How to use the Madrigal database for atmospheric science

Bill Rideout

MIT Haystack Observatory

brideout@mit.edu
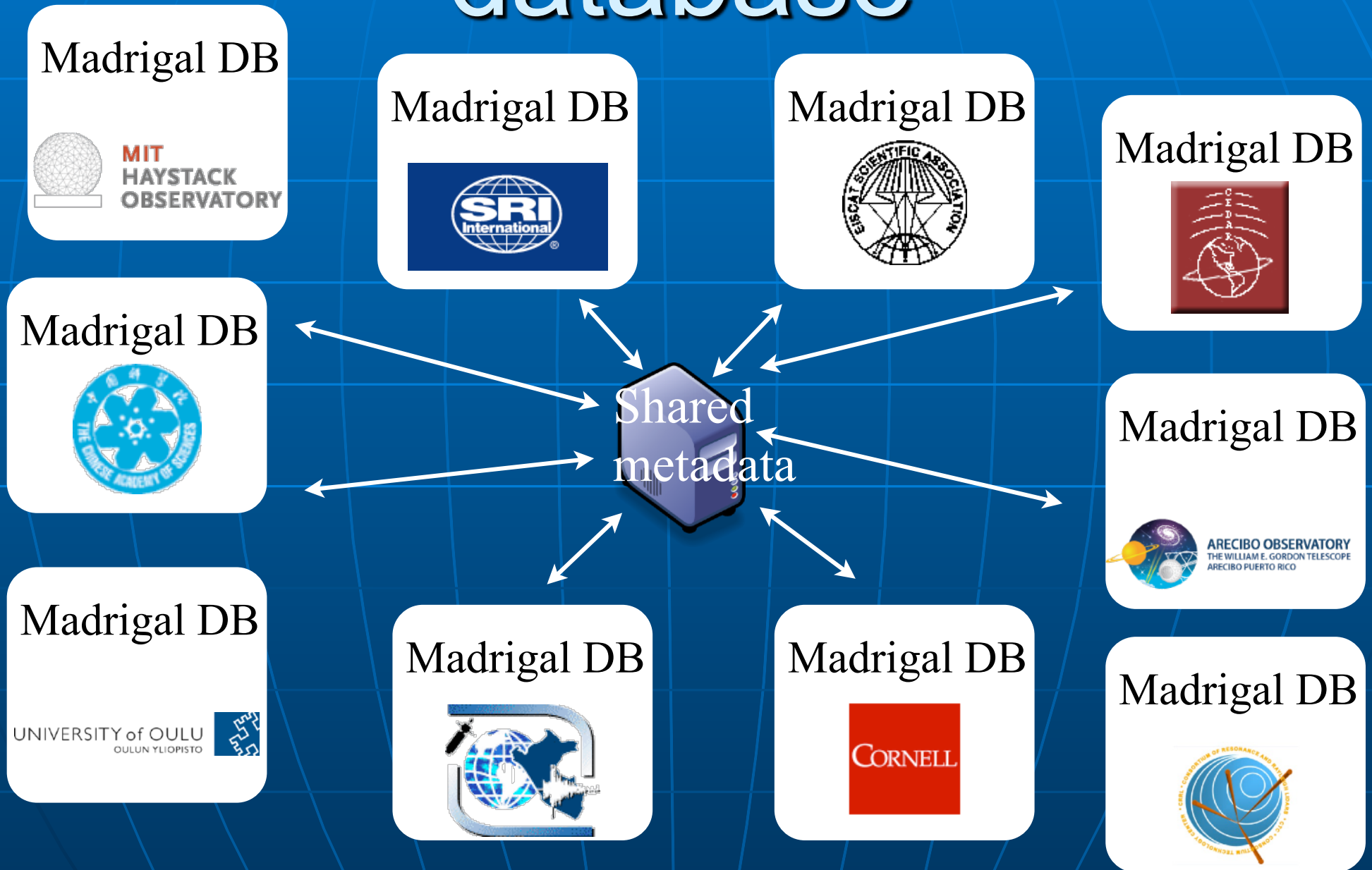
2023 ISR School
Fairbanks, Alaska

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

Madrigal DB

Madrigal DB

Madrigal DB

Madrigal DB

Madrigal DB

Madrigal DB

Madrigal DB

Madrigal DB

5
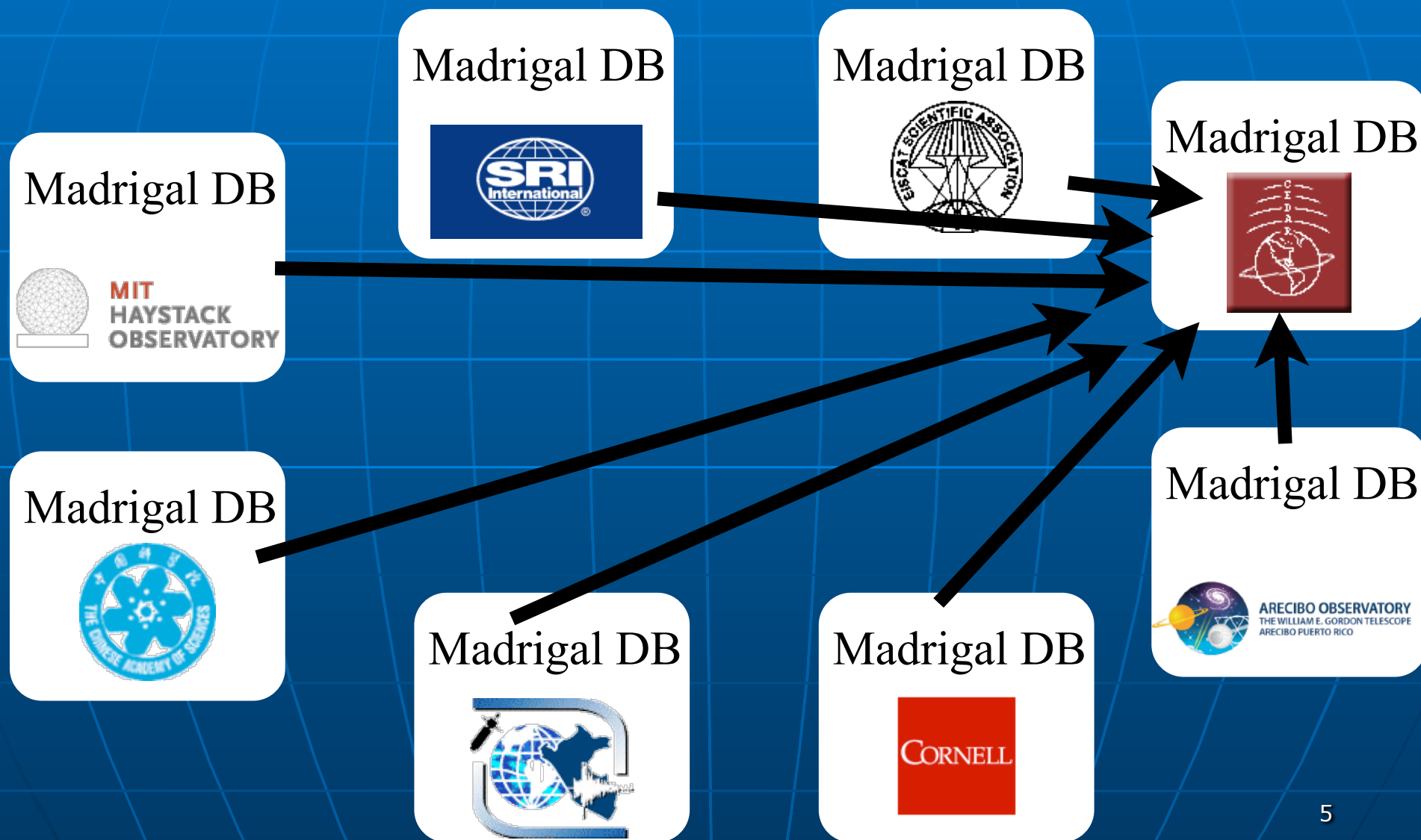
The Madrigal database stores data from a wide variety of upper atmosphere research instruments

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
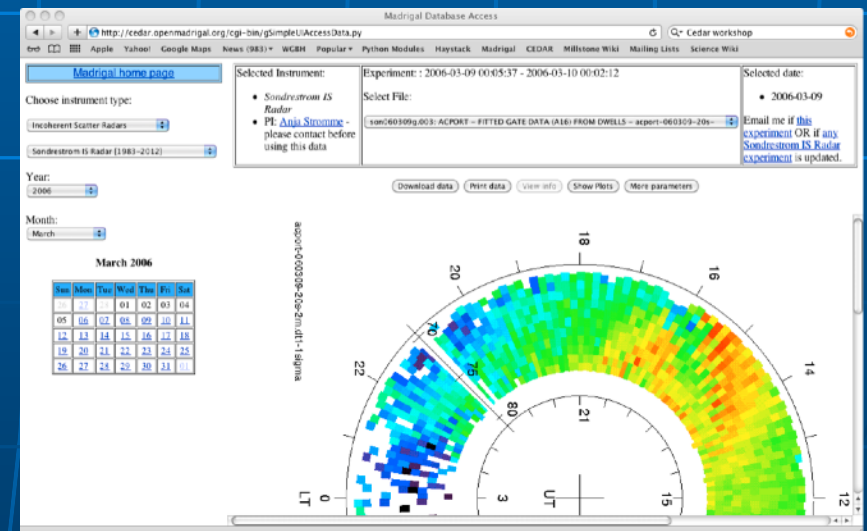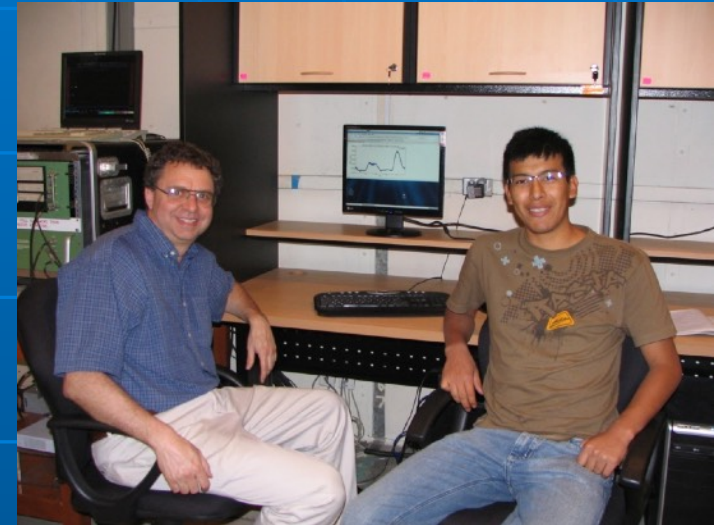
- What is the CEDAR database format?

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

Instrument   Start time   End time

One dimensional data

Parm

Multiple dimensional data - Each dimension has an associated independent parameter

Parm

Independent parm(s)

1
2
3
4
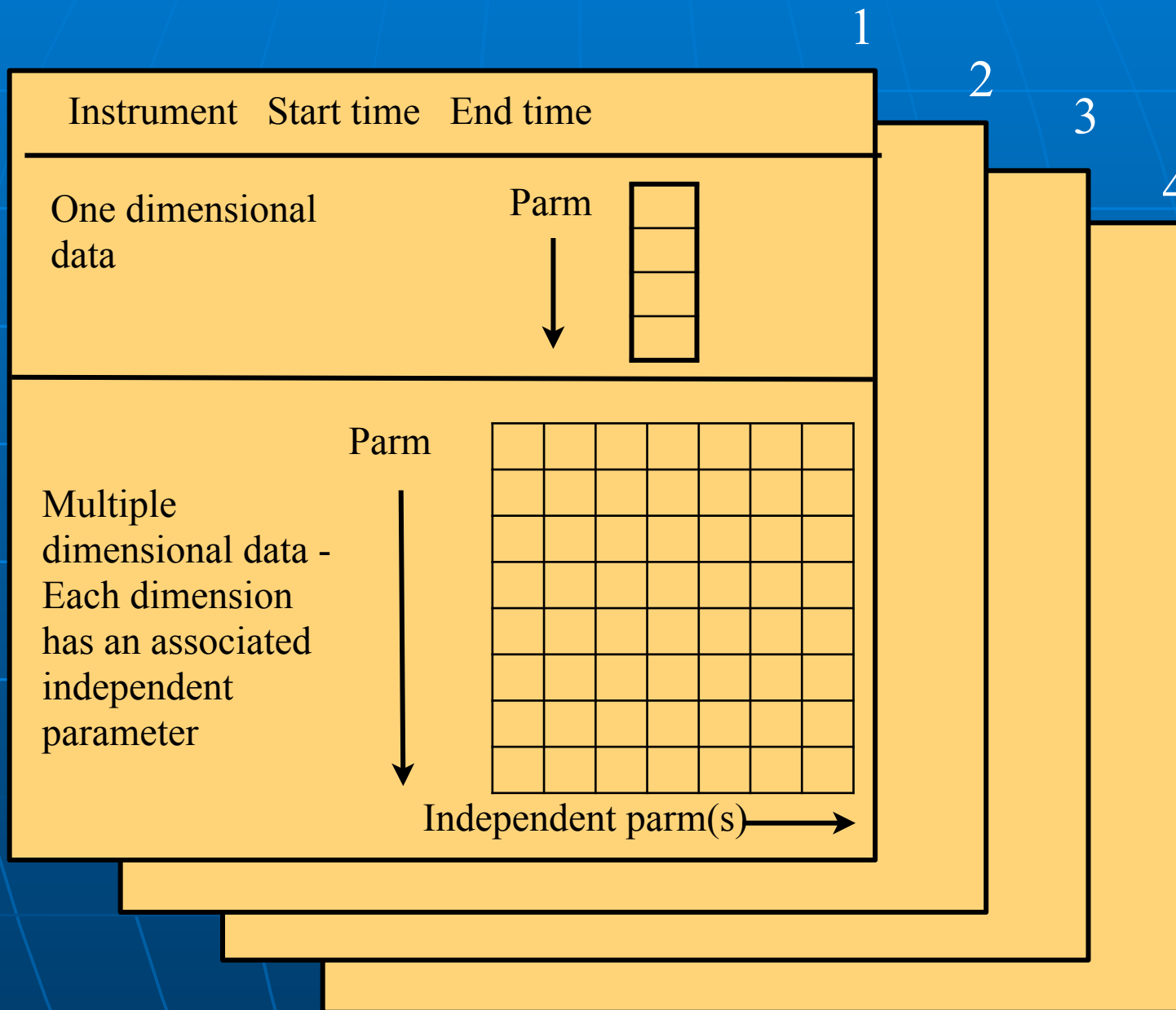
Cedar file format: Structured Hdf5

- Self-describing - all parameters defined, notes added
- Scientific standard
- Parms float, integers or strings
- Table Layout, Array Layout possible if repeating independent parms
-
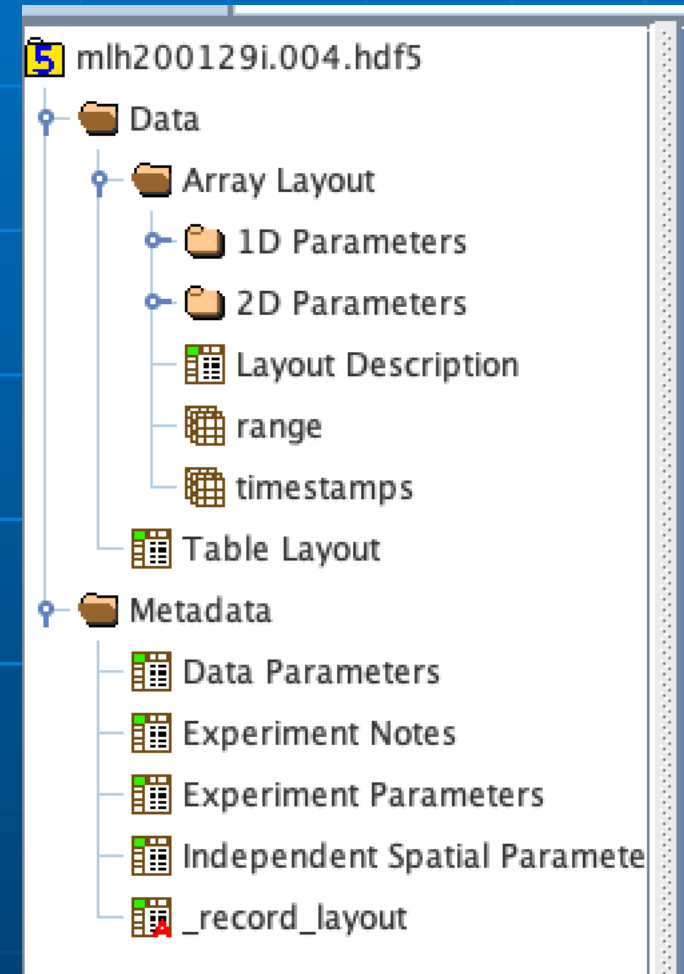
Exercise: use hdfview to examine Madrigal files

- Go to https://tinyurl.com/2023ISR

- Go down to Monday - Madrigal exercise 1

- 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

File parameters → Derivation Engine → File **and** derived parameters

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
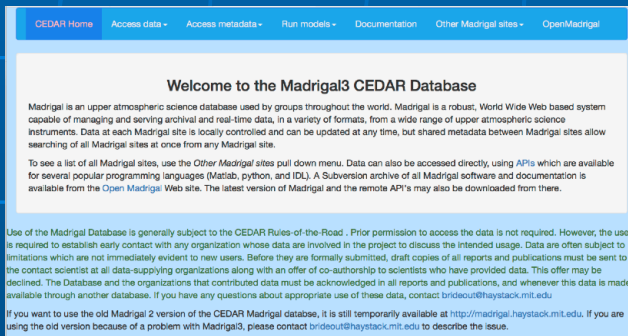- The PI is listed on every web page

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

Typical use - data discovery

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

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
  - https://data.amisr.com/madrigal/

Exercise 2: using the Madrigal web interface

- Go to https://tinyurl.com/2023ISR
- Go down to Monday - Madrigal exercise 2
- Work through exercise

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[24]

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!

First choose *Create a command*

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

Create a script to download files

More advanced globalIsprint scripts
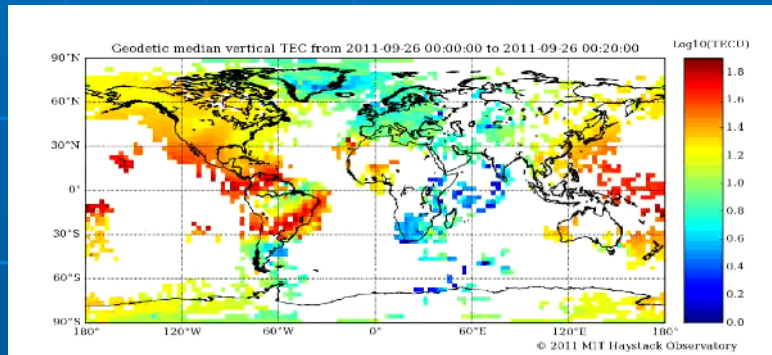
TEC data: instrument id = 8000

Madrigal DB

http://madrigal.iggcas.ac.cn/madrigal/
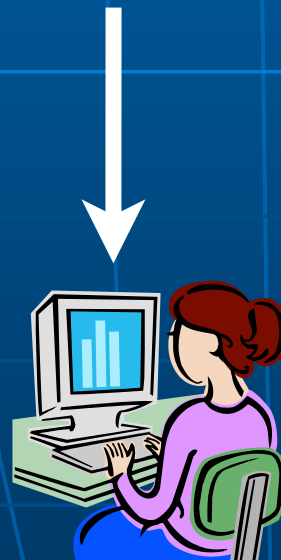
Show me only data where TEC > 100TECu when Kp > 7 in 2003

Create a script to select parms/filters - globalIsprint

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

Exercise 3: using the Madrigal script creation interface

- Go to https://tinyurl.com/2023ISR
- Go down to Monday - Madrigal exercise 3
- Work through exercise

Extending/contributing to Madrigal

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