International Max Planck Research School
on Earth System Modelling

Impact of Climate Change on the Coastal Climate of South-Western Africa

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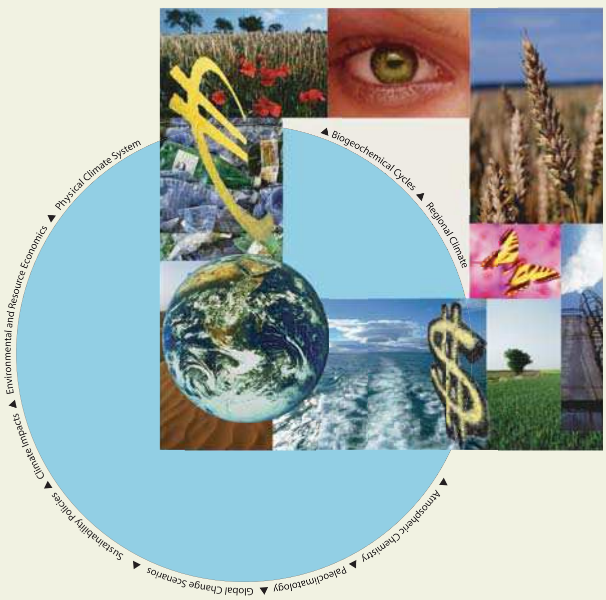
PhD Thesis prepared within the
International Max Planck Research School on
Earth System Modelling



Abstract

High-resolution regional climate simulations have recently been in the spotlight as they may offer an added value when compared to global climate model simulations. Regional models benefit from a better representation of topographic and land surface features. Unfortunately, over many regions of the globe, and especially over the southern African region, the availability of long-term high-resolution climate simulations is so far rather limited. In this thesis I present a suite of high-resolution regional climate simulations for the southern African region, conducted with the regional climate model (RCM) REMO at roughly 50 and 18 km grid spacing. The simulations considered comprise 50 year hindcast simulations (1958-2007) and transient climate change simulations for the period from 1960-2100. The 18 km transient climate change simulation is the longest available climate change projection at such a high resolution for the region. Additionally, a set of sensitivity simulations have been performed to account for deficits in the SST simulation of coupled general circulation models as well as time slice experiments to simulate the frequency of the southern African west coast fog. On the one hand, this unique set of high-resolution regional climate model simulations allowed to study large scale climate features and their potential future changes. On the other, it also enables to focus on regionally important mesoscale and local circulation patterns.

To ensure basic consistency with the local climatological features, in a first step the ability of the regional model to simulate the predominant climate characteristics over the region had to be assessed. Generally, it was found that the model is capable to adequately simulate the mesoscale circulation and related precipitation patterns of the southern African region. Especially along the focus region in south-west Africa, the application of REMO leads to an added value in the description of topographically induced precipitation events. With respect to the transient regional climate projection, a severe warming and drying is simulated for the southern African region towards the end of the 21st century. While the average magnitude of projected changes by REMO are in the same order as those of the general circulation model (GCM) used to force the simulation, the RCM projections provide more spatial details. However, the forcing coupled GCM suffered from poor resolution of the mesoscale upwelling regions offshore the southern African west coast. To remedy this deficit a method had to be established and applied to correct for the too warm sea surface temperatures in the forcing data before the transient climate projection was started. As this shortcoming is a common feature of all available coupled global climate models the established method was proposed to be used as the standard setup for regional downscaling studies over the region.

The high horizontal resolution of the RCM simulations further allowed to study, whether the model is able to capture regional and local scale processes such as the occurrence of west-coast fog and the local scale thermally induced wind systems over the Central Namib. It was in fact found that the major characteristics of both systems are adequately represented in REMO. For the future the model projected a reverse change in the fog characteristics with an increase at the coast and a decrease in fog frequency further inland. With respect to the local wind systems, rather constant behavior was projected by the model throughout the 21st century. At a first glance this seemed contradictory to the simulated strong thermal changes projected for the region. However, the lack in the climate change response could on the one hand be related to the nature of the small scale forcing for the wind systems, on the other also be a consequence of the identified missing feedback processes in the model between the ocean and the atmosphere.

In general the thesis clearly highlights the benefit of high-resolution regional climate simulations over southern Africa. The RCM offers improved representation of rainfall patterns, which increases the credibility of the regional projections in this region. Furthermore, the present study identifies important model deficits that were not pointed out previously. Thereby, it presents possibilities of compensating these shortcomings and puts forward questions for future research activities in the field of regional climate modelling.