Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 91 (2016) 690 – 699

Procedia Computer Science

Information Technology and Quantitative Management (ITQM 2016)

Analysis of Carbon Dioxide and Cloud Effects on Temperature in Northeast China

Hyunsoo Lee*

[a]Fort Hays State University, 420 Custer Drive, Custer Hall 241, Hays, KS and 67601, United States

Abstract

With the observed rise in temperature, many researchers have tried to identify the causes of such climate change to help mitigate its effects. The objective of this study is to determine whether, under the same carbon dioxide (CO_2) concentrations, CO_2 with lower cloud coverage would raise the temperature at a greater rate than CO_2 with higher cloud coverage. The hypothesis was tested through data analysis and modeling. The relationships between the temperature and the CO_2 emissions, the temperature and the cloud coverage, and the CO_2 emissions and the cloud coverage were identified using Pearson's correlation test. The data analysis concluded that the relationship between the temperature and the CO_2 emission is positively proportional with a significant correlation. The relationship between the cloud coverage and the temperature and the relationship between the CO_2 emissions and the cloud coverage were determined to be negatively proportional with significant correlations. For modeling, the temperature increased more rapidly as cloud coverage shrank. The results supported the hypothesis that the cloud coverage mitigates warming effects created by carbon dioxide emissions. Further research is anticipated to reduce the uncertainties in the data along with specification of cloud types.

Peer-review under responsibility of the Organizing Committee of ITQM 2016

Keywords: Carbon Dioxide Emissions; Cloud Coverage; Environmental Science

1. Introduction

1.1. Background Research

On The temperature of the Earth is determined by the balance between the input and output of energy [1]. In other words, if the energy coming in from the Sun and the energy escaping out of the Earth by emitting radiation to space were in balance, the Earth's temperature would remain constant [2]. However, according to the Intergovernmental Panel on Climate Change (IPCC), the average global temperature has risen roughly 0.85ºC in the last 100 years [3]. In addition, the last three decades from 1983 to 2012 were said to be the

*Corresponding Author. Tel.: +1-785-432-2483
E-mail address: h_lee7@mail.fhsu.edu

Peer-review under responsibility of the Organizing Committee of ITQM 2016
doi:10.1016/j.procs.2016.07.172

warmest period of the last 1400 years; the term for such trend is called climate change [3]. Thus, the temperature of the Earth has risen, and it is because of the energy imbalance [2].

As the amount of energy coming from the Sun is relatively constant, most scientists agree the main cause of the current global warming is the anthropogenic increase in the greenhouse gases that trap the energy radiation from the Earth toward the space [4]. Among other greenhouse gases, carbon dioxide (CO_2) gets most of the attention as the key element of the Earth's climate system [5]. For example, Delworth et al. claimed that the doubling of carbon dioxide had influenced many regions, especially the tropics, with an increase in temperature [6]. For the future, IPCC, in 2007, estimated that Earth would warm between two and six degrees Celsius over the next century, depending on how fast the carbon dioxide emissions grow [4]. Given the effects of CO_2 have on radiation and climate change, many researchers and policymakers have focused on finding the CO_2 reduction targets to lessen its effects [2].

While the question of what to do about future climate change has been pending, some researchers saw cloud coverage as a potential factor of temperature change. Carslaw, Harrison, and Kirkby suggested that variations in the intensity of galactic cosmic rays in the atmosphere would alter in cloud coverage, leading to change the temperature of the Earth [7]. However, the effects of clouds on temperature are uncertain so many studies have tried to identify whether the cloud coverage has a negative or a positive feedback to the warming effects. For example, Dessler concluded that cloud coverage has a positive effect on the temperature [8]. Likewise, Clement, Burgman, and Norris and Lauer et al. claimed the cloud has a positive effect over the eastern Pacific [9-10]. Spencer and Braswell even claimed not carbon dioxide but cloud cover causes global warming [11]. On the other hand, McLean claimed that the reduced cloud coverage from 1987 to late 1990s accounts for the rise in temperature since 1987 [12]. Similarly, Kauppinen, Heionen, and Malmi, discussing the impact of cloud cover on the temperature, claimed that one percent increase in low cloud cover decreases 0.11 degree Celsius [13].

Based on these studies, solutions related to clouds were proposed to lessen climate change. For instance, Lomborg of Copenhagen Consensus Center came up with a proposal to develop cloud whitening technology to reflect solar radiation [14]. Similarly, Russell claimed cloud brightening research had merit in combating global warming [15]. Since these recent studies have reflected the importance of clouds to the climate, it is time to verify the correlations among the CO_2 emissions, the cloud coverage, and the temperature and identify the impact of clouds.

1.2. Motive

The objective of this study is to examine the interactive effects of the CO2 emissions and the cloud coverage on temperature. By analyzing the relevant data sets from Northeast China and using the climate change model of NetLogo 5.2., this study is to identify the relationship and the interactions between CO2 concentration and cloud coverage and, thus, find a more efficient way to mitigate global warming.

2. Methodology

2.1. Hypothesis

If the Earth has a constant CO_2 concentration, then the CO_2 with lower cloud coverage will raise the temperature at a greater rate than the CO_2 with higher cloud coverage. In other words, the warming effects from the increase in the carbon dioxide level will be mitigated more when accompanied by the increase in cloud coverage than by the reduction in carbon dioxide emissions alone.

2.2. General Overview

This study applied two methods: data analysis and modeling. Real-world data from Northeast China will be analyzed to examine the correlation between the temperature and the CO_2 emissions, the correlation between temperature and cloud coverage, and the correlation between the cloud coverage and the carbon dioxide