SRI 2024 – June 11 - CRA SOILS End-of-term meeting

BELMONT FORUM

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, Peng Huang (IPSL, France)
Yadu Pokhrel, Amar Deep Tiwari, Tanjila Akhter (MSU, USA)
Min-Hui Lo, Ren-Jei Wu (NTU, Taiwan)
Bui Dong (Mekong River Commission)

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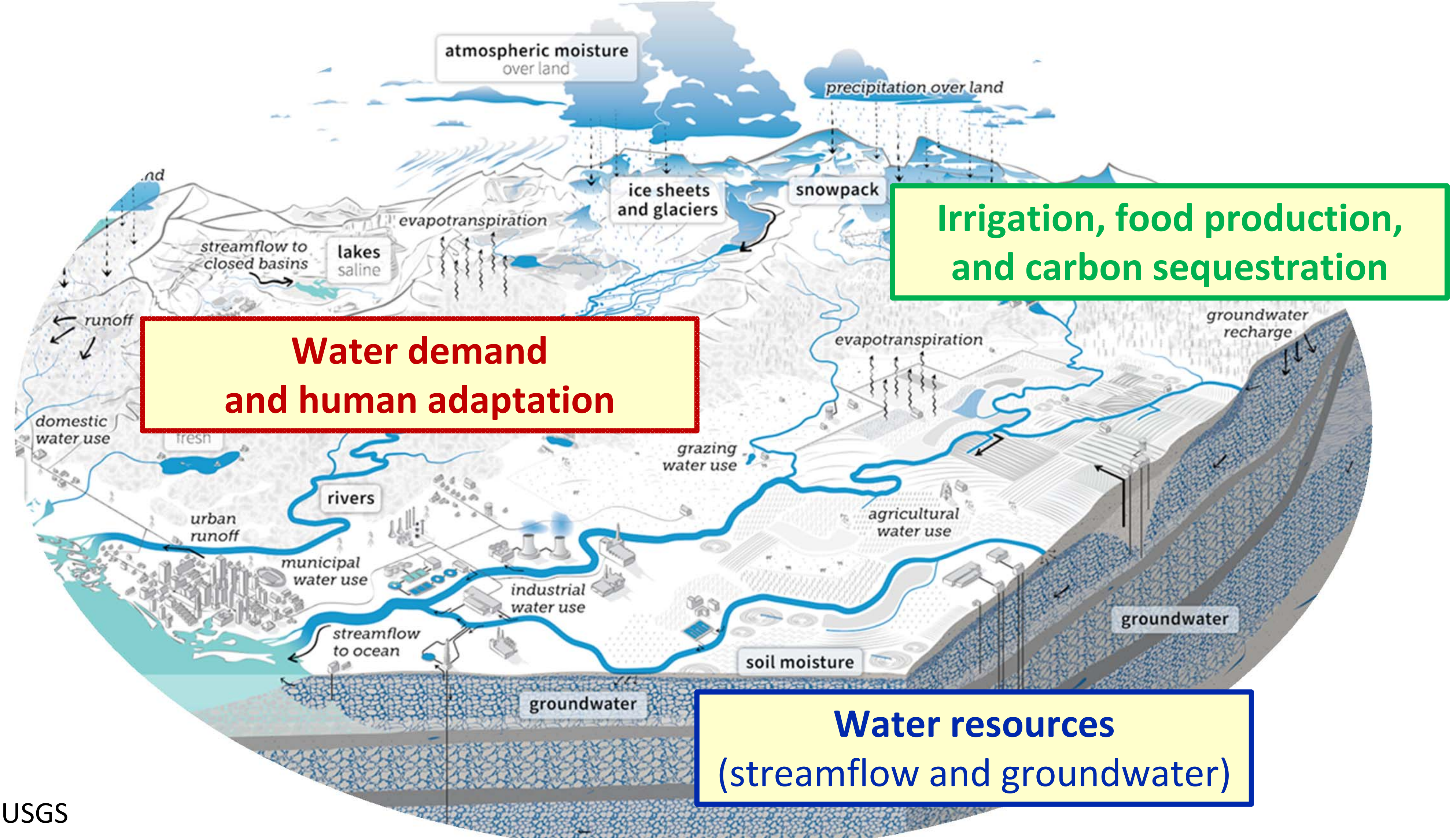
Stronger focus on the water cycle than soils



Source: USGS

BLUEGEM organization

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

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.

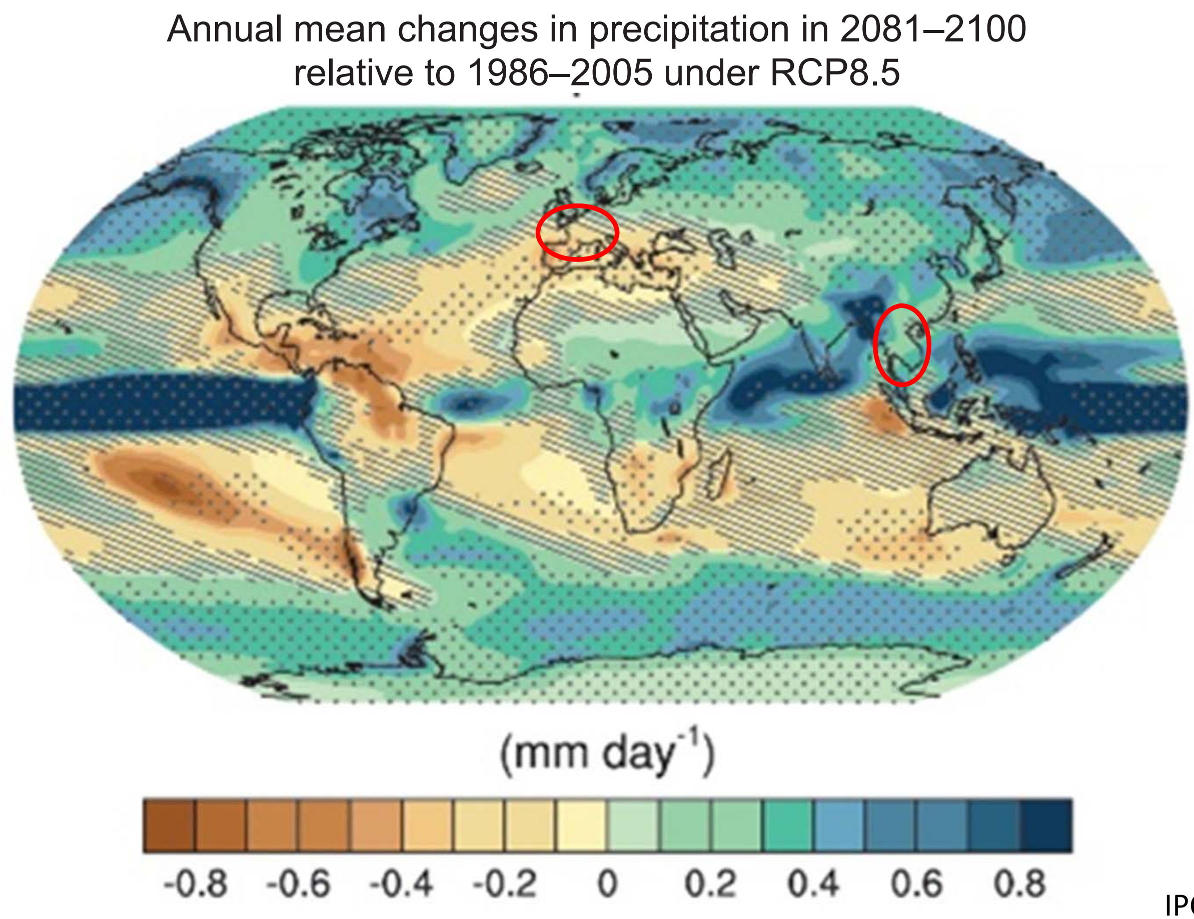
The Anthropocene perspective

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

Water resources
(streamflow and groundwater)

Irrigation, food production, and carbon sequestration

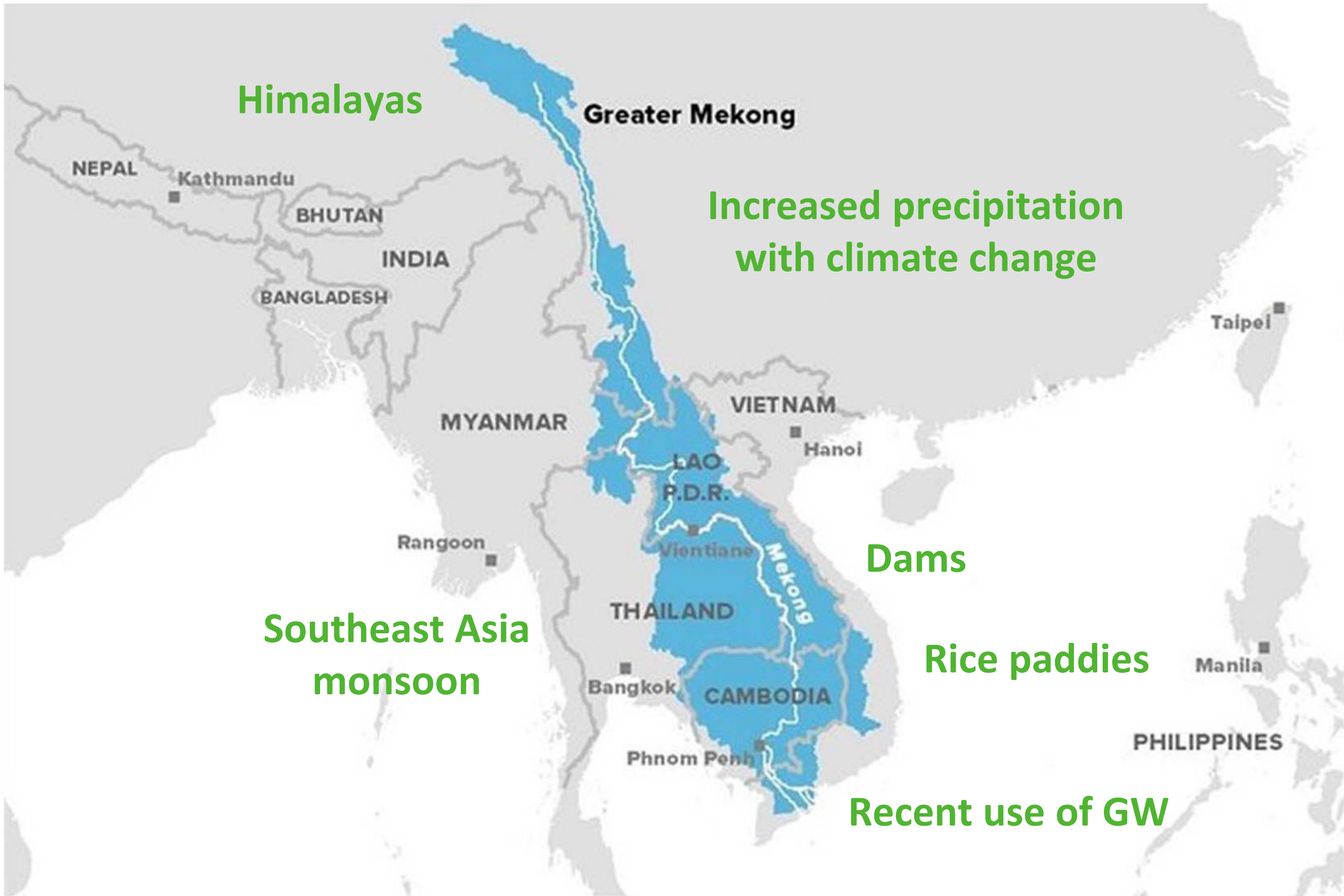
Water demand and human adaptation



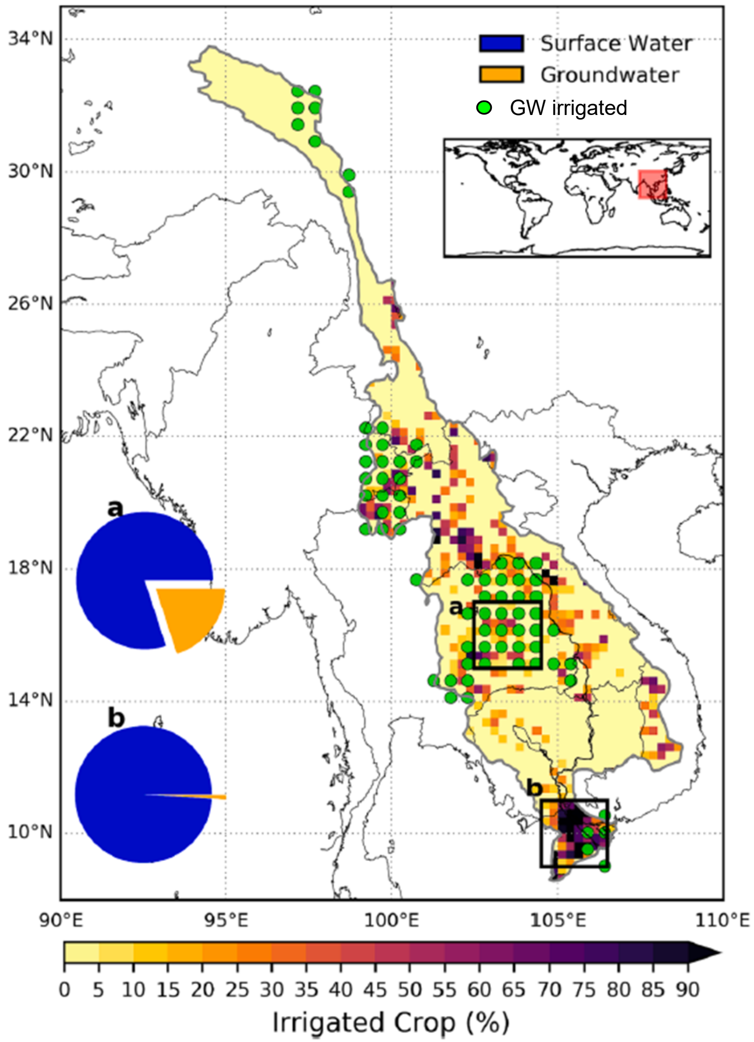
IPCC AR5

Earth system modelling: from the Mekong river basin to the global scale

To disentangle the main processes and drivers of water resources evolution



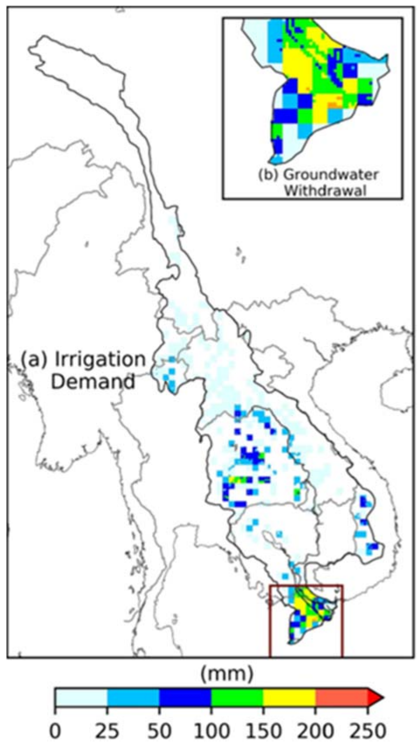
Coupled Irrigation-Groundwater Modeling

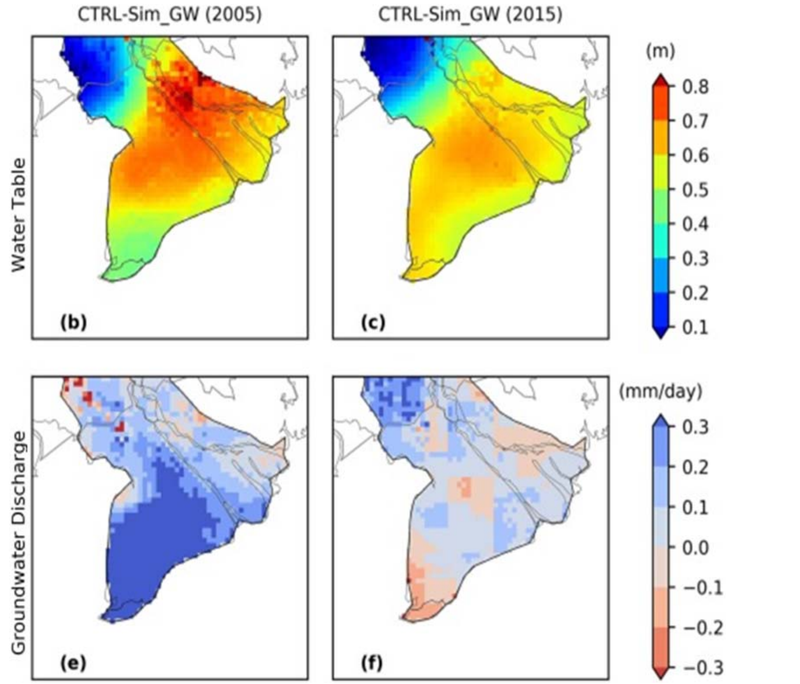


High-res irrigation-groundwater modeling (5 km)

→ **Strong added value in data-scarce regions**

e.g. irrigation-induced groundwater depletion

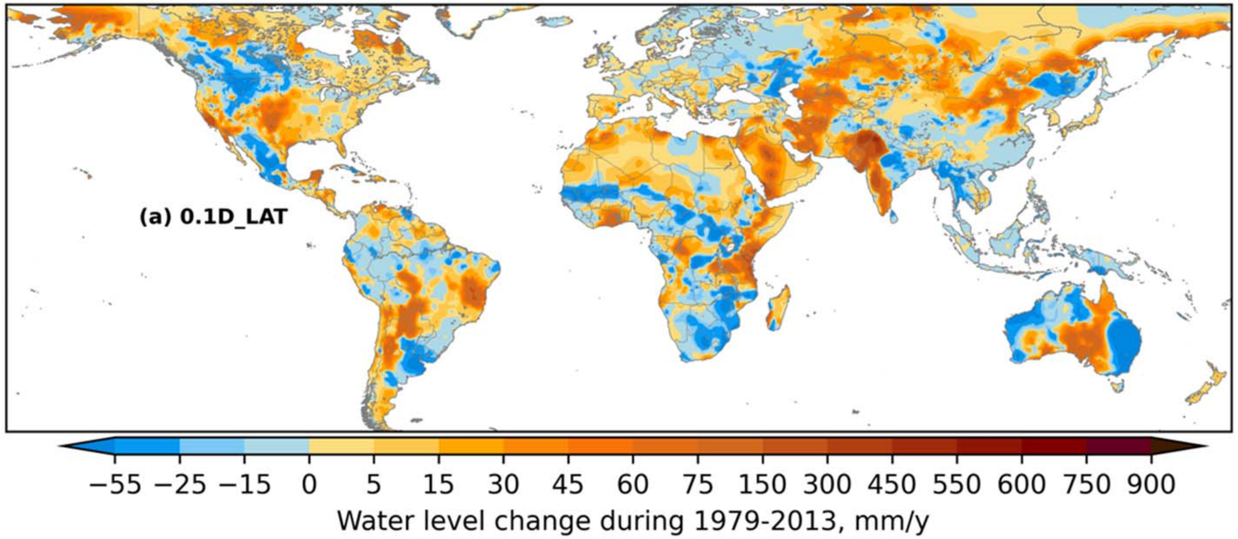




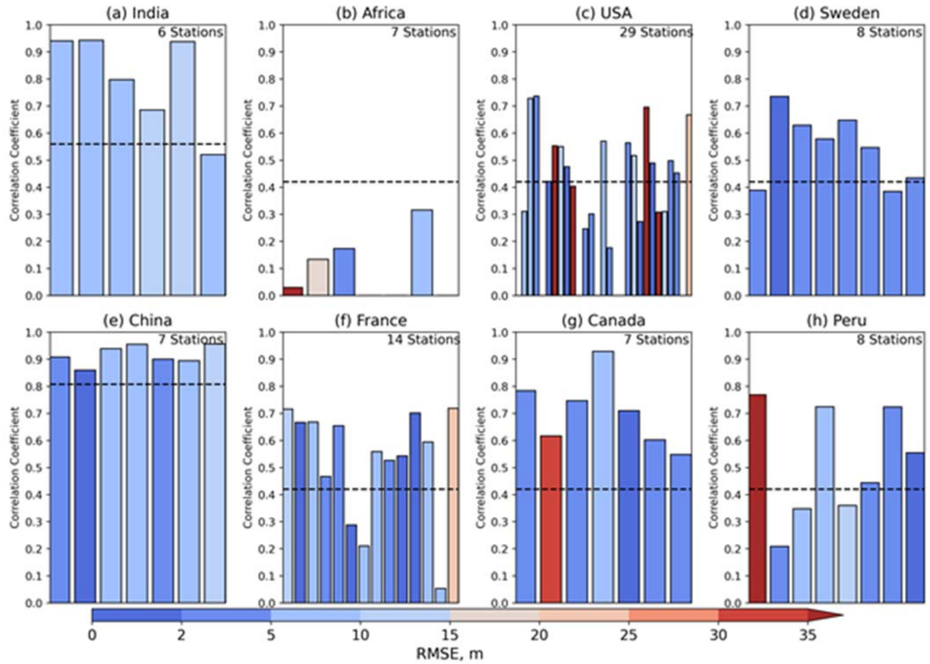
Kabir et al. (2023)

Coupled Irrigation-Groundwater Modeling

High-res irrigation-groundwater modeling (10 km)
→ **Many data-scarce regions at global scale**



Comparison to in situ GW level observations



Akhter et al. (in prep)

Coupled Irrigation-Groundwater-Climate Modeling

Two climate models used for IPCC's 6th assessment report, with GW-irrigation capacity

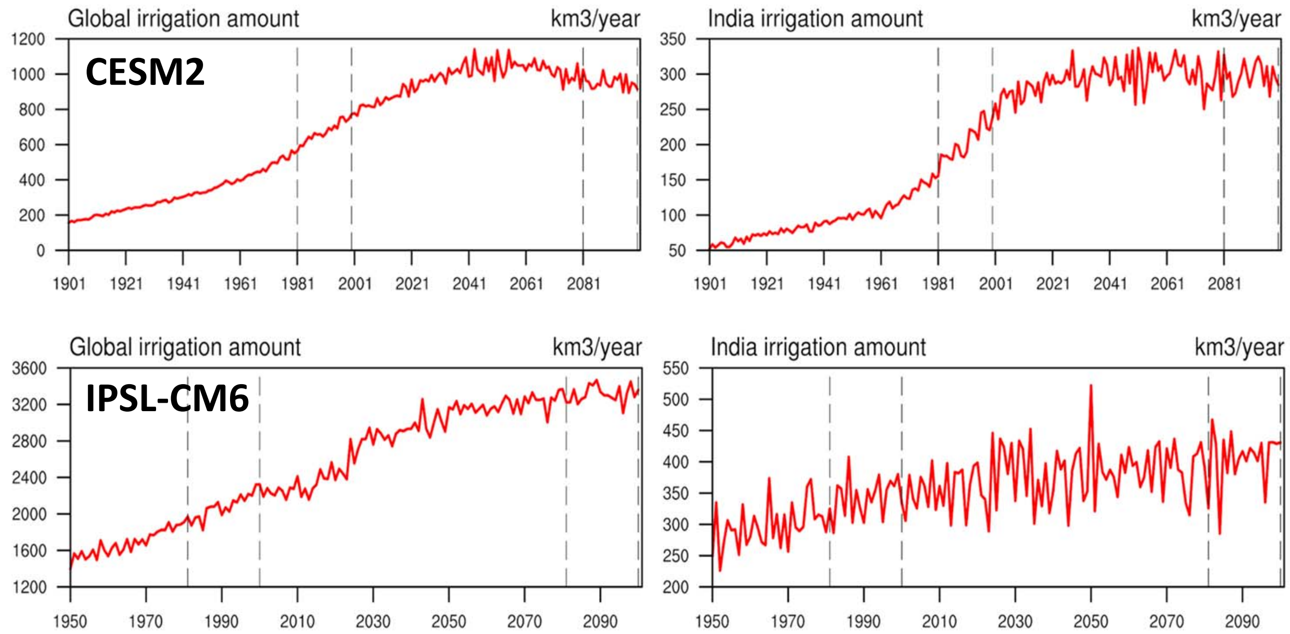
- CESM2 (0.9° x 1.25°)
- IPSL-CM6 (0.7° x 1.4°)

Two simulations for each model:

- with/without irrigation

Two periods for each simulation

- historical (1901-2014)
- SSP585 (2015-2100) under pessimistic radiative forcing scenario
- with global increase of irrigated areas



Global irrigation may rise by more than 50 % by 2100

Irrigated volumes are threefold higher in IPSL-CM6 compared to CESM2

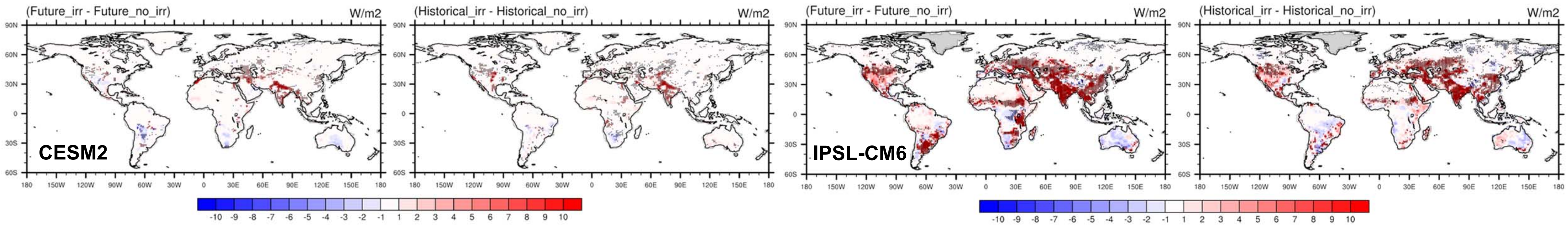
Coupled Irrigation-Groundwater-Climate Modeling

National Taiwan University

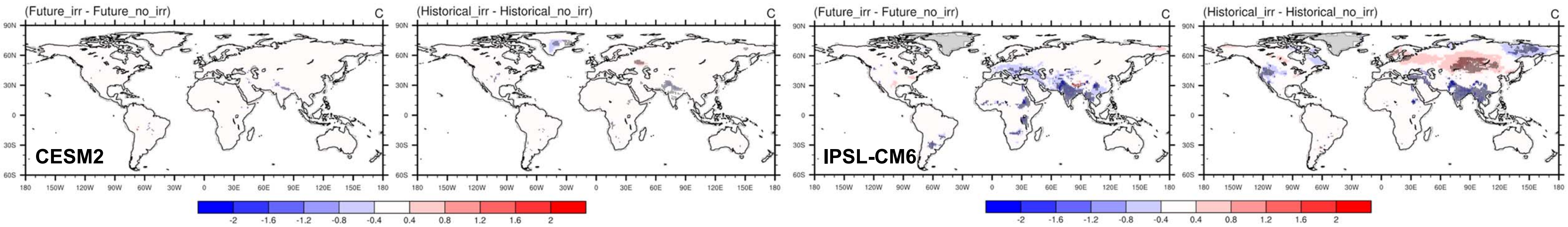
Sciences de l'environnement Institut Pierre Simon Laplace

Irrigation effects in historical and future (SSP) periods

Latent heat flux ➜ Stronger effect in IPSL-CM6, more extended in extra-tropical areas



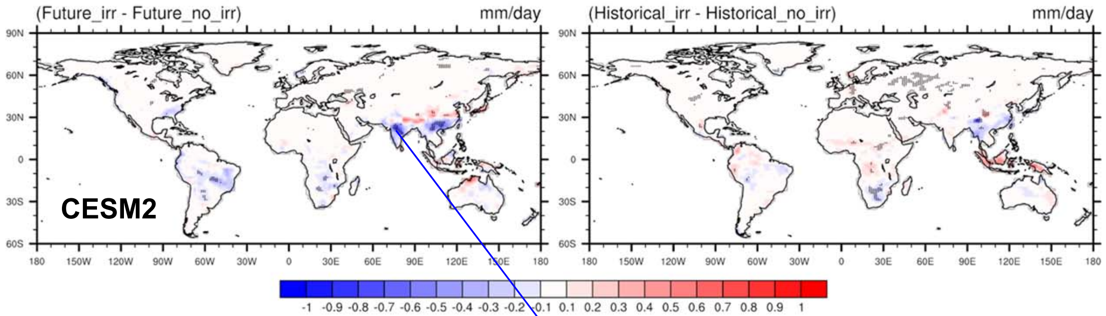
2m air temperature ➜ Only IPSL-CM6 exhibits a cooling effect of irrigation, stronger in future times

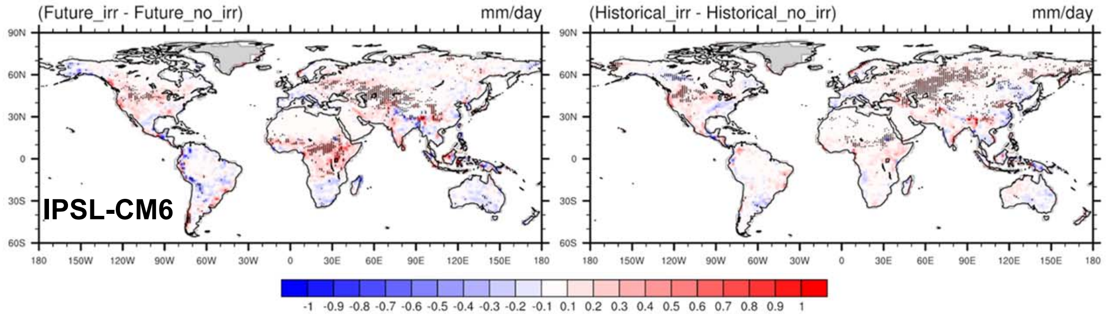


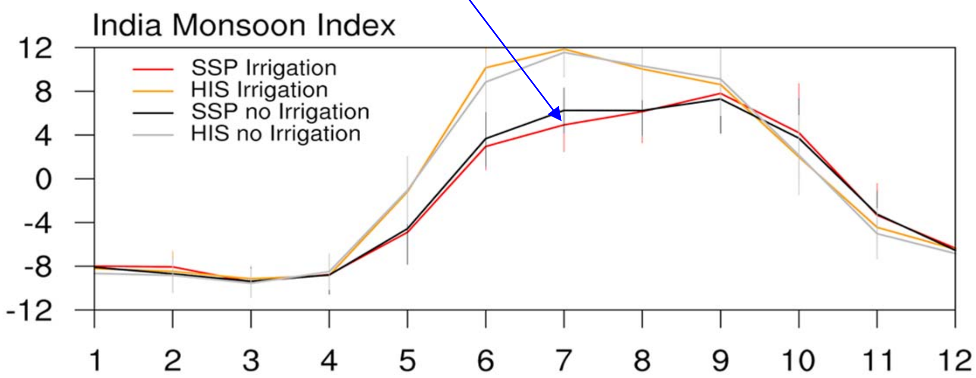
Coupled Irrigation-Groundwater-Climate Modeling

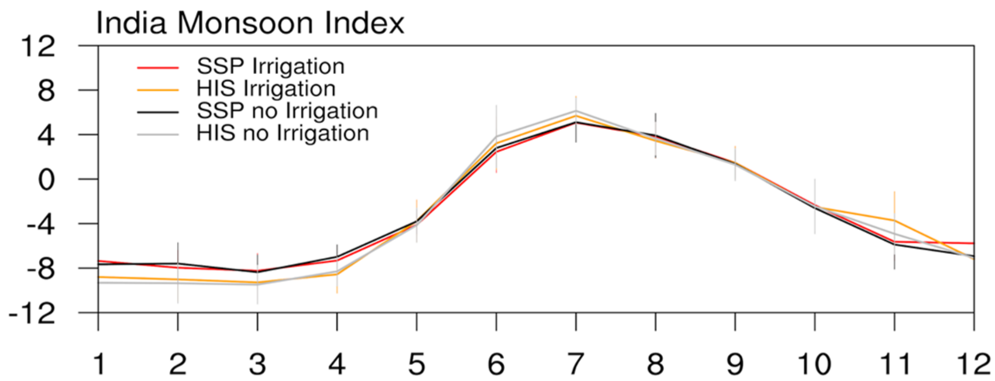
Irrigation effects in historical and future (SSP) periods

Precipitation ➞ No clear link between irrigation and precipitation changes, contrasting responses by the two models







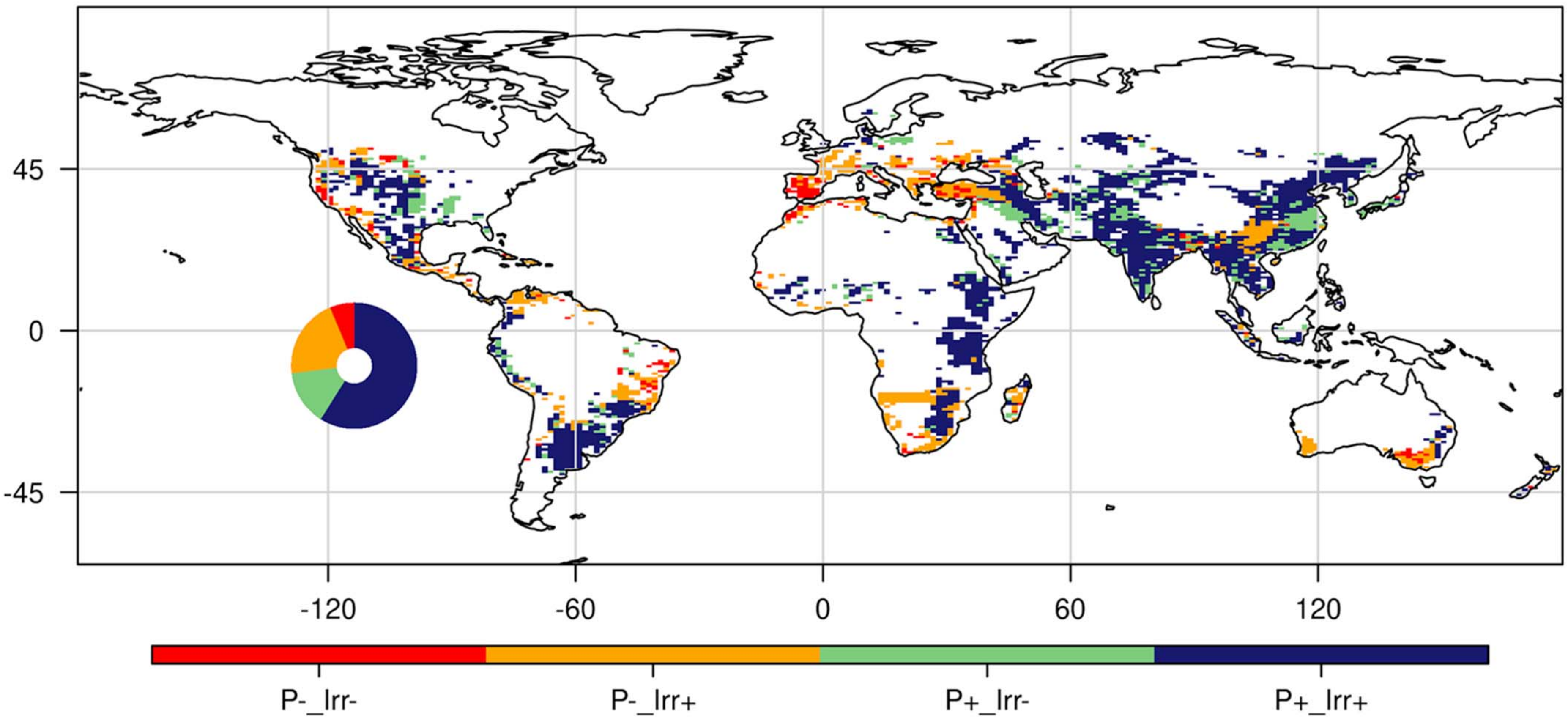


CESM2: strong response of Indian monsoon to climate change

Both models : weak response of Indian monsoon to irrigation

Coupled Irrigation-Groundwater-Climate Modeling

a) Joint trends of P and Irr



Irr ↘ because P ↘
P ↘ contributes to Irr ↘

Crop growth and irrigation limited by water availability

Irr ↗ to overcome P ↘

Irr ↘ because P ↗
No water stress

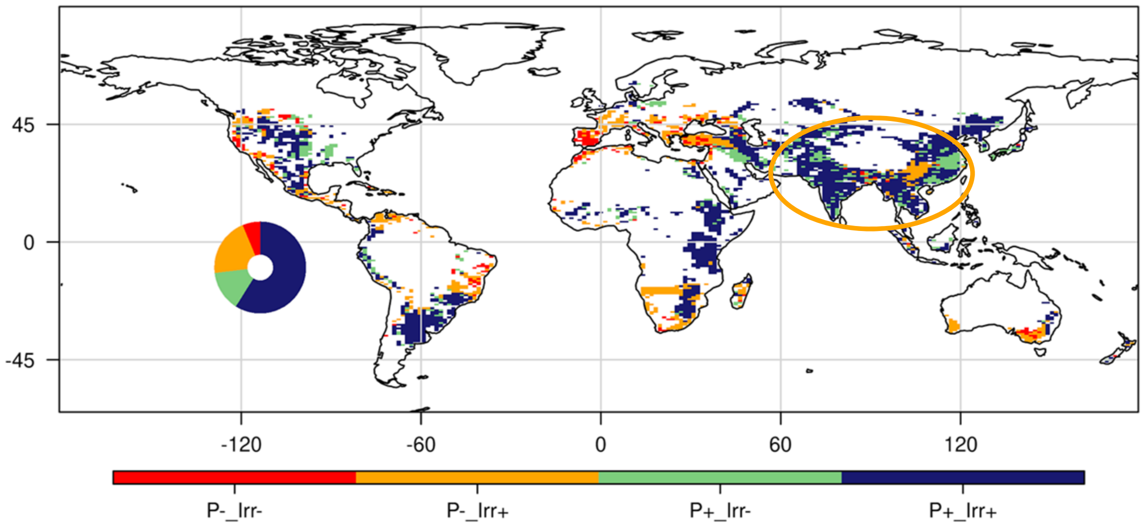
In real world, irrigated areas may then ↗

Irr ↗ because P ↗
Irr ↗ may contribute to P ↗

Crop growth is water limited
Irrigation enhanced by water availability

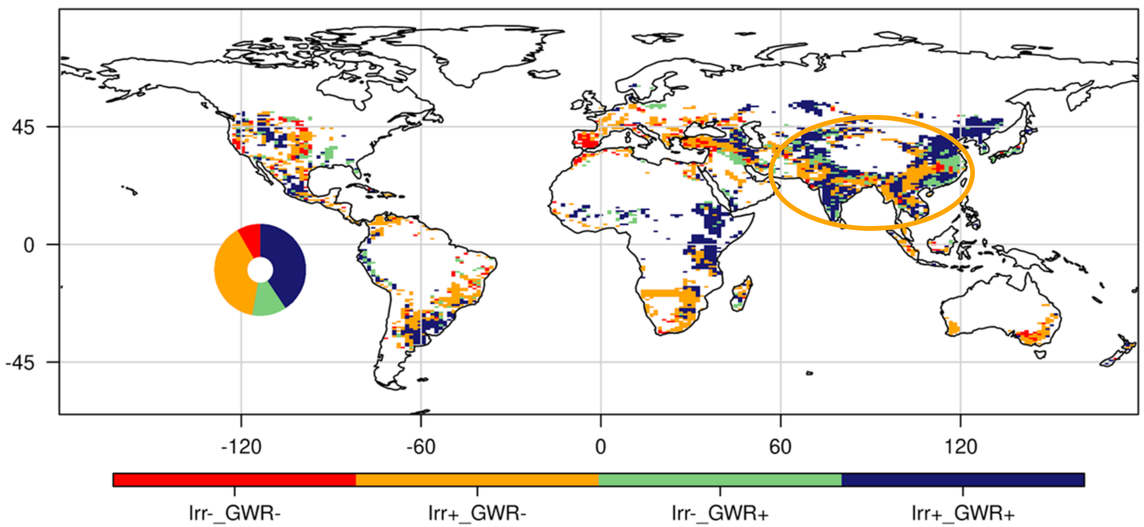
Coupled Irrigation-Groundwater-Climate Modeling

a) Joint trends of P and Irr



P ↘ over 1/4 of irrigated areas

b) Joint trends of Irr and GW reservoir



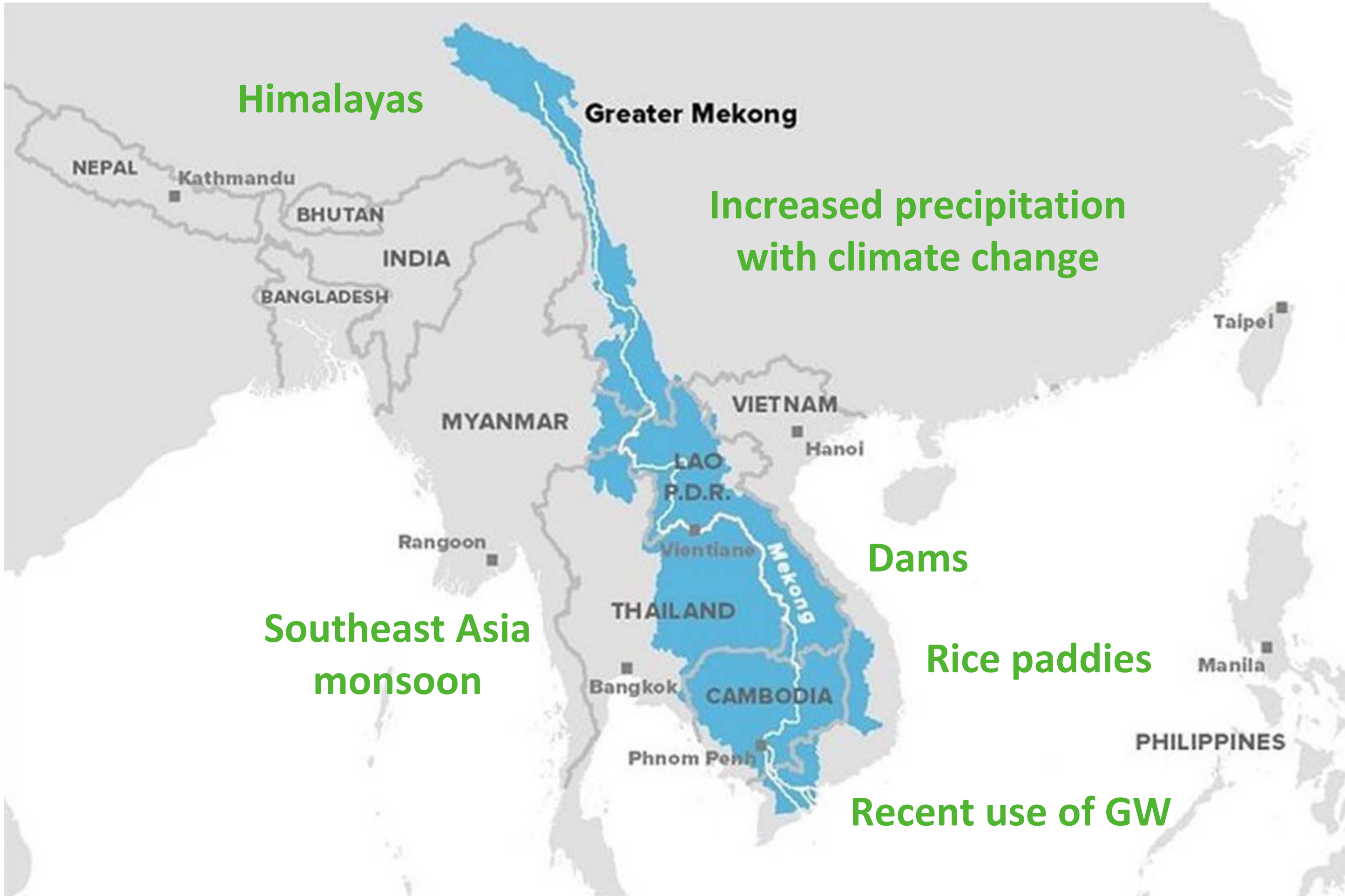
GW ↘ over 1/2 of irrigated areas

Additionnal 1/4 from areas where Irr ↗ because P ↗ (crop growth ↗)

Irrigation will continue to deplete resources unless carried out sustainably

Social Science: Farm Household Surveys

To understand farmers' perspectives on climate change, drought, water resources, irrigation and other farmer behaviors



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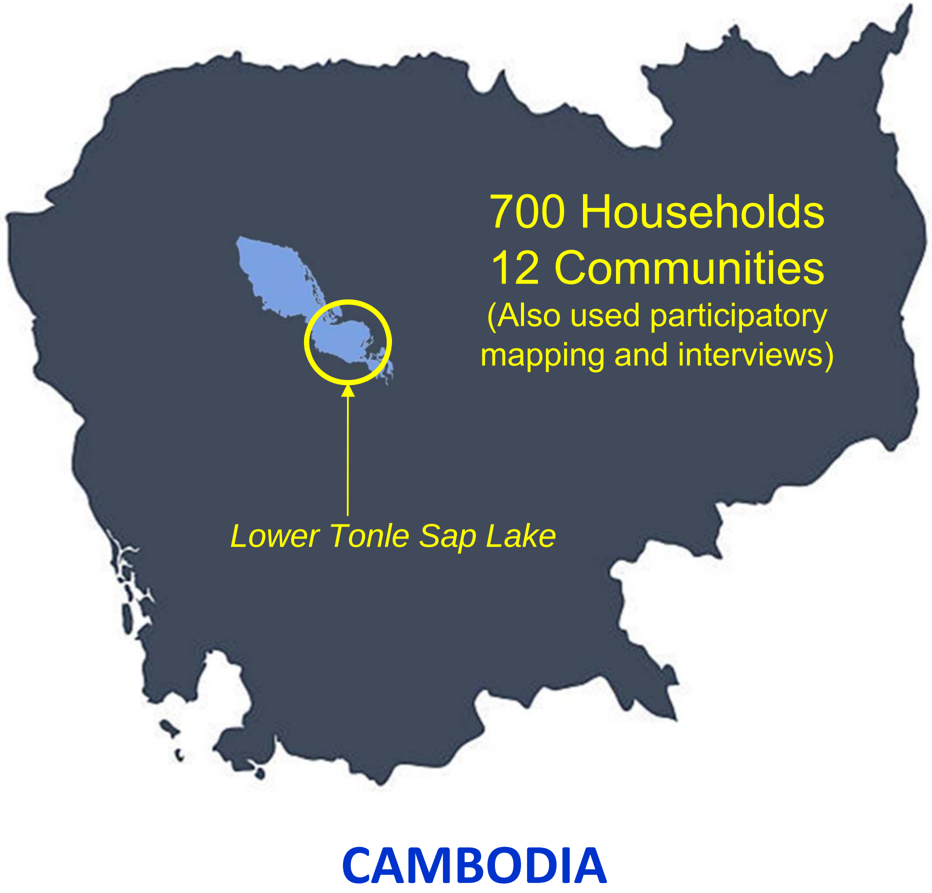
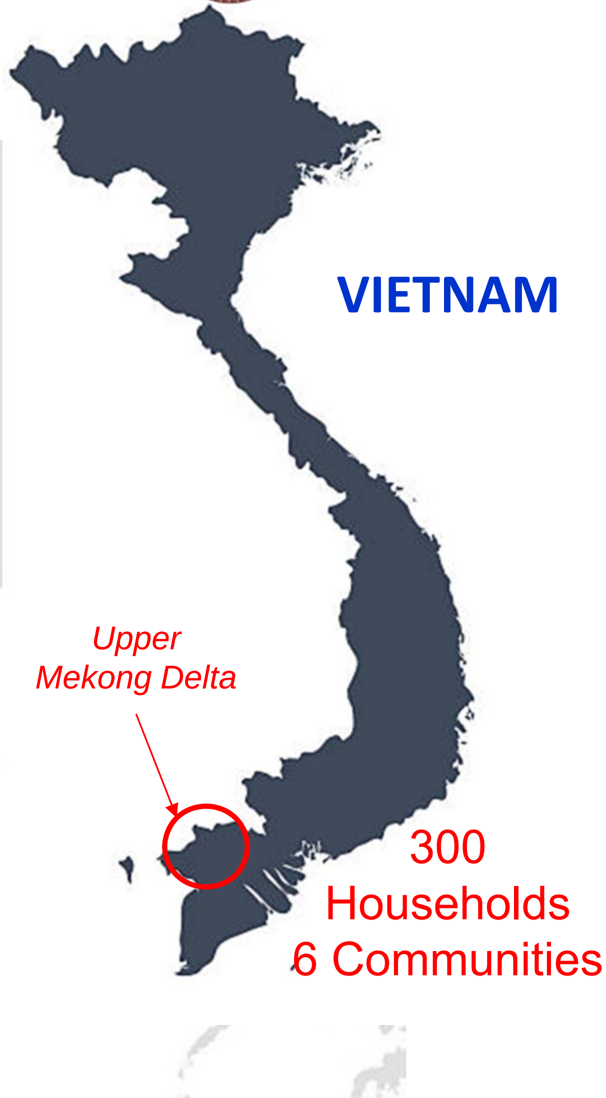




Social Science: Farm Household Surveys

National Taiwan University
MICHIGAN STATE UNIVERSITY

CAMBODIA	VIETNAM	CAMBODIA	VIETNAM
			

More Often Mentioned by Respondents ↑

OVERALL CONCERNS

CAMBODIA	VIETNAM
Drought	Storms
Food Prices	Salinity
Storms	Pests & Disease
Flood	Drought
Pests & Disease	Flood

CAUSES OF DROUGHT

CAMBODIA	VIETNAM
Lack of Rain	Lack of Rain
Dams	Poor Distribution
Overuse	Dams
Poor Distribution	Overuse

EFFECTS OF DROUGHT

CAMBODIA	VIETNAM
Less Income	Less Income
Lower Water Levels	Less Groundwater
Food Insecurity	Lower Water Levels
Lower Water Quality	Lower Water Quality
Less Groundwater	Food Insecurity
Health Effects	Conflict
Debt	
Migration	
Conflict	

Drought conditions and paddy rice. Source: Phnom Penh Post.

Responses in RED were NOT asked in both surveys

Social Science: Results

In Cambodia…

- Only **12%** of households have increased their use of irrigation in the past 5 years.
- Only **40%** of farm households use any irrigation and their sources include government irrigation (**47%**), local water bodies (**33%**), groundwater (**3%**), and other (**3%**)
- Farmers using irrigation are…
  - ***Wealthier***
  - ***More livelihood diverse***
  - ***Adopters of short term rice varieties***
  - ***Adopters of pesticides and fertilizers***
  - ***Connected to NGOs (not government)***
  - ***Experience fewer disruptive shocks***

Achang Irrigation Dam

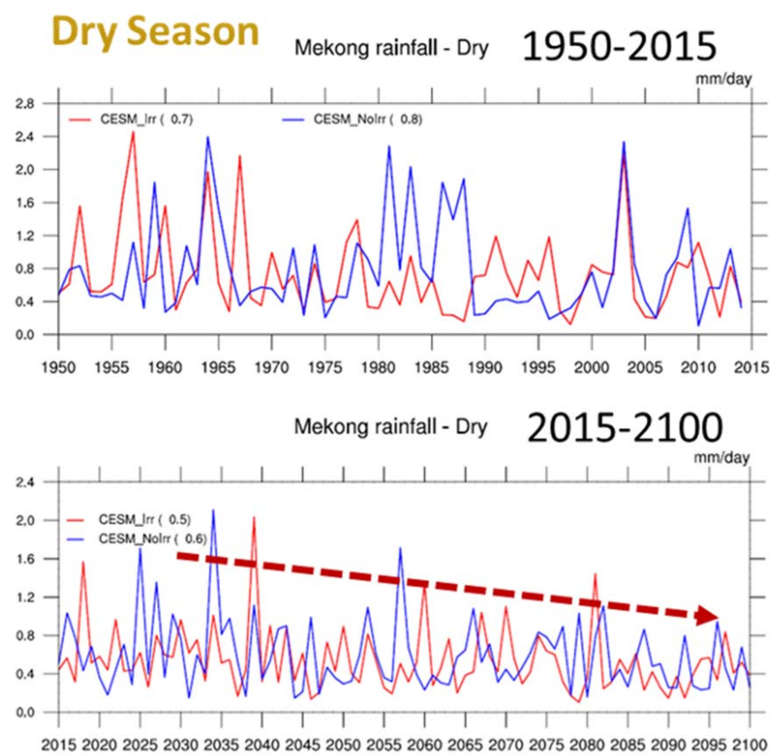
- ***BUT proximity to irrigation dams***, possession of land title, debt levels, food insecurity had **NO** relationship to irrigation use

Social Science: Results

National Taiwan University

In Vietnam…

- **Lack of drought experiences may lead to low risk perception**
  - Only **18 %** experienced drought
  - Only **21%** worried about drought
  - **67%** are not worried
  - **62%** think they are unlikely to encounter drought in the near future
- **Basic recognition of climate change does not link to drought**
  - **56%** agree climate change is happening
  - **57%** agree climate change is affecting Mekong Delta
  - **49%** are unaware that climate change may drive drought
- **Climate projection data shows a drying trend, but the local farmers may not be ready to take any measures (figure)**



Interdisciplinary research is difficult, ***particularly in data poor regions***
(e.g. mismatch of social and biophysical data - temporal and spatial scales)

BLUEGEM in numbers

Good scientific production

- **Science papers**: 14 published (including 1 data paper) + 1 submitted + 7 in prep
- **Communications :** 30 in international conferences, 11 in national conferences
- **Franco-Taiwanese Great Prize** : 1

Coordination and community building

- **Organized conferences** : SRI sessions + 2 sessions (IAH/UNESCO 2022; AGU 2023)
- **Quarterly plenary meetings**: 12
- **Hired post-docs**: 5 + 3 associated
- **PhD theses**: 2 defended + 3 in progress
- **Other graduate students**: 4 funded + 4 associated
- **Effective interdisciplinary development:** in 2.5/4 cases, if motivation and/or existing collaboration

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Group picture at last quarterly meeting, April 3rd 2024

Broader initiatives

- Multidisciplinary approaches to study irrigation impacts
- Collaborative platform for discussing GW and irrigation research
- Platforms for sharing research findings and methodologies
- Encouraging interdisciplinary collaboration

Aspen Workshop on Irrigation in the Earth System, 2023

Global irrigation water withdrawals and consumption estimates ([Mcdermid et al. 2023])

ISIMIP Inter-Sectoral Impact Model Intercomparison Project IRRMIP GEWEX

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Thank you for your attention

BLUEGEM

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Open discussion
on
Stakeholder engagement in research activity

JD Rinaudo (INCLUSIVE):

- **What stakeholders participated in our research and how ?**
- **What were their motivations, what were our strategies to build a relationship with them ?**
- **What difficulties did we encounter in engaging our stakeholders and why ?**
- **Lessons learnt and recommendations ?**

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BLUEGEM feedback

Slides presented
in April 2024

Why are we interested into the BLUEGEM project?

- To get information on the impacts of irrigation on long and middle-term at the global and regional scale
- To provide information on irrigation impacts to water users
- To mobilize water users to go further on their adaptation strategies
- To feed the water policies and climate change adaptation strategies

What can we do for the BLUEGEM project?

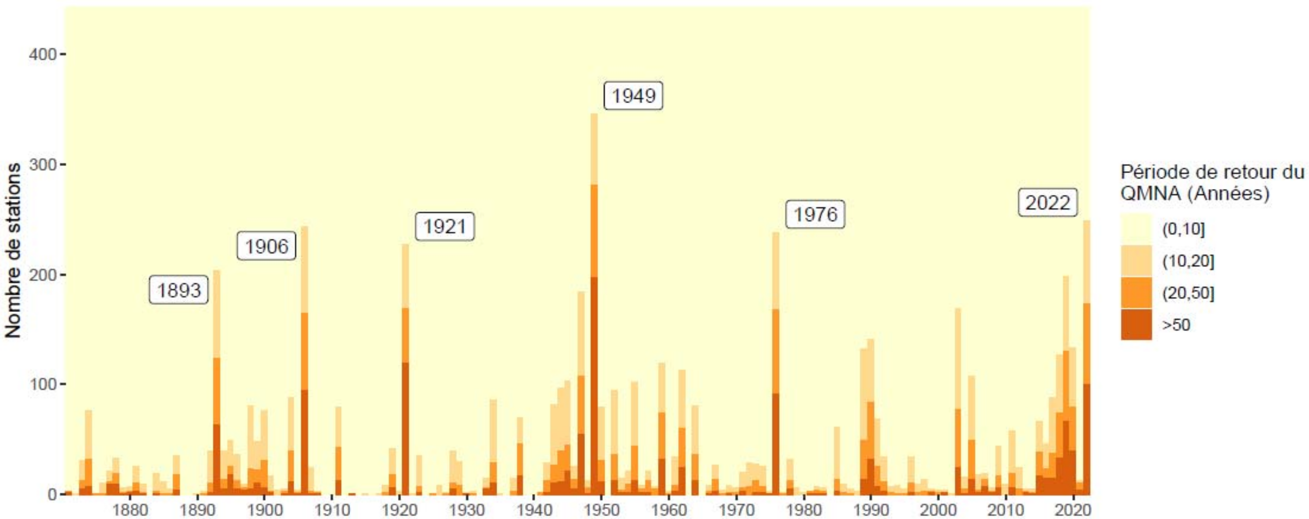
- Enhancing contacts with regional and local water stakeholders
- Providing data on water abstractions or hydrological data (observatory on low flows especially in intermittent rivers)
- Disseminating results by publishing articles in water managers journals or participating in meetings and workshops

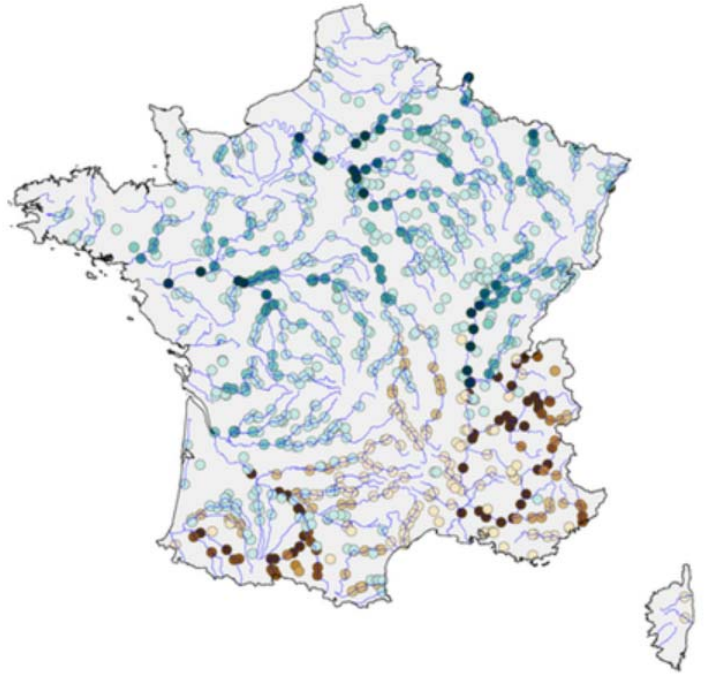
Useful scientific results

- **Providing high resolution simulations**

Discharge projections will be used by local water stakeholder to plan sustainable water resources management

- **Analysis of 2022 historical drought**





National disclosure of results on June 28, Ministry of Ecological Transition

To be continued (owing to spin-off project)

- **Co-construction of storylines with local water stakeholders**
  - Interviews were carried on
  - Synthesis of key messages was presented in a BLUEGEM meeting

⇒ **How to integrate local scenarios in simulations?**
- ➢ Sometimes discussed solutions are at a very fine scale (hedges and wetlands restoration, irrigation efficiency…)
- ➢ Strong heterogeneities among scenarios between nearby catchments

⇒ **What kind of feedback can we bring to local water stakeholders ?**

> Explaining uncertainties, helping them to deal with uncertainties

Broader perspectives

- Recycling ratios between precipitation and evapotranspiration
    - Active debate on the role of forests and irrigation on precipitation
    - Need scientific explanations and figures
- Relations between meteorological variability and water abstractions ?
    - Political objective of water use reduction of 10 %
    - Water abstraction monitoring is needed first

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