

# NUCAPS Soundings in AWIPS

Chris Barnet NOAA / STC

Antonia Gambacorta NOAA / STC

Scott Lindstrom UW CIMSS

Nadia Smith STC

Tony Reale NOAA / SMCD

Dan Nietfeld NOAA / NWS

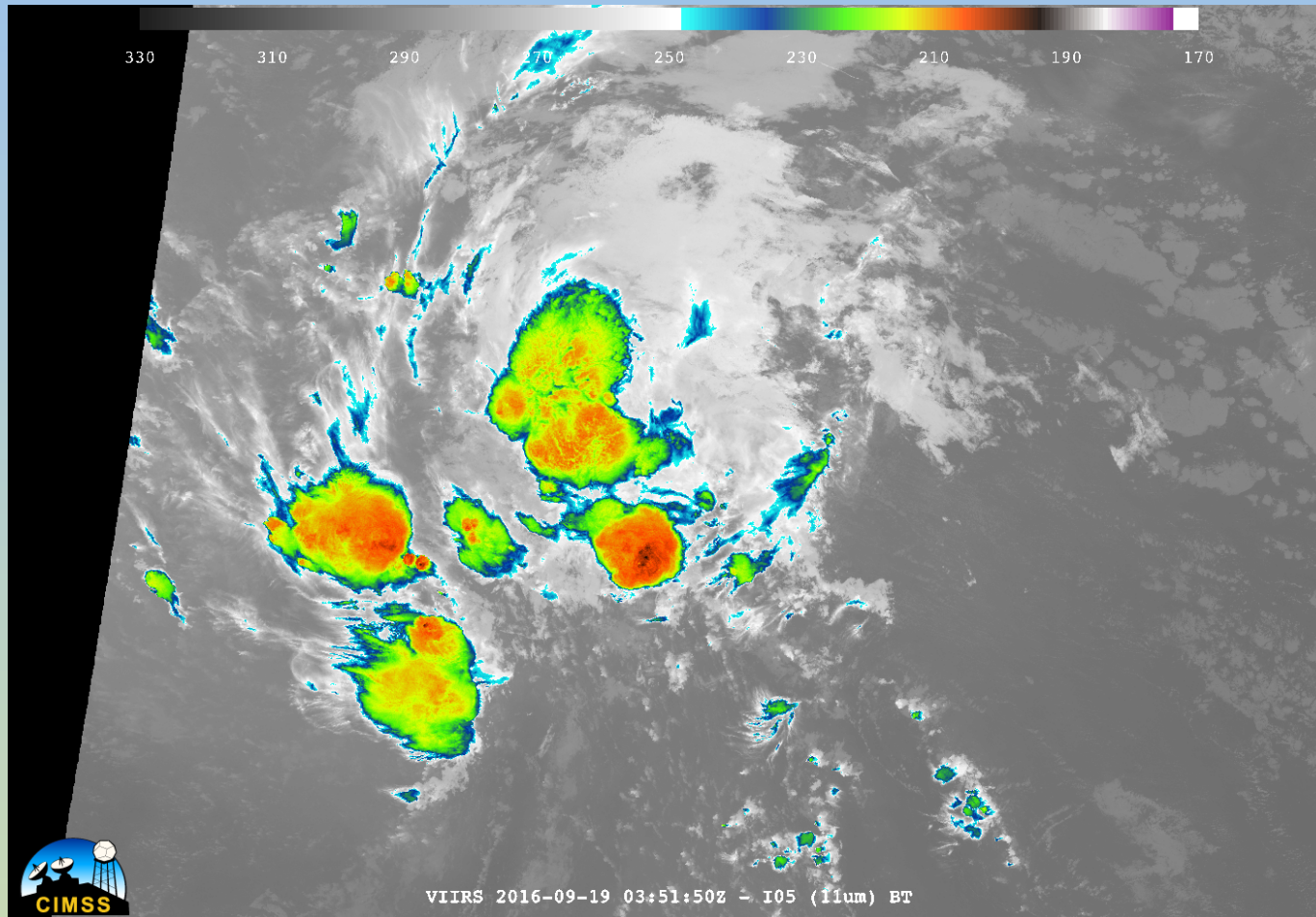
Dan Lindsey NOAA STAR / CIRA

Jack Dostalek CSU/CIRA

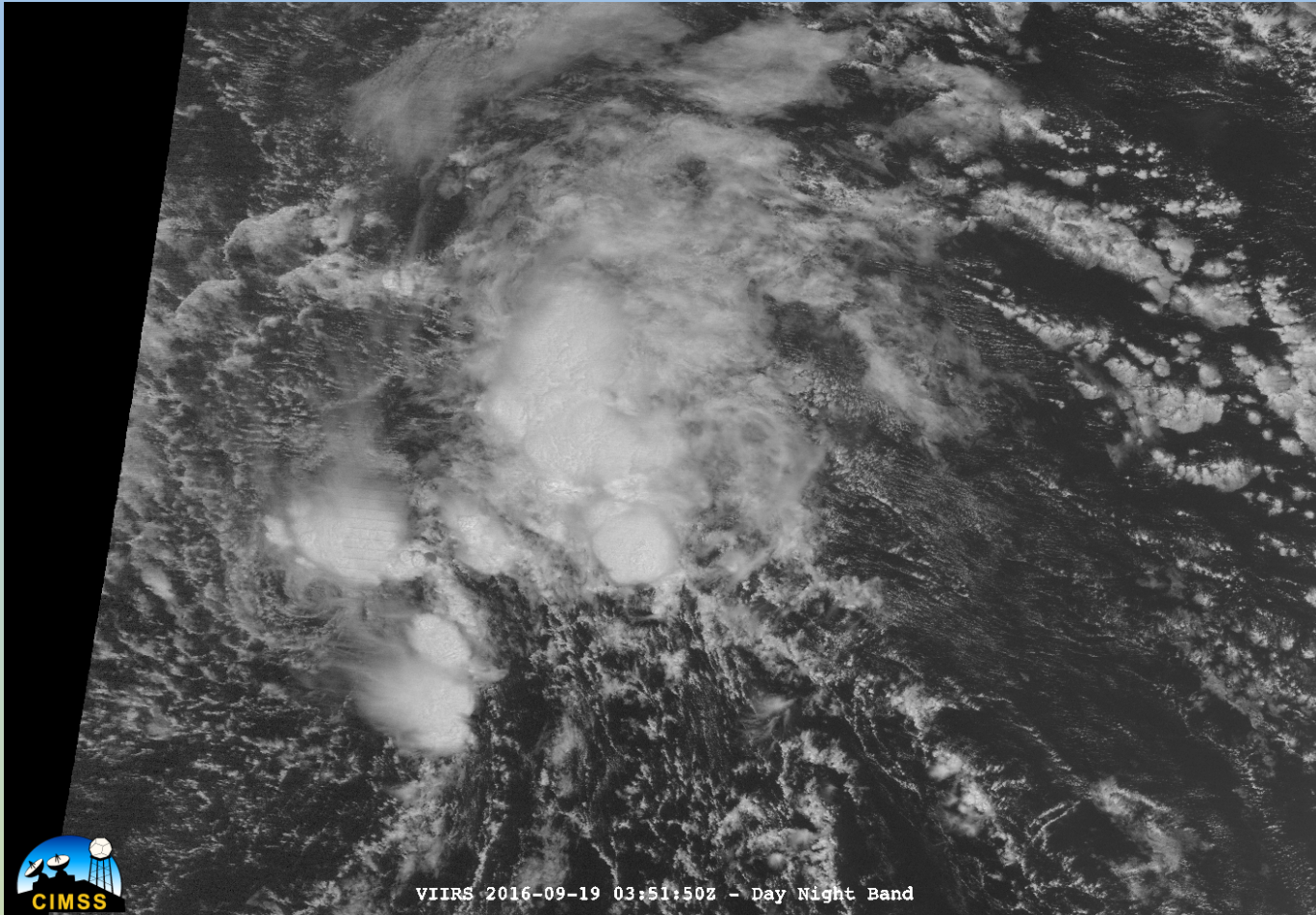
Guam WFO : April 2018



# Where's the low-level center?

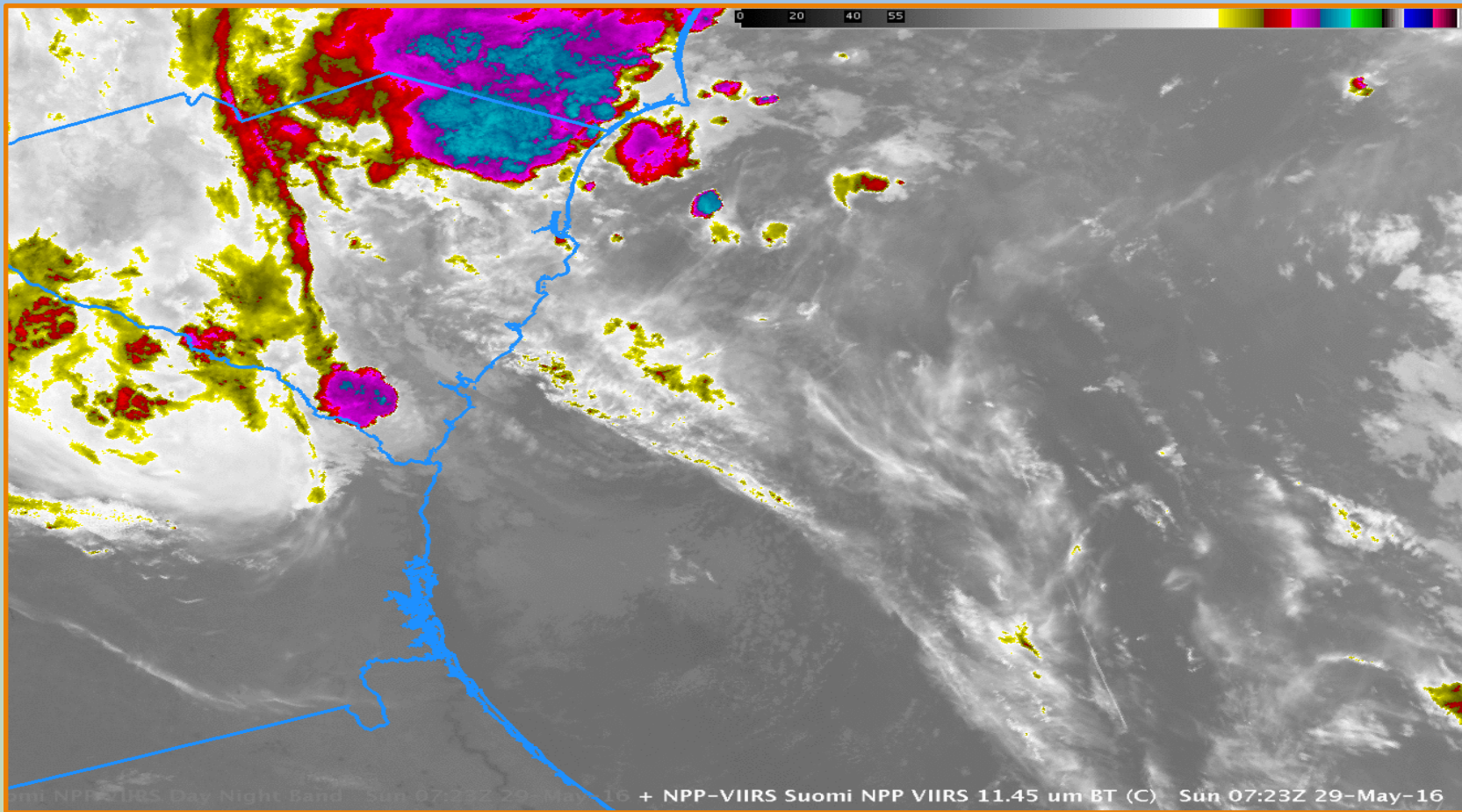


# Where's the low-level center?



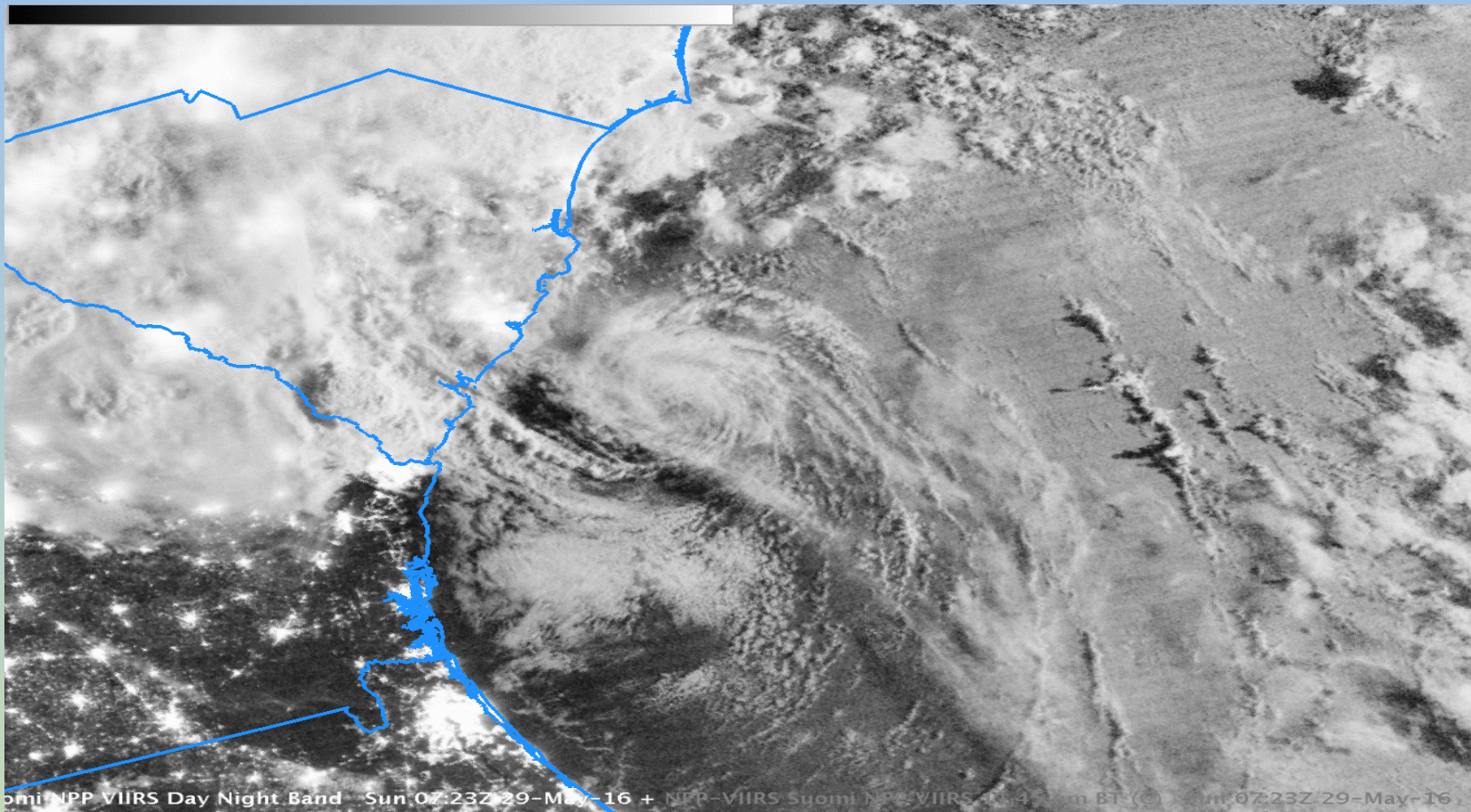


# Where's the low-level center?



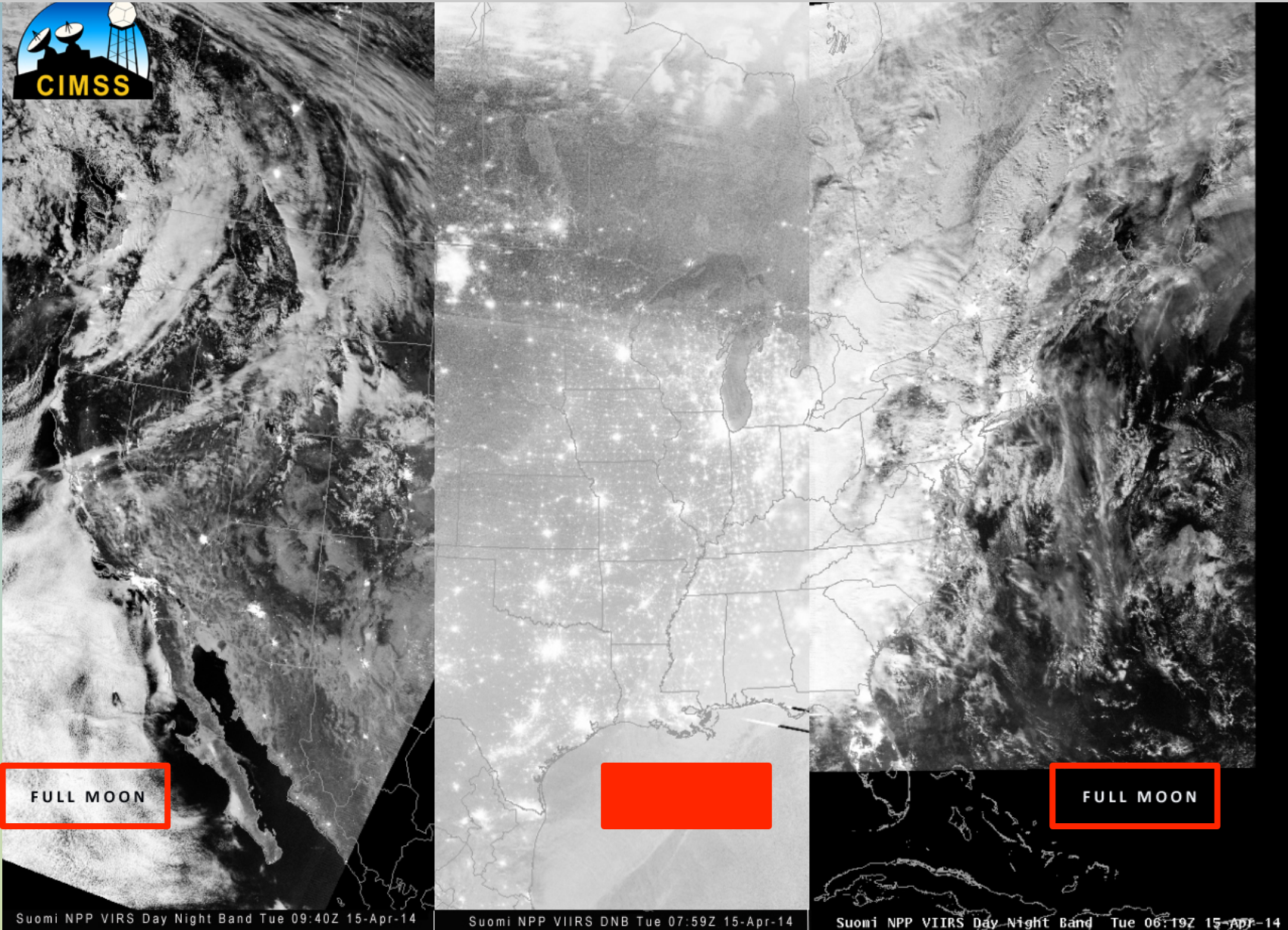


# Where's the low-level center?



# Reminder: It's Moonlight that is illuminating things!

(This shows three successive scans)



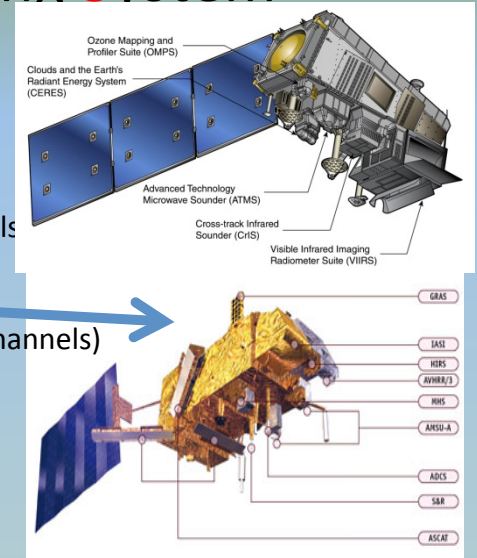


# NUCAPS

- **N**OAA-**U**nique **C**ombined **A**tmospheric **P**rocessing **S**ystem

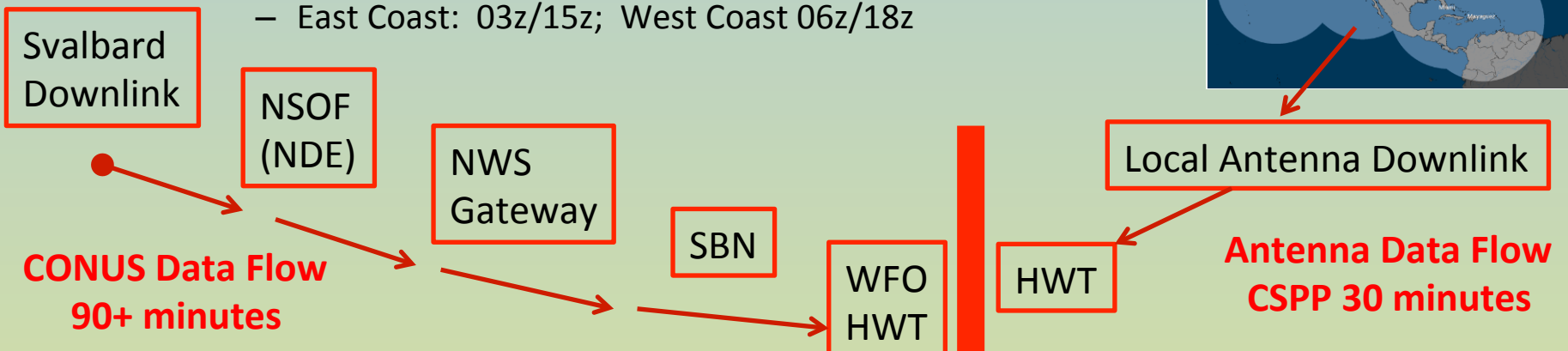
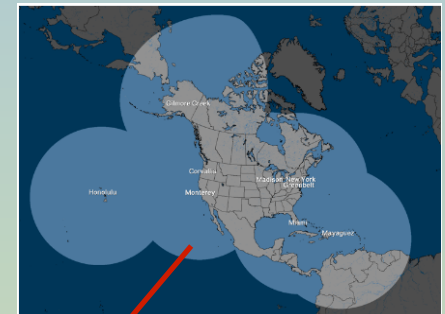
- What is Combined?

- Suomi NPP/JPSS-1
      - CrIS: Cross-track Infrared Sounder (1305 channels)
      - ATMS: Advanced Technology Microwave Sounder (22 channels)
    - Metop-A/Metop-B
      - IASI: Infrared Atmospheric Sounding Interferometer (8461 channels)
      - AMSU: Advanced Microwave Sounding Unit (12 channels)
      - MHS: Microwave Humidity Sensor (4+1 Channels)



- Overpass Times:

- Suomi NPP/NOAA-20: 0130 AM/1330 PM
    - East Coast: 05z/17z; Plains 07z/19z; West Coast 09z/21z
  - Metop-A
    - East Coast: 02z/14z; West Coast 05z/17z
  - Metop-B
    - East Coast: 03z/15z; West Coast 06z/18z

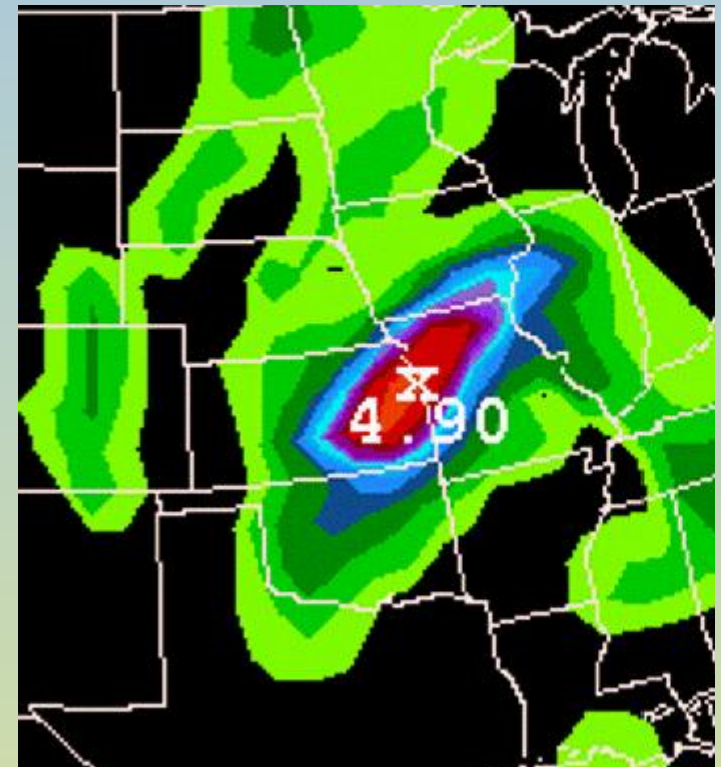
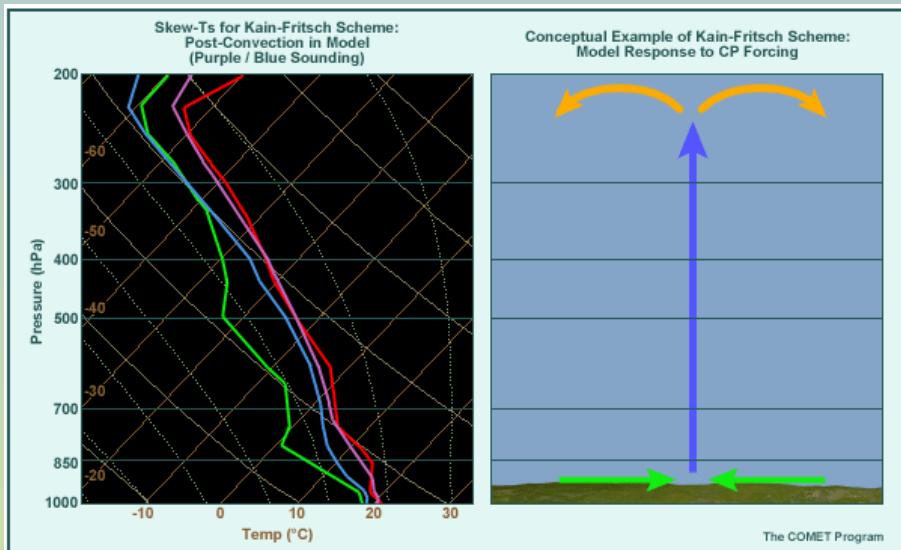




# Why not use the NWP sounding?

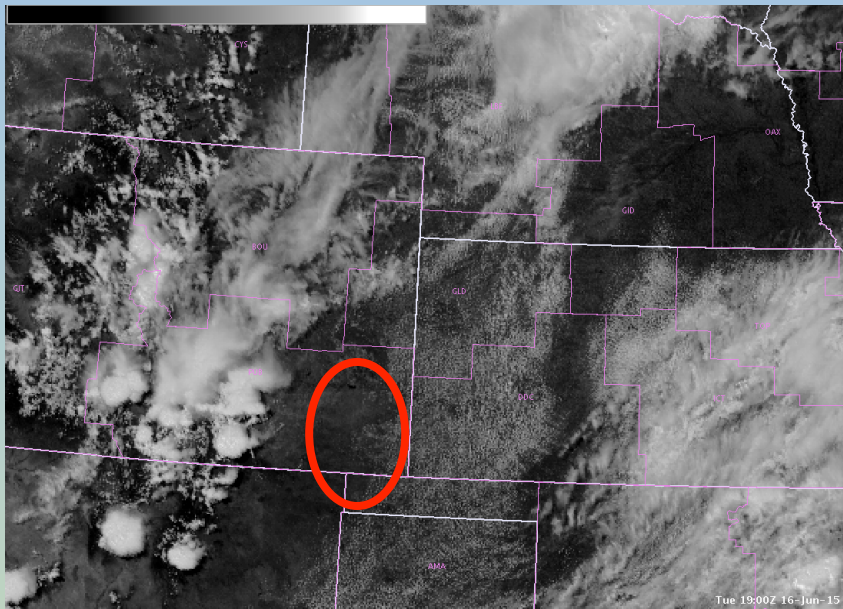
- Sometimes do, but subject to NWP issues/errors
- Soundings within model convection

***Convective Parameterization Schemes result in unrealistic profiles***



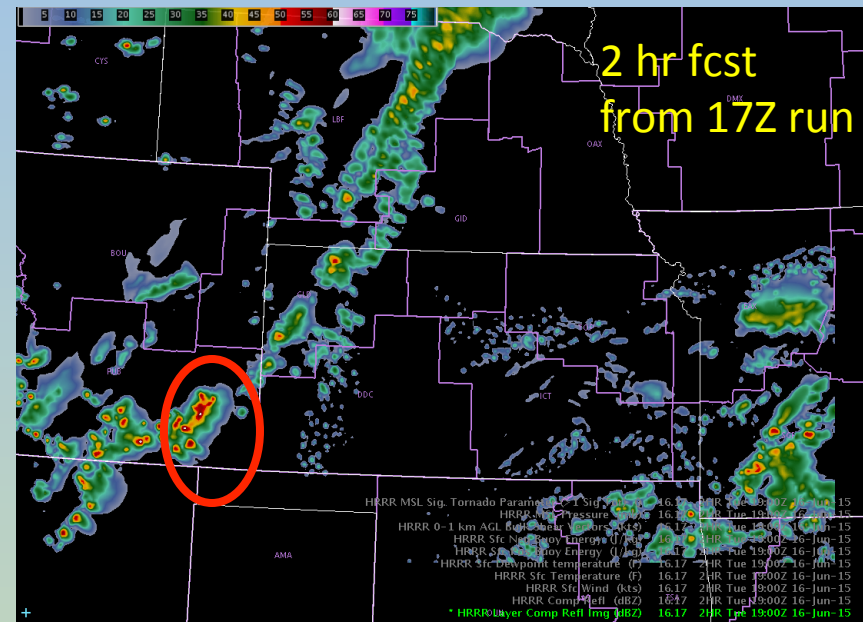
# Real vs. Modeled

## Observed GOES Visible



1900 UTC June 16, 2015  
Atmosphere with clear, blue sky

## HRRR 2-hr forecast



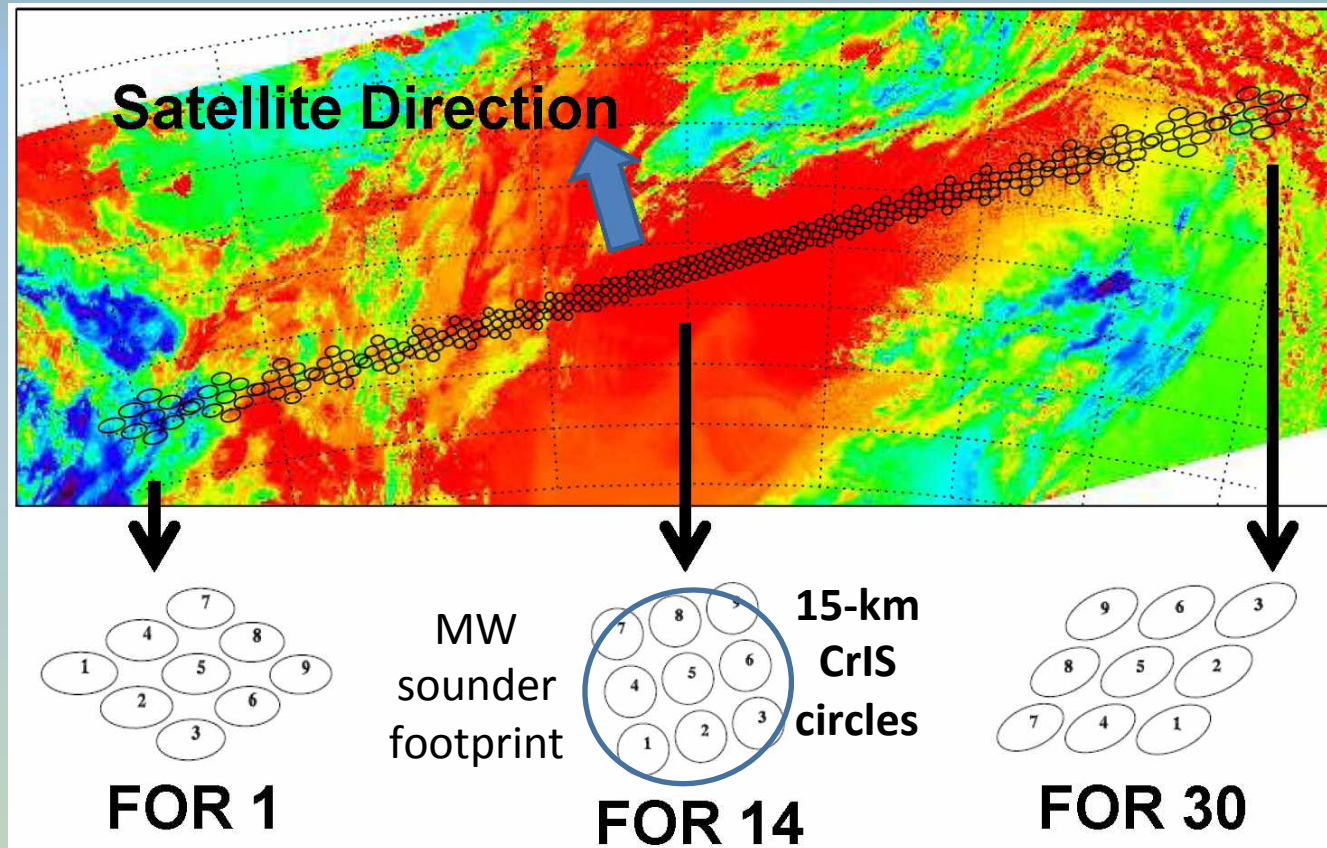
1900 UTC June 16, 2015  
Atmosphere with deep convection

# How are Vertical Profiles Produced

- **Regression** uses static coefficients (derived from ECMWF output for four focus days [2014: 6/18, 9/15, 12/20; 2015: 3/21]) to create a first guess/cloud-clearing field.
  - Regression **uses all** Sounder and Microwave channels
- **Retrieval** minimizes Observation-Calculation value
  - First Guess: NCEP-based **Climatology** + GFS Surface Pressure
  - If this doesn't converge to a solution, (because of clouds for infrared data, because of precipitation for Microwave data) sounding is still produced, but flagged
  - Retrieval **uses a subset** of channels
  - Shape-preserving; adjusts regression to the solution
- Final Sounding is computed on the 100 levels that are present in the Radiative Transfer Model
  - More levels than warranted by Sounder resolution
  - You always see the same levels in AWIPS : they're the Radiative Transfer Model levels



# CrIS Cross-Track Infrared Sounder



Each of the green dots in the NUCAPS display includes information from up to 9 Fields of Regard from the CrIS (or up to 4 from IASI). Dot #5 is the location of the green dot in the NUCAPS AWIPS Display

**It takes 8 seconds to scan these 30 Fields of Regard**

## For Suomi-NPP/JPSS-1/JPSS-2 Satellite

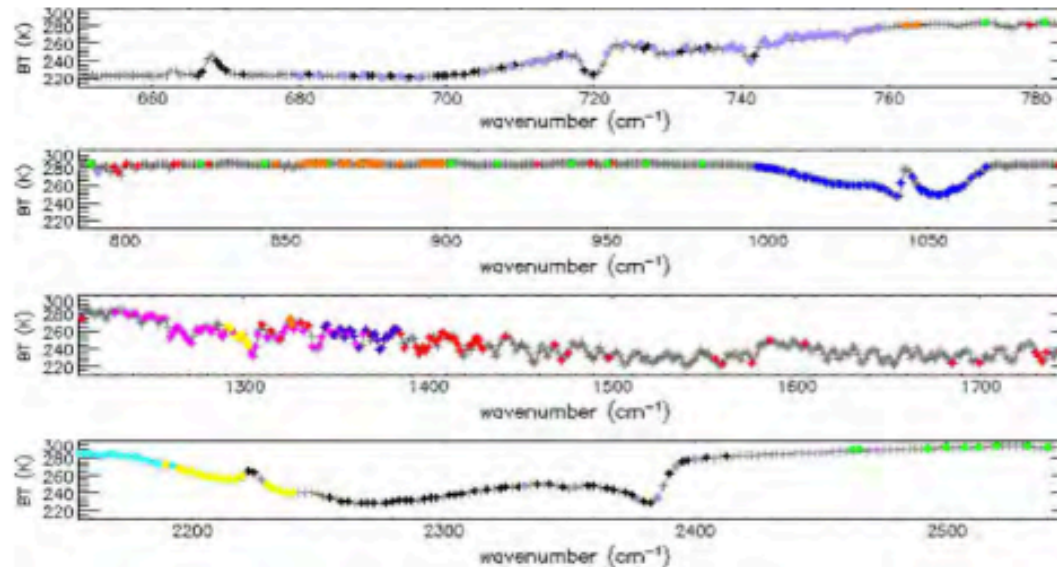


Fig. 2. Final channel selection. Gray cross symbols indicate the location of all 1305 channels present in CrIS original spectra. Superimposed colored cross symbols indicate the 10 channel subsets forming our final channel selection. The final selection is composed of (green) 24 surface temperature and emissivity, (black) 87 temperature, (red) 62 water vapor, (blue) 53 ozone, (cyan) 27 carbon monoxide, (magenta) 54 methane, (light purple) 53 carbon dioxide, (yellow) 24 N<sub>2</sub>O, (orange) 28 HNO<sub>3</sub>, and (dark purple) 24 SO<sub>2</sub> sounding channels. The total number of channels is 399.

Which CrIS channels are used for physical retrieval step? 399 of them

**24 for surface temperature**

**87 for atmospheric temperature**

**62 for water vapor**

Channels chosen most sensitive to one gas and least sensitive to other gases

All ATMS channels (22 of them) are used in NUCAPS for SNPP

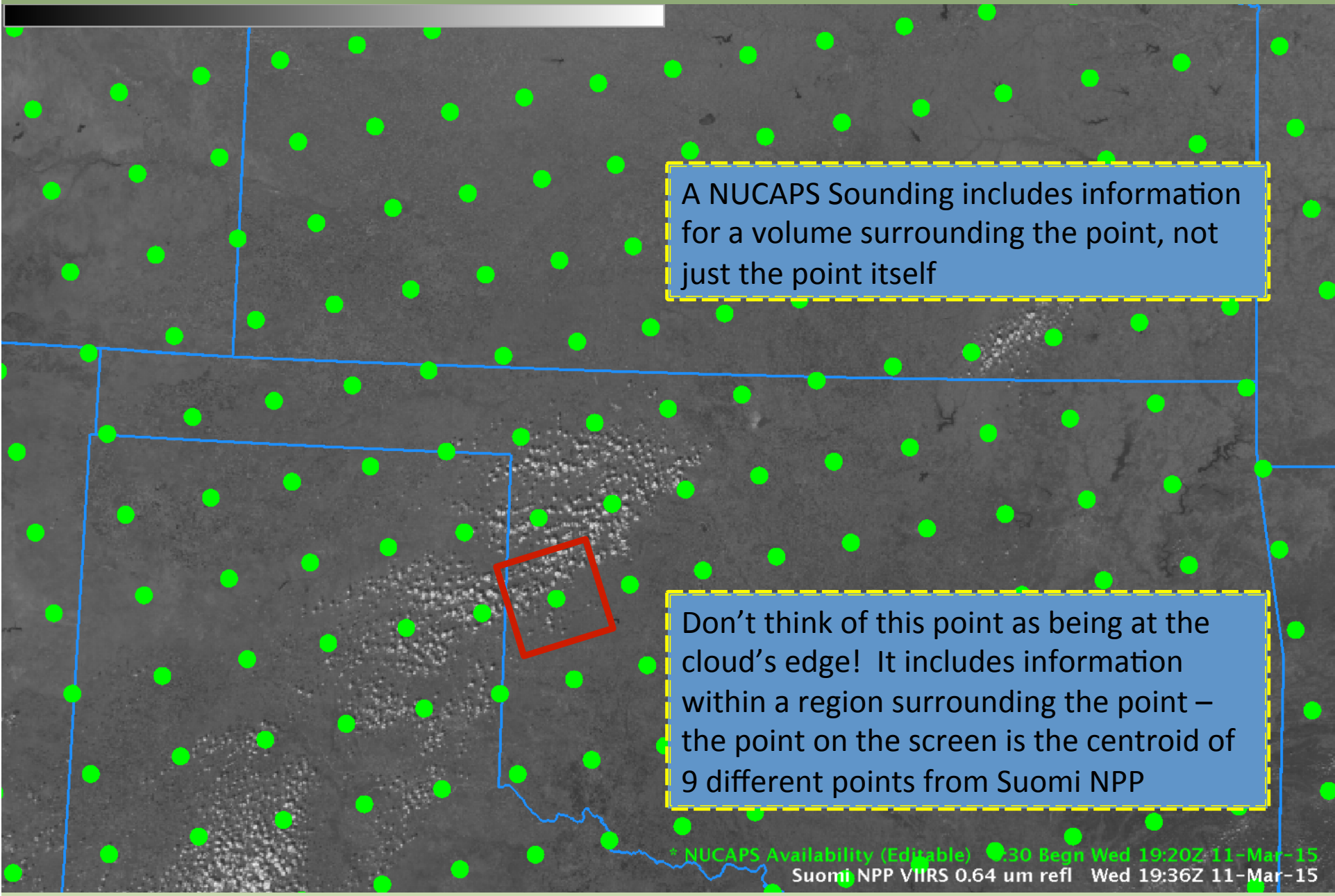
(Similar channel selection for Metop-A/B instruments – IASI has 8461 channels)

# Summary of products from NUCAPS (and AWIPS)

For Troposphere

gas	Precision	d.o.f.	Interfering Parameters	Sensitivity
Temperature Profile, T(p), SST, LST	1.5K/km	6-10	Emissivity, H <sub>2</sub> O, O <sub>3</sub> , N <sub>2</sub> O	surface to ~1 mb
Water Profile, H <sub>2</sub> O(p)	15%	4-6	CH <sub>4</sub> , HNO <sub>3</sub>	surface to ~300 mb
Cloud Top Pressure Cloud fraction	25 mbar, 1.5K, 5%	2 18	CO <sub>2</sub> , H <sub>2</sub> O	surface to tropopause
Ozone, O <sub>3</sub>	10%	1+	H <sub>2</sub> O, emissivity	Lower stratosphere
Carbon Monoxide, CO	15%	≈ 1	H <sub>2</sub> O, N <sub>2</sub> O	Mid-troposphere
Methane, CH <sub>4</sub>	1.5%	≈ 1	H <sub>2</sub> O, HNO <sub>3</sub> , N <sub>2</sub> O	Mid-troposphere
Carbon Dioxide, CO <sub>2</sub>	0.5%	≈ 1	H <sub>2</sub> O, O <sub>3</sub> , T(p)	Mid-troposphere
Sulfur Dioxide, SO <sub>2</sub>	≈ 50%	< 1	H <sub>2</sub> O, HNO <sub>3</sub>	Volcanic flag
Nitric Acid, HNO <sub>3</sub>	≈ 50%	< 1	emissivity H <sub>2</sub> O, CH <sub>4</sub> , N <sub>2</sub> O	Upper troposphere
Nitrous Oxide, N <sub>2</sub> O	≈ 5%	< 1	H <sub>2</sub> O, CO	Mid-troposphere





A NUCAPS Sounding includes information for a volume surrounding the point, not just the point itself

Don't think of this point as being at the cloud's edge! It includes information within a region surrounding the point – the point on the screen is the centroid of 9 different points from Suomi NPP

The screenshot shows the CAVE:OAX - D2D software interface. The main window displays a satellite imagery menu with various options. The menu is structured as follows:

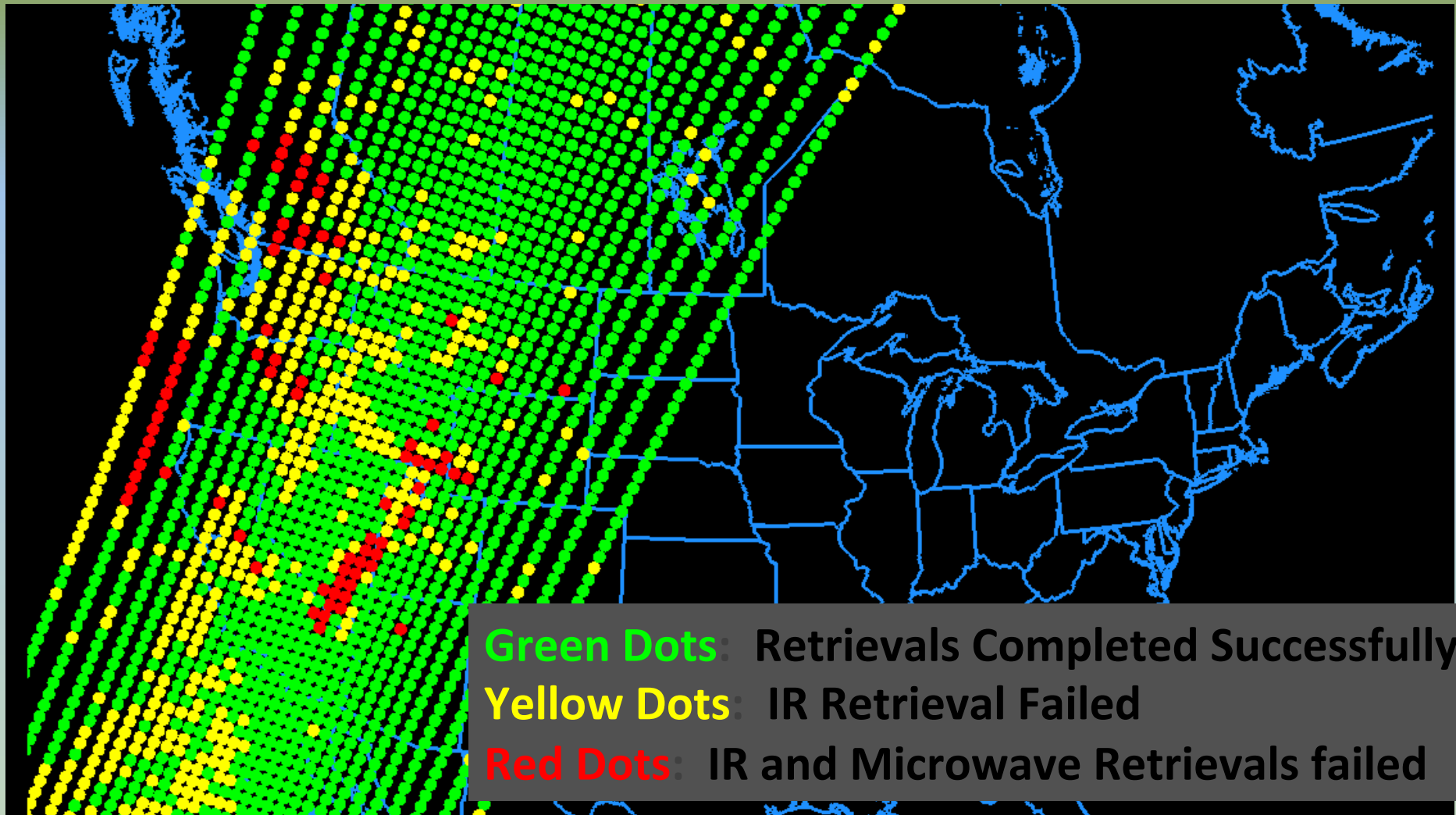
- GOES-16 >
  - IR Window 28.1300
  - Water Vapor 28.1300
  - Visible 28.1300
  - 3.9u 28.1315
  - 13u 28.1315
  - 11u-3.9u 28.1315
  - 11u-13u -----
  - WV/IR -----
  - 4 panel (GOES M-Q) 28.1315
- POES Imagery -----
- IR Window -----
- Visible -----
- 3.7u -----
- 11-3.7u -----
- Sounder Imagery >
- Derived Products Imagery >
- Derived Products Plots >
- NPP Products >
- OCONUS Imagery >
- NH/NA/US every image-----
- IR Window 28.1315
- Water Vapor 28.1315
- Visible 28.1315
- 3.9u 28.1315
- 13u 28.1315
- 11u-3.9u 28.1315
- 11u-13u 28.1315
- WV/IR 28.1315
- 4 Sat Composite -----
- IR Window 28.0900
- Water Vapor 28.0900
- Visible 28.0900
- WV/IR 28.0900
- NOAA/CIMSS Prob Severe Products -----
- NOAA/CIMSS Prob Severe Model (ConvectProb) ??.????
- NOAA/CIMSS Prob Severe Model ??.????
- NOAA/CIMSS Prob Severe Model (Light) ??.????
- NOAA/CIMSS Prob Tornado Model ??.????
- MRMS Merged QC Comp -----
- CIMSS Suomi NPP-VIIRS Products -----
- NPP-VIIRS (EAST) >
- NPP-VIIRS (WEST) >
- NPP-VIIRS (AK) >
- NPP-VIIRS (HI) >

The 'NPP Products' menu item is expanded, showing a sub-menu with the following options:

- VIIRS -----
- CONUS Imagery >
- Alaska Imagery >
- Pacific Imagery >
- Soundings -----
- NUCAPS Sounding Availability 28.1048

The 'WarnGen' button is highlighted in yellow. The main window displays a satellite image of the United States. The status bar at the bottom shows 'Frames: 1', 'Time: 13:28Z 28-Mar-18', and '588M of 1236M'.

In the WFO AWIPS,  
 NUCAPS soundings are under  
 Satellite > NPP Products > NUCAPS Sounding Availability

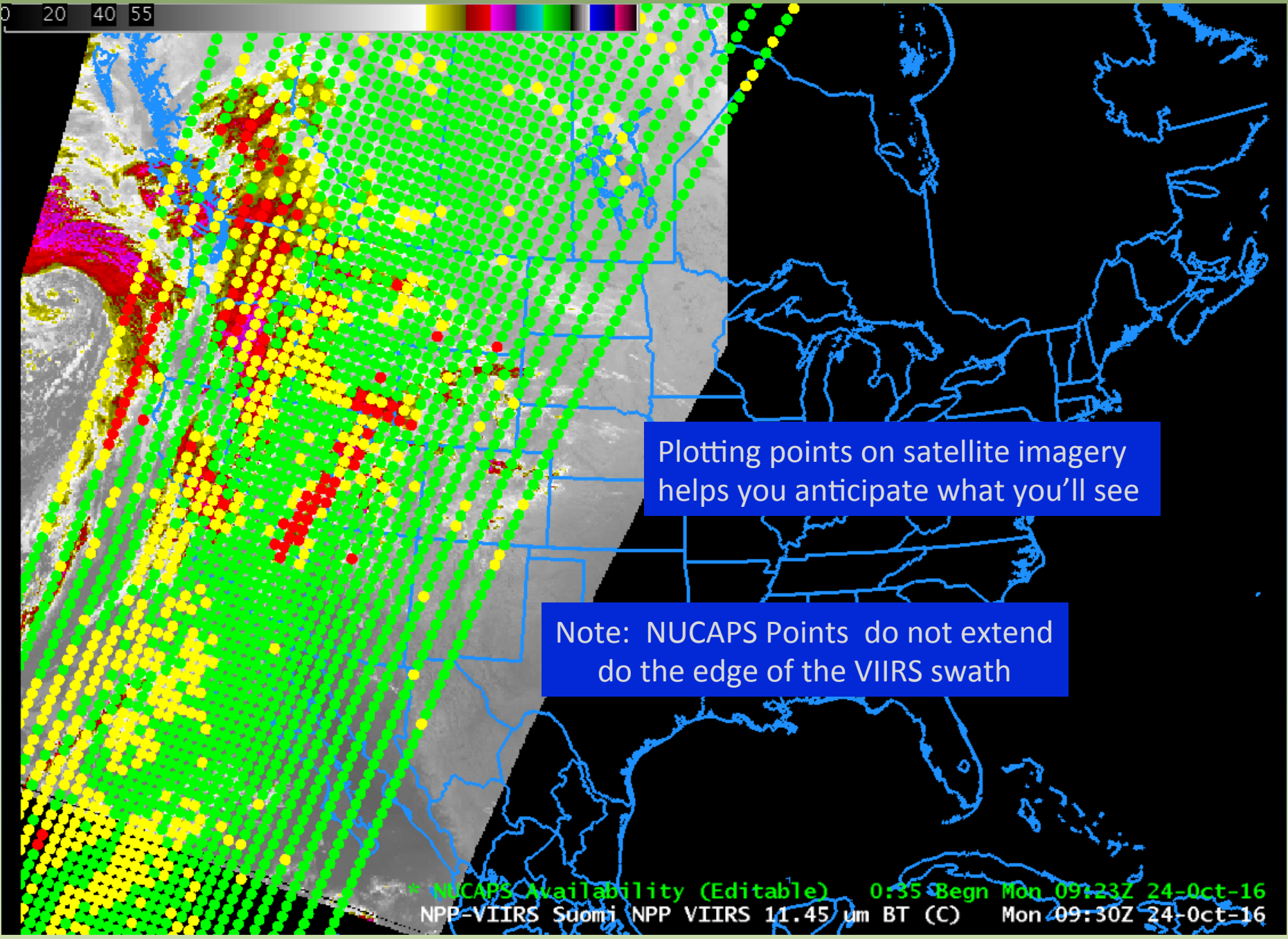


**Green Dots:** Retrievals Completed Successfully  
**Yellow Dots:** IR Retrieval Failed  
**Red Dots:** IR and Microwave Retrievals failed

- If the Soundings are flowing from Direct Broadcast (DB) sites, the swath will typically show up about 30 minutes after the pass – **Improved Latency/FASTER**
- If the Soundings are flowing from Svalbard/the SBN, The swath will typically show up 90 or more minutes after the pass **SLOW!**

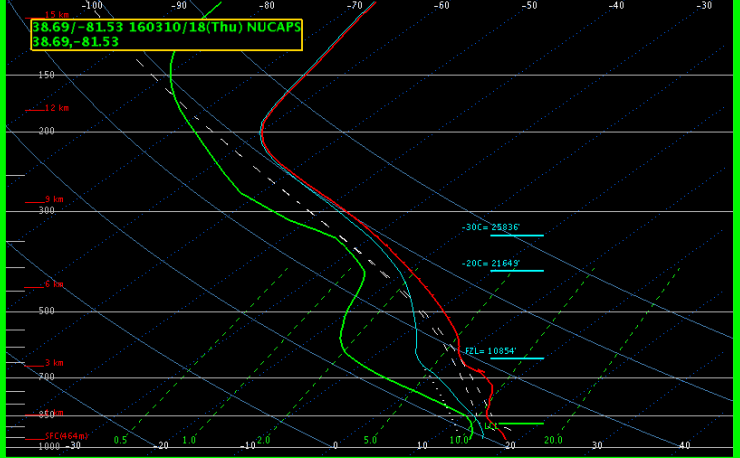
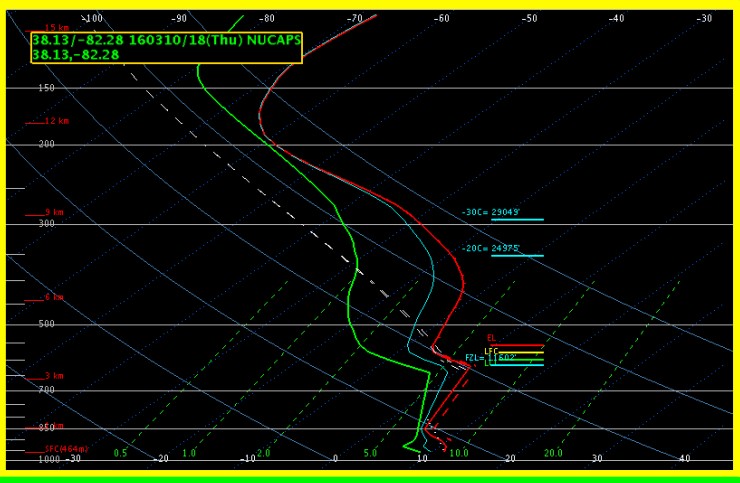
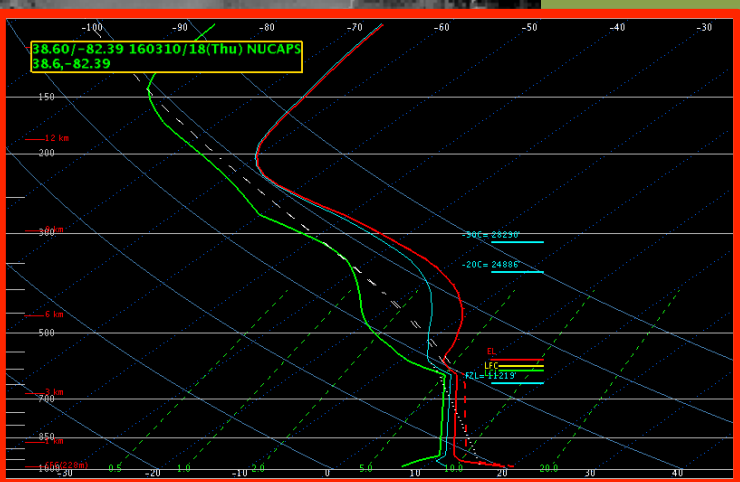
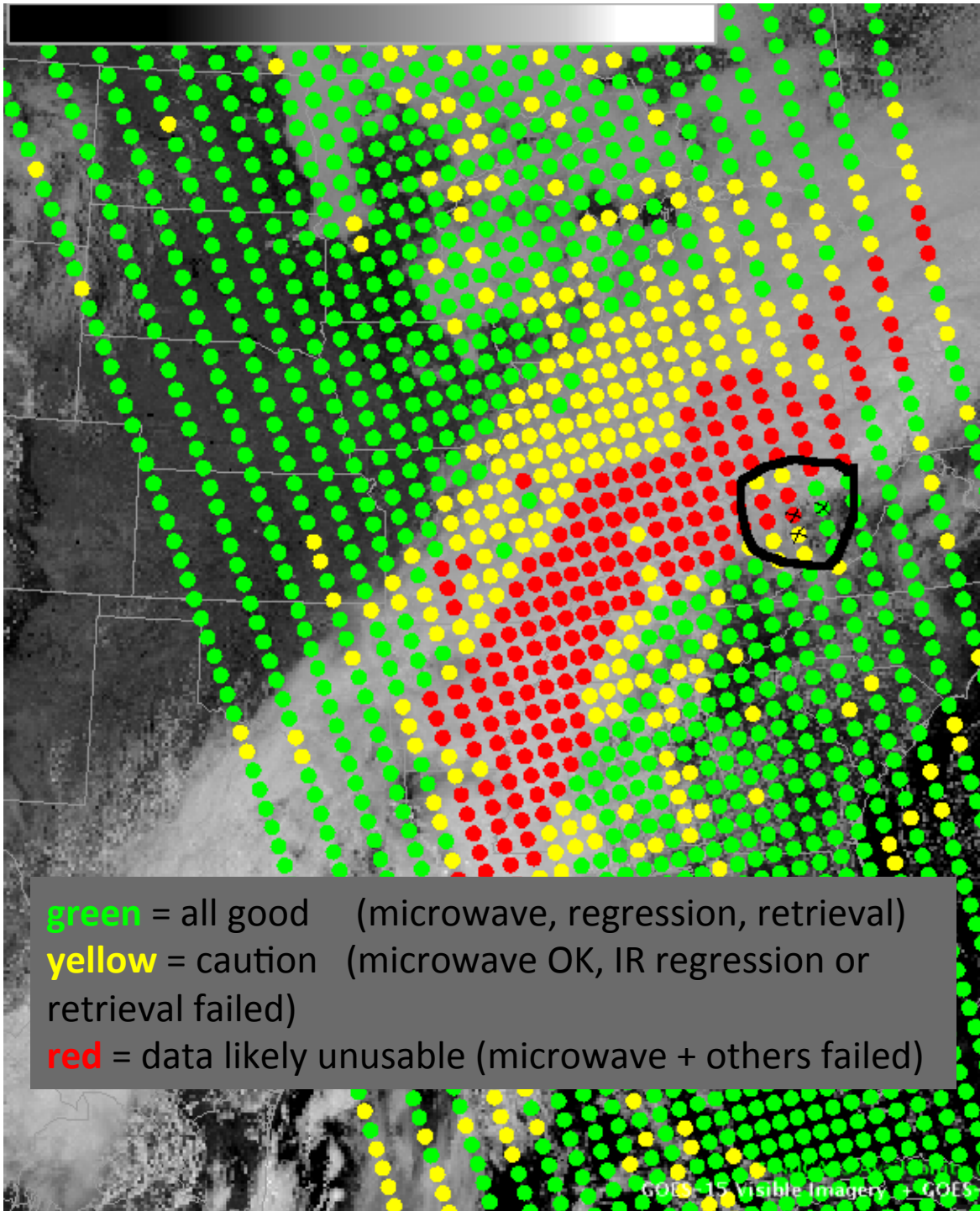


0 20 40 55



Plotting points on satellite imagery helps you anticipate what you'll see

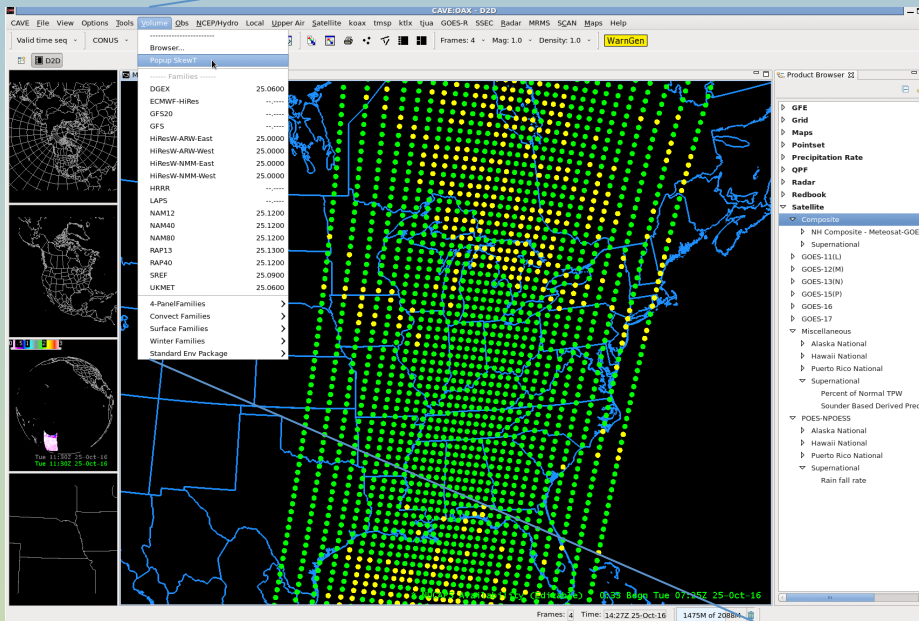
Note: NUCAPS Points do not extend to the edge of the VIIRS swath



**green** = all good (microwave, regression, retrieval)  
**yellow** = caution (microwave OK, IR regression or retrieval failed)  
**red** = data likely unusable (microwave + others failed)

# Popup SkewTs

- After you load the Soundings, enable **Popup SkewT** in Volume Browser so you can browse quickly through many Skew-Ts



Volume Browser...	
----- Families -----	
DGEX	25.0600
ECMWF-HiRes	--:----
GFS20	--:----
GFS	--:----
HiResW-ARW-East	25.0000
HiResW-ARW-West	25.0000
HiResW-NMM-East	25.0000
HiResW-NMM-West	25.0000
HRRR	--:----
LAPS	--:----
NAM12	25.1200
NAM40	25.1200
NAM80	25.1200
RAP13	25.1300
RAP40	25.1200
SREF	25.0900
UKMET	25.0600
4-PanelFamilies	>
Convect Families	>
Surface Families	>
Winter Families	>
Standard Env Package	>



# Popup SkewTs

The screenshot shows the CAVE software interface with a map of the United States. A context menu is open over the map, and a 'WarnGen' button is visible in the top right. A 'Product Browser' panel is on the right side.

**Right-click anywhere in image**

**Also: TURN ON Sampling!**

CAVE:OAX - D2D

CAVE File View Options Tools Volume Obs NCEP/Hydro Local Upper Air Satellite koax tmsp ktlx tjua GOES-R SSEC Radar MRMS SCAN Maps Help

Valid time seq CONUS Clear [Map] [Navigation icons] Frames: 3 Mag: 1.0 Density: 1.0 WarnGen

Map [Map]

Product Browser [Product Browser]

- ▷ GFE
- ▷ Grid
- ▷ Maps
- ▷ Pointset
- ▷ Precipitation Rate
- ▷ QPF
- ▷ Radar
- ▷ Redbook
- ▷ Satellite
  - ▷ Composite
    - ▷ NH Composite - Meteosat-GOES
    - ▷ Supernational
  - ▷ GOES-11(L)
  - ▷ GOES-12(M)
  - ▷ GOES-13(N)
  - ▷ GOES-15(P)
  - ▷ GOES-16
  - ▷ GOES-17
  - ▷ Miscellaneous
    - ▷ Alaska National
    - ▷ Hawaii National
    - ▷ Puerto Rico National
    - ▷ Supernational
      - Percent of Normal TPW
      - Sounder Based Derived Precip
  - ▷ POES-NPOESS
    - ▷ Alaska National
    - ▷ Hawaii National
    - ▷ Puerto Rico National
    - ▷ Supernational
      - Rain fall rate

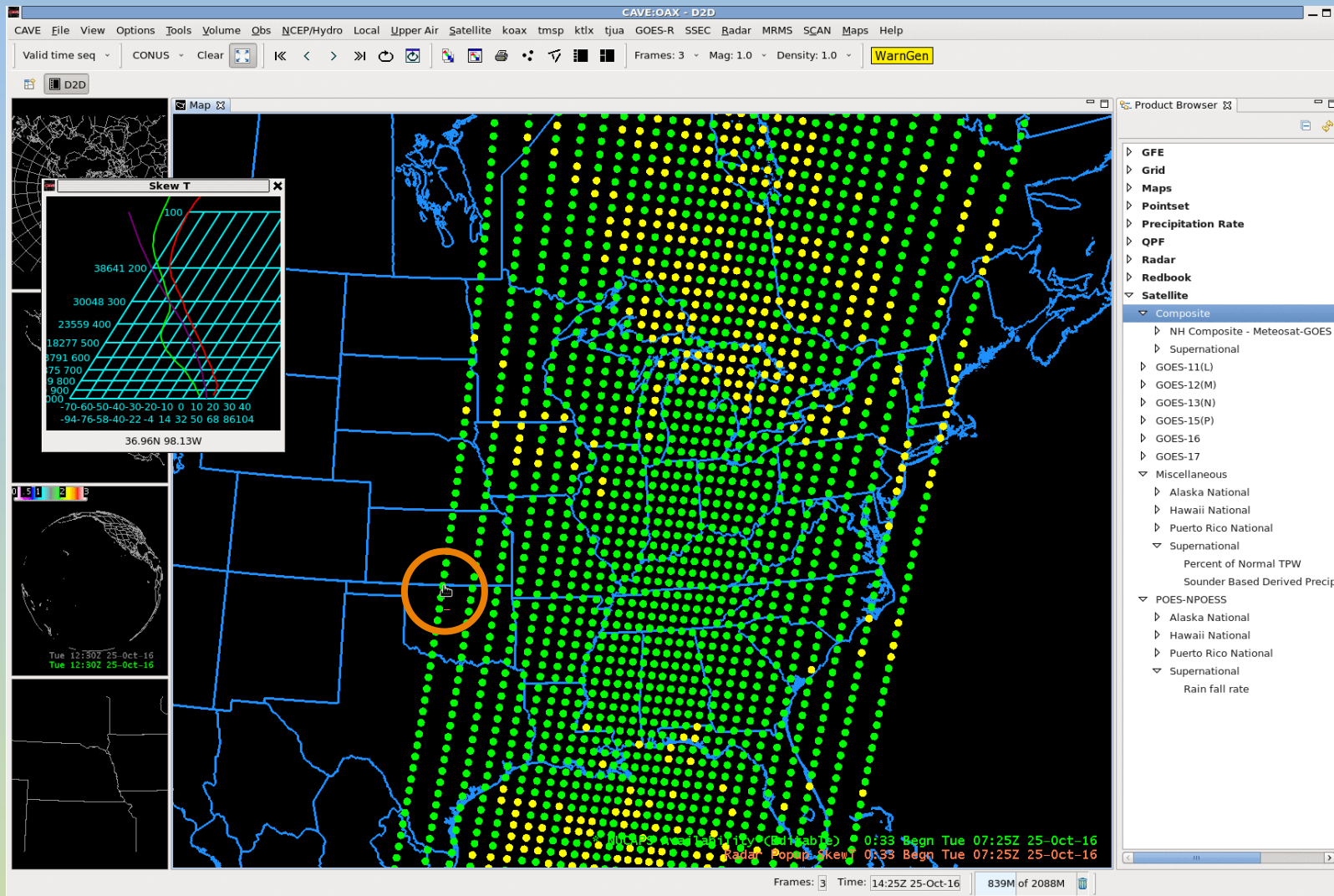
Sample Cloud Heights/Radar Skew T  
Hide Legends  
Show Map Legends  
Four Panel Layout  
Skip This Frame  
Skip Subsequent Frames  
Zoom  
Set Background Color...  
 Sample  
 Lat/Lon Readout  
Unload Graphics

No Sampling  
 NAM  
 GFS  
 RAP  
 Laps  
 From Raobs  
 NUCAPS  
 Skew T

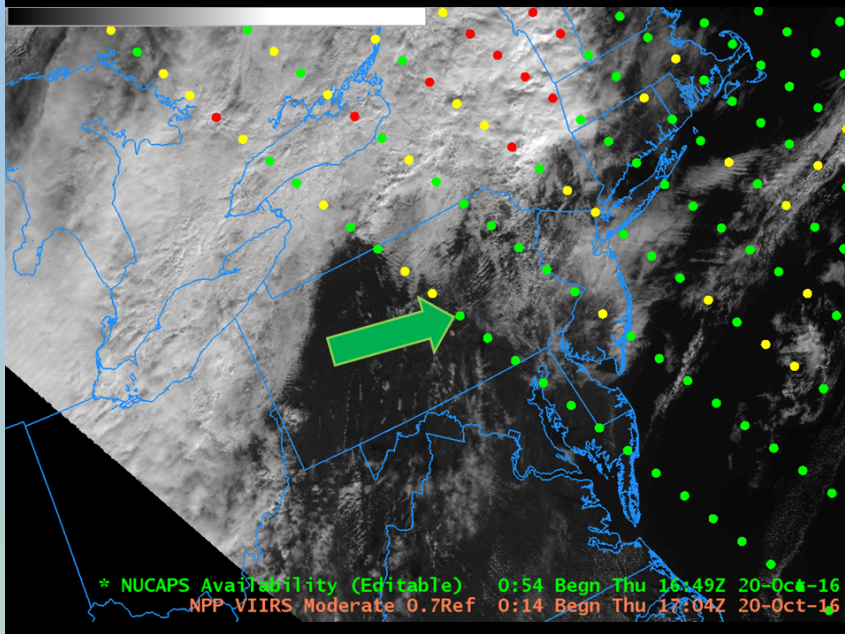
NUCAPS At 11:00:11y 2d (table) 0:33 Bgn Tue 07:25Z 25-Oct-16  
Radar Popup SkewT 0:33 Bgn Tue 07:25Z 25-Oct-16

Frames: 3 Time: 14:17Z 25-Oct-16 1369M of 2088M

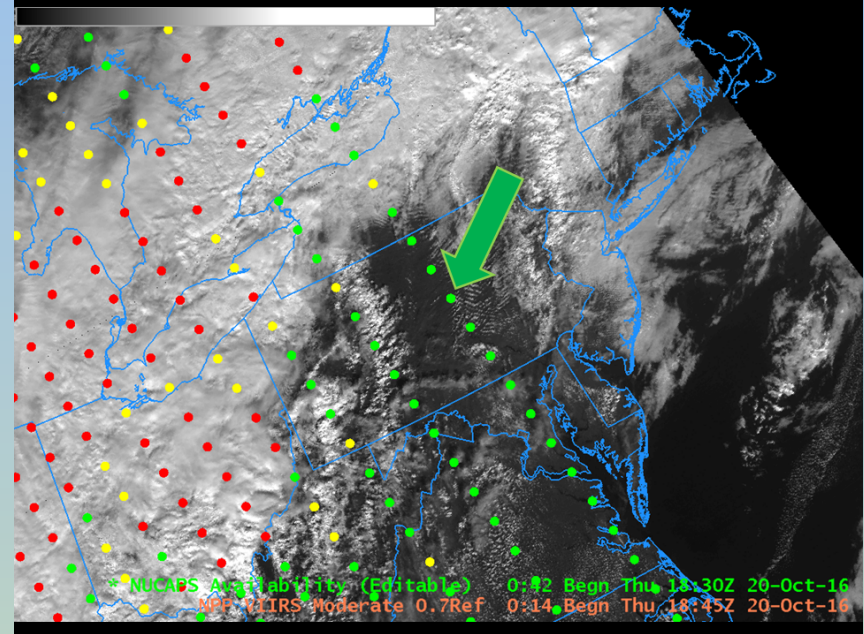
# Popup SkewTs



# What do Consecutive Soundings Get you?



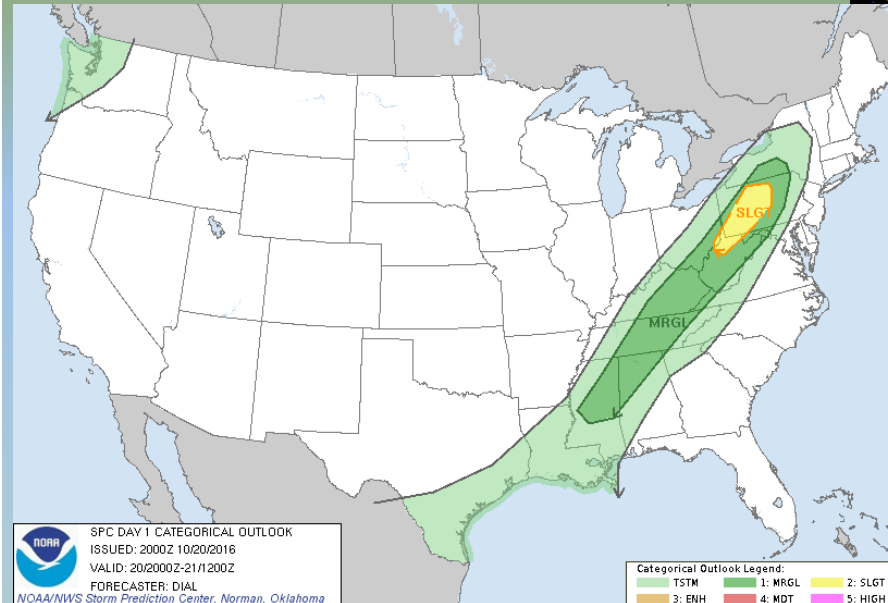
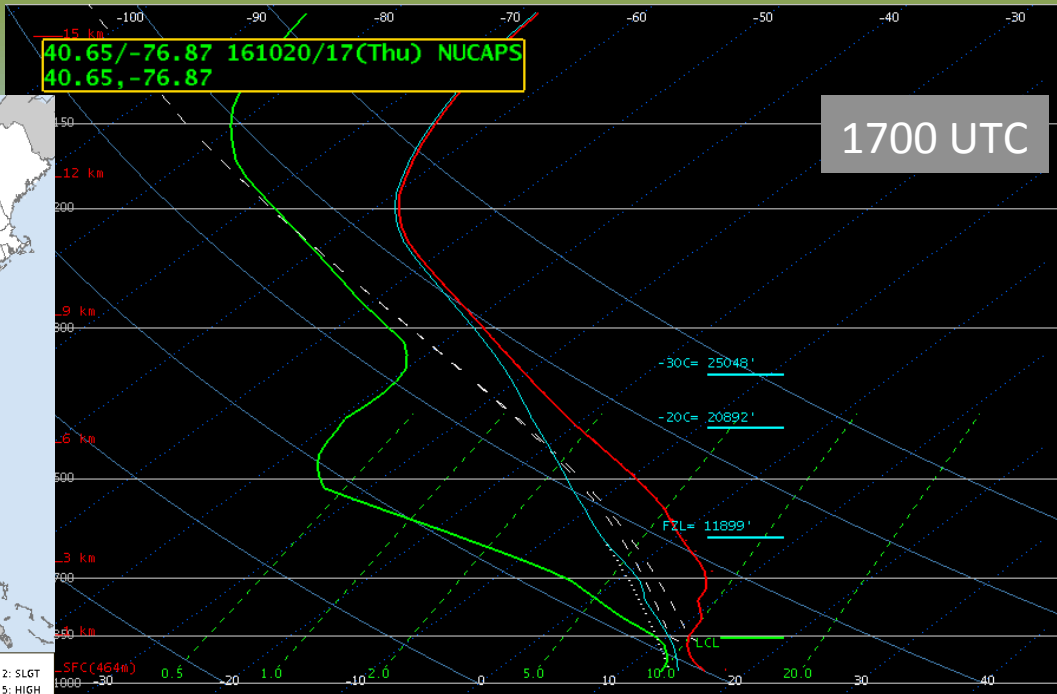
Western-most scan at ~1700 UTC




Eastern-most scan at ~1830 UTC

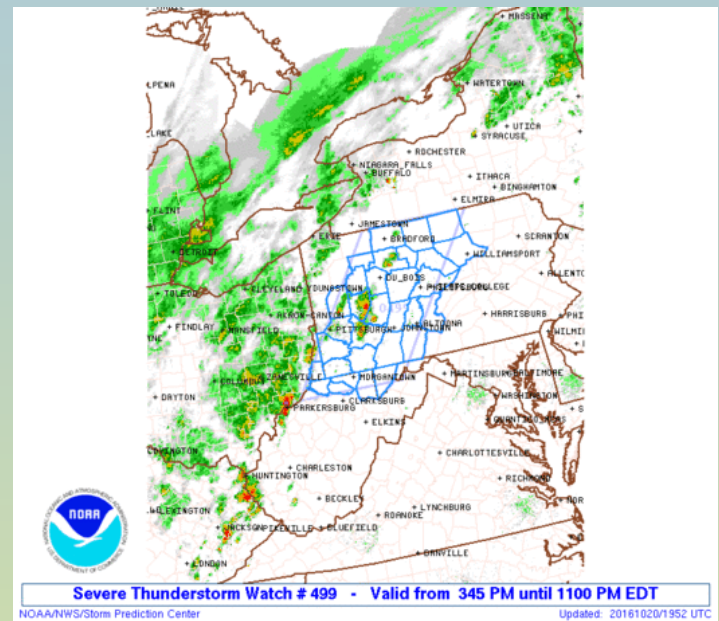
**Two samplings of a destabilizing atmosphere  
90 minutes apart – if you're lucky over CONUS.  
It's possible this will happen over Guam once NOAA-20  
NUCAPS profiles are in AWIPS**





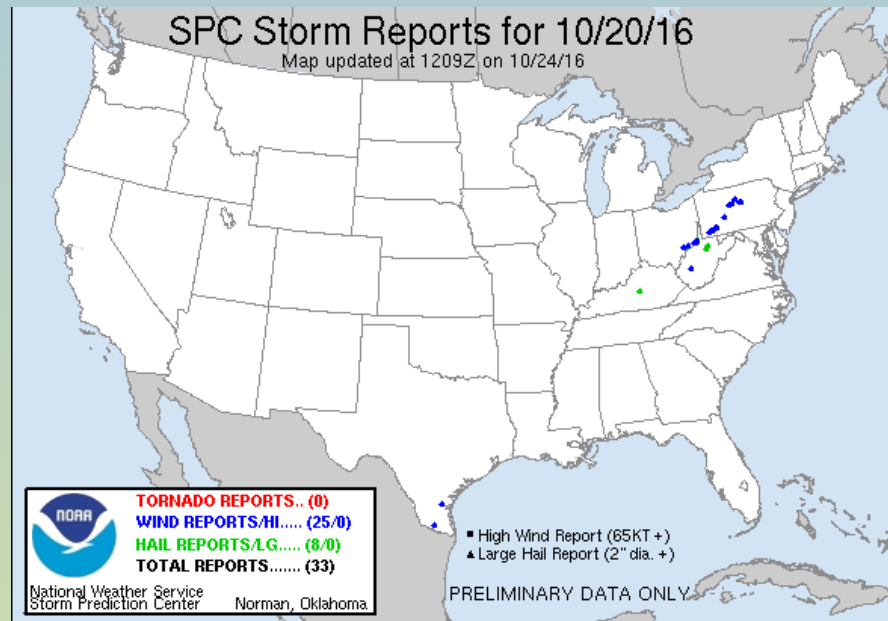

**SPC DAY 1 CATEGORICAL OUTLOOK**  
 ISSUED: 2000Z 10/20/2016  
 VALID: 20/2000Z-21/1200Z  
 FORECASTER: DIAL  
 NOAA/NWS Storm Prediction Center, Norman, Oklahoma

**Categorical Outlook Legend:**  
 TSTM: Green  
 ENH: Yellow  
 MDT: Red  
 HIGH: Purple  
 1: MRGL: Light Green  
 2: SLGT: Yellow-Orange  
 3: ENH: Orange  
 4: MDT: Red  
 5: HIGH: Purple




**Severe Thunderstorm Watch # 499 - Valid from 345 PM until 1100 PM EDT**

NOAA/NWS/Storm Prediction Center Updated: 20161020/1952 UTC



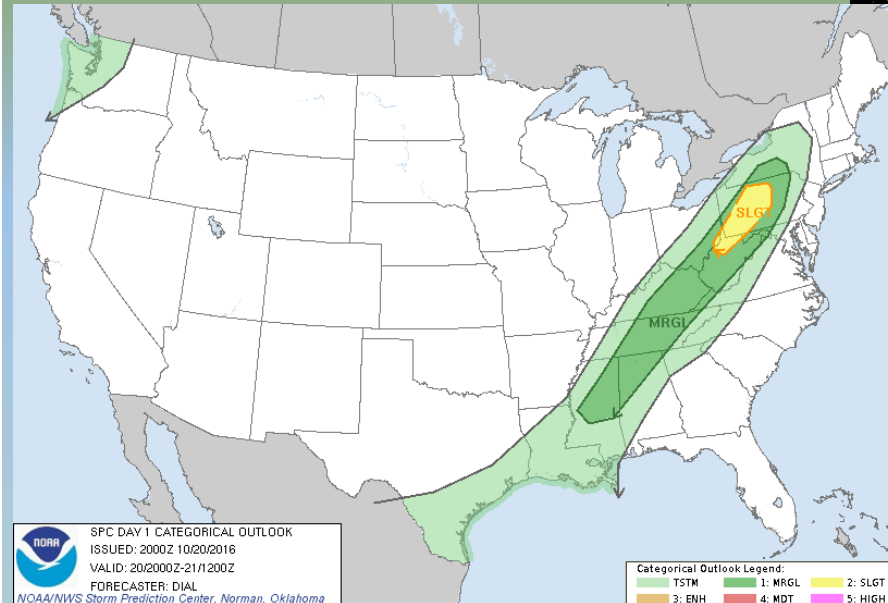
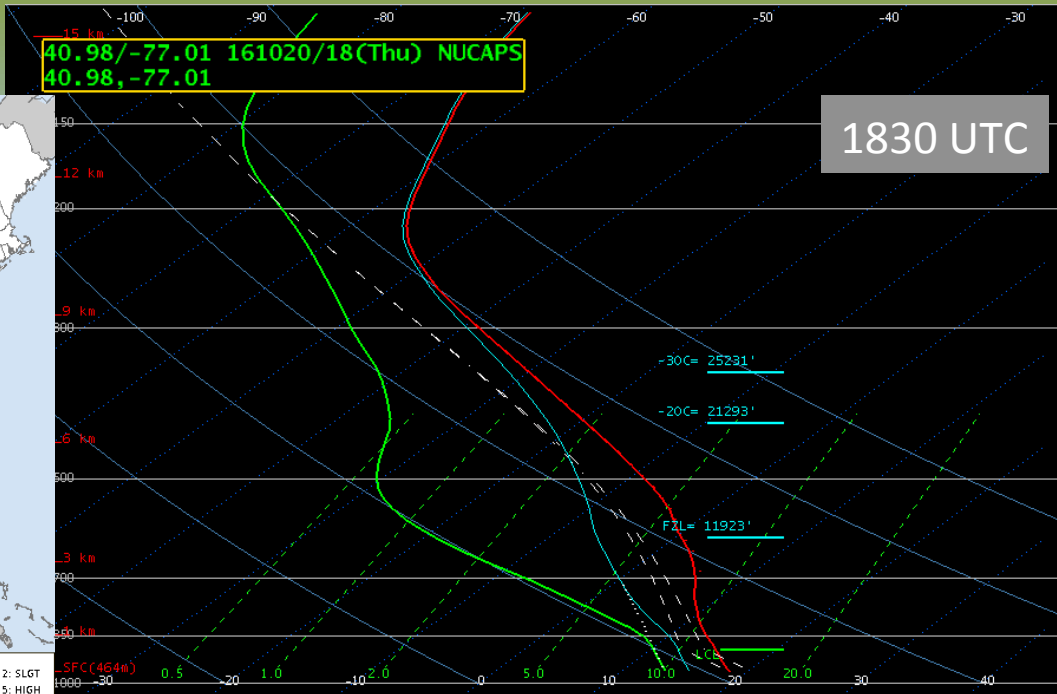
**SPC Storm Reports for 10/20/16**


Map updated at 1209Z on 10/24/16


**TORNADO REPORTS..... (0)**  
**WIND REPORTS/HI..... (25/0)**  
**HAIL REPORTS/LG..... (8/0)**  
**TOTAL REPORTS..... (33)**  
 National Weather Service  
 Storm Prediction Center Norman, Oklahoma

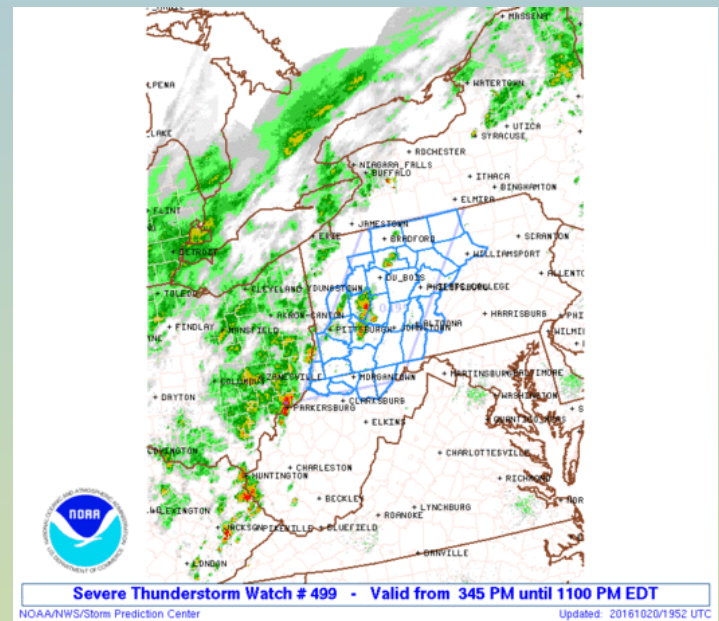
■ High Wind Report (65KT +)  
 ▲ Large Hail Report (2" dia. +)


PRELIMINARY DATA ONLY

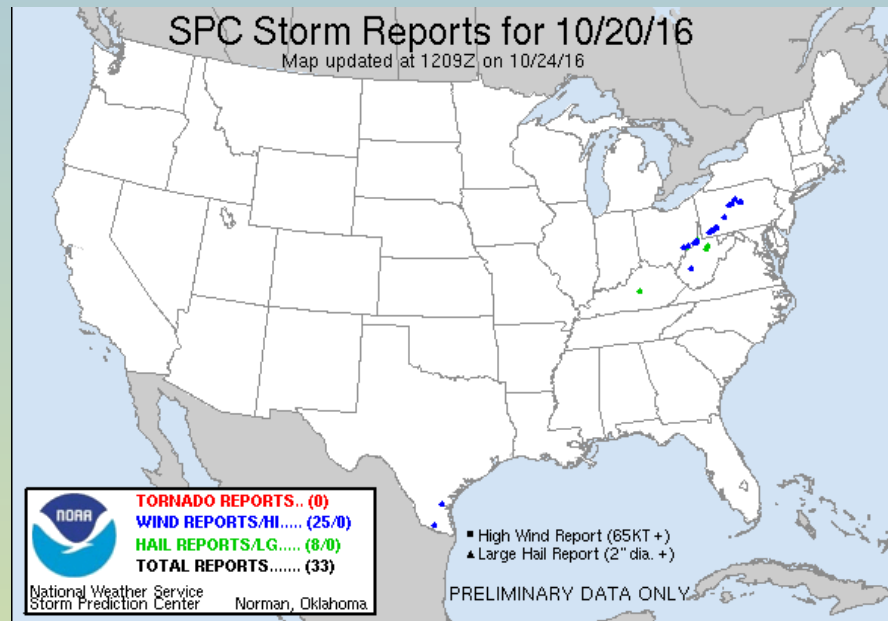




**SPC DAY 1 CATEGORICAL OUTLOOK**  
 ISSUED: 2000Z 10/20/2016  
 VALID: 20/2000Z-21/1200Z  
 FORECASTER: DIAL  
 NOAA/NWS Storm Prediction Center, Norman, Oklahoma

**Categorical Outlook Legend:**  
 TSTM (Green)    1: MRGL (Light Green)    2: SLGT (Yellow)    3: ENH (Orange)    4: MDT (Red)    5: HIGH (Purple)




**Severe Thunderstorm Watch # 499 - Valid from 345 PM until 1100 PM EDT**  
 NOAA/NWS/Storm Prediction Center    Updated: 20161020/1952 UTC




**TORNADO REPORTS.. (0)**  
**WIND REPORTS/HI..... (25/0)**  
**HAIL REPORTS/LG..... (8/0)**  
**TOTAL REPORTS..... (33)**  
 National Weather Service  
 Storm Prediction Center    Norman, Oklahoma

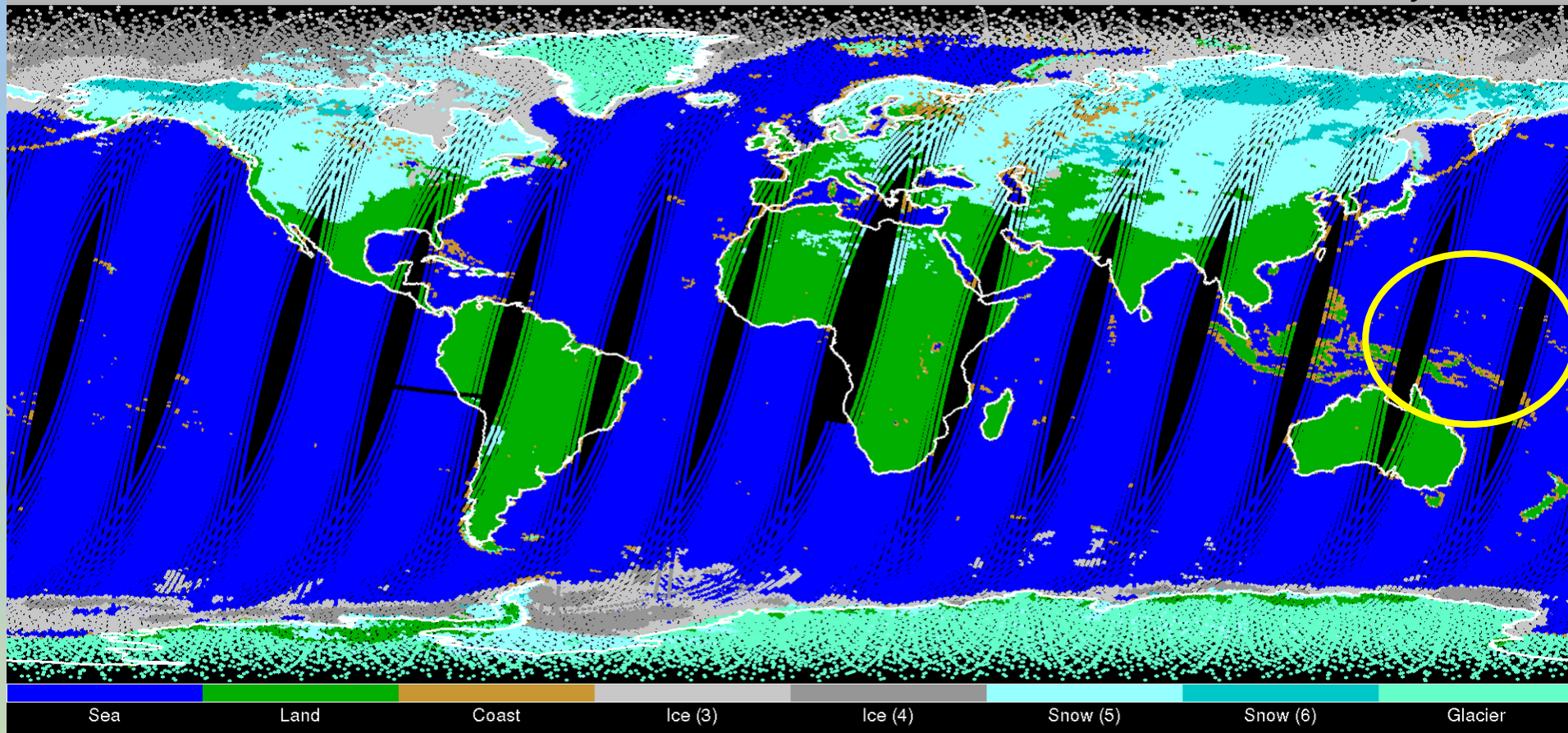
PRELIMINARY DATA ONLY

# NPP Polar Orbiting Global Coverage

NUCAPS

MW Surface Class

January 4, 2016



Near the Equator, there are holes in NUCAPS coverage every 12 hours  
**Note: If NOAA-20 orbits were plotted, the holes would be filled in**



# Feedback from HWT 2016

“ One of the beautiful things about NUCAPS in AWIPS is the ability to view pop-up Skew-Ts. One can move the cursor over the points from the .... satellite. These pop-up Skew-T can give a quick-look of thermodynamic profile across the green dots. Some of the yellow dots may look good too. Overall, Pop-Up Skew-Ts they rule!!! “

“ The lure is that it is an observation. I think it should remain observationally driven, even though we know there could be a source of error. If so, we know the source of the error. If you add in model data, you don't always know the source of the error. “

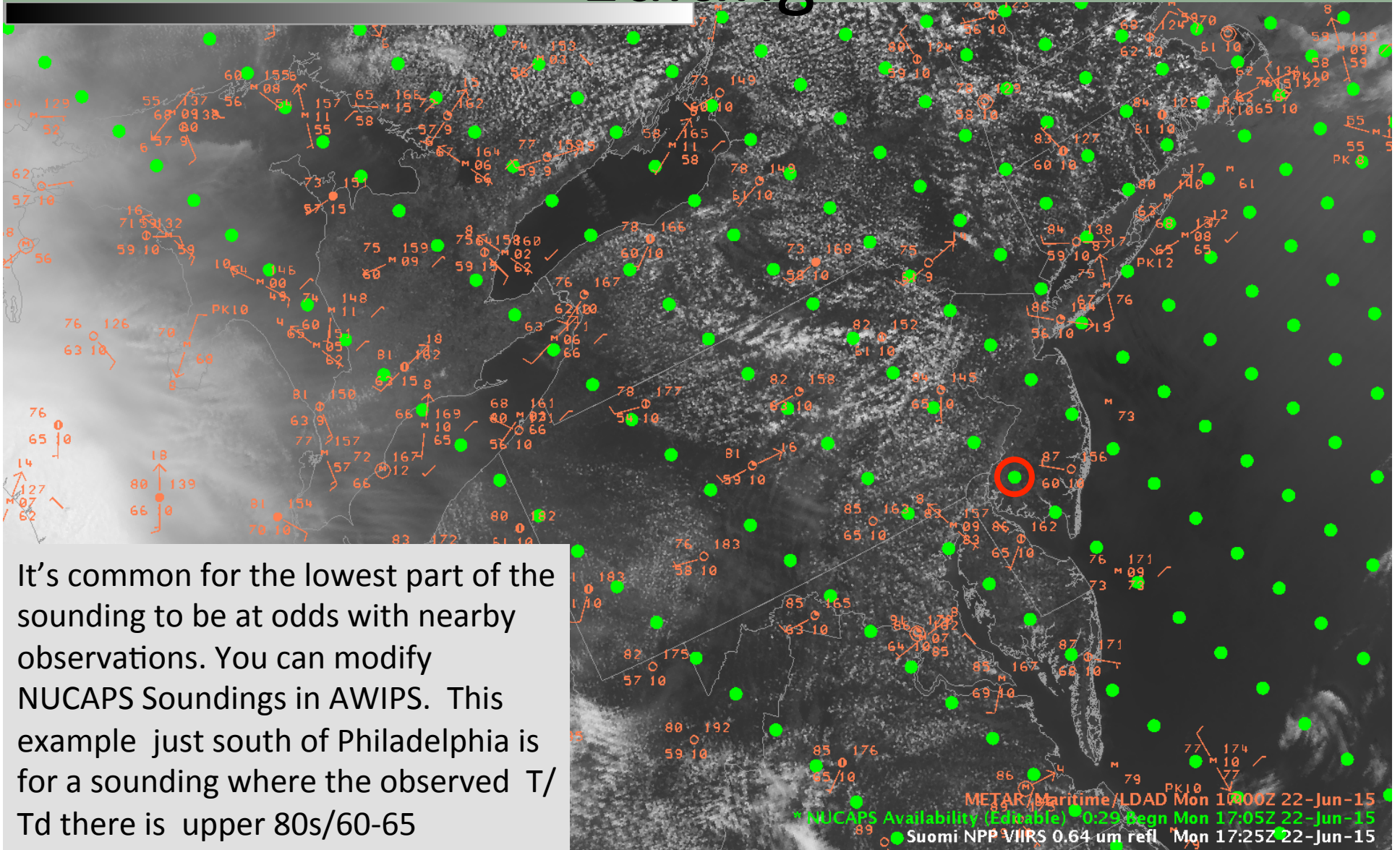
“ A modified NUCAPS sounding was sampled over the same location. The sounding depicts a similar moist low-layer, with a dry layer around 400 mb. CAPE is about 2200 j/kg, and TPW is 1.36 in, both similar to that from the observed radiosonde. “

“Pueblo is not an upper air site, so it was helpful there. IASI NUCAPS indicated only weak instability, which made sense given only weak convection/showers. Surface dew point and temperature were very accurate, perhaps because the atmosphere was so dry.

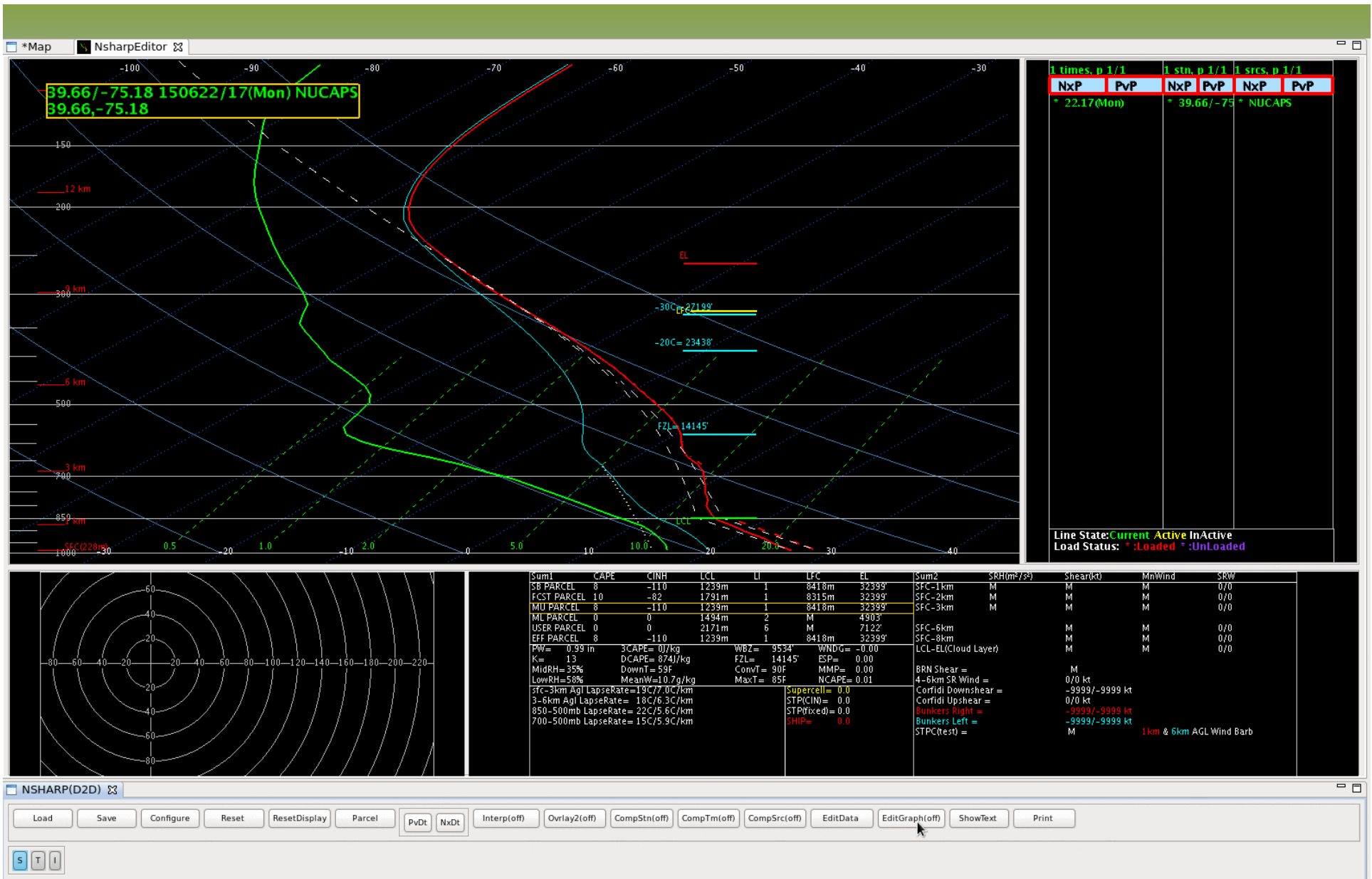
- In Texas, we used NUCAPS in our early analysis which proved to be helpful given sparse UA obs.

- NUCAPS had Wet Bulb Zero heights around 9000 ft, and FL around 12000 ft. With the kind of updrafts we had, I am not surprised we had such large hail.”

# Editing

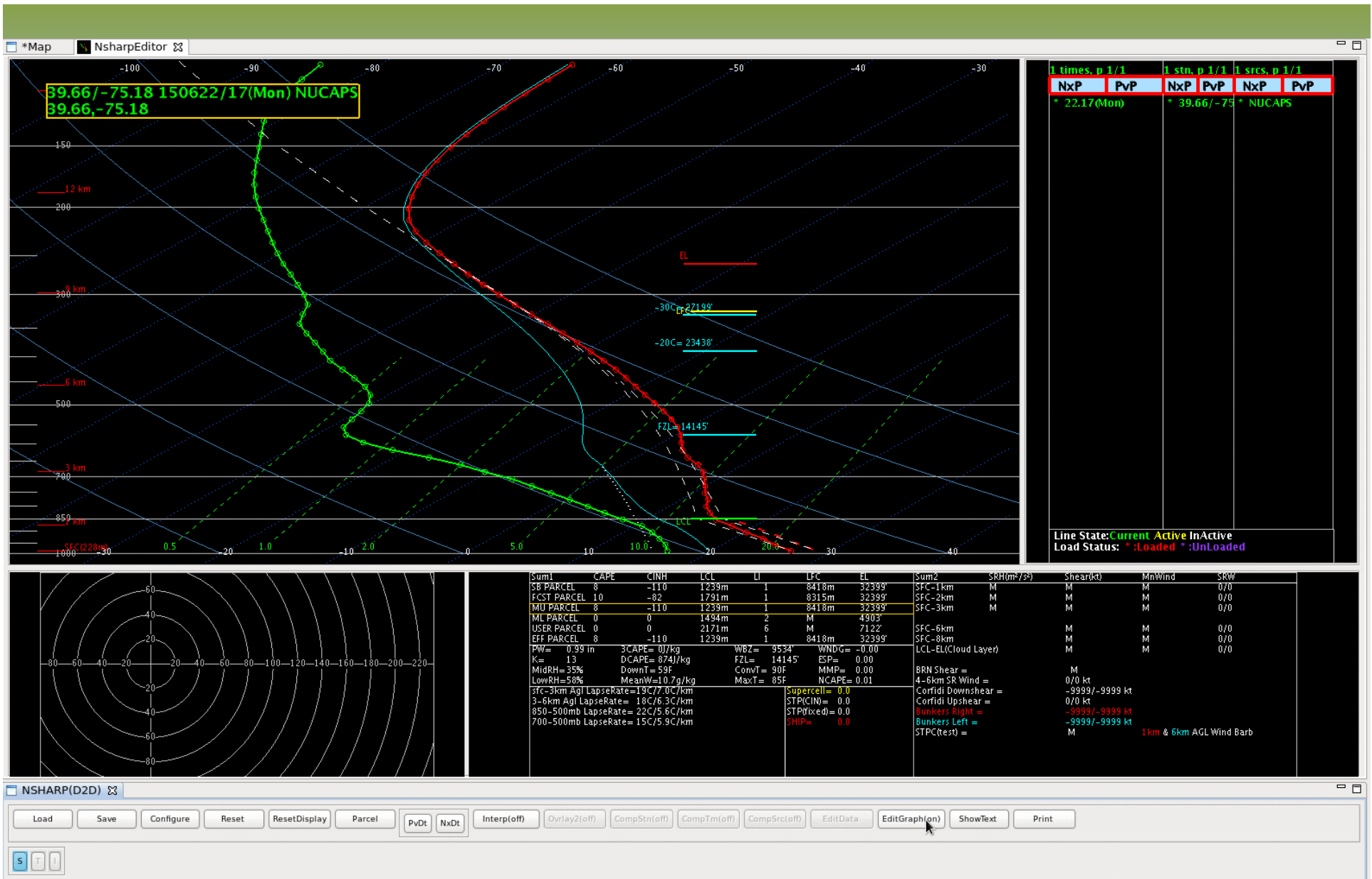


**Or you can edit things directly!**

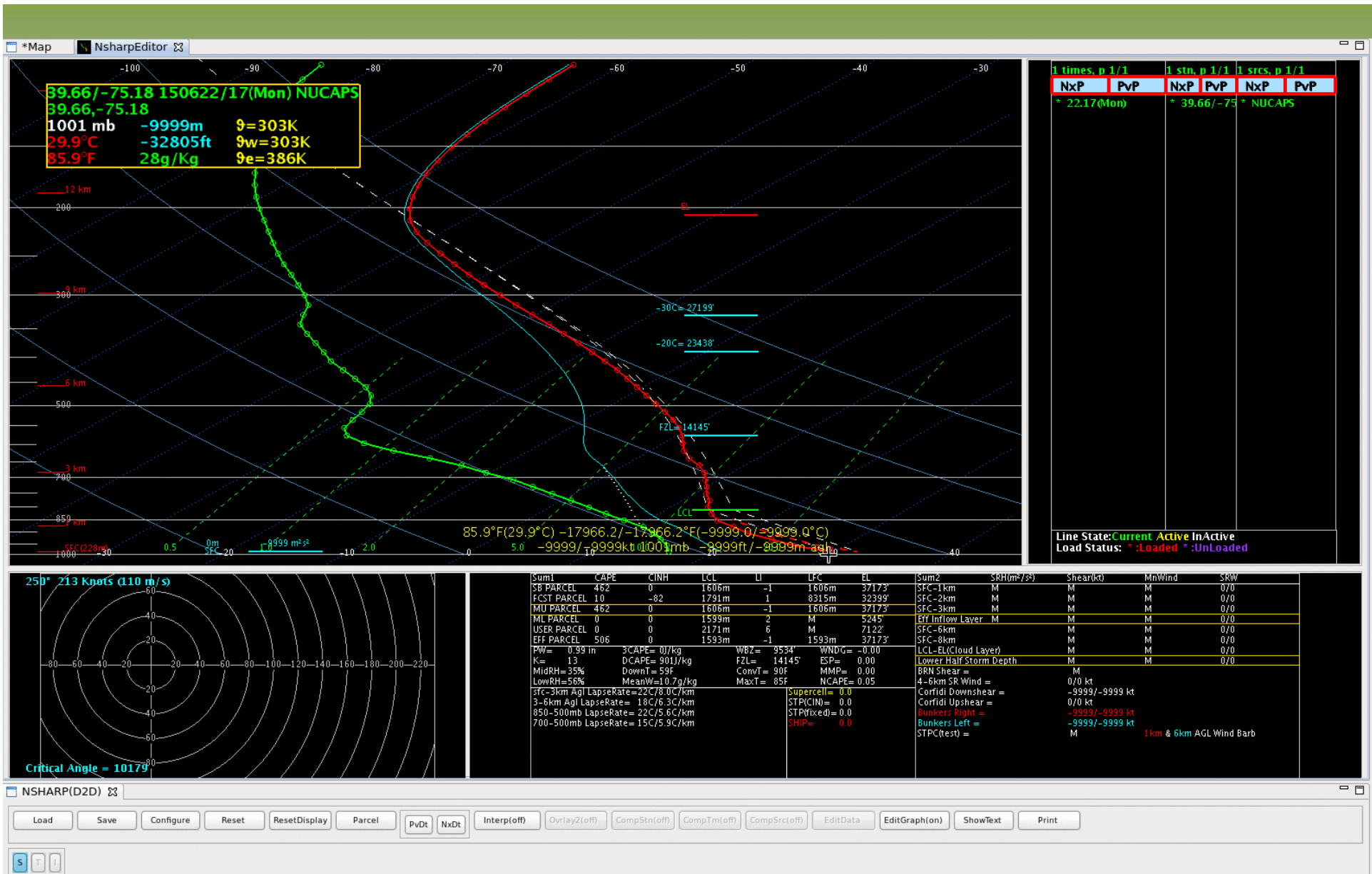


Do the surface values match observations as seen in the METAR plot? No. Change them.  
Toggle 'Edit Graph' to 'On'

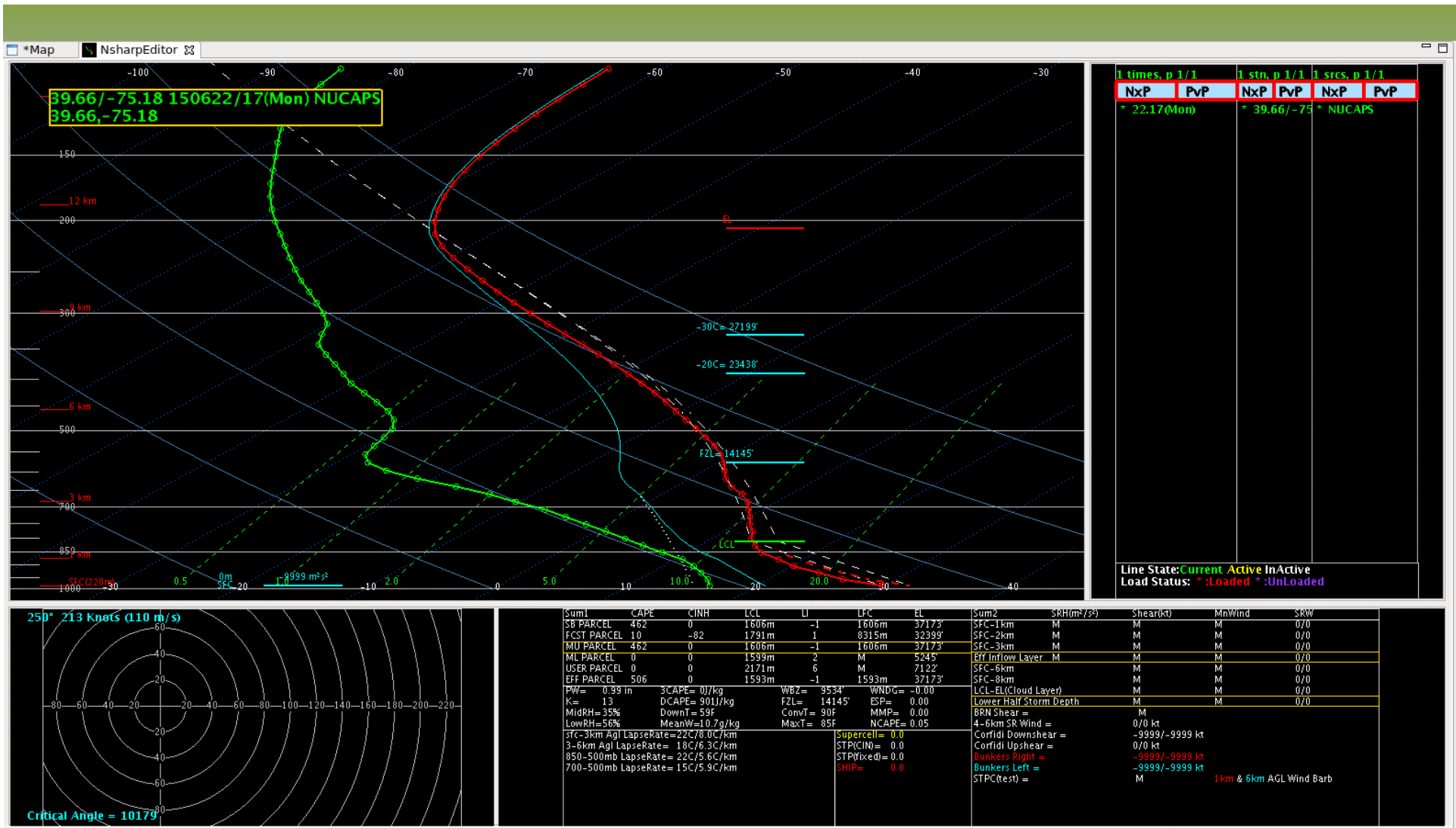




Draggable Points appear on the Temperature and Dewpoint lines. Move those points to values that are more appropriate



Don't like things you've changed? Click 'Reset' and start over. Once you're satisfied...

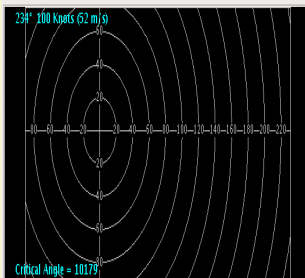
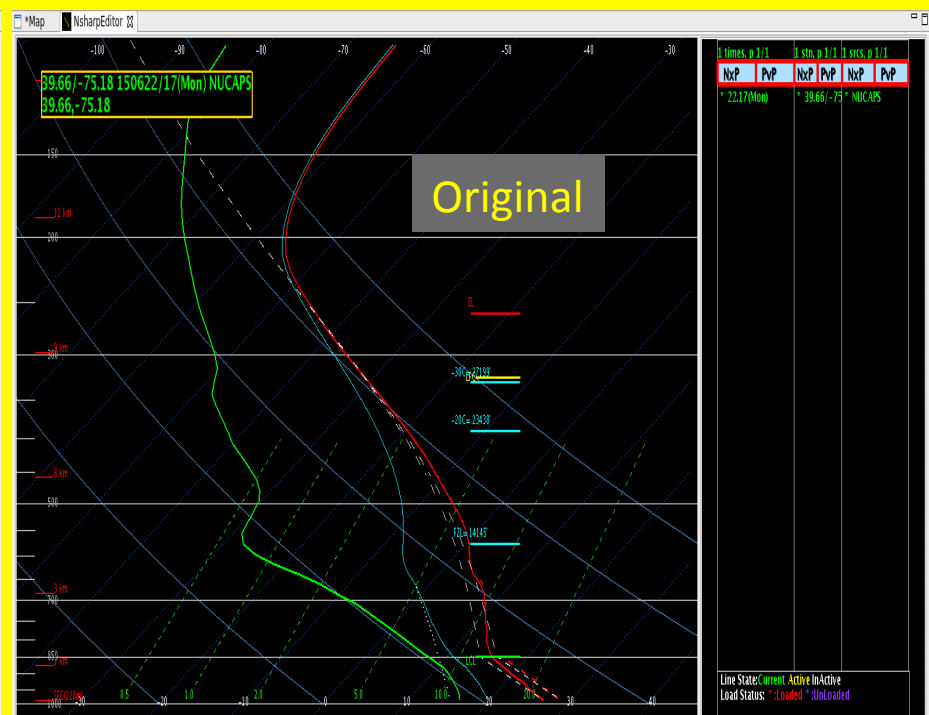
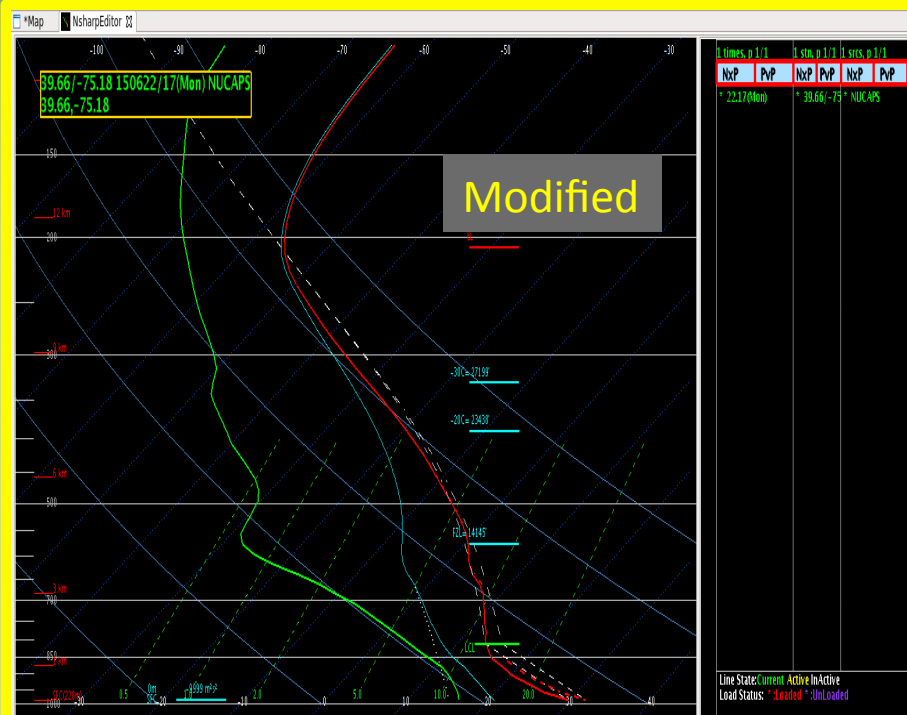


NSHARP(D2D) [X]

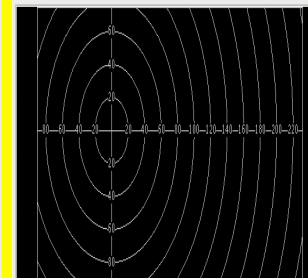
S [ ] [ ] [ ]

Toggle 'Edit Graph' back to off





ISM1	CAPE	CIN1	LCL	LI	LFC	EL	ISM2	ISM1P19	ShearP0	WindWind	SWN
SFC PARCEL	482	0	1166m	-1	1166m	27173	SFC-1km	M	M	M	0.0
SFC PARCEL	10	0	1736m	1	6315m	32339	SFC-2km	M	M	M	0.0
UNT PARCEL	482	0	1166m	-1	1166m	27173	SFC-3km	M	M	M	0.0
MIX PARCEL	0	0	1539m	2	M	5245	Eff Inflow Layer	M	M	M	0.0
USER PARCEL	0	0	2171m	6	M	7122	SFC-6km	M	M	M	0.0
EFF PARCEL	516	0	1539m	-1	1539m	27173	SFC-8km	M	M	M	0.0
							LCL-EL(Cloud Level)	M	M	M	0.0
							Lower RFB Storm Depth	M	M	M	0.0
							BRK Clear =				0.0
							4-km SW Wind =				0.0 kt
							Confid Downshear =				-9999 -9999 kt
							Confid Upshear =				0.0 kt
							Bankers Right =				-9999 -9999 kt
							Bankers Left =				-9999 -9999 kt
							STPCTherd =				M 1km & 6km AGL Wind Barb



ISM1	CAPE	CIN1	LCL	LI	LFC	EL	ISM2	ISM1P19	ShearP0	WindWind	SWN
SFC PARCEL	9	-110	1123m	1	6410m	22339	SFC-1km	M	M	M	0.0
SFC PARCEL	10	0	1736m	1	6315m	32339	SFC-2km	M	M	M	0.0
UNT PARCEL	1	-110	1123m	1	6410m	22339	SFC-3km	M	M	M	0.0
MIX PARCEL	0	0	1494m	2	M	4300					
USER PARCEL	0	0	2171m	6	M	7122	SFC-6km	M	M	M	0.0
EFF PARCEL	0	-110	1123m	1	6410m	22339	SFC-8km	M	M	M	0.0
							LCL-EL(Cloud Level)	M	M	M	0.0
							Lower RFB Storm Depth	M	M	M	0.0
							BRK Clear =				M
							4-km SW Wind =				0.0 kt
							Confid Downshear =				-9999 -9999 kt
							Confid Upshear =				0.0 kt
							Bankers Right =				-9999 -9999 kt
							Bankers Left =				-9999 -9999 kt
							STPCTherd =				M 1km & 6km AGL Wind Barb

NSHARP(D2D) 33

Load Save Configure Reset ResetDisplay Parcel PIdx NIdx Interplot Overlay2(off) CompStat(off) CompTm(off) CompGross(off) EditData EditGraph(off) ShowText Print

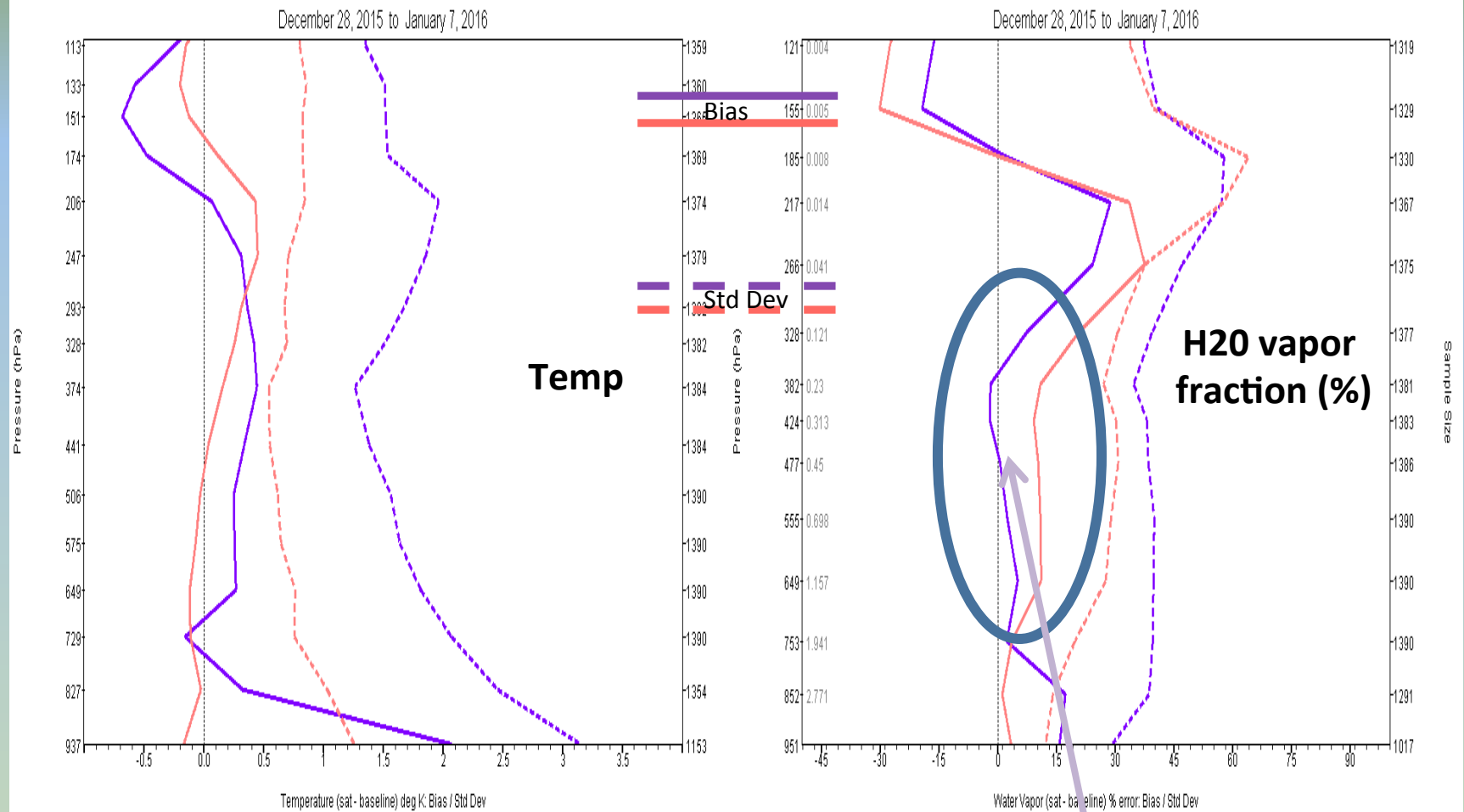
NSHARP(D2D) 33

Load Save Configure Reset ResetDisplay Parcel PIdx NIdx Interplot Overlay2(off) CompStat(off) CompTm(off) CompGross(off) EditData EditGraph(off) ShowText Print

How have convective parameters changed? CAPE? LCL? EL?  
Compare the two soundings. All that was changed was the temperature at a few of the lower levels

# Statistics of the NUCAPS Soundings

(Thanks to Tony Reale & Nick Nalli)



Baseline: Radiosonde Observed

Baseline: Radiosonde Observed

Radiosonde GFS 6 Hour

NUCAPS NPP

Radiosonde GFS 6 Hour

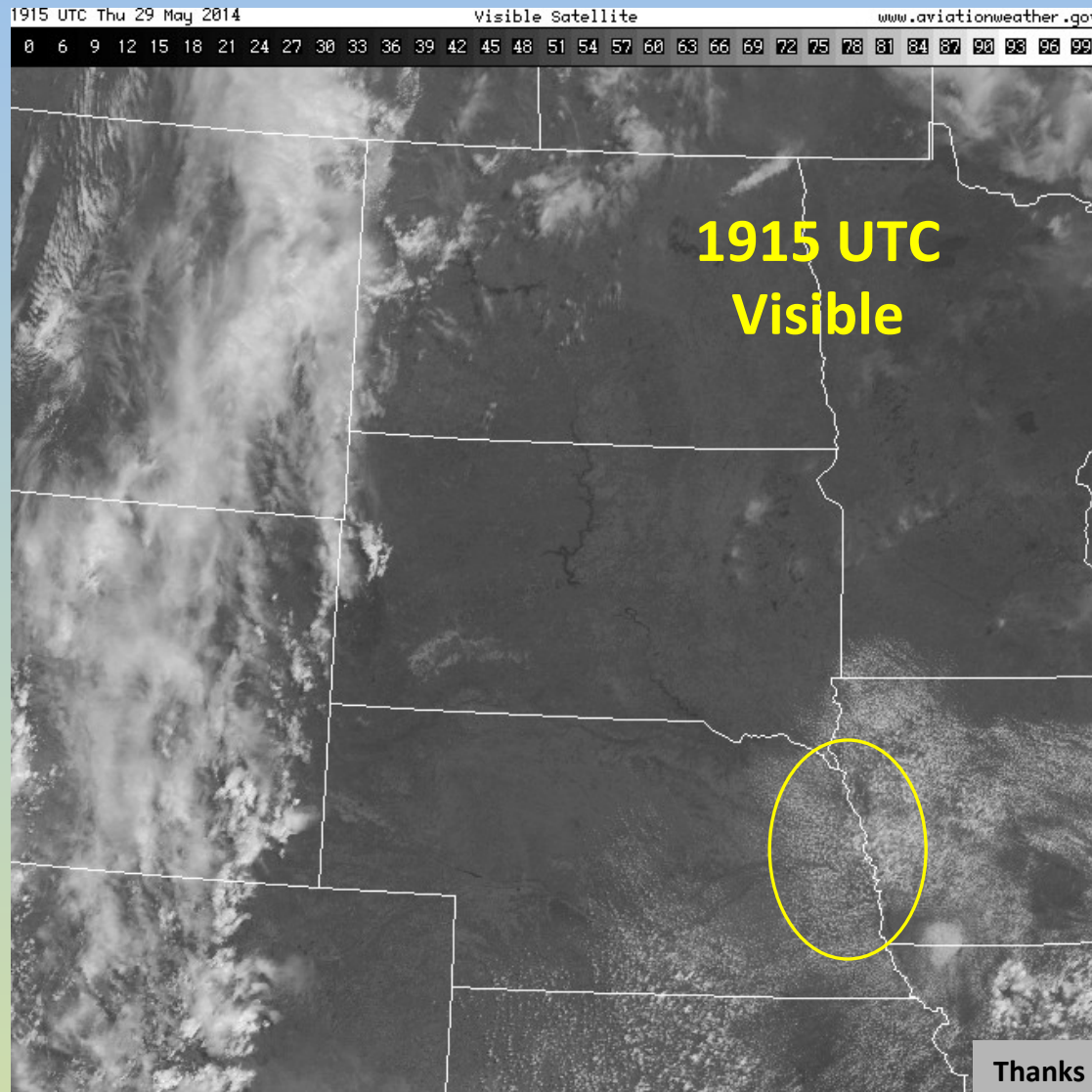
NUCAPS NPP

Dec 28 2015 to Jan 7 2016

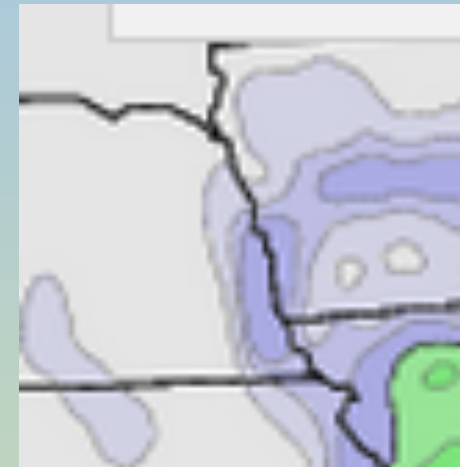
NUCAPS IR Pass QC  
CONUS

NUCAPS Bias closer to zero,  
better than GFS, from 300-700

# Forecast Problem: 29 May 2014 Afternoon/Evening Convection ?



GFS 9 hour forecast  
From 12UTC 29 May  
Valid 21 UTC 29 May



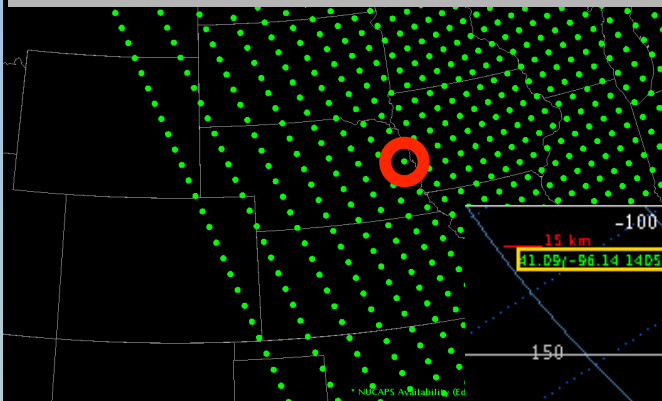
Will the Cumulus Field  
develop further? (As  
suggested by the GFS)

Thanks to Dan Nietfeld for this example and the next one too!

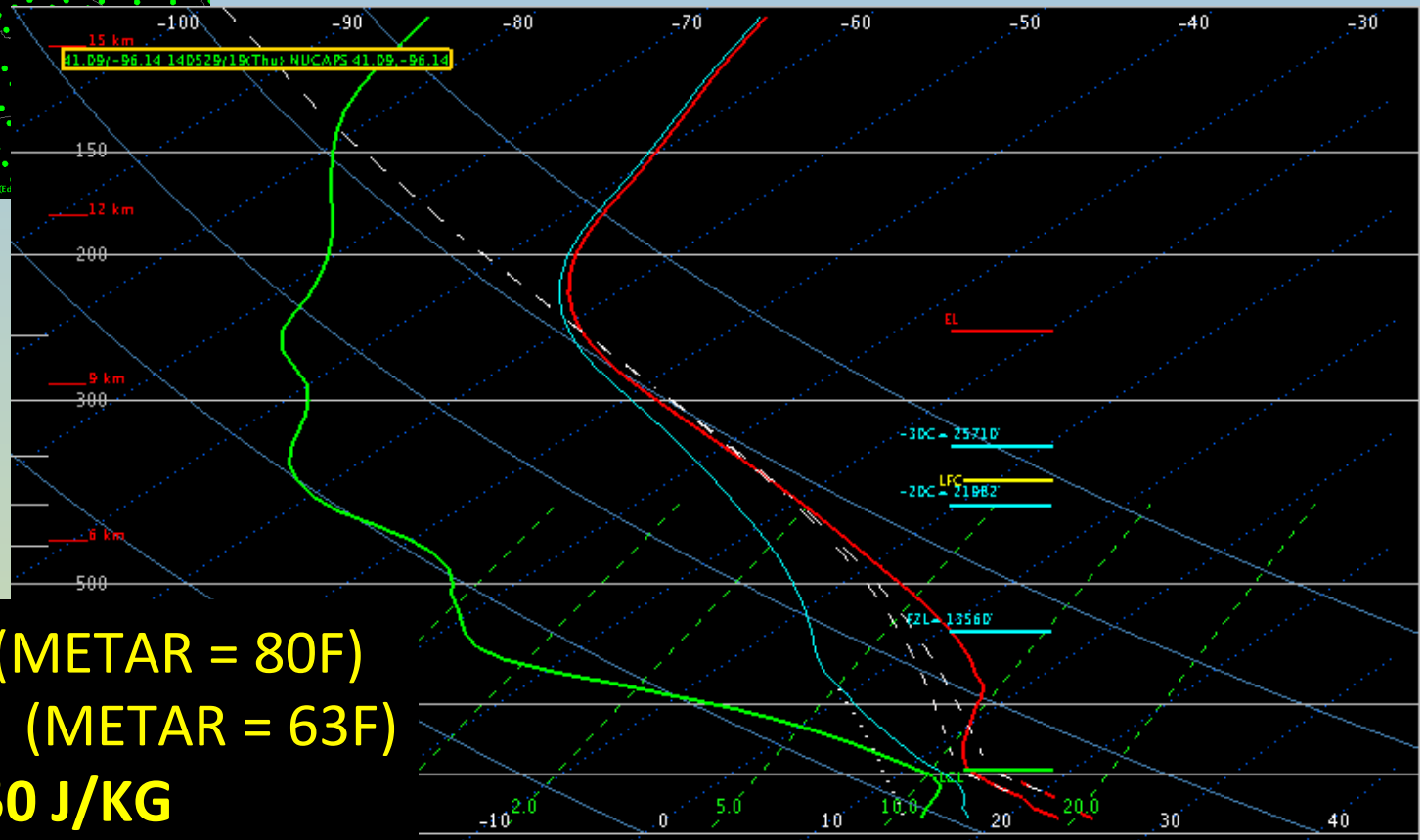


# NUCAPS Soundings give thermodynamic information at a convenient time!

1842 UTC NPP pass



Would you expect convective development?



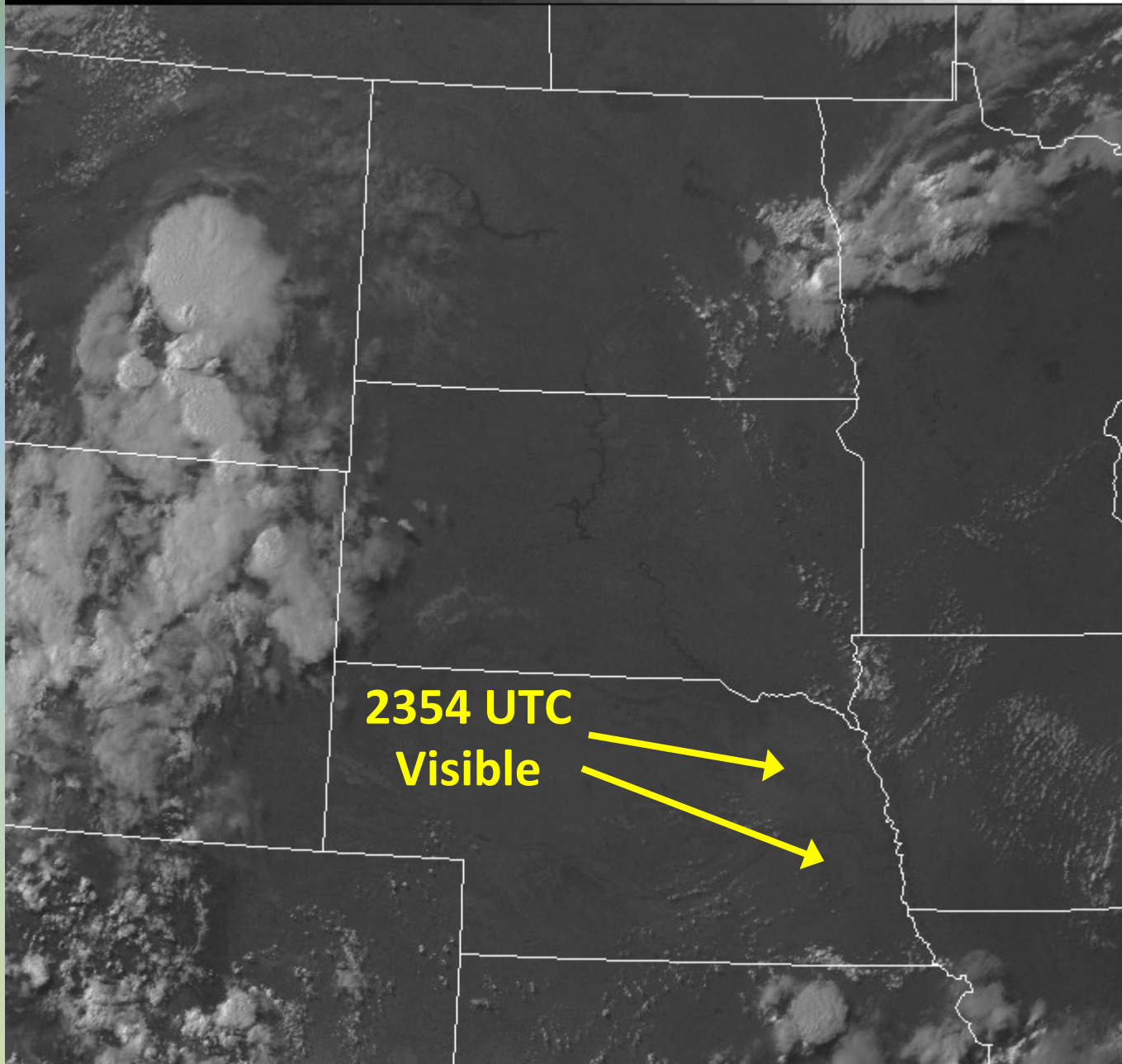
**T = 79F (METAR = 80F)**  
**Td = 60F (METAR = 63F)**  
**CAPE ~ 50 J/KG**

2354 UTC Wed 28 May 2014

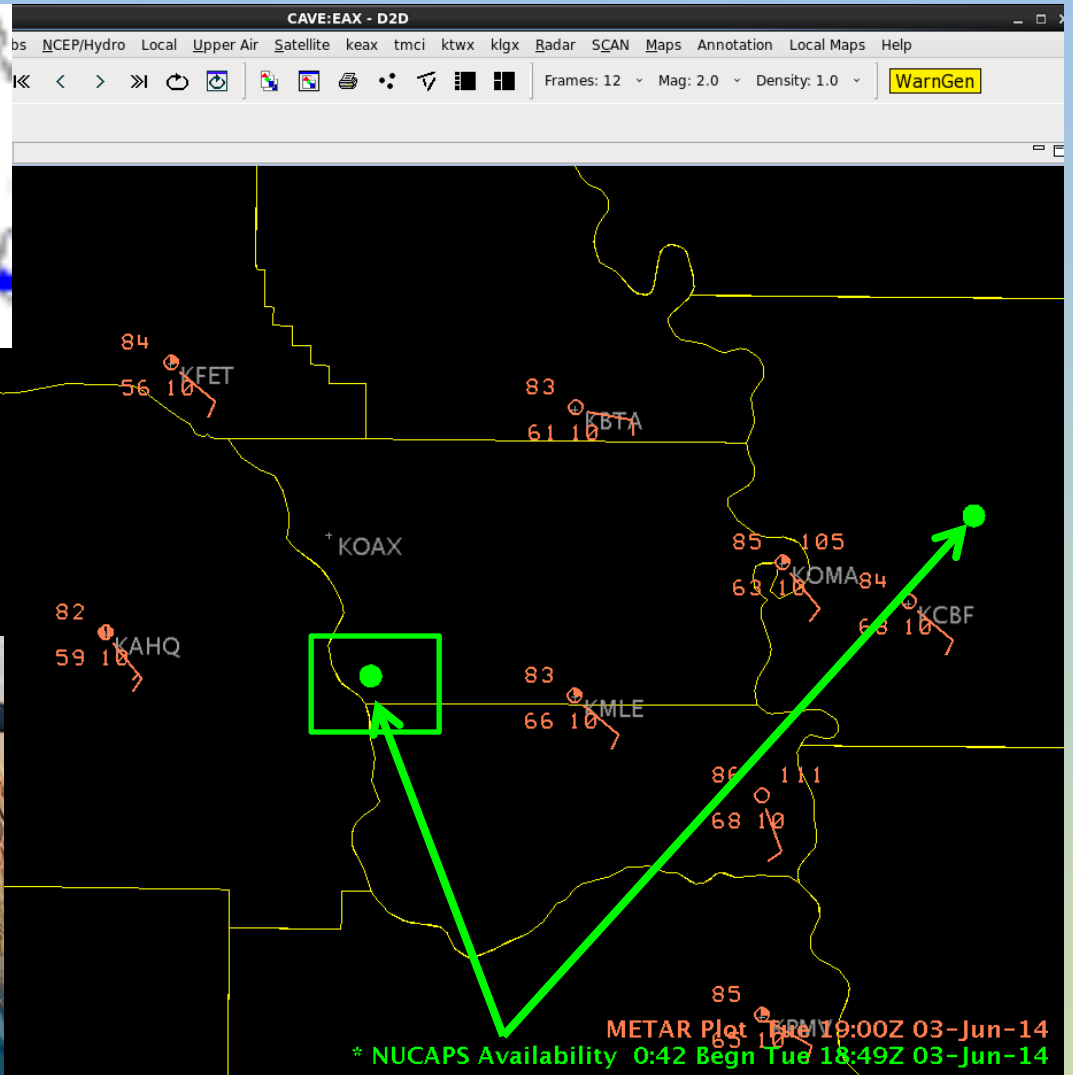
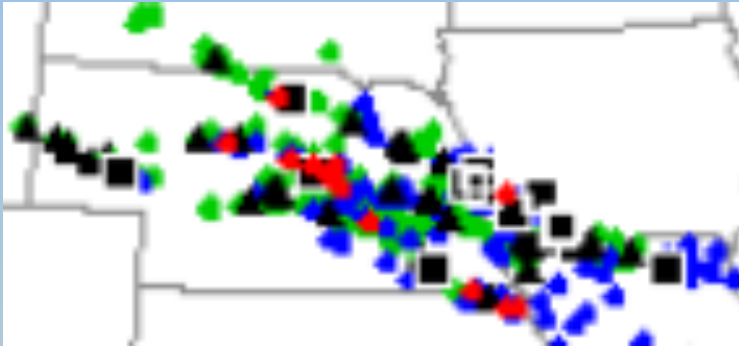
Visible Satellite

www.aviationweather.gov

0 6 9 12 15 18 21 24 27 30 33 36 39 42 45 48 51 54 57 60 63 66 69 72 75 78 81 84 87 90 93 96 99



# June 3, 2014 High Risk Severe Weather Event in Omaha

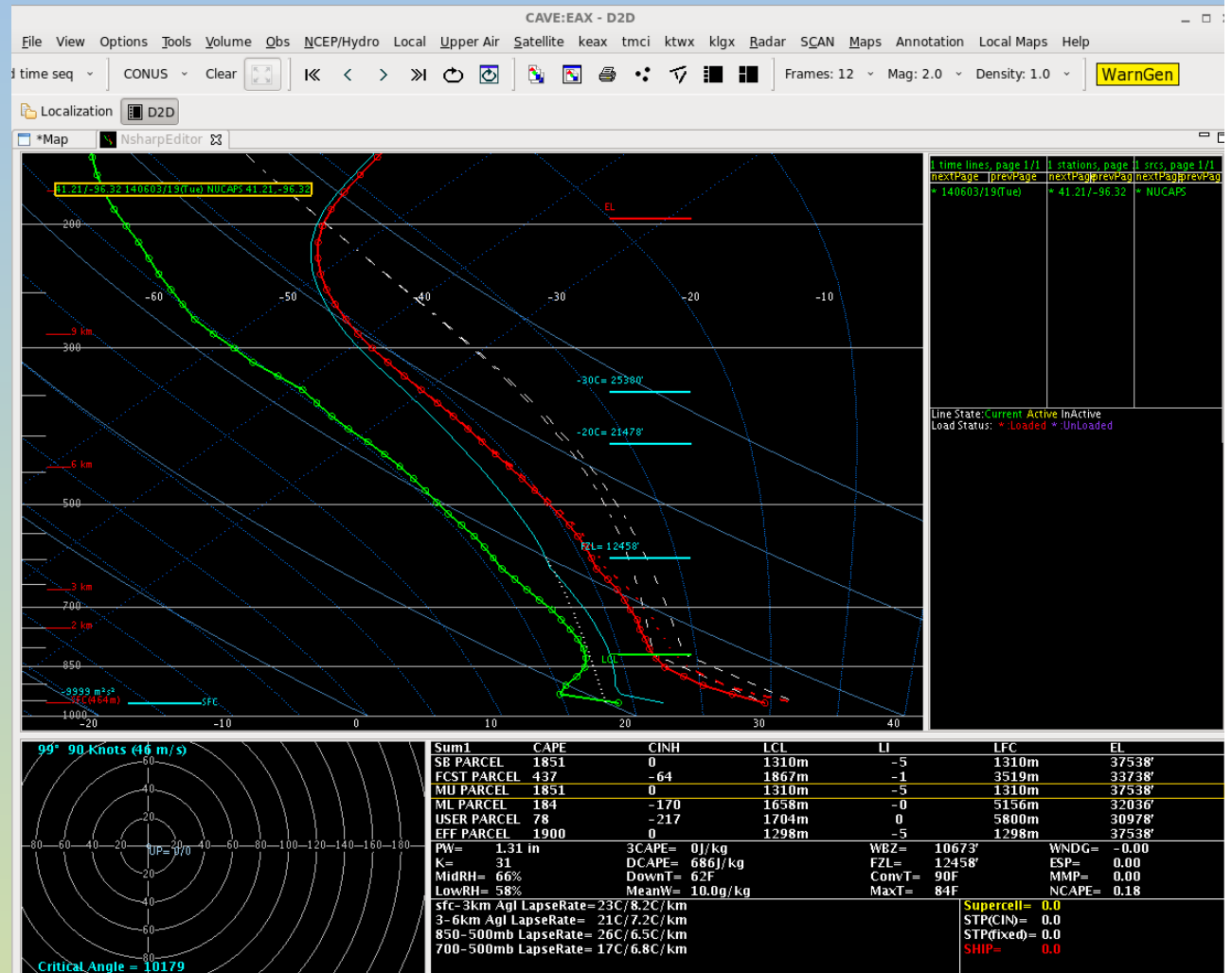




# June 3, 2014 High Risk Severe Weather Event in Omaha

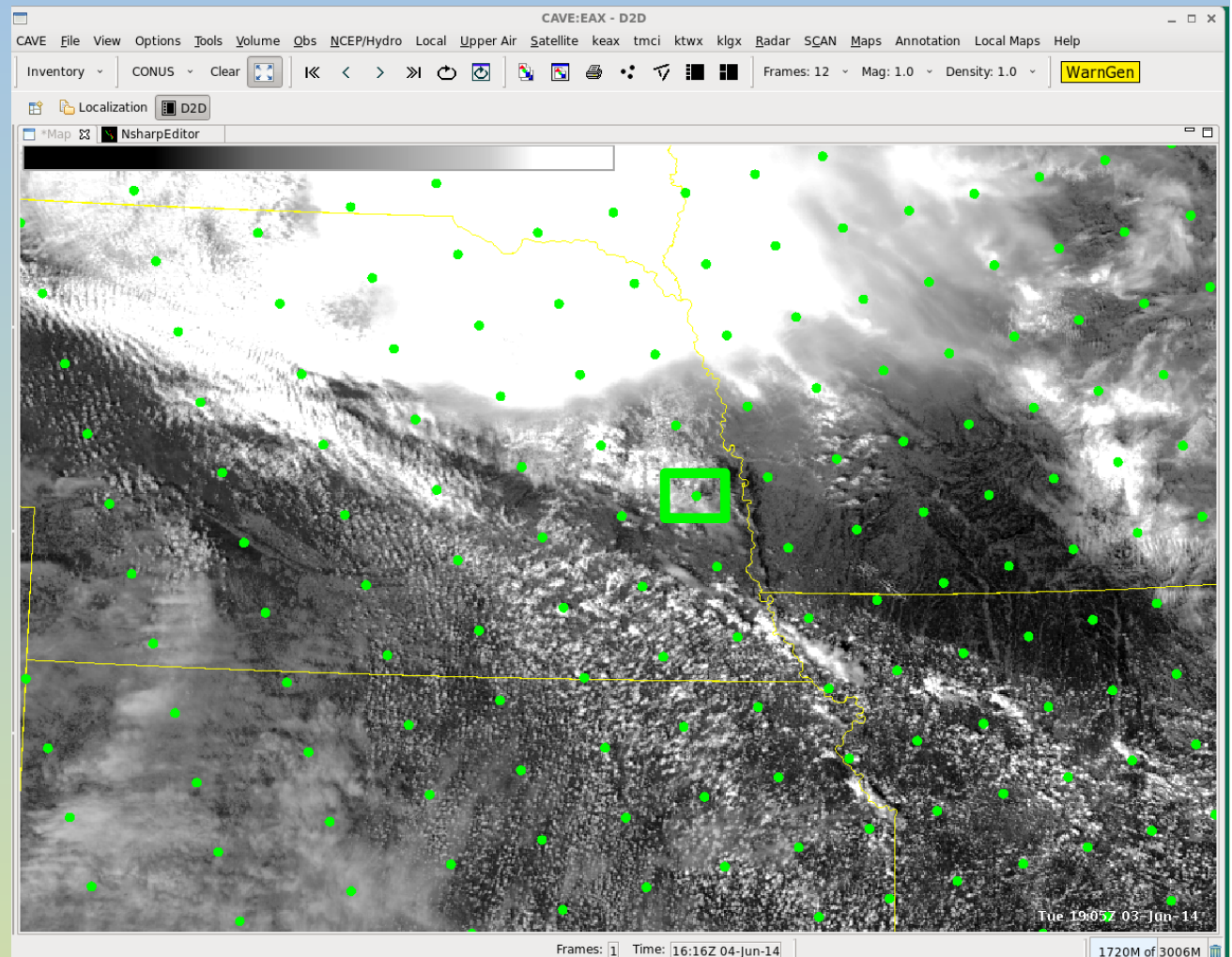
NUCAPS ~10 KM south of OAX  
1849Z June 3, 2014 – cloudy scene, but still gives info!

**Modified** for surface METAR  
Ob of T=83, Td=63  
SB CAPE = 1851



# June 3, 2014 High Risk Severe Weather Event in Omaha

**NUCAPS  
sounding  
locations  
overlain on  
VIIRS 0.64  
1905Z June 3,  
2014**



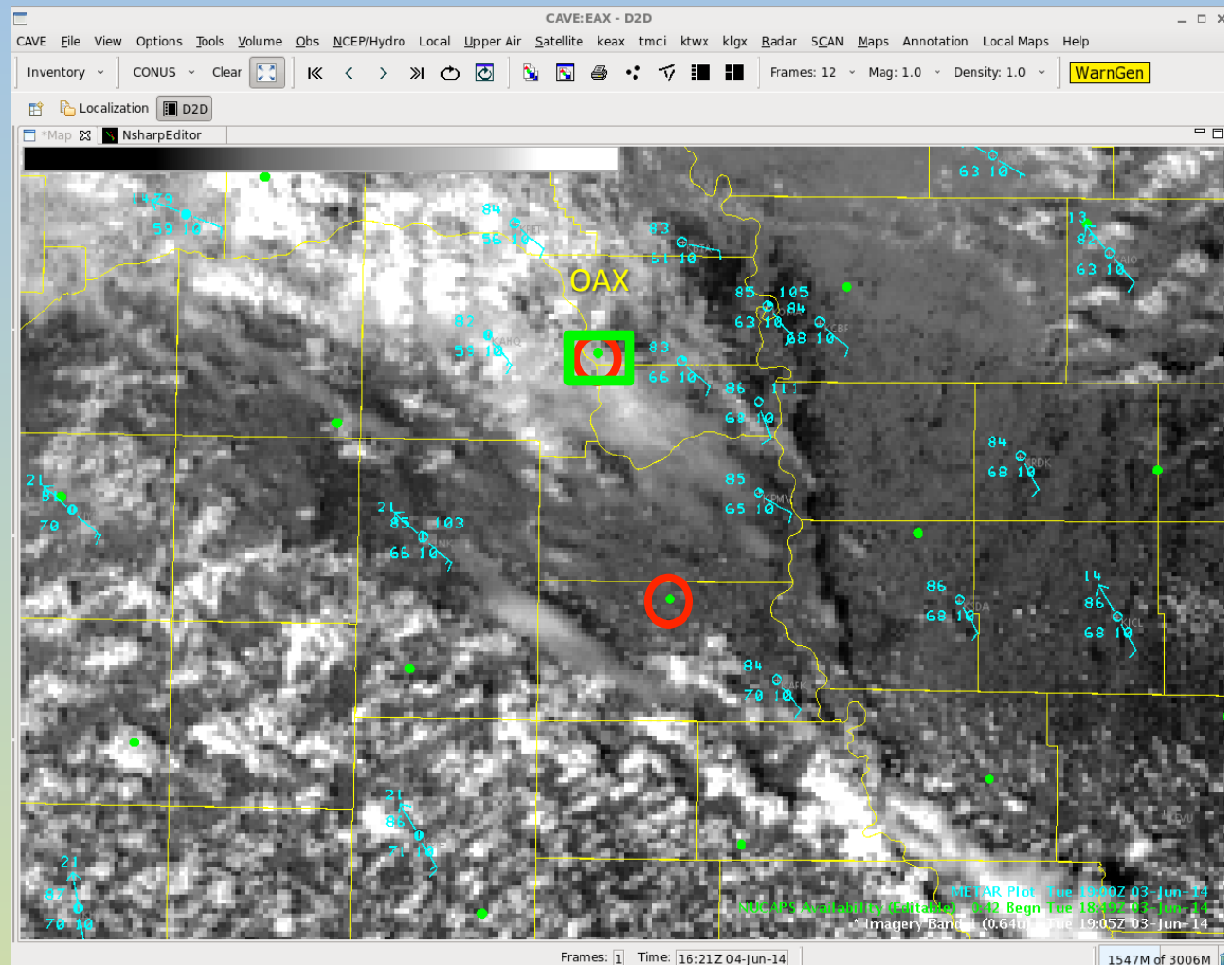
# June 3, 2014 High Risk Severe Weather Event in Omaha

NUCAPS sounding locations  
Overlaid with VIIRS 0.64  
1905Z June 3, 2014

Location of OAX in yellow

Northern dot is within a few  
KM of KOAX, but under  
cloud cover

Southern dot is in a nearly  
Cloud-free location, and is  
warmer and more humid

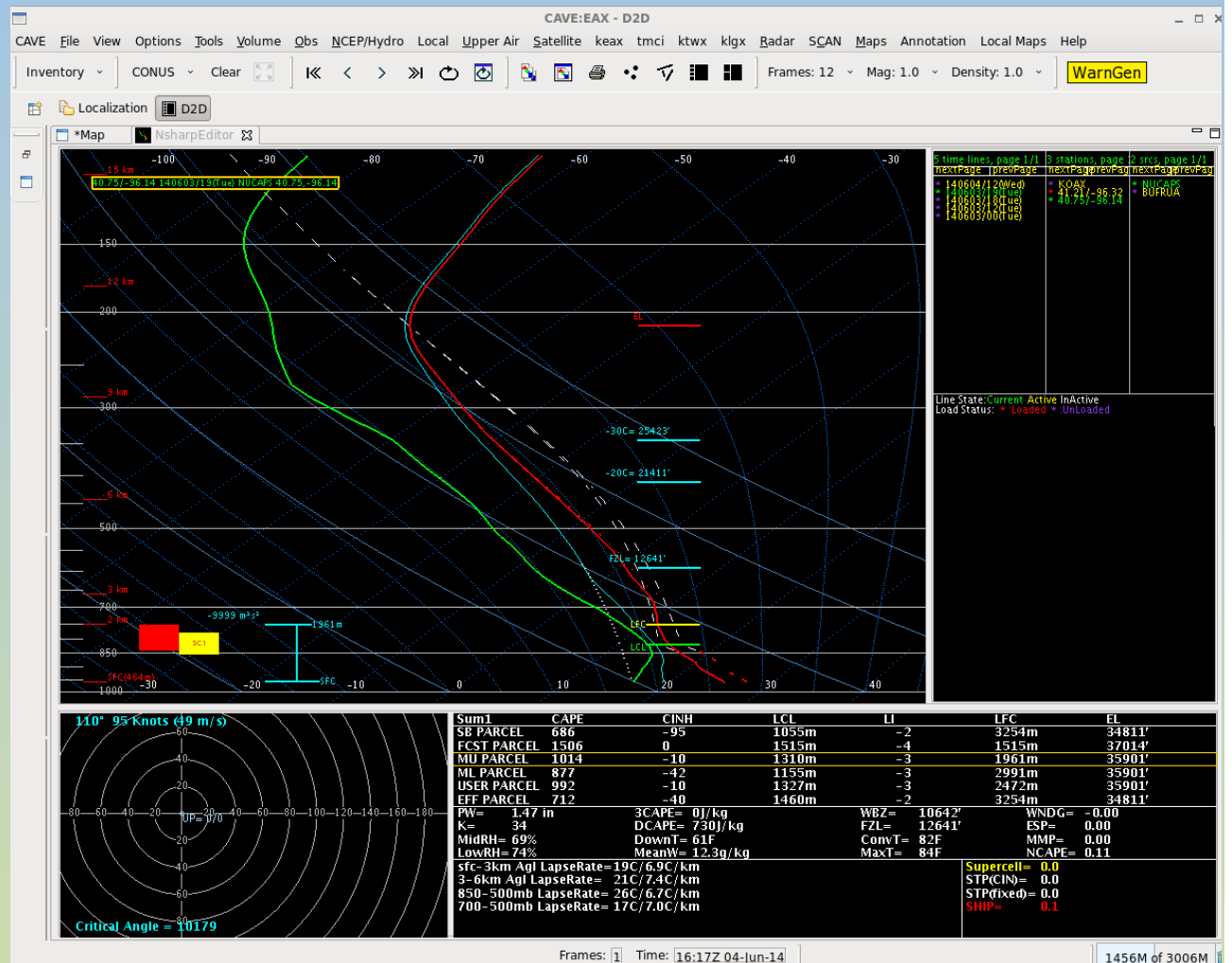




# June 3, 2014 High Risk Severe Weather Event in Omaha

NUCAPS sounding  
40 km south of OAX  
1849Z June 3, 2014

**Unmodified**  
SB CAPE = 686

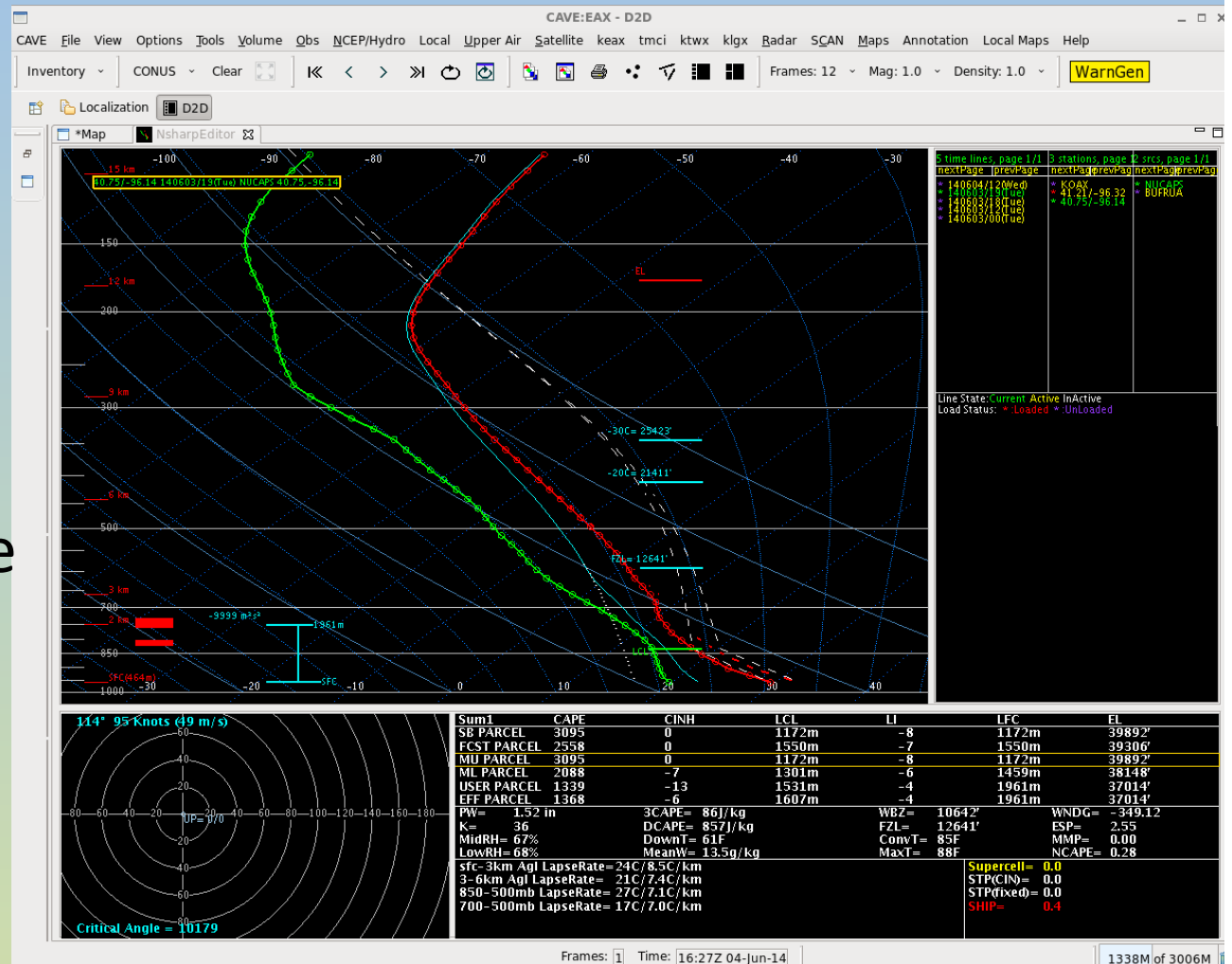


# June 3, 2014 High Risk Severe Weather Event in Omaha

NUCAPS sounding  
40 km south of OAX  
1849Z June 3, 2014

**Modified** for surface  
METAR

Ob of T=85, Td=68  
SB CAPE = 3095



# You can find these online!

- Link is :
- <http://www.ospo.noaa.gov/Products/atmosphere/soundings/nucaps/pskewt/USACON.html>

# Summary

- A mix of infrared and microwave information. If Infrared regression or retrieval fails, a microwave-only sounding will still be produced.
- At most 10 temperature layers and about five moisture layers are resolved in the troposphere.
- Time latency is about 30 minutes via DB sources for Suomi NPP NUCAPS!
- NUCAPS Soundings are also computed from Metop A and Metop B. Only Suomi NPP passes are in WFO AWIPS now
  - **Metop A and Metop B NUCAPS Soundings are available at HWT via the SBN**
- Learn how to modify the soundings if the lowest layers don't agree with nearby METARs or the RTMA
  - **Modified Soundings have been modified to match RTMA Thermodynamics: Is the boundary layer that is inserted correct?**
- NUCAPS data are also presented HWT as horizontal fields at one layer. There is training on that too!
- The HWT Blog has many NUCAPS examples. ([Link](#))