Geosci. Model Dev. Discuss., 7, C225–C228, 2014
www.geosci-model-dev-discuss.net/7/C225/2014/

Geoscientific Model Development Discussions
Open Access

Interactive comment on "Development of a tangent linear model (version 1.0) for the high-order method modelling environment dynamical core" *by* S. Kim et al.

S. Kim et al.

bj.jung@kiaps.org

Received and published: 2 April 2014

We are grateful to the reviewer for his/her careful reading of the manuscript and his/her thoughtful comments. We have followed all suggestions in all cases, and provide below a point-by-point response to the reviews. These will be corrected in revised manuscript. This feedback has helped us improve and clarify the manuscript.

Referee's comment(1) *As far as I know HOMME has two basic formulations which are based on SE and DG methods, however, both rely on same grid system and parallel communications. But the treatment of flux at the element edges and numerical viscosity*

are based on different ideas. On page 1179, lines 10-15, authors mention that they employ DG formulation for developing a TLM. However, hyper-viscosity filter is based on SE method not the part of DG discretization. Please clarify how you apply hyper-viscosity. Is your TLM formulation based on SE or DG?

Authors' response Thanks for pointing out the crucial issue. As you mentioned, HOMME has two dynamic formula, the spectral element (SE; or continuous galerkin, CG) and discontinuous galerkin (DG). We have developed the tangent linear model for SE method. So, we omit the word of DG in the sentence, in order to avoid the confusion.

Referee's comment(2) *On page 1184, lines 10-15: There are several basic operators such as div, curl, grad etc. involved in RHS estimation and hyper-viscosity computations. It will be interesting provide an example about your "hands-on" linearization for one of these operators at least, say "divergence_sphere", how does the liner version appear in terms of mathematical expressions? How do you handle the metric terms?*

Authors' response Thanks for your interest of how we coded the individual subroutines of HOMME. The subroutine of "divergence_sphere" is a linear routine, thus the corresponding TL code is not much interesting. Instead, the original nonlinear modules and developed tangent linear (TL) routines for "divergence_sphere" and "preq_vertadv" are attached in supplement. For example,"preq_vertadv" has a nonlinear part that is represent vertical advection terms. And, there are many "linearized" terms in its TL code. When developing TL codes, the linearizations are done with respect to the model state variables (i.e., prognostic variables) and their dependent variables. Thus, the metric terms are kept constant for TL code.

Referee's comment(3) *Did you ever test the TLM formulation in a simplified framework such as the spherical SW system, which is available in HOMME? If so, please provide* *some computational examples with one of the SW test cases.*

Authors' response Yes, we have developed the TLM for global spectral element shallow water (SW) system before, and also developed the representer-based variational data assimilation system including the adjoint model (ADM) and simple background error covariance model for SW system. The draft for this development is recently finished and submitted for referred journal "Tellus A" with title of "Representer-based variational data assimilation in a spectral element shallow water model on the cubed-sphere grid". It can be provided, if the referee request. Below we attached Figure 1 of the submitted draft, which shows the spreads of observation information with linear dynamic models (i.e., ADM and TLM). The adjoint sensitivity at initial time (Fig. a) related to the assumed single zonal wind observation spreads out with TLM integration. Note that the subsequent evolutions (Fig. b-f) of geopotential height fields and wind vector fields are dynamically related with a geostrophic balance.

Caption for figure 1 Spreads of observation information with the color shadings. (a) The structure of the initial sensitivity (time t =0) obtained by integrating ADM backward in time, and the zonal wind observation (×) is initially located at (35oW, 12.5oS) at 3 hour. Then, TLM is integrated with the initial sensitivity as the initial condition at time (b) 3, (c) 6, (d) 12, (e) 18, and (f) 24 hours, respectively. Arrows represent the wind vectors.

Referee's minor comment *Abstract Line 5, "spectral element method"*

Authors' response Thank you. We were not able to find this typo in our version. This will be corrected in revised manuscript.

Interactive comment on Geosci. Model Dev. Discuss., 7, 1175, 2014.

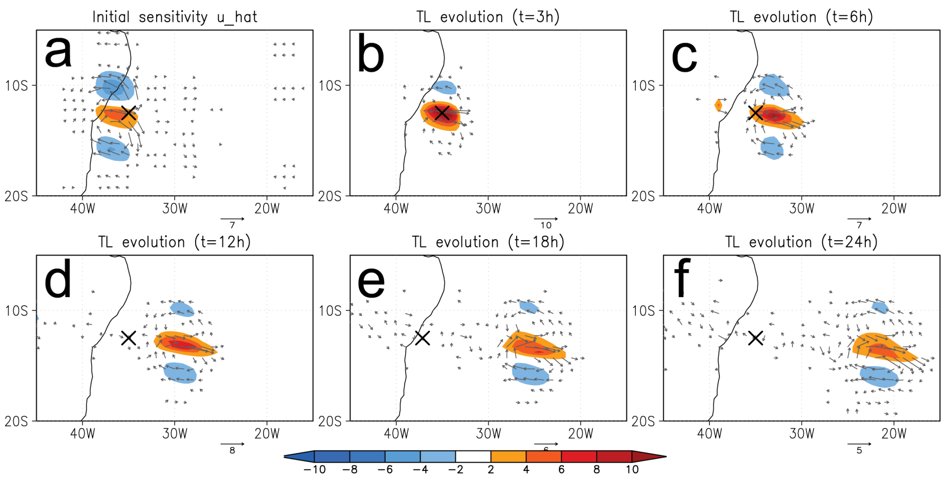

Fig. 1.