PlumeRise

a web tool for modelling volcanic plumes rising in a wind field.

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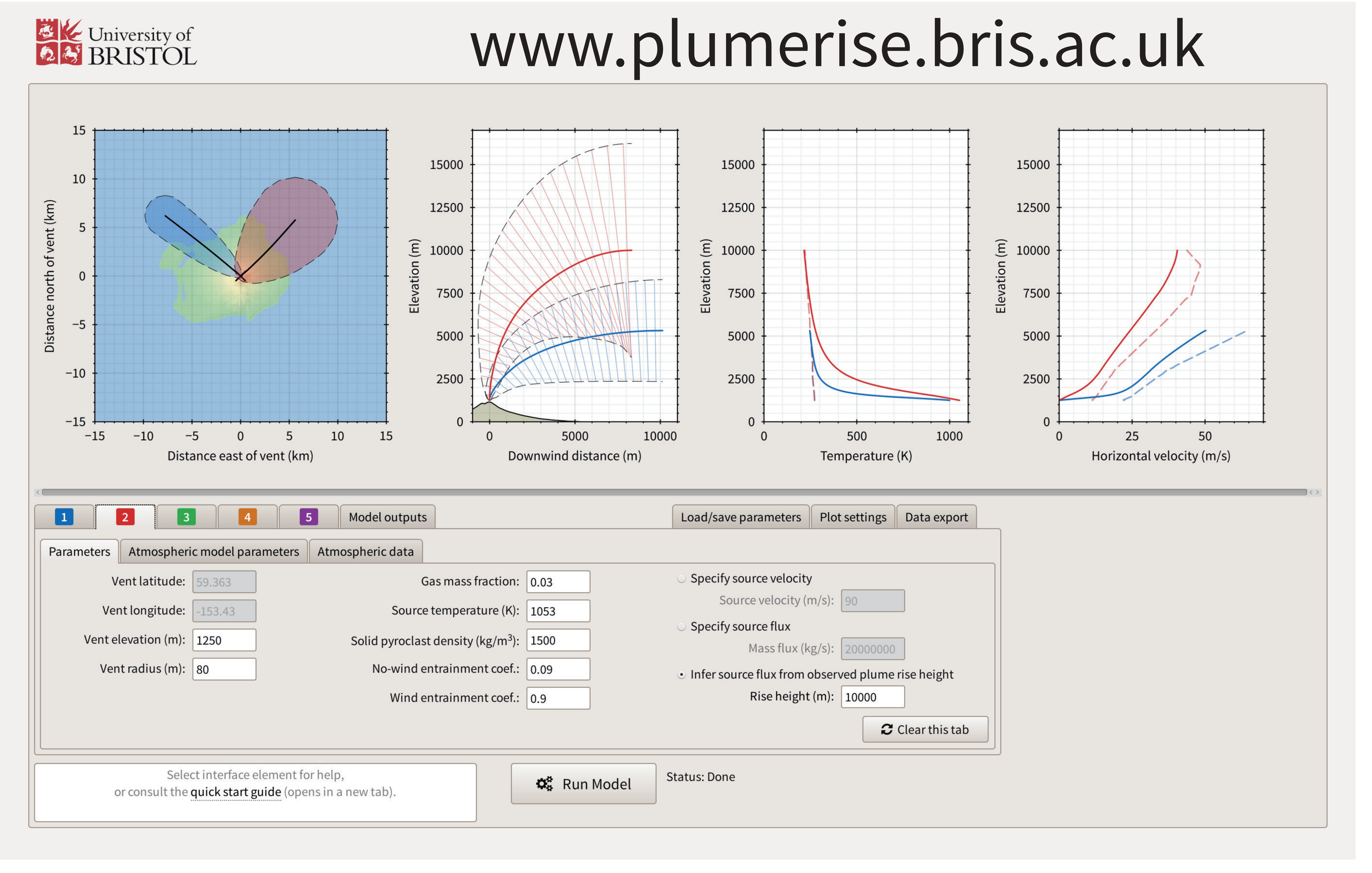


Integral models of volcanic plumes can be used to estimate the source conditions during eruptions by comparing model predictions with observations. The simple mathematical structure of integral models allows solutions to be readily obtained and an assessment of the effect of source and atmospheric conditions to be made.

We have formulated an integral model of volcanic eruption columns that utilizes meteorological observations to determine the trajectory of the plume motion (Woodhouse et al., 2013). For weakly-explosive eruptions, atmospheric conditions have a strong effect on the rise of the plume. In particular, atmospheric winds strongly influence the rise of volcanic plumes, with the wind restricting the rise height such that obtaining equivalent rise heights for a plume in a windy environment would require an order of magnitude increase in the source mass flux over a plume in a quiescent environment.

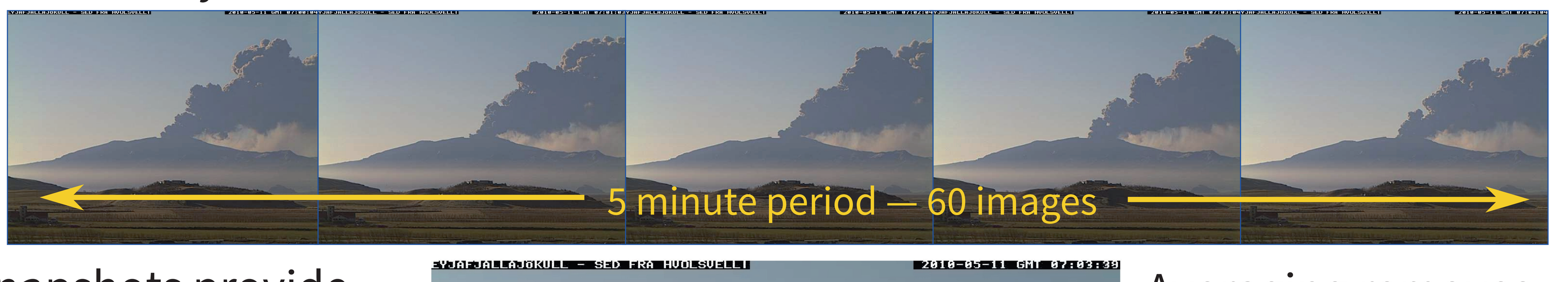
To allow plume model calculations that incorporate meteorology to be used for the assessment of volcanic source conditions, we have developed the PlumeRise web-tool — www.plumerise.bris.ac.uk

PlumeRise allows detailed meteorological profiles to be employed, and incorporates an inversion proceedure to allow the source mass flux to be estimated from the plume rise height.

Comparison with observations of the plume from the 2010 eruption of Eyjafjallajökull

Model comparisons to web-cam images

During the Eyjafjallajökull eruption, a webcamera captured images of the plume every 5 seconds.



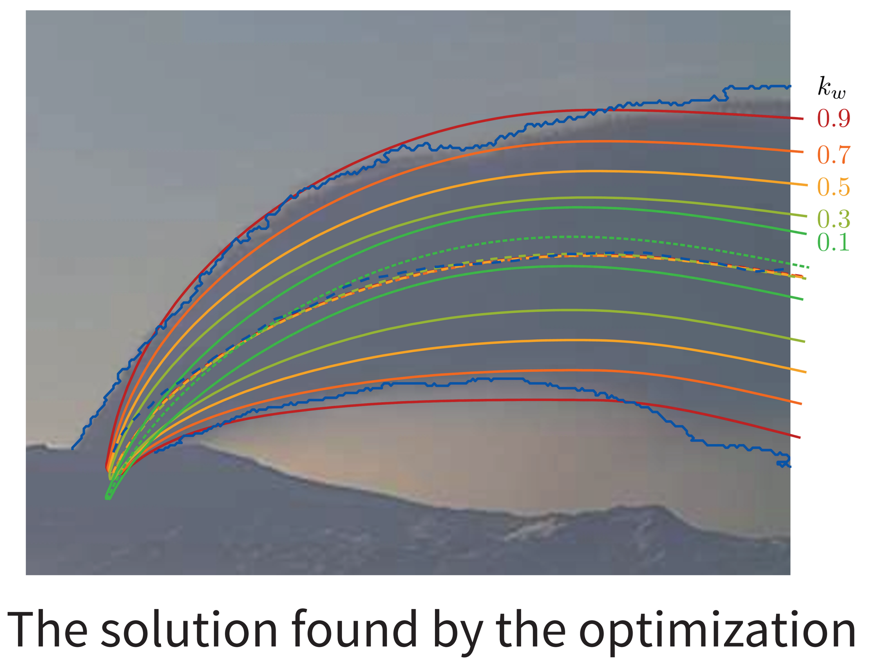
Snapshots provide details of the turbulent structure in the plume, with convective ‘thermals’ on the upper edge.

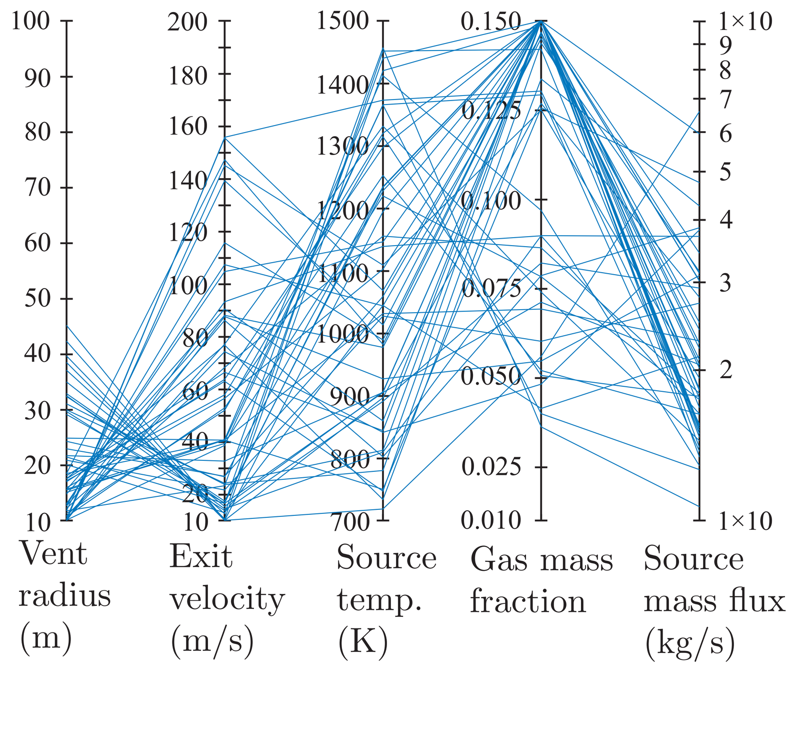
Averaging removes transient features leaving a time-averaged image suitable for comparison with plume model predictions.

Image processing can be used to discriminate plume edges from the background. From the edges the centreline trajectory can be found.

Inputs to the plume model are adjusted to optimize the match of predicted trajectory to the observed trajectory.

The comparison of the webcam image to the model predictions of the plume growth can be used to assess the values of the model parameters. Here we vary the wind-driven entrainment coefficient k_w and find k_w=0.7 – 0.9 give the best matches.



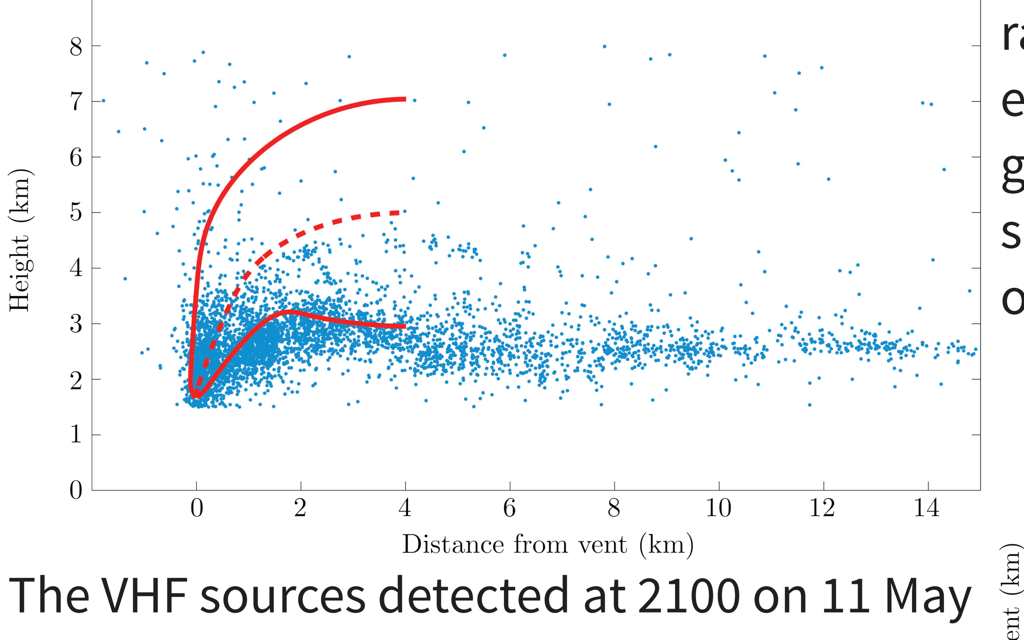


The solution found by the optimization routine depends on the ‘guess’ for the initial conditions. By sampling randomly over the space of possible inputs (using a latin hypercube design) the range of suitable initial conditions can be found.

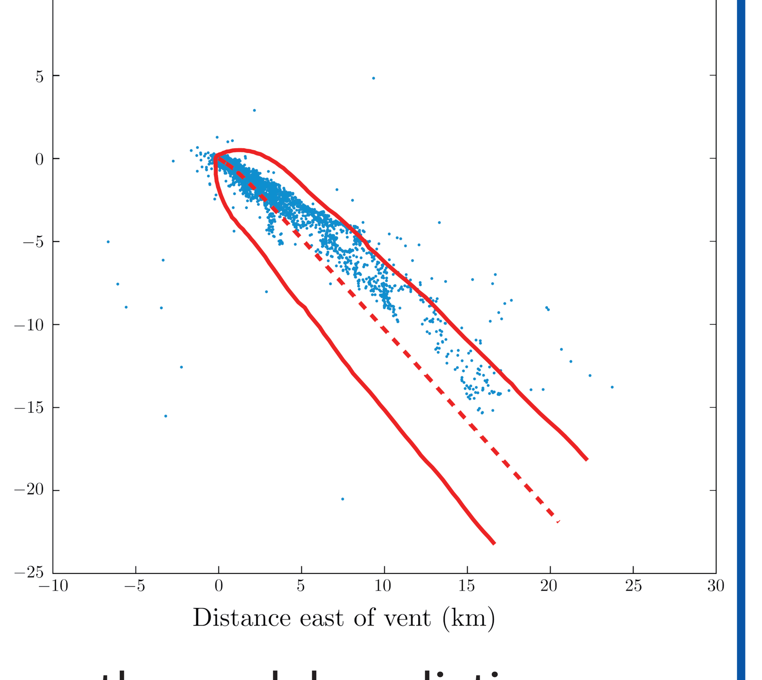
The parallel coordinates plot shows matched solutions typically have a high source water content. The mass flux is around 1–3×10^4 kg/s

Model comparisons to volcanic lightning mapping

During the second explosive phase of the eruption (5–17 May 2010), a lightning mapping array (LMA) around Eyjafjallajökull was operational (Behnke et al., 2013).

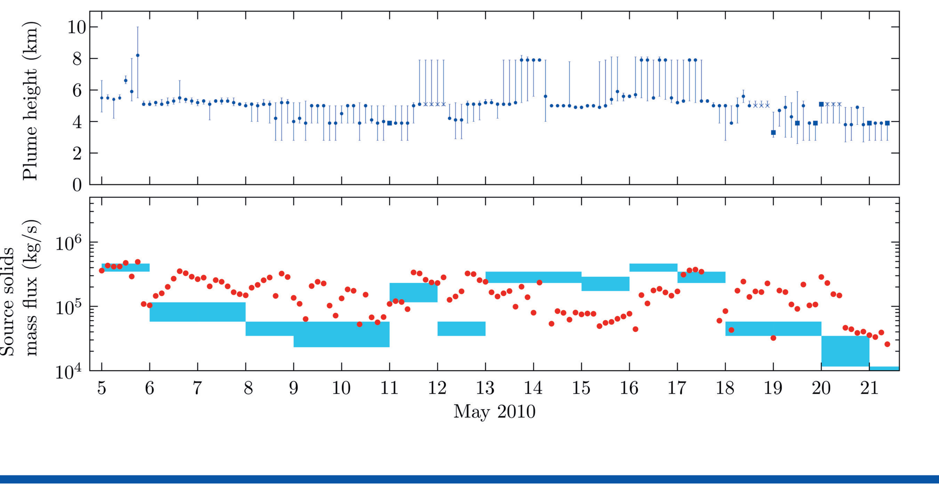


The LMA detects sources of VHF radiation produced during electrical breakdown of air, and gives a three-dimensional spatial and temporal indication of the location of the plume.



The VHF sources detected at 2100 on 11 May 2010 are compared to model predictions of the plume trajectory and growth, with model source conditions fixed by matching to an independent measurement of the plume height (from radar observations).

The plume model describes the trajectory of lightning reasonably well and provides quite a good envelope of the VHF sources.



From the model predictions, estimates of the source conditions can be made. Here we estimate the source mass flux (red points), and find our estimates are often reasonably close to those of Gudmundsson et al (2012) (blue areas), although at times differ substantially.

References:

Woodhouse MJ, Hogg AJ, Phillips JC, Sparks RSJ (2013) Interaction between volcanic plumes and wind during the 2010 Eyjafjallajökull eruption, Iceland. J Geophys Res 118

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Gudmundsson MT et al. (2012) Ash generation and distribution from the April–May 2010 eruption of Eyjafjallajökull, Iceland. Sci Rep 2

Behnke SA et al. (in review) The 2010 eruption of Eyjafjallajökull: Lightning and plume charge structure. J Geophys Res

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