CONTINUOUSLY OPERATING REFERNCE STATION(CORS): GNSS NETWORK CHALLENGES AND BENEFITS IN THE INDIAN CONTEXT

A Continuously Operating Reference Stations (CORS) GNSS Network is a modern tool to provide regional positioning service that can provide fit-for-purpose positioning. In CORS Infrastructure, the corrections are instantly sent to the rover receiver (user end) from control centre which helps to find very accurate positioning of rover in real time.

CORS plays a major role in achieving centimeter accuracy positioning in many applications, for example, cadastral mapping, land information management, large scale mapping, fleet management, tracking and navigation etc. To achieve this positioning service seamlessly at a regional level, a CORS network need to have an integrated national setup.

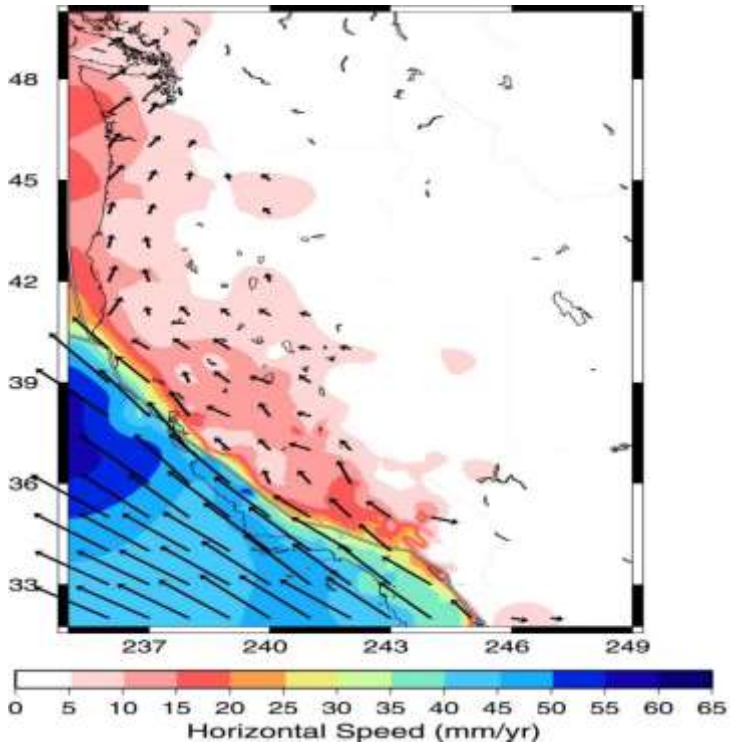
It is in great demand among industries like surveying, navigation, construction, mining, precision agriculture and scientific research that require greater positional accuracy, as well as continuity of data. Surveyors, GIS users, Administrators, Planners and Engineers also leverage CORS data for a wide variety of applications. Other popular user groups include Geophysicists, Meteorologists, Atmospheric and Ionospheric Scientists. In this paper, we will explore benefits from a CORS GNSS Network, and shed light on the methodology adopted for CORS GNSS network at the national level

IIRS- ISRO(DEHRADUN) CORS AT IIT MANDI CAMPUS FOR TEC STUDY

CORS Applications

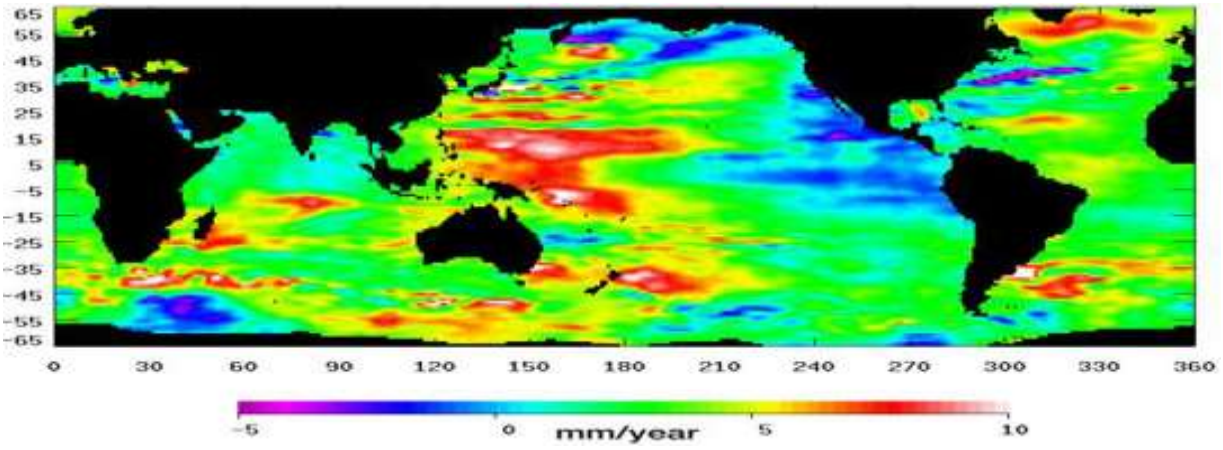
- **Crustal Motion**

Crustal motion monitoring is perhaps one of the most obvious of all CORS applications. If CORS data are rigorously processed and analyzed during a period of several years, then the motion of the Earth's crust can be determined wherever the CORS network provides sufficient coverage.



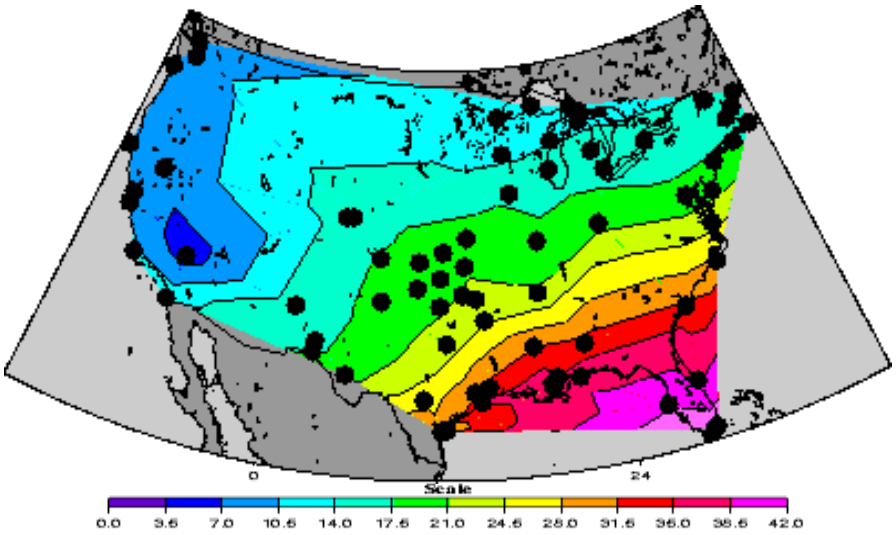
- **Sea Level Changes**

The variations of vertical crustal velocities at CORS sites near tide gauge stations may be used to determine the "absolute" sea level change with respect to the International Terrestrial Reference Frame. This type of analysis was impossible to conduct be- fore the proliferation of CORS in coastal areas. With time, more CORS data will become available near tide gauges to conduct investigations able to accurately estimate vertical crustal velocities and thereby absolute sea level rates with greater certainty.



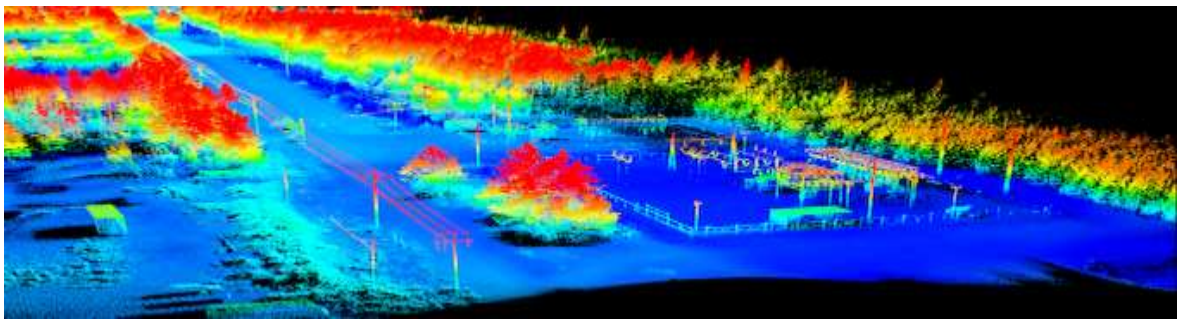
- **Ionospheric Studies**

Wide area ionospheric models have been developed to model and mitigate local ionospheric effects. Such models are based on dual frequency observations from a subset of the CORS network.
The ionosphere is a dispersive medium located in the region of the upper atmosphere that begins at an altitude of around 50 km and extends upwards several hundred kilometers. The radiation from the Sun and particles precipitating from the magnetosphere produces free electrons and ions that cause phase advances and group delays in radio waves. The state of the ionosphere is a function of the intensity of solar and magnetic activity, position on the Earth, local time and other factors. As GPS signals traverse the ionosphere, they are delayed by an amount proportional to the total electron content (TEC) within the ionosphere at a given time.



- **Geolocation of Aerial Moving Platforms**

Data available from CORS sites has been used in many remote sensing applications. The accurate positioning of aircrafts employed in aerial mapping is crucial to improve the reliability of photogrammetric restitution primarily for large-scale aerial survey applications over remote or inaccessible terrain. The same concepts implemented for geolocating landmarks from the air with digital cameras has been extended to a broad array of mapping terrain applications using cutting edge technologies such as scanning radar, light detection and ranging (LiDAR), inertial systems, interferometric synthetic aperture radar, and/or sonar. The use of CORS data in airborne mapping processes has proven to provide a significant alternative.



To Better Understand Seismic Precursor in the Himalayan Region, IIRS ISRO(Dehradun) has setup CORS to analyze TEC Variations observed by GNSS receiver in CORS Mode located in different parts of North-West Himalaya (Gopeshwar, Pantnagar, Haridwar, Nainital, Purola, IIT Mandi, HNBGU Srinagar)

CORS STATION ARIES NAINITAL

CORS STATION JNV PUROLA

CORS STATION HNBGU SRINAGAR

CORS STATION IIT MANDI

- Scientists from different backgrounds, using CORS on a daily basis by downloading GPS data through CORS and anonymous FTP, and then postprocessing these data for a variety of applications

TEC OBSERVATIONS AT DIFFERENT CORS STATION

TEC is measured to estimate the impact of ionosphere on the signals transmitted by GPS satellites to the receivers on Earth. Ionospheric TEC is the carrier phase delay of received radio signals transmitted from satellites which are located above the ionosphere.

TEC varies with time and space and it de- pends on solar activity, geomagnetic storm and receiving station location. The currents and energy introduced by a geomagnetic- storm increases the total height-integrated number of ionospheric electrons, or the TEC. During a geomagnetic storm, the solar wind energy dissipates into the ionosphere and thermosphere, and the energy transportation processes within the ionosphere become extreme and more complicate.

Solar flares are giant explosions on the sun that send energy, light and high-speed particles into space. These flares are often associated with solar magnetic storms known as coronal mass ejections (CMEs). During a solar flare, the sun releases energy in the form of electro-magnetic waves, which disrupts the normal balance of ion and its formation and recombination in the ionosphere. These factors result in the spatial variability of the ionosphere and cause ionospheric delays in the GPS signals.

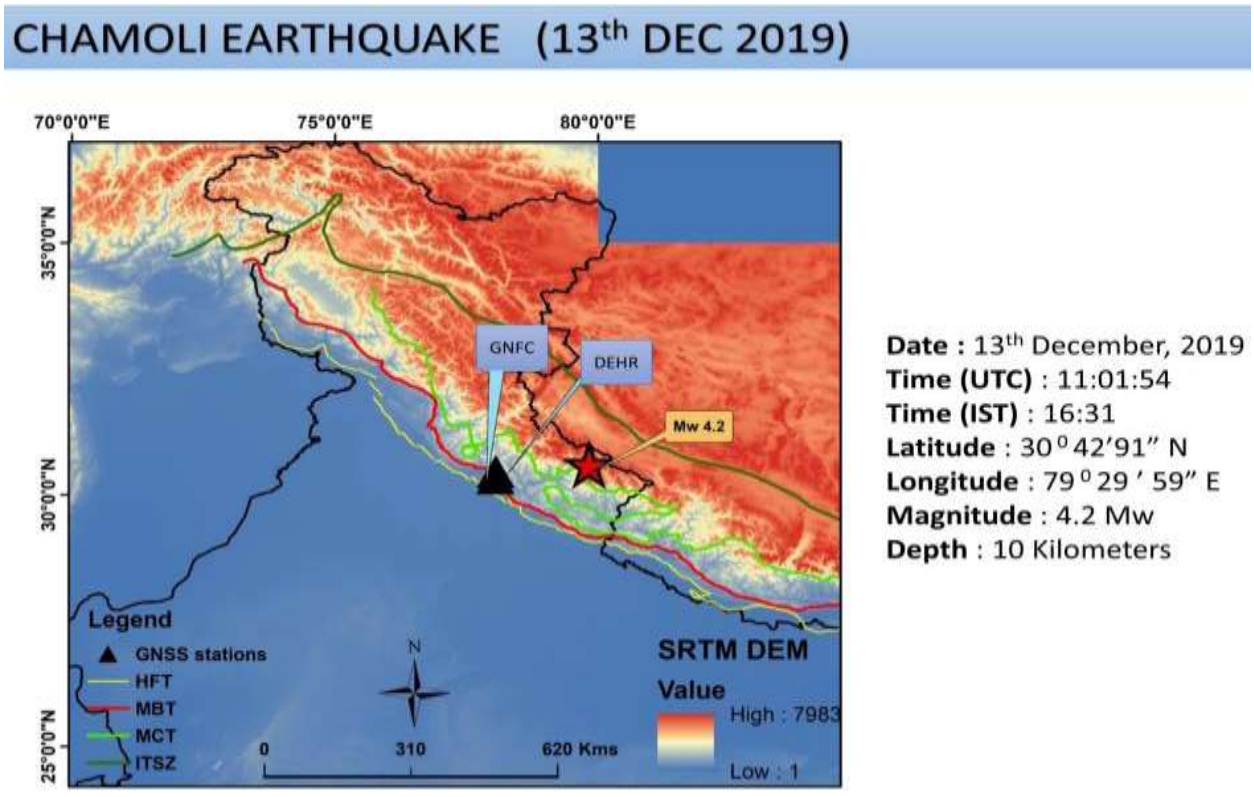


Figure 1: *Earthquake epicenter along with location of CORS.*

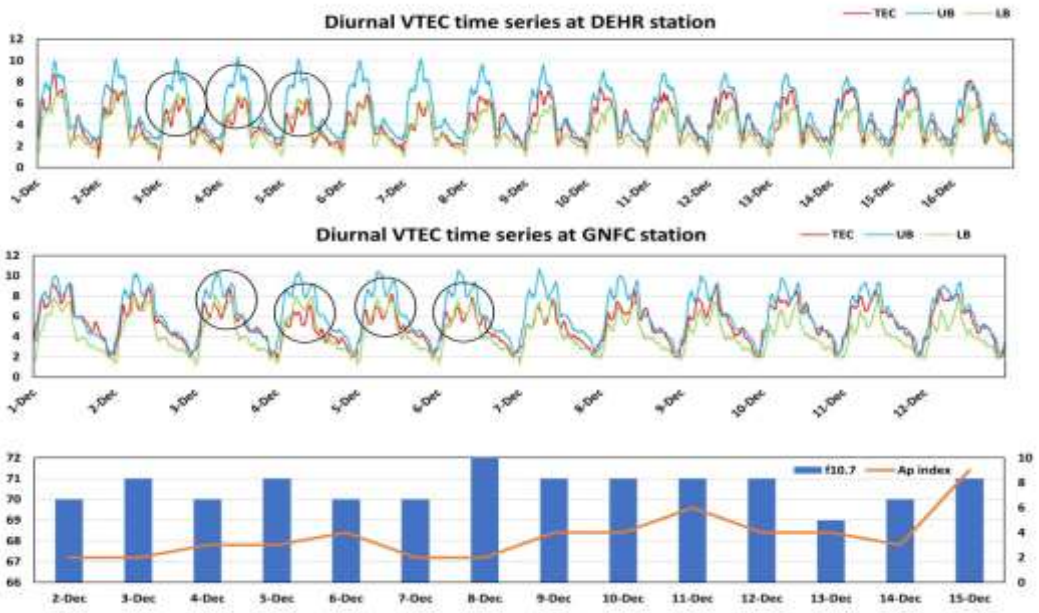


Figure 2: *Time series at DEHR (Dehradun) and GNFC (Mussoorie) station along with solar and geomagnetic data*

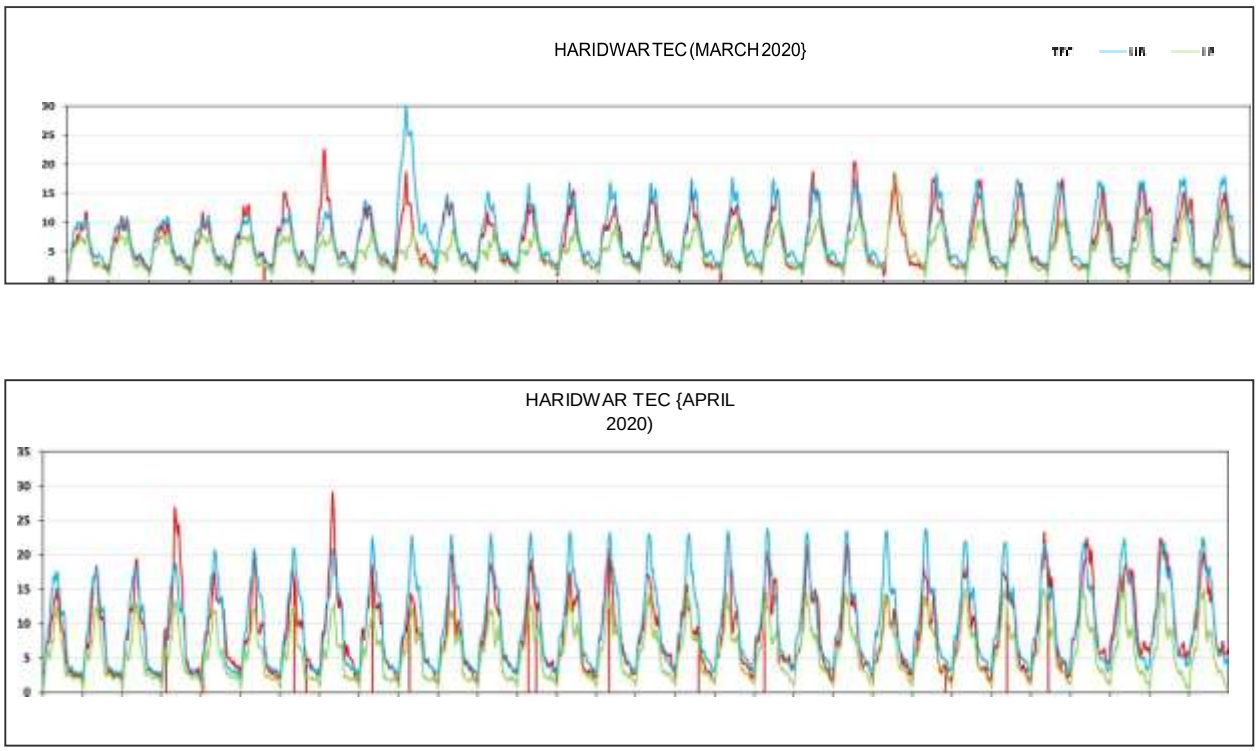


Figure 3: *TEC SERIES BHEL HARIDWAR (MARCH & APRIL 2020)*