Solar proton events and their response in the atmosphere as simulated with 3D models (chemical and dynamical aspects)

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General circulation and 3D chemical global transport-photochemical middle atmosphere models have been used for simulation of ozone, wind and temperature response to the strongest solar proton events (SPEs) of the 23^{rd} solar cycle : 14 July 2000, 4 November 2001; and 28 October 2003. It was assumed in the photochemical scheme that approximately one molecule of NO and two molecules of OH are produced for each pair of ions due to ionization of the atmosphere at high latitudes by solar protons. SPE–induced ionization rates have been calculated using high time-resolution satellite solar proton fluxes measurements provided by GOES. In accordance with calculations the maximums of ionization rates were localized in the mesosphere and higher stratosphere during SPEs. The results of photochemical simulations showed that ozone was strongly destroyed in the mesosphere and stratosphere over both polar regions after SPEs of 4 November 2001, and 28 October 2003, and ozone response was found only over Northern polar region after SPE of July 2000. A weak negative response of ozone over South Pole (night conditions) was found in simulations. The results of model runs obtained with GCM (COMMA/CAO) showed also, that SPE-induced ozone depletion leads to corresponding disturbances in temperature and dynamics mostly over high latitudes. So, energetic solar proton flux is a simultaneous source of external forcing for chemical composition and dynamics (including tides) in the atmosphere, which possibly leads to long-term effects.