High-latitude ionospheric monitoring by incoherent scatter radar: Case studies for mitigation of space weather effects on satellite navigation

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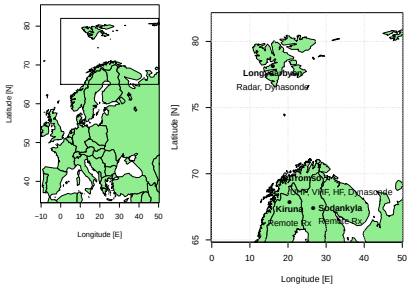
The European Incoherent Scatter Scientific Association (EISCAT) studies the ionosphere using incoherent scatter radars (ISR) and complementary instruments (dynasondes and a HF radar and heating facility). The locations of the EISCAT instruments in northern Europe are shown below.



EISCAT is funded by institutes in China, Finland, Germany, Japan, Norway, Sweden and the UK (the EISCAT Associates).

The radars are operated according to a campaign schedule whereas the dynasondes run at 2-minute intervals. From the ISR data analysis the following parameters can be estimated directly or through simple unit conversions:

- Backscatter power
- Electron density
- Ion temperature
- Electron temperature
- Ion drift velocity

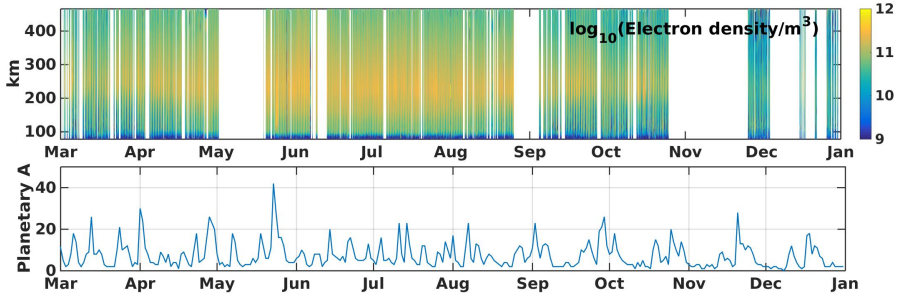
The dynasonde analysis also produces electron density profiles and several other parameters.

EISCAT provides data for selected events to the FP7 Mitigation of Space Weather Threats to GNSS Services (MISW) project (http://misw.info).

IPY 2007 EISCAT Svalbard radar run

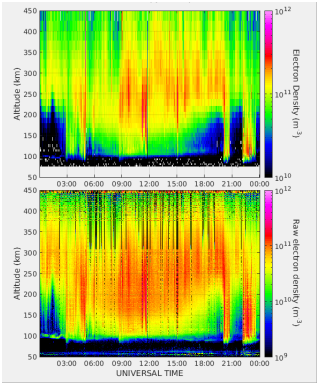
The EISCAT Svalbard radar was operated almost continuously during the international polar year 2007–2008. The figure below shows an overview of electron density profiles calculated from ion line measurements with the 42 m field-aligned antenna. Also shown is the A_p index (from NOAA SWPC) as an indicator of space weather events.
This comprehensive dataset contains data from all seasons and different atmospheric and space weather conditions.

Overview March-December 2007

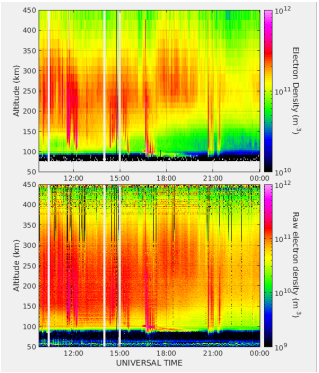


Retrieved and raw electron density

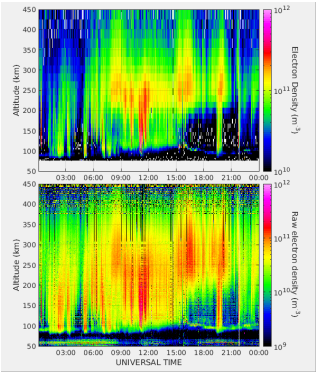
The following figures show two measures of electron density N_e: fitted as parameter of theoretical spectrum, and estimated raw power in units of equivalent N_e. The latter raw N_e is available also from the lowermost ionosphere, where incoherent scatter theory is not applicable.



1 April 2007



25 May 2007

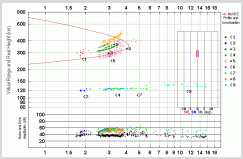


20 October 2007

TEC estimates from ionosonde and incoherent scatter radar

Dynasonde analysis

HF radars are operated at the Tromsø and Longyearbyen sites. The DSND analysis process (N. Zabotin, U. Colorado) provides true height profiles of electron density.

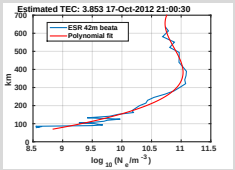


LR dynasonde 2012-10-17 21:00 UT

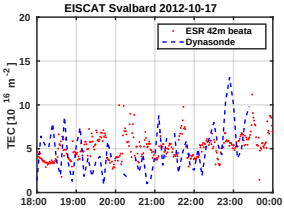
TEC is also an automatically calculated data product.

Integration of radar profiles

Line integrals of radar electron density must be calculated on smooth profiles. In these examples, polynomials were fitted to the height profiles of analysed electron density and integrated in the range 70–700 km.



Comparison for two MISW events



Summary and conclusions

- Incoherent scatter radars and dynasondes can provide measures of total electron content for mitigation of space weather effects on satellite navigation. The results in the presented case studies are of the same order of magnitude but not directly comparable (due to different slant line of sight directions, etc).
- The instruments also provide slant profiles of electron density for a more exact calculation of signal delays. Dedicated measurements are planned.
- Analysed electron density profiles are usually good in the E and F regions. During severe space weather events the raw electron densities are also useful for better estimates of D region effects.

More information

EISCAT	http://www.eiscat.se
MISW FP7	http://misw.info
Data available	http://www.espas-fp7.eu
Ionosonde data	http://dynserv.eiscat.uit.no (to be changed)