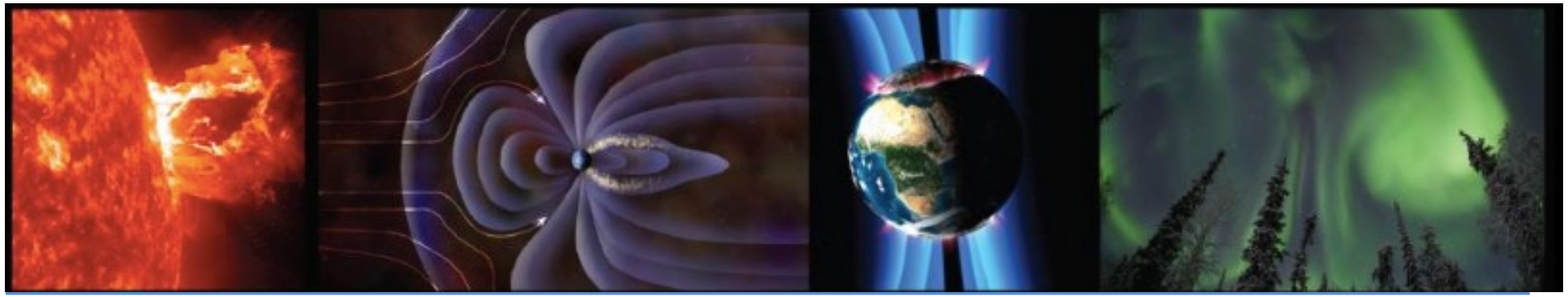


The MADRIGAL Database

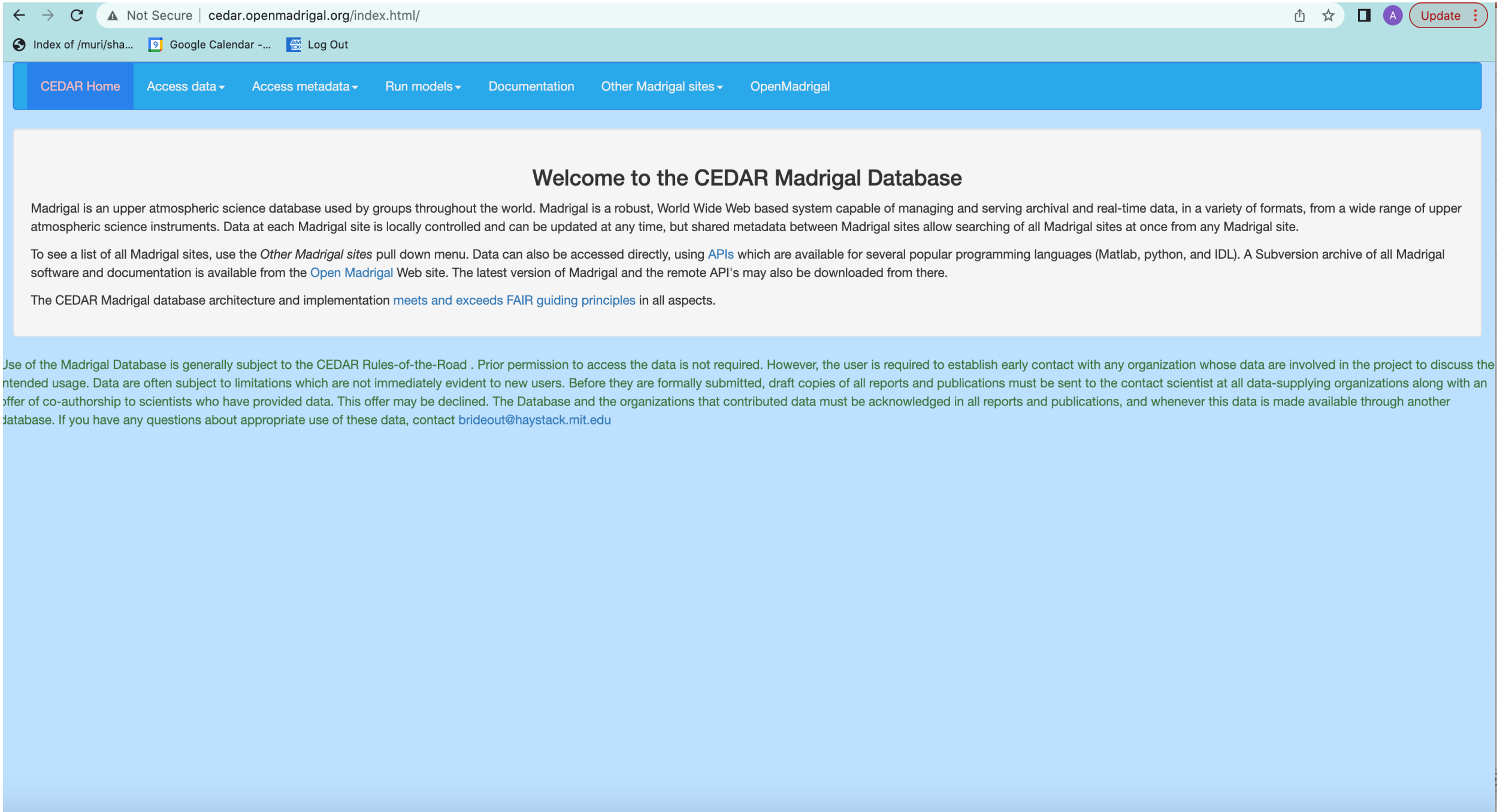
Anthea Coster (ajc@haystack.mit.edu)
Bill Rideout (brideout@haystack.mit.edu)
Nestor Aponte (aponen@mit.edu)

MIT Haystack Observatory

MIT
HAYSTACK
OBSERVATORY


Haystack Radar
Millstone Hill Radar(s)

http://cedar.openmadrigal.org/index.html/



https://www.haystack.mit.edu/

MIT HAYSTACK OBSERVATORY

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

Welcome to Haystack

Radio science & technology research center

- Pioneering radio astronomy
- Geodesy: measuring Earth
- Geospace from A to Z

MIT HAYSTACK OBSERVATORY

haystack.mit.edu/geospace/

Index of /muri/sha... Google Calendar -... Log Out

https://www.haystack.mit.edu/geospace

Update

MIT HAYSTACK OBSERVATORY

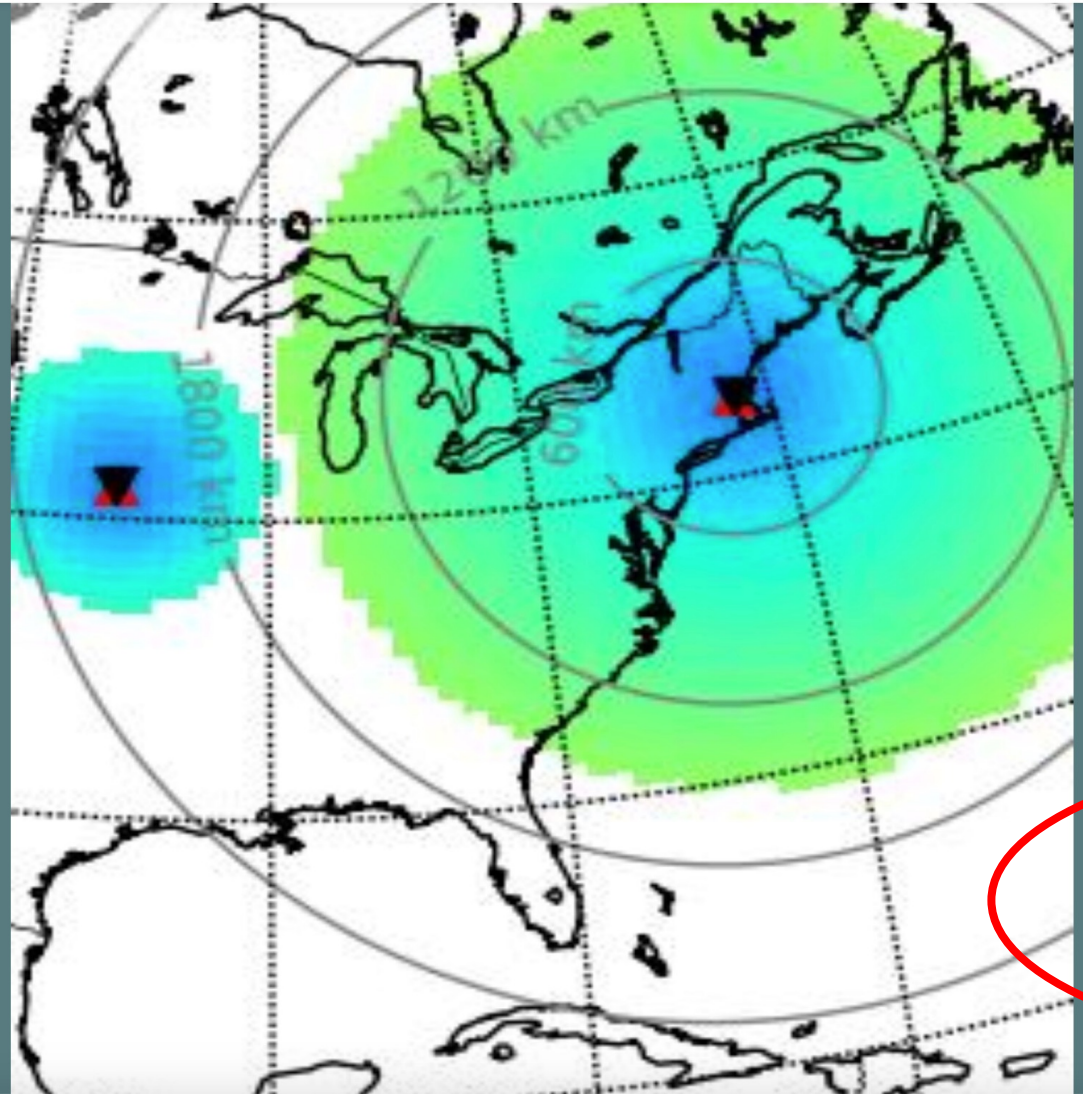
CONTACT NEWS EVENTS MEMOS INTERNAL SEARCH

About Our Researchers Astronomy Geodesy Geospace Space Technology

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.

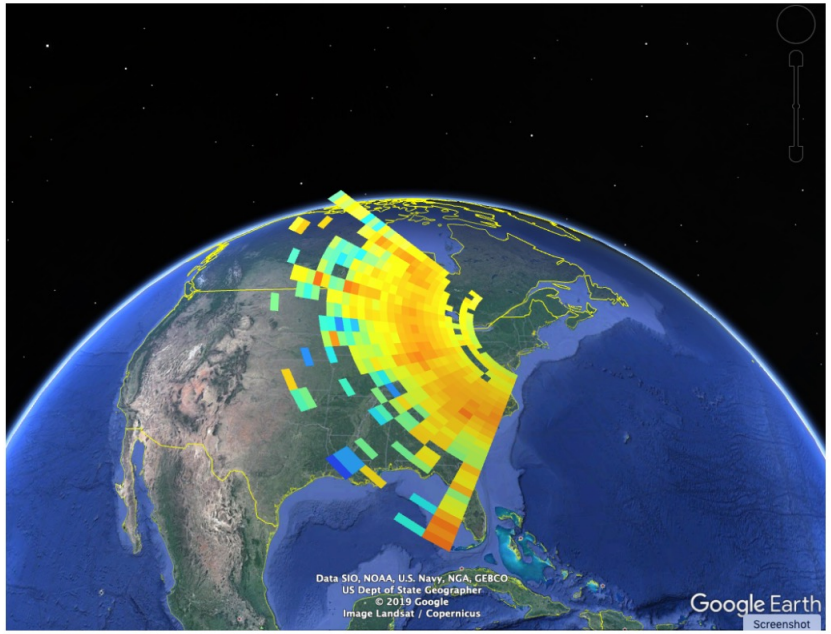
GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS)–BASED TOTAL ELECTRON CONTENT

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



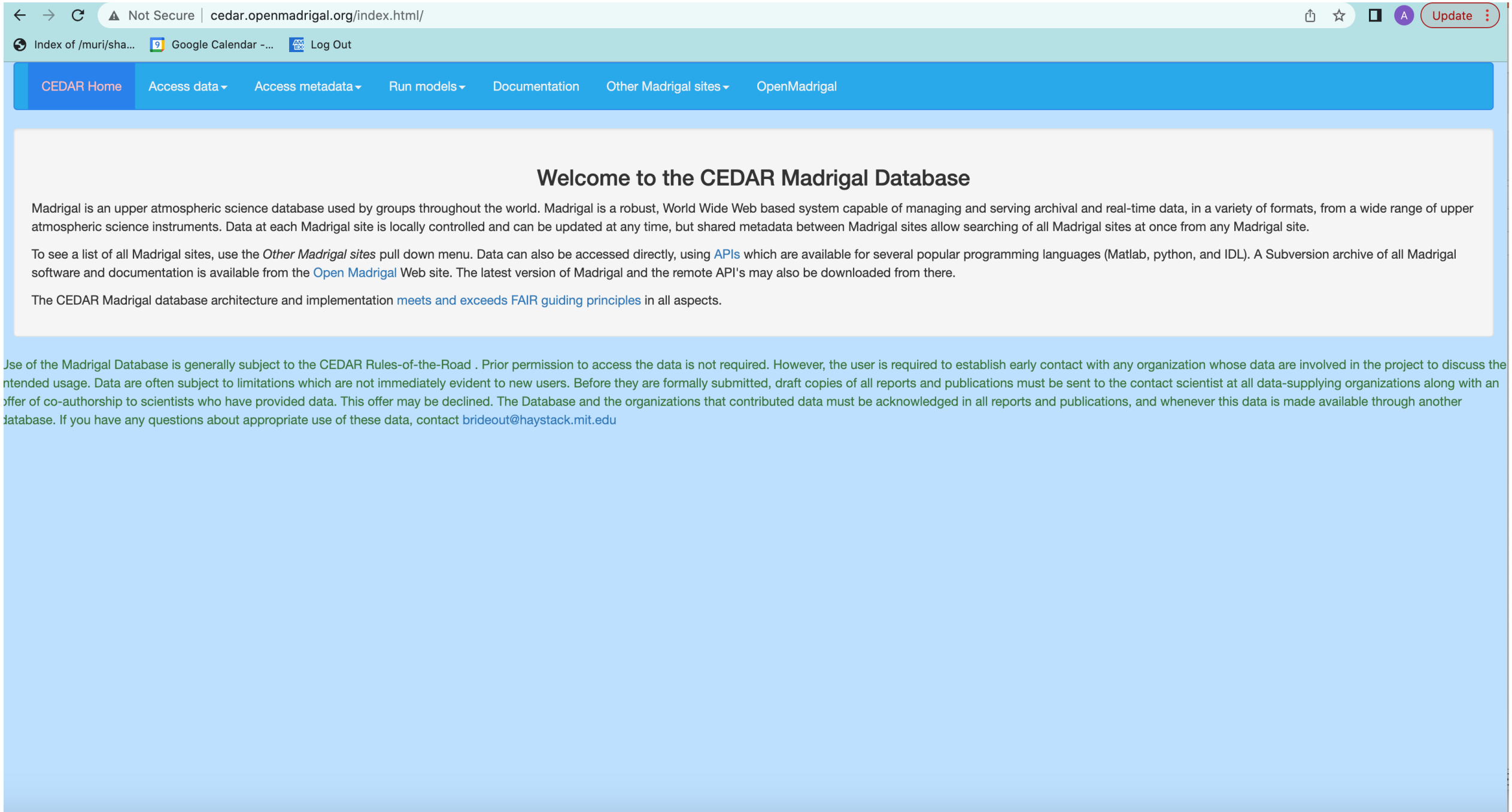
Madrigal data on a globe showing the range of the Millstone antenna to the southwest

Madrigal is an upper-atmospheric science database used by groups throughout the world. Madrigal is 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. 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.

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.

http://cedar.openmadrigal.org/index.html/

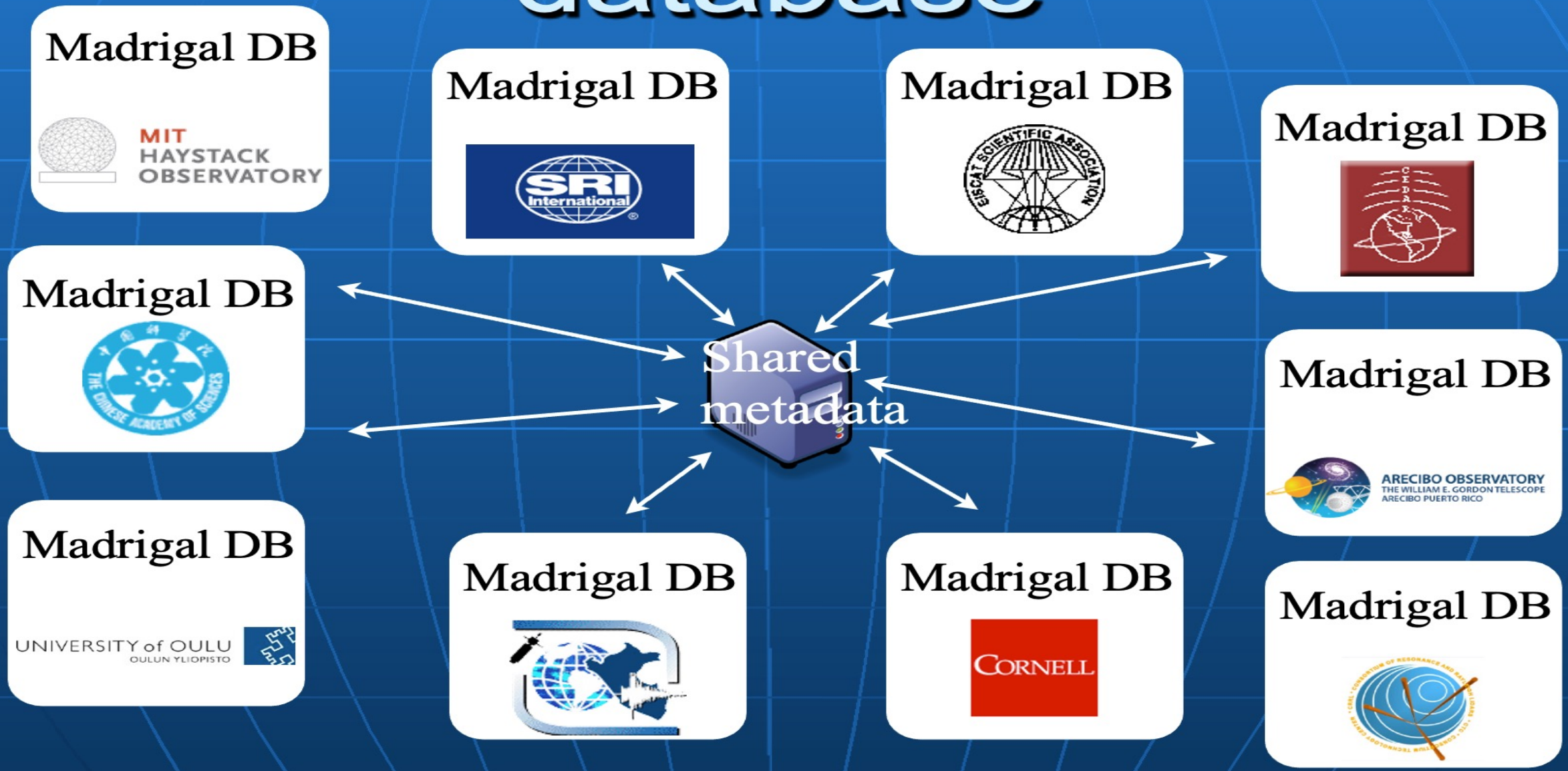


Outline

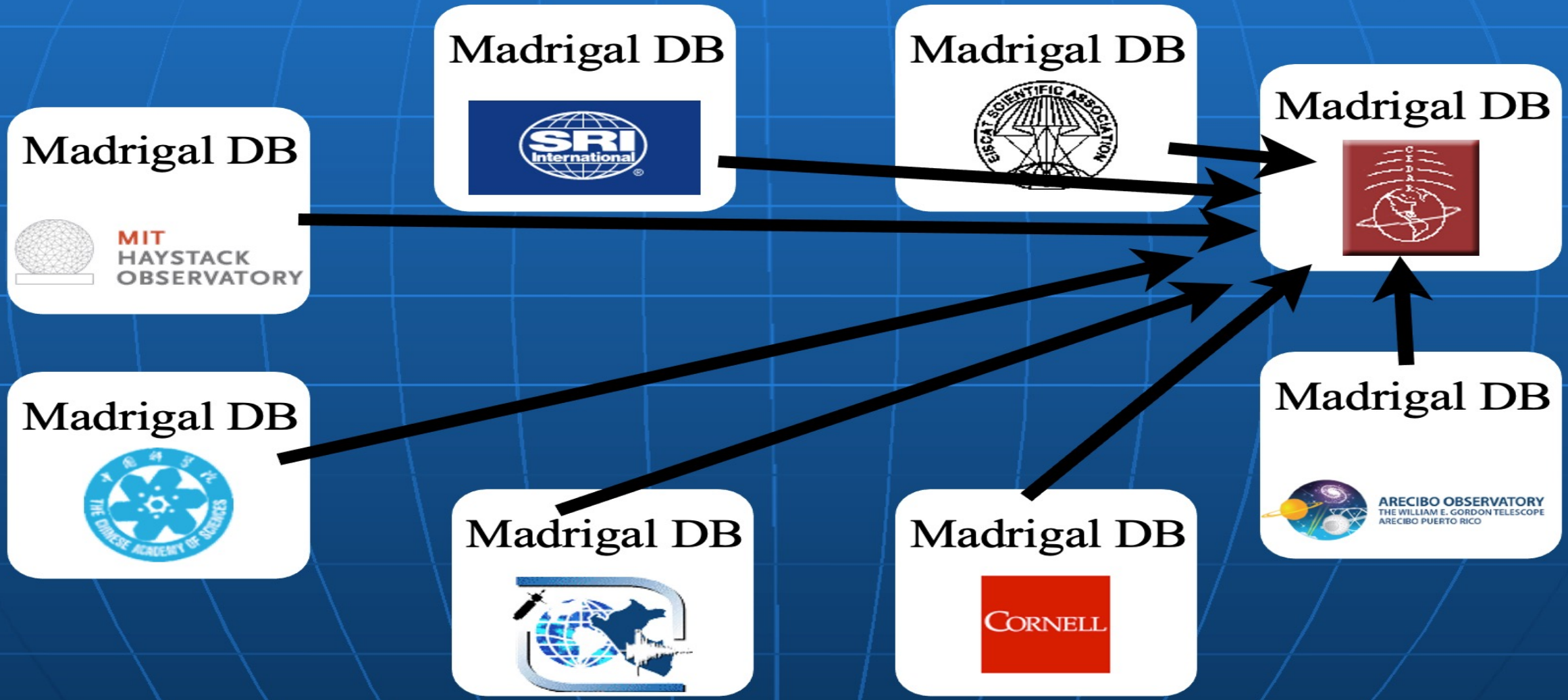
- What is Madrigal?
- What is the CEDAR database format?
  - Exercise - open a file with Hdfview
- In what formats can I get Madrigal data?
- How do I use Madrigal?
  - Background
  - The website
    - Exercise - use the website
  - Script data access
    - Exercise - write a script

What is Madrigal?

Madrigal is a distributed database



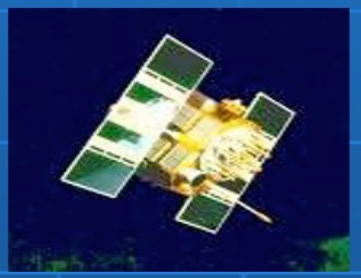
Cedar Madrigal archive imports all data weekly



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

Incoherent Scatter Radar

TEC via GPS



MF Radar

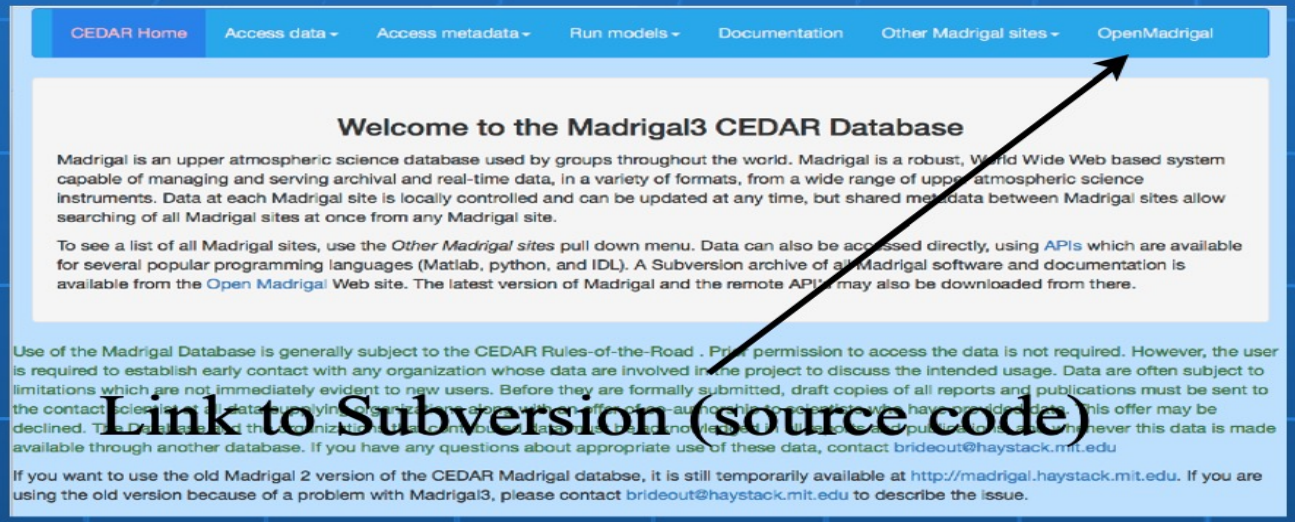
Examples of number of instruments in Madrigal:

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

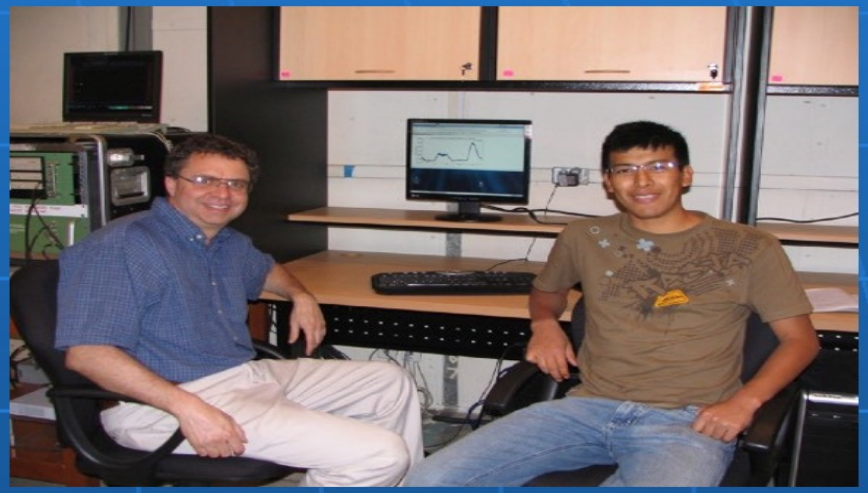
Other examples:

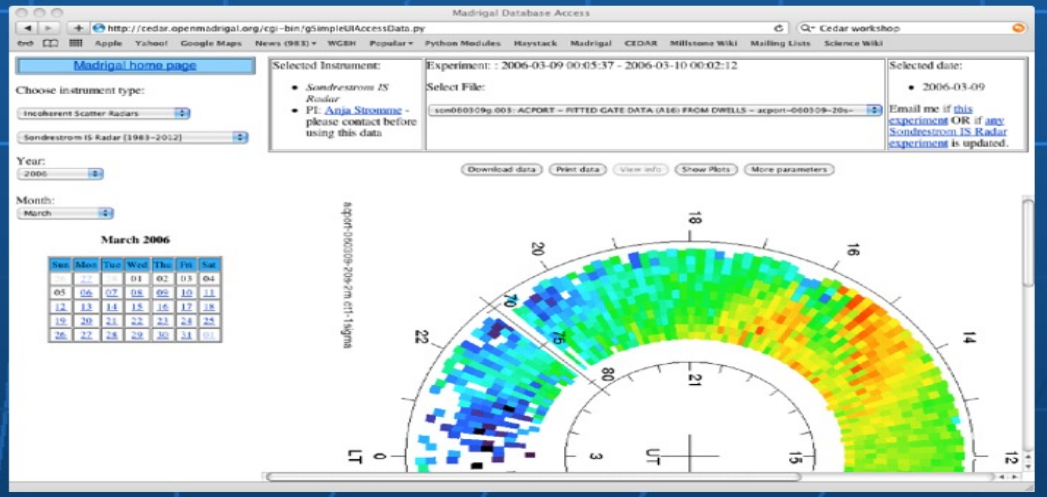
- GPS TEC
- DMSP

Madrigal is open-source



Link to Subversion (source code)





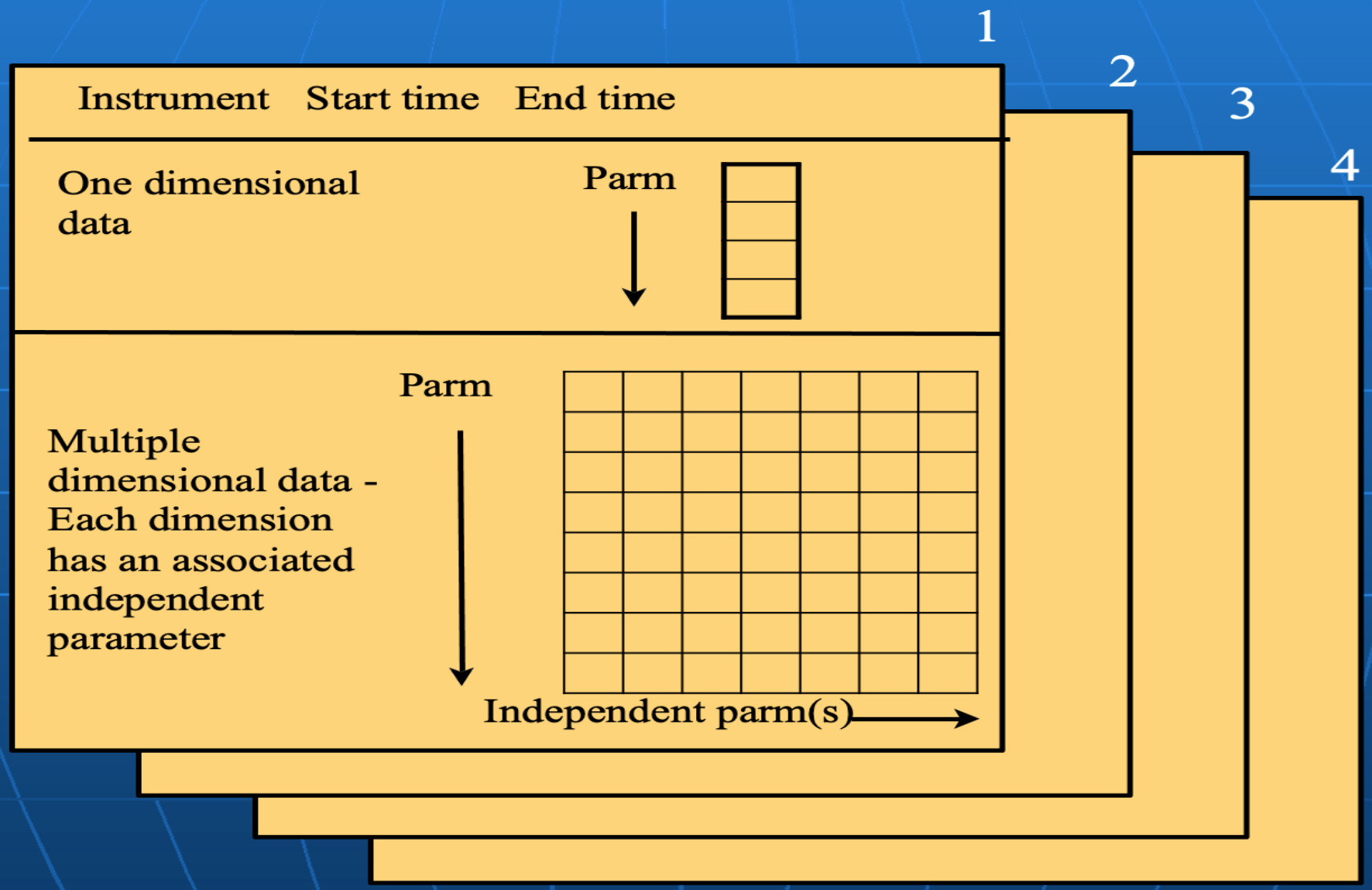
www.openmadrigal.org

- What is the CEDAR database format?

Well defined parameters

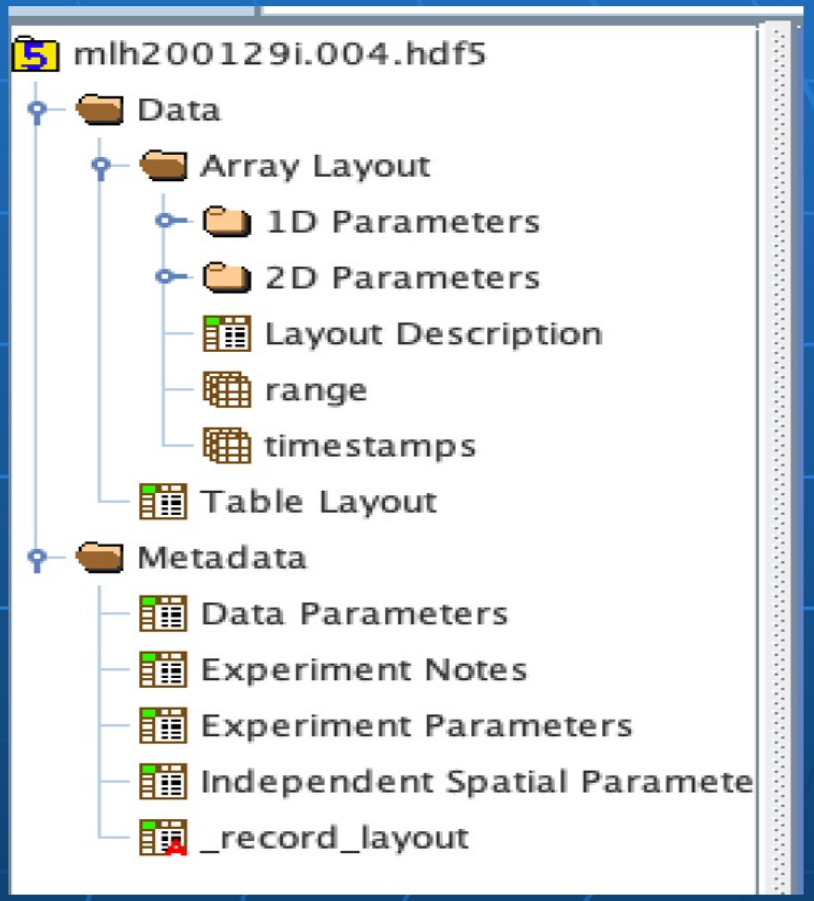
- Standard descriptions of all parameters
- Allows the existence of derivation engine
- Madrigal allows extended descriptions
- All parameters have corresponding error parameters
- Missing, Assumed

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?

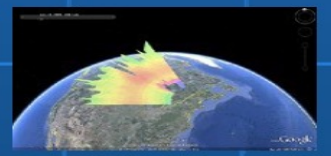
Madrigal Data Model

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

Madrigal DB

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

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



Data shared among all Madrigal sites

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

Records
(measurement over one period of time)

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

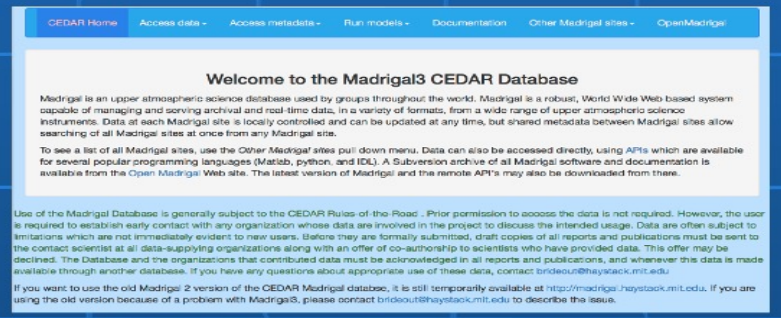
Rules of the road

- 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

Madrigal DB

- 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 site

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 → globalDownload

I want to only download filtered data with derived parameters → globalIsprint

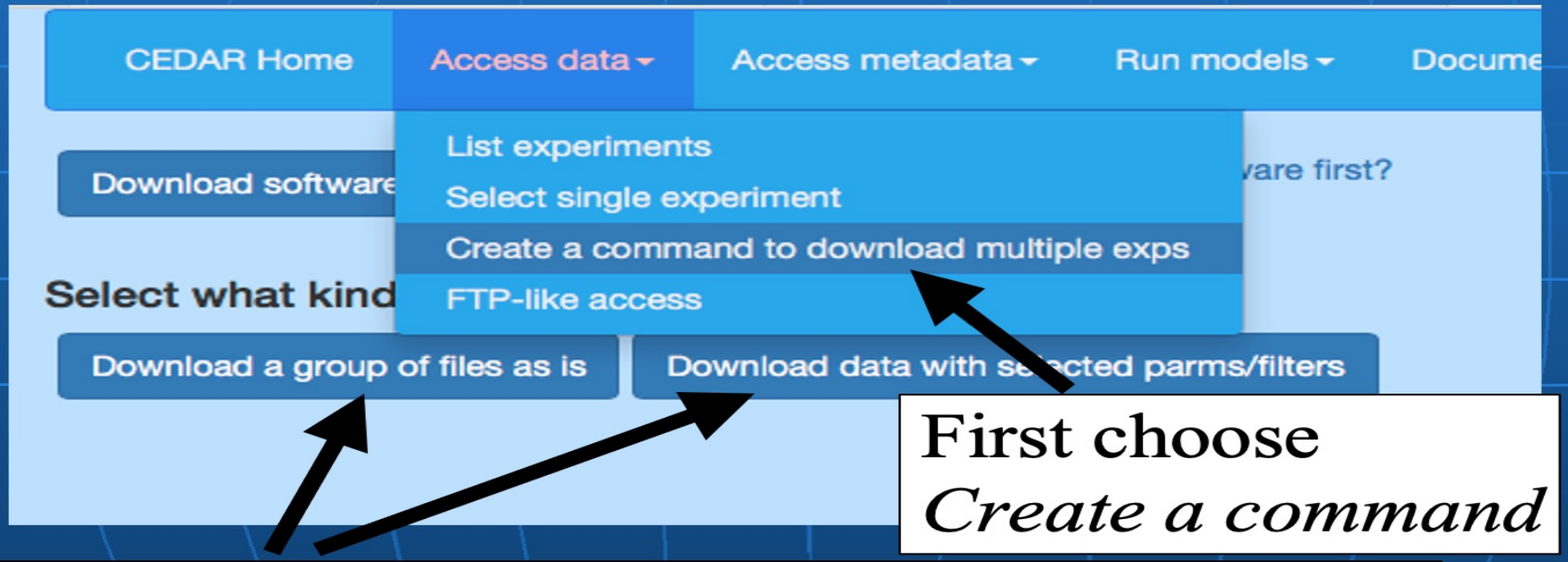
I want to write my own script → Work with API's

Live demo of Madrigal script creation page

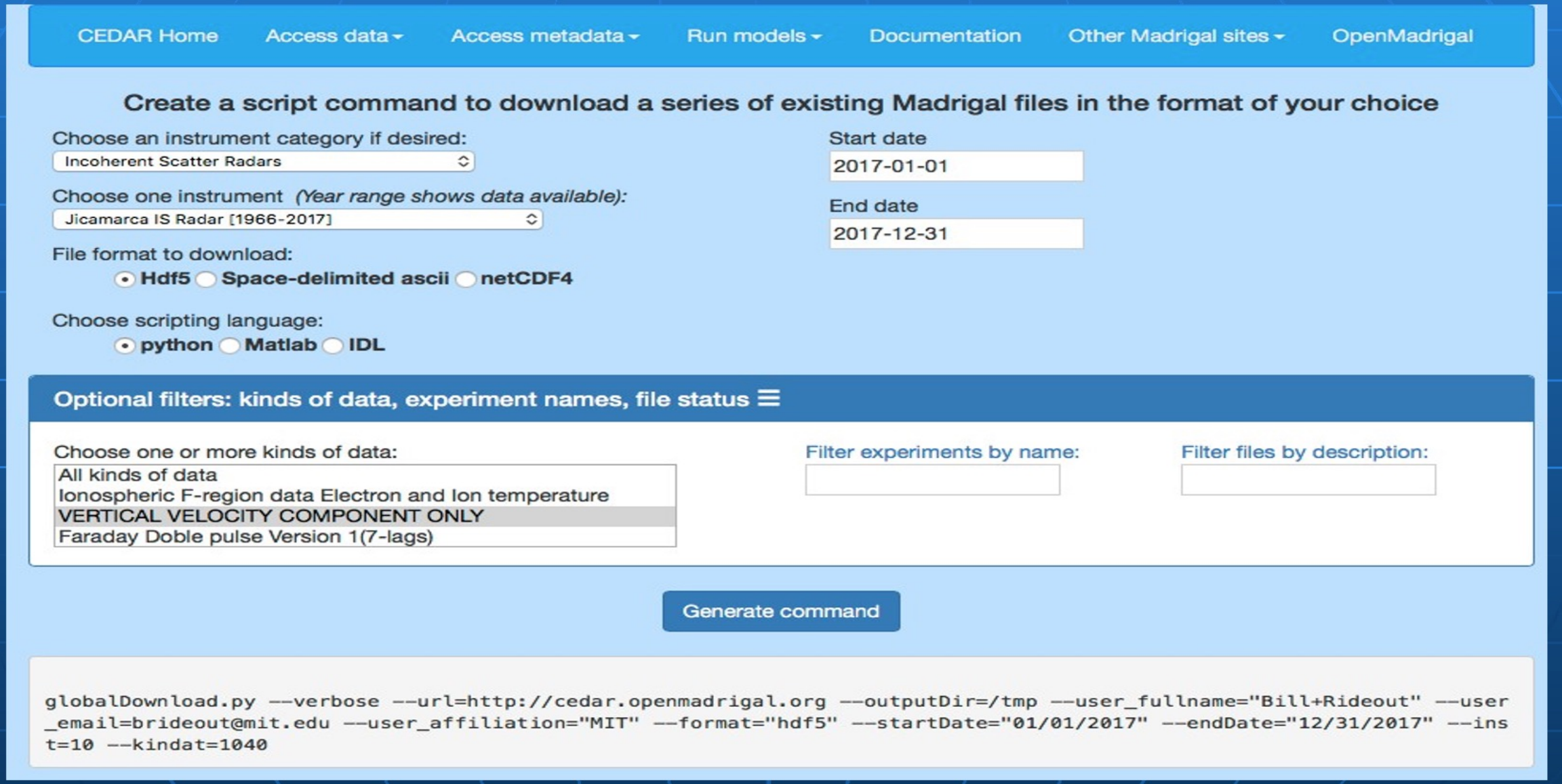
- CEDAR Madrigal site
  - http://cedar.openmadrigal.org
  - Access Data -> Create a command to download multiple exes

Scripts generated by web site

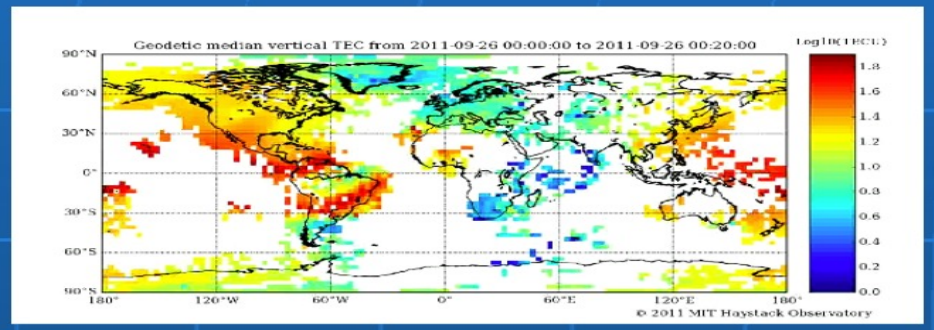
- No need to read any documentation!



Create a script to download files



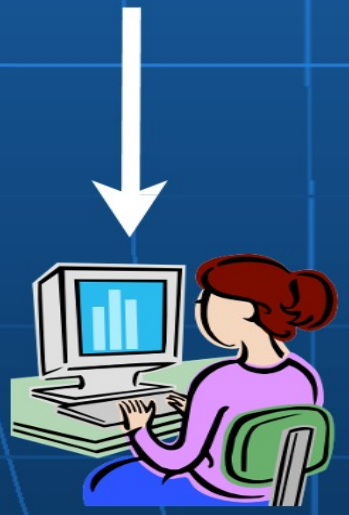
More advanced globallsprint scripts



TEC data: instrument id = 8000

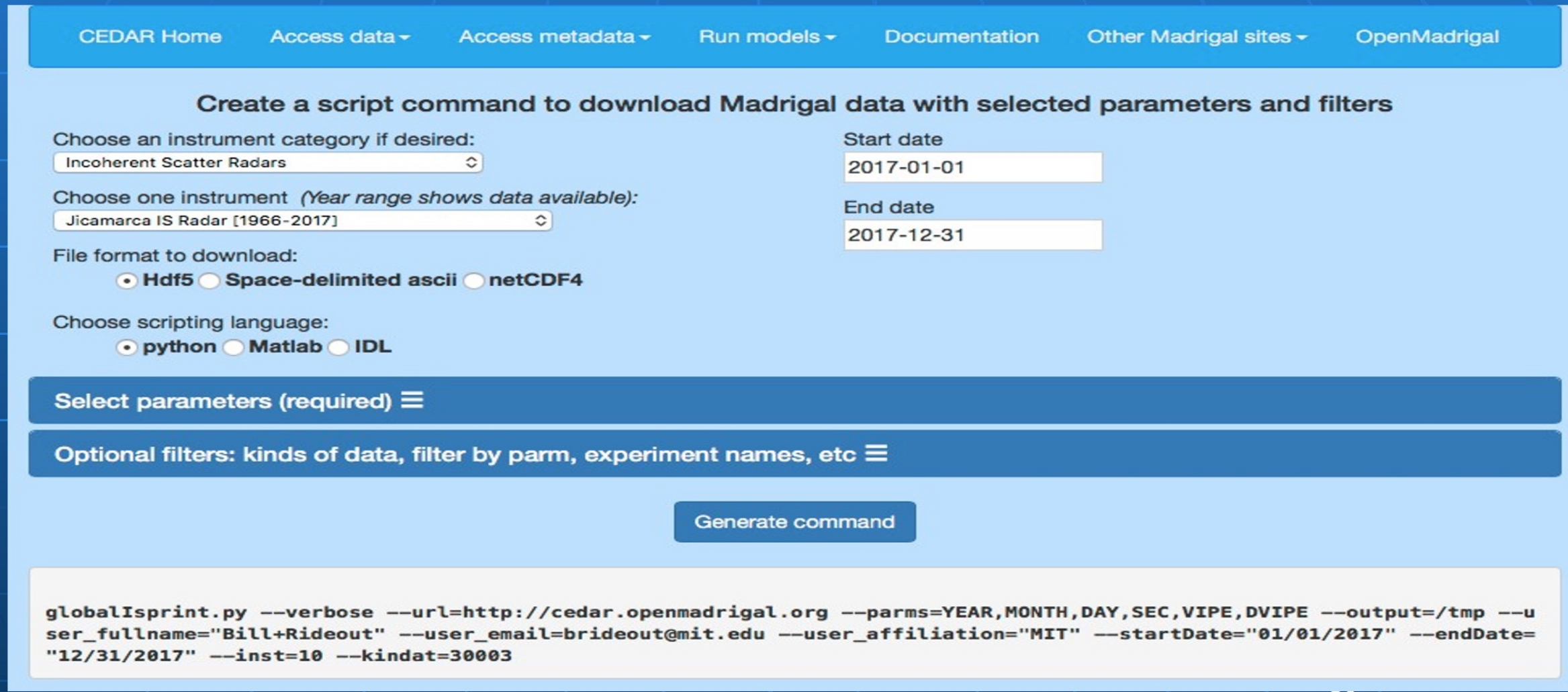
Madrigal DB

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



Show me only data where TEC > 100TECu when Kp > 7 in 2003

Create a script to select parms/filters - globallsprint



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/

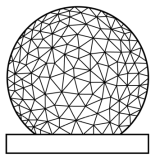
Exercise 1: Install hdfview

- 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



MIT
HAYSTACK
OBSERVATORY