WHY SOUNDER DATA CAN HELP YOU

(AND A PEEK INTO THE FUTURE)

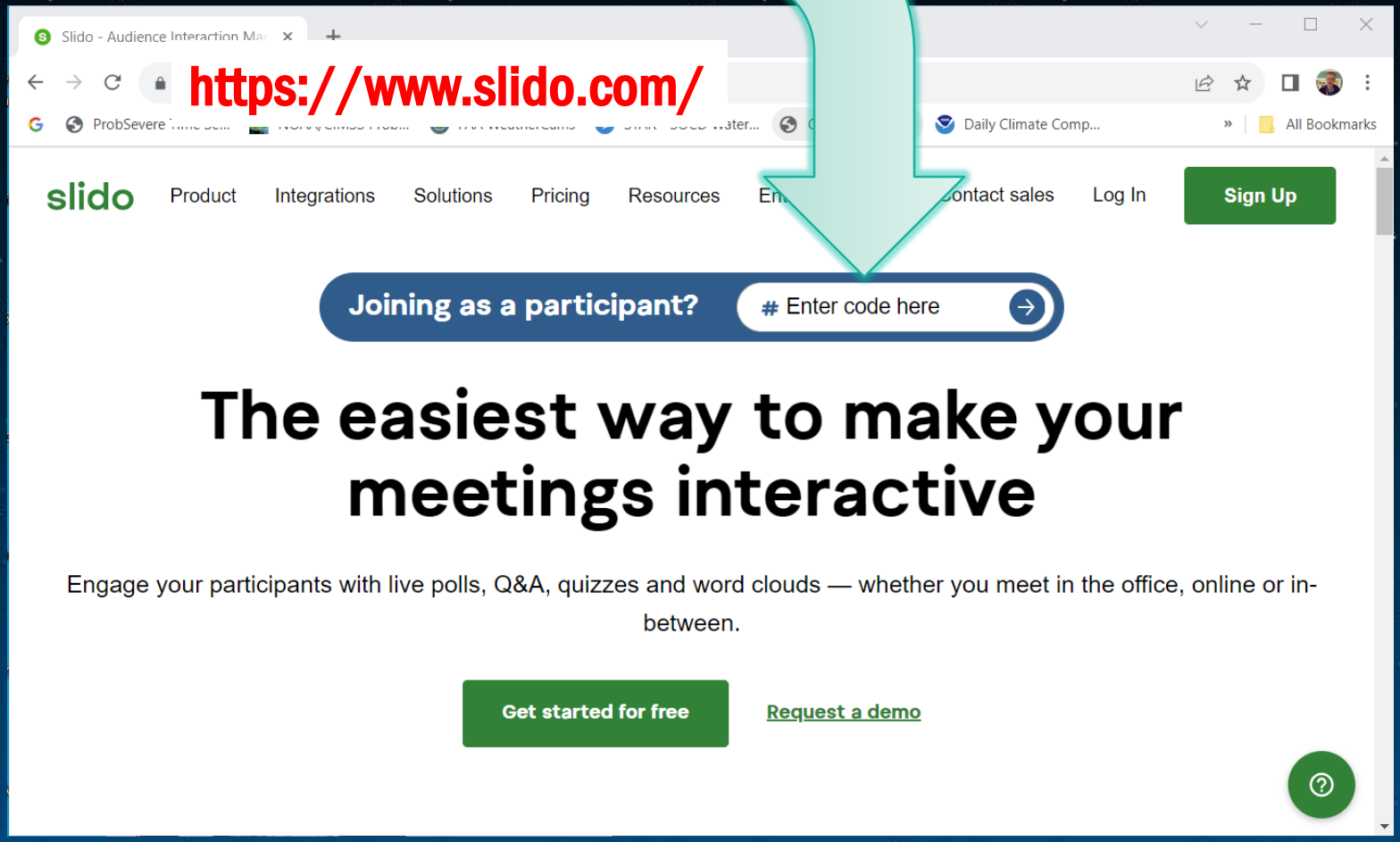
Scott Lindstrom, UW-Madison

Cooperative Institute for Meteorological Satellite Studies

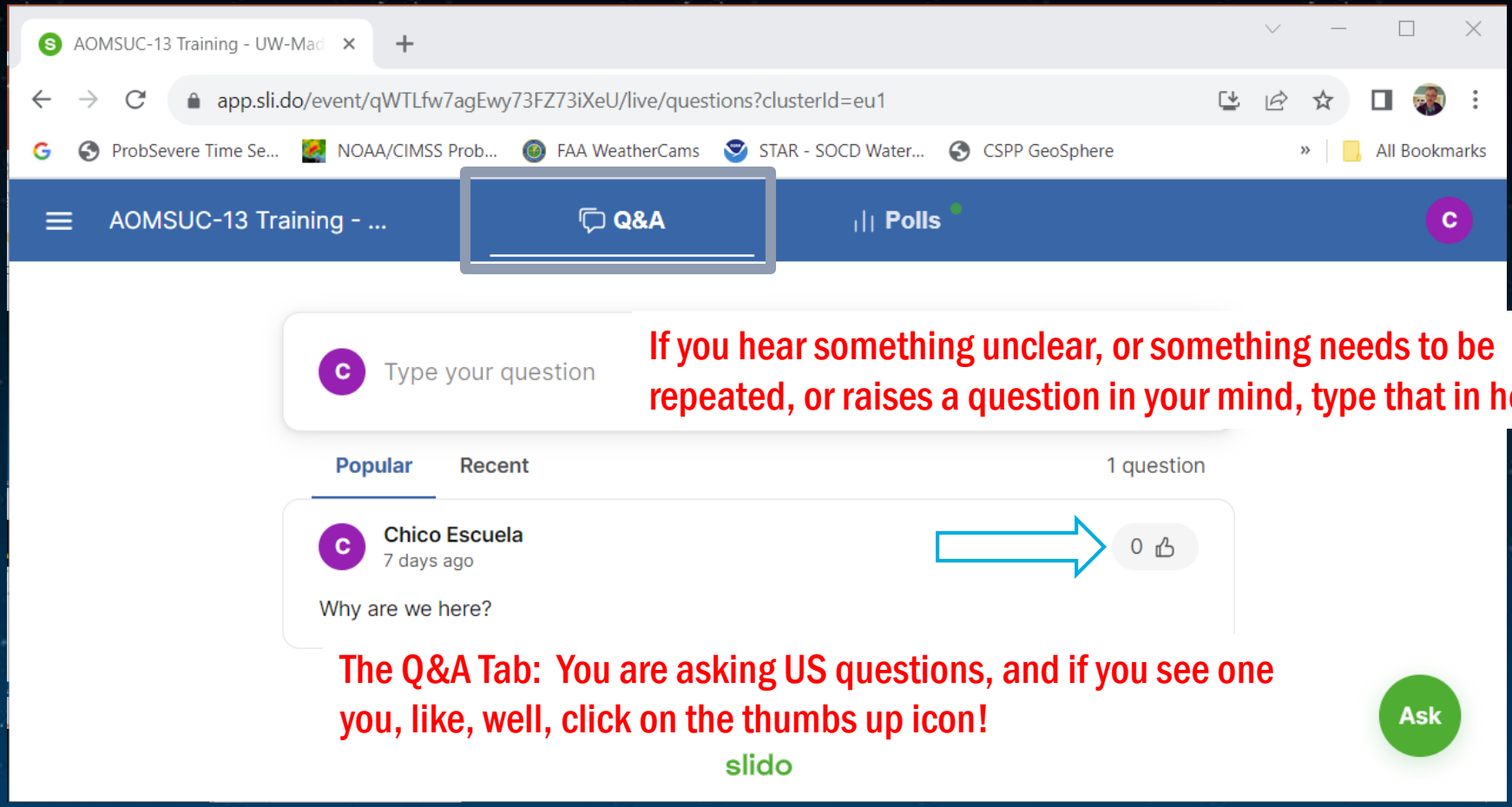
(CIMSS)

We are using slido.com!

- #AOMSUC13



You can do different things at slido



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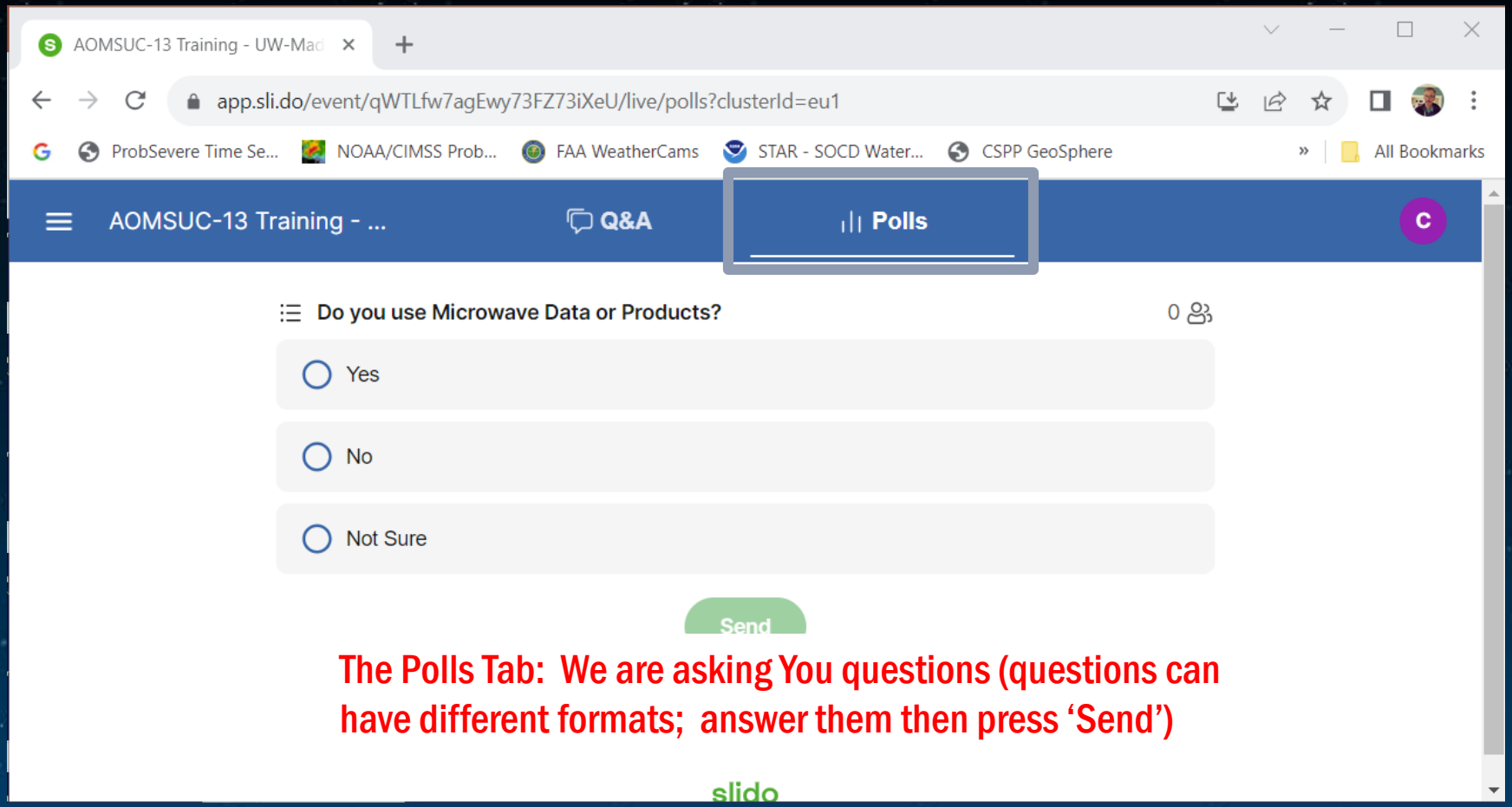


The Polls Tab: We are asking You questions (questions can have different formats; answer them then press 'Send')

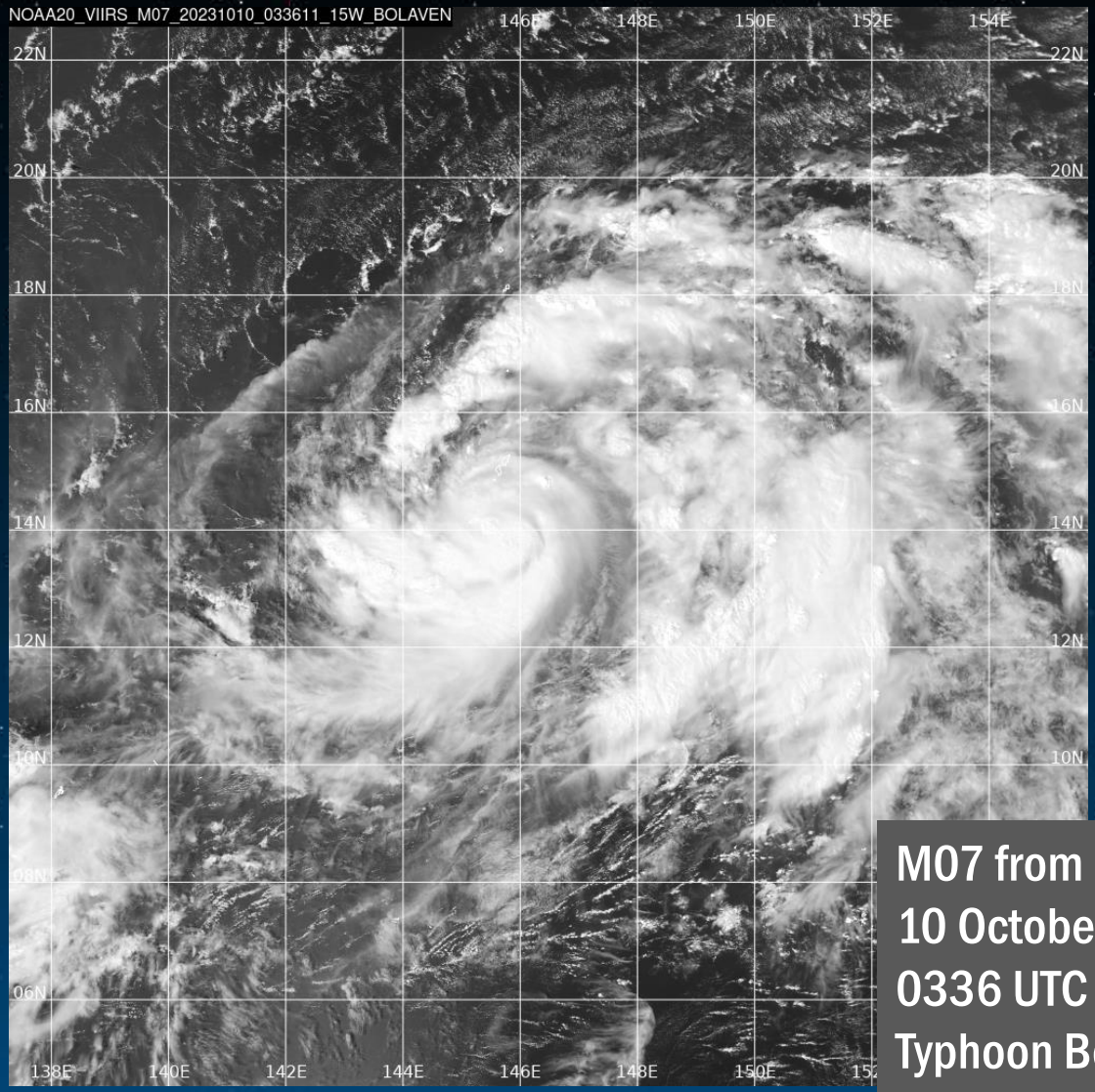
Imagers v. Sounders

- Maybe you're familiar with Imagers: AHI, AMI, AGRI, ABI, GHI
  - Advanced Himawari Imager (16 bands)
  - Advanced Meteorological Imager (16 bands)
  - Advanced Geostationary Radiation Imager (16 bands)
  - Advanced Baseline Imager (16 bands)
  - Geostationary High-speed Image (7 bands)
- Radiometers: AVHRR, VIIRS, VIRR
  - Advanced Very High Resolution Radiometer (5-6 bands)
  - Visible/Infrared Imager Radiometer Suite (22 bands)
  - Visible and Infrared Radiometer (10 bands)
- Other LEO Imagers: MERSI-1, MERSI-2, MERSI-LL
  - Medium Resolution Spectral Imager (up to 25 bands)

Slido Question #1

- Go to Slido.com and answer the questions, and we'll discuss!
- Question 1: What satellite data do you currently use?
- Question 2: How do you get that data?

Imagers give a view of a surface



You can use Imager data to derive products. Sometimes that derivation requires information from Numerical Models

(For example, I might have added a Sea Surface Temperature analysis under the image of Bolaven)

M07 from NOAA-20 VIIRS
10 October 2023
0336 UTC (0.86 μm)
Typhoon Bolaven, east of Guam

Imagers give information from one level
Sounders give volumetric information

- CrIS, IASI, HIRAS-2
  - Cross-Track Infrared Sounder (1305 bands)
    - 3.92 – 4.64 μm; 5.71 – 8.26 μm; 9.13 – 15.4 μm
    - 2155 – 2550 ; 1210 – 1750 ; 650 – 1095
  - Infrared Atmospheric Sounding Interferometer (8461 bands)
    - 3.62 – 15.5 μm ; 645 – 2760
  - Hyperspectral Infrared Atmospheric Sounding-2 (3000+ bands)
    - 3.92 – 4.64 μm ; 5.71 – 8.26 μm ; 8.8 – 15.38 μm
    - 2155 – 2550 ; 1210 – 1750 ; 650 – 1136
- GIIRS, GIIRS-2
  - Geostationary Interferometric Infrared Sounder (1188 detectors on FY-4B)

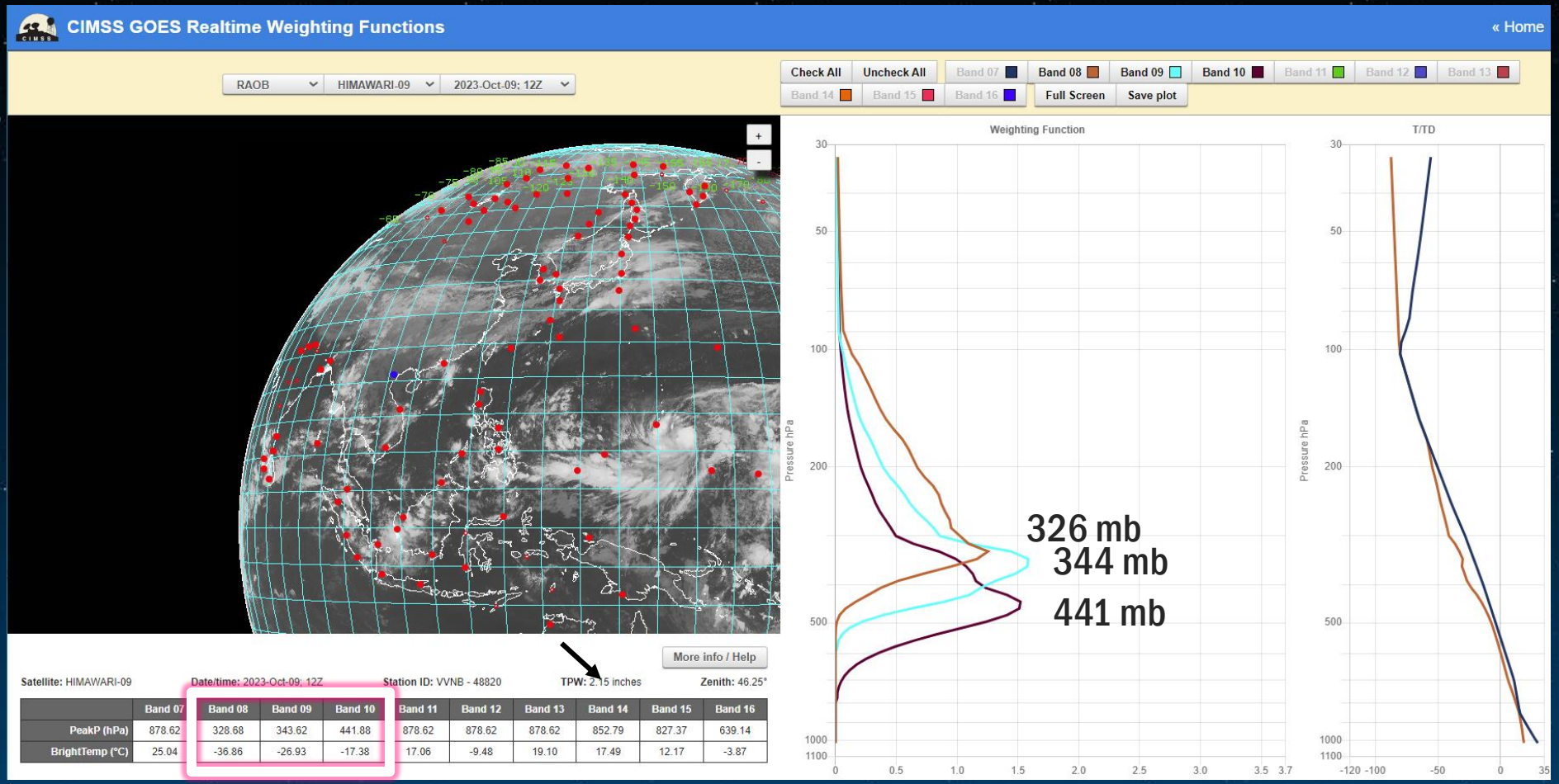
What can sounding data give you: Vertical Profiles of temperature and moisture

- The >1000 observations of radiances you get from a sounder could represent the emissions from more than one atmosphere
- The challenge is to find the most likely combination of temperature and moisture profiles that yield the observations
  - This is a tricky mathematical problem
  - For 40+ years this has been achieved using Radiative Transfer Models (RTMs) – that are computationally slow
  - How to become famous: Devise a speedy way to transform the observations to the most likely atmosphere

Slido Question #3

- In clear skies, from where does the information that a 'water vapor' infrared channel (for example, Band 8 on AMI at 6.24 μm) detects originate?
  - A: From the Earth's Surface
  - B: From around 900 mb
  - C: From around 550 mb
  - D: From around 350 mb
  - E: I need more information!

Weighting Function



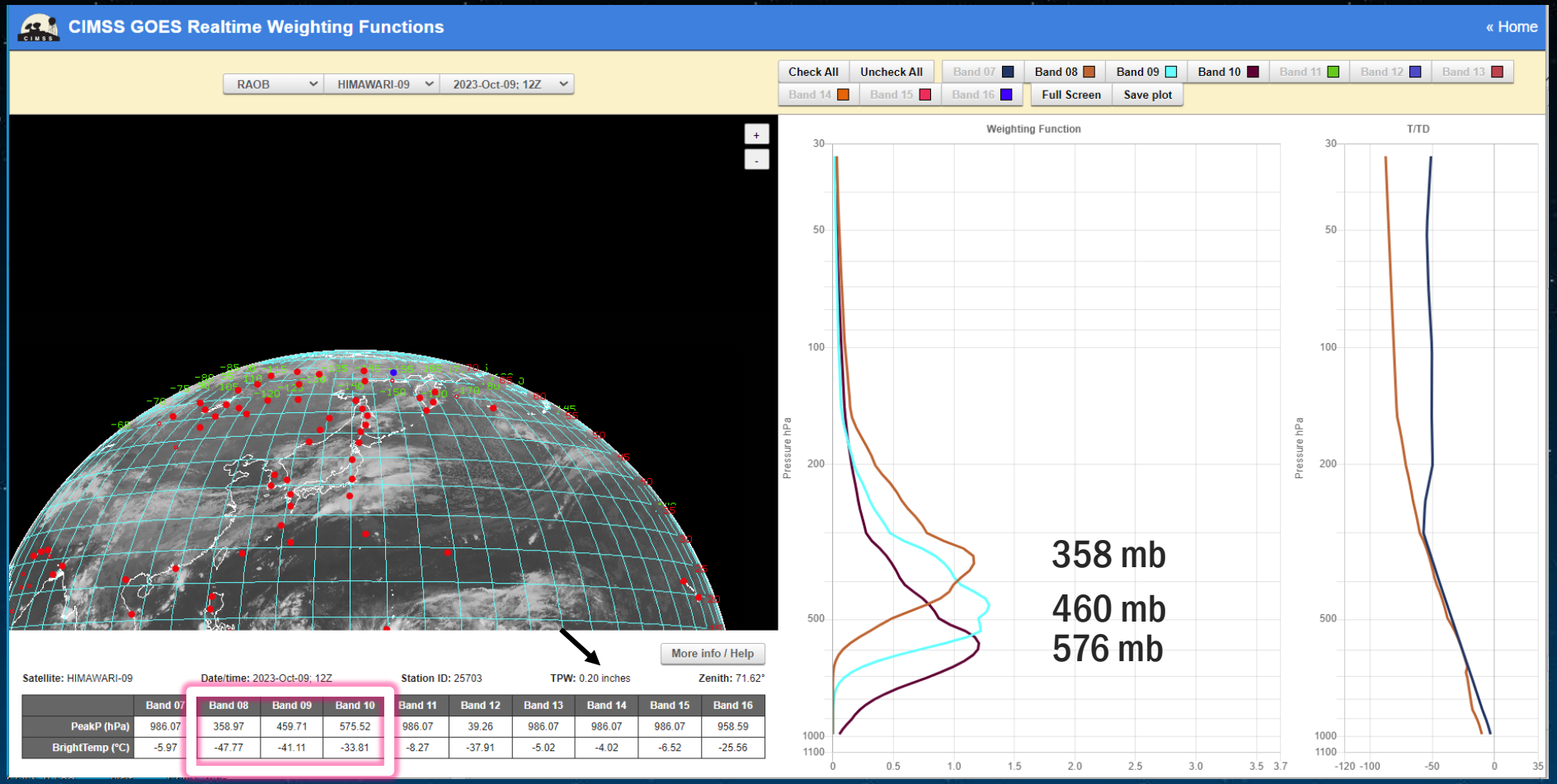
	Band 07	Band 08	Band 09	Band 10	Band 11	Band 12	Band 13	Band 14	Band 15	Band 16
PeakP (hPa)	878.62	328.68	343.62	441.88	878.62	878.62	878.62	852.79	827.37	639.14
BrightTemp (°C)	25.04	-36.86	-26.93	-17.38	17.06	-9.48	19.10	17.49	12.17	-3.87

AHI has 3 bands in the part of the spectrum that is sensitive to water vapor absorption

Where does the information sensed by those three channels originate in the vertical?

This is a function of water vapor in the column

Weighting Function



	Band 07	Band 08	Band 09	Band 10	Band 11	Band 12	Band 13	Band 14	Band 15	Band 16
PeakP (hPa)	986.07	358.97	459.71	575.52	986.07	39.26	986.07	986.07	986.07	958.59
BrightTemp (°C)	-5.97	-47.77	-41.11	-33.81	-8.27	-37.91	-5.02	-4.02	-6.52	-25.56

AHI has 3 bands in the part of the spectrum that is sensitive to water vapor absorption

Where does the information sensed by those three channels originate in the vertical?

This is a function of water vapor in the column

The complication of water vapor

- "Water Vapor" bands on a satellite are sensing emissions at different wavelengths (6.24, 6.95, 7.35 μm on AHI)
  - The ability of water molecules to absorb energy at those wavelengths varies as a function of wavelength
    - A thin region of water vapor might absorb most of the energy at 6.24 μm, but a lot of the 7.34 μm energy will move through it.
    - What is the temperature of the water vapor. That also affects the absorption.
    - Are there big gradients in temperature that can be sensed through the water vapor?

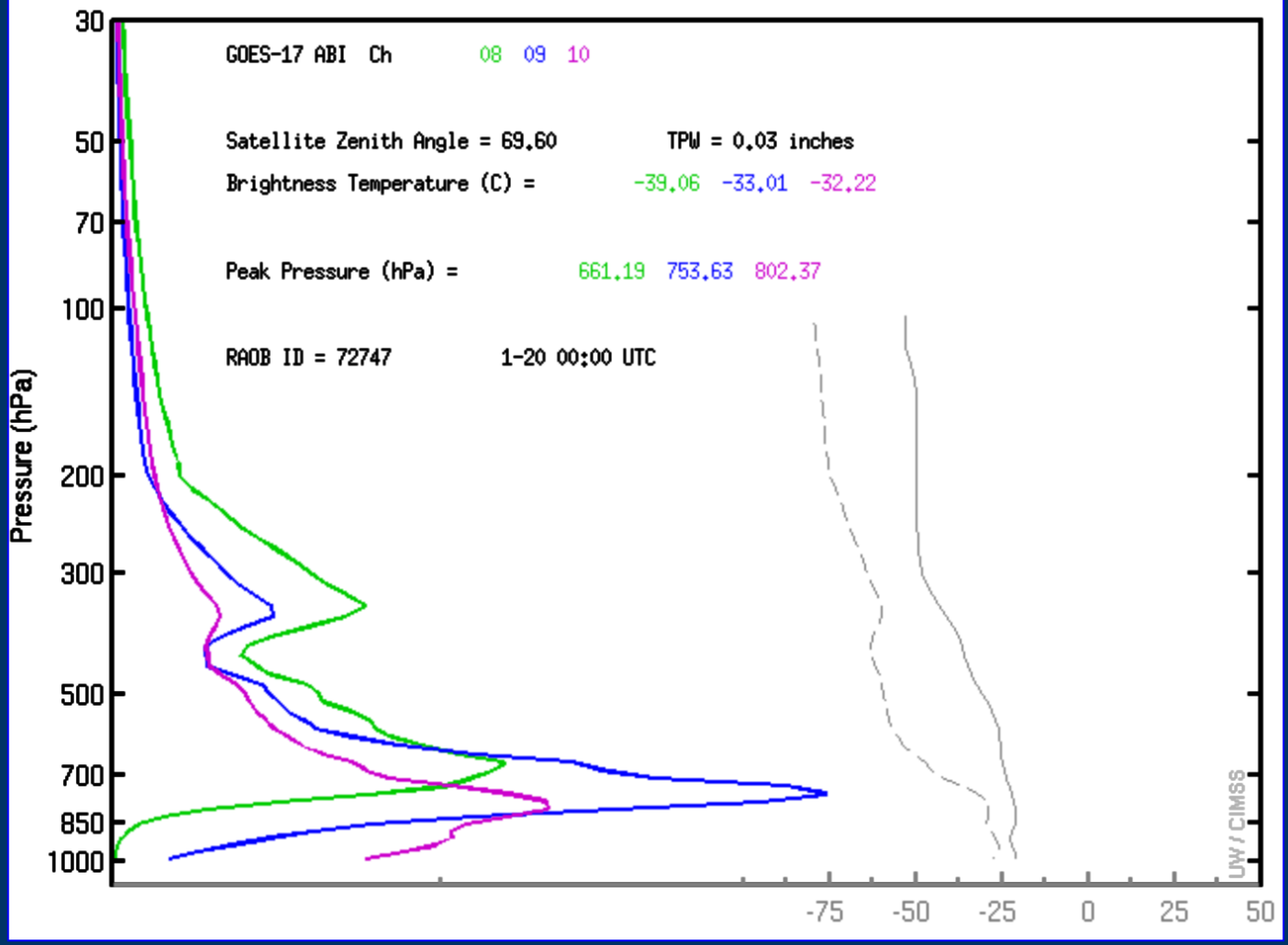
KINL - Intl Falls, MN 48:33:43N 93:23:52W 361m

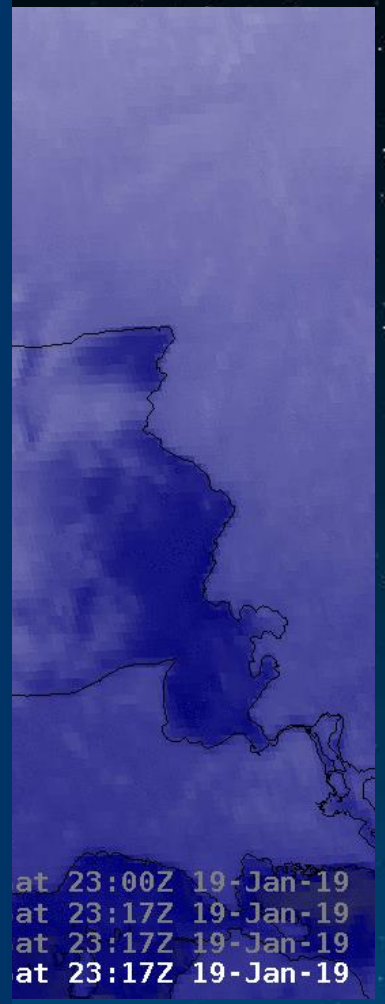
cold too)

imagery

ABI Bands:
- [ ] 7 (3.9 μm)
- [x] 8 (6.2 μm)
- [x] 9 (6.9 μm)
- [x] 10 (7.3 μm)
- [ ] 11 (8.4 μm)
- [ ] 12 (9.6 μm)
- [ ] 13 (10.3 μm)
- [ ] 14 (11.2 μm)
- [ ] 15 (12.3 μm)
- [ ] 16 (13.3 μm)

Profile:
- [x] Temperature (C)
- [x] Dew Point (C)
- [ ] Mixing Ratio (g/kg)

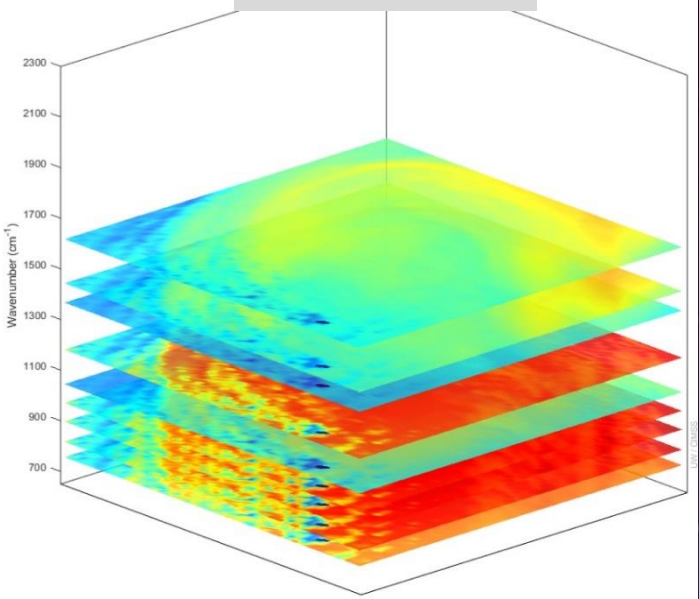




More spectral bands means more temperature/moisture information in the vertical

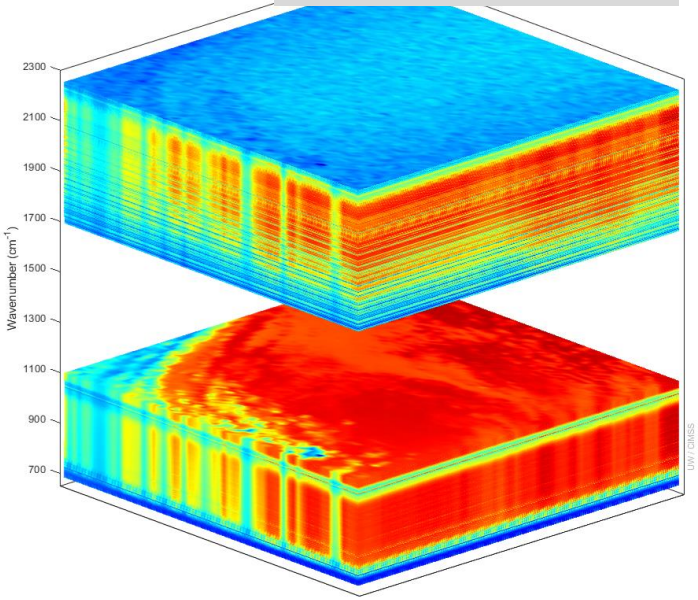
ABI

9 ABI IR Bands



GXS

1000s of GXS Bands



The weighting functions mean that 3 (overlapping) moisture layers are resolved (i

There are more than six times (temperature) and four times (moisture) of number of independent pieces of vertical information in this proposed sounder compared

nes more for thin clouds.)

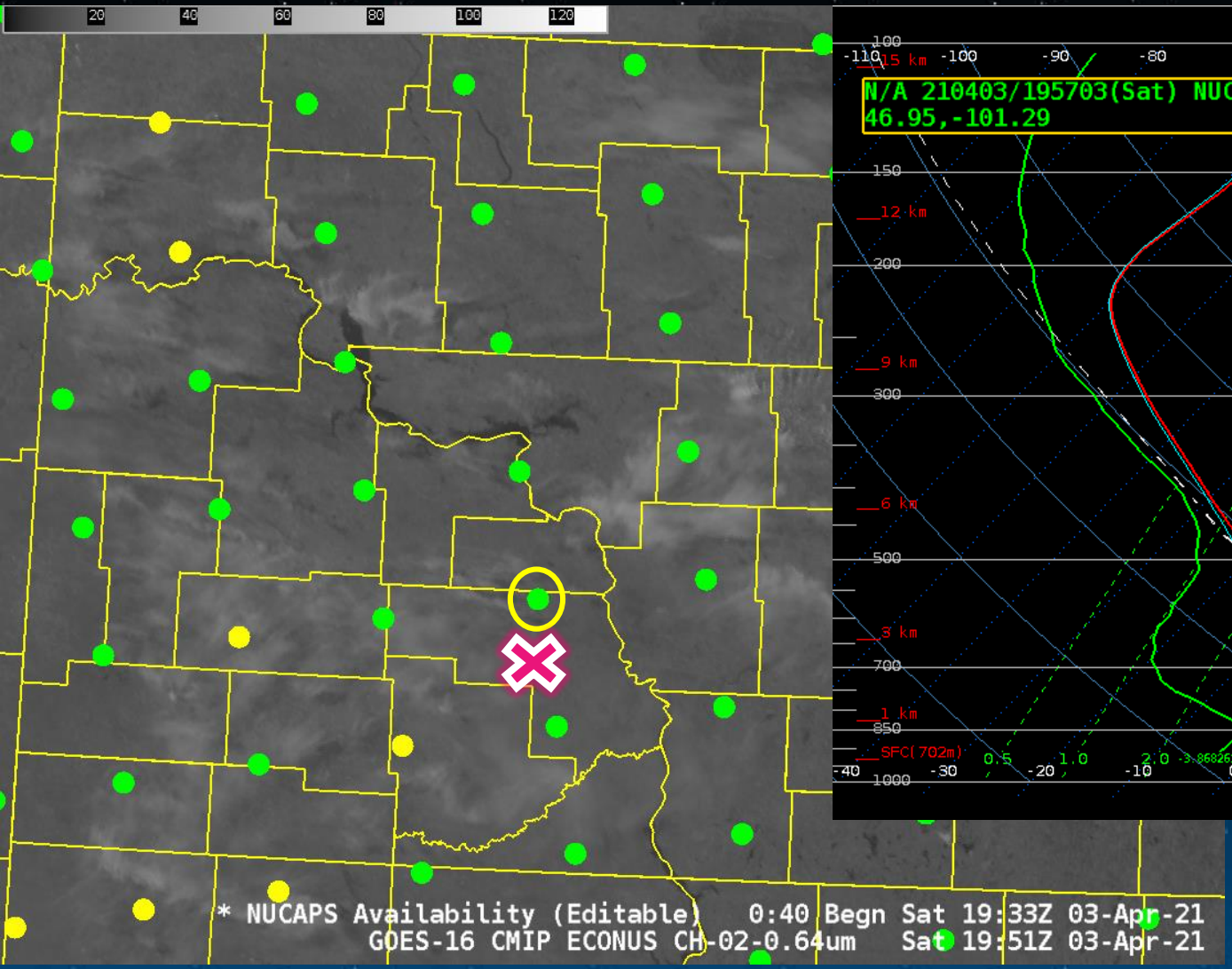
Number of Independent Pieces of Vertical Information		
	GXS	ABI
Temperature	13	2
Moisture	11	2.5

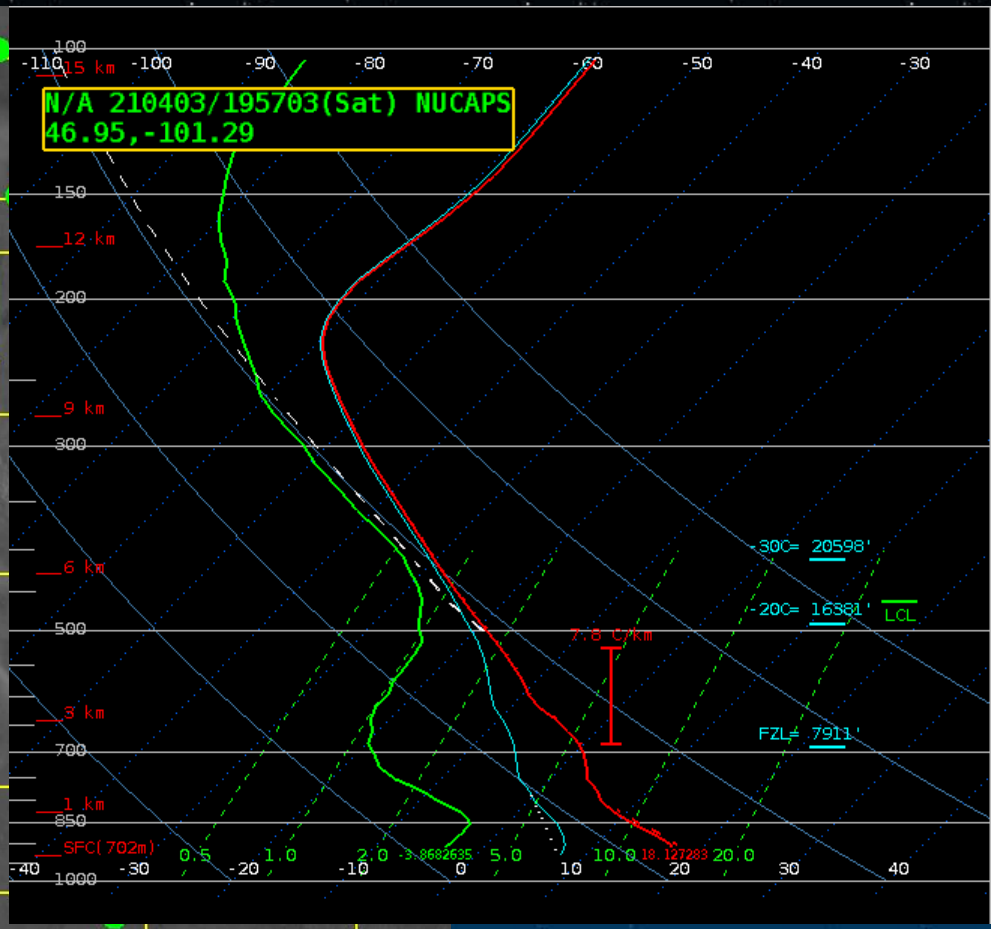
Slido Question 4:
What could you use Sounder information for?

Sounder data is in three dimensions

- You can show vertical profiles of information
- You can show horizontal fields of information

Example of using temperature/moisture data to determine environment

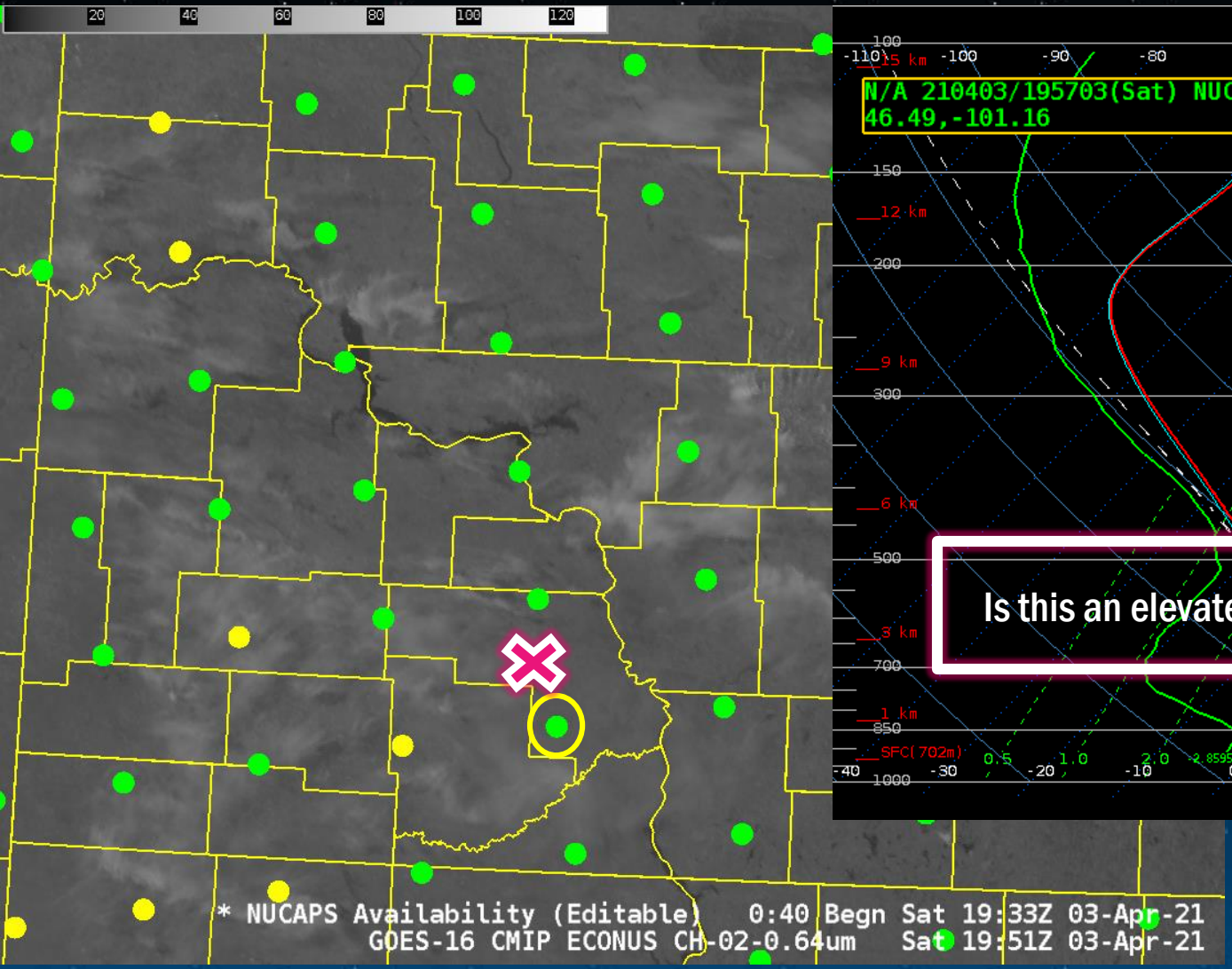


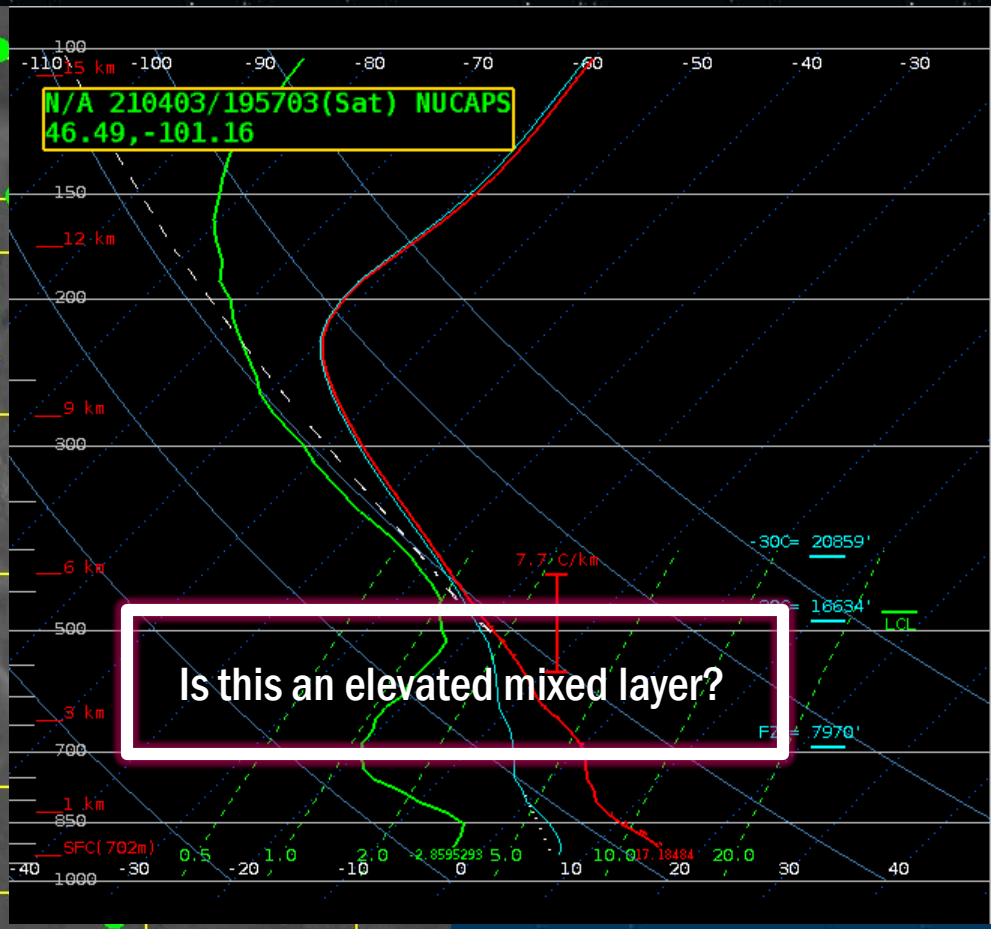


Retrieved Soundings from near a fire location ( )

Cooperative Institute for Meteorological Satellite Studies
University of Wisconsin - Madison

Example of using temperature/moisture data to determine environment

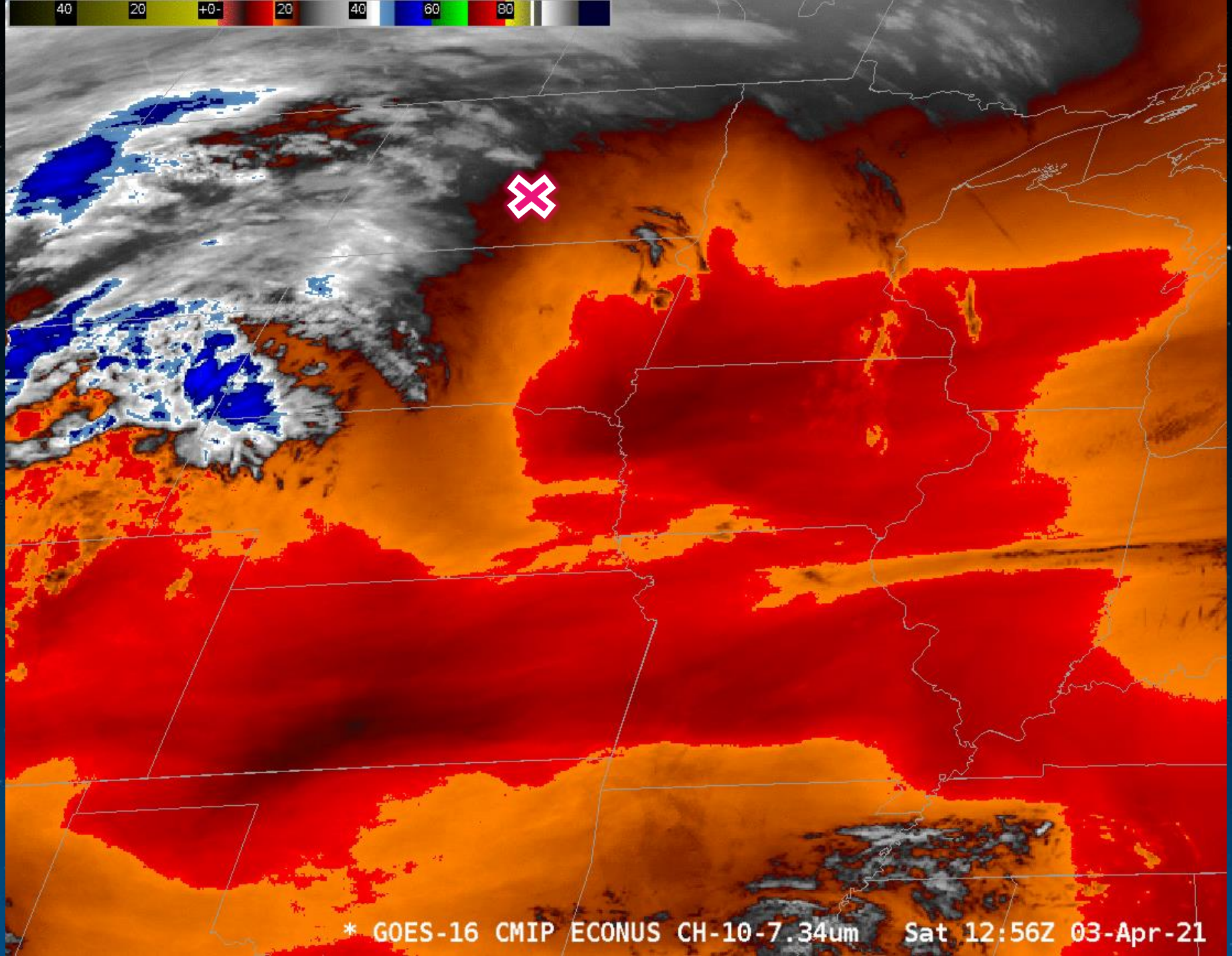




What does the Imager show?

Retrieved Soundings from near a fire location ( )

Cooperative Institute for Meteorological Satellite Studies
University of Wisconsin - Madison


40
20
+0-
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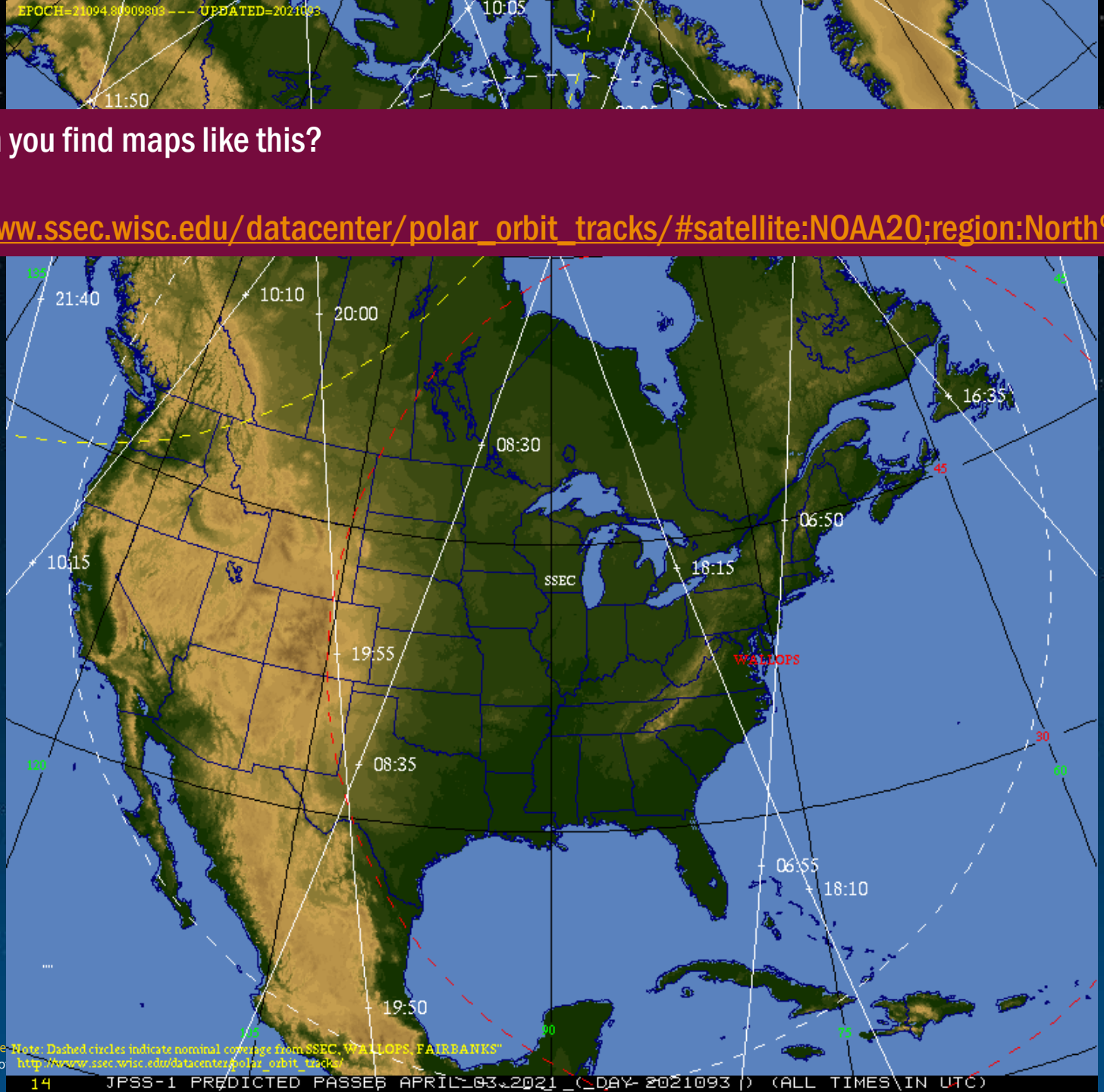
80
* GOES-16 CMIP ECONUS CH-10-7.34um Sat 12:56Z 03-Apr-21

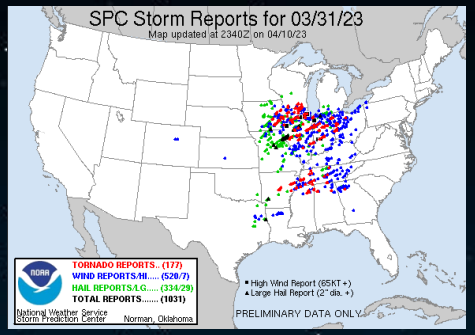
Where can you find maps like this?

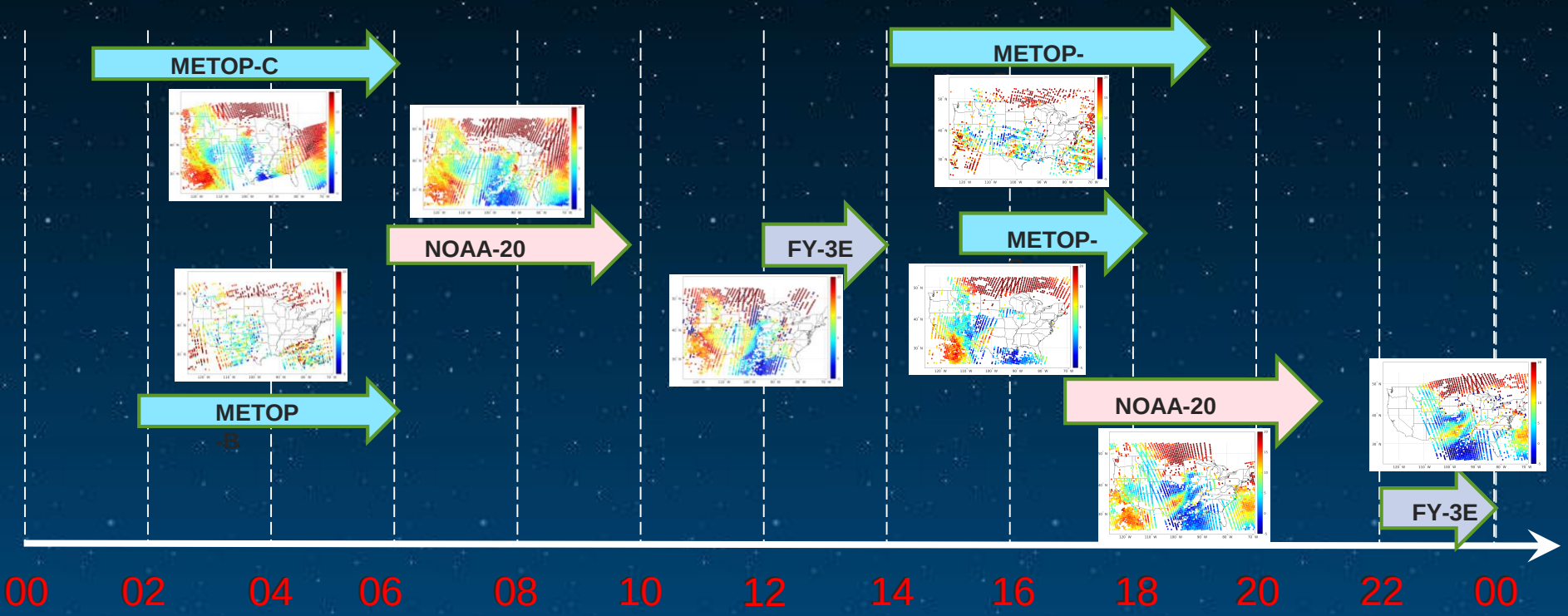
https://www.ssec.wisc.edu/datacenter/polar_orbit_tracks/#satellite:NOAA20;region:North%20America;

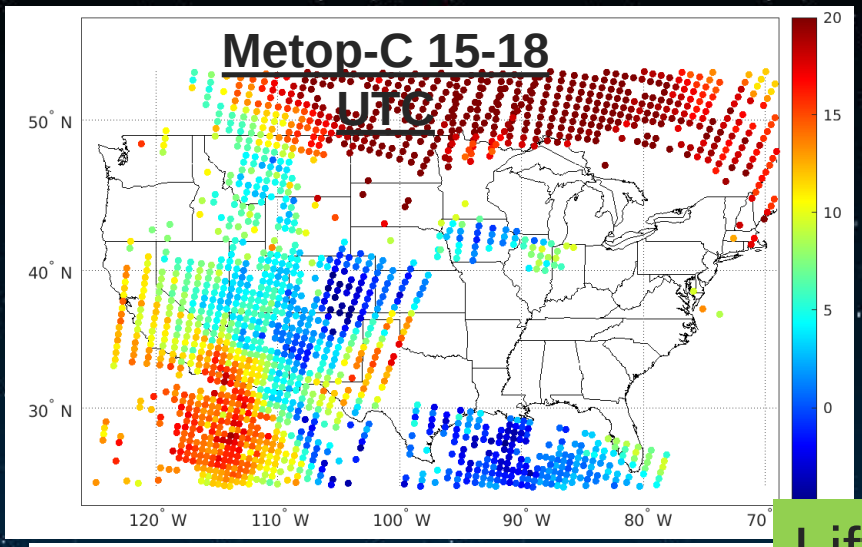


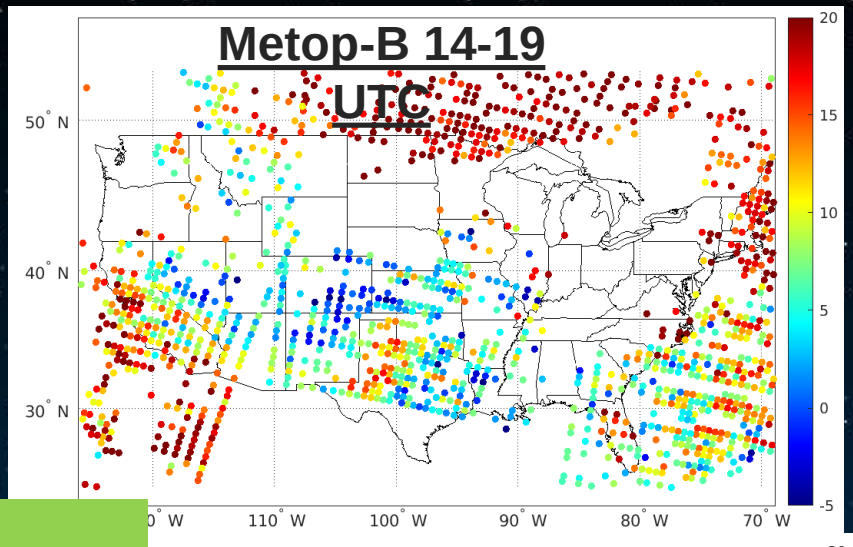
Satellite overpass time over CONUS on 31 March 2023

Early morning FY-3E sounding profiles to fill in the temporal gap!

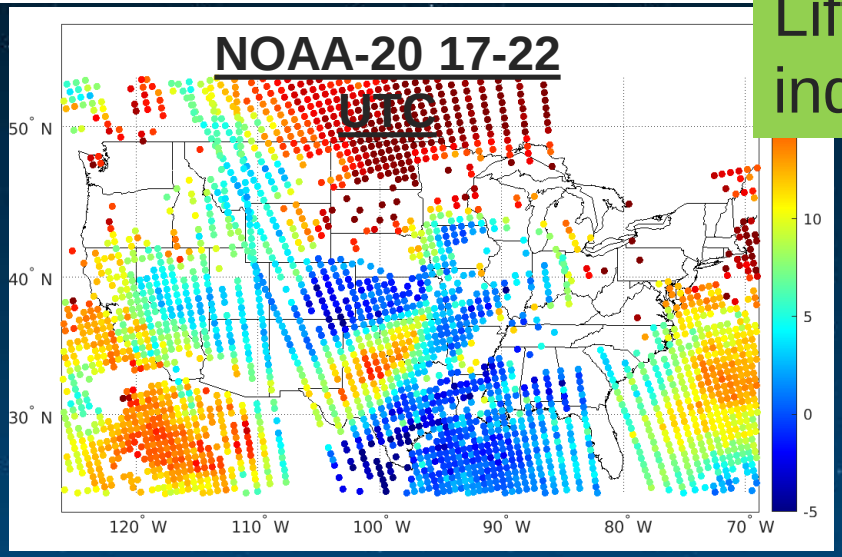


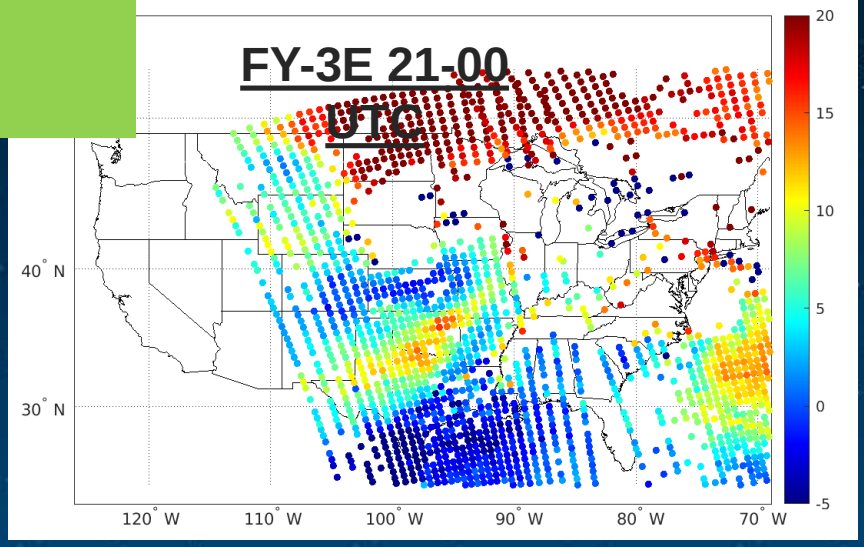






Lifted index



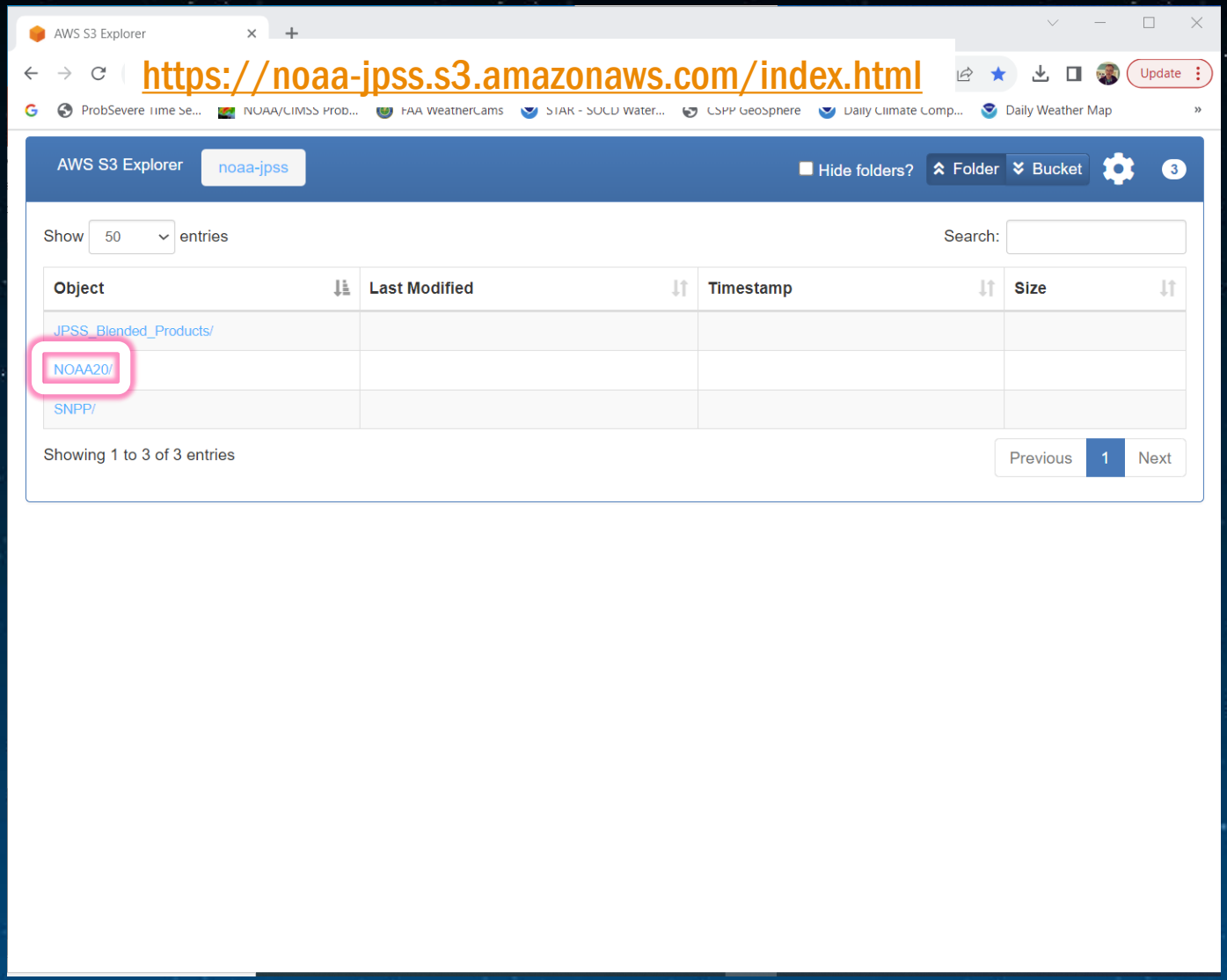


All that data on the previous page: Observed from satellite

- No need to worry about model biases or bad initialization
- However, infrared sounder data doesn't give great information where clouds are in the way

NOAA-20 (and Suomi NPP) sounding data are available online

https://noaa-jpss.s3.amazonaws.com/index.html



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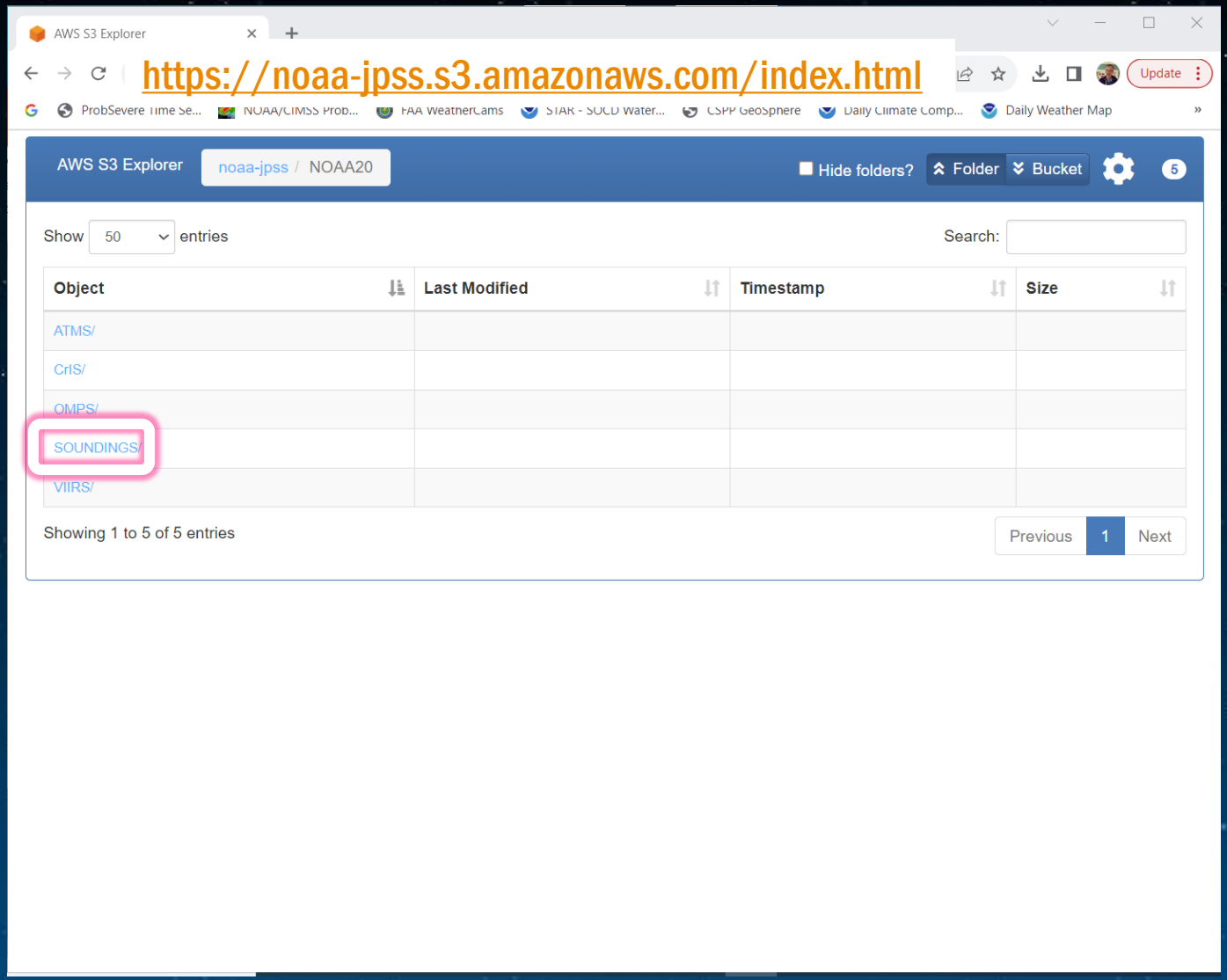

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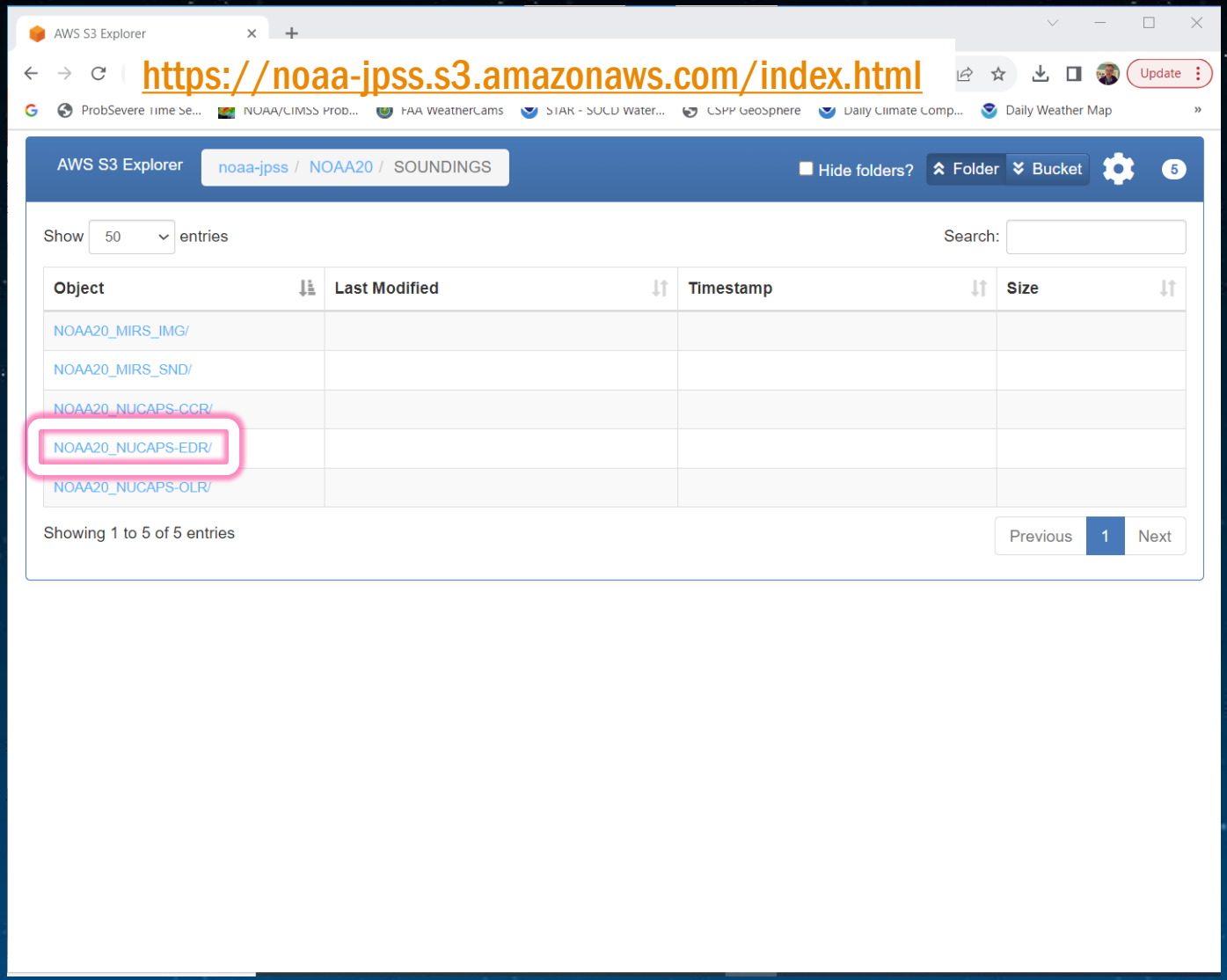

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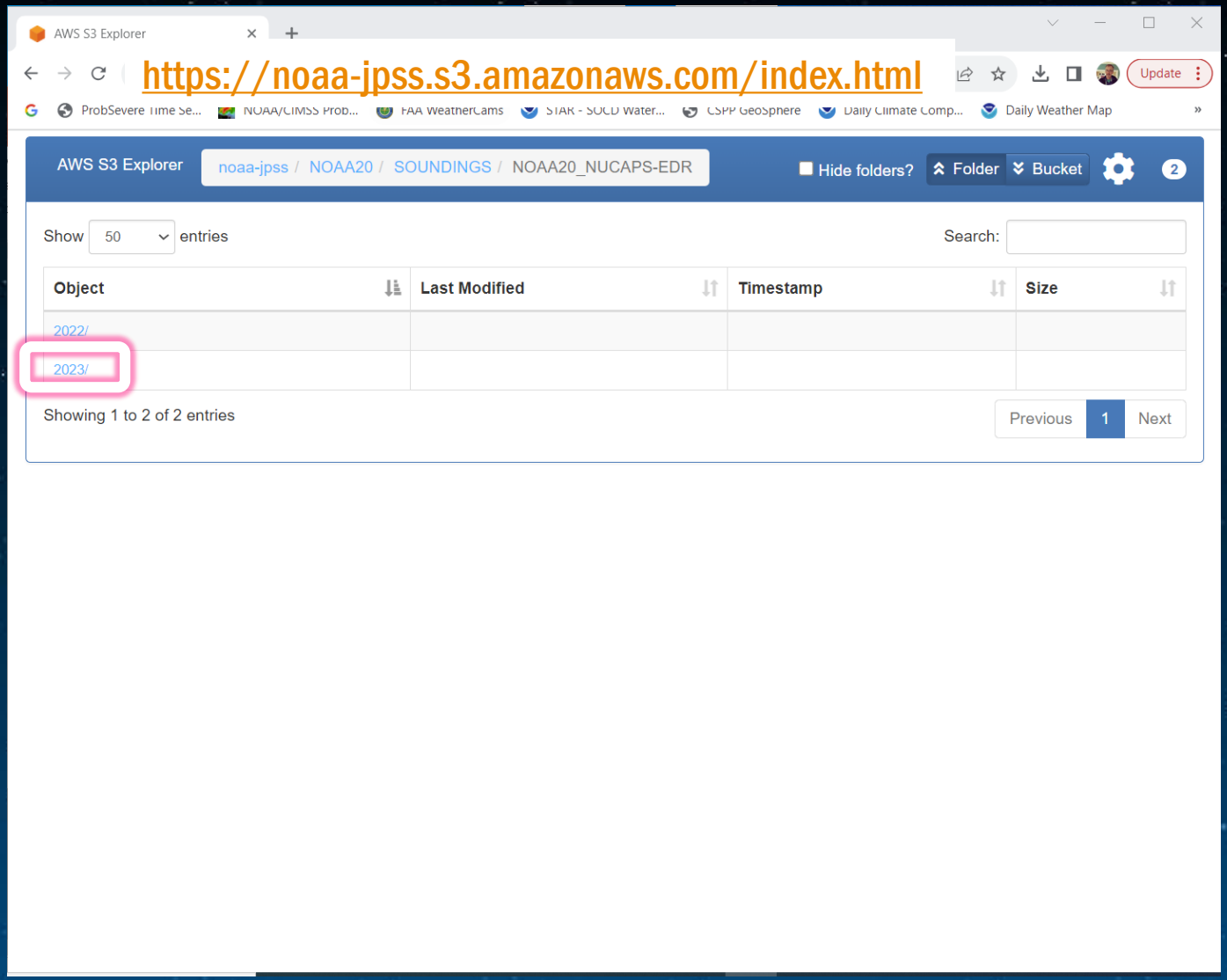

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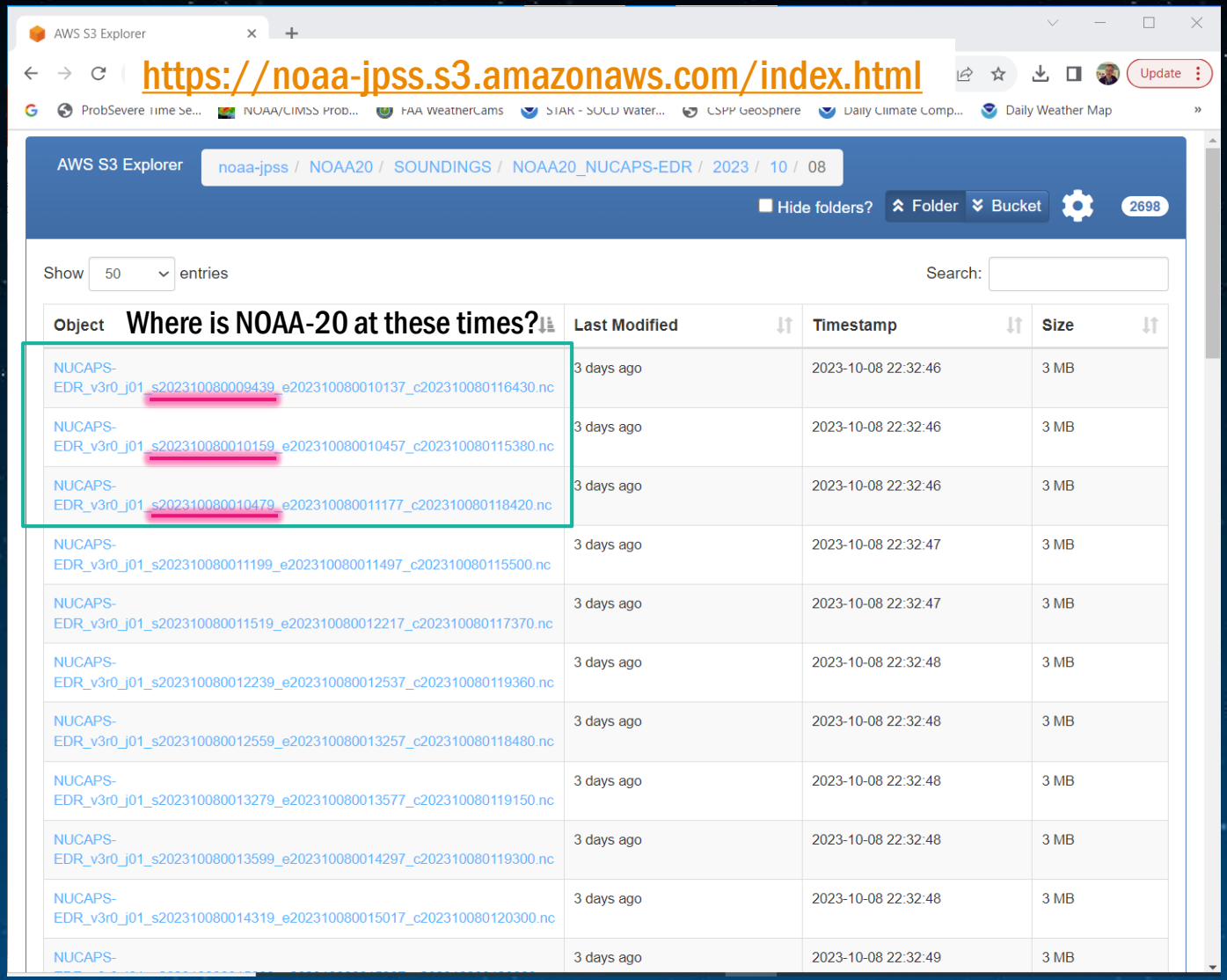
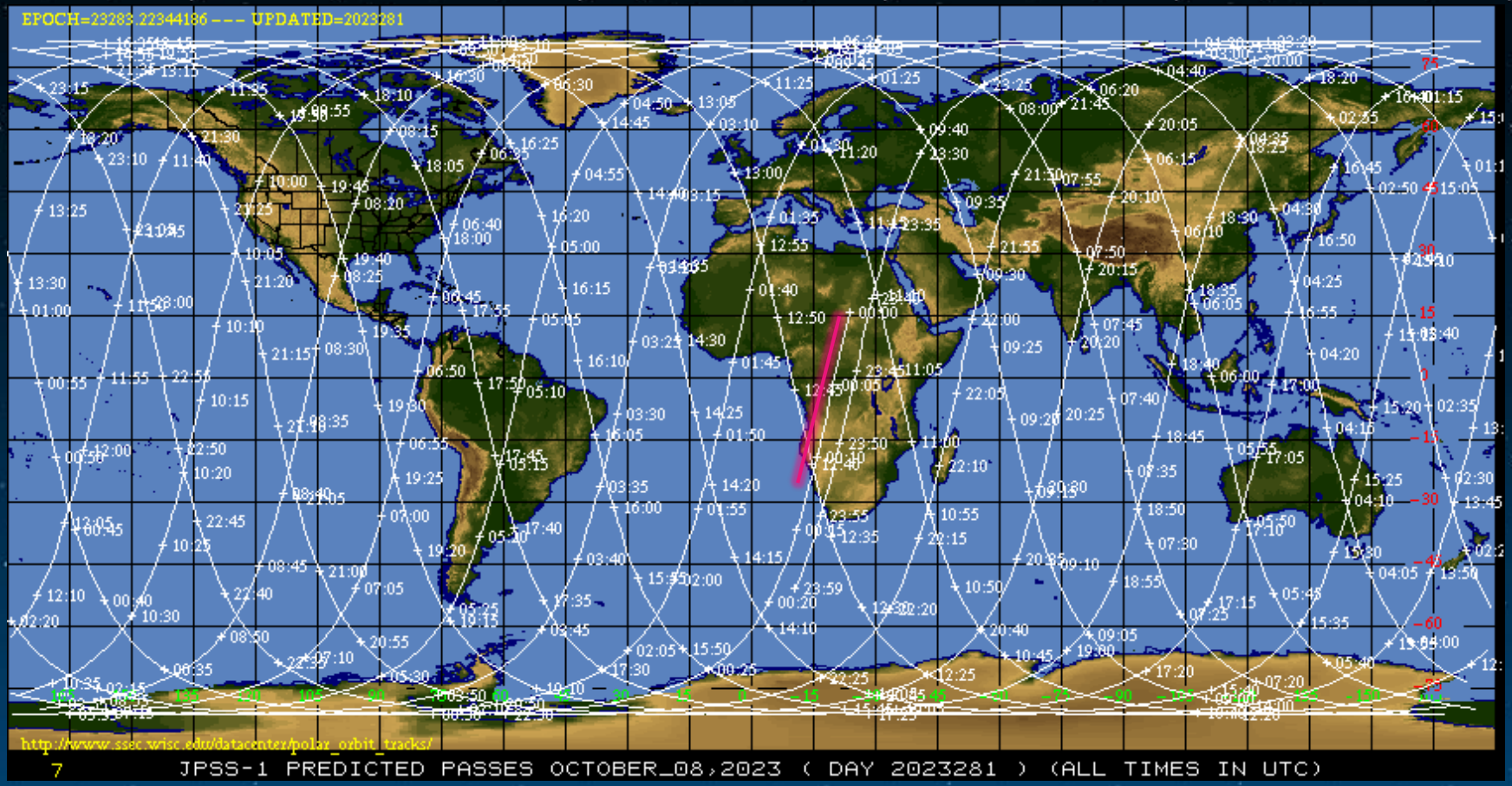


Find orbit paths online



https://www.ssec.wisc.edu/datacenter/polar_orbit_tracks/

How timely are the data at that website?

NUCAPS-EDR_v3r0_j01_s202310112122159_e202310112122457_c202310112155280.nc	a few seconds ago	2023-10-12 19:12:01	3 MB
NUCAPS-EDR_v3r0_j01_s202310112122479_e202310112123177_c202310112156480.nc	a few seconds ago	2023-10-12 19:12:02	3 MB
NUCAPS-EDR_v3r0_j01_s202310112122479_e202310112123177_c202310112156480.nc	a few seconds ago	2023-10-12 19:12:02	3 MB

Data from 2122 UTC on 11 October!

Written at 19:12 on 12 October
(or – 0012 UTC on 13 October)

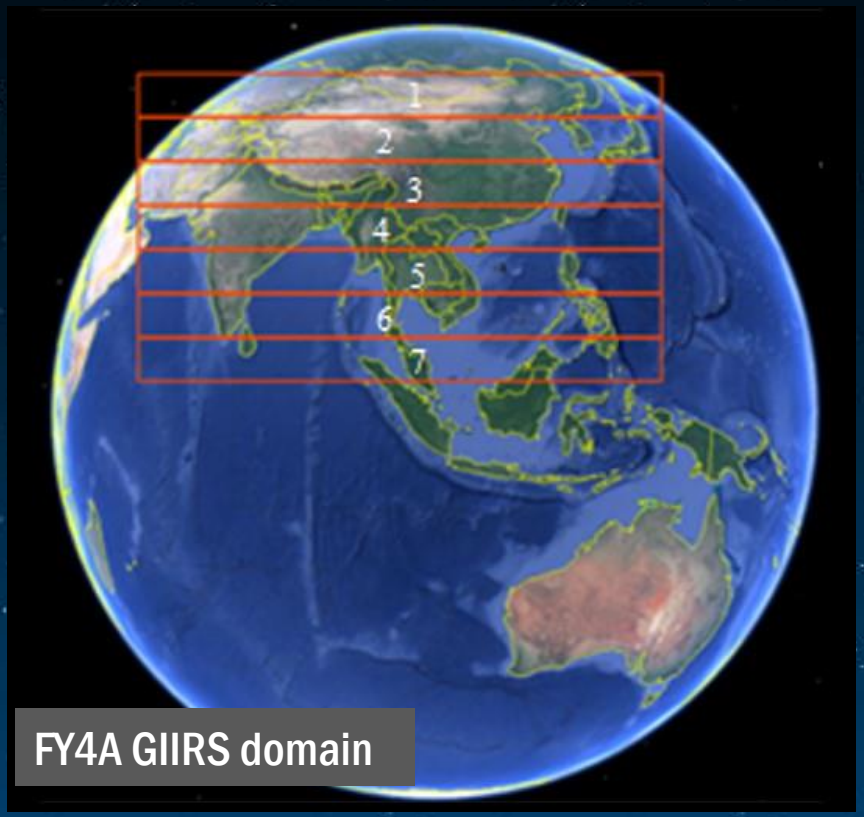
Conclusion: Data aren't useful for real-time, but are useful for post-storm analysis

Geostationary Sounders

- Constantly view one region (typically not full disk)
  - GIIRS (FY-4B) views
    - a 5000x5000 km China domain in 45 minutes
    - a 1000x1000 km meso domain in 15 minutes

- Direct link to website to view products: https://satellite.nsmc.org.cn/PortalSite/Data/DataView.aspx?SatelliteCode=FY4B&SatelliteType=1&InstrumentTypeCode=GIIRS&currentculture=en-US

Where does GIIRS view?



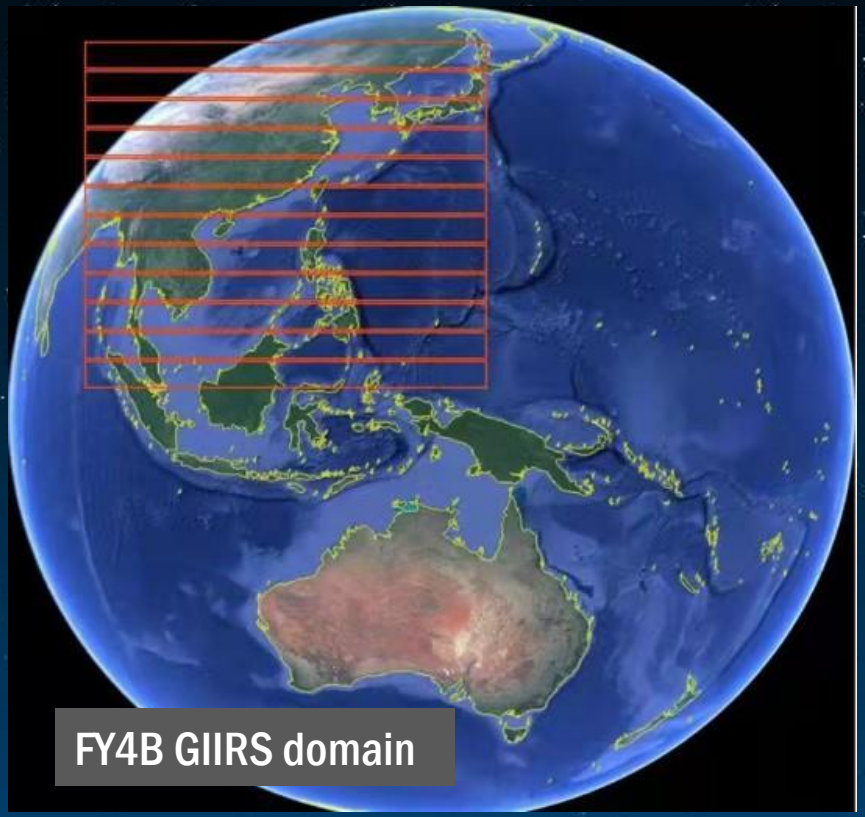
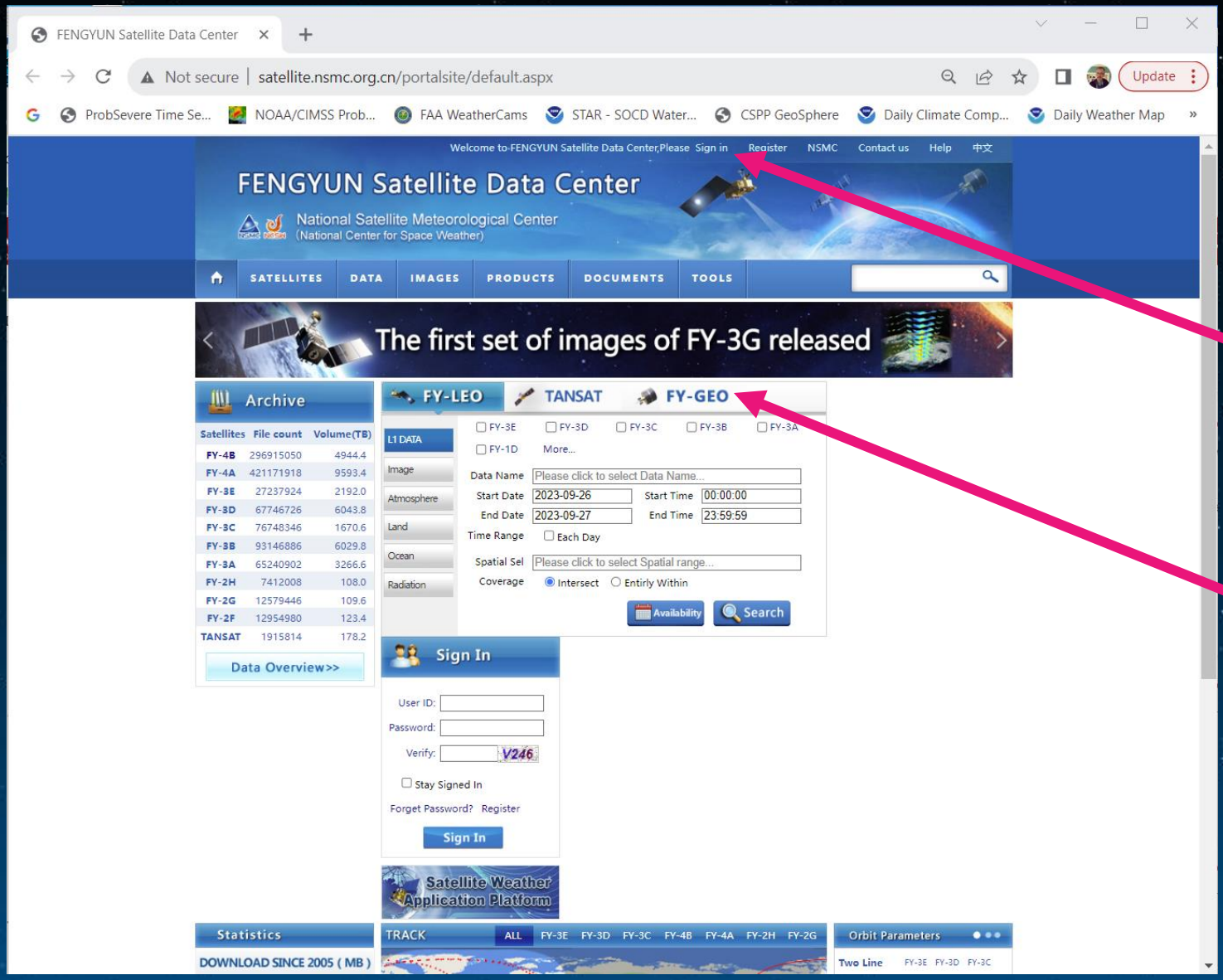


Image Source

How to get GIIRS data

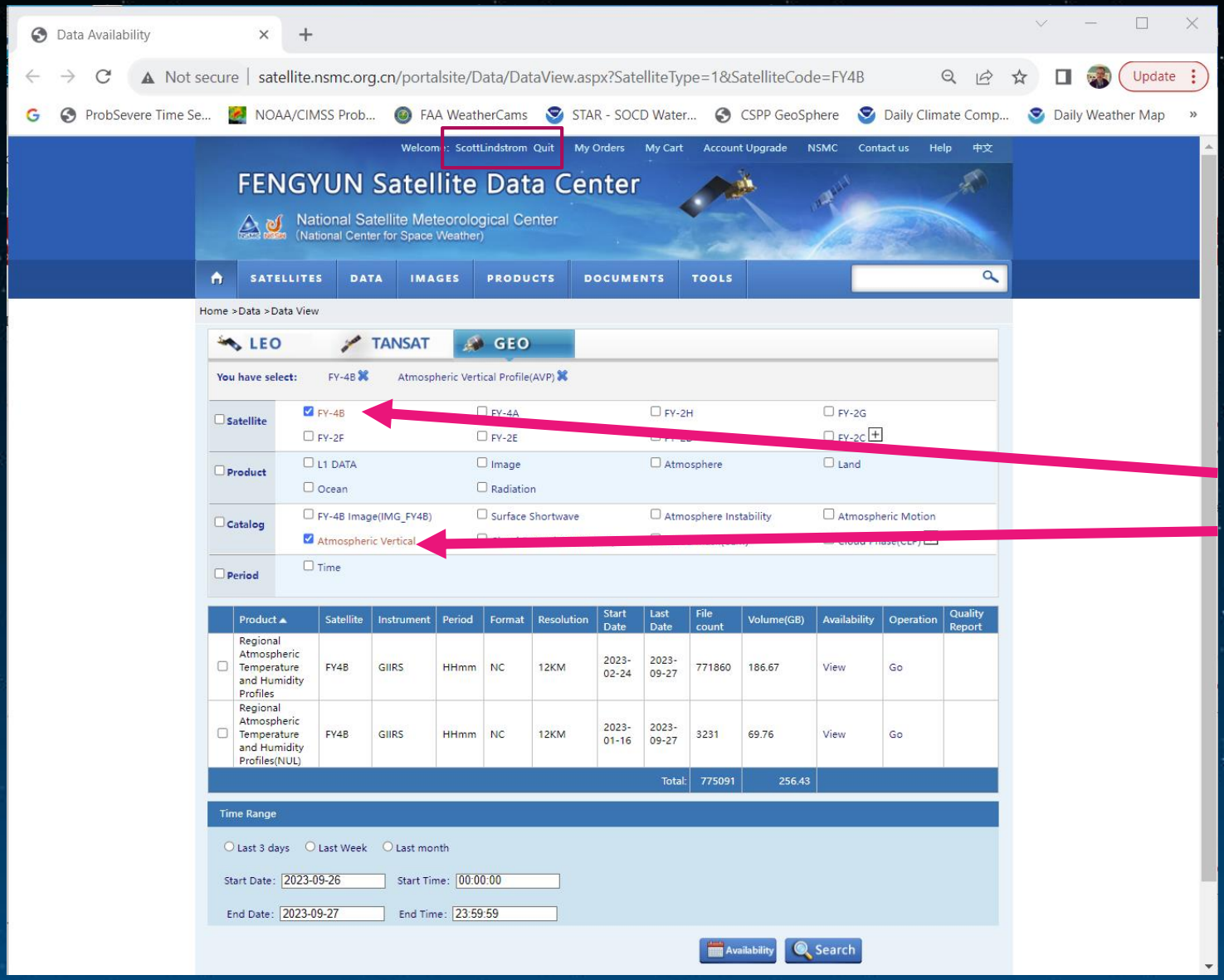


Create a User Presence

(or log in!)

We want to access GEO

How to get GIIRS data

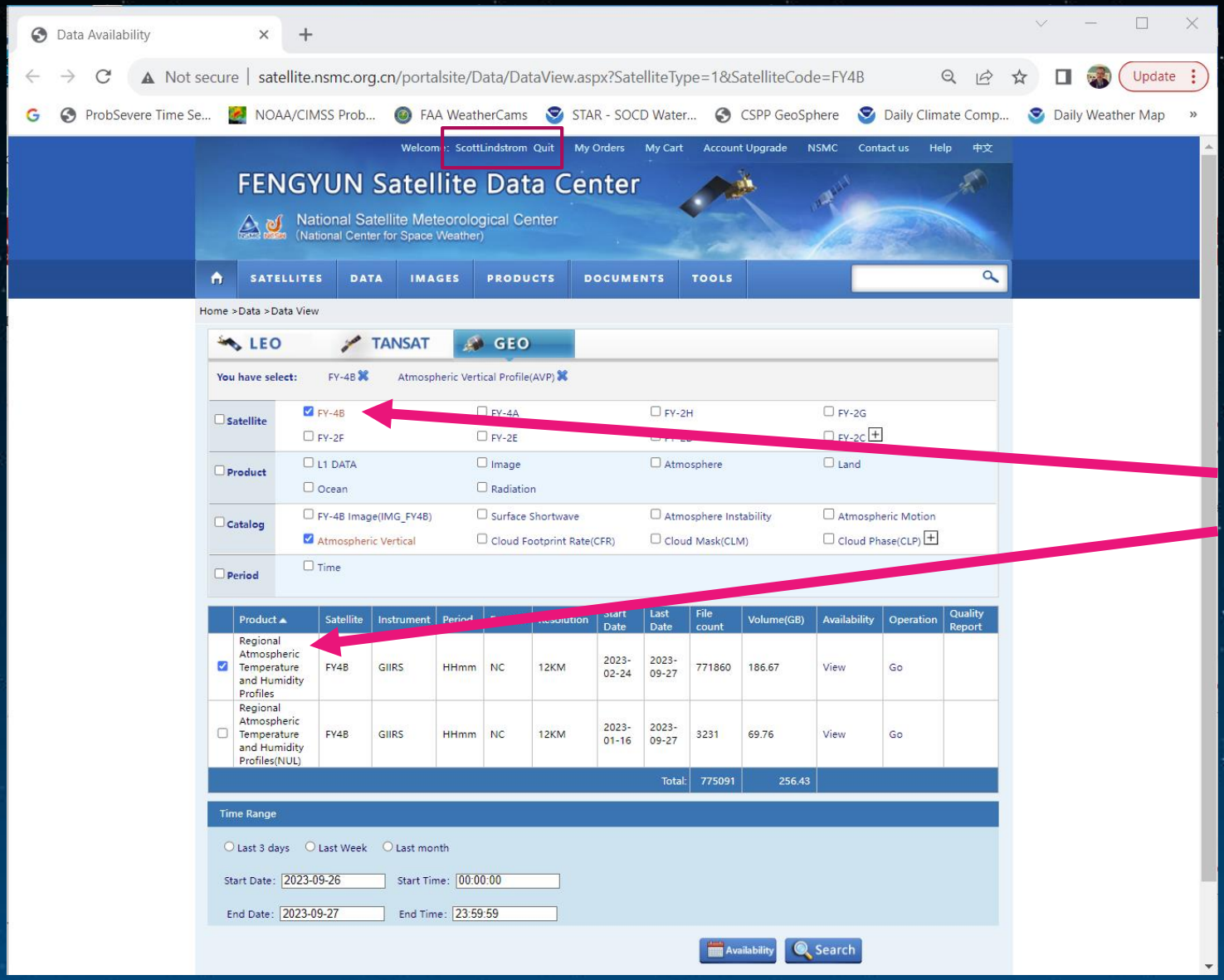


Choose what you want

Satellite

Data

How to get GIIRS data



Choose what you want

Satellite Data

Start/end Data as shown

How to get GIIRS data

Your Order(A202309270380921291) has been prepared

由于本站临时数据存储空间有限，您的订单将在线保存3天，之后系统将自动删除，请您及时下载数据。

您的订单处理结果如下：

订单号	文件总数	成功文件数	错误文件数
A202309270380921291	8	8	0

Email tells you where the data are

再次感谢您使用本站提供的相关数据！

邮件发送时间2023年09月27日 14时37分37秒(世界时)

Dear ScottLindstrom:

Your Order(Order ID is A202309270380921291)has been prepared on 2023-09-27 14:37:37(UTC). Welcome to use " FY Satellite Data Download Toolkit " that helps you to automatically download the satellite data.

You can also pick up your data set via ftp://A202309270380921291:MOcihS8_@ftp.nsmc.org.cn . Please download these files within 3 Days.

Order ID	Total Files	Available Files	Unavailable Files
A202309270380921291	8	8	0

Thank you.

EMail sending time 2023-09-27 14:37:37(UTC)

Email tells you where the data are

ftp server at ftp.nmsc.org.cn
User name: A202309270380921291
Password: MOcihS8_
(this changes with every order!!)

List of netCDF files (downloading takes a while)

```
variables:
        float Geo_Hgt(z, x, y) ;
                Geo_Hgt:long_name = "GIIRS L2 AVP: AVP vectorGeopotential Height" ;
                Geo_Hgt:standard_name = "Geopotential Height" ;
                Geo_Hgt:_Unsigned = "FALSE" ;
                Geo_Hgt:FillValue = -999999.f ;
netcdf FY4B-_GIIRS-_N_REGC_1330E_L2-_AVP-_MULT_NUL_20230917000328_20230917002945_012KM_V0001 {
dimensions:
        z = 101 ;
        x = 64 ;
        y = 216 ;
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                AT_Prof:scale_factor = 1.f ;
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                AT_Prof:units = "K" ;
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                AT_Prof:Description = "" ;
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                AQ_Prof:scale_factor = 1.f ;
                AQ_Prof:add_offset = 0.f ;
                AQ_Prof:units = "g/kg" ;
                AQ_Prof:resolution = "12KM" ;
                AQ_Prof:coordinates = "z,x,y" ;
                AQ_Prof:ancillary_variables = "NULL" ;
                AQ_Prof:Description = "" ;
```

z Dimension: Levels in RTM ; x: cross-track ; y: along-track

There's also a Quality Flag variable

GIIRS and AGRI and GHI possibilities

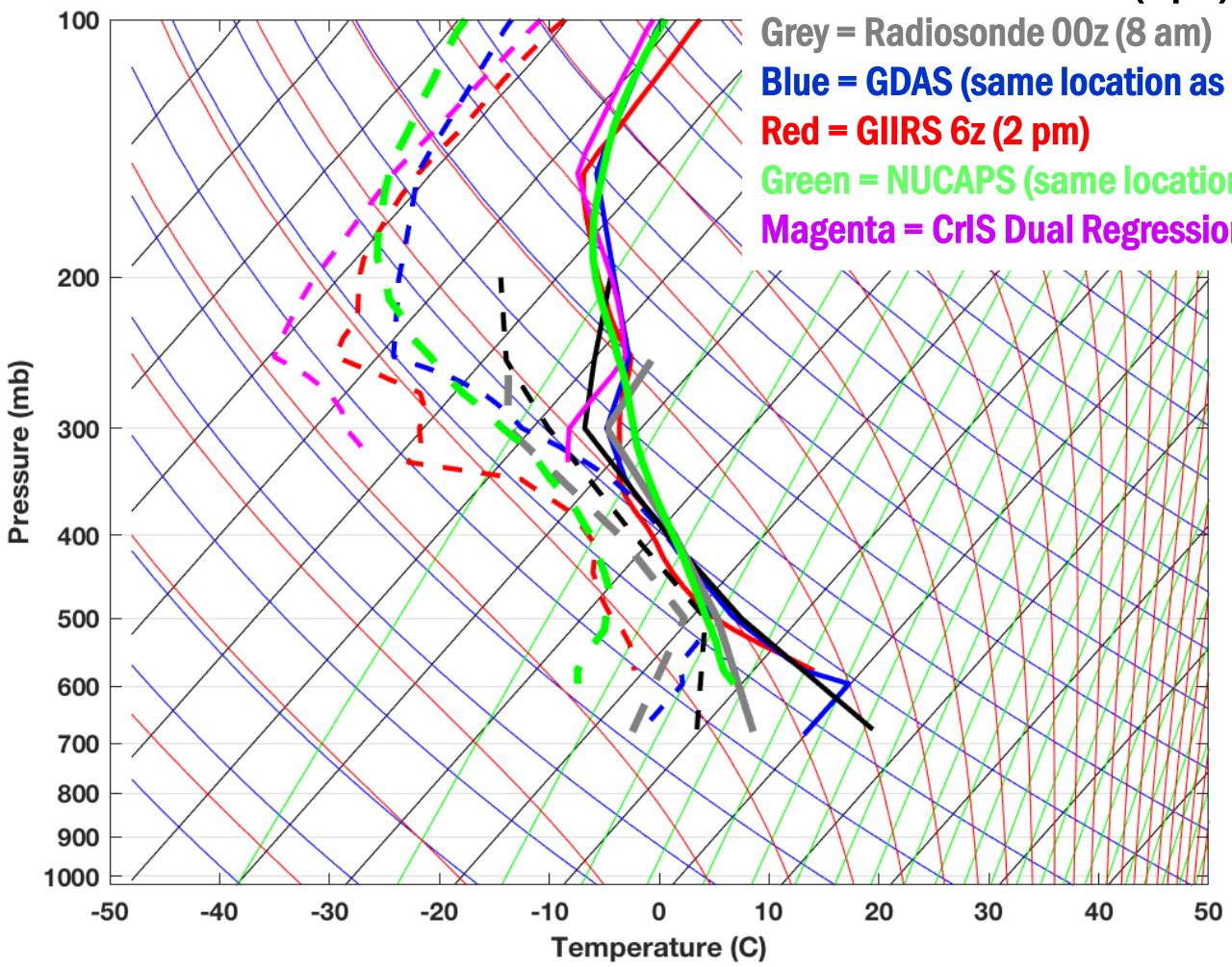
	product,Full Disk											
☐	Atmosphere Instability Index,REGC (NUL)	FY4B	GIIRS	HHmm	NC	12KM	2023-01-16	2023-10-11	3408	2.75	View	Go
☐	Regional Atmospheric Temperature and Humidity Profiles(NUL)	FY4B	GIIRS	HHmm	NC	12KM	2023-01-16	2023-10-11	3413	73.26	View	Go
☐	Land Surface Temperature product	FY4B	AGRI	HHmm	NC	4000M	2023-07-17	2023-10-11	8110	12.74	View	Go
☐	Cloud Type product, Full Disk	FY4B	AGRI	HHmm	NC	4000M	2022-08-20	2023-10-11	38872	42.69	View	Go
☐	Regional Atmospheric Temperature and Humidity Profiles	FY4B	GIIRS	HHmm	NC	12KM	2023-02-24	2023-10-11	823015	198.41	View	Go
☐	Surface Shortwave Radiation product	FY4B	AGRI	HHmm	NC	4000M	2023-07-17	2023-10-11	8110	465.86	View	Go
☐	Atmosphere Instability Index,REGC	FY4B	GIIRS	HHmm	NC	12KM	2023-02-24	2023-10-11	823151	80.94	View	Go
☐	Ocean Aerosol product	FY4B	AGRI	HHmm	NC	4000M	2023-07-17	2023-10-11	8111	61.4	View	Go
☐	Reflected Shortwave Radiation product	FY4B	AGRI	HHmm	NC	4000M	2023-07-17	2023-10-11	8110	49.1	View	Go
☐	Snow Cover product	FY4B	AGRI	HHmm	NC	4000M	2023-07-17	2023-10-11	8111	15.51	View	Go
☐	Snow Cover Daily product	FY4B	AGRI	HHmm	NC	4000M	2023-07-17	2023-10-10	86	0.02	View	Go
☐	Sea Surface Temperature monthly product	FY4B	AGRI	HHmm	NC	4000M	2023-08-01	2023-09-01	2	0.05	View	Go
☐	Sea Surface Temperature 5-day product	FY4B	AGRI	HHmm	NC	4000M	2023-07-21	2023-10-01	15	0.39	View	Go
☐	Ozone Profile product	FY4B	GIIRS	HHmm	NC	012KM	2023-07-17	2023-10-11	1064	2.75	View	Go
☐	Ozone Profile product,REGC	FY4B	GIIRS	HHmm	NC	012KM	2023-07-17	2023-10-11	301455	31.49	View	Go
☐	Cloud Phase product, Full Disk	FY4B	AGRI	HHmm	NC	4000M	2022-08-20	2023-10-11	38869	40.35	View	Go
☐	GHI L1 Regional, 2KM	FY4B	GHI	HHmm	HDF	2000M	2022-06-01	2023-10-11	448065	2260.79	View	Go

What's the problem with the above?

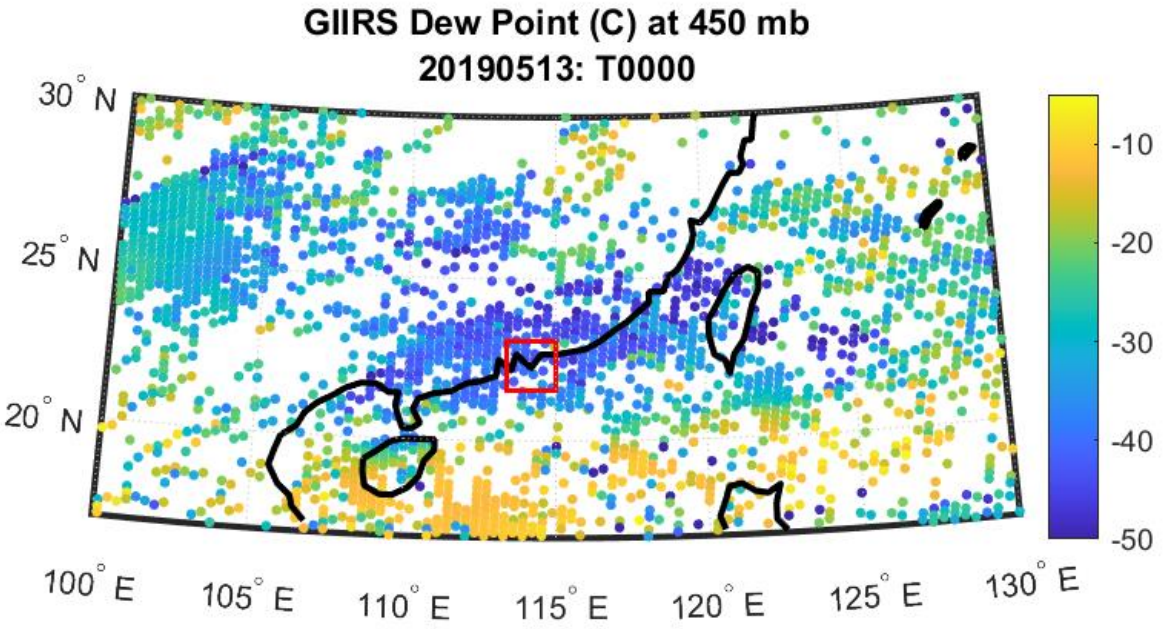
- You cannot automate this
  - Access requires you to go to the website, and order the data, and then go get it!
  - Maybe there are inter-governmental agreements out there that I don't know about that allow a quick transfer of data if it is taken over your region of interest

- Ask your bosses to streamline data access for Geo Sounder data, or from polar orbiting sounder data

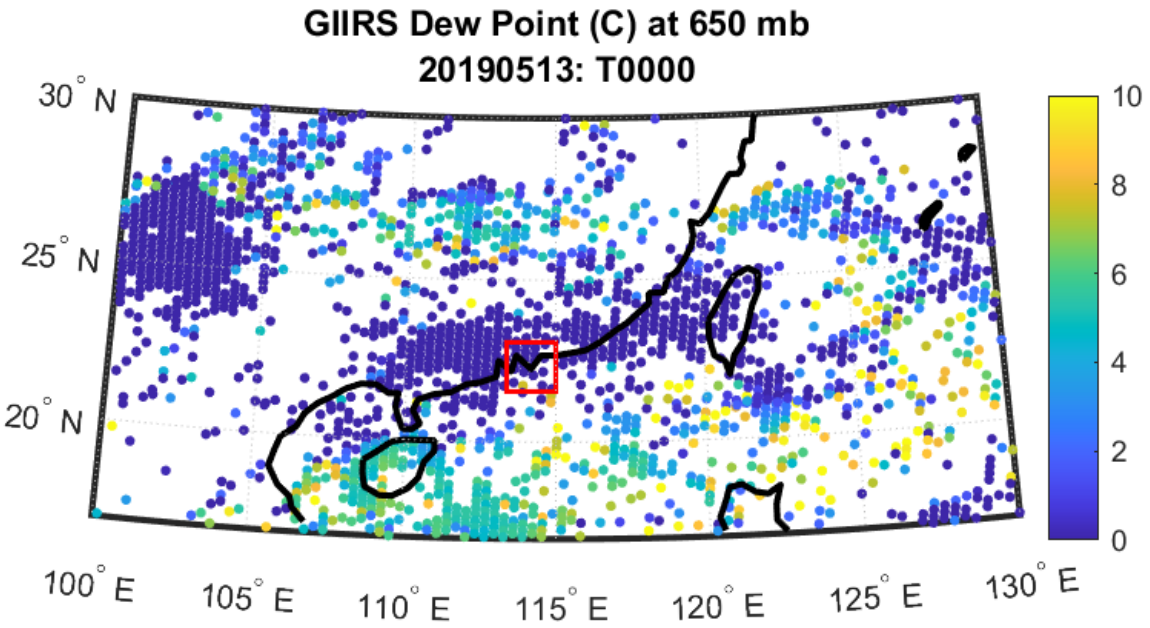
GIIRS Sounding



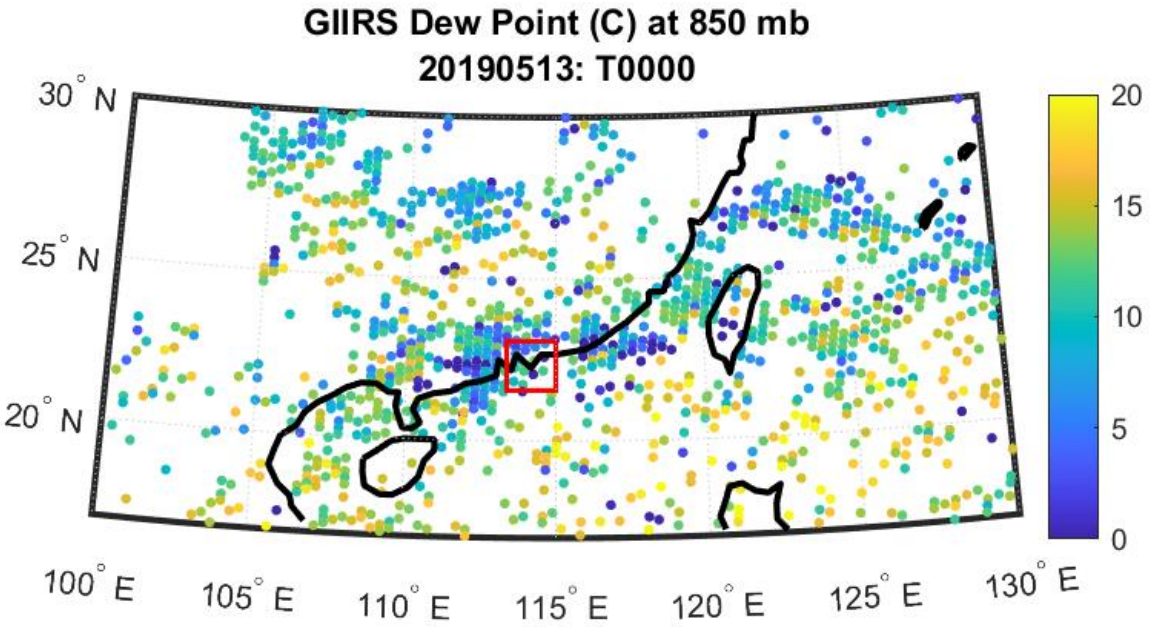
Derived GIIRS dewpoint at 450 mb



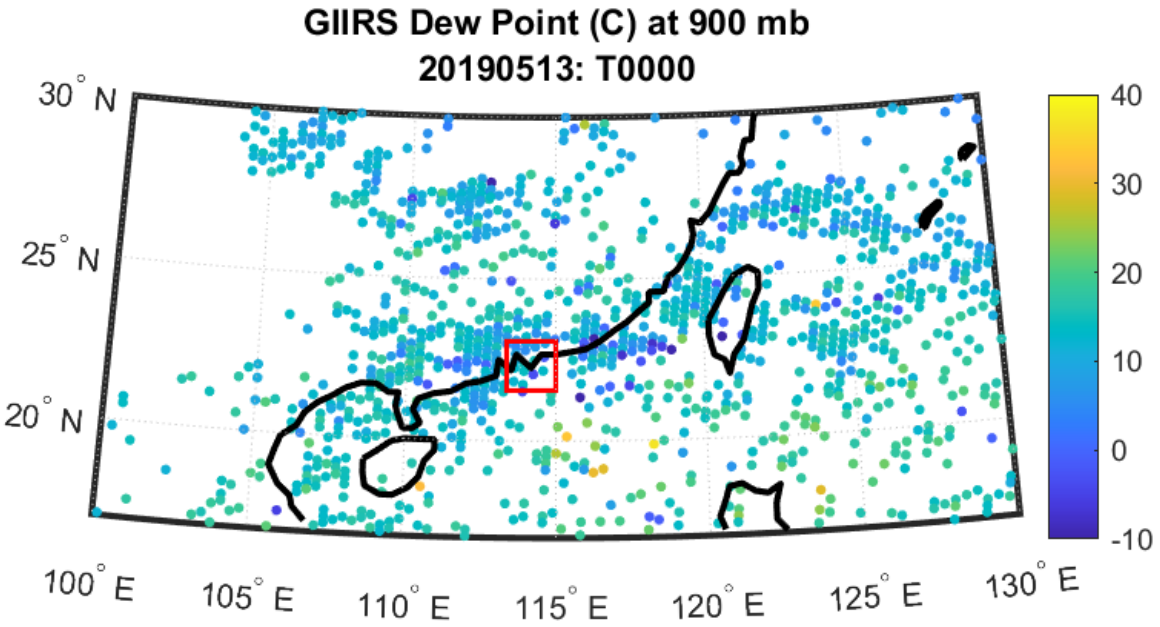
Derived GIIRS dewpoint at 650 mb



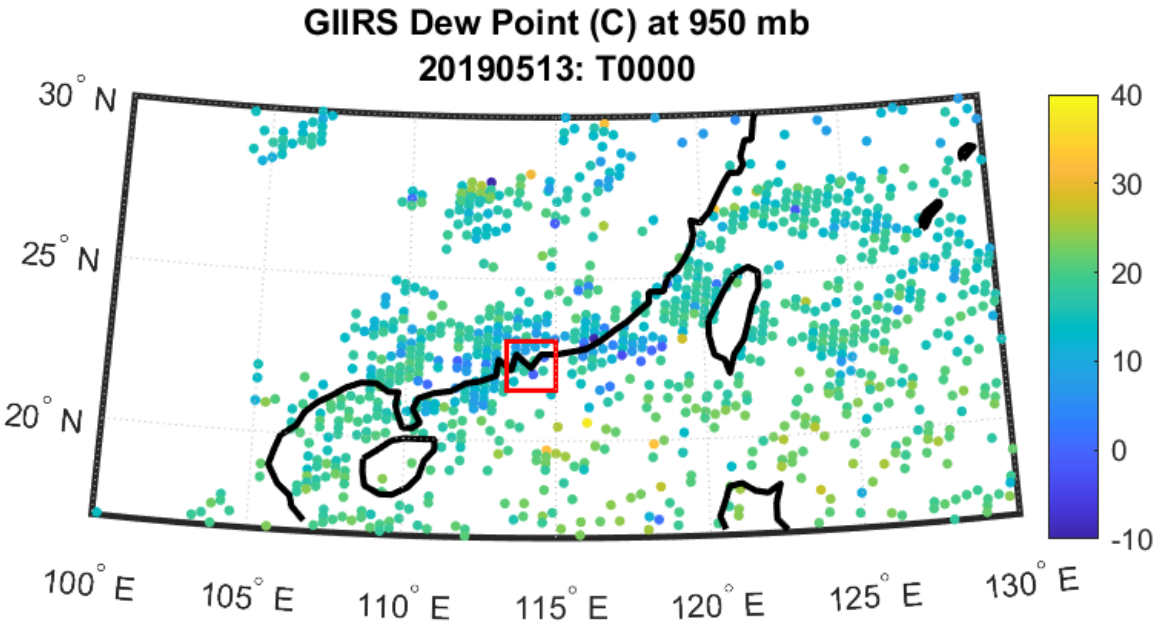
Derived GIIRS dewpoint at 850 mb



Derived GIIRS dewpoint at 900 mb



Derived GIIRS dewpoint at 950 mb



Satellite Observations

- These are current observations
- They give you information that is different from a model simulation/forecast
- Can help you fine-tune what you want to investigate
- Can help you better define what is happening right now, and what to expect

Geo Sounders are coming: Get used to using/understanding their data

- MTG-S1 will be launched in 2024:
  - IRS: 4.44-6.25 μm; 8.26 – 14.70 μm
  - Sentinel-4: UV sounder
- Himawari-10 will have GHMS: Geostationary HiMawari Sounder (launch: 2029)
- GeoXO (USA follow-on to GOES-R): mid 2030s

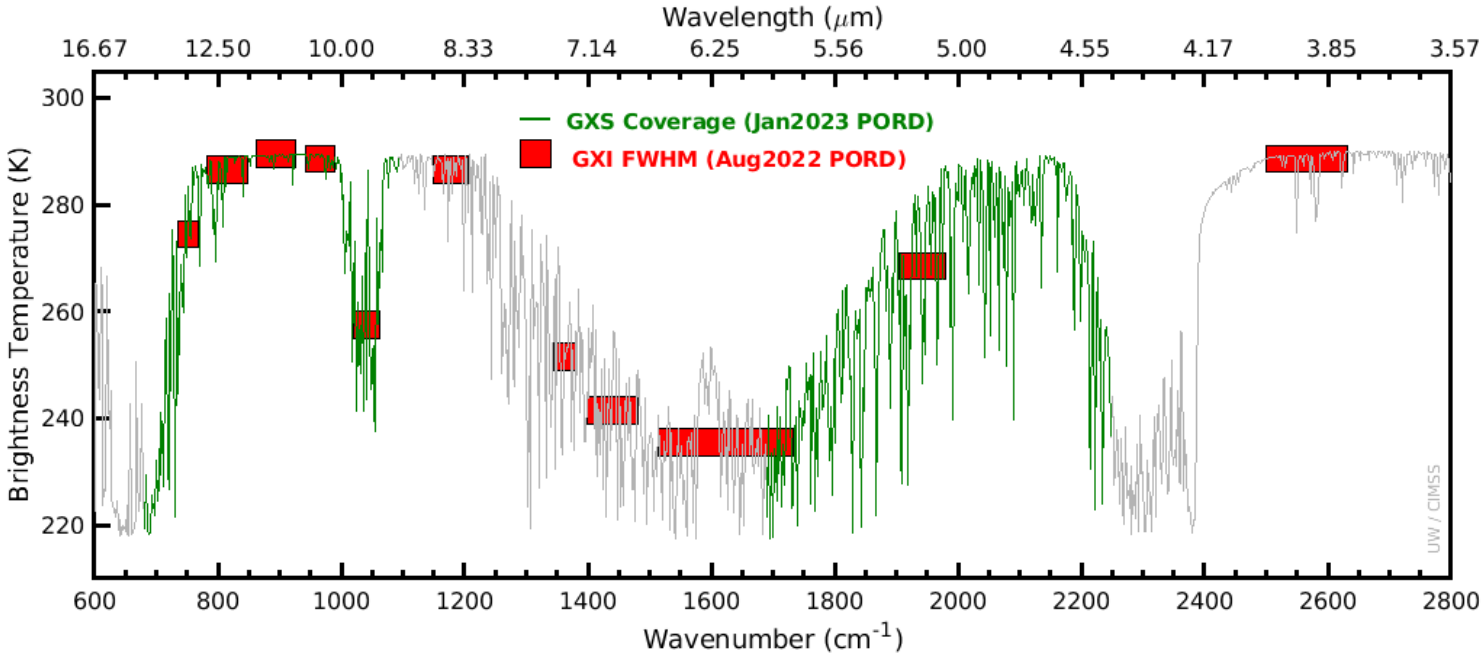
Coming in the 2030s: GXS (Sounder on US Geo Satellite)

Sounding Spectral Range Table

Band	Wavenumber (cm^{-1})	Wavelength (μm)
LWIR region (temperature, LWIR window, ozone, NH3, isoprene, HNO3, low level moisture)	680- 1095	14.7 – 9.13
MWIR region (vertical moisture, window and temperature, N_20 and CO)	1689 – 2250	5.92 – 4.44μm

Maximum Width for Sounding Channels Table

Spectral Range	Wavenumber (cm^{-1}) (FTS)	Wavelength (μm) (Grating)
680- 1095 (cm^{-1}) 14.7 – 9.13 (μm)	0.625	0.0052
1689 – 2250 (cm^{-1}) 5.92 – 4.44 (μm)	0.625	0.0012



IR Sounder Presentations at AOMSUC-13

- S2-14, 7 Nov: 13:45-14:00, Estimate of atmospheric vertical information using FY-4B/GIIRS ; Byung-il Lee ; NMSC/KMA
- S2-25, 7 Nov: 17:00-17:15, Equivalent cloud property retrievals algorithm based on the FengYun-4 GIIRS ; You Zhao ; Nanjing University

Thank you!

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