Towards better regional scale modeling: **LIAISE WG3 experimental protocol**

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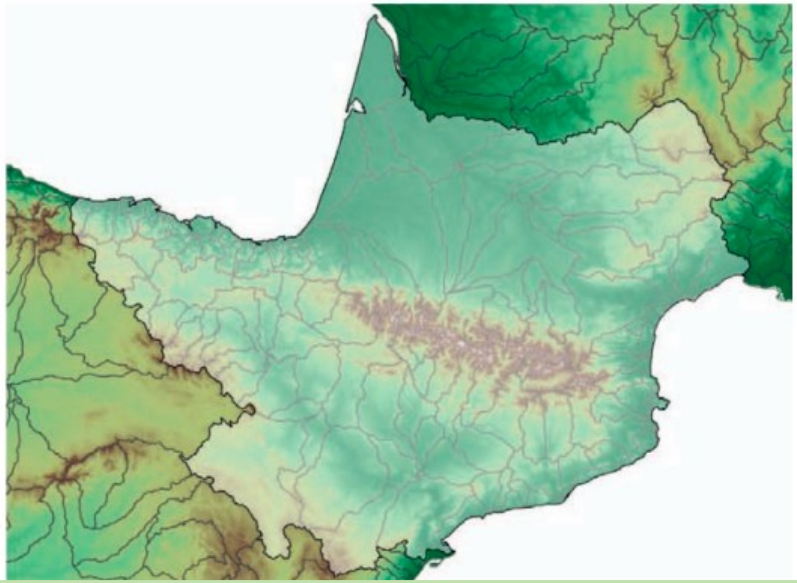


Area of interest

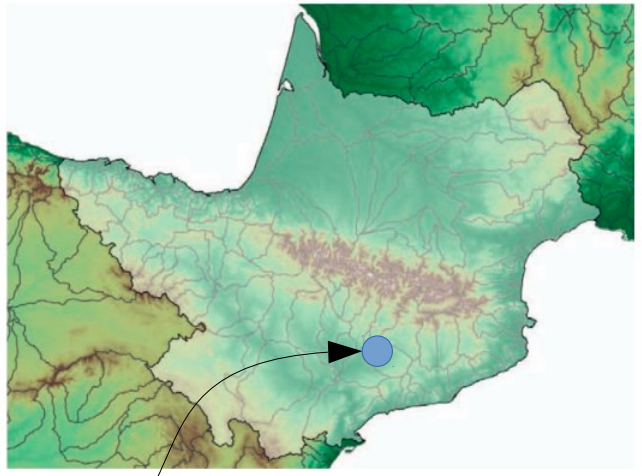
Project PIRAGUA
https://www.opcc-ctp.org/fr/piragua

1- Km-scale forcing files

- Domain

<u>Area of study</u> LIAISE project *(Boone, 2019)*

- Covers the area of the LIAISE field campaign
- Covers the full catchments of the main rivers of the area of interest (Ebro in Spain, Garonne in France)
- **Contrasted topography and climate**
- with a known **large impact of human water usage**.
- Rich existing climate datasets
- The region is known for having already suffered the consequence of **climate change** :
    - Less snow in the Pyrenees
    - More water demand from plants and thus irrigation needs



Project PIRAGUA
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1- Km-scale forcing files

- Method

Observation-based
coarser data set
SAFRAN
(1979-2013, daily)

Output from
convection-permitting regional climate runs (CPRCM)
of the EUCP project

(2000-2010, hourly)
High resolution grid (km scale),
Run in coupled mode **hourly scale**
Forced by ERA-interim reanalysis

Projected on a regular lat/lon grid ~ 3km resolution

Downscaling of the coarser dataset at km resolution…

...through a **bias correction** method + analogue day

Final km-scale forcings

- Regular lat/lon grid ~ 3km resolution

- Format corresponding to the GLASS ALMA protocol

- 1989-2013
(lack of more recent observations in SAFRAN-Spain does not allow us to move closer to real-time.)

More detail on the method freely available :
https://gitlab.in2p3.fr/ipsl/lmd/intro/liaise-forcing/-/wikis/home

1- Km-scale forcing files

- Sampling uncertainties

There are **two main uncertainties** which should be sampled :

- The **altitudinal dependence of the bias** between the models and station data.
- The **altitudinal variation** of the forcing variables **predicted by the CPRCM**

Favor either the altitudinal distribution from SAFRAN or from the CRPCM

Test different CRPCM for the downscaling (at least 2, maybe 3)

→ In order to sample these uncertainties **4 to 6 forcing data sets** will be produced

→ **Each forcing** will be about **300Gb** of data.
It will be provided through the IPSL servers and referenced with a DOI (ACTRIS catalogue where LIAISE is already residing).

2- Experimentation and protocole

- Baseline experiment
  - Objective :

Evaluate at **catchment scale** the **biases of the different models** depending on the forcing
→ Biases established at annual scales, between simulated P-E and the **observed discharge** at the gauging station which are selected

  - Hypotheses :

- The **biases of the models** are **within the uncertainty of the atmospheric variables** (P and PET)

→ km-scales the **atmospheric data are more uncertain** than our ability to represent surface processes

- They are **much larger**

→ at km-scales **land surface models have structural issues** independent of our knowledge of atmospheric conditions at these resolutions.

2- Experimentation and protocole

- Baseline experiment
  - Variables :

All models should report on the 3km grid daily values of the following variables :

- ***Precipitation*** (rainfall plus snowfall for verification) [kg/m²/s]
- ***Potential evaporation*** as defined by the model [kg/m²/s]
- ***Evaporation*** [kg/m²/s]
- ***Surface runoff*** [kg/m²/s]
- ***Deep drainage*** plus lateral flows [kg/m²/s]
- ***Snow water equivalent*** [kg/m²]
- ***Soil moisture index*** [-]
- ***Discharge*** at selected gauging stations *(if available)* [m³/s]

2- Experimentation and protocole

- Expected analyses

→ diagnostics will concentrate on the **water balance** of **catchments** defined by existing gauging stations, and their variability over the 25 years of forcing data.

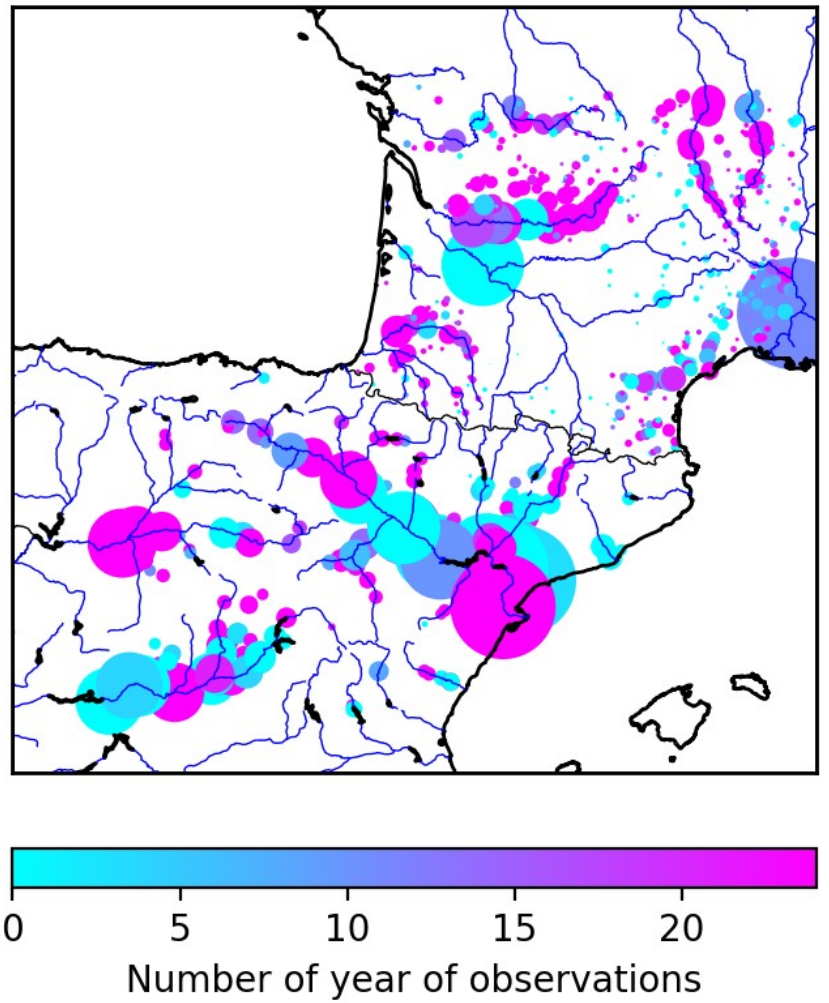
<u>Main lines of investigation :</u>

- How large are the **errors** in the **catchment scale water balance** of the various catchments ?
- Are these errors **dependent on size or altitude** of catchments ?
- Are they **larger than the forcing uncertainty** and **systematic between models** ?
- Are the errors **dependent on the degree of human intervention** within the catchments ?
- What is the **role of water advection** by aquifers at slope scale or larger ?
- **Are some models « outliers »** and can this be explained by their structure ?

Encouraging results

Discharge

Stations positionned on the forcing grid



For the period 1989-2013

Encouraging results

ORCHIDEE model

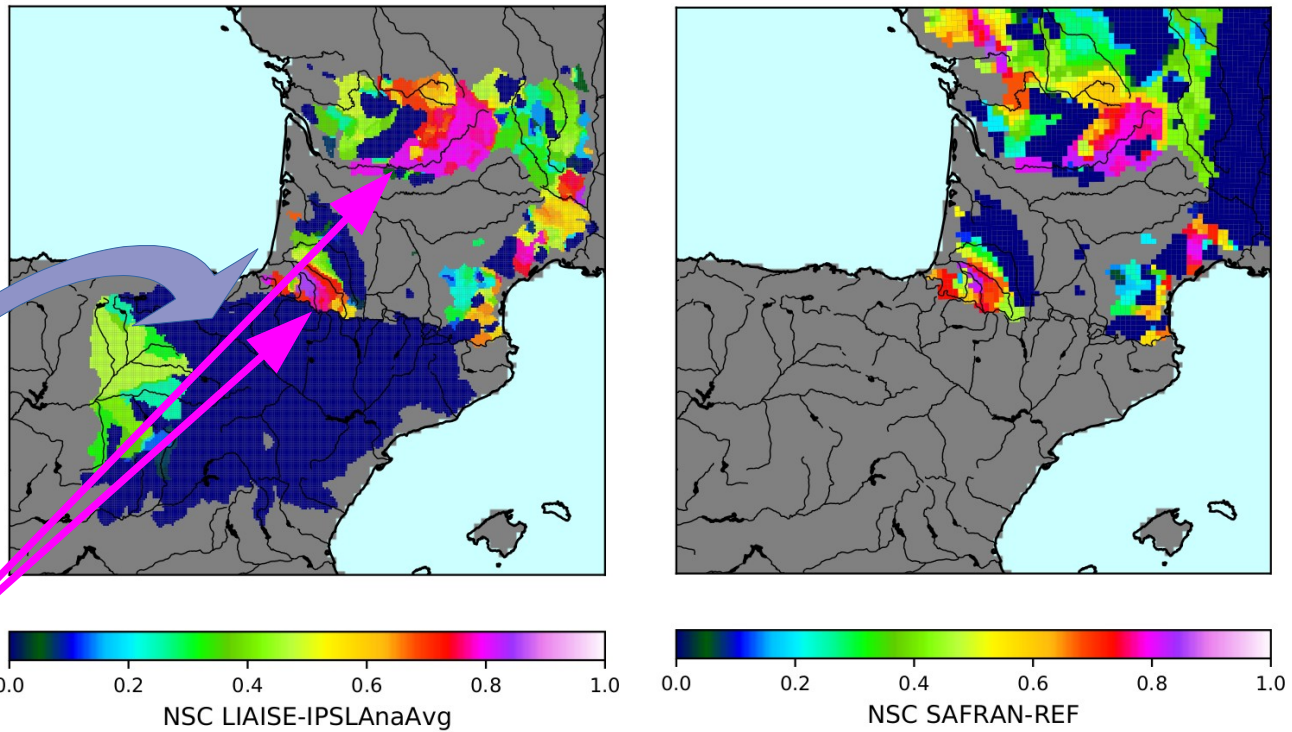
Discharge

Performance for the period 1989-2013: ***NSC***

~3km forcing with RegIPSL, Favoring altitudinal distribution of RegIPSL

- ***Main errors*** *: large and downstream valley basins*

- ***Best*** *: small mountainous basins*



SAFRAN forcing : disaggregated to 8km

- Similar results for both forcings → Similar temporal variations and annual cycles (by construction)

Error rather dependent on the model than on the forcing sensitivity

Encouraging results

ORCHIDEE model

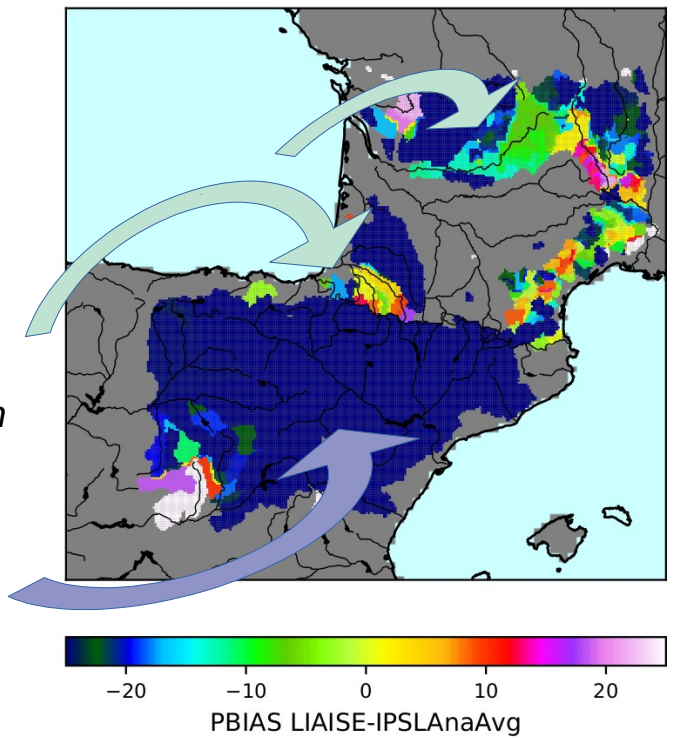
Discharge

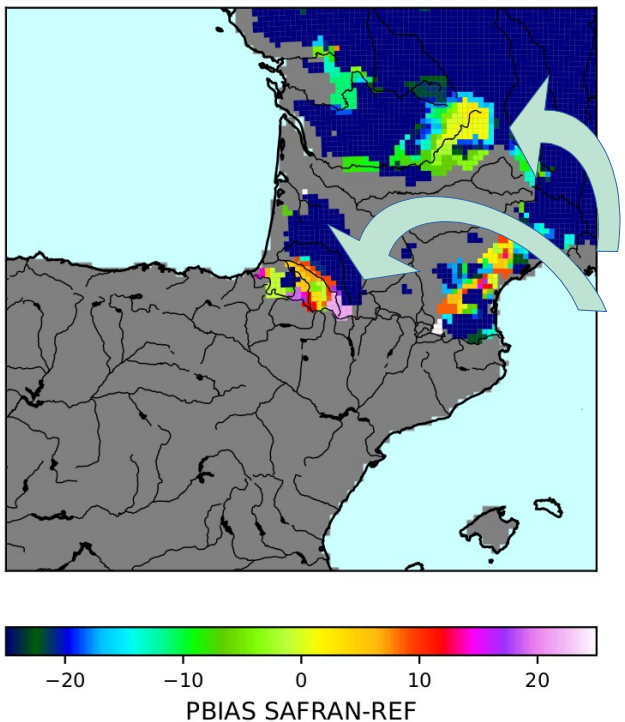
Performance for the period 1989-2013: ***PBIAS*** (Obs - Mod)/Obs

~3km forcing with RegIPSL, Favoring altitudinal distribution of RegIPSL

Less wet or towards dry bias *in small mountainous area*

Wet bias *in downstream area*





SAFRAN forcing : disaggregated to 8km

Similar results with dryer biases in mountainous catchments

Our 3km forcing puts more water in mountainous catchments
Wet bias in downstream area due to missing processes in the model

2- Experimentation and protocole

- Expected analyses

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<u>Main lines of investigation :</u>

- How large are the **errors** in the **catchment scale water balance** of the various catchments ?
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2- Experimentation and protocole

- Further experiments

Main hypothesis : → **lack of water transport** (natural or anthropogenic, surface or below ground) **in most models**

If confirmed by baseline experiments results, specific tests can be designed :

→ Modified one of the forcing (to be selected later) to represent the enhanced water availability in certain areas

→ **New precipitation field P' = P+ΔP** where ΔP is the increment to be distributed in space and time

Two main hypotheses

→ **Riparian or ground water processes** :
ΔP → runoff or drainage fluxes reaching downstream areas (This can be extracted from one of models of the reference simulation which represents these processes).

→ **Anthropogenic water management** :
ΔP → water transported by human infrastructures to irrigation areas.

Open discussion

Questions, remarks, new ideas to improve the protocole and analyses?

→ Final protocole and result of analyses will be added to the methodology for the forcing construction on Gitlab : https://gitlab.in2p3.fr/ipsl/lmd/intro/liaise-forcing/-/wikis/home