Atmospheric and Space Weather Systems Interaction

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The impact of meteorological processes near the Earth's surface upon the upper atmosphere cannot be ignored in conceptual space weather models. This paper will suggest examples of physical interactions between the two weather systems. A clear example might be the clear sky electric field (CSEF) and electrodynamic properties of the lower ionosphere. Both are controlled by the global thunderstorm activity which, in turn, is dependent on atmospheric weather, specifically on water evaporation processes, cloud formation and convective instability. The energy of discharges stored in the global Earth-ionosphere cavity (Schumann resonator) is partially spent on slightly increasing the electron temperature in the ionospheric D-region. The key question about the importance of near-surface energy releases and energy transport from bottom to top, i.e. to the geospace, is identification of a transport agent capable of transferring the mechanical (or thermal) energy released in the neutral atmosphere, to the terrestrial plasma. One of the perspective carriers of near-surface disturbances might be associated with the large-scale atmospheric gravity waves (AGW) traveling upwards to ionospheric heights and producing the effects known as traveling ionospheric disturbances (TIDs). The problem discussed in this paper in more detail is that of projection to geospace altitudes of the atmospheric phenomena of greatest power, i.e. cyclones. The original material that the research was started from had been provided by experiments in a region of high meteorological activity, namely the Antarctic coast of the Drake Straits, where the Ukrainian Antarctic station Akademik Vernadsky is located. The data used for the analysis were collected over the three years 1998 through 2000. Passages of cyclone fronts were in most cases accompanied by excitation of large scale.

AGWs, characterized by periods longer than one hour, that were distinctly detectable in the spectra of air pressure variations. A sensitive magnetometer (0.1 nT) at the station enabled us to perform parallel Fourier analyses of magnetic field and air pressure variations. The cyclones passing during magnetically quiet periods ($K<3$) were accompanied by quasiperiodic variations in all the three magnetic field components, showing the same time periods as the baric pressure and reaching amplitudes of a few nT. As follows from the cross-correlation analysis of the magnetic field and pressure variations, the magnetic field normally lagged behind the pressure by a few tens of minutes. These findings have permitted constructing a model; first a qualitative and then a quantitative one to describe the transfer of energy from the neutral to the ionized gas component in the atmosphere. The logic behind the modeling is as follows. AGWs excited near the Earth surface travel to the heights of the ionospheric dynamo region where they modulate the neutral component density (the plasma component making just a small fraction of the total quantity) and velocity of the charged particles. The result is a modulation of the transverse conductivity and current density, what eventually forced excitation of quasiperiodic variations in the magnetic field. Another interesting finding was as follows. The magnetically conjugate region of Vernadsky station lies not far from the US East coast. The results of cross-analysis of the magnetic field variations in Antarctica and in New England (upon passage of a cyclone in the South) demonstrate a high degree of statistical relation (correlation factor above 0.8). It can therefore be stated that powerful meteorological processes are projected to near-space altitudes not only directly above their location but also to the other hemisphere (at least, in the vicinity of the conjugate point, with the disturbance traveling along the appropriate L-shell). An important input in the experimental verification of the described effect could be given by the satellite measurements. Unfortunately, because of too short time of the satellite crossing of the corresponded L-shell it can not be used to extract the anomalous change of the magnetic field. But there is some hope to observe the propagation of Alfven wave measuring the current density. Both these measurements will be made onboard SICH-1M satellite, which will be launched in the beginning of 2004.

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