Improving Ionospheric Imaging via the Incorporation of Direct Ionosonde Observations Into GPS Tomography

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Abstract

The Multi Instrument Data Analysis system, MIDAS is an algorithm that images the ionosphere in three or four dimensions and was originally developed by *Mitchell and Spencer (2003) [1]*. MIDAS often operates using GPS measurements of slant Total Electron Content, but *Chartier et al. [*2012] [2] showed that incorporating ionosonde data into the algorithm could improve imaging of the ionosphere in the vertical dimension. Here we extend the technique to incorporation of multiple ionosondes, the key problem is to transition horizontally between regions of different peak height and changing densities. This approach is validated via comparisons with independent satellite data.

1. Introduction

The MIDAS (Multi Instrument Data Analysis system) algorithm currently makes use of a variety of data inputs and the hope is that ionosonde observations can be assimilated into this to improve the quality of ionospheric imaging. The basis functions for MIDAS are often derived using both 2D and 3D imaging of data via IRI, which makes use of both observational data provided by ionosondes and values created by IRI itself. Values of both FoF2 and HmF2 from ionosonde observations are considered to be highly accurate, with FoF2 values being the more reliable of the two. For this reason both of these values are given a superior weighting to IRI values during the derivation of the basis functions. Basis function decomposition refers to the sum of multiple profiles.

The process currently used to create an electron density image is shown visually in Figure 1.

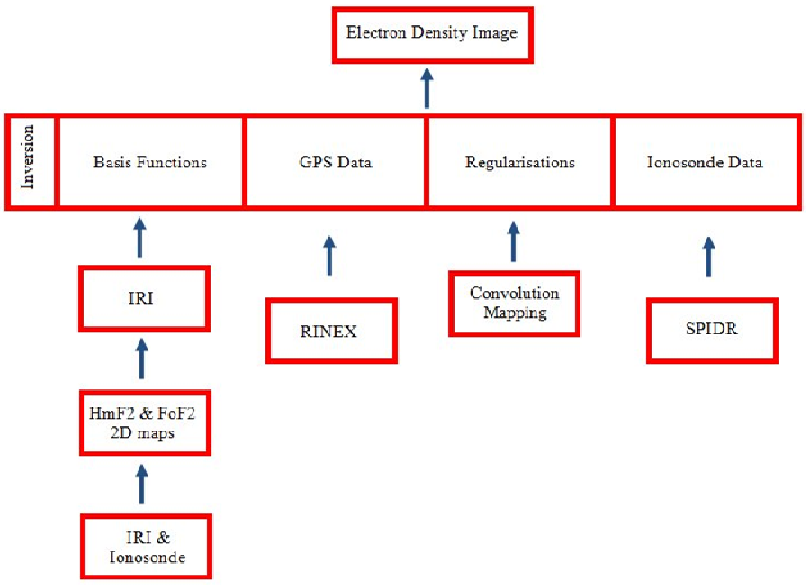

Figure 1: Process by which MIDAS creates electron density images using multiple data inputs

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The GPS data used by MIDAS were provided by RINEX (Receiver Independent Exchange Format), a network for communicating GPS data from receivers located across Europe and including data regarding measurement times, pseduo-range and carrier-phase (Gurtner and Estey 2007 [3]). Ionosonde data are acquired from SPIDR, the Space Physics Interactive Data Resource, which is an online database containing instrumental, environmental and space weather data (O'Laughlin 1997 [4]).

2. Process

Ionosonde data from Rome were incorporated into MIDAS by loading daily data files into a four dimensional ionospheric inversion that also included GPS data. The values created by this inversion were then inserted into a plotting routine. The ionosonde provides a measurement of the F2 peak, from which values for peak NmF2 and peak HmF2 can be determined. The data were interpolated across the region using data assimilation techniques described in Chartier 2012. this created a realistic vertical constraint to the imaging and allowed for realistic representation of the electron densities once the GNSS data were incorporated.

3. Results

Data has now been generated by MIDAS incorporating observations from a single ionosonde; current results illustrate that the method has been successfully implemented and is operational. Figure 2 is an example of a plot generated using this method, and shows Total Electron Content (TEC) values over Europe.

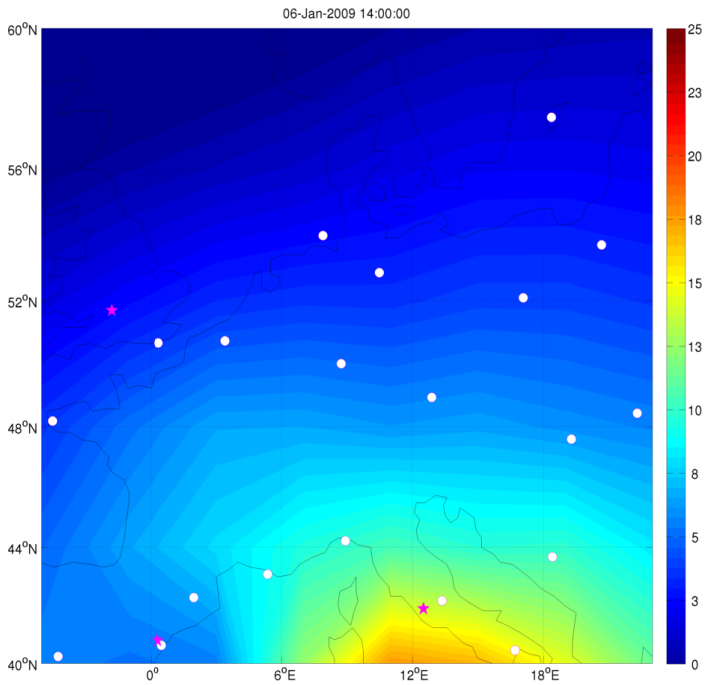

Figure 2: TEC maps of Europe using circular markers for site locations and star shaped markers for ionosonde locations

4. Summary

The images produced by MIDAS indicate that ionosonde data can be successfully integrated into MIDAS to work alongside GPS data and produce TEC images. As it has been shown that ionosonde data can be assimilated into MIDAS it should be possible to incorporate data from multiple ionosondes with the aim to improve global TEC imaging. The next goal for this project is to compare these results with independent satellite data to assess their accuracy. It is likely that one satellite selected for this comparison will be the CHAMP satellite. Once it has been shown that the assimilation of ionosonde observations into MIDAS is viable and results in improved imaging, the intention is to incorporate data from multiple ionosondes along with GPS data.

5. Acknowledgements

The authors gratefully thank the SPIDR and GNSS networks for the use of their data.

6. References

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