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Interactive simulation of an ash cloud of the volcano Grímsvötn

A project by
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GENERAL DESCRIPTION

This project was developed in June/July 2011 for the "Wissenschaftsmarkt" (Science Market) in Freiburg.
The background of the idea was the eruption of the volcano Grímsvötn on 21^{th} May 2011, around 5.30pm. The ash cloud also contained water vapour and ice particles and quickly reached a height of to 5500m (18000ft). At the beginning only the air space within a radius of 200km (124m) was closed, but then a storm drove the ash to the south in lower air layers, to the west in higher air layers. The air space over Scandinavia and Scotland had to be

closed next. Meanwhile the ash had risen in still higher layers, but still many airports in all Europe closed temporarily.
The program simulates how an ash cloud emitted by the Iceland volcano moves in a certain wind field which the user can draw on a map of Europe. The wind, that is, the velocity, does not change in time, as it would happen in reality. Like that it is clear and easy to see what happens when the volcano erupts and the ash cloud is moving over Europe. The ash transport is simulated by solving a partial differential equation (PDE).
The user will see the graphical interface. It provides input and output in an intuitive manner. The whole program consists of three parts: the graphical user interface and two background parts in which the calculations are realized. The graphical user interface gathers and stores information needed in the four steps of a program cycle.
One program cycle always starts with the positioning of the volcano. By touching the screen, clicking the mouse on the desired position the position of the erupting volcano can be chosen. If the desired position is reached, one can move on to the next step clicking the 'next' button.
In the next step, the user can draw some lines, which represent streamlines of the wind. Based on these lines a wind field is computed using the first background part.
Clicking once more on the 'next' button the computations of the wind field are performed, which might take a few seconds. After that the wind field is visualized on the screen, illustrated by blue arrows. Their shade of blue indicates the speed: They range from darker blue (high speed) to paler blue (lower speed).
After the computation of the wind field ends, the user can decide how much ash shall be dispersed by so-called micro-turbulences: There is a slider where the marked position is interpreted as the strength of the dispersion. If the user has chosen the strength of the dispersion and moves to the next step, the second background part starts its work. It computes the actual solution of the equation in the background. This may take some time and while the parallel computation is performed. The graphical user interface shows the progress of the ash on the Europe map. The progress of the simulation can be seen in the slider in the lower right. The slider also shows the actual shown frame, in this simulation 100 frames are generated using the second background part. This frames can be used to start an animation of the ash spreading over Europe. The animation is started/paused or stopped using the 'start/pause' or 'stop' buttons.
In the third and fourth step of one program cycle, the user may switch be-

tween different aspects of the velocity field with the 'arrow' button and also the grid cells can be made visible with the 'grid' button.
Whenever informations are needed the i-button gives a help screen for the program. Further information on each aspect of this simulation can be accessed using the 'Learn more about ...' links in the right hand panel, marked in blue.

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Authors

- Prof. Dr. Dietmar Kröner: idea, supervision
- David Nies, Janick Gerstenberger and Axel Pfeiffer: visualization, scripts, interfaces
- Tobias Malkmus: velocity field computation and problem adaptation in DUNE
- Dr. Robert Klöfkorn and Dr. Martin Nolte: support and problem adaptation in DUNE
- Theresa Strauch: problem adaptation in DUNE and organization

(References: see math_description.pdf)