Dynamics of upper tropospheric stationary wave anomalies induced by ENSO during the northern summer: A GCM study

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Ensemble seasonal integrations are carried out with the COLA GCM, with a view to understand the dynamical connection between warm SST anomalies in the equatorial central-eastern Pacific Ocean and the upper level stationary wave anomalies seen during drought years over the Indian summer monsoon region. In addition, experiments with and without orography are performed in order to examine the role of the Himalayas in modulating the El Niño induced stationary wave anomalies over the summer monsoon region.

The GCM simulations show a statistically significant weakening of the summer monsoon activity over India in response to the SST forcing in the equatorial Pacific Ocean. This weakening of the summer monsoon appears to be largely related to modifications of the local Hadley and Walker cells over the summer monsoon region. In addition, it is seen that the anomalous ENSO divergent forcing over the tropical Pacific Ocean can act as a potential source for Rossby wave dispersion. Here one finds the possibility of meridionally propagating Rossby waves, which emanate from the ENSO forcing region, to interact with the subtropical westerlies and generate anomalous highs and lows in the subtropics and extratropics. The quasi-stationary perturbations seen over west Asia, Pakistan and northwest India during drought years, seem to be generated by the above mechanism. An alternate mechanism that could be important for the persistence of the quasi-stationary perturbations seems to be based on the dynamic excitation of middle latitude normal modes which can extract energy from the zonally varying unstable basic flow.

It is seen from the GCM simulations, that the Himalayan orography plays a crucial role in anchoring the El Niño induced extratropical westerly troughs far to the west in the high latitude belt. In the absence of orography it is seen that the ENSO induced extra-tropical cyclonic anomalies tend to intrude southward into the monsoon region thereby destroying the regional scale circulations completely. Another effect due to the Himalayas is to generate lee waves on the eastern side of the topographic barrier which encircle the globe in the subtropics and midlatitudes.

1. Introduction

1.1 *Observational aspects*

The works of Keshavamurty and Awade (1974); Joseph (1978); Keshavamurty *et al* (1980); Joseph *et al* (1981); Verma (1982); and Rajeevan (1991, 1993)) indicate the occurrence of prominent circulation and thermal anomalies in the upper troposphere over north India and the neighbourhood during drought years. It is seen that these signals manifest in the form of well-defined cold cyclonic circulation anomalies in the upper troposphere. The quasi-stationary anomalies generally have a long persistence and indications of these anomalous signals can be traced right from the previous winter months (Joseph 1978). The persistence of such quasi-stationary features tends to inhibit the development of the upper

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