Future Collaborations

COOPEUS Deliverable 2.4

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1 Background

Task 2.4 of the COOPEUS project deals with the definition of potential case studies to test the harmonisation of the standards and to improve the interoperability between EISCAT and US incoherent scatter radar systems. This effort is based on earlier work (Task 2.3) in this project where a set of data and meta-data practices was agreed to strive for at the different incoherent scatter facilities. Specifically it was determined to base the data formatting in the future on the structure defined by the Open Data Initiative[1], in terms of source information, signal information, signal processing chain, conversion information, coherence information, signal description and signal data.

The aim of the case studies should be to test different aspects of harmonisation and interoperability between the facilities. In order to define good case studies, the central terms in the activity (harmonisation and interoperability) have to be defined.

1.1 Harmonisation

In these activities, the term harmonisation means the process of creating common standards across the different incoherent scatter radar infrastructures in the world in order to create a consistency in the data and meta-data formats as well as in the practices of operations and data policies.

1.2 Interoperability

Interoperability is the ability for the different incoherent scattering radar systems and organisations to work together. This means that common data formats should be well defined, but also that the procedures to initiate collaborative measurements should be clear and that the policies regarding the access to the data from these collaborations are standardised.

2 Modes of interoperation

There are more than ten active incoherent scatter radar systems in the world at the present. The European and the American communities are already relatively well integrated with occasional interoperation activities where both EISCAT and the US systems make simultaneous observations of the ionosphere. These activities are of two different types: planned interoperation and spontaneous interoperation. The possibility to coordinate these measurements depends on the level of harmonisation and interoperability.

1 www.openradar.org

The majority of the EISCAT observation time (about 90%) is devoted to the Common Programme and to the Special Programme. The planning of the Common Programme is made by the EISCAT Council based on recommendation of the Science Oversight Committee, while the Special Programme time is distributed by researchers in the EISCAT member countries.

2.1 Planned interoperation

The World Days are scheduled well in advance where the operations for two or more of the incoherent scatter radars in the world are coordinated for investigations on some common scientific objective. These days are coordinated through the Incoherent Scatter Working Group (ISWG) at the International Union of Radio Science[2] (URSI). There are 20 World Days spread out during one year, and the data from these days are made available on online data bases as soon as possible after the measurements. The World Days are part of the EISCAT Common Programme.

2.2 Spontaneous interoperation

Occasionally there are large events, such as coronal mass ejections, where it would be interesting to follow the ionospheric response with incoherent scatter radars on a global level. There is at the present no protocol for the coordination of such measurements, and the coordination also depends on whether there are personnel available and the radar facilities are not used for other (planned) experiments. The coordination of these measurements is usually made through telephone calls between radar operators and responsible scientists at the different radars. In addition, no standardised policy exists for the data from these events. These measurements are part of the Unusual Programmes, i.e. neither Common nor Special Programmes.

3 The EISCAT digital receiver chain

For the understanding of the different levels of digital data in the present EISCAT system, Figure 1 shows a schematic overview of the digital parts of an EISCAT receiver. The diagram starts from the analog-to-digital converter (ADC) which samples the down-converted bandwidth-limited radio frequency (RF) signal. The digitised values are sent to a data bus and this signal is the basis for all further standard processing.

3.1 Data levels in the present EISCAT system

Conceptually and practically, the EISCAT data sampling, storage and analysis systems represent four levels of digital data, out of which some also correspond to archived data products.

The digital data stream of sampled raw RF voltages represents the fundamental level of data and will be called level 0. Level 0 samples are not stored by EISCAT, but for certain experiments some users sample the raw voltage data either by auxiliary ADCs or by attaching their computers and storage to the data chain.

2 www.ursi.org

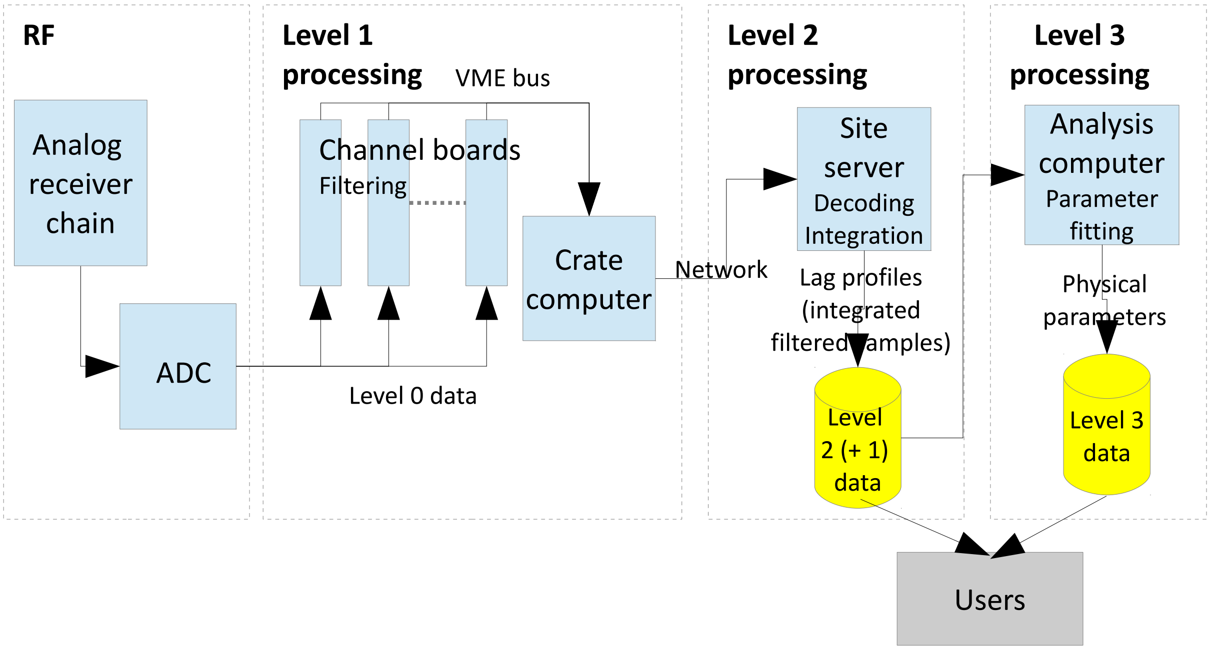

Figure 1: The EISCAT digital receiver chain. This setup is similar at all EISCAT radars and remote receiver. The radar controller system that controls both transmitter and receiver is not shown, neither the details of the analog RF parts.

Level 0 data are processed by a set of so-called channel boards, performing decimation and digital filtering of the data, and thus acting as a filter bank. Depending on the number of frequencies used by the transmission pulse code, one or more channel boards are in use during an experiment. The output data stream from the channel boards is handled by a single-board computer in the channel board crate. This computer formats the filtered data stream and feeds it as packets through a network connection into the main site computer of the station. After time integration, these filtered samples constitute level 1 data. These are normally neither stored due to disk space requirements, but this is possible on request for certain experiments such as interferometry and meteor research.

Correlator software decodes the data into integrated lag profile data, which are stored. This is data level 2 and is what most users will see as raw EISCAT data.

Profiles of physical parameters of the ionospheric plasma are retrieved by fitting a multi-parameter model to the lag profile data, usually by means of the standard Matlab Grand Unified Incoherent Scatted Design and Analysis Package (GUISDAP). The physical parameters are data at level 3 and this is the data product used by the majority of EISCAT users. Other retrieved parameters from special experiments, such as meteor orbit characteristics, are also examples of level 3 data.

Table 1 shows a summary of these data levels

Data level	Data type	Data products
0	ADC data stream	None (except when sampled by users)
1	Decimated, filtered and gated data samples	Stored filtered samples (in level 2 lag profile files on request)
2	Correlated and integrated data	Lag profile files
3	Fitted physical parameters	Parameter files

Table 1: Summary of levels of data in the present EISCAT radar systems.

3.2 Formats of archived data files

Table 2 shows a summary of the file formats used for data archiving at EISCAT. Correlated data are archived as .mat-files compatible with Matlab version 4 and several other software libraries. Future systems will instead use the standard Hierarchical Data Format v5 (HDF5) based format specified by the OpenRadar project[3] for data archiving. Analysed parameters are archived in the Madrigal database[4], which is a system used for data access at many incoherent scatter radar sites worldwide. This database will also be updated to HDF5 in near future.

Data product	Format	Access
Lag profile files (including level 1 samples on request)	.mat, compatible with Matlab v4	EISCAT raw data database, online through schedule page
Parameter files	NCAR (will change to HDF5)	Madrigal database

Table 2: Summary of EISCAT archive file formats.

3.3 Description of data formats

Table 3 lists where to find descriptions of the data and file formats on the different levels. Most users will use the physical parameter files (level 3) which contain descriptions of all parameters. When accessing these data through Madrigal, brief help on all parameters is also available.

To understand lower level data, it is necessary to know the experiment set-up, as it defines the transmission and the filtering of received data. Such parameters are set in the configuration files of the EISCAT Real-time Operating System (EROS): the .tlan files from which radar controller configurations are generated, and the .fil files which define the channel board configurations.

The GUISDAP analysis software must be properly set up to analyse the level 2 .mat files for each type of experiment and thus the format of these files can be unambiguously decoded from the GUISDAP setup.

3 www.openradar.org
4 www.openmadrigal.org

Data level	Authoritative source of format description
0	15 MHz 14-bit data
1	EROS experiment files (.tlan, .fil)
2	GUISDAP analysis setup for data files from given experiment
3	NCAR or HDF5 headers

Table 3: List of authoritative sources of descriptions of EISCAT data file formats.

3.4 Restrictions on data use and redistribution

Different restrictions on use and redistribution of EISCAT data products apply to the different levels. These are detailed in the data policy document.

4 Proposed use cases

Following the idea that the case studies should really test the level of harmonisation and interoperability between EISCAT and the US counterparts, a small set of use cases are proposed.

4.1 Low-level data interchange

In this use case, a common data format should be used for low-level data (up to level 2 in the description above) from EISCAT and the US radars. The study would involve exchanging data between the facilities, and later applying the different local analysis software on the different data sets. The results from the analysis software should then be compared and any differences between the results should be analysed carefully to determine the quality of the analysis. If this test of the data format is successful, the format would be the new standard for the EISCAT data.

4.2 Collaborative international radar school

In this use case, a collaborative international radar school should be arranged to educate in the use of both EISCAT and US radars. The results from this school should be evaluated after a year or so by testing the abilities of the students to change from one radar system to another and thus directly testing the interoperability of the radars.

4.3 Integrated ionospheric image

In this use case, AMISR and EISCAT (at least) should be operated together, in response to a geophysical trigger, to create an integrated ionospheric image. This would be a test of the protocols for the coordination of these events and of the harmonisation of an Unusual Programme.

4.4 Real-time display of ionospheric conditions

In this use case we would work towards a real time display of data from both EISCAT and US incoherent scatter radars on the same website. This would require giving the Madrigal system access to the data earlier than is being done today. Depending on data policies, this will at the present be restricted to times when Common Programmes are running since this case study requires open data access.

4.5 Parametrised risk factor

In this use case, EISCAT and the US radars should operate normally. The resulting data would be stored in Madrigal and be accessed through some externally made virtual observatory in order to be integrated into an ionospheric model, which would be used for now-casting to estimate a parametrised risk factor such as for high latitude air travel. The actual test involved in this case study is to look into methods and protocols to export data into space weather services in a harmonised manner. Similar to the last proposed case study, this one requires open data access and can only be performed during Common Programmes.