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Effect of the 27-day solar cycle on the Earth atmosphere calculated with the 3-D model HAMMONIA

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The effect of the 27-day cycle in solar radiation on composition, temperature, and dynamics of the Earth's atmosphere is studied with the help of the global 3-dimensional model HAMMONIA which is an extension of the general circulation model ECHAM-5 up to 250 km. Parameterizations for processes specifically important in the mesosphere and thermosphere are added to the model, and it is coupled to the MOZART3 photochemical scheme. The 27-day cycle in spectral solar irradiance within the range from the extreme UV to the infrared is an input parameter at the upper model boundary. The response of the atmosphere to this forcing is analyzed with different methods including high-resolution spectral methods and the wavelet technique. In the upper atmosphere, a very pronounced response at the forcing frequency occurs in different parameters: temperature, geopotential height, wind, and species concentrations. However, the effect may undergo significant changes at lower altitudes (depending on parameter). Generally, in the stratosphere and even in the mesosphere, the variations associated with the 27-day forcing may be intermittent; the amplitude of the variations and the phase shift between the variations and the forcing change with time. As a result, the mean period of the variations is not constant but varies, sometimes significantly, around the forcing period. Another important feature of the calculated response is its seasonal and interannual variability. For example, ozone variations with a period close to the forcing period have maximum amplitudes in layers 20-50 km and 80-110 km. At some levels, abrupt phase changes in ozone and temperature variations occur, but altitudes of these levels are also changeable. Generally, 3-dimensional modeling suggests that the response of the atmosphere to the 27-day solar forcing is significantly affected by an intrinsic atmospheric variability.