

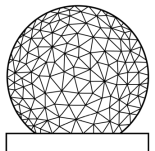
The MADRIGAL Database

Anthea Coster (ajc@haystack.mit.edu)

Bill Rideout (brideout@haystack.mit.edu)

Nestor Aponte (aponen@mit.edu)

MIT Haystack Observatory



MIT
HAYSTACK
OBSERVATORY

Haystack Radar

Millstone Hill Radar(s)

[CEDAR Home](#)

[Access data](#) ▾

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[OpenMadrigal](#)

Welcome to the CEDAR Madrigal Database

Madrigal is an upper atmospheric science database used by groups throughout the world. Madrigal is a robust, World Wide Web based system capable of managing and serving archival and real-time data, in a variety of formats, from a wide range of upper atmospheric science instruments. Data at each Madrigal site is locally controlled and can be updated at any time, but shared metadata between Madrigal sites allow searching of all Madrigal sites at once from any Madrigal site.

To see a list of all Madrigal sites, use the *Other Madrigal sites* pull down menu. Data can also be accessed directly, using [APIs](#) which are available for several popular programming languages (Matlab, python, and IDL). A Subversion archive of all Madrigal software and documentation is available from the [Open Madrigal](#) Web site. The latest version of Madrigal and the remote API's may also be downloaded from there.

The CEDAR Madrigal database architecture and implementation [meets and exceeds FAIR guiding principles](#) in all aspects.

Use of the Madrigal Database is generally subject to the CEDAR Rules-of-the-Road . Prior permission to access the data is not required. However, the user is required to establish early contact with any organization whose data are involved in the project to discuss the intended usage. Data are often subject to limitations which are not immediately evident to new users. Before they are formally submitted, draft copies of all reports and publications must be sent to the contact scientist at all data-supplying organizations along with an offer of co-authorship to scientists who have provided data. This offer may be declined. The Database and the organizations that contributed data must be acknowledged in all reports and publications, and whenever this data is made available through another database. If you have any questions about appropriate use of these data, contact brideout@haystack.mit.edu

Welcome to Haystack

Radio science & technology
research center



Pioneering radio
astronomy

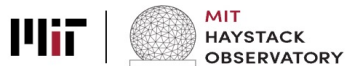


Geodesy: measuring
Earth



Geospace from A to Z

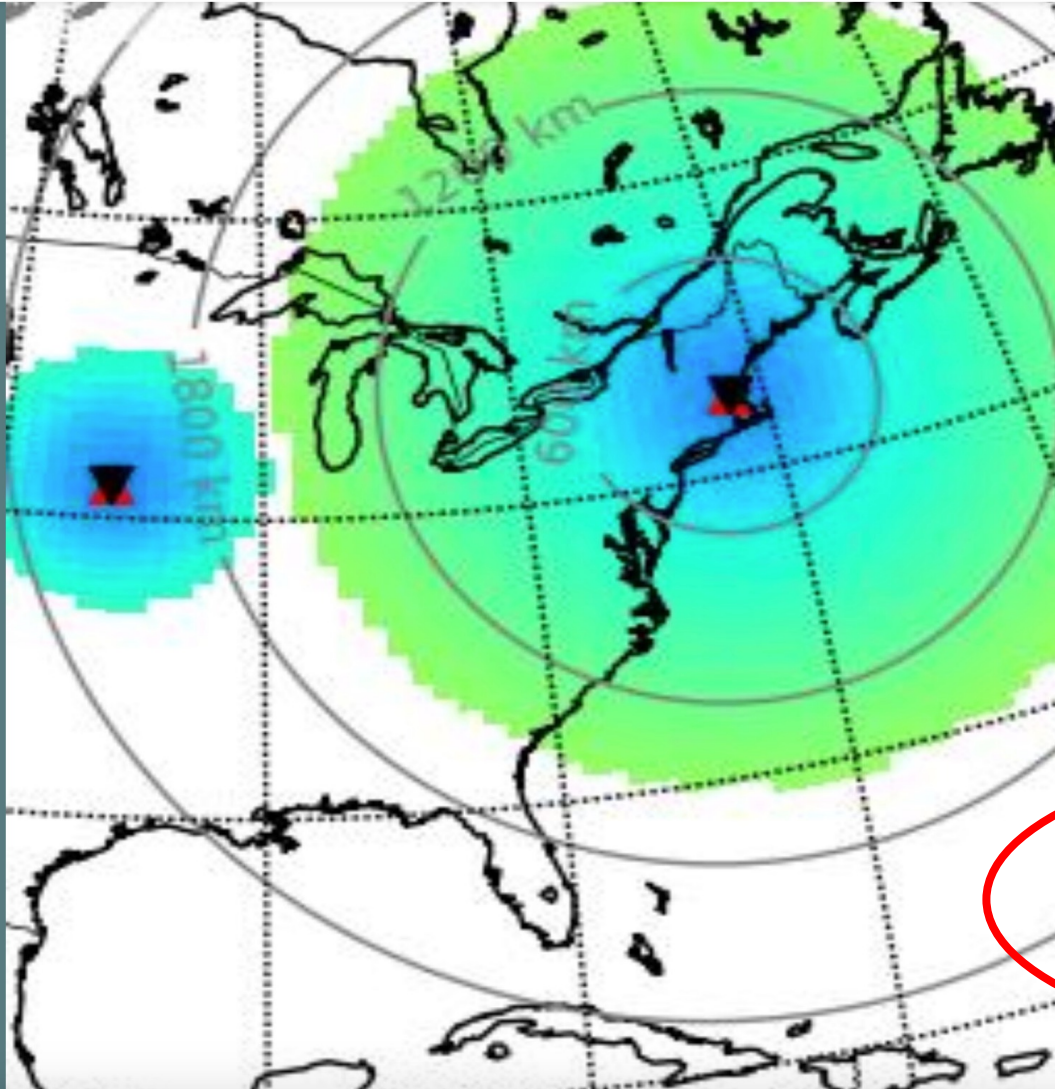




Geospace

Scroll down page until you find Madrigal database

About ▾ Our Researchers ▾ Astronomy ▾ Geodesy ▾ Geospace ▾ Space Technology ▾



Geospace Science

MILLSTONE HILL GEOSPACe FACILITY (MHGF)

The current centerpiece of the Millstone Hill Geospace Facility is its high-power, large-aperture incoherent scatter radar (IS radar) facility. MHGF comprises a scientific and technical team of people and a cluster of radio, radar, and distributed instruments.

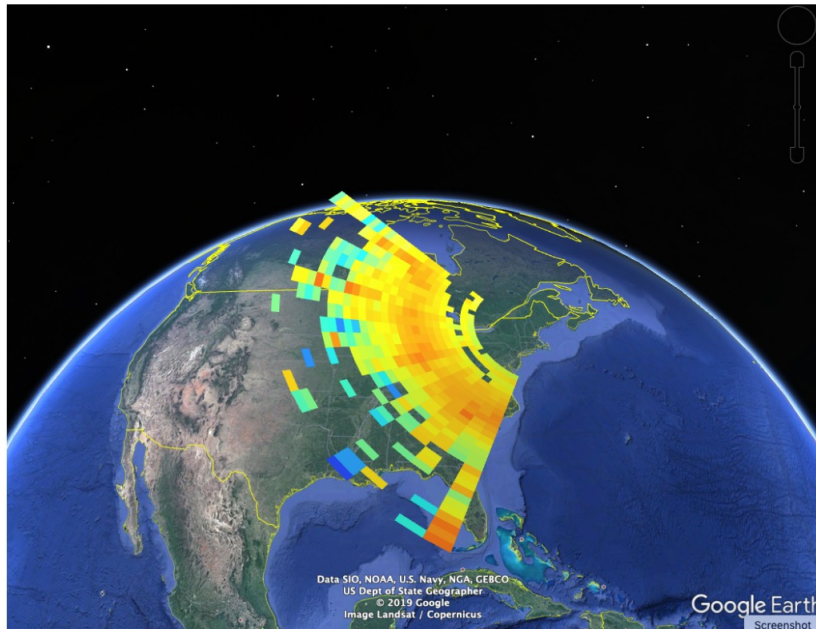
GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS)-BASED TOTAL ELECTRON CONTENT

GNSS systems for precision location yield as a by-product measurements of the total electron content (TEC) of the ionosphere. MIT makes this popular data available to the geospace community.

MADRIGAL DATABASE

Madrigal is an upper-atmospheric science database used by groups throughout the world—it's a robust, web-based system capable of managing and serving archival and real-time data, in a variety of formats, from a wide range of upper-atmospheric science instruments.

Madrigal Geospace Database



Madrigal data on a globe showing the range of the Millstone antenna to the southwest

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The main [CEDAR Madrigal site](#) contains a backup of all data at all site. All other sites can also be found from that page.

Millstone Hill has actively pursued the development of the Madrigal distributed data system to address the needs of staff and community scientists. A standard in the upper atmospheric community, Madrigal was

created and launched at MIT Haystack in the early 1980s prior to being adopted as the basis for the CEDAR database. In 2012, the main CEDAR database moved to a modernized version of the Madrigal platform hosted by MIT. As of 2019, there was data from 159 instruments in the CEDAR Madrigal database, totaling over 27 TB of data, with rapid growth each year.

[CEDAR Home](#)

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[OpenMadrigal](#)

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Outline

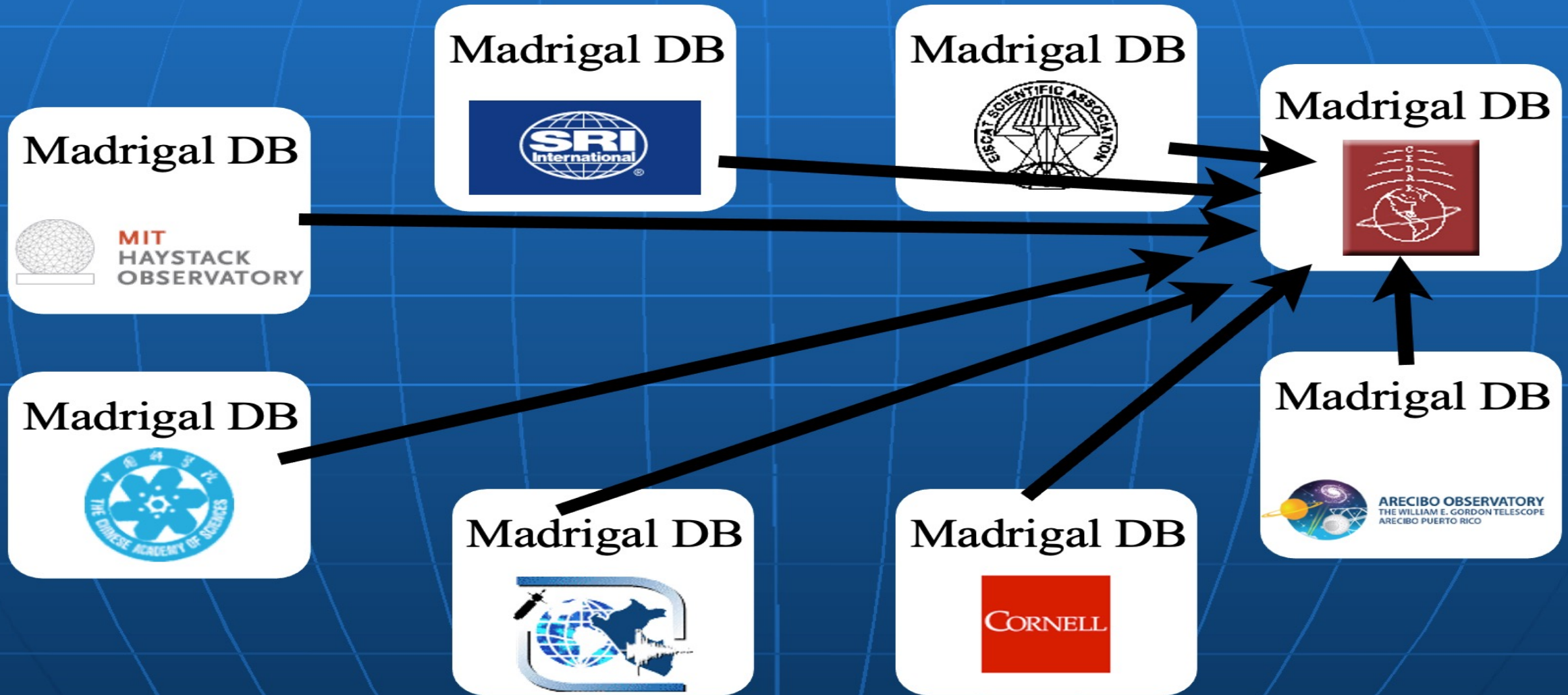
- What is Madrigal?
- What is the CEDAR database format?
 - Exercise - open a file with Hdfview
- In what formats can I get Madrigal data?
- How do I use Madrigal?
 - Background
 - The website
 - Exercise - use the website
 - Script data access
 - Exercise - write a script

What is Madrigal?

Madrigal is a distributed database



Cedar Madrigal archive imports all data weekly

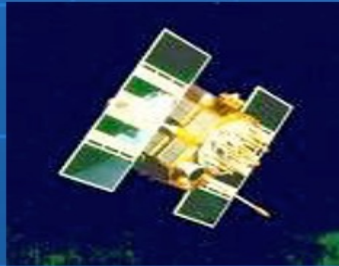


The Madrigal database stores data from a wide variety of upper atmosphere research instruments

Incoherent Scatter Radar



TEC via GPS



MF Radar



Examples of number of instruments in Madrigal:

- Incoherent scatter radars: 22
- MST radars: 3
- MF radars: 16
- Meteor radars: 11
- FPI: 32
- Michelson Interferometers: 6
- Lidars: 9
- Photometers: 7

Other examples:

- GPS TEC
- DMSP

Madrigal is open-source

[CEDAR Home](#) [Access data](#) [Access metadata](#) [Run models](#) [Documentation](#) [Other Madrigal sites](#) [OpenMadrigal](#)

Welcome to the Madrigal3 CEDAR Database

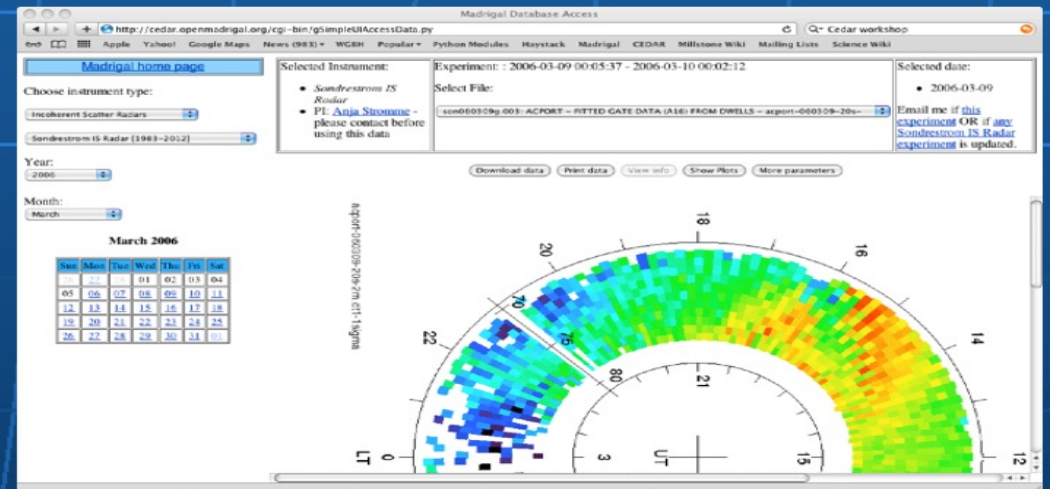
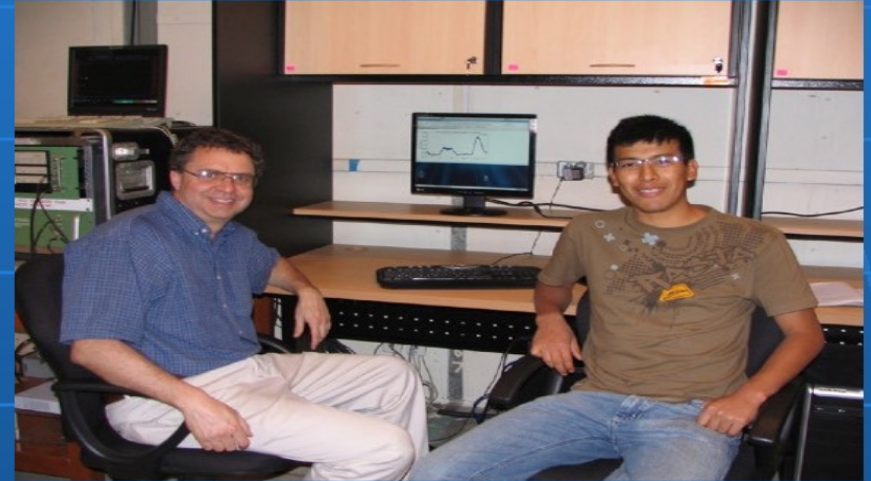
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Link to Subversion (source code)

If you want to use the old Madrigal 2 version of the CEDAR Madrigal database, it is still temporarily available at <http://madrigal.haystack.mit.edu>. If you are using the old version because of a problem with Madrigal3, please contact brideout@haystack.mit.edu to describe the issue.



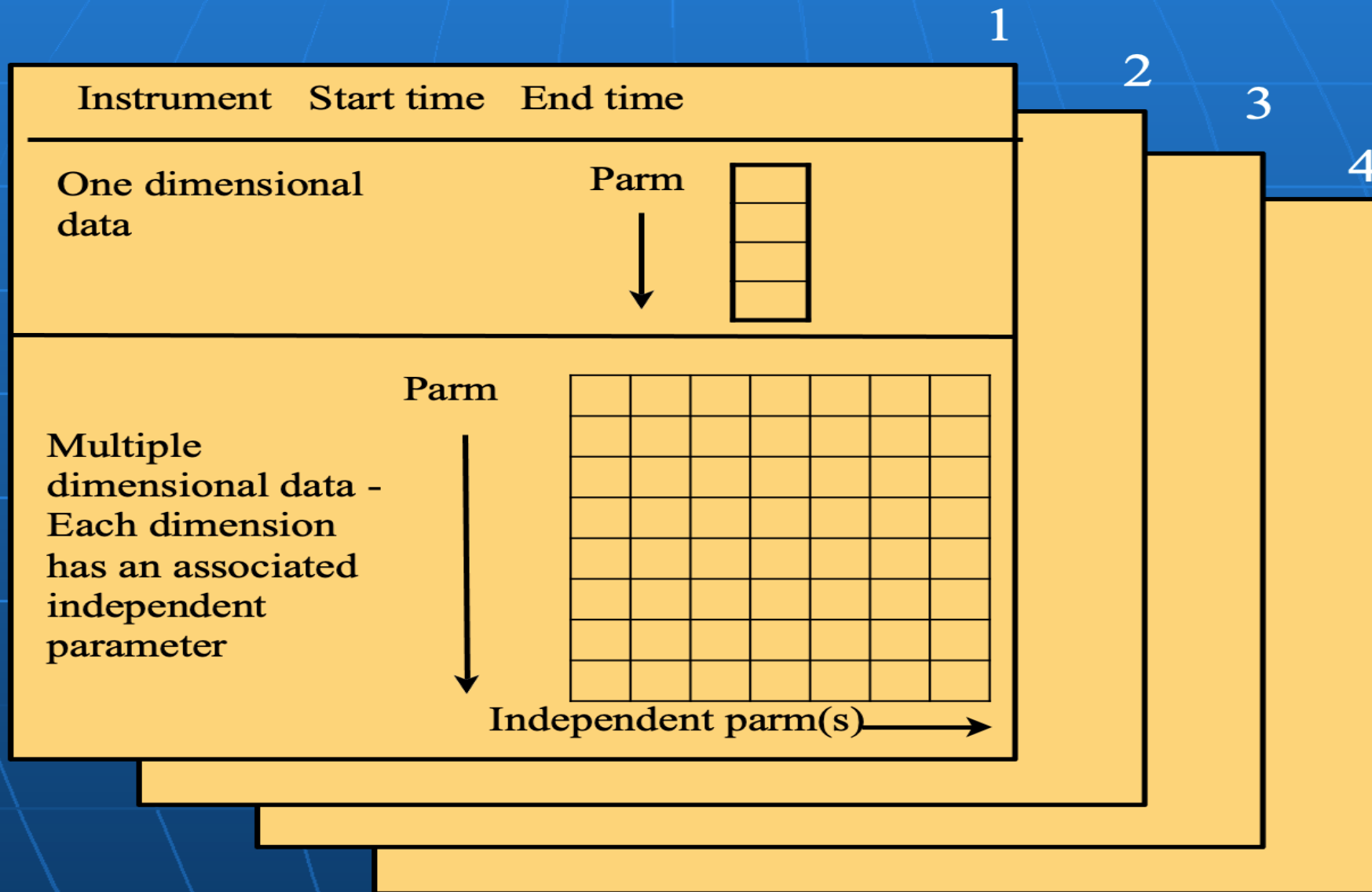
www.openmadrigal.org

- **What is the CEDAR database format?**

Well defined parameters

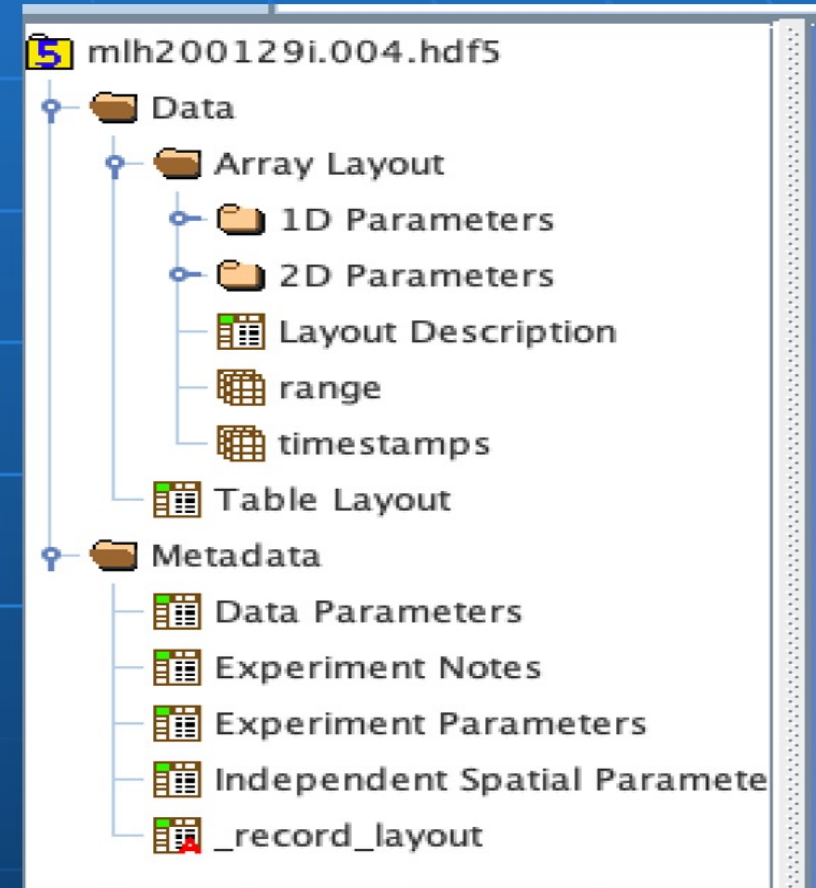
- Standard descriptions of all parameters
- Allows the existence of derivation engine
- Madrigal allows extended descriptions
- All parameters have corresponding error parameters
- Missing, Assumed

Cedar file data model



Cedar file format: Structured Hdf5

- Self-describing - all parameters defined, notes added
- Scientific standard
- Parms float, integers or strings
- Table Layout, Array Layout possible if repeating independent parms



Exercise: use hdfview to examine Madrigal files

- Install hdfview (<https://www.hdfgroup.org/downloads/hdfview/>) link also on web page
- Download example Poker Flat and Millstone ISR files with hdfview

**In what formats can I get
Madrigal data?**

Madrigal outputs

Underlying format	Hdf5
Output formats	Ascii, Hdf5, netCDF4
Formats with deriv parms	Ascii, Hdf5, netCDF4

- **What do I need to understand about Madrigal to use it?**

Madrigal Data Model

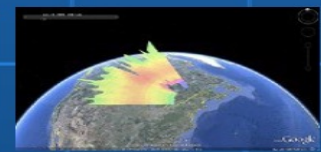
Madrigal site
(typically a facility with scientists and a Madrigal installation)



Instruments
(ground-based, typically with a set location)



Experiments
(typically of limited duration, with a single contact)



Experiment Files
(represents data from one analysis of the experiment)



Records
(measurement over one period of time)



Data shared among all Madrigal sites



Data unique to one Madrigal site

Madrigal Derivation Engine

- Derived parameters appear to be in file
- Engine determines all parameters that can be derived
- Easy to add new derived parameters using code written in C or Fortran



Classes of derived parameters

- **Space, time**
 - Examples: Local time, shadow height
- **Geophysical**
 - Examples: Kp, Dst, Imf, F10.7
- **Magnetic**
 - Examples: Bmag, Mag conjugate lat and long, Tsyganenko magnetic equatorial plane intercept
- **Models**
 - Examples: MSIS, IRI

- **Using Madrigal**

Rules of the road

- If you want to use data in Madrigal in a paper or talk, contact the PI
- The PI is listed on every web page

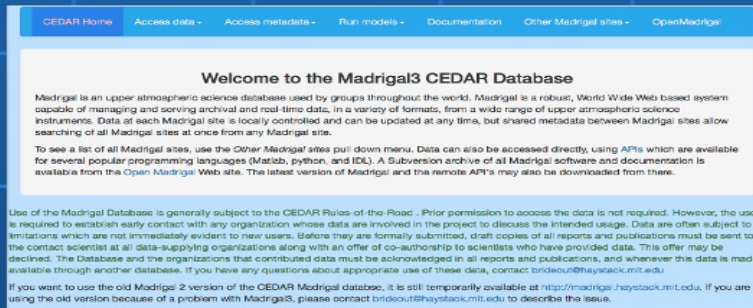


Use of data without informing PI may lead to seven years of bad luck in grant writing - don't let this happen to you!

How can the Madrigal database be accessed?



User



Web interface

Web services API

- From anywhere on internet
- Python API
- Matlab API
- IDL API

Typical use - data discovery

Create scripts using web interface: 99.9% of time no need to read documentation!

- Faster - download files
- More flexible - define parameters, filter

Live demo of Madrigal web page

- CEDAR Madrigal site
 - <http://cedar.openmadrigal.org>

How can I put my instrument's data on Madrigal?

Send data to CEDAR Madrigal



Set up your own Madrigal site



- Send data to MIT Haystack in your own format
- Loading program written by MIT Haystack, verified by you
- Add new data in batch or via automated upload (eg, sftp, web access, etc)

- MIT Haystack will help with installation and writing needed loading programs
- You control when data uploaded
- Automated backup to central CEDAR Madrigal site²³

Remote Access to Madrigal Data

- **Use the web interface to write scripts**
- Built on web services
- Like the web, available from anywhere on any platform
- Read only API
- Complete Python, Matlab, and IDL APIs written (python 2 and 3)
- More APIs available on request or via contribution

Remote Access to Madrigal Data

Use the web interface to write these scripts

Simple

Most complex



I just want to download lots of files to my PC

I want to only download filtered data with derived parameters

I want to write my own script



globalDownload

globalIsprint

Work with API's

Live demo of Madrigal script creation page

- CEDAR Madrigal site
 - <http://cedar.openmadrigal.org>
 - Access Data -> Create a command to download multiple exes

Scripts generated by web site

- No need to read any documentation!

The image shows a screenshot of the CEDAR website's navigation menu. The menu is blue with white text. The main navigation bar includes 'CEDAR Home', 'Access data', 'Access metadata', 'Run models', and 'Docume'. A dropdown menu is open under 'Access data', listing 'List experiments', 'Select single experiment', 'Create a command to download multiple exps', and 'FTP-like access'. Below the dropdown, there are two buttons: 'Download a group of files as is' and 'Download data with selected parms/filters'. A text box with the text 'First choose Create a command' has two arrows pointing to the 'Create a command to download multiple exps' menu item and the 'Download data with selected parms/filters' button.

Then decide to just download files as they are, or to select parms and/or filters.

Create a script to download files

[CEDAR Home](#)[Access data ▾](#)[Access metadata ▾](#)[Run models ▾](#)[Documentation](#)[Other Madrigal sites ▾](#)[OpenMadrigal](#)

Create a script command to download a series of existing Madrigal files in the format of your choice

Choose an instrument category if desired:

Choose one instrument (*Year range shows data available*):

File format to download:

Hdf5 Space-delimited ascii netCDF4

Choose scripting language:

python Matlab IDL

Start date

End date

Optional filters: kinds of data, experiment names, file status ≡

Choose one or more kinds of data:

All kinds of data
Ionospheric F-region data Electron and Ion temperature
VERTICAL VELOCITY COMPONENT ONLY
Faraday Doble pulse Version 1(7-lags)

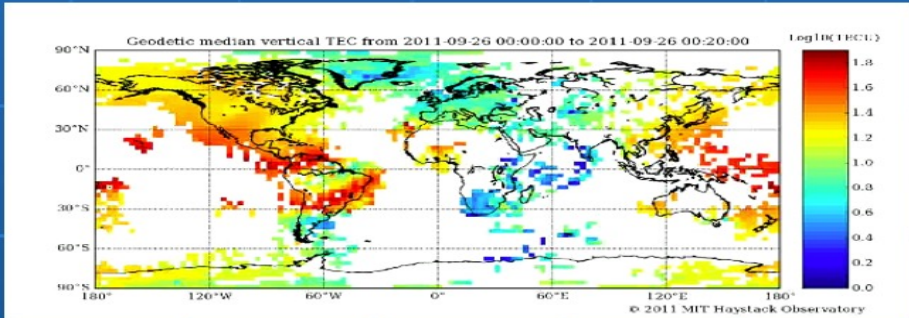
Filter experiments by name:

Filter files by description:

Generate command

```
globalDownload.py --verbose --url=http://cedar.openmadrigal.org --outputDir=/tmp --user_fullname="Bill+Rideout" --user_email=brideout@mit.edu --user_affiliation="MIT" --format="hdf5" --startDate="01/01/2017" --endDate="12/31/2017" --inst=10 --kindat=1040
```

More advanced globalprint scripts



Madrigal DB



<http://madrigal.iggcas.ac.cn/madrigal/>

TEC data: instrument id = 8000



Show me only data
where $TEC > 100TEC_u$
when $K_p > 7$ in 2003

Create a script to select parms/filters - globalsprint

[CEDAR Home](#)[Access data ▾](#)[Access metadata ▾](#)[Run models ▾](#)[Documentation](#)[Other Madrigal sites ▾](#)[OpenMadrigal](#)

Create a script command to download Madrigal data with selected parameters and filters

Choose an instrument category if desired:

Incoherent Scatter Radars ▾

Choose one instrument *(Year range shows data available)*:

Jicamarca IS Radar [1966-2017] ▾

File format to download:

Hdf5 Space-delimited ascii netCDF4

Choose scripting language:

python Matlab IDL

Start date

2017-01-01

End date

2017-12-31

Select parameters (required) ≡

Optional filters: kinds of data, filter by parm, experiment names, etc ≡

Generate command

```
globalIsprint.py --verbose --url=http://cedar.openmadrigal.org --parms=YEAR,MONTH,DAY,SEC,VIPE,DVIPE --output=/tmp --user_fullname="Bill+Rideout" --user_email=brideout@mit.edu --user_affiliation="MIT" --startDate="01/01/2017" --endDate="12/31/2017" --inst=10 --kindat=30003
```

But if you want to read the docs

- write your own script

- Use python, Matlab, IDL
- Methods
 - getInstrumentsWeb
 - getExperimentsWeb
 - getExperimentFilesWeb
 - getParametersWeb
 - isprintWeb
 - madDownloadFile
 - madCalculatorWeb
- Methods match Madrigal model

Extending/contributing to Madrigal

- Madrigal is completely open source
- See www.openmadrigal.org for CVS
- All new code is Python or C. Imported derivation methods sometimes in Fortran.
- We appreciate all contributions
 - Suggestions and ideas
 - Finding bugs
 - Code

<https://www.hdfgroup.org/downloads/hdfview/>

Exercise 1: Install hdfview

- Download Madrigal file and Look at Hdf file

Exercise 2 – in handouts

Exercise 3 – in handouts

Simple TEC instructions to download or look at on web - provided