Koninklijk Nederlands
Meteorologisch Instituut
Ministerie van Verkeer en Waterstaat

How did a (non-VAAC) Meteorological Institute make forecasts of the dispersion of volcanic ash from Eyjafjallajokull?

What information do meteorologists need?

Peter van Velthoven &
KNMI colleagues &

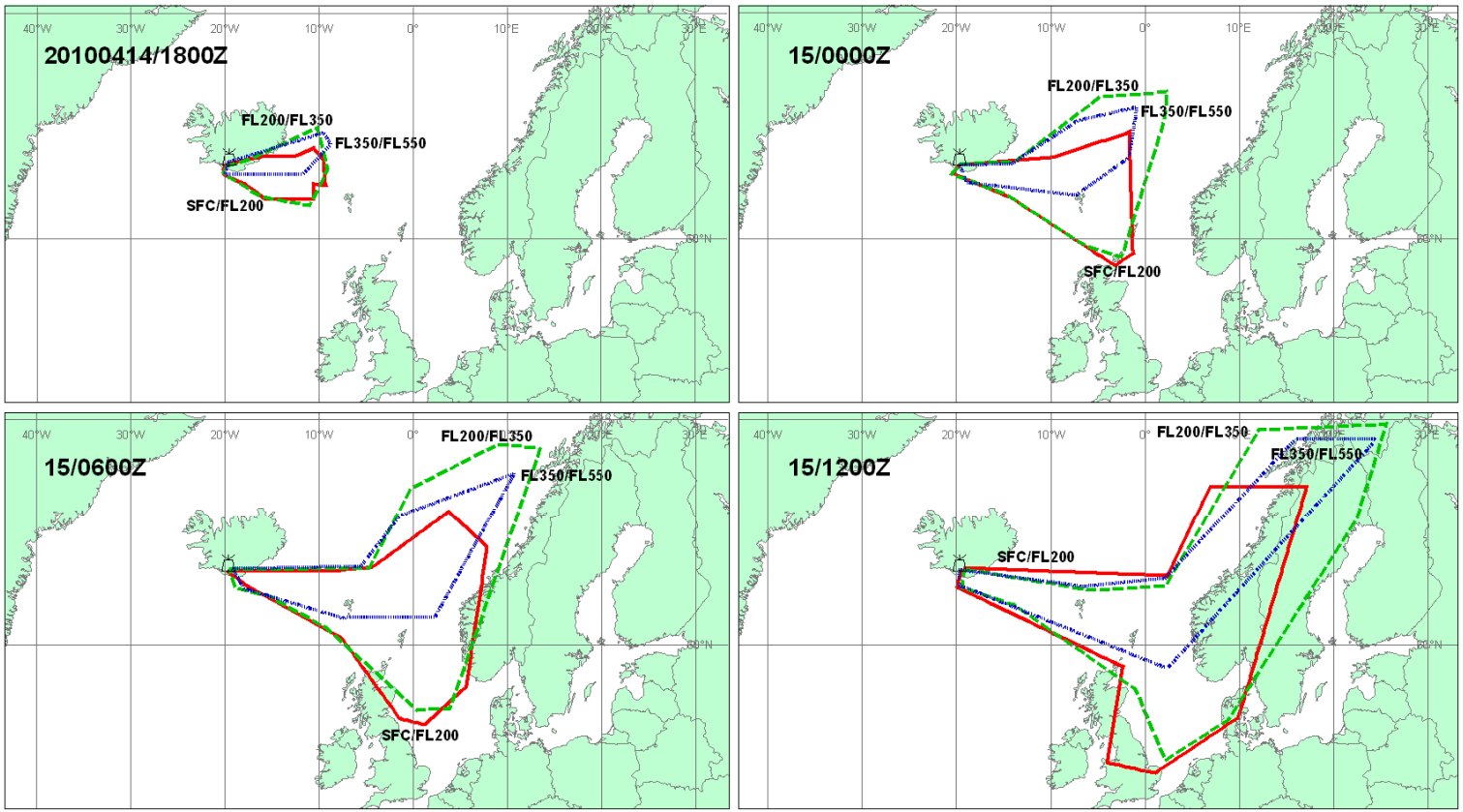
Henk Jentink &
NLR colleagues

NLR

Overview

- Intro: How did KNMI make ash dispersion forecasts?
- Which observations could we use?
  1. Satellite observations:
     - Meteosat 9 (MSG-Seviri): ash/dust RGB images
     - OMI (O3 Monitoring Instr.), GOME-2, MODIS: SO2, AAI, AOT
  2. Aircraft observations: NLR, DLR, FAAM, CARIBIC, etc.
  3. Ground-based observations:
     - UV & Raman lidars, Ceilometers, Aeronet radiometers
     - Weather balloons: Ozone + radiation measurement
- Need for confrontation with alternative model outputs!
  - Eulerian: e.g. TM4 driven by ECMWF, up to +10 days
  - Lagrangian: e.g. trajectories driven by HIRLAM, up to +3 days
- What is needed to evaluate the risks in the future
- Conclusions

How did KNMI make ash dispersion forecasts?



VA ADVISORY
DTG: 20100414/1800Z
VAAC: LONDON
VOLCANO:
EYJAFJALLAJOKULL
PSN: N6338 W01937
AREA: ICELAND

SUMMIT ELEV: 1666M
ADVISORY NR: 2010/002
INFO SOURCE: ICELAND MET OFFICE
AVIATION COLOUR CODE: UNKNOWN
ERUPTION DETAILS: PLUME FROM VOLCANO
REPORTED TO BE UP TO 11KM HEIGHT.

RMK:
NXT ADVISORY: 20100414/1800Z

What now?

How did KNMI make ash dispersion forecasts?

First ever Dutch Volcanic Ash SIGMET :

```
ZCZC
WSNL31 EHDB 150755
EHAA SIGMET 1 VALID 150900/151500 EHDB-
EHAA AMSTERDAM FIR VA CLD FCST 0900Z FL000/350 REACHING EXTREME NW
OF FIR FCST 1200Z FL000/350 NW OF LINE N5420 E00630 - N5355 E00622
- N5310 E00330 FCST 1500Z FL000/350 NW OF LINE N5330 E00650 -
N5130 E00200 MOV SE 20KT=
NNNN
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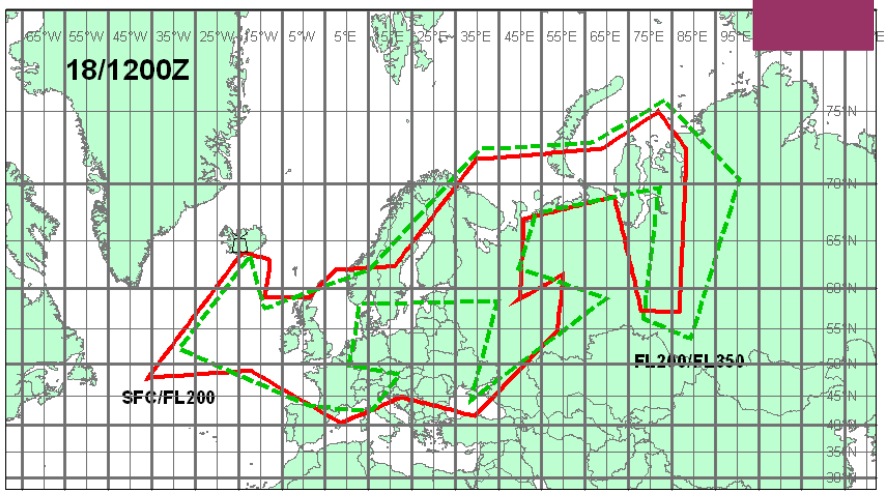
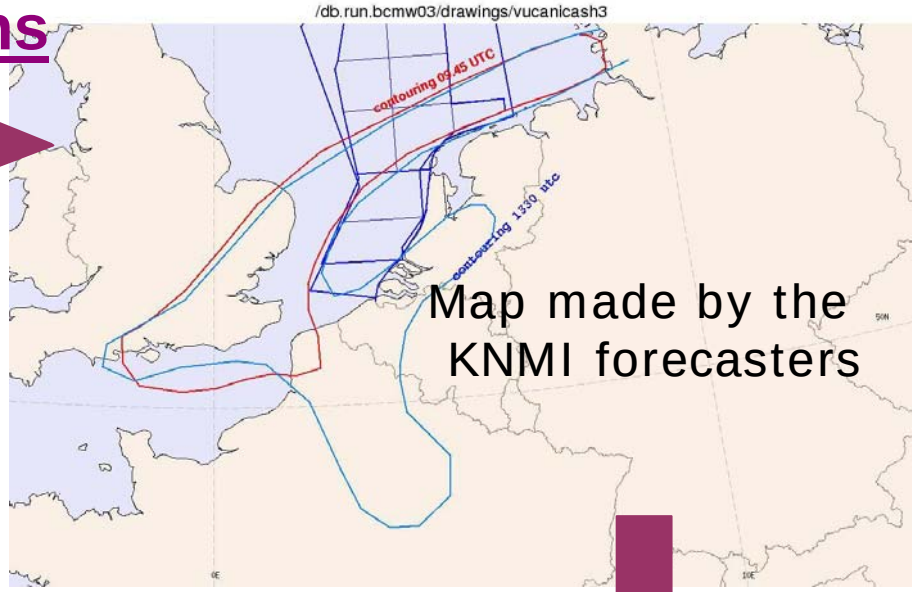
How did KNMI make ash dispersion forecasts?

Merge VAAC forecast info with available observational info!

Metosat, lidar, aircraft **observations**



London VAAC forecast chart

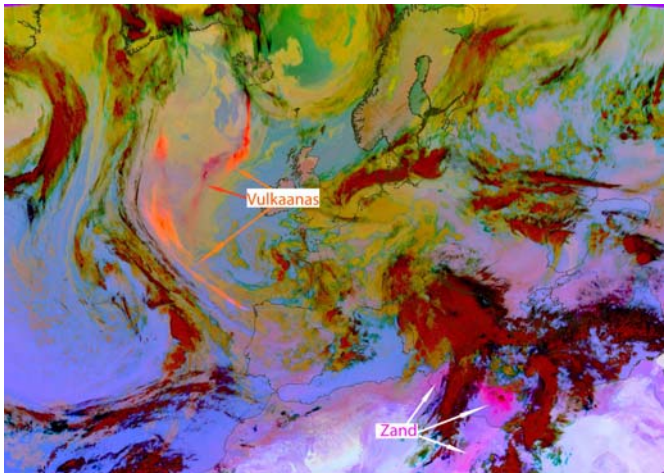


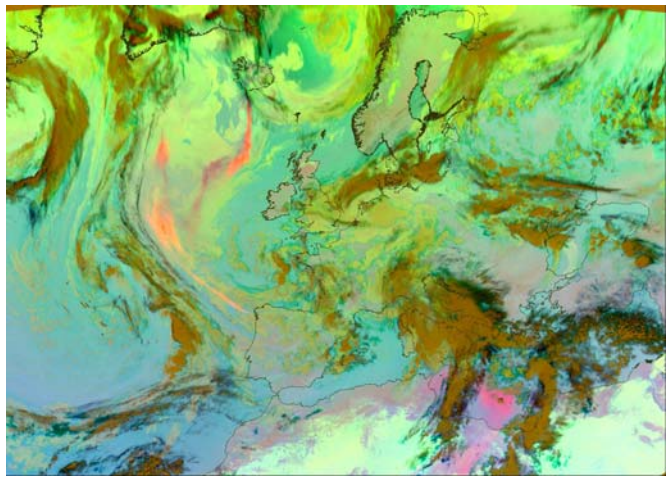
Map made by the KNMI forecasters

Meteorological advice to ATC, ATM & minister

Which observations could we use?
1) Special Meteosat 9(MSG-Seviri) image loops

For 7 May 2010 22h





- RGB “false colour images”
  - Red: 12,0-10.8 µm (volcanic ash, dust)
  - Green: 10,8-8.7 µm
  - Blue: 10 µm (clouds, 2 color choices in left and right panels)

Which observations could we use?

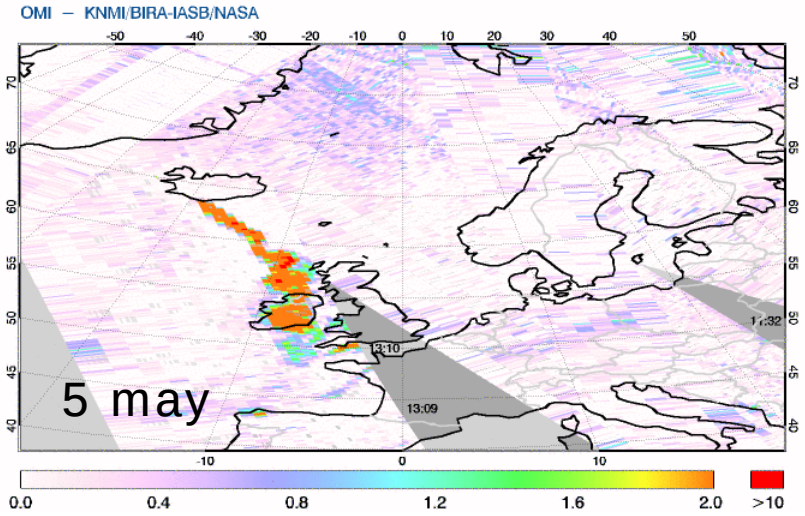
1. Satellite UV spectrometers: EOS-AURA OMI, METOP GOME-2

OMI products (NRT provided to VAACs via http://sacs.aeronomie.be/):

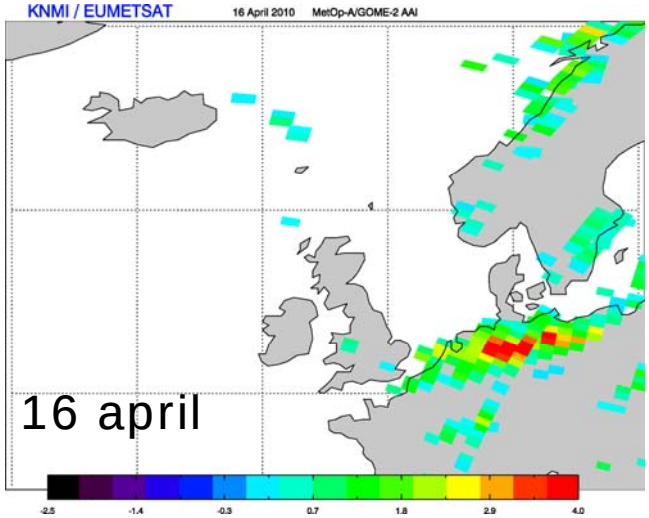
- SO_2 (**can be at a different altitude than ash!)**
- AAI (Aerosol Absorbing Index), AOT (Aerosol Optical Thickness)

OMI/GOME-2: Resolution 13x24/40x80 km^2 ; Overpass: daily at 10/14h

OMI
SO2

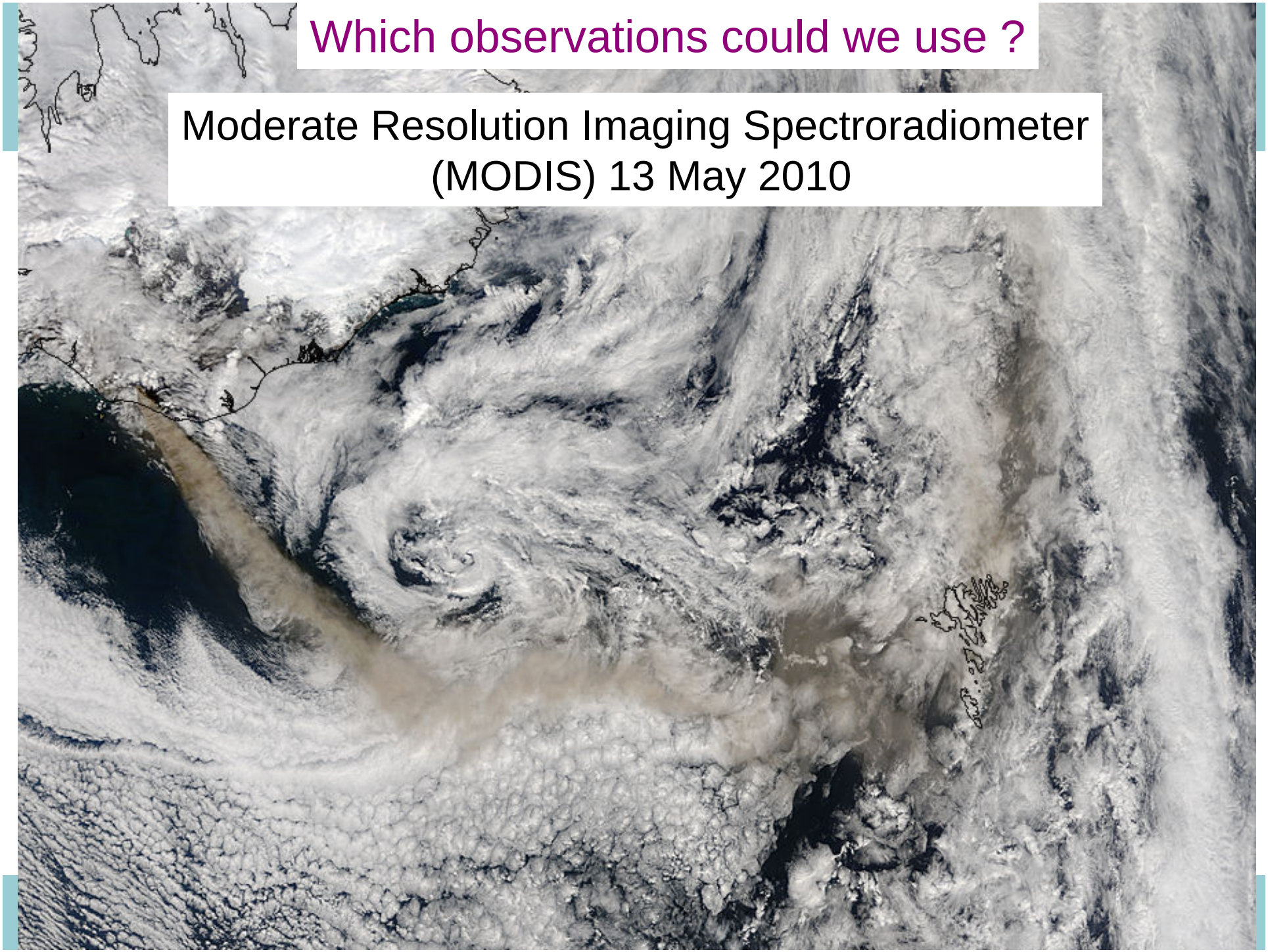


GOME-2
AAI



Which observations could we use ?

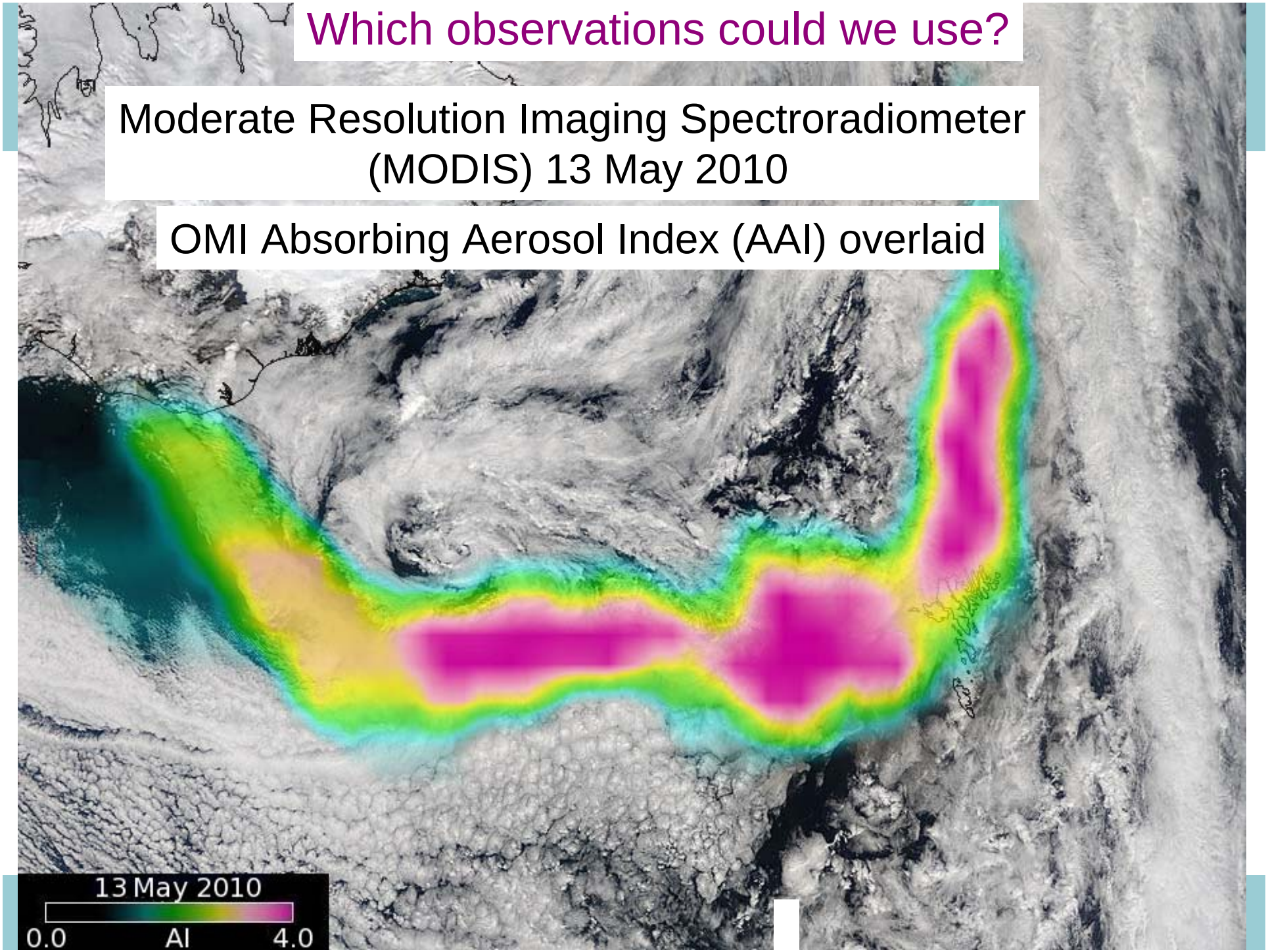
Moderate Resolution Imaging Spectroradiometer (MODIS) 13 May 2010



Which observations could we use?

Moderate Resolution Imaging Spectroradiometer (MODIS) 13 May 2010

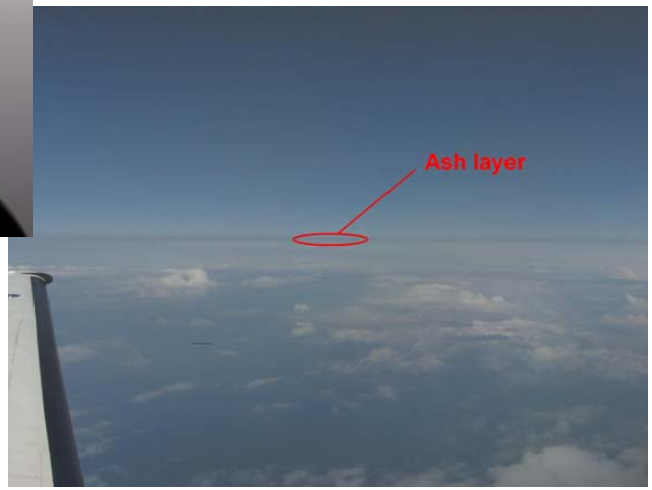
OMI Absorbing Aerosol Index (AAI) overlaid



Which observations could we use?

2. Aircraft observations: NLR Citation

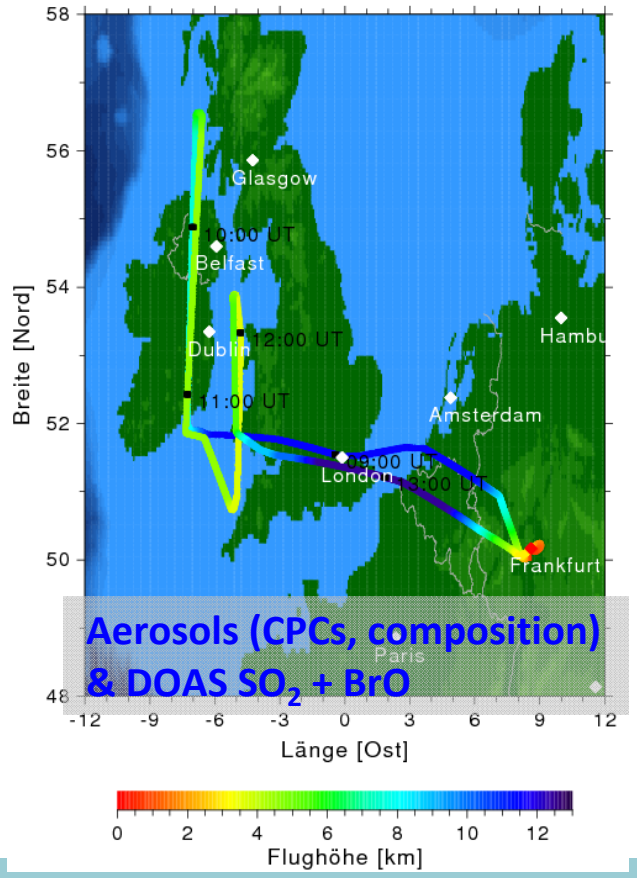
Including **KNMI observers on board**



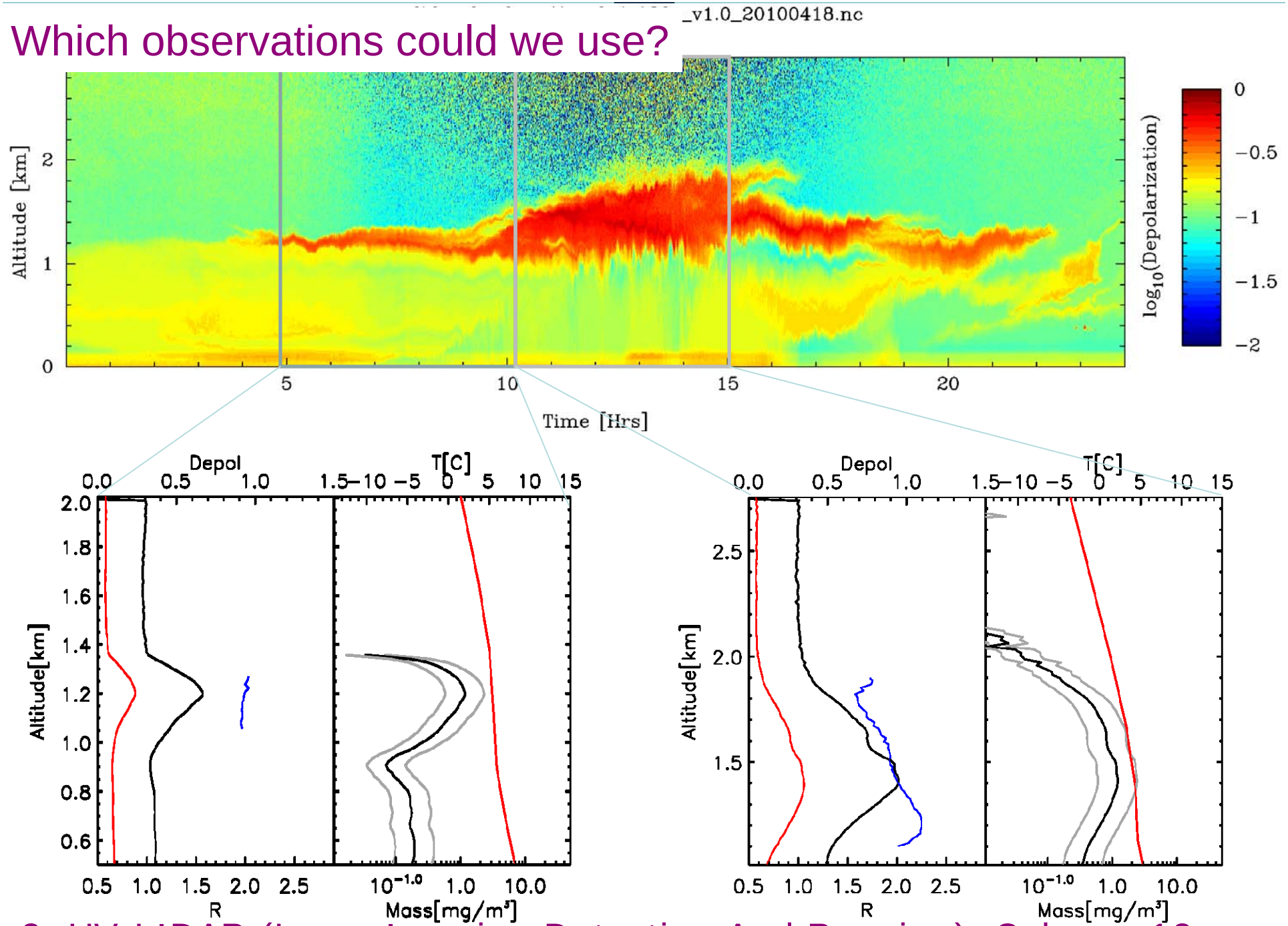
Which observations could we use?

2. Aircraft observations (NLR, DLR, FAAM, CARIBIC, etc.)

CARIBIC



Which observations could we use?

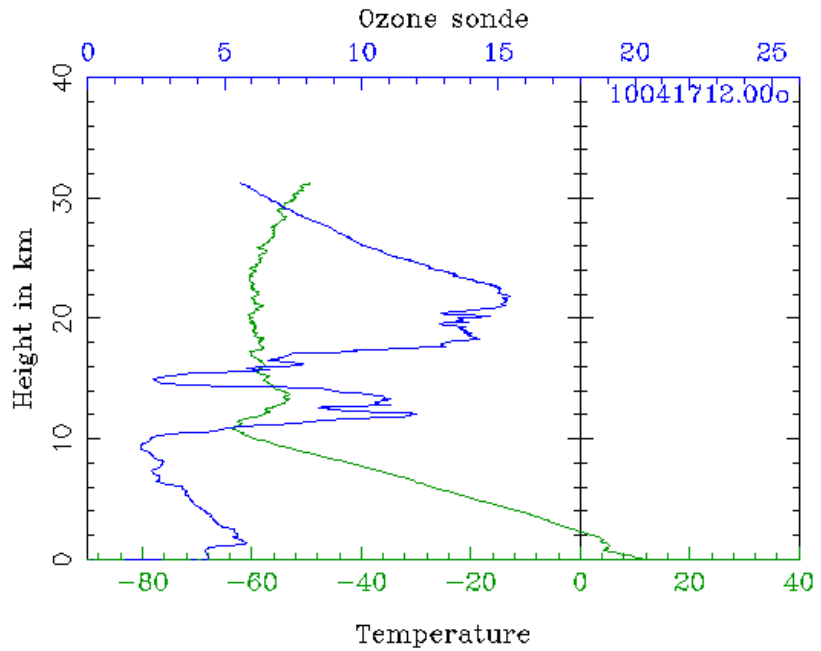


3. UV-LIDAR (Laser Imaging Detection And Ranging), Cabauw 18 apr

Which observations could we use ?

Weather balloons with ozone & radiation instruments

16-17 April at KNMI, De Bilt



Requirements for a volcanic ash observing system

- Cover **all flight levels**
- Measure ash concentration **quantitatively**
  e.g. with lidars or (optical) particle counters on board of aircraft or at the surface
- Make **upstream** observations
- Monitor the 3-D evolution of ash cloud **boundaries** (can be done qualitatively, e.g. with aircraft and satellites)
- Provide and **exchange** observations in almost **near real time** (within a a few hours-1 day) internationally

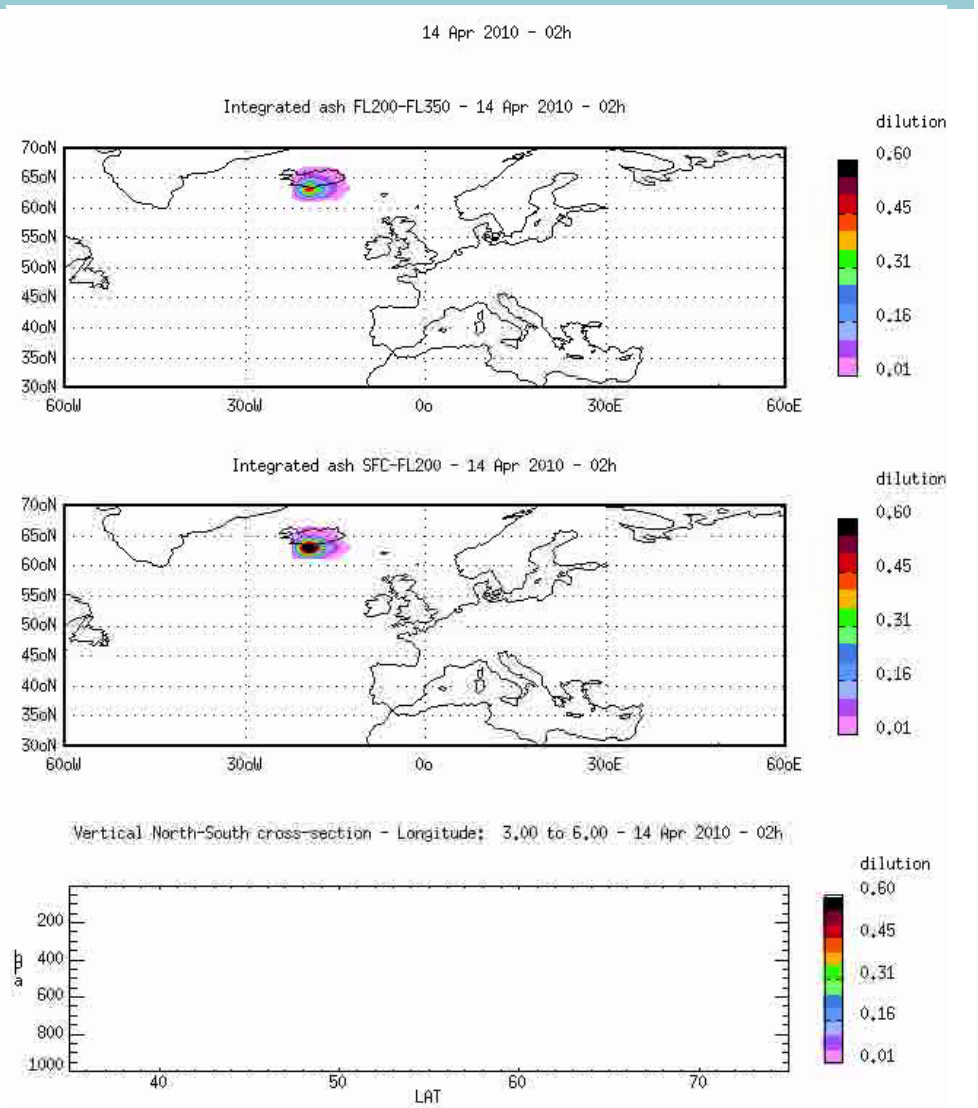
Confrontation with alternative model forecasts !

Eulerian: the TM5 global tracer transport model with regional zoom

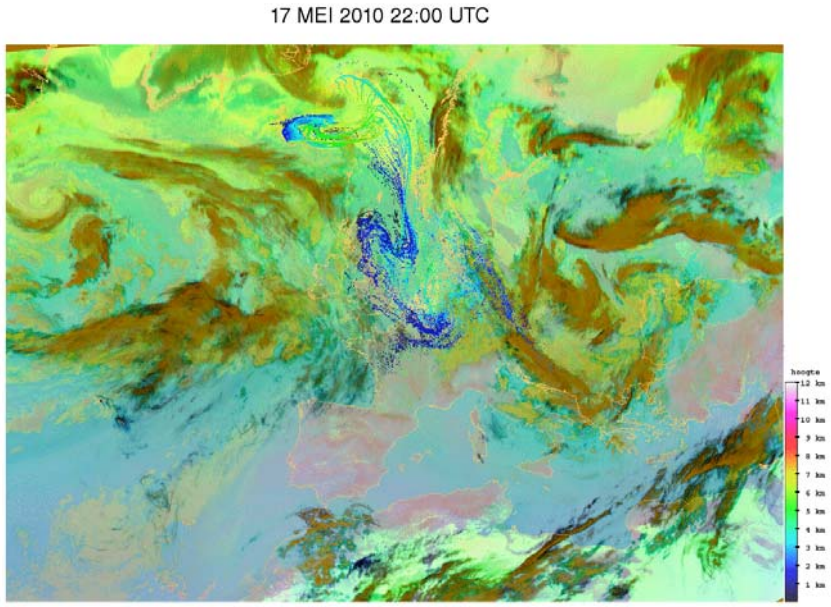
- TM5: global (chemistry) transport model driven by ECMWF meteorology (up to 10 day global forecasts)

- Continuous source over Eyjafjallajokull up to eruption plume top (2-7 km)

- First simulation done on 16 april for 14-23 april



Confrontation with alternative model forecasts



Lagrangian:
Ash dispersion simulation with the KNMI trajectory model driven by HIRLAM winds

- Particles released over volcano every 5 min from surface up to plume top
- Transport by 3-D HIRLAM winds (2-day forecasts produced 3 hrly)
- 4 particle sizes with sedimentation speeds of 5, 58, 540 and 5000 m/day
- Dry & wet deposition

Requirements for future forecasting of volcanic ash dispersion

1) Take into account 3 types of uncertainties:

- **Source** uncertainties: amount & particle size distribution, vertical distribution

  Solution: data assimilation, satellite & local observations

- **Meteorological** uncertainties

  Solution: meteorological ensemble

- **Dispersion model** uncertainties

  Solution: ensemble of dispersion models - include both Lagrangian and Eulerian models

2) Use **upstream observations** for model evaluation and assimilation

Conclusions

- Need to quantify uncertainties in the ash forecasts
- Major update/extension of (ash) observing system needed with lidars and instrumented aircraft
- Need to exchange observations between countries in almost near real time

Thank you for your attention

Questions or comments?

Acknowledgements:

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