LUCCi Land Use and Climate Change Interactions in Central Vietnam

P1: High-resolution climate modeling for Central Vietnam: Recommendations for impact modelers and information for stakeholders

Contact: Dr. Patrick Laux

P. Laux[1], P. Nguyen[1,2,3], T. Dang[1,3], J. Cullmann[2], V.T. Phan[4], T. Tran[3], H. Kunstmann[1]

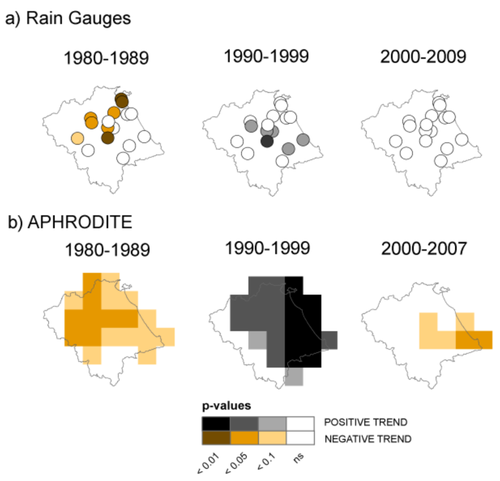
1 Karlsruhe Institute of Technology, Institute of Meteorology and Climate Research (KIT, IMK-IFU), 82467 Garmisch-Partenkirchen, Germany
2 IHP/HWRP Secretariat, Federal Institute of Hydrology, 56068 Koblenz, Germany
3 Vietnam Institute of Meteorology, Hydrology and Environment (IMHEN), Hanoi, Vietnam
4 Hanoi University of Science, Department of Meteorology, Hanoi, Vietnam

Introduction

- For data sparse regions such as Central Vietnam, **high-resolution hydrometeorological data** is crucial for climate impact studies, e.g. future water availability, crop yields, etc.
- Regional Climate Models may be suitable to simulate the **complex climate interactions** in Central Vietnam: monsoonal flows, cold air penetrations from north, tropical cyclones, and complex orography (Truong Son Range).
- To overcome the problem of data scarcity in the region, transient ***Weather Research and Forecast* (WRF)** simulations were conducted forced by ERA40, ERA-Interim, and ECHAM5 (A1B and B1 SRES scenario).

Analysis of hydrometeorological observations

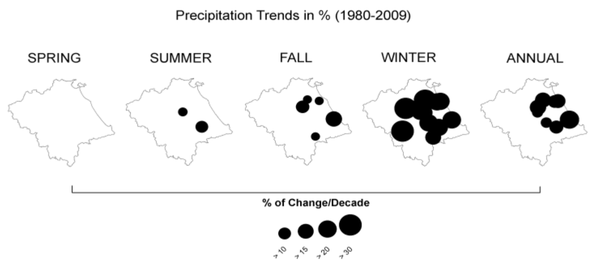
- Hydrometeorological observations (stations as well as gridded products) of the last decades were analyzed first for **trends** in the Vu Gia-Thu Bon (VGTB) basin.



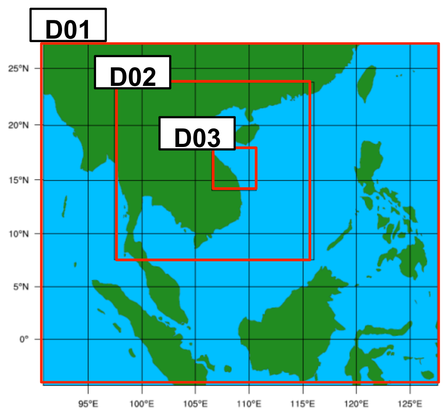
→ Predominantly significant negative (positive) trends in 1980s (1990s), trends negative but not significant in the 2000s.

→ Similar patterns for the gridded products identified.

→ Positive trend (rainfall increase) dominates for the whole period.
→ Highest increases for the rainy season (winter) identified, leading to significant increases in discharge (up to 30% per decade) → Aggravation of flood magnitudes and risks (Souvignet et al., 2014).



Regional climate simulations using WRF



Domain 1:
- horizontal: **45 km (**99x99 grid cells)
- vertical: 50 layers up to 50 hPa
- time step: 180 s

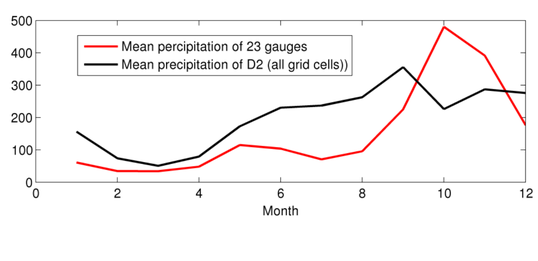
Domain 2
horizontal: **15 km** (142x145 grid cells)
vertical: 50 layers up to 50 hPa
time step: 120 s

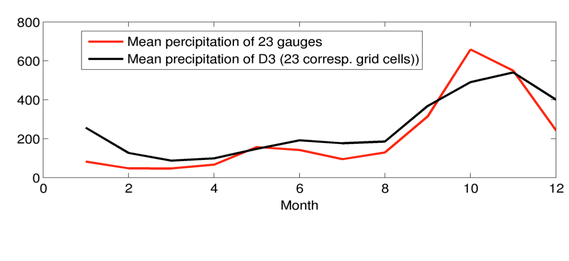
Domain 3
- horizontal: **5 km** (66x75 grid cells)
- vertical: 50 layers up to 5000 Pa
- time step: 30 s

WRF simulation domains (red boxes) as used for the transient climate simulations.

- **Parameterization studies** were conducted using reanalysis data (NCEP/NCAR, ERA40, ERA-Interim) to identify suitable schemes for Microphysics, Planetary Boundary Layer, and Cumulus Convection (Laux et al., 2012).
- The **patterns of WRF rainfall and temperature** in domain 2 (D02) are found to correspond well with the gridded APHRODITE and CRU data for rainfall and temperature.
- 5 km-resolution data exhibit highest correlation with observation station data.

Performance gain of downscaling





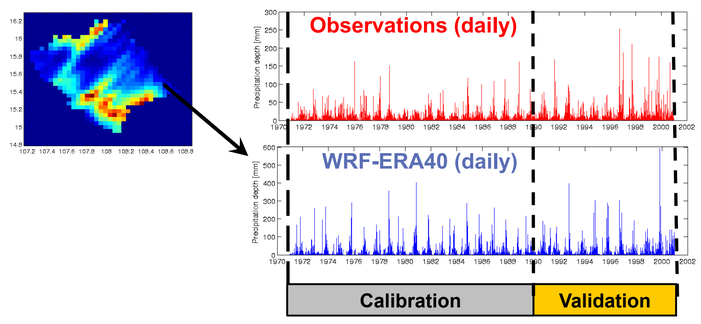
Domain 2 (D2), 15 km resolution:

→ @15 km, WRF is not able to reproduce the sea-sonality of precipitation in the basin: precipitation too heavy during summer months.

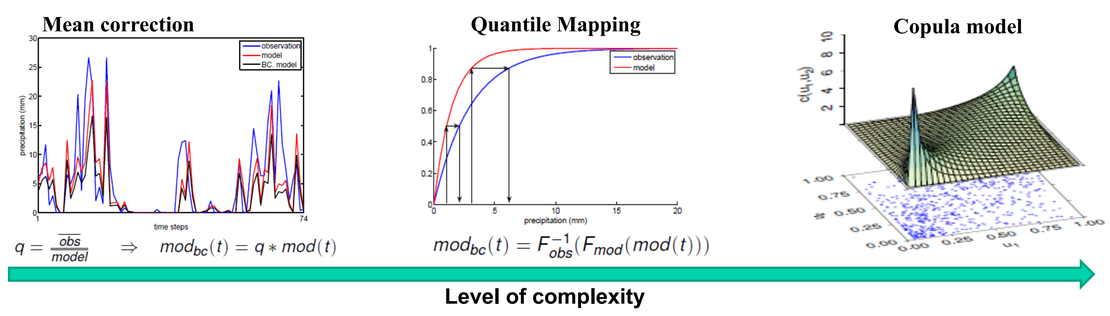
Domain 3 (D3), 5 km resolution:

→ @5 km, precipitation seasonality very well captured.

Bias correction of RCM results

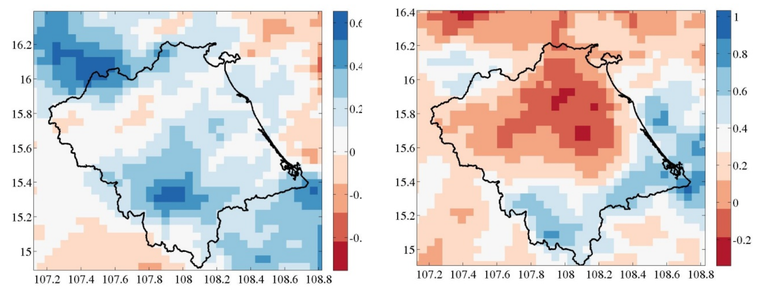


→ @ selected grid points, WRF time series are extracted and separated into a period for calibration and validation (left).
→ Different bias correction methods with different levels of complexity were applied.
→ *Quantile Mapping* works reasonably well.



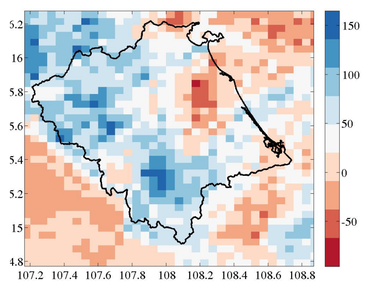
Future climate projections

WRF climate simulations in D3 (5 km resolution)



Expected precipitation change (mm/d) for 2001-2030 compared to 1971-2000 using ECHAM5 and A1B (left) and B1 (right), please see Laux et al., 2013 for further results.

Tailor-made information:
Harmful rain events for agriculture



Expected changes in number of harmful rain events (precipitation > 20 mm) during 2001-2030 (A1B).

Information for climate impact modelers

→ WRF results of highest resolutions (domain 3, 5km) should be used for climate (impact) studies
→ For local (field) scale applications, which were calibrated using data from observation stations, bias corrected time series of domain 3 should be used (based on *Quantile Mapping*).
→ For basin scale applications, the models should be calibrated using WRF downscaled reanalysis products. Each grid cell can be considered as a "synthetic observation station".
→ The produced climate will be made freely available by June 2015 in the RBIS data base of LUCCi project.

… and stakeholders

→ RCMs can realistically model hydrometeorological variables in the VGTB basin.
→ Future climate projections are uncertain because they heavily depend on assumptions (mainly GHG emission scenarios): Different assumptions about the future lead to different climate states, and thus different planning strategies.
→ Climate projections can be seen scientific sound and state-of-the-art tools to support planning decisions under a set of given assumptions.
→ If possible, multiple projections from various emission scenarios, global models (GCMs), regional models (RCMs), and bias correction tools should be considered to derive more robust planning strategies.

Laux, P., Phan, V.T., Lorenz, Ch., Thuc, T., Ribbe, L., Kunstmann, H. (2012), Setting up Regional Climate Simulations for Southeast Asia. High Performance Computing in Science and Engineering ' 12, Conference Proceedings, Wolfgang E. Nagel, Dietmar B. Kröner, Michael M. Resch (Eds.), Springer

Laux, P., Phan, V.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, Conference Proceedings, Wolfgang E. Nagel, Dietmar B. Kröner, Michael M. Resch (Eds.), p. 543-551, Springer.

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

Federal Ministry of Education and Research
FONA Forschung für nachhaltige Entwicklungen BMBF
SUSTAINABLE LAND MANAGEMENT