Automatic Estimation of Volcanic Plume Height using real-time Radar Data

Þórður Arason

Veðurstofa Íslands

Icelandic Meteorological Office, Reykjavík, Iceland

Fixed Position C-band Radars

Icelandic Met Office

Fljótsdalsheiði E-Iceland C-band radar.
Photo Geirfinnur S. Sigurðsson 8 October 2012

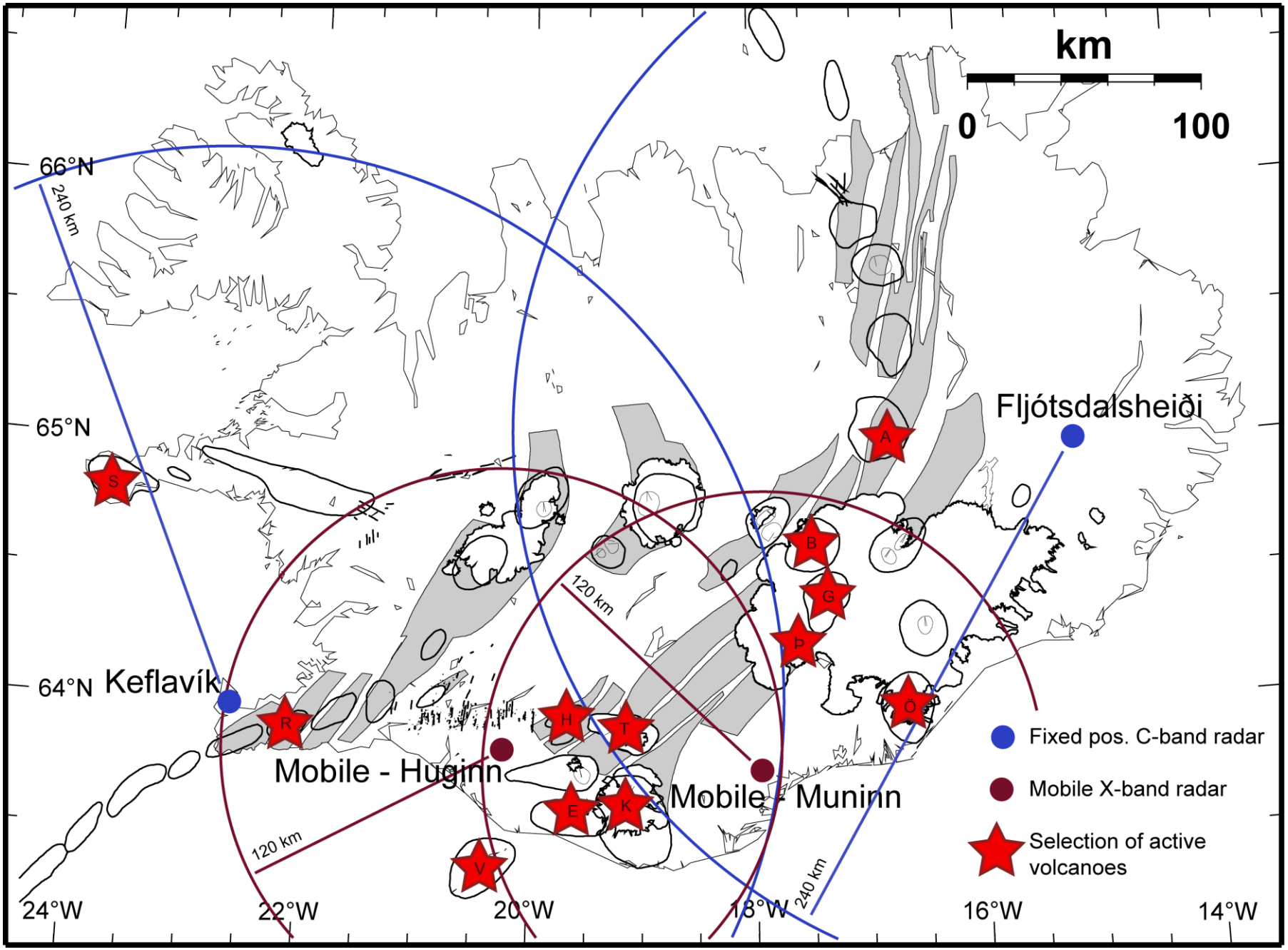
Keflavík SW-Iceland C-band radar.
Photo Þórður Arason 9 August 2011

Two Mobile X-band Radars

Icelandic Met Office

Specially adapted truck to take mobile radar off road.
Photo Geirfinnur S. Sigurðsson 25 September 2012

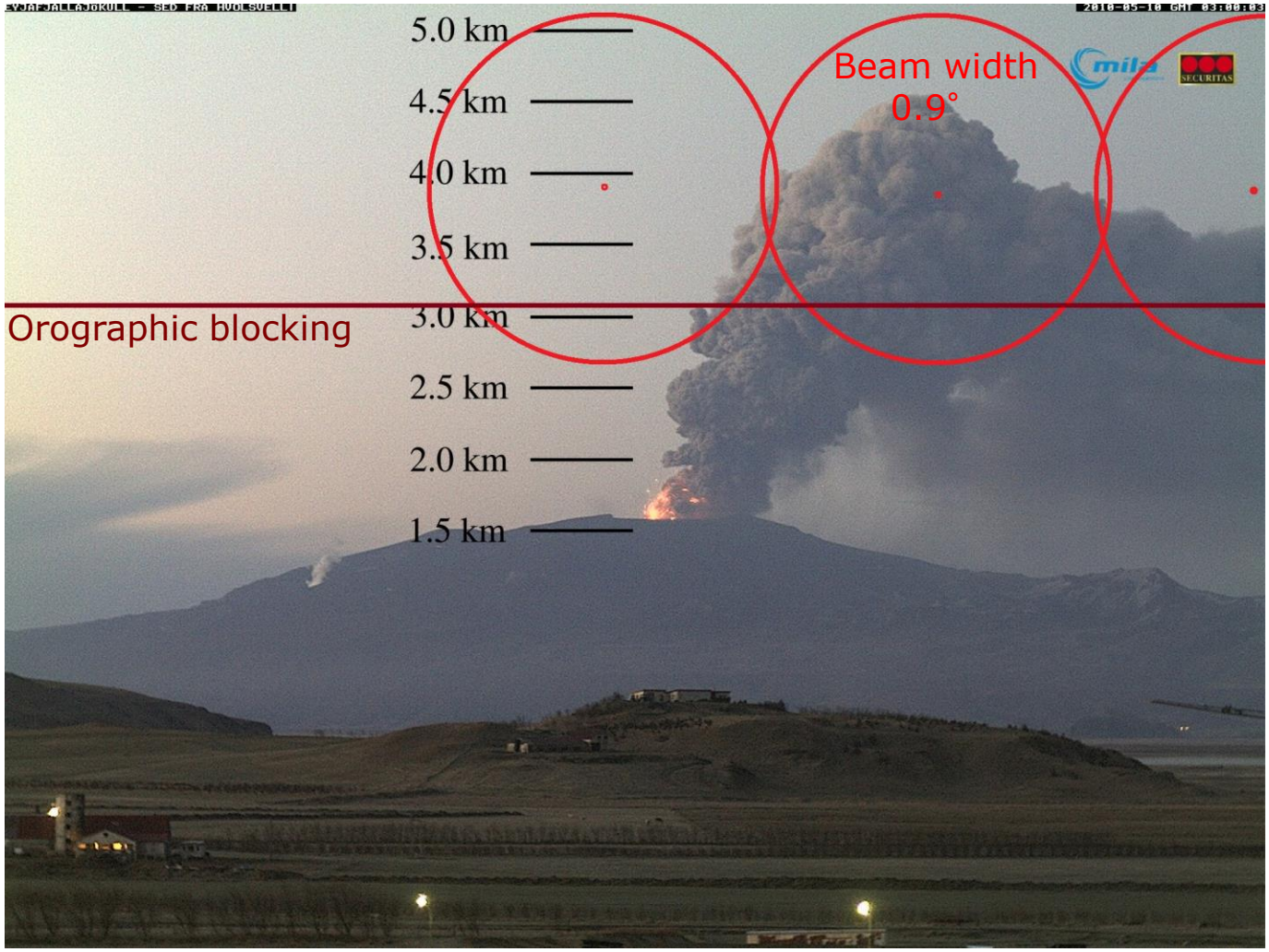
Mobile radar installed with clear view over Bárðarbunga before the eruption.
Photo Þorgils Ingvarsson 22 August 2014


km
0
100
66°N
65°N
64°N
24°W
22°W
20°W
18°W
16°W
14°W
240 km
120 km
120 km
240 km
Keflavík
Mobile - Huginn
Mobile - Muninn
Fljótsdalsheiði
S
R
H
T
E
K
V
A
B
G
Þ
Ö
Fixed pos. C-band radar
Mobile X-band radar
Selection of active volcanoes

Wide Radar Beam

Keflavík radar beam at Eyjafjallajökull 2010 (155 km)

Icelandic Met Office



View of Eyjafjallajökull from a web camera at Hvolsvöllur, 10 May 2010 at 03:00.

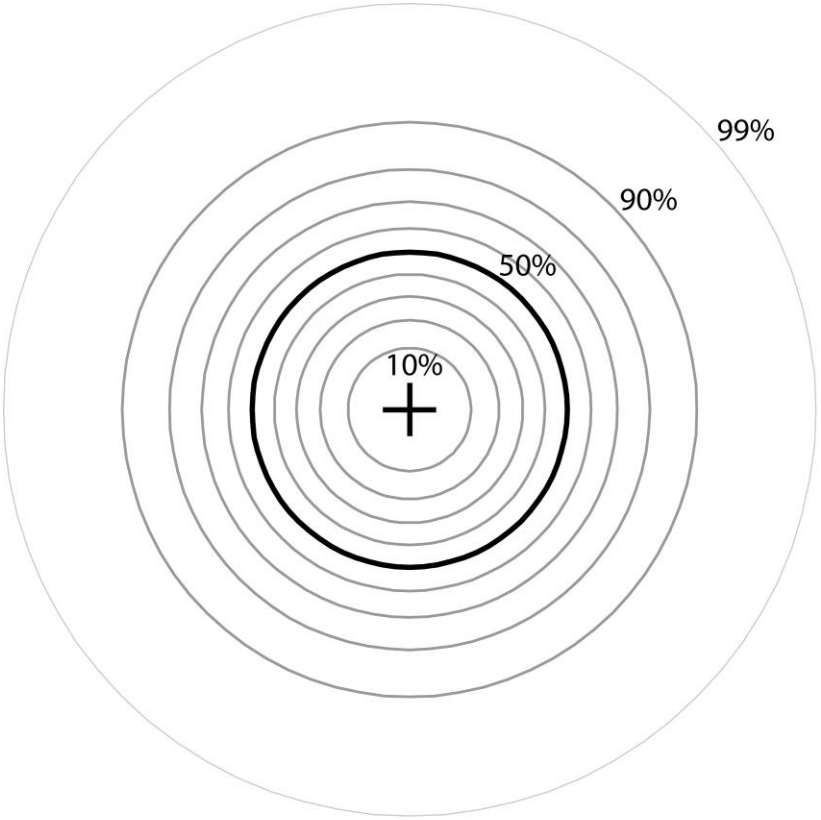
Smooth Radar Beam
It is not as sharp as we would like

Icelandic Met Office

- **The width of a radar beam is determined by the antenna size and radar frequency**
- **The beam width is measured where the center intensity has dropped by half**
- **Incidentally, 50% of the radar power is within the circle of the half power beam width**
- **IMO's radars have:**

  C-band w ≈ 0.9°

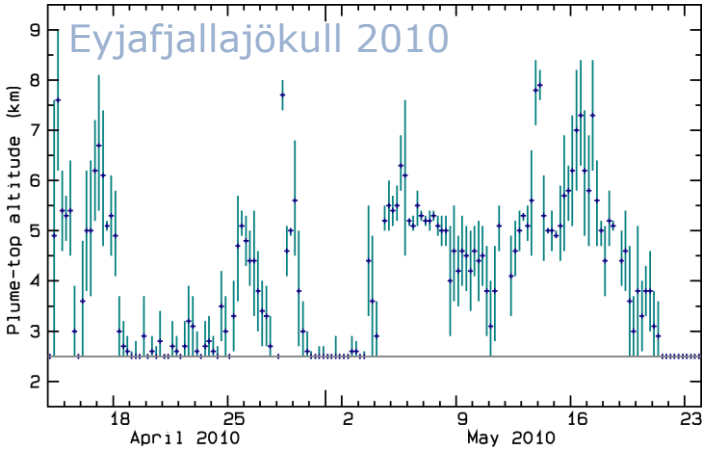
  X-band w ≈ 1.2°

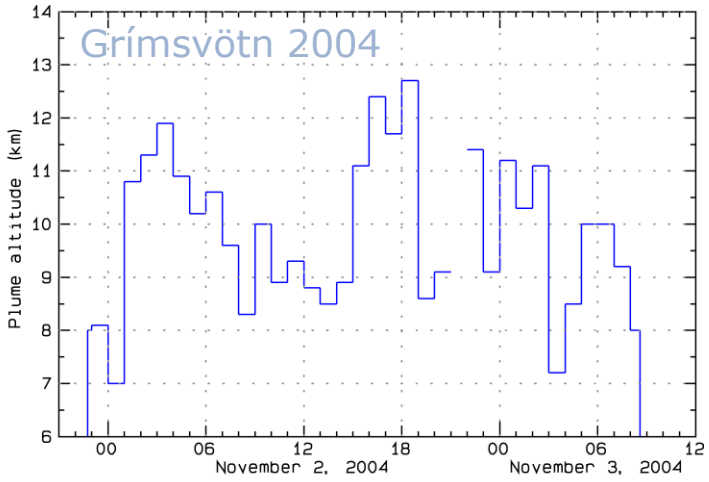


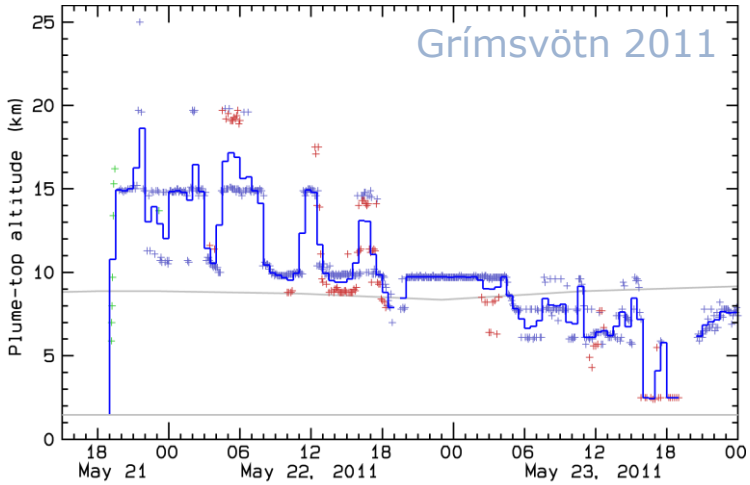
Radar power of 10, …, 50, …,90, 99% within concentric circles

Plume Heights
Manually estimated from radar images

Icelandic Met Office







EHT Suite of Scripts
Automatic plume height estimates

Icelandic Met Office

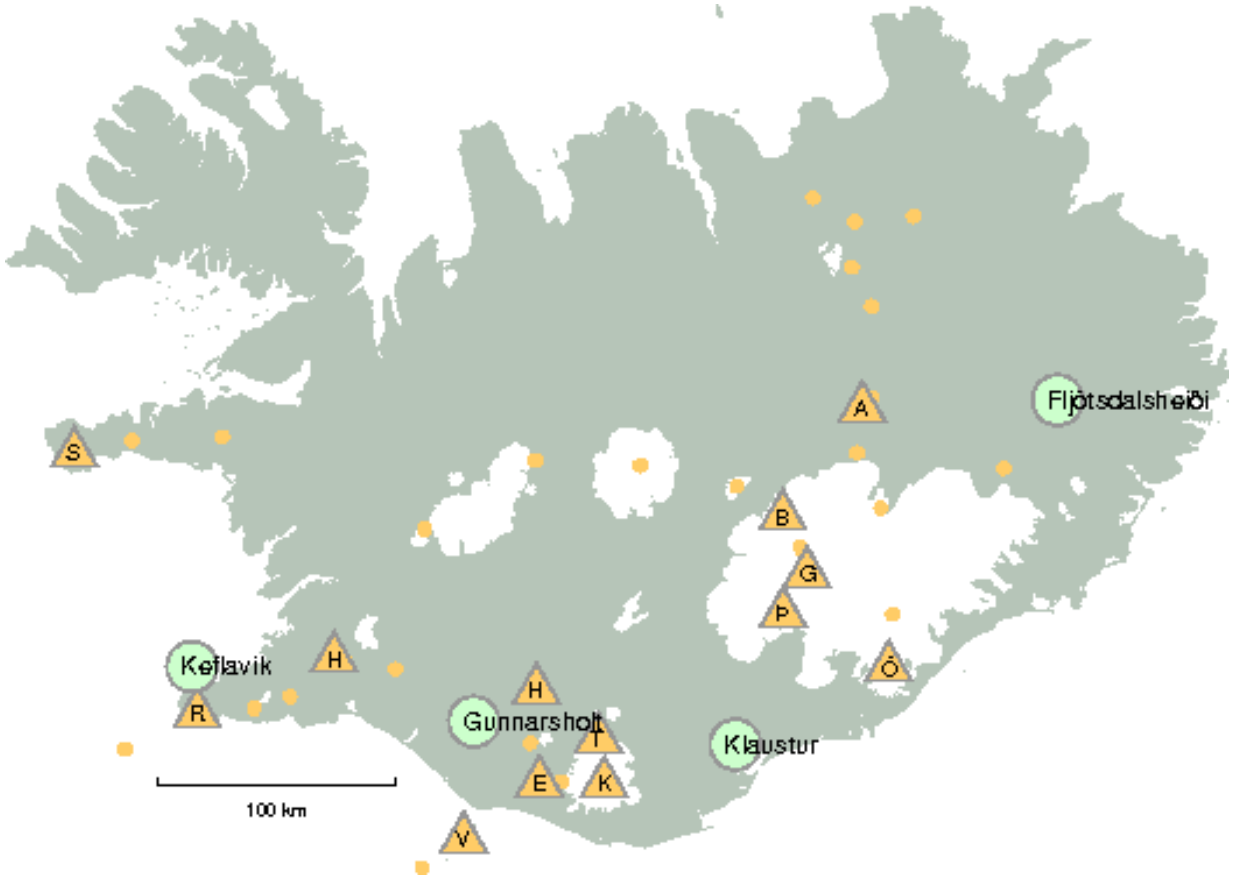
- A radar scan takes a few minutes and the volume-data is sent to IMO in Reykjavík
- When the data become available, the reflectivity of each pair of radar and predefined volcano sites are analyzed
- Data are transformed to a location and height of beam center above sea level. For a given radius around a volcano and observed reflectivities above a threshold, the maximum echo height is determined
- The height of the next radar beam above the maximum is also registered for reference

The prototype of the automatic Unix shell-scripts were written by Þórður Arason in March-April 2016

Automatic Plume Height Estimates

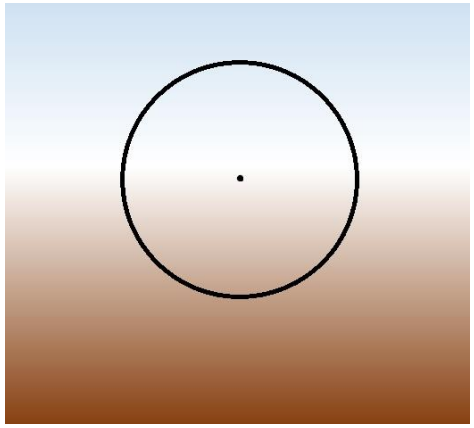
Icelandic Met Office

http://brunnur.vedur.is/pub/arason/radar/eldgos/

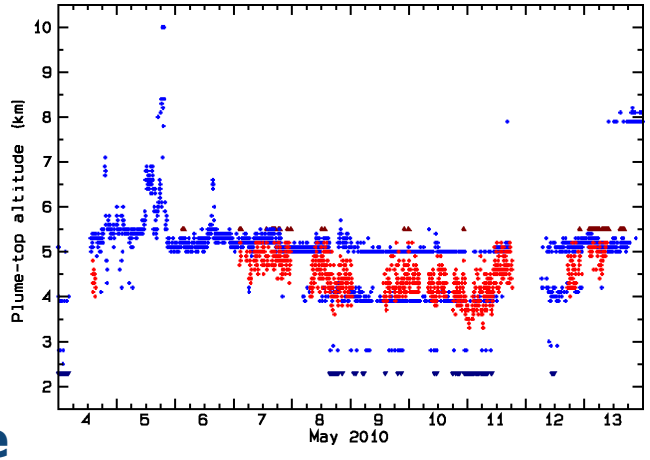


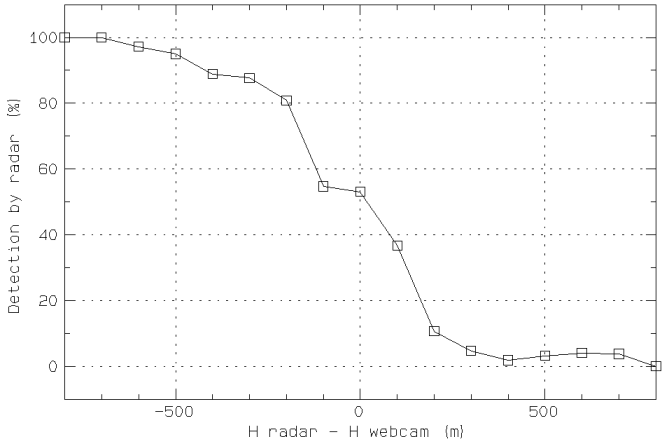
True Top vs. Central Beam Height

- There may be a bias between the true top height and radar central beam height. Variability in this bias is not known



- Furthermore, it may be possible to estimate the average vertical reflectivity gradient near the plume top





- Comparison of radar and web camera determined heights during Eyjafjallajökull 2010 may give constraints on these problems

Further Developments

Icelandic Met Office

- Adjustment of the radius about volcanoes (20 km)
- Adjustment of the threshold reflectivity (−20 dBZ)
- Analyzis of the difference between the height of the beam center and true plume top
- Analyzis of the vertical reflectivity gradient near plume tops
- Corrections for minor effects of variations in atmospheric refraction
- Automatic real-time calculations of mass eruption rates