WINTER 2010-11: LESSONS LEARNED

November, 2011 Winter Weather Workshops
Mike York (Forecaster / Winter Weather Program Leader)

Outline…

- Demonstration of banded snowfall, how it affected our forecasts last winter, and why it resulted in this research project
- Crash course in meteorology (painful)
- Methodical examination of 4 snowstorms
- Summary and lessons learned
- What's the next step in this project?

Seasonal Snowfall: 2010-11

- 18.9 inches snow at Paducah (normal is 10)
- 15.5 inches at Evansville (normal is 13)
- 10.6 inches at Carbondale (normal is 13)
- 10.5 inches at Poplar Bluff (normal is 8)

120 – 180 percent of normal

Except 82 percent of normal at Carbondale

Why the wide range (10-19”)?

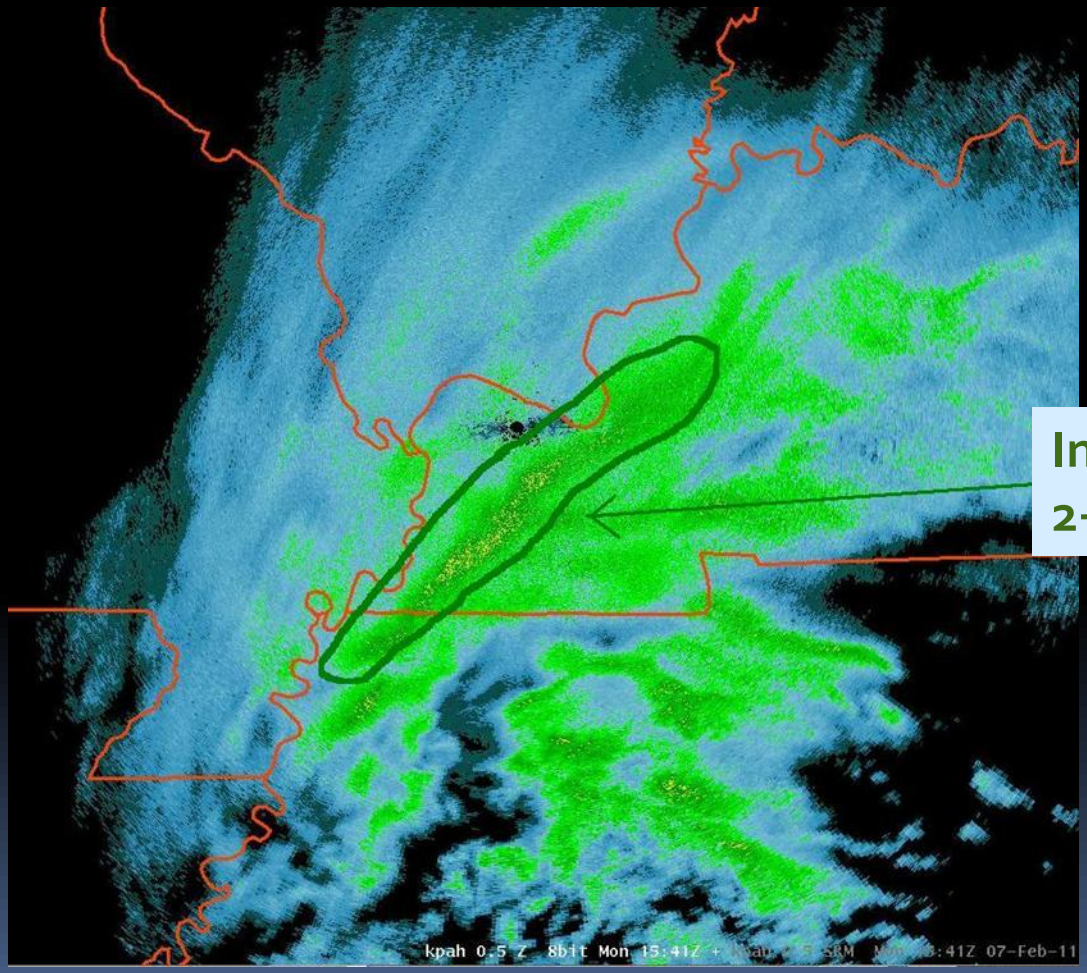
- The snow fell heavily in small-scale bands
  - We call these *mesoscale* events

2 to 200 kilometers

- or –

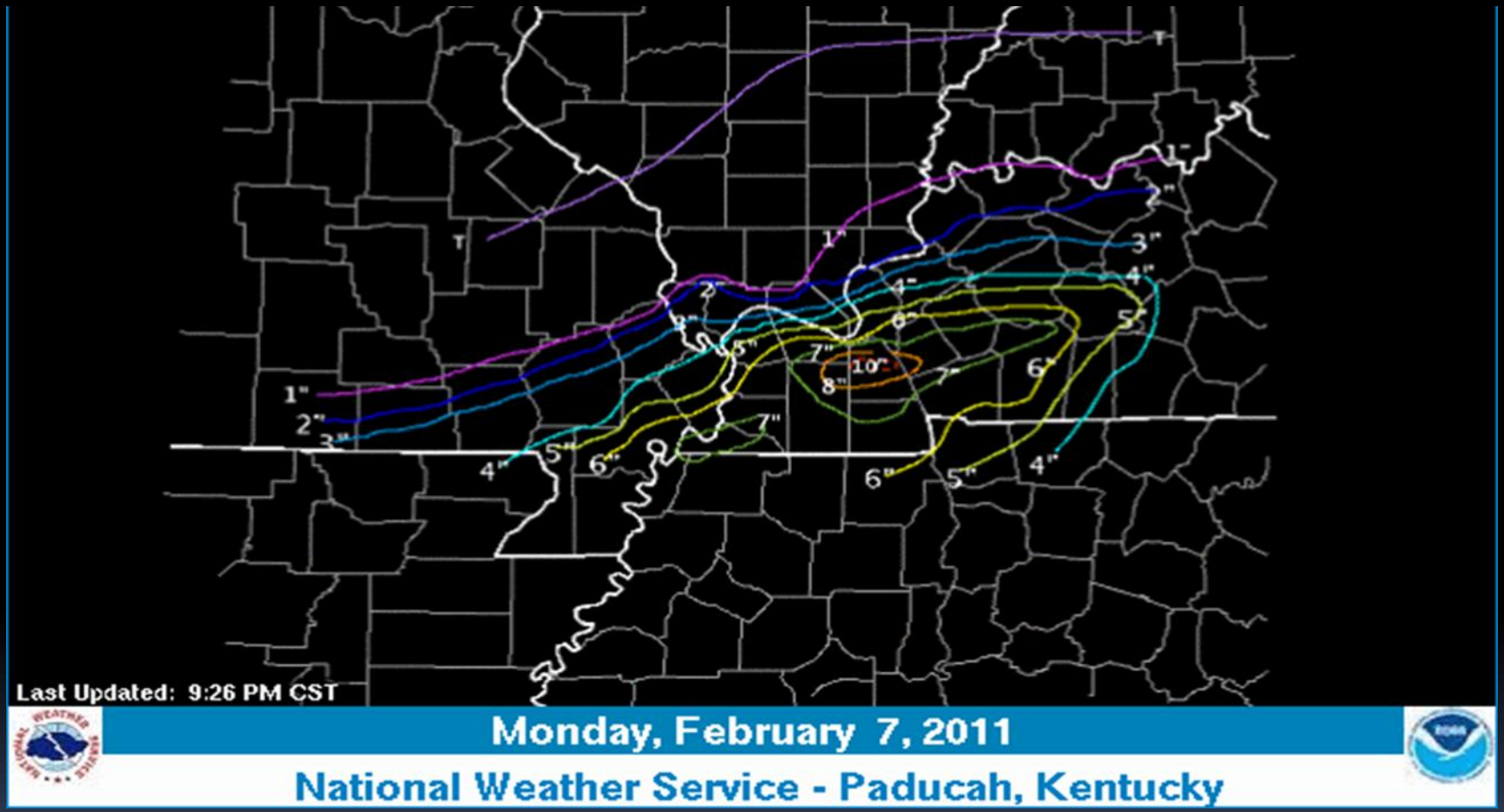
1 to 125 miles

Example of mesoscale banding



Feb. 7, 2011 – 9:41 A.M. CST

Snowfall total: Feb. 7



Mesoscale meteorology

- Examples of mesoscale events: Thunderstorm complexes, lake breezes, rain showers, snow bands
- Our operational computer models cannot explicitly forecast mesoscale events (YET!)
- BUT experimental mesoscale forecast models are showing great promise.

Forecasting last winter

- Preliminary Verification Statistics:
  - 70 county-based Winter Storm Warnings
  - Average Warning Lead Time: 5.1 hrs (Lead time = time from warning issuance until 4" is on ground)

Warning Lead Time

- 2010-11 Lead Time: 5.1 hrs
- vs. 5-year average of 21 hrs

Does not include outlooks and watches…

Outlooks and watches can give up to 7 days' advance notice

No outlooks or watches for 2010-11 events

After the 4th missed storm, the boss was not happy.

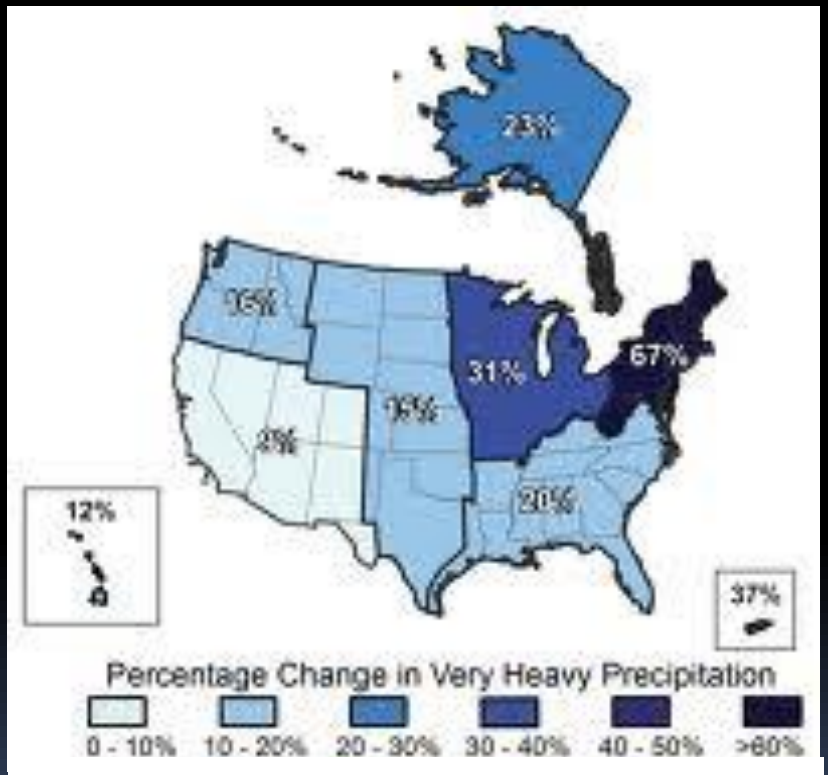
- Science team tasked with investigating why
- Preliminary results presented at National Weather Association conference last month

Four heavy snow events under review:

- Dec. 24 (Christmas Eve – Most of region)
- Jan. 25 (Pennyrile region)
- Feb. 7 (Western Kentucky)
- Feb. 9 (Tennessee border)

Part of a record-setting year for heavy precipitation events

Heavy snow/rain events are more frequent



50-year period: 1958-2007

- So we need to improve our forecasting of heavy precip events

Map Source: NOAA, et. al.

Step 1: Is there anything we missed?

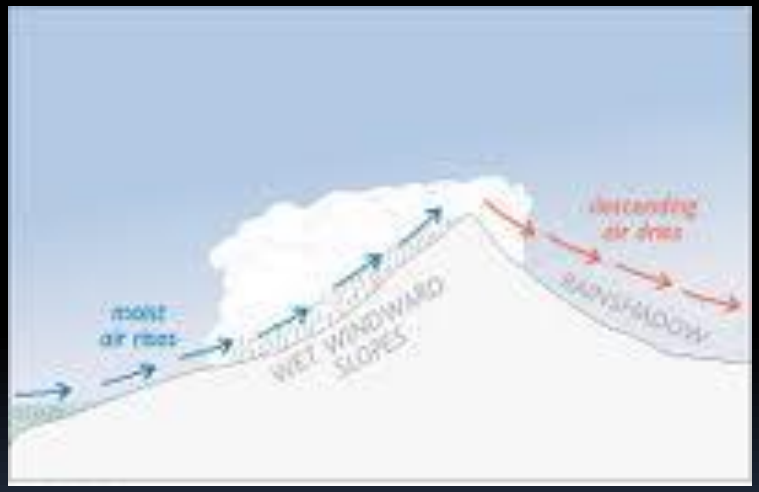
- What did the events have in common?
- Can we forecast mesoscale bands?
- Did the models show anything we missed?

After further review…

- Past research on these bands could have helped us
- In particular… the computer models could have been examined for two things…

Refresher in Meteorology - The Painful Part of this talk

- To get clouds and precipitation, we need something to lift the air



- Instability is helpful is maximizing the uplift (remember your elite spotter training)

Sources of uplift

- Fronts
- Mountains
- Jet streams / jet streaks
- Upper level disturbances
- Flow of warmer/moist air overrunning colder air

Clues for mesoscale bands:

- Frontogenesis (development of a front) in the low to mid levels of the atmosphere
- Divergence in the upper levels of the atmosphere, which causes low level air to rise to replace it (chimney effect)

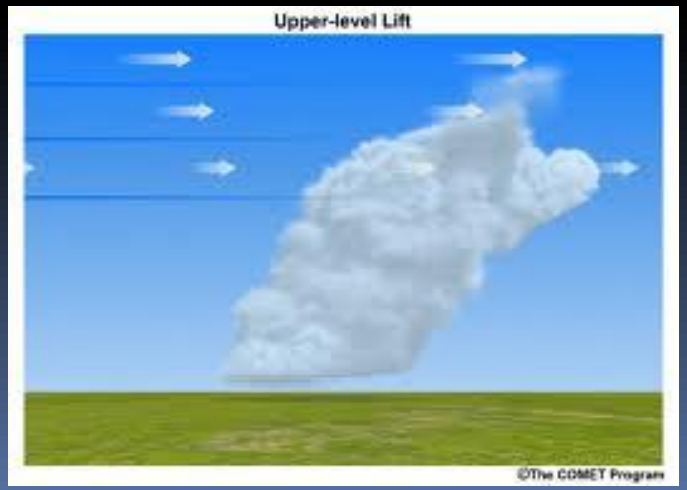


Image courtesy COMET

Finding Instability…

- Where instability and uplift co-exist, heavy precipitation is likely (if moisture is there)

1. In the vertical column, we look for the layer of the atmosphere where lift is occurring
2. We look near and just above that layer for instability
3. Look for negative values of EPV (equivalent potential vorticity), not Lifted Index or CAPE

Corn-fused? Feeling the pain?

Don't worry. It's just one principle…

- Uplift + instability + moisture=heavy precipitation

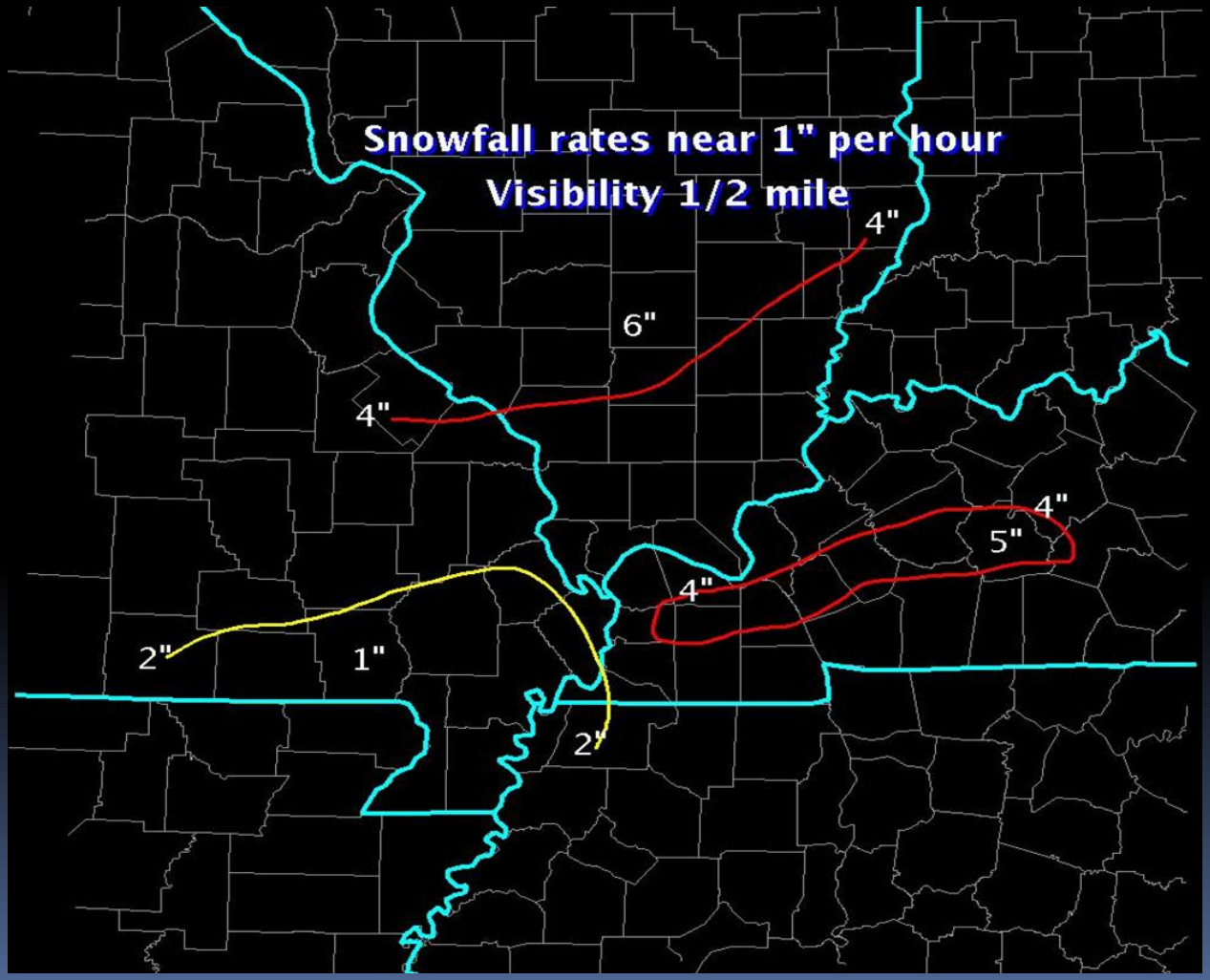
Methodology for each storm:

- Reviewed archived data sets on our WES (Weather Event Simulator)
- Reviewed what the computer models showed concerning…

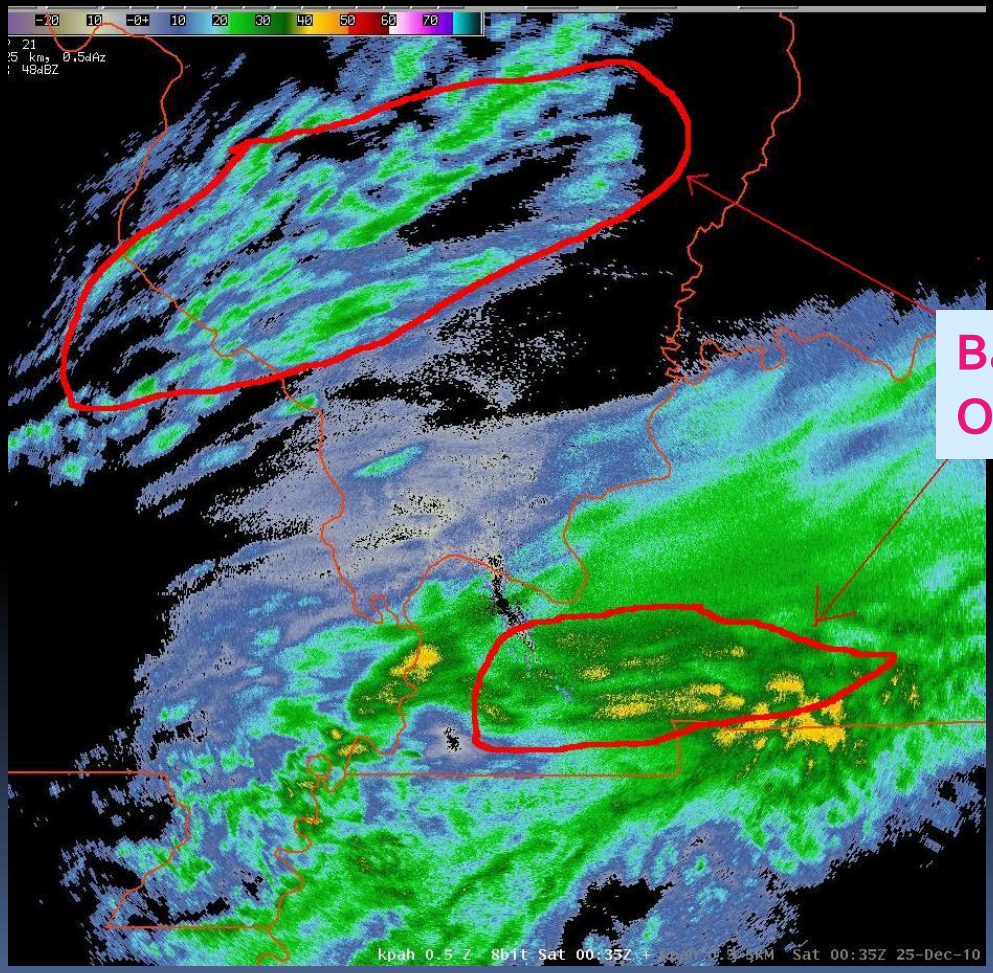
1. Instability and
2. Uplift generated by frontogenesis

Event #1: Christmas Eve…

About 3 hours of moderate to heavy snowfall

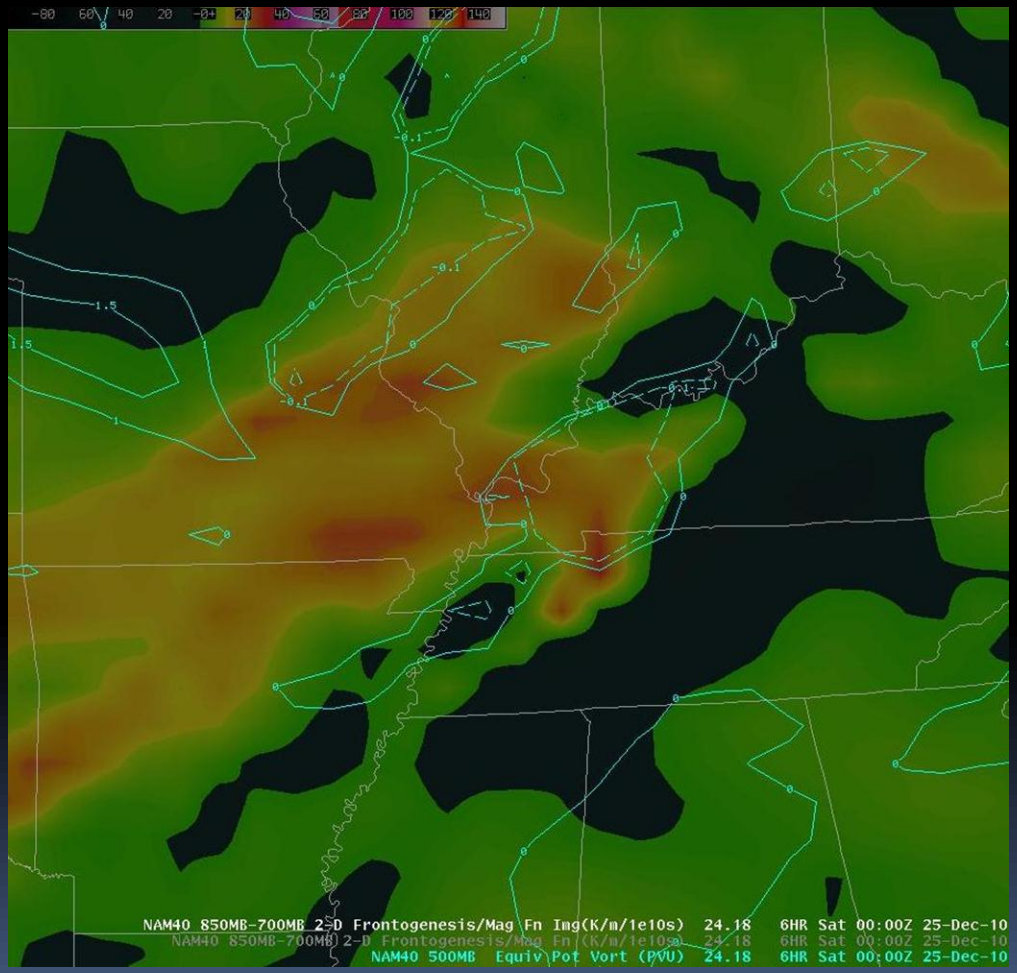


Christmas Eve radar image



Banding signatures – Over 1" per hour

Dec. 24 computer model output

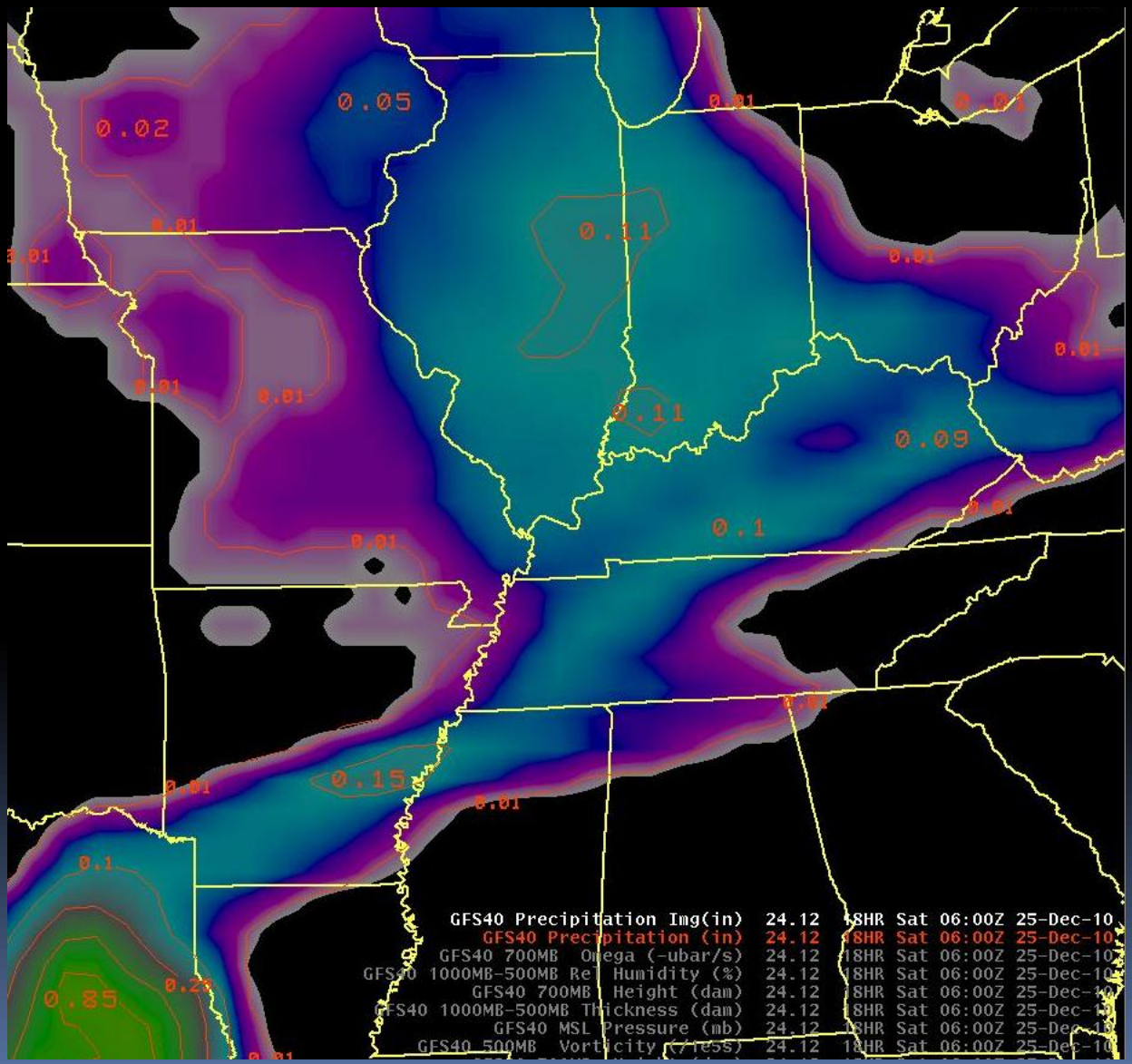


Dashed blue contours delineate instability

Colored areas represent frontal forcing for uplift

6-hour model forecast – valid 6 P.M.

Computer model precip forecast



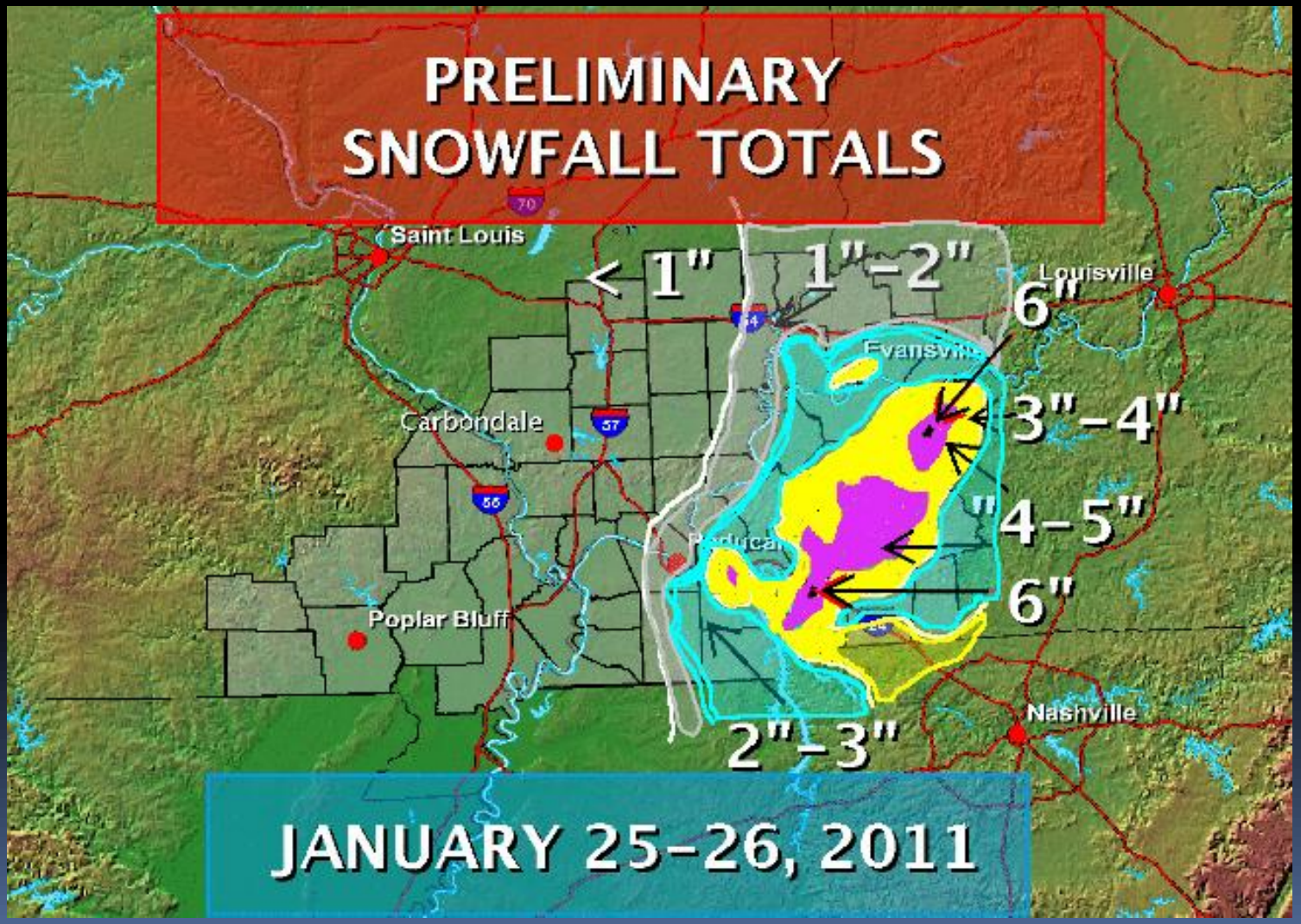
Liquid equivalent for the Christmas Eve snowstorm

GFS model – Dec. 24 morning

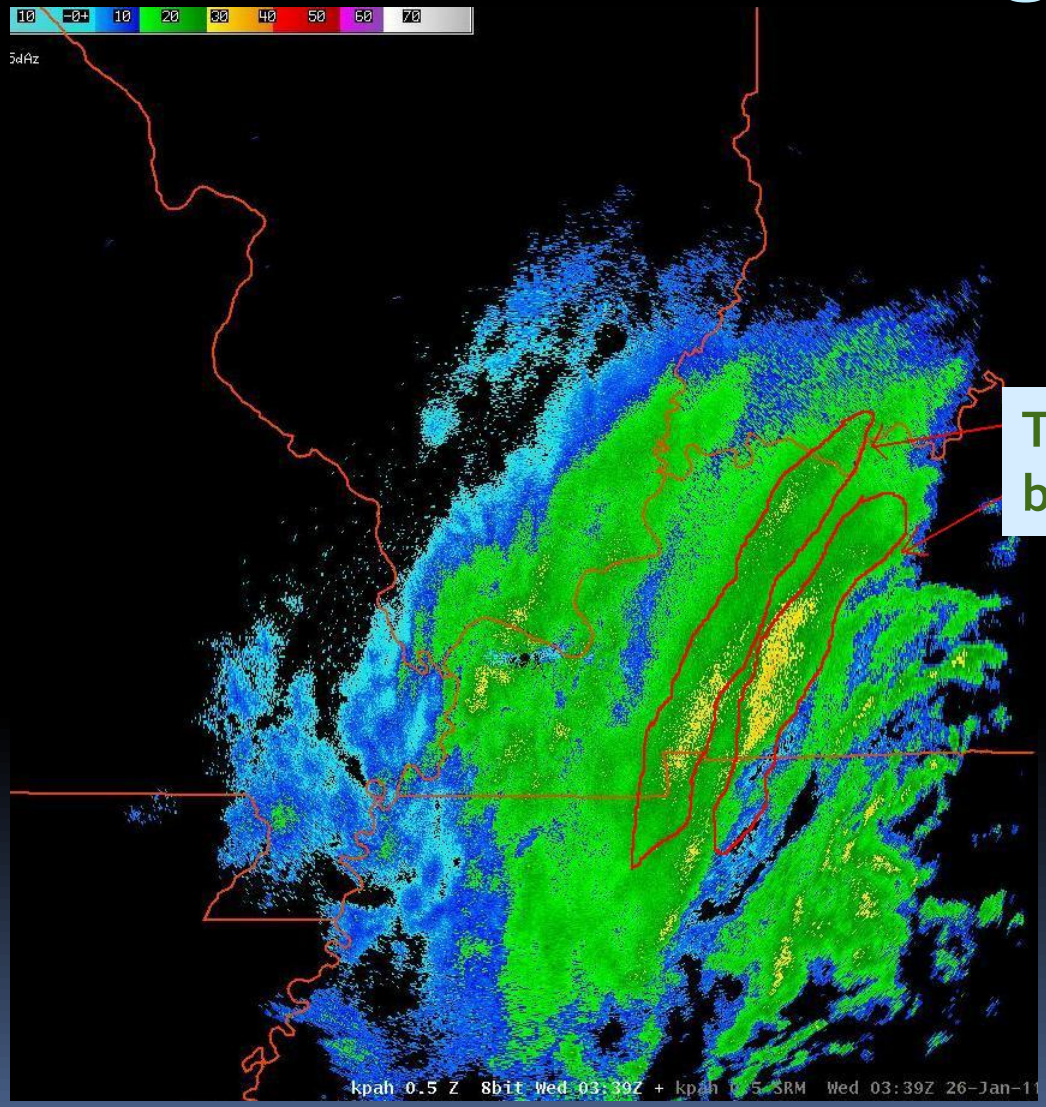
Dec. 24 Preliminary Findings

- Mesoscale banding played a role
- Instability and frontal forcing were factors
- Model precip amounts underforecast

Event 2: Jan. 25-26 (night)



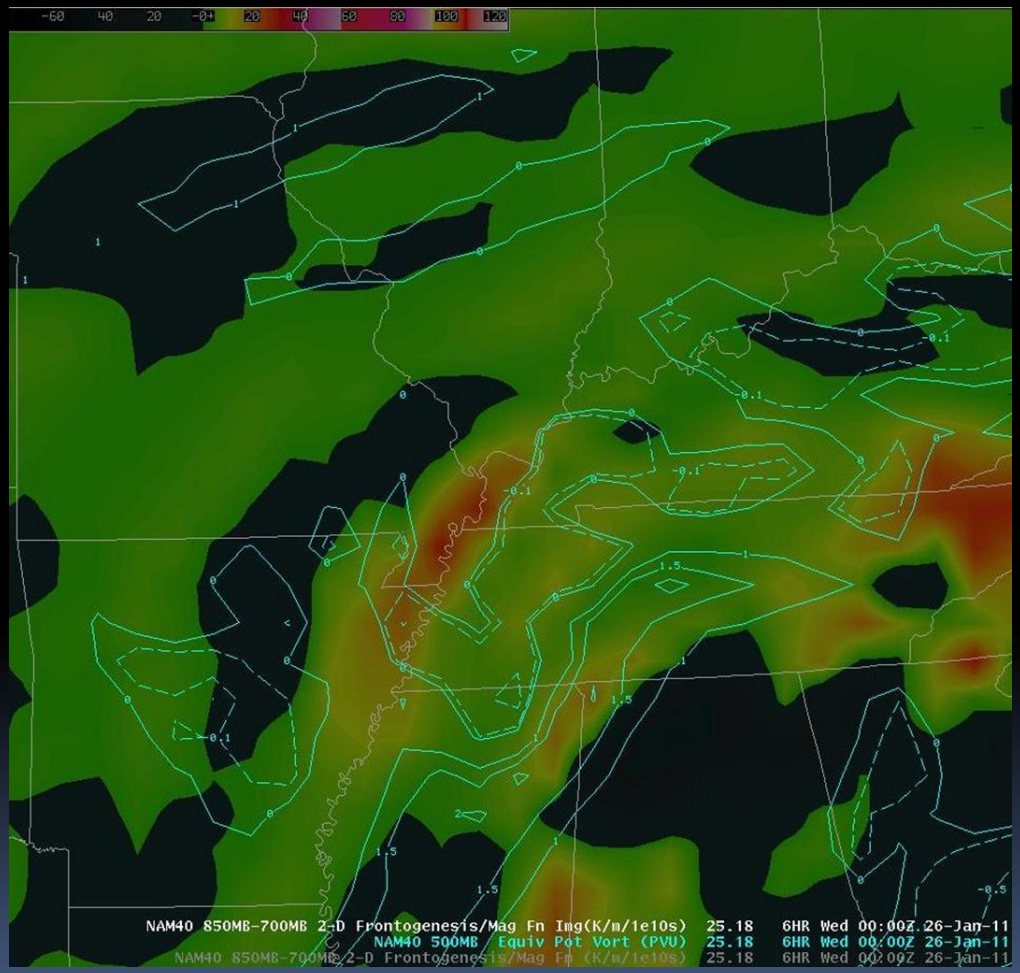
Jan. 25 Radar Image



Twin mesoscale bands

9:39 P.M. CST

Jan. 25 computer model output

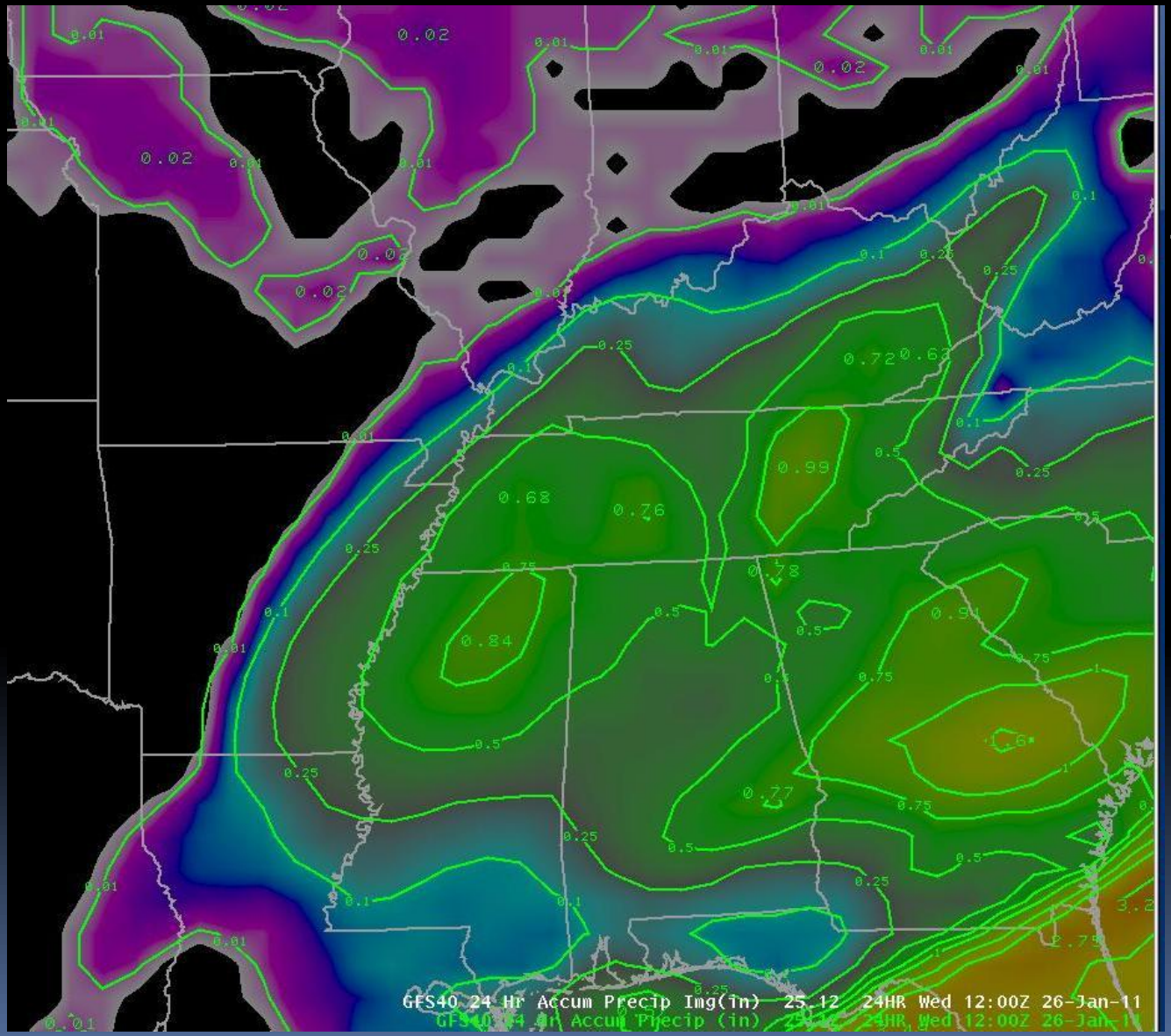


Dashed blue contours delineate instability

Colored areas represent frontal forcing for uplift

6-hour forecast - valid at 6 P.M.

Computer model precip forecast



Liquid equivalent for the Jan. 25-26 snowstorm

GFS model – Jan. 25 morning

Jan. 25 Preliminary Findings

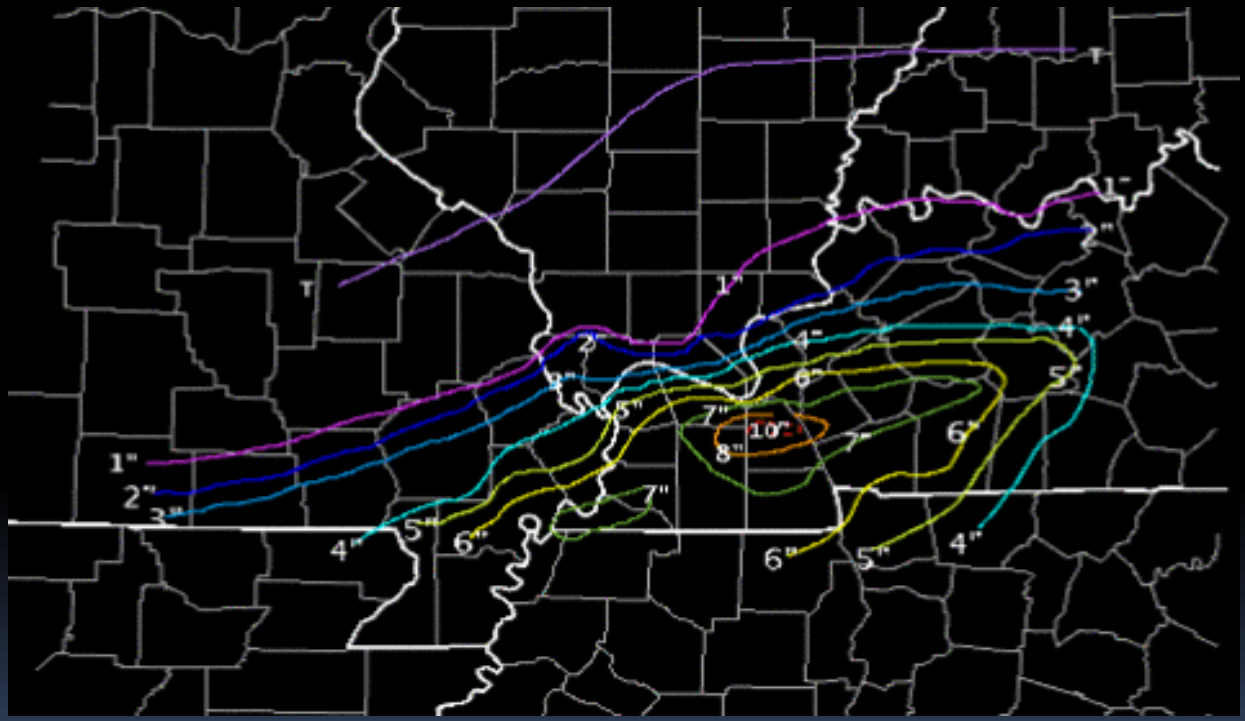
- Mesoscale banding
- Instability
- Frontogenetical forcing

ALL played a role

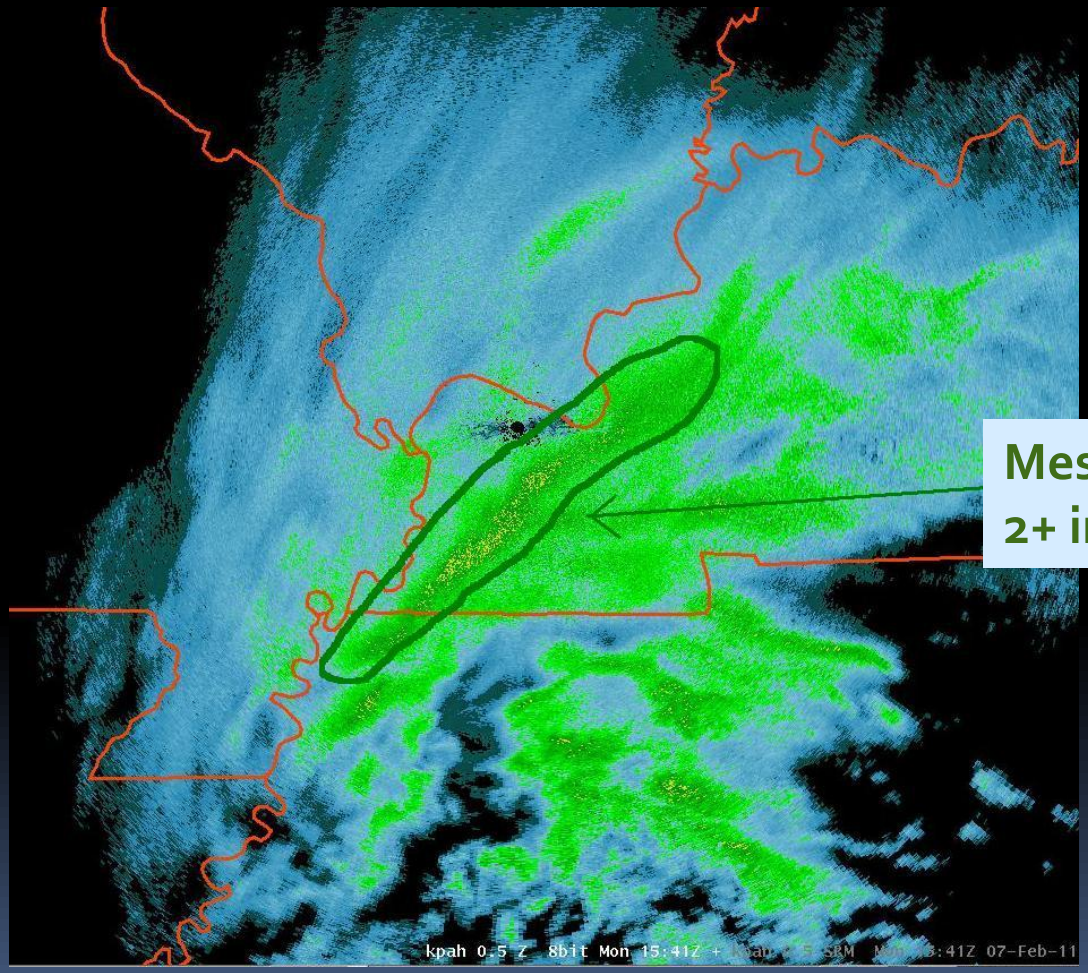
- Model precip amounts were good; but placement too far south and west

Event #3 - Feb. 7

Up to 3” per hour during morning commute

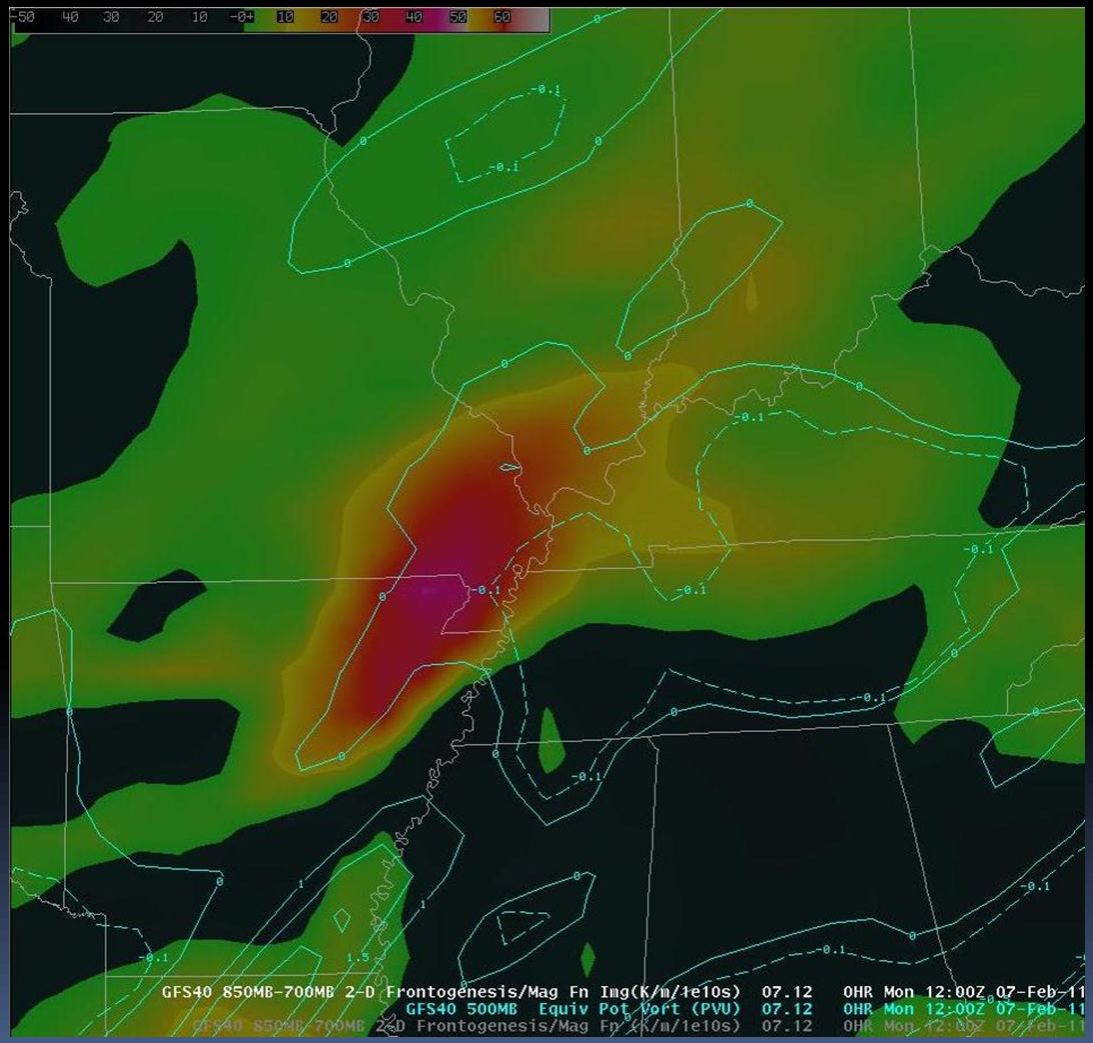


Feb. 7 Radar Image



9:41 A.M. CST

Feb. 7 computer model output

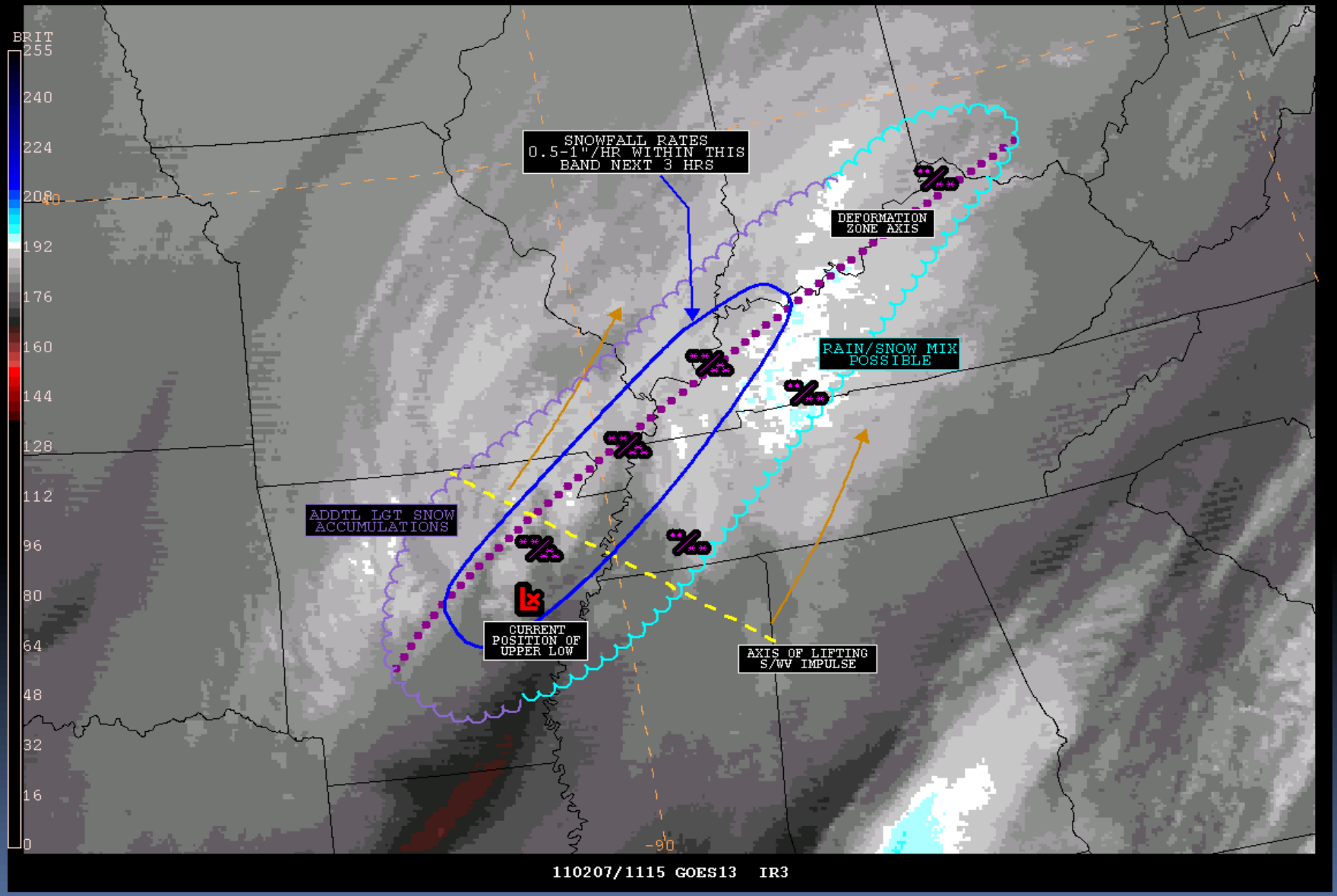


Dashed blue contours delineate instability

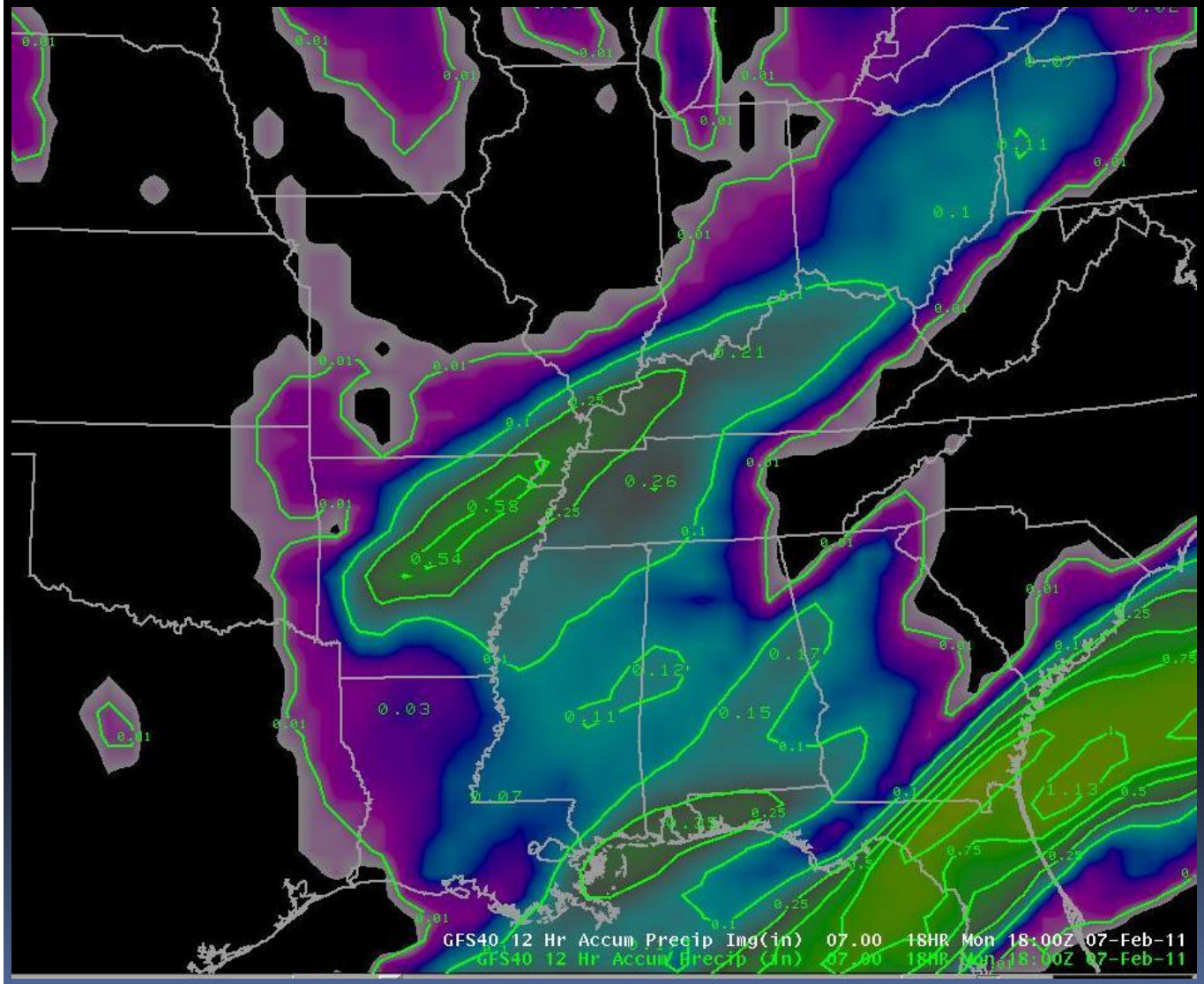
Colored areas represent frontal forcing for uplift

Model initialization – 6 A.M. Feb. 7

Feb. 7 - Satellite Precip Estimate:



Computer model precip forecast



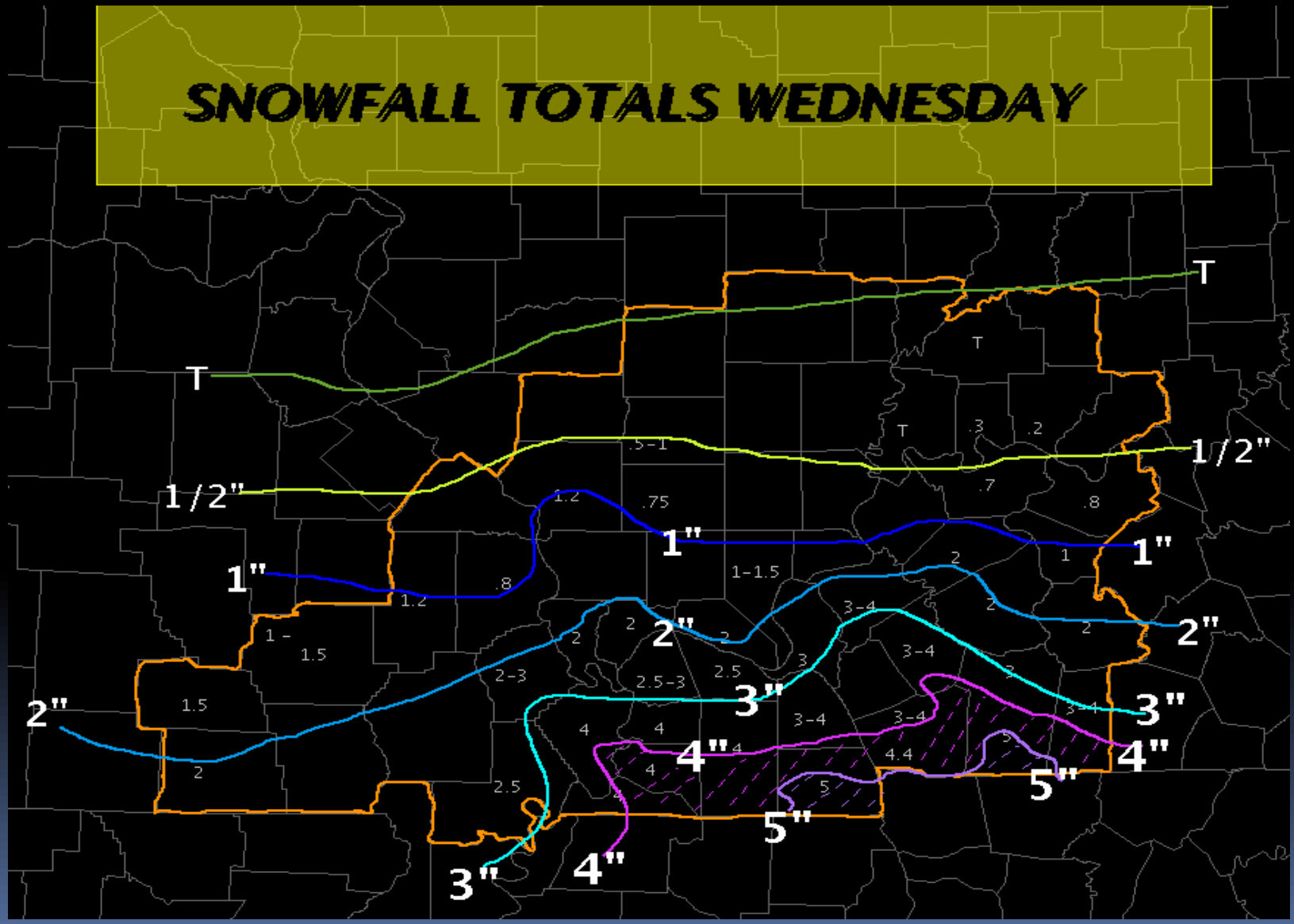
Liquid equivalent for the Feb. 7 snowstorm

GFS model – Feb. 6 evening

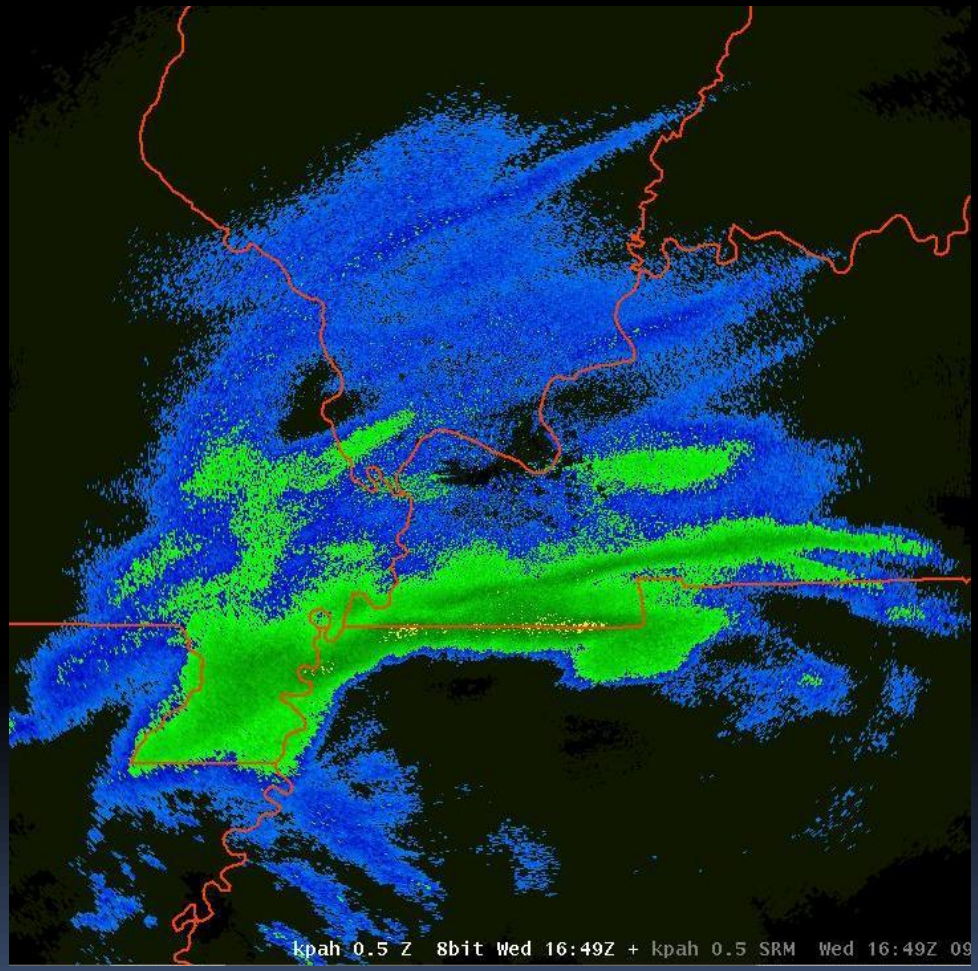
Feb. 7 Review:

- This was the most intense system of the four
- Satellite was an excellent tool for diagnosing model errors
- Warm pavement temps again a non-factor
- Model precip amounts missed the heaviest “bullseye” of snowfall

Event 4: Feb. 9 daytime



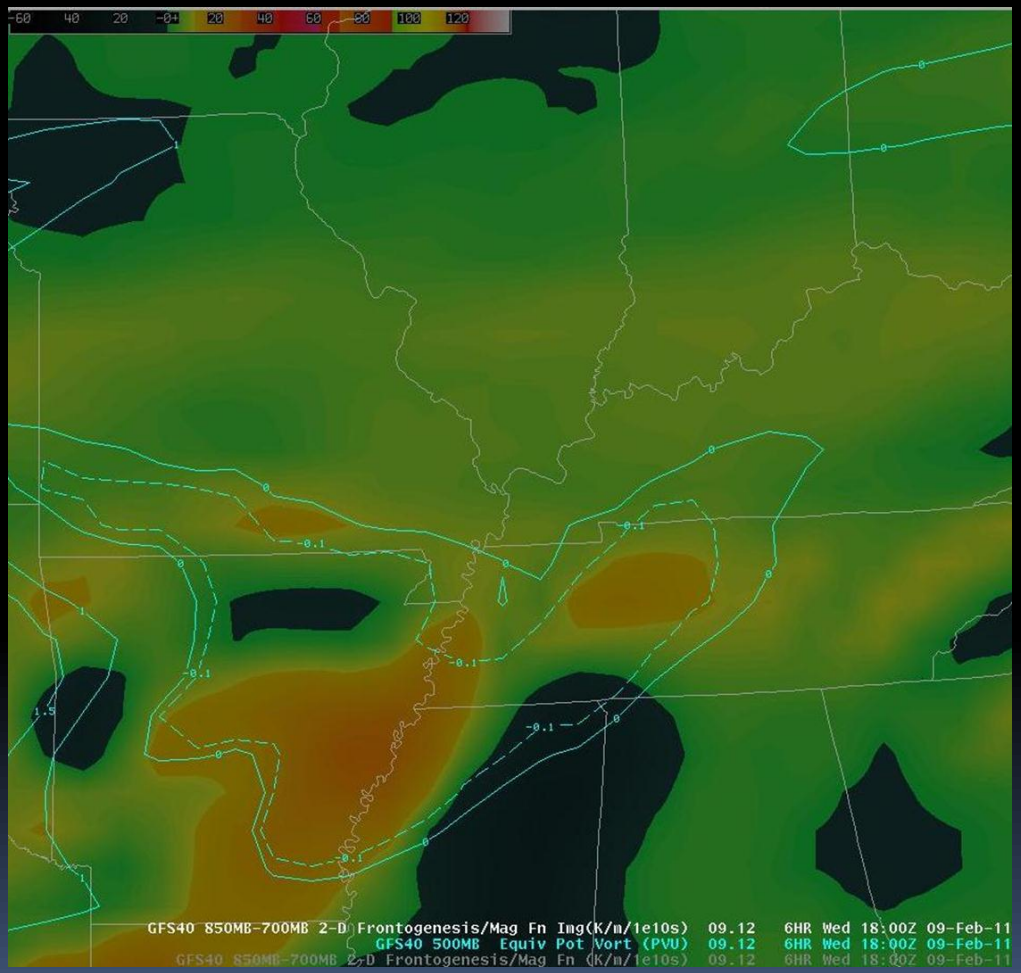
Feb. 9 Radar Image



Intense bands along Tennessee border

10:49 A.M. Feb. 9

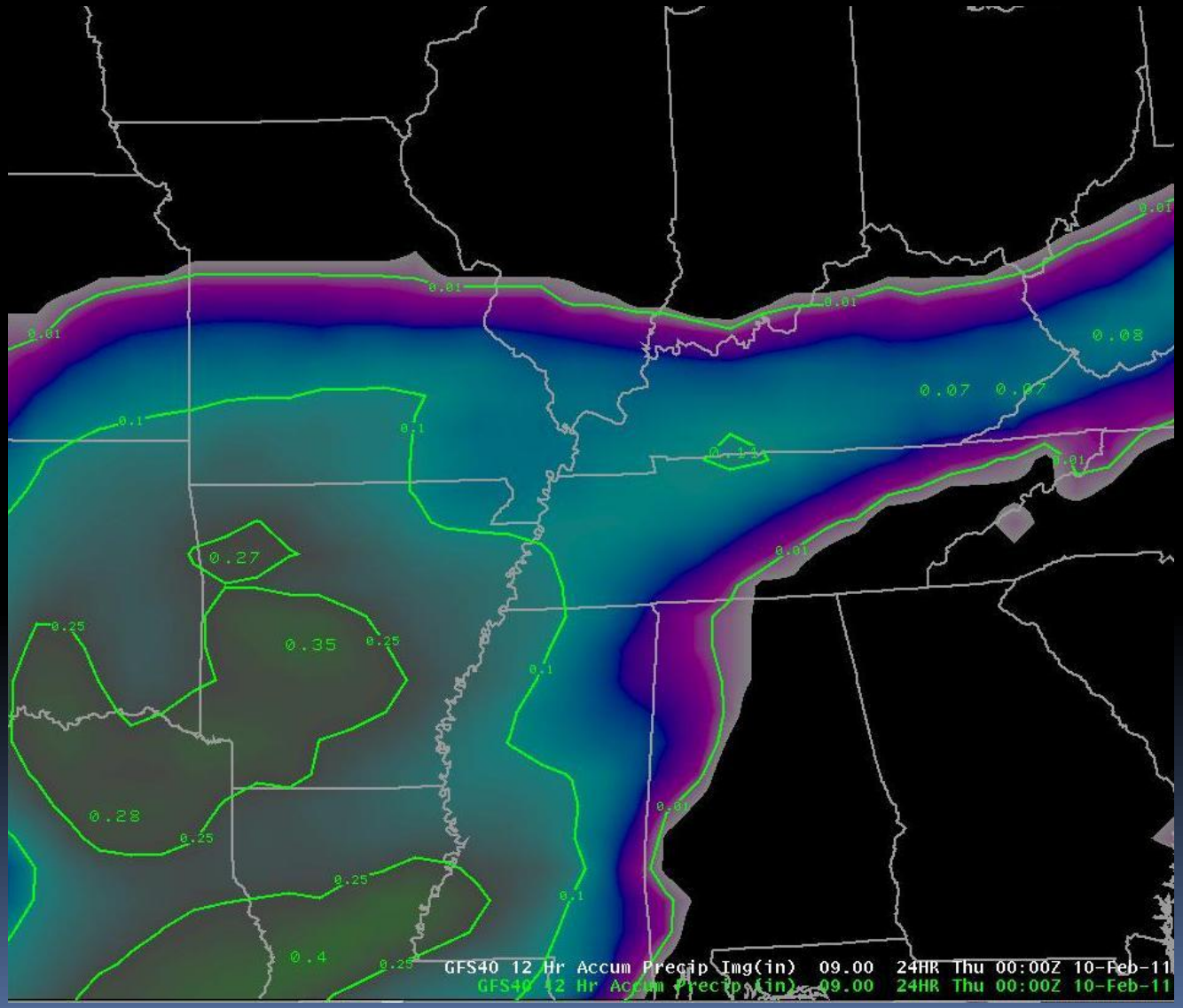
Feb. 9 computer model output



Indicated potential for mesoscale banding along Tennessee border

6-hour forecast valid at noon

Computer model precip forecast



Liquid equivalent for the Feb. 9 snowstorm

GFS model – Feb. 8 evening

Feb. 9 preliminary findings

- Based on similarities to Feb. 7, forecasters anticipated the models were too light with the snowfall amounts
- Snow was very dry and powdery, enabling rapid accumulations
- Model precip amounts were too light

In Summary:

1. Mesoscale banding occurred in all four storms
2. Models showed uplift (frontogenesis) and instability (neg EPV) in the area where banding occurred
3. Warm pavement temps were a non-factor in the events in which they were present

Lessons Learned:

- Examine the models for banding potential using the demonstrated technique
- Warm pavement temperatures can be overcome by high snowfall rates
- Use caution with the model forecasts of precipitation amounts!

How to handle snow bands:

- If we see *potential* for banding, consider going above the model precip amounts
- Once *identified*, specific details of bands can be included in storm updates

Feb. 5, 2004
Near Paducah, KY

Challenges ahead:

1. How often do models give “false positives” about banding?
2. Can we consistently outperform model precip amounts using this simple technique?
3. Can we forecast the areal coverage (number, size, and motion) of the bands?

What next?:

- Gather more data during future banding events to address the "challenges ahead"
- Present results to office staff during internal winter weather workshop on Dec. 6
- Publish work in NWA newsletter and on web

Credits:

Pat Spoden, Christine Wielgos, Dan Spaeth, Kevin Smith, Robin Smith

Next up: Christine on tornado response (Wed)

- Or Mary on the Spring flood (Thu/Fri)