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Global Dimming: Causes, Effects and Possible Solutions

AMIT KUMAR SHARMA*[1] AND ANAM FATMA[2]
[1]Assistant Professor and [2]Research Scholar
Department of Economics, DDU Gorakhpur University, Gorakhpur (U.P.) India

ABSTRACT

Solar radiation reaching the ground is the key determinant of surface temperature. Global dimming or Dimming of the Sun is a phenomenon which produces forces that act opposite to global warming in nature. Global dimming decreases the amount of sun's rays reaching the earth's atmosphere causing a drop of temperatures around the globe. The origin of dimming has shown to be internal to the climate system and not externally forced by the Sun. The study on global warming wouldn't be complete without incorporating global dimming. Global dimming creates has an opposite effect to global warming as it creates cooling effects so in essence, global dimming is helpful to the environment. The outcome of global dimming varies by locations, with some areas being poorly affected than others.The phenomenon of global dimming andbrightening is consequently a pure result of changes andprocesses that take place within the climate system, particularly in the atmosphere. The study is important because it is the root causes of Global Warming which is crucial for our planet system.

Key Words : SSR- Surface Solar Radiation, Global Dimming, Brown Cloud, Global Brightening, Global Warming, CO_2- Carbon Dioxide, Global Radiation/ Isolation

INTRODUCTION

Solar radiation reaching the ground is the key determinant of surface temperature. This is increasing evidence that solar radiation incident at the Earth's Surface (also known as Surface Solar Radiation, Global Radiation or Isolation) has not been constant over time. Global dimming or Dimming of the Sun is a phenomenon which produces forces that act different to global warming in nature. Global dimming reduces the amount of sun's rays reaching the earth's atmosphere which is the cause of decrease in temperatures around the globe. The origin of dimming has shown to be internal to the climate system. It is externally forced by the Sun. The study on global warming wouldn't be complete without mentioning global dimming. The Reduction of heat reaching the earth's surface is known as Global Dimming. Global dimming is caused by an increase in particulates such as sulphate aerosols in the atmosphere. The pollutants which are responsible for global dimming also lead to various environmental problems, such as photochemical smog, respiratory problems, acid rain and falling rainfall patterns. The relative importance of Aerosols, clouds and Aerosols-Cloud interaction as contributors to dimming which varies from region to region and not uniform over the globe also. The effect can be decreased by every individual participate his role by decreasing fuel consumption, creating awareness for the consumption of nonessential goods, walking, and planting trees.

The effect was first spotted by Gerry Stanhill, an English scientist working in Israel. Comparing Israeli sunlight was recorded from the year 1950 with current ones. Stanhill was shocked to find a large decline in solar radiation. According to G. Stanhill, "There was an amazing 22% drop in the sunlight, and that really restrained me".

After seeing the world scenario, by searching records from all around the world, and found the same thing almost everywhere he looked, with sunlight decreasing by 10% over the USA, nearly 30% in parts

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of the former Soviet Union, and 16% in different parts of the British Islands. Although the sunlight effect varies from one place to another places. The total decline amounted to 1-2% globally per decade between the 1950s and the 1990s.

Gerry's phenomenon of global dimming was published in 2001 but this fact was ignored by other scientists. But when his conclusions were confirmed by Australian scientists using a completely different methods to estimate surface solar radiation then climate scientists woke up to the reality of global dimming at last.

Scientists are now worried that dimming may disrupts the rainfall patterns in the world. There are suggestions that dimming was the reason behind the droughts in sub-Saharan Africa which claimed hundreds of thousands of lives in the 1970s and 1980s. There are some disturbing hints that same thing happening today in Asia which may cover to half the world's population. But perhaps the most alarming aspect of global dimming is that it may have led scientists to underestimate the true power of the greenhouse effect. They know how much extra energy is being trapped in the Earth's atmosphere by the extra carbon dioxide (CO_2). Surprising is that, this extra energy has so far resulted in a temperature rise of just 0.6°C.

Many famous scientists concluded that the present-day climatic behaviour is less sensitive to the effects of carbon dioxide than it was, during the ice age, a similar increase in CO_2 led to a temperature rise by 6°C. But it appears that the warming from greenhouse gases has been offset by a strong cooling effect from dimming – in effect two of our pollutants have been cancelling each other out. This means that the climatic behaviour is more sensitive to the greenhouse effect than it was thought.

Dr. Peter Cox, one of the world's leading climate modellers, gives a bad news. He says that CO_2 levels are projected to rise strongly over coming decades, whereas there are some encouraging signs that particle pollution will be brought under control. According to Cox, where the cooling pollutant is dropping off while the warming pollutant is going up. It means that we'll get decrease cooling and increased heating at the same time which is creating a problem for our world.

The dangerous situation of Global Dimming was first raised by a documentary called Horizon by BBC on 15 January 2005. Various regions in the world show different critical signs of global dimming for examples. The Southern Hemisphere has seen very little amounts of global dimming while Northern Hemisphere has witnessed very large significant reductions of 4-8%. There is a both type of situation in the context of global dimming. Regions such as some parts of Europe and North America have observed partial recovery from dimming while some parts of China and India have experienced an increase in global dimming. The present paper establishes the Global Dimming: Causes, Effects and Possible Solution. The paper is divided into Six Sections. Section (I) deals with the Causes of Global Dimming; Section (II) Explains The Effects of Global Dimming; Section (III) The Relationship between Global Dimming and The Hydrological Cycle and Global Dimming and Global Warming; Section (IV) Steps taken regarding Global Dimming; Section (V) discusses the Possible Solution to Reduce Global Dimming. In the last, Section (VI) provides important conclusions regarding Global Dimming.

Objectives:

The objectives of the present study are:

(i) To study the causes and effects of Global Dimming on Environment;

(ii) To shows the relationship between Global Dimming and Global Warming ;

(iii) To give possible solution regarding for Global Dimming.

DATA SOURCE AND METHODOLOGY

The present study is based on secondary data obtained from various national and international Sources. Research studies, articles, books and journals are the sources to obtain in this background. Present study is exploratory in nature which is based on secondary data. The study is not formula based.

Literature Review:

1. According to the study conducted by Scripps Institution of Oceanography, small soot particles, among other pollutants, have a significant effect on the hydrological cycles.
2. The decrease of surface solar radiation from the 1950s to the 1980s in the worldwide observational networks (Global Dimming) and a more recent recovery (Brightening), (Wild *et al.,* 2005, Wild, 2009, 2012, and 2016).
3. Various studies suggest that solar energy at the surface has not been stable over time but showed significant changes on decadal time

scales that is decrease the surface solar radiation from the early 1960's up to the 1980's (Global Dimming/Brightening) [Ohmura and Lang, 1989; Dutton *et al.*, 1991; Gilgen *et al.,* 1998; Stanhill and Cohen 2001; Liepert, 2002; Wild *et al.*, 2004, 2005].

4. Atmospheric aerosols from anthropogenic air pollution are considered important contributors to these changes [Streets *et al.*, 2006]. Such changes are likely to have an effect on surface temperature [Ramanathan *et al.*, 2001; Wild *et al.,* 2005].
5. Prof Veerhabhadran Ramanathan, world's leading climate scientists, says "My main concern is global dimming is also having a detrimental impact on the Asian monsoon and we are talking about billions of people in throughout the World.
6. Stanhill and Moreshet (1992b) who found adecline in SSR also at worldwide distributed sites remote from surface pollution sources between the 1950s and 1990.
7. India is one of the few regions around the world that shows a continuous and steady dimming from the 1960s to2000 [Wild *et al.*, 2005; Ramanathan *et al.,* 2005]. Also the recent period (2000–2005) shows some indications for a continuation of the decrease.

Section (I)

Various Causes of Global Dimming:

1. ***Aerosols:*** The major cause of global dimming is a combination of fine solid particles or liquid droplets in the air and other harmful gases. Most aerosols in the atmosphere is only scattered light from the sun and sending back to space. Some of the sun's radiant energy creates a cooling effect on the earth's climate. Sulphate aerosols in the atmosphere are due to human activities and affect the hydrological cycle by decreasing evaporation and may have decrease rainfall in some areas.
2. ***Particulate Matter:*** This includes sulphur dioxide, ash and soot, which are by-products of burning fossil fuels and internal combustion engines. Once they enter the atmosphere, they directly absorb solar energy and reflect back into the space radiation from the sun, before reaching the earth surface. By reflecting the radiation from the sun, they create a dimming in the energy and light from the sun.
3. ***Water Droplets:*** Water droplets in the atmosphere may have airborne particulates like sulphur dioxide, soot and ash, which form polluted clouds and these polluted clouds contains a heavier and larger number of droplets than normal clouds, which change the properties of a cloud.

   The polluted clouds also referred to as brown clouds (Layer of Air Pollution such as Black Carbon, Organic Carbon, Dust that absorb the Scatter Solar Radiation) have larger and denser water droplets. These droplets make the cloud more reflective in nature other than blocking the heat generated by the Earth's surface from reaching the atmosphere. The brown cloud also reflects more amount of sunlight into the atmosphere.
4. ***Vapours:*** Vapour in the atmosphere is collected from various sources such as evaporation from different bodies of water. However, the vapour collected from planes flying high in the sky, called contrails. They reflect heat from the sun back into space, causing global dimming. From the gaseous constituents in the atmosphere, water vapour has the largest potential to change surface solar radiation.
5. ***Wildfires:*** Over the last few years, wildfires have been more vicious than ever and in 2020 alone, wildfires have burnt across more than a million acres in Oregon and more than 4 million acres of forest in California. The wildfires have become so acute that entire cities are living in some sort of dim light for days due to the amount of smoke present in the atmosphere.

Section (II)

Effects of Global Dimming:

It creates various effects like;

– ***Effects on Water:*** The reflection of solar energy away from the surface of the earth, the water in the northern hemisphere is becoming cooler day by day. This is leading in slow evaporation and the generation of far lesser water droplets which gives a decline in the amount of rain reaching these areas of the

globe and result in drought and famine problems. The destructive consequences of these are adverse condition such as miserable lives, disturbed marine life and deaths due to starvation.

- ***Drought in Sub*** : Saharan Africa and Some Asian Countries: It has been seen that the drought and famine of The Sahel Region, which has killed thousands in sub-Saharan Africa in the 1970s was mainly due to global dimming. In the 1970s and 1980s, massive famines were caused by failed rains. The serious drought was first blamed on farmers in the region for degradation of the land and desertification.
  The Asian Monsoons brings rainfall to half the world's population. If air pollution and global dimming has affected this monsoon then perhaps 3 billion people could be affected.
- ***Change in Overall Land Temperatures:*** The effect of global dimming which reflects solar energy and heat that was meant for the earth's surface, the overall temperature on land decreases. Global dimming means there is a blanket in the atmosphere which prevents all the heat from the sun from reaching earth's surface, which is further responsible for colder days and finally lead to change in global temperatures.
- ***Effects on Plants:*** Plants depends on light for photosynthesis. A decline in sunlight or solar radiation will negatively affect the process of photosynthesis in plants. The process takes place in green plants uses light energy and converts water, carbon dioxide and minerals into oxygen and energy-rich organic compounds. Human's life depends on the oxygen for survival.
- ***Counters to Global Warming:*** Global dimming is believed to be counteracting the actual effects of carbon emissions on global warming. This creates a dangerous situation for which the only solution is denied by circumstances (Catch-22 situation). If efforts are made to decrease particulate emission causing global dimming, it will enhance global warming and increase the global temperatures to more than double, making the earth's atmosphere unsustainable for life.
  On the other hand, if we fight global warming by clearing the matter that causes global warming, will cause global brightening, which is considered more dangerous for all of us, and it causes more damage to the planet. To prevent such a paradox, it is important that the emission of particulate matter and greenhouse gases should be reduced simultaneously, balancing out the phenomena of Global Warming and Global Brightening.
- ***Health and Environmental Effects:*** The Pollutants which are responsible for global dimming also lead to various human and environmental problems such as smog, respiratory problem and acid rain.

Section (III)

The Relationship between Global Dimming and the Hydrological Cycle:

Atmospheric pollution caused by aerosol particulates weakens the water cycle on Earth by reducing rainfall and lowering the fresh water supply. The hydrological cycle derives energy from sunlight and heats up to the ocean, resulting in water move into the atmosphere in the form of moisture, which later lead to decrease in rainfall. Tropospheric aerosol reflects sunlight back into space thus declining down the hydrological cycle.

The Relationship between Global Dimming and Global Warming:

Many scientists believe that global dimming disguised the effects of global warming and that lowering direct irradiation can result in future temperature increase. While global warming increases the atmospheric temperature, global dimming helps reduce the atmospheric temperature. Global dimming is an opposite of global warming because it produces cooling effects. It is considered as the actual effect of carbon emission on global warming. Although these two phenomena have complementary effects which decrease the rate at which the temperature increased over the years. The brown clouds have masked over 50% of global warming through global dimming, and reducing the latter will increase the effects of the other phenomenon. Therefore, these two theories should be stopped at the same time so that, reducing the effect of one can create an acute condition which will be harmful on our planet system.

Section (IV)

Steps taken regarding Global Dimming:

There are some Good News and Bad News regarding Global Dimming:

Good News:

- Global dimming has already been reversed to a great extent in North America and Europe which is known as brightening. Since the 1980s, pollution controls have substantially reduced air pollution as it is the main contribution to dimming. Airplane contrails are still there which is providing dimming. Poland and Texas are still burning coal by the freight train load and doing their bit to keep the skies dim. But generally the developed world has either closed coal or substantially cramped the sewage.
- It is seen that different developing countries transforming and building a tone of wind and solar energy sources. Countries in the world are changing their energy mixes to renewable rapidly and realizing that pollution is killing their people and slowing their growth of economies. China and India are both shutting down coal plants, putting a halt to new coal construction and building a ton of wind and solar. China is also building a fair amount of nuclear power plant which is better than building made by coal generation. There will still be airplane contrails, forest fires, volcanoes and the like to deal with, but this is much closer to natural levels.

Bad News:

- China, Indonesia and India have been contributing a sufficient amount of the particulates and aerosols which leads to dimming. Regionally, they are experiencing dimming at the levels that North America and Europe were in the 1960s and 1970s. The problem hasn't gone away, but it has shifted its locations.
- Global dimming has been artificially suppressing global warming. The same thing is responsible for global warming — burning fossil fuels which are inexhaustible and creates nothing is responsible for and is creating global dimming for the entire world. Once the generation and transportation industries stop producing pollution and CO_2 into the air, the dimming problem will reduce quickly, but the CO_2 will take a long time more than hundred years. It means that sunlight which currently is not getting to the Earth's surface is being reflected as infrared rays and being absorbed by excess CO_2 today and it will be for tomorrow. That means that the temperature is forbid inhibitor of dimming will be removed and it will increase a degree or two warmer.

Section (V)

Possible Solution to Reduce Global Dimming:

There are some possible solutions to reduce the global dimming:

1. ***Moving towards Alternative Sources of Energy:*** Many countries that create high levels of global dimming can be characterized by the fact that they create their energy through the burning of fossil fuels which releases carbon dioxide and other greenhouse gases and contributes to global warming. At the same time, these gases also produce aerosols as a by-product of burning fossil fuels such as coal. These aerosols account for global dimming and in switching to alternative sources of energy, will reduce these aerosols and global dimming.
2. ***Lowering Levels of Pollution:*** Since the 1980s there have been movement's and controls that has significantly cut air pollution and particulates in the Air that could cause global dimming. Decreasing pollution can control the amount of particulate matter and pollutants in the atmosphere which is responsible for global dimming. More effects to be done because airplane contrails are still providing some dimming.
3. ***Fighting Wildfires:*** Wildfires have an impact on the atmosphere by creating regional darkening. Wildfires occur all over the world throughout the year and by minimizing or at least controlling them will reduce dimming.
4. ***Switching to Nuclear Energy:*** Nuclear energy is a much better superior substitute for fossil energy as it is free from producing outputs of carbon, although it creates more electricity than wind and solar power. It is the best option in most industrialized countries like the United

States of America and China. For instance, China and India are reducing their level of dimming by closing coal plants and increasing the number of nuclear energy plants.

Section (VI)

Conclusions:

Global dimming is possibly favoured by increasing air pollution, was effective in masking greenhouse warming up to the 1980s, but not thereafter, when the dimming disappeared, atmospheres started to clear up that is Global Brightening. The temperature response since the mid-1980s may therefore be a more genuine reflection of the greenhouse effect than during the decades before, which were subject to solar dimming.

Scientists looking at previous five decades of sunlight measurements have reached the disturbing conclusion that the amount of solar energy reaching the Earth's surface has been gradually falling.

The effects of global dimming vary by location, with some areas being badly affected than others. The phenomenon of global dimming and brightening is consequently a pure result of changes and processes that take place within the climate system, particularly in the atmosphere. The study is important because it is the root causes of Global Warming which is crucial for our planet system. A better understanding of the magnitude and origins of Surface Solar Radiation changes can also provide a basis for climate model improvement.

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