Realtime Storm-scale Ensemble Forecast for the NOAA Hazardous Weather Testbed 2009 Spring Experiment

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Forecast Configurations of Three Years

- Spring 2007: 10-member WRF-ARW, 4 km, 33 h, 21Z start time, NAM+SREF ICs. 5 members physics perturbations only, 5 with Phy+IC+LBC perturbations. 2/3 CONUS (*+ one single 2 km grid forecast*)
- Spring 2008: larger domain, 00Z start, Phy+IC+LBC pert for all members. **Radar Vr and Z data assimilation** (*+ one single 2 km grid forecast, with radar DA*)
- Spring 2009: 20 members, 4 km, 3 models (ARW, NMM, ARPS), mixed physics/IC/LBCs. (*+ one single 1 km grid forecast*). Radar DA on native grids.
- About 1.5 months each spring season from mid-April through early June

New Features in 2009

- **Add 8 WRF-NMM members** (planned 10) and **2 ARPS members** into the ensemble system. Total **20 members**.
- Upgrade to **WRF version 3.0.1.1** from version 2.2
- For NMM supporting, the ARPS-WRF interface package has been enhanced by adding two NMM-interface programs, *arps4wrf* and *nmm2arps*.

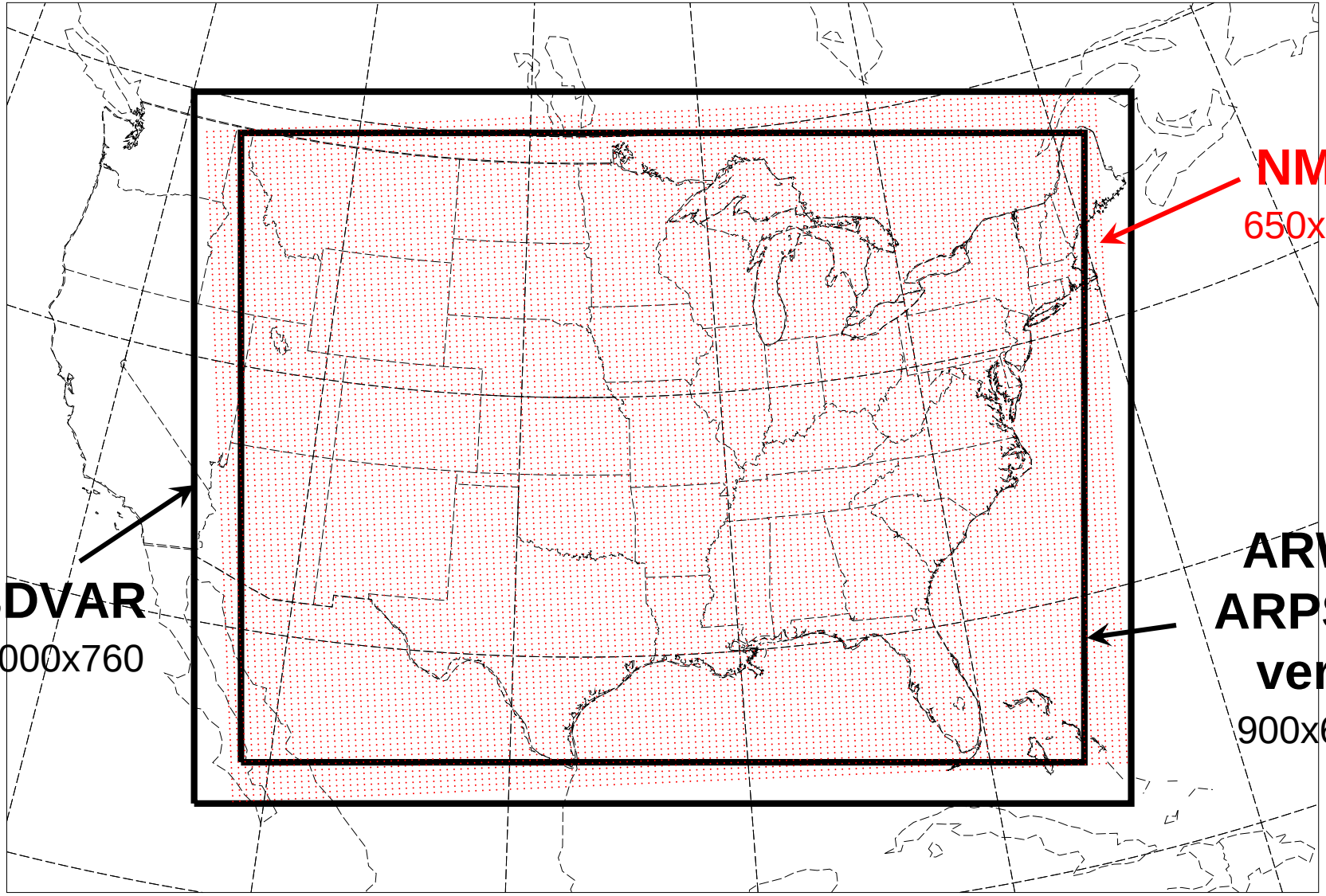
Highlight

- 4 km grid for ARW & ARPS; ~ 4.16 km for NMM
- 51 vertical levels for ARW & NMM; 43 for ARPS
- 30 hour forecast initialized at 00 UTC, ended at 06 UTC the next day
- Hourly output; 5-min high frequency output of composite reflectivity for ARW control members (for movie animation)
- April 20 – June 5 (weekday)
- Hourly output 2D data sent to SPC in realtime

Highlight

- NAM 12 km 00Z analysis/forecast to provide IC/LBC for control members
- Eight SREF 21Z forecast members to provide initial perturbations and LBCs for perturbed members (ARW & NMM)
- ARPS 3DVAR and Cloud Analysis are used to analyze 120 WSR-88D Level II radar radial wind and reflectivity to all but three members

2009 Spring Experiment Domains



WRF-ARW members

member	IC	LBC	Radar data	mp_physics	ra_sw-phy	sf_phy	pbl_physics
arw_cn	00Z ARPSa	00Z NAMf	yes	Thompson	Goddard	Noah	MYJ
arw_c0	00Z NAMa	00Z NAMf	no	Thompson	Goddard	Noah	MYJ
arw_n1	arw_cn – em_pert	21Z SREF em-n1	yes	Ferrier	Goddard	Noah	YSU
arw_p1	arw_cn + em_pert	21Z SREF em-p1	yes	WSM 6-class	Dudhia	Noah	MYJ
arw_n2	arw_cn – nmm_pert	21Z SREF nmm-n1	yes	Thompson	Dudhia	RUC	MYJ
arw_p2	arw_cn + nmm_pert	21Z SREF nmm-p1	yes	WSM 6-class	Dudhia	Noah	YSU
arw_n3	arw_cn – etaKF_pert	21Z SREF etaKF-n1	yes	Thompson	Dudhia	Noah	YSU
arw_p3	arw_cn + etaKF_pert	21Z SREF etaKF-p1	yes	Ferrier	Dudhia	Noah	MYJ
arw_n4	arw_cn – etaBMJ_pert	21Z SREF etaBMJ-n1	yes	WSM 6-class	Goddard	Noah	MYJ
arw_p4	arw_cn + etaBMJ_pert	21Z SREF etaBMJ-p1	yes	Thompson	Goddard	RUC	YSU

* For all members: ra_lw_physics= RRTM; cu_physics= NONE

WRF-NMM members

member	IC	LBC	Radar data	mp_phy	lw_phy	sw-phy	sf_phy	pbl_phy
nmm_cn	00Z ARPSa	00Z NAMf	yes	Ferrier	GFDL	GFDL	Noah	MYJ
nmm_c0	00Z NAMa	00Z NAMf	no	Ferrier	GFDL	GFDL	Noah	MYJ
nmm_n1	nmm_cn – em_pert	21Z SREF em-n1	yes	Thompson	RRTM	Dudhia	Noah	MYJ
nmm_p1	nmm_cn + em_pert	21Z SREF em-p1	yes	WSM 6-class	GFDL	GFDL	RUC	MYJ
nmm_n2	nmm_cn – nmm_pert	21Z SREF nmm-n1	yes	Ferrier	RRTM	Dudhia	Noah	YSU
nmm_p2	nmm_cn + nmm_pert	21Z SREF nmm-p1	yes	Thompson	GFDL	GFDL	RUC	YSU
nmm_n3	nmm_cn – etaKF_pert	21Z SREF etaKF-n1	yes	WSM 6-class	RRTM	Dudhia	Noah	YSU
nmm_p3	nmm_cn + etaKF_pert	21Z SREF etaKF-p1	yes	Thompson	RRTM	Dudhia	RUC	MYJ
nmm_n4	nmm_cn – etaBMJ_pert	21Z SREF etaBMJ-n1	yes	WSM 6-class	RRTM	Dudhia	RUC	MYJ
nmm_p4	nmm_cn + etaBMJ_pert	21Z SREF etaBMJ-p1	yes	Ferrier	RRTM	Dudhia	RUC	YSU

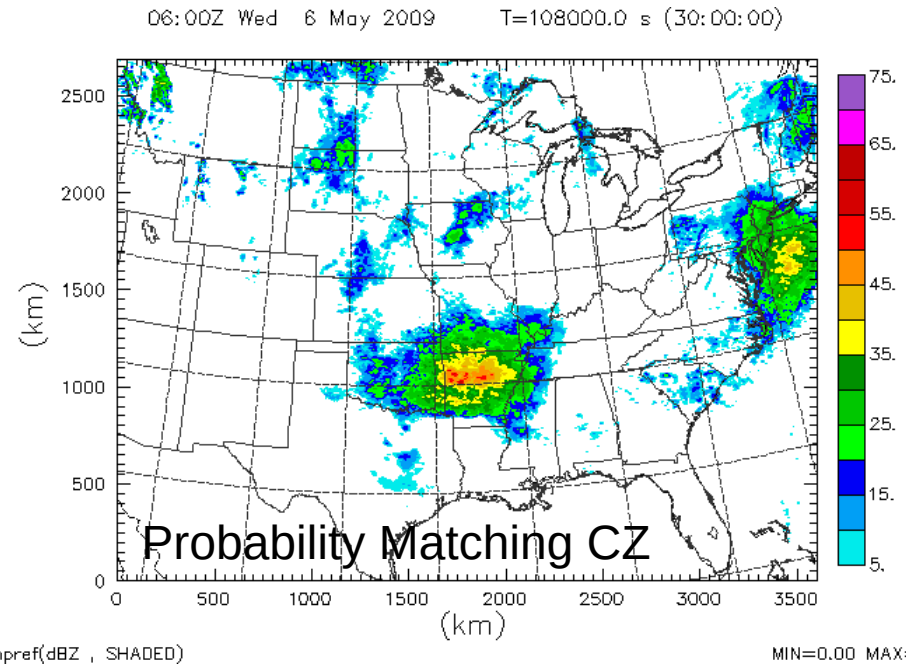
* For all NMM members: cu_physics= NONE; Grayed-out members dropped

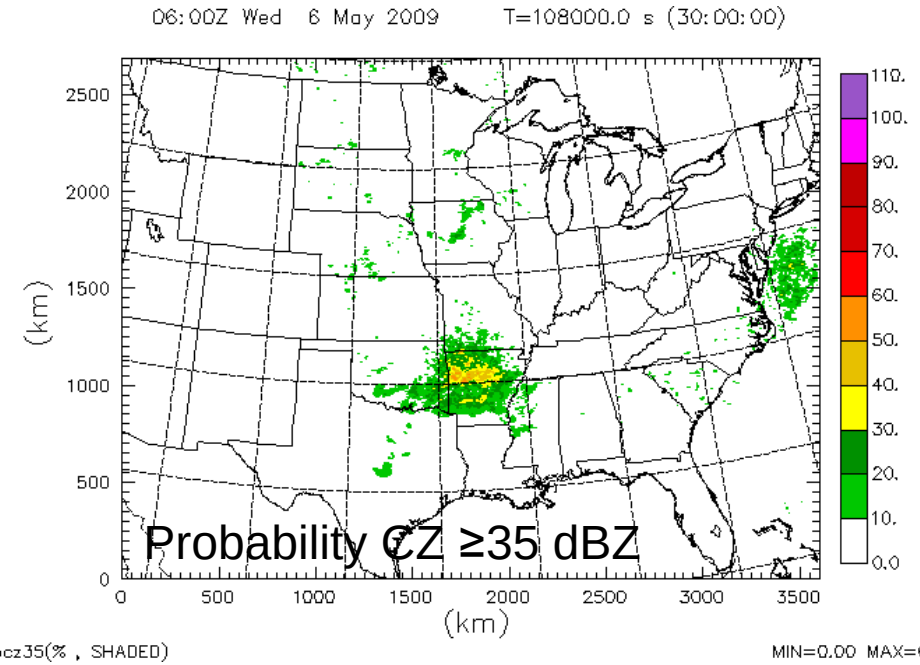
ARPS members

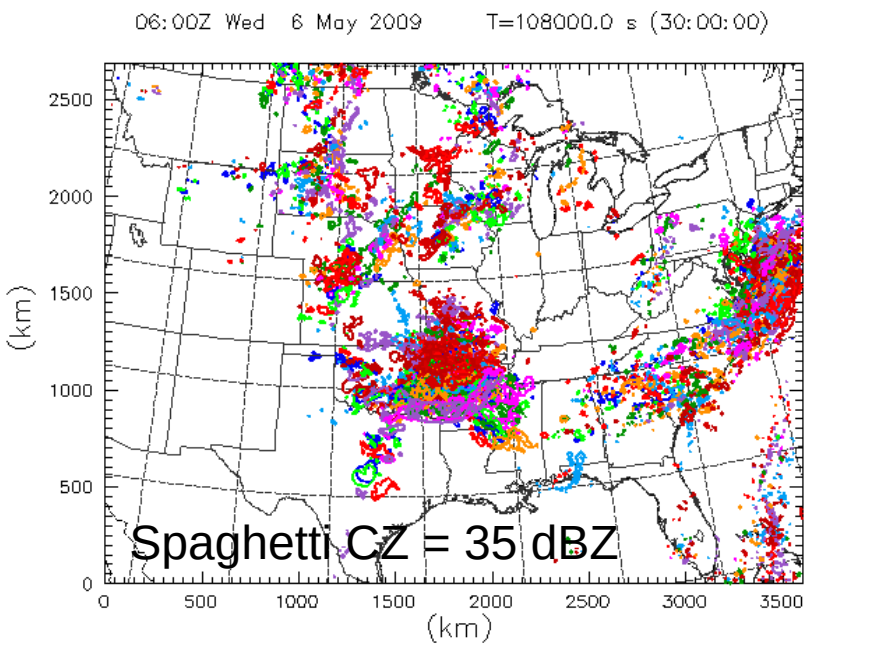
member	IC	LBC	Radar data	Microphysics	radiation	PBL	Turb	sf_phy
arps_cn	00Z ARPSa	00Z NAMf	yes	Lin	Goddard	TKE	3D TKE	Force-restore
arps_c0	00Z NAMa	00Z NAMf	no	Lin	Goddard	TKE	3D TKE	Force-restore

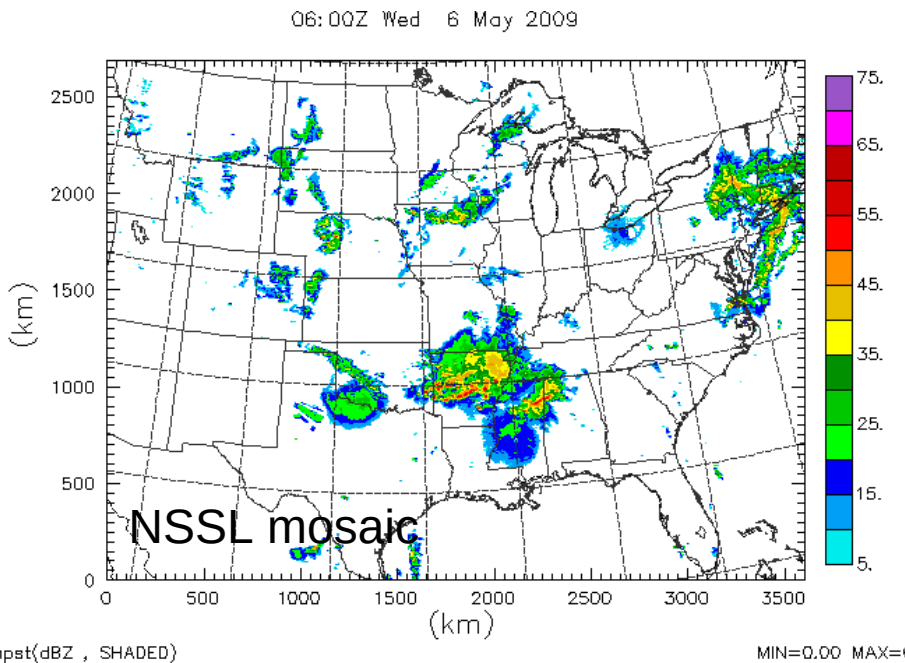
* For all ARPS members: no cumulus parameterization

Example: 30 h forecast, valid at 0600 UTC 6 May

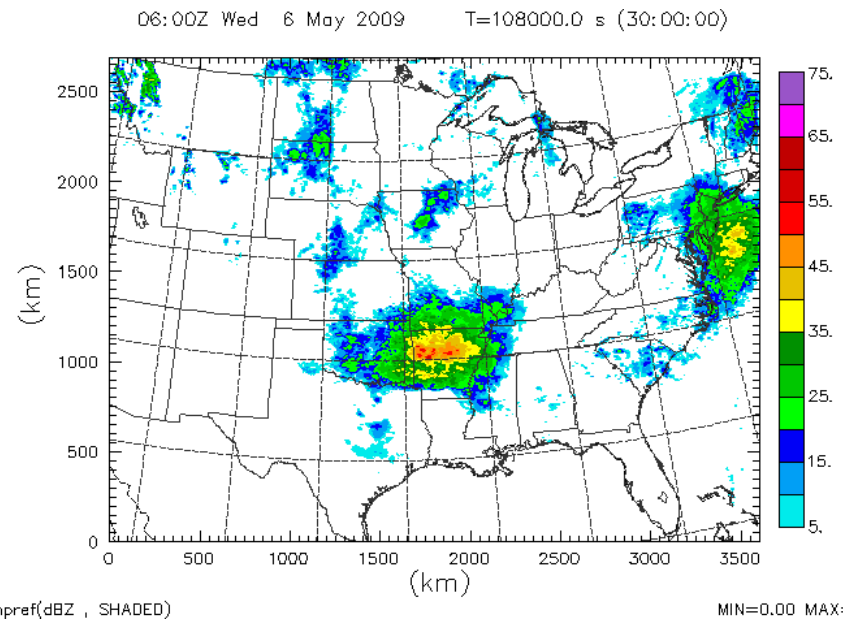




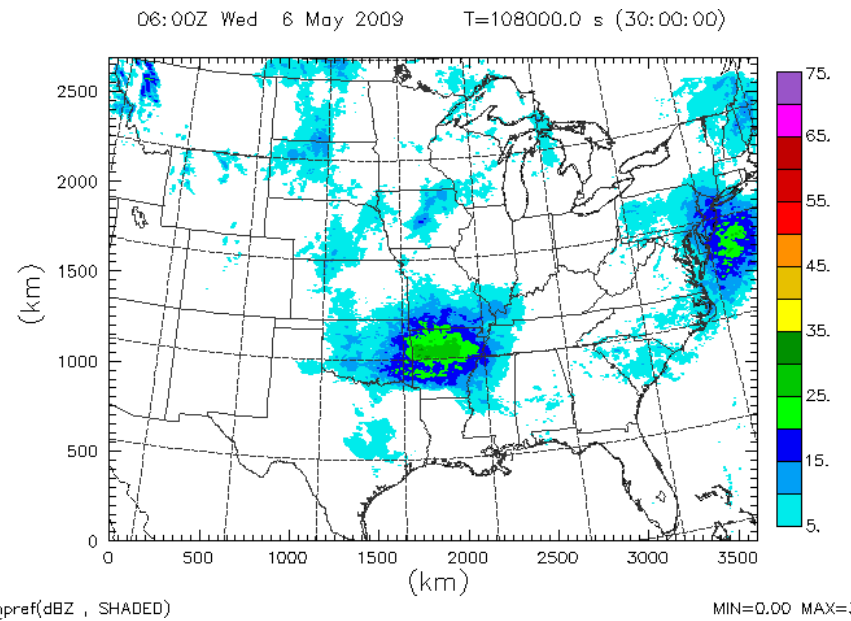




30 h forecast CompZ, valid at 0600 UTC 6 May



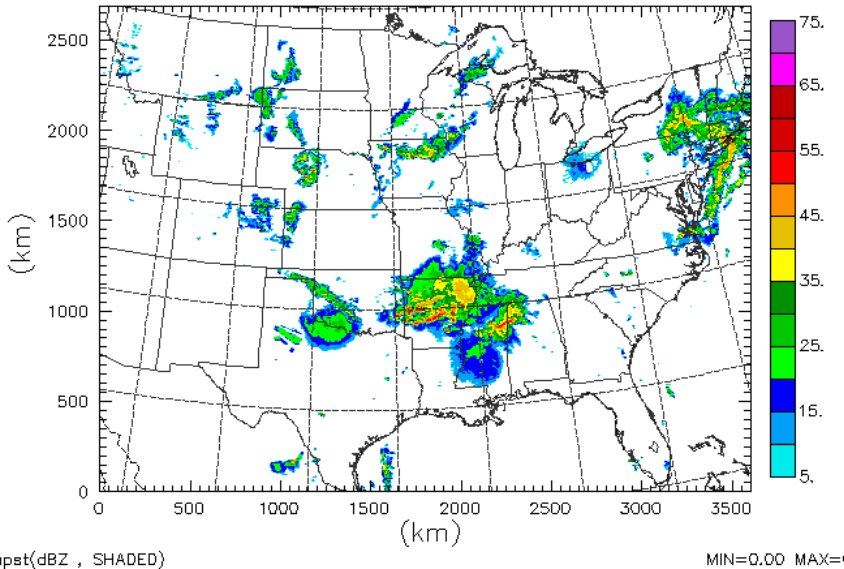
PM



mean

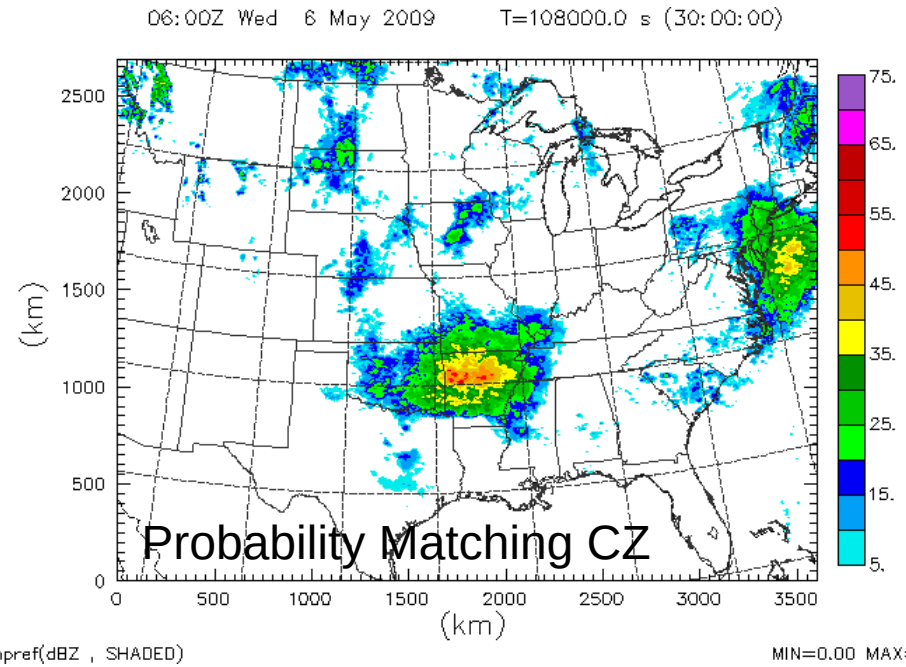
PM -

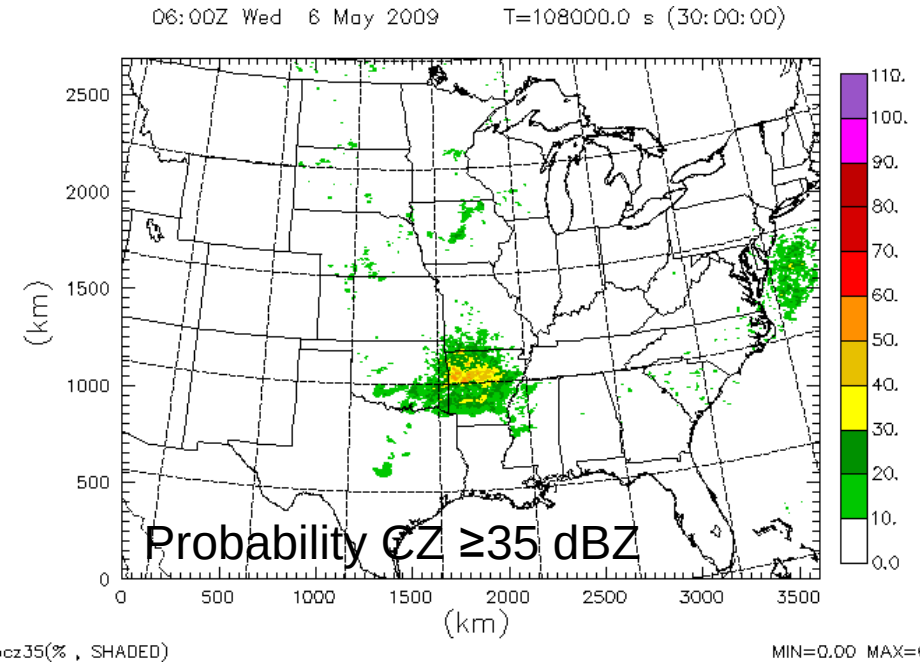
Probability **M**atching, according to Ebert (2001)

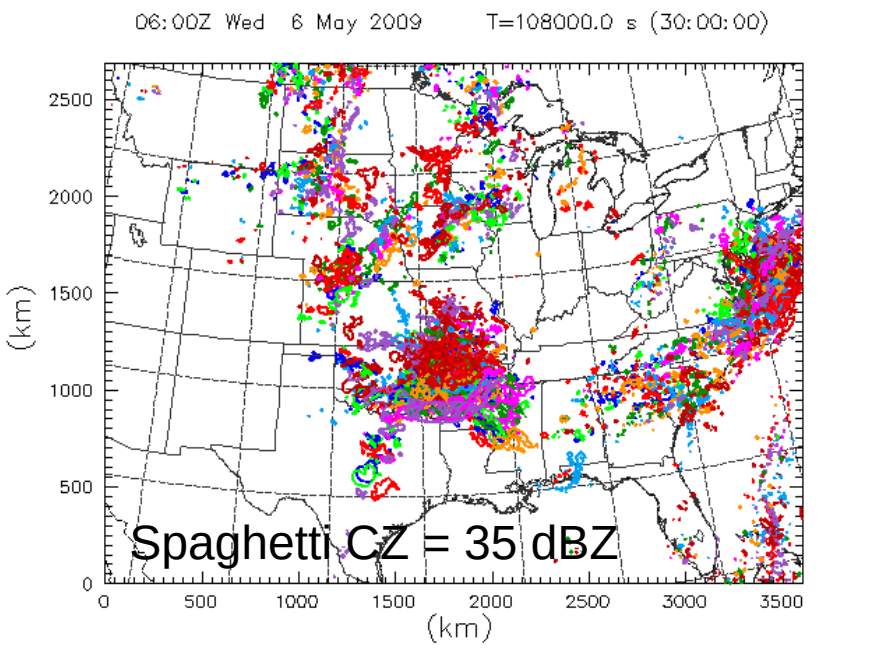


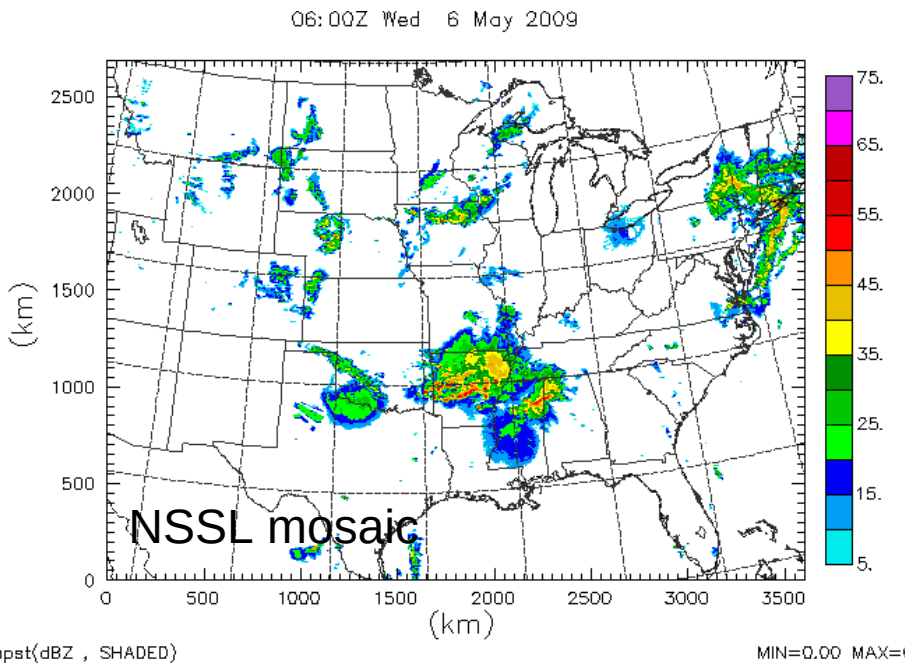
NSSL mosaic

Example: 30 h forecast, valid at 0600 UTC 6 May

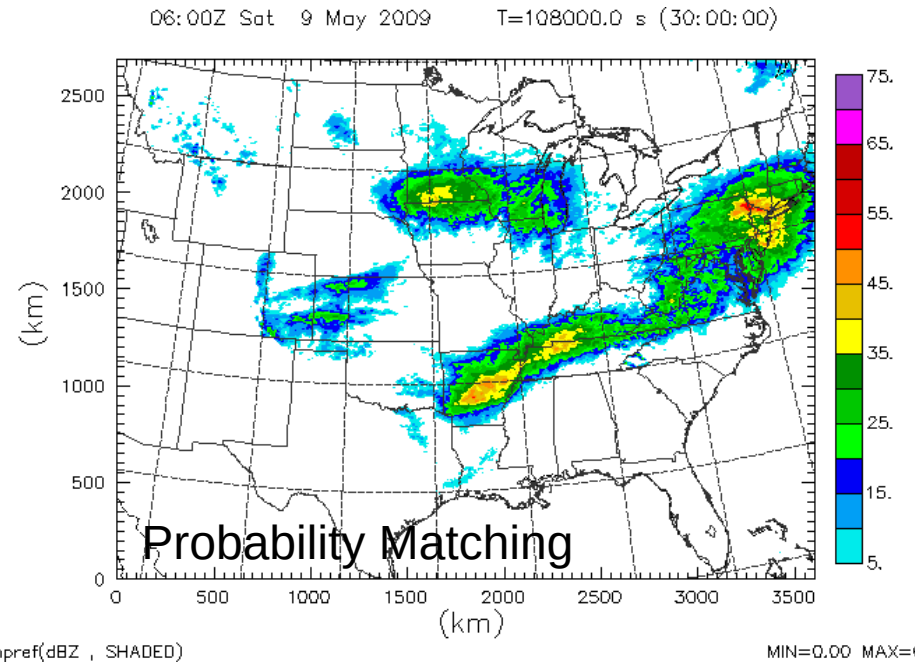


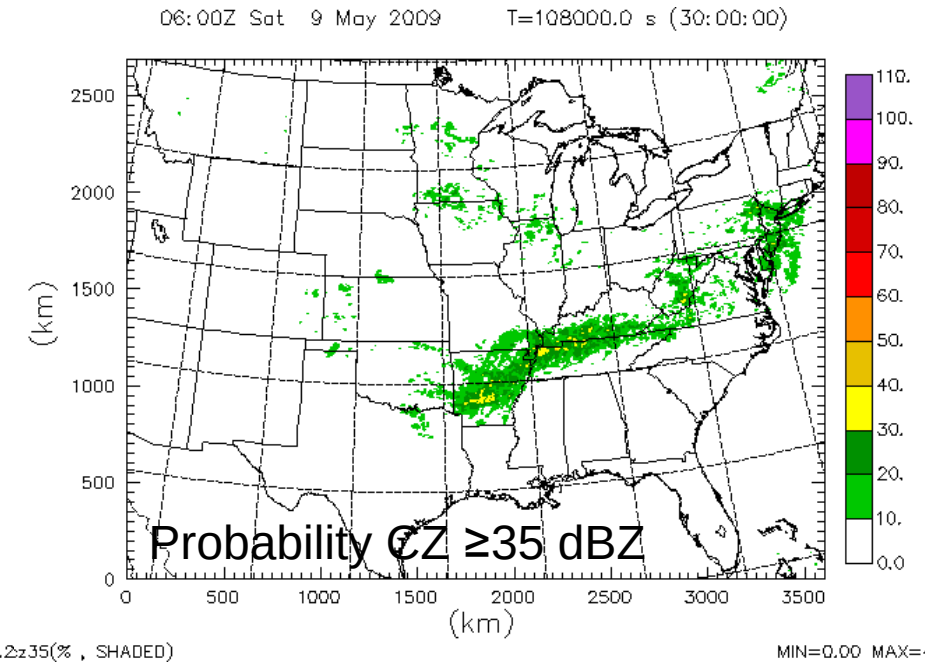


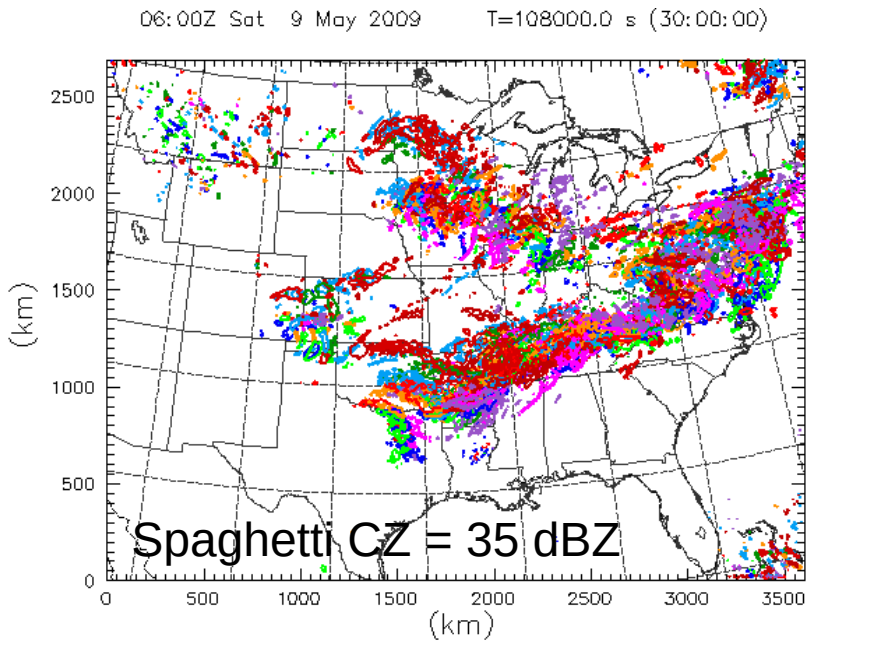


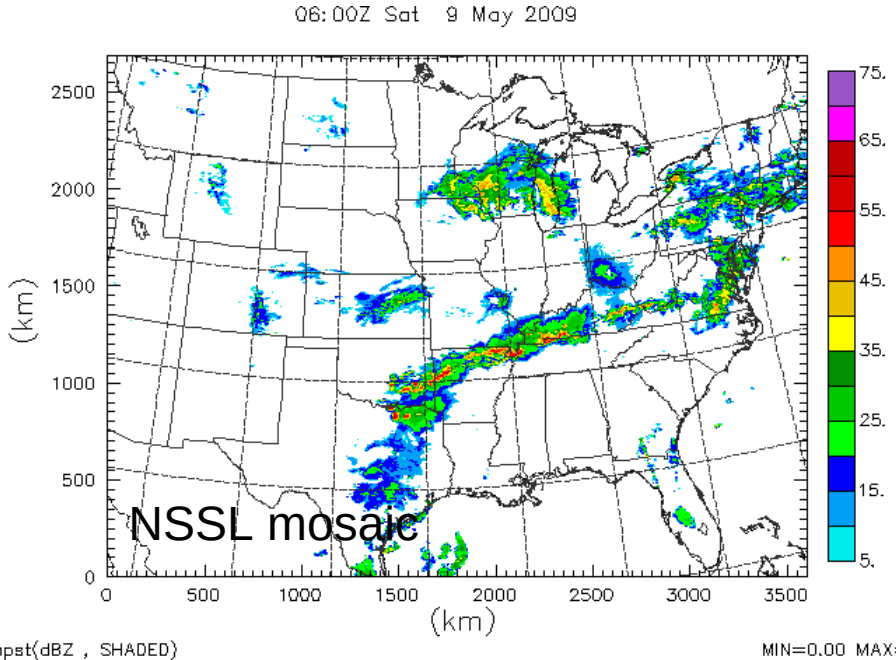


Example: 30 h forecast, valid at 0600 UTC 9 May

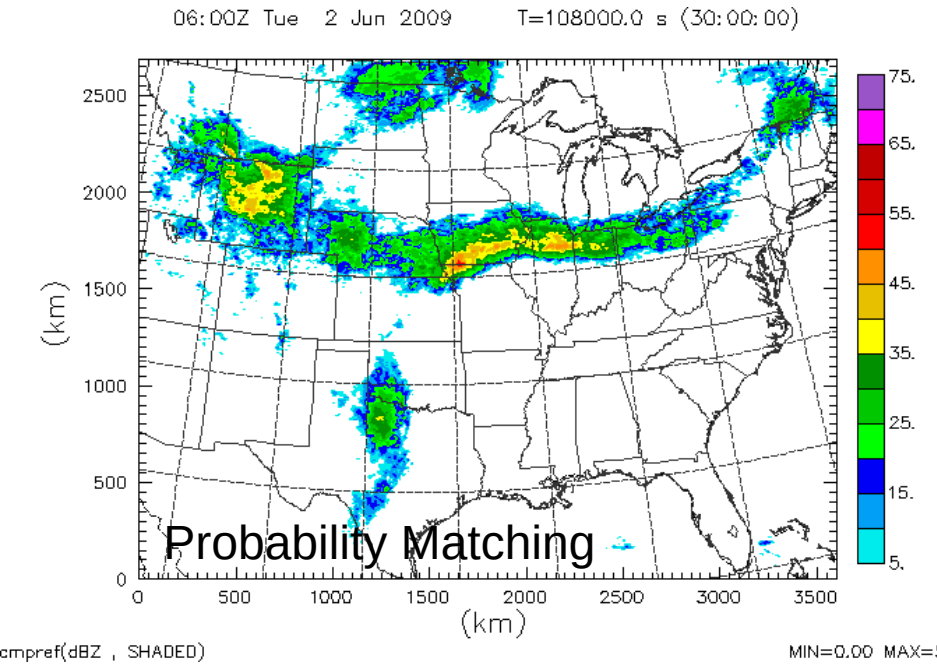


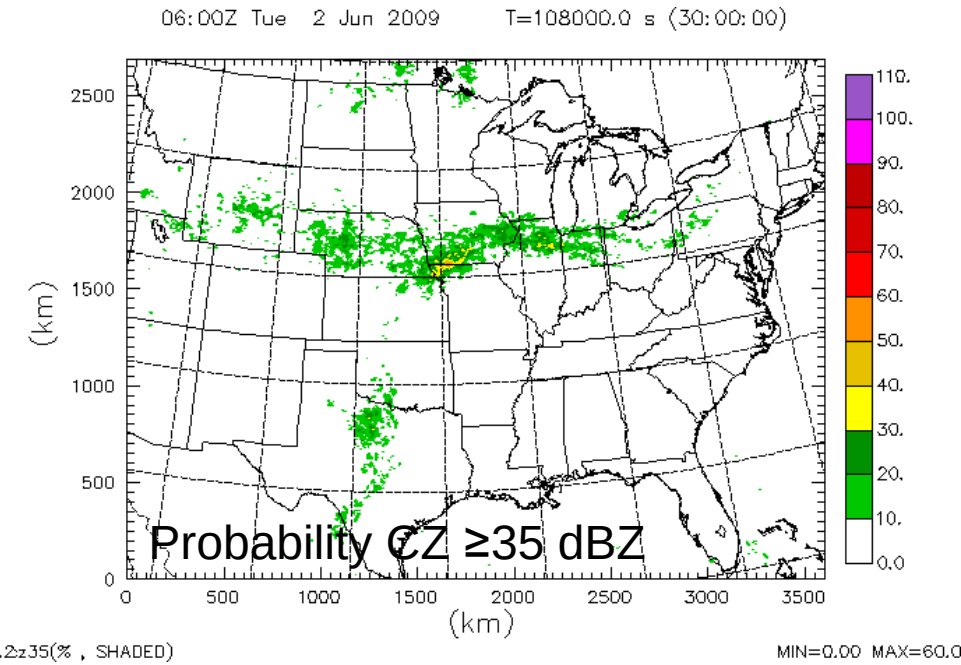


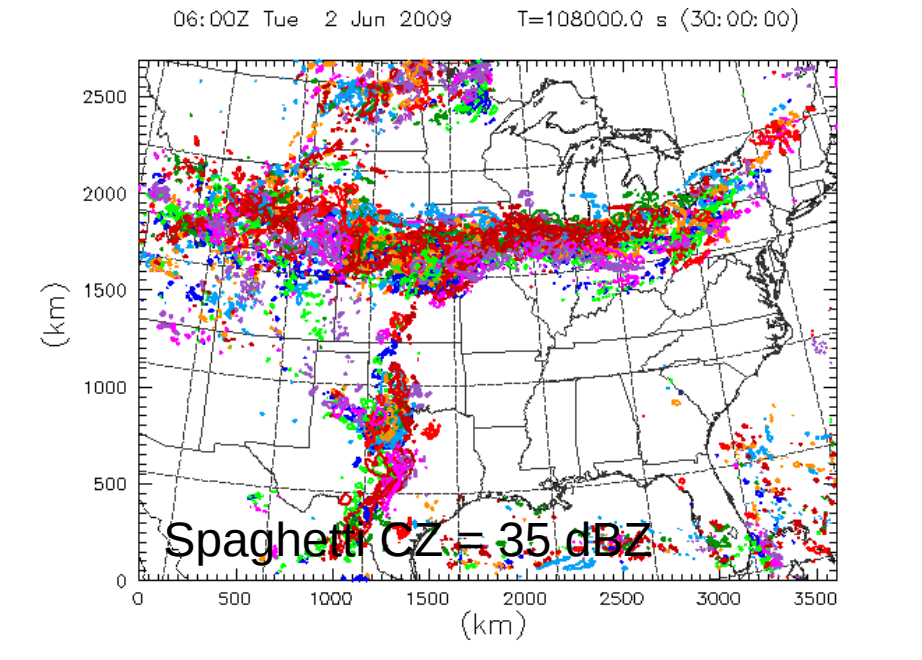


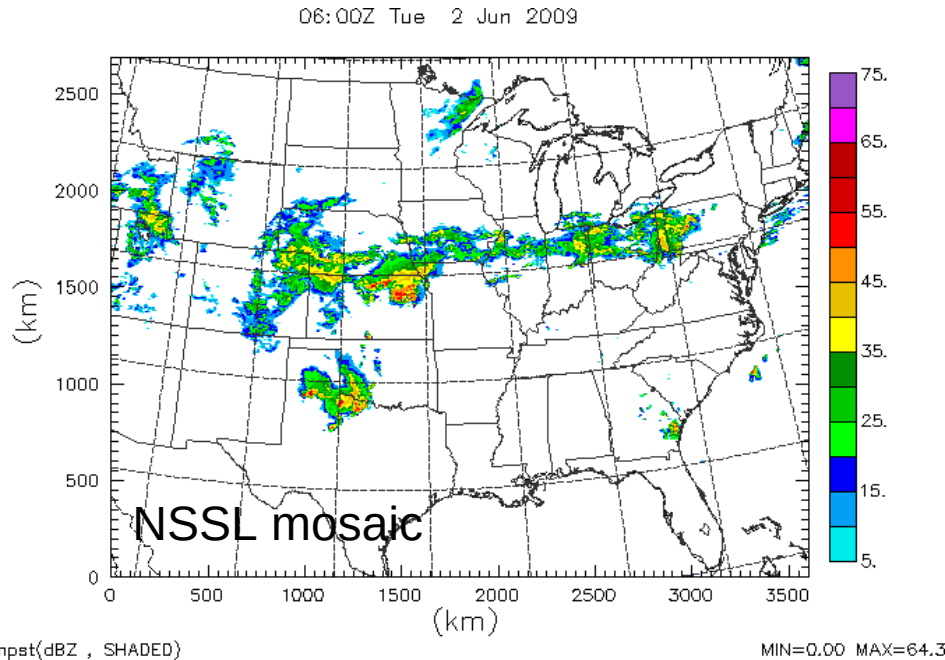


Example: 30 h forecast, valid at 0600 UTC 2 June

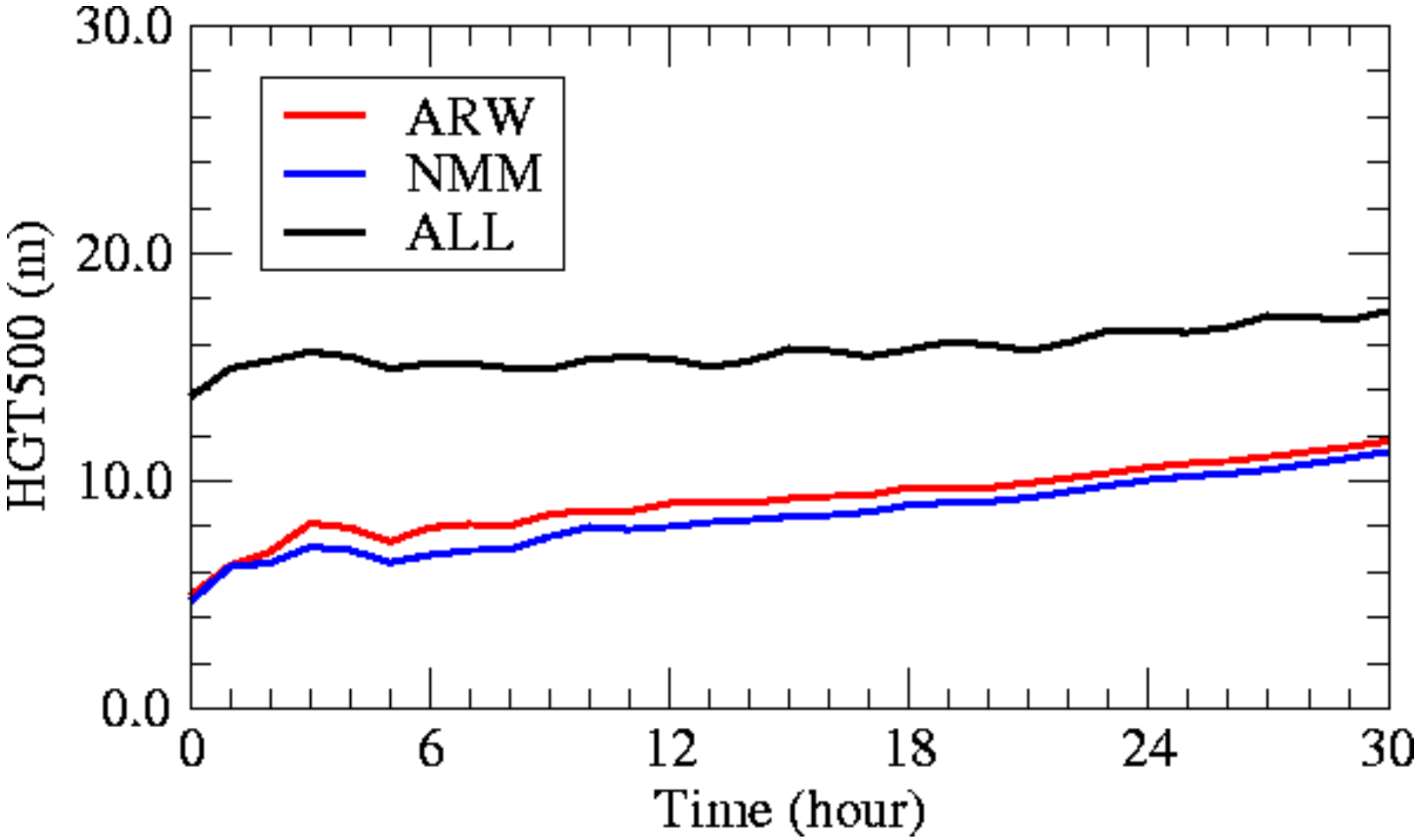




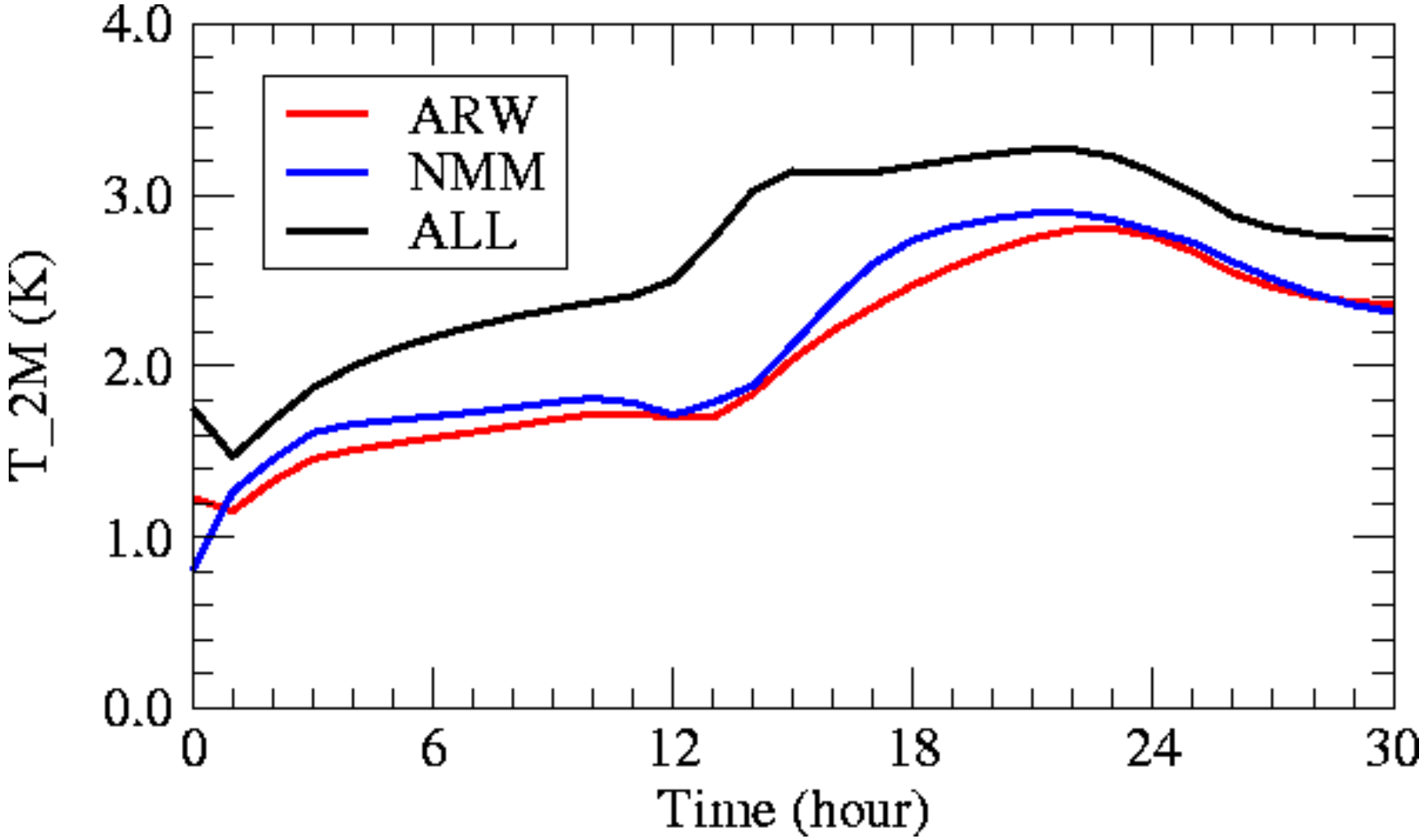




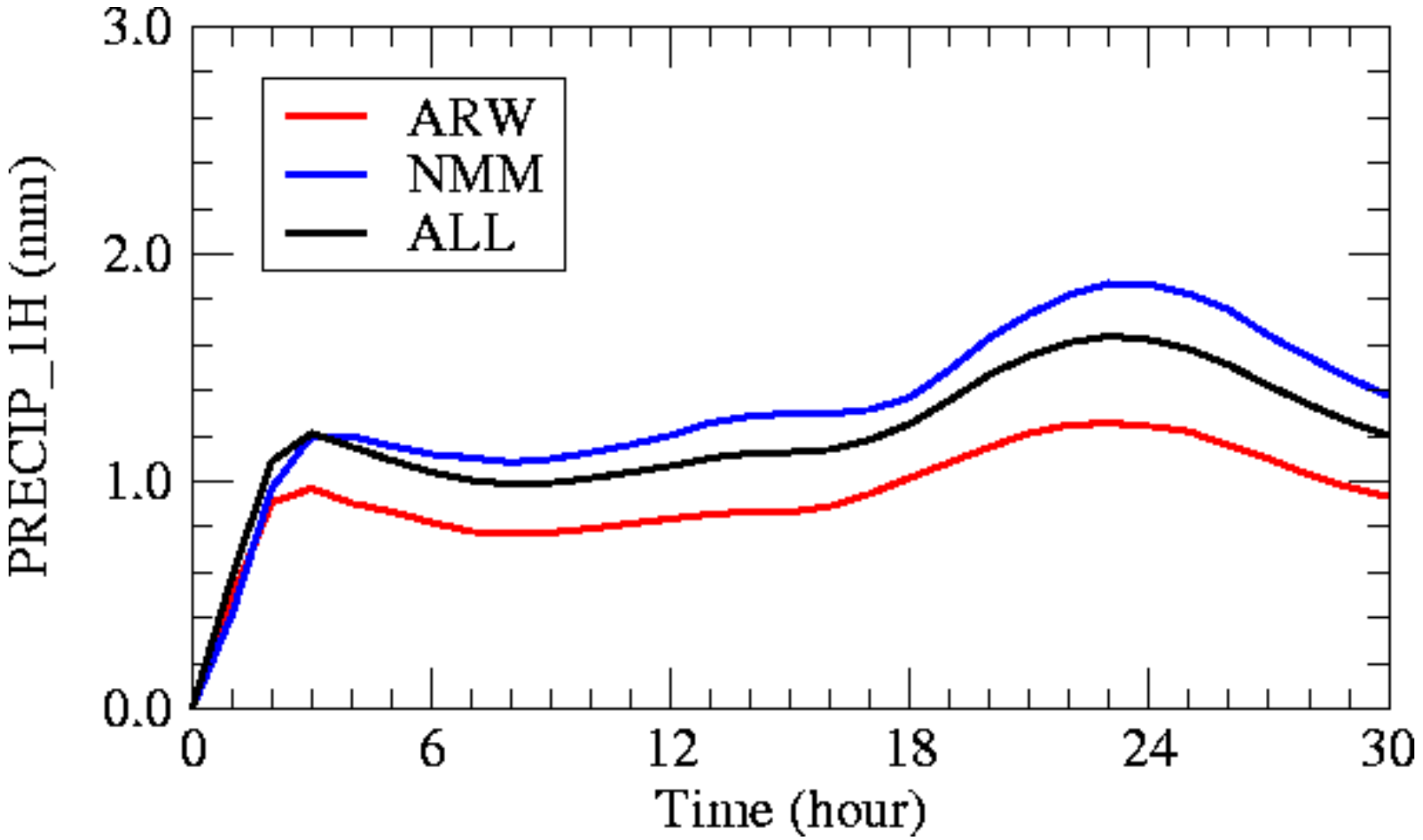
Domain-mean spread: hgt500 (averaged over all cases)



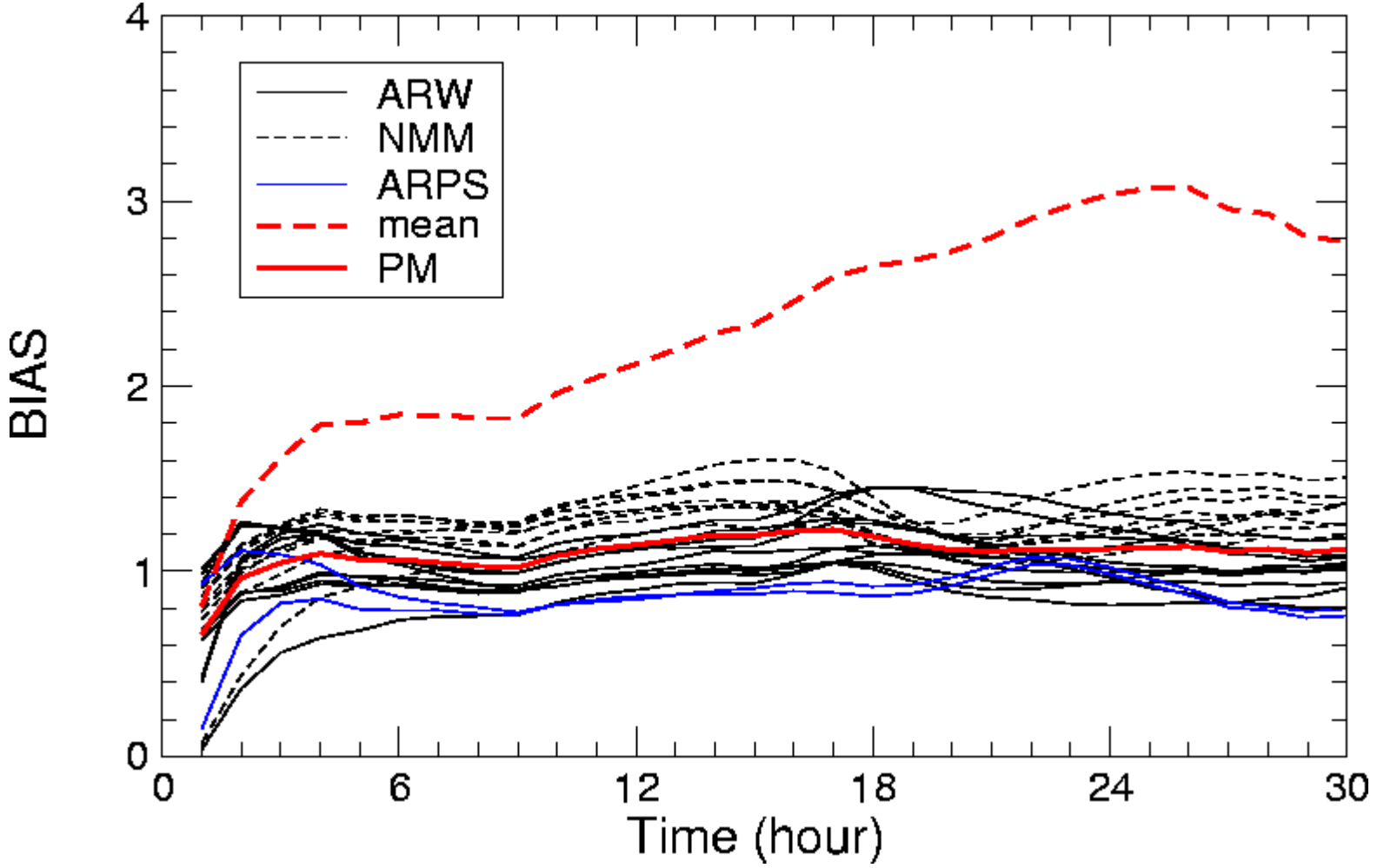
Domain-mean spread: t2m



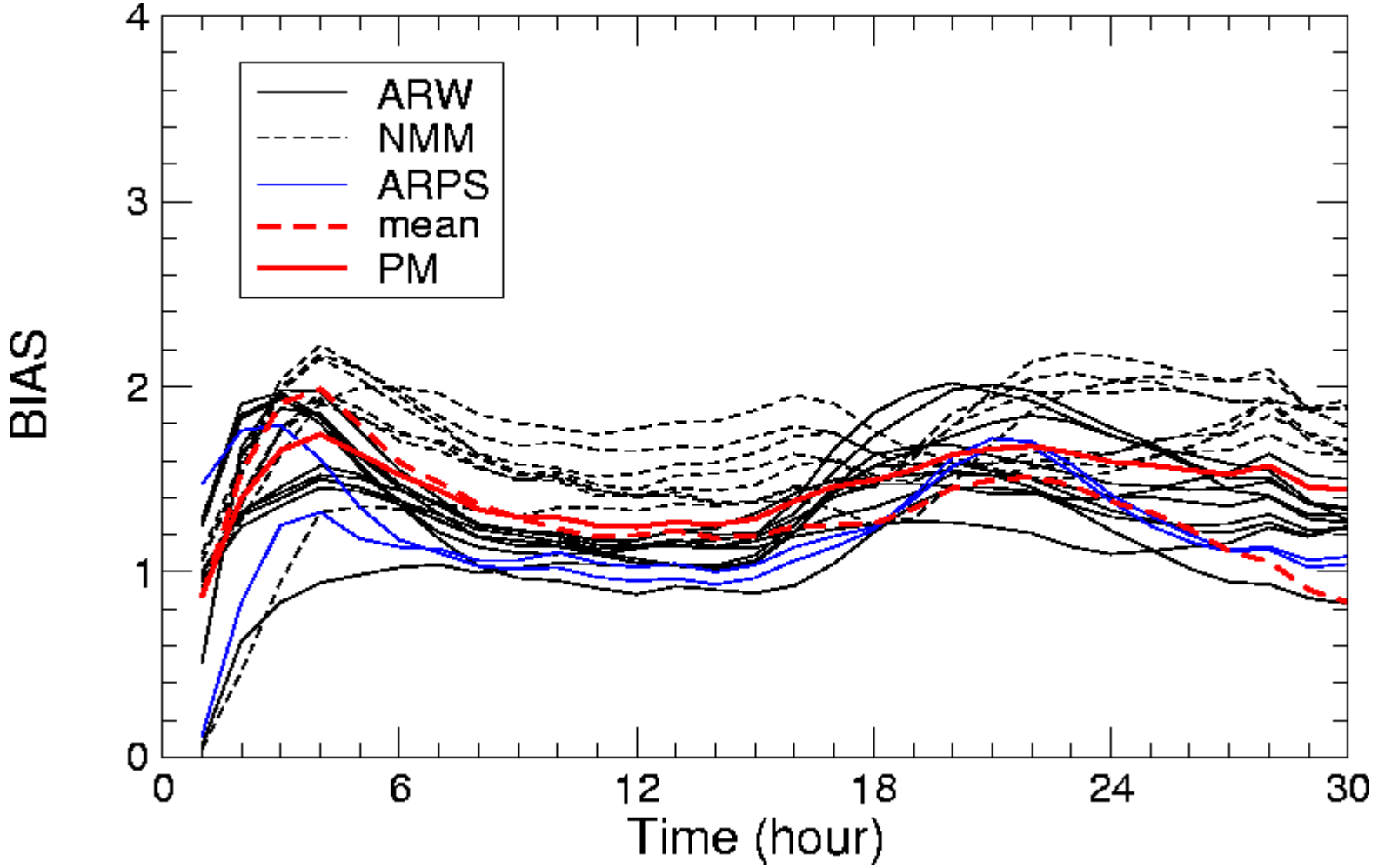
Domain-mean spread: precip_1h



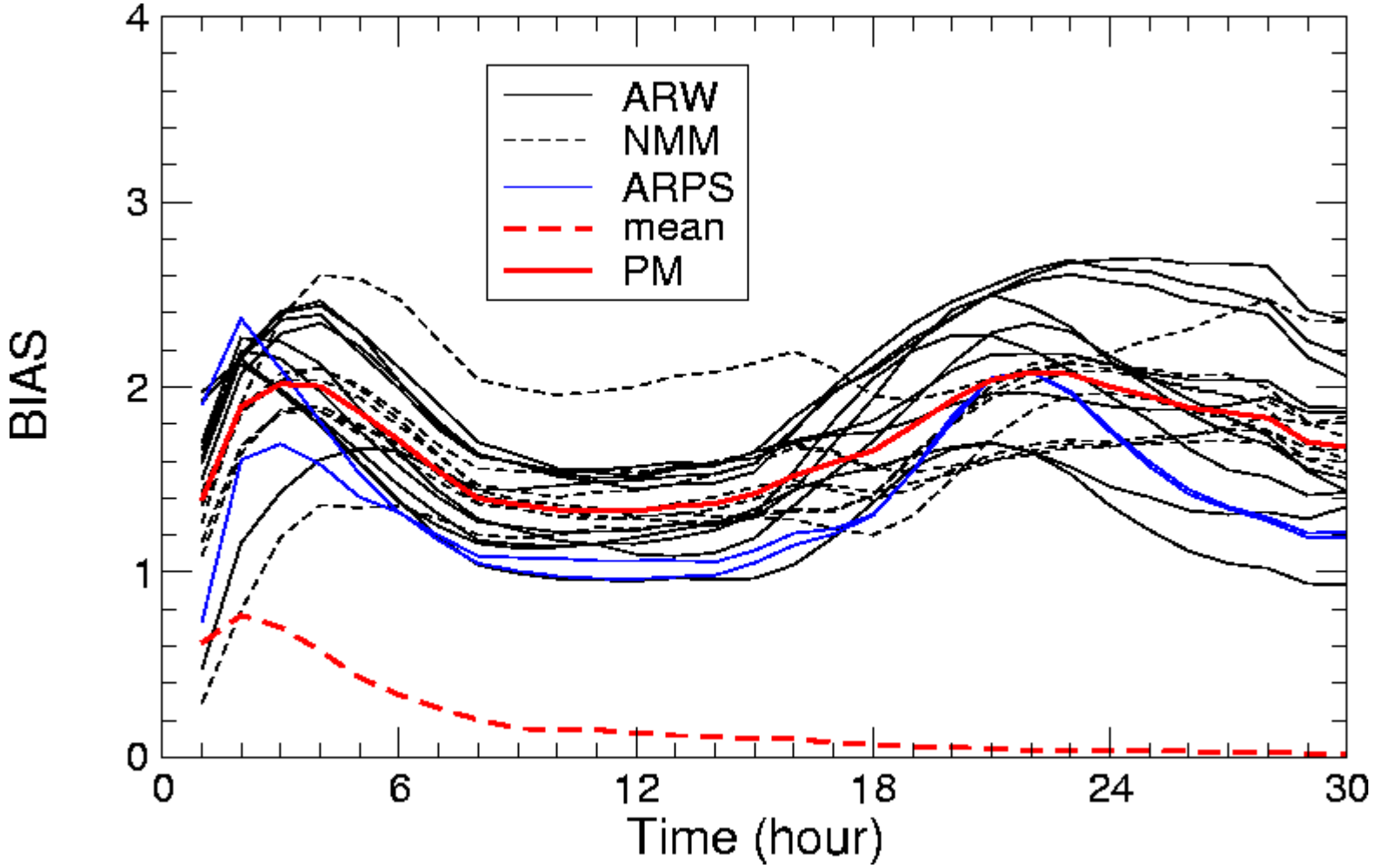
BIAS for 1 h precip ≥0.01 in



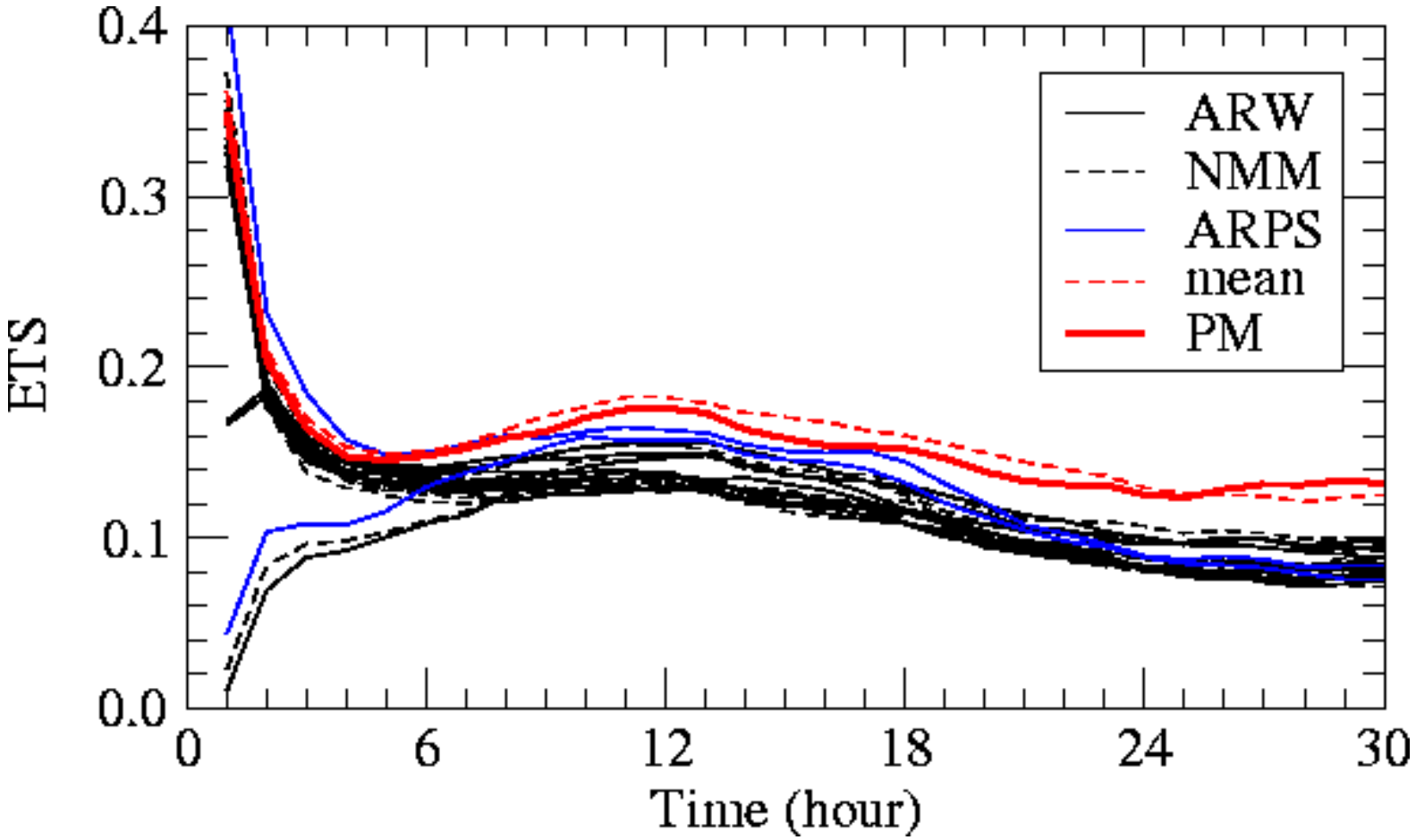
BIAS for 1 h precip ≥0.1 in



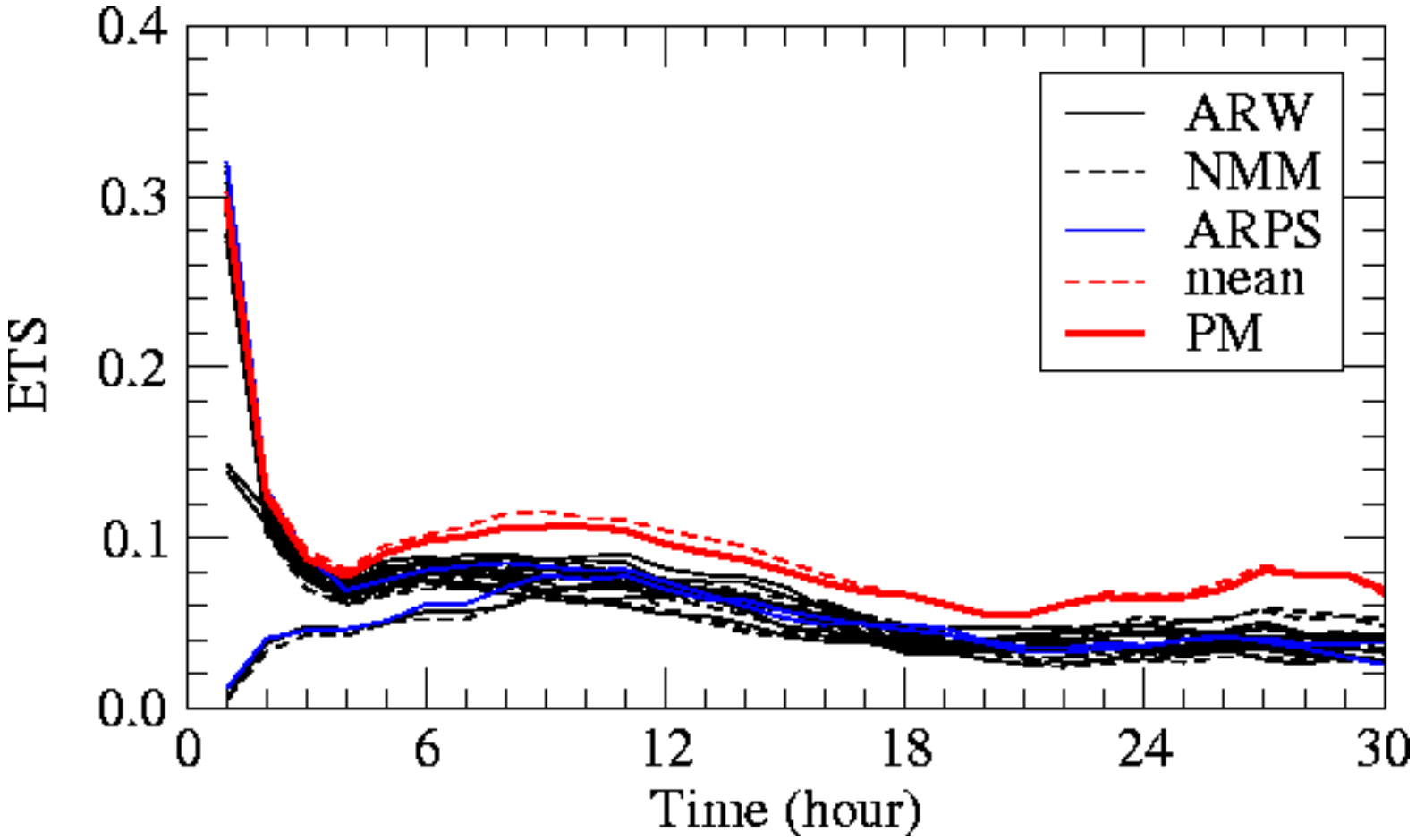
BIAS for CompZ ≥ 30 dBZ



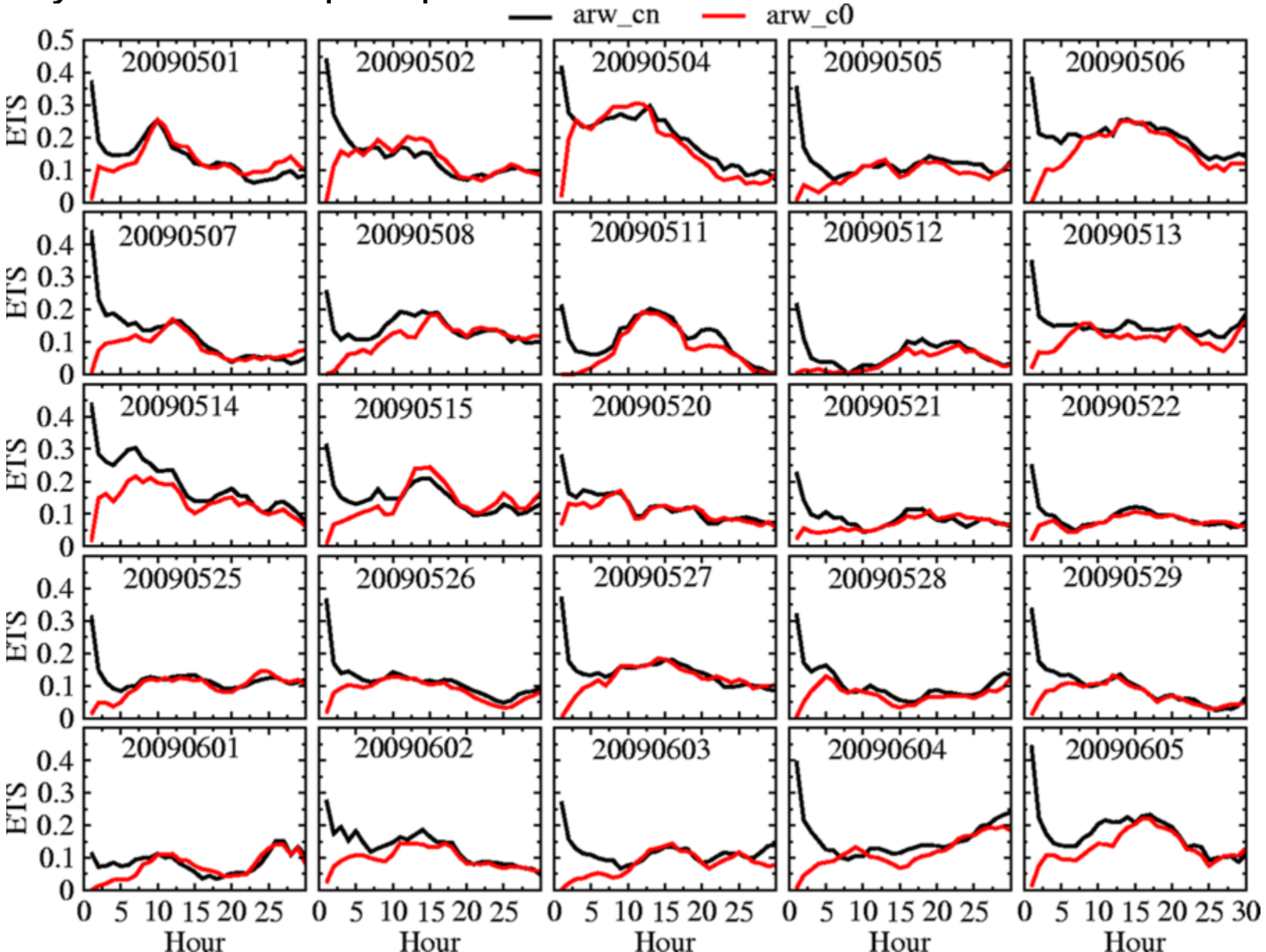
ETS for 1 h precip ≥ 0.01 in



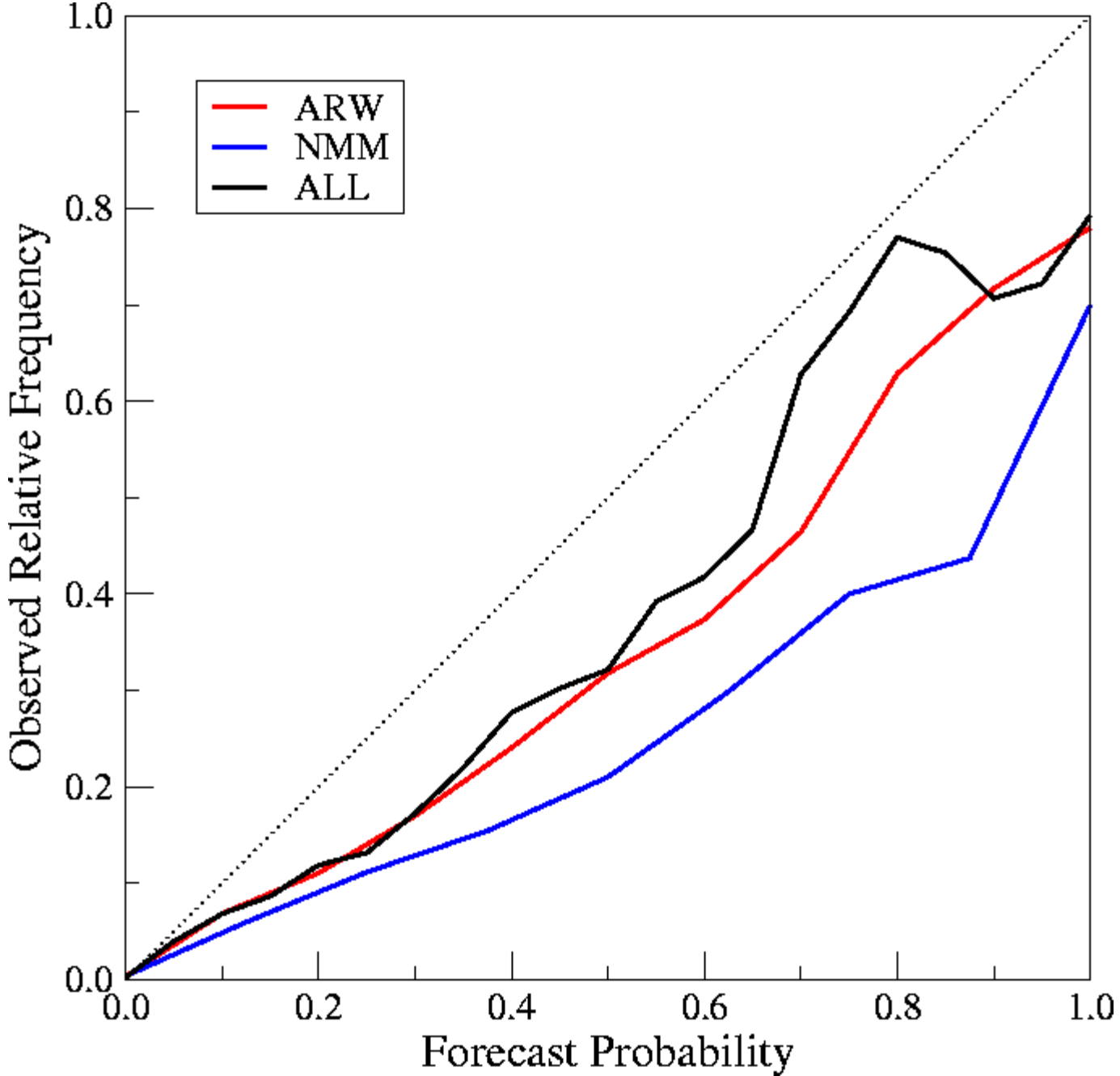
ETS for 1 h precip ≥ 0.1 in



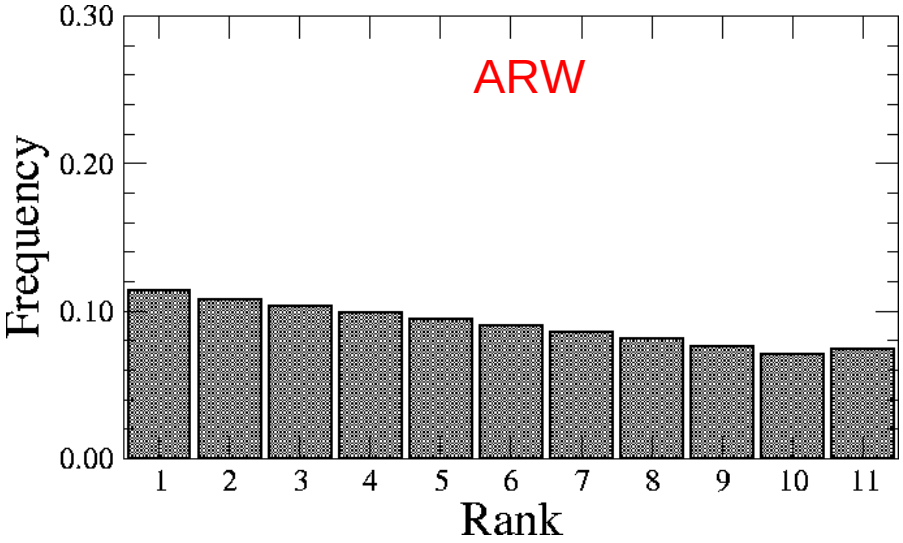
Daily ETS for 1 h precip ≥ 0.01 in

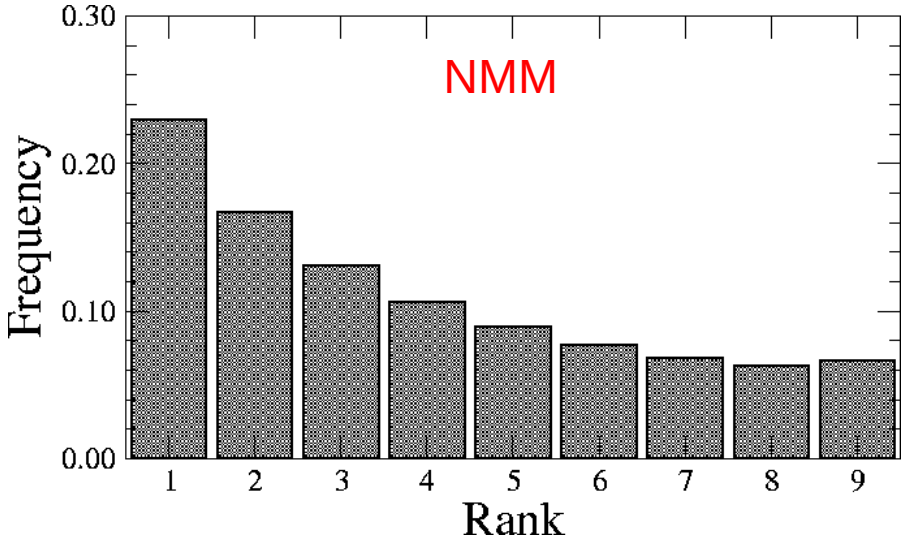


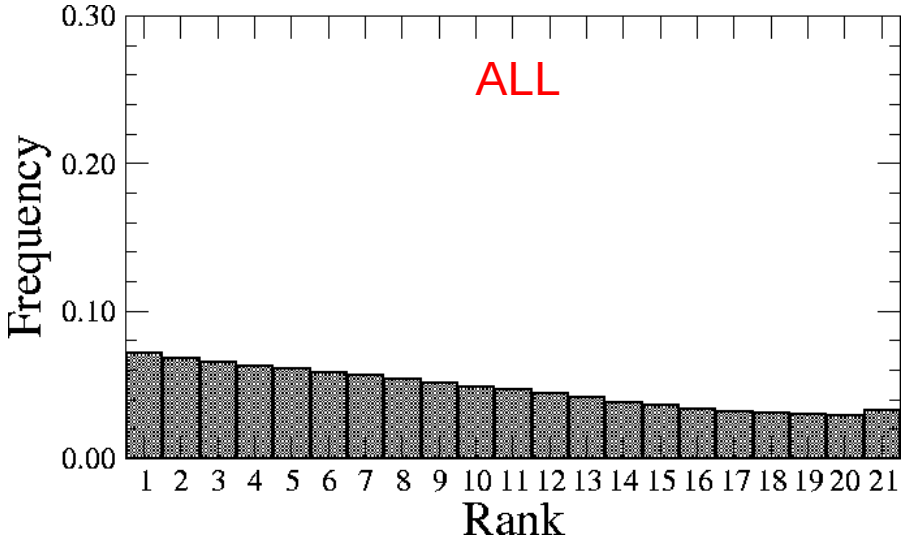
12 h forecast 1 h precip. ≥ 0.1in



24 h forecast 1 h precip.







List of referred publications from collaborations

- Schwartz, C., J. Kain, S. Weiss, M. Xue, D. Bright, F. Kong, K. Thomas, J. Levit, and M. Coniglio, 2009: Next-day convection-allowing WRF model guidance: A second look at 2 vs. 4 km grid spacing. Mon. Wea. Rev., Accepted.

- Schwartz, C. S., J. S. Kain, S. J. Weiss, M. Xue, D. R. Bright, F. Kong, K. W.Thomas, J. J. Levit, M. C. Coniglio, and M. S. Wandishin, 2009: Toward improved convection-allowing ensembles: model physics sensitivities and optimizing probabilistic guidance with small ensemble membership. Wea. Forcasting, Accepted.

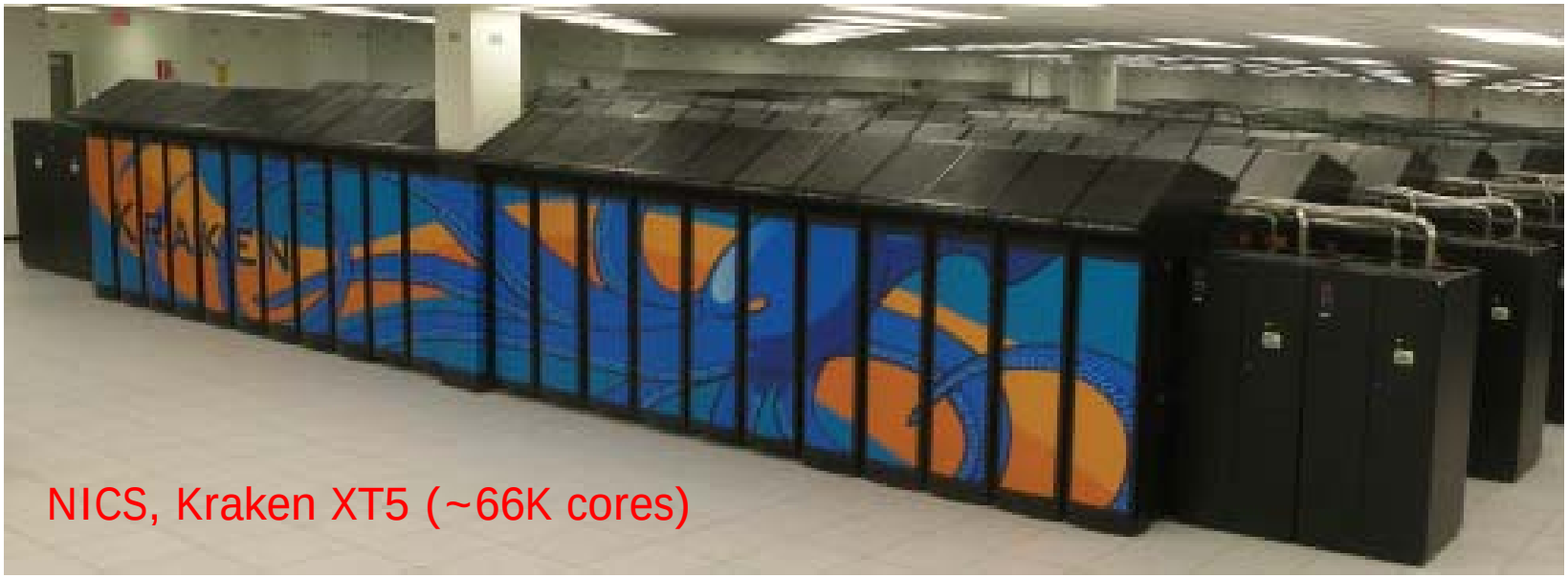
- Clark, A. J., W. A. Gallus, Jr., M. Xue, and F. Kong, 2009: A comparison of precipitation forecast skill between small near-convection-permitting and large convection-parameterizing ensembles. Wea. and Forecasting, Accepted.

- Clark, A. J., W. A. Gallus, Jr., M. Xue, and F. Kong, 2009: Growth of spread in convection-allowing and convection-parameterizing ensembles, Being submitted.

- Coniglio, M. C., K. L. Elmore, J. S. Kain, S. Weiss, and M. Xue, 2009: Evaluation of WRF model output for severe-weather forecasting from the 2008 NOAA Hazardous Weather Testbed Spring Experiment. Wea. Forcasting, Conditionally accepted.

- More coming.

The Heroes



NICS, Kraken XT5 (~66K cores)


PSC XT3 (4K cores)

Thank you.

Questions?

Summary

- Clear impact of radar data assimilation – up to 30 hours in some cases
- Significant sensitivity to model physics.
- **Many issues need to be addressed**
- Huge amount of valuable data waiting to be analyzed/exploited (38 days in 2007; 36 days in 2008; 30 days in 2009) – some are easily accessible 2D form. Collaborations welcome!

http://www.caps.ou.edu/~fkong/sub_atm/spring09.html

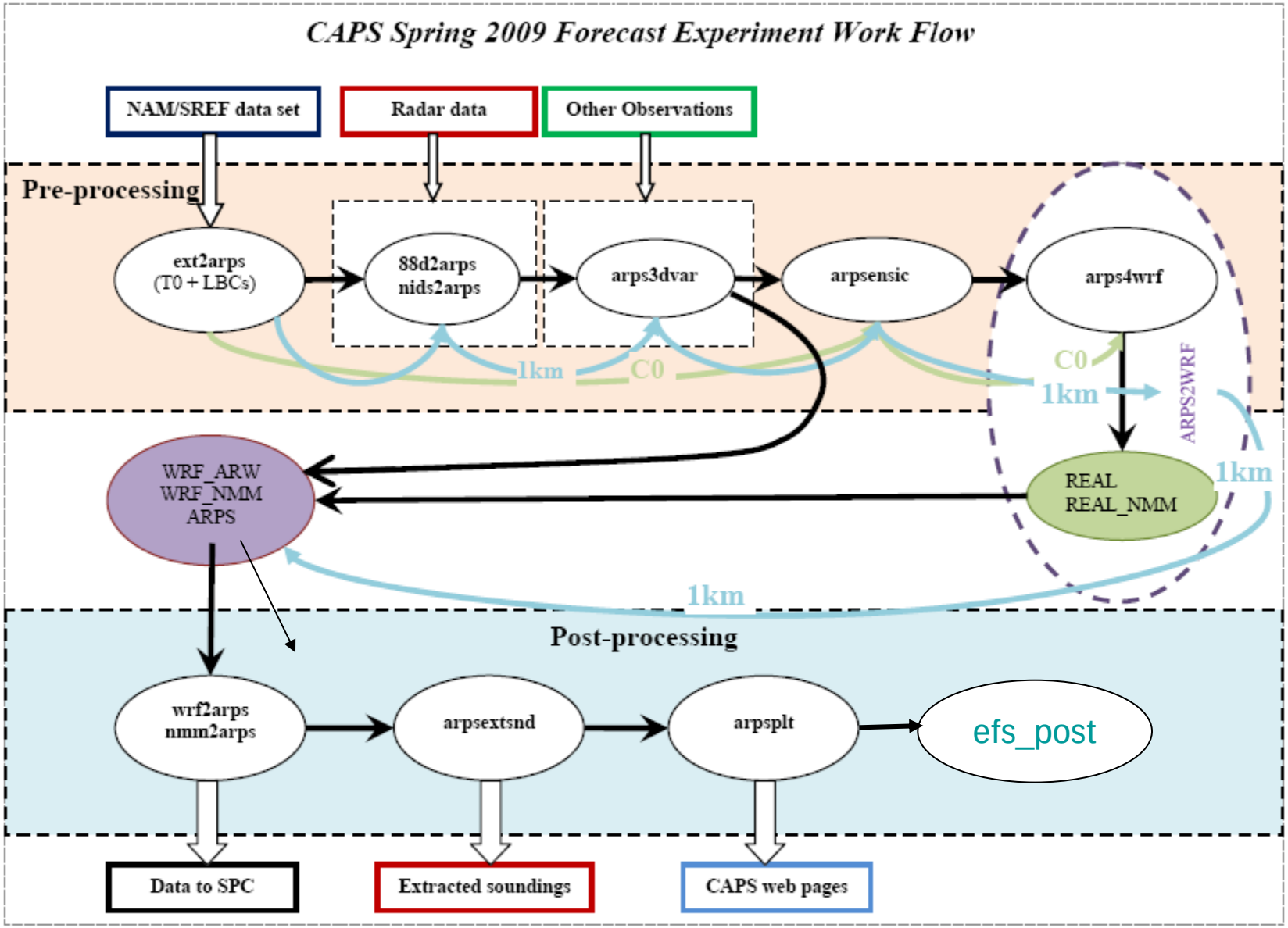
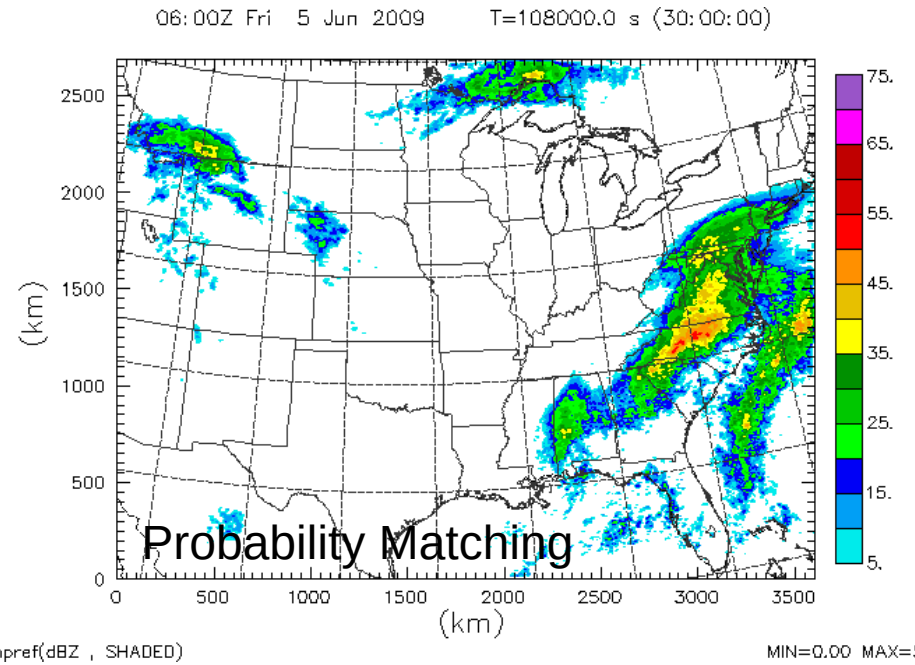
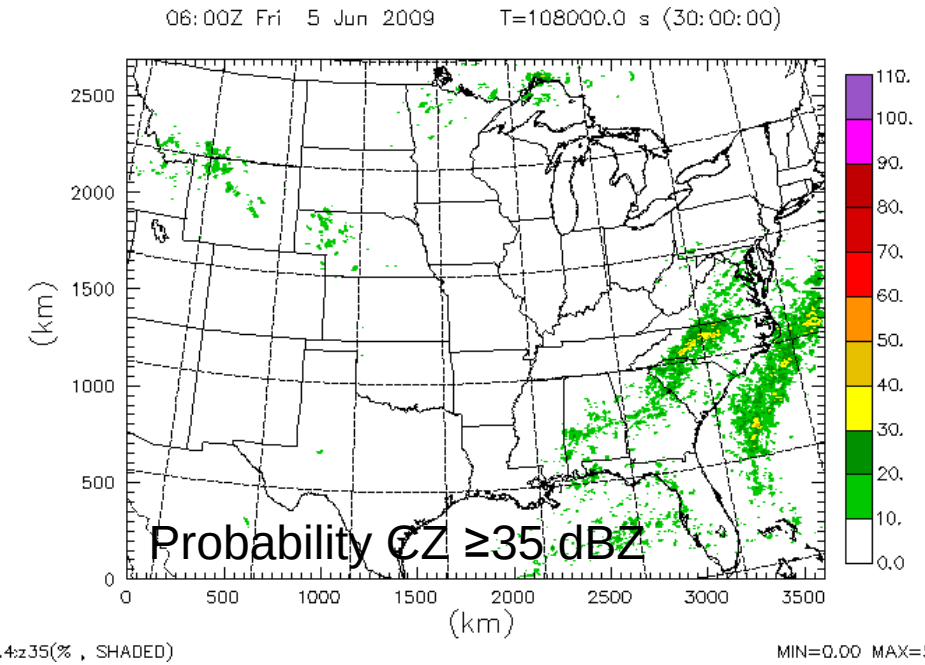
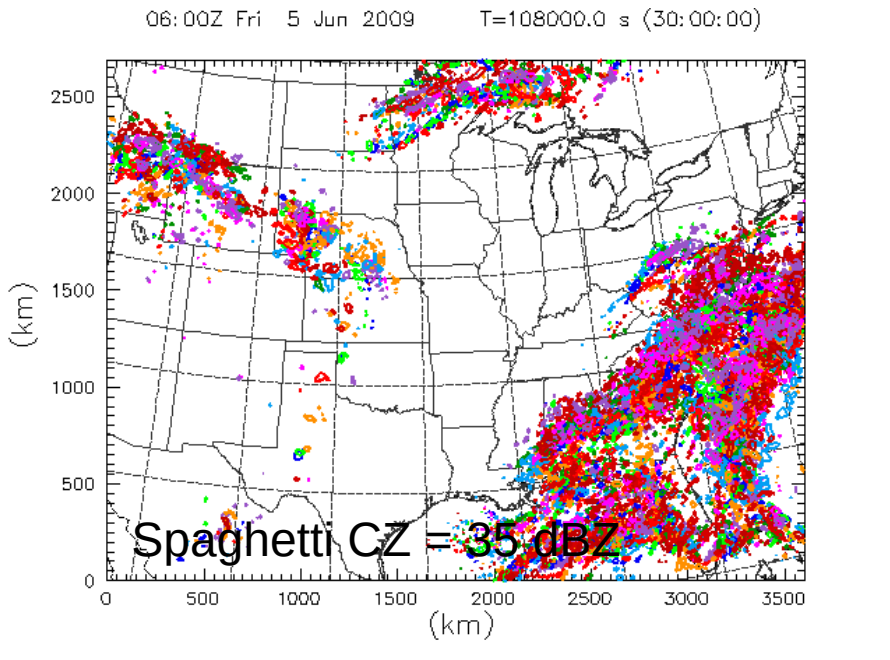


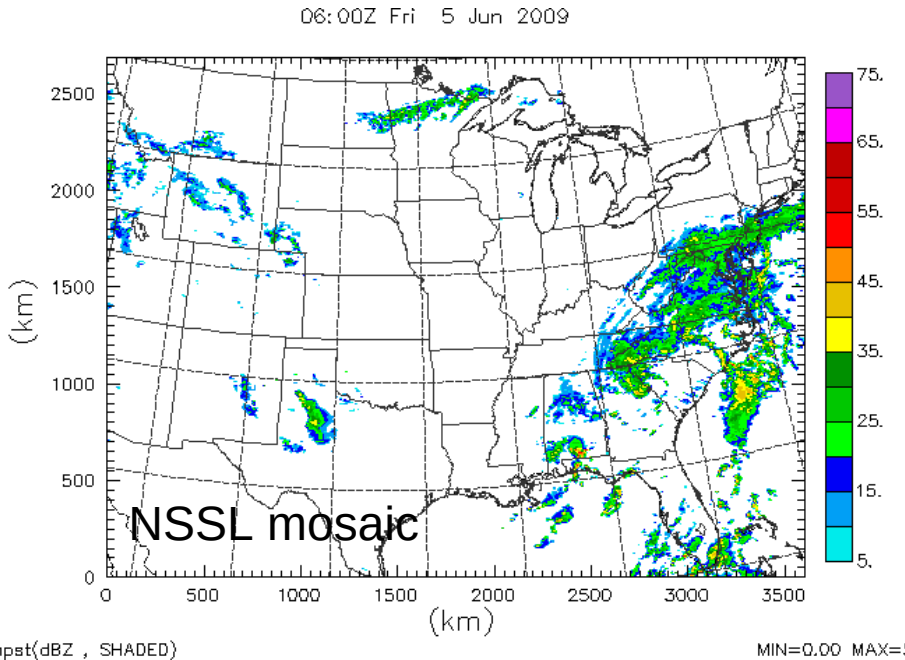
Fig. 4. The 2009 CAPS Spring Forecast Experiment workflow, in which gridded NAM and SREF data are first interpolated to a lager ARPS grid, and radar and other observational data are preprocessed for analysis by the ARPS 3DVAR. The 3DVAR analysis is combined with SREF perturbations to create perturbed initial conditions and these initial conditions as well as the boundary conditions are converted into WRF ARW and WRF NMM IC and LBC fields for running the ensemble forecasts. The model outputs are interpolated to a common ARPS grid for post-processing.

Example: 30 h forecast, valid at 0600 UTC 5 June

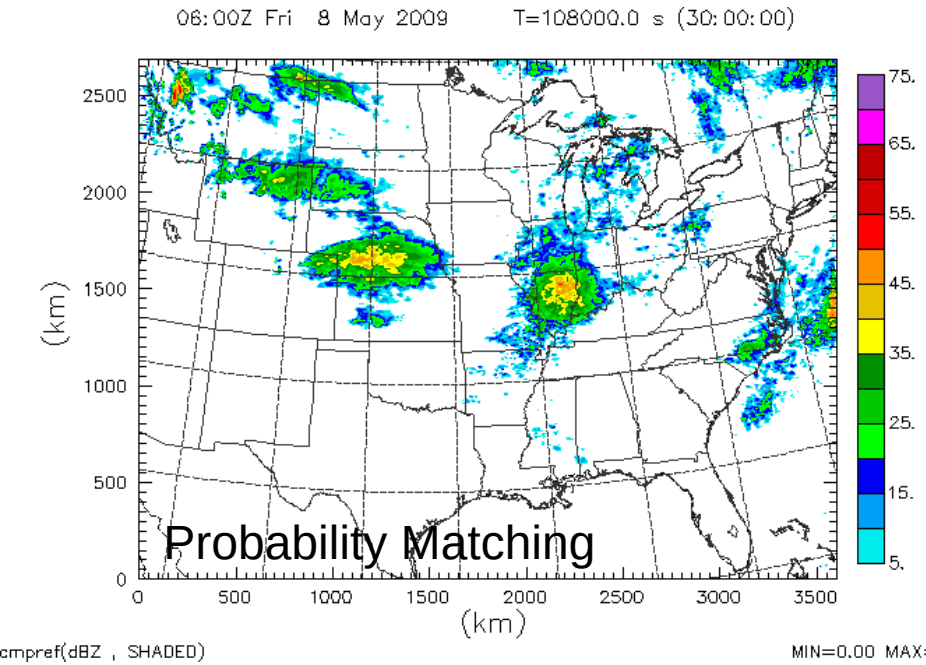


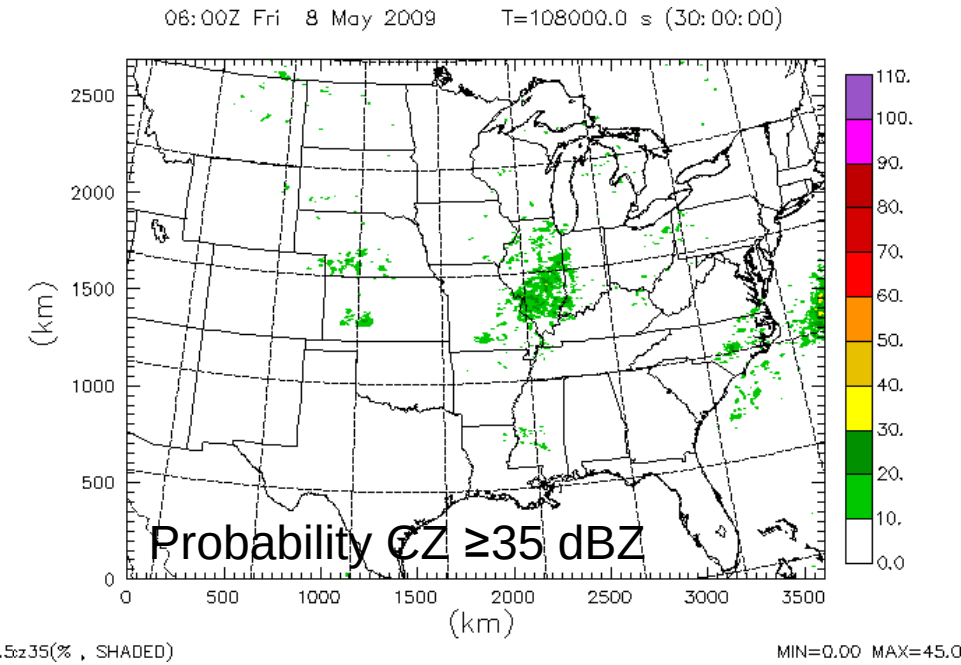


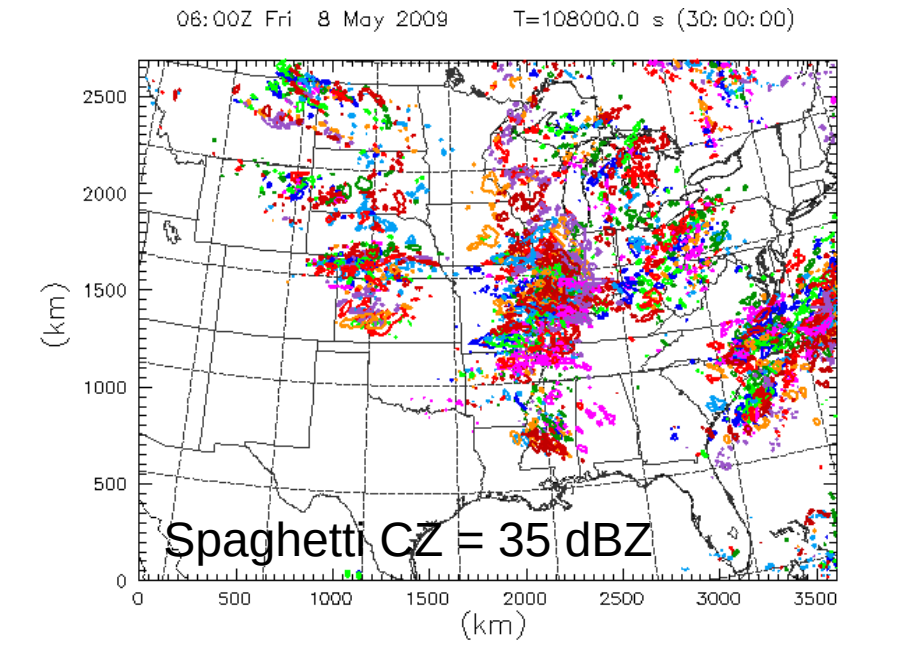


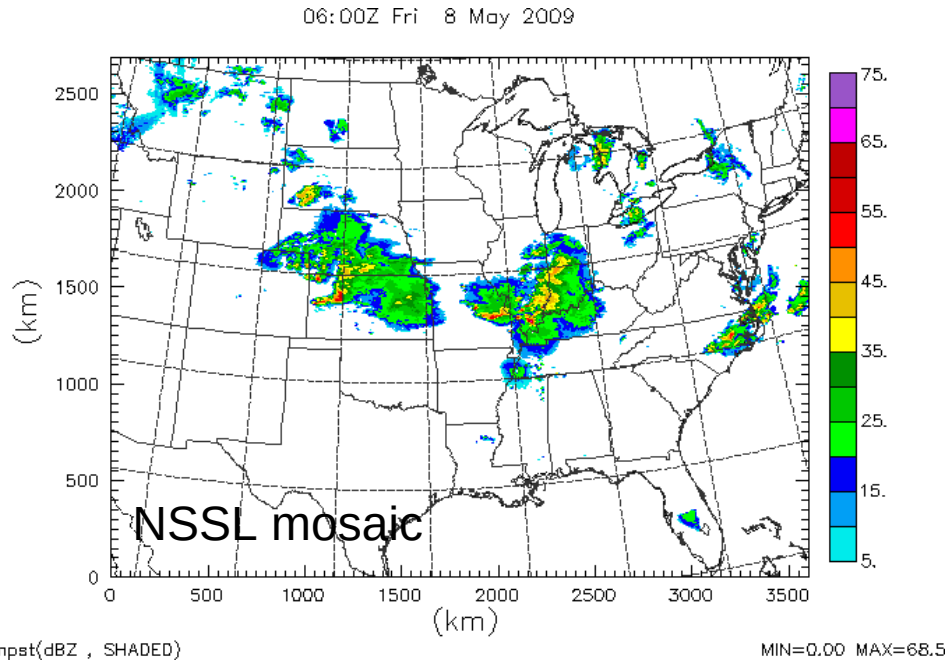


Example: 30 h forecast, valid at 0600 UTC 8 May



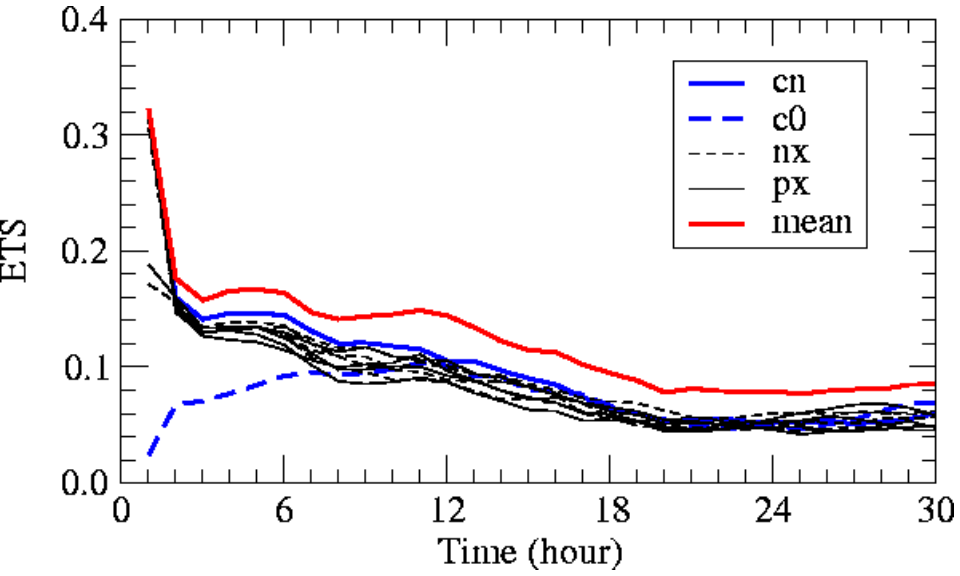




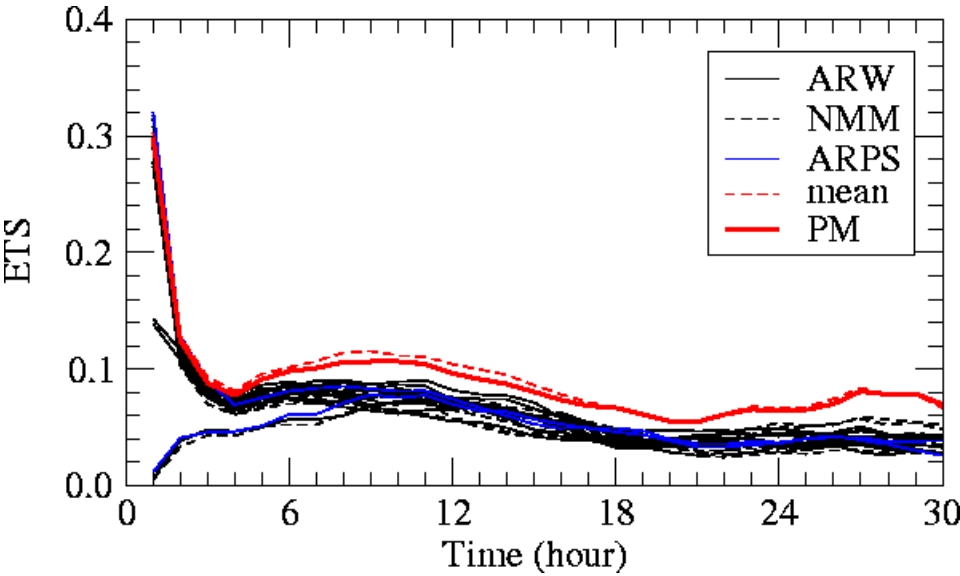


ETS for 1 h precip ≥ 0.1 in

2008



2009



Domain-mean spread: mslp