Ionospheric Based Monitoring of Large Earthquakes

Why in News

Recently, scientists of Indian Institute of Geomagnetism (IIG) have come up with a study of the signatures of recent large **earthquakes** into the ionosphere. The aim was to derive the seismic source characteristics from the ionosphere.

- The research is a part of the interdisciplinary program **'Coupled Lithosphere-Atmosphere- Ionosphere-Magnetosphere System (CLAIMs)'** of IIG. CLAIMS focuses on energy transfer to the atmosphere during solid Earth processes such as earthquakes as well as tsunamis.
- IIG is an autonomous institution of the Department of Science and Technology.

Key Points

- Scientists noticed that the spatial distribution of near field **co-seismic ionospheric perturbations (CIP) associated with the earthquake could reflect well the ground deformation pattern** evolved around the epicentre.
    - These CIP were derived using the **Global Positioning System** (GPS) measured **Total Electron Content (TEC).**
        The TEC is the total number of electrons present along a path between a radio transmitter and receiver.
    - The CIP distribution was estimated at **ionospheric piercing point (IPP)** altitude.

- **Co-seismic Ionospheric Perturbations (CIP):**
    In general, the Earth crust uplift during any earthquake produces compressional (i.e. pressure) waves in the overlying atmosphere.
        - These waves propagate upward in the region of exponentially decreasing atmospheric neutral density, and thus, waves amplitudes increase with atmospheric heights.
        - **On arrival at ionospheric heights, the waves redistribute ionospheric electron density** and **produce electron density perturbations (disruption)** known as **Co-seismic Ionospheric Perturbations (CIP).**
- However, evolution of seismic/tectonically induced ionospheric perturbation is **highly controlled by the non-tectonic forcing mechanisms.**
- The major effective **non-tectonic forcing mechanisms at ionospheric altitudes** are the
    - orientation between the ambient geomagnetic field and seismic induced neutral wave perturbations.
    - orientation between the moving satellite line of sights and the wave perturbations.
    - ambient ionospheric electron density gradient.
- **Challenge:** The ionosphere is a **highly dynamic region** and the **origin of any perturbations** in ionospheric electron density can be traced to various origins **either from above** (e.g. solar, geomagnetic etc) **or below** (e.g. lower atmospheric, seismic etc) the ionosphere. This is a major challenge while identifying the CIP.
- **Inference**: The manifestation of **CIP has to be seen in light of the prevailing non-tectonic forcing mechanisms.**
    In this line, it is believed that the present study may assist while designing a tool for the ionospheric based seismic source characterisation.

Ionosphere

- The ionosphere is defined as the layer of the Earth's atmosphere that is ionized by solar and cosmic radiation. It **overlaps** the **mesosphere, thermosphere,** and **exosphere.**
- It lies 75-1000 km above the Earth.

Source: PIB