Optics and Radar Based Observations F7003R, 7.5 ECTS

2011

EISCAT HQ / V. Barabash

**Practical**

**EISCAT ESR – incoherent scatter and weather in space**

Assignment shall be done in a group of 2 people. Each group shall submit one report.

**1. Introduction**

The purpose of this laboratory experiment is to give an opportunity to get acquainted with the EISCAT Svalbard Radar (ESR) system, 500 MHz. The transmitter/receiver of ESR is situated in Longyearbyen, Svalbard at 78º09´11´´N, 16°01´44´´E. You will run the radar system remotely with assistance from EISCAT staff.

The main objective of the experiment is to understand how the ESR system works, which physical parameters that can be studied in the data analysis and to compare the obtained results with space weather observations from other sources.

**2. Running the experiment**

The system is controlled by the **EROS** (Eiscat Realtime Operating System) software. A certain number of files are necessary to define and run the experiment. Examples of different experiments will be treated. Descriptions of some of the most common ones are described on:

http://www.eiscat.se/groups/Documentation/UserGuides/usersguide/annot\_experiment.html

Common for all experiments is that they consist of files according to the list below where **exp1** represents an arbitrary experiment name such as steffe, **beata**, manda etc.:

**exp1.elan** (Experiment LANguage): A tcl program that contains the main definition of the experiment and will load the other control files when executed. The hardware will be initialized, antenna movement and other “slow” synchronizations are described.

**exp1.tlan** (from TARLAN = Transmitter And Receiver LANguage): a file in which the transmission and reception sequences (“fast” synchronization), which frequencies that are transmitted and which channel boards that are used for reception are defined. The file must be compiled.

**exp1.fil** Configuration of how the data should be read from the channel boards, if, and in that case what kind of, computations that should be made (e.g. decoding of alternating code sequences). The file must be compiled.

**b**<*bw*>**d**<*df*>**.fir** Definition of FIR filter to be used by the digital channel boards. The A/D converter runs at a frequency of *fA/D*=15 MHz. The sampling frequency *fs* used in the experiment is defined by <*df*> according to

<*bw*> is a measure of the one-sided -3 dB bandwidth in kHz and should be chosen to match the sampling frequency.

**chN\_exp1.nco** (N = 1..6) contains definitions of the frequency settings of the N channel boards.

**ac.txt** contains the definition of the coded sequence (**ac** is used here as an abbreviation of alternating code) if such is used in the experiment.

**2.1 EROS**

Experiments are started and controlled in the window titled EROS console. A list of possible commands can be found on

http://www.sgo.fi/~jussi/eiscat/erosdoc/esr\_radar.html

**printexperiment** Print status and some information about the present experiment on the screen.

**printantenna** Print azimuth and elevation of antenna on the screen.

**runexperiment /kst/exp/exp1 time** Start experiment **exp1** (the full path must be given) at time **time**, which can be given at as HH:MM:SS or **now** or **fullminute** etc.

**enablerecording** Start recording data.

**disablerecording** Stop recording data.

**stopexperiment time** If the experiment should be stopped immediately, time does not need

to be given. In that case the parameter will be set to now.

**2.2 Look at results in real time**

The results can be studied in real time with help of the real time graph software rtg. It is possible for example to choose different axes and post-integrate the data with help of buttons in the rtg Matlab window.

**2.3 Data storage**

Data storage does not start automatically when the experiment is started. It has to be initiated by an explicit command in EROS. The results are stored as Matlab compatible files of size chosen by the experimenter, usually five seconds worth of data in each file. The file names are generated automatically and consist of eight digits, **time in seconds** (rounded off to the nearest smaller integer) since 00:00:00 UTC, January 1 of the present year and **.mat**. A description of the parameters stored in the files can be found on

http://www.eiscat.se/groups/Documentation/UserGuides/parameterblock.html

**2.4 Data servers**

Data is stored in the folder **/data1** on **e10023.esr.eiscat.no** at the ESR site. After the exercise, the data can be retrieved from anywhere via the EISCAT scheduling page on

http://www.eiscat.se:8080/schedule/schedule.cgi?year=2010&month=5&S=on&A=on&ESR=on

**3. Data analysis**

**3.1 GUISDAP**

The analysis software GUISDAP is installed on the computers pointed out by the lab assistant in computer room D2. Detailed instructions about where the data to analyse is located and where to save the results will be given at the time of the scheduled data analysis.

To start GUISDAP, give the command analyse at the Matlab command line. A window called ‘GUISDAP for Dummies’ will appear, in which you can make the following choices:

**Data path** Path to the data files.

**Start time** GUISDAP tries to guess an appropriate start time from the data files, but if you for example only want to analyse a part of the contents of the data path, the start time has to be given manually.

**Stop time** GUISDAP tries to guess an appropriate stop time, for manual tuning see above.

**Dsp expr** Choose the correct type of experiment from /guisdap8/exps/

**Site** Site according to: L → Longyearbyen

**Result path** Where to save the results (*should be an EMPTY folder*). End the path name with /AUTO and GUISDAP will make sure that the results end up in a logical structure of folders.

**Real time** Only applicable if data is analysed in real time.

**Integration time** Select an integration time for each fit in seconds. 0 = limited to antenna movement: for a scanning experiment the integration time will be the time the antenna stood still during every scan.

**Disp figures** Select which plots to show and not to show (1/0) during the analysis: data dump, power profile, fit, parameter profiles, time series of the result. Suitable values are 0 1 0 1 1 for ESR.

**Special** Here you can give Matlab commands to be performed on the data before analysis, for example if parameters need to be corrected and calibrated.

Button GO starts the analysis. A window will come up with the profiles of uncorrected electron density and fitted values for four parameters, and finally a summary plot of the whole experiment run.

**3.2 Fit parameters**

GUISDAP analyses data by making a least-squares-t of model data to observed data. Data parameters are collected in the data matrix **r\_param** with the size of 6 x (number of height gates). Positions of the parameters are the following:

1. Electron density, m-3
2. Ion temperature, K
3. Ratio between electron and ion temperature
4. Collision frequency, Hz
5. Ion drift velocity (the component along the line-of-sight), m/s
6. Composition O+/e- (under assumption that the ions are composed to *c* % of O+ and to (100-*c*)% of an imaginary ion with a mass of 30.5 amu, that is a typical value for a mixture of NO+ and O2+)

The number of height gates is determined by the vector **r\_h** .

Parameters fitted in this experiment are electron temperature, ion temperature, temperature ratio and ion drift velocity. Thus, the analysis results in height profiles for these parameters.

**3.3 Calibration of electron density and analysis**

1. Collect information about the current space weather conditions, i.e. geomagnetic storms, sunspot number, solar wind parameters. Use different sources outlined in the folder Space Weather Today.

2. Plot a vertical profile of the electron number density from the International Reference Ionosphere (IRI) model. Go to <http://iri.gsfc.nasa.gov>. Press “RUN ONLINE”. Select current date and time of your experiment, geographic coordinates of the EISCAT radar and a profile type. Please note, that you do not need to run “Optional Input”. You will receive an ASCII file of the modelled electron density profile. Please note, that the negative values are NaN.

3. Plot a vertical profile of the electron number density from the EISCAT radar data. Determine max electron number density *Ne* (m-3). The derived values of the electron density are not necessarily quantitatively correct but need to be calibrated. Explain the reason for this.

4. Determine *f0F2* from the EISCAT dynasonde data <http://dynserv.eiscat.uit.no/LR/latestLR.html> (Press “Plain text data tables”, then go to “Critical frequencies”, frequency values are given in MHz). Calculate the maximum of electron number density *Ne* from *f0F2*. *f0F2* (in Hz) is related to the maximum electron density *Ne* (in m-3) at the electron density peak situated in the F-region as:

5. Compare the maximum of *Ne* from EISCAT radar with the maximum of *Ne* from the dynasonde.

If the values differ from each other more than 10% the electron number density profile should be calibrated. You have to re-run the GUISDAP programme and introduce the parameter *Magic\_const =* *maxNe\_dynasonde / maxNe\_EISCAT* in the box **Special**. The Magic constant has been introduced and agreed by EISCAT HQ in order to take into account the effect of external environment on the transmitted power, i.e. snow on the antenna etc. The Magic constant is a scale factor for the real radar constant.

6.Compare the calibrated vertical profile *Ne* of with the *Ne* profile from the IRI model. Plot the profiles together and explain the reason for differences.

7.Compare *f0F2* from the EISCAT radar on Svalbard with *f0F2* (one hour value)obtainedfrom Sodankylä ionosonde <http://www.sgo.fi/Data/RealTime/ionogram.php> (Go to “Data Archive”, “Ionosonde Data”, select a day). **OBS! Data is available during the next day after the experiment.**

Compare *f0F2* from the EISCAT radar on Svalbard with *f0F2* from Tomsk dynosonde <http://d21.tsu.ru/> . Download the real time plot. **OBS! The plots should be downloaded during the EISCAT experiment.**

Discuss the reasons for variations between the values obtained at different locations.

8. Plot vertical profiles of the ion temperature and ratio between electron and ion temperature from the EISCAT radar data. Discuss briefly the results in terms of the current space weather.

**4. Report**

The structure of the report should be:

* Title page
* Introduction to the problem.
* Experiment
* Data analysis and discussion. References should be given in the text.
* Conclusion
* List of references. Web pages are permitted.
* Confirmation that you have participated in the current work.

The report should include a description of the space weather conditions during the time of the experiment, and a discussion of how these conditions relate to the data you obtained from the radar. The length of the report (excluding the title page) should not exceed 10 pages.

Please note that using “copy-paste” techniques will result in report rejection. Plagiarism will be reported to LTUs lawyer according to the Swedish national legislation.