# D-REGION REFLECTION HEIGHT MODIFICATION BY WHISTLER-INDUCED ELECTRON PRECIPITATION (WEP)

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**ABSTRACT**

Ionospheric modifications are caused by whistler-induced electron precipitation (WEP) from the Van Allen radiation belts into the lower ionosphere. We examine the electron density profile expected for lower ionospheric changes due to a single 0.2s whistler-induced electron precipitation burst with experimentally determined properties. We go on to consider the cumulative response of the nighttime *D*-region to a sustained series of WEP bursts observed through experimentally observed VLF perturbation activity on one night in the Antarctic. The additional WEP produced ionization leads to increases in the high altitude (>70km) electron densities, until a new equilibrium level is reached.

## INTRODUCTION

A technique that has proved successful for studying the ionospheric *D*-region (the part of the ionosphere below 90 km) is monitoring signals from VLF transmitters which propagate inside the Earth-ionosphere waveguide. Short time-scale (~100 s) modifications of the *D*-region leading to VLF phase and amplitude perturbations associated with whistler-induced electron precipitation [1] are known as "Trimpi" perturbations. Trimpi perturbations are caused by whistler-induced electron precipitation (WEP) from the Van Allen radiation belts increasing the electron concentration. The energetic electron precipitation arises from lightning produced whistlers interacting with cyclotron resonant radiation belt electrons in the equatorial zone.

## IONOSPHERIC EFFECT OF A SINGLE WEP BURST

We examine the electron density profile expected in the lower ionosphere due to a 0.2 s whistler-induced electron precipitation burst. The burst is characterized using the experimentally determined properties reported from the SEEP experiment onboard the low-altitude S81-1 satellite [2]. The ionization rate (found using expressions in [3]) in the lower ionosphere due to a single such WEP event has a height variation with a rather broad maximum, leading to additional electron densities of about ~5 el.cm$^{-3}$ stretching over altitudes of ~75-92 km. For ambient nighttime conditions, a single WEP burst with these parameters will lead to a significant electron density changes only for altitudes below ~85 km.

## IONOSPHERIC EFFECT OF REPEATED WEP BURSTS

We go on to consider the cumulative response of the nighttime *D*-region to a sustained series of WEP bursts observed through Trimpi perturbation activity on one night in the Antarctic. The ionospheric modifications caused by each WEP-burst (as indicated by the Trimpi data) are added to a running ionospheric electron density profile that is initially equal to the ambient night-time profile. The ionospheric modifications relax according to calculated electron loss rates [4]. For altitudes >70 km significant long-term changes in electron densities due to WEP-bursts can occur. The additional WEP produced ionization leads to increases in the high altitude electron densities, until a new equilibrium level is reached. Peak changes in electron density are ~16 times ambient at 85 km and ~7 times ambient at 90 km, occurring in the ~15 min period during which the WEP rate is at its peak (~4.5 per min). The simulation suggests that electron density levels "settle" into a new quasi-equilibrium state during the ~3 hour period where the ionization at 85 km altitude is 10-12 times ambient due to WEP bursts occur at ~3 per minute. The ionization changes produced by WEP bursts lead to lower reflection heights for VLF and LF radio waves (in the Earth-ionosphere waveguide).

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