A Deep Learning Model of Proton Auroras On Mars

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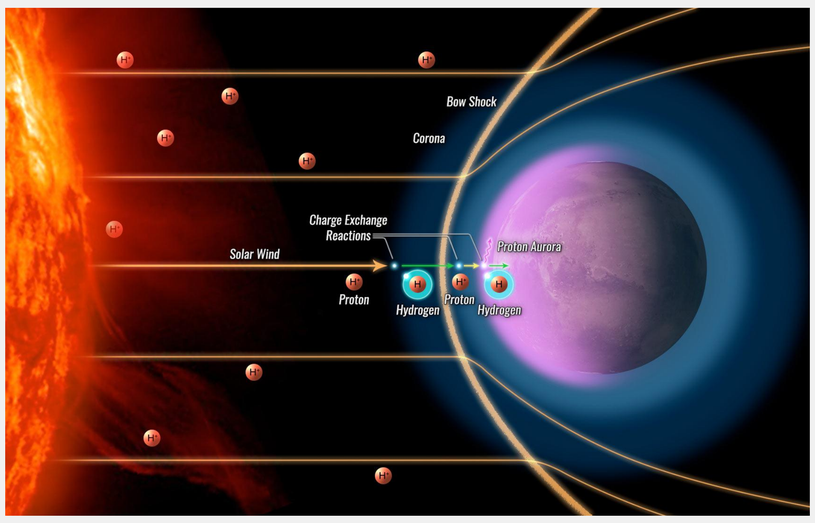
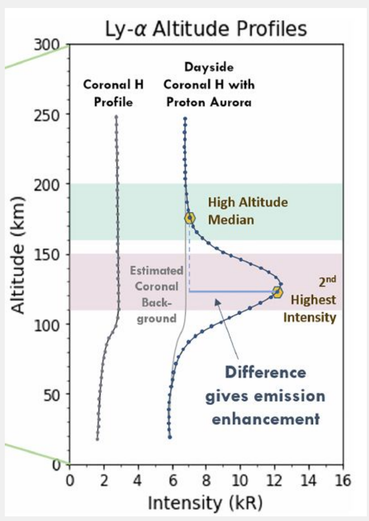
Abstract

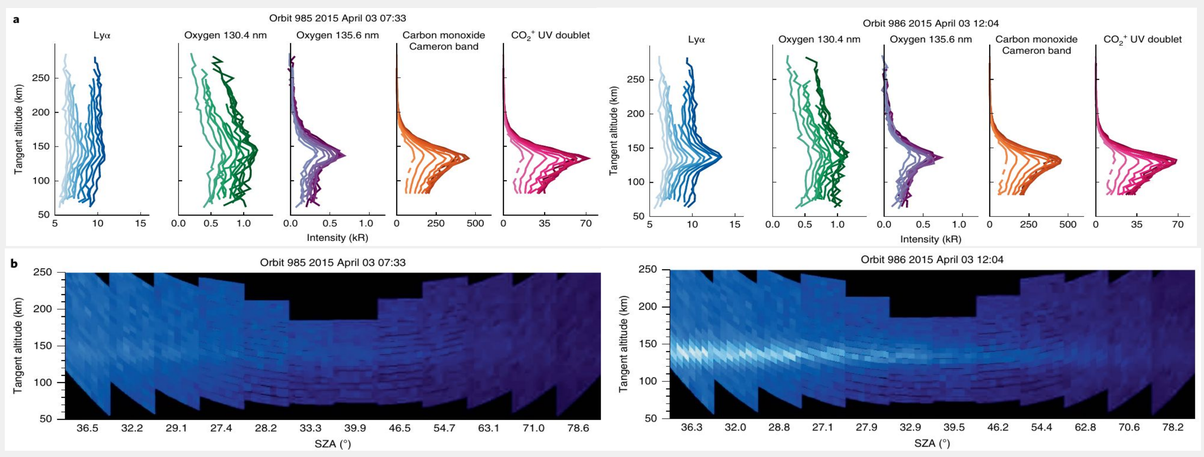
We present a deep learning model of proton aurora observations on Mars made using the Imaging UltraViolet Spectrograph (IUVS) onboard NASA's Mars Atmosphere and Volatile EvolutioN (MAVEN) spacecraft. Proton auroras are one of the most widely observed auroras on Mars, identified as a significant intensity enhancement in the hydrogen Lyman-α (121.6 nm) dayglow emission between ~110 and 150 km altitudes. These auroras are believed to be triggered by electron stripping and charge exchange between solar wind protons and the neutral hydrogen in the corona forming the energetic neutral hydrogen atoms that penetrate down to the thermosphere. We created a training database of Lyman-α profiles from IUVS limb scan observations between October 2014 - December 2017. We design a multi-input deep neural network to reproduce these Lyman-α profiles using MAVEN in-situ measurements of density, speed, temperature and magnetic field as well as energy spectra of penetrating protons. We demonstrate that the individual Lyman-α intensities are reproduced with a Pearson correlation 90% along with a faithful reconstruction of the observed ly alpha profile. We perform statistical analysis of accurately reconstructed Lyman-α observations to understand the impact of Mars induced magnetic fields on proton auroras.

Solar Wind Protons Penetrating as Energetic Neutral Atoms Trigger Auroras Widely Observed On Mars' Dayside



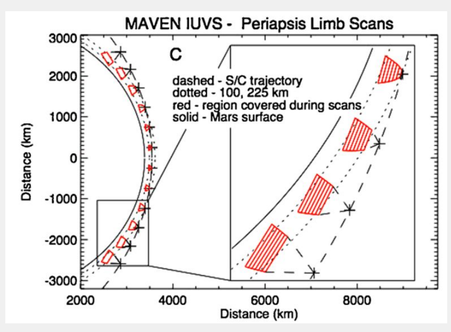


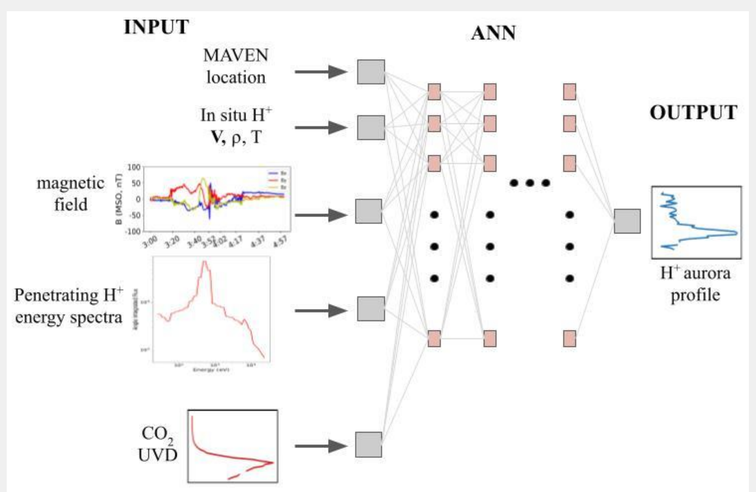
From: Hughes + (2019)

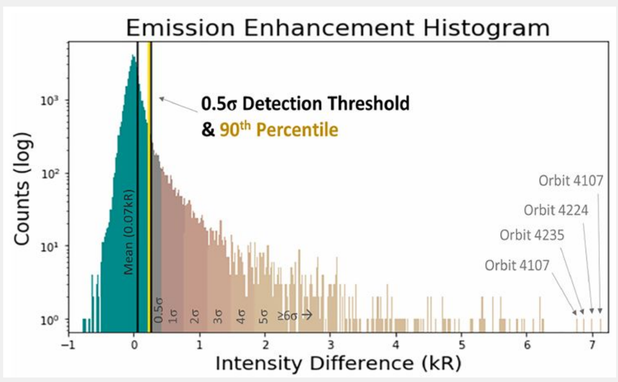


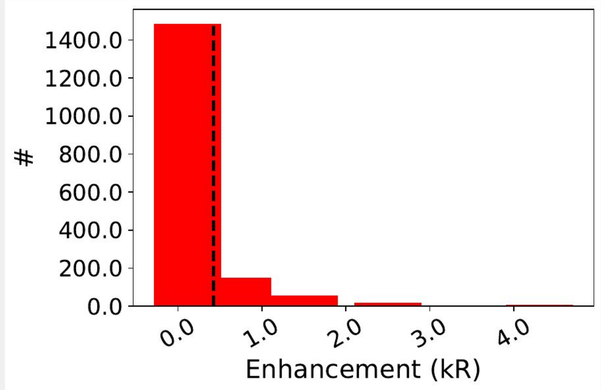
From: Deighan + (2017)

Multi-input Artificial Neural Network to Reconstruct MAVEN/IUVS Limb-scan Ly-α Profiles



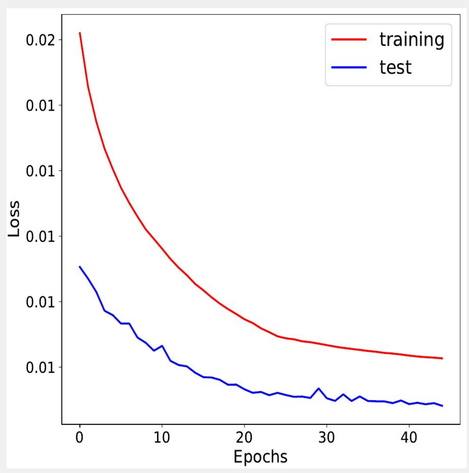


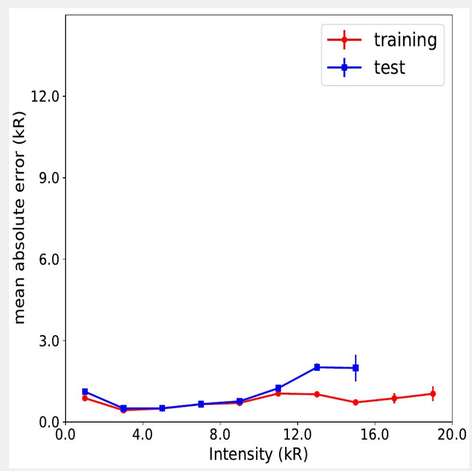


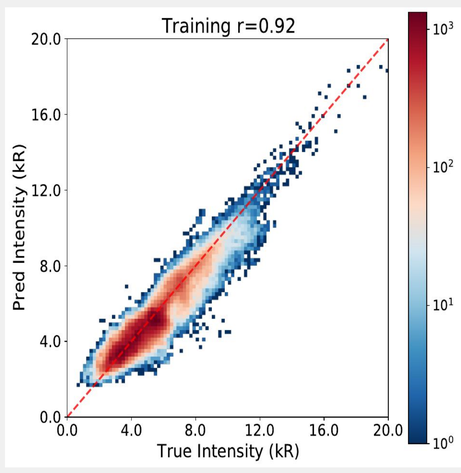


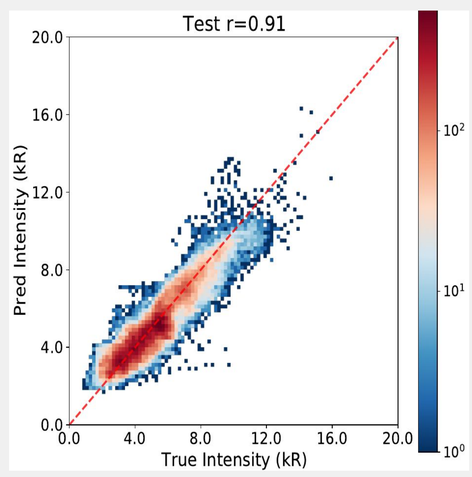
- Training samples ~ 7500
- Test samples ~ 3300

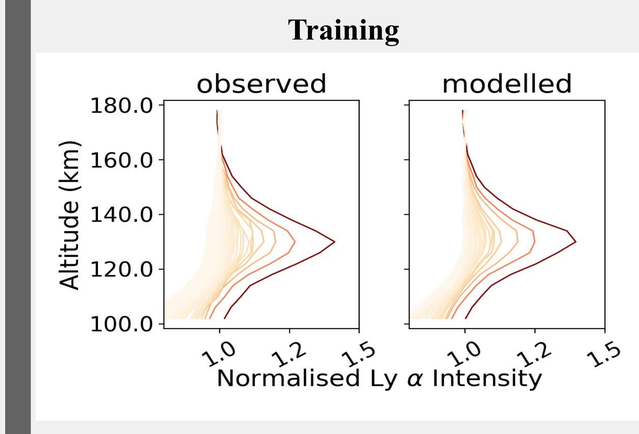
ANN reconstructs Ly-α profiles reasonably well

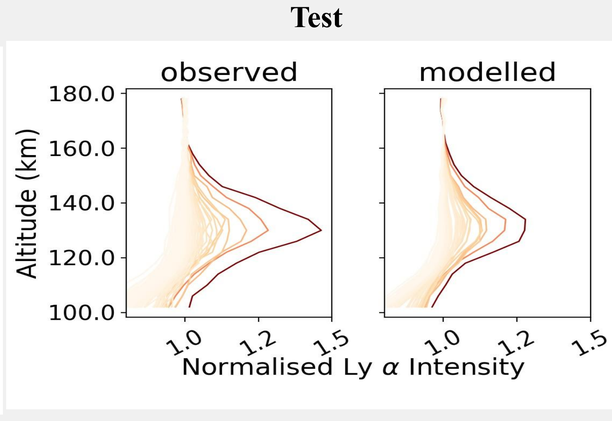




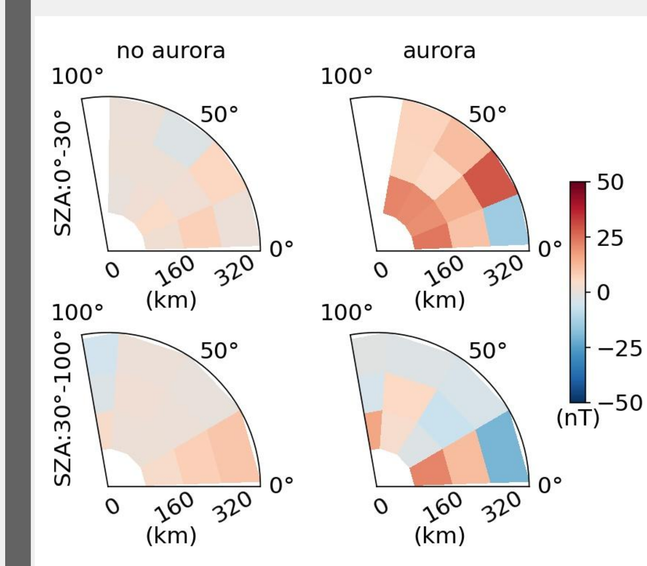


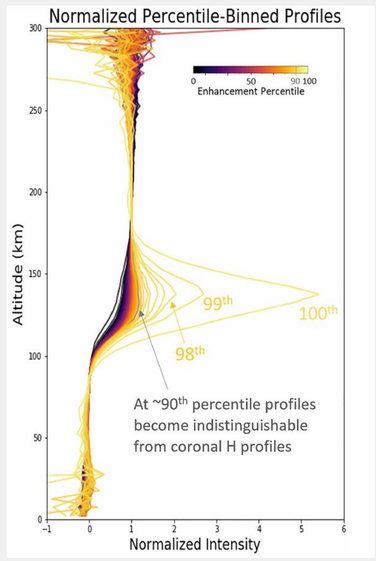


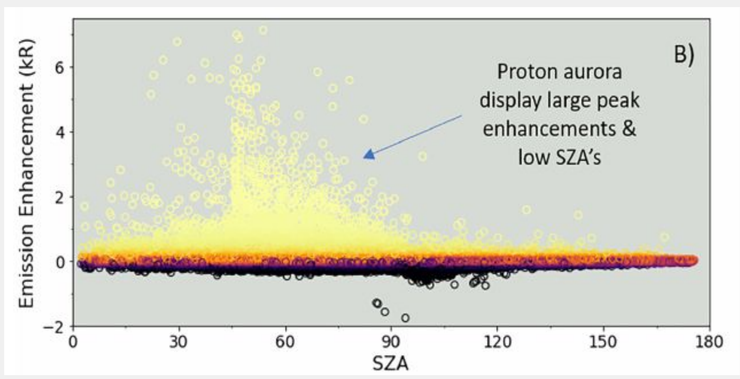




Stronger Induced Magnetic Fields Appear to Facilitate Proton Auroras in Subsolar Regions







From: Hughes + (2019)