Effect of temporal covariances on the apparent mean Eady growth rate

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One of the simplest measures of baroclinicity was derived by Eady (1949). It pertains to the growth rate of the most unstable mode, and can be written as

$$\sigma = 0.3098 \, \frac{|f| \left| \dfrac{\partial U(z)}{\partial z} \right|}{N}$$

where N is the Brunt-Väisälä frequency ($N^2 = \dfrac{g}{\theta}\dfrac{\partial \theta}{\partial z}$, g being the acceleration due to gravity, z the vertical coordinate and θ the potential temperature) and f the Coriolis parameter, whose meridional derivative is denoted by β. $U(z)$ denotes the vertical profile of the background zonal velocity. In very many studies the time mean Eady growth rate is calculated from the means of the shear and of the Brunt-Väisälä frequency (method M). However, the growth rate expression is a nonlinear combination of these two variables and hence, in general, this is not an appropriate technique to calculate the mean growth rates. It can be argued that a more appropriate method to calculate the time mean growth rates at a given location is to calculate the rates at each synoptic time over a given epoch, and then take the average of those rates. This approach takes into account the temporal covariances associated with transient systems (method T).

We investigate the effect of these temporal covariances on the apparent mean Eady growth rate with the Japanese 25-year reanalysis (JRA-25) (Onogi et al. 2007). The reanalysis data set is archived every 6 hours and is available on a global 2.5° x 2.5° lat.-long. grid. We use the data for period of 1979–2007. The top panel in Fig. 1 shows the mean SH winter (JJA) 500 hPa growth rate calculated using the 'classical' method (method M). By contrast, the middle panel displays the rates when synoptic information is used (method T). The difference (T minus M) is shown in the bottom panel, and it shows that in the midlatitudes the significant changes are confined to the Pacific sector (particularly in the lee of Tasmania and New Zealand). Method T diagnoses increasingly greater growth rates with latitude which culminate in differences in excess of 0.15 day^{-1} off much of Antarctica. These represent large changes to the diagnosed baroclinicity around and to the south of 60°S, and are consistent with the high observed rates of cyclogenesis at these high latitudes (Simmonds et al. 2003).

The structure of the difference plot indicates that the application of Method T shifts the zones of maximum baroclinicity to the south. Our experiments indicate that care must been taken when calculating and interpreting simple measures of baroclinicity. Further details may be found in Simmonds and Lim (2009).

Eady, E. T., 1949: Long waves and cyclone waves. *Tellus,* **1,** 33-52.
Onogi, K., and Coauthors, 2007: The JRA-25 reanalysis. *J. Meteor. Soc. Japan,* **85,** 369-432.
Simmonds, I., and E.-P. Lim, 2009: Biases in the calculation of Southern Hemisphere mean baroclinic eddy growth rate. *Geophys. Res. Let.,* **36,** L01707, doi:10.1029/2008GL036320.
Simmonds, I., and Coauthors, 2003: Synoptic activity in the seas around Antarctica. *Mon. Wea. Rev.,* **131,** 272-288.

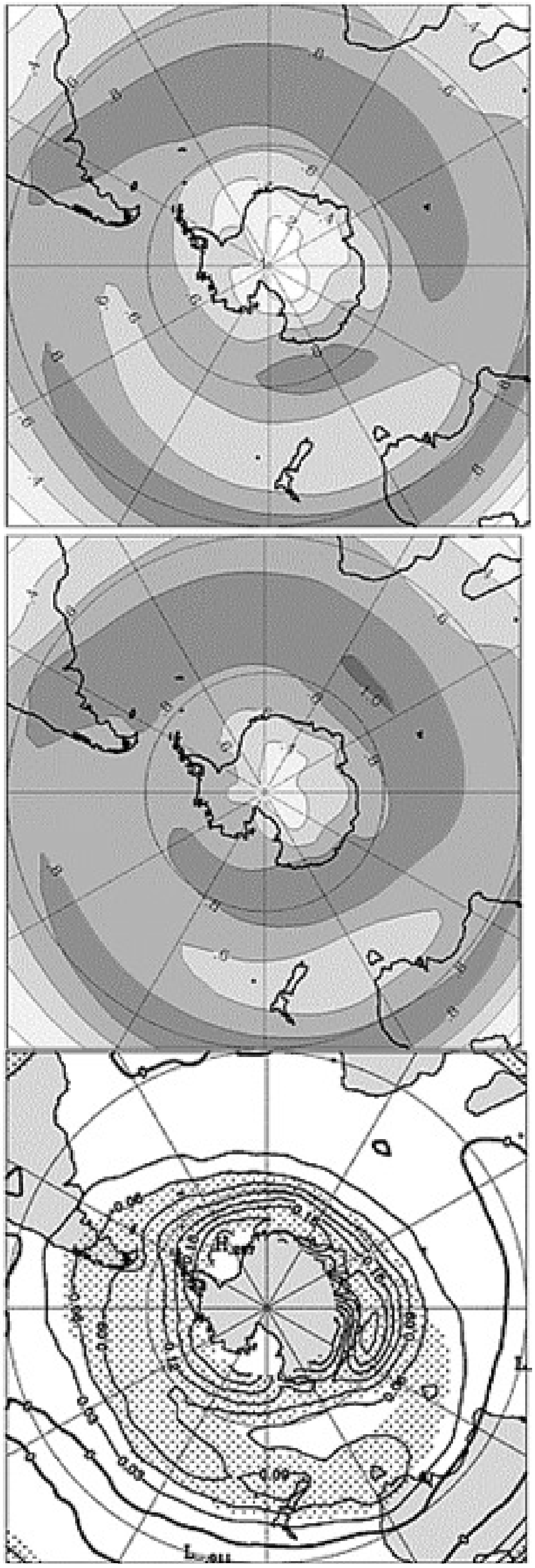

Figure 1: Climatology of the JJA maximum Eady growth rate at 500 hPa calculated with (top) seasonal mean vertical shear and N (method M) and (middle) 6-hourly vertical shear and N (method T). The bottom panel shows the difference (T minus M). The contour interval is 0.2 day^{-1} in the top two panels, and 0.03 day^{-1} in the bottom panel. The stippled area in this last indicates that the difference is significantly different from zero at the 95% confidence level (data poleward of 75^{o}S are masked).