The application of satellite data to support the London VAAC

Sarah Millington, Michael Cooke, Peter Francis & Roger Saunders

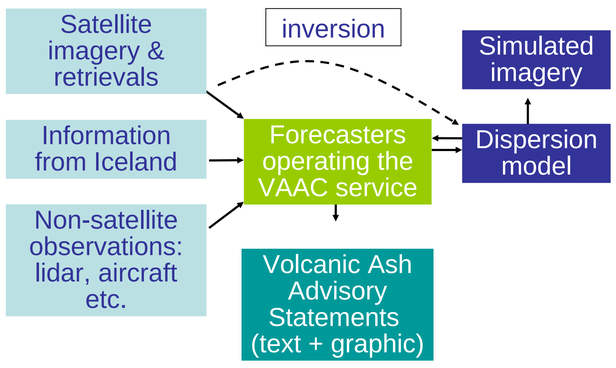
Poster: 8

IUGG – WMO Workshop

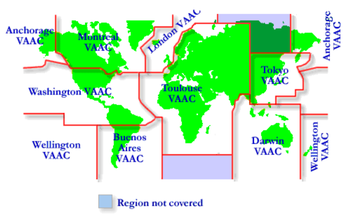
Geneva 2013

The London Volcanic Ash Advisory Centre (VAAC)

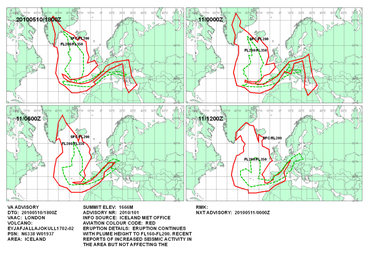
- London VAAC is operated by the Met Office in Exeter and is responsible for an area in the north-east Atlantic and Arctic
- Issues Volcanic Ash Advisory statements every 6 hours with current and forecast (out to T+18) ash locations
- Geostationary (SEVIRI) and polar orbiter (AVHRR, MODIS, IASI, OMI, GOME) satellite data are used to support the VAAC service via imagery and derived products
- Satellite imagery products are continuously being developed at the Met Office for volcanic emissions monitoring and used alongside external products



Operation of the London VAAC



VAAC areas of responsibility

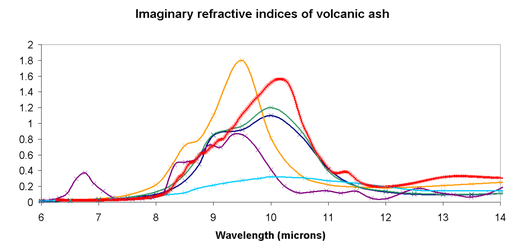


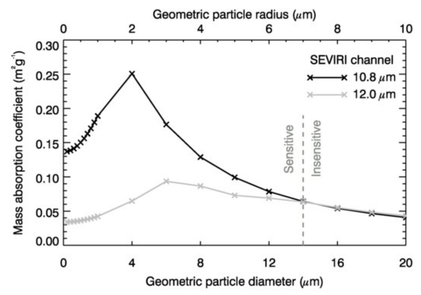
Volcanic Ash Advisory graphic for 2010 Eyjafjallajökull eruption

Volcanic ash microphysical properties

Refractive indices

- Dependent on the ash composition (not known at the time of an eruption)
- Used in retrievals and simulated imagery

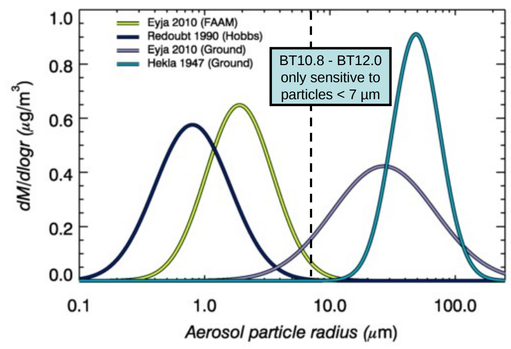




Mass absorption coefficients for SEVIRI channels at 10.8 and 12.0 μm for spherical andesite particles
(size distribution: geometric standard deviation = 1.0001, i.e. all particles are a single size)

Particle size distribution

- Only a few observations and these vary greatly: particularly between ground-based and airborne-based observations
- Large impact on simulated imagery
- Critical to understand the proportion of ash particles outside the infrared range of sensitivity so that errors in retrieved mass (used in inversions) can be estimated
- Commonly-used BT10.8 – BT12.0 method not sensitive to ash particles with radii > 7 μm (see figure below left)

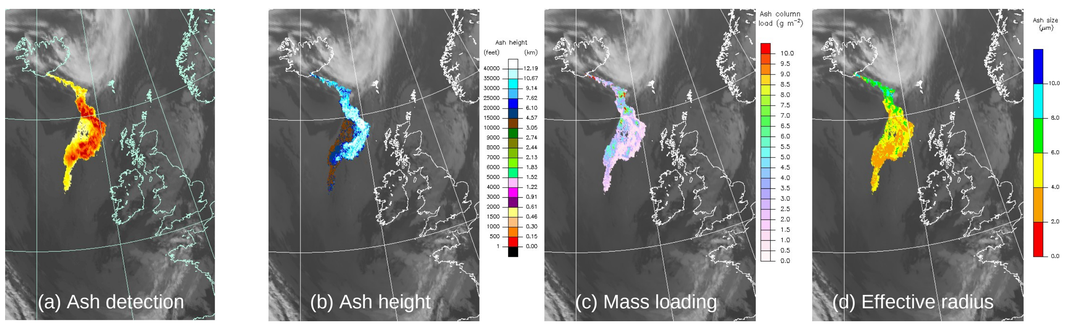


A selection of observed ash particle size distributions and limit of BT10.8 – BT12.0 sensitivity

Volcanic ash detection & retrieval of properties

- Ash detection and retrievals are performed using SEVIRI data every 15 minutes
- Detection is a series of tests using the 8.7 μm, 10.8 μm and 12.0 μm channels
- A 1D-Var framework is used to retrieve ash cloud pressure (height), column mass loading and particle effective radius using the 10.8 μm, 12.0 μm and 13.4 μm channels
- Refractive indices and size distributions are used to compute extinction coefficients used in the retrieval, with the cost (an indication of the uncertainty) indicating the optimal result.
- The data are used by forecasters to monitor the current situation and some of the data are used in the inversion system described below

Reference: Francis, P. N., M. C. Cooke, and R. W. Saunders (2012), Retrieval of physical properties of volcanic ash using Meteosat: A case study from the 2010 Eyjafjallajökull eruption, J. Geophys. Res., 117, D00U09, doi:10.1029/2011JD016788.



Detection of ash and retrieval of height, mass loading and effective radius using SEVIRI data at 1900 UTC on 6th May 2010.

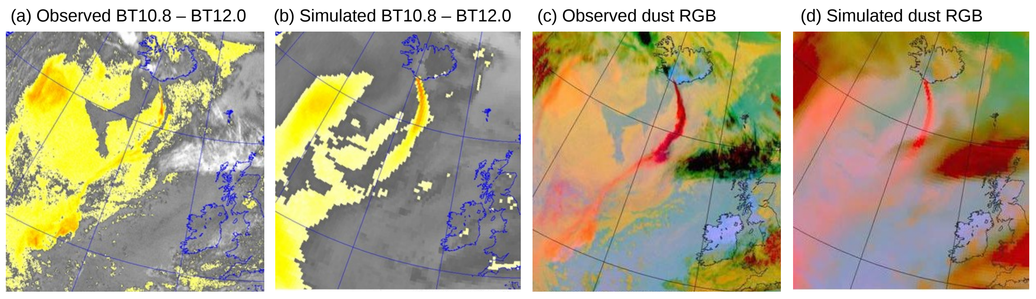
Simulated volcanic ash imagery

- NAME atmospheric dispersion model ash concentration data are used along with NWP data in RTTOV (radiative transfer model) to simulate SEVIRI brightness temperatures
- Absorption and scattering coefficients are calculated from refractive indices and particles size distributions
- Simulated imagery is available with every NAME ash forecast to be used as a forecaster tool to aid identification of dispersion model errors
- Also a useful tool to study the sensitivities and limitations of infrared detection and retrieval of volcanic ash (e.g. insensitive to large ash particles)

References:

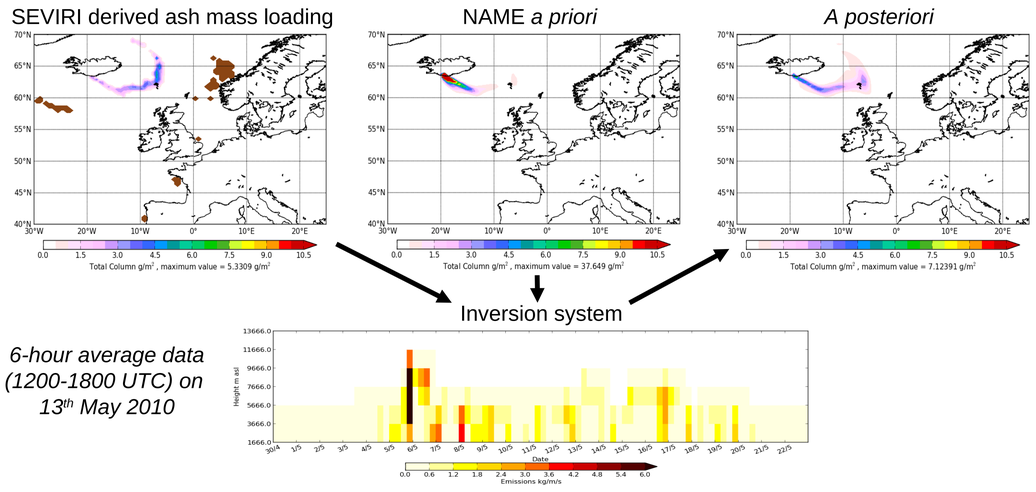
Millington, S. C., R. W. Saunders, P. N. Francis, and H. N. Webster (2012), Simulated volcanic ash imagery: A method to compare NAME ash concentration forecasts with SEVIRI imagery for the Eyjafjallajökull eruption in 2010, J. Geophys. Res., 117, D00U17, doi:10.1029/2011JD016770.

Stevenson, J.A, S.C. Millington, F. Beckett, G.T. Swindles, and T. Thordarson (*in preparation*), Ultragiant aerosol particles of extremely fine volcanic ash travel long distances: implications for remote sensing.



Observed and simulated BT10.8 – BT12.0 and dust RGB images at 1200 UTC on 8th May 2010.

Inversion: improving the dispersion model source term



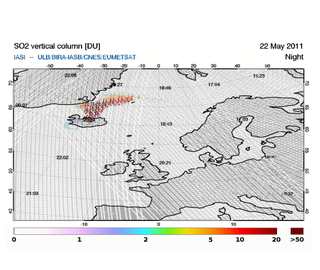
6-hour average data (1200-1800 UTC) on 13th May 2010

- Using satellite retrievals to improve the NAME dispersion model forecasts
- Temporally averaged satellite derived ash column loadings are combined with the NAME dispersion model using an optimal estimation variational analysis framework
- The result is an improved source term estimate

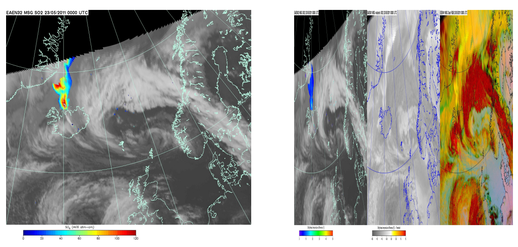
Sulphur dioxide monitoring

- SO_2 detection and quantification is performed using SEVIRI data every 15 minutes
- Detection is a series of tests using the 6.2 μm, 7.3 μm, 12.0 μm and 13.4 μm channels.
- A quantitative estimate is produced using the SEVIRI channel at 8.7 μm and an absorption coefficient derived by comparison with column loadings from AIRS data.
- IASI and MODIS data are used to improve polar tracking of SO_2 plumes.
- Support to Aviation Control Service (SACS) images are also used.

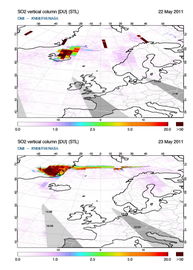
Reference: Cooke, M.C., P.N. Francis, S.C. Millington and R.W. Saunders (submitted), Grímsvötn Volcanic Eruption 2011: detection of the volcanic plumes using infrared satellite measurements. Atmospheric Science Letters.



SO_2 IASI composite image night of 22nd May 2011 (from SACS)



SO_2 and dust RGB SEVIRI images for the Grímsvötn eruption at 0000 UTC on 23rd May 2011



SO_2 OMI composite images (from SACS)

Met Office FitzRoy Road, Exeter, Devon, EX1 3PB United Kingdom
Tel: 01392 885680 Fax: 01392 885681
Email: sarah.millington@metoffice.gov.uk