Effect of Air Traffic on the Frequency and Optical Properties of Cirrus Clouds

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Introduction

The main concern of the team is the effect airplane travel has on weather. In order to investigate this, we began to ask about the effects burning kerosene had on the Upper Thermosphere Lower Stratosphere (UTLS), where planes generally fly. We used GOES satellite data to help us understand this. More specifically, animation loops of IR Bands One and Four were used in this investigation. We focused on the effects that black carbon has on cirrus clouds frequency and optical properties since these changes can have varying effects on weather.

Hypothesis

We believe that with more time, we will notice patterns of change in frequency and optical changes in cirrus clouds.

Basically, Black Carbon will cause the clouds to get darker when it's within the cloud Which will cause the sun to be attracted to the cloud therefore causing the cloud to dissipate.

Density of Black Carbon in the Upper Thermosphere and Lower Stratosphere (UTLS)

In the diagram 1, which measures Black Carbon density, and takes place in the UTLS (35,000 feet high), the black, red and orange areas have the most air traffic, on average, and the green, blue and white contain the least. Our team used this to determine the location for our data, as the central great lakes have the most air traffic, the southern south america region has very little, and is on land, and the tropical pacific ocean has very little air traffic and is on water. We used these to see if air traffic had any influence on the cloud coverage and particulate matter in the air in different areas.

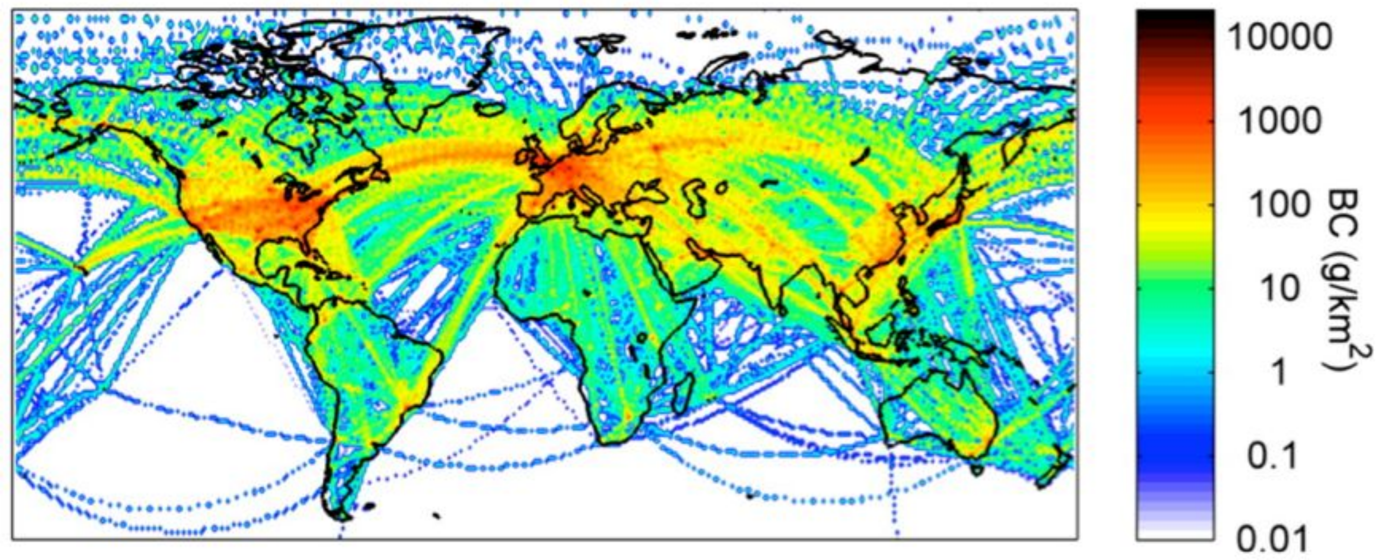

Diagram 1: The density of Black Carbon in the UTLS

Kerosene and how Black Carbon is produced by planes

Kerosene is a light fuel and a combustible hydrocarbon liquid most commonly used in jet engine fuel. Kerosene may be obtained from distilling petroleum. Petroleum is a naturally occurring yellow or black liquid found in certain geological formations. When burned kerosene creates the byproducts carbon monoxide and oxides of nitrogen but most importantly to our research, soot. Black carbon(soot) is the same thing that comes from campfires. This is a black particulate matter/aerosol emitted from burning kerosene or wood. 1.2 million barrels of kerosene are burned per year from all purposes. Black carbon is found in the UTLS from airplane emissions (as well as other resources). In 2015 alone, 6.6 million tons of black carbon was released into the air.

Black Carbon effects on clouds

When black carbon is present in clouds, it changes not only the optical properties of a cloud, but also the amount of light and heat it gets from the sun. Normally, the sun has various effects on cirrus clouds. However, when black carbon is present inside of a cloud (Figure 1), the sun causes it to heat up more. Also, the black carbon causes the cloud to get darker and speeds up the dissipation of the cloud. If black carbon is present underneath (Figure 2) or above a cloud (Figure 3), it sustains the cloud for a longer period of time and becomes more reflective, this could have a cooling or a heating effect on ground temperature.

Figure 1: Black Carbon Inside of A Cloud

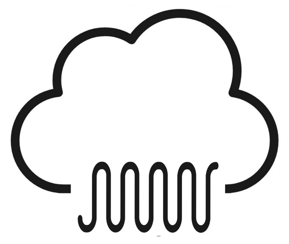

Figure 2: Black Carbon Underneath A Cloud

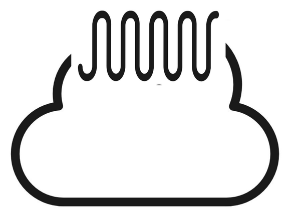

Figure 3: Black Carbon Above A Cloud

ABI BANDS

GOES IR Band One

The main purpose of band one (0.47 µm) is to highlight regions where visibility is reduced because of particulate matter. This is important to our research because we are concerned about the optical properties of cirrus clouds do to black carbon.

GOES IR Band Four

The main purpose of band four (1.37 µm) is to show cirrus clouds in the area. This is important because we can see the frequency of the cirrus clouds over time.

ABI Band One Results

We captured data from Band Four at approx. 10:00am and 3:00pm in three different locations (Central Great Lakes, Southern South America, and the Tropical Pacific Ocean) with a different amount of air traffic to identify the effect of particulate matter in the UTLS. We captured the data from April 19th to April 29th, 2019. Below are 2 example images of this data.

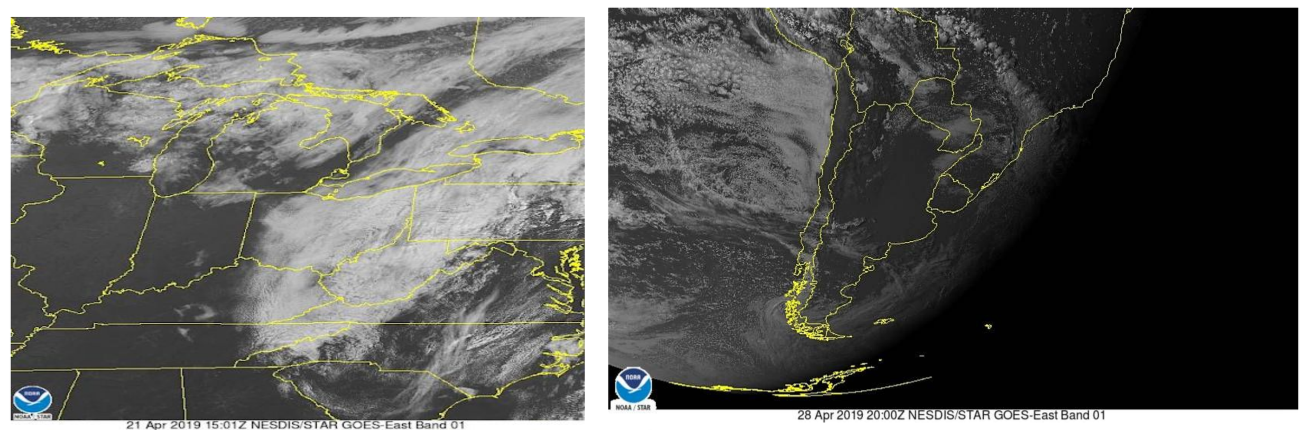

Image 1: April 21st at 3:00pm in the Central Great Lakes
Image 2: April 28th at 3:00pm in Southern South America

ABI Band Four Results

We captured data from band four at approx. 10:00 AM between April 19th and April 29th in different locations with different air traffic levels to identify the amounts of black carbon in the UTLS in areas with high air traffic activity and with low air traffic activity.

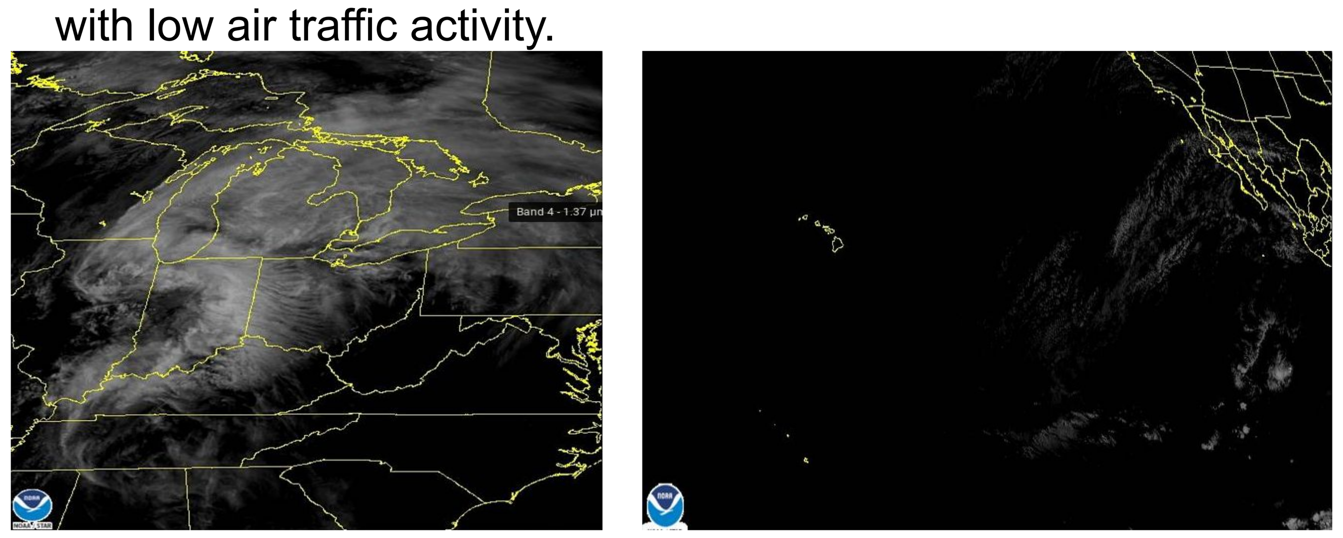

Image 3: April 29th at 10:00am in the Central Great Lakes
Image 4: April 19th at 10:00am in the Tropical Pacific Ocean

Conclusions

Black Carbon emissions from airplanes in the UTLS has mixed effects on cirrus clouds depending on where the black carbon is in relation to the clouds. Using the GOES image viewer, we can see the effects black carbon has on the optical properties of cirrus clouds as well as the overall frequency of the cirrus clouds over time. We were not able to gather quantitative data on the frequency or optical properties of cirrus clouds, but with more time we would like to expand our data collection of the IR Bands to capture this data. The goal of this would be to see how temperature data is a connected to the data from the GOES image viewer and the corresponding quantitative data.