Examining the GFS Model in a Busted Snow Event: 15 – 16 January 2003

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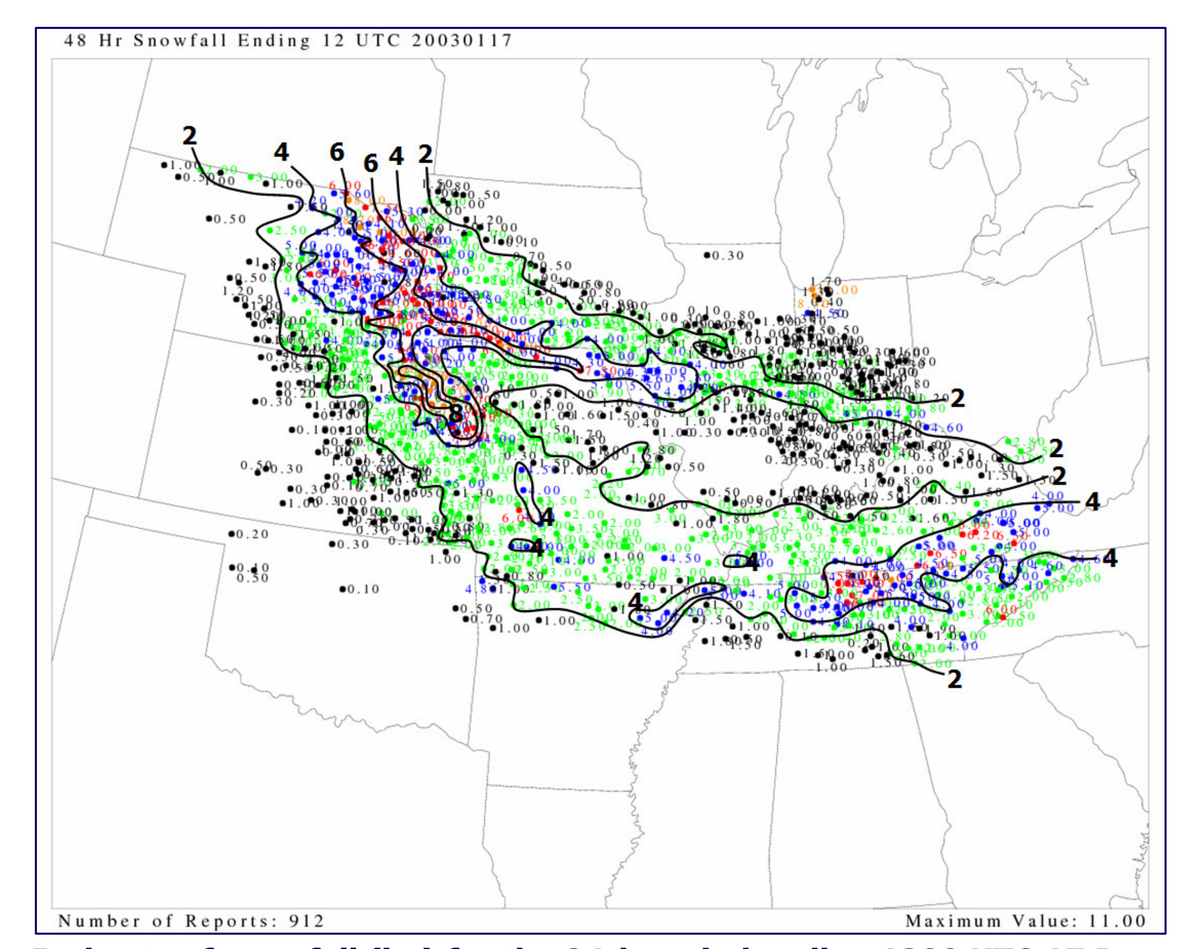
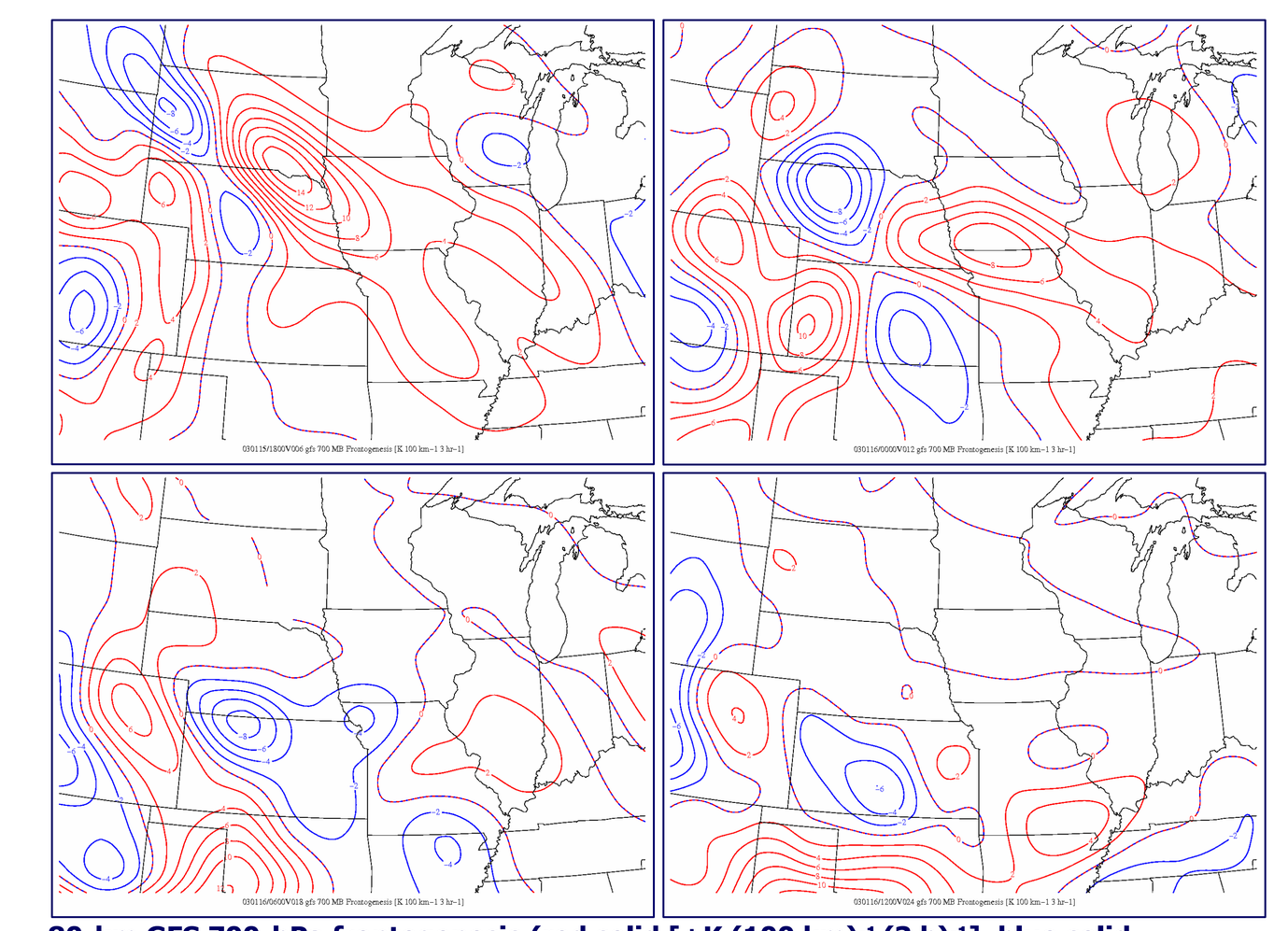
Introduction

- One of the goals of the National Oceanic and Atmospheric Administration's (NOAA) strategic plan for the 21st century is to provide information, services, and products that support the United States society and economy with safe and efficient transportation systems (NOAA 2005).
- Currently, one reason that critical weather information and products fall short of national needs and expectations is due to an incomplete understanding of meteorological processes (NOAA 2005).
- On 15 – 16 January 2003, a major winter storm had been forecasted to impact the entire lower Missouri River Valley and the St. Louis, MO county warning forecast area with up to 8 inches of snow.
- Up to that date during the 2002 – 2003 winter season, the GFS had exhibited superior performance and was the model of choice for this event.
- The poster will examine:
  - The GFS model run available to the St. Louis NWSFO forecasters when the winter storm warning was issued for the county wide area.
  - The Rapid Update Cycle's (RUC) analysis of the event.
  - How the dProg/dt method can be quantitatively applied to diagnose model trends in comparison to existing conceptual models.

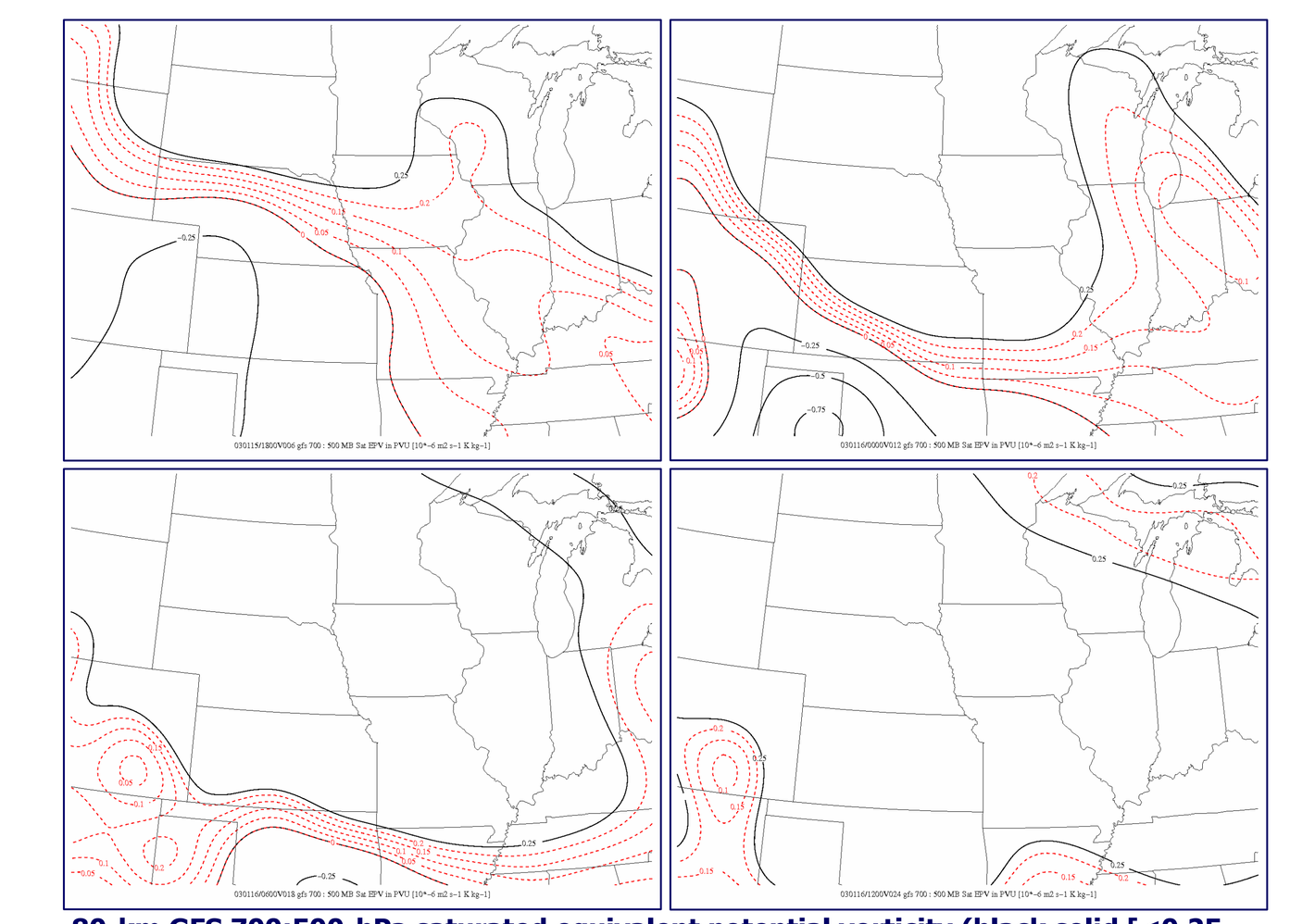


Isohyets of snowfall (in.) for the 24-h period ending 1200 UTC 17 Jan 2003, based upon cooperative station data from NCDC.

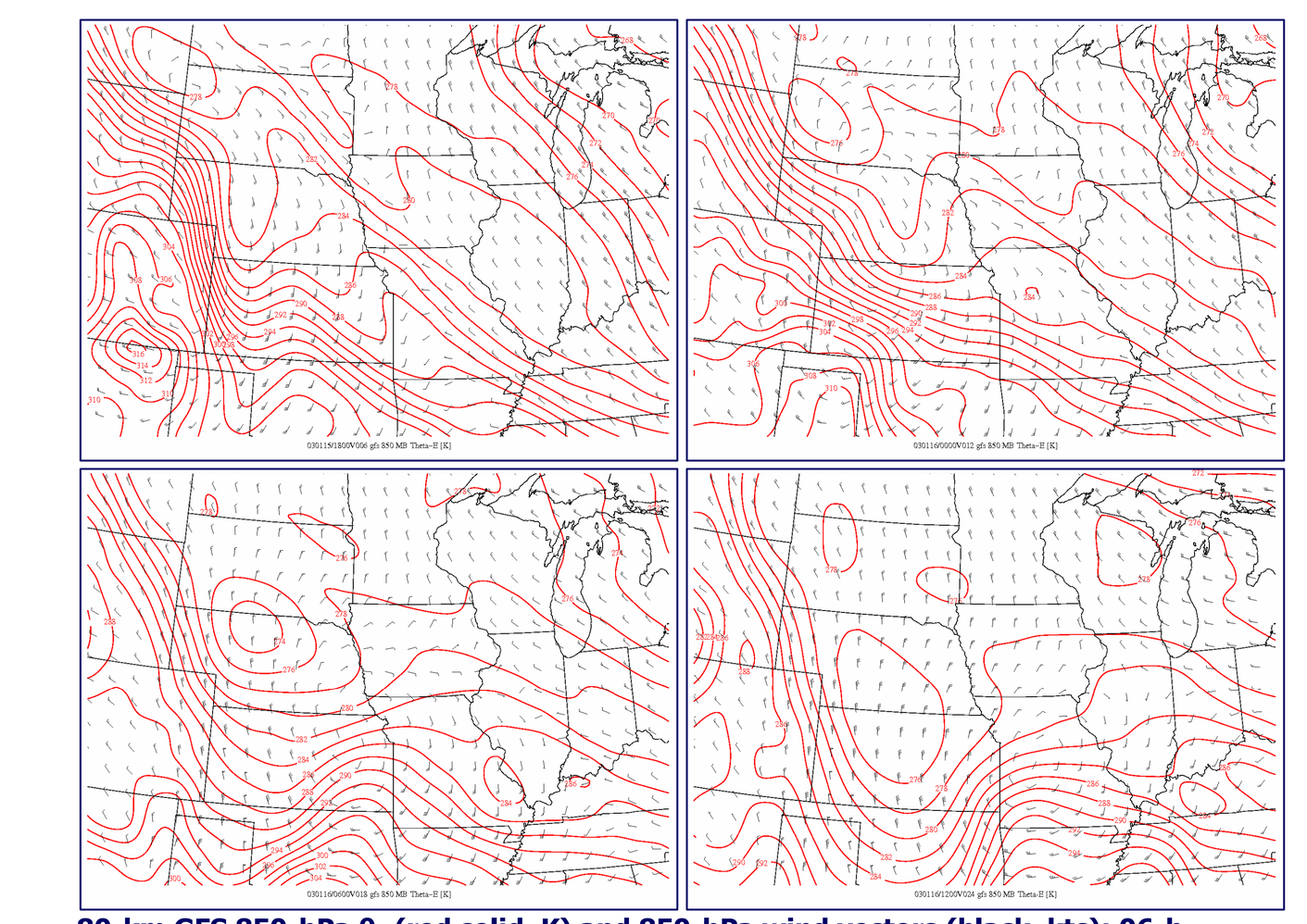
GFS Forecasts – 1200 UTC 15 January 2003 Run



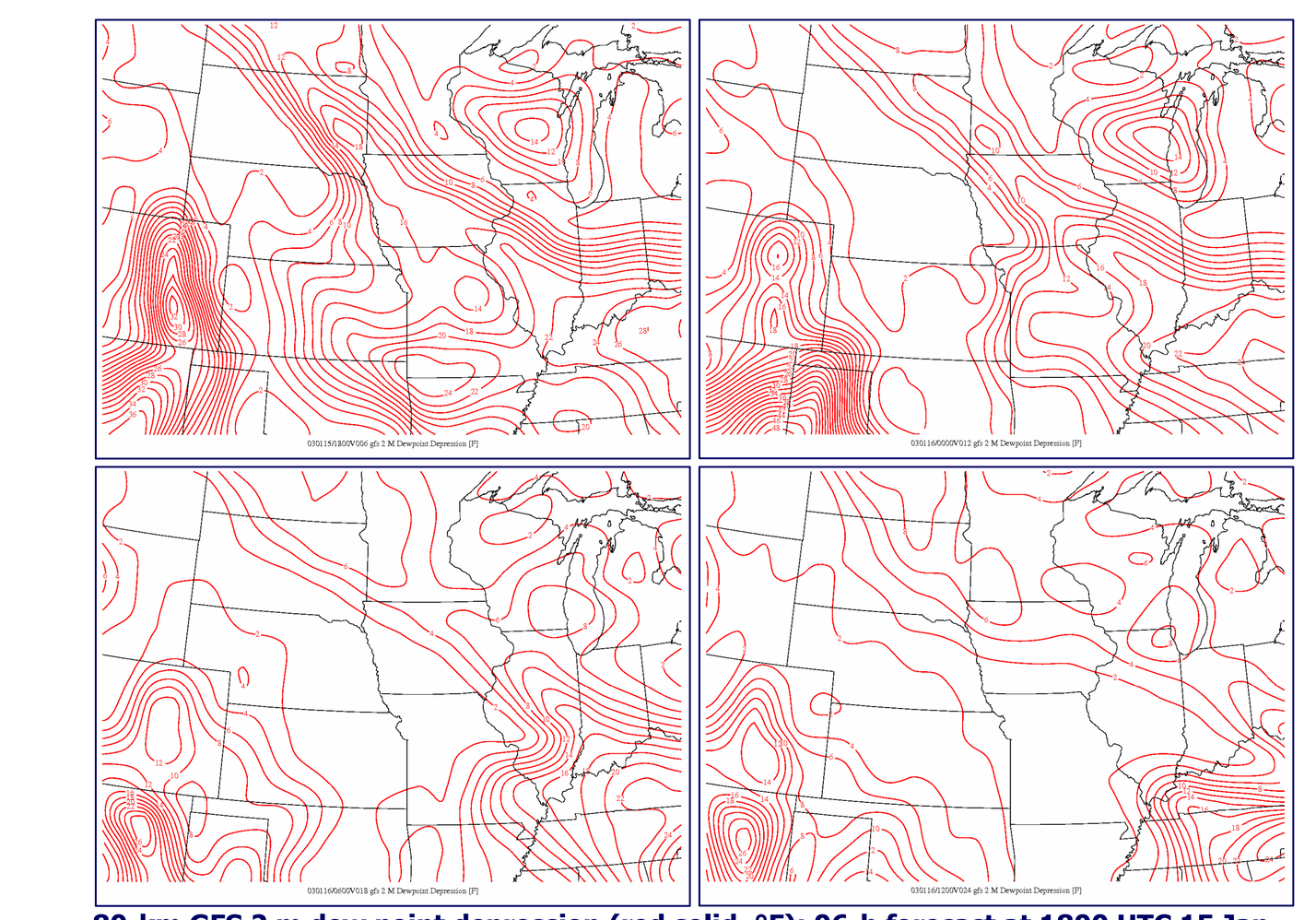
80-km GFS 700-hPa frontogenesis (red solid [+K (100 km)$^{-1}$ (3 h)$^{-1}$], blue solid [-K (100 km)$^{-1}$ (3 h)$^{-1}$]): 06-h forecast at 1800 UTC 15 Jan 2003 (upper left), 12-h forecast at 0000 UTC 16 Jan 2003 (upper right), 18-h forecast at 0600 UTC 16 Jan 2003 (lower left), 24-h forecast at 1200 UTC 16 Jan 2003 (lower right).



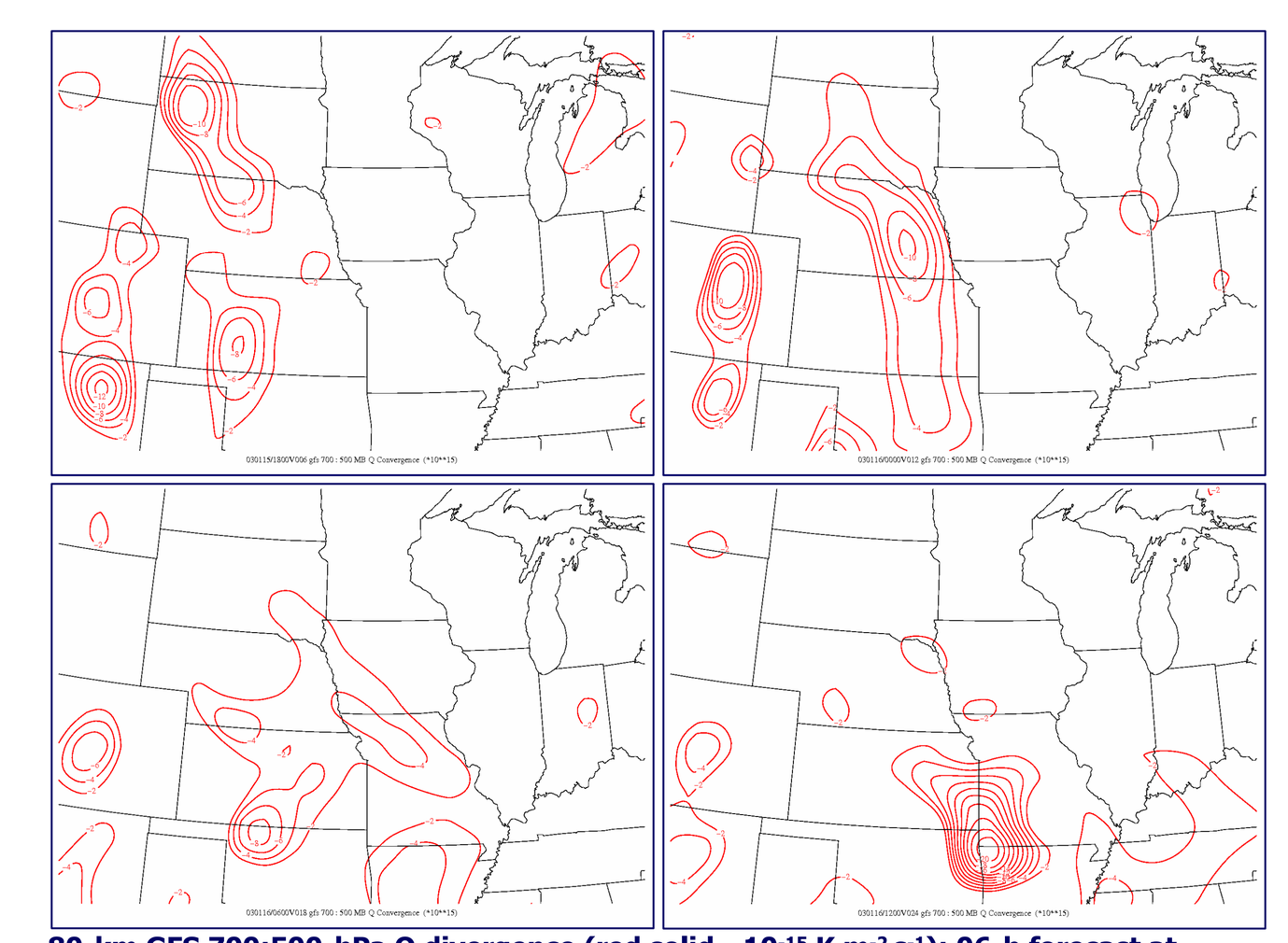
80-km GFS 700:500-hPa saturated equivalent potential vorticity (black solid [<0.25 PVU], red dashed [0.25 – 0.00 PVU]): 06-h forecast at 1800 UTC 15 Jan 2003 (upper left), 12-h forecast at 0000 UTC 16 Jan 2003 (upper right), 18-h forecast at 0600 UTC 16 Jan 2003 (lower left), 24-h forecast at 1200 UTC 16 Jan 2003 (lower right).



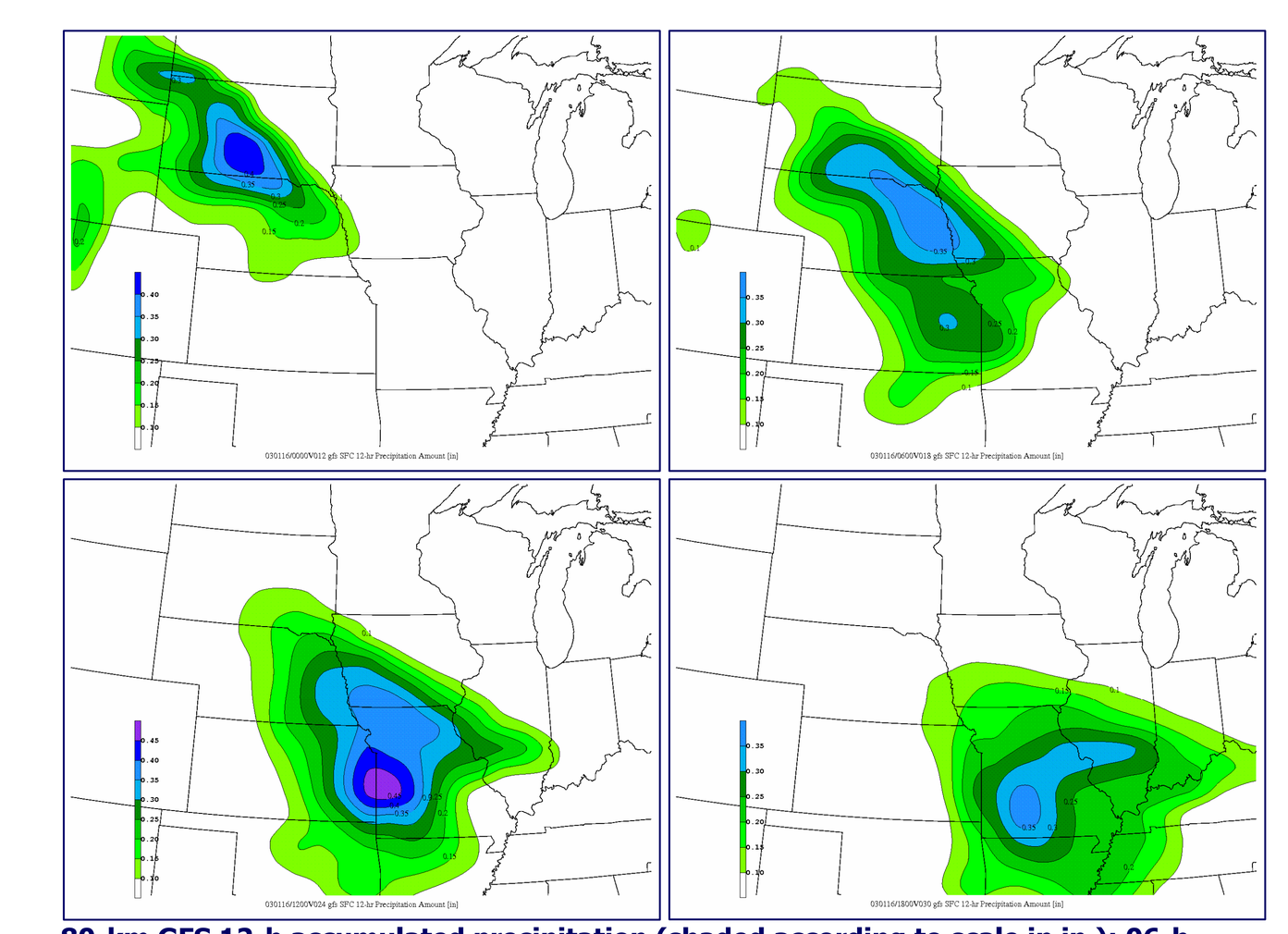
80-km GFS 850-hPa θ_e (red solid, K) and 850-hPa wind vectors (black, kts): 06-h forecast at 1800 UTC 15 Jan 2003 (upper left), 12-h forecast at 0000 UTC 16 Jan 2003 (upper right), 18-h forecast at 0600 UTC 16 Jan 2003 (lower left), 24-h forecast at 1200 UTC 16 Jan 2003 (lower right).



80-km GFS 2 m dew point depression (red solid, °F): 06-h forecast at 1800 UTC 15 Jan 2003 (upper left), 12-h forecast at 0000 UTC 16 Jan 2003 (upper right), 18-h forecast at 0600 UTC 16 Jan 2003 (lower left), 24-h forecast at 1200 UTC 16 Jan 2003 (lower right).



80-km GFS 700:500-hPa Q divergence (red solid, -10^{-15} K m^{-2} s^{-1}): 06-h forecast at 1800 UTC 15 Jan 2003 (upper left), 12-h forecast at 0000 UTC 16 Jan 2003 (upper right), 18-h forecast at 0600 UTC 16 Jan 2003 (lower left), 24-h forecast at 1200 UTC 16 Jan 2003 (lower right).



80-km GFS 12-h accumulated precipitation (shaded according to scale in in.): 06-h forecast at 1800 UTC 15 Jan 2003 (upper left), 12-h forecast at 0000 UTC 16 Jan 2003 (upper right), 18-h forecast at 0600 UTC 16 Jan 2003 (lower left), 24-h forecast at 1200 UTC 16 Jan 2003 (lower right).

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FXUS63 KLSX 152018
AFDSTL
AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE ST LOUIS MO
215 PM CST WED JAN 15 2003

THERE STILL RMNS A GREAT DEAL OF UNCERTAINTY WITH THE UPCOMING WNTR STRM. NAMELY WHERE THE HIGHEST
SNOWFALL AMTS WL OCCUR. IT SEEMS PRETTY MUCH A GIVEN THAT THE ENTIRE CWFA WL SEE A GD DEAL OF
MEASURABLE SNOW ON THE ORDER OF 4-5 INCHES...HOWEVER EXACTLY WHERE THE EMBDD BANDS OF HIER TOTALS
FALL IS STILL NOT TOTALLY CLR. THE SYS IS CURRENTLY UNFOLDING PRETTY MUCH AS EXPECTED. THE RGL RADAR
COMPOSITE LOOP IS SHWG AN EVOLVING NW-SE BAND FM SD INTO ERN NEB ASSOCD WITH THE WRM CONVEYOUR BELT
AND RESULTANT LOW-MID LVL FRONTOGENESIS. MOISTENING OF THE LWR LEVELS IS SLOW BUT IS PROGRESSING ON
THE SE FRINGE OVR ERN NEB/WRN IA. THE GUID IS ALL SUPPORTIVE THAT THIS BAND WL TRANSLATE SEWD TNGT AS
UPR TROF MOVS SEWD ...MOVING ACRS THE NRN HALF OF THE CWFA AS THE NGT PROGRESSES. HOW THINGS UNFOLD
LATE TNGT AND INTO ERLY THURS ARE THE TRICKIEST. IT RMNS UNCLEAR WHAT THE FUTURE OF THIS
WAA/FRONTOGENETICALLY DRIVEN BAND WL DO...WL IT DRY UP AS IT MOVS SEWD INTO THE OH VLY LATE TGNT OR
WL IT MERGE ON THE WRN END WITH AN EVOLVING DEFORMATION BAND ASSOCD WITH THE UPR SYS. WE CUD END UP
WITH ONE GOOD BAND ACRS NRN MO INTO WC / SC IL AND ANOTHER FM NR MKC THRU THE LAKE OF THE OZARKS THRU
FAM. I CONT TO FAVOR THE GFS FOR THE DETAILS AS IT RMNS RELATIVELY CONSISTENT OVR THE LAST 5 RUNS.
HPC/JUNKER'S DY1 QPF ALSO FITS THIS SCENARIO WELL AND LKS QUITE GD ATTM. LTL HAS CHGD IN THINKING WITH
SNOW TO LIQ RATIOS. DP THERMAL PROFILES CONT TO SUPPORT AT LEAST 20:1 RATIOS. GIVEN DRY/FLUFFY NATURE
TO THE SNOW...IT LKS LIKE BLOWING AND DRIFTING WL BCM A PROBLEM LATE THURS/THURS NGT AS GUSTY NW WNDS
RESULT FM THE INCRSD PRES GRAD FM THE DEPARTING SFC LOW AND THE HI BLDG SWD ACRS THE PLAINS. RURAL
AREAS CUD REALLY HV THEIR HANDS FULL. WL CONT WITH CLRG TRENDS THURS NGT. BYD TMW WL TREND TMPS AOB
COLDEST MOS GIVEN ANTICIPATED SN CVR.

.STL...WINTER STORM WARNING TONIGHT AND THURSDAY FOR THE ENTIRE CWFA.
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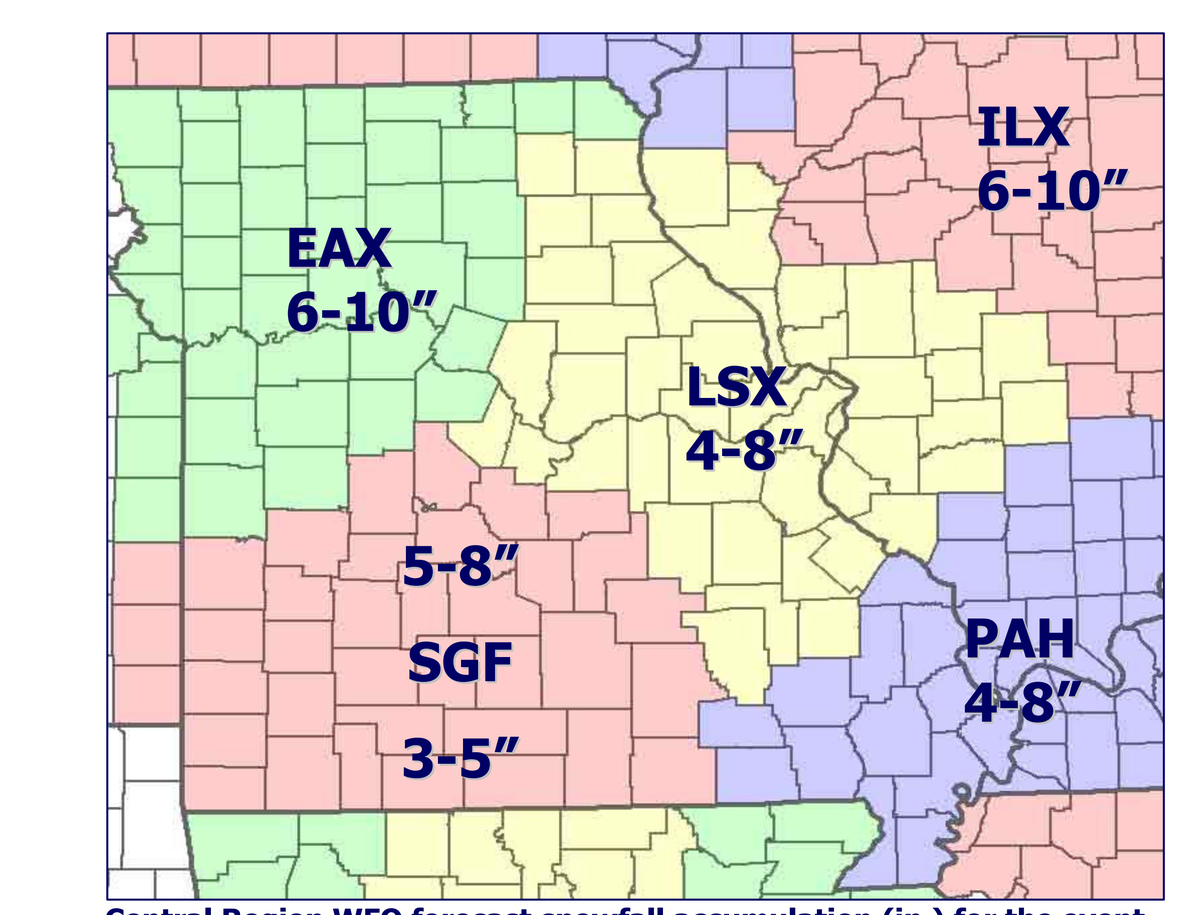
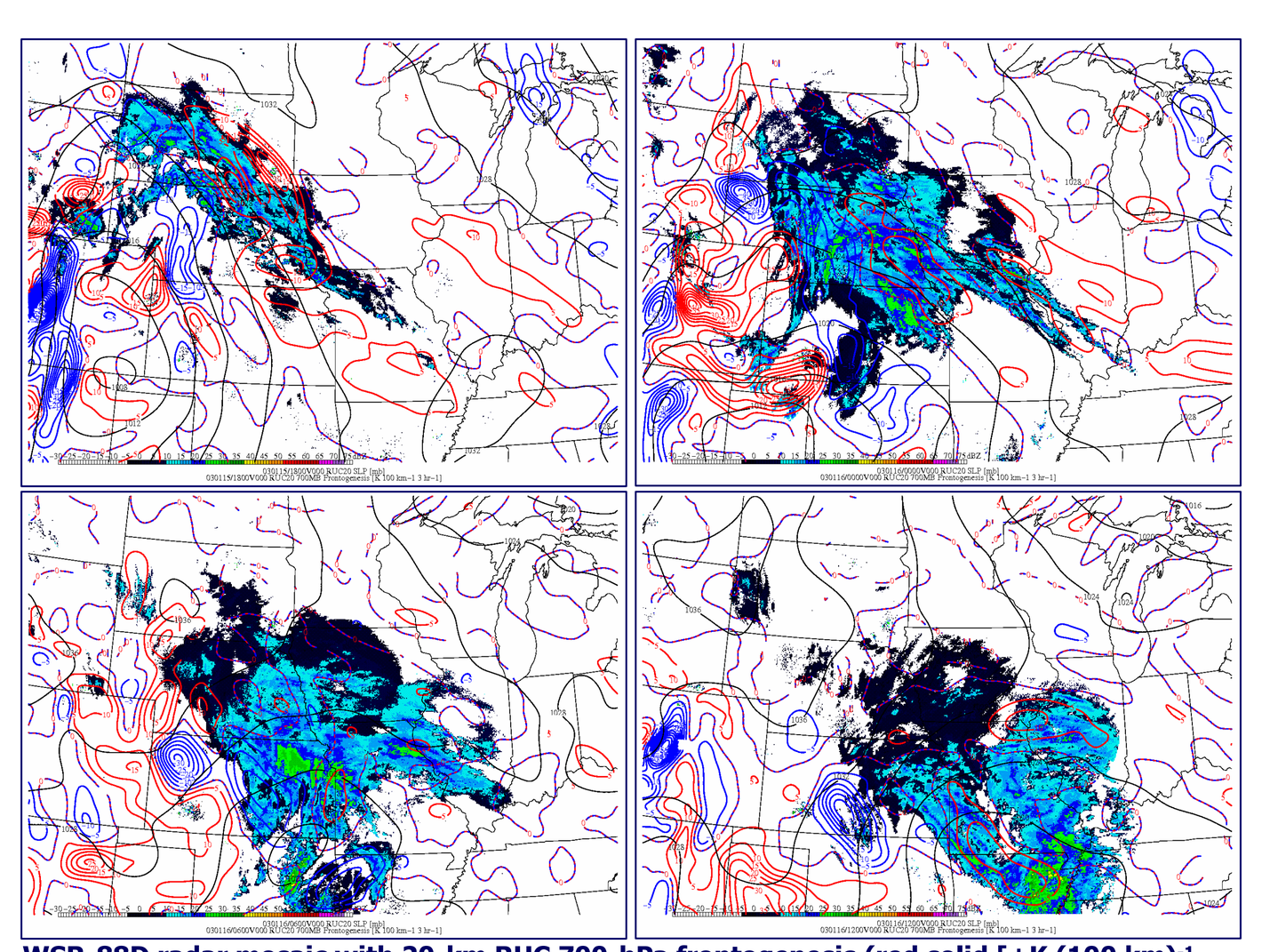
Excerpt from the AFD issued by the LSX WFO at 2015 UTC (0215 CST) 15 Jan 2003.

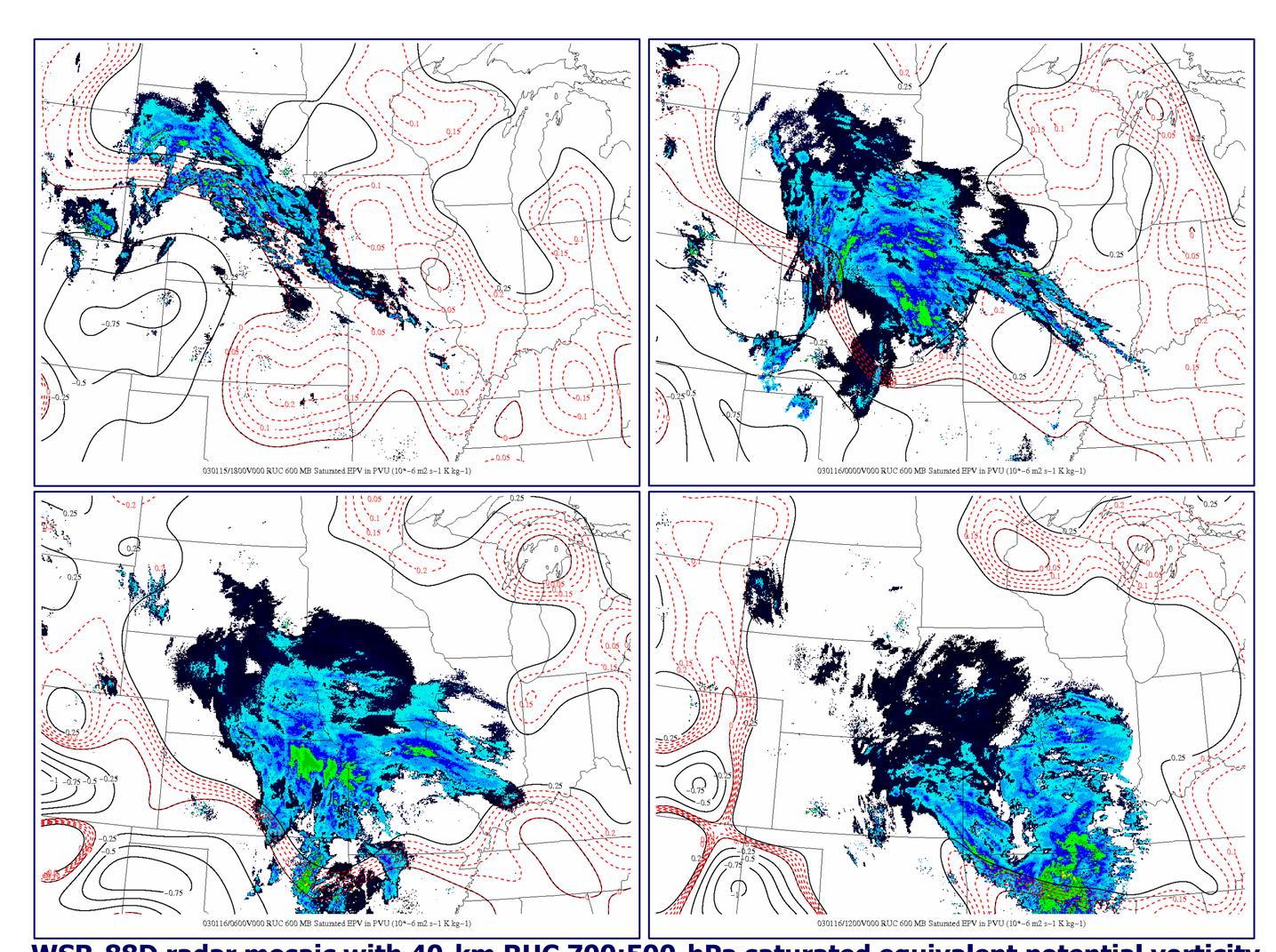


Central Region WFO forecast snowfall accumulation (in.) for the event on 15-16 Jan 2003.

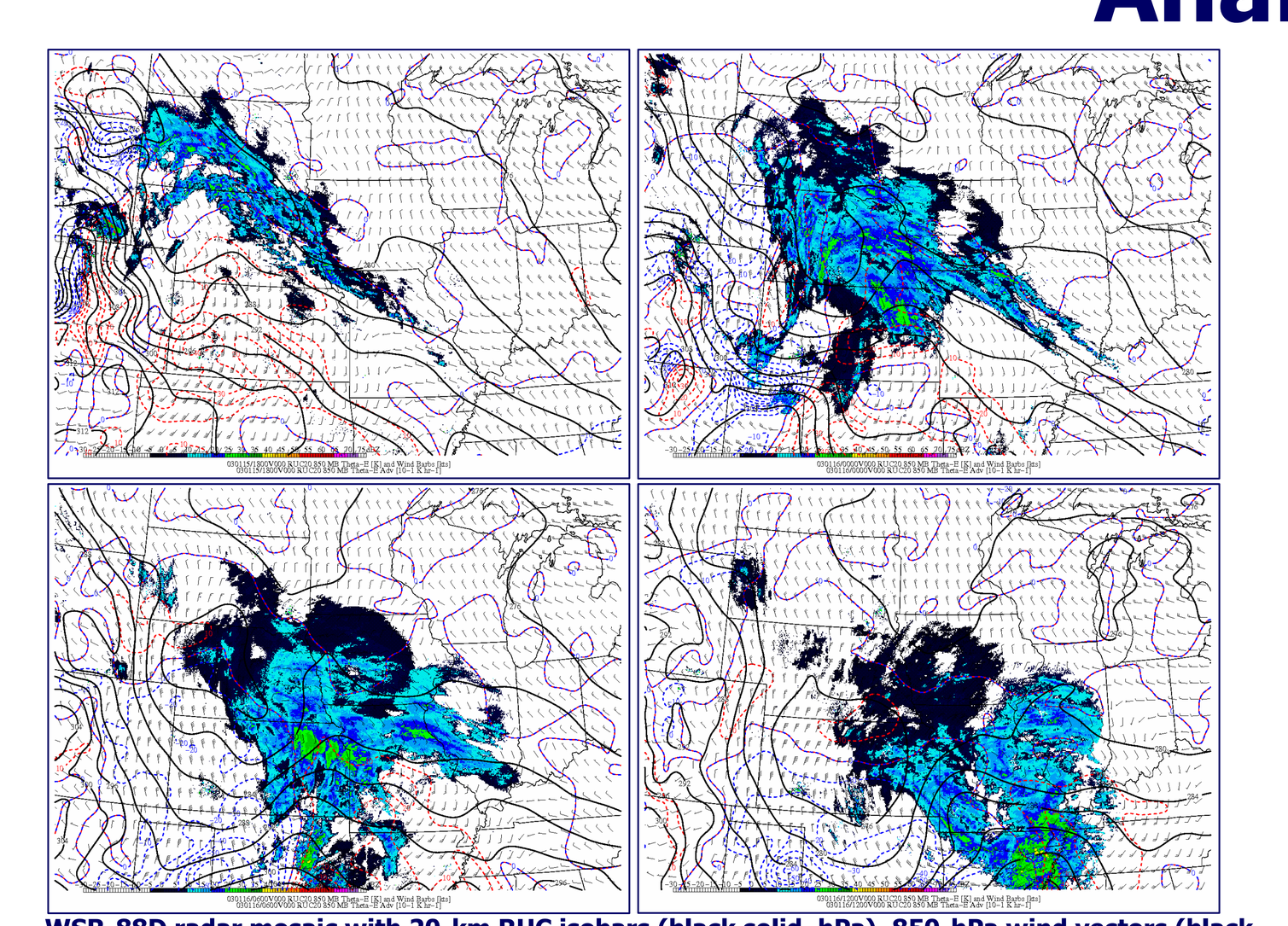
Analysis



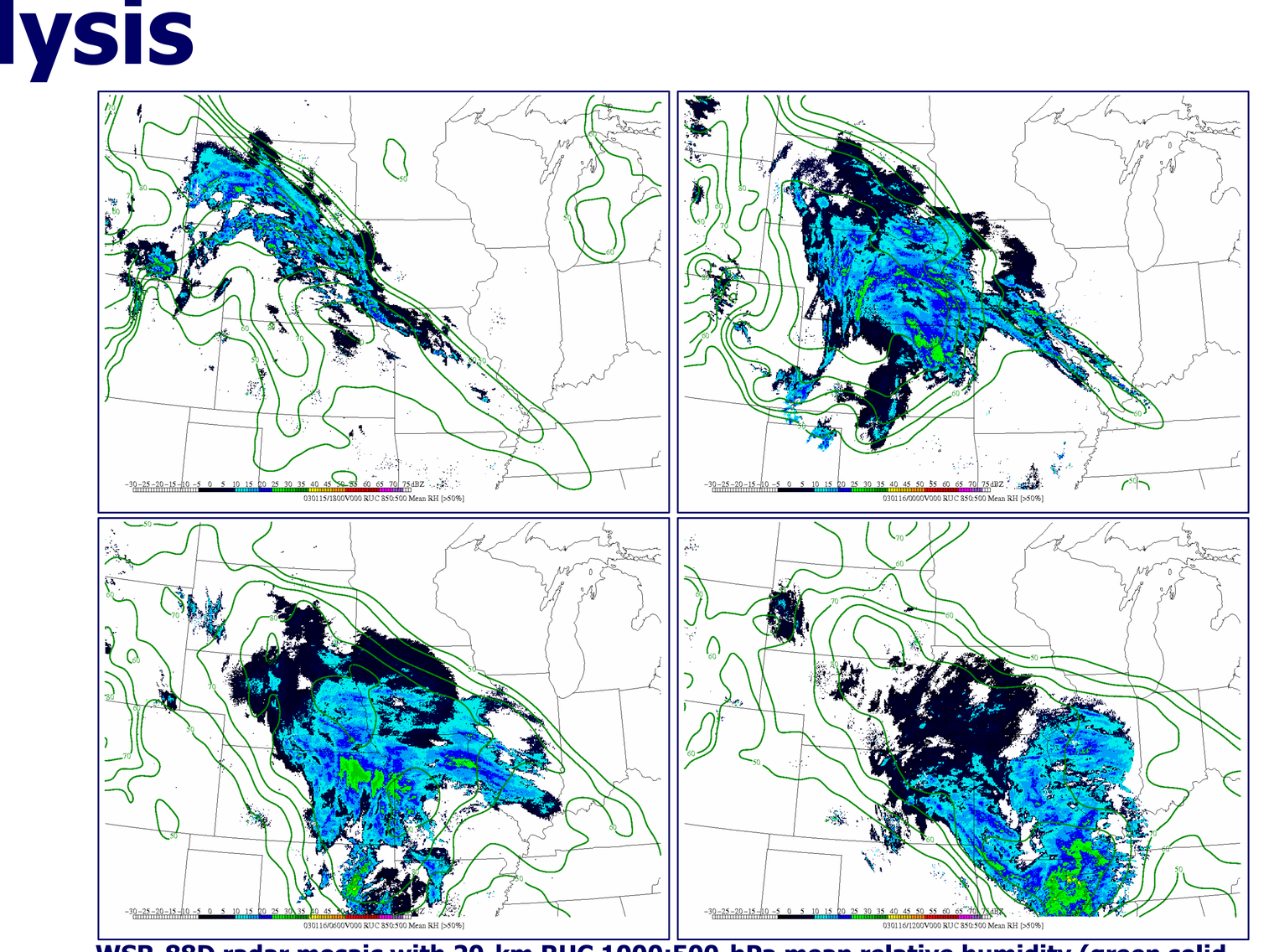
WSR-88D radar mosaic with 20-km RUC 700-hPa frontogenesis (red solid [+K (100 km)$^{-1}$ (3 h)$^{-1}$], blue solid [-K (100 km)$^{-1}$ (3 h)$^{-1}$]) analysis: 1800 UTC 15 Jan 2003 (upper left), 0000 UTC 16 Jan 2003 (upper right), 0600 UTC 16 Jan 2003 (lower left), 1200 UTC 16 Jan 2003 (lower right).



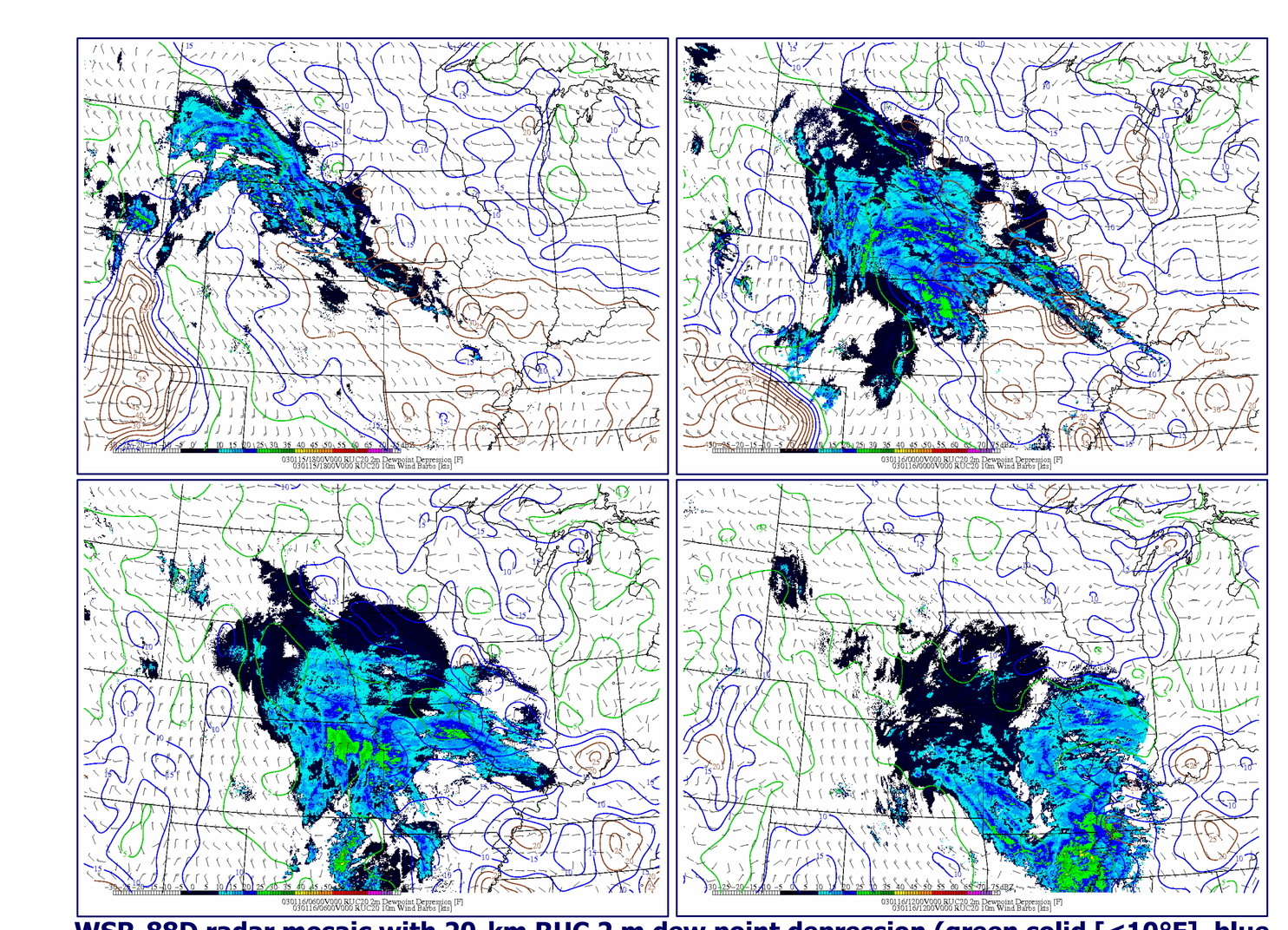
WSR-88D radar mosaic with 40-km RUC 700:500-hPa saturated equivalent potential vorticity (black solid [<0.25 PVU], red dashed [0.25 – 0.00 PVU]) analysis: 1800 UTC 15 Jan 2003 (upper left), 0000 UTC 16 Jan 2003 (upper right), 0600 UTC 16 Jan 2003 (lower left), 1200 UTC 16 Jan 2003 (lower right).



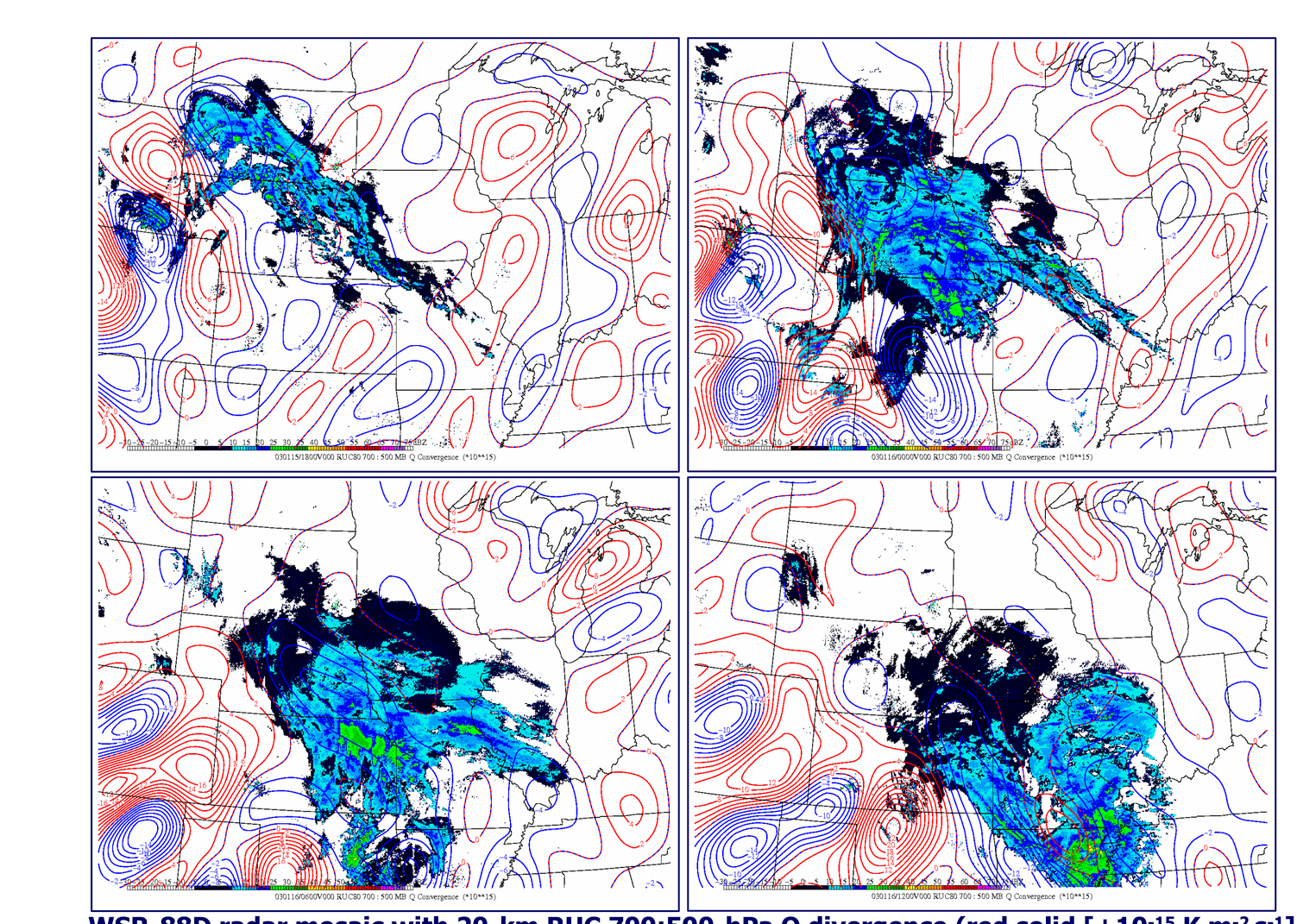
WSR-88D radar mosaic with 20-km RUC isobars (black solid, hPa), 850-hPa wind vectors (black, kts), and 850-hPa θ_e advection (red dashed [+10^{-1} K hr^{-1}], blue dashed [-10^{-1} K hr^{-1}]) analysis: 1800 UTC 15 Jan 2003 (upper left), 0000 UTC 16 Jan 2003 (upper right), 0600 UTC 16 Jan 2003 (lower left), 1200 UTC 16 Jan 2003 (lower right).



WSR-88D radar mosaic with 20-km RUC 1000:500-hPa mean relative humidity (green solid, >50%) analysis: 1800 UTC 15 Jan 2003 (upper left), 0000 UTC 16 Jan 2003 (upper right), 0600 UTC 16 Jan 2003 (lower left), 1200 UTC 16 Jan 2003 (lower right).



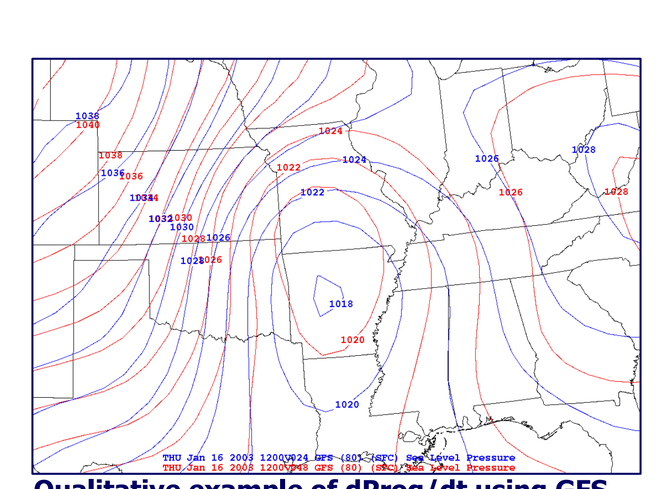
WSR-88D radar mosaic with 20-km RUC 2 m dew point depression (green solid [<10°F], blue solid [10-20°F], brown solid [>20°F]) and 10 m wind vectors (black, kts) analysis: 1800 UTC 15 Jan 2003 (upper left), 0000 UTC 16 Jan 2003 (upper right), 0600 UTC 16 Jan 2003 (lower left), 1200 UTC 16 Jan 2003 (lower right).



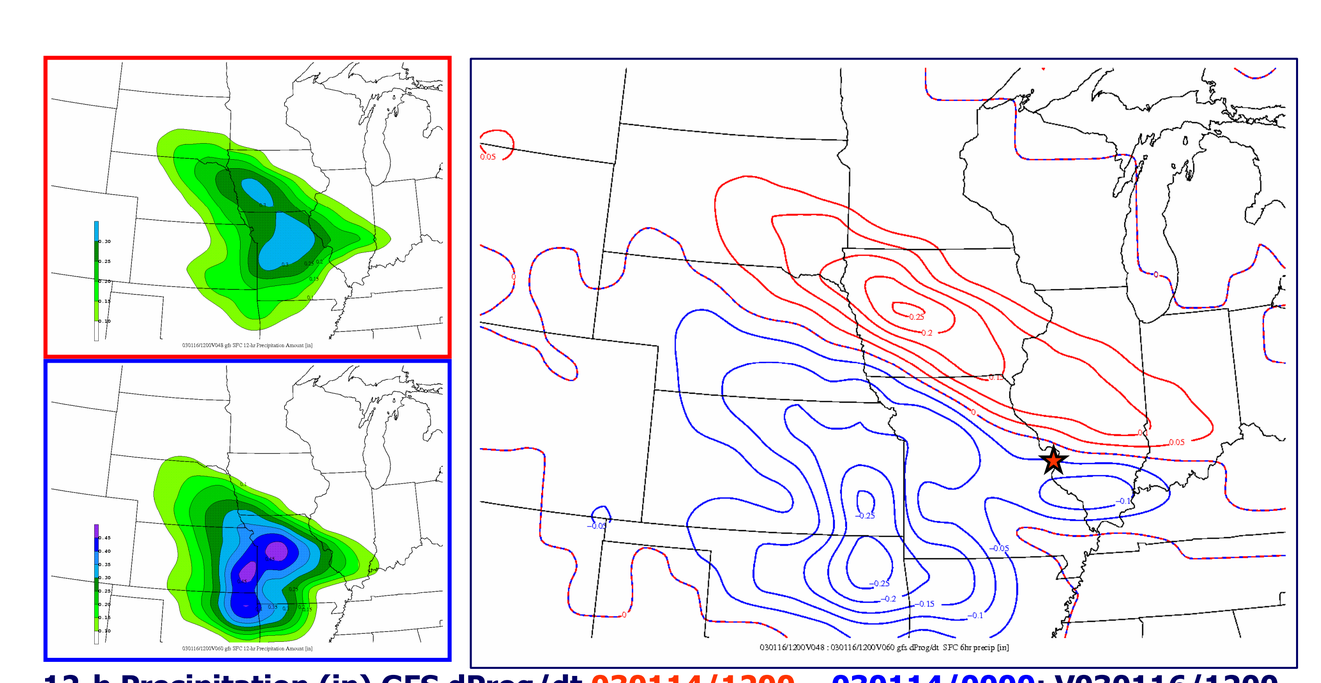
WSR-88D radar mosaic with 20-km RUC 700:500-hPa Q divergence (red solid [+10^{-15} K m^{-2} s^{-1}], blue solid [-10^{-15} K m^{-2} s^{-1}]) analysis: 1800 UTC 15 Jan 2003 (upper left), 0000 UTC 16 Jan 2003 (upper right), 0600 UTC 16 Jan 2003 (lower left), 1200 UTC 16 Jan 2003 (lower right).

GFS dProg/dt

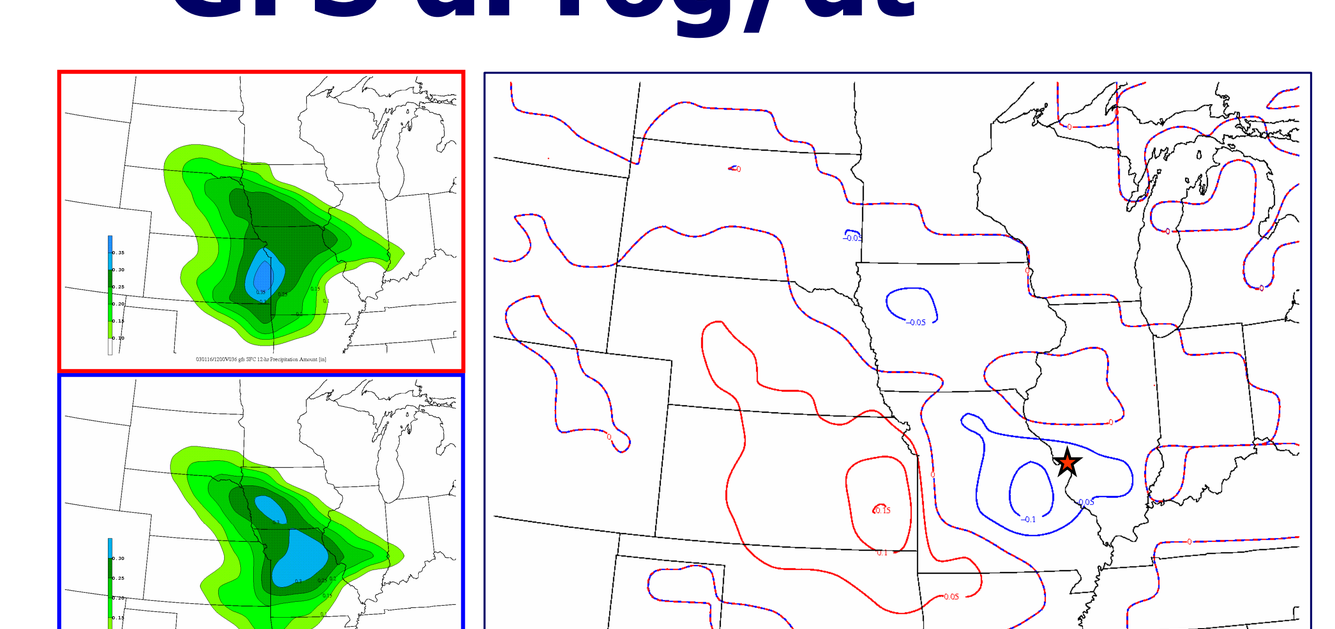
- An evaluation of trends in lagged forecasts.
- Example: SLP dProg/dt is negative, meaning that more recent NWP forecasts are trending deeper with the surface cyclone.
- Most common approach is a qualitative analysis; overlaying two different forecasts valid at the same time.
- My method:
- Plot the difference of the most recent GFS forecast with the previous forecast, 12 hours earlier.
- Quantitative approach.
- Easier to pick out patterns with the trends.



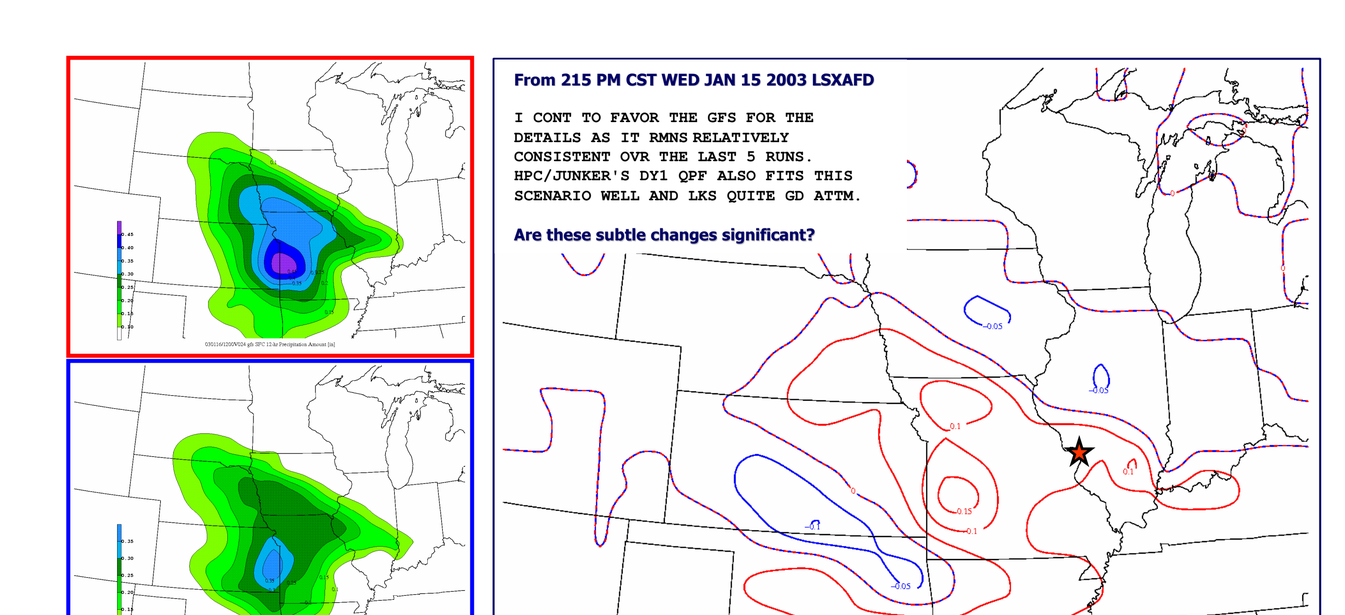
Qualitative example of dProg/dt using GFS 030114/1200 (red solid, hPa) and 030115/1200 (blue solid, hPa) both valid at 030116/1200.



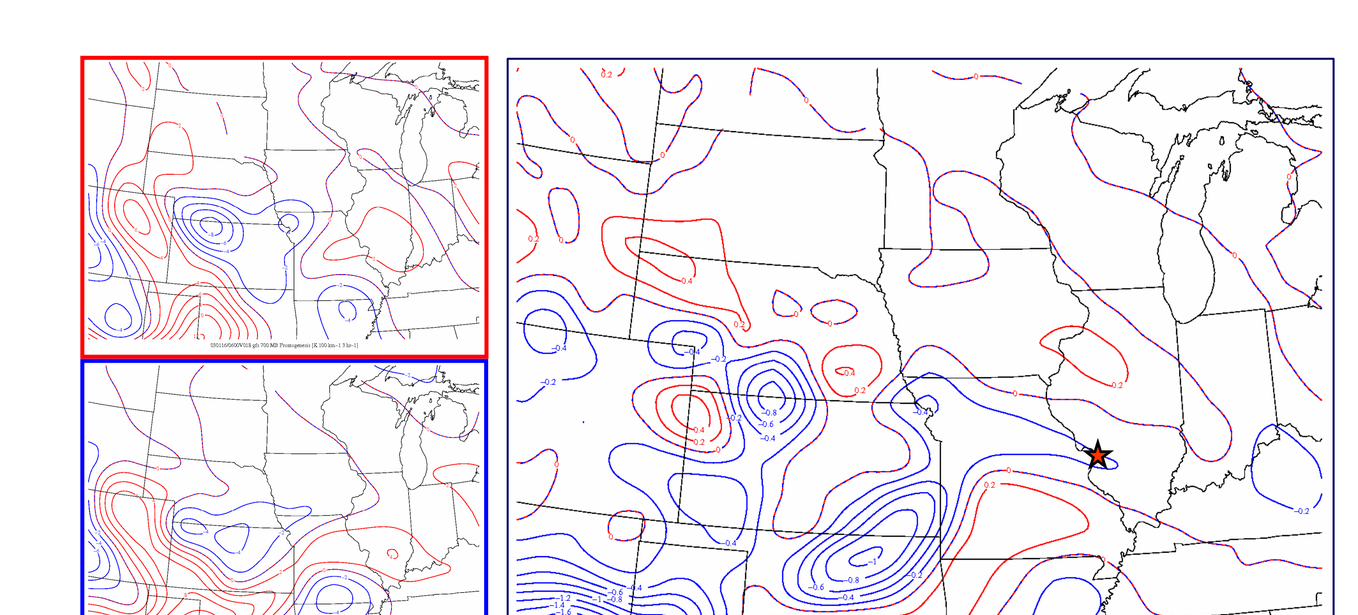
12-h Precipitation (in) GFS dProg/dt 030114/1200 – 030114/0000: V030116/1200



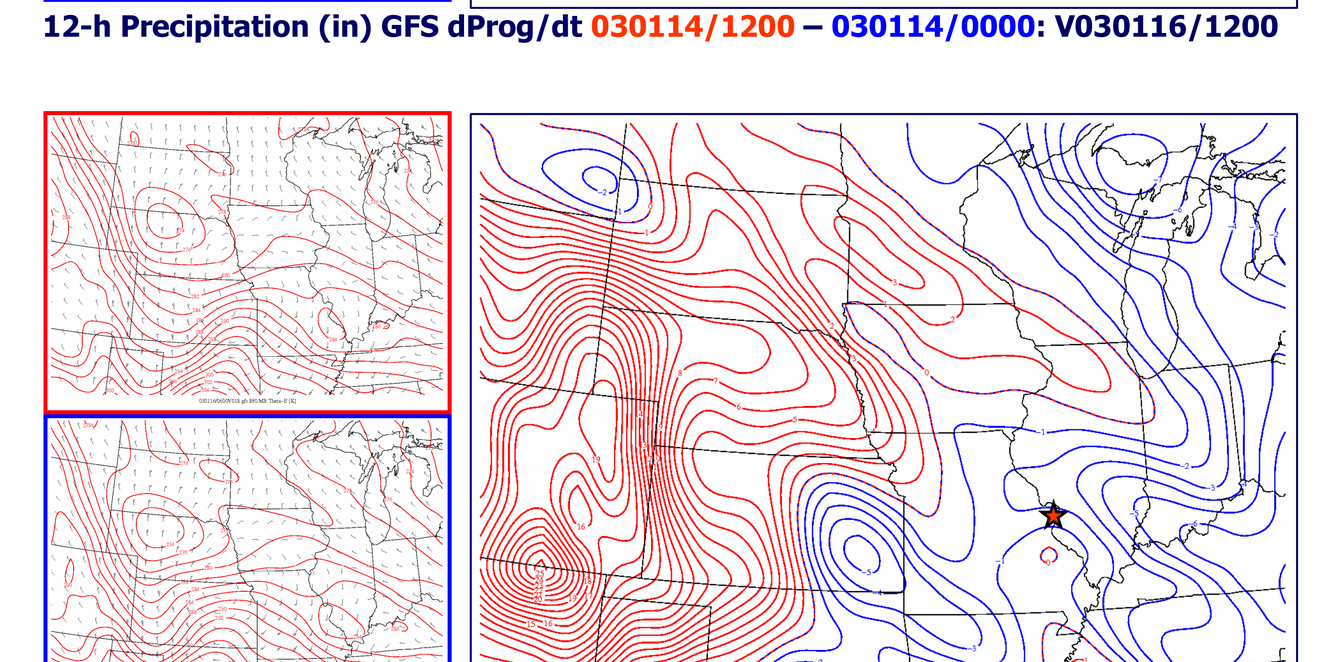
12-h Precipitation (in) GFS dProg/dt 030115/0000 – 030114/1200: V030116/1200



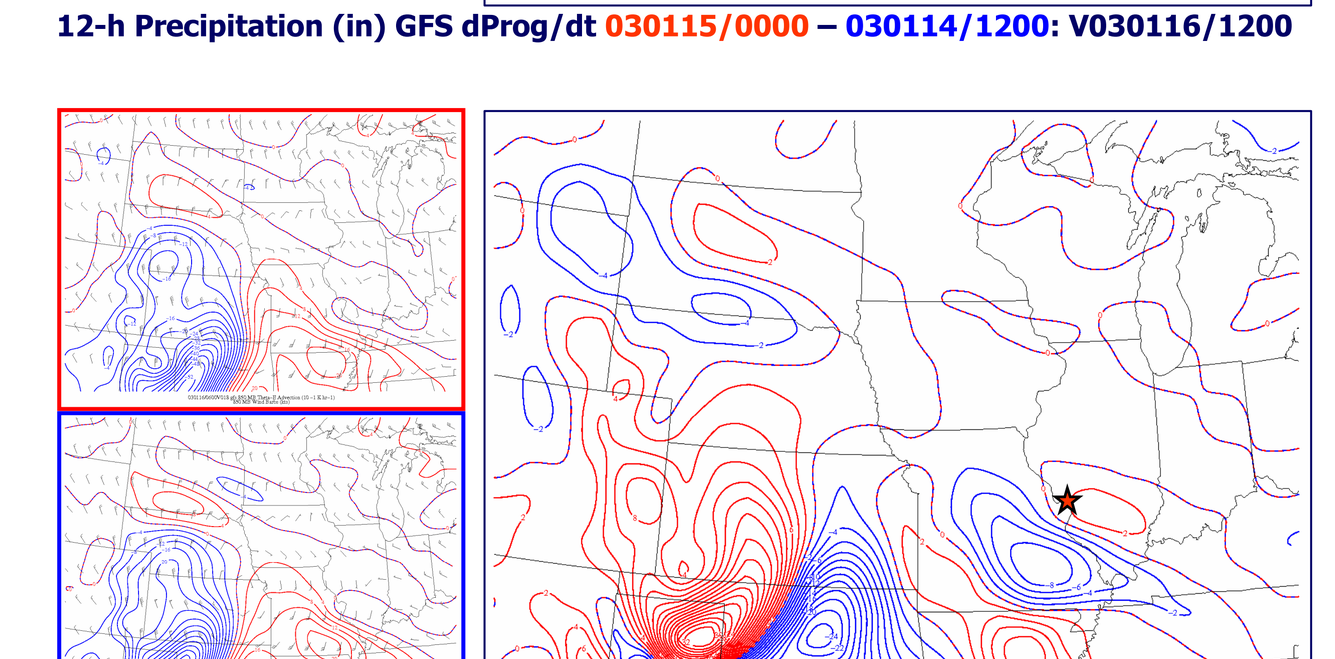
12-h Precipitation (in) GFS dProg/dt 030115/1200 – 030115/0000: V030116/1200



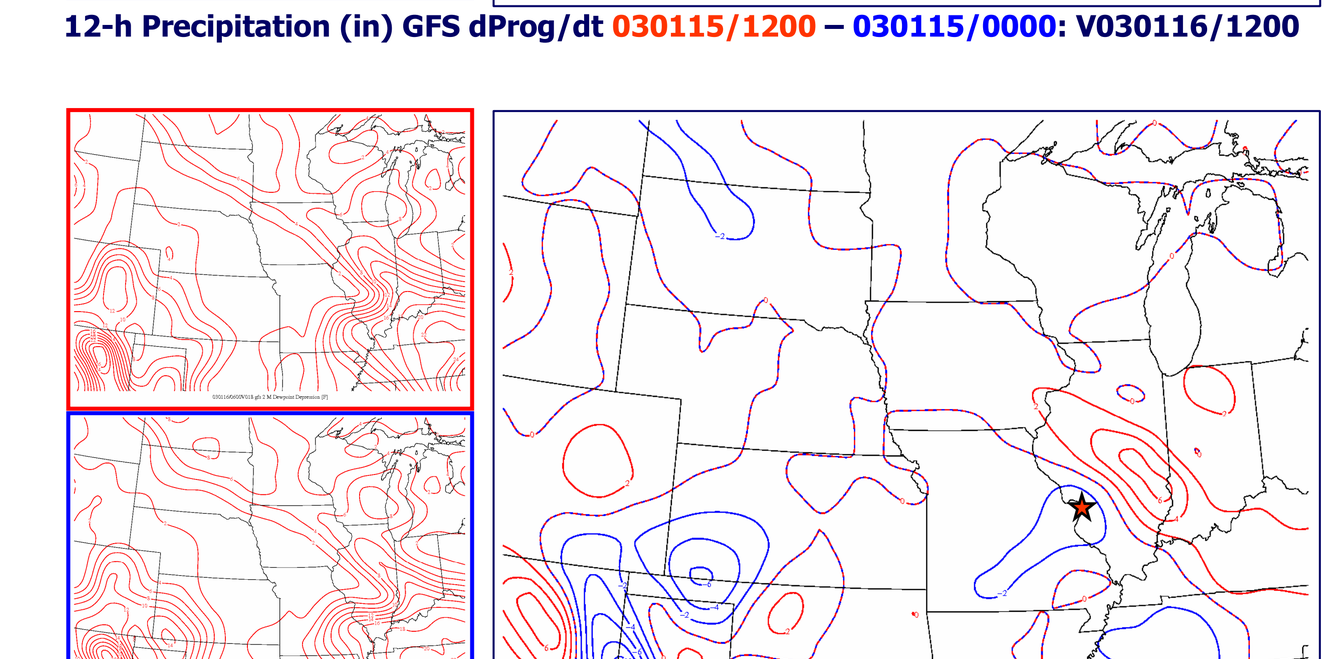
700 Frontogensis GFS dProg/dt 030115/1200 – 030115/0000: V030116/0600



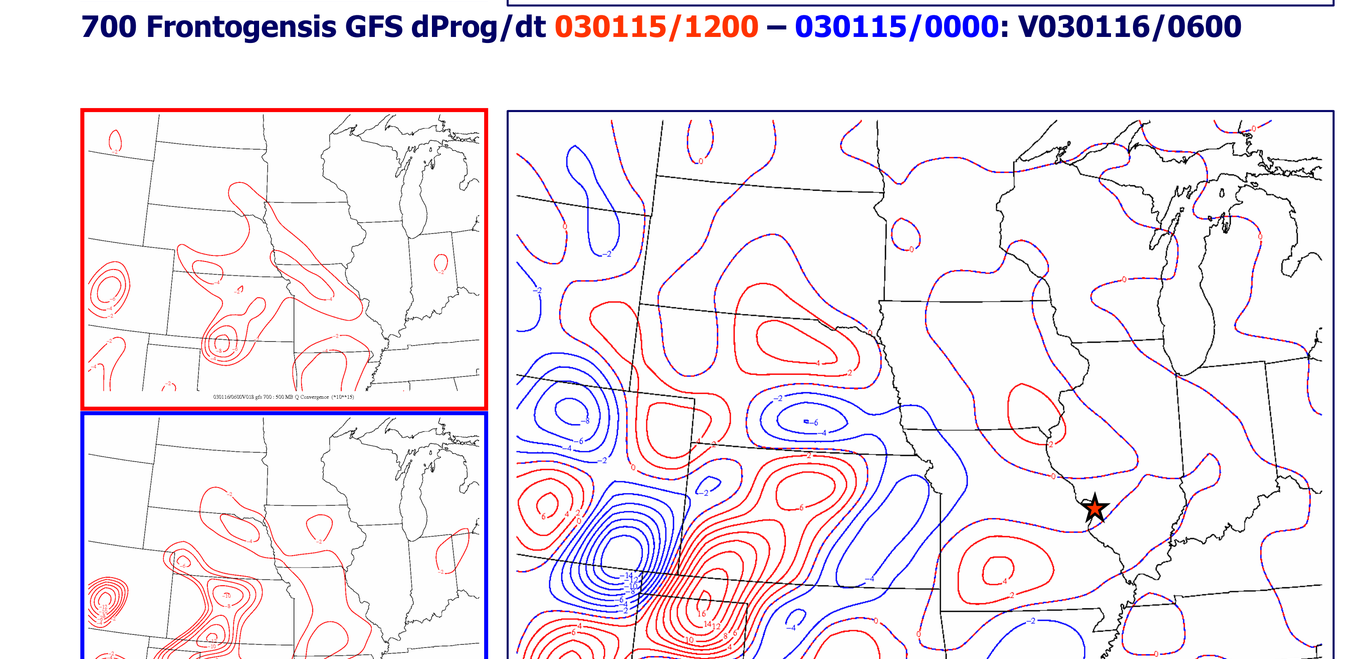
850 θ_e GFS dProg/dt 030115/1200 – 030115/0000: V030116/0600



850 θ_e Advection GFS dProg/dt 030115/1200 – 030115/0000: V030116/0600



Sfc Dewpoint Dep GFS dProg/dt 030115/1200 – 030115/0000: V030116/0600



700:500 Q-Con GFS dProg/dt 030115/1200 – 030115/0000: V030116/0600

Conclusions

- This forecast was not only a bust in the LSX CWA, but also in surrounding offices and nationally at HPC.
- In LSX CWA: Everyone would see 4-5 inches with higher amounts in banding. But in this case, there needed to be mesoscale forcing in combination with large scale forcing to overcome the dry air at the surface.
- In addition, an increasingly stable environment needed to be overcome by mesoscale processes.
- dProg/dt is another tool to interrogate the model.
- Preliminary research indicates that subtle changes in the QPF field and the lack of forcing for mesoscale winter precipitation may have been able to give clues that the QPF was overdone.
- Apply the dProg/dt method to:
  - Cases where NWP accurately predicted and was consistent for a snow event.
  - Additional snowfall "busts".
  - Different models in specific cases. How to choose the model of choice? Does less variability imply accuracy?
  - What is the significance of the magnitudes/patterns?
- This research was made possible by the NOAA-CSTAR program.
- This presentation can be viewed on the CIPS website at: www.eas.slu.edu/CIPS/Presentations