The Stratospheric Aerosol Layer

The Junge Layer

While searching for cosmic dust and debris from nuclear bomb tests, Christian Junge discovered in 1960 a layer of microscopic aerosol particles between the tropopause and about 18 miles (30 km) altitude. These particles are composed of sulfuric acid and water and are formed by the chemical transformation of sulfur-containing gases. This layer is called the *Junge Layer* or the *Stratospheric Aerosol Layer*.

The photograph on the left shows a sunrise over Pecos, Texas, as photographed from the space shuttle. Clouds (blue-white) and the stratospheric aerosol layer (red) are clearly visible in this image. The SAGE II (Stratospheric Aerosol and Gas Experiment) instrument aboard the ERBS satellite measures the obscuration of the sun by the Earth's atmosphere from a geometry similar to that in this image. The dependence of the obscuration on the color of light and altitude permits us to derive vertical profiles of aerosol, ozone, and other trace species.

By screening out sunlight, the stratospheric aerosol layer affects the atmospheric energy balance and hence climate. See NASA's fact sheet on Volcanoes and Global Cooling. The layer can also alter chemical cycles and perturb ozone levels.

The stratospheric aerosol layer is sustained by natural emissions of carbonyl sulfide (OCS) through biogenic processes. Carbonyl sulfide is relatively stable can mix into the stratosphere where it is photochemically broken down resulting in the formation of microscopic droplets of sulfuric acid.

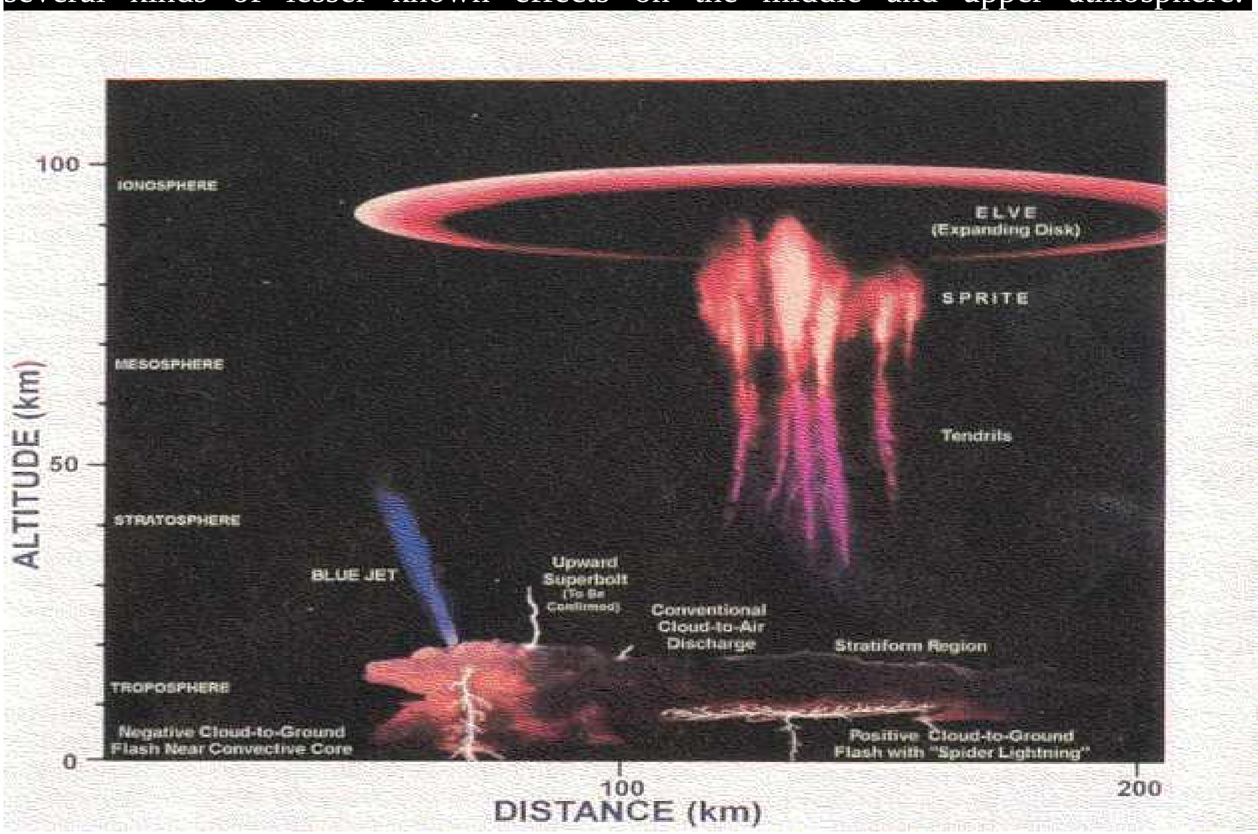
Another sulfur-containing gas, sulfur dioxide (SO_2), is normally too reactive to reach the stratosphere, instead it is rained out (as acid rain downwind of its sources). Volcanic eruptions, however, can inject SO_2 directly into the stratosphere where it too undergoes tranformation into sulfuric acid. But most volcanic eruptions do not penetrate into the stratosphere. In fact only a small number of eruptions in this century have had a significant impact on the Junge Layer. The most recent example is the June 1991 eruptions of Mt. Pinatubo. The impact of volcanoes on the Earth System was dramatically demonstrated by the eruption of Mt. Pinatubo in the Philippines. The eruptions had near-global effects on weather and climate via the introduction of sulfur dioxide and aerosols into the atmosphere. Satellite observations showed that the stratospheric aerosol layer was significantly enhanced for over three years. Many parts of the world experienced a drop in average temperature of approximately 1 degree Fahrenheit in 1992 compared to the 30-year average.

In addition the links above, other interesting sites are: NASA's Goddard Institute for Space Studies (GISS) page with graphs depicting the optical thickness (opacity) of the Junge Layer List of large and largest known volcanic eruptions Volcano World with everything you want to know about volcanoes.

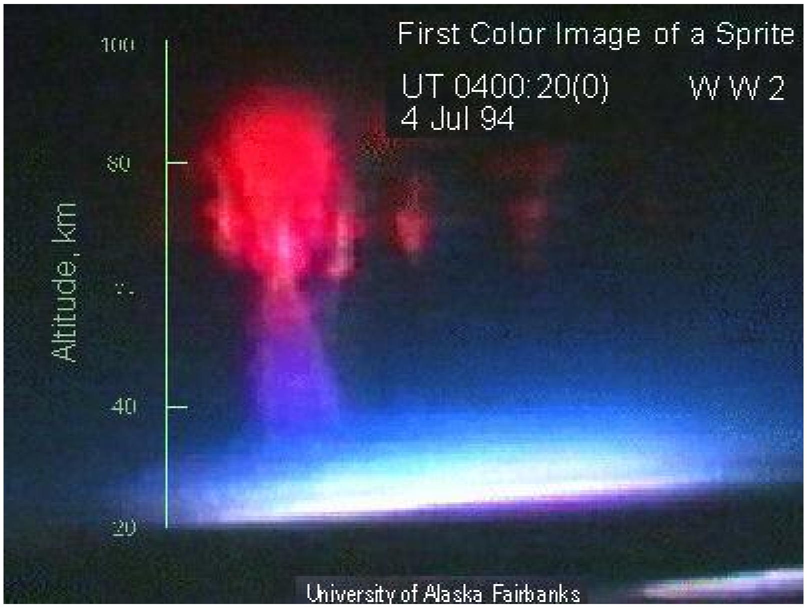
The story behind Edvard Munch's well-known painting *"The Scream"*

Red Sprites, Blue Jets and Elves

In addition to their well-known effects in the troposphere, large thunderstorms produce several kinds of lesser known effects on the middle and upper atmosphere.



Red sprites, blue jets and elves are upper atmospheric optical phenomena associated with thunderstorms that have only recently been documented by using low light level television technology. These phenomena are collectively called Transient Luminous Events (TLE's). As observations continue, scientists are collecting a confusing menagerie of phenomena.



Transient Luminous Events

Red sprites are large but weak luminous flashes that appear directly above an active thunderstorm system and are coincident with powerful positive cloud-to-ground lightning strokes. Their spatial structures range from small single or multiple vertically elongated spots, to bright groupings which extend from above the cloud tops to altitudes up to almost 60 miles (about 95 km. Sprites are predominantly red and they usually last no more than a few milliseconds. The brightest region lies in the altitude range 40 to 45 miles (about 65-75 km), above which there is often a faint red glow or wispy structure that extends to about 55 miles (90 km). Below the bright red region, blue tendril-like filamentary structures often extend downward to as low as 20 miles (30 km). Some events are loosely packed and may extend across horizontal distances of 30 miles (50 km) or more. Their shapes can be variously described as resembling jellyfish, carrots, or columns. Because of their low surface brightness, they have only been imaged at night (primarily with highly sensitive cameras). However, if ones eyes are sufficiently dark-adapted, one can actually detect them without any visual aid. The first images of a sprite were accidently obtained in 1989, although anecdotal reports of "rocket-like" and other optical emissions above thunderstorms go back more than a century (see for example an early account by Johann Georg Estor. Early research reports for these events referred to them by a variety of names, including "upward lightning," "upward discharges," "cloud-to-stratosphere discharges," and "cloud-to-ionosphere discharges." Now they are simply referred to as sprites, a whimsical term that evokes a sense of their fleeting nature, while at the same time remaining nonjudgemental about physical processes that have yet to be determined. More on the "discovery" and confirmation of sprites

Blue jets are a second high altitude optical phenomenon, distinct from sprites and first documented in 1994 (although pilots had earlier reported similar sightings). Blue jets are optical ejections from the top of the electrically active core regions of thunderstorms, but not directly associated with cloud-to-ground lightning. Following their emergence from the top of the thundercloud, they typically propagate upward in narrow cones of about 15 degrees, fanning out and disappearing at heights of about 25-30 miles (40-50 km) with a lifetime of a couple of tenths of a second.

Blue starters differ from blue jets in that they are brighter but shorter (reaching to only about 12 miles altitude). These were reported to occur over regions where large hailstones were falling.

Upward lightning is similar to a conventional lightning bolt, generally rather straight and may be tilted off vertical axis, but does not flicker like cloud-to-ground flashes. Lasts one, two and even 5 seconds with a yellow or white lightning channel, maybe with blue flames above.

Elves are rapidly expanding (up to 300 miles across) disk-shaped regions of luminosity, lasting less than a thousandth of a second, which occur high above energetic cloud-to-ground lightning of positive or negative polarity. Elves most likely result when an energetic electromagnetic pulse (EMP) propagates into the ionosphere. Though they can be accompanied by sprites, the causative mechanism is of an entirely different nature. Predicted to exist in 1991and discovered with a low-light video camera aboard the Space Shuttle in 1992, elves got their name as an acronym for Emission of Light and Very Low Frequency perturbations due to Electromagnetic Pulse Sources.

Sprite halos were mistaken as elves until 1999. They are diffuse disk shaped glows that apparently precede sprites and propagate downward from about 50 miles to 40 miles (85 to 70 km) altitude and last about a millisecond.

Trolls, also recently observed, resemble blue jets, but are red and seem to occur after tendrils of vigorous sprites extend downward toward the cloud tops.

Gnomes are possibly just a different manifestation of blue starters but appear with a more compact shape above convective domes.

Pixies are pinpoints of light, lasting less than 16 milliseconds, on the surface of convective domes that produced gnomes.

Gigantic jets, first documented in July 2002, are similar to carrot-shaped red sprites in spatial extent but propagate upward from the core of oceanic thunderstorms and are not directly associated with cloud-to-ground lightning.

Non-luminous emissions

There have recently been observed from space other types of unexpected non-luminous emissions that appear to originate from thunderstorms. These are:

TIPPS (Trans-Ionospheric Pulse Pairs) are extremely intense pairs of VHF pulses originating from thunderstorm regions, but some 10,000 times stronger than sferics produced by normal lightning activity. They were first observed by the ALEXIS satellite.

Gamma ray bursts of short duration (about 1 millisecond) with terrestrial origin have been detected by the Compton Gamma Ray Observatory. They are observed to occur over thunderstorm regions, and their source is believed to lie at altitudes greater than 30 km.

For additional info and more pictures:

University of Alaska "Sprite Pages"

Sky-Fire.tv "Sprites Page"

New Mexico Tech "Sprite Page"

PBS Nova program At the Edge of Space aired on Nov 2013