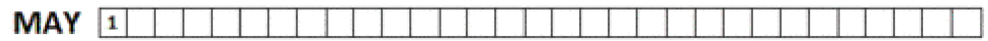
Why do GEO-Satellite-based NearCasts?

00 Hr NearCast Analysis - Valid: 05/01/2011-00z

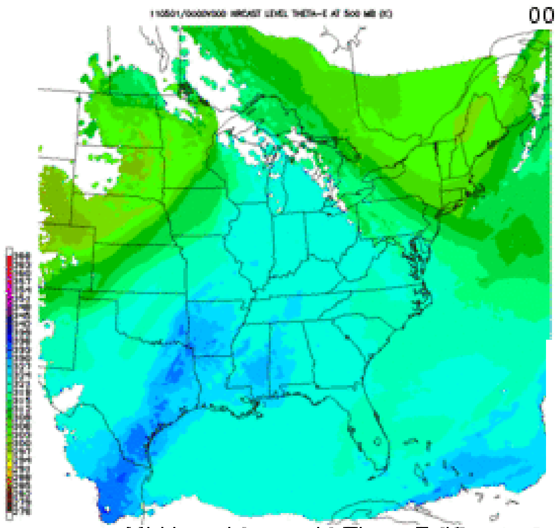


May-June 2011

Mesoscale Moisture Climatology

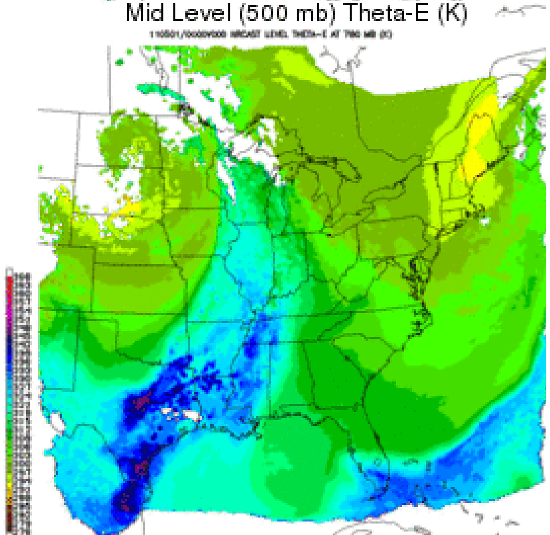
(Hourly Analyses – May-June 2011)

Mid-Level Theta-E



Mid Level (500 mb) Theta-E (K)

Lower-Level Theta-E



Low Level (780 mb) Theta-E (K)

Because they provide unprecedented understanding of the evolution of Upper-Level and Lower-Level Moisture fields

University of Wisconsin-Madison Space Science and Engineering Center

Cooperative Institute for Meteorological Satellite Studies

What are NearCasts?

How can NearCasts be used to improve forecaster awareness and reduce false alarms?

Can SEVIRI sounder data be incorporated to improve short-range forecasts of the Pre-Convection Environment over Europe/Africa?

Ralph Petersen[1], Robert M Aune[2] and Bill Line[1]

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Improving the utility of GOES products in operational forecasting

What are we trying to improve?

Short-range forecasts of timing and locations of severe thunderstorms

- especially hard-to-forecast, isolated summer-time convection

What are NearCasts?

NearCasts are 1-9 hour forecasts specifically designed to monitor conditions where hazardous weather will (or will not) form.

NearCasts are designed:

- ***to be available within minutes of observation times,***
- ***to be frequently updated (hourly or sub-hourly), and***
- ***to rely on observations more than traditional NWP products***

GOES NearCasts use high-density observations of moisture and humidity made over land from the GOES sounder.

These data are not included in any operational NWP system

What are we trying to improve?

Short-range forecasts of timing and locations of severe thunderstorms

- especially hard-to-forecast, isolated summer-time convection

What are we trying to correct?

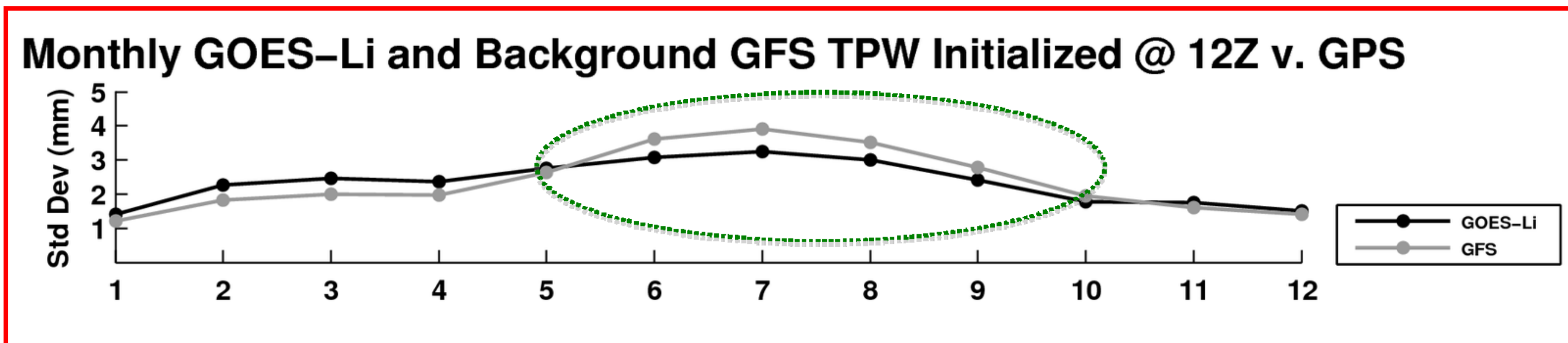
- ***Poor precipitation forecast accuracy in short-range NWP (esp. in summer)***
- ***Under-utilization of GEO satellite moisture information over land in NWP***
- ***Time lags in getting NWP guidance to forecasters***
- ***Excessive smoothing of mesoscale moisture patterns in NWP data assimilation***
- ***Loss of Infra-Red (IR) satellite information about the convective environment after convection has begun***
- ***Need objective, observation-based tools for forecastersto use in detecting and monitoring the pre-convective environments 1-9 hours in advance***

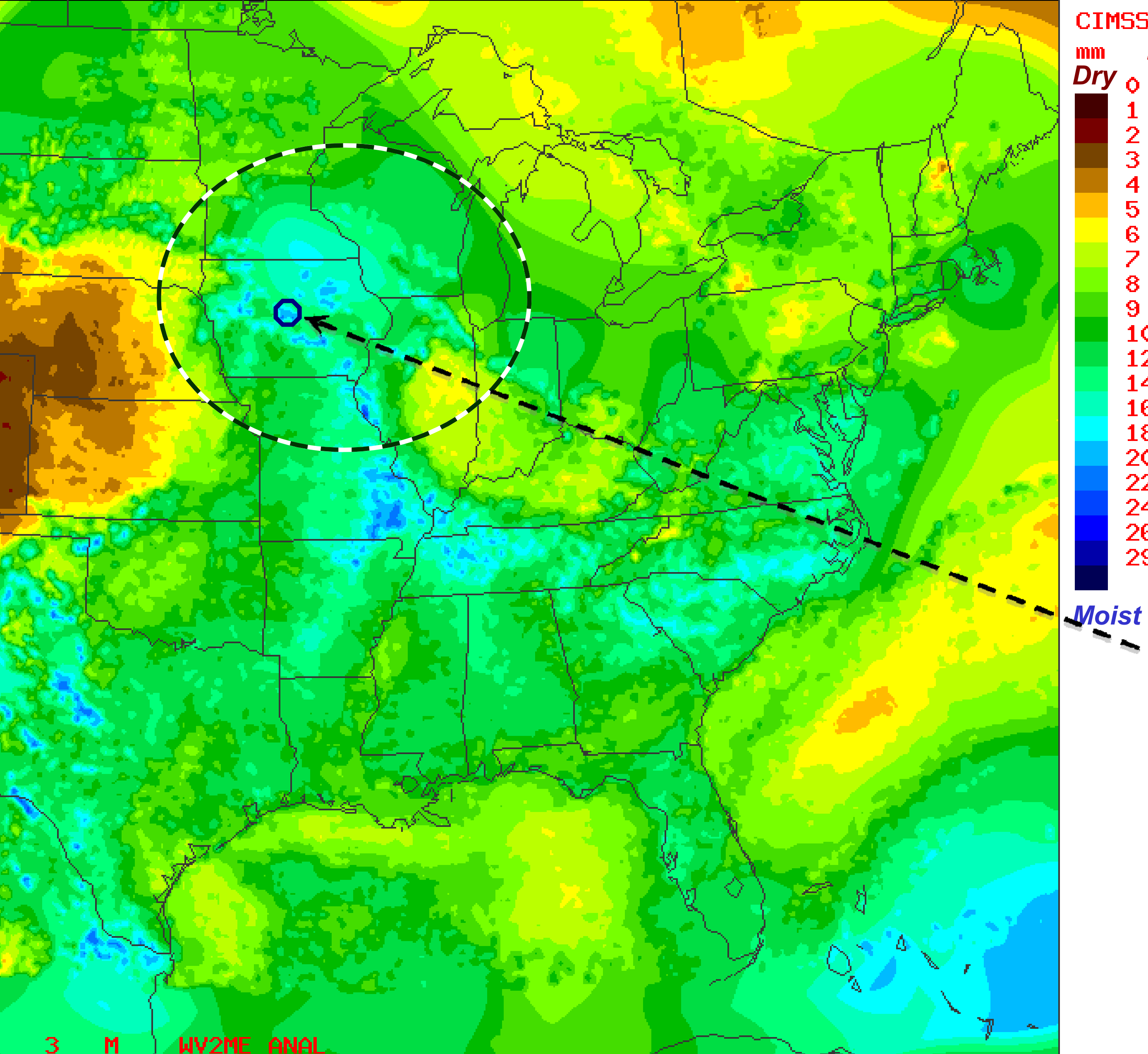
Evaluation of GOES Precipitable Water Retrievals
(Using NCEP GFS for First Guess)

- Comparisons against GPS TPW observations around the US show:

- GOES TPW (Li retrievals) data have a wet bias
  - Worst at time of day when GFS has highest precipitation bias

- GOES TPW data show greatest improvement over First Guess:
  1) In warm months (*when NWP precipitation skill is worst*) and
  2) Using 06Z, **<u>12Z</u>** and 18Z GFS guess fields





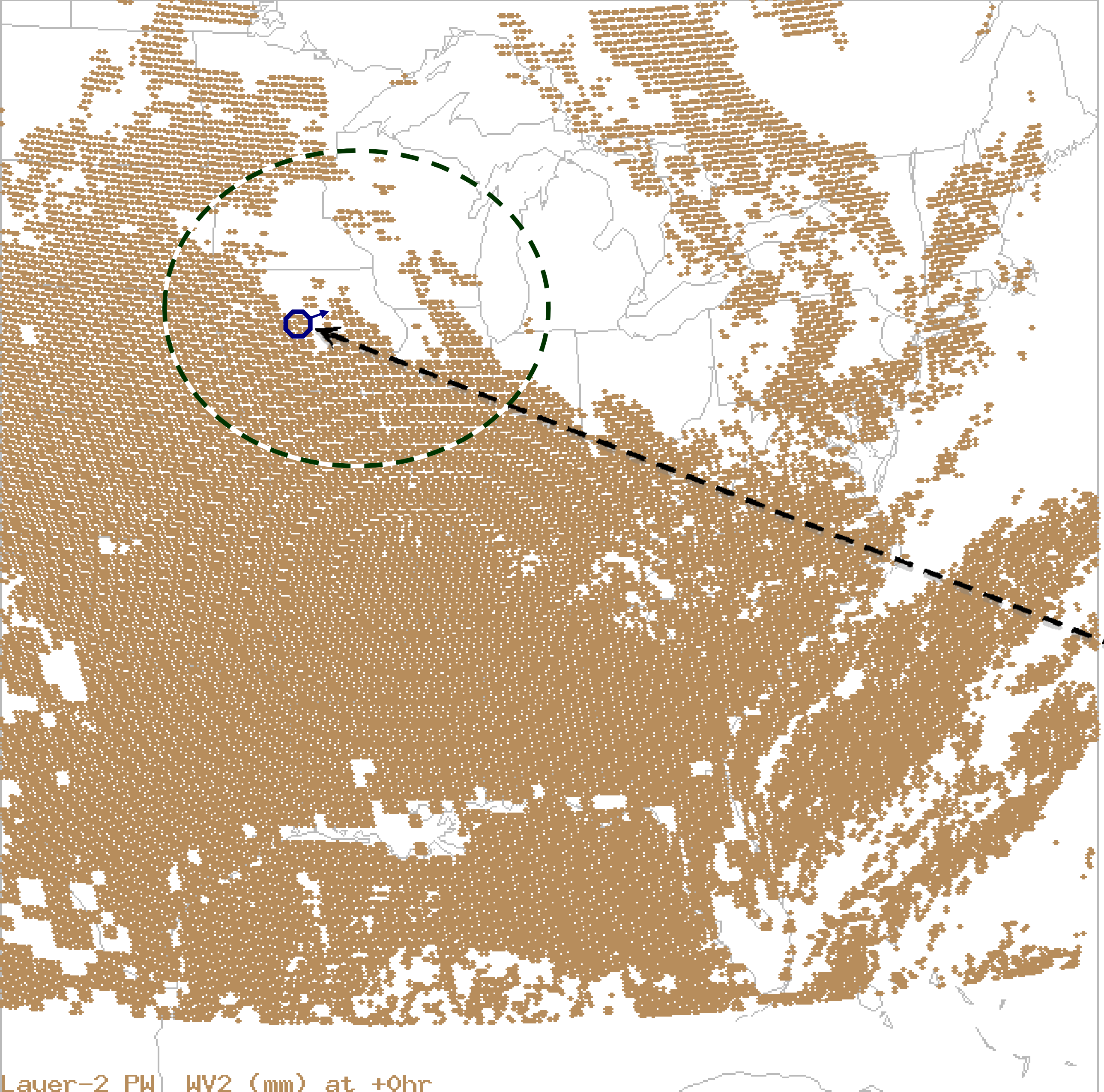
13 April 2006 – 2100 UTC
900-700 hPa GOES PW
0 Hour NearCast

Lagrangian NearCast

How it works:

Consider how a 3-hour NearCast is made for an observation over Iowa

Instead of interpolating randomly spaced moisture observations to a fixed grid (and smooth data) as done in convectional NWP, the Lagrangian approach ***interpolates winds to every moisture observation.***



13 April 2006 – 2100 UTC
900-700 hPa GOES PW
0 Hour Ob Locations

Lagrangian NearCast
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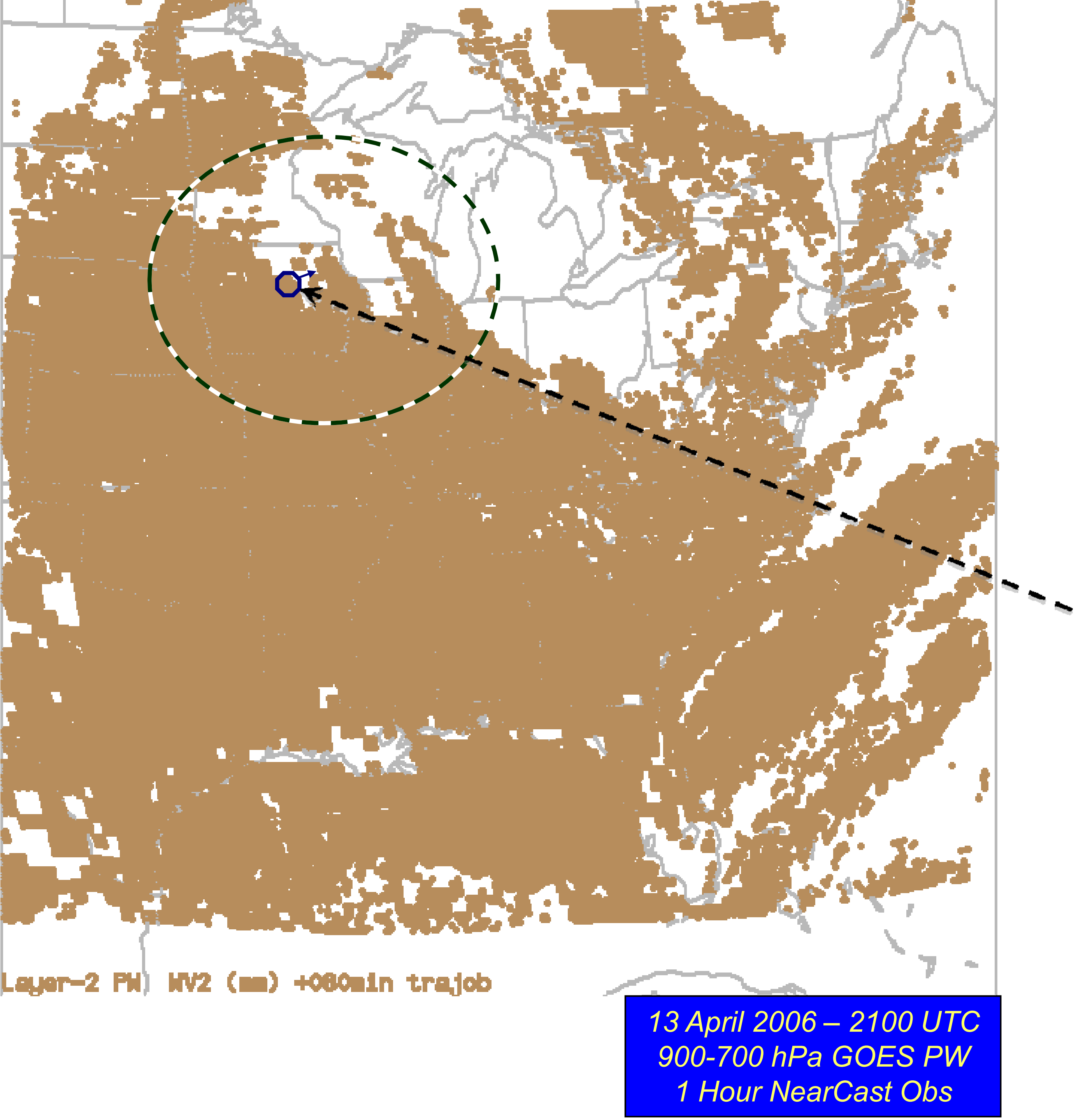
*Instead of interpolating randomly spaced moisture observations to a fixed grid (and smooth data) as done in convectional NWP, the Lagrangian approach **interpolates winds to every moisture observation.***

***The 10 km data are then moved to new locations, using dynamically changing wind forecasts** using 'long' (10-15 min.) time steps*



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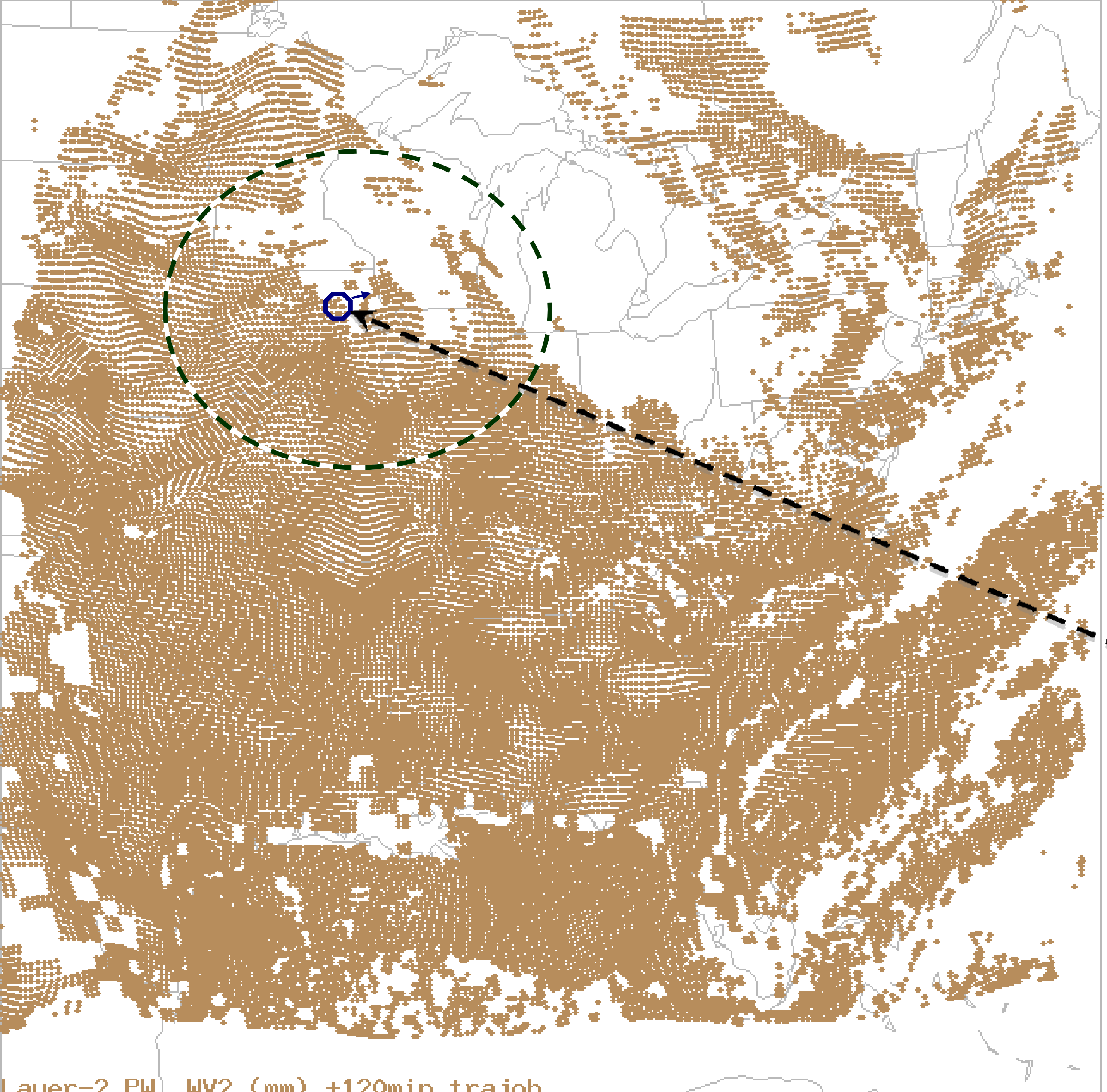

13 April 2006 – 2100 UTC
900-700 hPa GOES PW
2 Hour NearCast Obs

Consider how a 3-hour NearCast is made for an observation over Iowa

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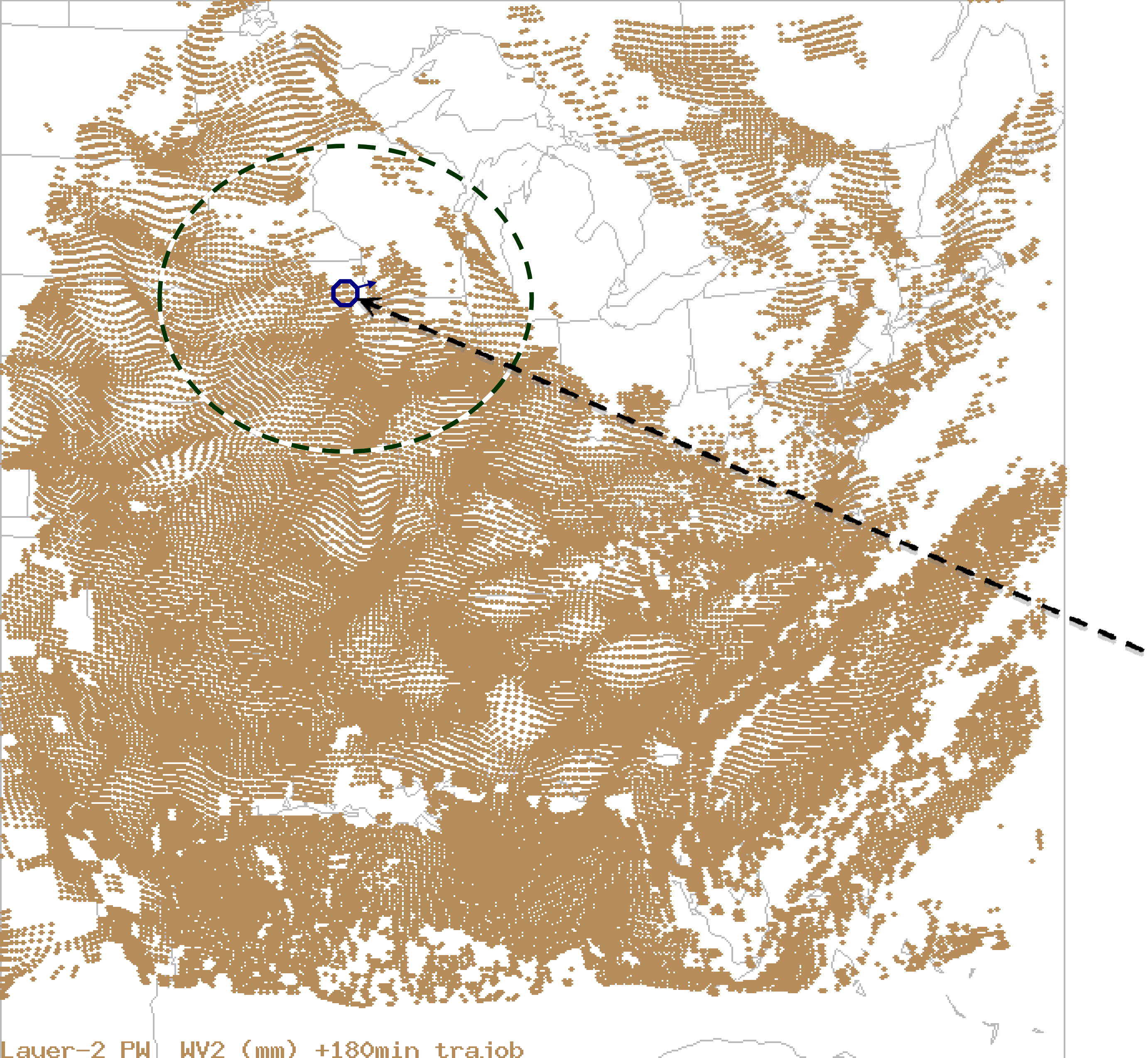
Lagrangian NearCast

How it works:



13 April 2006 – 2100 UTC
900-700 hPa GOES PW
3 Hour NearCast Obs

Consider how a 3-hour NearCast is made for an observation over Iowa

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Lagrangian NearCast

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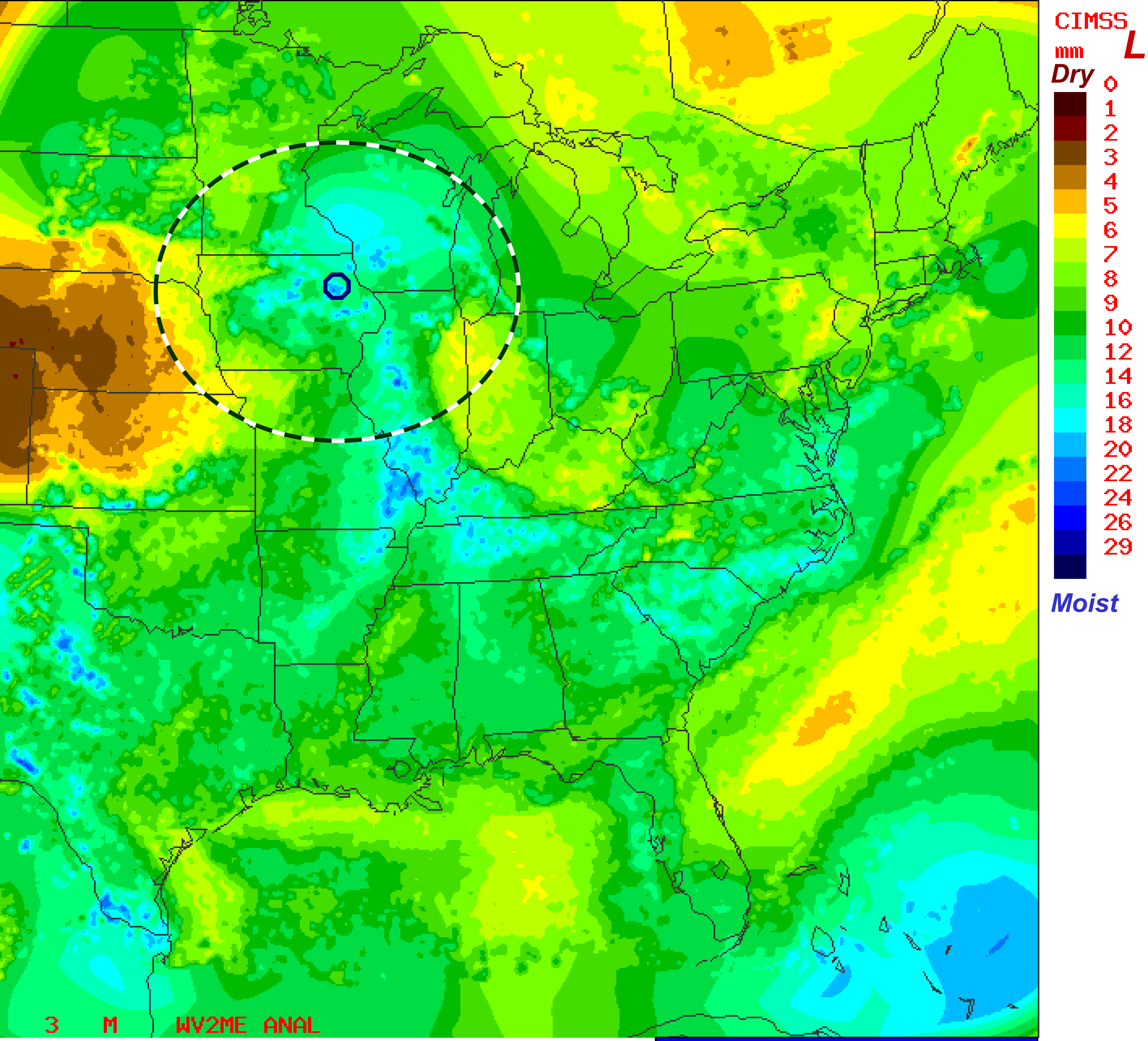

Consider how a 3-hour NearCast is made for an observation over Iowa

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The 10 km data are then moved to new locations, using dynamically changing wind forecasts *using 'long' (10-15 min.) time steps*

The full set of 'moved' moisture observations are then interpolated to an "image grid" for display.

10 km data, 10 minute time steps

13 April 2006 – 2100 UTC
900-700 hPa GOES PW
3 Hour NearCast Image

-

The following examples demonstrates:

-The ability of the NearCasts using data from multiple successive observation times to improve data coverage

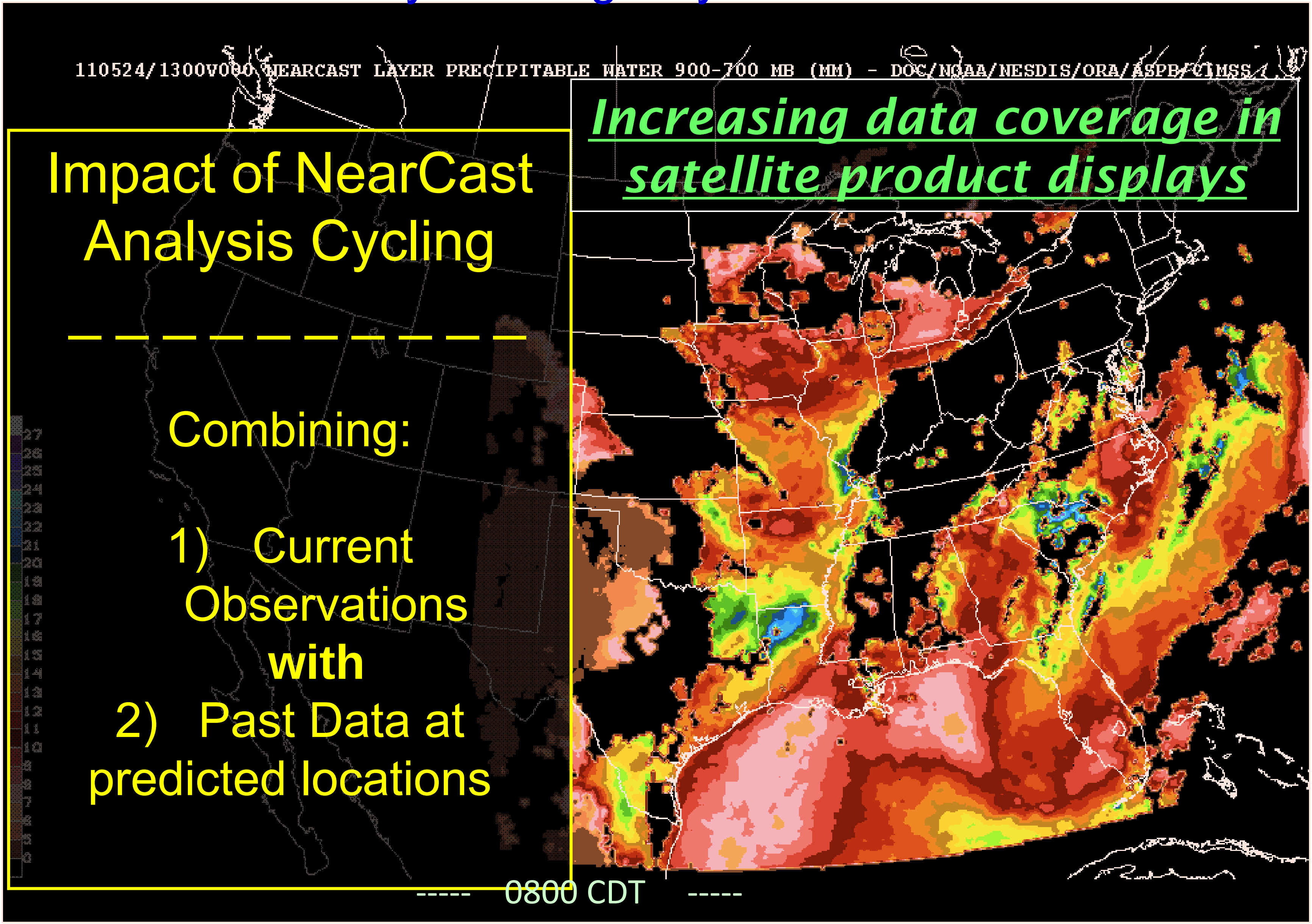
-The advantage of using Equivalent Potential Temperature (θe) both:

1) To monitor lower-level moisture sources and

2) To define Convective Destabilization more completely

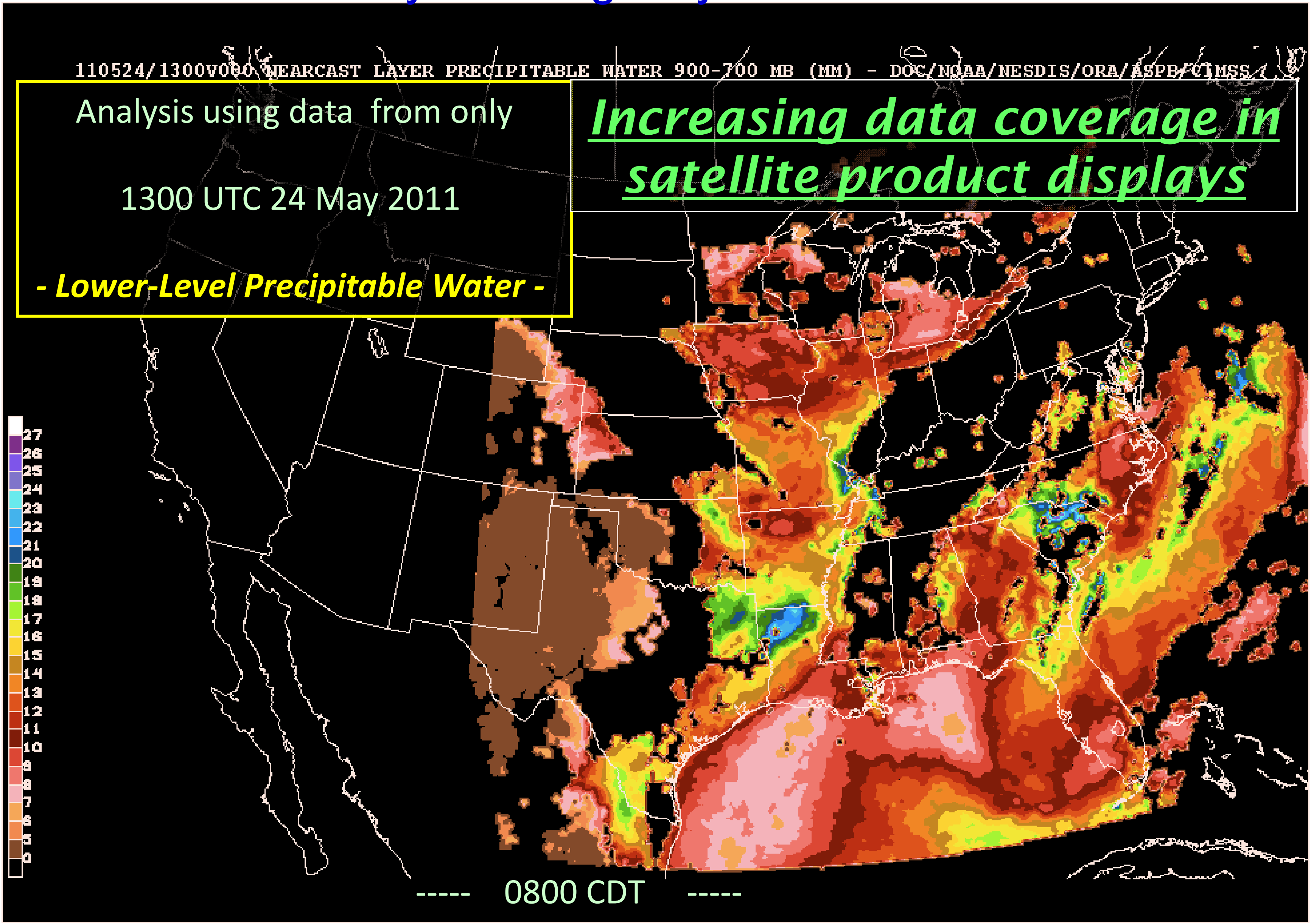
NearCasts are useful in defining where and when convection will and will not occur

NearCast Analysis using only one "On-time" data set



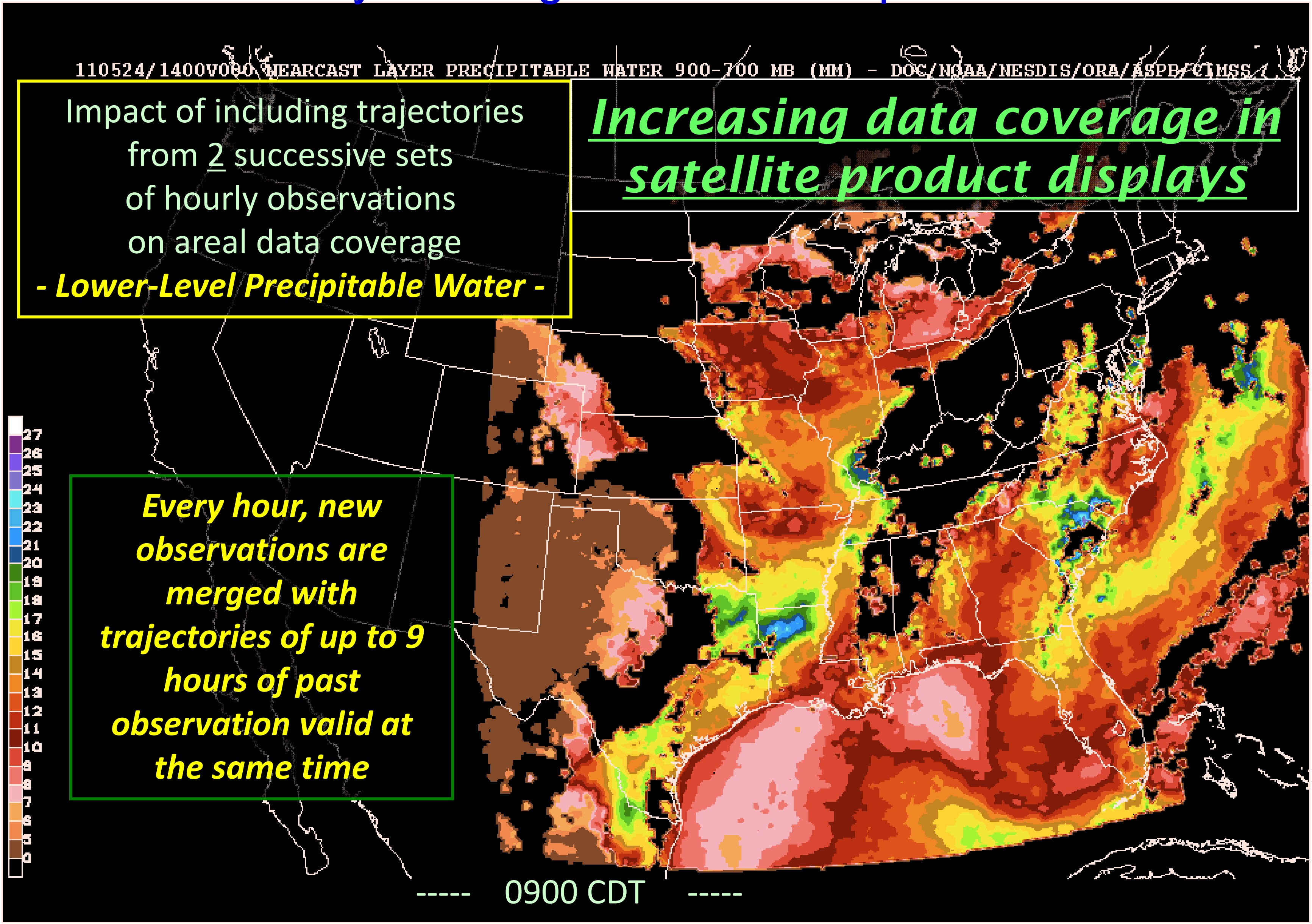
Lower-level Moisture Analyses using only one set of GOES sounder observations (1300UTC) contain substantial data voids

NearCast Analysis using only one "On-time" data set



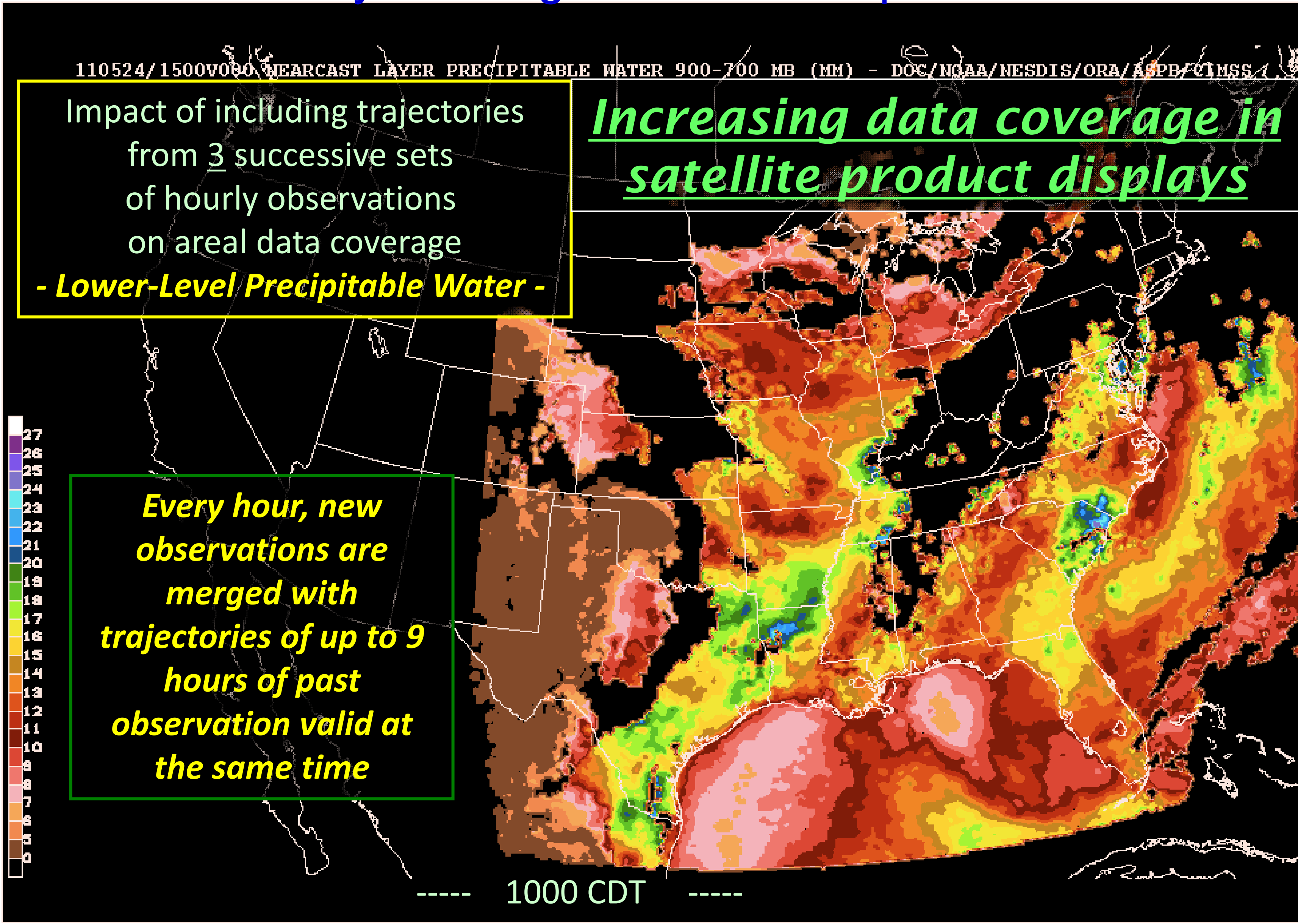
Lower-level Moisture Analyses using only one set of GOES sounder observations (1300UTC) contain substantial data voids

NearCast Analysis using “On-time” + 1 previous data sets



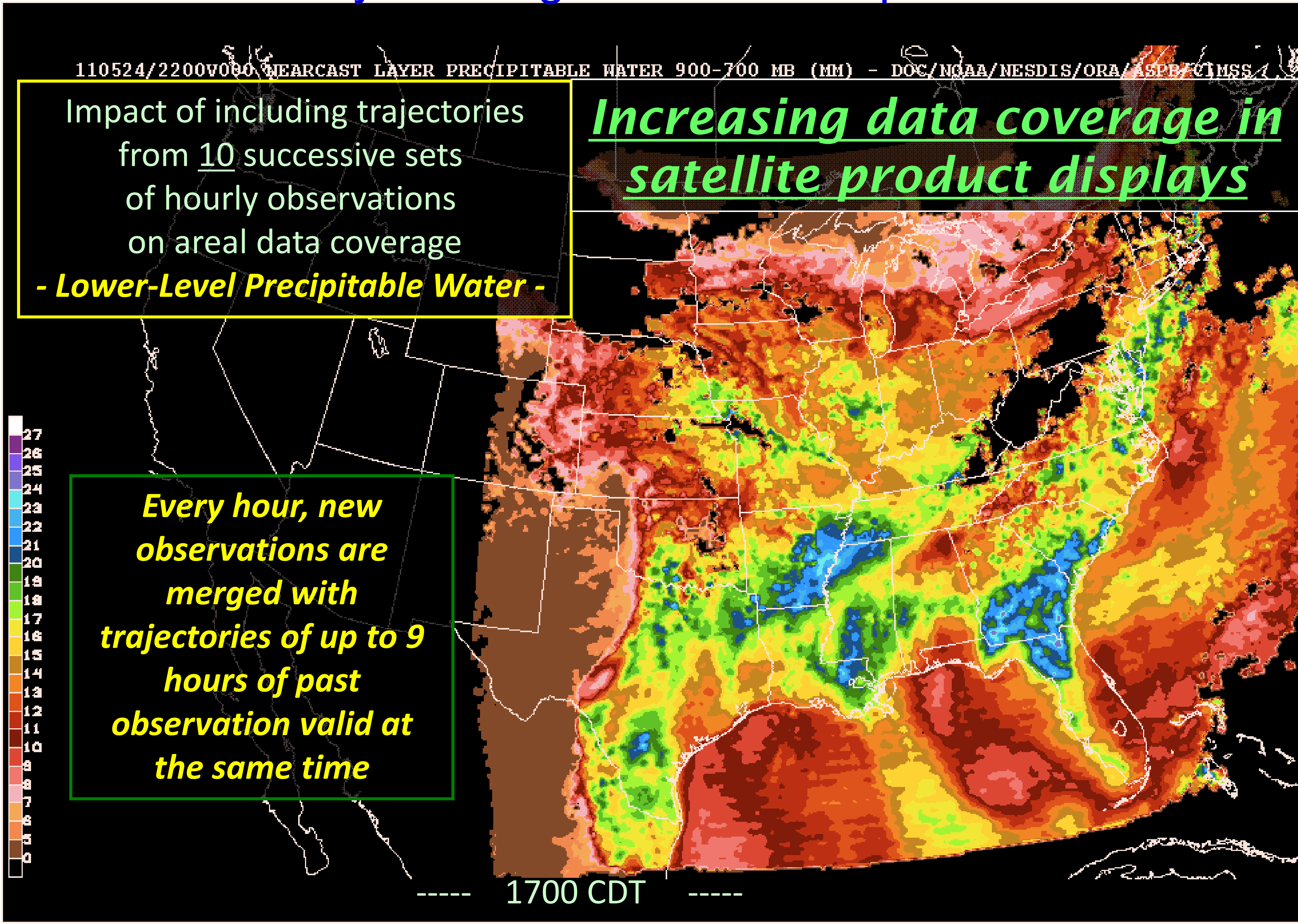
Analyses that combine projected “pseudo-observations” from 1300UTC with new GOES sounder observations at 1400UTC reduces data voids

NearCast Analysis using “On-time” + 2 previous data sets



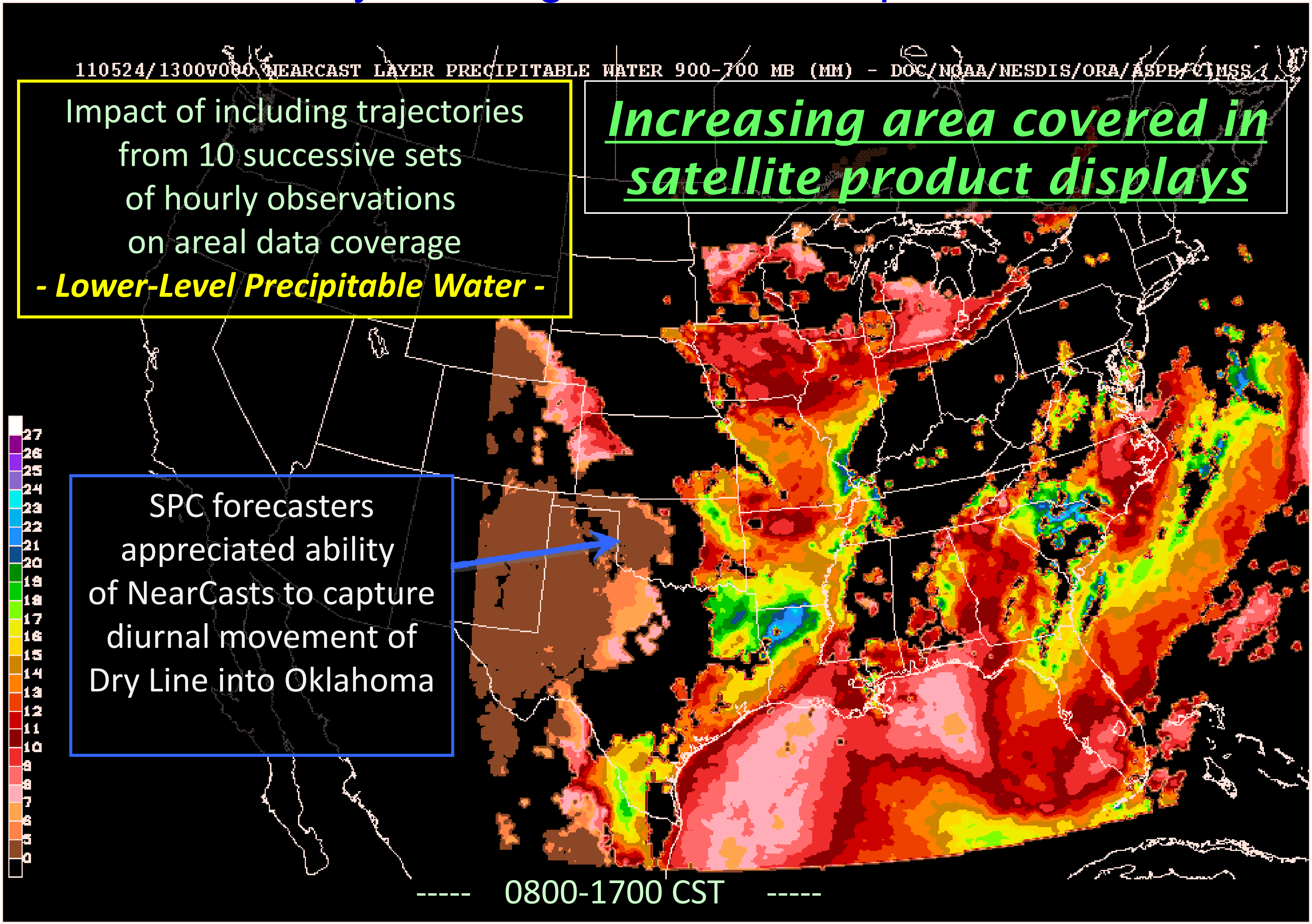
Analyses that combine “pseudo-observations” from 1300 and 1400 UTC with GOES sounder observations at 1500UTC further reduces data voids

NearCast Analysis using "On-time" + 9 previous data sets



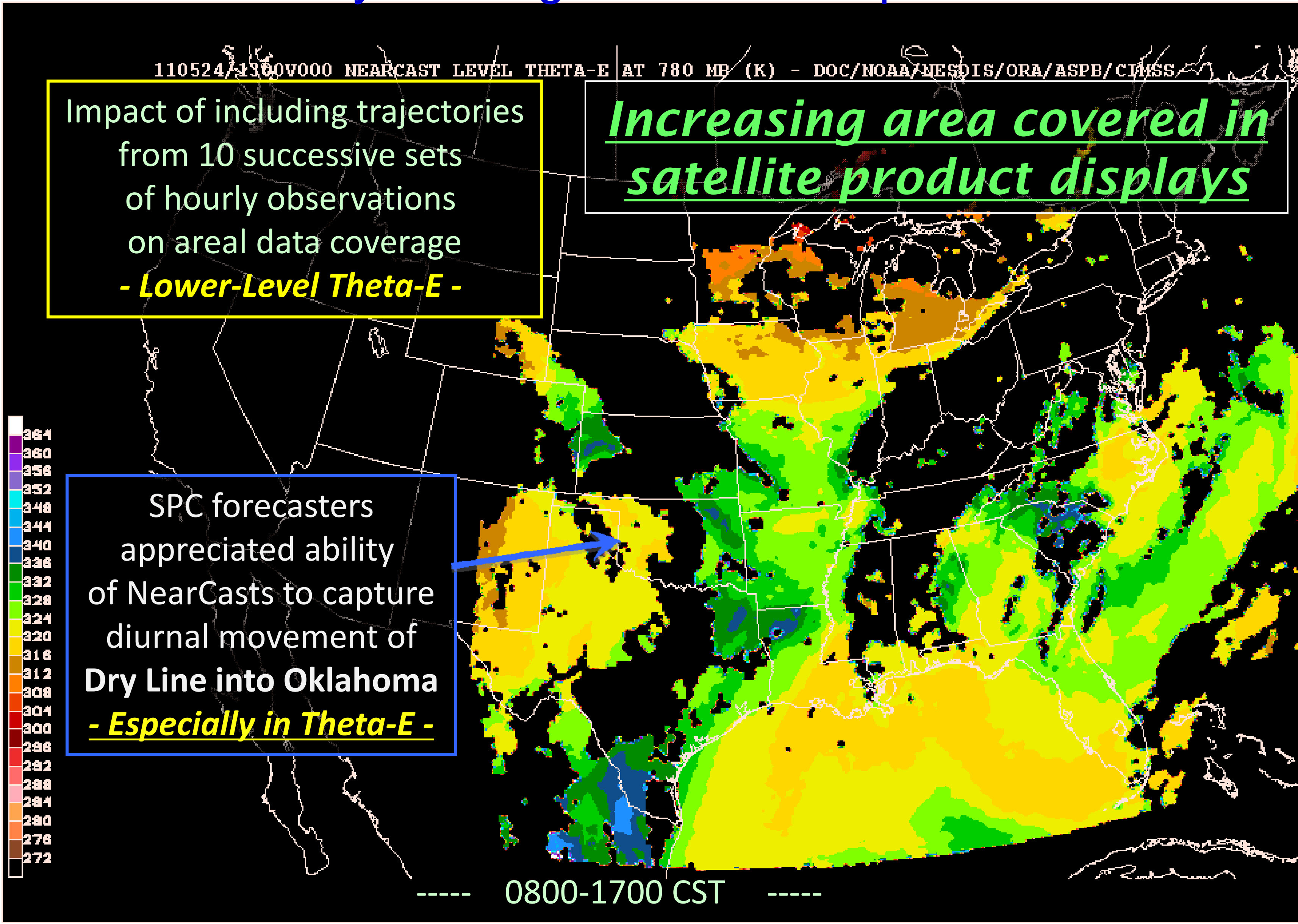
Combining 9 sets of "pseudo-observations" between 1300 and 2100UTC with GOES sounder observations at 2200UTC greatly shrinks data voids

NearCast Analysis using "On-time" + 9 previous data sets



Combining 9 sets of "pseudo-observations" between 1300 and 2100UTC with GOES sounder observations at 2200UTC greatly shrinks data voids

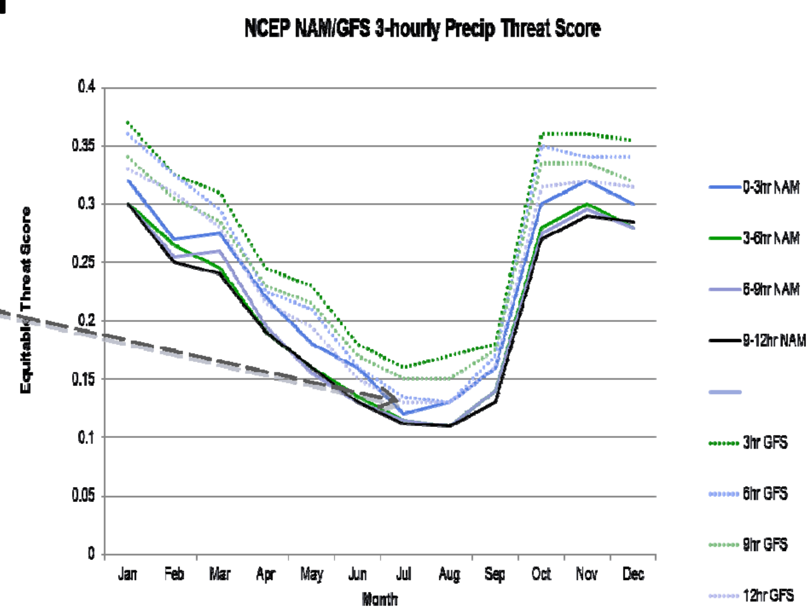
NearCast Analysis using "On-time" + 9 previous data sets



Combining Lower-level Moisture and Temperature into Equivalent Potential Temperature (θe) improves depiction of total moist energy and stability

NearCasting evaluations comments included:

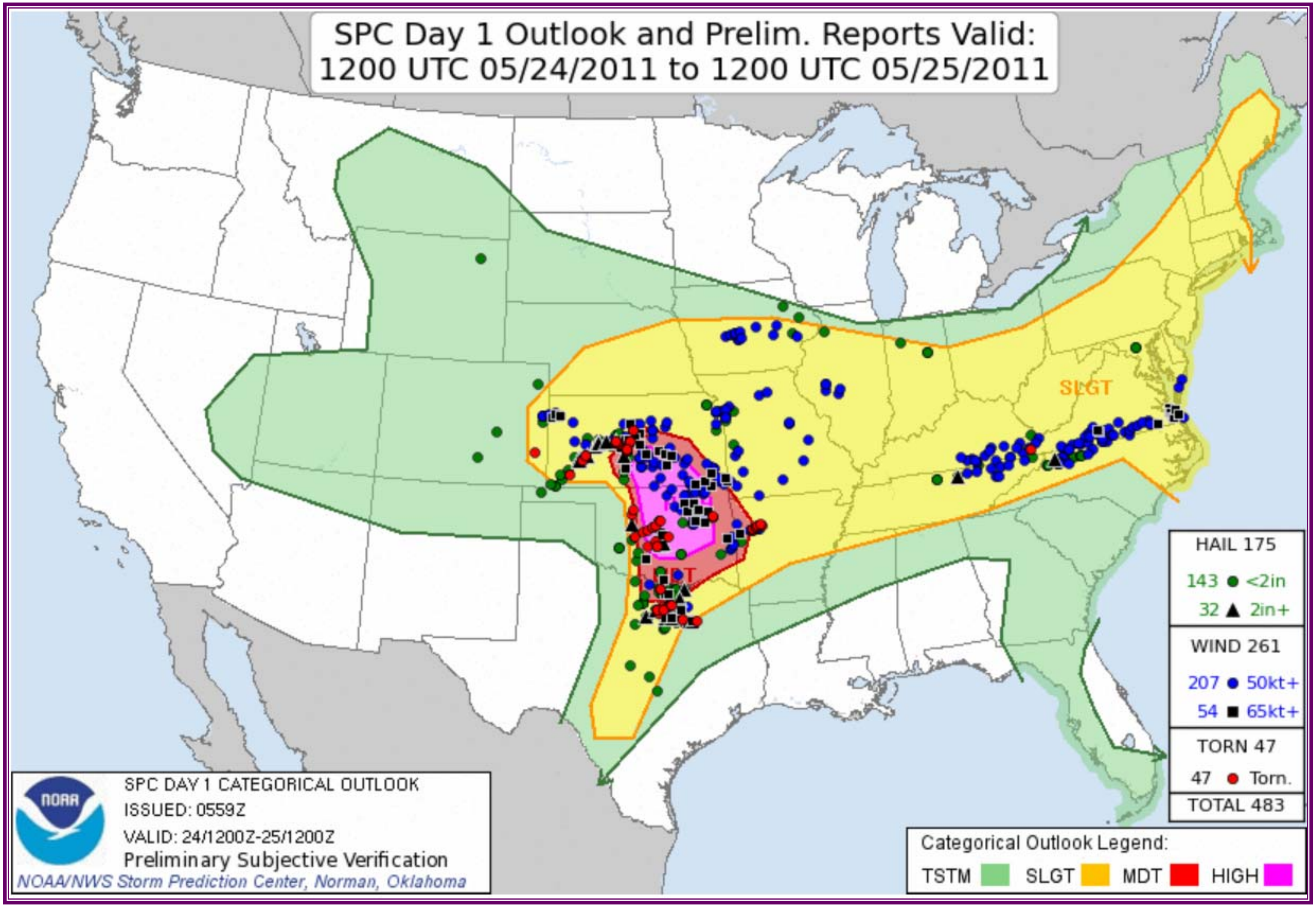
1. **Provide information about dynamic triggering** *(underway)*
2. **Extend forecast length** *(increased from 6 to 9 hours)*
3. **Clouds limit the usefulness of product at times** *(Extended analysis cycling using past data has helped)*
4. **Nearcast fields (especially tendencies) were most useful when used to diagnose initial growth and coverage**
5. **Nearcasts most valuable when used in conjunction with observations and other model data (both where convection *will* and *will not* occur)**
   - *Useful in updating/verifying NWP guidance*
   - *Note: NWP correct only ~15% in summer*



6. **Forecasters need more experience using new products and help interpreting the observed fields & combined NearCast parameters**

Example from 24 May 2011

– Oklahoma Tornados – DFW Shutdown -



Generally good forecasts, but

Example from 24 May 2011

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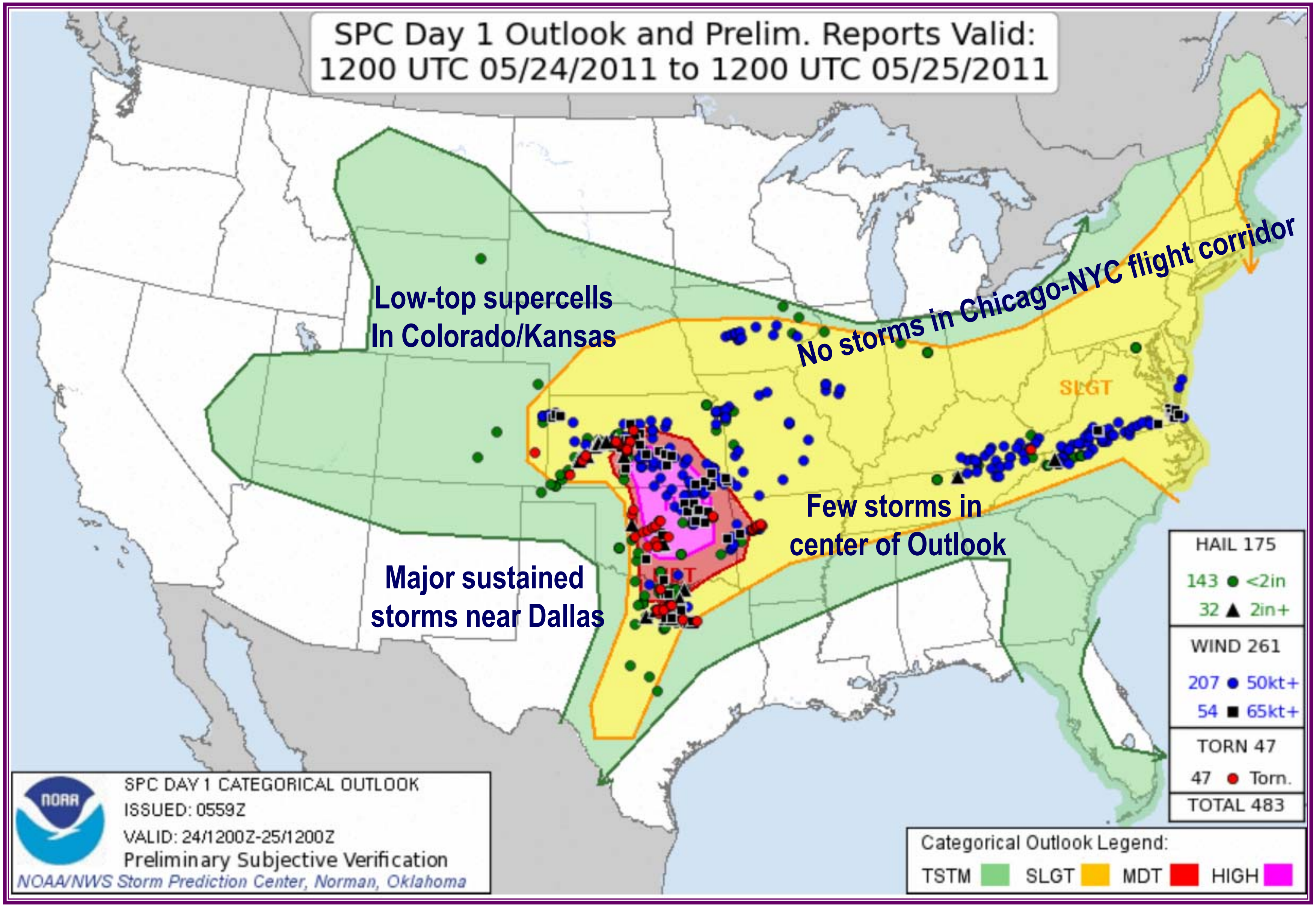

Generally good forecasts, but

Example from 24 May 2011

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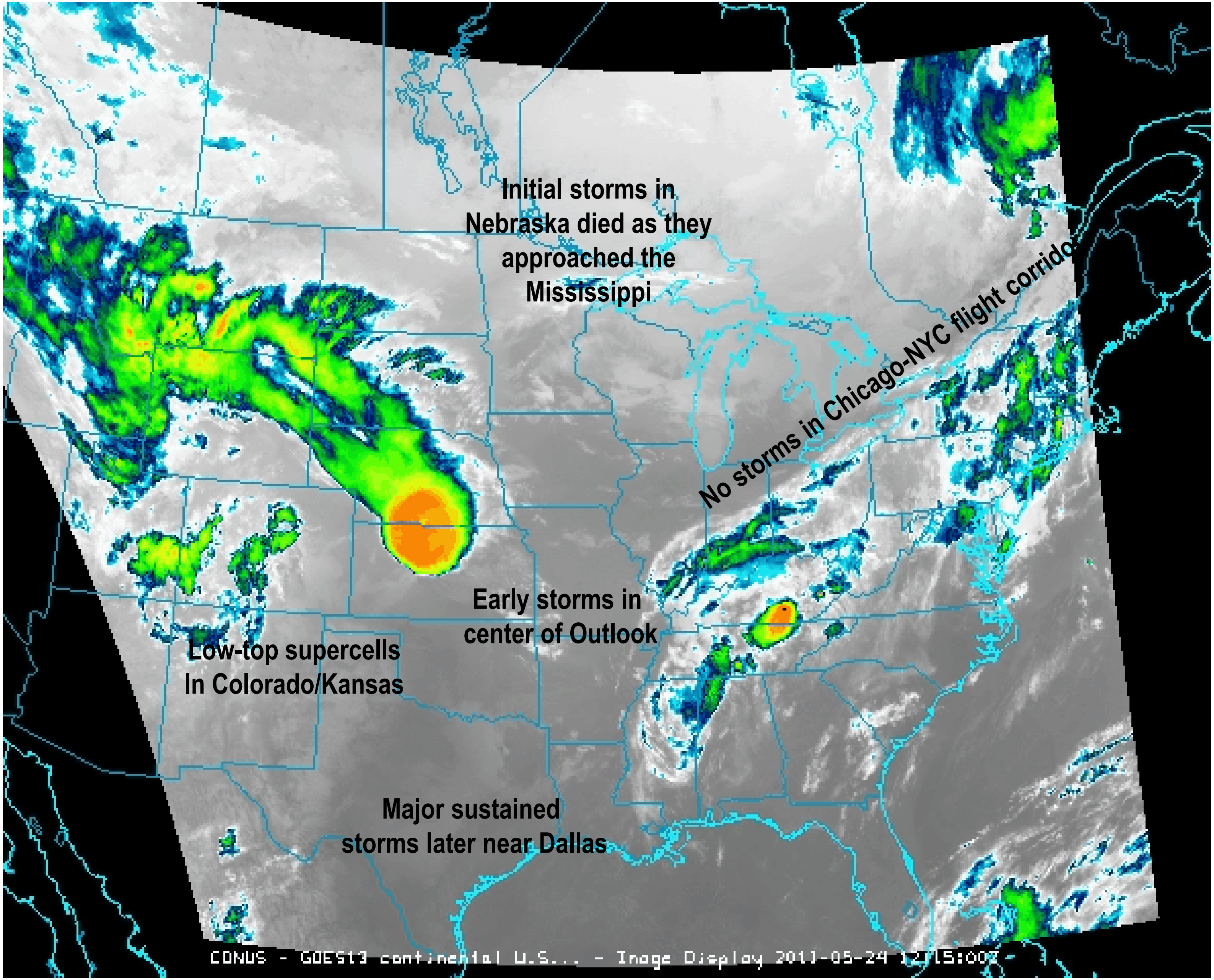
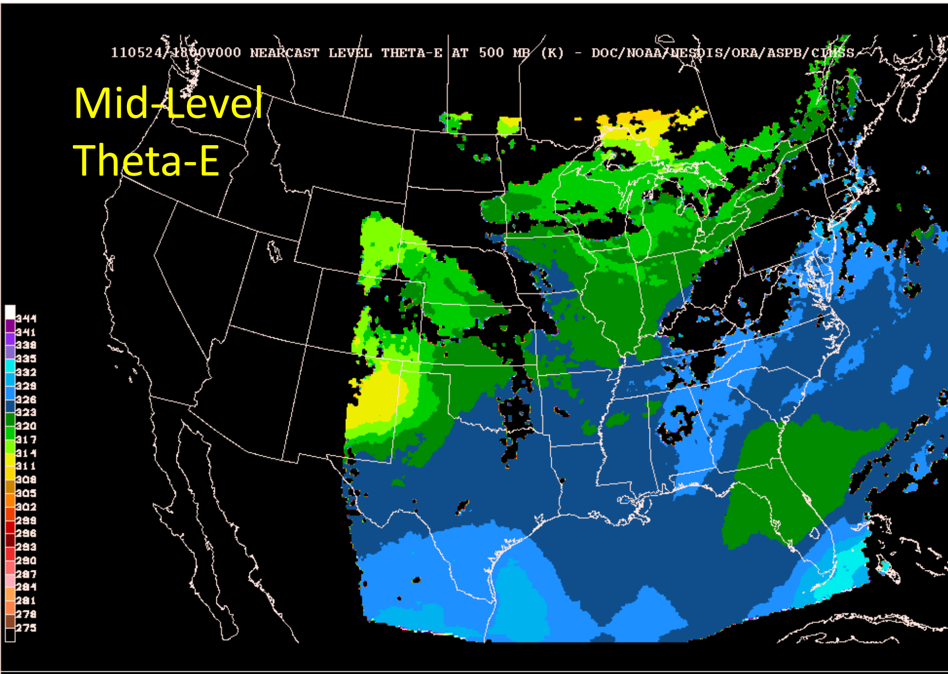


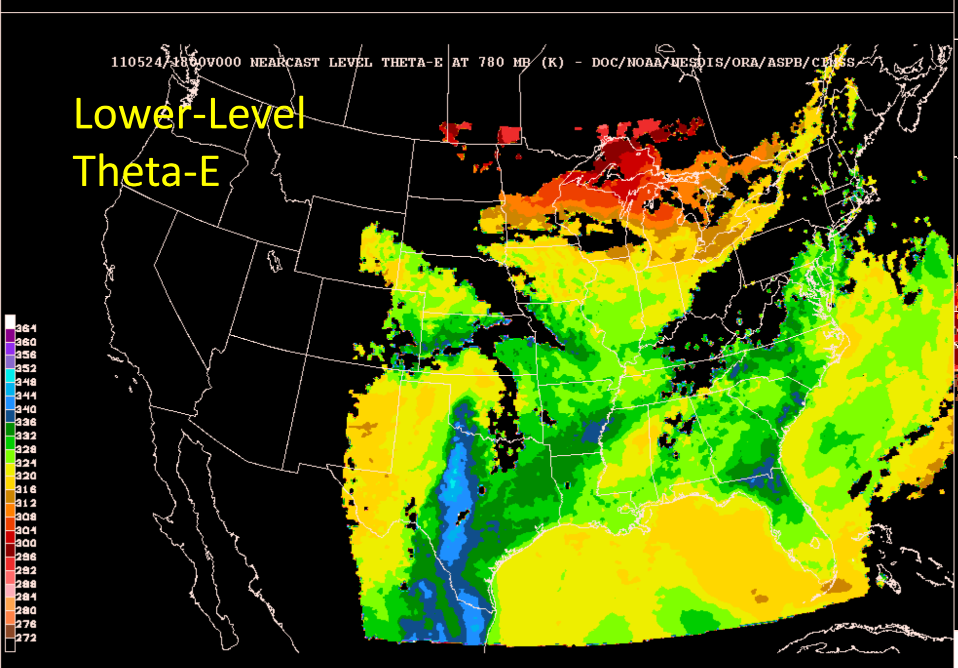
0 hours NearCasts from 1800 UTC 24 May 2011

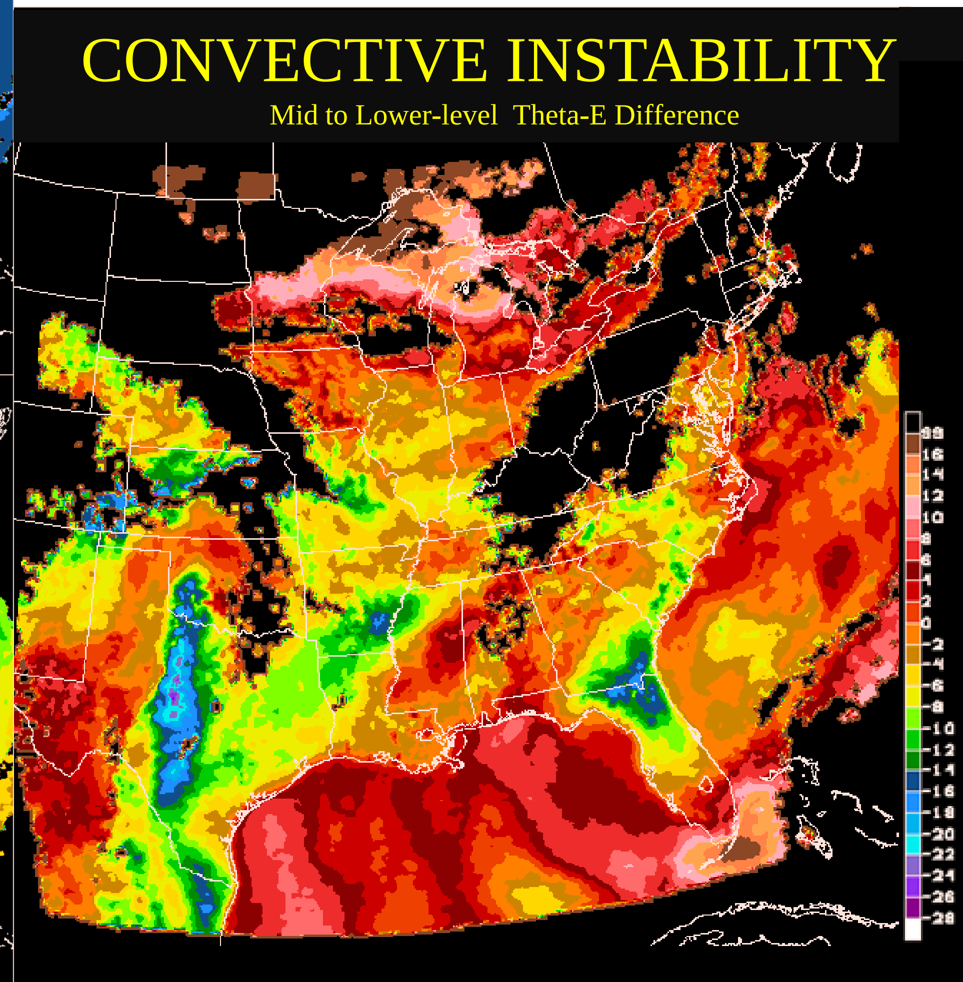
We will use Multiple-Parameter Displays that <u>explain the physical processes producing Convective Instability</u>

They are more useful than multiple sets of single parameter images

<u>Choice of color bars for display is critical</u>



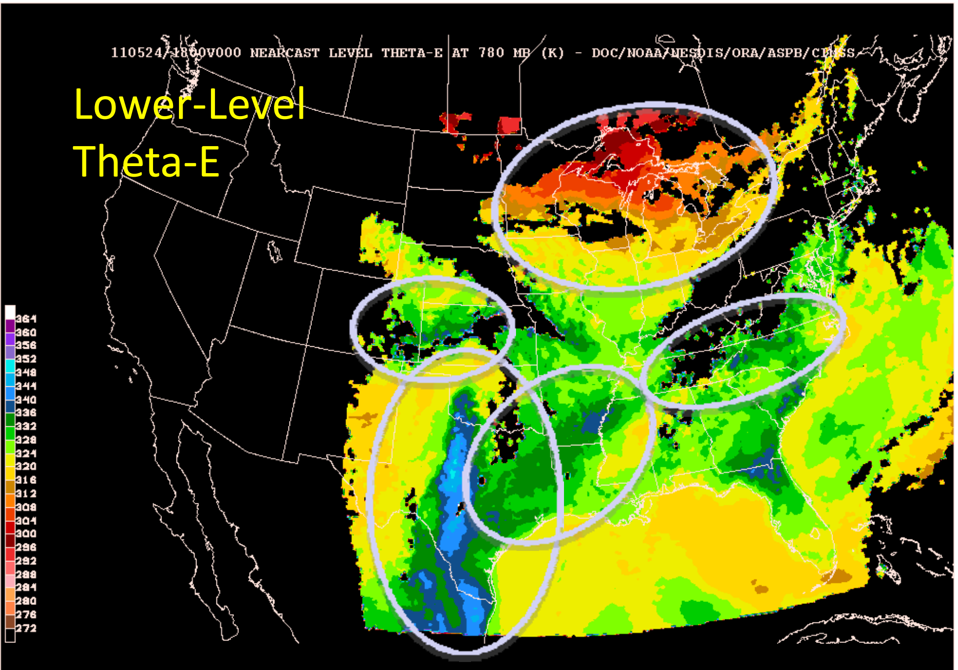




0 hour NearCasts from 1800 UTC 24 May 2011

Begin by examining the predicted evolution of
***Lower-Level* θe Fields.**

These show the areas with the
greatest total lower-level thermal energy



At 1800 UTC, the Lower-Level θe NearCast Analysis shows:

1) A north-south band of very moist/warm air extending across central Texas into far SW Oklahoma,

2) A secondary band of moderately high θe across NE Texas into Arkansas,

3) A small area of enhanced θe near the Virginia/North Carolina border,

4) An area of higher θe surrounding a cloudy area in SE Colorado and western Kansas, and

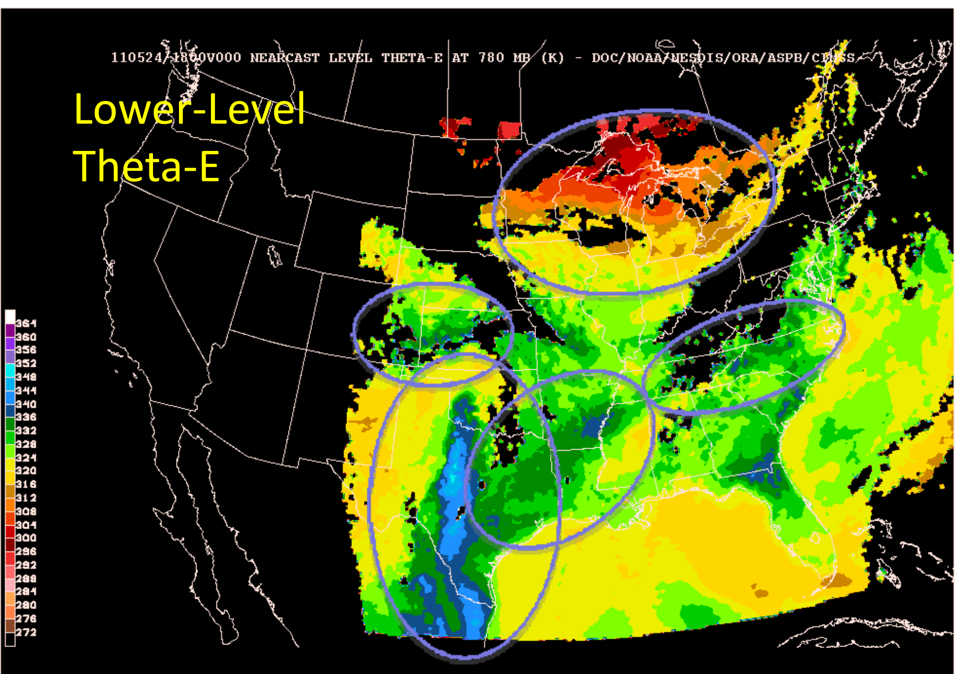
5) An area of very low θe over the upper Great Lakes and extending as far SE as Lakes Erie and Ontario

0-9 hours NearCasts from 1800 UTC 24 May 2011

Begin by examining the predicted evolution of *Lower-Level* θe Fields.

These show the areas with the greatest total lower-level thermal energy

The dynamical evolution of the Low-Level θe structures in the various areas are especially apparent when the images are looped.



Lower-Level θe NearCast Prediction shows:

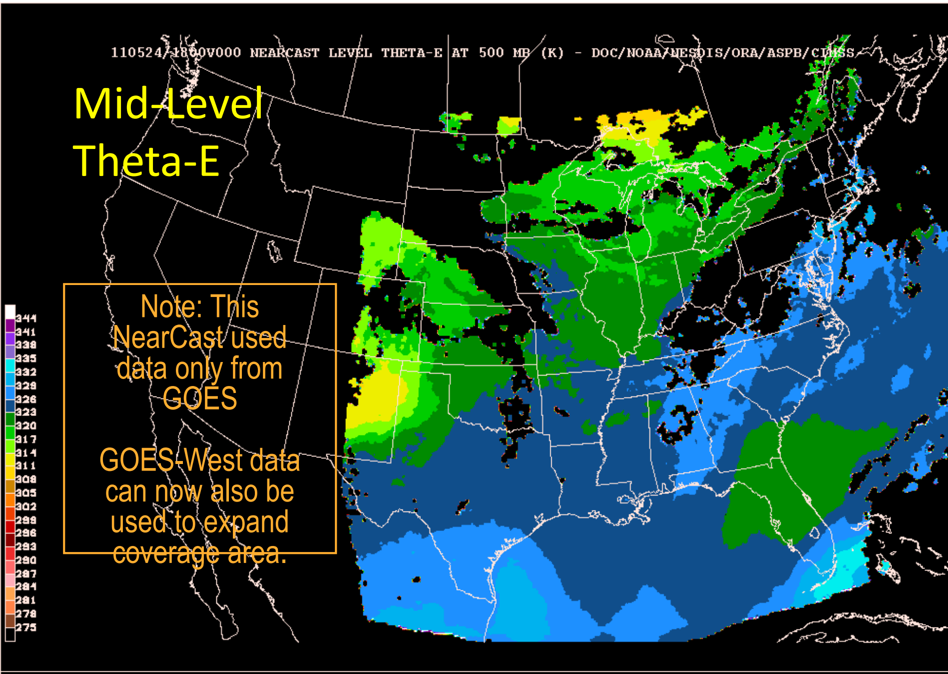
1) The very moist/warm air initially from central Texas and SW Oklahoma shows a distinct maximum near Dallas and extending in an arc across central Oklahoma

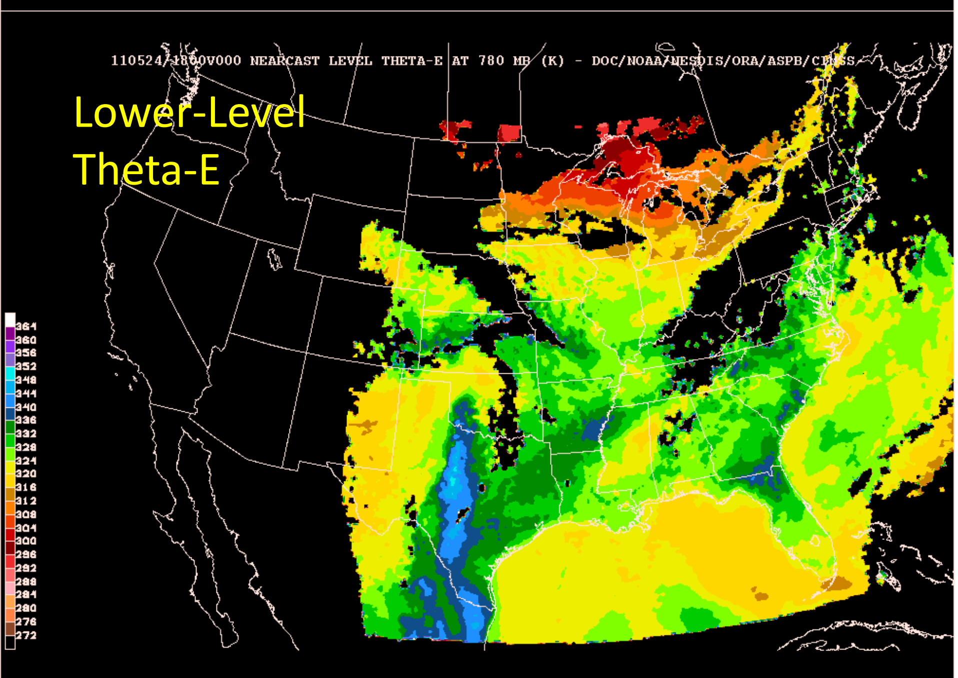
2) The small area of higher θe near the Virginia/North Carolina border continues to move slightly east,

3) The area of higher θe in SE Colorado and western Kansas continues to rotates cyclonically, and

3) The area of low θe over the upper Great Lakes reaches into central Pennsylvania.

0-9 hours NearCasts from 1800 UTC 24 May 2011





Next, examine the predicted evolution of *Mid-Level* θe Fields.

These show the areas Upper- and Mid-Level Dryness

Mid--Level θe NearCast Prediction shows:

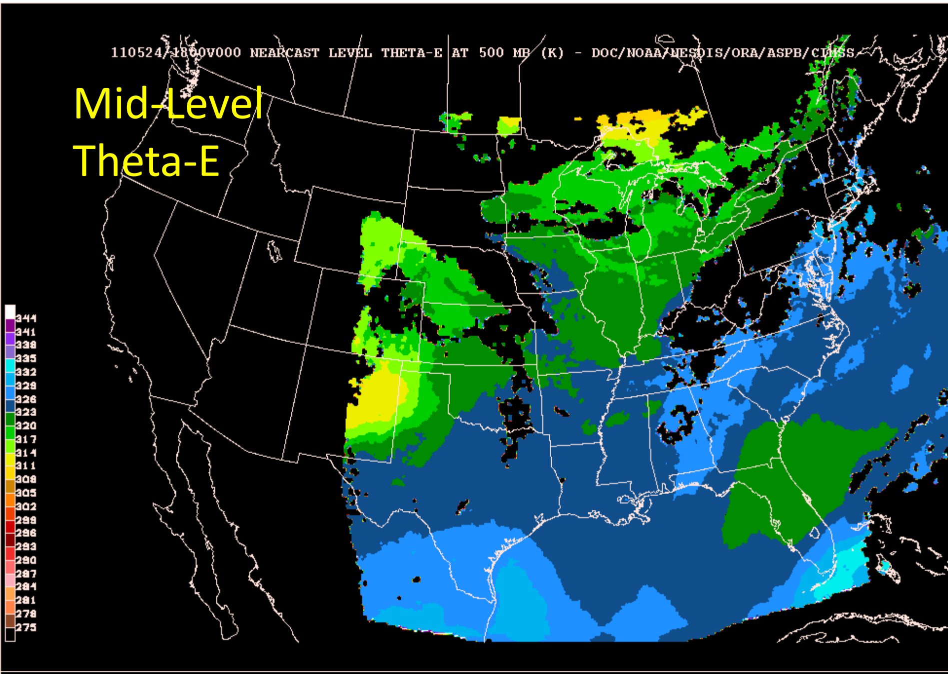
1) Dry air aloft, initially over New Mexico, moving from the west over the very moist/warm air initially from central Texas and SW Oklahoma due to differential advection,

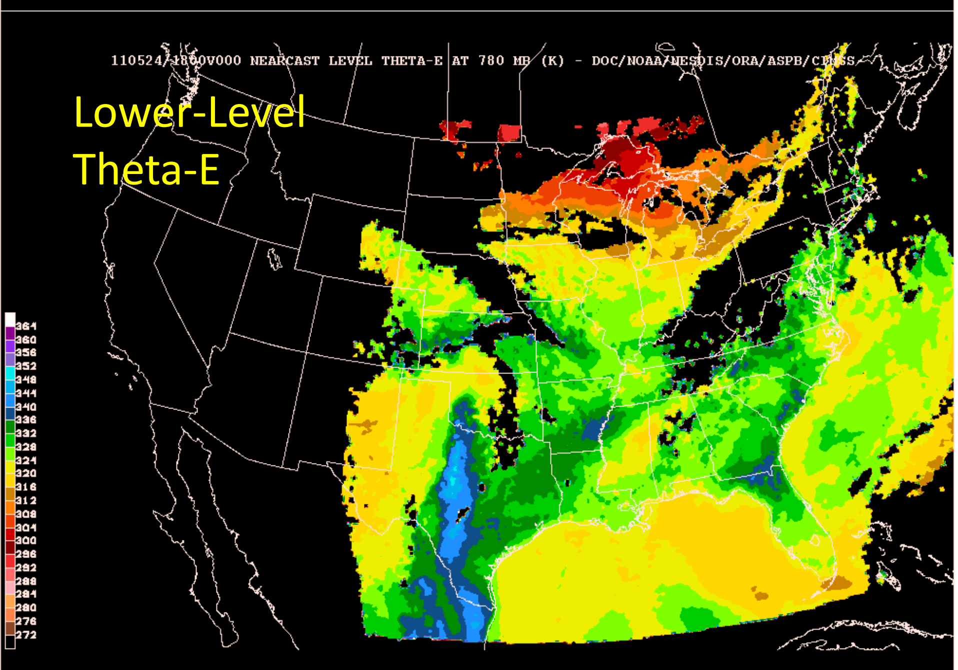
2) Less dry air over the higher θe near the Virginia/North Carolina border,

3) Dry air from Northern New Mexico rotating cyclonically over the higher θe in SE Colorado and western Kansas, and

4) The dry/cool air (and low θe) over the upper Great Lakes extends through the full atmosphere.

0-9 hours NearCasts from 1800 UTC 24 May 2011





Combining information about local stability patterns using the predicted evolution of *Low- and Mid-Level* θe Fields.

To better isolate that areas where differential advection is forcing upper-level dry/cool air to override lower-level warm/moist air, the two images on the left can be subtracted to create a depiction of the Deep-Layer Convective Instability.

This is equivalent to a Modified Lifted Index, where the stable/unstable threshold is shifted from 0° to -4°.

GOES/SEVIRI observe this well !

In the following derived images, yellows, greens, blues and purples indicate increasingly unstable air.

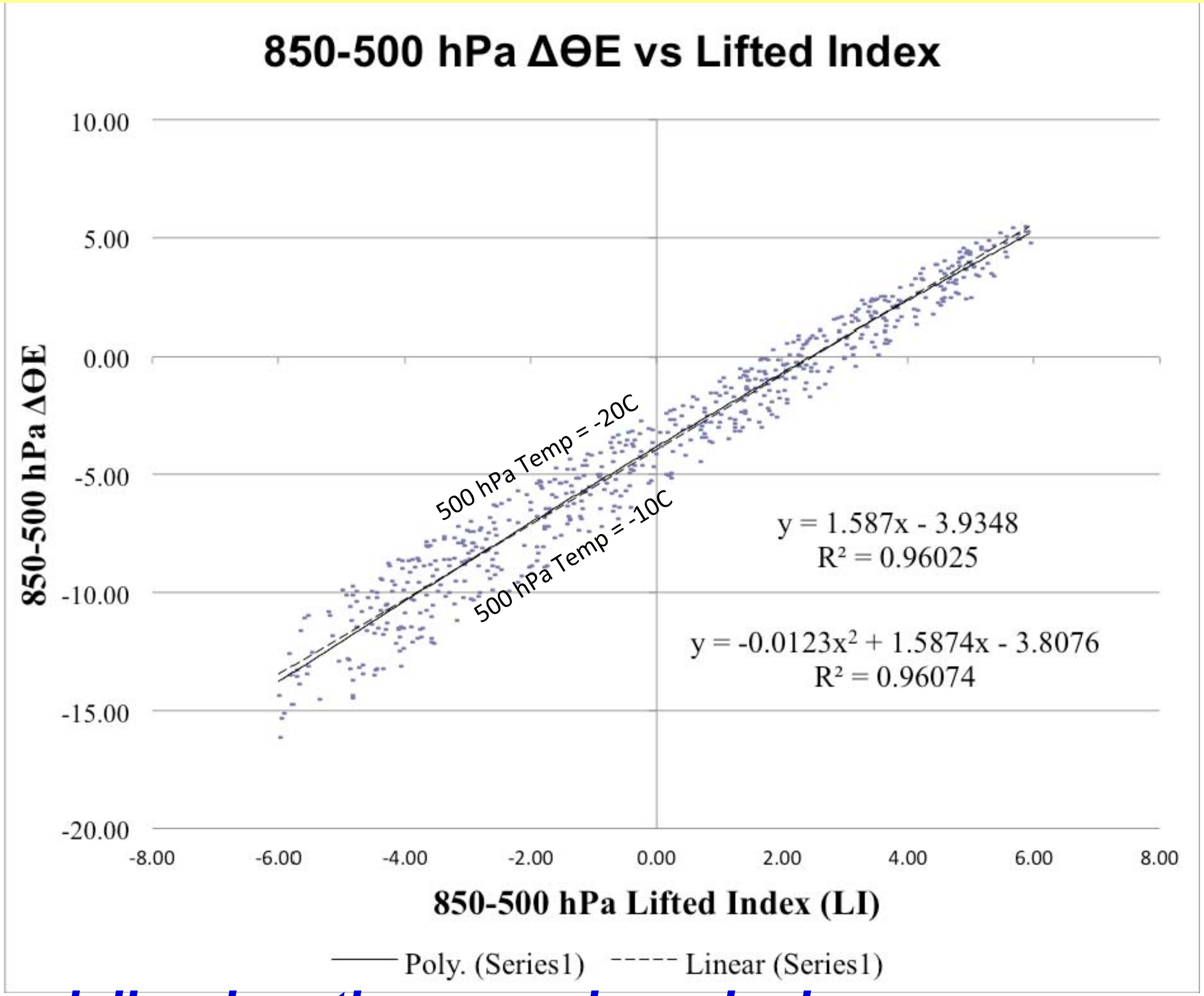
Note: The Instability well only be released in areas where Low-level lifting is also present

Comparing Convective Instability to Lifted Index

Although imagery repeatedly shows that convection forms as dry air aloft overtakes areas of low-level moisture, **confusion persists about the choice between Layer-based Convective Instability and Parcel-based Indices (e/g/, LI)**

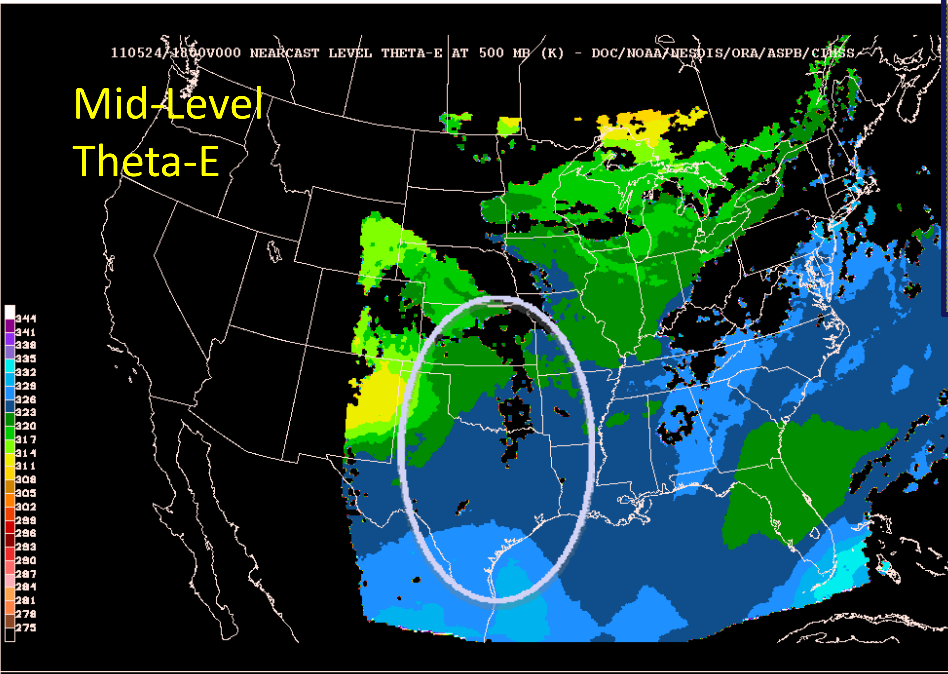
Note:
NearCasts determine ***Deep-layer*** *Convective Instability from ∂Θe/∂p*

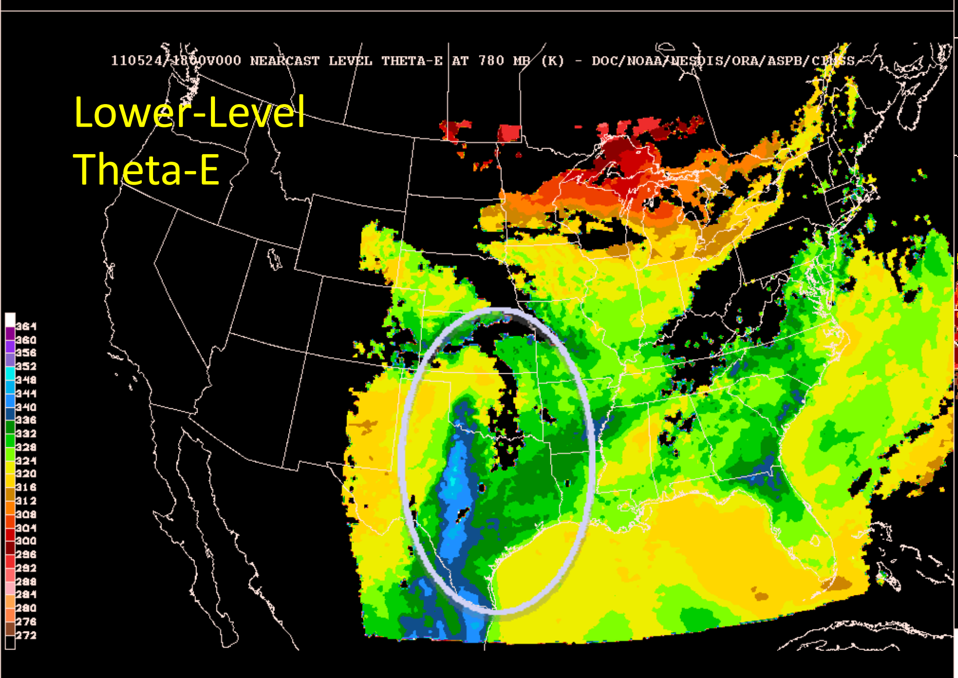
Tests show that because ambient mid-level θ_E and T are very similar, ***LI and Convective Instability are nearly equivalent and vary nearly linear, with ~3-4° offset, especially when the upper-layer is dry.***



0-9 hours NearCasts from 1800 UTC 24 May 2011

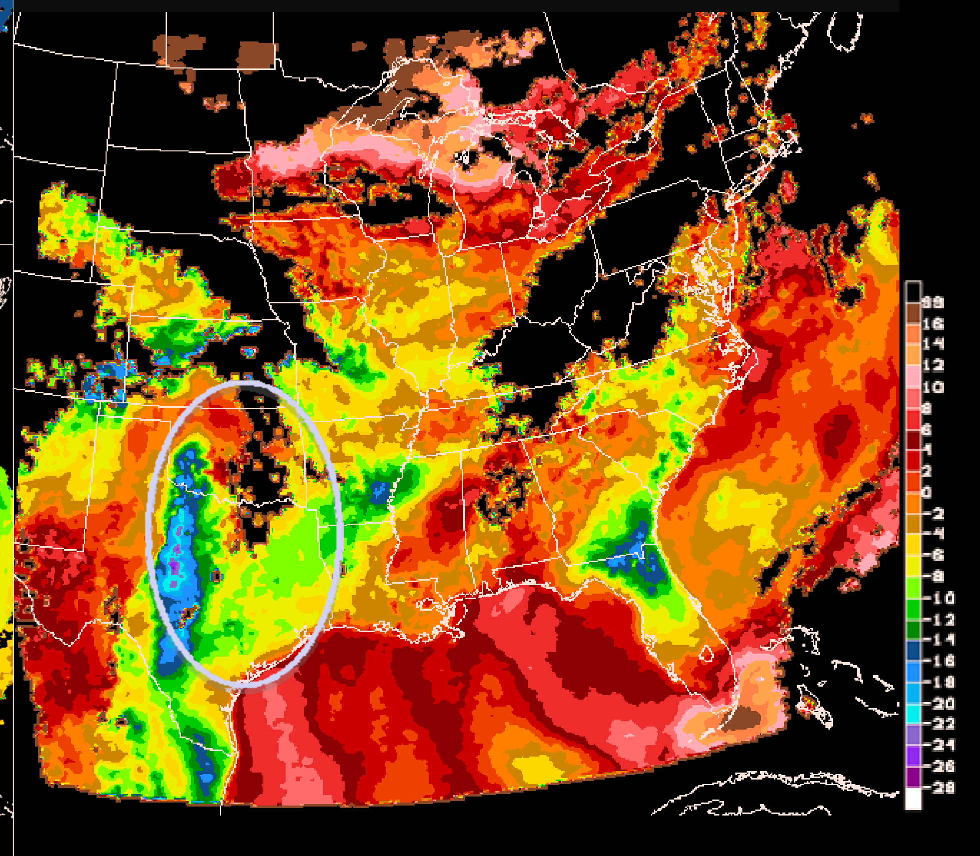
Note:
- Instability moves first to central Oklahoma
- Instability increases, reaching Dallas later
- Instability intensifies over western Kansas near low-top super-cells
- Stable air from Great Lakes moves to cover most of Pennsylvania by end of end of period



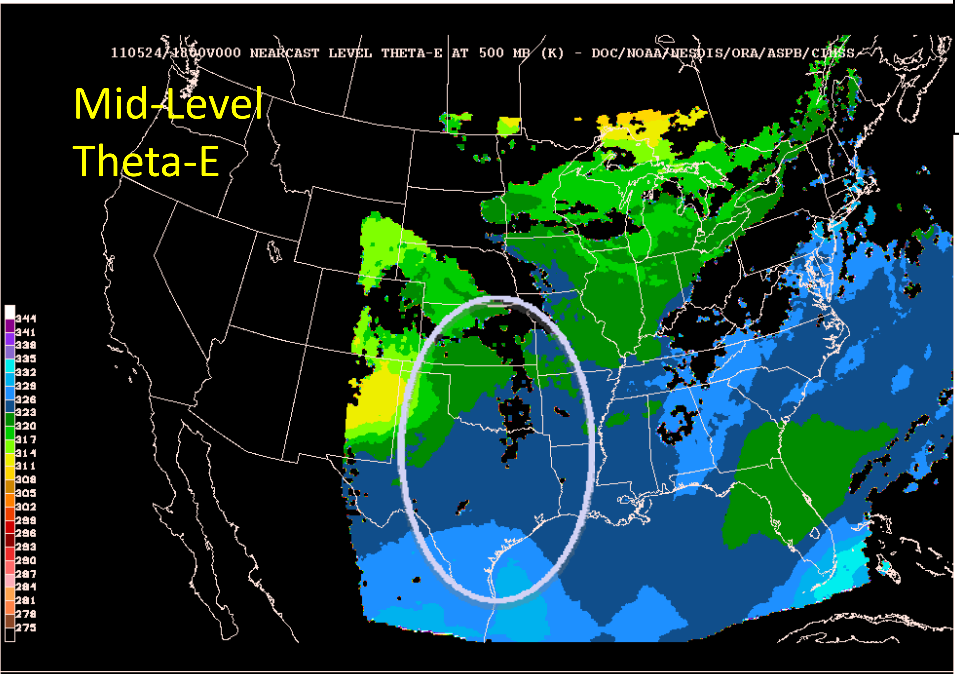


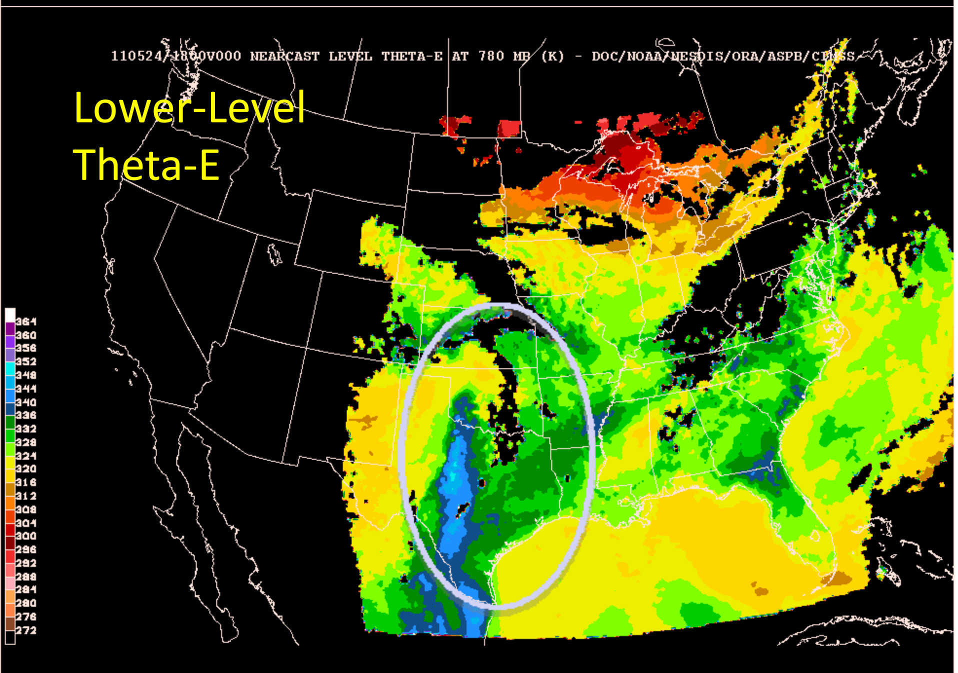
CONVECTIVE INSTABILITY

Mid to Lower-level Theta-E Difference



0-9 hours NearCasts from 1800 UTC 24 May 2011





Combining information about local stability patterns using the predicted evolution of *Low- and Mid-Level* θe Fields.

To better isolate areas where prolonged convection can be supported, an additional combination of NearCast outputs can be used to constructed a

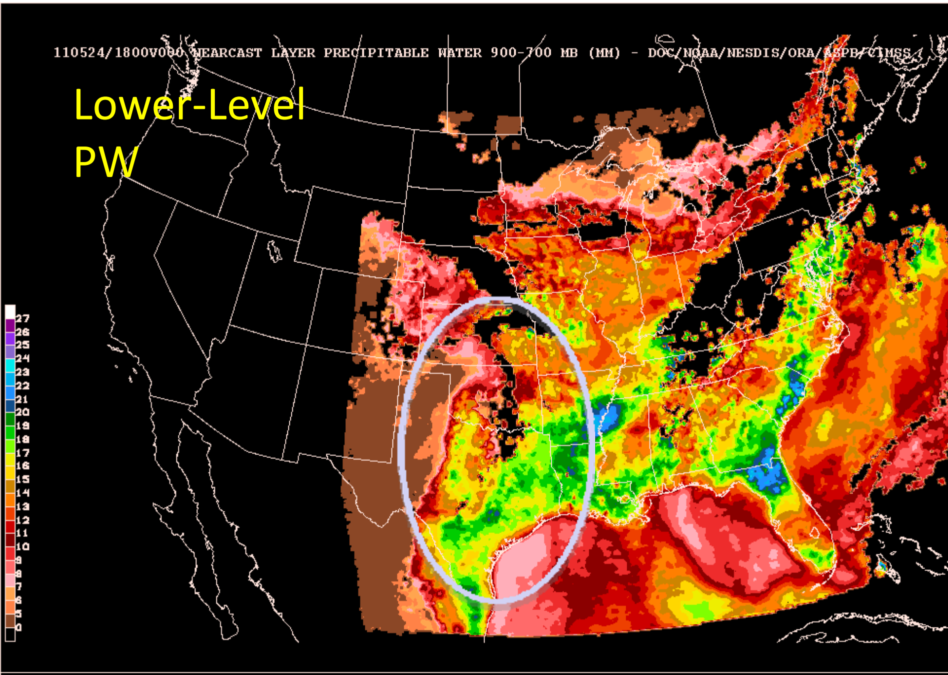
"Long-Lived Convection Parameter"

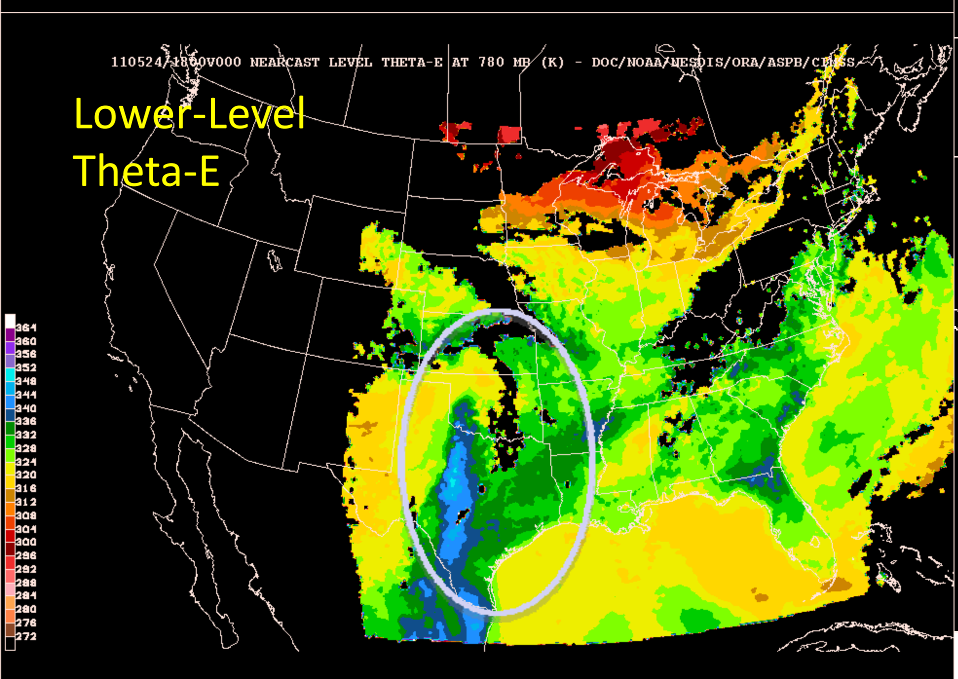
This product of the Convective Instability, Low-Level θe and Precipitable Water provides additional guidance as to both:

1)Where convection is likely to form rapidly, and

1)Where there is a large supply of warm and especially moist air already present to support continued growth of the storms

0-9 hours NearCasts from 1800 UTC 24 May 2011





Introduction of New Indices (*e.g., a Long-Lived Convection Parameter that combines Conv. Instab., Ll PW and Θe*) was much easier when the 'Logic' for the Indices was included in the multi-parameter displays

LONG-LIVED CONVECTION PARAMETER

Convective Instability * Lower-Level THETA-E *Lower-Level PW