CCLRC

Ionosonde Case Study

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Version #	Revision #	Revision Description	Made	Made By

Title	DCC Case Study – World Data Centre Ionosonde Holdings
Creator	Esther Conway
Contributors	David Giaretta, Mathew Dunckley, Stephen Rankin, Matthew Wild, Chris Davis, Simon Lambert, Rita Blake and Ruth Bamford

About the DCC

Scientists, researchers and scholars across the UK generate increasingly vast amounts of digital data, with further investment in digitization and purchase of digital content and information. The scientific record and the documentary heritage created in digital form are at risk from technology obsolescence, from the fragility of digital media, and from lack of the basics of good practice, such as adequate documentation for the data. Working with other practitioners, the Digital Curation Centre aims to support UK institutions who store, manage and preserve these data to help ensure their enhancement and their continuing long-term use. The over-riding purpose of the DCC is to support and promote continuing improvement in the quality of data curation and of associated digital preservation. The DCC is funded by the Joint Information Systems Committee (JISC), an independent advisory body that works with further and higher education establishments, and the e-Science core program.

About CASPAR

CASPAR - Cultural, Artistic and Scientific knowledge for Preservation, Access and Retrieval - is an Integrated Project co-financed by the European Union within the Sixth Framework Programme (Priority IST-2005-2.5.10, "Access to and preservation of cultural and scientific resources").

CASPAR intends to:

- Implement, extend, and validate the OAIS reference model (ISO:14721:2002)
- Enhance the techniques for capturing Representation Information and other preservation related information for content objects
- Design virtualisation services supporting long term digital resource preservation, despite changes in the underlying computing (hardware and software) and storage systems, and the Designated Communities.
- Integrate digital rights management, authentication, and accreditation as standard features of CASPAR.
- Research more sophisticated access to and use of preserved digital resources including intuitive query and browsing mechanisms
- Develop case studies to validate the CASPAR approach to digital resource preservation across different user communities and assess the conditions for a successful replication.
- Actively contribute to the relevant standardisation activities in areas addressed by CASPAR.
- Raise awareness about the critical importance of digital preservation among the relevant user-communities and facilitate the emergence of a more diverse offer of systems and services for preservation of digital resources.

Introduction

This document is the result of a joint DCC/CASPAR detailed preservation requirements gathering and analysis process. The steps involved in developing the case studies have been to:

(1) examine a number of datasets in detail, identifying, as far as possible, all types of information implicitly or explicitly used by knowledgeable users to extract usable information from bit sequences.

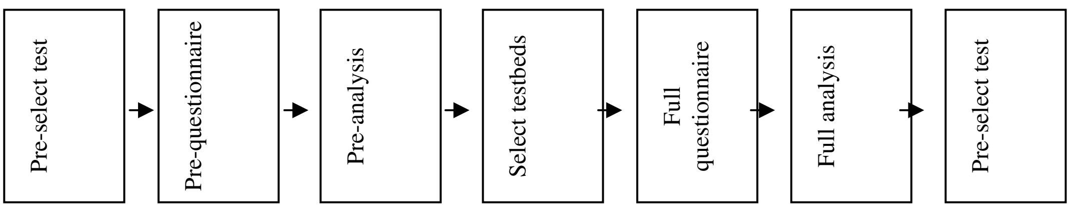
(2) identify a number of issues, requirements and test bed scenarios covering, as far as possible, all aspects of changes which might affect the preservability of the information encoded in bit sequences.

THE APPROACH TO REQUIREMENTS ACQUISITION

The methodology adopted was developed by taking the best aspects of the InterPARES [InterPARES-1] and ERPANET [ERPANET-1] questionnaire methodologies, but structuring the resulting questionnaire much more strongly in line with OAIS and focussing on specific datasets. However, in order to prioritise the datasets, specific selection phases were introduced based on a "pre-questionnaire". The resulting methodology involves five stages:

1. Prepare pre-questionnaire and full questionnaire, based on OAIS, the CASPAR validation metrics, and additional sections designed to elucidate digital rights management (DRM), authenticity and provenance.
2. Identify candidate repositories/projects/datasets in the three domains (science, cultural heritage and performing arts).
3. Obtain input from pre-questionnaires and produce prioritised list.
4. Interviewers then obtained information to answer the full questionnaires from a prioritised list of candidates, based on the pre-questionnaires.
5. Subsequent analysis identified appropriate scenarios for testbeds and requirements for components and the framework.

For each repository the following diagram shows the process flow.



QUESTIONNAIRES

The questionnaires were structured to be aligned with the draft high level CASPAR architecture and components, but with sufficient flexibility to capture the preservation plans which may already have been in place for each dataset.

Pre-questionnaire

The pre-questionnaire was a very short version of the full questionnaire and designed to be completed by data managers by themselves if necessary. The aim of the pre-questionnaire was to be able to select a number of datasets to investigate in more depth.

Each repository was characterised at the outset by the following basic features.

1. Holdings: overview of the type of data held, and a list of data sets.
2. Data Set: A description of the digitally encoded information to be preserved, from the bit level to the knowledge it conveys to its user community. We do not at this stage need very detailed descriptions. In addition we need a brief description of
    a. access restrictions
    b. what information/behaviour the data encodes
    c. how the data is stored
    d. how the required data is located and retrieved (including DRM and Legal issues)
    e. what additional data, equipment or knowledge is employed to extract required information/behaviour from the data.
3. Data Producer: A brief description of the group, individual or institution that produced the data set.
4. User Community: A description of the current user community and the characteristics of the designated community for whom this data might be preserved.
5. Current preservation plans.

Structure of the full questionnaire

The questionnaires is structured following the CASPAR architecture, components and framework. Thus it covers:

For each dataset, more details of:

1. production: description of the way in which the information is captured or created
2. current use:
   - finding aids
   - software used to access the digital encodings
   - software/mechanisms to use/perform the encoded information

and, in alignment with the CASPAR high level architecture:

- ingestion into the repository
- access control
- knowledge/behaviour encoded
- domain specific virtual objects e.g. sound recordings, moving images, Earth observation images, Solar Terrestrial Physics datasets – these can be made from:
- generic virtual objects e.g. images, tables, sequences, etc plus simple values
- binary encodings of the information
- storage mechanisms

The questionnaire is available on the CASPAR web site (http://www.casparpreserves.eu) and also as an appendix to this document. Completed pre-questionnaires and full questionnaires are available as separate documents.

Use of full questionnaire

The full questionnaire was written to be understandable by the interviewers, who have a common understanding of the questions, and enable them to obtain a minimum depth of detail for each case. The interviewers talked to a variety of people, as appropriate, involved with each repository in order to gather information to complete the questionnaire.

Archive Background

The WDC receives data from the many ionosonde stations around the world through a variety of means including ftp, email, CD-ROM. Data is provided in a number of formats: URSI (simple hourly resolution) and IIWG (more complex, time varying) standard formats as well as station specific “bulletins”. The WDC stored data in digital formats comprises 2.9GB of data in IIWG format and 70GB of raw MMM, SAO, ART files from Lowell digisondes. The WDC also holds about 40,000 rolls of 16/35mm film ionograms and ~10,000 monthly bulletins of scaled ionospheric data. Some of this data is already in digital from, but much, particularly the ionogram images, is not yet digitised.

- Many stations’ data is provided in IIWG or URSI format directly. This data may be automatically or manually scaled.
- A selection of European stations provide “raw” format data from Lowell digisondes, a particular make of ionosonde, as part of a COST project. This data is in a proprietary format, but Lowell provide Java based software for analysis. The WDC uses this software to manipulate this data, particularly from the CCLRC’s own Ionospheric Monitoring Groups ionosondes at Chilton, UK and Stanley, Falkland Islands. The autoscaled data from these stations is also stored in a PostgreSQL database.
- Other stations provide a small set of standard parameters in a station specific “bulletin” format which is similar to the paper bulletins traditionally produced from the 1950s onwards. The WDC has some bespoke, configurable software to extract the data from these bulletins and convert it to IIWG format.

It is important to realise that this is a totally voluntary data collection and archive system. The WDCs have no control or means of enforcing a “standard” means of data processing or dissemination, though “weight” of history and ease-of-use tends to make this the preferred option.

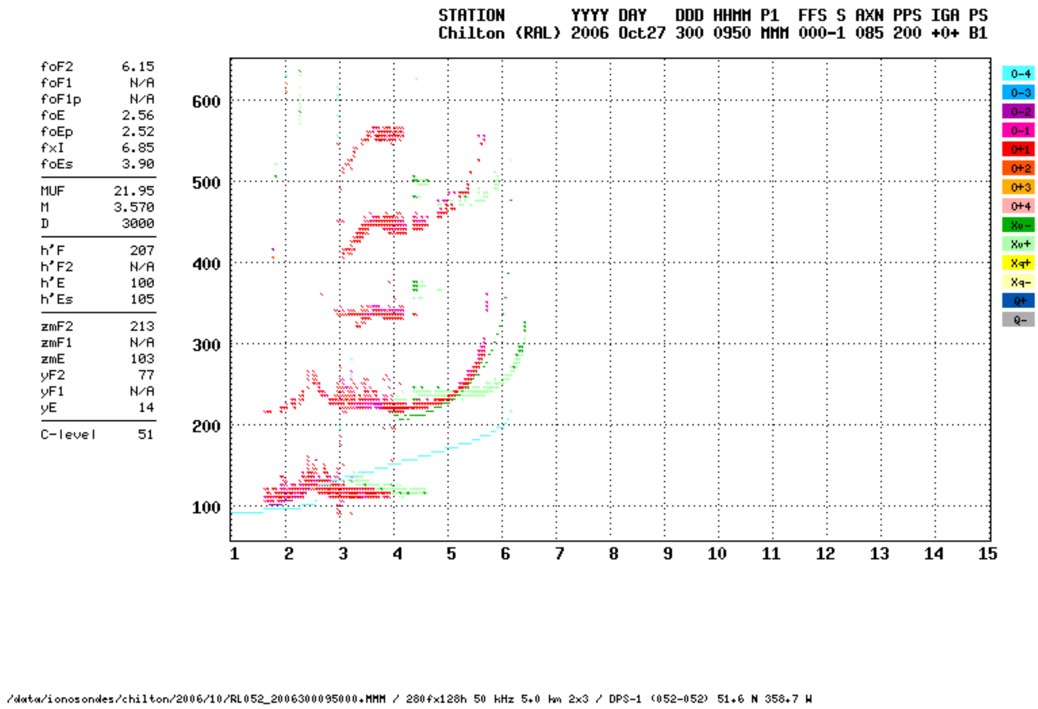


Illustration 1: Sample ionogram from a Lowell digisonde

Most ionosondes are provided by a small number of commercial companies which may also provide proprietary analysis software.
Recreating the actual plasma density profile from ionogram data is an important use of ionosonde data. Such a procedure is known as real or true height analysis.
The time of flight from each echo (frequency sweep) in an ionogram, gives some indication of the height at which the radio wave was reflected. This cannot be taken as the true-height of the layer due to the effect of any ionisation in the path of the wave. In order to obtain true height values, the whole ray path must be reconstructed and this requires assumptions to be made about the electron concentration along the ray path. The assumptions which allow one to do this are embedded in community knowledge and software which have evolved over time.

As a testbed this collection of data allows us to explore data resulting from same type observation using similar types of instrument over long period of time. It will permit us to examine the issues surrounding data originating from geographically diverse locations, operated by different types of organisation, using different models of instrument, employing different modes of operation whilst additionally being subject to different software and manual interpretive processing. It will also allow us to inspect the evolution and preservation requirements of the knowledge base that surrounds a relatively mature area of scientific Investigation.

Preservation significance
Importance: The primary interests of the organizations who co-operate to provide this global network of observational data fall into four different fields. The data, being environmental monitoring is also impossible to reproduce and may have future relevance not currently seen. As seen by its recent use in global climate change studies.

For those involved in geophysical studies the data also allow one to examine various types of geophysical phenomena. The current WDC user community comprises approximately 1000 users annually with over 2 million individual data accesses.

Uniqueness of data and holding: The WDC based at Rutherford Appleton Laboratories is part of a larger international WDC system which is continually evolving due to scientific, technical and economic factors. When the WDCs were originally set up in 1957, multiple centres were deemed advisable to guard against catastrophic loss of data, and for the convenience of data providers and users. According to the WDC the system is currently healthy and viable with most centres maintaining their funding, though not without struggle.

What Information/Performance/Behaviour does your current user(s) extract from this data and what needs preserving?

This is quite an open ended question but it is essential to establish the nature of the information you are attempting to preserve as this helps to define what needs to be preserved. This definition does not limit the potential information the archive is capable of providing, but rather helps define a minimum level of information to be preserved. The definition of knowledge that a data set is capable of imparting to any future designated user community has a profound impact on preservation requirements for an archive.

It was noted early on that consulting different sources had a significant impact on the scope of knowledge the archive was aiming to preserve. With this in mind we reviewed the broadest possible spectrum of sources we were able to within a tight timeframe

Information requirements of funding organisations
PPARC had until recently funded the Rutherford Appleton based Ionosonde funded the http://www.pparc.ac.uk/Rs/Pp/Sp/STP_Ionosondes.asp
Information requirements of end users
Active users of the data CCLRC based Scientists Chris Davis and Ruth Bamford were interviewed and analysis of some of their personal scientific output was carried out.
Information based on scientific output
We were able to inspect scientific paper through online products such as Web of Science, bibliographies produced by URSI and other interested organisations.
Data Producers
Key members of the Ionospheric Monitoring group based at Rutherford Appleton were also able to describe how they thought the data was currently being used. They also raised the interesting issue that the scientific potential of the data set was frequently not recorded and many scientific theories and knowledge surrounding this data was in danger of disappearing once key personnel retired. It was felt that the ability to annotate this data in some way was highly desirable.
Data Archivist
Matthew Wilde was able to describe how he thought the data was principally being used based on research and report for funding bodies.

The digital holdings of Ionosonde related information held by the WDC fall into the following categories

- Ionsonde instruments/station details location data availability and managing organisation/scientist
- Raw output from a global network of ionosonde instruments which measure the time of flight for specific frequencies to rebound from particular regions of the ionosphere at location and time
- "autoscaled" parameters for ionospheric features resulting from ARTIST/ADEP software which have been derived from raw data stored in archive
- Manually scaled parameters derived from raw data stored in archive
- Profiles of ionosphere based standardised profiling techniques e.g. POLAN & NCHP derived using either autoscaled or manually scaled data
- Scientific support materials bibliographic references and links to supporting communities/suppliers of further processing software.

The primary interests of the organizations who co-operate to provide this global network of observational data fall into four different fields

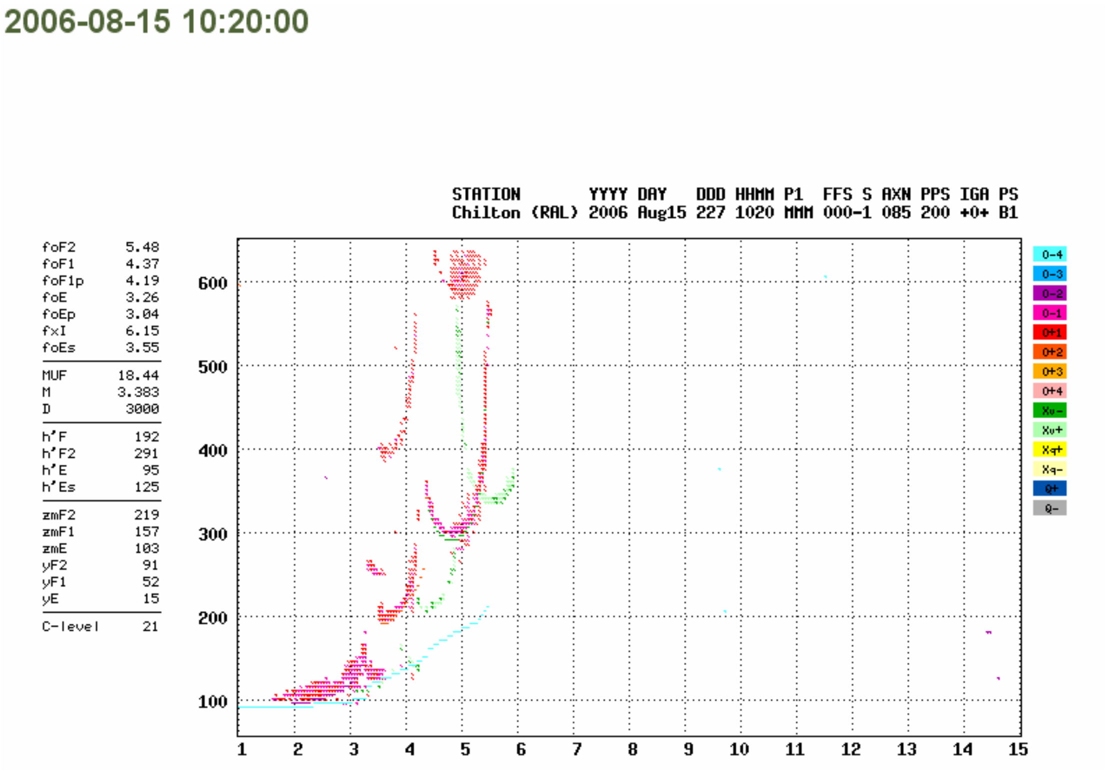
- Those primarily concerned with earth environment studies the data allows for long term global monitoring and mapping

- Those interested in the exact form of the ionosphere at a specified time, e.g. for comparison with a rocket or satellite data or for studying time variation in events.

- Those primarily concerned with radio propagation problems and communications research , both surface and space.

- For those involved in geophysical studies the data also allows you to examine the following types of geophysical phenomena
    - travelling ionospheric disturbances
    - atmospheric gravity waves
    - ionospheric storms
    - thermospheric winds
    - composition changes
    - solar eclipses
    - UV supernovae flashes
    - solar disturbance effects (flares, Coronal Mass ejections, co-rotating streams)
    - atmospheric explosions.

The primary data set produced by an ionosonde is an ionogram which can take anything from one to five minutes to complete depending on the frequencies used and mode of operation..



The interpretation and reduction of these Ionograms allows the production of standardised parameters which permit

- The phenomenological descripton of the ionogram.
- A simplified parametric description of the ionosphere overhead.
- The determination of the electron density/height profile overhead.
- The identification or measurement of parameters which determine or describe the physical characteristics of the ionosphere.

“It must be stressed that many ionosonde parameters, e.g., h’f, M(3000)F2 which are invaluable for geophysical or prediction purposes, do not directly measure physical phenomena and may be mis-leading in particular circumstances unless their properties are clearly understood. It is clearly the users responsibility to make himself conversant with subject unless their properties are clearly understood. It is clearly the users responsibility to make himself conversant with the subject so as to understand these points, whereas it is the operators responsibility to reduce a difficult ionogram adequately according to established rule” URSI Handbook 1978

Ionosondes routinely provide measurements of foF2, foFl, fmnF, fmnE, foE, foEs, fmin, fXI, M3000F2, MUF3000F2, h'F, h'F2, h'E, h'Es and type of Es (see section 3 for full parameter description). For the Chilton and Port Stanley based Lowell ionsondes automatic scaling is done in real time by ARTIST software and then checked and corrected on-line using the ADEP editor. Data from the KEL ionsonsonde is automatically scaled using SMARTIST software with the CADI (Canadian Digital Ionsonde) and Dynosnde again using alternative software. Manual scaling is also carried out at the individual facilities where additional parameters can be scaled on request.

What information do you provide to a new data user, and what support do you give them during their use of the data?

This is to ascertain if there is any useful information would be given to new data users to help them get started using the data. More importantly, it is also intended to "get at" the types of information that are not written down but are typically asked for and are needed by users (a data FAQ) to produce results.

Inevitably there will always be information in the heads of the people that run the archive that is not written down, but would be useful to some users both now and in the future. This is also assuming that the people that created and run the archive are not around to help the "unborn users", so in future they will not have the support.

Much support is given to users by communities within Research, Academic and Military Institutions who have long and well established tradition of working with Ionosonde and have amassed considerable expertise.

User support from the CCLRC WDC is primarily via e-mail and focuses on the provision of data set via the internet. In addition to the supply of data online it also provides the following online support materials

Guidance Notes on Ionsonde Data

IIWG format help (see appendix A)
URSI Ionospheric parameter codes (see appendix B)
URSI Qualify Code and descriptor letters (see appendix C)
Ionosonde Theory (see appendix D)
Ionosonde Interpretation (see appendix E)
Ionosonde Maps (see appendix F)
POLAN information (see appendix G)
True Height Analysis (see appendix H)
Description and Use of the Polynomial Analysis subroutine (see appendix I)

Bulletins

The UKSSDC/WDC publishes regular bulletins of various ionospheric and geophysical parameters:

Ionospheric Indices of Solar Activity

Monthly and quarterly bulletins giving values of the ionospheric indices IG and IF2.

Provisional Solar-geomagnetic Indices

Monthly bulletin giving daily and monthly mean values of the sunspot number measured at Boulder, the Solar 10.7 cm Radio Flux measured at Ottawa and provisional daily Ap values issued by SEC, Boulder.

Resending of daily URSIGRAM message from Solar Influences Data analysis Center, Brussels.

Resending of daily Solar Daily Forecast and Solar Geophysical Activity Summary reports issued by SEL, Boulder.

Papers

- UKSSDC co-authored papers

Papers from users of UKSSDC data

Links to external websites

- Link to ionospheric monitoring group
- Link to the virtual library Aeronomy, Solar-Terrestrial Physics and Chemistry *aka* Space Physics
- WDC-A for STP at Boulder; part of WDC-A at NGDC. The Space Environment Center (SEC) - real-time monitoring and forecasting of solar and geophysical events.
- The Satellite Situation Center (SSC). A site giving details of spacecraft trajectories and providing magnetospheric mapping facilities.
- The International Solar-Terrestrial Physics Project (ISTP) and its Science Planning and Operations Facility (SPOF) .
- NASA's Space Physics Data Facility (SPDF).
- The NSSDC Space Physics Catalog and FTP Services.

The Status of support organizations such as the Ionospheric Monitoring group and URSI needs to be monitored. An archive would benefit from research into the information support provided by the listed organization. As such information would enhance the level and quality of knowledge that can be extracted from an archive if it could be preserved by incorporation into the archive. Organizations are frequently the sole holders of key hardcopy information which may be at risk if an organization ceased to exist or was to merge with another which did not understand the significance of it holdings or the knowledge of it personnel.

The content of external website should be monitored for changes and any relevant material preserved within the archive if deemed to be at preservation risk, this one include wiki's blog and evolving community websites.

A clear definition for the information contained in the dataset

The definition of the data set must be sufficient to clearly identify what information is being preserved and should if relevant include the authority or reasoning behind the assertion that the data is what the producers e.g. the particle physical data came from CERN a trusted provider or Video footage from a BBC archive. Any factors that could to affect the interpretation of the data and therefore the quality of information preserved should also be explored.

(1)What were the physical factors (e.g. hardware/instrumentation/recording equipment etc) involved in creating this data ?

If any of physical factors in data creation e.g. calibration were found to be false would an additional information be required for data reconstruction and is this within the scope of your archive?

Ionosonde data has been produced using a variety of Instruments and Positions which do have an impact on the quality of observation made

Lowell commercially produces the instrument currently operating at Chilton and Port Stanley amongst others. As on organization with commercial\interests it is reluctant to release detailed technical information. The difficulty in obtaining this material which contains important provenance information and highlights the need for active preservation monitoring organisation who may be able to provide valuable information at a later date. Correctly recording the make and model of instrument against the data produced is therefore important.

http://ulcar.uml.edu/digisonde.html

Comparisons work has been done by the Ionosonde support group at RAL - This instrument is a Lowell Digisonde, DPS1 and it continues the sequence of soundings started in Slough in 1931. In order to make sure that the change of site did not affect the data sequence, operation of both the Chilton and Slough ionosondes was carried out for over a year. Both data sets were compared, and the results of this comparison can be found by following the link below. The Slough site closed in 1995.

http://www.ukssdc.ac.uk/ionosondes/contents.html

Other research into comparing site and instruments can be found in journals and papers. Relating this information to the data and dealing with it's associated DRM and copyright issues is a key requirement

UAG-104 Ionosondes and Ionosonde NetworksProceedings of Session G6 at the XXIVth General Assembly of the International Union of Radio Science (URSI) The meeting was held at the During the URSI General Assembly held in Kyoto , 1993, one of the Commission G sessions was on Ionosondes and Ionosonde Networks. The oral and poster papers for this session were collected together to form a Proceedings that was later published by the WDC-A for STP as part of their UAG series (UAG-104).

http://www.ips.gov.au/IPSHosted/INAG/uag-104/index.html

Lowell Ionosonde - Comparison of Digisonde 256 and DPS data

http://www.ips.gov.au/IPSHosted/INAG/uag-104/text/bodo.html

KEL Iononsonde info

http://www.kel.com.au/products/ips71.htm

Sondonkyla Ionosonde

http://www.sgo.fi/Data/Ionosonde/latestIonosonde.php

(2) What were the human factors involved in creating this data (interpretations/sociological factors/adopted schools of thought etc)?

If any of human factors in data creation were found to be corrupt would additional information be required for data reconstruction and is this within the scope of your archive?

Manual Scaling has been performed by different scalers on file hard copy and currently autoscaled digital files in order to produce the following standardised parameters

Fmin, f0Es, fbEs, FoF2, fxI, h'Es, h'F, M(3000)F2, Type of Es, f0E, FoF1, h'E, h'F2 M(3000)F1

The basic accepted rules of Ionospheric Scaling are contained in the following five publications

* These publications had previously existed only in hardcopy. We have arranged to have them scanned into PDF. If you want to examine the full text please email e.a.conway@rl.ac.uk

- World Data Centre – U.R.S.I handbook of Ionogram interpretation and reduction Nov 1972
- World Data Centre – High latitude supplement to the U.R.S.I handbook of ionospheric interpretation and reduction Oct 1975
- World Data Centre – Revision of Chapters 1-4 U.R.S.I handbook of interpretation and reduction second edition July 1978
- World Data Centre – Ionogram Analysis with Generalised program POLAN December 1985
- MANUAL OF IONOGRAM SCALING Revised Edition By N. Wakai, H. Ohyama and T. Koizumi, July 1986

Training for Rita Blake the manual scalar who was interviewed was principally in the form of one to one mentoring for approximately 2 hours a day over a period of 9 months in order to develop sufficient skill to visually recognise

- Standard Ionospheric behaviour
- Ionospheric phenomena
- Equipment malfunction

[1] M. W. Fox and C. Blundell, "Automatic scaling of digital ionograms", Radio Science, vol. 24, 747-761, 1989.
[2] B. W. Reinisch and X. Huang, "Automatic calculation of electron density profiles from digital ionograms 3.
Processing of bottomside ionograms", Radio Science, vol. 18, 477-492, 1983.
[3] Tripathi ,Y., "Autoscale software computerized processing from years of hourly data comparison", Proceedings
of Session G5 at the XXVth General Assembly of the International Union of Radio Science (URSI), Lille, France,
August 28 - September 5, 22-29, 1996.
[4] L. C. Tsai, F. T Berkey, and J. Y. Liu, "Automatic ionogram trace identification using fuzzy classification
techniques", Proceedings of Session G5 at the XXVth General Assembly of the International Union of Radio Science
(URSI), Lille, France, August 28 - September 5, 45-50,1996.

It should be noted that manual scaling has been carried out by different individuals within different organisations with majority of data currently being automatically scaled which produces lower quality data. IIWG formatted parameters currently define whether the data has been manually or automatically scale. Additional meta data which provides more information on type of scaling used would benefit the future user. This however would be a massive undertaking due to vafriety of scaling techniques used.

(3) What scientific/intellectual assumptions have been made during the data creation or gathering process that allow you to make the assertion that the data is what you say it is?

If any the assumptions in data creation were found to be corrupt would additional information be required for data reconstruction and is this within the scope of your archive? *Who will be responsible for monitoring these assumptions and be responsible for any system changes?

Basic Scientific assumption as defined by Chris Davis of the ionospheric monitoring group based at CCLRC

http://www.ukssdc.ac.uk/ionosondes/ionosonde_basics.html

Key Text on Ionospheric Science are also held by the Ionospheric monitoring group at CCLRC for example the following Ionospheric Theory and Phenomena by J.K Hargreaves. This text is just one example of vital texts which are at preservation risk as they are out of print and are not recorded in a formal bibliography.

One example of a formal bibliography is the background to Ionospheric Sounding- The Center for Atmospheric Research at the University of Massachusetts Lowell 29/08/06. Please note that it was felt that this bibliography was biased towards Lowell ionosondes and research. This highlights a preservation risk of producing a biased or inadequate which does not reflect current scientific understanding of the subject area. The CCLRC based suggested a list people capable of producing such a bibliography which we will discuss later in the document. Also highlighted is the question of how to deal with materials still under copyright by referencing external repositories of information such as the British Library.

Bibliograpgy suggested by Lowell

http://ulcar.uml.edu/digisonde_dps.html

Barker R.H., "Group Synchronizing of Binary Digital Systems", Communication Theory, London, pp. 273-287, 1953

Bibl, K. and Reinisch B.W., "Digisonde 128P, An Advanced Ionospheric Digital Sounder", University of Lowell Research Foundation, 1975.

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Buchau, J., Weber E.J. , Anderson D.N., Carlson H.C. Jr, Moore J.G., Reinisch B.W. and Livingston R.C., "Ionospheric Structures in the Polar Cap: Their Origin and Relation to 250 MHz Scintillation", *Radio Science*, 20, No. 3, pp 325-338, May-June 1985.

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Huffman D. A., "The Generation of Impulse-Equivalent Pulse Trains", IRE Trans. on Information Theory, IT-8, Sep 1962.

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Oppenheim, A. V., and R. W. Schafer, "Digital Signal Processing", Prentice Hall, 1976.

Peebles, P. Z., "Communication System Principles", Addison-Wesley, 1979.

Reinisch, B.W., "New Techniques in Ground-Based Ionospheric Sounding and Studies", *Radio Science*, 21, No. 3, May-June 1987.

Reinisch, B.W., Buchau, J. and Weber, E.J., "Digital Ionosonde Observations of the Polar Cap F Region Convection", *Physica Scripta*, 36, pp. 372-377, 1987.

Reinisch, B. W., et al., "The Digisonde 256 Ionospheric Sounder World Ionosphere/ Thermosphere Study, *WITS Handbook*, Vol. 2, Ed. by C. H. Liu, December 1989.

Reinisch, B.W., Haines, D.M. and Kuklinski, W.S., "The New Portable Digisonde for Vertical and Oblique Sounding," AGARD-CP-502, February 1992.

Rush, C.M., "An Ionospheric Observation Network for use in Short-term Propagation Predictions", *Telecomm, J.*, 43, p 544, 1978.

Sarwate D.V. and Pursley M.B., "Crosscorrelation Properties of Pseudorandom and Related Sequences", *Proc. of the IEEE*, Vol 68, No 5, May 1980.

Scali, J.L., "Online Digisonde Drift Analysis", User's Manual, University of Massachusetts Lowell Center for Atmospheric Research, 1993.

Schmidt G., Ruster R. and Czechowsky, P., "Complementary Code and Digital Filtering for Detection of Weak VHF Radar Signals from the Mesosphere", *IEEE Trans on Geoscience Electronics*, May 1979.

Wright, J.W. and Pitteway M.L.V., "Data Processing for the Dynasonde", *J. Geophys. Rsch*, 87, p 1589, 1986.

(4) PARAMETER DEFINITION AND DESCRIPTION

Definition for the IIWG parameters can be found in appendix A. It should be noted that additional semantic information can be found in the URSI handbooks and other texts

Data contained within MMM files are described in appendix I it was felt that parameter definition in this document in some cases were not adequate with a risk of semantic meaning being lost over time.

How is the digitally encoded information ingested into the repository?

(1)Where does it come from and how is this verified?

The data sets come from over 252 different locations and organisations. Verification of the data relies on the extensive knowledge of Matthew Wild the current archivist. The data from CCLRC operated and a number of trusted producers of Lowell Ionosonde data is FTP and automatically reformatted. A considerable amount of other data is manually inspected with key parameters extracted in order to produce the required IIWG formatted files. The current system is reliant on the Archivist knowledge of the Global network of Ionosondes in order to maintain supply of data.

(2) How is it packaged?

The data is packaged in a number of ways depending on the producer. The current system is reliant on the archivist knowledge to extract the required data from the packaged data. The archivist is heavily involved in negotiating the method of supply of data. This needs to be flexible arrangement as imposing rigid restriction on how the data is to be supplied may result in cessation.

(3) For one dataset, how many "files" does it consist of?

The number of file depends on the supply arrangement at a minimum hourly soundings which get concatenated into monthly files.

(4) Is the data transformed in any way?

Yes the required IIWG are extracted form varying file formats before deposit in the archive.

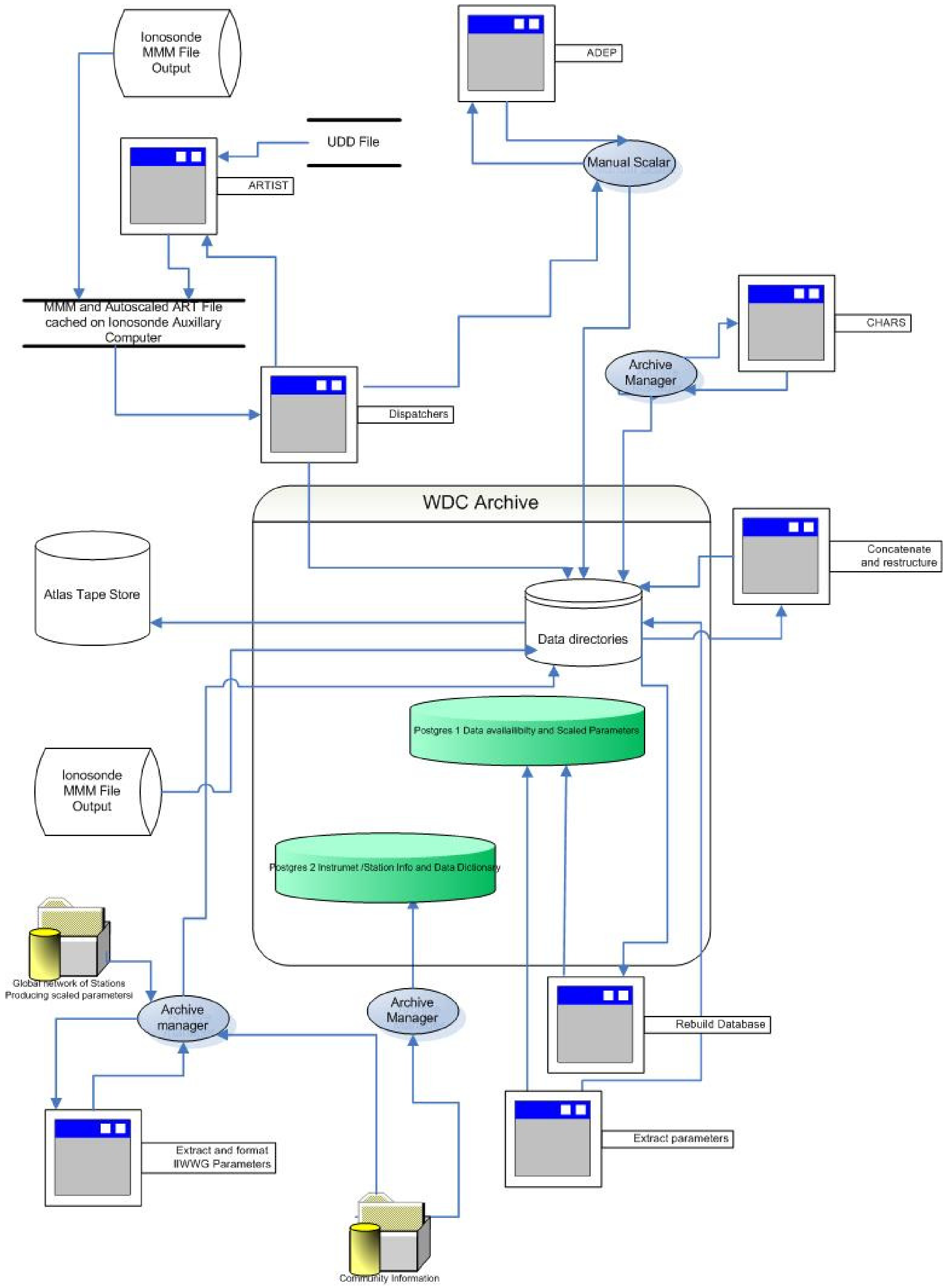
(5) Is information added (e.g. additional metadata, references etc)?

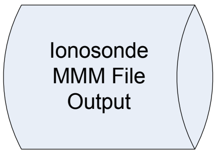
Yes station code is added along with URSI codes as part of the formatting process

(6) Data volume (of the particular collection and each granule, i.e. file, of the data) and the rate at which it arrives

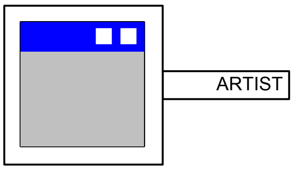
Data Volume and rates of all deposits are sufficiently small so as not be an issue.

(7) Ingestion Data Flow Diagram



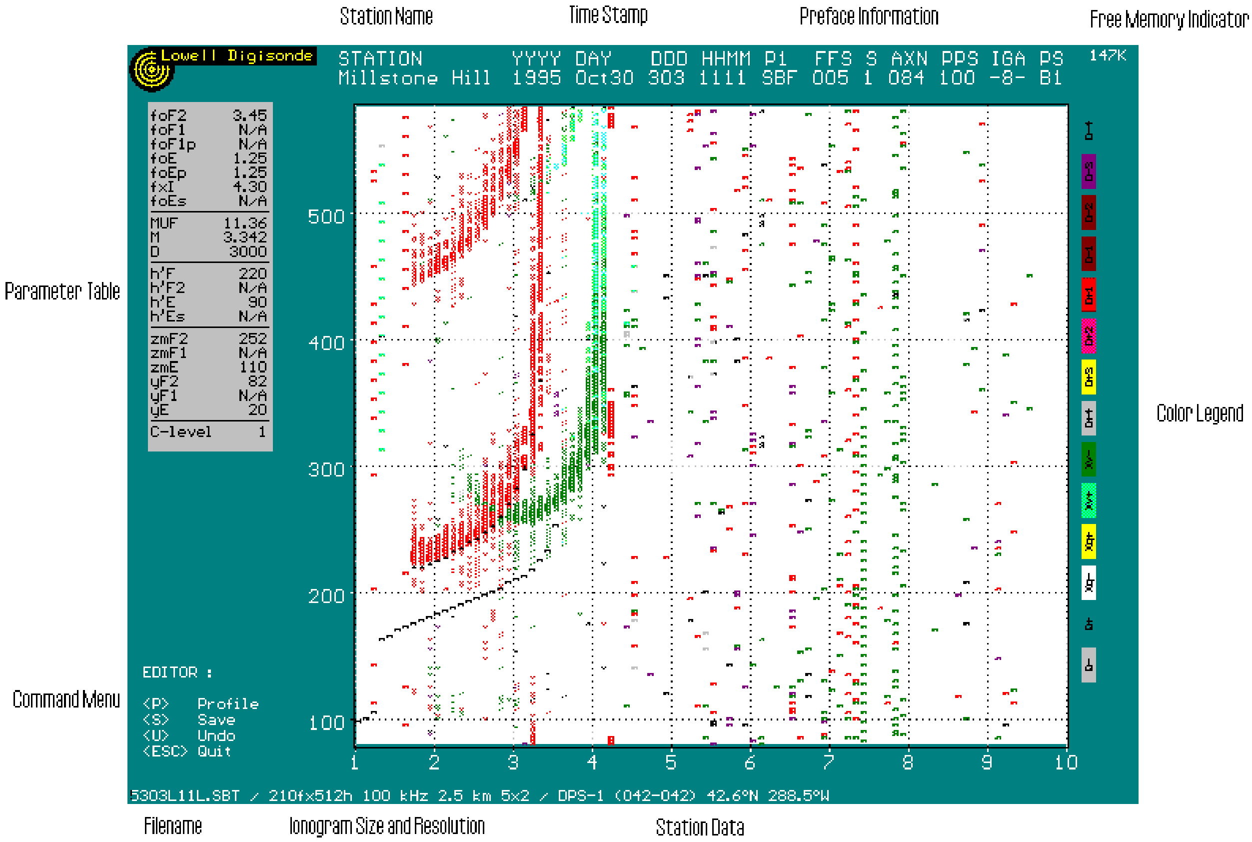


Raw data post signal processing is outputted from the Ionosonde. A copy of this raw data is saved on the Ionosonde auxilliary computer



ARTIST system [2], developed at University of Lowell, Center for Atmospheric Research (UMLCAR).
ARTIST-4 computer runs a native 32 bit Windows NT version of ARTIST ionogram autoscaling software, *"ARTIST-4"*.
ARTIST 4 computer description- http://ulcar.uml.edu/%7Eiag/Artist-4.htm

The ARTIST software takes the raw mmm file and is signed to scale the ionograms without using information on polarization producing an ART file in SAO format



The SAO file contains the following additional information (for full description see appendix J)

- Geophysical Constants
- Scaled Ionospheric Characteristics
- ARTIST Analysis Flags
- Doppler Translation Table
- Trace Virtual Heights
- True Heights
- Trace Amplitudes
- Trace Doppler Numbers
- Trace Frequencies
- Median Amplitude of F Echo
- Median Amplitude of E Echo
- Median Amplitude of Es Echo
- True Height Coefficients for the F2 Layer
- True Height Coefficients for the F1 Layer
- True Height Coefficients for the E Layer
- Quazi-Parabolic Segments Fitted to the Profile
- Edit Flags: Characteristics
- Valley Characteristics UMLCAR model
- Regular True Height Profile
- Qualifying and Descriptive Letters
- Edit Flags: Traces and Profile
- True Height Coefficients for the Ea Layer
- Auroral True Height Profile

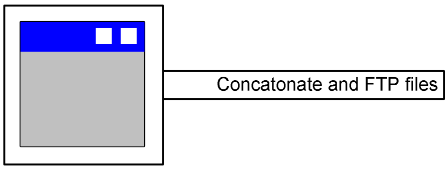
UDD File

Station UDD Files - http://ulcar.uml.edu/%7Eiag/Artist-4.htm

UDD\ subdirectory of the VIEWER directory stores Station UDD files. Each sounder must have the Station UDD file created and placed in the subdirectory. The name of the file is NNN.udd, where NNN is the Station ID (receiver) specified in the ARMENU.DPS system settings file of the sounder and stored in each data file in the Preface section. For Full parameter description see appendix J

MMM and Autoscaled ART File cached on Ionosonde Auxillary Computer

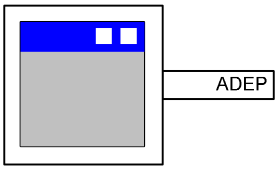
Temporary store of mmm and ARTIST output SAO files on auxilliarey computer



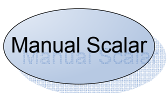
On a daily basis this program bundles and transfer the appropriate file into the WDC archive and hourly soundings sent to the ADEP machine for manual editing

Hourly ART/ SAO file for manual Scaling

Temporary cache of mmm files for autoscaling



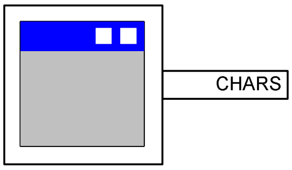
ADEP software developed by Lowell and licensed to RAL allows for the manual editing of the Autoscaled SAO file. This software allows a person to alter traces and parameters based on their inspection of the ionogram



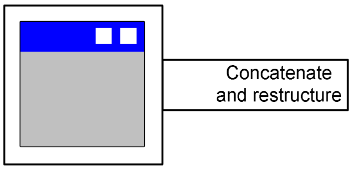
Group or individual carrying out manual scaling

Autoscaled Files

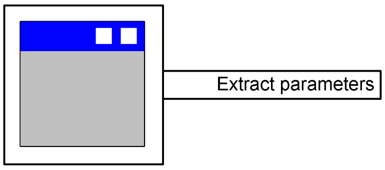
Temporary store of manually scaled file for ingest into the WDC archive



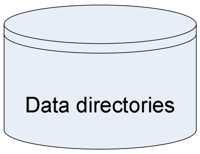
CHARS software extracts parameters from the SAO and creates IIWG formatted files



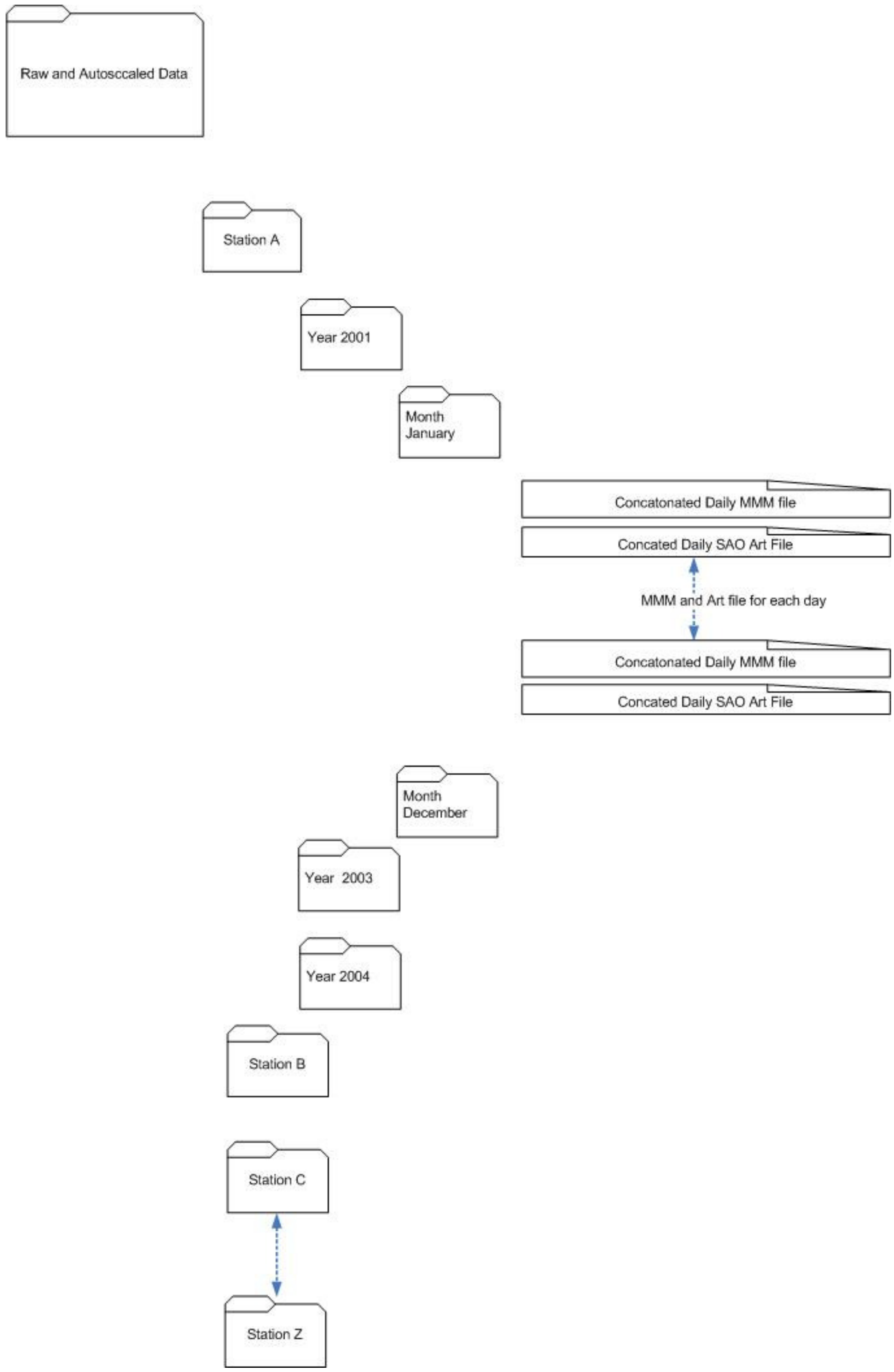
This software regularly inspects the data directories restructure the data and updates Postgres 1 database

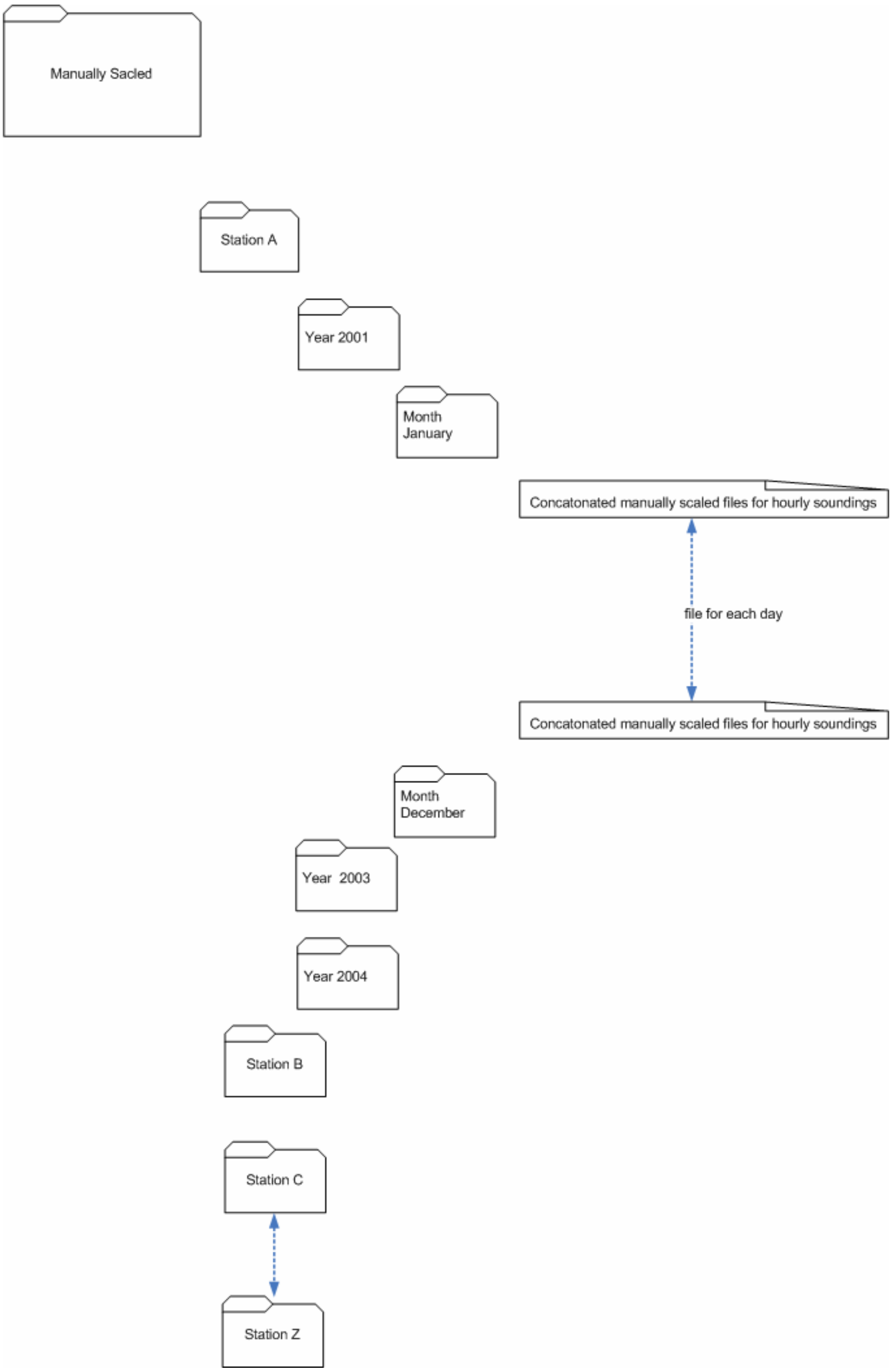


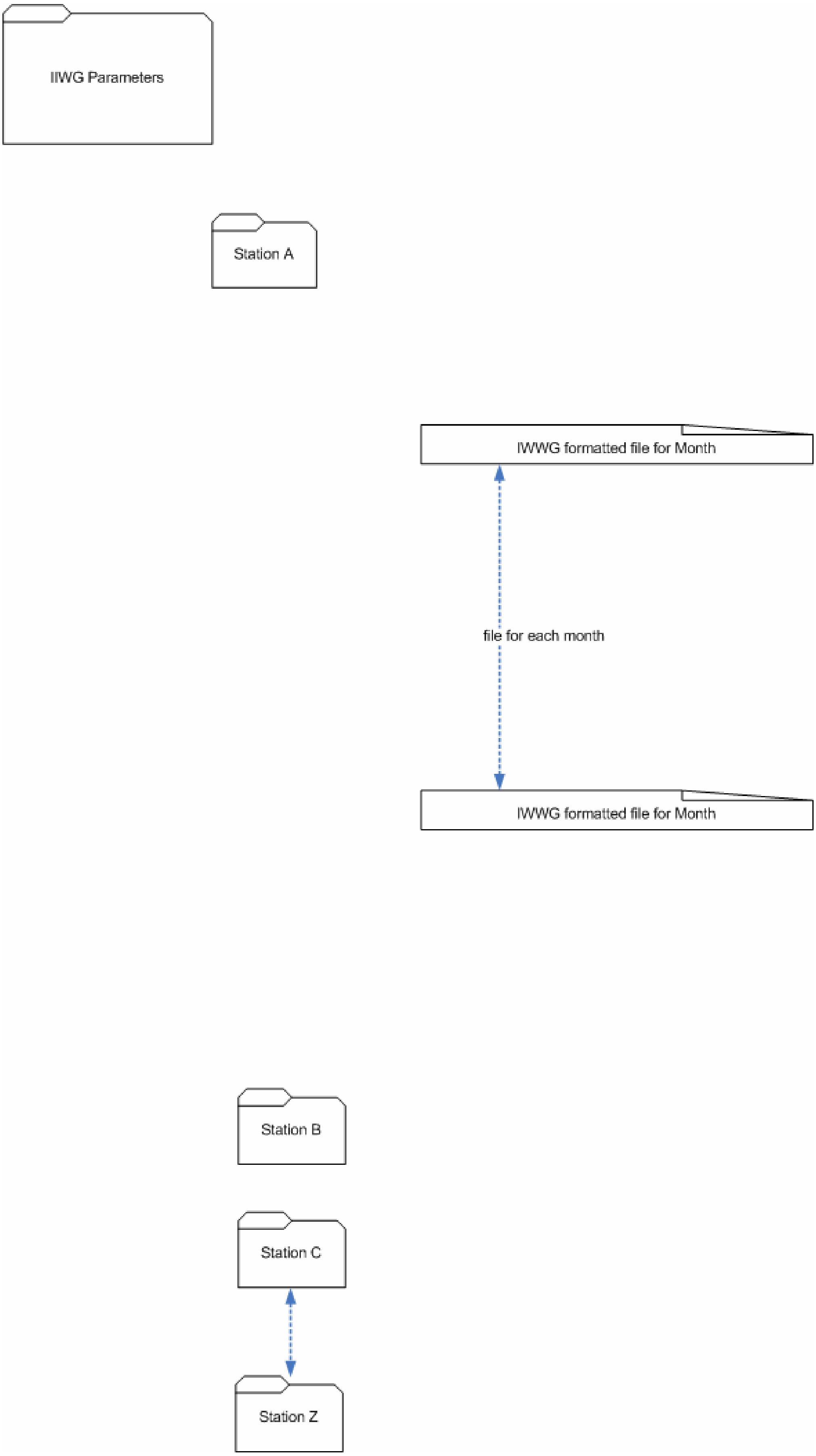
Extract Parameter from SAO file to populate database



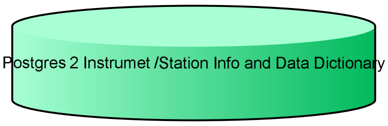
Contains raw mmm files autoscaled , manually scaled SAO files and IIWG formatted ASDCII file in the following directory structures. Aproximately 50 Gigabytes in volume stored on RAID.


Raw and Autosccaled Data
Station A
Year 2001
Month
January
Concatonated Daily MMM file
Concated Daily SAO Art File
MMM and Art file for each day
Concatonated Daily MMM file
Concated Daily SAO Art File
Month
December
Year 2003
Year 2004
Station B
Station C
Station Z


Manually Sacled
Station A
Year 2001
Month
January
Concatonated manually scaled files for hourly soundings
file for each day
Concatonated manually scaled files for hourly soundings
Month
December
Year 2003
Year 2004
Station B
Station C
Station Z

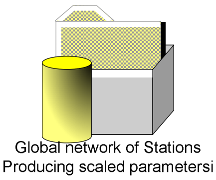

IIWG Parameters
Station A
IWWG formatted file for Month
file for each month
IWWG formatted file for Month
Station B
Station C
Station Z

Schema available through Matthew Wild

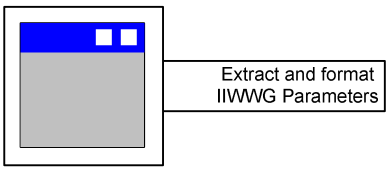


Schema available through Mathew Wild

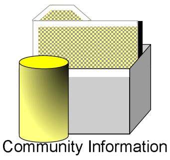
Back up of Databases and Data Directories



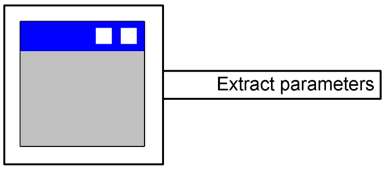
Network of global ionosonde stations who send parameter data to the Archive manager using a wide variety of methods e-mail, ftp or on cd via the post



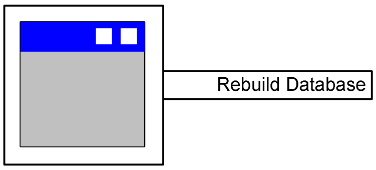
A number of programs have been written at RAL to extract and place these parameters in the appropriate format



Information from the global network of ionosondes



Extracts parameters from data directories to populate database Postgres 1



Updates database with current info on content of data directories

How is the required data currently located and accessed?

(1) What information do current users need/possess that allows them to locate the data which provides them with information that they are seeking?

Currently users locate the information they require through knowledge of time and date of the phenomena they wish to study

(2)What search and retrieval software do they utilise in order to do this?

For details of the specific software see detailed breakdown below

(3)What additional stored data does this software utilise?

Mapping between geographic location, station name and URSI station code

(4)How will the designated community maintain awareness of the information's existence?

Currently organisations such as the WDC and URSI help maintain awareness.

(5)Are there measures to preserve the access software and any hardware it depends on?

Not currently preservation of access relies on the active efforts of the WDC.

(6) Does the access software utilise any supplementary data, e.g. an index database, a thesaurus?

Yes community information is contained in a database linked to the data by station code.

(7) If the software/hardware were not preserved, would it be possible to perform manual search and retrieval? Is there sufficient documentation to enable this?

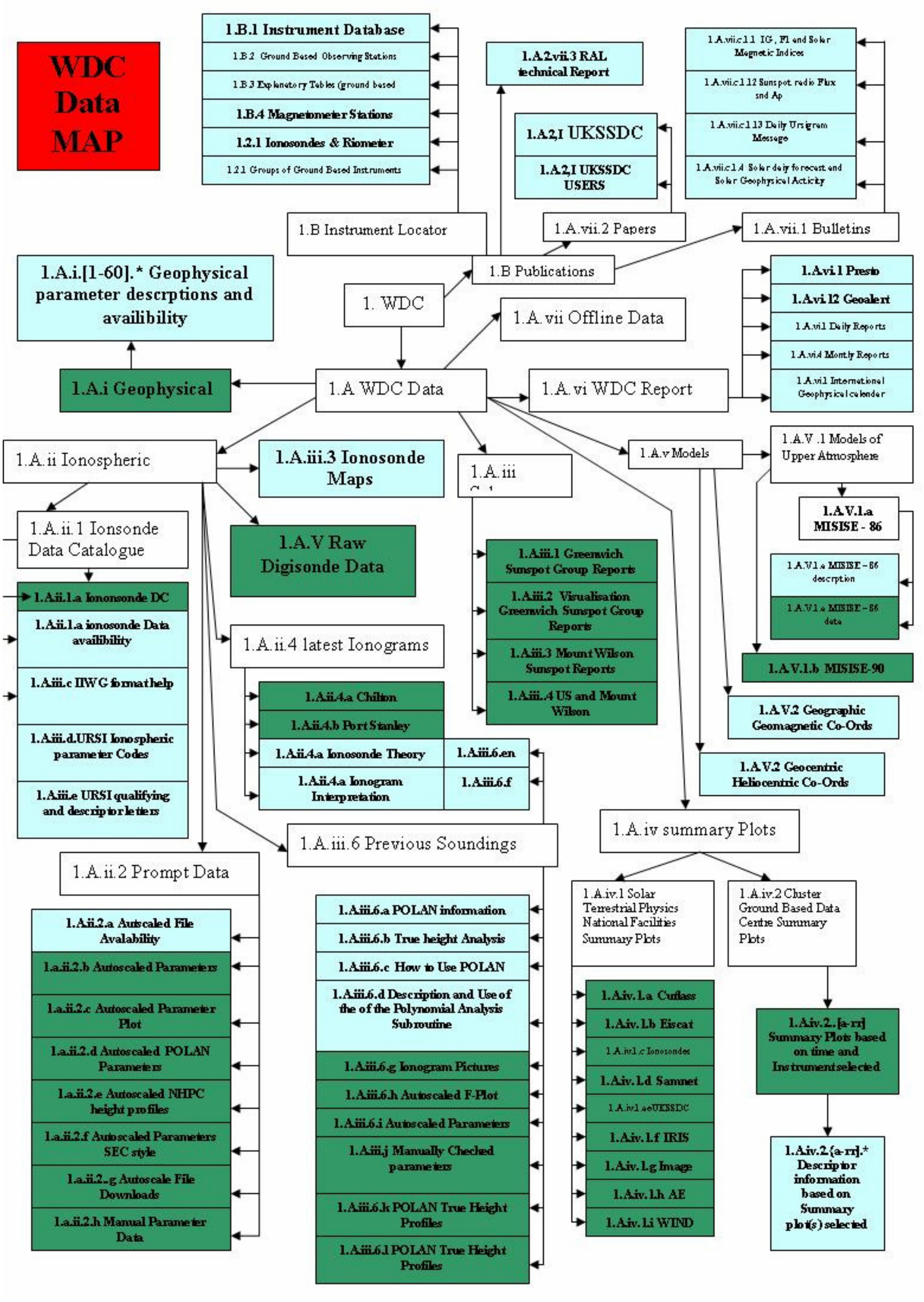
Not currently for full detail see breakdown below

(8) Is the data used by the user a bit-copy of the data held in the archive or might it be created "on-the-fly"?

For some data products "on-the-fly" data is produced. Some of the software which produce this data is at preservation risk and is documented below.

How is the data currently Accesed ?

WORLD DATA CENTRE FOR SOLAR-TERRESTRIAL PHYSICS - DATA MAP



a. WDC Data

i. Ionospheric

1. Ionosonde Data Catalogue

a. Ionosonde Data Catalogue – Retrieved by Station Name/ID/Position and date parameters

b. fxF2

c. fzF2

d. M3000F2

e. h'F2

f. hpF2

g. h'Ox

h. MUF3000F2

i. Hc

j. Qc

k. foF1

l. fxF1

m. M3000F1

n. h'F1

o. h'F

p. MUF3000F1

q. foE

r. foE2

s. foEa

t. h'E

u. h'E2

v. foes

w. fxEs

x. fbEs

y. fEs

z. h'Es

aa. Type of Es

bb. foF1.5

cc. Fmin

dd. M3000F1.5

ee. h'F1.5

ff. fm2

gg. Hm

hh. fm3

ii. foI

jj. fxI

kk. fmI

ll. M3000I

mm. h'I

nn. foP

oo. h'P
pp. dfS
qq. fh'F2
rr. fh'F
ss. h'mF1
tt. h1
uu. h2
vv. h3
ww. h4
xx. h5
yy. H
zz. I2000
aaa. I
bbb. Ixxxx
ccc. T
ddd. fmnF
eee. fmnE
fff. hmE
ggg. hmF1
hhh. hmF2
iii. zhalfNm

jjj. Ionsonde Data Availibilty
kkk. IIWG Format Help
lll. URSI Ionospheric Parameter Codes
mmm. URSI Qualifying and Descriptive Letters for Ionospheric Parameters

2. Prompt Data(Available for Europe and Falkland Islands station retrieved by station and date parameters)
    a. Autoscaled File Avalibility
        i. Date
        ii. Name(Station)
        iii. File
    b. Autoscaled Parameters
        i. Timestamp
        ii. Station
        iii. foF2
        iv. foF1
        v. MF2
        vi. MUFF2
        vii. Fmin
        viii. foes
        ix. fminF
        x. fminE
        xi. foE
        xii. fxI
        xiii. h'F
        xiv. h'F2
        xv. h'E
        xvi. h'Es
        xvii. fh'F
        xviii. fh'F2
    c. Autoscaled Parameter Plot (for parameter see above)
    d. Autoscaled POLAN height Parameters (for prespecified parameters e.g. Peak 4.935 (+/-0.017) MHz, Height 270.9 (+/- 0.8) km. Scale Height 25.8 (+/- 1.3) km. Slab (to peak) = 37.8 km)
        i. Height
        ii. Frequency
    e. Autoscaled NHPC height profiles
        i. Height
        ii. Frequency
        iii. Denisty
    f. Autoscaled Parameters SEC-style
        i. YR
        ii. MO
        iii. DA

iv. HHMM
v. foF2
vi. hmF2
vii. M(D)
viii. D h'F
ix. yF2
x. fMUF
xi. h'
xii. fxI
xiii. foF1
xiv. foE
xv. hmE
xvi. foes
xvii. fbEs
xviii. ITEC

g. Autoscaled File Download **(E-Mail & FTP only)**
h. Manual Parameter Data
    i. Timestamp
    ii. Station
    iii. foF2
    iv. foF1
    v. MF2
    vi. MUFF2
    vii. fmin
    viii. foEs
    ix. fminF
    x. fminE
    xi. foE
    xii. fxI
    xiii. h'F
    xiv. h'F2
    xv. h'E
    xvi. h'Es
    xvii. fh'F
    xviii. fh'F2

3. Ionosonde Maps
    a. Whole World
    b. Northern Hemisphere
    c. Southern Hemisphere
4. Latest Ionograms
    a. Chilton
    b. Port Stanley
    c. Ionsonde Theory
    d. Ionogram Interpretation
5. Raw Digisonde Data created by station (Chilton/Port Stanley/Lerwick and selected by date). To make use of this data, it must be processed through the University of Lowell Center for Atmospheric Research **data processing tool 'SAOExplorer'**. The daily files contain both ionogram (MMM) and ARTIST (ART) auto scaled data files for each sounding.

6.
7. Previous Soundings
    a. POLAN Information
    b. True Height Analysis
    c. How to Use Polan
    d. Description and Use of the Polynomial Analysis Subroutine
    e. Ionosonde Theory
    f. Ionosonde Interpretation
    g. Ionogram Pictures
    h. Autoscaled F-plot
    i. Autoscaled Parameters
        i. YYYY
        ii. DDD
        iii. hh
        iv. mm
        v. ss
        vi. foF2
        vii. foF1
        viii. MF2
        ix. MUFF2
        x. fmin
        xi. foEs
        xii. fminF
        xiii. fminE
        xiv. foE
        xv. fxI
        xvi. h'F
        xvii. h'F2
        xviii. h'E
        xix. h'Es
        xx. fh'F
        xxi. fh'F2
    j. Manually Checked Parameters
        i. YYYY
        ii. DDD
        iii. hh
        iv. mm
        v. ss
        vi. foF2
        vii. foF1
        viii. MF2
        ix. MUFF2
        x. fmin
        xi. foEs
        xii. fminF
        xiii. fminE
        xiv. foE

xv. fxI
xvi. h'F
xvii. h'F2
xviii. h'E
xix. h'Es
xx. fh'F
xxi. fh'F2

k. POLAN True Height Profiles
   i. Frequency
   ii. Height
l. POLAN True Height Profiles(manually Checked mfor specified parameters e.g. Peak 3.314 (+/- 0.051) MHz, Height 355.8 (+/- 5.2) km. Scale Height 47.9 (+/- 3.1) km. Slab (to peak) = 69.5 km.)
   i. Frequency
   ii. Height

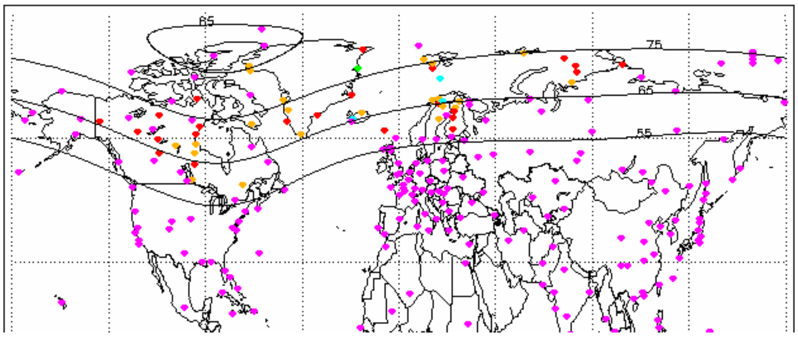
INSTRUMENT RECORDS

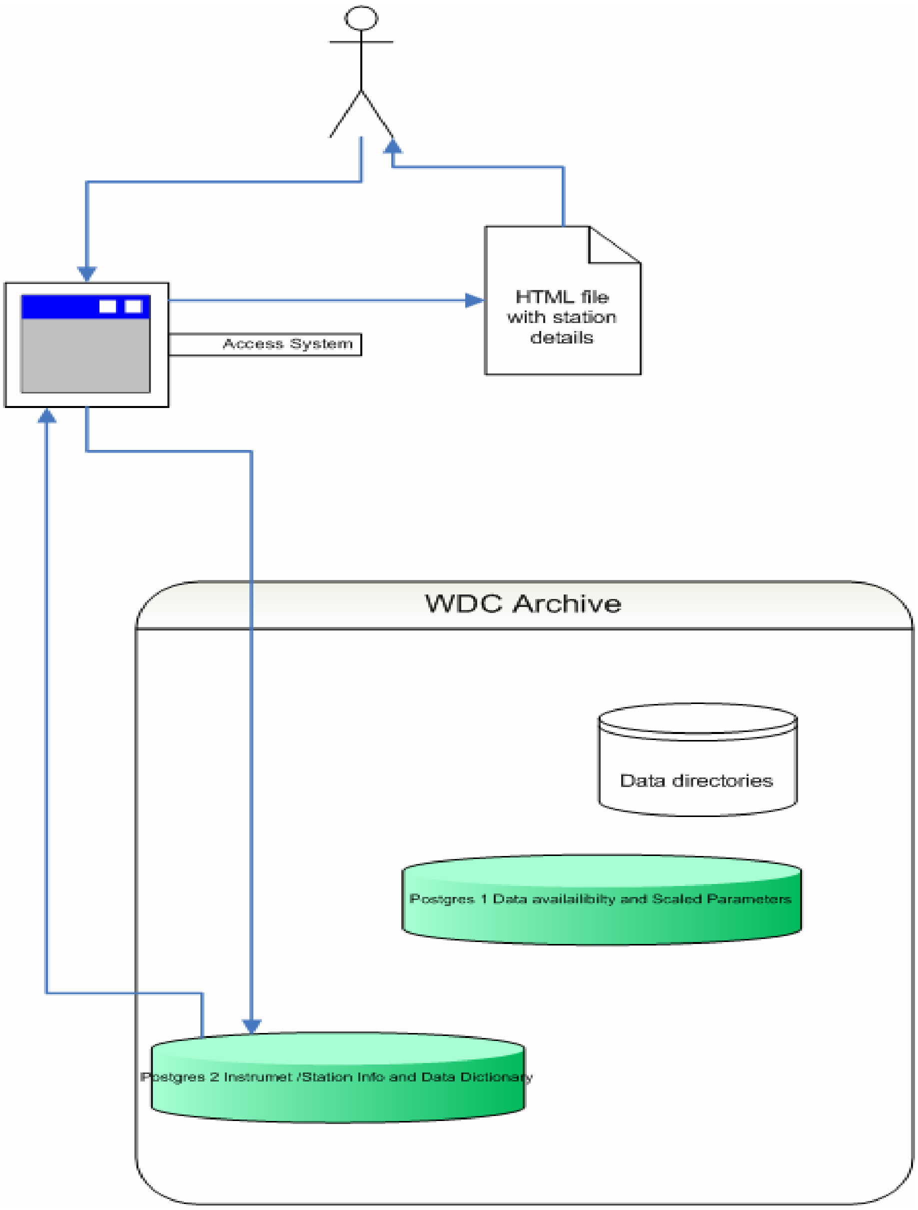
Station records can be accessed through a hyperlinked list

Station	Code	lat (-90,+90)	long (0,360)	Instrument	Chain or Data Provider	Contact e-mail
* AGO A77	B1	-77.580	336.630	M	AGONET	jrdu@pcmail.nerc-bas
* AGO A77	B1	-77.580	336.630	MP	AGONET	engebret@augsburg.ec
* AGO A77	B1	-77.580	336.630	P	AGONET	jrdu@pcmail.nerc-bas
* AGO A77	B1	-77.580	336.630	R	AGONET	jrdu@pcmail.nerc-bas
* AGO A80	B2	-80.750	339.600	LF-HF	AGONET	james.w.labelle@dart
* AGO A80	B2	-80.750	339.600	M	AGONET	jrdu@pcmail.nerc-bas
* AGO A80	B2	-80.750	339.600	MP	AGONET	engebret@augsburg.ec
* AGO A80	B2	-80.750	339.600	P		jrdu@pcmail.nerc-bas
* AGO A80	B2	-80.750	339.600	R	AGONET	jrdu@pcmail.nerc-bas
* AGO A80	B2	-80.750	339.600	VLF	AGONET	jrdu@pcmail.nerc-bas

Or via a hyperlinked map projection

World (cylindical projection)



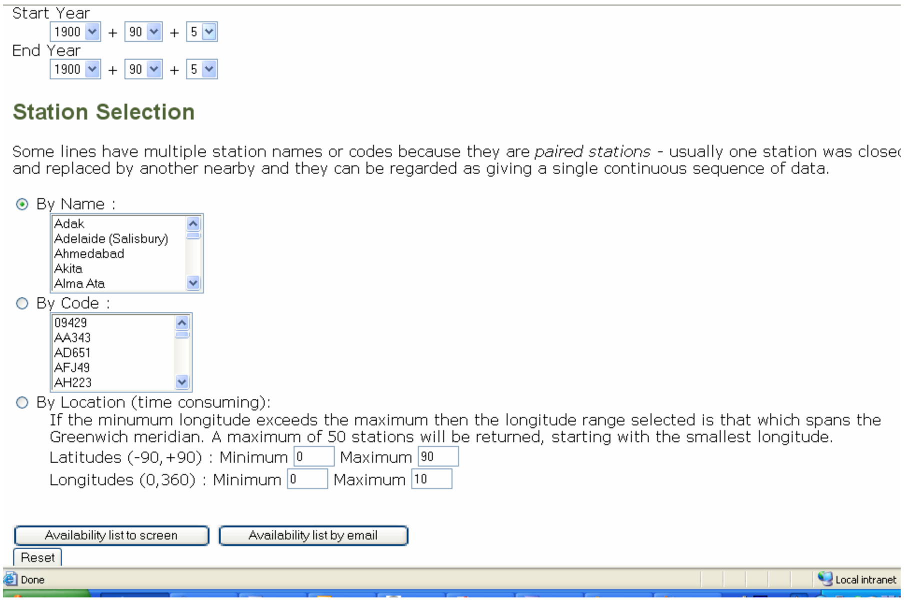


The access system uses perl scripts to extract the relevant information from the Postgres 2 database and returns the information in a html file.

No real preservation issues only mode of retrieval needs to be preserved

DATA AVAILABILITY LISTINGS

Accessible by filling web form specifying date range, station name, station code, latitude, longitude (see below)



Start Year
1900 + 90 + 5
End Year
1900 + 90 + 5

Station Selection

Some lines have multiple station names or codes because they are *paired stations* - usually one station was closed and replaced by another nearby and they can be regarded as giving a single continuous sequence of data.

By Name :
Adak
Adelaide (Salisbury)
Ahmedabad
Akita
Alma Ata

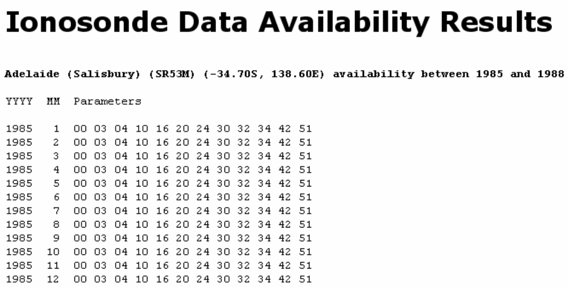
By Code :
09429
AA343
AD651
AFJ49
AH223

By Location (time consuming):
If the minumum longitude exceeds the maximum then the longitude range selected is that which spans the Greenwich meridian. A maximum of 50 stations will be returned, starting with the smallest longitude.
Latitudes (-90,+90) : Minimum 0 Maximum 90
Longitudes (0,360) : Minimum 0 Maximum 10

Availability list to screen | Availability list by email
Reset

Done | Local intranet

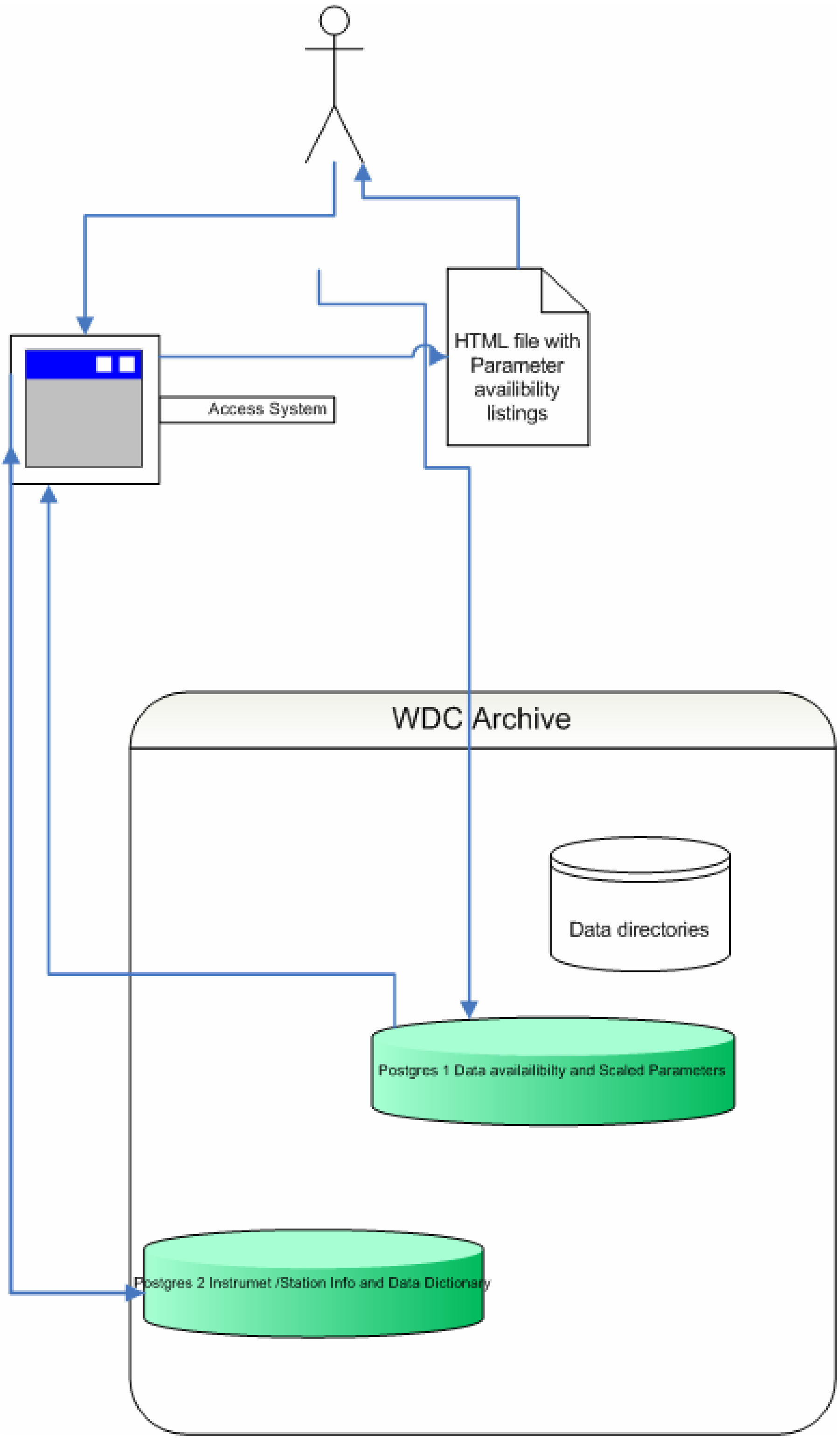
Result returned by screen or e-mail



Ionosonde Data Availability Results

Adelaide (Salisbury) (SR53M) (-34.70S, 138.60E) availability between 1985 and 1988

YYYY	MM	Parameters
1985	1	00 03 04 10 16 20 24 30 32 34 42 51
1985	2	00 03 04 10 16 20 24 30 32 34 42 51
1985	3	00 03 04 10 16 20 24 30 32 34 42 51
1985	4	00 03 04 10 16 20 24 30 32 34 42 51
1985	5	00 03 04 10 16 20 24 30 32 34 42 51
1985	6	00 03 04 10 16 20 24 30 32 34 42 51
1985	7	00 03 04 10 16 20 24 30 32 34 42 51
1985	8	00 03 04 10 16 20 24 30 32 34 42 51
1985	9	00 03 04 10 16 20 24 30 32 34 42 51
1985	10	00 03 04 10 16 20 24 30 32 34 42 51
1985	11	00 03 04 10 16 20 24 30 32 34 42 51
1985	12	00 03 04 10 16 20 24 30 32 34 42 51

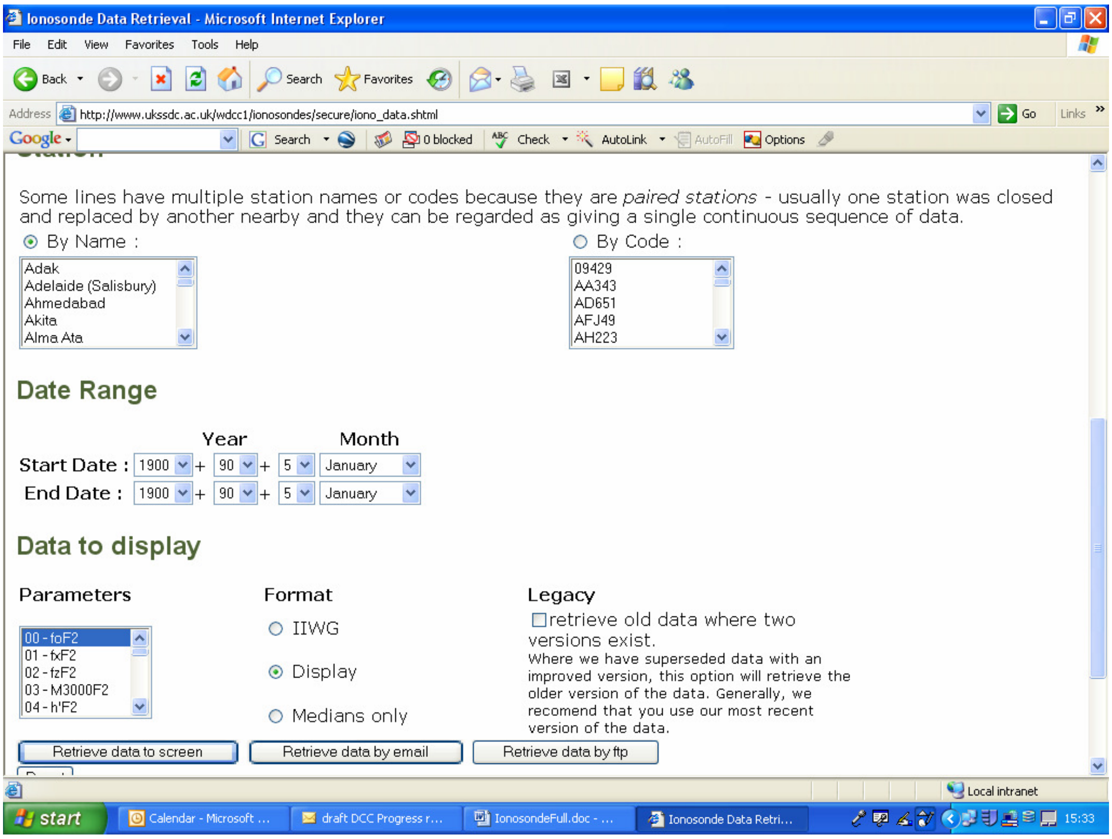


The access system uses perl script to extract the relevant information from the postgres 1 & 2 database sand returns the information in a html file.

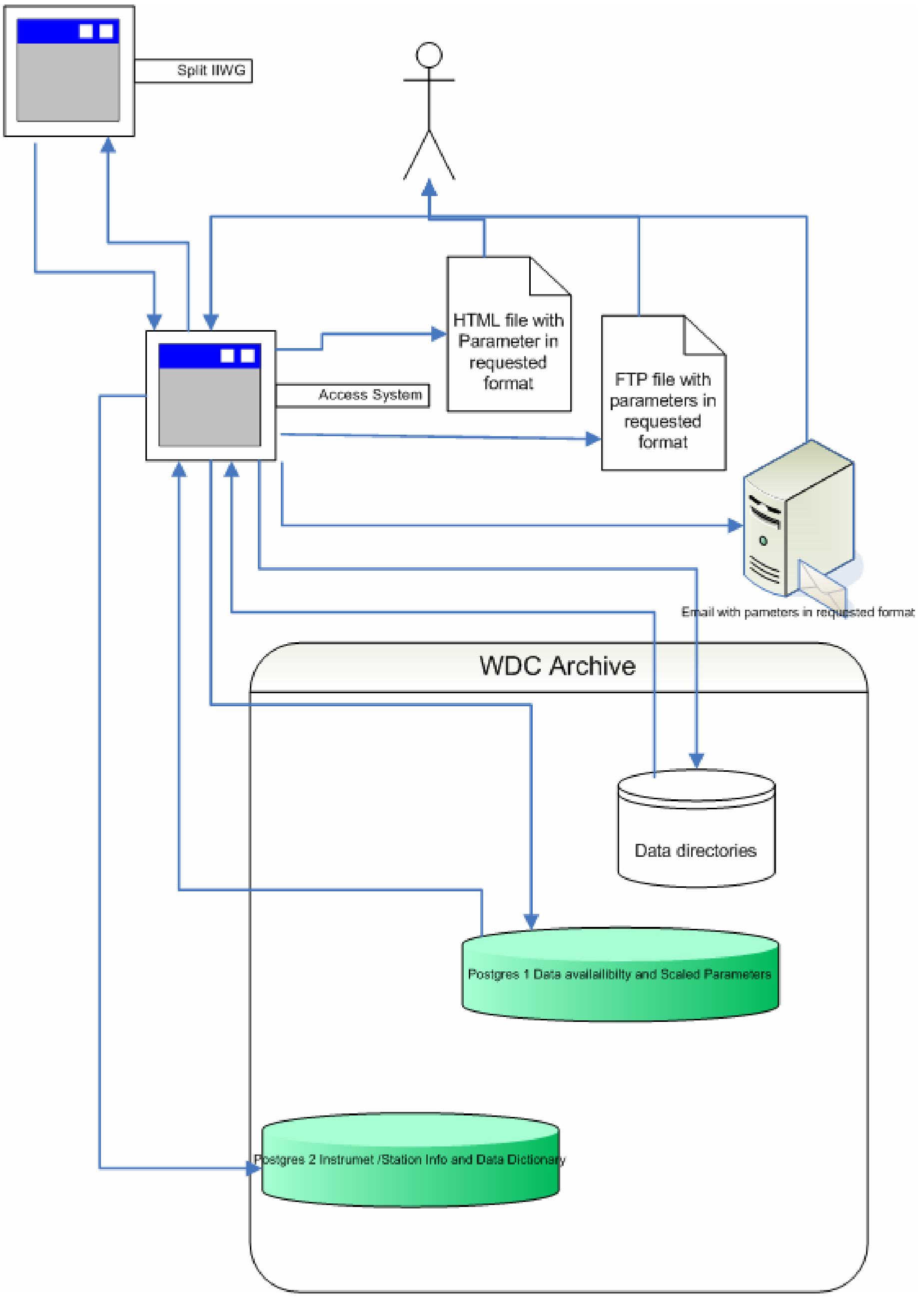
No real preservation issues only mode of retrieval needs to be preserved

IWWG Paramters

Overs 60 different ionogram parameters may be retrieved by specify the station (either by name or code), for a specified the time period .



In addition the method of delivery can also be specified as direct to screen, e-mail\or FTP.



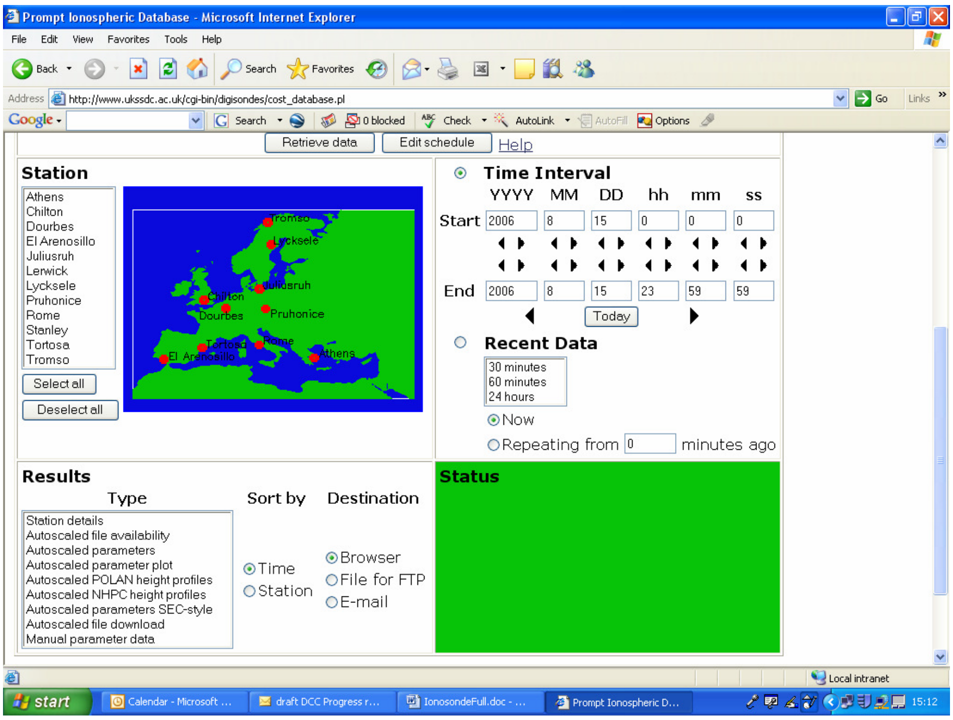
The access system uses perl script to extract the relevant station code from Postgres 2 information the file location id identified from information in the postgres 1 database. The correct file is the extracted and sent to the split IIWG program which extract the parameters from the file and returns the information in an html file to users browser by ftp or via e-mail.

Either the software to extract correct parameters (perl script written in house) needs to be preserved or documentation on how to extract the correct parameters (see appendix A)

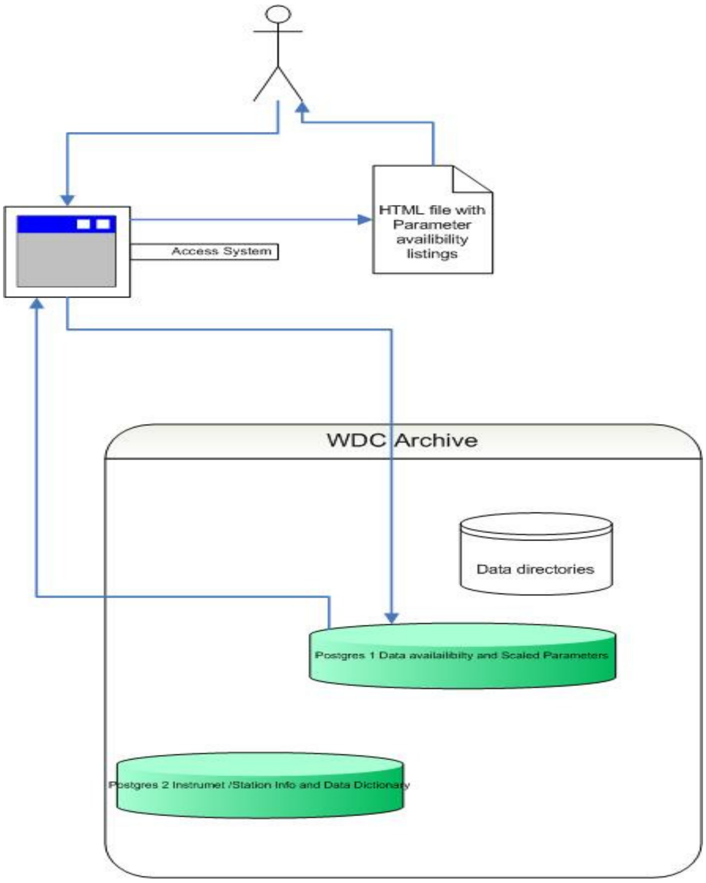
PROMPT DATA

Prompt data is again available by filling in a web form which specifies the station(s) and time period for which you to receive Ionospheric data. You can then additionally specify the type and format of the data you wish receive

- Data availability listings
- Autoscaled Parameters
- Autoscaled Parameter Plot
- Autoscaled POLAN height profiles
- Autoscaled NHPC height profiles
- Autoscaled Parameters Sec Style
- Autoscaled File Download
- Manual Parameter Data



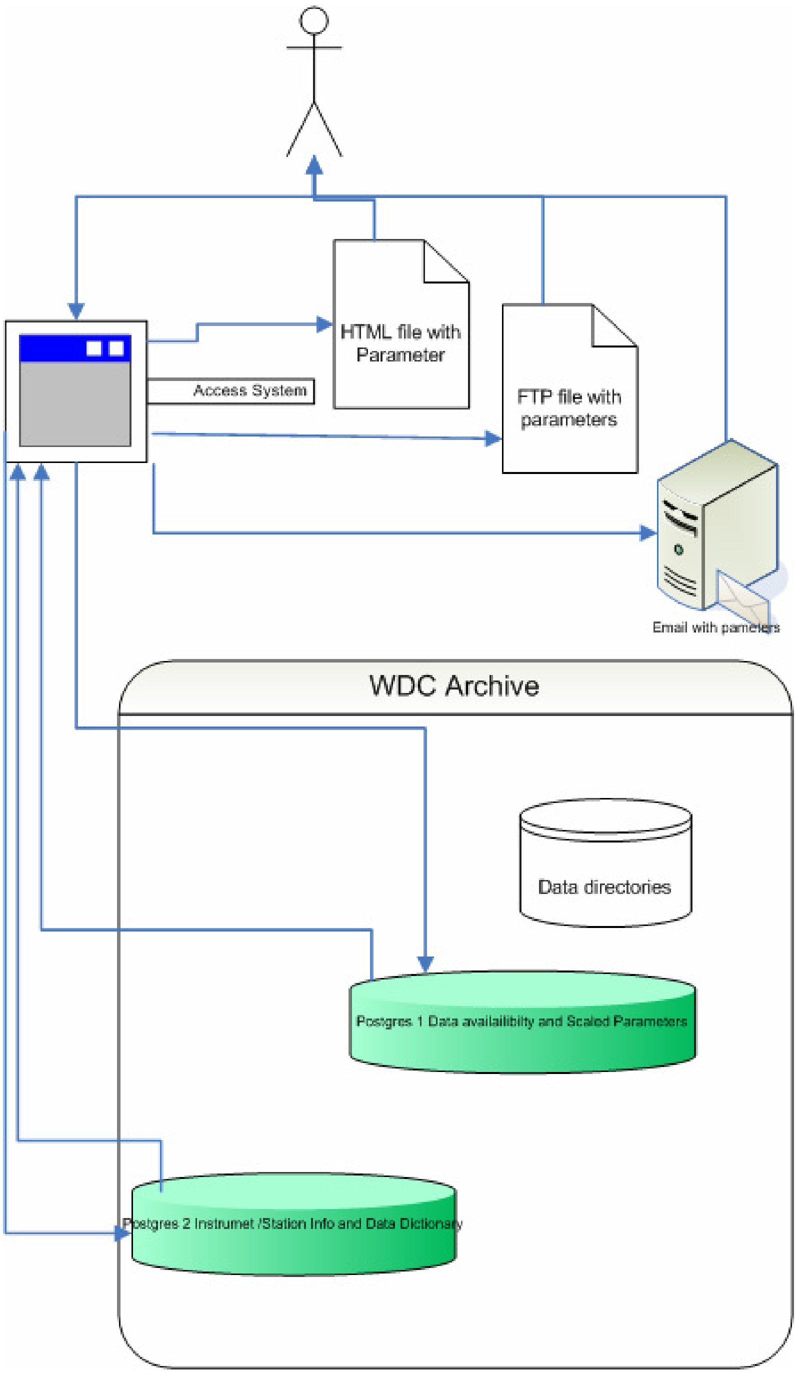
Data availability listings



The access system uses perl script to extract the relevant information from the postgres 1 database and returns the information in an html file to users browser.

No real preservation issues only mode of retrieval needs to be preserved

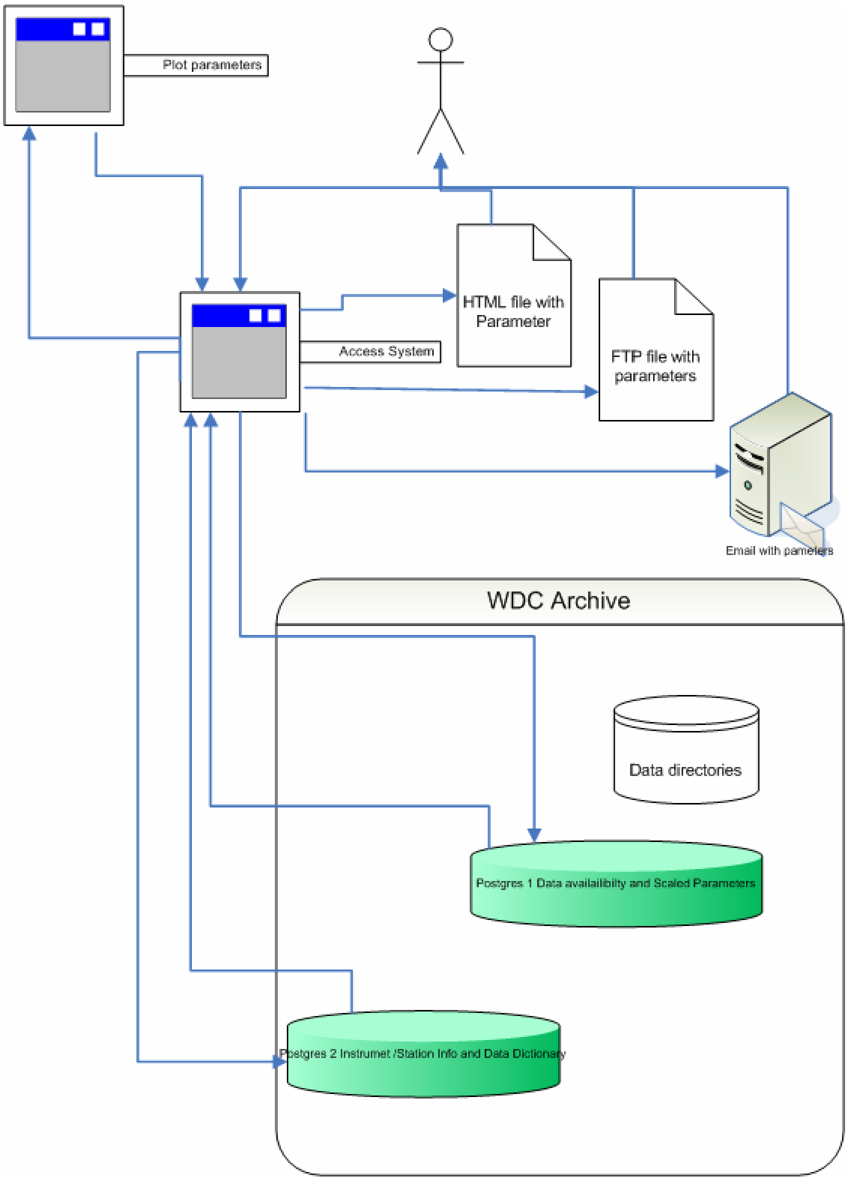
Autoscaled Parameters



The access system uses perl script to extract the relevant information from the postgres 1 & 2 database and returns the information in an html file to users browser by ftp or via e-mail.

No real preservation issues only mode of retrieval needs to be preserved

Autoscaled Parameter Plot

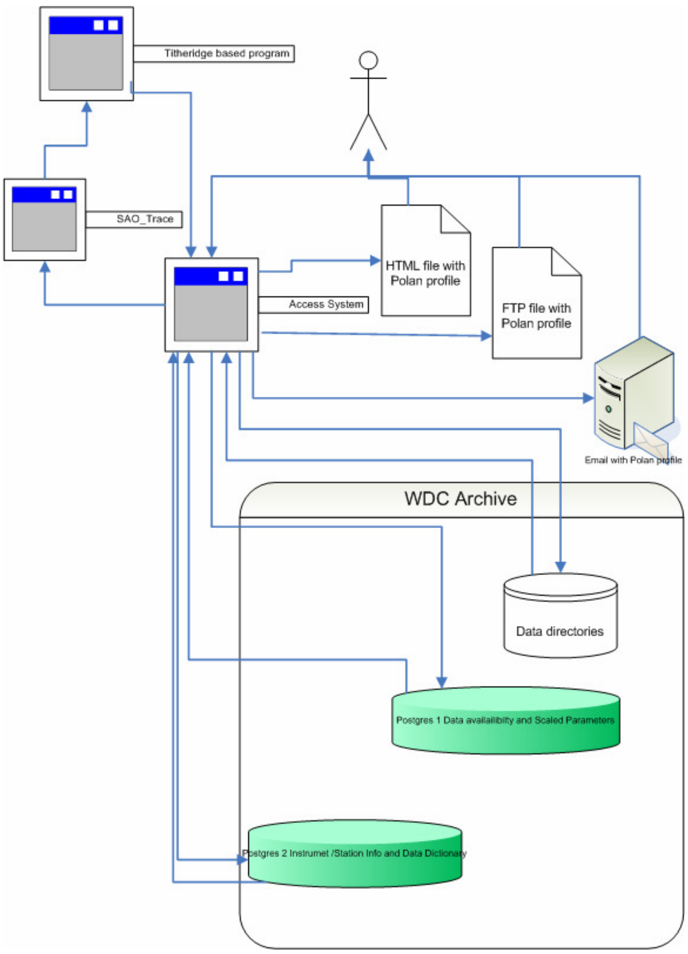


The access system uses perl script to extract the relevant information from the Postgres 1 database and sends the relevant parameters to the F-plot program which plot s the parameters creates an image of the plot. This is returned to the access system which creates an html file sent to users browser, by ftp or via e-mail.

The F-plot program was written at by the WDC at RAL. This program merely represents the data in graphical format and does not perform any processing on the data.

No real preservation issues only mode of retrieval needs to be preserved as the plot program written in IDL is very basic and it was felt it was not really worth preserving

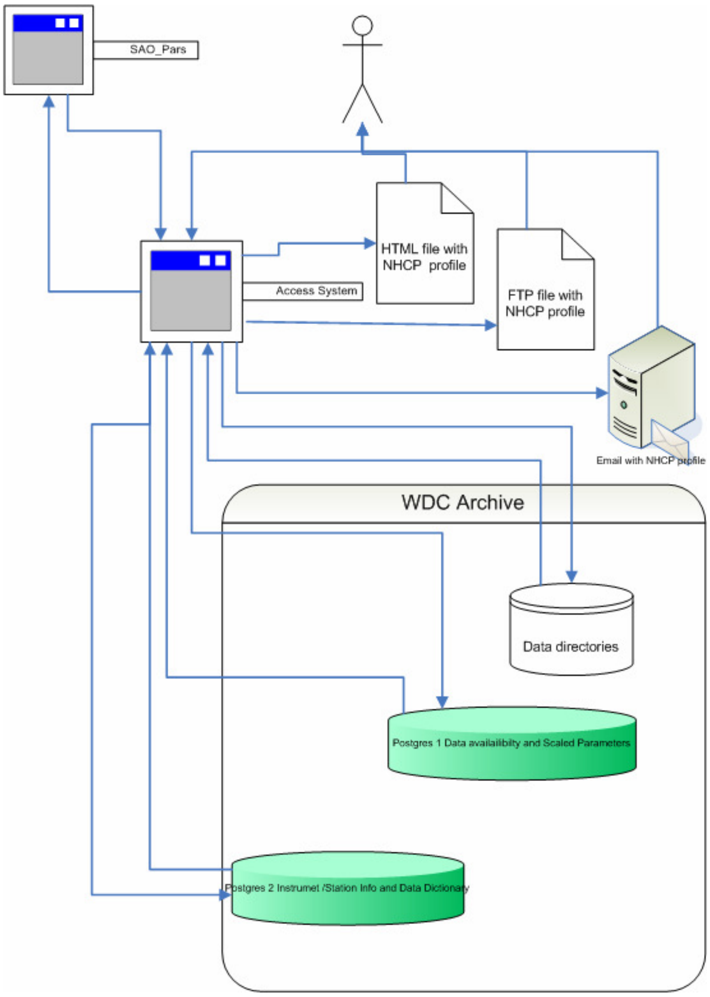
Autoscaled POLAN height profiles



The access system uses Perl script to extract the relevant information from the Postgres 1 database. This identifies the correct SAO file within the data directories. The SAO file is sends the relevant SAO_file to the SAO_Trace (written in C)program(developed by WDC at RAL) which extract the relevant trace values from the SAO. These values are then inputted to the POLAN program which performs a TRUE height analysis (please see appendix I for further detail). The core of the POLAN program (FORTRAN) was developed by John Titheridge and is the public domain. The WDC "wrapped" this program in order to produce the POLAN profiles "on the fly". This program runs on a HP alpha digital server running 264 UNIX .These profiles values are returned to the access system which creates an html file sent to user's browser, by ftp or via e-mail.

This software would either need to be be preserved with accompanying explanatory note e.g. World Data Centre – Ionogram Analysis with Generalised program POLAN December 1985 or supportive documentation to allow for manual extraction and analysis

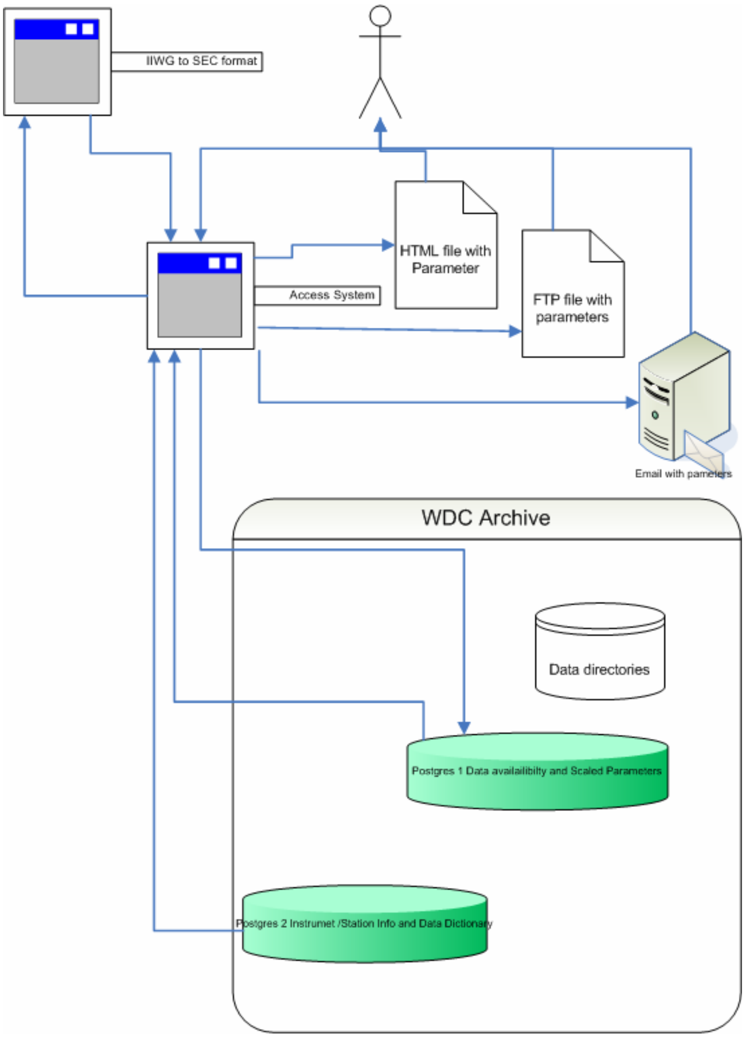
Autoscaled NHPC height profiles



The access system uses Perl script to extract the relevant information from the Postgres 1 database. This identifies the correct SAO file within the data directories. The SAO file is sends the relevant SAO_file to the SAO_pars (developed by WDC at RAL written in C) program which extract the relevant NCHP values from the SAO file. These values are then returned to the access system which creates an html file sent to user's browser, by ftp or via e-mail.

SAO pars would need to preserved or supporting documentation written to allow manually extract of the NHCP profile

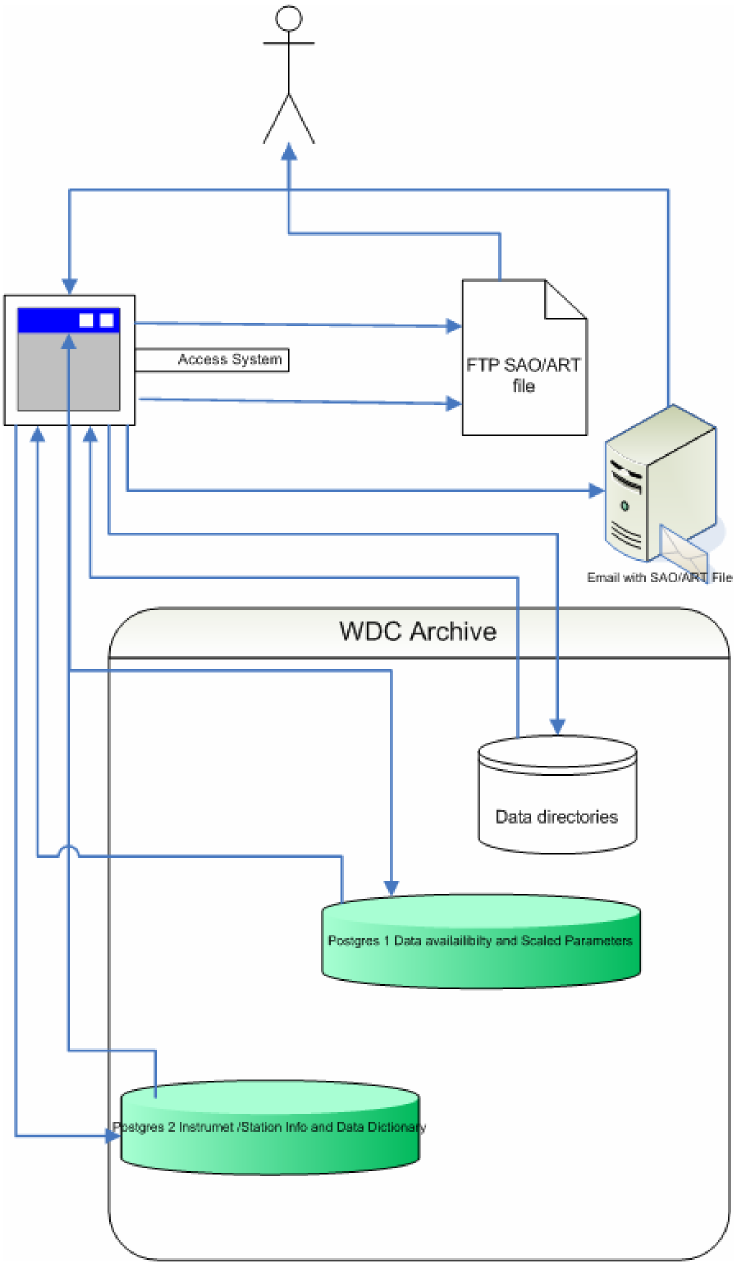
Autoscaled Parameters Sec Style



The access system uses Perl script to extract the relevant information from the Postgres 1 database. This is sent to a program for reformatting no transformation is carried out on the data, which is returned the information in an html file to users browser by ftp or via e-mail.

Either the software to extract correct parameters (perl script written in house) needs to be preserved or documentation on how to extract the correct parameters (see appendix A) along with addition information to reformat to SEC style

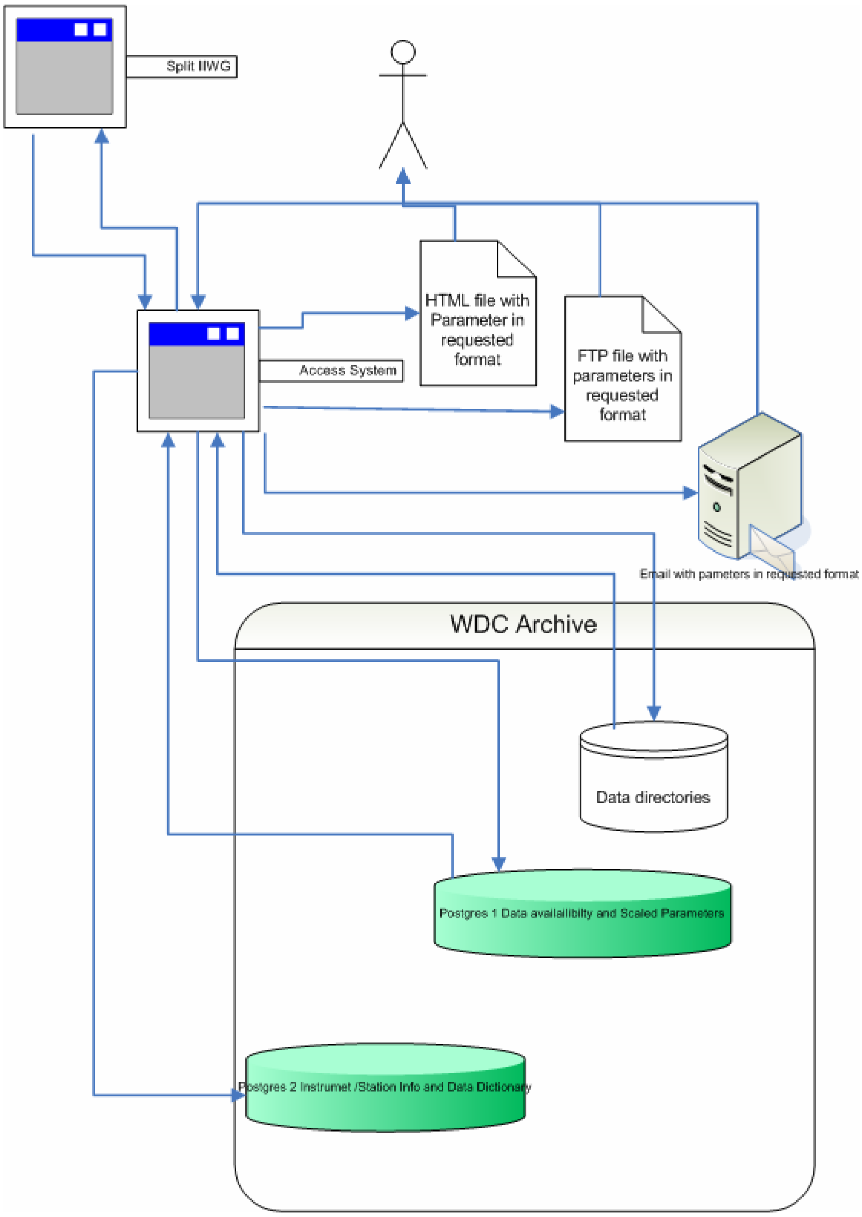
Autoscaled File Download



The access system uses Perl script to extract the relevant information from the Postgres 1 & 2 databases. This identifies the correct SAO file within the data directories. The SAO file is sends the relevant SAO_file .This file is then returned to the access system which creates an html file sent to user's via e-mail.

No real preservation issues only mode of retrieval needs to be preserved

Manual Parameter Data

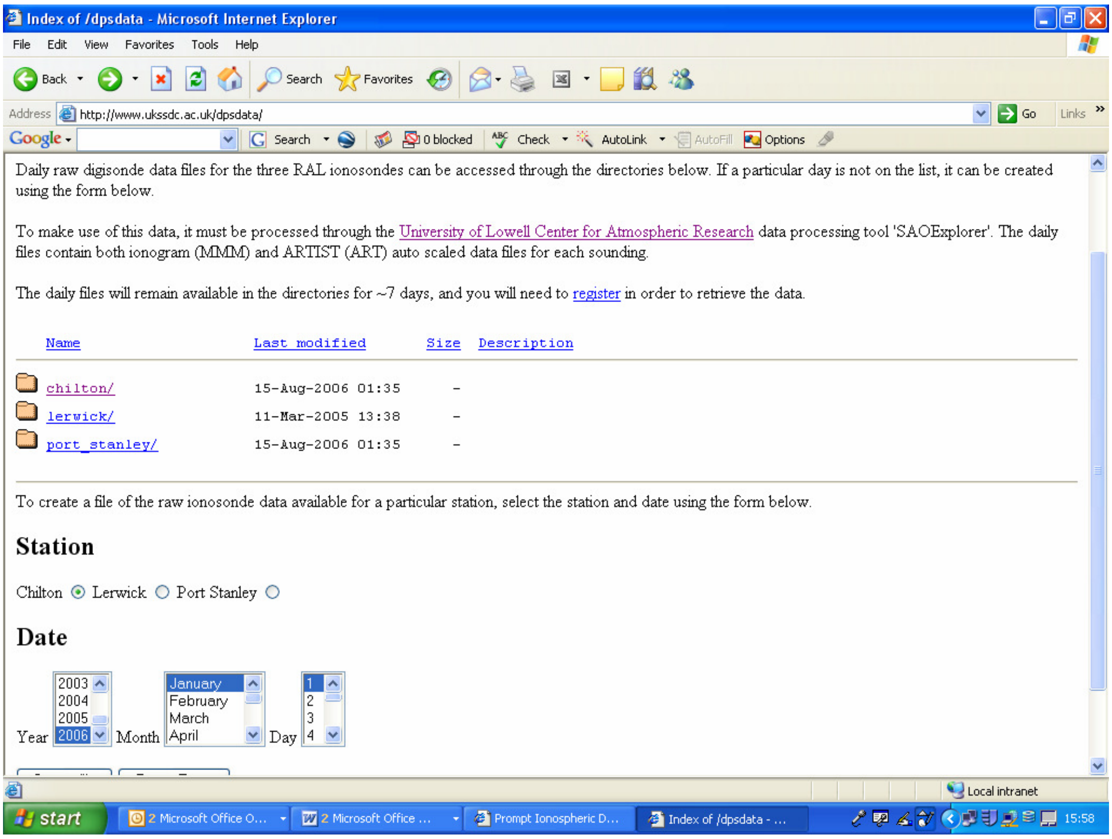


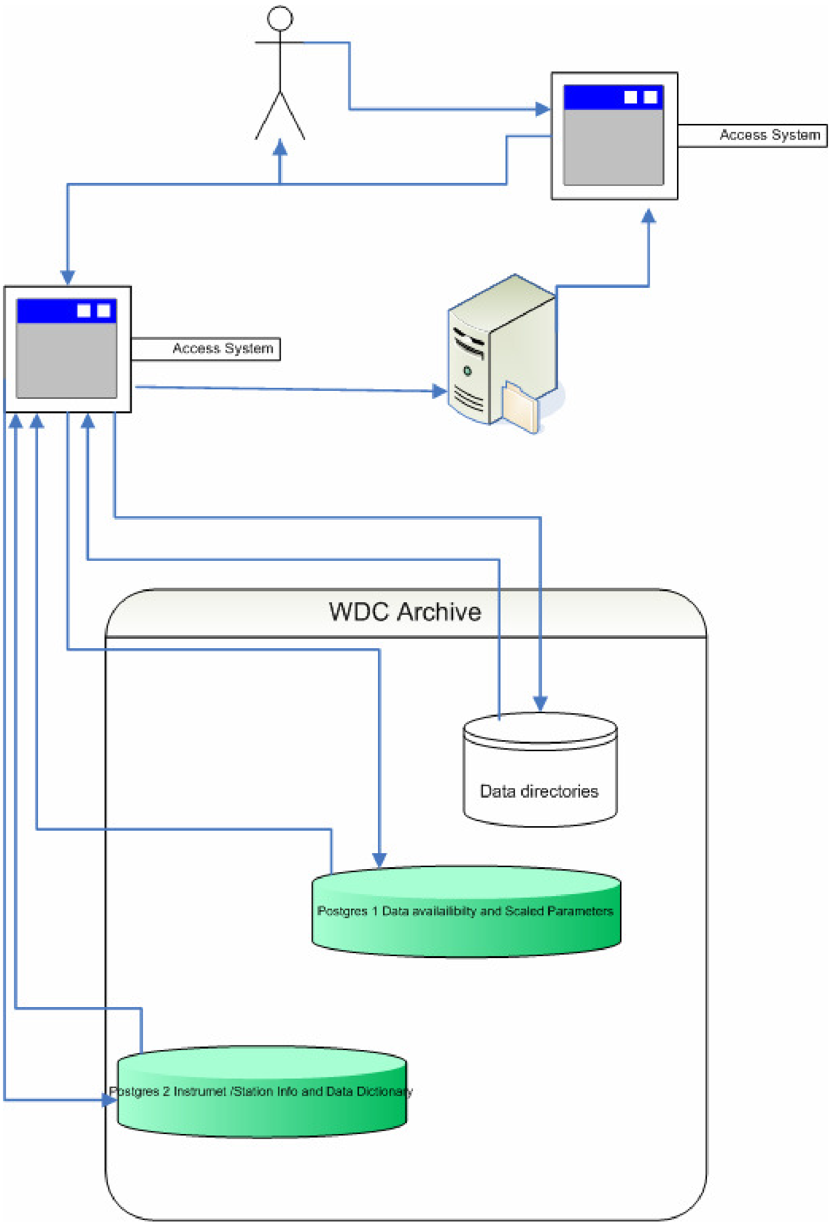
The access system uses Perl script to extract the relevant information from the Postgres 1 & 2 databases and returns the information in an html file to users browser by ftp or via e-mail.

No real preservation issues only mode of retrieval needs to be preserved

Raw Data Files

Raw data files can additionally be download by specifying the station and time and downloaded





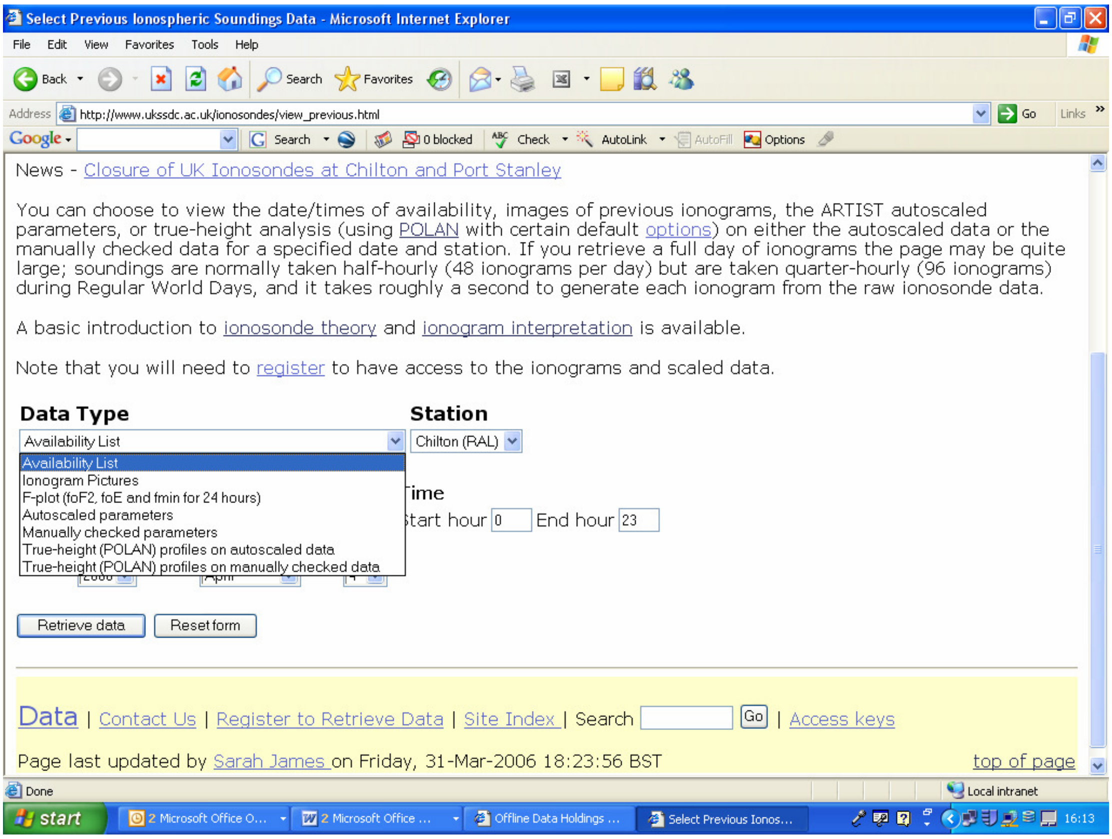
The access system uses Perl script to extract the relevant information from the Postgres 1 database. This identifies the correct files within the data directories. The files are placed on a temporary cache on a file server .By returning to the original access screen the requested then are available to download form the appropriate directory.

No real preservation issues only mode of retrieval needs to be preserved

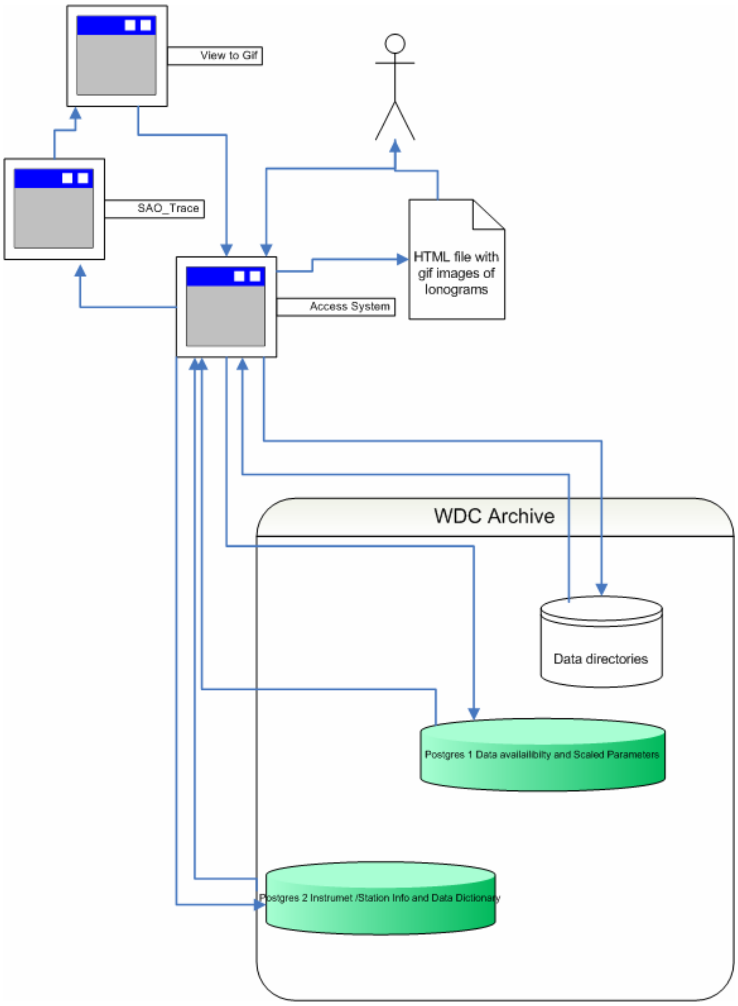
Recent Ionsonde products

It is also possible to select recent Ionosonde digital products for 7 different stations based on date.

- Ionogram Pictures
- F-plot
- Autoscaled Parameters
- Manually Checked Parameters
- True height (POLAN) profiles on autoscaled data
- True height (POLAN) profiles on manually scaled data



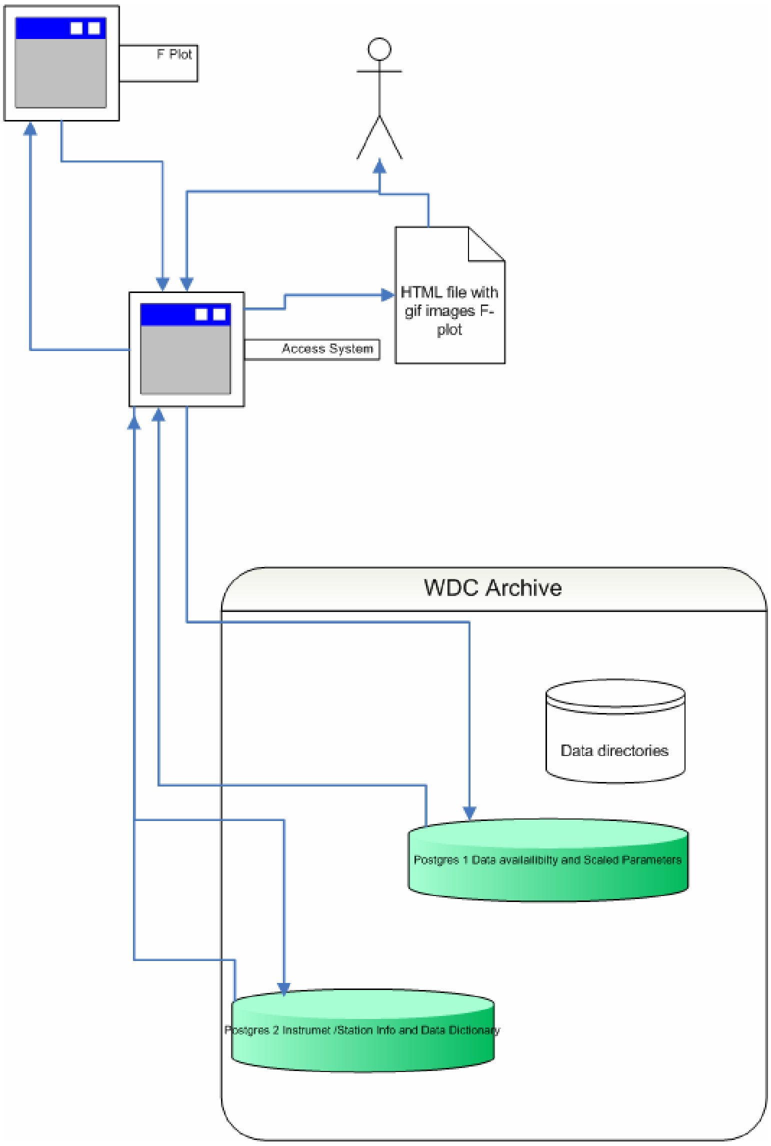
Ionogram Pictures



The access system uses Perl script to extract the relevant information from the Postgres 1 & 2 databases . This identifies the correct SAO file within the data directories. The SAO file is sent to the SAO_trace program (written in C and developed by WDC at RAL) which extracts the ionogram data from the mmm and SAO file. This data is sent to the Lowell developed program(C++) view-to gif which produces a gif file.This gif image values are then returned to the access system which creates an html file sent to user's browser, by ftp or via e-mail.

Either the software to extract correct trace values needs to be preserved or documentation on how to extract the correct parameters (see appendix J) along with additional information on how to visually present an ionogram.

F-plot

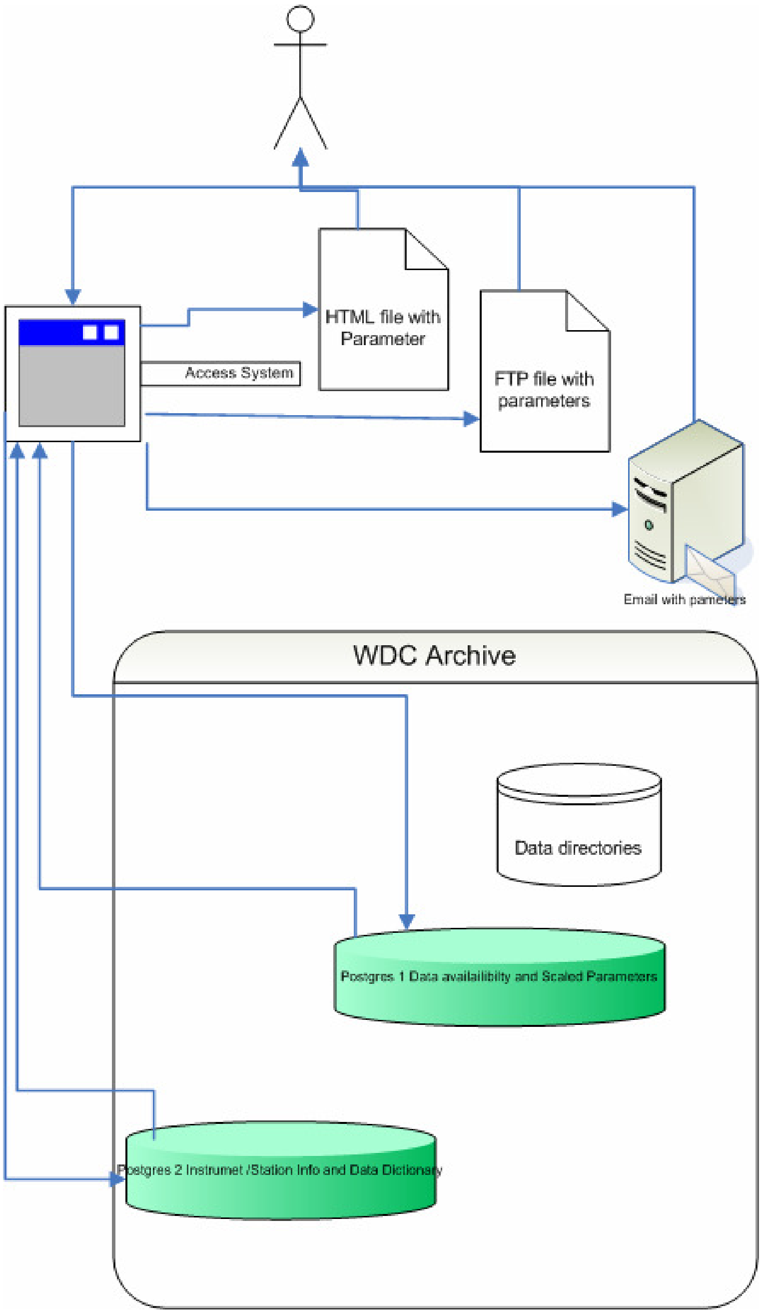


The access system uses perl script to extract the relevant information from the Postgres 1 database and sends the relevant parameters to the F-plot program which plot s the parameters creates an image of the plot. This is returned to the access system which creates an html file sent to users browser, by ftp or via e-mail.

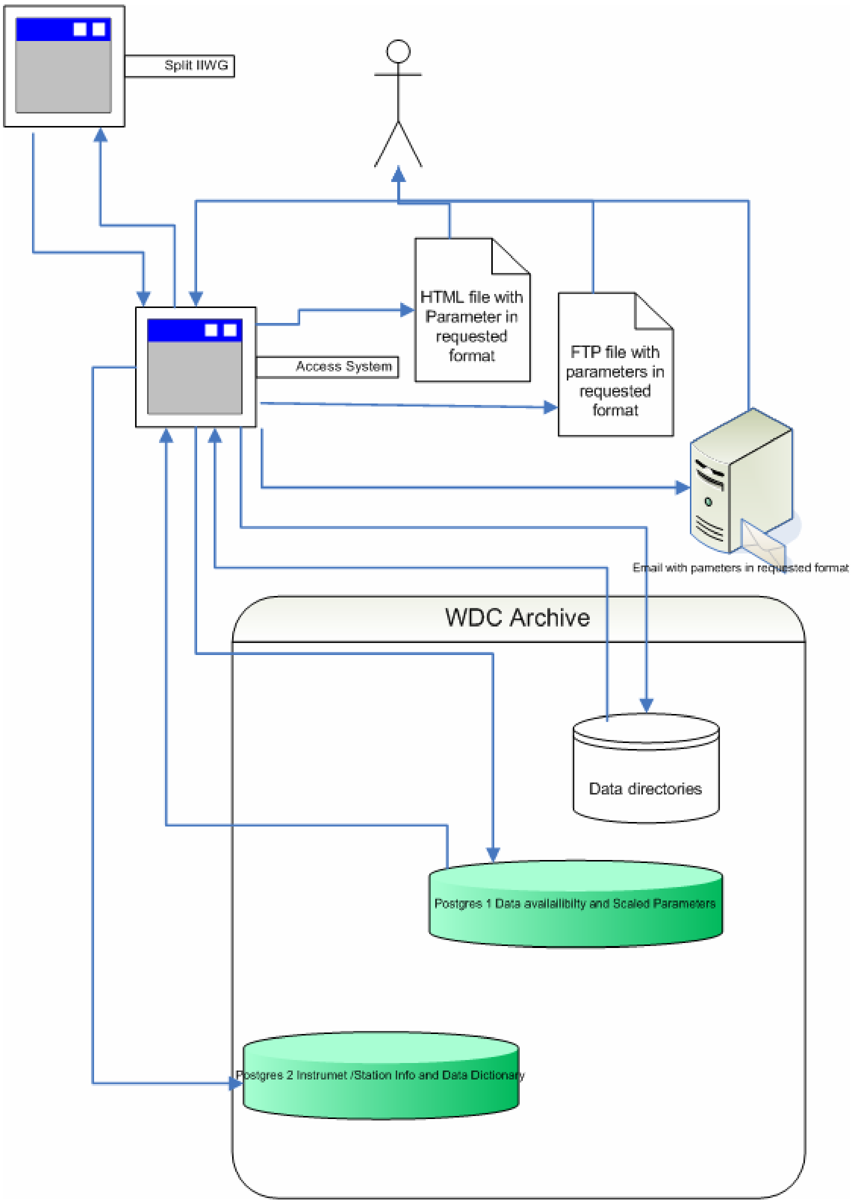
The F-plot program was written at by the WDC at RAL. This program merely represents the data in graphical format and does not perform any processing on the data.

No real preservation issues only mode of retrieval needs to be preserved as the plot program written in IDL is very basic and it was felt it was not really worth preserving

Autoscaled Parameters



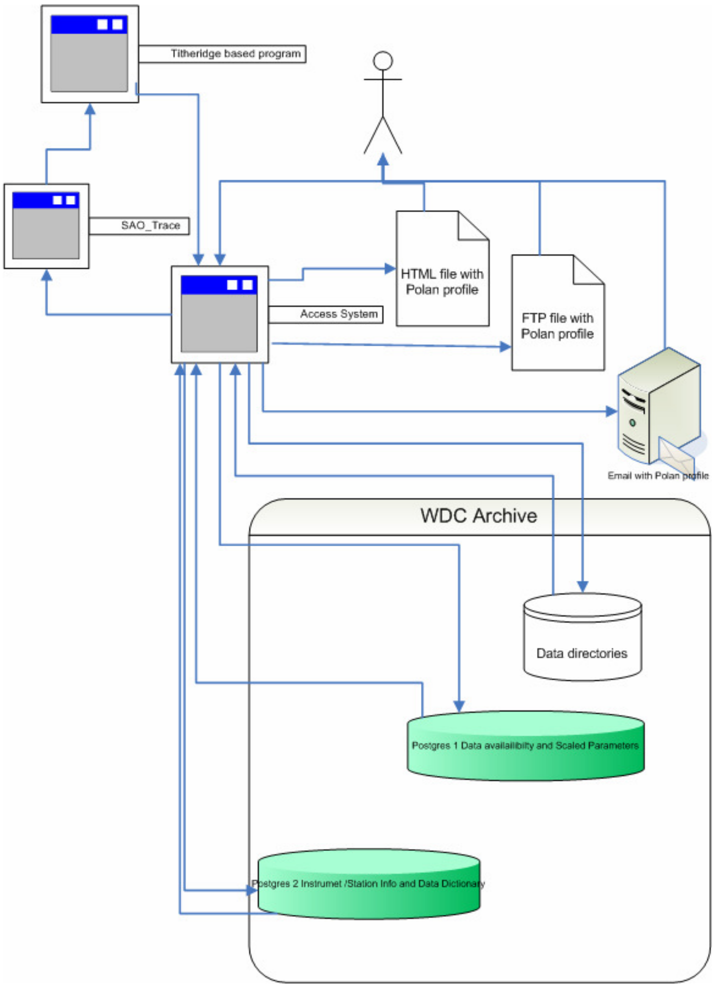
Maually Checked Parameters



The access system uses Perl script to extract the relevant information from the Postgres 1 & 2 databases and returns the information in an html file to users browser by ftp or via e-mail.

No real preservation issues only mode of retrieval needs to be preserved

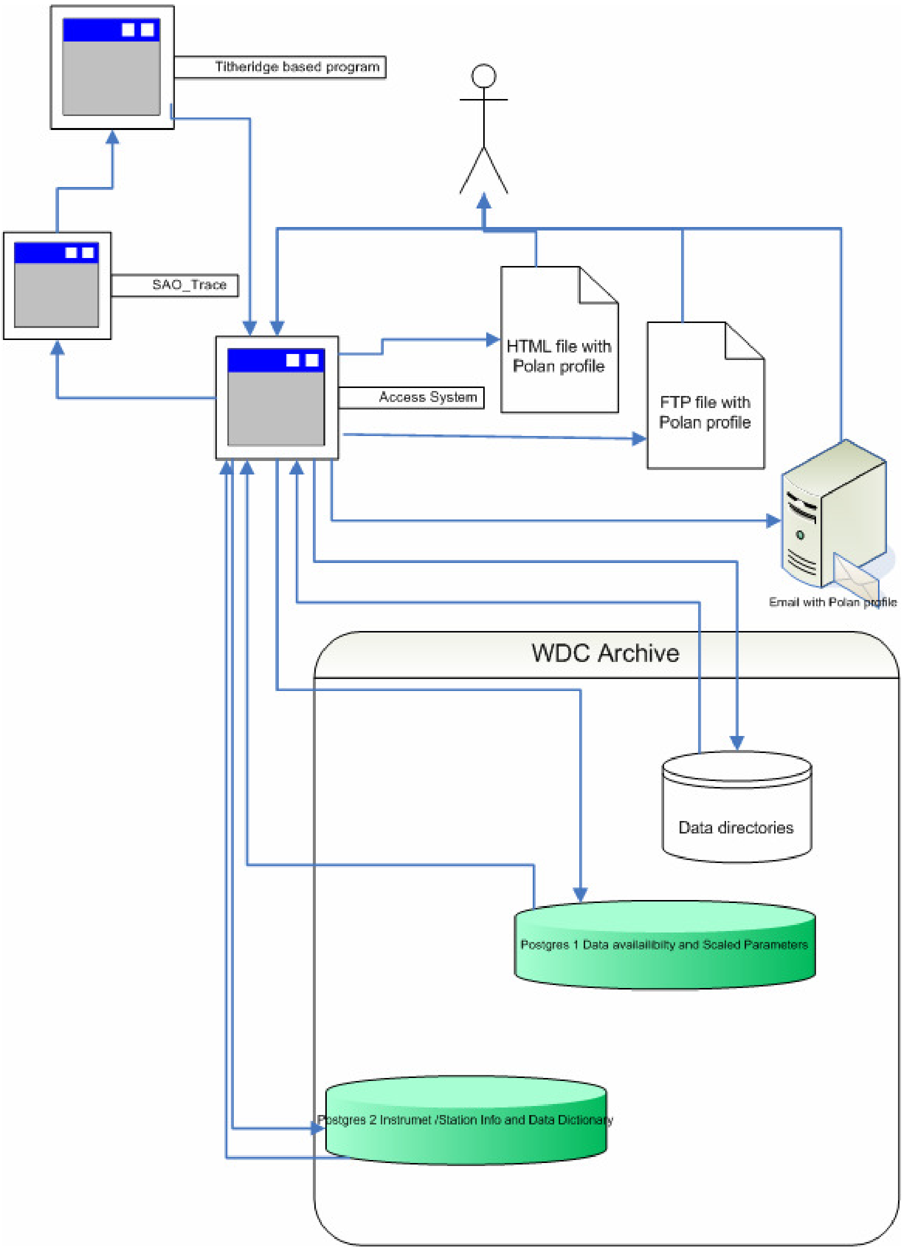
True height (POLAN) profiles on autoscaled data



The access system uses Perl script to extract the relevant information from the Postgres 1 database. This identifies the correct SAO file within the data directories. The SAO file is sends the relevant SAO_file to the SAO_Trace (written in C)program(developed by WDC at RAL) which extract the relevant trace values from the SAO. These values are then inputted to the POLAN program which performs a TRUE height analysis (please see appendix I for further detail). The core of the POLAN program (FORTRAN) was developed by John Titheridge and is the public domain. The WDC "wrapped" this program in order to produce the POLAN profiles "on the fly". This program runs on a HP alpha digital server running 264 UNIX .These profiles values are returned to the access system which creates an html file sent to user's browser, by ftp or via e-mail.

This software would either need to be be preserved with accompanying explanatory note e.g. World Data Centre – Ionogram Analysis with Generalised program POLAN December 1985 or supportive documentation to allow for manual extraction and analysis

True height (POLAN) profiles on manually scaled data



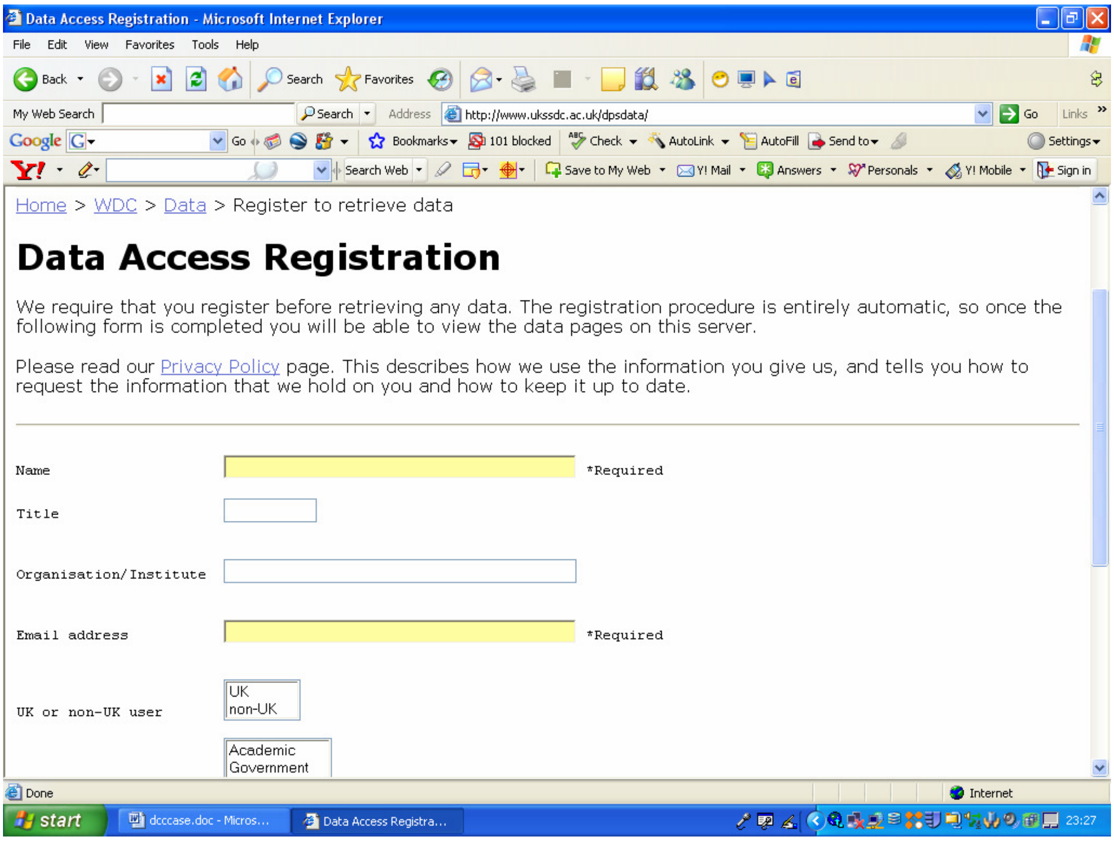
The access system uses Perl script to extract the relevant information from the Postgres 1 database. This identifies the correct SAO file within the data directories. The SAO file is sends the relevant SAO_file to the SAO_pars (developed by WDC at RAL written in C) program which extract the relevant NCHP values from the SAO file. These values are then returned to the access system which creates an html file sent to user's browser, by ftp or via e-mail.

SAO pars would need to preserved or supporting documentation written to allow manually extract of the NHCP profile

Are there any access restrictions?

(1)Are there any restrictions on whom or how you can access or use your data?

None the WDC simply requires the e-mail address of users and maintains an access log based on this



Identify common "domain objects" currently used

In the following section provide a complete listing and desription of the simple digital object the archive provides to the end user.

INSTRUMENT RECORDS

Simple linked HTML pages containing data and hyperlinks to relevant external sites
As below information as below

Instrument Description
Ionosonde, Digital : AE42L

Station Name
Alice Springs
Geodetic Latitude, Longitude
-24.000, 143.000
Operating Institutions
Defence Science and Technology Organization
Instrument or Data Providing Groups
ULCAR - University of Lowell Center for Atmospheric Research
Status
Currently operating
Contact Person
Dr Bruce Ward

Institution Details
Defence Science and Technology Organization

Australia
Website :http://www.dsto.defence.gov.au/
Group Details
ULCAR - University of Lowell Center for Atmospheric Research

Contact person
Web Page

Contact Details
Dr Bruce Ward

Defence Science and Technology Organization
Australia
E-mail : bruce.ward@dsto.defence.gov.au

DATA AVAILABILITY LISTINGS

Tables of Data in an HTML page

Chilton (RL052) (51.60N, 358.70E) availability between 1965 and 1969

YYYY MM Parameters

1965 1 no data available
1965 2 no data available
1965 3 no data available
1965 4 no data available
1965 5 no data available
1965 6 no data available
1965 7 no data available
1965 8 no data available
1965 9 no data available
1965 10 no data available
1965 11 no data available
1965 12 no data available

Slough (SL051) (51.51N, 359.40E) availability between 1965 and 1969

YYYY MM Parameters

1965 1 00 03 04 10 13 16 20 24 30 32 34 42
1965 2 00 03 04 10 13 16 20 24 30 32 34 42
1965 3 00 03 04 10 13 16 20 24 30 32 34 42
1965 4 00 03 04 10 13 16 20 24 30 32 34 42
1965 5 00 03 04 10 13 16 20 24 30 32 34 42
1965 6 00 03 04 10 13 16 20 24 30 32 34 42
1965 7 00 03 04 10 13 16 20 24 30 32 34 42
1965 8 00 03 04 10 13 16 20 24 30 32 34 42
1965 9 00 03 04 10 13 16 20 24 30 32 34 42
1965 10 00 03 04 10 13 16 20 24 30 32 34 42
1965 11 00 03 04 10 13 16 20 24 30 32 34 42
1965 12 00 03 16 20 24 30 32 34 42

(truncated)

IIWG PARAMETERS

IIWG formatted parameters are presented in an HTML
Ionosonde Data Retrieval Results
Legacy data search is: off
Chilton (RL052) : 1975-01 to 1977-01
No data.
Slough (SL051) : 1975-01 to 1977-01
SLOUGH SL051 0 51.5359.4 Manual Edited
1975 1 31 2 744 24 24 24 24 24 24 24 24 24 24 24 24 24 24 24 24 24
24 24 24 24 24 24 24 24
24 24 24 24 24 24
foF2 M3000F2
0.1 MHz 0.01
0003
00000 10000 20000 30000 40000 50000 60000 70000 80000
900001000001100001200001300001400001500001600001700001800001900000
2000002100002200002300000 00000 10000 20000 30000 40000 50000 60000 70000
80000 9000010000011000012000013000014000015000O
1600001700001800001900002000002100002200002300000 00000 10000 20000
30000 40000 50000 60000 70000 80000 900001000001100000
1200001300001400001500001600001700001800001900002000002100002200000230
000 00000 10000 20000 30000 40000 50000 60000 70000

(truncated)

FILE AVAILABILITY

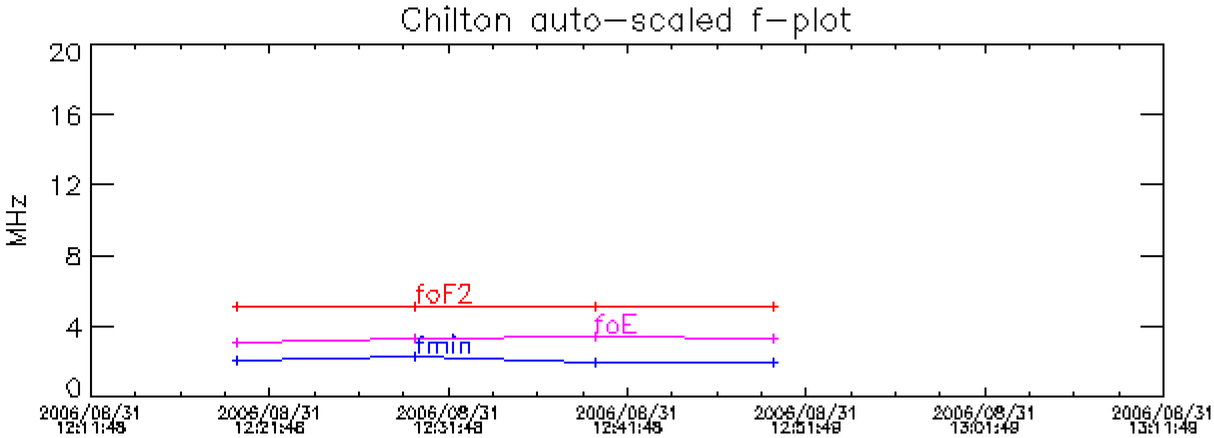
Date	Name	Files
2006-08-31 12:10:00	Chilton	RL052_2006243121000.ART,RL052_2006243121000.MMM,RL052_2006243121000.SAO
2006-08-31 12:20:00	Chilton	RL052_2006243122000.ART,RL052_2006243122000.MMM,RL052_2006243122000.SAO
2006-08-31 12:30:00	Chilton	RL052_2006243123000.ART,RL052_2006243123000.MMM,RL052_2006243123000.SAO
2006-08-31 12:40:00	Chilton	RL052_2006243124000.ART,RL052_2006243124000.MMM,RL052_2006243124000.SAO
2006-08-31 12:50:00	Chilton	RL052_2006243125000.ART,RL052_2006243125000.MMM,RL052_2006243125000.SAO

AUTOSCALED PARAMETERS

Timestamp	Station	foF2	foF1	MF2	MUFF2	fmin	foEs	fminF	fminE	foE	fxI	h'F	h'F2	h'E	h'Es	fh'F	fh'F2
2006-08-31 12:20:00	Chilton	5.06	4.27	3.046	15.38	2.05	4.00	3.45	2.05	3.06	5.75	210	360	95	100	3.45	4.50
2006-08-31 12:30:00	Chilton	5.17	4.17	3.143	16.19	2.25	4.10	3.60	2.25	3.26	5.85	240	335	95	105	3.60	4.55
2006-08-31 12:40:00	Chilton	5.12	4.17	3.267	16.66	1.95	3.70	3.45	1.95	3.41	5.80	205	326	95	115	3.45	4.50
2006-08-31 12:50:00	Chilton	5.12	4.17	3.115	15.89	1.95	3.75	3.75	1.95	3.31	5.80	225	336	95	105	3.75	4.40

(truncated)

AUTOSCALED PARAMETER PLOT



POLAN height profiles

```
Chilton (rl052): 2006-08-31 12:20:00
 freq height
  MHz    km

0*****reduce: data error at f, h =   2.100  95.000   2.150  94.996
2.200  94.992
 Peak  3.076 (+/-0.043) MHz,    Height 102.6 (+/- 0.5) km.    Scale
Height  6.3 (+/- 1.1) km.     Slab (to peak) =   6.5 km.
  2  valley   9.9 km wide,   0.03 MHz deep.       devn  1.30 km
7 terms fitting  7 O + 0 X rays  + 4        hx = 128.3
 Peak  5.093 (+/-0.017) MHz,    Height 243.2 (+/- 1.5) km.    Scale
Height 49.7 (+/- 2.3) km.     Slab (to peak) =  97.6 km.
 0.50  95.00
 1.27  95.00
 2.05  95.00
 2.10  95.00
 2.15  95.00
 2.20  95.02
 2.30  95.27
 2.35  95.46
 2.40  95.62
 2.45  95.75
 2.50  95.92
 2.55  96.19
 2.60  96.50
```

(truncated)

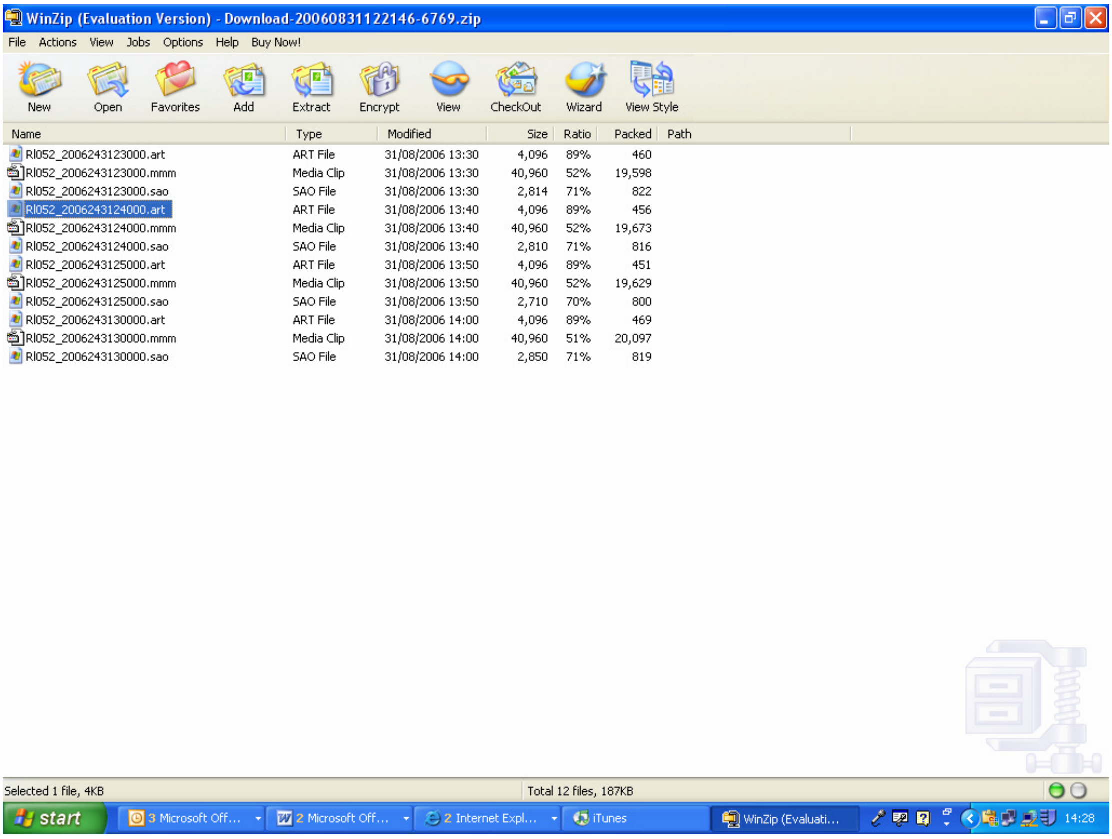
AUTOSCALED NHPC HEIGHT PROFILES

Autoscaled Parameters Sec Style

```
:Product:
cost_database.pl?retrieve=Retrieve%20data;ursi=at138;syear=1995;smont
h=8;sday=25;shour=0;sminute=0;ssecond=0;eyear=1995;emonth=8;eday=31;e
hour=23;eminute=59;esecond=59;datetype=recent;recent=60;repeat=no;off
set=60;type=SEC;sort=Time;destination=Browser
:Issued: 2006 Aug 31 1320 UT
# Prepared by the WDC for STP, Chilton
# Please send comments and suggestions to wdc@www.wdc.rl.ac.uk
#
# Units for foF2, MUF(D), foEs, foE, fMUF, & fbEs = MHz
# Units for yF2, D, hmE, h'F & hmF2 = km
# Units for TEC = 10^16 el/m^2
# Missing data: -1.0,-1,-1.00
#
#       Real-Time Ionosonde Data
#       Athens
#
# UT Date   Time
# YR MO DA  HHMM    foF2 hmF2 M(D)   D  h'F yF2 fMUF  h'  fxI foF1
foE hmE foEs fbEs  ITEC
#---------------------------------------------------------------------
-----------------------
2006  8 30  0000    -1.0  -1 -1.00 3000  -1  -1 -1.0  -1 -1.0 -1.0 -
1.0  -1  3.8 -1.0  -1.0
2006  8 30  0100     3.2  -1  3.21 3000 335  -1 -1.0  -1 -1.0 -1.0 -
1.0  -1  3.2 -1.0  -1.0
2006  8 30  0200     3.0  -1  3.15 3000 262  -1 -1.0  -1 -1.0 -1.0 -
1.0  -1 -1.0 -1.0  -1.0
2006  8 30  0300     2.9  -1  3.16 3000 310  -1 -1.0  -1 -1.0 -1.0 -
1.0  -1 -1.0 -1.0  -1.0
2006  8 30  0400     3.8  -1  3.37 3000 258  -1 -1.0  -1 -1.0 -1.0 -
1.0  -1 -1.0 -1.0  -1.0
2006  8 30  0500     4.7  -1  3.72 3000 222  -1 -1.0  -1 -1.0 -1.0 -
1.0  -1 -1.0 -1.0  -1.0
2006  8 30  0600    -1.0  -1 -1.00 3000  -1  -1 -1.0  -1 -1.0 -1.0 -
1.0  -1  4.5 -1.0  -1.0
2006  8 30  0700     5.5  -1  3.31 3000 306  -1 -1.0  -1 -1.0 -1.0 -
1.0  -1  5.2 -1.0  -1.0
2006  8 30  0800    -1.0  -1 -1.00 3000  -1  -1 -1.0  -1 -1.0 -1.0 -
1.0  -1  5.6 -1.0  -1.0
2006  8 30  0900     5.5  -1  3.52 3000 310  -1 -1.0  -1 -1.0  4.5 -
1.0  -1  4.2 -1.0  -1.0
2006  8 30  1000     5.7  -1  3.22 3000 320  -1 -1.0  -1 -1.0 -1.0 -
1.0  -1 -1.0 -1.0  -1.0
2006  8 30  1100    -1.0  -1 -1.00 3000  -1  -1 -1.0  -1 -1.0 -1.0 -
```

(truncated)

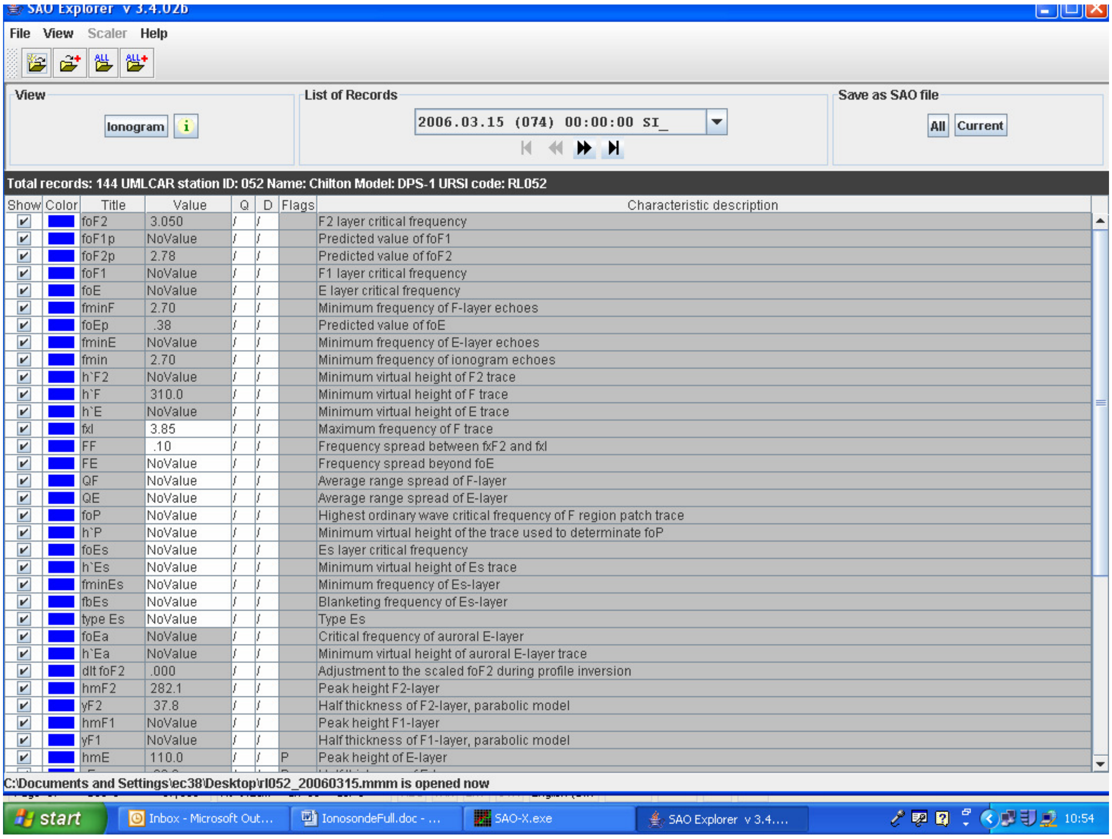
AUTOSCALED FILE DOWNLOAD AND RAW DATA



SAO EXPLORER

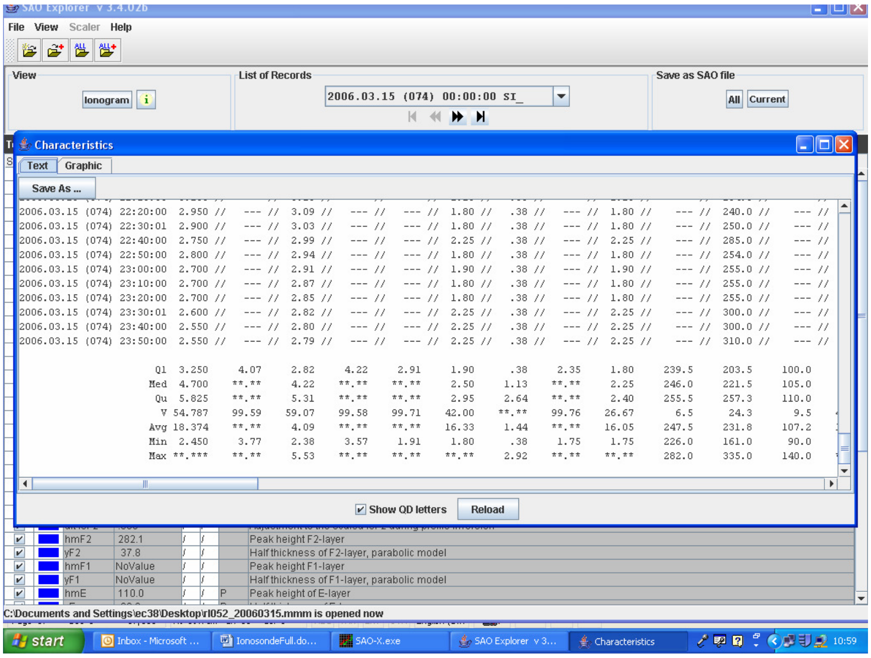
http://ulcar.uml.edu/SAO-X/SAO-X.html
http://ulcar.uml.edu/SAO-X/UsersGuide.html

The following digital object are produce by the SAO explorer

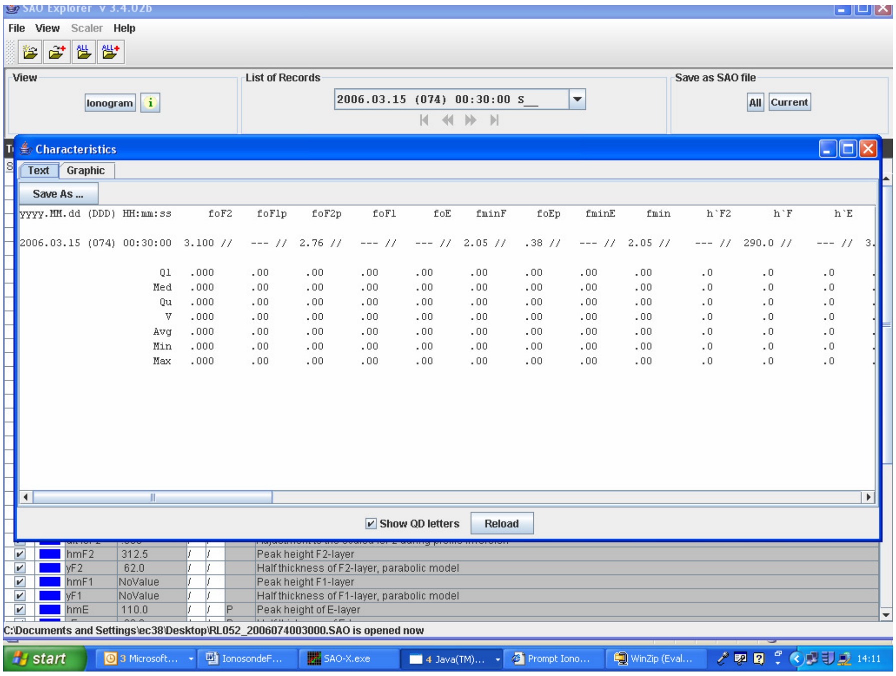


Characteristics: text and graphic representation of time series of the ionospheric characteristics.

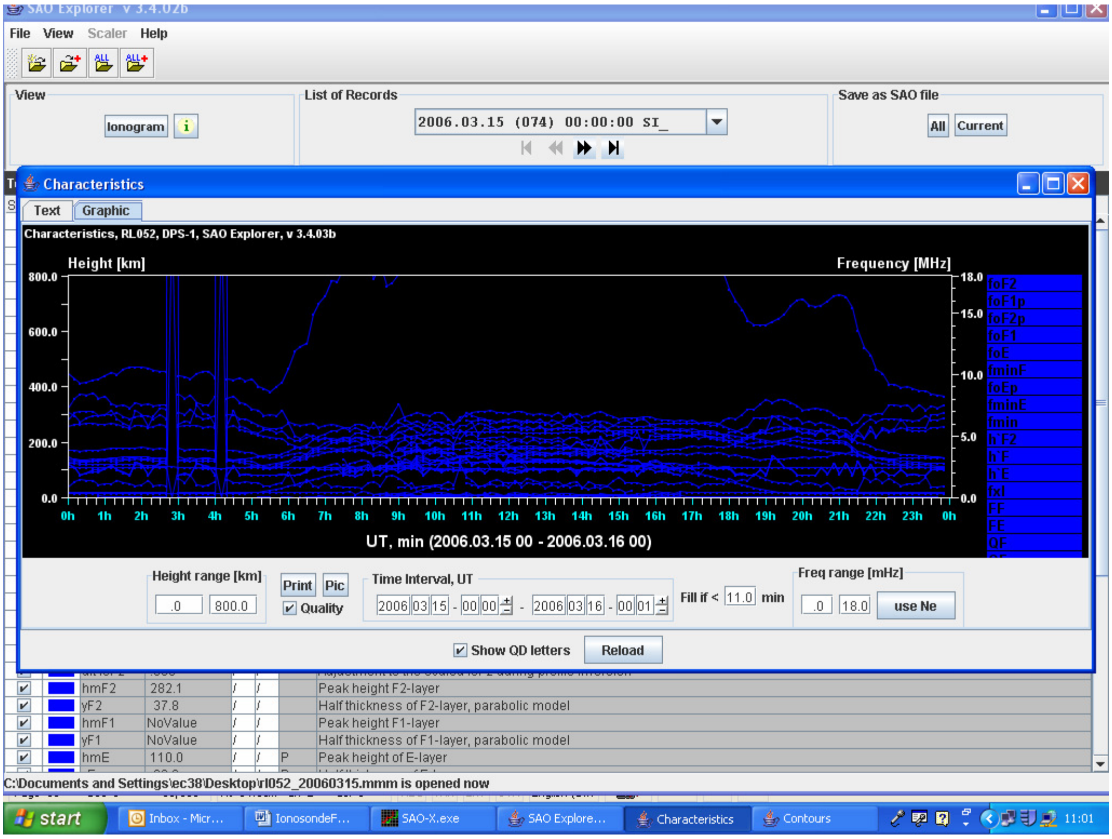
MMM file



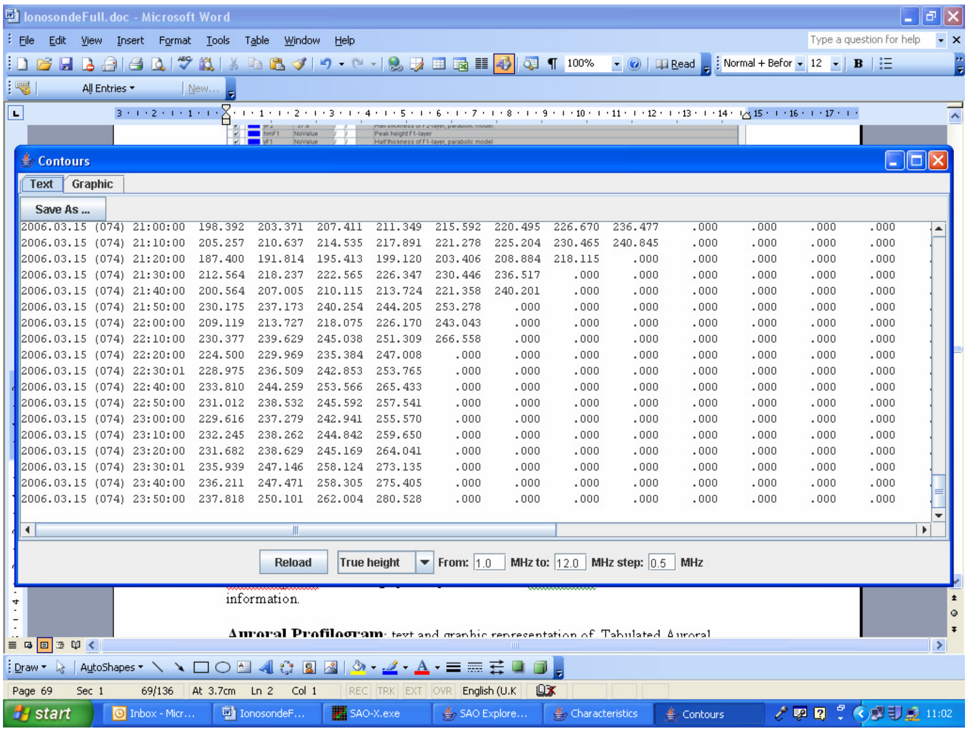
SAO file



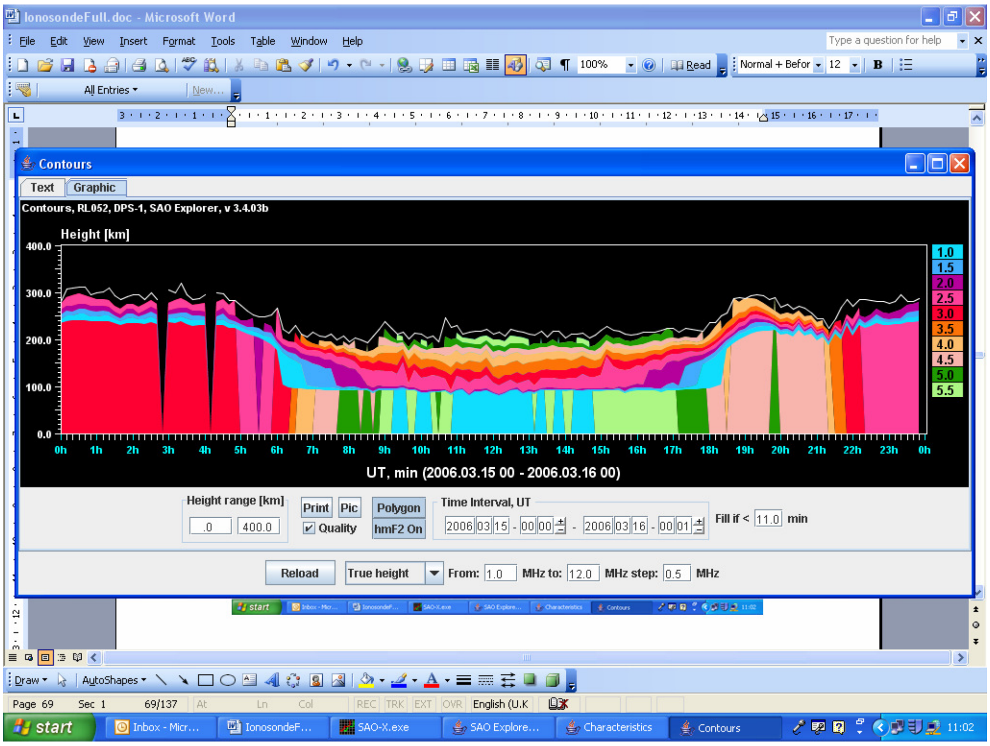
Graphic MMM file



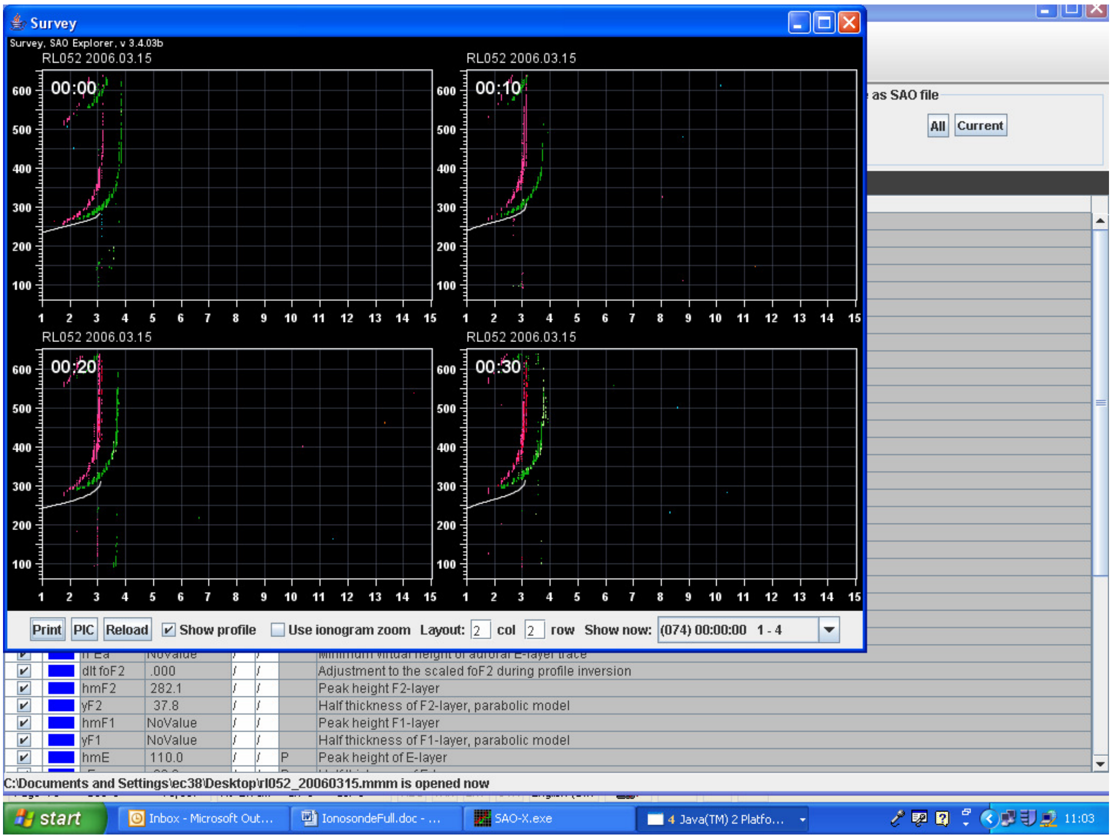
Contour: text and graphic representation of electron density profile contours.

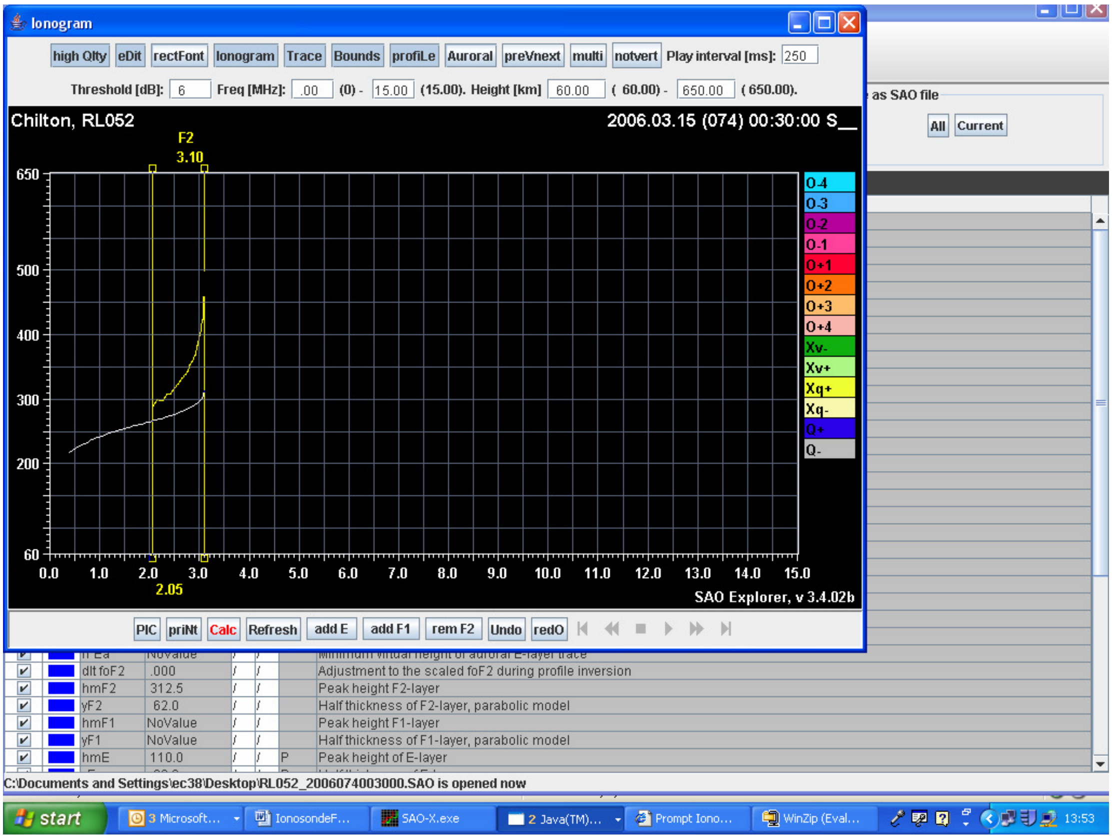


2006.03.15	(074)	21:00:00	198.392	203.371	207.411	211.349	215.592	220.495	226.670	236.477	.000	.000	.000	.000
2006.03.15	(074)	21:10:00	205.257	210.637	214.535	217.891	221.278	225.204	230.465	240.845	.000	.000	.000	.000
2006.03.15	(074)	21:20:00	187.400	191.814	195.413	199.120	203.406	208.884	218.115	.000	.000	.000	.000	.000
2006.03.15	(074)	21:30:00	212.564	218.237	222.565	226.347	230.446	236.517	.000	.000	.000	.000	.000	.000
2006.03.15	(074)	21:40:00	200.564	207.005	210.115	213.724	221.358	240.201	.000	.000	.000	.000	.000	.000
2006.03.15	(074)	21:50:00	230.175	237.173	240.254	244.205	253.278	.000	.000	.000	.000	.000	.000	.000
2006.03.15	(074)	22:00:00	209.119	213.727	218.075	226.170	243.043	.000	.000	.000	.000	.000	.000	.000
2006.03.15	(074)	22:10:00	230.377	239.629	245.038	251.309	266.558	.000	.000	.000	.000	.000	.000	.000
2006.03.15	(074)	22:20:00	224.500	229.969	235.384	247.008	.000	.000	.000	.000	.000	.000	.000	.000
2006.03.15	(074)	22:30:01	228.975	236.509	242.853	253.765	.000	.000	.000	.000	.000	.000	.000	.000
2006.03.15	(074)	22:40:00	233.810	244.259	253.566	265.433	.000	.000	.000	.000	.000	.000	.000	.000
2006.03.15	(074)	22:50:00	231.012	238.532	245.592	257.541	.000	.000	.000	.000	.000	.000	.000	.000
2006.03.15	(074)	23:00:00	229.616	237.279	242.941	255.570	.000	.000	.000	.000	.000	.000	.000	.000
2006.03.15	(074)	23:10:00	232.245	238.262	244.842	259.650	.000	.000	.000	.000	.000	.000	.000	.000
2006.03.15	(074)	23:20:00	231.682	238.629	245.169	264.041	.000	.000	.000	.000	.000	.000	.000	.000
2006.03.15	(074)	23:30:01	235.939	247.146	258.124	273.135	.000	.000	.000	.000	.000	.000	.000	.000
2006.03.15	(074)	23:40:00	236.211	247.471	258.305	275.405	.000	.000	.000	.000	.000	.000	.000	.000
2006.03.15	(074)	23:50:00	237.818	250.101	262.004	280.528	.000	.000	.000	.000	.000	.000	.000	.000



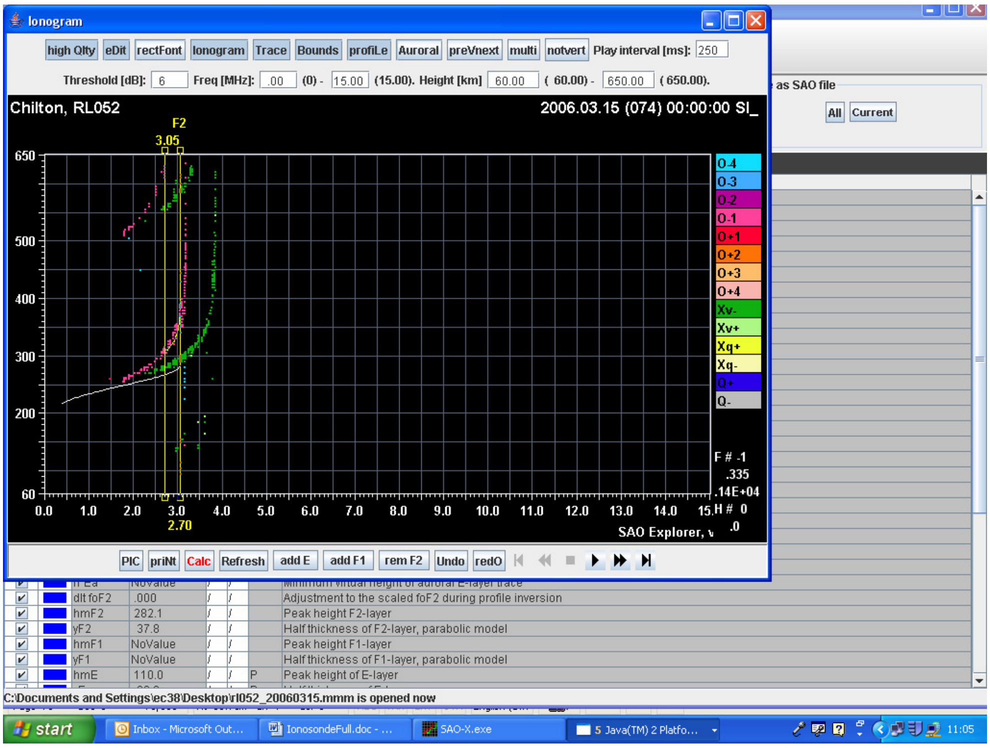
Survey: Ionogram survey screen.



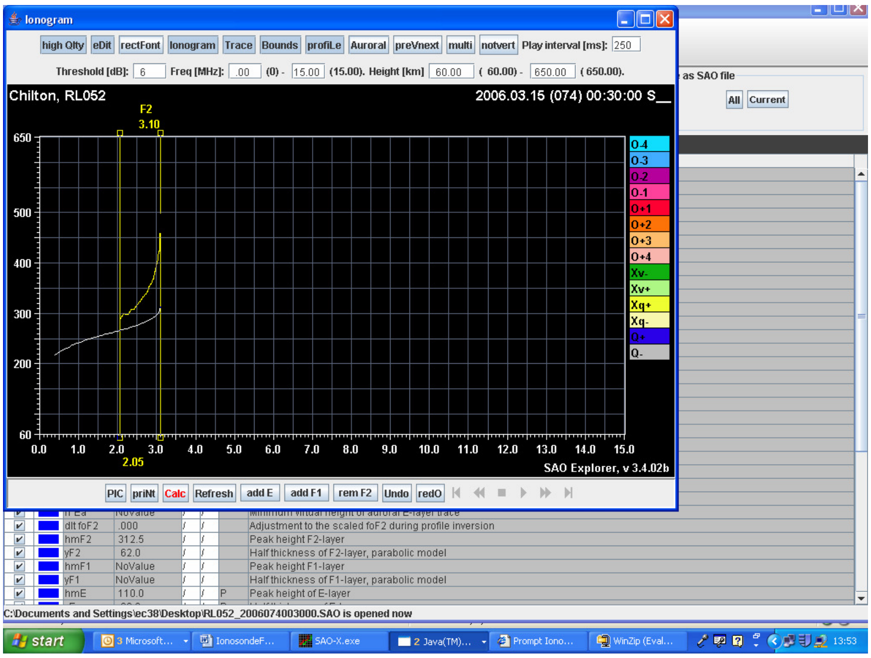

Ionogram
high Qlty eDit rectFont Ionogram Trace Bounds profiLe Auroral preVnext multi notvert Play interval [ms]: 250
Threshold [dB]: 6 Freq [MHz]: .00 (0) - 15.00 (15.00). Height [km] 60.00 (60.00) - 650.00 (650.00).
Chilton, RL052
2006.03.15 (074) 00:30:00 S
F2
3.10
2.05
SAO Explorer, v 3.4.02b
PIC priNt Calc Refresh add E add F1 rem F2 Undo redO
as SAO file
All Current
dlt foF2 .000 Adjustment to the scaled foF2 during profile inversion
hmF2 312.5 Peak height F2-layer
yF2 62.0 Half thickness of F2-layer, parabolic model
hmF1 NoValue Peak height F1-layer
yF1 NoValue Half thickness of F1-layer, parabolic model
hmE 110.0 P Peak height of E-layer
C:\Documents and Settings\ec38\Desktop\RL052_2006074003000.SAO is opened now
start
13:53

Ionogram: ionogram display and editor tool

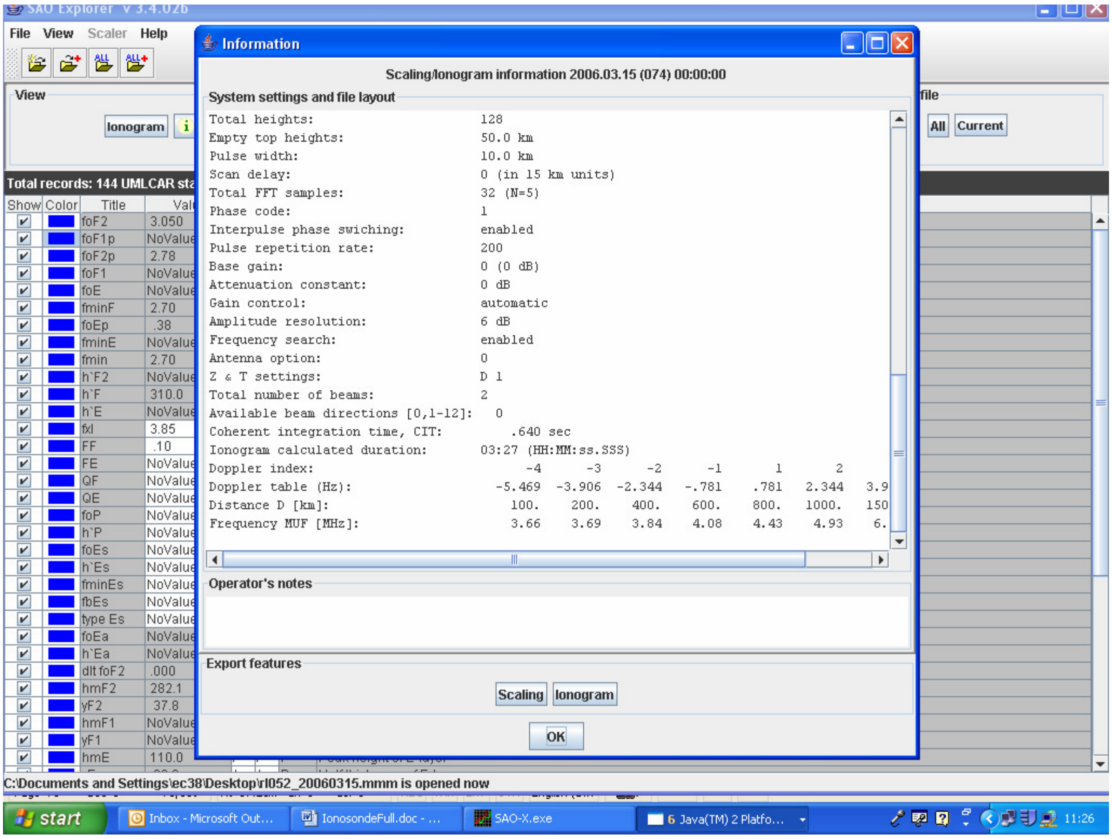
MMM file



SAO File



Info: station constants, related files, Digisonde settings, Geomagnetic info, and other descriptive data.



Are these objects special cases of simpler objects?

For example is the special types of image made up of a "simple" image plus additional simple objects?
A number of Ionospheric models exist in the community. Information on the principal models can be found at the following

URL: http://modelweb.gsfc.nasa.gov/ionos/ionos_index.html

We are initially concentrating on the most significant model the IRI although it was felt a more in depth survey of community software which has knowledge embedded in was required.

The International Reference Ionosphere

The international reference ionosphere is probably the most signifigant of these.
The International Reference Ionosphere (IRI) is an international project sponsored by the Committee on Space Research (COSPAR) and the International Union of Radio Science (URSI). These organizations formed a Working Group (members) in the late sixties to produce an empirical standard model of the ionosphere, based on all available data sources (charter). Several steadily improved editions of the model have been released. For given location, time and date, IRI describes the electron density, electron temperature, ion temperature, and ion composition in the altitude range from about 50 km to about 2000 km; and also the electron content. It provides monthly averages in the non-auroral ionosphere for magnetically quiet conditions. The major data sources are the **worldwide network of ionosondes,** the powerful incoherent scatter radars (Jicamarca, Arecibo, Millstone Hill, Malvern, St. Santin), the ISIS and Alouette topside sounders, and in situ instruments on several satellites and rockets. IRI is updated yearly during special IRI Workshops (e.g., during COSPAR general assembly). More information can be found in the workshop reports. Several extensions are planned, including models for the ion drift, description of the auroral and polar ionosphere, and consideration of magnetic storm effects.

The IRI master copy is held at the National Space Science Data Center (NSSDC) and updated according to the decisions of the Working Group. The software package distributed by NSSDC includes the FORTRAN subroutines, model coefficients (CCIR and URSI), and documentation files. ftp://nssdcftp.gsfc.nasa.gov/models/
The IRI build-up and formulas described in detail in a 158-page NSSDC report (Bilitza, 1990). [*** PDF: pages 0-84, pages 85-end ***]

IRI generated parameters be used to generate maps and movies based on this model Some examples are

- MIT have generated 24 hour global maps for NmF2, hmF2 and TEC http://madrigal.haystack.mit.edu/models/IRI/index.html
- IPS radio and space services produce real time maps for the Total Electron content http://www.ips.gov.au/Satellite/2/1
- The WDC at Kyoto combine information from the IRI with CIRA75 model http://nssdcftp.gsfc.nasa.gov/models/atmospheric/cira/Please_read.txt to produce an Ionospheric conductivity model http://swdcwww.kugi.kyoto-u.ac.jp/ionocond/index.html
- MPEG movies of global maps of IRI density and temperature at the Space Environments Branch of NASA Glenn Research Center

Models and an appreciation of their usefulness, relevancy and accuracy is something that continually evolves. Assessments of these aspects are oftencontained within associated literature and the monitoring of community opinion on model is something that would benefit from monitoring.

Journal List of Advances in Space Research Issues Related to IRI

http://modelweb.gsfc.nasa.gov/ionos/iri/asr_list.html

C. Barth, D. Offermann, K. Labitzke, J. Vette, K. Rawer, and H. Taylor, The Upper Atmosphere of the Earth and Planets, Advances in Space Research, Volume 2, Number 10, 1982.

K. Rawer, C. Minnis, and K. Serafimov, Towards an Improved International Reference Ionosphere, Advances in Space Research, Volume 4, Number 1, 1984.

K. Rawer, C. Minnis, K. Champion, and M. Roemer, Models of the Atmosphere and Ionosphere, Advances in Space Research, Volume 5, Number 7, 1985.

K. Rawer, Y. Ramanamurty, International Reference Ionosphere - Status 1986/87, Advances in Space Research, Volume 5, Number 10, 1985.

K. Rawer and P. Bradley, International Reference Ionosphere - Status 1986/87, Advances in Space Research, Volume 7, Number 6, 1987.

K. Rawer, T. Gulyaeva, and B. Reinisch, Ionospheric Informatics, Advances in Space Research, Volume 8, Number 4, 1988.

K. Rawer and P. Bradley, Ionospheric Informatics and Empirical Modelling, Advances in Space Research, Volume 10, Number 8, 1990.

K. Rawer and W. Piggott, Development of IRI-90, Advances in Space Research, Volume 10, Number 11, 1990.

K. Rawer and W. Piggott, Enlarged Space and Ground Data Base for Ionospheric Modelling, Advances in Space Research, Volume 11, Number 10, 1991.

K. Rawer, W. Piggott, and A. Paul, Advances in Global/Regional Description of Ionospheric Parameters, Advances in Space Research, Volume 13, Number 3, 1993.

D. Bilitza, K. Rawer, and E. Gruen, Ionospheric Models, Advances in Space Research, Volume 14, Number 12, 1994.

K. Rawer, W. Piggott, and A. Paul, Off Median Phenomena and the International Reference Ionosphere, Advances in Space Research, Volume 15, Number 2, 1995.

K. Rawer, D. Bilitza, and W. Singer, The High Latitudes in the International Reference Ionosphere, Advances in Space Research, Volume 16, Number 1, 1995.

K. Rawer, D. Bilitza, K. Mahajan, and A. Mitra, Low and Equatorial Latitudes in the International Reference Ionosphere, Advances in Space Research, Volume 18, Number 6, 1996.

K. Rawer and D. Bilitza, Quantitative Description of Ionospheric Storm Effects and Irregularities, Advances in Space Research, Volume 20, Number 9, 1997.

K. Rawer and P. Bradley, IRI 1997 Symposium: New Developments in Ionospheric Modelling and Prediction, Advances in Space Research, Volume 22, Number 6, 1998.

K. Rawer, D. Bilitza, K. Oyama, and W. Singer, Lower Ionosphere: Maesurements and Models, Advances in Space Research, Volume 25, Number 1, 2000.

K. Rawer, D. Bilitza, B. Reinisch, International Reference Ionosphere - Workshop 1999, Advances in Space Research, Volume 27, Number 1, 2001.

K. Rawer, D. Bilitza, B. Reinisch, Modelling the topside ionosphere and plasmasphere, Advances in Space Research, Volume 29, Number 6, 2002.

Bilitza, D., K. Rawer, B. Reinisch (eds.), Description of the low latitude and equatorial ionosphere in the International Reference Ionosphere, Advances in Space Research, Volume 31, Number 3, 2003.

Bilitza, D., K. Rawer, B. Reinisch (eds.), Path Toward Improved Ionosphere Specification and Forecast Models, Advances in Space Research, Volume 33, Number 6, 2004.

What information is required to reconstruct the information objects or reproduce the performance or duplicate the required behaviour?

Basic assumed knowledge

- Knowledge of the English language
- Undergraduate level physics degree – It was felt that there was little realistic preservation risk to this knowledge as it well documented and supported
- Mathematically literate with ability to perform meaningful statistical analysis on the data set – It was felt that there was little realistic preservation risk to this knowledge as it well documented and supported

Organisational support is provided by the following key groups
CCLRC Ionsonde support group
http://www.wdc.rl.ac.uk/ionosondes/ionosondes.html
IPS http://www.ips.gov.au/
URSI http://www.ursi.org/
UCAR http://www.ucar.edu/

A lot of supporting information is documented in Websites and other forms of publication which is detailed elsewhere in this document. However it was felt that a lot of other support is supplied to users less formally. The full extent, quality, nature and impact of this type of support would be desirable information. Unfortunately the time and resource to explore this avenue further are not available a time. Usage logs and registration kept by RAL would be a good starting point for such an investigation as they indicate the institution that may end users are situated in as would a review of literature resulting from ionospheric data.

Bibliography
The need to create an unbiased bibliography in consultation with key people in the field of Ionospheric Science was strongly felt. The Ionospheric monitoring group based at RAL felt the following people would be most qualified to create such a bibliography

CCLRC based staff
Sarah James
Ruth Bamford
Matthew Wild
Chris Davis
Mike Hapgood
Mike Lockwood

UK based
Les Barclay - Lancaster University
Paul Cannon – Qinetiq
Mark Lester – Leicester University
Mark Warrington – Leicester University

International
Phil Wilkinson – IPS Australia
Bodo Reinisch – University of Masachusetts Lowell

Preservation of key texts
The texts relating contain the mature well established scientific theory. There is a very significant preservation risk with material this material as the majority of it is out of print with no record of numbers/holders of copies or organisational responsibility for preservation. The number of text you would wish to store within the archive is dependant on the depth and breadth of knowledge you are seeking to preserve so it is difficult to provide an estimate of this.

Preservations of organisational Support Materials
Organisational support materials are again a high preservation risk a mechanisms and strategies for digitising storing and cataloguing a wide range of materials which originate from diverse groups would be highly desirable.

Preserving the ability to access key journals
Current end users have become dependent of subscription product such as web of science http://scientific.thomson.com/products/wos/ to locate journal material. This constitutes a significant risk preservation risk ability to preserve such listings along with relevant subject indexing is something that requires further investigation.

Preserving the ability to access copyrighted materials in the future
The WDC is unable to electronically copy store and supply many highly important journal article, scholarly texts and materials as they are subject to copyright. The ability to monitor the status of copyright owning organisation and to receive alerts when copyright expires on key material to allow for their ingest would be welcomed.

Preserve higher level community knowledge through annotation
There are lot of theories within the community which have not had sufficient research done to make into journal literature. The annotation of these theories to the appropriate data would be welcomed

Structure Representation Information – (non media dependent encoding)

Closely connected with single file formats, but also includes complex inter-related collections of files.

Provide a list of file format(s) in which the data held

MMM file format see appendix I
SAO file format see appendix J
IIWG format see appendix A

This data set does not contain complex interrelated collections of files they do however have the following simple relationships

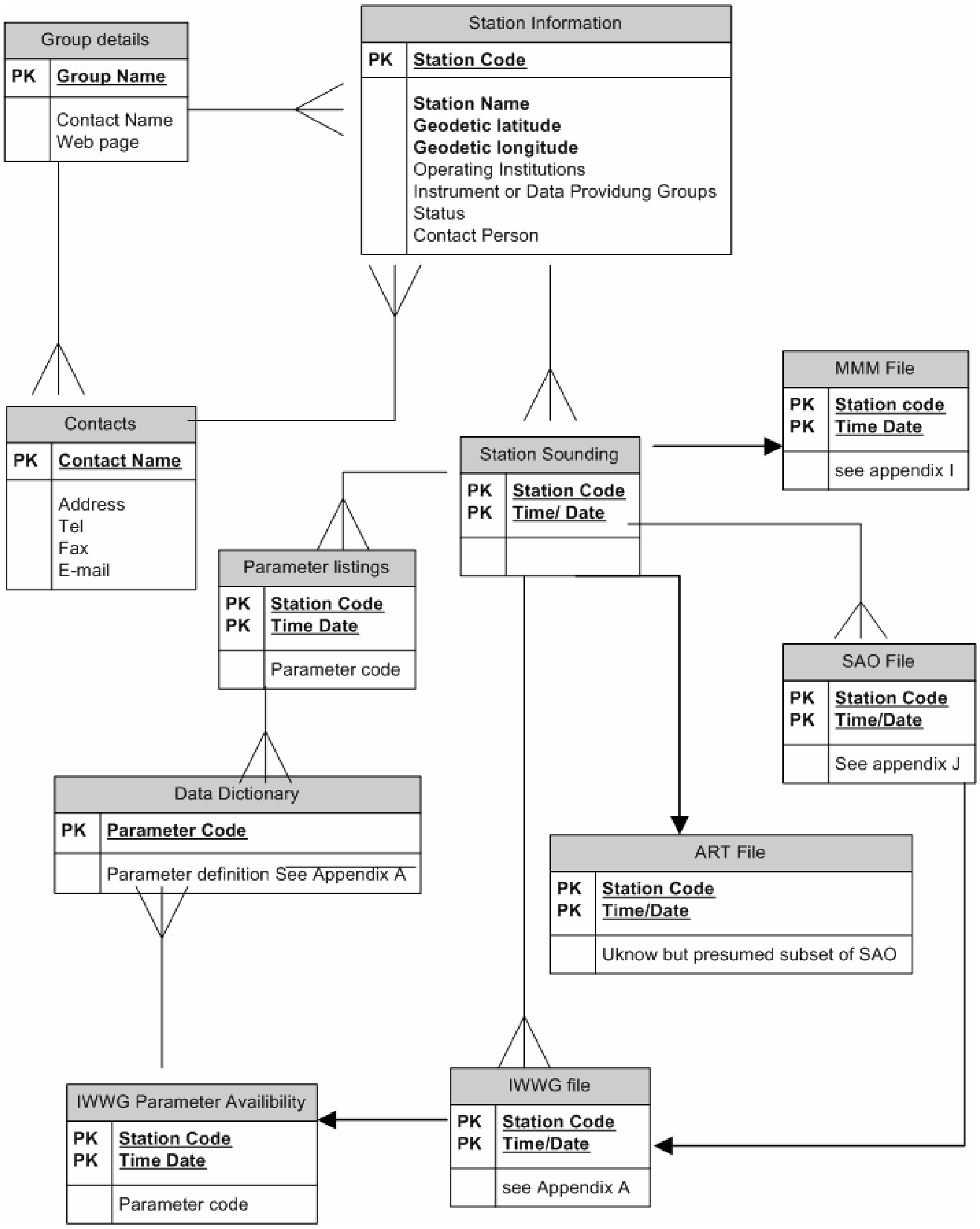
- Relationship based on time. It will be possible to reconstruct simple time based relationships. However reconstructing relationships based on "epochs of significance" for different atmospheric phenomena may be lost.
- Relationships based on geographic location. Again it will be simple to reconstruct simple spatial relationships. However those relationships that currently rely on community knowledge to recreate are at high preservation risk
- Relationships based on data provenance such as instrument type and scaling technique employed are embedded in journals articles and technical reports. The development of representation information for these data files which would allow relationships between them to be clearly presented to the future user would be highly desirable.

Semantic Representation Information

Can you provide a comprehensive listing and definition of all separate data entities (most granular type of data held within file) contained within the file

MMM entity descriptions can be found in appendix I
SAO entity descriptions can be found in appendix J
IIWG entity descriptions can be found in appendix A
ART file entity are a subset of those found in the SAO file in appendix J

The following is crude representation of the key data entities attributes and their relationships. The actual data base schemas are much more complex for historical reasons.


Group details
PK Group Name
Contact Name
Web page
Station Information
PK Station Code
Station Name
Geodetic latitude
Geodetic longitude
Operating Institutions
Instrument or Data Providung Groups
Status
Contact Person
MMM File
PK Station code
PK Time Date
see appendix I
Contacts
PK Contact Name
Address
Tel
Fax
E-mail
Station Sounding
PK Station Code
PK Time/ Date
Parameter listings
PK Station Code
PK Time Date
Parameter code
SAO File
PK Station Code
PK Time/Date
See appendix J
Data Dictionary
PK Parameter Code
Parameter definition See Appendix A
ART File
PK Station Code
PK Time/Date
Uknow but presumed subset of SAO
IWWG Parameter Availibility
PK Station Code
PK Time Date
Parameter code
IWWG file
PK Station Code
PK Time/Date
see Appendix A

Can you fully describe any entity relationships?

Group details – Station information

A single scientific group may operate a particular station uniquely identified by station code. It should be noted that in the current archive this information is recorded only for current status of the station with no “station history” availible

Group details – Contacts

A group may have many scientific contacts but contains no retirements history or chronological information on these contacts

Contacts – Station information

A scientist or “contact” may be working with more than one station

Station Information – Station Sounding

A Ionosonde sounding which is a unique and most granular data set for a particular Ionosonde is uniquely identified by station code and time

Station Sounding – MMM File

A station may deposit an MMM File contains raw sounding data with the archive which is uniquely identified by station code and time combination

Station Sounding – ART File

A station may deposit an ART File which contain artist Autoscaled data with the archive which is uniquely identified by station code and time combination

Station Sounding – SAO File

A station may deposit an SAO File which contain artist Autoscaled and automatically profiles data with the archive which is uniquely identified by station code and time combination (although with manual scaling more than one file per sounding may be produced).

Station Sounding – IIWG File

IIWG parameter can be extracted from SAO files or a number of other formats before ingestion into the archive. In theory more that one set of IIWG parameters for a sounding can be produced although there should only be one on the archive uniquely identified by time and station code.

Station Sounding – Parameter Listings

For every station sounding there is a list of available parameters

Parameter Listings – Data Dictionary

For every parameter code there is definition within the data dictionary

IIWG Parameter Availibility – IIWG File

For every IIWG parameter at a given time it is possible to produce a list of IIWG file which contain it.

SAO File – IIWG File

For every SAO File in the Archive there should be an IIWG file which contains the extracted parameters

How is the data physically stored?

(1)How many independent off-site copies are there?

A back up copy of the data is currently held in the ATLAS data store although this still within the Rutherford Appleton site.

(2)Is the data fundamentally random access or sequential access in nature?

The primary copy is random access on RAID the secondary copy is sequential on magnetic tape.

(3)What is the physical media upon which the data is stored e.g. CD, SDLT tape? Is this likely to change in the next 5 years?

Primary on RAID secondary on DLT magnetic tape no current plan exist to change this with the next five years.

(4)Can you provide any relevant technical specification and physical description of how this information is mechanically transferred onto the storage media?

Yes the Archive Manager can get this information if required. RAID is a well known and documented storage media and the ATLAS data store

(5) Was there any media specific encoding employed the data file was written to the physical media?

No

(6)Can you provide decoding instruction which allow the file to be reconstructed?

N/A

(7)Has any integrity checking mechanism been allowed which will assist in file reconstruction?

None

(8)Is any metadata physically recorded along with the files e.g. time stamps or id of machine writing to the media?

Yes in the secondary data store time and origin of data is recorded in the section header

(6)What is the volume of data held?

Approximately 60 Gigabytes

(7)What disaster recovery procedures need to be put in place?

Currently no disaster recovery procedures are in place

For further detail on storage structure please section on ingest

Are there any additional preservation requirements?

(1)Are there any preservation requirements on the dataset imposed by governments, institutional policies etc?

No currently PPARC the funding organisation has no data policy ?

(2)Does your institution have any specialist preservation or long term access requirement or standards that must be adhered to? If so please detail.

At the moment PPARC again have now data policy something which would be welcomed by the Archive Manager

WDC preservation requirements

"To ensure permanent archiving and availability of geophysical, solar, and environment data for the benefit of the world research and education community. "

http://www.ngdc.noaa.gov/wdc/reports/WDC_Constitution_final.pdf

Apart from this very general statement the WDC has not specific preservation requirements.

http://www.ngdc.noaa.gov/wdc/guide/gdsystema.html

International Council for Science - World Data Center System

A. Principles and Responsibilities of ICSU World Data Centers
The basic principles and responsibilities of the international exchange of solar, geophysical and environmental data through the World Data Centers have carried forward under ICSU rules, essentially unchanged since the establishment of the WDC system for the IGY. The following text replaces the sections on "Principles and Responsibilities of the World Data Centers" in Part I of the ***Guide to the World Data Center System***, dated November 1987.

1. World Data Centers are operated for the benefit of the international scientific community. WDCs in the United States are designated as WDCA, in Russia as WDC-B, in other European countries as WDC-C or WDC-C1, in Japan or India as WDC-C2, and in China as WDC-D. They are supported by national organizations according to these Principles laid down by the ICSU Panel on World Data Centers.
2. The resources required to operate WDCs are the responsibility of the host country or institution, which is expected to provide these resources on a long-term basis. If for any reason a WDC is closed, the data holdings shall be transferred to another WDC.
3. WDCs will, subject to their financial resources, accept data according to the data management plans of appropriate ICSU scientific programs or monitoring activities, and store these data safely and in good condition. WDCs may enhance their holdings by seeking and collecting related data sets. They may prepare higher-order data products such as indices of activity and collated or condensed data sets.
4. WDCs will prepare and publish catalogs of their data holdings, or otherwise make freely available information on their holdings, e.g., by electronic access.
5. WDCs will exchange data among themselves, as mutually agreed and when-ever possible without charge, to facilitate data availability, to provide back-up copies, and to aid the preparation of higher order data products.
6. No confidential or security-classified data are to be held in a WDC.
7. Data may be subject to privileged use by their originators, for a period to be agreed beforehand, and not to exceed two years from the date of acquisition by the WDC.
8. WDCs will provide data to scientists in any country free of charge, on an exchange basis or at a cost not to exceed the cost of copying and sending the requested data. Additional charges may be made for special services, or for acquiring data from outside the WDC system.
9. WDCs will accept any scientist as a visitor to work on site with data holdings held under WDC auspices.

WDCs will report to the ICSU Panel as requested.

Digital Rights Management requirements

What kind of copyright information are your currently keeping? What copyright material would you like to keep in the future?

Currently Ionosonde data has no copyright restrictions imposed by CCLRC.

A core requirement for the preservation of the knowledge extract from and usability of the data set are copyrighted materials which include:

- Journal Articles
- Bilbliographies
- Books (standard texts)
- Websites
- Software
- Technical Manuals

More detailed information on these materialsand the context for it's user is available throughout the document
Copyright restriction and ability to deal copyright issues is major reason for much of the material not being added to the archive

Do you currently keep an electronic record of digital rights?
N/A

Under which legal framework for copyright licensing are you currently operating?

The Archive would benefit from guidance as to which framework they should be operating under for the types of materials mentioned above and implications for cross border supply and International Intellectual Property rights .

Is your organization the copyright owner of the content you are going to preserve or are you collecting content belonging to different copyright owners?

Although CCLRC would be the copyright holder for some of the data and support material it would wish these to be freely accessible in the public domain.

If your organisation holds rights for the content to be preserved , which are the conditions you're applying for public / restricted / personal access to such content?

N/A

Do you have any formal authorization from copyright holders for the preservation of digital content under their copyright? Is content adaption or transformation for preservation purposes allowed under this agreement?

No agreements or formal authorization procedure or policies in place. These may need to developed from scratch.

How is your organisation planning to give access to the preserved content? Which cost model are you going to apply?

The intention is to continue to provide free open access to the data

Do you perform rights clearance?
N/A

Is your content encrypted or using some kind of copy protection mechanism?

No

Knowledge Management and Information Access

KIND OF METADATA

1. Does your metadata include elements (e.g. attribute values) coming from specific ontologies? If yes please give details. If not, would this kind of metadata be useful for you? Please explain.

Yes please see appendices
A – IWWG parameter descriptions
B – URSI Ionospheric Parameter Codes
C - URSI Qualifying and Descriptive letters for Ionospheric Parameters
I - Description of Metadata Parameters embedded in MMM file
J – Description of Metadata Parameters embedded in SAO files

However data set would benefit from the development of more provenance meta especially regarding the different instruments.

2. Is there any ontology that describes the main concepts of your domain and is important for the preservation of your information objects? If yes please provide details. If not, would that be useful for you?

3. What kind of provenance metadata do (or would like) to have?

Metadata which describes any aspect of the instrument(make/model) its mode operation and calibration which would impact the quality of observation. More research is required to establish all relevant factors. See sections 3 for indication of what these are likely to be.

4. In what knowledge representation languages your ontology is expressed in (e.g. RDF/S, OWL, XML, proprietary syntax)? Please provide details.

N/A

Ingesting Metadata

1. What is the more complex validation process of your metadata? Please provide details and examples.

None

2. Should the preservation environment be able to ingest metadata expressed over previous versions of the current metadata schema or ontology?

Yes

Evolution of Metadata

1. Does your metadata evolve over time? If yes do you (or would like to) keep the previous versions of the metadata? Please provide examples.

Potentially the WDC may try to enter it's URSI defined pameters as standard names in something like the CF conventions http://www.cgd.ucar.edu/cms/eaton/cf-metadata/ .Objections from the community may requiring mapping of meta data terms to others accepted within a conventions list

2. Can the (semantic) interpretation of a term change over time? Do you need to model explicitly the context of a term for being able to interpret it correctly in the future? Please provide examples.

Yes interpretation of what parameters represents is a matter of considerable debate which evolves over time. The sematic definotion a can be subject of journal article and papers

3. In case you (or your metadata) use ontologies do they evolve over time? How often? Are you the responsible for updating these ontologies, or is this done by an external party? Is there any need to keep the previous versions of these ontologies?

Understanding of what is being measured or identified may evolve over time. Previous ontologies should be preserved to better understand the science that was conducted during that period.

4. In case you use ontologies and they evolve over time have you faced the need for changing/transforming the already stored metadata? Please provide examples.

N/A

General Questions

1. Do the issues described in the presentation at http://dev.dcc.ac.uk/caspar/pub/Main/TaskId2103/KMcomponentPragaJuly18.zip make sense to you? Feel free to develop your thoughts and ideas.

ACCESS

Queries

1. Would you like to allow querying your dataset on the basis of the stored metadata (including preservation specific metadata)? What kind of queries you expect to have on what kind of metadata? How complex are they? Please provide details and examples.

Yes please see section on access for required types of query

2. Should the preservation environment be able to answer queries expressed over previous versions of the current metadata schema or ontology? Please provide examples of the kind of queries you would like to ask.

N/A

3. Do you require information-retrieval like querying, such as full-text search? If yes, do you ask these queries on metadata or on document contents? Do you have any multimedia information retrieval requirement, such as retrieving images by color similarity? Please provide examples of the kind of queries you would like to ask.

No

4. Do you require querying based on domain-specific criteria, such as geo-spatial location for scientific data? Please provide examples of the kind of queries you would like to ask.

See section on current modes of access which need to be preserved

Requests

1. Please describe with in the most precise way, what kind of requests you expect the OAIS to be able to provide, illustrating with examples.

Please section on current access

Reports

2. Please describe with in the most precise way, what kind of reports you expect the OAIS to be able to provide, illustrating with examples.

Again please see section on current access

Conclusions

Changes in Hardware/Software

Hardware/Software obsolescence affects the ability to run software capable of

1. reading file formats
2. processing data
3. rendering data
4. manipulating data.

We can see these issues manifesting themselves across the data set in a number of ways.

1. Lowell's provision and support of SAO explorer needs to be monitored. If it no longer provides or supports SAO Explorer the archive needs to preserve the ability to scale ionospheric parameters and Ionogram trace from SAO and MMM files Either the SAO explorer program (Java) needs to be preserved along with the ability to run the program with accompanying user documentation.
2. If an operating system is no longer capable of running postgreSQL Relationship between station Information and data directories needs to be preserved so all modes of access to data is preserved when new database system is queried. Requires PostgreSQL or data migration to similar ANSI/ISO SQL database management system.
3. IIWG manipulation – combine-iiwg, display-iiwg, medians-iiwg, merge-iiwg, month-iiwg, split-iiwg, verify-iiwg – Standard C programs for appropriate manipulation of IIWG files. Requires ANSI C compiler for recompilation on new system.
4. Documentation on IIWG format freely available therefore reproduction of this software is feasible if necessary. Requires preservation of IIWG format documentation.
5. SAO extraction – sao_find, sao_itec, sao_pars, sao_split, sao_trace – Standard C programs for discovery and extraction of particular sections of SAO files. Requires ANSI C compiler for recompilation on new system.
6. Documentation on SAO format available therefore reproduction of this software is feasible if necessary. Requires preservation of SAO format documentation – multiple versions!

7. Change of operating system affecting ability to run POLAN program (FORTRAN).Need to preserve ability to create POLAN profiles. The WDC website currently allows the generation of POLAN profiles automatically from the Ionogram trace extracted from SAO files). The ability to run the POLAN analysis program on these values needs to be preserved. Either the ability to run the Titheridge POLAN analysis program to produce these profiles needs to be preserved (requires standard FORTRAN-77 compiler) or the archive needs to provide sufficient documentation to recreate the data processing algorithms within new software (Titheridge algorithms in UAG-93 and scientific literature).
8. Change of operating system affecting ability to run View to Gif program (C++) Need to preserve ability to create Ionogram from raw data files either by preserving viewtogif (developed at Lowell). Either software or the ability to run it must be preserved or sufficient documentation to allow for the development of automated extraction in the future. Requires full documentation of MMM format from Lowell,
9. Not all Ionosonde data corresponding to parameters is held In SAO & MMM files. Some exists in paper format or in different digital file format information at different Institutions. An extension to the basic requirement would be the inclusion of documentation and the preservation of software programs that would allow trace information from these sources to have POLAN analysis performed on it (see UAG report - 93 Ionogram analysis with generalised program POLAN for further details)

Ideally any solutions would avoid dependence on proprietary formats and software with their attendant preservation risks. However current cost and technology constraints mean that solutions for some scenarios would involve other preservation techniques. Solutions utilising software preservation, emulation and format conversion amongst other techniques will be employed in order to provide the realistic solutions that are urgently needed.

Storage Media

All storage media have some inherent preservation risks due to the storage media wearing out or hardware/software obsolescence may affect retrieval of data from storage medium. In this case CCLRC data access copies on RAID with back up in the ATLAS data store. The key requirement would be the orchestration of advice to the archive manager on the preservation issues surrounding the storage media they are currently using

Changes in organisations

A range of organisations supply information to members within the present day designated user community of an archive. This information may not be incorporated into the archive, may not exist in digital form or not been documented at all. This information is often essential for the discovery comprehension and use of the archived data. The information which needs to preserved falls into the following three categories

1. The knowledge the dataset is capable of imparting to the user

The reasons why one may wish to use data within the archive (a description of the knowledge the archive was intended to preserve).

The core requirement is the capture of all such relevant information from an organisation ands its ingestion into the archive. This requirement results from the fact that user awareness of the potential of information is vital for the reuse of any dataset. This information must be stored in such a way that a future access system would be capable of searching and retrieving the data which corresponds to the identified knowledge requirement.

As previously mentioned the scope of knowledge the data is capable of imparting to a user is quite wide ranging but as a minimum it should

- Allows for long term global monitoring and mapping of the Ionosphere
- Allow users to examine exact form of the ionosphere at a specified time, e.g. for comparison with a rocket or satellite data or for studying time variation in events.
- Assist those concerned with radio propagation problems and communications research , both surface and space.
- Allow those involved in geophysical studies to examine the following types of geophysical phenomena
    - travelling ionospheric disturbances
    - atmospheric gravity waves
    - ionospheric storms
    - thermospheric winds
    - composition changes
    - solar eclipses
    - UV supernovae flashes
    - solar disturbance effects (flares, Coronal Mass ejections, co-rotating streams)
    - atmospheric explosions.

2. Data Provenance

There is a strong requirement for the preservation of provenance information. This adds value to and is vital for the correct interpretation and use of the core data set.

- Information on authoring body, commissioning organisation, experimental scientist or group
- Mechanisms for the data collection instruments, modes of operation and calibration and associated information on the impact on data quality
- Human scaling techniques employed and associated information on its impact on the quality of data

It is important to preserve and relate this provenance information to the corresponding data.

3. How to use the retrieved data to produce knowledge

All domain data sets exhibit the need for the preservation of representation information, the capacity to virtualise/render the data and information capable of regenerating the higher level knowledge which is required for the interpretation of the resulting digital objects.

Representation information examples

- Data dictionaries containing parameters
- Formal descriptions of file formats
- Information from Interpretive Handbooks

The capture of representation information in order to provide adequate description of key data entities is a key requirement. The relationship between data entities and any other information element within the archive needs to be captured and preserved.

Virtualisation/Rendering examples

- Software
- Digital processing algorithms

Capture of key processing and rendering software is a key require. It should be noted that any software that is capture will then be subject to the additional set of requirements specified for software

Higher Level information examples

- Texts
- Journals
- Reference materials
- Instructional materials for correct use/operation of software
- Instructional materials for the use/operation of specialised models
- Instructional materials for correct interpretation or analysis of rendered data

The requirement is the capture of at least the minimal set of materials capable of reconstructing the knowledge base of the designated user community.

The standard texts contain the mature well established scientific theory. There is a very significant preservation risk with this material as the majority of it is out of print with no record of numbers/holders of copies or organisational responsibility for preservation.

The number of texts one would wish to store within the archive is dependant on the depth and breadth of knowledge one is seeking to preserve so it is difficult to provide and estimate of this.

Current end users have become dependent on subscription products such as web of science http://scientific.thomson.com/products/wos/ to locate journal material. This constitutes a significant preservation risk and our ability to preserve such listings along with relevant subject indexing is something that requires further investigation. The result is a need to create an unbiased bibliography in consultation with key people in the field of Ionospheric Science

There are addition ally lot of theories within the community which have not had sufficient research done to make it into journal literature. The annotation of these theories to the appropriate data would be welcomed as would identification of events affecting the ionosphere, comments on scaling quality or behaviour of the ionosonde affecting quality of observation.

Retirement of key personnel

The ingestion process can be quite complex and relies on the personal knowledge of the archive staff and internal documentation as this is not always a fully automated process in addition to the use of software developed in-house. Data arrives from the global network of ionosondes by a number of methods as well as being in a number of different formats. This data may require additional processing so it is in the correct format for deposit i.e. IIWG or extracted ionospheric parameters.
On occasion the data does not automatically arrive and the archive staff personal knowledge is relied upon to make note of this and contact the appropriate organisation to obtain the appropriate data if possible. The quality of the archive also relies on the archive staff maintaining the ingest from the global network.

There are additionally a number of processes which occur post the initial ingest which extract parameters, update and populate the postgreSQL databases and manage the directory structures. The complexity of ingest process, including role played by staff of the archive in detecting and acting on anomalies cause a preservation risk.

Collapse of an organisation supporting knowledge base

Organisational monitoring is significant so previously withheld information may be requested from an organisation which may have lost its funding become bankrupt etc. An archive would benefit from research into the information support provided by the listed organization. As such information would enhance the level and quality of knowledge that can be extracted from an archive if it could be preserved by incorporation into the archive

Organisational support materials are again a high preservation risk. Mechanisms and strategies for digitising storing and cataloguing a wide range of materials which originate from diverse groups would be highly desirable
The content of external website should be monitored for changes and any relevant material preserved within the archive if deemed to be at risk

Awareness of the knowledge such data provides may also evolve over time due to changes in scientific knowledge or society. This is due the user community discovering more diverse types of knowledge which may be extracted from the data. The ability to add or annotate in some way additional information regarding the potential knowledge the data can provide is an additional requirement

Changes in Legislation

All archives are potentially subject to evolving restrictions be they at a governmental or organisational level (i.e. between an archive and a user community). A repository of information which describes changes in legislation relating to an archive holdings and any element of its' designated community would be desirable.

Copyright restrictions on data, software, hardware and supporting information evolves over time and potentially expires. The result of this evolution is the need to ingest or release access to the previously identified materials, information or data. Some form of monitoring of the identified copyrighted materials and owning institutions is required to facilitate this.
A core requirement for the preservation of the knowledge extract from and usability of the data set are copyrighted or otherwise restricted materials which include:

- Journal Articles
- Bilbliographies
- Books (standard texts)
- Websites
- Software
- Technical Manuals
- Copyright restriction and ability to deal copyright issues is major reason for much of the material not being added to the archive.

The Archive would benefit from guidance as to which framework they should be operating under for the types of materials mentioned above and implications for cross border supply and International Intellectual Property rights .
An alert service advising of key changes affecting such types of materials may be of use. As would automated alert to the clearance of copyright on specified (by archive manager) material such as key journal or texts so they be digitised and added to the archive or released from a dark archive.

Change in user community

As science evolves the reason why a scientist may wish to use this type of observational data. It is extremely difficult to attempt to anticipate how a user community will change. However connecting this data into larger ontology which evolves over time for atmospheric science would assist the discovery and use of this data.

APPENDICES

APPENDIX A- IIWG FORMAT HELP

The format is designed to allow the storage of arbitrary numbers of parameters for arbitrary times. The logical unit is the station-month; parameters for one month for one station can be stored in a single record, and a file can consist of multiple records if desired.

RECORD FORMAT

```
Record #        Format          Description

        1       A30             Station Name
        1       A5              Station code
        1       I4              Meridian time used by station
        1       F5.1            Latitude N
        1       F5.1            Longitude E
        1       A10             Scaling type: Manual/Automatic
        1       A10             Data editings: Edited/Non-edited/Mixed
        1       A30             Ionosonde system name

        2,3     30I4*           Year
                                Month
                                Number of days in the month, M
                                Number of characteristics
                                Total number of measurements
                                Number of measurements for each of the
M days,NM

        4,i     12A10*          List of characteristics
        i+1,j   12A10*          Dimensions
        j+1,k   60A2*           List of corresponding URSI codes

        k+1,l   20(3I2)*        The NM sample times HHMMSS for each of
the M days

        l+1,m   24(I3,A2)*      The N1 values of characteristic 1 for
day 1
        ...     ...             ...repeated for each of the M days
        m+1     24(I3,A2)       Hourly medians for characteristic 1
        m+2     24(I2,I3)       The counts for the hourly medians,
Range
        m+3     24(I3,A2)       Upper quartile
        m+4     24(I3,A2)       Lower quartile
        m+5     24(I3,A2)       Upper decile
        m+6     24(I3,A2)       Lower decile

        m+7,n   24(I3,A2)*      The N1 values of characteristic 2 for
day 1
        ...     ...             ...

... repeat for each characteristic.
```

APPENDIX B - URSI IONOSPHERIC PARAMETER CODES

The definitions of the parameters have been extracted from UAG23 (URSI Handbook of Ionogram Interpretation and Reduction, November, 1972).
The definitions of the parameters for Codes 70-89, 93-99, and A0-D2 have been included from ulcar.uml.edu
F Layer Parameters

Parameter	Code	Dimension	Description
foF2	00	.1 MHz	F2 layer o-mode (ordinary) critical frequency.
fxF2	01	.1 MHz	F2 layer x-mode (extraordinary) critical frequency.
fzF2	02	.1 MHz	F2 layer z-mode critical frequency.
M3000F2	03	.01	F2 layer M factor (the ratio of the maximum usable frequency divided by the critical frequency).
h'F2	04	km	F2 layer o-mode minimum virtual height.
hpF2	05	km	An estimate of the true height of the F2 layer (measurement of the ordinary mode virtual height at a frequency of 83.4% of the foF2).
h'Ox	06	km	F layer minmum virual height of the x-mode trace at a frequency equal to the foF2.
MUF3000F2	07	.1 MHz	F2 layer maximum usable frequency for 3000km path.
hc	08	km	The height of the maximum obtained by fitting a theorectical h'F curve for the parabola of best fit to the observed ordinary mode trace near foF2 and correcting for under-lying ionizaton.
qc	09	km	EF layer scale height.
foF1	10	.01 MHz	F1 layer o-mode critical frequency.
fxF1	11	.01 MHz	F1 layer x-mode critical frequency
M3000F1	13	.01 MHz	F1 layer M factor (see code 03).
h'F1	14	km	F1 layer o-mode minimum virtual height.

Parameter	Code	Dimension	Description
h'F	16	km	F layer o-mode minimum virual height.
MUF3000F1	17	.1 MHz	F1 layer maximum usable frequency(see code 07).

E Layer Parameters

Parameter	Code	Dimension	Description
foE	20	.01 MHz	E layer o-mode critical frequency.
foE2	22	.01 MHz	E2 layer o-mode critical frequency (when it occurs it is between the normal E and F1 layers).
h'E	24	km	E layer o-mode minmum virual height.
h'E2	26	km	E2 layer o-mode minimum virtual height.

Es Layer Parameters

Parameter	Code	Dimension	Description
foEs	30	.1 MHz	Es layer hightest o-mode frequency are which a mainly continuous Es trace is observed.
fxE	31	.1 MHz	Es layer highest x-mode frequency are which a mainly continuous Es trace is observed.
fbEs	32	.1 MHz	The blanketing frequency of layer used to derive foEs.
ftEs	33	.1 MHz	Top frequency of the Es trace (any mode).
h'Es	34	km	The minimim virtual height of the layer used to derive foEs.
Type of Es	36		A characterization of the shape of Es trace.

Other Parameters

Parameter	Code	Dimension	Description
foF1.5	40	.01 MHz	The o-mode critical frequency of the F1.5 intermediate stratification (between F1 and F2).
fmin	42	.1 MHz	The lowest frequency at whcih an o-mode echo is observed on the ionogram.

Parameter	Code	Dimension	Description
M3000F1.5	43	.01 MHz	F1.5 layer M factor (see code 03).
h'F1.5	44	km	F1.5 layer o-mode minimum virtual height.
fm2	47	.1 MHz	The fmin for the second order o-mode trace.
hm	48	km	The height of the maximum electron density of the F2 later calculated by the Titheridge method.
fm3	49	.1 MHz	The fmin for the third order o-mode trace.

Spread E/Oblique Parameter

Parameter	Code	Dimension	Description
foI	50	.1 MHz	The highest o-mode frequency of spread F.
fxI	51	.1 MHz	The highest frequency of spread F traces (any mode).
fmI	52	.1 MHz	The lowest o-mode frequency at which spread traces are observed for the F layer.
M30001	53	.01 MHz	M Factor deduces from upper frequency edge of spread traces and fxI (see code 03).
h'I	54	km	Minimum slant range of the spread F trace.
dfs	57	.1 MHz	Frequency range of the spread.

N(h) Titheridge

Parameter	Code	Dimension	Description
fh'F2	60	.1 MHz	Thse frequency at which h'F2 is measured.
fh'F	61	.1 MHz	The frequency at which h'F is measured.
h'mF1	63	km	The maximum virula height in the o-mode F1 cusp.
h1	64	km	True height at f1 Titheridge method.
h2	65	km	True height at f2 Titheridge method.

Parameter	Code	Dimension	Description
h3	66	.01 MHz	True height at f3 Titheridge method.
h4	67	.01 MHz	True height at f4 Titheridge method.
h5	68	km	True height at f5 Titheridge method.
H	69	km	Effective scale height at hmF2 Titheridge method.

T.E.C.

Parameter	Code	Dimension	Description
I2000	70	10^{16} e/m2	Ionospheric electron content Faraday technique.
I	71	10^{16} e/m2	Total electron content to geostationary satellite.
I1000	72	10^{16} e/m2	Ionospheric electron content to height 100 km using Digisonde technique.
T	79	10^{16} e/m2	Total sub-peak content. Titheridge method.

Other 2

Parameter	Code	Dimension	Description
FMINF	80	.1 MHz	Minimum frequency of E trace (50 kHz increments)Equals fbEs when E present.
FMINE	81	.1 MHz	Minimum frequency of E trace (50 kHz increments).
HOM	82	km	Parabolic E layer peak height.
yE	83	km	Parabolic E layer semi-thickness.
QF	84	km	Average range spread of F trace.
QE	85	km	Average range spread of E trace.
FF	86	.01 MHz	Frequency spread between fxF2 and fxI.
FE	87	.01 MHz	As FF but considered beyond foE.
fMUF3000	88	.01 MHz	MUF (D) /obliquity factor.
h'MUF3000	89	km	Virtual height at fMUF.

N(h)

Parameter	Code	Dimension	Description

Parameter	Code	Dimension	Description
hmE (zmE)	90	km	True height of E-layer, ??? method.
hmF1 (zmF1)	91	km	True height of F1 peak, ??? method.
hmF2 (zmF2)	92	km	True height of F2 peak, ??? method.
zhalfNm	93	km	True height at half peak electron density.
yF2	94	km	Parabolic F2 layer semi-thickness.
yF1	95	km	Parabolic F1 layer semi-thickness.

Digisonde profile, F2 layer

Parameter	Code	Dimension	Description
[A0F2]	A0	km	Coefficient A0, truncated to integer km.
<A0F2>	A1	m	A0 - [A0], truncation reminder.
[A1F2]	A2	km	Coefficient A1.
<A1F2>	A3	m	A1 - [A1].
[A2F2]	A4	km	Coefficient A2.
<A2F2>	A5	m	A2 - [A2].
[A3F2]	A6	km	Coefficient A3.
<A3F2>	A7	m	A3 -[A3.]
[A4F2]	A8	km	Coefficient A4.
<A4F2>	A9	m	A4 - [A4].
[fsF2]	AA	MHz	starting frequency of the layer, truncate.
<fsF2>	AB	kHz	fs - [fs].
[fmF2]	AC	MHz	ending frequency fm.
<fmF2>	AD	kHz	fm - [fm].
[hmF2]	AE	km	peak height, truncated.
<hmF2>	AF	m	hm - [hm].
EppF2	AG	0.1 km	error per point an average mismatch of original h'(f) trace and the trace reconstructed from the calculated profiles.

Digisonde profile, F1 layer

Parameter	Code	Dimension	Description

Parameter	Code	Dimension	Description
[A0F1]	B0	km	Coefficient A0, truncated to integer km.
<A0F1>	B1	m	A0 - [A0], truncation reminder.
[A1F1]	B2	km	Coefficient A1.
<A1F1>	B3	m	A1 - [A1].
[A2F1]	B4	km	Coefficient A2.
<A2F1>	B5	m	A2 - [A2].
[A3F1]	B6	km	Coefficient A3.
<A3F1>	B7	m	A3 -[A3].
[A4F1]	B8	km	Coefficient A4.
<A4F1>	B9	m	A4 - [A4].
[fsF1]	BA	MHz	starting frequency of the layer, truncate.
<fsF1>	BB	kHz	fs - [fs].
[fmF1]	BC	MHz	ending frequency fm.
<fmF1>	BD	kHz	fm - [fm].
[hmF1]	BE	km	peak height, truncated.
<hmF1>	BF	m	hm - [hm].
EppF1	BG	0.1 km	error per point an average mismatch of original h'(f) trace and the trace reconstructed from the calculated profiles.

Digisonde profile, E layer

Parameter	Code	Dimension	Description
[A0E]	C0	km	Coefficient A0, truncated to integer km.
<A0E>	C1	m	A0 - [A0], truncation reminder.
[A1E]	C2	km	Coefficient A1.
<A1E>	C3	m	A1 - [A1.]
[A2E]	C4	km	Coefficient A2.
<A2E>	C5	m	A2 - [A2].
[W]	C6	km	Valley width [W], truncated.
<W>	C7	m	W - [W].

Parameter	Code	Dimension	Description
[D]	C8	km	Valley depth [D], truncated.
<D>	C9	m	D - [D].
[fsE]	CA	MHz	starting frequency.
<fsE>	CB	kHz	fs - [fs].
[fmE]	CC	MHz	ending frequency.
<fmE>	CD	kHz	fm - [fm].
[hmE]	CE	km	peak height, truncated.
<hmE>	CF	m	hm - [hm].
EppE	CG	0.1 km	error per point an average mismatch of original h'(f) trace and the trace reconstructed from the calculated profiles.
Valley ID	CH		Valley Model ID.
B0	D0	km	IRI Thickness parameter.
B1	D1	0.1	IRI Profile Shape parameter.
D1	D2	0.1	IRI Profile Shape parameter, F1 layer.

APPENDIX C - URSI QUALIFYING AND DESCRIPTIVE LETTERS FOR IONOSPHERIC PARAMETERS

Format

A five symbol format is used throughout. In all tables except Es types the first three symbols give the numerical value of the parameter. The fourth symbol is a qualifying letter and the fifth is a descriptive letter. Qualifying letters are used to indicate the nature or degree of uncertainty in a value. They are always accompanied by a descriptive letter with the possible exception of the median value. Descriptive letters are used to indicate the presence of a phenomenon or the reason for the use of a qualifying letter. Where only a descriptive letter appears in the five symbol group, a numerical value has not been possible within the limits imposed by the qualifying letters.

Qualifying Letters

A Less than. Used only with fbEs.
D Actual value greater than the given numerical value by between 5 and 20%.
E Actual value less than the given numerical value by between 5 and 20%.
I Missing value replaced by an interpolated value.
J Ordinary component deduced from the extraordinary component.
M Interpretation of measurements questionable because ordinary and extraordinary components are not distinguishable.
O Extraordinary component deduced from ordinary component. Used for x characteristics only.
T Actual observation is inconsistent or doubtful. The value has been determined from a sequence of observations.
U Doubtful value with an uncertainty of between 2 and 5%.
Z Measurement deduced from the third magneto-ionic component (Z).

Descriptive Letters

A Measurement influenced by, or impossible because of, the presence of a lower, thin layer. For example, Es.
B Measurement influenced by, or impossible because of, absorption near fmin.
C Measurement influenced by, or impossible because of, any non-ionospheric reason. For example equipment failure, local transmitters, rain and snow static.
D Measurement influenced by, or impossible because of, the upper limit of frequency range recorded.
E Measurement influenced by, or impossible because of, the lower limit of frequency range recorded.
F Measurement influenced by, or impossible because of, the presence of spread echoes.
G Measurement influenced by, or impossible because of, the electron density being too small for accurate observation.
H Measurement influenced by, or impossible because of, the presence of stratification.
K Indicates particle E layer present.
L Measurement influenced by or impossible because the trace has no

sufficiently definite cusp between layers.
M Measurement influenced or impossible because the ordinary and extraordinary components are not distinguishable.
N Measurement influenced or impossible because of conditions which cannot be interpreted.
O Measurement refers to the ordinary component.
P Man-made perturbations of the observed parameter; or spur-type spread-F present.
Q Range spread present.
R Measurement influenced by, or impossible because of, attenuation near a critical frequency.
S Measurement influenced by, or impossible because of, atmospheric or broadcast interference.
T Actual observation is inconsistent. The value has been determined from a sequence of observations.
V Measurement influenced by the presence of a forked trace.
W Measurement influenced or impossible because the echo lies outside the height range recorded.
X Measurement refers to the extraordinary component.
Y Measurement influenced by, or impossible because of, the presence of lacuna or a severe F layer tilt.
Z Indicates the presence of the third magneto-ionic component (Z).

The following descriptive letters are used to show spread-F types and take precedence over all other letters:

F Frequency spread present. Is used in foF2 and fxI tables only.
L Mixed spread present. foF2 and fxI tables only.
P Polar spur present. Is used in fxI table only.
Q Range spread present. Is used mainly in h'F and h'F2 tables, but appears occasionally in foF2 and fxI tables.

Es Type Tables

In the Es type table, the first letter denotes the type of layer from which foes has been evaluated. This letter is followed by the number of multiple reflections from the layer. Other Es layers are recorded in order of number of multiples.

Es Types

F A clean Es trace which shows no appreciable increase of height with frequency. Applied only to night-time Es.
L A flat Es trace below the normal E or particle E minimum virtual height. Mainly applied to Es in the daytime.
C An Es trace showing a relatively symmetrical cusp at or below the critical frequency, foE. Applied only in the daytime.
H An Es trace showing a discontinuity in height with the normal E layer trace. The cusp is not symmetrical, the height of the low frequency part of the Es trace is higher than that of the high frequency normal E layer trace. Applied only in the daytime.
Q An Es trace which is diffuse and non-blanketing over a wide frequency range.
R An Es trace showing an increase in virtual height at the high frequency end but which becomes partially transparent below foEs.

K Denotes the presence of a particle E layer, similar in appearance to normal E, which obscures higher layers up to its critical frequency.

A Denotes all types of very spread Es traces. The typical pattern shows a well-defined flat or gradually rising lower edge with stratified or diffuse traces present above it.

S A diffuse Es trace whose virtual height rises steadily with frequency.

D A weak diffuse trace at or below 95 km associated with high absorption and consequently high fmin.

N An Es trace which does not fall into any of the standard categories above.

APPENDIX D- IONOSONDE THEORY

The path of a radio wave is affected by any free charges in the medium through which it is travelling. The refractive index is governed by the electron concentration and the magnetic field of the medium and the frequency and polarisation of the transmitted wave. These lead to some important properties for waves propagating in the ionosphere;

- The refractive index is proportional to the electron concentration.
- The refractive index is inversely proportional to the frequency of the transmitted wave.
- There are two possible ray paths depending on the sense of polarisation of the transmitted wave. This is a result of the magnetic field, which causes the ionosphere to be birefringent. The two rays are referred to as the ordinary and extraordinary components.

The ionisation in the atmosphere is in the form of several horizontal layers, and so the electron concentration and therefore the refractive index of the ionosphere vary with height. By broadcasting a range of frequencies, and measuring the time it takes for each frequency to be reflected, it is possible to estimate the concentration and height of each layer of ionisation.

An ionosonde broadcasts a sweep of frequencies, usually in the range of 0.1 to 30 MHz. As the frequency increases, each wave is refracted less by the ionisation in the layer, and so each penetrates further before it is reflected. As a wave approaches the reflection point, its group velocity approaches zero and this increases the time-of-flight of the signal. Eventually, a frequency is reached that enables the wave to penetrate the layer without being reflected. For ordinary mode waves, this occurs when the transmitted frequency just exceeds the peak plasma frequency of the layer. In the case of the extraordinary wave, the magnetic field has an additional effect, and reflection occurs at a frequency that is higher than the ordinary wave by half the electron gyrofrequency.

The frequency at which a wave just penetrates a layer of ionisation is known as the critical frequency of that layer. The critical frequency is related to the electron density by the simple relation;

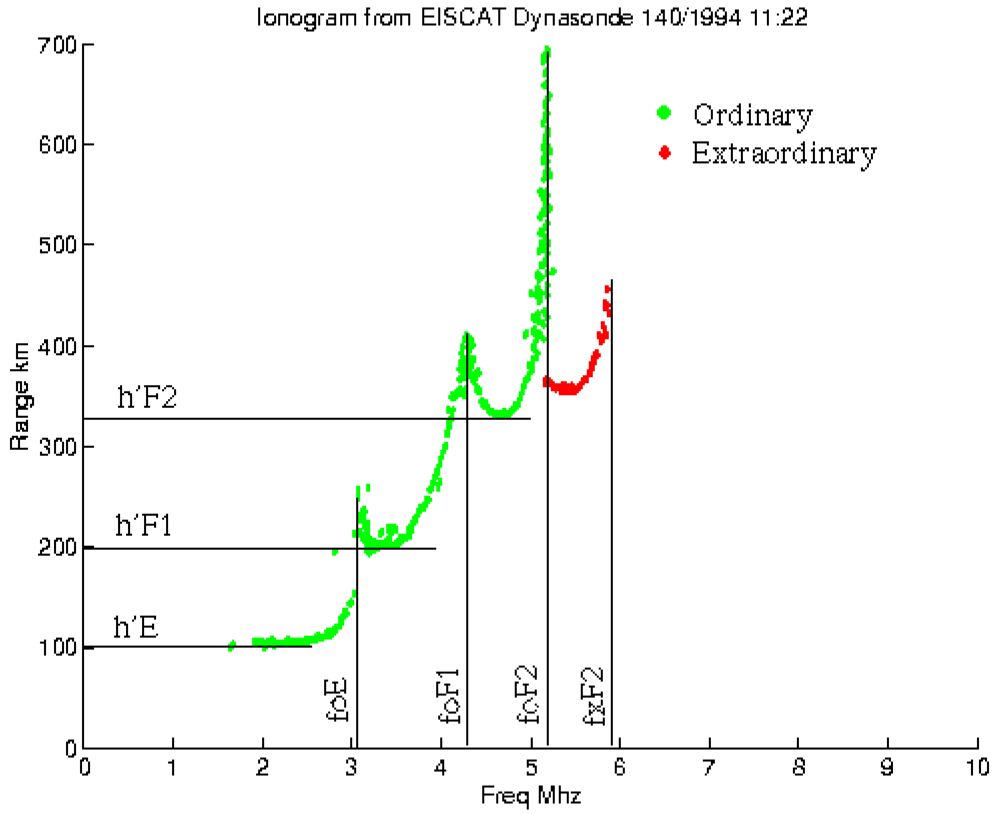
F_c = 8.98*sqrt(Ne) for the ordinary mode.
and
F_c = 8.98*sqrt(Ne) + 0.5*Be/m for the extraordinary mode.

Here *F_c* is the critical frequency in Hz, *Ne* is the electron concentration per metre cubed, *B* is the magnetic field strength, *e* is the charge on an electron and *m* is the mass of an electron.

All transmitted frequencies above this critical frequency will penetrate the layer without being reflected. Their group velocity will however, will be slowed by any ionisation, and this will add to the time-of-flight. If such a wave encounters another layer, whose plasma frequency is higher than the frequency of the wave, it will be reflected, and the return signal will be further delayed as it travels back through the underlying ionisation. The apparent, or *virtual* height indicated by this time delay will therefore be greater than the true height. The difference between true-height and virtual height is governed by the amount of ionisation that the wave has passed through. Recreating the true-height profile of electron concentration from ionogram data is an important use of ionosonde data. Such a procedure is known as true height analysis.

APPENDIX E - IONOSONDE INTERPRETATION

The ionogram



An ionogram is a graph of time-of-flight against transmitted frequency. Each ionospheric layer shows up as an approximately smooth curve, separated from each other by an asymptote at the critical frequency of that layer. The upwardly curving sections at the beginning of each layer are due to the transmitted wave being slowed by, but not reflected from, underlying ionisation which has a plasma frequency close to, but not equaling the transmitted frequency. The critical frequency of each layer is scaled from the asymptote, and the virtual height of each layer is scaled from the lowest point on each curve.

An ionogram can be much more complicated than just two layers. There can also be such phenomenon as;

The F1 layer. An additional layer which appears in the F region, between the two existing peaks. To tell the two Flayers apart, the upper layer is referred to as the F2 layer, and the lower layer the F1 layer.

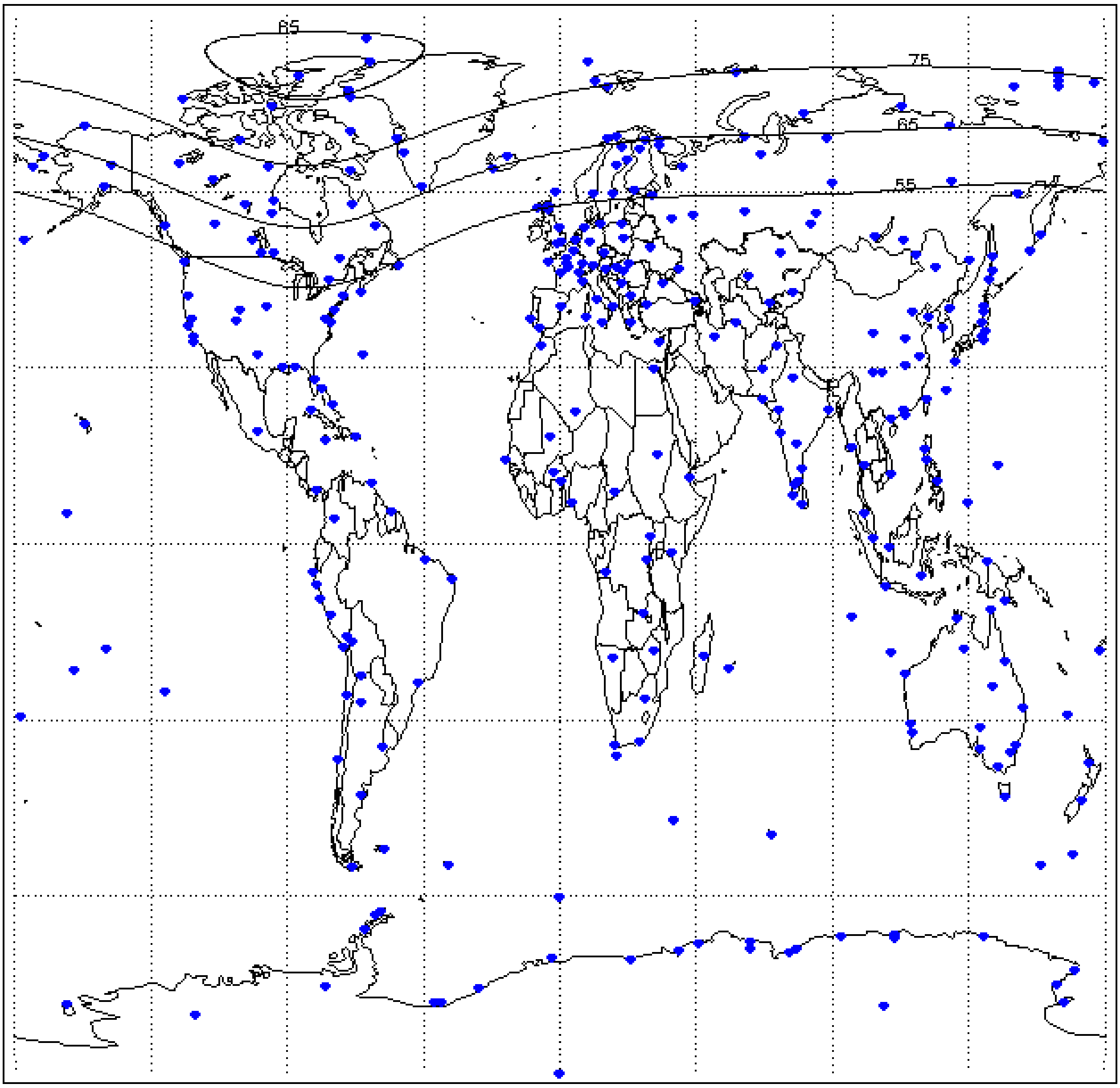
Sporadic E, Es. This layer is a patchy, very dense layer sometimes exceeding 16 Mhz (3.1 x 10^11 /m^3). Despite their intensity, these layers do not extend over a large height range, and so do not exhibit an asymptote at the critical frequency, as the transition is too sudden. They appear on an ionogram as a narrow horizontal line at around 100km. An intense Es layer can prevent any echoes from reaching the upper layers This is known as *blanketing*.

Multiple hops The return signal can skip from the Earth to the ionosphere and back again, sometimes several times before it is attenuated. These multiple echoes appear on an ionogram at multiples of the original virtual height.
D-region Absorption. This is caused by ionisation in the D-region that absorbs the transmitted wave before it can return to the ground. This absorption is characterised by no echoes being received from the low frequency end of an ionogram.
Lacuna. When turbulence occurs (as the result of large electric fields for example), the stratified nature of the ionosphere gives way to a more complex structure. Under such conditions, the reflected signal may not reach the receivers, and so the height range at which the turbulence occurs is lost on the ionosonde trace. Such gaps are termed *Lacuna* and their position on an ionogram gives some indication as to the height at which the turbulence is occurring.
Spread-F. With an ionosonde, echos are received from any portion of the ionosphere where the electron density gradient is perpendicular to the transmitted wave. This most often happens overhead, but occasionally conditions exist such that echoes from other regions of the sky return to the ionosonde. If the electron concentration in these regions differs from the ionosphere overhead, two traces are observed. For a given angle from the zenith, the horizontal separation is greatest in the F-region, and so differences in ionospheric conditions are most likely to be observed in the F-region. If the geometry is right for echoes to be received from a whole range of locations and the ionospheric conditions vary over that range (such as when a trough is overhead) multiple traces will appear on an ionogram, and the F trace is said to be 'spread'. With a digital ionosonde, such as the Dynasonde, these traces can be resolved by considering the horizontal position of each echo.

APPENDIX F – IONOSONDE MAPS

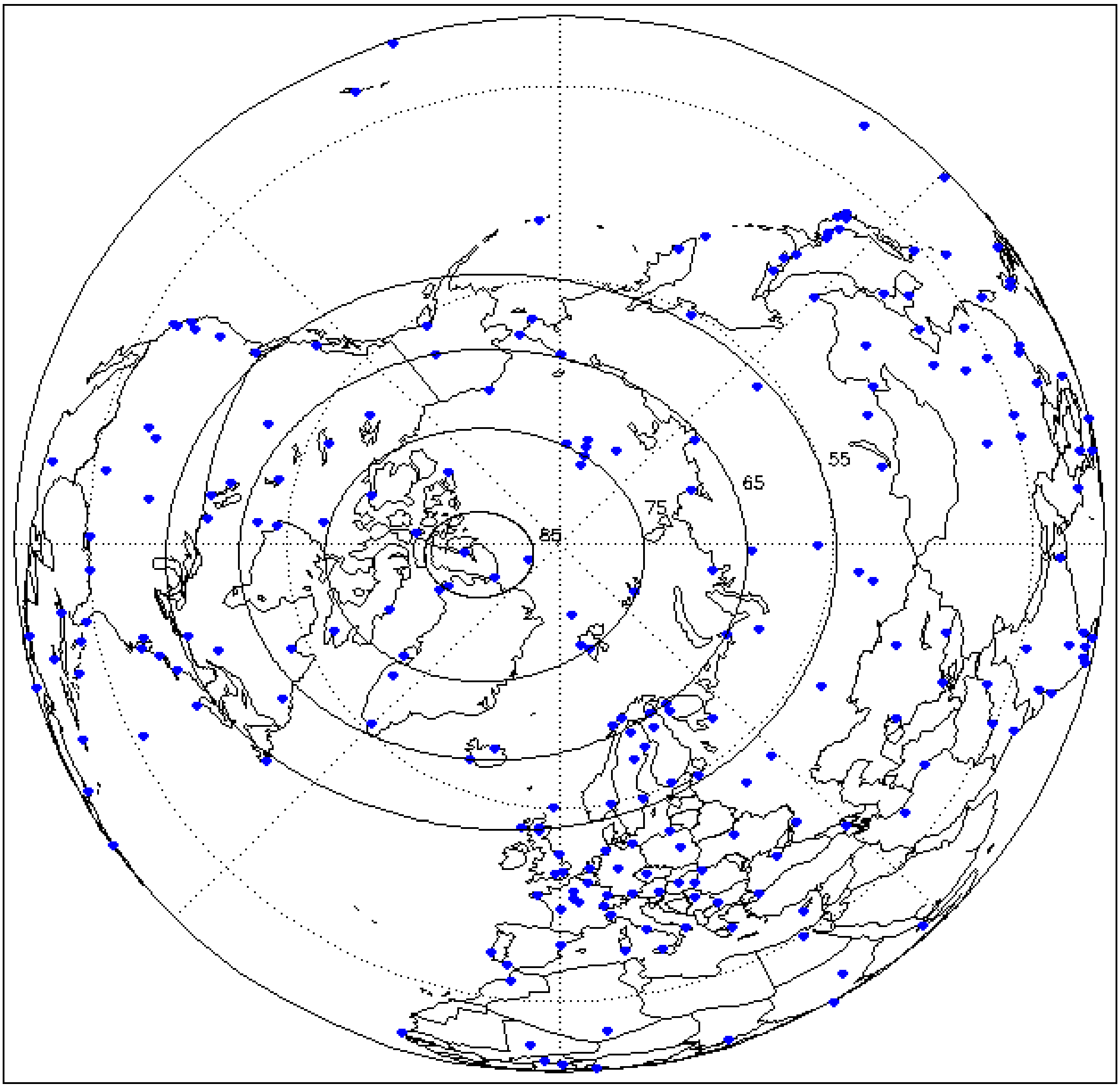
Ionospheric Stations - The World

Click on the map and the details of the closest ionosonde, marked in blue, will be returned with the option to check data availability or select data if we have some data from that instrument.

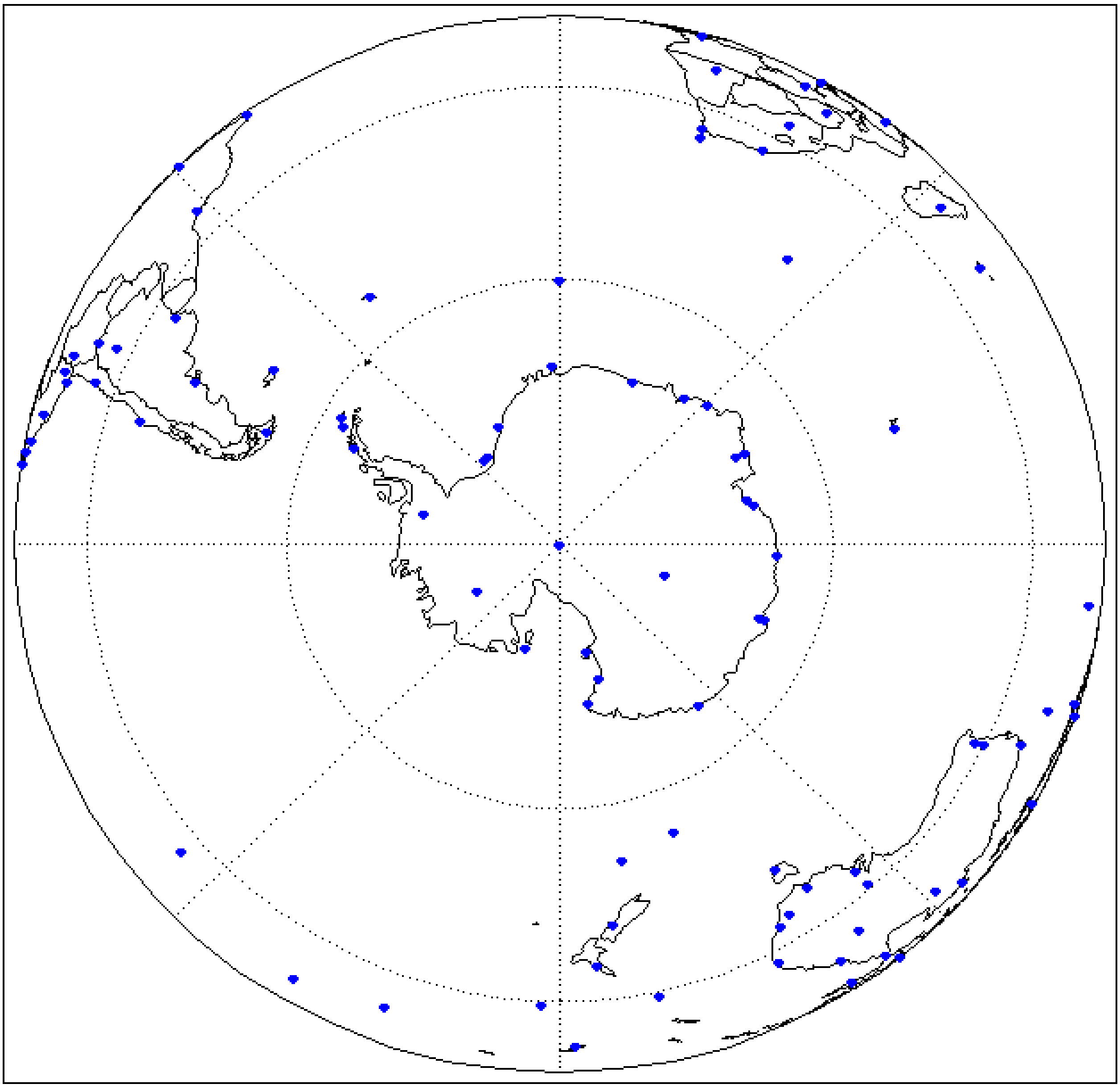


Ionospheric Stations - Northern Hemisphere

.



Ionospheric Stations - Southern Hemisphere



APPENDIX G POLAN INFORMATION

The sweep-frequency ionosonde is a basic tool for ionospheric research. It produces records which can, in theory, be analysed to give the variation of electron density with height up to the peak of the ionosphere. Such electron-density profiles provide most of the information required for studies of the ionosphere and its effect on radio communications. Only a minute fraction of the recorded ionograms are analysed in this way, however, because of the effort required and the uncertain accuracy. To improve this situation we must make better use of the computing power now available, to reduce the need for manual selection of data and for careful appraisal of the results.

An ideal procedure for routine ionogram analysis should give consistently good results without operator intervention. This requires some built-in "intelligence" and adaptability. With high quality data we want the highest attainable accuracy. With normal data the procedure should have criteria for judging the acceptability of each individual point or profile parameter. It should be able to test, impose and remove physical constraints, and to smooth, de-weight, or reject bad data. Where a section of the profile cannot be calculated directly (such as the underlying, peak or valley regions) the procedure should use a defined physically-based model. Thus it should automatically do the "best" thing, in a consistent fashion, with widely varying types of data; if a normal best is not possible it should explain why and do the next-best.

The **POL**ynomial **AN**alysis program POLAN is an attempt to meet some of these requirements. It provides an accurate and flexible procedure with adjustable resolution and the ability to mix physically desirable conditions with observed data in a weighted least-squares solution. The analysis can adapt readily to changes in the density and quality of data points, and respond in different ways to different situations. For routine work POLAN may be used as a "black box" with only the virtual height data, the magnetic dip angle and the gyrofrequency as required inputs. Optimised default procedures are then used in the analysis. If the input data is not self-consistent, and implies some physically unacceptable feature in the profile, this is noted and corrected. All results are obtained in a fully automatic, one-pass analysis.

POLAN is designed to reproduce current techniques (using linear laminations, parabolic laminations, single polynomials or fourth-order overlapping polynomials) by selection of a single parameter. It also provides a wide range of high order procedures, which are preferable for most work. When extraordinary ray data are not available, clearly defined and physically reasonable models are used for the start and valley regions. This allows direct comparison of results obtained under different conditions. When extraordinary ray data are available these are combined with the ordinary data in optimised procedures to resolve the starting and valley ambiguities. The physical models are included in the least-squares solutions for these regions, so that ill-defined data will give reasonable results (based primarily on the models). Peak parameters are determined by a least squares Chapman-layer fit to avoid the systematic scale height error inherent in a parabolic-peak approximation. Observed ordinary and extraordinary ray critical frequencies may be included in the peak calculation, to obtain best estimates of the critical frequency **FC**, the probable error in FC, the peak height and the scale height at the peak. With this careful combination of extraordinary ray data and physical constraints, POLAN is well suited to studies of the ionospheric scale height, the size of the valley between the **E**, **F1** and **F2** layers, and of ionisation below the night F layer.

For a given set of virtual-height data, real-height analysis using POLAN takes roughly twice as long as a simple lamination analysis. For a given overall accuracy, however, POLAN requires only about half as many data points. Thus there is little final difference in computing time, and there can be a worthwhile saving in the time required for scaling the ionograms.

In normal operation results are obtained using a polynomial representation of the real-height profile, fitted to several points each side of the section being calculated. This provides an accurate interpolation between scaled frequencies, which is necessary for an accurate analysis. Virtual height data define primarily the real-height gradients at the scaled frequencies. Real heights are therefore defined most accurately between the scaled frequencies (*Titheridge, 1979*). Thus when an accurate analysis is used to obtain real heights at the scaled frequencies, it is dealing directly with the most difficult points. Tests have shown that direct second difference interpolation is then sufficient to reproduce the profile between scaled frequencies with little or no increase in the mean error. Results obtained by POLAN are therefore normally stored as arrays giving the scaled frequencies and corresponding real heights. Some extrapolated points are added above the layer peaks, for simpler calculation of mean profiles and to give smooth plots with second or third order parametric interpolation (which is necessary to cope with non-monotonic profiles).

Reference
This information is taken from Report UAG-93: *Ionogram Analysis with the Generalised Program POLAN*, by J.E. Titheridge, University of Auckland, New Zealand, December 1985. The report provides comprehensive information on the background and operation of the POLAN software.

Copies of this report can be obtained from WDC-C1 STP or the National Geophysical Data, Solar-Terrestrial Physics Division (E/GC2), 325 Broadway, Boulder, Colorado 80303, USA.

POLAN default options

POLAN has a comprehensive range of options to allow the true-height analysis to be tailored completely to the users requirements. For a service based on automatic provision of data and results, these parameters have to be set to some sensible default values. These may not always produce the best results, but will provide a consistent analysis of the data. Tools for a more interactive user led analysis are available via the WDC or Ionosondes group at RAL (Usage and Notes).

The various default options chosen are :-

Gyrofrequency at the ground - Taken from data file, set to negative value for constant value in the analysis.

Magnetic Dip angle - Taken from the data file.

Starting height - With START set to 0, POLAN derives a starting height h_s to use at 0.5Mhz, by extrapolating the first few virtual height data points and limiting the result to a reasonable range.

Analysis mode - Defaulted to 0, POLAN then uses the mode 5 analysis (changing to 15 at high dip angles) which appears most suitable for general work.

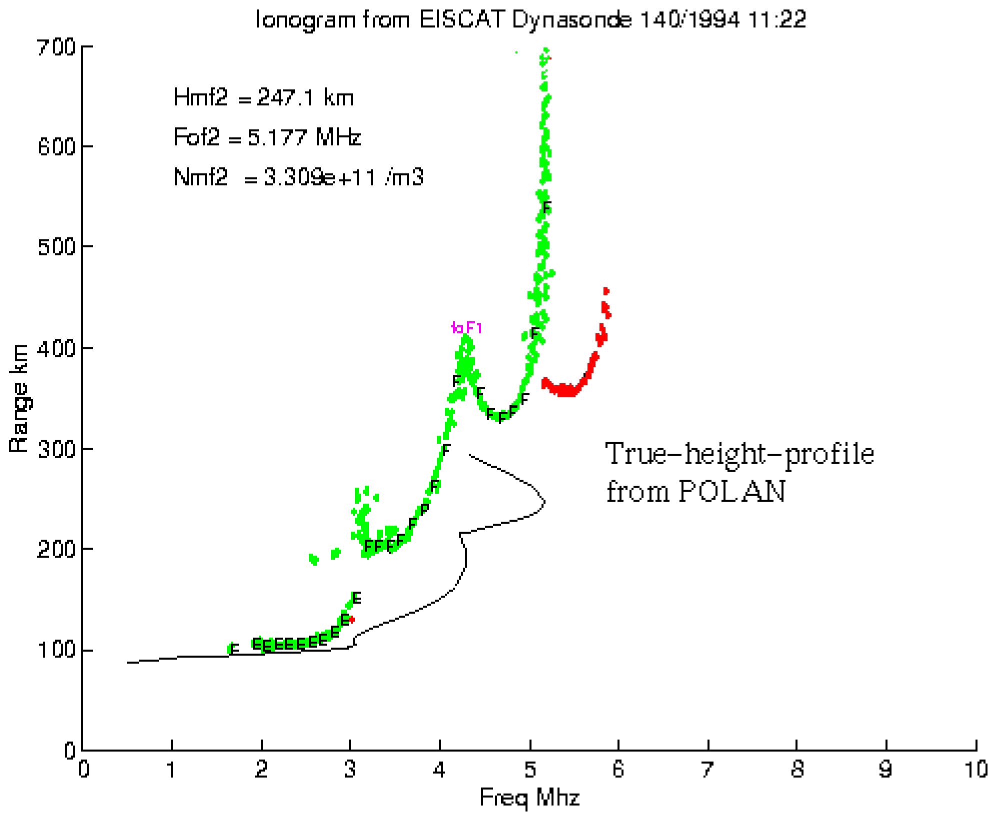
Valley - Set to 0 for most routine calculations. POLAN then inserts between layers a valley selected from the "standard" family. The width (km) and depth (MHz) of this valley depend on the height of the underlying peak.

Other assumptions :-

No critical frequencies specified - This stops POLAN trying to calculate the profile past the peak.

No Extraordinary (X) ray data is included. Good X-ray data can improve the analysis slightly, but poor X-ray data can have serious consequences for the quality of the analysis.

Appendix H True height analysis



Recreating the actual plasma density profile from ionogram data is an important use of ionosonde data. Such a procedure is known as real or true- height analysis.

The time-of-flight from each echo in an ionogram, gives some indication of the height at which the radio wave was reflected. This cannot be taken as the true-height of the layer due to the effect of any ionisation in the path of the wave. Instead, this time-of-flight is referred to as the virtual height of the layer, *h'*. There is usually an insignificant amount of ionisation below the lowest layer, and so the true and virtual heights of this layer are often identical. True-height analysis becomes more complex however, if there is more than one layer.

All transmitted frequencies which are greater than the critical frequency of the first layer, will penetrate that layer without being reflected. Their path will however, be refracted by any overlying ionisation, and this will add to the time-of-flight. If such a wave encounters a second layer, more dense than the first, it will be reflected, and the return signal will be further delayed as it travels back through the underlying ionisation. The virtual height of the second layer will therefore be greater than the true height. The difference between true-height and virtual height is governed by the amount of ionisation along the ray path.

In order to obtain true height values, the whole ray path must be reconstructed, and this requires assumptions to be made about the electron concentration along the ray path. The resultant true-height profile is sensitive to two approximations in particular.

The start approximation

When calculating true-height profiles from ionosonde data, it is important to account for all underlying ionisation. The true-height profile program POLAN estimates the start height in one of two ways.

In the simplest method, the start height is estimated from the virtual height of the lowest frequency echoes on an ionogram. This method uses the assumption that there is no ionisation below this height and therefore the virtual height represents the true-height of these echoes.

A more complex approach makes use of a synoptic model which calculates the most likely start height due to parameters such as latitude, date, local time and solar zenith angle (the position of the sun with respect to the ionosonde). This procedure is outlined in *Starting models for the real height analysis of ionograms by J. E. Titheridge, J.A.T.P, 48, pp 435-446 1986* .

The valley approximation

The virtual height of a layer will be affected by the amount of ionisation below it. The ionisation in each layer is known from the critical frequency, but information about the ionisation between the layers cannot be measured by an ionosonde, since the electron concentration there is less than the critical frequency of the lower layer, and any wave which has a frequency sufficient to penetrate the first layer will not be reflected back to the ionosonde by these lower density electrons.

In order to re-create the true-height-profile, the ionisation in the valley must be estimated. A maximum estimate for the true-height of the upper peak can be made by assuming no electrons between the layers. Likewise, a minimum estimate for the true-height of the upper layer can be made by assuming that the ionisation between the layers is the same as the peak density of the lower layer (ie, that there is no valley, merely a cusp). In true-height profile analysis therefore, the valley approximation is very important. Work has been done to model the variation in height and depth of the valley with time of day, date and latitude. The true-height analysis program POLAN approximates the valley in this way.

Some work has been done on estimating the size of the valley from the MSIS86 atmospheric model. This work is however, limited to the mid-latitude ionosphere. For more information consult the reference *Aeronomical calculations of valley size in the ionosphere by J. E. Titheridge, Adv Spac. Res. 10, pp 821-824, 1990*

This is a subjective and complex task, and much work has been done to produce reliable profiles from ionogram data. As a result, there are several programs available which do this. The most stable and well tested of these programs is POLAN, written by *J. E. Titheridge*.

APPENDIX H - DESCRIPTION AND USE OF THE POLYNOMIAL ANALYSIS SUBROUTINE

POLAN (N, FV,HT, NDIM, FB,DIP, START, AMODE, VALLEY, LIST, QQ).
for the calculation of real-height profiles from sweep-frequency ionograms.

This outline is for the Version of September 1986. It supplements the information contained in the report *Ionogram analysis with the generalised program POLAN*, obtainable as report *UAG-93*
from:-
World Data Center A, NOAA E/GC2, 325 Broadway, Boulder, Colorado 80303
If problems arise, run one data set with LIST = 3, and mail all output to:
J.E. Titheridge, Physics Dept., University of Auckland, New Zealand.
NEW TO THIS VERSION (September 1986)
(a) Addition of the parameters NDIM and QQ in the call to POLAN. Use of NDIM makes it unnecessary to reset N (to the dimension of the input arrays) on each call. QQ returns the coefficients for single-polynomial representations. It is now a required parameter in the call to POLAN, but is not used if (initially) QQ(1) = -1. (Previous use of QQ returned one less coefficient than described in *section 4.2* below, since the count was taken to include the constant HA).
(b) Use of a negative scale height, to indicate use of a model value rather than one derived from the data, is restricted to the output listing (and the output array QQ). In some previous versions, -SH was accidentally carried over to later stages creating numerous problems.
(c) The default analysis (obtained at AMODE = 0.0) has been changed from Mode 5 to Mode 6. Experience has shown some benefits and no problems with the higher modes, particularly since the change (d) below which gives good results even when the scaled frequency interval varies considerably.
(d) Weighting of different points in the least-squares calculation has been made proportional to the scaled frequency interval. This stops smooth sections of the profile, where fewer points may have been scaled, from getting too low a weight. It reduces spurious fluctuations in high order modes to well below the levels described in *J. Atmosph. Terr. Phys. 44, 657-669, 1982*.
(e) The START model has been revised to the procedure described in *J. Atmosph. Terr. Phys. 48, 435-446, 1986*.
(f) Minor improvements have been made in several steps of the calculation. Programs will now run at DIP = 0. Calculations proceed normally with 2 or more data points for each layer, while a layer with only one point (and no FC) is ignored.
(g) Descriptive comments have been extracted from the listing of POLAN.FOR, into this file.

---

1. DATA ARRAYS
POLAN is called with frequency, height data in the arrays FV, HT.
NDIM gives the dimension of the arrays FV, HT; this must be greater than 30 + the number of data points in the arrays.

QQ is an output array, used only with single-polynomial calculations . For 3 layers and 8-term polynomials, the dimension of QQ must exceed 50. POLAN will not write over a value of -1. in QQ, so setting the last element of QQ equal to -1.0 will prevent any overflow. The data returned in QQ is described in *Section 4.2* below. If this data is not required, use Dimension QQ(2) and set QQ(1)= -1.
In the data arrays, intermediate layers are terminated by a scaled (or zero) value for the critical frequency, with:-
h' = 0.0 for a Chapman peak and normal valley,
h' = 10.0 for a peak with no following valley,
h' = negative and less than 50 is used to set the valley constants, for this valley only, as described below.
h' = negative (equal to minus the scaled virtual height) for a cusp-type discontinuity only.
The o-ray FC (scaled or zero) may be followed by an x-ray value (-FCX).
The final layer is terminated by at least 2 null points, with h=f=0.
Data can be terminated without a peak by using a final frequency of -1.0.
Data for the extraordinary ray, if any, precedes the o-ray data for each layer. This is because x-ray data is used only to calculate the (start or valley) corrections to be made at the beginning of the calculation for that layer.
The format for input data is best seen by study of the examples in the test file POLRUN.DAT.

---

2. INPUT PARAMETERS
FB gives the gyrofrequency at the ground in MHz, for an inverse cube variation. If you have only the gyrofrequency FH at a height h km, the ground value is obtained from FB = FH * (1. + h/6371.2)**3.
To use a gyrofrequency (FH, say) which is independent of height, set FB = -FH.
DIP is the magnetic dip angle IN DEGREES. Use of a negative value for DIP suppresses the physical checks which are normally applied to the calculated profile, so that the result obtained is the best mathematical (but possibly non-physical) fit to the virtual-height data. [Some physically based equations are still included in start and valley calculations, unless AMODE is negative.]
START normally gives a model height at 0.5 MHz. Typical values are:

noon	sunset-2/rise+2hr	set/rise	set+1hr	set+2	set+4 to rise-1
85km	88km(E layer)	90(E)/80(F)	100 km	130 km	150 km.

A preferred procedure is to calculate model values of START from the equations given in *J. Atmosph. Terr. Phys. 48, 435-446, 1986.*
Use of START = 0.0 makes some allowance for underlying ionisation based on a limited extrapolation of the first few virtual heights.
With initial x-ray data, START is taken to give the gyrofrequency height for underlying ionisation calculations; the values listed above are still suitable for this purpose. The x-ray data is used to calculate a slab start correction from 0.3*fmin (adding points at 0.3, 0.6 and 0.8 *fmin).
[Alternative procedures can be obtained using non-standard values of START:-
START between 0 and 44 defines the plasma frequency for a model start.

Start = -1.0 uses a direct start, from the first scaled point.
Start < -1.0 for x-starts to use a polynomial from (-Start -1.0) MHz.]

THE final three parameters - AMODE, VALLEY and LIST, are zero for most work.
AMODE sets the type of analysis, as listed below. Zero uses mode 6. Use AMODE+10. for 12-point integrals, for high accuracy at large dip angles (this is done automatically, at DIP > 60, when AMODE=0).
Values of AMODE greater than 29.0 are used to specify the number of polynomial constants to be used to describe each ionospheric layer; thus
80. uses an 8-term real height polynomial for each separate layer.
85. uses 8 terms for the final layer and 5 terms for lower layers.
853. uses 8 terms for the last, 3 terms for the first, and 5 terms for any intermediate layer.
Setting AMODE negative causes physical relations to be omitted from the start and valley calculations.
VALLEY= 0.0 or 1.0 uses a valley width equal to the initial default value of twice the local scale height. The initial default depth is 0.05 MHz. The calculated depth is scaled according to (calculated width)**2.
Alternative solutions may be obtained as follows:
VALLEY = 10.0 gives a monotonic (no valley) analysis.
VALLEY = 5.0 gives a maximum valley (upper reasonable limit) analysis.
VALLEY = 0.1 to 5.0 multiplies the standard valley width by this factor.
VALLEY =-.01 to -.99 uses -Valley as the initial depth (instead of the default value of 0.05 MHz).
VALLEY = -1.0 iterates both valley depth and width for best fit, with x-ray data.
(VALLEY = -1.d iterates from an initial depth of 0.d MHz).
VALLEY < -2.0 specifies a fixed valley width of 2*int(-VALLEY) km. If VALLEY has a decimal part d, this specifies a depth of 2*d in MHz.
LIST =
0 prints results for the start, peak and valley regions only.
1 adds one line of output showing the frequency range and the polynomial coefficients calculated at each step.
2, 3 add additional output.
4 to 9 show the data used at each step, and the calculated polynomial coefficients.
5 shows each set of simultaneous equations, in the call to SOLVE.
6/7/8/9 give detail in the start/reduction/peak/valley steps.
LIST negative suppresses most trace output below the first peak. LIST= -10 suppresses all output, even the normal layer summaries.

---

3. RETURNED DATA
The arrays FV, HT contain the calculated frequencies and real heights.
N gives the number of calculated real-height data points.
The peak of the last layer is at FC = fv(N-3), Hmax = ht(N-3).
Points at N-2, N-1 and N in the output arrays are extrapolated heights at 0.5, 1.0 and 1.5 scale heights above the peak (calculated using the Chapman expression with a scale height gradient of 0.2).
fv(N+1) gives the standard error of the last critical frequency, in MHz.
ht(N+1) gives the standard error of the last peak height Hmax, in km.

fv(N+2) gives the slab thickness, in km. This is equal to the sub-peak electron content divided by the peak density.
ht(N+2) gives the scale height SH of the last peak, in km.
A negative value of SH shows that a model value was used for the scale height, to limit an unreasonable peak extrapolation.
QQ returns the real-height coefficients, for single-polynomial calculations, as described under *Section 4.2* below.

---

4. MODES OF ANALYSIS.
4.1 THE TEN STANDARD MODES
MODE is obtained from the input parameter AMODE, modified to the range 1 to 10, and is used to select the type of analysis as summarised below. All Modes include an estimated start correction, a Chapman-layer peak, and a model valley between layers.
MODE=
1.- The Linear-Lamination analysis.
2.- A Parabolic-Lamination analysis, matching end gradients(=Paul).
3.- Overlapping Cubics, with no spurious oscillations (*JATP 1982 p657*).
4.- Fourth Order Overlapping Polynomials (*Radio Science 1967, p1169*).
5.- Fifth Order Least-Squares fit to 6 points (4 virtual + 2 real).
6.- Sixth Order Least-Squares fit to 8 points (5 virtual + 3 real).
7.- Sixth Order fit to 7 virtual +3 real heights; calculates 2 new hts.
8.- Sixth Order fit to 8 virtual +4 real heights; calculates 2 new hts.
9.- Seventh Order fit to 13 virtual + 6 real hts; calculates 3 new hts.
10. A Single Polynomial, fitting 0.73(NV+2) terms to NV heights.
The basic parameters which define the type of analysis depend on the parameter MODE, and are obtained from the arrays given below.
NT is the number of terms used in the polynomial representation of each real-height segment.
NV is the number of virtual heights which are fitted in this step.
NR is the number of previously-calculated real heights which are fitted (in addition to the origin FA, HA). A negative value of NR indicates that one of the fitted real heights is below the origin. If NT = NV + NR we get an exact fit to the data, and if NT > NV + NR the calculated profile segment is a least-squares fit.
NH is the number of new real heights to be calculated. 'First step' values are used at the beginning of an analysis, or when starting on a new layer, when no real heights are known above the starting point. In this case the number of known real heights is zero, and the tabulated values of NR define the position of the origin (counting backwards from the last calculated real height) for the following step.

```
       |-------- First step ------|    |------- Following steps --|

MODE=  1, 2  3  4  5  6  7  8  9 10    1  2  3  4  5  6  7  8  9 10

 NT =  1, 2, 3, 4, 4, 5, 6, 6, 7,73,   1, 2, 3, 4, 5, 6, 6, 6, 7,73

 NV =  1, 2, 3, 4, 5, 7, 8,10,12,40,   1, 1, 2, 3, 4, 5, 7, 8,13,40

 NR =  0, 0, 0, 1, 1, 2, 2, 3, 5, 2,   0,-1,-1, 1,-2,-3,-3,-4,-6,-3
```

NH = 1, 1, 2, 3, 3, 4, 5, 6, 8,28, 1, 1, 1, 1, 1, 1, 2, 2, 3,28

4.2 SINGLE-POLYNOMIAL MODES
These use a defined number of real-height coefficients for each layer, and return all profile parameters in the array QQ.The order of the analysis is set by the parameter AMODE, as follows.
AMODE = 10L, where L is an integer in the range 3 to 15, uses a single polynomial with L terms to describe each ionospheric layer.
AMODE = 10L+M uses L terms for the final layer, and M for earlier layers.
AMODE = 100L+10M+F is L terms for Last, M for Middle and F for First layer.
QQ returns the real-height parameters which describe the profile, for single-polynomial modes of analysis (unless QQ(1) was set equal to -1.0 by the calling program).
The returned value of QQ(1) gives the total number of stored values (mq). Starting at QQ(2), the parameters returned for each layer are:
FA, HA, nq, q1, q2, .. qn, devn, FM, FC, HM, and SH.
nq is the number of polynomial coefficients (q1 to qn) used for this layer. This is normally equal to the number of coefficients requested in AMODE.
HA is the true height at FA, after any start or valley adjustments, so the real-height profile is
h = HA + q1.(f-FA) + q2.(f-FA)^2 + ... qn.(f-FA)^nq.

devn is the rms deviation (in km) of the fit to the virtual height data.

FC, HM andSH are the constants which define the Chapman-layer peak; this joins the polynomial section at the frequency FM (the highest scaled frequency for the layer). For a 2nd (or 3rd) layer, FA, HA give the new real-height origin at the top of the valley region. Thus FA is equal to the previous FC, and the valley width is W = HA - HM in km. The valley depth D, (in MHz) can be obtained from the width using equations (14) of the report *UAG-93*, which give

D = 0.008 W**2/(20 + W) MHz, followed by D = D.FC/(D + FC).
The end point of the data in QQ is verified by a value QQ(mq+1) = -99 for a normal exit, and -98. for an error exit.

---

5. PROCESSING - Outline of the REAL-HEIGHT ANALYSIS LOOP within POLAN.
5.1 THE OVERALL PROCEDURE, FOR ONE CYCLE OF THE CALCULATION
Analysis can proceed with a minimum of 2 scaled virtual heights (or 1 height and a critical frequency) for each layer. If the number of data points NV is less than the number of polynomial terms NT (as specified by AMODE), NT is automatically decreased.
Calculate one polynomial, with NT terms, from the point FA = fv(K) ,HA = ht(K), to fit the next NV virtual and NR real heights. (The fitted real heights include one point below HA, if NR is negative.)
The real-height origin (FA,HA) is at K = KR, in the data arrays FV, HT. The corresponding virtual height is at K = KV.

With x-ray data (-ve frequencies), at the start or after a peak, recalculate HA to include the correction for underlying or valley ionisation. Calculate a further NH real heights, and set KR = KR + NH; KV = KV + NH.
Repeat this loop, calculating successive overlapping real-height sections, until a critical frequency (or end-of-layer) is found in the range KV+1 to KV+NV+1. Then calculate real heights at the remaining scaled frequencies and determine a least-squares Chapman-layer peak.
5.2 INDIVIDUAL STEPS WITHIN EACH CYCLE
(numbered according to the corresponding section in the program POLAN.)
SECTION 2.2 Count initial x-rays. Check frequency sequencing. Check for cusp, peak, or end of data.

Set;
NF = number of o-rays (= NV,if sufficient points exist before a following peak);
NX = number of x-rays; MV = NF+NX;
FM = fv(mf) = the top frequency used in this step.
FCC=
FC or 0.1 for a peak,
-0.1 for a cusp (gradient discontinuity) at FM,
0.0 otherwise.
SECTION 2.3 Subtract the group retardation due to the last calculated real-height section. This modifies all the virtual heights at f > FA (where FA = fv(KR)), and increases the index LK (which gives the point up to which the group retardation has been removed) to KR.
SECTION 3. Set up equations for the next profile step. Check for the occurrence of a valley; if this is required, set the valley flag HVAL and set initial values for the width and depth. Set up equations in the matrix B. For start calculations using x-ray data, or for any valley calculations, add suitably weighted equations specifying desired physical properties of the solution.
SECTION 4. Solve the set of simultaneous equations in the array B.
Check that the solution satisfies basic physical constraints. If it does not, obtain a new least-squares solution with the limiting constraints imposed (in the subroutine ADJUST).
For an x-start or valley calculation, iterate the solution as required to ensure the use of a correct gyrofrequency height, and the correct relation between depth and width of the valley. For an o-ray valley, loop once to adjust the valley depth.
SECTION 5. Calculate and store the real heights. Set KRM as the index for the highest calculated real height.
SECTION 6. Least-squares fitting of a Chapman layer peak.
Calculate the critical frequency and the scale height of a layer peak, by an iterative fit to the real-height gradients at the last few calculated points (as in *Radio Science 20, 247, 1985*). Determine the height of the peak by fitting the peak shape to a weighted mean of the last few calculated real heights. Adjust the last real height to agree exactly with the Chapman peak (sept'86).
SECTION 7. Go to section 2, to restart for a new layer.
If there are no further data, extrapolate 3 points for the topside ionosphere (assuming a Chapman layer with a scale height gradient of 0.2 km/km), store constants relating to the last layer peak, and return.

J.E. Titheridge, November 1987.

APPENDIX I – MMM FILE FORMAT

This section contains a description of the raw MMM (Modified Maximum Method) for the DPS and the DGS-256 file formats for storage of MMM ionograms. There are 5 types of Digisonde, each producing one of two MMM formats DPS or DGS-256.

- DGS-256 Digisonde-256
- DISS Digital Ionospheric Sounding System of US Air Force, AWS - standardized DGS-256
- DPS-1 Single-Receiver Digisonde Portable Sounder
- DPS-4 Four-Receiver Digisonde Portable Sounder
- VIS Vertical Incidence Sounder for Telstra Australia - Standardized DPS-1

The format of the MMM filename is VVVVV_YYYYMMDD.mmm
Where VVVVV is the site ID and site Code e.g rl052
YYYY is the year, MM is the month and DD is the day of the month

MMM DPS – Description

The MMM DPS (Digisonde Portable Sounder) file is arranged in blocks, each block being 4096 bytes in length. Each block has a Header section, followed by a data section split over 30 groups, each group is split into a Prelude and a data-points series of bytes consisting of A-scans taken at each sounding frequency, each A-Scan holding 128 bins and each bin consisting of an Amplitude (The MSB ‘Upper Nibble’) and a Channel Number (the LSB ‘Lower Nibble’). In general there are 281 blocks in the MMM DSP file.

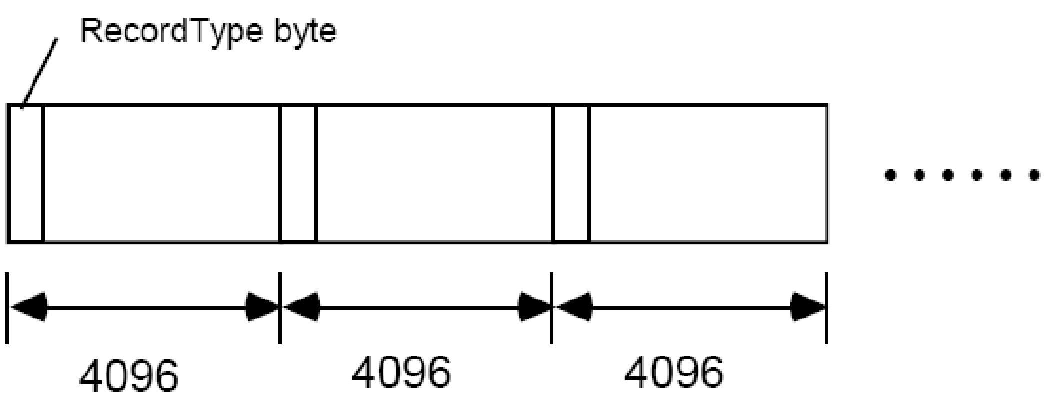


Figure 1.01 – MMM File Structure

The Header Section consists of 3 bytes the Record_type, the Header Length and a Spare byte followed by the PREFACE, a 57 byte description of the time and frequency sounding and other relevant operating and control parameters.

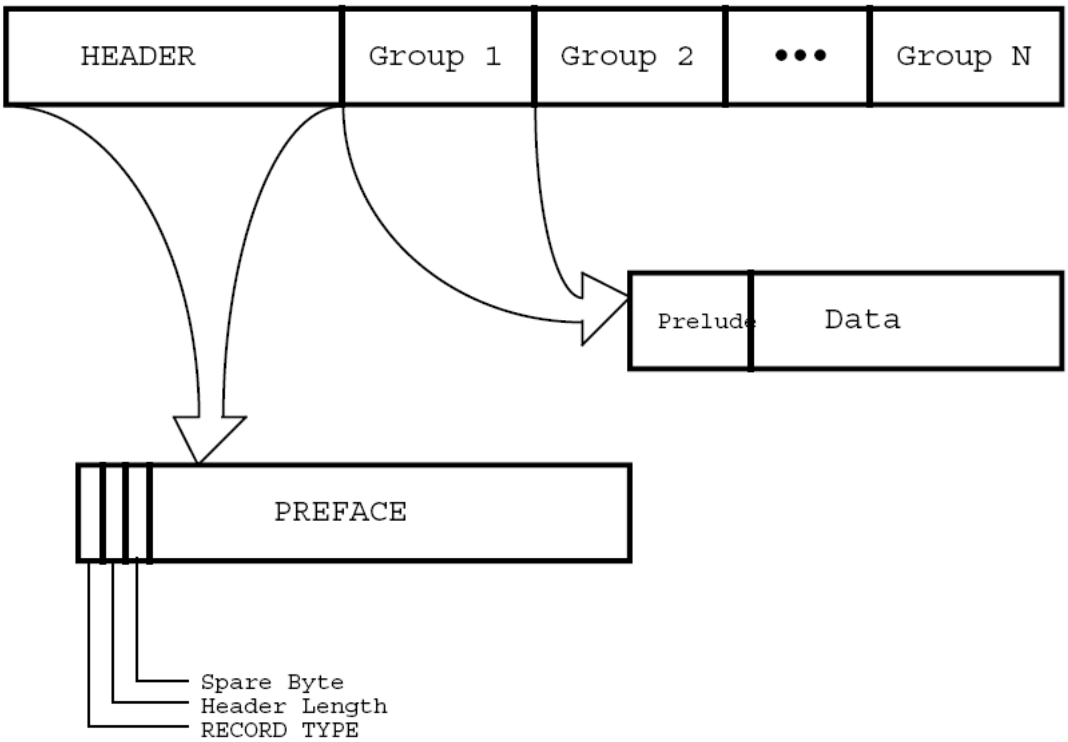


Figure 1.02 – MMM single Block Structure

DPS header section:

Byte	Parameter	Range	Units	Description
1	RECORD_TYPE			The **record_type** denotes the start of a block, the value is 09 for the first block and 08 for subsequent blocks.
2	HEADER_LENGTH			The **Header_length** byte denotes the length of the header in Bytes before the start of the group.
3	SPARE_BYTE			Unused byte
4-5	YY	0-99	Years	2 Year field Bytes
6-8	DDD	1-366	Days	3 Day Bytes
9-10	HH	0-23	Hours	2 Hour Bytes
11-12	MM	0-59	Minutes	2 Minute Bytes
13-14	SS	0-59	Seconds	2 Second Bytes
15	SCHEDULE	1-6		**Schedule**
16	PROGRAM	1-7		**Program**
17	F		1Khz	**Fine Frequency Step**, the frequency can be changed enabling the sounder to alternate the sampling of received signals

				from one or four antennas for as many as 16 frequencies and 2 polarizations.
18	J2			**Journal 2**, J2 is set to 2 in DPS
19	**BLANK**			Unused byte
20	E			**First Height** in 10s Km[3]
21	H	2,5,10		**Height resolution**, can take values (2,5,10) 2 – 2.5Km 5 – 5Km 10 – 10 Km
22	M	1,2		**Number of Heights**, can take values (1,2) denotes what number of complex amplitude samples (1=128, 2=256) made after transmission of each waveform was chosen in the program.
23-28	FFFFFF	0-999999	100Hz	6 Bytes **Nominal Start Frequency** Byte (100Hz)
29	P1	1		**Output Control 1**, Date storage format for Disk Files, P1 specifies the file format and indicates the measurement being made. 1 = MMM
30	P2	0-2		**Output Control 2**, Printer Output 0 None 1 for black and white printing, 2 for color printing.
31	P3	0-17		**Output Control 3**- MMM options 0 No processing 1 Birdie removal 2 channel toss-out 4 Show tossed-out channels 8 ARTIST output and bit combinations multiple options are summed
32	**BLANK**			Unused byte
33	S	-15-+15		**Number of Small Steps** in the scan, If S is positive all frequency steps are completed before make each subsequent time domain sample on the first frequency, measurements are the

				various frequencies is done simultaneously. If S is negative a coherent integration is done for each frequency before changing frequency, providing a larger Doppler range and a series of sequential measurements to be made.
34	A	1-7		**Multi-Antenna Sequencing**, Four antenna elements are available, it is possible to select them individually or sum them to form a vertical or obliquely tipped beam. Settings are: 0 – Antenna signals are summed into a vertical beam. 1-4 All samples are made on the specified single antenna 5-6 (Not used) 7 – Signals are sampled from all four antennas in rapid sequence or simultaneously.
35	**BLANK**			Unused byte
36-37	LL	0-99	100Hz	**Start Frequency** in ionogram, the first frequency transmitted.
38	C	0-5	1KHz	**Coarse Frequency step** {0,1,2,3,4,5}, The size of the frequency step in KHz to be made between frequency measurements. 0 – 0.2 KHz 1 – 0.1 KHz 2 – 0.05 KHz 3 – 0.025 KHz 4 – 0.01 KHz 5 – 0.05 KHz
39-40	UU	0-99	100Hz	**Stop frequency** in Ionogram, the last coarse frequency step in the a stepped frequency
41	HINOISE	0-2		**HiNoise setting** (0..2) related to the gain.
42	Y4	0-9		**year** digit 4
43	Y3	0-9		**year** digit 3
44-46	VVV	0-999		**Station ID**, identifies the station where the measurement was made.

47	X	1,2,3,4,8		**Phase Code** 1 – complim 2 – Short 3 - 75% duty 4 – 100% duty 8 – no phase switch
48	L			**Azimuth Correction** Not used for DPS
49	Z			**Antenna Sequencing Setting Z** related to the way the receivers are polled.
50	T			**Antenna Sequencing Setting T,** related to the way the receivers are polled.
51	N			**Number of Samples**, a power of 2 defining the number of coherent samples going into each Doppler integration. This is the number of times the program scans through S fine frequency steps, 1 or 4 antenna steps, 1 or 2 polarisation steps and 1 or 2 code modulation steps.
52	R	1-3	pps	**Pulse Repetition Rate**, denotes what rate was chosen in the program. 1- 50 2 - 100 3 - 200
53	W	4		**Pulse Width** Set to 4 in DPS
54	D			**Delay** in 50 usec steps, The precision timing offset allows different programs to receive oblique transmission from other locations with the current time delay. D denotes the delay count entered.
55	**BLANK**			Unused Byte
56	**BLANK**			Unused Byte
57	H	0-2		**Range Increment** {0,1,2), the digitizer sampling period. 0 – 2.5 Km 1 – 5 Km 2 – 10Km

58	E	0-3		**Range Start** {0,1,2,3}, denotes what range height value was set in the program in Km of the first sample made after transmission of each waveform. 0 – 0Km 1 – 10Km 2 – 60Km 3 – 160Km
59	I	0(No), 1(yes)		**Frequency Search Enabled**, If enabled the programs frequency search function scans the receiver through four additional possible frequencies, symmetric about the nominal frequency.
60	G	0-7 +8 (8-15)	dB	**Nominal Gain Enabled** 0-7 (0-42db) + 8 auto gain Fixed or Automatic gain can be selected manual (0-7) gain in 6dB steps. +8 will give same gain as before plus an automatic correction of as much as +36dB.

Group Section:

The Preface added to the length of 30 groups does not add up to 4096 so there is a portion of the file left unused. The 'END' character is used to denote the last group in a block.

The group is split into a Prelude section and the A-Scan data section. The 30 groups use up 4080 byte of the file with one byte (4081) for the 'END' character and the last 15 bytes unused. Each prelude byte is split into MSB and LSB 4 bits. The prelude precedes each set of range bins ins frequency group.

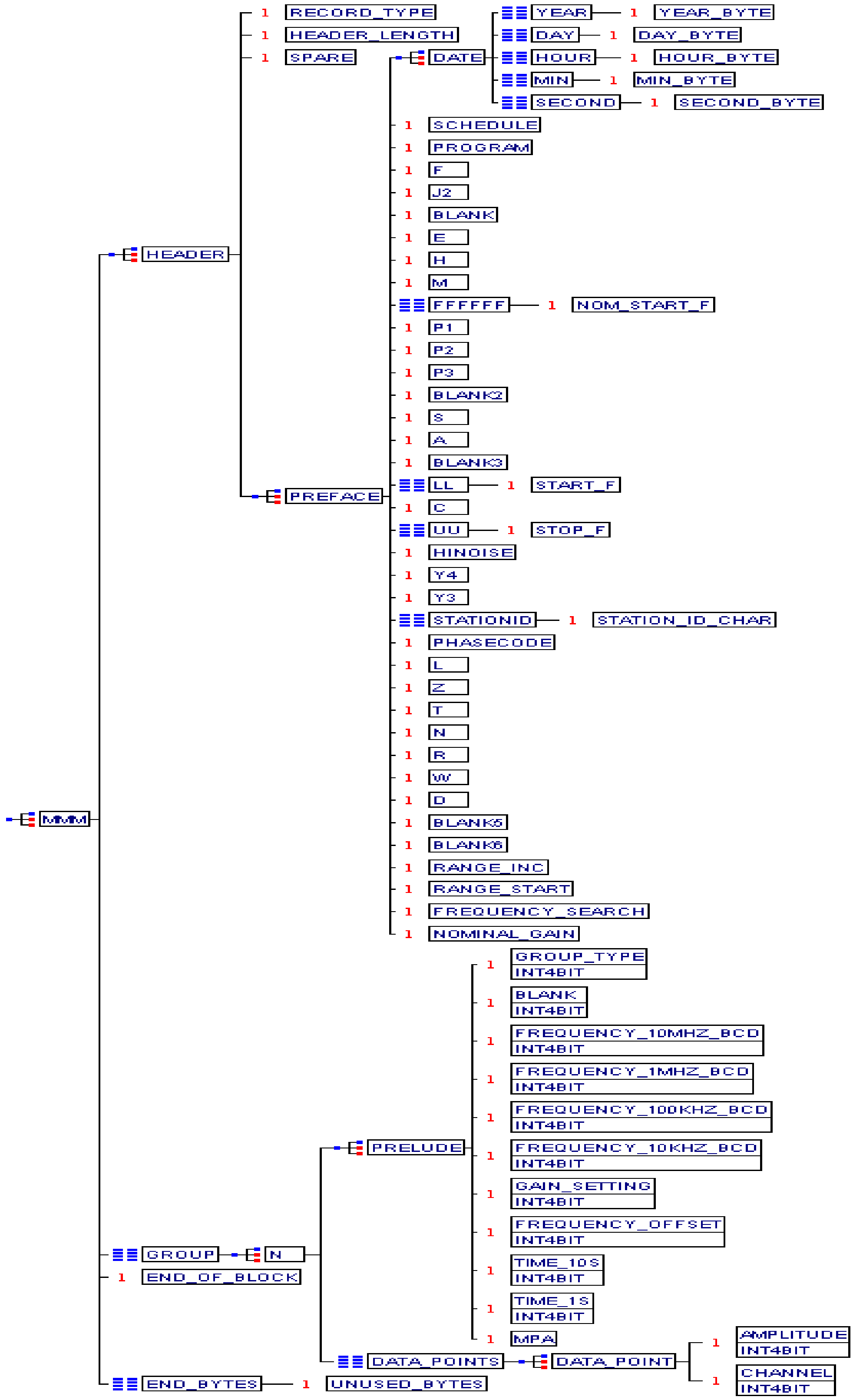
Prelude has the format:

Byte	**Name**	**Description**
1	Group Type	4 bits MSB (Low Nibble) denotes what type of MMM the file is DPS are group 1
	BLANK	LSB 4 bits Unused
2	Frequency Reading 10s MHz	4 bits MSB (Low Nibble)
	Frequency Reading 1s MHz	LSB 4 bits
3	Frequency Reading	

	100s KHz	
	Frequency Reading	
	10s KHz	
4	Frequency Offset	0 – -20KHz 1 – -10KHz 2 no offset 3 - +10KHz 4 - +20KHz
	Gain setting	0-15
5	Seconds 10s	
	Seconds 1s	
	MPA (0-31)	Most Probable Amplitude – the ‘Noise’ floor, either in height in a profile or a Doppler spectrum containing random noise contamination. This is a value of the peak of a probability density distribution of amplitudes in a profile or Doppler spectrum.

Each group has a Prelude 6 bytes followed by 128 data Bytes. Each data byte is split into [AAAACCCC] a 4bit Amplitude encoded in the High nibble and 4-bit Channel Number in the low Nibble, the Doppler Value can be derived from the Channel Number using lookup tables.

The figure 1.03 below shows a hierarchical model of the data structure in EAST created using the OASIS software. The EAST logical description provides enough bit level representation to show placement of data in the record.



MMM
HEADER
RECORD_TYPE
HEADER_LENGTH
SPARE
PREFACE
DATE
YEAR
YEAR_BYTE
DAY
DAY_BYTE
HOUR
HOUR_BYTE
MIN
MIN_BYTE
SECOND
SECOND_BYTE
SCHEDULE
PROGRAM
F
J2
BLANK
E
H
M
FFFFFF
NOM_START_F
P1
P2
P3
BLANK2
S
A
BLANK3
LL
START_F
C
UU
STOP_F
HINOISE
Y4
Y3
STATIONID
STATION_ID_CHAR
PHASECODE
L
Z
T
N
R
W
D
BLANK5
BLANK6
RANGE_INC
RANGE_START
FREQUENCY_SEARCH
NOMINAL_GAIN
GROUP
N
END_OF_BLOCK
PRELUDE
GROUP_TYPE INT4BIT
BLANK INT4BIT
FREQUENCY_10MHZ_BCD INT4BIT
FREQUENCY_1MHZ_BCD INT4BIT
FREQUENCY_100KHZ_BCD INT4BIT
FREQUENCY_10KHZ_BCD INT4BIT
GAIN_SETTING INT4BIT
FREQUENCY_OFFSET INT4BIT
TIME_10S INT4BIT
TIME_1S INT4BIT
MPA
DATA_POINTS
DATA_POINT
AMPLITUDE INT4BIT
CHANNEL INT4BIT
END_BYTES
UNUSED_BYTES

Figure 1.03 – The East Description Model of the MMM DPS file

MMM DGS-256 – Description

The MMM DGS (Digisonde 256) file is arranged in blocks each block is 4096 bytes in length. Each block has a Header section, followed by a data section split over 15 groups, each group is split into a Prelude and a data-points series of bytes consisting of A-scans taken at each sounding frequency, each A-Scan holding 256 bins and each bin consisting of an Amplitude (The 5 bit MSB 'Upper Nibble') and a Channel Number (the 3 bit LSB 'Lower Nibble'). In general there are 281 blocks in the MMM DGS-256 file.

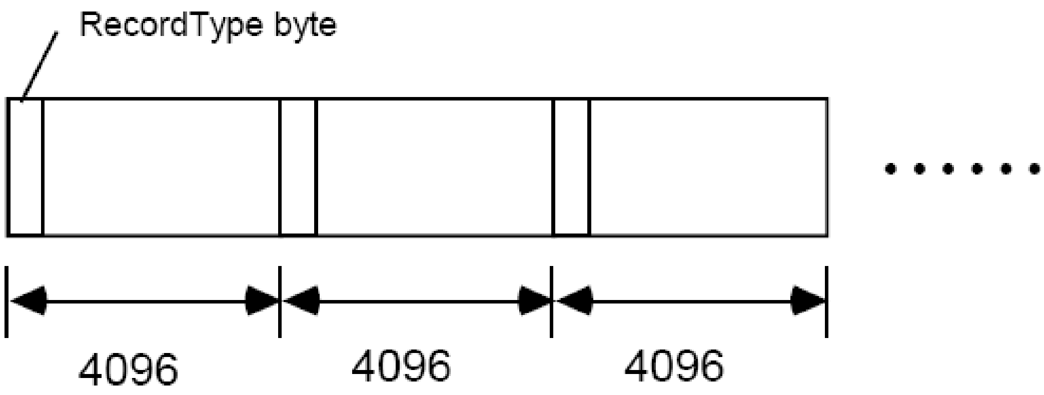


Figure 1.04 – MMM File Structure

The Header Section consists of 3 bytes the Record_type, the Header Length and a Spare byte followed by the PREFACE, a 57 byte description of the time and frequency sounding and other relevant operating and control parameters.

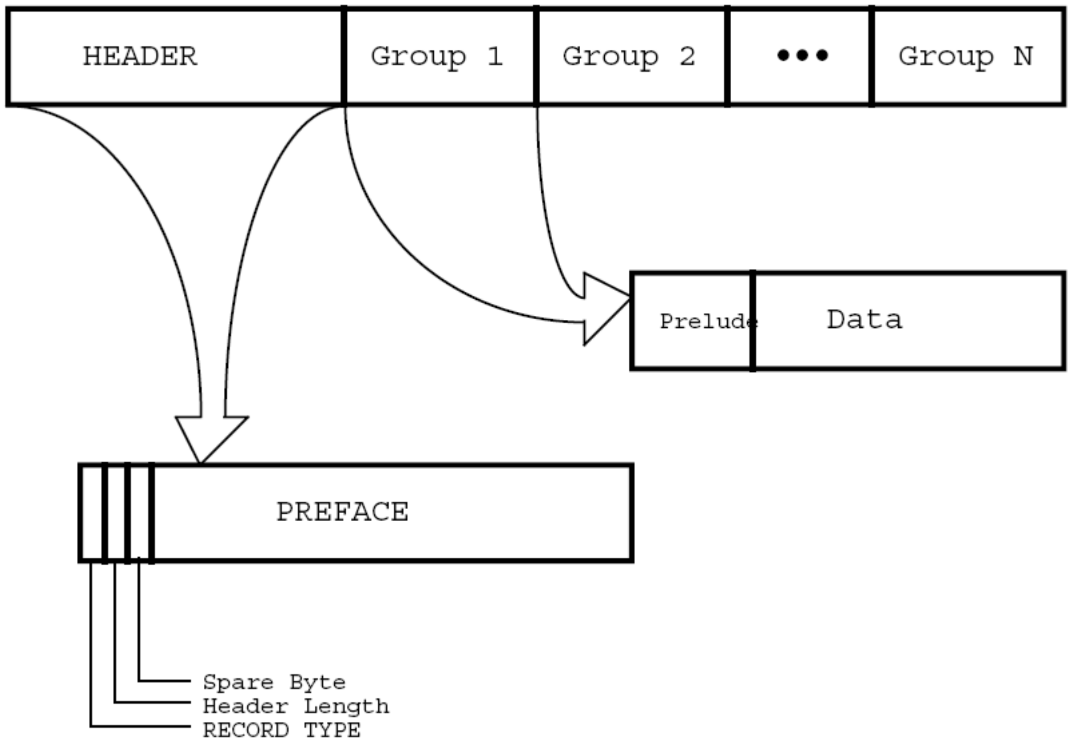


Figure 1.05 – MMM single Block Structure

DGS-256 Header Section:

Byte	Parameter	Range	Units	Description
1	RECORD_TYPE			The **record_type** denotes the start of a block, the value is 09 for the first block and 08 for subsequent blocks.
2	HEADER_LENGTH			The **Header_length** byte denotes the length of the header in Bytes before the start of the group.
3	SPARE_BYTE			Unused byte
4-5	YY	0-99	Years	2 Year field Bytes
6-8	DDD	1-366	Days	3 Day Bytes
9-10	HH	0-23	Hours	2 Hour Bytes
11-12	MM	0-59	Minutes	2 Minute Bytes
13-14	SS	0-59	Seconds	2 Second Bytes
15	SCHEDULE	1-6		**Schedule**
16	PROGRAM	1-7		**Program**
17	J1			**Journal 1**
18	J2			**Journal 2**
19	**BLANK**			Unused byte
20	J4			**Journal 4**,

21	J5	2,5,10		**Journal 5**,
22	J6	1,2		**Journal 6**,
23-28	FFFFFF	0-999999	100Hz	6 Bytes **Nominal Start Frequency** Byte (100Hz)
29	P1	1		**Output Control 1**, Date storage format for Disk Files, P1 specifies the file format and indicates the measurement being made. 1 = MMM
30	P2	0-2		**Output Control 2**, Printer Output 0 None 1 for black and white printing, 2 for color printing.
31	P3	0-17		**Output Control 3**- MMM options 0 No processing 1 Birdie removal 2 channel toss-out 4 Show tossed-out channels 8 ARTIST output and bit combinations multiple options are summed
32	P4	3,4		Printer Cleaning Threshold (3,4)
33	P5	0,1		**Printer Amplitude font**
34	P6	1-7		**Frequency Sequencing**
35	**BLANK**			Unused byte
36-37	LL	0-99	100Hz	**Start Frequency** in ionogram, the first frequency transmitted.
38	C	0-5	1KHz	**Coarse Frequency step** {0,1,2,3,4,5}, The size of the frequency step in KHz to be made between frequency measurements. 0 – 0.2 KHz 1 – 0.1 KHz 2 – 0.05 KHz 3 – 0.025 KHz 4 – 0.01 KHz 5 – 0.05 KHz
39-40	UU	0-99	100Hz	**Stop frequency** in Ionogram, the last coarse frequency step in the a stepped frequency
41	Trigger	0-2		**Trigger**

42	A	0-9		**Channel A**
43	B	0-9		**Channel B**
44-46	VVV	0-999		**Station ID**, identifies the station where the measurement was made.
47	X	1,2,3,4,8		**Phase Code** 1 – complim 2 – Short 3 - 75% duty 4 – 100% duty 8 – no phase switch
48	L			**Azimuth Correction**
49	Z			**Antenna Sequencing Setting Z** related to the way the receivers are polled.
50	T			**Antenna Sequencing Setting T,** related to the way the receivers are polled.
51	N			**Number of Samples**, a power of 2 defining the number of coherent samples going into each Doppler integration. This is the number of times the program scans through S fine frequency steps, 1 or 4 antenna steps, 1 or 2 polarisation steps and 1 or 2 code modulation steps.
52	R	1-3	pps	**Pulse Repetition Rate**, denotes what rate was chosen in the program. 1- 50 2 - 100 3 - 200
53	W	4		**Pulse Width**
54	K			**Time Control**
55	**I**			Frequency Correction
56	**G**			Gain Correction
57	H	0-2		**Range Increment** {0,1,2), the digitizer sampling period. 0 – 2.5 Km 1 – 5 Km 2 – 10Km
58	E	0-3		**Range Start** {0,1,2,3}, denotes what range height value was set in the program in Km of the first

				sample made after transmission of each waveform. 0 – 0Km 1 – 10Km 2 – 60Km 3 – 160Km
59	Frequency_search	0(No), 1(yes)		**Frequency Search Enabled**, If enabled the programs frequency search function scans the receiver through four additional possible frequencies, symmetric about the nominal frequency.
60	Nominal_Gain	0-7 +8 (8-15)	dB	**Nominal Gain Enabled** 0-7 (0-42db) + 8 auto gain Fixed or Automatic gain can be selected manual (0-7) gain in 6dB steps. +8 will give same gain as before plus an automatic correction of as much as +36dB.

Group Section

The Preface added to the length of 15 groups does not add up to 4096 so there is a portion of the file left unused. The 'END' character is used to denote the last group in a block.

The group is split into a Prelude section and the A-Scan data section. The 15 groups use up 3990 byte of the file with one byte (3991) for the 'END' character and the last 104 bytes unused. Each prelude byte is split into MSB and LSB 4 bits. The prelude precedes each set of range bins ins frequency group.

Prelude has the format:

Byte	Name	Description
1	Group Type	4 bits MSB (Low Nibble) denotes what type of MMM the file is DPS are group 1
	BLANK	LSB 4 bits Unused
2	Frequency Reading 10s MHz	4 bits MSB (Low Nibble)
	Frequency Reading 1s MHz	LSB 4 bits
3	Frequency Reading 100s KHz	
	Frequency Reading 10s KHz	

4	Frequency Offset	0 – -20KHz 1 – -10KHz 2 no offset 3 - +10KHz 4 - +20KHz
	Gain setting	0-15
5	Seconds 10s	
	Seconds 1s	
	MPA (0-31)	Most Probable Amplitude – the 'Noise' floor, either in height in a profile or a Doppler spectrum containing random noise contamination. This is a value of the peak of a probability density distribution of amplitudes in a profile or Doppler spectrum.

Each group has a Prelude 6 bytes followed by 256 data Bytes. Each data byte is split into [AAAAASSS] a 5bit Amplitude and a 3-bit Status, the Doppler Value can be derived from the Status using lookup tables.

The figure 1.06 below shows a hierarchical model of the data structure in EAST created using the OASIS software. The EAST logical description provides enough bit level representation to show placement of data in the record.

APPENDIX J - STANDARD ARCHIVING OUTPUT (SAO) FORMAT

Introduction

Automatic scaling of ionogram data has come a long way and the quality of the autoscaled data has reached a remarkable level. Consequently the time has arrived to directly transfer ionosonde data to the World Data Centers using the Internet. We have begun to equip the Digisondes with Internet connections. The first Internet links were established between the Okinawa Digisonde (CRL, Japan) and the WDC-C2 in Tokyo, the Millstone Hill Digisonde (UML, USA) and the WDC-A in Boulder, Colorado, and Chilton Digisonde (RAL, GB) and the WDC-C1 in Chilton. All data generated in the Digisonde are made available for electronic transfer: ionogram data, scaled data, and drift data.

Starting in 1987, the Ionospheric Informatics Working Group (IIWG) of Commission G of URSI has developed recommendations for the data formats to be used for dissemination and archiving of scaled ionogram data and for the monthly ionospheric characteristics. The IIWG abstained (wisely) from trying to develop a common data format for the system-dependent ionogram and drift data.

The attached report gives a detailed description of the Standard Archiving Output (SAO) format. Each SAO (text) file contains the scaled data for one ionogram including the echo traces h'(f), echo amplitudes, frequency and range spread, etc. and the electron density profile.

The upgraded or new Digisondes produce the SAO files in real time for local recording and/or electronic transfer. The older Digisondes generate only binary files, but offline editing results are usually stored in the SAO format. Since these Digisonde ionograms SAO files are now becoming available to any user either through the WDC sites or via the web pages of the connected Digisonde stations it seems important to publish a description of the SAO format.

The SAO format was originally designed for storing Digisonde ionograms scaled by autoscaling software ARTIST and edited using ADEP utility. However, in subsequent releases a special effort was made to generalize SAO design so that it can hold scaled data produced by other sounder systems. With release of version 4.1, the degree of format universality became high enough to promote SAO as a standard format for exchange of scaled ionogram data.

SAO Format version 4.3

The SAO file structure has remained the same since it was developed by the IIWG in 1989, but the content has been expanded in subsequent releases. The following is a description of the SAO format version 4.3 *[Gamache et al.,* 1996*]*.

A SAO file is an ASCII text file with a maximum line length of 120 characters. In order to concisely describe the database some definitions are necessary. The nomenclature is as follows:

File	a collection of many *Records*
Record	all data for a single observation (ionogram)
Group	all *Lines* of a datum type
Line	a sequence of *Elements* of a datum type, CR/LF terminated
Element	a single datum in the specified format

The *Record* structure is composed of two basic components: a **Data Index** and **Data**. The format and size of the **Data Index** is fixed. It describes the contents of the **Data** in the *Record*. The **Data** component of each *Record* contains a varying number of *Groups* as indicated by the **Data Index**. The format and length of data varies from one *Group* to the next; however, all data *Elements* within a single *Group* are of the same type and length. The number of characters in a given *Group* can easily exceed the 120 characters per line limit. In this case, the output overflows to succeeding lines, thus a data *Group* may extend over several *Lines*.

This format design allows storing variable amount of information per ionogram, depending not only on ionospheric conditions, but also on sounder system specifics. There is only a subset of *Groups* that have to be present in a *Record.* As explained below, all others may be omitted and their corresponding index in the **Data Index** section set to zero. Data systems engineers have to decide which *Groups* to use to report data available from their sounders, if different from Digisonde. There are three situations, described in detail below, where system-specific data can be readily ingested using existing SAO-4 format:

System Description line (using *tokens* of an arbitrary format)

Operator's Message (using any text format)
Sounder Settings (by requesting a version indicator and submitting format specification to their local WDC)
Groups 63 to 79 are currently vacant for specification formats of other data items currently missing from SAO-4. Each addition of a Group has to be accompanied with a new release of SAO 4 format (versions 4.2, 4.3,...) which contains format specification for the new Group. If necessary. the number of vacant *Groups* may be expanded by addition of new line(s) in the **Data Index**.

Data Index

The Data Index contains 80 three digit integers. The position in the list corresponds to the data for the data *Group* number. These are shown in Table 1. The first integer is the **number of *Elements*** in the data *Group* 1, Geophysical Constants, in the current *Record*. The second integer represents the **number of *Elements*** in the second data *Group*, System Description, etc. A value of zero indicates that there is no data for the *Group* in the *Record*. Position 80 of the Data Index array is not used to specify the format of the data to follow. It is reserved for the SAO version indicator:

0 SAO-3
1 SAO-3.1
2 SAO-4.0
3 SAO-4.1
4 SAO-4.2
5 SAO-4.3

If the demand for vacant *Groups* grows beyond the existing limit, the Data Index will have to expand and include more lines. The 80th element of the Data Index will still be used as the Version Indicator so that the reading logic will be aware of extra index lines.
Column **Req.** of Table 1 indicates which Groups are required to specify in a minimum content SAO-4 file. Red "x" marks indicate mandatory groups. If trace points are availble for output in the file, each trace has to be specified with at least two groups (virtual heights and frequencies) as indicated by a "xx" cyan marks.

Table 1. SAO Record Format

Group	**Req.**	**FORTRAN Format**	**Description**	**Reference**
	x	2(40I3)	DATA FILE INDEX	
1	x	16F7.3	GEOPHYSICAL CONSTANTS	Table 2
2		A120	SYSTEM DESCRIPTION AND OPERATOR'S MESSAGE	
3	x	120A1	TIME STAMP AND SOUNDER SETTINGS	Table 3,4,5
4	x	15F8.3	SCALED IONOSPHERIC CHARACTERISTICS	Table 6,7
5		60I2	ANALYSIS FLAGS	Table 8
6		16F7.3	DOPPLER TRANSLATION TABLE	
			O-TRACE POINTS - F2 LAYER	
7	xx	15F8.3	VIRTUAL HEIGHTS	
8		15F8.3	TRUE HEIGHTS	
9		40I3	AMPLITUDES	
10		120I1	DOPPLER NUMBERS	
11	xx	15F8.3	FREQUENCIES	

			O-TRACE POINTS - F1 LAYER	
12	xx	15F8.3	VIRTUAL HEIGHTS	
13		15F8.3	TRUE HEIGHTS	
14		40I3	AMPLITUDES	
15		120I1	DOPPLER NUMBERS	
16	xx	15F8.3	FREQUENCIES	
			O-TRACE POINTS - E LAYER	
17	xx	15F8.3	VIRTUAL HEIGHTS	
18		15F8.3	TRUE HEIGHTS	
19		40I3	AMPLITUDES	
20		120I1	DOPPLER NUMBERS	
21	xx	15F8.3	FREQUENCIES	
			X-TRACE POINTS - F2 LAYER	
22		15F8.3	VIRTUAL HEIGHTS	
23		40I3	AMPLITUDES	
24		120I1	DOPPLER NUMBERS	
25		15F8.3	FREQUENCIES	
			X-TRACE POINTS - F1 LAYER	
26		15F8.3	VIRTUAL HEIGHTS	
27		40I3	AMPLITUDES	
28		120I1	DOPPLER NUMBERS	
29		15F8.3	FREQUENCIES	
			X-TRACE POINTS - E LAYER	
30		15F8.3	VIRTUAL HEIGHTS	
31		40I3	AMPLITUDES	
32		120I1	DOPPLER NUMBERS	
33		15F8.3	FREQUENCIES	
34		40I3	MEDIAN AMPLITUDES OF F ECHOES	
35		40I3	MEDIAN AMPLITUDES OF E ECHOES	
36		40I3	MEDIAN AMPLITUDES OF ES ECHOES	

37		10E11.6E1	TRUE HEIGHTS COEFFICIENTS F2 LAYER UMLCAR METHOD	Table 9
38		10E11.6E1	TRUE HEIGHTS COEFFICIENTS F1 LAYER UMLCAR METHOD	Table 9
39		10E11.6E1	TRUE HEIGHTS COEFFICIENTS E LAYER UMLCAR METHOD	Table 9
40		6E20.12E2	QUAZI-PARABOLIC SEGMENTS FITTED TO THE PROFILE	Table 10
41		120I1	EDIT FLAGS - CHARACTERISTICS	Table 12
42		10E11.6E1	VALLEY DESCRIPTION - W,D UMLCAR MODEL	
			O-TRACE POINTS - Es LAYER	
43		15F8.3	VIRTUAL HEIGHTS	
44		40I3	AMPLITUDES	
45		120I1	DOPPLER NUMBERS	
46		15F8.3	FREQUENCIES	
			O-TRACE POINTS - E AURORAL LAYER	
47		15F8.3	VIRTUAL HEIGHTS	
48		40I3	AMPLITUDES	
49		120I1	DOPPLER NUMBERS	
50		15F8.3	FREQUENCIES	
			TRUE HEIGHT PROFILE	
51		15F8.3	TRUE HEIGHTS	
52		15F8.3	PLASMA FREQUENCIES	
53		15E8.3E1	ELECTRON DENSITIES [e/cm^3]	
			URSI QUALIFYING AND DESCRIPTIVE LETTERS	
54		120A1	QUALIFYING LETTERS	
55		120A1	DESCRIPTIVE LETTERS	
56		120I1	EDIT FLAGS - TRACES AND PROFILE	Table 13
			AURORAL E_LAYER PROFILE DATA	
57		10E11.6E1	TRUE HEIGHTS COEFFICIENTS Ea LAYER UMLCAR METHOD	Table 9
58		15F8.3	TRUE HEIGHTS	
59		15F8.3	PLASMA FREQUENCIES	

60		15E8.3E1	ELECTRON DENSITIES [e/cm^3]	
80		--	(Reserved)	

Group 1: Geophysical Constants

The values of the Geophysical Constants shown in Table 2 are specified for the station producing the data in the file. Frequencies are in MHz, angles are in degrees.

Table 2. Geophysical Constants

Position	**Req**	**Description**
1	x	Gyrofrequency (MHz)
2	x	Dip angle (-90.0 to 90.0 degrees)
3	x	Geographic Latitude (-90.0 to +90.0 degrees)
4	x	Geographic Longitude East(0.0 to 359.9 degrees)
5		Sunspot Number for the current year

Group 2: System Description and Operator's Message

This Group allows the user to give a description of the system which recorded the data and to store a free format text message. The Group 2 is given in A120 format, so the Data Index entry for the Group 2 counts total number of 120-character *Lines* of text. One text line is used to store system description; if an operator's message is given, it takes another text line. Thus, the Data Index can be 0 (no information), 1 (system description) or 2 (system description and operator's message).

The minimum contents of the System Description line should include sounder model and station IDs. To accomodate all possible station-specific information in an organized and flexible fashion, the concept of a *token* is introduced. System Description line is arranged in comma-separated tokens, where each token consists of a registered keyword and a data field. The first token is always the sounder model, local station ID and URSI station code number. One space character separates sounder model and IDs. Station IDs are separated by a forward slash. Local station ID is determined by host institution or sounder manufacturer. URSI station code number is assigned through World Data Center A for Solar-Terrestrial Physics, contact person Raymond O. Conkright.

For example, the System Description Line for a UMLCAR Digisonde Portable Sounder may look like this:

DPS-4 042/MHJ45, ARTIST 1297, NH 1.3, ADEP 2.19

It contains four tokens:

DPS-4 042/MHJ45 -- keyword **DPS-4** indicates the Digisonde model "DPS-4", and data filed **042/MHJ45** contains UMASS Lowell Station ID *(042)* and URSI station code number *(MHJ45)*

ARTIST 1297 -- keyword **ARTIST** indicates ARTIST software, and **1297** is the ARTIST version number,

NH 1.3 -- keyword **NH** indicates true height profile inversion algorithm, and **1.3** is the algorithm version number,

ADEP 2.19 -- keyword **ADEP** indicates ADEP software, and **2.19** is the ADEP version number.

Thus, each item that the data support engineer needs in include into the SAO-4 System Description line has to form a token where the item is preceeded by a keyword. Another example can be given for a DISS sounder:

DISS 038/, NAME Wallops Island, WMOID HIGL BTGS 04231, ARTIST 0790, NH 1.3, ADEP 2.19

The SAO reading routine works as a simple string parser. It has to get the first word in the System Description line to identify the sounder system. Then, depending on the sounder model, it can scan the rest of the line for keywords and fill appropriate structures with corresponding data field contents. If the sounder model could not be identified, then the system Description line is used only as single text line, without analysis of individual tokens.

Group 3: Timestamp and Sounder Settings

Group 3 contains three fileds: **Version Indicator**, **Timestamp** of the measurement and a **Sounder Settings.** Only the first two fields are required in the minimum contents of the Group. In the minimum case, the Version Indicator should be set to AA as shown in the Table 3.

Table 3. Minimum Contents of Group 3			
Number	**Req.**	**Description**	**Possible Values**
1-2.	x	Version Indicator	AA
3-6.	x	4 digit Year.	(1976-...)
7-9.	x	Day of Year	(1-366)
10-11.	x	Month	(1-12)
12-13.	x	Day of Month	(1-31)
14-15.	x	Hour [All times and dates correspond to UT.]	(0-23)
16-17.	x	Minutes	(0-59)
18-19.	x	Seconds	(0-59)

The Sounder Settings field is intended to allow users to assign codes that identify how the measurement is made with reference to particular sounders. For each particular sounder system, the format of System Preface Parameters Group must be personalized and a unique two-letter Version Indicator should be chosen to distinguish it from other sounder systems. The Version Indicator is then stored in the first two positions of the Group 3.
DPS data is represented by "FF" Version Indicator, and "FE" is allocated for Digisonde 256 data. Example formats of this Group for Digisonde Portable Sounder (DPS) and Digisonde 256 are shown in Table 4 and Table 5, respectively.

Table 4. DPS System Preface Parameters		
Number	**Description**	**Possible Values**
1-2.	Version Indicator	FF
3-6.	4 digit Year.	(1976-...)
7-9.	Day of Year	(1-366)
10-11.	Month	(1-12)
12-13.	Day of Month	(1-31)
14-15.	Hour [All times and dates correspond to UT.]	(0-23)
16-17.	Minutes	(0-59)
18-19.	Seconds	(0-59)
20-22.	Receiver Station ID (three digits)	(000-999)
23-25.	Transmitter Station ID.	(000-999)
26.	DPS Schedule	(1-6)
27.	DPS Program	(1-7)
28-32.	Start Frequency, 1 kHz resolution	(01000 - 45000)
33-36.	Coarse Frequency Step, 1 kHz resolution	(1-2000)
37-41.	Stop Frequency, 1 kHz resolution	(01000 - 45000)
42-45.	DPS Fine Frequency Step, 1 kHz resolution	(0000 - 9999)
46.	Multiplexing disabled [0 - multiplexing enabled, 1 - disabled].	(0,1)
47.	Number of DPS Small Steps in a scan	(1 to F)
48.	DPS Phase Code	(1-4, 9-C)
49.	Alternative antenna setup [0 - standard, 1 - alternative].	(0,1)
50.	DPS Antenna Options	(0 to F)

51.	Total FFT samples [power of 2]	(3-7)
52.	DPS Radio Silent Mode [1 - no transmission]	(0,1)
53-55.	Pulse Repetition Rate (pps)	(0-999)
56-59.	Range Start, 1 km resolution	(0-9999)
60.	DPS Range Increment [2 - 2.5 km, 5 - 5 km, A - 10 km]	(2,5,A)
61-64.	Number of ranges	(1-9999)
65-68.	Scan Delay, 15 km units	(0-1500)
69.	DPS Base Gain	(0-F, encoded)
70.	DPS Frequency Search Enabled	(0,1)
71.	DPS Operating Mode [0 - Vertical beam, 5 - multi-beam ionogram]	(0-7)
72.	ARTIST Enabled	(0,1)
73.	DPS Data Format [1 - MMM, 4 - RSF, 5 - SBF]	(0-6)
74.	On-line printer selection [0 - no printer,1 - b/w, 2 - color]	(0,1,2)
75-76.	Ionogram thresholded for FTP transfer [0-no thresholding]	(0-20, encoded)
77.	High interference condition [1 - extra 12 dB attenuation]	(0,1)

Table 5. Digisonde 256 System Preface Parameters

Number	**Code**	**Description**	**Possible Values**
1-2.	-	Version Indicator	FE
3-6.	-	4 digit Year.	(1976-...)
7-9.	-	Day of Year	(1-366)
10-11.	-	Month	(1-12)
12-13.	-	Day of Month	(1-31)
14-15.	-	Hour [All times and dates correspond to UT.]	(0-23)
16-17.	-	Minutes	(0-59)
18-19.	-	Seconds	(0-59)
20-30.	-	Digisonde Preface Timestamp	YYDDDHHMMSS
31.	S	Program Set	(1-3)
32.	P	Program Type	(A,B,C,F,G)
33-38.	J	Journal	encoded
39-44.	F	Nominal Frequency, 100 Hz resolution	(001000 - 045000)
45-51.	P#	Output Controls	encoded
52-53.	SS	Start Frequency, 1 MHz resolution	(00-10)
54.	Q	Frequency Increment	(0-9,A-C,encoded)
55-56.	UU	Stop frequency, 1 MHz resolution	(01-30)
57-59.	CAB	Test Output	encoded
60-62.	V	Station ID	(000-999)
63.	X	Phase Code	(0-F, encoded)
64.	L	Antenna Azimuth	(0-F, encoded)
65.	Z	Antenna Scan	(0-7, encoded)

66.	T	Antenna Option and Doppler Spacing	(0-F, encoded)
67.	N	Number of Samples	(1-8)
68.	R	Repetition Rate	(0,2-8,A,B, encoded)
69.	W	Pulse width and code	(0-7, encoded)
70.	K	Time control	encoded
71.	I*	Frequency correction	(0-4, encoded)
72.	G*	Gain correction	(0-7, encoded)
73.	H	Range increment	(0-3,8-C, encoded)
74.	E	Range start	(0-7, encoded)
75.	I	Frequency Search	(0-7, encoded)
76.	G	Nominal Gain	(0-F, encoded)
77.	-	Spare	0

Group 4: Scaled Ionospheric Characteristics

The Scaled Ionospheric Characteristics may be obtained by ARTIST, ADEP, some other autoscaling or editing/validating software, or typed in manually. All numbers represent either frequency in Megahertz or altitude in kilometers except as indicated in Table 6. The format *F8.3* (DDDD.DDD) is used to report the characteristics which is equivalent to 1 kHz precision in frequencies and 1 m precision in heights. The accuracy of the stored values is usually 1 ionogram pixel (frequency step or height increment) except as indicated in Table 6.

There are currently 49 Scaled Ionospheric Characteristics defined. It is possible to report less than 48 characteristics and indicate that in the Data Index section of the record. Otherwise, all characteristics which are not scaled for a particular ionogram must be set to a default "No reading" value. which is 999.900 MHz for frequencies and 9999.000 km for heights.

Table 6. Scaled Ionospheric Characteristics

#	**Description**	**Units**	**Accuracy**	**No reading**
1	foF2 : F2 layer critical frequency, including the adjustment by the true height profile algorithm	MHz	at least quarter of frequency increment	9999.000
2	foF1 : F1 layer critical frequency	MHz	1 frequency increment	9999.000
3	M(D) = MUF(D)/foF2	-	-	9999.000
4	MUF(D) : Maximum usable frequency for ground distance D	MHz	1 frequency increment	9999.000
5	fmin: minimum frequency of ionogram echoes	MHz	1 frequency increment	9999.000
6	foEs : Es layer critical frequency	MHz	1 frequency increment	9999.000
7	fminF : Minimum frequency of F-layer echoes	MHz	1 frequency increment	9999.000
8	fminE : Minimum frequency of E-layer echoes	MHz	1 frequency increment	9999.000
9	foE : E layer critical frequency	MHz	1 frequency increment	9999.000
10	fxI : Maximum frequency of F-trace	MHz	1 frequency increment	9999.000
11	h'F : Minimum virtual height of F trace	km	1 height increment	9999.000
12	h'F2 : Minimum virtual height of F2 trace	km	1 height increment	9999.000
13	h'E : Minimum virtual height of E trace	km	1 height increment	9999.000
14	h'Es : Minimum virtual height of Es trace	km	1 height increment	9999.000
15	zmE : Peak height of E-layer	km	1 height increment	9999.000
16	yE : Half thickness of E layer	km	1 height increment	9999.000
17	QF : Average range spread of F layer	km	1 height increment	9999.000

18	QE : Average range spread of E layer	km	1 height increment	9999.000
19	DownF : Lowering of F trace to the leading edge	km	1 height increment	9999.000
20	DownE : Lowering of E trace to the leading edge	km	1 height increment	9999.000
21	DownEs : Lowering of Es trace to the leading edge	km	1 height increment	9999.000
22	FF : Frequency spread between fxF2 and fxI	MHz	1 frequency increment	9999.000
23	FE : Frequency spread beyond foE	MHz	1 frequency increment	9999.000
24	D : Distance for MUF calculation	km	1 km	9999.000
25	fMUF : MUF/OblFactor	MHz	1 frequency increment	9999.000
26	h'(fMUF) : Virtual height at MUF/OblFactor frequency	MHz	1 height increment	9999.000
27	delta_foF2 : Adjustment to the scaled foF2 during profile inversion	MHz	1 kHz	9999.000
28	foEp : predicted value of foE	MHz	±0.3 MHz	9999.000
29	f(h'F) : frequency at which h'F occurs	MHz	1 frequency increment	9999.000
30	f(h'F2) : frequency at which h'F2 occurs	MHz	1 frequency increment	9999.000
31	foF1p : predicted value of foF1	MHz	± 0.5 MHz	9999.000
32	peak height of F2 layer	km		9999.000
33	peak height of F1 layer	km		9999.000
34	zhalfNm : the true height at half the maximum density in the F2 layer	km	1 km	9999.000
35	foF2p : predicted value of foF2	MHz	± 2.0 MHz	9999.000
36	fminEs : minimum frequency of Es layer	MHz	1 frequency increment	9999.000
37	yF2 : half thickness of the F2 layer, parabolic model	km	100 m	9999.000
38	yF1 : half thickness of the F1 layer, parabolic model	km	100 m	9999.000
39	TEC : total electron content	10^{16} m^{-2}	-	9999.000
40	Scale height at the F2 peak	km	1km	9999.000
41	B0, IRI thickness parameter	km	-	9999.000
42	B1, IRI profile shape parameter	-	-	9999.000
43	D1, IRI profile shape parameter, F1 layer	-	-	9999.000
44	foEa, critical frequency of auroral E layer	MHz	1 frequency increment	9999.000
45	h'Ea, minimum virtual height of auroral E layer trace	km	1 height increment	9999.000
46	foP, highest ordinary wave critical frequency of F region patch trace	MHz	1 frequency increment	9999.000
47	h'P, minimum virtual height of the trace used to determine foP	km	1 height increment	9999.000
48	fbEs, blanketing frequency of Es layer	MHz	1 frequency increment	9999.000
49	Type Es	-	See Table 7	9999.000

Type Es is a letter characteristic which has to be reported in the Table 6 as a number using Lookup Table 7.

Table 7. Lookup Table for Type Es Characteristic

Type Es	Value reported in Group 4	Description

A	1.0	Auroral
C	2.0	Cusp
D	3.0	below 95 km
F	4.0	Flat
H	5.0	Height discontinuity with normal E
K	6.0	in the presence of night E
L	7.0	Flat Es below E
N	8.0	Non-standard
Q	9.0	Diffuse and non-blanketing
R	10.0	Retardation

Group 5: ARTIST Analysis Flags

The ARTIST Analysis Flags are a sequence of two digit integers (60I2 format) which indicate and qualify some of the ARTIST scaled results. Table 8 is a description of the flags and the meaning of their possible values.

Table 8. ARTIST Flags

Position	**Content**	**Description**
1	1	foE scaled using E-region trace data
	2	No E-region trace obtained, only predicted foE available
	3	No E-region trace obtained, but foE scaled using F trace
2	0	No F trace scaled
	1	E layer profile only
	2	Separate soliutions for E and F layers
	4	Frequency range error in E trace
	5	Frequency range error in F2 trace
	6	Frequency range error in F1 trace
	7	Physically unreasonable E trace
	8	Physically unreasonable F2 trace
	9	Physically unreasonable F1 trace
	10	F1 layer solution too thick
	11	Oscillating solution in F1 layer
	12	F2 trace too short
	13	F1 trace too short
	18	Oscillating solution in F1 layer
	25	Root in F1 layer too severe to correct
	26	Root in F2 layer too severe to correct

3		Not used
4	0	foF1 not scaled
	1	foF1 scaled
5	0	No AWS Qualifier applies
	1	Blanketing Sporadic E
	2	Non-Deviative Absorption
	3	Equipment Outage
	4	foF2 greater than equipment limits
	5	fmin lower than equipment limits
	6	Spread F
	7	foF2 less than foF1
	8	Interference
	9	Deviative absorption
6-9		Not used
10	0-5	Confidence level, 0-highest confidence, 5-lowest confidence
11-19		Not used
20		Internal ARTIST use

Group 6: Doppler Translation Table

The Doppler Translation Table is a sequence of floating point numbers in the 16F7.3 format which convert the trace Doppler Number into a Doppler frequency in Hertz. These numbers should be read into a floating point array. Using the Doppler Number as an index to that array will result in the Doppler shift for the scaled trace point in question. The first element of the Doppler translation table corresponds to the Doppler number 0.

Trace Points

The following Groups include ionogram trace information obtained in some automated or interactive manner. The data format and content is identical for any of the F2, F1, E, or Es traces with either ordinary (O) or extraordinary (X) polarization although not all traces may be present in any one ionogram. For example, the ARTIST program currently does not scale the complete X-traces, however space has been provided for implementation of this feature at a later date.

The data for each trace are contained in five *Groups*. For the F2 O-trace they are in *Groups* 7, 8, 9, 10, and 11; for the F1 O-trace they are in *Groups* 12, 13, 14, 15, and 16; etc. (see Table 1). The groups for sporadic E, auroral night E leayrs and all extraordinary data groups do not contain the true height group. Also, Groups 51, 52, and 53 are reserved for an accurate representation of the electron density profile, including the valley. There is a one-to-one positional correspondence between *elements* in these five *Groups*, in that the first Virtual Height, True Height, Amplitude, Doppler Number and Frequency all correspond to the first Trace point on the ionogram. The same is true of the second point, and so on throughout the entire trace.

Autoscaling or editing software may interpolate or extrapolate missing trace points to maintain consistent frequency stepping within the trace or provide better accuracy of the scaled characteristics. Because of explicit specification of all trace point frequencies in the SAO format, the interpolated or extrapolated points may be omitted. However, in this case the value of true hieght obtained for that frequency will be missing as well. If included, the interpolated/extrapolated points shall be reported with amplitude set to 0 and Doppler number set to 9.

Groups 7, 12, 17, 22, 26, 30, 43, 47: Trace Virtual Heights

This *group* consists of a number of Virtual Heights in 15F8.3 format for the layer indicated. The number of these heights depends upon the length of the trace on the corresponding ionogram. Virtual Heights are reported in kilometers of altitude.

Groups 8, 13, 18: True Heights

This *group* consists of a number of True Heights in 15F8.3 format for the layer indicated. The number of these heights depends upon the length of the trace on the corresponding ionogram (compare to complete profiles specification in *Groups* 51-53). True Heights are reported in kilometers of altitude. Virtual heights of 0 km can be present in this group as "no-value" filler of missing trace points added to preserve continuous frequency stepping.

Groups 9, 14, 19, 23, 27, 31, 44, 48: Trace Amplitudes

The amplitude in dB of each trace point is recorded in 40I3 format.

Groups 10, 15, 20, 24, 28, 32, 45, 49: Trace Doppler Numbers

The Doppler Number, as measured by the Digisonde, for each trace point is recorded here in 120I1 format. To convert this number to an actual Doppler shift in Hertz, use this integer as the index to the Doppler Translation Table provided in *Group* 6. Index for 8 element Doppler Translation Table runs from 0 to 7. Value 9 is reported for interpolated or extrapolated points where information about Doppler frequency shift is unavailable.

Groups 11, 16, 21, 25, 29, 33, 46, 50: Trace Frequencies

The frequency (in MHz) of the trace point is given in this *Group* in the 15F8.3 format. Originally, this *Group* was provided for the possibility of uneven frequency stepping and would normally be left empty for Digisonde ionograms with a constant frequency step. <u>This is no longer acceptable</u>. The sounder settings which are required to restore linear step frequencies can be obtained only from a valid Sounder Settings *Group* 3 and Scaled Characteristics *Group* 4 and may appear to be missing for some sounder systems.

Group 34: Median Amplitude of F Echo

These values are an amplitude in dB for the F trace. It is calculated every integer MHz between fminF and foF2. See Code 4 for fmin and foF2. The Median Amplitude is calculated by taking the median of the trace amplitudes over a 0.5 MHz in frequency by five height range rectangle and then scaling this median value to appear as if it were at 100 km altitude.

Group 35: Median Amplitude of E Echo

Same as per Code 34, but for the E echo between fminE and foE.

Group 36: Median Amplitude of Es Echo

Same as per Code 34, but for the Es echo between fminE and foEs.

Group 37: True Height Coefficients for the F2 Layer

The True Height Data for F2 layer from the UMLCAR method are stored in the E11.6E1 format. There are up to 10 *elements*. The meaning of each *element* is given in Table 9.

Table 9. True Height Coefficients

Position	Parameter	Description
1	fstart	Start frequency (MHz) of the F2 layer
2	fend	The end frequency of the F2 layer
3	zpeak	The height of the peak of the F2 layer
4	dev	The fitting error in km/point.
5-9	A0-A4	Shifted Chebyshev polynomial coefficients
10	zhalfNm	Height at half peak electron density

Group 38: True Height Coefficients for the F1 Layer

The True Height Data for the F1 layer from the UMLCAR method have the same format as those for the F2 layer (*Group* 37) above with the exception of zhalfNm (see Table 9).

Group 39: True Height Coefficients for the E Layer

The True Height Data for the E layer from the UMLCAR method have a format very similar to that for the F2 and F1 layers (*Codes* 37 and 38) above. The difference lies in that there are only seven *elements* stored in this *Group*. The first four parameters are fstart, fend, zpeak and dev as defined for the F2 layer. There are, however, only three coefficients for the shifted Chebyshev polynomials (A0 - A2) for the E layer true height.

Group 40: Quazi-Parabolic Segments Fitted to the Profile

An arbitrary number of parabolic segments may be fitted to the profile to approximate its shape. Each segment can be expressed as:

$f_N^2 = A/R^2 + B/R + C$

where

f_N is the plasma frequency in MHz,

A, B, and C are the parabolic coefficients

R is the distance from the center of the Earth in km, which varies from R1 to R2 for the segment.

If *n* segments are fitted to the profile, the Group 40 will contain *n*+1 entries. The first *n* entries store 6 values per segment (R1, R2, A, B, C, and fitting error E) in the E20.12E2 format, and the last lines contains the Earth radius, as is shown in Table 10.

Table 10. QP Segments reported in Group 40

#	Value 1	Value 2	Value 3	Value 4	Value 5	Value 6
1	R11	R12	A1	B1	C1	E1
2	R21	R22	A2	B2	C2	E2
...						
n	R*n*1	R*n*2	A*n*	B*n*	C*n*	E*n*
n+1	R_e	-	-	-	-	-

The Earth radius, R_e, is the actual value used in the fitting process and is given in SAO file to ensure proper restoring of the profile shape.

Group 41: Edit Flags: Characteristics

The edit flags are written in 120I1 format and are used to indicate whether the reported ionospheric characteristics are result of autoscaling, manual input, or long-term prediction. One edit flag is a sum of three indicators, EDITED(1), PREDICTED(2) and VALIDATED(4). Table 11 shows possible combinations of the indicators.

Table 11. Edit Flag (characteristics) and its possible meanings

EDITED	PREDICTED	VALIDATED	EDIT FLAG VALUE	Description
0	0	0	0+0+0 = 0	autoscaled value
0	0	4	0+0+4 = 4	autoscaled value, validated by an operator
1	0	4	1+0+4 = 5	manually specified value; the autoscaled value was incorrect or unavailable
0	2	0	0+2+0 = 2	long-term prediction

The position in the edit flag list corresponds to the order of the characteristics listed in Table 6. A complete list is given in Table 12. The edit flags may be used to set the slash (/) indicators in the URSI-IIWG characteristics database, if the indicators are not given in the *Groups* 54-55.

Table 12. Edit Flags: Characteristics

#	Scaled Characteristic	Description
1	foF2	F2 layer critical frequency

2	foF1	F1 layer critical frequency
3	M(D)	M-factor, MUF(D)/foF2, for distance D
4	MUF(D)	Maximum usable frequency for distance D
5	fmin	Minimum frequency for E or F echoes
6	foEs	Es layer critical frequency
7	fminF	Minimum frequency of F-trace
8	fminE	Minimum frequency of E-trace
9	foE	E layer critical frequency
10	fxI	Maximum frequency of F-trace
11	h'F	Minimum virtual height of F trace
12	h'F2	Minimum virtual height of F2 trace
13	h'E	Minimum virtual height of E trace
14	h'Es	Minimum virtual height of Es layer
15	HOM	Peak of E layer using parabolic model
16	Ym	Corresponding half thickness of E layer
17	QF	Average range spread of F-trace
18	QE	Average range spread of E-trace
19	Down F2	Lowering of F-trace maximum to leading edge
20	Down E	Lowering of E-trace maximum to leading edge
21	Down Es	Lowering of Es-trace maximum to leading edge
22	FF	Frequency spread between fxF2 and fxI
23	FE	As FF but considered beyond foE
24	D	Distance used for MUF calculation
25	fMUF(D)	MUF(D)/obliquity factor(
26	h'MUF(D)	Virtual height at fMUF
27	foF2c	correction to add to foF2 to get actual foF2
28	foEp	Predicted foE
29	f(h'F)	Frequency at which hminF occurs
30	f(h'F2)	Frequency at which hminF2 occurs
31	foF1p	Predicted foF1
32	Zpeak	Peak height F2 layer
33	ZpeakF1	Peak height F2 layer
34	zhalfnm	Height at half peak electron density
35	foF2p	Predicted foF2
36	fminEs	Minimum frequency of Es layer
37	YF2	Half-thickness of F2 layer in parabolic model
38	YF1	Half-thickness of F1 layer in parabolic model
39	TEC	Total electron content
40	HscaleF2	Scale height at F2 peak
41	B0	IRI thickness parameter
42	B1	IRI profile shape parameter

43	D1	IRI F1 profile shape parameter
44	foEa	Critical frequency of auroral E layer
45	h'Ea	Minimum virtual height of auroral E layer trace
46	foP	Highest ordinary wave critical frequency of F region patch trace
47	h'P	Minimum virtual height of the trace used to determine foP
48	fbEs	Blanketing frequency of Es layer
49	Type Es	Type of Es layer

Group 42: Valley Characteristics UMLCAR model

The current content for this Group is two parameters describing the width and depth of the valley region in the UMLCAR model.

Group 51-53: Regular True Height Profile

The complete true height profile of electron density up to 1000 km is given here, including all layers and the valley. The profile is reported with the true height as the argument of the N(h) function, i.e. all heights within the valid range are scanned with a fixed increment, say, 1 km, and put in Group 51. Corresponding frequencies and electron densities are given in Group 52 and Group 53. Also, a few additional height points are reported in the groups: all peak heights of the layers and the starting height of the profile. The additional points might not be multiples of the height increment. One-to-one positional correspondence of individual elements in Groups 51-53 is preserved, so that, for example, the first element of Groups 51-53 refers to the starting height of the profile.
The height increment and coverage for the profile specification is determined by the program which created the SAO file.

Group 54-55: Qualifying and Descriptive Letters

These two groups store URSI Qualifying (Group 54) and Descriptive (Group 55) letters *[URSI Handbook of Ionogram Interpretation and Reduction, 1972]* using 120A1 format. The letters are used by manual scaling operators to reflect reliability of measurement and indicate the presence of certain ionospheric phenomena. The layout of the Groups 54-55 corresponds to Table 6 (Scaled Ionospheric Characteristics). The number of items stored in the Groups 54 and 55 must be the same as in Group 6. When no qualifying or descriptive letter is applied to a characteristic but its value has been verified or edited, the correspoding entry in the Group 54 should read "/" (forward slash) and Group 55 should read " " (space) [see IIWG regulations, Table 3, here]. For autoscaled data, the IIWG regulations suggest storing "/" in both groups, but SAO-4 file created by the autoscaling software may simply omit Groups 54 and 55 and report only Group 41 (Edit Flags).

Group 56: Edit Flags: Traces and Profile

The edit flags are written in 120I1 format and correspond to whether ionogram traces and profile were modified as a result of manual scaling of the data. Autoscaling software must not report this group to distinguish it from the manual editing/validating. If no trace points were adjusted and profile was not recalculated in the process of manual editing/validation, the Group 56 must still be reported with all zero settings to distinguish it from autoscaled data.

Table 13. Edit Flags: Traces and Profile

#	Name	Description
1	F2 trace	F2 trace points were edited
2	F1 trace	F1 trace points were edited
3	E trace	E trace points were edited
4	z(h)	true height was recalculated with edited traces
5	Es trace	Es trace points were edited

Group 57: True Height Coefficients for the Ea Layer

The True Height Data for the E auroral layer from the UMLCAR method have a format identical to Group 39 for E layer above.

Group 58-60: Auroral True Height Profile

The complete true height profile of electron density up to 1000 km is given here, including all layers and the valley. The profile is reported with the true height as the argument of the N(h) function, i.e. all heights within the valid range are scanned with a fixed increment, say, 1 km, and put in Group 58. Corresponding frequencies and electron densities are given in Group 59 and Group 60. Also, a few additional height points are reported in the groups: all peak heights of the layers and the starting height of the profile. The additional points might not be multiples of the height increment. One-to-one positional correspondence of individual elements in Groups 58-60 is preserved, so that, for example, the first element of Groups 58-60 refers to the starting height of the profile.

References

Gamache R. R., I.A. Galkin, and B. W. Reinisch, "A Database Record Structure for Ionogram Data", University of Lowell Center for Atmospheric Research, UMLCAR 96-01, 1996.

URSI Handbook of Ionogram Interpretation and Reduction. Ed. W.R.Pigott and K.Rawer. WDC-A for STP, 1972.

Last Modified: June 6, 2003

Appendix K – UDD file

A Station UDD file is an ASCII text file. All UDD parameters are detailed in the Table 1.

Table 1. List of Parameters in the VIEWER Station UDD Files.

Parameter Name	Parameter No.	Units	Range	Precision	Data Type	Format
Station Site Name	*304	-	-	-	string	<20 char
Station Latitude	*101	degree	-90 to 90	0.1°	real	F5.1
Station Longitude	*102	degree East	0 to 359.9	0.1°	real	F5.1
Station Gyrofreq	*104	MHz	0.5 - 2.0	0.1MHz	real	F3.1
Station Dip Angle	*105	degree	-90 to 90	0.1°	real	F5.1
Sunspot #	*011	-	10 - 200	integer	integer	I3
Noise Threshold	*089	3 dB	-31 to 31 (off MPA)	3 dB	integer	I3
Spikes Removal	*081	-	0 - no 1 - yes	-	integer	I1
Antenna Layout	*086	-	0 - standard 1 - rotated 2 - mirror	-	integer	I1
Sounder Model	*032	-	1 - DGS-256 2 - DPS-1 3 - DPS-4	-	integer	I1

The following is an example Station UDD file:

```
VIEWER STATION UDD FILE

*304 STATION NAME <Melbourne>
*101 GEOGRAPHIC LATITUDE <-37.0> degrees
*102 GEOGRAPHIC EAST LONGITUDE <145.0> degrees
*104 GYROFREQUENCY <1.5> MHz
*105 DIP ANGLE <-69.0> degrees
*011 SUNSPOT NUMBER <30>

NOISE THRESHOLD, relative to MPA (-31 to +31, in 3dB steps)
Example: 1 means 3 dB above MPA
*089 < 1 >

SPIKES REMOVAL
0 no
1 yes
*081 < 1 >
```

```
ANTENNA LAYOUT
0 Standard per Manual
1 180 deg rotation (Karachi,Beijing,Kokubunji)
2 Mirror Image (Millstone, Beveridge, Goose Bay)
086 < 0 >

DIGISONDE MODEL
1 DGS 256
2 DPS 1
3 DPS 4
*032 <2>
```