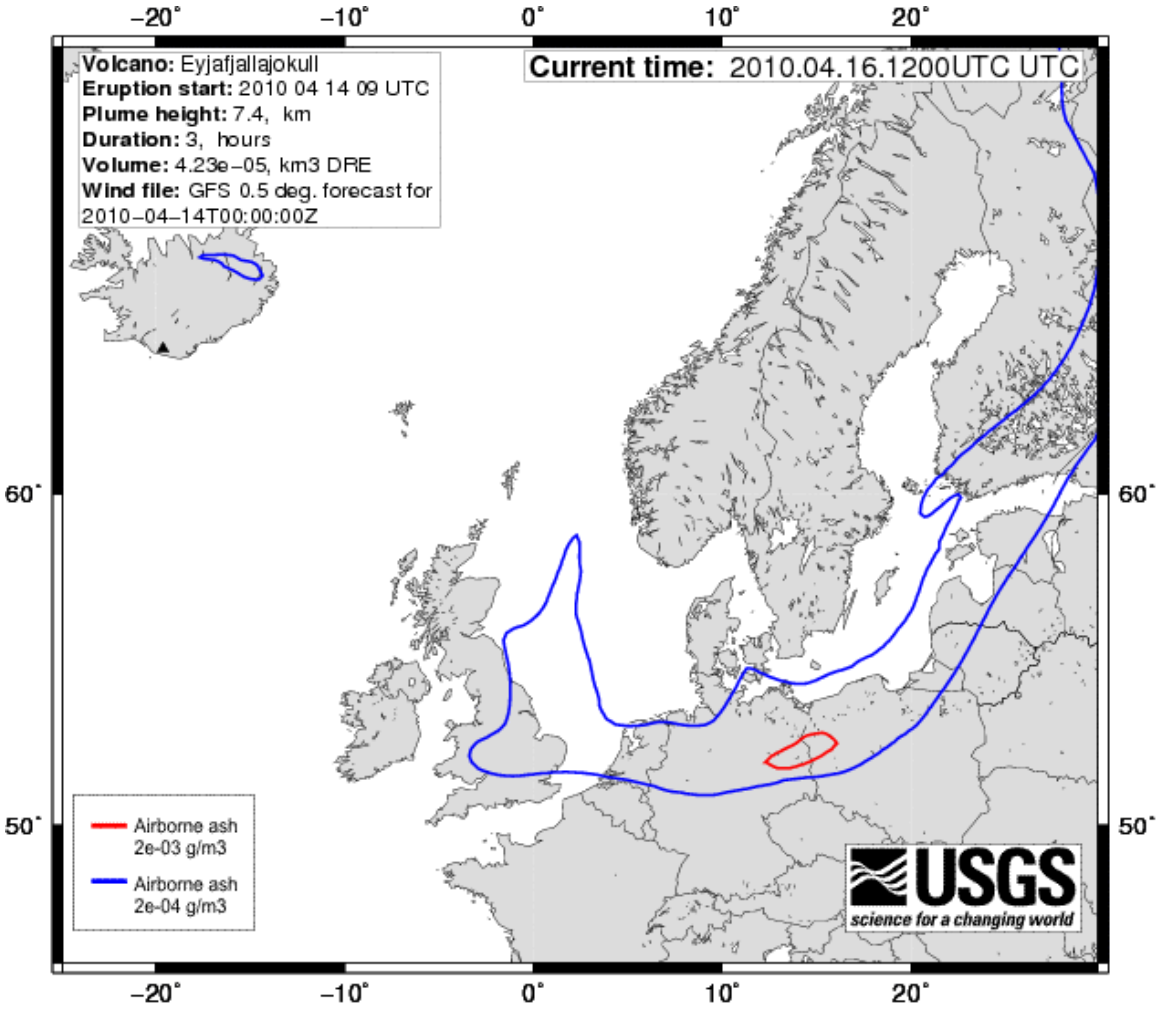
Understanding and using the web graphical user interface to the USGS Ash3d model



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Introduction

This document is furnished with output generated by the USGS Ash3d volcanic ash dispersion model to explain the use and significance of the model output. It includes instructions on running simulations using the Ash3d web interface and on viewing and interpreting the model results.

Entering the Ash3d web interface

The Ash3d web interface is located at http://vsc-ash.wr.usgs.gov. After navigating there you will need to log in using a username and password assigned to you. After logging in you will enter the Ash3d Home page similar to Fig. 1, showing a list of jobs already executed by you.

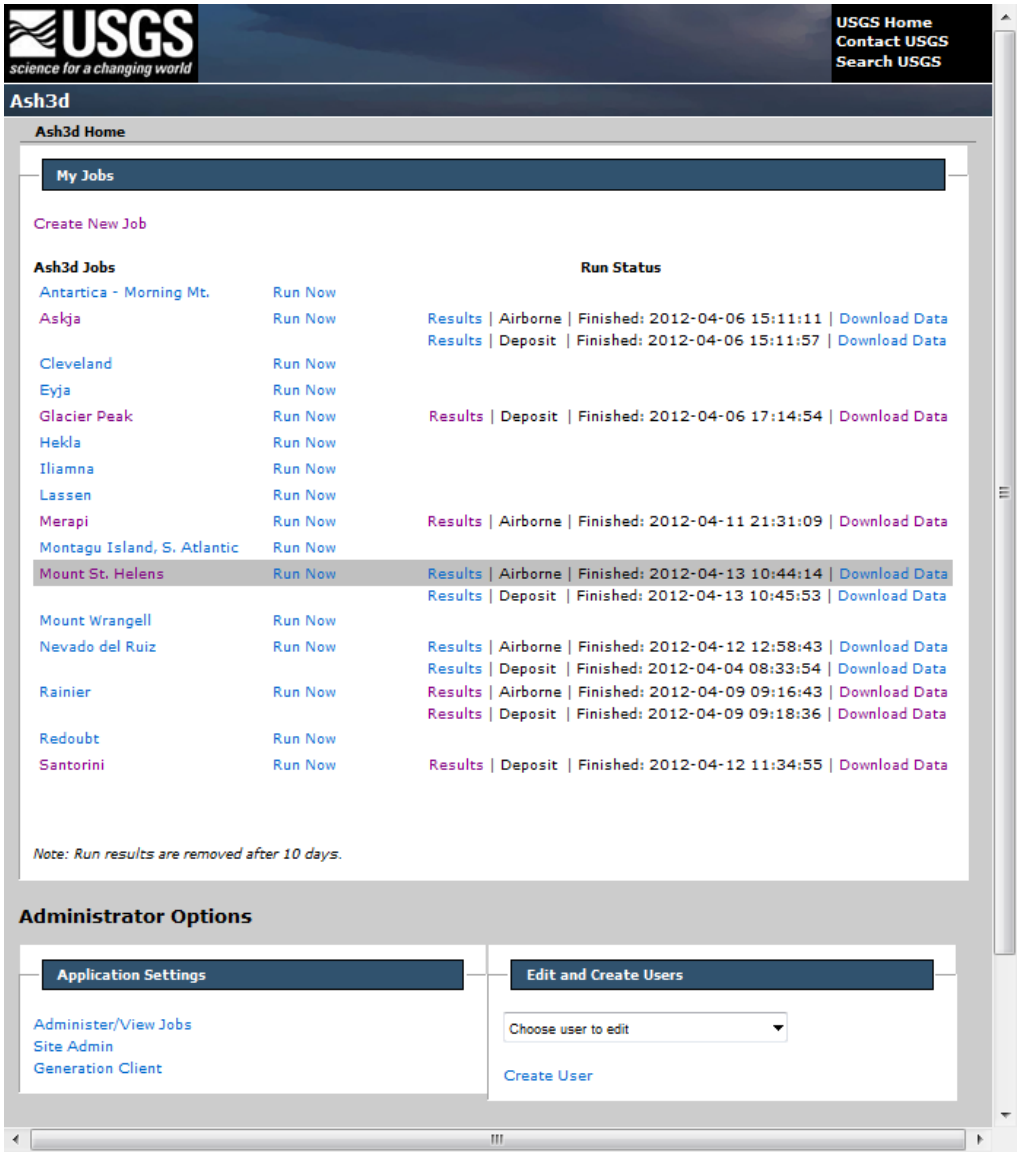

Figure 1: the Ash3d jobs page.

Creating or editing a job

After clicking “Create New Job” or clicking on any of the existing jobs, you will be sent to the Ash3d Job page which appears similar to Fig. 2.

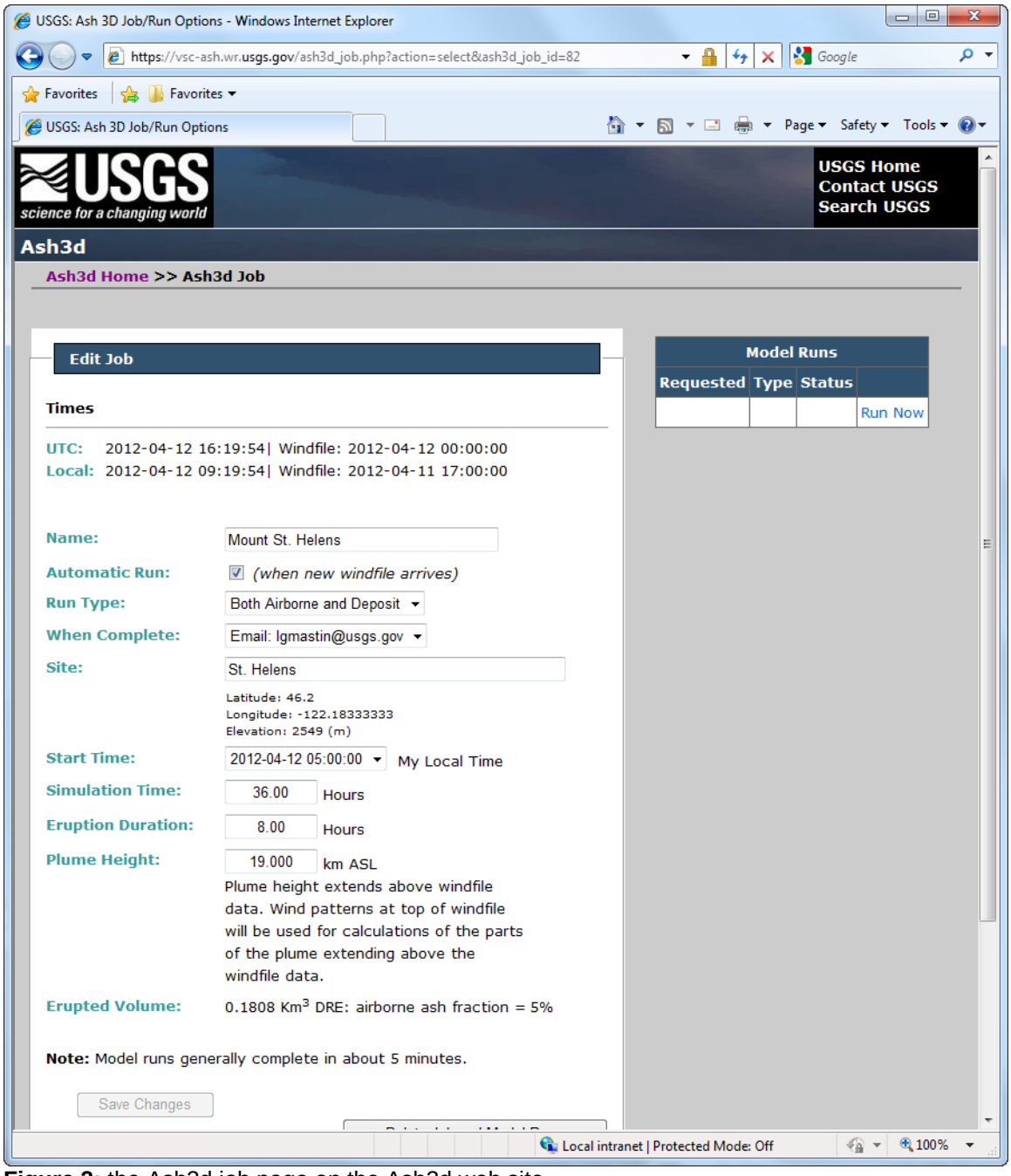

Figure 2: the Ash3d job page on the Ash3d web site.

This page allows you to enter or edit the following items:

(1) The job name (Mount St. Helens is given in Fig. 2, though you can enter any name)
(2) A checkbox that allows you to choose an automatic run. If selected, the run will start when a new wind file arrives (wind files are currently downloaded twice per day, at roughly 0500 and 1700 UTC).
(3) A dropdown list for run type, which may be (1) airborne ash; (2) ash deposit; or (3) Both airborne and deposit)
(4) The site or volcano name. Currently you must enter the name of a volcano that is in the Smithsonian Institution's list of Active Volcanoes of the World (http://www.volcano.si.edu). As you type, you will see choices of volcanoes in that database whose names start with the letters you've typed in. Once you choose a volcano, its latitude, longitude, and summit elevation are displayed below the text box.
(5) The eruption start time. The dropdown list gives times in one-hour intervals, starting from the first available time in the current wind file and extending ahead 24 hours.
(6) The simulation time in hours. This is the number of hours over which the simulation is to be run. It must be longer than the eruption duration, given next.
(7) Eruption duration, in hours
(8) Plume height in kilometers above sea level.

Limitations of the wind field used

The Ash3d graphical user interface uses a global wind field provided by the NOAA Global Forecast System numerical weather prediction (NWP) model (http://www.emc.ncep.noaa.gov/GFS/), which provides wind vectors at pressure elevations ranging from 100 kiloPascals (kPa, roughly sea level) to 10 kPa (roughly 16 km elevation). If a plume height greater than about 16 km above sea level is specified, you will see the warning message illustrated in Fig. 2 ("Plume height extends above wind file data . . . "). The model will still run, but the wind vectors used at higher elevations will be the same as those at the highest (10 kPa) level in the NWP model output.

Kinds of model runs: airborne and deposit

Ash3d is an Eulerian model, meaning that it calculates the movement of tephra by dividing the atmosphere into three-dimensional cells and calculating the flux across cell walls. Before a simulation is run, the geographic area and height of the model domain must be given, as well as the number of grain sizes in the simulation. The appropriate domain size and number of grain sizes differ for airborne and deposit runs. Ash clouds move farther downwind than deposits, hence a larger model domain must be used; and distal ash clouds (more than several hundred kilometers downwind) contain almost exclusively very fine ash with a very low settling velocity. In airborne model runs we specify a single grain size (0.0625 mm) with negligible settling velocity, allowing the model to run quickly. For modeling deposits, we use 7 grain sizes (4, 2, 1, 0.5, 0.25, 0.125, and 0.0625 mm). This number of grain sizes is the approximate minimum we need to generate a realistic-looking deposit while still keeping the model runtime under

about 10 minutes. (Ash3d can use an arbitrarily large number of grain sizes but the option of specifying grain sizes is not currently implemented in the GUI).

If "both Airborne and Deposit" is chosen in the Run Type dropdown list, the GUI executes two simulations, one for airborne ash and a second for the deposit.

Eruption source parameters

The eruption start time, duration, and plume height define the eruption source parameters. Once those parameters are entered, the interface estimates an erupted volume V, in km^3 dense-rock equivalent (DRE) using the plume height H (km), summit elevation E (km), and duration D (hrs) using the following relationship between plume height and eruption rate (Mastin et al., 2009, eq. 1):

$$V = 3.6\times10^{-6}\cdot\left(\frac{(H-E)}{2}\right)^{4.2}\cdot D \qquad (0.1)$$

This is considered the approximate total erupted volume of magma in dense-rock equivalent or DRE (i.e. the magma's volume once bubbles are removed). For airborne ash simulations, The Ash3d web interface takes 5% of this calculated volume as the volume injected into the cloud. The value of 5% is based on studies suggesting that a few to several percent of the total erupted volume typically goes into the ash that is transported several hundred kilometers or more downwind (Dacre et al., 2011 (in press); Devenish et al., 2012 (in press); Wen and Rose, 1994)

Model execution

When "Run now" is pressed in the upper-right hand side of Fig. 1, a simulation is run at very low model resolution (large cell size) and large domain size. The time required for execution is seconds and the results are too coarse to be directly useable; but the output outlines the approximate geographic region covered by the cloud or deposit. Based on the output of this run, a new model domain is specified that concentrates on this region, and a second, higher-resolution run produces the main model output.

Model output

The model output is wrapped in a zip file that can be downloaded at the end of a simulation. The contents of the folders, listed in Table 1, differ slightly for airborne and deposit simulations.

Table 1: List of the files included in Ash3d zip folders. The columns titled "A" and "D" indicate which files are included in zip folders that result from airborne runs ("A") and which are included in deposit runs ("D")

File name	A	D	
ash3d_input.inp	x	x	ASCII input file used to run this model. The model name is a variable but all input files have the suffix .inp. A detailed explanation of the contents of this file is given in Mastin et al. (2012, in review)
Ash3d.lst	x	x	Log file that records messages written out during the simulation.
AshArrivalTimes.txt	x	x	Text file giving the arrival time of the ash cloud at airports. Contents of this file are also displayed in the Results page of the GUI. **Note:** for airborne ash

			simulations, a single grain size of negligible settling velocity is used, hence deposit thicknesses listed in this file will not be accurate. But the arrival times of the cloud overhead and the number of hours during which the cloud will remain overhead should be reasonably accurate.
AshArrivalTimes.kmz	x	x	kmz file showing the locations of airports over which the ash cloud has moved Each airport marker, when clicked, opens a balloon that displays the arrival time of the cloud and the deposit, the number of hours during which the cloud will remain overhead, the number of hours during which ash will fall, and the total deposit thickness (mm). As with AshArrivalTimes.txt, the values for the deposit are not accurate for airborne simulations, but values for the cloud should be reasonably accurate.
CloudArrivalTime.kmz	x	x	A kmz file showing a static map of cloud arrival times in hours after the eruption start.
CloudConcentration.kmz	x	x	A kmz file showing an animation of cloud movement. Colors in the cloud indicate the maximum ash concentration in milligrams per cubic meter at that location at that time.
CloudHeight.kmz	x	x	A kmz file showing an animation of cloud movement with colors in the cloud that indicate the height of the cloud top in km above sea level.
CloudLoad.kmz	x	x	A kmz file showing an animation of cloud movement with colors in the cloud that indicate the integrated mass load of the cloud, in tonnes per square kilometer.
Deposit.kmz		x	A kmz file of deposit thickness. This file contains both a static map of deposit thickness, and a series of maps showing deposit thickness at various times during the eruption.
DepositArrivalTime.kmz		x	A kmz file showing a static map of deposit arrival time in hours after the eruption start.
deposit.gif		x	a gif image showing contours of deposit thickness. For deposit runs, this gif image is also displayed in the Results page of the GUI.
Time-stamped gif files of cloud concentration (e.g. 2012.04.11.1200UTC.gif)	x		A series of gif files illustrating the location of the cloud at a given time, with contours of 0.2 mg/m3 and 2 mg/m3. The time of the image is given in the file name (e.g. 2012.04.11.1200UTC.gif means April 11, 2012 at 1200 UTC) and in the upper right-hand corner of the gif image. The time interval between these images may be 0.5, 1, 2, 3, or 6 hours depending on the length of the simulation.
output_FC.gif	x		An animated gif image of cloud movement, with contours of concentration (0.2 and 2 mg/m3), generated by putting together the time-stamped gif images. For airborne ash runs, this image is also displayed in the Results page of the GUI.

Gif images of the ash cloud

The output from airborne ash simulations includes a series of gif files showing the location of the cloud at a given time with contours for ash concentration (0.2 and 2

mg/m^3, Fig. 3). An animated gif image (output_FC.gif) is generated by combining these static images. In order to see the animation it may be necessary to open the gif image with Microsoft Internet Explorer, as many default picture viewers like Picasa will not show the animation.

The output from deposit simulations includes a single gif image of the deposit (Fig. 4) with contour values of ash thickness (0.8, 6, 25, and 100 mm) that separate zones of ash impact termed "trace", "minor", "substantial", "heavy", and "severe", as delineated by the USGS and the U.S. National Weather Service (reference?). Ash3d actually calculates mass load of the deposit (kg/m^2), and then converts this to deposit thickness assuming a deposit density of 1,000 kg/m3. At this density, the deposit thickness in millimeters is numerically equal to the mass load in kg/m^2.

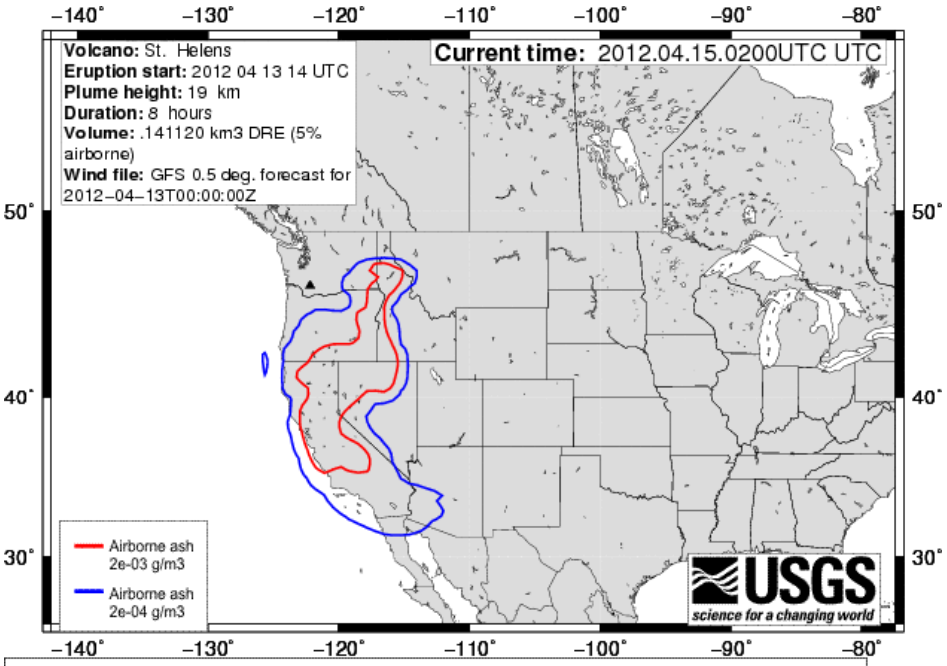

Figure 3: Gif image of an ash cloud from Mount St. Helens. The source parameters for this run are in the legend on the upper-left, and the current time is given in the upper right. Contours of ash concentration are given in blue (0.2 mg/m3) and red (2 mg/m3).

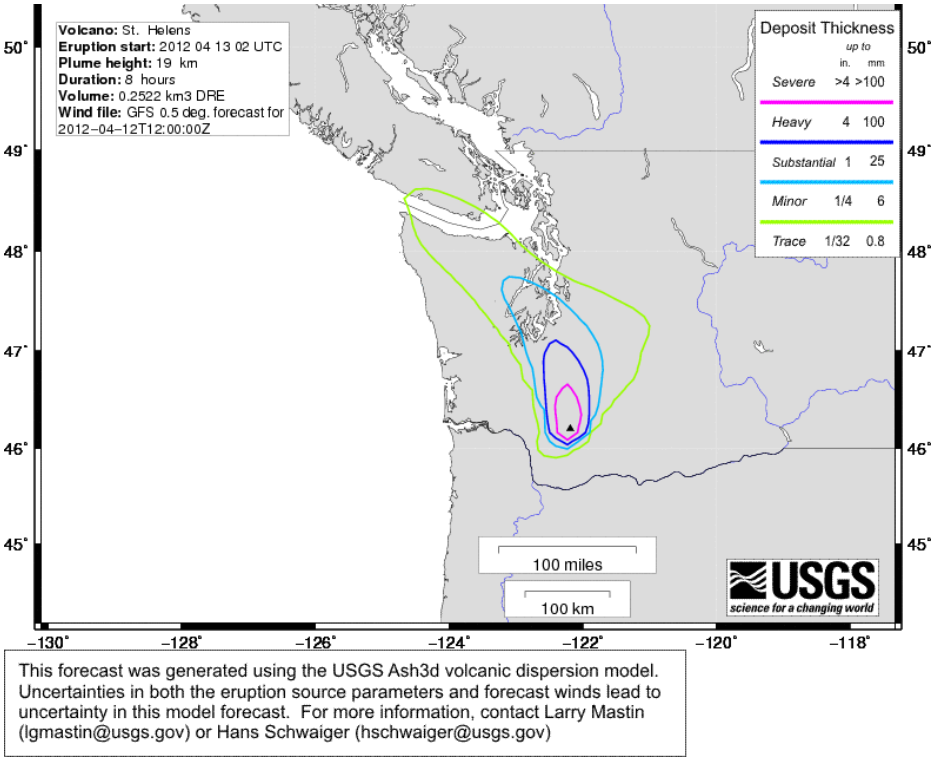

Figure 4: Gif image of the deposit from a deposit run of Mount St. Helens. Eruption source parameters are on the upper left. The thickness contours divide zones where tephra thickness is named (trace, minor, substantial etc.) according to levels identified by the National Weather Service and USGS (ref?)

Opening and viewing kmz files in Google Earth

Files having the suffix kmz can be opened by Virtual Globes software such as Google Earth®. These are zipped keyhole markup language (kml) files that graphically display animations of cloud movement, cloud or deposit arrival times, the thickness distribution of the deposit, and arrival times of ash at airports. If you have Google Earth installed on your computer, you can open these files by double-clicking on them or by opening Google Earth and going to the File menu and choosing "open . . ."

Viewing the kmz files

Using an example eruption from Cleveland volcano, Figure 1 illustrates the location of the cloud and of impacted airports as viewed in Google Earth®. Placing the mouse arrow over any of the airport symbols causes the airport name to be displayed, and clicking on an airport symbol opens a dialog box that displays the arrival time of the cloud and deposit (in hours after the eruption start), and the total deposit thickness at that location (Fig. 3).

The movement of the cloud and the appearance of impacted airports can be animated using the timeline in the upper left (label '3", Fig. 5, and Fig. 7).

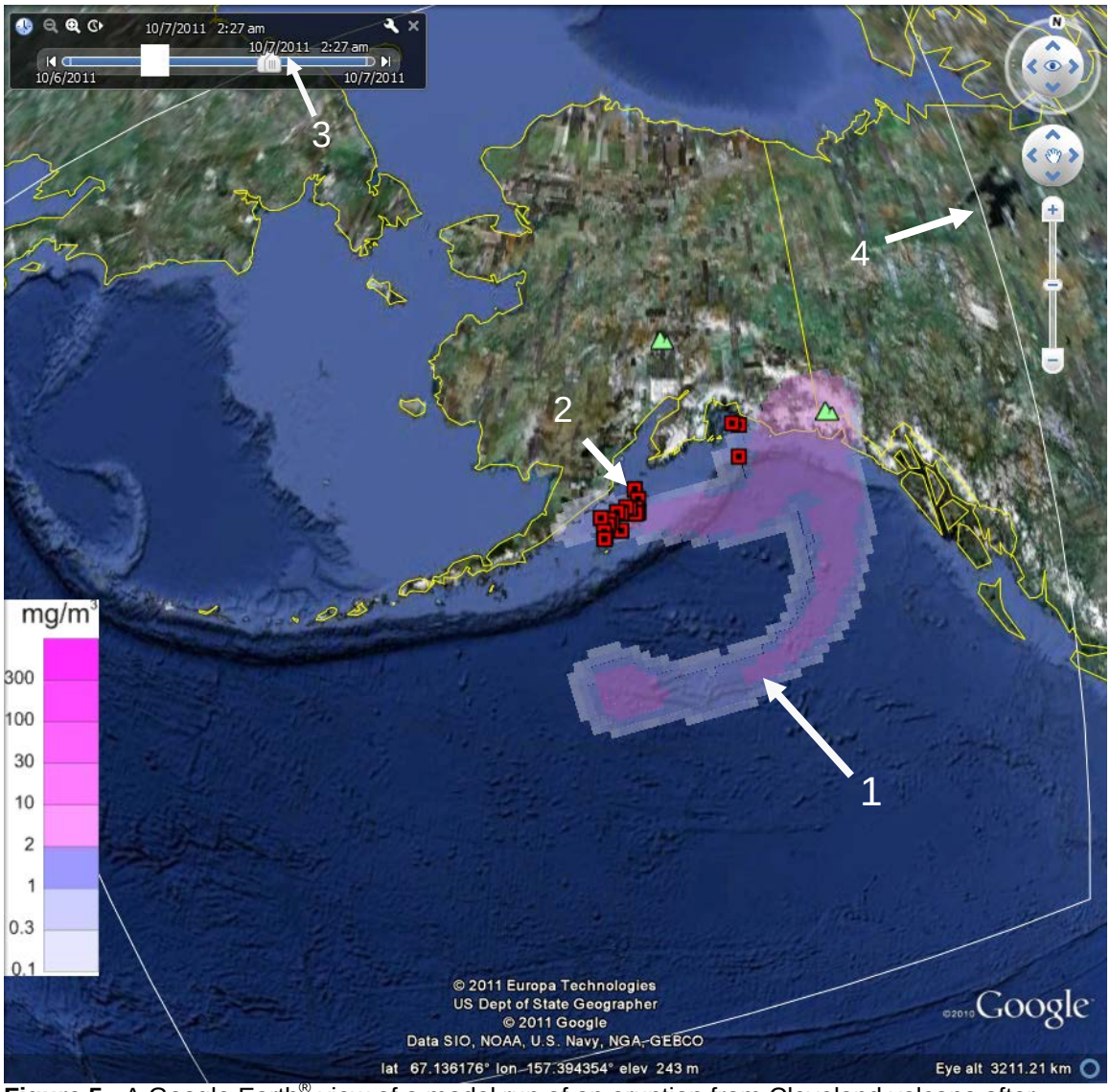

Figure 5. A Google Earth® view of a model run of an eruption from Cleveland volcano after opening the files CloudConcentration.kmz and AirportAshArrivaltimes.kmz. The cloud ("1") is illustrated with shades of pink that correspond to the maximum concentration, in mg/m^3 of cells at that location, as shown in the legend at left. The red squares ("2") give the locations of airports that were impacted by ash. The movement of the cloud and the appearance of the airport symbols can be animated using the timeline in the upper left ("3"). The boundary of the model domain is indicated by the white box ("4").

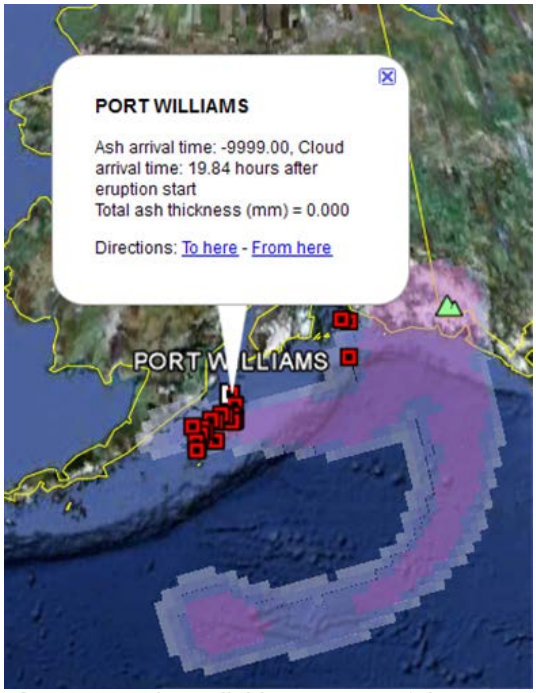

Figure 6: When clicking on one of the airport symbols, a dialog box appears giving the arrival time of the ash deposit and of the cloud. The ash arrival time -9999.00 indicates that the ash deposit did not reach this location.

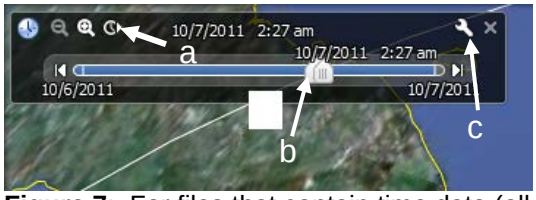

Figure 7: For files that contain time data (all but CloudArrivalTime.kmz, and DepositArrivalTime.kmz), output can be animated by clicking the "run" button ("a") on the timeline. Make sure that the pincers ("b") on the timeline caliper are pressed together to display a point in time rather than a span of time. And make sure that the times at each end of the timeline correspond with the start and end of the simulation. If they don't it's likely that another file with time data is checked on the left sidebar of the Google Earth window. You may also wish to set for a looping animation or adjusting the animation speed by adjusting the settings that appear when the wrench icon ("c") is clicked.

Figure 8: By mousing over one of the polygons in the cloud, an outline of the polygon appears ("a") and the value of the polygon (in this case ash concentration in mg/m3) is displayed.

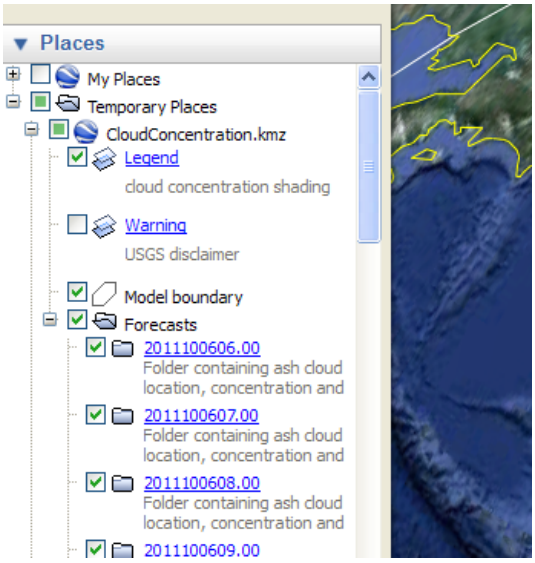

Figure 9: Left sidebar of Google Earth illustrating the contents of the CloudConcentration.kmz file.

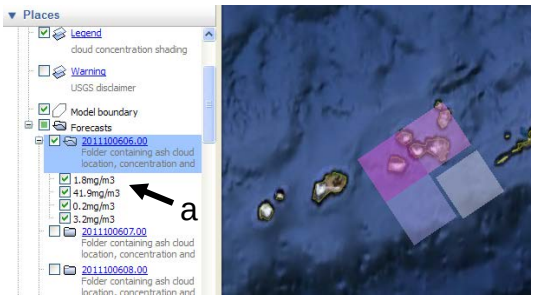

Figure 10: A subfolder has been set so that individual polygons can be viewed in the left sidebar ("a")

The cloud that's visible in the Google Earth window is actually a set of polygons, each of which has the size and location that corresponds (in 2-D) to one of the cells in the Ash3d model. When viewed from the side, these polygons are located at an elevation that corresponds to the top of the cloud. Because of their 3-D position, the polygons sometimes appear to have small gaps or overlaps between them when viewed at from overhead.

To view the concentration at a particular location in the cloud, place the mouse over that location. The outline of that node will appear (Fig. 8), and the cloud concentration value, in mg/m3, will be displayed. This feature also displays other properties, such as deposit thickness (mm) or cloud load (tonnes/km2) in other kmz files. This display is a 2-D representation of the 3-D cloud, hence the value of ash concentration displayed is actually the maximum in a vertical column of nodes at that x and y location.

Troubleshooting animations

Occasionally animations do not display properly when viewing a kmz file. The most common problems and their solution are given below.

1. ***The clouds from all times are overlapping in the Google Earth window.*** Ensure that the two caliper pincers on the timeline are pressed together (Fig. 7). If they are not, the timeline is set to display a time range rather than a single point in time.
2. ***Pressing the animation button doesn't make the cloud appear.*** Check the timeline to make sure that the start and end times displayed correspond to the beginning and end of the simulation time. If they indicate a much larger time span, you likely have another folder checked in "My Places" or "Temporary Places" on the left sidebar. Make sure that all other folders with time data are unchecked and try the animation again.
3. ***The animation runs too slowly or too fast, or doesn't loop.*** These settings can be adjusted by clicking on the wrench icon on the timeline (Fig. 7).

Manipulating the contents of a kmz file.

On the left sidebar of Google Earth, under "Temporary Places", one can view the contents of CloudConcentration.kmz. It contains a legend, a graphical USGS disclaimer, the model boundary, and a folder containing forecasts. Each sub-folder in the Forecasts folder contains an image of the cloud at a time which is specified by the folder name, in year, month, day, hour, and decimal hour (UTC). To view the cloud at just one of these specified times, uncheck the box next to the Forecasts folder, and then check on next to a single subfolder.

The contents of each subfolder may also be displayed by right-clicking that subfolder, choosing "Properties", and then checking the box labeled "Allow this folder to be expanded".

Summary comments

Ash3d is in a continual state of development. The descriptions provided here relate to the version of Ash3d that exists as of April 2012. For updates, check the Ash3d web page at http://vsc-ash.wr.usgs.gov. A detailed description of the model is provided in Schwaiger et al. (in review), while a User's Manual explaining the use of Ash3d outside of the graphical user interface is in preparation (Mastin et al., 2012 (in preparation)).

References

Dacre, H.F., Grant, A.L.M., Hogan, R.J., Belcher, S.E., Thomson, D.J., Devenish, B., Marenco, F., Haywood, J., Ansmann, A., Mattis, I., 2011 (in press). The structure and magnitude of the ash plume during the initial phase of the Eyjafjallajökull eruption, evaluated using lidar observations and NAME simulations. Journal of Geophysical Research.

Devenish, B., Francis, P.N., Johnson, B.T., Sparks, R.S.J., Thomson, D.J., 2012 (in press). Sensitivity analysis of dispersion modelling of volcanic ash from Eyjafjallajökull in May 2010. Journal of Geophysical Research.

Mastin, L.G., Guffanti, M., Servranckx, R., Webley, P., Barsotti, S., Dean, K., Denlinger, R., Durant, A., Ewert, J.W., Neri, A., Rose, W.I., Schneider, D., Siebert, L., Stunder, B., Swanson, G., Tupper, A., Volentik, A., Waythomas, C.F., 2009. A multidisciplinary effort to assign realistic source parameters to models of volcanic ash-cloud transport and dispersion during eruptions. Journal of Volcanology and Geothermal Research 186, 10-21.

Mastin, L.G., Schwaiger, H., Denlinger, R., 2012 (in preparation). User's Guide to Ash3d: A 3-D Eulerian Atmospheric Tephra Transport and Dispersion Model, U.S. Geological Survey Open-File Report.

Schwaiger, H., Denlinger, R., Mastin, L.G., in review. Ash3d: a finite-volume, conservative numerical model for ash transport and tephra deposition. Journal of Geophysical Research.

Wen, S., Rose, W.I., 1994. Retrieval of sizes and total masses of particles in volcanic clouds using AVHRR bands 4 and 5. Journal of Geophysical Research 99(D3), 5421-5431.