Ionosondes and Ionospheric Measurements in Relation to Propagation

An **ionosonde** is a radar-like instrument used to study the ionosphere, the layer of Earth's atmosphere containing ionized particles. It works by transmitting radio waves and analyzing their refracted returns back by the ionosphere. Here's a breakdown of how ionosondes work and the process:

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1. Transmission of Radio Waves

- The ionosonde emits short pulses of radio waves vertically into the atmosphere.
- These radio waves have varying frequencies, typically ranging from 1 to 30 MHz.

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2. Interaction with the Ionosphere

- As the radio waves travel upward, they encounter different layers of the ionosphere (D, E, and F regions). These layers refract radio waves depending on their frequency and the electron density of the ionosphere.
- Low-frequency waves are absorbed by the D layer and are refracted by lower layers (e.g., E layer), while higher-frequency waves penetrate deeper into the upper layers (e.g., F layer).

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3. Refraction Back to Earth

- When a wave encounters a region where the electron density matches its critical frequency, it is refracted back to the ionosonde.
- Waves with frequencies above the critical frequency for the highest ionospheric layer pass through the ionosphere and are not refracted or reflected.

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4. Detection of Refracted Waves

- The ionosonde receives the reflected signals and measures:
    - **Time delay**: Determines the virtual height (apparent altitude) of the ionospheric layer.
    - **Frequency**: Helps identify the layer and critical frequency.

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5. Creation of an Ionogram

- The ionosonde generates an **ionogram**, a graph that plots the refraction time (or virtual height) against frequency.
- Key features of an ionogram include:
    - **Critical frequency (fo)**: The highest frequency reflected by each layer.
    - **Virtual height (h'):** The apparent height of the refracting layers.
    - **Cutoff frequency**: Where waves begin to penetrate the ionosphere without refraction.

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6. Analysis and Applications

- By analyzing the ionogram, scientists can:
    - Determine ionospheric electron density profiles.
    - Study ionospheric conditions (e.g., during solar storms or at different times of the day).

- Support communication systems by identifying usable radio frequencies for long-distance transmission.
- Assist in GPS accuracy by accounting for ionospheric delays.

In summary, ionosondes work by transmitting radio waves into the ionosphere, analyzing their refracted returns, and interpreting the results through ionograms to study ionospheric properties. This process is crucial for understanding space weather and improving communication technologies.

The above is an edited summary from AI

Ionosondes

In practical terms, Ionosondes work by transmitting radio waves (1-30 mHz) into the ionosphere , analyzing their refracted returns, and interpreting the results through ionograms to study ionospheric properties. This process is crucial for understanding space weather and improving communication technologies. Since the Minimum and Maximum Usable Frequencies are determined by the ever-changing fluid ionosphere, NVIS and DX propagation will differ according to geological location (QTH). "What is true in Kansas will not necessarily be true in San Francisco pertaining to ionospheric conditions."

In general, during the daytime the D layer tends to absorb frequencies 8 mHz and below. At night the D layer disappears and longer skip below 8 mHz is available.

When the Ionosphere is highly charged, skip is generally enhanced in the higher frequencies 30m -10m. While refraction above 10m is rare, an excited F-layer refraction can occur as high as 2m .

The relationship between the ionosphere, frequency, time of day, season, number of sunspots, and radio propagation is a complex interactive dynamic which still is not fully understood by science.

Ionosondes Online

Note that the following internet sources are not always avaiable. The Utah National Lab being the most reliable.

The three closest Ionosonde stations to Co Co County are Point Arguello, Boulder (currently inactive), and Idaho National Laboratory. One source is https://giro.uml.edu/didbase/scaled.php which presents scaled Ionosondes

At the home page you enter the start and stop date and time, the location (Point ARGUELLO is located south of Vandenberg AFB, north of Point Conception, and west of Santa Barbara). From the pull-down menu select foF2, then SEARCH. It returns the data table, the first part of which is in the pic below. They ask in their “Rules of the Road” for noncommercial uses only and reference the source in any publications. A ton of other data is also available, including max usable freq.

The Point Arguello ionosonde has the designation PA836 and is apparently still operating (but cannot be brought up from https://hamwaves.com/nvis/en/index.html, as before. The Pt Arguello ionosonde PA836 can be found at https://lgdc.uml.edu/common/DIDBMonthListForYearAndStation?ursiCode=PA836&year=2025.

Similarly, try:

https://giro.uml.edu/didbase/

https://giro.uml.edu/ionoweb/

HF Propagation conditions are measured by various indexes.

Solar Flux is a prime indicator for good refraction off the ionosphere's F layer. The higher the Solar Flux number density, the are skip conditions. SF roughly corresponds to the number of sunspots. It is measured on 10.7cm.

Kp Index is a measure of how electromagnetic storms affect the geomagnetic disturbances (0-10) which generate RF noise. The lower the number, the more quiet the atmospheric noise floor. Often called the K index, 0-2 is quiet, 3-4 moderate, 5 corresponds to a G1 storm (noisy), and Kp 9 and above correspond to a G5 storm, which is considered a wipeout.

There are numerous other corresponding indicators (see below)

https://hamwaves.com/propagation/en/index.html (For General Propagation)

https://hamwaves.com/nvis/en/index.html (For NVIS)

https://www.solarham.com/ (A quick user-friendly one stop source]

https://www.wm7d.net/hamradio/solar/

https://solar.w5mmw.net/

https://www.spaceweather.com/

Similarly:

The Miyake Event: https://spaceweatherarchive.com/2025/02/01/a-warning-from-the-trees-miyake-events/

Underground Geoelectric Field Effects caused by CMEs
https://www.swpc.noaa.gov/products/geoelectric-field-models-1-minute#tabs-3

The Carrington Event: https://spaceweatherarchive.com/2020/08/30/a-warning-from-history-the-carrington-event-was-not-unique/
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