MEDiterranean Services Chain based On climate PrEdictions

Dynamical proxies, bias correction, and statistical downscaling as tools for seasonal forecast

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The MEDSCOPE Project

… will serve as a **community builder** for future **climate service** activities based on climate predictions in the **Mediterranean**, contributing to the building of a common and shared knowledge.

WP3: Forecast Calibration, Verification, and Information Synthesis

… will develop and release **advanced tools** to improve the extraction of relevant information from climate prediction systems and assess their robustness and uncertainty.

Copernicus Climate Change Service (C3S)

Seasonal Forecast

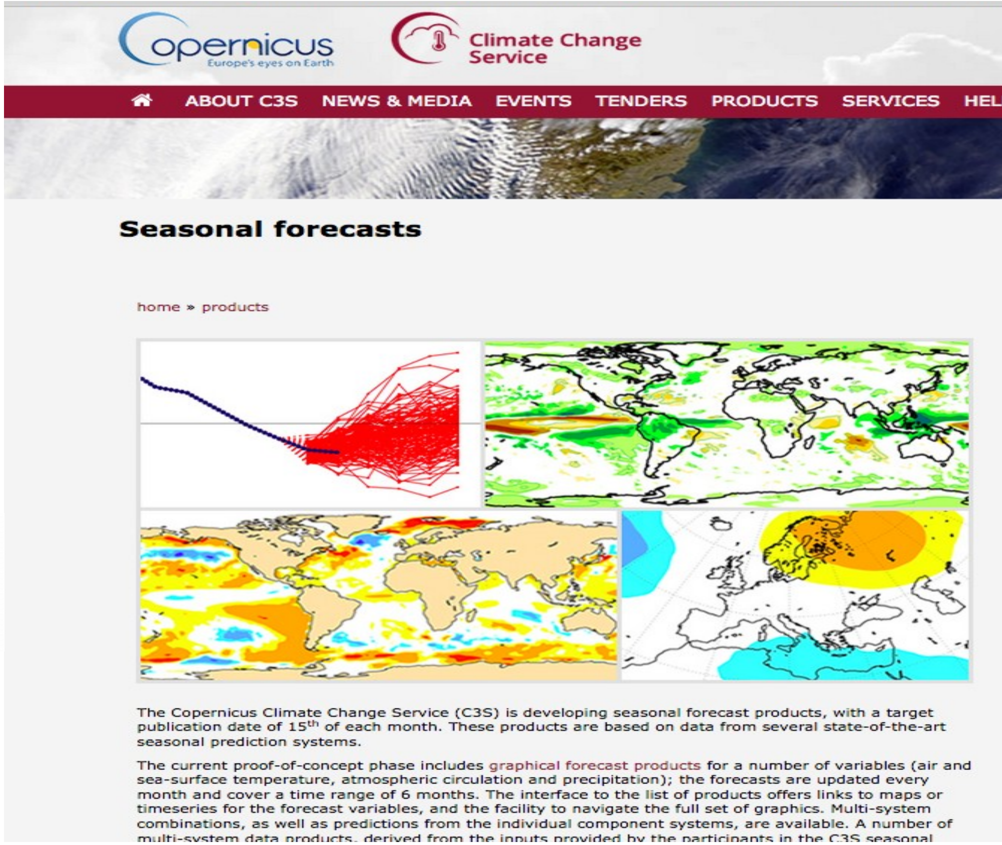
MEDSCOPE mainly focuses on the **seasonal timescale** **using forecasts already available in C3S**. Exploring also the potential of predictions at longer time–scales (multiannual).

Copernicus — Europe's eyes on Earth

Climate Change Service

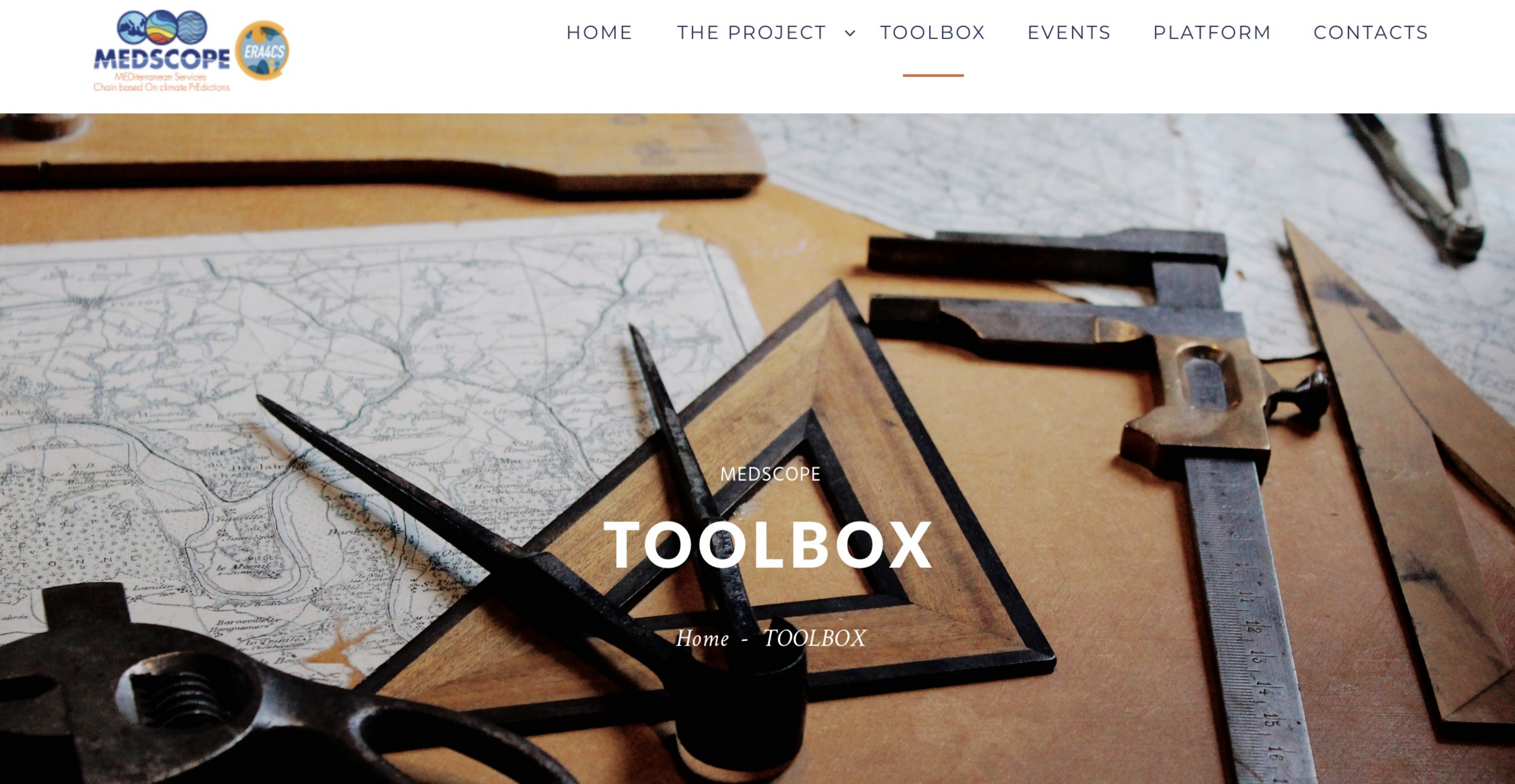
cmcc — Centro Euro-Mediterraneo sui Cambiamenti Climatici

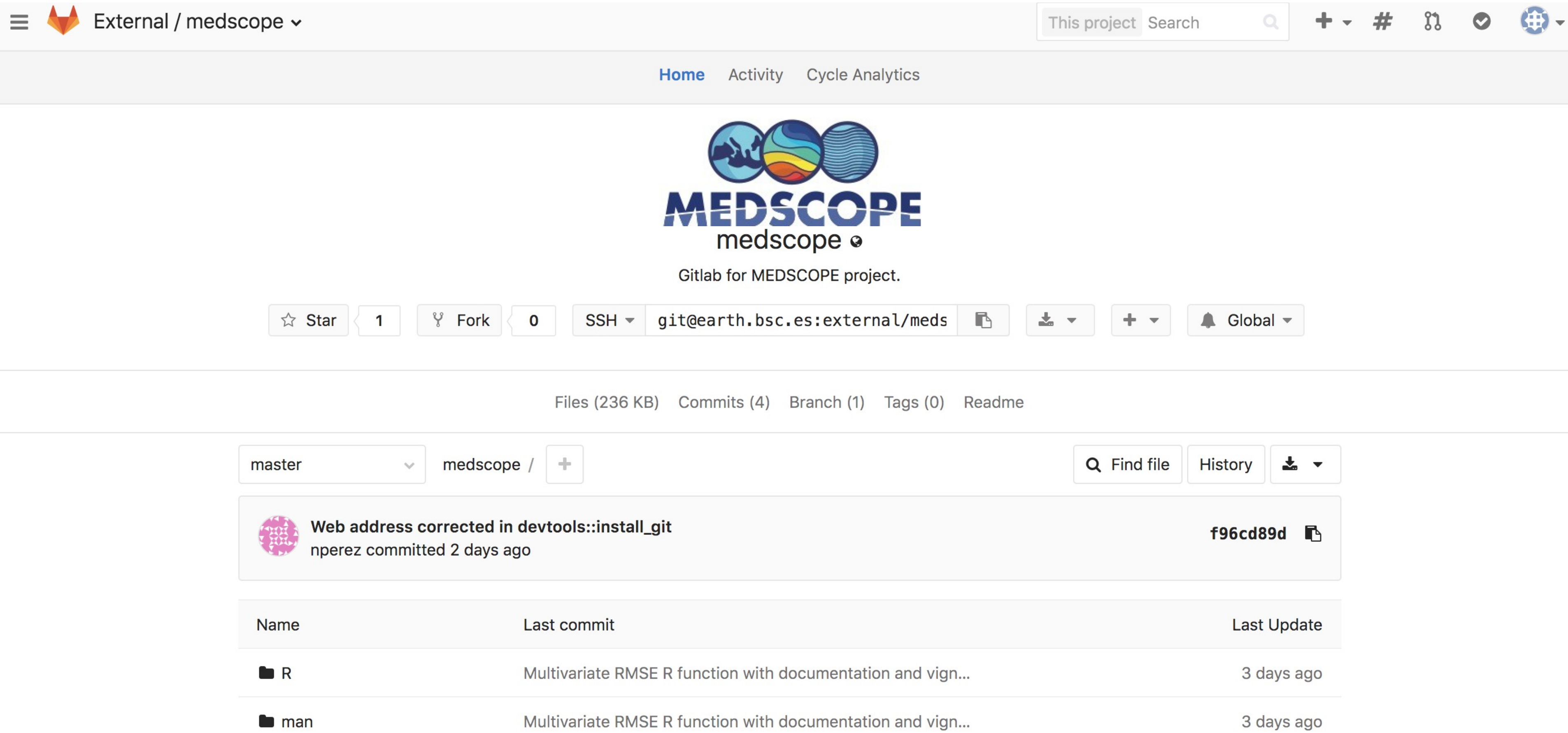
METEO FRANCE | Met Office | DWD | ECMWF — European Centre for Medium Range Weather Forecasts



Toolbox

- Developing methodologies to extract usable information from predictions. We will produce tools for prediction **verification, calibration, downscaling, ensemble member combination and selection** that will be publicly released via a **toolbox** and shared among partners and users.

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Toolbox

1) Bias correction and forecast calibration:

- Analogs using weather regimes
- ADAMONT: multivariate bias correction
- Forecast assimilation method for calibrating
- Dynamical based-bias correction

2) Statistical/stochastic downscaling

- Rainfarm: complex orography
- ADAMONT: multivariate downscaling
- Analogs
- SMOP: Mountaineus regions

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3) Advanced multivariable forecast scores:

- Multivariate RMSE
- s2d verification
- Indices multivariable EOFS

4) Forecast system combination and selection of sub-ensembles for applications

- ensemble calibration with selection and weighting
- weighting ensembles according NAO
- clustering techniques. EOFS and K-means

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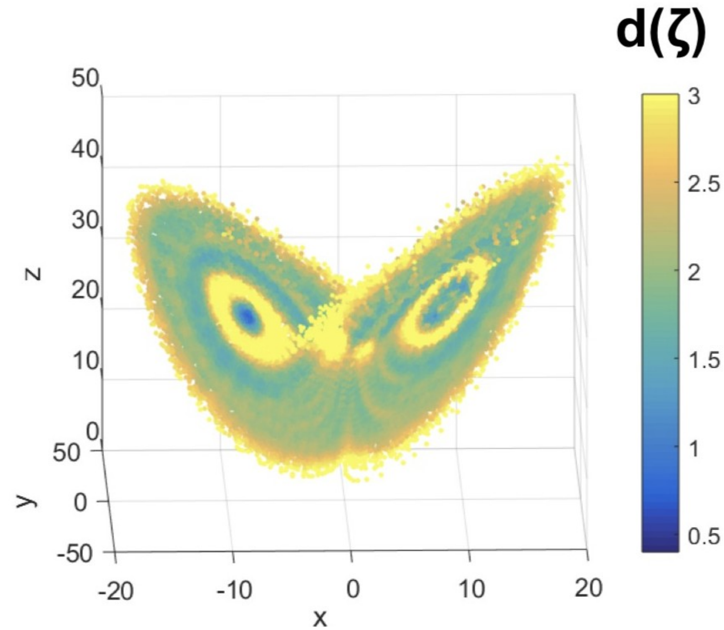
Dynamical Systems

Compute Dynamical Systems metrics to characterize atmospheric states, verifying that a long series of observations sample the underlying attractor.



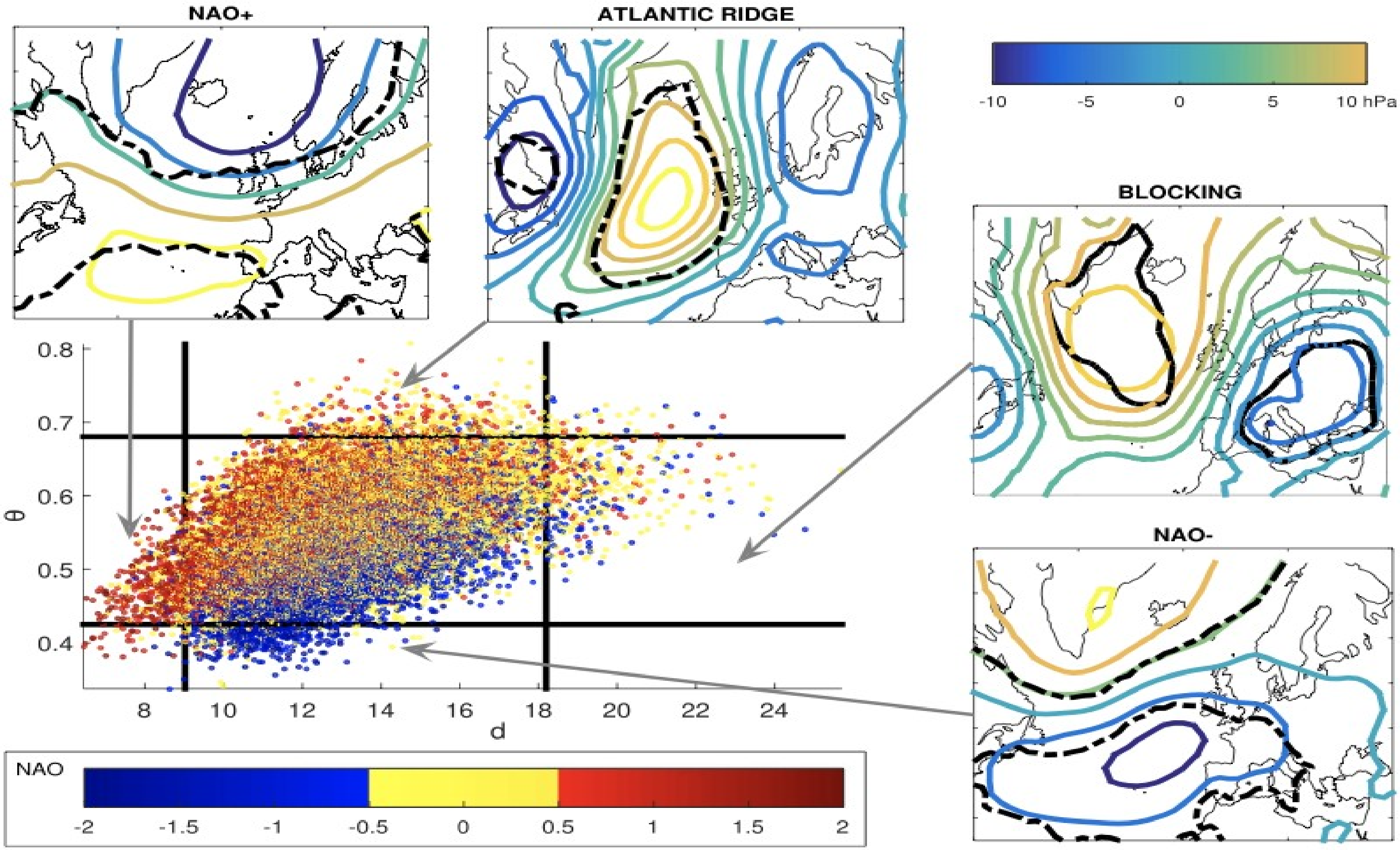
Local Dimensions *d*

t is proportional to the number of possible configurations (**number of degrees of freedom**) originating and resulting from the atmospheric field analyzed.

Persistence Θ

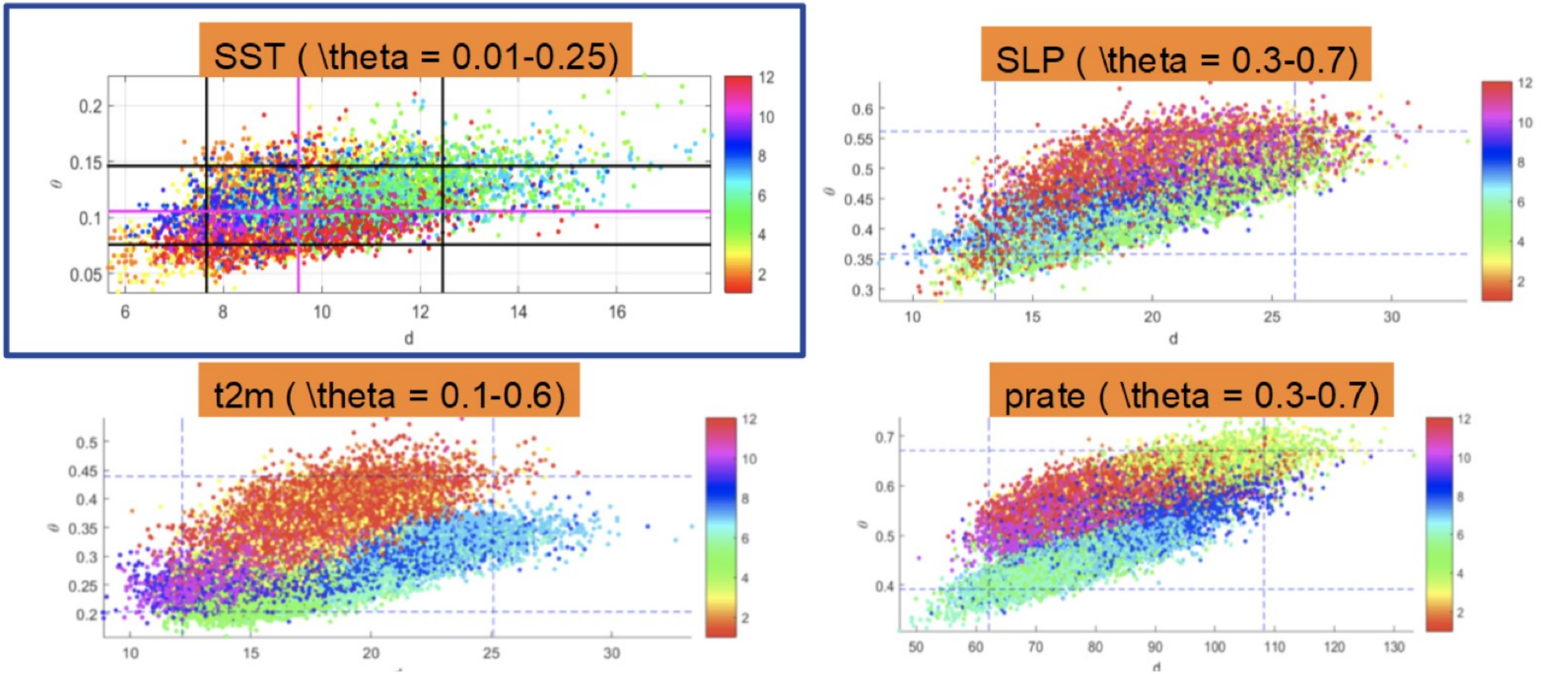
its inverse tells for **how long the atmospheric field will look like the one under examination**. For the present analysis Θ is an inverse number of persistance days.

SLP attractor for winter NCEP data. Low values of Theta and dimension are the most predictable configurations and represents NAO+/-, high values on Theta and dimension are the most unpredictable configurations and represents in SLP Blocking and AR.

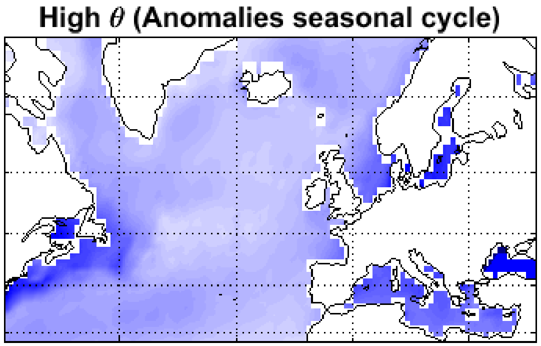


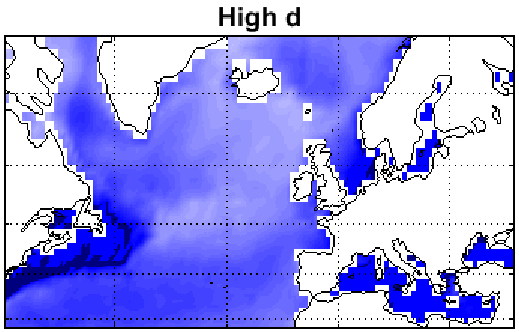
Faranda et al, 2017

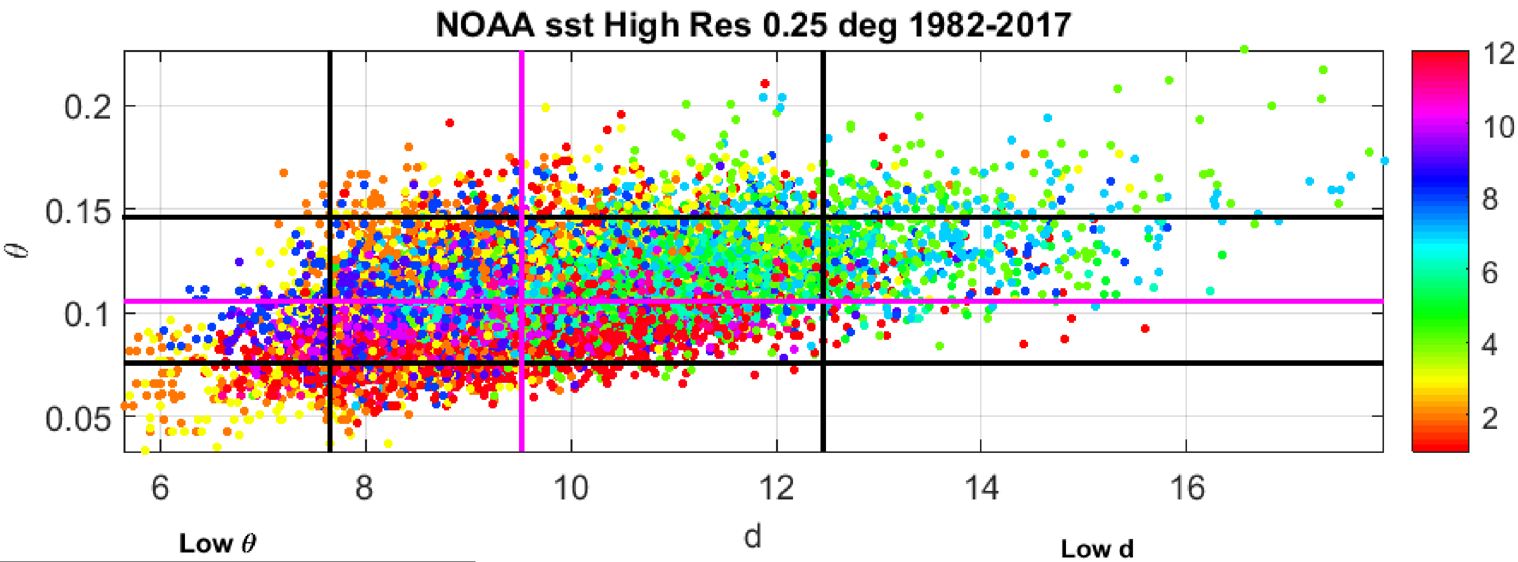
North Atlantic Attractor for different variables (SST, SLP, t2m, prate). Theta values for SST are the smallest in comparison with the rest of variables which means more predictability and the reason to use this variable to apply the bias correction method.

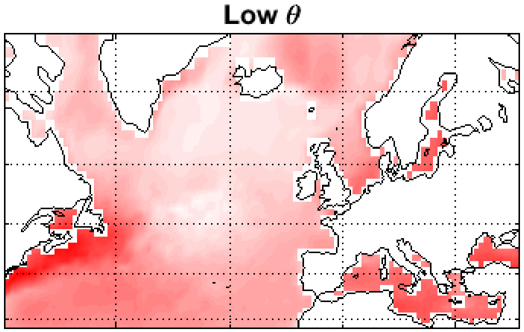


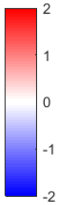
Faranda et al, 2018 NPG

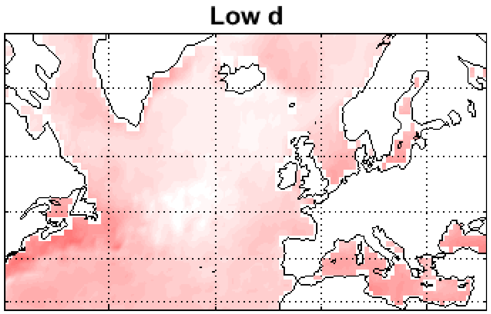












Alvarez-Castro, in prep

Definition

A method to apply multivariate bias correction to seasonal forecast data.

It is based on a quantile mapping method for statistical adjustment of climate simulations, but also uses information from dynamical systems (Faranda et al., 2017) based on persistence and local dimension of the predictors in the North Atlantic region in order to correct the bias on precipitation and temperature in the Mediterranean area.

Data and method

- observations from NCEP and GPCC - 40 members CMCC SPSv3

- dynamical-conditioned BC method:

using an Index or "weather regimes" in a climate/seasonal model.

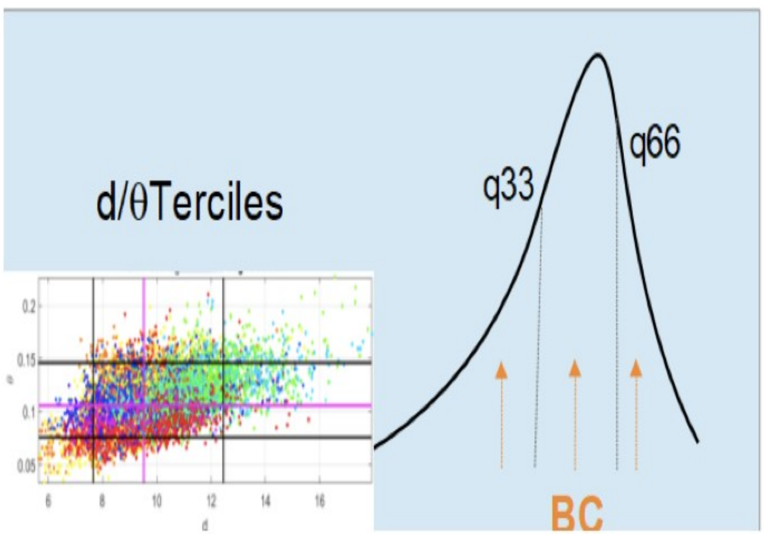
Quantile map is close to the observations but takes into account just the statistics, this method take into account the interannual variability that should produce time series much more realistic.

Obs: 1982-2017 (SST, Precipitation) → (NOAA,GPCC)

1982 — Hindcast Period → 2010

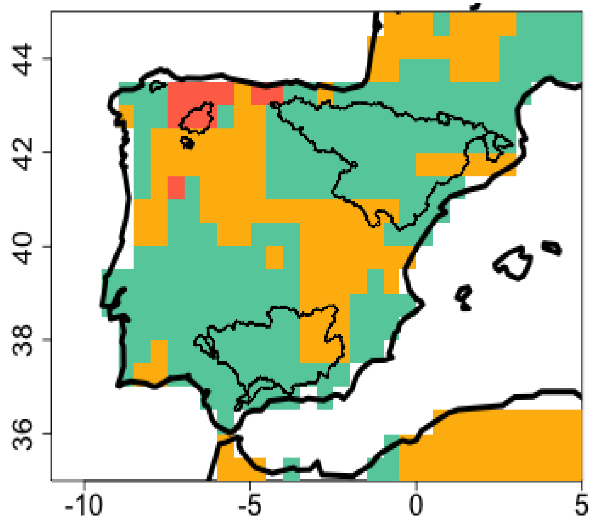
2017

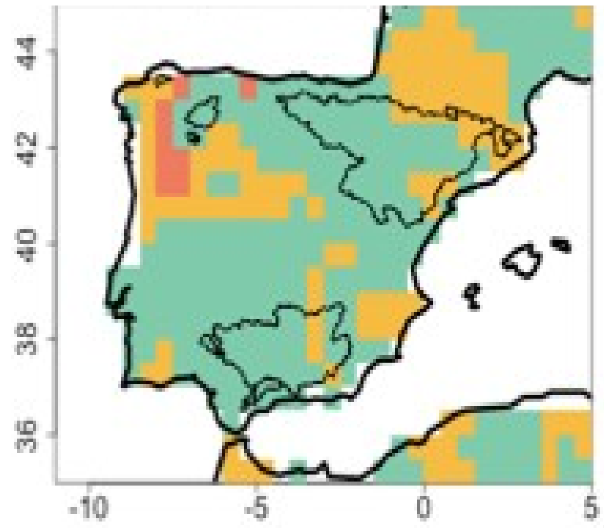
Forecast Period →

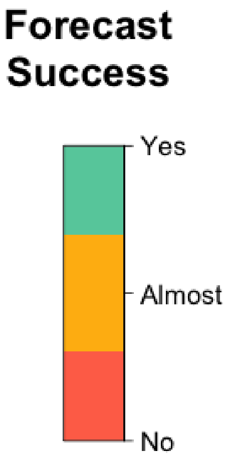


Calibration: NCEP and CMCC-CESM model

Example for September 2018 (NMME) :







Functions for MEDSCOPE Toolbox: Bias Correction

1. **R functions for the computation of d and Theta:**
   a. To compute local dimension and persistence
   b. Results Visualization Tools

2. **R functions for the bias correction:**
   a. Quantiles based on local dimension and theta
   b. Existing quantile map functions (qmap)
   c. Computation of probabilities for ensembles

3. **R functions for visualization of verification:**
   a. Traffic lights figures for verification
   b. Contingency tables

North Atlantic and Mediterranean regions

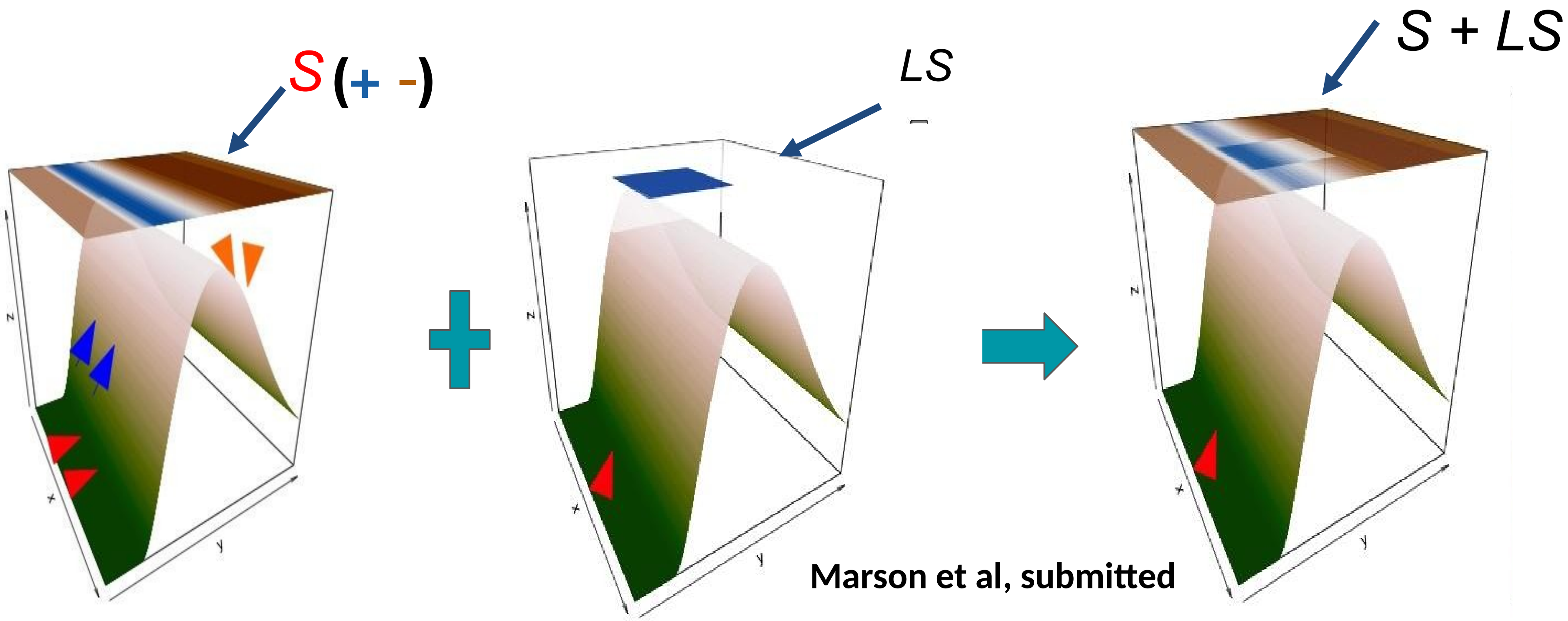
Trained using:
- SST NOAA high res
- NCEP
- EOBS
- CMCC-CM model
- Seasonal Forecast C3S-CMCC

A Process-Informed Statistical Model of Orographic Precipitation (SMOP)

1. Spatialization of precipitation fields in mountainous areas
2. Predictive Downscaling of Climate Models

Small Scale orographic source of condensation computed analitically [Smith, 2003]

Large Scale source of precipitation (frontal systems, l-s convection)



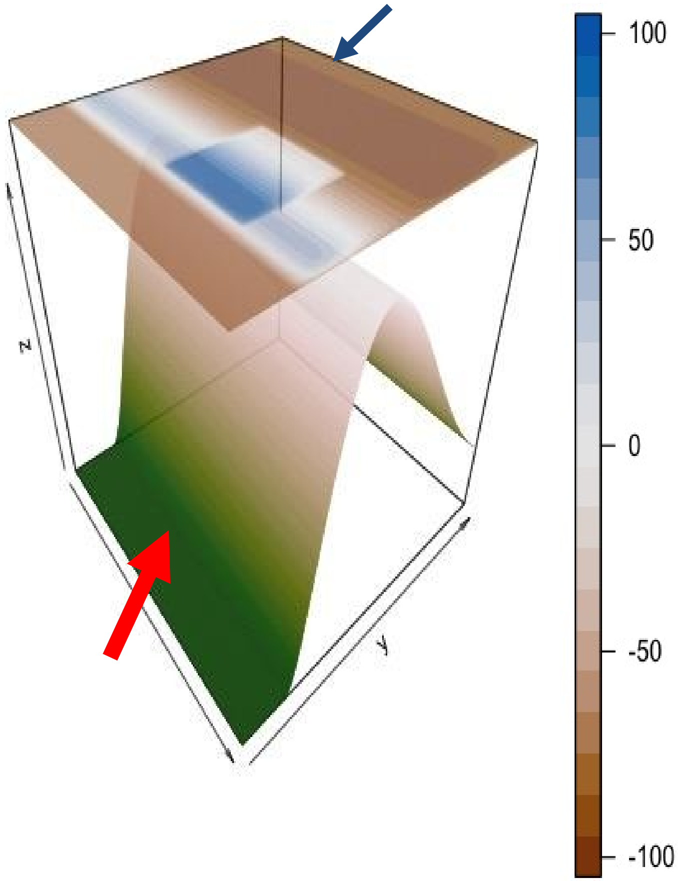
Marson et al, submitted

- **Time scale:**

$$\tau_f = 1000s$$

The total source is then adevented by the horizontal wind before precipitate on the ground example of the spatial pattern of “precipitation potential” produced adverting the total source for 5000,10000, 20000, 50000 seconds

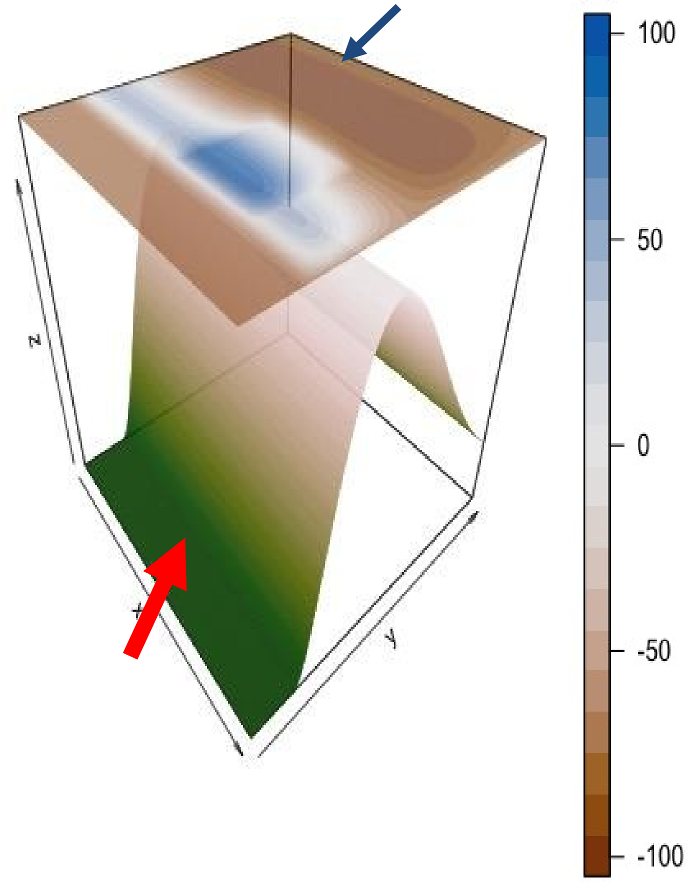
p^* *(potential precipitation* $\frac{mm}{day}$ *)*



- **Time scale:**

$$\tau_f = 5000\text{s}$$

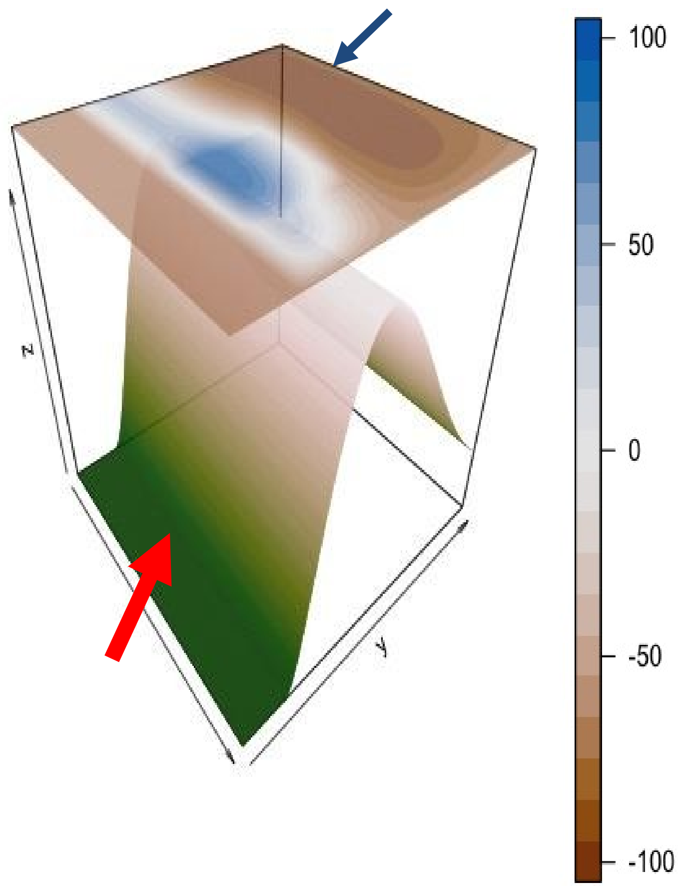
p^* *(potential precipitation* $\frac{mm}{day}$ *)*



- **Time scale:**

$$\tau_f = 10000\text{s}$$

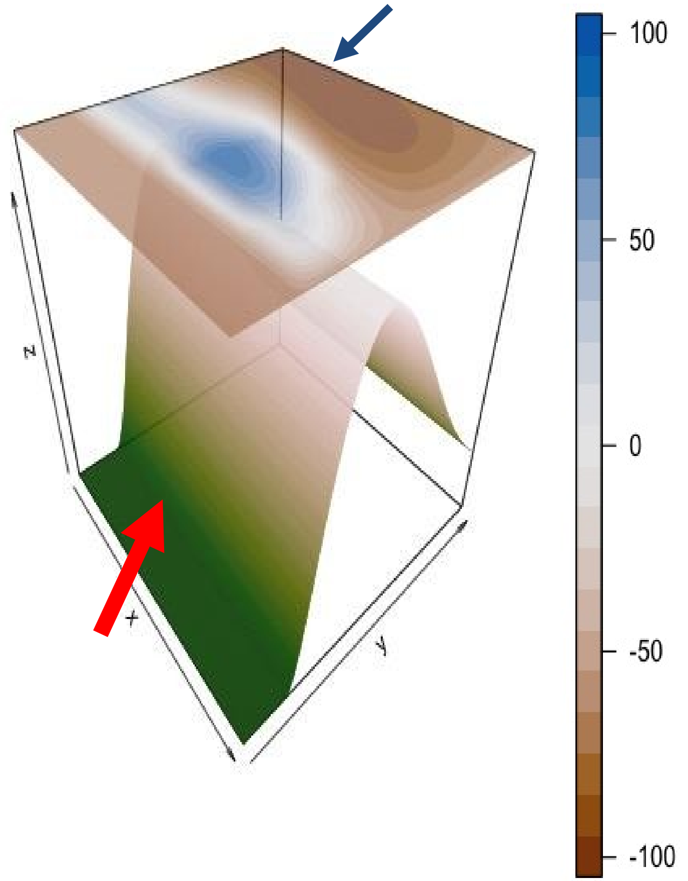
p^* *(potential precipitation* $\frac{mm}{day}$ *)*



- **Time scale:**

$$\tau_f = 20000\mathrm{s}$$

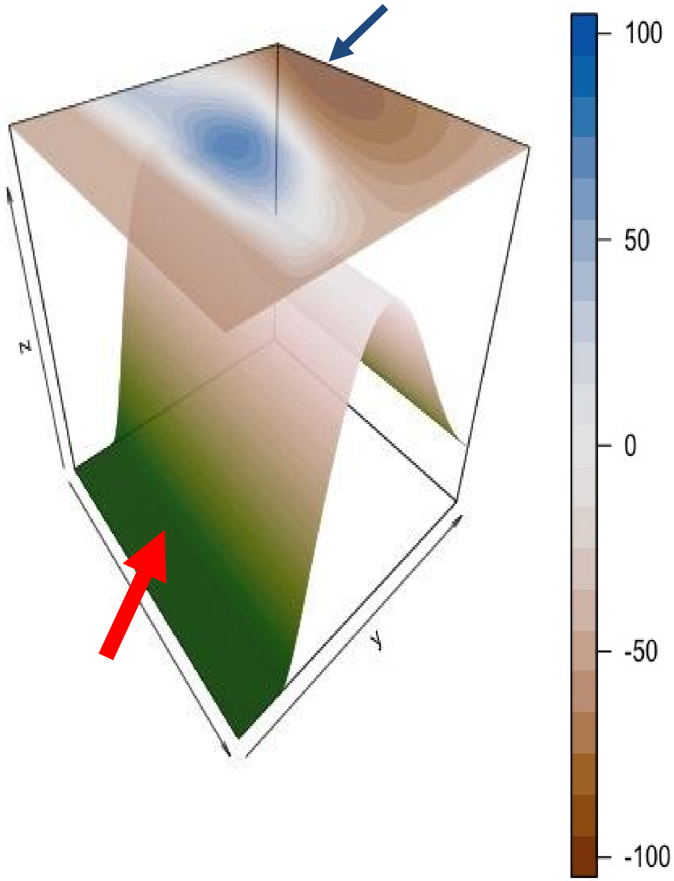
p^* *(potential precipitation* $\frac{mm}{day}$ *)*



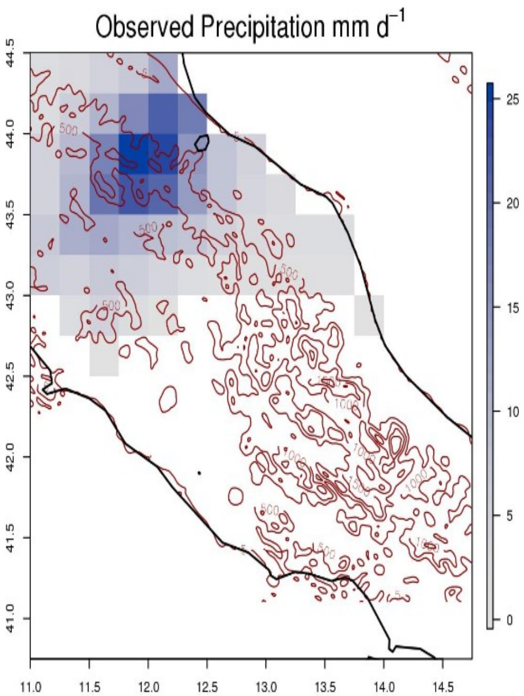
- **Time scale:**

$$\tau_f = 50000\text{s}$$

p^* *(potential precipitation* $\frac{mm}{day}$ *)*



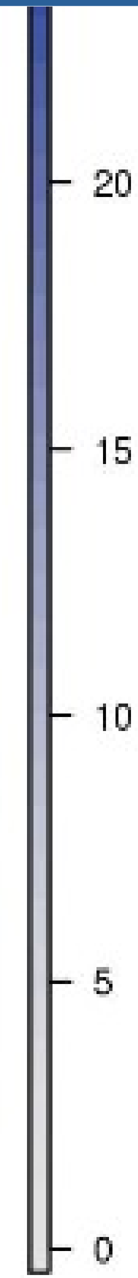
A Real Case Study Over Central I



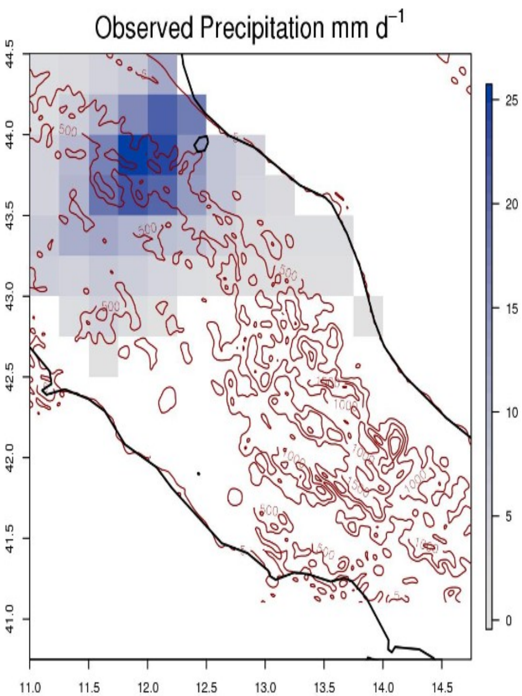
E-OBS (Haylock et al. 2008)
.25 x .25 deg Regular Grid

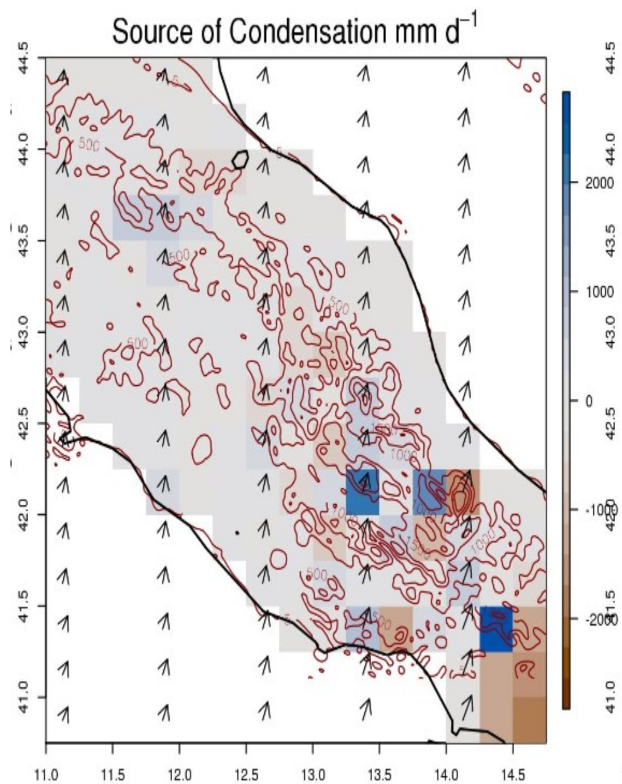
Domain and Data

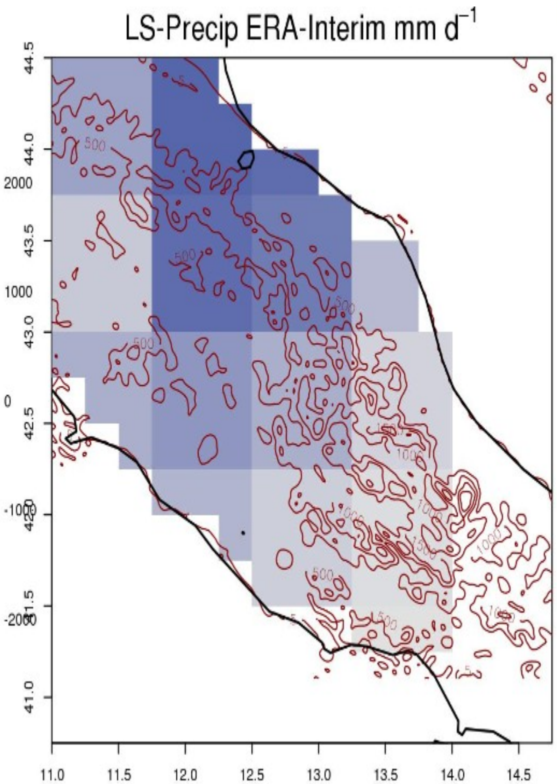
- Terrain: GTOPO30 (95% variance)
- ERA-Interim: (U, T, RH, LS-prec)

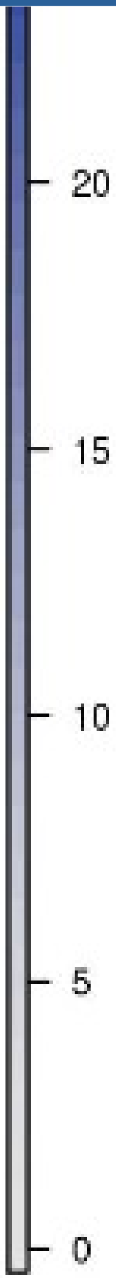


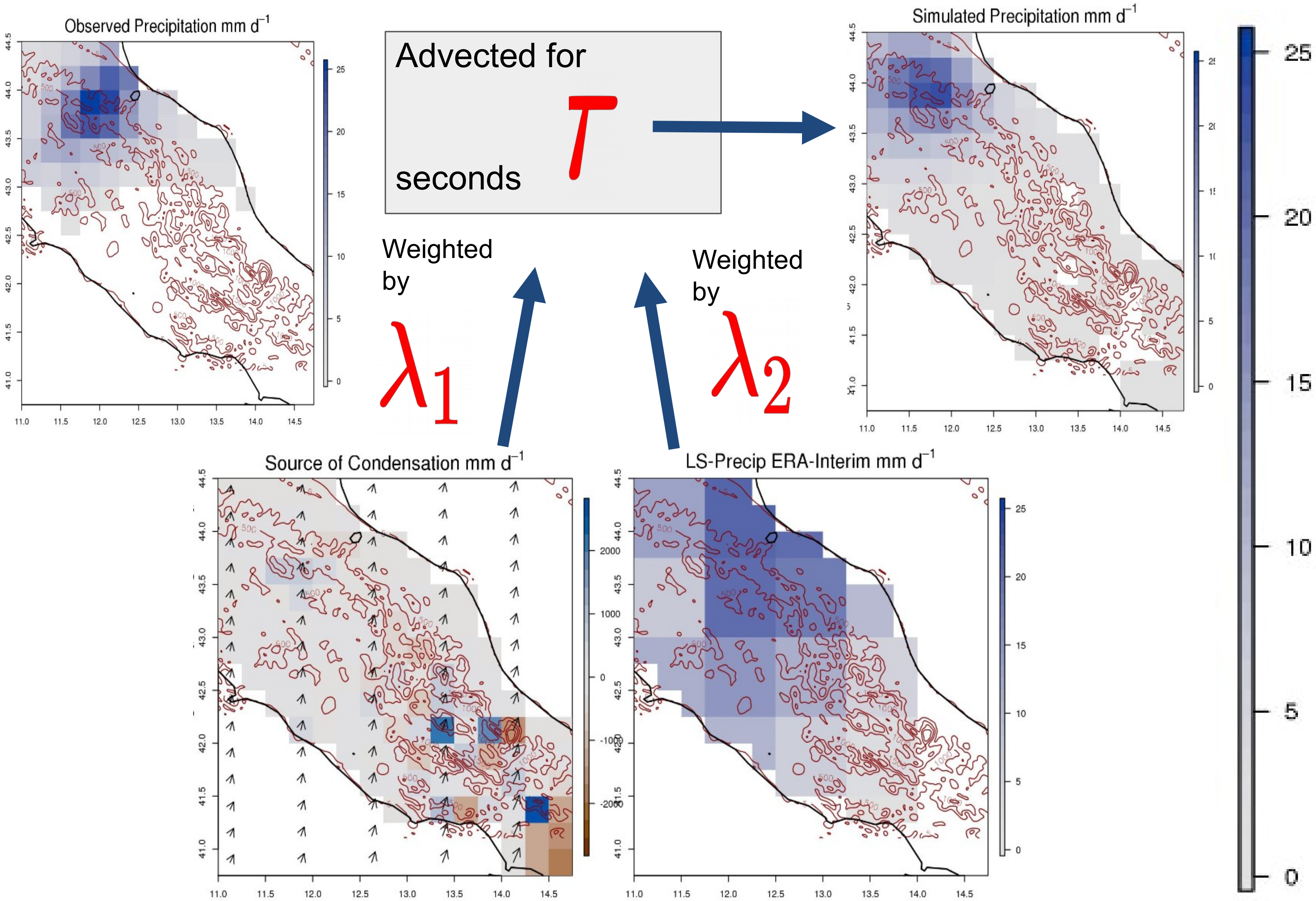
- Positive (blue) where condensation occurs and
- negative (brown) where instead evaporation occurs









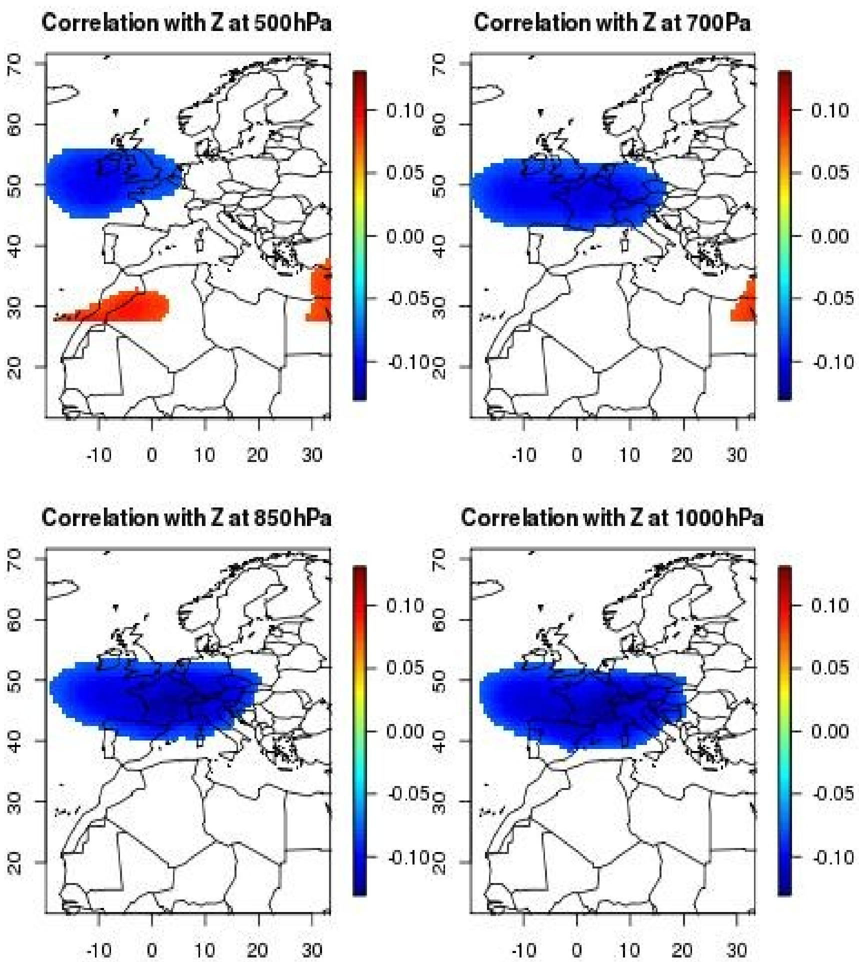

Observed Precipitation mm d^{-1}
Advected for
τ
seconds
Simulated Precipitation mm d^{-1}
Weighted by
λ_1
Weighted by
λ_2
Source of Condensation mm d^{-1}
LS-Precip ERA-Interim mm d^{-1}

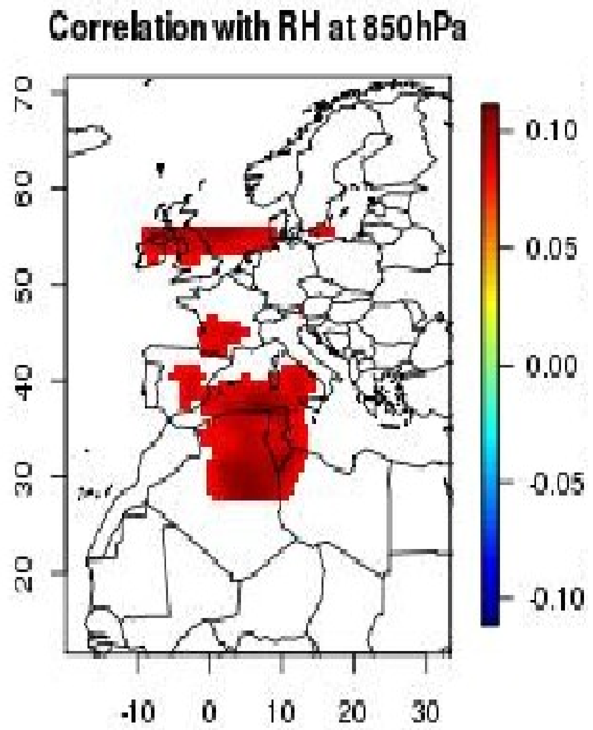
Predictive Downscaling

λ_1, λ_2 Can be predicted in the future by exploiting their relation with large-scale fields

geopotential height λ_2

λ_1 relative humidity





Functions for MEDSCOPE Toolbox: Statistical Downscaling

1. **R functions for the spatialization of precipitation:**
   a. To compute local sources of condensation;
   b. To estimate $\lambda_1, \lambda_2, \tau$ from data (3 versions):
      i. For precipitation occurrence only
      ii. For precipitation occurrence + power transform to obtain intensities
      iii. For precipitation occurrence and intensities simultaneously
   c. To apply the spatialization on the desired grid
   d. Results Visualization Tools

2. **R functions for the predictive downscaling:**
   a. To search linkages between $\lambda_1, \lambda_2, \tau$ and large-scale fields
   b. To predict in time $\lambda_1, \lambda_2, \tau$ using an “analog approach”
   c. To predict in time and spatialize the precipitation field.
   d. Results Visualization Tools

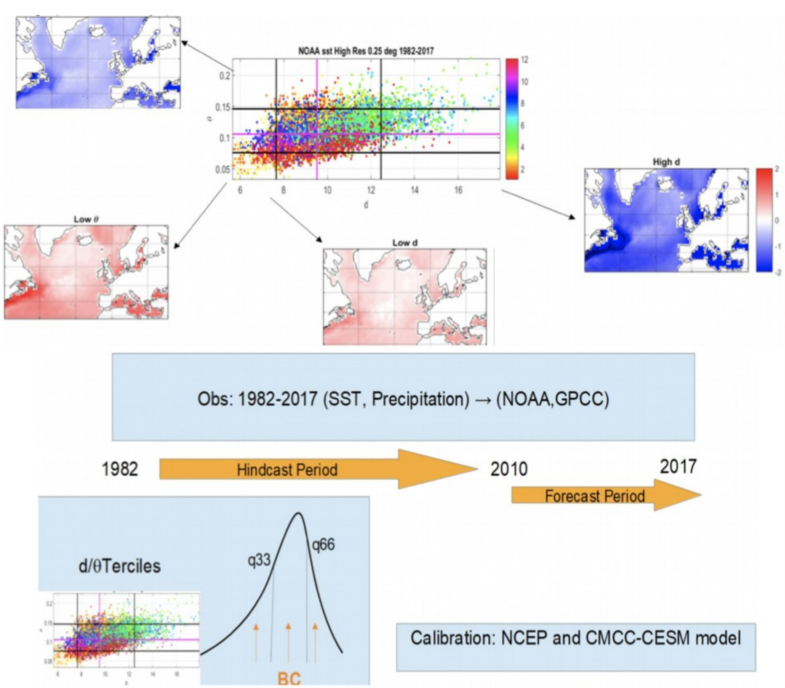
3. **SMOP already trained on three geographical areas, ready for applying spatialization/downscaling:**

Central Italy; Pyrennes; Southern France

Trained using:
EOBS;
ERA-Interim
Seasonal Forecast
C3S-CMCC

Bias Correction:

A new dynamical-conditioned bias correction method for seasonal forecast on precipitation and temperature in the Mediterranean Region



- New tool for WP3 Medscope toolbox developed in R and available in the upcoming months.

- We make use of recent advances in dynamical systems theory to estimate **two instantaneous dynamical properties** of the SST fields for the North Atlantic sector and the Mediterranean region: **local dimension and persistence** (Faranda et al, 2017).

- This tool combine dynamical to statistical information in order to better apply a bias correction method (as in Manzanas et al, 2018)

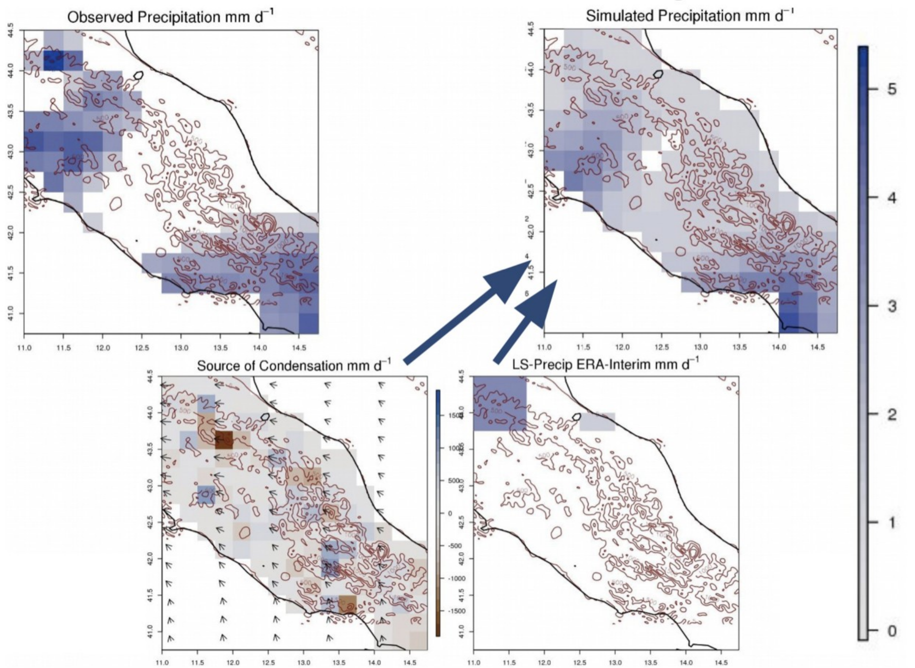
- SST in North Atlantic give us values of predictability (in terms of dynamical systems) higher than for SLP.

- warming ocean seems to lead to more predictable configurations

Statistical Downscaling:

A process-informed statistical framework for precipitation in mountainous regions

Winter storm in Central Italy



Sub-grid refinement by combining
- **Local scale processes causing orographic rainfall (analytical)**
- **Large scale precipitation component (from climate models)**

in a spatial autoregressive framework.

The relative contribution of local and large-scale sources is adjusted by observations.
The approach may be used as kernel for predictive downscaling techniques.

Finding linkages between the parameters lambda1, lambda2, tau, and the large-scale fields it is possible to predict their values in the future using maps of the selected large scale fields.

Thank you

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