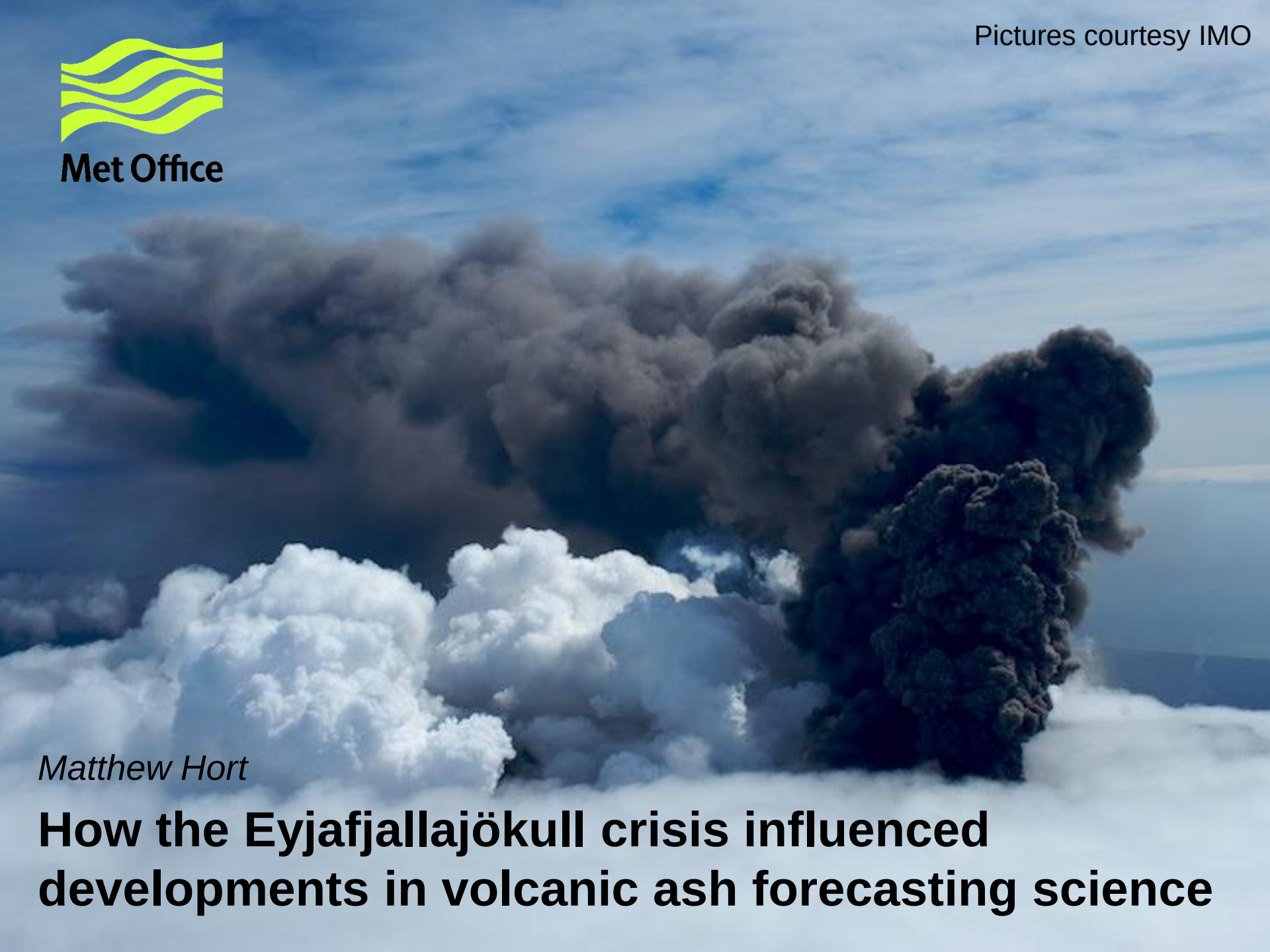


Pictures courtesy IMO

Matthew Hort

How the Eyjafjallajökull crisis influenced developments in volcanic ash forecasting science

Outline

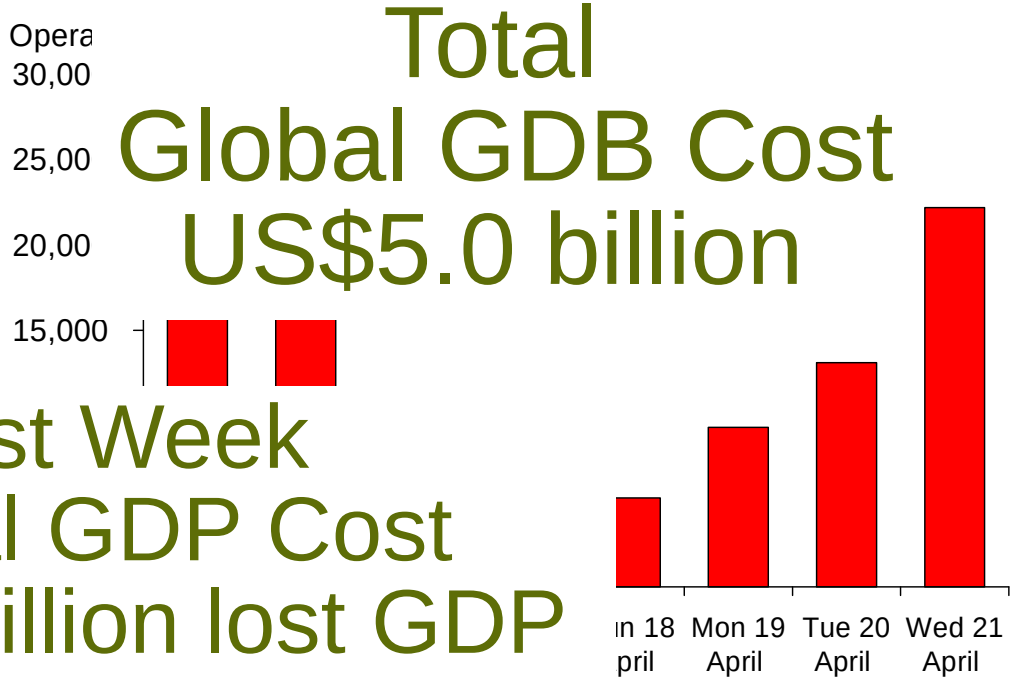
- Very brief 2010 recap
- Heighted activity
- The challenge
- Forecasting developments
  - Scince and operations
- The legacy
- Ongoing steps and challenges

The Crisis


CANCELLED
CANCELLED
CANCELLED
CANCELLED
CANCELLED
FLIGHTS FROM ALL UK
AIRPORTS ARE DISRUPTED
DUE TO VOLCANIC ASH.
PASSENGERS ADVISED TO
CHECK WITH THEIR AIRLINE.

Some numbers

Figure 1-1: European Flights Operating



Source : Eurocontrol

Total
Global GDB Cost
US$5.0 billion

First Week
Global GDP Cost
US$4.7 billion lost GDP

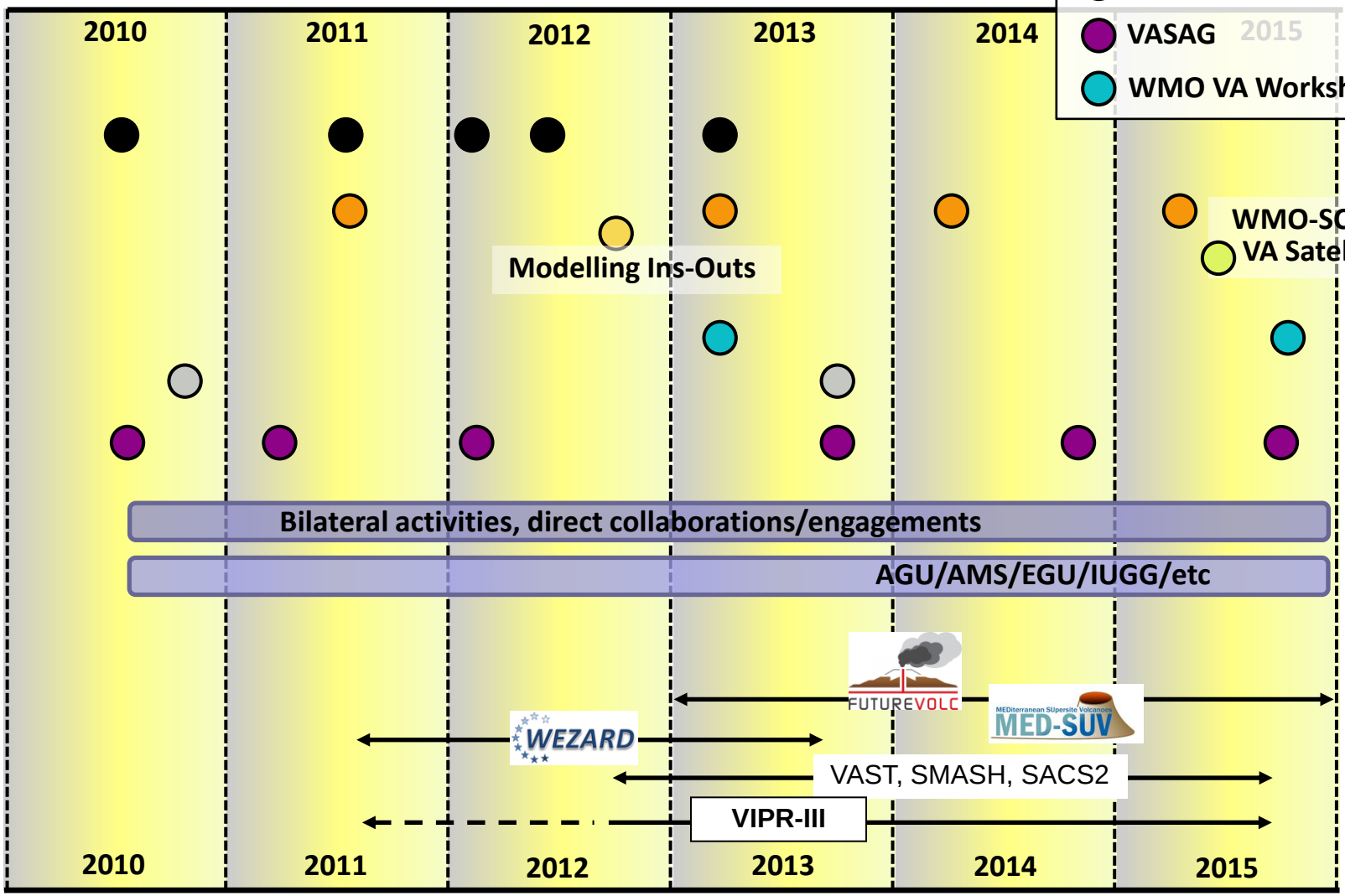
First Week
Aviation Sector Costs
US$2.2 billion

Quantifying the hazard

- Europe moved to concentrations
  - Aim– to allow more flights though more information
  - Implemented in haste
  - Widely discredited as a viable operational approach
- Quantitative science and engineering clearly has value though….
- Outcome
  - Science, engineering, operations, regulators all thinking anew about the challenge
- Similar potential disruption will happen again
  - No field of human activity has ever benefited form standing still

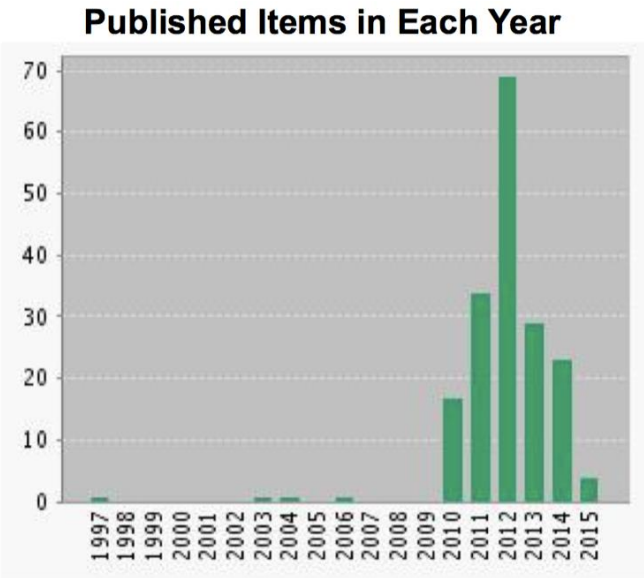

Met Office
A HEIGHTENED STATE OF ACTIVITY

A Busy Time

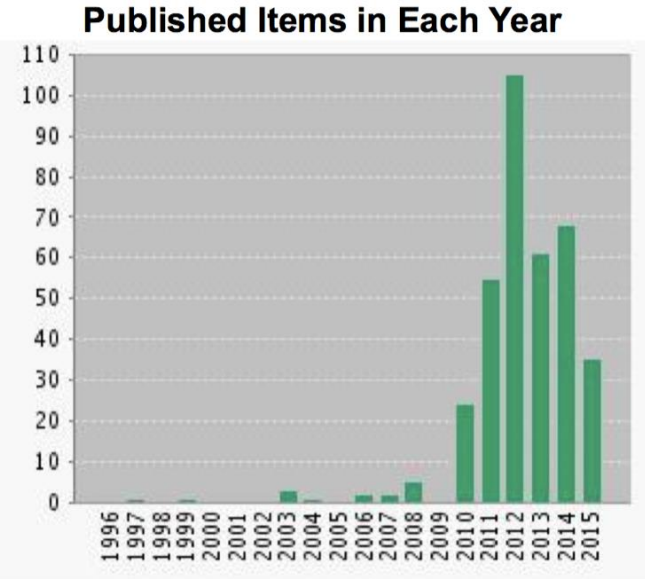


A Busy Time

Papers by title: “Eyjafjallajökull”



Papers by topic: “Eyjafjallajökull”



Numbers from Web Of Science search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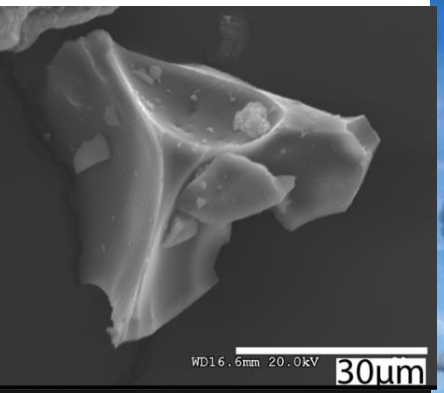
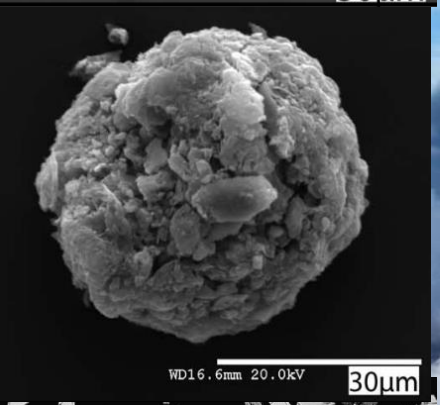
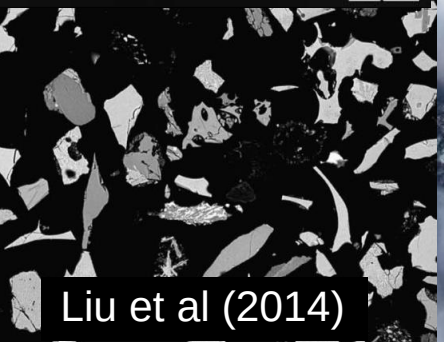
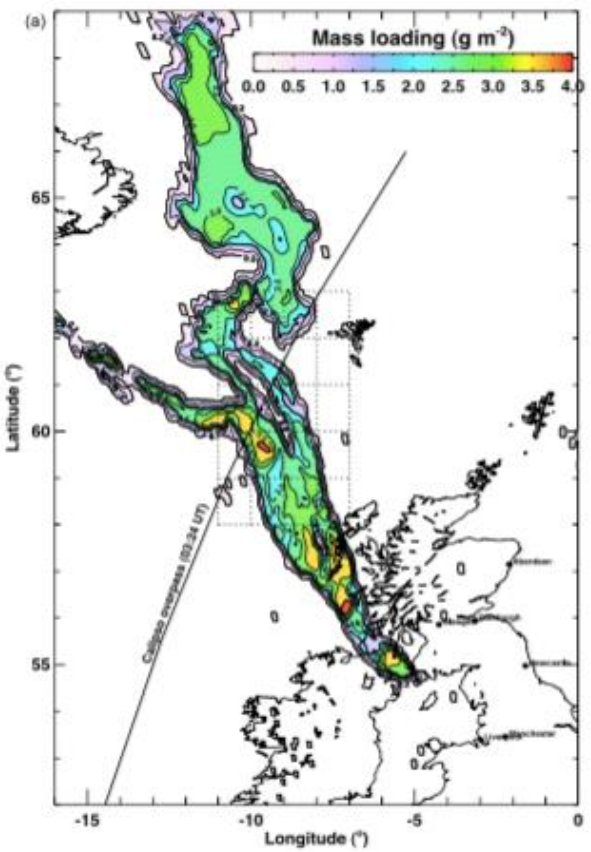
THE CHALLENGE

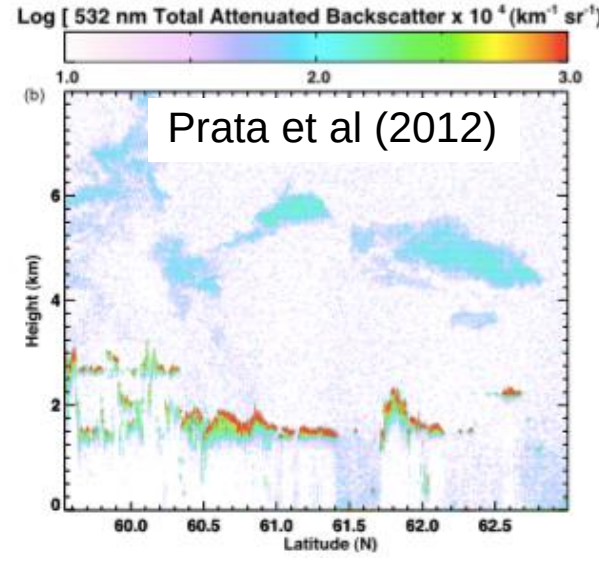
Met Office






Liu et al (2014)





Prata et al (2012)

Themes & Recommendations

IUGG-WMO 2010 & 2013; VAAC modelling; VAAC BP, etc

Collaboration

Communications

Dispersion model improvements

More NRT observations

Inversion / Data Assimilation

Source terms:
observations and modelling

Model validation

Probabilistic modelling

Quantitative
observations + modelling
is way forward

NWP

Understand & reduce uncertainty
In observations and modelling

Communication of uncertainty

Re-suspension

Need too quantify hazard to engines

Volcanic Gasses i.e. SO_2

Data on aircraft encounters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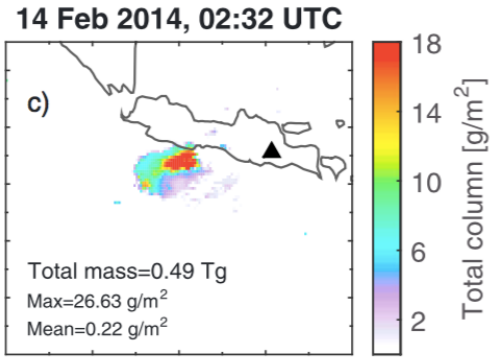
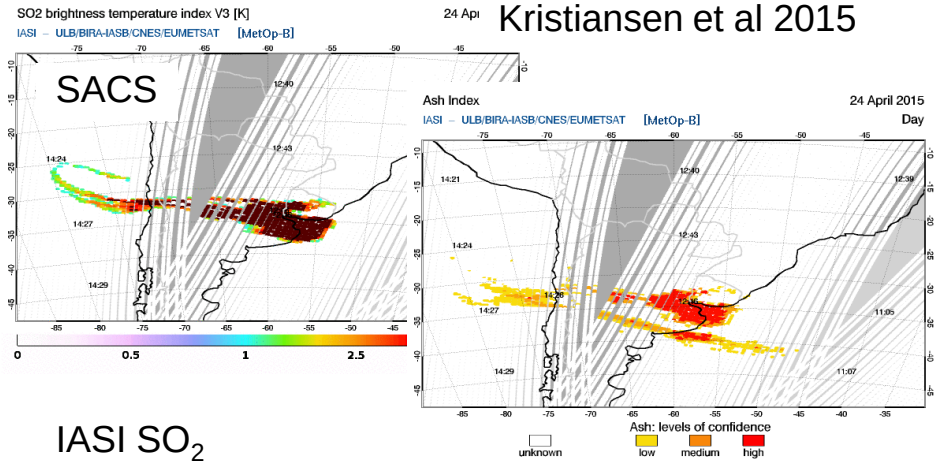
Some developments
SCIENCE

Observations

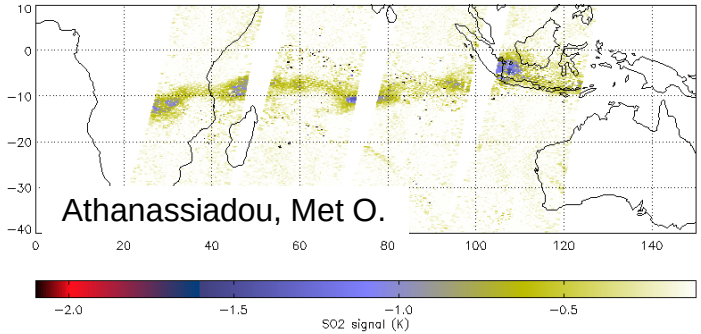
Met Office

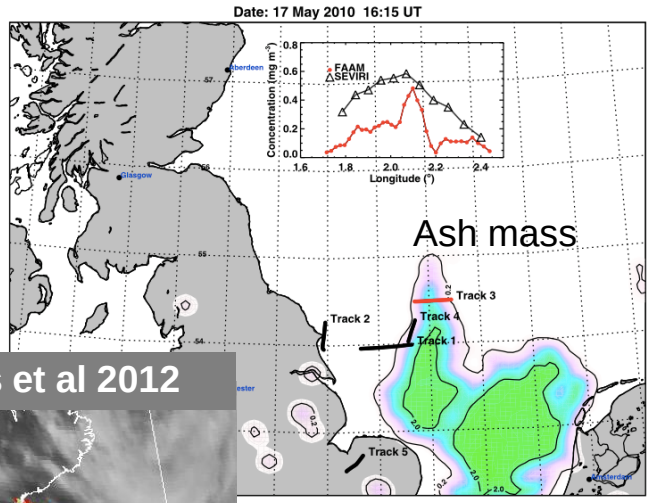


Kristiansen et al 2015

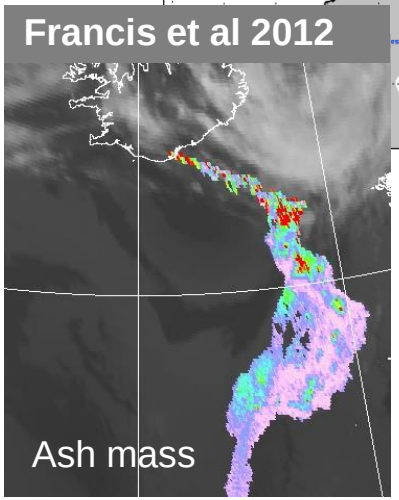


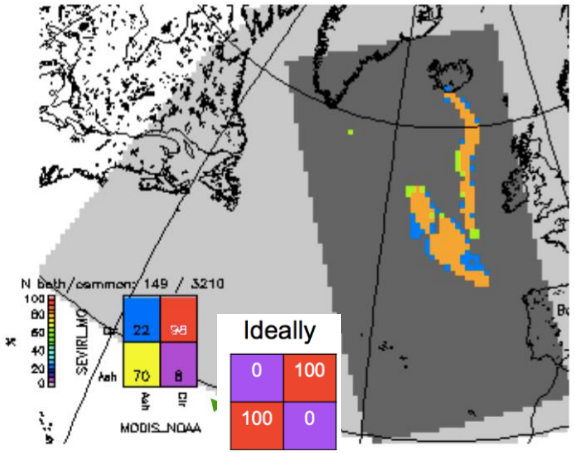
IASI SO_2





Prata et al 2012





WMO SCOPE: VA Satellite Inter-comparison (Pavolonis et al)

Observations

Met Office

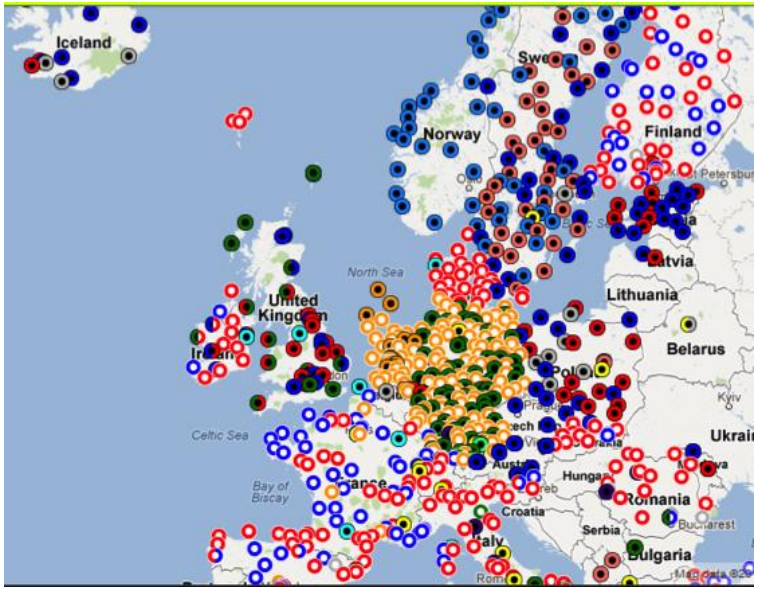
Aircraft

DLR

Dusseldorf University

Met O

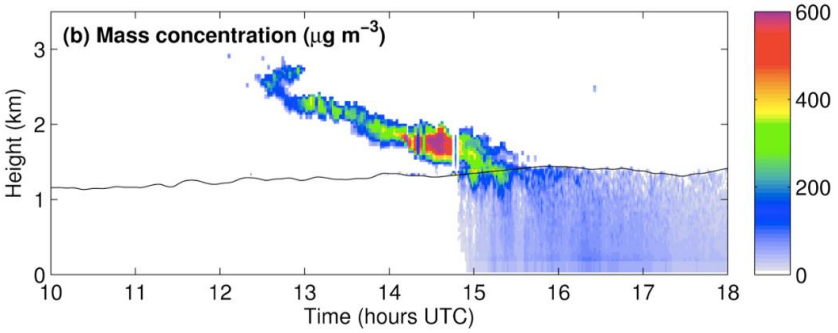
Ceilometers and LIDAR

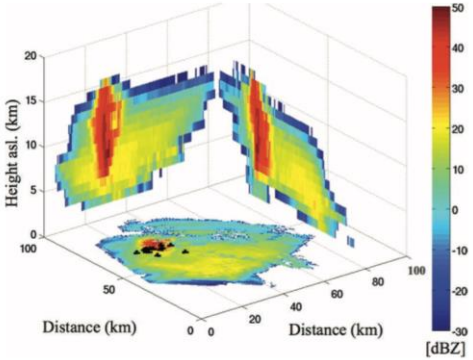


Radar

New sensors

ZEUS sensor



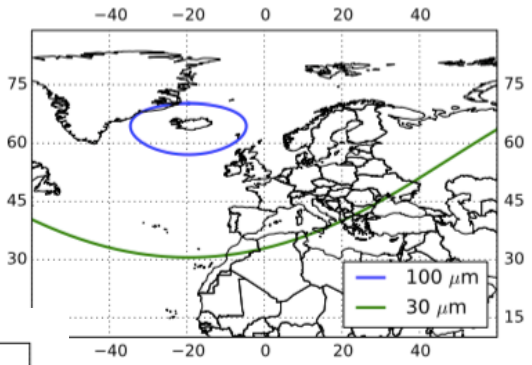


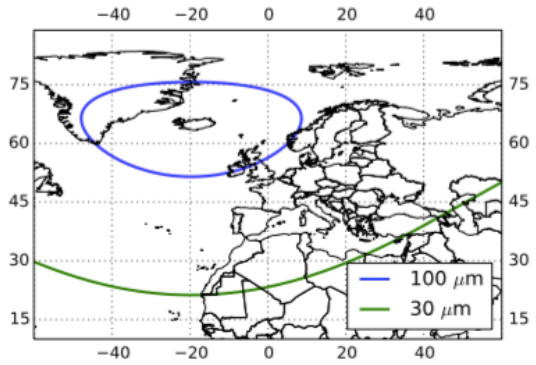
Marzano et al (2013)

Ash properties

Impact of observations and models

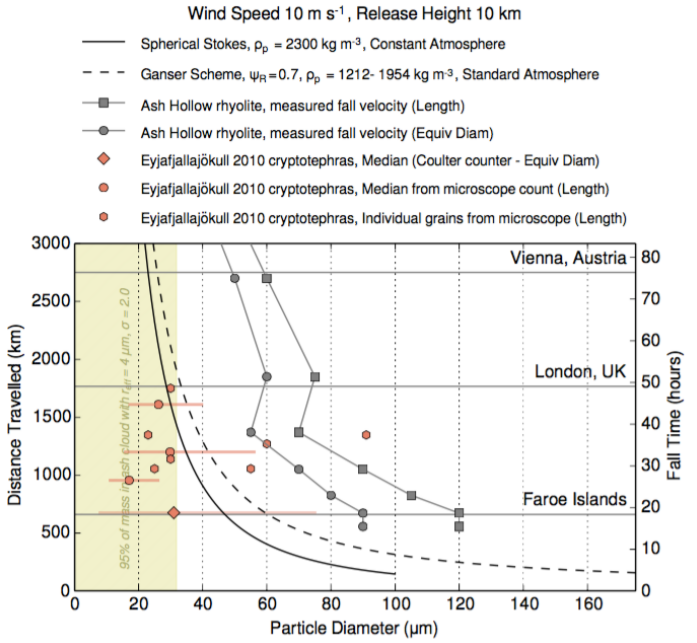
(a)London VAAC operaitonal and (b) Non-spherical particles with ΨR = 0.4 and the density distribution attributed to Eyjafjallajokull 2010 ash





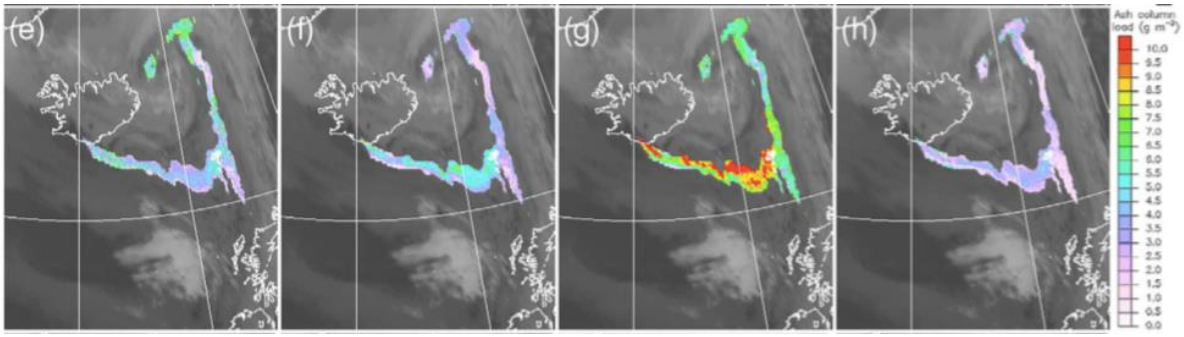
Beckett et al submitted (2015)

Travel distance for different diameter, density, shape



Stevenson et al 2015

Ash mass: 4 different refractive indices



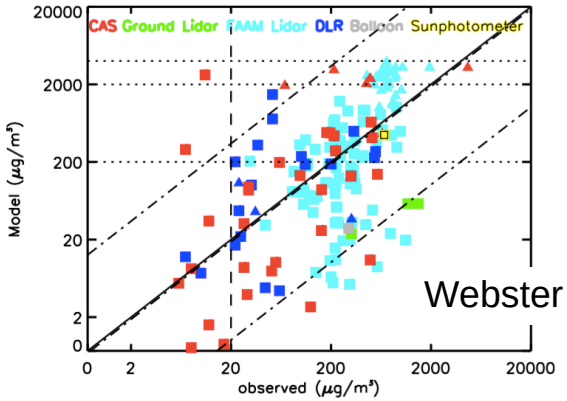
Francis et al 2012

Modelling

Ash3d, Fall3d, Flexpart, HYSPLIT, LPDM, MLDP0, NAME, Puff, VOL-CALPUFF, etc

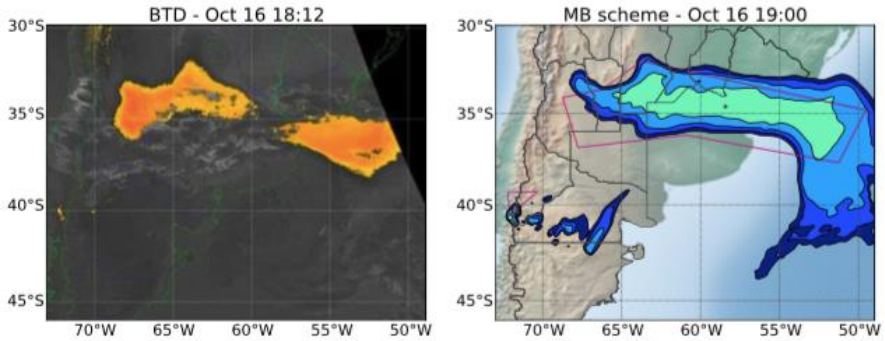
- Growing body of Validation
  - Ash and SO_2
- Process investigation and developemnt
  - Layering; umbrella clouds; plume rise; deposition; treatment of convection; non-sphericity; re-suspension; aggregation; etc
- Assessment of prediction uncertainties and ensemble approaches

Model vs Observations



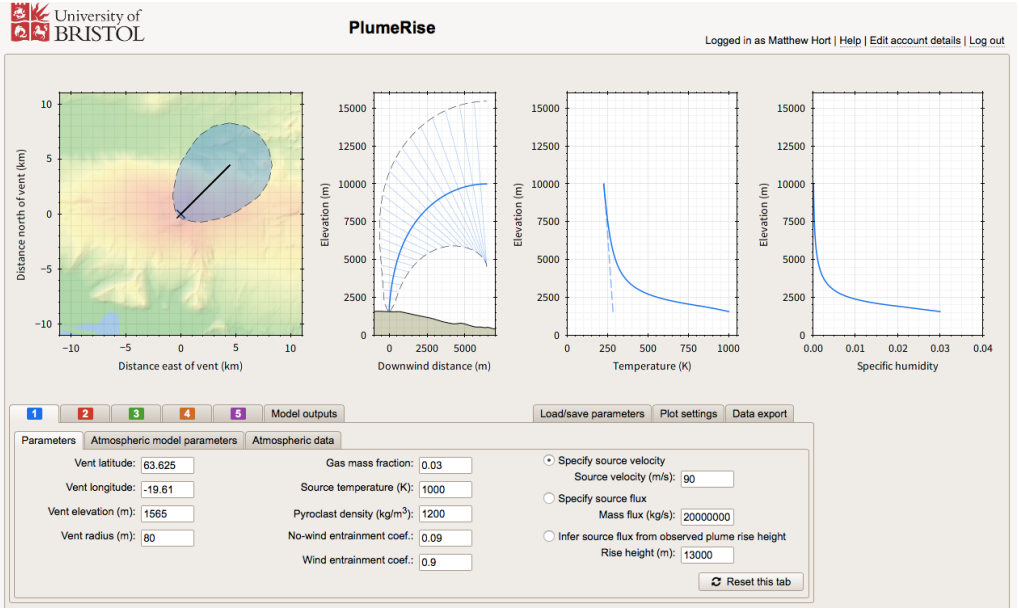
Webster et al (2012)

Re-suspension over Argentina



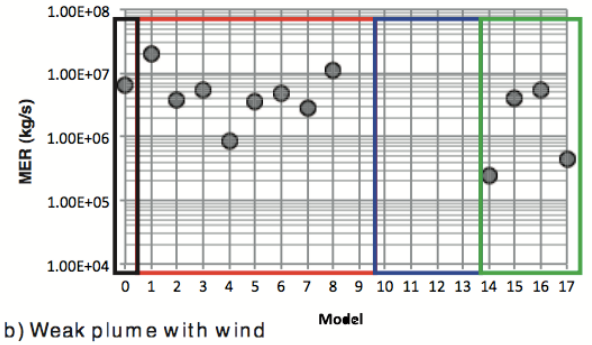
Folch et al (2014)

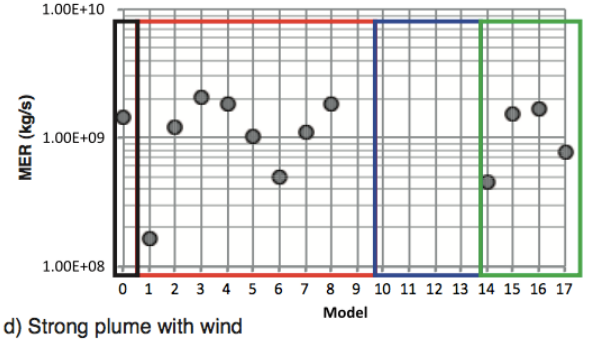
Modelling



University of Bristol Web Interface to Woodhouse et al plume rise model

Plume rise model inter-comparison





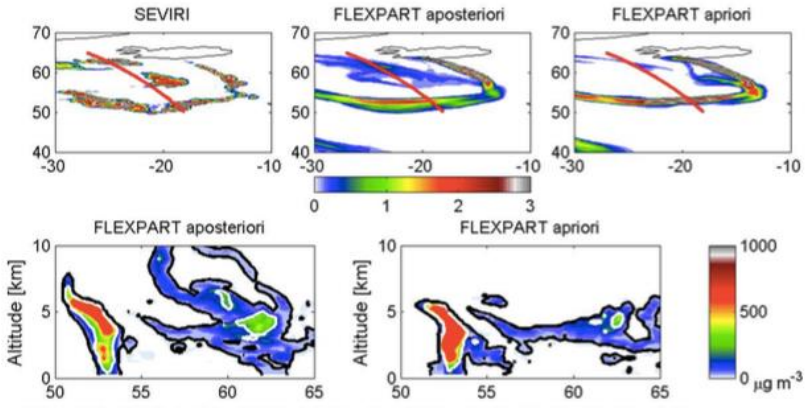
Costa et al (Submitted)

Modelling + Observations

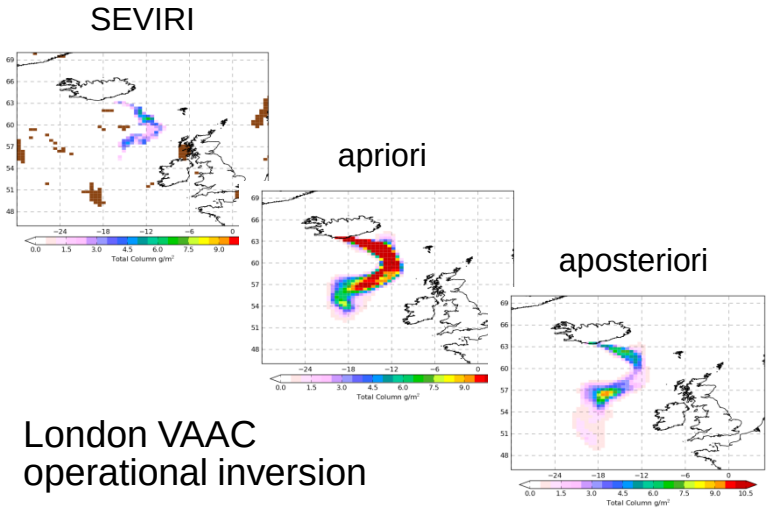
Inversion and data assimilation

- Complex 4-dimensional scaling
- Not a silver bullet
- In infancy but being worked on

Model run(s) x scaling = Observations



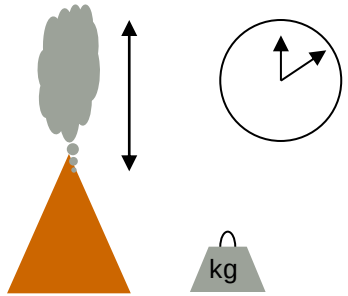
Stohl et al (2011)



London VAAC
operational inversion

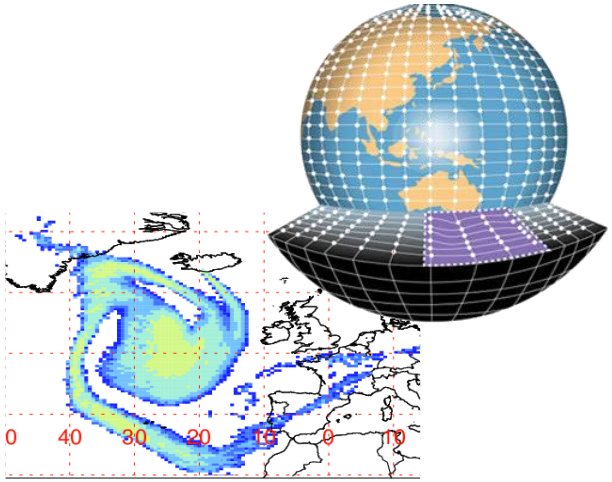

Met Office
FORECASTING

Forecast Process



Source Terms

Interpretation



Modelling

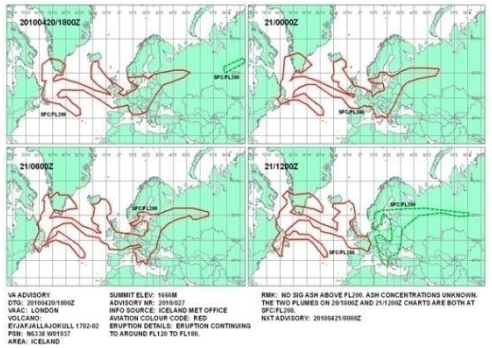
Interpretation

Interpretation

Interpretation

Interpretation

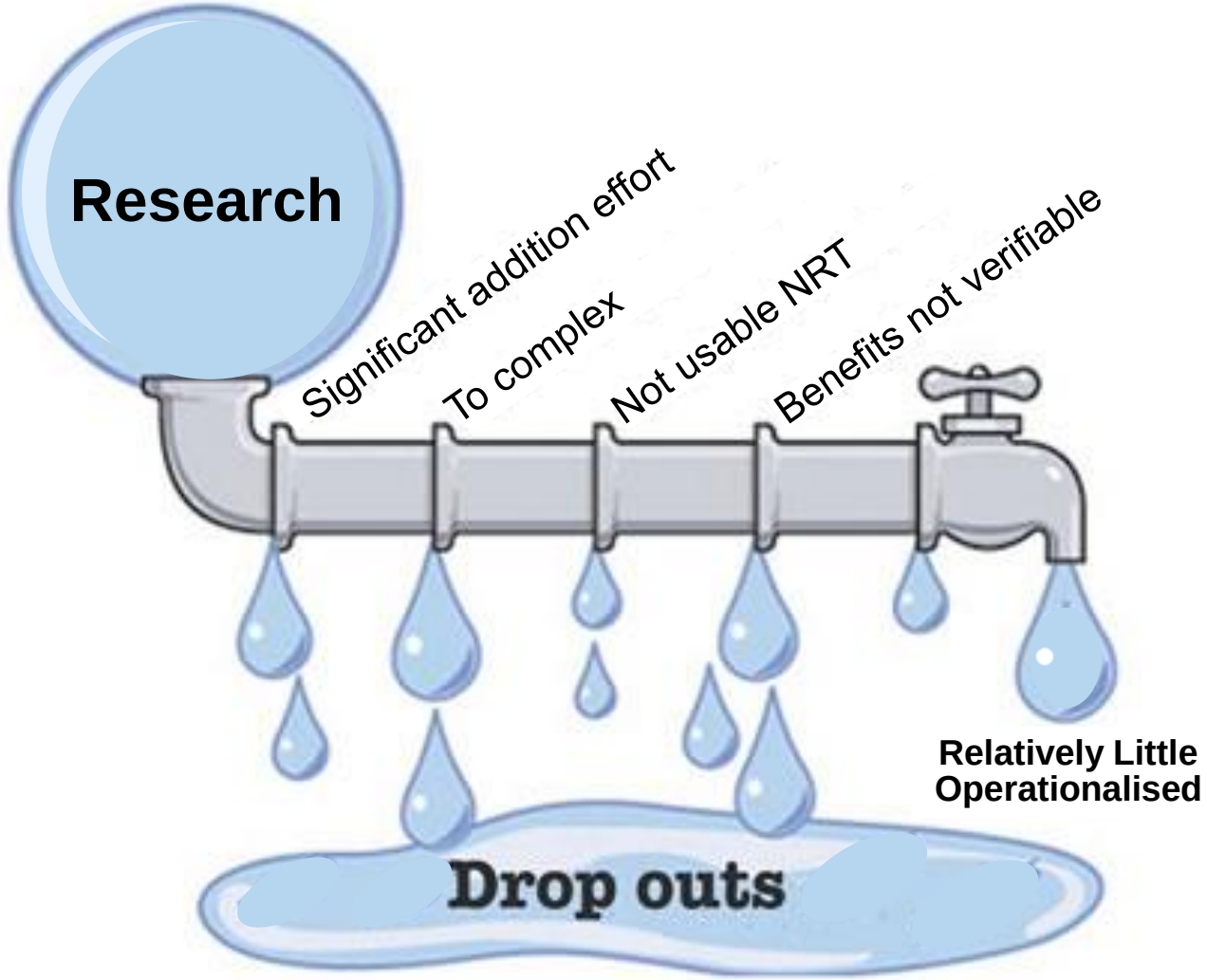
Observations



Forecast

Research to Operations

Not that easy



VAAC Changes

- Access to and processing of more observations
- Improved use of observations
- Improved and adoption of new models
- Improved use/initialisation of models
  - Deposition, PSD, plume rise, etc
- Some use of ensembles/uncertainty
- Inversion
- Stronger links with
  - Each other
  - Volcano observatory
  - Researchers

LEGACY AND FUTURE

Legacy

- A great data set
- Significant advances
- Significant increase in research effort
- More instruments, focus and thought
  - We are extracting more understanding from each eruption
  - Awareness of collaborative and cross-disciplinary nature of work
- Better models
- A strong multidisciplinary international community

On going steps and challenges

- Science
  - Quantitative observations & modelling
  - Model + Observation fusion
  - Quantification of uncertainty
- Forecasting
  - Managing fusion of information
  - Communication of certainty
- Aviation
  - Pilots role in ‘local in flight’ information
  - OEM data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