Abstract

This thesis reports some methodological studies on the climate regionalization by a dynamic approach. The geographical domain covers a large area from the middle of the North Atlantic to Eastern Europe, and from the Sahel to the Arctic. The improvement of regional climate is not the core of our study. However, it focuses on three keys points which are commonly met by all attempts to regionalize the climate. Firstly, the nesting scheme: one-way nesting (OWN) or two-way nesting (TWN). Secondly, it examines the nesting method which is generally a Newtonian relaxation operation added to the model’s prognostic equations. Last but not least, the mesh refinement in the RCM.

The objective of this manuscript consists in conceptualizing and carrying out numerical simulations to treat the above three points in order to isolate and quantify them. The general circulation model LMDZ is used for all experiments. It performs both the role of the GCM and the RCM. In both cases, it strictly keeps its physical parameterizations and its dynamic configuration, as well as all external forcing or parameters. Our experimental strategy referred to as “Master versus Slave”, consists two related protocols: “DS-300-to-300” and “DS-300-to-100”. The former means downscaling of the GCM at 300 km of horizontal resolution and at the same time, the RCM has the same spatial resolution at 300 km which is identical to the GCM. The later means downscaling from 300 km (GCM) to 100 km (RCM).

It is clear that “DS-300-to-300” is an idealized framework, particularly appropriate to evaluate the relaxation operation effect. Meanwhile, the “DS-300-to100” protocol, subtracted from the “DS-300-to-300” allows assessing precisely the effect of the resolution increase for the RCM. In each protocol, two communication schemes between the RCM and the GCM have been implemented, one (OWN) is the classic one-way methodology to control the RCM by the outputs of the GCM, the other (TWN) is to establish a mutual exchange between two models (RCM and GCM).

The regional climate is sensitive to the choice of the communication scheme between the RCM and the GCM, especially at mid-latitudes. TWN brings a clear improvement on the representation of boundary information. For the regional atmospheric circulation modes, expressed in EOF structures, both OWN and TWN are able to reproduce them, but with slight deformation in space. Newtonian relaxation, widely used in the climate regionalization, allows the RCM to follow the GCM’s synoptic trajectory. However, temporal concomitance and spatial resemblance depend on the variables considered, the seasons, the weather regimes, and the spatiotemporal scales of atmospheric circulation. De-correlation cases are remarkable when the regional dominant circulation is at small scales. Moreover，mesh refinement increases the freedom of the RCM to develop its internal dynamics, especially not only at small scales, but also across the ensemble spectrum circulation through the interaction scales. Thus，the RCM becomes more independent and deviates more from the GCM. This thesis, based on the methodological aspects of climate regionalization, helps to gain a better comprehension on the practice. Il also sends a precautionary message to the RCM community to invites them to verify their regionalization methodology.