NearCast Model

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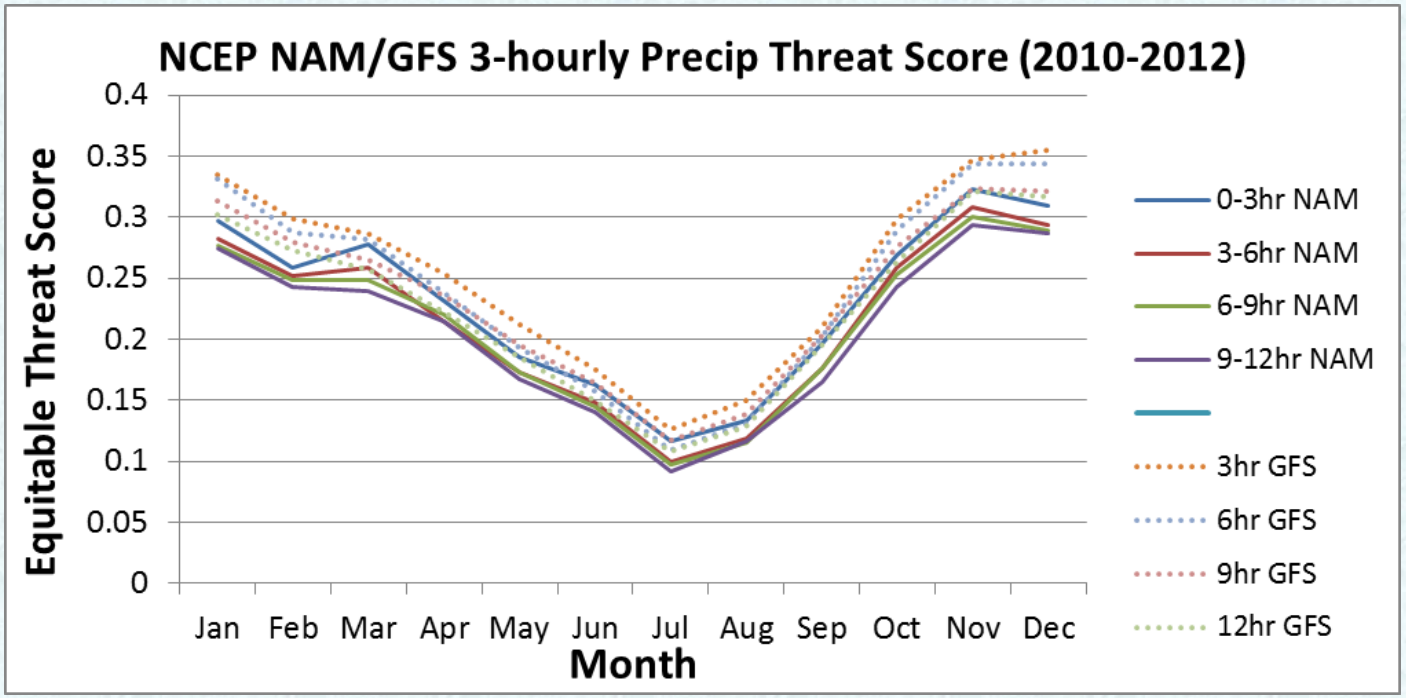
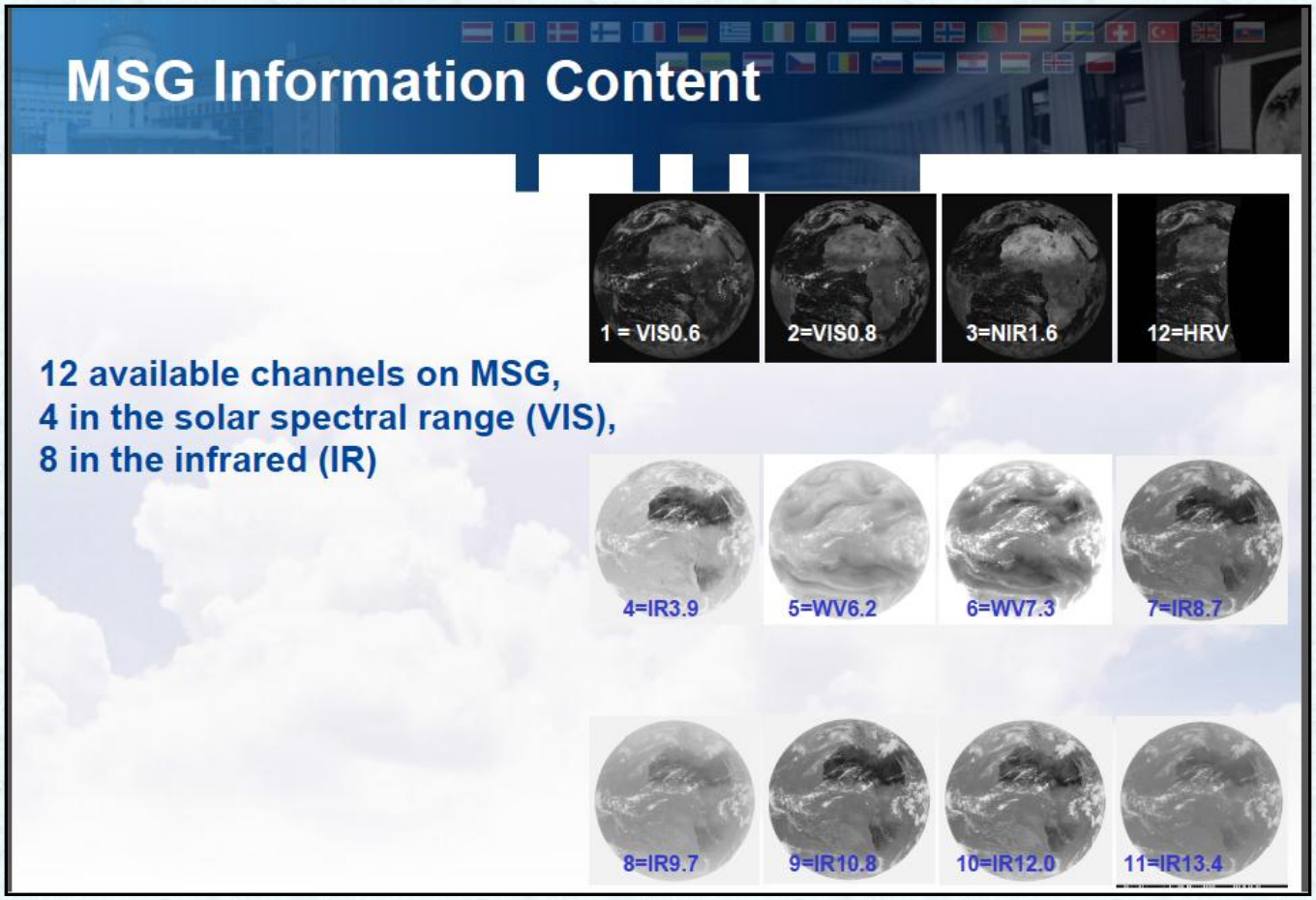
Motivation

- NWP performance in predicting short term convective weather/QPF needs to be improved, especially in warm season
  - Partially due to inability to observe/predict mesoscale moisture features



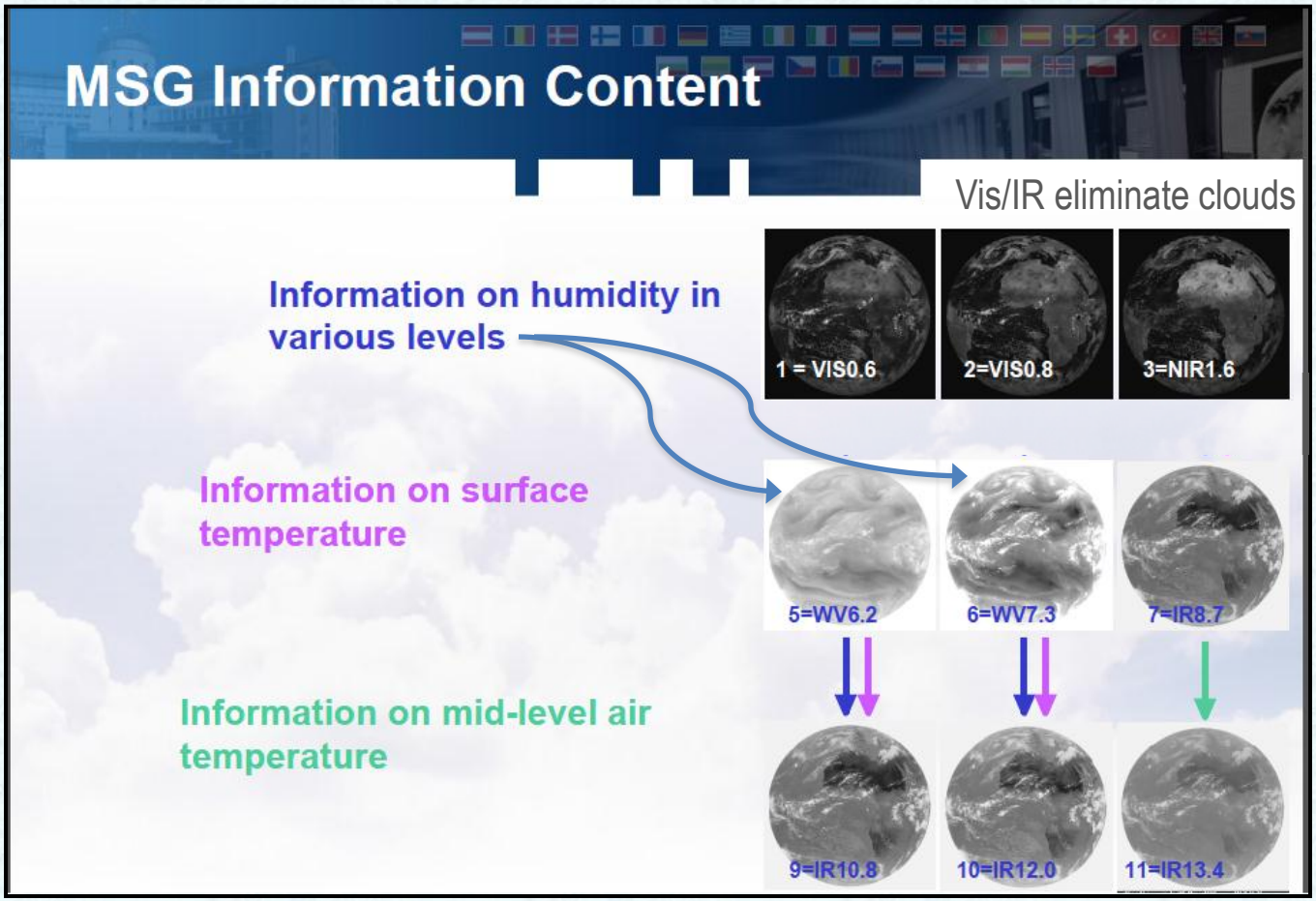
- Satellite observations reveal such details well

Raw Data from MSG-SEVIRI



How can we use this information better?

Producing Soundings from MSG-SEVIRI



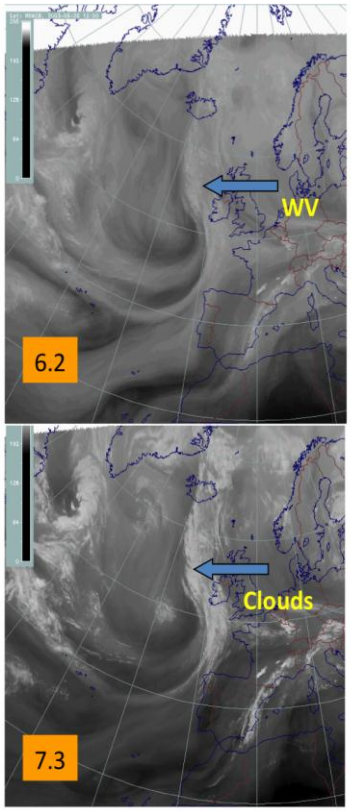
- SEVIRI retrievals = **data fusion**: melds NWP and satellite radiance information
  - Correct errors in model first guess
  - Available at high temporal and horizontal resolution
  - Pre-convective environment
  - **Under-utilized**

How can we use this information better?

Producing Soundings from MSG-SEVIRI

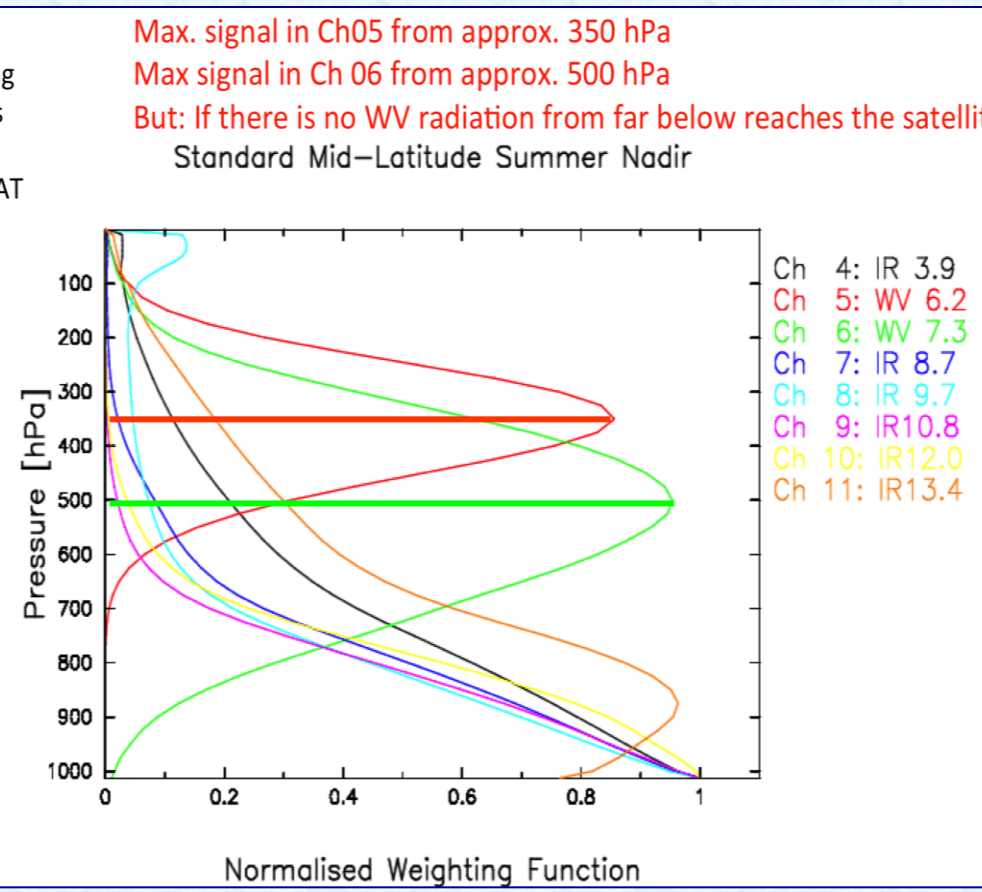
Some Characteristics: WV 6.2 und 7.3

- WV content in two layers
  - Differentiation between WV content in the lower and higher middle troposphere
- AMV Calculation
- Height of semi-transparent clouds



Weighting functions
Source: EUMETSAT

Max. signal in Ch05 from approx. 350 hPa
Max signal in Ch 06 from approx. 500 hPa
But: If there is no WV radiation from far below reaches the satellite



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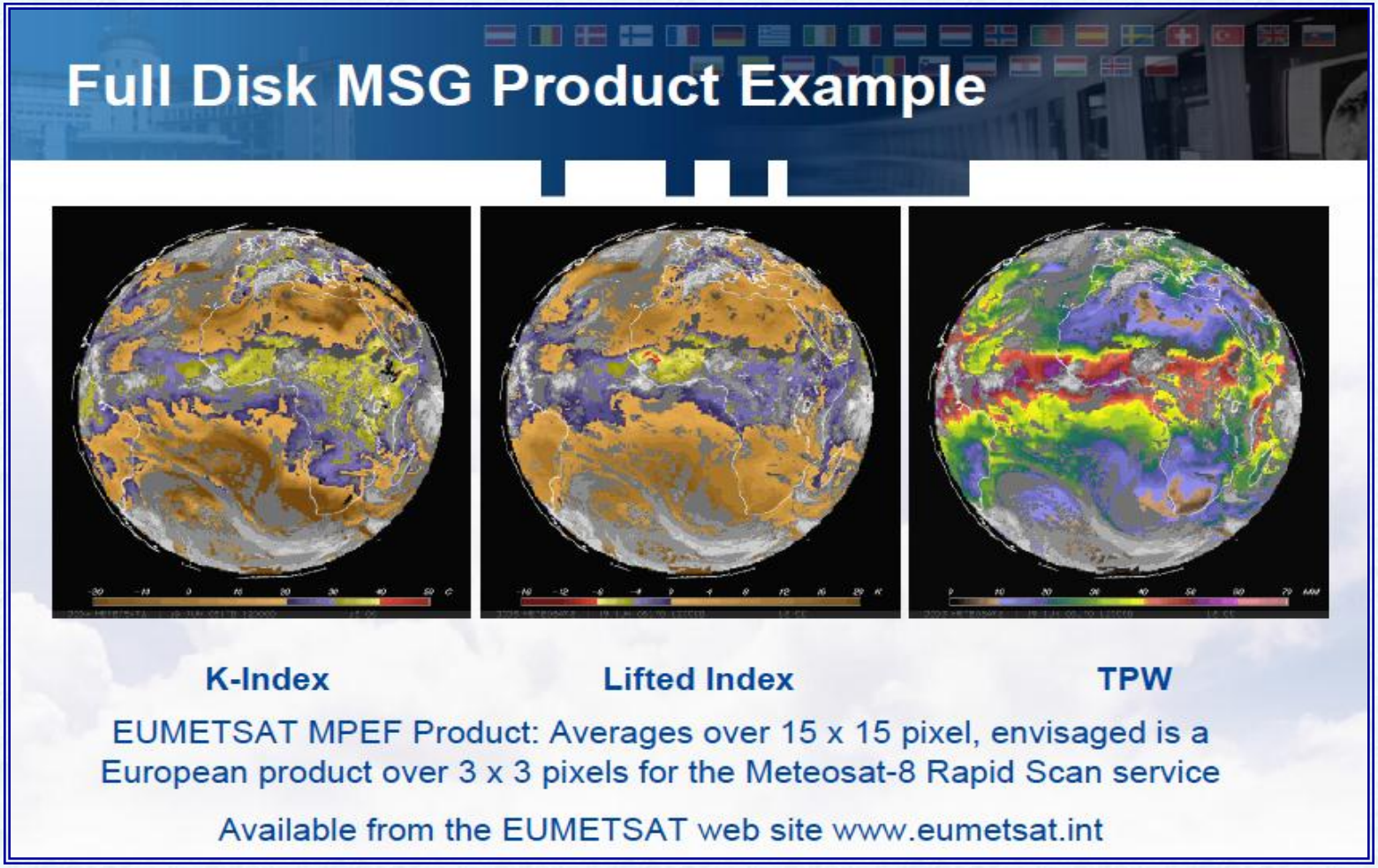
How can we use this information better?

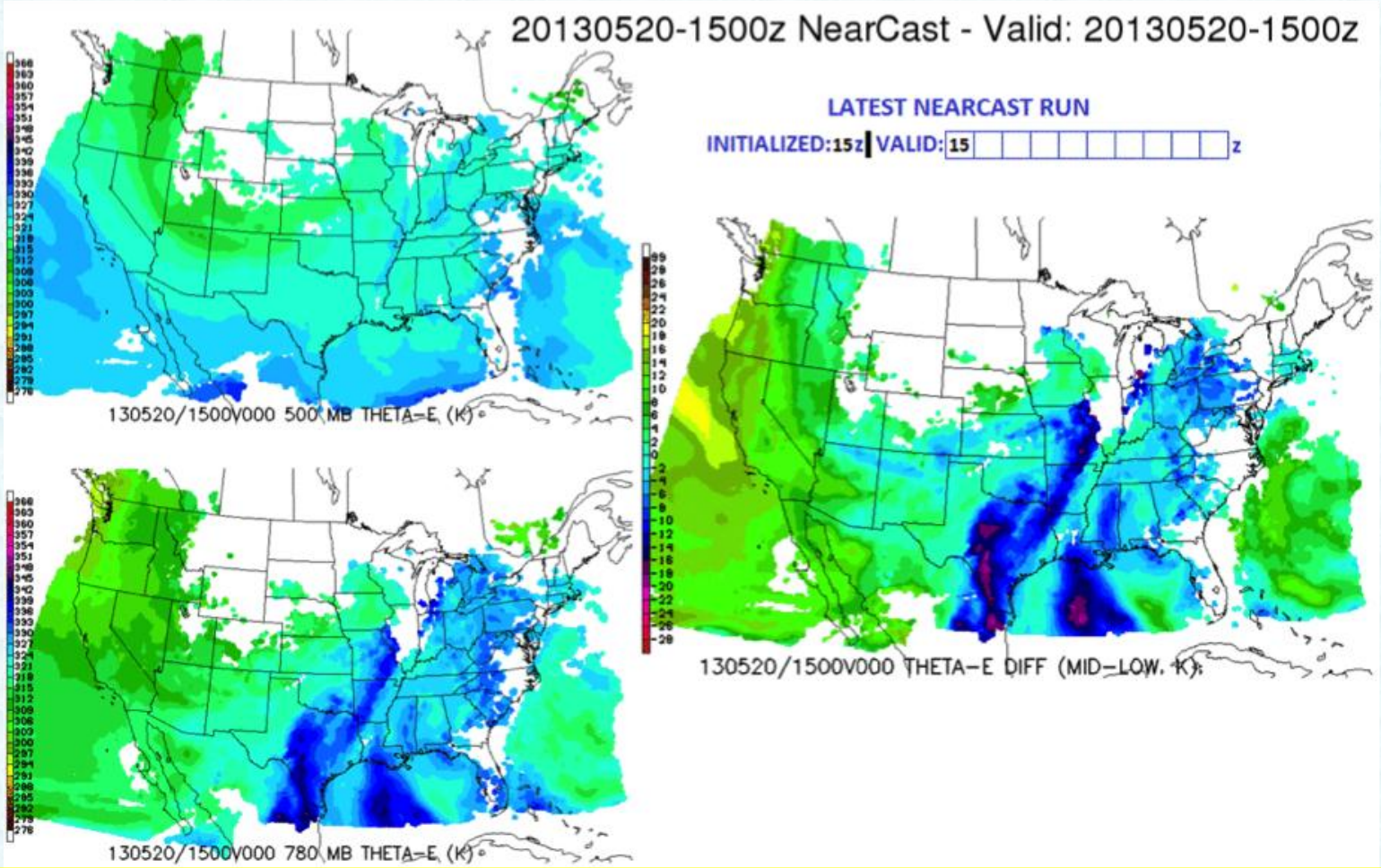
Using MSG-SEVIRI Retrievals



Global Instability Indices (GII) provide easy way to visualize current conditions, *but what about the near-future or areas where data is lost after clouds form?*

Question: Can we add forecast value to these observations?

An Alternative Approach:
Products from the NearCast Model



Lagrangian system that dynamically projects satellite moisture and temperature sounding information from multiple atmospheric levels forward in space and time for up to 9 hours

Insert AniFig1.gif here

Loop Continuously

Goals of the NearCast Model

- Provide forecasters with observation-driven analyses and 1-9 hour forecasts of the thermodynamic and wind environment , helping to:
  - Predict where/when convection is more (and less) likely to occur in the near future
  - Assess whether the downstream environment will support persistence or further growth after initial convection has begun
  - Monitor NWP model performance

Advantages of this Method

- Increases the utility of SEVIRI sounding from observations of current conditions to forecasting tools
- Model updates whenever new observations are available (hourly to ½ hourly for MSG-SEVIRI)
- Projections are available immediately after soundings are produced
  - Long (10 minute) time steps reduces run-time (1-2 minutes) and produces small product latency
- Data used without smoothing, so details detected in the observations (moisture minima, maxima, boundaries) are preserved at full resolution
  - NearCast Model products are *observation-driven*
  - Analyses include current and previous observations

The importance of Preserving Previous Observations in NearCast Analyses and Forecasts:

Stopping "Gapposis"

NearCast Analyses and Forecasts retain up to 10 hours of previous observations, filling in data-gaps, further utilizing every observation.

Forecast Initialization	Forecast Valid																			
	00z	01z	02z	03z	04z	05z	06z	07z	08z	09z	10z	11z	12z	13z	14z	15z	16z	17z	18z	19z	20z
00z	A	1	2	3	4	5	6	7	8	9	10										
01z		A	1	2	3	4	5	6	7	8	9	10									
02z			A	1	2	3	4	5	6	7	8	9	10								
03z				A	1	2	3	4	5	6	7	8	9	10							
04z					A	1	2	3	4	5	6	7	8	9	10						
05z						A	1	2	3	4	5	6	7	8	9	10					
06z							A	1	2	3	4	5	6	7	8	9	10				
07z								A	1	2	3	4	5	6	7	8	9	10			
08z									A	1	2	3	4	5	6	7	8	9	10		
09z										A	1	2	3	4	5	6	7	8	9	10	
10z	← CURRENT CYCLE →										A	1	2	3	4	5	6	7	8	9	10

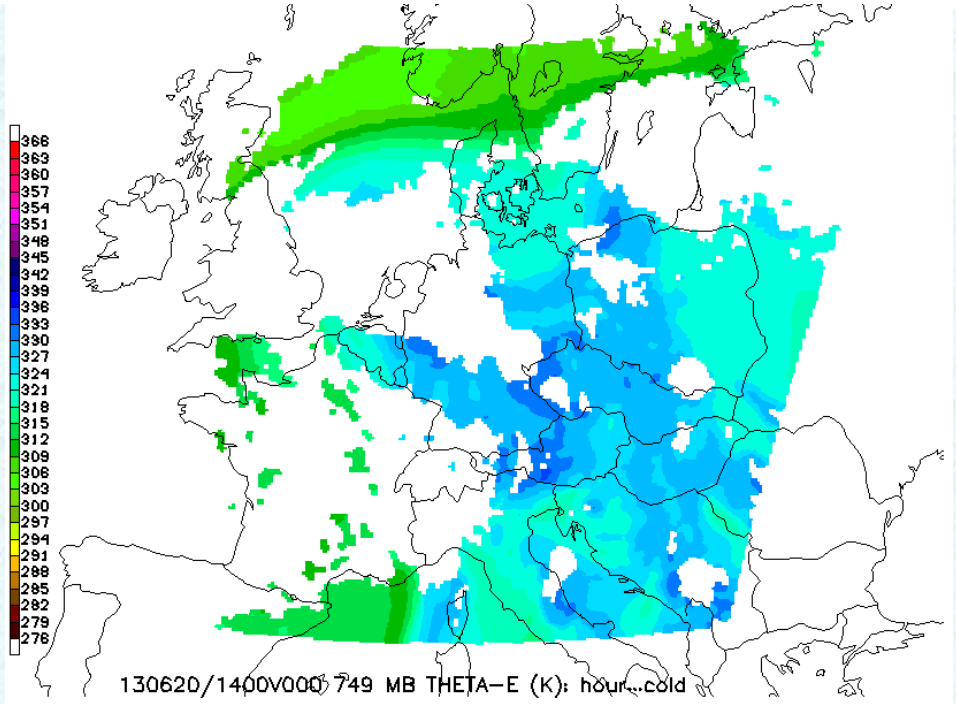
ANALYSIS

6HR FORECAST

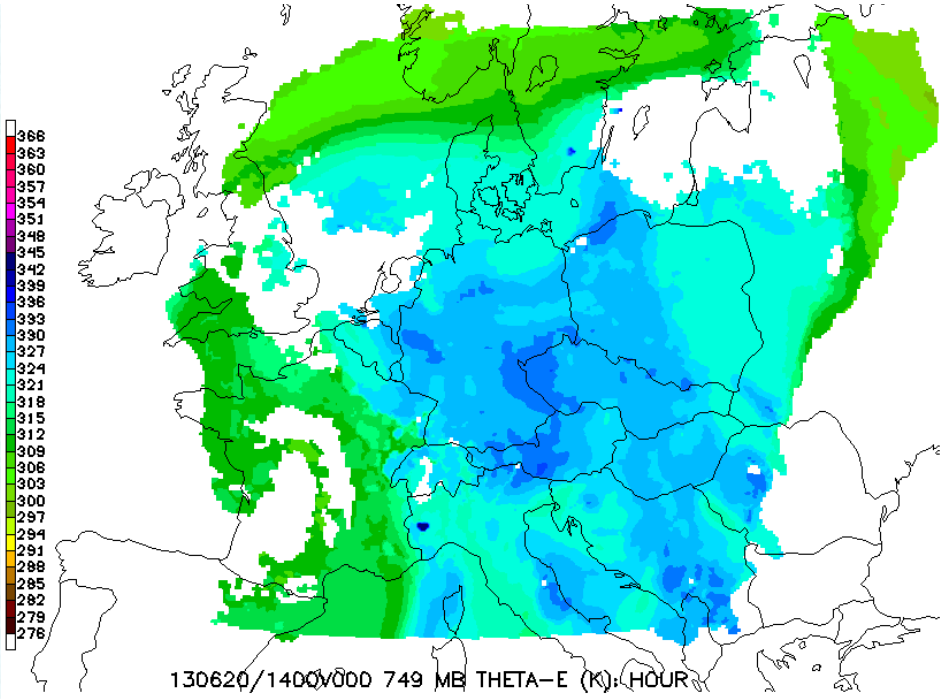
The importance of Preserving Previous Observations in NearCast Analyses and Forecasts:

Stopping "Gapposis"

Analysis using only current retrievals



Analysis with current and projections of 10-hour earlier retrievals valid at the same time



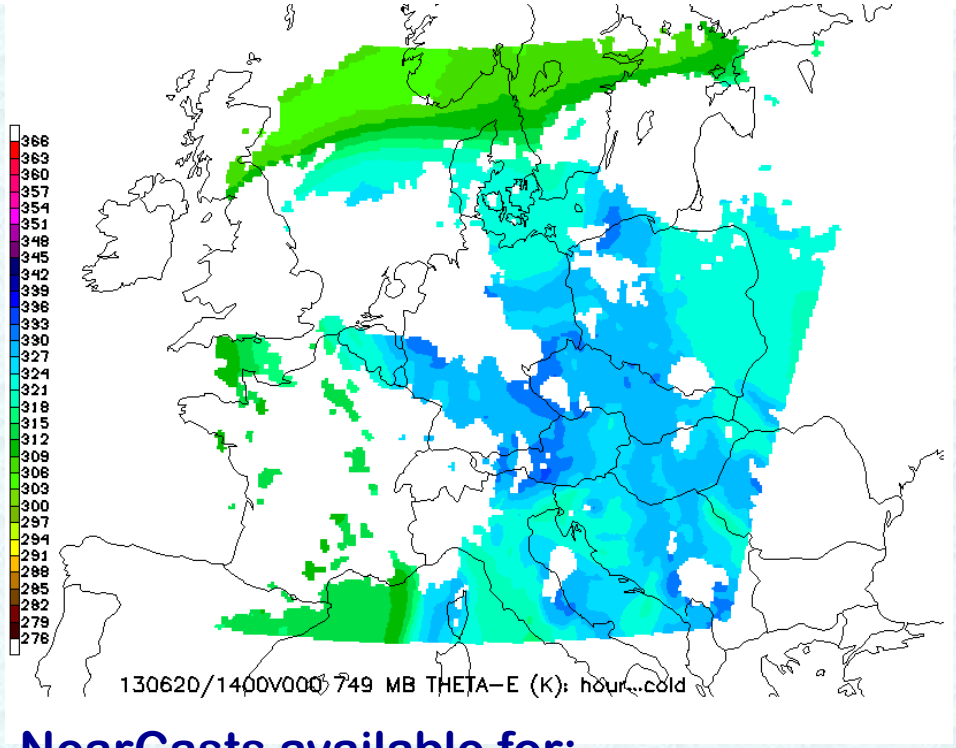
Adding full-resolution projections of earlier retrievals to current observations:

- ***Increases data coverage by > 30%***
- ***Adds information 'under' cloudy areas***

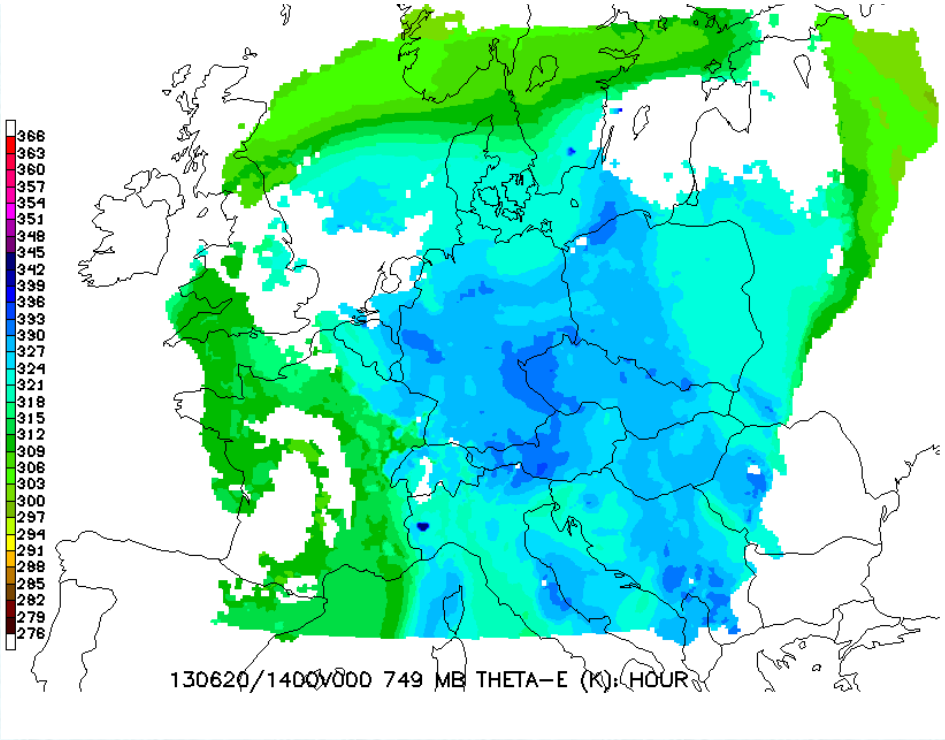
The importance of Preserving Previous Observations in NearCast Analyses and Forecasts:

Stopping "Gapposis"

Analysis using only current retrievals



Analysis with current and projections of 10-hour earlier retrievals valid at the same time

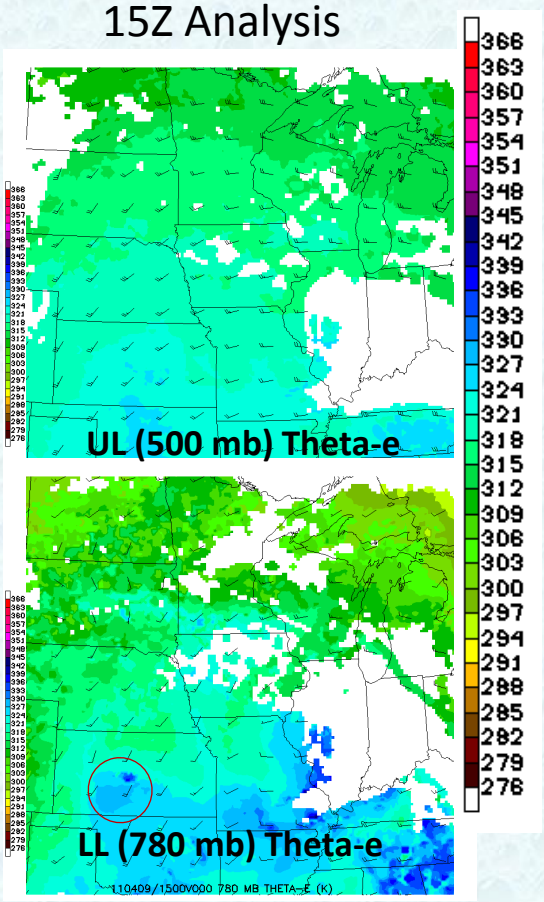


NearCasts available for:

- Precipitable Water, Temperature, Mixing Ratio, Winds, Equivalent Potential Temperature (θe)

How the Lagrangian NearCasts work:

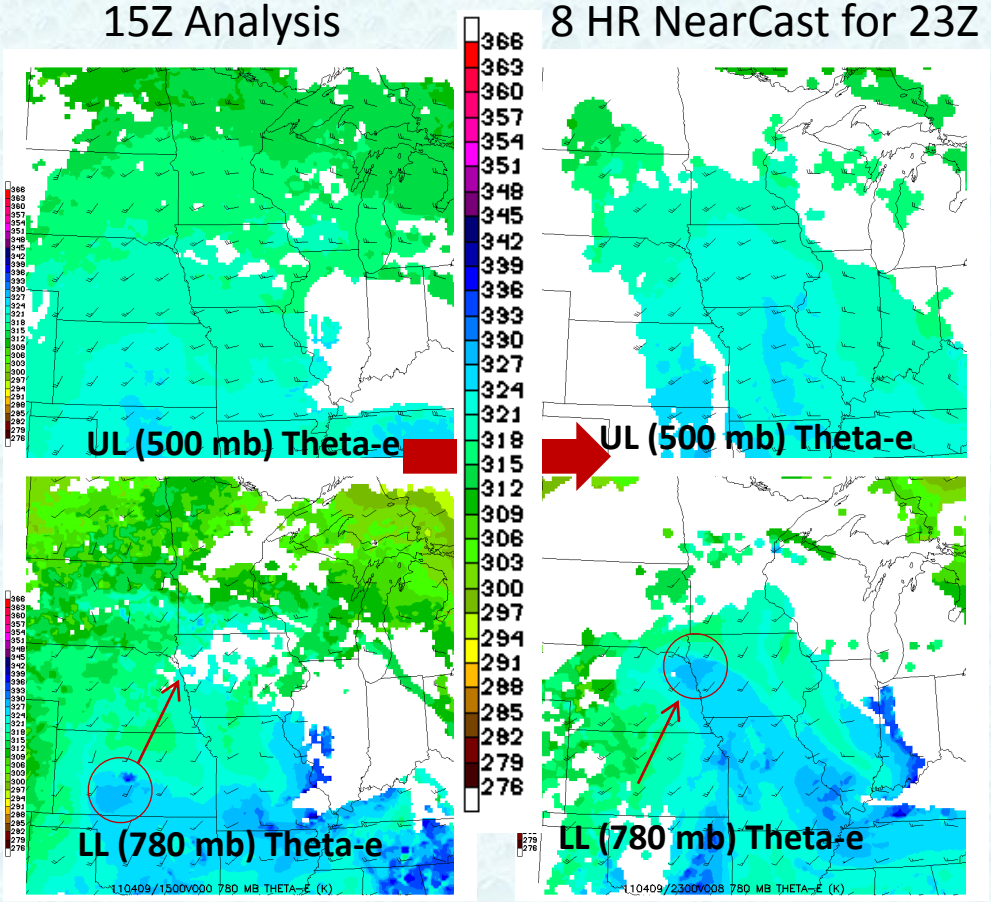
15Z Analysis



1 - Interpolate wind data to locations of full resolution GEO multi-layer moisture & temperature observations, including Maxima/Minima

How the Lagrangian NearCasts work:

15Z Analysis



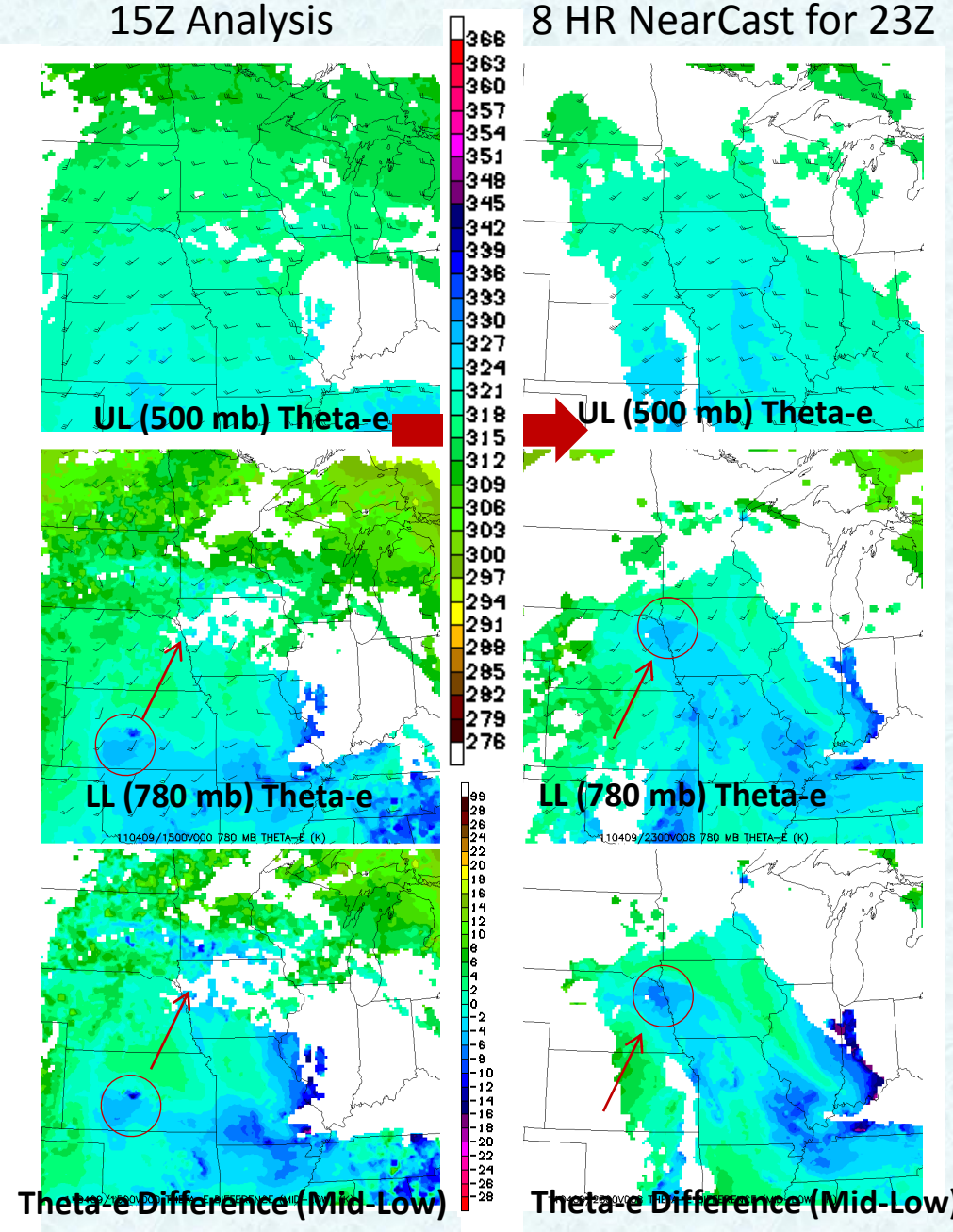
8 HR NearCast for 23Z

2 - <u>Move these high-definition data to future locations</u>, using dynamically changing winds with 'long' (10 min.) time steps.

How the Lagrangian NearCasts work:

15Z Analysis

8 HR NearCast for 23Z

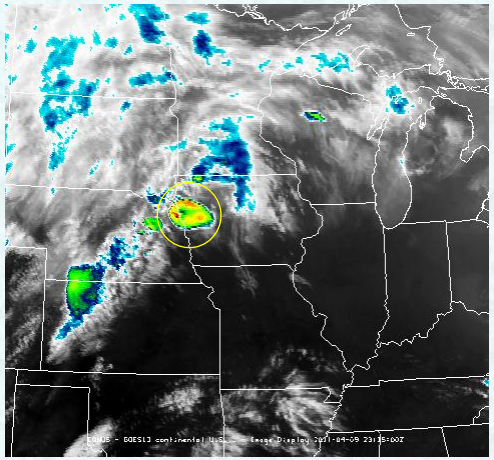


3 - Create grids from these 'projected parcels' for display and diagnosis

a) Combine outputs to produce a variety of derived parameters

b) Compare between layers to derive "Stability Indices" that can be combined with 'conventional tools' to identify mesoscale areas where severe convective can/cannot develop

c) NearCasts transform GEO IR Sounding *from observations to forecasts*, adding forecaster utility - *even after convection has begun*.



How are the Satellite Observations Used to Gauge Atmospheric Stability?

- **Equivalent Potential Temperature (θe)** contains information about the Total Thermal Energy (temperature and moisture) content of air .

- In the NearCast model- Theta-e Difference:

$$\theta_e^{500mb} - \theta_e^{780mb} > 0, \text{convectively stable}$$

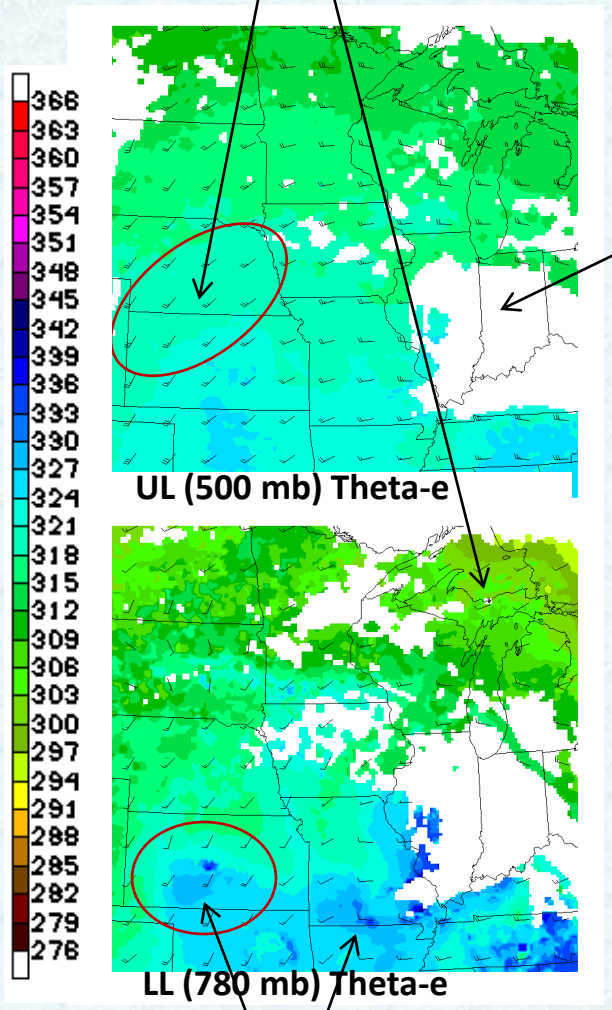
$$\theta_e^{500mb} - \theta_e^{780mb} < 0, \text{convectively unstable}$$

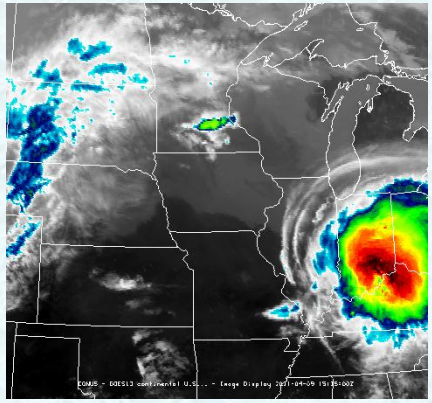
- Although the processes involved in producing an environment conducive for severe convection are complex, this "convective instability" parameter provides an objective means of monitoring where very dry air at the upper levels is moving over moist air at the low levels.
  - *Years of experience using WV imagery shows a strong correlation to development of thunderstorms in these areas*
  - *Also related to development of sheared environments*

April 09, 2011 15Z Analysis

Cool, dry air (low theta-e)

No Data (Cloud Cover and no past forecast data)





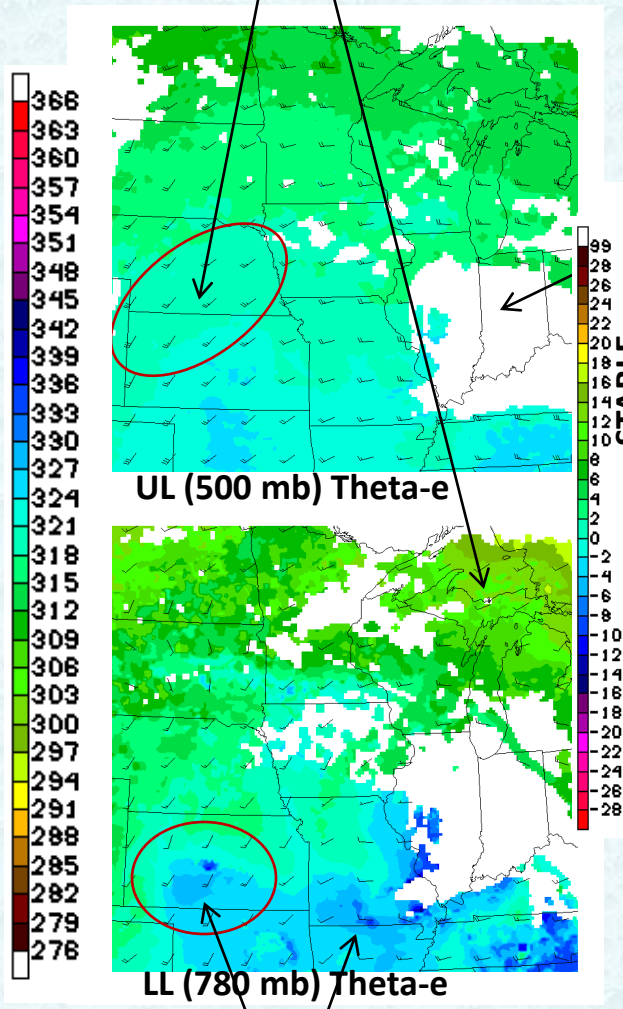
Warm, moist air (high theta-e)

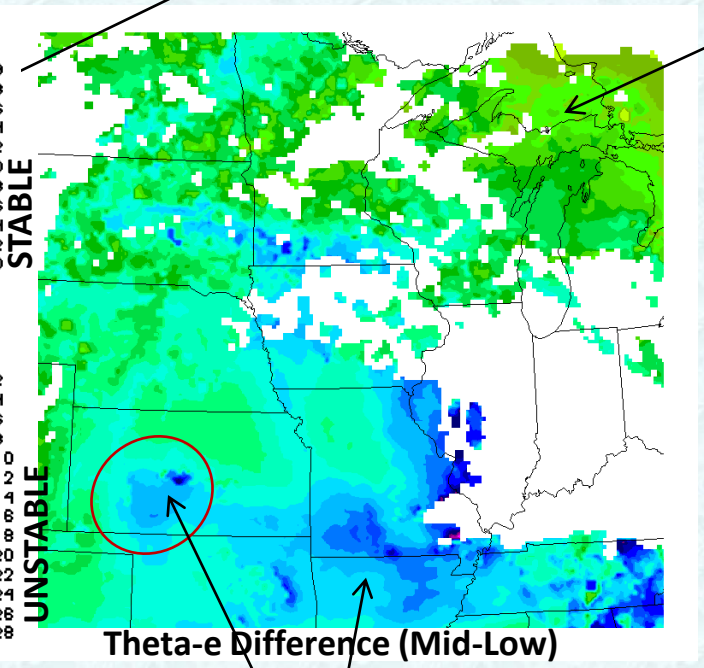
April 09, 2011 15Z Analysis

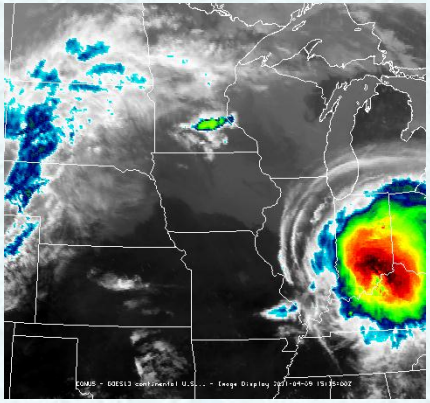
Cool, dry air (low theta-e)

No Data (Cloud Cover and no past forecast data)

Warm, moist air (higher theta-e) overriding relatively cool, dry air (lower theta-e) = convective stability. $\frac{\partial \theta_e}{\partial z} > 0$





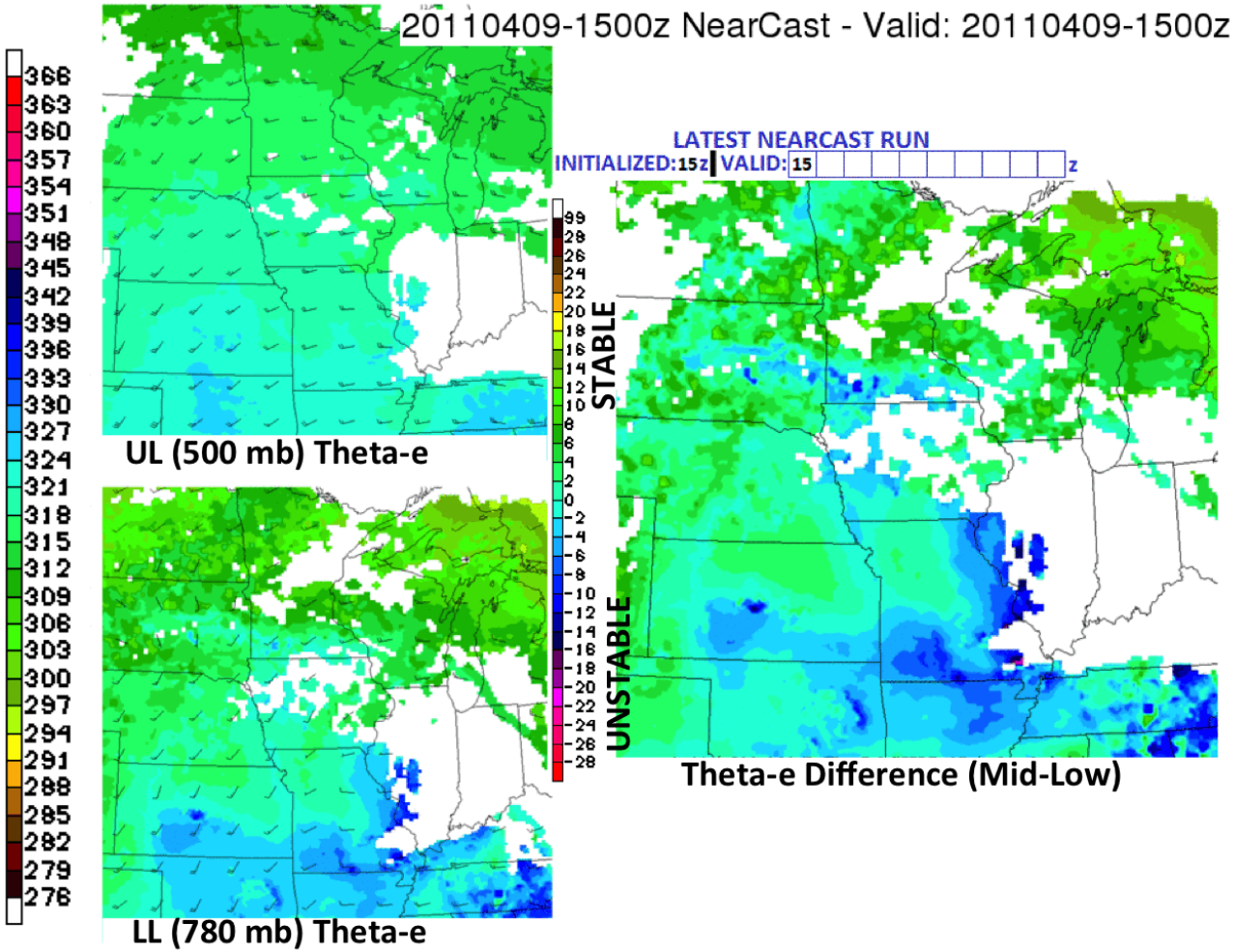


Warm, moist air (high theta-e)

Dry, cool air (low theta-e) overriding relatively warm, moist air (high theta-e) = convective instability: $\frac{\partial \theta_e}{\partial z} < 0$

April 09, 2011 15Z Forecast Cycle

Stability Trends can be especially important



Rapid Destabilization Trends

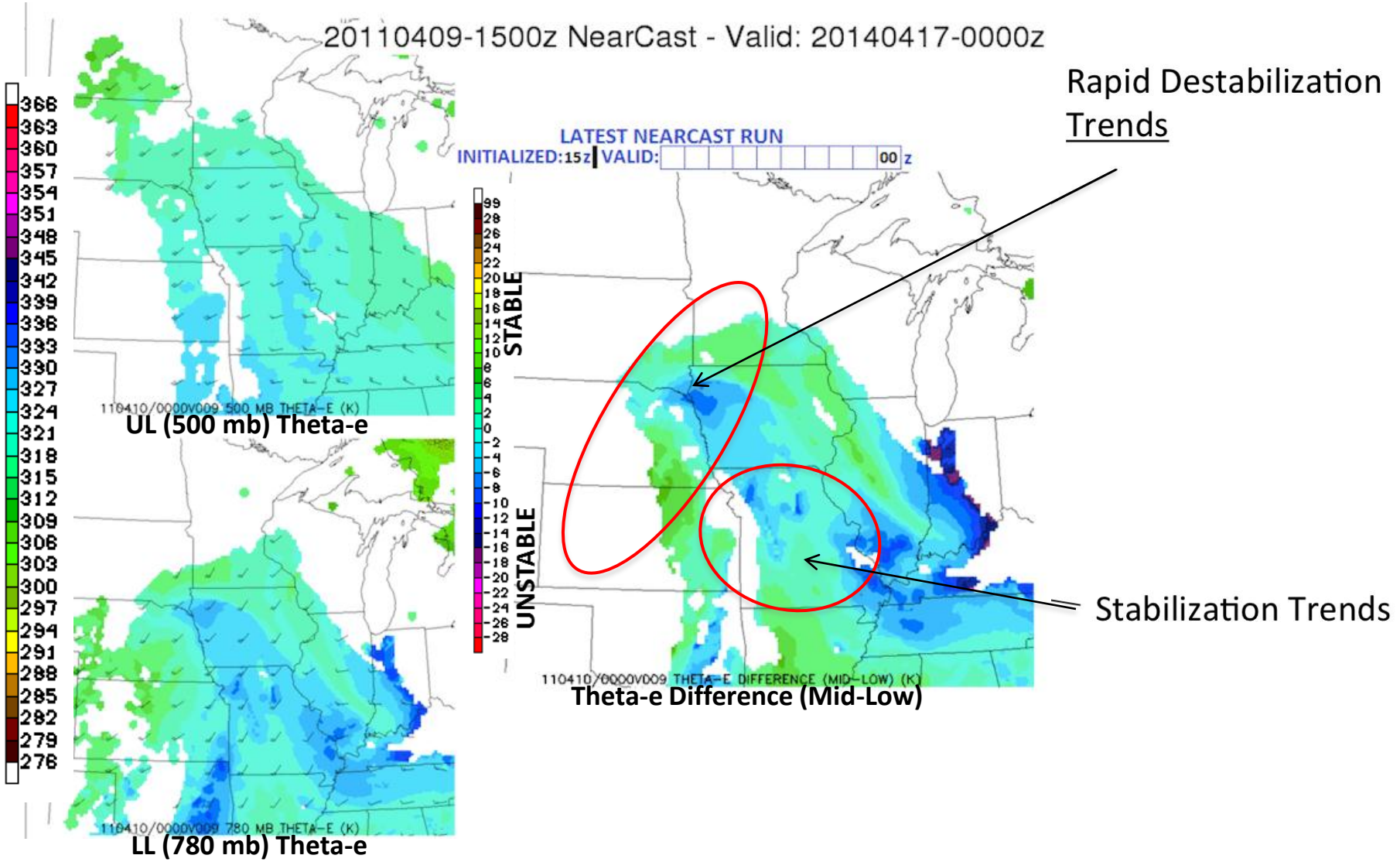
On the following animation, *where do you see*?

Stabilization Trends

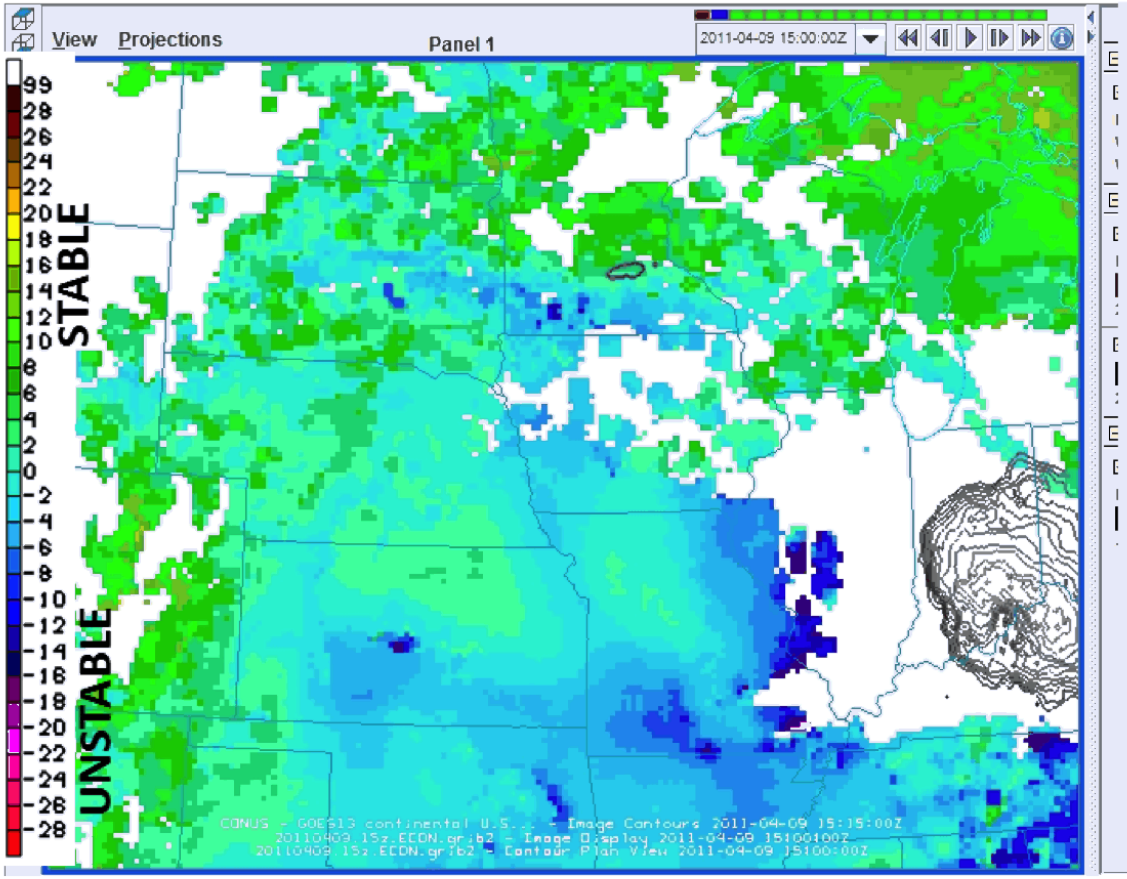
Insert AniFig2.gif here

Loop Continuously

April 09, 2011 15Z Forecast Cycle

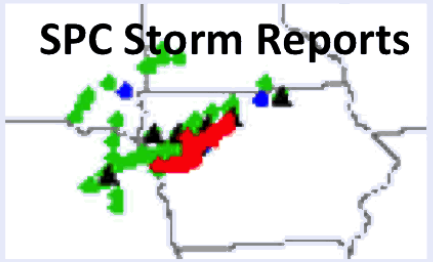


April 09, 2011 15Z NearCast Verification



Theta-e Difference (Mid-Low)

Mapleton, Iowa EF3 Tornado

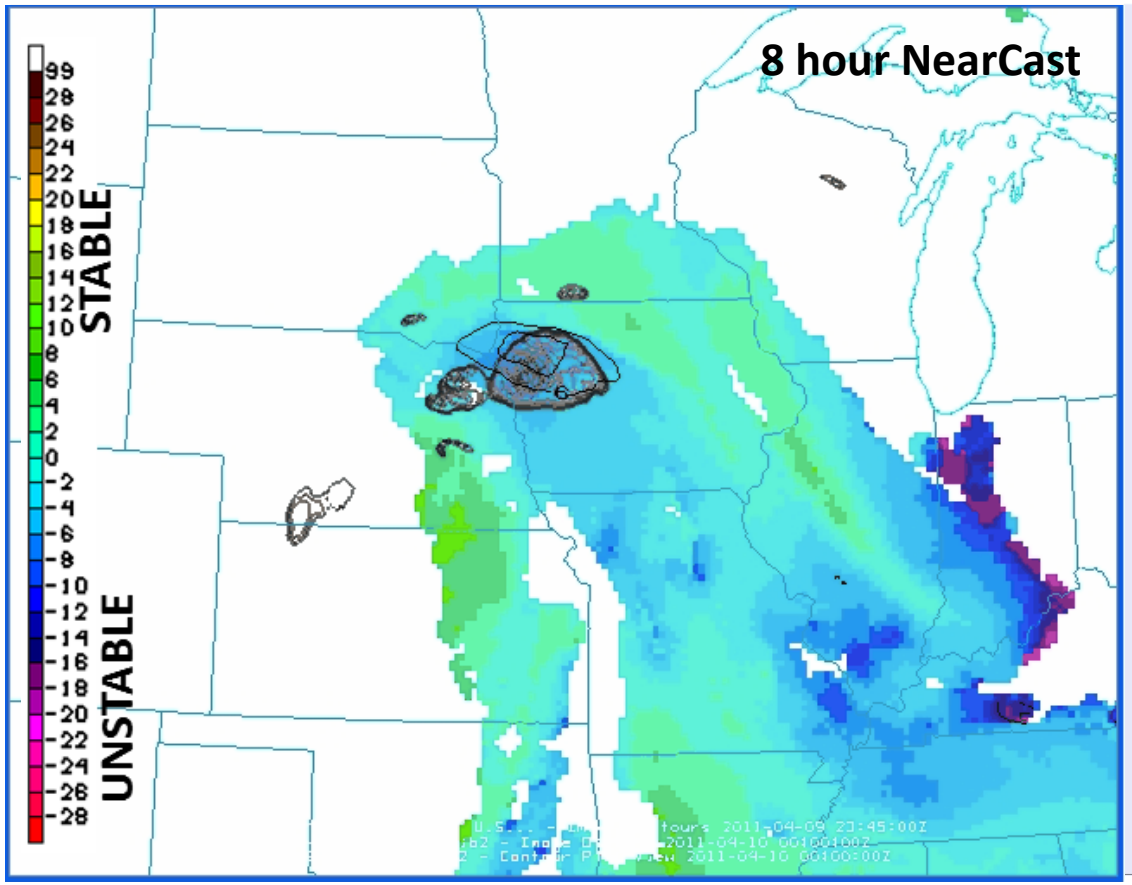


- 9 hour NearCast of vertical θe difference
  - Thin black contours are 2 hour destabilization time tendencies
  - Thick grey contours are IR Brightness Temperature.

Insert AniFig3.gif here

Loop Continuously

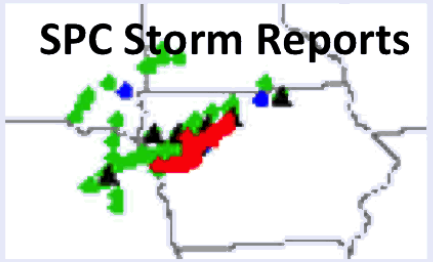
April 09, 2011 15Z NearCast Verification



Theta-e Difference (Mid-Low)

Convection developed within forecast position of greatest instability and destabilization trends

Mapleton, Iowa EF3 Tornado



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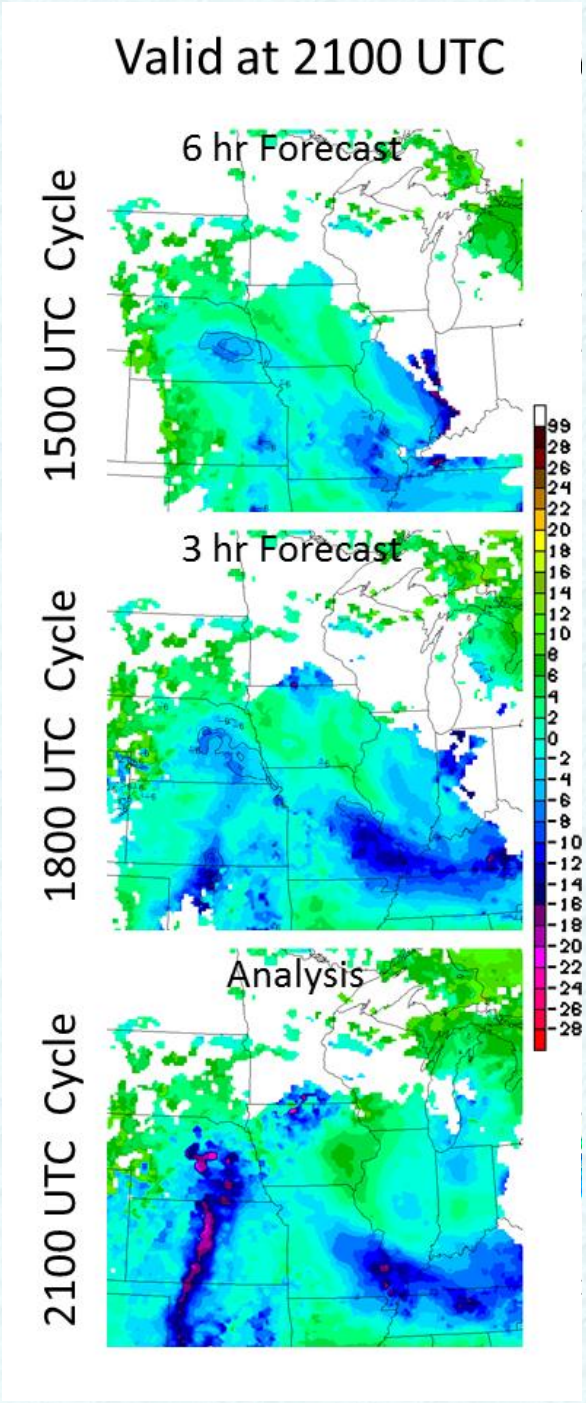
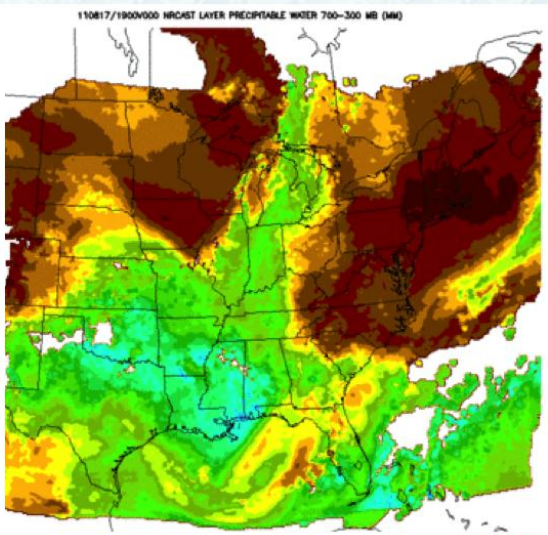


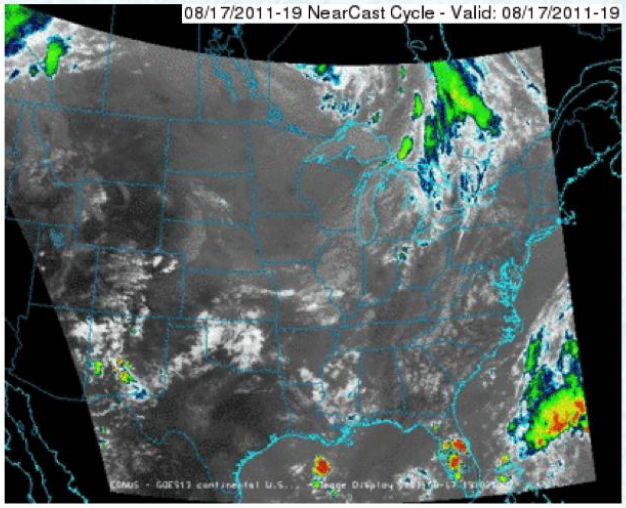
Forecast Consistency

- Theta-e Difference field for 15, 18 and 21 Z cycles all valid at 21 Z on April 09, 2011
- Lower-level θe will often increase later in the day, resulting in greater instability

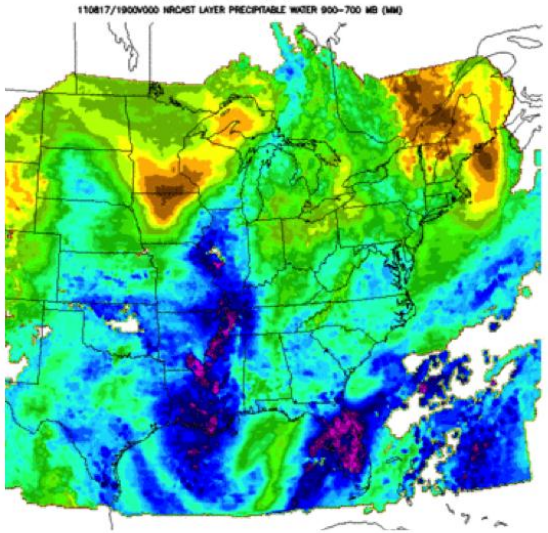
Precipitable Water fields



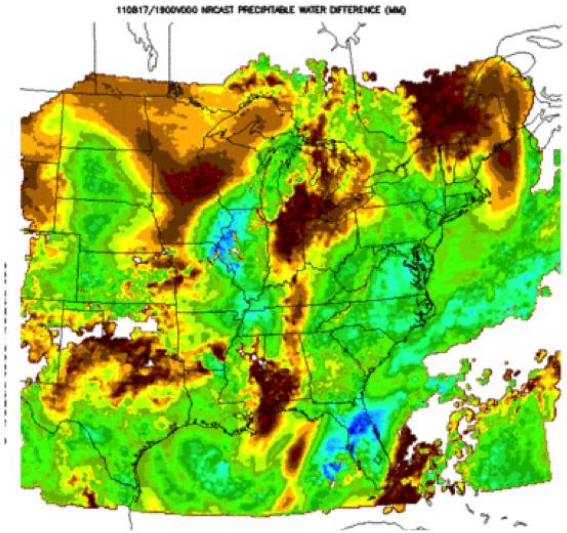
UL PW



INITIALIZED: 19 Z | VALID: 19 Z



LL PW



Vertical PW difference

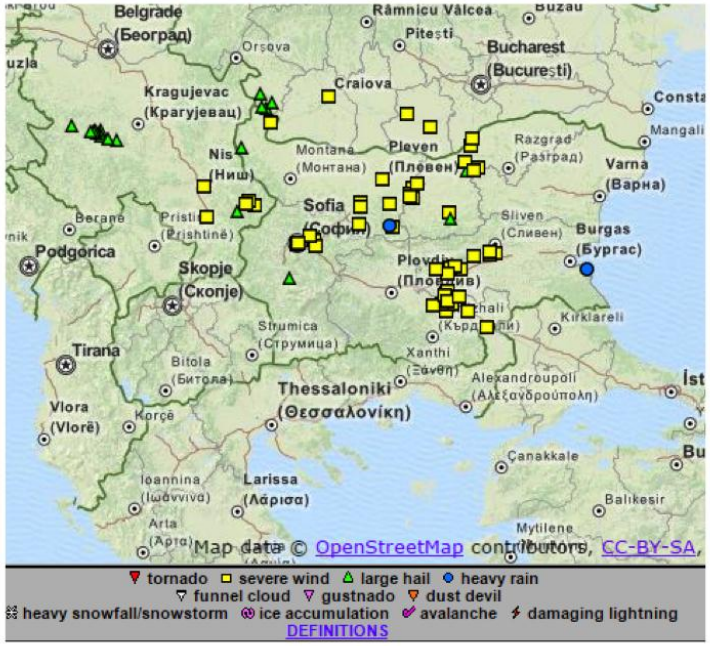
- Low- (900-700 mb) and mid- (700-300 mb) level layer average Precipitable Water and Wind Analyses and forecasts are also available from MSG SEVIRI.
- Especially useful in monitoring and NWP guidance parameters

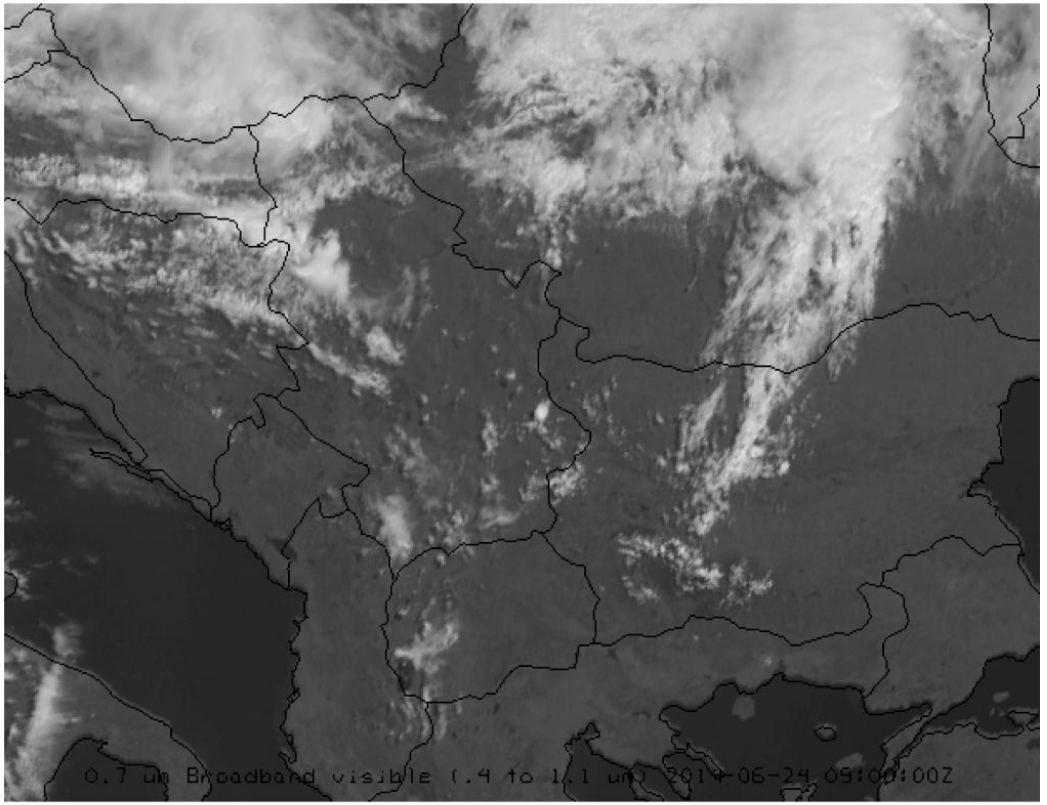
Case Studies

Let’s look at some convective events over different parts of Europe using real-time SEVIRI products

June 24, 2014 Serbia Hail

Convection initiated throughout Serbia around 11Z. East-southeast moving storms produced Large hail in Serbia and strong winds later across Bulgaria

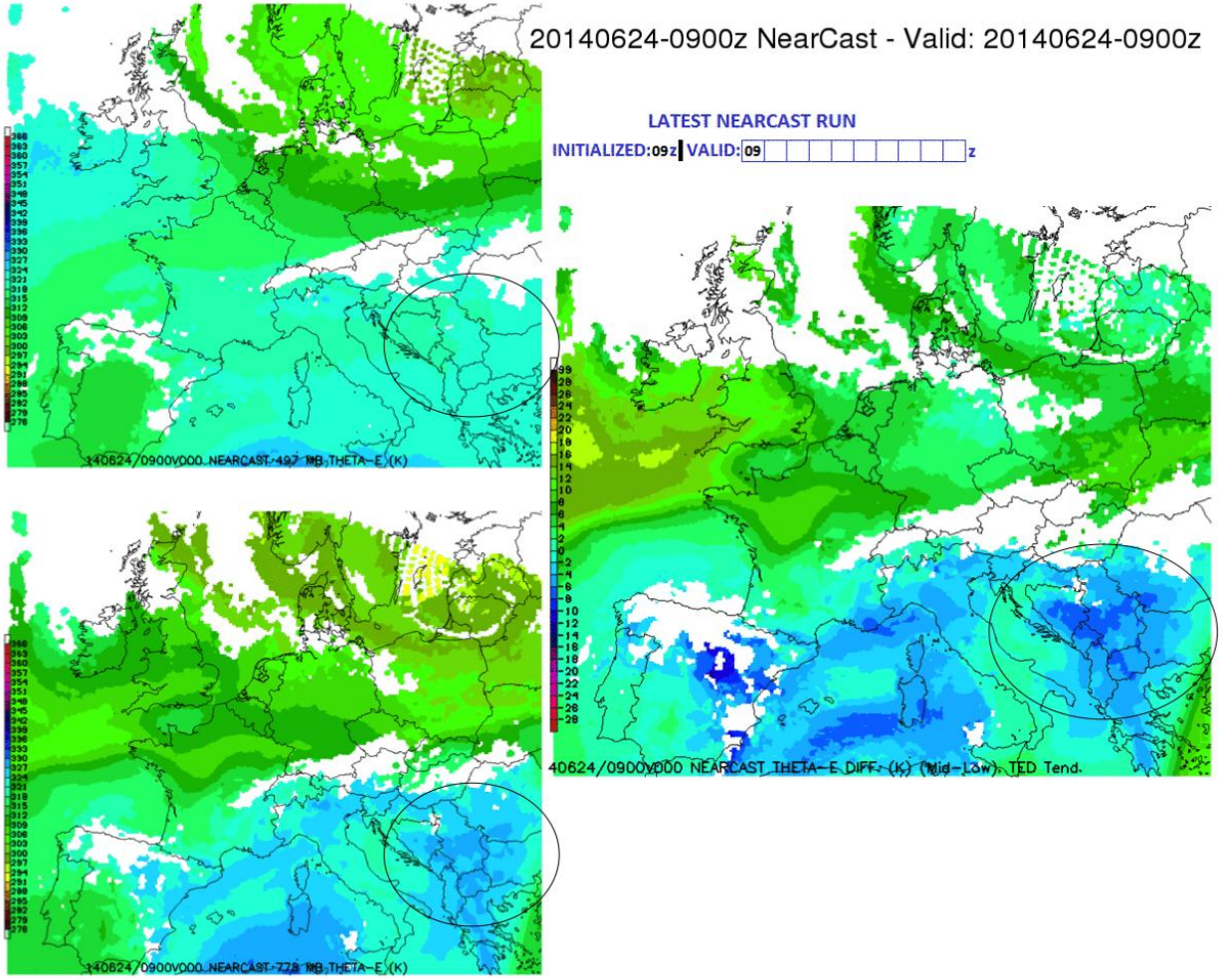




Insert AniFig4.gif here

Loop Continuously

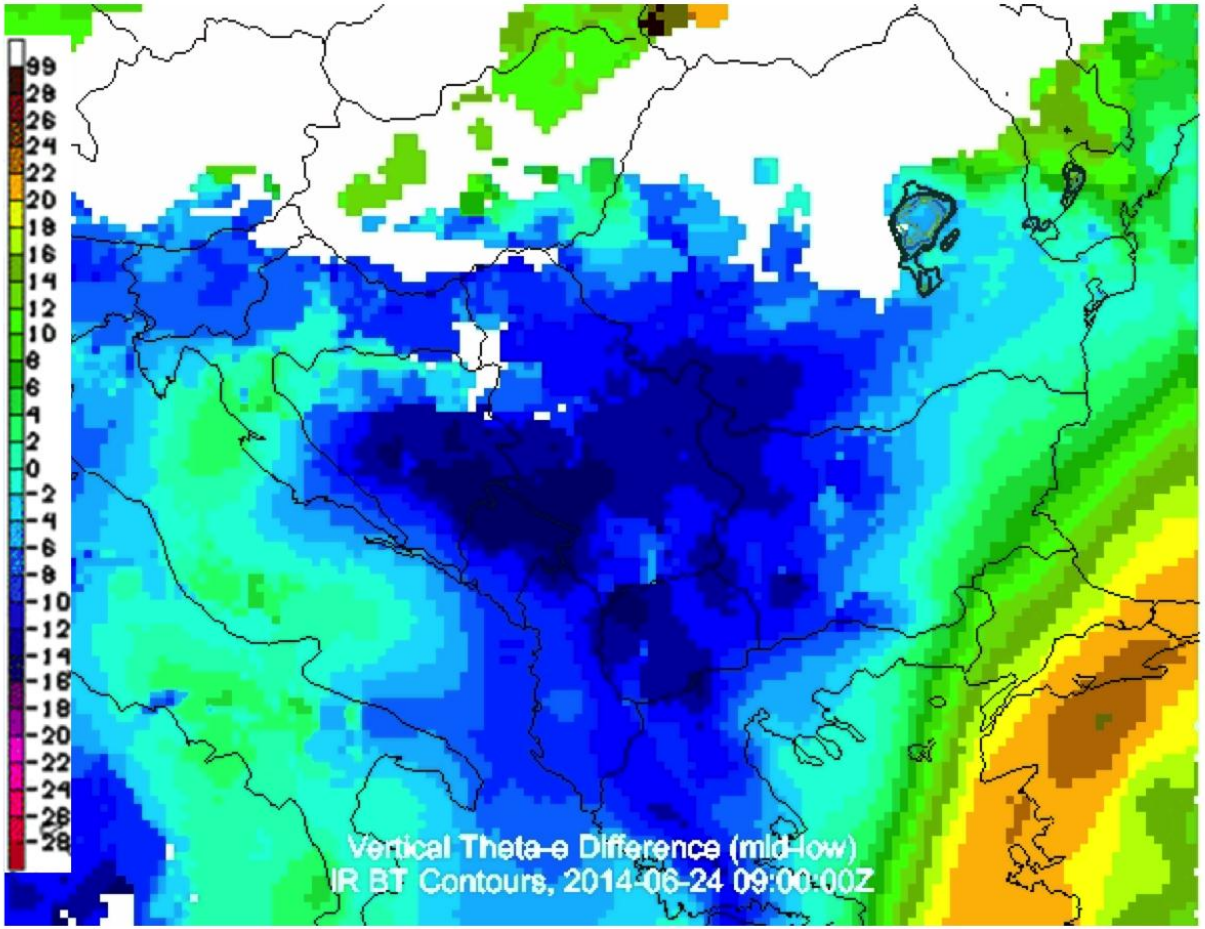
The 09Z NearCast Model forecast cycle indicated a region of relatively warm and moist air (high theta-e) originating over Serbia would drift to the East throughout the forecast period. At the same time, drier/cooler air (lower theta-e) would continue to be present aloft. This setup resulted in a region of relatively high convective instability shifting eastward throughout the forecast period.



Insert AniFig5.gif here

Loop Continuously

Verification shows convection (contours) developed around 11Z within the forecast position of greatest instability and continued to evolve with the forecast movement of the unstable feature. Notice that convection would not develop in the stable atmosphere to the west and east.

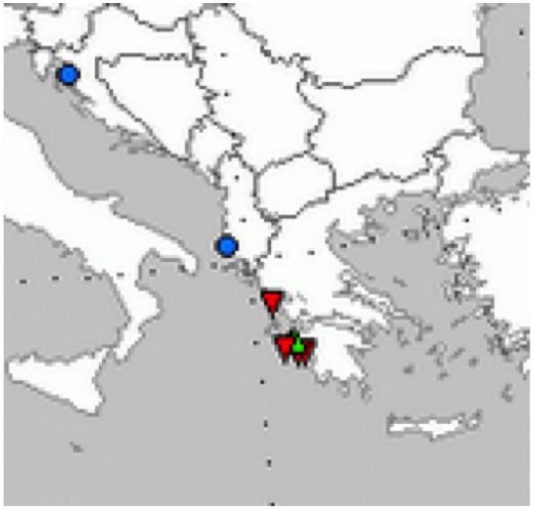


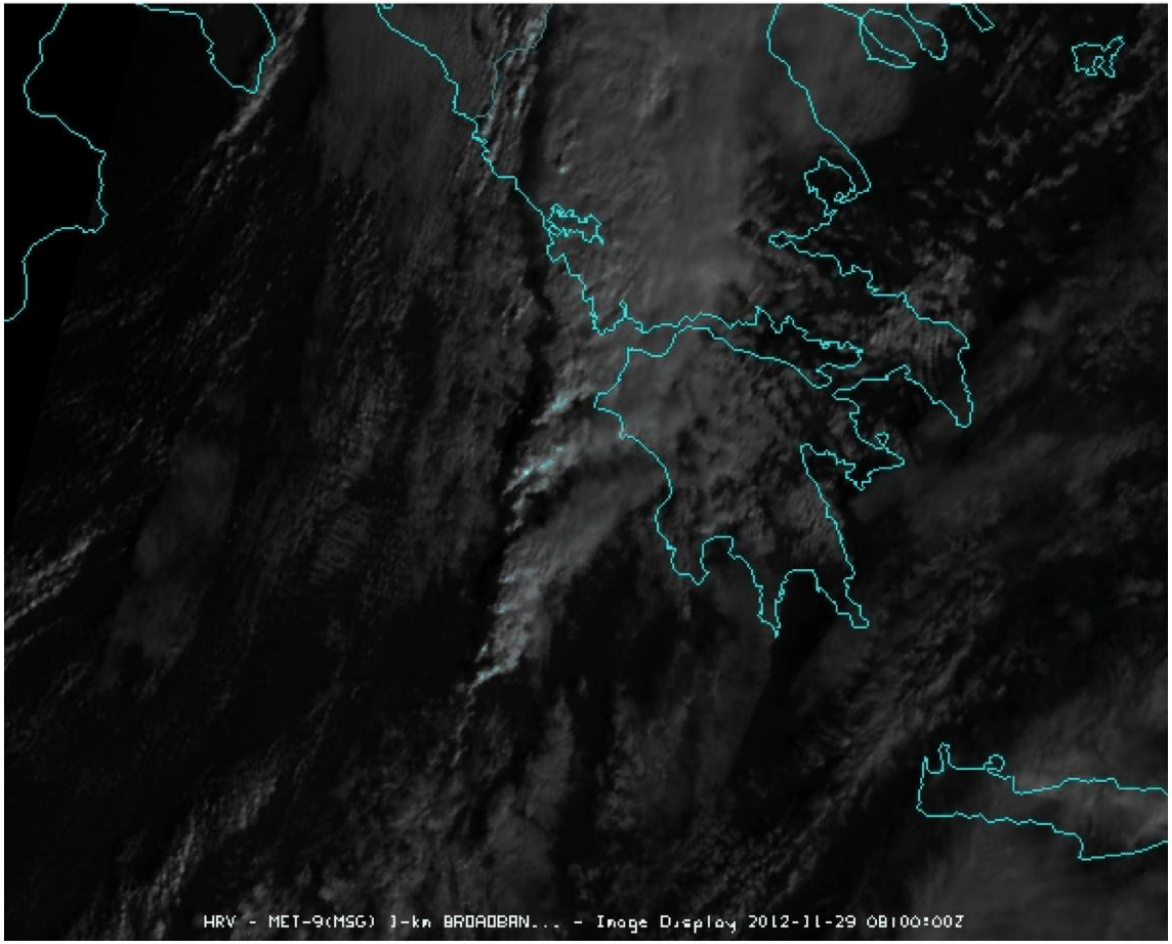
Insert AniFig6.gif here

Loop Continuously

November 29, 2012 Greece Tornados and Hail

Line of strong convection advanced eastward across Greece producing hail and few tornados primarily between 08 and 12Z

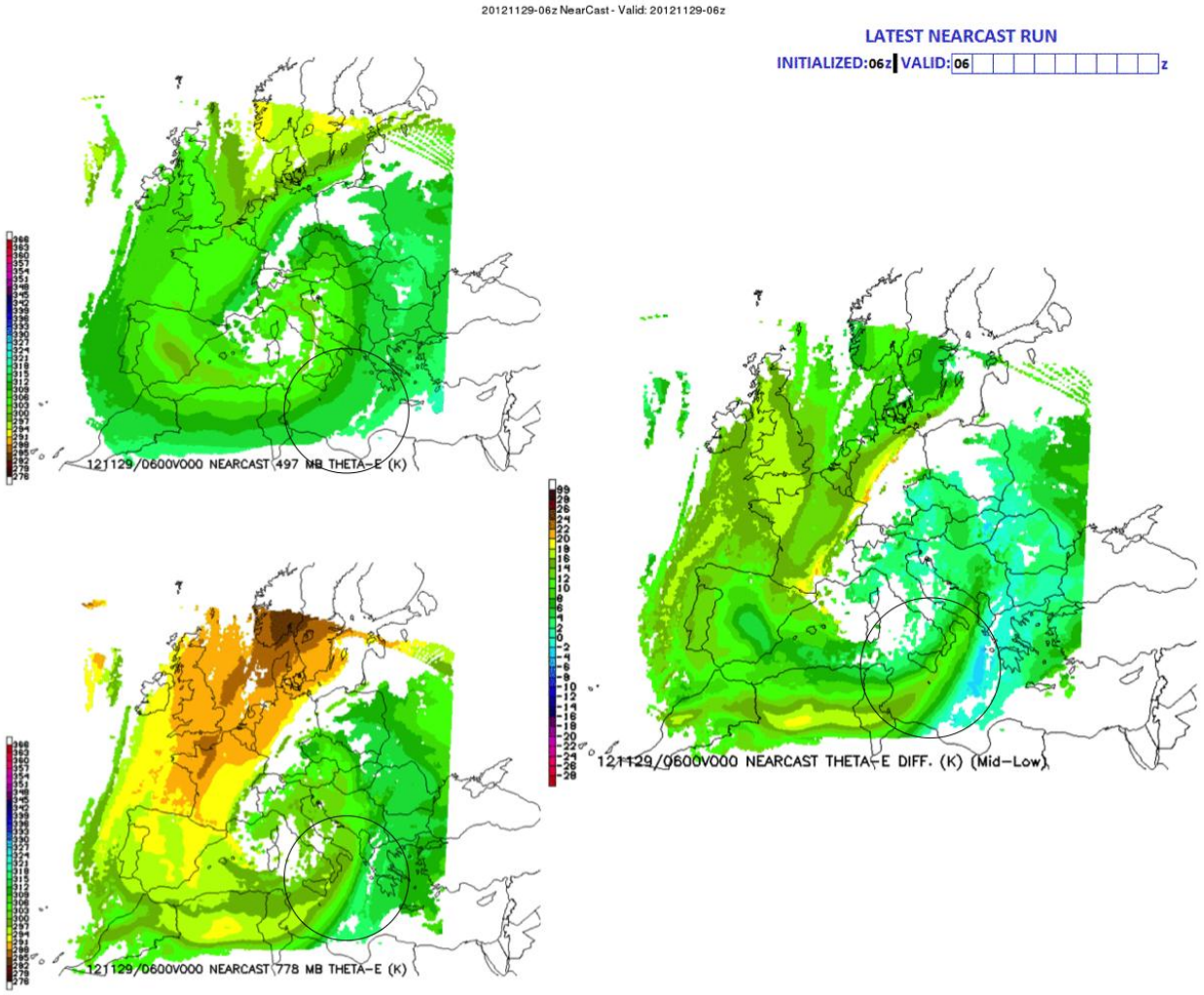




Insert AniFig7.gif here

Loop Continuously

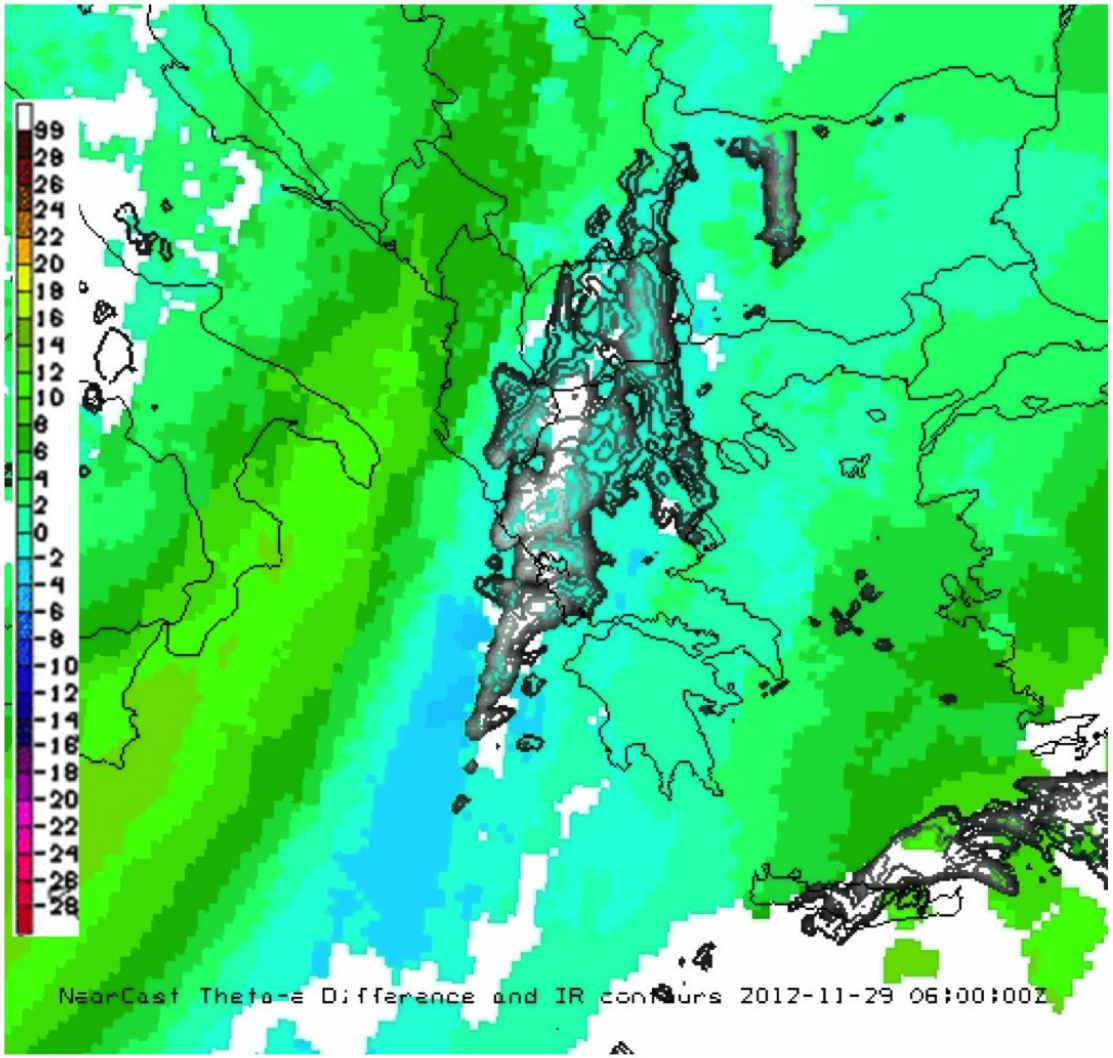
The 06Z NearCast Model forecast cycle predicted a southwest to northeast oriented strip of convective instability to quickly advance to the northeast throughout the forecast period as dry air aloft was overrunning moist air below. Meanwhile, significantly more stable air was predicted to move in from the west.



Insert AniFig8.gif here

Loop Continuously

Verification shows that convection (contours) followed the motion of greatest instability as forecast in the NearCast Model. Stable air to the east and west remained free of convection.



Insert AniFig9.gif here

Loop Continuously

Important Points:

- Look for trends in instability/moisture fields
- Look for instability/moisture boundaries/maxima.
  - Pay less attention to actual magnitudes
- Note changes in low-level moisture and instability between each cycle
- Monitor predictions of trends using recent NearCast moisture and instability analyses

- Available fields will include
  - Low- and mid-level θe, low- and mid-level PW
  - Vertical differences (implied convective instability),
  - Layer Winds and Shear.

NearCast Collaborations

- NearCast Model has been modified to run anywhere on the globe
  - Currently being run in real-time over Europe using retrievals from SEVIRI (*GRIB and graphic outputs*)
  - Has been tested over Lake Victoria, Africa
  - NearCast Model over Alaska using Polar satellite data now under development
    - *Serves as a preview of the MTG Sounder*
- Under continued evaluation at several NCEP Centers
- Webpages with real-time nearcast products:
  - *http://cimss.ssec.wisc.edu/model/nrc/*
    - *Will soon include dedicated displays of all of Europe and selected sub-regions*

Questions?

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