Validation of gridded precipitation products in Spain

P. Quintana-Seguí (Observatori de l'Ebre, URL-CSIC, Roquetes, Spain)
M. Turco (Barcelona Supercomputing Center – Centro Nacional de Supercomputación, BSC-CNS, Barcelona, Spain)
G. Míguez-Macho (Universidade de Santiago de Compostela, Santiago de Compostela, Spain)
A. Barella-Ortiz (UCLM, Toledo, Spain; Observatori de l'Ebre, URL-CSIC, Roquetes, Spain)

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Introduction

- Land-surface models (LSM)
  - Physically based approach.
  - Understanding of physical processes
- The quality of the simulations depends on:
  - Model structure.
  - Physiographic data.
  - **Meteorological forcing.**
- Precipitation
  - High spatial and temporal heterogeneity.
  - Difficult variable to analyze or to interpolate.
  - **High impact on LSM simulations.**

This applies to our current projects:

- eartH2Observe (EU-FP7)
  - Simulation of drought processes in Spain by means of LSMs.
  - 1995/96-2006/07.
- MARCO (Spanish)
  - Improvement of the capacity of RCMs to simulate hydrometeorological extremes.
  - Offline LSM simulations used as a baseline.
  - 1979/80-2013/14.

In both cases, good forcing data is necessary.

Available forcing datasets

Which datasets are available in Spain in order to force LSM models?

Product	Method	Available in Spain	Sufficient resolution	Long period?	Enough variables
ERA-Interim, WFDEI, eartH2Observe, etc.	Global reanalysis.	Yes. Global.	No	Yes	Yes
E-OBS	Kriging.	Yes. Europe	No	Yes	No
Spain02	Kriging.	Yes. Spain.	No (improving)	Yes	No
SAFRAN	Optimal interp.	Now yes!	Yes	Now Yes!	Yes ++
SPAN (HIRLAM)	Optimal interp.	Yes. Spain	Yes	Work in progress	Yes

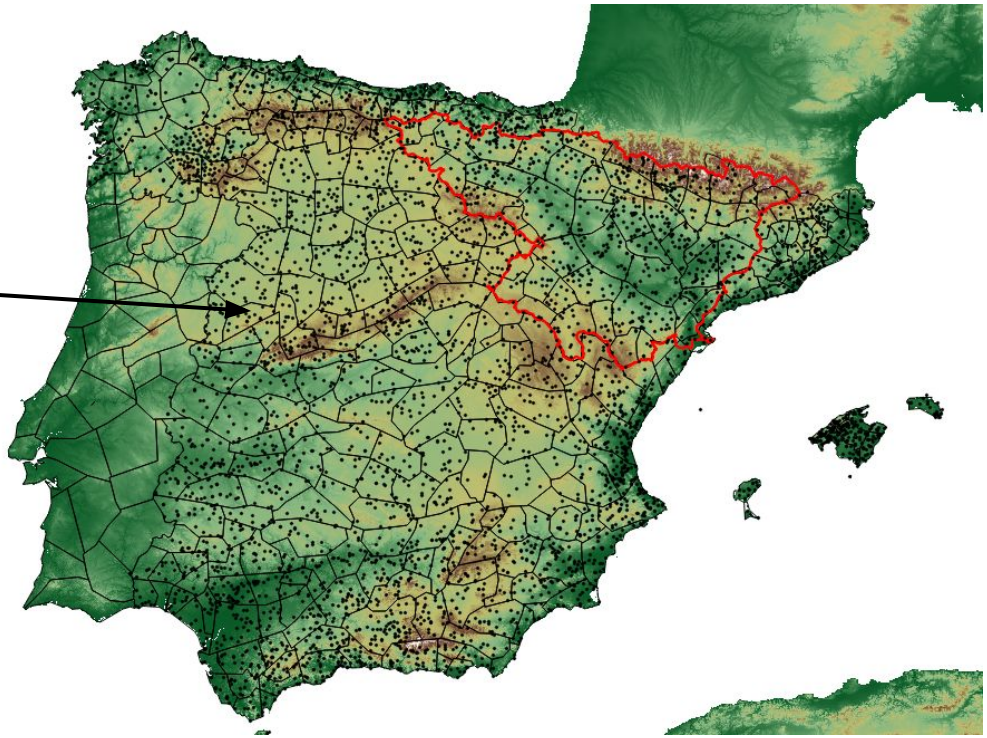
A long SAFRAN dataset has been created for Spain.

SAFRAN

SAFRAN Analysis (Météo-France)

- Optimal interpolation.
- Climatological homogeneous zones.
- P, T, W, RH, C.
- Downward VIS and IR (model).
- Input
  - Observations : AEMET data.
  - First Guess : ERA-Interim.
- Output:
  - 1h time step. 5 km resolution.
- Successfully tested in NE Spain by QS et al. (2015).

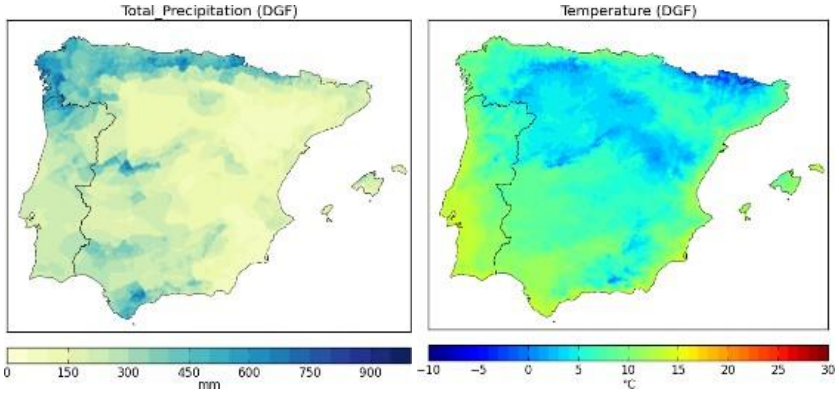
AEMET precipitation stations used in the analysis



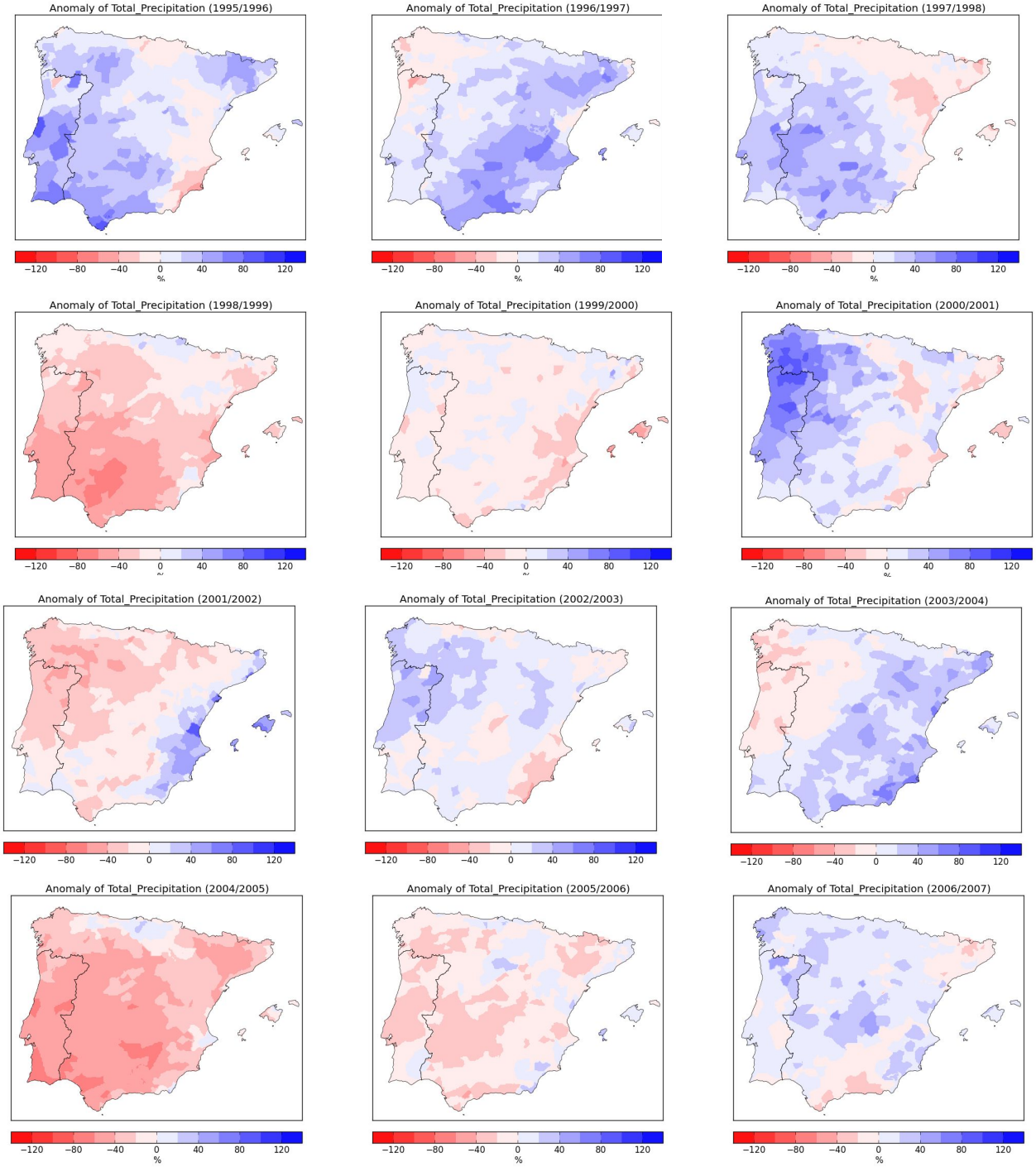
New dataset

- Continental Spain and Balearic Islands.
- 1995/96-2006/07 is **freely available** in the HyMeX database.
  - There are already some users within the E2O community.
- **1979/80-2013/14** was recently run.

Examples of precipitation and temperature fields



Meteorological analysis systems in north-east Spain. Validation of SAFRAN and SPAN, P. Quintana-Seguí, C. Peral, M. Turco, M.C. Llasat, E. Martin, Journal of Environmental Informatics, Accepted, 2015.



SAFRAN

Evolution of the annual anomalies of precipitation (%) for 12 years.

How good is SAFRAN?

From previous studies we know it works as well in Spain as in France.

We also know that it is on par with SPAN (AEMET's analysis).

Quintana-Seguí et al. (2015)

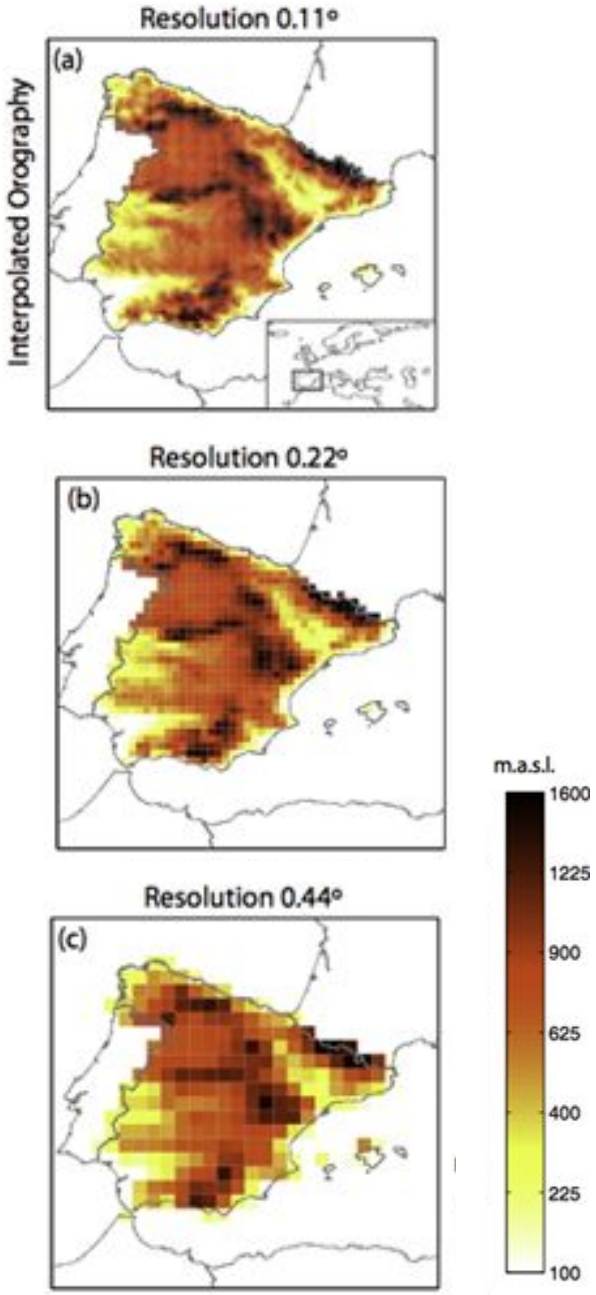
How good is compared to Spain02?

Spain02

- Gridded dataset
  - **Daily precipitation**
  - Maximum and minimum temperature
- 1950-2007
- Observations from: AEMET (National Meteorological Agency).
- Three different resolutions (0.11º, 0.22º and 0.44º).
- Different methodologies.
  - Ordinary kriging (point representative).
  - Areal averages (area representative)
    - Using auxiliary 0.01º grid.
    - **AA-3D** : using the relief as a covariable.

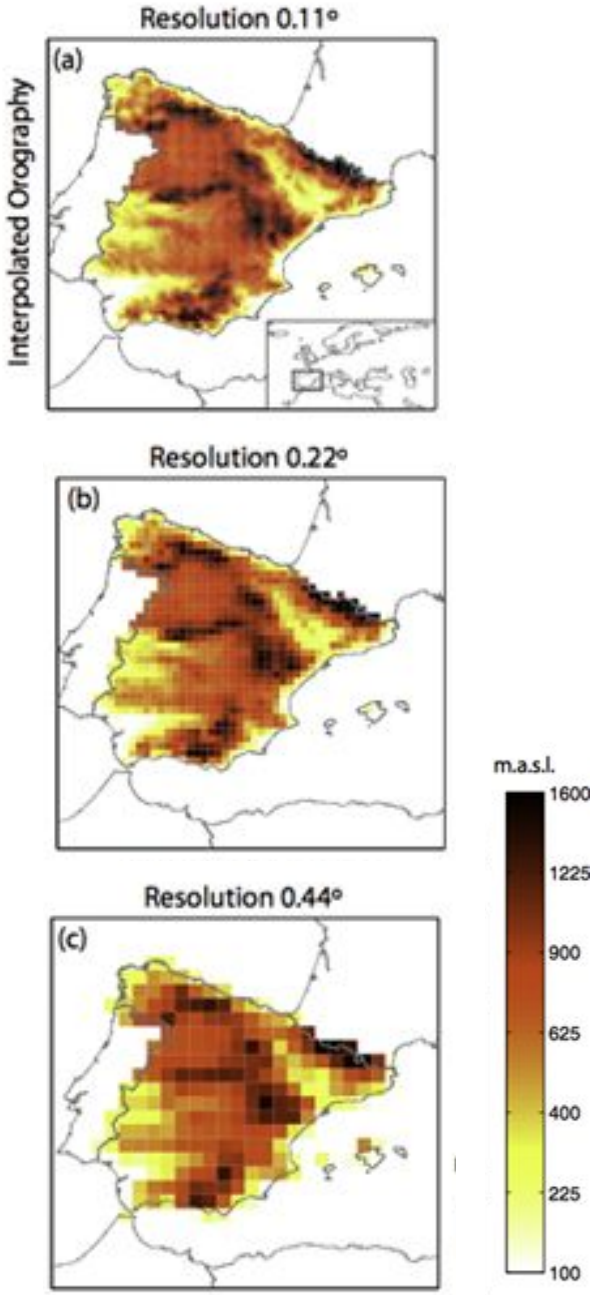
Herrera et al. (2011, 2012, 2015).

http://www.meteo.unican.es/es/datasets/spain02



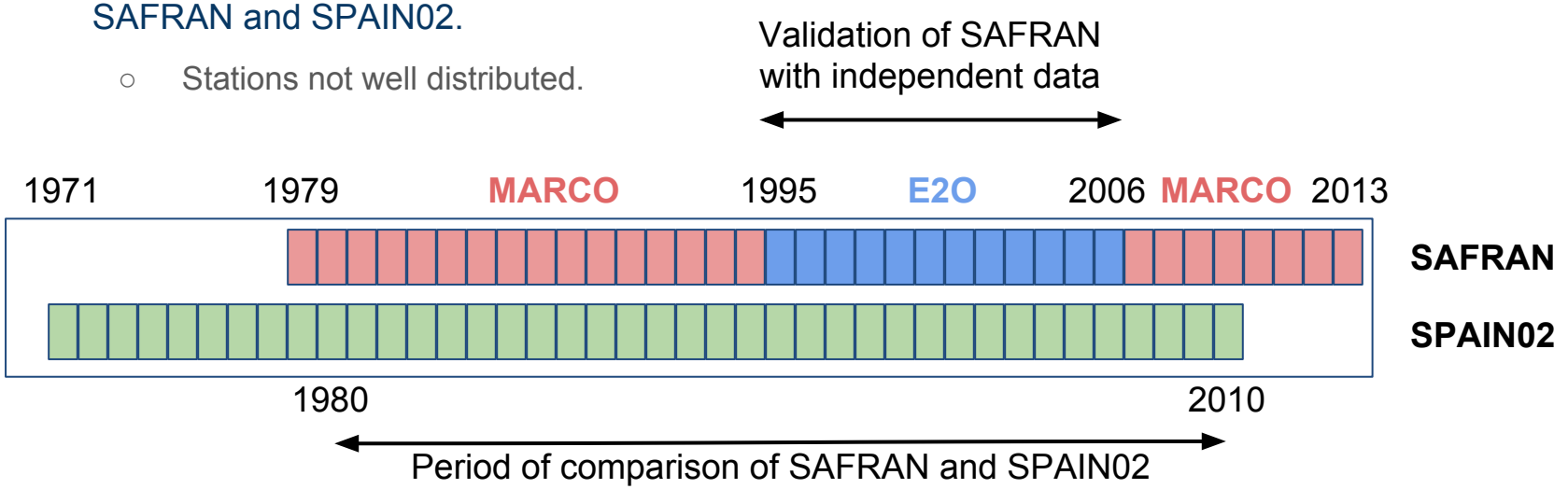
Spain02

- Spain02 has some important limitations for the land surface modeler.
  - It does not offer all necessary variables to force a LSM.
  - The dataset is daily, it doesn't offer hourly data.
- However, this is the most widely used precipitation product in Spain.
- **We decided to compare SAFRAN's precipitation to the best product available in Spain.**



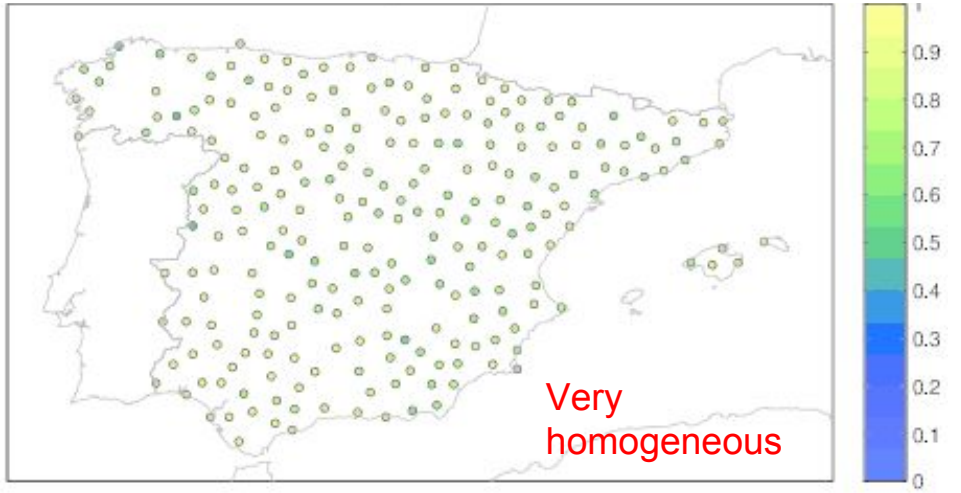
Datasets and periods

- The SAFRAN dataset has been build in two different time periods (MARCO & E2O).
  - Each period has its own independent dataset (stations not used in the analysis).
- It was not possible to obtain a good dataset of independent stations for both SAFRAN and SPAIN02.
  - Stations not well distributed.
- SAFRAN validated with independent data in the E2O period.
- SAFRAN and SPAIN02 compared in the 1980-2010 period.
  - The stations selected for the comparison are dependent for SAFRAN and mostly dependent for Spain02.
  - There are thousands of stations.

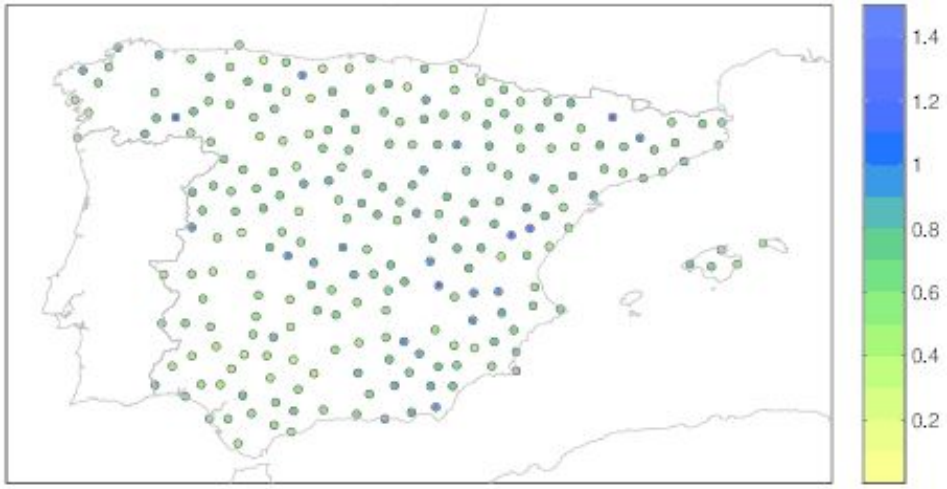


Validation of SAFRAN with independent data. Time series.

Correlation (SFR vs OBS)



MAEr (SFR vs OBS)

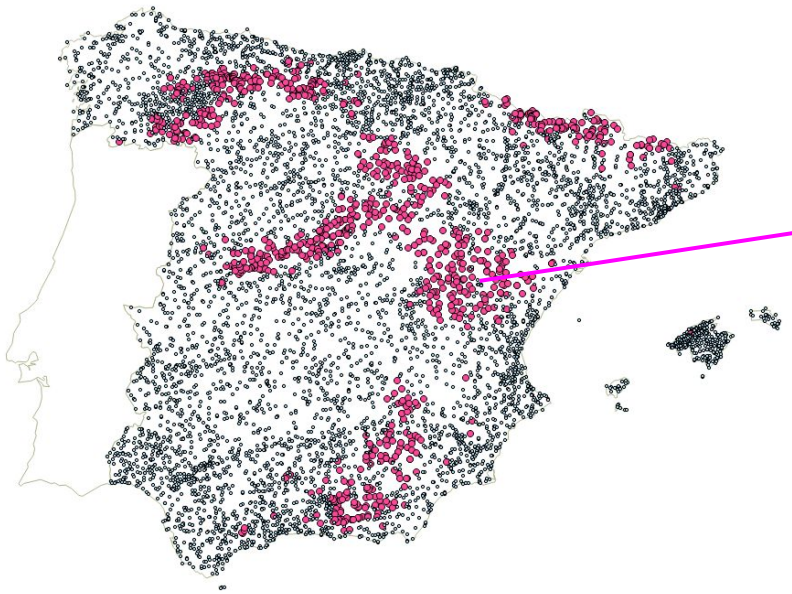


	Correlation			MAEr		
	Mean	**Q25**	**Q75**	**Mean**	**Q25**	**Q75**
Independent observations.	0.82	0.75	0.86	0.62	0.54	0.75
Dependent observations.	0.82	0.77	0.87	0.62	0.53	0.72

SAFRAN is robust, against independent data. The statistics are close to those with dependent data.

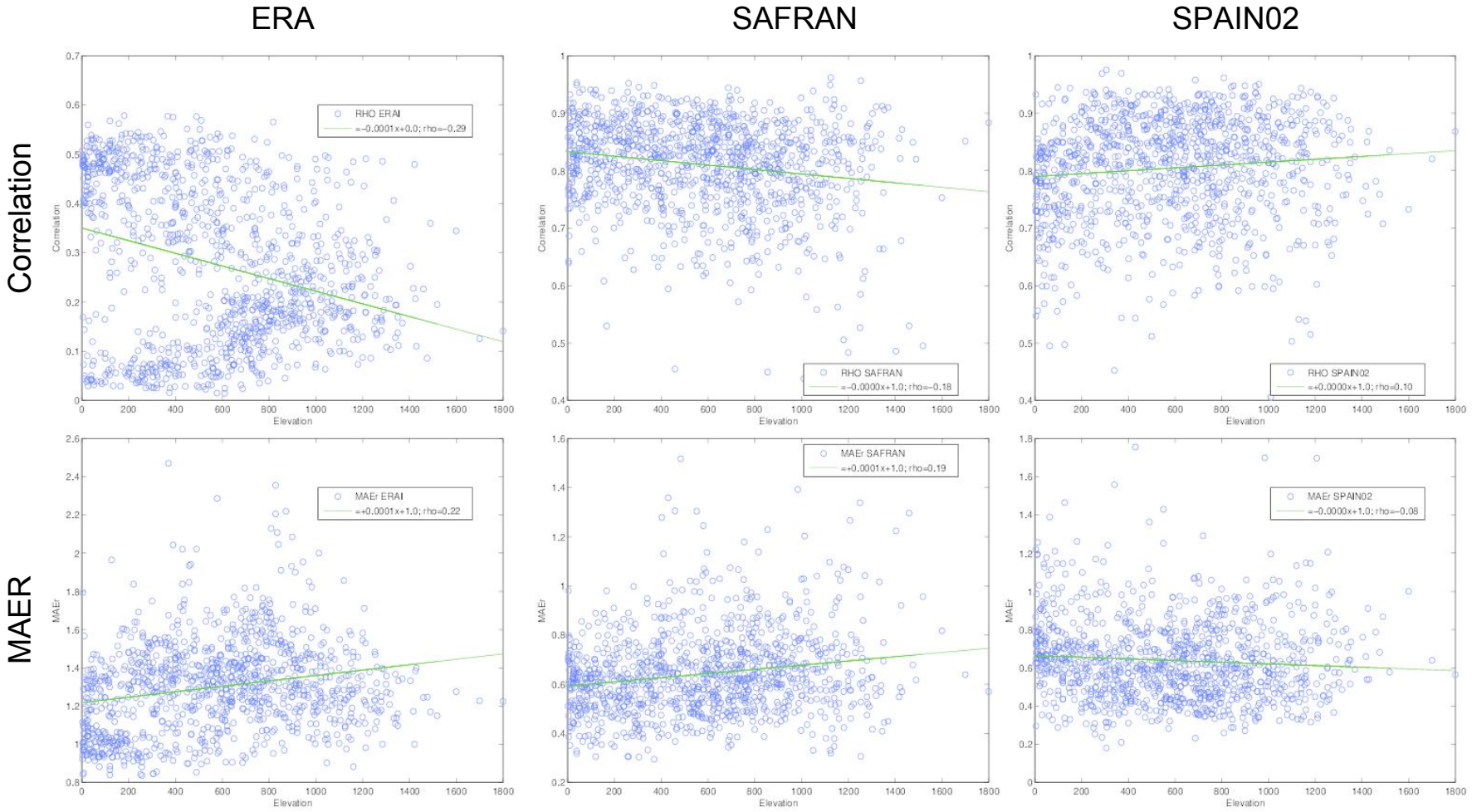
Comparison of SAFRAN and Spain02 time series

- Dependent dataset.
- Almost identical results between SAFRAN and Spain02.
- There are no significant differences between all the stations and those



	Correlation			MAEr		
	Mean	**Q25**	**Q75**	**Mean**	**Q25**	**Q75**
	All stations					
ERA	0.26	0.14	0.43	1.30	1.14	1.44
SFR	**0.82**	0.77	**0.87**	**0.62**	0.53	**0.72**
SP02	**0.82**	**0.75**	**0.87**	**0.62**	**0.49**	0.75
	> 1000 m.					
ERA	0.21	0.04	0.36	1.23	1.11	1.43
SFR	**0.82**	**0.75**	0.86	0.64	0.55	0.77
SP02	**0.82**	**0.75**	**0.88**	**0.61**	**0.49**	**0.76**

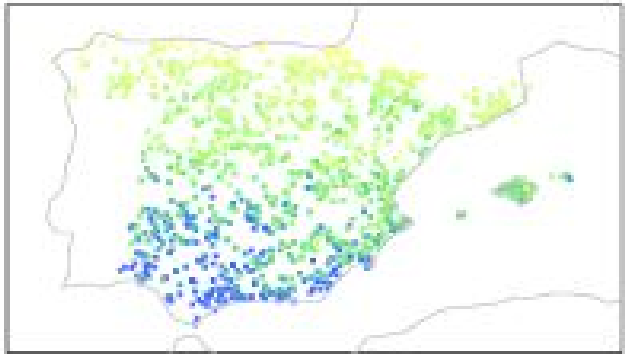
Scores do not depend on altitude



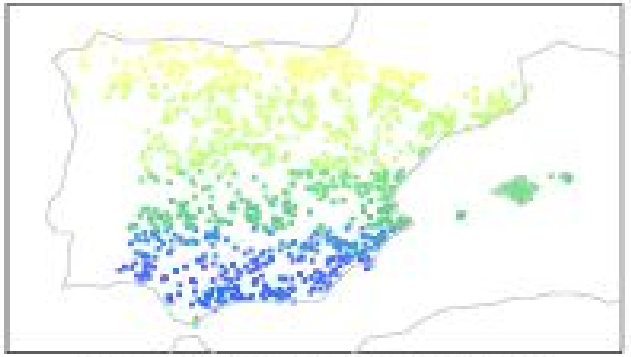
The trends with altitude are not significant.

Spatial validation of precipitation indices

Observations



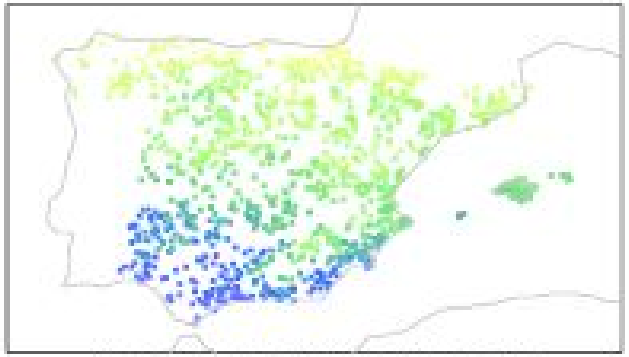
ERA-Interim



M=−0.01 S=1.28 R=0.69 C=0.85

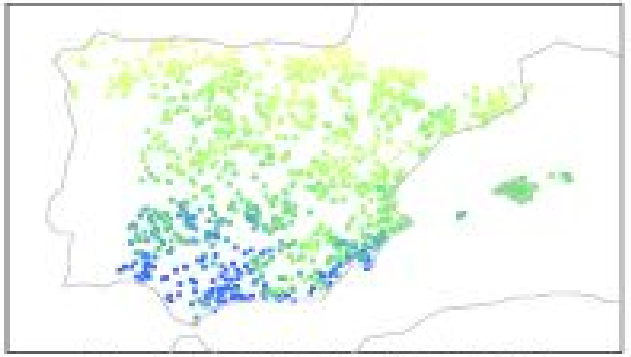
Consecutive Dry Days

SAFRAN



M=0.04 S=1.04 R=0.49 C=0.88

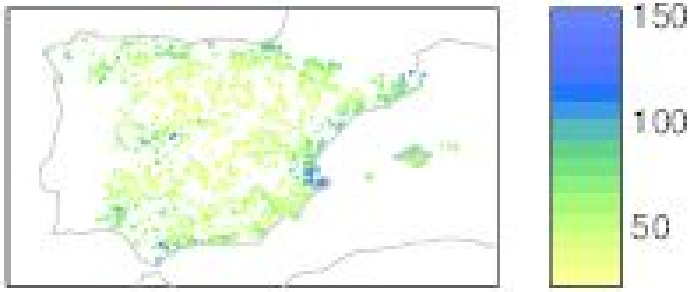
Spain02



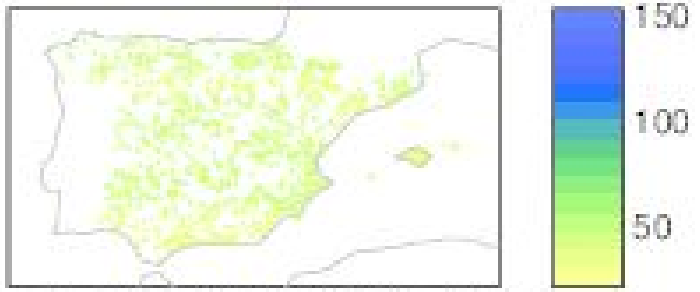
M=−0.03 S=0.91 R=0.50 C=0.87

Spatial validation of precipitation indices

Observations



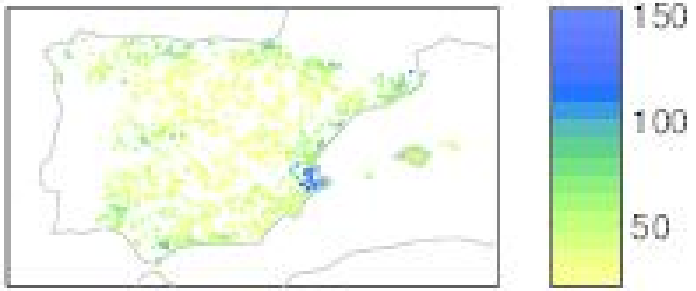
ERA-Interim



M=−0.29 S=0.26 R=1.04 C=−0.02

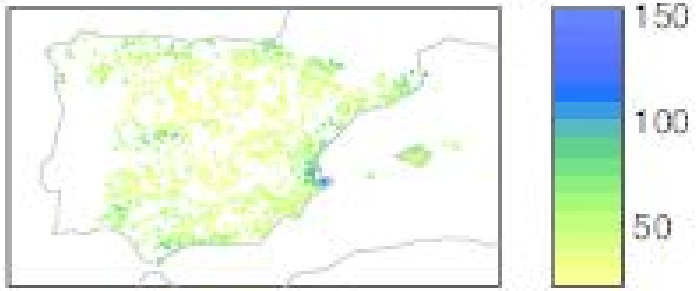
Max. precipitation in 1 day.

SAFRAN



M=−0.18 S=0.96 R=0.59 C=0.82

Spain02



M=−0.15 S=0.78 R=0.46 C=0.90

Spatial validation of precipitation indices

- Comparison of the spatial fields.
- Consecutive Dry Days
  - ERA is quite good!
  - SFR and SP02 are very similar.
- Consecutive Wet Days
  - ERA is surprisingly good!
  - **Why are SFR and SP02 suffering with this index?**
- Total precipitation
  - Both SFR and SP02 are very similar.

	Relative Bias	Relative Std. Dev	Relative Centred RMSE	Corre-lation
	Consecutive Dry Days			
ERA	**-0.01**	1.28	0.69	**0.85**
SFR	0.04	**1.04**	**0.49**	0.88
SP02	-0.03	0.91	0.50	0.87
	Consecutive Wet Days			
ERA	**0.26**	**1.08**	0.89	0.64
SFR	0.44	1.47	0.75	0.88
SP02	0.27	1.27	**0.55**	**0.91**
	Total Precipitation			
ERA	-0.16	0.81	0.80	0.63
SFR	**0.01**	**1.00**	0.39	0.92
SP02	0.04	0.97	**0.34**	**0.94**

Spatial validation of precipitation indices

- Number of Rainy days
  - SP02 is the best product.
  - SAFRAN's problems caused by the zones?
- Number of days P>10 and P >20 mm.
  - SP02 and SFR very close. SP02 slightly better.
  - SAFRAN suffering with stronger precipitation events.
    - Again, is this due to the zones? The quality control?

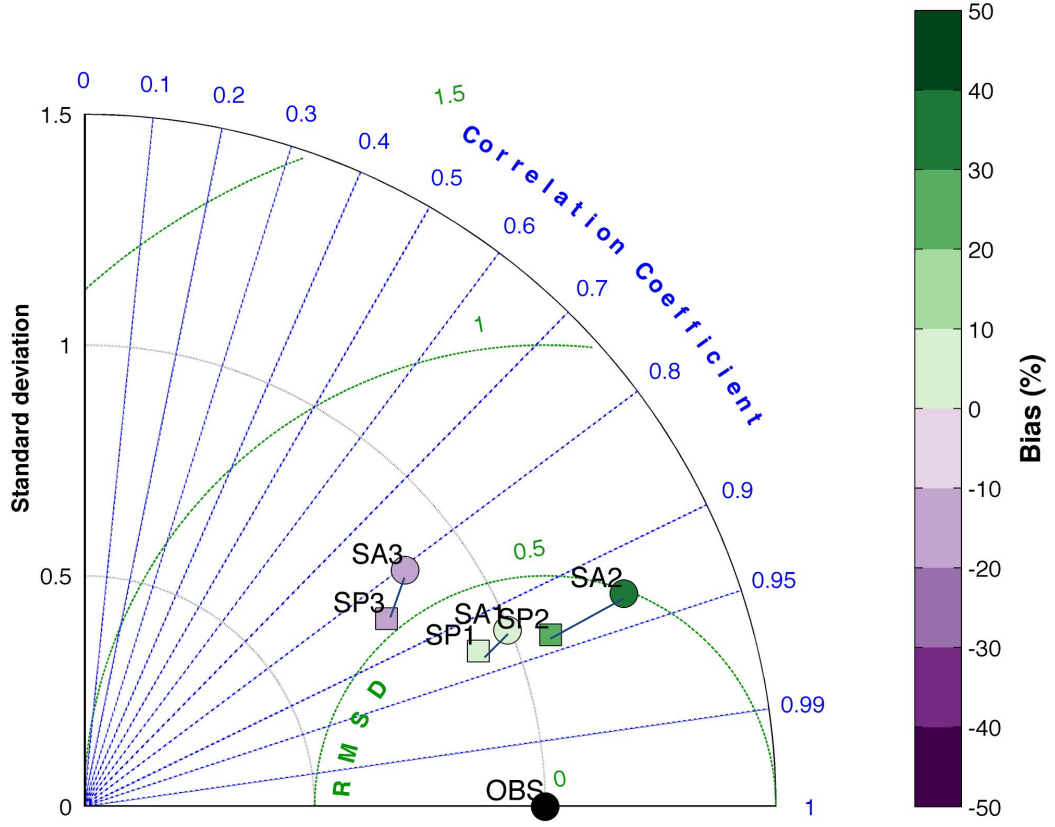
	Relative Bias	Relative Std. Dev	Relative Centred RMSE	Corre-lation
	Number of Rainy days (P>1mm)			
ERA	0.39	1.66	1.06	0.79
SFR	0.40	1.27	0.50	0.93
SP02	**0.30**	**1.18**	**0.41**	**0.94**
	Number of days of P>10mm			
ERA	-0.31	0.71	0.78	0.64
SFR	**-0.04**	1.08	0.40	0.93
SP02	0.05	**1.06**	**0.34**	**0.95**
	Number of days of P>20mm			
ERA	-0.57	0.25	0.94	0.38
SFR	-0.22	**0.94**	0.46	0.89
SP02	**-0.09**	**0.94**	**0.40**	**0.92**

Spatial validation of precipitation indices

- Max precip in 1 and 5 days.
  - SP02 is better with these extremes.
  - SFR has better spatial variability. Why?
- Mean precipitation of a wet day.
  - SP02 is better. Probably due to intense events.
- In general
  - SP02 is better.
  - SAFRAN is very close.
  - SAFRAN's problems probably due to its hypothesis of climatological homogeneous zones.

	Relative Bias	Relative Std. Dev	Relative Centred RMSE	Corre-lation
	Max. Precip in 1 day			
ERA	-0.29	0.26	1.04	-0.02
SFR	-0.18	**0.96**	0.59	0.82
SP02	**-0.15**	0.78	**0.46**	**0.90**
	Max Precip in 5 days			
ERA	-0.27	0.26	1.01	0.10
SFR	-0.07	**0.94**	0.54	0.84
SP02	**-0.06**	0.85	**0.42**	**0.91**
	Mean precipitation of a wet day			
ERA	-0.40	0.16	1.03	-0.11
SFR	-0.26	**0.68**	0.66	0.76
SP02	**-0.18**	0.67	**0.59**	**0.82**

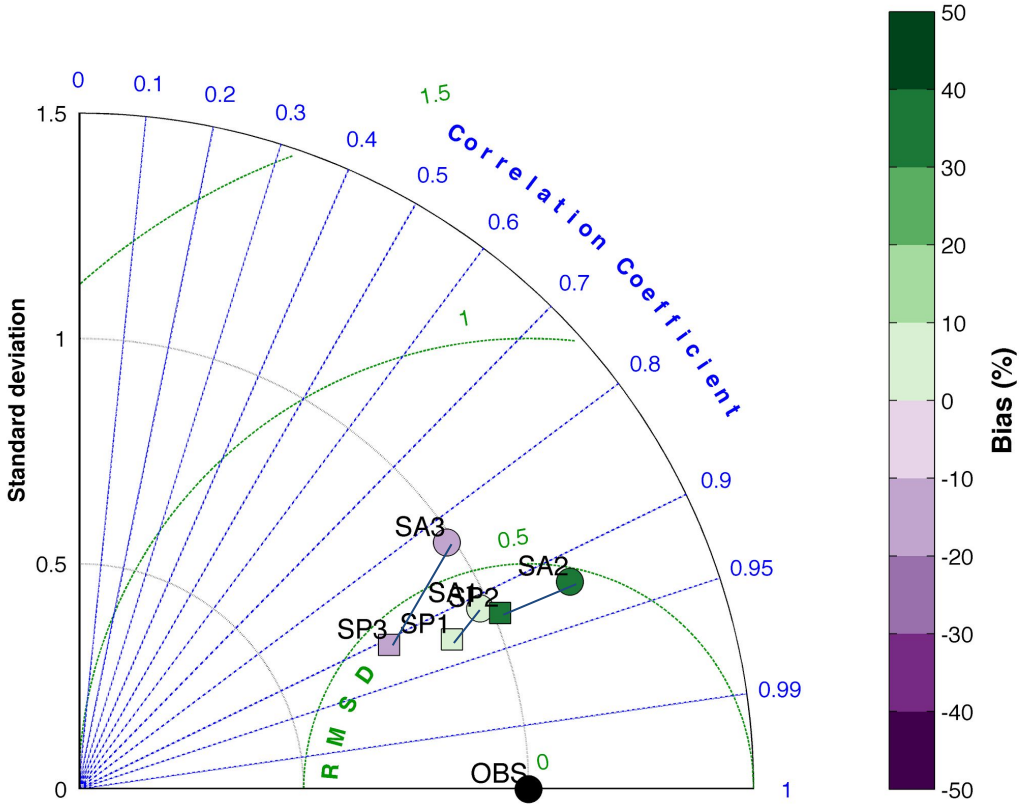
Taylor Diagram. Spring (MAM).



- The TD clearly shows that SP02 is slightly better.
- R1 shows the most important differences.

1 = PRCPTOT; 2 = R1; 3 = RX1DAY.

Taylor Diagram. Autumn (SON).



- Robustness.
  - The results are very similar to those of spring (and winter, and summer).

1 = PRCPTOT; 2 = R1; 3 = RX1DAY.

Hydrological simulation

SAFRAN is being implemented in Spain in order to be able to study the continental water cycle using a physically based and distributed approach based on a Land-Surface Model.

- Both SAFRAN and SURFEX (our model of choice) have been implemented.
- The implementation of the river routing scheme is in progress.

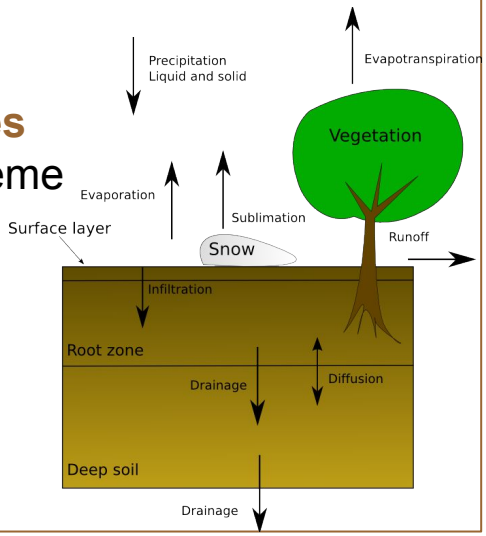
ATMOSPHERE *(SAFRAN)* → **LAND SURFACE** → **RIVER SYSTEM**

SURFEX

- Land Surface **modelling platform** of Météo-France
- **Off-line**
- **Modular**

ISBA-3L

- Scheme for **natural surfaces**
- **3 layered** force restore scheme
- **Robust**



EAU-DYSSÉE

- Integrated **modelling platform**
- Couples **specialized existing** models
- Developed at CNRS (France)

Modules:

- Water Balance (FP)
- **Surface (ISO)**
- **River routing (RAPID)**
- River levels (Q2Z)
- Unsaturated zone (ZNS)
- Underground Water (SAM)

Hydrological simulation

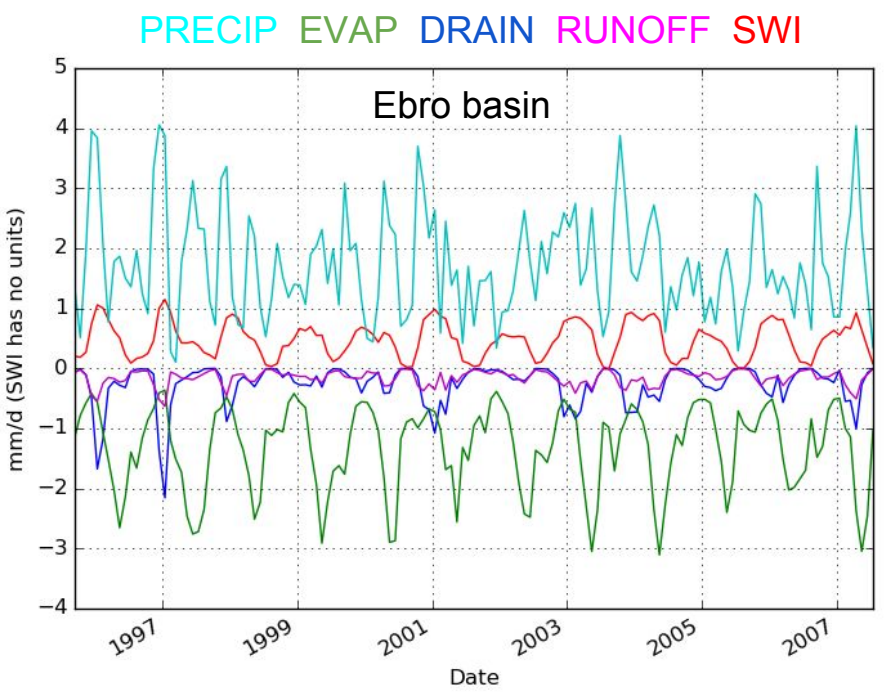
Water Balance (SURFEX)

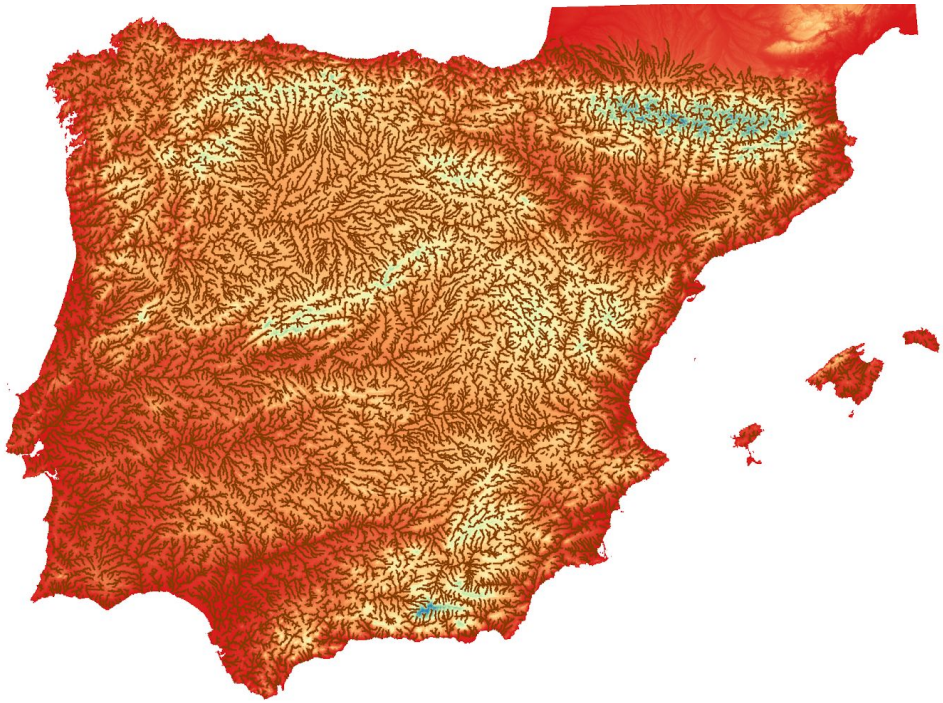
- SAFRAN-SURFEX simulation (1979-2014) already performed.

River routing modeling framework (Eau-Dyssée)

- **Hydrography**:
  - Hydrosheds (river network, drainage direction, flow accumulation).
    - Hydrosheds is a fine product, but it is not perfect.
  - Hydrodem: ongoing work at Irstea (Etienne Leblois, FR).
    - Closer to official data and more precise.
- **ISO**: routes runoff to the river network using isochronal zones.
- **RAPID**: routing scheme
  - Muskingum type model.
  - Flow estimation at any river network point.
  - Parallel computation
  - **Inclusion of anthropic effects (dams)**

Already implemented in SIM-France model (David et al,. 2011, Habets et al. 2014)





Conclusions and perspectives

Main conclusion

- SAFRAN is a very complete product (all variables necessary to force a LSM), whose daily precipitation is almost as good as Spain02's, which is a more specialised product.

Data sharing

- A 12 year dataset is already in the HyMeX database.
- The rest will follow.
- Contact me if you are interested in using the data.

Next steps

- Publish a paper with these results.
- Finish the implementation of the river flow model and run complete hydrological simulations.
- SURFEX-RAPID model adjustments, calibration and validation.
- Use the resulting simulations in order to:
  - Study drought processes in Spain (eartH2Observe project).
  - Study the performance of RCMs in studying hydrometeorological extremes (MARCO project).

Longer term

- Implement dams using simple rules.
- Improve the LSM simulation (we are now using ISBA-3L, there is room for improvement).

Thank You!