

# Chapter 5

## Global Dimming and Global Warming: Dangerous Alliance

Monika Thakur

**Abstract** Global dimming is a phenomenon which produces forces that act opposite to [global](#) warming in nature. Global dimming reduces the amount of sun's rays reaching the earth's atmosphere causing a drop of temperatures around the globe. In addition, global dimming interferes with the hydrological cycles in the biosphere and reduces evaporation rate. The study on global warming wouldn't be complete without mentioning global dimming. Global dimming is caused by an increase in [particulates](#) such as [sulfate aerosols](#) in the atmosphere. The pollutants that lead to global dimming also lead to various environmental problems, such as phytochemical smog, respiratory problems, and acid rain. The present review discusses the combined effect of global dimming and global warming. Global Dimming and Global Alliance have been opposite phenomenon with contrasting effects and are destructive to plants. The effect can be reduced by every individual playing his role by reducing fuel consumption, creating awareness for the consumption of non-essential commodities, walking, and planting trees.

**Keywords** Pollutants • Greenhouse gases • Global dimming • Global warming • Suspended pollutants • Surface solar radiations

### 1 Introduction

The changing climate impacts our health and well-being. The major health organizations of the world visualize climate change as a critical public health problem. Climate change expresses an increase in the temperature of the planet, ocean expansions, rise in the sea level, floods, and droughts.

Weather and climate are very often confused. There is a lot of difference between climate and weather. *Weather* is short-term variations in atmospheric phenomenon that interact and affect environment and life; whereas, *Climate* is a long-term

---

M. Thakur (✉)

Amity Institute of Food Technology, Amity University, Noida, Uttar Pradesh 201303, India  
e-mail: [mthakur1@amity.edu](mailto:mthakur1@amity.edu)

© The Author(s) 2018

T. Jindal (ed.), *Paradigms in Pollution Prevention*, SpringerBriefs in Environmental Science, DOI 10.1007/978-3-319-58415-7\_5

61

average of variation in weather for a particular area. Global climate (temperature) is changing and humans are influencing the change in climate. Global climate has changed in the geological past; various factors influence global climate change. Climate will probably change in the future too.

The amount of solar radiation incident at the earth's surface is not stable over the years but undergoes significant decadal variations (Pathirana 2008). Wild (2009) reviewed the evidence for the changes, magnitude, possible causes, representation in climate models, and their potential implications for climate change. Solar radiation incident at the earth's surface is the ultimate energy source for the life on this planet, and majorly determines the climatic conditions of the planet. The amount of solar energy reaching the earth's surface is a major component of the surface energy and governs a large number of diverse surface processes: evaporation, snow, glacier melting, photosynthesis, terrestrial carbon uptake, diurnal and seasonal course of surface temperatures, etc. Changes in the amount of solar energy reaching the earth's surface can therefore have profound environmental, societal, and economic implications. On the other hand, there is growing evidence that human interference with and in climate leads to various alterations of solar radiation in polluted atmospheres. Solar energy reaches the earth's surface either as direct beam from the sun or in diffuse form after scattering in the atmosphere. The sum of the direct and diffuse radiation incident on the surface is known as Global Radiation or Surface Solar Radiation (SSR).

Nowadays, the main focus of climatologists is on global dimming (GD) and global warming (GW). GD reduces the amount of sun's rays reaching the earth's atmosphere and causes a drop of temperature around the globe. In addition, global dimming interferes with the hydrological cycles of the biosphere and reduces the rate of evaporation. The study on global warming wouldn't be complete without mentioning global dimming. Global dimming is a phenomenon which produces forces that have to act opposite to [global](#) warming in nature. The combined effects of GD and GW are deadly; climatologists nowadays emphasize dealing with both global dimming causing pollutants and global warming causing greenhouse gases together at global level. GW is accelerating day by day because of the increased amount of particulate pollution in the atmosphere. We can combat the combined effect of global dimming and global warming only by reducing carbon emissions in all forms and by taking steps which reduce the use of fossil fuels. Therefore, each individual must play his role by reducing fuel consumption, creating awareness for the consumption of nonessential commodities, walking, planting trees, or just by being a citizen aware of this globalized world. This chapter summarizes the introduction, impact, and effects of global warming and dimming. The main focus was on their joint alliance so that both the deadly problems can be dealt simultaneously.

## 2 Global Dimming

Global dimming is the gradual reduction in the amount of direct **irradiance** at the **earth's** surface. It has been caused by an increase in **particulates** such as **sulfate and aerosols** in the atmosphere due to various human activities. The pollutants that lead to global dimming also lead to different human and environmental problems, such as smog, respiratory problems, and acid rain. Global dimming is basically from air pollutants and fossil fuels which make clouds reflect more of the sun rays back to the space. This leads to global dimming, whereby less heat and energy reaches the earth (Sarkar 2009). Global dimming is the increase of reflection and absorption of solar radiation by the troposphere (Pathirana 2008).

Due to this phenomenon, there is a decrease in the amounts of solar radiations reaching the surface of the earth. Use of fossil fuel produces various greenhouse gases and releases other by-products such as sulfur dioxide, soot, and ash (Hansen and Lacis 1990) which are also pollutants. These pollutants change the properties of clouds and make them more reflective. More of the sun's heat and energy is therefore reflected back into space. Eccleston (2007) called global dimming as a darkening problem all over the globe.

Human activities could cause cooling effect in the nature. Reflection from atmospheric particles could reduce incoming solar radiation by 10% in the process of global dimming.

### 2.1 Causes of Global Dimming

Earlier it was thought that changes in the sun's luminosity cause global dimming but, later, it was realized that this was a very small aspect of the same. The **burning of fossil fuels** used by industry emits various by-products, and aerosols have been found to be major cause of global dimming. Ramanathan et al. (2001) stated that these aerosols together form particulate **pollution**. They act as precursor to global dimming in the following two ways:

- The particle matters enter the atmosphere and directly absorb solar energy, and they then reflect radiation back into the space, before it reaches the planet's surface.
- Water droplets containing these air-borne particles form polluted clouds. These polluted clouds have heavier and larger number of droplets. Because of the changed properties of the clouds, they are called as "brown clouds" and are more reflective (Ramanathan et al. 2005). Figure 5.1 explains the formation of polluted clouds.

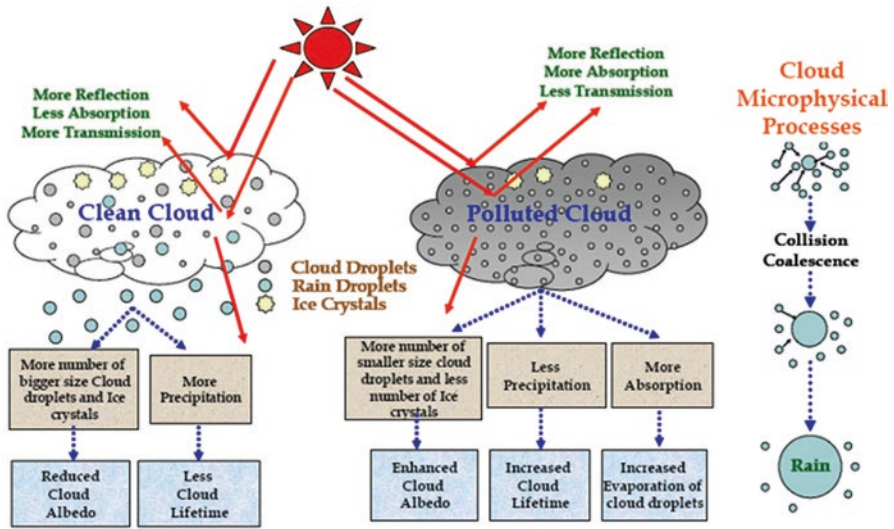


Fig. 5.1 Polluted clouds

## 2.2 Impact of Global Dimming on Climate System

Global dimming has devastating effects on the earth’s environment and living beings. Global dimming and [global warming](#) have caused severe changes in the rainfall patterns (Max and Seattle 2010). The clear-cut effect of global dimming is “famine” and “drought.” The famines of 1970s and 1980s were a direct effect of rainfall shortage which resulted from this phenomenon. Many people from all over the world including America, Europe, Asia, and Africa experienced famines. The anthropogenic pollutants added in the developed countries are affected by acid rain, which is caused by the aerosols in the clouds. The process of photosynthesis in the plants gets reduced due to the shortage of solar radiations. The sulfur aerosols when inhaled can cause various respiratory diseases in human beings.

Global dimming is also believed to cause [heat waves and runaway fires](#). GD is thought to be counteracting the actual effect of carbon emissions on global warming. So, if efforts are made to reduce particulate emission causing global dimming, it will enhance global warming and double the global temperatures. This will make planet Earth, almost uninhabitable. To prevent such a situation, it is important that emission of both greenhouse gases and particulate matters are to be reduced simultaneously to balance out both the phenomena.

It is well known that the fossil fuel productions generate greenhouse gases that cause global warming and release by-products which are pollutants that cause global dimming (Wild et al. 2007). These pollutants also lead to difference. The impacts of global dimming itself, however, can be devastating. Various studies have been conducted on the impacts of global dimming and climate change. Some of the major effects have been discussed below:

- Less solar energy will limit the rate of photosynthesis.
- Masking effects of global warming.
- Chemical nature of clouds will be changed.
- Causes famine and drought.
- Acid rain formation.
- The pollutants can cause congenital (birth) defects, coughing, sneezing, itchy throat, lung damage, and other respiratory diseases.
- Because of GD process, the water in some areas has cooled and has resulted in less rainfall. This has led to bad crops or droughts for a longer period in many parts of the world.
- Global dimming also leads to [acid rain](#), [smog](#), and respiratory diseases in humans.

### 2.3 *Evidences of Global Dimming*

Sukumar (2011) discussed the change in the United States after 9/11 attacks. Three days after the attack scientists found that the sky was abnormally very clear. The contrails (artificial vapor cloud) were the causes for such a climatic change. It was later revealed that the temperature during the 3 days after 9/11 was reduced to 1 °C from the average range before 9/11 and few days after the incident. The 1 °C reduction in temperature is nothing much for a common man, but scientific records reveal that this kind of abrupt reduction in temperature can have adverse effects in the near future.

### 2.4 *Global Warming*

There are three different factors of temperatures on earth's surface: (i) the amount of sunlight received; (ii) the amount of solar energy reflected and absorbed; (iii) the amount of retention by atmosphere. Earth is absorbing the short wavelength solar energy, and then radiating long wavelength IR radiation. In global warming, the greenhouse gases are actually needed to keep the earth warm. Without the greenhouse effect, the water on the earth's surface would be frozen. Earth would be a very cold place. However, the excessive greenhouse gases could potentially warm the earth too much. Several atmospheric gases: CO<sub>2</sub>, CH<sub>4</sub>, CFCs, nitrogen oxides trapping more heat and warming up the lower atmosphere, similar to the effect of a greenhouse. The concentration of green house gases have been increased in the environment due to anthropogenic sources (especially burning fossil fuels). Figure 5.2 illustrates the energy balance on the earth's surface as how the 100% incoming solar radiations on the earth's surface will be distributed and reflected back.

It is a phenomenon caused by an increase in the atmospheric temperature of the earth's surface, due to the increase in concentration of greenhouse gases such as CO<sub>2</sub>, CH<sub>4</sub>, and CFCs. These greenhouse gases trap the solar rays and cause temperature rise in the earth's atmosphere (Fig. 5.3). This process of trapping solar energy

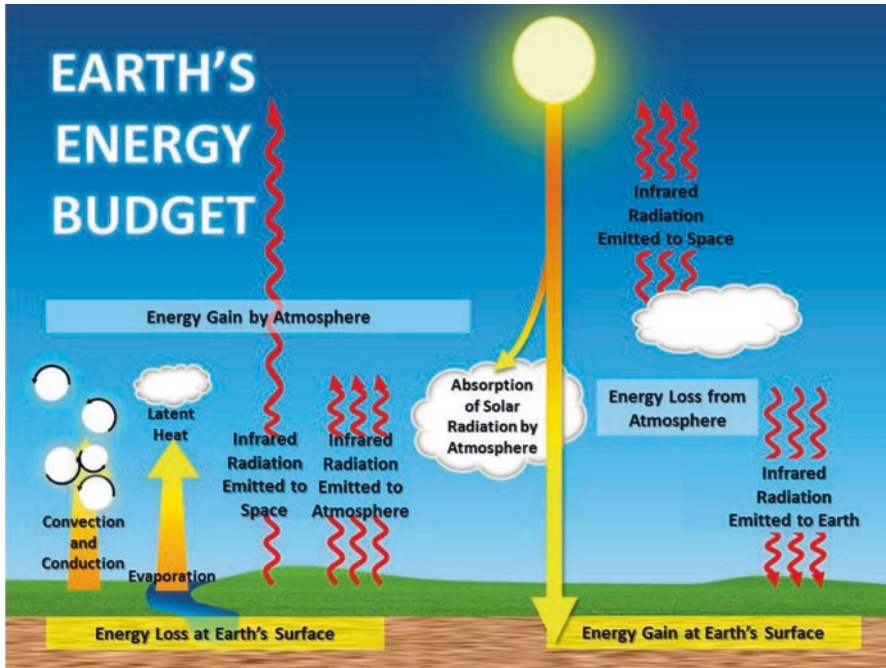
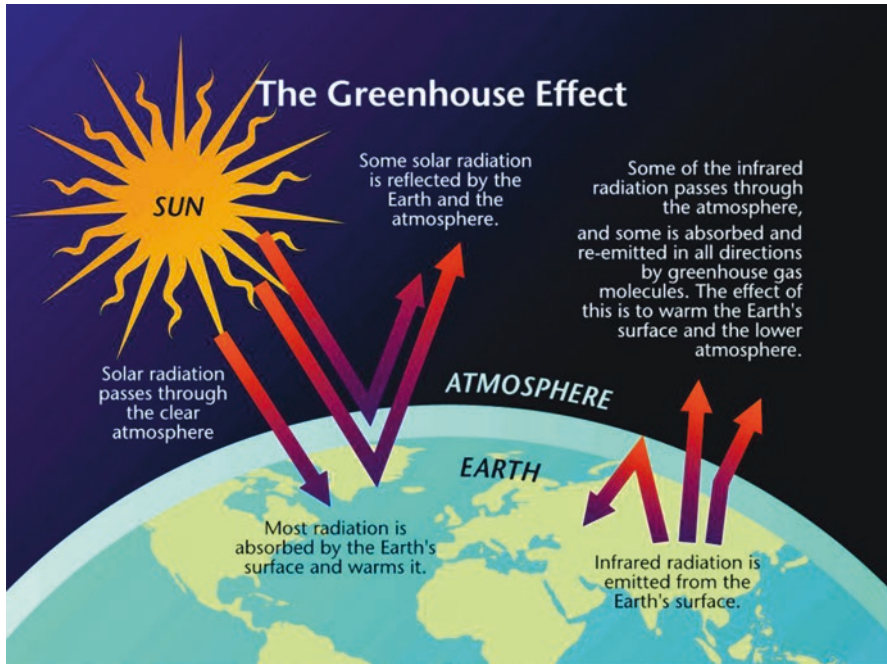


Fig. 5.2 Energy balance of earth's surface

is called greenhouse effect. Increase in population causes demand in energy sources by burning fossil fuels and cutting down trees (deforestation) which is major cause for global warming. It is clear now that the burning of fossil fuels directly contributes to global warming by releasing greenhouse gases (GHG). Trees and plants take in  $\text{CO}_2$  and give out  $\text{O}_2$ . If these plants and trees are cut down, the  $\text{CO}_2$  will remain unused in the atmosphere and increase the temperature of the earth's surface, which is called global warming (Sukumar 2011).

## 2.5 Impacts of Global Warming and Climate System

In recent years, we have heard a lot about various natural disasters like floods, hurricanes, tornadoes, droughts, extinction of certain species, earthquakes, etc. Basically, humans are interfering too much with the nature and act against it in many ways. The natural balance in the earth is being shaken by various human activities and the direct result is global warming. Glaciers in the Polar Regions and mountains melt down and the sea level rises which is all due to the increase in temperature, and it causes floods and damage the food crops. Large areas of lands are damaged permanently due to extraction of fossil fuels from deep underground. This leads to frequent earthquakes on earth. Ozone layer is a blanket that



**Fig. 5.3** Greenhouse effect (incoming infrared radiation has short wavelengths but the outgoing infrared radiation has longer wavelengths)

entirely covers the earth's surface and protects it from harmful UV (ultraviolet) radiations. The CFC that is emitted from refrigerators, insecticides, and other resources depletes the ozone layer and makes our earth vulnerable to harmful UV rays (Sukumar 2011).

Various effects of global warming have been listed below:

- As there is doubling in the amount of the greenhouse gases, then 1.5–6 °C (2.6–10.2 °F) increase in average global temperature.
- Significant rise of sea level and melting of glacierice due to the increase in planet temperature have been affecting more seriously the island nations and also increased coastal erosion worldwide.
- The number of retreating glaciers accelerating in many areas of the world.
- Global warming leads to significant changes of rainfall and soil moisture.
- Agricultural activities and world food supplies affected greatly by climatic factors.
- Global warming affects the frequency, intensity, and distribution of various natural hazards.
- Desert areas have been expanding gradually.

## 2.6 *Comparison Between Global Dimming and Global Warming*

The two deadly phenomena that have great effect on our earth are global warming and global dimming, and they have attracted much attention in the recent years. Due to industrial revolution, increase in population, and growing demands of the people, these issues are booming out at a greater pace. They pose great danger to our earth, and the sole responsibility is in the hands of human beings.

**Global warming** and global dimming are opposite phenomena. Global warming is defined as the increase in the atmospheric temperature. This is largely caused by **greenhouse gases**. Greenhouse gases produced from the burning of fossil fuels traps the infrared radiations. This heats up the earth's atmosphere. Global dimming is a less well known but real phenomenon resulting from atmospheric pollution. It has devastating effects on the earth's environment and living beings. The burning of fossil fuels in the industries, in addition to releasing the carbon dioxide, traps the sun's heat within our atmosphere, causing the emission of the so-called particulate pollution—composed primarily of sulfur dioxide, soot, ash, etc. When these particulates enter the atmosphere, they absorb solar energy and reflect sunlight otherwise bound for the earth's surface back into space. Particulate pollution also changes the properties of clouds—the so-called brown clouds are more reflective and produce less rainfall than their more pristine counterparts (Ramanathan et al. 2005). The reduction in heat reaching the earth's surface as a result of these processes is global dimming.

**“The twin effects of Global Warming and Global Dimming due to human pollution can be extremely disastrous. While global warming increases temperature due to the greenhouse gases, global dimming reduces sun's intensity due to suspended solid pollutants. They can cause massive climatic change and catastrophic natural disasters like cyclones, droughts, floods, hurricanes, etc.”**

Though both the phenomena are opposite with contrasting effects, they are destructive to the planet. It is due to both global warming and global dimming that the earth's temperature has increased less than what it should have been. Without global dimming, this planet would have turned to be too hot for all of us to survive. Both of them are dangerous and can prove fatal for our environment and need to be solved together. If the focus is really not made on such conditions, it may be harmful and may prove fatal for all of us.

- The global warming causes heating effect in the earth's atmosphere, whereas global dimming causes cooling effect.
- Global warming is caused by greenhouse gases, and global dimming is caused by aerosols and other pollutants.
- GW traps sunlight and GD blocks sunlight.
- GW will damage the environment whereas GD will cause health problems to living organisms.



## 2.7 *Common Factors of GD and GM*

The commonality between these two phenomena is that both are destructive alliances to our earth, which will cause environmental and ecological problems. Scientists in developed and developing countries should be more cautious and take the necessary steps to mitigate the effects of global warming and global dimming. The developing countries are always the most affected and fall prey to these phenomena, due to industrialization and other acts of the people in the developed countries. It is important that we all should join hands and protect our earth from the adverse effects of global warming and global dimming (Sukumar 2011).

## 3 Future Challenges

Since both the phenomena are dangerous alliances and are to be dealt with greater importance, various steps are to be taken to protect the earth from their adverse effects. Various solutions have been suggested below:

1. Simultaneous tackling of global dimming and global warming
2. Reductions of particulates matter in the atmosphere
3. Simultaneous effect at global level

We as humans need to create a balance, so that both global warming and global dimming can be kept in control. Some anthropogenic measures can wisely be taken as mentioned below:

- We need to reduce our dependence on fossil fuels and turn towards new green technologies.
- We need to create strict regulations for industries, so that gas emitting from factories can be reduced to the acceptable levels.
- Awareness programmes on Global Dimming and Global warming
- We need to protect our natural resources such as forests, oceans, and snow-capped mountains.

This chapter discusses in detail and emphasizes the need to keep focused on all solar and thermal components of the earth's atmosphere. Both GD and GM are deadly, therefore, creating awareness and tackling them together is necessary. We should fully quantify and understand the anthropogenic and natural perturbations of the radiation balance, which are on at the sole basis of global climate change. In conclusion, joint efforts and association is required so that the problems being directly / indirectly screened and their hazardous impacts may be minimized on human population and the climate.

## References

- Eccleston CH (2007) Global Dimming: A Darkening Problem. *Environ Pract* 3:152–153
- Hansen JE, Laci AA (1990) Sun and dust versus greenhouse gases: an assessment of their relative roles in global climate change. *Nature* 346:713–718
- Max S, Seattle WA (2010) Dear Earth Talk: I've heard of global warming, of course, but what on Earth is "global dimming"? Retrieved from [business-ethics.com](http://business-ethics.com). Earth Talk—Consumer Info. Accessed 2 Feb 2016
- Pathirana A (2008) Global dimming—a cure for climate change or an agent for making its impacts worse. In: Proceedings of the 11th international conference on urban drainage, 31 August 2008
- Ramanathan V et al (2001) ATMOSPHERE: aerosols, climate, and the hydrological cycle. *Science* 5549:2119–2126
- Ramanathan V et al (2005) Inaugural article: atmospheric brown clouds: impacts on South Asian climate and hydrological cycle. *Proc Natl Acad Sci U S A* 102:5326–5333
- Sarkar AN (2009) Global climate change and sustainable energy development. Pentagon Press, New Delhi, India
- Sukumar S (2011) <http://www.buzzle.com/articles/what-is-the-difference-between-global-dimming-and-global-warming.html>. Accessed Feb 2015
- Wild M (2009) Global dimming and brightening: a review. *J Geophys Res Atmos*. doi:10.1029/2008JD011470
- Wild M, Ohmura A, Makowskim K (2007) Impact of global dimming and brightening on global warming. *Geophys Res Lett* 34(4):L04702. doi:10.1029/2006GL028031