NAEFS and NCEP Global Ensemble

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Presentation for National DOH Workshop
July 16th 2008

Outlines

- NAEFS History and Milestones
- GEFS, NAEFS and THORPEX
- Review Major Implementation (FY07)
- Review NAEFS Products (FY07)
- Statistical Downscaling
- Ensemble Data Distribution Information
- GEFS Major Implementation Plan (FY08)
- NAEFS Product Upgrade Plan (FY08)
- NAEFS Expansion and Future Plan

NAEFS History and Milestones

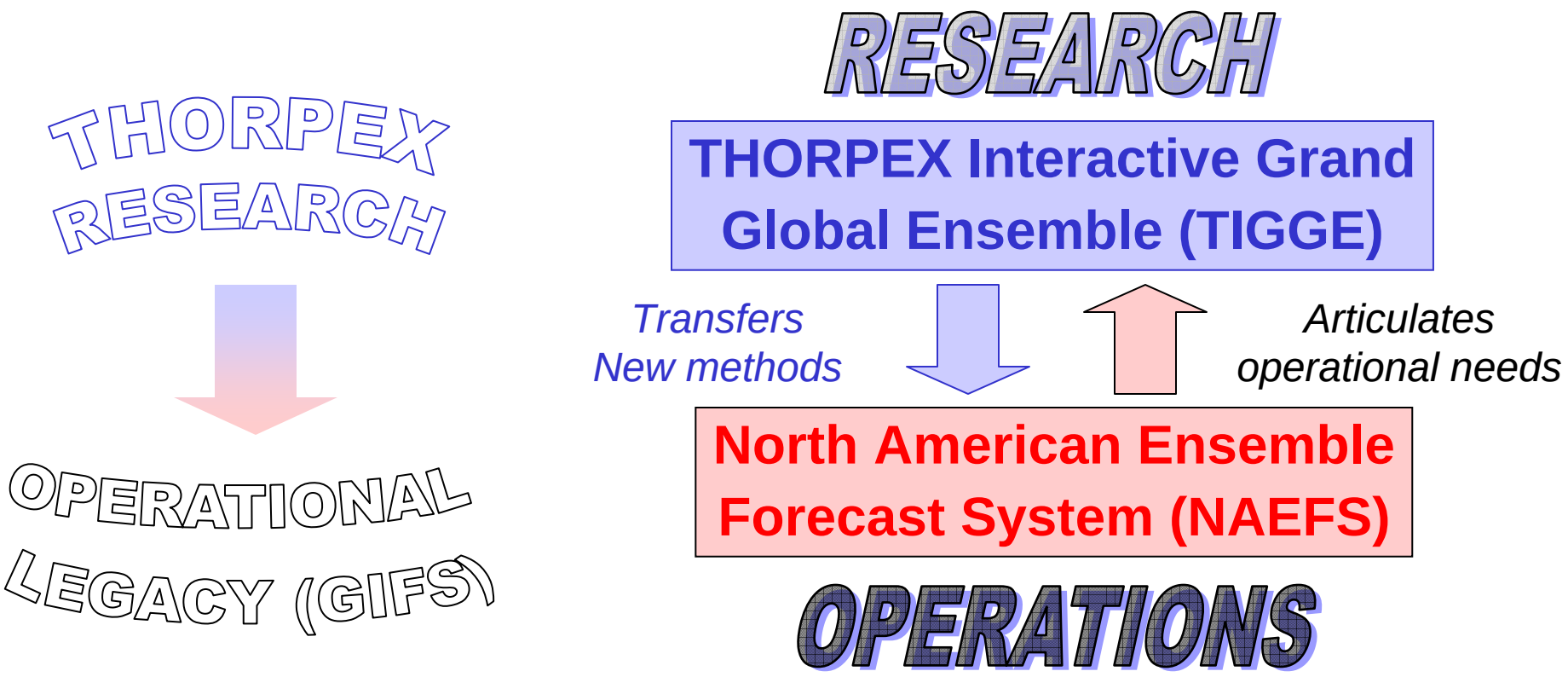
- February 2003, Long Beach, CA
  - NOAA / MSC high level agreement about joint ensemble research/development work

  (J. Hayes, L. Uccellini, D. Rogers, M. Beland, P. Dubreuil, J. Abraham)
- May 2003, Montreal (MSC)
  - 1st NAEFS Workshop, planning started
- November 2003, MSC & NWS
  - 1st draft of NAEFS Research, Development & Implementation Plan complete
- May 2004, Camp Springs, MD (NCEP)
  - Executive Review
- September 2004, MSC & NWS
  - Initial Operational Capability implemented at MSC & NWS
- November 2004, Camp Springs
  - ***Inauguration ceremony & 2nd NAEFS Workshop***
    - Leaders of NMS of Canada, Mexico, USA signed memorandum
    - 50 scientists from 5 countries & 8 agencies
- May 2006, MSC & NWS
  - 1st Operational Implementation
    - Bias correction
    - Climate anomaly forecasts
- June 2006, Montreal (MSC)
  - 3rd NAEFS Workshop
- March 2007, NWS
  - NCEP/GEFS increasing ensemble membership from 14 to 20 per cycle
- July 2007, MSC
  - CMC/GEFS increasing ensemble membership from 16 to 20 per cycle
- December 2007, NWS
  - NAEFS adding new production for CONUS
- September 2008, MSC, NWS
  - Follow-up implementations-Improved and expanded product suite

GEFS, NAEFS and THORPEX

- NCEP Global Ensemble Forecast System (GEFS) is part of NAEFS
- NAEFS is combining NCEP and CMC global ensemble
- THORPEX is the research project:
  - Provides framework for transitioning research into operations
  - Prototype for ensemble component of THORPEX legacy forecast system:

Global Interactive Forecast System (GIFS)



Review NAEFS Implementation (FY07)

- NAEFS: NCEP/GEFS.
  - Increasing membership from 14 to 20 members per cycle.
    - Tuning initial perturbations.
    - Using 80 cold start initial perturbations (schematic map)
      - From 24-h forecasts and many dates.
      - To have large spread of sampling
  - This change is intended to improve ensemble based probabilistic forecast over all and to support NAEFS (North American Ensemble Forecast System) project.
  - Results:
    - Improving probabilistic skills.
    - Not much improvement for ensemble mean (expected).

Review NAEFS Implementation (FY07)

- NAEFS: CMC/GEFS
  - Improvement of the data assimilation component
    - Horizontal resolution is increased from 1.2 to 0.9 degree
    - The 24 different configuration of the GEM model are introduced instead of one to produce the trial fields.
    - Trial fields at 3, 4.5, 6, 7.5 and 9-h allow time interpolation toward observation – become a 4-D data assimilation
  - Increasing the membership
    - from 16 to 20 per cycle, two cycle per day
  - Modification to the forecast model
    - Now only one dynamical core: GEM (SEF is dropped)
    - Horizontal resolution is increased from 1.2 to 0.9 degree
    - Addition of stochastic perturbation of the physical tendencies as in Buizza et al (1999) (random number between 0.5 and 1.5)
    - An stochastic kinetic energy back-scattering parameterization is used as in Shutts (2005)
    - The physical parameterization package was extended to include the Kain & Fritsch deep convection scheme and the Bougeault-Lacarrere mixing length formulation (see Table for details)

NAEFS current configurations

	NCEP/GEFS	CMC/GEFS
Model	GFS	GEM
Initial uncertainty	*ETR*	*ETKF*
Model uncertainty	None	Yes
Tropical storm	Relocation	None
Daily frequency	00,06,12 and 18UTC	00 and 12UTC
Hi-re control (GFS)	T382L64 (d0-d7.5) T190L64 (d7.5-d16)	None
Low-re control (ensemble control)	T126L28 (d0-d16) 00,06,12 and 18UTC	~100km and L28 00 and 12UTC
Membership	Perturbed members 20 for each cycle	Multi-model/physics 20 for each cycle
Forecast length	16 days (384 hours)	16 days (384 hours)
Last implementation	March 27th 2007	July 10th 2007

Review NAEFS Product Upgrading (FY07)

- CMC web products
  - http://www.meteo.gc.ca/ensemble/index_naefs_e.html
  - Temperature Anomaly: Day 8 to 14 Outlooks
  - EPSgrams for cities of Canada, Mexico and USA
  - Ensemble mean and standard deviation charts
  - Maps of probabilities of occurrence of several weather events
- NCEP web products for NCEP/GEFS (Plan for NAEFS 1Q/2009)
  - http://www.nco.ncep.noaa.gov/pmb/nwprod/analysis/
  - Spaghetti Charts for 200hPa, 500hPa height and MSLP
  - Mean, spread and vorticity for 500hPa, 700hPa and 850hPa height
  - Mean and spread for 500hPa, 700hPa, 850hPa and 2-m Temperature, 10-m winds
  - Dominate precipitation types
- NCEP/EMC web products (experimental)
  - http://wwwt.emc.ncep.noaa.gov/gmb/ens/NAEFS/NAEFS-prods-NCEP.html
  - Climate anomaly for 10%, 50% and 90% 2-meter temperature
  - QPF/PQPF maps, side by side comparison
  - Bias comparison maps which include
    - NCEP raw ensemble mean bias and accumulated difference between GDAS and CDAS
    - NCEP bias corrected ensemble mean bias
    - CMC control member bias
    - CMC bias corrected control member bias
- NCEP/CPC week-2 web products (experimental)
  - http://www.cpc.ncep.noaa.gov/products/predictions/short_range/NAEFS/Outlook_D264.00.php
  - NAEFS 8-14 days guidance for
    - 2-meter temperature
    - 500hPa height

Review NAEFS Product Upgrading (FY07)

(December 4th 2007)

- Bias corrected GFS forecast
  - Use the same algorithm as ensemble bias correction
  - Up to 180 hours (method and verify statistics)
- Combine bias corrected GFS and ensemble forecast
  - Dual resolution ensemble approach for short lead time
  - Adjustable weight coefficient
  - GFS has higher weights at short lead time (figs)
- NAEFS new products (example, verification, seasonal variation)
  - Combine NCEP/GEFS (20m) and CMC/GEFS (20m)
  - All bias corrected forecast
  - Consider the difference between NCEP and CMC's analyses
  - Produce Ensemble mean, spread, mode, 10% 50%(median) and 90% probability forecast at 1*1 degree resolution
    - Climate anomaly (percentile) forecasts also generated for ens. mean
- Statistical downscaling
  - Use RTMA as reference - NDGD resolution (5km), CONUS only
  - Generate mean, mode, 10%, 50%(median) and 90% probability forecasts

Statistical downscaling for NAEFS forecast

- Proxy for truth
  - RTMA at 5km resolution for CONUS region
    - RTMA represents “Real Time Meso-scale Analysis”
  - Variables
    - surface pressure, 2-m temperature, and 10-meter U and V
- Downscaling vector
  - Interpolate GDAS analysis to 5km resolution
  - Compare difference between interpolated GDAS and RTMA
  - Apply decaying weight (w=0.3) to accumulate this difference – downscaling vector
- Downscaled forecast
  - Interpolate bias corrected 1*1 degree NAEFS forecast to 5km resolution
  - Add the downscaling vector to interpolated NAEFS forecast
- Application
  - Ensemble mean, mode, 10%, 50%(median) and 90% forecasts
- Verification statistics for 2-meter temperature
  - Mean absolute errors (maps, all forecast lead time)
  - Probabilistic verification (CRPS)
  - Comparing to NDFD and GMOS (absolute errors)

NAEFS Products Distribution

System	Current available products
Config.	1.deg 0-384h, every 6 hours, 20 members (NCEP) and 20 members (CMC), ens. control (NCEP and CMC)
Format	GRIB1 (and GRIB2, GIF images for web display)
CCS	NCEP: pgrba, pgrbb, pgrba_bc, pgrba_an, pgrba_wt, ensstat, ndgd CMC: pgrba, pgrba_bc, pgrba_an, pgrba_wt, ensstat NAEFS: ndgd, pgrba_an, pgrba_bc
NCEP FTPPRD	ftp://ftpprd.ncep.noaa.gov/pub/data/nccf/com/gens/prod cd gefs.${yyyymmdd} for NCEP ensemble 1. pgrb2a (00, 06, 12 and 18UTC) (1.0 degree, all lead times, 1(c) + 20 (p)) 2. pgrb2alr (00, 06, 12 and 18UTC (2.5 degree, all lead times, 1(c) +20 (p)) 2. pgrb2b (00, 06, 12 and 18UTC) (1.0 degree, all lead times, 1(c) + 20 (p)) 4. pgrb2blr (00 and 12UTC) (2.5 degree, all lead times, 1(c) + 20 (p)) 5. ensstat (00UTC) (prcp_bc, pqpf and pqpf_bc files) 6. wafs (00 and 12UTC) 7. ndgd_gb2 (00, 06, 12, 18UTC) (CONUS-5km, all lead times and all probability forecasts) ftp://ftpprd.ncep.noaa.gov/pub/data/nccf/com/gens/prod cd cmce.${yyyymmdd} for CMC ensemble 1. pgrba (00 and 12UTC) (1.0 degree, all lead times,1 control + 20 members) ftp://ftpprd.ncep.noaa.gov/pub/data/nccf/com/gens/prod cd naefs.${yyyymmdd} for NAEFS products 1. pgrb2a_an (00, 12UTC) (1.0 degree, all lead times, anomaly for ensemble mean) 2. pgrb2a_bc (00,12UTC) (1.0 degree, all lead times, probabilistic forecasts) 3. ndgd_gb2 (00,12UTC) (CONUS-5km, all lead times, probabilistic forecasts)
TOC	ftp://tgftp.nws.noaa.gov/SL.us008001/ST.opnl/ cd MT.ensg_CY.${cyc}/RD.${yyyymmdd} for NCEP only 1. PT.grid_DF.gr1_RE.high (00 and 12UTC) (Pgrba: 1.0 and 2.5 degree, 0-384 hrs, c + 10 (p)) 2. PT.grid_DF.gr1_RE.low (00 and 12UTC) (Pgrbb: 1.0 degree, 0-84 hrs, 2.5 d, 90-384 hrs, c + 10 (p)) 3. PT_grid_DF.bb
NOMADS	http://nomad5.ncep.noaa.gov/ncep_data/ for ftp: combined pgrba and pgrbb at 1 degree resolution, for all ensemble members (c+14(p)) and all lead time (0-384 hours) http://nomad5.ncep.noaa.gov/pub/gens/archive/ for http: combined pgrba and pgrbb at 1 degree resolution

NCEP/GEFS Major Implementation Plan (FY08)

- Using new GFS/GSI version??
  - New radiation
  - New coordinates
  - New gravity wave drag
  - Configuration changes between GFS and GEFS (adv. And disadv.)
- Upgrade horizontal resolution from T126 to T190 for 20 perturbed forecasts
  - 4 cycles per day
  - Up to 180 hours
  - T126 from 180 hours , up to 384 hours (16 days)
  - Using 8^{th} order horizontal diffusion for all leading time forecast
- Extended 16 days forecast to 31 days
  - 00Z cycle only
  - T126L28 resolution
  - User request (for MJO prediction)
- Introduce ESMF (Earth System Modeling Framework) for GEFS
  - Version 3.10
  - allows concurrent generation of all ensemble members.
- Add stochastic perturbation scheme to account for model errors
  - Increasing model spread
  - Improving the forecast skills

NAEFS product upgrade plan (FY08)

- NAEFS data exchange
  - Add approximately 15-23 new variables to current 51 pgrba for NAEFS data exchange (in discussion)
    - Such as vertical shear, helicity, u,v, t, RH for 100, 50hPa, LH, SWR, LWR at surface, and etc..
  - Use GRIB2 format for data exchange
    - Approximated 45-60m time saving
- New NAEFS downscaling products
  - For Alaska region (~6km NDGD grids)
    - Surface pressure, T2m, U10m and V10m
  - Having new variables for both CONUS and Alaska regions
    - Tman, Tmin, 10m wind direction and speed
- Dedicated line for NCEP and CMC NAEFS data exchange
  - DS-3 (sooner?)
  - Time saving (high expectation)

NAEFS Expansion and Future Plan

- Plans to be coordinated with THORPEX
  - Links with Phase-2 TIGGE archive and beyond (GIFS)
- Expansion
  - FNMOC (current status and future plan)
    - Experimental data exchange started from April 2008
    - Preliminary evaluation by end of 2008 (1 year evaluation period)
    - Operational implementation by summer 09 (subject to improved performance)
  - ECMWF (current status)
    - Start to collect ECMWF ensemble data from May 2008
    - Preliminary evaluation by May of 2009 (1 year evaluation period)
    - Operational adding bias corrected ECMWF ensemble to NAEFS (subject to improved performance)
  - UK Metoffice
    - Decision on going operational & possibly joining NAEFS - by 2008
  - KMA, CMA, JMA
    - Expressed interest, no detailed plans yet
- Real-time generation of hind-cast at new GEFS resolution.
  - Apply to next computer
  - 4 cycles per day
  - 4/28 hind-casts for each cycle since 1979 (in discussion)
  - Using CFS reanalysis as initial conditions (T382L64 resolution)
- Downscaling products
  - Pending on RTMA availability
  - Extended variables and regions (Hawaii, Guam and Puerto Rico regions)
- Statistical post-processing
  - Enhance current bias correction method (mini-Bayesian, Krzystofowicz, UVA)
  - Bias correction for precipitation (jointed with pseudo-precipitation, Schultz ESRL)
  - Pending on hind-cast information for first and high moments bias correction
    - Full Bayesian
    - Apply to all model forecast variables
- Verifications

THORPEX LINKS

PRODUCT DEVELOPMENT

- Goals:
  - Develop new numerical model applications
  - Develop new product generation tools and products

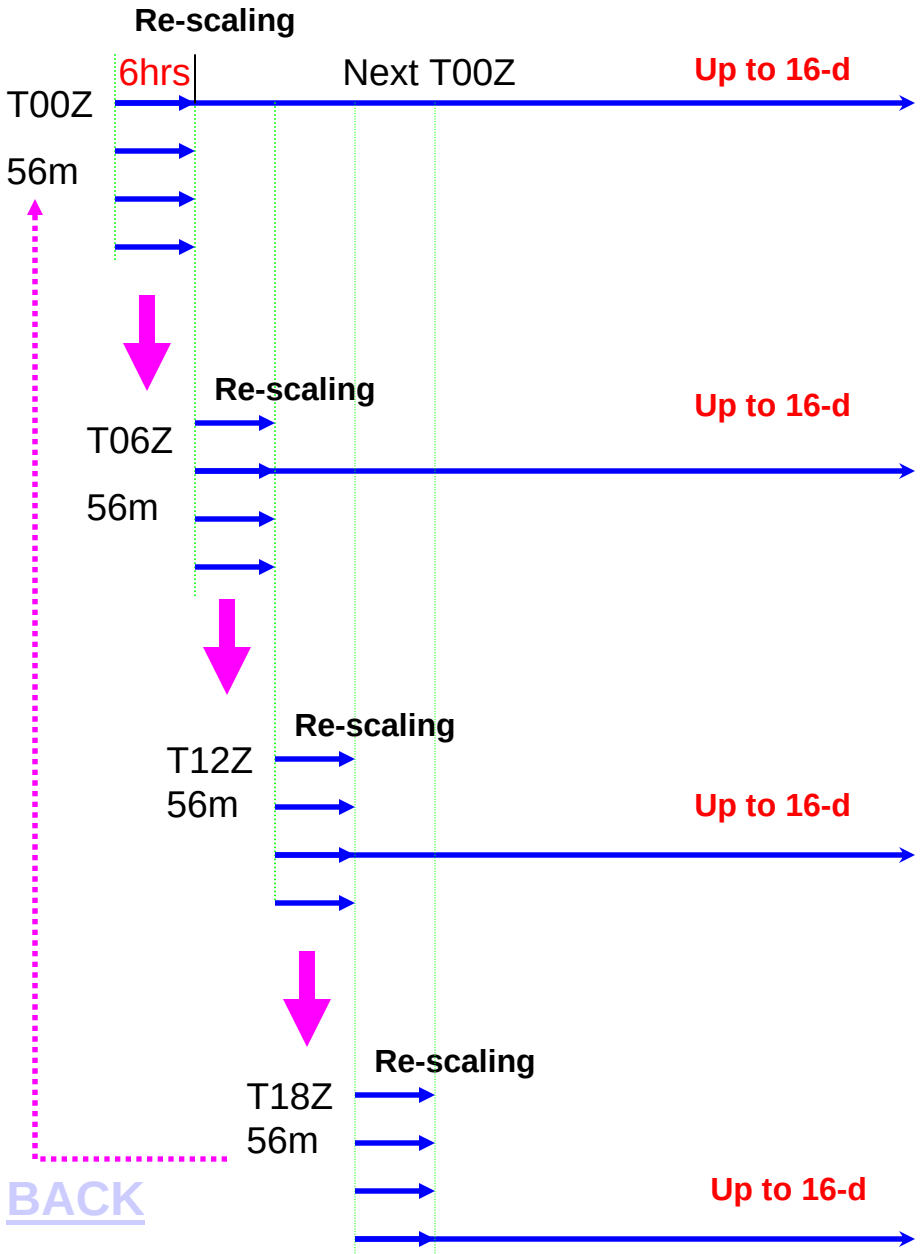
- Participants / Contributions
  - Scott Jacobs et al. (NCO)
    - NAWIPS ensemble functionalities
  - Richard Verret et al. (Meteorological Service of Canada, MSC)
    - NAEFS web-based products
  - David Unger et al. (CPC) and Richard Verret et al. (MSC)
    - Week-2 NAEFS products
  - Bob Grumbine (EMC)
    - Sea ice ensemble application
  - Dingchen Hou (EMC)
    - River flow ensemble application
  - Steve Silberberg, Binbin Zhou (NCEP)
    - Aviation weather guidance
  - Yuejian Zhu (NCEP)
    - NAEFS coordination

- Supported partially by NOAA THORPEX program

Thanks !!!

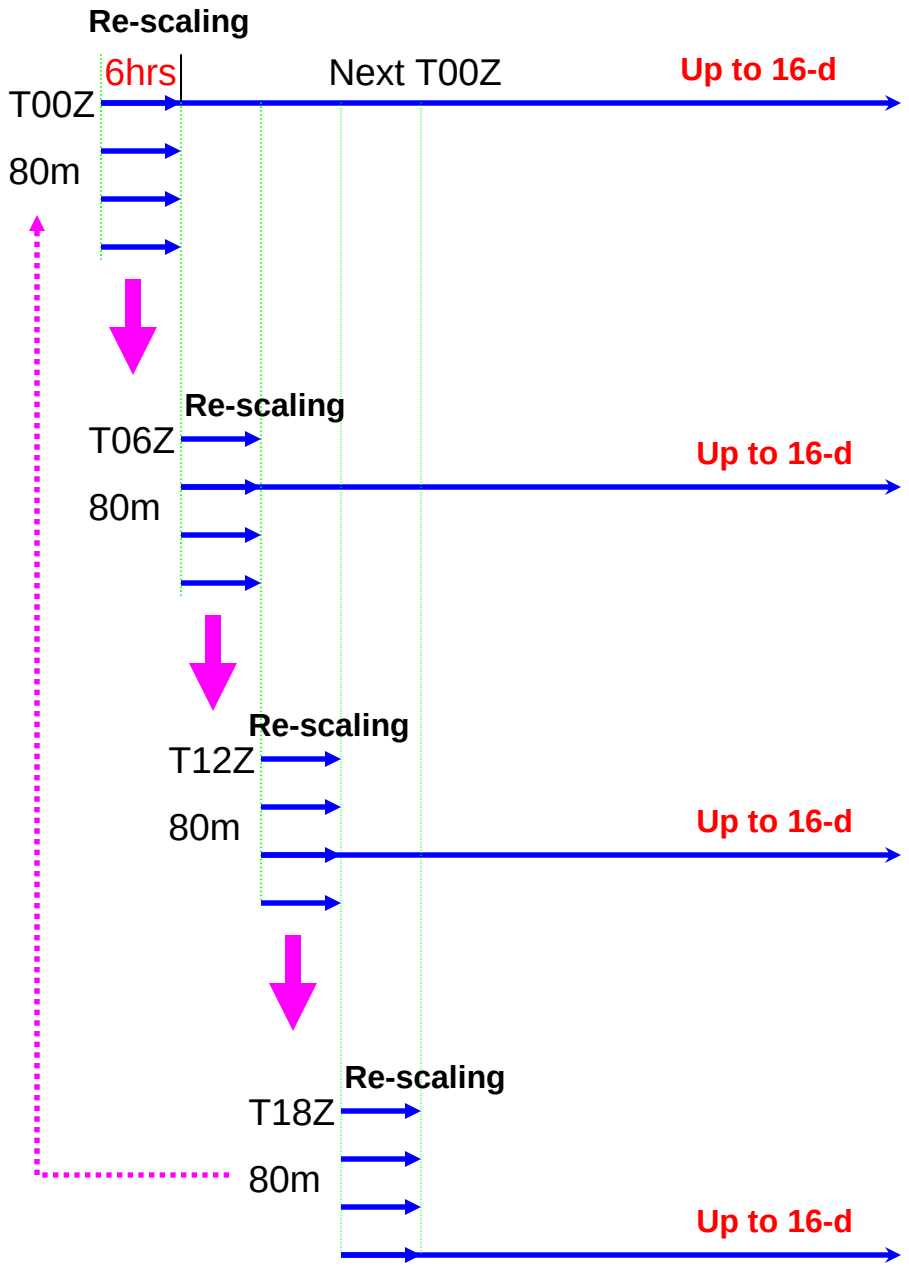
6 hours breeding cycle

Old



6 hours breeding cycle

New

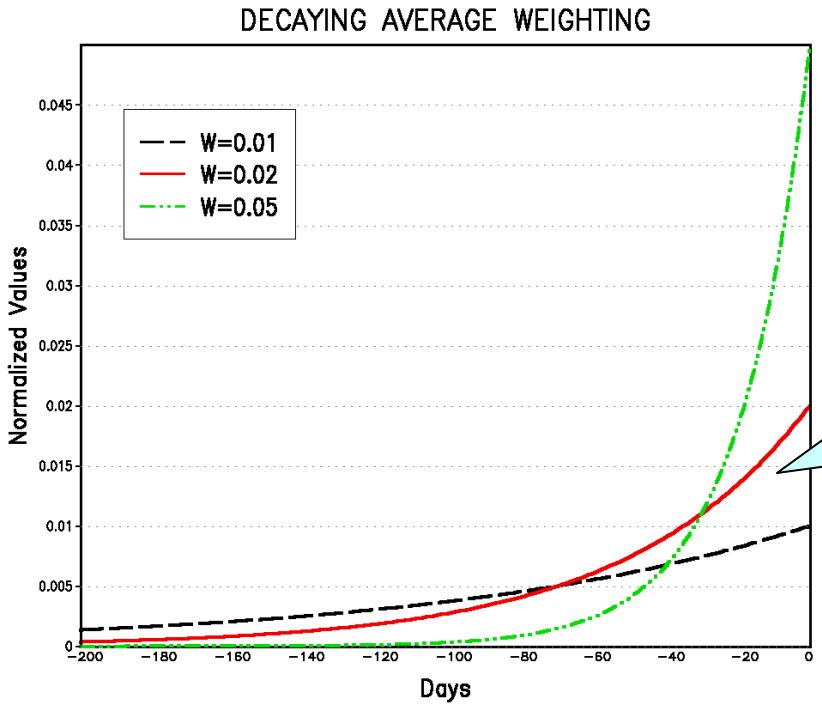


Multi-model EPS for the assimilation

#	Deep convection	Surface scheme	Mixing length	Vertical mixing parameter
1	Kain & Fritsch	ISBA	Bougeault	1.0
2	Oldkuo	ISBA	Blackadar	0.85
3	Relaxed Arakawa Schubert	force-restore	Bougeault	0.85
4	Kuo Symétrique	force-restore	Blackadar	1.0
5	Oldkuo	force-restore	Bougeault	1.0
6	Kain & Fritsch	force-restore	Blackadar	0.85
7	Kuo Symétrique	ISBA	Bougeault	0.85
8	Relaxed Arakawa Schubert	ISBA	Blackadar	1.0
9	Kain & Fritsch	ISBA	Blackadar	0.85
10	Oldkuo	ISBA	Bougeault	1.0
11	Relaxed Arakawa Schubert	force-restore	Blackadar	1.0
12	Kuo Symétrique	force-restore	Bougeault	0.85
13	Oldkuo	force-restore	Blackadar	0.85
14	Kain & Fritsch	force-restore	Bougeault	1.0
15	Kuo Symétrique	ISBA	Blackadar	1.0
16	Relaxed Arakawa Schubert	ISBA	Bougeault	0.85
17	Kuo Symmetric	force-restore	Bougeault	1.0
18	Kain & Fritsch	ISBA	Blackadar	0.85
19	Oldkuo	ISBA	Bougeault	0.85
20	Relaxed Arakawa Schubert	force-restore	Blackadar	1.0
21	Relaxed Arakawa Schubert	ISBA	Blackadar	0.85
22	Oldkuo	force-restore	Bougeault	1.0
23	Kain & Fritsch	force-restore	Blackadar	1.0
24	Kuo Symétrique	ISBA	Bougeault	0.85

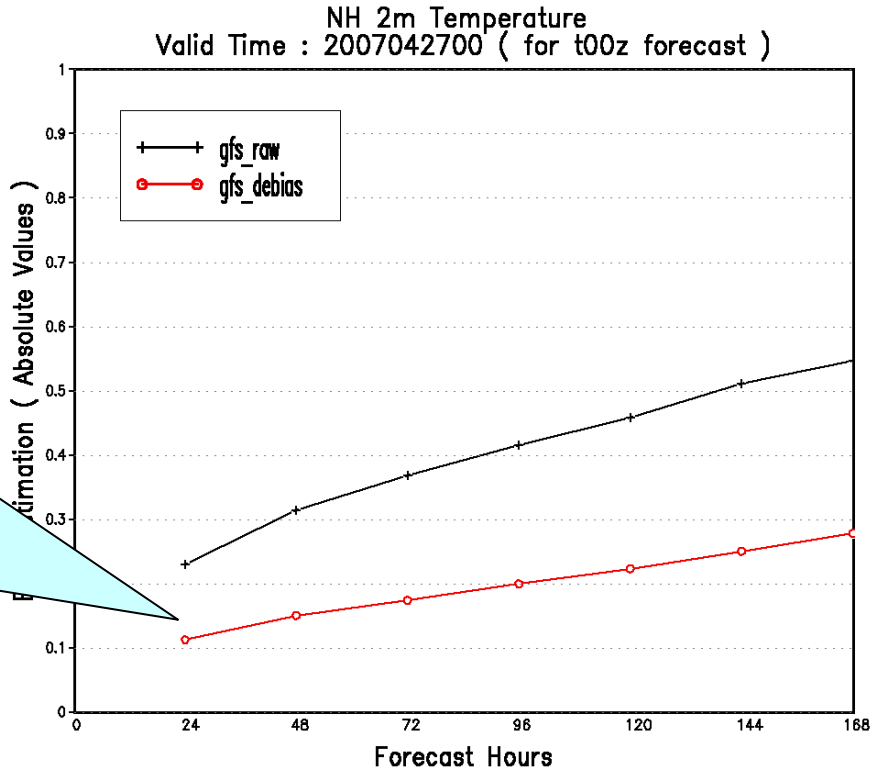
BACK

P. Houtekamer, ARMA



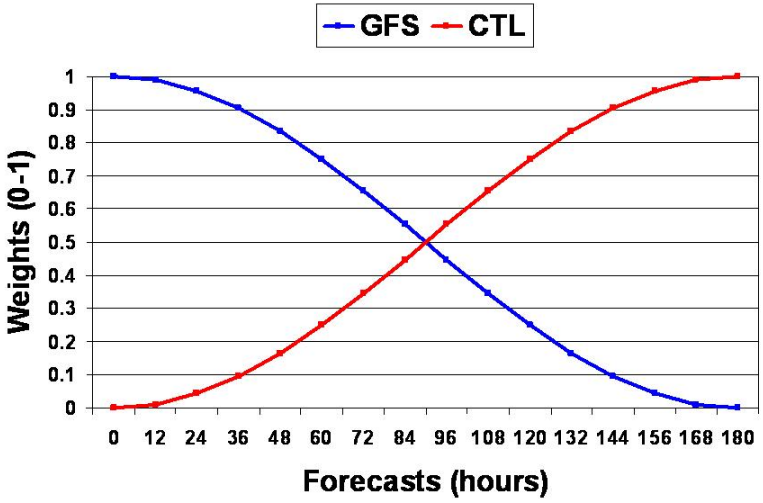
GFS bias correction based on an accumulated bias by using decaying average weight (0.02) which is the same as GEFS used

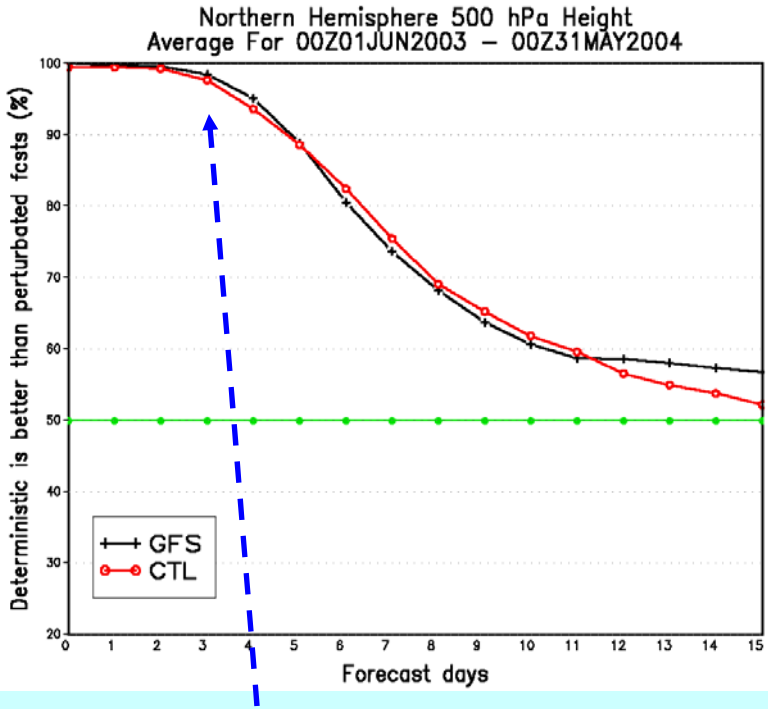
The absolute errors are reduced after bias correction for 2-meter temperature (The stats are accumulated from 0.02 decaying average)

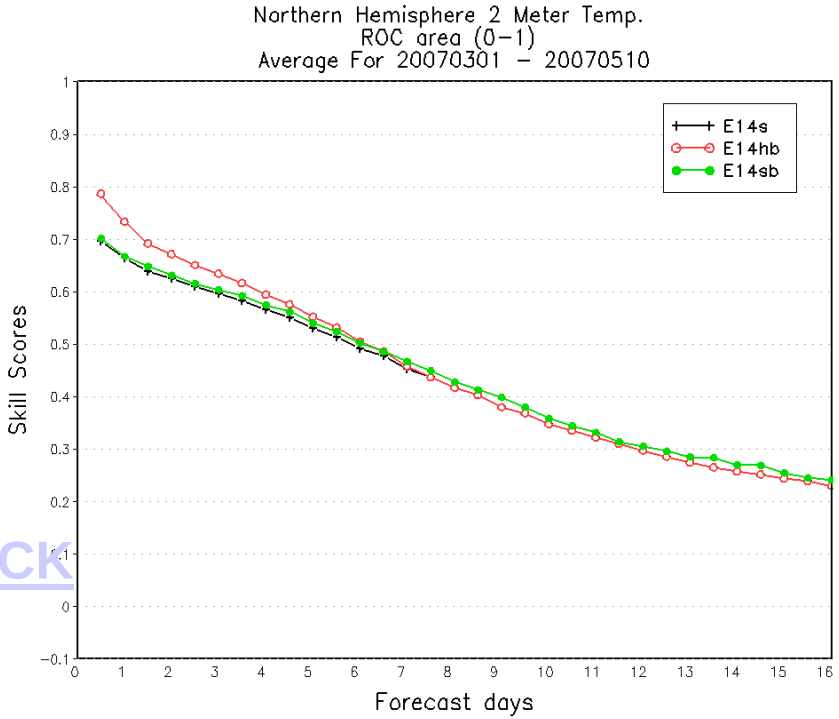


BACK

Combined GFS and GEFS forecasts at first 180hr





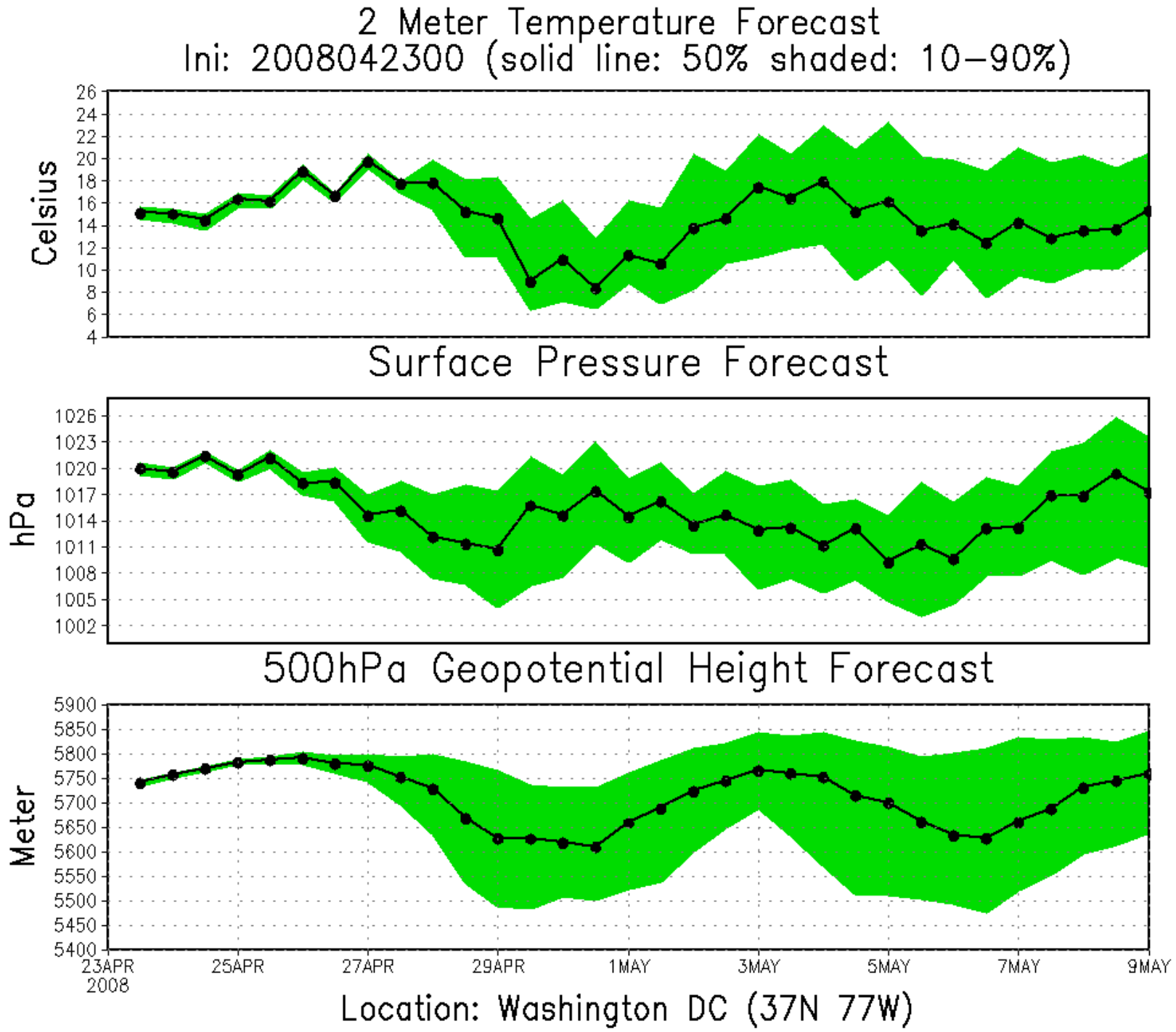


GFS has more skill than ensemble control for short lead time

Combined GFS and GEFS Forecast has more skill (red) than GEFS only (black)

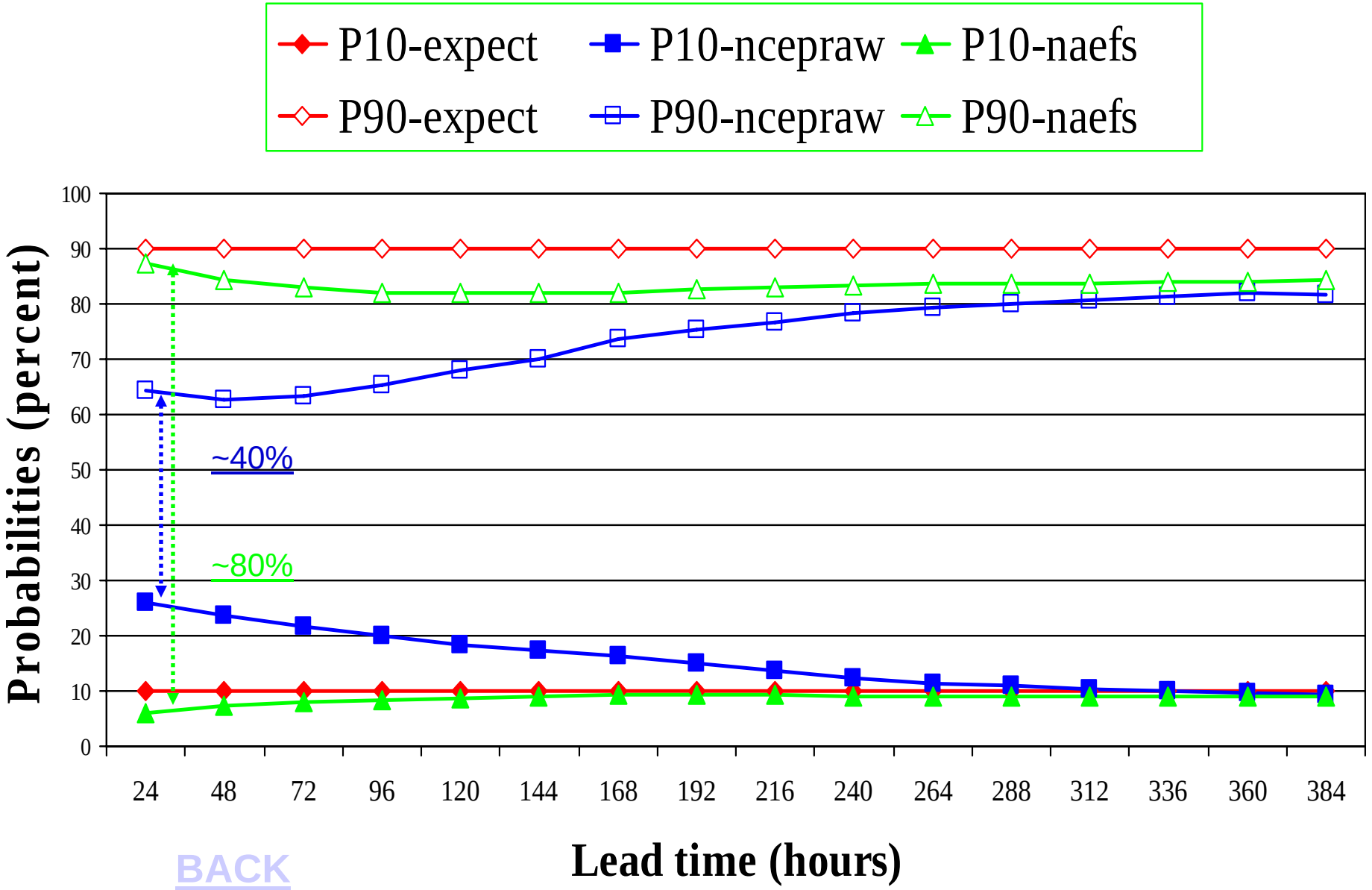
Jun Du first introduced dual-resolution to SREF, by using constant weight

BACK


2 Meter Temperature Forecast
Ini: 2008042300 (solid line: 50% shaded: 10-90%)
Celsius
26
24
22
20
18
16
14
12
10
8
6
4
Surface Pressure Forecast
hPa
1026
1023
1020
1017
1014
1011
1008
1005
1002
500hPa Geopotential Height Forecast
Meter
5900
5850
5800
5750
5700
5650
5600
5550
5500
5450
5400
23APR
2008
25APR
27APR
29APR
1MAY
3MAY
5MAY
7MAY
9MAY
Location: Washington DC (37N 77W)

BACK

2-meter temperature 10/90 probability forecast verification
Northern Hemisphere, period of Dec. 2007 – Feb. 2008



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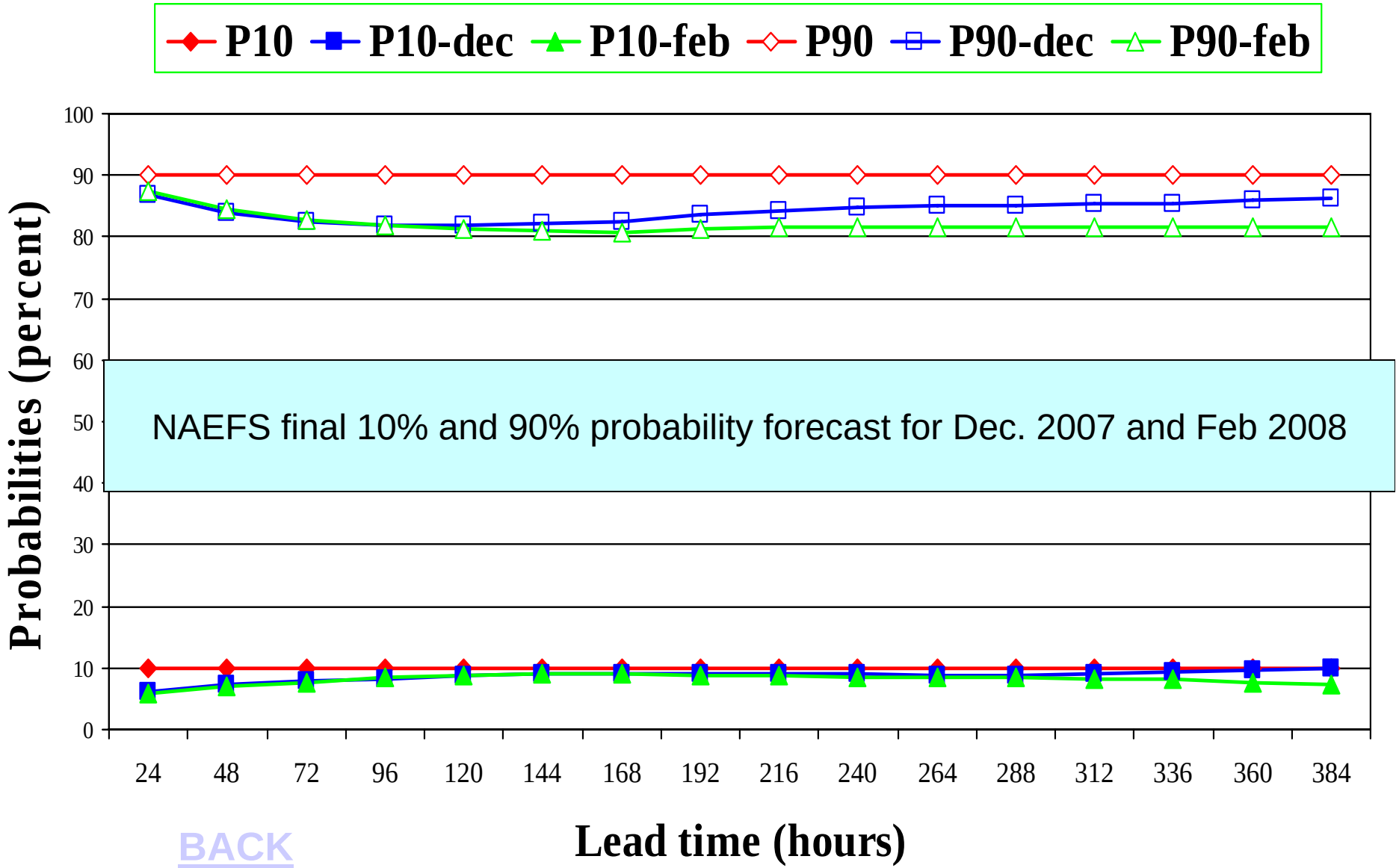
2-meter temperature 10/90 probability forecast verification
Northern Hemisphere, seasonal variation for NAEFS



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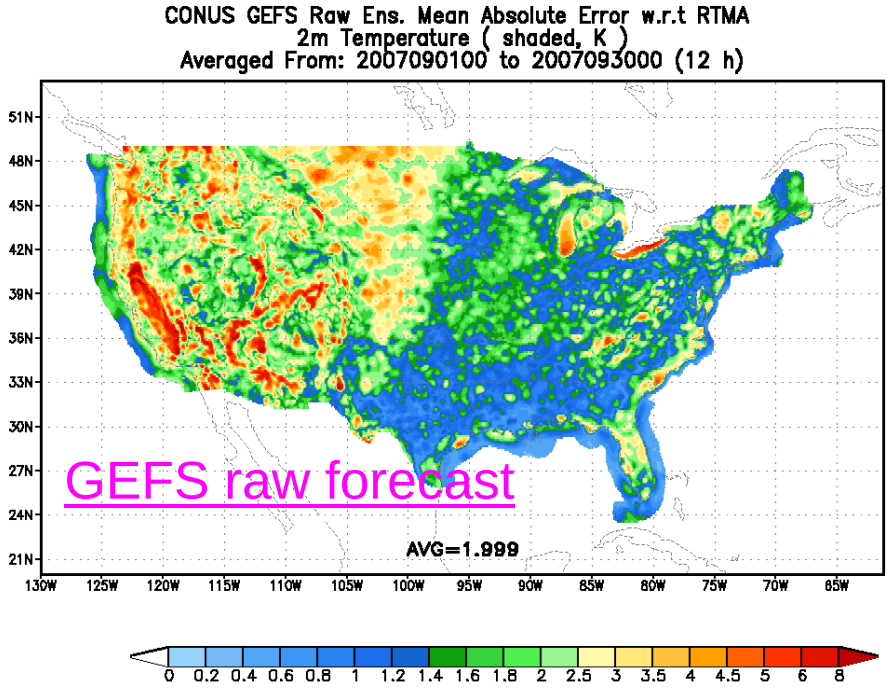
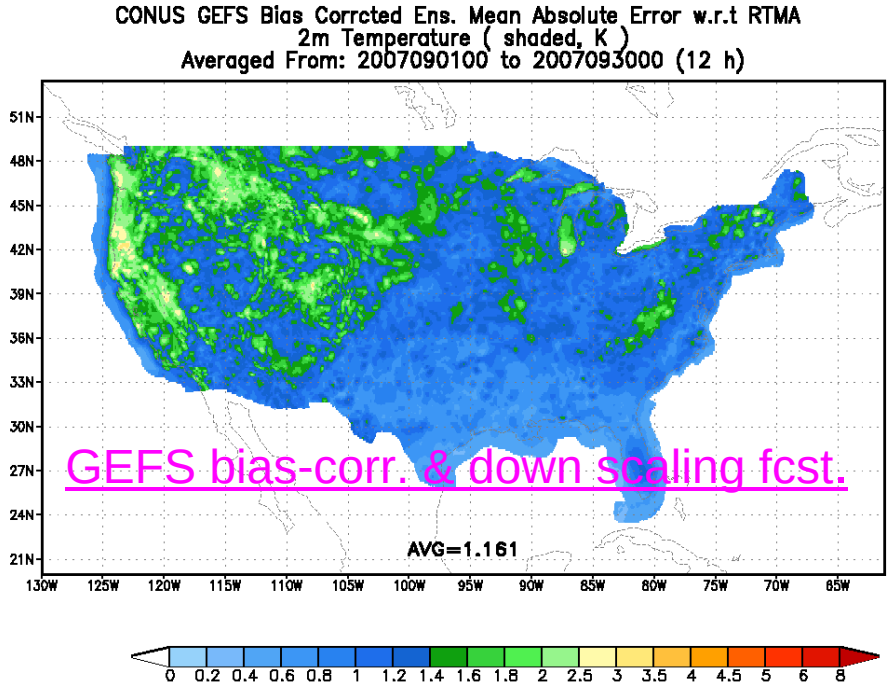
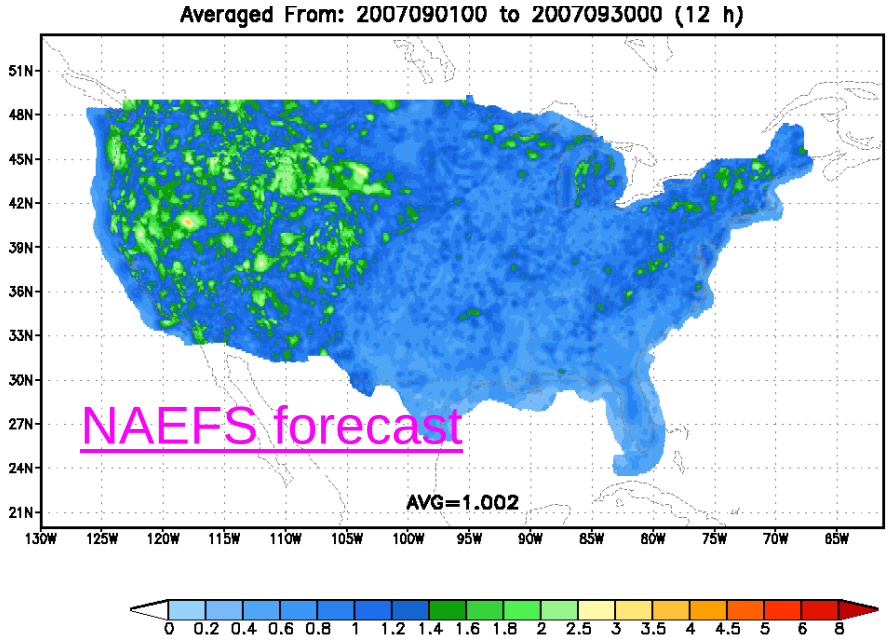
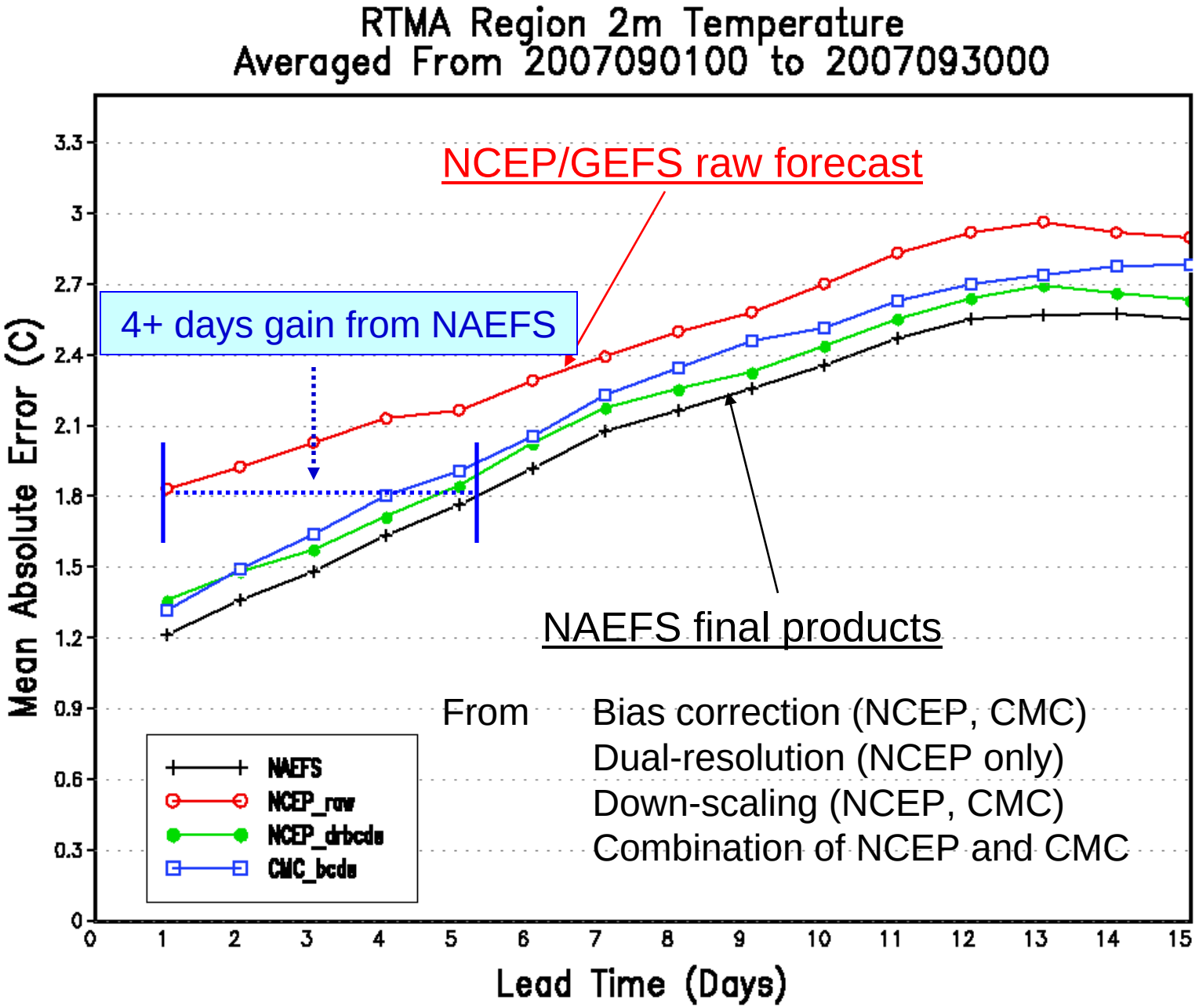






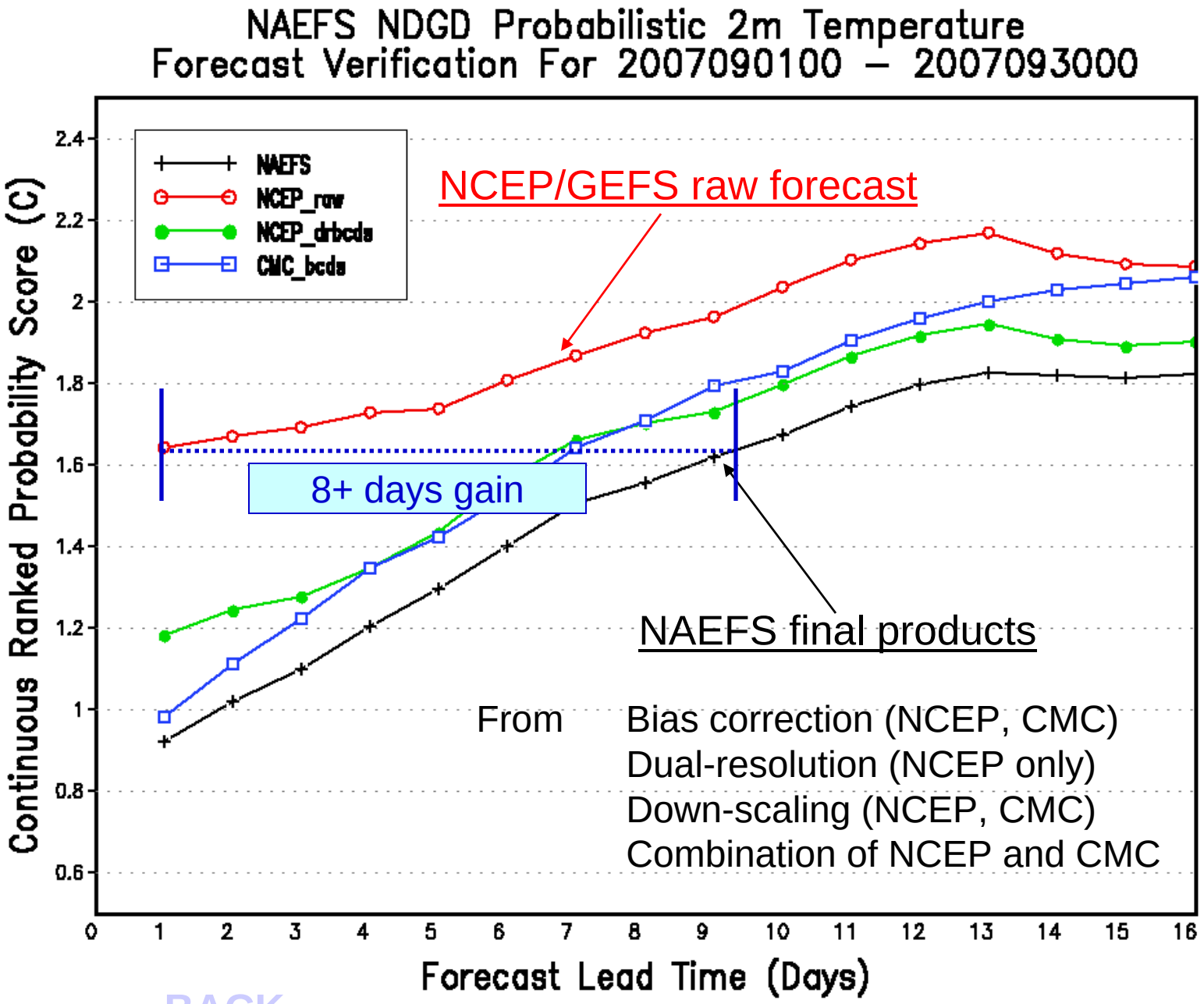
12hr 2m T forecast
Mean Absolute Error
w.r.t RTMA for CONUS
Average for September

BACK



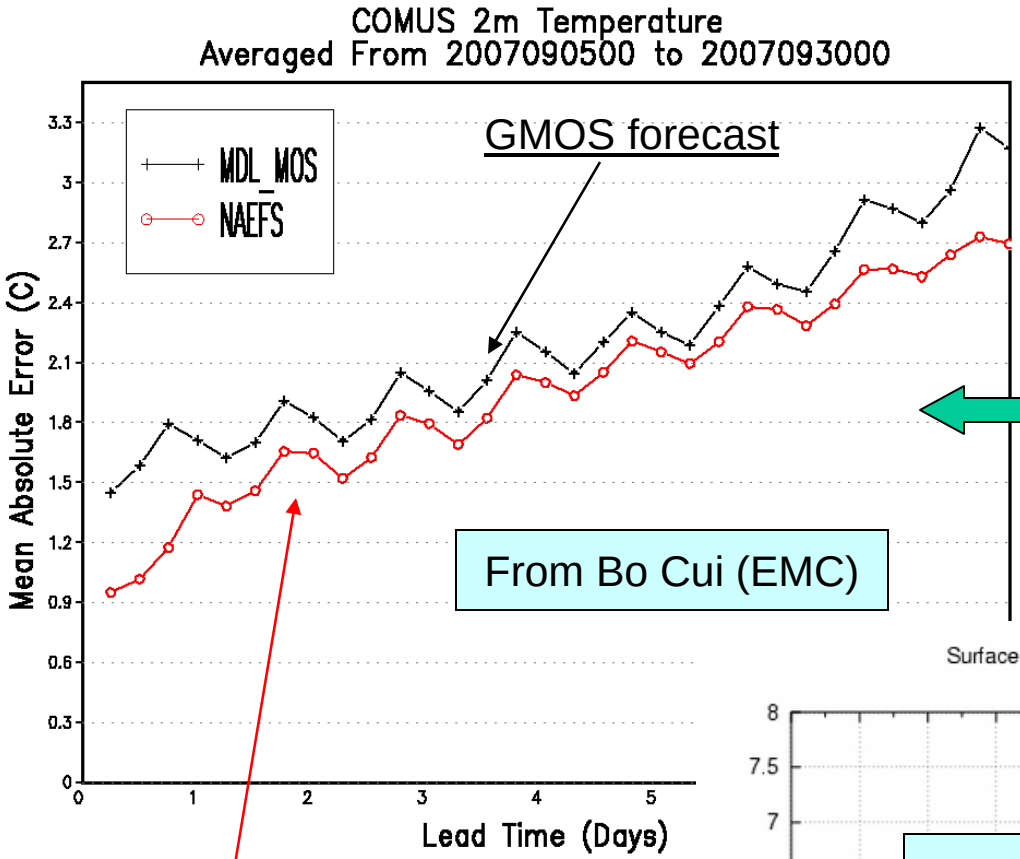
BACK

BO CUI, GCWMB/EMC/NCEP/NOAA



BACK

BO CUI, GCWMB/EMC/NCEP/NOAA



GMOS forecast

From Bo Cui (EMC)

NAEFS final products

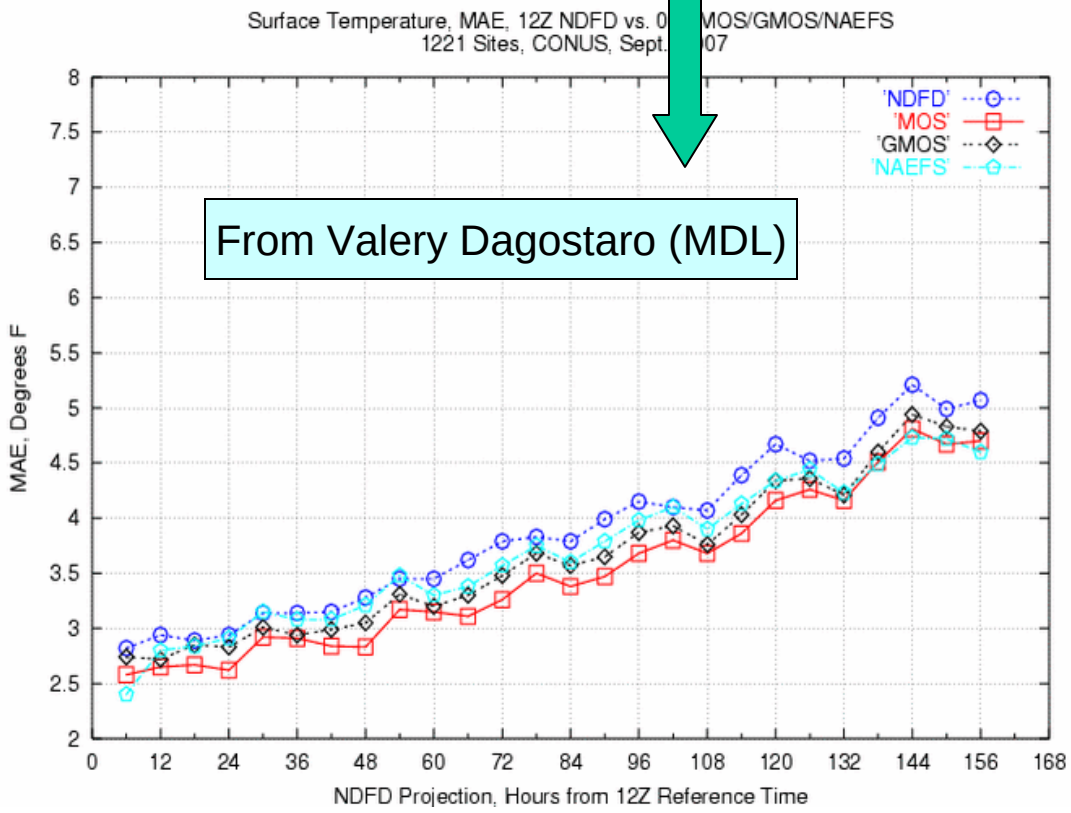
From :
Bias correction (NCEP, CMC)
Dual-resolution (NCEP only)
Down-scaling (NCEP, CMC)
Combination of NCEP and CMC

CONUS 2m Temperature

For September 2007

Verify against RTMA

Verify against observation



From Valery Dagostaro (MDL)

BACK

Current/future FNMOC Global EFS

(From Michael Sestak)

- Current FNMOC GEFS
  - 96 members with perturbed initial conditions from NOGAPS control run
  - Updated 4 times per day from 00Z, 06Z, 12Z, 18Z
  - Forecasts to 252 hours (10.5 days) for 16 members, once per day for 00Z (remaining runs and updates 6 hr forecasts), full forecast members rotate through all members over 6 days.
  - Grid resolution: spectral T119, truncated from T239 control
  - 30 vertical levels from surface to 1 mb, same as control
  - Perturbations created using the Ensemble Transform technique, analysis error estimate from NAVDAS
  - 16 global WaveWatch3 runs forced by the winds from the 16 NOGAPS full forecast members
- Short-term plan (1-2 years)
  - Full forecast twice per day 00Z and 12Z
  - Full forecasts to 360 hours (15 days)
  - Grid resolution: spectral T159 (approximately 2/3 degree in latitude and longitude)
- Long-term plan (>2 years)
  - Grid resolution: spectral T239 (approximately 1/2 degree in latitude and longitude)
  - 32 members
  - Perturbations using Ensemble Transform Kalman Filter (ETKF) technique
  - Mesoscale Ensemble from AFWA/FNMOC Joint Ensemble Forecast System

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ECMWF Global EFS

- Current ECMWF GEFS
  - 51 (50+1) perturbed ensemble runs (SV)
  - Variable resolutions
    - T399L62 (0-7d, dt=1800s)
    - T255L62 (6-15d, dt=2700s)
    - T255L62 (15-32d, dt=2700s) coupling with ocean model
  - Updated 2 times per day from 00UTC and 12UTC
  - Addition of stochastic perturbation of the physical tendencies
- Currently NCEP received
  - Partly forecasts (30 variables)
  - Twice per day 00UTC and 12UTC
  - Every 12 hour up to 240 hours
  - 1*1 degree resolution
- What do we expect (in process)
  - More forecasts (around 50 variables)
  - Twice per day at 00UTC and 12UTC
  - Every 6 hours up to 360 hours

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