Convective Weather: Evaluation of Windsor Tornado Simulations, and Forecast initiation

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Outline

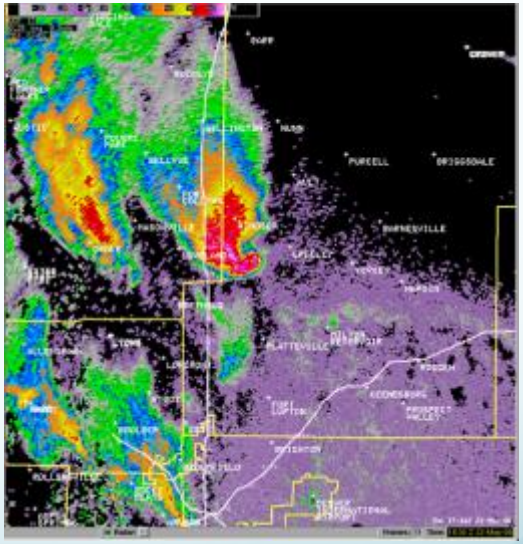
Background from R, various OBS data

- Some fact about Windsor Tornado
- Description of Several Simulations at different resolutions
- Success and challenges in these simulations
- Brief discussion on forecast initiation
- Future plans

Windsor Tornado, 22 May 2008

- Tornado touched down at Windsor, CO around 17:40 UTC
- Most expensive Tornado in Colorado's history, ~$200 million
- 1 fatality, 15-20 injuries, 850 home damages,
- EF3 (wind as high as 130 to 150 mph)

NWS Doppler Radar Image at 11:44 AM MDT



Tornado swept N-NW for 34 miles

(Slide Courtesy of Huiling Yuan and Yuanfu Xie)

Simulations of Windsor Tornado, on going research

Model	Initial Conditions	Boundary Condition	Resolution
wrf-ruc	RUCp analysis	RUCp	3km (Yuan)
wrf-ruc-laps	RUCp analysis + LAPS	RUCp + WRF da_update_bc	3km (Yuan)
wrf-ruc-hyb	RUCb analysis, hybrid	RUCb	3km (Yuan)
wrf-wsm6	RUCp 3h fcst + Variational LAPS	RUCp+WRF da_update_bc	1.67km (Xie)
wrf-tom	RUCp 3h fcst + Variational LAPS analysis	RUCp + WRF da_update_bc	3km (Jiang)

These are the runs done among Huiling Yuan, Yuanfu Xie, and me for comparison and sensitivity study.

Simulation of Windsor Tornado, on going research

Background from R, various OBS data

- Initial condition
  - Background model: RUCp at 13km (initialized at 12UTC)
  - LAPS cloud analysis
  - Various OBS data used in variational LAPS analysis

- Boundary conditions (BCs):
  - RUCp 13km, 3-h RUC forecast
  - BC updated to be consistent with initial condition

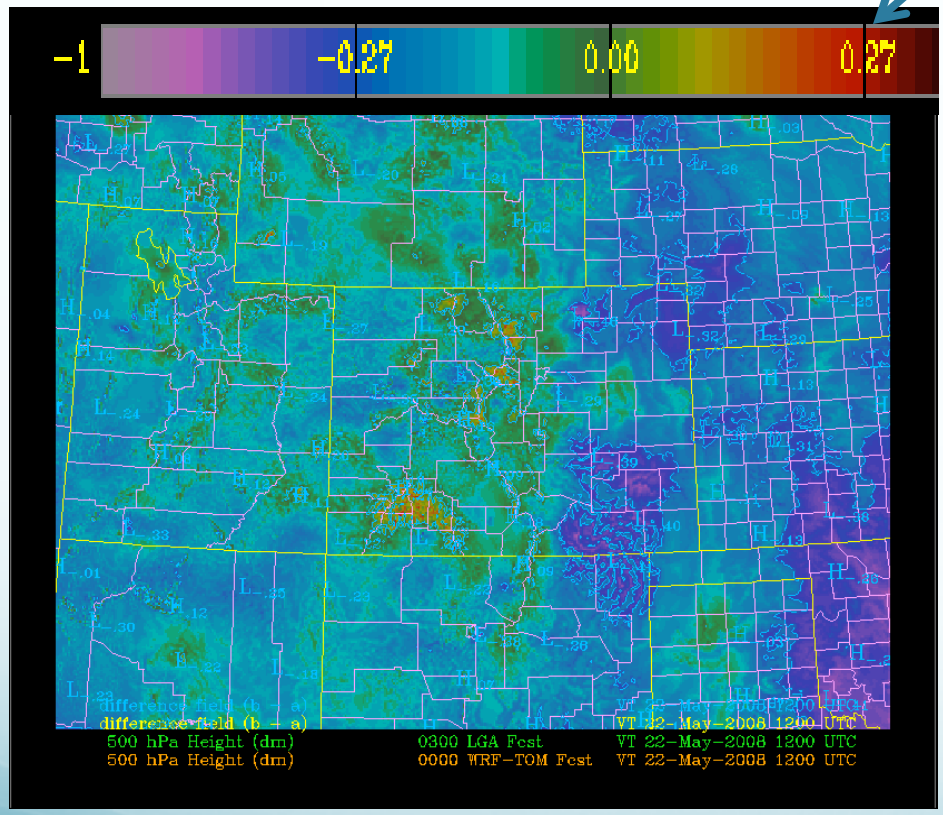
- WRF-ARW V3.4.1
  - 3 km single domain, forecast out to 12 h
  - Number grid: 465x347, 81 vertical levels
  - Thompson microphysics
  - 15 min output

- Goal of 3km run: to capture the synoptic scale features
- Post-processing: reflectivity, 500mb Height, PMSL

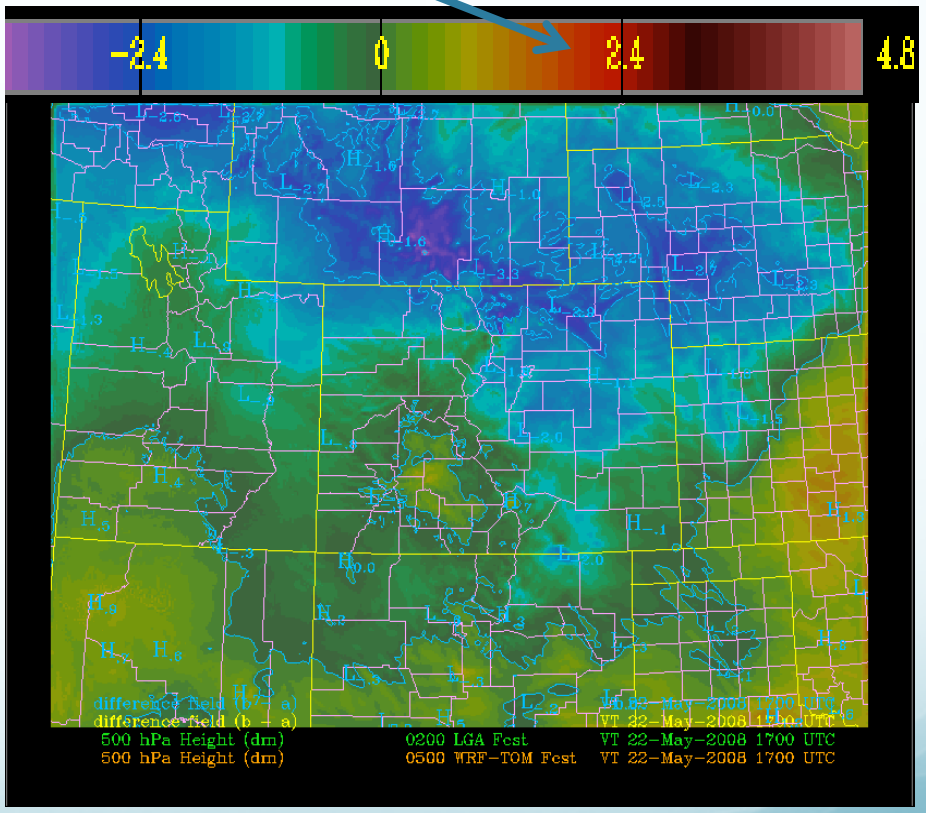
500 mb Height difference (in dm)
diff = RUC – WRF 3km FCST

Notice the different scales

1200UTC



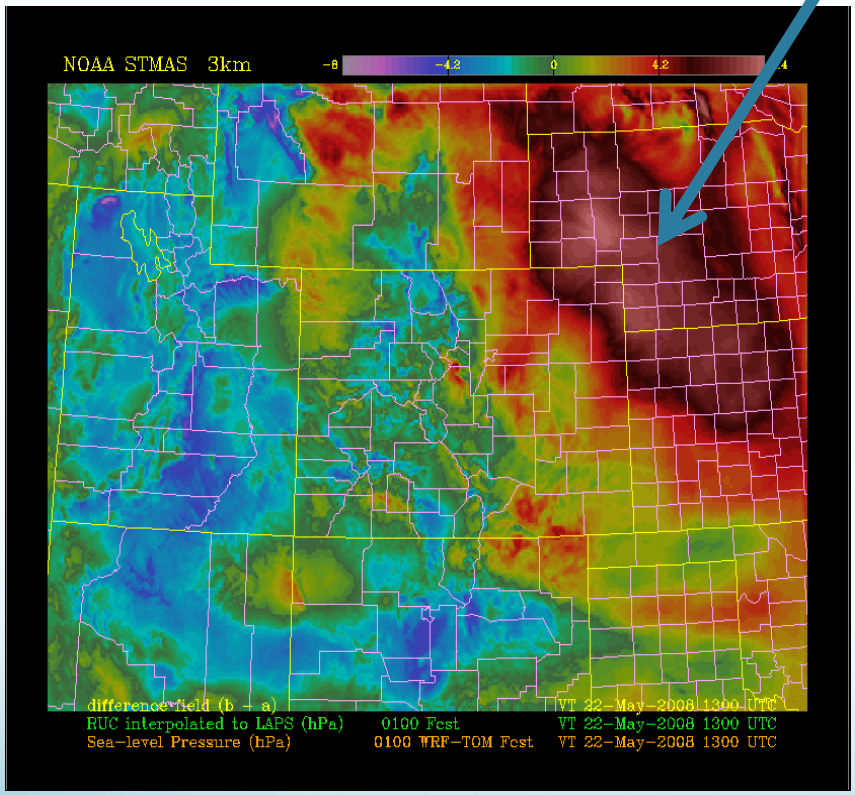
1700UTC



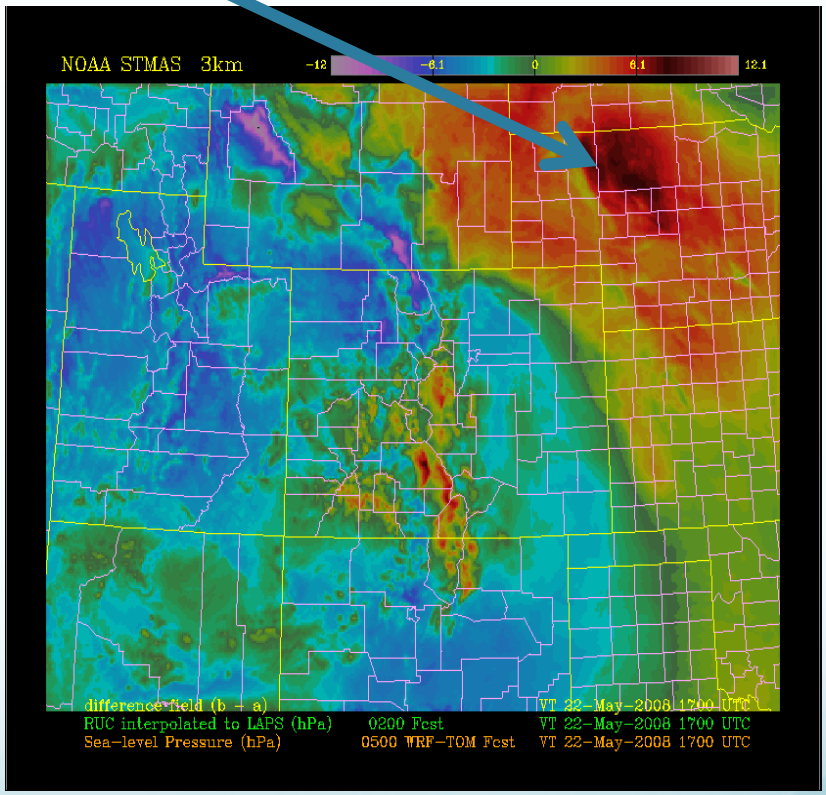
Mean Sea Level Pressure differences (in hPa)
diff = RUC – WRF 3km FCST

Maximum is About 5 hPa

1300UTC



1700UTC



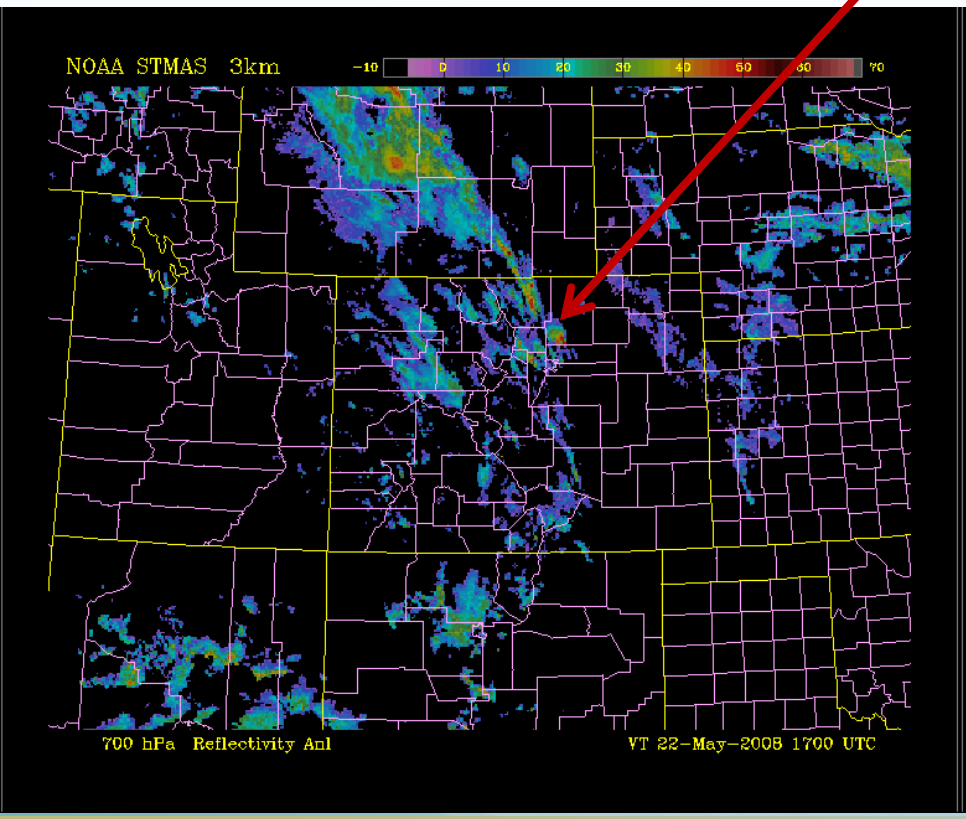
700 mb reflectivity
initial=2008052212, show time=17 – 18 UTC
Mosaic radar vs. WRF forecast (3km res)

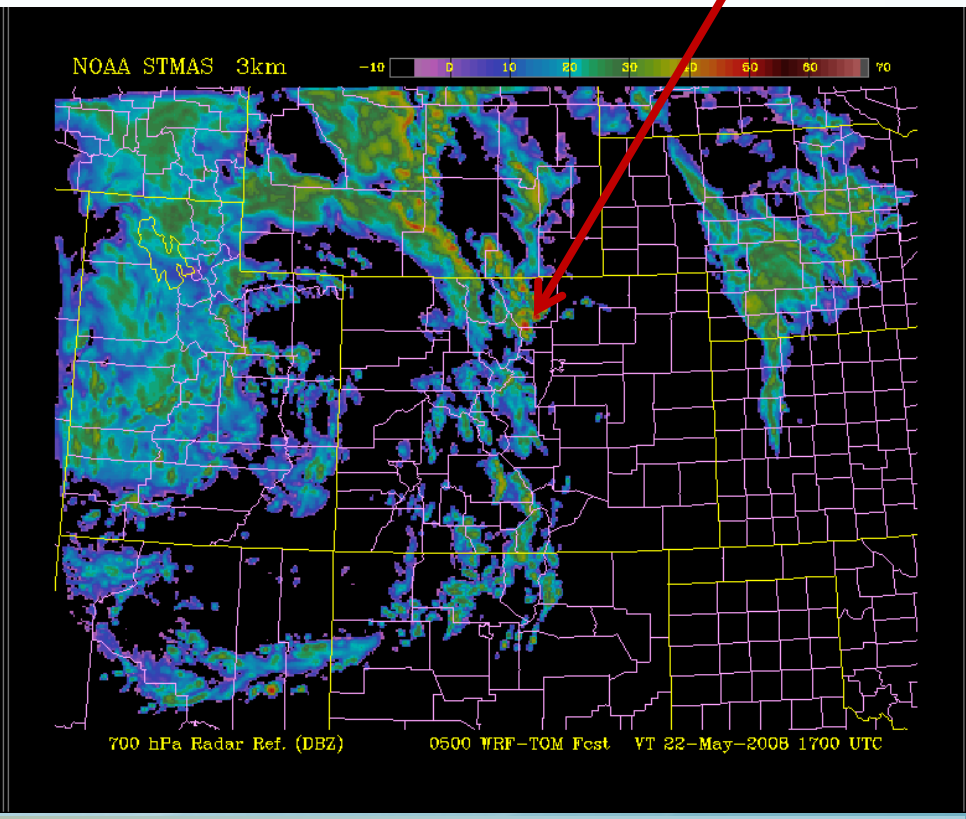
Maximum at 17:45UTC

Too far to the west

Radar / 15 min

Forecast



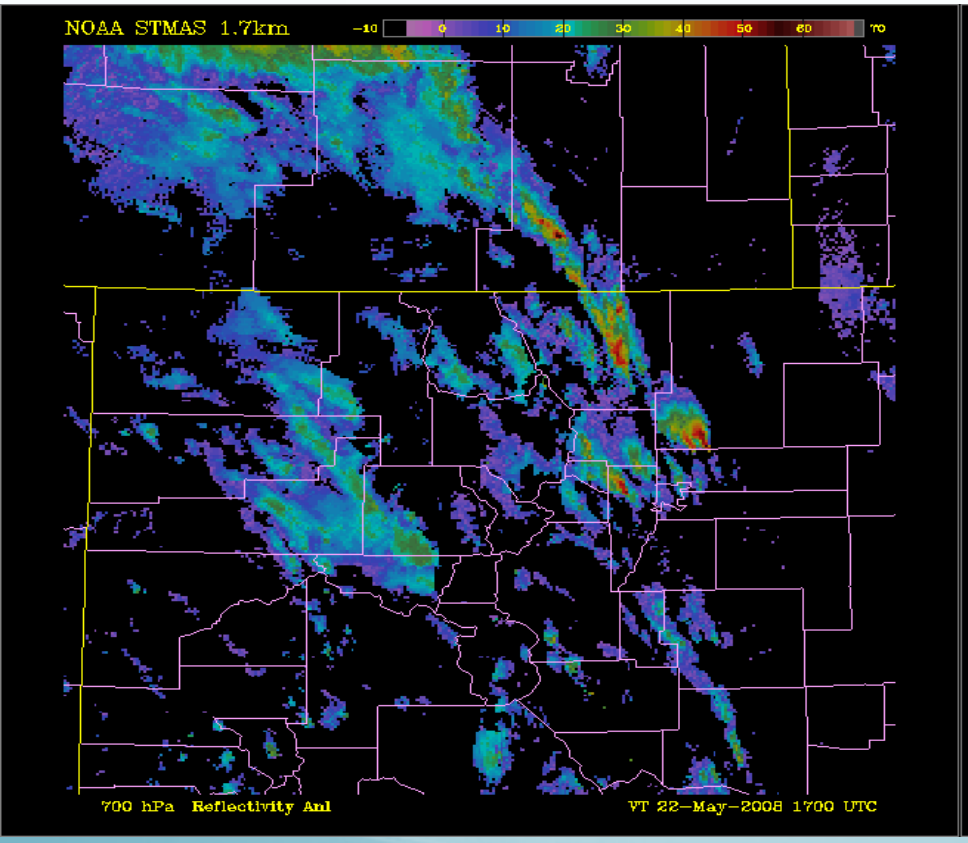


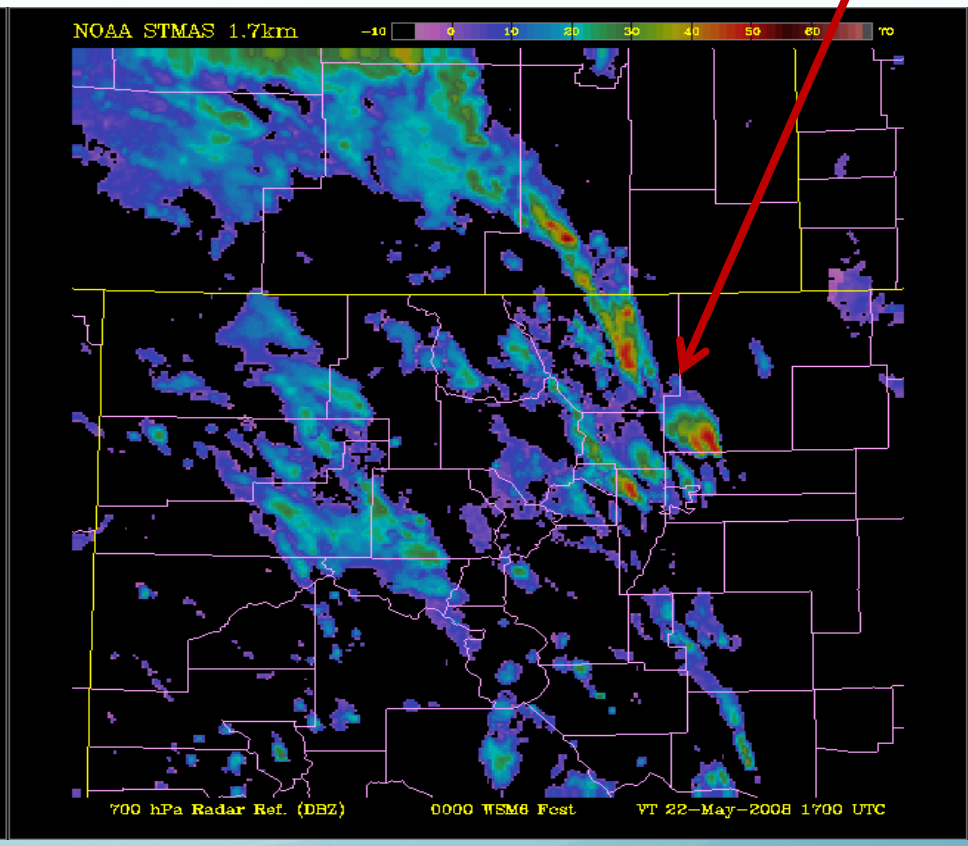
700 mb reflectivity
initial=2008052217, 1h fcst
Mosaic radar vs. WRF forecast (1.67 km res)

Radar / 10 min

Forecast

Improved over 3km run, still west

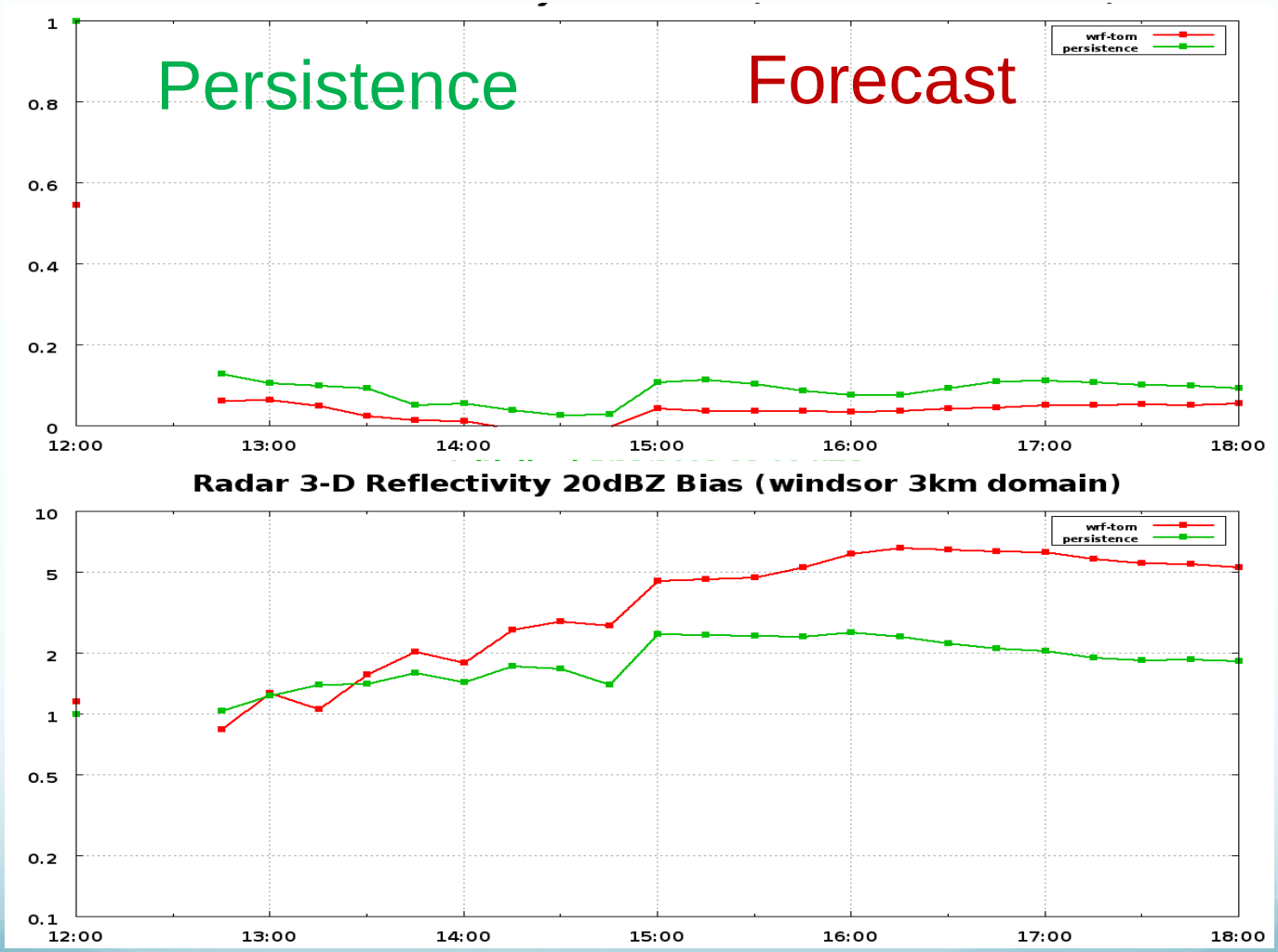




(Results taken from simulations done by Yuanfu Xie)

Verification: 3 km resolution simulation, 6h fcst
3-D Radar Reflectivity 20dBZ (Windsor)

3D Radar Reflectivity



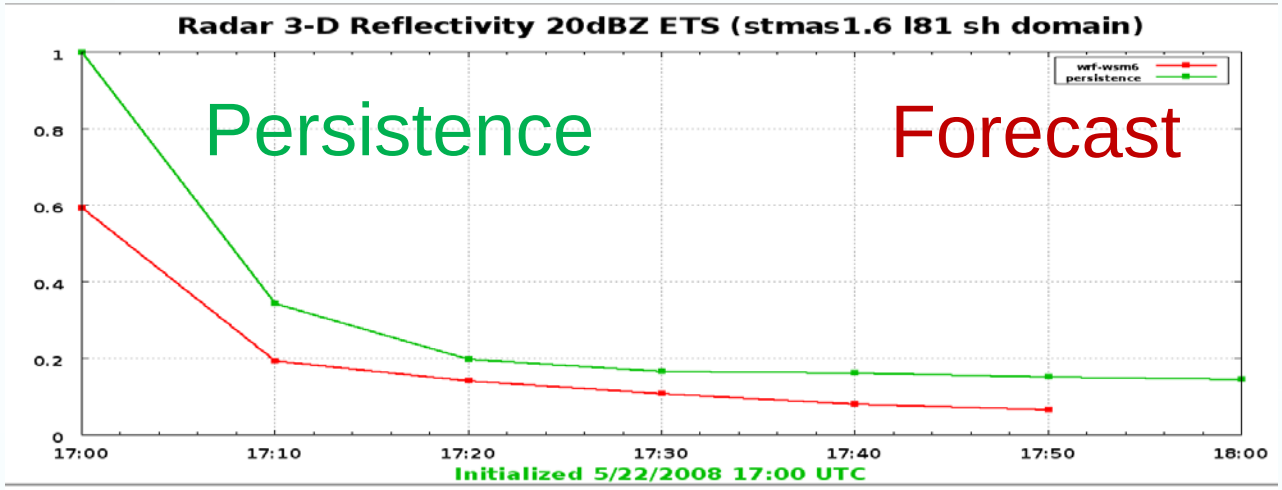
ETS

BIAS

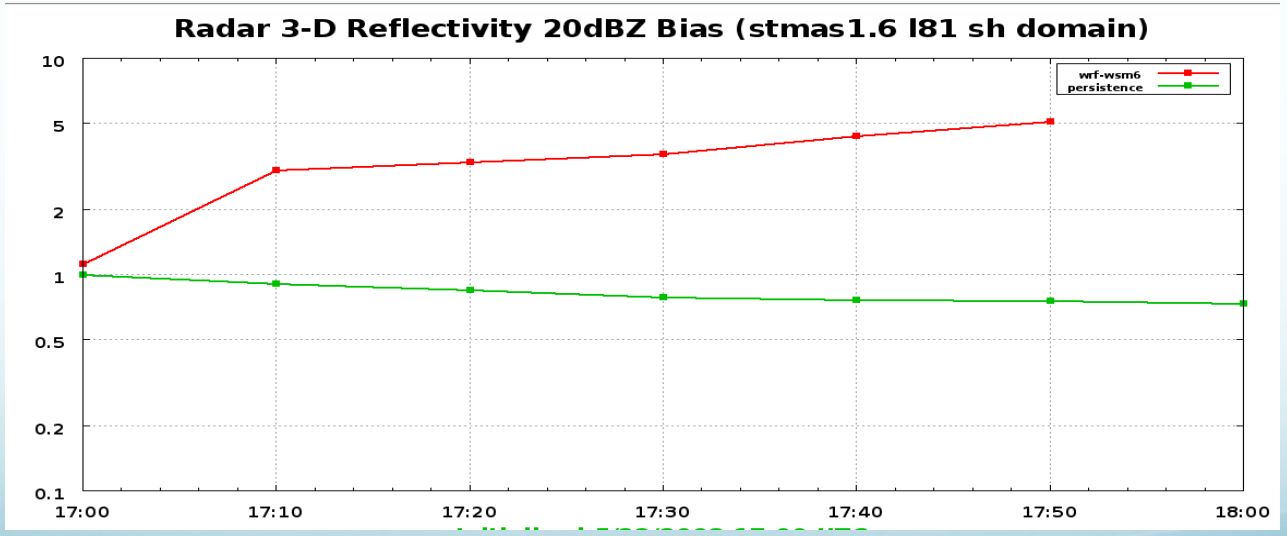
Initialized 5/22/2008 12:00UTC

Verification: 1.67 km simulation, 1 h fcst
3-D Radar Reflectivity 20dBZ

3D Radar Reflectivity



ETS



BIAS

Initialized 5/22/2008 17:00UTC

Summary of Simulation Results

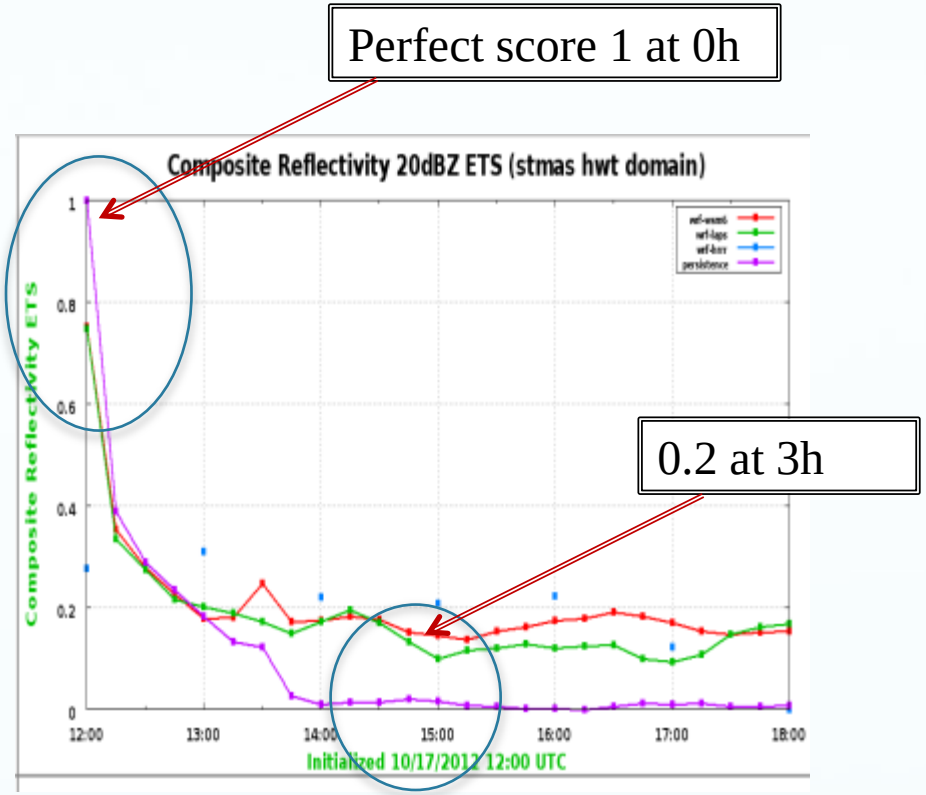
Success:

- From 700 mb reflectivity, 12z initialized WRF 3km forecast, and 17z initialized WRF 1.67km forecast capture the general structure, and the orientation of convective line
- The maximum reflectivity in 1.67km run is located closer to observations than the 3km simulations
- The 1.67 km run improves in the ETS, but the bias is still high
- Resolutions: 3km vs. 1.67km
- Microphysics: tom vs. wsm6

Challenges and on-going

- To get Tornado location, onset, intensity close to OBS,
- Evaluate other fields, such as Updraft Helicity, Vorticity, Humidity (RH) to understand the results better

Forecast Initiation



To get forecast initiation, mode, and dissipation of severe convective storms right in Warn-on-Forecast (0-3h) warning environment, key factors:

- high resolution (spatial and temporal) 3DVAR data assimilation + better model initialization
- Improve ETS score, and reduce bias

Summary

1. Future plan: Downscale the WRF 3km to 1km, and initialize WRF at 15 UTC or 16 UTC for improved forecast

2. We will continue to improve the variational LAPS (STMAS) to improve forecast initiation in the Warn-on-Forecast environment

Thank you!