UNIVERSITY OF LEEDS

The Role of Lidars for the Detection of Volcanic Ash in the Atmosphere

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Volcanic Ash – Why do we care?

- Aviation disruption
  - Damages jet engines
  - Abrasion to outside of planes
  - Very costly to check planes if known to have flown through an ash cloud

- Respiratory health issues
- Damage to agriculture (both livestock and crops)
- Damage to domestic houses and lives

Detection of Volcanic Ash in the Atmosphere

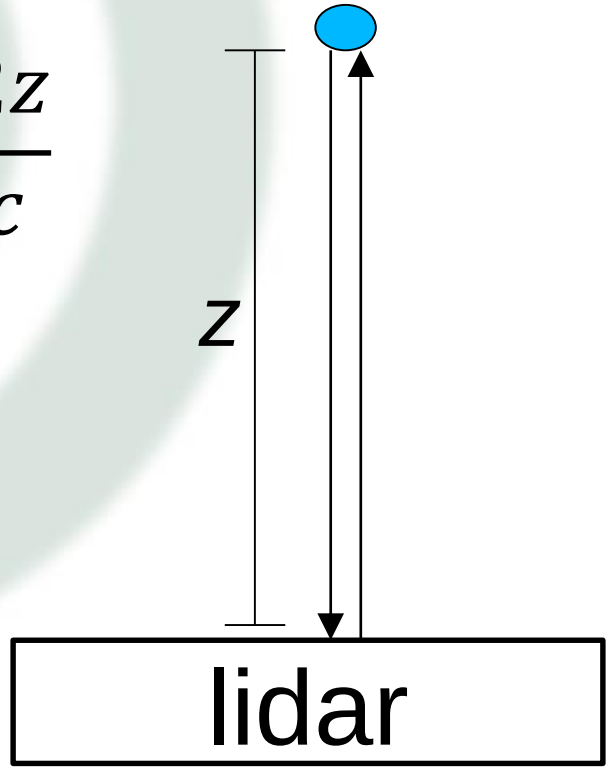
A number of instruments and models can help to determine where ash is in the atmosphere – a lidar (‘light radar’) is one of them

Lidar data must be used alongside other instruments in order to get a full picture of atmospheric ash

Lidar Basics

Measures backscatter from particles

$$t = \frac{2z}{c}$$



Lidar Basics

Backscatter depends on

- Particle size
- Refractive Index
- Concentration of particles
- Lidar wavelength

Particle data mostly unknown for volcanic ash!

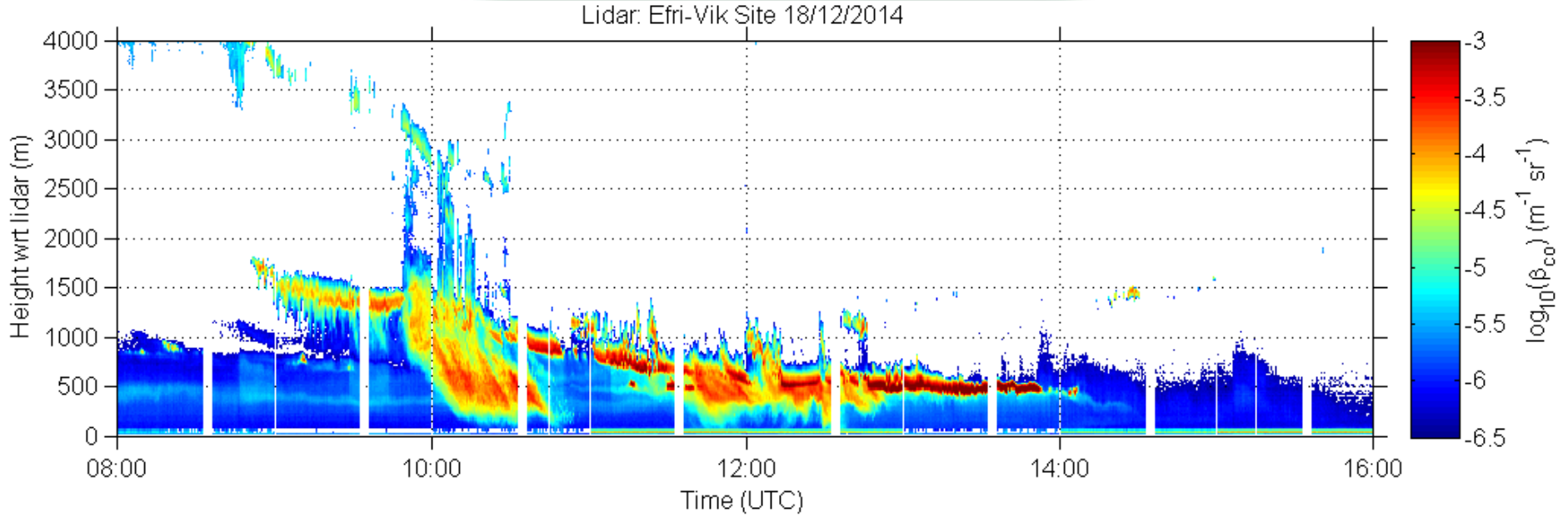
Lidar Basics

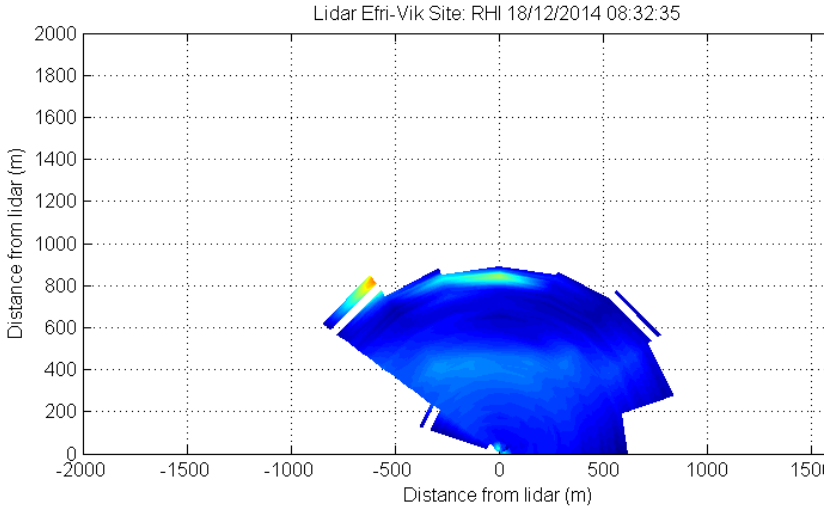
- A lidar can point straight up and give a picture of the sky directly above it

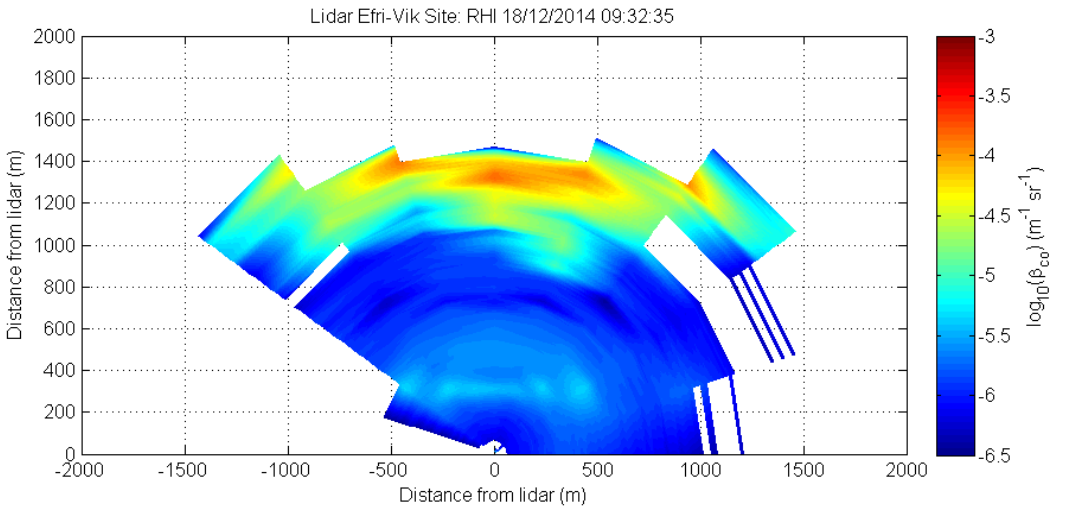
or …

- A lidar can scan the area around it by systematically changing the azimuth and elevation of the scanning head

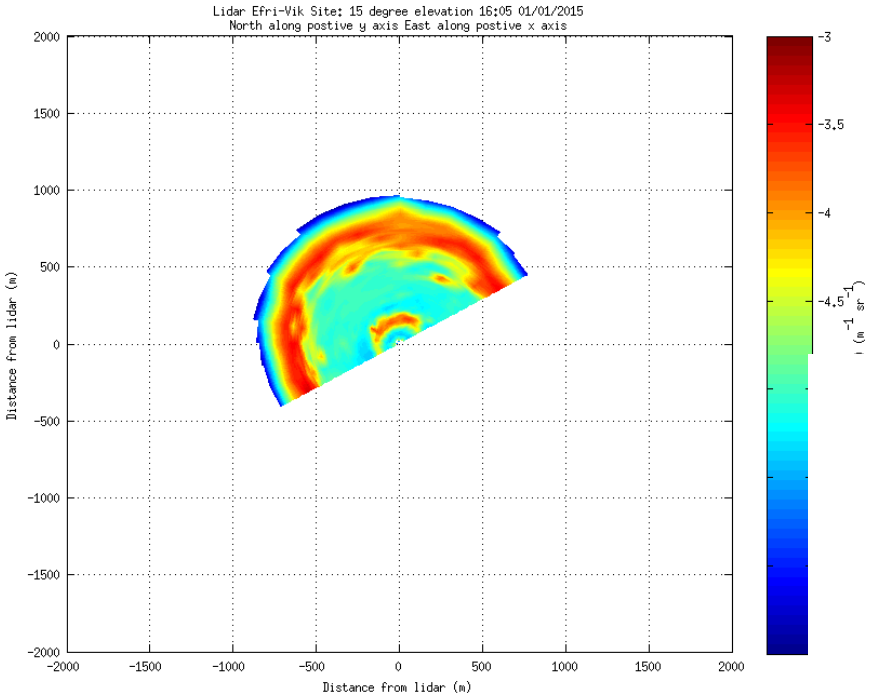
Lidar Scans

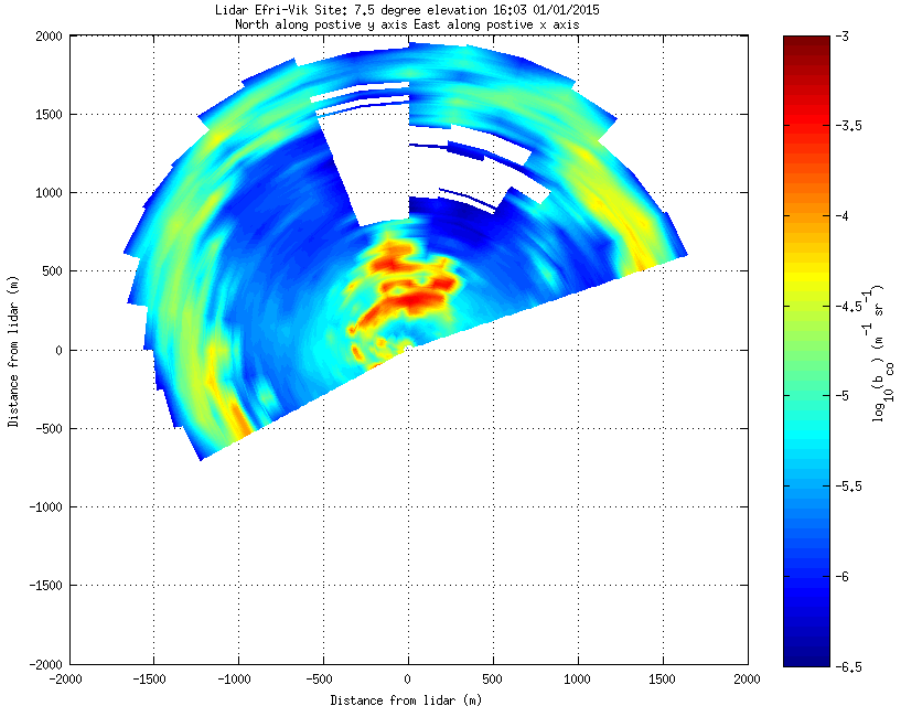

Lidar: Efri-Vik Site 18/12/2014
Height wrt lidar (m)
4000
3500
3000
2500
2000
1500
1000
500
0
08:00
10:00
12:00
14:00
16:00
Time (UTC)
-3
-3.5
-4
-4.5
-5
-5.5
-6
-6.5
log10(βco) (m-1 sr-1)


Lidar Efri-Vik Site: RHI 18/12/2014 08:32:35
Distance from lidar (m)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
-2000
-1500
-1000
-500
0
500
1000
Distance from lidar (m)


Lidar Efri-Vik Site: RHI 18/12/2014 09:32:35
Distance from lidar (m)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
-2000
-1500
-1000
-500
0
500
1000
1500
2000
Distance from lidar (m)
-3
-3.5
-4
-4.5
-5
-5.5
-6
-6.5
log10(βco) (m-1 sr-1)

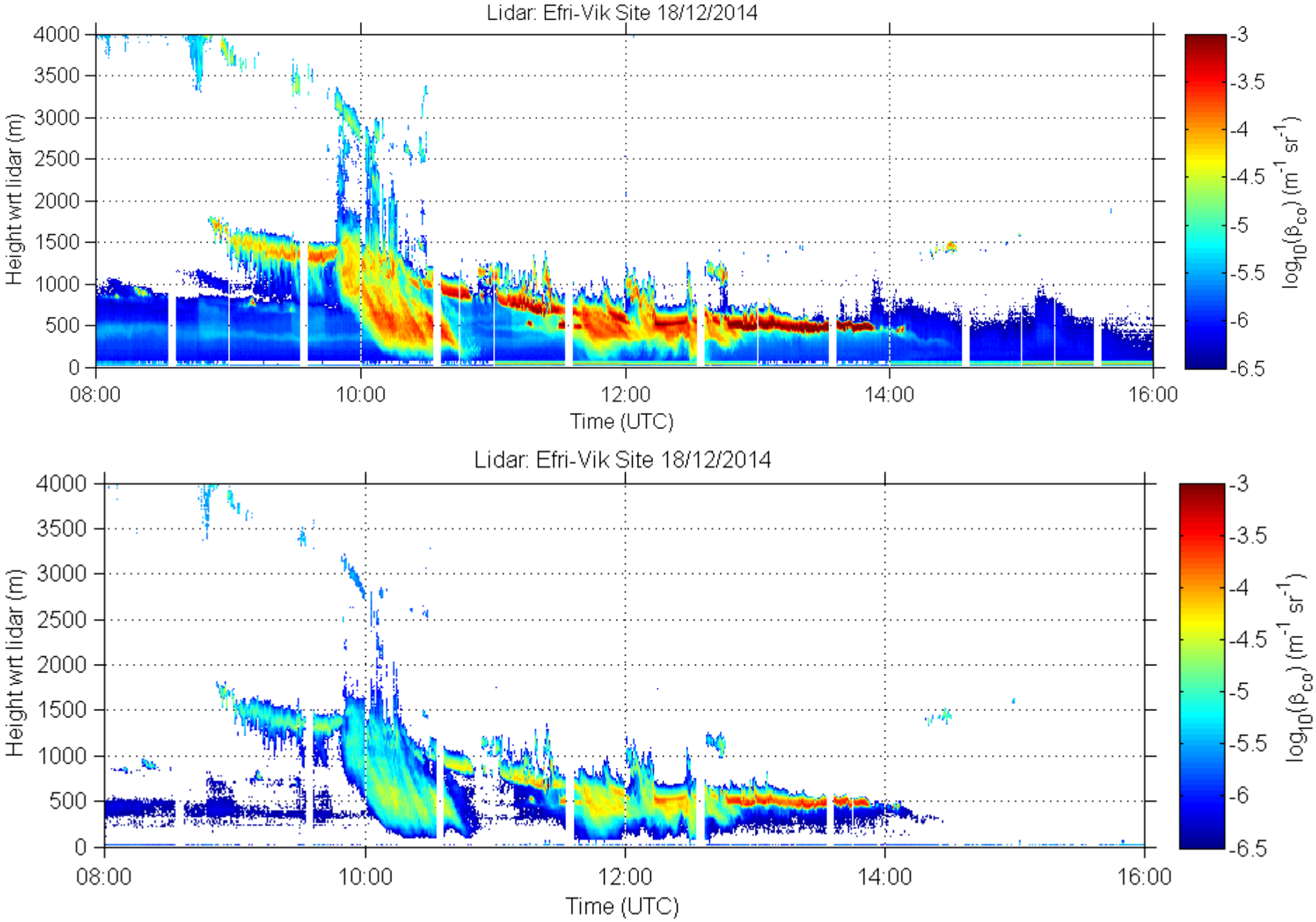
Lidar Scans


Lidar Efri-Vik Site: 15 degree elevation 16:05 01/01/2015
North along postive y axis East along postive x axis
Distance from lidar (m)
Distance from lidar (m)
2000
1500
1000
500
0
-500
-1000
-1500
-2000
-3
-3.5
-4
-4.5


Lidar Efri-Vik Site: 7.5 degree elevation 16:03 01/01/2015
North along postive y axis East along postive x axis
Distance from lidar (m)
Distance from lidar (m)
2000
1500
1000
500
0
-500
-1000
-1500
-2000
-3
-3.5
-4
-4.5
-5
-5.5
-6
-6.5

Our lidar

- Halophotonics ‘Streamline’ lidar
- Operates at 1.55µm
- Doppler lidar (wind measurements)
- Depolarisation channel (gives an indication of particle homogenity)


Lidar: Efri-Vik Site 18/12/2014
Height wrt lidar (m)
4000
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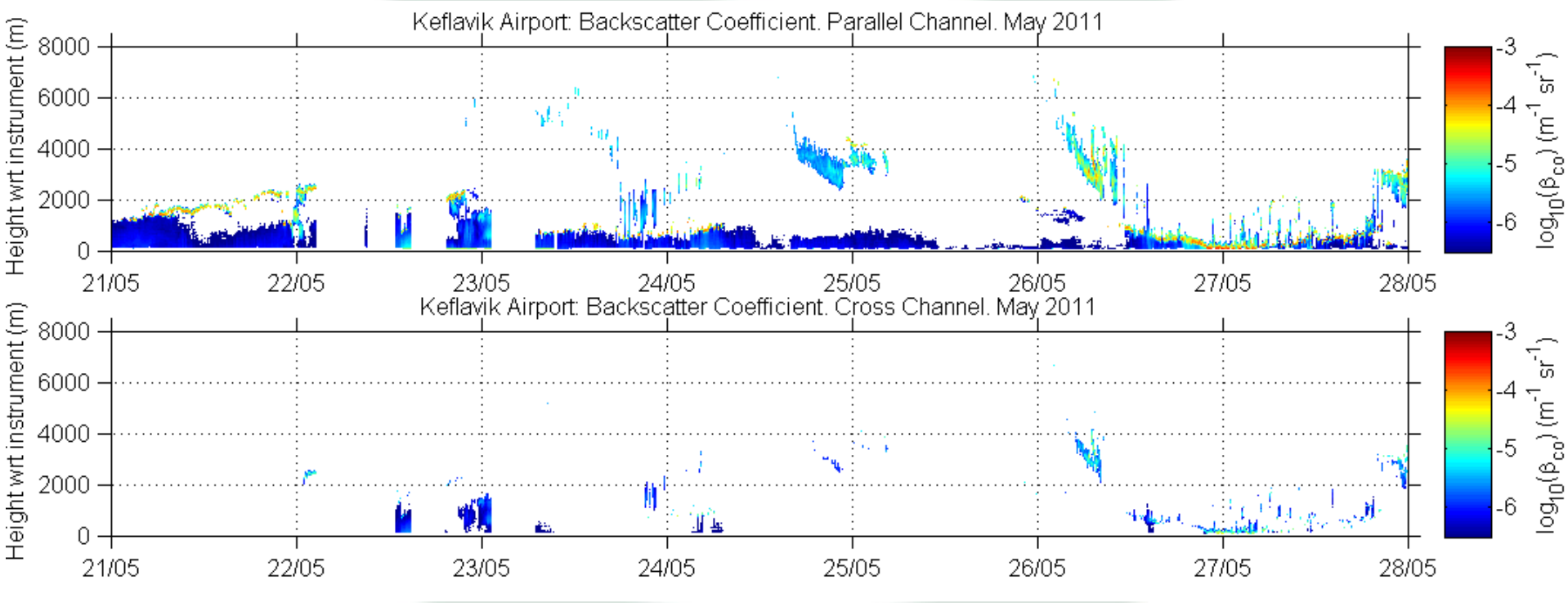
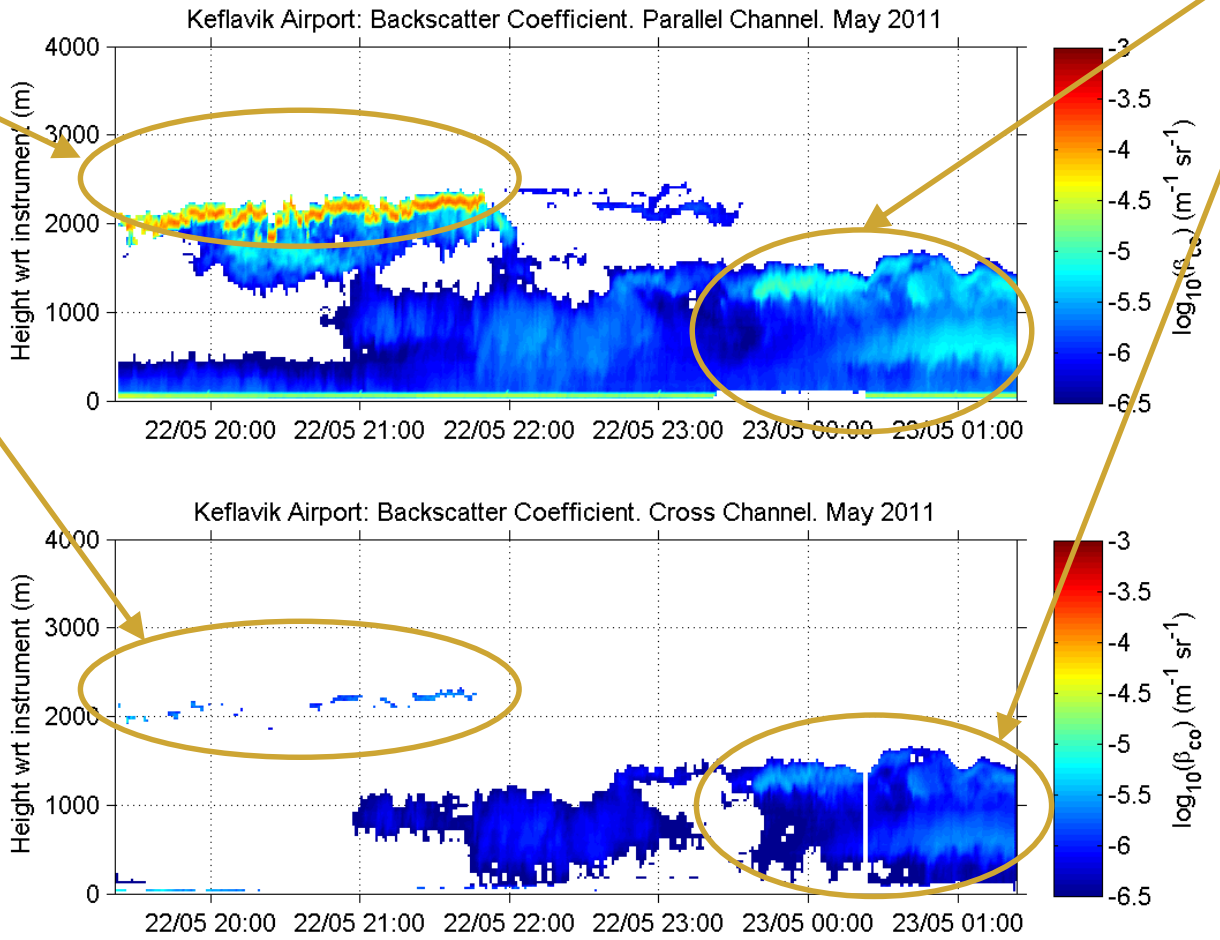
-6.5
log10(βco) (m-1 sr-1)
Lidar: Efri-Vik Site 18/12/2014
Height wrt lidar (m)
Time (UTC)
log10(βco) (m-1 sr-1)

Observations: Grímsvötn



Very strong backscattering, with accompanying weak cross planar signal – indicates multiple scattering

Strong backscattering with similar accompanying cross planar signal - ash layers?



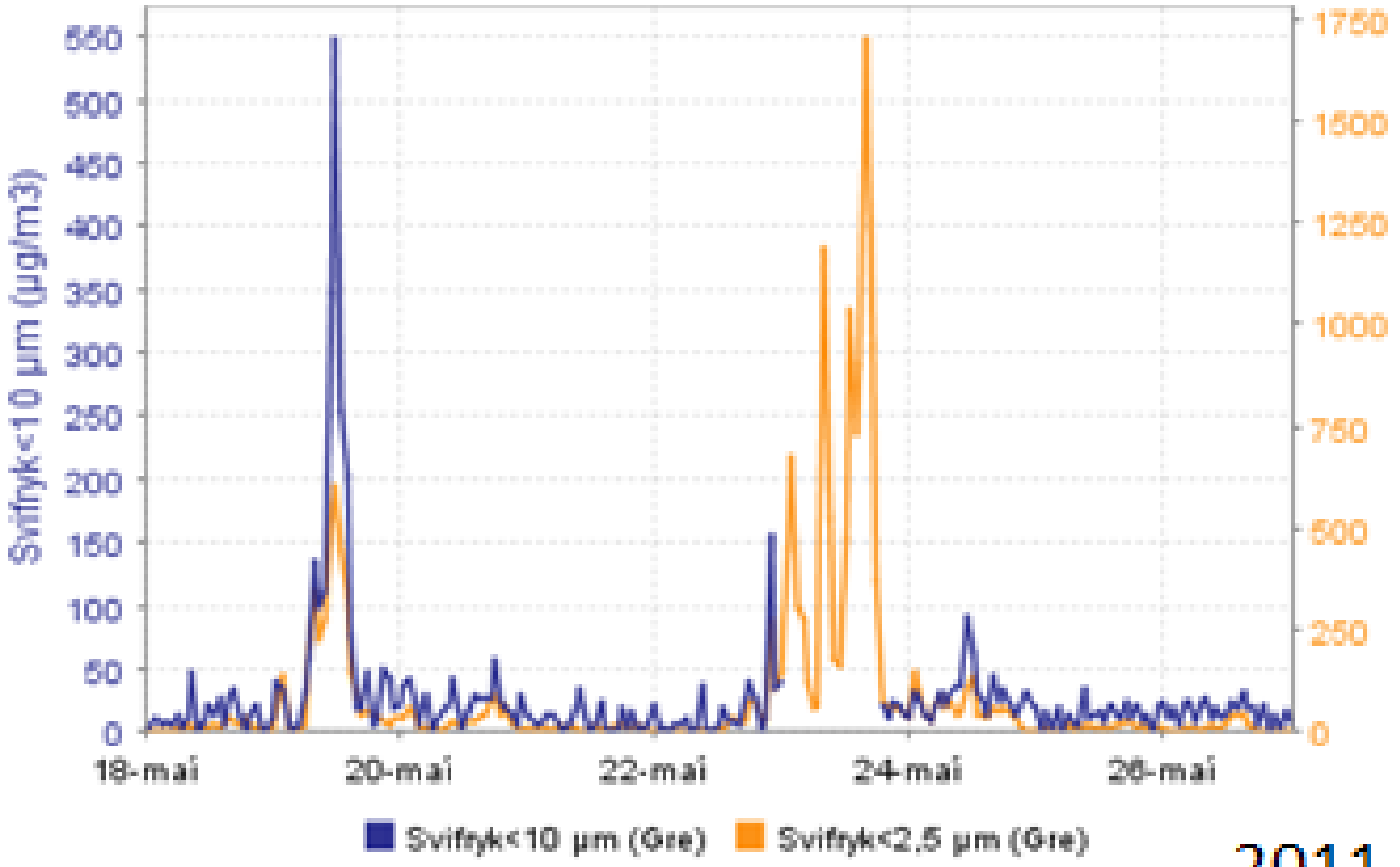
Low level scattering in both channels – mixture of spherical and irregular shaped particles. Ash mixed with water soluble aerosols?

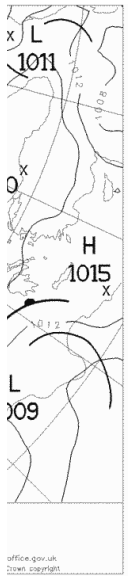
Acc tions

Grímsvötn volcano
Status Report: 17:00 GMT, 22 May 2011
Icelandic Meteorological Office and Institute of Earth Sciences, University of Iceland

NOAA HYSPLIT MODEL
Backward trajectories ending at 0300 UTC 23 May 11
GHDA Meteorological Data

Lidar

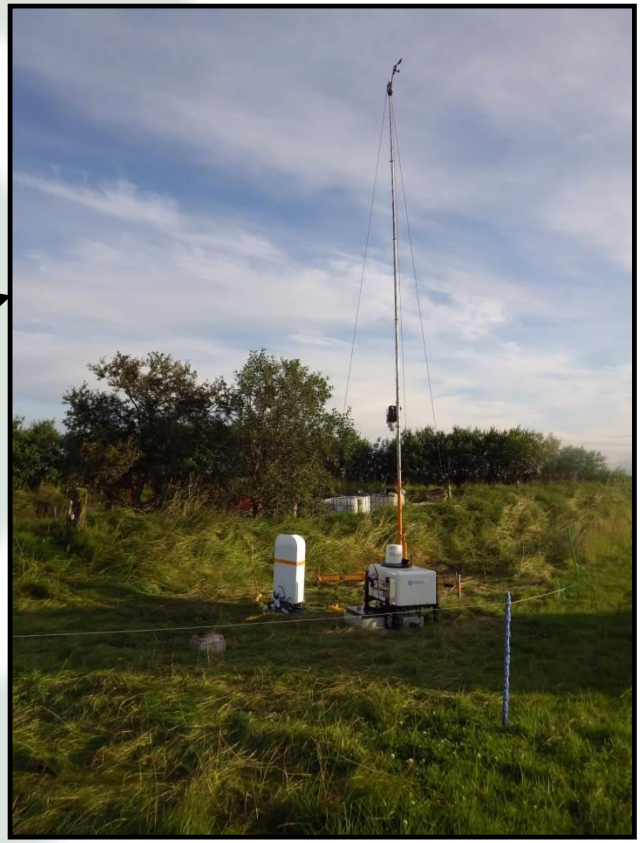




2011

expected

Field Measurements



Lidar:

Halo Photonics, doppler, depolarisation, 1.55µm

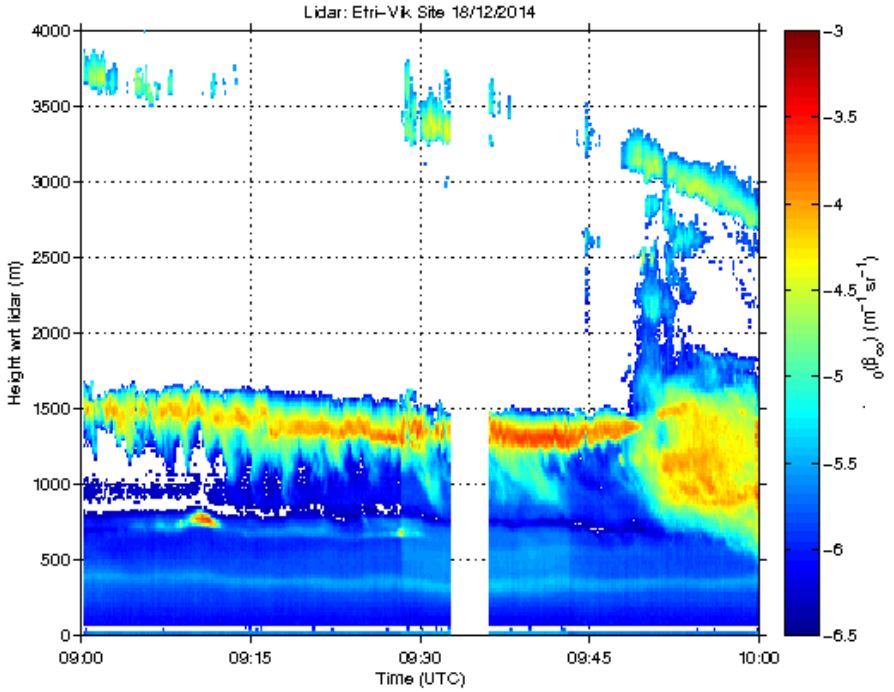
Ceilometer:

Campbell Scientific, full backscatter output, 905nm

Additional data from webcams and weather station

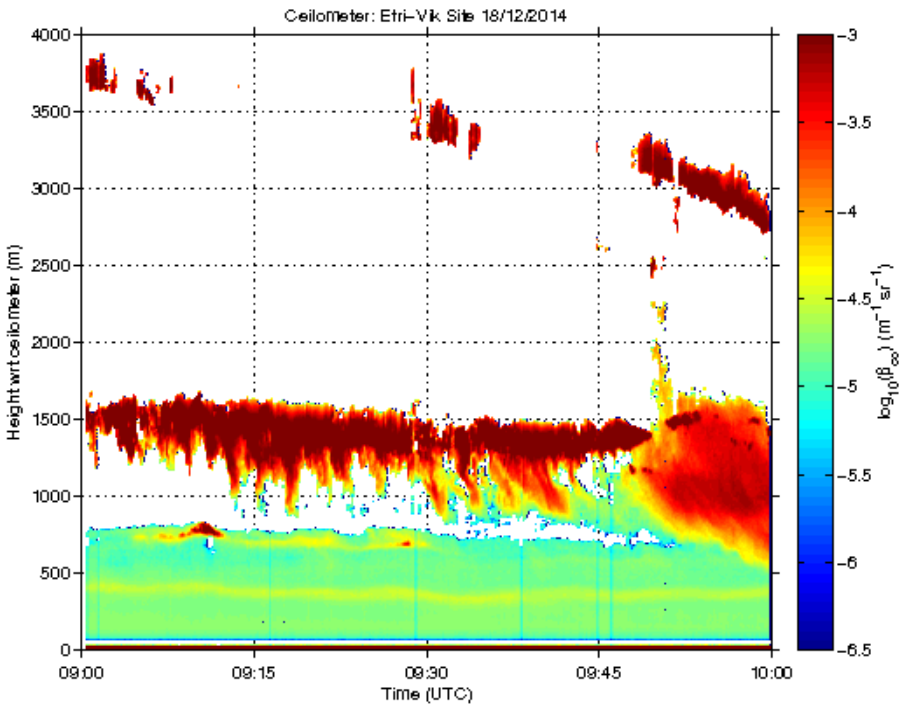
Co-located with IMO radar

Lidar vs Ceilometer



1500 nm

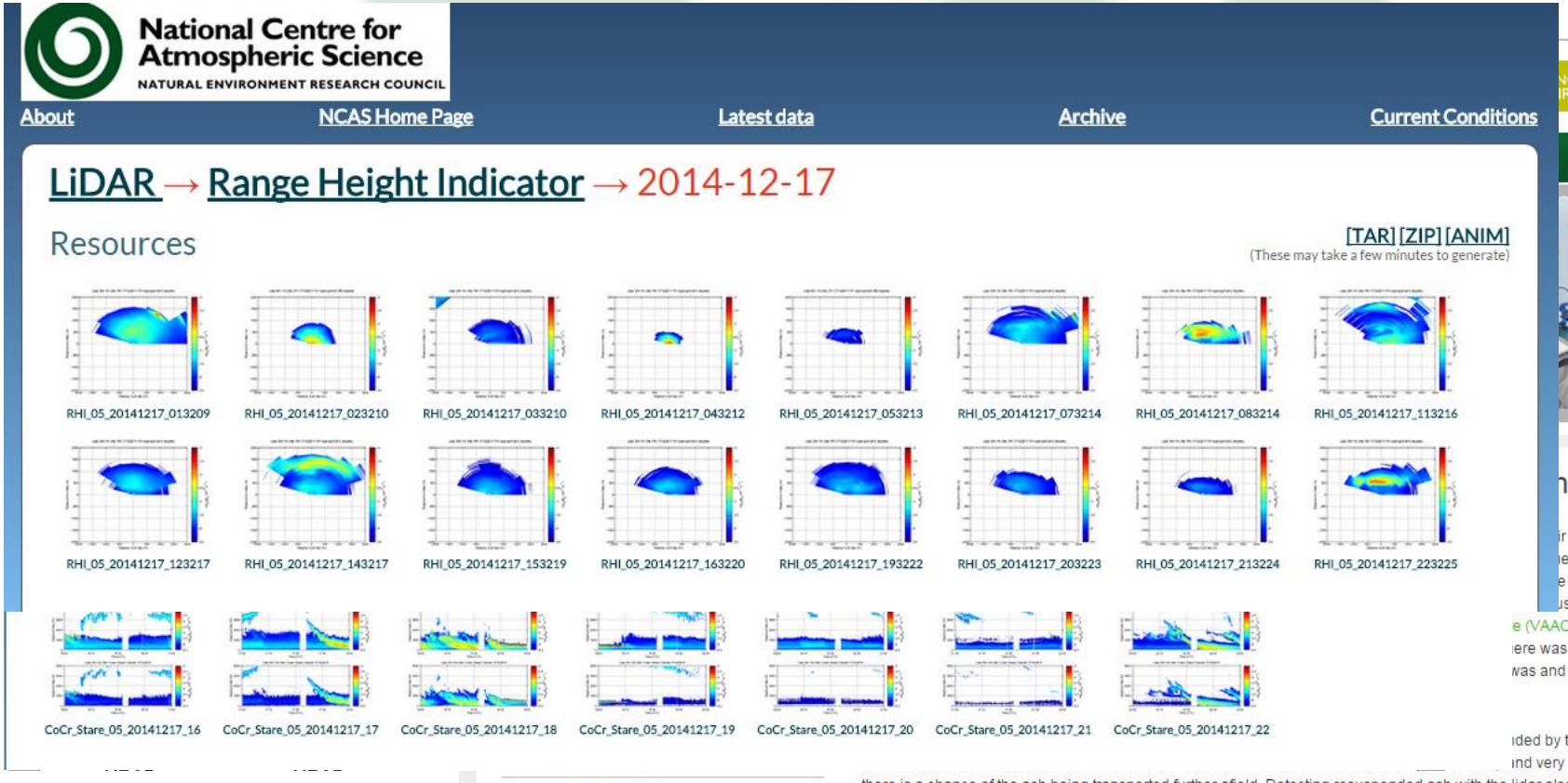
900 nm



Field Measurements

Website:

- Overview of site
- Quick look data plots of current data (last hour usually)
- Catalogue of previous data since July 2014 (with some missing data).



Field Measurements

Need to analyse this data further,
- no ash from an eruption yet
- look in detail for any ash re-suspension events
- lots of data to look at

Next steps:

- Sizing of particles using lidar & ceilometer data together
- Sun photometer loan (to get size distributions)
- Comparisons to IMO lidar
- Comparisons with radar data?