Geophysical Research Abstracts, Vol. 8, 03136, 2006
SRef-ID: 1607-7962/gra/EGU06-A-03136
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Stratospheric Influence on Baroclinic Development

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Following the authors' recent work on the important role of synoptic eddies in mediating the dynamical influence of the stratosphere on the troposphere, we specifically examine the effect of varying the stratospheric vertical shear on baroclinic development.

We start by revisiting the Eady model, as the simplest model of baroclinic instability, which we extend to comprise both a tropospheric and a stratospheric layer. The linear theory for this problem shows that the growth rate is an increasing function of vertical wind shear, but sheds little light on the latitudinal structure of the heat and momentum fluxes.

Next we examine the most unstable linear modes in a primitive equations model for a family of more realistic jets that differ only in the value of the vertical wind shear in the stratosphere. Here the dependence of the growth rates and mode structures on the stratospheric shear is qualitatively similar to that of the Eady model. In addition, we find that as the stratospheric wind shear varies from negative to positive, the poleward momentum flux increases.

We also perform initial value problems with this same family of jets, and verify that the nonlinear development produces an annular mode response that is consistent with observations: a high AO/NAM index in the stratosphere, corresponding to a strong polar vortex and high shear leads to a high A0/NAM index in the troposphere, corresponding to a poleward displacement of the midlatitude jet.

Using NCEP/NCAR reanalyses, we show that the observed high and low anomalies in tropospheric momentum fluxes are in fact associated with high and low anomalies of stratospheric shear.

Finally, we present work in progress that shows that both lower stratospheric shear, and stratospheric NAM indices explain significant fractions in the variance in storm-transit statistics in the storm tracks.