SUMMARY OF RESULTS FROM OVER 10 YEARS OF CONTINUOUS GPS OBSERVATIONS IN ICELAND

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Abstract

Iceland is located on the divergent plate boundary between the Eurasian and North American plates with frequent eruptions and drastic changes in ice-load due to climate changes, making it an excellent place for geodetic studies. Currently around 70 GPS stations in Iceland are continuously logging data. The Icelandic Meteorological Office (IMO) operates 58 of these stations along with many different collaborators. Of these, around 50 stations transmit data automatically at least once per day and an effort is being made to bring more sites on-line. During the past three years the sites have tripled in number. The primary purpose of the network is monitoring and research of crustal deformation, but the data have been used for a variety of different applications including GPS-meteorology and reference for high-resolution mapping.

Continuous GPS measurements in Iceland started in 1995 when the German institution "Bundesamt für Kartographie und Geodäsie" (BKG) installed a site in Reykjavik. The site is a part of the IGS (International GNSS Service) network and is among other things used for calculation of satellite orbits. BKG installed a station in south-east Iceland in 1997 (HOFN). Following intense seismic activity during 1994 – 1998 in the Hengill area in south-west Iceland, four sites were installed in the area in collaboration of IMO, the University of Iceland, and the Nordic Volcanological Centre (now a part of the Institute of the Earth Sciences at the University of Iceland) marking the initiation of the ISGPS network. The first site (VOGS) started collecting data on March 18, 1999. In 2006, when the network counted 20 sites, the Earth Science Institute of the University of Iceland and IMO received a grant to install a number of new sites in close cooperation with research groups outside of Iceland.

Plate spreading of about 2 cm per year usually dominates the horizontal site motion. The deformation is taken up on a 50-100 km wide zone following the plate boundary. Because of warming climate, the glaciers in Iceland are thinning and retreating, resulting in a widespread uplift with maximum uplift rates exceeding 2 cm per year. The strength of continuous GPS measurements lies in the time resolution and continuity of the observations. Annual load changes of the glaciers cause a sinusoidal signal of 2 cm peak to peak in the vertical component at the stations closest to the glaciers as an elastic response. The long-term uplift due to the retreat of the ice caps is controlled by viscoelastic, as well as elastic, response of the crust. The CGPS network captured co-seismic deformation due to two earthquake doublets in the south Iceland seismic zone, the first in 2000 and the second in 2008. In 2000, the deformation from each of the two M_w=6.5 earthquakes was well resolved as there were 3 days between the earthquakes. In 2008, the two M_w=6.1 earthquakes were separated only by 2-3 seconds. Normally the instruments collect data every 15 seconds, but a few sites collect data at 1 s intervals. These high-rate sites gave direct observations of displacement coda of seismic waves from the 2008 earthquakes for the first time in Iceland.

CGPS observations play an important part in research and monitoring of magma movements. During 2007 and 2008 a magma intrusion took place at a depth of 12 to 20 km in an area north of Vatnajökull ice cap. The deformation was observed at nearby CGPS sites, which were originally installed to monitor deformation due to load changes around one of the largest water reservoir in Iceland. Modelling of the surface deformation along with seismic observations made it possible to estimate the amount of magma intruded and monitor the time evolution of the intrusive event. Two localized uplift events have been ongoing in 2009; at Eyjafjallajökull in south-Iceland, and at Kleifarvatn on the Reykjanes peninsula.

Continuous GPS measurements along with seismic observations and other geodetic techniques have proven important for monitoring and research of crustal deformation processes in Iceland. Although the network is dense in many areas that have been active in the past decade, some areas deserve closer attention.