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A six-year record of volcanic ash detection with Envisat MIPAS

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Volcanic ash particles have an impact on the Earth's radiation budget and pose a severe danger to air traffic. Therefore, the ability to detect and characterize volcanic ash layers on a global and altitude-dependent scale is essential.

The Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) on-board ESA's Envisat is mainly used for measurements of vertical profiles of atmospheric trace gases. It is also very sensitive to cloud and aerosol particles. We developed a fast, simple, and reliable method to detect volcanic ash using MIPAS spectra. From calculations of volcanic ash and ice particle optical properties, such as extinction coefficients and single scattering albedos as well as simulated MIPAS radiance spectra, we derived two optimal micro windows at 10.5 and 12.1 μm to detect volcanic ash. The calculations were performed with the JUelich RApid Spectral Simulation Code (JURASSIC), which includes a scattering module.

Our method applies two radiance thresholds to detect volcanic ash. The first one is derived from a statistical analysis of six years of measured MIPAS radiances in the selected spectral windows. This statistical threshold accounts only for pure volcanic ash detections. The second threshold is derived from simulations of MIPAS radiances with JURASSIC for a broad range of atmospheric conditions and tangent altitudes for volcanic ash and ice particles. The second threshold allows more volcanic ash detections, because it accounts also for mixtures of ice and volcanic ash particles within the instrument's field of view.

With the new method major eruptions (from e.g. Chaiten, Okmok, Kasatochi, Sarychev, Eyafjallajökull, Merapi, Grimsvötn, Puyehue-Cordon Caulle, Nabro) as well as several smaller eruptions at mid-latitudes and in polar regions between 2006 - 2011 were clearly identified in the MIPAS data. Trajectory calculations using the Chemical Langangian Model of the Stratosphere (CLaMS) are used to locate a volcanic eruption for each detection.

In a case study of the 2011 eruption of the Chilean volcano Puyehue-Cordon Caulle we show how the volcanic ash spreads over the complete southern hemisphere mid-latitudes, is diluted and descends slowly with time. Ash is detected up to two month after the first eruption.