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RePLaT-Chaos: a software for educational purposes to illustrate the chaotic behavior of the advection of volcanic ash clouds

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In everyday life we often read about the hazards due to volcanic ash clouds and other atmospheric pollutants. Nevertheless, it is not well-known that pollutant clouds do not disperse in the atmosphere like dye blobs on clothes, rather an initially compact pollutant cloud becomes soon strongly stretched, its length grows rapidly, while becoming filamentary, tortuous and folded. The RePLaT-Chaos software's simulations, utilizing reanalysis meteorological data, follow the time evolution of individual particles, by solving Newton's equation. They illustrate the typical structure of the spreading pollutant clouds, consisting or aerosol or gas particles, in an interactive way. RePLaT-Chaos is also a suitable tool for studying the chaotic features of the advection, such as sensitivity to the initial conditions (the trajectories of initially nearby particles diverge within short time), irregular motion, and complex but regular (fractal) structures. Besides the dispersion simulations, RePLaT-Chaos also determines two chaotic measures: the stretching rate, the strength of the exponential stretching of pollutant clouds, and the escape rate, the rate of the exponential decrease of the number of the particles not yet deposited from the atmosphere to the surface.
RePLaT-Chaos, created specifically for educational purposes, is a simpler version of the previously developed RePLaT (Real Particle Lagrangian Trajectory) model [1, 2]. In the full version of RePLaT-Chaos each simulation parameter can be changed. The student version tries to draw the students' attention by eye-catching animations of pollutant clouds emanated from different volcanic eruptions and includes easy to understand explanations. RePLaT-Chaos was tested in Berzsenyi Dániel Grammar School (Budapest, Hungary) by 7th and 12th grade students. The software is available at theorphys.elte.hu/fiztan/volcano/index.html.

[1] Haszpra, T., Tél, T. (2013): Escape rate: a Lagrangian measure of particle deposition from the atmosphere, Nonlin. Proc. Geophys. 20(5), 867–881.
[2] Haszpra, T., Horányi, A. (2014): Some aspects of the impact of meteorological forecast uncertainties on environmental dispersion prediction. Időjárás, 118(4), 335–347.