hal-00638549, version 1 - 5 Nov 2011

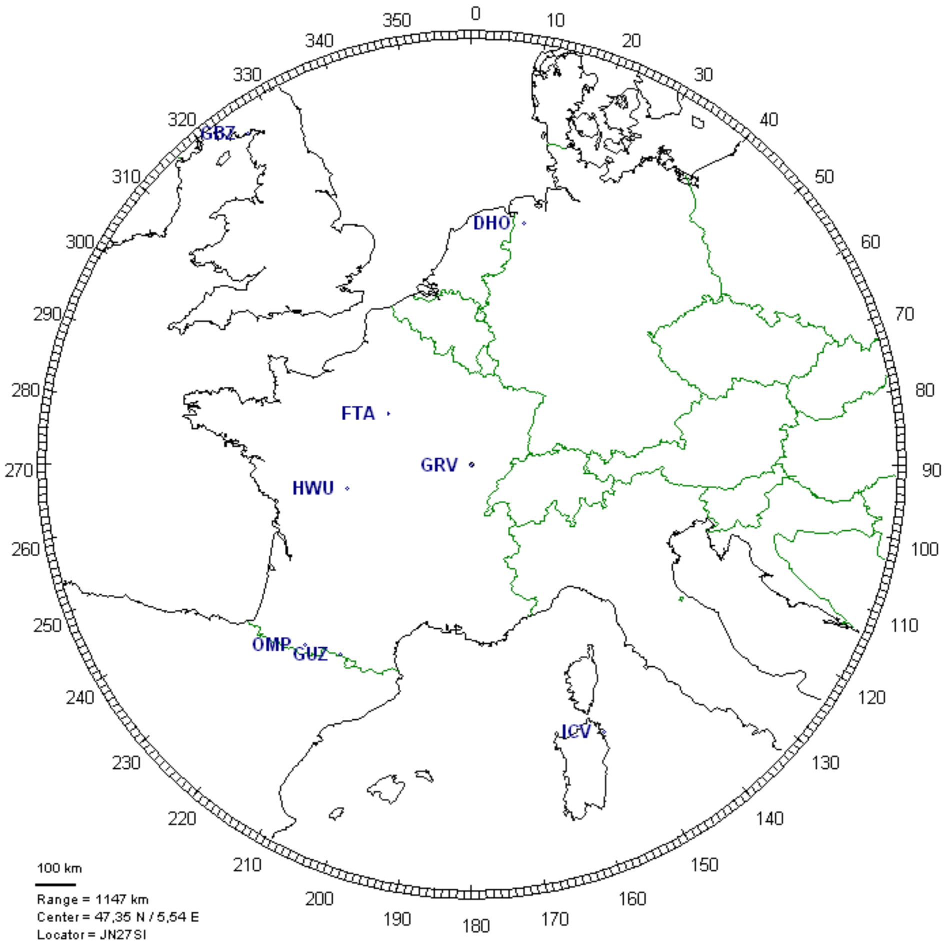
Micro-SIDs induced by meteors

Question: Can a SID (Sudden Ionospheric Disturbance) be triggered by a meteoroid entering the Earth atmosphere ?

Answer: Yes, it looks like it can.

To answer the question, the following experiment was conducted during the Geminids 2010 meteor shower. The observation location was at the Pic du Midi Observatory, France (2877m ASL).
Meteors were observed by recording their VHF forward scatter echoes, using a distant military radar (GRAVES radar located near Dijon) as targets illuminator.
The amplitude of several VLF transmitters (FTA and HWU in France, GBZ in UK, ICV in Sardinia Island, DHO38 in Germany) was simultaneously recorded with the VHF meteor echoes.

The map below shows the positions of the observation location (OMP), of the VHF radar (GRV) and of the VLF transmitters (GBZ, HWU, FTA, DHO38 and ICV).



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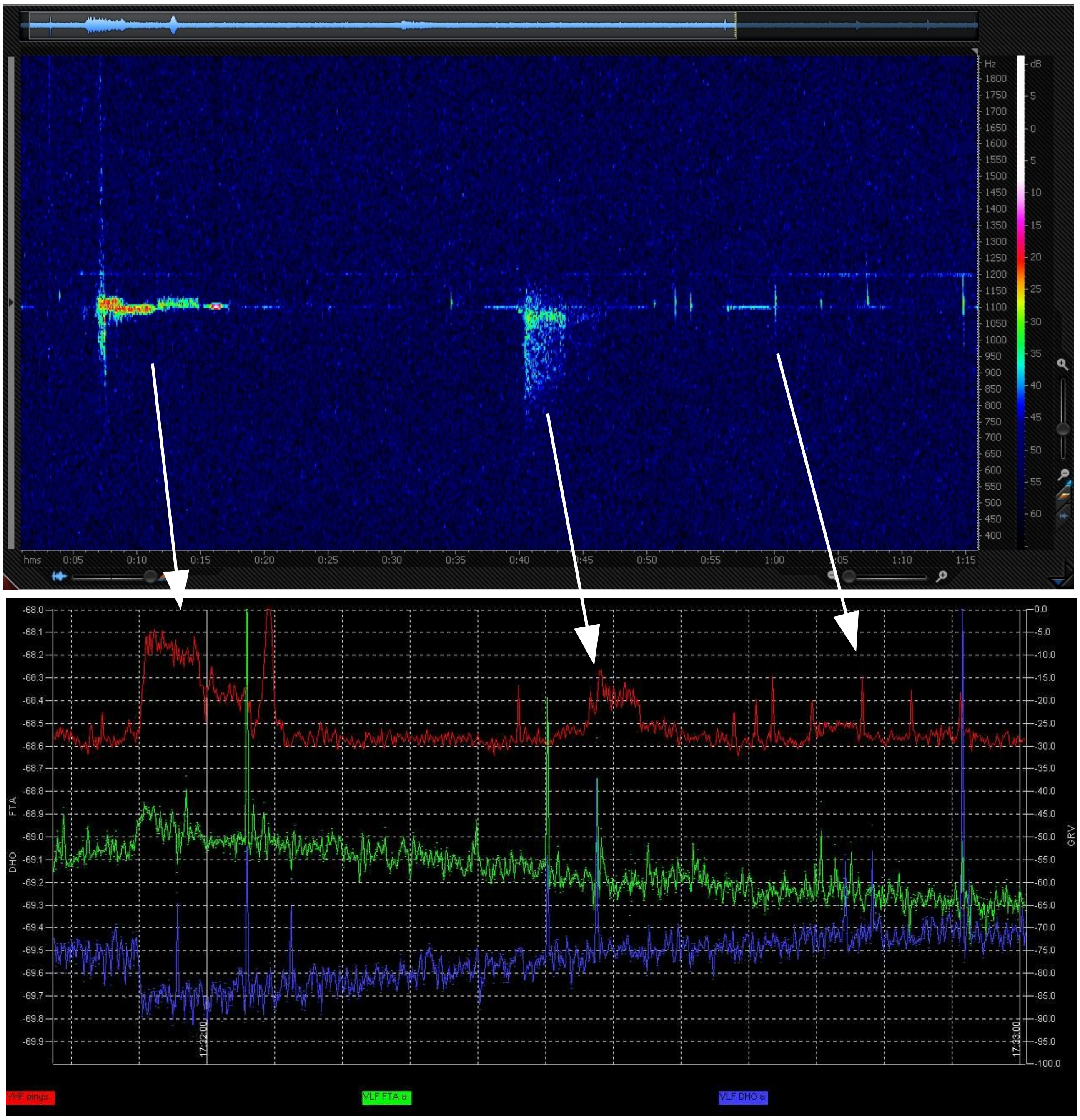
The first following picture is a spectral analysis of several successive meteor echoes: the vertical axis is the frequency analysis axis, and the horizontal one is the time.
The first large echo on the left consists in a vertical line representing the Doppler shift due to a fast moving meteor body, followed by an horizontal line representing a long echo on the over dense ionized trail created by the meteor.
The second large echo in the middle is a Doppler spread echo on a turbulent ionised meteor trail. The head echo of that second moving body is not detectable.
On the left of the picture, several under dense meteor echoes appear as quasi vertical thin lines.

The bottom picture is an analysis of the same signals in the same time slot, but represented in the amplitude domain. The vertical axis represents the amplitudes of the same meteor echoes and of the VLF signals. The red line shows the meteor echoes amplitudes, the green one is the amplitude of the french VLF transmitter (FTA) and the blue one is the amplitude of the German (DHO38) VLF transmitter.



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The three white arrows show for three meteor echoes the correspondence between the frequency domain and the amplitude domain same events.

On the picture above, it appears that the first over dense meteor is triggering a Sudden Ionospheric Disturbance (SID) on the propagation of the french and german VLF transmitters.
The shapes of these SIDs are similar to the ones triggered by the Sun UV and X-ray bursts: the sharp variation of the VLF signal amplitudes is followed by a long recovery time.

The SID shown above has opposite effects on the two VLF signal traces: the french FTA signal is increased by about + 0.15 dB, the german DHO38 signal amplitude is decreased by about 0.2 dB. This means that for FTA, the signal received at Pic du Midi observatory was the result of a constructive interference between the VLF ground wave and corresponding sky wave. For DHO38, the VLF signal received at Pic du Midi was the result of a destructive interference.
The recovery time for both signals is similar (about 1 mn long).
This SID had no visible effects on the other observed VLF signals (UK and Sardinia transmitters).

Only the first over dense echo induced a detectable SID, the second one and the following under dense meteors did not present any detectable effects.

This observation was performed during the peak of the Geminids 2010 meteor shower, at around 01:00 UTC. So there was no D layer during that night period. The meteors are supposed to create free electrons in the 80 to 100 km altitude range. This corresponds to the bottom of the E layer of the ionosphere.

The conclusion at the moment is that large over dense meteors are able to create enough free electrons in the lower part of the ionospheric E layer to modify the propagation of some VLF signals.

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