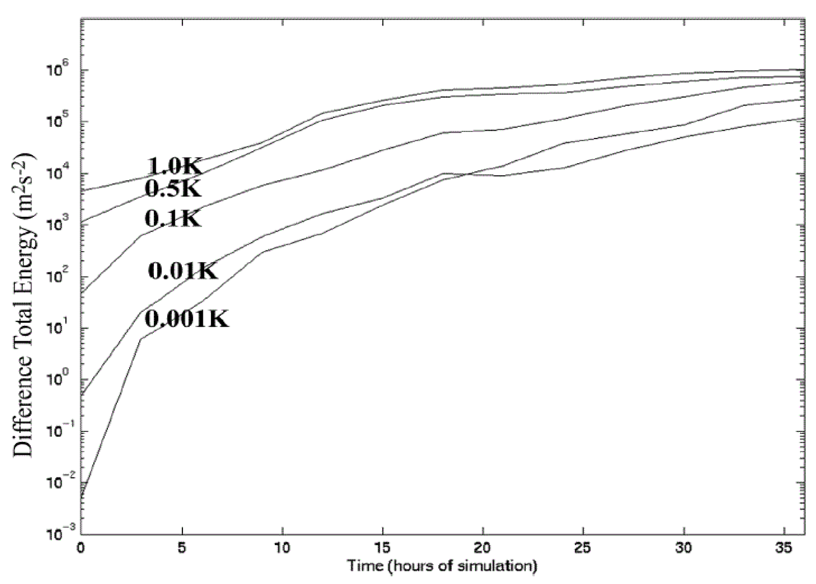
The Effects of Numerical Noise on Perturbation Experiments

Brian Ancell, Department of Geosciences, Texas Tech University

INTRODUCTION

Perturbation experiments are useful for applications such as data assimilation observation impact experiments, simulations to investigate inadvertent weather modification, or forecast sensitivity runs. In turn, numerous studies have executed perturbation experiments, measuring key differences between simulations that differ by their initial conditions. It has been discovered, however, that perturbations can introduce noise to model variables not physically related to the perturbation, which can grow rapidly through nonlinear processes. This work aims to understand whether these effects can lead to misinterpretations of perturbation experimental results.

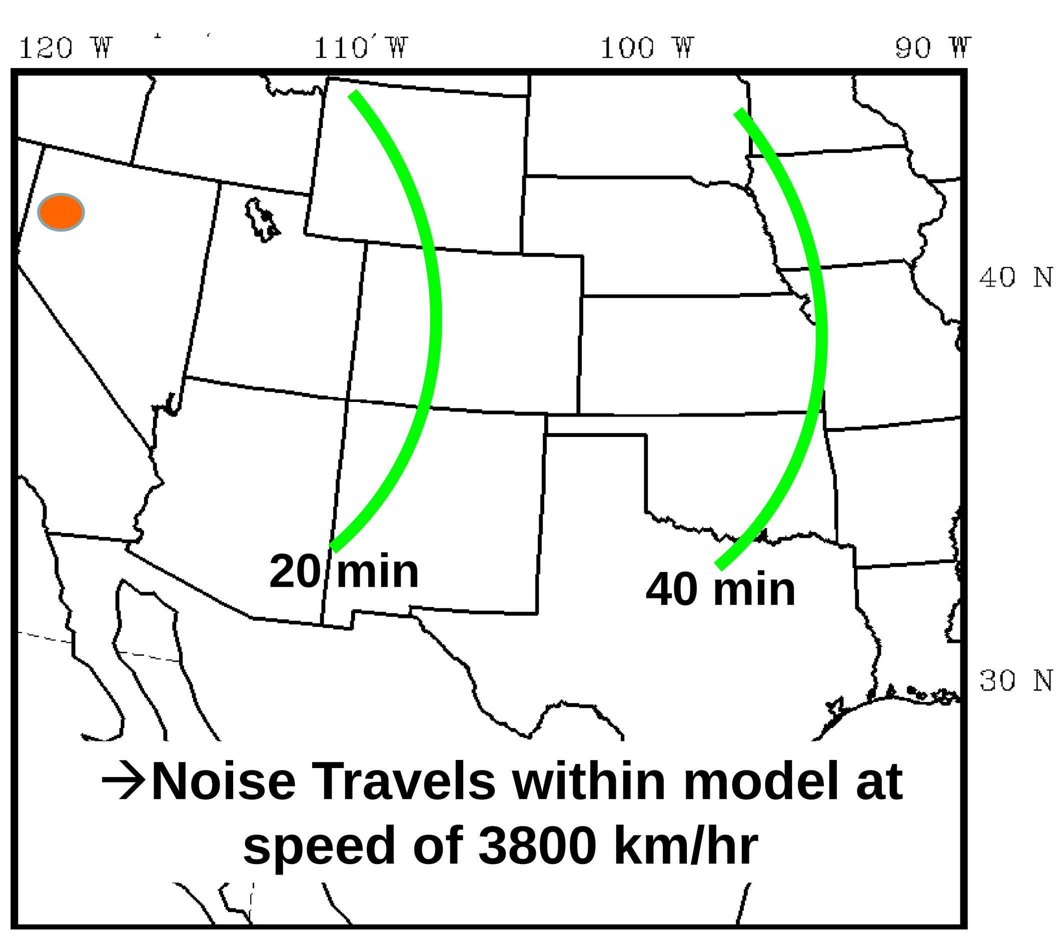
BACKGROUND AND MOTIVATION



Evolution of perturbation total energy for different temperature perturbation magnitudes (from Zhang et al. 2003, JAS)

→ Growth rates within moist convection are much more rapid for the smallest perturbations

- These nonlinear growth processes provide the mechanism for very small perturbations to significantly affect forecasts



● - Soil Moisture Perturbation

TIME (min)	0KM	500KM	1000KM	1500KM	2000KM
0	0	0	0	0	0
10	-0.179	$2.5x10^{-5}$	0	0	0
20	-0.288	$4.7x10^{-5}$	$2.4x10^{-7}$	0	0
30	-0.06	$4.8x10^{-5}$	$-6.8x10^{-5}$	$5.0x10^{-6}$	0
40	-0.07	$-6.1x10^{-5}$	$1.3x10^{-5}$	$5.5x10^{-5}$	$-1.2x10^{-5}$

Horizontal propagation of numerical noise to the surface potential temperature field (K) relative to the source of the perturbation

→ Can unphysical processes initiate rapid error growth within perturbation experiments?

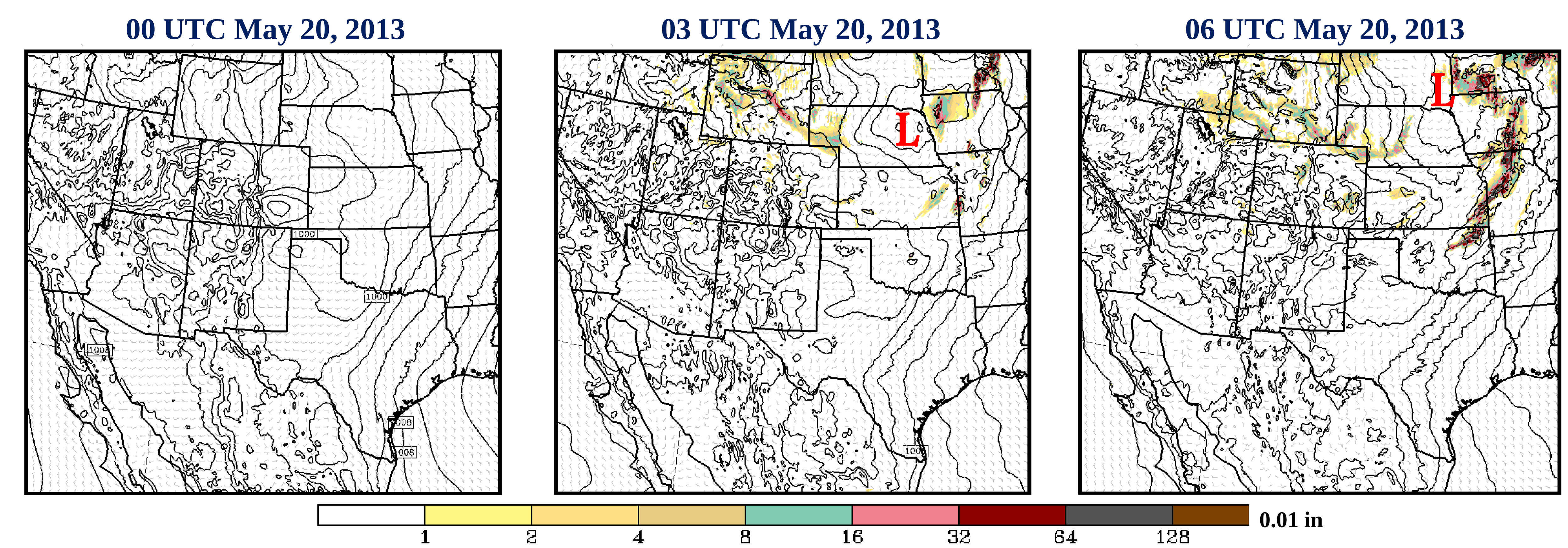
Author contact information: brian.ancell@ttu.edu

METHODOLOGY

-Perturbation experiments are executed using the WRF-ARW mesoscale model V3.5.1 with nonlocal soil moisture perturbations to the initial conditions

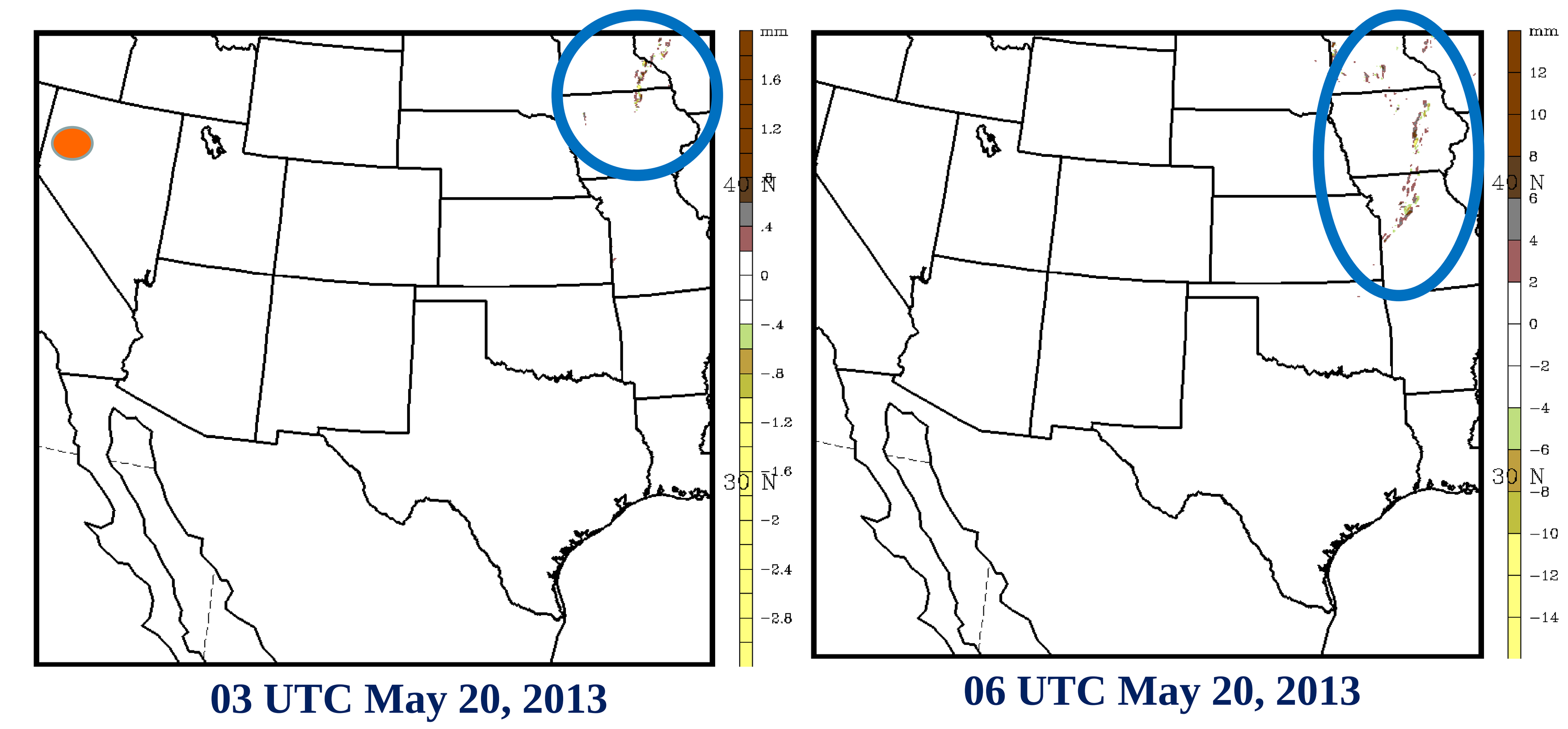
- Perturbation effects are examined for nonlocal convection

RESULTS



Hourly precipitation (shaded), sea level pressure (black contours, countour interval 2 hPa), and surface winds (barbs) at 00hr, 03hr, and 06hr for the control run

Precipitation differences begin 2-3 hr after initialization, and are very likely the result of rapid growth of fast-spreading numerical noise



IMPLICATIONS

- Rapid propagation and growth of numerical noise within convection is an efficient mechanism through which chaos can amplify unrealistic effects
- Such “contamination” can indeed contribute to misinterpretations of perturbation experimental results such as those involved with data assimilation impact or forecast sensitivity experiments

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