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The Magic of Environmental Detection and Future Prediction by Satellite

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ABSTRACT

Climate change is one of the important issues that face the world in this technological era. We have used data collected from the publicly available GISTEMP data, the Global Surface Temperature Change data distributed by the National Aeronautics and Space Administration Goddard Institute for Space Studies (NASA-GISS). The data consisted of the mean surface temperature change with respect to baseline climatology corresponding to the period 1951-1980. The data covers the time period of 1961-2019. We studied the change in temperature in the countries like Greenland and India using the regression models. All the regression graphs were plotted in the Spyder software using python. From the regression models we observed the significant rise in temperature in these countries caused due to global warming. These models will help us to predict the change in temperature in future.

Key words : Satellite Image Processing, Spyder software, Regression, Global Warming, CSV (comma-separated values), Python, IPCC

1. INTRODUCTION

Global Warming is putting its adverse effect on our environment causing a change in the temperature as well as the overall climate of a particular area. No matter what we do to reduce greenhouse gas emissions that contribute to global warming, summer sea ice in the Arctic Ocean may be extinct by the 2030s, according to a new scientific study, that was published in the journal Nature Communications [15]. The peer-reviewed findings show that even capping global warming at 1.5 degrees Celsius in line with the Paris climate treaty will not prevent the north pole's vast expanse of floating ice from melting away. Earlier projections had found that stronger action to slow global warming might be enough to preserve the summer ice. The latest research suggests that, where Arctic sea ice is concerned, only steep, sharp emissions cuts might be able to reverse the effects of the warming already underway. Sea ice reflects solar radiation back into space, so lesser the ice is there the faster will Arctic region and rest of the world warm. Warm Arctic causes Greenland ice sheet to melt more quickly adding to sea level rise globally. The difference in temperature between the North pole and the

Equator determines storm tracks and wind speed in the mid latitudes. Hence Arctic warming effect shall cause climatic change with weather events like extreme rainfall or heat waves. This shall occur in temperate regions of North America, Europe, and Asia.

Satellites play a vital role in Earth surveillance and research, provides a base map for reference, space data collection and research, communications, monitoring climate change and many more. These satellites are launched into orbits with the help of programmed rockets. Organizations like NASA, NOAA, ISRO and ESA use the data to monitor greenhouse gases concentration, weather patterns, melting of glaciers and polar ice, etc. Technological innovations are leading to miniaturization of sensors, high-speed data transfer, upgraded storage capacity, etc. Countries which have advanced in Satellite Technology are US, Russia, China, France, India, UK and Japan.

Satellite Image Processing is an important field in research and development and consists of the images of earth and satellites taken by the means of artificial satellites. Firstly, the photographs are taken in digital form and later are processed by the computers to extract the information. Statistical methods are applied to the digital images and after processing the various discrete surfaces are identified by analyzing the pixel values [2].

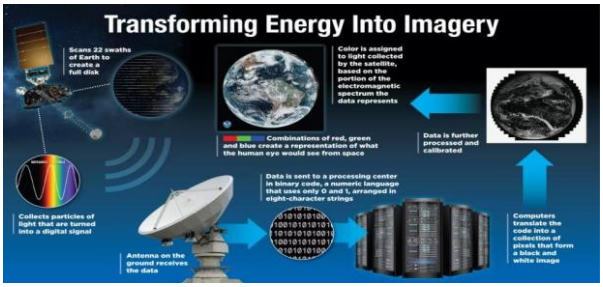

Figure 1: Satellite Image Processing

We can see from Figure 1 that satellites capture data by assigning a digital value to each pixel based on the reflectance of the corresponding area on the ground (and above the atmosphere) within a predetermined band within the light spectrum captured by the sensor. Satellites also capture information in the non-visible spectrum of light. In each band, different features are reflected differently, such as rock, bare soil, vegetation, burned ground, snow, sediment-rich water, etc. This is called a 'spectral signature'.

False-colour composite images are created by substituting one or more of the RGB bands for others, such as infrared or near-infrared, which are not visible to the human eye.A snowy mountain top, for example, will appear white in all light spectrum images, as snow reflects all visible light. However, it will appear darker in infrared images since the snow has less reflectance in infrared.

There are majorly four kinds of resolution associated with satellite imagery. They are spatial resolution, spectral resolution, temporal resolution and radiometric resolution [2].

Some environmental change patterns are :

a. Global warming and change in temperature
b. Ozone layer depletion
c. Melting of icecaps
d. Rise in sea level
e. Natural disasters
f. change in forest cover

Here we are trying to observe that most of the climate changes and natural disasters are occurring due to global warming and also we are studying the effects of this phenomenon. We are also trying to predict our future climatic conditions by plotting graphs.

So we have the case studies of certain places to study more about them. These places are chosen based on the different climatic conditions to know more on how and to what extent the places are getting affected due to global warming.

The paper is organized as follows. First here we have the Abstract where we get to see the brief view of the entire paper. Section 1 is about the introduction. Moving ahead with the Section 2 we get to know about the material and method followed here. Section 3 comprise of the entire experimental process. In Section 4 and Section 5 we mentioned the results and the inferences respectively for both Greenland and India. Next in the Section 6 where we have tried to give an impact about it's effect and thus created Future Awareness. The conclusion is presented in the final section of the Paper.

2. MATERIALS AND METHODS

The materials used for the study are –

1. Satellite Data collected from the publicly available GISTEMP(Goddard Institute Surface Temperature Analysis) data about the Global Surface Temperature Change data distributed by the NASA-GISS
2. Spyder software for python coding
3. Windows 11 platform was used to run the software.

We have collected data from the publicly available GISTEMP data about the Global Surface Temperature Change data distributed by the National Aeronautics and Space Administration Goddard Institute for Space Studies (NASA-

GISS)[1].The data consisted of the mean surface temperature change with respect to baseline climatology corresponding to the period 1951-1980 . The data covers the time period of 1961-2019. We have studied the data collected over the years and plotted them on a monthly basis . So for every month we have studied the data over the years. Based on the collected data regression models of temperature change over the years in different months were made for Greenland and India. The standard deviation of the regression models from the original plots were calculated. The mean, standard deviation, slope, intercept, standard errors, maximum value and minimum value of the regression models of different months were all denoted and written in a table for each country. All the regression graphs were plotted using python coding in Spyder software.

3. EXPERIMENT DONE

We read the data from the downloaded CSV (comma-separated values) file and stored it in a dataframe. We eliminated the unnecessary columns and reduced the dataframe to a suitable form to plot the data. Using loop we plotted the scatter graphs on temperature change over the years for each month and also performed regression using the linregress() function. The regression function in python returned the values of the slope, intercept and standard errors for the regression models. The maximum and minimum values for each regression models were noted and standard deviation and mean for each regression graph was calculated using stdev() function and mean() in python. All the values were noted ,stored in a dataframe and are shown in a tabular format.

4. RESULTS

4.1 For Greenland

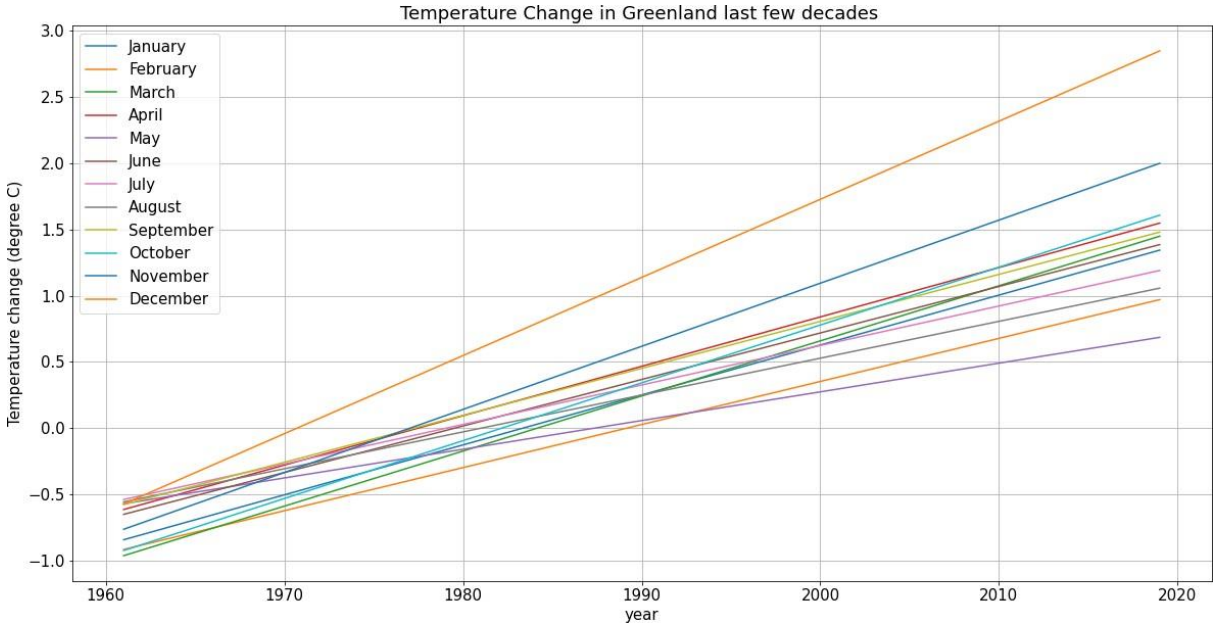

Figure 2: Plotting of regression graphs which are the best fit graphs for the collected data for temperature change over the years in different months in Greenland. In the above plots, the X-axis signifies Years (1961-2019) and Y-axis signifies Temperature Change (°C). Each curve corresponds to temperature change over the years in a month from January to December .

Table 1: Output table for regression graphs of Greenland containing the mean, standard deviation, slope, intercept, standard errors, maximum value and minimum value of the regression models of different months. Each row in the table corresponds to a month graph of Figure 2(for example the first row contain the values of the regression graph of Greenland for the month of January)

Index	Month	slope	Standard error	intercept	Percentage change	maximum value	minimum value	mean	Standard Deviation
0	January	0.0376729	0.0187553	-74.7182	259.633	1.34345	-0.841583	0.250932	0.647054
1	February	0.0324964	0.0206143	-64.6401	206.052	0.970073	-0.914717	0.027678	0.558144
2	March	0.0415583	0.01701	-82.4577	250.607	1.44856	-0.961819	0.243373	0.713788
3	April	0.0372559	0.0116778	-73.6722	352.242	1.54739	-0.613454	0.466966	0.639891
4	May	0.0216505	0.00935953	-43.0268	220.231	0.685542	-0.570186	0.057678	0.371859
5	June	0.0350908	0.00609031	-69.4631	313.131	1.38529	-0.649973	0.367661	0.602705
6	July	0.029791	0.00557516	-58.9579	321.294	1.19009	-0.537786	0.326153	0.511677
7	August	0.027803	0.006202	-55.0778	290.014	1.05654	-0.556034	0.250254	0.477533
8	September	0.0354398	0.00646378	-70.0735	356.812	1.47943	-0.576076	0.451678	0.608699
9	October	0.043622	0.00889403	-86.4655	274.174	1.60727	-0.9228	0.342237	0.749232
10	November	0.0476057	0.0109851	-94.1172	362.101	1.9986	-0.762531	0.618034	0.817654
11	December	0.0589349	0.0159672	-116.143	598.219	2.84682	-0.5714	1.13771	1.01224

4.2 For India

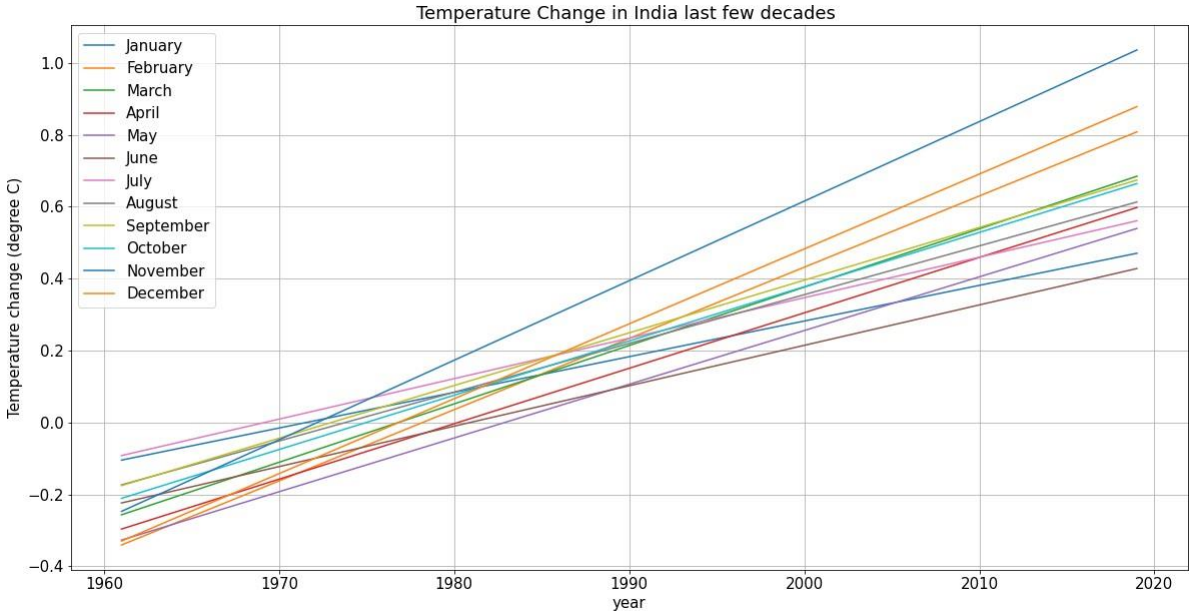

Figure 3: Plotting of regression graphs which are the best fit graphs for the collected data for temperature change over the years in different months in India. In the above plots, the X-axis signifies Years (1961-2019) and Y-axis signifies Temperature Change (°C). Each curve corresponds to temperature change over the years in a month from January to December .

Table 2: Output table for regression graphs of India containing the mean, standard deviation, slope, intercept, standard errors, maximum value and minimum value of the regression models of different months. Each row in the table corresponds to a month graph of Figure 3(for example the first row contain the values of the regression graph of India for the month of January).

Month	slope	Standard error	intercept	Percentage change	maximum value	minimum value	mean	Standard Deviation
January	0.00991666	0.0040448	-19.551	550.764	0.470736	-0.104431	0.183153	0.170324
February	0.0198058	0.00577434	-39.1796	337.414	0.808283	-0.340453	0.233915	0.340176
March	0.0162316	0.00565862	-32.0867	367.036	0.684937	-0.256497	0.21422	0.278787
April	0.0154154	0.00519109	-30.5258	301.89	0.597929	-0.296166	0.150881	0.264769
May	0.0149397	0.0040479	-29.6236	265.139	0.539693	-0.326812	0.106441	0.256599
June	0.0112382	0.00509227	-22.2616	291.529	0.428229	-0.223585	0.102322	0.193022
July	0.0112558	0.00326654	-22.1644	711.217	0.561046	-0.0917915	0.234627	0.193325
August	0.0135613	0.00289228	-26.767	453.927	0.613278	-0.173278	0.22	0.232923
September	0.014649	0.00239977	-28.902	484.411	0.674244	-0.175397	0.249424	0.251604
October	0.0150907	0.00327909	-29.8037	415.243	0.664478	-0.210783	0.226847	0.259191
November	0.02212	0.00453805	-43.6244	519.439	1.03597	-0.24699	0.394492	0.379924
December	0.0208274	0.00378985	-41.172	366.591	0.878468	-0.329519	0.274475	0.357722

5. INFERENCE

5.1 For Greenland

From results of **Greenland** we can conclude that the country's massive ice sheets are melting twice as fast as they were just a decade ago, according to a new study published in the Proceedings of the National Academy of Sciences. Greenland has lost 4,976 gigatons of water since 1972. The Greenland ice sheet is losing an average of around 250 billion metric tons of ice per year [2]. NASA used two satellites, called Grace and Grace Follow-On, which have been observing Greenland since 2002, to measure the loss [4]. Lower-elevation and coastal areas around Greenland experienced over 5 meters of ice mass loss and the largest mass decreases occurred along the West Greenland coast, according to NASA [3]. There has been rise in sea level due melting of Greenland ice sheets. Global mean sea level has risen approximately 210–240 millimeters (mm) since 1880, with about a third coming in just the last two and a half decades. Melting Greenland ice increases global sea level by at least 0.5 millimeters each year, though recent studies suggest this rate may be increasing. The melt zone, where summer warmth turns snow and ice into slush and melt ponds of meltwater, has been expanding at an accelerating rate in recent years. We can expect the ocean to rise between 10 and 30 inches (26 to 77 centimeters) by 2100 with temperatures warming 1.5°C, if current trends continue according to a recent special report from the Intergovernmental Panel on Climate Change [5,6].

This is also evident from the graph shown in Figure 2 that the temperature has an increasing trend over the years which is becoming a matter of concern. The data of Greenland in Table 1 suggests that the slope is maximum for the month of December and minimum for the month of May.

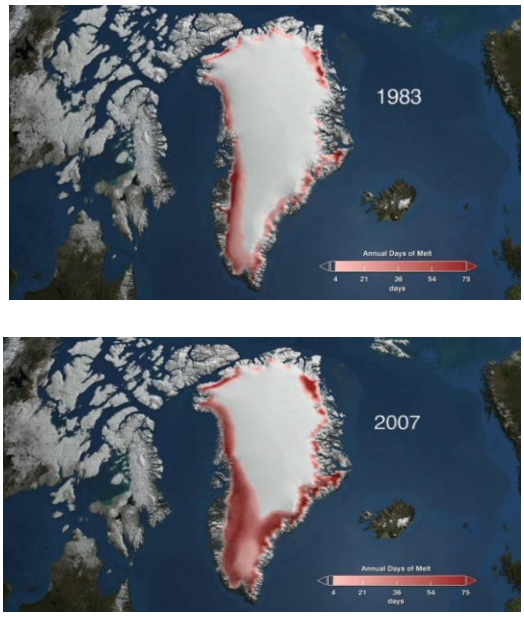

Figure 4: Change in ice cover over the years in Greenland (1983- 2007). Darker red colors indicate areas with the highest number of melt days. The darkest red corresponding to places where there was melting ice during more than 75 days. Areas that had three or less days of melting ice are not colored.

5.2 For India

From results of **India** we can conclude that India's average temperature has risen by around 0.7°C during 1901–2018. This rise in temperature is largely on account of Greenhouse Gas-induced warming, partially offset by forcing due to anthropogenic aerosols. By the end of the twenty-first century, average temperature over India is projected to rise by approximately 4.4°C relative to the recent past (1976–2005 average). In the recent 30-year period (1986–2015), temperatures of the warmest day and the coldest night of the year have risen by about 0.63°C and 0.4°C, respectively. In particular, areas over central India, southwest coast, southern peninsula and north-eastern India have experienced more than 2 droughts per decade, on average, during this period. The area affected by drought has also increased by 1.3% per decade over the same period [7].

Figure 3 proves that the graphs are increasing in nature and by this we are getting a practical view of the temperature rise over the years.

Table 2 states that the change in temperature is more significant, i.e.,the slope is greatest for the month of November and lowest for the month of June.

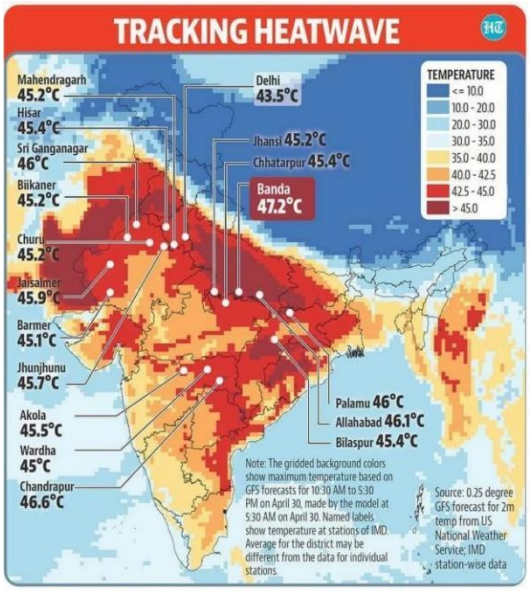

Figure 5: Tracking heatwave in India (2022)

The Hindu Kush Himalayas (HKH) experienced a temperature rise of about 1.3°C during 1951–2014. Several areas of HKH have experienced a declining trend in snowfall and also retreat of glaciers in recent decades. By the end of the twenty-first century, the annual mean surface temperature over HKH is projected to increase by about 5.2°C [8].

Figure 6: Hindu Kush Range

Due to sea level rise between 1975 and 1990, islands like the Lohachara and Bedford Islands disappeared from their original location. Satellite images show that in 1975 Ghoramara had a total area of 8.51 s km, which shrunk to just 4.43 sq km in 2012 [9]. In 2020 and 2021, cyclones Amphan, Tauktae, Yaas, Nisarga and Nivar— all arising in either the Bay of Bengal or the Arabian Sea—made landfall, causing immense destruction because the overheated waters of the northern Indian Ocean have become a breeding ground for cyclones. In the Arabian Sea, Sea Surface Temperatures have been 1.2-1.4 degree Celsius higher than normal due to which in the past 20 years, there has been a 52% increase in the number of cyclones [10]. According to the Intergovernmental Panel on Climate Change (IPCC) report of 2007, observations over the past 20 years show that the increasing intensity and spread of forest fires in India were largely related to rises in temperature and declines in precipitation, in combination with an increasing intensity of land use [11].

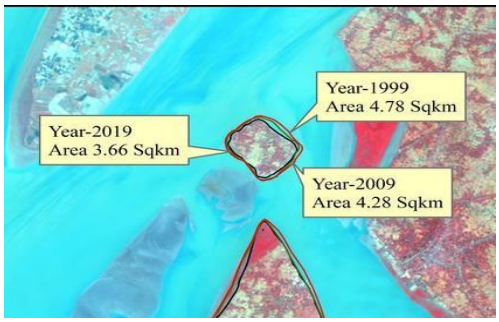

Figure 7: Lohachara island under water

Figure 8: Location of Ghoramara Island

6. FUTURE AWARENESS

As we can see that the graphs of Greenland and India are increasing by nature, so this indicates that the temperature will keep on increasing. Increases in average global temperatures are expected to be within the range of 0.5°F to 8.6°F by 2100 [12]. A warming of 0.5 ℃ is likely over all India by the year 2030 (approximately equal to the warming over the 20th century) and a warming of 24℃ by the end of this century, with the maximum increase over northern India [13]. Global observations of melting glaciers suggest that climate change is well under way in the India, with glaciers receding at an average rate of 10–15 meters per year. If the rate increases, flooding is likely in river valleys fed by these glaciers, followed by diminished flows, resulting in water scarcity for drinking and irrigation.

Figure 9: Causes of global warming

According to a NASA study, global sea level rise has been accelerating in recent decades, driven by increased melting in Greenland. If current trends continue, by 2100 the world's seas could have swelled by twice the projected level.

One recent study found that it's now inevitable that at least 3.3 percent of Greenland will eventually melt away, adding nearly a foot to the ocean's rising levels.

Meltwater from ice sheets contribute about a third of the total global sea level rise. The IPCC report [14] projected that Greenland would contribute 3.1 to 10.6 inches (8 to 27 cm) to global sea level rise between 2000-2100.

7. CONCLUSION

Hence, we can conclude from our experiment that there has been a rise in temperature of the countries over the years especially during the summer months. The slopes of the graphs are always positive which indicates the same. This has resulted in several harmful effects on the Earth, the most significant ones include melting of polar ice caps, rise in sea level, reduction in the span of winter, disappearance of islands, drought, and many more.

This is due to increase in concentration of greenhouse gases due to vehicular emissions, burning of fossil fuels, cutting down of trees, setting up of more and more industries, etc.

This is a matter of grave concern and if we do not take up measures to reduce this then we would be facing even more problems in our near future. So all the available resources must be utilized properly and proper care should be taken to reduce the emissions of greenhouse gases.

The result of this work states that the impacts of green house gas emission on Arctic, is going to cause a drastic climatic pattern change very fast both worldwide and our homeland. This prediction emphasizes the importance of future planning to be done in terms of change in lifestyle, economy for adapting and accommodating to the upcoming changes.

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