The impact of solar eclipses on the structure and dynamics of Earth's upper atmosphere

September 26 2023, by McKenzie Denton

Earth's limb at night, seen from the International Space Station, with airglow visual composited into the image. Credit: NASA

Solar eclipses can have a noticeable impact on the structure and dynamics of Earth's upper atmosphere—the ionosphere. This is primarily due to the sudden reduction in solar radiation reaching the Earth's atmosphere during the eclipse. Since the ionosphere contains charged particles (ions and electrons) and is responsible for reflecting and refracting radio waves, changes to the ionosphere can also affect radio communications and navigation systems.

How solar eclipses can impact the ionospheric structure and dynamics:

- **Ionization Changes:** In the ionosphere, solar radiation is a

primary source of ionization, which the process in which an atom or molecule becomes charged when it gains or loses electrons. During a solar eclipse, the reduction in solar radiation leads to a decrease in ionization, particularly in the region of the ionosphere at an altitude around 37 to 56 miles. This decrease in ionization can cause a temporary drop in the density of electrons in the ionosphere.

- **Temperature Changes:** The decrease in solar radiation during an eclipse can also lead to cooling of the upper atmosphere. This cooling can affect the temperature structure of the ionosphere, potentially causing changes in ionospheric densities and altitudes.
- **Electron Density Variations:** The reduction in ionization and cooling during an eclipse can lead to a decrease in the electron density in the ionosphere. This can affect the propagation of radio waves, particularly in the high frequency, or HF, range, which rely on ionospheric reflection for long-distance communication.
- **Ionospheric Anomalies:** The sudden changes in ionospheric conditions during an eclipse can lead to the formation of ionospheric anomalies, such as ionospheric holes or depletions. These anomalies can disrupt radio signals and GPS navigation systems, affecting communication and navigation over the affected regions.
- **Propagation Effects:** The altered ionospheric conditions during an eclipse can change how radio waves propagate through the ionosphere. This can cause signal fading, absorption, and refraction, affecting shortwave and satellite communication systems.

Solar eclipses provide a unique opportunity for researchers to study the ionosphere and its response to sudden changes in solar radiation. Scientists can use various instruments, such as ionosondes, GPS receivers, and radar systems, to measure and monitor ionospheric

variations during an eclipse, helping improve our understanding of ionospheric dynamics.

While solar eclipses can have noticeable effects on the ionosphere, they are generally temporary and localized to the region experiencing the eclipse. The ionosphere typically returns to its normal state after the eclipse event is over, and solar radiation levels return to normal.

If you're interested in learning more about this topic, visit our website. HamSCI—the Ham Radio Science Citizen Investigation—furthers radio science with the help of amateur radio operators. HamSCI will host the Festivals of Eclipse Ionospheric Science in 2023 and 2024 to gather data for space physics research and help scientists understand how eclipses impact the ionosphere's structure and dynamics. Participation is open to volunteer amateur radio operators, short wave listeners, and scientific researchers.

Provided by NASA

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