An OSSE study of RTFDDA radar data assimilation

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Outline

1. RTFDDA Radar Data Assimilation
2. Observing System Simulation Experiments (OSSEs)
3. Results of OSSEs
4. Summary and future work

Radar Data Assimilation

- **Radar assimilation methods:**

3DVAR (Xiao et al., 2005; Gao and Stensrud, 2012)

4DVAR (Sun and Crook, 1997)

EnKF (Tong and Xue, 2005; Dowell et al., 2011)

Nudging (Newtonian relaxation, Haase et al., 2000; Stephan, et al., 2008)

RTFDDA Radar Data Assimilation

RTFDDA-RDA

- **RTFDDA** is a WRF-based real-time four-dimensional data assimilation and forecasting system developed at NCAR/RAL, which effectively assimilates diverse observations for real-time NWP.
- **RTFDDA-RDA** is a radar data assimilation based on hydrometeor and latent heat nudging (HLHN) to assimilate radar reflectivity for improving short-term forecast of convection.

A Description of RTFDDA-RDA

- **RTFDDA-RDA procedures**
  - Estimate hydrometeor (Qr/Qs) from radar reflectivity
  - Adjust the thermodynamic and microphysical fields based on the differences between model and observations.
- **Two tunable parameters**: time window and nudging coefficient
- **Advantages**: simplicity, ease of implementation and computational efficiency
- **Disadvantages**: empirical relationships between the hydrometeor variables and observed reflectivity, uncertainties exist in nudging parameters

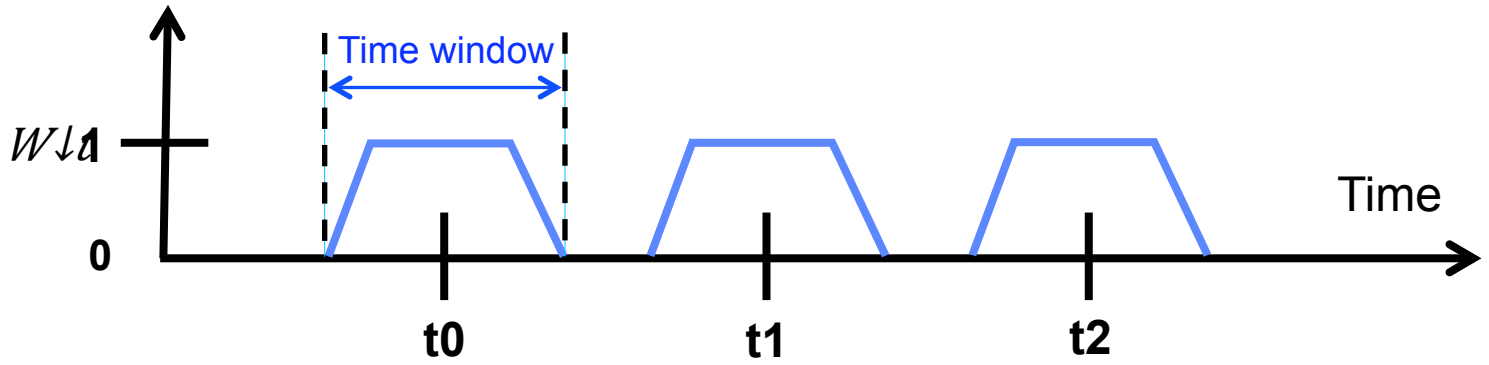
Motivation

The purpose of this study is to investigate the influence of varying nudging coefficients and assimilation time windows on the short-term precipitation forecasting.

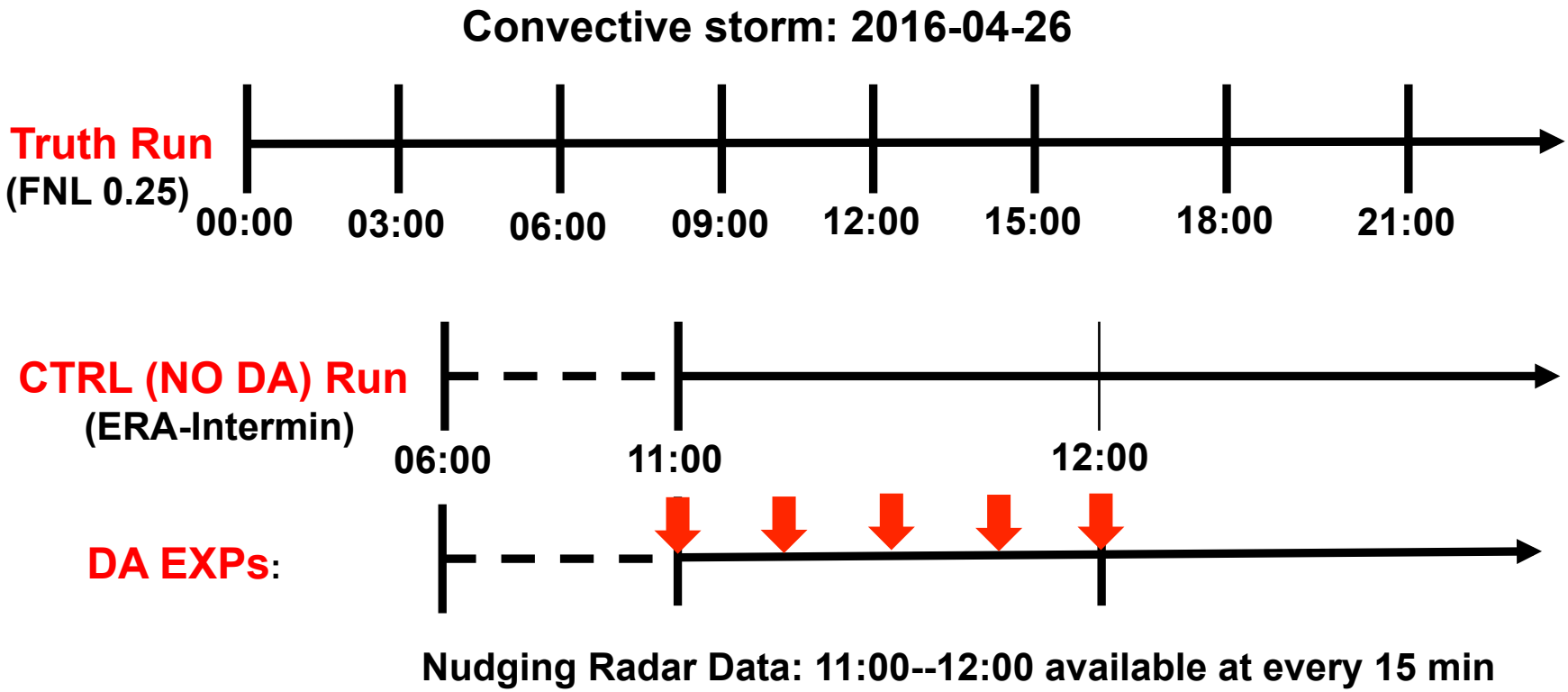
$$\partial \mu\alpha/\partial t = F(\alpha,t) + G\downarrow\alpha \cdot W\downarrow t \cdot W\downarrow z \cdot \mu(\alpha\downarrow o - \alpha)$$

$G\downarrow\alpha$ -- nudging coefficient (nudging inverse time scale)

$W\downarrow t$ -- temporal weight



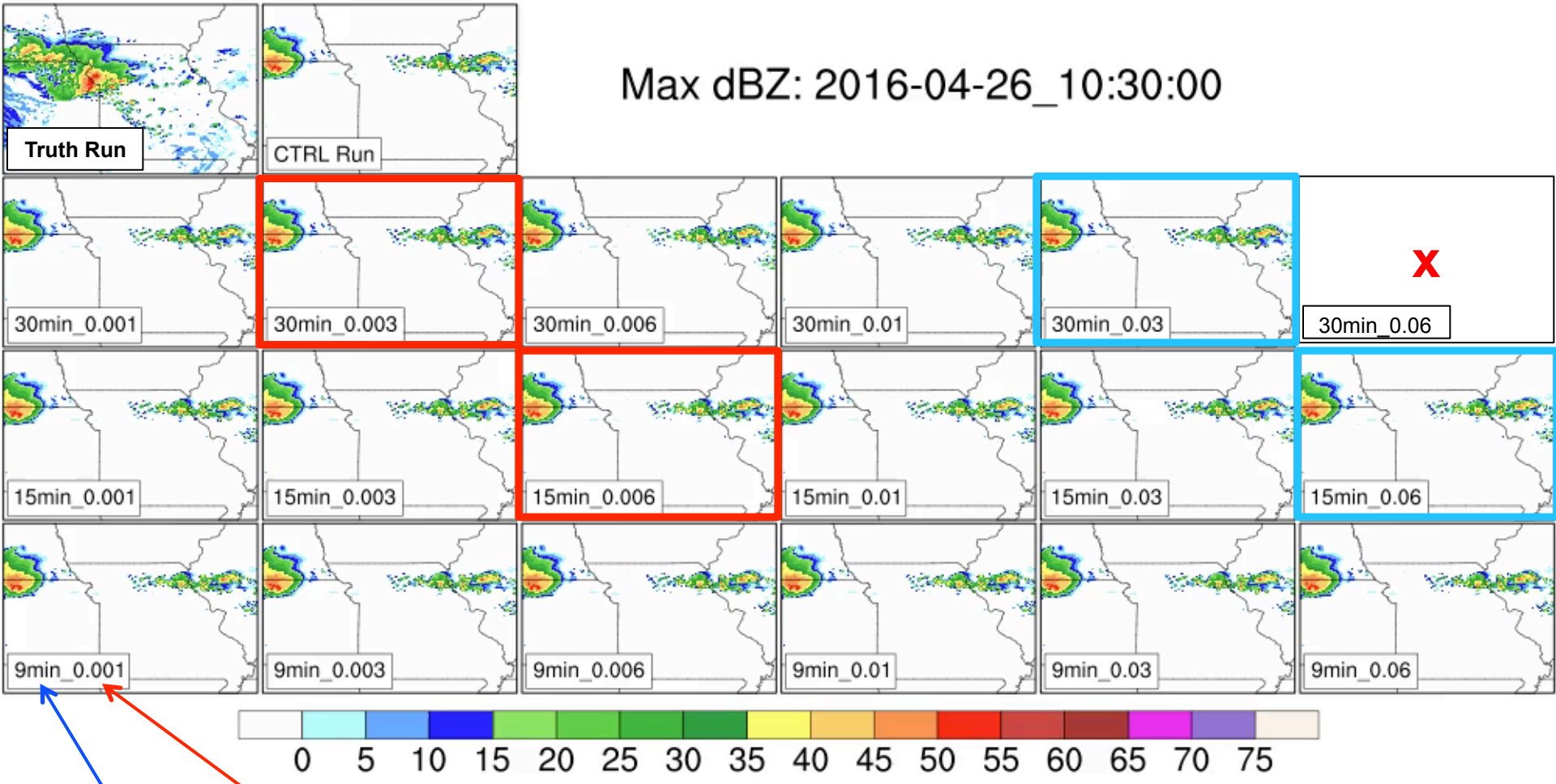
Observing System Simulation Experiments (OSSEs)



EXP on time windows: 30, 15, and 9 minutes

EXP on nudging coefficient: 0.001, 0.003, 0.006, 0.01, 0.03, and 0.06

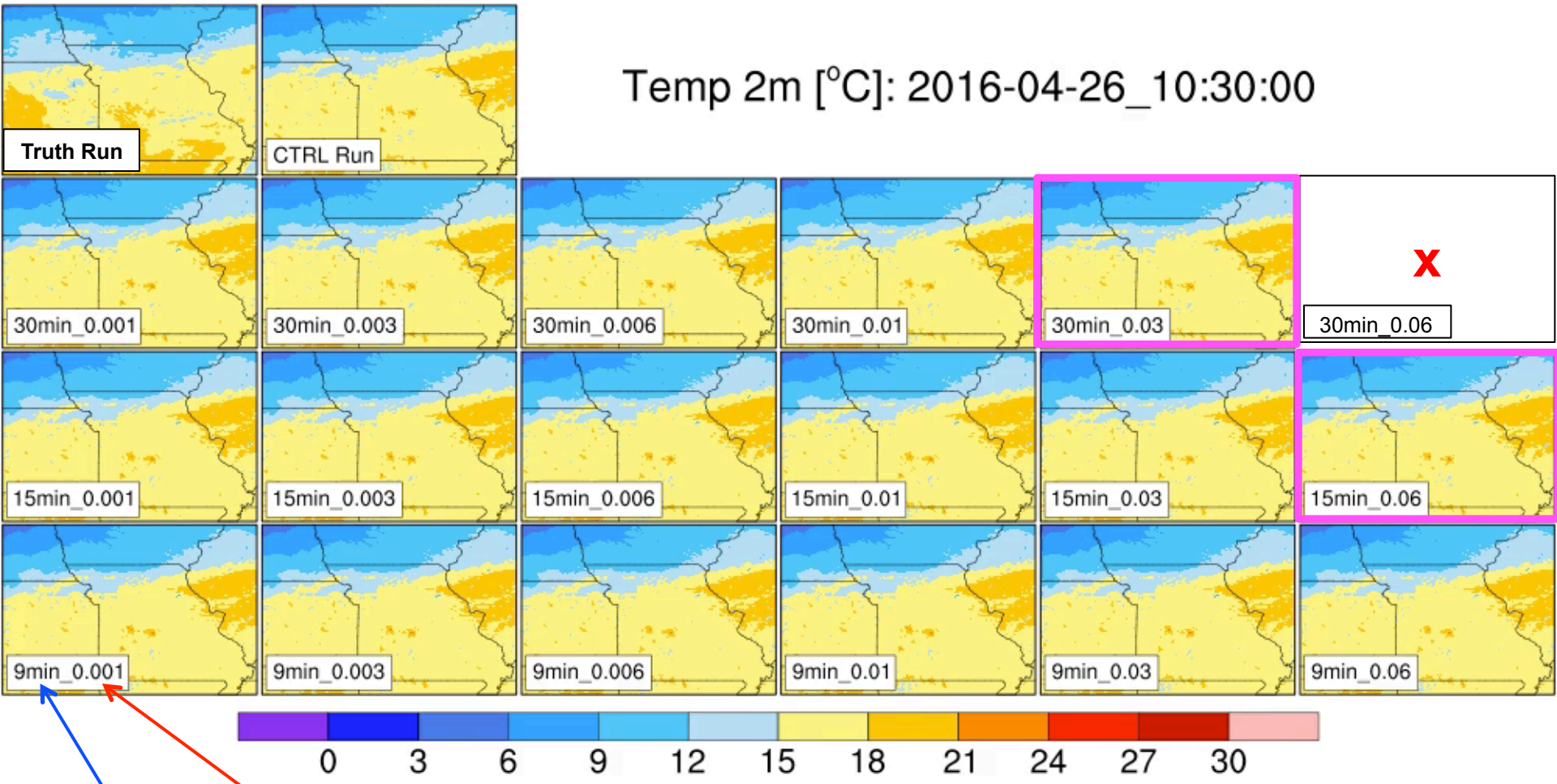
Experiment Results: Reflectivity



TimeWindow_NudgingCoefficient

Animation from 10:30 to 18:00 at 5-min intervals

Experiment Results: Surface Temperatures

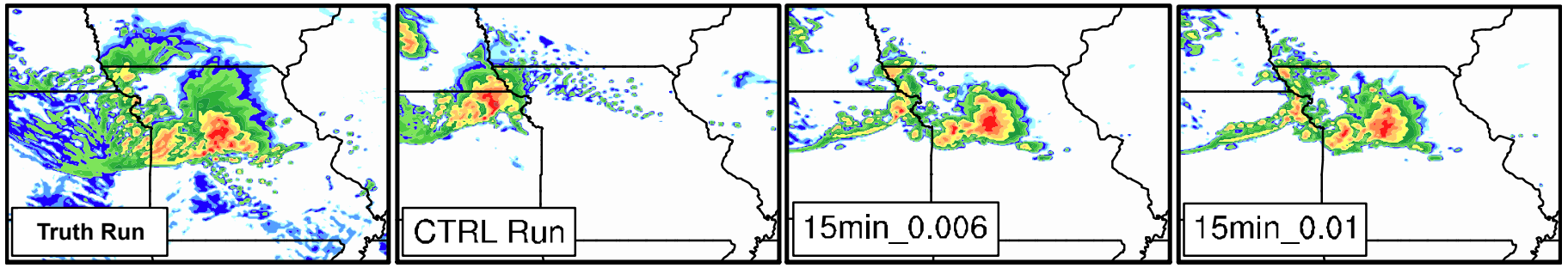


TimeWindow_NudgingCoefficient

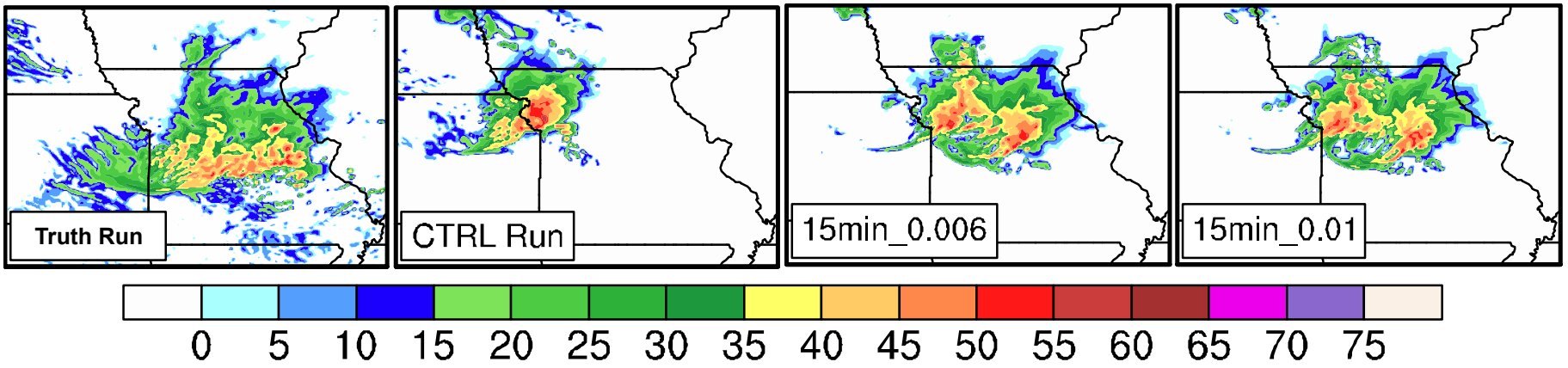
Animation from 10:30 to 18:00 at 5-min intervals

Tolerance to Reasonable Nudging Parameters

1-hour Max radar equivalent reflectivity factor (dBZ) forecast (13Z)



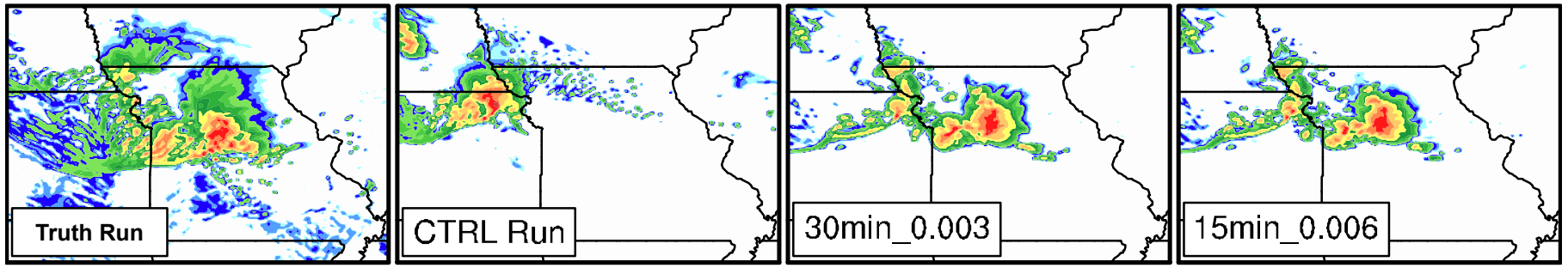
3-hour Max radar equivalent reflectivity factor (dBZ) forecast (15Z)



Results are similar when nudging coefficient is in a certain range.

Mutual Compensation between Time window and Nudging Coefficient

1-hour Max radar equivalent reflectivity factor (dBZ) forecast (13Z)



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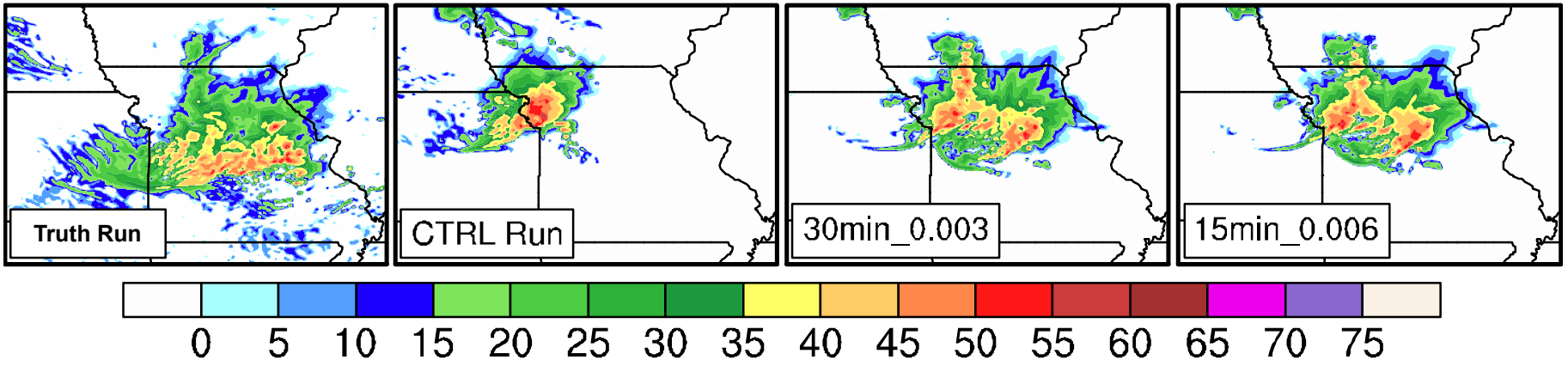
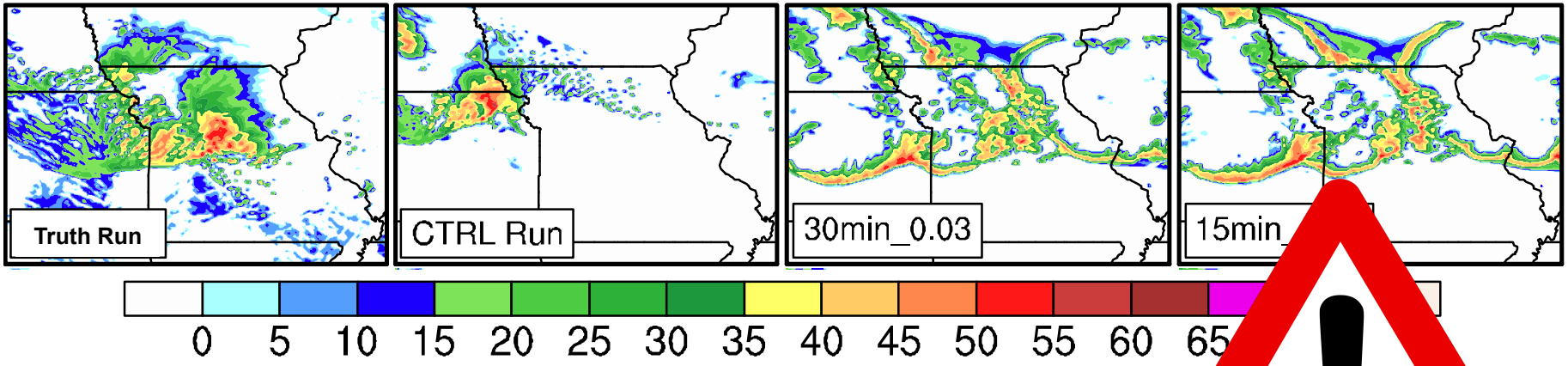


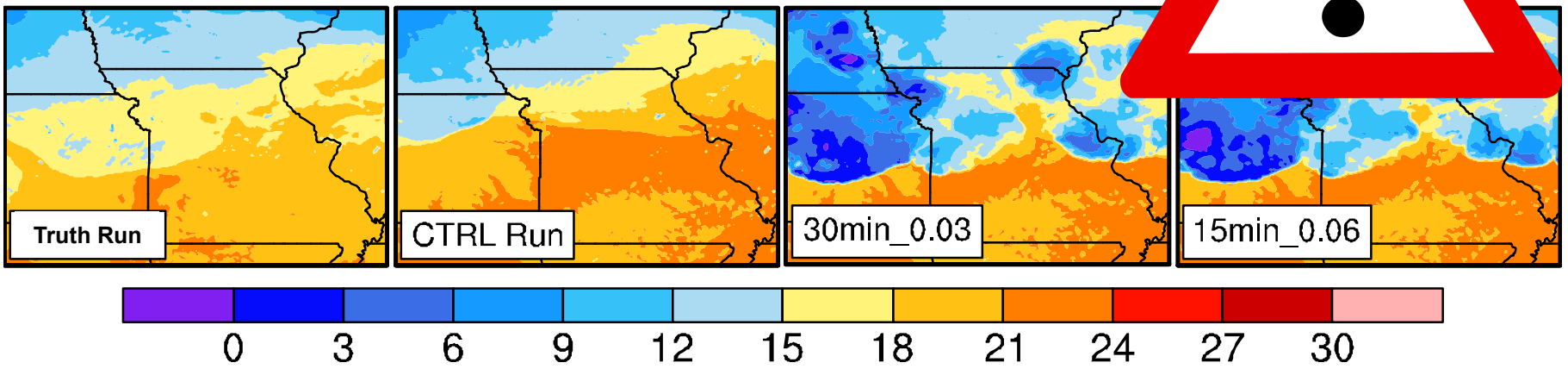
Linear features exist in a short time window.

Impact of Excessive Nudging Forcing

1-hour Max radar equivalent reflectivity factor (dBZ) forecast (13Z)

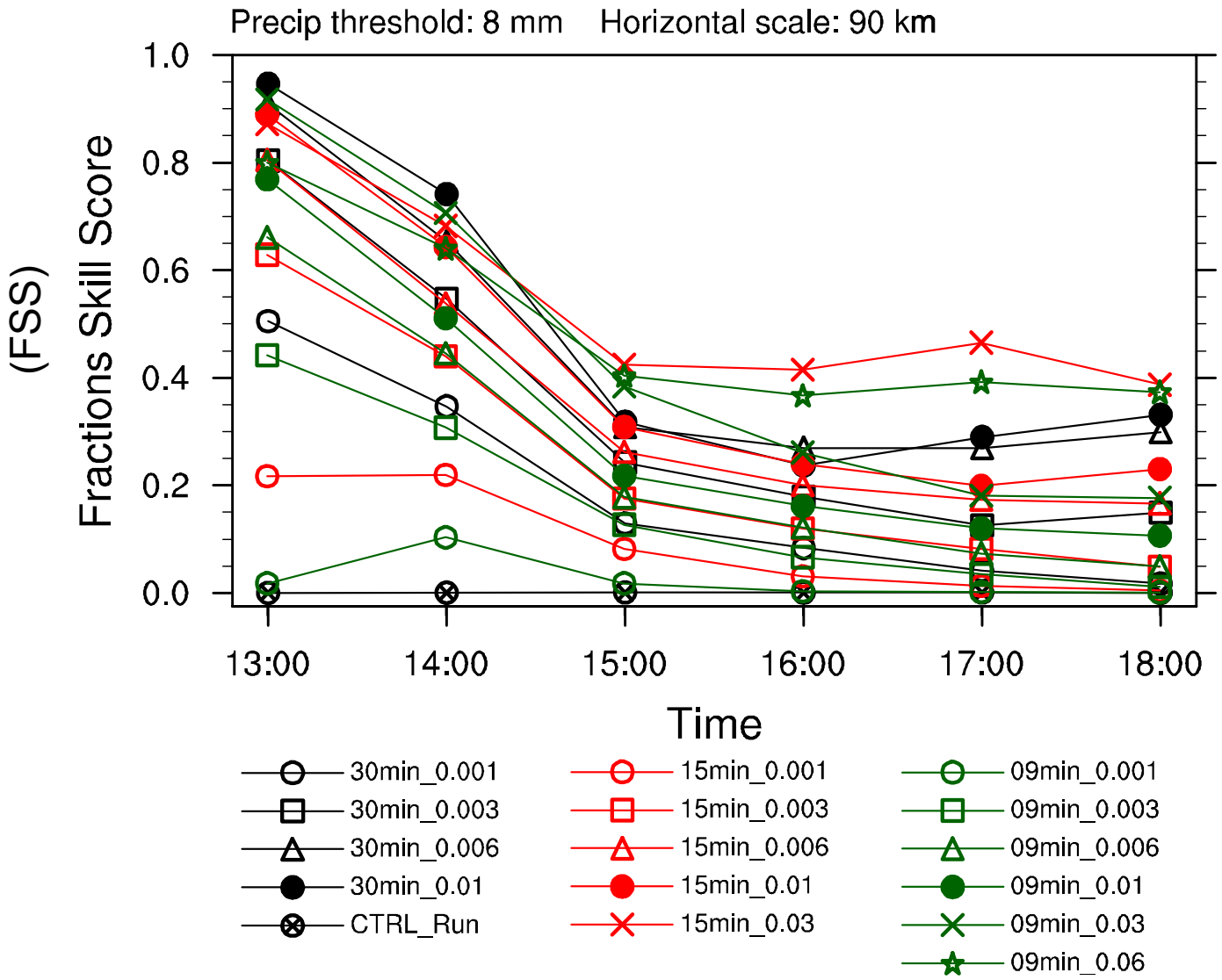


1-hour air temperature at 2 m (°C) forecast (1



Large nudging coefficient can cause strong cold pools near land surface

Precipitation Forecasting Skill Score



Summary

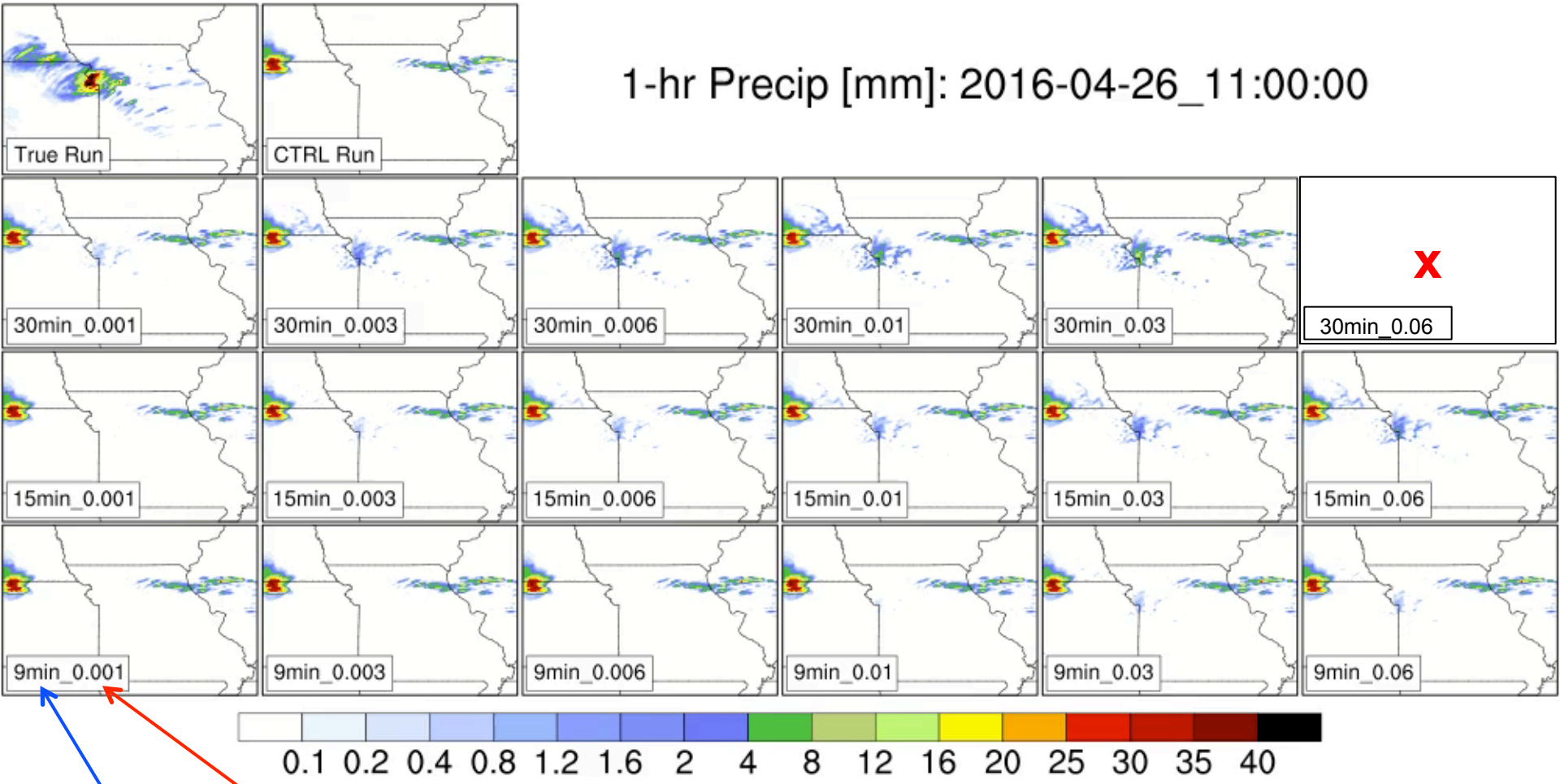
- **The nudging time window and nudging coefficients of the RTFDDA-RDA scheme is studied with OSSEs.**
- **The simulation results are insensitive to the value of the nudging parameters when they are in a reasonable range.**
- **For near-linear dynamics, the nudging time window length and nudging coefficient may mutually compliment.**
- **An excessively large nudging coefficient can cause overly strong cold pools near land surface and stimulates fallacious convection.**
- **RTFDDA-RDA presents a reasonable capability for nowcasting and short-term forecasting of convective precipitation systems**

Future Work

- **Find reasonable location and amount of latent heating**
- **Evaluate the performance of RTFDDA-RDA with a set of real weather convection cases, and study the impact of the nudging parameters on different convection systems.**

Thank you!

Experiment Results: Surface Precipitation

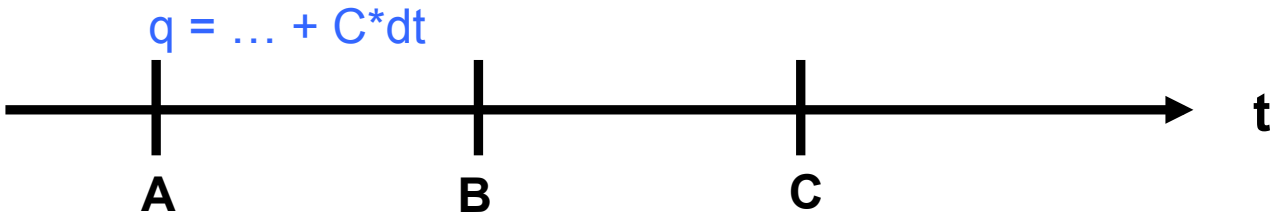


TimeWindow_NudgingCoefficient

Animation from 10:30 to 18:00 at 5-min intervals

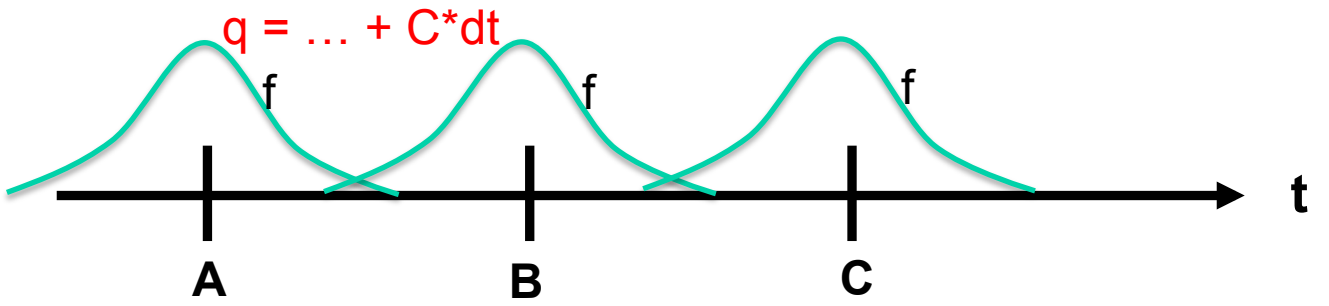
RTFDDA Radar Data Assimilation

Original scheme (Grid-nudging) : Nudging term C = $G(q_B-q_A)/(t_B-t_A)$



Limitations: 1) both q_B and q_A must exist,
2) weather processes between A and B must be linear,
3) and it performs badly for fast moving storms.

New scheme (Grid-Obs nudging hybrid) : $C = Gq_Af(t-t_A) + Gq_Bf(t-t_B) + Gq_Cf(t-t_C)$



From Liu

Advantage: effectively overcomes the disadvantages of the old scheme.