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The grant supported studies using several models along with observations in order to investigate some questions of wave-mean flow interaction and transport in the extratropical winter stratosphere. A quasi-geostrophic wave model was used to investigate the possibility that resonant growth of planetary wave 2 may have played a role in the sudden stratospheric warming of February 1979 (Smith, 1989). The results of the time-dependent integration support the interpretation of resonance during February, 1979.

The dynamical events during sudden warmings can be strongly influenced by the presence of critical lines (where the wave phase speed is equal to the zonal wind speed) in the very region where the wave-mean flow interaction was occurring. The treatment of critical line behavior in a simple wave model such as that used in the sudden warming studies is approximate at best, and may in fact give inaccurate results. Because of the possibility that the model treatment of critical line interactions exerted a controlling influence on the atmospheric dynamics, a more accurate model was needed for wave-mean flow interaction studies. A new model was adapted from the 3-dimensional primitive equation model developed by K. Rose and G. Brasseur.

A look at the NMC data for the period 1978-1989 indicates many similarities between the warmings of February, 1979 and February, 1989, as noted by Fairlie et al. (1990). Both began when

the zonal mean wind profile was characterized by a high latitude jet in the lower stratosphere (~10 mb, 65-70oN) with near-zero or negative (easterly) winds extending quite far into the winter hemisphere from the tropics, and with very weak wind speeds near the stratopause. In both warmings, wave 2 was dominant, although the 1989 warming it did not have the eastward phase progression seen in 1979. Simulations with the 3-d model (without chemistry), initialized with NMC data from a week before each of these two warmings, indicate that the stratospheric flow had been preconditioned for a warming. Additional numerical integrations indicated that the preconditioning did not depend on the details of the wave pulse that caused the warming and that it was more sensitive to the flow in the lower stratosphere than to that in the upper stratosphere. These results are described in Smith (1992).

A number of improvements were made to the 3-d model, and it is still in current use by the P.I. and others. In its present form it is global, rather than hemispheric; it contains an infrared cooling algorithm supplied by D. Schwartzkopf, and a parameterized solar heating; it has parameterized gravity wave drag; and the chemistry has been entirely revised.

Publications

Smith, A. K., An investigation of resonant waves in a numerical model of an observed sudden stratospheric warming. J. Atmos. Sci., 46, 3038-3054, 1989.

Smith, A. K., Preconditioning for sudden stratospheric warmings: Sensitivity studies with a numerical model. J. Atmos. Sci., 49, 1003-1019, 1992.

Conference presentations

Smith, A. K., Preconditioning for Stratospheric Sudden Warmings: Sensitivity Studies with a Numerical Model. AMS Eighth Conference on the Meteorology of the Middle Atmosphere, 1992.

Other work using 3-d model developed with support of grant NAGW1744

Lefevre, F., G. Brasseur, I. Folkins, and A. K. Smith, Highly

perturbed Arctic stratosphere in January 1992, J. Geophys. Res., in press.

Smith, A. K., Numerical simulation of global variations of temperature, ozone and trace species in the stratosphere, submitted to J. Geophys. Res.