highest values in spring and summer (~ 16%).



In winter, the recycling is confined to the SE corner of the IP. In spring, higher values towards the Mediterranean coast. Remarkable differences in summer due to differences in soil moisture content. Autumn is a transition season.



High heterogeneity of Moisture Recycling values during 2010-2018 in DA experiment. Some years strong peaks during spring, others with the absence of it.



Precipitation and Soil moisture are synchronized, but the delay between Precipitation and Moisture Recycling over the IP is five months.

FURTHER INFORMATION

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Paper already published in Atmosphere:

Open Access Article

Moisture Recycling over the Iberian Peninsula: The Impact of 3DVAR Data Assimilation

by Santos J. González-Rojí [1,2,*], Jon Sáenz [3,4], Javier Díaz de Argandoña [5] and Gabriel Ibarra-Berastegi [4,6]

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Cited Literature:

- González-Rojí et. al, 2018: Moisture balance over the Iberian Peninsula according to a regional climate model: The impact of 3DVAR data assimilation. *Journal of Geophysical Research: Atmospheres*, 123, 708– 729. https://doi.org/10.1002/2017JD027511
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