



Scientific Report

ESF Short Visit 9-13 April, 2012

Grant 4559

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1. Purpose of the visit

At present, Transient Luminous Events (TLEs) are routinely observed and recorded over central and southern Europe. The observations in Northern Europe are more difficult to establish because the bright northern summer makes the optical TLE recordings more challenging. The first photographs of TLEs near Finland were obtained in 2009 (see Mäkelä et al., 2010). Since then, a campaign called FinSprite has observed more than 20 TLEs. The goal of the campaign is to find the parent strokes of the TLEs from the data of the Nordic Lightning Information System (NORDLIS), which provides besides the temporal and spatial information of lightning strokes also the estimate for the peak current and polarity (Fig. 1).

TLEs emit also distinctive acoustic signatures (chirps) at infrasonic frequencies, which are measured in the northern Europe by the Swedish Institute of Space Physics (IRF). Acoustic sensors are situated in the central and northern Sweden, and one sensor is installed also in Sodankylä, Finland.

The motivation of the Short Visit was

- (i) to establish a cooperation between the Finnish Meteorological Institute (FMI) and IRF regarding lightning and TLE detection in northern Europe, and
- (ii) to make plans regarding a cooperative TLE detection network consisting of optical, acoustic, and electromagnetic measurements in Sweden and Finland. The results of this kind of combined network would provide unique information about the properties of TLEs at high latitudes.



Fig. 1: The area (red) inside which thunderstorm measurements with multiple instruments can be made. The symbols on the map are the sensor locations of the Nordic Lightning Information System (NORDLIS).

2. Description of the work carried out during the visit

The agenda of the Visit consisted of the following items:

- Introduction and background
 - Infrasonic measurements at IRF
 - Lightning location data usage in Scandinavia
- Motivation for the visit
 - Infrasonic chirps: general understanding of the phenomena
 - Transient Luminous Events (TLE) at high latitudes: general characteristics
 - Lightning location data and its applicability to TLE monitoring
 - FinSprite: usability in infrasonic observations?
 - Wintertime lightning in the Kvarken -area and its relation to thunderstorms in the

Crozet Islands

- Infrasonic observations vs. lightning location data – joined real time monitoring?
- Planning of a funding application
- Conclusions and Action Items
 - Planning of a Scientific Report or joined publication

During the first day, the Visitor (Mäkelä) gave an introductory presentation about his areas of interest and expertise regarding lightning detection and location. Also, Mäkelä gave a presentation about the motives of the Short Visit and the possible outcomes. Prof. Liszka gave an introduction to IRF and the available measurements and data sets there.

The following days consisted of data exchange and comparisons. Mäkelä combined the data sets of the FMI lightning location data and the IRF chirp data. The idea was to find correlations, i.e., the parent strokes which had caused the observed acoustic signatures. Because IRF have observations of chirps already since 1995, there is a good data set for a comparison. The FMI lightning location data set is available since 2002 with approximately 95% detection efficiency, it was decided to use for the comparison the period starting since 2002. The data set 2002-2012 consists of about 100 chirps.

The next topic was to isolate from the chirp data set those events which had occurred in the wintertime (January-March) over the Gulf of Bothnia. This specific research topic is especially interesting because there are no thunderstorms occurring in that area during the winter. Therefore the generation of the observed chirps must be either because of a non-thunderstorm mechanism, or that the observed acoustic signals have propagated to the area from somewhere else. The former explanation is highly questionable, because no other source than thunderstorm should give this kind of signals. However, the latter explanation is theoretically possible: the observed signal could have originated from a conjugate magnetic point on the other side of the Earth. For the Gulf of Bothnia, this conjugate point is located at the Southern Ocean near the Crozet Islands (Fig. 2). Unfortunately during the visit, no lightning location data was available from the Southern Ocean which could have been used to correlate with the observed chirps. However, Mäkelä will pursue to find lightning location data from that area.



Fig. 2: The conjugate points at the Southern Ocean (green) and at the Gulf of Bothnia (red).

The last visit day consisted of discussions regarding the plans of further scientific cooperation between IRF and FMI.

3. Description of the main results obtained

The main result of the visit was the exchange of knowledge between IRF and FMI. Before the visit, Mäkelä was not strongly familiar with acoustic thunderstorm observations, and on the other hand, IRF was not highly familiar with lightning location systems, especially those operating in the Scandinavia. The visit made possible to deepen the cooperation in the future,

and to make possible even more accurate and detailed observations of thunderstorms at high latitudes in Europe.

The secondary result was the discussion regarding a funding application, which Mäkelä will possibly send for the Academy of Finland in September 2012. The application consists of a funding for 3-5 years in the field of thunderstorm research, and especially the observations of Transient Luminous Events in Scandinavia.

4. Future collaboration with host institution

The future collaboration with the host institute includes a joined monitoring of thunderstorms in Scandinavia with several instruments or detection systems: acoustic measurements, lightning location data, and optical (video) measurements. The cooperation will start in summer 2012 and it will deepen afterwards. The main task for year 2012 is to set up the joined platform for the different observations.

5. Projected publications / articles resulting or to result from the grant

A joined publication will be made, if the theory of the conjugate chirp observations (discussed in Section 2) is proven to be true and enough evidence is found to back up the theory. For this, we need more observations from the thunderstorm occurrence at the Southern Ocean.

6. Other comments

The Visitor appreciates highly this Grant and the opportunity to make this visit to widen his knowledge regarding thunderstorm research. The Visitor is grateful to Prof. Liszka regarding the fruitful discussions.