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Extraterrestrial Remote Sensing

1.1 Introduction

Extraterrestrial remote sensing is a fast developing and emerging science to understand not only climate change but the origin and survival of life in only one place of the universe, that is, the Earth. In the solar system, there is a planetary system but life exists only on the Earth. If we consider the origin and development of the magnetic field in and around the Earth during prebiotic evolution, life came to exist on the Earth in a specific magnetic field condition between Sun and the Earth. The evolution of different natural cycles inside and outside the Earth was governed by the intricacies of Sun–Earth–Cosmic connection. In this consequence, a different climatic niche was evolved. In this universe, everything is changing continuously, so the climate was affected by not only the human activity but it had a larger impact by changes in the extraterrestrial variables, which continuously interact with the Earth system. Climate change is a complex phenomenon and it is required to monitor the changes of anthropogenic and geogenic origin as well as influence from outer space in the ever-changing system. We are aware of the changes in seasonal temperature, wind pattern, and rainfall/snowfall variation in space and time. However, the changes are not uniform globally. Decadal survey on various themes of terrestrial and extraterrestrial origin have been studied; it shows that most of the parameters are not uniform in its character and origin. We are convinced about the effect of climate change and the role of anthropogenic activities in this process but have yet to explain the mechanism of sudden catastrophic changes in the environment. Some changes are having manifestations on different environmental components, but some other changes in atmosphere, biosphere, and geosphere are unexplained. However, a periodic depletion of some of the changes is being studied, which can be correlated with the changes in the Sun, other planets, and stars. A scintillating study was carried out on extraterrestrial remote sensing about sudden snowfall on 24 December 2004 in higher latitude and longitude.

If we jot down the global phenomena, most of the times we either try to see the crisis of the environment of the Earth due to our developmental activities or some calamities, which we cannot predict. The problem is not with the global change; the problem is that we are yet to develop an early warning system. An attempt has been initiated to understand the influence of extraterrestrial changes in the environment of the Earth.

It appears that the Earth and its climate are dependent on the changes in extraterrestrial influence. These extraterrestrial forces are governed by the Sun and Star constellation. Attempts are being made to interpret climate change on the Earth using the terrestrial data of different environmental components; however, the efforts are being made to understand the sudden global changes. The shift of the poles of the Earth to the glacial melting in North and South poles and the high altitude terrain including the Himalayas appear to be under the influence of Sun–Earth–Cosmic

field changes. The polar position of the Earth has recently shifted. The position of North has shifted toward East, and South poles of the Earth toward West direction. It has been identified by a research team of the University of Leeds, UK, that the North Magnetic Pole of the Earth has shifted away from Canada toward Siberia.

It is postulated that the decade-long low magnetic field between Sun and Earth due to low activity of the Sun is one of the reasons for the pole shift. Further, the swarm of microtremors and a few large earthquakes in Antarctica in 2020–2021 have compelled us to think there is a relationship between tectonic activities and extraterrestrial change. The shift of the Earth's magnetic pole toward Siberia is a phenomenon of change in the earth's interior as well triggered by the changes beyond the Earth. The manifestation of polar wandering is climate change due to the solar and galactic changes.

Polar wandering, terrestrial climate change, and the COVID-19 pandemic outbreak are linked with each other. It is a series of events initiated in outer space in the form of changes in the galactic plane. Impact of the galactic plane has changed the Sun–Earth–Cosmic equilibrium. More galactic cosmic rays and fewer ultraviolet rays from the Sun due to improved ozone layer have changed the mutation probability of viruses. The persistent solar minimum of 2019–2020 is a near replica of the 2009–2010 solar minimum. It is imperative that extraterrestrial change may affect terrestrial environment and health of the living beings of the Earth by evolution of new species of virus. The mechanisms of virus mutations were not very clear till now. Sudden outbreak of pandemics like swine flu of 2009 and COVID-19 have compelled us to see it is possible to develop a correlation of solar-minimum-induced climate change and its implications on initiation or triggering of different types of the viral mutations.

Reduction in greenhouse gases by anthropogenic activities coupled with the low electron flux from the Sun has been responsible for reduction in ultraviolet rays from the Sun. A correlation is being attempted to be established between triggering of COVID-19 pandemics of 2019–2021 with an unprecedented solar minimum. During this solar minimum continuous low electron flux, low proton flux and low planetary indices have been observed from the Sun. Sudden changes in electron flux, proton flux, and planetary indices (Kp values) coupled with the high galactic cosmic rays has been observed. Further, the polar wandering has some bearing on the intensity of galactic cosmic ray change.

Extraterrestrial influence on the quality of air has been observed during and after the solar eclipse. Aerosol, carbon dioxide, ozone, nitrous oxide gases, and cloud covers have shown direct relation with the electron flux, proton flux, and planetary indices level fluctuation.

Solar maximum and solar minimum both have specific impact on the environment of the Earth as well as the man-made environment. In 2013, the sudden rise in proton flux had an impact on glacial melting and its release of trapped black carbon in the atmosphere to initiate a local catastrophe in the Himalayan terrain of India. The latest impact of the extraterrestrial change has been observed on the formation of the Southern Ocean in Antarctica in 2021 due to melting and breaking of a huge iceberg A 76. There were two incidents recorded prior to the breaking of the icebergs:

1. Sudden changes in heliophysical parameters: It was recorded that Earth entered a stream of solar wind flowing faster than 500 km/s from an equatorial hole in the Sun's atmosphere. On 20 May there was sparked a minor G1-class geomagnetic storm, which was followed by more aggressive geomagnetic storms.
2. Microtremors in Antarctica: during May 2021, Antarctica It was recorded that was shaken by 6 quakes of magnitude 4.0 or above, 36 quakes between 3.0 and 4.0, and 33 quakes between 2.0 and 3.0.

These two incidents give an indication that the space weather is related with the environment of the Earth.

Subdued solar prominences are manifested as very few or no sunspots and sometimes the Sun is spotless shows that no Sunspots during a specific year on the Earth facing side of the Sun.

Contrary to that, the graph below shows the number of days with a geomagnetic storm per year and how strong those storms were. This gives an idea in which years there were a lot of geomagnetic storms.

For the hundreds of millions of people living in coastal regions around the world, rising seas driven by climate change pose a direct threat. It is imperative to infer that there is a need to plan for the coastal areas of the whole Earth. These measurements of sea-level changes are difficult to get from satellites. In view of this problem, the European Space Agency (ESA) initiated research that demonstrates how processing satellite altimetry data in a specific way now makes it possible to determine sea-level change in coastal areas with millimeter per year accuracy, even if the sea is covered by ice.

As an experiment, the Baltic Sea data were processed by ESA, which shows regional differences in sea-level rise, drastically improving and extending previous sea-level trend maps. It shows that between 1995 and 2019, the sea level has risen at an annual rate of 2–3 mm in the south, along the German and Danish coasts, compared to a few millimeters in the northeast, in the Bay of Bothnia.

Now it is clear that both the ocean and the atmosphere warm together because of climate change. Sea levels are likely to continue to rise for many years in the near future. Based on the studies of IPCC, it is clear that the climate change we face is because of sea-level rise. Further, the report reveals that the ocean and cryosphere both are in a changing climate state with global mean sea level, which is likely to rise between 0.29 and 1.1 m by the end of this century.

Radar altimetry has been tracking the changing height of the ocean surface and shows that global mean sea level has risen at the rate of over 3 mm every year and the rate of rise has increased in recent years. However, as with any average, the term “global mean sea level rise” does not tell the whole story. Sea level is not rising at the same rate everywhere. Throughout the globe, the coastal boundary may change and the ocean may recapture some parts of the carbon due to the very complex relationship between cryosphere–ocean and atmosphere.

Another satellite Jason data combined with ESA’s Envisat, Cryosat, and the Copernicus Sentinel-3 satellites have provided essential data to monitor sea-level rise in the open ocean, precise mapping of rise nearer the coastline but it is more difficult. The reason behind this fact is that mountains, bays, and offshore islands distort the radar signal that is reflected back to the satellite. Besides the existing global warming, another problem is sea ice, which covers parts of the oceans in winter and is impenetrable to radar.

Through ESA’s Earth Observation Science for Society Baltic Sea Level project, it was found that those sea-level changes in coastal areas were linked to sea glacier melting.

Data between 1995 and 2019 from satellite missions including the Jason series, Envisat, CryoSat, and Copernicus Sentinel-3, the team developed a multistage process. It was calibrated that with measurements from the various satellite missions using specially developed algorithms, it is possible to detect signals from the ice-covered seawater in the radar reflections produced along cracks and fissures called leads. It was possible to determine sea levels for the winter months, which also achieved better resolution of radar echoes close to land. It is now possible to measure sea level in coastal areas and compare the results with local tidal records. Sea level has risen at an annual rate of 2–3 mm in the south, which is less than in the Bay of Bothnia. The cause of this large rise is strong southwesterly winds that drive the waters to the north and eastward. This above-average increase in sea level does not pose a threat to coastal dwellers, however, because since the end of the last Ice Age, the land here has been rising by up to 1 cm a year as a result of post-glacial rebound.

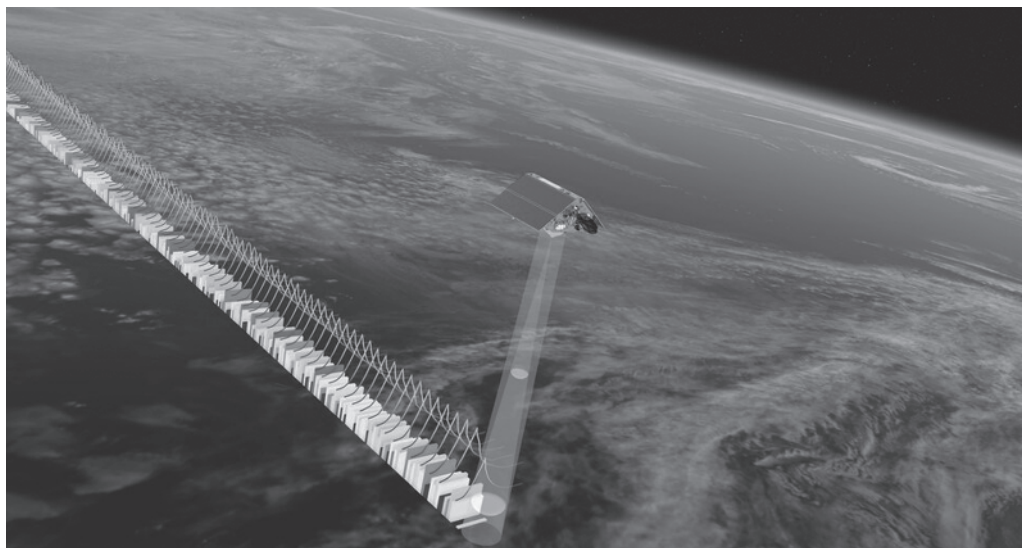


Figure 1.1 Copernicus Sentinel-6 radar altimeter. Source: ESA/ATG.

The researchers have also created a comprehensive dataset for the North Sea region. The sea level here is rising by 2.6 mm yr^{-1} , and by 3.2 mm in the German Bight. Local trends can be determined using the dataset and the user manual – both of which are freely accessible online (Figure 1.1).

The Baltic SEAL project has produced excellent results, demonstrating the value of Earth observation for society. This new way of processing satellite radar altimetry data is really going to help authorities to take appropriate measures to protect citizens and infrastructure from sea-level rise. We are also keenly awaiting the high-resolution data that will come from the new Copernicus Sentinel-6 mission, which also promises to map sea-surface height close to the coastline using an additional new processing algorithm called fully focused synthetic aperture radar to drastically increase the retrieved resolution (Courtesy: European Space Agency 2021).

The impact of the solar maximum can release more protons from the Sun during coronal mass ejection (CME) and continuous solar flares. This was evident in the power grid failures of Canada in 1959 and Northern India in 2012 and 2001. In all these incidents, the activity of the Sun showed sudden changes. The internal mechanism of the fluctuation of solar maximum and solar minimum is a complex subject that can be explained by the comprehensive study of the Forbush decrease due to the sunspot starspot formation and impact of star burst on the magnetic field of the solar system. The effect of solar maximum may lead to the release of excessive ultraviolet rays from the Sun. CME from active Sun leads to more ultraviolet radiation. Ultraviolet radiation, along with its many other biomolecular effects, has an effect on actin protein. Lambda max of protein is 280 nm , which falls in the UV-B range. As a result of exposure to UV-B radiation of the same dose, which occurs during days of earth-directed CME to the actin monomer, the rate of formation of polymer from actin monomer is found to be lower. Actin polymer acts as a platform for various vital cellular reactions. Since the location of sunspots, which leads to CME, corresponds to a particular geo-coordinate of Earth, the entire biomass (as all living cells contain actin protein) of that particular area of the Earth will be affected adversely due to ultraviolet radiation (Geophysical Research Abstracts, Vol. 7, 00139, 2005 SRef-ID: 1607-7962/gra/EGU05-A-00139 © European Geosciences Union 2005).

Study of different planets of the solar system is important, keeping in view developing and understanding natural resources and natural disasters. The influence of extraterrestrial changes

has different if any impacts on planets, which depend on the outer and inner composition of these celestial objects and their environment. Detailed discussion of mineralogical and morphological variability is the key to understanding the tectonic framework of the Moon, which has changed the concept of global information system. Keeping in view the terrestrial analog correlation, the study of the Moon and Mars is important. Using indigenous satellite Chandrayaan (Moon Satellite) and Mangalyan (Mars Orbiter Probe) when correlated with tectonic framework and mineral distribution on the surface, it has the potential to solve issues of sustainable development.

We have used data from the Mars Color Camera (MCC) and Thermal Infrared Spectrometer (TIS) payloads of the Mars Orbiter Mission. MCC returns “True Color” images in different resolutions. Hence, it is possible to provide high-resolution localized scenes (attaining a spatial resolution of 19.5 m pix^{-1} @ at periapsis) as well as a synoptic view of the planet depending upon the orbit. However, the coverage of high-resolution images was very low and often a shift in the geo-referencing was observed. TIS dataset was noisy and smoothening of the results often led to deviation from the actual observations. True color images of the MCC was an ingenious idea and we would recommend the same with perhaps better resolution in upcoming missions.

Mineralogy is an important aspect in studying geological evolution of a planet. Currently, OMEGA and CRISM sensors provide data in the near-infrared range (NIR) for studying secondary hydrated minerals. However, usage of OMEGA is not as widely popular as CRISM, probably because of the ease (also availability) in data processing. Nevertheless, current coverage of CRISM is reduced to half resolution short (HRS). Recent reports of artifacts in the dataset as well as the detector coolant malfunction (of CRISM) have raised questions of previous investigations, especially of sulfates. Thus, sending an Indian satellite to Mars with an IR (NIR + TIR) sensor which makes use of these research gaps would be very useful for scientists worldwide. At present we do not have a full Mars digital elevation model beyond 100 m (created by merging HRSC and MOLA datasets). But this dataset is also interpolated due to missing data in some areas. Therefore, we can work towards developing higher resolution altimeter as in the Chandrayaan mission.

Net Mars mission should be landing site inspired. Nevertheless, as the main focus of upcoming missions has shifted to finding biosignatures, it is important to first create a team of scientists with expertise in different areas to carry out field studies. This would help in understanding the kind of biosignatures that can be expected with least possible destruction due to heat in experiments, UV, etc. Based on liability of the compounds, we can focus on devising a sensor for specific classes such as lipids, proteins, amino acids, etc. A miniature XRF/MS/Raman spectrometer may help in detection of biosignatures intercalated within the rocks. Perhaps a subsurface exploration in this case may be a more fruitful and novel approach as other missions are planning to explore the surface. Recent results from Insight lander have opened a new area for exploration on Mars. Thus, magnetic and seismic studies of Martian subsurface (especially in the volcanically active areas of the past or deep crater basins) may give interesting results. Extraterrestrial remote sensing not only has the potential to infer the materialistic information of natural hazards and natural resources of the Earth and planetary system but can unveil the mystical universe.

Further Reading

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