# Impacts of ocean-atmospheric oscillations on Mediterranean hydrology

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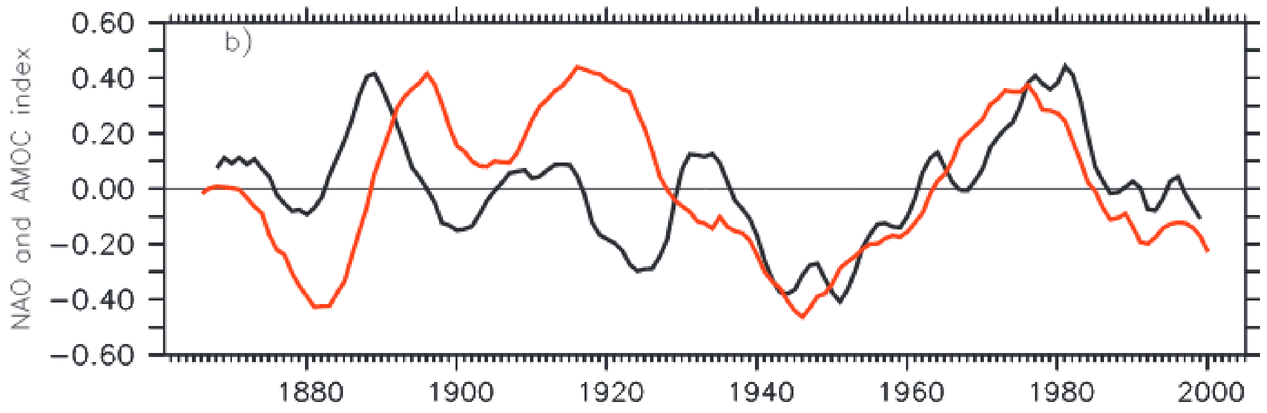
Picture: © NASA Visible Earth

# Atlantic Meridional Overturning Circulation (*AMOC*)

- Global warming is expected to weaken the *AMOC* due to melting of Greenland ice cap [*Cheng et al., 2013*; *Rahmstorf et al., 2015*]
- A slowing down of the *AMOC* would alter the **course** and **amplitude** of the Gulfstream and, hence, the path of Atlantic storm tracks [*Joyce and Zhang, 2010*]

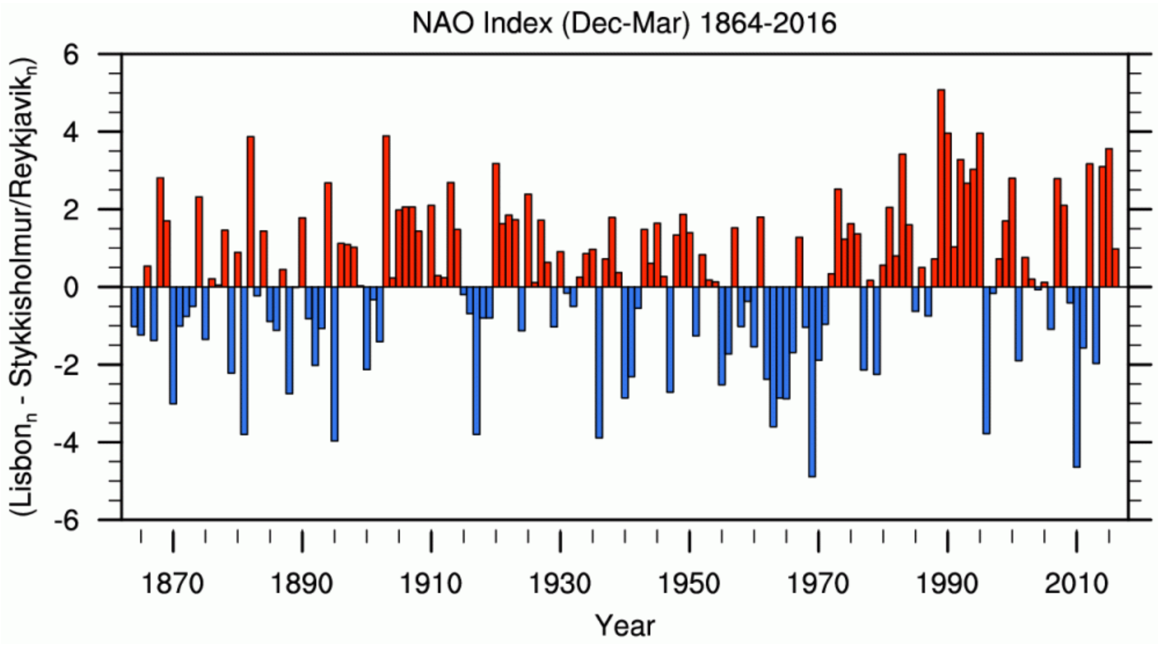



**red**: *NAO*, **black**: *AMOC*


*[Cheng et al., 2013]*

Example: **N**orth **A**tlantic **O**scillation

- *NAO* index is based on the difference of normalized sea level pressure (*SLP*) between Lisbon, Portugal and Stykkisholmur/Reykjavik, Iceland

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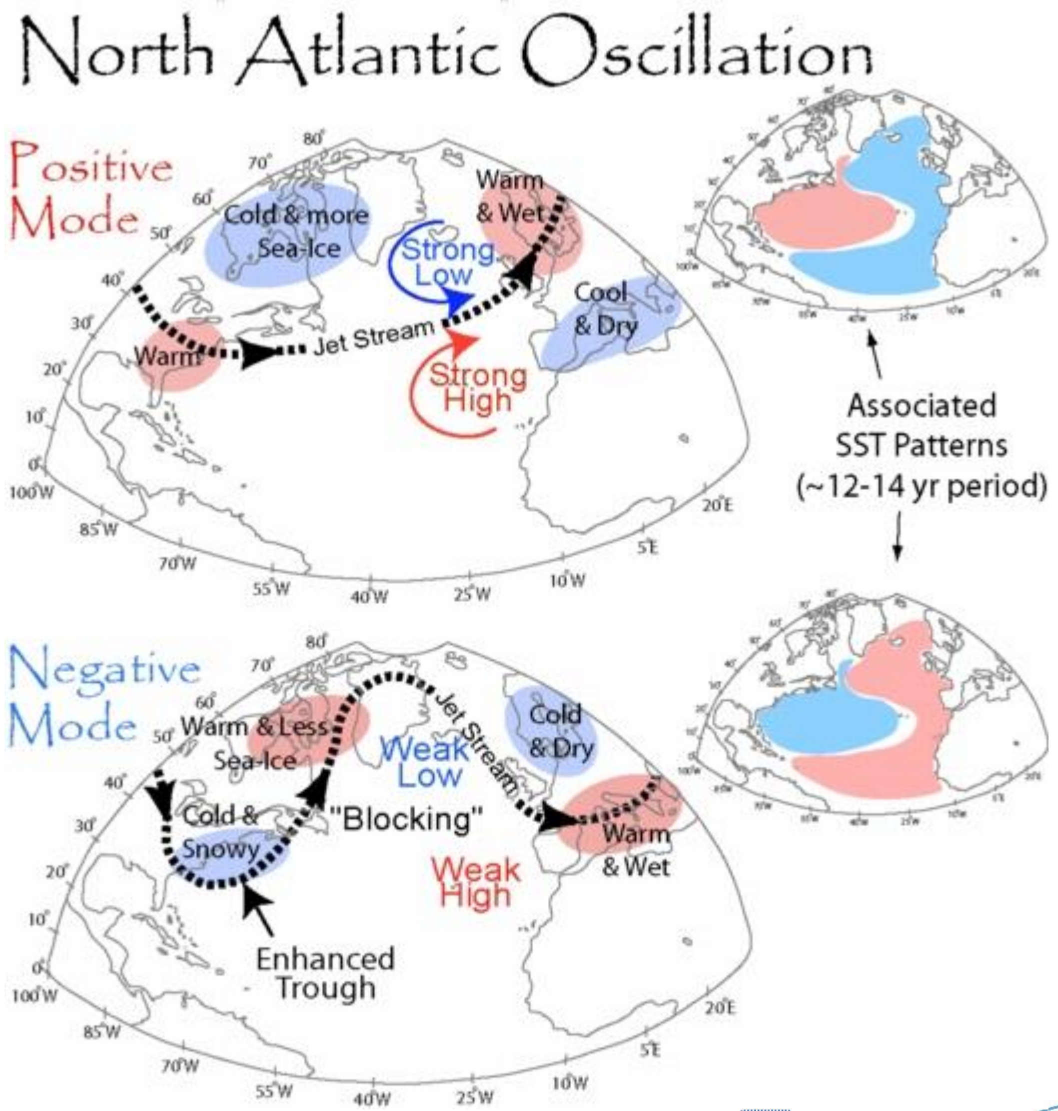
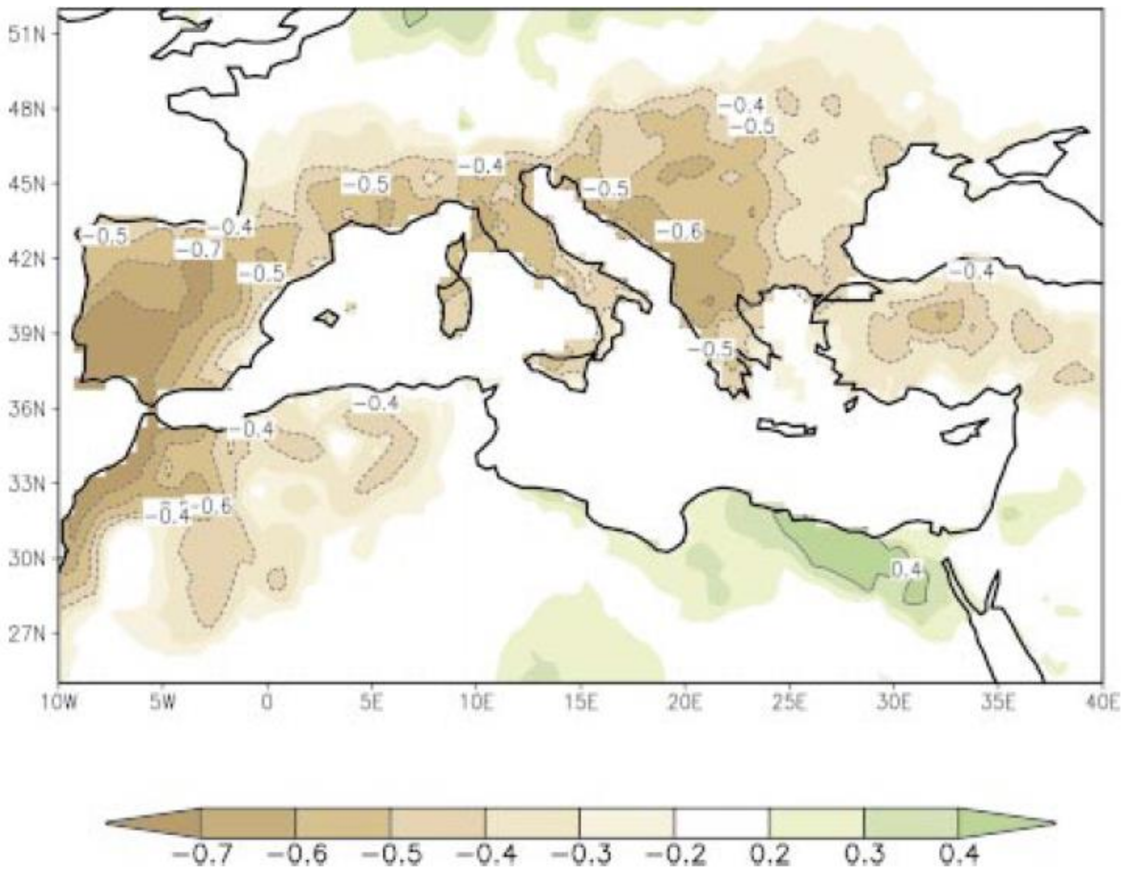
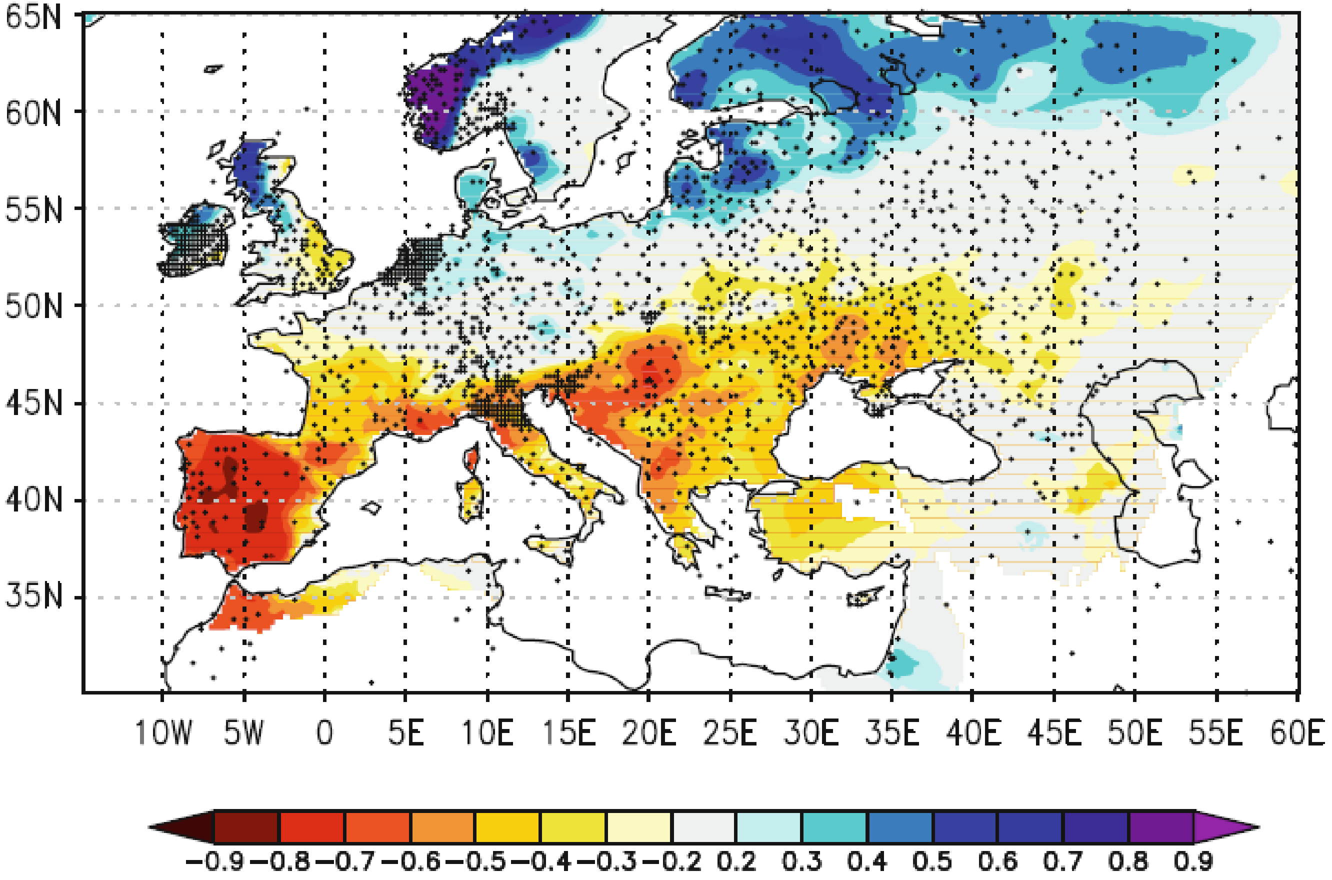



www.newx-forecasts.com

# Previous studies




correlation between *CRU* precipitation and *NAO* for the winter season (1949-1996)

correlation between the winter *NAO* index and precipitation (1950-2010)

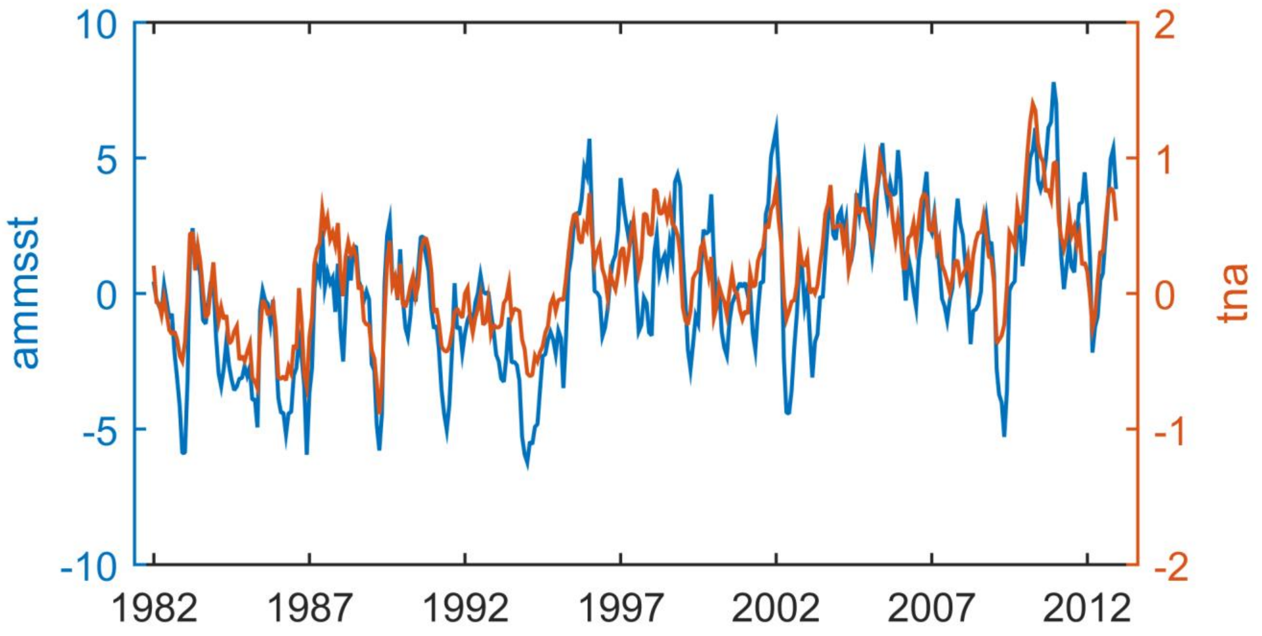
[Mariotti et al., 2001]

[Bladé et al., 2011]

# Our studies

**aim:**

- determine impact of multiple climate modes
- is there a significant impact on precipitation?
- disentangle the impact of individual climate modes
- consider possible time lags




**challenges:**

- uncertainties in the observations
- co-varying behaviour of multiple oscillations

**approach:**

- optimised precipitation dataset
- supervised learning:
  **L**east **A**bsolute **S**hrinkage and **S**election **O**perator (**LASSO**)

# Method





- LASSO regression

$$\hat{\beta} = argmin\left\{\sum_{i=1}^{n}\left(y_i - \beta_0 - \sum_{j=1}^{p}\beta_j x_{ij}\right)^2 + \alpha\sum_{j=1}^{p}\left|\beta_j\right|\right\}$$

$\hat{\beta}$… p-dimensional vector with the estimated regression coefficients

$n$ … number of training samples in the dataset

$y_i$ … value of the target variable in sample i

$p$ … number of features

$x_{ij}$ … value of feature j in sample i

$\alpha\sum_{j=1}^{p}\left|\beta_j\right|$… regularization → minimize the sum of the absolute values of the coefficients

→ α controls the amount of regularization

→ regularization prevents overfitting by restricting the model, typically to reduce its complexity

- nested 5-fold cross validation (CV)
  - 5-fold CV for determination of α
  - 5-fold CV for calculation of **R²** (= coefficient of determination)

$$\boldsymbol{R}^2 = \left(\frac{\sum(y-\bar{y})(y_{pred}-\bar{y}_{pred})}{\sqrt{\sum(y-\bar{y})^2 (y_{pred}-\bar{y}_{pred})^2}}\right)^2$$ = squared correlation between $y$ and $y_{pred}$

$y$ … target value

$y_{pred}$ … prediction of target value

$\bar{y}$ … mean vector of $y$ , $\bar{y}_{pred}$ … mean vector of $y_{pred}$

- significance test

# Target variable: Precipitation

**Victor Pellet**
Tue, 10 Apr
08:44 - 08:46
PICO spot A

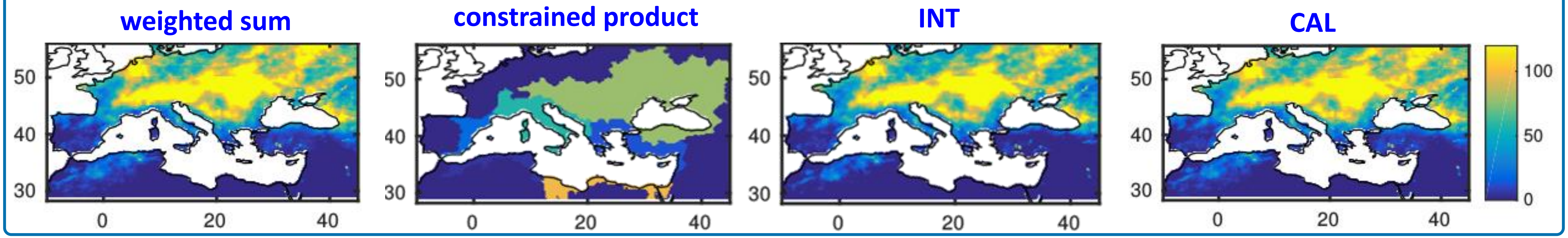
**multiple satellite product**

- weighted sum of various precipitation datasets
- constrained product → closes the water budget at sub-basin scale
- INTegration estimate (limited temporal extend: 2004-2009)
- CALibration estimate (long temporal coverage: 1980-2012)

temporal resolution: **monthly**
spatial resolution: **0.25°**

**advantages:**

- minimizes uncertainties
- consistent → better solves the water budget
- long time coverage



# Predictors

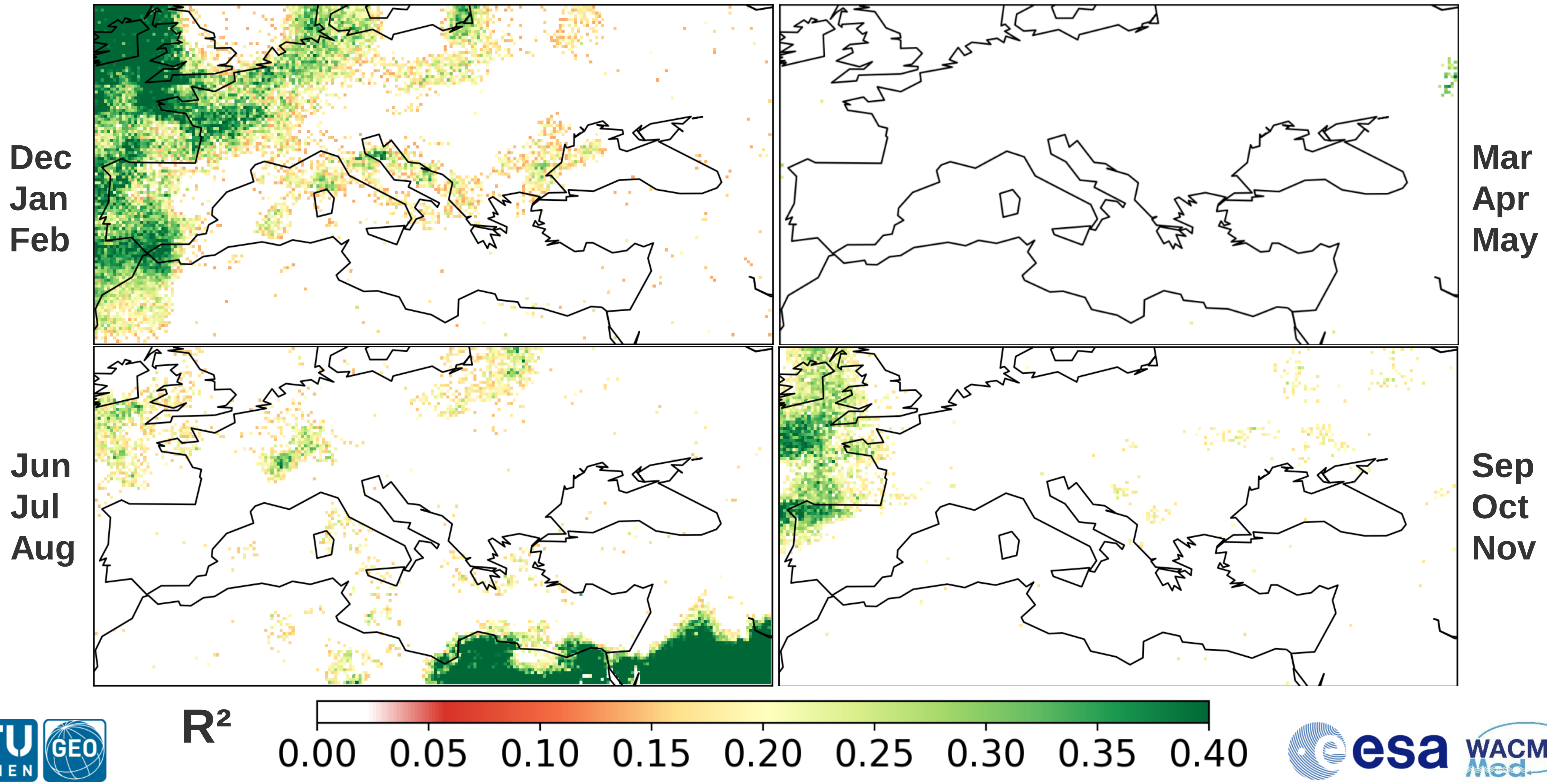
temporal resolution:
**monthly**


**102 features**

| CLIMATE OSCILLATION INDICES |
|---|
| Atlantic Meridional Mode (**AMMSST**) |
| Atlantic Multidecadal Oscillation (**AMO**) |
| Dipole Mode Index (**DMI**) |
| East Atlantic (**EA**) |
| East Atlantic / Western Russia (**EAWR**) |
| East Pacific-North Pacific (**EPNP**) |
| Northern Annular Mode (**NAM**) |
| North Atlantic Oscillation (**NAO**) |
| Pacific Decadal Oscillation (**PDO**) |
| Polar / Eurasia (**PEA**) |
| Pacific / North American Index (**PNA**) |
| Southern Annular Mode (**SAM**) |
| Scandinavia (**SCAND**) |
| Southern Oscillation Index (**SOI**) |
| Tropical Northern Atlantic (**TNA**) |
| Tropical Southern Atlantic (**TSA**) |
| Western Pacific (**WP**) |

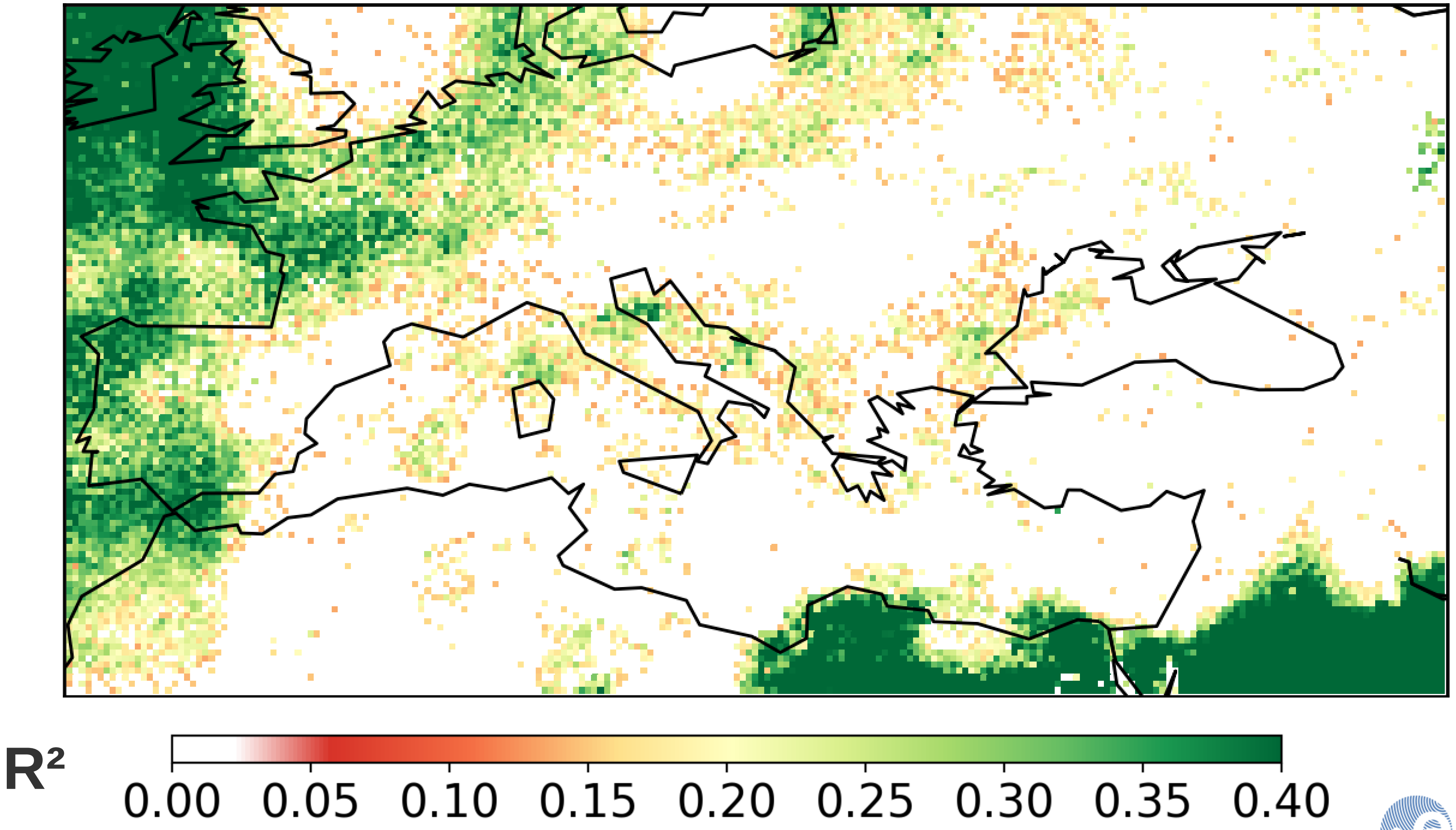
# Precipitation
## (1982-01 – 2012-12)





# Precipitation
## (1982-01 – 2012-12)

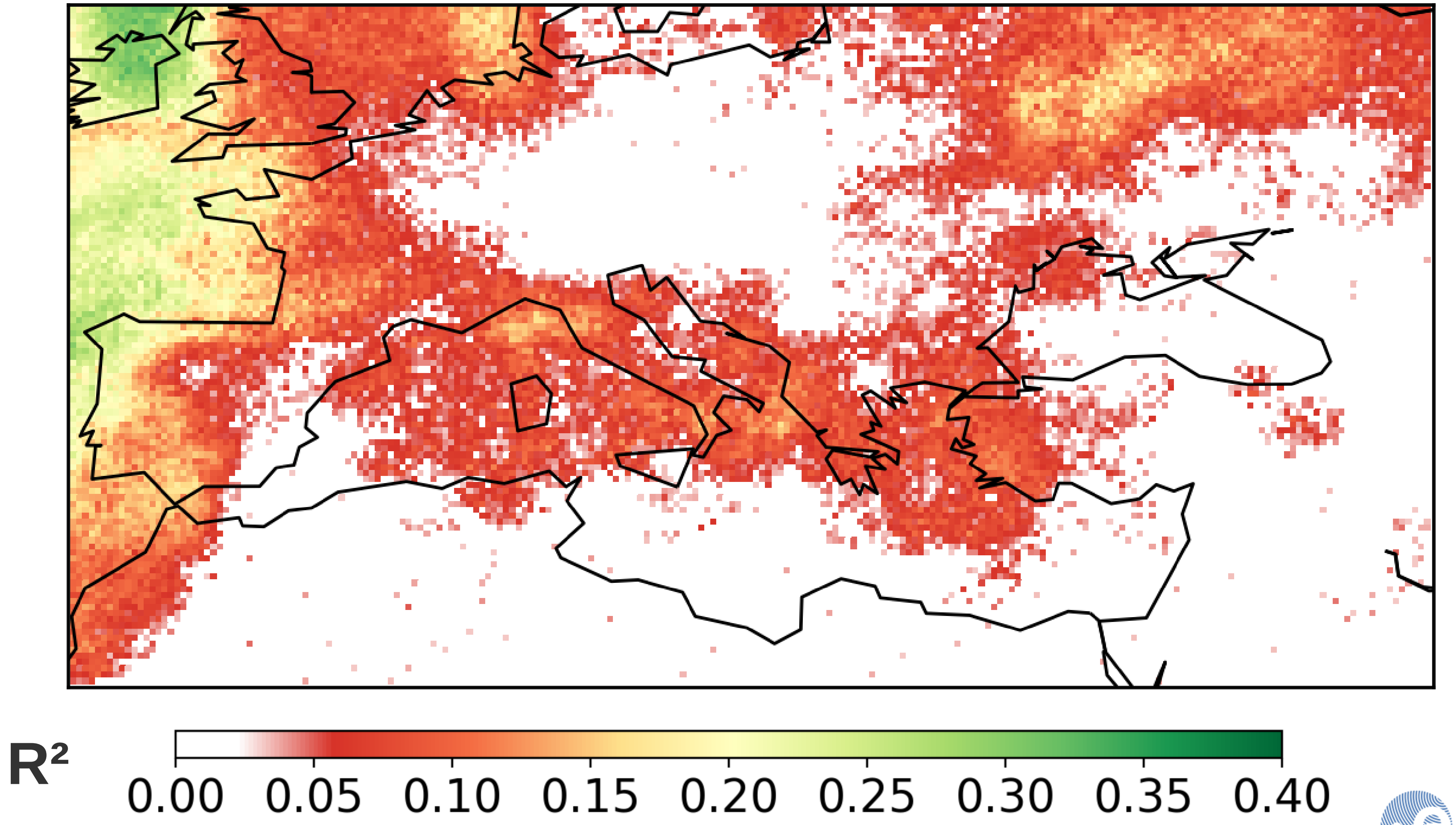
merged seasonal models



# Precipitation
# (1982-01 – 2012-12)



## entire time period



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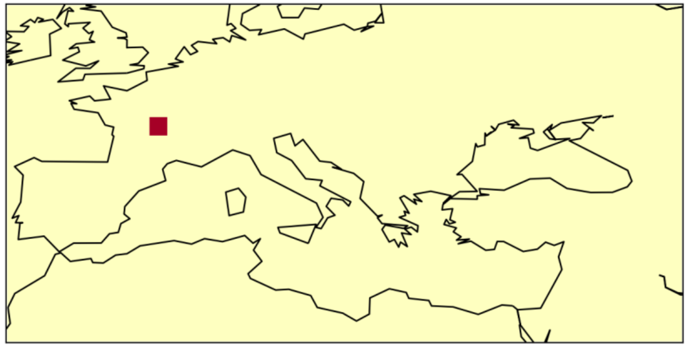
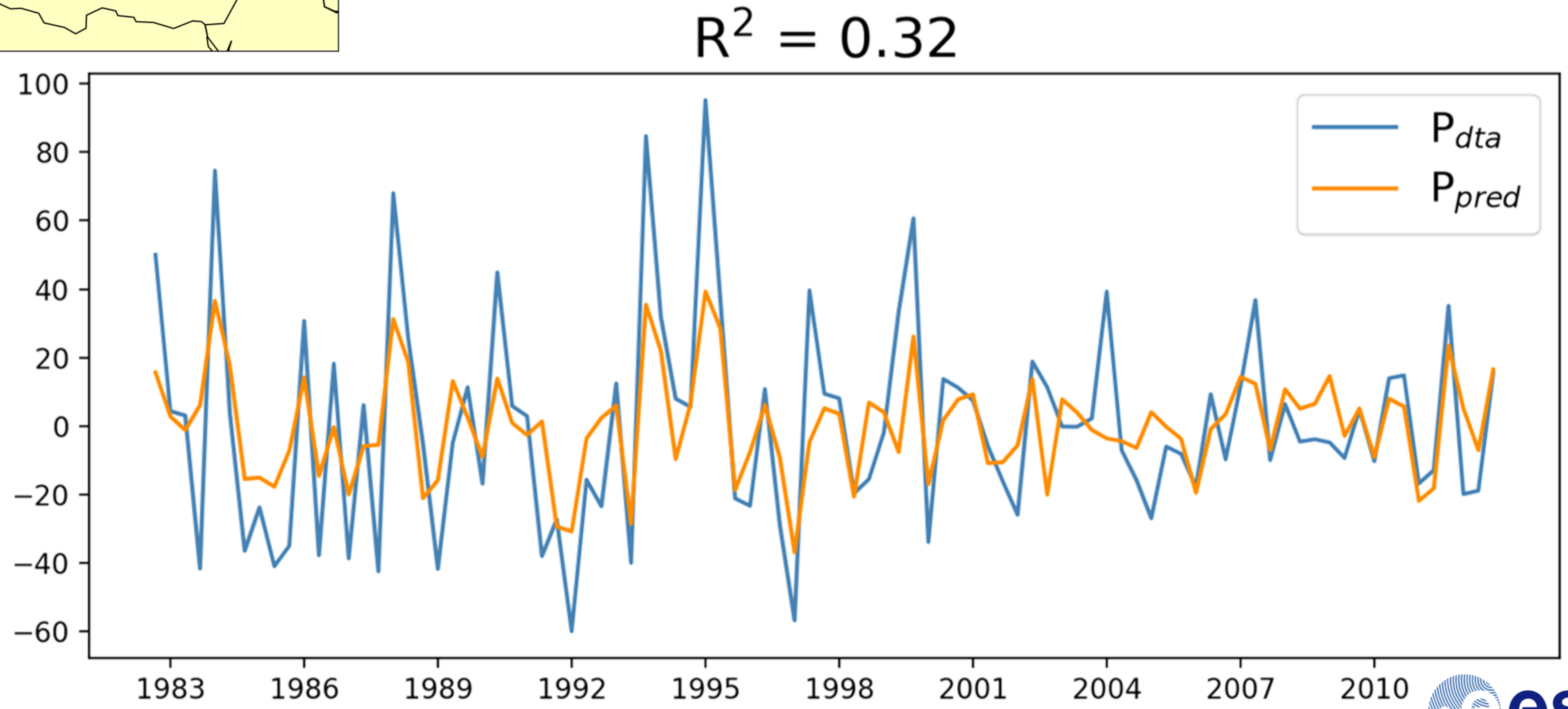
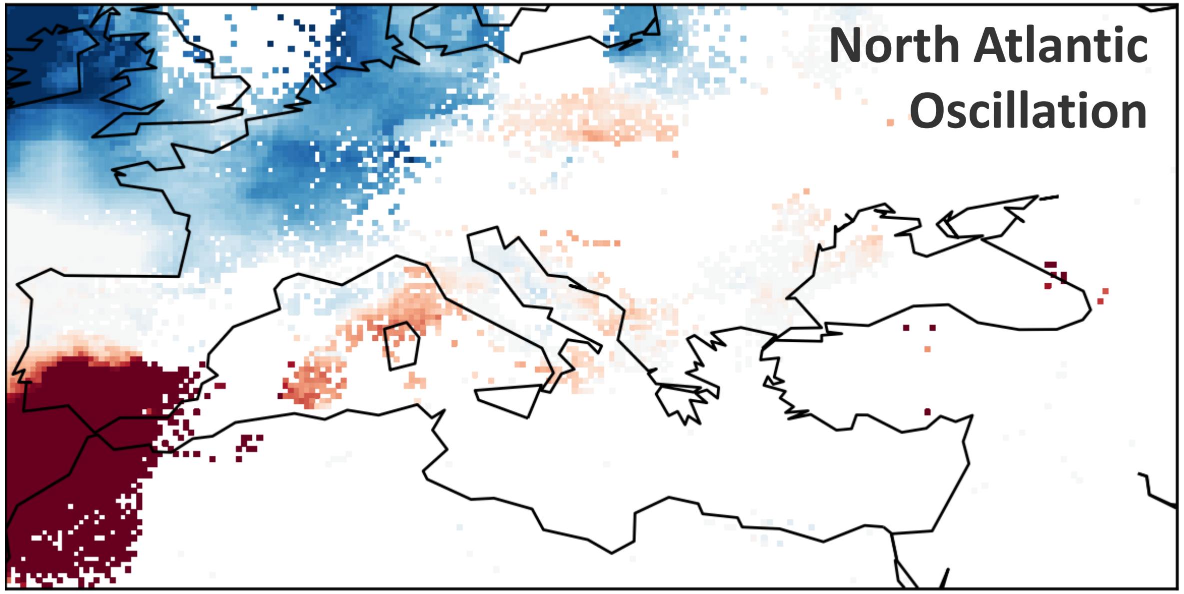
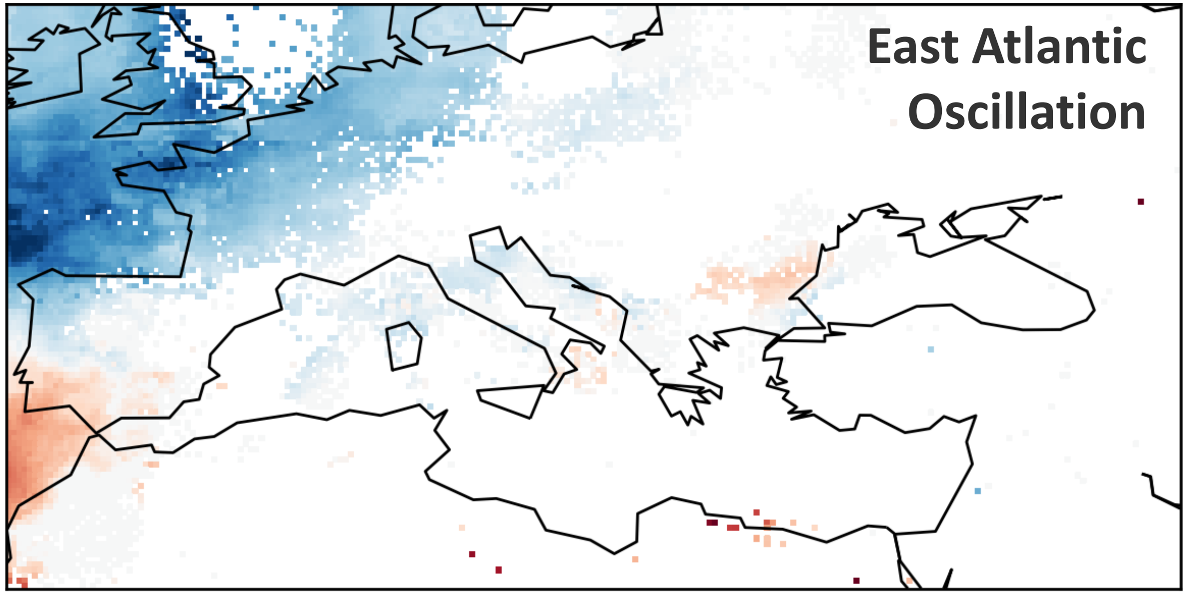
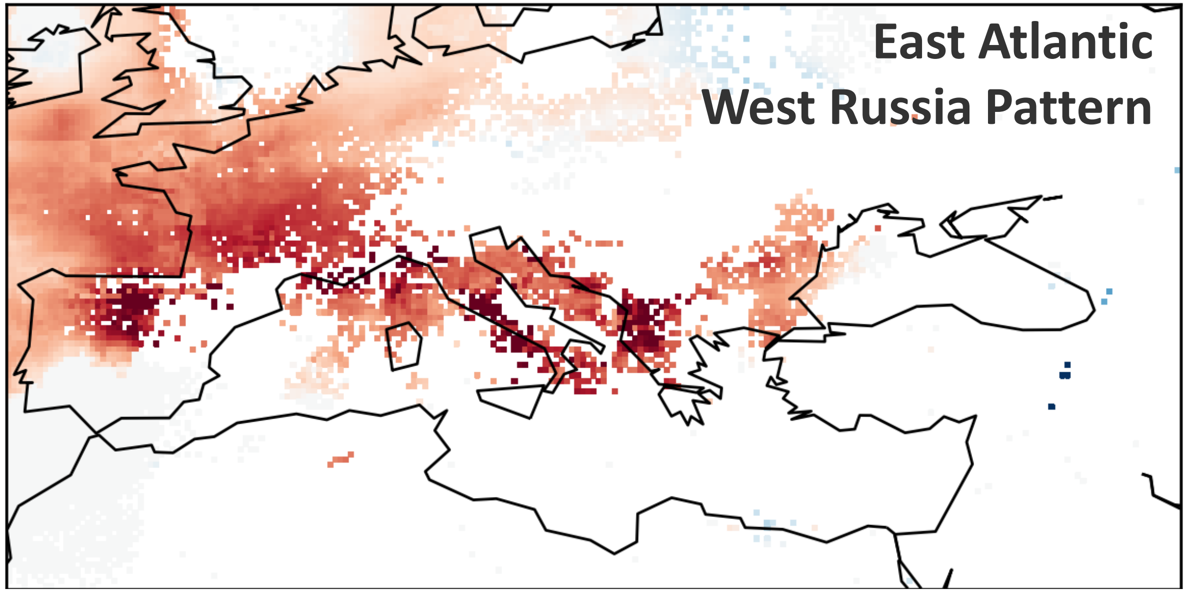


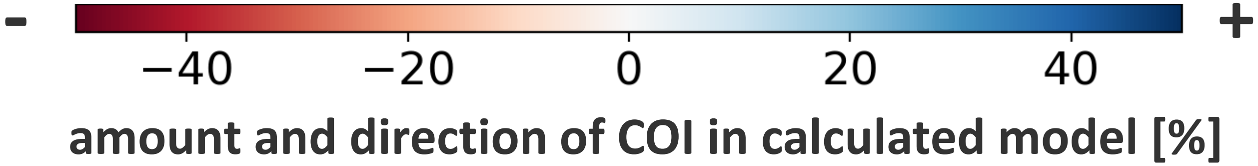


# coefficients – seasonal Dec-Jan-Feb



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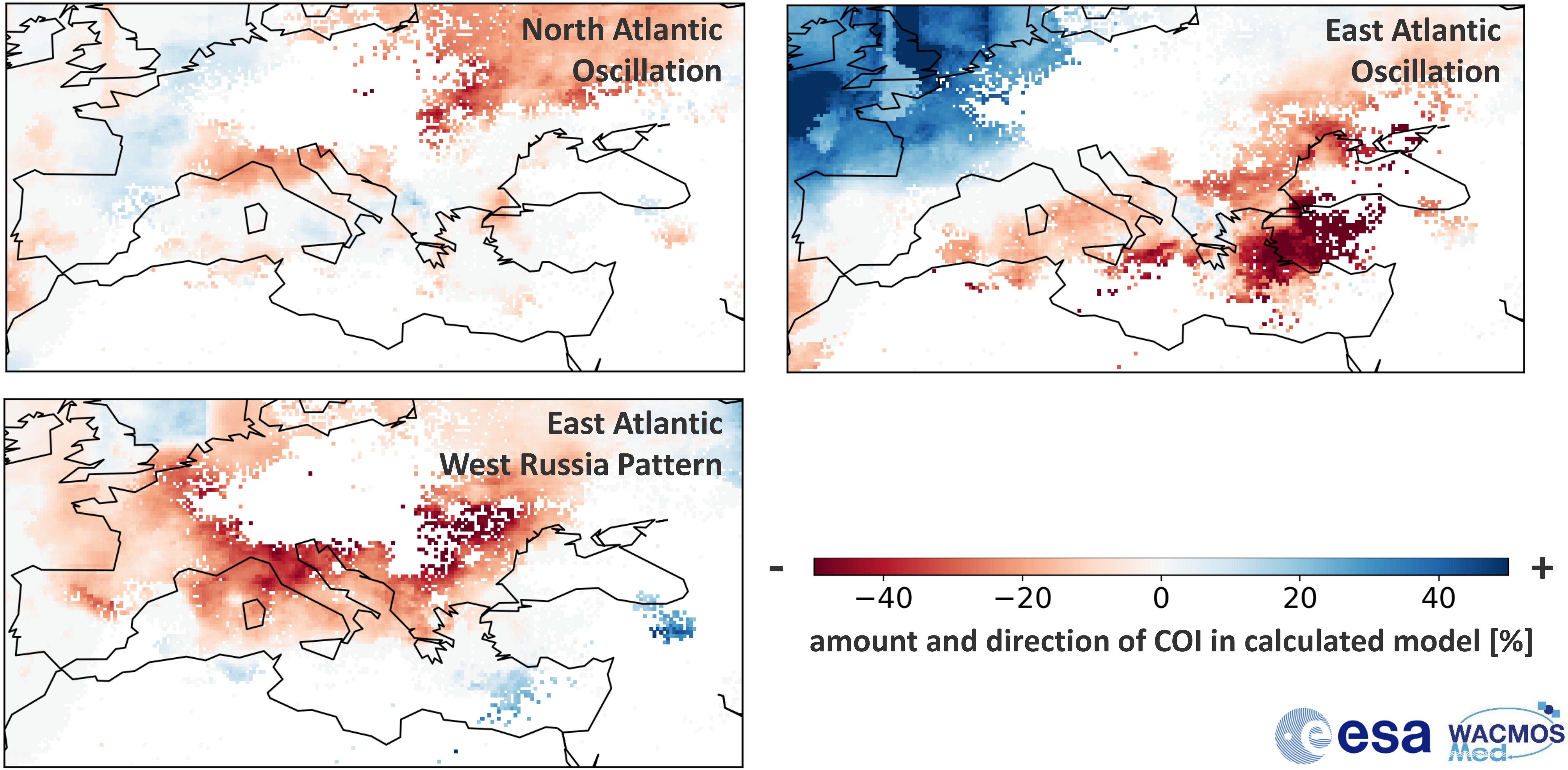
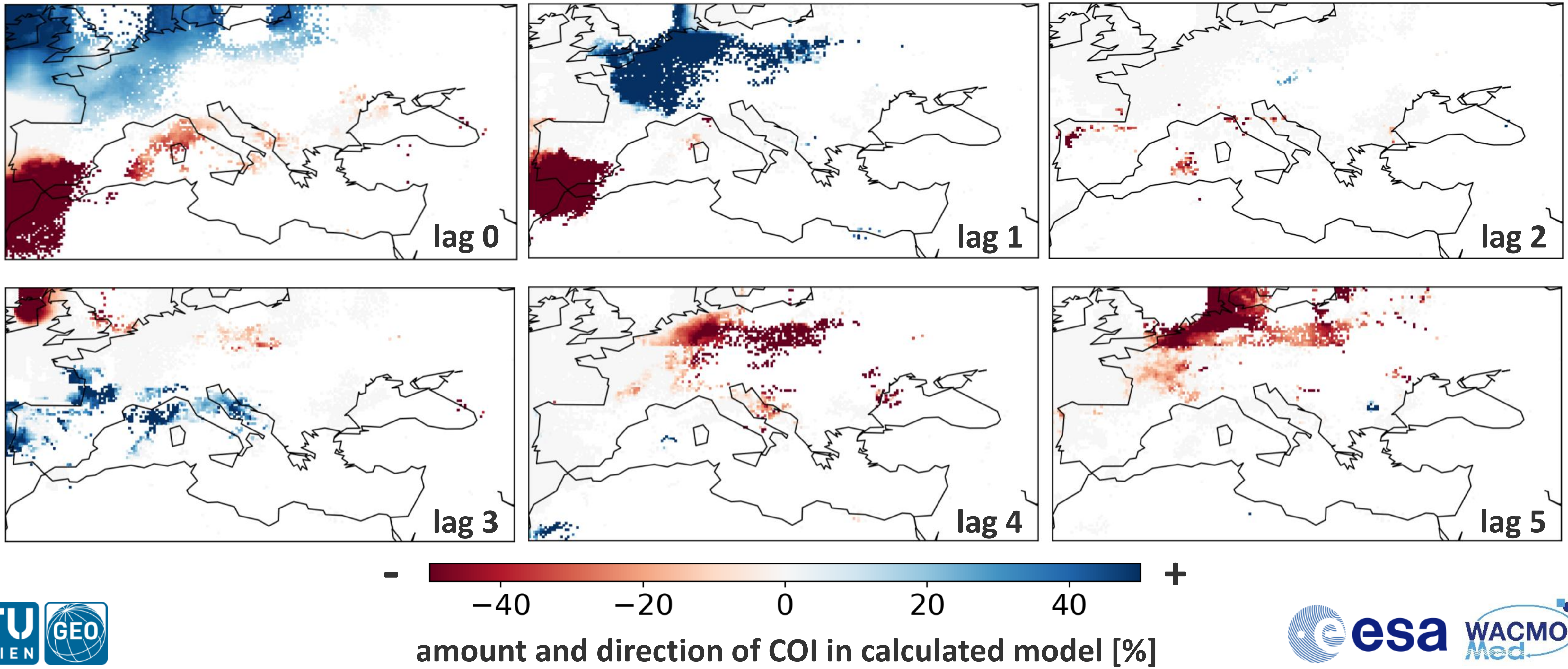


# Precipitation
## North Atlantic Oscillation lag 0 - 5

- coefficients for NAO with monthly time lags



# Thank you for your attention!



**Conclusion:**

- Our results show that climate modes have a significant impact on precipitation
- LASSO Regression can be used to disentangle the impact of multiple, potentially correlated COIs
- Strongest signal from:
  - North Atlantic Oscillation
  - East Atlantic Oscillation
  - East Atlantic West Russia Pattern

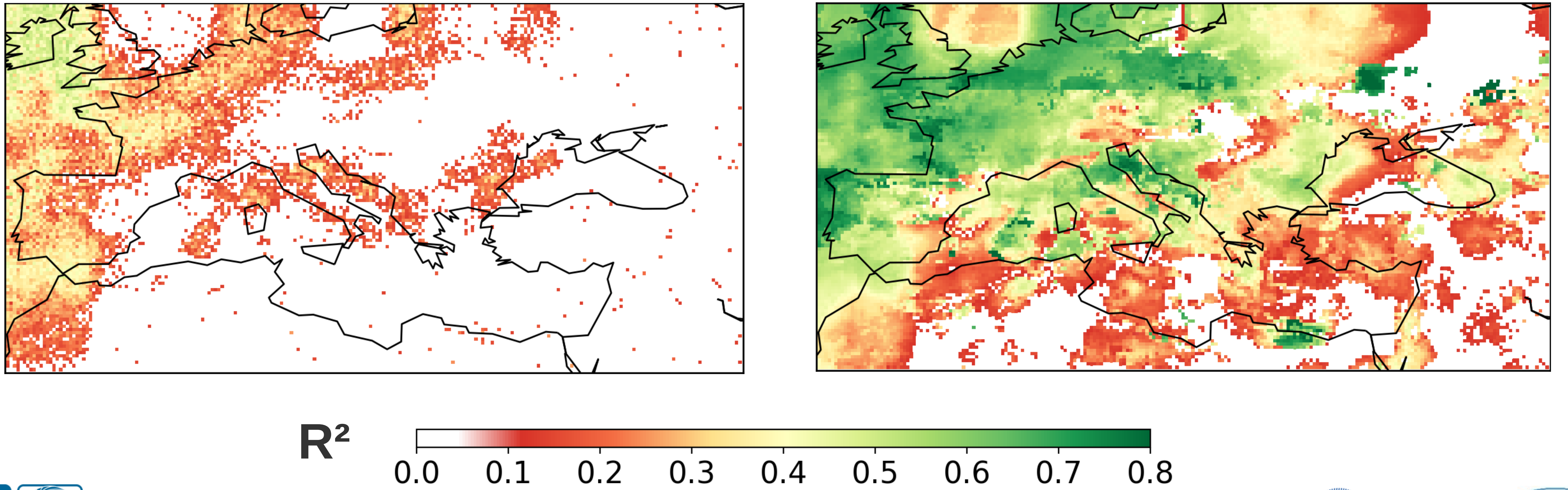
**Outlook:**

- Impact on other target datasets like Evapo(transpi)ration, Water Storage …
- Improve our understanding of impact from climate change on Mediterranean basin

# Precipitation (1982-01 – 2012-12) – seasonal Dec-Jan-Feb
## with and without nested 5-fold cross validation

- $R^2$ <u>without</u> nested 5-fold cross validation
  - better because entire dataset is used for prediction (100%) and not only 80%

**nested 5-fold CV ($R^2$, α)** **5-fold CV (α)**



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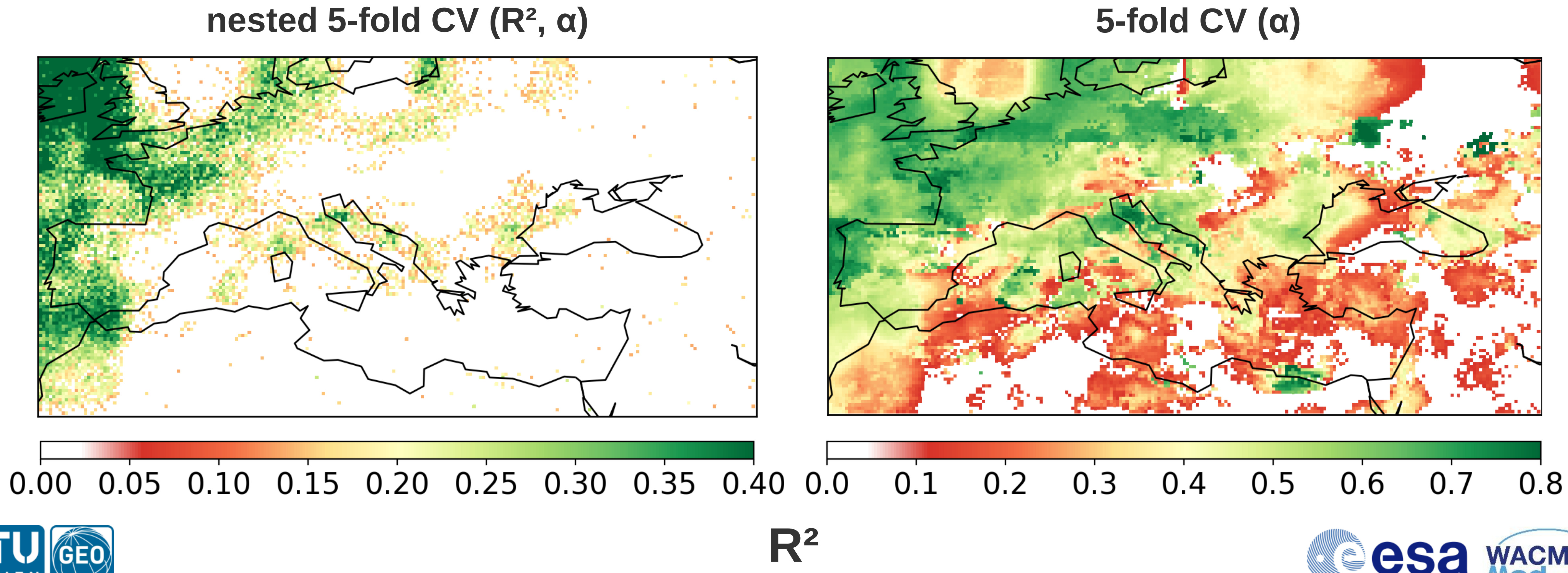

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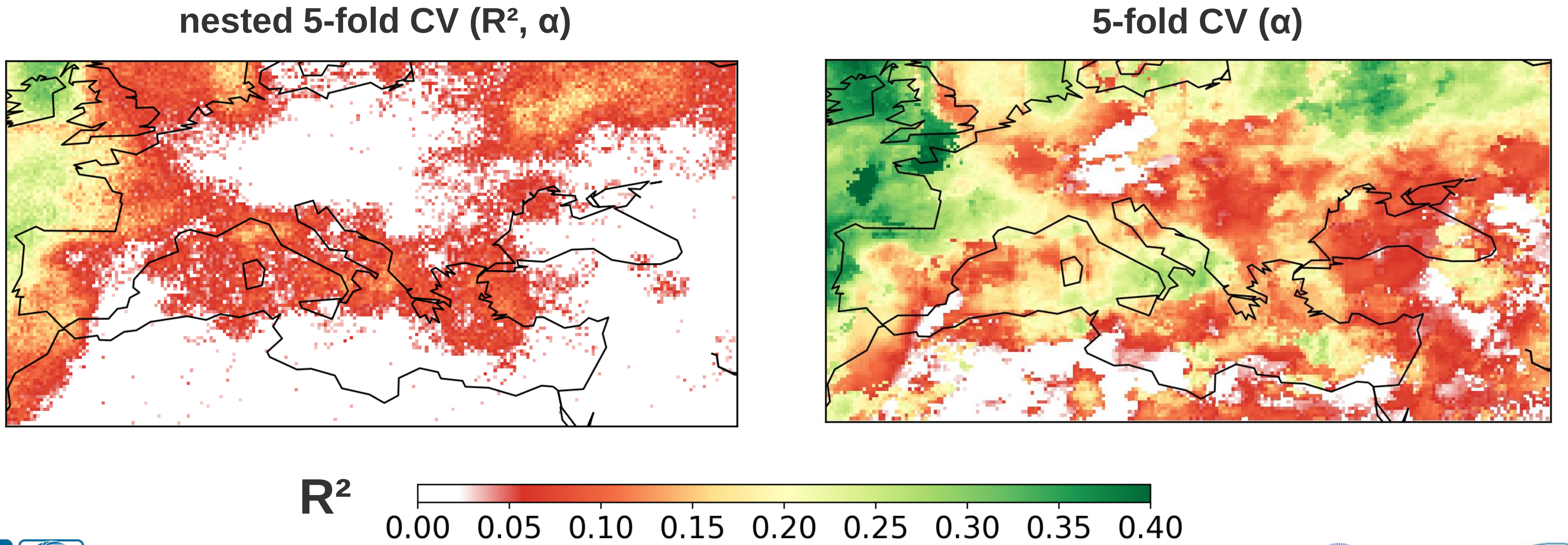

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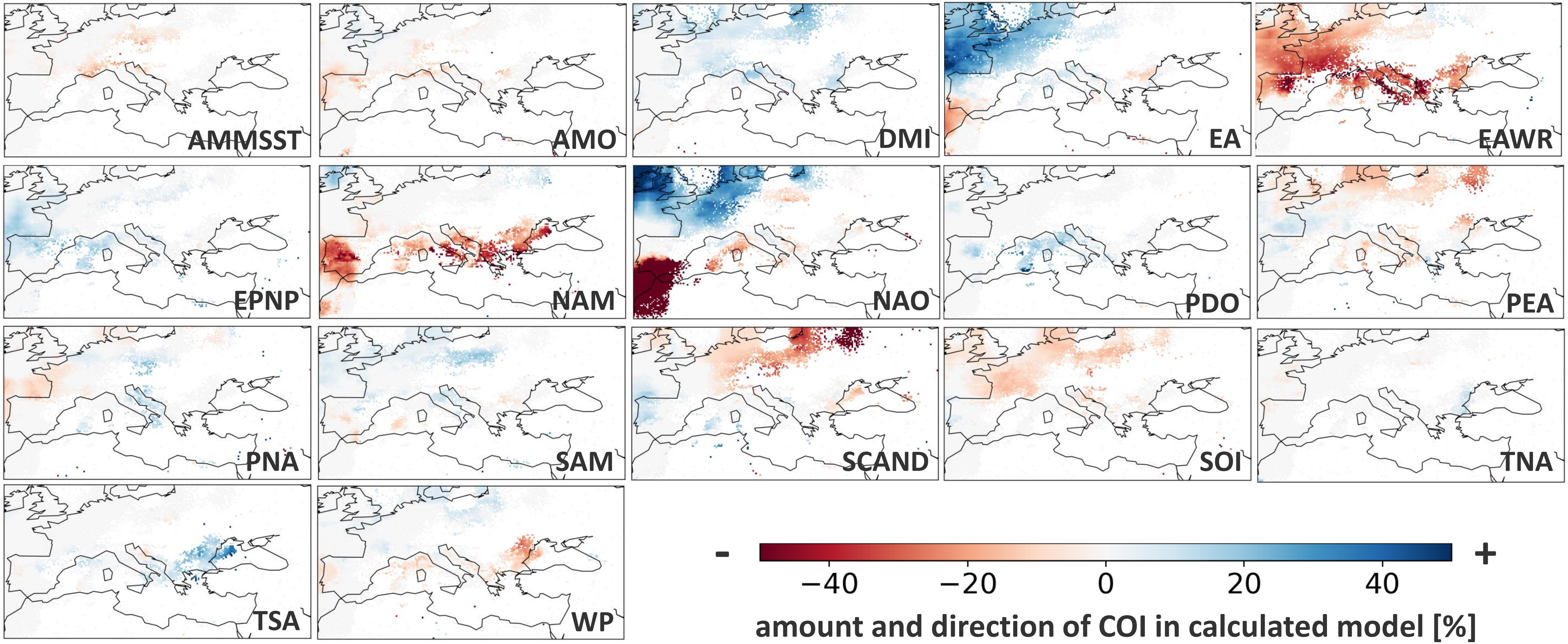

# coefficients – entire time period