

National Weather Service's use of Hyperspectral Profiles in Operational Forecast and Warning Services

NASA Sounder Science Team Meeting

October 13-16, 2015

Daniel Nietfeld

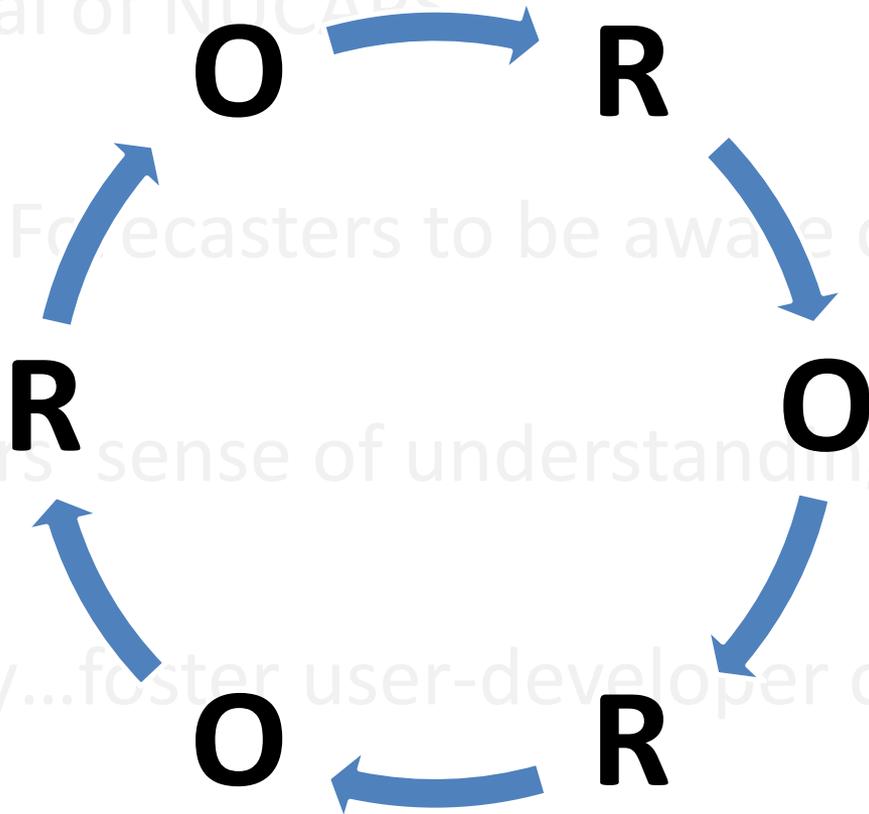
*Science and Operations Officer (SOO) NOAA-NWS-WFO Omaha
Branch Chief NOAA-NWS-NCEP-WPC Development and Training Branch*

Hopeful Takeaways

- The Appeal of Hyperspectral Profile Retrievals
- Issues for Forecasters to be aware of
- Forecasters' sense of understanding “error”
- Ultimately...foster user-developer collaboration
 - R2O
 - O2R

Hopeful Takeaways

- The Appeal of NUICAPS
- Issues for Forecasters to be aware of
- Forecasters' sense of understanding "error"
- Ultimately...foster user-developer collaboration
 - R2O
 - O2R

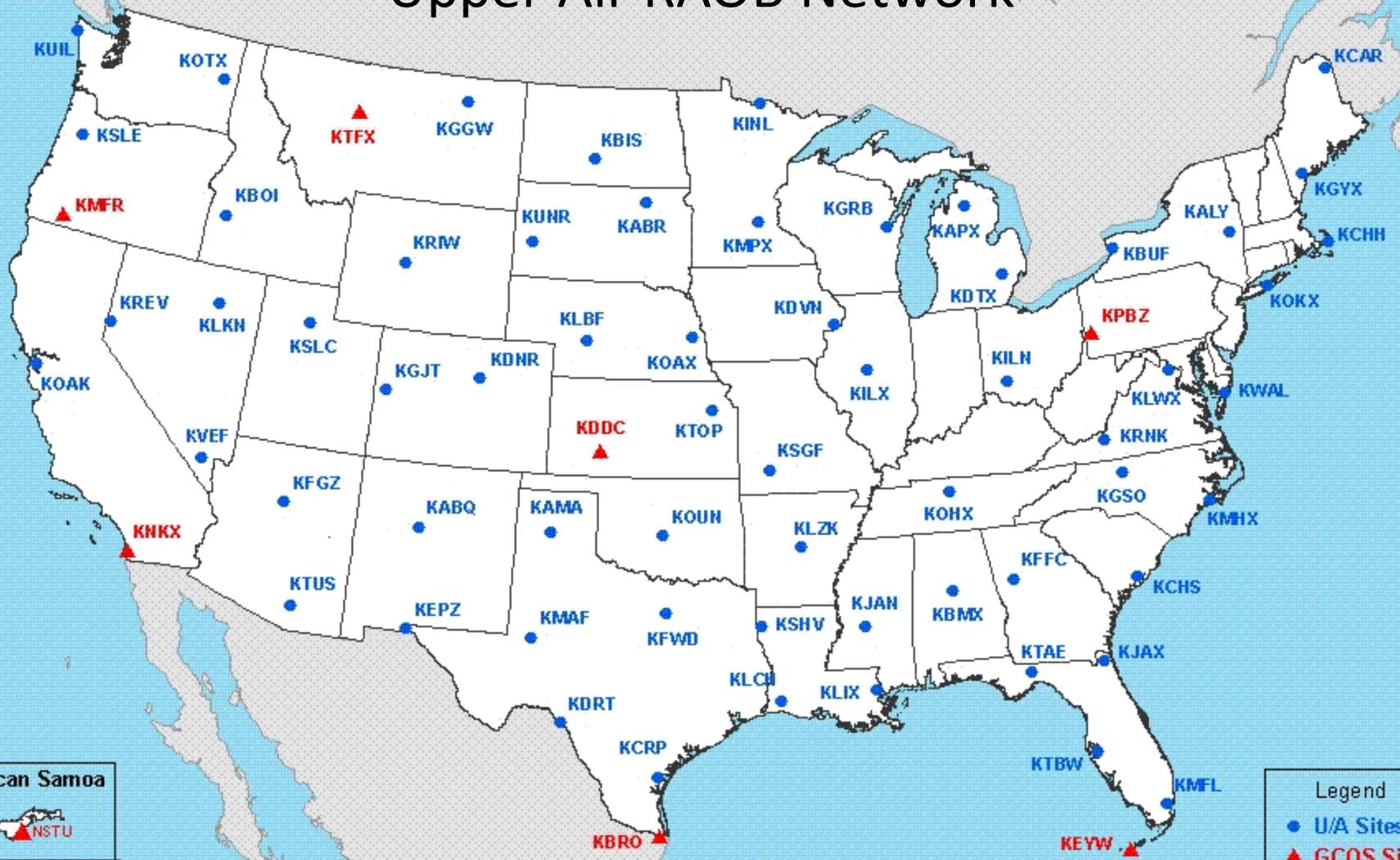


“Day in the Life” of a NWS Forecaster in the Midwest

- Convection is a common forecast problem
- Accustomed to looking at the 12Z RAOB, with density of ~ 2 per state



Upper Air RAOB Network



American Samoa



Hawaii



Mariana Islands



Legend

- U/A Sites
- ▲ GCOS Sites

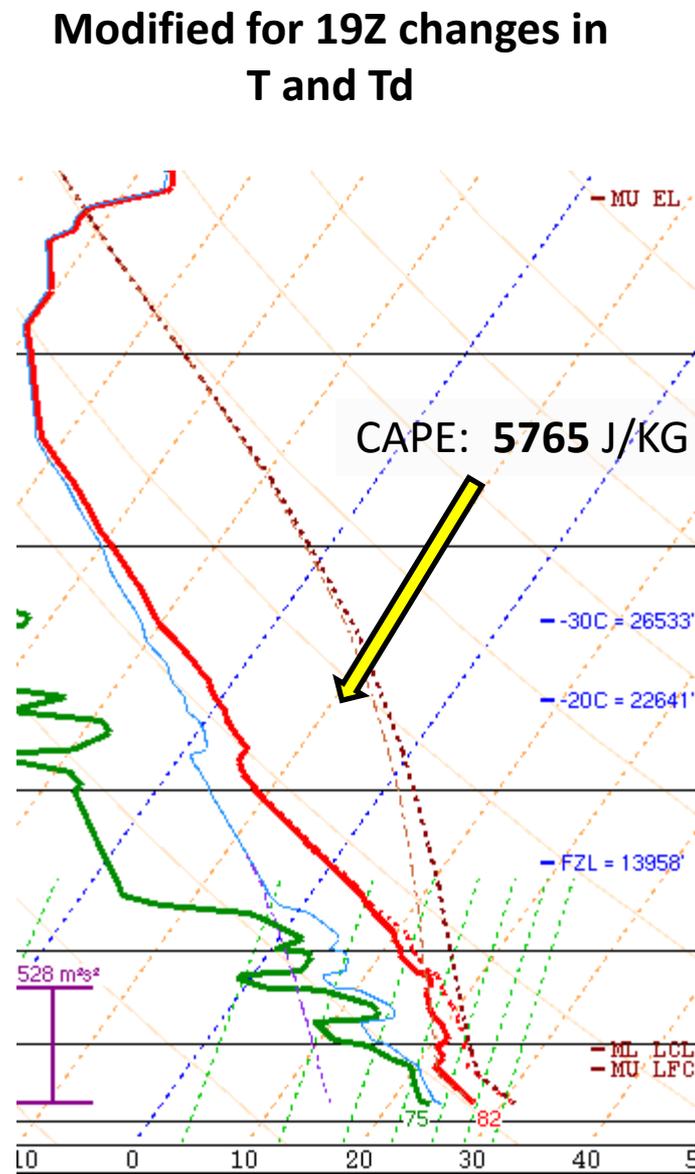
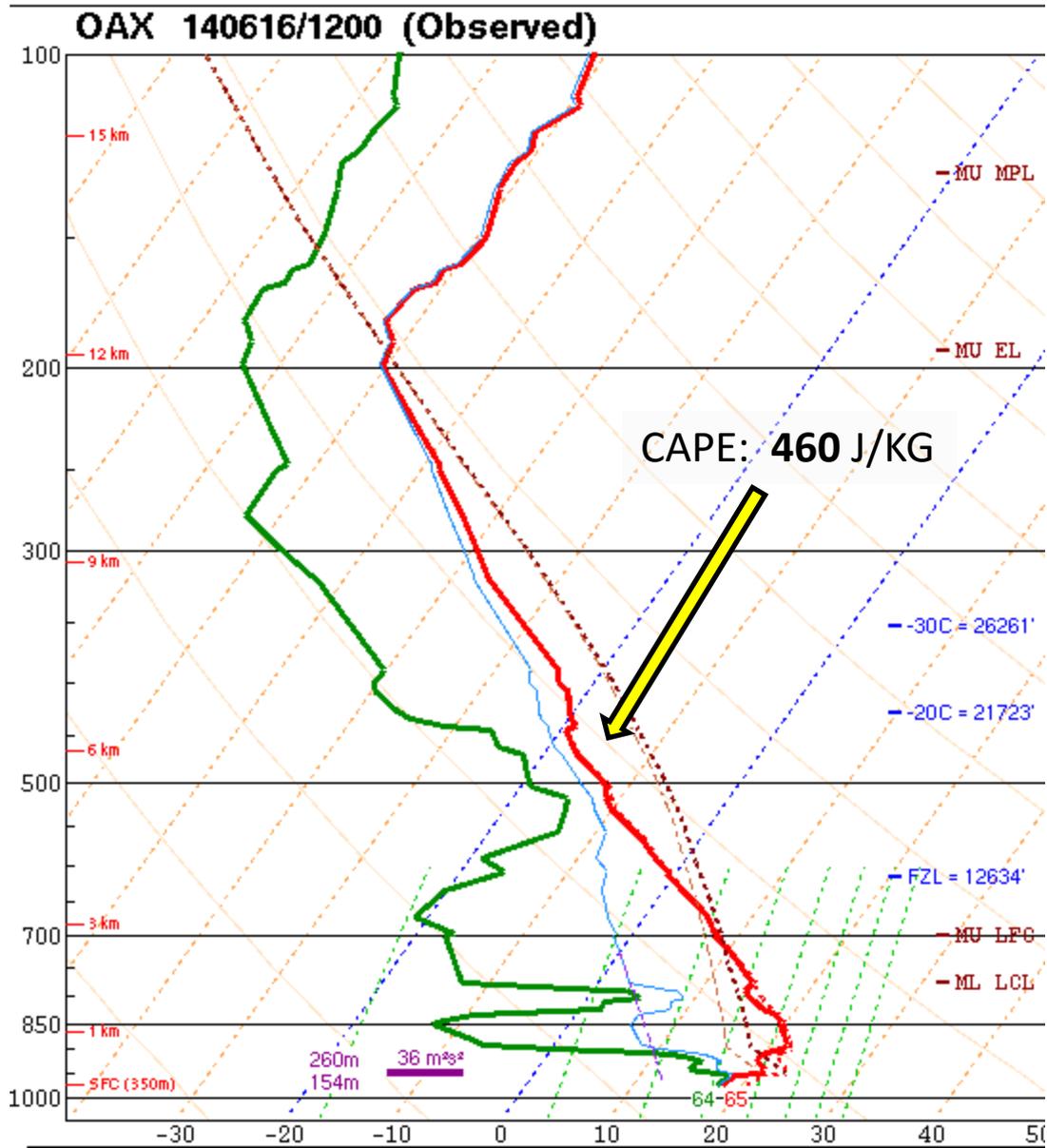
Puerto Rico and Virgin Islands



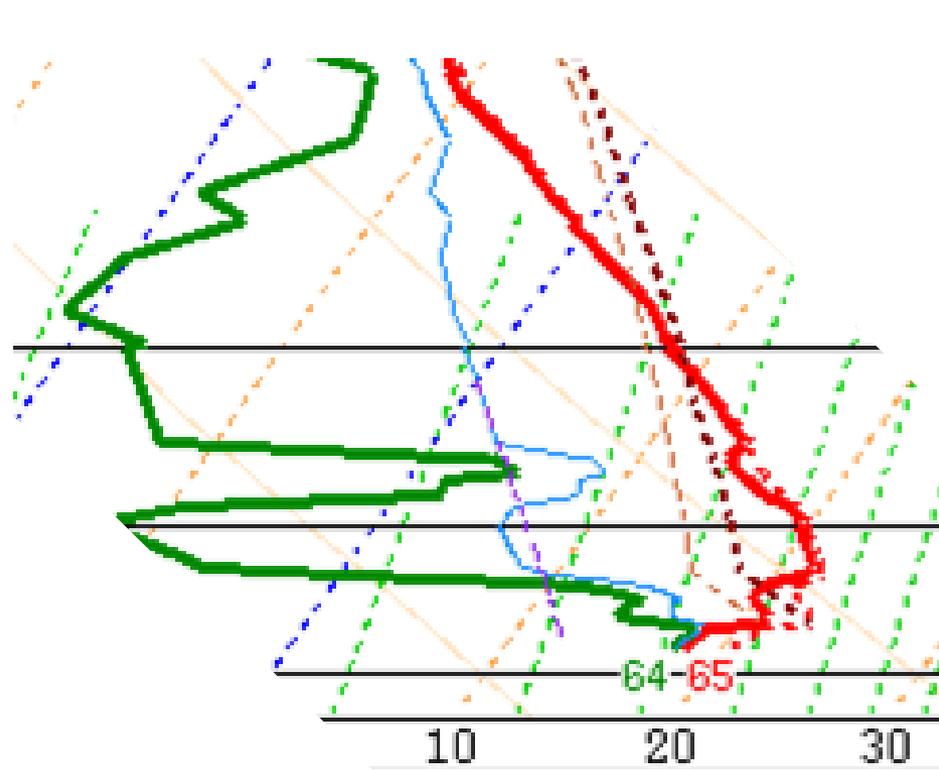
Day in the Life of a Forecaster in a Midwest WFO

- Convection is a common forecast problem
- Accustomed to looking at the 12Z RAOB, with density of ~ 2 per state
- During the pre-convective, ***early afternoon***, I modify the 12Z RAOB for current surface conditions, and try to modify it for any changes in the airmass (from upstream)

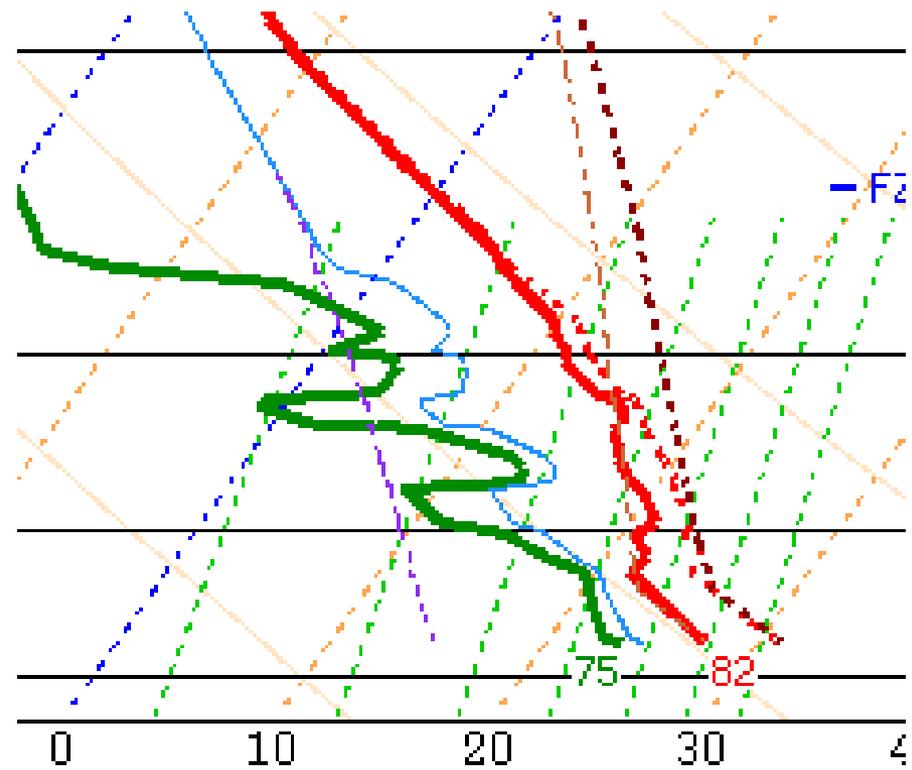
Example: June 16, 2014 - Omaha



19Z Profile Supported Development of 4 Violent Tornadoes



12Z



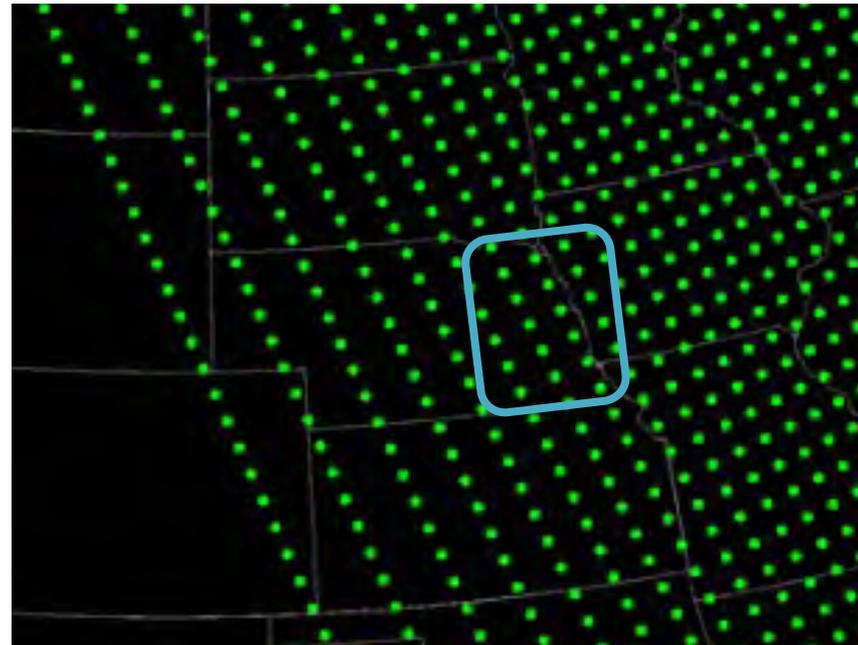
19Z

Day in the Life of a Forecaster in a Midwest WFO

- 18Z (or 19Z) Special RAOB is a luxury
 - I don't have to guess about the airmass changes
 - I typically still need to tweak the surface conditions due to the sensitivity to dewpoint
 - Only valid for the point of the RAOB
- We occasionally get an Aircraft observation
- I look at all of my data with some sense of the margin of error (*and I try to learn what that margin of error is*).
 - Observations from instrumentation
 - NWP

Quote from a Forecaster (2014):

- “Last year some really smart people gave me 23 satellite sounding retrievals over my area in the 18Z-19Z timeframe!”
 - Using a new polar orbiter satellite
 - With a hyperspectral IR sounder and microwave sounder
 - 50 km spatial scene



How can we take advantage of these observations???

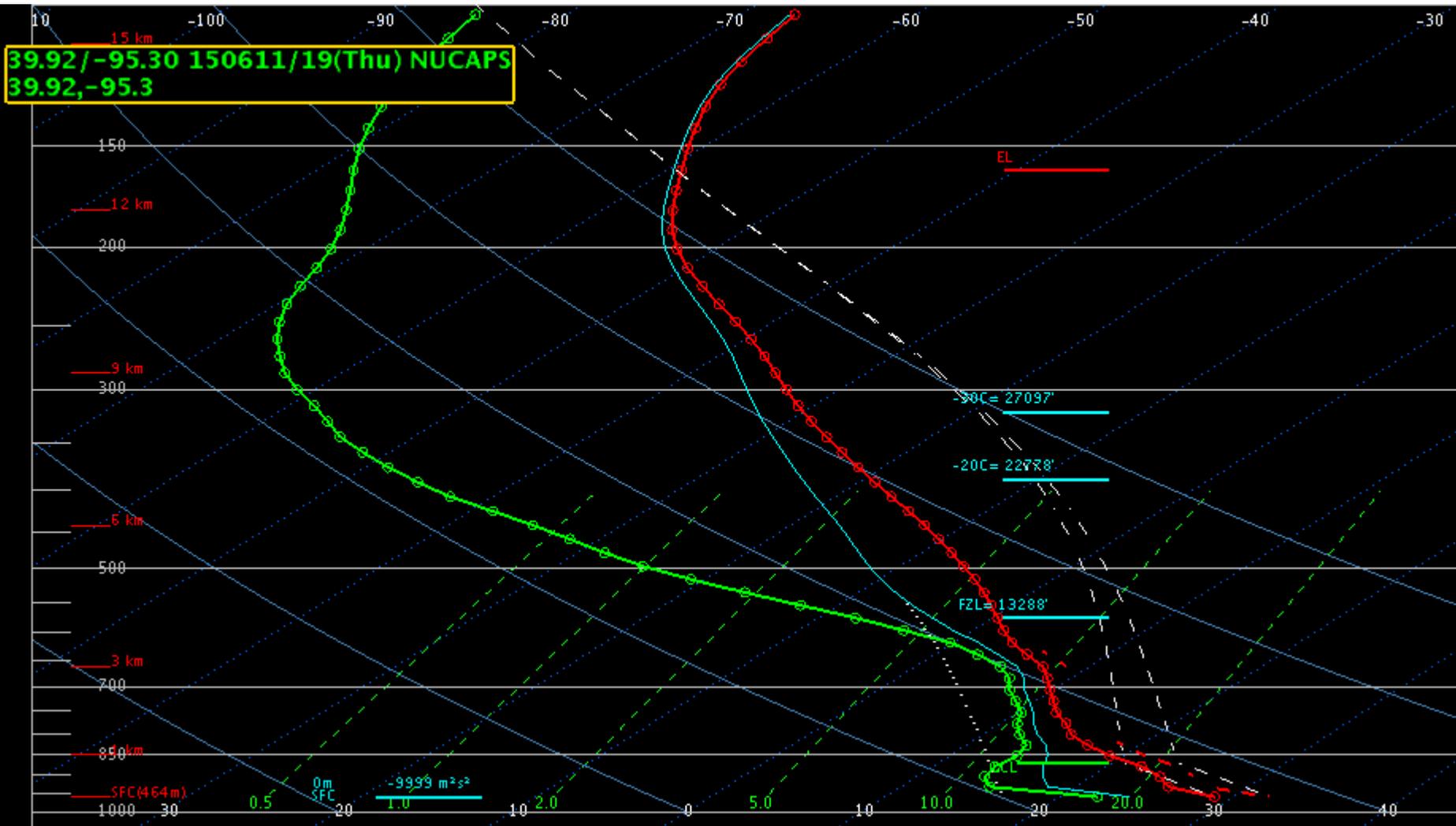
(Over one year later...)

- Learned a lot from Chris Barnett and Antonia Gambocorta about the details of how the retrievals are obtained/created
 - Helped answer the question: “*what exactly are we looking at ???*”
 - Strengths
 - Weaknesses
- Beneficial training material has been developed
- Great interaction between developers and field forecasters
(and through the Hazardous Weather Testbed...)

Issue #1: Smoothing

(early feedback from NWS Omaha Forecasters)

- Vertical resolution is a bit coarse
 - ~20 temperature layers
 - ~10 moisture layers
- Significant smoothing
- Affects identification of warm capping layers
- Affects identification of dry layers aloft
(downburst potential)



*Forecasters are becoming accustomed to accepting the vertical resolution of retrievals
And understanding the differences between the details of a RAOB and a retrieval*

Issue #2: Surface/BL Modification

(early feedback from NWS Omaha Forecasters)

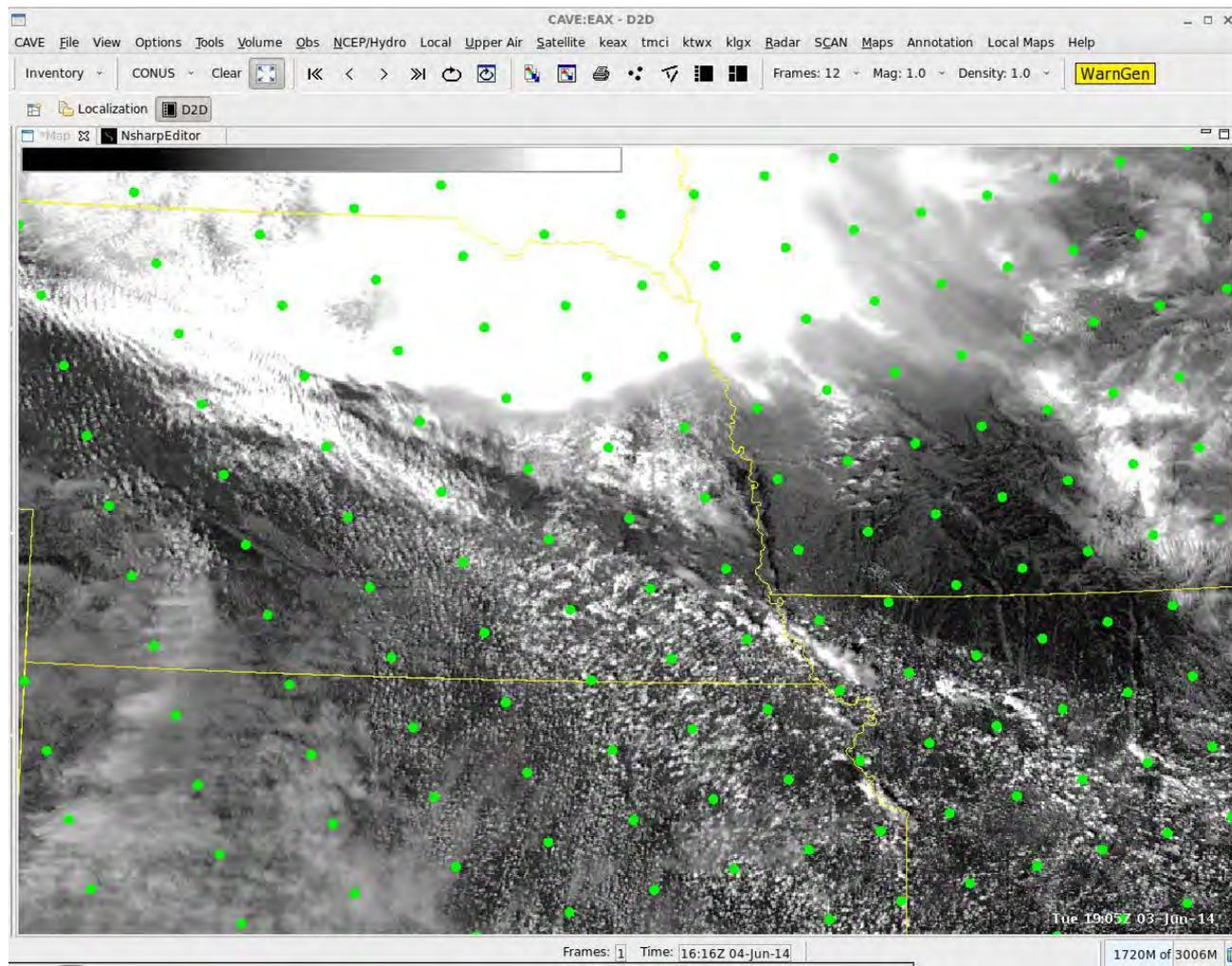
- Modification is necessary 99+% of the time due to errors in low level T and Td (surface-based)
- Automation of Sounding Modification at the Surface and in the BL needed
- Important JPSS funded project:

“Improving NUCAPS Soundings for CONUS Severe Weather Applications via Data Fusion”

- Dan Lindsey PI

June 3, 2014 High Risk Severe Weather Event in Omaha

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



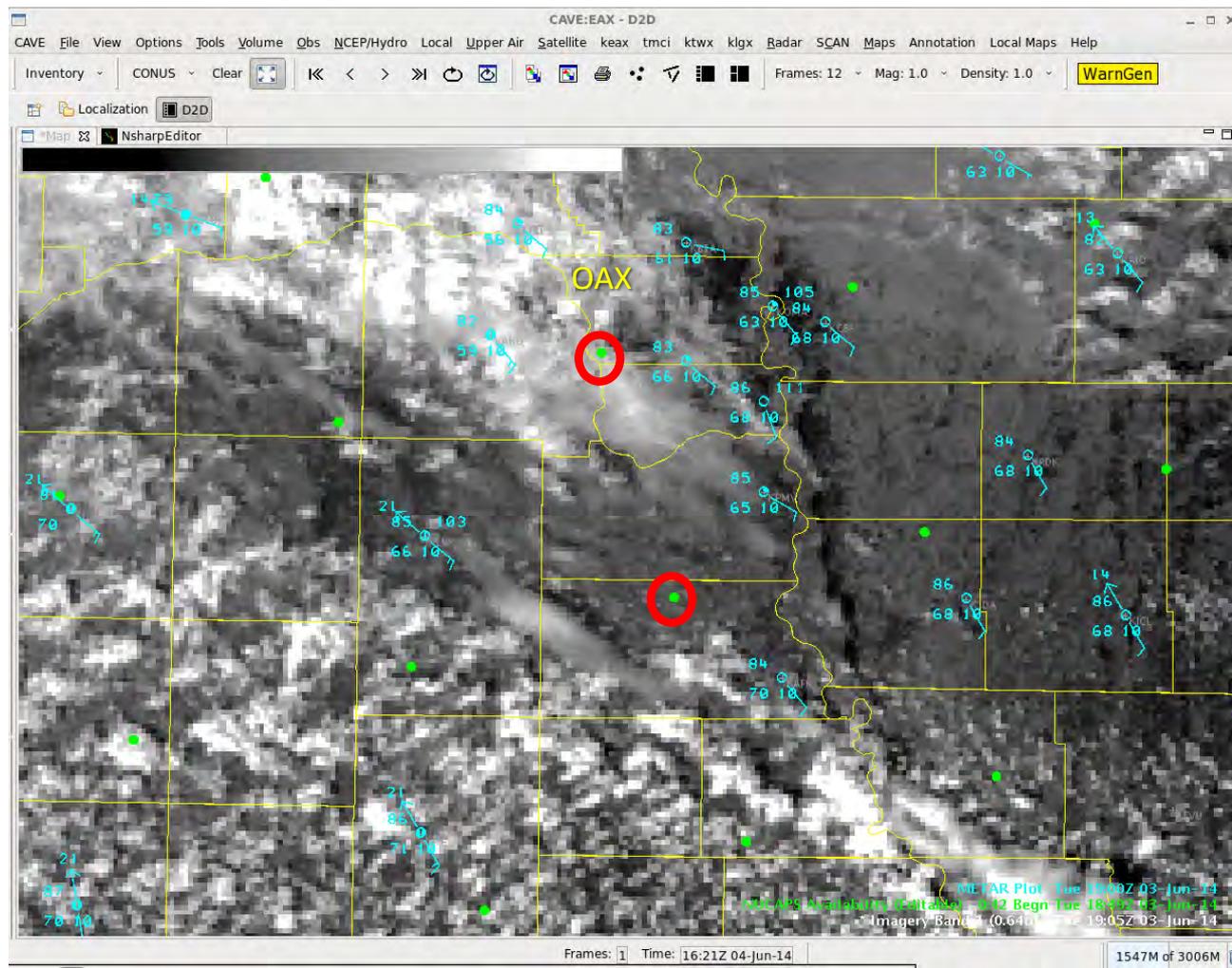
June 3, 2014 High Risk Severe Weather Event in Omaha

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

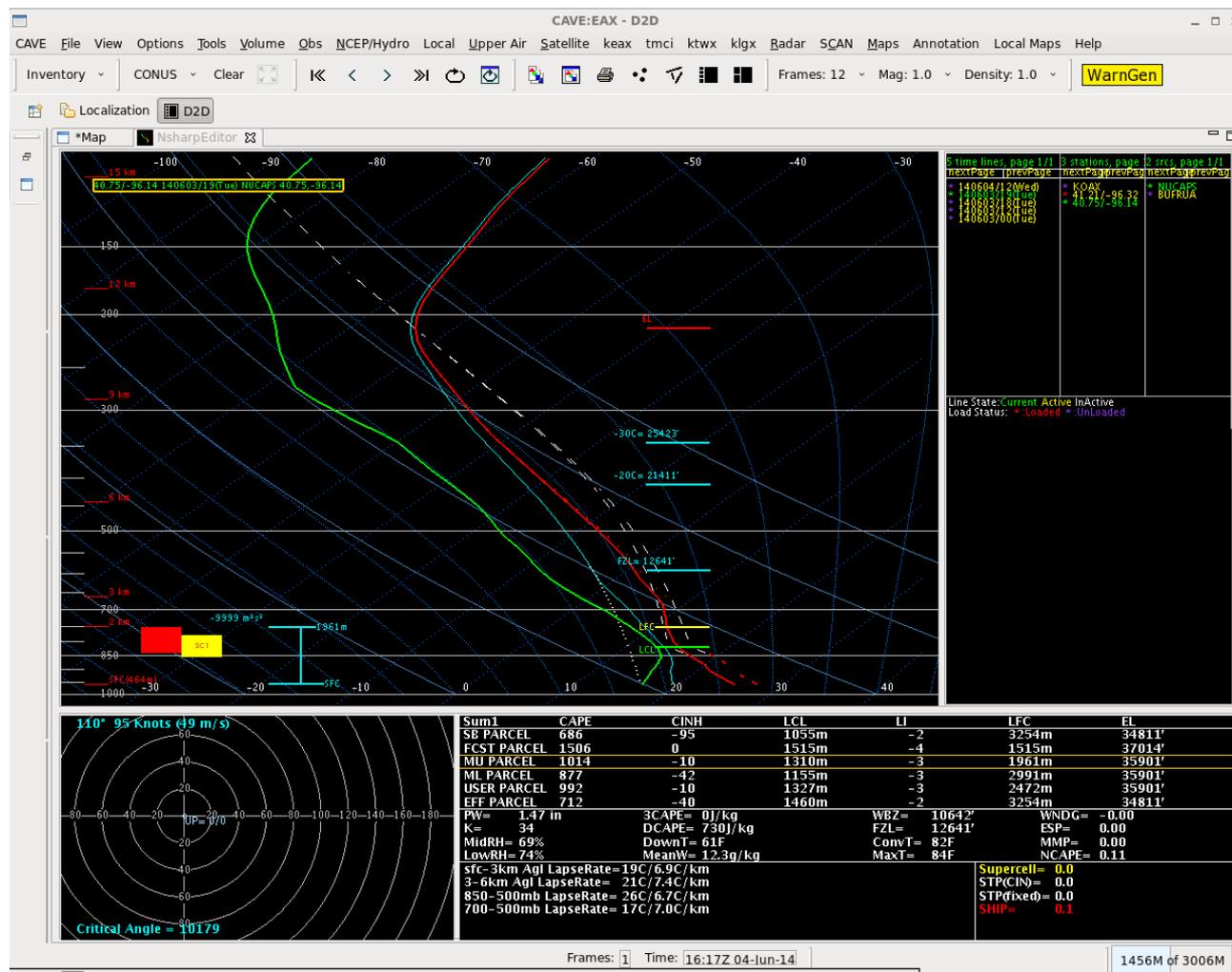
Southern dot is in a nearly
Cloud-free location, and is
warmer and more humid



June 3, 2014 High Risk Severe Weather Event in Omaha

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

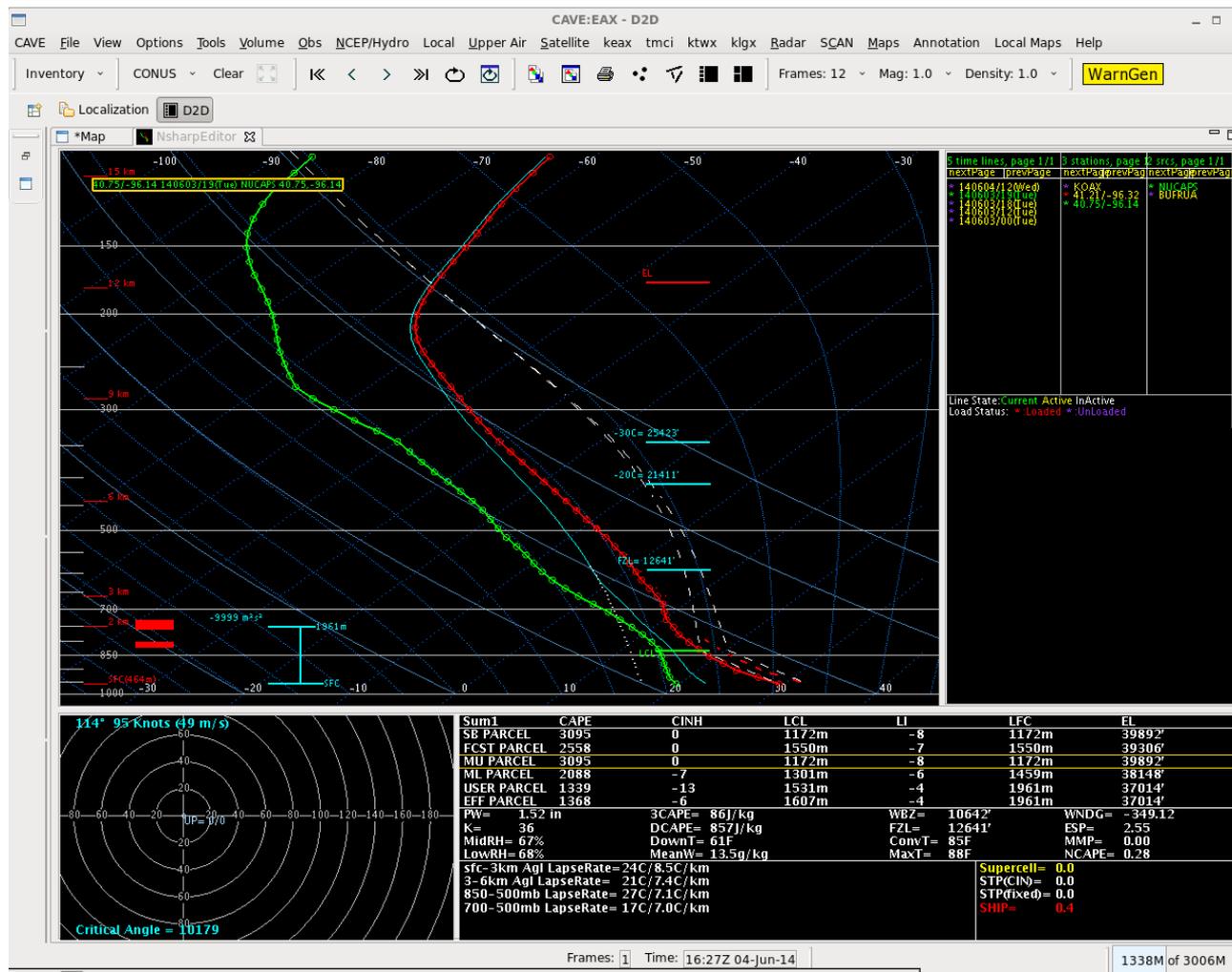
Unmodified
SB CAPE = 686



June 3, 2014 High Risk Severe Weather Event in Omaha

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

Modified for surface METAR
Ob of T=85, Td=68
SB CAPE = 3095

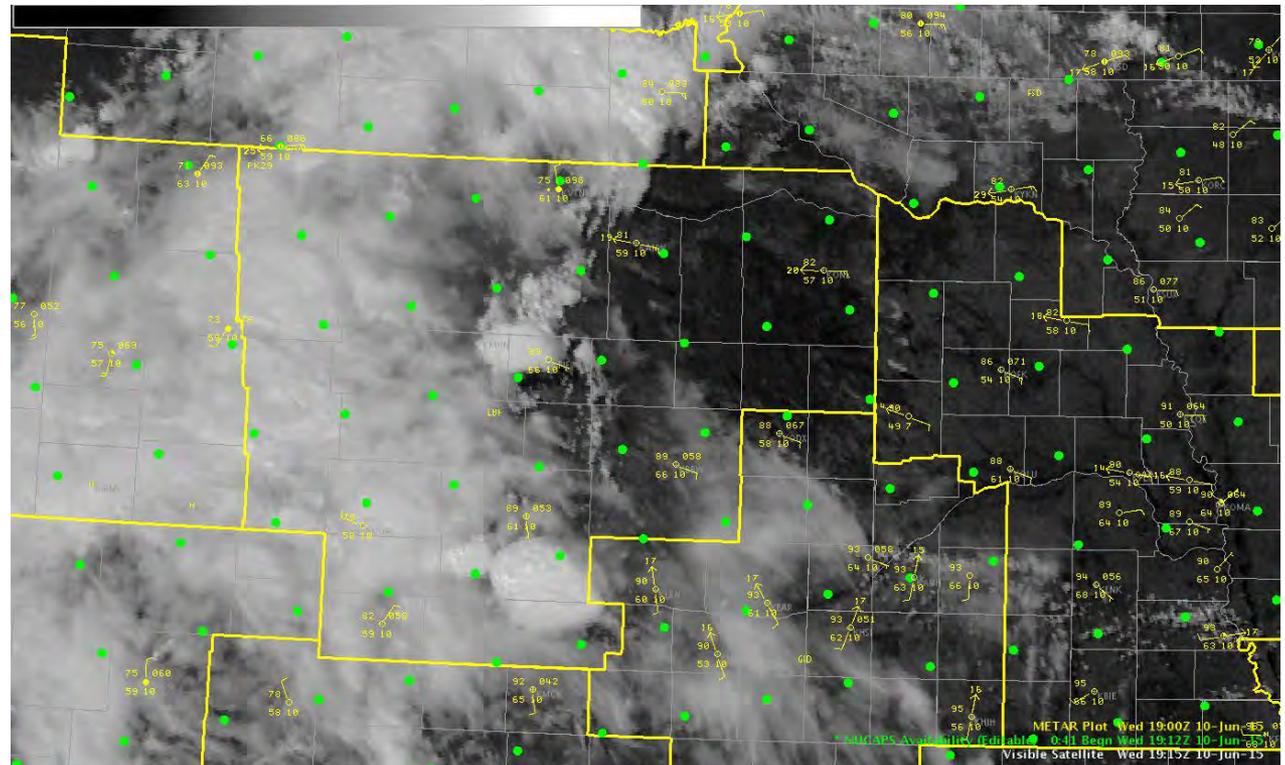


Issue #3: Clouds/Rain Errors

(early feedback from NWS Omaha Forecasters)

- Clear sky, **partly cloudy**, cloudy conditions?
- Extra caution/scrutiny is needed with clouds

***Excited about
the recent 2015
improvements!***



Formal Evaluation of NUCAPS in NOAA's Hazardous Weather Testbed 2015 Spring Experiment

- Norman, Oklahoma (OU/NOAA Facility)
- 5 NWS forecasters, 1 broadcaster *per week* (**30 total**; and PI's)
- 5 weeks in May and June, 2015
- “Can NUCAPS data provide unique value to the severe weather nowcast and warning process?”

Hazardous Weather Testbed

- Facility and organization
- Jointly managed by NSSL, SPC, WFO-Norman
- Annual Spring Experiment



**Experimental
Forecast
Program**

Prediction of hazardous weather events from a few hours to a week in advance



**Experimental
Warning
Program**

Detection and prediction of hazardous weather events up to several hours in advance



NUCAPS in Spring 2015 HWT

- Timing of profiles

- East: ~1730-1800
- Central: ~1900-1930Z
- West: 2030-2100Z



Plus ~75 minute
latency to AWIPS-II

- Most common uses in HWT

- Analysis of pre-convective environment
 - Asses instability, boundaries, etc
- Analysis of near-storm environment
- Comparisons with NWP, RAOBS

- ❖ Sfc/near-surface modifications to profiles necessary in most cases
- ❖ Clear-sky selections recommended

In general, forecasters felt that, when modified, the profiles provide an adequate and ***useful representation*** of the current state of the atmosphere ...
... leading them to see the value in having this information to fill the spatiotemporal gaps that exist in observed sounding information.

Blog Post: “NUCAPS Sample”

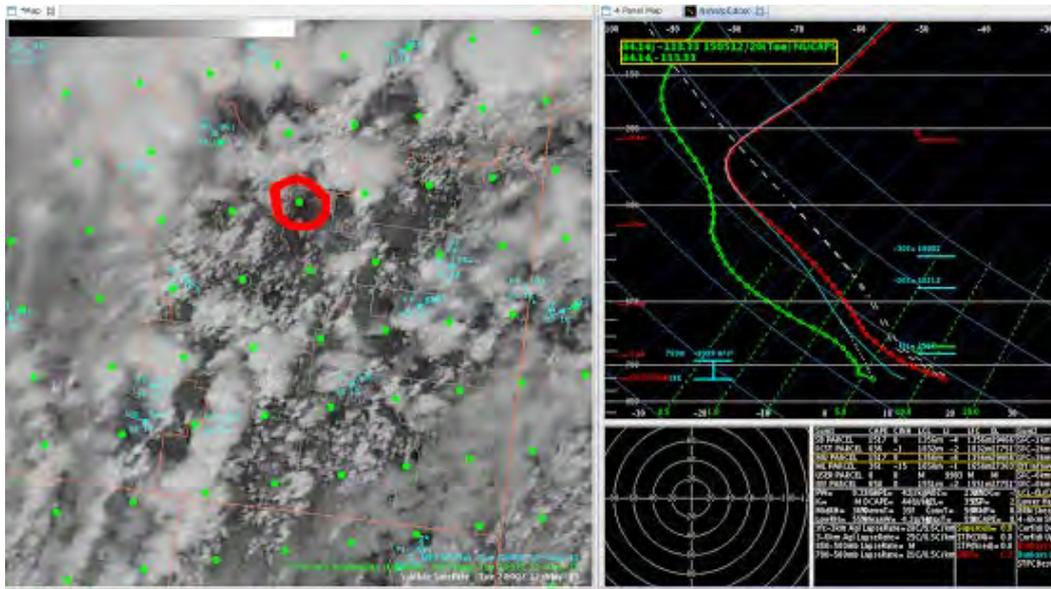
May 12 - Pocatello, ID

- “The instability seems a little high, but it could be localized. Will see how the thunderstorms in the area develop over the next few hours.... ”



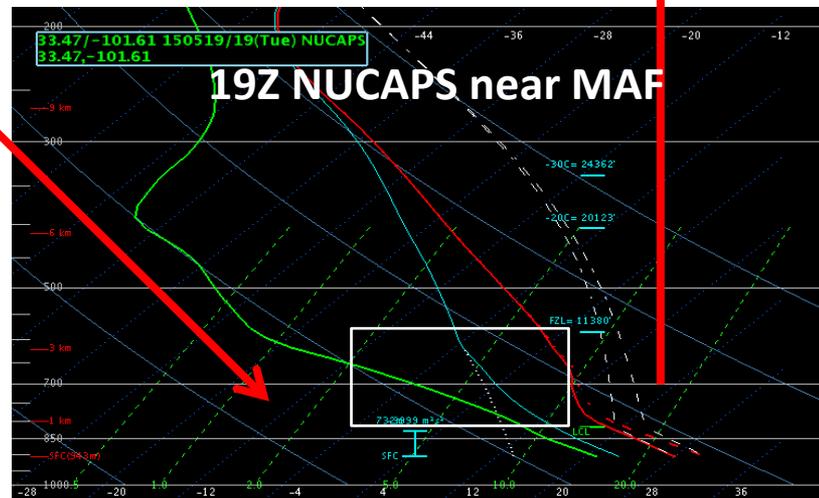
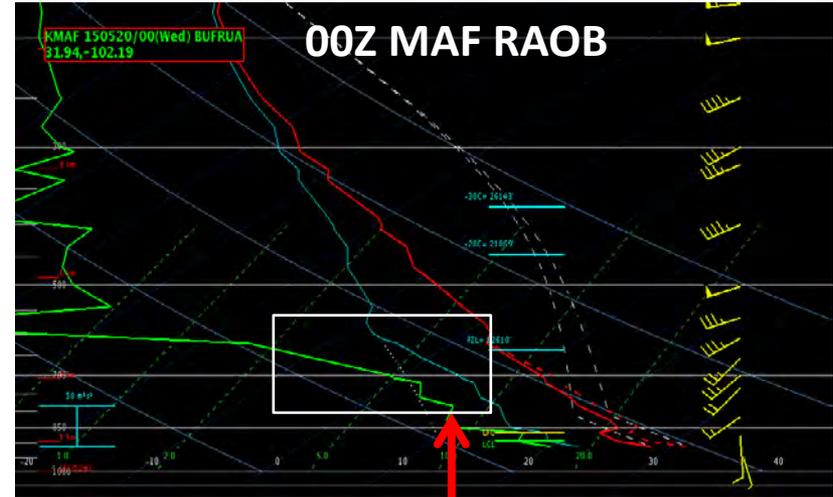
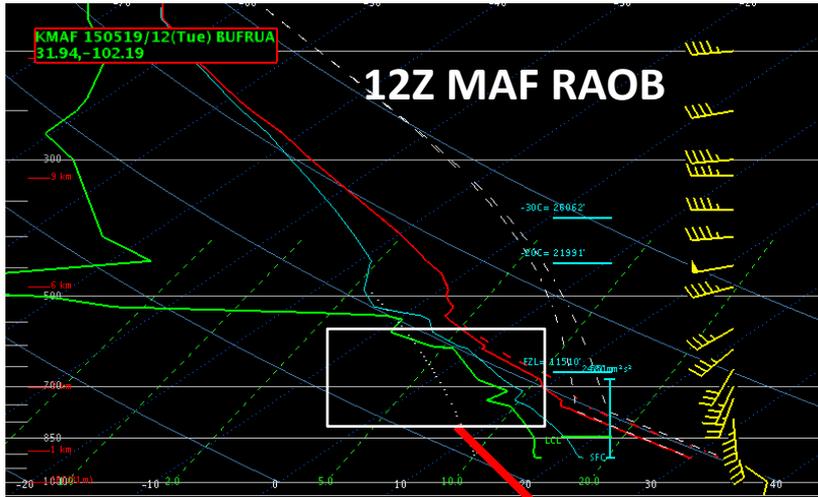
- “This thunderstorm moved over the sampled area about two hours later. It peaked at about 55-60 dBZ Composite Refl ”

“With our office between ROAB sites, having the NUCAPS soundings will be a good way for us to get a handle on the conditions in our area.”



Blog Post: “West Texas Soundings”

May 19 – Midland, TX



Even if magnitude is off, drastic change and trend is significant & useful!

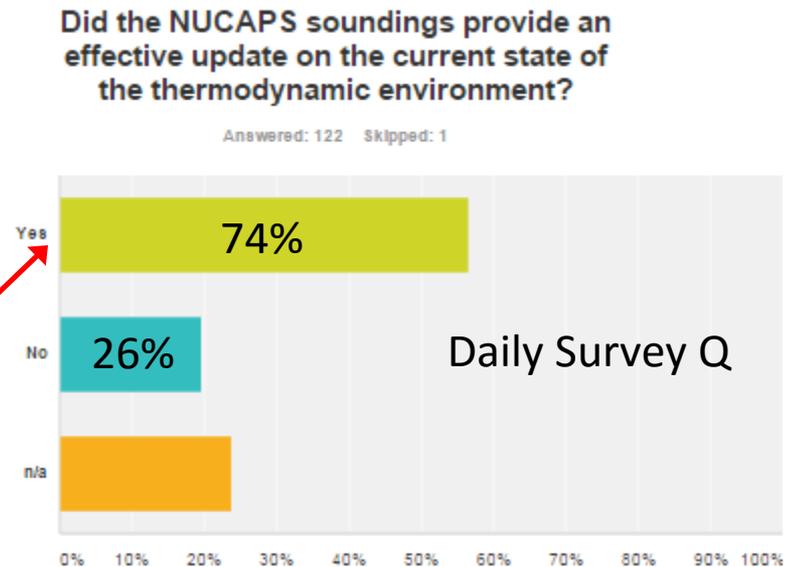
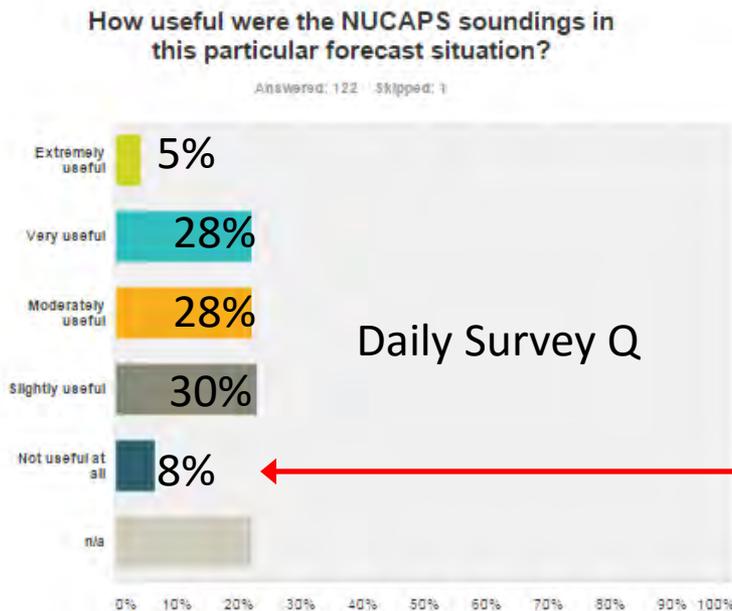
“The drying of the air at 600-800 mb since 12Z is reflected by intermediate NUCAPS soundings.”

“The NUCAPS soundings are a good way to see changes in the airmass since the RAOB soundings have been taken.”

NUCAPS Feedback

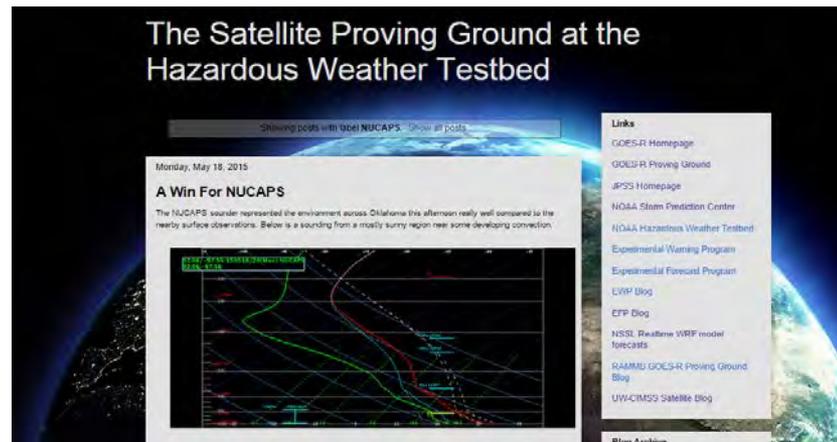
(Spring 2015 Hazardous Weather Testbed Participants)

- All participants answered that they understand the differences between space-based soundings and RAOBs
- Only 1 NWS participant already uses NUCAPS at home office (Alaska)
 - 20/23 say they will



NUCAPS Feedback

- General shape and stability/moisture parameter values seemed realistic
 - Comparable to observed soundings
- Important features and details such as capping inversions not depicted well (or at all) in the soundings
 - Stable layer sometimes apparent (bump); how to interpret this was unknown
- Surface/ML modification often necessary, too cumbersome
 - “Automating the modifications would be great, including the low-level mixing”
- QC Flags a must
 - “QC flags would give me more confidence in the soundings, as it is difficult to judge with just the cloud data.”
- Various AWIPS-II requests
- Training requests
 - More severe app examples
 - Verification statistics



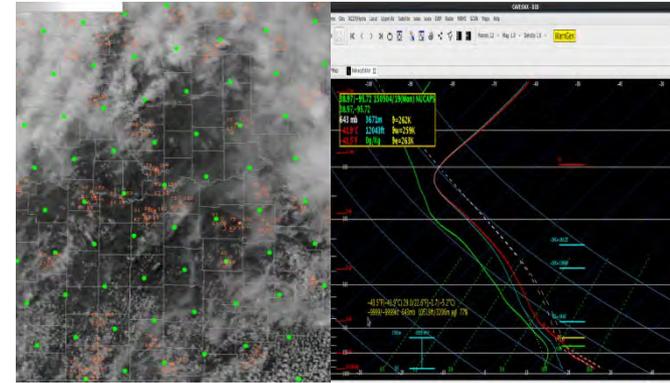
- Feedback available online
 - ❖ Blog: <http://goesrhwt.blogspot.com/search/label/NUCAPS>
 - ❖ “Tales” webinars: <http://hwt.nssl.noaa.gov/ewp/>
 - ❖ Final Report: Coming soon

Some Forecaster Quotes

- “In San Diego, it will benefit us during the summer monsoon. Also, the San Diego RAOB is not representative of the mountains in our CWA”
- “I can see myself using this a lot in the winter.”
- “Drawbacks are they are only 2x day and seem to lack the vertical resolution and critical details of inversions and moisture compared to the RAP/HRRR/RAOB.”
- “I may not use it every day, but getting additional experience will help me understand the environments and situations where it will provide the most critical value.”
- “Presence of a cold pocket aloft and relatively low precipitable water values around a half an inch confirm elevated convection along with the scattered reports of severe hail in eastern Idaho”
- “With our office between ROAB sites, having the NUCAPS soundings will be a good way for us to get a handle on the conditions in our area.”
- “It would be helpful because the climate within our CWA varies so greatly. Our sounding is not representative of the environment over the deserts, and the nearest soundings are a bit too far and not consistent.”
- “This will be great for WR where observations are more scarce.”

Future of NUCAPS in the HWT

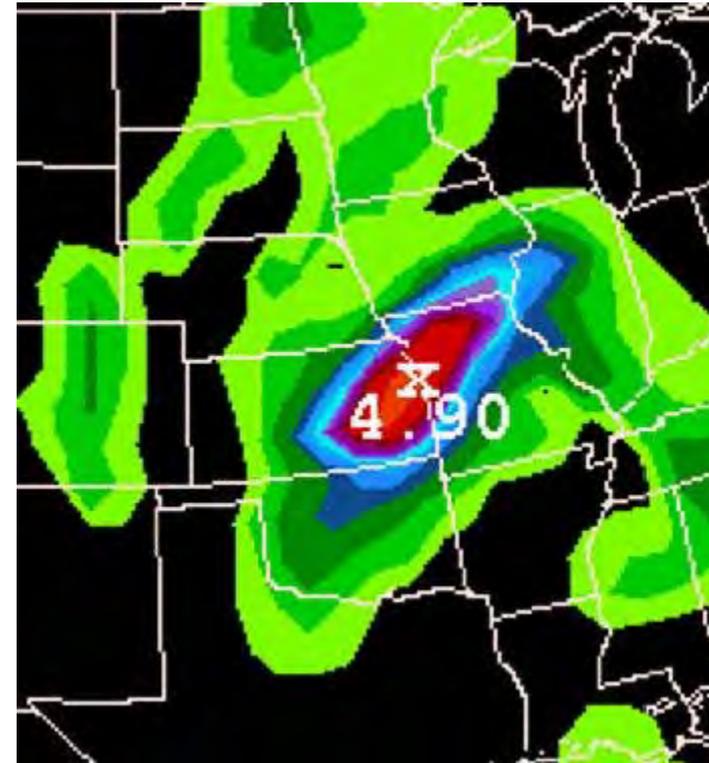
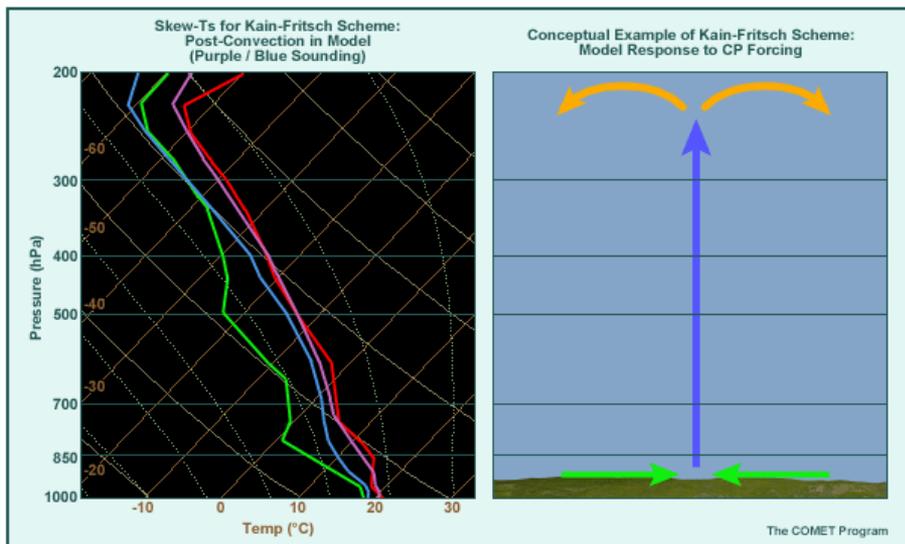
- 2016 Spring Experiment
 - Code upgrades
 - Additional satellites (Metop/IASI)
 - QC flags
 - Additional visualization options
- 2017 Spring Experiment
 - Evaluate automated surface modification NUCAPS project



Why not use the NWP sounding?

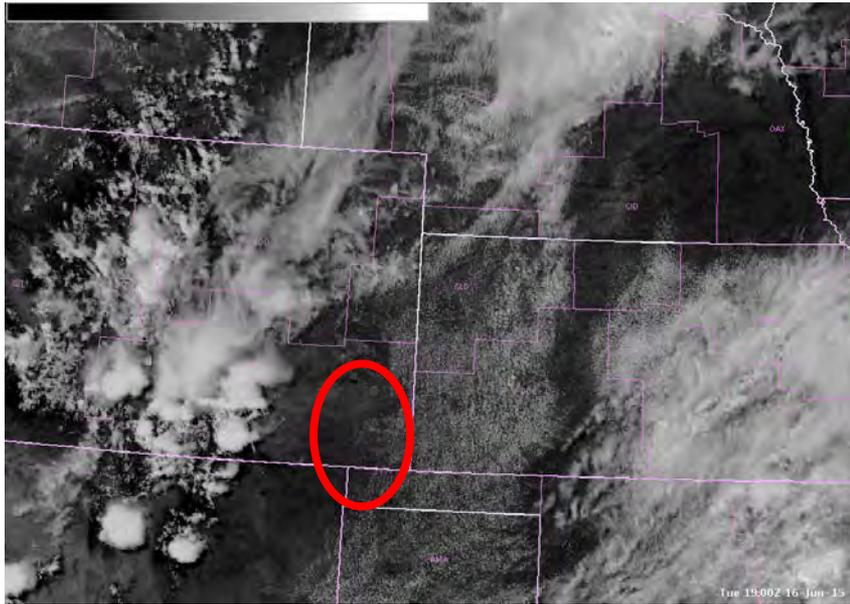
- Sometimes do, but subject to NWP issues/errors
- Soundings within model convection especially useless
- ***Typically need to modify the low levels similar to NUCAPS modifications***

Convective Parameterization Schemes result in unrealistic profiles



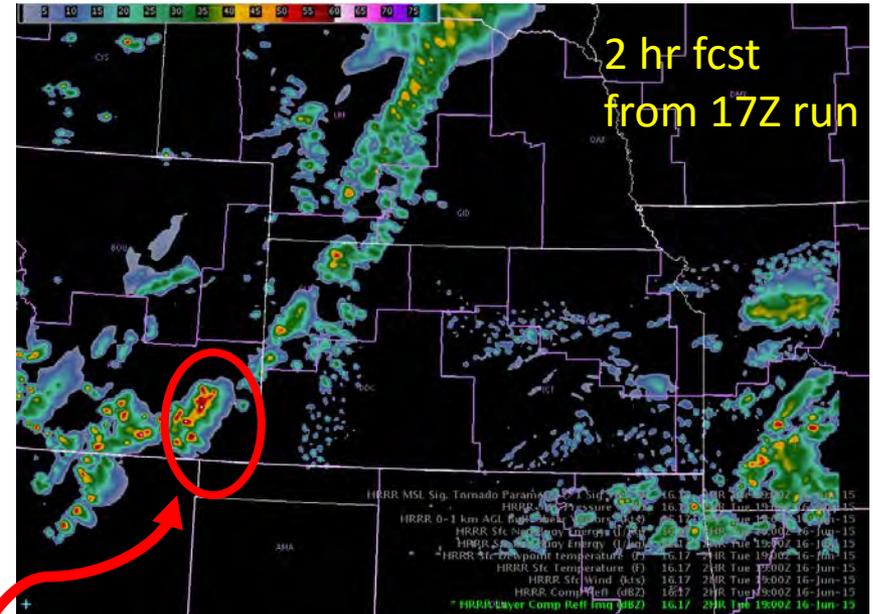
Real vs. Modeled

Observed GOES Visible



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

HRRR (NWP) 2-hr forecast

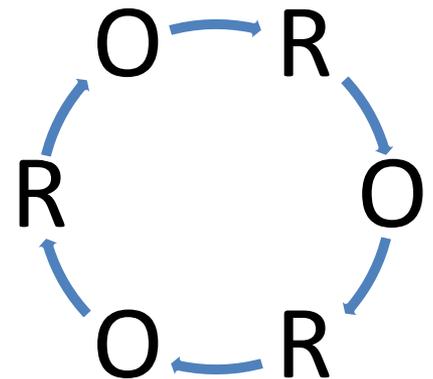


1900 UTC June 16, 2015
Atmosphere with deep convection

Imagine how erroneous a NWP sounding would be in the red circle

A Case for O2R/R2O

- Forecasters are difficult to predict
- Generally, good things come from interaction between forecasters and researchers/developers
 - What the users' needs are
 - What the developers can provide
 - Bias Tuning
 - Sources of error and improvements
- We won't know if we can't explore



***THANK YOU for this opportunity
and for this technology!***

**Special thanks to Bill Line (CIMMS/SPC)
and Chris Barnett (STC)**

National Weather Service's use of
Hyperspectral Profiles in
Operational Forecast and Warning Services

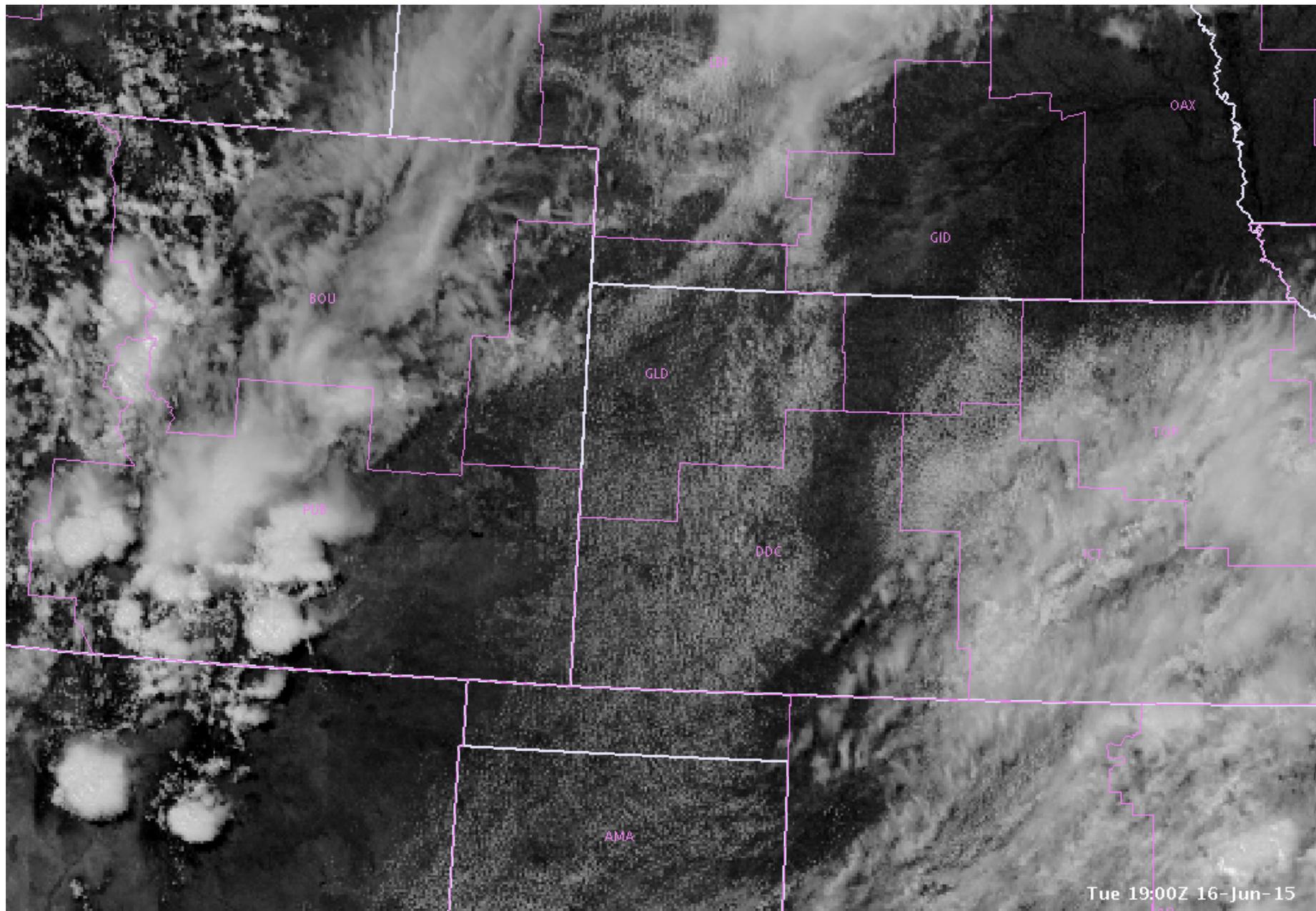
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Daniel Nietfeld

*Science and Operations Officer (SOO) NWS-WFO Omaha
Branch Chief (Acting) NCEP-WPC Development and Training Branch*

BACKUP



2015 Hazardous Weather Testbed (HWT) Experimental Warning Program (EWP) Spring Warning Project

- Real-time, simulated nowcast/warning environment using AWIPS-II.
 - “mesoscale forecast updates” (via live blog posts)
 - experimental severe t-storm and tornado warnings (in AWIPS-II).
- Weeks of May 4, 11, 18, June 1, 8 (5 weeks)
 - Mon: 11a-7p, Tues-Thurs: Flex (start b/t 11a and 3p), Fri: 9a-1p
- 5 NWS forecasters, 1 broadcaster per week (30 total; and PI’s)
- GOES-R/JPSS and ENI demonstration's (including NUCAPS)
- Training: 10-30 min Articulate PowerPoint Presentations
- Feedback: Daily and weekly debriefs, daily surveys, blog posts, TFFT Webinar
- **Final Report available shortly**



NUCAPS HWT-EWP 2015

Demonstration

- Capture the value added by NUCAPS to the severe weather nowcast and warning process
- Learn what adjustments could be made to enhance operational usefulness of NUCAPS in AWIPS-II
- Enlighten participants to the existence of NUCAPS in AWIPS-II



NUCAPS HWT 2015 Training

- 13 minute Articulate PowerPoint

- http://rammb.cira.colostate.edu/training/visit/training_sessions/nucaps_soundings_in_awips/

NUCAPS Soundings in AWIPS

Chris Barnet NOAA/STC Antonia Gambacorta NOAA/STC
 Scott Lindstrom UW CIMSS Bill Line NOAA / SPC
 Brian Motta NOAA / FDTD Dan Nietfeld NOAA / NWS O&M

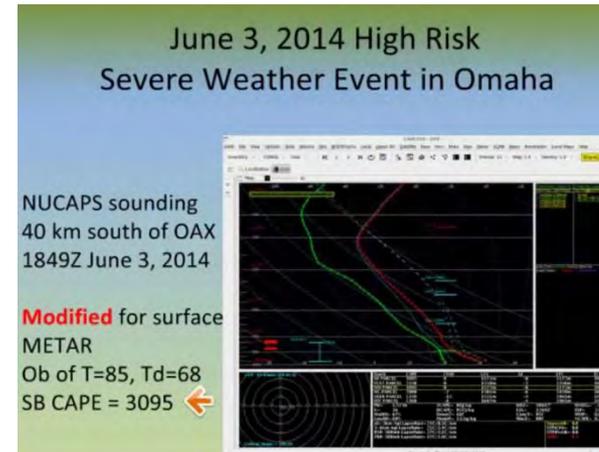
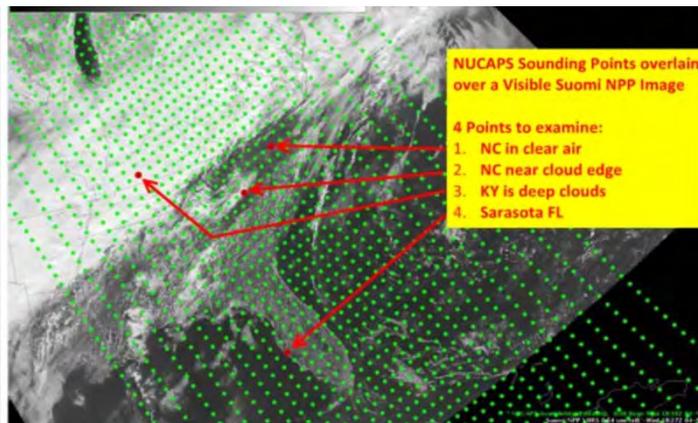
NUCAPS

- NOAA Unique CrIS ATMS Processing System**
 - CrIS: Cross-track Infrared Sounder (1305 channels)
 - ATMS: Advanced Technology Microwave Sounder (2 channels)
- All instruments on **Suomi/NPP**
 - East Coast: 05z/17z
 - Plains: 07z/19z
 - West Coast: 11z/23z
 - Alaska: Lots!

CONUS Data Flow: Svalbard Downlink → NSOF (NDE) → NWS Gateway → SBN → WFO

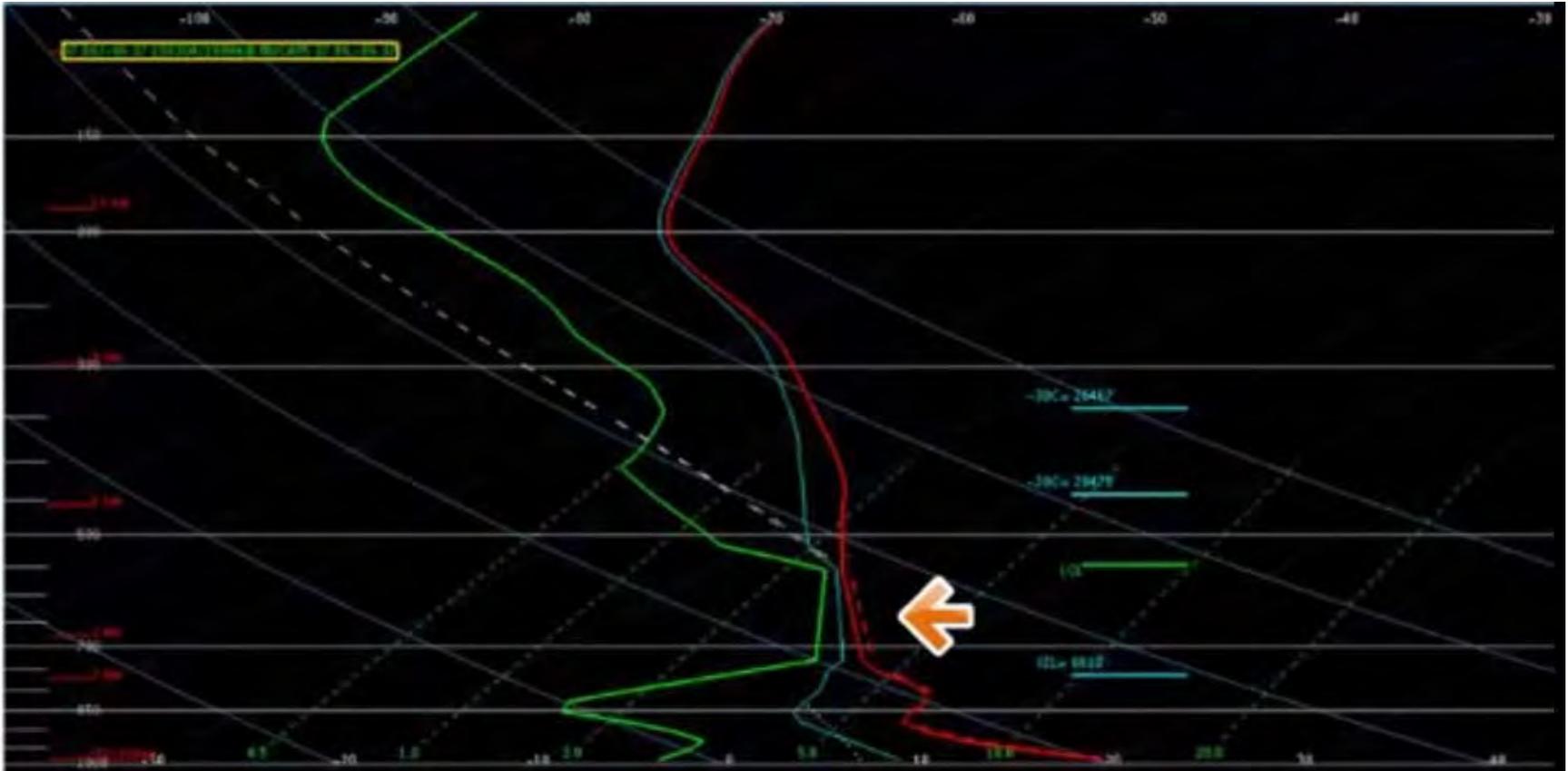
Summary of products from NUCAPS (and AWIPS-II)

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

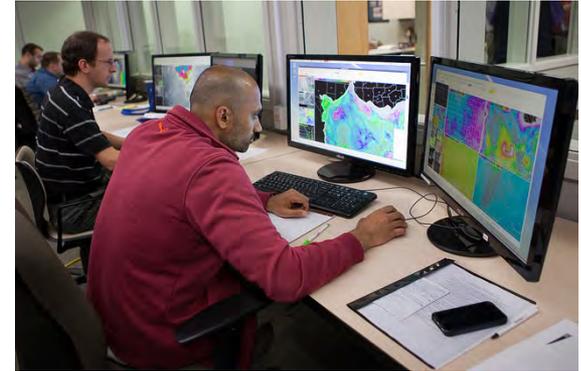
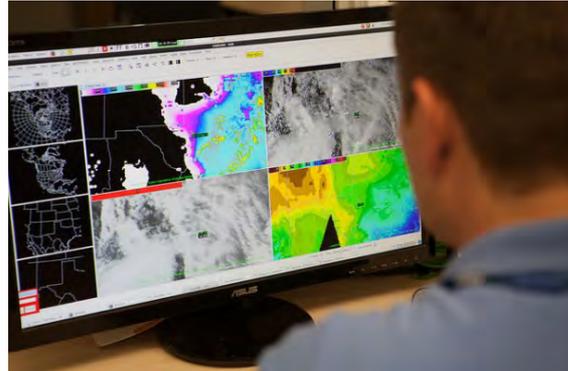


- Participants across all weeks felt the training articulate adequately prepared them for the NUCAPS evaluation.

NUCAPS in Thick Clouds



Satellite Product Demonstrations in the HWT



- Forecaster feedback is abundant
 - Ideas for improving algorithm, enhancing display, best practices, etc.
- Test algorithms in operational systems
- Prepare/train various users for /current satellite systems
 - NWS forecasters (WFO, CWSU, SPC, etc.), broadcasters, researchers
- Foster interaction b/t research and operational communities
- Enhance/promote use of satellite data in forecast/warning ops

Initial Requests (many are NSHARP-related)

- Quality control flags into AWIPS-II
- Automated correction of surface/ML conditions
- Ability to sample sounding locations “dots” for environmental information
- Provide nearest city after clicking on sounding and/or include map in sounding window with location marked
- Indicator in display after a sounding has been clicked
- Undo button when editing profile
- Overlay NUCAPS soundings with others (NWP, RAOB, etc)
- Make sure the AWIPS fix is implemented
 - Many requests for this code already have been fulfilled.

Blog Post: “Comparing NUCAPS Soundings at Two Locations in the FA”

June 03 – Jacksonville, FL

- “Having the NUCAPS soundings available was important to my situational awareness in this particular case... At my office in Columbia, SC, we do not have upper air and there really aren't any upper air sites close by, so having these available would be extremely beneficial.”

