Modeling innovations at the London VAAC

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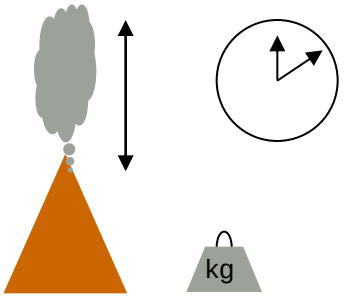
Talk Outline

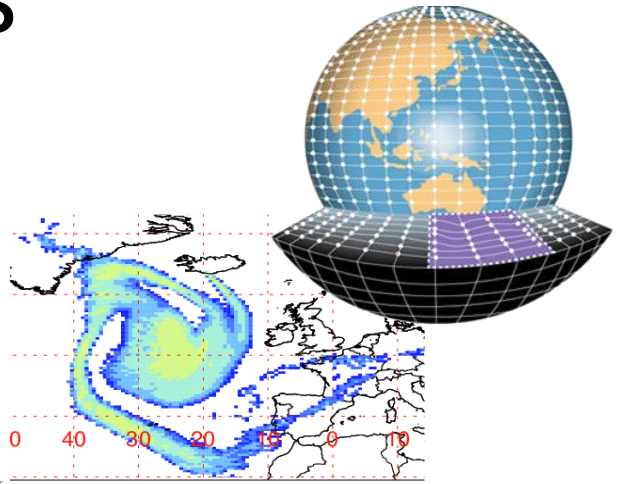
- Forecast process
- Inputs, processes and outputs
- Model developments
  - **NWP**
  - Impact of ash properties
  - Plume rise model
  - **SO_2 modelling**
  - **Inversion**
  - Improved deep convection scheme
- Uncertainty
- Summary

Forecast Process



Source Terms

Interpretation



Modelling

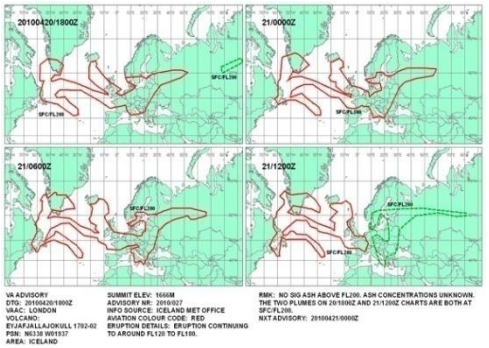
Interpretation

Interpretation

Interpretation

Interpretation

Observations

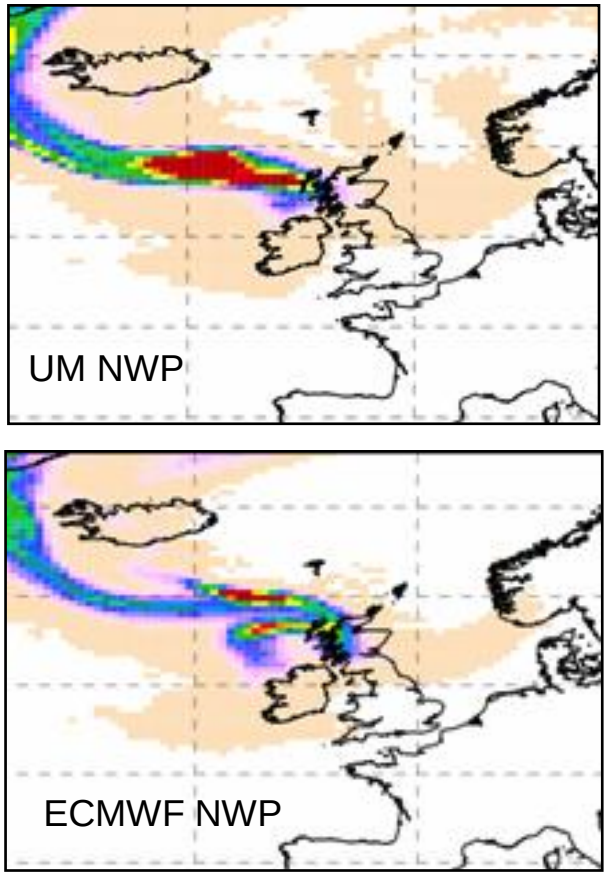


Forecast

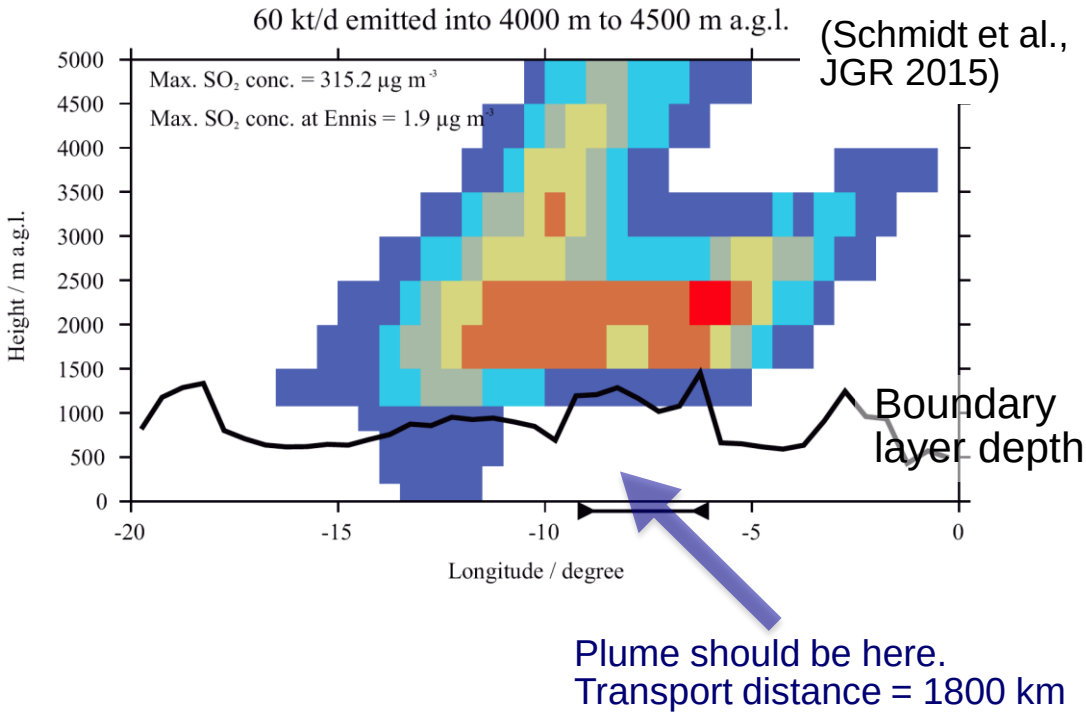
Meteorological Impact

a.k.a. why getting the weather correct is important

Grímsvötn 2011



Bárðarbunga 2014

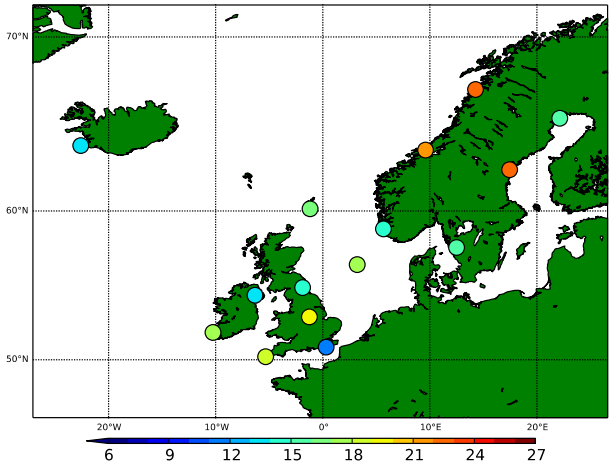


(Schmidt et al., JGR 2015)

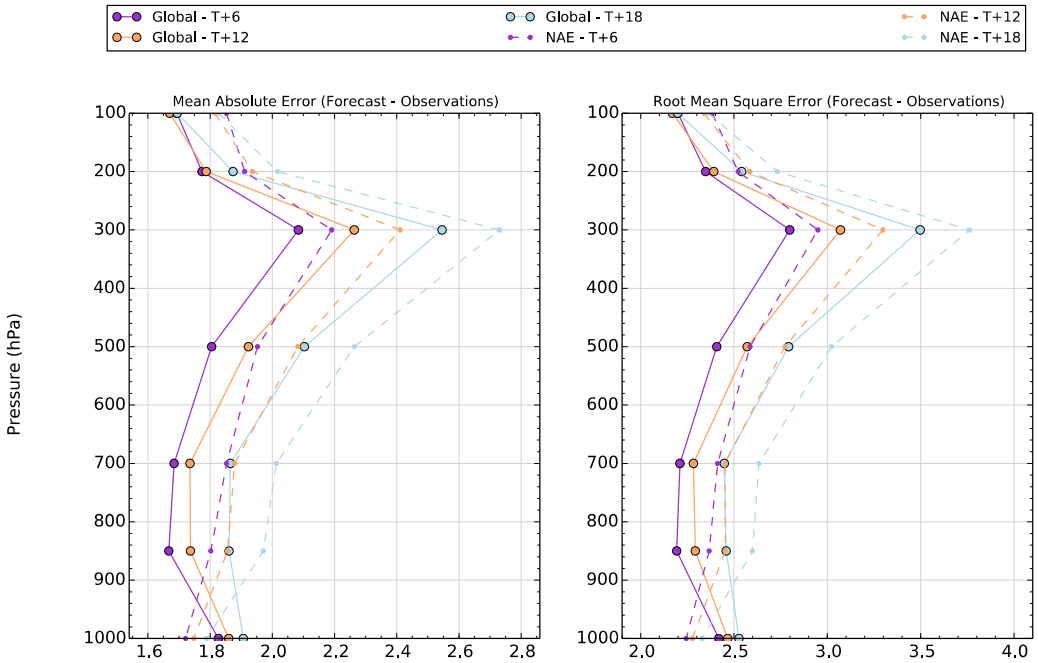
Meteorology

Evaluation of Skill

RMSE of wind direction @ 300 hPa for 2015



Wind speed (m/s) for 2010 00Z and 12Z sondes

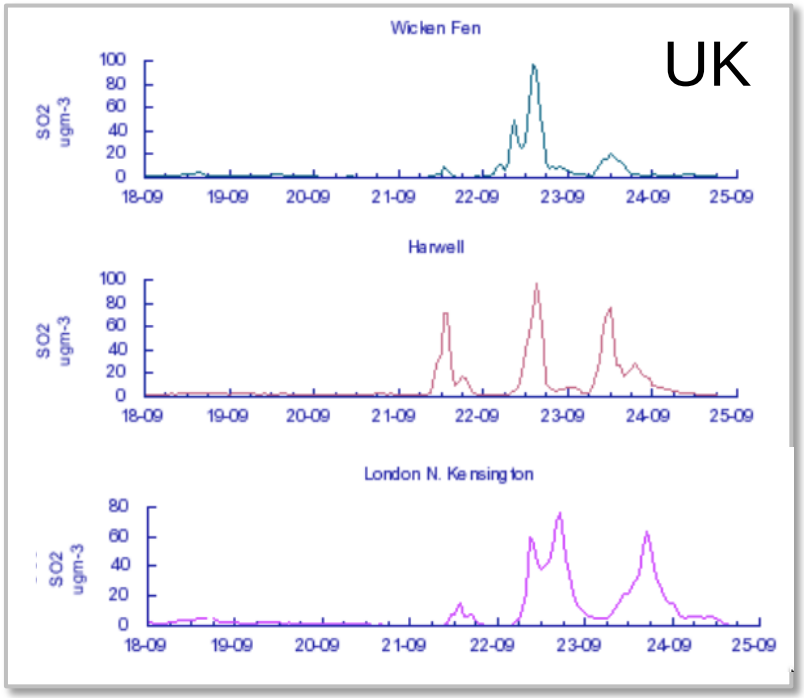


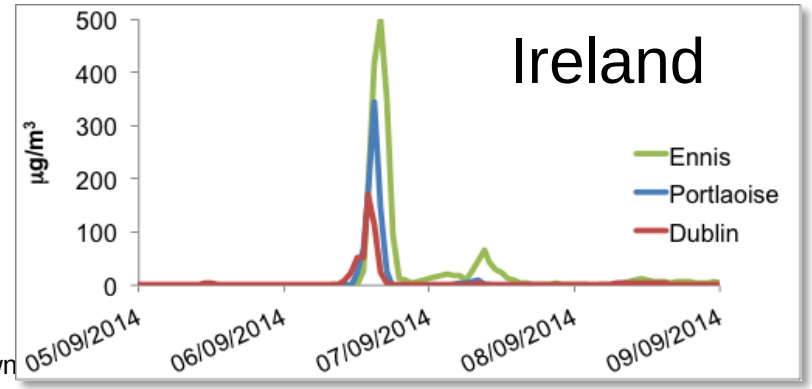
"UM Global model configuration has been shown to be consistently more accurate than UM LAM output at forecasting upper air winds over the area of responsibility covered by the London VAAC."

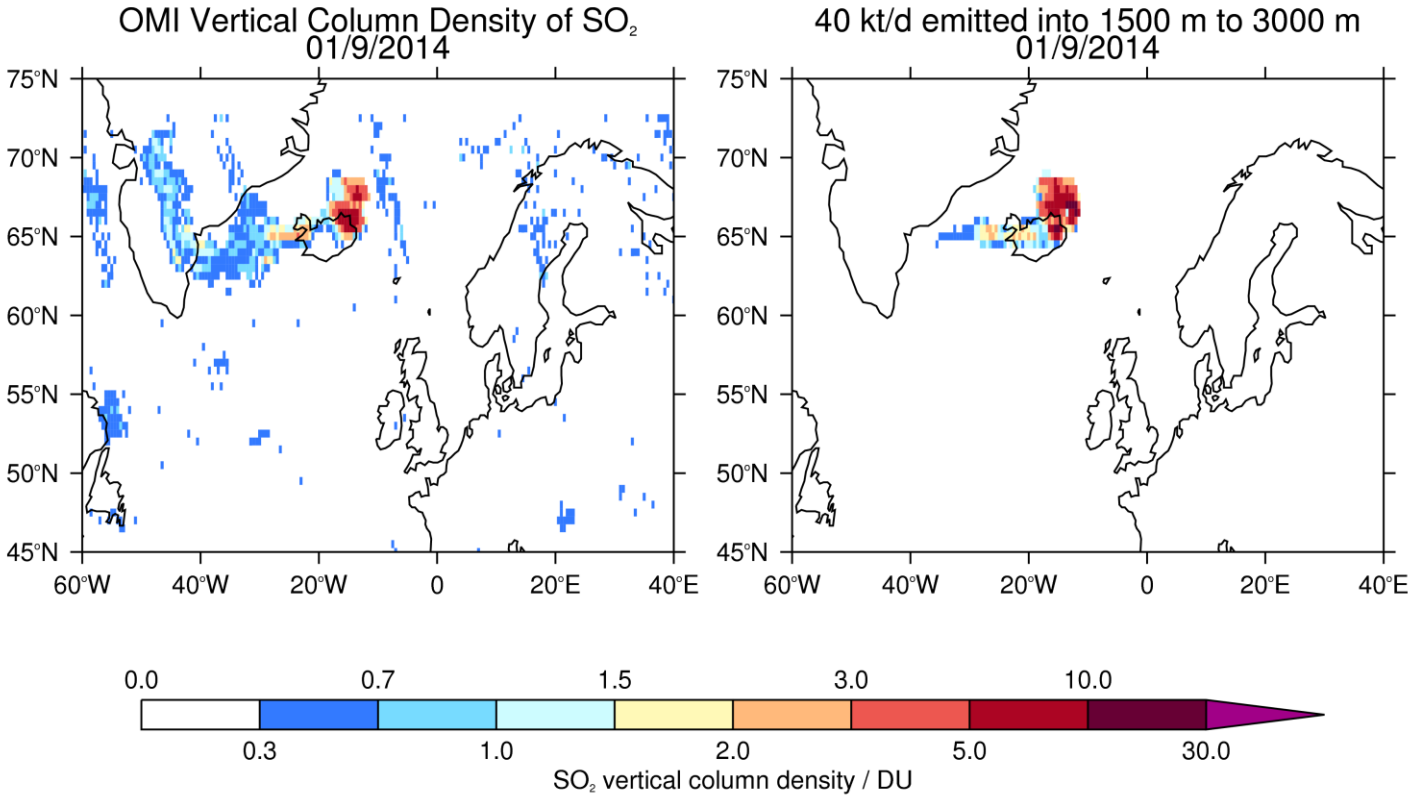
(Beckett et al 2015 – MetO Futurevolc report)

SO_2 Modelling

- Why:
  - Considered a UK National Risk (Laki 1783)
  - Aviation ‘interest’
  - Another source of verification/testing
- Bárðarbunga
  - UK government interest
  - Great modelling/observation opportunity



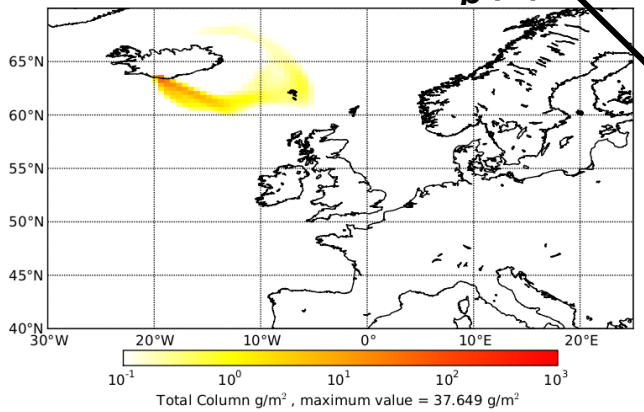



OMI Vertical Column Density of SO2
01/9/2014
40 kt/d emitted into 1500 m to 3000 m
01/9/2014
75°N
70°N
65°N
60°N
55°N
50°N
45°N
60°W
40°W
20°W
0
20°E
40°E
0.0
0.3
0.7
1.0
1.5
2.0
3.0
5.0
10.0
30.0
SO2 vertical column density / DU

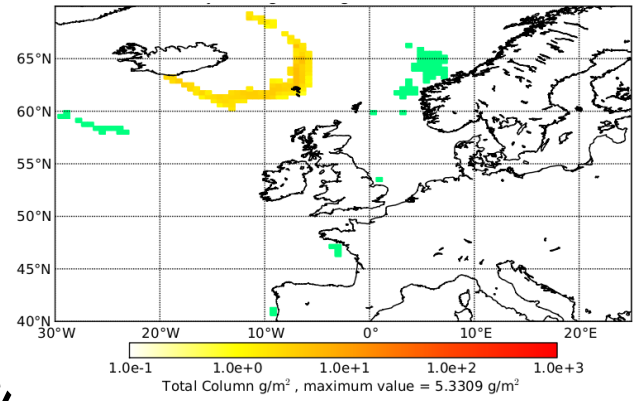
Inversion

Making model = Observations (sort of)

Model predicts observations as function of **e**: $\boldsymbol{o_p(e)}$



Observational Data (satellite column loads)

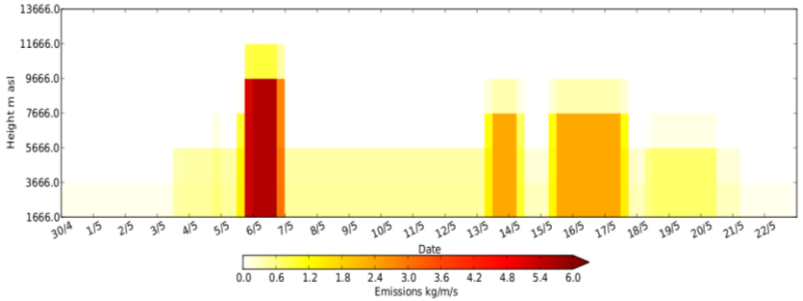


$$\boldsymbol{o_p(e) \approx o_a}$$

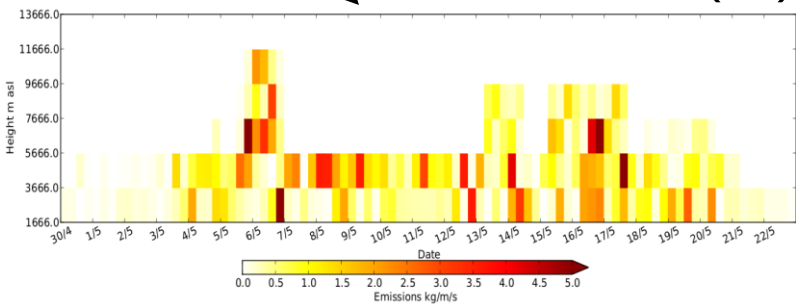
$$\boldsymbol{e \approx e_{ap}}$$

Inversion calculation

A priori view of emissions $\boldsymbol{_{ap}}(z,t)$ (from plume rise height)

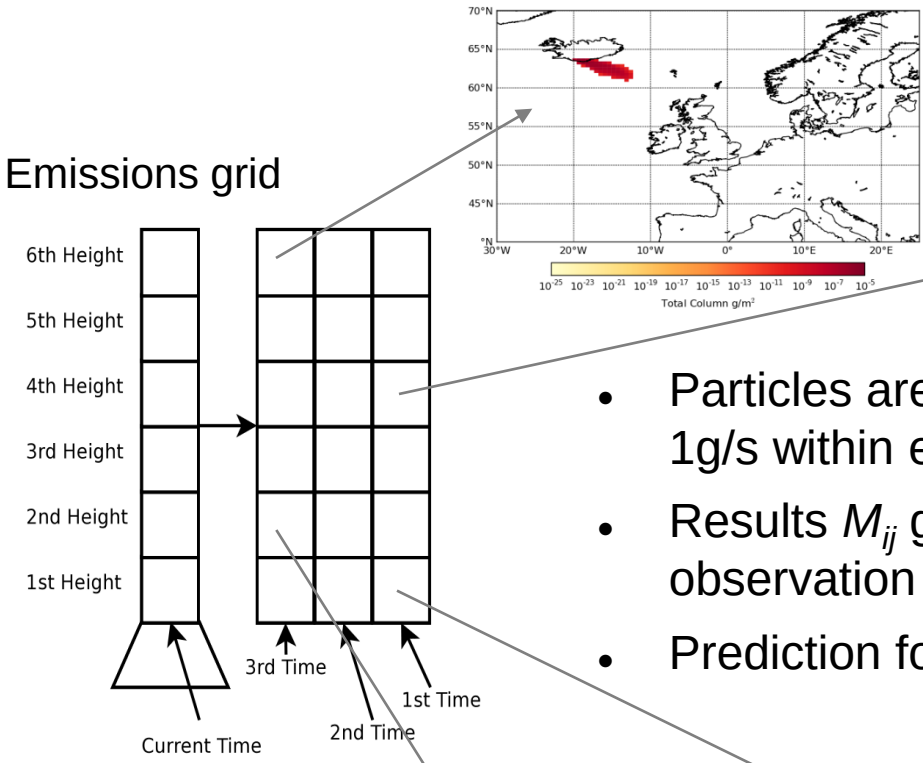


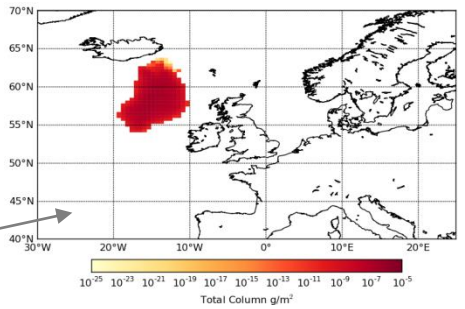
Best fit estimate of emissions **e**(z,t)



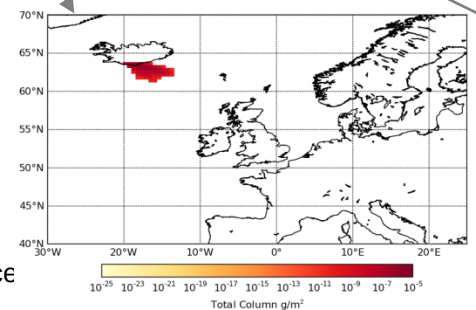
Inversion

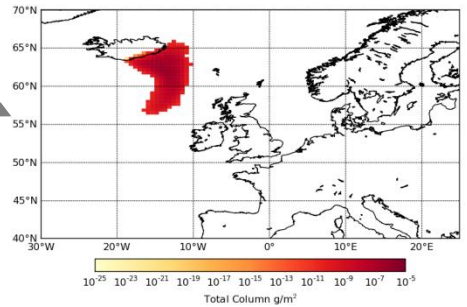
Model predictions of observations: $\boldsymbol{o_p(e)}$





- Particles are released from the volcano at a rate of 1g/s within each height block.
- Results M_{ij} give column load prediction for observation *i* resulting from emission from source *j*
- Prediction for arbitrary source vector ***e*** is then ***Me***

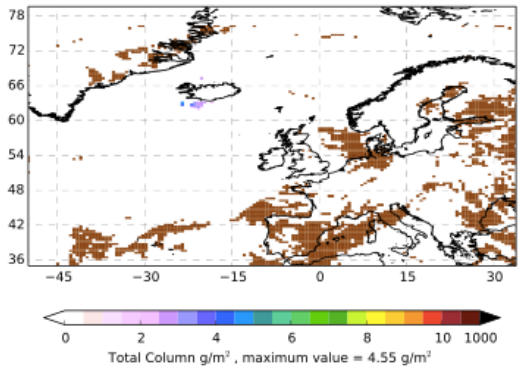




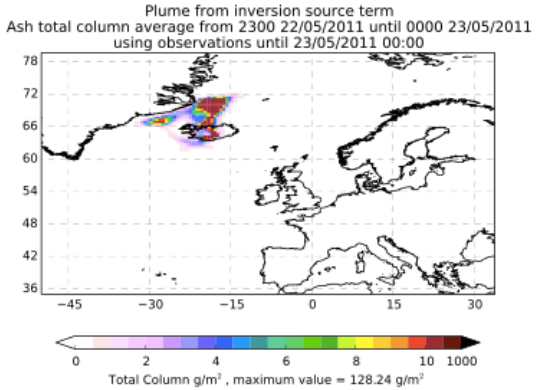
Grimsvotn Results

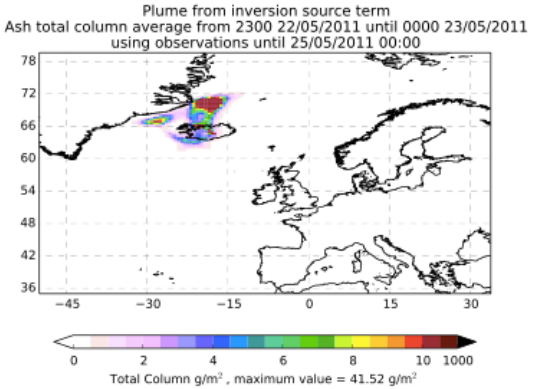
Images for 2200 22/05/11 → 0000 23/05/11

Satellite ash and clear sky

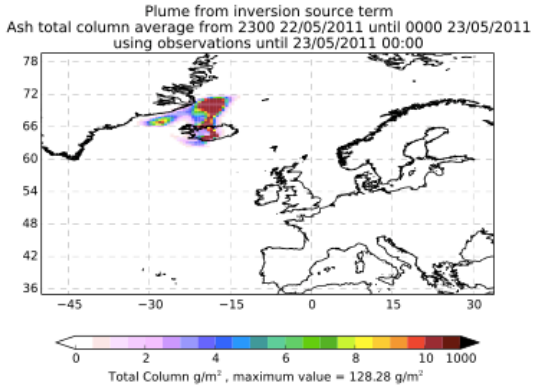


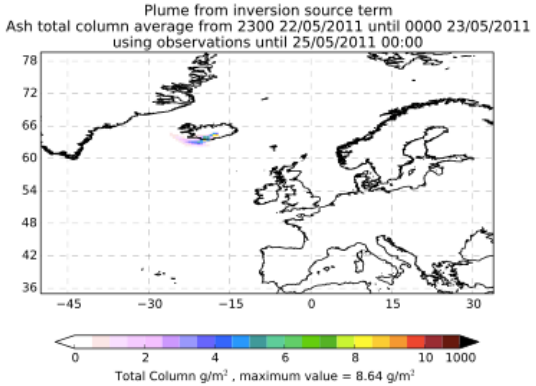
Ash only inversion





Ash+clear sky inversion

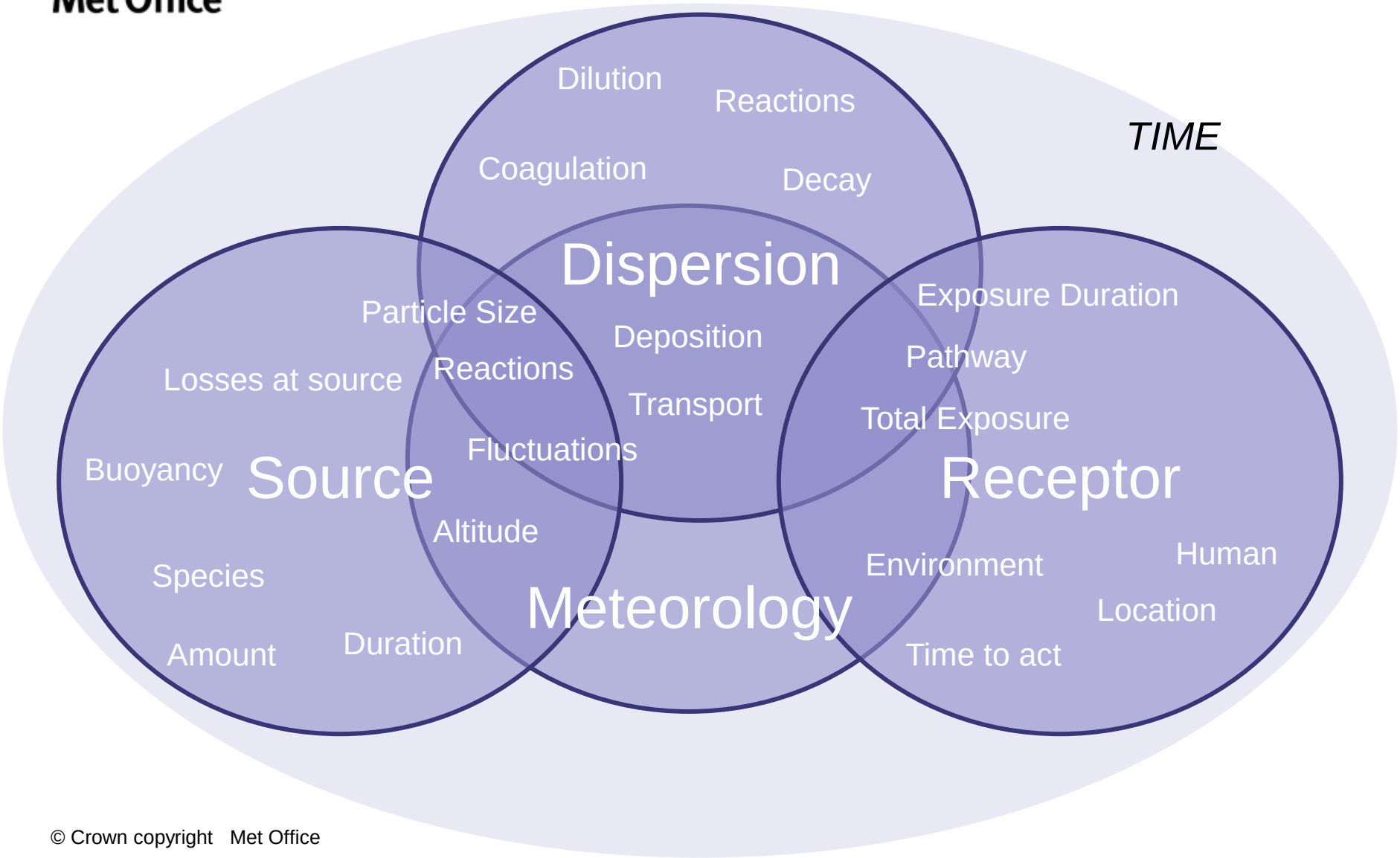




HANDLING SOURCES OF UNCERTAINTY

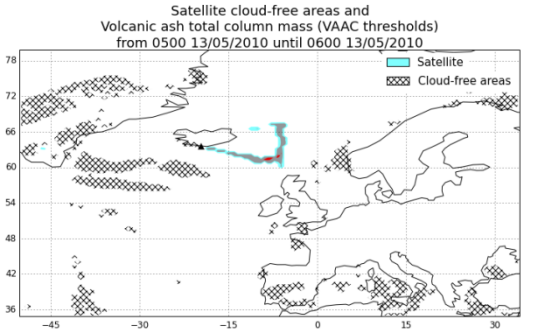
Inputs, Processes and Outputs

a.k.a. sources of uncertainty



Uncertainty

Explicit Representation



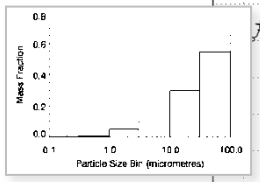
Probabilistic forecast

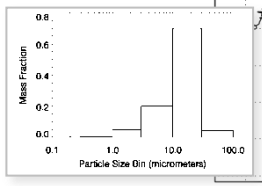
Changing size distribution

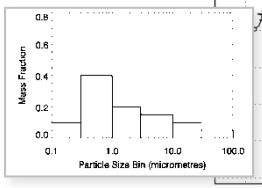
Coarse

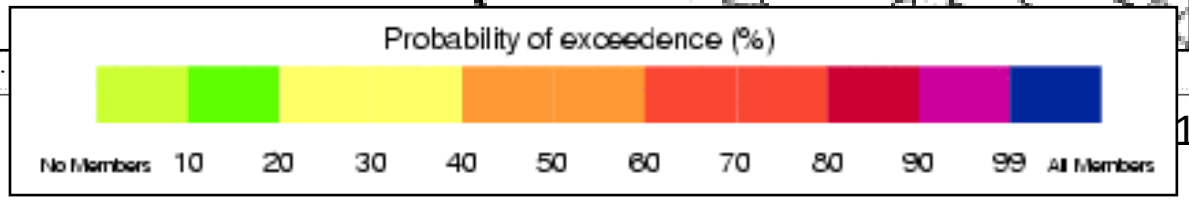
Default

Fine









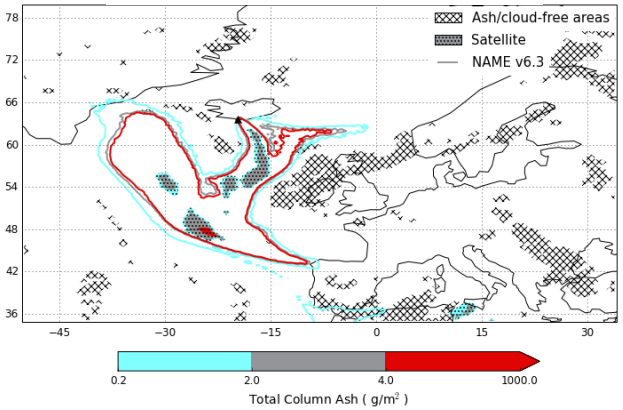
15%

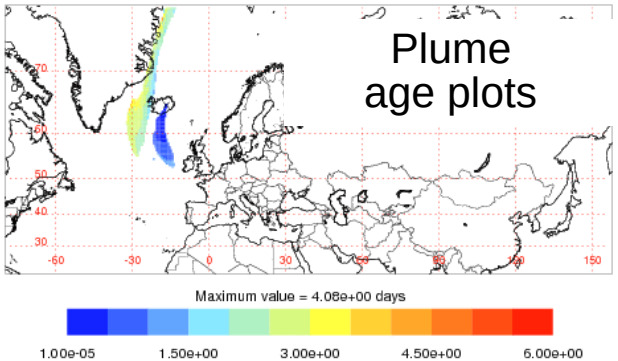
Changing mass fraction

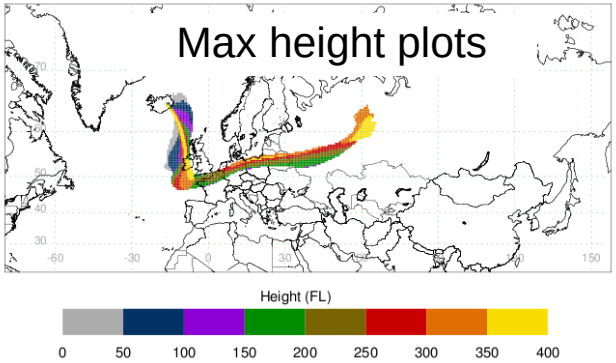
Model Visualisation

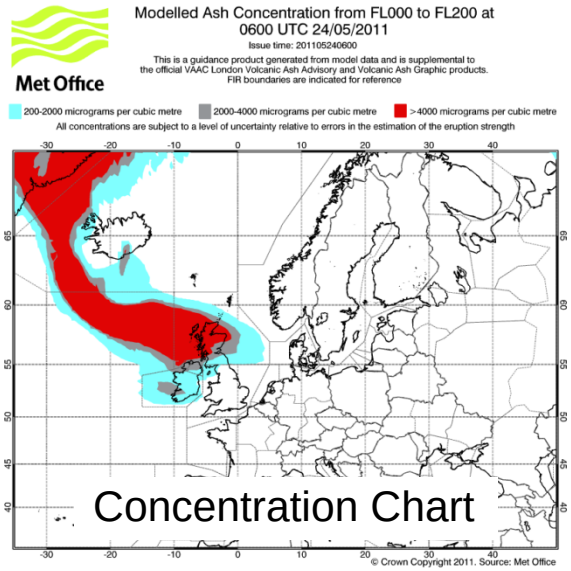
Supporting Interpretation

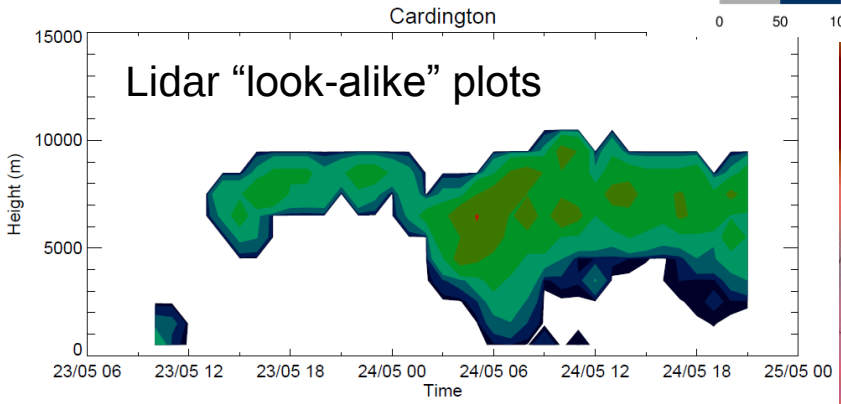
Composite

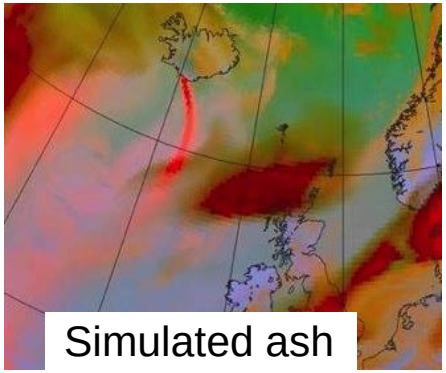


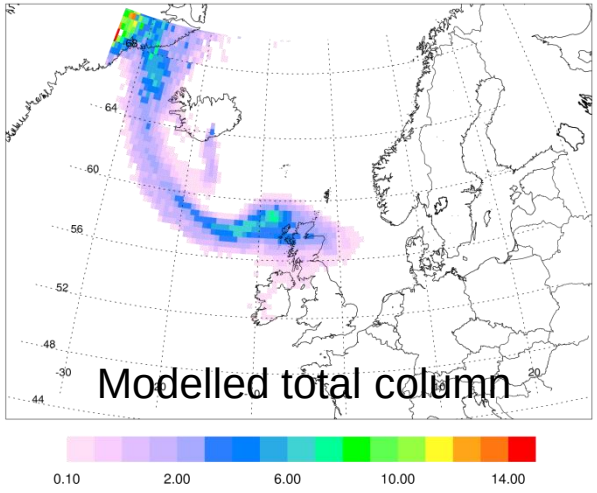












Expert Exchange/Elicitation

- Close links across science and operations
- Cross team training
- Strong national and international links
- Focused science input e.g. Grimsvötn Advisory team
  - Make up: MetO science and academia
  - Focus: supporting operational changes to input parameters
  - Output: Agreed, accepted common position

Summary

- Ongoing research vital for
  - Understanding, constraining and reducing uncertainty
  - Advancing 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
- Operational use presents additional challenges for science