3-d modeling of the middle and upper atmosphere response to the 27-day solar variation

A. Gruzdev (1), H. Schmidt (2), G. Brasseur (3)

(1) A.M. Obukhov Institute of Atmospheric Physics, Moscow, Russia, (2) Max-Planck-Institut fuer Meteorologie, Hamburg, Germany, (3) National Center for Atmospheric Research, Boulder, CO, USA (a.n.gruzdev@mail.ru)

We present results of an analysis of the effect of the 27-day solar variation on composition and temperature of the stratosphere, mesosphere and lower thermosphere calculated with the 3-dimensional chemistry climate model HAMMONIA. The spectral amplitudes of the 27-day solar cycle within the wavelength range from Lyman-á to the short infrared, which are input parameters at the upper boundary of the model, were calculated from data of UARS SOLSTICE measurements. A combination of high resolution spectral and cross-spectral analyses allows determining 27-day variations in the Earth atmosphere which are related to the 27-day solar forcing. These methods give also estimates of the amplitude (and hence sensitivity) and phase of the response. While the calculated thermal and chemical responses are very distinct and permanent in the upper atmosphere, the responses in the stratosphere and mesosphere are intermittent in time and affected as well by interannual variability. It is due to interference of the inherent atmospheric variability and the variability forced by the 27-day solar cycle, which sophisticates the response to the 27-day solar forcing in large parts of the model stratosphere and mesosphere. In the extratropical latitudes the responses are seasonally dependent. Altitude-latitude distributions of sensitivities and phases of the responses to the 27-day solar forcing are analyzed in detail for temperature and chemical species important for ozone chemistry. The sensitivity and phase of the ozone response in the tropical stratosphere and lower mesosphere are in satisfactory agreement with available observational results, while above 70-75 km there is a principal difference between calculated and observed phases of the ozone response. In the case of the low-latitude temperature response, amplitudes and phases observed by different authors differ considerably. The calculated temperature response in the upper stratosphere-lower mesosphere correspond to some of the observations. However, there is no correspondence between calculated and observed (only one experimental data set) temperature responses above 75 km. Model calculations show significant nonlinearity of temperature and species responses to the forcing, which generally results in a decrease in sensitivities of the responses with increasing amplitude of the forcing. An important deduction from this model study is that, at present, there is insufficient data for comprehensive comparison of modeled and observed effects of the 27-day solar cycle. Analysis of observational data should include not only periods with significant amplitude of the 27-day solar cycle, but also periods when this cycle

is absent or relatively weak. This would provide information about inherent variability of the atmosphere, which is important for understanding of whether or not the atmospheric variability at 27-day period is related to solar forcing.