1. Introduction

Regional Climate Models (RCM) simulate the atmospheric processes that are nonlinear by nature and their simulations are therefore characterised by Internal Variability (IV). Previous studies have demonstrated that the nested RCM have reduced IV compared to Global Climate Models due to the control exerted by lateral boundary conditions. RCM IV is function of the variable that is studied, and depends on the domain size and location, season, and the synoptic conditions.

In the present work, we focus on episodes with rapid growth of IV, using Singular Vectors (SV) as a basis for initial-condition perturbations of an RCM. SVs are defined as the orthogonal set of perturbations that provide the maximum linear growth with respect to a given norm, over a finite time. Generally, SV match well with regions and periods characterised by an important hydrodynamical instability. The primary objective of this project is to investigate if the use of SV permits a better understanding of the IV taking place in RCM simulations.

2. Classical ensemble

10 Canadian RCM simulations with different initial conditions beginning in May and finishing on 1st September 1993 (Alexandru et al., 2001)
   - GCM physics
   - 128 by 128 grid points at 45 km horizontal resolution, 18 vertical levels
   - time step: 15 min
   - nested one-way by 6-hourly NCEP re-analysis


The leading 10 SVs for the 18 July 1993 NCEP re-analysis with an optimisation time interval of 48h,
   - Tangent-linear and adjoint versions of Canadian Global Environmental Multiscale model (GEM version 3.0, physics version 4.3)
   - 240 x 120 uniform Gaussian grid, 58 eta vertical levels
   - Initial condition:
     - initial norm: global
     - final norm: localised over a sub-domain of RCM.
   - dry energy norm:
     - initial norm: global
     - final norm: localised over a sub-domain of RCM.

4. Total-energy horizontal distribution

Average horizontal distribution of the total energy (x 10^5 J/m^2) of the classical ensemble deviations, for (a) 18 July and (b) 20 July. The vertical integral is made between the 100 hPa and 1000 hPa vertical levels.

Energy maxima are located over Atlantic Ocean and reach the regions where a low-pressure system develops.

5. Conclusion

An episode of rapid growth of IV in the CRCM was identified using the classical ensemble approach, and a set of SVs was calculated for this particular period. The final time norm in the SV calculation was chosen to fit with the regional domain of the CRCM. Comparison of average horizontal distributions of energy, derived from the ensemble deviations and from the SVs, show that energy maxima partly overlap within the CRCM domain, and follow the path of a developing low-pressure system over the ocean. As the ensemble deviations, kinetic energy is the dominant energy component for SVs at final time. The energy growth rate of SVs (here derived from the tangent-linear propagation of the initial-time SVs) appears to be larger than the growth rate obtained from the ensemble.

Next we plan to address the following questions:
   - What is the behaviour of an ensemble, built from a set of SVs added to the CRCM nonlinear trajectory?
   - To what extent can SVs explain episodes of high internal variability in an RCM?

6. References


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