The Grueling Journey of Regional Climate Model Validation

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Introduction
Validating regional climate models (RCM) has never been an easy task since difficulties come from both observations and RCMs. Even nowadays, typical RCM grid meshes are still too coarse to compare easily with station observations. Gridded observations datasets, coming from in situ or remote sensing data, are very useful but have their limitations. The emergence of simulations produced at convection-resolving resolutions will certainly exacerbate many observations-related issues. Most of RCM-related errors sources fall into three main categories: formulation, inputs and configurations.

Sources of bias

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<th>Observations</th>
<th>RCM Formulation</th>
<th>RCM Inputs</th>
<th>RCM Configuration</th>
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<td>• Instrument precision and error</td>
<td>• Misrepresented or missing parameterization designed for coarser GCM or assimilated NWP</td>
<td>• Unrealistic geographical datasets</td>
<td>• Horizontal and vertical resolution</td>
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<td>• Missing data</td>
<td>• Problem inherited from the driving dataset – GCM or reanalysis</td>
<td>• Size and location of the regional grid</td>
<td>• Nesting technique</td>
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<td>• Homogenization technique</td>
<td>• Retrieval algorithm of remote sensing measurements</td>
<td>• Etc.</td>
<td>• Etc.</td>
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Case 1: Unrealistic extent of the Boreal Forest

Context
Regional climate simulation analyses for the project, « Water footprint and impact of Quebec’s boreal hydroelectric reservoirs on the regional climate »

Problem
Researchers in charge of the field campaign noticed that the La Grande River watershed evergreen coverage was strongly underestimated in the model compared to reality.

Consequences
Overestimation of surface albedo that contributes to the cold bias and the excessive snowpack over the watershed.

Solution
Replace USGS vegetation dataset by GLC2000 as a CRCM5 geophysical input – The new simulations are underway!

Acknowledgments
CRCM5 has been developed through a partnership between:

The invoked projects are supported by:

The ClimEx project is funded by the Beaver State Ministry for the Environment and Consumer Protection.

Case 2: Spurious pattern in Snow Water Equivalent

Context
Analysis of snow related variables for Ouranos projects.

Problem
ESCOR decided to modify the USGS original datasets by reducing the evergreen fraction in order to boost the bare soil fraction at the southern limit of the Boreal Forest. This choice was motivated by an excessive evergreen density compared to reality.

Consequences
While this solution had the desired effect of a significantly improved the winter warm bias, it had the downside of generating spurious and non-physical patterns in the snow water equivalent and snow depth fields.

Solution
Use GLC2000 for CRCM5 geophysical input fields.

Case 3: Warm bias in sea surface conditions

Context
Ouarus collaborators from ISMER used CRCM5 outputs to force their regional ocean model over the Gulf of St. Lawrence.

Problem
ISMER noticed that SST were much warmer than observations. In CRCM5, SST and sea ice are prescribed from the driver.

Consequences
Those inherited warm SST contribute to the warm air temperature bias around the Gulf of St. Lawrence and Hudson Bay. ISMER ocean model had difficulty to produce sea ice when forced by CRCM5.

Solution
Bias-correction of CRCM5 outputs

Case 4: Remaining precipitation extreme in the wake of a weather system

Context
Analysis of extreme precipitation events from the ClimEx large ensemble.

Problem
A precipitation event dissipates except for one persistent grid point with very high accumulations. After a few hours, a new cell develops and moves away with the circulation.

Consequences
Off the charts 24-h total precipitation over a single ocean grid point, no matter the driver.

Solution
Under investigation. In the mean time, those unrealistic events are discarded from the study.

Case 5: Insufficient moisture transport from Gulf of Mexico

Context
Regional climate simulation validation for the needs of a Climate reconstruciton a Ouranos pour le Québec (CROQ) project.

Problem
Due to computer resources limitations, the QC11d1 domain does not include the Gulf of Mexico leading to an insufficient moisture transport through the inflow boundaries. Potential lack of moisture transport in ERA-interim grids.

Consequences
Strong precipitation deficit with respect to CRU TS 3.2.3 gridded observations along the south and west boundaries of the QC11d1 grid despite the overall wet bias.

Solution
Extend regional domain further south and further west to include this key area for Quebec’s climate. Activate large scale nudging

Fifth-generation Canadian Regional Climate Model (CRCM5)

Dynamical core
Gleocm v3.3.3.1

Subgrid-scale physical parameterization
Kan-Fritsch deep convection parameterization (Kan and Fritsch, 1990)
Kuo-transient shallow convection (Kuo 1965, Bélair et al. 2005)
Sundqvist resolved-scale condensation (Sundqvist et al. 1989)
Corral-Halsor and tropical terrestrial convective (Dyer and Barker 2005)
Low-level orographic blocking parameterization (Zadra et al. 2003,2012).
Planetary boundary layer parameterization and vertical diffusion (Benetti et al. 1989, Delage and Girard 1992, Delage 1993) including turbulent hysteresis (Zadra et al. 2012) and suppression of turbulent vertical fluxes under very stable conditions.
A weak lateral diffusion (6th order)

Coupled lake model
one-dimensional lake model Flake (Mirinov et al. 2010) for both the resolved- and sub-grid scale lakes following a land type surface approach.

Nesting
standard 10-point sponge relaxation zone (Davies, 1976) for all prognostic atmospheric variables

RCM Inputs

RCM Configurations

RCM Outputs

References


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