Testing the Downscaling Ability of Regional Climate Models with the "Big-Brother Experiment"

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The fundamental hypothesis underlying the use of nested, limited-area models for climate applications (Regional Climate Models, RCM) is that they have skill in generating meaningful fine-scale features that are missing from the driving atmospheric information at the lateral boundaries of the computational domain. We try to experimentally check the validity of this assumption by following a perfect-model approach, and this methodology is used for testing the downscaling ability of nested RCMs. The proposed methodology is nicknamed the Big-Brother Experiment (BBE); it is based on a perfect-prognosis approach, and hence does not suffer from model errors nor from limitations in observed climatologies. The BBE consists in first establishing a reference climate by performing a large-domain high-resolution RCM simulation: this simulation is called the Big Brother. This reference simulation is then degraded by filtering short scales that are unresolved in today's global objective analysis (OA) and/or general circulation models when integrated for climate projections. This filtered reference is then used to drive the same nested RCM (called the Little Brother), integrated at the same high-resolution as the Big Brother, but over a smaller domain embedded in the Big-Brother domain. The climate statistics of the Little Brother are then compared with those of the Big Brother over the common intersection of Little-Brother domain. Differences can thus be attributed unambiguously to errors associated with the nesting and downscaling technique, and not to model errors or observation limitations.

The BBE protocol was developed and first applied by PhD Student Bertrand Denis at UQAM. Limited results of the BBE applied to a one-month winter simulation over Eastern North-America at 45-km grid spacing show than the one-way nesting strategy has skill in downscaling large-scale information to the regional scales. The time mean and variability of fine-scale features in a number of fields, such as sea level pressure, precipitation and 975-hPa temperature, are successfully reproduced, particularly over regions where small-scale surface forcing is strong. Over other regions, such as over ocean surfaces and away from the surface, the small-scale reproducibility is more difficult to achieve.

Experiments have also been performed with a one-way nested RCM to study the sensitivity of the simulated climate to the lateral boundary condition (LBC) resolutions. The goal was to determine the maximum acceptable resolution jump between the driver and the nested model. Preliminary results show that a resolution jump of a factor of 10 is the maximum that can be used without affecting unacceptably the climate. Similar experiments are underway to assess the dependency of the simulated climate to the updating frequency of the LBC.