Characteristics of the atmospheric boundary layer structure and cloud properties for precipitating convection with data assimilation

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Introduction: The major objective of this project is to create realistic estimates of high-resolution atmospheric boundary layer structure and the characteristics of precipitating convection, including updraft and downdraft cumulus mass fluxes and cold pool properties from analyses that assimilate the surface mesonet observations and available profiling data from single or multiple surface stations. As part of efforts, data assimilation experiments have been conducted for the major convective cases during the Midlatitude Continental Convective Clouds Experiment (MC3E) using the mesoscale community Weather Research and Forecasting (WRF) model and its data assimilation system. Sample results in this poster demonstrate the sensitivity of numerical simulations/analyses of cool pool properties to data assimilation and various microphysics and planetary boundary layer schemes. The interaction between convectively generated cold pools and convection is also examined.

Impact of data assimilation on numerical simulation of mesoscale convective systems and properties

May 19-20 convective case during MC3E

WRF model resolution: 12km/4km/1.33km

Assimilation and forecast window: During 12 UTC to 15 UTC 19 May 2011, hourly surface Mesonet observations (wind, temperature, pressure) are assimilated. Forecast is then extended till 12 UTC 21 May 2011.

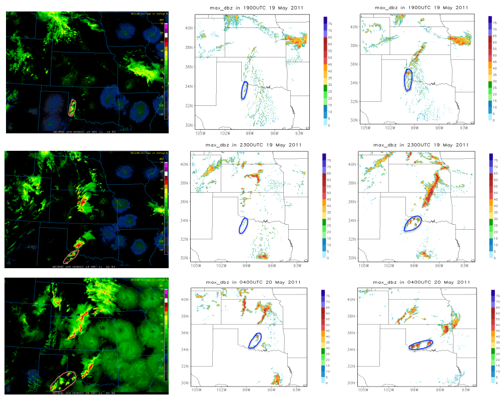
Control (CTRL): Simulation initialized by NCEP NAM analysis (without assimilation of surface Mesonet observations).

Exp.(Data Assimilation): Simulation with assimilation of surface mesonet data.

May 19-20, 2011 primary and secondary convective Initiation

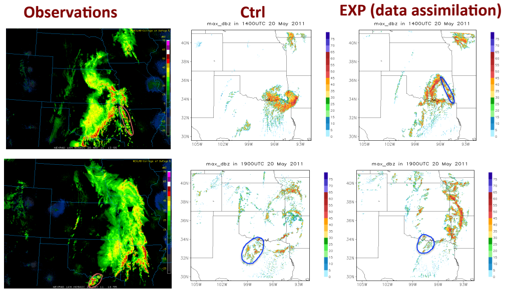
Primary initiation

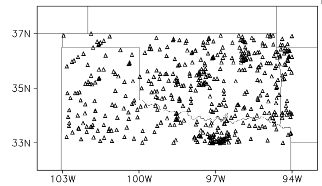
Observations **Ctrl** **EXP (data assimilation)**



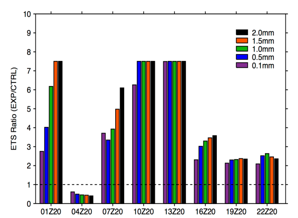
Secondary initiation

Observations **Ctrl** **EXP (data assimilation)**





Oklahoma Mesonet stations



The ratio of equitable threat scores (ETS) for 1-h accumulated precipitation between CTRL and data assimilation (EXP) experiments. When ratio is greater than 1, the quantitative precipitation forecasting (QPF) skill is improved by data assimilation.

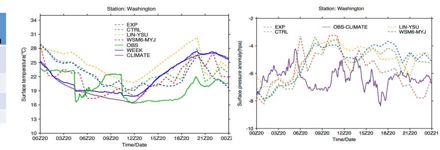
- Data assimilation results in significant improvements in numerical simulations of mesoscale convective initiations.
- Results imply that improved near-surface atmospheric conditions (such as cold pools) have an influence on convective initiation.

Sensitivity of cold pool representation to WRF microphysics and PBL schemes and data assimilation

Configuration of WRF sensitivity experiments

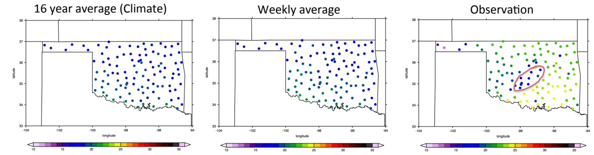
Exp.	Microphysics	Surface Layer Physics	PBL	Data Assimilation
CTRL	LIN	Monin-Obukhov (Eta)	MYJ	N
WSM6-MYJ	WSM6	Monin-Obukhov (Eta)	MYJ	N
LIN-YSU	LIN	Monin-Obukhov (MM5)	YSU	N
EXP	LIN	Monin-Obukhov (Eta)	MYJ	Y

Temperature and pressure anomaly – May 20, 2011

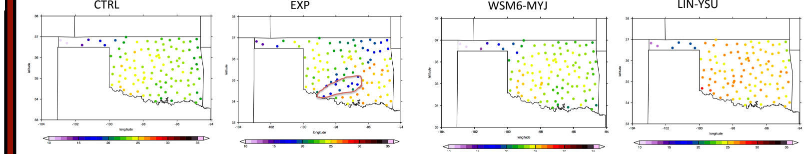


Surface temperature at 0500 UTC 20 May 2011 over OK Mesonet stations

16 year average (Climate) Weekly average Observation

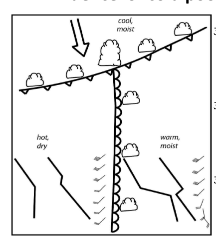


CTRL EXP WSM6-MYJ LIN-YSU

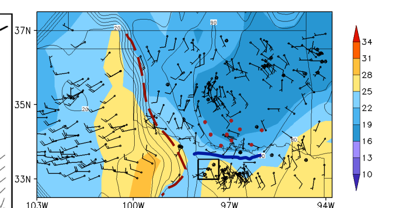


- A cold pool occurred around 0400 -0600 UTC 20 May.
- Numerical results revealed that WRF simulation of cold pools is sensitive to physical parameterization options.
- With assimilation of surface observations, the cold pool was well simulated.

Influence of cold pool on convective initiation

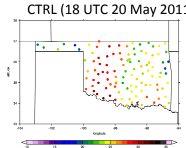


Conceptual model of cold front, dryline, and cold pool interactions. [Weiss and Bluestein (2002)]

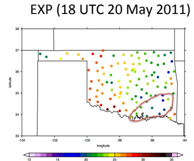


Surface weather map on 1800 UTC 20 May 2011: wind barbs, temperature (shaded), relative humidity (contour). Red dots denote the cold pool. The thick blue line marks cold front. The purple dashed line represents the dryline.The box indicates the area of convective initiation.

CTRL (18 UTC 20 May 2011)



EXP (18 UTC 20 May 2011)



On-going and future work

- Complete high-resolution analyses for all major MC3E convective cases with assimilation of available surface and sounding profiles; validate these analyses with observations.
- Use these high-resolution analyses to characterize convective systems and precipitating properties. Ultimately, to study the evolution of cloud life cycles.
- Compare WRF 4D analyses with standard ARM large-scale forcing data.

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ASR Atmospheric System Research