NAEFS Upgrade and Future Plan

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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 3.1.0r
  - 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 (26 more) to pgrba files
  - Based on user request
  - From current 52 (variables) to future 78 (variables)
  - For NAEFS ensemble data exchange

NAEFS future configuration

Updated: October 2008

	NCEP	CMC
Model	GFS	GEM
Initial uncertainty	ETR	EnKF
Model uncertainty	None	Yes
Stochastic physics	Yes	Yes
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
    - 75% additional computer resources

- ## 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 78 (26)
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)
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	Convective available potential energy	1 (0)
SOIL	SOILW(0-10cm), WEASD(water equiv. of accum. snow depth), SNOD(surface), TMP(0-10cm down)	4 (4)
		26 new vars
Notes	Surface GHT is only in analysis file and first pgrb file when the resolution changed. 23 of 26 new variables are from pgrbb files, 10, 50hPa RH and SNOD are new variables	

NEXT NAEFS pgrba bc files
(bias correction)

Variables	pgrba_bc file	Total 48 (13)
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)
PRES	Surface, PRMSL	2 (0)
VGRD	10m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000hPa	11 (3)
FLUX (top)	ULWRF (toa - OLR)	1 (1)
		13 new vars
Notes		

Horizontal resolution change

Ensemble control only (deterministic)

From T126 to T190

NH 500hPa geopotential height

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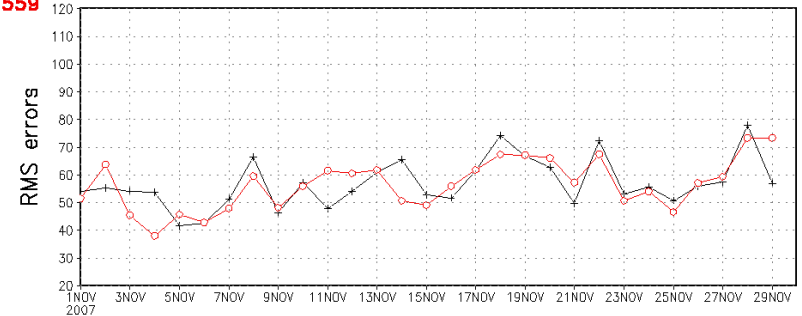for 00Z01NOV2007 – 00Z30NOV2007

T126=0.980
T190=0.983

T126=19.081
T190=17.565

26 : 4

AVERAGE FOR 00Z01NOV2007 – 00Z30NOV2007

NH 500 mb Height (wave 1-3 AC)

NH 500 mb Height (wave 4-9 AC)

T126

T190

NH 500 mb Height (wave 10-20 AC)

NH 500 mb Height (wave 1-20 AC)

Gains from short waves

NH 500 hPa Geopotential Height at day 5
for 00Z01NOV2007 – 00Z30NOV2007
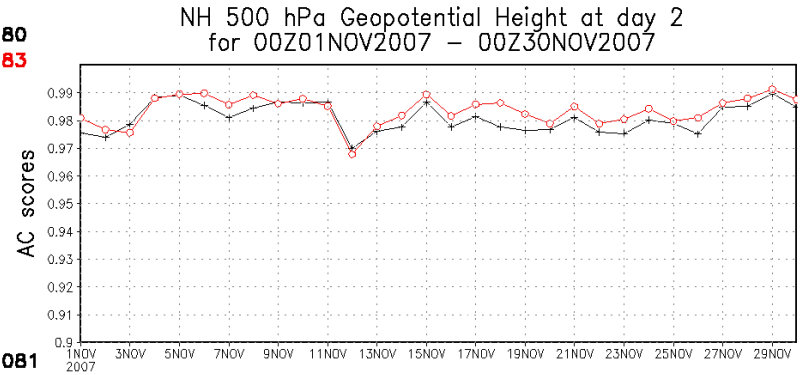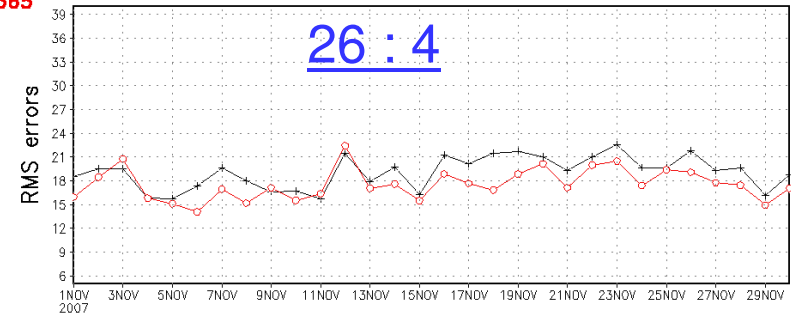
T126=0.829
T190=0.833
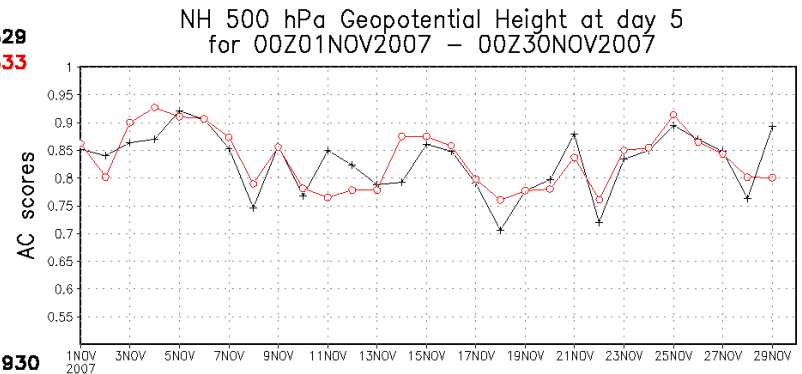
T126=56.930
T190=56.559

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

OPR=0.975
NHD=0.978
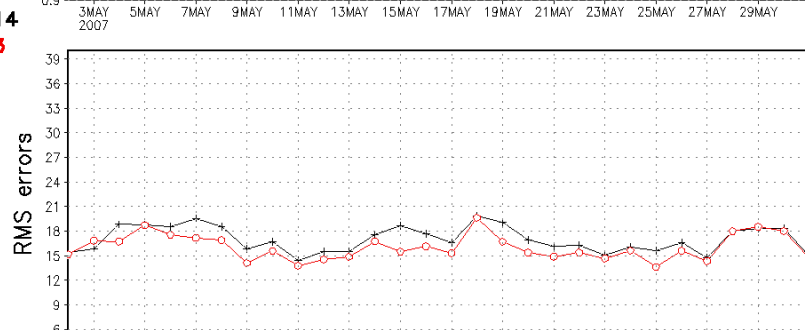
OPR=17.014
NHD=16.03

Horizontal diffusions

Ensemble controls only

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

OPR=0.980
NHD=0.983

OPR=19.131
NHD=17.588

OPR(T126)-4th order

NHD(T126)-8th order
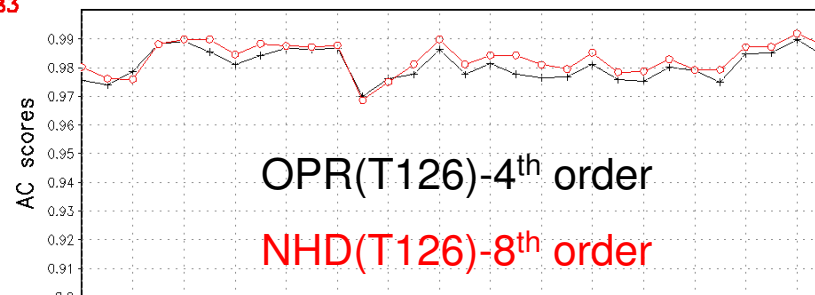
SH 500 hPa Geopotential Height at day 2
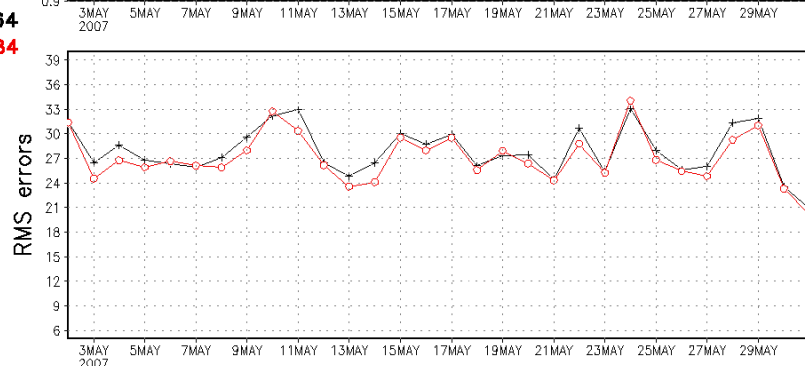for 00Z02MAY2007 – 00Z31MAY2007

OPR=0.968
NHD=0.969

OPR=27.864
NHD=27.084

May 2007
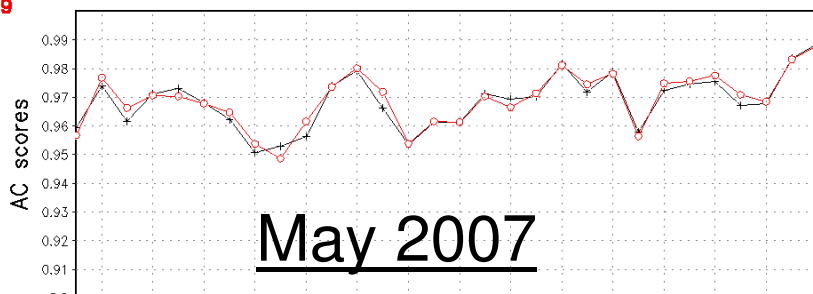
SH 500 hPa Geopotential Height at day 2
for 00Z01NOV2007 – 00Z30NOV2007

OPR=0.978
NHD=0.978
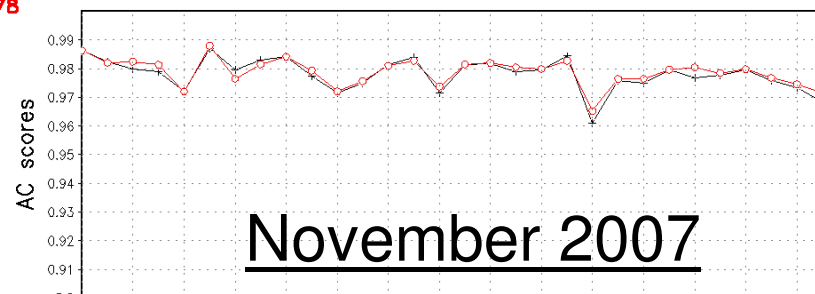
OPR=20.943
NHD=20.336

November 2007
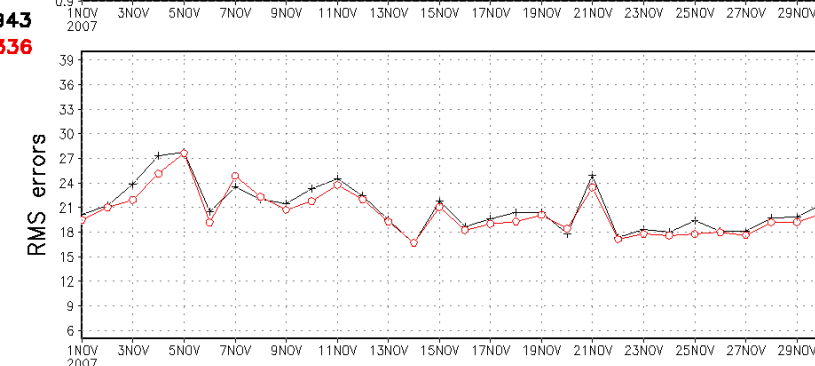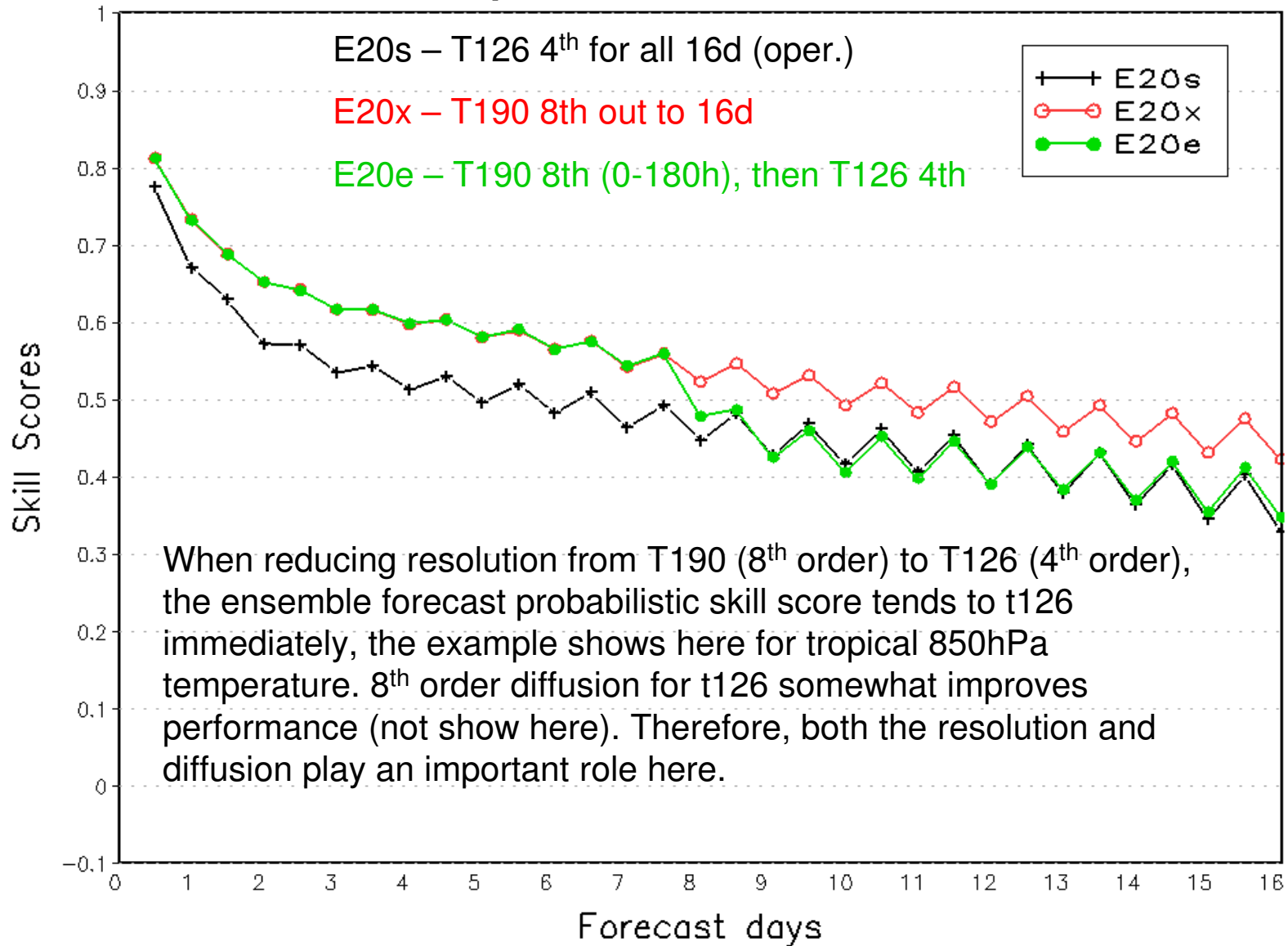
Resolution and Diffusion for Global Ensemble Without Stochastic

Tropical 850hPa Temp.
ROC area (0-1)
Average For 20071101 - 20071212

E20s – T126 4th for all 16d (oper.)

E20x – T190 8th out to 16d

E20e – T190 8th (0-180h), then T126 4th

When reducing resolution from T190 (8th order) to T126 (4th order), the ensemble forecast probabilistic skill score tends to t126 immediately, the example shows here for tropical 850hPa temperature. 8th order diffusion for t126 somewhat improves performance (not show here). Therefore, both the resolution and diffusion play an important role here.

Northern Hemisphere 500hPa Height
Ensemble Mean RMSE and Ensemble SPREAD
Average For 20070801 − 20070929
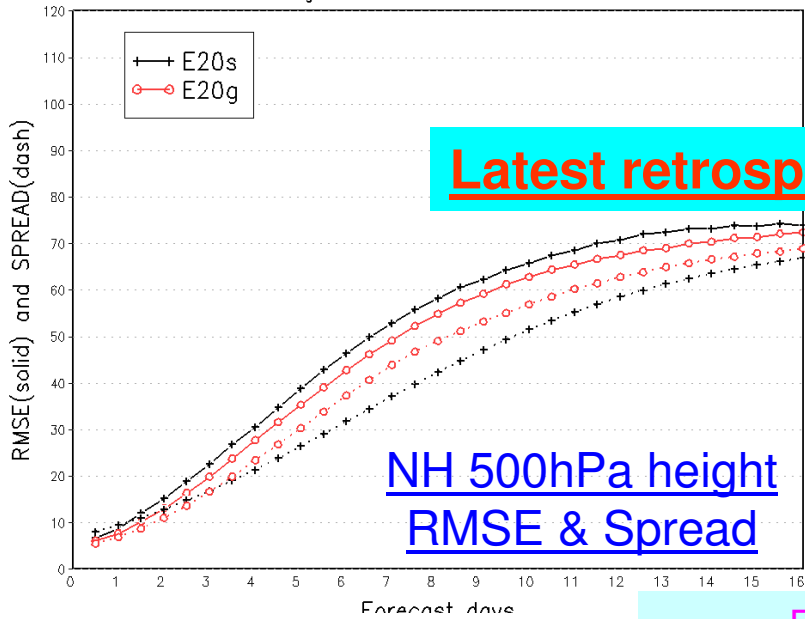
Northern Hemisphere 2 Meter Temp.
Ensemble Mean RMSE and Ensemble SPREAD
Average For 20070801 − 20070929
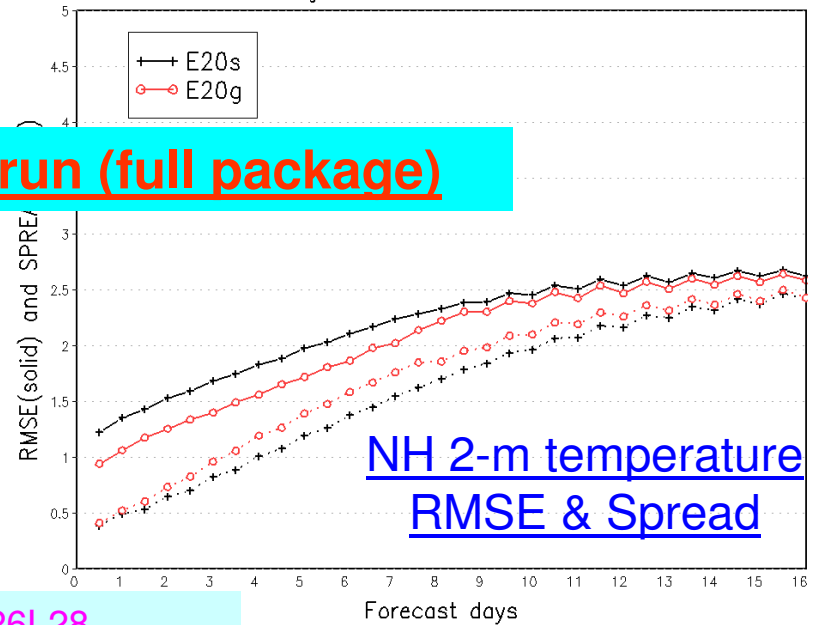
Latest retrospective run (full package)

NH 500hPa height
RMSE & Spread

NH 2-m temperature
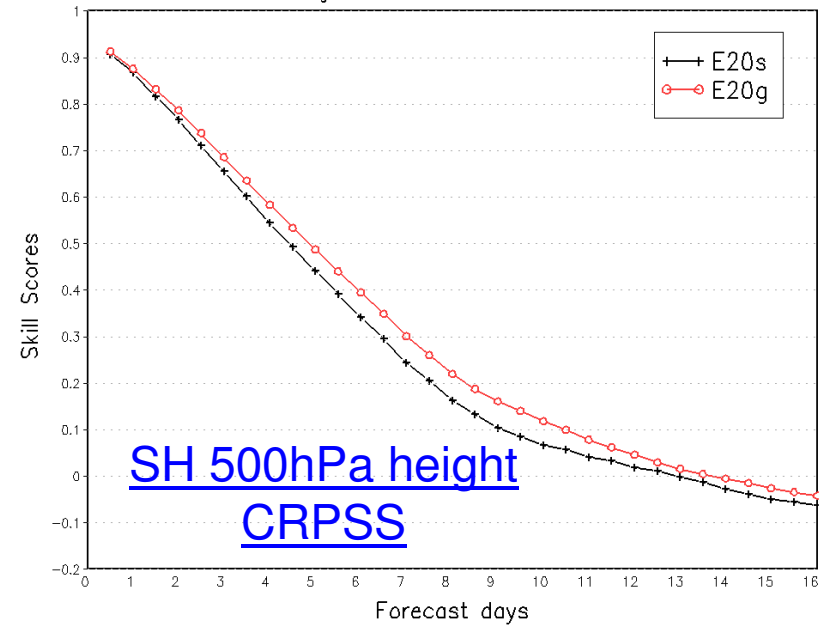RMSE & Spread

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

Northern Hemisphere 500hPa Height
Continous Ranked Probability Skill Score
Average For 20070801 − 20070929
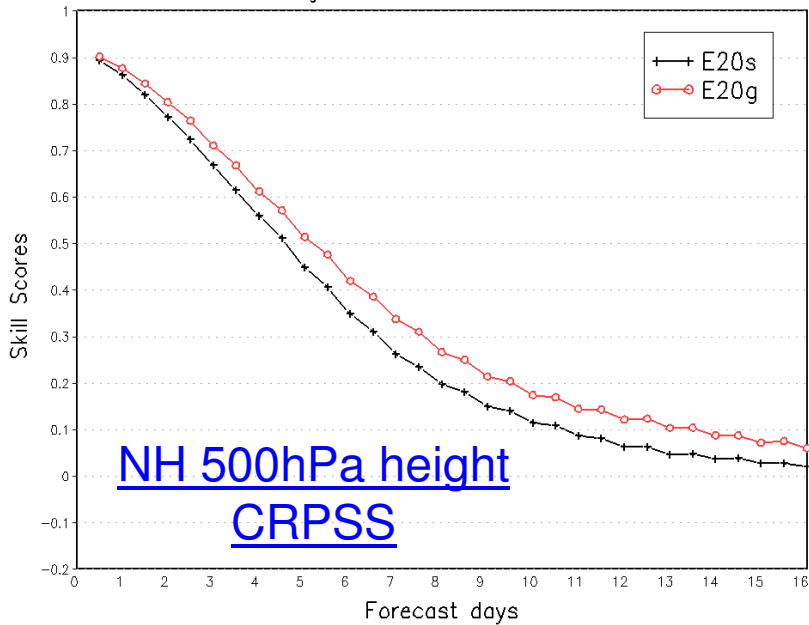
Southern Hemisphere 500hPa Height
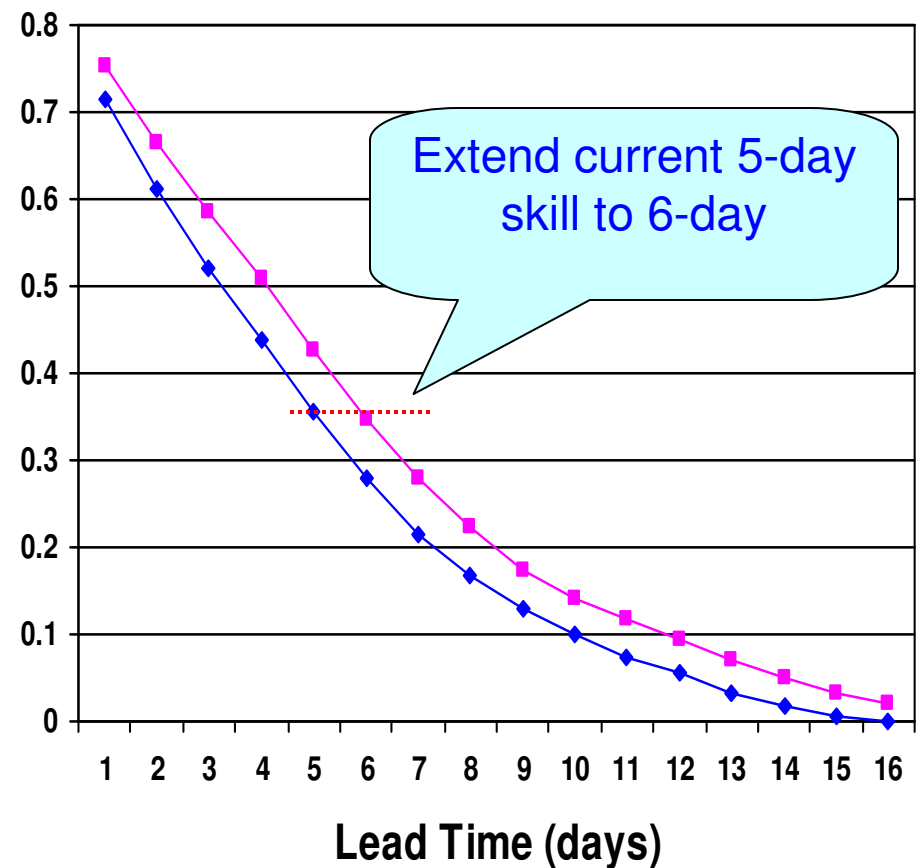Continous Ranked Probability Skill Scores
Average For 20070801 − 20070929

NH 500hPa height
CRPSS

SH 500hPa height
CRPSS

CRPSS for NH 850hPa temperature

Summer (08/01-09/30/2007)

Winter (11/01-12/30/2007)
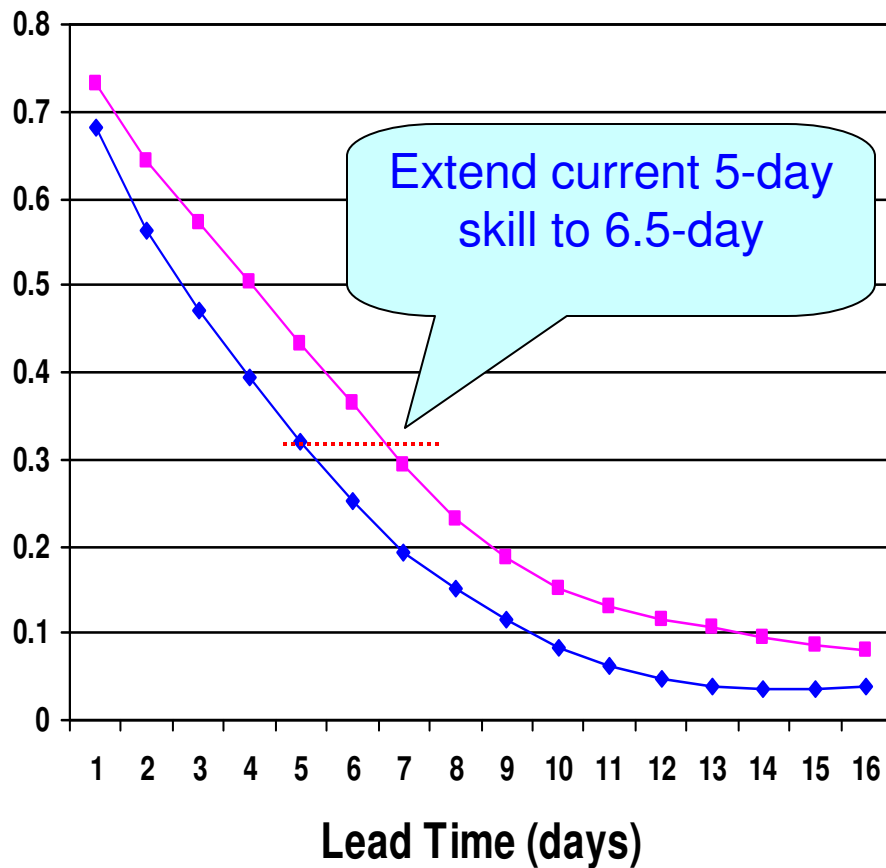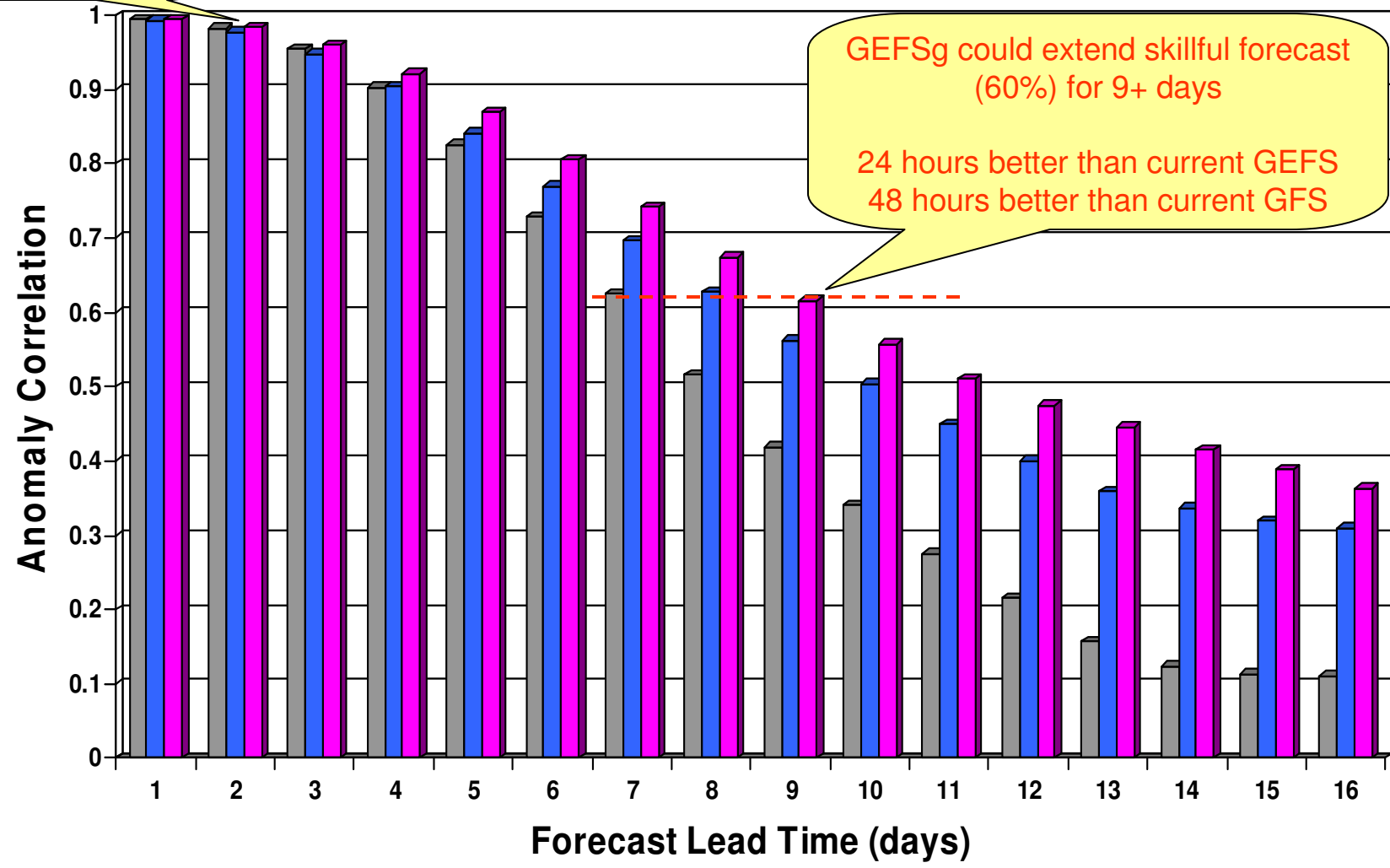
Conclusion

- Based on two sets of retrospective runs (summer and winter 2007)
  - New package improved the forecast skill (score) significantly
    - For deterministic (ensemble mean)
    - For probabilistic (ensemble distribution)
- The better results is benefited from:
  - Increase horizontal resolution (include diffusion)
  - Stochastic perturbation scheme
  - Better initial condition (analysis)
  - Better 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

Plans for FY2009 and beyond

- ## GEFS
  - ### Configuration: (4Q 2009)
    - Hind-cast at GEFS resolution (T190L28 (0-384h),
      - Details setting up in discussion
    - Hydro-meteorological ensemble (river ensemble)
      - Pending on operational LDAS/GLDAS
    - Coupling ocean-land-atmosphere model for GEFS
      - Considering ocean model in ESMF
    - Extend forecast to 35(?) days (once per day)
      - With coupled ocean-land-atmosphere model
  - ### Science:
    - 3-D mask for ET with re-scaling (4Q 2009)
    - Surface perturbations (4Q 2009)

Plans for FY2009 and beyond (cont.)

- NAEFS products
  - Products (1Q-2Q 2009)
    - Statistical down-scaling for CONUS:
      - Additional variables (Tmax and Tmin, wind speed and direction)
      - Pending on RTMA availability
    - Statistical down-scaling for Alaska:
      - 8 variables (T2m, Tmax, Tmin, Psfc, U10m, V10m, 10 meter Ws and Wd)
      - In testing
    - Statistical down-scaling for other regions:
      - Hawaii, Puerto Rico and Guam
      - Pending on RTMA availability
  - NAEFS new variables for data exchange (1Q/2Q 2009)
    - Approximated 25 additional variables for NAEFS data exchange
    - Using GRIB2 format – saving additional 30m
    - Need to coordinate with CMC/MSC
  - Dedicated line for NCEP and CMC NAEFS data exchange
    - DS-3 (sooner?)
    - Time saving (high expectation)
  - Precipitation bias correction (4Q 2009 – 2Q 2010)
    - Full-Bayesian with pseudo-precipitation

Plans for FY2009 and beyond (cont.)

- NAEFS expansion and verification
  - FNMOC global ensemble
    - Blending to NAEFS (2010 plan)
    - Pending on one year evaluation (August 2008 –July 2009)
    - Using mini-Bayesian method for first moment correction
    - Need to coordinate with CMC/MSC
    - Need to resolve the problem for data transform (still missing forecast data for FNMOC)
  - ECMWF global ensemble
    - Blending to NAEFS (2010 plan)
    - Pending on one year evaluation (August 2008 – July 2009)
    - Using mini-Bayesian method for first moment correction
    - Need to coordinate with NCO for 00UTC data and 6hr forecast intervals
  - Probabilistic verification
    - Unified probabilistic verification (3Q, 2009)
    - Shared codes with SREF

Plans for FY2010

- GEFS
  - Configuration:
    - Variable resolutions:
      - T270L42 (0-180hr) (considering half-degree products)
      - T190L28 (180-384hr)
      - T126L28 (384-840hr)
    - Full coupling with ocean model (assume in)
  - Science:
    - Improving TS relocation
      - Adopt all new developed TS relocation schemes
    - Improving stochastic scheme
      - Adaptive 2/3-demisional parameters adjustment

Plans for FY2010 (Cont.)

- NAEFS
  - New NAEFS component – FNMOC global ensemble
    - 4Q 2009 – 2Q 2010
    - Pending on one year evaluation (May 2008 – April 2009)
    - Using mini-Bayesian method for first moment correction
    - Need to coordinate with CMC/MSC
  - Improving NAEFS products
    - Introduce full Bayesian model to calibrate high moments
      - For precipitation forecast
      - All variables
  - Statistical down-scaling
    - Precipitation
    - Improving current method
    - Adding new variables (pending on RTMA availability)
  - TC related products
    - Including bias correction
  - Seamless weather-climate interface
    - Merge GEFS and CFS

Background!!!