

How to use the Madrigal database for atmospheric science

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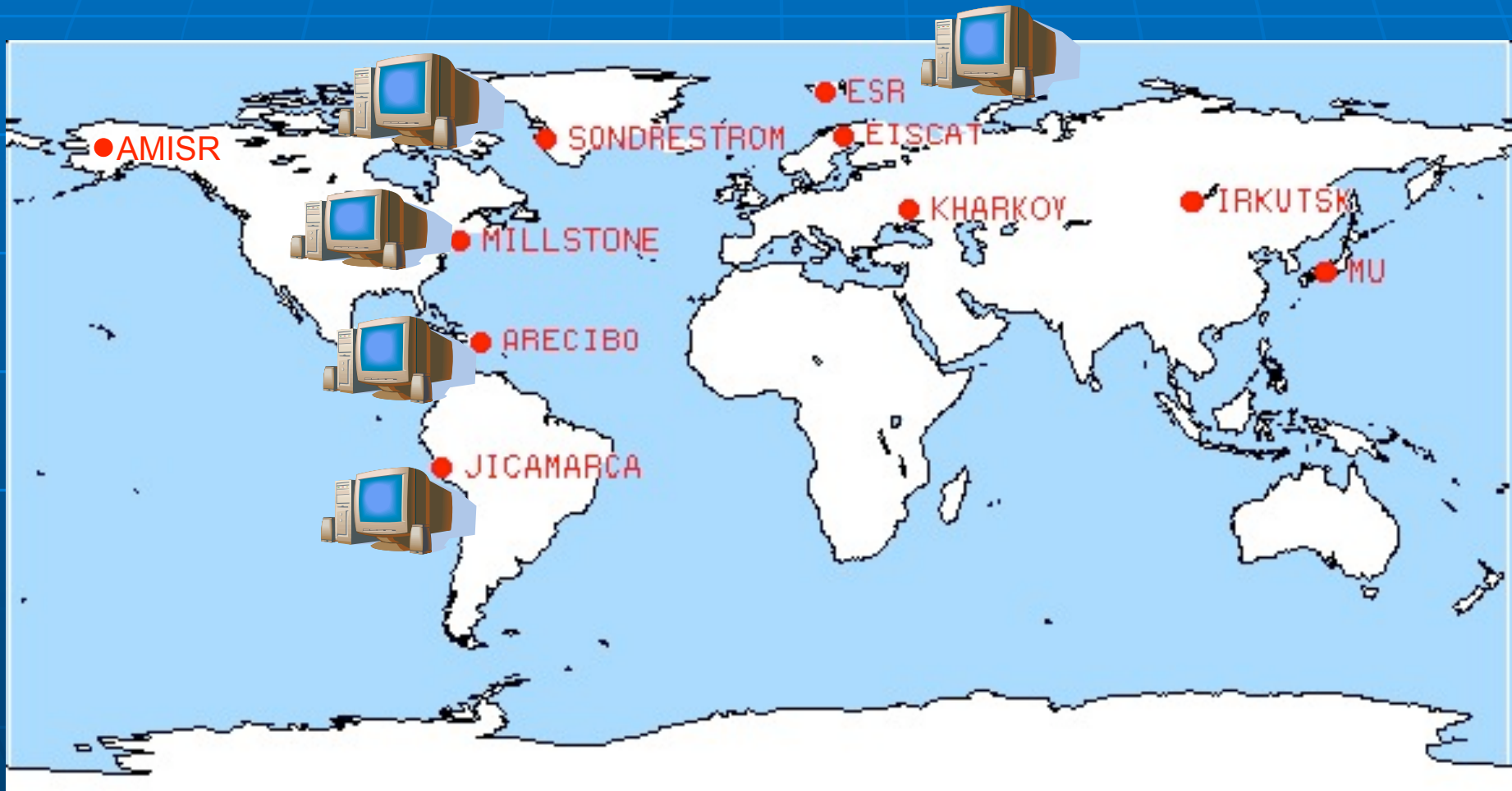
ISR workshop
Kangerlussuaq, Greenland
July 18, 2011

Outline

- What is Madrigal?
- How is Madrigal different from an ftp site?
- How do I use Madrigal?
 - The website
 - Script data access
- What's coming soon with Madrigal?

What is Madrigal?

Open-source, standard-based local databases that share metadata



Madrigal is a **Science** database.

The Madrigal database stores data from a wide variety of upper atmosphere research instruments in the Cedar database format.

Incoherent Scatter Radar



TEC via GPS

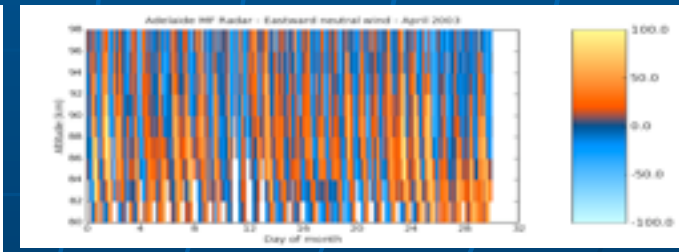
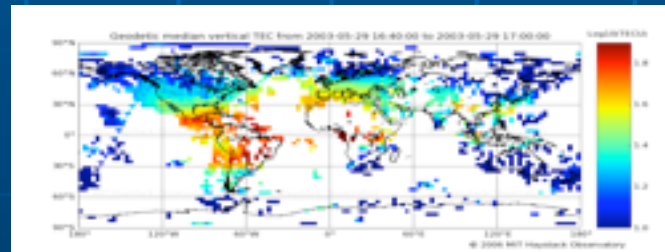
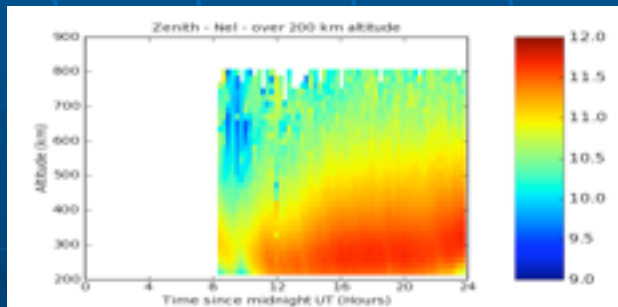


MF Radar



Cedar database format

Loading programs can be written in Python, C, or Tcl



Other instrument types in Madrigal: Meteor radar, Digisonde, Fabry-Perot, Geophysical indices

Madrigal is open-source



The Open Madrigal Initiative

[MIT Haystack Observatory](#), home of the [Millstone Hill](#) Incoherent Scatter Radar, has supported an on-line incoherent scatter database since 1980. This early database evolved into both the [CEDAR Database](#) at the National Center for Atmospheric Research (NCAR) and the Madrigal Database at Millstone Hill. The CEDAR and Madrigal Databases have very different user interfaces and capabilities, but use the same basic data format, and data files are easily exchanged between the two systems.

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 instruments. Data can be accessed from the Madrigal sites at [Millstone Hill, USA](#), [EISCAT](#), Norway, [SRI International](#), USA, [Arecibo](#), Puerto Rico, [Cornell University](#), USA, [Jicamarca](#), Peru, [The Institute of Solar-Terrestrial Physics](#), Russia, and Wuhan Ionospheric Observatory, the Chinese Academy of Science., and using standard Web browsers; and directly, using APIs which are available for several popular programming languages.

The distributed Madrigal Database has been recognized by a Sun Microsystems Academic Excellence Award which included the Haystack Observatory server which hosts the Open Madrigal project.

Madrigal Sites

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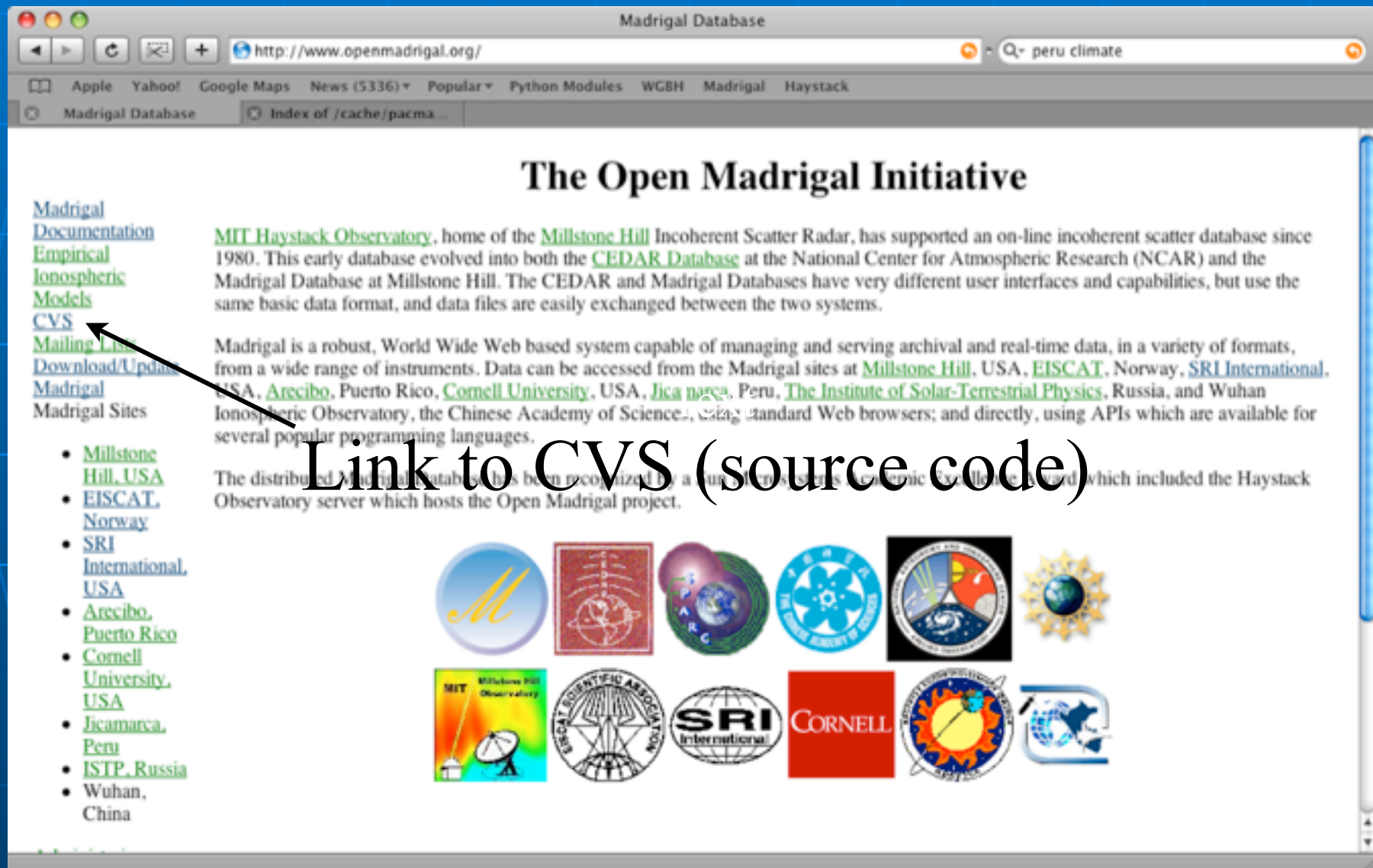
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www.openmadrigal.org

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The screenshot shows a web browser window titled "Madrigal Database" with the URL "http://www.openmadrigal.org/". The page content includes a navigation menu on the left with links for "Madrigal", "Documentation", "Empirical", "Ionospheric", "Models", "CVS", "Mailing List", "Download/Updates", and "Madrigal Sites". The main heading is "The Open Madrigal Initiative". Below this, there are two paragraphs of text. The first paragraph describes the history of the database, mentioning MIT Haystack Observatory, CEDAR Database, and the National Center for Atmospheric Research (NCAR). The second paragraph describes the system's capabilities, listing various sites like Millstone Hill, EISCAT, SRI International, Arecibo, Cornell University, Jicamarca, and ISTP. A large black arrow points from the "CVS" link in the navigation menu to the text "Link to CVS (source code)" which is overlaid on the page. Below the text, there is a row of logos for various institutions and observatories, including MIT Haystack Observatory, Arecibo, SRI International, Cornell University, and others.

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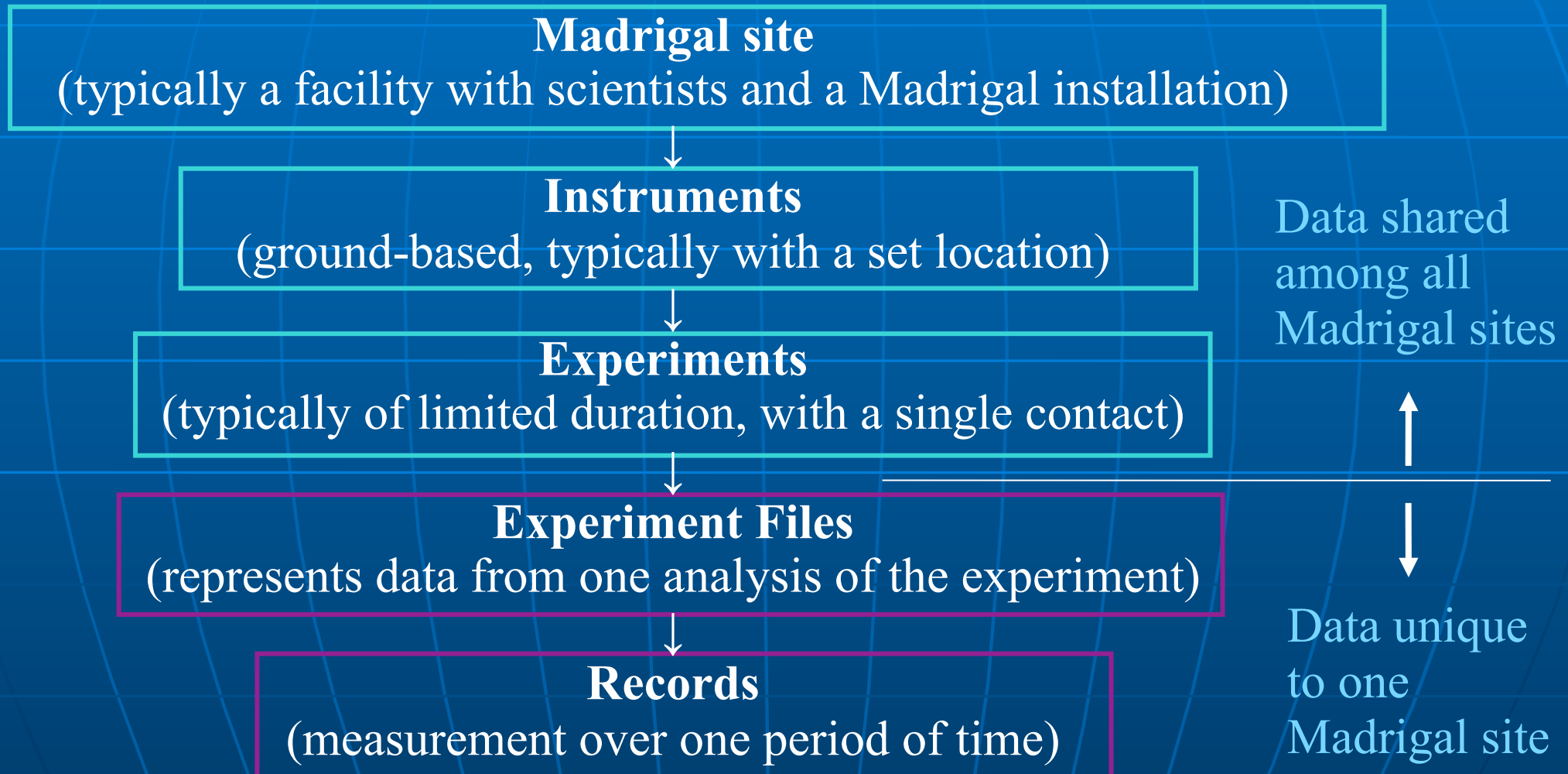
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 - http://cedarweb.hao.ucar.edu/cgi-bin/cedar_file_access.pl?filename=documents/cedar_fmt.pdf

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Madrigal Data Model



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- 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

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- Models
 - Examples: MSIS, IRI

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- **How does this help a scientist?**

Example data search problem

- Find out how well the a model compares with measured data depending on geophysical conditions.

Ftp site approach

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Madrigal approach

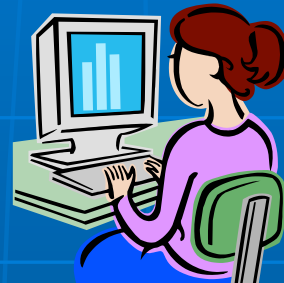
Madrigal approach

- Use script `globalIsprint.py` - done

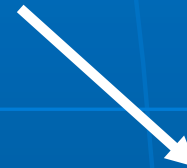
Madrigal approach

- Use script `globalIsprint.py` - done
- Use global search web interface - done

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://isr.sri.com/madrigal>)

Remote Access to Madrigal Data

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- 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
- See <http://madrigal.haystack.edu/madrigal/remotePythonAPI.html> for documentation, more examples, and source

Live Python API demo

- See `demoMadriganWebServices.py` at http://www.haystack.mit.edu/cgi-bin/madrigan_viewcvs.cgi/madroot/source/madpy/madriganWeb/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**



Simple Matlab example, continued

- See <http://madrigal.haystack.edu/madrigal/remoteMatlabAPI.html> for complete documentation and more examples

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
- Just added in July 2010

Madrigal application global sprint.*

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

globalsprint 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)

```
./globalSprint.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
```

What's coming soon for Madrigal?

- NSF funded development
 - Release 2.6
 - Release 3.0
- Open source development with Jicamarca

NSF funded development for next release

- Transition of CEDAR database to Madrigal platform
 - Ability of Madrigal to automatically import data from other Madrigal sites
 - Importing of existing non-Madrigal data into Madrigal
- Ability to extend Madrigal with external hard drives

Next release development, continued

- Work with Jicamarca to integrate new UI into Madrigal
- Export HDF5 format
- FTP like interface added?
- Users can register interest in experiment
- Experiment PI, analyst now shared metadata
- IDL API added to Matlab, python₃₅

Following release (Madrigal 3.0)

- Conversion of CEDAR format to CEDAR HDF5/NetCDF4 format
 - Parameter definitions/data model unchanged
 - Each file will be self-describing
 - No more scale factors, integer storage
 - No more duplicate parameters with different ranges
 - Madrigal derivation engine will interface with it

Madrigal 3.0 continued

- Conversion of CEDAR format to CEDAR HDF5/NetCDF4 format
 - Conversion will be automatic using script
 - To create new CEDAR format
 - Create file old way, run convert script
 - Using python API, change one line of code
- Community standard
 - Interface to download latest standard, request new parameters

Open source development with Jicamarca

- Project is one of 3 based on Oct 2010 meeting
- Development of
 - New simple web UI
 - Export HDF5 format
- Modern open source project
 - Shared access to source control (Subversion)
- Millstone responsible for final testing, release, support

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