PARTICULATES ABSORB SOLAR ENERGY IN THE ATMOSPHERE

By Dr. Timothy Ball

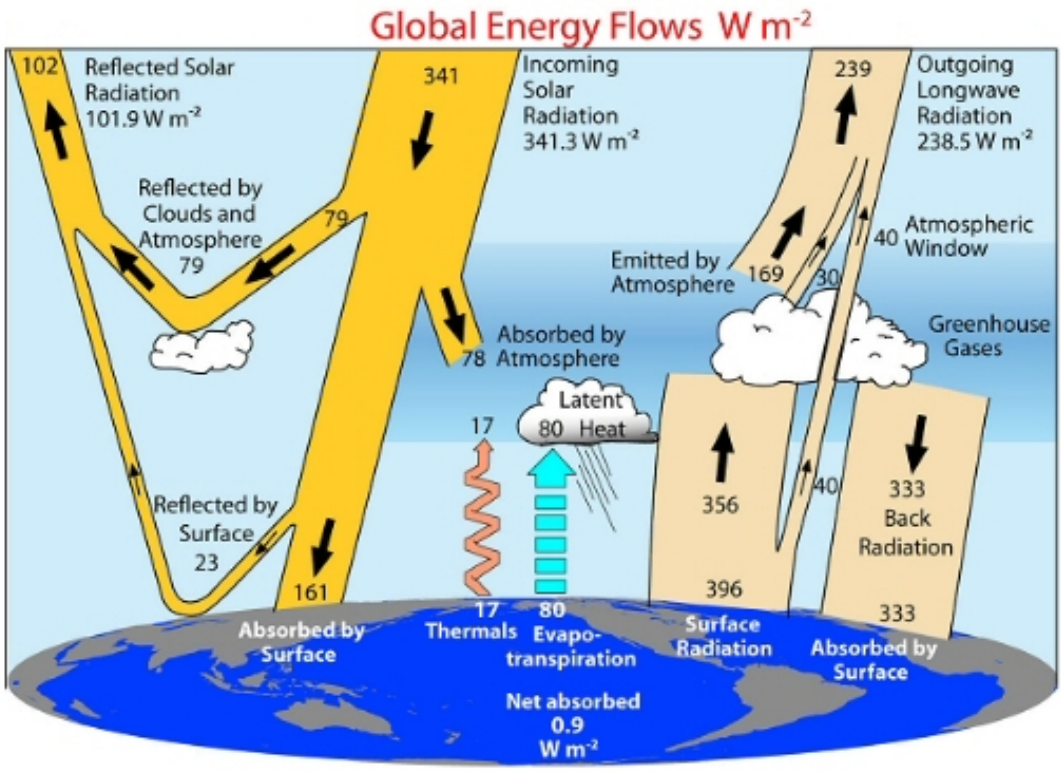
Introduction

A problem for astronomy even after the telescope was invented was distortion caused by material in the atmosphere. Once the Hubble telescope was placed beyond the atmosphere an entirely new vision of space emerged. Variations in the opacity were useful for some. For over 400 years farmers of the Inca Empire used a change in upper level atmospheric conditions to determine planting patterns. Their main crop, potatoes, is very susceptible to drought so adequate moisture, especially during early growth is very important. Each year just before dawn between June 15 and 24th, they observed the cluster of stars known as the Pleiades. They noted the time they appeared above the horizon, clarity of the stars, size of the cluster and the position of the brightest star. If the skies were clear, the stars bright and the cluster large because all the faint stars around the edge were visible, they expected early and adequate rains for the growing season from October to May (Southern hemisphere). They planted early. If the stars were hazy and in a small cluster they expected drought they delayed planting as much as 4 to 6 weeks to wait for better moisture conditions. Variations were due to the pattern of El Nino events. Warm conditions meant instability more rising air and greater concentration of material in the atmosphere. Cool conditions meant stability less rising air and clearer skies. Inca did not know the mechanism but their empirical knowledge identified cyclical variations in atmospheric conditions. Of course they were not always correct. The Andes are a volcanically active region that put large volumes of volcanic ash into the atmosphere. The Atacama Desert on the west coast of South America, from the Chile/Peru border to 30°south latitude, is probably the driest hot desert on Earth. Like all deserts it is a major source of dust, but the amount varies for a variety of reasons. These remarks apply to the west coast of South America but the same situations exist globally, often on a much larger scale. How much material is in the atmosphere and how much does it vary over time? The blunt answer is we don't really know.

Particulates /Aerosols

Contrary to popular understanding, virtually all numbers used in climate studies are estimates. These determine that the amount of sunlight absorbed in the atmosphere is approximately 19%, but this number varies depending

on the source. In the diagram of global energy flows it is shown as 22% (78 Wm^{-2}). Absorbing materials are collectively called aerosols and they vary over time. How much they vary is poorly determined, yet their effect is significant when compared with the effects of human produced CO2.



The most recent report of the Intergovernmental Panel on Climate Change (IPCC) acknowledges the problem (IPCC AR4 Chapter 2 section 2.4).

The IPCC only examines human sources of aerosols as their mandate dictates, but there is a massive volume of materials in the atmosphere. There are very few estimates of the amount. Mitchell (1973) estimated the total amount of dust, smoke and other particles as approximately 4×10^7 tons (40 million tons). In the early days the word particulates was used to apply specifically to solids in the atmosphere. Then the word aerosol came into use encompassing the solid particles but also water droplets. This is massively confusing and goes part way to explaining why so little is known and the issue is not fully considered.

NASA confirms the problems;
Scientists have much to learn about the way aerosols affect regional and global climate. We have yet to accurately quantify the relative impacts on climate of natural aerosols and those of human origin. Moreover, we do not know in what regions of the planet the amount of atmospheric aerosol is increasing, is diminishing, and is remaining roughly constant. Overall, we are even unsure whether aerosols are warming or cooling our planet.

http://earthobservatory.nasa.gov/Features/Aerosols/

Major sources of particulates in the atmosphere include the deserts or any exposed soil surface and the oceans. Only fine material tends to stay in the atmosphere. Salt particles stay in the atmosphere after being carried up as spray. When we flew anti-submarine patrols over the ocean the aircraft were usually between 150 and 300 m for several hours each trip. On return the planes were washed to remove considerable salt accumulations.

Over land the major particles are very fine material, usually clays. Large sizes fall out quickly and much material is washed out. Most of the research on the distribution and size of particles are related to health issues so they concentrate on small particulates close to the surface. What we need are more statistics on the volumes of particulates throughout the atmosphere. This material absorbs the solar energy and heats the atmosphere directly and until we know how much this varies it is one more reason why we cannot attribute temperature change especially warming to humans. A major part of the problem of mixing water droplets with particulates is it exacerbates the problem identified by NASA about whether aerosols are warming or cooling the planet.

Measurements

Aerosol effects are generally measured by comparing observations of reflected and transmitted sunlight between satellite sensors and ground sensors. The few observations available produce columnar data, which are then used in models to simulate what is thought to be happening. The Global Earth Observation and Monitoring GEOMON proposed in 2006 underscores how inadequate the methods and data are. The project is designed as *"a first step to build a future integrated pan-European Atmospheric Observing System dealing with systematic observations of long-lived greenhouse gases, reactive gases, aerosols, and stratospheric ozone."*

The strategic objectives of the project summarize the limitations of the information available on atmospheric composition and how it changes through time.

This strategic objective will answer the three overarching scientific questions:
Question 1. *What are the regional European trends and variability of greenhouse gases, tropospheric and stratospheric ozone, aerosols, and pollutants in relation to changes in surface emissions?*
Question 2*. How to validate top-down satellite observation of the changing atmospheric composition, and integrate them with ground based stations and airborne observations into a coherent picture?*
Question 3. *What are the global trends of atmospheric composition from ground-based and satellite observations assimilated in modelling studies, and what key measurements should be added for reducing uncertainties on surface emissions and atmospheric processes?*

http://geomon.ipsl.jussieu.fr/documents/abridged GEOMON DOW from final.pdf

Wind speed is another weather variable that receives inadequate attention. It is a major determinant of the amount of dust in the atmosphere. Deserts are the windiest climate regions and therefore contribute a great deal of atmospheric dust.

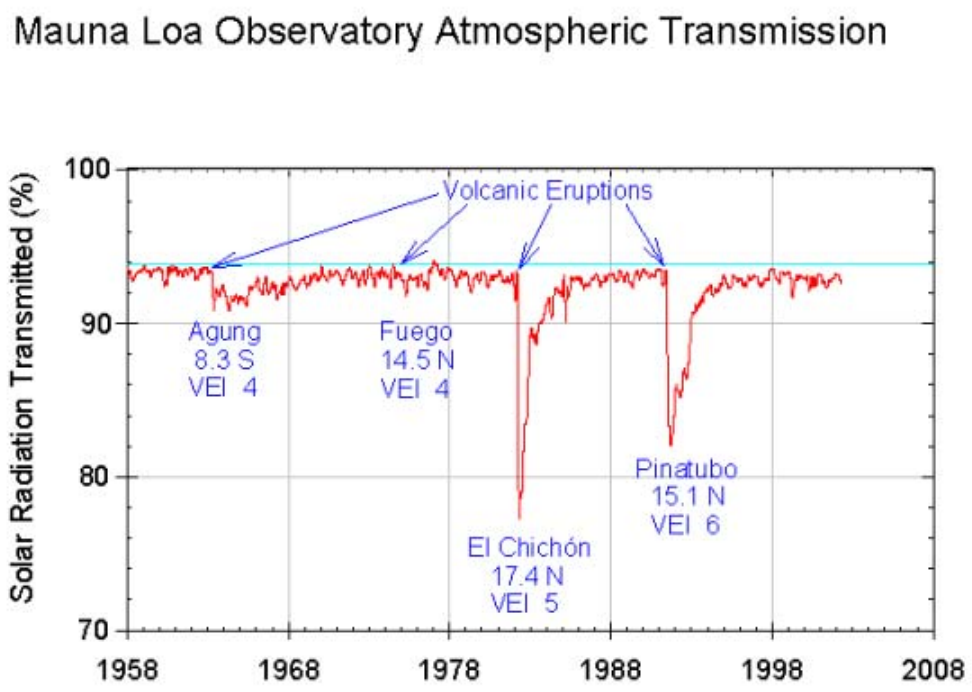
Volcanoes

In 1970 Hubert Lamb published an article on volcanic dust in the atmosphere.

http://cdiac.ornl.gov/ftp/ndp013/ndp013.pdf

From this he evolved a Dust Veil Index (DVI), a quantification of changes in atmospheric composition and its impact on the Earth's energy balance. It covers eruptions from 1500 to 1983 A.D. It needs updating.

The following diagram shows the change in atmospheric ability at the Mauna Loa observatory in Hawaii. Four volcanoes are identified but each with distinctly different impacts, which raises important questions.



http://upload.wikimedia.org/wikipedia/commons/9/9c/Mauna_Loa_atmospheric_transmission.png

Two of the volcanoes, Fuego and El Chichon, are in the Americas and two, Agung and Pinatubo are in southeast Asia. What they all have in common is they are in the equatorial region and they are what are called stratovolcanoes. These are volcanoes formed on continental crust as opposed to Hawaiian type volcanoes on oceanic crust. Because of the difference in source material stratovolcanoes are explosive.

For an eruption to have a large climate impact there are four general requirements.

1. It is an explosive type volcano.
2. The eruption is vertical (unlike Mt St Helens, which went sideways) and places material in the stratosphere.
3. They are near the equator.
4. They have a high percentage of sulfur in the dust ejected.

It is apparent from the record that El Chichón and Pinatubo met all four requirements. Most dust from any eruption falls out within days and more is

washed out in precipitation. Finer material especially that in the stratosphere takes much longer as the plot shows.

One factor not considered is the frequencies of sunlight most affected. For example, Pinatubo reduced global annual average temperature by approximately 1°C. Most of the reduction in sunlight was in the yellow portion of the sunlight because of the sulfur dust in the stratosphere. This is important for energy balance but also for the effect on plants and animals. All this generally speaks to energy reduction at the surface; it does not estimate the increased direct heating of the atmosphere.

Summary

There are many factors that can cause climate change. Only a few are considered in the current scientific debate and virtually all of them are based on estimated data or very inadequate data. The amount and nature of aerosols in the atmosphere and how they affect the amount of solar energy that heats the atmosphere directly or limit the amount reaching the surface is one of them.

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