Implementation of a distributed model for the simulation of the past, present and future water balance of the NE Iberian Peninsula

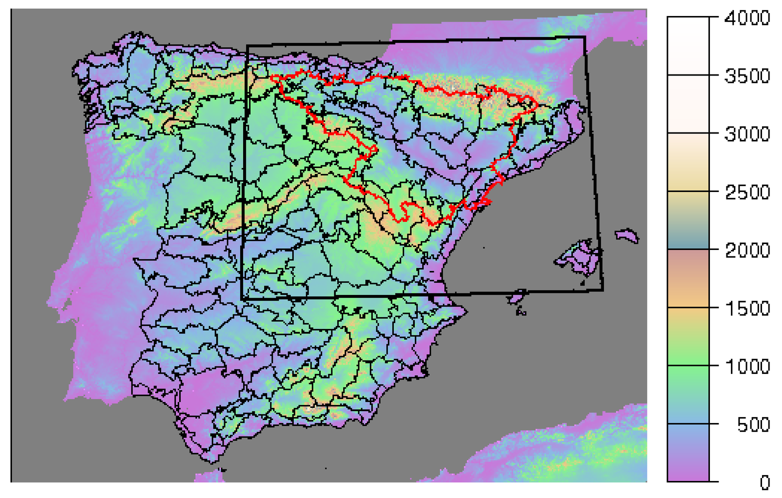
P. Quintana Seguí[1], M. Turco[2] and M.C. Llasat[2]
1: Observatori de l'Ebre (Universitat Ramon Llull – CSIC), Spain.
2: GAMA Team, Dept. of Astronomy and Meteorology, Fac. of Physics, Universitat de Barcelona, Spain.

Introduction

Due to the risks associated with the variability of the Iberian climate and the anthropogenic changes in the water cycle, including climate change, it is important to have a precise knowledge of the past, present and future water balance between the land surface (including soil and vegetation) and the atmosphere.

Currently, the scientific community is showing a strong interest in the Mediterranean water cycle, including the water balance on the continental surface. The HyMeX project (http://www.hymex.org) is instigating the development of systems that allow a better understanding of the hydrological cycle in the Mediterranean basins.

Under this Mediterranean perspective, the Ebro river basin is a very suitable study area. The Ebro river constitutes a major basin in the Iberian Peninsula and the western Mediterranean, along with the Rhône and the Po. Both the landscape and the precipitation regime of the Ebro show a great variability. In addition, snow plays an important role in the functioning of the basin. Due to these features, the Ebro basin is a demanding test for any hydrological modeling system.

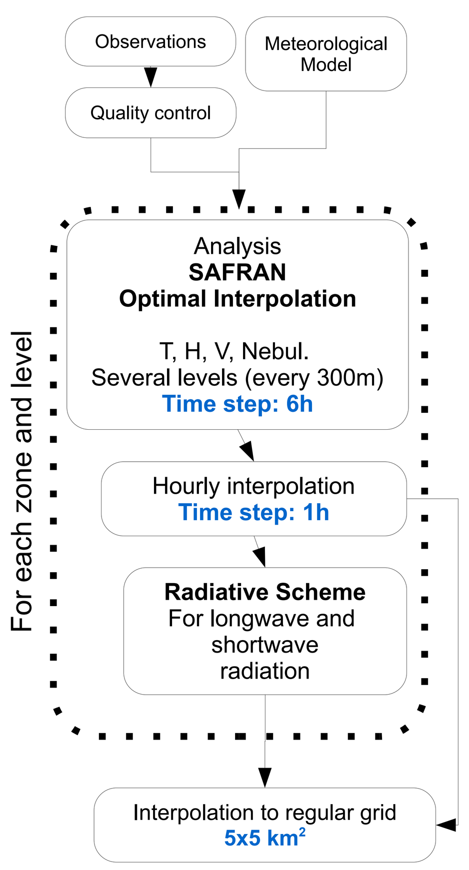


Area of study:
•NE of the Iberian Peninsula (black square)
•Focus on
- the Ebro river basin (red line)
- Internal basins of Catalonia (NE tip of the Peninsula)

• The black borders show the meteorological alert-zones of AEMET, the Spanish meteorological service.

Time period:
Our first prototype of the system is applied to the hydrological year **2009/2010**.

SAFRAN Meteorological Analysis



SAFRAN (Durand et al., 1993; Quintana-Seguí et al., 2008) provides the meteorological forcing to the system.

Inputs:
•All available observations
•First guess (meteorological model HIRLAM HNR)
Outputs:
• A gridded dataset of screen-level atmospheric observations:
- all variables necessary to force a land-surface model.
- high resolution: temporal (hourly) and spatial (5 km).

The analysis is done over irregular zones which are "climatically homogeneous".

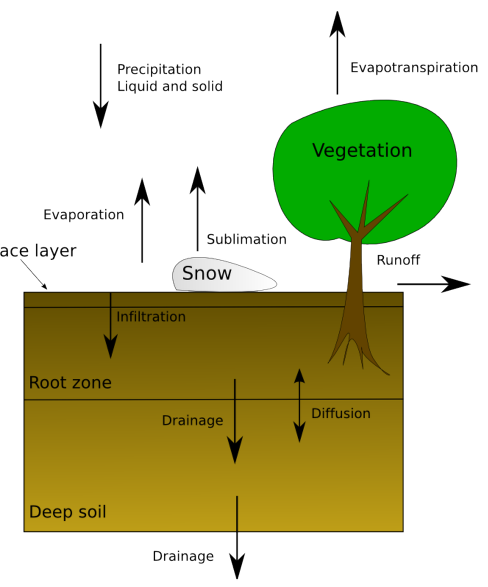
Ideally, within each zone, the spatial gradients are only due to differences in topography (altitude). There must be observations within each zone.

There is one analysis for each zone and level (there is a level each 300 m.).

The method is well adapted to mountainous areas (common in the Iberian Peninsula), as it deals very well with vertical gradients.

Long and short wave radiation is calculated with a radiation scheme due to the lack of observations.

SURFEX Land Surface Model



Our next step is to force the SURFEX land surface model with SAFRAN data.

SURFEX is a modular land-surface model. We will use the ISBA scheme (Noilhan and Planton, 1989) offline, forced by SAFRAN. ISBA calculates the water and energy balances.

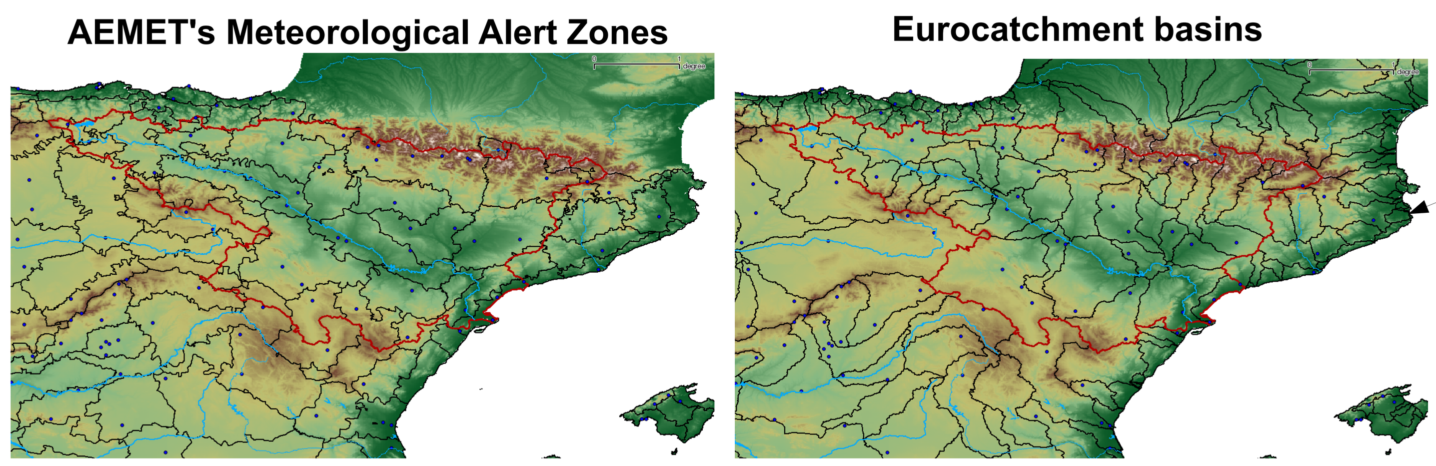
We will use the simple force-restore method with three layers (as shown on the figure). In the future we might use a multi-layer diffusion version.

ISBA was first developed as a scheme for meteorological models, but it has been improved for hydrological contexts (Quintana-Seguí et al. 2009).

Results

In this section, a preliminar validation of SAFRAN applied to the NE of the Iberian Peninsula is shown.

Two possible sets of "climatically homogeneous" zones are being tested:

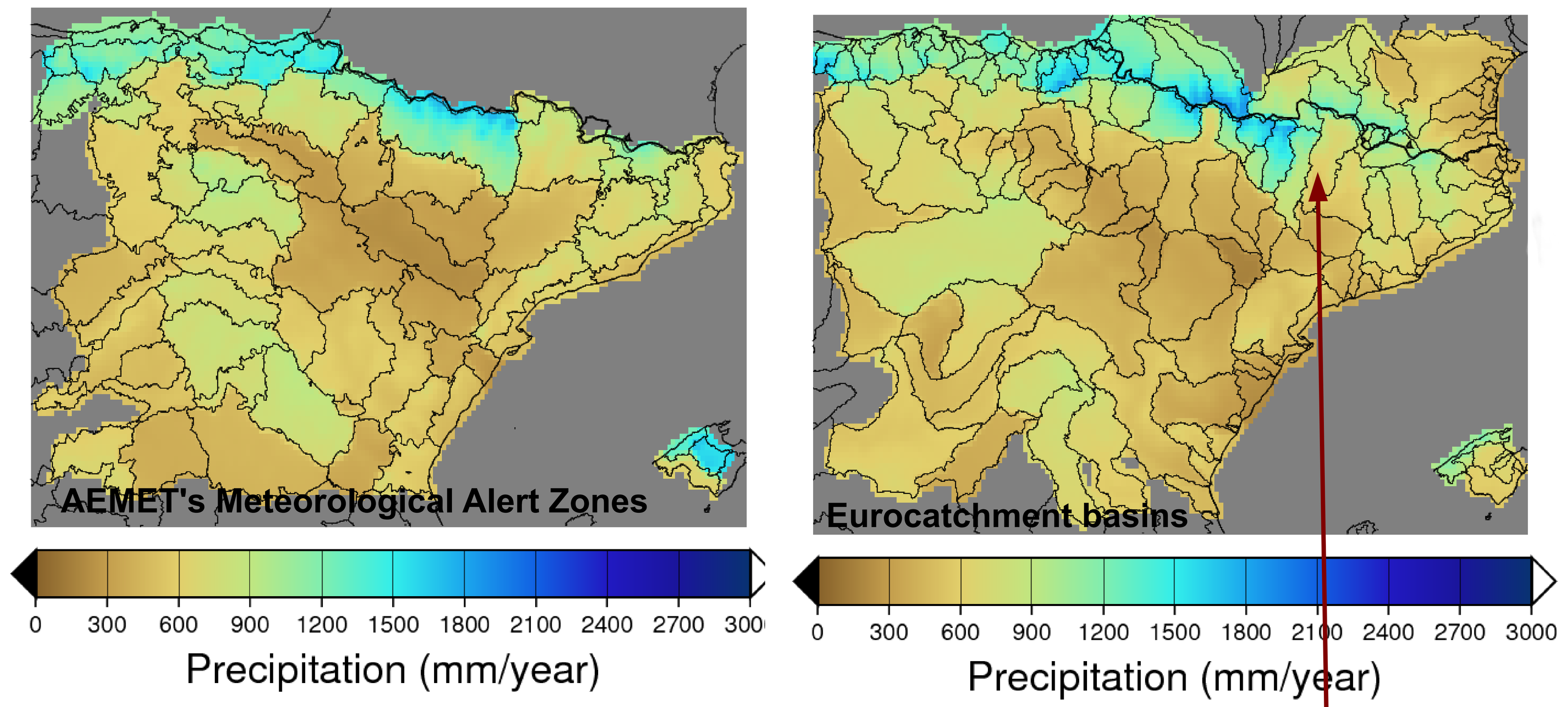


•In order to use Eurocatchment, the smallest basins will be joined together.
• The Ebro basin is depicted in red as a reference.

- Defined using the experience of AEMET
- They respect the climatology
- They respect the adminstrative borders
- This is the same method used in France
- The French zones are smaller than the Spanish ones.

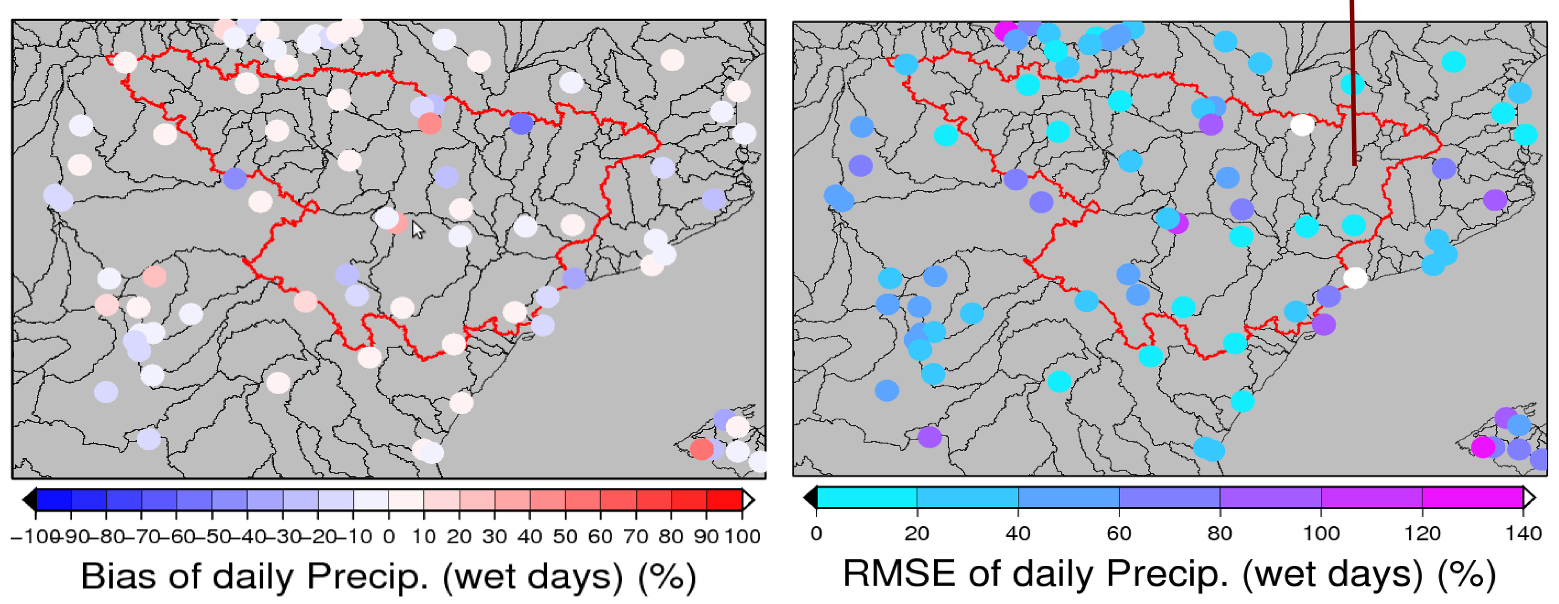
- The catchment is the natural space unit of hydrology
- Based on topography
- They respect water management borders
- *Eurocatchment*: It is official in the EU.
- Size is very variable

•The following figures and table show the results for the hydrological year 2009/2010.
•We only show precipitation, but SAFRAN also analyses temperature, wind speed, relative humidity and cloudiness.



•The scores were calculated using the same data used to do the analysis, so it is not an independent validation.
• For precipitation, it is better not to use the first guess, as the model degrades the analysis instead of improving it. For the other variables, which the model simulates well, we use the meteorological model as a first guess.

As there is no data in these zones, the analysis severely underestimates precipitation.



•A day is wet if precipitation > 1 mm/d.
• Biases are generally small,
- but sometimes there are some dipolar structures when the zones are not climatically homogeneous.

• The results are similar with both divisions (not shown).
• The number of stations is too small, there are zones without observations. In this areas, SAFRAN cannot do the analysis reliably.

In the following table we compare the general statistics using both sets of zones and we compare them to the scores in France (from Quintana-Seguí et al 2008).

	Temperature (C)		Wind Speed (m/s)		Precipitation (mm/d)	
	<Bias>	<RMSE>	<Bias>	<RMSE>	<Bias>	<RMSE>
meteoalerta	0,0	0,9	−0,2	1,1	0,0	3,2
eurocatchment	0,0	0,8	−0,3	1,1	0,0	2,5
SAFRAN/F 0102	0,0	1,5	−0,3	1,4	0,0	2,4
SAFRAN/F 0405	0,0	1,4	−0,2	1,4	0,0	2,4

The scores of SAFRAN in Spain are comparable to the scores in France.

Summary and conclusions

• SAFRAN has been successfully implemented on the NE of the Iberian Peninsula.
•Our results are still preliminary:
- more data of precipitation is needed.
- the validation was not done using independent data.

• The choice of SAFRAN for this area of study is pertinent, as it performs similarly as it does in France, where it is operationally used in many contexts.
• The meteorological alert zones are generally homogeneous, nevertheless, our preliminary results show that the division in basins (eurocatchment) is better, mainly for precipitation, which is not a surprise from an hydrological perspective.
- The meteorological alert zones were not defined using an objective methodology, they were defined using the experience of AEMET's forecasters. This study is an indirect validation of the homogeneity of the zones.

• We are in the right direction to build a model similar to the French SAFRAN-ISBA-MODCOU (Habets et al. 2008, Quintana Seguí et al., 2009).
- The availability of a good data set is usually the major difficulty to overcome before using a land-surface model.

• The SAFRAN gridded database (which include many atmospheric variables of interest) and the simulations of the water balance (in the present and future climate) will be very useful for research on hydrology (water resources, drought, etc.), agronomy, risk of forest fires, etc.

Future work

Concerning the meteorological analysis, we will:
• dramatically increase the number of observations of temperature and precipitation.
• validate SAFRAN using independent data.
• choose the definitive set of zones (probably eurocatchment)
• compare it with the first guess
• compare it with AEMET's SPAN analysis system, which also uses optimal interpolation.

Concerning the land surface model, we will:
• implement it (soon).
• force it with SAFRAN and SPAN (to compare the differences).
• validate the system with independent data (soil moisture, fluxes, etc.)

Within the HyMeX project we will:
• Compare the hydrological cycle on both sides of the Pyrenees, comparing our simulations with the French SAFRAN-ISBA-MODCOU.
• Compare our model and the Mediterranean Land Data Assimilation System (MELDAS) on the Ebro river basin.

Impacts of climate change:
• The system described, once fully implemented, will also be used to study the impact of climate change.
•We are currently developing a statistical downscaling system especially suited to the Mediterranean region of the Iberian Peninsula (within the esTcena project). The downscaling system, will use the SAFRAN database as the observational database and will create forcing data suitable for use with SURFEX and any other distributed surface model (including hydrology, agronomy, etc.).

Hydrology:
• In 2012 we plan to couple SAFRAN-SURFEX to a routing scheme in order to simulate river discharge.

References

Durand, Y et al. 1993. "A meteorological estimation of relevant parameters for snow models." Annals of Glaciology 18:65-71.
Noilhan, J, and S Planton. 1989. "A Simple Parameterization of Land Surface Processes for Meteorological Models." Monthly Weather Review 117:536-549.
Habets, F. et al. 2008. "The SAFRAN-ISBA-MODCOU hydrometeorological model applied over France." Journal of Geophysical Research 113.
Quintana-Seguí, P. et al. 2008. "Analysis of Near-Surface Atmospheric Variables: Validation of the SAFRAN Analysis over France." Journal of Applied Meteorology and Climatology 47:92.
Quintana Seguí, P, E Martin, F Habets, and J Noilhan. 2009. "Improvement, calibration and validation of a distributed hydrological model over France." Hydrol. Earth Syst. Sci. 13:163-181.
Quintana Seguí, P., A. Ribes, E. Martin, F. Habets, and J. Boé. 2010. "Comparison of three downscaling methods in simulating the impact of climate change on the hydrology of Mediterranean basins." Journal of Hydrology 383:111-124. http://linkinghub.elsevier.com/retrieve/pii/S0022169409006246.

Acknowledgements

This project is possible thanks to the collaboration with the Spanish meteorological service (AEMET) and the French National Center for Meteorological Research (CNRM-GAME, Météo-France CNRS).

European Geosciences Union, General Assembly 2011, Vienna (Austria), 03 – 08 April 2011.
Contact: Pere Quintana Seguí, pquintana@obsebre.es, http://pere.quintanasegui.com, http://www.obsebre.es
Download the abstract: http://meetingorganizer.copernicus.org/EGU2011/EGU2011-6700-1.pdf
Download the poster: http://pere.quintanasegui.com/coses/quintana-egu-2011-poster.pdf