Testing of Stochastic Physics Approach for Use in Regional Ensembles

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Stochastic physics for use in Regional Ensembles

Motivation

- Issues with mixed-physics approach
  - Maintenance
  - Inconsistent ensemble system (some schemes closer related than others)
  - Each member has a unique climatology and mean error
- Compare mixed-physics approach to stochastic parameter perturbation (SPP), Stochastic Kinetic Energy Backscatter (SKEB) and Stochastic Perturbation of Physics Tendencies (SPPT).

Experiment Design

- Regional RAP model simulations
- 7 days from 2013 convective season: May 23,29; June 7, 14, 20, 28; July 4
- 24 h forecasts
- 00 and12 Z initializations using different GEFS members
- Stochastic Parameter Perturbation, SKEB and SPPT
- Focus on convective Grell-Freitas and MYNN PBL
- Verification performed over CONUS
- Statistical significance testing by employing boot strap method with 95% confidence interval

Experiments

CU comparison

Control mixed physics (CU and PBL)

SPP (CU and PBL)

PBL comparison

SPP+SKEB (CU + PBL)

SPP+SPPT (CU+PBL)

SPP+SKEB+SPPT (CU+PBL)

Impact of adding SKEB and SPPT on stochastic parameter perturbation

Mixed-physics and stochastic members

Mixed-physics members	Convective	PBL	LSM
control0	OSAS	MYNN	RUC
contol1	BMJ	MYNN	RUC
control2	GF	MYNN	RUC
control3	NSAS	MYNN	RUC
control4	GF	MYJ	RUC
control5	GF	YSU	RUC
control6	GF	BOULAC	RUC
control7	GF	MYNN	RUC

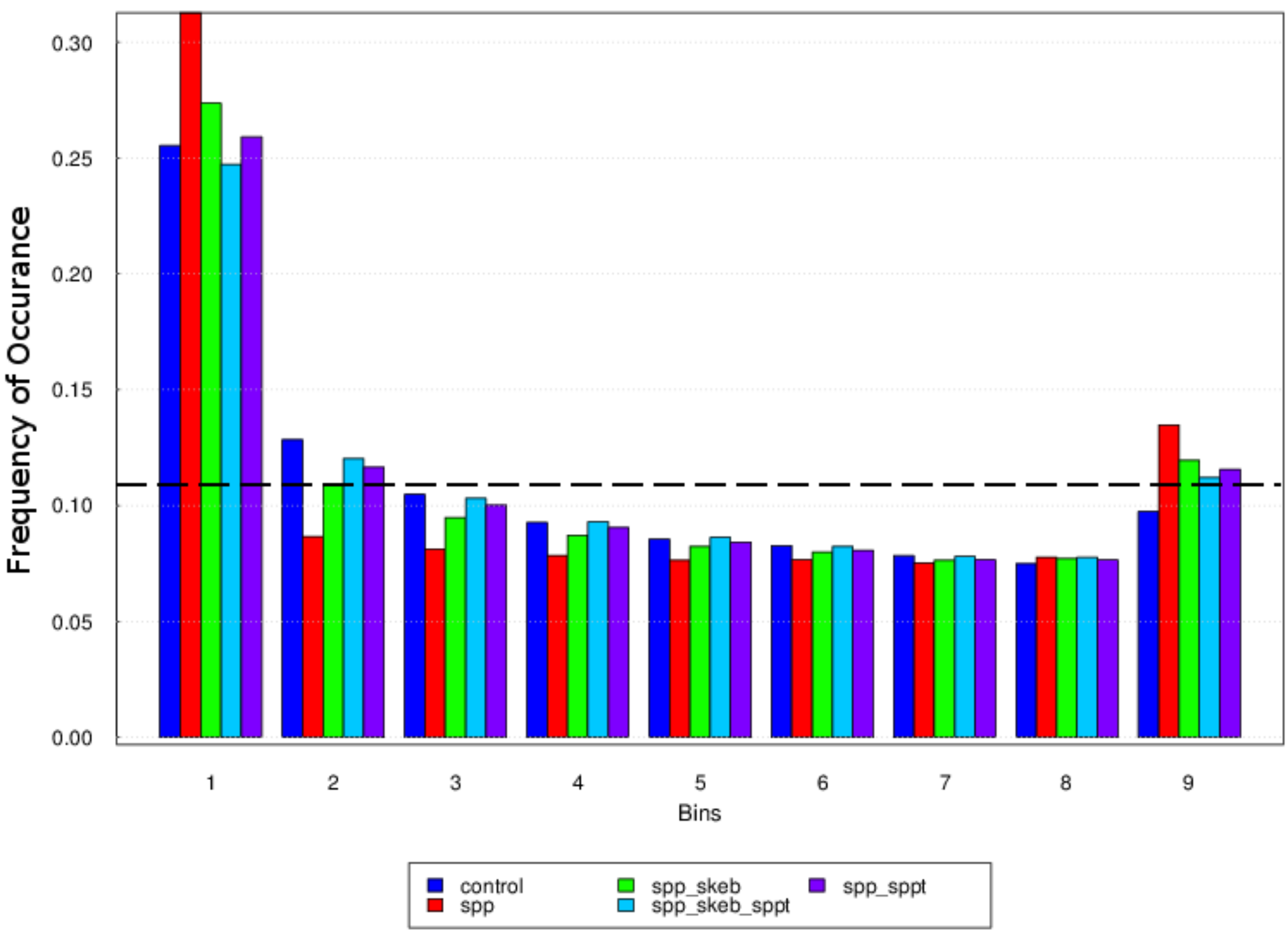
Stochastic	Convective	PBL	LSM
stoch0	GF-pert	MYNN	RUC
stoch1	GF-pert	MYNN	RUC
stoch2	GF-pert	MYNN	RUC
stoch3	GF-pert	MYNN	RUC
stoch4	GF	MYNN-p	RUC
stoch5	GF	MYNN-p	RUC
stoch6	GF	MYNN-p	RUC
stoch7	GF	MYNN-p	RUC

Perturbed parameters

GF CU scheme: Closures

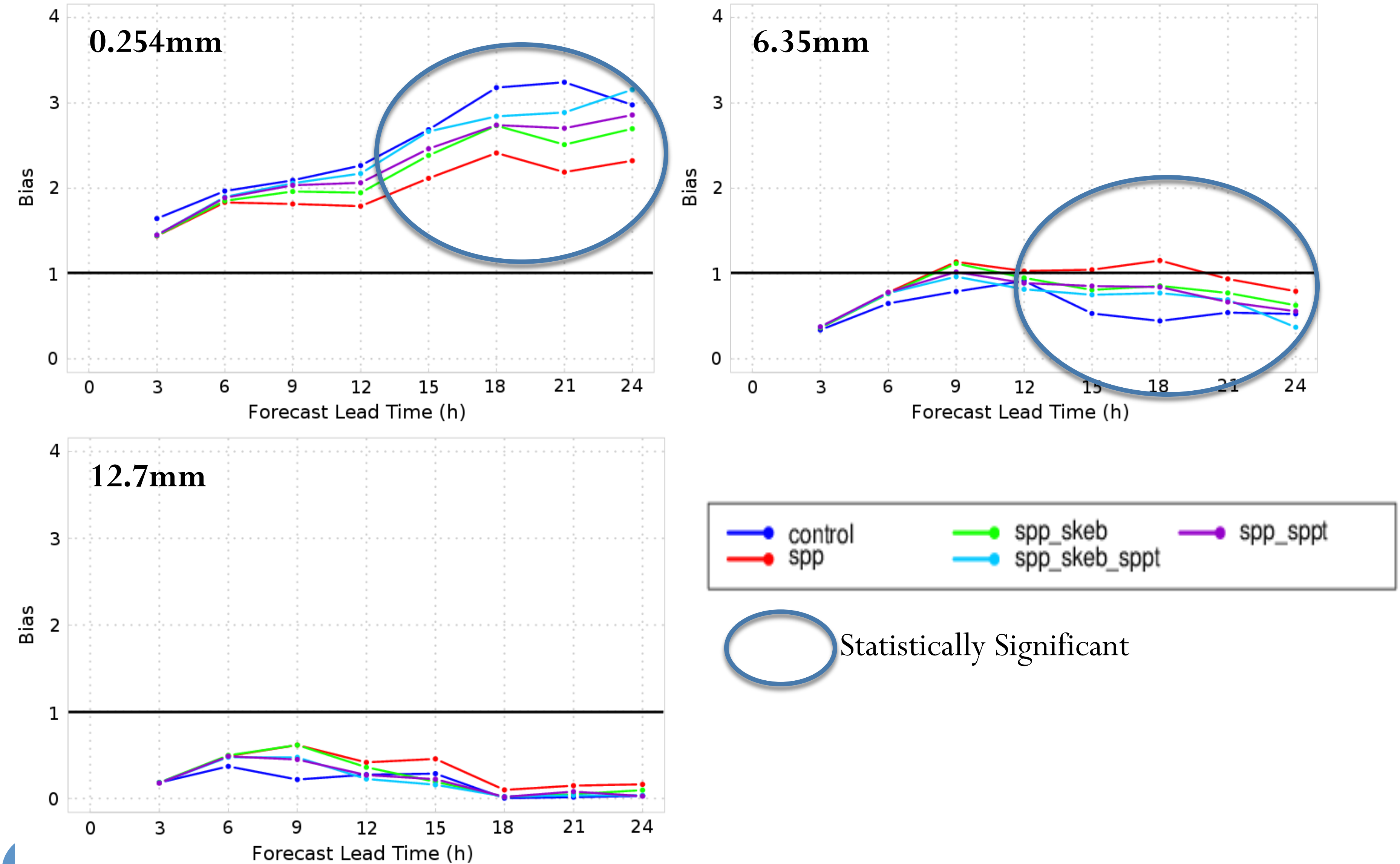
MYNN PBL: Turbulent mixing length
Sub-grid cloud fraction
Roughness length (T & moist.)

Precipitation Rank histograms for 00 Z initialization:

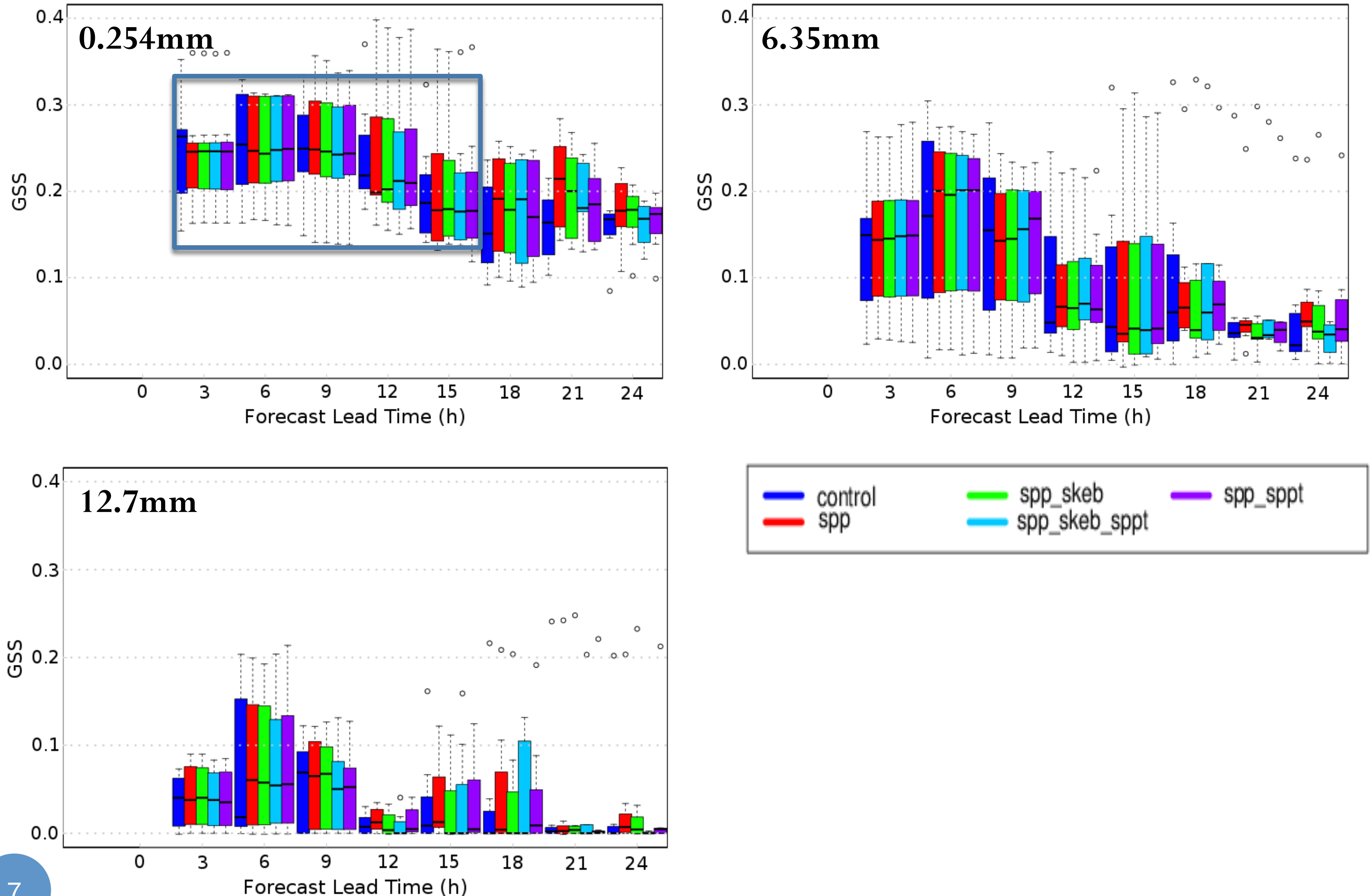


Developmental Testbed Center

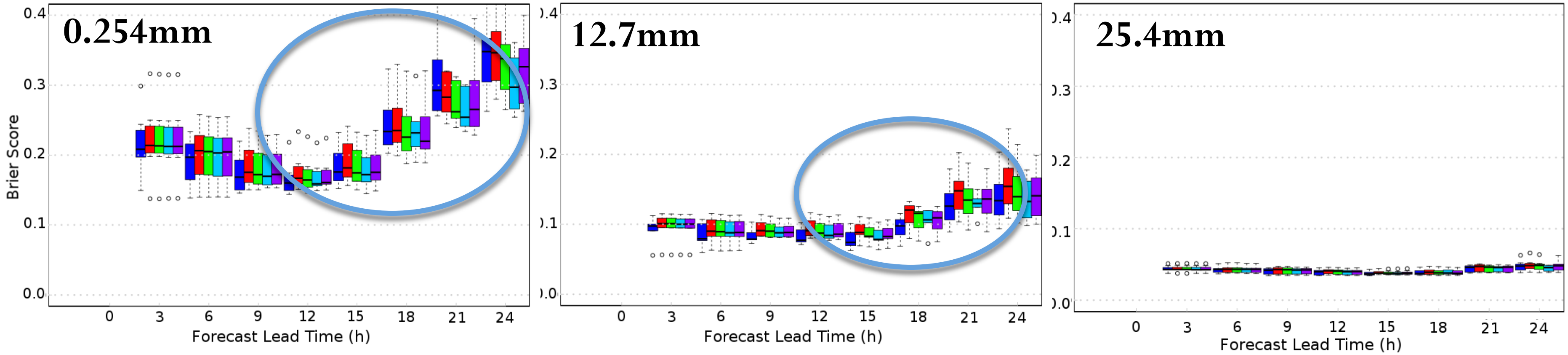
Ensemble Mean Bias – 00Z init.



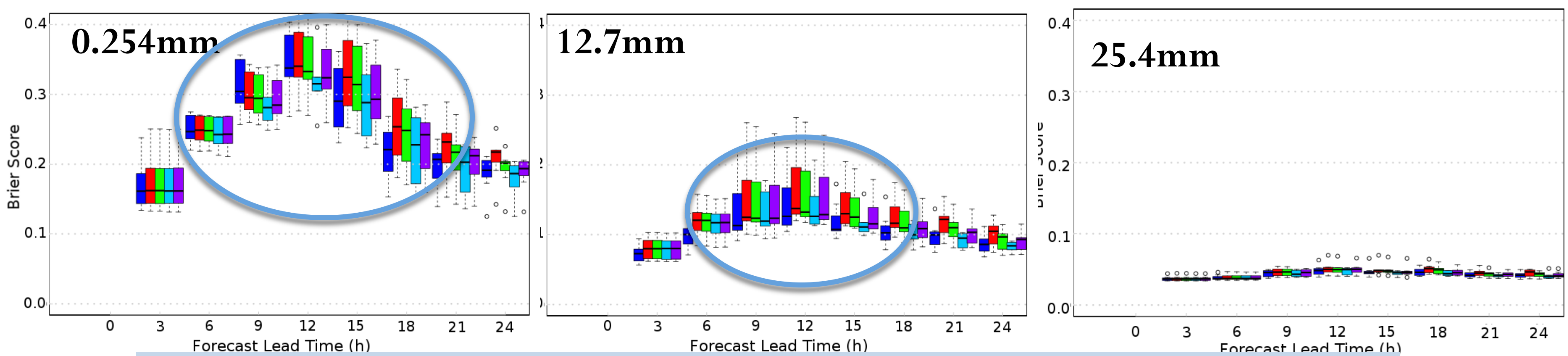
Ensemble Mean GSS – 00Z Init.



Brier Score - 00 Z initialization



Brier Score - 12 Z initialization

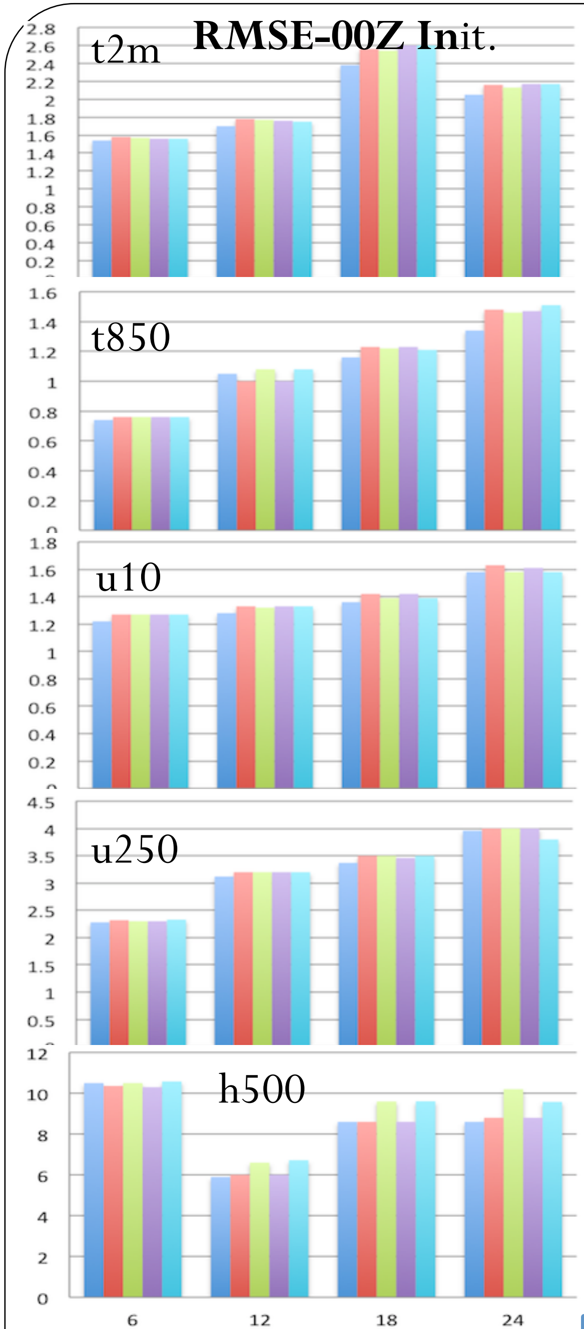


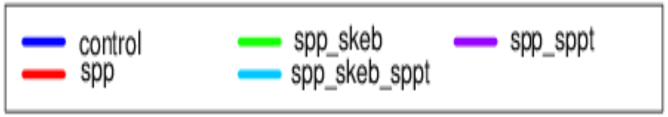
During the day stochastic experiments significantly outperform the control.

spp_skeb_sppt significantly better than others.

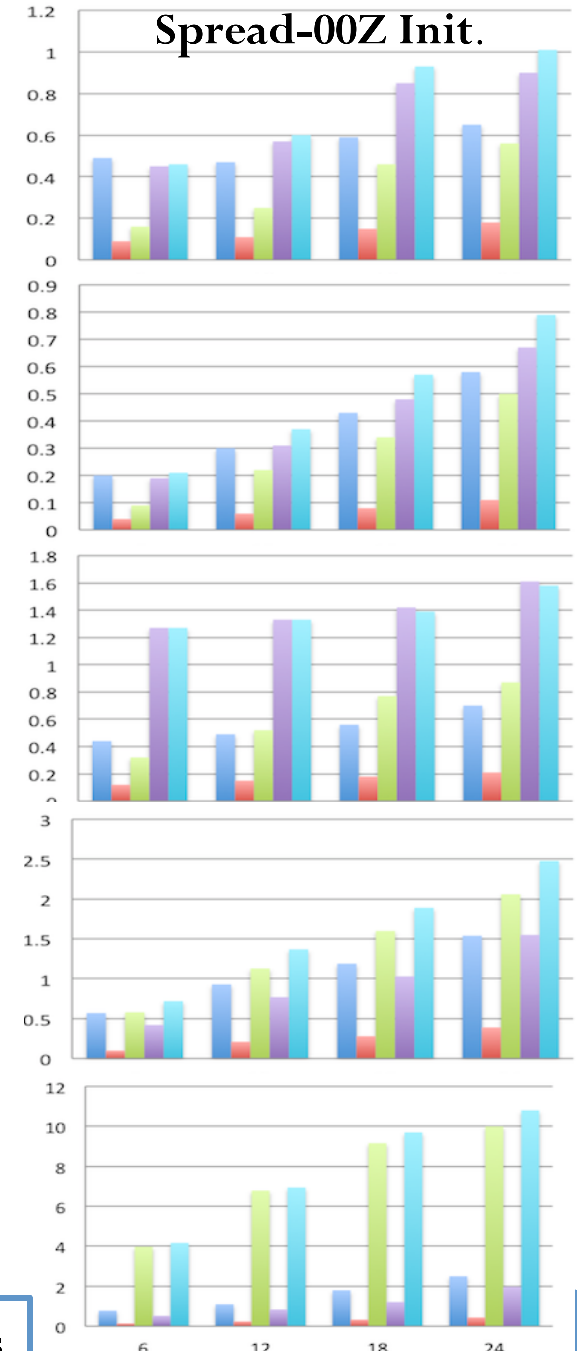
Situation opposite **during the night**.

Developmental Testbed Center



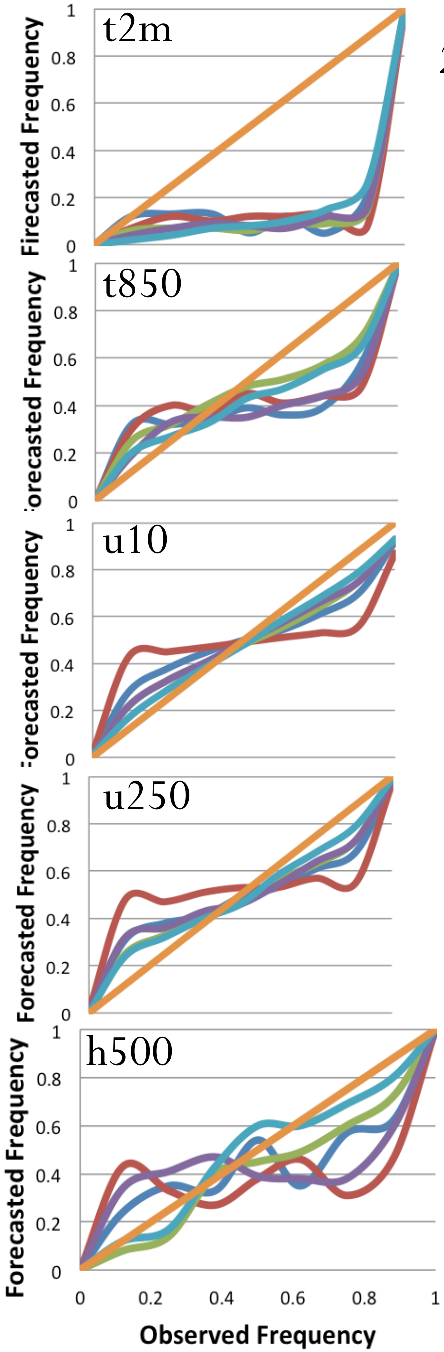


spp_skeb_sppt spread significantly higher when compared to the control experiment, for most of the lead times (longer than 6hrs) and all variables.

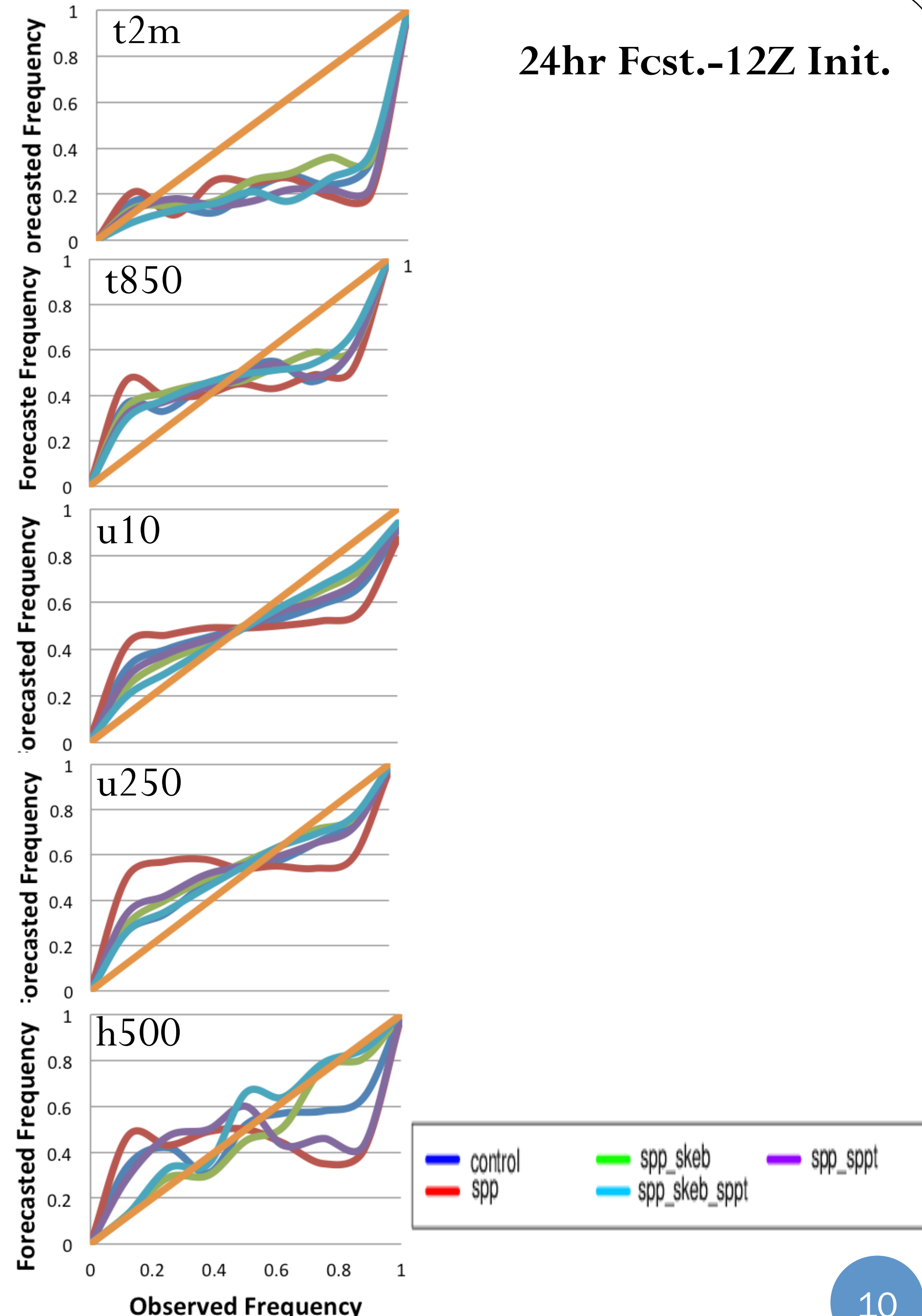


Very similar results for 12Z simulations

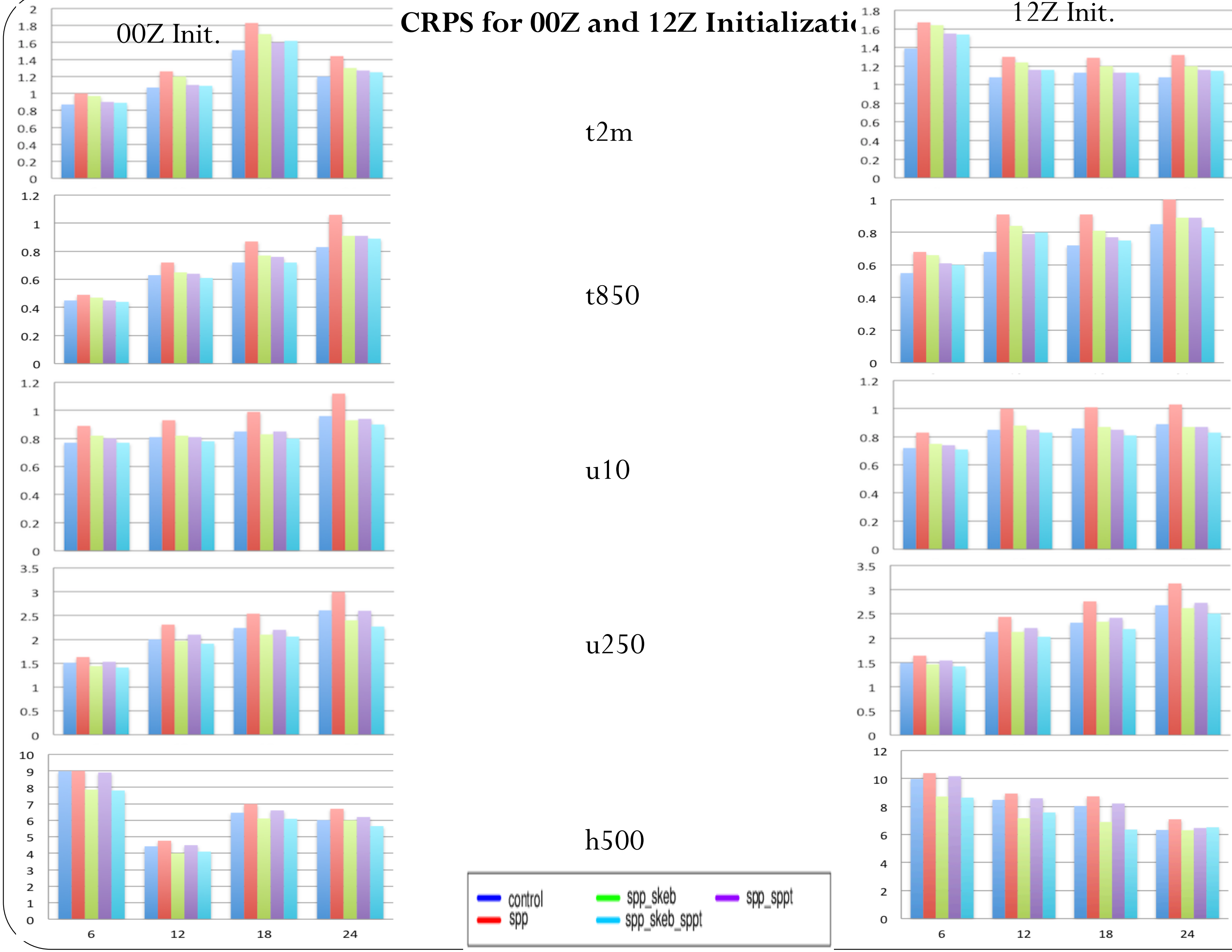
24hr Fcst.-00Z Init.



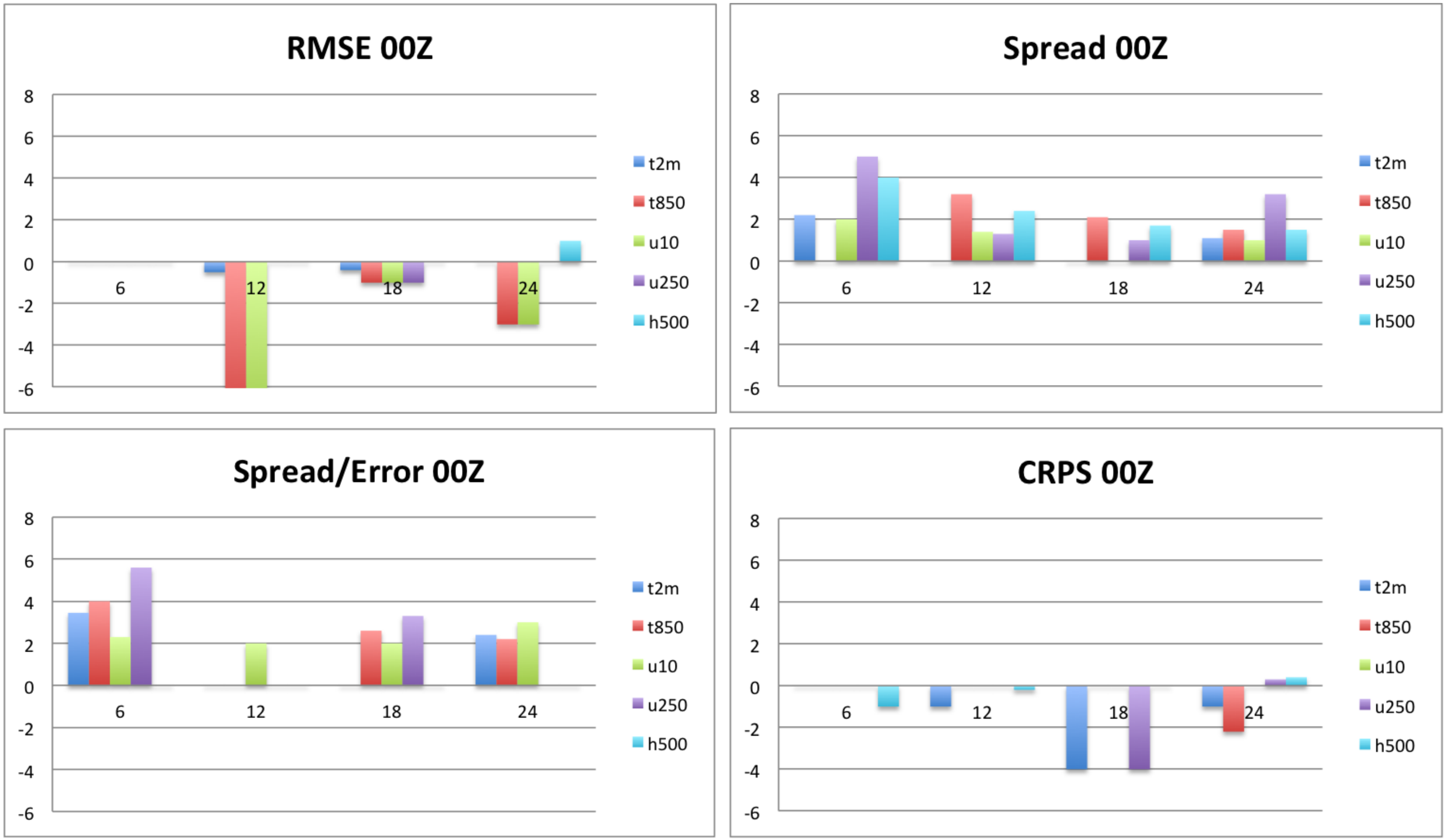
24hr Fcst.-12Z Init.



CRPS for 00Z and 12Z Initializatio



Stoch. + SPP impact for 00Z runs



Summary

- Alone, the parameter perturbations of SPP introduce insufficient spread.
- When combined with SKEB and/or SPPT the spread is as large and for some instances even larger than for a multi-physics ensemble.
- An ensemble created by combining three stochastic approaches (SPP, SKEB and SPPT generally outperformed the multi-physics, control ensemble for most of the examined variables, most of the evaluated lead times, and most of the employed statistics.
- SKEB made a larger impact on spread associated with upper level wind and geopotential heights, while SPPT had a larger impact on spread for near-surface temperature.
- Combining SPP with SPPT has generally a positive impact, on the order of a 2-10% improvement over an ensemble using SPPT alone.

1. ***The results confirm the findings of previous studies that parameter perturbations alone do not generate sufficient spread to remedy the under-dispersion in short-term ensemble forecasts***
2. ***A combination of several stochastic schemes outperforms any single scheme. This result implies that a synthesis of different approaches is best suited to capture model error in its full complexity.***

Current and Future Work

- Adding 14 more cases to the previous study
- Experimenting with HRRR (3km grid spacing) for application in HREF (for both ensemble DA and forecasting purposes)
- Focus on PBL and LSM:
  - PBL-In addition to mixing length, roughness length and cloud fraction we added perturbations to mass fluxes
  - LSM-Hydraulic Conductivity is currently being perturbed