The Madrigal Database

Anthea Coster, Bill Rideout, Nestor Aponte, MIT Haystack Observatory

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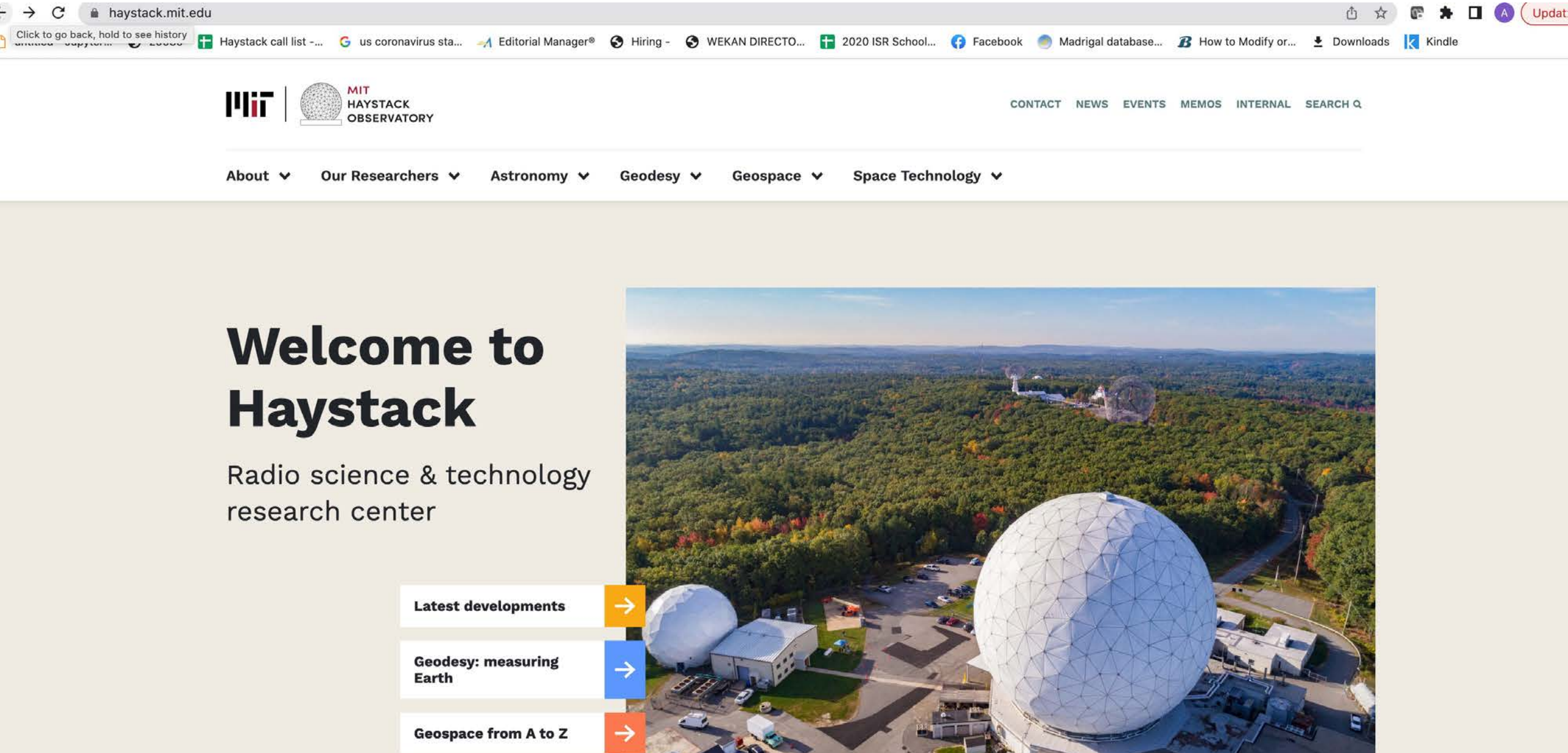
www.haystack.mit.edu

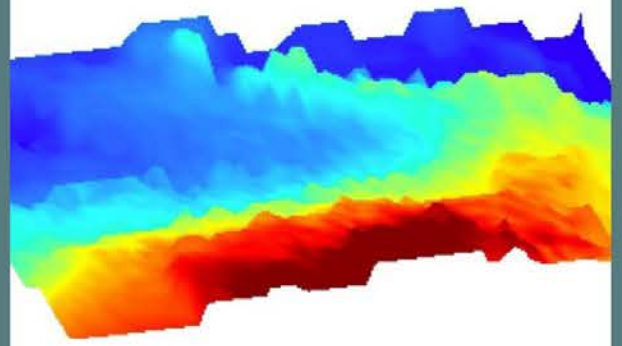


MIT Public Outreach and Lesson Plans

https://www.haystack.mit.edu/haystack-public-outreach/k-12-lesson-plans/

https://www.haystack.mit.edu/haystack-public-outreach/

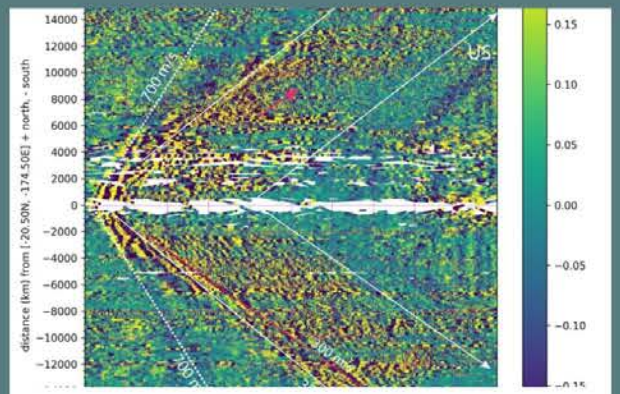
Hit “Latest Developments”. Try today!!!



Imaging geomagnetic storms in the Earth’s ionosphere—in 3D

A team of researchers led by MIT Haystack Observatory has created a system to image in 3D ionospheric changes during storms.

Read more



2022 Tonga volcanic eruption induced global propagation of ionospheric disturbances via Lamb waves

This study provides substantial first evidence of long-duration Lamb wave imprints in the global ionosphere.

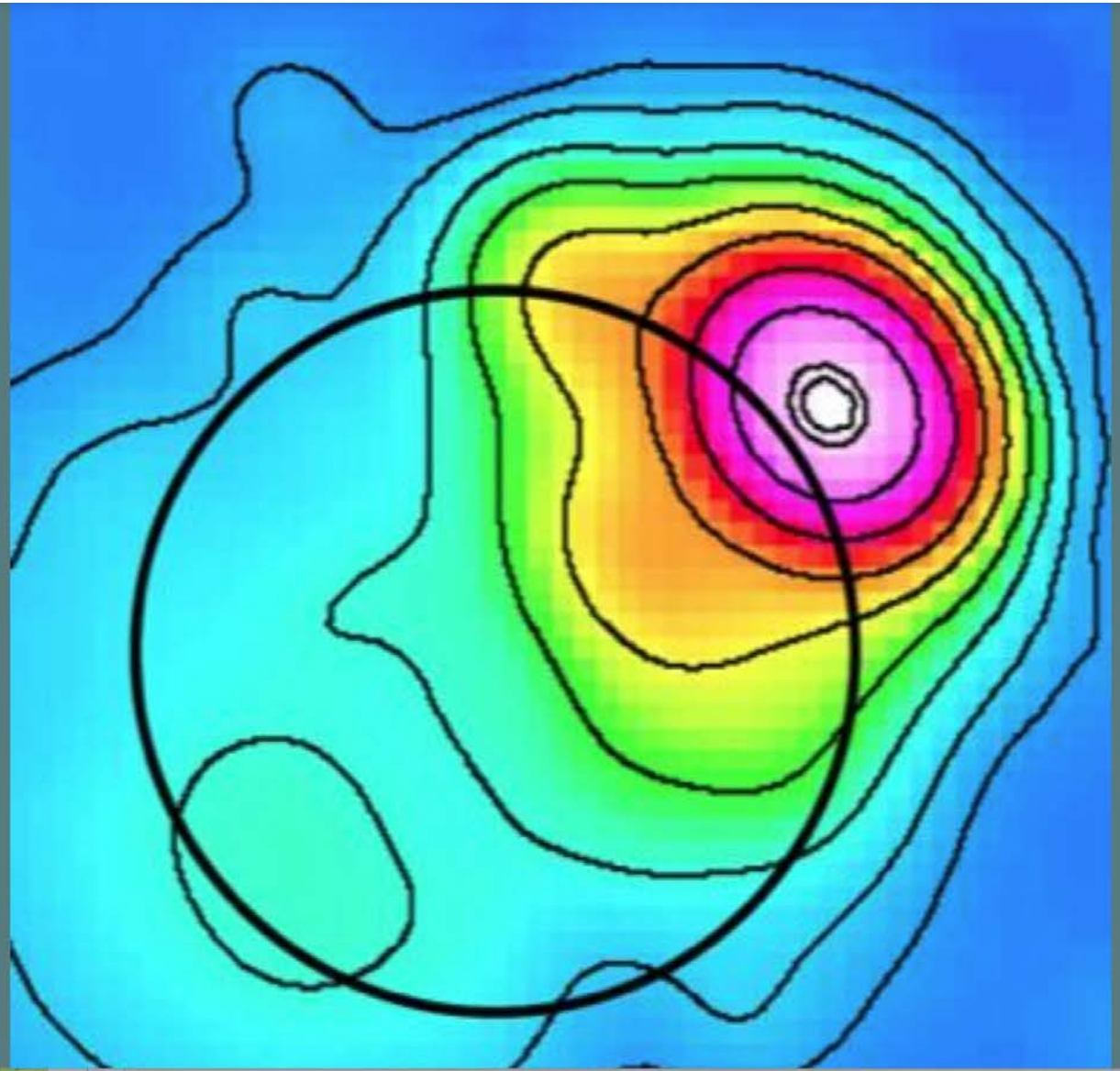
Read more

Swoboda awarded ONR Young Investigator Program grant

Dr. John Swoboda receives grant from the Office of Naval Research.

Read more

Astronomy and Astrophysics



Astronomy & Astrophysics

PHYSICS OF BLACK HOLES

Researchers at Haystack study supermassive black holes in the centers of galaxies to explore the fundamental physics of spacetime and understand how black holes shape their host galaxies.

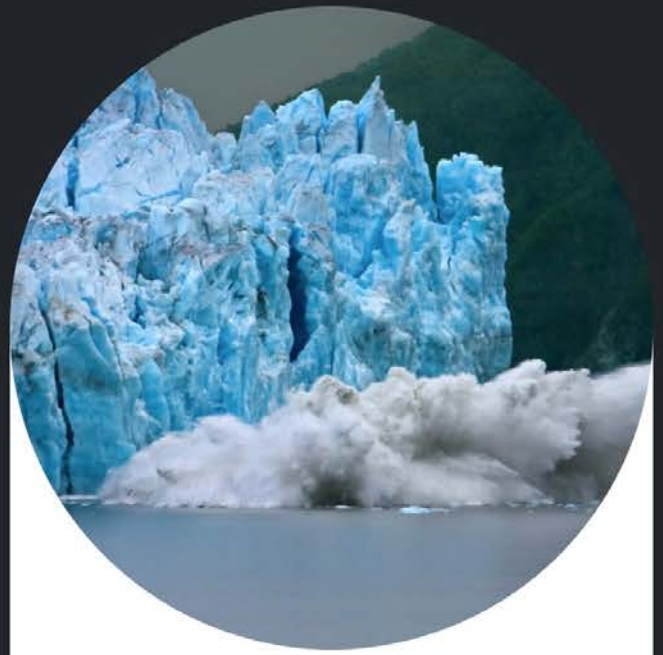
EPOCH OF REIONIZATION

Haystack astronomers explore the onset of star and galaxy formation in the early phases of the universe.

RADIO STARS

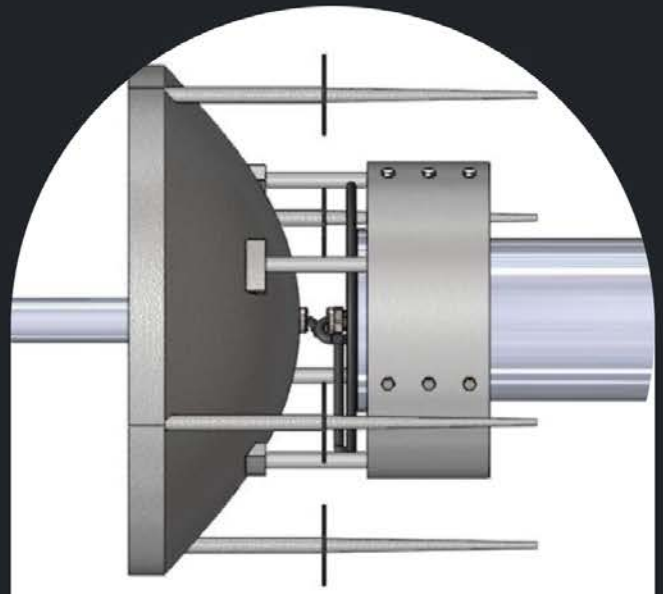
Investigators at Haystack use radio observations to explore the last stages in the lives of stars and learn more about the physical processes on the surface of the sun.

Geodesy



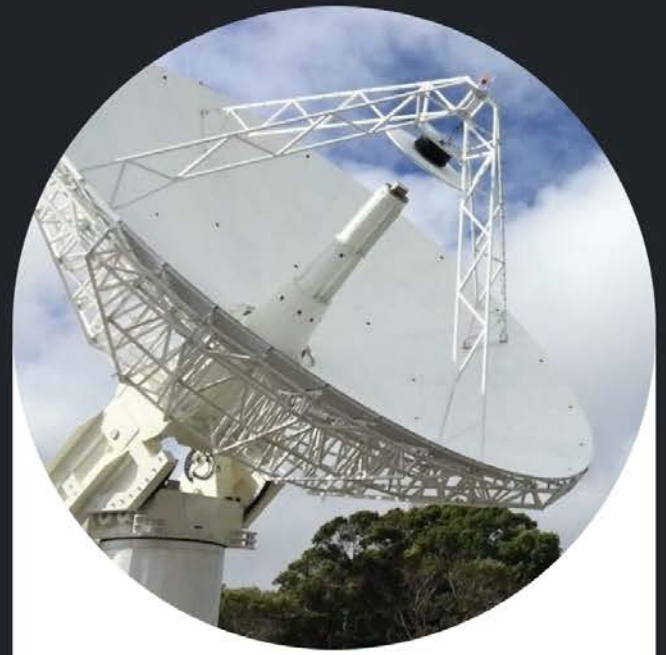
SIDEx: Sea Ice Dynamic Experiment

Measuring ice in the Arctic Circle.



SGIP: Antarctic Seismo-Geodetic Ice Penetrator

Monitoring the response of ice shelves in Antarctica to ocean forces.



Advancing VGOS

The Haystack VLBI Geodetic Observing System (VGOS) signal chain has been in development since 2007 and in service since 2010. It was developed for NASA and has been installed in Texas and Hawaii.

Geospace

Geospace

Home › Geospace

The Atmospheric and Geospace Sciences group at Haystack conducts fundamental and collaborative scientific research into the complex and highly intercoupled near-Earth space environment using a wide variety of observational experimental data sets. These include radio (passive), radar (active), and other remote sensing tools using instruments such as incoherent/Thomson scatter radar, ionosondes, HF based convection radars (SuperDARN), optical neutral airglow observations, and in-situ satellite instruments, including small satellite platforms.

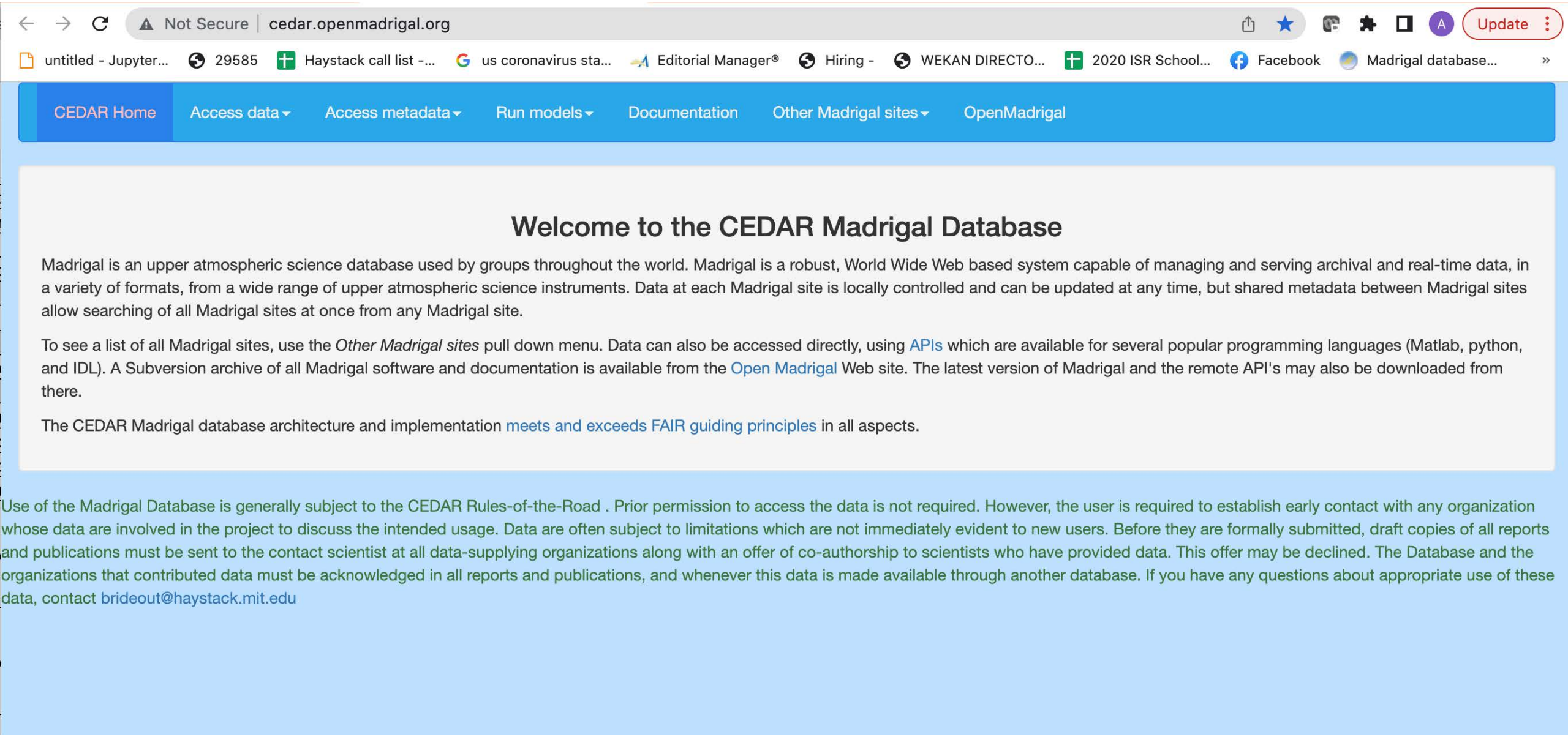
Studies of ionospheric response in both quiet and active times also involve collaborative data-model investigations using frontier whole atmosphere community models.

The Madrigal database is available at: http://cedar.openmadrigal.org/.

What is now available through CEDAR Madrigal Web

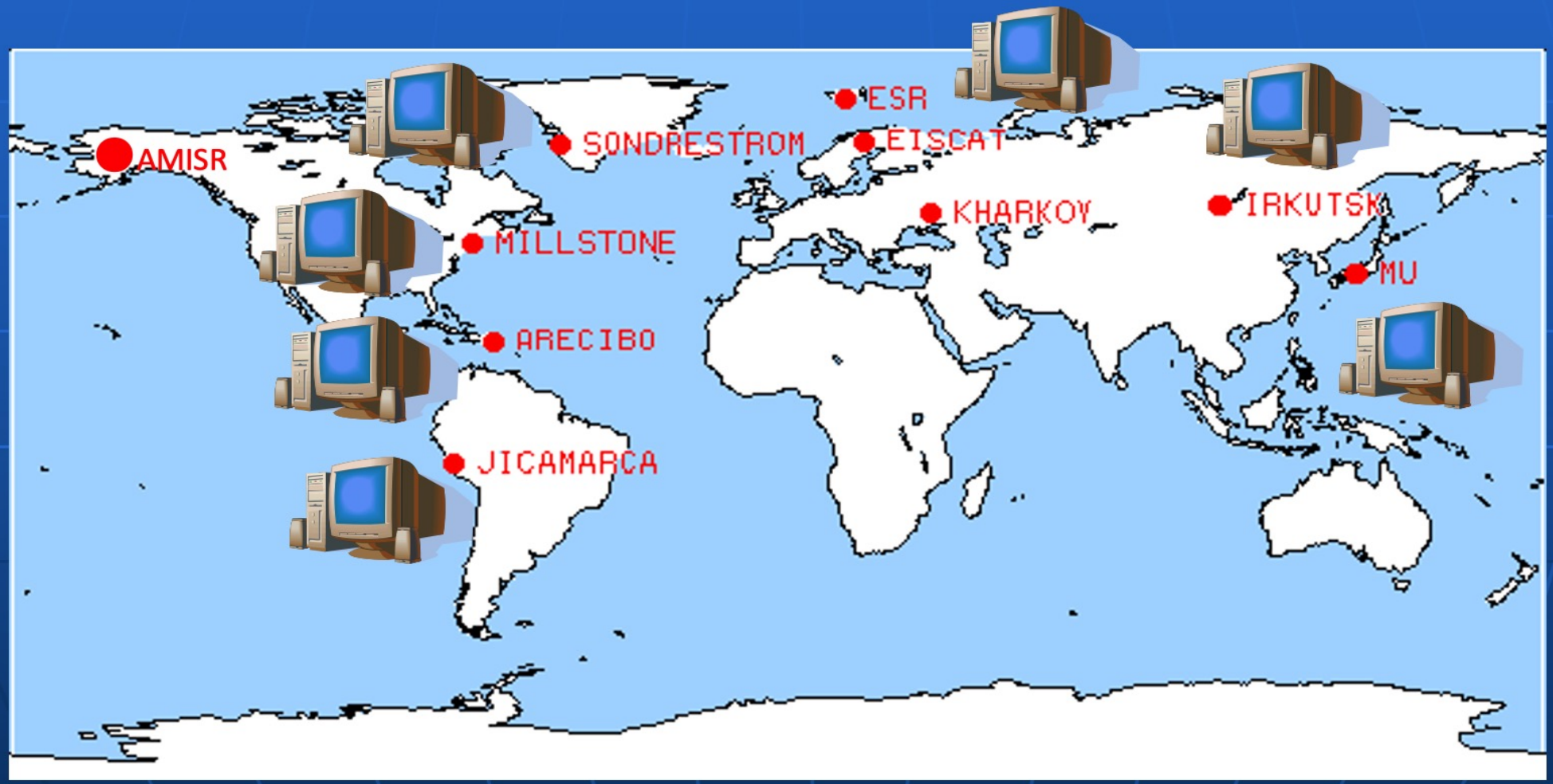
http://cedar.openmadrigal.org/

Cedar Madrigal site: http://cedar.openmadrigal.org

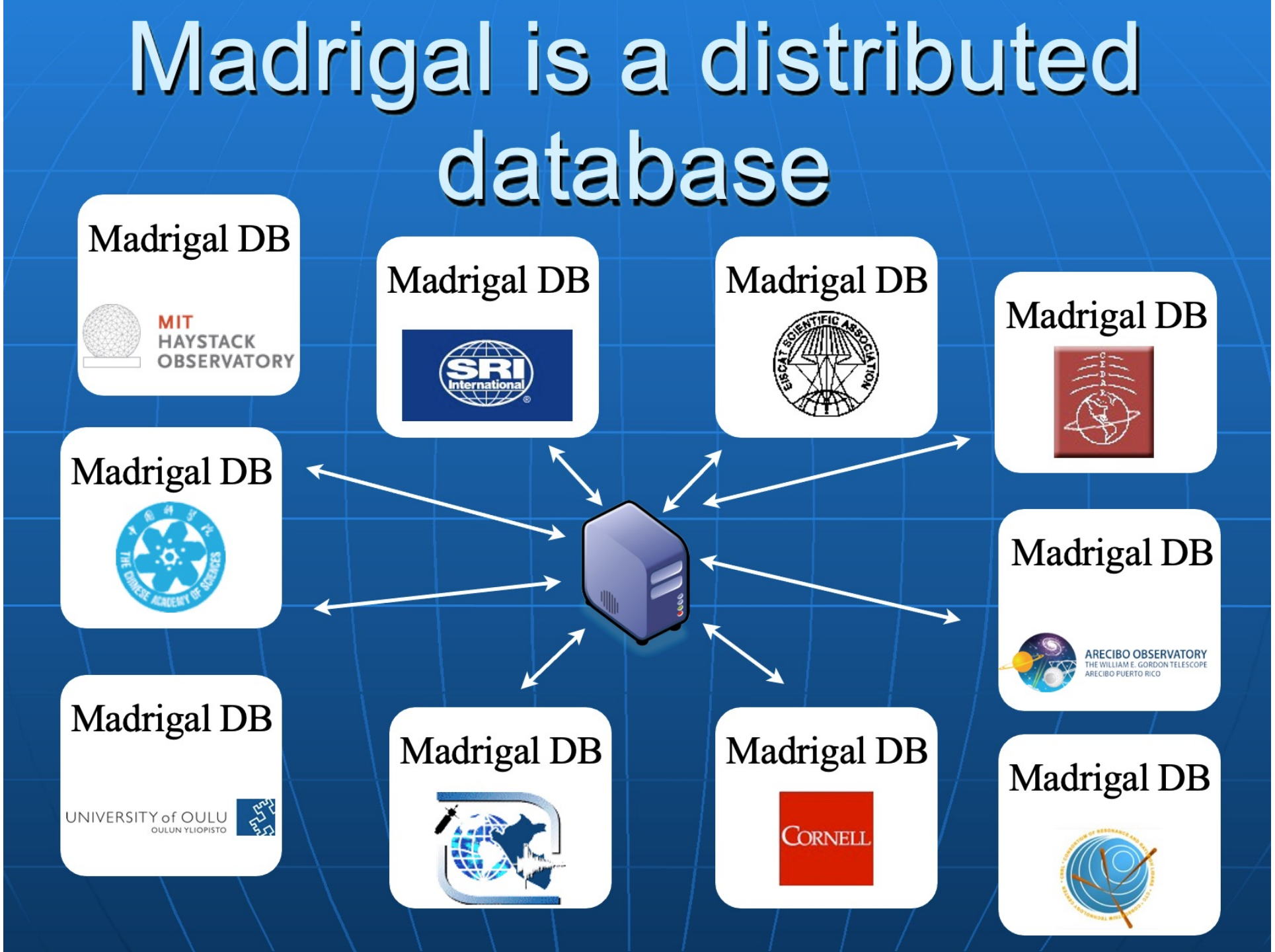


What is Madrigal?

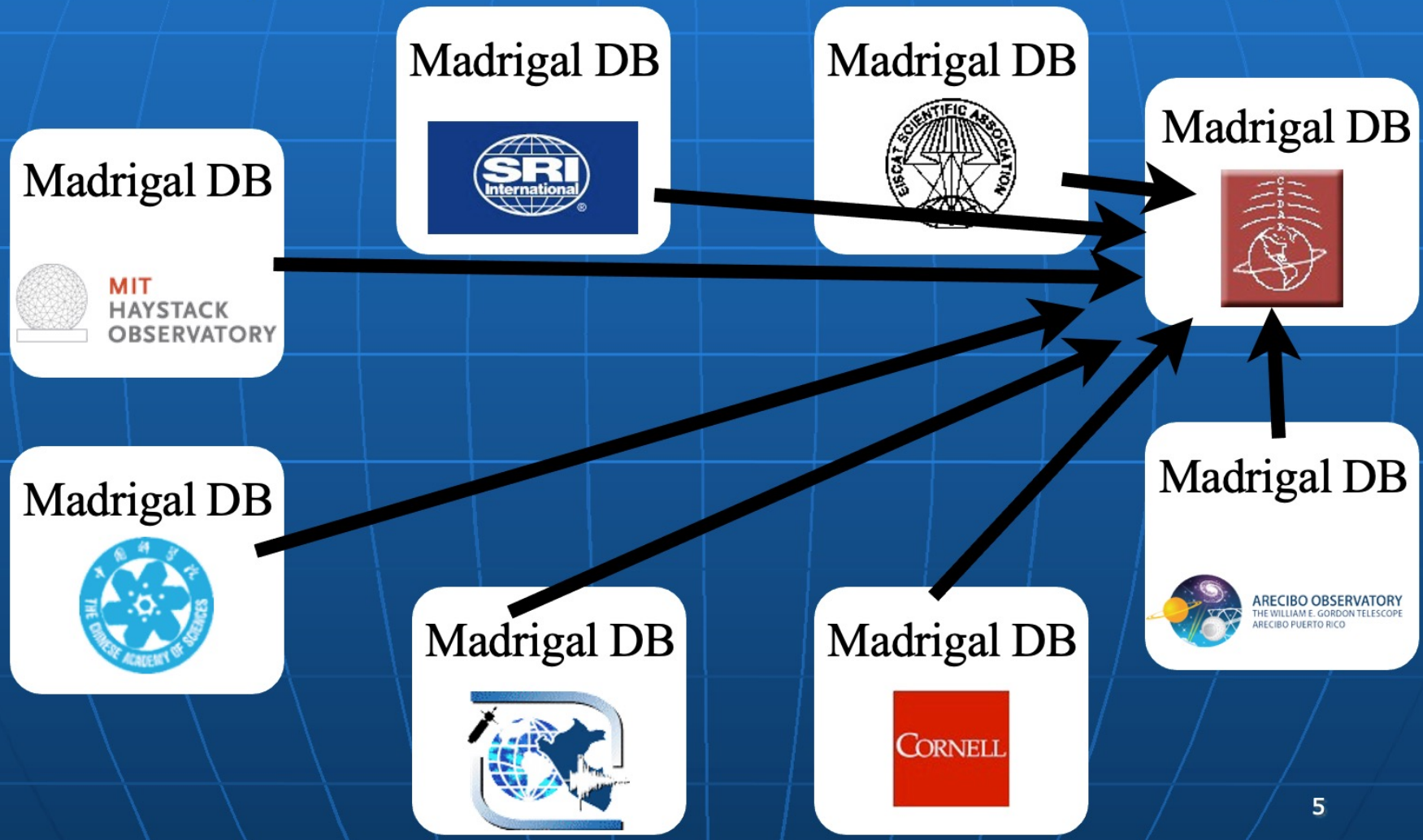
Distributed, open-source, standards-based local databases that share metadata and have VO-features built in



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

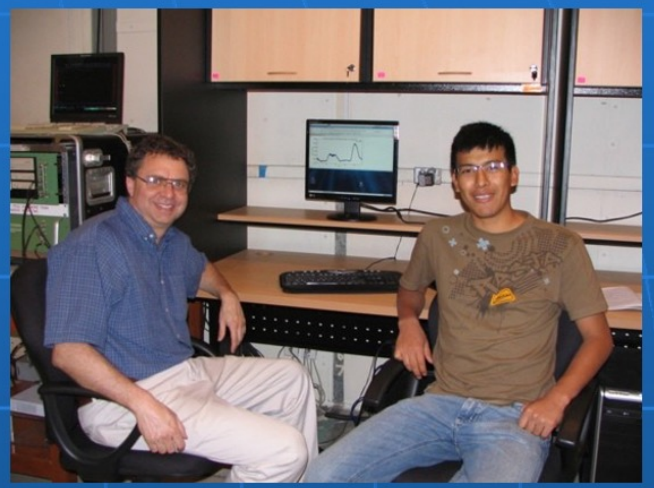
TEC via GPS

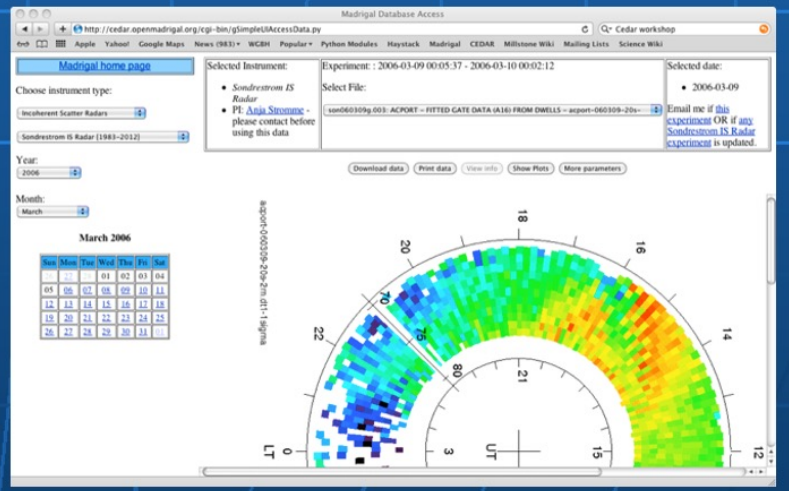
MF Radar

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





www.openmadriagl.org

Cedar file format:

Cedar file format

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

Hdf5

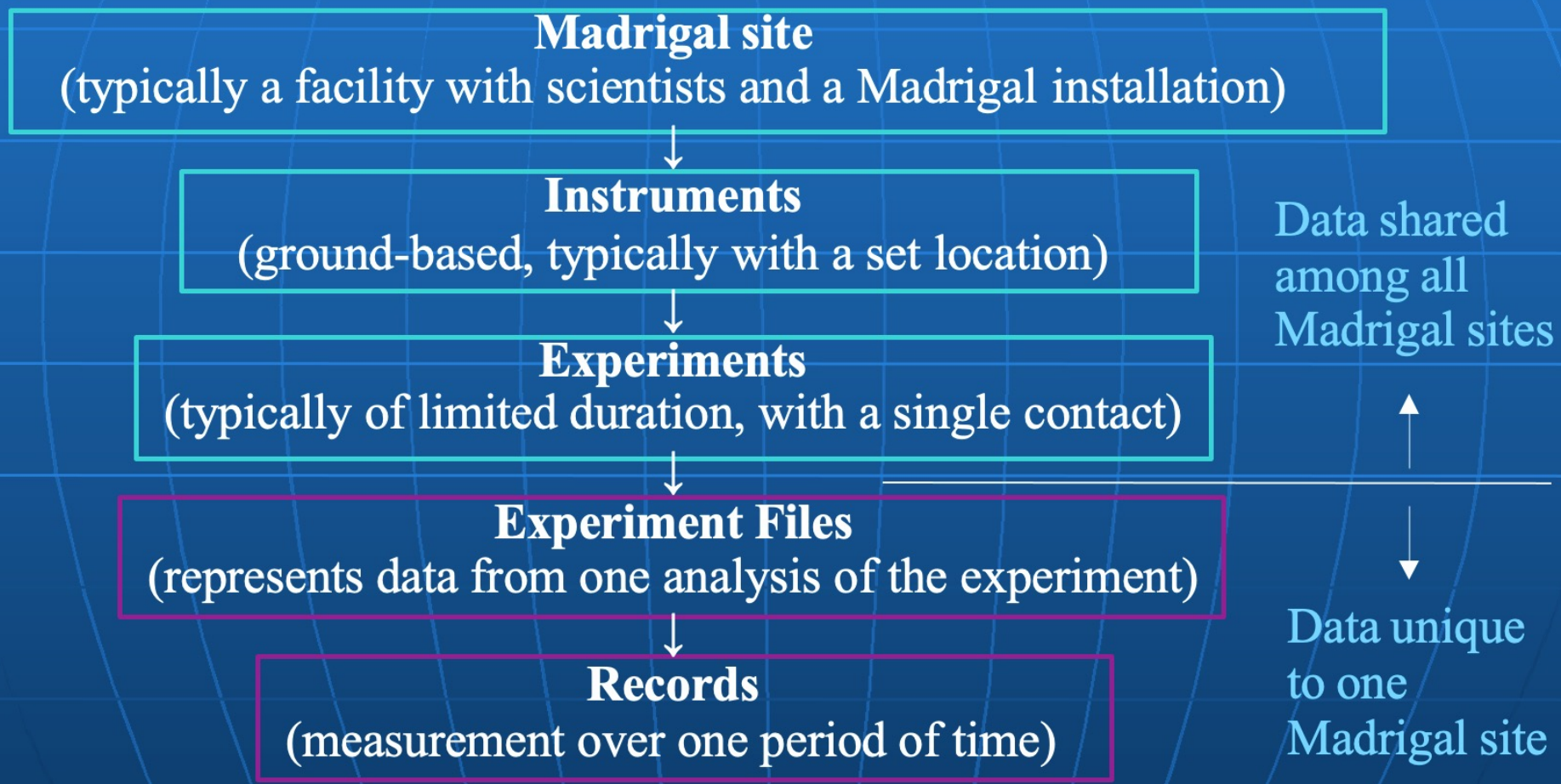
- Scientific standard
- Float based
- Flexible arrangement
- Table data, optional grid

What is the CEDAR database format?

Madrigal 3.0
Hdf5
Ascii, Hdf5, netCDF4 Cedar file
Ascii, Hdf5, netCDF4

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

Madrigal Data Model



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

How can the Madrigal database be accessed?

User

Web interface

Web services API

- From anywhere on internet
- Python API
- Matlab API
- IDL API
- Others can be written

The python, Matlab, and IDL API's now all have a globalDownload method, which allows you to download any group of Madrigal files with one simple command.

Download remote python Madrigal API - This 2.2.1 release includes a new script, globalDownload.py, which allows a user to download any number of Madrigal files in either Hdf5 or ascii format. It also supports the new web services released in Madrigal 2.6. The method getExperiments now has a field realUrl that will give the real experiment url to any experiment.

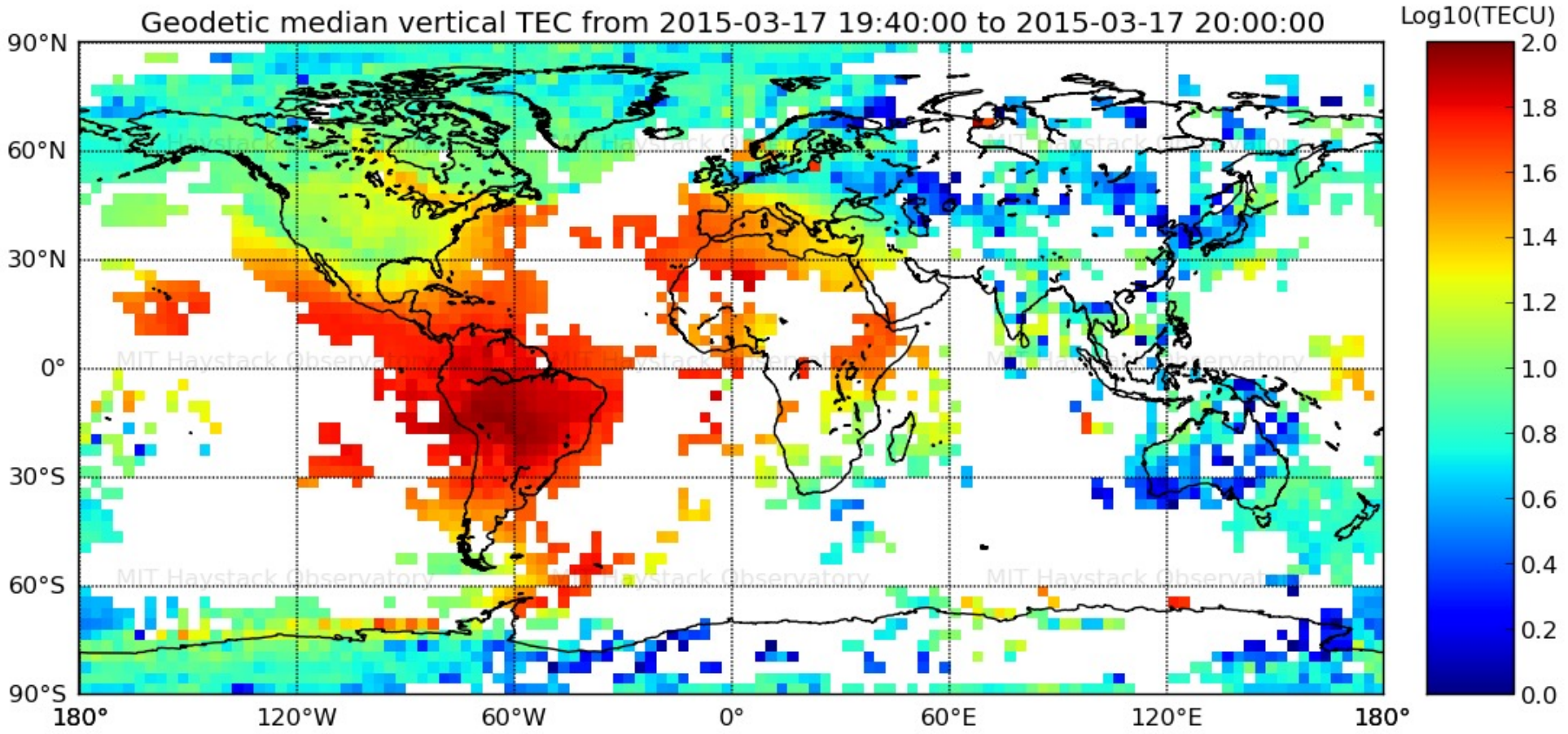
remotePythonAPI-2.2.1.tar.gz (last updated Jul. 30, 2014)

remotePythonAPI-2.2.1.zip (last updated Jul. 30, 2014)

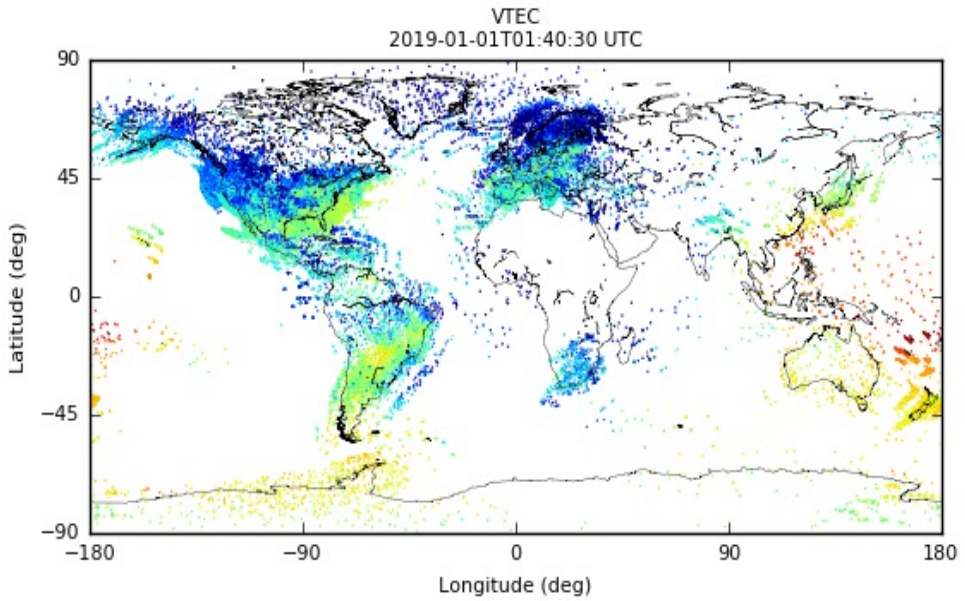
Documentation - Scripts, Tutorial, Reference

Standard TEC Data in Madrigal available since 2000

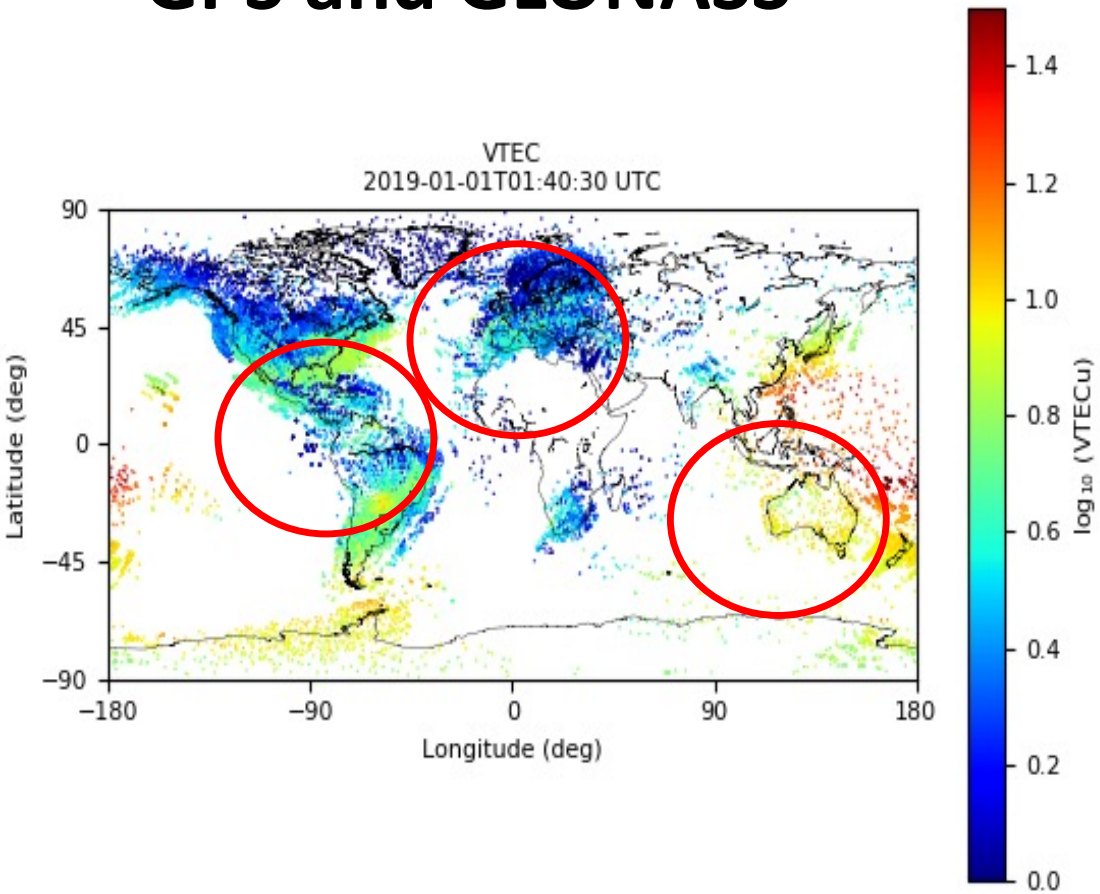
1. Provided in 1 degree by 1 degree bins
2. Provided every 5 minutes
3. Vertical TEC data estimates and Errors on these estimates
4. Geographic Lat and Long
5. Only provides data where observations are available. Does not attempt to model TEC where data is not available. Uses all GNSS data available.
6. GLONASS TEC has been added observations


Geodetic median vertical TEC from 2015-03-17 19:40:00 to 2015-03-17 20:00:00
Log10(TECU)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
90°N
60°N
30°N
0°
30°S
60°S
90°S
180°
120°W
60°W
0°
60°E
120°E
180°
© 2015 MIT Haystack Observatory

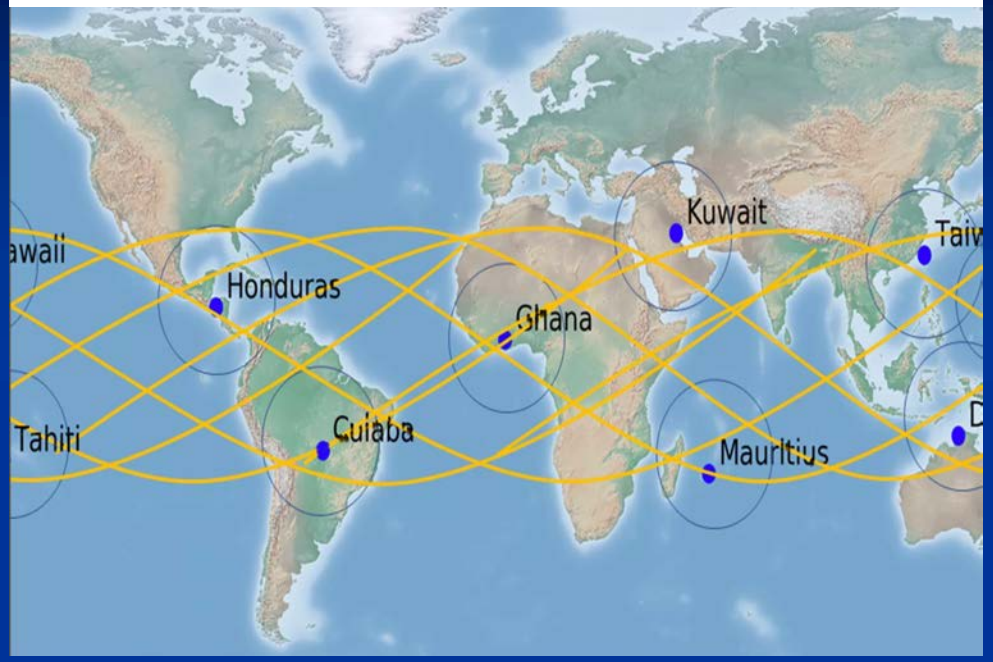
GPS Only

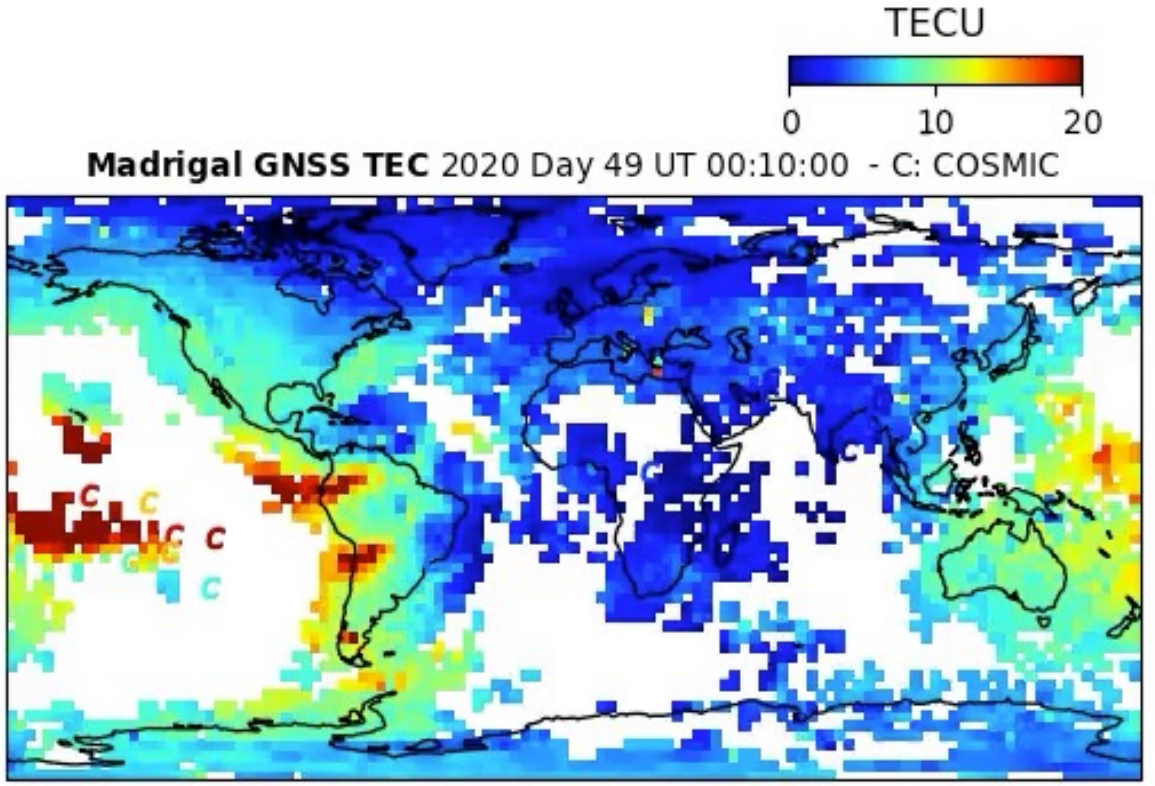


GPS and GLONASS



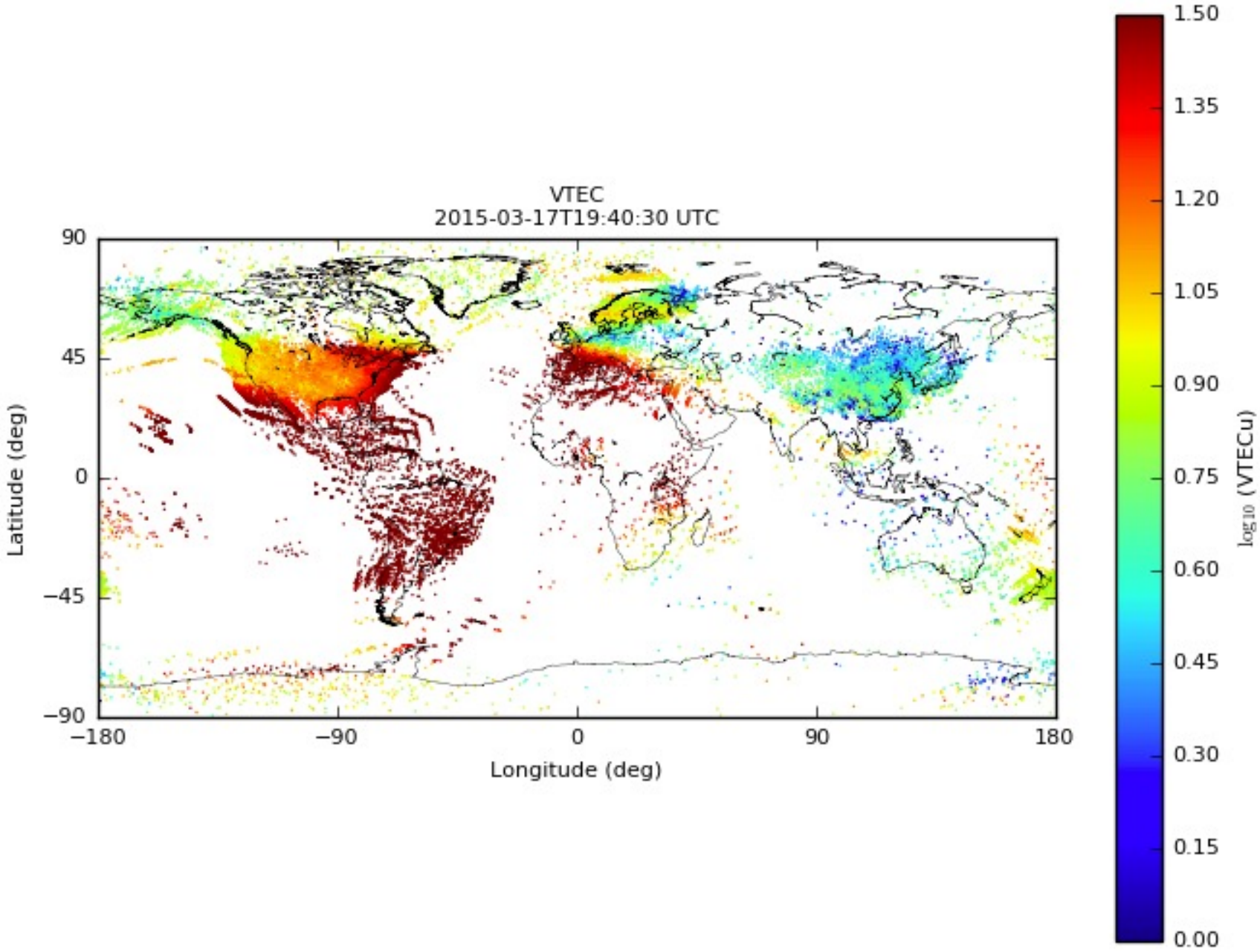
COSMIC-2


Kuwait
Honduras
Ghana
Tahiti
Cuiaba
Mauritius


TECU
0
10
20
Madrigal GNSS TEC 2020 Day 49 UT 00:10:00 - C: COSMIC

Line of Site TEC Data in Madrigal available now for ~ 5 years

1. Provided for every receiver
2. Provided every 20-30 seconds
3. Satellite and Receiver ID
4. Geographic Lat and Long of Receiver
5. Pierce Point: Altitude, Lat and Long
6. Azimuth and Elevation to Satellite
7. Files are LARGE
8. HDF5 format


VTEC
2015-03-17T19:40:30 UTC
Latitude (deg)
90
45
0
−45
−90
−180
−90
0
90
180
Longitude (deg)
1.50
1.35
1.20
1.05
0.90
0.75
0.60
0.45
0.30
0.15
0.00
log10 (VTECu)