Report on the PhD thesis entitled

Acoustic-gravity waves at ionospheric heights generated by meteorological activity in the troposphere by Tereza Sindelarova

The subject of the thesis deals with the observations in the ionosphere of gravity waves related with meteorological activity in the troposphere.

The first studies in this field were performed in the sixties and seventies, with the first generation of HF Doppler sounders, and ionospheric wave activity has been related to severe weather in US. The thesis subject is then not new because of these first observations and because the technology presently used is the same. However, these first observations mainly provided qualitative results and ionospheric observations related to meteorological disturbances in countries outside USA were very rare. In most studies the energy exchanges between the atmospheric layers are still neglected. A new interest about such atmospheric coupling is increasing in Europe with the first sprite observations in 2000 and with the projects TARANIS and ASIM dedicated to measurements of the effects of lightning and sprites in the atmosphere, ionosphere and magnetosphere. It has been shown that thunderstorm activity in Europe is more important than expected with, for example, large thunderstorms occurring in winter over Mediterranean Sea. The question about global or regional effects of large thunderstorms is still open.

The thesis is composed of 4 main parts
The first part is dedicated to the Introduction. The thesis subject is very wide and it needs a good understanding of different fields as ionosphere and ionospheric measurement technology, geomagnetic activity, acoustic and gravity waves, meteorology and convective systems, coupling between the atmosphere and ionosphere. The introduction is clear and well documented. The observation technologies are well described. They include HF radar technology, meteorological radars and geomagnetic observations performed in Czech Republic. The objectives of the thesis are clear and well presented.

The second part is dedicated to data and methods. The thesis first step has been to identify convective storms in the observation days. This has been performed by the definition and use of a specific index representative of the convective activity. This index takes into account the extension and the height of the convective system compared to the tropopause height. Ionospheric data have then been analyzed by using the trace of the Doppler frequency shift. A wavelet processing has been developed for the identification of the wave trains. This method is well adapted to characterize waves in a broad frequency range. This same processing has been used for the analysis of geomagnetic data.

The third part of the thesis concerns results. The analysis of the storm of July 29, 2005 is well presented with ionospheric diagrams, radar and lightning map. The wave systems measured by HF Doppler sounding are complex and can be produced by magnetohydrodynamic waves produced by magnetic activity or by the acoustic gravity waves coming from the atmospheric convective storms in the troposphere. Some oscillations are not related to magnetic waves and could be related to the convective storm. However, it is difficult to discriminate both origins, because the wave velocity which could allow this differentiation, is not measured with only one ionospheric HF link, exploitable for the thesis work.

The observation of the cyclone of 18 January 2007 is very interesting and shows wave activity not related to magnetic activity and then probably produced by the cyclone. However, the meteorologic radar and lightning maps are only provided for July 29. It is difficult to know the distance between the convective areas and the propagation path as well as the evolution in the time of the convective areas.

Many other days of data have been analyzed, in the frame of the thesis, from July 2005 to January 2007. Details are in the Appendix and in the CD –ROM provided at the end of the thesis manuscript. This represents a good analysis of the data base. All diagrams present information related to the Doppler effect, reflection altitude, presence of sporadic E and magnetic disturbances. However the meteorological data (radar and lightning maps) were not included and only shorts comments in the appendix and the convective storm index inform the reader about the convective activity. The distance between the active storm areas and the reflection point is not always very clear. It is just specified when the active area crosses the radio link.

In recent studies using microbarometer observations in Europe, it has been shown that gravity waves produced by convective storms are only observed when the storm is very near the observation point. The distance between the convective areas and the reflection point as well as the time evolution of the convective areas could allow a better identification of the ionospheric effects and such information should be better considered in future studies. Also the observation of storms with microbarometers will be an important complementary information to better identify the possible effects in the future.

In the thesis discussion, a large part is dedicated to the comparison between US and European convective storms. Activity in Europe is weaker than in USA. This part is well documented. However several important storms have been identify during the measurement campaigns performed since 2003 in Europe, and effects can be expected for such storms, even if the storm occurrence is smaller than in USA. The studies, open in the frame of this thesis, are interesting for the future projects TARANIS and ASIM, and they should continue. Perspectives with additional Doppler links and the microbarometer stations are very relevant.

The thesis is well written and well documented. The work performed for the data analysis is important and well presented in the thesis manuscript and in the CD-ROM. The thesis work has been published in two different papers in which Tereza Sindelarova is first author. I then give a very favourable advice for the attribution of the PhD degree to Tereza Sindelarova

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