SRI 2023 – June 28 - CRA SOILS Mid-term meeting

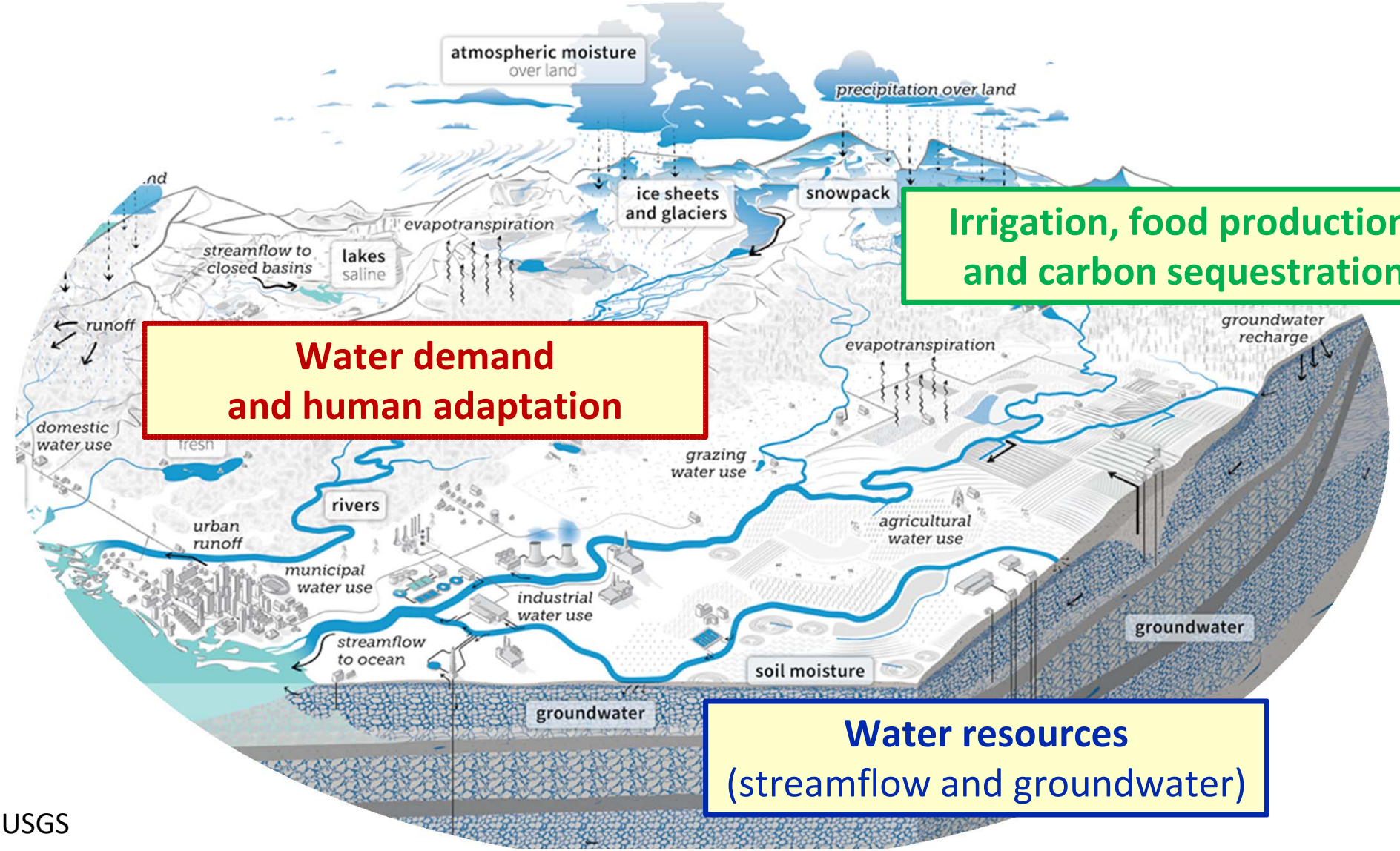
BLUEGEM

Biosphere and Land Use Exchanges with Groundwater and soils in Earth system Models

Project's web site:
www.metis.upmc.fr/~ducharne/bluegem/

Connected project members:
Agnès Ducharne, Pedro Arboleda (IPSL, France)
Yadu Pokhrel, Dan Kramer, Amar D Tiwari (MSU, USA)

Stronger focus on the water cycle than soils



Irrigation, food production, and carbon sequestration

Water demand and human adaptation

Water resources (streamflow and groundwater)

Source: USGS

The Anthropocene perspective

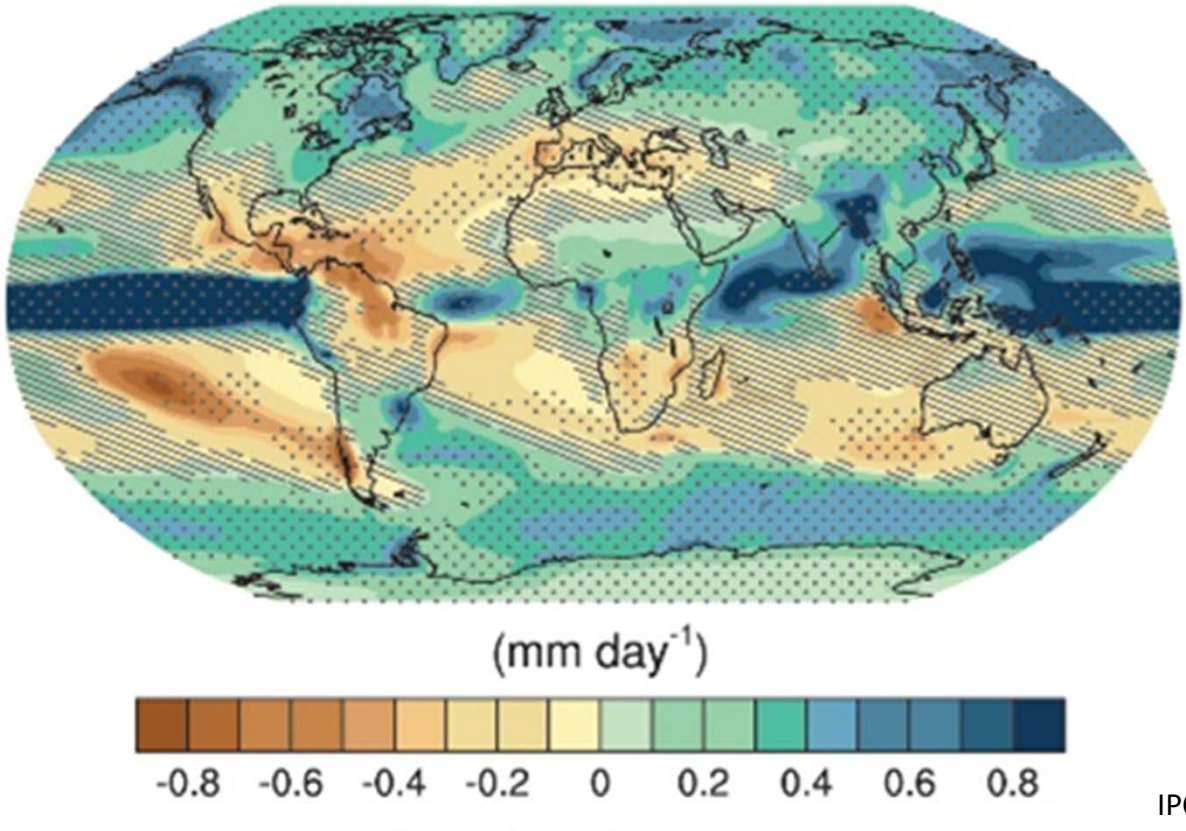
Water resources
(streamflow and groundwater)

Irrigation, food production, and carbon sequestration

Water demand and human adaptation

Expected changes in dry areas under the dry gets drier / wet gets wetter paradigm

Annual mean changes in precipitation in 2081–2100 relative to 1986–2005 under RCP8.5



IPCC AR5

BLUEGEM organization

Main goal

Explore the joint evolutions of climate, soils, groundwater, and irrigation, throughout the Anthropocene (1900-2100)

To better understand their coupling, foresee their potential changes, and identify possible social consequences.

Advanced numerical modelling
climate models, downscaling methods, hydrological models, agro-economic models

Global scale
France
Mekong

Various participatory methods with local and regional actors
participatory GIS, participatory cultural mapping, and storylines

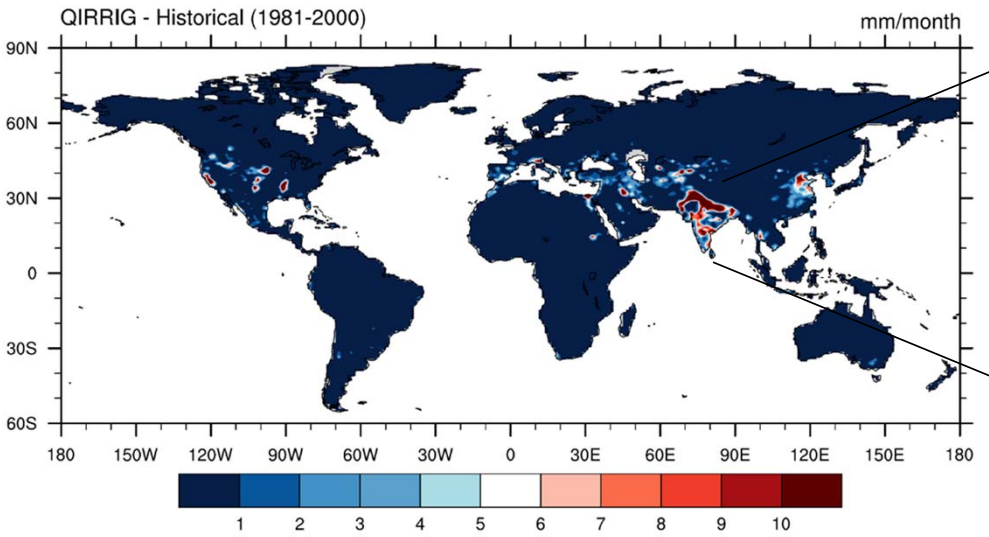
Mid-term results (12 items)

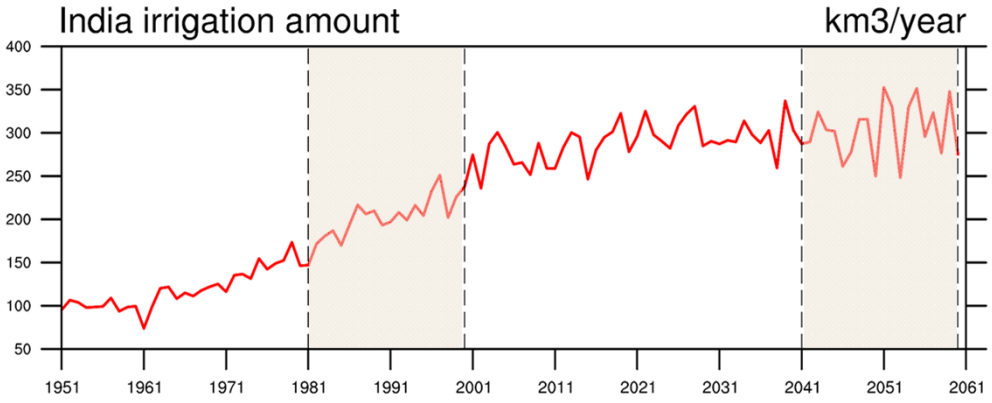
	Earth system science	Social science
Global	NTU: Irrigation's impacts on climate in a warmer world IPSL: New irrigation module in the ORCHIDEE LSM IPSL: Soil carbon response to soil moisture UTokyo: Bias correction and Downscaling UTokyo: Data management	
Mekong	MSU: Process-based Irrigation-Groundwater Modeling MSU: Data synthesis	MSU: Social science in Cambodia NTU: Farmer's survey in Vietnam
France	IPSL: Climate change impact on water resources IPSL: How to Construct Plausible Drought Storylines?	INRAE: Water pricing in a agro-economic model

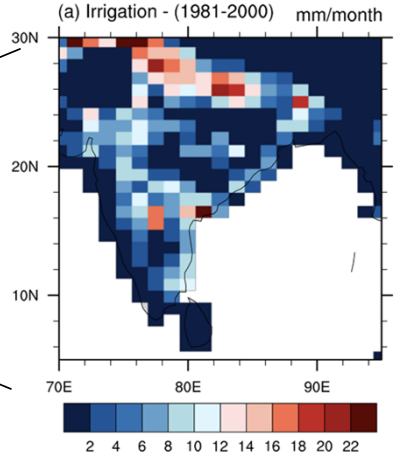
#1 Earth system science / Global

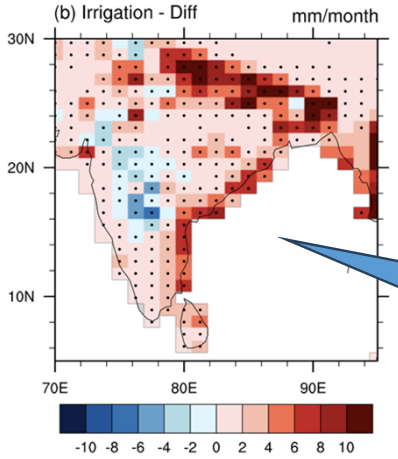
National Taiwan University

Irrigation's impacts on climate in a warmer world





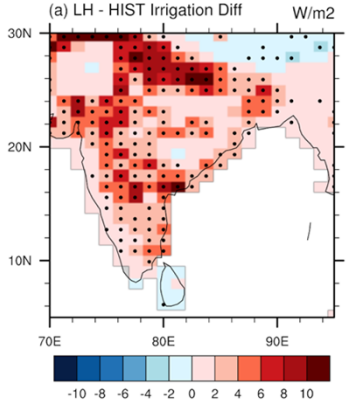




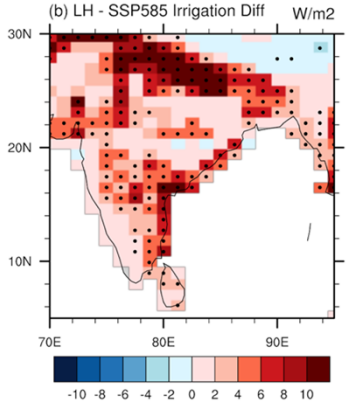
- **Two global climate simulations from 1950 to 2100 : with and without irrigation**
- **Land use change data from historical records and SSP5-8.5 scenario**
- **The effects of irrigation on various variables during the historical period (1981-2000) and in a future climate projection (2041-2060) are examined.**
- **Target on India first**

Irrigation amount difference between 2041-2060 and 1981-2000

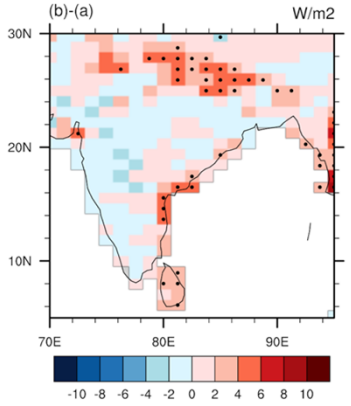
a. LH changes due to irrigation in 1981~2000



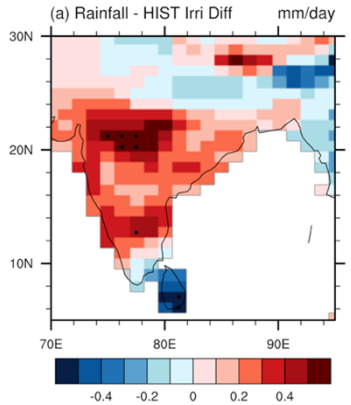
b. LH changes due to irrigation in 2041~2060



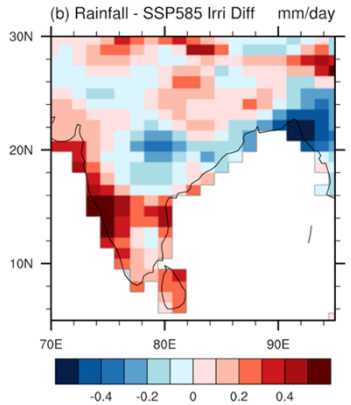
b-a warmer climate modulates irrigation's impacts on LH



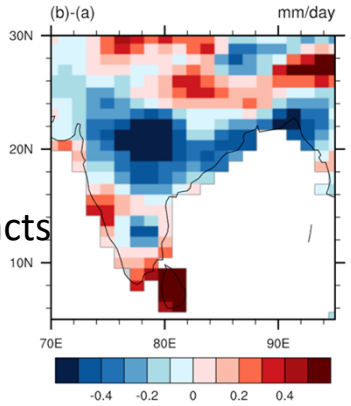
a. Rainfall changes due to irrigation in 1981~2000



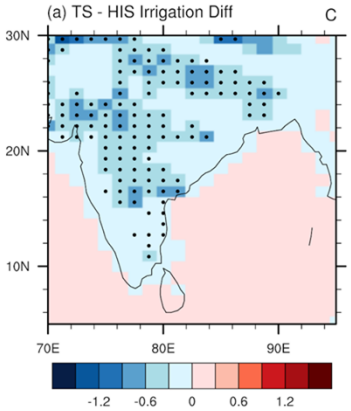
b. Rainfall changes due to irrigation in 2041~2060



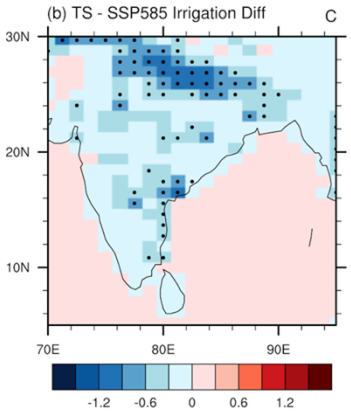
b-a warmer climate modulates irrigation's impacts on rainfall



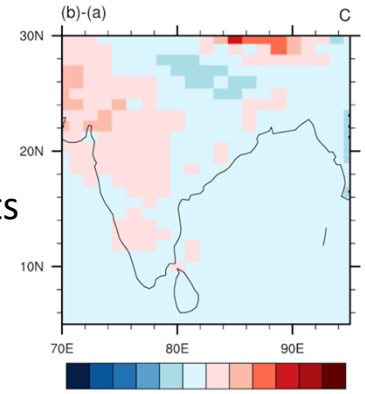
a. Ts changes due to irrigation in 1981~2000



b. Ts changes due to irrigation in 2041~2060



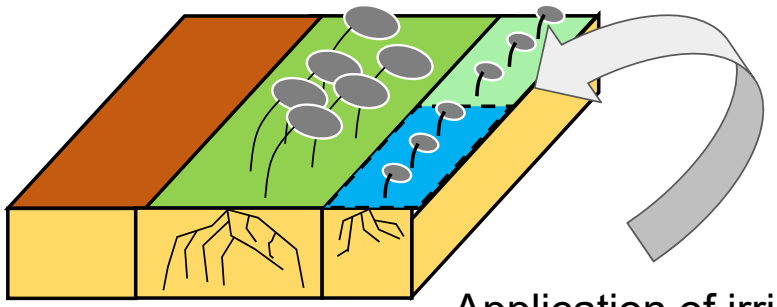
b-a warmer climate modulates irrigation's impacts on Ts



#2 Earth system science / Global

Institut Pierre Simon Laplace

New irrigation module in the ORCHIDEE land surface model

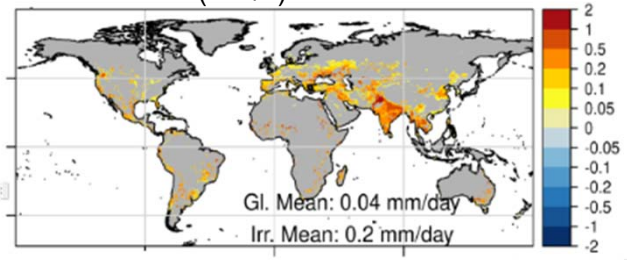


Application of irrigation

- Irrigation demand based on soil moisture deficit, with natural supply from rivers and aquifers
- Simple representation of distant sources, environmental flow and GW / SW pumping facilities
- Irrigation shortage when supply is limited

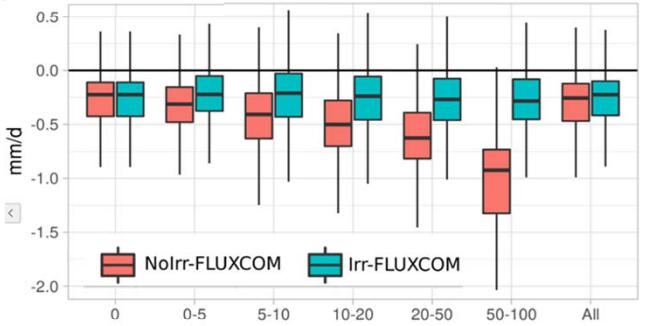
Correct estimation of global irrigation amount
(10% underestimation ca 2000 vs AQUASTAT)

Irr-NoIrr : ΔET (mm/d)

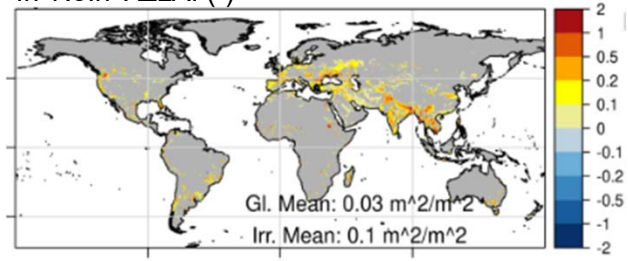


Increase of ET

Decrease of ET bias

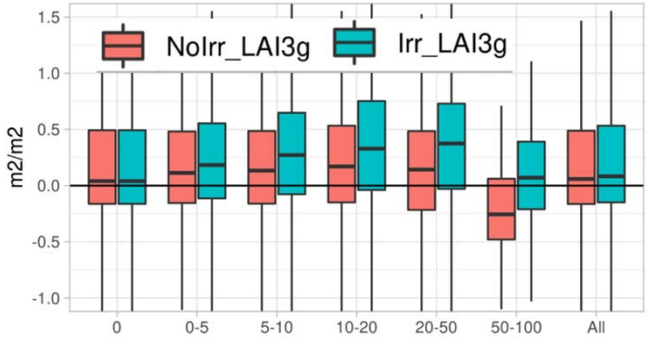


Irr-NoIrr : ΔLAI (-)



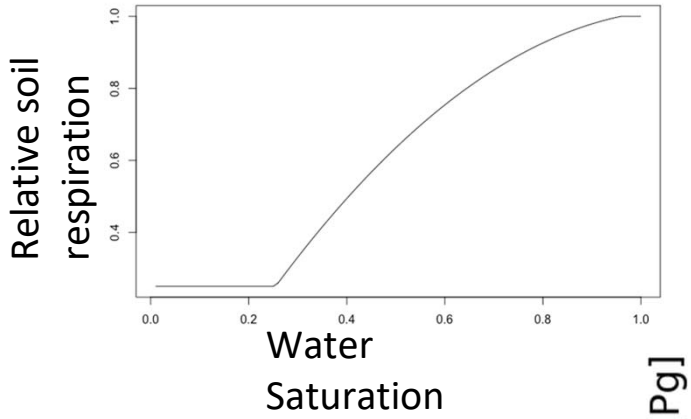
Increase of LAI

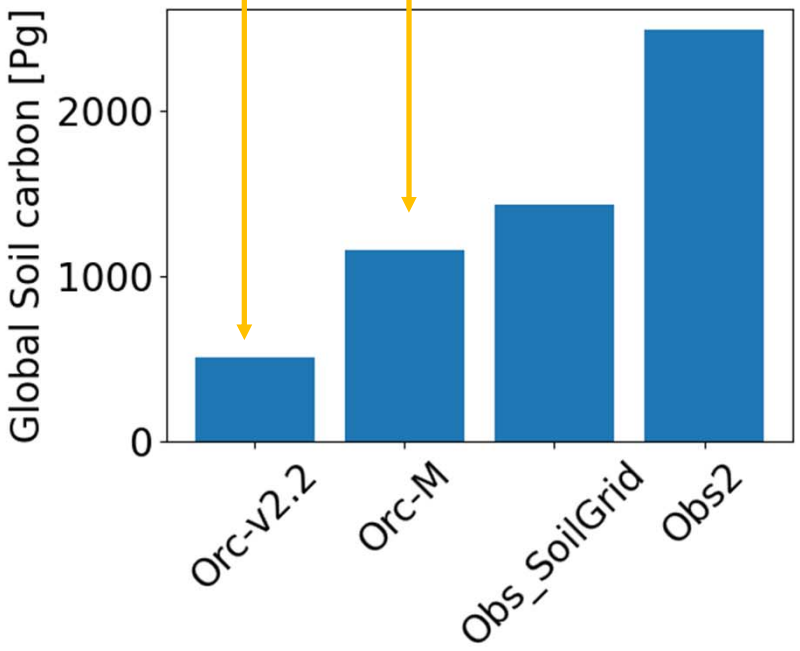
Decrease of LAI bias



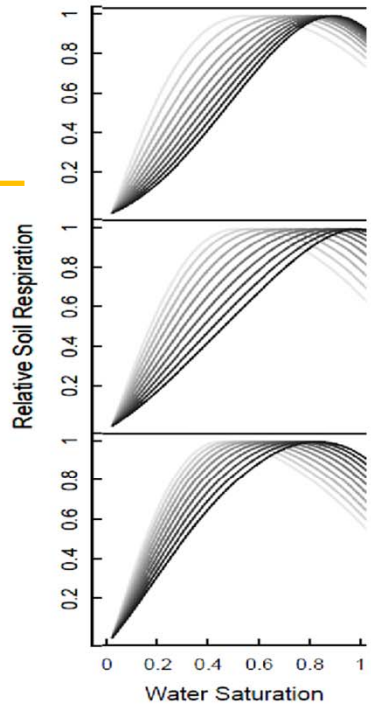
A NEW FUNCTION TO REPRESENT SOIL MOISTURE EFFECT ON SOIL CARBON DYNAMIC

Standard function





Bell curves



Clay content

Organic Carbon

Bulk Density

Moyano et al., 2012

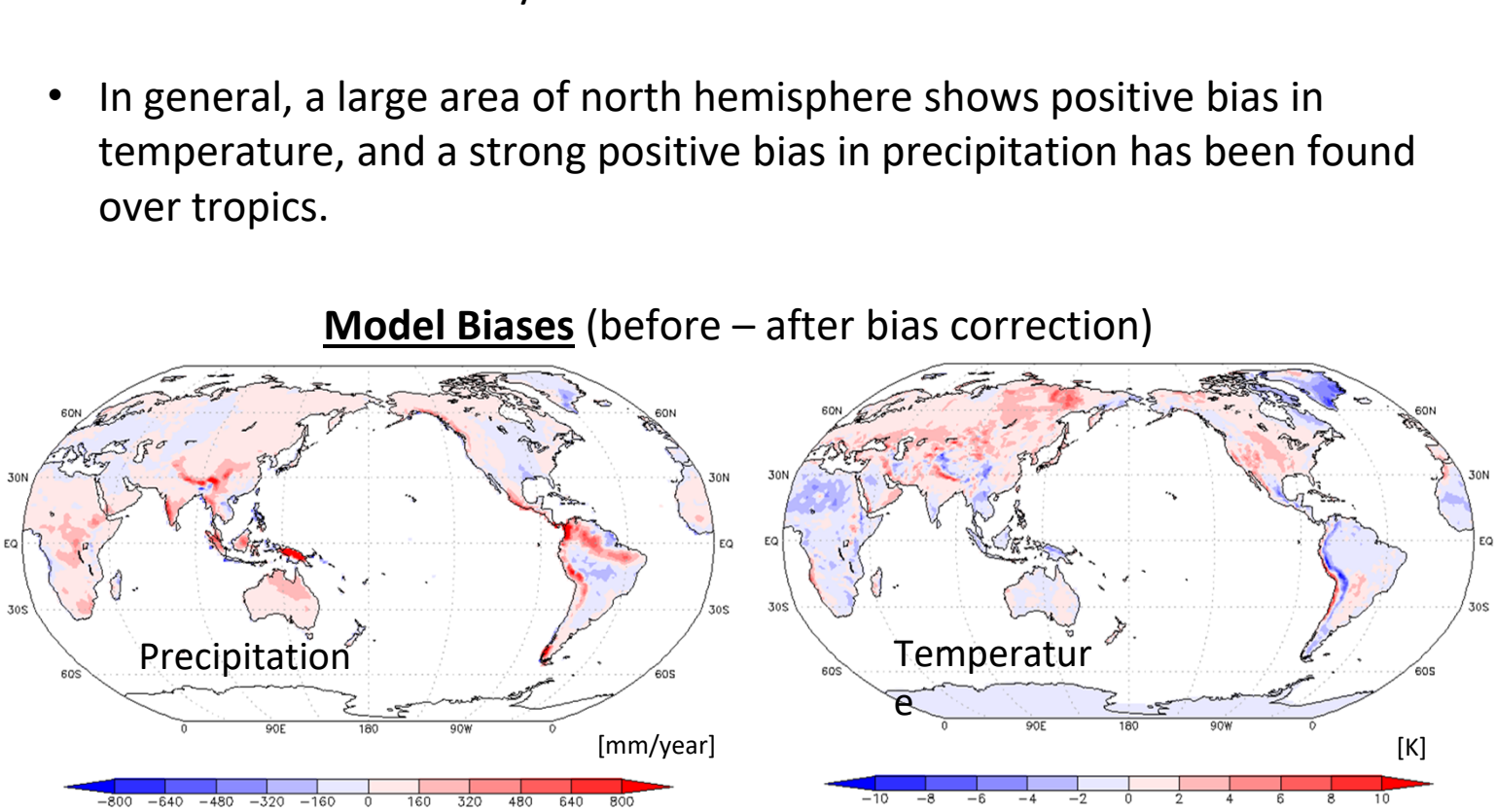
Institut Pierre Simon Laplace

#3 Earth system science / Global

Bias correction and Downscaling

- A numerical method for bias-correction and downscaling has been proposed for France and the Mekong focal regions.
- Test has been carried out at the global scale for the period 1901-2010, using GSWP3 data as a reference on the CESM simulation by NTU.

- In general, a large area of north hemisphere shows positive bias in temperature, and a strong positive bias in precipitation has been found over tropics.



Model Biases (before – after bias correction)

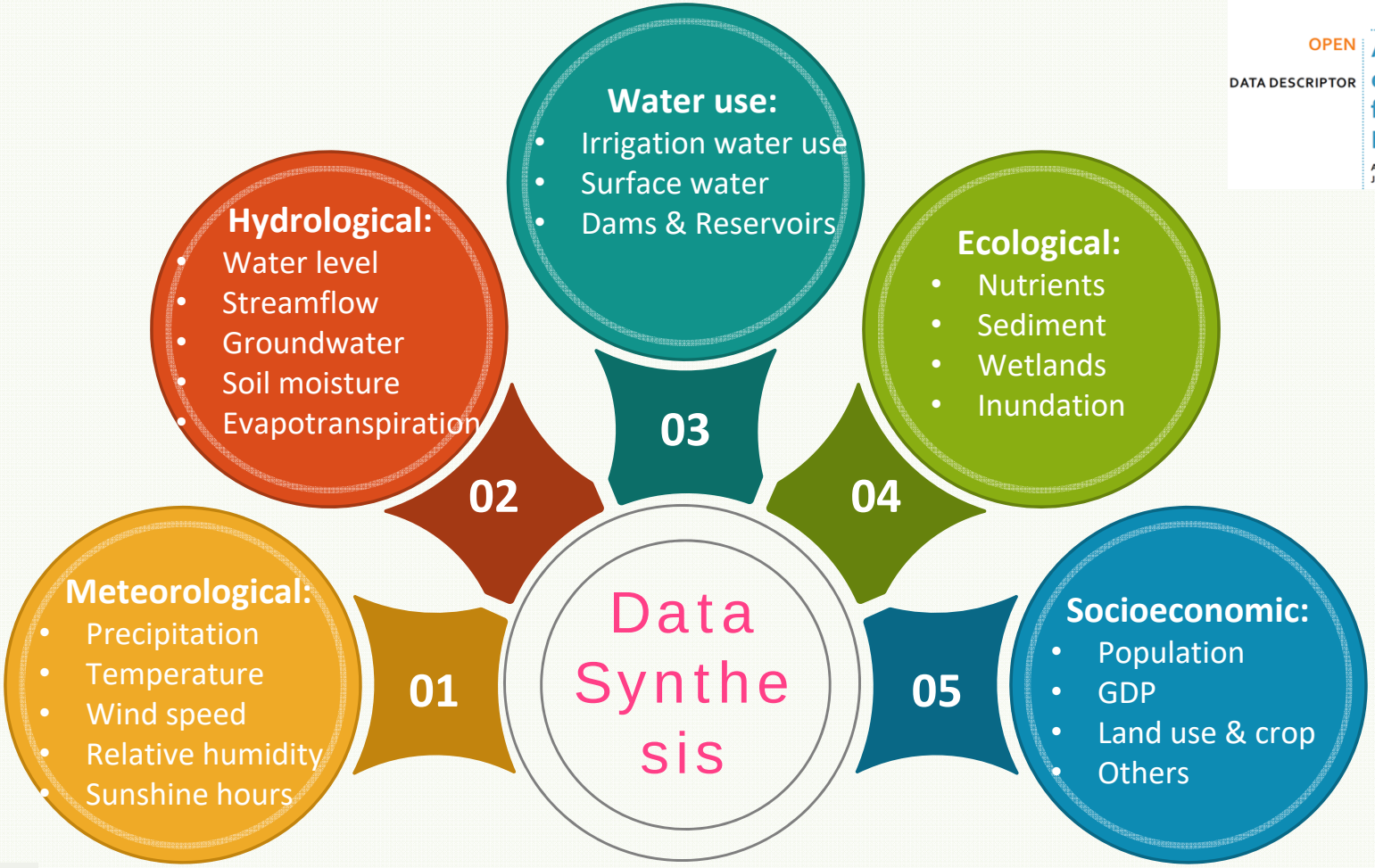
Data management and exchanges among project partners

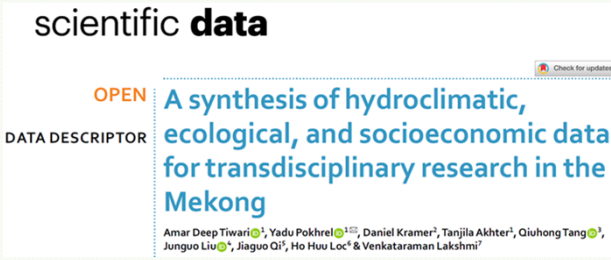
We have built a virtual machine within DIAS, Japan to prepare a service to archive and disseminate data as project outcomes.

1. Consortium Database
   - DIAS services provided for building a shared database
   - Utilized Virtual Machine with 40TB storage, 50GB RAM, and 24 CPU cores for database creation
   - Enables aggregation and utilization of hosted data
2. Future Collaboration
   - Collaborative team will continue to provide simulation results and survey data.
   - Model benchmarking framework will be prepared incorporating various types of data from the project.

Data spec	
Date	1901/1/1 to 2014/12/31
Temporal Characteristics	3hourly
region	global
row/column	192/288 (1.25 grid)
Data type	netCDF4
all data size	513 GB
variables	precipitation, wind speed, air temperature, humidity, surface pressure, short-/long-wave radiation

Data Synthesis for Mekong River Basin – Case Example





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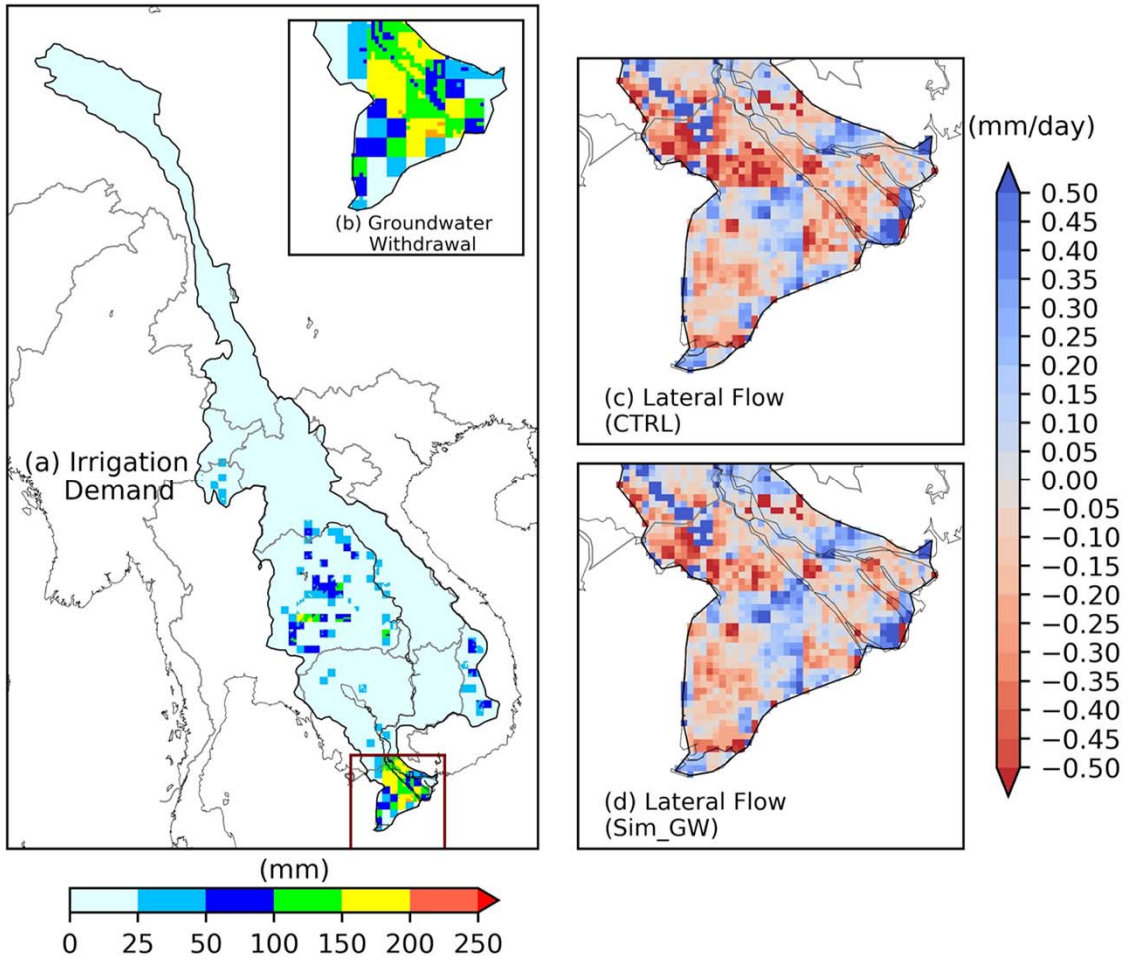
MEKONG RIVER COMMISSION FOR SUSTAINABLE DEVELOPMENT

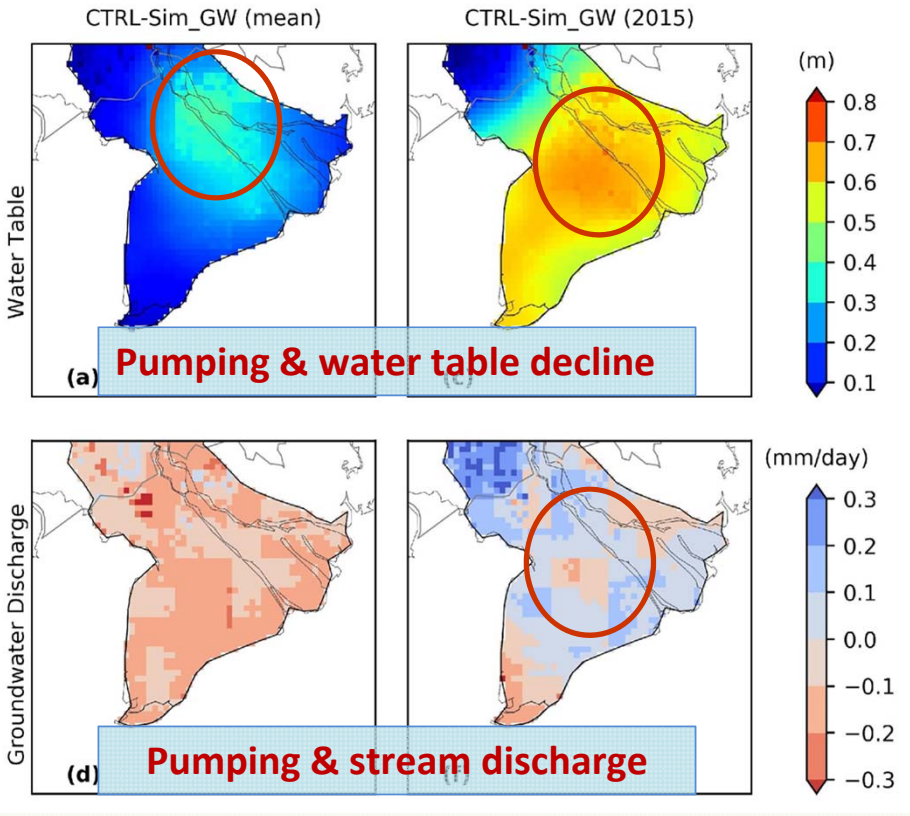
#6 Mekong

Process-based Irrigation-Groundwater Modeling

Process-based groundwater modeling in the Mekong



Impacts of irrigation



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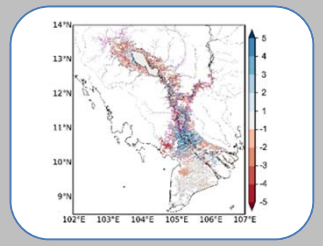
Social Science in Cambodia



Hydrological & Land Use Modeling

Governance & Social Equity

Nature's Contributions to People

Livelihoods & Culture

Resilience, Adaptation, Vulnerability

Household Surveys 12 Communities 700 Households

Cambodian Agricultural Survey (13', 20')

Participatory Mapping

Ethnography & Cultural Mapping

Key Informant Interviews

Topic

Methods

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 # 8 Social science / Mekong

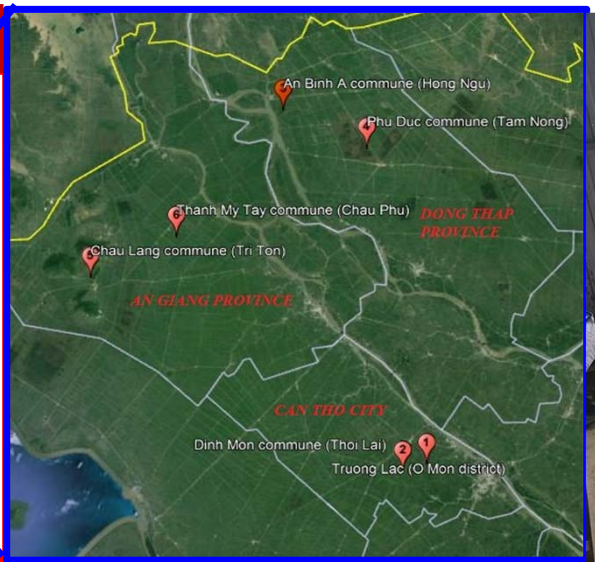
National Taiwan University

Farmer's survey in Vietnam

- **Why?** To investigate local farmers' perspectives regarding climate change/drought, water resource, irrigation and agriculture behaviors
- **Where?** Upper Delta: 3 provinces, 6 communes
- **How Many?** 300 samples in total
- **When?** May 5-May 10, 2023

- **Who?** **National Taiwan University**, collaborating with a local research partner: Vietnam National University Ho Chi Minh City University of Science
- **How?**
  - Household Sampling → door to door
  - Mostly by motor bikes in farms near roads

Survey analysis is in process



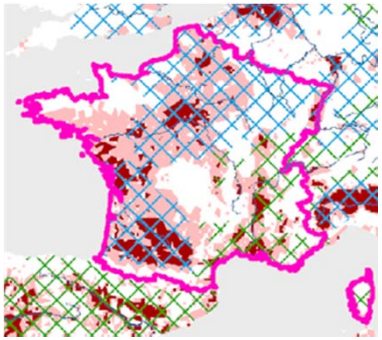
Water pricing in a agro-economic model

#10 Social science / France

INRAE

la science pour la vie, l'humain, la terre

1. Main goal



Estimate how irrigated areas may evolve in France as a result of different drivers:

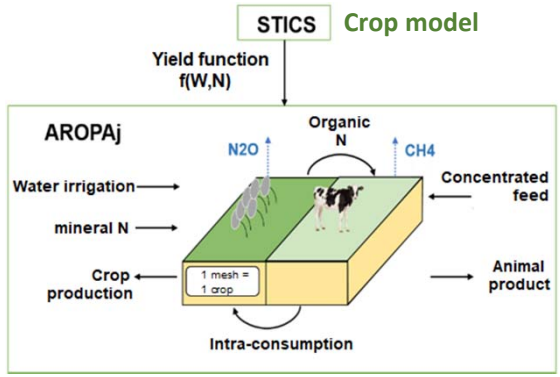
- **Farm economics**
- **Public policies**
- **Climate & water resource changes**

2. Confronting economic supply and demand

Need for irrigation water → **economic demand** from farmers

Water resources (surface, ground) → **economic supply**

3. Soft coupling of several models



Agro-economic model (AROPAj) : static model simulating the economic behavior of farming systems, using optimization under constraints

4. Accounting for water availability

The irrigation volume estimated by AROPAj depends on :

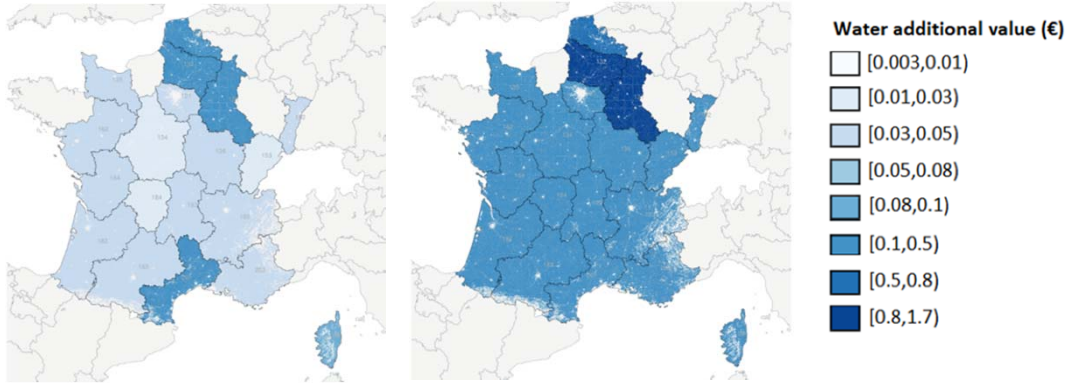
- farmers' needs via the yield function calculated by STICS,
- Declared irrigated volume in European statistics (FADN)

Need to account for water availability to become a new constraint →the true economic value is quantified by a **shadow price which increases with water scarcity**

We show tests with a priori scarcity, later informed by the ORCHIDEE model under climate change.

50% of the demand is available

10% of the demand is available



Shadow prices in €/m3 calculated for year 2016 under decreasing water availability

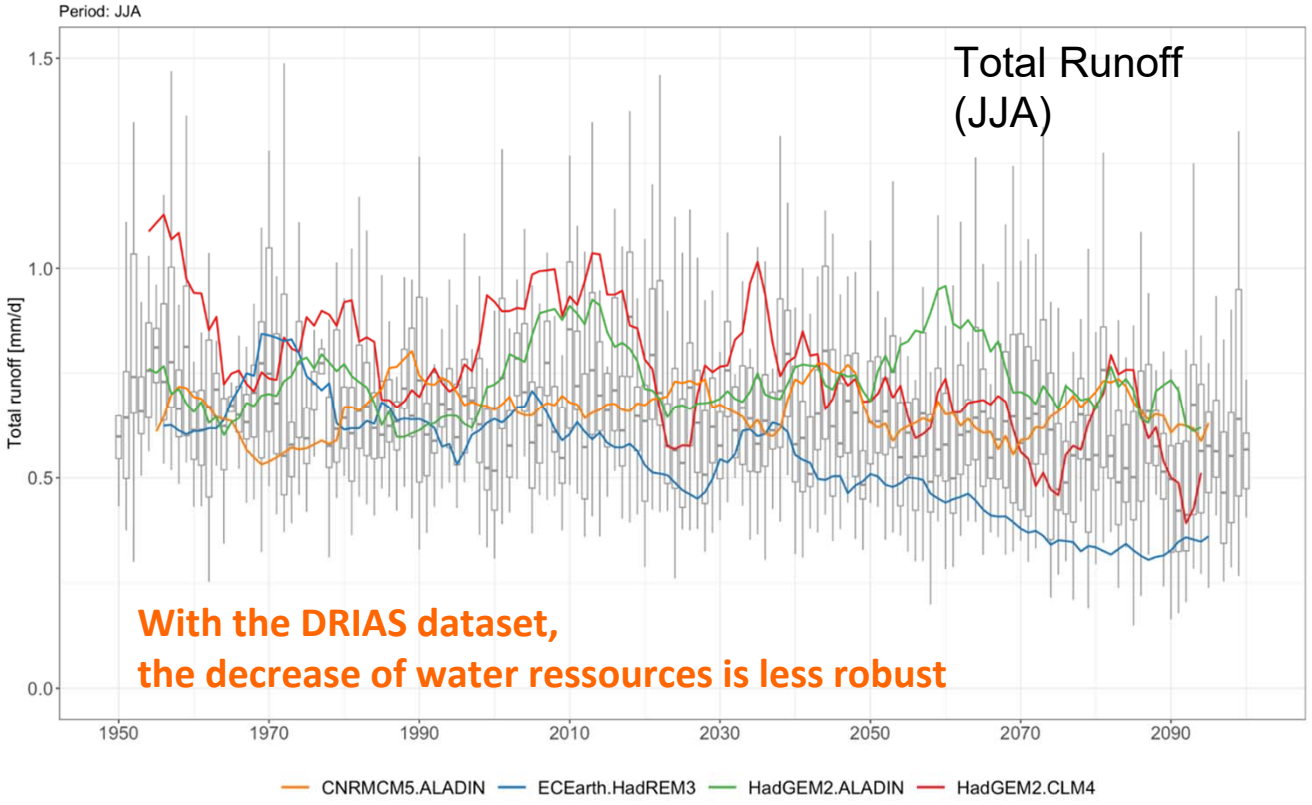
Climate change impact on water resources

18 climate change projections for France (DRIAS database)

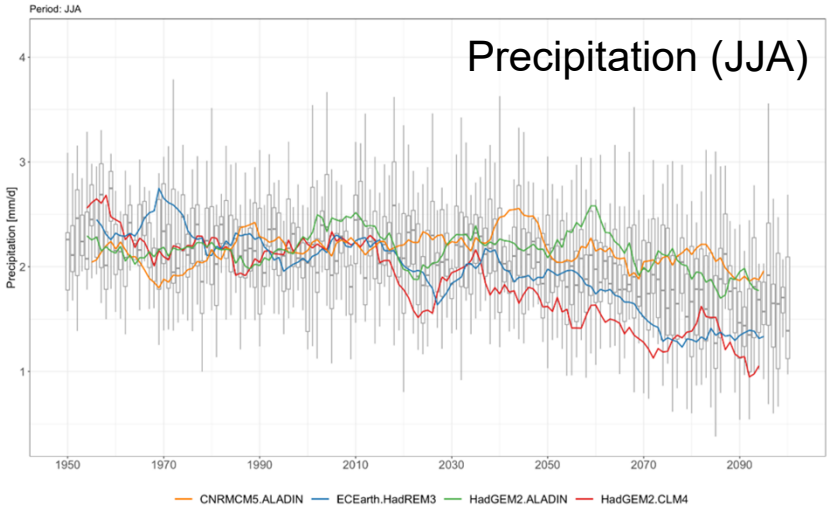
- All assuming pessimistic emissions (RCP8.5)
- Global models →Regional models →bias-correction

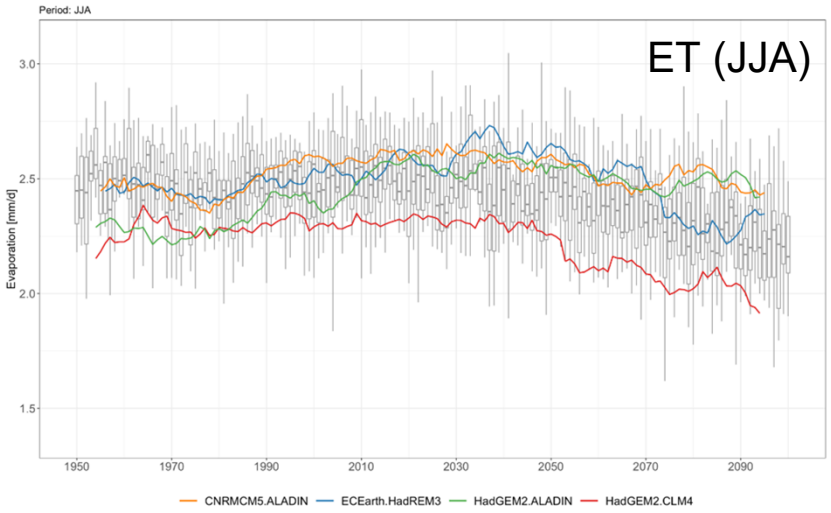
Processed by the ORCHIDEE land surface model

Trends of summer means, on average over the entire France



With the DRIAS dataset,
the decrease of water ressources is less robust





How to Construct Plausible Drought Storylines?

Example of Multi-year Droughts in France

#12 Social science / France

16 Model Outputs
1 Observation

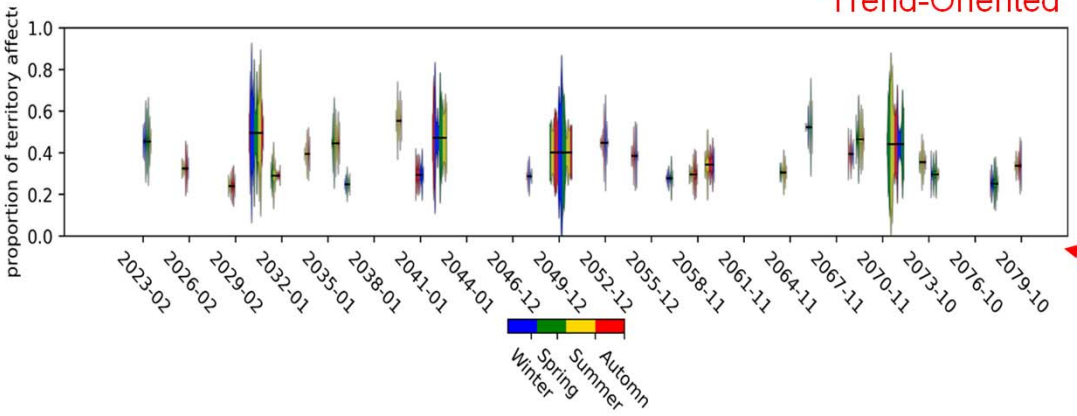
{ Potential Evapotranspiration
+ Precipitation Data

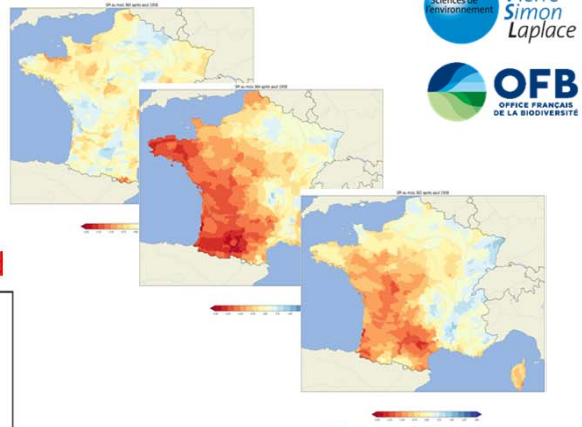
Connected Components 3D

Sets of Drought Events

Computation of indices

For each Drought Event
- Total Time
- Perceived Time
- Mean Surface
- Total Intensity
- Mean Intensity



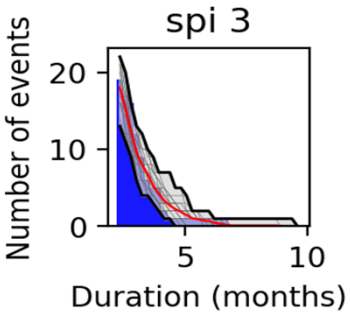


Event-Oriented

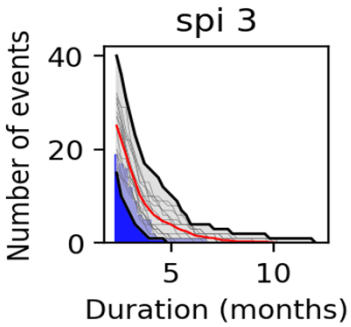
Construction of Storylines

Data Mining of Projections

Validation of Model Outputs (historical)



Future Droughts (ssp585)



BLUEGEM

Biosphere and Land Use Exchanges with Groundwater and soils in Earth system Models

- The project advances well despite some delays, impacting coordination activities
- Data dissemination is starting
- Proposed meetings:
  - AGU Fall 2023 session https://agu.confex.com/agu/fm23/prelim.cgi/Session/188375

    Abstracts due before August 2nd
  - Workshop in Paris after SRI 2024 (focused on adaptation of soil and water management?)

Thank you for your attention