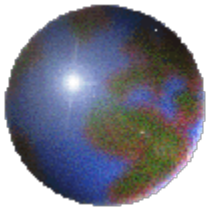
Sensitivity of numerical simulations of a convective system and associated cold pools to WRF physics parameterizations



Chao Lin and Zhaoxia Pu
Department of Atmospheric Sciences
University of Utah

14th WRF Users' Workshop
June 24-28, 2013
Boulder, Co

Outline

- Background and objectives
- Case description
- Experimental design
- Simulation evaluation

  - Cold pool and outflow boundary: observations versus simulations

- Concluding remarks and future work

Background and objectives

Background

- Accurate forecast of mesoscale convective systems (MCS) is very important. However, convective system initiation and evolution are often not well predicted by operational numerical guidance.
- Cold pools have influence to the internal structures of MCS. Outflow boundary is a primary mechanism for the sustenance of multi-cell thunderstorms.
- Proper representation of cold pool and outflow boundary in numerical models is essential for an accurate predication of MCS.

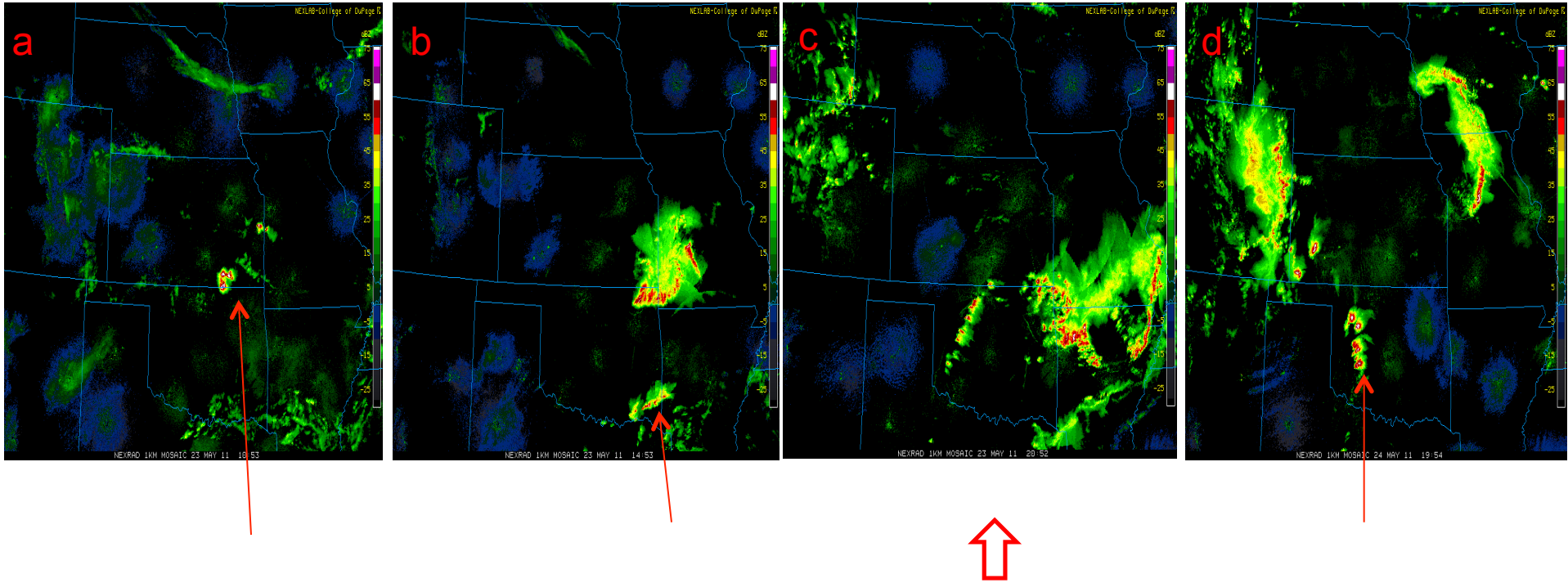
Objectives

- Examine WRF model's ability to simulate a MCS and associated cold pools
- Understand the role of cold pools and outflow boundary in the initiation and evolution of MCS.

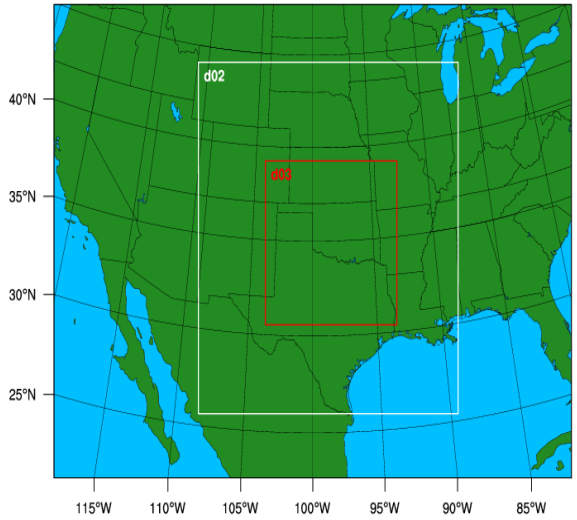
Mesocale convective case

May 23-25, 2011

1100 UTC 23 | 1500 UTC 23 | 2100 UTC 23 | 2000 UTC 24

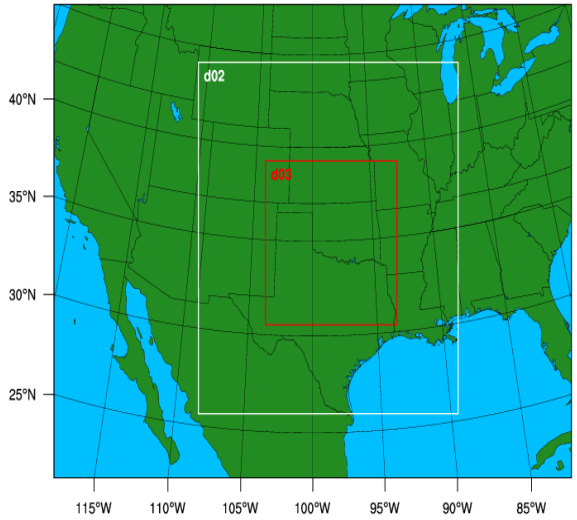


WRF sensitivity experiments



- WRF ARW, Version 3.4.1
- One-way, three-level nested domains
- Horizontal grid spacings: 12km, 4km and 1.33km
- 46 levels vertically.
- Initial and boundary condition: NCEP North America Mesoscale (NAM) Model

WRF sensitivity experiments



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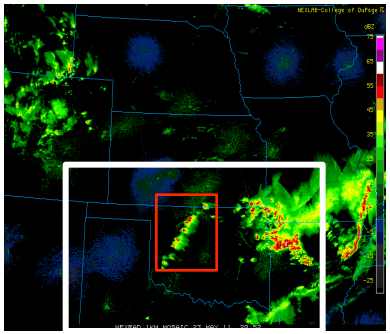
	Initial time	Microphysics Scheme	Surface Physics	PBL scheme	Land surface scheme
06-Lin-MYJ-Noah	2011052306	Lin	Monin-Obukhov	Mellor-Yamada-Janjic	unified Noah
00-Lin-MYJ-Noah	2011052300	Lin	Monin-Obukhov	Mellor-Yamada-Janjic	unified Noah
00-Lin-YSU-Noah	2011052300	Lin	MM5 Monin-Obukhov	Yonsei University	unified Noah
00-5Ferrier-MYJ-Noah	2011052300	5Ferrier (new Eta)	Monin-Obukhov	Mellor-Yamada-Janjic	unified Noah
00-WSM6-MYJ-Noah	2011052300	WSM 6-CLASS	Monin-Obukhov	Mellor-Yamada-Janjic	unified Noah
00-Thom-MYJ-Noah	2011052300	Thompson	Monin-Obukhov	Mellor-Yamada-Janjic	unified Noah
00-Lin-MYJ-RUC	2011052300	Lin	Monin-Obukhov	Mellor-Yamada-Janjic	RUC

Simulation Evaluation

2100 UTC 23 May, 2011 (initiation phase)

Radar observation



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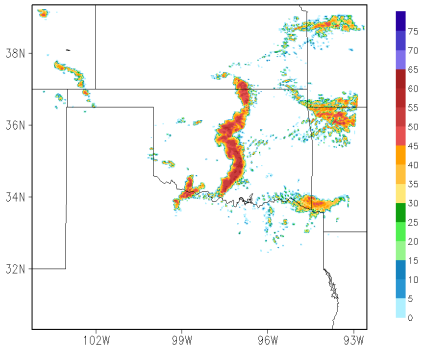

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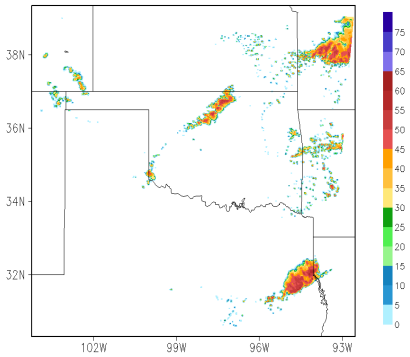

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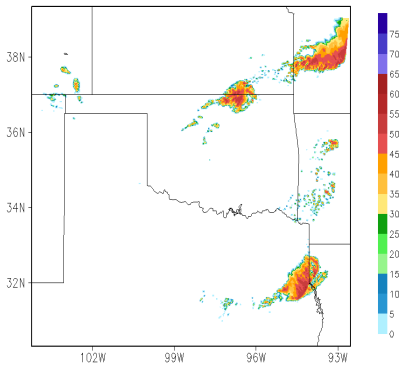
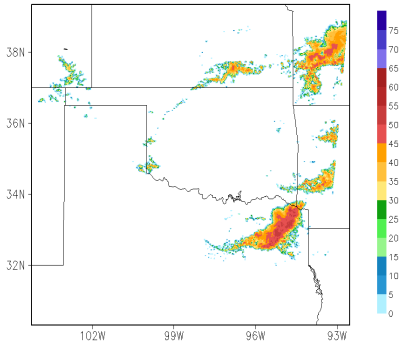


00-5Ferrier-MYJ-Noah



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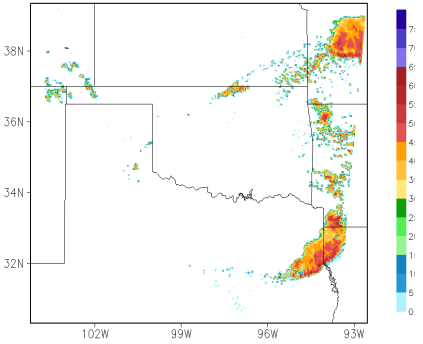

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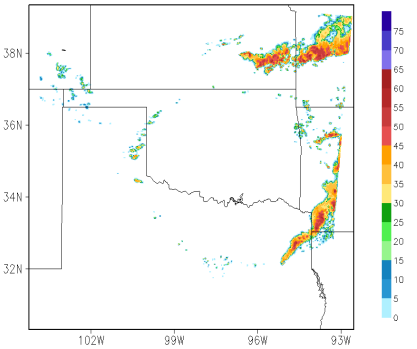
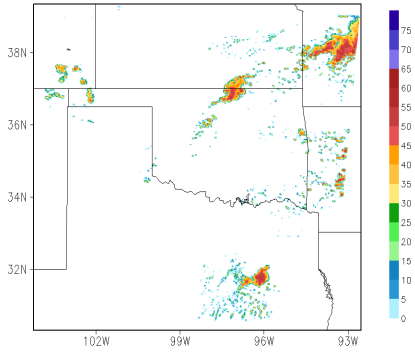


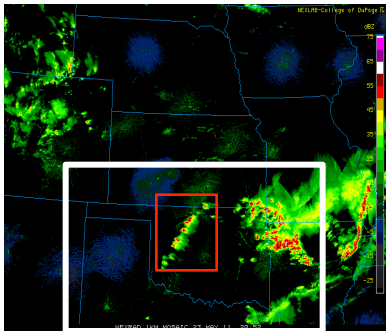
00-Lin-MYJ-RUC



Simulation Evaluation

2100 UTC 23 May, 2011 (initiation phase)

Radar observation



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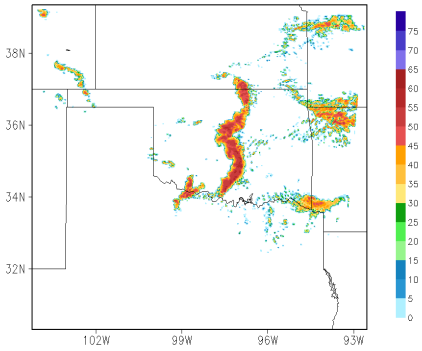

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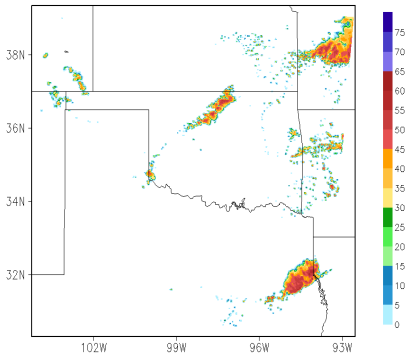

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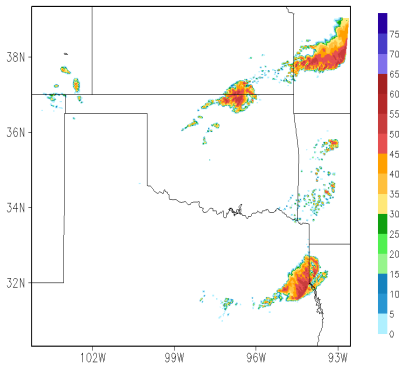
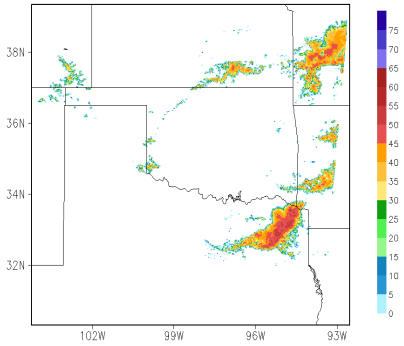


00-5Ferrier-MYJ-Noah



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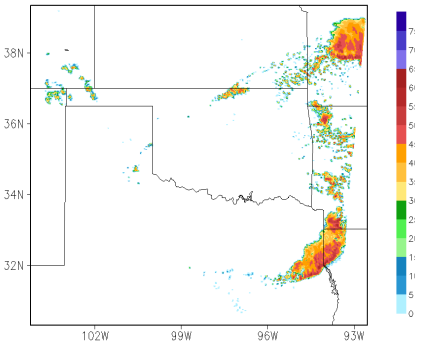

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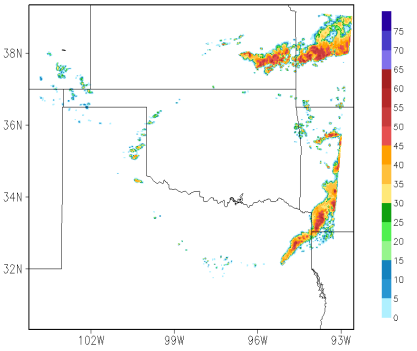

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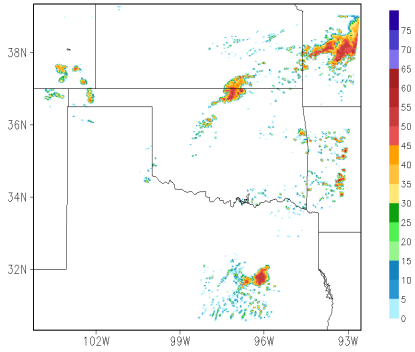
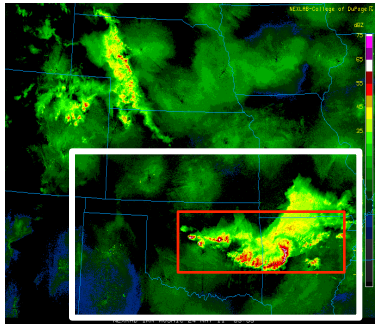


Numerical simulation of the convective system is sensitive to the choice of model initial time, PBL, land surface, and microphysics schemes.

Simulation Evaluation

0400 UTC 24 May 2011 (dissipation phase)

Observation



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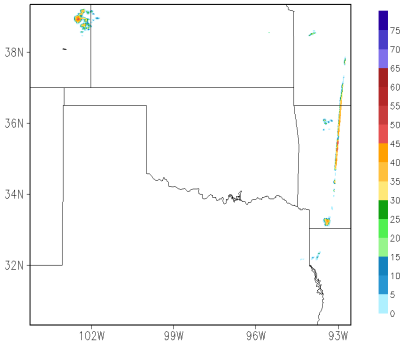

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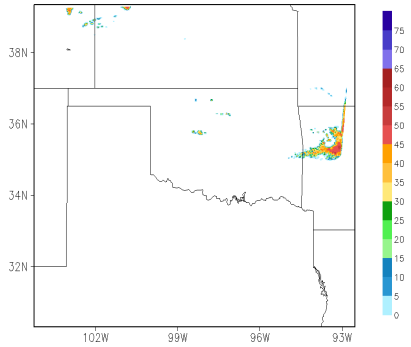

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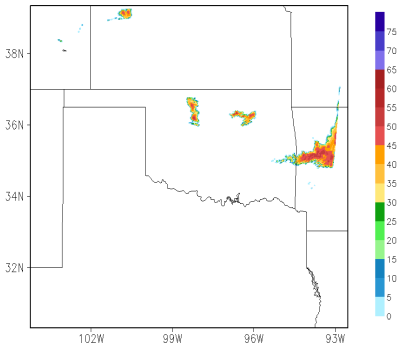

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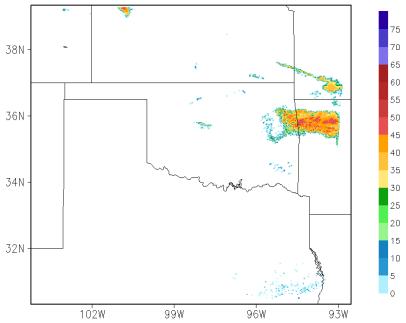

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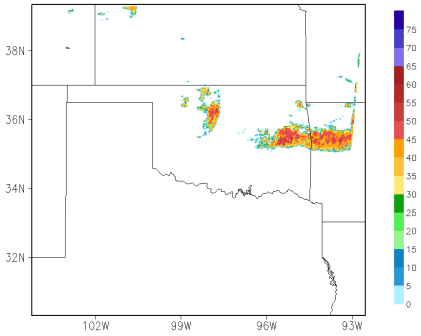
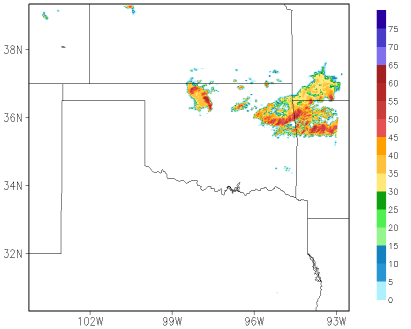
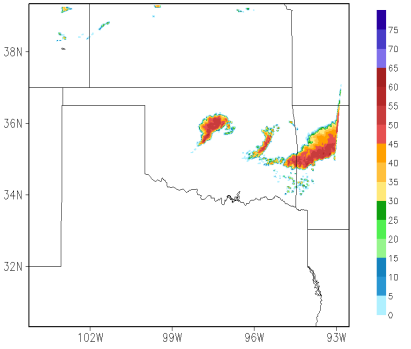


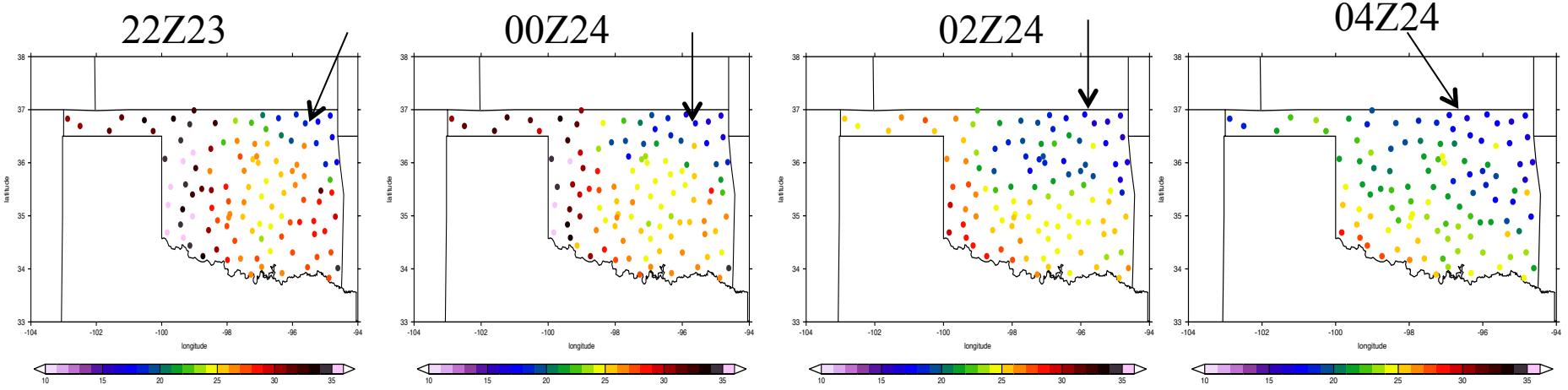
00-Thom-MYJ-Noah



00-Lin-MYJ-RUC



Observed cold pool and outflow boundary



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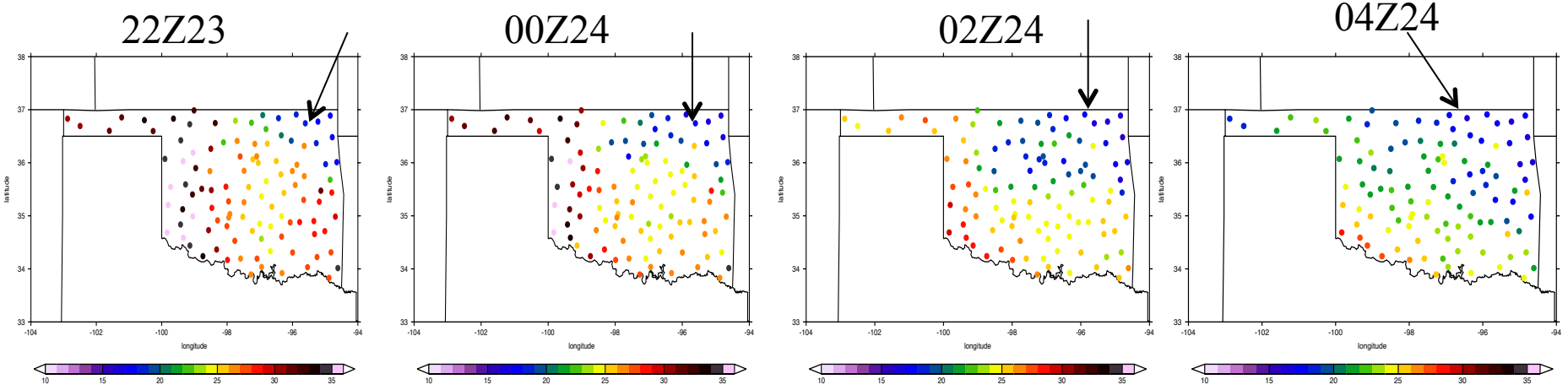
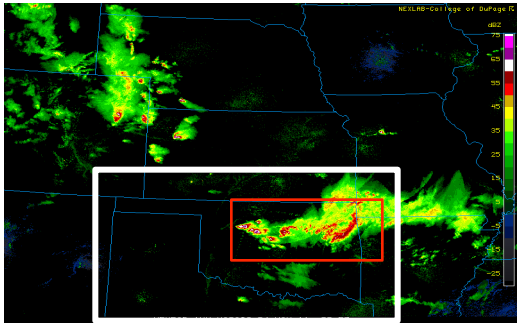
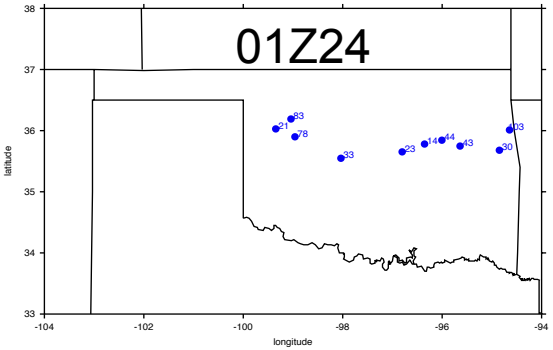
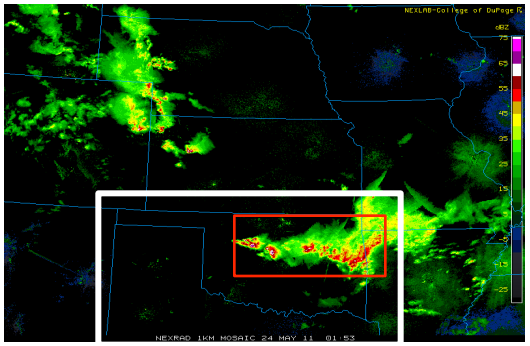
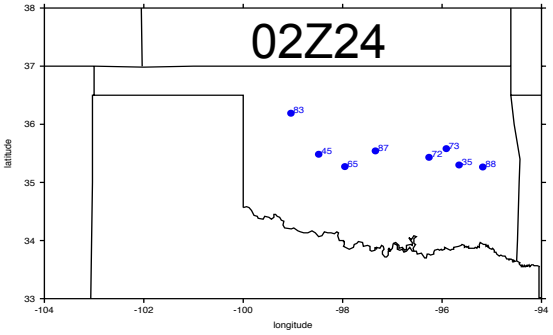






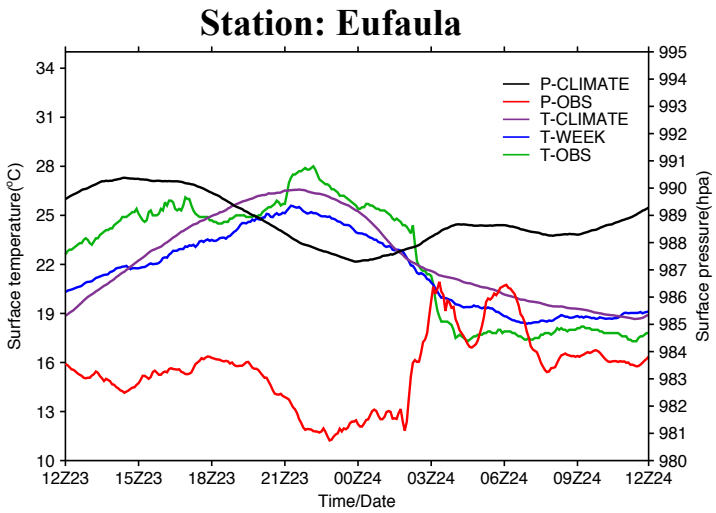
Cold pool is obvious in observation data.

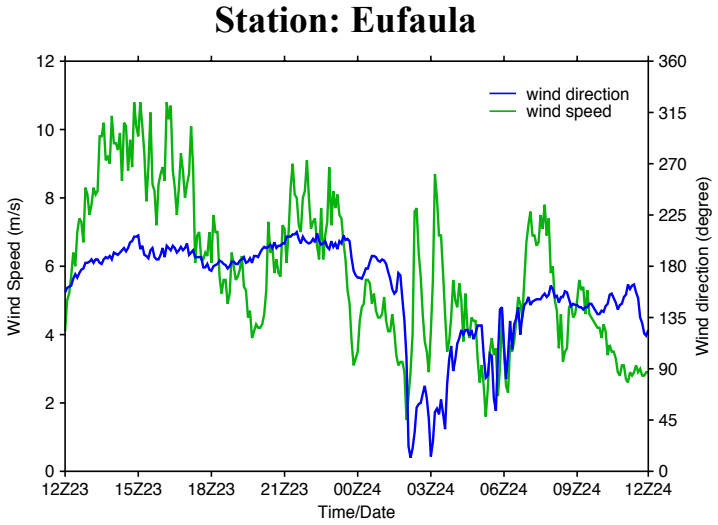




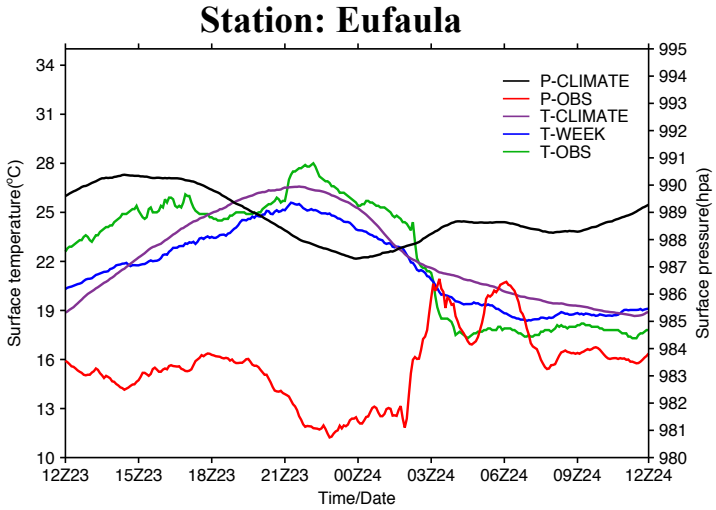
Outflow boundary marked the leading edge of the squall line

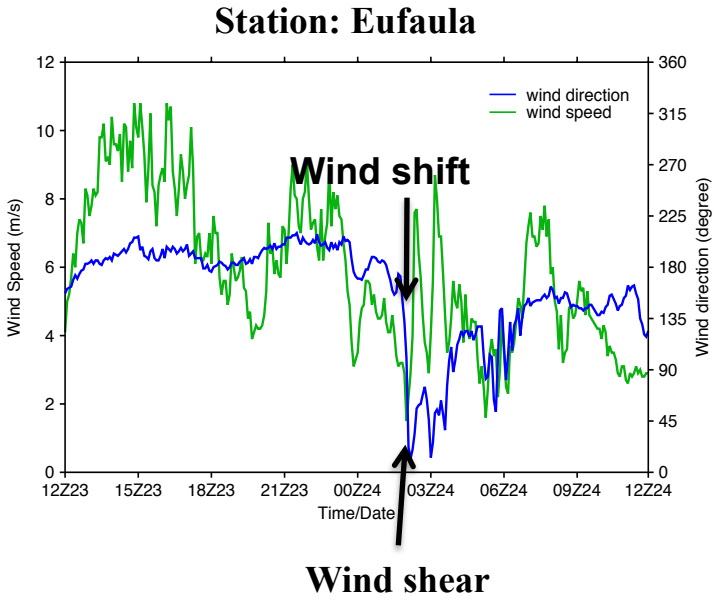
Observed cold pool and outflow boundary



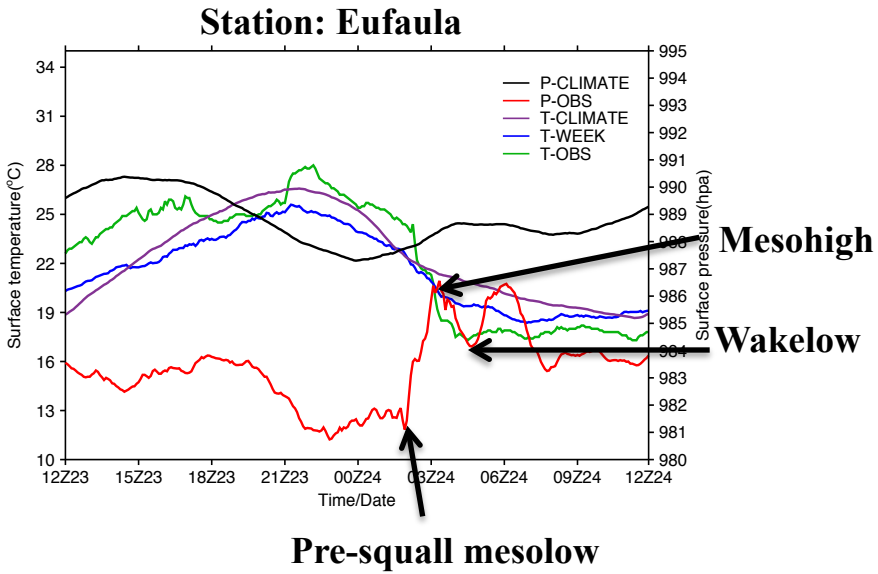


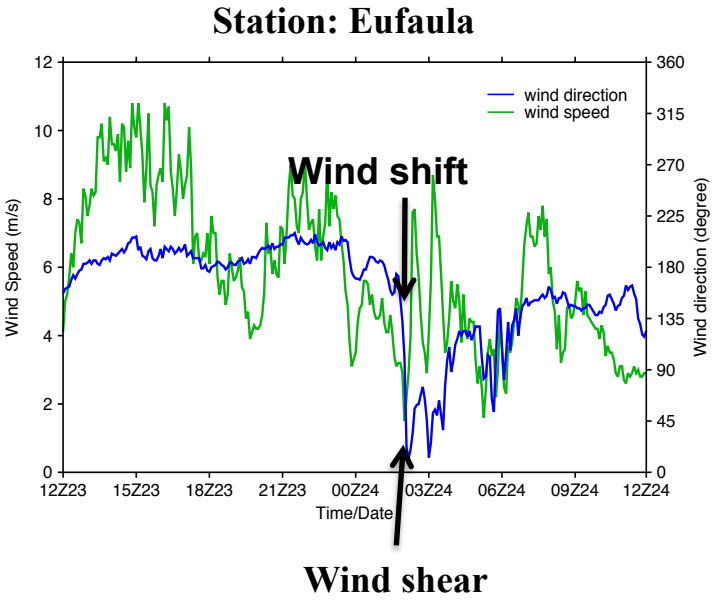
Observed cold pool and outflow boundary



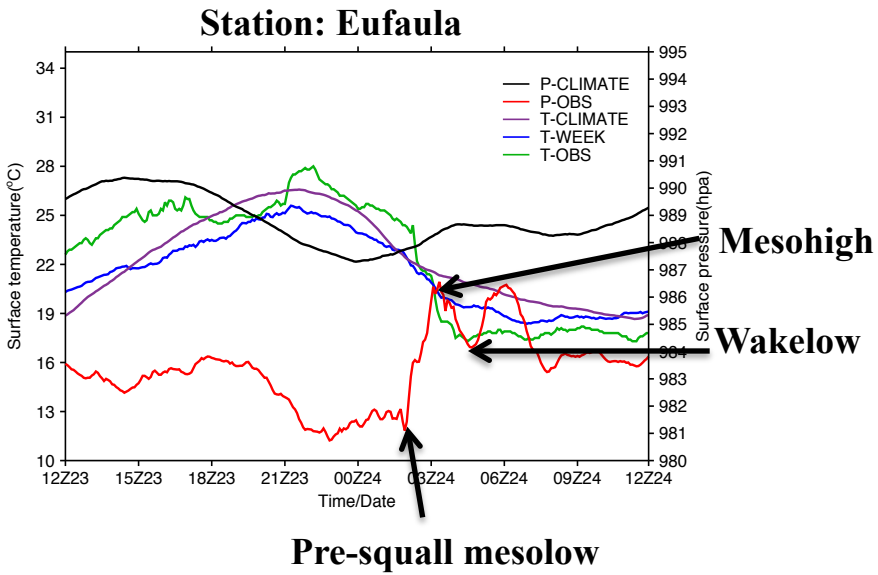


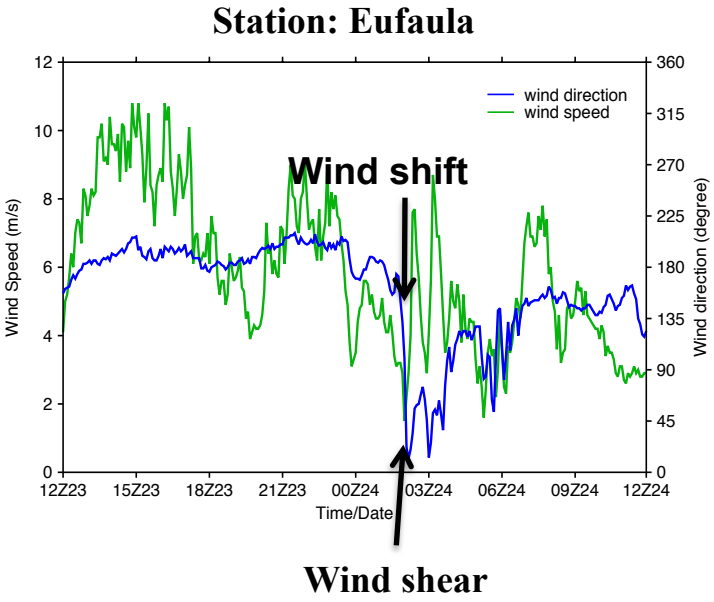
Observed cold pool and outflow boundary





Observed cold pool and outflow boundary





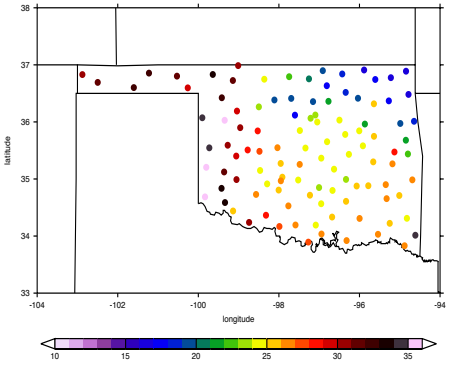
Short summary for observation cold pool:

- Cold pool is observed in surface observation data.
- Outflow boundary marked the leading edge of the convection.
- Pressure increase is prior to the temperature decrease for most of the stations.
- Three well-known features are observed: pre-squall mesolow, mesohigh and wake low.

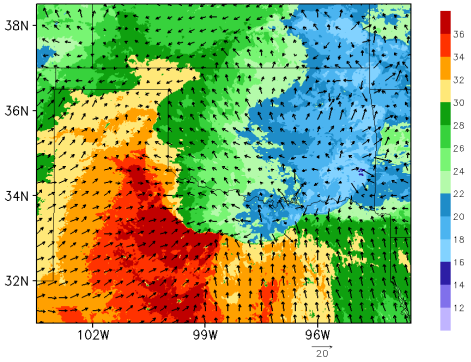
Cold pools in numerical simulations

0000UTC 24 May, 2011

Observation



06-Lin-MYJ-Noah



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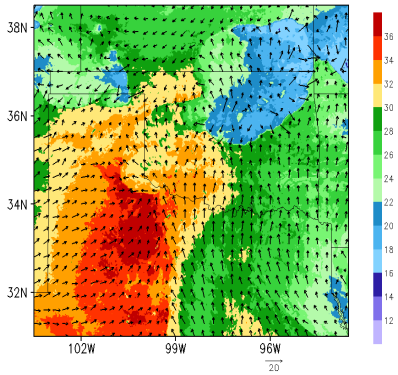

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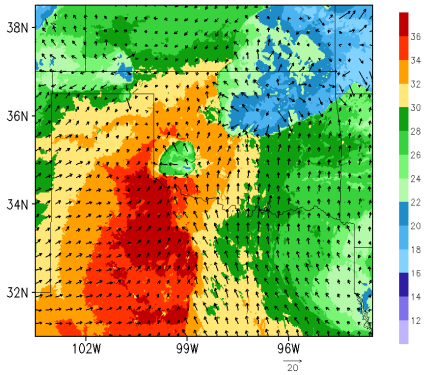
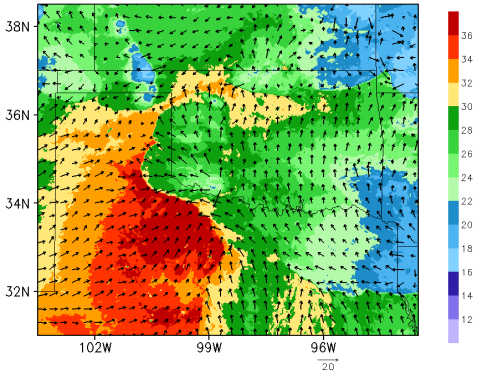


00-5Ferrier-MYJ-Noah



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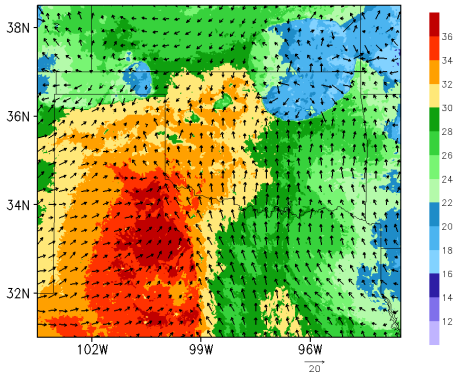
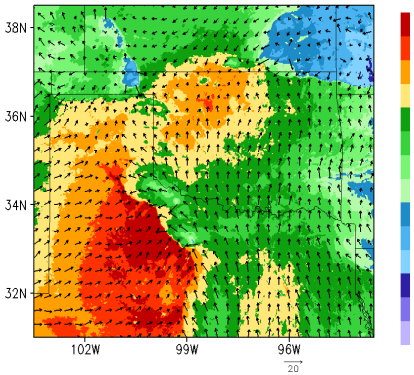
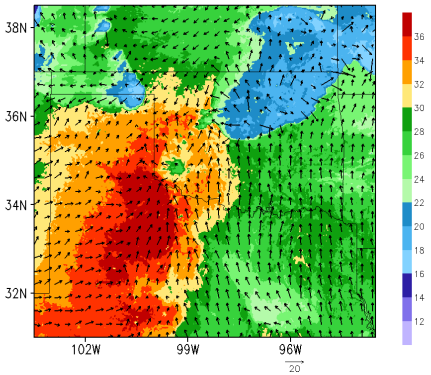


00-Thom-MYJ-Noah



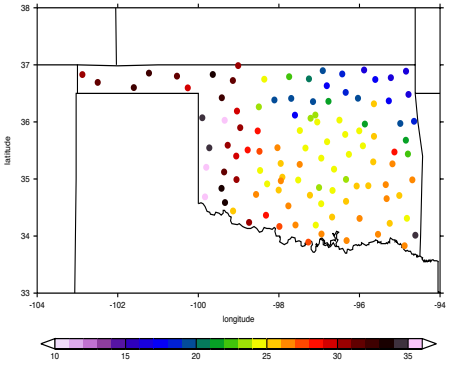
00-Lin-MYJ-RUC



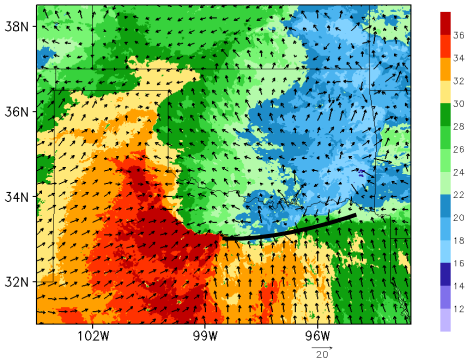
Cold pools in numerical simulations

0000UTC 24 May, 2011

Observation



06-Lin-MYJ-Noah



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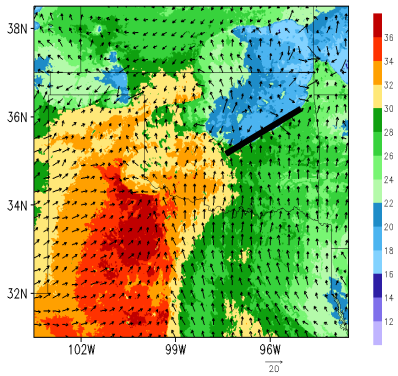

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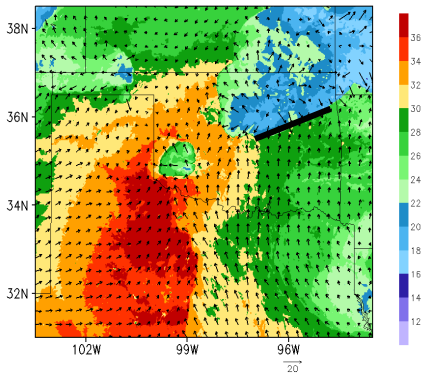

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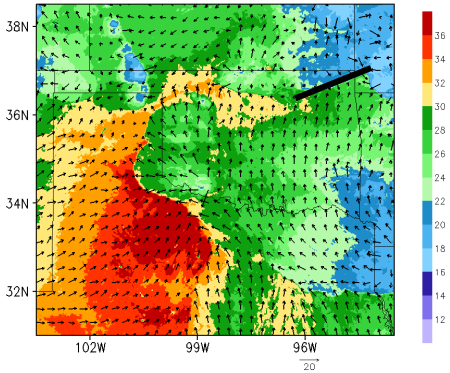

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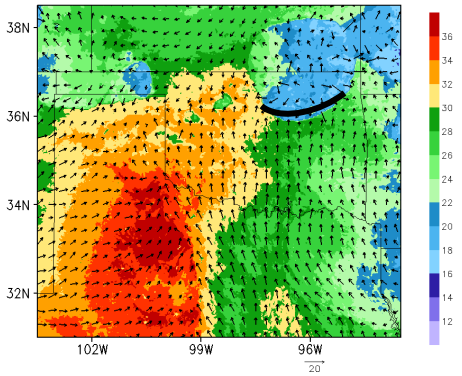

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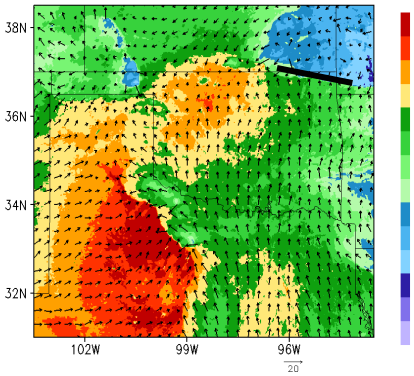

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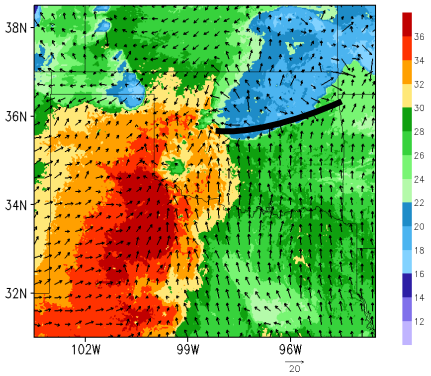
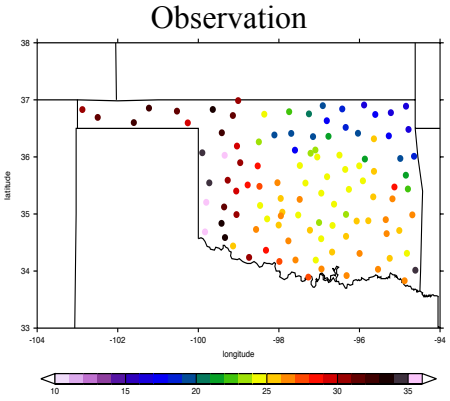
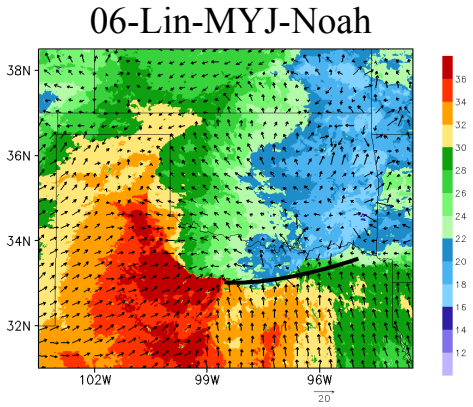
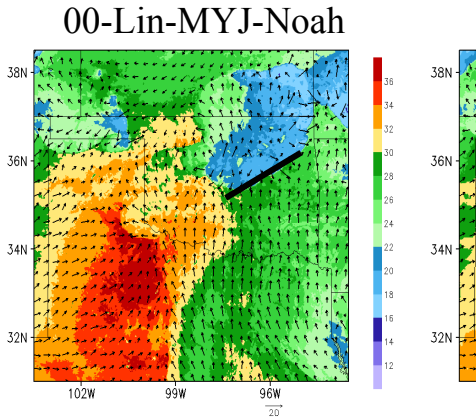


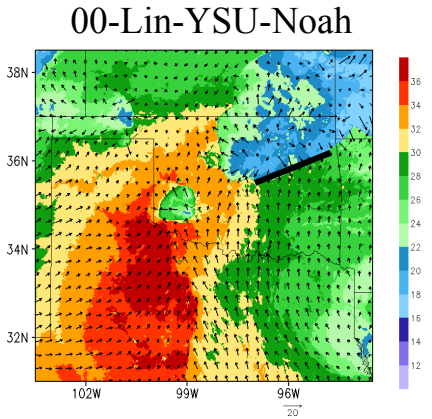
Cold pools in numerical simulations

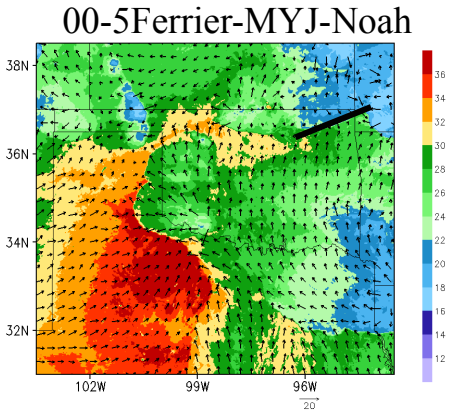
0000UTC 24 May, 2011

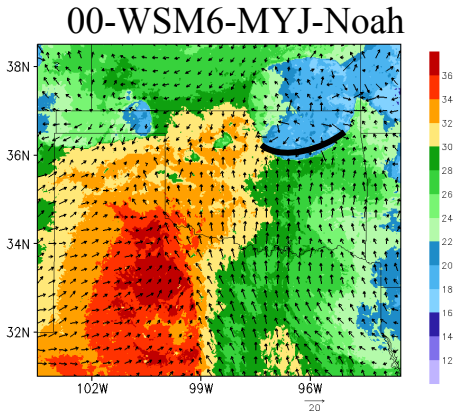


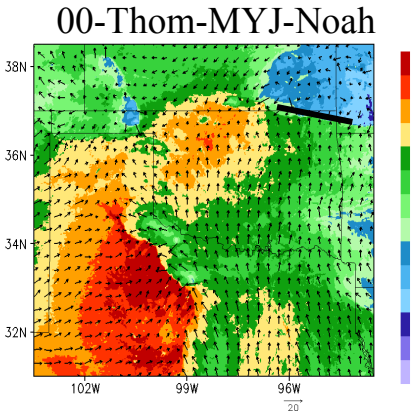


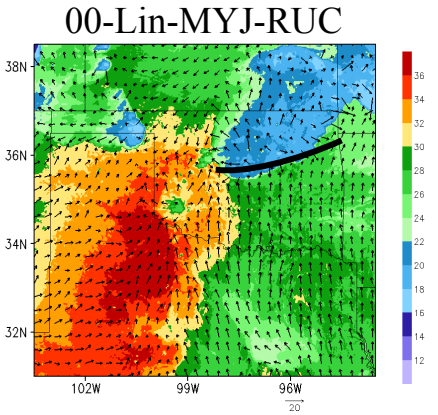












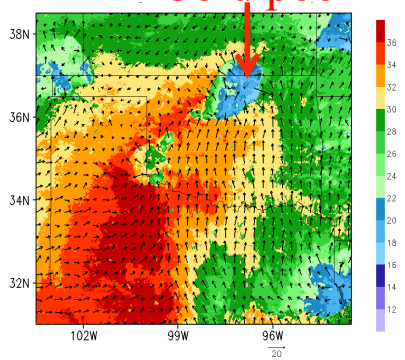
- Numerical simulations of convective cold pools are sensitive to model initial time, PBL, microphysics, and land surface schemes.
- Model initial time deems to be more sensitive factor, implying initial condition is an important factor.

Interaction between cold pool and convection

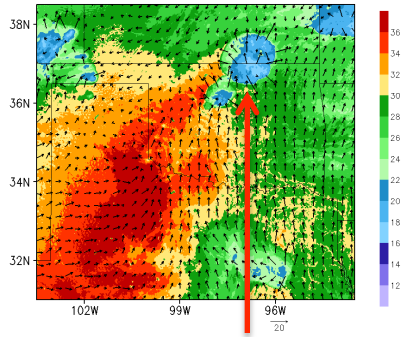
22Z23

Cold pool

Noah



RUC



Cold pool

Interaction between cold pool and convection

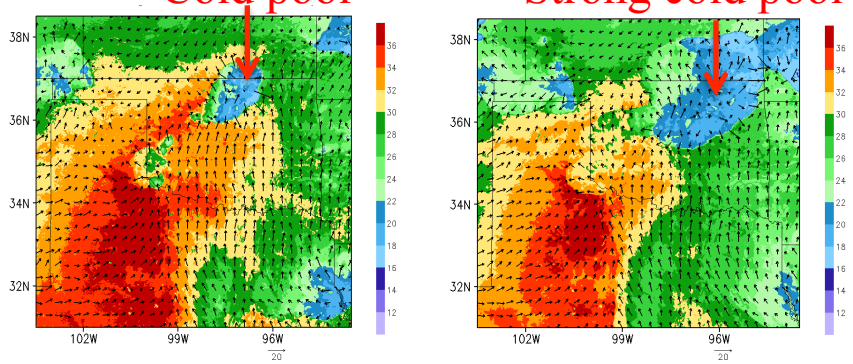
22Z23

00Z24

Noah

Cold pool

Strong cold pool



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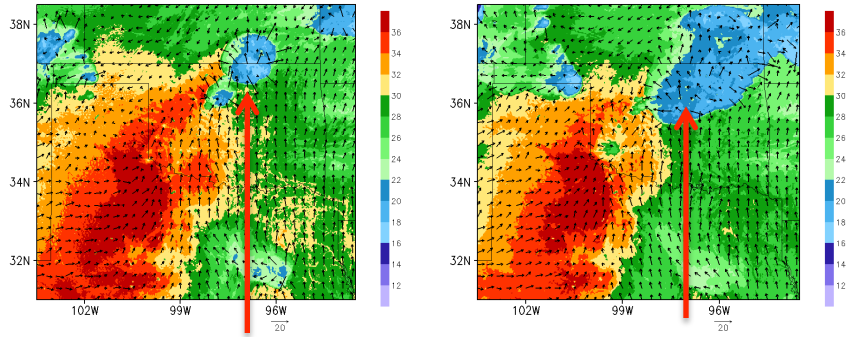


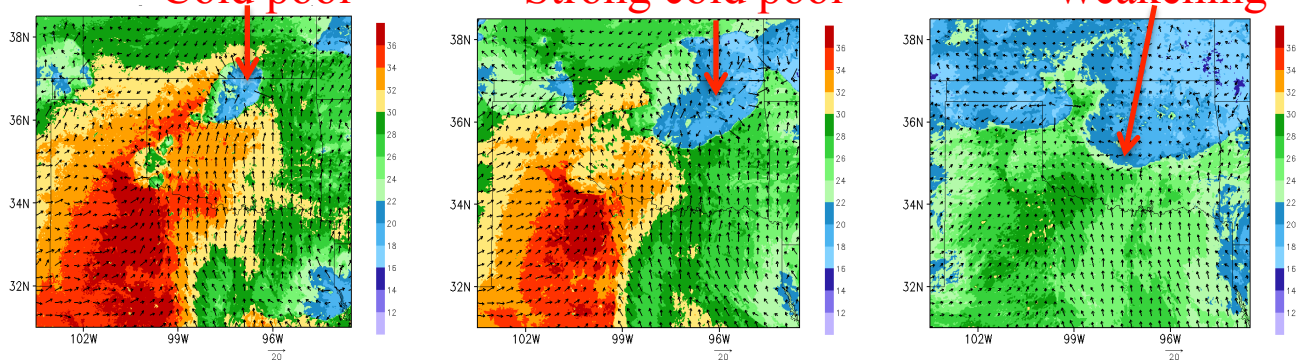
Cold pool

Strong cold pool

Interaction between cold pool and convection

22Z23 00Z24 02Z24

Noah



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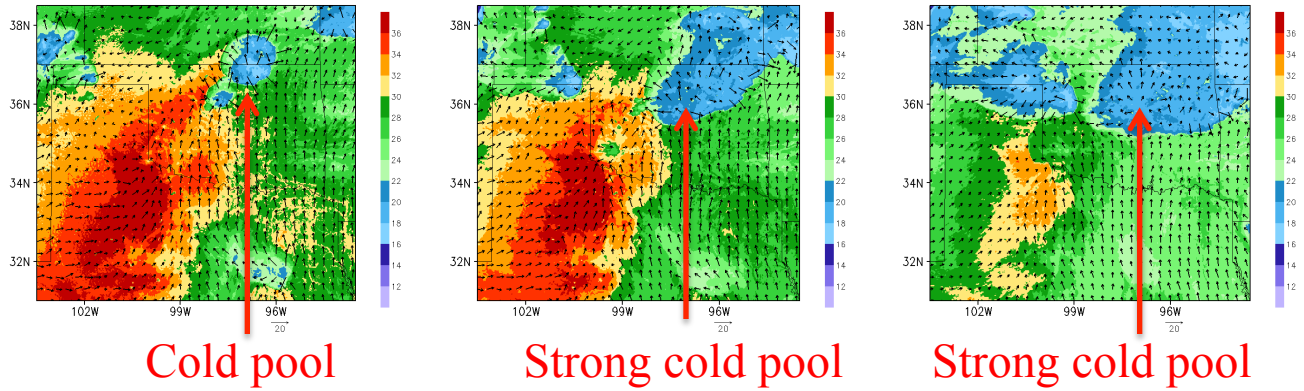
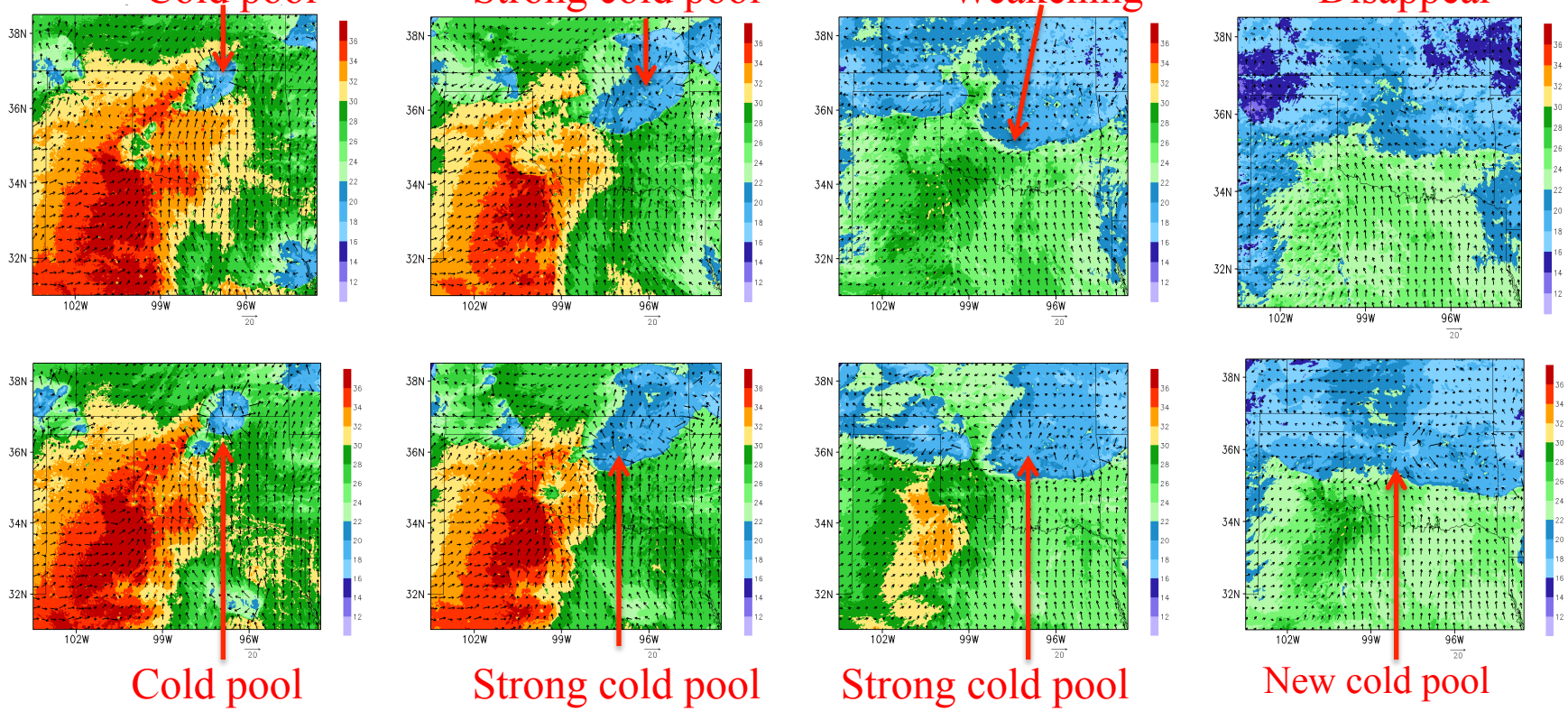


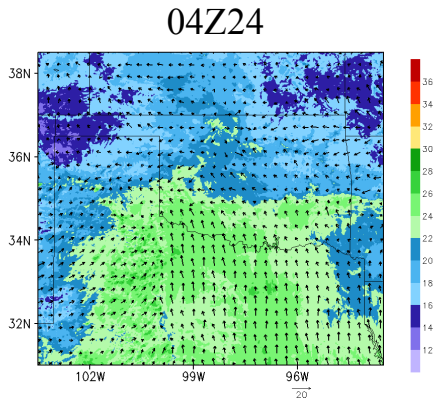
Interaction between cold pool and convection

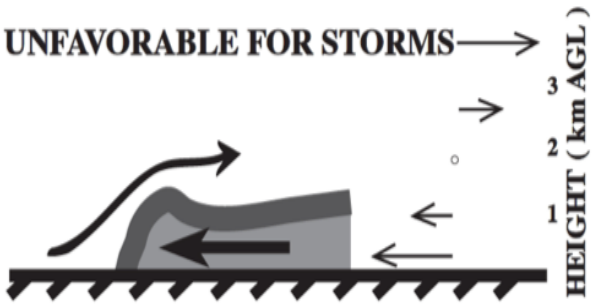
	22Z23	00Z24	02Z24	04Z24
Noah	Cold pool	Strong cold pool	Weakening	Disappear
RUC	Cold pool	Strong cold pool	Strong cold pool	New cold pool

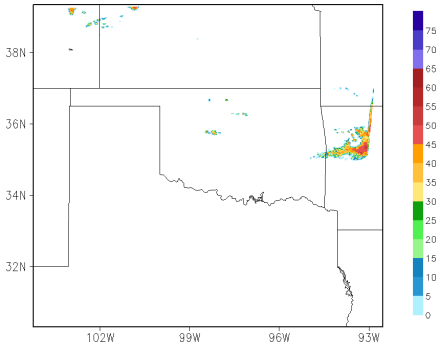


Interaction between cold pool and convection

Noah







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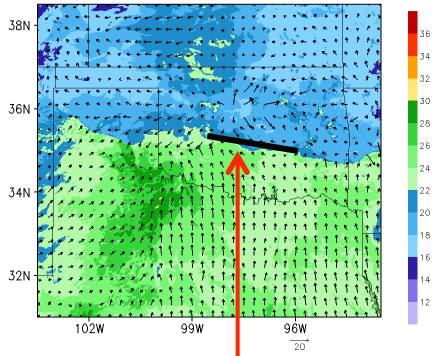
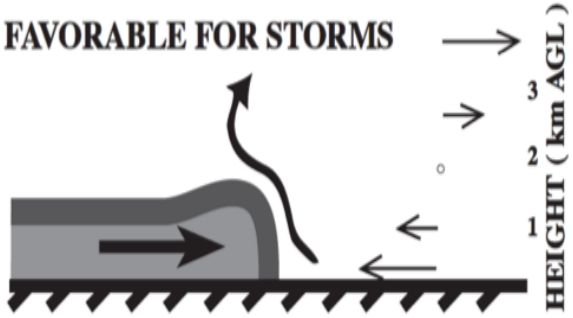
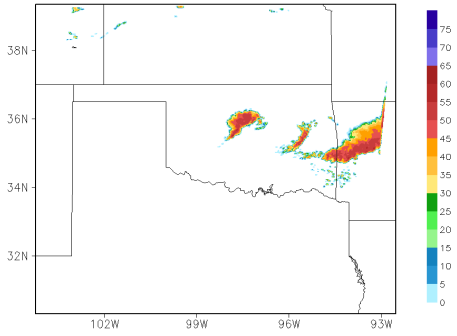


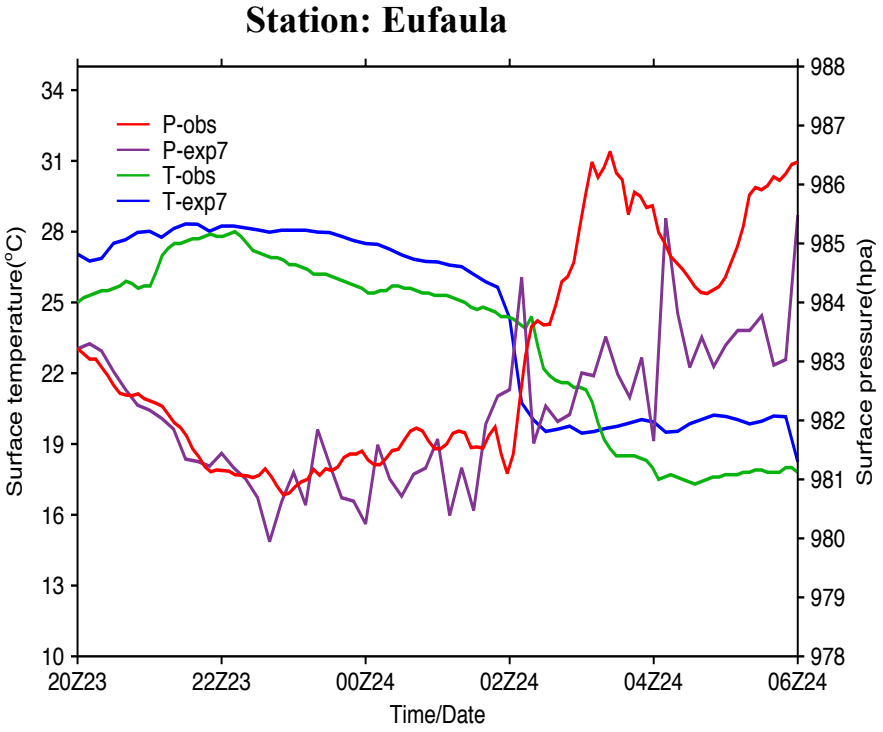


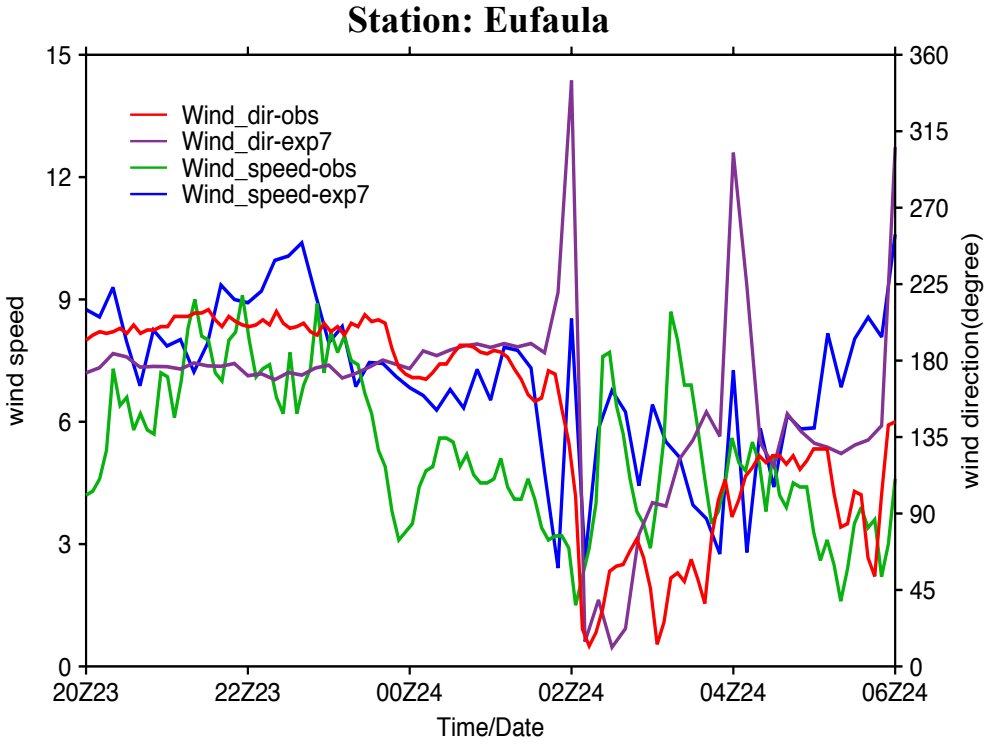


Wilson et al.1998

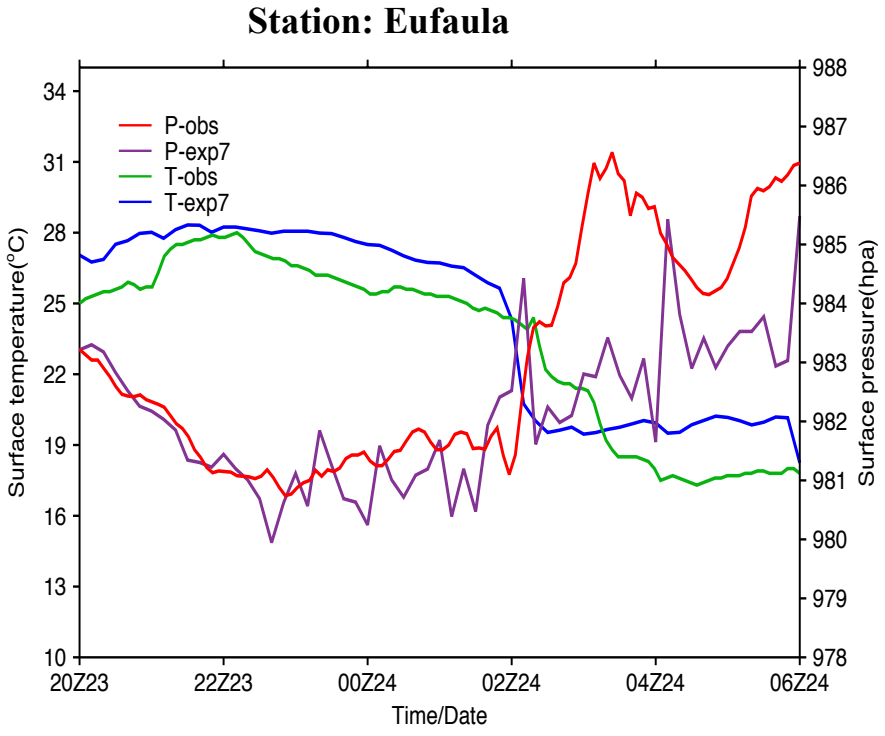
Outflow boundary (convergence zone)

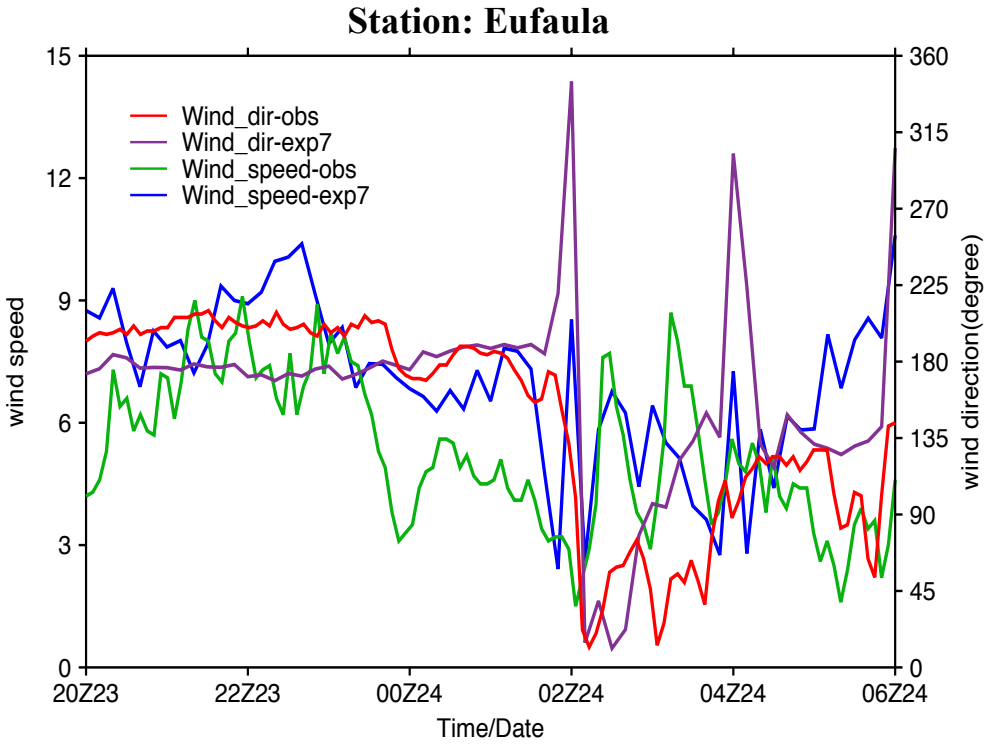
Model simulated cold pool





Model simulated cold pool





WRF Simulation captured main characteristics of the cold pool:

- Pressure increase is prior to the temperature decrease for most of the stations.
- Three well-known features: pre-squall mesolow, mesohigh and wake low.

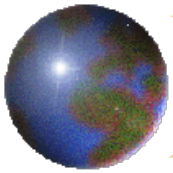
Concluding remarks and future work

Concluding remarks

- High resolution WRF model is capable of simulating the convective initiation, evolution and the associated cold pools.
- Numerical simulations of convective system and cold pools are sensitive to initial time, PBL, microphysics, and land surface schemes in the WRF model.
- Deep and strong cold pool is an important character of a long-lived convection. Accurate representation and prediction of the cold pool are important to the predictability of mesoscale convective systems.

Future work

- Conduct more case studies to obtain robust insights.
- Further analyze 3D characteristics of cold pools and their relationship with convection initiation and evolution.



Thank You!