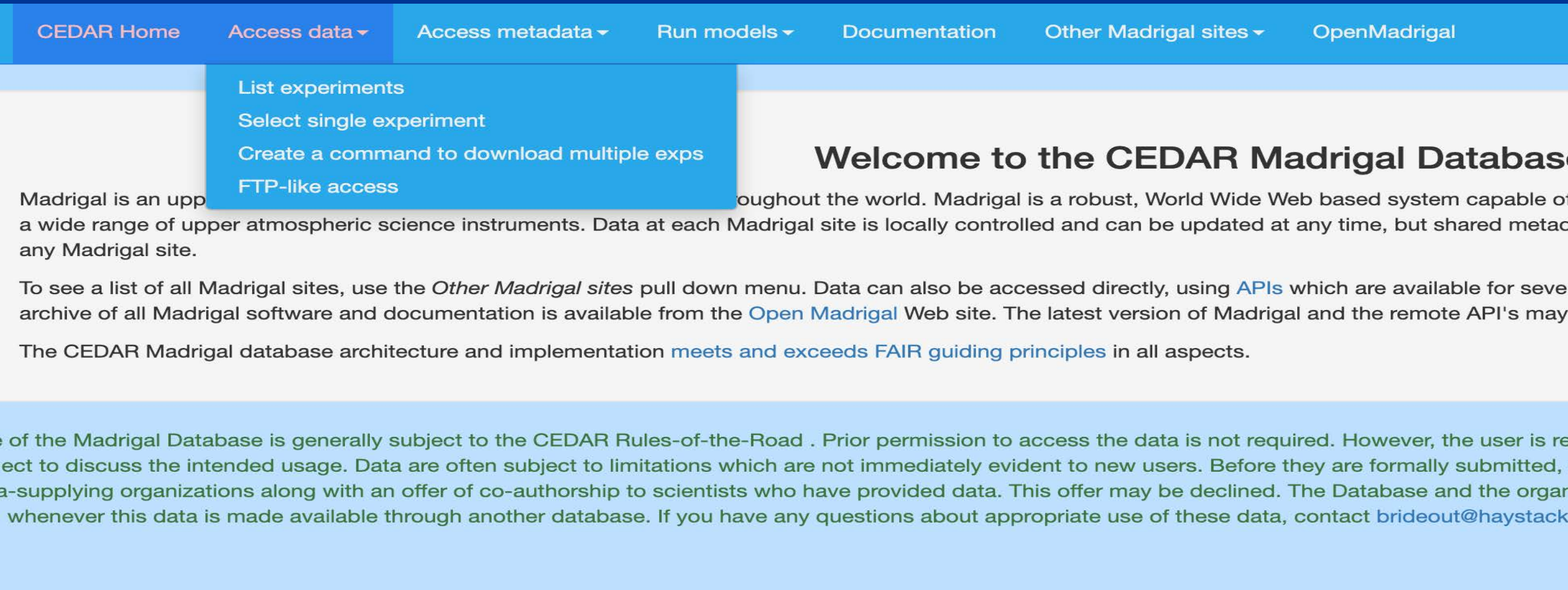
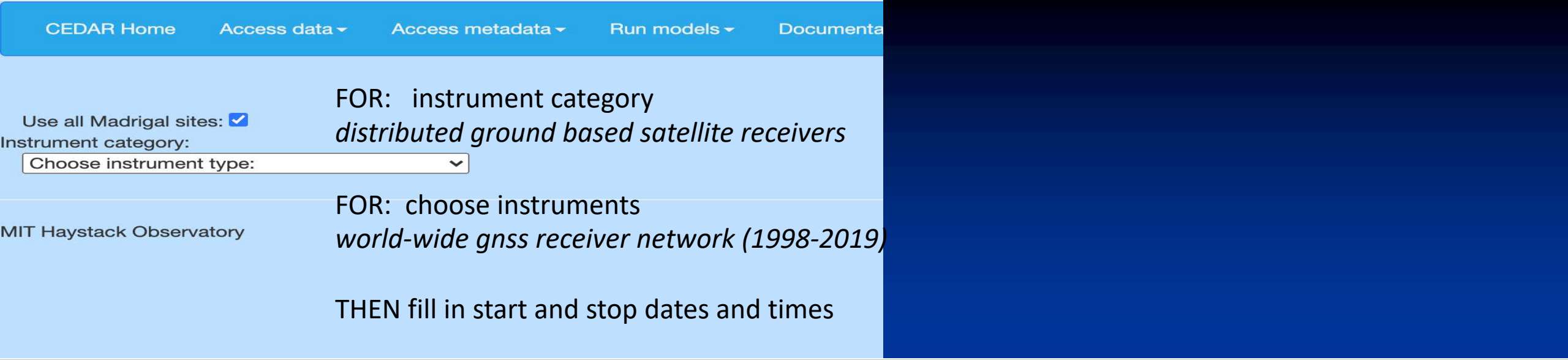
To obtain both types of data (the gridded gps and los files), go to a madrigal website.
http://cedar.openmadrigal.org
You may have to register your name and institution.
Then - from the main page select : Access Data
A list will appear – hit select single experiment to start.

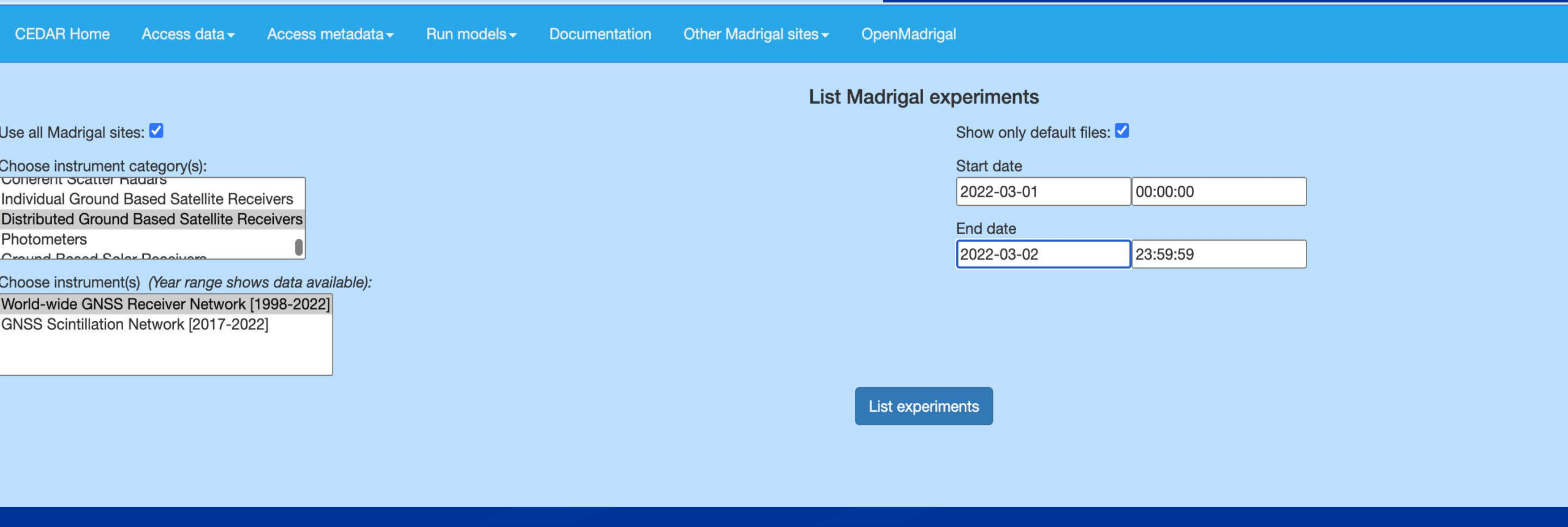




FOR: instrument category
distributed ground based satellite receivers

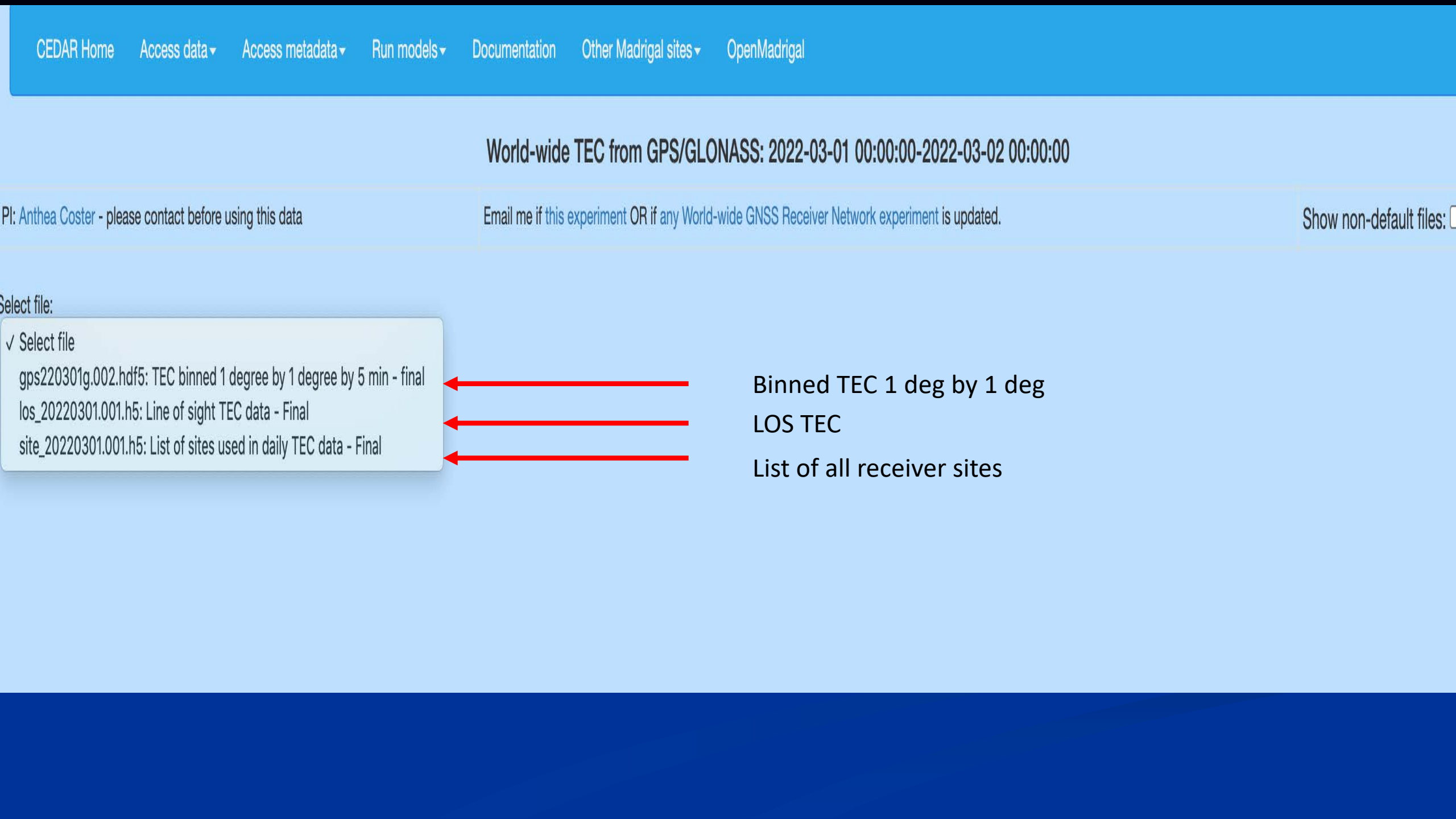
FOR: choose instruments
world-wide gnss receiver network (1998-2019)

THEN fill in start and stop dates and times



List of selected Madrigal experiments

Madrigal site	Instrument name	Start	End	Experiment name
CEDAR	World-wide GNSS Receiver Network	2022-02-28 00:00:00	2022-03-01 00:00:00	World-wide TEC from GPS/GLONASS
CEDAR	World-wide GNSS Receiver Network	2022-03-01 00:00:00	2022-03-02 00:00:00	World-wide TEC from GPS/GLONASS
CEDAR	World-wide GNSS Receiver Network	2022-03-02 00:00:00	2022-03-03 00:00:00	World-wide TEC from GPS/GLONASS


CEDAR Home
Access data
Access metadata
Run models
Documentation
Other Madrigal sites
OpenMadrigal
World-wide TEC from GPS/GLONASS: 2022-03-01 00:00:00-2022-03-02 00:00:00
PI: Anthea Coster - please contact before using this data
Email me if this experiment OR if any World-wide GNSS Receiver Network experiment is updated.
Show non-default files:
Select file:
✓ Select file
gps220301g.002.hdf5: TEC binned 1 degree by 1 degree by 5 min - final
los_20220301.001.h5: Line of sight TEC data - Final
site_20220301.001.h5: List of sites used in daily TEC data - Final
Binned TEC 1 deg by 1 deg
LOS TEC
List of all receiver sites

CEDAR Home | Access data | Access metadata | Run models | Documentation | Other Madrigal sites | OpenMadrigal

World-wide TEC from GPS/GLONASS: 2022-03-01 00:00:00-2022-03-02 00:00:00

PI: Anthea Coster - please contact before using this data

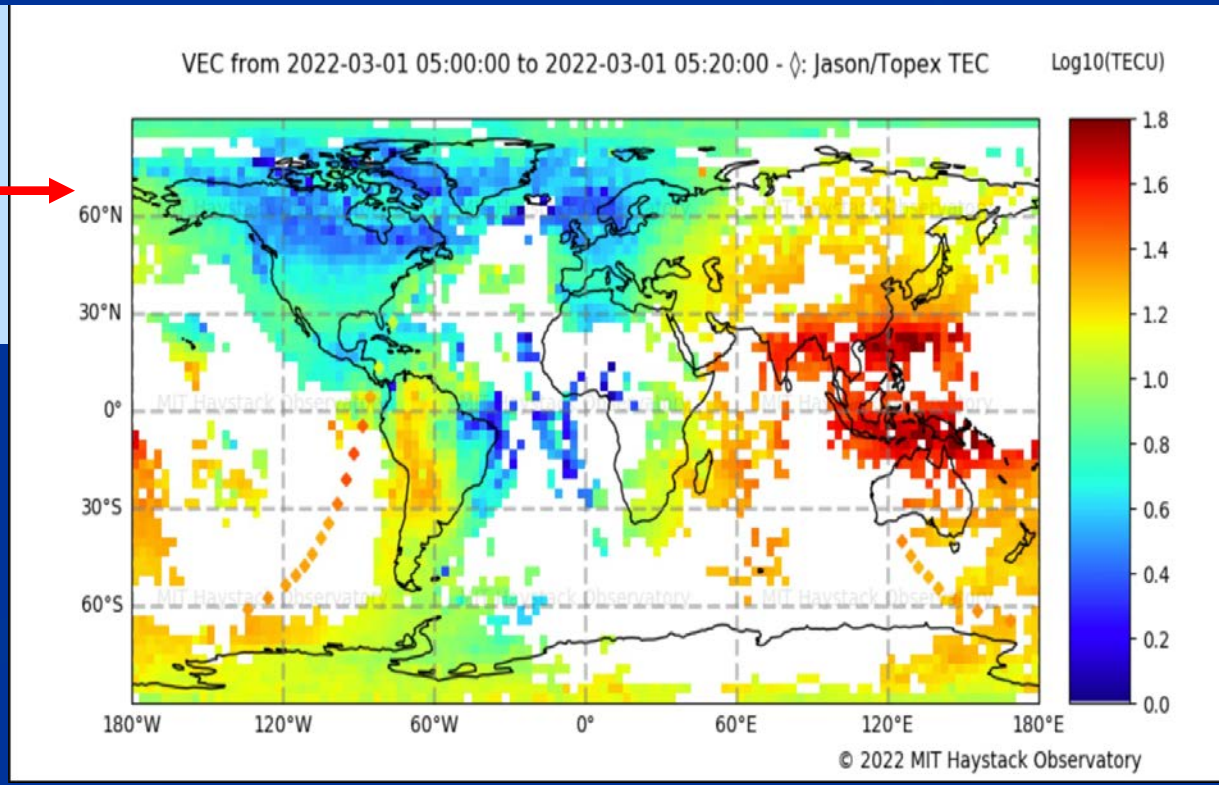
Email me if this experiment OR if any World-wide GNSS Receiver Network experiment is updated.

Select file:

gps220301g.002.hdf5: TEC binned 1 degree by 1 degree by 5 min - final

Plots/Docs | Download file | Print file | View file info | Cite this file

- Data source list for TEC processing
- Python programming tips for reading line-of-site TEC files
- Papers describing processing algorithms used
- Click here for TEC maps for 2022-03-01
- Create interactive TEC/SuperDARN plots
- Click here for plots of raw LOS converted to vertical TEC for 2022-03-01



CEDAR Home | Access data | Access metadata | Run models | Documentation | Other Madrigal sites | OpenMadrigal

World-wide TEC from GPS/GLONASS: 2022-03-01 00:00:00-2022-03-02 00:00:00

PI: Anthea Coster - please contact before using this data

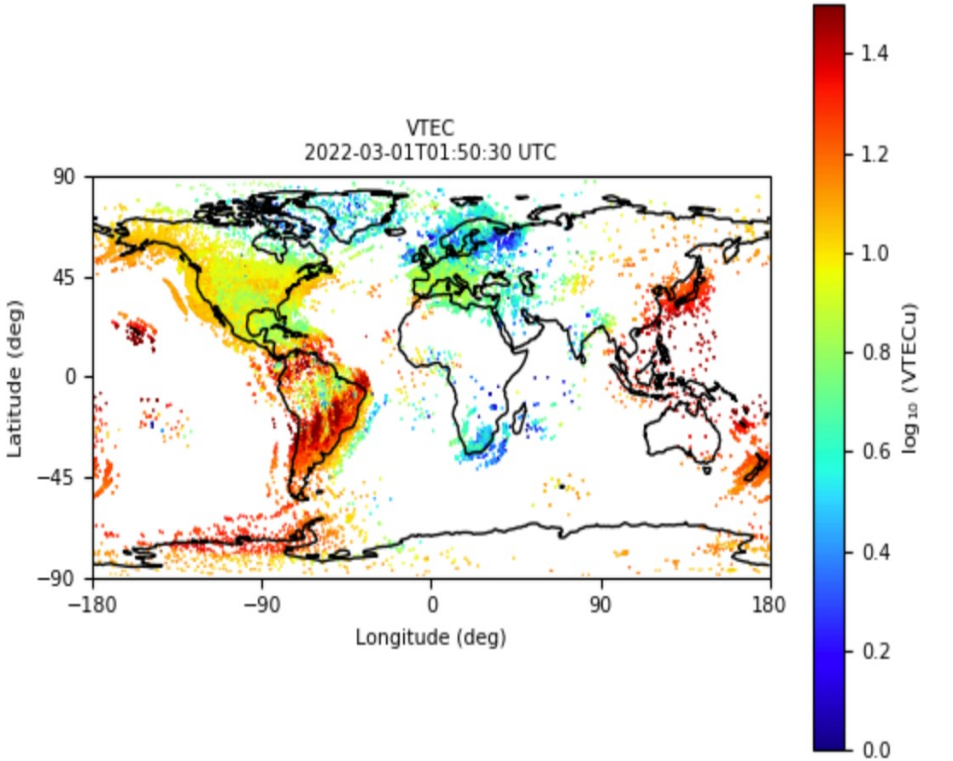
Email me if this experiment OR if any World-wide GNSS Receiver Network experiment is updated.

Select file:

gps220301g.002.hdf5: TEC binned 1 degree by 1 degree by 5 min - final

Plots/Docs | Download file | Print file | View file info | Cite this file

- Data source list for TEC processing
- Python programming tips for reading line-of-site TEC files
- Papers describing processing algorithms used
- Click here for TEC maps for 2022-03-01
- Create interactive TEC/SuperDARN plots
- Click here for plots of raw LOS converted to vertical TEC for 2022-03-01



CEDAR Home | Access data | Access metadata | Run models | Documentation | Other Madrigal sites | OpenMadrigal

World-wide TEC from GPS/GLONASS: 2022-03-01 00:00:00-2022-03-02 00:00:00

PI: Anthea Coster - please contact before using this data

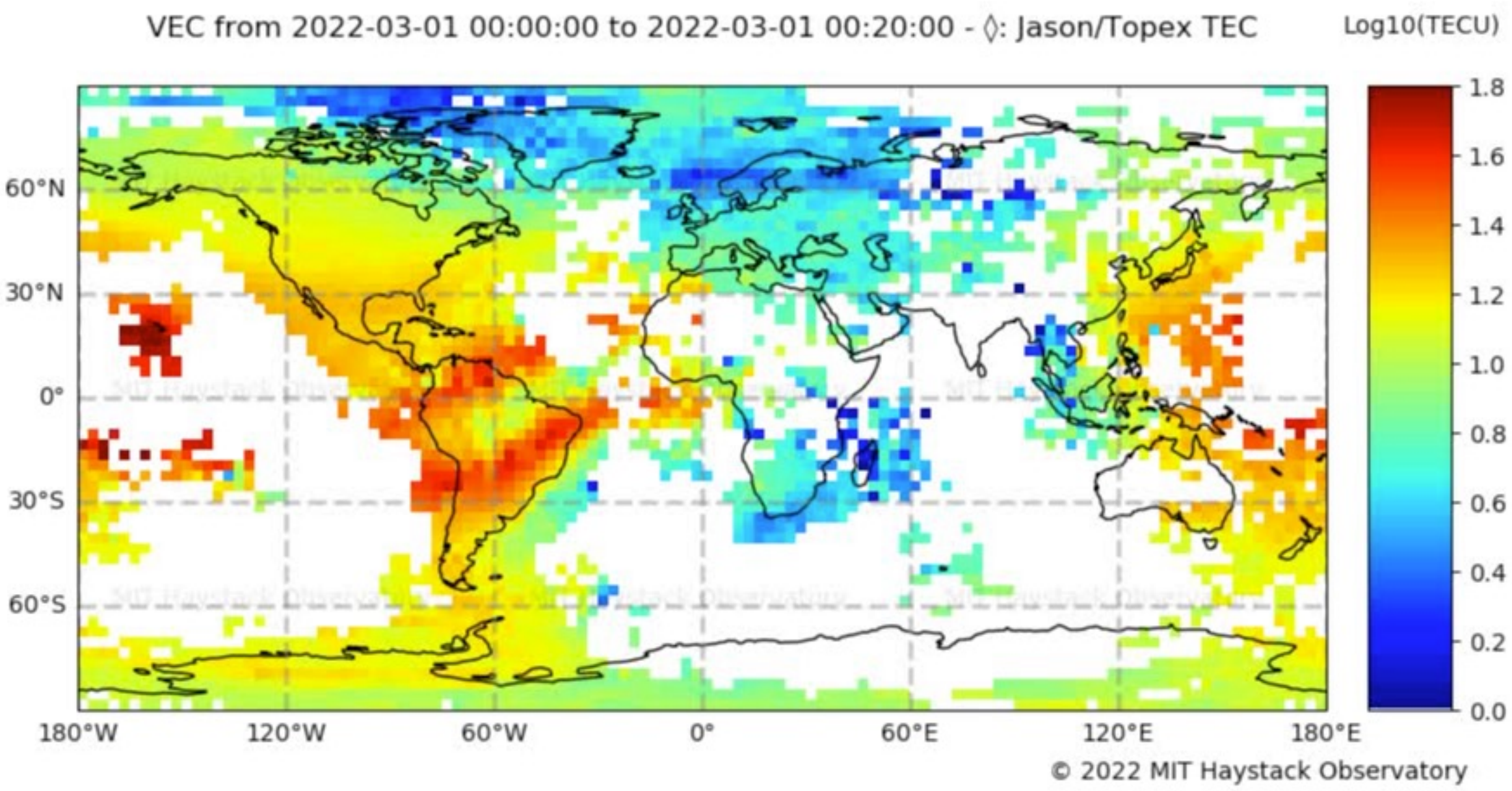
Email me if this experiment OR if any World-wide GNSS Receiver Network experiment is updated.

elect file:

site_20220301.001.h5: List of sites used in daily TEC data - Final

Plots/Docs | Download file | Print File | View file info | Cite this file

YEAR	MONTH	DAY	HOUR	MIN	SEC	RECNO	KINDAT	KINST	UT1_UNIX	UT2_UNIX	GPS_SITE	GDLATR	GDLONR
2022	3	1	11	59	59	0	3506	8000	1646092800.000	1646179199.000	b'0194'	3.91856e+01	1.39548e+02
2022	3	1	11	59	59	0	3506	8000	1646092800.000	1646179199.000	b'019b'	3.91856e+01	1.39548e+02
2022	3	1	11	59	59	0	3506	8000	1646092800.000	1646179199.000	b'0bis'	5.77250e+01	1.18919e+01
2022	3	1	11	59	59	0	3506	8000	1646092800.000	1646179199.000	b'0bru'	5.77300e+01	1.19721e+01
2022	3	1	11	59	59	0	3506	8000	1646092800.000	1646179199.000	b'0frl'	5.76502e+01	1.19122e+01
2022	3	1	11	59	59	0	3506	8000	1646092800.000	1646179199.000	b'0hdg'	5.92217e+01	1.79341e+01
2022	3	1	11	59	59	0	3506	8000	1646092800.000	1646179199.000	b'0hna'	6.05349e+01	1.78800e+01
2022	3	1	11	59	59	0	3506	8000	1646092800.000	1646179199.000	b'0kro'	5.76802e+01	1.19845e+01
2022	3	1	11	59	59	0	3506	8000	1646092800.000	1646179199.000	b'0kth'	5.93499e+01	1.80694e+01
2022	3	1	11	59	59	0	3506	8000	1646092800.000	1646179199.000	b'0lio'	5.93657e+01	1.81269e+01
2022	3	1	11	59	59	0	3506	8000	1646092800.000	1646179199.000	b'0lod'	5.57669e+01	1.29957e+01
2022	3	1	11	59	59	0	3506	8000	1646092800.000	1646179199.000	b'0mos'	5.93184e+01	1.80742e+01
2022	3	1	11	59	59	0	3506	8000	1646092800.000	1646179199.000	b'0nyb'	6.57959e+01	2.31700e+01
2022	3	1	11	59	59	0	3506	8000	1646092800.000	1646179199.000	b'0nyk'	5.87700e+01	1.69776e+01
2022	3	1	11	59	59	0	3506	8000	1646092800.000	1646179199.000	b'0okc'	5.72519e+01	1.64654e+01
2022	3	1	11	59	59	0	3506	8000	1646092800.000	1646179199.000	b'0oxe'	5.86710e+01	1.71070e+01
2022	3	1	11	59	59	0	3506	8000	1646092800.000	1646179199.000	b'0skl'	5.54749e+01	1.42794e+01
2022	3	1	11	59	59	0	3506	8000	1646092800.000	1646179199.000	b'0skn'	5.54138e+01	1.28579e+01
2022	3	1	11	59	59	0	3506	8000	1646092800.000	1646179199.000	b'0str'	5.89366e+01	1.11813e+01
2022	3	1	11	59	59	0	3506	8000	1646092800.000	1646179199.000	b'0tyr'	5.92219e+01	1.82056e+01


VEC from 2022-03-01 00:00:00 to 2022-03-01 00:20:00 - ◊: Jason/Topex TEC
Log10(TECU)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
60°N
30°N
0°
30°S
60°S
180°W
120°W
60°W
0°
60°E
120°E
180°E
© 2022 MIT Haystack Observatory

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.

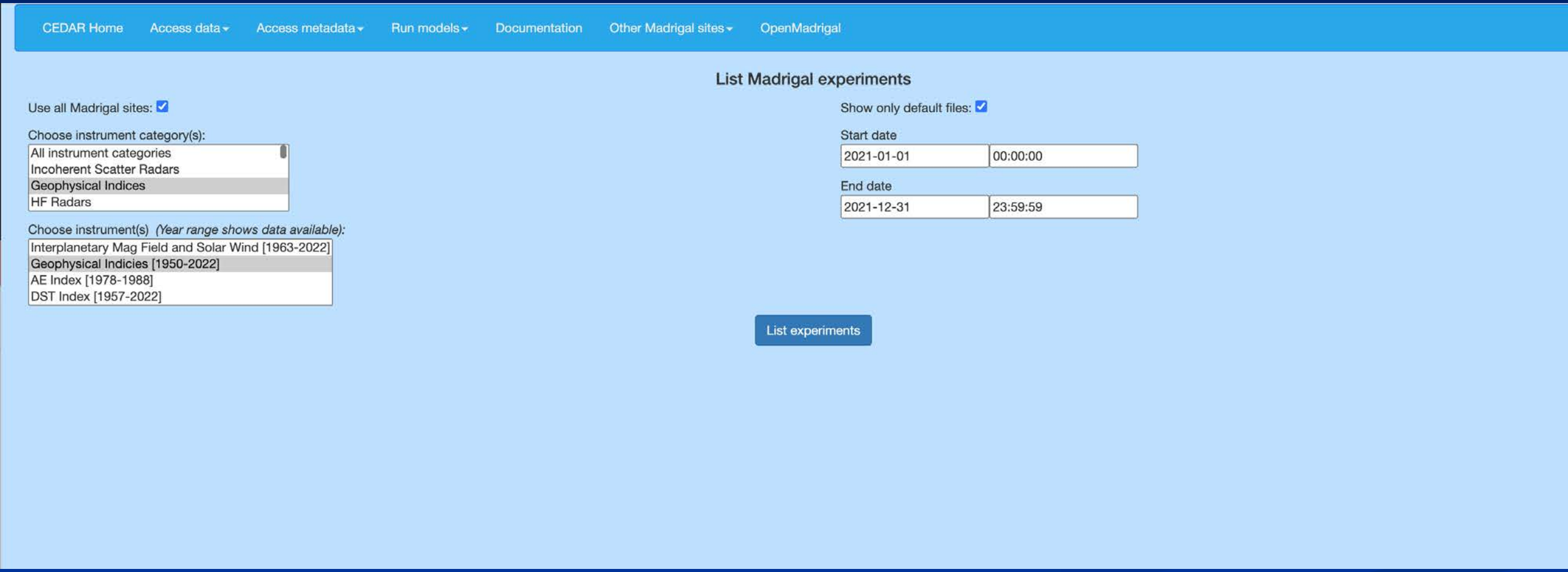
remotePythonAPI-2.2.1.tar.gz (last updated Jul. 30, 2014)

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

Documentation - Scripts, Tutorial, Reference

How to find all Kp's > 4 in 2021

From Access Data – select geophysical indices



CEDAR Home | Access data | Access metadata | Run models | Documentation | Other Madrigal sites | OpenMadrigal

List of selected Madrigal experiments

Madrigal site	Instrument name	Start	End	Experiment name
CEDAR	Geophysical Indicies	1950-01-01 00:00:00	2022-05-08 23:59:59	Kp; Ap; 10.7 cm flux; sunspot number etc

Not Secure | cedar.openmadrigal.org/showExperiment?experiment_list=100238479

untitled - Jupyter... | 29585 | Haystack call list -... | us coronavirus sta... | Editorial Manager® | Hiring - | WEKAN DIRECTO... | 2020 ISR School... | Facebook | Madrigal database... | How to Modify or... | Downloads | Kindle

CEDAR Home | Access data | Access metadata | Run models | Documentation | Other Madrigal sites | OpenMadrigal

Click here to return to the home page of the CEDAR Madrigal site.

Kp; Ap; 10.7 cm flux; sunspot number etc: 1950-01-01 00:00:00-2022-05-08 23:59:59

PI: - ore using this data

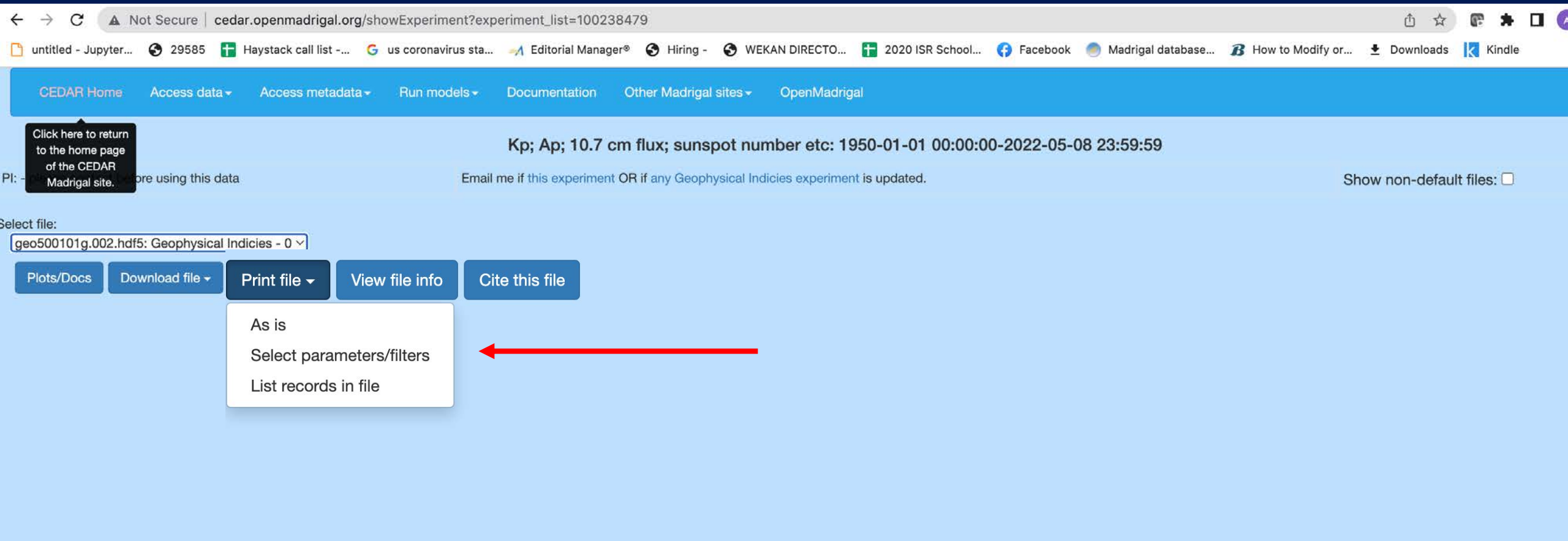
Email me if this experiment OR if any Geophysical Indicies experiment is updated.

Show non-default files:

Select file:

geo500101g.002.hdf5: Geophysical Indicies - 0

Plots/Docs | Download file | Print file | View file info | Cite this file


Not Secure | cedar.openmadrigal.org/showExperiment?experiment_list=100238479
untitled - Jupyter...
29585
Haystack call list -...
us coronavirus sta...
Editorial Manager®
Hiring -
WEKAN DIRECTO...
2020 ISR School...
Facebook
Madrigal database...
How to Modify or...
Downloads
Kindle
CEDAR Home
Access data
Access metadata
Run models
Documentation
Other Madrigal sites
OpenMadrigal
Click here to return to the home page of the CEDAR Madrigal site.
Kp; Ap; 10.7 cm flux; sunspot number etc: 1950-01-01 00:00:00-2022-05-08 23:59:59
PI: -
ore using this data
Email me if this experiment OR if any Geophysical Indicies experiment is updated.
Show non-default files:
Select file:
geo500101g.002.hdf5: Geophysical Indicies - 0
Plots/Docs
Download file
Print file
View file info
Cite this file
As is
Select parameters/filters
List records in file

CEDAR Home | Access data | Access metadata | Run models | Documentation | Other Madrigal sites | OpenMadrigal

Print Madrigal file with selected parameters/filters

Experiment: *Kp; Ap; 10.7 cm flux; sunspot number etc* **File:** *geo500101g.002.hdf5* **Type of data:** *Geophysical Indicies*

Format output ☰

Show headers: ☐ Missing value string: NaN

Select Parameters to include ☰

Select Filters to use (optional) ☰

Print file

CEDAR Home | Access data | Access metadata | Run models | Documentation | Other Madrigal sites | OpenMadrigal

Print Madrigal file with selected parameters/filters

Experiment: *Kp; Ap; 10.7 cm flux; sunspot number etc* **File:** *geo500101g.002.hdf5* **Type of data:** *Geophysical Indicies*

Format output ☰

Select Parameters to include ☰

Select all parms in original file | Unselect all parms in original file

Blue parameters are from the original file | Grey parameters are derivable from those in the original file

Madrigal Hdf5 Prolog Parameters

- YEAR
- MONTH
- DAY
- HOUR
- MIN
- SEC
- UT1_UNIX
- UT2_UNIX
- RECNO
- KINST
- KINDAT

Time Related Parameter

- BMONTH
- BDAY
- MD
- DAYNO
- BHM
- BHHMMSS
- EHHMMSS
- FYEAR
- UTH
- SLT
- B_UTH
- UT
- BEG_UT
- JULIAN_DATE
- UT1
- UT2
- DUT21

Geographic Coordinate

- GDLAT
- GLON
- SZEN
- SDWHT

Geophysical Index

- KP
- DST
- AP3
- AP
- F10.7
- FBAR

Interplanetary Magnetic Field

- BXGSM
- BYGSM
- BZGSM
- BIMF
- BXGSE
- BYGSE
- BZGSE
- SWDEN
- SWSPD
- SWQ

tec_2015_3_17.mp4

Show

CEDAR World-wide GNSS Receiver Network 2022-03-21 00:00:00 20

Select Parameters to include ☰

Select all parms in original file | Unselect all parms in original file

Blue parameters are from the original file | Grey parameters are derivable from those in the original file

Madrigal Hdf5 Prolog Parameters

- [x] YEAR
- [x] MONTH
- [x] DAY
- [x] HOUR
- [ ] MIN
- [ ] SEC
- [ ] UT1_UNIX
- [ ] UT2_UNIX
- [ ] RECNO
- [ ] KINST
- [ ] KINDAT

Time Related Parameter

- [ ] BMONTH
- [ ] BDAY
- [ ] MD
- [ ] DAYNO
- [ ] BHM
- [ ] BHHMMSS
- [ ] EHHMMSS
- [ ] FYEAR
- [ ] UTH
- [ ] SLT
- [ ] B_UTH
- [ ] UT
- [ ] BEG_UT
- [ ] JULIAN_DATE
- [ ] UT1
- [ ] UT2
- [ ] DUT21

Geographic Coordinate

- [ ] GDLAT
- [ ] GLON
- [ ] SZEN
- [ ] SDWHT

Geophysical Index

- [x] KP
- [ ] DST
- [ ] AP3
- [ ] AP
- [ ] F10.7
- [ ] FBAR

Interplanetary Magnetic Field

- [ ] BXGSM
- [ ] BYGSM
- [ ] BZGSM
- [ ] BIMF
- [ ] BXGSE
- [ ] BYGSE
- [ ] BZGSE
- [ ] SWDEN
- [ ] SWSPD
- [ ] SWQ

Select Filters to use (optional) ☰

Start datetime	1950-01-01T00:00:00	End datetime	2022-05-08T23:59:59

Optional filters using any parameter mnemonic on this page	Lower limit (leave blank if no lower limit)	Upper limit (leave blank if no upper limit)
YEAR	2021	2022
KP	4	
None		

Not Secure | cedar.openmadrigal.org/chooseScript

Update

untitled - Jupyter... 29585 Haystack call list -... us coronavirus sta... Editorial Manager® Hiring - WEKAN DIRECTO... 2020 ISR School... Facebook Madrigal database...

CEDAR Home | Access data | Access metadata | Run models | Documentation | Other Madrigal sites | OpenMadrigal

Download software (first time only) Why do I need to download software first?

Select what kind of command to create

Download a group of files as is (faster) Download data with selected parms/filters (slower)

If you want to create a citation to a **group** of files, instructions on using the globalCitation.py script are here.

CEDAR Home | Access data | Access metadata | Run models | Documentation | Other Madrigal sites | OpenMadrigal

Create a script command to download Madrigal data with selected parameters and filters

Choose an instrument category if desired:

Geophysical Indices

Choose one instrument *(Year range shows data available)*:

Geophysical Indicies [1950-2022]

Start date

1950-01-01

End date

2022-12-31

File format to download:

(•) **Hdf5** ( ) **Space-delimited ascii** ( ) **netCDF4**

If ascii, download result to:

(•) **Directory** ( ) **File**

Choose scripting language:

(•) **python** ( ) **Matlab** ( ) **IDL**

Select parameters (required) ☰

Optional filters: kinds of data, filter by parm, experiment names, etc ☰

Generate command

Create a script command to download Madrigal data with selected parameters and filters

Choose an instrument category if desired:
Geophysical Indices

Choose one instrument *(Year range shows data available):*
Geophysical Indicies [1950-2022]

File format to download:
○ **Hdf5** ◉ **Space-delimited ascii** ○ **netCDF4**

If ascii, download result to:
○ **Directory** ◉ **File**

Choose scripting language:
◉ **python** ○ **Matlab** ○ **IDL**

Start date
1950-01-01

End date
2022-12-31

Select parameters (required) ☰

Madrigal Hdf5 Prolog Parameters

☑ YEAR ☐ MONTH ☑ DAY ☐ HOUR ☐ MIN ☐ SEC
☐ UT1_UNIX ☐ UT2_UNIX ☐ RECNO ☐ KINST ☐ KINDAT

Time Related Parameter

☐ BMONTH ☐ BDAY ☐ MD ☐ DAYNO ☐ BHM ☐ BHHMMSS
☐ EHHMMSS ☐ FYEAR ☐ UTH ☐ SLT ☐ B_UTH ☐ UT
☐ BEG_UT ☐ JULIAN_DATE ☐ UT1 ☐ UT2 ☐ DUT21

Geographic Coordinate

☐ GDLAT ☐ GLON ☐ SZEN ☐ SDWHT

Geophysical Index

☑ KP ☐ DST ☐ AP3 ☐ AP ☐ F10.7 ☐ FBAR

Interplanetary Magnetic Field

If ascii, download result to:

○ **Directory** ◉ **File**

Choose scripting language:

◉ **python** ○ **Matlab** ○ **IDL**

Select parameters (required) ☰

Optional filters: kinds of data, filter by parm, experiment names, etc ☰

Choose one or more kinds of data:

All kinds of data
Geophysical Indicies

Filter experiments by name:

Filter files by description:

Select data from only a part of the year by changing the values below:

Optional seasonal start day/month: 1 1

Optional seasonal end day/month: 31 12

Add optional filters based on parameter values below:

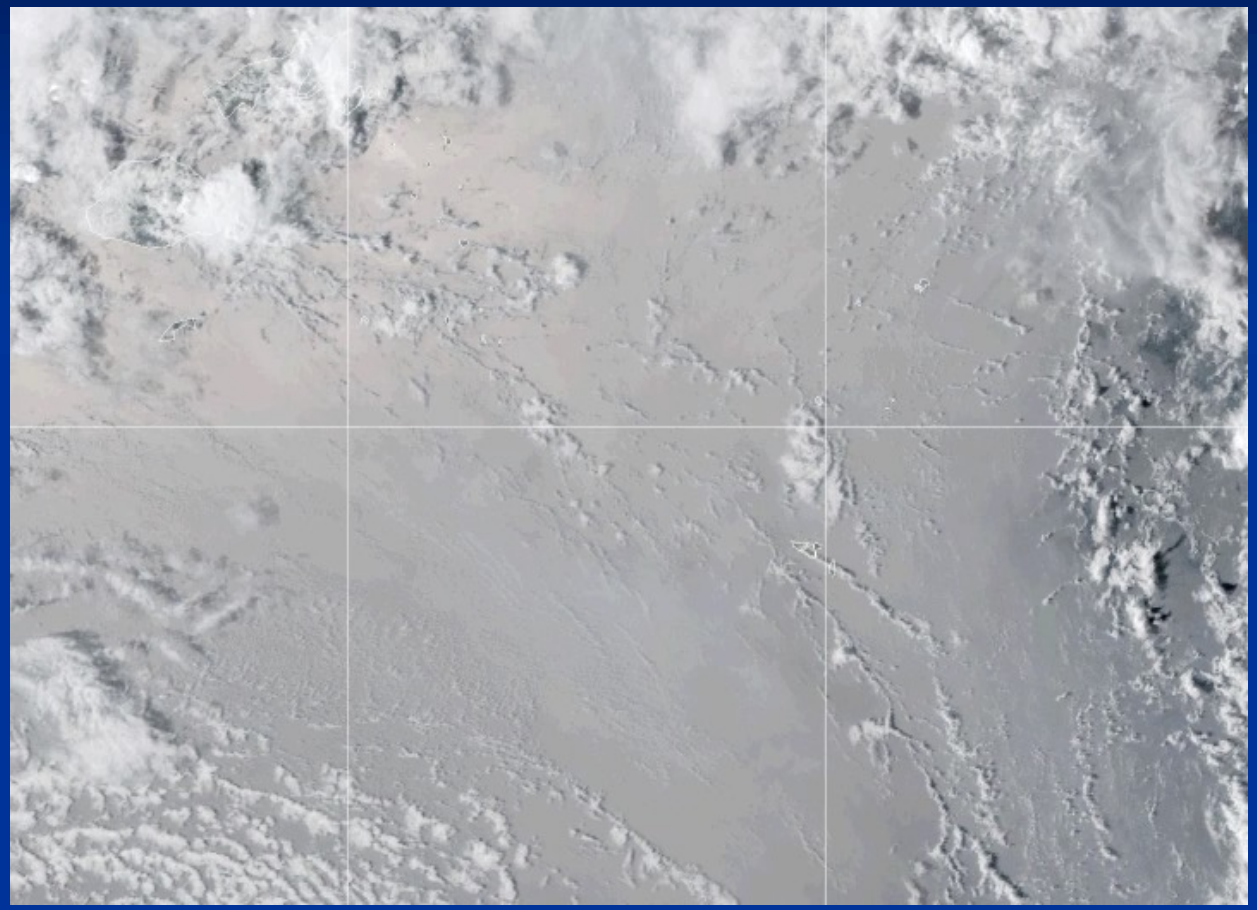
Optional filters using any parameter mnemonic for this instrument	Lower limit (leave blank if no lower limit)	Upper limit (leave blank if no upper limit)
YEAR	2021	2022
KP	4	
None		

Generate command

globalIsprint.py --verbose --url=http://cedar.openmadrigal.org --parms=YEAR,DAY,KP --output=example.txt --user_fullname="Anthea+J+Coster" --user_email=ajc@haystack.mit.edu --user_affiliation=”MIT" --startDate="01/01/1950" --endDate="12/31/2022" --inst=210 --filter=YEAR,2021,2022 --filter=KP,4, --kindat=30007

To end on a new science result – data from the Tonga eruption

2022 Tonga volcanic eruption induced TID global propagation



This looping video shows a series of GOES-17 satellite images that caught an umbrella cloud generated by the underwater eruption of the Hunga Tonga-Hunga Ha'apai volcano on Jan. 15, 2022.

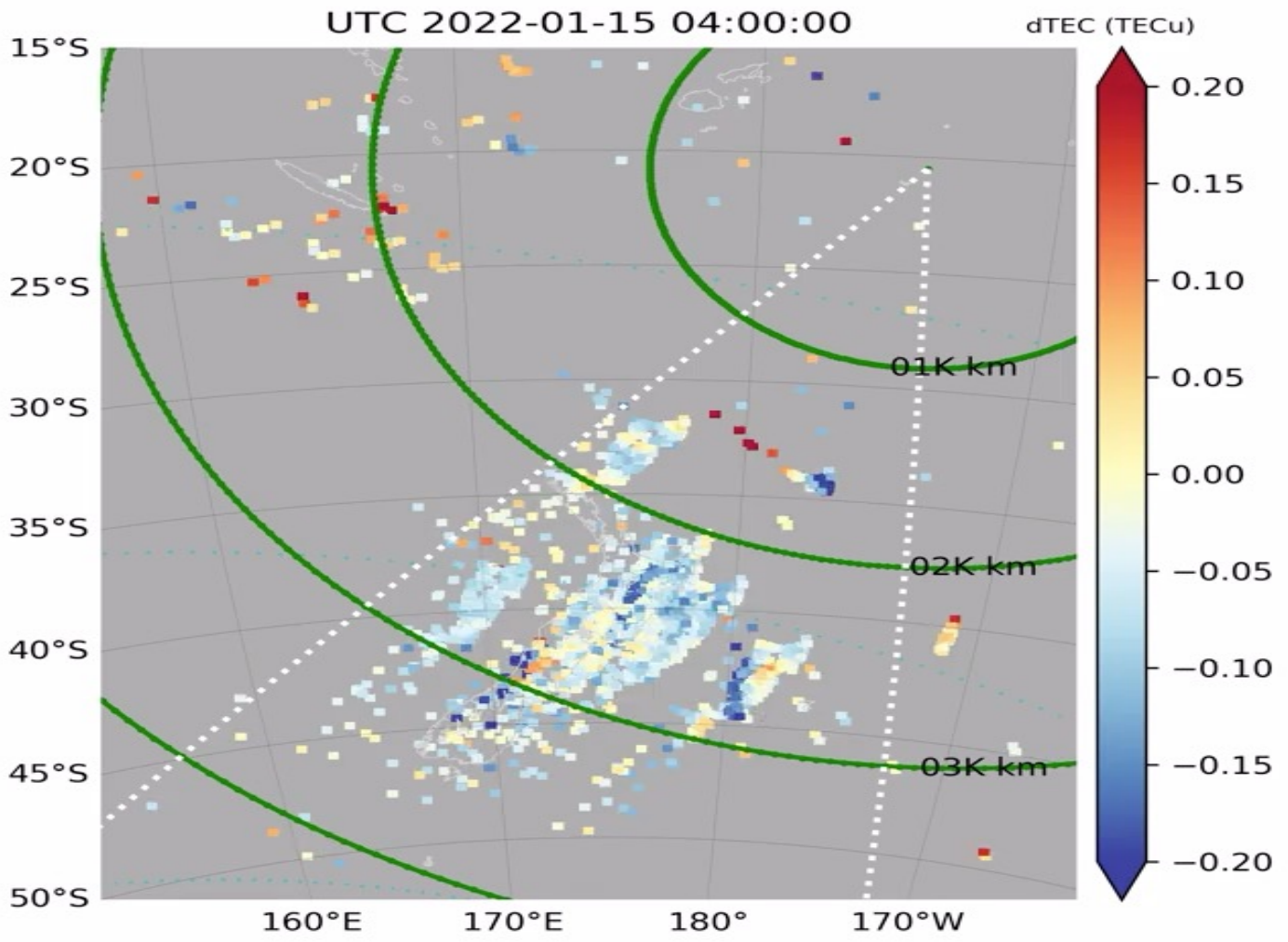
Crescent-shaped bow shock waves and numerous lighting strikes are also visible.

Credit: NASA Earth Observatory image by Joshua Stevens using GOES imagery courtesy of NOAA and NESDIS
words from https://www.jpl.nasa.gov/news/tonga-eruption-sent-ripples-through-earths-ionosphere)

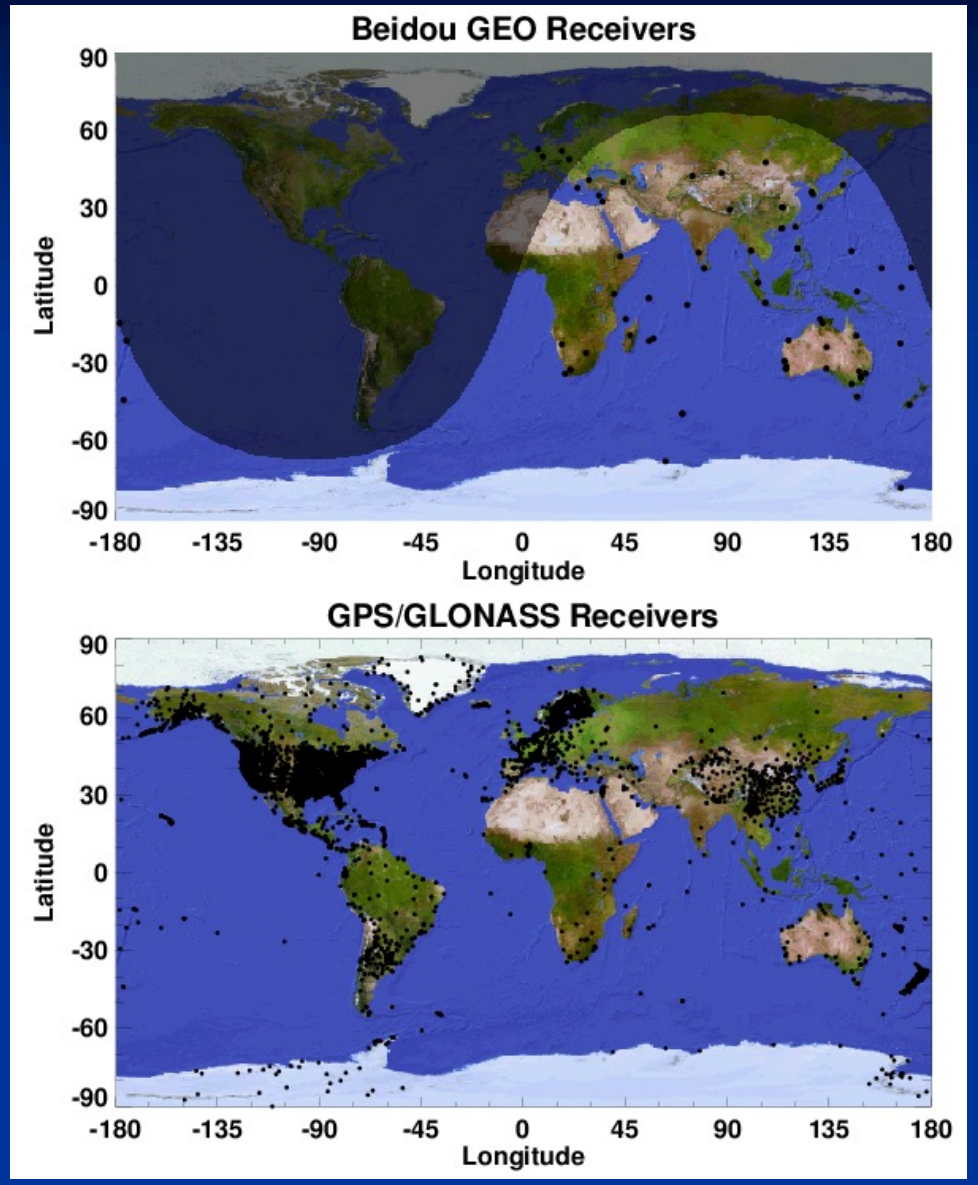
New Zealand (Animation)

Initial waves had huge amplitudes and wavelengths (~ 2K km!)

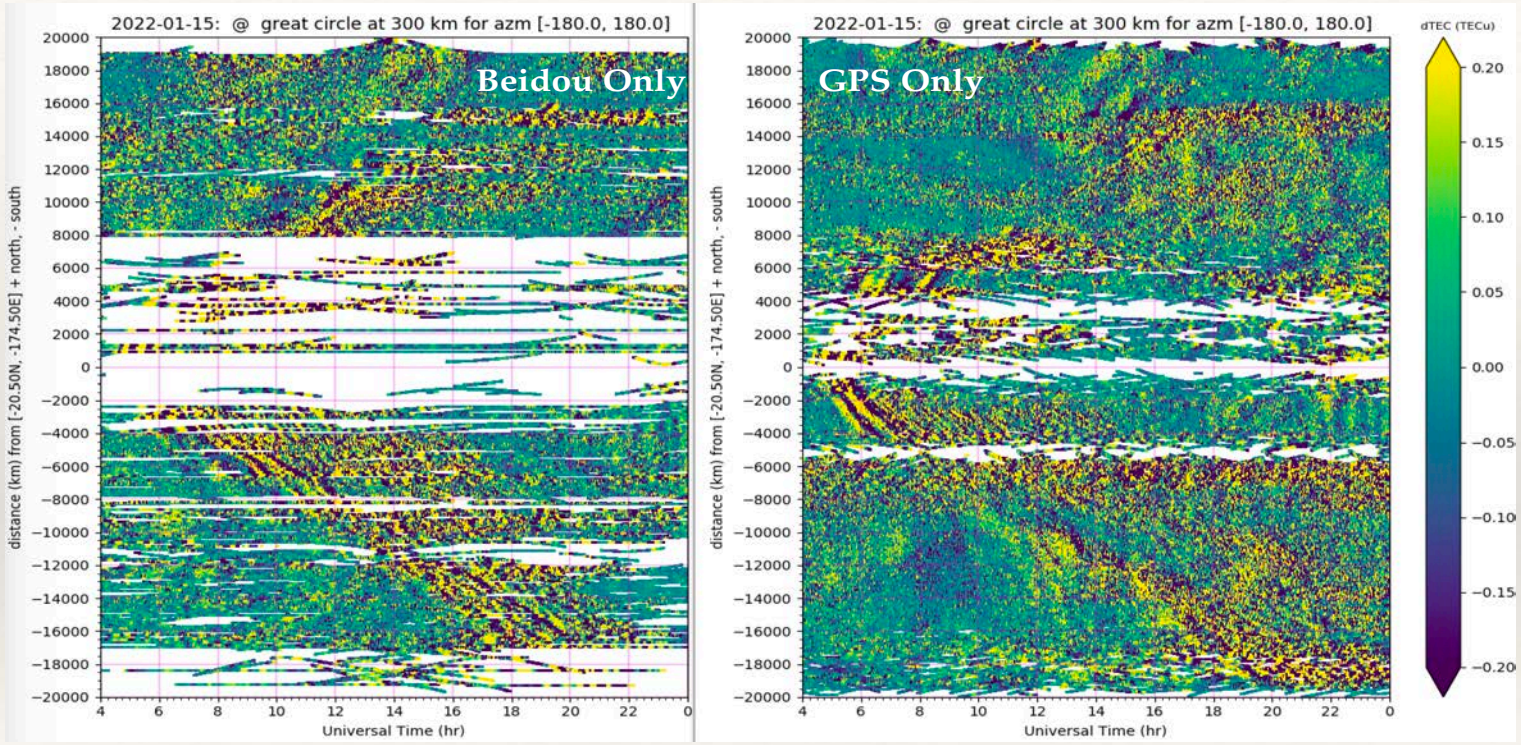
Subsequent waves had 300-500 km wavelengths



MIT HAYSTACK OBSERVATORY



Beidou and GPS data coverage for Tonga eruption study



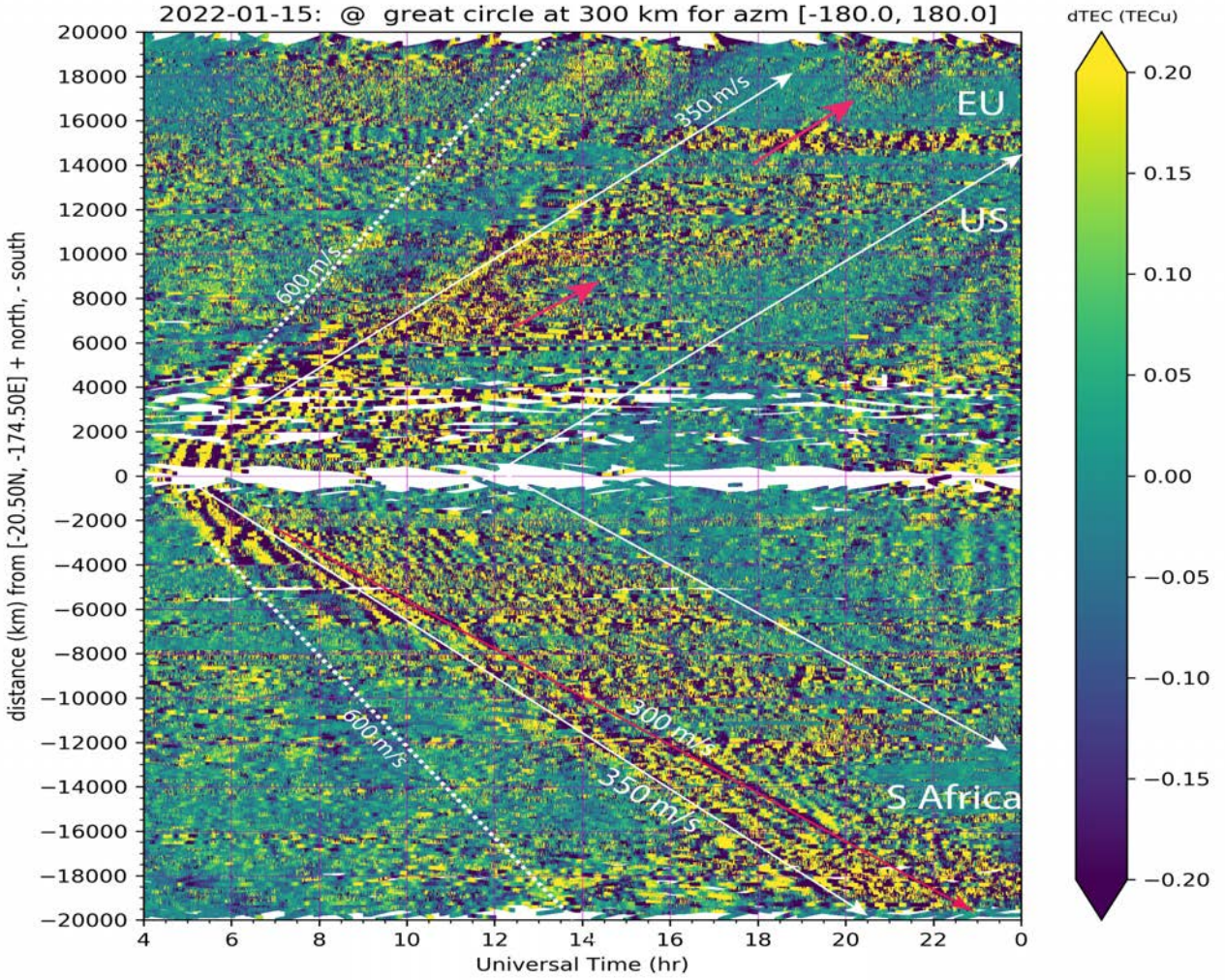
MIT HAYSTACK OBSERVATORY

Distance-Time plot to show eruption induced global TID propagation

https://www.frontiersin.org/articles/10.3389/fspas.2022.871275/full

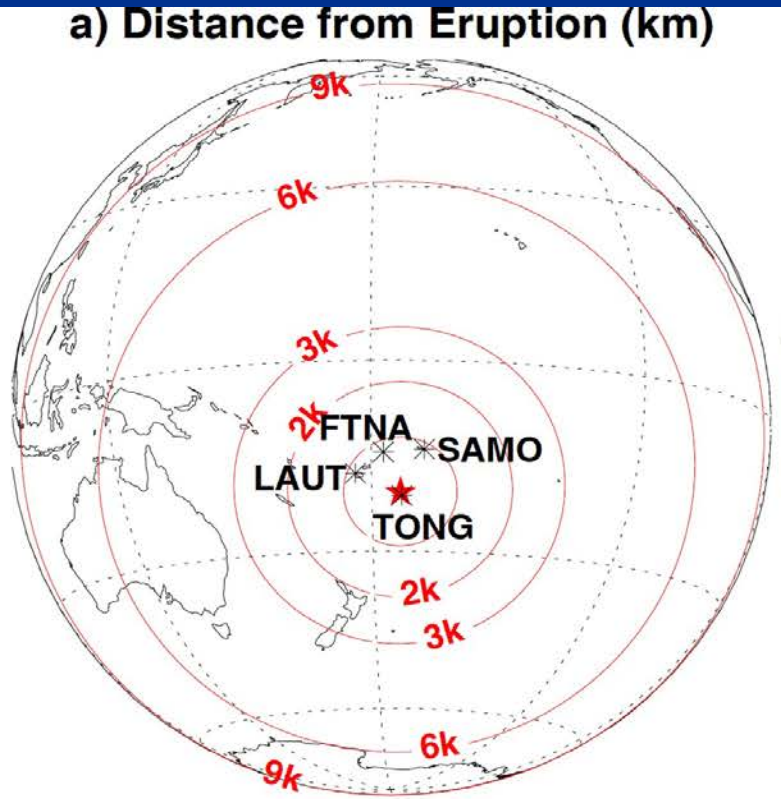
Global View: N-S Propagation

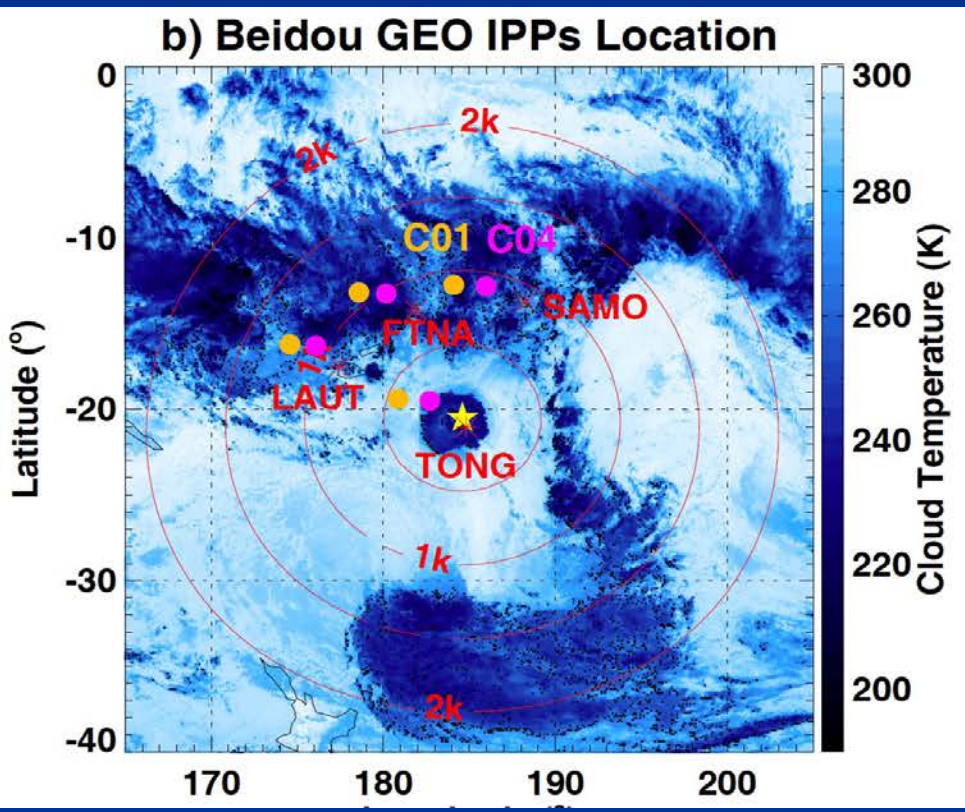
- Evident TID occurrence was based on the distance from the epic center;
- TIDs reached 20K km distance 17 hrs after the eruption;
- Shock fronts travled at ~ 350 m/s
- Regional disturbances lasted for 8-10 hrs

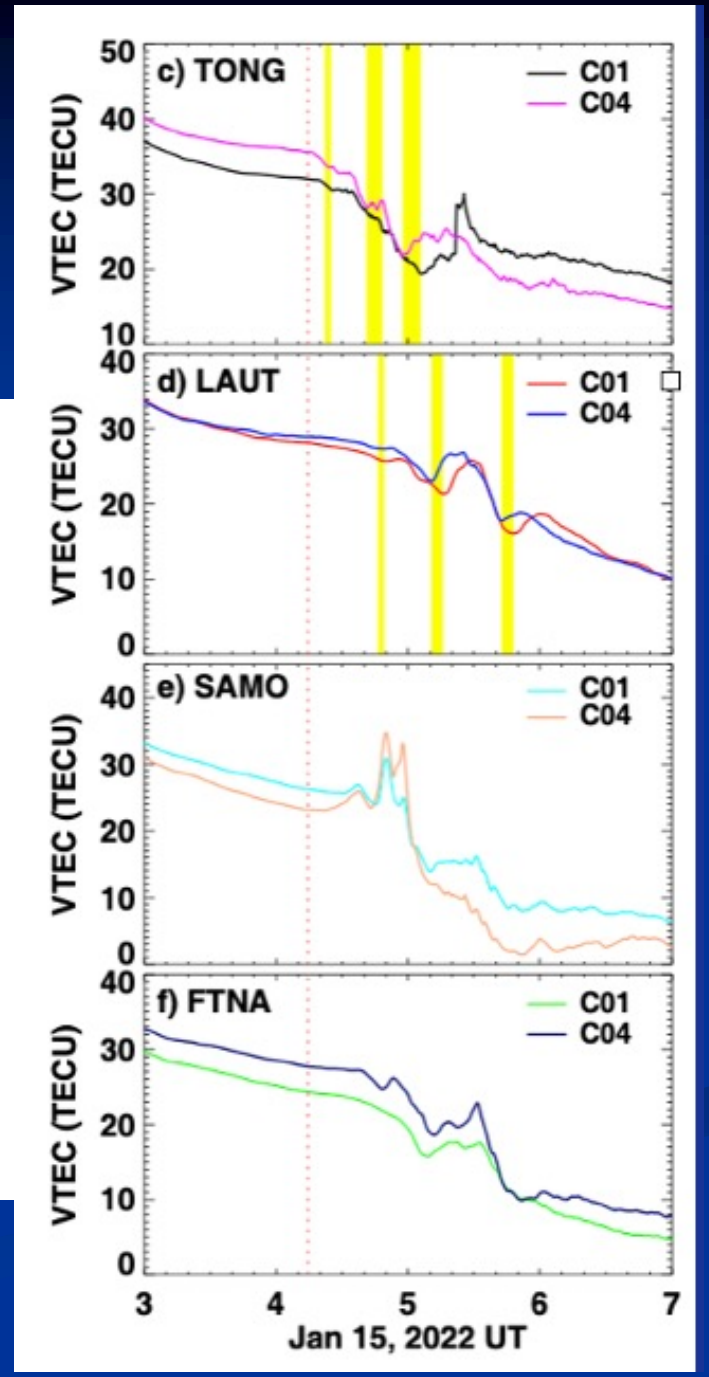


MIT HAYSTACK OBSERVATORY

BEIDOU has 5 GEOSTATIONARY satellites and 4 MEO satellites. The GEO satellites allow for accurate TEC data because of stationary ionospheric pierce point with fixed azimuth and elevation







Madrigal Data Base

- How to get TEC data from Madrigal
- How to access and filter Kp data

- The Tonga data shows you how science has been enabled

- Learn more about Madrigal – API's, what is there
- http://cedar.openmadrigal.org/docs/name/madContents.html