Structure of Stratospheric Wave Responses to ENSO Convection

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Generalized Maximum Covariance Analysis (GMCA) has been developed and applied to diagnosing the relationships between ENSO tropospheric heating variations and tropical stratospheric waves. GMCA identifies the most important patterns of co-variability between interannual heating variations and eddy zonal and meridional velocities, temperatures, and ozone mixing ratios in the tropics between 200 and 10 hPa. The first two sets of GMCA time coefficients have variations which are strongly related to ENSO and are highly correlated at a lag of about a year. The diagnosed spatial patterns have broad wave number one characteristics, which are associated with ENSO.

Method: GMCA is the decomposition of a covariance (or correlation) matrix $C$ in terms of right $R$ and left $L$ matrices of vectors ordered by the squared covariance (correlation) explained. $S$ matrix is calculated from the five principle components (PC) of an Empirical Orthogonal Function (EOF) analysis of OLR variations for the 30ºS-30ºN domain. The $Z$ matrix in the present GMCA analysis is calculated using the Fourier/Hermite coefficients of the adjusted departures from the instantaneous zonal means of $u$, $v$, $T$ and $O_3$ for the region between 45ºS and 45ºN at eight levels (10, 20, 30, 50, 70, 100, 150 and 200 hPa) at lags from -20 to +20 months for the period 1981-1999.

Results: The first two sets of GMCA time coefficients ($L(t), R(t)$) have variations which are strongly related to ENSO (gray bars) and are highly correlated at a lag of about a year. The associated patterns of tropical OLR ($L_1, L_2$) are similar to the canonical ENSO SST patterns with strong negative sign regions stretching along the equator from the western to the eastern Pacific.

Conclusions: The dominant modes of heating variations are linked to a rich three-dimensional pattern of stratospheric eddy perturbations over a wide range of lags. Generally, major features propagate slowly to the east along with the tropospheric heating anomaly. This tilt is associated with wave number one gravity waves propagating into the stratosphere. The patterns are such that in the lower stratosphere regions of divergence (convergence), corresponding to upward vertical motion are broadly associated with lower (higher) temperatures and reduced (enhanced) ozone mixing ratios.