Project: 897
Project title: GlobE-Wetlands
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The subject of the GlobE-Wetlands project (BMBF) is a development of climate scenarios and storylines for the agricultural use of East African Wetland areas. The food production in many regions of East Africa reveals stagnation or even descending tendencies in the recent years. In contrast, the wetlands of East Africa actually provide soils rich in nutrients and all year round water availability, thus enabling multiple crops per year. The project GlobE-Wetlands postulates that the usage of wetlands for crops can ensure the food security for the whole region. Still, the sustainability can only be possible if the intensified usage of the wetlands is in accord with the maintenance of the local ecosystems.
Within the GlobE-Wetlands project, models and various assessment tools are employed for cross-disciplinary and cross-scale integration and regional projections under different global change scenarios. The task of our research group is to deliver the atmospheric forcing for other sub-projects within the "GlobE-Wetlands"-project. With this aim, high-resolution regional climate projections are needed especially for precipitation. Using model simulations and observation data, past and future climate variability shall be analysed for four exemplary East African wetlands (Fig 1). These results enable the development of storylines and scenarios, which will be used e.g., by hydrologists and agronomists of the project for intervention scenarios.

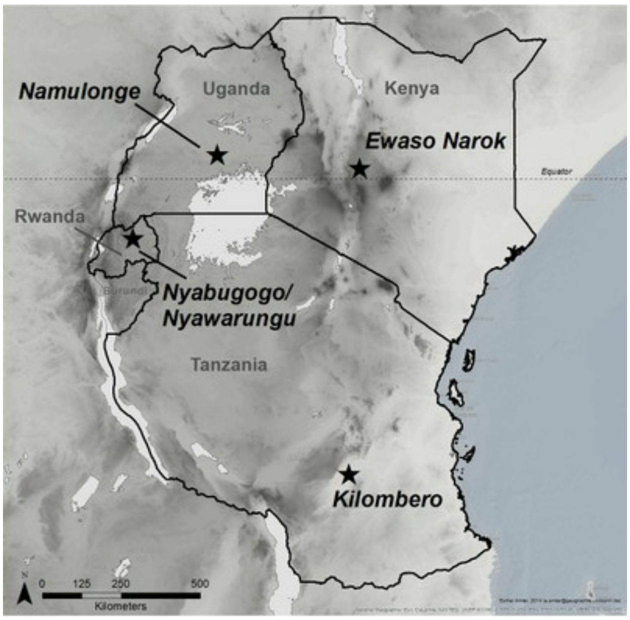

Figure 1: Area of interest. The stars mark the East African Wetlands, which are subjects of the project and the current study. Adopted from http://www.wetlands-africa.de/region.

First tests with COSMO-CLM 4.8 have shown that the East African Great Lakes play an important role for local convection. The use of the standard lake parameterization, which interpolates the sea surface temperature between the nearest water grid points, leads to a strong underestimation of precipitation in large parts of the East African Rift Valley. In case of the East African Great Lakes, the sea surface temperature is actually interpolated from Atlantic and Indian Ocean SSTs. The usage of the COSMO-CLM internal lake parameterization FLake improves the modeled precipitation, but the rainfall is still underestimated in comparison to observations. The effect of Lake Victoria is quite noticeable at a resolution of 0.22° (Fig. 2). For higher resolution simulations (7km), this effect is much higher, thus considerably worsening the results (not shown). We suggest that moisture fluxes from vegetation play here an important role in modifying the precipitation. The default SVAT TERRA implemented in COSMO-CLM does not yet include dynamical vegetation. Early modeled onsets of the rainy season can thus considerably deviate from measurements due to predefined vegetation seasonality. Model results of Thiery et al. (2015), focusing on the impact of East African Great Lakes on regional climate, showed that using the Community Land Model (http://www.cgd.ucar.edu/tss/clm/) in combination with the lake parameterization FLake leads to very good results in this region. Moreover, the Community Land Model includes wetlands as a separate surface type (see further CLM3.0 User' Guide), which is suitable for our tasks.

In the recently introduced version 5 of COSMO-CLM, the inclusion of alternative SVATs is simplified in comparison to previous model versions. A positive effect is expected for the use of the Community Land Model, which has been recommended by Thiery et al. (2015) for this area. Therefore, we decided to make use of CCLM5 with the Community Land Model and consequently delay the model runs planned for 2015 to 2016.

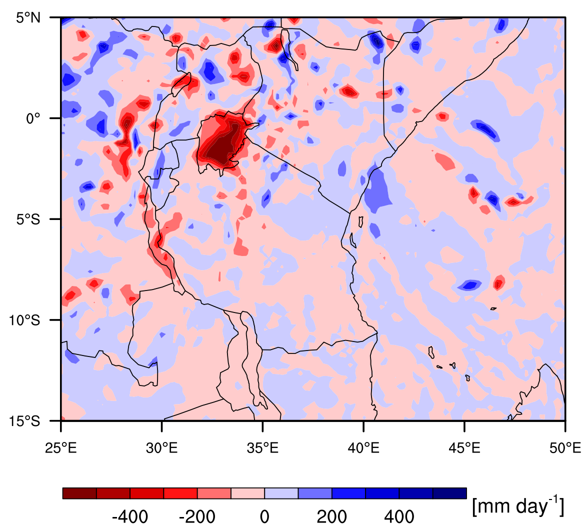

Figure 2: Difference between an exemplary simulation with lake parameterizations and without lake parameterization with 0.22° resolution for the month April 1997.

Due to the delay of the modeling to 2016, we focused on the diagnostic part of the studies in the region. The subjects of the reported period deal with climate variability and main circulation patterns during recent decades. The results will become important in order to choose representative time periods for model runs and scenarios.

To quantify the past climate variability and trends, ETCCDI climate indices, Standardized Precipitation Index (SPI) and their trends for annual and seasonal timescales based on different datasets were calculated (Fig. 3). The investigation showed mainly increasing precipitation trends during the second rainy season in OND, while the trends for the first rainy season in MAM reveal varying trends.

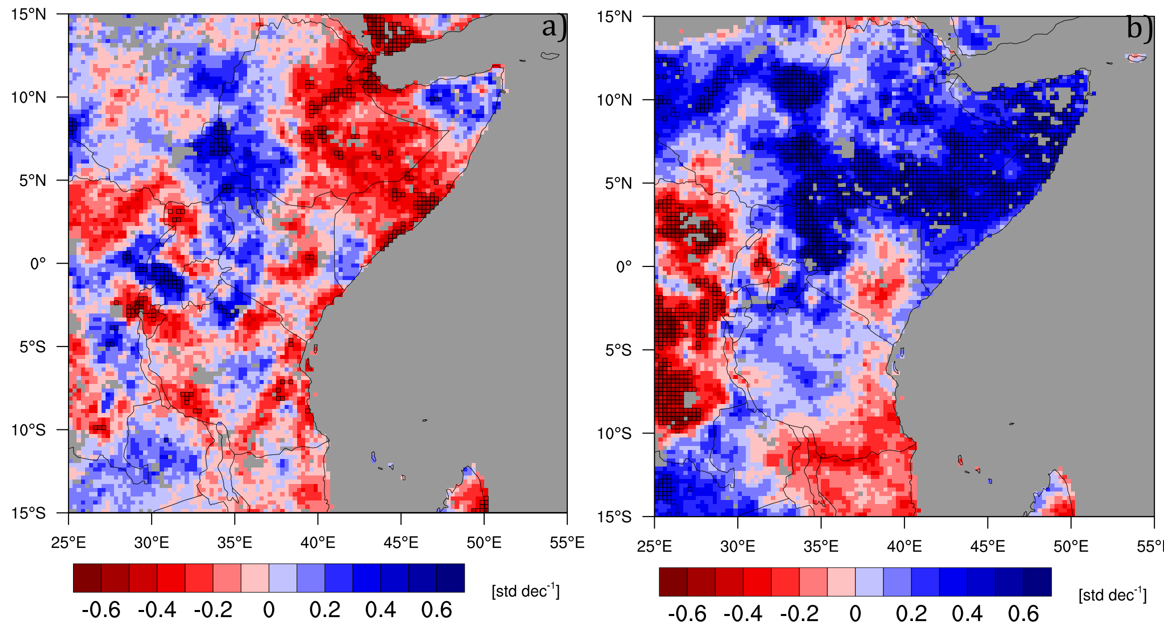

Figure 3: Trends of SPI based on CHIRPS satellite product in (std/10 years) for the seasons a) MAM and b) OND. Black squares mark significant trends.

One of the weaknesses of seasonal trend analyses in East Africa is the high variability of rainfall onset, which does not always coincide with the climatological rainy seasons. We suggest, that these trends are also connected with the onset of the rainy season. The overall rainfall climate also varies due to East African Great Lakes and topography effects, thus an objective and calendar-independent rainfall onset criterion is necessary. For detection of rainfall onset, we modified the onset criterion of Wang and LinHo (2001) for the East Africa Region. One main difference is the use of 96 Fourier harmonics (Fig. 4) instead of 12 as in the original method.

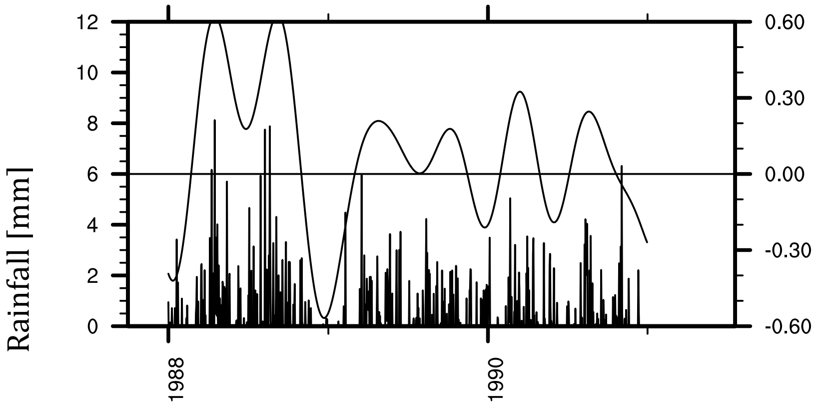

Figure 4: Application of the onset criterion for an exemplary rainfall station. The bars show the daily precipitation of three years, the line marks the function of the first 96 Fourier harmonics. The onset of the rainy season is located at the point, when the line reaches positive values.

The rainfall onset depends on the large-scale circulation and the movement of the Inner Tropical Convergence Zone (ITCZ). Our analyses of precipitation and the large-scale circulation based on satellite observations and ERA-Interim Reanalysis show that weak rainy seasons coincide with highly developed subtropical high-pressure ridge, while strong rainy seasons go ahead with a weakly developed subtropical high pressure ridge.

Connections of the subtropical high-pressure ridge, the rainfall onset and commonly known patterns of the sea surface temperature like El Niño Southern Oscillation need further investigation. The position of the peak of the subtropical ridge in the Indian Ocean could serve as a predictor in a statistical-dynamical downscaling.

References:

CLM3.0 User Documents: User's Guide, available at http://www.cesm.ucar.edu/models/ccsm3.0/clm3/

Thiery W, Davin EL, Panitz HJ, Demuziere M, Lhermitte S, Van Lipzig N (2015) The Impact of Great African Lakes on the Regional Climate. Journal of Climate 4061:4085, DOI: 10.1175/JCLI-D-14-00565.1

Wang B, LinHo (2001) Rainy Season of the Asian-Pacific Summer Monsoon, Journal of Climate 386:398.