December 2008 Upgrade of the NCEP Global Ensemble Forecast System (NAEFS)

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http://wwwt.emc.ncep.noaa.gov/gmb/yzhu/html/imp/200811_imp.html

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Planned Changes - Summary

- Continue using current operational GFS
- Upgrade horizontal resolution from T126 to T190
  - 4 cycles per day, 20+1 members per cycle
  - Up to 384 hours (16 days)
- Use 8th order horizontal diffusion for all resolutions
  - Improved forecast skills and ensemble spread
- Introduce ESMF (Earth System Modeling Framework) for GEFS
  - Version 3.1.0rp2
  - Allows concurrent generation of all ensemble members
  - Needed for efficiency of stochastic perturbation scheme
- Add stochastic perturbation scheme to account for random model errors
  - Increased ensemble spread and forecast skill (reliability)
- Add new variables (28 more) to pgrba files
  - Based on user request
  - From current 52 (variables) to future 80 (variables)
  - For NAEFS ensemble data exchange

NAEFS future configuration

Updated: September 2008

	NCEP	CMC
Model	GFS	GEM
Initial uncertainty	ETR	EnKF
Model uncertainty/Stochastic	Yes (Stochastic Pert)	Yes (mulit-physics)
Tropical storm	Relocation	None
Daily frequency	00,06,12 and 18UTC	00 and 12UTC
Resolution	T190L28 (d0-d16)~70km	(d0-d16) ~1.0degree
Control	Yes	Yes
Ensemble members	20 for each cycle	20 for each cycle
Forecast length	16 days (384 hours)	16 days (384 hours)
Post-process	Bias correction for ensemble mean	Bias correction for each member
Last implementation	December 2008 (plan)	July 10th 2007

CCS resources (estimated)

- Computation (Current)
  - T126L28 out to 384 hours
    - Assigned window (75min)
    - Actually using 45 minutes
    - Average 38 nodes
- Computation (future)
  - T190L28 out to 384 hours
    - Use 50 min
    - Average 60 nodes (p6)
    - 75% additional computer resources
    - <45m, <20n (p6)
- Space (current)
  - T126L28 out to 384 hours
    - Pgrba files
    - 17 days on CCS for bias correction
    - 55G (x4 per a day)
- Space (future)
  - T190L28 out to 384 hours
    - Pgrba files
    - 17 days on CCS for bias correction
    - 83G needed (x4 for a day)

NEXT NAEFS exchange pgrba files

Variables	pgrba file	Total 80 (28)
GHT	Surface, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000hPa	11 (3)
TMP	2m, 2mMax, 2mMin, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000hPa	13 (3)
RH	2m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000hPa	11 (3)
UGRD	10m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000hPa	11 (3)
VGRD	10m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000hPa	11 (3)
VVEL	850hPa	1 (1)
PRES	Surface, PRMSL	2 (0)
PRCP (types)	APCP, CRAIN, CSNOW, CFRZR, CICEP	5 (0)
FLUX (surface)	LHTFL, SHTFL, DSWRF, DLWRF, USWRF, ULWRF	6 (6)
FLUX (top)	ULWRF (OLR)	1 (1)
PWAT	Total precipitable water at atmospheric column	1 (0)
TCDC	Total cloud cover at atmospheric column	1 (0)
CAPE and CIN	Convective available potential energy, Convective Inhibition	2 (1)
SOIL	SOILW(0-10cm), WEASD(water equiv. of accum. snow depth), SNOD(surface), TMP(0-10cm down)	4 (4)
Notes	Surface GHT is only in analysis file and first pgrb file when the resolution changed. 25 of 28 new variables are from pgrbb files, 10, 50hPa RH and SNOD are new variables	28 new vars

NEXT NAEFS pgrba_bc files

(bias correction)

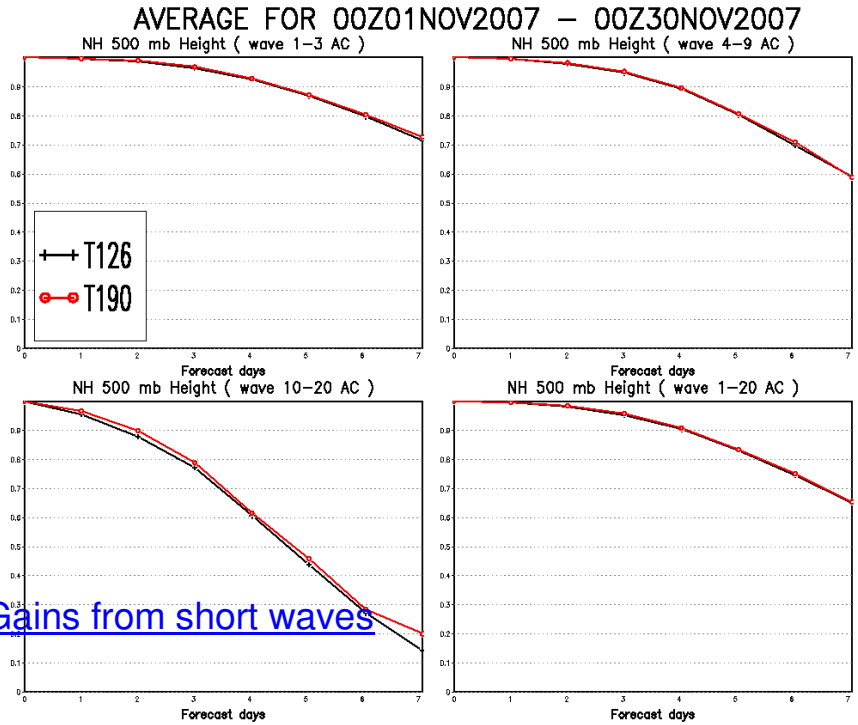
Variables	pgrba_bc file	Total 49 (14)
GHT	10, 50, 100, 200, 250, 500, 700, 850, 925, 1000hPa	10 (3)
TMP	2m, 2mMax, 2mMin, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000hPa	13 (3)
UGRD	10m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000hPa	11 (3)
VGRD	10m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000hPa	11 (3)
VVEL	850hPa	1(1)
PRES	Surface, PRMSL	2(0)
FLUX (top)	ULWRF (toa - OLR)	1 (1)
		14 new vars
Notes		

Horizontal resolution change

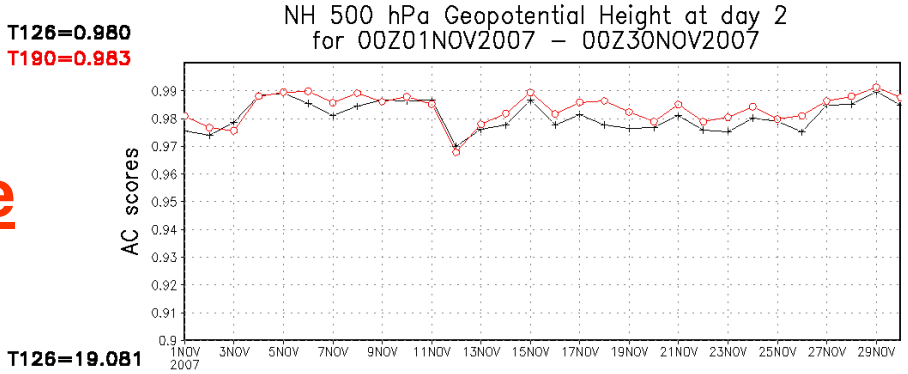
Ensemble control only (deterministic)

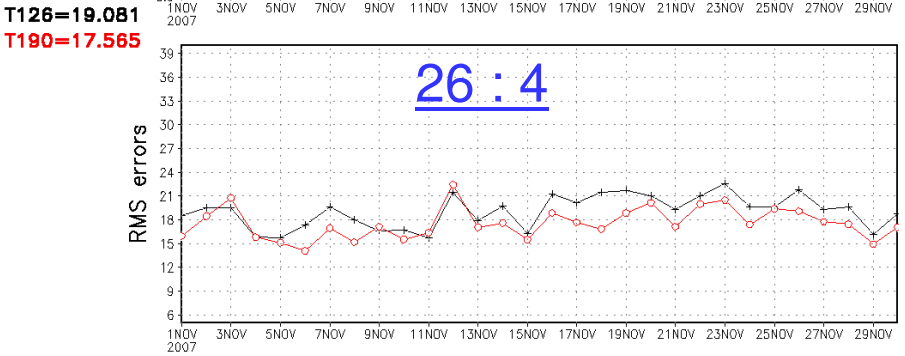
From T126 to T190

NH 500hPa geopotential height

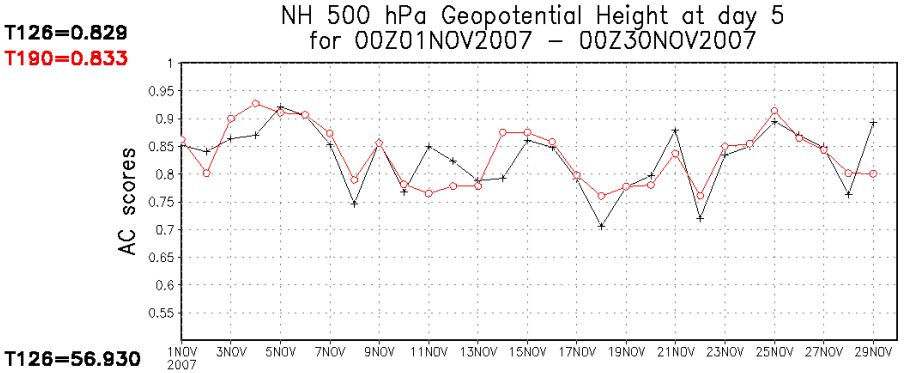


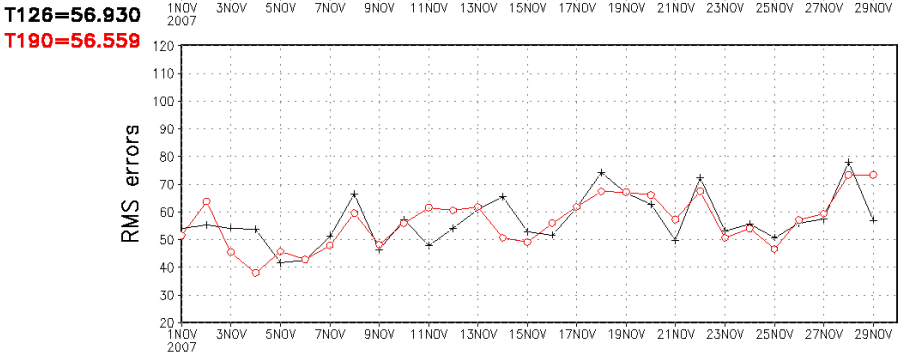
Gains from short waves





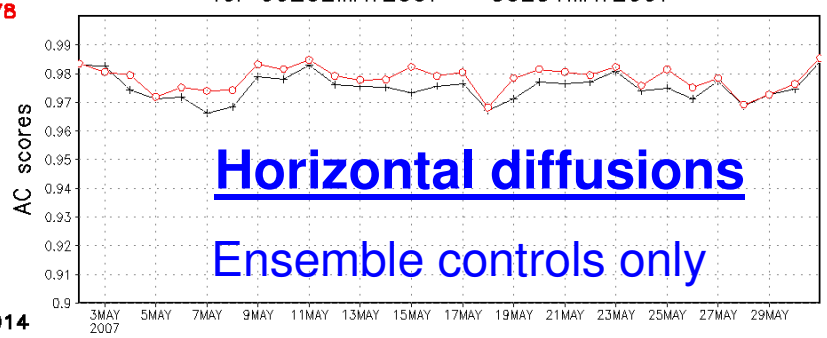
26 : 4





OPR=0.975
NHD=0.978

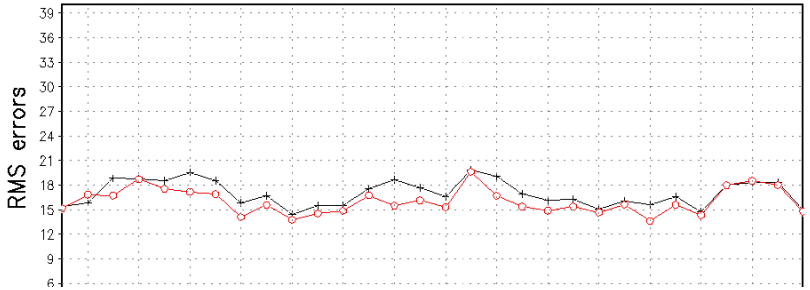
NH 500 hPa Geopotential Height at day 2
for 00Z02MAY2007 – 00Z31MAY2007



Horizontal diffusions

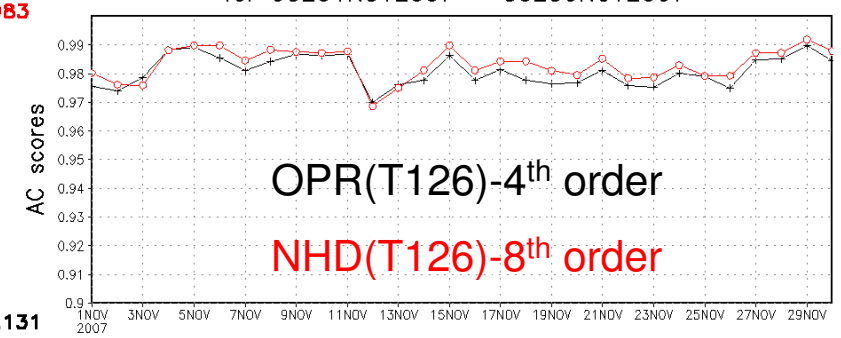
Ensemble controls only

OPR=17.014
NHD=16.03



OPR=0.980
NHD=0.983

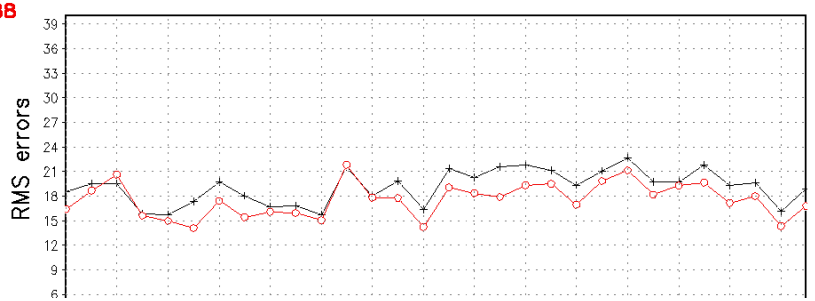
NH 500 hPa Geopotential Height at day 2
for 00Z01NOV2007 – 00Z30NOV2007



OPR(T126)-4th order

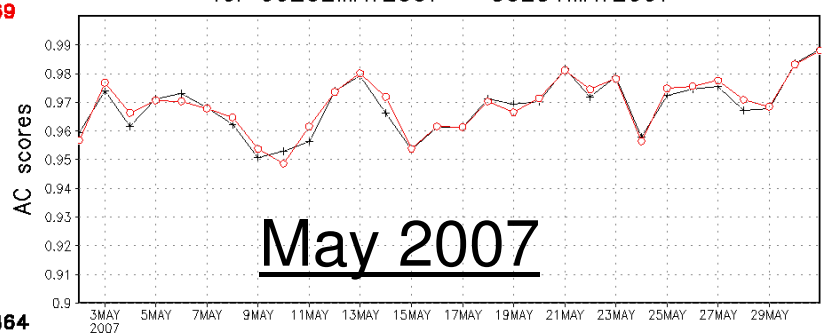
NHD(T126)-8th order

OPR=19.131
NHD=17.588



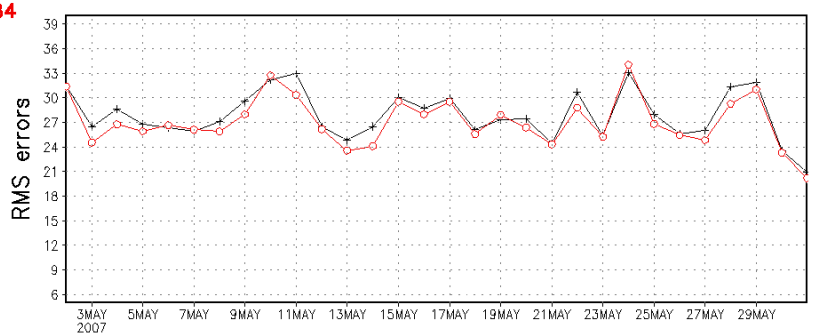
OPR=0.968
NHD=0.969

SH 500 hPa Geopotential Height at day 2
for 00Z02MAY2007 – 00Z31MAY2007



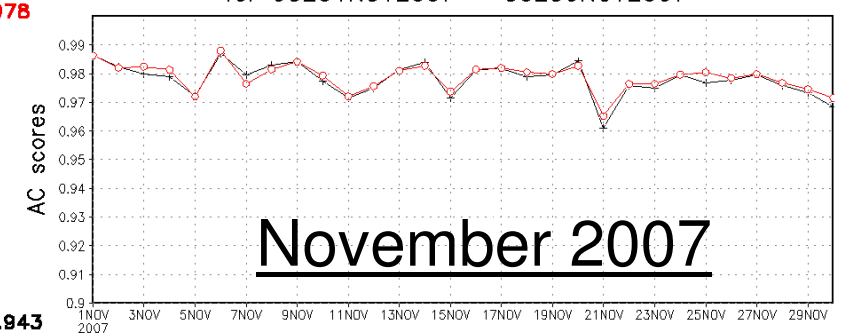
May 2007

OPR=27.864
NHD=27.084



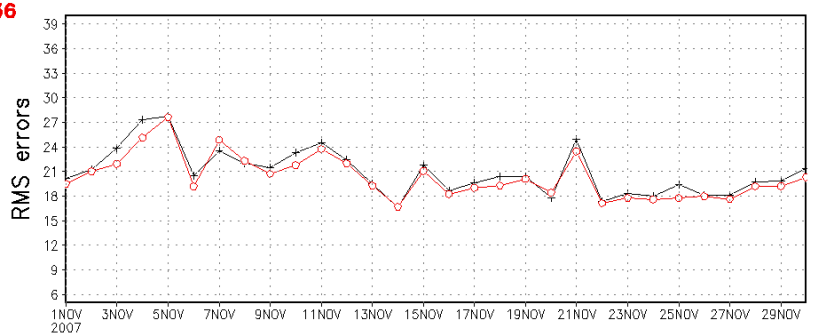
OPR=0.978
NHD=0.978

SH 500 hPa Geopotential Height at day 2
for 00Z01NOV2007 – 00Z30NOV2007

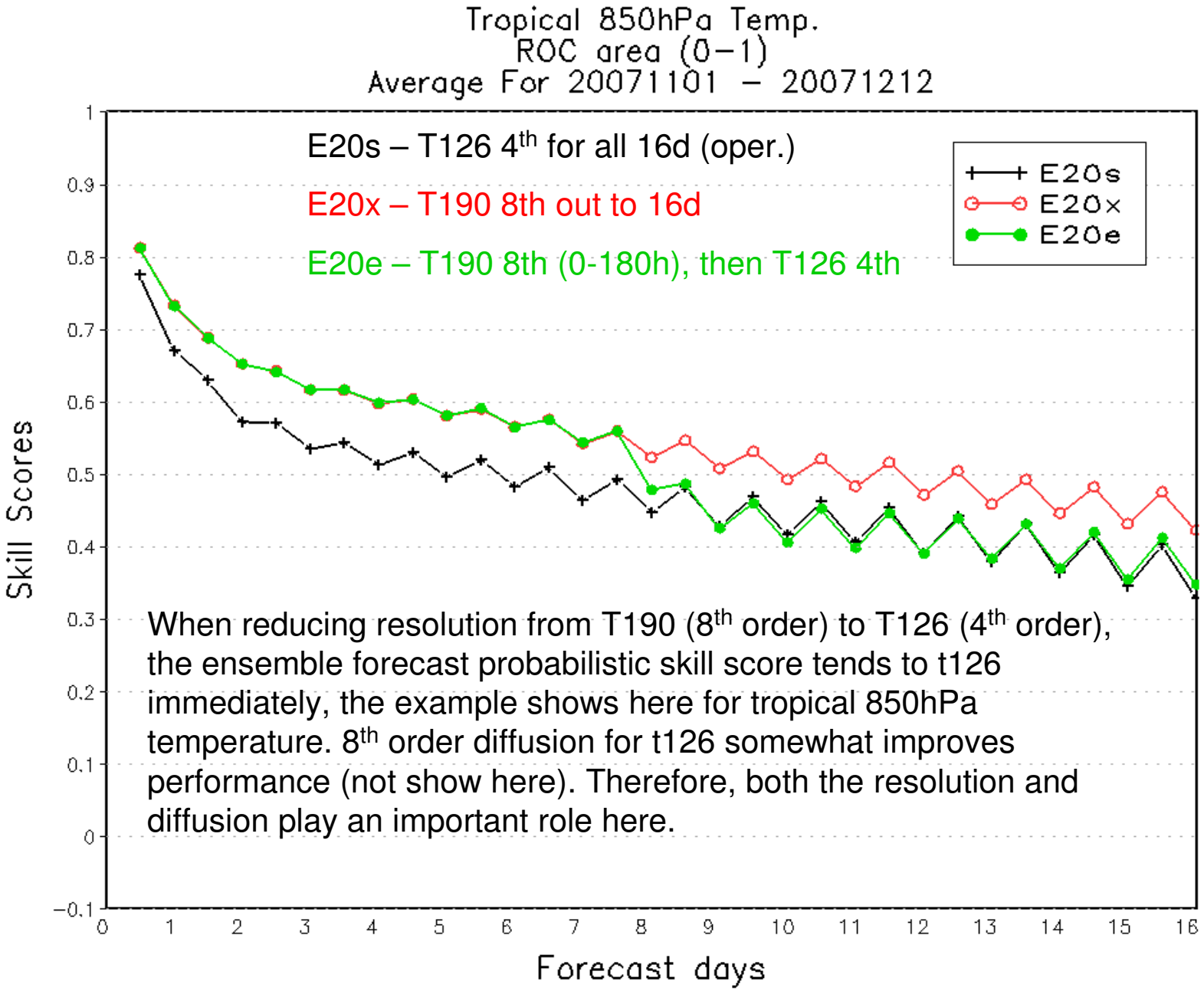


November 2007

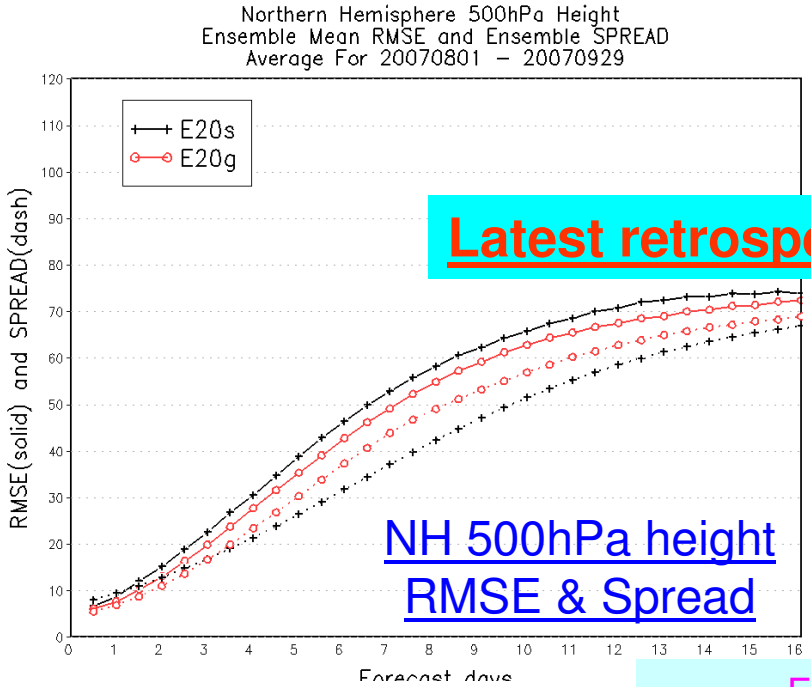
OPR=20.943
NHD=20.336



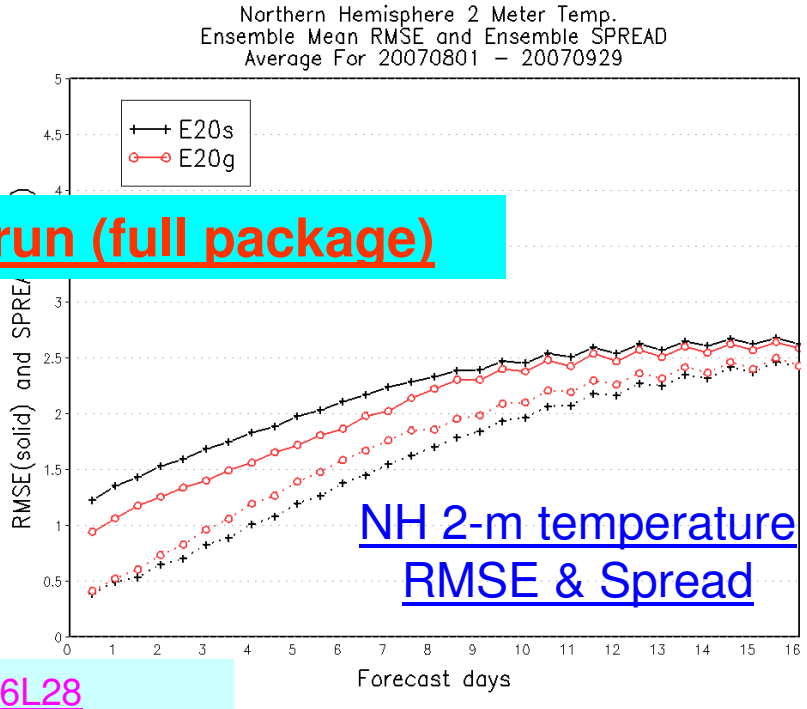
Resolution and Diffusion for Global Ensemble Without Stochastic



Latest retrospective run (full package)

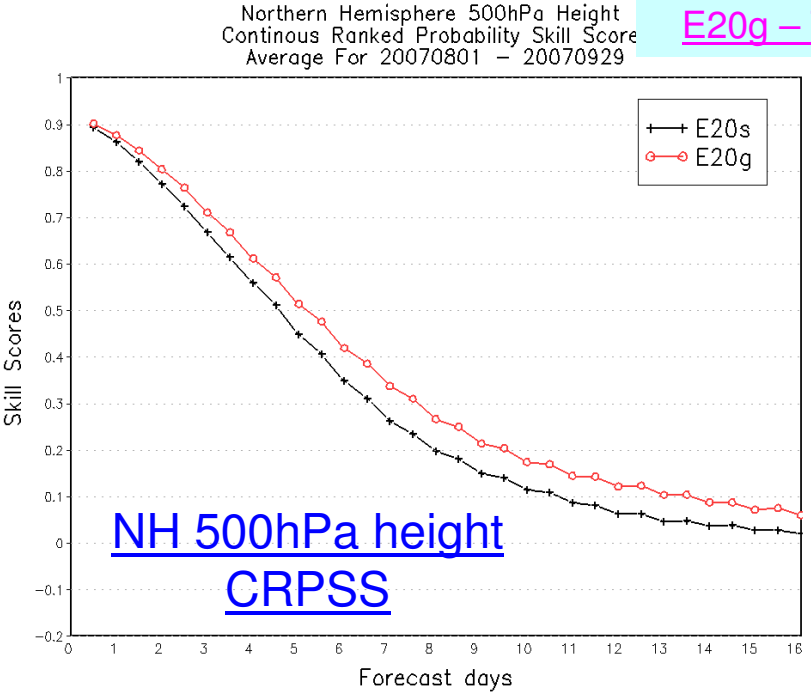


NH 500hPa height
RMSE & Spread

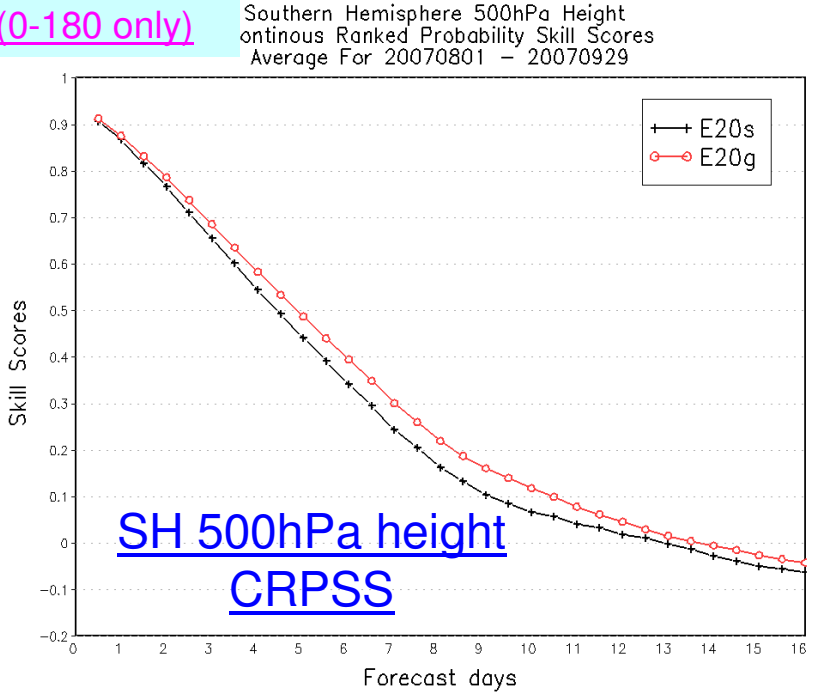


NH 2-m temperature
RMSE & Spread

E20s – T126L28
E20g – T190L28 (0-180 only)

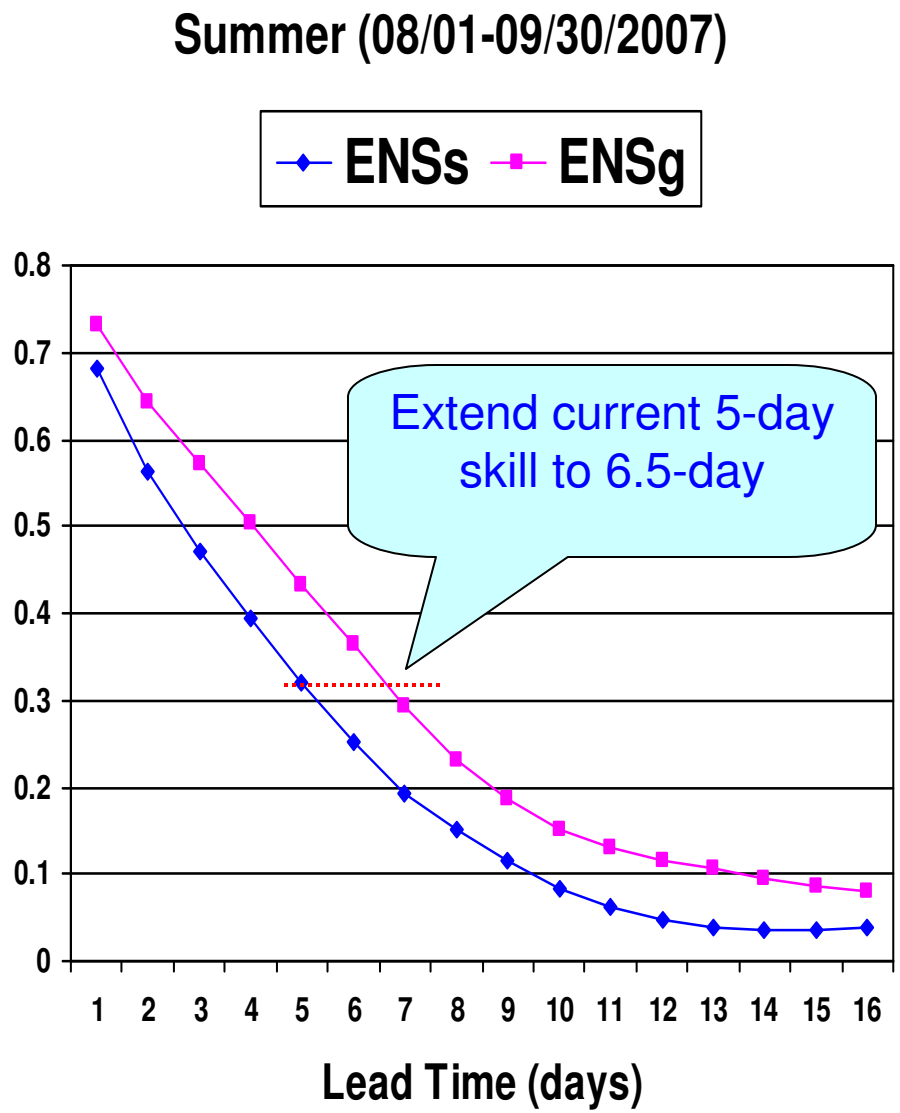


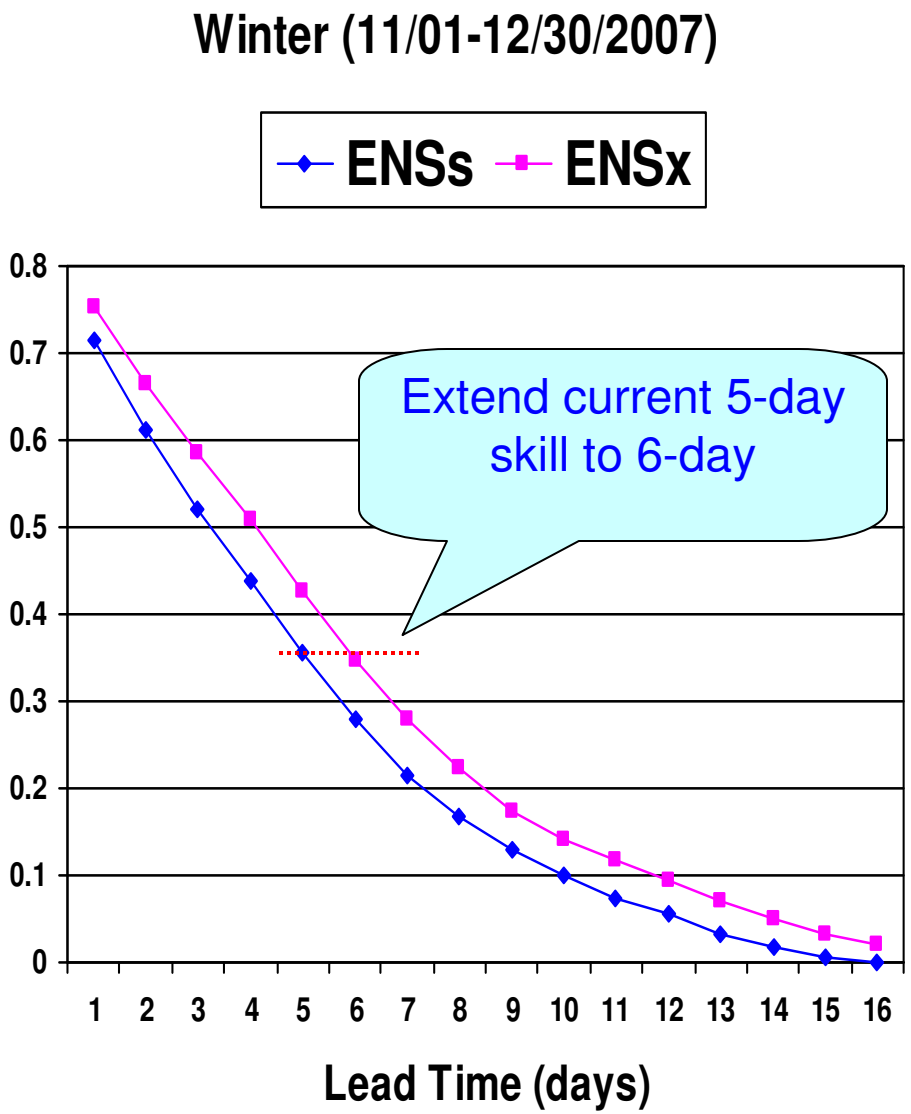
NH 500hPa height
CRPSS



SH 500hPa height
CRPSS

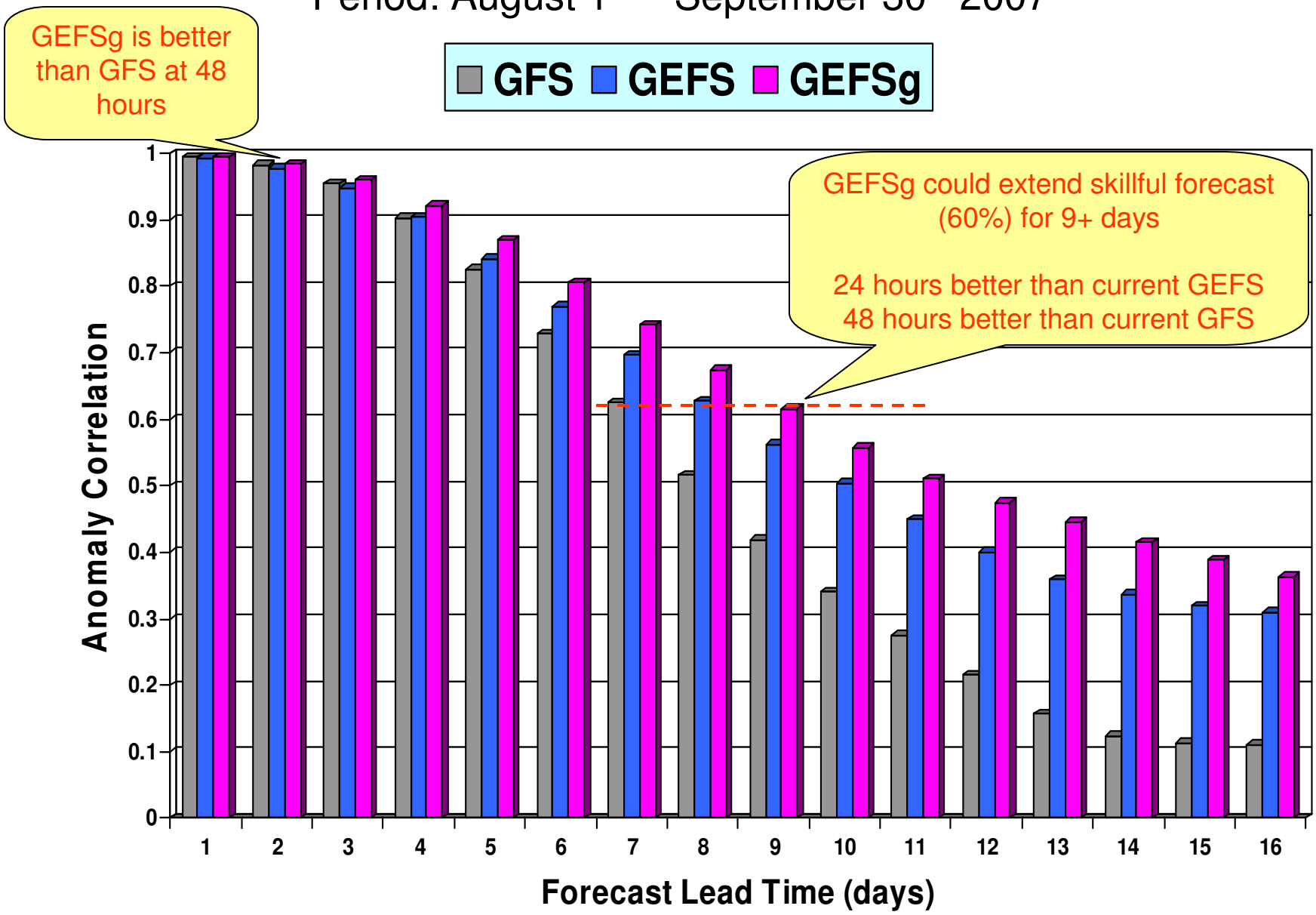
CRPSS for NH 850hPa temperature

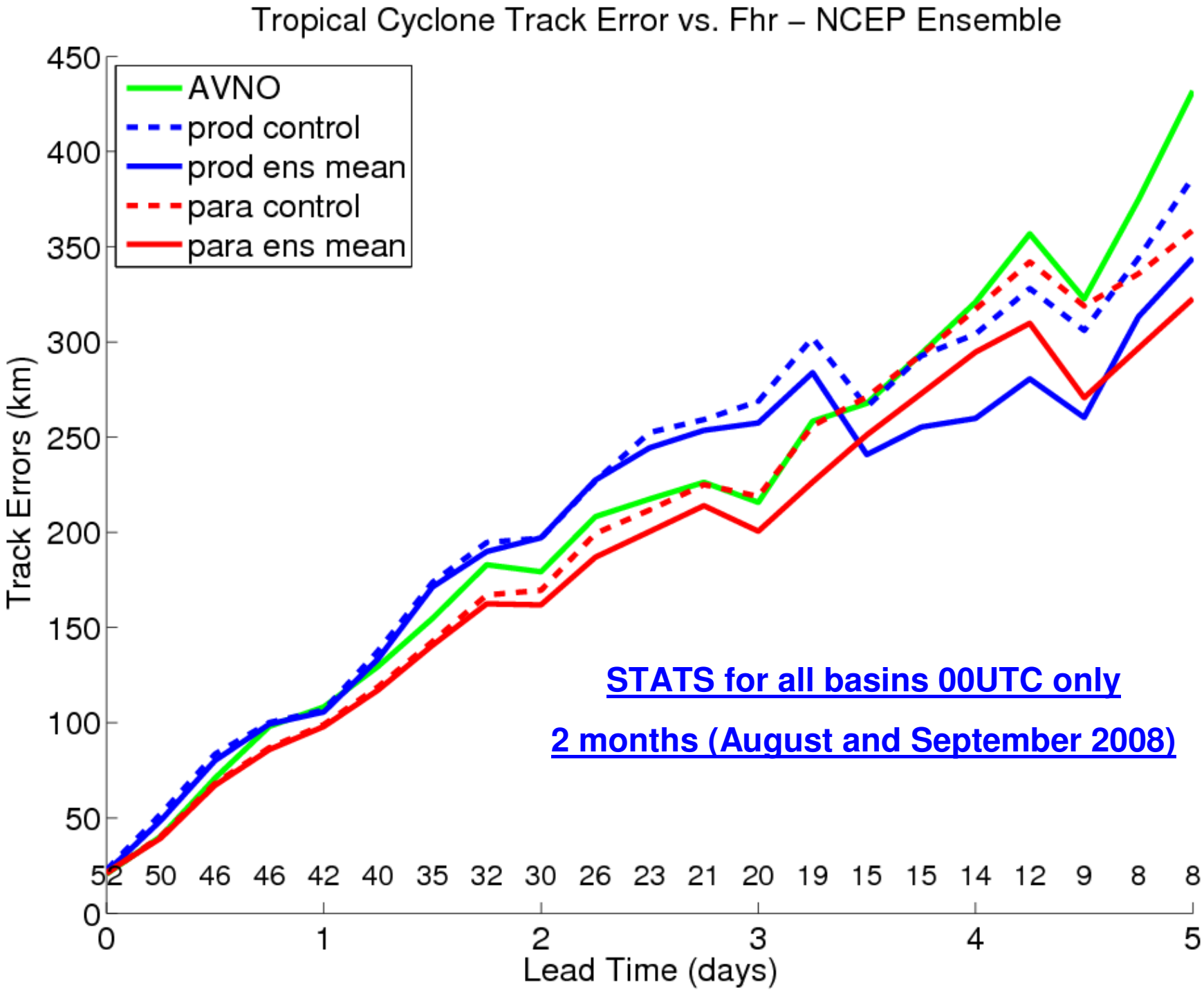




NH Anomaly Correlation for 500hPa Height

Period: August 1st – September 30th 2007




Tropical Cyclone Track Error vs. Fhr – NCEP Ensemble
AVNO
prod control
prod ens mean
para control
para ens mean
Track Errors (km)
Lead Time (days)
450
400
350
300
250
200
150
100
50
0
0
1
2
3
4
5
52 50 46 46 42 40 35 32 30 26 23 21 20 19 15 15 14 12 9 8 8
STATS for all basins 00UTC only
2 months (August and September 2008)

Conclusion

- Based on three sets of retrospective runs (summer, winter 2007, and summer 2008)
  - New package improved the forecast skill (score) significantly
    - For deterministic (ensemble mean)
    - For probabilistic (ensemble distribution)
- The better results are mainly from:
  - Increase horizontal resolution (include diffusion)
  - Stochastic perturbation scheme
- The better results are benefited from
  - The improvement of analysis (initial conditions)
  - The progress of forecast model (GFS)

Remain Issues

- Tune initial perturbation (may leave this to next implementation)
  - Need to adjust the size of initial perturbation, due to:
    - Model resolution changed
    - Model diffusion scheme changed
    - Improved analysis
  - Experiments are running, but very slow
    - Due to limit computation resource
- Examine bias corrected forecast and down scaling forecast
  - No enough CCS disk storage for 17d pgrb files on line
- Verify tropical storm tracks
  - Working on 2007 summer season
  - Planned for 2008 summer season
- Resource problem
  - Personnel
  - Computation and storage

Downstream Dependencies

- Sigma files
  - SREF
    - Yes
    - It uses sigma forecast
  - Wave ensemble
    - No
    - It uses bias corrected 10m winds
  - Tracking
    - No
    - It uses pgrba file
  - MDL GMOS
    - No
    - It uses pgrba and pgrbb files
  - Public access
    - No
    - We don't post sigma files to public

- pgrb files (pgrba + pgrbb)
  - SREF
    - No
    - It produces pgrb file by itself
  - Wave ensemble
    - Yes
    - But file has the same format for 10m wind
  - Tracking
    - Yes
    - But it uses pgrba file only, the file has the same format
  - MDL GMOS
    - Yes
    - It uses both pgrba and pgrbb
  - Public access
    - Yes
    - pgrba and pgrbb

Background!!!