# Impact of assimilating pre-convective upsonde observations on short-term forecasts of convection observed during MPEX

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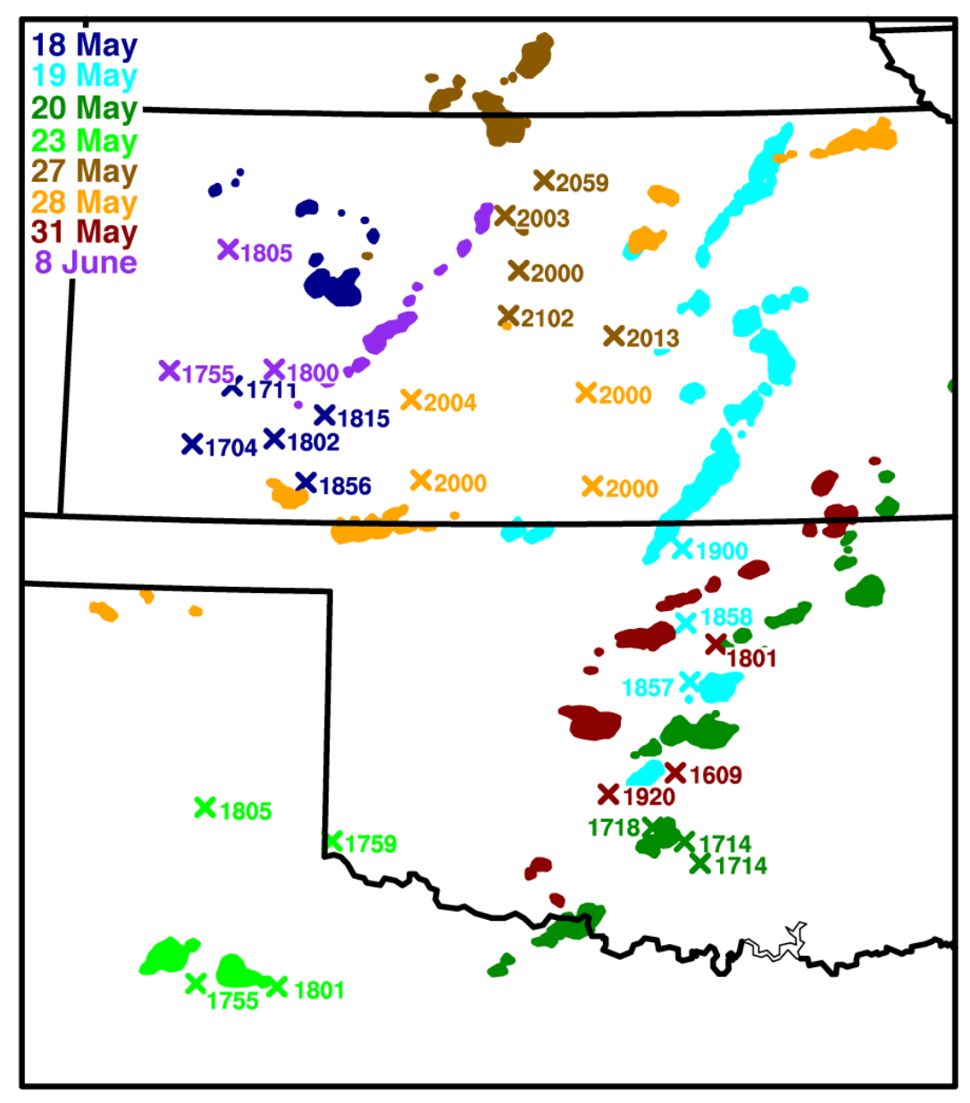
**Question**: Does the assimilation of balloon-borne rawinsonde (upsonde) observations of T, rh, u, and v taken a few hours prior to subsequent CI improve 1 – 9 h forecasts of convection?

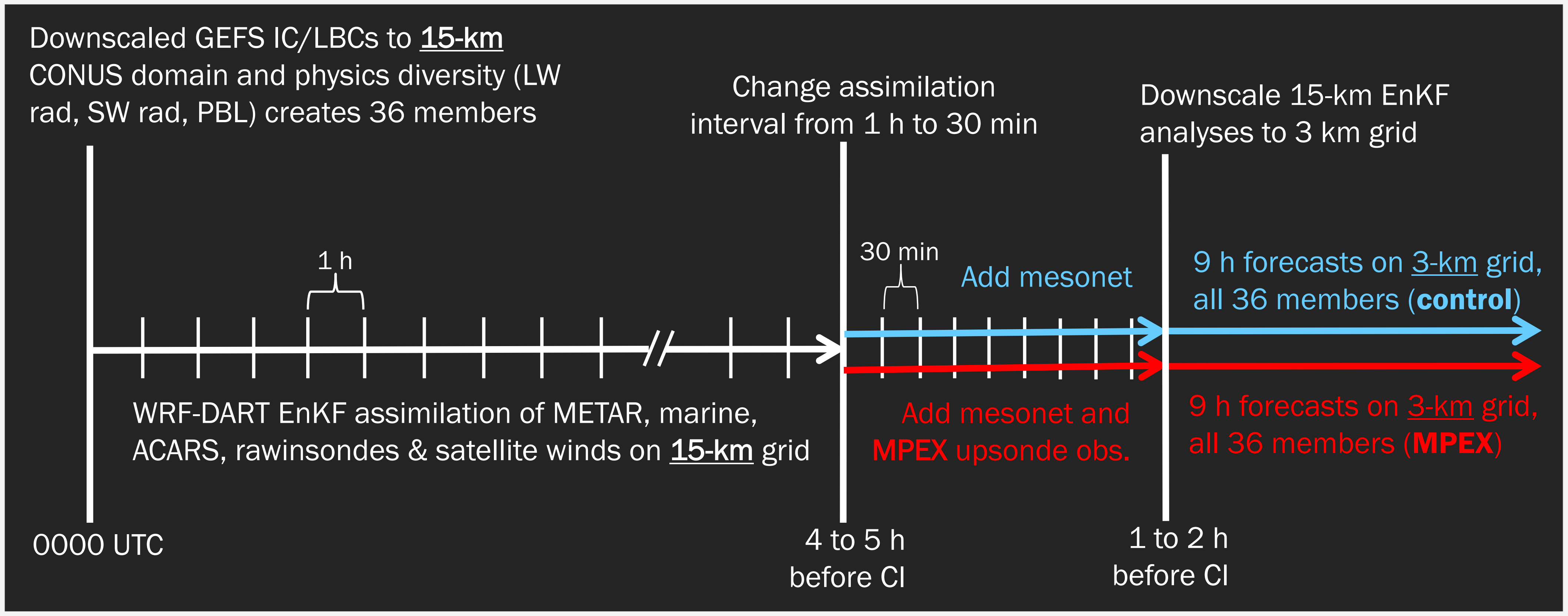
**Requirement**: At least three upsondes taken at least 1 h before CI, a 'clean slate' environment, and convection in both nature and in forecasts. Eight (8) MPEX cases qualified.

| Date | Region | Storm Type | # sondes |
|---|---|---|---|
| May 18 | Western KS | Tornadic supercells | 5 |
| May 19 | Central OK | Tornadic supercells | 3 |
| May 20 | Central OK | Tornadic to non-tornadic supercell | 3 |
| May 23 | Western TX | Tornadic supercell to MCS | 4 |
| May 27 | Central KS | Tornadic and a weak supercell | 5 |
| May 28 | Central KS | Tornadic supercell and MCS | 5 |
| May 31 | Central OK | Tornadic supercell to MCS | 3 |
| June 8 | SW KS/NW OK/TX | Squall line w/embedded supercells | 3 |



Locations (X) and times (UTC) of pre-CI upsondes that are assimilated for the eight MPEX cases (color coded by day). Filled contours show NSSL MRMS composite reflectivity > 50 dBZ near the radiosonde locations approximately three hours after the final radiosonde release for each day.

## NWP and Data Assimilation Framework



Downscaled GEFS IC/LBCs to 15-km CONUS domain and physics diversity (LW rad, SW rad, PBL) creates 36 members

Change assimilation interval from 1 h to 30 min

Downscale 15-km EnKF analyses to 3 km grid

1 h

30 min

Add mesonet

9 h forecasts on 3-km grid, all 36 members (**control**)

WRF-DART EnKF assimilation of METAR, marine, ACARS, rawinsondes & satellite winds on 15-km grid

Add mesonet and MPEX upsonde obs.

9 h forecasts on 3-km grid, all 36 members (**MPEX**)

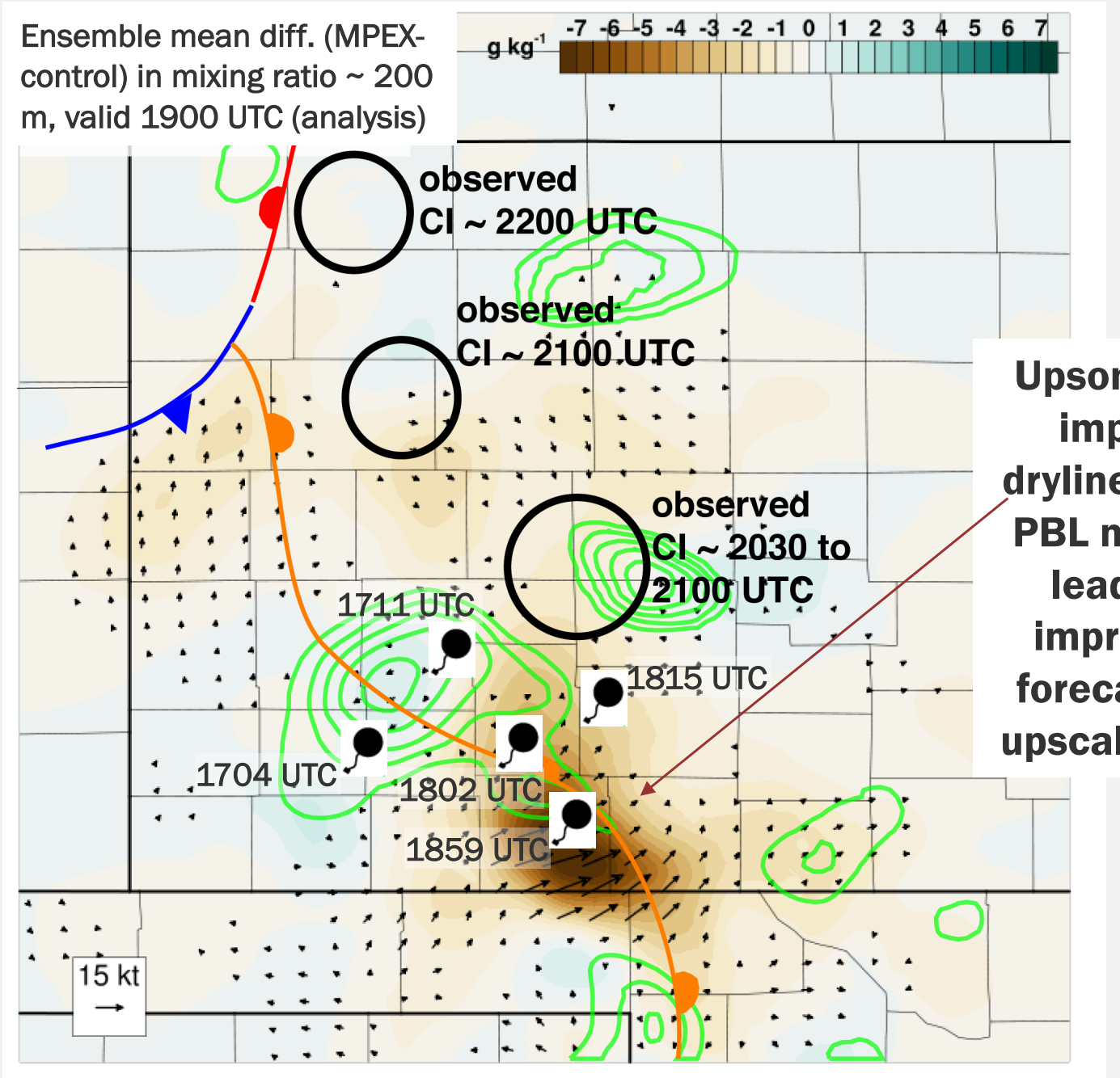
0000 UTC

4 to 5 h before CI

1 to 2 h before CI

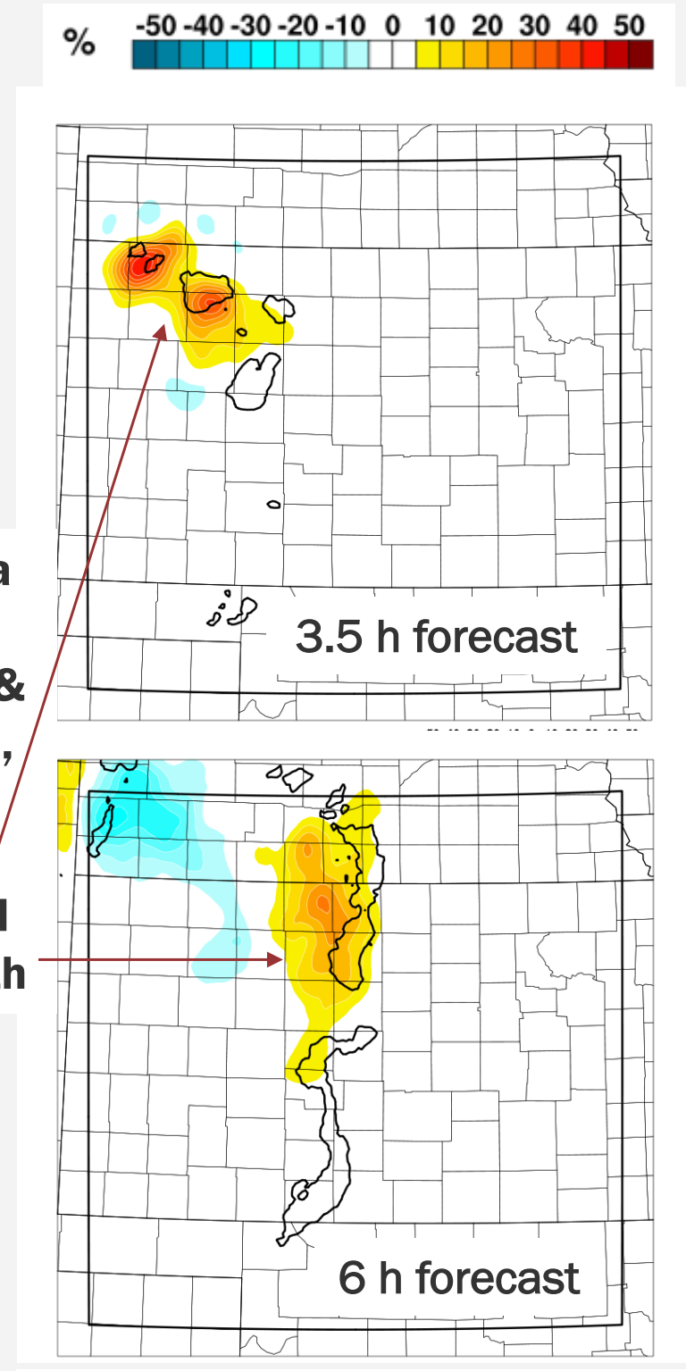
**When considering verification neighborhoods approximating the smallest resolvable scales of the 3-km grid (8Δ): Four cases showed positive impacts, and four cases showed neutral to negative impacts**

### Best Case: 18 May 2013



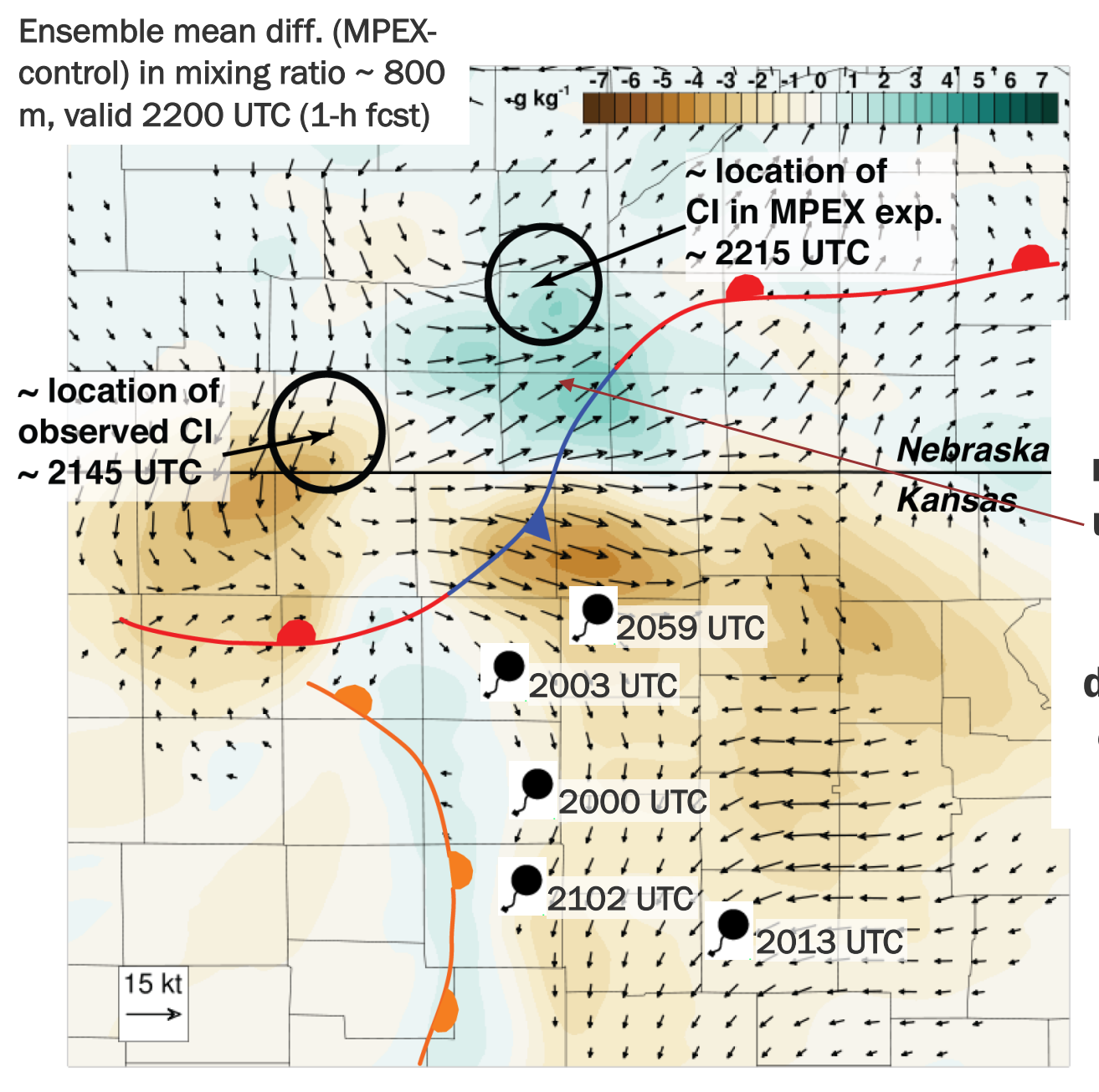
Ensemble mean difference (MPEX - control) in water vapor mixing ratio (g kg$^{-1}$) and winds (kt) at ~200 m AGL (color shading) and near the top of the PBL (green contours every 0.25 g kg$^{-1}$) valid 1900 UTC 18 May 2013 (initialization time of the 3 km forecasts). Analyzed positions of a stationary front and dryline are shown along with the locations of observed CI circled in black (CI in the model forecasts occurred about 30-60 min later). Balloon icons mark the location of the five MPEX soundings taken between 1700 and 1900 UTC.

**Upsonde data improved dryline bulge & PBL moisture, leading to improved CI forecasts and upscale growth**



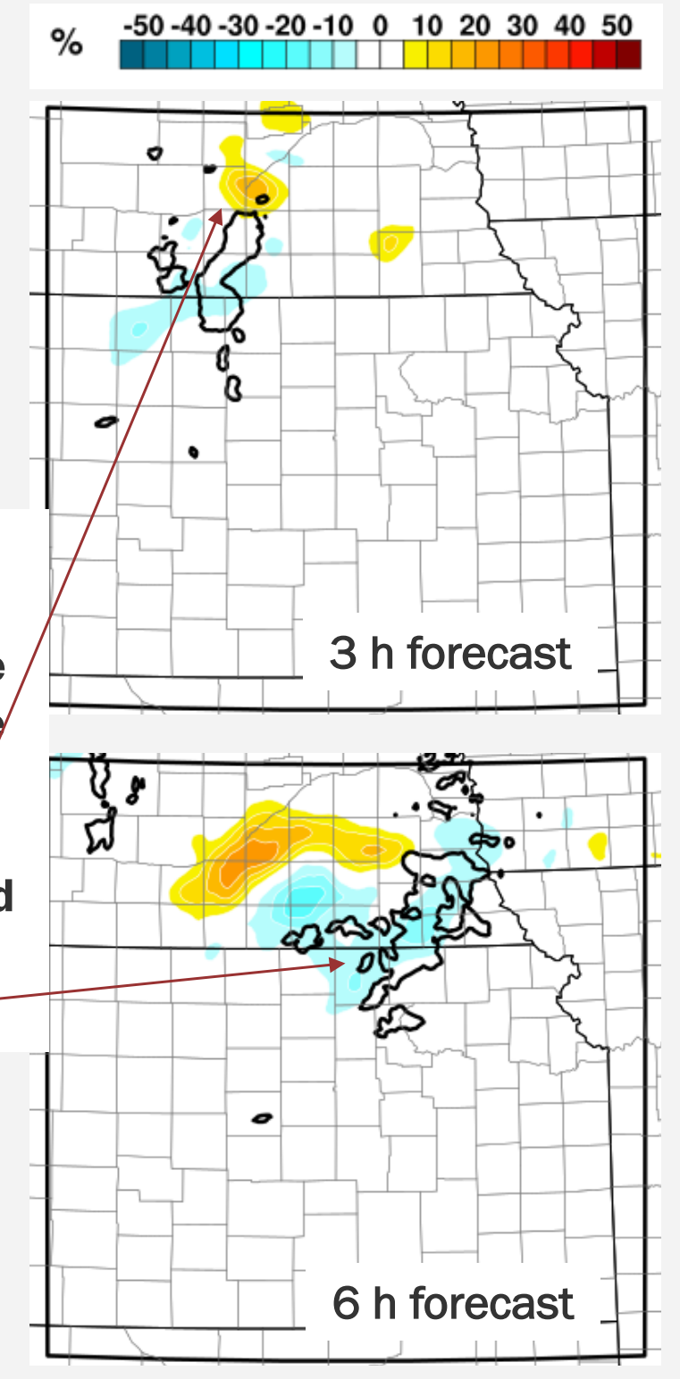
Difference (MPEX - control) of smoothed simulated reflectivity > 40 dBZ for 3.5 h forecasts (top panel) and 6 h forecasts (bottom panel). The black contour shows the NSSL MRMS composite reflectivity > 40 dBZ.

### Worst Case: 27 May 2013



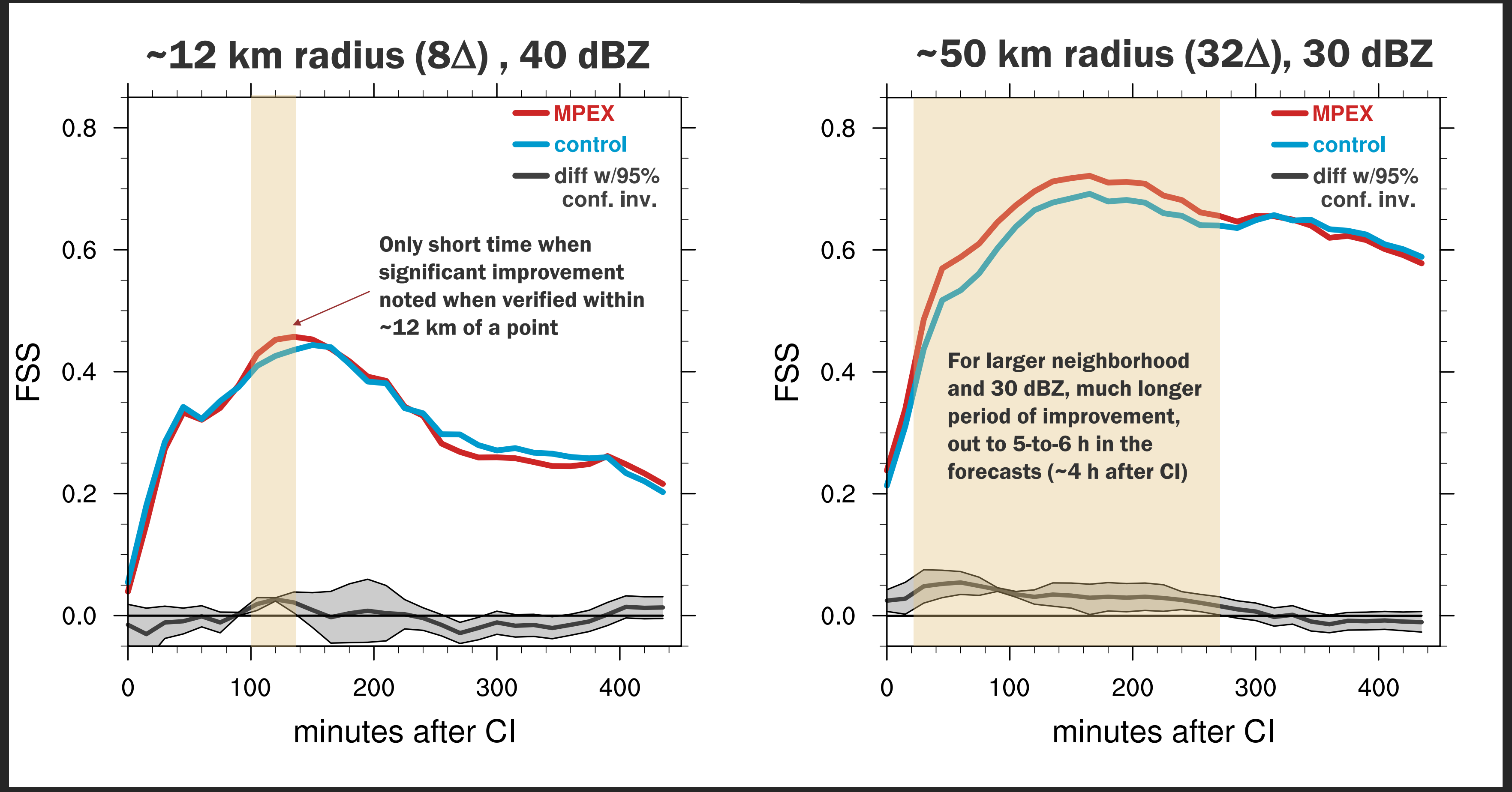
Ensemble mean difference (MPEX - control) in water vapor mixing ratio (g kg$^{-1}$) and winds (kt) at ~800 m AGL (color shading) valid 2200 UTC 27 May 2013 (1-h forecasts). Analyzed positions of a stationary front and dryline are shown along with the location of the first observed CI circled in black. Balloon icons mark the location of the five MPEX soundings taken between 2000 and 2100 UTC.

**Upsonde data increased PBL moisture on the unsampled side of the front leading to displaced CI and eventual phase error to MCS**



Difference (MPEX - control) of smoothed simulated reflectivity > 40 dBZ for 3 h forecasts (top panel) and 6 h forecasts (bottom panel). The black contour shows the NSSL MRMS composite reflectivity > 40 dBZ.

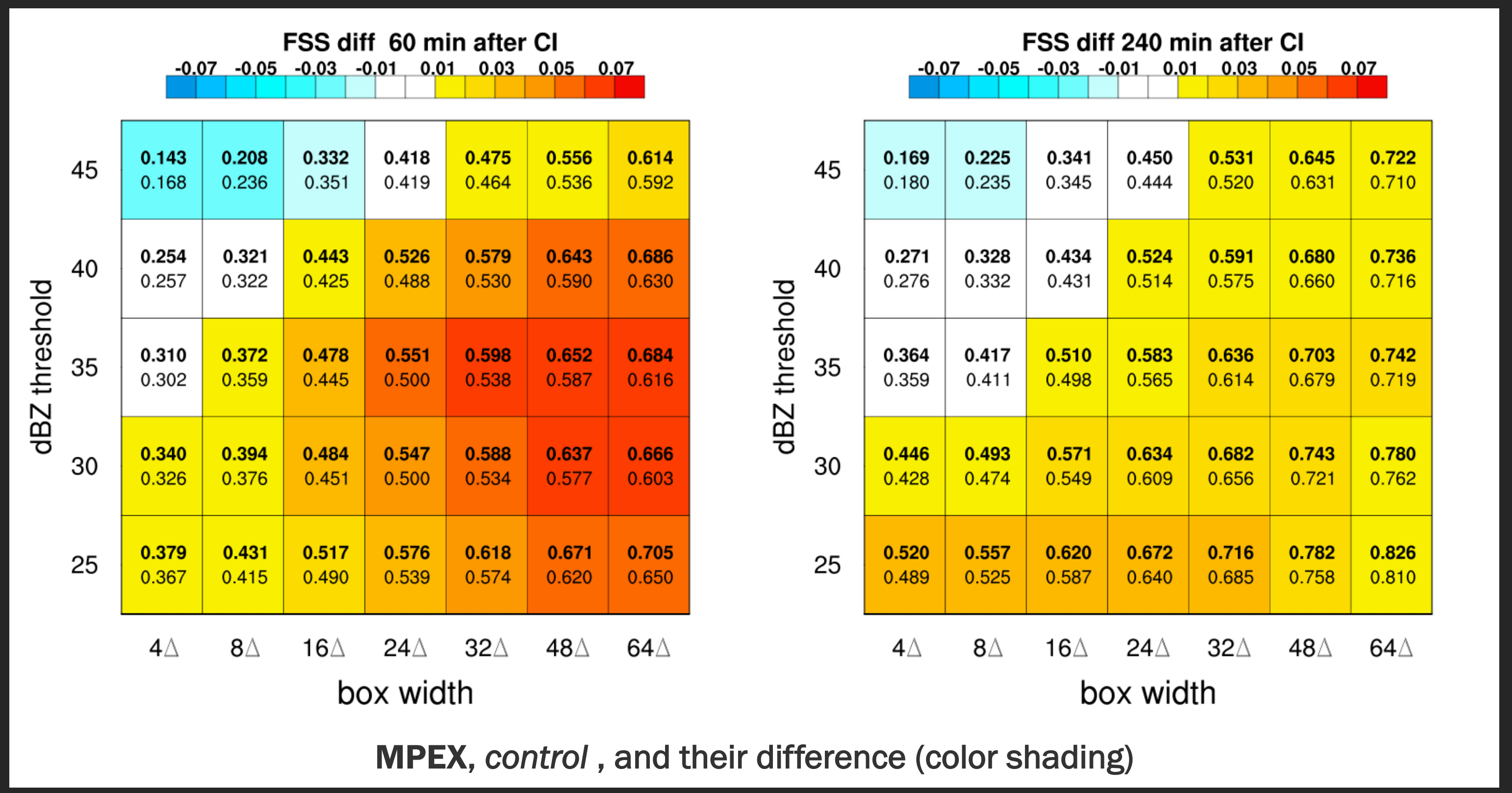
**Time evolution of Fractions Skill Score (FSS) aggregated over all 8 cases for two neighborhood/dBZ threshold combinations out to 7 h after CI**



Only short time when significant improvement noted when verified within ~12 km of a point

For larger neighborhood and 30 dBZ, much longer period of improvement, out to 5-to-6 h in the forecasts (~4 h after CI)

**Fractions Skill Score (FSS) aggregated over all 8 cases for five neighborhoods and seven dBZ thresholds for 1h forecasts and 4 h forecasts after CI**



FSS diff 60 min after CI

| dBZ threshold | 4Δ | 8Δ | 16Δ | 24Δ | 32Δ | 48Δ | 64Δ |
|---|---|---|---|---|---|---|---|
| 45 | **0.143**<br>0.168 | **0.208**<br>0.236 | **0.332**<br>0.351 | **0.418**<br>0.419 | **0.475**<br>0.464 | **0.556**<br>0.536 | **0.614**<br>0.592 |
| 40 | **0.254**<br>0.257 | **0.321**<br>0.322 | **0.443**<br>0.425 | **0.526**<br>0.488 | **0.579**<br>0.530 | **0.643**<br>0.590 | **0.686**<br>0.630 |
| 35 | **0.310**<br>0.302 | **0.372**<br>0.359 | **0.478**<br>0.445 | **0.551**<br>0.500 | **0.598**<br>0.538 | **0.652**<br>0.587 | **0.684**<br>0.616 |
| 30 | **0.340**<br>0.326 | **0.394**<br>0.376 | **0.484**<br>0.451 | **0.547**<br>0.500 | **0.588**<br>0.534 | **0.637**<br>0.577 | **0.666**<br>0.603 |
| 25 | **0.379**<br>0.367 | **0.431**<br>0.415 | **0.517**<br>0.490 | **0.576**<br>0.539 | **0.618**<br>0.574 | **0.671**<br>0.620 | **0.705**<br>0.650 |

FSS diff 240 min after CI

| dBZ threshold | 4Δ | 8Δ | 16Δ | 24Δ | 32Δ | 48Δ | 64Δ |
|---|---|---|---|---|---|---|---|
| 45 | **0.169**<br>0.180 | **0.225**<br>0.235 | **0.341**<br>0.345 | **0.450**<br>0.444 | **0.531**<br>0.520 | **0.645**<br>0.631 | **0.722**<br>0.710 |
| 40 | **0.271**<br>0.276 | **0.328**<br>0.332 | **0.434**<br>0.431 | **0.524**<br>0.514 | **0.591**<br>0.575 | **0.680**<br>0.660 | **0.736**<br>0.716 |
| 35 | **0.364**<br>0.359 | **0.417**<br>0.411 | **0.510**<br>0.498 | **0.583**<br>0.565 | **0.636**<br>0.614 | **0.703**<br>0.679 | **0.742**<br>0.719 |
| 30 | **0.446**<br>0.428 | **0.493**<br>0.474 | **0.571**<br>0.549 | **0.634**<br>0.609 | **0.682**<br>0.656 | **0.743**<br>0.721 | **0.780**<br>0.762 |
| 25 | **0.520**<br>0.489 | **0.557**<br>0.525 | **0.620**<br>0.587 | **0.672**<br>0.640 | **0.716**<br>0.685 | **0.782**<br>0.758 | **0.826**<br>0.810 |

**MPEX**, *control* , and their difference (color shading)

**Main Result**: Statistically significant Improvement in forecasts out 5-to-6 h seen when aggregating over all 8 cases for meso-β (and larger) scales, but some improvements seen in individual cases on scales close to the smallest resolvable scales of the grid.

Results likely can be improved further: Inspection of analysis increments on days with neutral to negative impacts near the grid-scale suggests that the sampling locations were sub-optimal for the convection of interest.

Data is being collected in 2016-17 using ensemble sensitivity analysis (ESA) to address this issue ("mini-MPEX") and further test impacts of radiosonde data compared to boundary-layer profiler data (from a Doppler Wind Lidar and an AERI).

**Recommendation: Rapidly-deployable upper-air observing systems (w/rawinsondes, boundary-layer profilers, UASs) could be operational at select NWS offices to supplement the radiosonde network on potentially significant severe weather days!**

For more details see: Coniglio, M., S. Hitchcock, and K. Knopfmeier, 2016: Impact of Assimilating Preconvective Upsonde Observations on Short-Term Forecasts of Convection Observed during MPEX. *Mon. Wea. Rev.*, **144**, 4301–4325