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Robust electron density inferences with multivariate regression

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The measurement of electron densities in the ionosphere is notorious difficult. In situ measurements are typically made using Langmuir probe characteristics from which densities and temperatures are inferred using a variety of analytic models. These include but not limited to the Orbital Motion Limited (OML) introduced a century ago by Tonks and Langmuir (Physical review 34.6 (1929): 876), and empirical corrections constructed using comparisons with other measurements. Analytic models however are based on simplifying assumptions, which don't account for the full complexity of the conditions under which measurements are made. Electron densities can also be measured remotely using techniques such ionosondes, Incoherent Scattering Radars (ISR), and Total Electron Contents obtained from arrays of GPS satellites and ground stations. These remote sensing measurements have their limitations due to the distance between instruments and plasma being diagnosed. As a result, these measurements typically sample large volumes of ionospheric plasma, over times in which plasma physical parameters can vary significantly. As such, remote sensing cannot be expected to provide the spatial and temporal resolution in measurements that are directly comparable to in situ measurements made with particle sensors mounted on satellites. In this presentation, multivariate regression is applied to construct a simple and efficient model to infer ionospheric densities by combining kinetic simulations capable of accounting for actual conditions under which in situ measurements are made, with machine learning techniques. The robustness the model to noise is also assessed and quantified by augmenting data sets obtained from simulations, in which different levels of noise is introduced. The results show that densities can be measured with a relative uncertainty of order 30% or less under realistic conditions.

Keyword-1

Ionospheric density inference

Keyword-2

Multivariate regression

Keyword-3

Machine learning

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