5B.2

TOWARDS A WAVELET-BASED CONVECTIVE REPRESENTATION FOR GCM: RATIONALES AND PRELIMINARY RESULTS

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1. INTRODUCTION: CRM AS A DIAGNOSTIC TOOL

In spite of its widely recognized importance, little progress has been achieved for the cumulus parameterization in last decades. Although the cloud-resolving model (CRM) is nowadays widely accepted as a useful tool to verify these parameterizations, it is yet to play a fully active role in critically diagnosing the formulation for the latters, in spite of the fact that CRMs are capable of simulating three-dimensional convective systems reasonably.

Indeed, various statistics have already been taken out from CRM experiments. For example, the bulk mass-fluxes for updrafts and downdrafts have been estimated (*e.g.*, Guichard *et al.* 1997), but these are only used as an indirect reference in revising parameterizations (*cf.*, Gregory and Guichard 2002). Little has been proposed for a new formulation based on such CRM experiments, and those do not go beyond anything more than estimates of parameters for a formulation already given.

2. PROBLEMS OF THE MASS-FLUX FORMULATION

One of the problems is traced to the mass-flux formulation widely used for cumulus parameterizations, which decomposes a convective system into an ensemble of sign-definite up- and down-drafts. However, it is not straightforward to decompose an actual realization from a CRM experiment into an ensemble of such sign-definite drafts.

2.1. PRACTICAL PROBLEM: THRESHOLD DEPENDENCE

Instead, an empirical and less direct method, originally developed for analyzing the radar observation data, is simply substituted into CRM context (*cf.*, Guichard *et al.* 1997, Gregory and Guichard 2002). The method is based on the idea of categorizing the precipitating fields into the convective (convective–towers) and stratiform (mesoscale) components *mostly* (see Guichard *et al.* 1997 for more details) based on the precipitation rate threshold. Importantly, there is no consideration on their spatial–scales nor the dynamical characters for these two components is made (*cf.*, Yano *et al.* 2001b). These diagnoses are also found to be sensitive to the threshold values and the details of the categorization strategies (*cf.*, Gregory and Guichard 2002).

2.2. MATHEMATICAL DEFICIENCY: LACK OF ADMISSIBILITY

The inherent difficulty of decomposing the CRM simulated fields into the mass–flux components can be traced to the lack of admissibility in such a decomposition. The admissibility condition (*cf.*, Mallat 1998, Sec. 4.3.1) insists that the individual spatially–isolated modes should not have a nonvanishing domain mean in order to ensure a unique decomposition of a field by this mode set. The lack of this properly in the mass–flux decomposition makes it mathematically rather ill–posed, and practically leaves a wide margin of freedom for subjective criterions.

4. WAVELET–BASED APPROACH

The wavelets have been proposed (Yano *et al.* 2001a, b) as an alternative method to diagnose outputs from CRM simulations in order to objectively characterize the convective system. In the present paper, we further propose the wavelets as a diagnostic tool in order to construct a convective representation in a more logical manner through such objective diagnoses. Here, it is no longer called a 'parameterization', because the convective elements are more explicitly considered in this approach.

Our basic strategy is to construct a subgrid-scale convective representation scheme by directly simplifying a cloud-resolving model (CRM) step by step with the wavelet expansion method. This approach

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enables to tackle long recognized, but less addressed issues of the convective representation more systematically: 1) its internal structure such as mesoscale organizations (*cf.*, M.W. Moncrieff's archetypes), and 2) the triggering mechanism induced by the formers, such as those by cold pools in the surface layer (*cf.*, J.–Y. Grandpeix and J.–P.Lafore, personal communication). The core of this proposal is to substitute the convective parameterization by CRM, as attempted by Grabowski (2001) and others, but with a drastic simplification in the wavelet space.

The efficiency of the wavelets to represent the spatially–isolated coherencies (*cf.*, Yano *et al.* 2001a, b) guarantees such a drastic simplification of CRM. Good analogies may be found in a low–dimensional chaos model by Lorenz (1963), as well as in highly–truncated quasi–geostrophic models in the Fourier space, as pioneered by Charney and DeVore (1979), which have been extensively used as theoretical models for the atmospheric blockings. Such a highly–truncated CRM model is placed at every global grid–box in order to crudely represent the subgrid–scale moist convective processes, but *explicitly.* A major difference here is that the truncation is made *sparse* in space employing the technique of 'data compression'.

An analogy for this *sparse truncation* is nesting approaches in regional weather modellings. Here, the wavelets play the role of highly flexible nestings, by adding the fine–scale wavelet modes locally, where a convective system arises, for example. These wavelet modes are deactivated, when a convective period is over locally. By continuously activating and deactivating the wavelet modes, the subgrid–scale convective systems are represented highly efficiently, but keeping the required number of modes at any instant the minimum.

A practical advantage of the present approach is that such a representation scheme can be constructed in a very logical manner, as a direct simplification of CRM. without any ad-hoc assumptions about the 'cloud models' (*e.g.*, entraining plumes). Although we may introduce some statistical descriptions, these can also be directly tested by the original CRM.

5. PRELIMINARY RESULTS

Some preliminary analyses towards this goal are presented, which include tests for the capacity (compressibility) for efficient representation of convective systems by wavelets, and the wavelet representation of the vertical heat and moisture fluxes. The Meso–NH model wss run in 512 km × 512 km domain for both TOGA–COARE and ARM cases with the 2–km resolution, and the analyses were performed on these outputs.

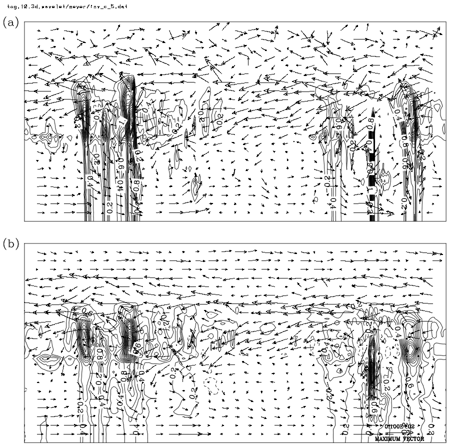

Figure 1: Example of wavelet compression of data (1-% level: b), compared with the original cross–section (a)

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