

Are more advanced hydrological models necessary to help water managers adapt to climate change?

Louise MIMÉAU¹, Louis Hérault¹, Jean-Philippe Vidal¹, Flora Branger¹

¹RIVERLY, INRAE Lyon-Villeurbanne, FR

What are the main hydrological changes expected in the medium to long term in my catchment area?

What frequencies and intensities of high or low flows levels should we prepare for?

What are the main hydrological changes expected in the medium to long term in my catchment area?

What frequencies and intensities of high or low flows levels should we prepare for?

Hydrological models enable to simulate catchments hydrological response to various scenarios (climate change, land use change, water management strategies).

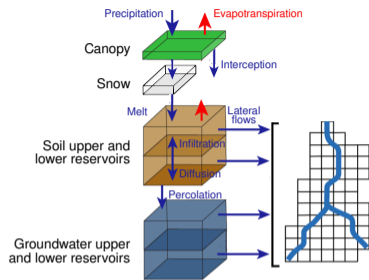
What are the main hydrological changes expected in the medium to long term in my catchment area?

What frequencies and intensities of high or low flows levels should we prepare for?

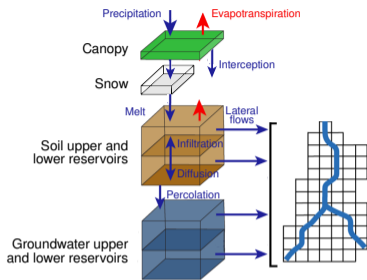
Hydrological models enable to simulate catchments hydrological response to various scenarios (climate change, land use change, water management strategies).

To what extent must hydrological models accurately represent catchment areas and hydrological processes in order to address local water management challenges?

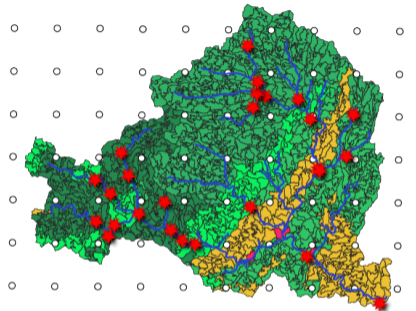
J2000: a spatially distributed hydrological model



J2000: a spatially distributed hydrological model



Ardèche catchment (2 260 km²)
1 466 cells and 143 reaches



Steps involved in building a model:

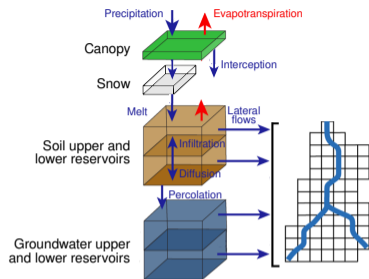
- ▶ Construction of the catchment grid
- ▶ Parameterisation of land use, soil and geology
- ▶ Climate data processing
- ▶ Calibration and evaluation

- * Gauging stations
- Climate forcing data

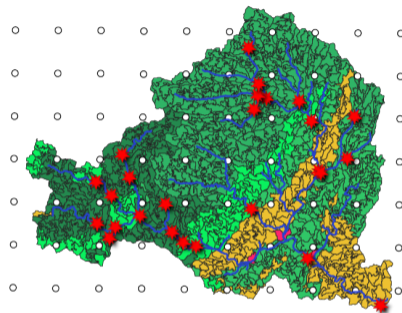
Landuse type

■ ■ ■ ■ ■

J2000: a spatially distributed hydrological model



Ardèche catchment (2 260 km²)
1 466 cells and 143 reaches



Steps involved in building a model:

- ▶ Construction of the catchment grid
- ▶ Parameterisation of land use, soil and geology
- ▶ Climate data processing
- ▶ Calibration and evaluation

- * Gauging stations
- Climate forcing data

Landuse type



It usually takes months before the model is ready to run climate change, land use or water management scenarios.

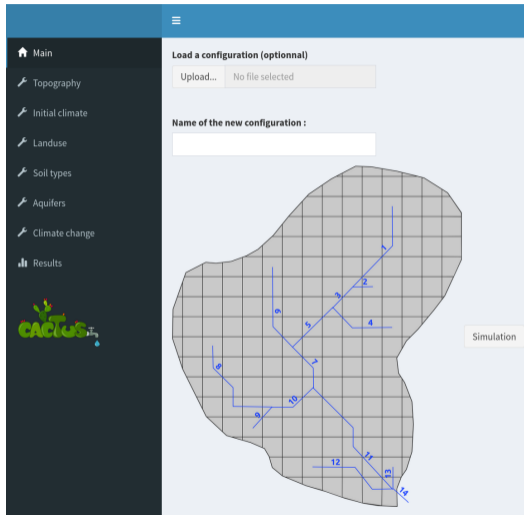
J2000-CACTUS: a simplified distributed model

J2000-CACTUS : Customisable
Catchment model for water Use
Scenarios

Interactive modelling tool for:

- ▶ customising the characteristics of a simplified catchment
- ▶ running simulations with climate or land use change scenarios
- ▶ visualising the simulation results

≈ 10-15 minutes to configure the catchment and a few seconds to run a 40-yr simulation



The screenshot displays the J2000-CACTUS web interface. On the left is a dark sidebar menu with the following items: 'Main' (with a home icon), 'Topography', 'Initial climate', 'Landuse', 'Soil types', 'Aquifers', 'Climate change', and 'Results' (with a bar chart icon). Below the menu is the 'CACTUS' logo. The main content area has a blue header with a hamburger menu icon. Below the header, there is a section titled 'Load a configuration (optional)' with an 'Upload...' button and the text 'No file selected'. Below that is a text input field labeled 'Name of the new configuration :'. The central part of the interface shows a map of a catchment area overlaid with a grid. A blue stream network is drawn on the map, with segments numbered 1 through 14. A 'Simulation' button is located to the right of the map.

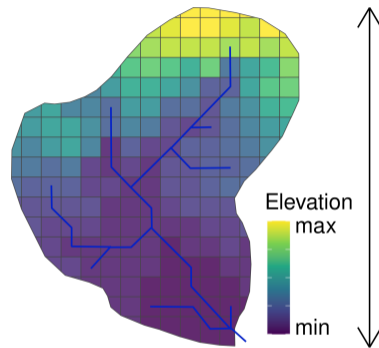
J2000-CACTUS: a simplified distributed model

Main simplifications:

- ▶ **Fixed shape and spatial discretization**

User can only configure:

- ▶ the catchment area
- ▶ the min and max elevations



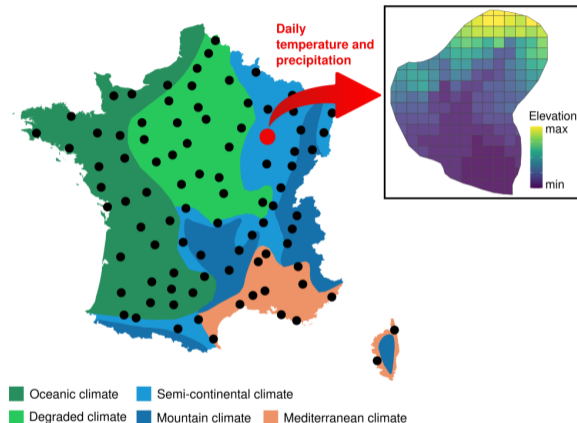
185 cells and 14 reaches

Area between 50 and 5 000 km²

J2000-CACTUS: a simplified distributed model

Main simplifications:

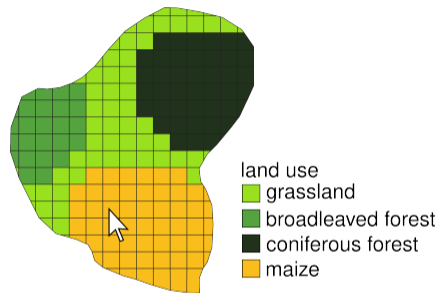
- ▶ Fixed shape and spatial discretization
- ▶ **Simplified climate forcing data**
 - ▶ P, T from the closest major city
 - ▶ P: spatially uniform
 - ▶ T: spatialized with a fixed lapse rate
 - ▶ ET: Penman-Monteith replaced with Oudin formula $f(T, \text{lat})$



J2000-CACTUS: a simplified distributed model

Main simplifications:

- ▶ Fixed shape and spatial discretization
- ▶ Simplified climate forcing data
- ▶ **Pre-determined classes and parameters of land use, soil types and aquifers (no calibration)**



17 classes of land use

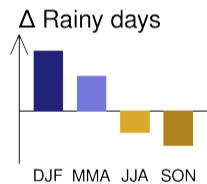
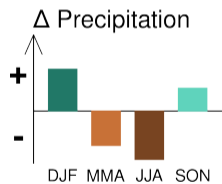
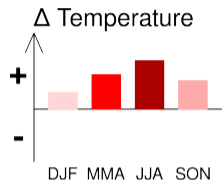
12 textures and 5 depths of soils

7 classes of aquifers

J2000-CACTUS: a simplified distributed model

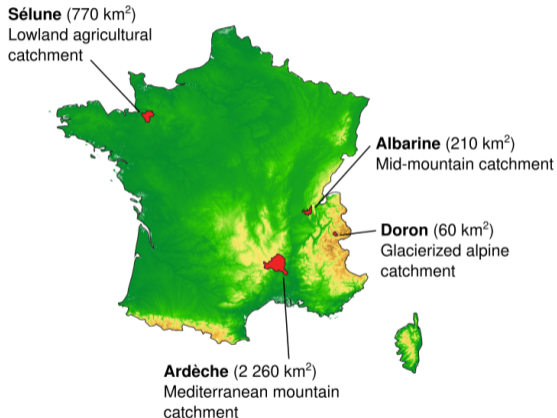
Main simplifications:

- ▶ Fixed shape and spatial discretization
- ▶ Simplified climate forcing data
- ▶ Pre-determined classes and parameters of land use, soil types and aquifers (no calibration)
- ▶ **Climate change scenarios:
perturbation of observed P and T**



J2000-CACTUS: How does it compare to other models?

Evaluation on 4 contrasted catchments:

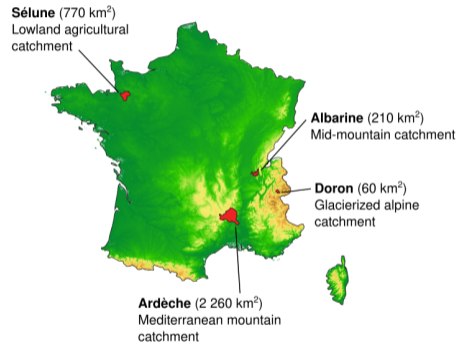
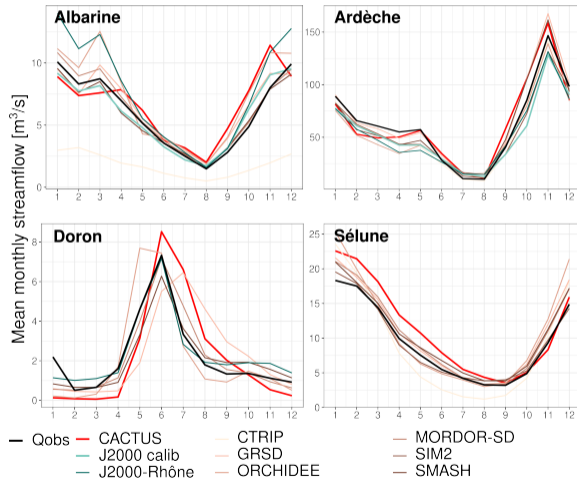


Comparison with:

- ▶ observed streamflows
- ▶ streamflows simulated with calibrated J2000 models
- ▶ streamflow projections from 6 other hydrological models and 4 climate projections (Sauquet et al. 2026)

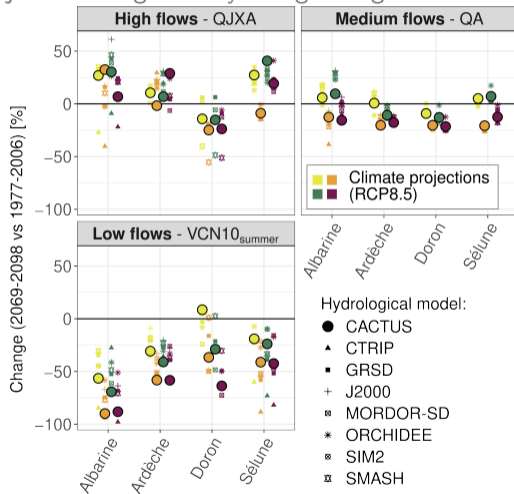
J2000-CACTUS: How does it compare to other models?

Hydrological regime under present climate (1990-2020)



J2000-CACTUS: How does it compare to other models?

Projected changes on hydrological signatures



QJXA: annual maximum daily streamflow

QA: annual average daily streamflow

VCN10: annual minimum of the 10-day mean flow

Conclusions

Summary

- ▶ Hydrological regimes and changes in hydrological signatures simulated with the simplified J2000-CACTUS model are consistent with observed data and other hydrological models simulations.

Implications

- ▶ Simplified hydrological models can provide water managers with a valuable primary level information for initiating an exploration of adaptation strategies.

Outlooks

- ▶ Further analysis of the contexts in which model simplifications succeed or fail to accurately simulate catchment hydrology
- ▶ Online publication of the J2000-CACTUS app (coming soon)

Demo video

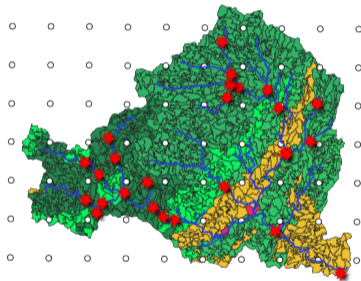


J2000-CACTUS: a simplified distributed model

Ardèche catchment (2 260 km²)

J2000

1 466 cells and 143 reaches



Climate variables: P, T, WS, RH, SW, LW at 8x8 km

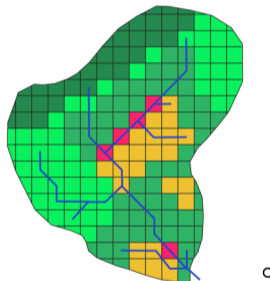
Calibrated

Climate change scenarios: projections from
4 GCM/RCM

INRAE

J2000-CACTUS

185 cells and 14 reaches



Climate variables: P, T

Not calibrated

Climate change scenarios: seasonal
perturbation of observed climate

- ★ Gauging stations
- Climate forcing data

Land use

- Coniferous forest
- Broad-leaved forest
- Grassland
- Agricultural area
- Urban area

PrepCACTUS

RShiny app designed to easily retrieve J2000-CACTUS parameterisation data, for all French catchments.



Selection of a catchment in
prepCACTUS

Databases:

HydroBASINS (*watersheds and area*)

SAFRAN reanalysis (*elevations and present climate*)

Corine Land Cover 2018 (*land use*)

Soil Geographical Data Base of France (*soils*)

BDLisa (*geology*)

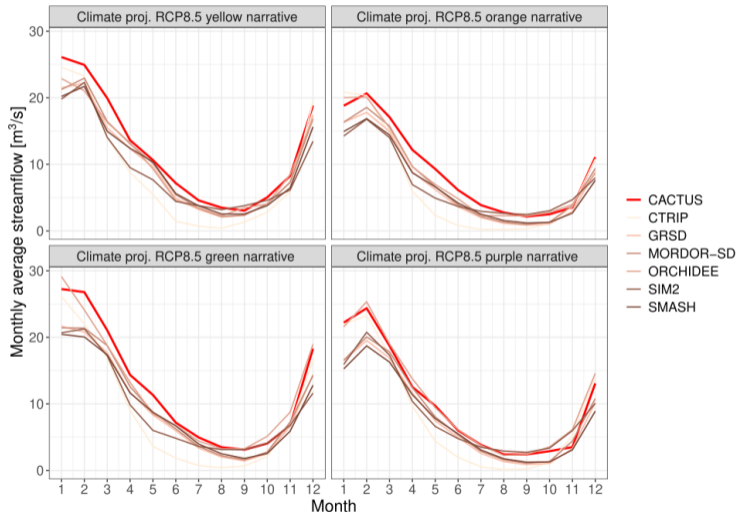
Explore2 (*climate change projections*)

Demo video



J2000-CACTUS: How does it compare to other models?

Projected hydrological regime at horizon 2070-2099 in the Sélune catchment



References

-  Sauquet, E. et al. (2026). “A large transient multi-scenario multi-model ensemble of future streamflow and groundwater projections in France”. In: *Hydrology and Earth System Sciences* 30.8, pp. 2277–2300.