ATS/CIRA Colloquium

Aditi Sheshadri

Visiting ATS from Stanford University

Propagating annular modes of the troposphere and stratosphere

Hosted by David Thompson

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ATS room 101
Discussion will begin at 11:15 a.m.

The two leading Empirical Orthogonal Functions (EOFs) of zonal mean zonal wind describe north-south fluctuations, and intensification and narrowing, respectively, of the midlatitude jet. Under certain circumstances, these two leading EOFs cannot be regarded as independent, but are in fact, manifestations of a single, coupled, underlying mode of the dynamical system describing the evolution in time of zonal wind anomalies. The true modes, the Principal Oscillation Patterns (POPs) are calculated using a novel approach that yields results that are more robust than those obtained hitherto. The leading mode and its associated eigenvalue are complex, its structure involves at least two EOFs, and it describes poleward (or equatorward) propagation of zonal mean zonal wind anomalies. In this propagating regime, the Principal Component (PC) time series associated with the two leading EOFs decay non-exponentially, and the response of the system to external forcing in a given EOF does not depend solely on the projection of the forcing onto that EOF. These considerations are illustrated using results from an idealized dynamical core model. Results from southern hemisphere ERA-I data are consistent with the behavior of the model’s propagating regime. Amongst other things, these results imply that the timescale that determines the sensitivity of a model to external forcing might be different from the decorrelation time of the leading PC, and involves both the rate of decay of the dynamical mode, and the period associated with propagation.

Stratosphere-troposphere interactions are conventionally characterized using the first EOF of fields such as zonal mean zonal wind. Perpetual winter integrations of an idealized model are used to contrast the vertical structures of EOFs with those of POPs. POP structures are shown to be insensitive to pressure weighting of the time series of interest, a factor that is particularly important for a deep system such as the stratosphere and troposphere. In contrast, EOFs change from being dominated by tropospheric variability with pressure weighting to being dominated by stratospheric variability without it. The analysis reveals separate tropospheric and stratospheric modes in model integrations that are set up to resemble midwinter variability of the troposphere and stratosphere in both hemispheres. Movies illustrating the time evolution of POP structures show the existence of a fast, propagating, tropospheric mode in both integrations, and a pulsing stratospheric mode with a tropospheric extension in the northern hemisphere-like integration.