How to use the Madrigal database for atmospheric science

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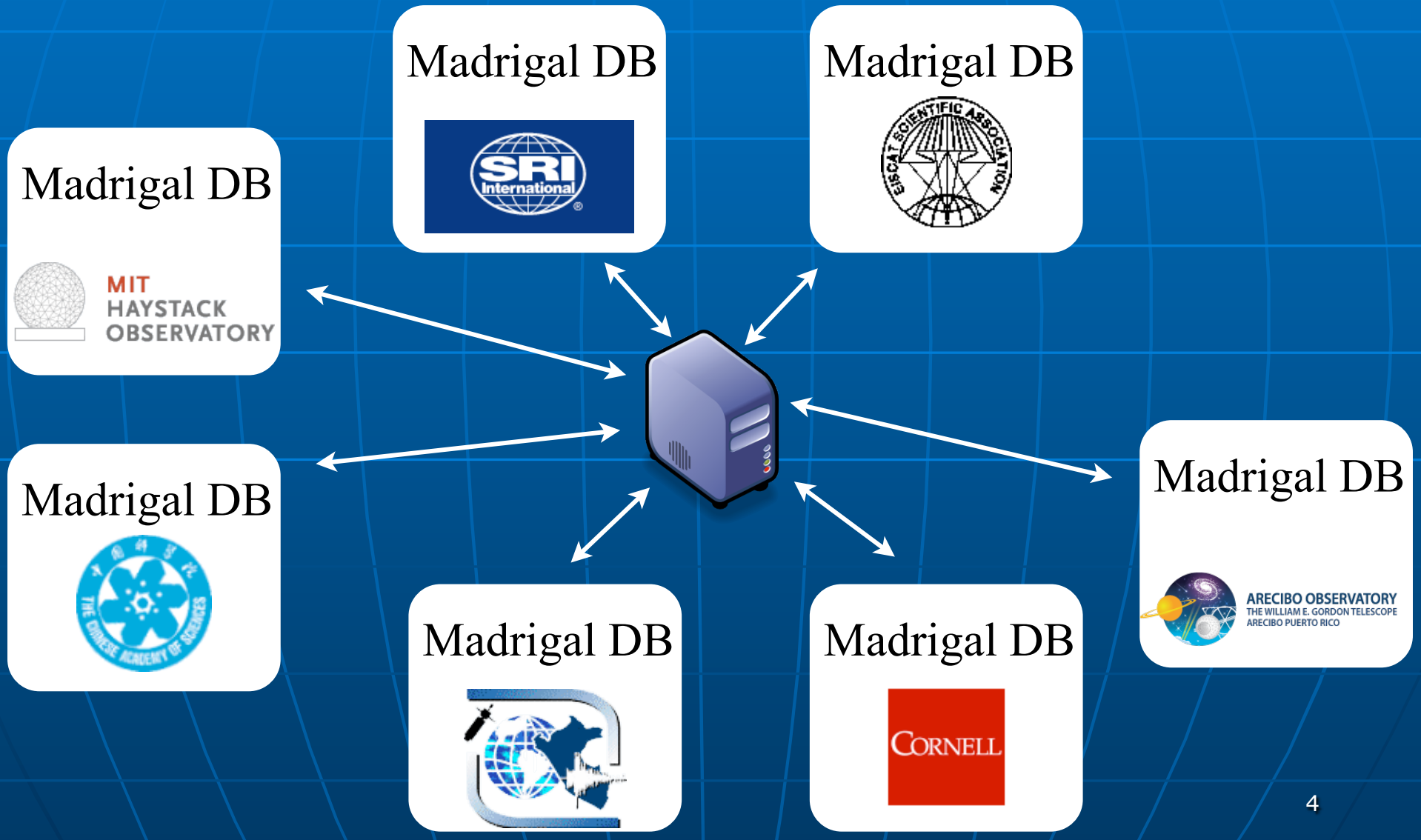
ISR workshop
Banff, Alberta, Canada
July 30, 2012

Outline

- What is Madrigal?
- What is the CEDAR database format?
- In what formats can I get Madrigal data?
- How do I use Madrigal?
  - Background
  - The website
    - Simple local data access
    - Full Access
  - Script data access

What is Madrigal?

Madrigal is a distributed database



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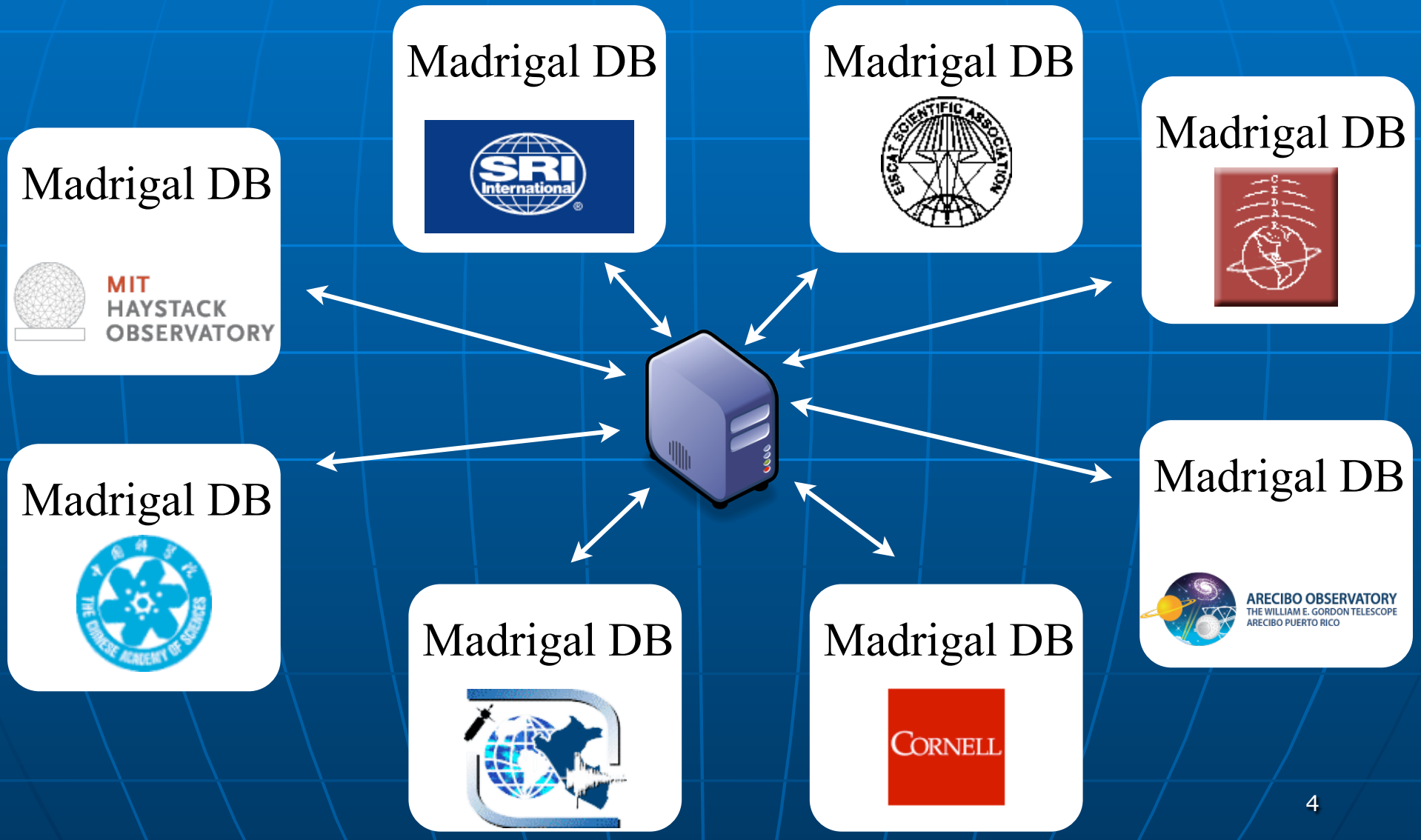

Cedar Madrigal archive imports all data weekly

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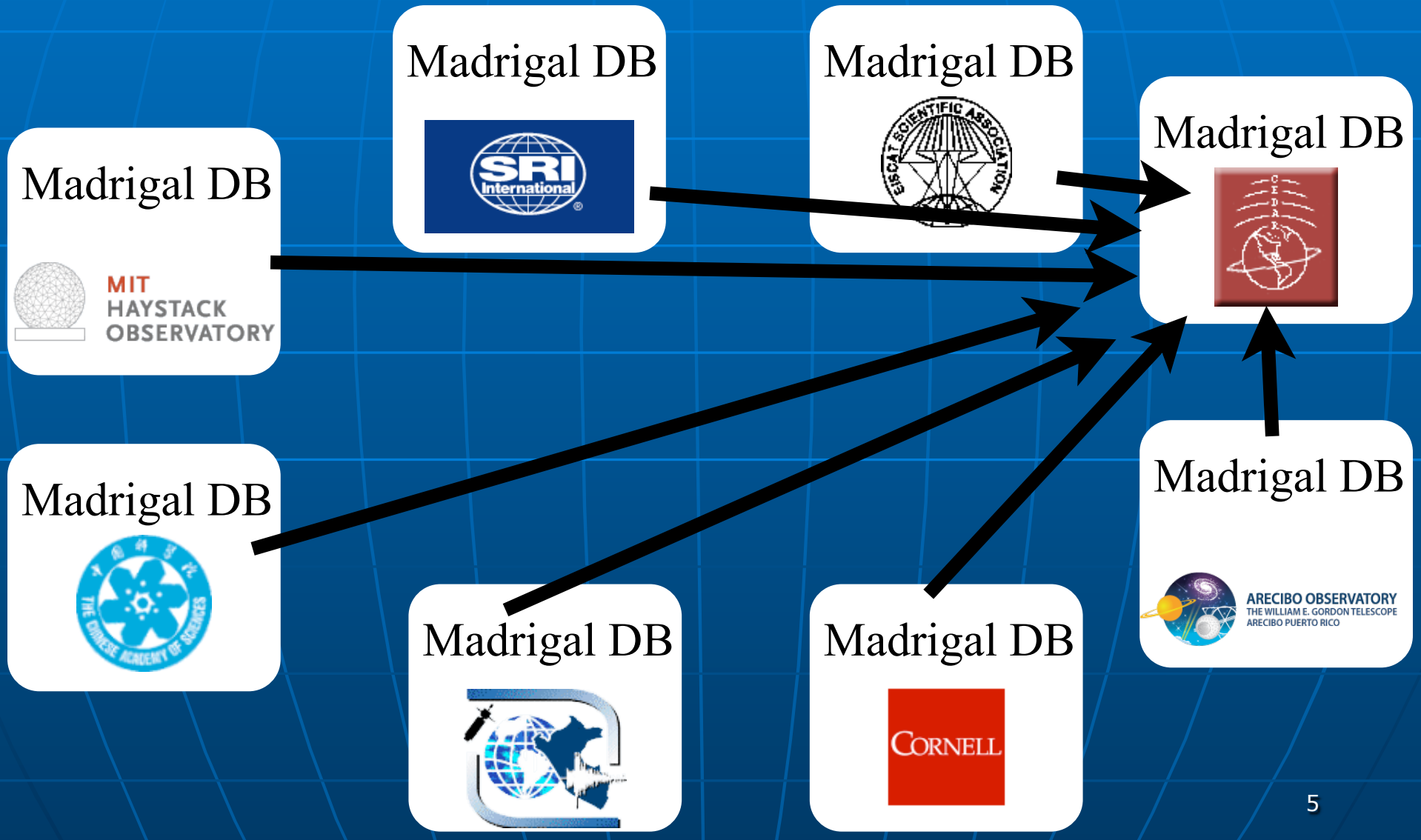


The Madrigal database stores data from a wide variety of upper atmosphere research instruments

Incoherent Scatter Radar

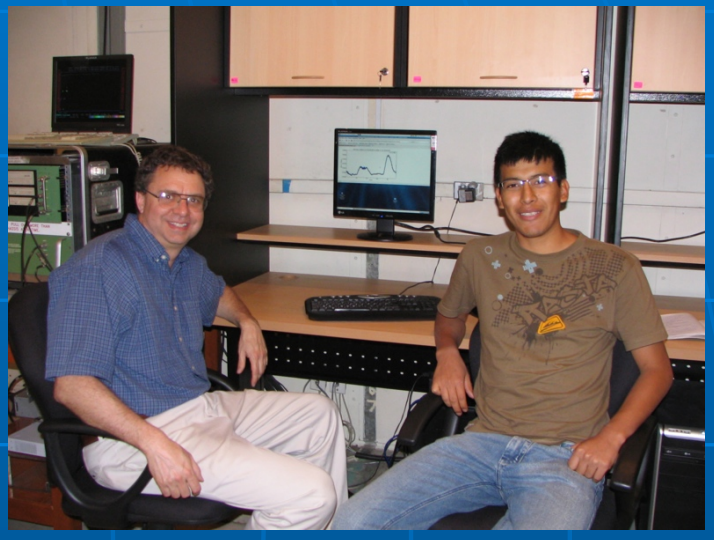
TEC via GPS

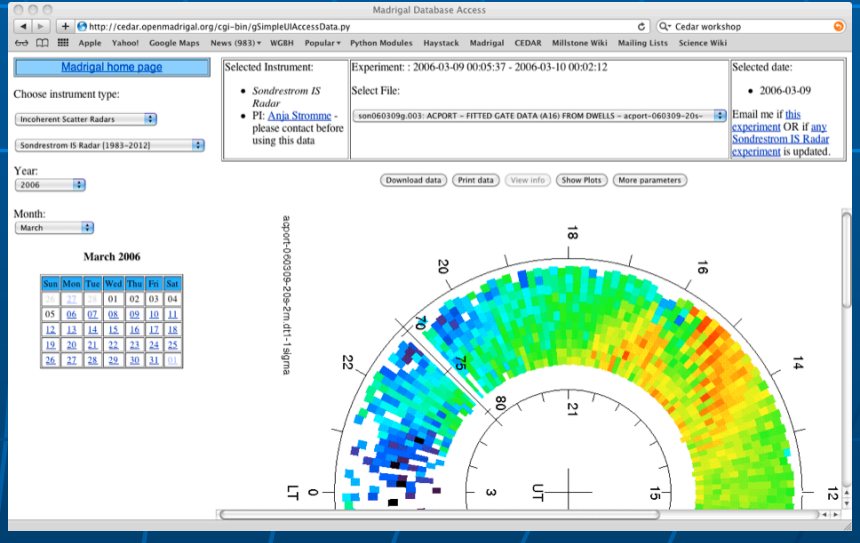
MF Radar

Number of instruments in Madrigal:

- Incoherent scatter radars: 22
- MST radars: 3
- MF radars: 16
- Meteor radars: 7
- FPI: 23
- Michelson Interferometers: 6
- Lidars: 4
- Photometers: 4

Madrigal is open-source





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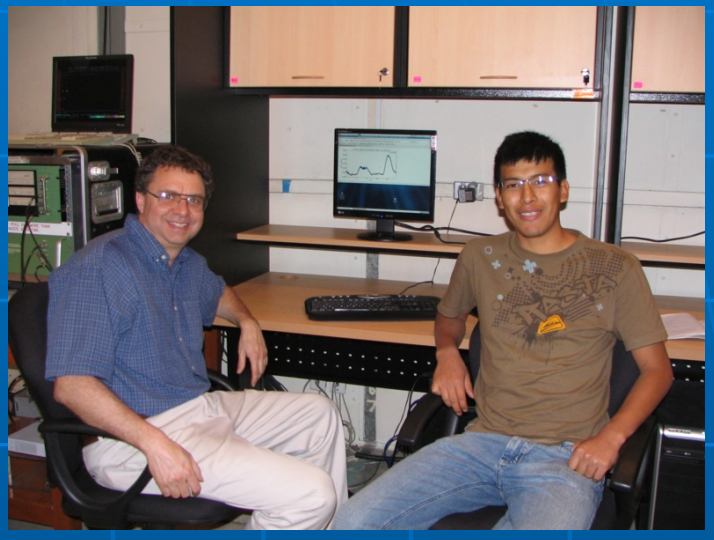
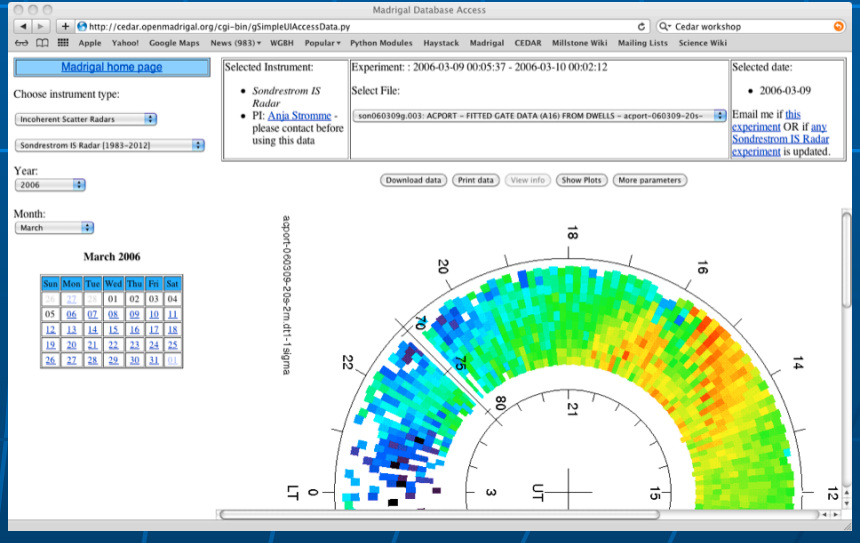




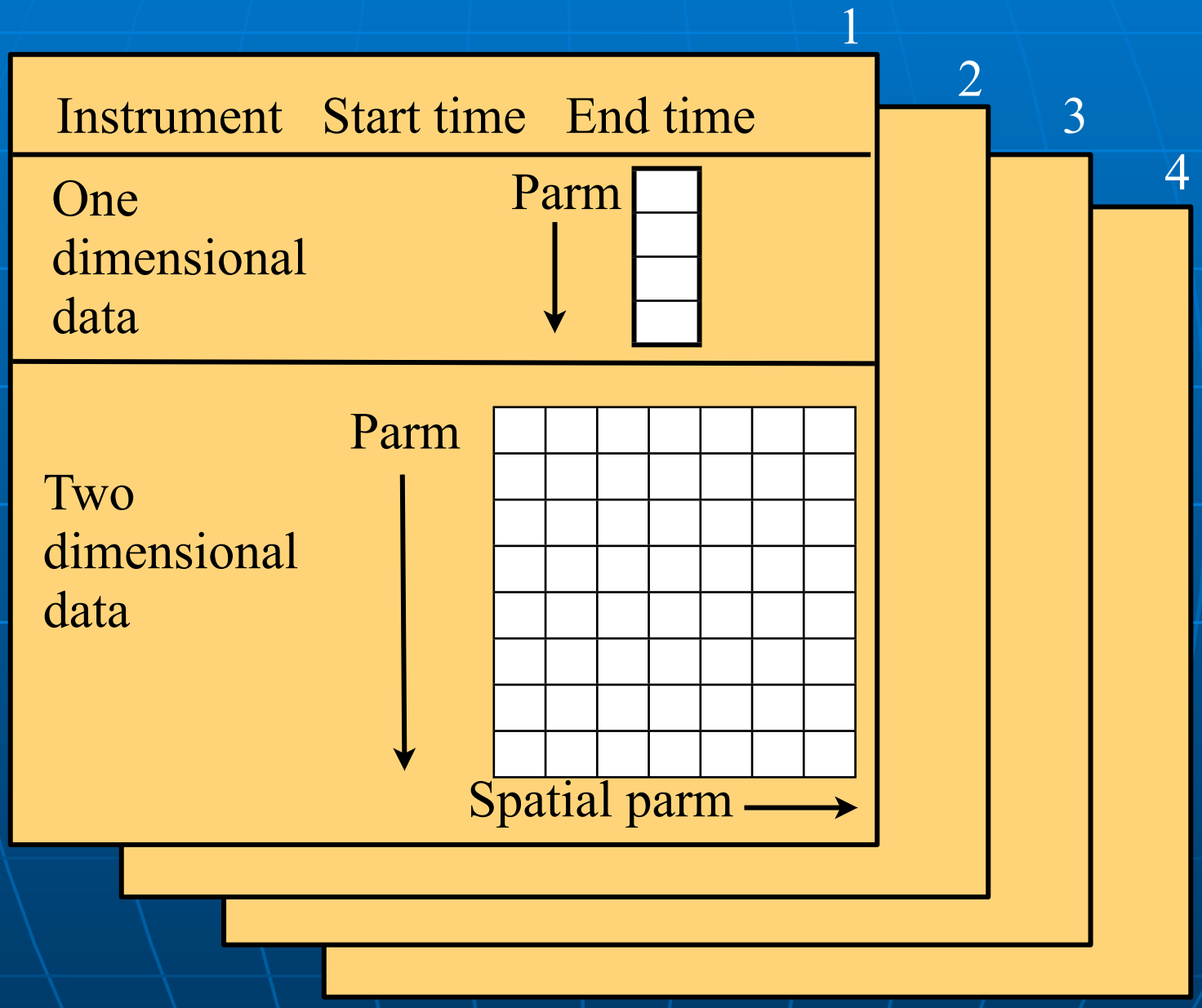
www.openmadrigal.org

- What is the CEDAR database format?

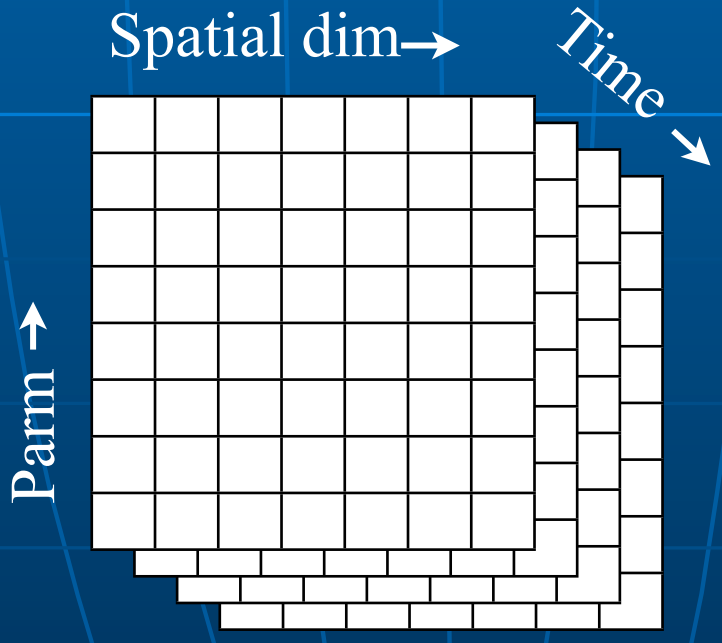
Well defined parameters

- 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



Flexibility versus ease-of-plotting



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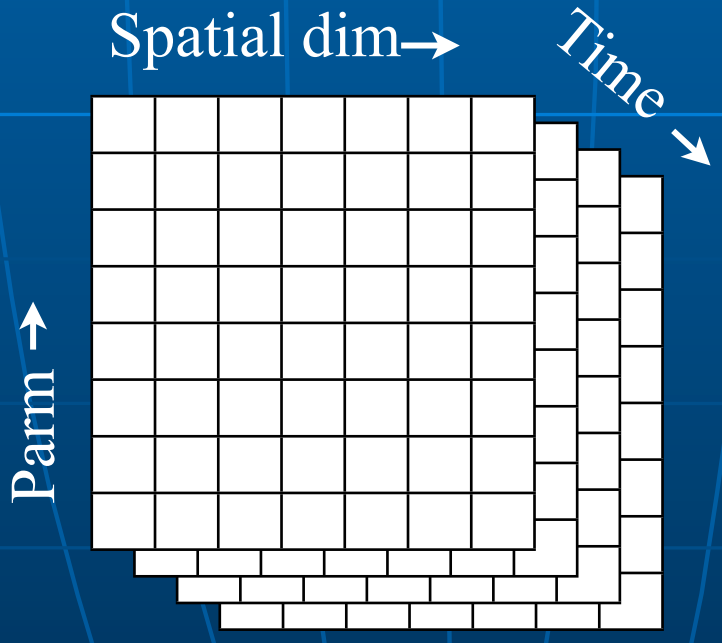

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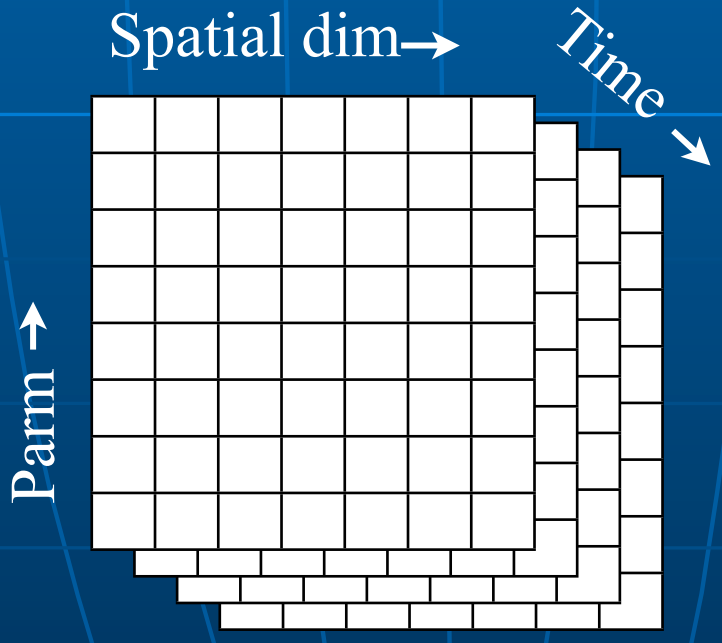
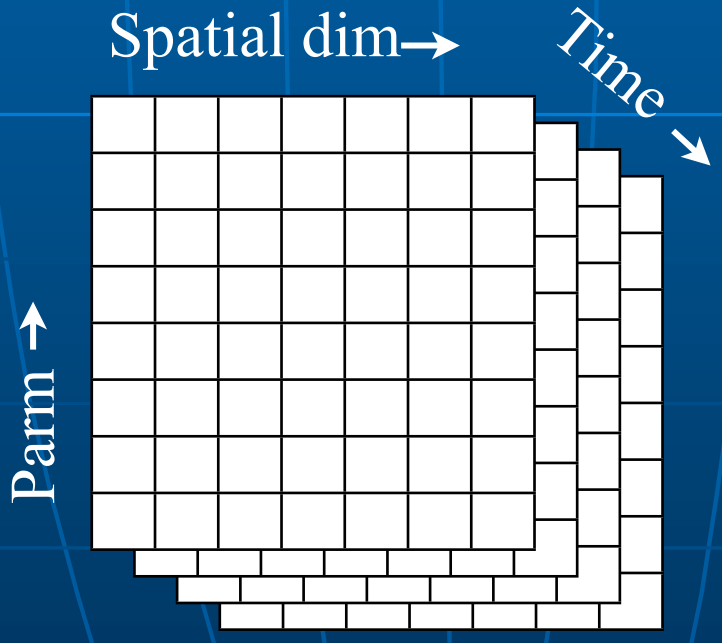


Flexibility versus ease-of-plotting

- Does not require consistent parameters
- Does not require consistent spatial steps
- Often data is uniform



In what formats can I get Madrigal data?

Cedar file format: past and future

Cedar file format

- Developed in 1980
- 16 bit integer
  - Dynamic range problems

Hdf5

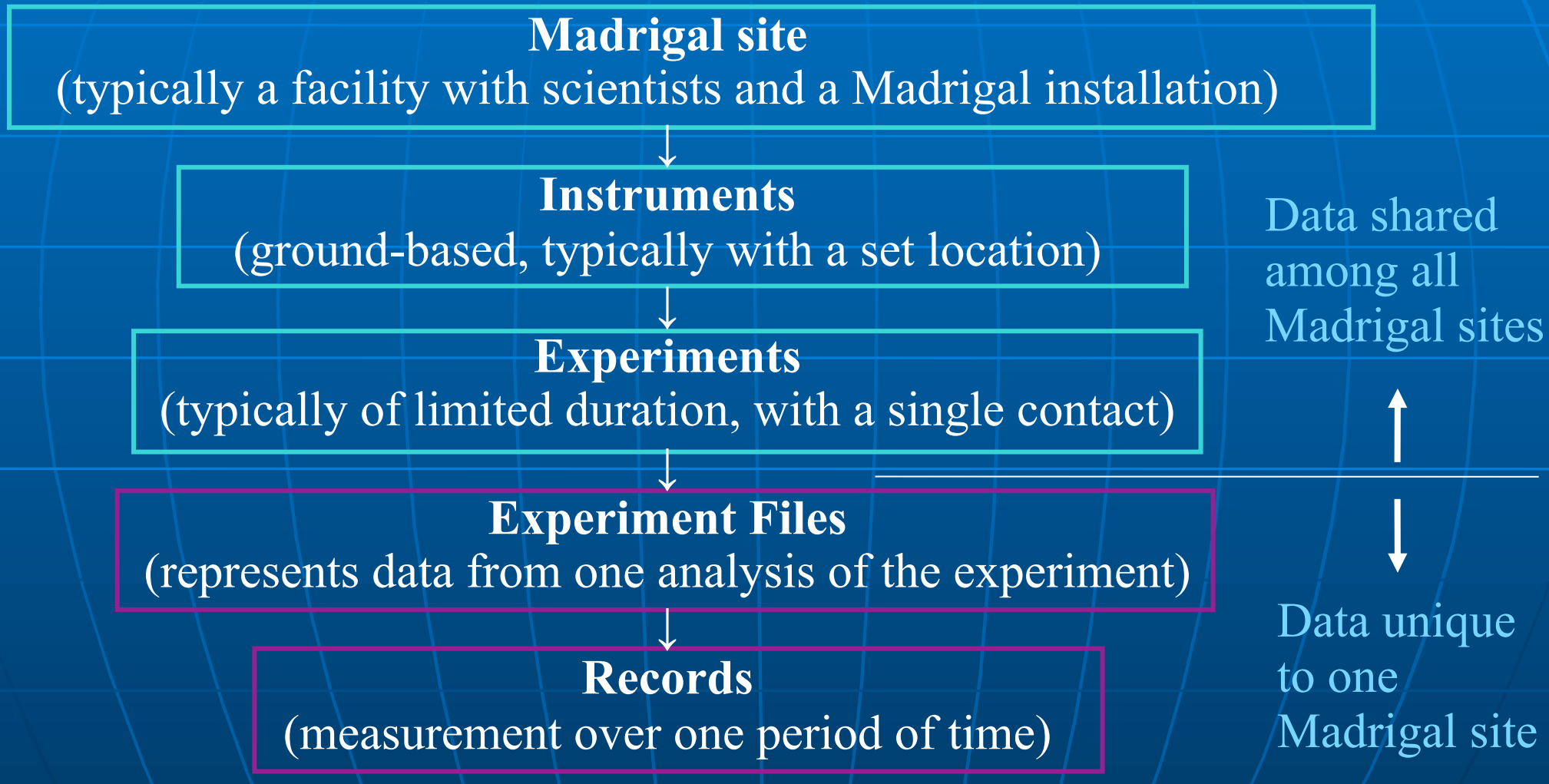
- Scientific standard
- Float based
- Flexible arrangement
- Table data, optional grid

Madrigal versions

Release	Madrigal 2.6 (now)	Madrigal 3.0
Underlying format	Cedar file format	Hdf5
Output formats	Ascii, Hdf5, Cedar file format	Ascii, Hdf5, netCDF4 Cedar file
Formats with deriv parms	Ascii	Ascii, Hdf5, netCDF4

- How do I use Madrigal?

Madrigal Data Model



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

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- Models
  - Examples: MSIS, IRI

How can the Madrigal database be accessed?

User

Web interface

Web services API

- From anywhere on internet
- Python API
- Matlab API
- IDL API
- Other could be written

Live demo of Madrigal web page

- Start at any Madrigal server (e.g., http://cedar.openmadrigal.org or http://isr.sri.com/madrigal)

Remote Access to Madrigal Data

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- Read only API
- Complete Python, Matlab, and IDL APIs written
- More APIs available on request or via contribution

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- Not based on SOAP or XmlRpc since no support in languages such as Matlab
- CGI arguments and output fully documented at http://www.haystack.edu/madrigal/remoteAPIs.html

Simple Python example

```
    # create the main object to get all needed info from
    Madrigal
madrigalUrl = "http://www.haystack.mit.edu/madrigal"
testData = madrigalWeb.madrigalWeb.MadrigalData(madrigalUrl)

# get all MLH experiments in 1998
expList = testData.getExperiments(30, 1998,1,1,0,0,0,1998,
                                  12,31,23,59,59)
for exp in expList:
      # print out all experiments
      print exp

# print list of all files in first experiment
fileList = testData.getExperimentFiles(expList[0].id)
      for thisfile in fileList:
          print thisfile
```

Python Remote API

- Can run on any platform with python (PC, Unix, Mac, etc)
- Fully documented with examples
- Links
  - Reference: http://madrigal.haystack.mit.edu/madrigal/madpyDoc/remotePythonAPI/index.html
  - Tutorial: http://madrigal.haystack.mit.edu/madrigal/rt_python.html

Live Python API demo

- See demoMadrigalWebServices.py at http://atlas.haystack.mit.edu/cgi-bin/millstone_viewvc.cgi/openmadrigal/trunk/madroot/source/madpy/madrigalWeb/examples/

Matlab Remote API

- Methods
  - getInstrumentsWeb
  - getExperimentsWeb
  - getExperimentFilesWeb
  - getParametersWeb
  - isprintWeb
  - madDownloadFile
  - madCalculatorWeb
  - globalIsprint
- Methods match Madrigal model

Simple Matlab example

```
filename = '/usr/local/madroot/experiments
                /2003/tro/05jun03/NCAR_2003-06-05_tau2pl_60_uhf.bin';

eiscat_cgi_url = 'http://www.eiscat.se/madrigal/cgi-bin/';

% download the following parameters from the above file: ut, gdalt, ti

parms = 'ut,gdalt,ti';

filterStr = 'filter=gdalt,200,600 filter=ti,0,5000';

% returns a three dimensional array of double with the dimensions:
%
%   [Number of rows, number of parameters requested, number of records]
%
%  If error or no data returned, will return error explanation string instead.
data = isprintWeb(eiscat_cgi_url, filename, parms, filterStr);
```

Matlab Madrigal API call

- Matlab API Links
  - Reference: http://madrigal.haystack.mit.edu/madrigal/rr_matlab.html
  - Tutorial: http://madrigal.haystack.mit.edu/madrigal/rt_matlab.html

Live Matlab API demo

- See demoMadrigalWebServices.m at http://www.haystack.mit.edu/cgi-bin/madrigal_viewcvs.cgi/madroot/source/madmatlab/

IDL Remote API

- Methods
  - madGetAllInstruments
  - madGetExperiments
  - madGetExperimentFiles
  - madGetExperimentFileParameters
  - madSimplePrint
  - madPrint
  - madDownloadFile
  - madCalculator
  - madGlobalPrint
- Methods again match Madrigal model

- IDL API Links
  - Reference: http://madrigal.haystack.mit.edu/madrigal/rr_idl.html
  - Tutorial: http://madrigal.haystack.mit.edu/madrigal/rt_idl.html

Madrigal application globallsprint.*

- Installed with all three remote API's.
- Generate command using web UI
  - Live demo
- More robust that global search web UI.
  - Data stored locally
  - Error messages on local terminal
- Documented under Documentation-> Command line interface and in API

globallsprint example

- Poker Flat
- March 10-20, 2007
- Alternating code (File kindat 5951)
- Kp above 4
- Alt between 240 and 260 and
- Ne > 2e11

Example command line (python version)

```
./globalIsprint.py \
--url=http://isr.sri.com/madrigal \
--parms=year,month,day,hour,min,sec,elm,azm,gdalt,gdlat,glon,kp,ne,te,ti \
--output=demo.txt \
--user_fullname="Bill Rideout" \
--user_email=brideout@haystack.mit.edu \
--user_affiliation=MIT \
--startDate=02/01/2007 --endDate=02/28/2007 \
--inst="Poker*" \
--kindat=5951 \
--filter=ap3,15, \
--filter=gdalt,240,260 \
--filter=ne,2e11, \
--filter=te,1000, \
--verbose
```

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.
- I appreciate all contributions
  - Suggestions and ideas
  - Finding bugs
  - Code

Madrigal hands-on exercises

- Fully described on wiki at http://www.haystack.mit.edu/cgi-bin/asg_science/science.cgi/Using_Madrigal_practically_and_productively
- Web practice
- Script practice using python, Matlab, or IDL