Statistical tools for Mediterranean Seasonal Forecast

M. Carmen Alvarez-Castro[1*],

Paola Marson[1,2], Stefano Materia[1], Davide Faranda[3,4], Andrea Borrelli[1], Silvio Gualdi[1,5]

[1]Centro Euro-Mediterraneo sui Cambiamenti Climatici, CMCC, Bologna, Italy

[2]MétéoFrance, France, [3]Laboratoire des Sciences du Climat et de l'Environnement, CEA Saclay, Gif-sur-Yvette, France

[4]London Mathematical Laboratory, London, UK

[5]Instituto Nazionale de Geofisica e Vulcanologia, Bologna, Italy

*carmen.alvarez-castro@cmcc.it

MEDSCOPE MEDiterranean Services Chain based On climate PrEdictions

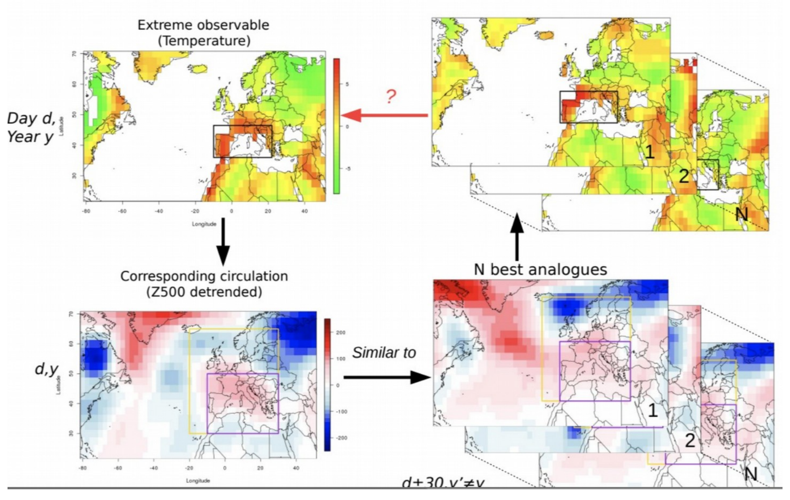
Seasonal forecasts are essential tools to offer early-warning decision support, that can help to reduce the socio-economics related risk associated with anomalous events. Advances in statistical prediction are often linked with the enhance of understanding that usually leads to improve dynamical forecast. Thereby, both approaches are frequently combined in order to increase the robustness of the forecast.

MEDSCOPE project (MEDiterranean Services Chain based On climate PrEdictions) aims to improve the predictability of climate predictions from seasonal to decadal timescales over the Mediterranean area. One of the main lines of research of MEDSCOPE is to improve the extraction of relevant information from climate prediction systems and assess their robustness and uncertainty through a toolbox "CSTools". In this Toolbox, we are developing methodologies to extract usable information from predictions, producing tools for prediction verification, calibration, downscaling, ensemble member combination and selection that will be publicly released in a R-package and a Gitlab webpage.

CMCC contribution to MEDSCOPE toolbox (Rpackage 'CSTools')

1. Downscaling (Analogs)

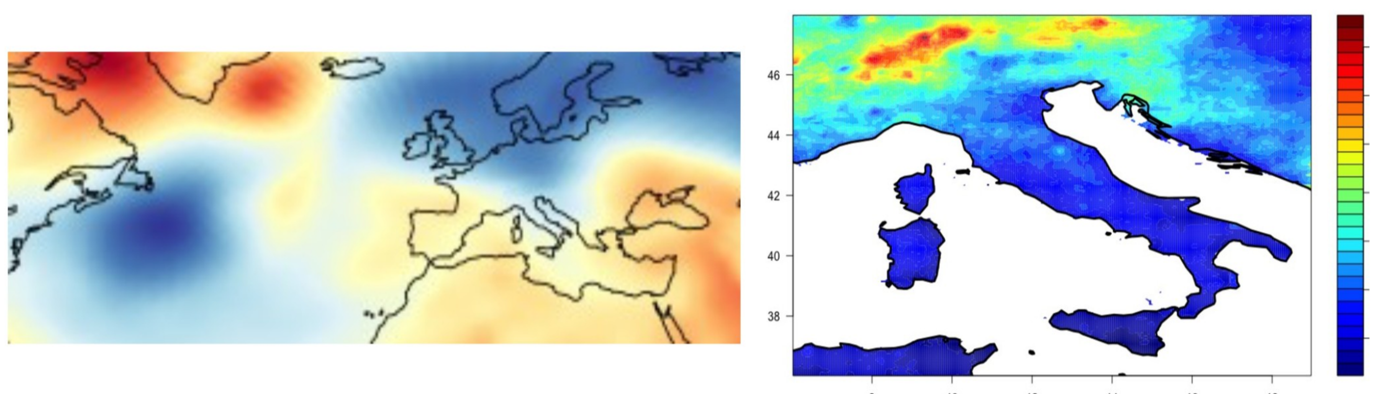
Based on the method of Jézéquel et al 2017, we have adapted the analogs method to seasonal forecast (Copernicus). The analogs are days within the database which have a similar circulation to the day of interest. The temperature (or precipitation) of the analogs are then compared to the temperature (precipitation) of the day of interest.



Jézéquel et al 2017

Predictors: SLP, Precipitation at Large Scale (Copernicus seasonal forecast models)

Predictands: Precipitation, Temperature at Local Scale (EOBS, ERA5)



Temporal Scale: daily fields

Criteria to select Best Analogs: Minimum Euclidean distance and maxima of correlation

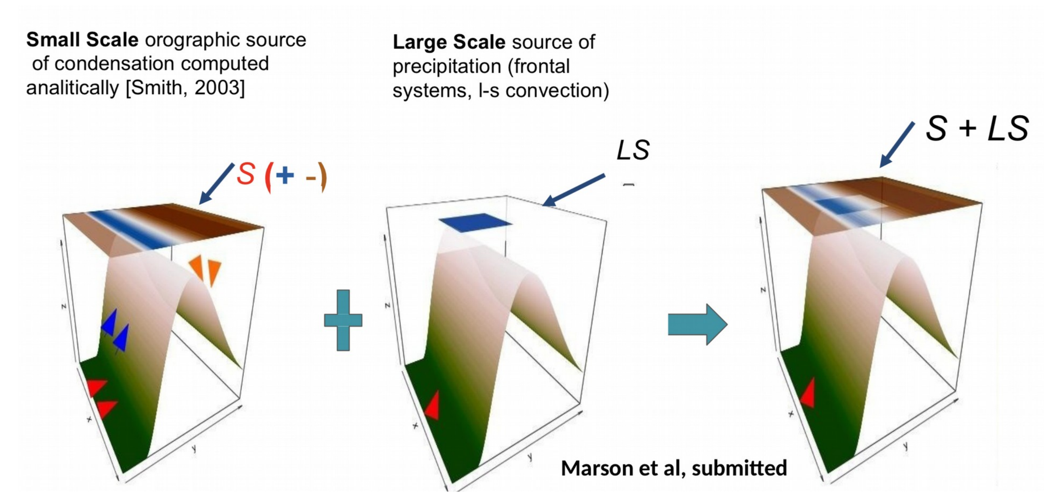
date	dist	corr
19860507	146	0.90
19920520	356	0.78
19980511	425	0.74
20010515	478	0.65
20130510	553	0.61
20090523	740	0.59

2. Downscaling (SMOP)

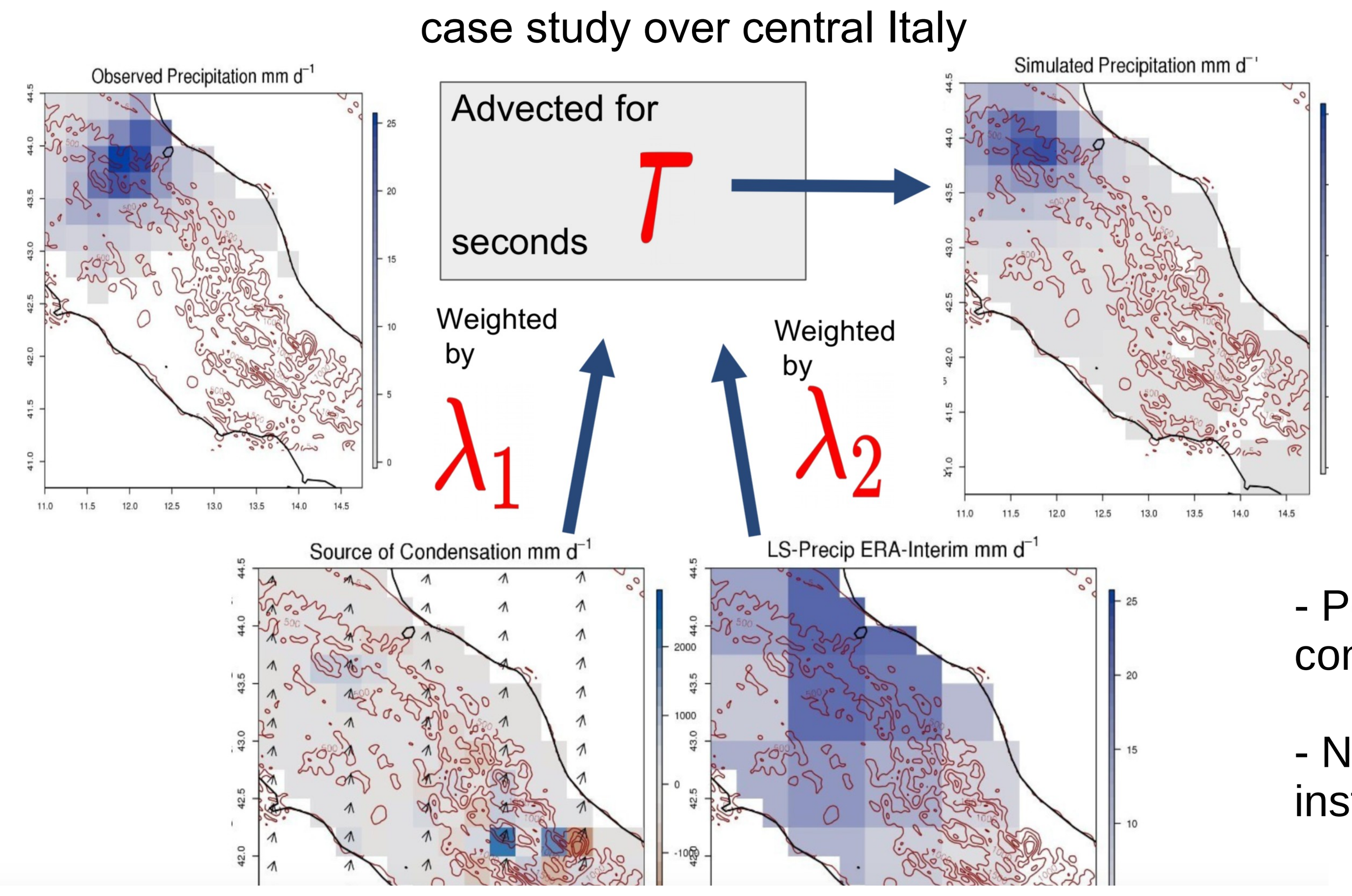
Statistical Model of Orographic Precipitation (SMOP) is a process-informed statistical framework for precipitation in mountainous regions. Sub-grid refinement by combining:

a) Local scale processes causing orographic rainfall (analytical)
b) 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.



case study over central Italy



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.

- Positive (blue) where condensation occurs and

- Negative (brown) where instead evaporation occurs

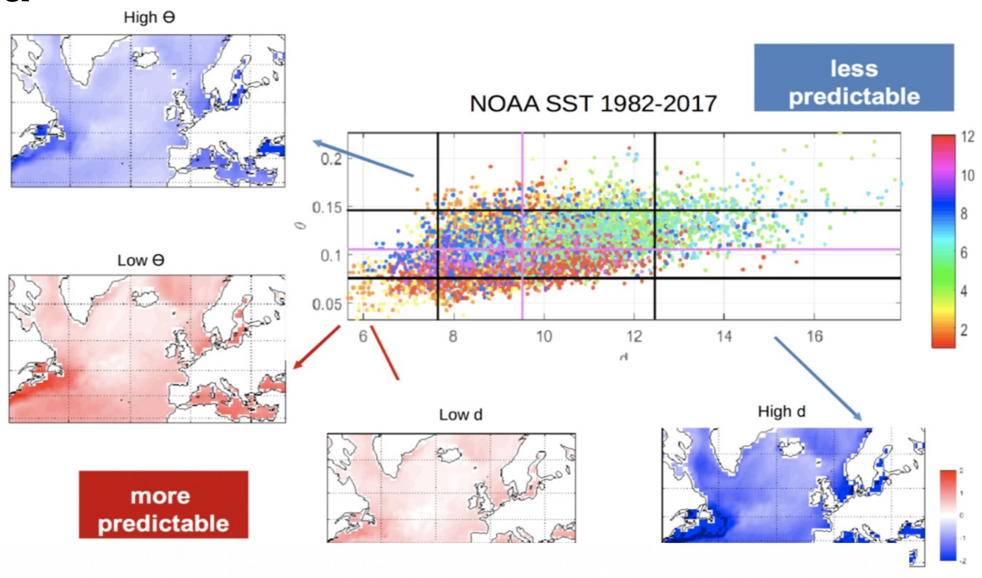
3. Bias correction

DynBiasCorrection is 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** [3] based on persistence and local dimension of the predictors (SST or SLP) in the North Atlantic region in order to correct the bias on precipitation and temperature in the Mediterranean area.

measuring SST: SST in North Atlantic give as values of predictability higher than for SLP. Thus, warming ocean seems to lead to more predictable configurations: **Hammam effect** [4]

a

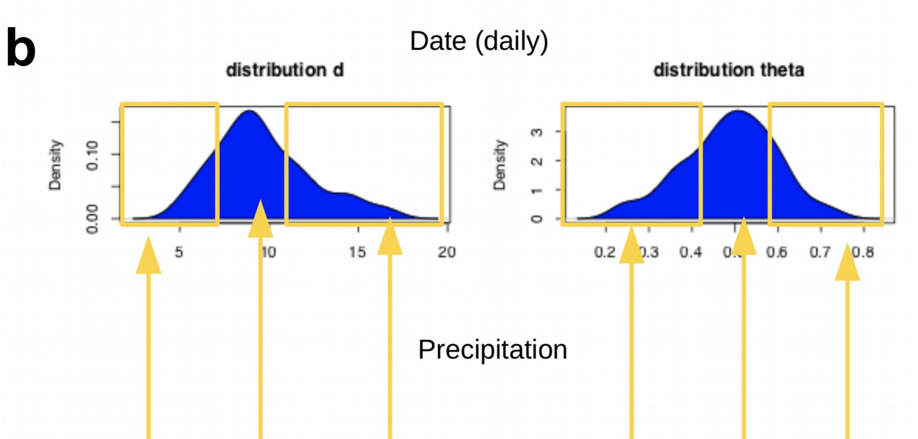


Hammam Effect:

Warmer SSTs correspond to more predictable atmospheric configurations, since d_{SLP} is lower for warmer ocean states.

We name this robust signal the hammam effect [4].

b



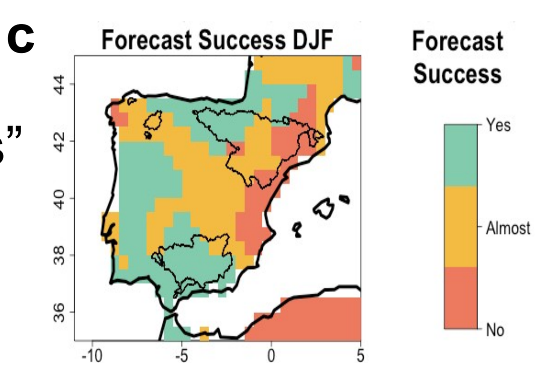
Alvarez-Castro, in preparation

bias correction **bias correction**

4. Verification: Scores and visualization

c

"Traffic lights" figures for verification



d Computation of Scores based on predictability (dynamical systems):

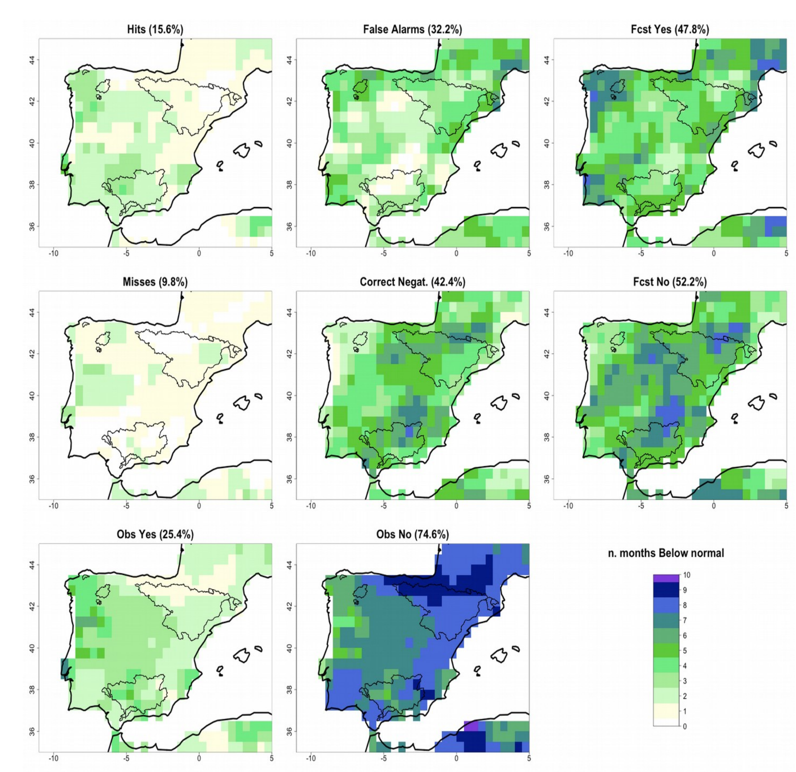
DynScores	d1	d2	d3
ϴ1	ϴ1d1	ϴ1d2	ϴ1d3
ϴ2	ϴ2d1	ϴ2d2	ϴ2d3
ϴ3	ϴ3d1	ϴ3d2	ϴ3d3

DynScores= weight ϴ and d in base of the quantile

e Contingency

	Obs yes	Obs no	
Fcst yes	hits	false alarms	Fcst yes
Fcst no	misses	correct negatives	Fcst no
	Total Obs yes	Total Obs no	Total

Table 1: Contingency table scheme that have been used to create contingency figures by the two categories 'Above normal' and 'Below normal'.



The **CSTools** R package is on the **CRAN** repository:
https://cran.r-project.org/package=CSTools

References:

[1] Aglaé Jézéquel, Pascal Yiou, Sabine Radanovics. Role of circulation in European heatwaves using flow analogues. Climate Dynamics, 2017

[2] A Process-Informed Statistical Framework for the Spatial Distribution and Intensity of Orographic Precipitation Paola Marson, Stefano Materia, Douglas Nychka, Stefano Tibaldi and Silvio Gualdi (submitted)

[3] Rodrigues, D., Alvarez-Castro, M. C., Messori, G., Yiou, P., Robin, Y., & Faranda, D. (2018). Dynamical properties of the North Atlantic atmospheric circulation in the past 150 years in CMIP5 models and the 20CRv2c Reanalysis. Journal of Climate, 31(15), 6097-6111.

[4] Faranda, D., Alvarez-Castro, M. C., Messori, G., Rodrigues, D., & Yiou, P. (2019). The hammam effect or how a warm ocean enhances large scale atmospheric predictability. *Nature communications*, *10*(1), 1316.