Design and use of Online Geo-Forms for Public Observations of Natural Hazards in Iceland

GI Norden and LÍSA conference, 12 October 2017

Matthew J. Roberts

Group leader: Water and Glaciers

Icelandic Meteorological Office, Reykjavík

E-mail: matthew@vedur.is
IMO web-site: http://www.vedur.is
Presentation co-authors
A collaboration between IMO and Geological Survey of Denmark and Greenland (GEUS)

- Bogi Brynjar Björnsson, IMO
- Hans Jørgen Henriksen, GEUS
- Peter van der Keur, GEUS
- Davíð Egilson, IMO
- Sara Barsotti, IMO
- Sigrún Karlsdóttir, IMO
Purpose of today’s presentation

- At the Icelandic Meteorological Office (IMO), GIS-based registration pages have been developed to allow the public to send photographs and descriptions of an evolving hazard.
- The design and use of these pages will be outlined, with a focus on floods and volcanic eruptions.
Motivation and rationale

- Iceland is affected by many types of natural hazards, ranging from severe weather to volcanic eruptions (see next slide).
- Monitoring data and forecasting results provide the basis for most public warnings.
- However, **warning accuracy** is often difficult to assess, as the impact of the ongoing hazard may not be apparent immediately.
- For weather-related floods, the lag between rainfall and river-response could span several hours, hence there are opportunities to gather impact-related observations.
Eruptions in Iceland since 1991
In recent decades, an eruption has occurred every 3 – 4 years

1. Hekla 1991
2. Gjálp 1996
4. Hekla 2000
5. Grímsvötn 2004
6. Fimmvörðuháls 2010
7. Eyjafjallajökull 2010
8. Grímsvötn 2011
Background I: What constitutes an early warning service?

- Early warning and monitoring systems (EWMS) are defined as a set of “capacities needed to generate and disseminate timely and meaningful information to enable individuals, communities and organisations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss” (United Nations Office for Disaster Reduction, 2009).
Background II: What is a geo-form?
https://www.arcgis.com/apps/GeoForm/index.html

• An ESRI geo-form is a configurable template for form-based data input and visualisation.

• Users enter data via an on-line form, taking advantage of editable feature services such as automatic geo-location.

• The platform is straightforward to set-up and publicise.

• Geo-forms are particularly useful for collecting data from a large audience of non-technical users.

Source: http://gisinc.com
Why do observations from the public matter? Verification of impact!

Public observations can be incorporated into existing monitoring networks and forecasting systems so that:

i. more timely and accurate warnings can be issued;

ii. more comprehensive compilations of damage impacts are received; and

iii. hazard awareness and perception of risk are improved.
Improving resilience to natural hazards via the NORDRESS project

• The R&D work presented here is part of the ongoing NORDRESS project (2015–2019).
• The project is funded by the Social Security Programme of NordForsk, and the overall goal is improved understanding of societal resilience to natural hazards.
• We contribute to community resilience by involving the public in the reporting of an evolving natural hazard, such as a flood.
• URL: http://nordress.hi.is/
Causes of flooding in Iceland – a brief overview

River flooding

- Meteorological floods (overtopping of river banks)
  - Intense rainfall / snow-melt (exacerbated by frozen ground)
- Flash flooding (mountain gullies; ephemeral watercourses)
  - Steep coastal slopes; localised, intense rainfall; rapid run-off
- Ice-jam flooding
  - Freeze-up jams; frazil ice; break-up of ice-jams by upstream flooding
- Glacial outburst floods (jökulhlaup)
  - Ice-dammed lakes
  - Volcanic eruptions

Flash flooding in Siglufjörður, 28 Aug 2015
Credit: Sveinn Þorsteinsson, via http://hedinsfjordur.is/
Automated hydrological observations: dense network but unavoidable gaps

Hydrological data are relayed to IMO in Reykjavík.

Around 20 stations form the backbone of the national flood-monitoring network, with data sent to IMO within ~5 minutes of a measurement being made.
Example of a recent jökulhlaup from subglacial lake Grímsvötn. The affected river was Gígjukvísl, which originates from Skeiðarárjökull (Q_{max} \approx 680 \text{ m}^{3} \text{ s}^{-1})

http://vmkerfi.vedur.is
Flood warning opportunities in relation to river-length: Short river, often little pre-warning

- For short, glacial rivers such as Múlakvísl, the time-frame for issuing a warning is <40 minutes!
- 13.1 km river length and propagation velocity of 5 m s\(^{-1}\) = 44-minute travel-time.
Flood forecasting lead-time

Notice how the approach is strictly one-way – how are flood forecasts revised in light of impact reports?

Source: https://www.wmo.int
IMO’s web-site: Stream-flow results updated regularly

IMO’s hydrological monitoring page during autumn rainfall, 08-09-2015
Conceptual view of scalable flood-monitoring and forecast system

Scalable, yes, but how can impacts be taken into consideration?

Source: http://www.wesenseit.eu/
Flood forecasting with in-built verification of river changes (NORDRESS)

Danish case-study from the NORDRESS project (Henriksen et al., submitted)

Use of gauging data and visual observations for more accurate discharge estimates
Participatory-based approach to early warnings – NORDRESS
Components of a geo-form registration page

Internet

Feature Service

Feature template

Web Map

3

GIS Specialist

4

Geo-form

Public

5

Web Server

Intranet

1

SHP

2

Components of a geo-form registration page
Design steps to launching a geo-form for crowd-based data collection

i. Create template shapefile with attributes to collect.

ii. Publish shapefile as a hosted feature service on ArcGIS Online.

iii. Create a web-map and add the hosted feature-service on ArcGIS Online.

iv. Deploy the geo-form Javascript code on a web-server and make it accessible to Internet.

v. Link web-map to the geo-form via map ID.

For specific requirements and configurable options, see: https://www.arcgis.com/apps/GeoForm/index.html and https://github.com/Esri/geoform-template-js
Geo-form used during the 2014–2015 eruption at Holuhraun, Iceland

Used by first-responders and the public in various locations throughout the country to record their assessment of SO$_2$ concentration.

1. Skráið upplýsingar

Fannst brennisteinslykt? (Nauðsynlegt að skrái)
- Nei
- Já

Veiljó já eða nei aður en haldið er lengra.

Dagsetning og tími? (Nauðsynlegt að skrái)
10/11/2017 1:25 PM

Tilgreinð hvenær brennisteinslykti fannst eða fannst ekki (ef svarið var nei hér að ofan), eins nákvæmlega og mögulegt er (tilgreinð a.m.k. dagsetningu).

Fannstu fyrir einkennum í hálsi?
- Nei
- Já

See: http://www.vedur.is/skraning_brennisteinsmengun/

The pages are designed to be used in real-time or retrospectively; this greatly expands the potential of crowd-sourced observations.
Geo-form used during the 2014–2015 eruption at Holuhraun

Hundreds of reports received during the eruption
Geo-form data were used to assess impact of $SO_2$ emissions on air quality

Web-based interface for viewing measurements over time
Experimental online geo-form at IMO for registering flooding
http://vatnsflod.vedur.is

Web-based map (example below)

Feature layer for supporting map-based locations of flooding (see next slide)

Tilkynning um vatnsflóð
Vinsamlegast tilkynnið um hvers konar vatnsflóð sem vart verður við því að gefa upp upplýsingar sem öskjað er eftir hér að neðan. Ljósmyndir eða önnur gögn sem sýna aðburðin eru vel þegnar.

Athugið! Veðurstofa Íslands áskilur sér rétt til að birta skráningar á vef stofnunarinnar án takmarkana. Þátttaka jafngildir samþykki fyrir sliktu birtingu. Vinsamlegast beinið spurningum og/eða ábendingum til fyrrispurmir@vedur.is, kærar þakkr.
The ‘vatnsflod’ feature-service
The interface includes various customisable attributes, as well as a record of received observations.

URL: http://vatnsflod.vedur.is
Mobile version of the page allows for easy input of observations and automatic geo-location

URL: http://vatnsflod.vedur.is
A simple case-study: Freeze-up ice-jam on Jökulsá á Fjöllum

Local river-level (stage) in cm

Disturbances in measurements

01 Dec 2014 – 01 Apr 2015

Photographer: Njáll Fannar Reynisson, 20 January 2015
On-site observations help to put remote measurements into context

- People can provide valuable on-site observations...

...especially in remote, highland regions where automated measurements are difficult.

Photographer: Bragi Benediktsson, 18 January 2015
Geo-form services have a role in the disaster-risk-recovery cycle

Participatory early warning systems take advantage of people-centred observations via a two-way exchange of warnings and local feedback, helping to:

i. improve risk awareness within the affected region;

ii. increase the technical capacity to monitor, model and forecast with higher accuracy;

iii. improve the content and timeliness of public warning, thereby helping to maintain trust; and

iv. heighten response capabilities, both during the hazard itself and in the long-term recovery between recurring events.
On-line GIS services can help communities at risk via awareness and education

ALNAP: http://www.alnap.org/resource/5839
Next steps at IMO and within the NORDRESS project

i. Further improvement of an ‘operational dashboard’ for viewing incoming observations from the public.

ii. Visual improvements and cross-platform access issues.

iii. Automatic display of preferred language, based on browser locale setting. (*This improvement would allow foreign tourists to use IMO’s registration forms.*)

iv. Automatic alerting of newly uploaded photographs via a monitoring script. (*This would make IMO monitoring staff aware of new imagery within minutes of an upload.*)

The paper explores links between risk knowledge, monitoring and warning services, public communication, and response capabilities.

GIS-based examples from Denmark, Finland, and Iceland.
Conclusions

i. On-line GIS services are clearly a viable and effective way of gathering non-technical information from the public.

ii. Public participation in key stages of the warning process can help to validate forecasts and provide early recognition of potentially harmful changes.

iii. Public reports of unusual or damaging natural events not only provide scientists and first-responders with valuable local information and context, they also help to increase public awareness of natural hazards.