Improvements to the NCEP Global and Regional Data Assimilation Systems

Stephen J. Lord
Director
NCEP Environmental Modeling Center

EMC Staff

NCEP: "where America's climate, weather, and ocean services begin"

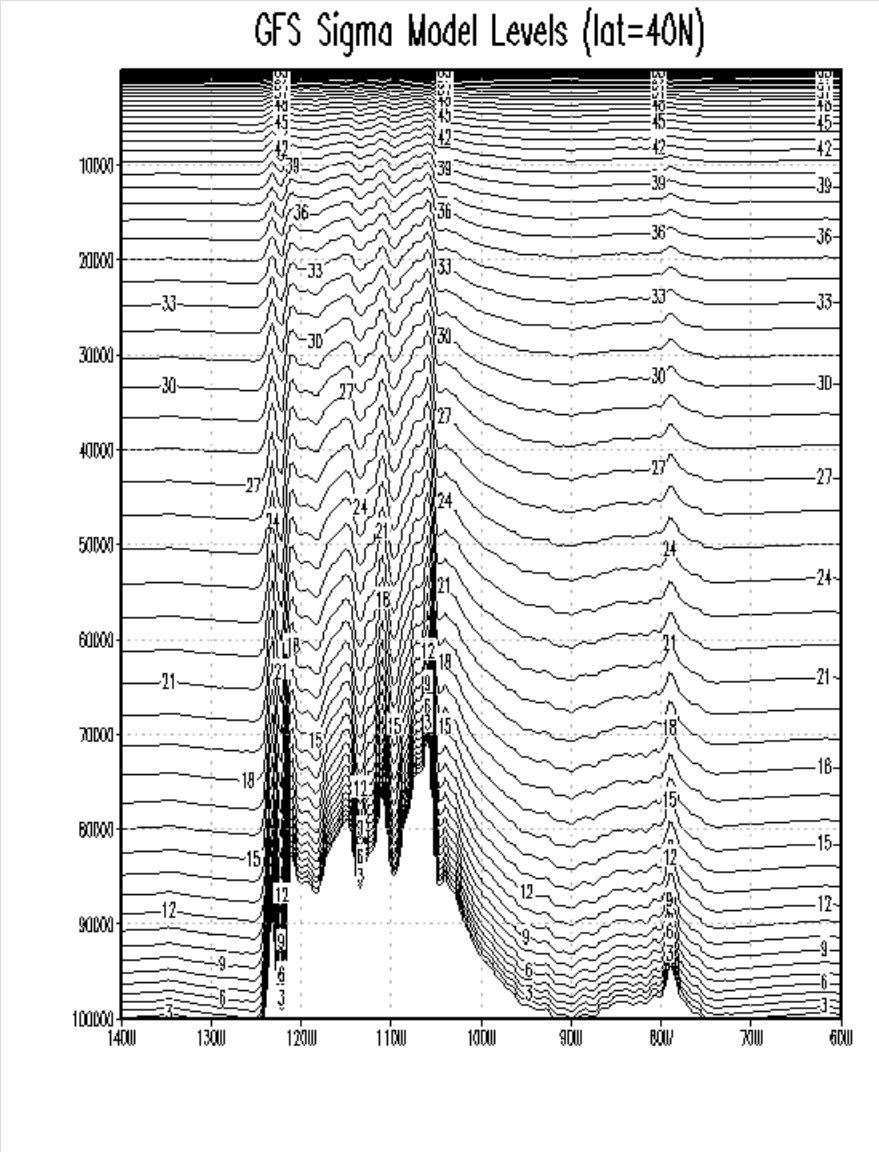
Overview

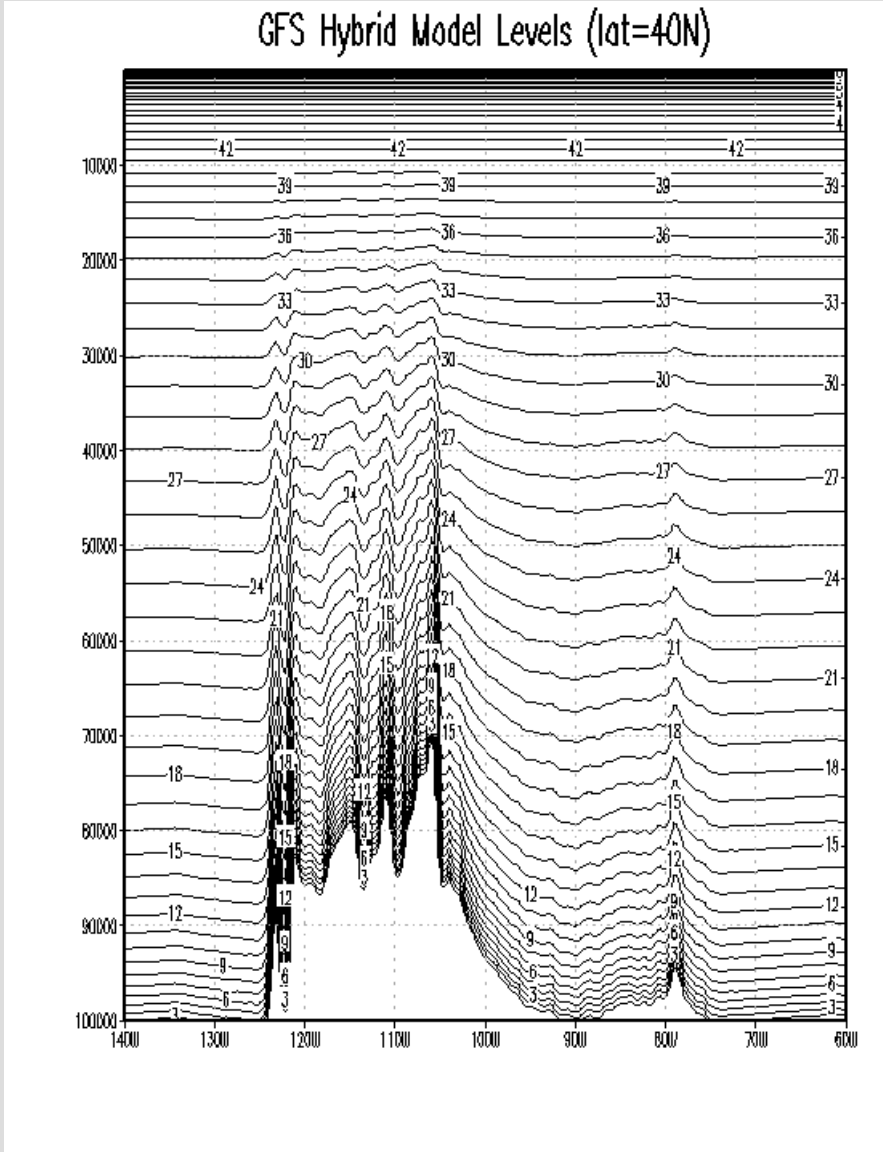
- Global Forecast System (GFS) implementations – May 2007 and April 2008
- North American Model (NAM) implementation – February 2008
- Plans for future
- Summary

GFS implementation – 1 May 2007

- **Gridpoint Statistical Interpolation (GSI)** analysis
  - Unify the NCEP 3DVAR assimilation system (global and regional)
  - Prepare for future analysis improvements (e.g. simplified 4d-var, situation-dependent background errors)
- **Add new observing systems**
  - COSMIC
  - Full resolution AIRS
- **Change vertical coordinate to hybrid sigma-pressure**, reducing some upper air model errors
- Modernize the radiation package
- Increase output particularly for hydrology

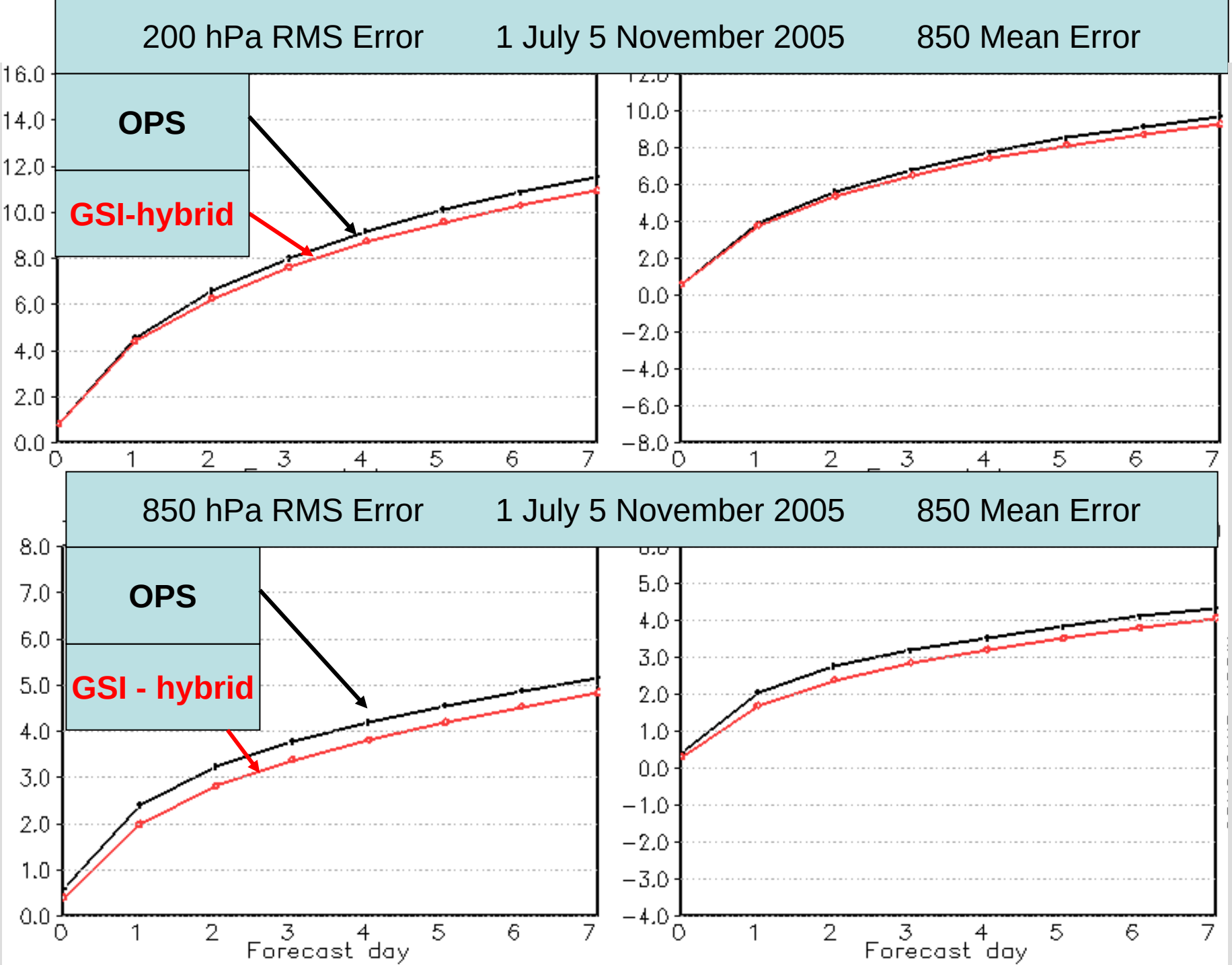
Vertical coordinate comparison across North America





Final testing set

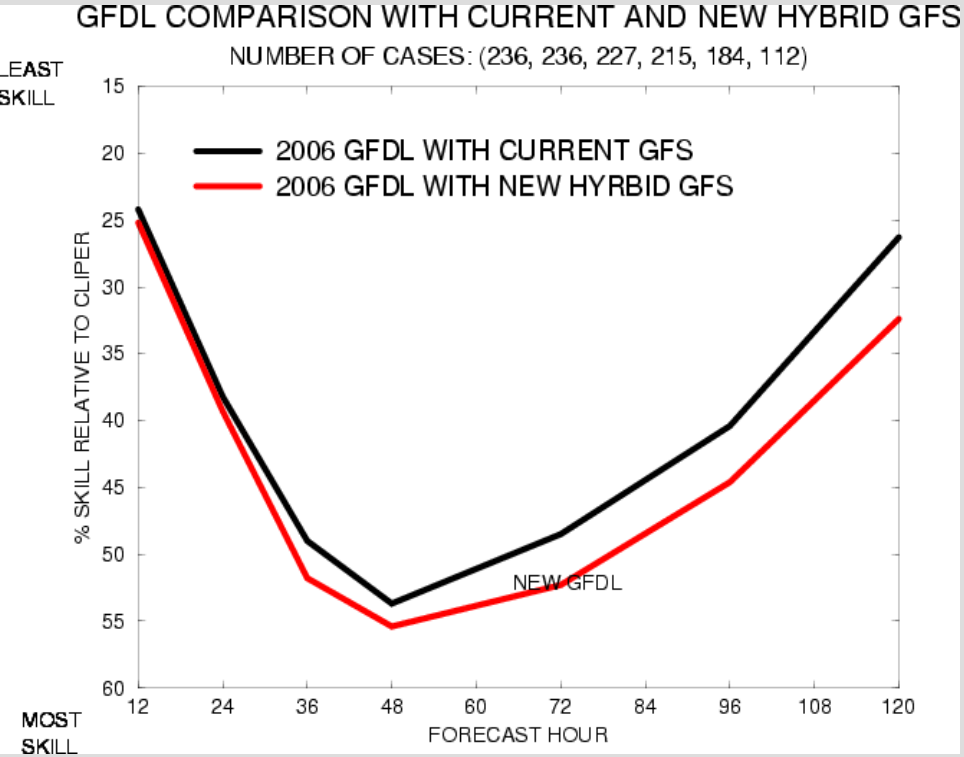
- Retrospective testing
  - 15 June 2005 to 5 November 2005
    http://wwwt.emc.ncep.noaa.gov/gmb/para/paralog.2005tropics_retro_gsihybrid.html
  - 31 July 2006 to 5 November 2006
    http://wwwt.emc.ncep.noaa.gov/gmb/para/paralog.2006tropics_retro_gsihybrid.html
  - 24 October 2006 to 5 February 2007
    http://wwwt.emc.ncep.noaa.gov/gmb/para/paralog.200607winter_retro_gsihybrid.html
- Pre-implementation parallel run
  - January-May 2007


200 hPa RMS Error
1 July 5 November 2005
850 Mean Error
OPS
GSI-hybrid
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
10.0
8.0
6.0
4.0
2.0
0.0
−2.0
−4.0
−6.0
−8.0
0
1
2
3
4
5
6
7
850 hPa RMS Error
1 July 5 November 2005
850 Mean Error
OPS
GSI - hybrid
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
5.0
4.0
3.0
2.0
1.0
0.0
−1.0
−2.0
−3.0
−4.0
Forecast day
Forecast day

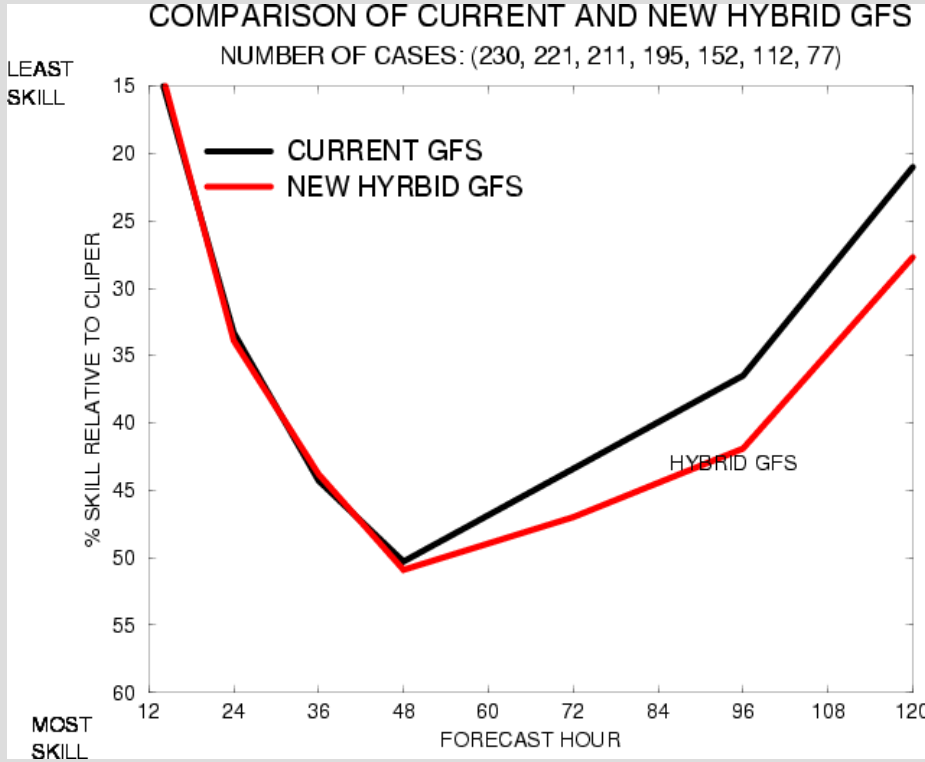
Hurricane Track Errors Improved

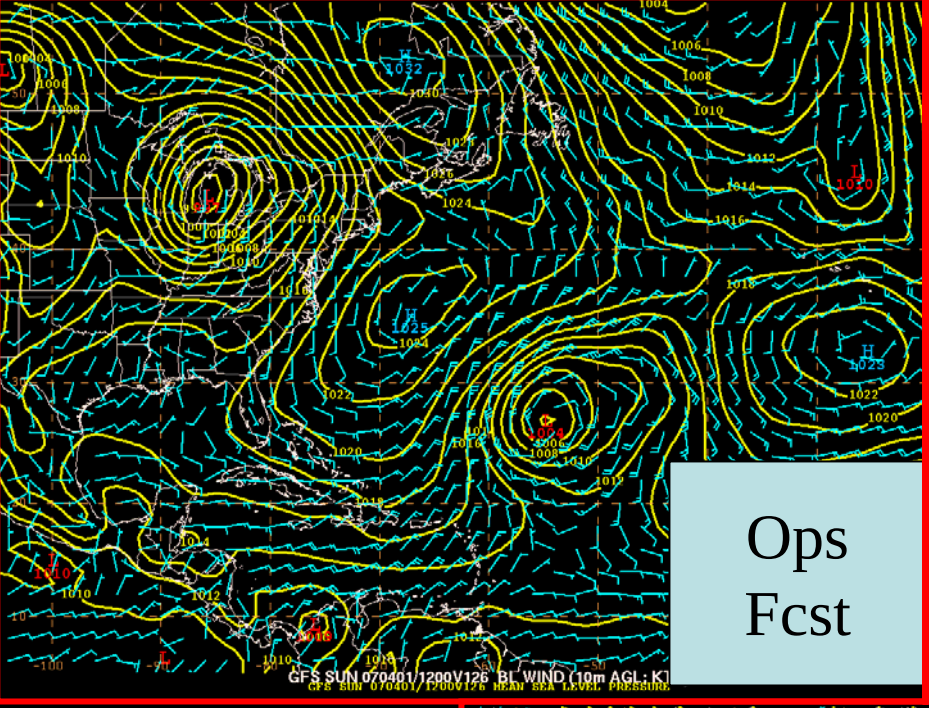
2005-2006 Atlantic Season Average Track Error Using Operational and GSI/Hybrid

GFDL model

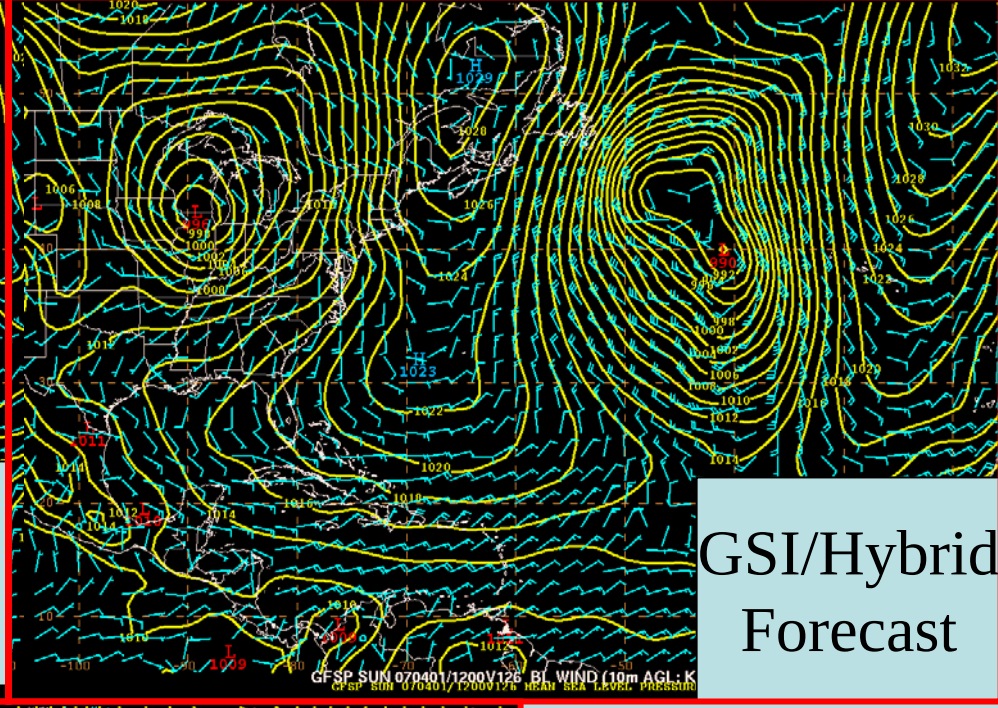


GFS

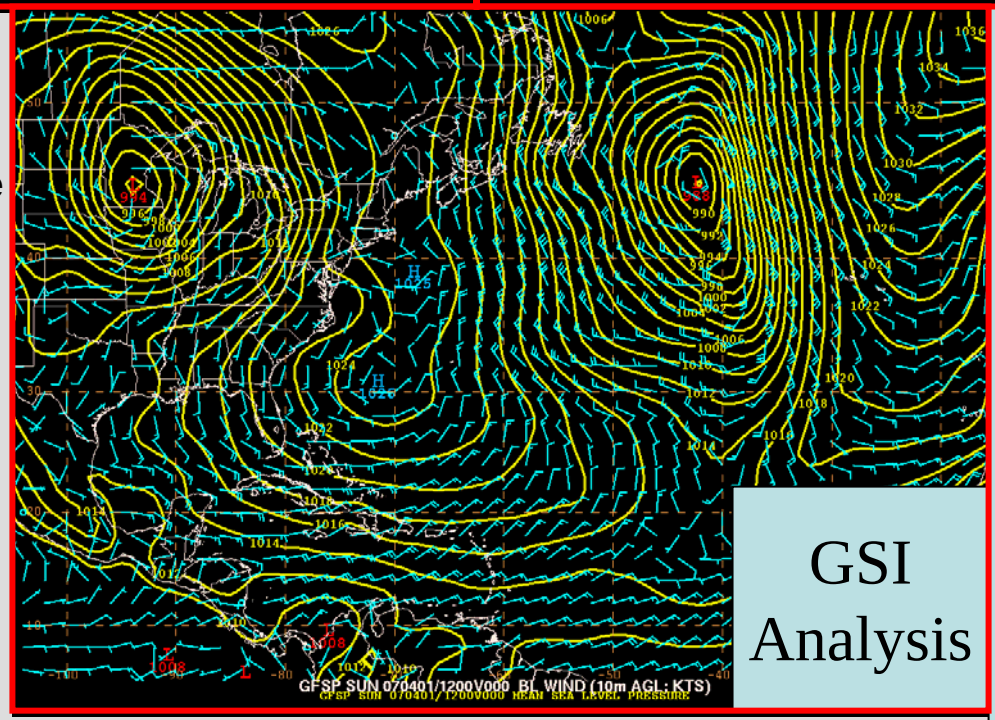




Ops Fcst



GSI/Hybrid Forecast



GSI Analysis

~5 day forecasts from the operational GFS (top left) and the hybrid/GSI GFS (top right) and verifying analysis (bottom) on 1 April 1200 UTC

Example Of 5 day Forecast

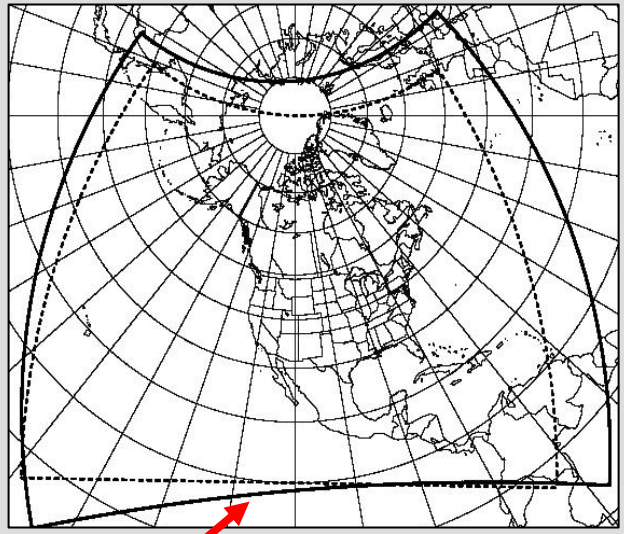
10 m wind

Valid 1 April 2007

NCEP GSI/Hybrid System

2008 NAM Upgrades

- Analysis
  - New GSI code
    - Current with GFS version
  - Recomputed NMM background error covariances
  - Assimilation of additional observations
    - AIRS
    - MODIS winds
    - SFOV GOES
    - Mesonet surface obs
- Model
  - GFS Gravity Wave Drag
  - New terrain processing (smoother)
  - Unify with public version distributed by DTC
  - Upgrade WRF-NMM code to IJK (12% faster)
  - Enlarge the computational domain of the NAM by 18%
  - Use 12-36 h forecast precipitation from the 00Z operational NAM as driver for NDAS soil moisture in regions outside of the CONUS



2008 NAM Upgrades (cont)

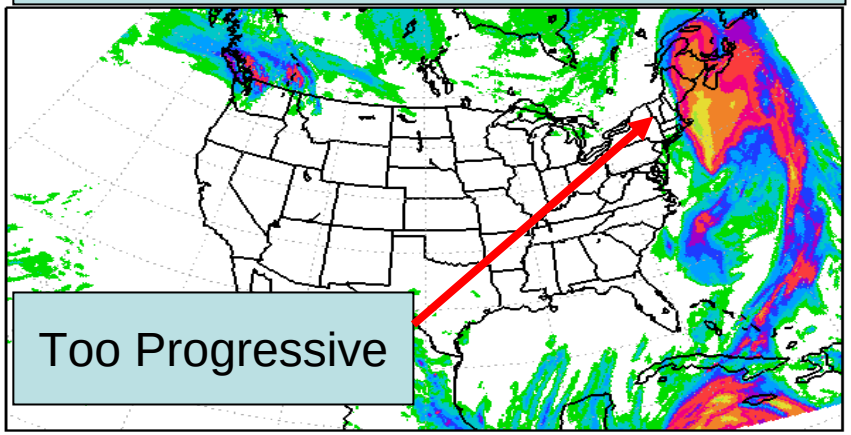
- Improved fits to background due to recomputed background error covariances

	Q	T	u/v	psfc
Ops	**13.34**	**1.49**	**4.22**	**1.21**
NB	**13.23**	**1.46**	**4.03**	**1.13**

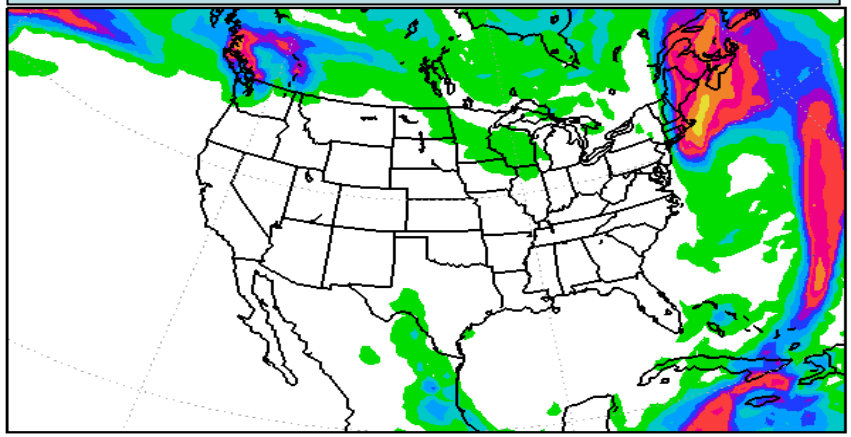
- GFS Gravity Wave Drag Package
  - Mountain blocking follows Lott & Miller (1997) with minor changes
  - Gravity wave drag (Form Drag) follows Alpert et al., (1988, 1996) and Kim and Arakawa (1995)

November 2007 New England Precipitation Event
36-60 h Fcst

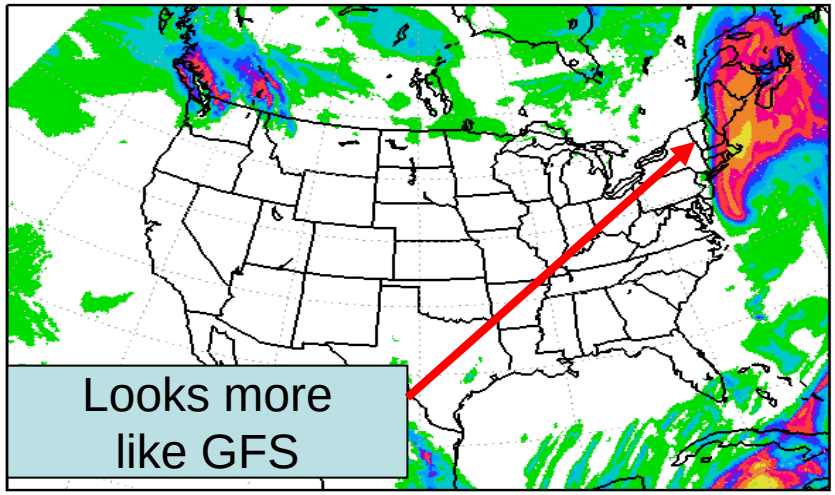
OPS NAM



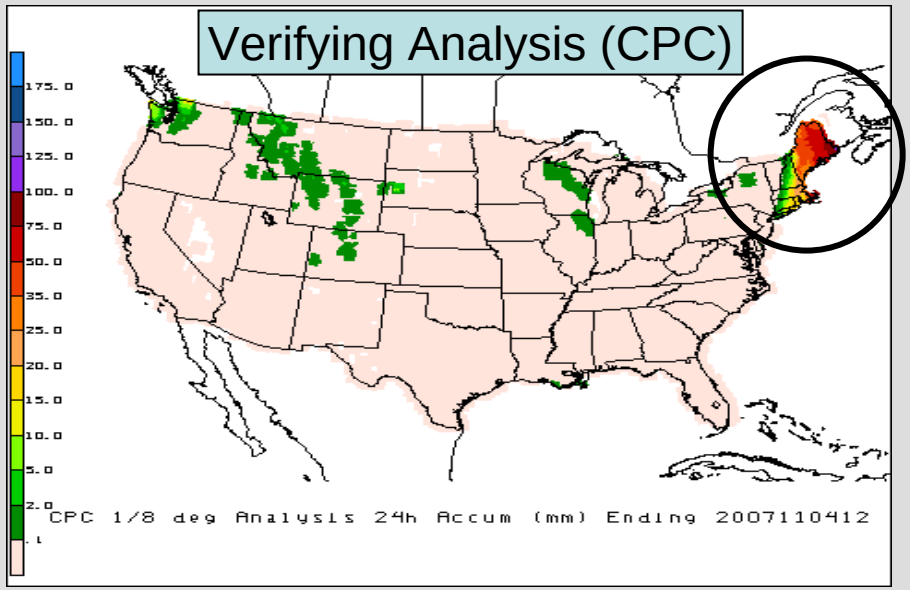
GFS



NAM Experimental



Verifying Analysis (CPC)



Summary of Overall Net Change Package Component Results

Symbol Legend:

+++ large positive impact
++ moderate positive impact
+ slight positive impact
o neutral impact
- slight negative impact
-- moderate negative impact
--- large negative impact

Component / Parallel	Dates Summarized	Near Surface Impact	Precipitation Impact	Upper Air Impact
Upgrade	1-30 Aug	**o**	**-**	**++**
Upgrade	8 Sep - 3 Oct	**-**	**+**	**++**
Upgrade	25 Oct -18 Nov	**o**	**++**	**+**
Domain expansion	24 Oct–19 Nov	**-**	**+**	**-**
Topography	28 Sep -15 Oct	**+**	**o**	**o**
GWD	19 Oct–19 Nov	**+**	**+**	**++**

Plans for future

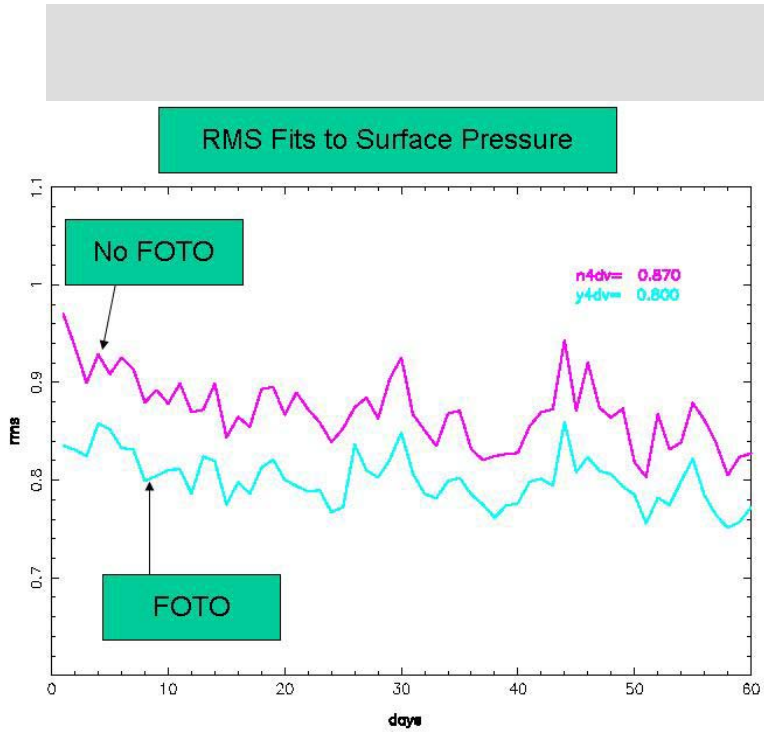
- NPOESS will provide
  - Advanced IR sounder (CrIS)
  - Advanced MW sounder (ATMS)
  - Ozone (OMPS)
  - Imager (VIIRS)
  - Faster data delivery (28 minutes) compared to
    - NPP in 100 minutes
    - POES/DMSP in 150 minutes
- Activities in response to NPOESS
  1. Instrument preparation
     - AIRS
     - IASI
     - SSMIS
  2. Advanced data assimilation techniques
  3. Next-generation NCEP Production Suite re-design to
     - Accommodate earlier data delivery
     - Provide improved forecast products

1. Instrument Preparation

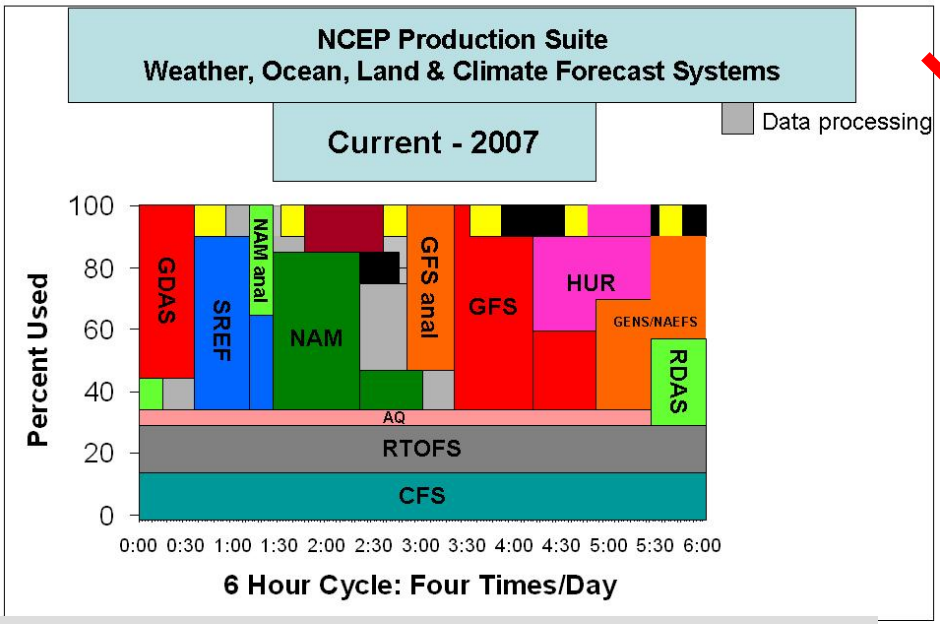
- **AIRS**
  - Full FOV implemented May 2007
- **IASI**
  - BUFR formatting issues resolved
    - Modified BUFR tables
    - Improved memory efficiency
    - Updated NCEP BUFR library
  - IASI data processed in real time
    - Operational time constraints being used
    - Data files are being generated for GDAS and GFS
    - Data are being pushed to the NOAA R&D IBM for testing
  - Software has been written and incorporated into the latest (Dec 2007) version of the GSI (includes updated CRTM) to read and assimilate IASI data
  - IASI data monitoring underway using the GSI
  - Different QC statistics than AIRS
    - CRTM checked out against assimilation test case
    - IASI channel subsets (NESDIS + EUMETSAT) have more online channels than AIRS
    - More upper level IASI data is passing QC.
    - Compact OPTRAN fitting error statistics do not show large differences between on- and off-line channels
- **SSMIS**
  - Initial experiments by Kazumori completed, positive impact (summer 2007)
  - Quality control and bias correction improvements to be tested (spring 2008)
  - F16 data over ocean scheduled for implementation (summer 2008)

2. Advanced Data Assimilation Techniques

- **F**irst **O**rder **T**ime-extrapolation to **O**bservations (**FOTO**)
  - "Simplified 4d-var" technique
  - Will be implemented in next GFS upgrade (April 2008)
- **4d-var (more complex than FOTO)**
  - If resources can be obtained
    - Global and regional system available ~2013 (global) & ~2015 (regional)
  - Global application in time for NPOESS
  - NCEP/EMC collaboration with NASA/GMAO makes this effort possible

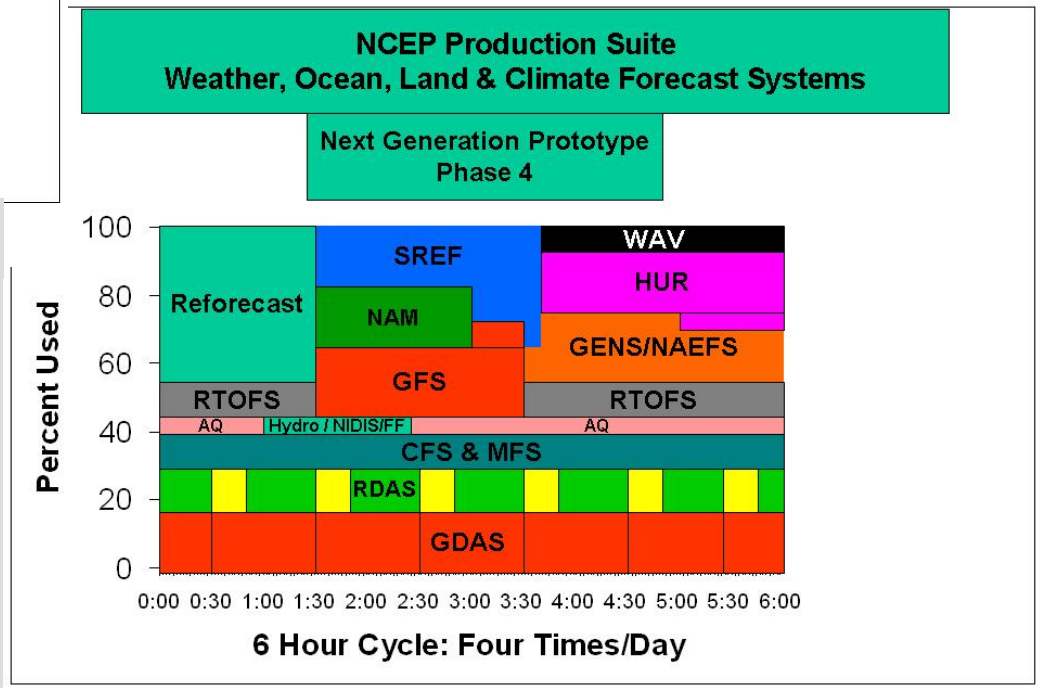


3. Next-generation NCEP Production Suite Re-design



(+ sufficient computing and human resources)

~2015



Next-generation
NCEP Production Suite

- GFS 2 h earlier
- NAM, GFS, SREF concurrent
- More resources for GDAS, RDAS
- Reforecasts operational
- Full suite of calibrated probabilistic products

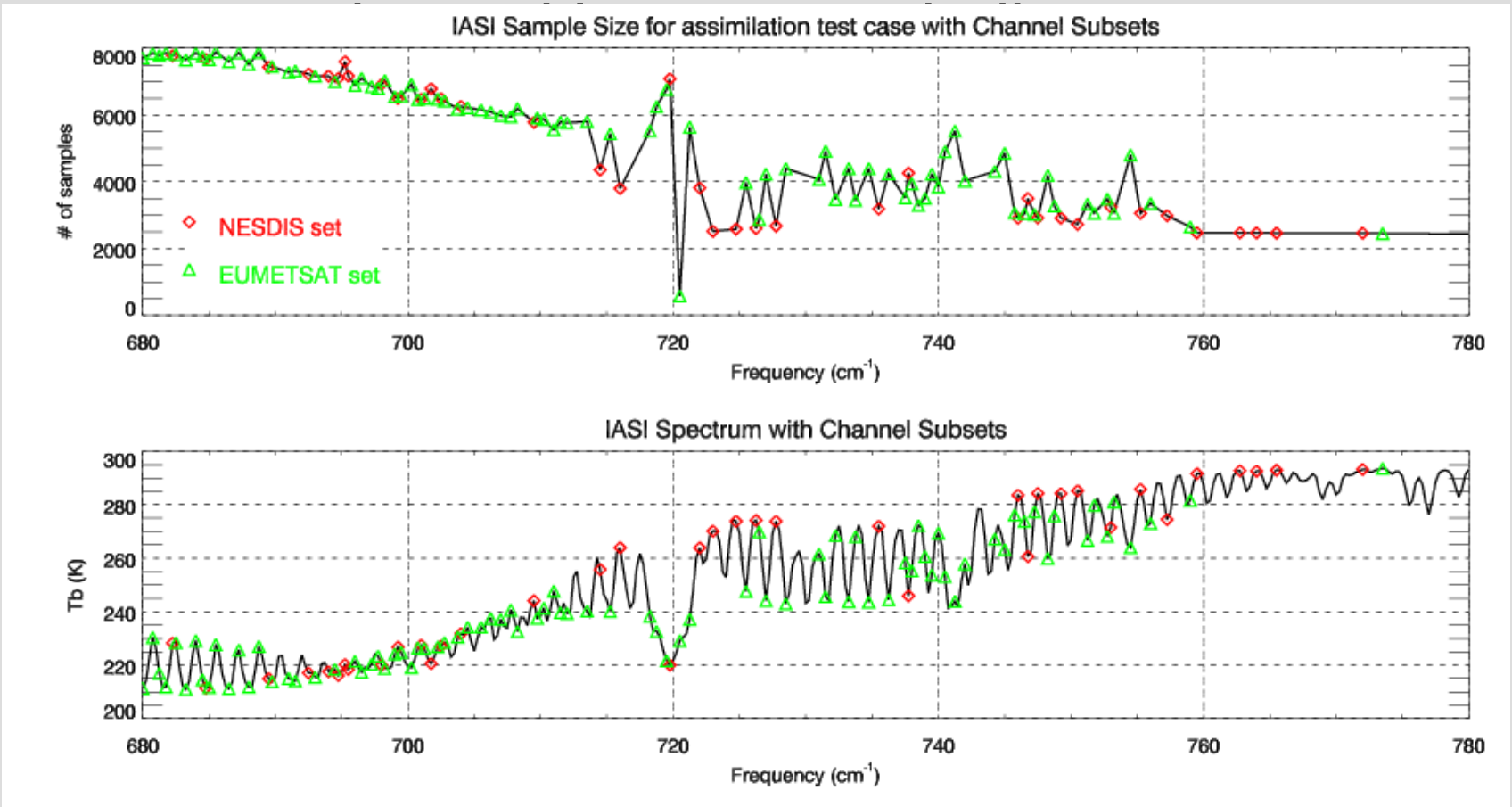
Summary

- Preparation for advanced NPOESS instruments is under way
  - Benefits from experience with AIRS and IASI
- Given additional computing and human resources:
  - Earlier NPOESS data delivery AND improved use of satellite data will enable major changes in NCEP forecast suite
    - Concurrent GFS and NAM
    - Earlier GFS delivery
    - Calibrated, probabilistic products based on GFS, NAM, SREF data

Thanks
Questions?

Characteristics of IASI Data

- Characteristics of retained IASI data in the longwave CO_2 band edge different from AIRS.



Characteristics of AIRS Data

- Characteristics of retained AIRS data in the longwave CO_2 band edge is much smoother.