Volcanism as a Forcing Factor

Introduction

Climate forcing had and still has a major effect in the climatic condition of the earth. Forcing can be defined as an imposed perturbation of Earth's energy balance. Energy flows in from the sun, a huge percentage of it is in the visible light wavelengths, and back out again as long-wave infrared (heat) radiation. An increase in the luminosity of the sun, for example, is a positive forcing that tends to make Earth warmer. In this paper I would discuss volcanic eruption as a forcing factor. Volcanic eruption is a natural forcing factor, a very large volcanic eruption can increase the aerosols in the lower stratosphere that reflect sunlight to space and thus reduce the solar energy delivered to Earth's surface. More will be discussed in this paper. Human induced forcing factor can include the burning of fossil fuel to release carbon and all other Greenhouse Gases into the atmosphere.

Volcanism

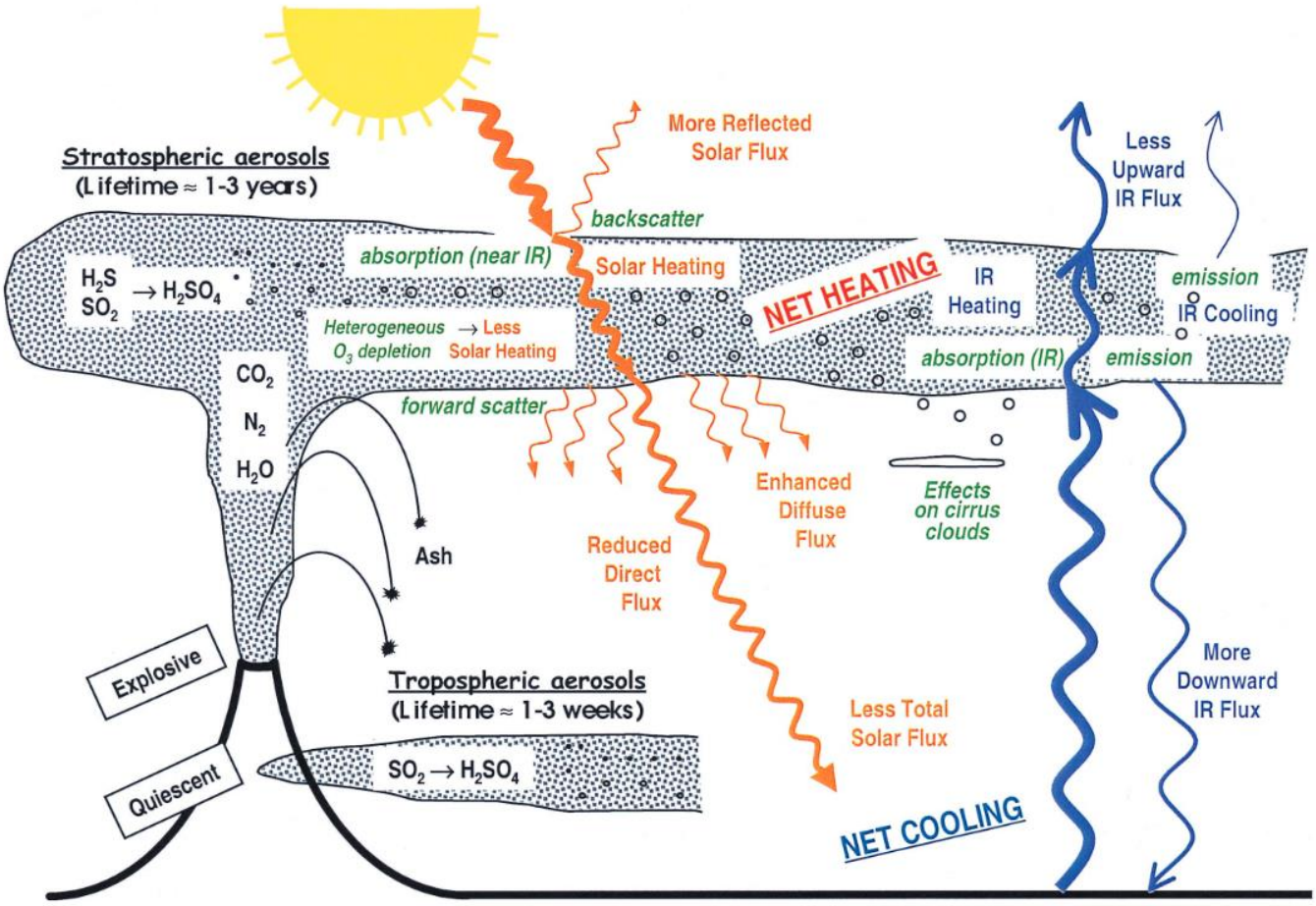
A volcano occurs when a part of the earth's upper mantle or lower crust melts and magma forms. A volcano is practically an opening or a vent through which this magma and the dissolved gases it contains are discharged. Several factors trigger a volcanic eruption including the buoyancy of the magma, the pressure from the absolved gases in the magma and the injection of a new batch of magma into an already filled magma chamber. As rock inside the earth melts, its mass remains the same while its volume increases thus producing a melt that is less dense than the surrounding rock. This lighter magma then rises toward the surface because of its buoyancy. If the density of the magma between the zone of its generation and the surface is less than that of the surrounding

and overlying rocks, the magma reaches the surface and erupts. Explosive eruptions can inject large quantities of dust and gaseous material like sulphur dioxide into the upper atmosphere where sulphur dioxide is rapidly converted into sulphuric acid aerosols. Whereas volcanic pollution of the lower atmosphere is removed within days by the effects of rainfall and gravity, stratospheric pollution may remain there for several years, gradually spreading to cover much of the globe. This is the major cause of the externality produced by volcanic eruption. The volcanic pollution results in a substantial reduction in the direct solar radiation, largely through scattering by the highly reflective sulphuric acid aerosols. The reduction, is however, compensated for by an increase in diffuse radiation and by the absorption of outgoing terrestrial radiation causing the greenhouse effect. Volcanic eruptions are said to have played a very major role in shaping the climate systems of the earth in the past.

Explanation of controls & influences of forcing factor

When volcanic eruptions occur, it is clear that the volcanic pollution affects the energy balance of the atmosphere while the dust and aerosols remain in the stratosphere. Observational and modelling studies (Kelly & Sear, 1984; Sear *et al*., 1987) of the likely effect of recent volcanic eruptions suggest that an individual eruption may cause a global cooling of up to 0.3°C, with the effects lasting 1 to 2 years. Taking a case study from the mount Pinatubo eruption of 1991 in the Philippines, stratospheric sulfate aerosols generated by the Pinatubo eruption cloud have had a huge impact on the radiation budget, atmospheric and surface temperatures, regional weather patterns, global climatic changes, and atmospheric chemistry, including environmentally important atmospheric effects such as global ozone depletion. The Pinatubo aerosol cloud persisted for 3 years. Radiative forcing of the climate system by stratospheric aerosols depends on the geographic distribution, altitude, size distribution, and optical depth of the aerosols, but

tropospheric temperatures are most strongly dependent on the total optical depth (Lacis and others, 1992). The optically dense Pinatubo aerosol cloud caused marked changes in the amount of radiation reaching the Earth's surface; in turn, these changes affected weather and climate over the past 3 years following the eruption.



Volcanic inputs to the atmosphere and their effects. Simarski [1992], drawn by L. Walter and R. Turco. *(Fig. 1)*

As for local influences, the main effect on weather right near a volcano is that there is often a lot of rain, lightning, and thunder during an eruption, commonly called volcanic weather. This is caused when the ash particles that are thrown up into the atmosphere attract and

collect water droplets. It is not quite known exactly how the lightning is caused but it probably involves the particles moving through the air and separating positively and negatively charged particles. Also the formation of vog, or volcanic fog occurs around such regions. For a world-wide effect, the eruption has to be an explosive one, when there are large explosive eruptions that throw material into the stratosphere. If it only gets into the troposphere it gets flushed out by rain. But the effects of such type of eruption on the climate varies as It seems to depend on the size of the particles which are mostly droplets of sulfuric acid. If these particles are big then they let sunlight in but don't let heat radiated from the Earth's surface out, and the net result is a warmer Earth; the Greenhouse effect. If the particles are smaller, probably smaller than about 2 microns then they *block* some of the incoming energy from the Sun and the Earth cools off a little. The effect of the Pinatubo eruption caused about a 1/2 degree of cooling noticed around the world.

Conclusion

Various climatic forcing has a major effect in the climatic condition of the earth and these forcing cause a perturbation of the earth's energy balance and thereby one way or the other causes either cooling or heating of the atmosphere. Volcanism which is the forcing factor considered in this paper is the eruption of molten rock (magma) onto the surface of the Earth, this magma has sulphur ($S0_2$) quantities of about 10% in them, but when ejected in large quantities into the atmosphere, the sulphur is hugely ejected into the atmosphere. Sulphur in itself is a cooling agent. However, if these particles are big, they allow more incoming solar radiation and trap more infrared radiation thereby cause warming, but if they are to small, they reflect more incoming solar radiation and thereby cause a cooling effect. Volcanic eruptions have a huge effect on the climate both regionally and global and has contributed tremendously to the perturbation of the earth's climate system in the past.

References

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