The coupled stratosphere-troposphere response to impulsive forcing from the troposphere

Paul J. Kushner
Department of Physics
University of Toronto
60 St. George Street
Toronto, Ontario M5S 1A7

Abstract

A simple atmospheric general circulation model (GCM) is used to investigate the transient response of the stratosphere-troposphere system to externally imposed pulses of lower-tropospheric planetary wave activity. The atmospheric GCM is a dry, hydrostatic, global primitive-equations model, whose circulation includes an active polar vortex and a tropospheric jet maintained by baroclinic eddies. Planetary wave activity pulses are generated by a perturbation of the solid lower boundary that grow and decay over a period of ten days. The planetary wave pulses propagate upward and break in the stratosphere. Subsequently, a zonal-mean circulation anomaly propagates downward, often into the troposphere, at lags of 30 to 100 days. The evolution of the response is found to be dependent on the state of the stratosphere-troposphere system at the time the pulse is generated. In particular, on the basis of a large ensemble of these simulations, we find that the length of time the signal takes to propagate downward from the stratosphere is controlled by initial anomalies in the zonal-mean circulation and in the zonal-mean wave drag. Criteria based on these anomaly patterns can be used, therefore, to predict the longterm surface response of the stratosphere-troposphere system to a planetary wave pulse up to 90 days after the pulse is generated. In an independent test, we verify that the initial states that most strongly satisfy these criteria respond in the expected way to the lower tropospheric wave-activity pulse.

(T.J. Reichler — University of Utah; P.J. Kushner — University of Toronto, L.M. Polvani – Columbia University, 2005, J. Atmos. Sci., in press)

Preprints available at:

http://individual.utoronto.ca/paul_kushner.