Stratospheric aerosols

By C. Bingen

Stratospheric aerosols are constituted by thin particles. Their origine can be terrestrial, antropogenic or cosmic (from meteoritic fragments).

During volcanic eruptions, sulfur compounds are injected into the stratosphere, giving rise to thin droplets of sulfuric acid and water.

In the period following the eruption, the size and number of particles varies, and the most part of aerosol falls back into the lower part of the atmosphere. Due to this fact, the influence of aerosols on the light transmission through the atmosphere can vary considerably, depending on the importance of the volcanic activity at the considered period.

May 18th, 1980: Explosion of the Mount St Helens (Oregon, USA)

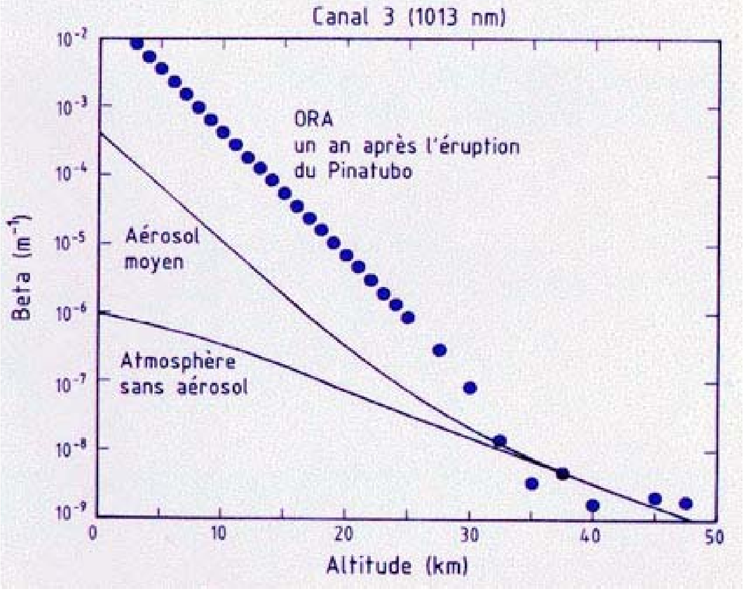
For instance, the decay of the solar radiation at ground level due to stratospheric aerosols was about 10% just after the eruption of Pinatubo in June 1991, whereas it was about 0.1% in May 1991.

Photographs of the Earth limb above the same region of France. Those photographs were taken before (left side) and after (right side) the eruption of Mount St Helens.

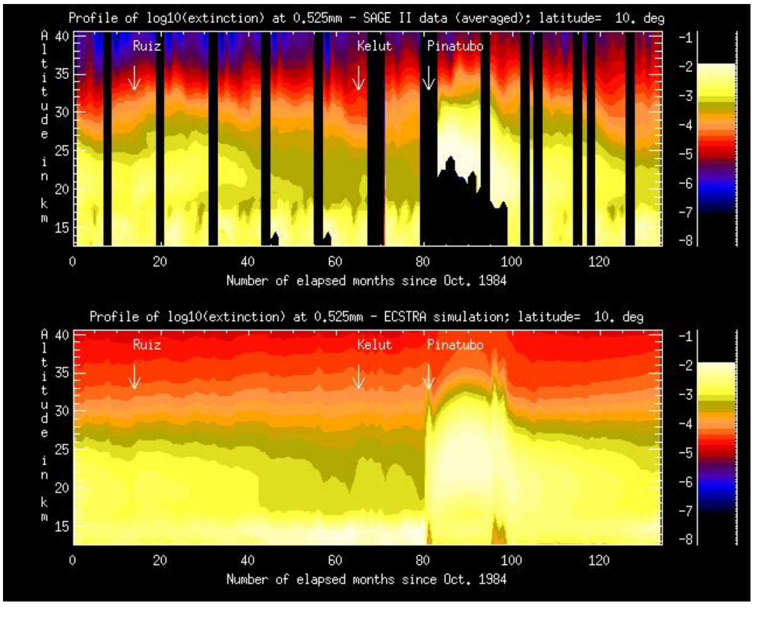
On June 5th, 1980, volcanic particles were spread in the whole lower stratosphere, and the clouds coverage could not be distinguished anymore, due to the importance of light diffusion by those particles.

Stratospheric aerosols reflect and absorb a part of the solar radiation.

The intensity decay per length unit of a sunbeam is quantified by the extinction coefficient.
The extinction value depends on the altitude and of course, on the aerosol mass loading of the atmosphere.



Extinction profile measured by the ORA experiment (dotted line). A comparison of those experimental data with two theoretical models processed in the case of clean and rather loady atmospheres (solid lines, with respective annotations 'Atmosphère sans aérosol' and 'Aérosol moyen') reveals the effect of the Pinatubo eruption..



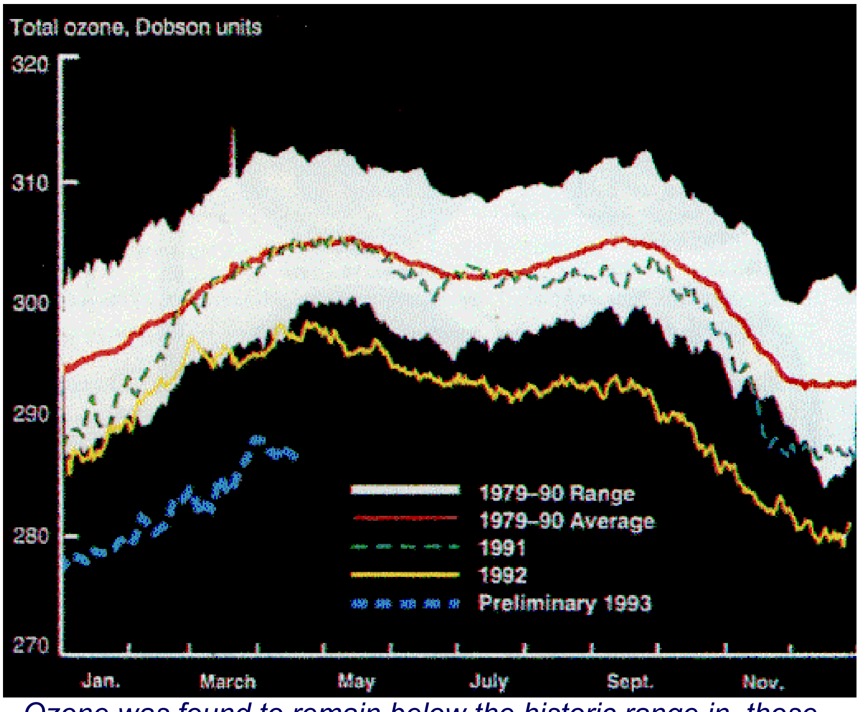
Extinction profiles plotted as a function of time and altitude.

The first contour graph was processed from data supplied by the SAGE II experiment. This experiment was launched aboard a satellite by the NASA. The considered data set is the result of 11 year uninterrupted measurement, from the launch time in October 1984.

The second contour graph shows a numerical simulation of the same extinction profile by the ECSTRA model developed at our Institute. The influence of major volcanic eruptions can be noticed: they induce a significant increase of the extinction coefficient in the lower and middle stratosphere.

Stratospheric aerosols also constitute a support for particular chemical reactions. Therefore, they play a significant rule in the mechanisms leading to the ozone depletion.

Aerosols influence the climate by modifying the circulation of stratospheric air masses. They also can induce a warming of the stratosphere due to light absorption, and corresponding to this, a cooling of the troposphere because of the decreasing amount of light in this region of the atmosphere.



Ozone was found to remain below the historic range in those observations from May 1992 to the beginning of 1993. The eruption of Mount Pinatubo is suspected to be responsible for this ozone depletion.

Aerosols also contribute to the changing colours of the twilight. They were observed in those particular conditions at our Institute, by using photographs of the Earth limb taken from stratospheric balloons.

Aerosol concentration was also measured by radiometric and spectrometric techniques from satellites (ORA experiment, developed at our Institute; experiments like SAM, SAGE I, SAGE II, ... developed by the NASA, etc.). From such observations, the aerosol size, number density and index of refraction can be determined as a function of altitude.

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Example of a photograph of the Earth limb taken aboard a stratospheric balloon.

Although the scientific community shows a great interest in this topic since several decades, the complex study of aerosols remains a topical subject. On the one hand, because of the technical improvements, in particular in the spatial research, allowing to refine our knowledge of the optical properties of aerosols; on the other hand, because the scientific researchers have realized the most importance to well understand and precisely quantify the effects of stratospheric aerosols. It is an essential condition to can correctly approach all the physico-chemical mechanisms playing a rule in the state and evolution of our atmosphere.