VERSITA

Acta Geophysica
vol. 55, no. 2, pp. 231-252
DOI 10.2478/s11600-006-0035-6

Impact of the surface temperature and vertical shear of zonal wind on the dynamics of a simple two-layer model of the atmosphere

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A b s t r a c t

The paper presents and analyzes, from the point of view of smooth dynamic systems theory, a two-layer baroclinic model of the troposphere in geostrophic approximation. The model describes airflow in β-channel within the tropospheric part of the main Hadley circulation cell. It enables to obtain, after application of the Galerkin method, a fairly simple low-parametric dynamic system describing the phenomena of non-linear interactions, bifurcations and blocking in the atmosphere. This enables to take into consideration such basic factors influencing the atmospheric dynamics like the heat exchange within the surface, orography, vertical variability of zonal wind and hydrostatic stability.

Impact of zonal thermal variability of the surface and vertical shear of zonal wind in the troposphere on the orographic bifurcation was investigated and the oscillation character in the dynamic system after Hopf bifurcation of the second kind was analyzed. Additionally, the model dynamics was investigated in conditions including momentum forcing in the upper and lower parts of the troposphere and excluding orographic interaction, as well as in the conditions of thermal interaction between the troposphere and the surface for the vertical shear of zonal wind in both tropospheric layers. Impact of the mean zonal wind in the troposphere on the properties of model dynamics was assessed.

It was proved that zonally varied surface temperature and layered mean zonal wind in the atmosphere are the parameters that have basic influence on the model

dynamics. They cause numerous bifurcations and strongly influence the periods of oscillations of the model variables. They are often Hopf bifurcations of the second kind during which tropospheric states fairly distant from the ones before the bifurcations are generated. This significantly influences the model predictability.

Key words: atmospheric models, orographic bifurcation, thermal bifurcation, baroclinic atmosphere, zonal wind.