The High Frequency Active Auroral Research Program

HAARP

What Are the Effects of HAARP on the Ionosphere?

Overview of Active Ionospheric Research

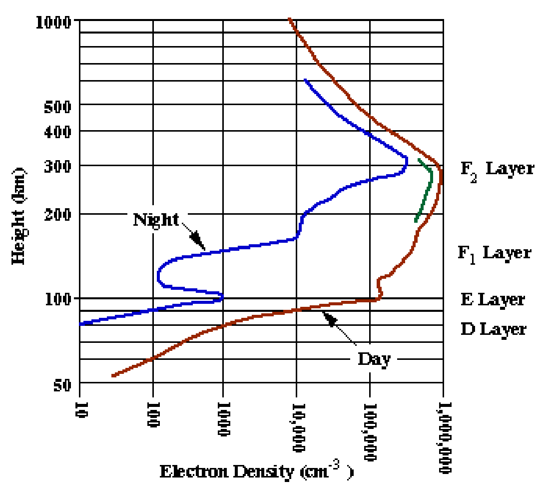
In the field of geophysics, the use of high power transmitters, such as the one located at the HAARP facility, to study the upper atmosphere is called "active ionospheric research." The HAARP facility will be used to introduce a small, known amount of energy into a specific ionospheric layer for the purpose of studying the complex physical processes that occur in these naturally occurring plasma regions that are created each day by the sun. The effects of this added energy are limited to a small region directly over the HAARP observatory ranging in size from 9 km in radius to as much as 40 km in radius.

It is important to realize that HAARP interacts **only** with charged (or ionized) particles in a limited region of the ionosphere directly over the facility. Interaction occurs because a charged particle (electron or positive ion) will react to an external electric field. HAARP does not interact with the neutral atoms and molecules that make up the bulk of the gas at all atmospheric heights.

When the HAARP HF transmitter is shut down at the end of an experiment, any ionospheric effects rapidly dissipate, becoming imperceptible over time frames ranging from fractions of a second to minutes. Extensive research conducted over many years at other active ionospheric research facilities around the world has shown that there are no permanent or long term effects resulting from this research method. The following sections discuss these points in greater detail.

How Ionization Varies Naturally

The following chart [1] shows the degree of ionization measured in number of electrons per cm^3 as a function of height in kilometers for a typical case. The chart also shows the generally accepted positions for the most important ionospheric regions: the D, E, F_1 and F_2 layers. The red curve in this chart shows the level of ionization that is typical during the daytime and the blue curve, the ionization during the evening hours. (The actual ionization levels and ionospheric layer heights will vary substantially over the 11 year solar cycle as well as for different geographic locations and in different seasons of the year.)



It is quite apparent from this chart that the ionosphere undergoes a dramatic change in ionization from day to night. The D layer, for example, disappears entirely as soon as the sun sets. The electron (and ion) density in the E-layer decreases by a factor of 200 to 1 and in the F_1-layer by nearly 100:1. For all practical purposes, the lower layers disappear during the evening hours as the sun's radiation is no longer creating new ions and the recombination process depletes the existing ion supply. The density of neutral (non-ionized) particles, on the other hand, does not vary from day to night.

How is the Ionosphere Affected by HAARP?

During active ionospheric research, a small, known amount of energy is added to a specific region of one of the ionospheric layers as discussed previously. This limited interactive region directly over the facility, will range in size, depending on the frequency of operation and layer height, from as little as 9 km in radius to as much as 40 km in radius and may be as much as 10 km in thickness. The interactions occur only with ionized particles in the layer; neutral (non-ionized) particles, which outnumber ionized particles by 500:1 or greater, remain unaffected.

Effects produced by HAARP are thermal in nature and do not result in new ionization. HAARP is not able to produce artificial ionization for the following two reasons.

1. The frequencies used by the HAARP facility are in the High Frequency (HF) portion of the spectrum. Electromagnetic radiation in the HF frequency range is *non-ionizing* - as opposed to the sun's ultraviolet and X-ray radiation whose photons have sufficient energy to be *ionizing*.
2. The intensity of the radiation from the completed HAARP facility at ionospheric heights will be too weak to produce artificial ionization through particle interactions. The power density produced by the completed facility will not exceed 3 to 4 microwatts per cm^2, about two orders of magnitude below the level required for that process.

We have provided a separate page that allows you to calculate the diameter of the affected ionospheric region and the power density that can be produced in that region by HAARP for any frequency and any layer height. The calculator also allows selection of various array sizes up to the full 180 element, completed array.

What Effects Are Produced By HAARP?

A portion of the energy contained in the high frequency radio wave transmitted by HAARP can be transferred to existing electrons or ions making up the ionospheric plasma through a process called **absorption**, thus raising the local effective temperature. As an example, the typical electron temperature at a height of 275 km (the peak of the F_2 region) may be on the order of 1400°K. [2]. Work at other active ionospheric research facilities has shown that it is possible to raise this temperature by as much as 30% within a small, localized region during an experiment. The affected region would then temporarily display electrical characteristics different from neighboring regions of the layer. Sensitive scientific instruments on the ground can then be used to study the dynamic physical properties of this region in great detail.

As the electrons (and ions) acquire additional energy, their temperature increases, their kinetic energy increases and they begin to move more rapidly. In the F layer, this increased movement or expansion results in a decrease in the electron density (electrons move into adjacent undisturbed regions). Experience at other active ionospheric research facilities [3] has shown that electron densities in the small, affected region may be reduced by 10% to 20%. This reduction in electon density is shown in the above chart by the dark green line.

Natural ionization in the F layer may produce an electron and ion density during the daytime of 1,000,000 cm^{-3}, about 0.2% of the total gas present. Active ionospheric research using the HAARP HF transmitter (interacting *only* with the ionized particles and not the neutral gas) could suppress this electron density in a localized region to 800,000 cm^{-3}. Compare this with the decrease in electron density that occurs naturally through a large portion of the nighttime F region (shown in the blue curve) of 500,000 cm^{-3} or less and it is clear that active ionospheric heating cannot duplicate what happens naturally, even within the small affected region directly over the facility.

For ionospheric layers below about 200 km in altitude (the "D" and "E" layers, for example), the electron density may actually **increase** as a result of active heating because of the suppression of recombination processes. Compare this with the natural depletion that occurs after sunset every evening when the E-layer electron density **falls** by as much as 200 times to levels of 1,000 cm^{-3} over almost the whole nighttime hemisphere.

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References

[1] Davies,Kenneth, **Ionospheric Radio**, Peter Peregrinus Ltd.:London, 1990, p-57.

[2] Kelley, M. C., **The Earth's Ionosphere**, Academic Press, Inc:San Diego, 1989.

[3] Davies,Kenneth, p-518.

Pioneering Ionospheric Radio Science Research for the Twenty-First Century

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