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GPS imaging of the Earth's ionosphere at low-, mid- and high-latitudes

Cathryn N Mitchell, Robert W Meggs, Ping Yin, Richard Dear and Bettina Zapfe,

University of Bath, UK.

The Earth's ionosphere is a highly variable environment that benefits from real-time measurements to characterize its behaviour, especially during extreme space-weather events. The large number of geodetic GPS receivers, constantly monitoring dual-frequency signals, provides a freely available but confusing array of integrated slant measurements through the ionosphere. In order to use these data for scientific studies they must be ordered in some manner, either by 1 or 2-D approximations or by ionospheric imaging.

The inversion algorithm (known as MIDAS, Multi-Instrument Data Analysis System) is a MATLAB based program that can be used with any ionospheric measurement (or model) suitable for linear inversion. Examples of ionospheric data that have been used in the program are from:

- Ground-based TRANSIT receivers
- Ground-based GPS receivers
- Space-based GPS receivers (GPSMET, CHAMP)
- Space-based sea reflecting radar (TOPEX POSEIDON)
- Inverted ionograms

Examples of the imaging are shown from the low-, mid- and high latitudes, in particular the regions of South America, Europe and USA and Northern Scandinavia. The different regions require slightly modified approaches to the imaging technique which are described and explained. Examples from the disturbed mid-latitude ionosphere during a severe space-weather event demonstrate the necessity of real-time monitoring of the ionosphere.