Geosci. Model Dev. Discuss., 7, C3546–C3550, 2015
www.geosci-model-dev-discuss.net/7/C3546/2015/

Geoscientific Model Development Discussions

Interactive comment on "Normal-mode function representation of global 3-D datasets: an open-access software for atmospheric research community" *by* N. Žagar et al.

N. Žagar et al.

nedjeljka.zagar@fmf.uni-lj.si

Received and published: 17 March 2015

Response to the comments of Referee 2 on

"Normal-mode function representation of global 3D datasets: an open-access software for atmospheric research community"

by N. Žagar, A. Kasahara, K. Terasaki, J. Tribbia and H. Tanaka

Geosci. Model Dev. Discuss., 7, C2964-C2965, 2015

We would like to thank Referee very much for his/her comments on the manuscript.

The revised manuscript has updated discussion at several places. In Introduction and throughout the paper we discus that the main purpose of this method is to provide 3D picture of unbalanced circulation, especially in the tropics. We discuss that this has not been very meaningful before since the models and observations were not capable to resolve the inertio-gravity modes in global NWP and climate models. In this respect, we do not think that disadvantages of the method have been the reason why it has not been applied much. For example, a simplified version of the method, the linear wave decomposition based on the shallow-water equations on the equatorial $\beta-$plane has been applied a lot in the past decades. In the discussion of the NMF projection, we try to discuss the shortcomings of the method such as those related to the numerical solution of the vertical structure equation.

We are not aware of other open-access software that generates and projects 3D normal modes. The polar filtering used in some models has to our understanding a purpose of removing unwanted unrealistic oscillations in the models. Our 3D NMF representation will project unrealistic oscillations onto the IG modes. In this respect it can also be used as a diagnostic tool for the model balance.

We have tried to cite the most relevant work dealing with the initialization of NWP models based on normal modes (NNMI). It is possible that we missed to cite important papers and we would appreciate very much further advice. A large body of work on balanced dynamics is not of direct relevance for the present paper since the inertio-gravity modes are often filtered from the underlying equations.

Below we reply to the comments and questions raised by the Reviewer using the same organisation as in the review.

Specific comments

p2 L7 change to "the majority of studies"

Corrected as suggested.

p2 L15 change to "linearly balanced"

Corrected as suggested.

p2 L25 change to "eigensolutions of the Laplace operator on the sphere."

Text "eigensolutions of the global barotropic vorticity equation" has been changed to "eigensolutions of the global barotropic vorticity equation involving the Laplace operator on the sphere".

p3 L12 change to "the primitive equations linearized about a very simple reference state, and ..."

Text "the linearized governing (or primitive) equations, and ..." has been changed to "the primitive equations linearized about a simple reference state of rest, and ..."

p4 L14 NWP normal modes that used a reference state of the same constant T at all levels are 3d orthogonal with respect to the quadratic total energy norm.

Sentence "We also note that sets of normal modes derived for the initialization of NWP models were not 3-D orthogonal." has been replaced by "We also note that the sets of normal modes derived for the initialization of NWP models were, in general, not 3-D orthogonal, though orthogonal models can be constructed (Kasahara and Shigehisa, 1983).

p4 L26 change "contrary" to "contrast"

Corrected as suggested.

p17 L8 I doubt this is true, and there is evidence suggesting otherwise for the internal modes. One must be careful of citing an old work, for example limited by both vertical and horizontal resolution. Also, did Kasahara examine the projections of all the modes from the one set onto the other? How realistic was his reference state?

The paragraph on p17, L3-12 has been replaced by the following more detailed discussion: "When the mean zonal flow is taken into account, the frequencies of wave solutions of the linearized global shallow water equations become different from the wave frequencies associated with the linearization around the state of rest. Kasahara (1980) showed that in this case the frequency spectrum can become continuous, except for a few of the lowest balanced modes. Furthermore, solutions to such system can become unstable due to barotropic instability. On the other hand, the structure of associated Hough functions does not change significantly if the linearization is performed around the non-zero mean zonal flow (see Corrigendum to Kasahara, 1981). This implies that it is suitable to use the 3D normal modes constructed with reference to the basic state at rest as a universal set of the spectral expansion functions to represent global atmospheric data."

p19 L21 This involves an approximation to the true APE since a linearization about a non-isothermal reference state does not produce an APE that is quadratic (see Lorenz 1960 Tellus)

We thank the reviewer for pointing this out. There are assumptions made in the computation of available potential energy to be conserved for the global mass integral. A

rigorous conservation is lost when non-isothermal reference state is used, or when the static stability parameter varies in the vertical direction. What we are computing is an approximation to the available potential energy defined originally by Lorenz. We have updated sentence on p20, L9-11 as follows: "The energy P_m is more appropriately referred to as an approximation to available potential energy. This represents a portion of the total potential energy which may be available for conversion into kinetic energy (Lorenz 1955, Lorenz 1960)."

Yours sincerely,

N. Žagar, A. Kasahara, K. Terasaki, J. Tribbia and H. Tanaka

Interactive comment on Geosci. Model Dev. Discuss., 7, 8805, 2014.