Impact of the Wintertime Meteor Showers on the Sporadic E Layer Activity at Midlatitudes

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Introduction, measurement methods

- The impact of meteor showers and individual meteors on the ionosphere has been investigated during wintertime meteor showers using synchronised measurements of two DPS-4D Digisondes installed at Pruhonice (50°, 14.5°) and at Sopron (47.63°, 16.72°).
- High cadence campaigns have been performed to observe behavior of sporadic E layer (Es) during the Leonids, Geminids and Quadrantids meteor showers in 2018 and 2019.
- The time resolution of the ionograms have been set to approximately 0.5 - 2 ionograms per minute.
- We used vertical and oblique reflections to investigate the fine structure and the movement of Es layer.
- Beside the regular behavior of Es we concentrated on observation of intervals of increased plasma frequency in the Es region presumably directly induced by the meteors.
- Comparison of the ionograms measured during meteor showers with the optical data to determine the plasma trails of individual meteors.

Conclusions of the first results

Most important findings of the campaign measurements of Es activity:

- Based on the first results the oblique sounding is a good technique to detect the Es activity between two stations. The benefit of this method is that we were able to record periods (typically 10 to 40 minutes) when the Es was observed using oblique trace but there was no observation of Es layer in vertical ionograms.
- Double Es structures have been detected more times for tens of minutes during the observation nights.

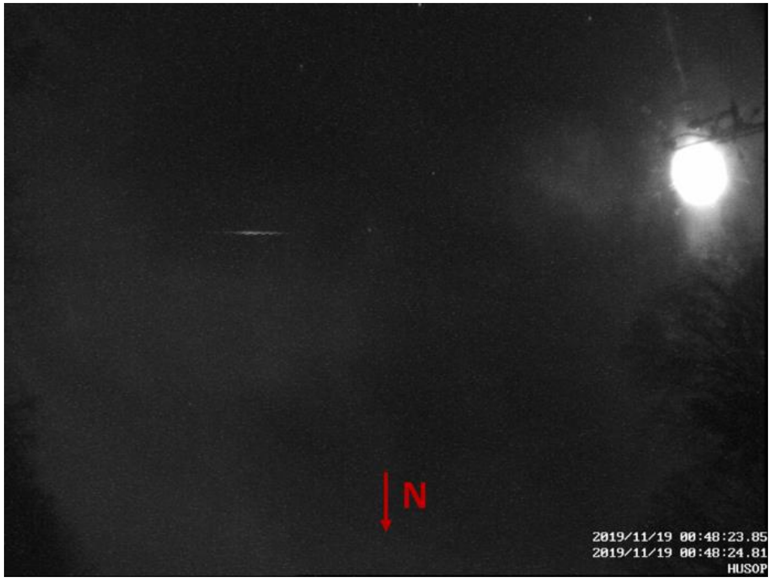
Results related to the detection of individual meteors:

- In the 20-25% of the observed meteors a faint, short-lived (1-2 min) Es layers were detected on the ionograms at Sopron during and after (< 1 min) the optical record.
- The direction of the detected plasma traces determined by the SAO Explorer was in good agreement with the direction of the optically observed meteors in most of the cases.
- In most of the cases no similar short-lived Es was recorded at Pruhonice in the same time
- → The observed faint, short-lived Es layers can be identified as local plasma irregularities probably caused by the meteors.
- **Consequently, plasma trace of individual meteors could be detected on the high time resolution ionograms.**

Detection of individual meteors by ionosonde

1st sample: Leonid 2019-11-19, optical observation: 00:48:23, Maximal brightness between +0.9 and +1.0 magnitude, Ionograms: 00:48:40

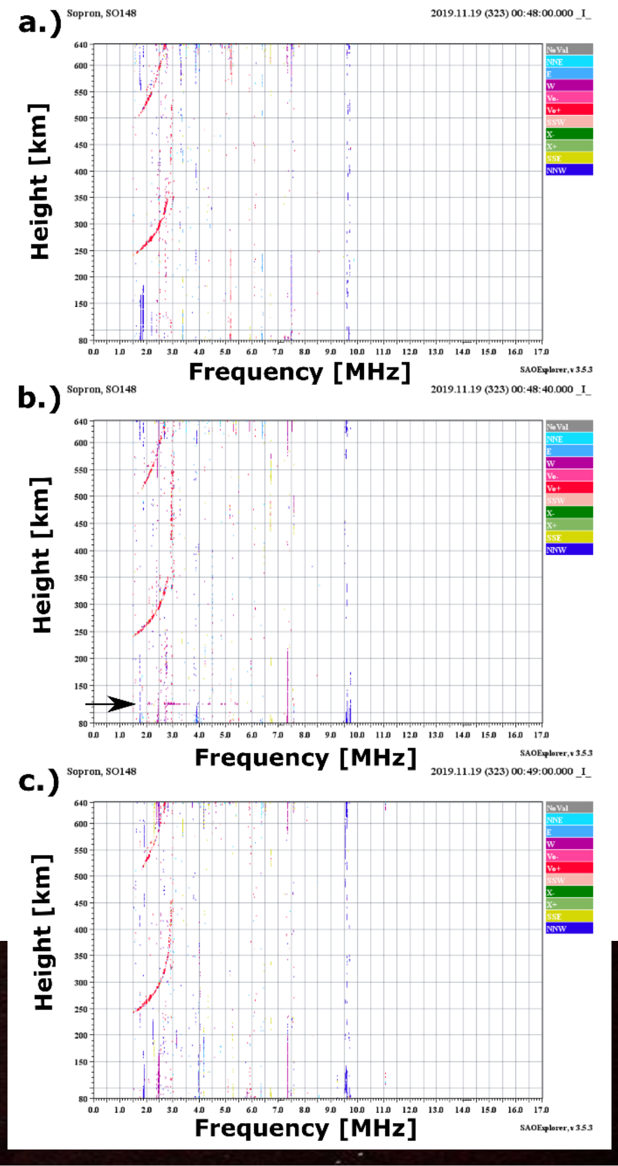
Optical measurement



- Faint sporadic E layer up to 5.5 MHz at 115 km height at 00:48:40
- Direction determined by SAO Explorer (W) is in good agreement with optical measurement
- No Es activity was detected at Pruhonice in the same time

→ **Local plasma irregularity probably related to the meteor**

Ionograms

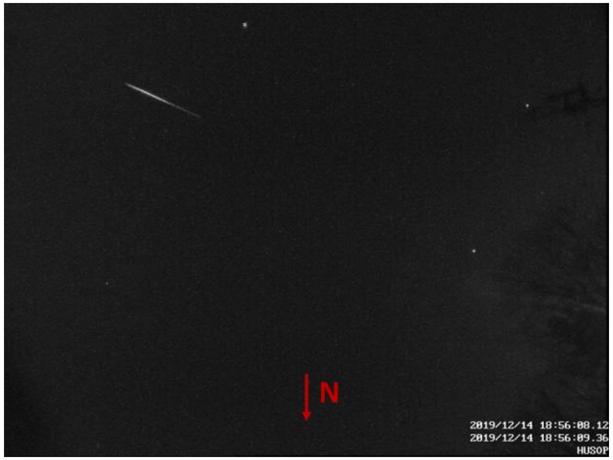


Detection of individual meteors by ionosonde

2nd sample: Geminid 2019-12-14, optical observation: 18:56:08 in the South-South-West direction from the zenith

Ionograms: 18:57:00 – 18:58:36

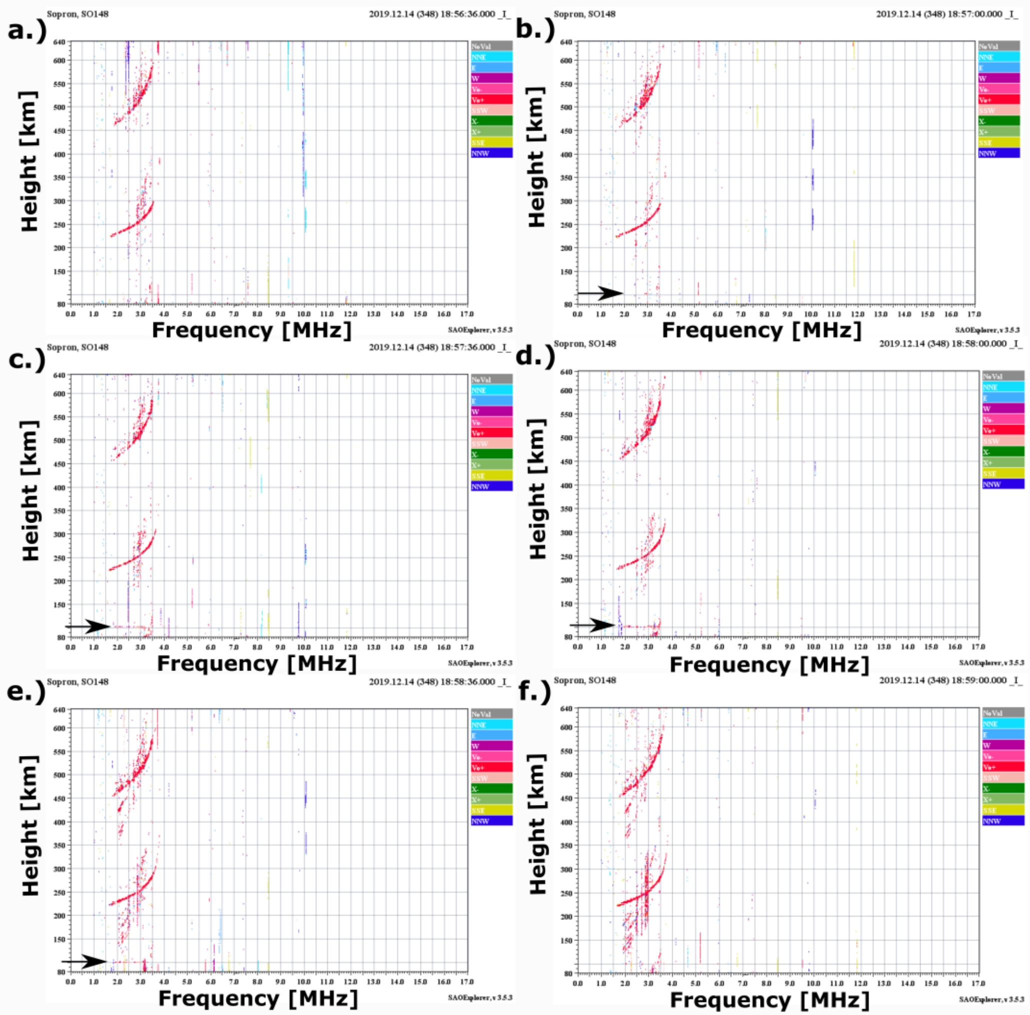
Optical measurement



- Faint Es layer up to 3.5 MHz at ~ 100 km
- Direction determined by SAO Explorer (SSW) is in good agreement with optical measurement
- No Es activity was detected at Pruhonice in the same time

→ **Local plasma irregularity caused by the meteor**

Ionograms



Detection of individual meteors by ionosonde

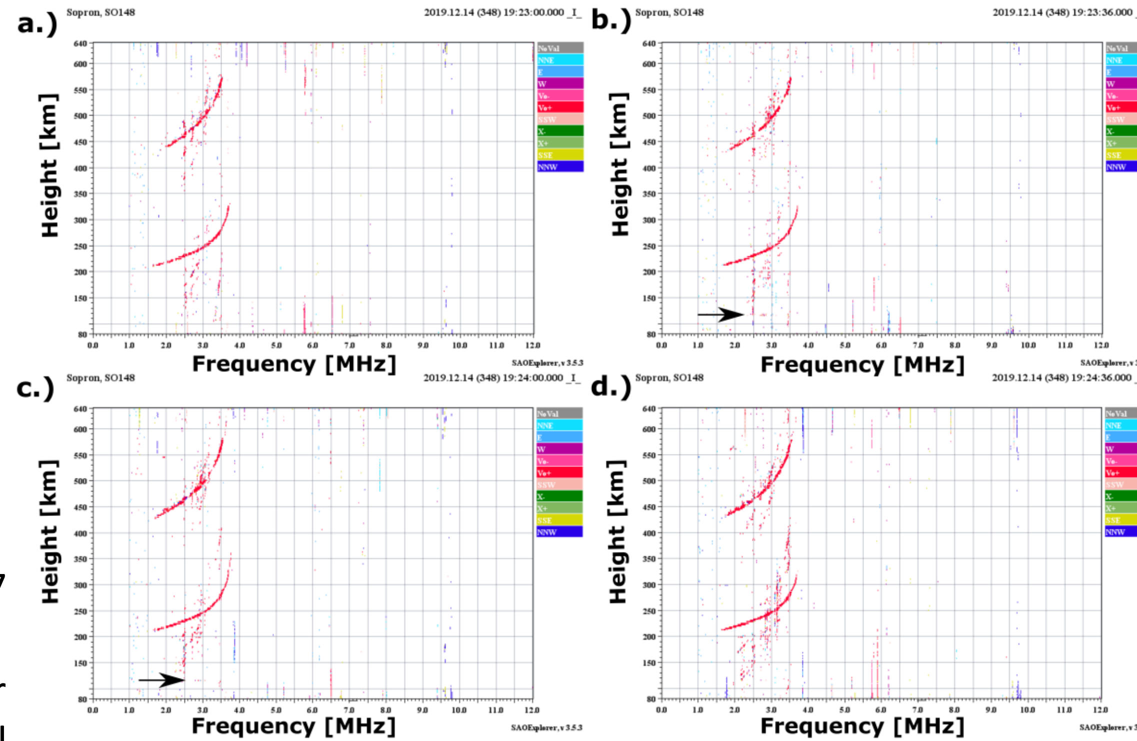
3rd sample: Geminid 2019-12-14, optical observation: 19:22:43 in the South-South-West direction from the zenith

Ionograms: 19:23:36 – 19:24:00

Optical measurement

- Faint Es layer up to ~ 3.2 MHz at ~ 117 km height
- Direction determined by SAO Explorer (SSW) is in good agreement with optical measurement
- Regular strong Es activity was detected at Pruhonice in the same time, but no faint short lived Es

Ionograms



→ **The observed faint short-lived Es is a local plasma irregularity probably caused by the meteor**

Acknowledgment

- The installation of the DPS-4D ionosonde and the optical meteor observation were supported by the GINOP-2.3.2-15-2016-00003 “Kozmikus Kockázatok” project.

- The campaign measurements performed by the two digisonde were supported by the bilateral agreement between the Czech and Hungarian Academy of Sciences, NKM55/2019 (“Multiinstrumental investigation of the midlatitude ionospheric variability”).