MAPTEK™ Vulcan™

# MODELLING VOLCANIC ASH CLOUDS

**Maptek Vulcan™ was applied to modelling volcanic ash clouds to help improve hazard management.**

*Vulcan model of volcanic ash concentrations in a plume 1200 seconds after eruption*

Dr Shannon Nawotniak of the Department of Geosciences at Idaho State University has applied Vulcan to modelling volcanic ash clouds for the purpose of improving hazard management.

Explosive volcanic eruption columns cause local, regional and global hazards. Where the ash settles and where the tephra - a general term for all solid phase material - ends up during and after an eruption impacts aviation, agriculture and habitation.

ADVANCES IN VISUALISATION TECHNOLOGY PROVIDE OPPORTUNITIES FOR BETTER MODELLING, AIDING COMMUNICATION TO IMPROVE REACTION TIME.

Volcanoes exhibit different behavioural patterns, on a variety of scales, with different results.

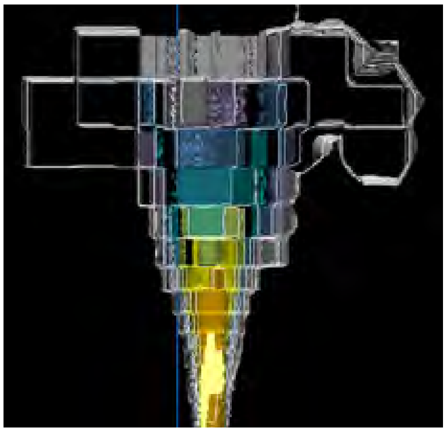
The catastrophic eruption of Mt Vesuvius in AD79 is well-known. The city of Pompeii was entombed when the relatively air starved pyroclastic flow collapsed.

Other volcanoes generate large columns which pull in enough ambient air to allow them to rise buoyantly. Sediment ash can rain down like liquid concrete onto structures, causing them to collapse. Acid rain can also be generated.

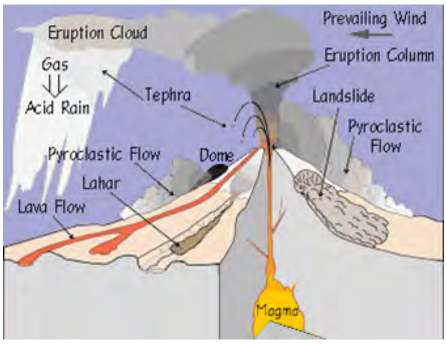
In 2010 Mt Eyjafjallajokull in Iceland sent a plume of ash up to 9 km high, with a billion dollar effect on the European and global aviation industry. Pressure to revise the zero tolerance for flying planes when ash clouds are present means that reliable tools are needed to accurately model plumes and visualise their behaviour in 3D.

By modelling ash clouds we can better understand their general anatomy and behaviour. Since eruption columns are opaque, we can't see what is going on inside them. What are the global $SO_2$ and $CO_2$ loads, and how does this affect farming? Where is the greatest risk of the ash cloud for aviation routes? These are all important questions.

Imagine that Mt St Helens was going to erupt tomorrow morning, and how useful it would be if we could predict where the ash would go during the next 8 hours. This information could be fed directly to the aviation industry for adjusting flight schedules. Emergency services could devise and implement evacuation plans. To be effective, the methodology needs to be fast and tools readily available.



*Model of volcanic ash concentrations in a plume 600 seconds after eruption*




*USGS diagram depicting volcanic eruptions*

Standard integral models invoke a bullseye pattern - big ash inside, small ash outside. When affected by wind, the bullseye is stretched and becomes elongate.

Nomograms, graphical tables describing these ash deposition patterns using simple models, are widely used to interpret prehistoric eruptions. Unfortunately, the simple models used to build the nomograms are inadequate when it comes to bent, wind-affected plumes.

Recent advances in modelling employ multi-phase, physics-based simulations. The Active Tracer High-resolution Atmospheric Model (ATHAM, originally from the labs of Hans Graf and Michael Herzog) uses computational fluid dynamics techniques to model the eruption column in 3D as a multiphase fluid flow, accounting for changing dynamics in a very complex system.

Our large study area - 100 km in three dimensions - required radical filtering of the vast numbers of data points. ATHAM data was imported into Vulcan to take advantage of the 3D modelling and visualisation capabilities. Block models and grade shells were generated.

VISUALISING THE MODELS IN 3D IS KEY TO UNDERSTANDING WHAT THE DATA ACTUALLY MEANS.

Using Vulcan we combined files and filtered out zero concentrations to visualise a short event, allowing us to compare it directly with real eruption plumes. Showing how a plume behaves in windy conditions allowed us to talk meaningfully with risk mitigation experts.

Simulating the eruption with variable wind conditions takes hours to capture minutes worth of simulation time. With more time, mappable regimes of flow can be generated. Cross sections can be produced to show gradations of ash concentration.

Seeing the morphology and concentrations change over time provides valuable information on the amount of ash, where it is in the atmosphere, and where flights can operate safely.

Once the data is modelled it can be merged with topography and hazard maps. For instance, one can easily show tephra accumulating on the ground and intersecting with evacuation routes. Being able to assess risk factors and communicate this information clearly is vital for emergency crews and preparatory mitigation planning.

*From a paper presented at*
*Maptek North America User Conference 2012*

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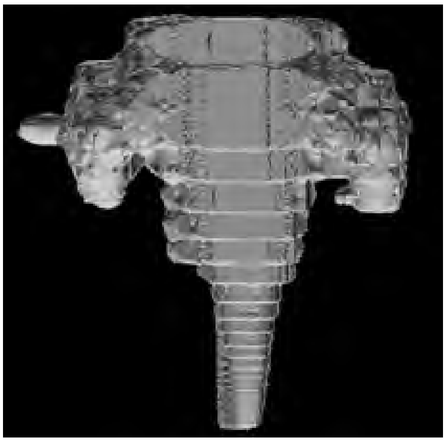
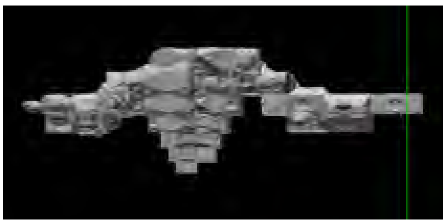


*Using Vulcan, an animation can be captured to show the changing shape of the plume exterior over time. At 600 seconds after eruption (above) a dense inner core spreads out as more air is entrained. At 1200 seconds (below) we can visualise the plume dying.*



*Different volcanoes exhibit different phenomena. Top to bottom: A blast at Cerro Negro; a plume at Eyjafjallajokull; a pyroclastic flow at Soufriere Hills. [photo sources acknowledged at conference]*

On average, 20 volcanoes are erupting at any given time. More than 1500 volcanoes have been active in the past decade; 600 volcanoes have historic eruptions and 50-70 volcanoes erupt each year. Some volcanoes are active for many years with little impact, while others have short duration but very great impact.

Mt St Helens in the USA ejected 1 $km^3$ of material in 1980. Mt Pinatubo, in the Philippines in 1991, was 10 times the size of Mt St Helens in terms of ejected mass. Mt Tambora in Indonesia erupted in 1815, disgorging 160 $km^3$ of matter. By comparison, Yellowstone Caldera ‘supervolcano’ covered 30-50% of the United States with 1000 $km^3$ of ash 600,000 years ago.

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