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Signatures of meteorological phenomena in the ionosphere-thermosphere system (Julius Bartels Medal Lecture)

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One of the numerous topics Julius Bartels was studying is tidal signatures in geophysical quantities. During past decades this topic lost its attraction because the important phenomena were considered to be well understood. Only recently many researchers have discovered their interest in investigating non-migrating tides. Based on model studies it had been predicted that latent heat released from deep tropical convection (thunderstorms) produce prominent longitudinal and local time variations in bulk ionosphere-thermosphere-mesosphere properties. Starting in 2006 a growing number of publications presented satellite observations confirming the existence of non-migrating tidal signatures in the upper atmosphere. The effects reach altitudes even higher than originally anticipated. In this respect we are now at an exciting research frontier, realising that large-scale tropospheric weather systems affect geospace up to the exosphere. Observations during the last solar cycle show that the tidal forcing from below is strongest during solar minimum. Particularly outstanding in this respect is the very low recent minimum. Commonly used models of the ionosphere and thermosphere, parameterised by solar and magnetic activity indices, failed to predict the degree of atmospheric depletion. Obviously other forces than the externals have taken over control. In particular, during the minimum years 2008 and 2009 clear signatures of tropospheric/stratospheric forcing are observable in the high-altitude atmosphere from phenomena like the quasi-biannual oscillation, stratospheric warming or El Nino Southern Oscillation. Improved future models of the upper atmosphere have to consider both the forcing from above and below.