December 2007 Upgrade of the NCEP Global Ensemble Forecast System (NAEFS)

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Acknowledgements

EMC: Dingchen Hou, Jun Du, Manuel Pondeca, Geoff DiMego, Mark Iredell and Steve Lord

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MDL: Valery Dagostaro and Kathryn Gilbert

MSC/Canada: Yves Pelletier, Lewis Poulin, Gilles Verner, Andre Methot and Louis Lefaivre

Planned Changes - Summary

- Bias corrected GFS forecast
  - Use the same algorithm as ensemble bias correction
  - Up to 180 hours
- Combine bias corrected GFS and ensemble forecast
  - Dual resolution ensemble approach for short lead time
  - GFS has higher weights at short lead time
- NAEFS new products
  - Combine NCEP/GEFS (20m) and CMC/GEFS (20m)
  - 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

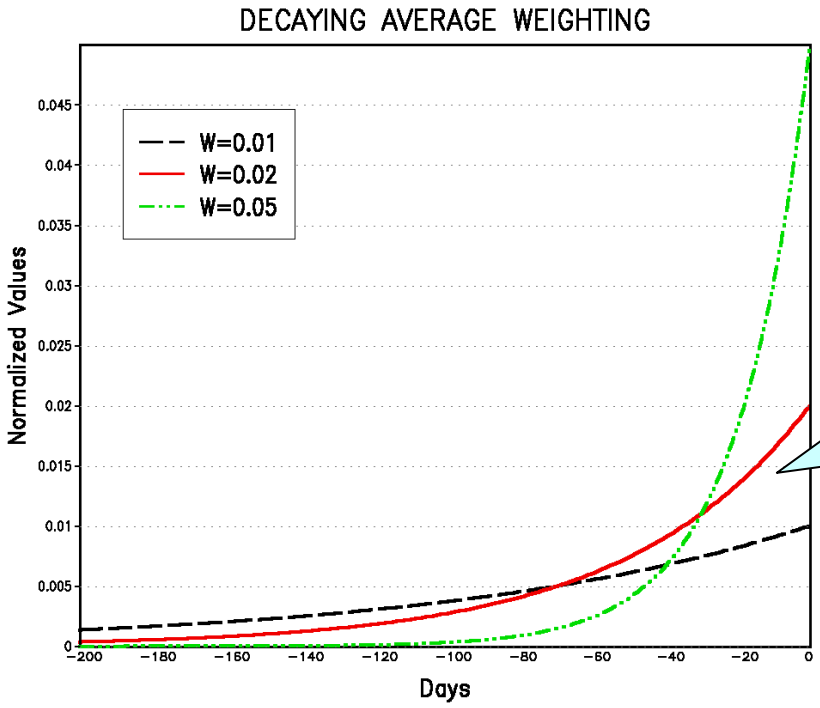
NAEFS current configuration

Updated: July 2007

	NCEP	CMC
Model	GFS	GEM
Initial uncertainty	ETR	EnKF
Model uncertainty	None	Yes
Stochastic physics	None	Yes
Tropical storm	Relocation	None
Daily frequency	00,06,12 and 18UTC	00 and 12UTC
Resolution	T126L28 (d0-d16) ~90km	(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	March 27th 2007	July 10th 2007

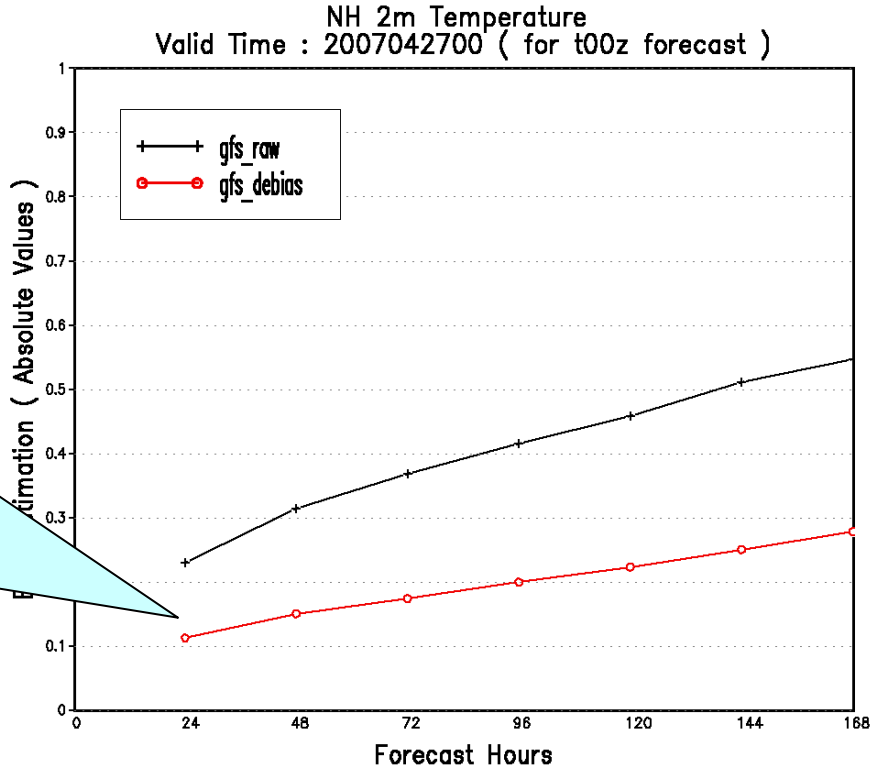
New Products in CCS - Summary

- Bias corrected GFS forecast
  - Directory:/com/gens/para/gefs.yyyymmdd/cyc/pgrba_bc
    - Files: gegfs* (up to 180 hours)
- NAEFS new products: (early run: NCEP/GEFS only)
  - Probabilistic forecasts at 1*1 degree resolution (global)
    - Directory:/com/gens/para/gefs.yyyymmdd/cyc/pgrba_ bc
    - Files: geavg*, gespr*,gemode*,ge10p*,ge50p*,ge90p* represent ensemble mean, spread, mode, 10%, 50% (median) and 90% probability forecast
  - Anomaly forecast for ensemble mean at 1*1 degree resolution (global)
    - Directory:/com/gens/para/gefs.yyyymmdd/cyc/pgrba_an
    - Files: geavg*
  - At 5km resolution (down-scaling for CONUS only)
    - Directory:/com/gens/para/gefs.yyyymmdd/cyc/ndgd
    - Files: geavg*,gemode*,ge10p*,ge50p* and ge90p*
- NAEFS new products: (later run: combine NCEP and CMC's ensemble)
  - Probabilistic forecast at 1*1 degree resolution (global)
    - Directory:/com/gens/para/naefs.yyyymmdd/cyc/pgrba_bc
    - Files: geavg*,gespr*,gemode*,ge10p*,ge50p* and ge90p*
  - Anomaly forecast for ensemble mean at 1*1 degree resolution (global)
    - Directory:/com/gens/para/naefs.yyyymmdd/cyc/pgrba_an
    - Files: geavg*
  - At 5km resolution (down-scaling for CONUS only)
    - Directory:/com/gens/para/naefs.yyyymmdd/cyc/ndgd
    - Files: geavg*,gemode*,ge10p*,ge50p* and ge90p*
    - File: dvrtma.t00z.ndgd_conus (down-scaling vector)

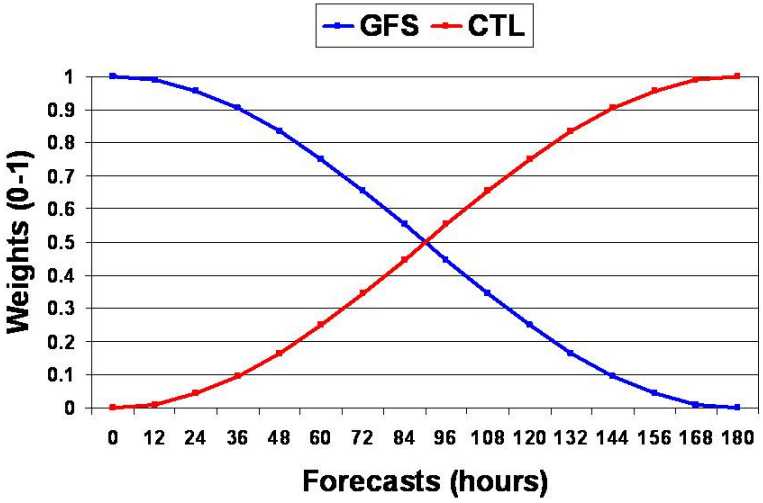


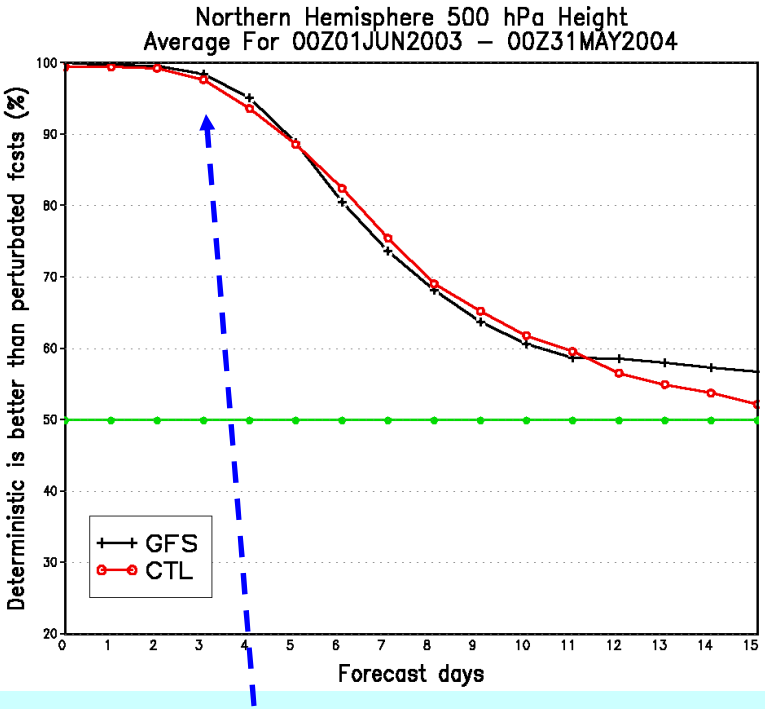
GFS bias correction based on an accumulated bias by using decaying average weight (0.02) which is the same as GEFS used

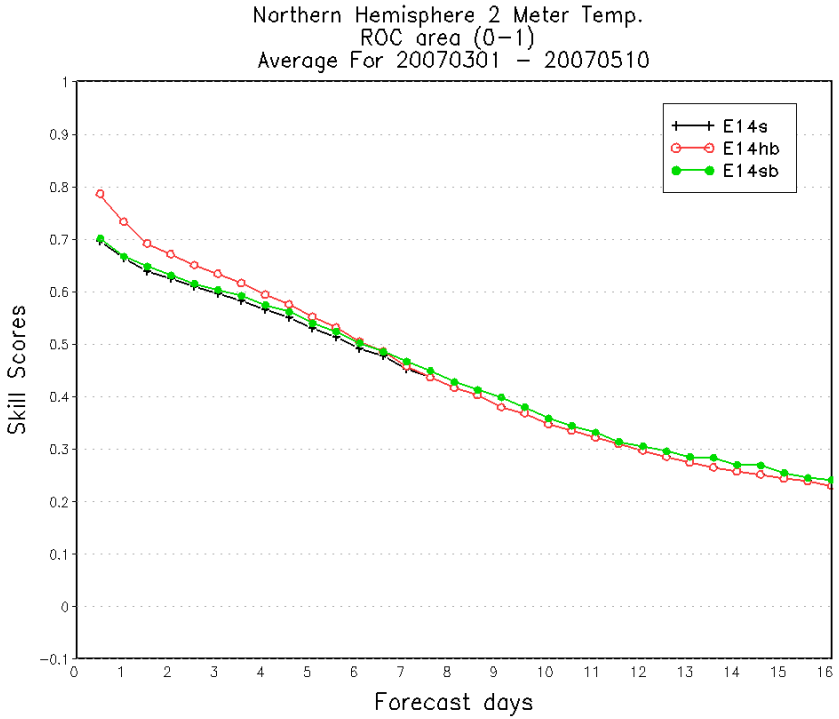
The absolute errors are reduced after bias correction for 2-meter temperature (The stats are accumulated from 0.02 decaying average)



Combined GFS and GEFS forecasts at first 180hr





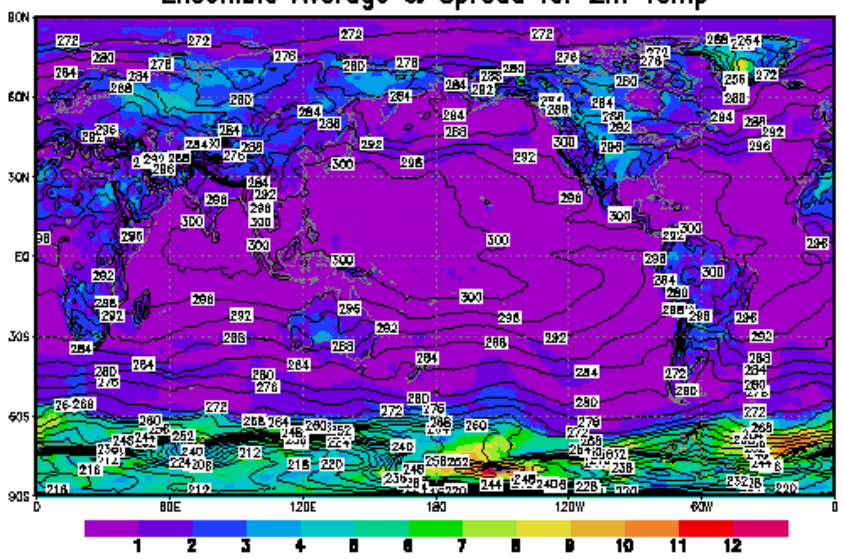


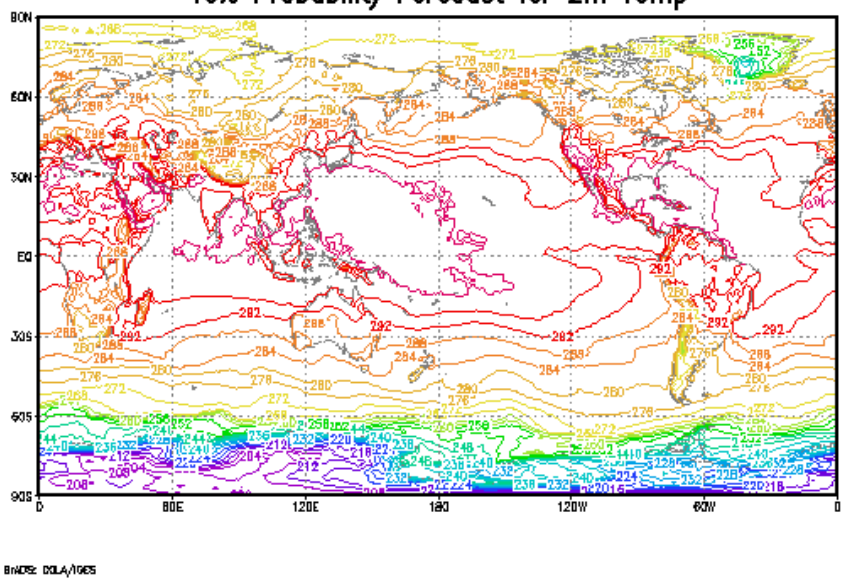
GFS has more skill than ensemble control for short lead time

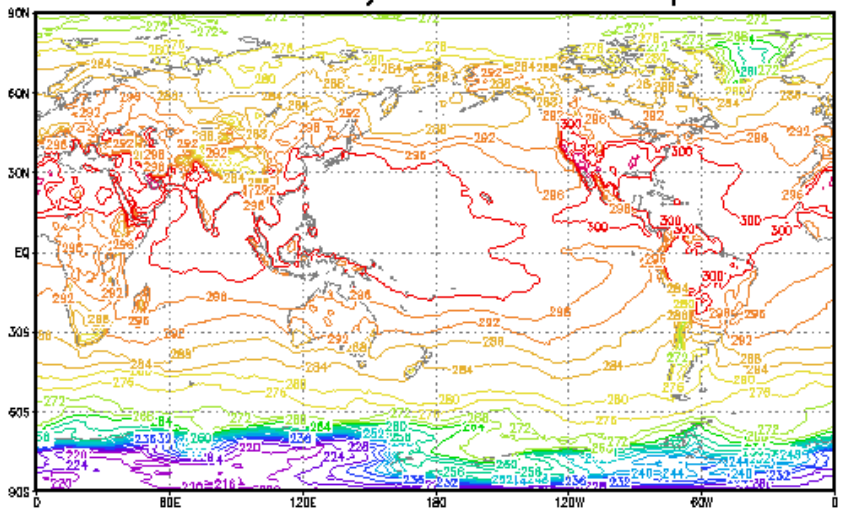
Combined GFS and GEFS Forecast has more skill (red) than GEFS only (black)

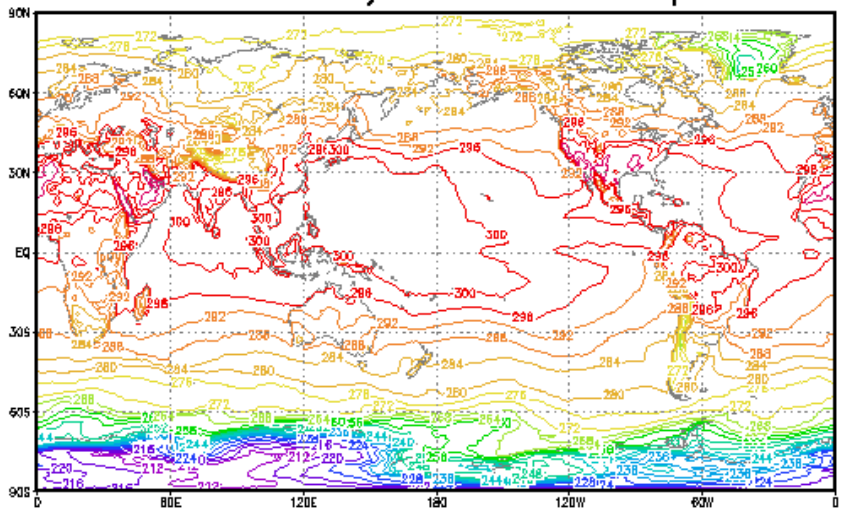
Jun Du first introduced dual-resolution to SREF, by using constant weight

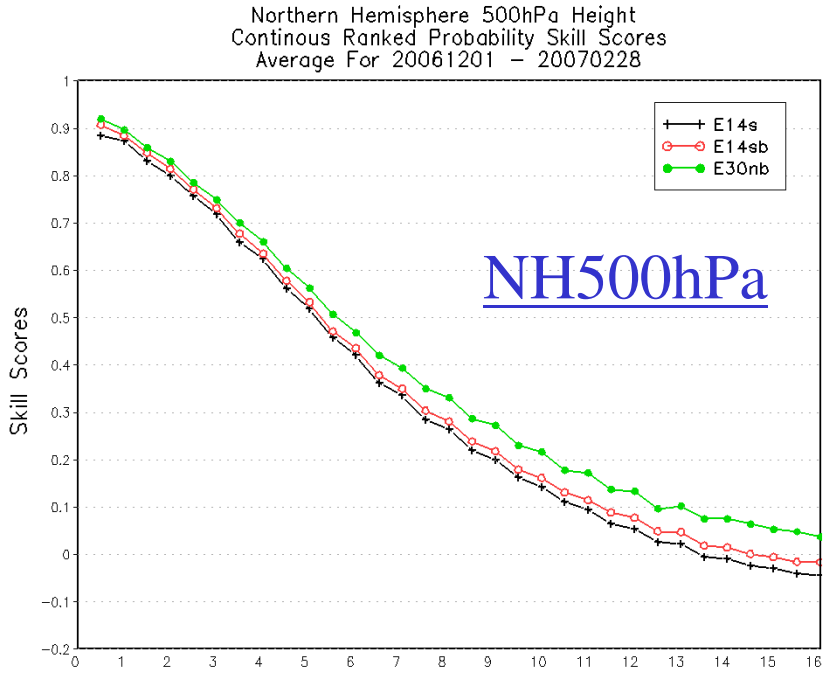
Examples of NAEFS product

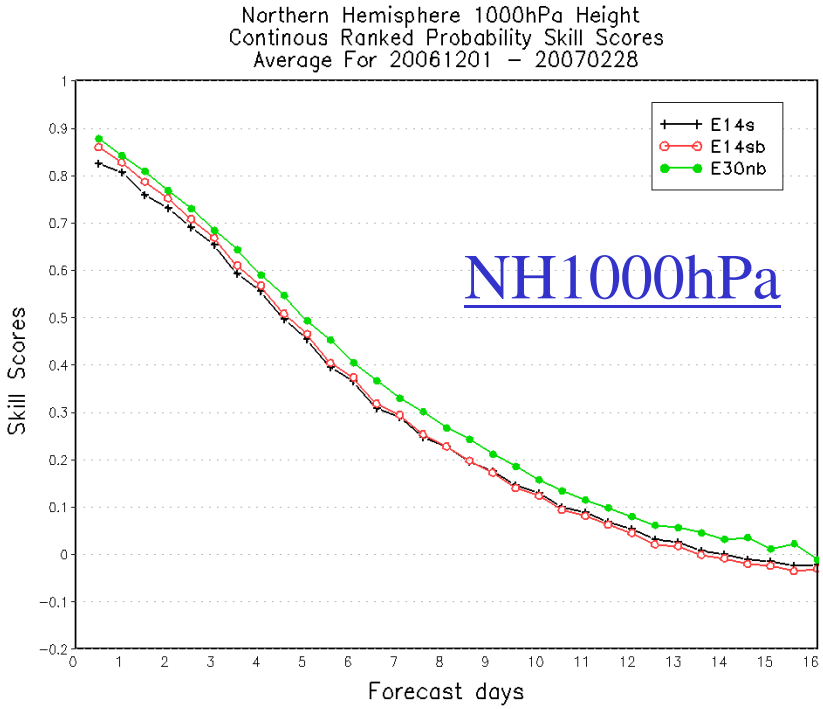


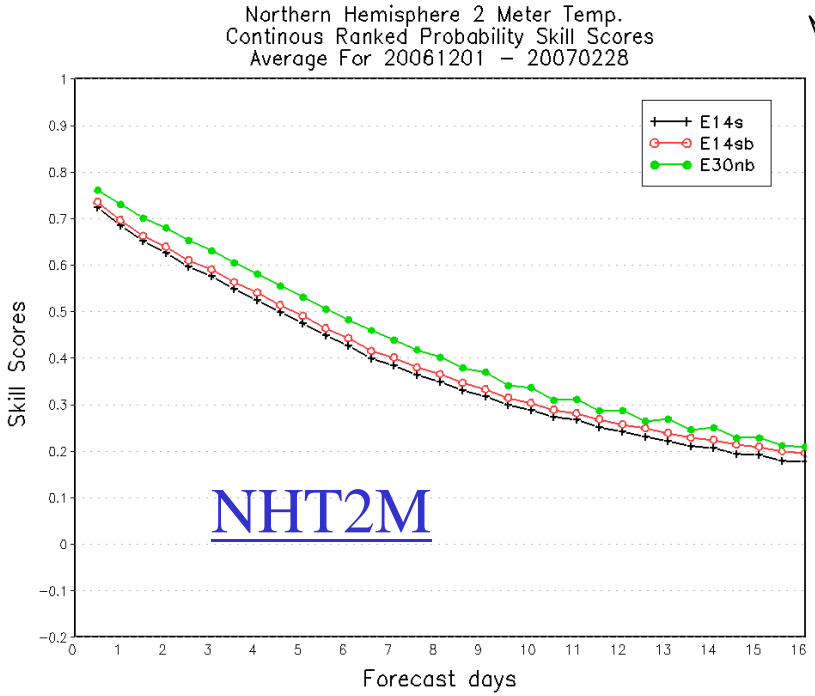












All these stats show the best values from probabilistic distribution of joined ensemble (NAEFS) for upper atmosphere and near surface. Green line is from NAEFS.

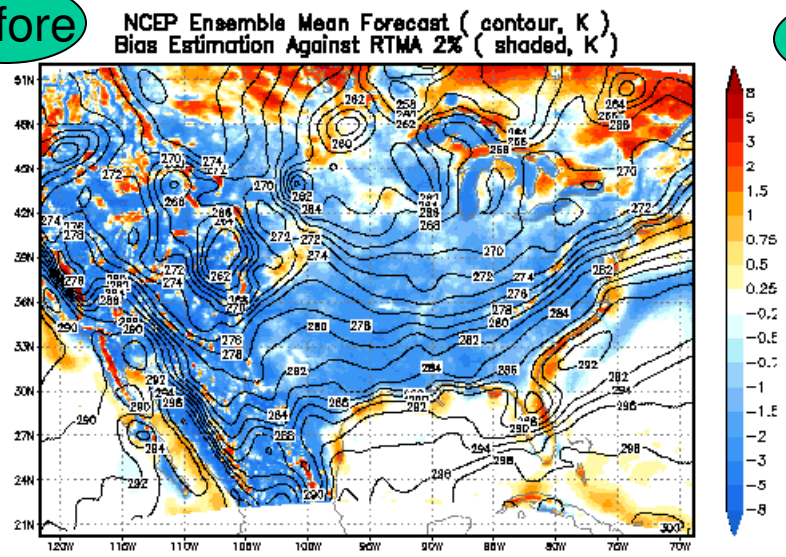
Statistical downscaling for NAEFS forecast

- Proxy for truth
  - RTMA at 5km resolution
  - Variables (surface pressure, 2-m temperature, and 10-meter wind)
- Downscaling vector
  - Interpolate GDAS analysis to 5km resolution
  - Compare difference between interpolated GDAS and RTMA
  - Apply decaying weight to accumulate this difference – downscaling vector
- Downscaled forecast
  - Interpolate bias corrected 1*1 degree NAEFS to 5km resolution
  - Add the downscaling vector to interpolated NAEFS forecast
- Application
  - Ensemble mean, mode, 10%, 50%(median) and 90% forecasts

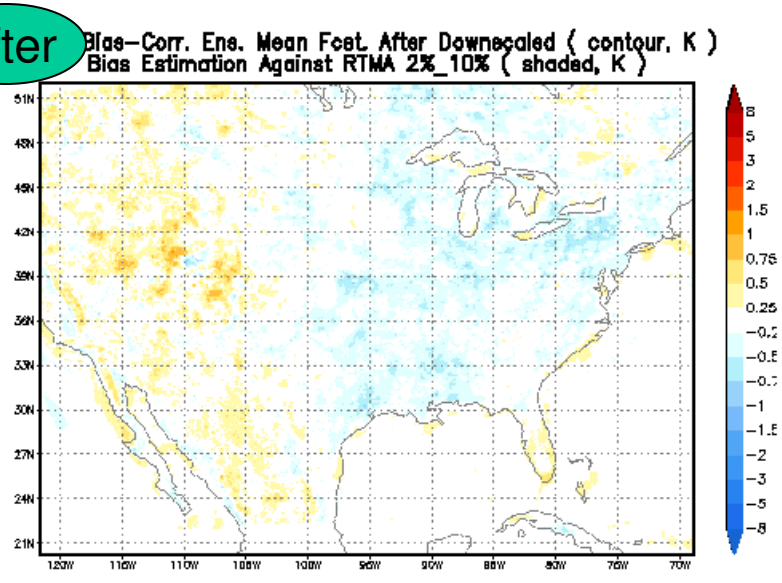
00hr GEFS Ensemble Mean & Bias Before/After Downscaling 10%

2m Temperature

Before

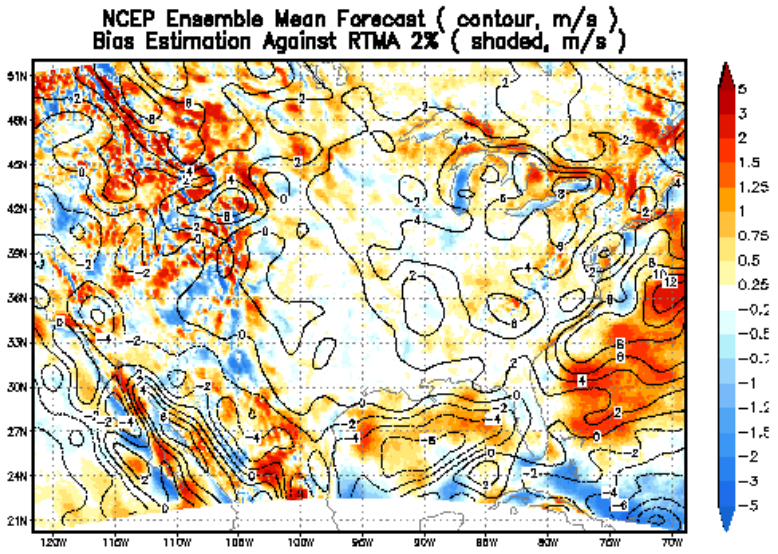


After

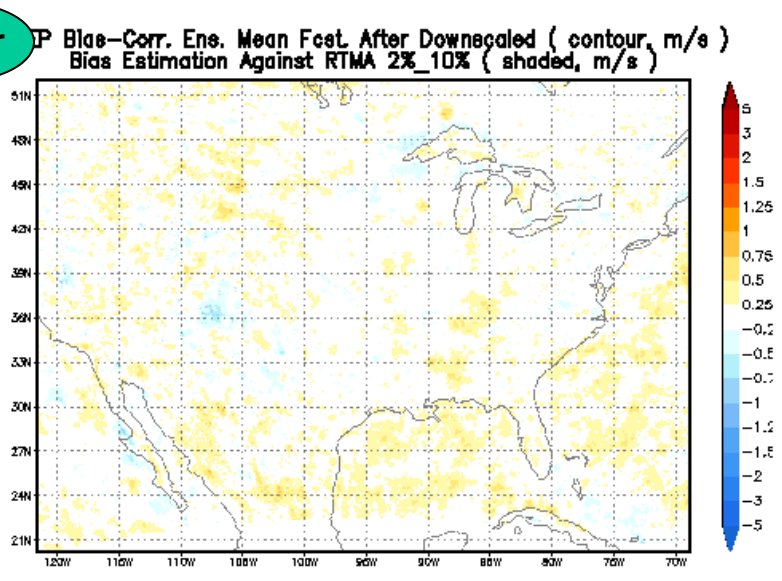


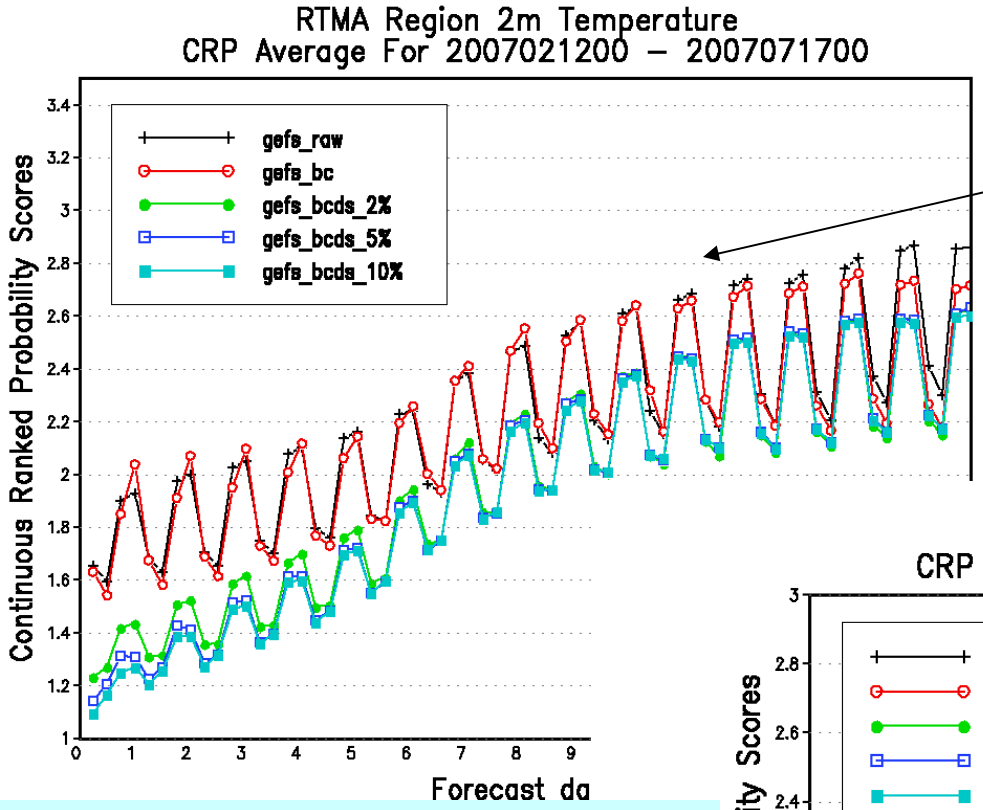
10m U Wind

Before



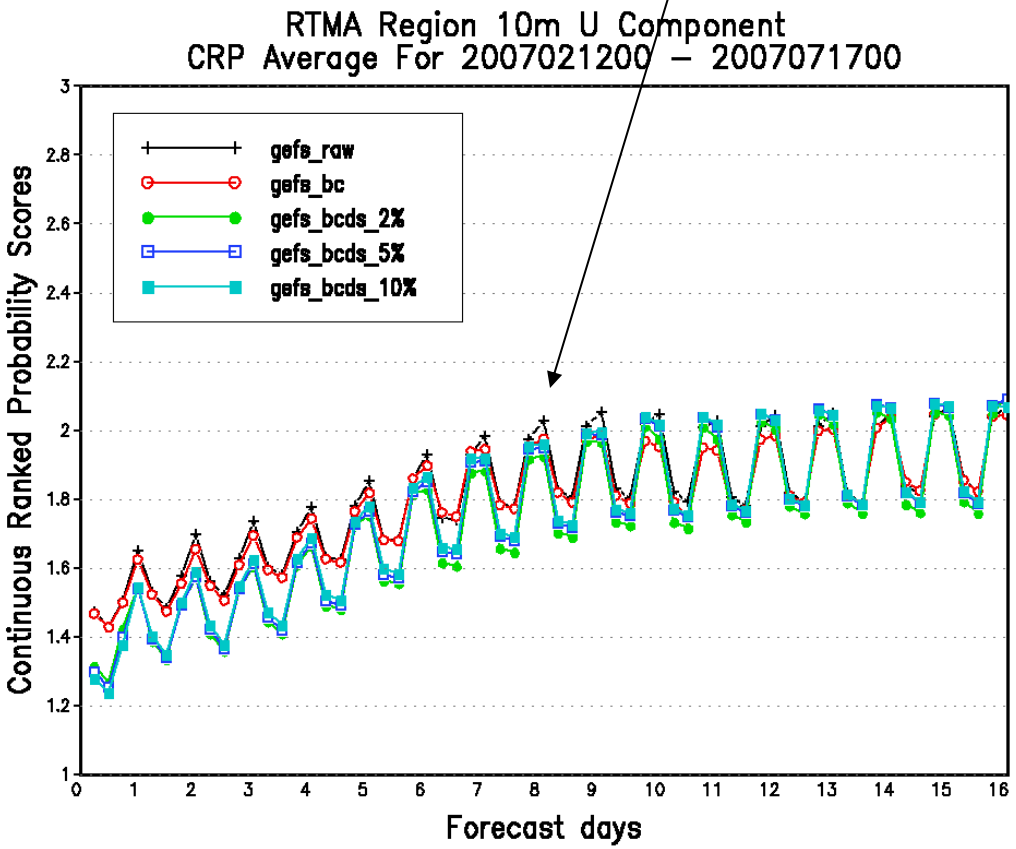
After





T2M for CONUS

U10m for CONUS



Continuous Ranked Probability Scores (CRPS) is to measure the distance of truth from ensemble's distribution. These two stats show which decaying weight is best to CONUS region statistical down-scaling

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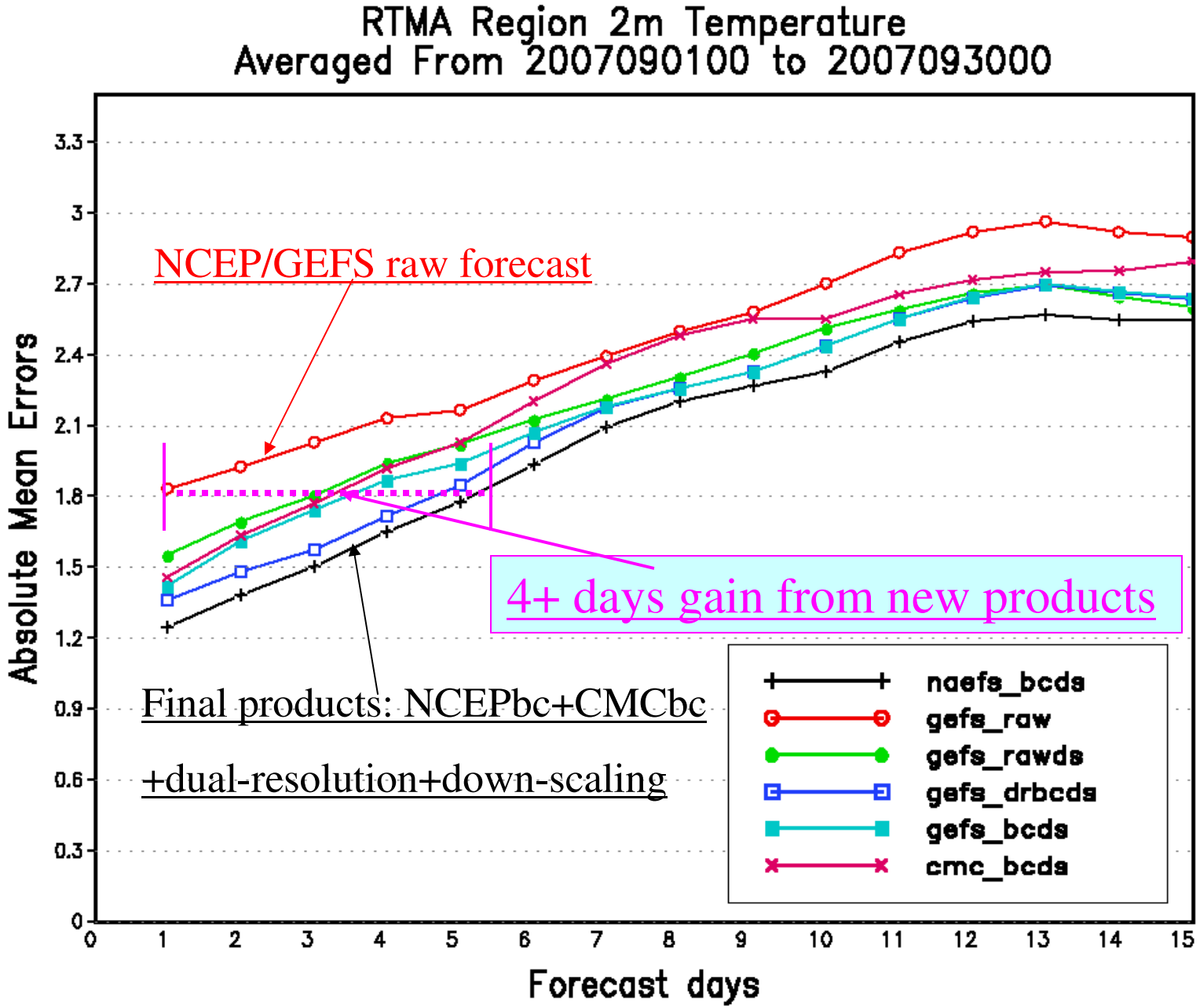
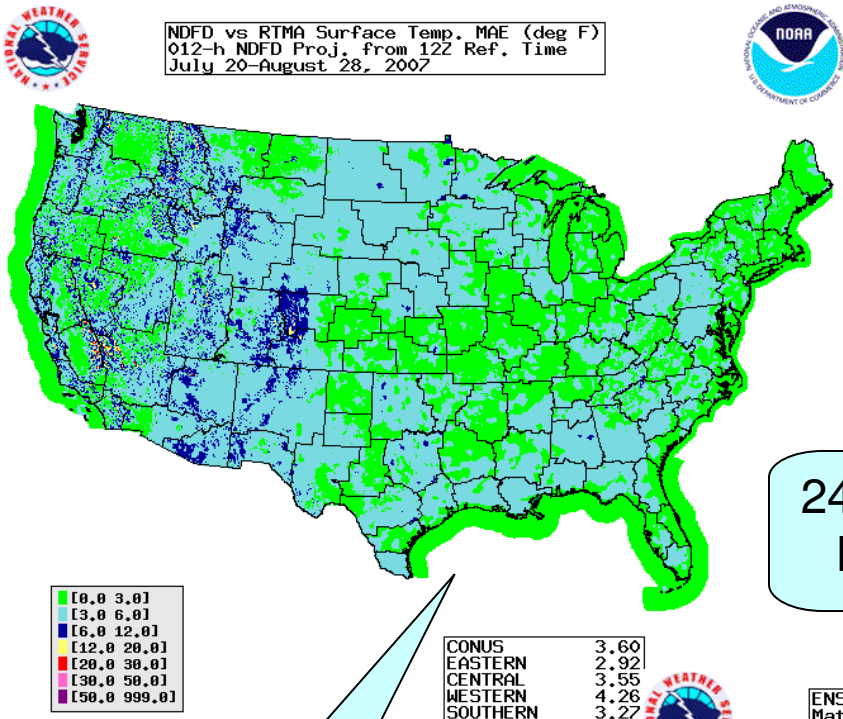


BO CUI, GCWMB/EMC/NCEP/NOAA

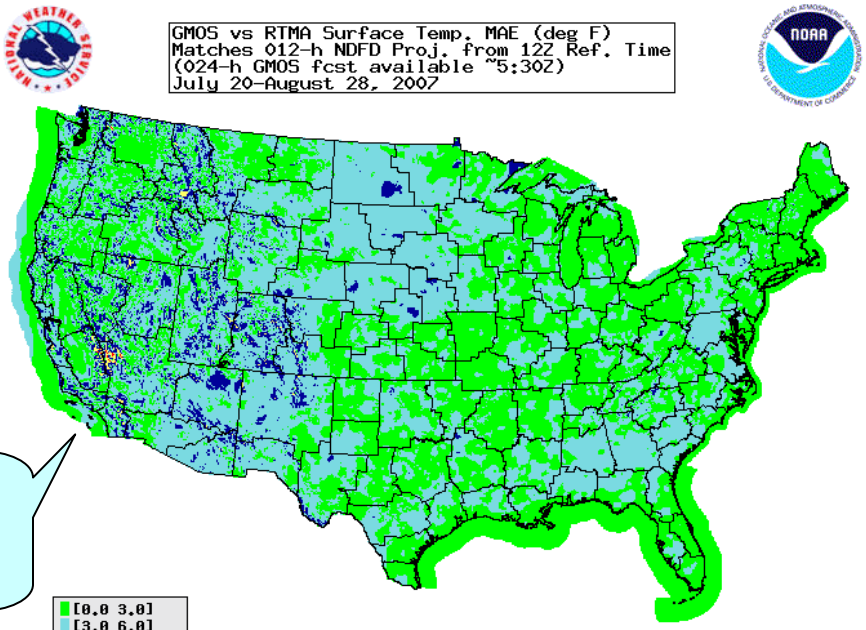
Statistical Downscaling Verification

-Contribute by MDL

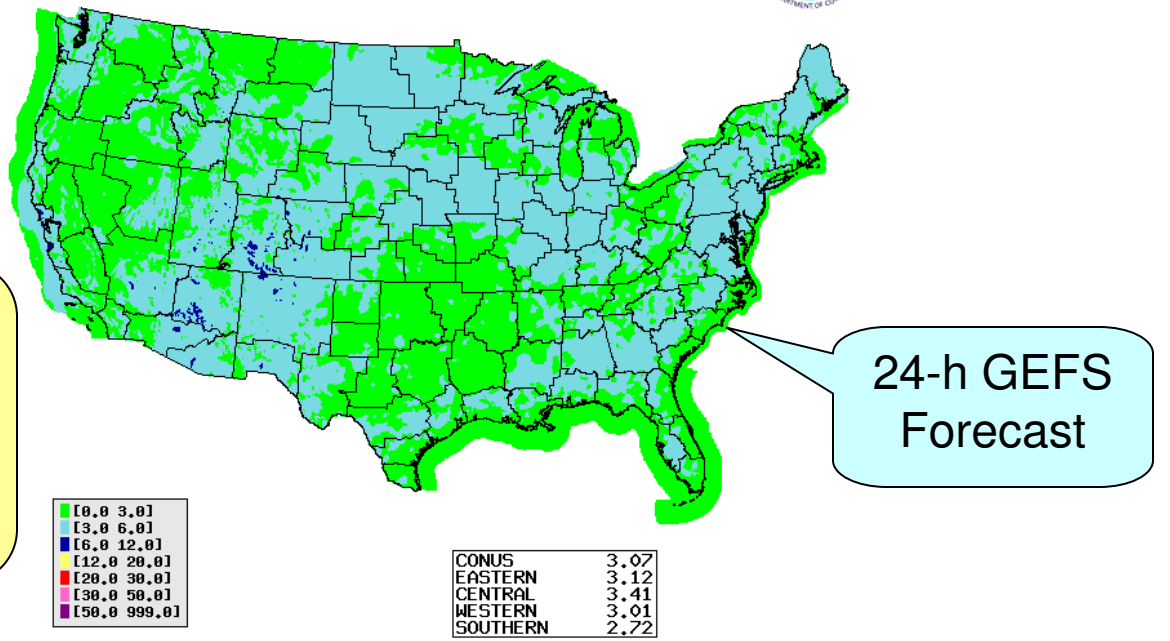
- 2-meter temperature only
- Period: July 20 – August 28 2007 (40 days)
- All verifications against RTMA
- NDFD: Official forecasts from previous day 12UTC
- GMOS: Gridded MOS forecasts from 00UTC
- GEFS: Bias corrected & downscaled 00UTC GEFS forecasts
  - Bias corrected NCEP GEFS ensemble mean only
    - Significant improvements not assess yet from
      - Dual resolution GEFS
      - NAEFS combination (GEFS + CMC)
      - Tuned downscaling method (0.3 coefficient instead of 0.1)



12-h NDFD Forecast



24-h GMOS Forecast



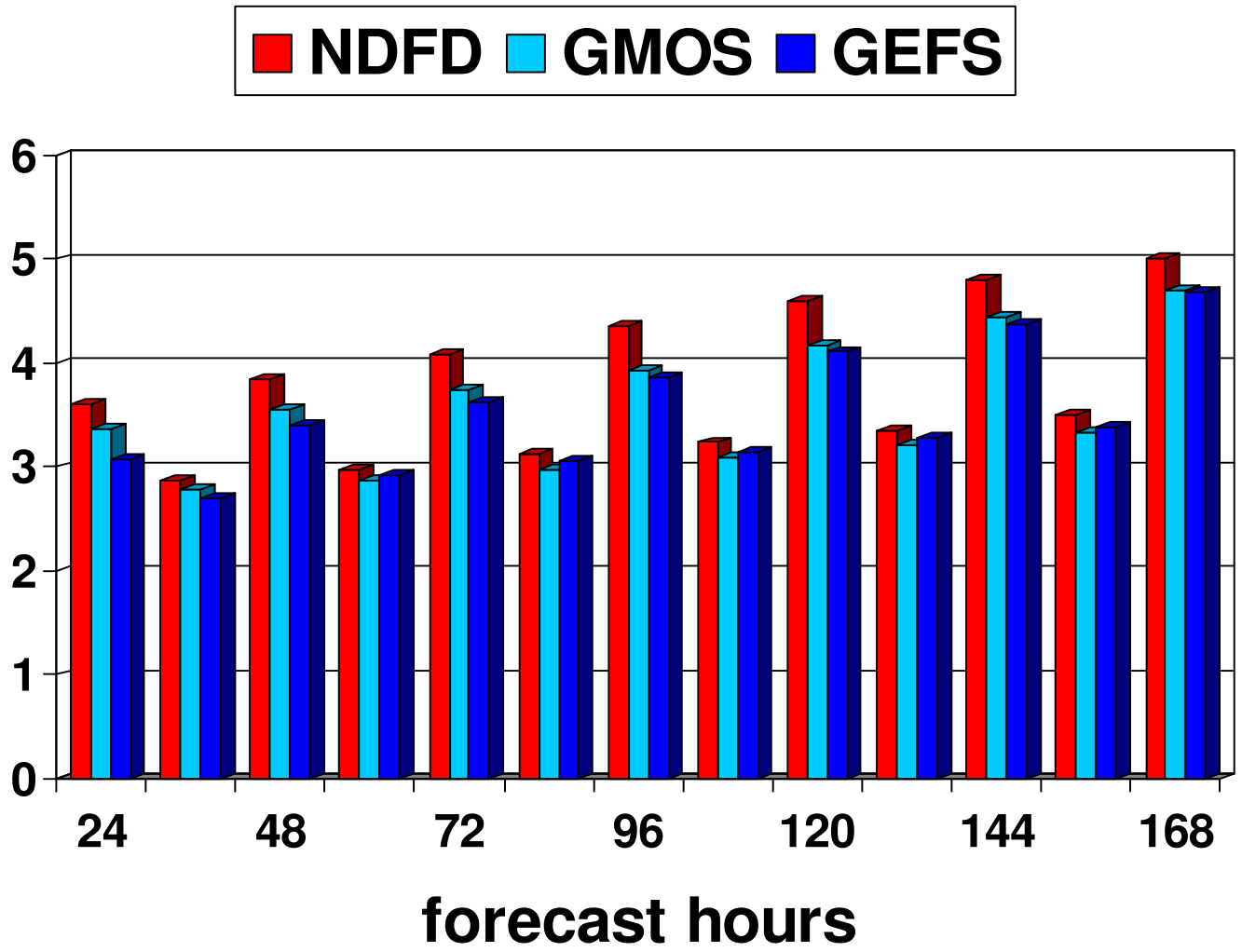
24-h GEFS Forecast

For CONUS:
GEFS(3.07) : NDFD(3.60)
17% impr. over NDFD
GEFS(3.07) : GMOS(3.37)
10% impr. over GMOS

40 day average absolute errors of 2-meter temperature (NDFD has 12hr advantage)

COUNS only – verified against RTMA

2-m temp. forecast errors



Subjective Evaluation

- TPC, HPC, MDL, and CPC were requested to participate
- TPC Evaluation
  - Determined that new products would not be utilized in their forecast process and opted out of the evaluation
- CPC Evaluation
  - The proposed changes to the NAEFS and GEFS are not expected to have any impact on current CPC operational products. The proposed changes do not affect the data used in current operational CPC products.
- MDL evaluation
  - Scores were dependent on analysis used for verification
    - The NAEFS temperature forecasts were up to 0.5 degrees F better than the NDFD and Gridded MOS when compared to the RTMA
    - NDFD and Gridded MOS were better than the NAEFS when compared to MDL's BCDG* (gridded MOS) analysis.

Subjective Evaluation

- HPC Evaluation
  - In past, GEFS ensemble mean often too strongly resembled the operational GFS solution. The added diversity in the NAEFS has somewhat alleviated this issue.
  - HPC medium range forecasters have commented positively about the availability of additional uncertainty information with the NAEFS
  - A specific example where the NAEFS showed improvement over the GEFS ensemble mean was in the cast of Hurricane Noel's extratropical transition and its impacts in the Northeastern United States. The NAEFS ensemble mean forecast from 00 UTC 31 October showed a low center farther west than the GEFS ensemble mean and closer to the eventual track of Noel as it passed east of New England. Perhaps not surprisingly, the NAEFS ensemble mean looked like a blend of the CMC and GEFS means. Closer to the time of Noel's extratropical transition, there was added value in the spread from the NAEFS which indicated large spread to the northeast and southwest of the mean position, suggesting significant timing and heading variability within the ensemble at a 2-3 day lead time.
  - NAEFS products will certainly have utility for HPC operations

User comments

- Data distribution:
  - Currently, there is only partial GEFS/NAEFS data for public
    - Very limited on TOC
    - Limited on NCEP public server “ftpprd”
    - There is no bias corrected 1.0 degree data available on TOC and ftpprd
  - User requirement
    - To improve our data distribution system to allow most/all ensemble products to public
    - It’s very important to have NAEFS final product to users/public
- Data ingest:
  - To improve our encode/decode utilities to allow NCEP service centres, WFO to evaluate and use our new products.
  - To have the way to ingest GEFS/NAEFS data to AWIPS, and NAWIPS easily.
- Special acknowledgement to Joey Carr’s group from
  - Richard Grumm (WFO at State College, PA)

Summary

- This is a major implementation
- System delivery: September 11
- NCEP Initial testing: September 17-October 12
- Parallel testing: October 16 – present
- Final version of system delivered: October 16
- NCEP parallel evaluation period:
  - Request for participation - 10/16/07
  - Evaluation period is 10/24/07 through 11/23/07
  - Evaluations are due 11/26/07
- Implementation date: December 4th
- Full summary of this implementation: http://wwwt.emc.ncep.noaa.gov/gmb/yzhu/html/imp/200711_imp.html
- This package will be suitable for SREF, too.

Future Plan

- Correct NAEFS downscaling algorithm
  - Error in software implementation found on Nov. 15
    - Downscaling of Canadian ensemble data affected
      - Negatively affects primarily forecasts from 06, 12, 18Z cycles
  - Must implement correction operationally as soon as practical
- Apply statistical down-scaling method to other regions, Alaska, Hawaii, Puerto Rico and Guam, when RTMA is available
  - Needed in support of Alaska Desk, etc
  - Streamline implementation process?
- Add new variables to NDFD grids, such as wind speed/direction, maximum/minimum temperature, 2-meter dew point temperature etc…
- Enhance products by
  - Improvements to RTMA
    - Bias correction of forecast first guess using recursive algorithm
      - Under testing