

# Abstract

This thesis focuses on the development of regional climate simulations for the East Asian domain. Therefor two fundamentally different modelling approaches were applied. The dynamical regional climate modelling approach using CCLM and the statistical modelling approach using STARS. The simulations were conducted under the guidelines of the Coordinated Regional Climate Downscaling Experiment (CORDEX). Both models were calibrated for the climatic conditions of East Asia. For the first time the statistical climate model STARS was applied on continental scales. On the basis of the calibrated and evaluated models, projections of future climate evolutions were conducted.

The thesis comprises the development of a complex evaluation scheme to allow for a fast evaluation of a large number of simulations. The evaluation scheme uses a scoring system based on the linearized relative model difference. Due to its simplicity the scoring system is easily adaptable to various questions within the climate modelling and evaluation framework. Within this thesis the scoring system is used to create two different types of overall scores. A univariate score dealing only with univariate statistical measures like the average, trend or variance and a bivariate score to evaluate the bivariate sample distribution of two variables (like temperature and precipitation).

By using the developed evaluation scheme a large part of the parameter space of the statistical model STARS could be analyzed. According the calibration only a minority of the model parameters have a significant influence on the simulation. The majority of parameter show only a small and nonsystematic effects. Furthermore the analyses identified the utilized univariate exchange technique of STARS as a deficit of the model with regard to the change signal of dependent variables. The evaluation scheme was also used for calibration of CCLM. Due to the coarse horizontal resolution of the model significant improvements of the simulations could be obtained by adjusting the subgrid physical parameterizations. The calibration of the numerical integration scheme shows only a small difference between the available schemes (Runge-Kutta and Leapfrog). Hence the deciding factor was computing time.

Both models underwent a comprehensive final evaluation. It comprises the validation of spatial bias, simulated seasonal cycle and modelling of the Asian monsoon phenomenon. With regard to the spatial bias no significant difference between CCLM and STARS could be observed. Both models show a marked overestimation of 2m temperature in winter throughout the northern parts of CORDEX-East Asia and an overestimation of air pressure over the Tibetan Plateau. Differences between both models could be identified in the simulated seasonal cycle. CCLM underestimates the intensity of the Indian summer monsoon and overestimates the summer monsoon over the tropical North Pacific. As a consequence summer precipitation over India, Indonesia and South China is underestimated and overestimated across the Philippines and South China Sea. The statistical climate model STARS shows a deformation in the seasonal cycle and the spatial and temporal evolution of the monsoon. Over East Asia STARS shows a deviation in the timing of rain and dry season and a deformation in the asymmetric movement of the monsoon precipitation. Overall both models show similar evaluation results as state-of-the-art Reanalysis (ERA-Interim). Hence despite the identified weaknesses, CCLM and STARS are able to reproduce the climate of East Asia at sufficient detail.

After calibration and evaluation of CCLM and STARS future climate projections were conducted. The projections cover three time periods: early (2020–2046), mid (2041–2070) and late (2071–2100) future, under emission scenarios RCP2.6, RCP4.5 and RCP8.5. The projections show a major limitation of the statistical model STARS in terms of simulated period and change signal, resulting from the large difference of observations and anticipated changes. Therefore projections of STARS cover only the early projection period (2020–2046) and emission scenarios RCP2.6 and RCP4.5. Projections of both models show a marked and statistical significant increase of 2m temperature with higher values over land areas. No statistical significant change signals could be identified for precipitation and sea level pressure for the early projection period, due to their large inter annual variability. However projections of CCLM for the late period show distinct changes. 2m temperature over the Tibetan Plateau increases by more than 7 K for 2071–2100. Heterogeneous but statistical significant change signals were identified for precipitation and sea level pressure.

Changing patterns of sea level pressure indicate a reduced intensity of Indian summer monsoon circulation and a strong intensification of western north pacific summer monsoon. The changing monsoon circulation leads to a statistically significant increase in summer precipitation across the Bay of Bengal, South China Sea and the Philippines and reduced precipitation in North India and Indonesia. Weak precipitation changes over East Asia indicate a decoupling of the East Asian summer monsoon circulation from the Western North Pacific monsoon system. In the northern part for CORDEX-East Asia a slight increase of winter precipitation is projected. Despite the spatial heterogeneous changes in mean precipitation most of the regions show an increase in extreme precipitation.