Global Ensemble and NAEFS

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NOAA/NWS/NCEP

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Presentation for RFC Short-Term Ensemble Workshop
November 30th 2006

Outlines

- NAEFS History and Milestones
- GEFS, NAEFS and THORPEX
- Review GEFS Implementation (FY06)
- Review First NAEFS Implementation (FY06)
- Ensemble Products and Functionalities
- Ensemble Data Request Information
- GEFS Major Implementation Plan (FY07)
- NAEFS Upgrade Plan (FY07)
- NAEFS Expansion and Future Plan

NAEFS History and Milestones

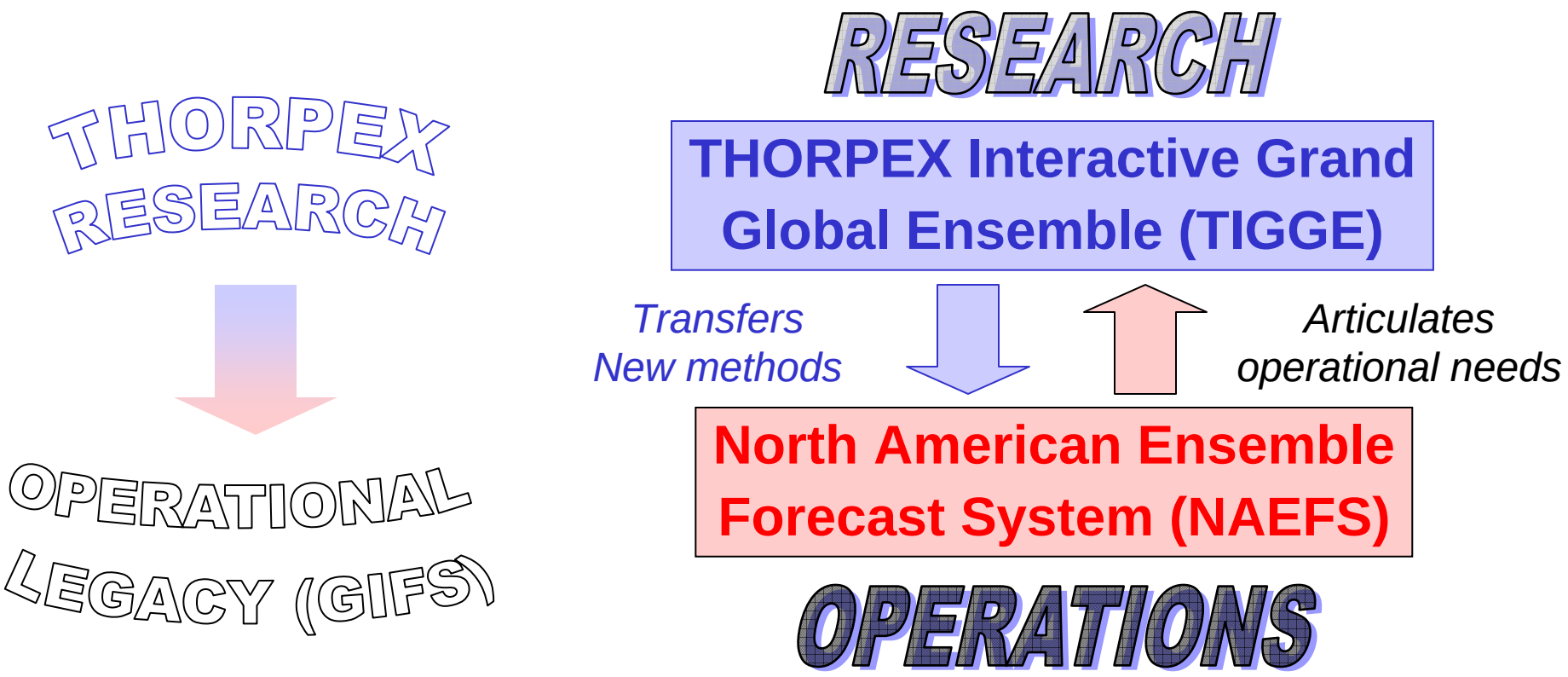
- February 2003, Long Beach, CA
  - NOAA / MSC high level agreement about joint ensemble research/development work

  (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, 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)



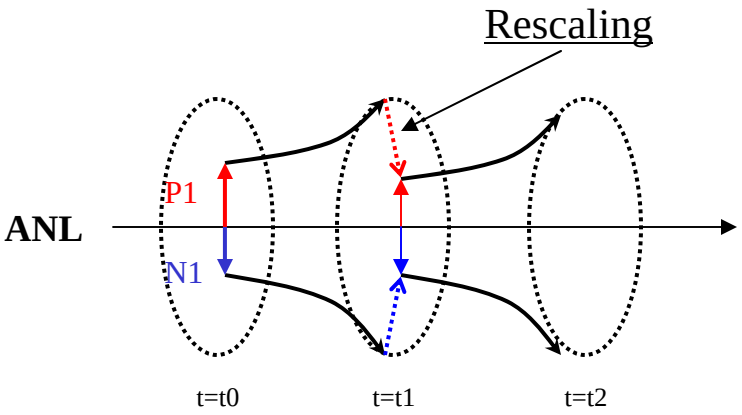
Review GEFS Implementation (FY06)

1. Increase the number of perturbed ensemble members
   - 14 (in place of current 10) perturbed runs for each cycle (20 by early 2007)
     - NAEFS requirement
   - This change is intended to improve ensemble based prob. forecasts
     - Results: improved probabilistic skill, slightly improved ensemble mean skill (seasonally dependent)
2. Add control runs for 06, 12 and 18Z cycles
   - This change is intended to enable for relocation of perturbed tropical storm
   - Facilitates comparison of high & lower resolution ensemble controls
     - If lores control and ensemble mean differ – indication of nonlinearities
     - If high & lores controls differ – indication for possible effect of resolution
3. Introduce Ensemble Transform (ET) into GEFS breeding method
   - ET breeding method creates globally orthogonal initial perturbations
   - Uses simplex method to create individual (not paired) perturbations
   - This change is intended to improve probabilistic forecast skill
     - Results: Improved probabilistic forecast skill; Slightly reduced ensemble mean hurricane track errors for 12-96 hours
4. Changes of File Names and Structures

GEFS configurations

	Current	Plan
Model	GFS	GFS
Initial uncertainty	*BV*	*ETBV*
Model uncertainty	None	None
Tropical storm	Relocation	same
Daily frequency	00,06,12 and 18UTC	same
Hi-re control (GFS)	T382L64 (d0-d7.5) T190L64 (d7.5-d16)	same
Low-re control (ensemble control)	T126L28 (d0-d16) *00UTC only*	T126L28 (d0-d16) *00,06,12 and 18UTC*
Perturbed members	*10* for each cycle	*14 (20)* for each cycle
Forecast length	16 days (384 hours)	same
Implementation	August 17th 2005	May 30th 2006

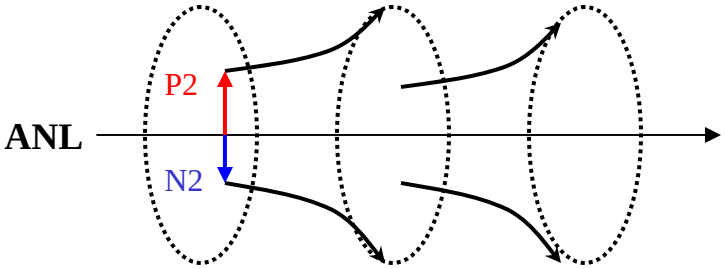
Bred Vector
(Current)



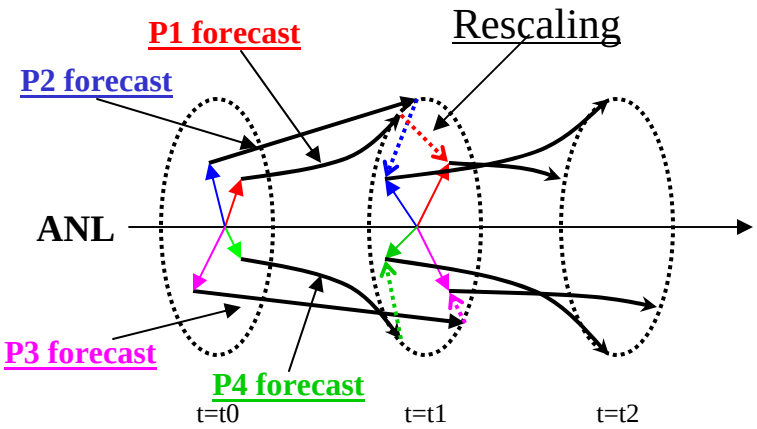
P#, N# are the pairs of positive and negative

P1 and P2 are independent vectors

Simple scaling down (no direction change)



Ensemble Transform Bred Vector
(Plan)



P1, P2, P3, P4 are orthogonal vectors

No pairs any more

To centralize all perturbed vectors (sum of all vectors are equal to zero)

Scaling down by applying mask,

The direction of vectors will be tuned by ET.

Changes of File Names and Structures

- Pressure GRIB Files Split into Two
  - Pgrba – 51 Variables For NAEFS Exchange
  - Pgrbb – Remaining 278 Variables
- Perturbation runs from pairs to single size
  - P1, n1, p2, n2 … convert to p0, p02, p03, p04 …
- Enspost.* and Ensemble.* Files Eliminated
  - Data Was Duplicate to Pressure GRIB Data Packed in Different Format
- Ensemble Extensions Corrected in Pressure GRIB Files
- 6-Hourly Precipitation/Max/Min Accumulations Available in Pressure GRIB Files
- GEMPAK Files Created for NAEFS Members for Raw and Bias Corrected pgrba Files
- GEMPAK Metafiles For HPC Medium Range Desk Created in Production

Review First NAEFS Implementation (FY06)

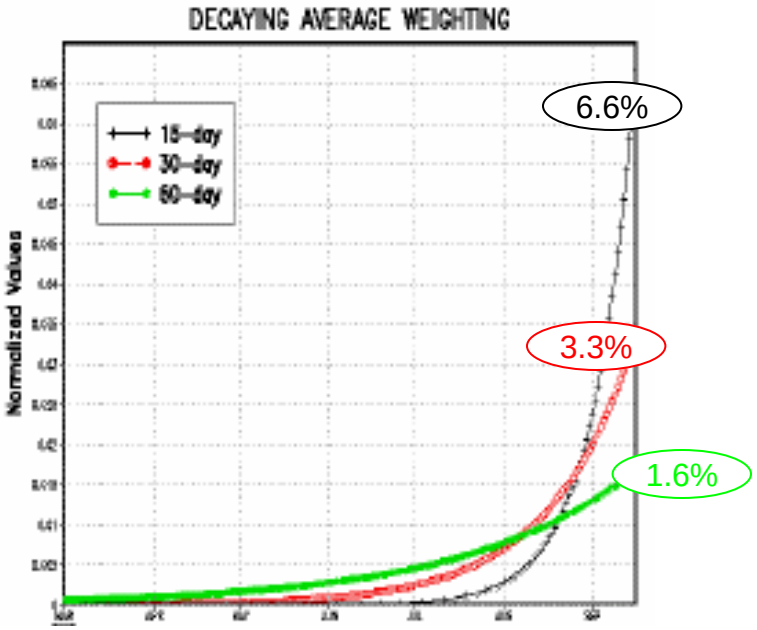
1. Bias corrected members of joint MSC-NCEP ensemble
   - Decaying accumulated bias (~past 50 days) for each var. for each grid point
   - For selected 35 of 50 NAEFS variables
   - 32(00Z), 15(06Z), 32(12Z) and 15(18Z) joint ensemble members
   - Bias correction against each center's own operational analysis
2. Weights for each member for creating joint ensemble (equal weights now – unequal weights to be added later)
   - Weights don't depend on the variables
   - Weights depend on geographical location (low precision packing)
   - Weights depend on the lead time
3. Climate anomaly percentiles for each member
   - Based on NCEP/NCAR 40-year reanalysis
     - Used first 4 Fourier modes for daily mean,
     - Estimated climate pdf distribution (standard deviation) from daily mean
   - For selected 19 of 50 NAEFS variables
   - 32(00Z), 15(06Z), 32(12Z) and 15(18Z) joint ensemble members
   - Adjustment made to account for difference between oper. & re-analysis
   - Provides basis for downscaling if local climatology available
     - Non-dimensional unit

Bias Correction Method & Application

- Bias Assessment: adaptive (Kalman Filter type) algorithm

decaying averaging mean error = (1-*w*) * prior t.m.e + *w* * (f – a)

For separated cycles, each lead time and individual grid point, t.m.e = time mean error



Toth, Z., and Y. Zhu, 2001

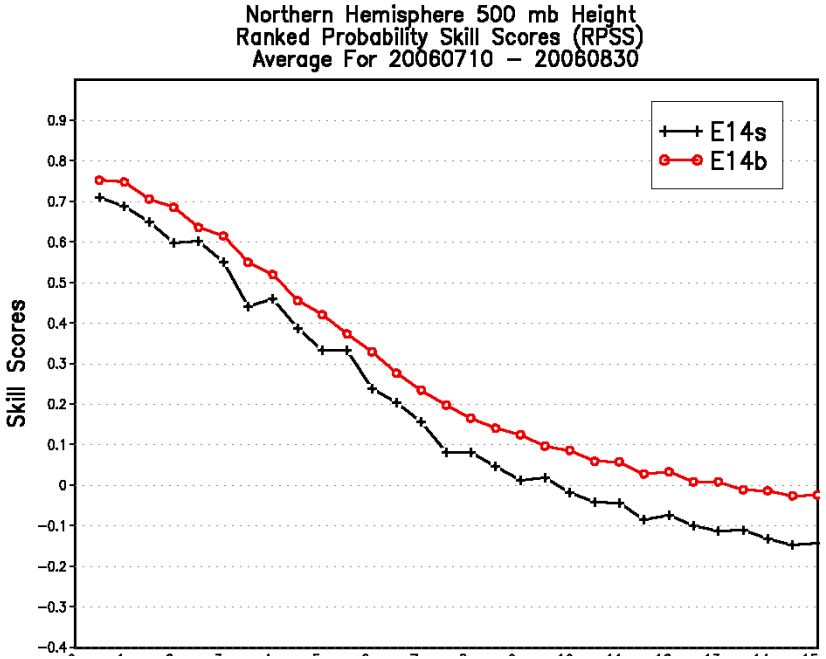
- Test different decaying weights. 0.25%, 0.5%, 1%, 2%, 5% and 10%, respectively
- Decide to use 2% (~ 50 days) decaying accumulation bias estimation

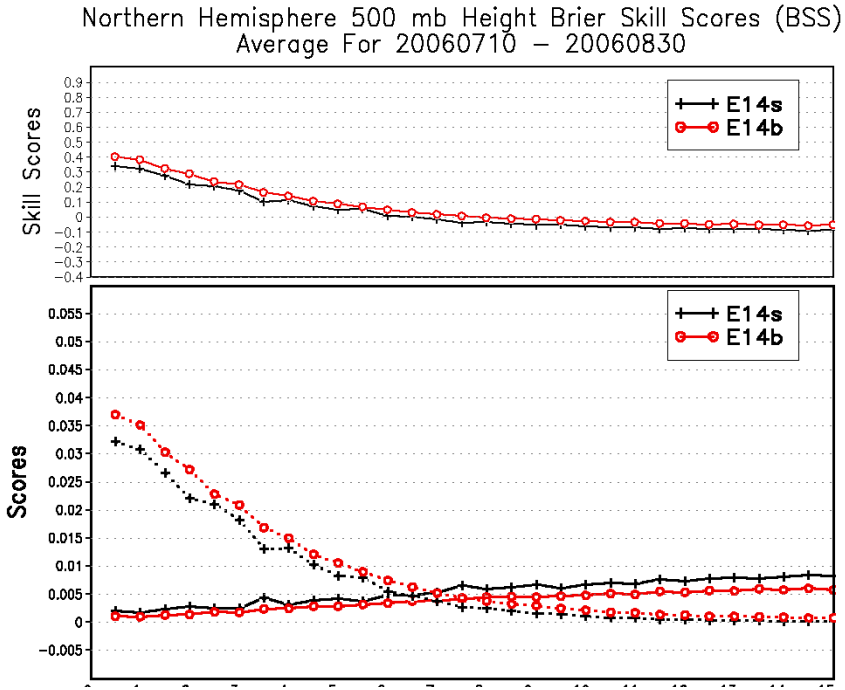
- Bias Correction: application to NCEP operational ensemble 15 members

List of Variables for Bias Correction, Weights and Forecast Anomalies for CMC & NCEP Ensemble

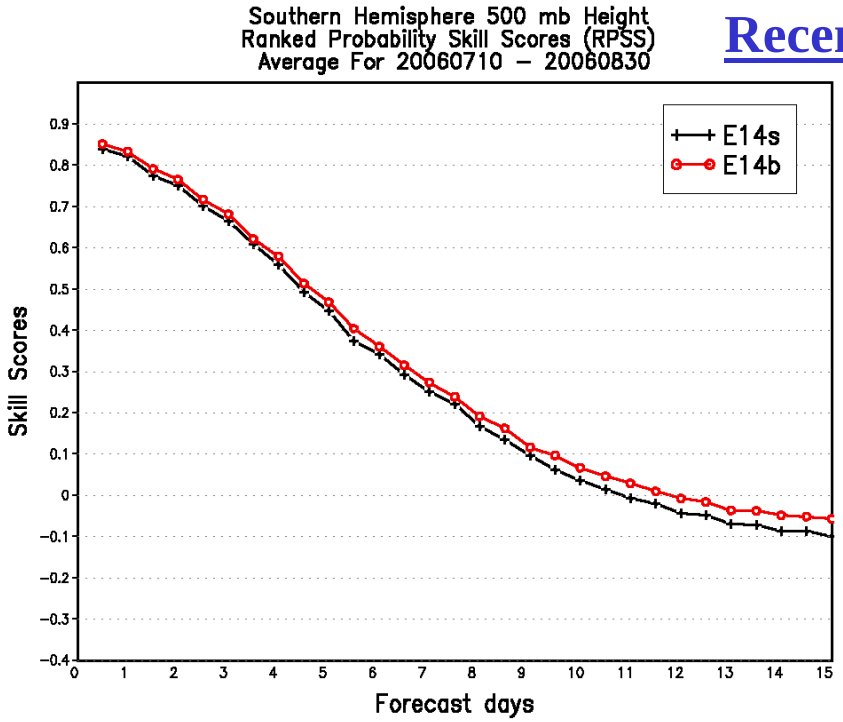
	CMC & NCEP
Ensemble	CMC (8 SEF, 8 GEM), NCEP (14 GFS)
GRID	1x1 deg (360x180 lat-lon)
DOMAIN	Global
FORMAT	WMO Grib Format
HOURS	6 hourly out of 384 hours (current 240 hours for CMC Ensemble)
GZ	200, 250, 500,700, 850 ,925,1000
TT	200, 250, 500,700, 850 ,925,1000
U,V	200, 250, 500,700, 850 ,925,1000
TT	2m
U, V	10m
MSLP	Sea Level Pressure
Sfc Pres	Surface Pressure
Tmax	2m
Tmin	2m

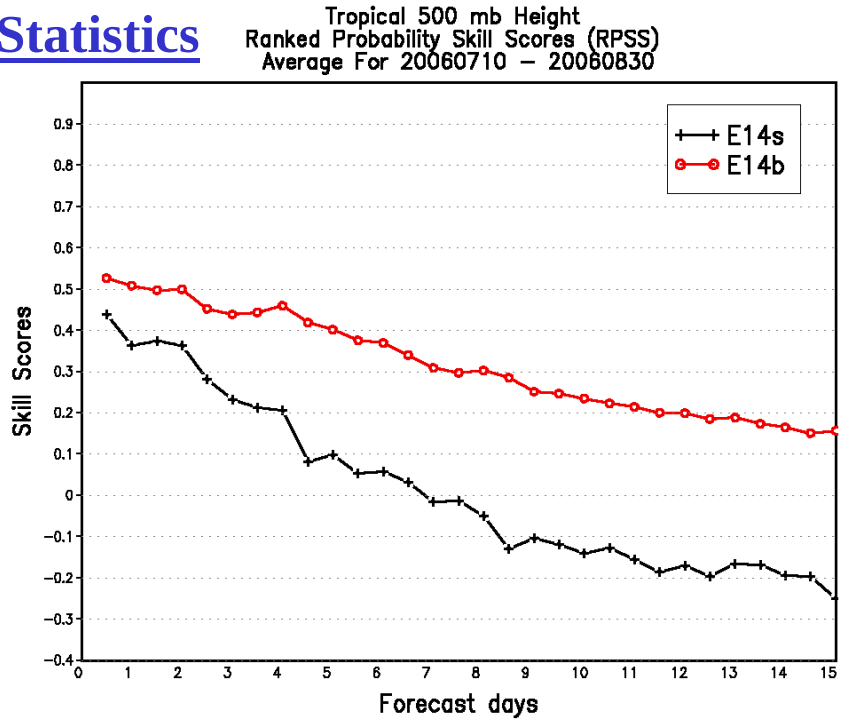
Note: 35 Variables in total, red variables are for climate anomalies only



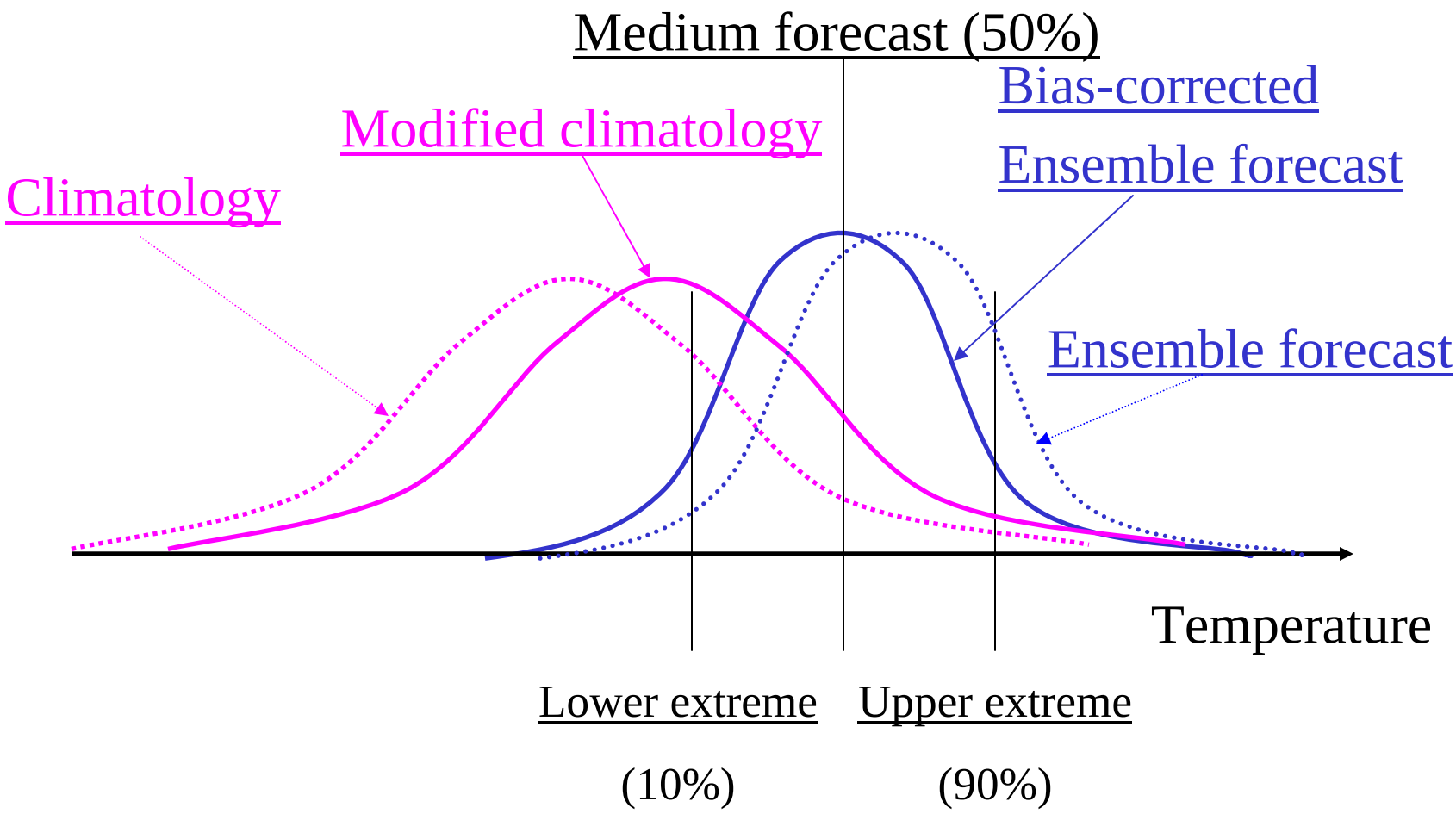


Recently Statistics





Schematic diagram for forecast anomalies

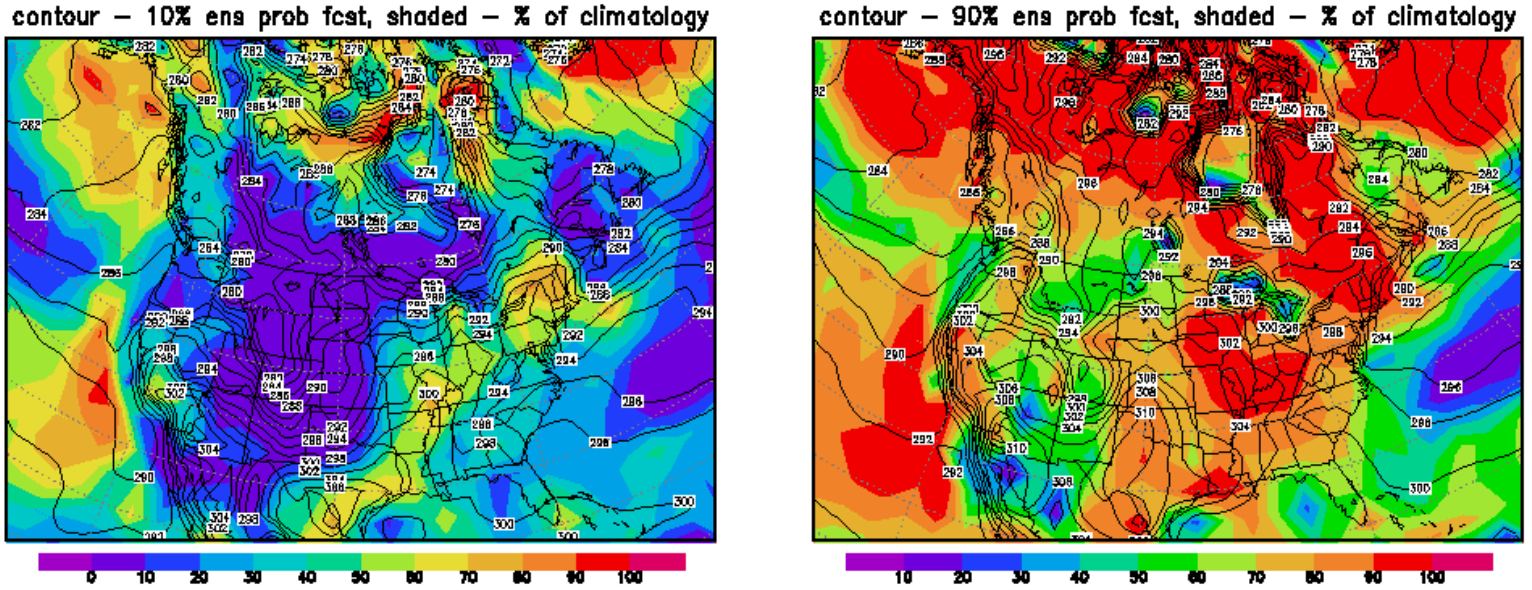


Clmatology is generated from NCEP/NCAR reanalysis

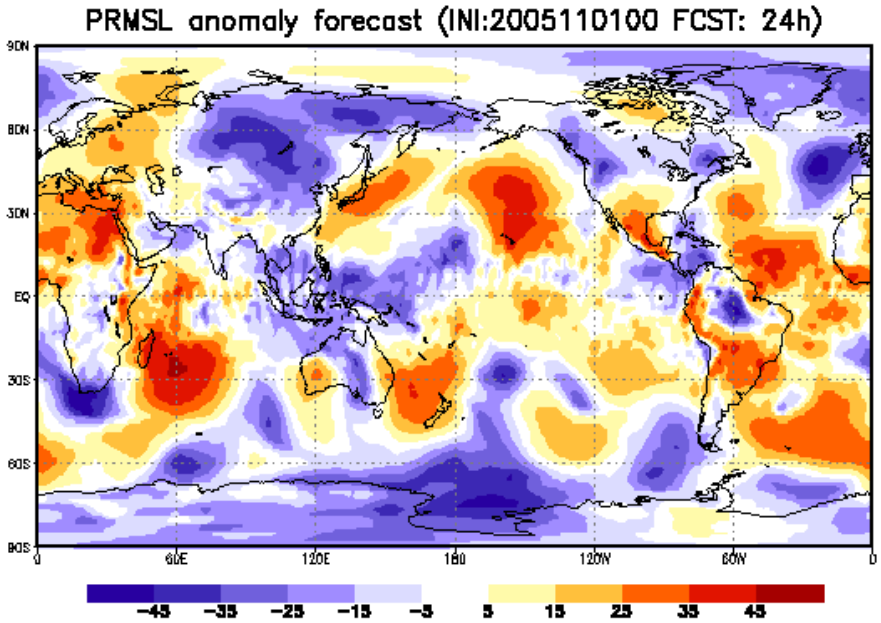
(40 years from 1958 to 1997)

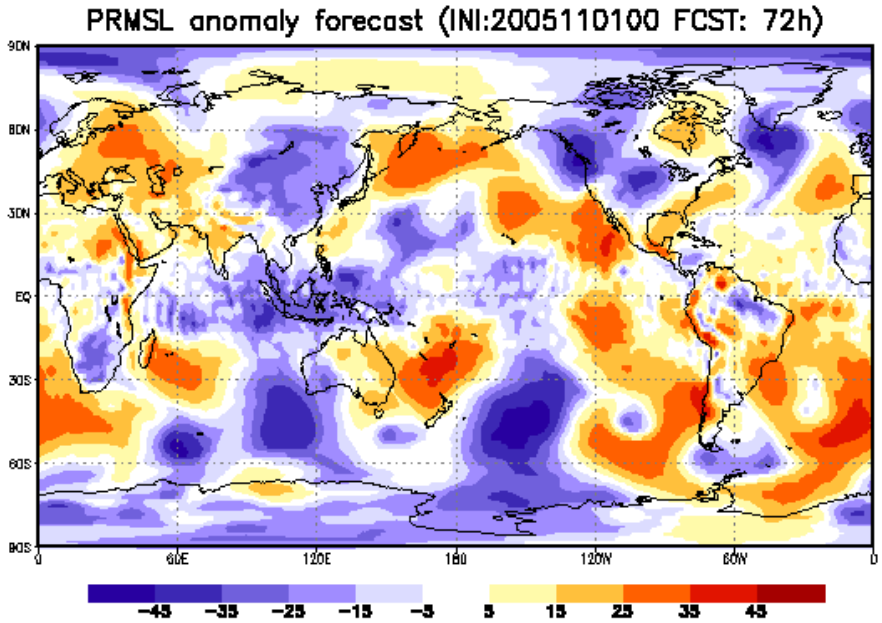
ENSEMBLE 10-, 50- (MEDIAN) & 90-PERCENTILE FORECAST VALUES (BLACK CONTOURS) AND CORRESPONDING CLIMATE PERCENTILES (SHADES OF COLOR)

2–meter temperature 5–day forecast (valid at 06/15/2005)

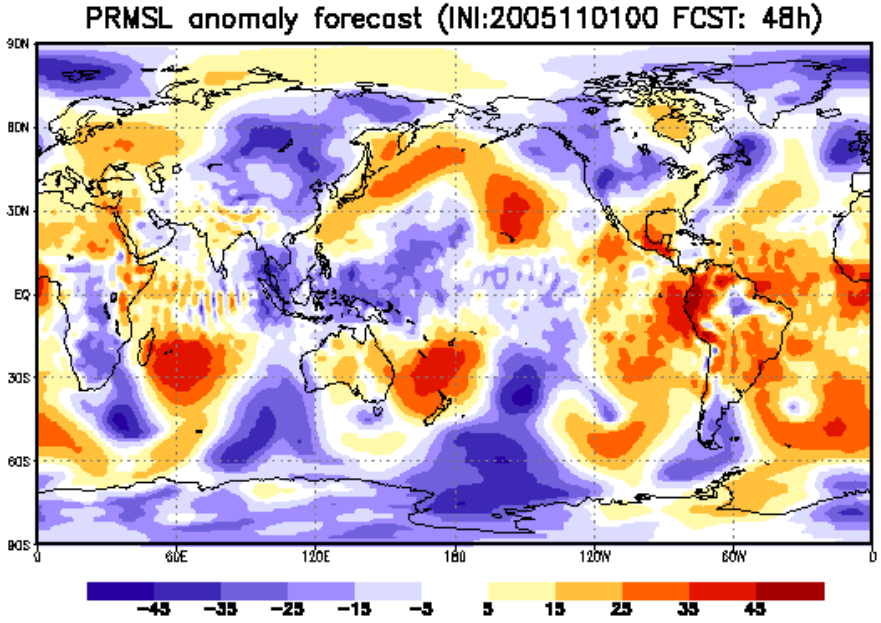


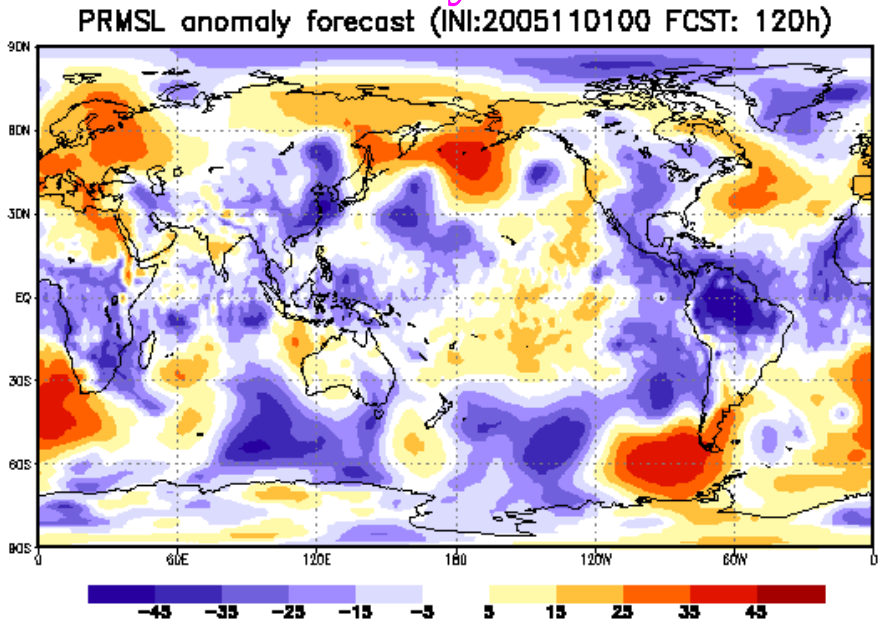
Example of probabilistic forecast in terms of climatology





Based on raw forecasts, no climate and current analysis correction





Ensemble Product Request List

NCEP SERVICE CENTERS, OTHER PROJECTS

FUNCTIONALITY	CENTRALLY MADE PRODUCTS	DOMAIN	CENTER #'s	CENTER
Mean	PMSL	NH,NA,SA,CA,AF,glob	6	**AMMA, HPC,LAP,OPC,SPC,TPC**
Mean	Z: 500mb	NH,NA,SA,CA,AF,glob	6	**AMMA,HPC,LAP,OPC,SPC,TPC**
Spread	Z: 500mb	NH,NA,SA,CA,AF, glob	6	**AMMA,HPC,LAP,OPC,SPC,TPC**
Mean	T (K): 500mb	NH,NA,AF,global	5	**AMMA,HPC,OPC,SPC,TPC**
Mean	T (K): 700mb	NH,NA,AF,global	5	**AMMA,HPC,OPC,SPC,TPC**
Mean	T (K): 850mb	NH,NA,AF,global	5	**AMMA,HPC,OPC,SPC,TPC**
Mean	Wind: 500mb	NH,NA,AF,global	5	**AMMA,HPC,OPC,SPC,TPC**
Mean	Wind: 700mb	NH,NA,AF,global	5	**AMMA,HPC,OPC,SPC,TPC**
Mean	Wind: 850mb	NH,NA,AF,global	5	**AMMA,HPC,OPC,SPC,TPC**
Mean	Z: 700mb	NH,NA,AF,global	5	**AMMA,HPC,OPC,SPC,TPC**
Mean	Z: 850mb	NH,NA,AF,global	5	**AMMA,HPC,OPC,SPC,TPC**
Spread	Wind: 10 m	NH, NA,AF,global	5	**AWC,OPC,TPC,AMMA,SPC**
Grouping	pmsl: lows/troughs/mins & highs/ridges/maxes	NH, global,NA,SA,CA	4	**HPC,LAP,OPC,TPC**
Mean	T (K): 300mb	NH,AF, global	4	**AMMA,OPC,SPC,TPC**
Mean	Wind: 10 m	NH, NA,AF,global	4	**AMMA,OPC,SPC,TPC**
Mean	Wind: 250mb	NH,NA,AF,global	4	**AMMA,HPC,OPC,TPC**
Mean	Wind: 300mb	NH,AF, global,NA	4	**AMMA,OPC,SPC,TPC**
Mean	Wind: 925mb	NH,NA,AF, global	4	**AMMA,OPC,SPC,TPC**
Spread	Wind: 500mb	NH,NA,AF, global	4	**AMMA,OPC,SPC,TPC**
Spread	Wind: 850mb	NH,NA,AF, global	4	**AMMA,OPC,SPC,TPC**
Spread	Wind: 925mb	NH,NA,AF, global	4	**AMMA,OPC,SPC,TPC**
Spread	Z: 700mb	NH,AF, global	4	**AMMA,OPC,SPC,TPC**
Spread	Z: 850mb	NH,AF, global	4	**AMMA,OPC,SPC,TPC**
Mean	AVOR: 500mb	NA,SA,CA	3	**HPC,LAP,SPC**
Mean	AVOR: 850mb	NA,SA,CA	3	**HPC,LAP,SPC**
Mean	CAPE	NA,AF	3	**AMMA,HPC,SPC**
Mean	QPF	NA,SA,CA,AF	3	**AMMA,HPC, LAP**

Ensemble Functionalities

List of centrally/locally/interactively generated products required by NCEP Service Centers for each functionality are provided in attached tables (eg., *MSLP, Z,T,U,V,RH, etc, at 925,850,700,500, 400, 300, 250, 100, etc hPa)*

	FUNCTIONALITY	***CENTRALLY GENERATED***	***LOCALLY GENERATED***	***INTERACTIVE ACCESS***
1	Mean of selected members *Done*			
2	Spread of selected members *Done*			
3	Median of selected values *Done Sept. 2005*			
4	Lowest value in selected members *Done Sept. 2005*			
5	Highest value in selected members *Done Sept. 2005*			
6	Range between lowest and highest values *Done Sept. 2005*			
7	Univariate exceedance probabilities for a selectable threshold value *Done, Dec 05*			
8	Multivariate (up to 5) exceedance probabilities for a selectable threshold value *Done, Dec 05*			
9	Forecast value associated with selected univariate percentile value *Done Sept. 2005*			
10	Tracking center of maxima or minima in a gridded field (eg – low pressure centers) *Done Sept. 2005*			
11	Objective grouping of members *Planning starts FY06, Deliver FY07-08*			
12	Plot Frequency / Fitted probability density function at selected location/time (lower priority) *Detailed Planning FY06, Deliver FY07*			
13	Plot Frequency / Fitted probability density as a function of forecast lead time, at selected location (lower priority) *Detailed Planning FY06, Deliver FY07*			
14	Spaghetti (ability to interactively change contour/domain etc) *Basic function done; Interactive version to be scheduled (TBS)*			

Additional basic GUI functionalities:

- Ability to manually select/identify members *(TBS)*
- Ability to weight selected members *Done, Sept. 05*

Potentially useful functionalities that need further development:

- Mean/Spread/Median/Ranges for amplitude of specific features *(TBS)*
- Mean/Spread/Median/Ranges for phase of specific features *(TBS)*

Ensemble Data Request Information

- AT NCDC : Over 10 days, 09/26-10/05

0026 meteo.noa.gr
0003 dip0.t-ipconnect.de
1527 weathersa.co.za
1860 fsu.edu

- In a ten day period 09/26-10/05

0001 retail.telecomitalia.it
0001 196.12.132.227
0001 rr.com
0002 proxy2.enpc.fr
0003 202.131.2.222
0065 fi.upm.es
0071 bruneiweather.com.bn
0150 abo.wanadoo.fr
0152 meteo.noa.gr
0297 zedxinc.com
0968 buran.meteotest.ch
1050 nps.edu
1141 nuvox.net
1298 sd.cesga.es
1927 live-servers.net
9489 psu.edu
137069 cox.net

Ensemble Data Request Information (Cont.)

- A list of the users who pulled GEFS data from the NCEP anonymous ftp server in September, and have left a valid email address at login.
  - 26 e-mail lists
- A list of the users who pulled GEFS data from the WOC server in the past month, and have left a valid email address at login.
  - 26 e-mail lists.

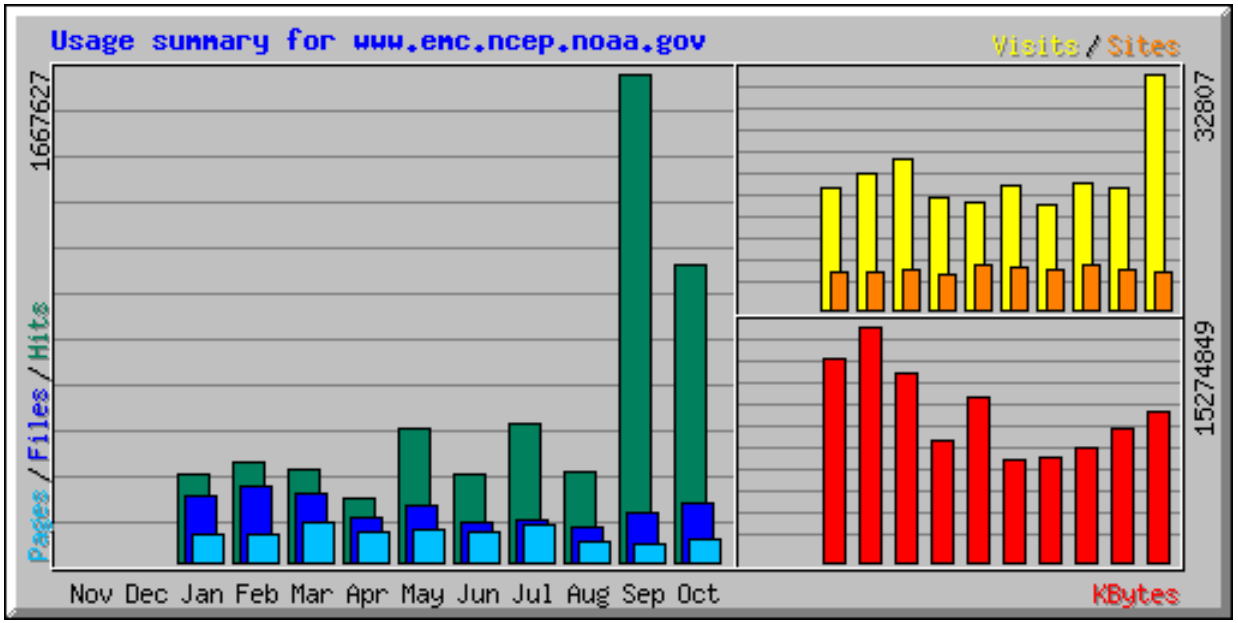
GEFS Major Implementation Plan (FY07)

- Upgrade vertical resolution from 28 to 64 levels for 20 perturbed forecasts
  - 4 cycles per day
  - T126L64
  - Up to 384 hours (16 days)
- Real-time generation of hind-cast at T126/L64 resolution.
  - 4 cycles per day
  - 27 hind-casts for each cycle since 1979
  - Using reanalysis II initial conditions (T62L28 resolution)
  - Add random noise to high frequency (T63-T170) by using
    - Cycling (6-hr T170 model forecast)
    - Other method?
- (Alternate) – upgrade both horizontal and vertical resolution to T170/L64
- Introduce ESMF scheme that allows concurrent generation of all ensemble members.
- Add stochastic perturbation scheme to account for model errors (tentative plan)

Ensemble Web-Page Access Information

Usage Statistics for GMB ENS www.emc.ncep.noaa.gov

Summary Period: Last 12 Months
Generated 30-Oct-2006 14:30 EST



NAEFS upgrade plan (FY07)

- Add approximately 15 new variables to current 51 pgrba for NAEFS data exchange.
  - Such as vertical shear, helicity, u,v, t, RH for 100, 50hPa, LH, SWR, LWR at surface, and etc..
- Add GFS high resolution control bias correction by using current method for ensemble.
  - There is a problem when we estimate bias after GFS change resolution after 180 hours
- Set up GFS low resolution (ensemble) control run on NCO's real time parallel prior to GFS upgrade in the future.
  - As bias estimation of GFS major/minor implementation
  - Need to compare the bias of ensemble mean and control
- Improve bias correction algorithm.
  - Pending on hind-cast information
  - Two weights: one from real-time (analysis and forecast) bias estimation (mainly for week-1), another one from hind-cast (mainly for week-2)

NAEFS Expansion and Future Plan

- Plans to be coordinated with THORPEX
  - Links with Phase-2 TIGGE archive and beyond (GIFS)
- Expansion
  - FNMOC
    - Experimental data exchange by Dec 2006
    - Preliminary evaluation by Dec 07
    - Operational implementation by Dec 08 (subject to improved performance)
  - UK Metoffice
    - Decision on going operational & possibly joining NAEFS - by 2008
  - KMA, CMA, JMA
    - Expressed interest, no detailed plans yet
- Data exchange with MSC
  - Replace current ftp with more reliable telecom by Dec 08
- Statistical post-processing
  - Continual enhancements to current methods (2nd moment correction, addtnl vars)
  - Testing (Dec 08) & possible implementation (09) of advanced methods
- Products
  - Week-2 – experimental by Nov 06
  - Web graphics
    - MSC – Nov 06
    - NCEP – Mar 07

THORPEX LINKS

PRODUCT DEVELOPMENT

- Goals:
  - Develop new numerical modeling 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