A GSI-based convection-allowing EnKF and ensemble forecast system for PECAN

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Plains Elevated Convection At Night (PECAN)

- Field experiment to comprehensively observe nocturnal convection features.

- Both fixed and mobile observing instruments.

- Accurate convective scale forecasts needed to deploy mobile instruments.

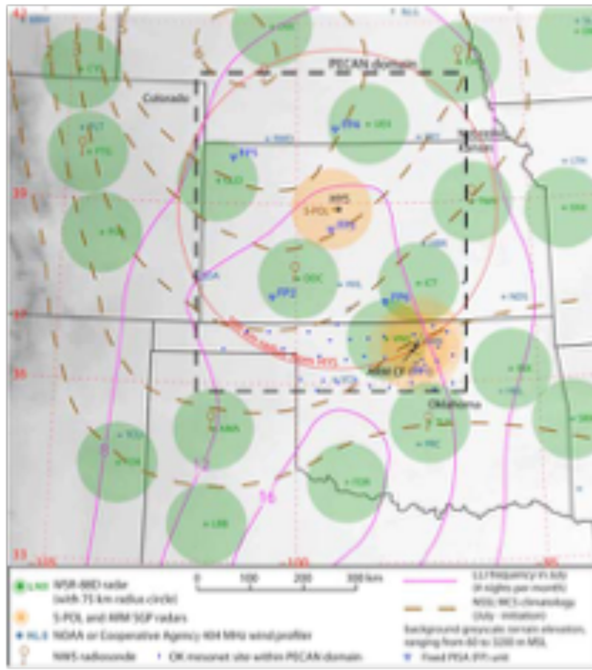


Fig. 7: *Location of the PECAN domain in the Great Plains (bold dashed line). Also shown are the operational radar and wind profiler network, the fixed PECAN radar other PISA facilities, and LLJ and MCS climatological information. Adapted from the EDO (Geerts*

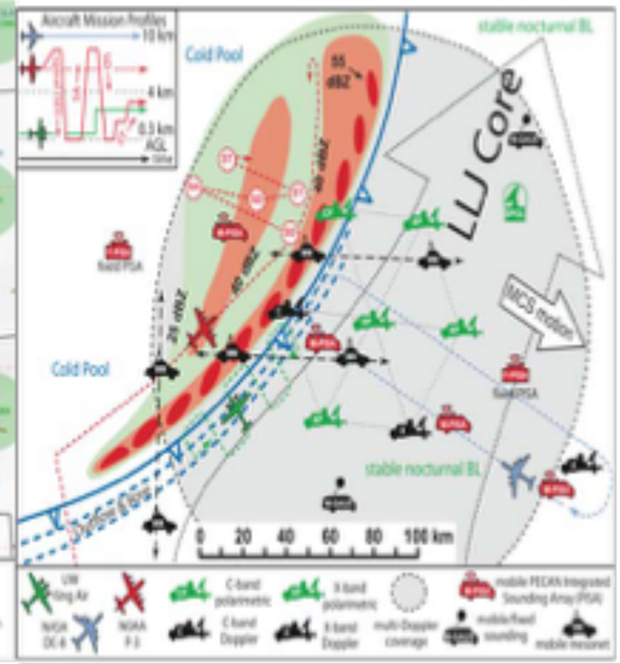


Fig. 8: *MCS deployment strategy. The mission starts around the time that widespread convective storms have developed and begun clustering. Radars and PISAs remain in a fixed deployment, while other mobile platforms adjust for system motion. From the EDO (Geerts et al. 2012)*

Nocturnal convection prediction

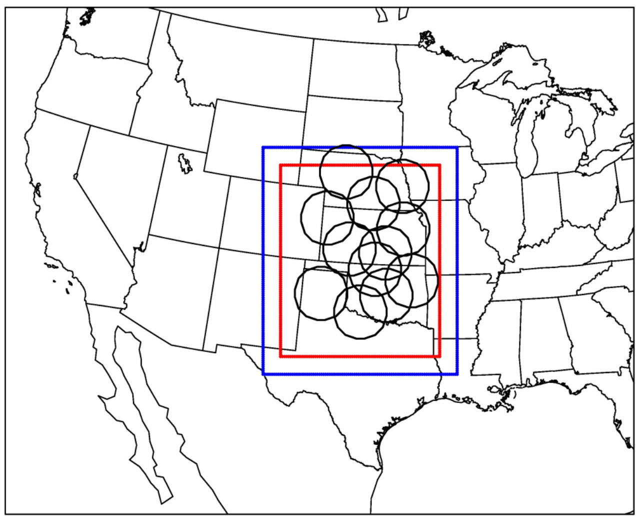
- Typically elevated and strongly influenced by LLJs and bores
- Improve prediction of nocturnal CI, nocturnal MCSs, bores, and LLJs "*with a particular focus on the next generation convective-permitting models and advanced assimilation techniques*".
- (1) Optimize configuration of GSI-based multi-scale EnKF and ensemble forecast system (Johnson et al. 2015).
- (2) Implement and evaluate the system in real-time during PECAN.

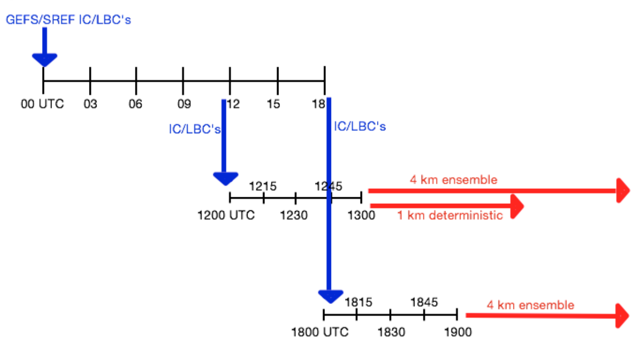
Overview of Talk

- Experiments with 20 cases from 2014 show impacts of different configurations of DA and forecast components of the system (Johnson and Wang 2016, submitted).
- During 1 June - 15 July 2015, GSI-based EnKF and ensemble forecast system used to initialize 4km ensemble forecasts at 1300 and 1900 UTC, and 1km deterministic at 1300 UTC.
- Evaluation of 2015 real-time forecasts specifically focused on nocturnal MCS, LLJ, bore and CI predictions (Johnson et al. 2016, to be submitted).

Multi-scale GSI-based EnKF and ensemble forecast configuration

- Convection-permitting domain focused on Great Plains.
- Daily forecast timeline guided by PECAN forecaster needs.
- Ensemble diversity guided by Pre-PECAN experiments.
- Different configuration for DA and forecast components



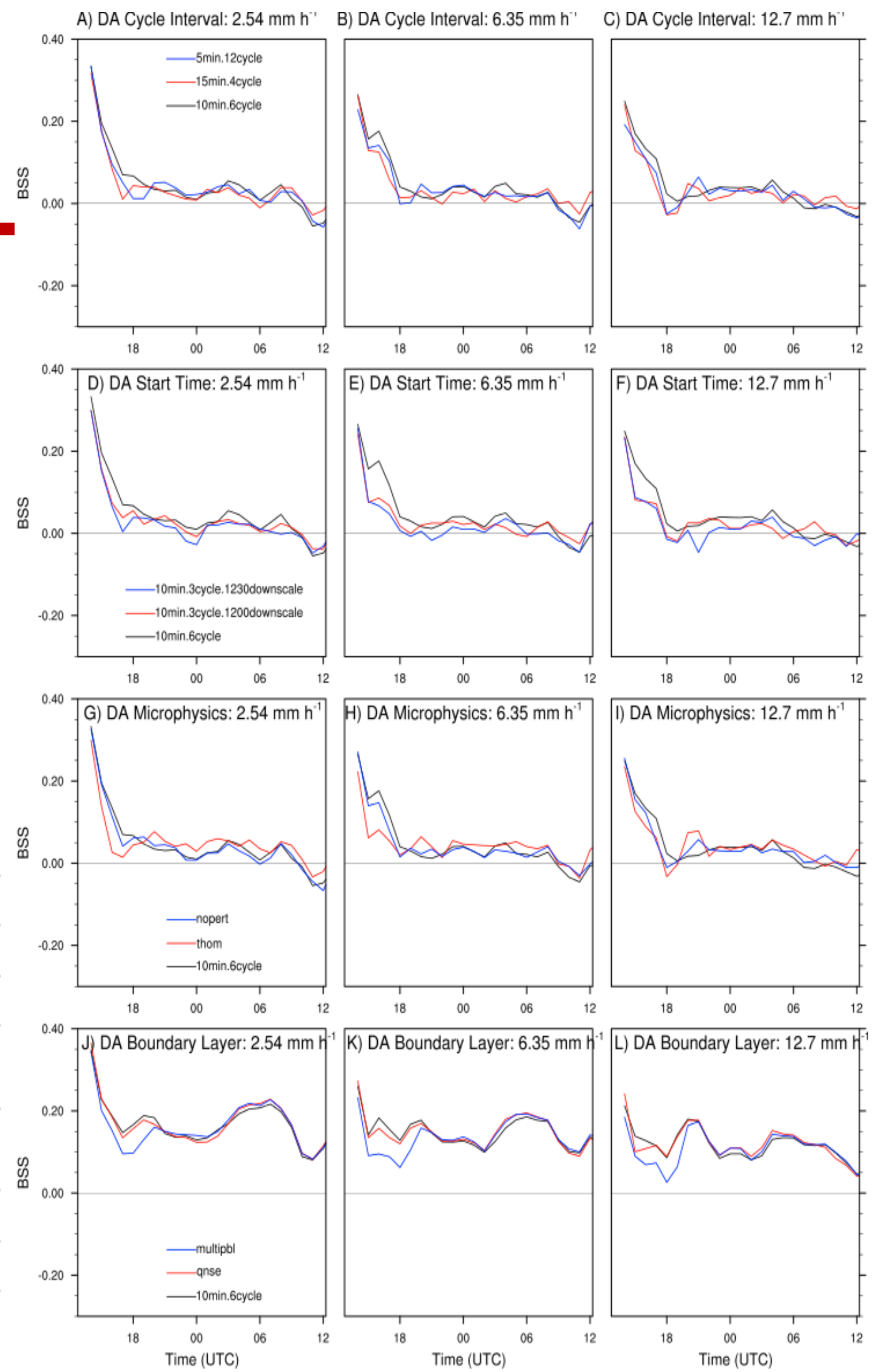


Name	DA PBL	Forec PBL	DA MP	Forec. MP	12 km CP	IC/LBC
hires	N/A	MYNN	N/A	Thom	Grell-3	4km mean.
001	QNSE	MYNN	WSM6	Thom	Grell-3	GEFS.001
002	QNSE	QNSE	WSM6	WDM6	Kain-Fritsch	GEFS.002
003	QNSE	YSU	WSM6	Lin	Kain-Fritsch	GEFS.003
004	QNSE	ACM2	WSM6	Thom	Grell-F	GEFS.004
005	QNSE	MYJ	WSM6	WDM6	Grell-3	GEFS.005
006	QNSE	MYNN	WSM6	Morrison	Kain-Fritsch	GEFS.006
007	QNSE	QNSE	WSM6	Thom	Kain-Fritsch	GEFS.007
008	QNSE	YSU	WSM6	WDM6	Grell-F	GEFS.008
009	QNSE	ACM2	WSM6	Lin	Grell-3	GEFS.009
010	QNSE	MYJ	WSM6	Thom	Kain-Fritsch	GEFS.010
011	QNSE	MYNN	WSM6	WDM6	Kain-Fritsch	GEFS.011
012	QNSE	QNSE	WSM6	Morrison	Grell-F	GEFS.012
013	QNSE	YSU	WSM6	Thom	Grell-3	GEFS.013
014	QNSE	ACM2	WSM6	WDM6	Kain-Fritsch	GEFS.014
015	QNSE	MYJ	WSM6	Thom	Kain-Fritsch	GEFS.015
016	QNSE	MYNN	WSM6	Morrison	Grell-F	GEFS.016
017	QNSE	QNSE	WSM6	Thom	Grell-3	GEFS.017
018	QNSE	YSU	WSM6	Thom	Kain-Fritsch	GEFS.018
019	QNSE	ACM2	WSM6	Thom	Kain-Fritsch	GEFS.019
020	QNSE	MYJ	WSM6	Thom	Grell-F	GEFS.020
021	QNSE	N/A	WSM6	N/A	Grell-3	SREF_em.ctl
022	QNSE	N/A	WSM6	N/A	Kain-Fritsch	SREF_em.n1
023	QNSE	N/A	WSM6	N/A	Kain-Fritsch	SREF_em.p1
024	QNSE	N/A	WSM6	N/A	Grell-F	SREF_em.n2
025	QNSE	N/A	WSM6	N/A	Grell-3	SREF_em.p2
026	QNSE	N/A	WSM6	N/A	Kain-Fritsch	SREF_em.n3
027	QNSE	N/A	WSM6	N/A	Kain-Fritsch	SREF_em.p3
028	QNSE	N/A	WSM6	N/A	Grell-F	SREF_nmm.ctl
029	QNSE	N/A	WSM6	N/A	Grell-3	SREF_nmm.n1
030	QNSE	N/A	WSM6	N/A	Kain-Fritsch	SREF_nmm.p1
031	QNSE	N/A	WSM6	N/A	Kain-Fritsch	SREF_nmm.n2
032	QNSE	N/A	WSM6	N/A	Grell-F	SREF_nmm.p2
033	QNSE	N/A	WSM6	N/A	Grell-3	SREF_nmm.n3
034	QNSE	N/A	WSM6	N/A	Kain-Fritsch	SREF_nmm.p3
035	QNSE	N/A	WSM6	N/A	Kain-Fritsch	SREF_nmb.n1
036	QNSE	N/A	WSM6	N/A	Grell-F	SREF_nmb.p1
037	QNSE	N/A	WSM6	N/A	Grell-3	SREF_nmb.n2
038	QNSE	N/A	WSM6	N/A	Kain-Fritsch	SREF_nmb.p2
039	QNSE	N/A	WSM6	N/A	Kain-Fritsch	SREF_nmb.n3
040	QNSE	N/A	WSM6	N/A	Grell-F	SREF_nmb.p3

DA Configuration experiments

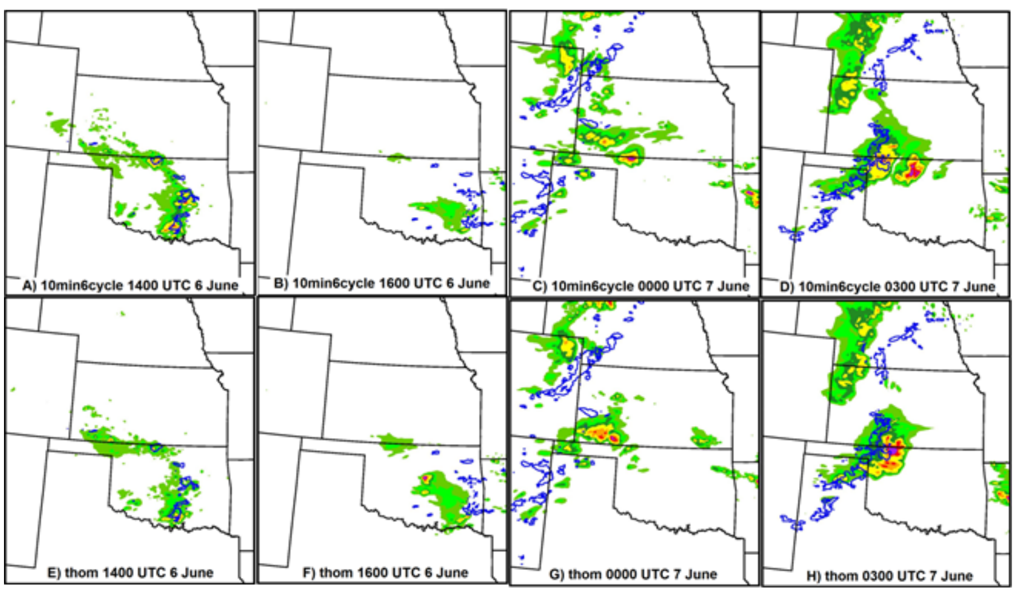
- Impacts of radar DA at 12-13 UTC persist through nocturnal period
- 10 min cycling is better than both 5 min and 15 min cycling.
- One hour of radar DA is better than 30 min.
- Thompson during DA is least skillful at first, most skillful later.
- Multi-PBL during DA is worse than any single-PBL during DA.

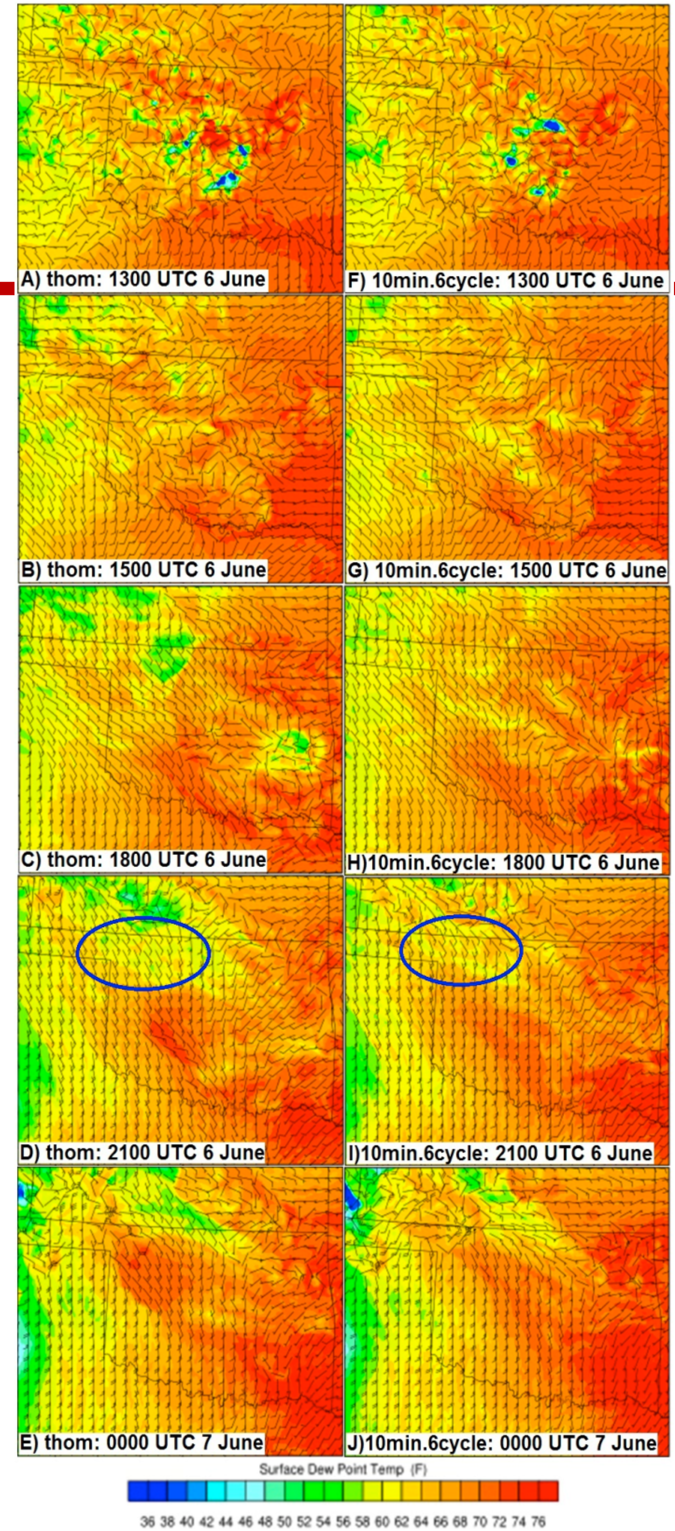
Experiment	Cycling interval	Length of DA	Start time of DA	Downscale time from outer domain	MP scheme during DA
5min.12cycle	5 min.	60 min.	1200	1200	WSM6*
10min.6cycle (i.e., CTL)	10 min.	60 min.	1200	1200	WSM6*
15min.4cycle	15 min.	60 min.	1200	1200	WSM6*
10min.3cycle.1200 downscale	10 min.	30 min.	1230	1200	WSM6*
10min.3cycle.1230downscale	10 min.	30 min.	1230	1230	WSM6*
nopert	10 min.	60 min.	1200	1200	WSM6
thom	10 min.	60 min.	1200	1200	Thompson



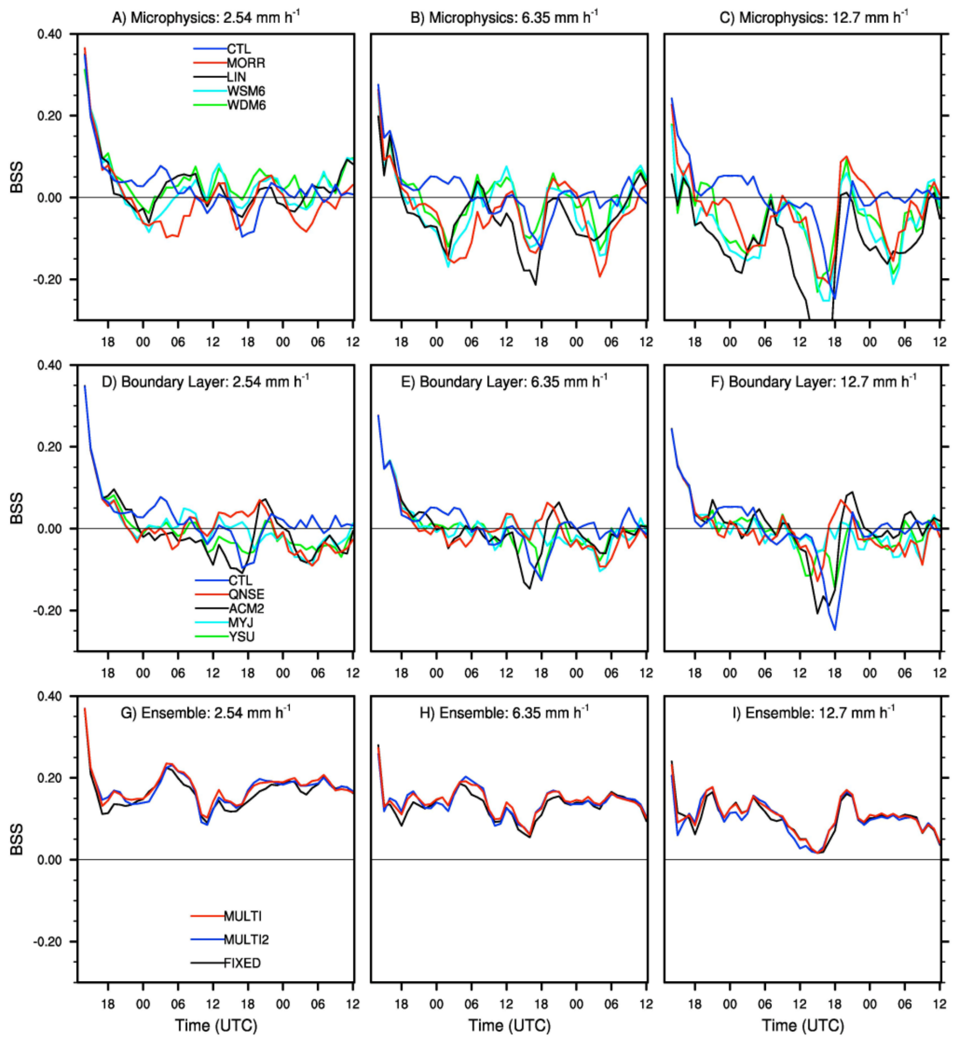
Impact of DA microphysics

- Analyses using Thompson for DA have less skillful forecasts at first, but are more skillful the following night.
- On this case, Thompson analyzes dry air above boundary layer that mixes down the following afternoon.
- Impact of convective overturning during DA on mesoscale environment, rather than convection itself, was better analyzed with Thompson.

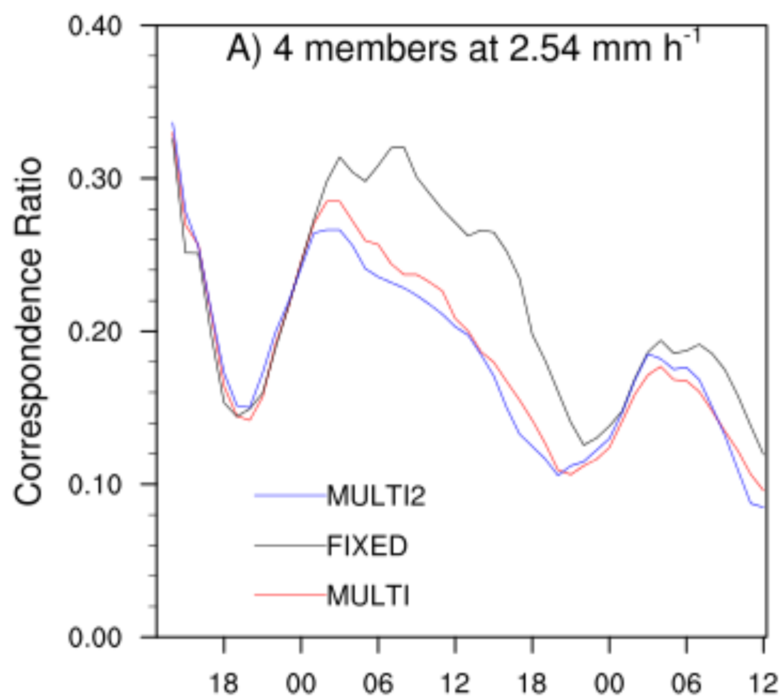




Forecast Configuration experiments

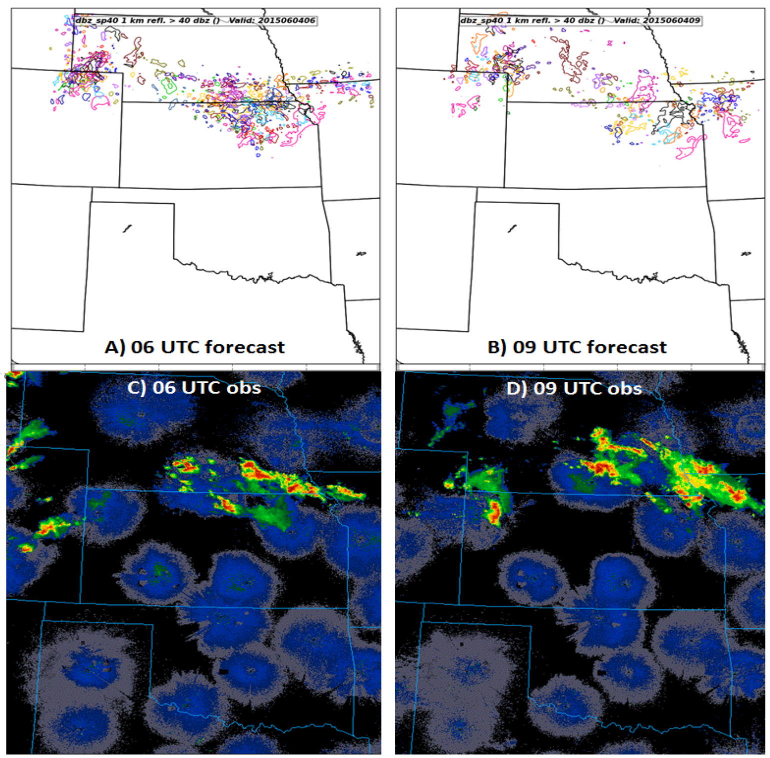


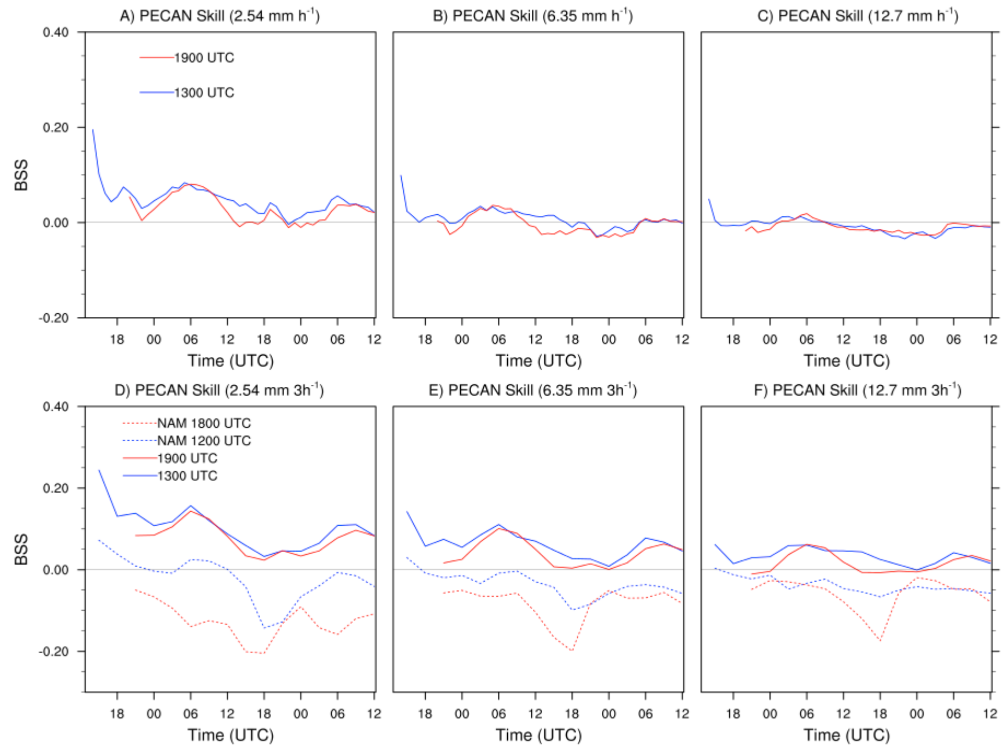
- Thompson microphysics and MYNN PBL scheme are most skillful during nocturnal period.
- Multi-physics forecast ensembles showed slight skill advantage over fixed-physics and more pronounced spread increase.



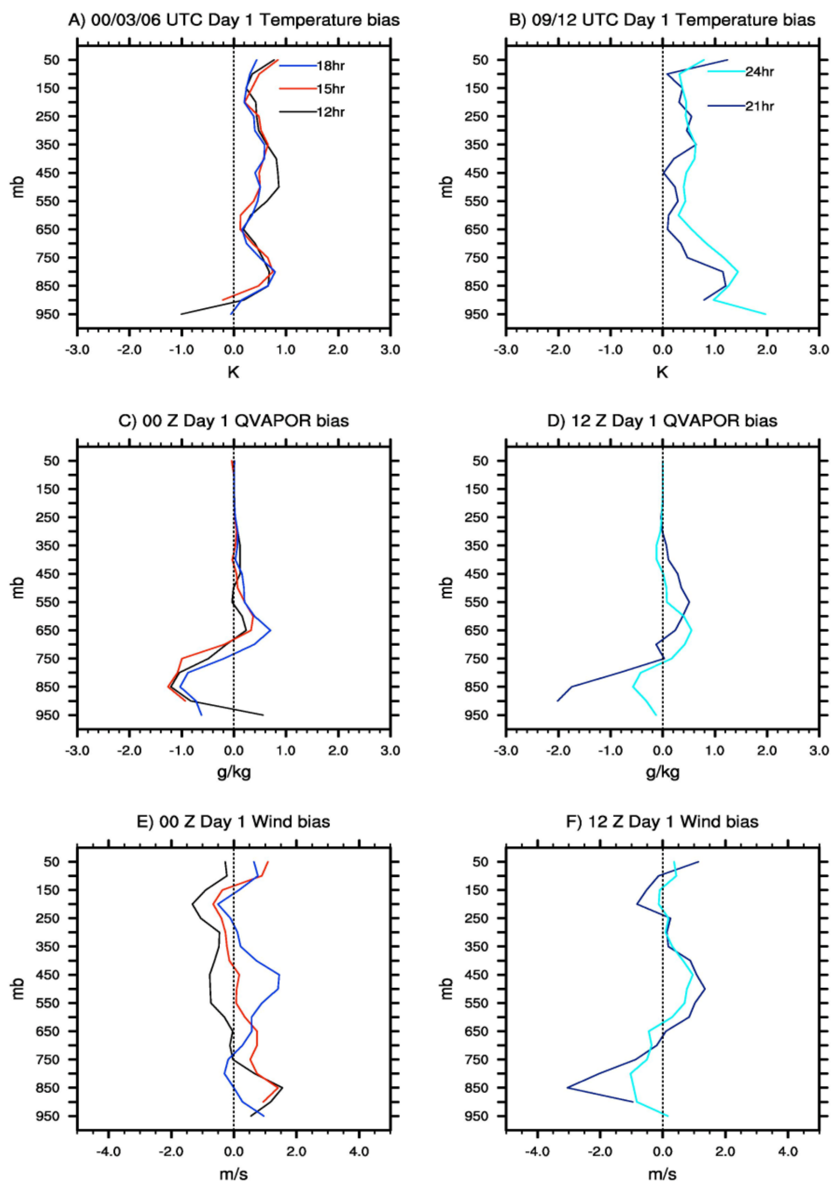
Real-time nocturnal MCS prediction during PECAN

- Nocturnal convection forecasts subjectively performed well on some cases and not so well on other cases.
- Objective verification shows skill levels consistent with expectations based on previous studies.
- 1900 UTC initialization was less skillful than longer-lead forecasts from 1300 UTC initialization.
  - This is also the case for operational NAM forecasts





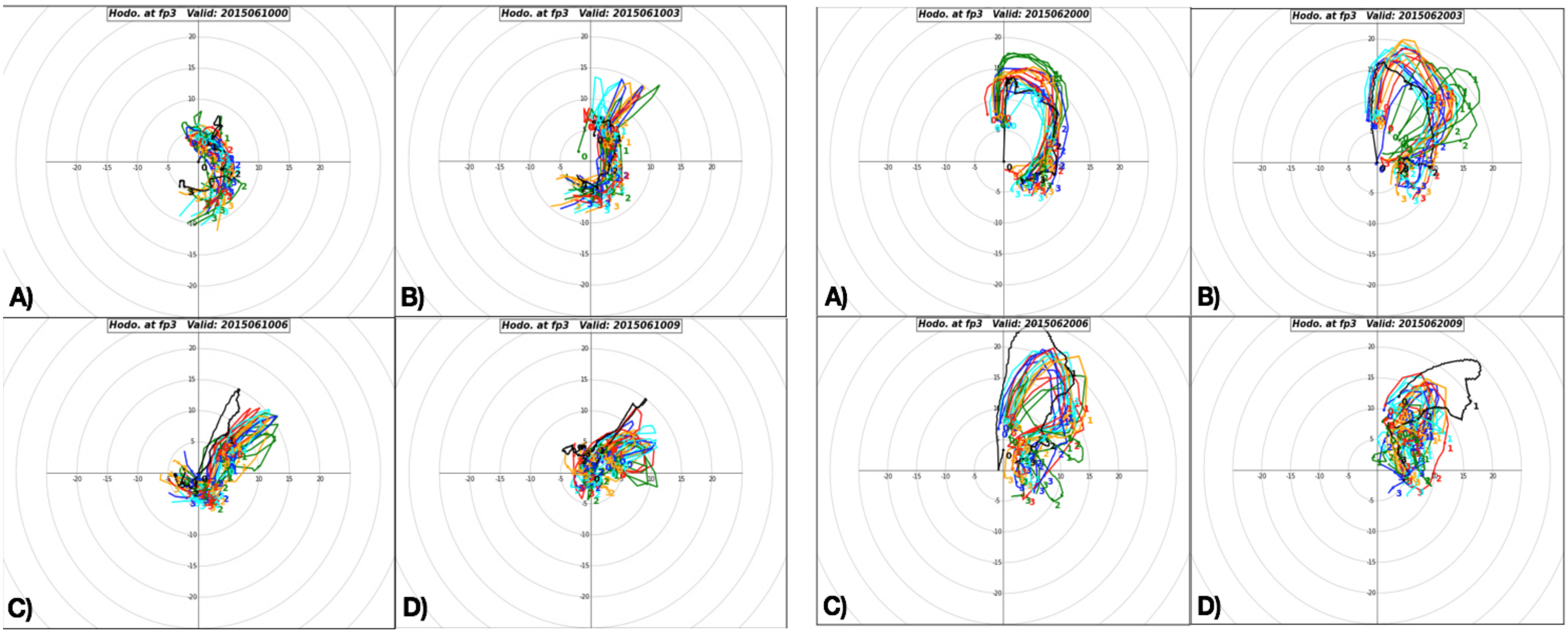
Verification against fixed PISA soundings



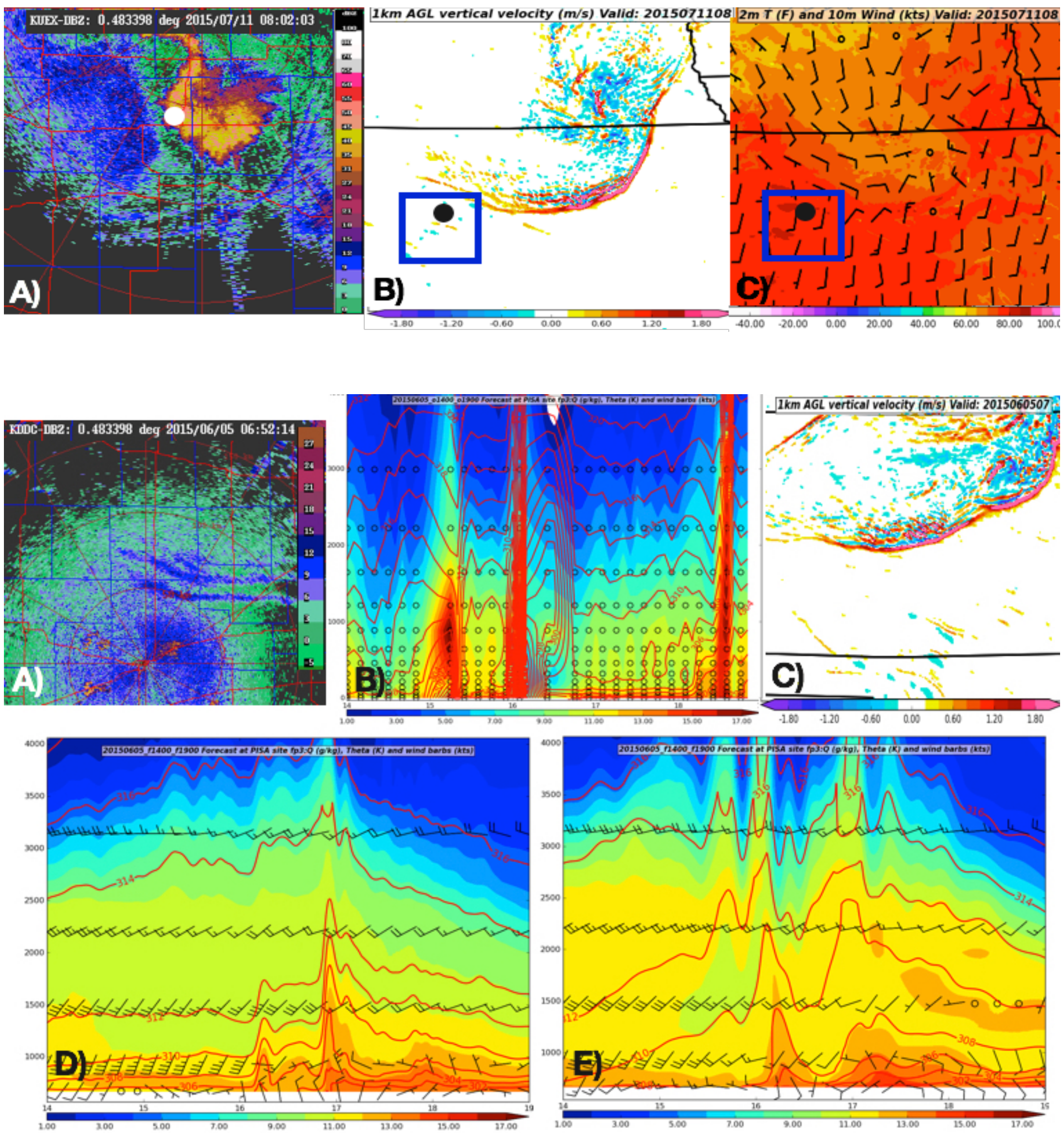
- PECAN special observations included 3-hourly soundings at fixed PISA sites.
- Forecasts show generally warm and dry bias during overnight hours.
- Low level wind bias is positive early in the night and negative later in the night.

Nocturnal LLJ prediction during PECAN

- Forecasts predict LLJ to strengthen, veer, dissipate too early compared to observations.
- Source of this bias (vertical resolution, physics, etc.) is still being investigated.

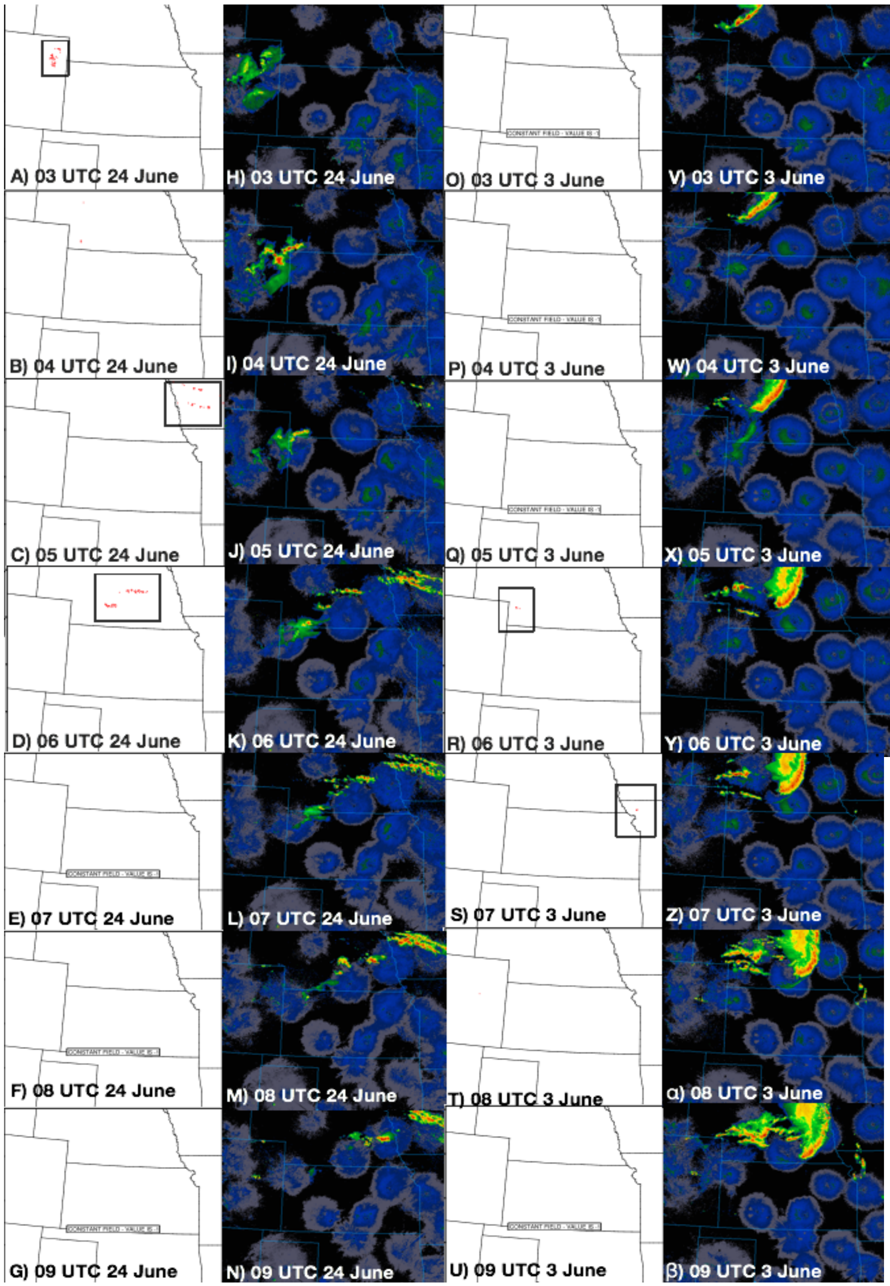


Bore prediction during PECAN



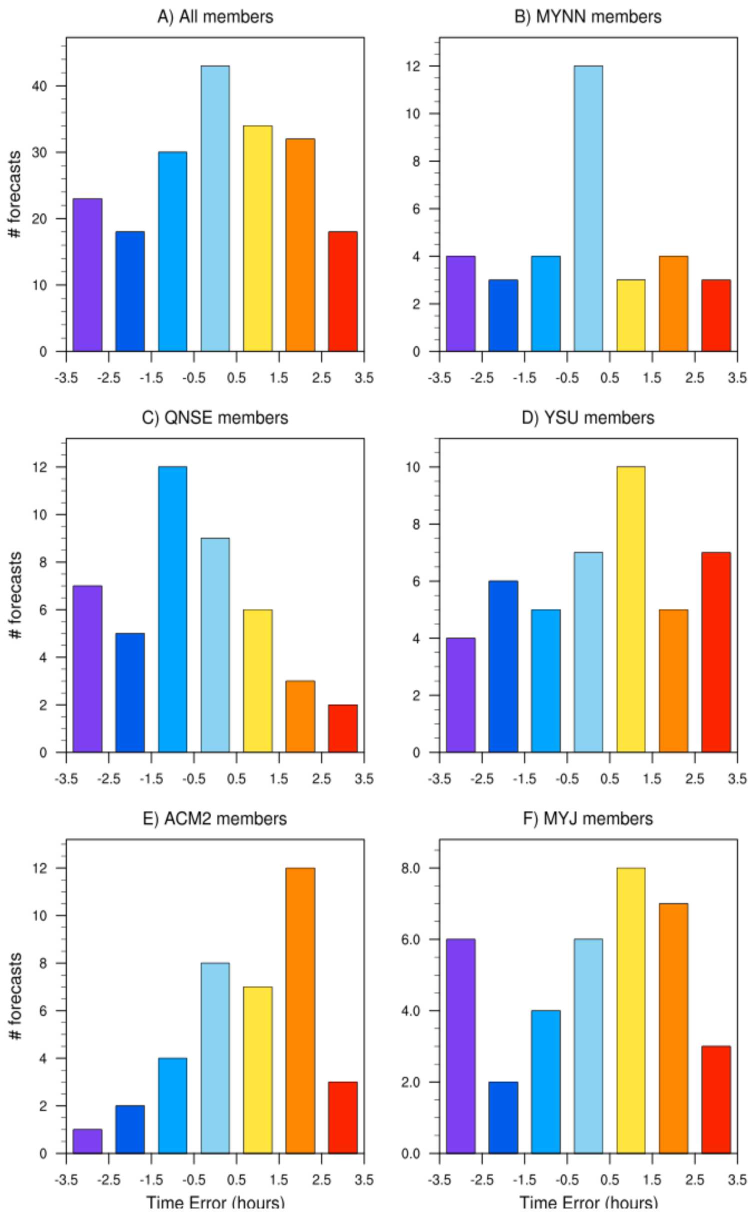
- 1km deterministic forecast resolves patterns consistent with radar-indicated undular bores.
- AERI T/Q retrievals at FP sites provide truth data in time-height format for model validation.
- 1 km bore forecast is much more realistic than at 4 km.

Nocturnal CI prediction during PECAN



- Define CI as convectively active grid points without nearby convection 1h previous.
- Manually eliminate isolated CI of insufficient magnitude and duration.
- Evaluate timing of each observed CI event between the hours of 0000 UTC and 1200 UTC against each member's forecast in the same region.

Nocturnal CI prediction during PECAN



- Overall, unbiased prediction of CI time.
- MYNN members perform best, consistent with results described earlier.
- QNSE members have an early bias while ACM2 and MYJ members have a late bias.
- YSU members have only a slight late bias but a lot of spread (i.e., flat histogram).

Summary and Conclusions

- Optimal GSI-based EnKF configuration for nocturnal convection during 2014 was 10-min. radar DA cycling for one hour, with Thompson microphysics and QNSE single-PBL scheme.
- Thompson and MYNN were best forecast physics during 2014, with further advantages or multi-physics configurations.

- These experiments guided implementation of a real-time multi-scale GSI-based EnKF and ensemble forecast system during PECAN.

- Nocturnal convective precipitation was better predicted by 1300 UTC than 1900 UTC initialization.
- Time-varying wind biases resulted from forecast LLJs strengthening, veering and dissipating too early.
  - Controlled experiments ongoing to understand cause.
- 1 km deterministic member showed realistic looking bores that were not well resolved at 4km.
  - Controlled experiments on vertical grid spacing and further reduction of horizontal grid spacing ongoing.
- Strong sensitivity of nocturnal CI forecasts to the PBL scheme, despite expected inactivity of PBL scheme overnight.
  - Future work should investigate the exact role of the PBL scheme in CI prediction during the nocturnal period.