



# News from regional climate modeling at CNRM

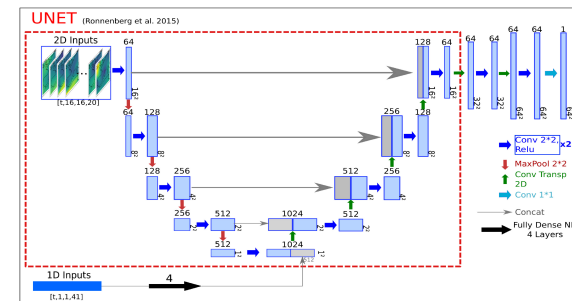
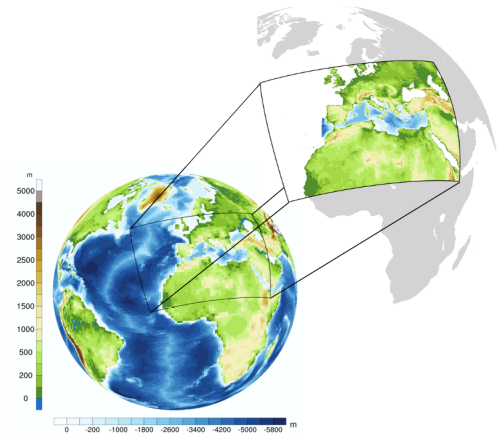
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Pierre Nabat, Cécile Caillaud, Amarys Casnin, Antoine Doury,  
Manon Gévaudan, Elizabeth Harader-Coustau, Romain Lenoble,  
Florence Sevault, Samuel Somot and the CNRM MOSCA team

CNRM/GMGEC/MOSCA  
14/04/2026

# Regional climate modeling at CNRM : the MOSCA team

- **Regional climate modeling team** aiming at improving knowledge on regional climate through a dedicated modeling approach
- **Scientific objectives : modeling, characterizing and understanding**
  - 1) past regional climate variability
  - 2) regional climate response to climate change
  - 3) key regional climate phenomena and their variability
- **A dedicated modeling approach : developement and use of a family of numeric models**
  - **Physical** : CNRM-ALADIN (12-50km) and CNRM-AROME (2.5km) for the atmosphere, CNRM-RCSM / AROBASE for coupled system
  - **Statistic** : CNRM-UNET (AI emulator)
- **Other activities :**
  - Regional impacts of climate change
  - Contribution to climate services at Meteo-France



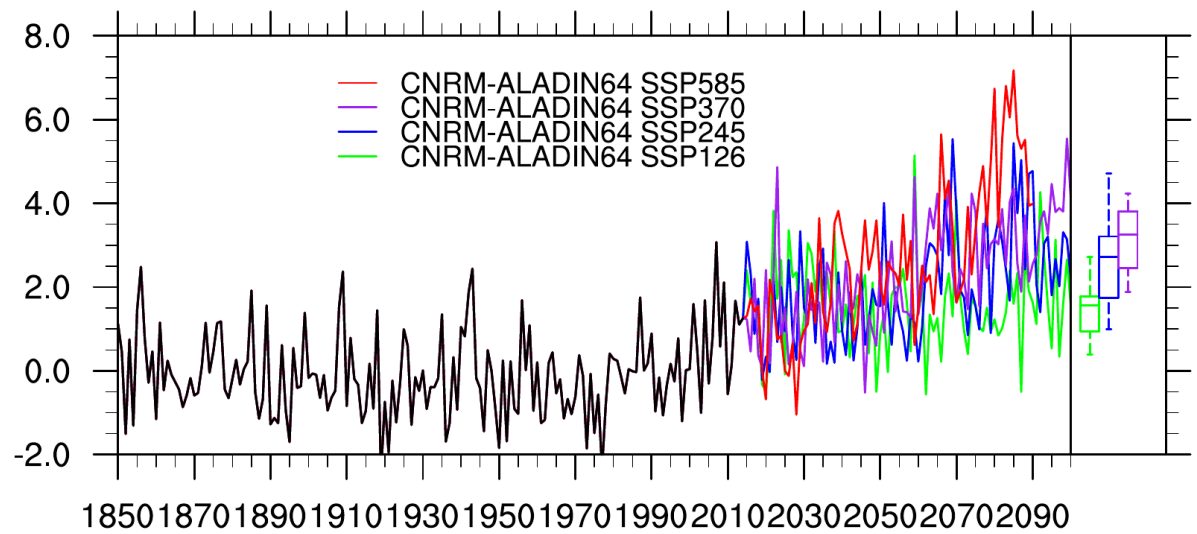
# ALADIN – AROME : the current versions

Component	ALADIN	AROME
<b>Atmosphere</b> <i>(convection / turbulence / radiation / microphysics)</i>	Cycle 37 – climate version 6.5 <i>(PCMT / Cuxart00 / FMR-RRTM / Lopez02)</i>	Cycle 46t1 <i>(PMMC09 (shallow) / Cuxart00 / FMR-RRTM / ICE3)</i>
<b>Surface</b> <i>(patches / land / cities / lakes / air-sea fluxes / land-use)</i>	SURFEX 8.0climate <i>(12 patches / ISBA-DIF / no / FLake / ECUME6 / constant)</i>	SURFEX 8.1 <i>(3 patches / ISBA-DIF / TEB-Garden-BEM / Charnok / ECUME6 / constant)</i>
<b>Aerosols / Chemistry</b>	Interactive aerosols (TACTIC) / no	Monthly AOD files / no
<b>Simulation workflow</b>	ECLIS	Scripts
<b>Postprocessing</b>	Online (XIOS)	Offline (Postald)
<b>Coupling</b>	NEMOMED - CTRIP	No coupling (in development with AROBASE)
<b>Calibration</b>	« Manual » calibration + New semi-automatic method (HighTune) for EURO- and CAM-CORDEX domains	« Manual » calibration

# New simulations for CORDEX and climate services

- **Important production of regional climate simulations in 2024-2025 with CNRM-ALADIN, CNRM-AROME and CNRM-RCSM (CORDEX-CMIP6, climate services)**
  - Europe (atm-aerosols-land-rivers, 12km, 1850-2100, 13 projections, 1743 years) + western Europe (atm-land, 2,5km, 1991-2100, 4 projections, 360 years)
  - Mediterranean (atm-aerosols-land-rivers-ocean, 12km, 1980-2100, 1 projection, 121 years)
  - Tropical Atlantic / Central America (atm-aerosols-land, 20km, 1950-2100, 1 projection, 151 years) + Antilles (atm-land, 2.5km, 1991-2100, 1 projection, 110 years)
  - Pacific Ocean (atm-land, 20km, 1950-2100, 1 projection, 151 years) + New-Caledonia + French Polynesia (atm-land, 2.5km, 1991-2100, 1 projection, 110 years x 2)
  - Indian Ocean (atm-land, 12km, 1950-2100, 4 projections, 409 years) + La Réunion Island (atm-land, 2.5km, 1991-2010+2081-2100, 1 projection, 40 years)
- **Next step : publication of output on ESGF (2026-2027)**

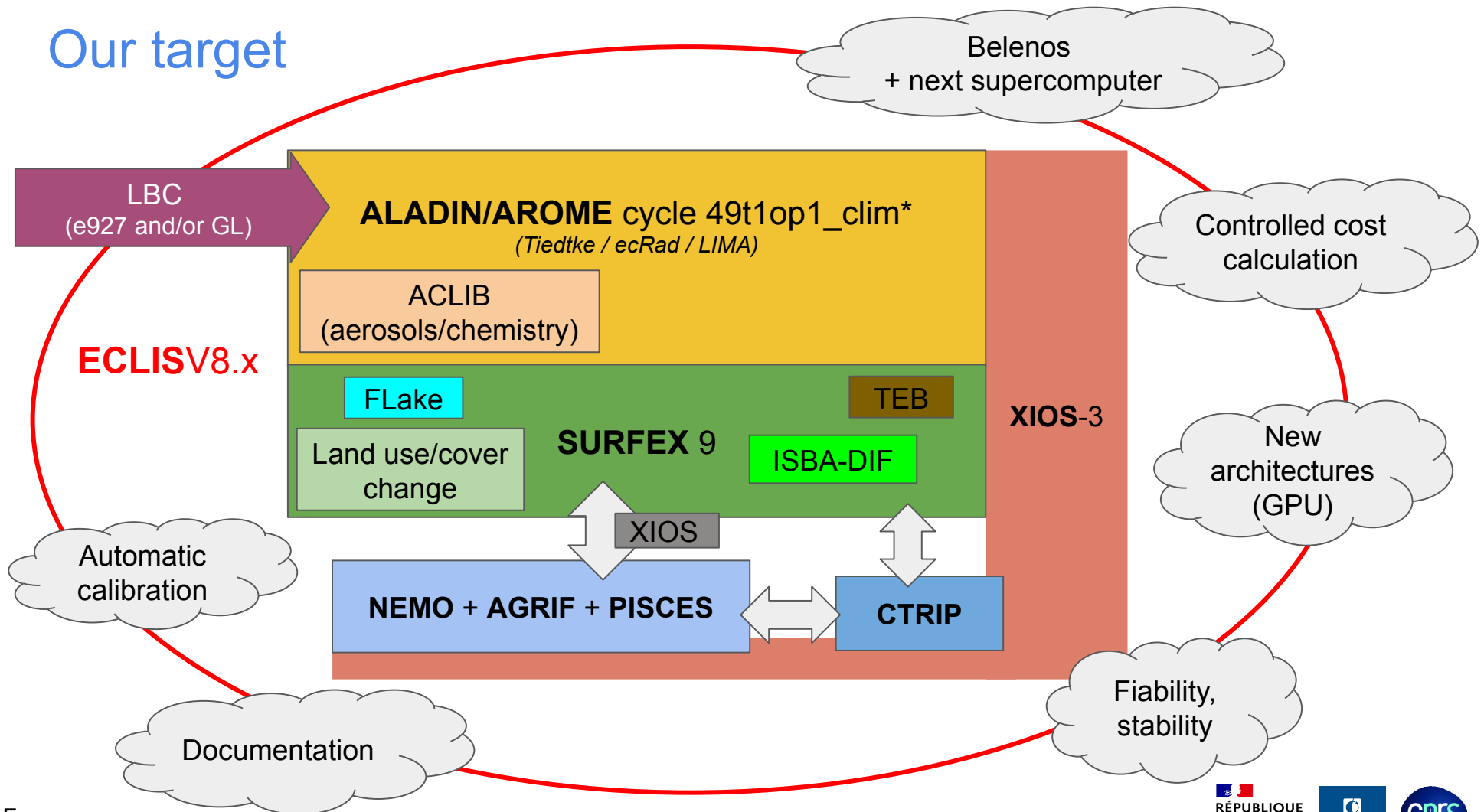
Near-surface temperature changes  
in CNRM-ALADIN64E1  
(°C, Central Europe, JJA, ref : 1850-1900)



# Towards the next generation of regional climate models

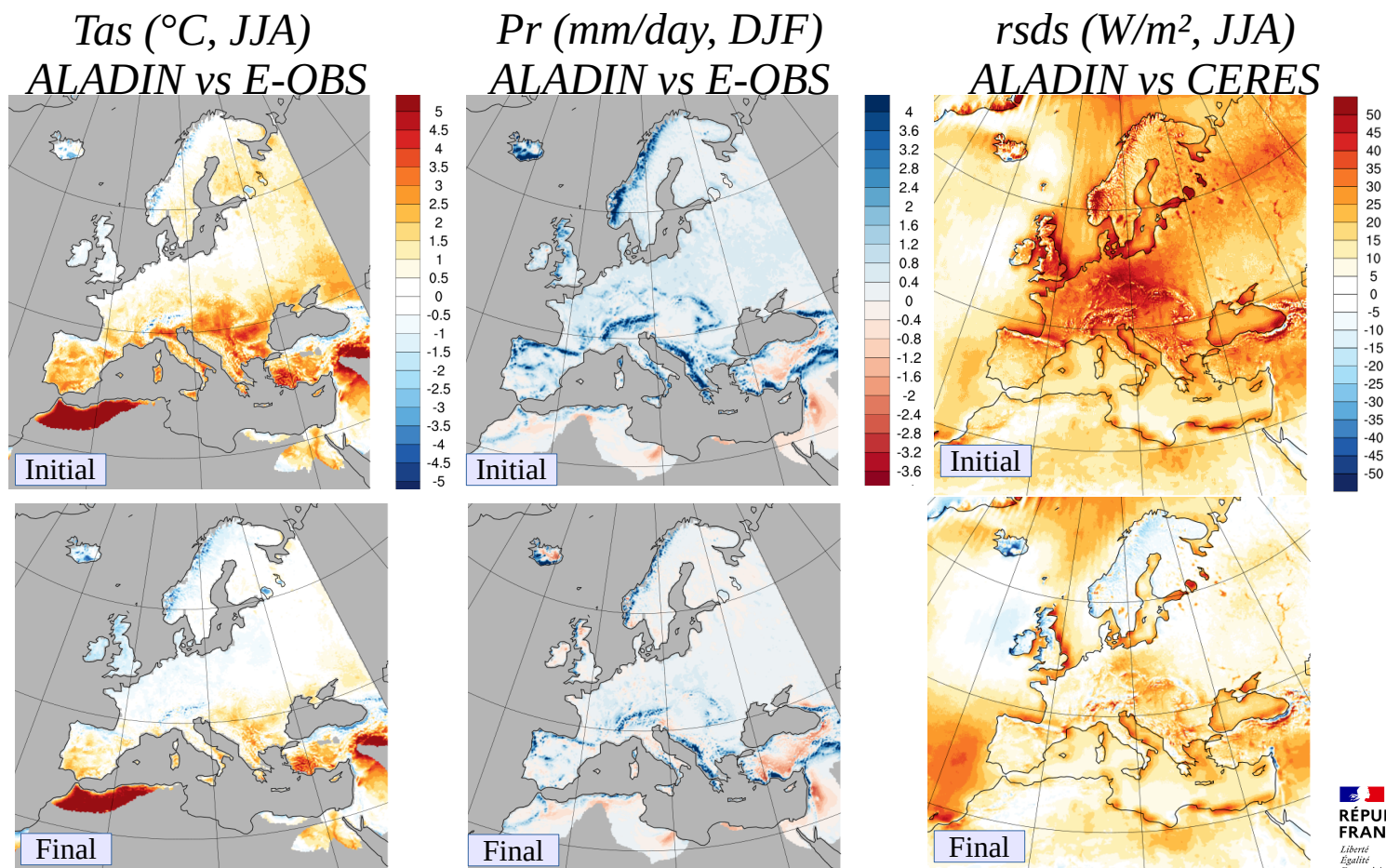
- **Objective** : development of a regional « Earth System Model » (RESM), at kilometer-scale, modular, high-quality, robust, repositionnable and calibrated
- Consistent modeling workflow in the CNRM climate group from global to regional

## Our target



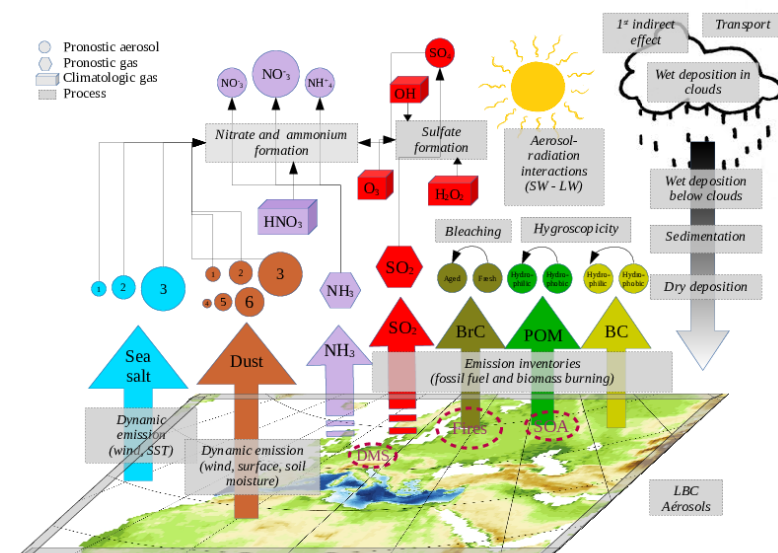
# Automatic calibration of CNRM-ALADIN

- **Use of the HighTune Explorer tool** (Couvreur et al. 2021, Hourdin et al. 2021) over the EURO- and CAM-domains
  - 42 parameters (convection, turbulence, microphysics, radiation), 248 metrics (Variable + domain + season + operation for 13 variables, 9 domains, 4 seasons, e.g. tas\_EuropeLand\_JJA\_mean,)
  - 5 waves of 200 1-year simulations
  - Gaussian process emulator to predict the metrics for any values of the parameters + history matching method to rule out impossible values of parameters
  - Final choice among the best simulations



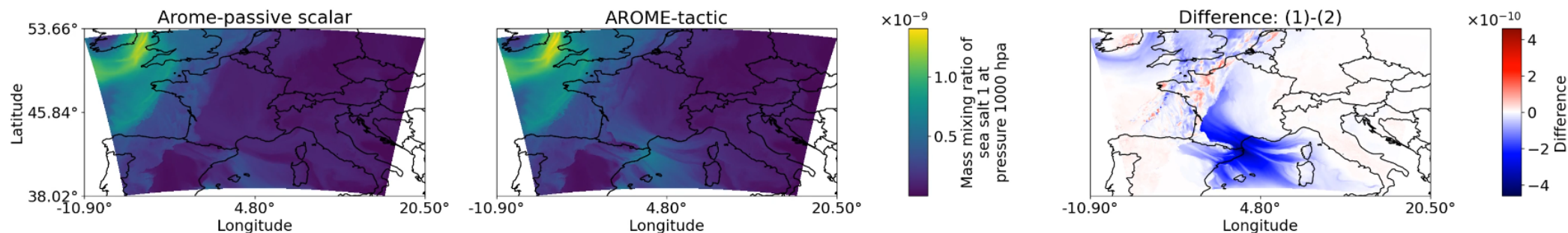
# Use of interactive aerosols (and chemistry) via ACLIB

- **Interactive aerosol scheme (TACTIC) in ALADIN simulations**
  - Bulk-bin aerosol scheme (12 variables)
  - Adapted cost to multi-decadal climate simulations
  - Coupling with radiation + 1st indirect aerosol effect
  - Now included in the new **ACLIB** library, gathering all aerosol and chemistry schemes developed at CNRM



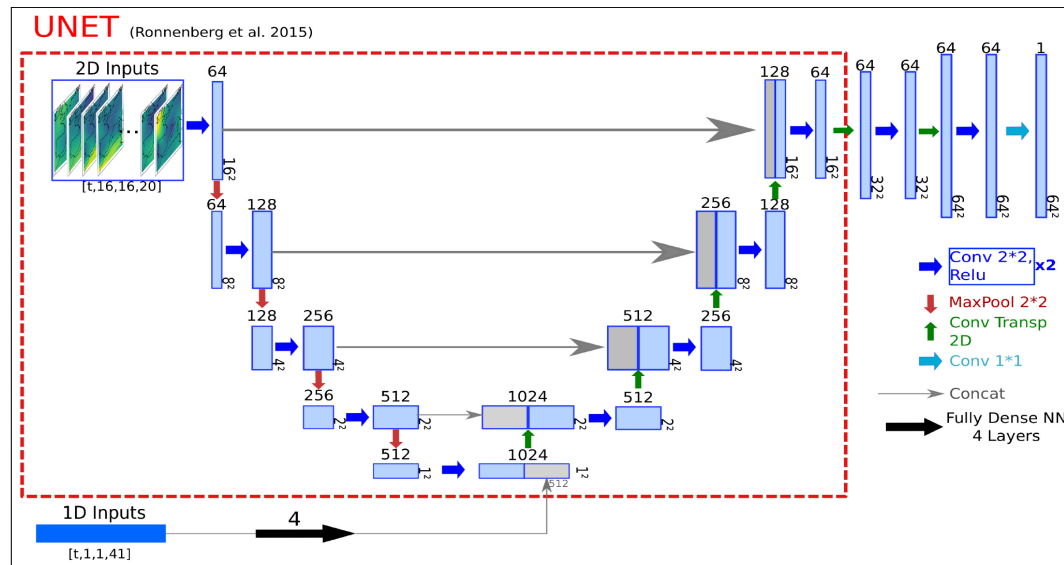
- **Development to use TACTIC in AROME simulations (*post-doc Romain Lenoble*)**
  - Introduction of TACTIC (via ACLIB) in AROME physics
  - Case studies to evaluate aerosols (HyMeX, dust outbreaks, ...)
  - Objective to study aerosol-cloud interactions (coupling with LIMA microphysics scheme)

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# Development of the emulator of regional climate models

- **Statistic model** : CNRM-UNET (Doury et al. 2023, 2024)
    - Development of an emulator of regional climate models, based on neural networks
    - Estimating the downscaling function included in the RCM (ALADIN)
    - Trained to produce daily output of near-surface temperature and precipitation (separately)
    - Able to reproduce the complex spatial structure and the daily temporal variability
    - Realization of a large ensemble over Europe (5x30 members, driven by CNRM-CM6)
    - On-going developments (training on AROME, multi-variables, meteorological objects)
- => Need to find the good adequation between physical and statistical models
- => Quantify, understand and reduce uncertainties in regional climate simulations



# Interests for collaboration in ACCORD

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- GL software
- Tuning strategy
- Aerosols and aerosol-radiation-cloud interactions
- Coupling / new climate components (ocean, rivers, waves, ...)