

Initial Results of the Icelandic Lightning Location System

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Abstract

A lightning location system has been operational in Iceland since the summer of 1997. In this paper we describe the system and our initial results of winter-lightnings between 60°N and 67°N. Although the high latitude winter thunderstorms that we have observed give only a few lightnings per storm, we are observing more thunderstorms than previous estimates from human observations have indicated. Usually we observe only one stroke per lightning. Furthermore, the data indicate that positive-lightnings are more abundant than the negative ones. Our lightning current estimates are extremely high, or on the average close to 100 kA.



The DF station at the farm Syðri-Nesland by Lake Mývatn.



The DF station at Asgarður.



Working Group on Lightning Research in Iceland

The working group was established in 1996 by eight institutes to acquire and operate for an experimental period a lightning location system.

- Icelandic Meteorological Office
- National Power Company
- Iceland State Electricity
- Reykjavik Electricity
- Government Agency on Electrical Safety
- Iceland Telecom
- Icelandic Civil Aviation Administration
- Association of Icelandic Insurance Companies

The working group bought a used LLP system from Norway in 1996. The system has four sets of DF 80-02 connected by direct phone lines to a central APA 281 unit at the Icelandic Meteorological Office in Reykjavik.

Due to problems with the APA we set up a parallel system of PC's at the DF stations to record the data. Those PC's are connected by regular phone lines to a central PC at the Met-Office. The central PC retrieves data from the stations on a regular basis and synchronises the clocks.

The data is stored and processed automatically on UNIX computers at the Met-Office. This includes publishing the lightning data on the Web, both the raw data as well as locations, current estimates and maps.

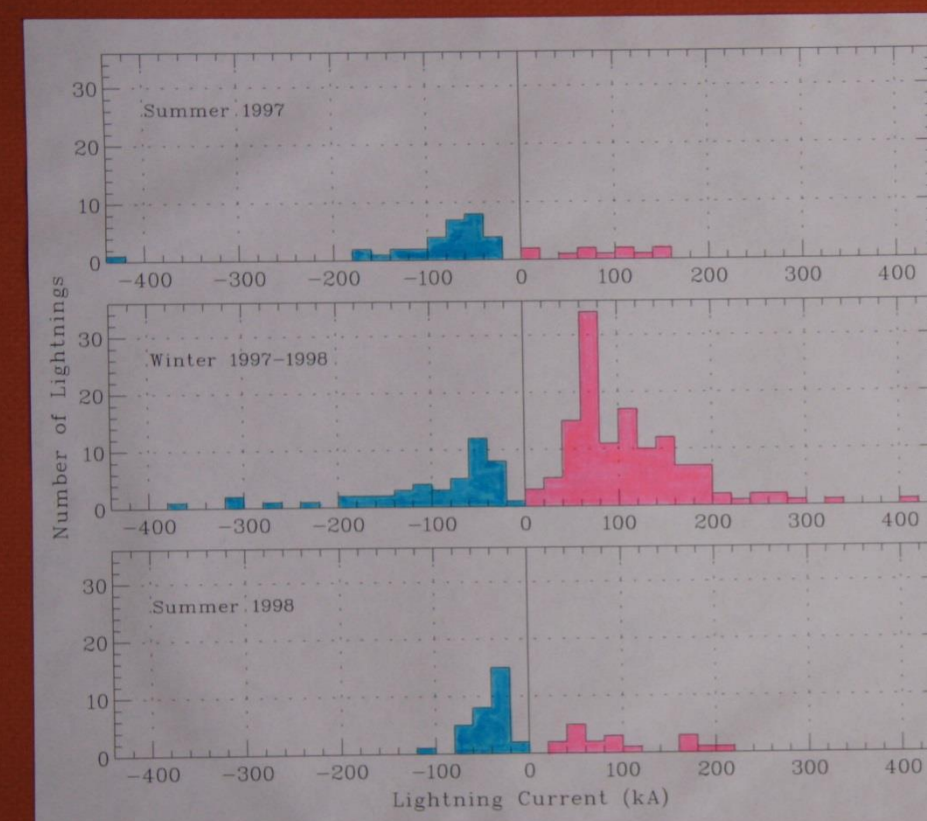
The Icelandic Lightning Location System became operational in the summer of 1997.

Located Lightnings

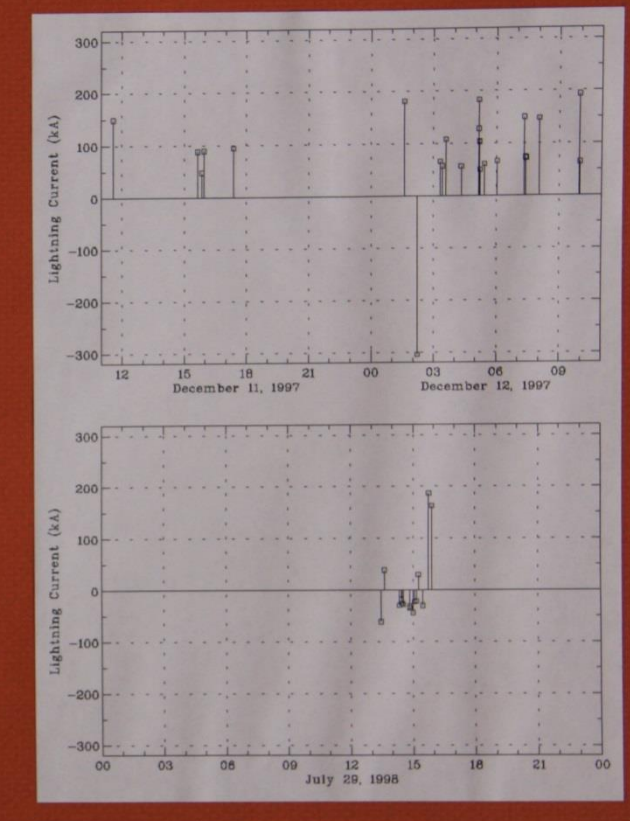
To locate the lightnings we use a non-linear least squares inversion technique to minimise the angular differences between observed and calculated directions for all the stations. To calculate the directions to a lightning we assume a spherical Earth and use spherical trigonometry.

The figure shows by month the number of lightnings (red) and number of days with lightnings (blue) in our first year of operation. The dashed lines show number of events detected synchronously by at least two DF-stations. Some of these events are believed to be from distant lightnings. The solid columns show the number of located lightnings in an area around Iceland (latitude between 60°N and 70°N, longitude between 0° and 40°W).

This figure shows a distinct separation between summer- and winter-thunderstorms at these high latitudes.



These histograms show by season, the current (kA) of our lightning data. It appears that the winter-storms are dominated by positive-polarities, whereas in the summer we record more negative-polarity lightnings. These initial data also indicate that the positive-polarity lightnings have quite high currents, on average close to a 100 kA.



An example of a winter-storm and a summer-storm, where both graphs show 24 hours of data. On December 11-12, 1997 we recorded 24 lightnings over a period of 22½ hours. Of these, 23 had positive polarity and one negative. By contrast, on July 29, 1998 we recorded 15 lightnings in 2½ hours. Of these 11 had negative polarity and four positive. It is worth noting that the negative polarity lightnings of the summer-storm have a more moderate current strength.

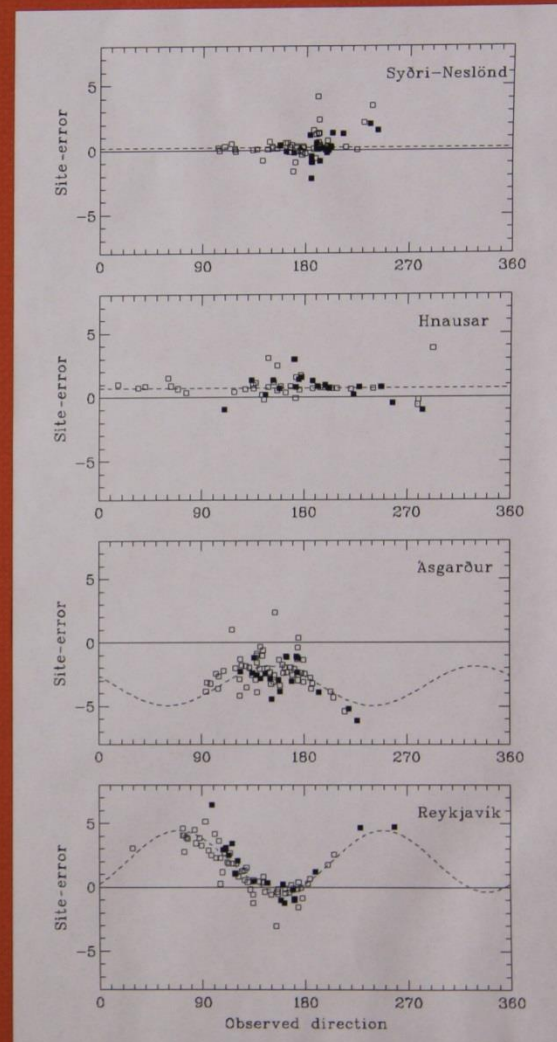
Site-Error Corrections

The site-error analysis was based on lightning locations from June 1997 to April 1998, where three or four stations participated in locating a lightning. A total of 19 lightnings were observed by all four stations, whereas 71 lightnings were located by three stations. These 90 lightnings were used to constrain our estimates of site-errors.

For a located lightning we calculated the difference between the measured and calculated direction for each DF. For two of the stations we only fitted a constant shift to the directional anomalies, and the other two, we fitted a constant shift and a two-cycle sinusoid to the anomalies versus observed direction. The least-squares fit was our choice for a site-error correction. The choice of a particular site-error function will slightly affect the lightning locations. Therefore, we used our selected site-error correction to get better locations for the selected 90 lightnings. By an iterative process we adjusted the site-error functions and the locations until a stable solution was found. We used 10 iterations to find this solution.

Unfortunately, the locations are not ideally distributed, as most of them are South of Iceland, outside the system. Therefore, our site-error values can only be viewed as crude first estimates, subject to change as we gather more data.

Site-error corrections (in degrees) of this study for individual stations, shown by the dashed curves. Filled/open squares represent site-error estimates for individual stations from lightnings observed by four/three stations. This figure shows that the differences are quite small. In fact, after the correction, the standard deviation is 1.0°, and the chosen site-error functions have decreased the variance in the observed anomalies by 70%.



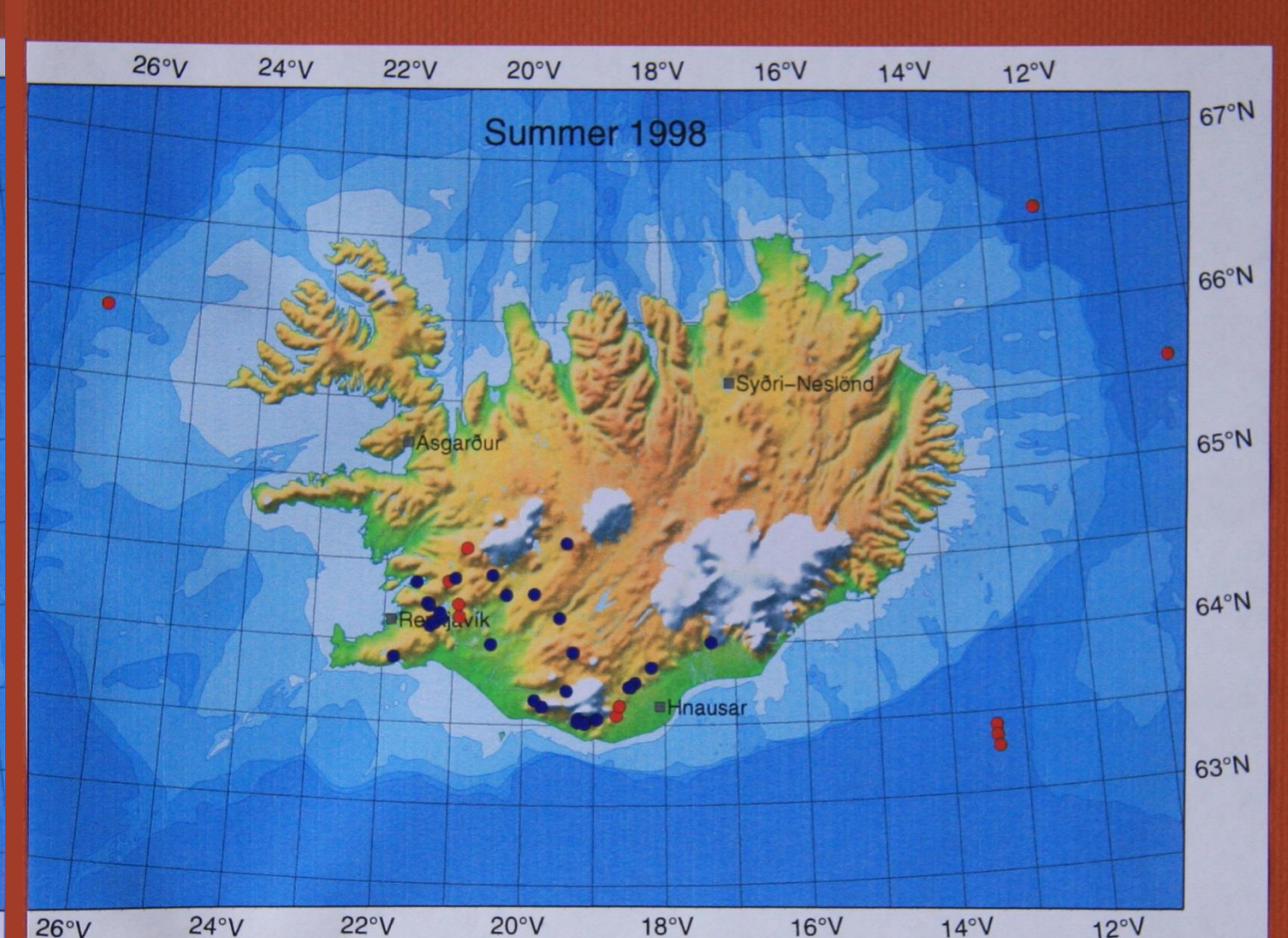
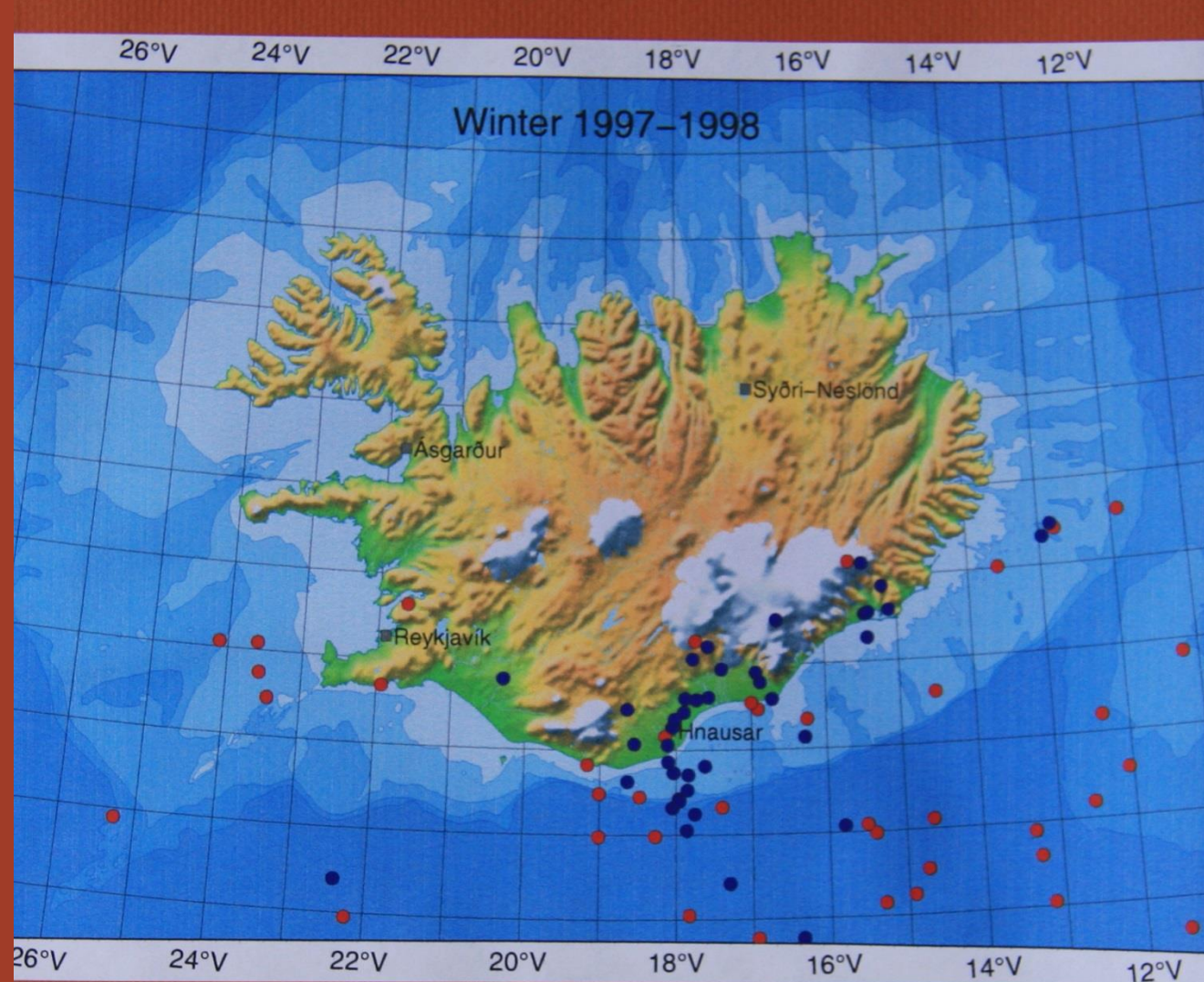
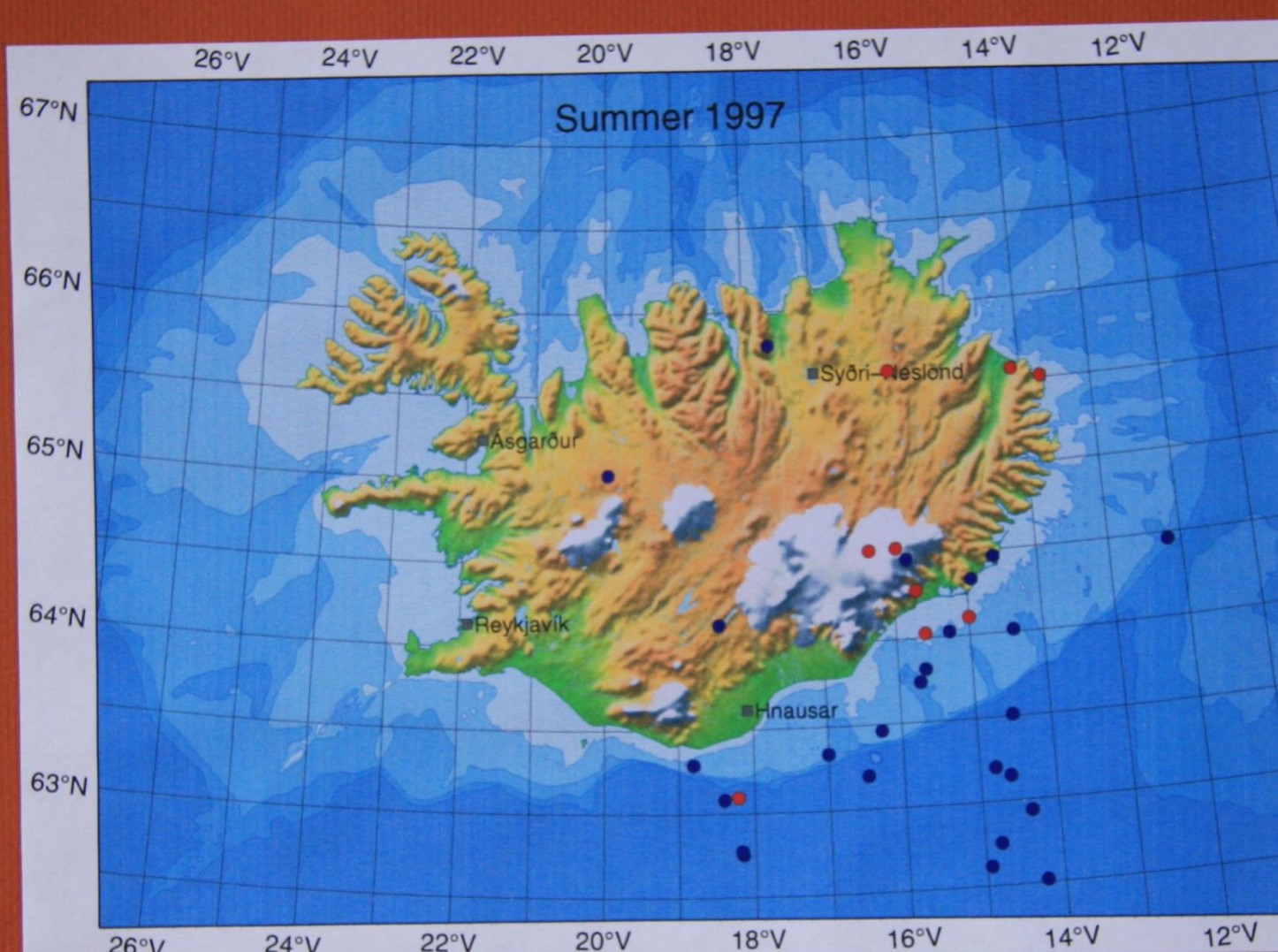
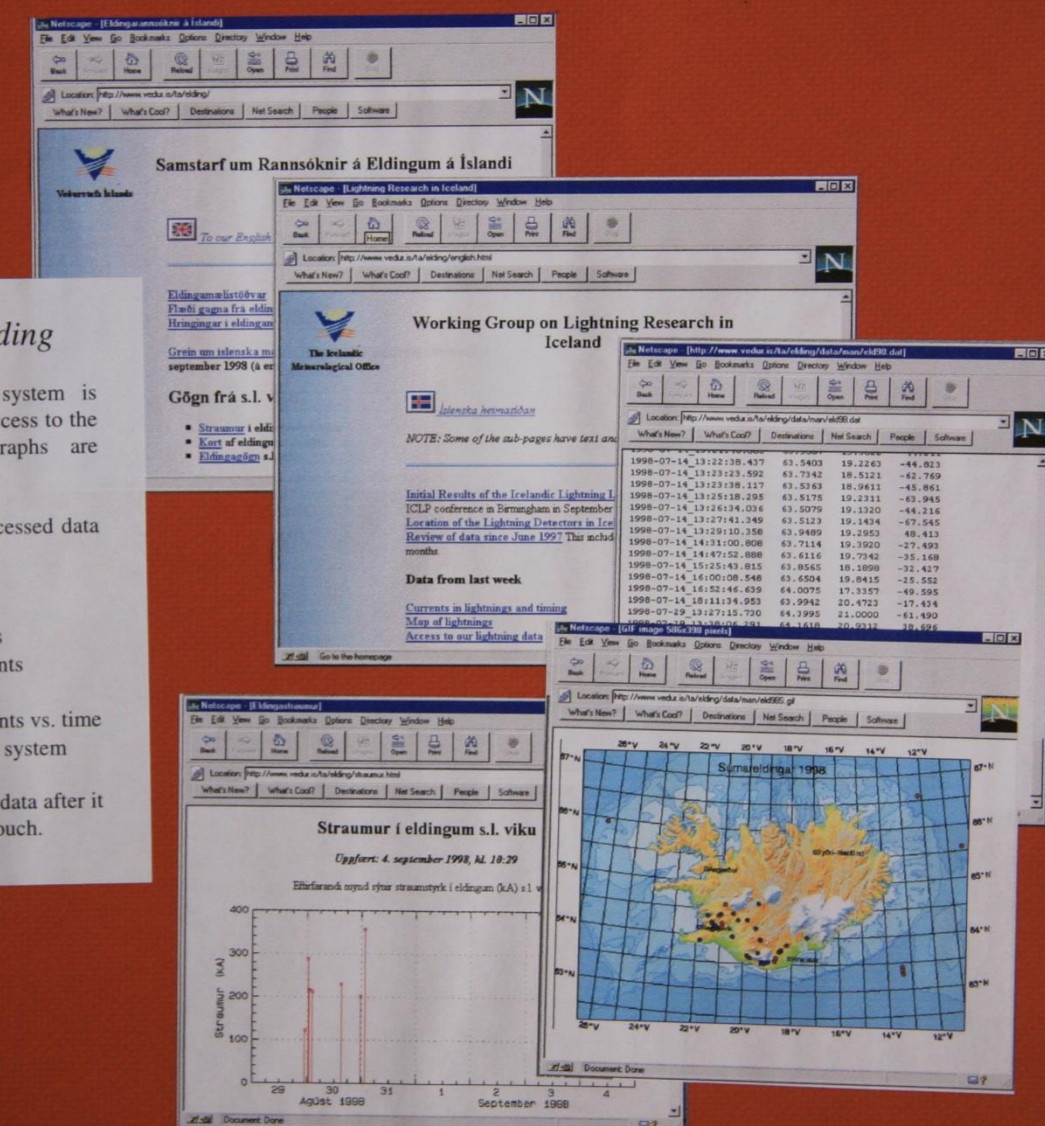
<http://www.vedur.is/ta/elding>

The lightning data of the Icelandic system is available on the World Wide Web, and access to the pages is open. The data and graphs are automatically updated every 3 hours.

The user has access to automatically processed data of the last week:

- Raw data from the DF-stations
- Analysis of clock drift at the stations
- Lightning locations, times and currents
- Map of lightning locations
- Graphs of signal strengths and currents vs. time
- Status and statistics of the recording system

Furthermore, the user has access to older data after it has been analysed further with a human touch.



Lightning locations of the Icelandic system in its first year of operation. Blue dots represent negative lightnings and red positive ones.