Radar Radial Velocity Data Assimilation Using WRFDA-3DVAR over the Central United States and its Impact on 0-12 hour Precipitation Forecast

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Objectives

- To evaluate the 0-12 hour precipitation forecast skill of WRFDA-3DVAR with radar radial velocity assimilation over a consecutive period

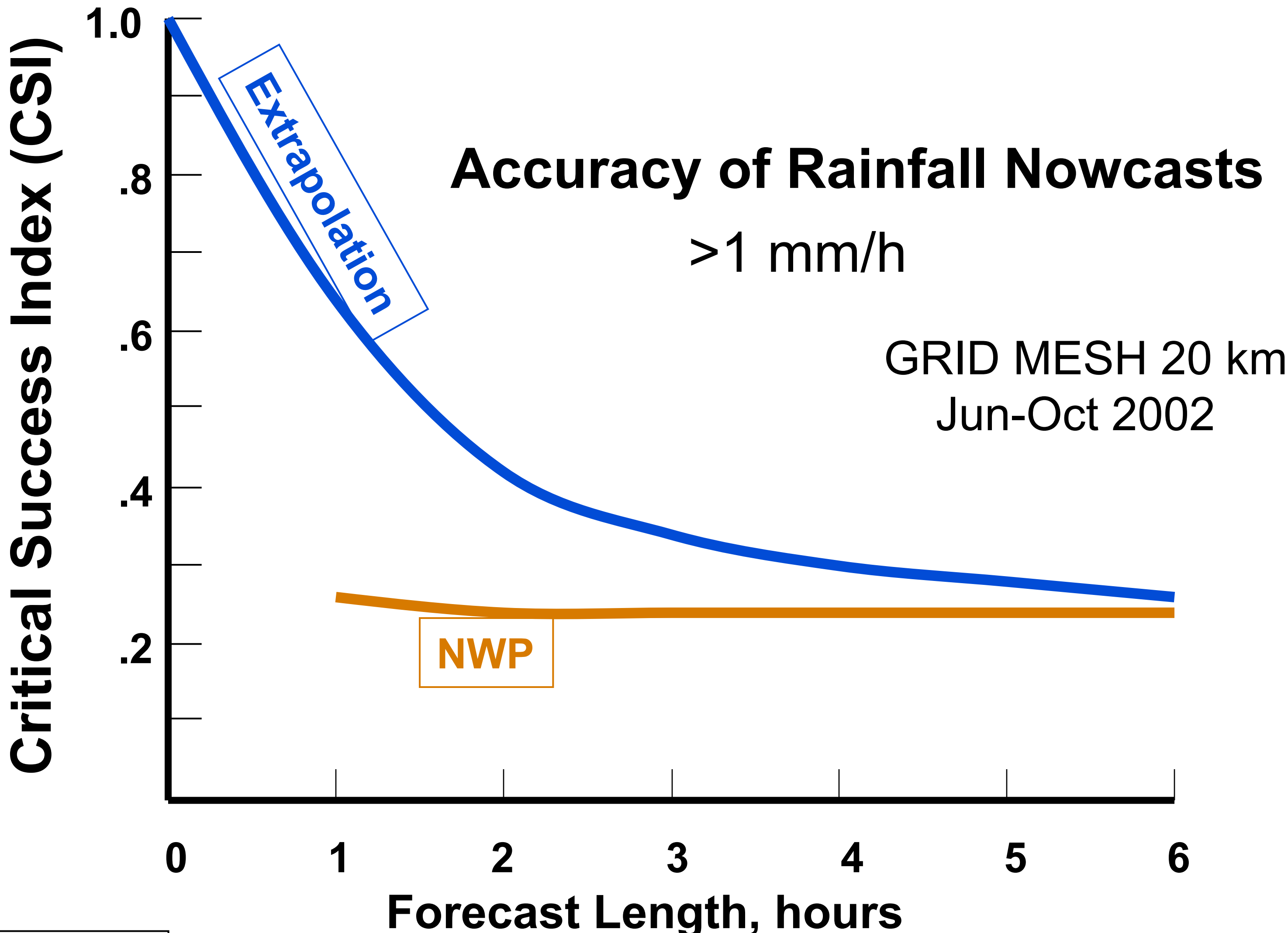
  - 10-16 2002 over IHOP domain

- To compare the sensitivity of WRF forecast with respect to initialization (with and without radar) and with respect to physics

- To diagnose the physical cause of the success or failure with radar data assimilation

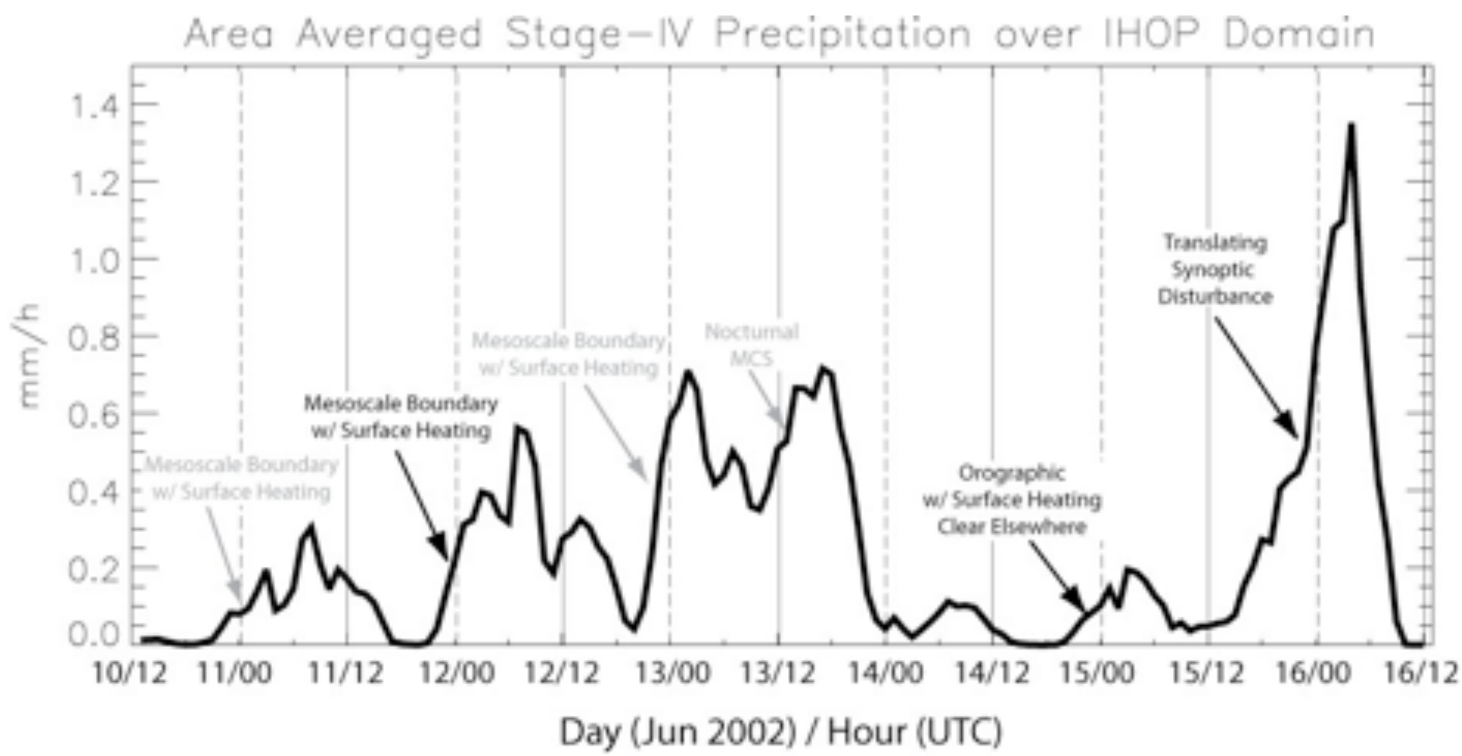
- To determine what is needed for further improvement of WRF radar data assimilation

Why focus on 0-12 hours?



Courtesy of
Shingo Yamada
JMA

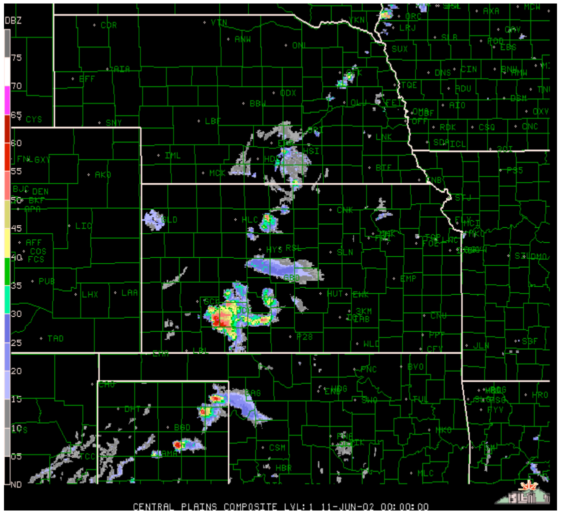
Time sequence of area averaged stage IV precipitation during 10-16 2002



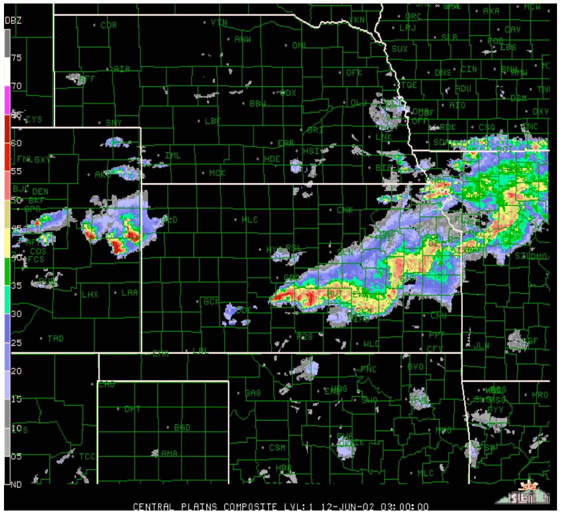
22 initiation episodes according to Wilson and Roberts (2005)

Major convective systems during 10-16 June 2002

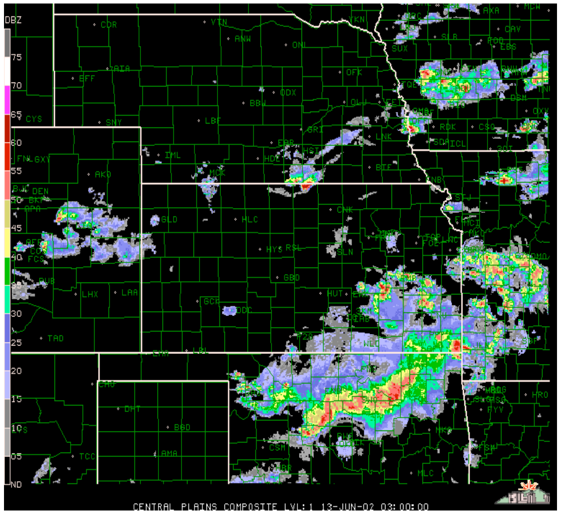
06/11/02 00 UTC Radar



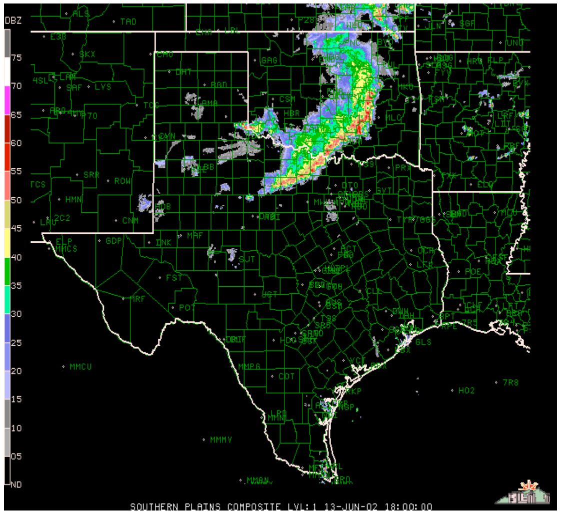
06/12/02 03 UTC Radar



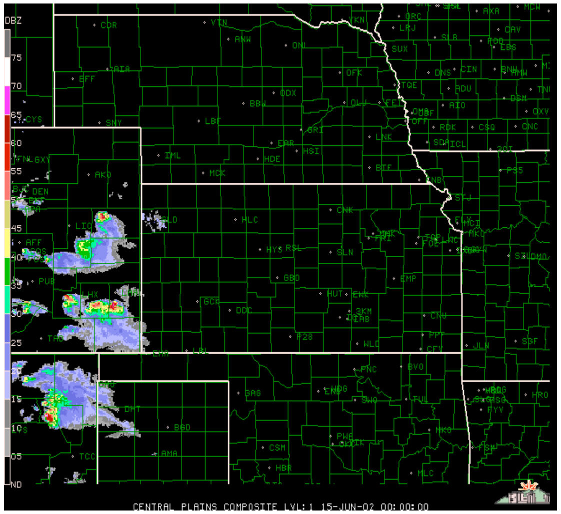
06/13/02 03 UTC Radar



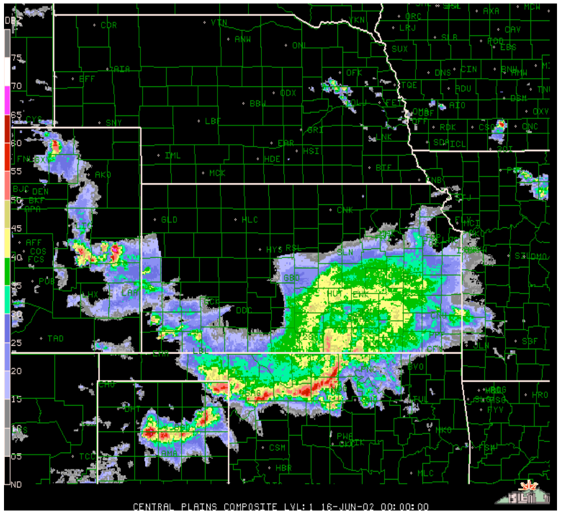
06/14/02 18 UTC Radar



06/15/02 00 UTC Radar

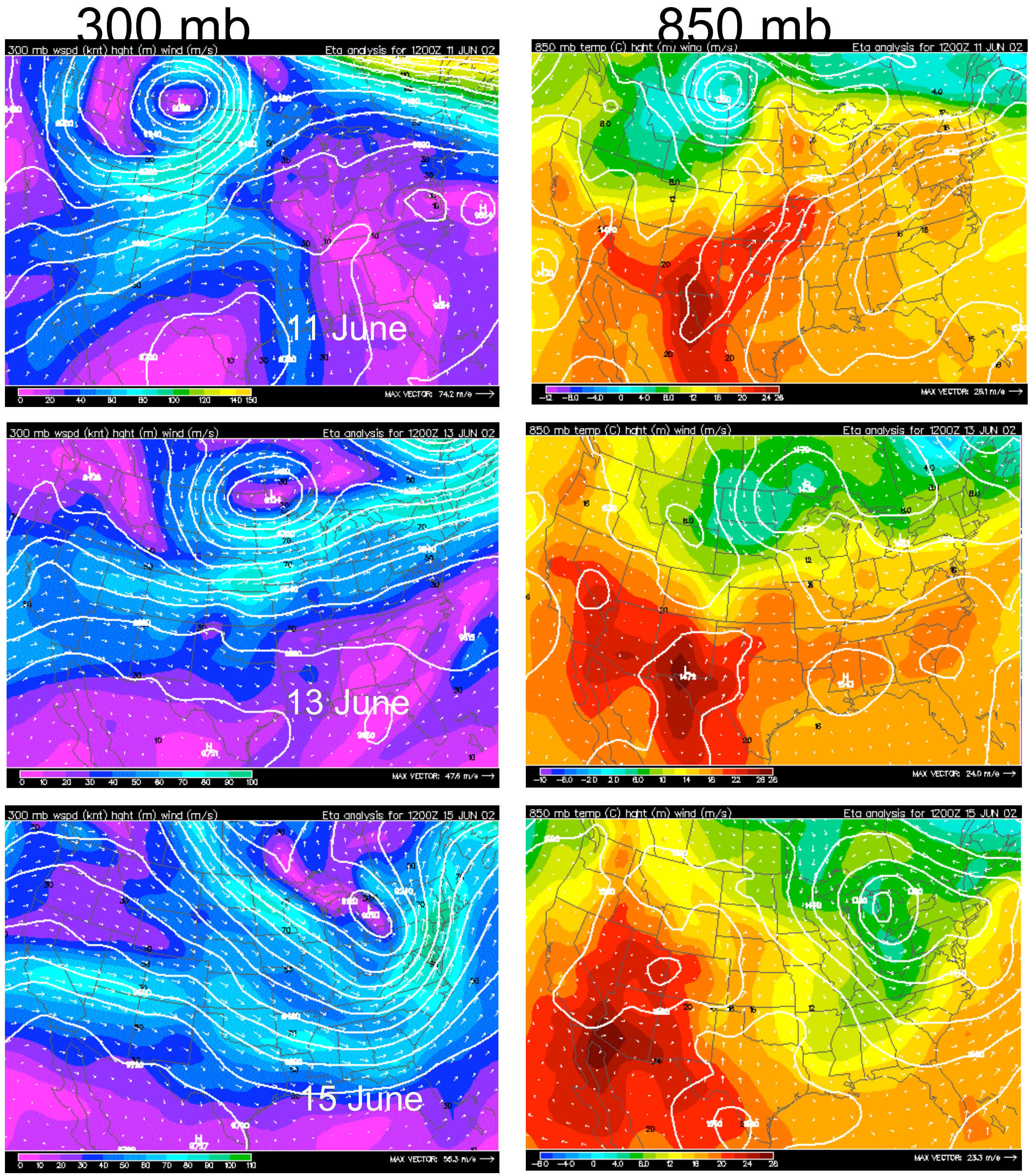


06/16/02 00 UTC Radar



Large-scale flow pattern of the IHOP period 10-16 June

- Strong upper level trough progressed eastward
- Short-waves
- Surface: moist, unstable air to cold front



Summary of experiments

CTRL Baseline run initialized by ETA analysis MYJ PBL, Thompson microphysics

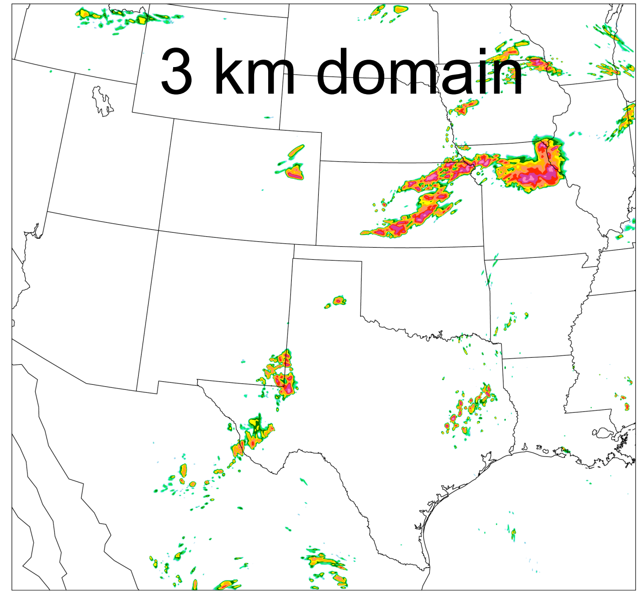
GFS Same as CTRL but initialized by GFS global analysis

WRFDA WRF 3DVAR with 3-hourly update cycle radial velocity data assimilation

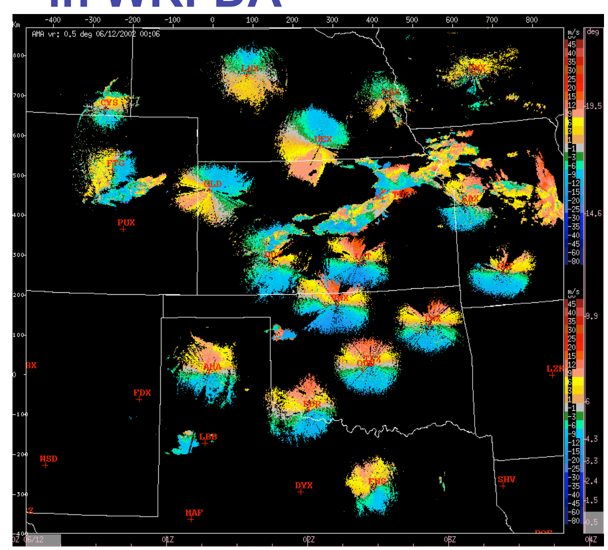
WSM6 Same as CTRL but with WSM6 microphysics

YSU Same as CTRL but with YSU PBL

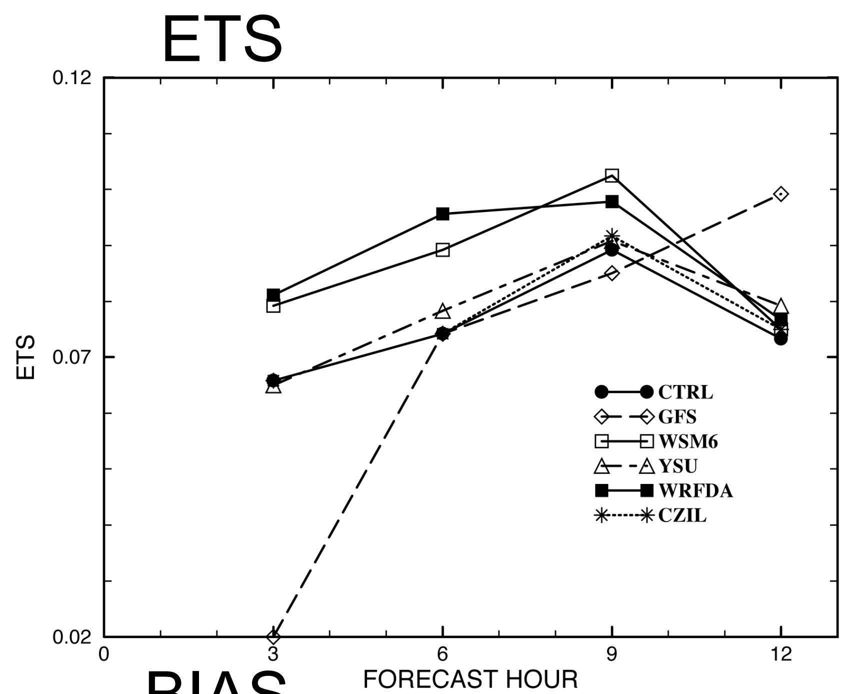
CZIL Same as CTRL but with variable CZIL (determines the strength of coupling between surface and atmosphere)



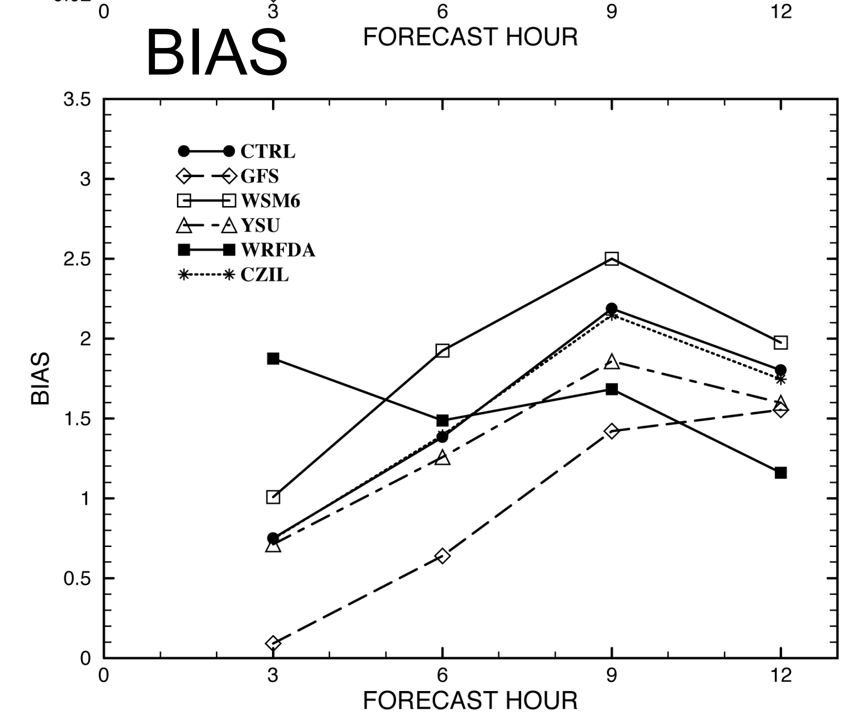
25 NEXRADs assimilated in WRFDA



ETS (a) and Bias (b) of 3-hourly precipitation exceeding 5mm h-1 as a function of forecast time for six experiments



- WRFDA and WSM6 has the highest ETS
- WSM6 has high bias
- Forecasts are more sensitive to initialization than to physics
- GFS has 6 hour spin-up period

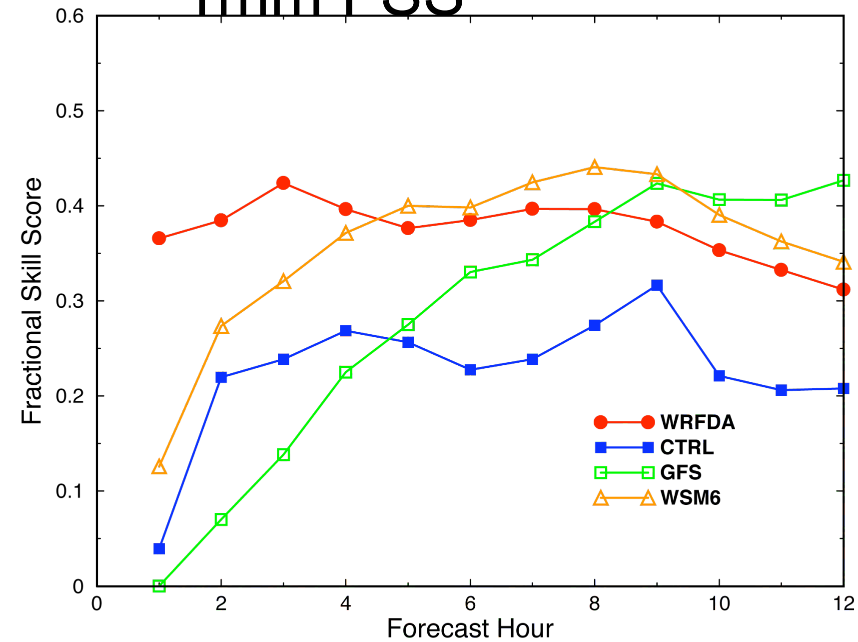


Fractional Skill Score of hourly precipitation exceeding (a) 1mm

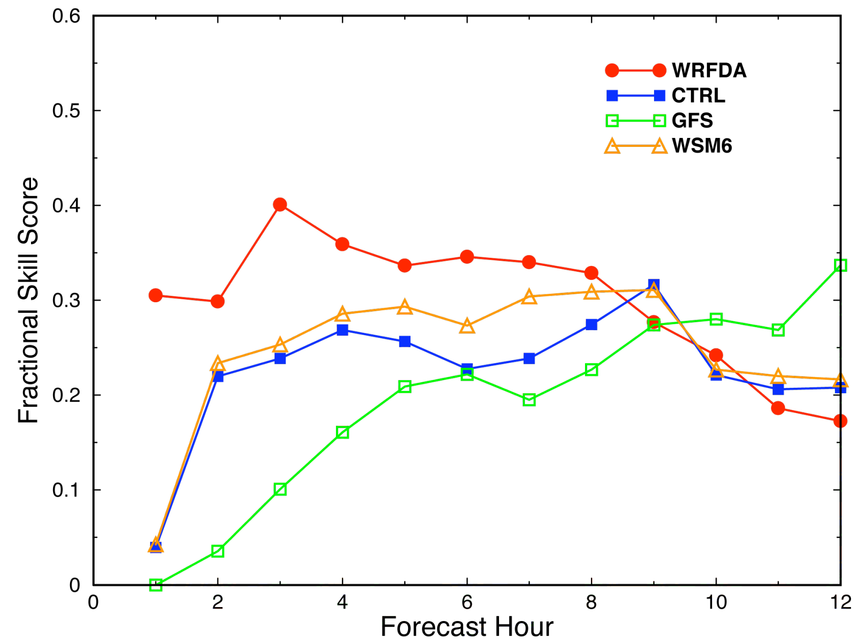
and (b) 5mm h^{-1} as a function of time aggregated over all days of IHOP_RETR with a radius of influence of 50 km.

- For both thresholds, WRFDA gives significant higher scores than CTRL
- WRFDA initiates convection within one hour
- WRFDA has better score in the first 8 hours at 5 mm threshold

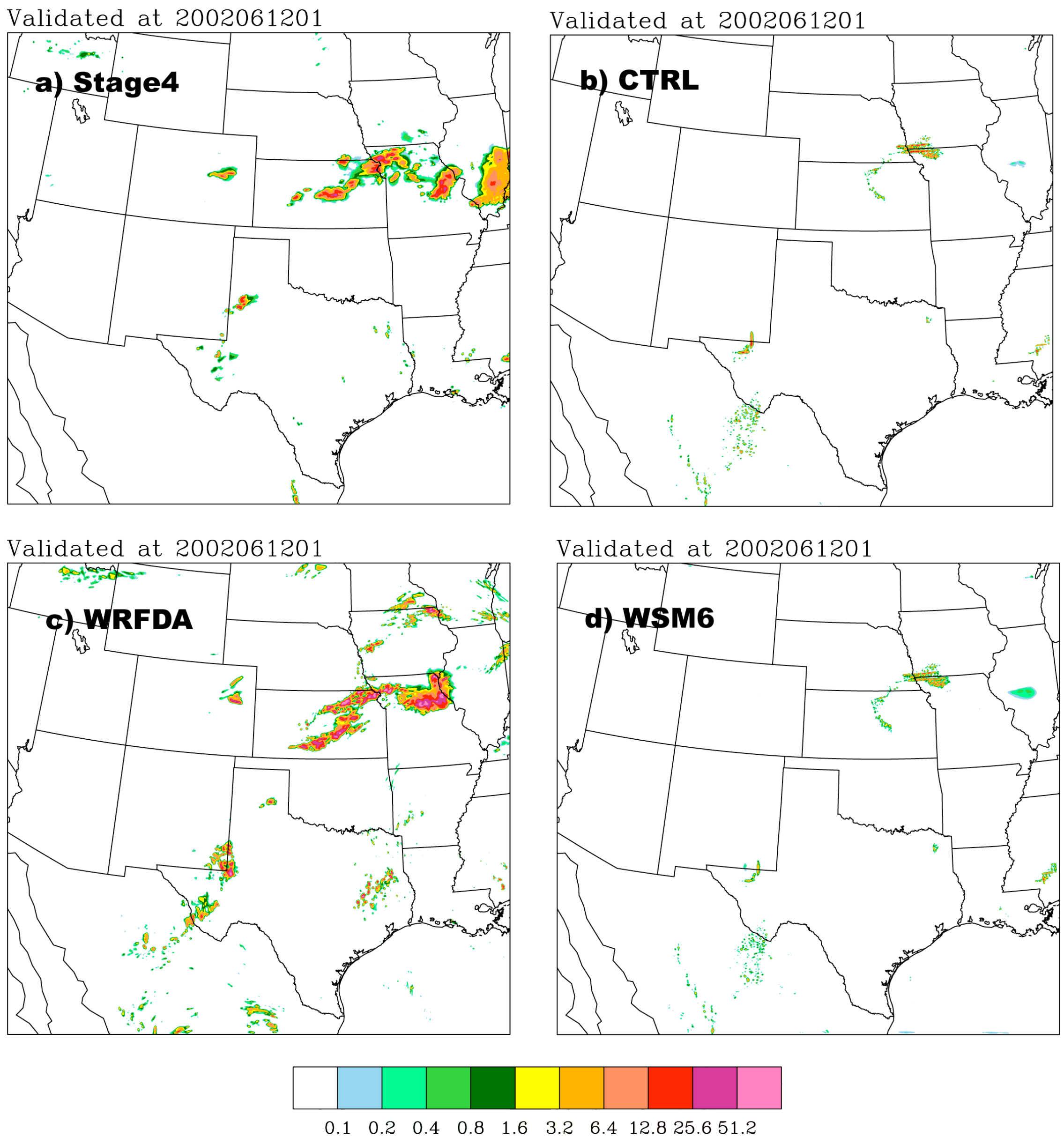
1mm FSS



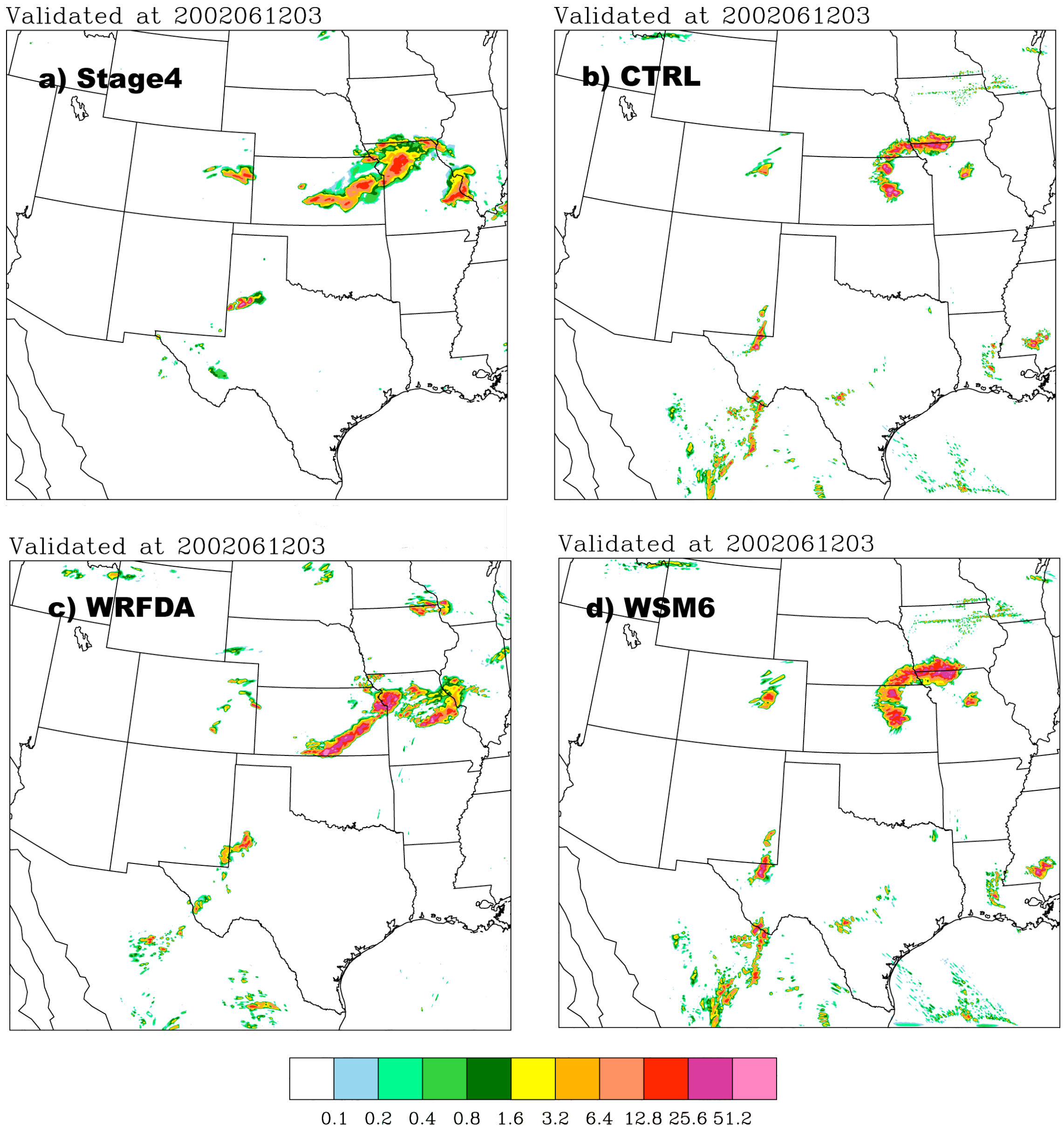
5mm FSS



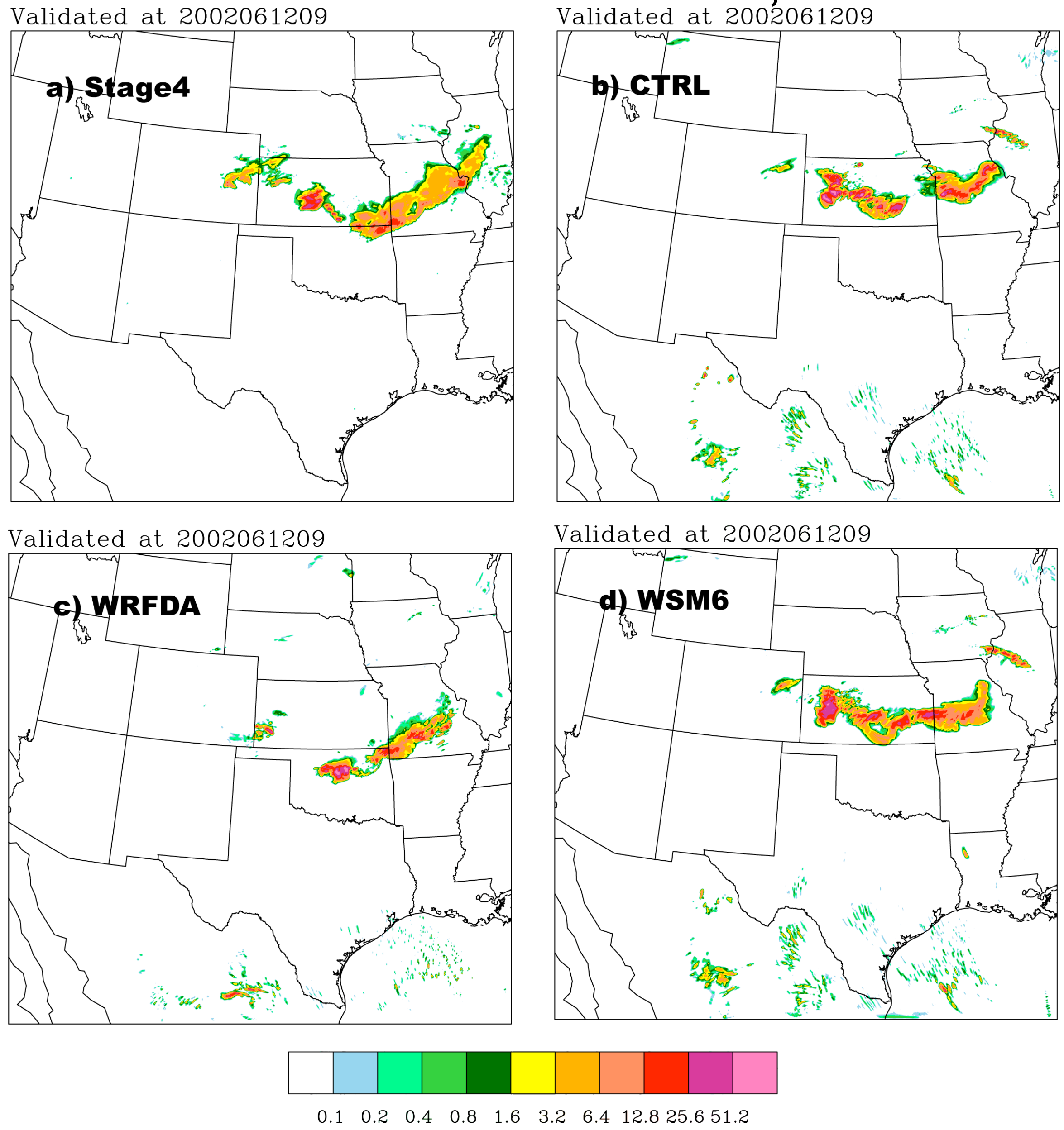
1-hour forecast of hourly precipitation valid at 01 UTC on **June 12**, 2002.



3-hour forecast of hourly precipitation valid at 03 UTC on June 12, 2002.

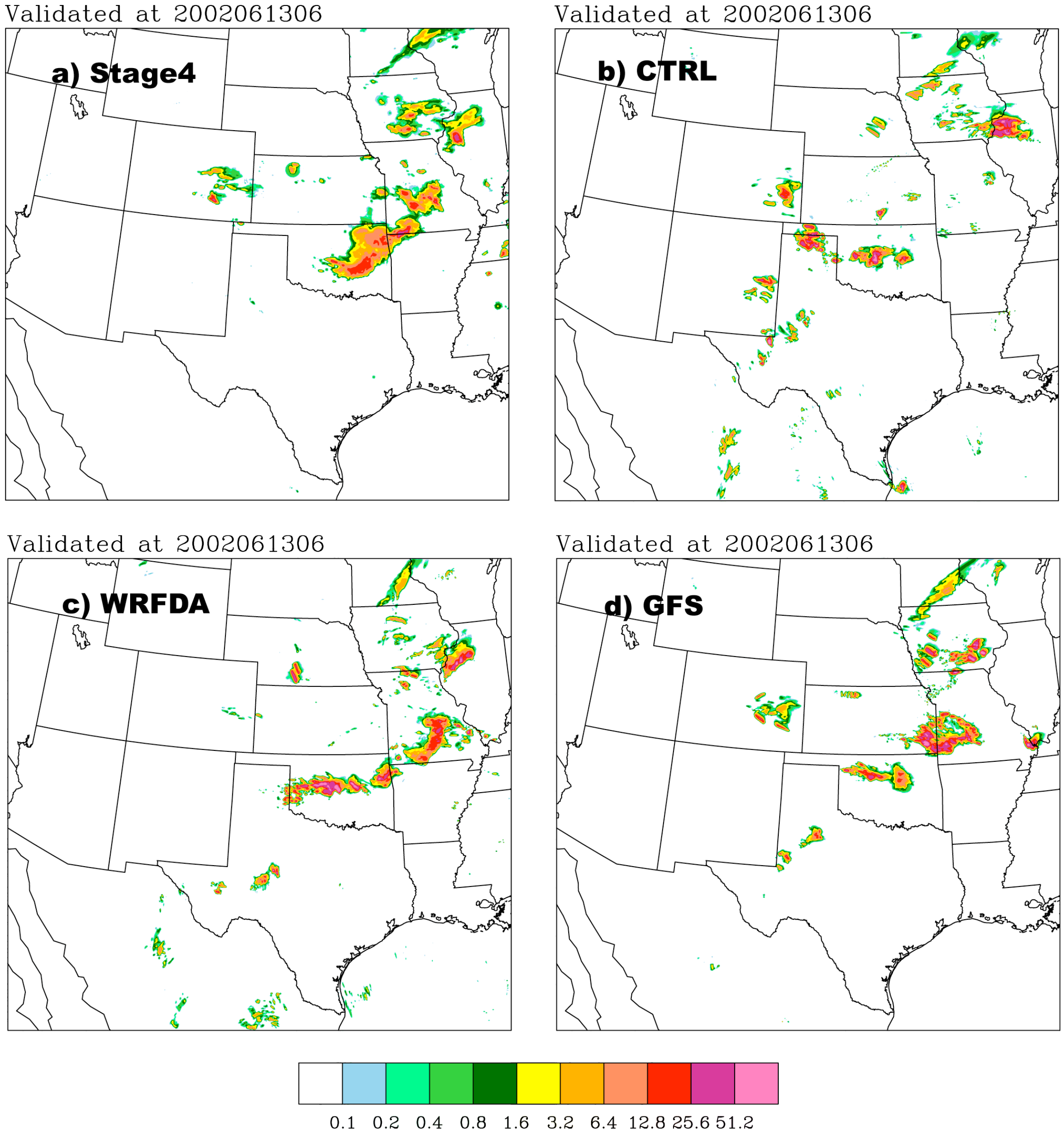


9-hour forecast of hourly precipitation valid at 09 UTC on June 12, 2002.

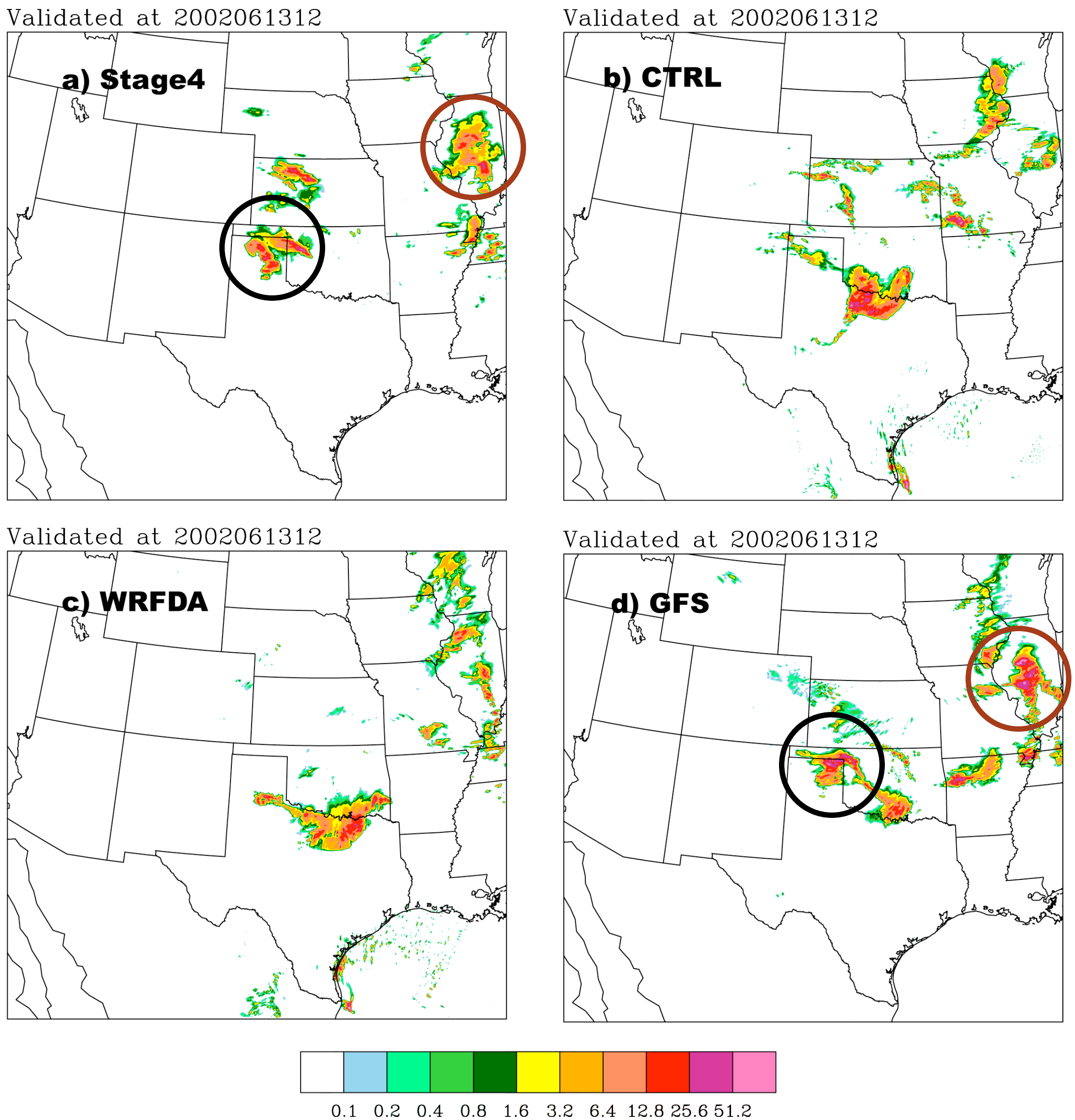


6-hour forecast of hourly precipitation valid at

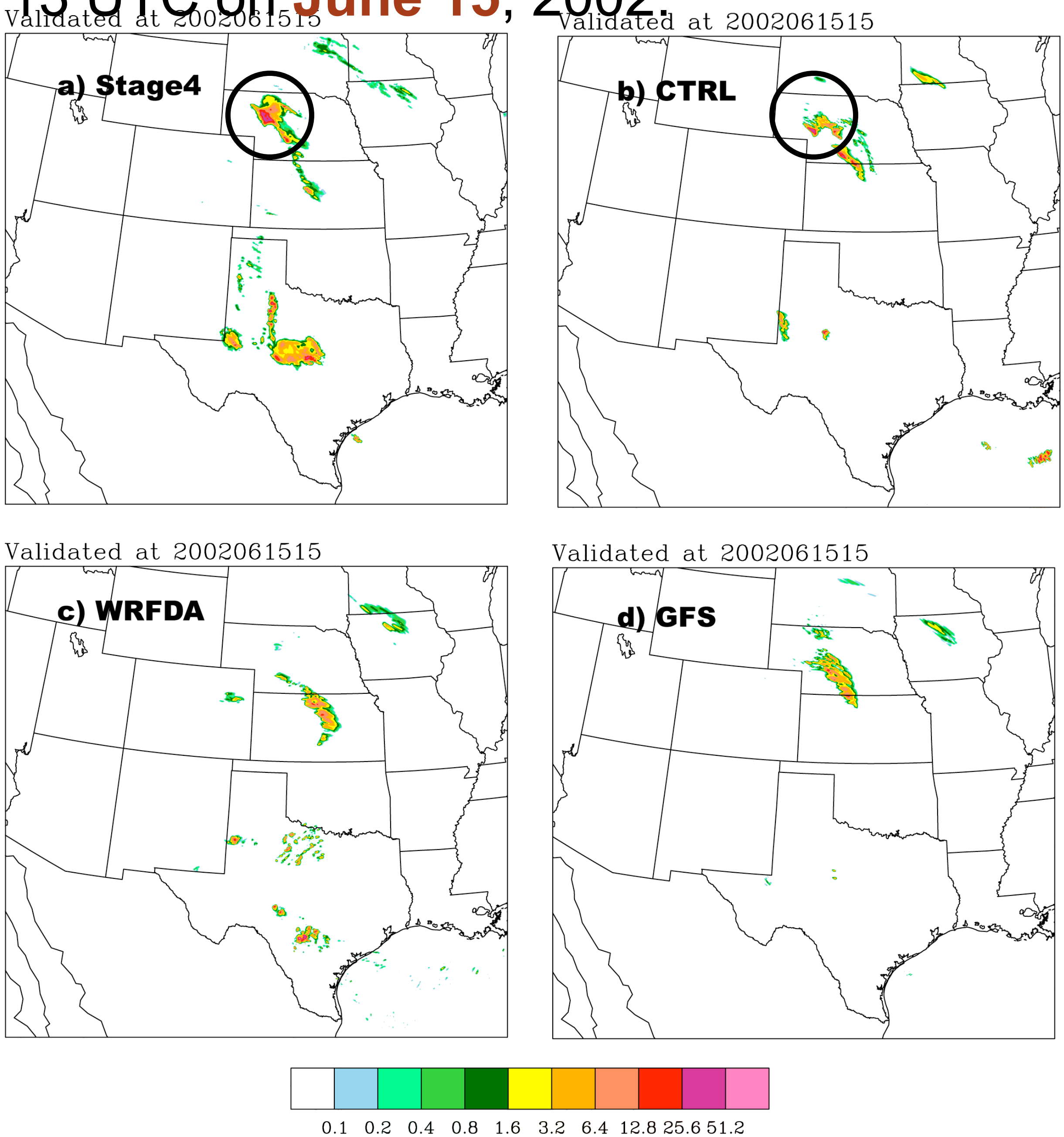
06 UTC on **June 13**, 2002.



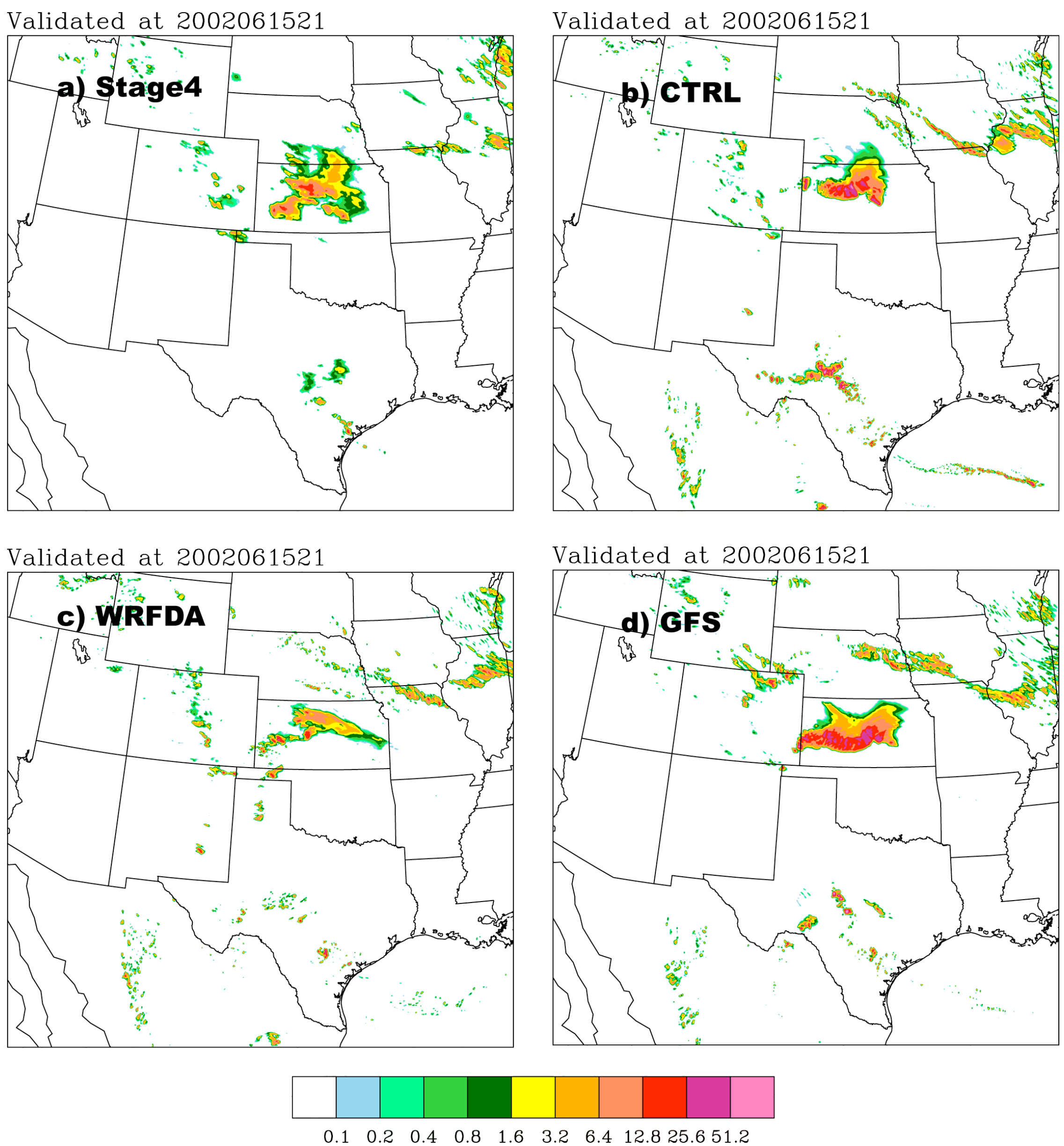
12-hour forecast of hourly precipitation valid at 12 UTC on June 13, 2002.



1-hour forecast of hourly precipitation valid at 13 UTC on **June 15**, 2002.



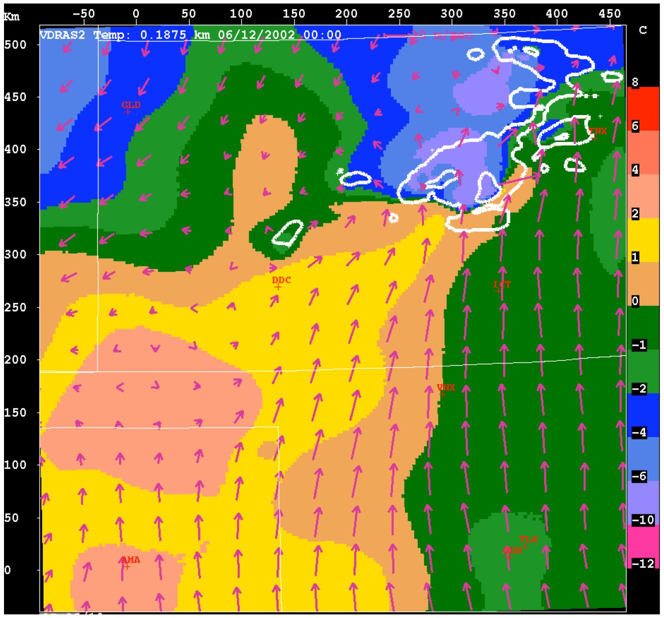
9-hour forecast of hourly precipitation valid at 21 UTC on **June 15**, 2002.



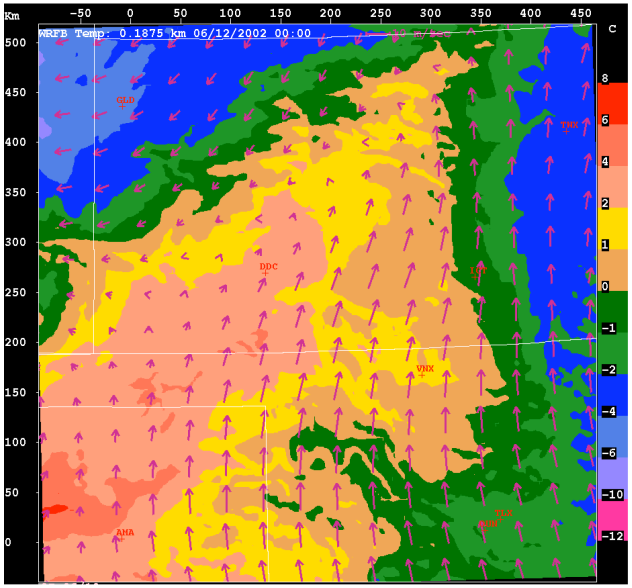
Cold pool diagnosis for 12 June

- WRFDA analyzes a cold pool but too strong
- However, it improves the forecast for this surface-based convection

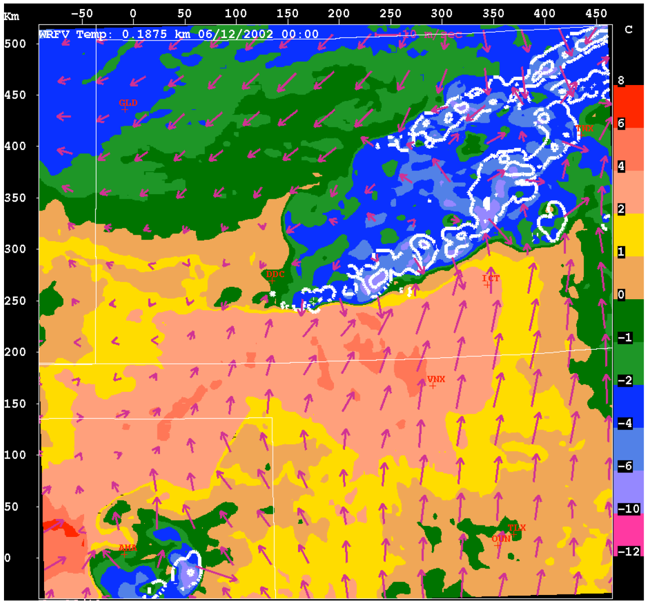
VDRAS



CTRL



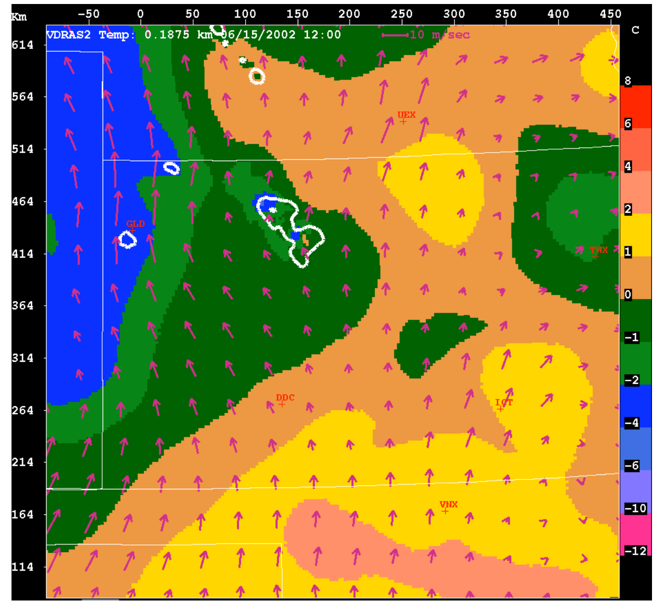
WRFDA



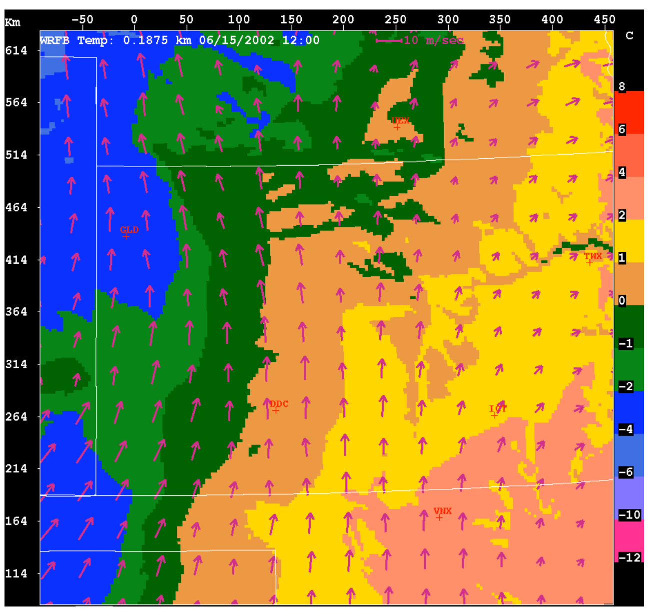
Cold pool diagnosis for 15 June

- WRFDA analyzes a cold pool
- CTRL and VDRAS have no cold pools but large scale temperature contrast
- The erroneous surface cold pool disturbs large-scale balance that is responsible for the elevated convection

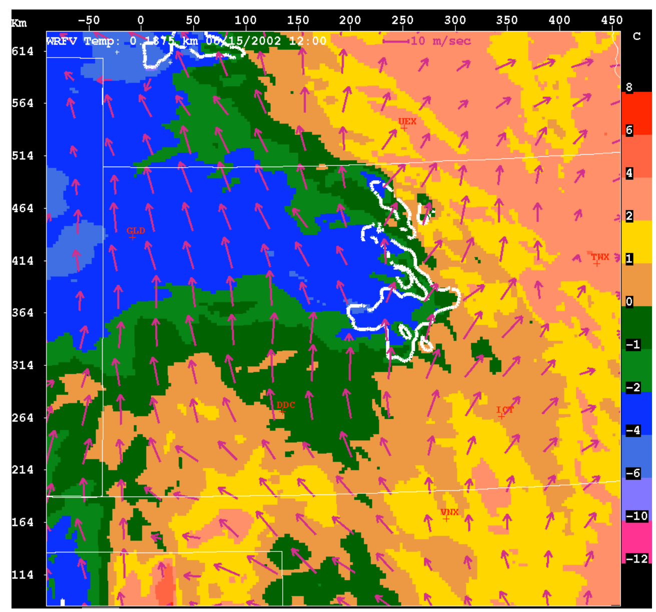
VDRAS



CTRL



WRFDA



Summary

- WRFDA 3DVAR with radar radial velocity assimilation improved precipitation forecast up to 9 hours
- WRF precipitation forecast is more sensitive with respect to initial conditions than to physics
- The radar data assimilation seems to improve surface-based convection and may have a negative impact on large-scale forced elevated convection
- WRFDA 3DVAR radar data assimilation results in a stronger surface cold pool than VDRAS analysis

Future and ongoing work

- Reflectivity data assimilation using grid nudging technique (Xu et al. P.15)
- Hybrid of 3DVAR and grid nudging (Yu et al. 3A.10)
- Reflectivity data assimilation using DDFI
- Radar data assimilation using WRF 4DVAR (Wang et al. P.13)