VAAC London: Modelling and forecasting uncertainty

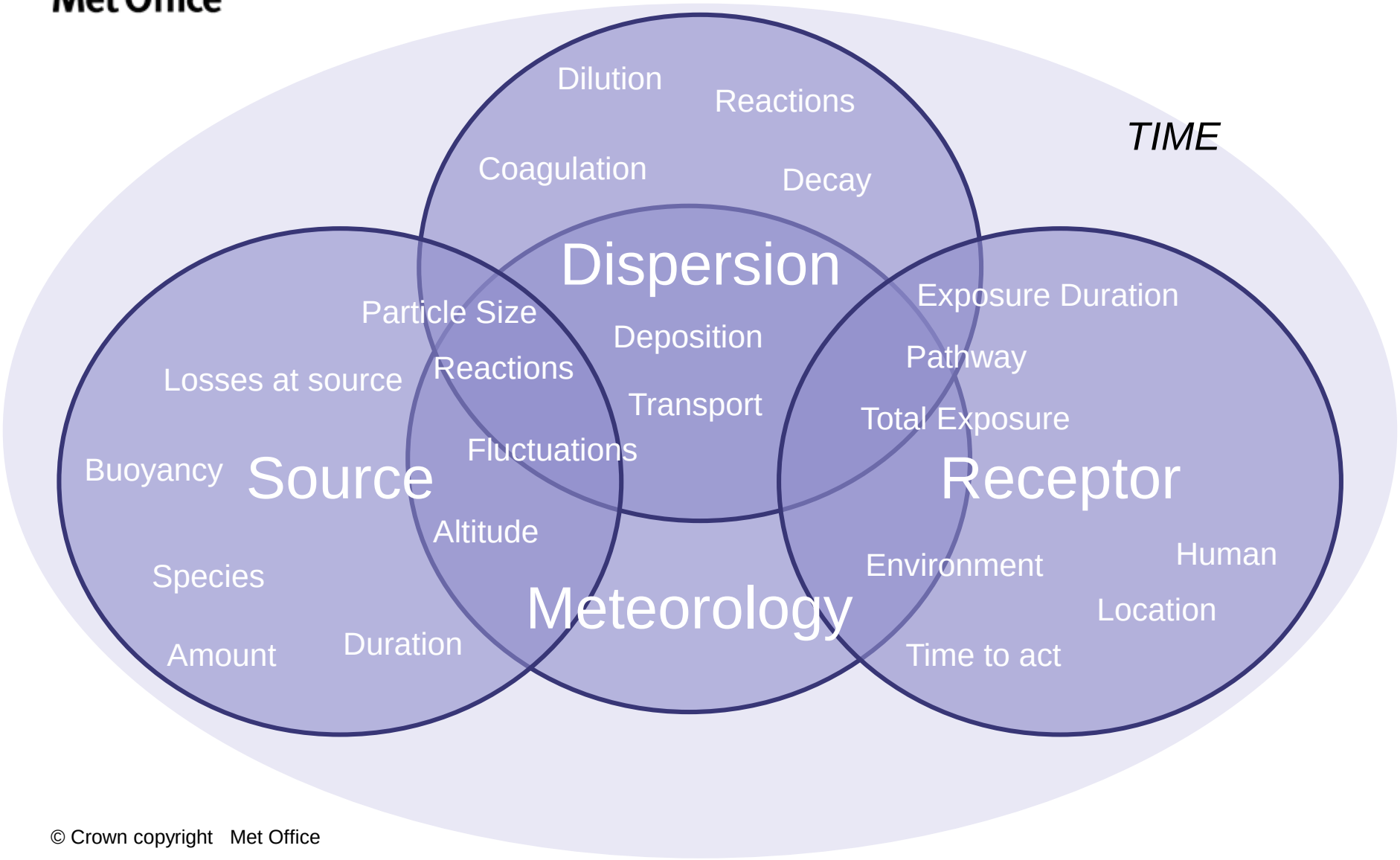
Dr Matthew Hort (Talking about the work of many others…)

Contents

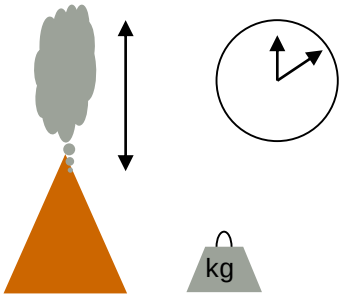
- Sources of uncertainty
- Forecast process
  - Why it is more than just modelling
- Parts of forecast chain & how uncertainty incorporated
  - Observations
  - Meteorology
  - Dispersion modelling
  - Interpretation and expert judgment
- Summary

Inputs, Processes and Outputs

a.k.a. sources of uncertainty

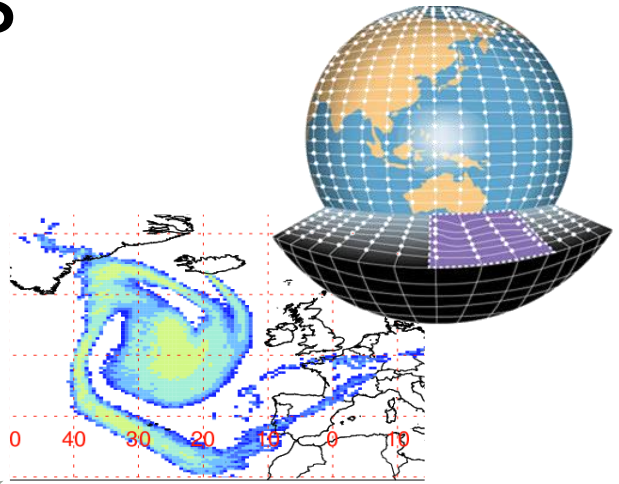


Forecast Process



Source Terms

Interpretation



Modelling

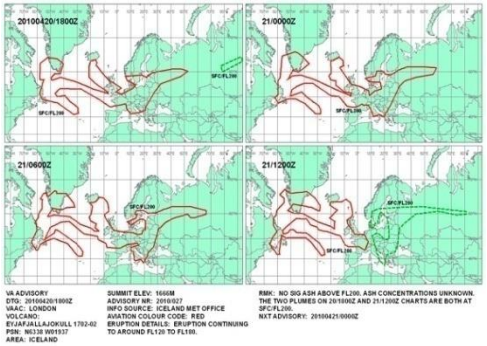
Interpretation

Interpretation

Interpretation

Interpretation

Observations



Forecast

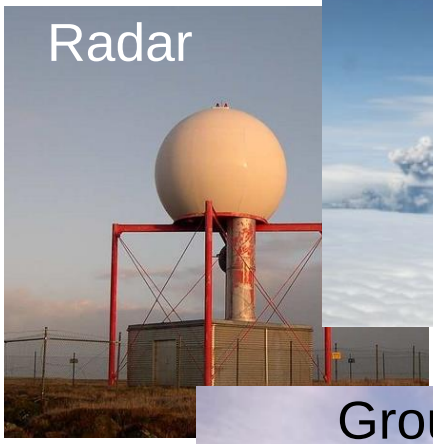
Forecast Process

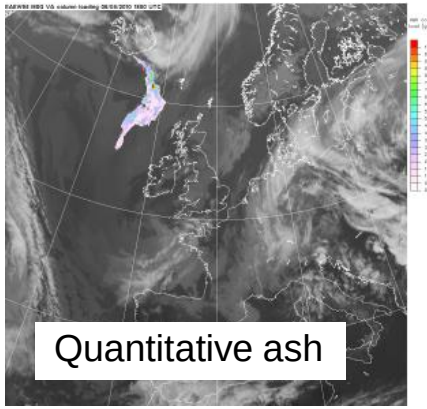
- Observations are limited
- Modelling is a simplified representation of reality
- Impacts/end users are varied
  - What is the purpose of forecast?
- Judgment and interpretation must occur at every step
  - Requires information and expertise
  - London VAAC process is a collaborative team approach

HANDLING SOURCES OF UNCERTAINTY

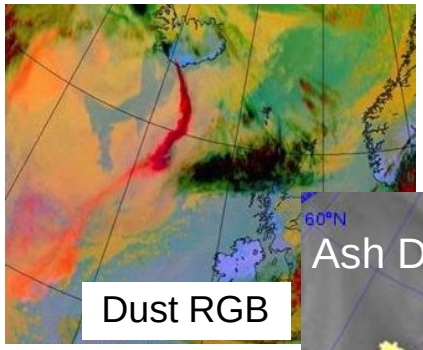
Observations

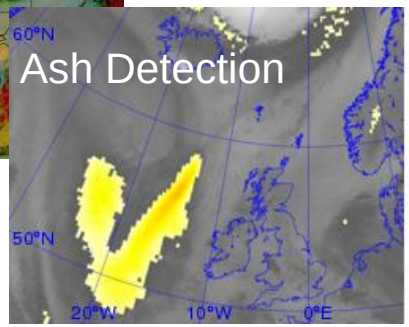
Multi-layered

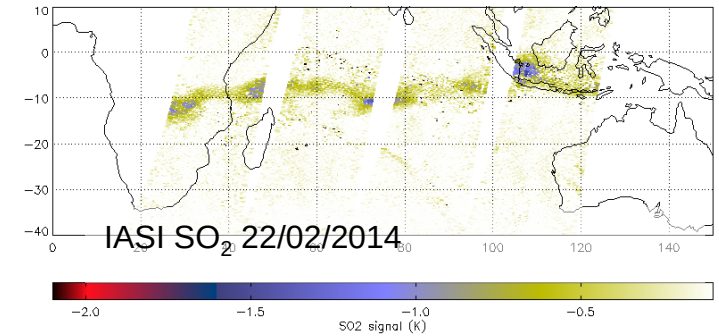


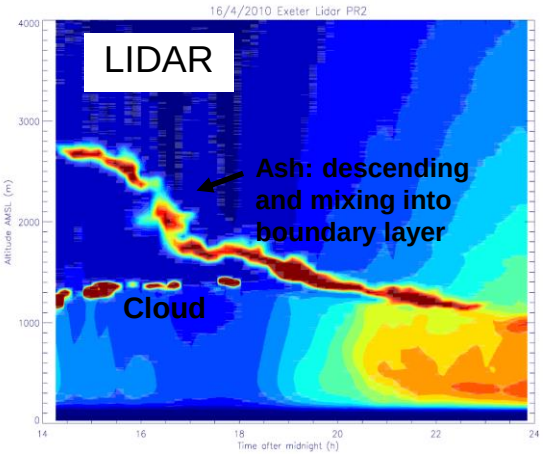


Satellite

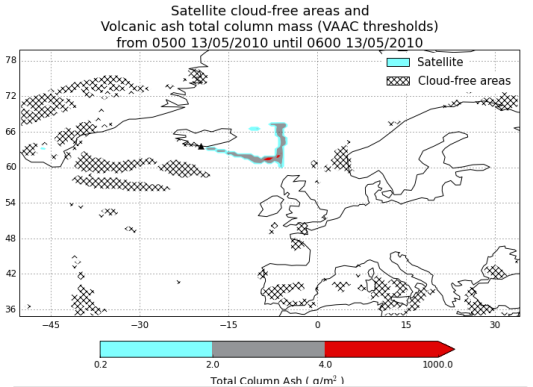








Source Term Uncertainty



Changing size distribution

Coarse

Default

Fine

1.7%

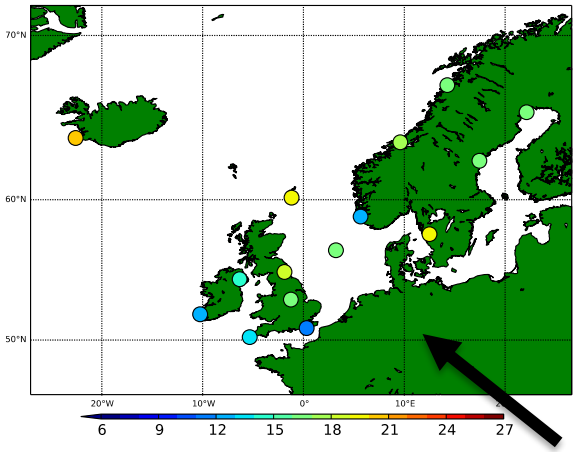
5%

15%

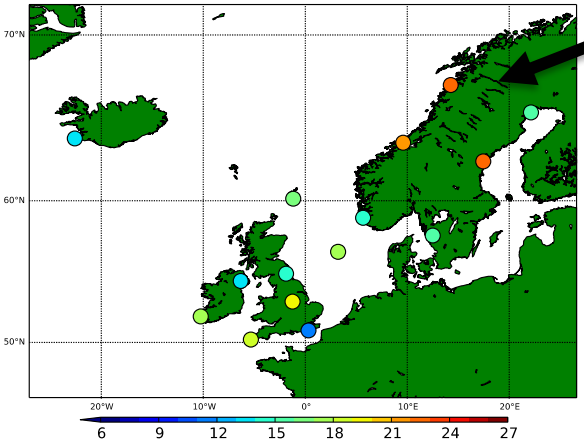
Changing mass fraction

Meteorological Uncertainty

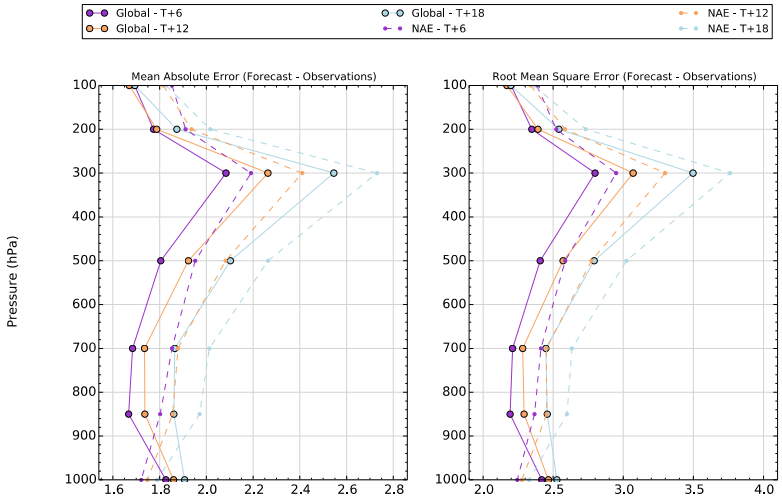
Systematic Analysis



RMSE of wind direction @ 300 hPa for 2010 and 2015



Wind speed (m/s) for 2010 Combined Stations



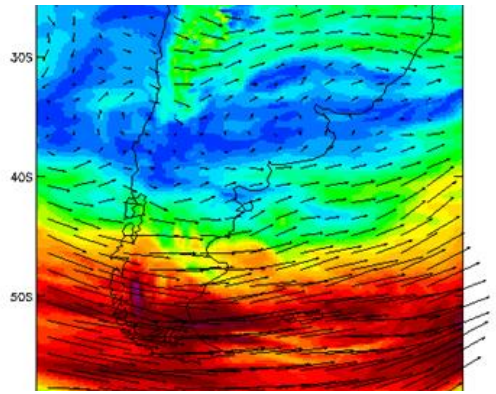
"UM Global model configuration has been shown to be consistently more accurate than UM LAM output at forecasting upper air winds over the area of responsibility covered by the London VAAC."

(Beckett et al 2015 – MetO Futurevolc report)

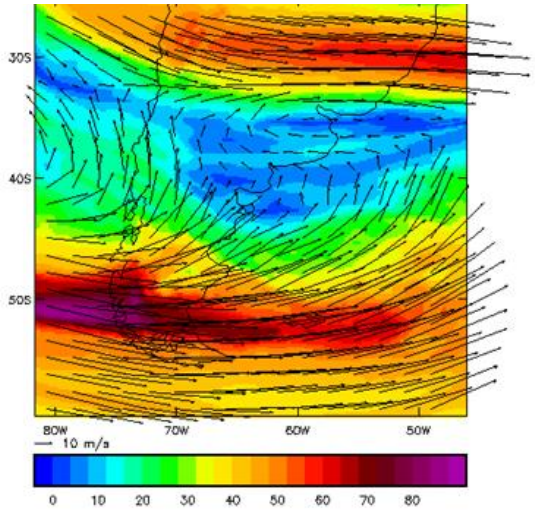
Meteorological Uncertainty

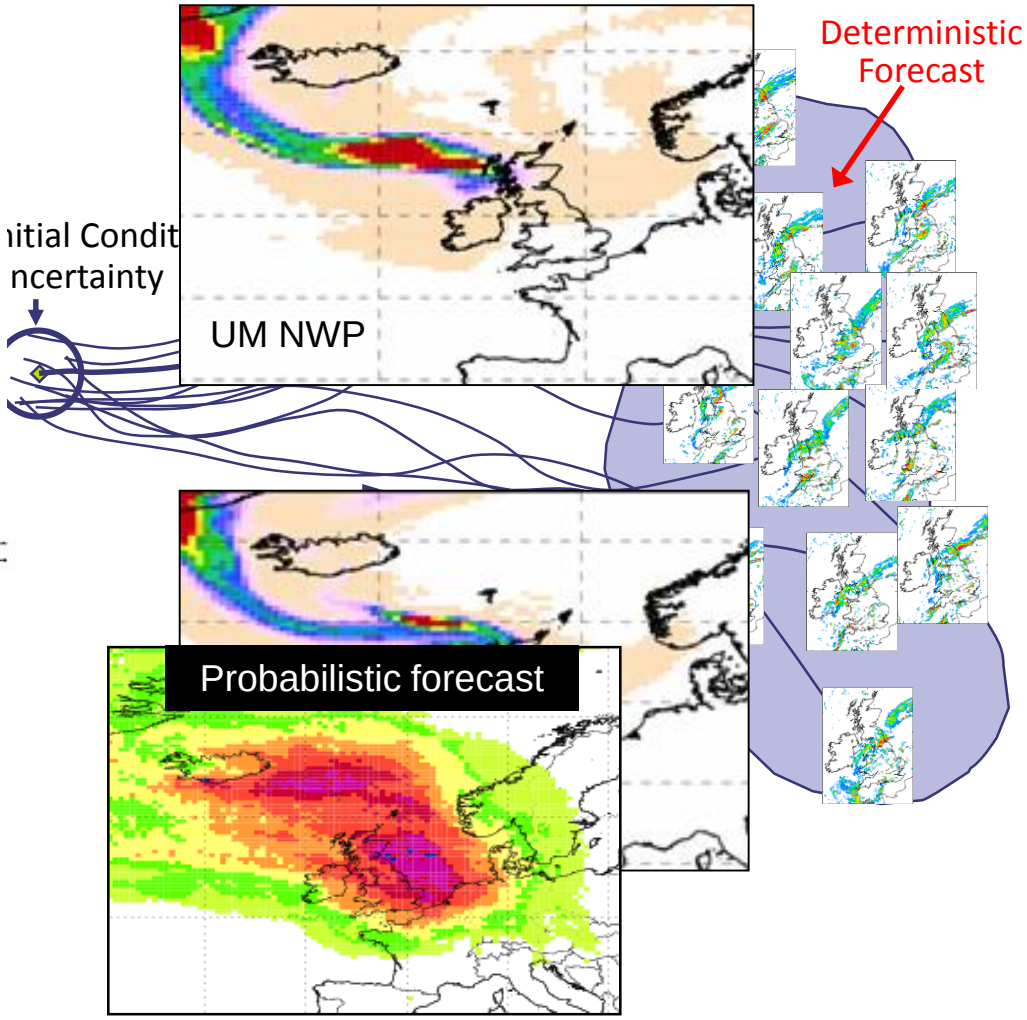
Event Analysis

Velocity @ 4330 m asl
21:00 22/04/15 from 18:00 forecast



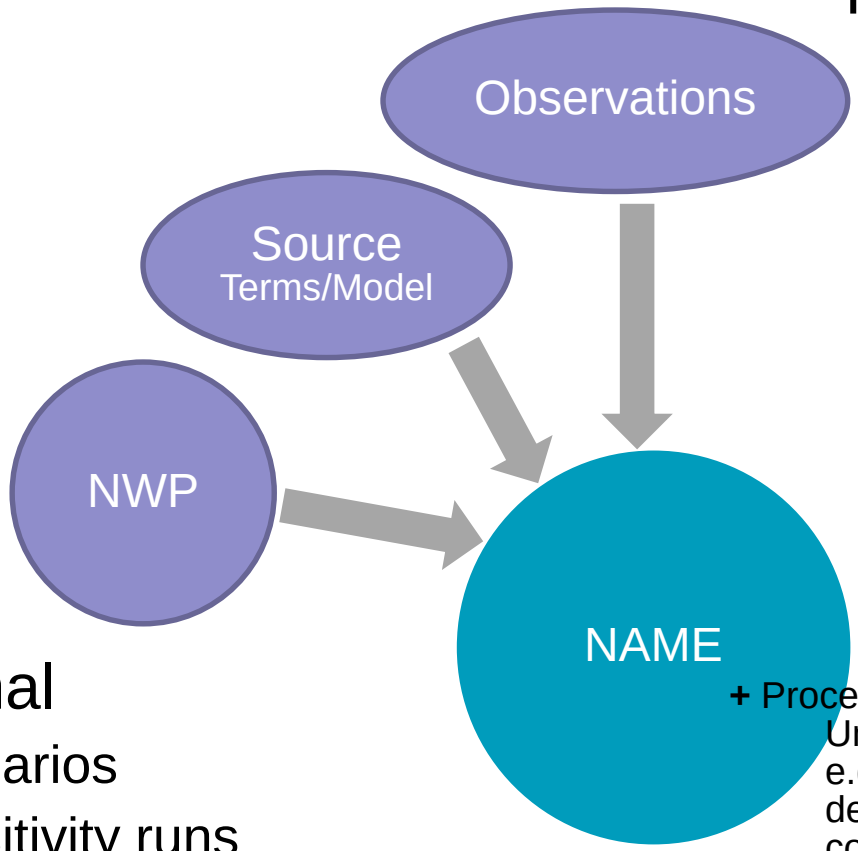
Velocity @ 10940 m asl
21:00 22/04/15 from 18:00 forecast





Dispersion Modelling

A melting pot



Research

- Particle characteristics
- Plume rise
- Free-trop turbulence
- Convection
- Validation
- etc, etc

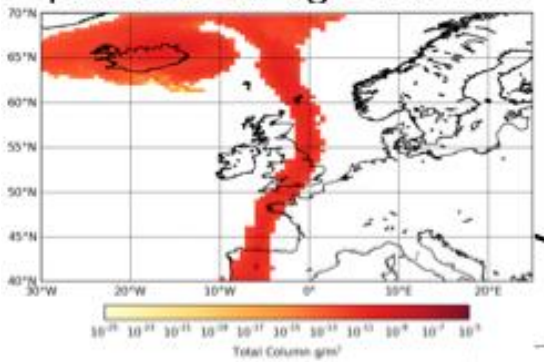
Operational

- Scenarios
- Sensitivity runs
- Multi-model ensembles
- Plume rise models

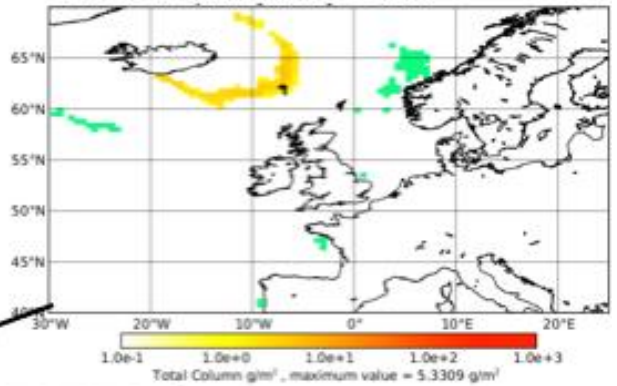
Modelling + Observations

Inversion

Example of modelled plume from 1g/s release

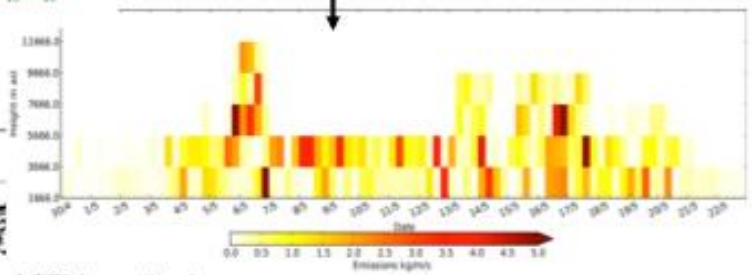


Observational Data

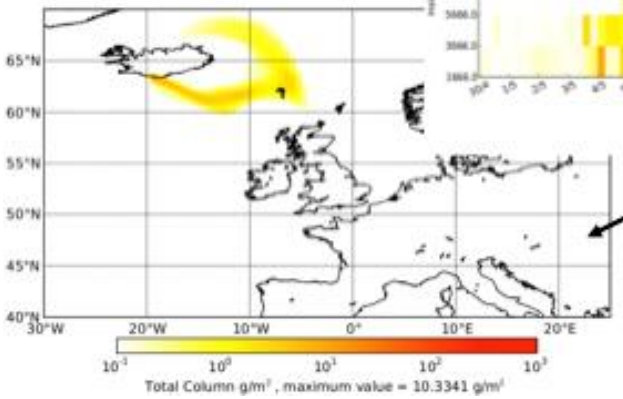


Inversion system

$\mathbf{Me} \approx \mathbf{o}_a$



New source term profile

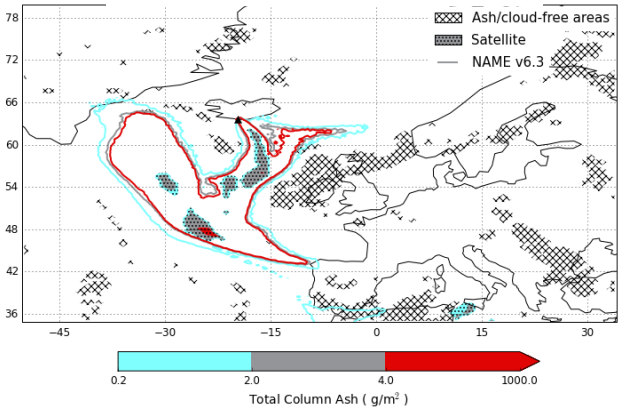


Gives a new modelled plume closer to satellite observations

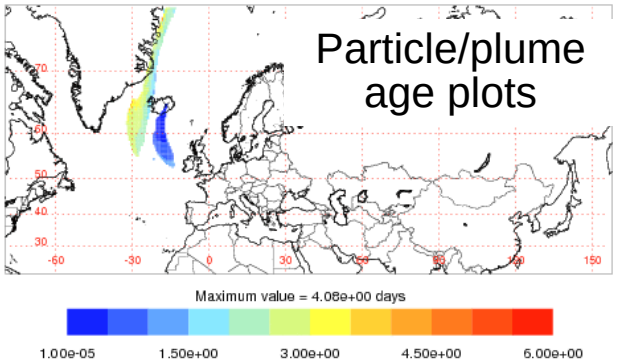
Model Visualisation

Supporting Interpretation

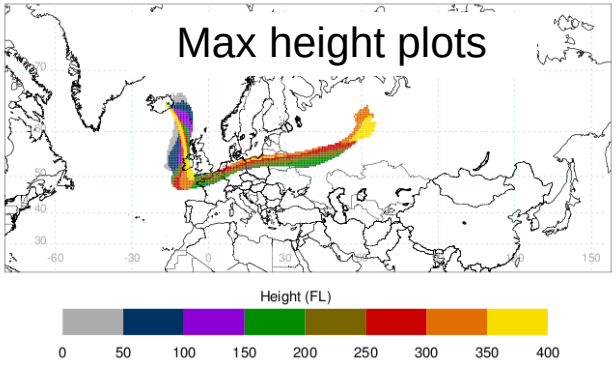
Composite

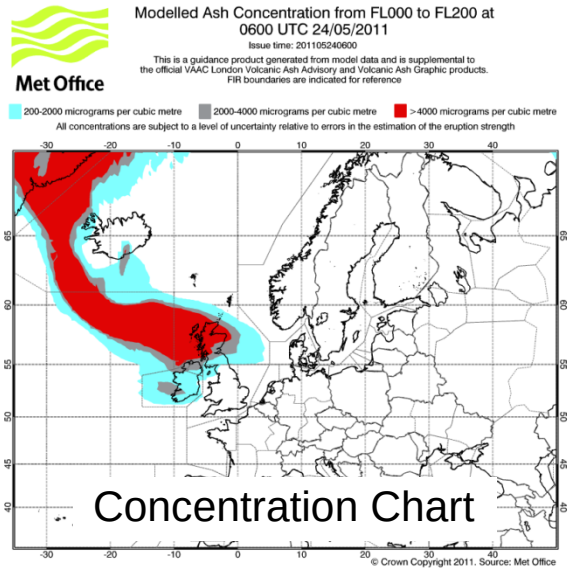


Particle/plume age plots



Max height plots

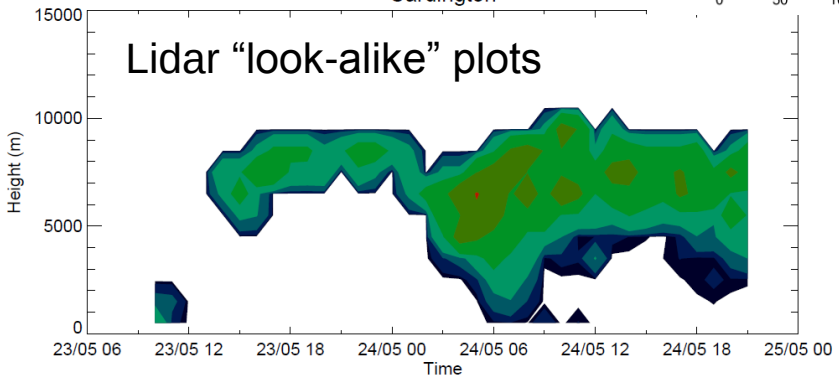


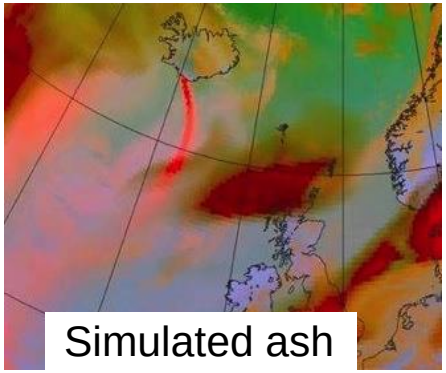


Concentration Chart

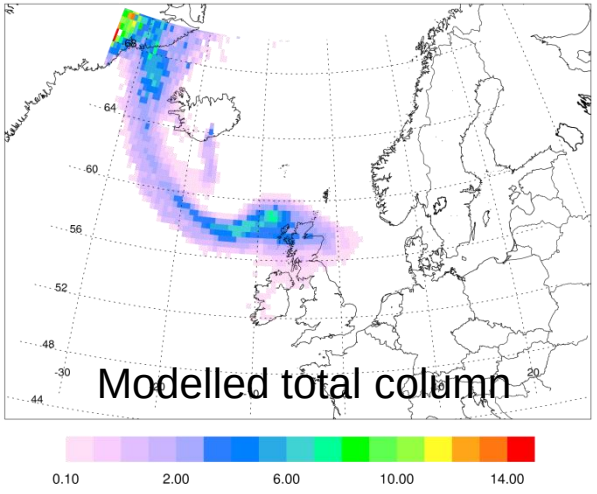
Cardington

Lidar “look-alike” plots





Simulated ash



Modelled total column

Expert Interaction

"Elicitation"

- Close links across teams within science and with operations
- Cross team training delivered between operations, science, advisors, etc
- Strong national and international links
- Example
  - Grimsvötn Advisory team
  - Focus: supporting operational changes to input parameters
  - Output: Agreed, accepted and common position

Summary

- Ongoing research vital for
  - Understanding, constraining and reducing uncertainty
  - Maintaining expert capability
- Collaboration is key
  - Subjects are wide ranging and need multi-disciplinary collaboration/understanding
  - Delivery agencies/organisations must also maintain ongoing/growing collaboration and links
- Validation – volcanic ash and wider:
  - Volcanic gas; Fukushima; biomass burning