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An Insight into the GLOBE Data and its Comparison with Ground-Based Observations

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Abstract

This paper intends to delineate the work done to observe clouds from the ground and compare it with the results obtained from the Geostationary Earth Observation (GEO) satellites. The mobile application 'GLOBE Observer' was used to identify and report the observations on the different types of clouds available for Android and IOS-based devices in support of science for society. The data submission was followed by a comparison with the reporting of the satellite data (METEOSAT-8 in this case). The satellite data and the observer's data were compiled, the report of which was sent (communication) by the team at NASA Langley Research center. The final dataset helped to identify and differentiate the high-level clouds from the satellite match reports with the idea of the areal coverage as suggested by the latitude and longitude values.

Keywords: Clouds; GLOBE; Visible; Infrared; Satellite Images; Climate Change

Introduction

The Global Learning and Observations to Benefit the Environment (GLOBE) program has been providing students and the public worldwide with the opportunity to meaningfully contribute to our understanding of the Earth system and the global environment. As an international science and education program, GLOBE is dedicated to supplying the STEM professionals of tomorrow with the scientific knowledge necessary to tackle Earth's biggest mysteries (GLOBE, 2019).The GLOBE program provided us with protocols on clouds, mosquito habitat mappers, land cover, and trees.

It helped in understanding the Earth's system and global environment. Global land cover and land use (LCLU) mapping are critical in understanding the impact of changing climatic conditions and human decisions on natural landscapes (Sleeter et al., 2018).It has also helped scientists and citizen scientists from all parts of the world, in using it as a tool for collecting widespread reference data in support of studies of land cover and land use change, particularly if multiple people document the same site (Foody, 2015a).

Similarly, protocols like those for clouds require us to first have a thorough knowledge of the distribution of clouds in the troposphere. The vertical profile in this distribution introduces us to the basic concept that temperature decreases with an increase in altitude. Thus, the low, middle, and high-level clouds are present and differ in shapes and sizes and have effects on our Earth's climate.

Satellites only see the top of the clouds while we watch the bottom. Thus, producing an idea of a more complete geometrical profile of the clouds in the atmosphere as they play an important role in keeping our planet both warm and cool. The good news for users of Android and Apple is that the Globe observer app can be directly downloaded from the link. https://observer.globe.gov/about/get-the-app

Materials, Methods, and Procedures

GLOBE Observer (GO) is a mobile application compatible with Android and Apple devices used to collect environmental data in support of Earth science (Amos et al., 2020). GO collections can serve as reference data, complementing satellite imagery to improve and verify the distribution of clouds at different levels. The application automatically collects the date, time, and location when a user begins an observation. Location is recorded in latitude and longitude coordinates determined through the mobile device's location services [cellular, Wi-Fi, Global Positioning System (GPS)]. The accuracy of these coordinates is shown on-screen, providing the user the opportunity to improve the location coordinate accuracy, with a maximum accuracy of 3-meters, or the option to manually adjust the location using a map (Kohl et al., 2021).

The documentation included the appearance of the sky whether filled with clouds or contrails or obscured by smoke, dust, haze, fog, etc. followed by classification for the percentage of the whole sky covered by clouds as shown in Table 1.

Table 1. Showing the classification of cloud cover and percentage

Cloud Cover	Percentage
Few	0-10%
Isolated	10-25%
Scattered	25-50%
Broken	50-90%
Overcast	90-100%

Some details about the deepest shade of blue in the sky and sky visibility across the horizon were mentioned. The cloud base <2000m, 2000-6000m, and beyond are classified as low, middle, and high-level clouds respectively. The shape of the clouds is usually puffy or cumulus, layered or stratus, and wispy or cirrus. Note that the shape does not govern the height and the rain clouds can come at a low level before the precipitation begins. The commonly used prefixes are alto- for middle-level and cirrus- for high-level clouds. The cloud triangle (Fig 1.) as shows the classification.

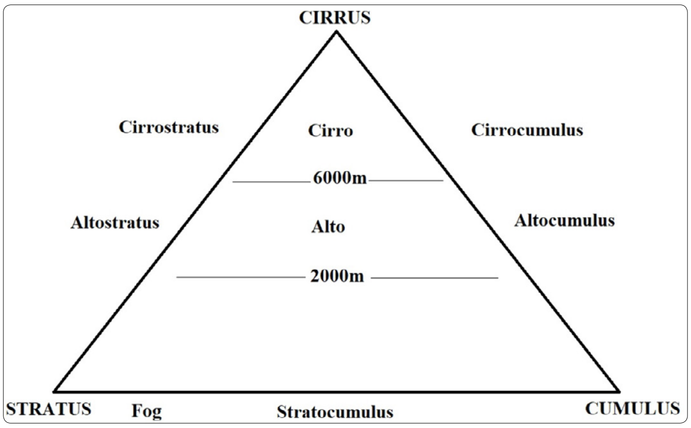

Figure 1. Cloud triangle diagram for classification of clouds

In the current scenario, the observations were made in India for latitude 26.481700E and longitude 74.645400N. With clear sky visibility for the blue sky in the daylight at 12:58pm IST, no clouds were visible as such although a few were scattered. The application requires capturing images to support the documentation and a 'West' view of the observed clouds in the sky was captured and submitted for review. On raising our arms at a fist length and measuring the approximate angle from the horizon or a reference, we obtained an angle of approx. 20°. The surface conditions, such as dry ground, leaves on trees, etc were also reported.

After submitting the ground data, the satellite images sent by the METEOSAT-8 (Europe, EOEMS)that were procured by the team at NASA Langley Research center and the GLOBE program helped me as a scientist to compare the two satellite images for the visible and infrared conditions.

The visible image showed what the satellite METEOSAT-8 (a geostationary Earth satellite) captured in the visible portion of the electromagnetic spectrum. The blue circle and dot pinpointed the exact location of the observer on Earth based on the GPS coordinates with the North being the top of the image. Gray lines showed the latitude and longitude lines with values in red and green. State and country lines were shown by pink contours. Shades of white were mainly clouds while the shades of grey were not as shown in Fig 2A. The infrared image (Fig 2B.) showed what the satellite captured in the infrared portion of the electromagnetic spectrum. Infrared helps to detect the temperature signatures giving the idea of the warm and cold conditions of the clouds and as in general, temperature decreases with an increase in altitude, the colored portions of Figure 2. give an idea about the high-level clouds.

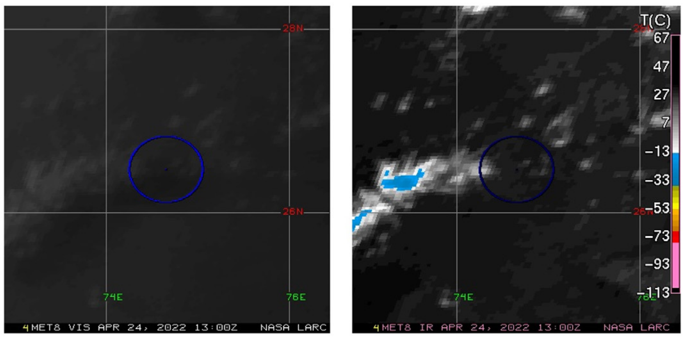

Figure 2: 2A (left) Shows the visible portion as captured by the satellite.

2B (right) shows the product of the infrared portion of the electromagnetic spectrum. A temperature scale (inset in 2B) was already provided

Discussions

Looking up to the sky and wondering what the clouds hold for us, has got a lot to do with position of the observer and the time during which the observations were captured. While the satellite images work with a bigger space and multiple data points, our field of observations are limited to a relatively smaller space and limited data points. This tale of spaces and feasibility of recording observations require a lot of efforts. It might not be easy to venture into the private lands (surface) or in the middle of busy roads to capture the observations. So, it is highly recommended by the GLOBE mobile apps to stay cautious while uploading the observations.

The satellite images can track the bigger picture being free from on-ground human interferences, but we should be cautious about the false positives too. So, it is always good to engage more citizens to take up such projects and report their findings to the research teams so that an extensive dataset can be prepared to help people together with the society.

Yet again, it should be emphasised that there could be (in certain cases) instances where a smoke cloud might be present in the middle of the many other clouds. As we stay in an era, where climate change and fossil fuel industry are always debating against each other, this simple mobile application can empower everyone to track changes near them. This is further seen with the type of the data that can be retrieved from the satellite images. Although not yet established, but the smoke cloud (due to volcanic eruptions and burning of fossil fuels) would have a lot of differences in temperature at different points in a space and time. The length of the region over which the different points would be captured (on-ground) would determine the space of interest but it should certainly give amazing representations. The waste products released into the atmosphere are the most difficult to deal with as they cannot be tracked easily as compared to solid wastes which could be upcycled to help with recycling but what remains untracked is the waste products released into the atmosphere. Thus, this simple citizen science project with the "Globe Observer" mobile app is certainly good to go with.

Results

Thus, what was detected on-ground was in the range of low to middle-level clouds. Each grid cell was 2*2 deg which was converted in kilometres' by the concept of 1deg equivalent to 110km approx. Thus, the area coverage of satellite views in square kilometres' is indeed high as compared to our estimates in a localized region. The blue circle and dot in Fig 2A. and 2B. clearly show that the temperature was higher as compared to the colder ones shown in color, as per the temperature scale, in the low to middle-level clouds. The same was true for recorded temperatures of the region of interest.

Conclusions

It is important to remember that satellites only see the top of the clouds while we watch the bottom. This means that we have an important role to play by submitting more observations utilizing the GLOBE observer and assessing the impact. The cloud cover was almost 2.70% in the range of 0-10% as per the satellite match but more corrections could be provided. It is important to note that the clouds are having spaces or gaps between them as seen in the images in different shades of grey other than white shades for clouds. The darker shades could be the product of other bodies like water or forests, etc. It is to be noted that color could be assigned later in further processing of the satellite images through computers where different bands are allocated to distinguish different bodies or objects. The purpose of this study has helped a lot in gaining new perspectives to add scientific methods to practice and promote science for society through citizen science.

Challenges

If the satellite's overpass times do not coincide with the measurement times on the ground, there might be some differences in the results. It could be recommended that readings should be taken during overpass times to obtain more precise results. However, there might not be drastic changes in the results if there's no strong influence of winds nearby. Had there been live tracking of each moment at a point, the readings might be more comparable, but these limitations could be avoided by limiting their use to the purposes. It should be noted that the clouds are not static or stationary points. It is thus, subjected to be dynamic and affected by several factors due to wind, water, ice, and dust. In the present case, our purpose is limited to the weather and communication, which is being served by satellites, Meteosat-8 for this corner of the world in India.

The recordings in the day would differ from those in the night wrt the amount of light reflected from various earth bodies like water, land, and trees. While at night, only certain parts of the electromagnetic spectrum will provide results.

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