by Andres Thorarinsson and Gunnar Sigurdsson

FORCE OF NATURE

The infrastructure of the Icelandic Hydrological Service was in the right place at the right time to record flood data in the wake of the massive eruption of Eyjafjallajökull

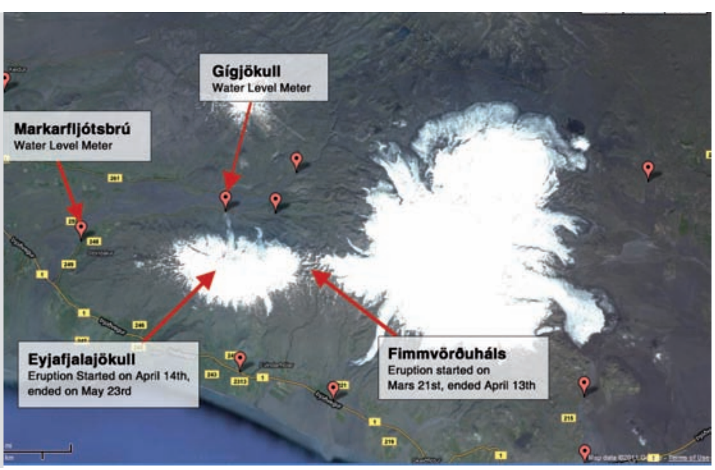
Bridge at Markarfljót on May 25, 2010, looking toward Eyjafjallajökull. Even four weeks after the end of the eruption in Eyjafjallajökull there is still ash in the air, resulting in limited visibility and causing breathing problems for some people

If there is any one person who started the modern day Hydrological Service in Iceland, it is Sigurjón Rist. Born in 1917, he began his career with the Office of Electrical Infrastructure in 1947, and studied hydrological science in Sweden, Norway, and the USA. He was the head of the Hydrological Service in Iceland for 40 years until his retirement in 1987, and he died in 1994.

One of Rist's achievements was to build almost single-handedly a network of water level recording meters in all of the main rivers in Iceland, many in the highlands. In those days, recording meters were paper chart recorders with movement driven by long-lasting springs. Rist visited the level metering stations at regular intervals to re-wind the springs and renew the paper chart. There are countless stories of rough journeys and river crossings during winter blizzards that had to be overcome when maintaining the important metering network to ensure there was a continuous set of time series charts for level and flow measurements.

In 1990 new techniques emerged that totally changed the way of level and flow metering in Iceland. The use of computers, data loggers, and low-cost communications was welcomed by the Hydrological Service, which quickly adopted the new way of metering and in 1998 started a real-time monitoring network of hydrometric stations all equipped with cellular modems. Of the 140 stations now in the network, 12 are classified as geochemical warning stations for floods caused by subglacial eruptions. The geochemical warning stations are situated on glacial rivers draining the Mýrdalsjökull and Vatnajökull glaciers in southern and northern Iceland.

Since the original system was planned, the number of real-time stations with various duties has doubled. They are all based on the robust Campbell Scientific range of data loggers, and presentation of the data is handled by the versatile Vista Data Vision web-based applications. The Hydrological Service, now part of the Icelandic Meteorological Office, has open access to data from over 100 of its real-time measuring stations.



This Google Map display of southern Iceland shows the location of the two volcanic eruption areas as well as the location of all measurement stations in the area. The measurement stations at Markarfljótsbrú and Gígjökull are marked

Geo-activity

What makes Iceland such a special and unique place from a hydrological point of view is its geothermal activity. It is volcanically one of the most dynamic parts of the earth's surface.

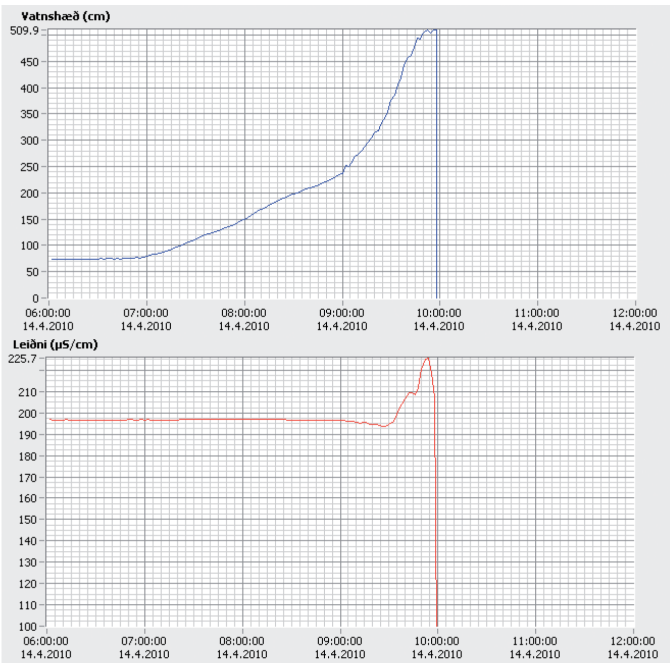
On average there is a volcanic eruption every five years. Considering that more than 11% of Iceland's surface is covered with glaciers, it is no surprise that mega-floods are not uncommon, as a result of sub-glacial volcanic activity.

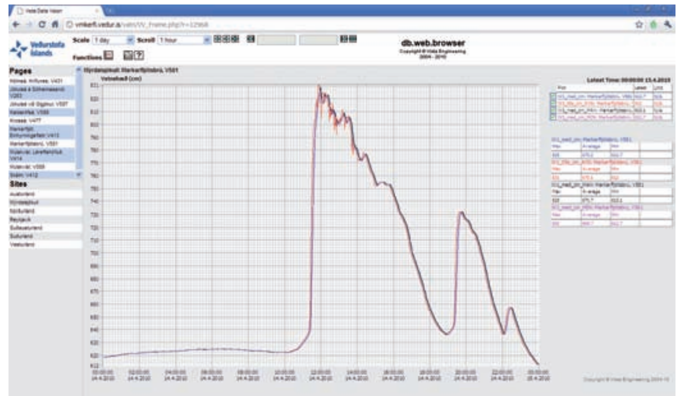
A catastrophic flood occurred in river Skeidará, southern Iceland in 1996. At its peak it reached 55,000m^3/sec flow, which is more than the combined average discharge of rivers Nile, Yukon, Volga, Mekong, Rhine, and Mississippi. This flood triggered the building of the real-time monitoring and alarming network, with the

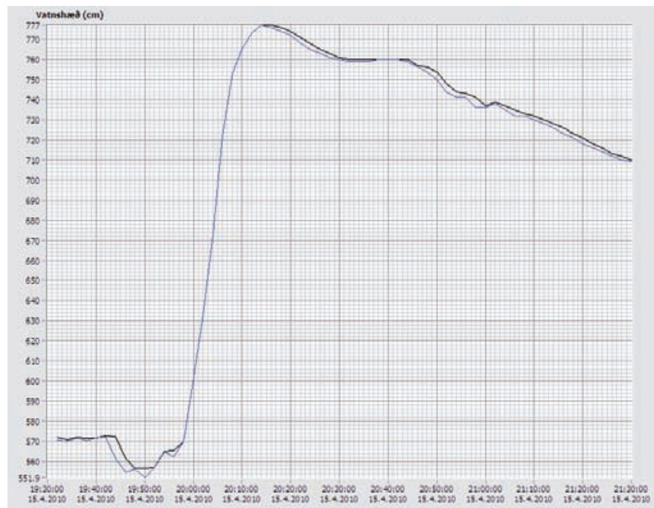
Below: Level and conductivity measurements from the outlet of Gígjökull, showing the first flood wave on the morning of April 14, 2010

Right: Level measurements from the Markarfljót bridge, showing the first wave of the flood

Bottom right: A second wave hit the bridge of Markarfljót at 20:00 on April 15, as seen on this graph of water level







intention of initiating alarms if a flood caused by volcanic activity occurs. The stations classified as geochemical warning stations are equipped with electric conductivity and temperature meters. Alarm conditions are valid when either the water level or the electrical conductivity of the river water reaches alarm values defined by the system operators. This network has proved to work well.

Last year there was a volcanic eruption from Mt Fimmvörduháls, which started just before midnight on March 20, 2010 and ended on April 12. Two days later, on April 14, 2010 a volcanic eruption in the glacier Eyjafjallajökull, which is only a few kilometers to the west, began. This was the fourth eruption in Eyjafjallajökull and around the 155th eruption across Iceland since the country was settled in the year 870AD. The latest eruption lasted for five weeks. There was a tremendous amount of volcanic ash pumped into the air, which caused a massive disturbance to air traffic over the North Atlantic and Europe. However, the data collected from the rivers around the area is most interesting.

Volcanic data collection

It is important to look at three samples of data: two from the bridge of Markarfljót and one from a measurement point at Gígjökull, north of the volcano (see overview map).

On April 14, 2010, a few hours after the start of the eruption in Eyjafjallajökull, a massive flood broke loose as a result of volcanic activity under the glacier. This flood went northward (see graphs, above left). On the north side of Eyjafjallajökull, at the main outlet of the river from Gígjökull, there was a water level meter equipped with conductivity meter. It happened to be perfectly located and it recorded the first wave of the flood.

The flood started at 07:00 and developed quickly, rising more than 4m in this open channel in just three hours. Just before 10:00, the instruments were lost in the stream and a few minutes later the data logger itself was lost as well. This flood progressed westward over an open area and hit the bridge at Markarfljót 90 minutes later. The distance is 15km.

The graph top right shows the abrupt increase in water level at 11:30 on April 14, when the flood water struck the bridge on former Highway 1 crossing the river Markarfljót some 12 hours after the eruption started and 90 minutes after the flood peaked at Gígjökull outlet. As shown, the water level rose by 200cm in only 30 minutes. The peak discharge was estimated as 2,750m^3/sec.

A second flood burst from Eyjafjallajökull later on April 15 (see graph bottom right) and hit Markarfljótsbrú just before 20:00. It was smaller but more intense as the water level rise was 1.6m in only 10 minutes.

The infrastructure of the Icelandic Meteorological Office proved to be solid and did what was expected. It recorded water level, conductivity, and turbidity at numerous measuring stations in the area, data that will be used by scientists to better understand the mechanisms of volcanic eruptions. ∎

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See data from the Icelandic Meteorological Office's real-time measuring stations at http://vmkerfi.vedur.is/vatn/index.php (username/password: vatnshaed/rennsli)