LUCCi Land Use and Climate Change Interactions in Central Vietnam

BMBF-LUCCi climate simulations and potential applications for agriculture

Lower Mekong River Basin (LMRB) & Vu Ghia Thu Bon (VGTB)

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Motivation: Climate simulations SE Asia

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- **Sparse observation network** of hydrometeorological data
  - Few hydrometeorological stations (located in lowlands)

- Stakeholders demand **scientific sound CC adaptation strategies**
  - Flood protection measures (adaptation of infrastructure)
  - Future hydropower potential (low flows)
  - Agricultural applications (e.g. irrigation strategies)

→ High-resolution meteorological data (past and future) required for CC impact modelers (e.g. agric., hydrol.)

Method: Regional climate projections

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Population Growth, Economic Development & Technological Progress

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Emission Scenarios
Greenhouse Gas Concentrations

↓

Global Climate Models

↓

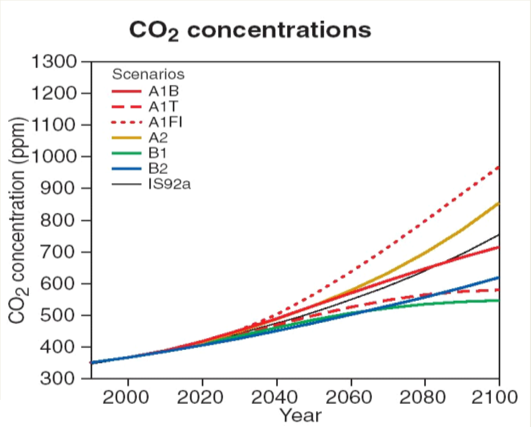
Global Climate Scenarios

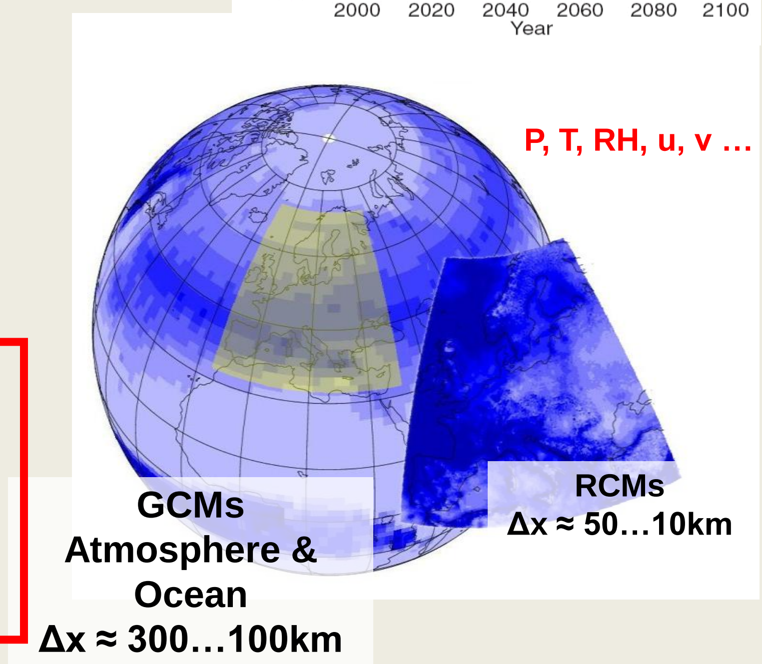
↓

Downscaling Methods

↓

Regional Climate Scenarios





Downscaling setup for 2 case studies

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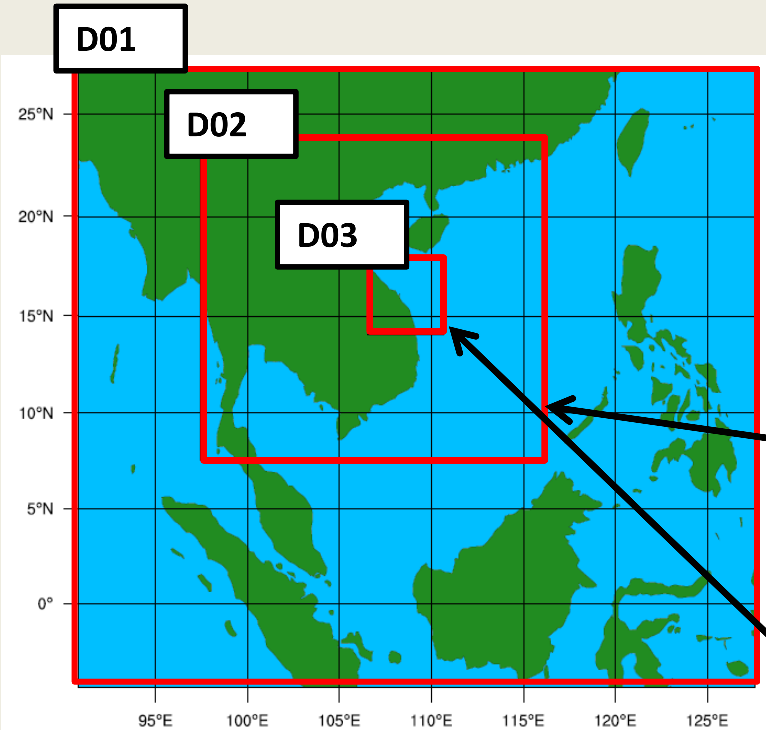
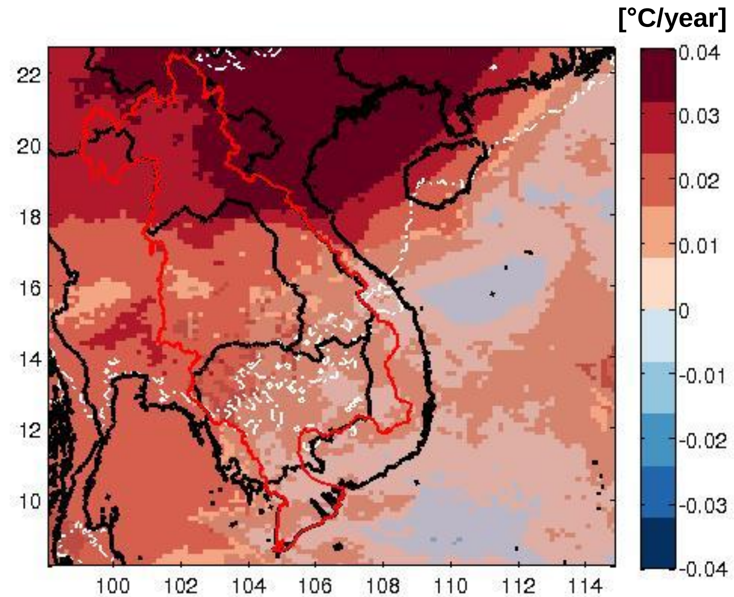


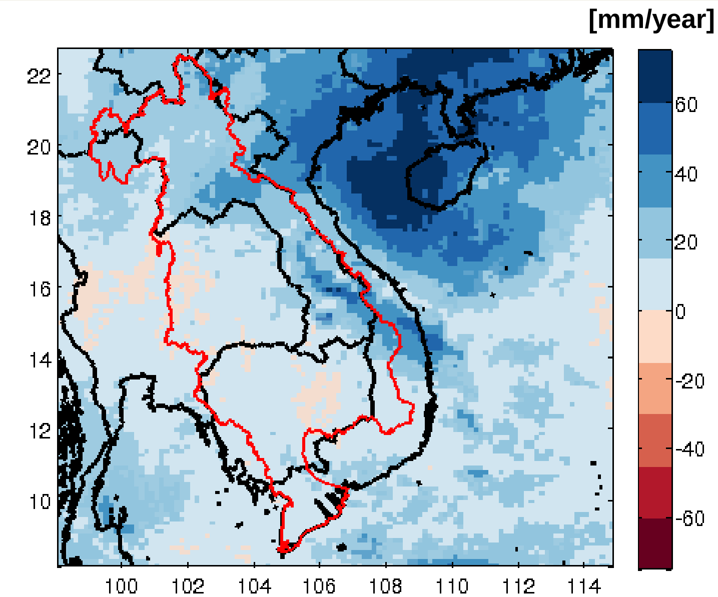
- **Domain 1**
  - horizontal: 99 x 99 grid points with a resolution of **45 km**
  - vertical: 50 layers up to 50 hPa
  - time step: 180 s
- **Domain 2: Case study of LMRB**
  - horizontal: 142 x 145 grid points with a resolution of **15 km**
  - vertical: 50 layers up to 50 hPa
  - time step: 120 s
- **Domain 3: Case study of VGTB**
  - horizontal: 66 x 75 grid points with a resolution of **5 km**
  - vertical: 50 layers up to 5000 Pa
  - time step: 30 s

LMRB: Detected trends

Temperature (1971-2000)



Rainfall (1971-2000)



→ Temperature increased up to 1.2 °C (1971-2000)

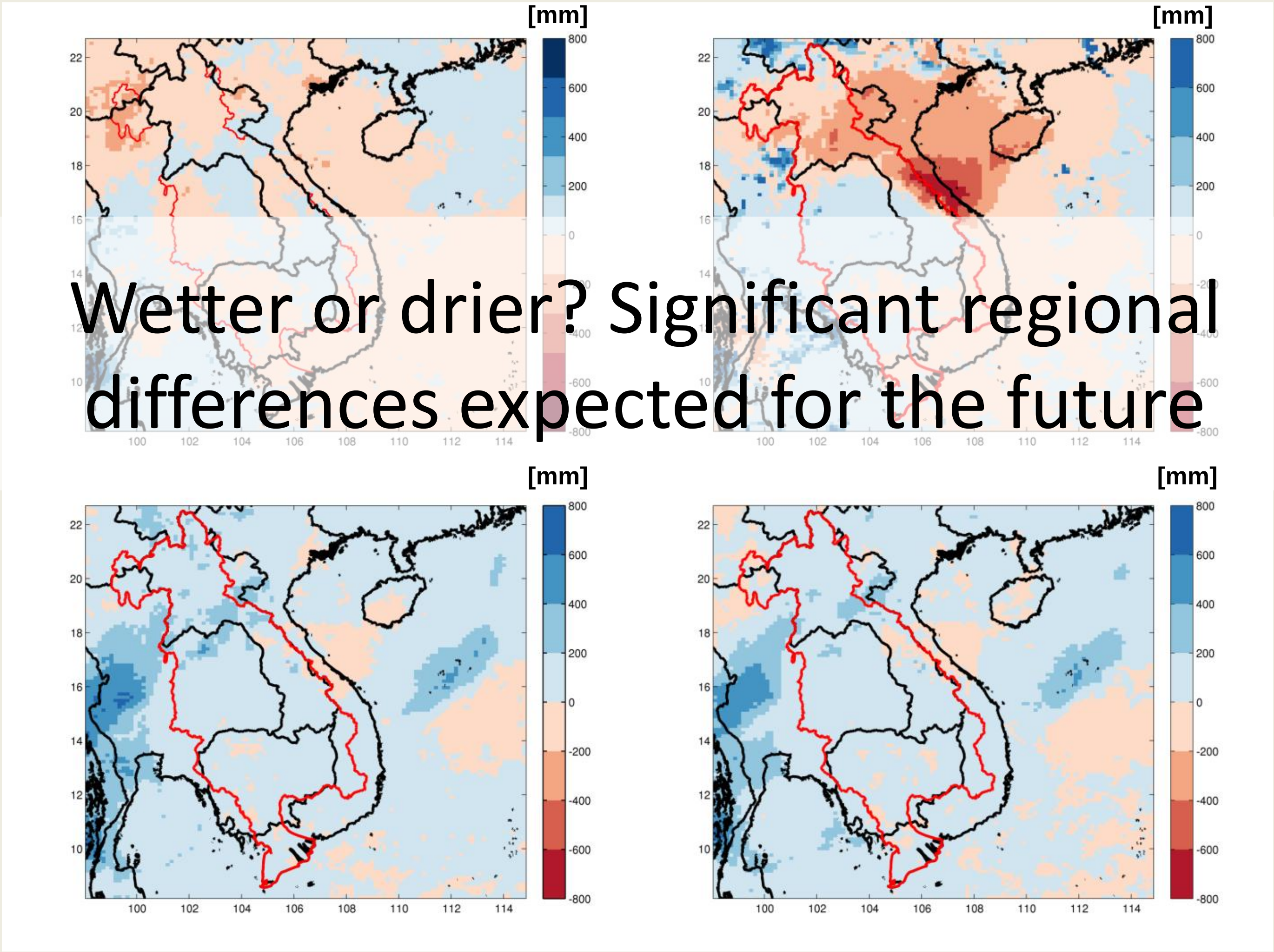
→ Rainfall increased for most locations; LMRB: ~ 450 mm (1971-2000)

LMRB: Expected rainfall change

2001-2030 | 2021-2050

A1b

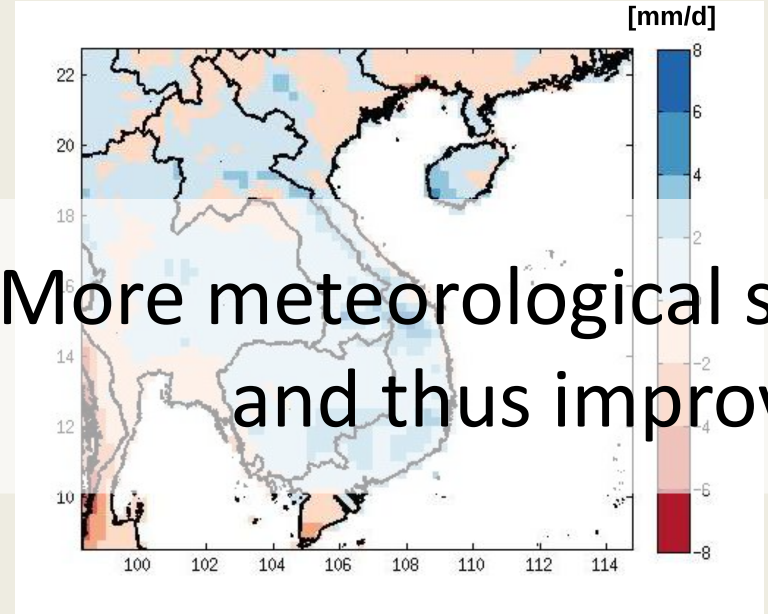
B1



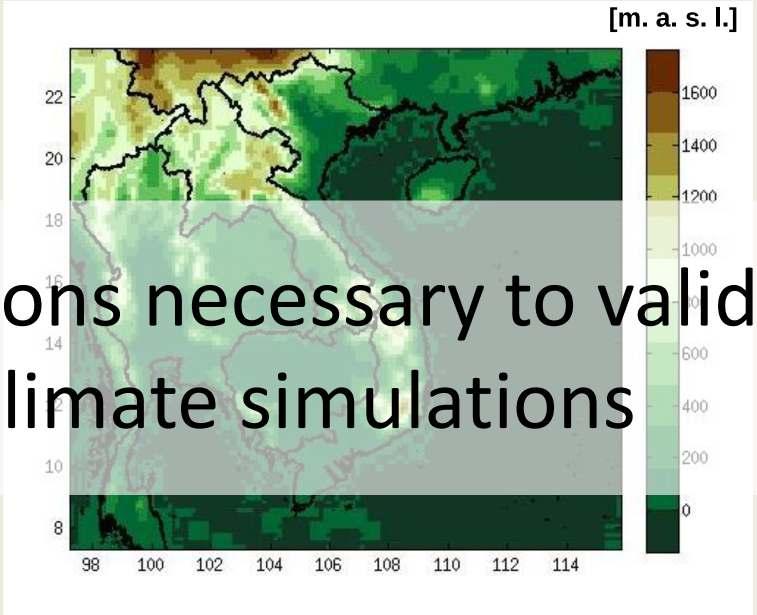
Wetter or drier? Significant regional differences expected for the future

LMRB: Reliability of simulations

Mean daily precipitation deviations for 1971-2000 (WRF-ERA40 *minus* APHRODITE)



DEM as used in WRF



More meteorological stations necessary to validate and thus improve climate simulations

→ Model performs good on average (+/- 2 mm)

→ Highly elevated areas: WRF bias or interpolation error of observations?

VGTB: Expected rainfall change

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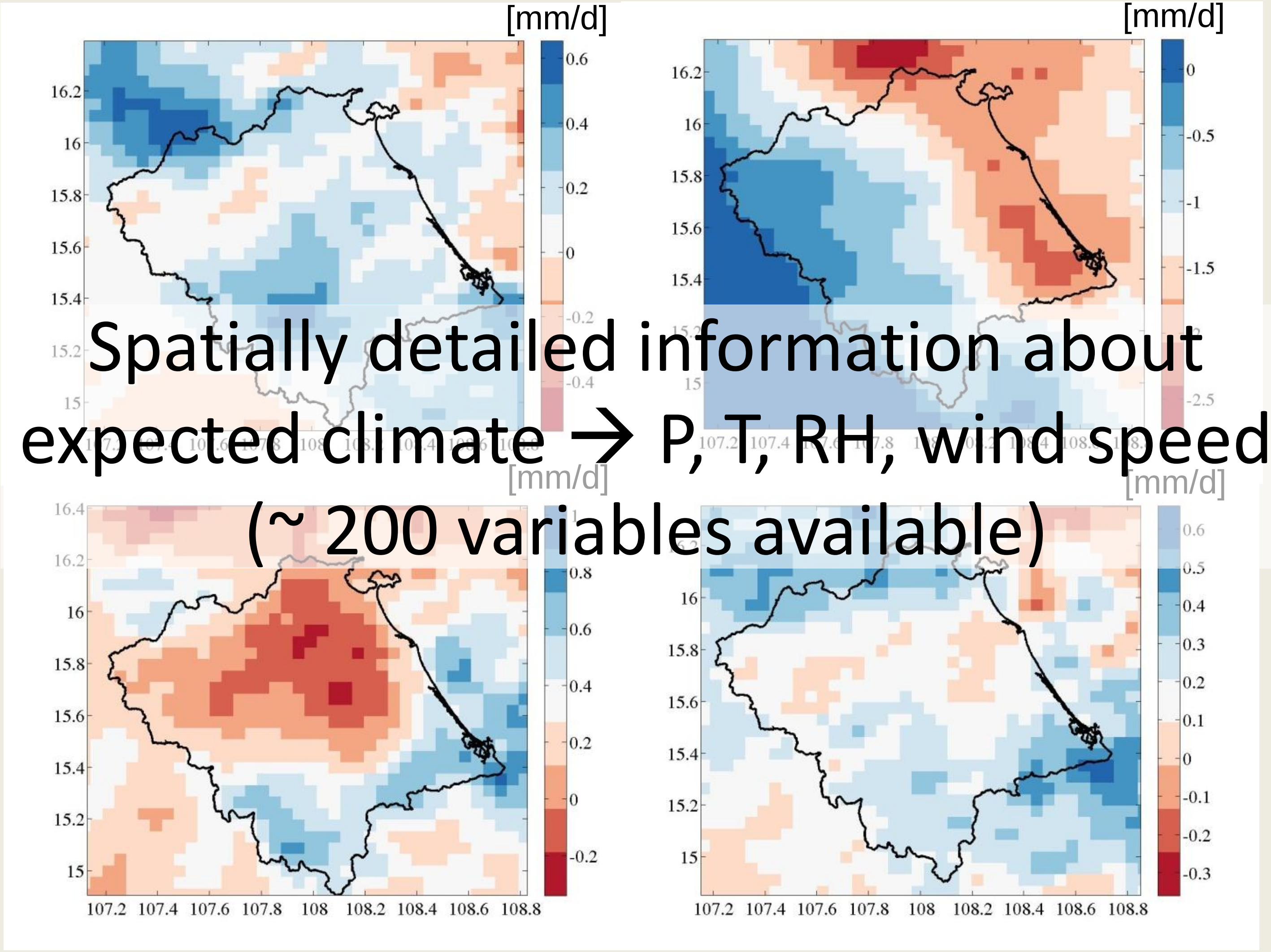
2001-2030 | 2021-2050

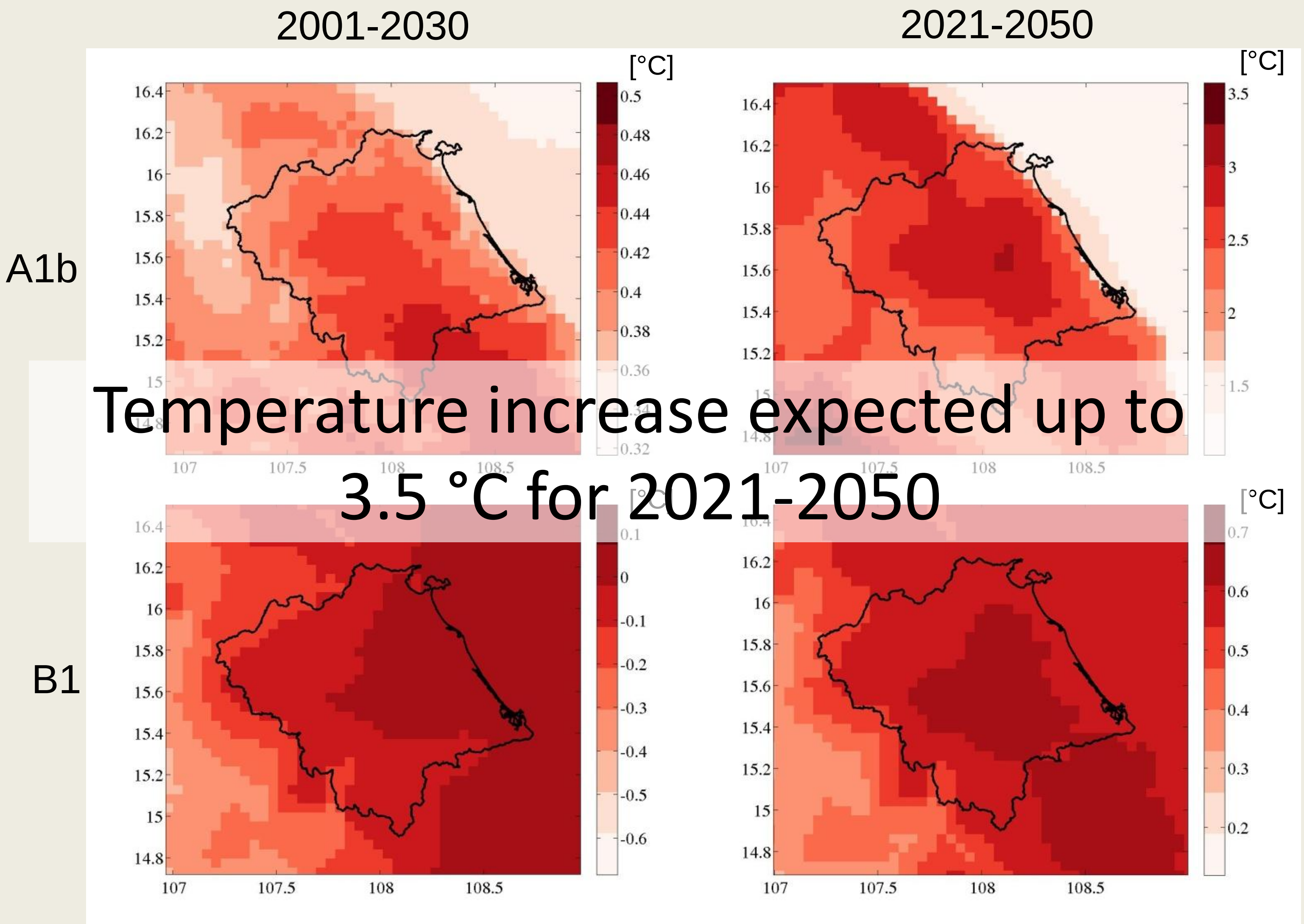
A1b

B1



Spatially detailed information about expected climate → P, T, RH, wind speed (~ 200 variables available)

VGTB: Expected temperature change

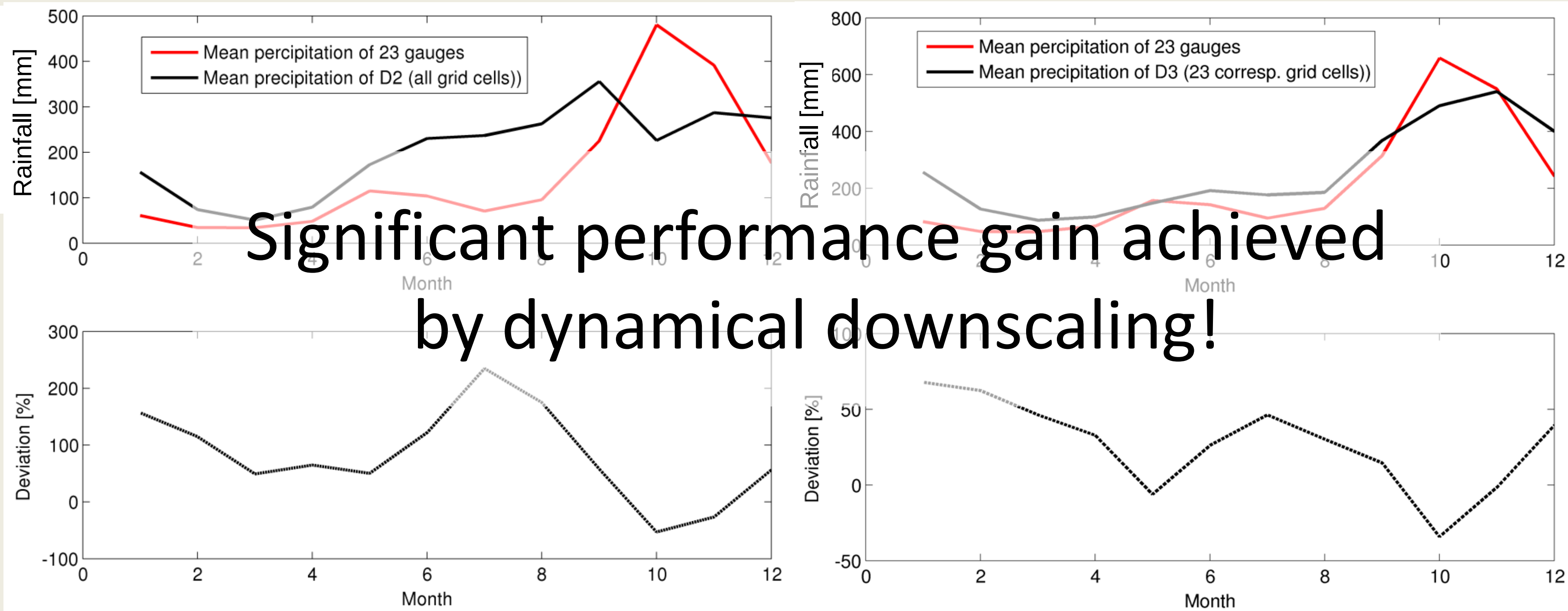


Temperature increase expected up to 3.5 °C for 2021-2050

VGTB: Reliability & Performance

D2 @ 15 km

D3 @ 5 km



Significant performance gain achieved by dynamical downscaling!

→ D2: Seasonality not well captured, high deviations from observations

→ D3: Improved seasonality, acceptable deviations

Potential applications of climate data

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Hydrology

- Water balance estimation
- Flood frequencies
- Construction of dams, etc.

Energy

- Hydropower
- Wind energy

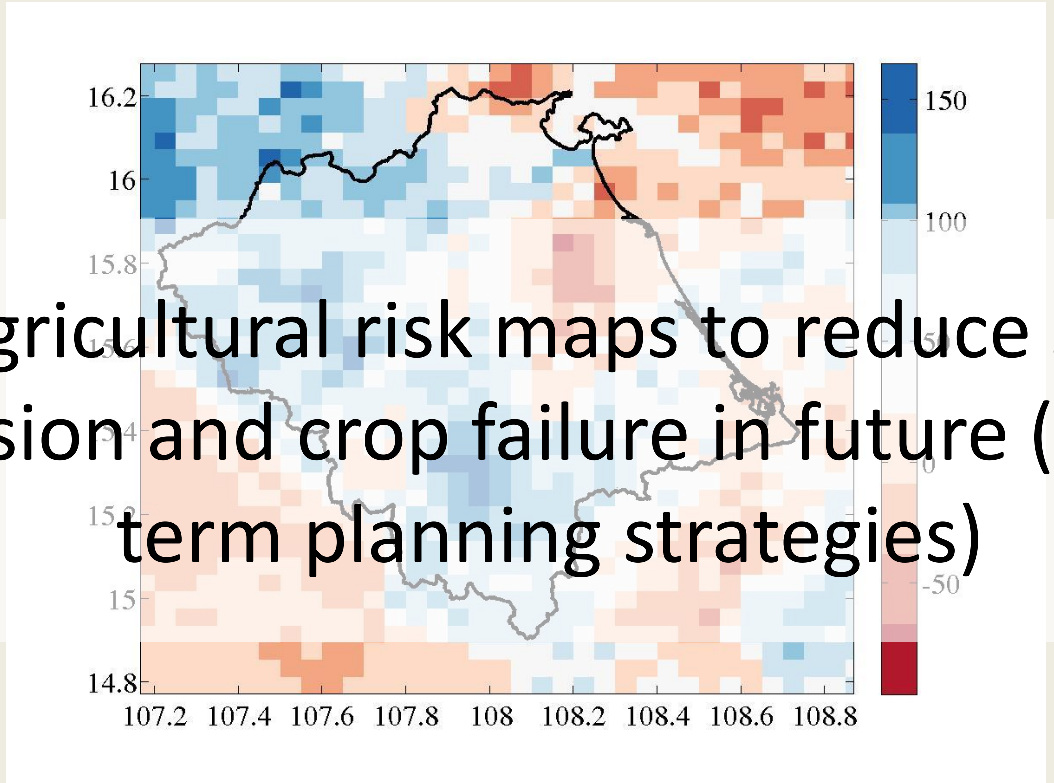
Agric

- Adapt cropping locations
- Crops/varieties (seasonally)
- Planting date adaptations (long-term)

Tourism

- Heat waves
- etc.

Tailor-made agricultural products



Agricultural risk maps to reduce soil erosion and crop failure in future (long-term planning strategies)

Expected changes in number of heavy rainfall events (precip > 20 mm) during 2001-2030 (A1b)

Capacity building

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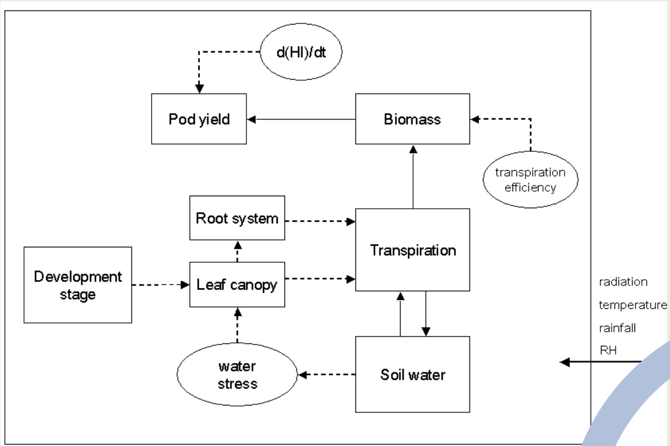
Supervision PhD's:

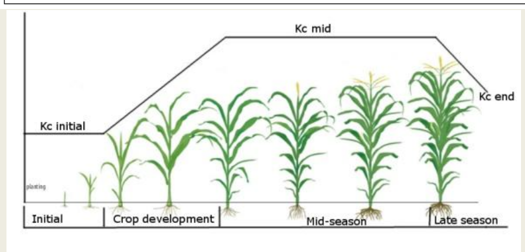
- **Nguyen Phuong** (LUCCi): Impacts of land use change on meteorological surface variables using dynamic land use information in the climate simulations
- **Dang Thinh** (DAAD): Identification of **optimized cultivation strategies** (rice, cash crop) and **sustainable water management strategies** in the VGTB river basin using coupled WaSim - Gams simulations

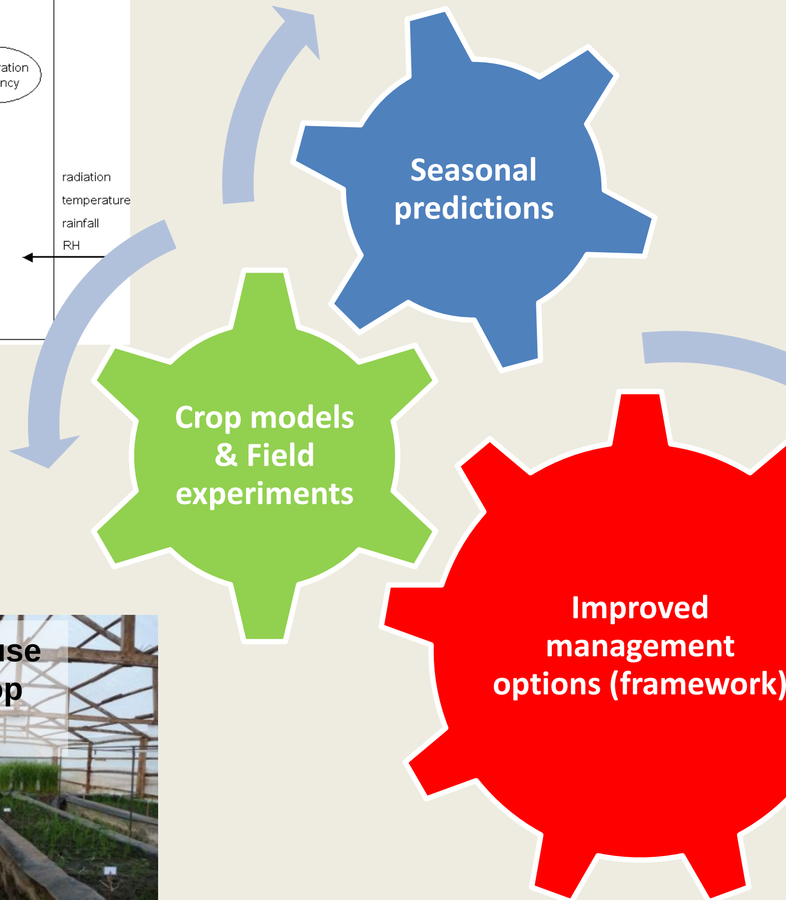
Courses / Lectures planned in 2014/2015:

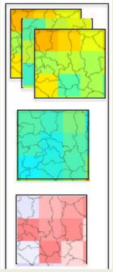
- dynamical downscaling,
- climate change impact analysis,
- risk mapping,
- climate-smart agricultural

Towards climate-smart agriculture







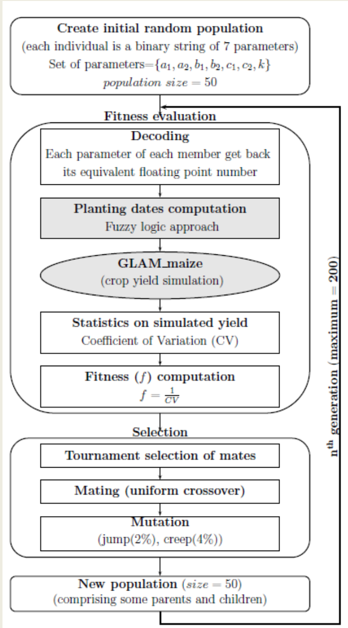


RCMs

Weather (P, RR, T),

Soil,

Management



Goal: Improving existing cropping calendars

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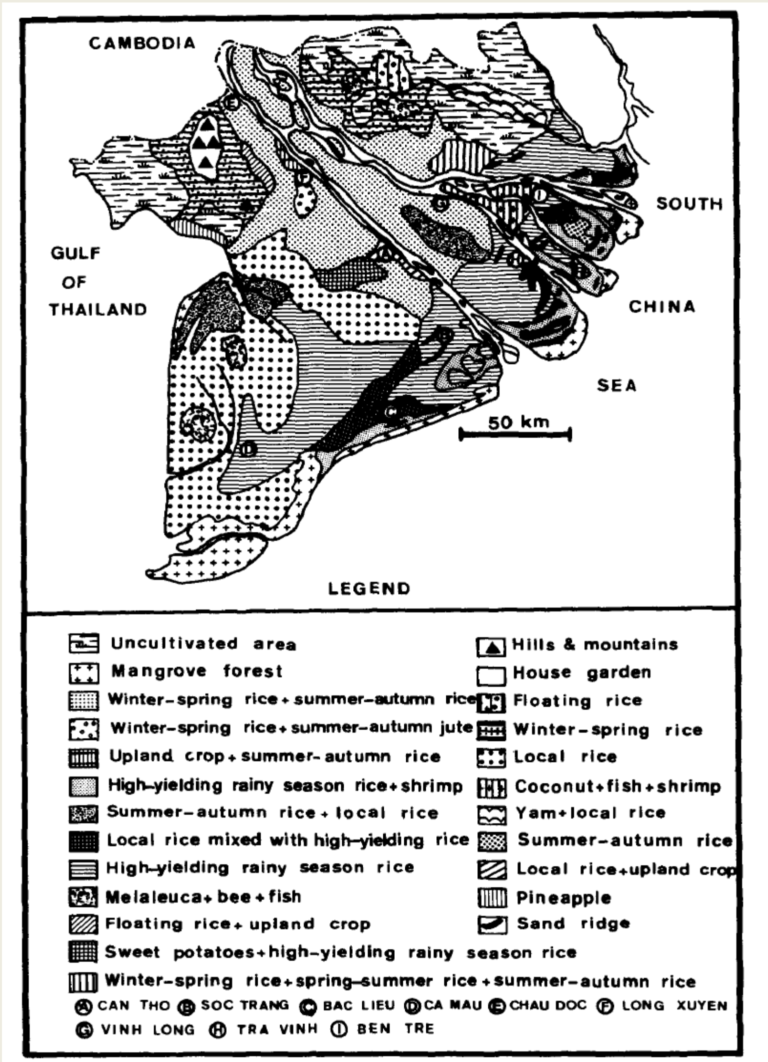
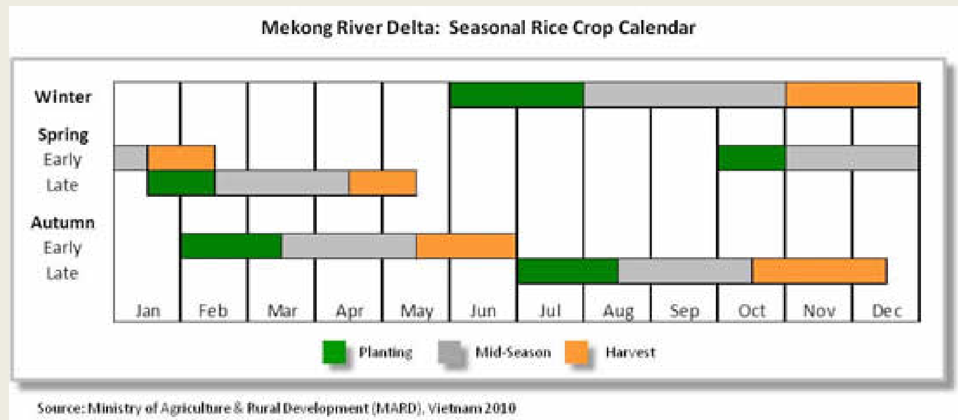
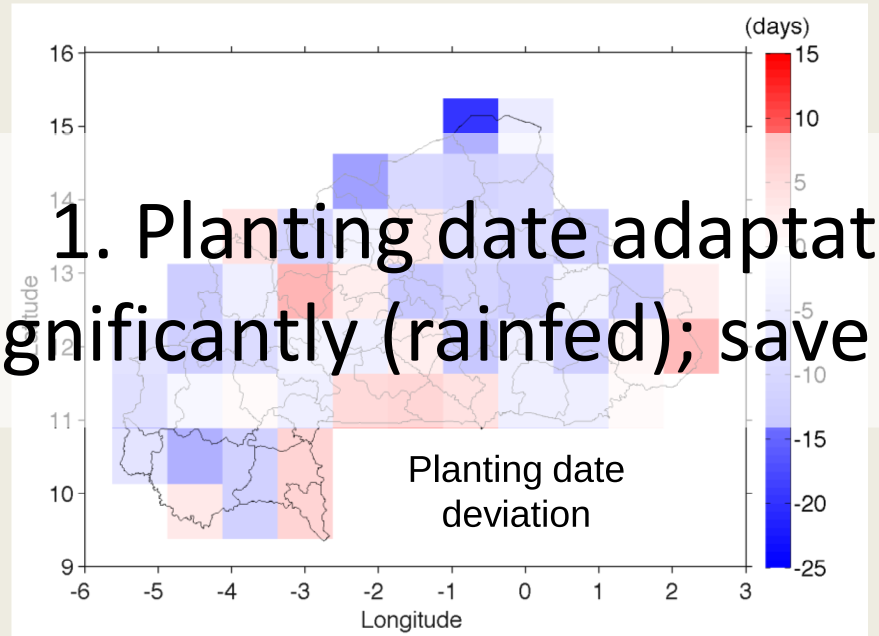
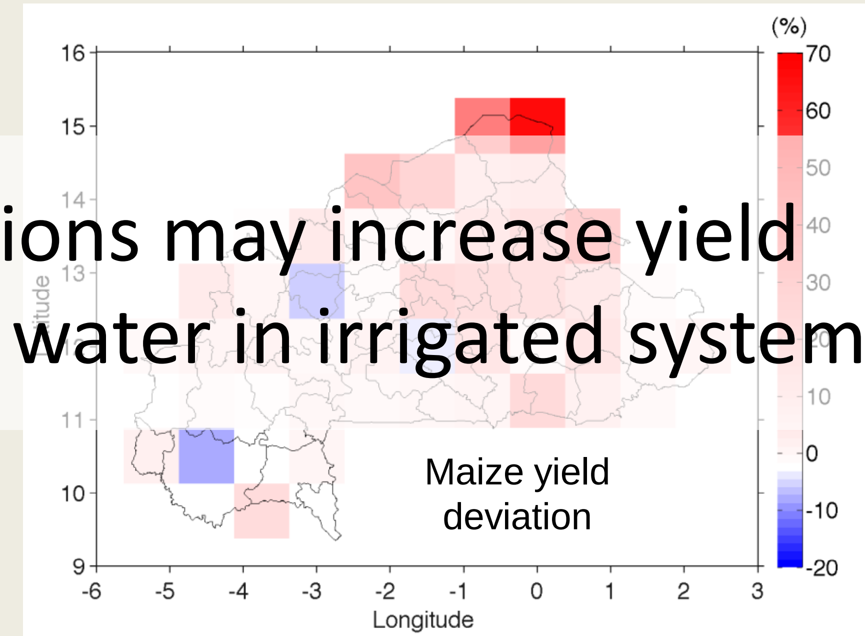




Lessons learnt from other projects (WASCAL)

New approach (Waongo et al., 2014) *minus* traditional approach (Diallo et al., 2008)





1. Planting date adaptations may increase yield significantly (rainfed); save water in irrigated systems

Waongo, M, Laux, P., Traore, S., Sanon, M., Kunstmann, H. (2014): A Crop Model and Fuzzy Rule Based Approach for Optimizing Maize Planting Dates in Burkina Faso, West Africa. Journal of Applied Meteorology and Climatology, 53:598-613.

Lessons learnt from other projects (WASCAL)

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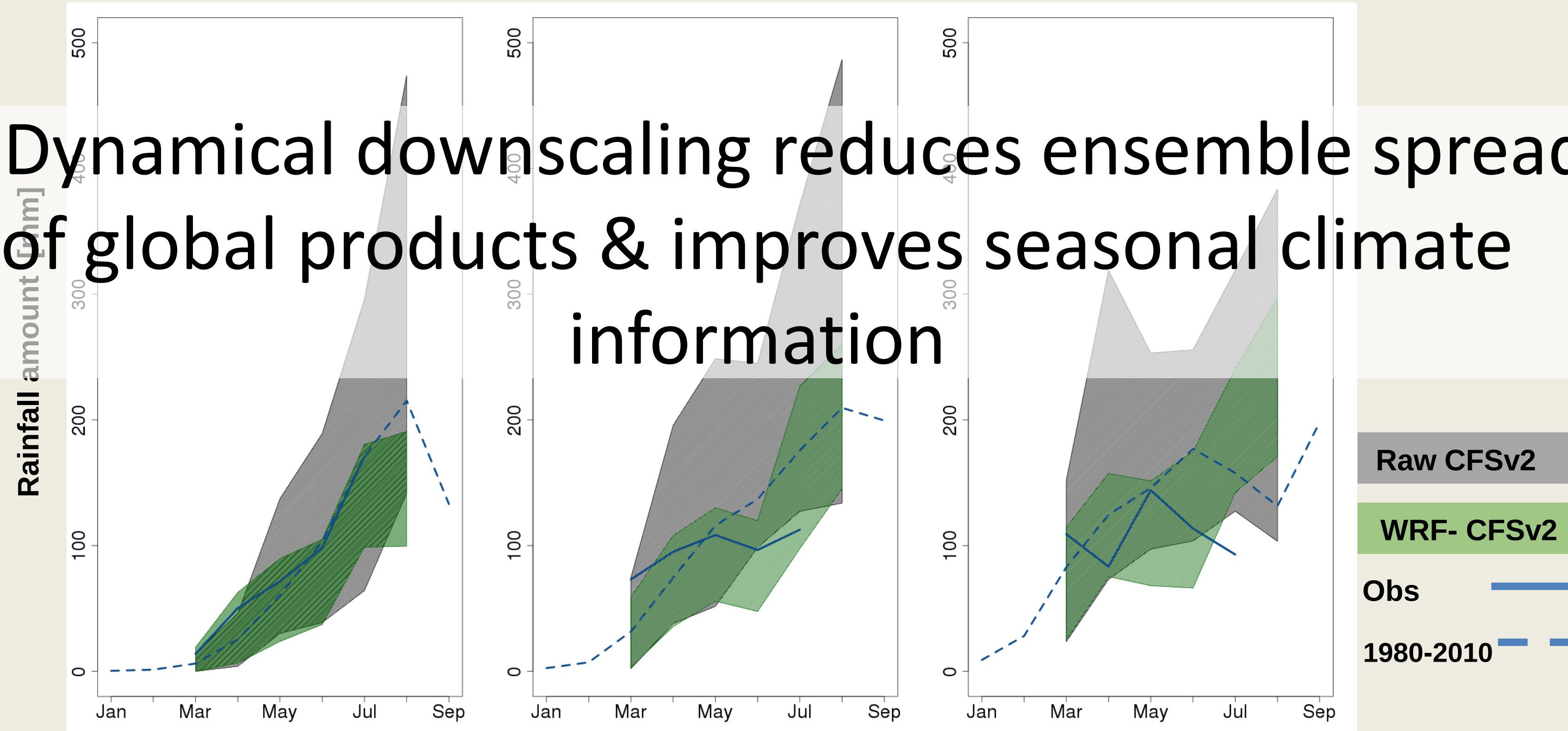
WRF ensemble downscaling of seasonal forecasts CFSv2 for Volta basin:
Rainfall amount March - August (2013)



2. Dynamical downscaling reduces ensemble spread of global products & improves seasonal climate information

Siegmung, J., Laux, P., Bliefernicht, J., Kunstmann, H.: Seasonal Precipitation Prediction for West Africa: Evaluation and Dynamical Downscaling of CFS2's Global Seasonal Predictions (in prep.)

Summary & Recommendations

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- **Long-term climate simulations** are performed and provided: Reliable in general, validation for highlands not possible

  → Investment in measurements
- Specific **tailor-made information** (e.g. agricultural risk maps) can be developed **in cooperation with local researchers**

  → Supporting collaborations/projects
- Existing **seasonal climate predictions** are not useful to give scientifically sound agricultural recommendations (what to plant when, and where for the coming season?)

  → Investment in projects about improved seasonal climate products and coupled climate-agricultural modeling systems
- Knowledge from LUCCi and other projects and interested in **future collaborations** in Vietnam

  → Contact us (patrick.laux@kit.edu)

Further reading

Souvignet M, Laux P, Freer J, Cloke H, Thinh DQ, Thuc T, Cullmann J, Nauditt A, Flügel WA, Kunstmann H, Ribbe L (2013) Recent climatic trends and linkages to river discharge in Central Vietnam. Hydrol. Process.. doi: 10.1002/hyp.9693.

Laux P, Phan VT, Thuc T, Kunstmann H (2013) High Resolution Climate Change Information for the Lower Mekong River Basin of Southeast Asia. High Performance Computing in Science and Engineering 13. Nagel W, Kröner D, Resch, M (eds.). Springer Berlin Heidelberg (in press).

Laux P, Phan VT, Lorenz C, Thuc T, Ribbe L, Kunstmann H (2012) Setting Up Regional Climate Simulations for Southeast Asia. High Performance Computing in Science and Engineering 12. Nagel W, Kröner D, Resch, M (eds.). Springer Berlin Heidelberg, 391–406.

Thank you very much for your attention