NUCAPS Boundary Layer Corrections in Pre-Convective Environments

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Hazardous Weather Testbed/Experimental Warning Program (HWT/EWP)

"…to test and evaluate new applications, techniques, and products to support NWS Weather Forecast Office (WFO) severe convective weather warning operations."

- Joint Project NWS/NSSL
- Conducted in Spring (Started in 2008)
- NWS and broadcast meteorologists travel to Norman to practice warning on severe weather events while evaluating both operational and experimental products
- NUCAPS retrievals among the tested products

NUCAPS in the Experimental Warning Program

Survey Question:
"Will you use the NUCAPS soundings at your home office?"

Common Sentiment:
"Yes, I will start Using NUCAPS as is. I will start using it now to get a sense of the environment but I will find it much more reliable when the low-level modification is automated."

Data Fusion

- Near-surface values of NUCAPS temperature and dewpoint prone to error
- Errors in CAPE and CIN can result
- Replace lower-levels of NUCAPS temperature and dewpoint with values based on surface observations from the Real-Time Mesoscale Analysis (RTMA)
  - More than just replacing surface temperature and dewpoint temperature – replace several near-surface levels
  - Create a mixed layer and blend with the NUCAPS retrieval in the free atmosphere
  - Resulting CAPE values more like the mixed-layer CAPE preferred by NWS forecasters over the surface-based CAPE
- Not generally applicable, developed for the warm, moist air masses in pre-convective environments

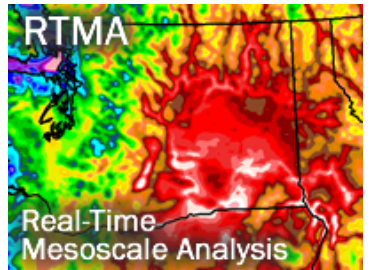
Modification of Lowest Layers of NUCAPS Temperature and Moisture Profile (Theory)

$$z_{i+1} = \left[z_i^2 + \frac{2}{\gamma} C_H |\boldsymbol{V}| (\theta_{Skin} - \theta_{Air}) \Delta t \right]^{\frac{1}{2}}$$

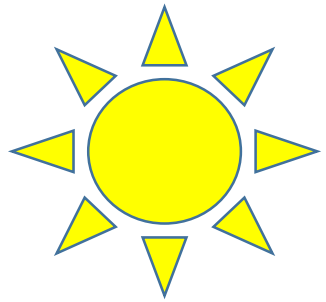
Stull, *Introduction to Boundary Layer Meteorology*

z: height of mixed layer
Θ_{Skin}: Potential temperature of surface skin (GOES-16 11/12 µm)
Θ_{Air}: Potential temperature of surface air (RTMA)
$|\mathbf{V}|$: Wind speed (RTMA)
γ: Lapse rate of free atmosphere (NUCAPS T profile)
C_H: Exchange coefficient

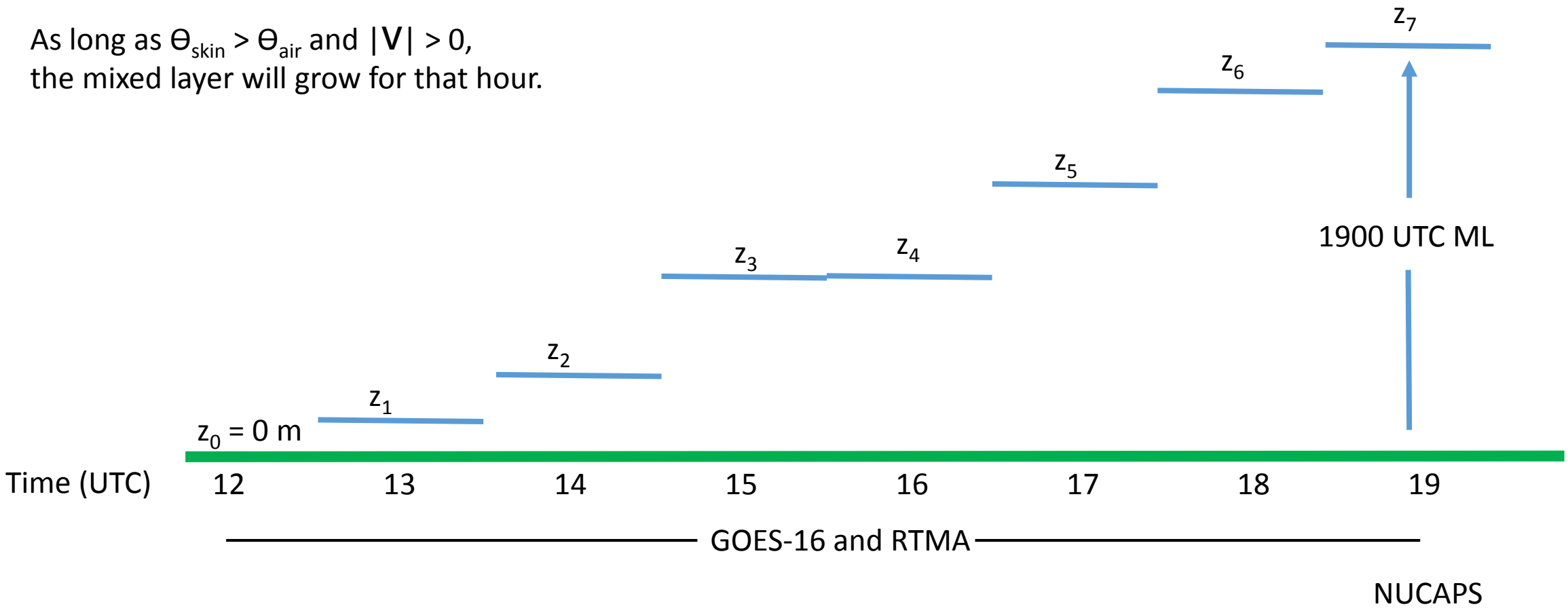
Apply equation to get mixed layer depth as function of time.

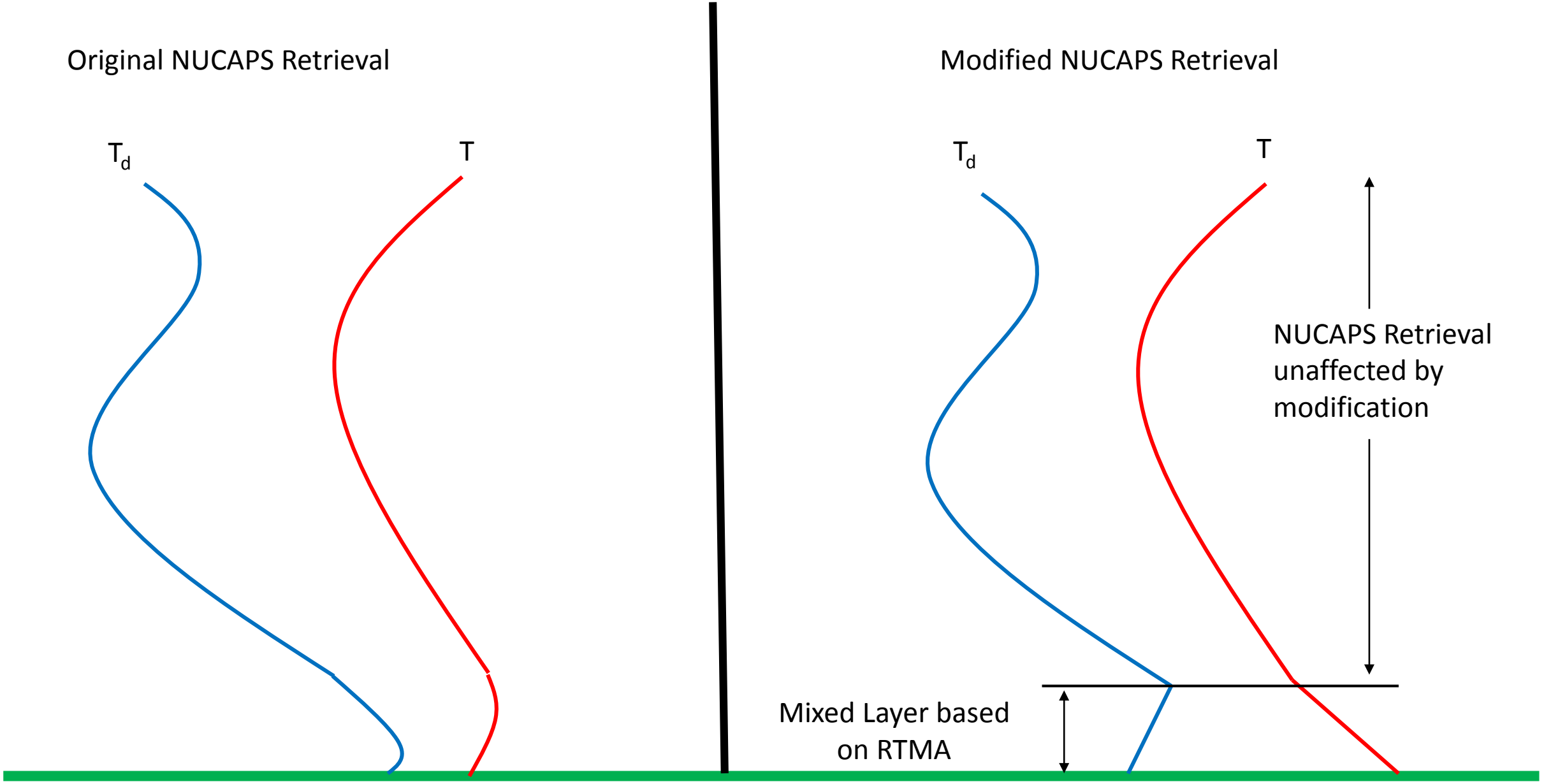


For 1900 UTC Overpass



As long as $\Theta_{skin} > \Theta_{air}$ and $|\mathbf{V}| > 0$,
the mixed layer will grow for that hour.




Original NUCAPS Retrieval
T_d
T
Modified NUCAPS Retrieval
T_d
T
NUCAPS Retrieval unaffected by modification
Mixed Layer based on RTMA

EXAMPLES

Blog Post from 2017 HWT Spring Experiment (20 June 2017)

"The modified NUCAPS soundings have shown significant improvement when compared to the operational NUCAPS soundings.

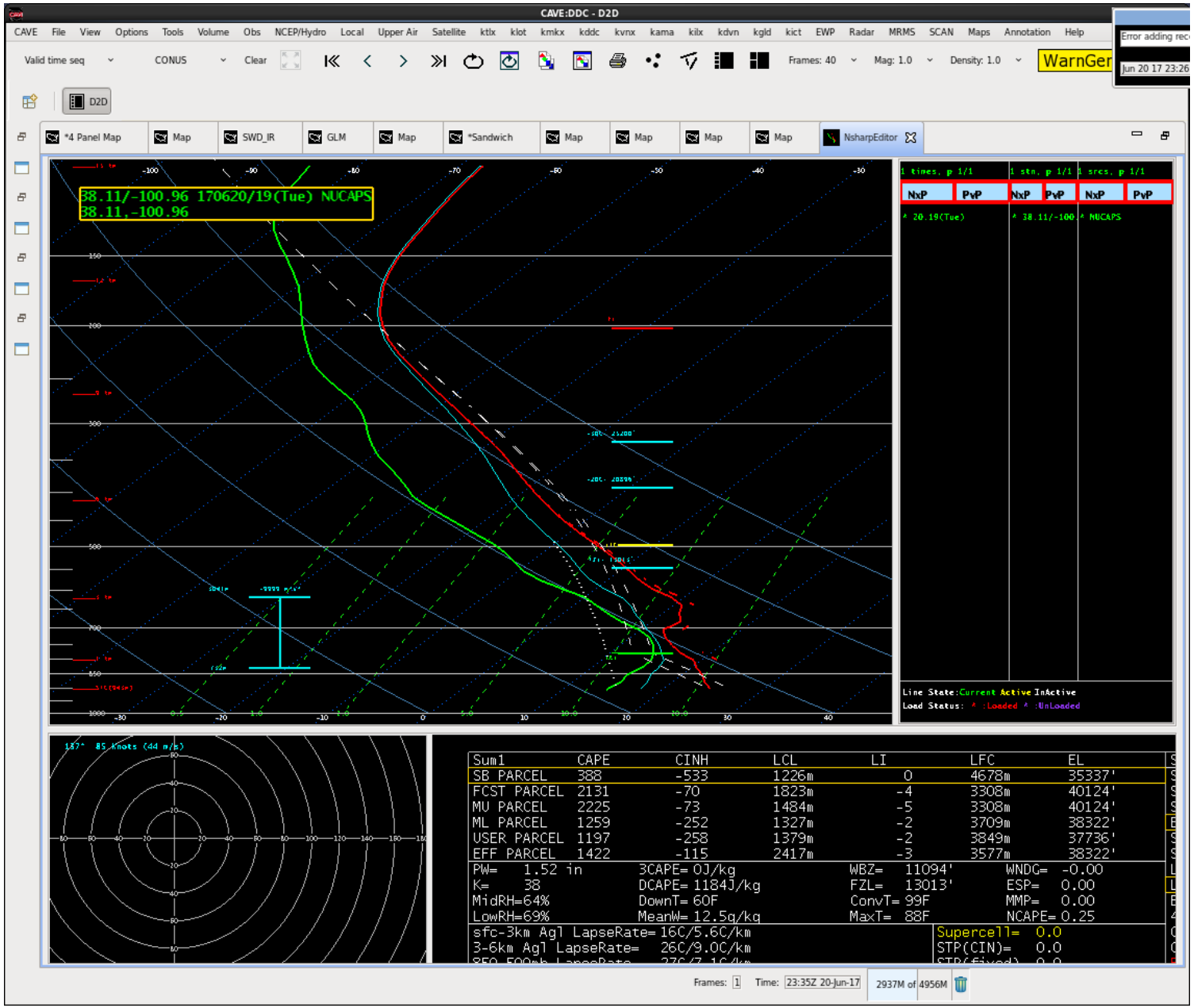
Here is an example where SBCAPE increased from 388 J/kg to 2770 J/kg in a modified NUCAPS sounding:

Even more significant is change in CINH from -533 J/kg to -27 J/kg--essentially going from a very strong (unbreakable) cap to a weakly capped environment.

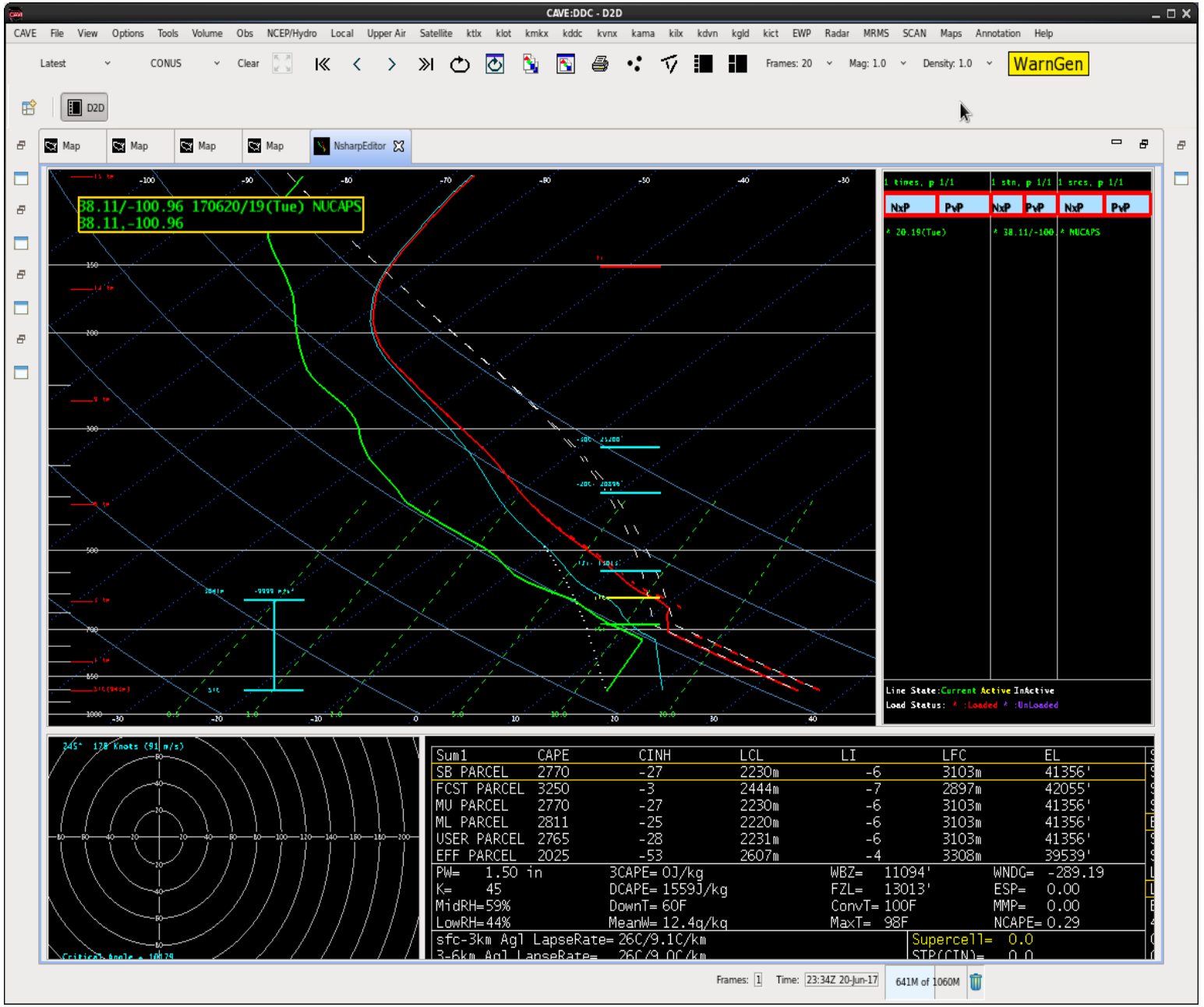
Thunderstorms rapidly intensified as they moved into the environment sampled by the sounding.

Therefore, it seems reasonable that the modified sounding is a better representation of the thermodynamic environment than the operational sounding."

Operational NUCAPS Retrieval (1900 UTC Southwestern Kansas)

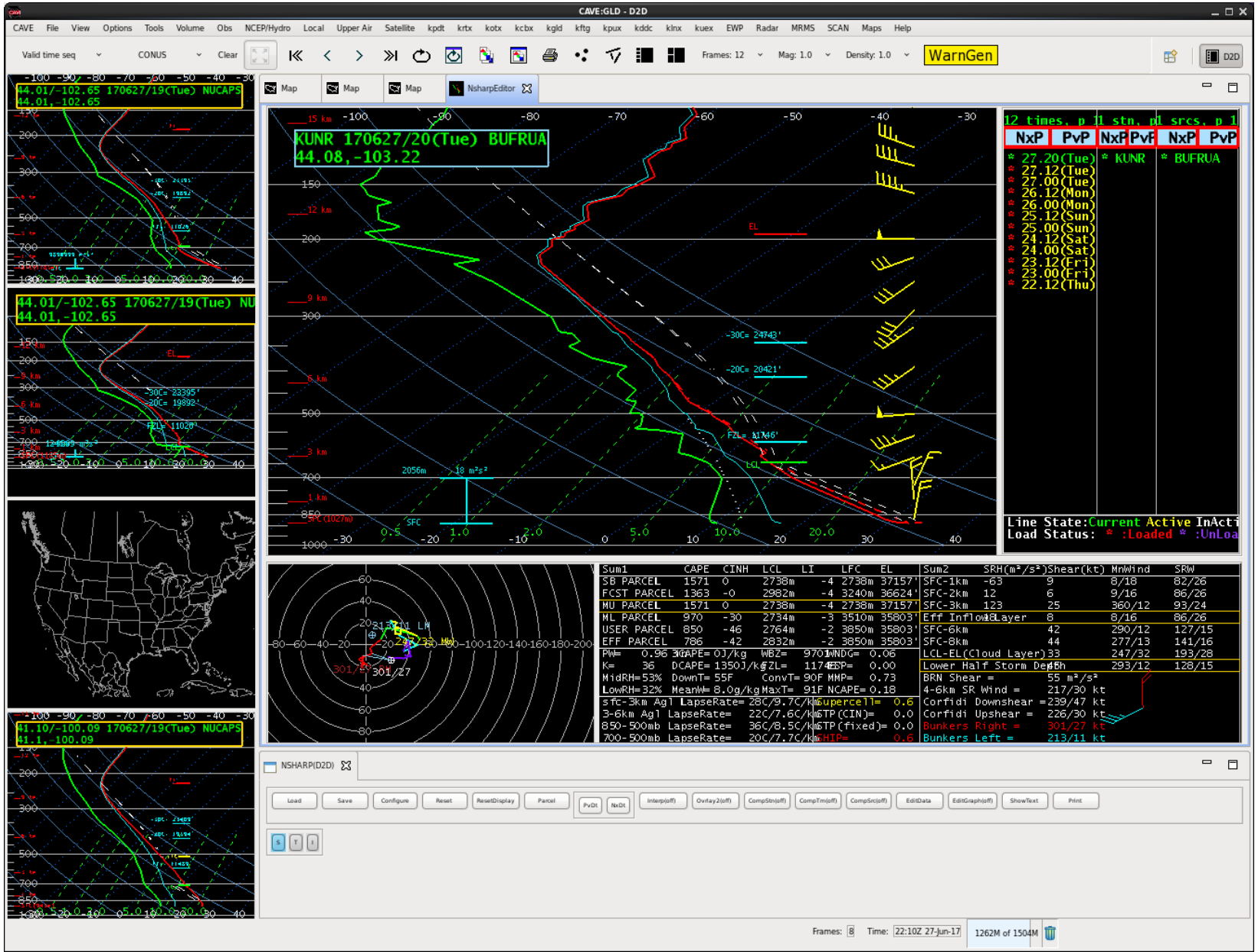


Experimental NUCAPS Retrieval

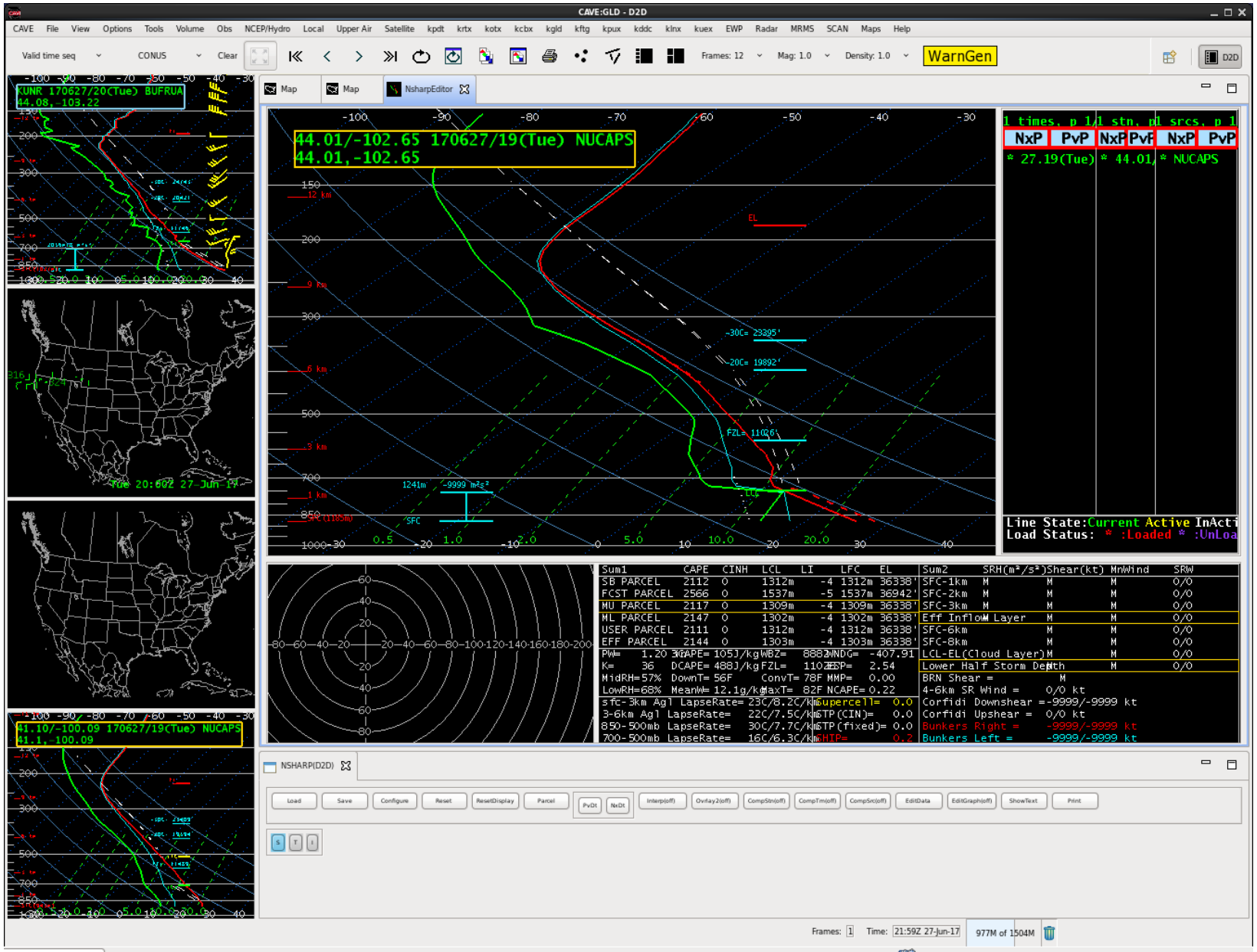


The experimental retrieval depends on the accuracy of the RTMA and the assumption of a well-mixed near-surface layer …

Rapid City, SD 2000 UTC Radiosonde 27 June 2017



Collocated Experimental NUCAPS Retrieval 1900 UTC



Next Steps

1) Work on improvements
    a) Boundary layer, particularly moisture, is not always well mixed
    b) In contact with NUCAPS development team (Antonia Gambacorta, Nadia Smith, Chris Barnet)
    c) More sophisticated algorithm may be needed

2) Continued Testing/Feedback
    a) Prepare for further evaluation at 2018 Spring Experiment
    b) Make available to interested WFOs

3) Latency
    a) Original NUCAPS usually comes in two hours old, experimental arrives 30 minutes later
    b) Direct Broadcast