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Reply to: Comments on "Notes on the appropriateness of 'bred modes' for generating initial perturbations"

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In our paper (Errico and Langland, 1999; hereafter EL) examining the theoretical arguments supporting the appropriateness of "bred growing vectors" (BGVs), we attempted to clarify a number of issues and claims that have been presented by other investigators. We focused on the most recent paper (Szunyogh et al., 1997; hereafter SKT) that was available to us at the time of writing that expounded these arguments as well as some supporting papers referenced in it (Iyengar et al., 1996). We believed several details of those arguments, especially those regarding the relation between BGVs and analysis errors, were controversial, and that the community needed to be aware of this before attempting to apply or interpret BGVs in ensemble prediction, data assimilation, or observation targeting.

The primary criticism raised in EL was that the limited, imperfect, and inhomogeneous nature of observations appears neglected in the theoretical arguments relating BGVs to the character of analysis errors, and therefore the validity of applications of BGVs based on that relationship is questionable. Some statistics or aspects of BGVs may be similar to those of a portion of analysis errors produced by a data assimilation system, but no indisputable evidence has been offered that this portion is greatest in either magnitude or importance. In particular, if initially small-scale baroclinic errors have greater effect on subsequent short-term forecasts, as indicated in predictability studies using singular vectors (SVs) cited in EL, then even if such errors are smaller, they may be more important to consider.

Toth et al. (1999) make a number of claims that EL have not presented their criticism carefully and have misrepresented statements in SKT. Examples are the claims regarding discussion in EL about errors in attributing rapid SV growth to geostrophic adjustment. While EL did not state that SVs are entirely geostrophically balanced or that predictability studies using SVs have addressed this issue, EL did cite several papers that present evidence that perturbed gravitational modes do not grow appreciably in models. EL were also very careful to distinguished fast from slow gravity waves when relevant. Additionally, although SKT interpreted Ehrendorfer and Errico (1995) as demonstrating that geostrophic adjustment can yield exceptionally large growth of an energy norm, they failed to note the experiments described therein supporting the alternative explanation that such growth was spuriously due to improper expression of the norm.

Unfortunately, space does not permit us the opportunity to address the response by Toth et al. (1999) to our paper in greater detail here. We still support our previous comments. We do not believe we have made misleading statements, furthered confusion, or neglected directly relevant works published before our paper (or even since then, so far as we know). Anyone wanting a detailed response by us to Toth et al. (1999) may obtain one directly from us.

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