

Comparison of Forecast Skills between NCEP GFS Four Cycles and on the Value of 06Z and 18Z Cycles

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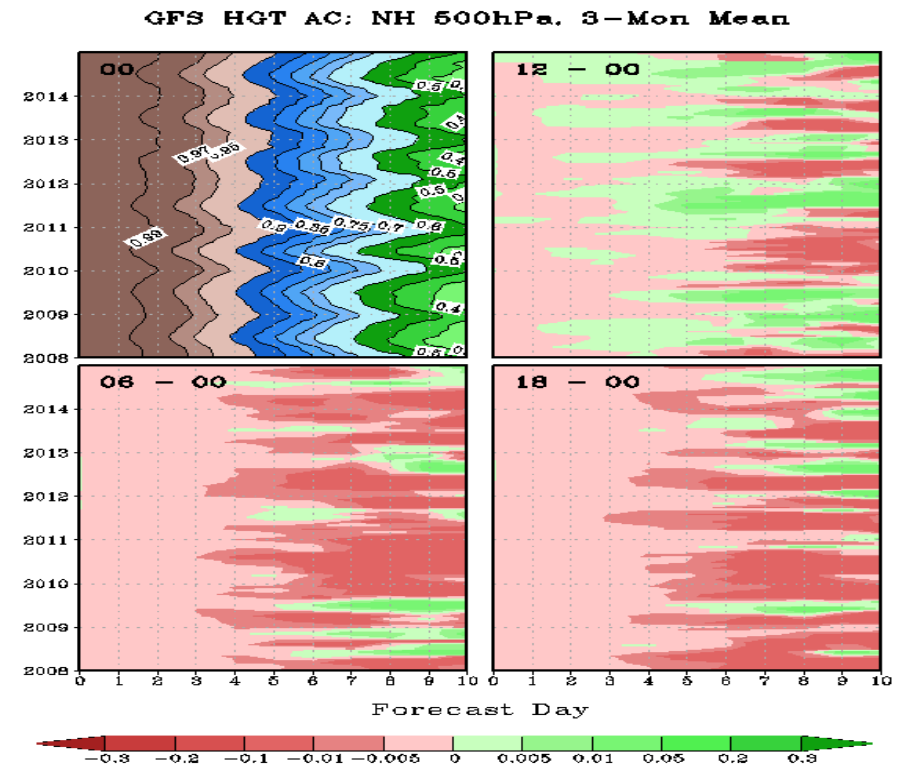
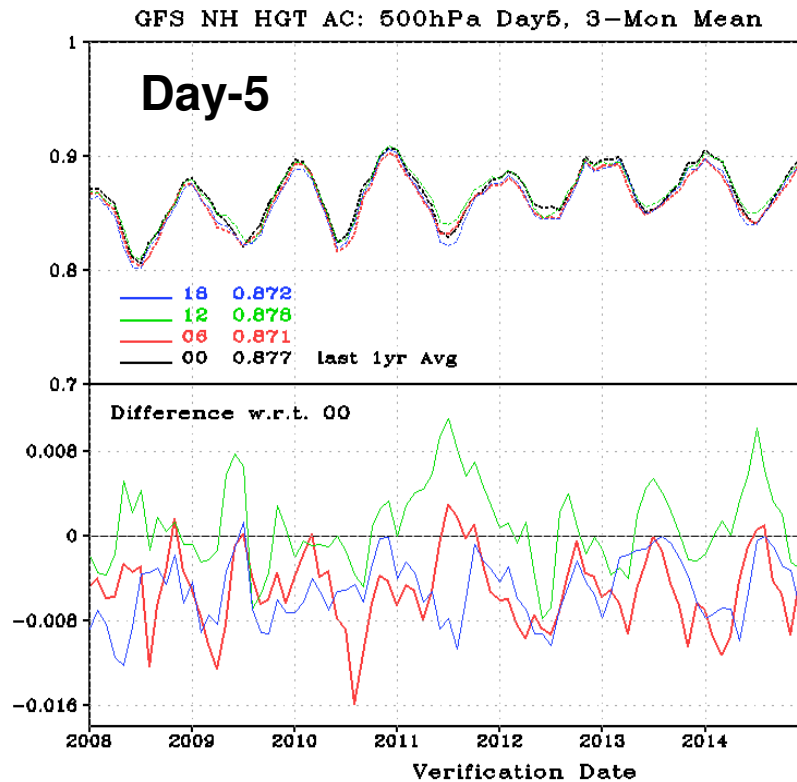
Motives

- 1. NCEP runs its Global Forecast Systems (GFS) four times per day to satisfy the request of user communities. Is there any difference in forecast skills between the four cycles? And Why?**
- 2. Most international NWP centers run global weather forecasts two times per day (00Z and 12Z cycles). Do the NCEP 06Z and 18Z cycles provide any extra value for forecasters and downstream jobs?**
- 3. NCEP will review its operational forecast suite later this year. This study is aimed to provide certain guidance on the decision of NCEP future global forecast systems.**

Outline

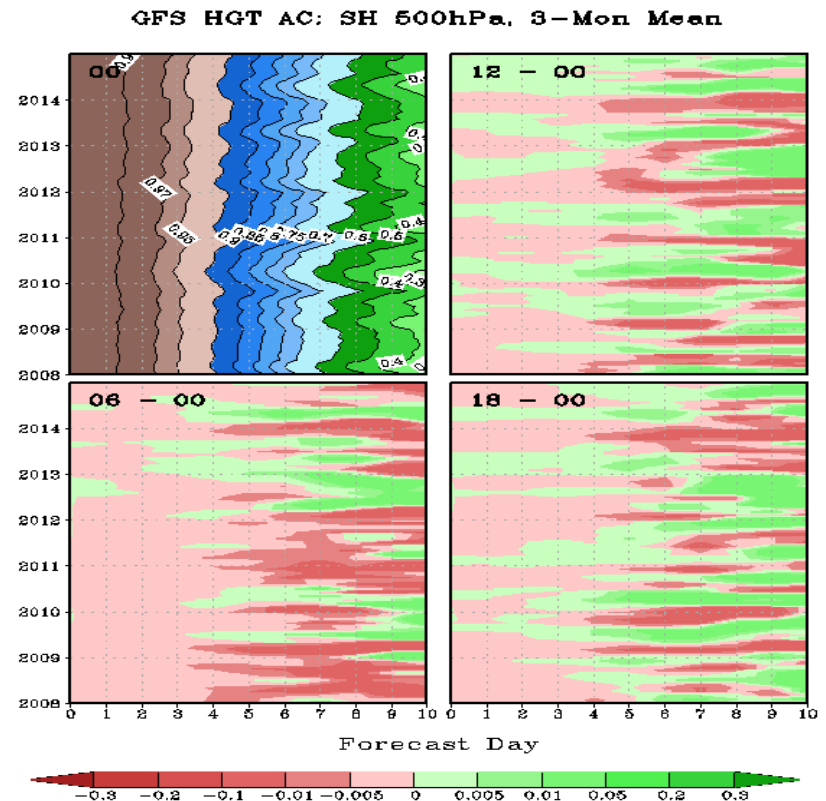
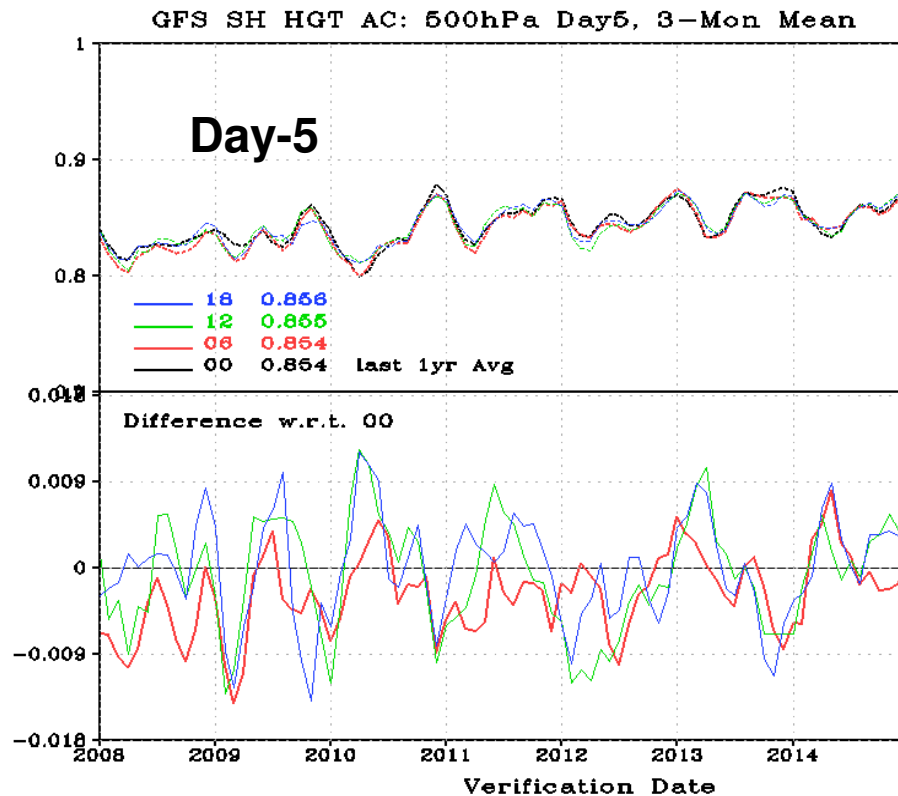
- 1. Difference in forecast skills between GFS four cycles (00Z, 06Z, 12Z and 18Z)**
- 2. Usage of conventional and satellite data among the four cycles**
- 3. The value of GFS 06Z and 18Z cycles**

GFS NH 500-hPa HGT Anomaly Correlation Since 2008



- All cycles have been steadily improved.
- 12Z cycle is comparable to 00Z cycle.
- 06Z and 18Z cycles are worse than 00Z and 12Z cycles

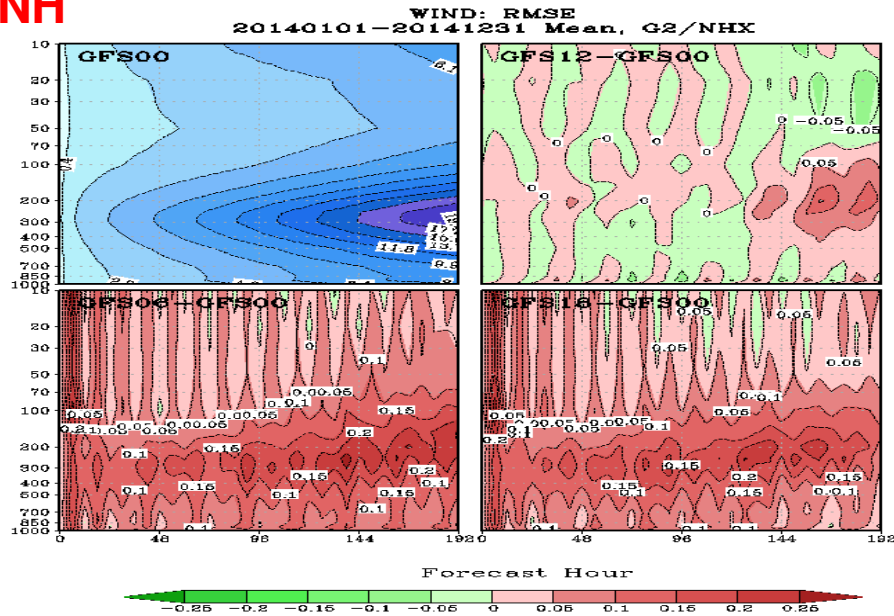
GFS SH 500-hPa HGT Anomaly Correlation Since 2008



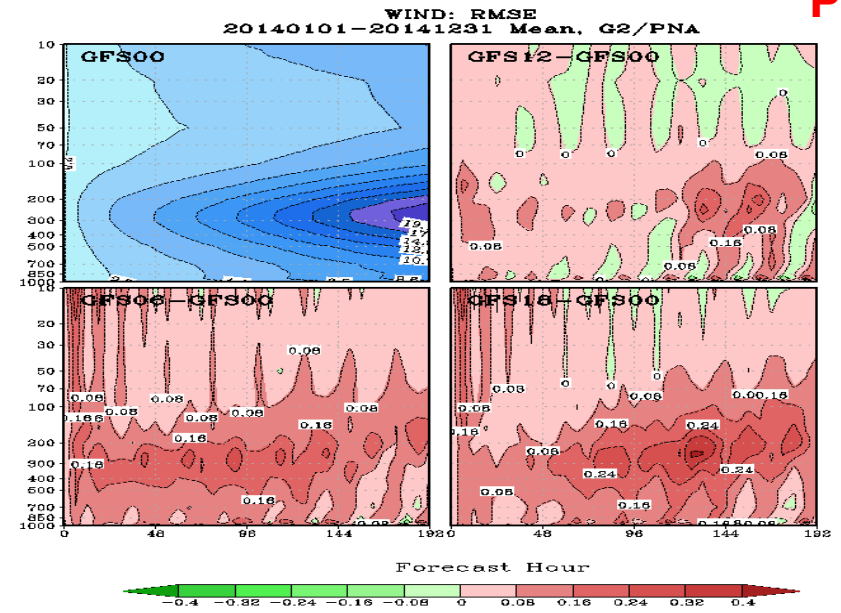
- In contrast to the NH, there is no systematic differences between the four cycles except that the 06Z cycle is slightly worse.

Differences in Wind RMSE

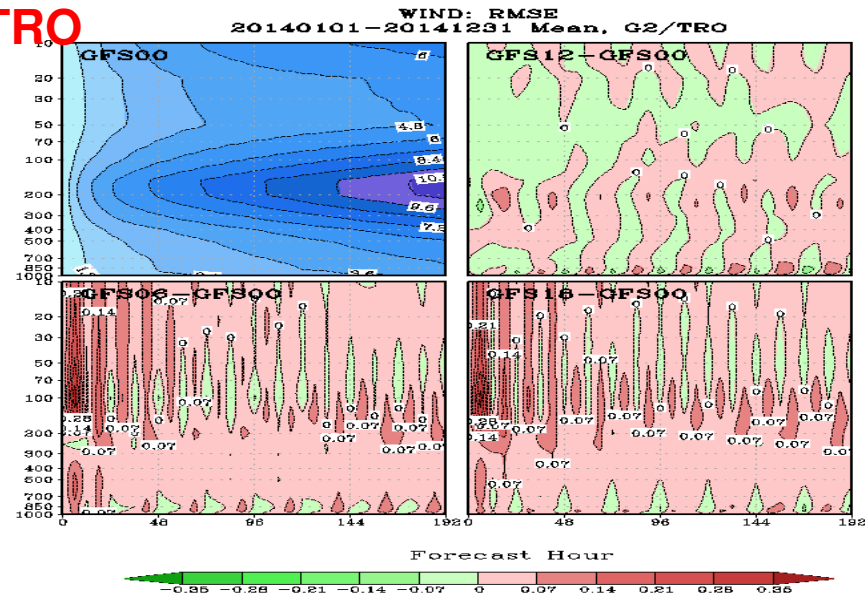
NH



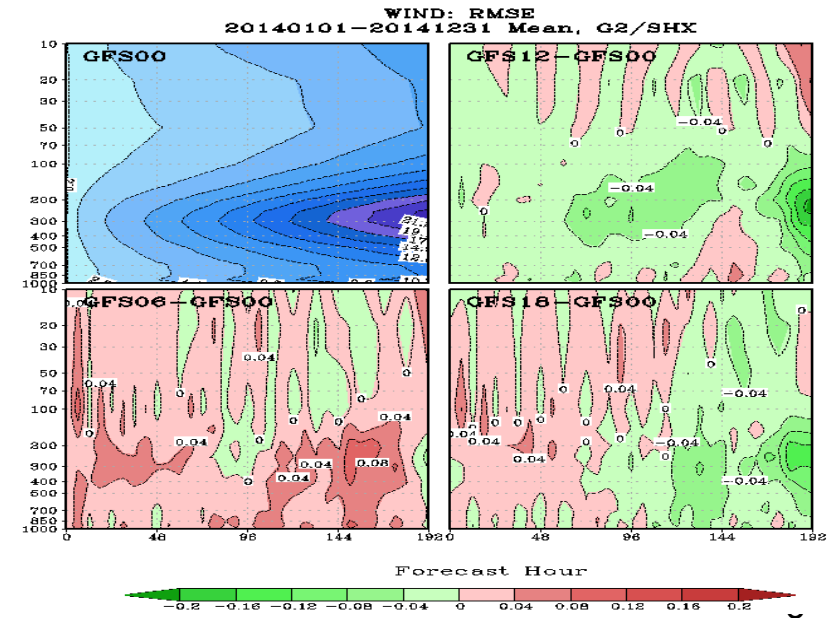
PNA



TRO



SH



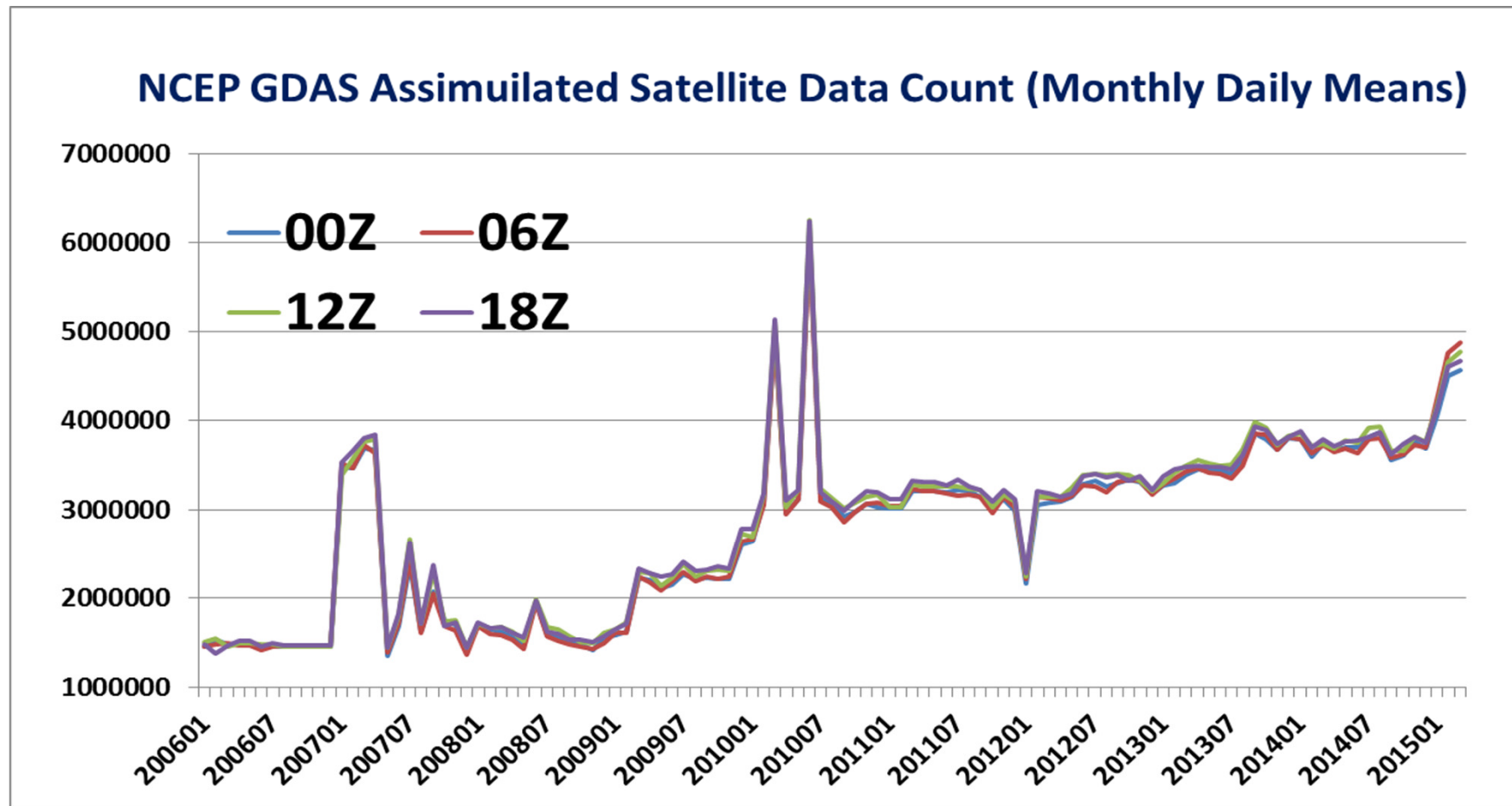
The largest difference is found in the NH 06Z and 18Z cycles

Findings

- **GFS 06Z and 18Z cycle are less skillful than the 00Z and 12Z cycles.**
- **The difference in the NH is the largest**

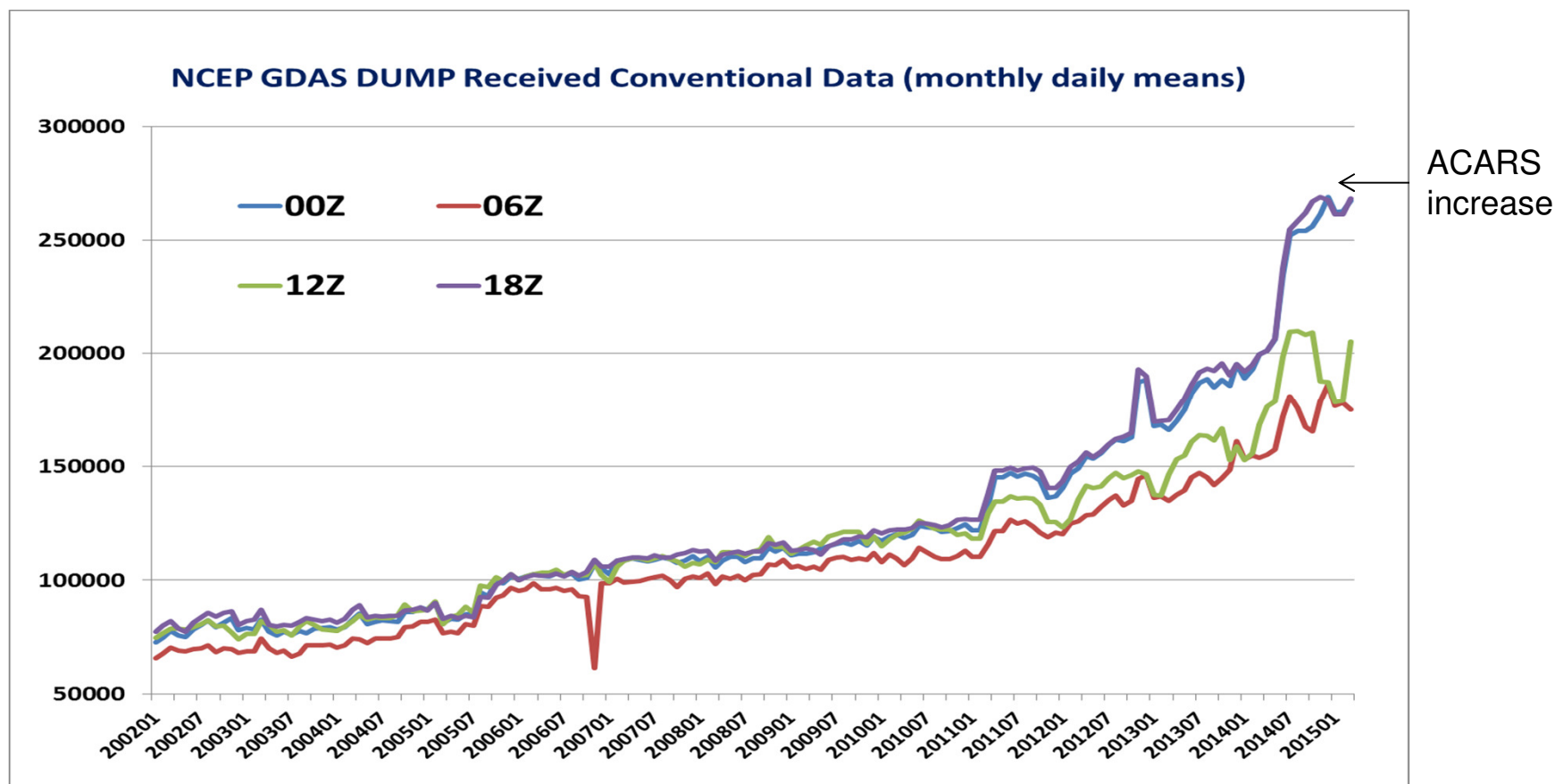
Outline

1. Difference in forecast skills between GFS four cycles (00Z, 06Z, 12Z and 18Z)
2. **Usage of conventional and satellite data among the four cycles**
3. The value of GFS 06Z and 18Z cycles



No significant difference in the number of satellite data assimilated in the GFS forecast system among the four cycles.

Conventional Data



- **06Z data count is always less (10~30%) than other cycles.**
- **Even though the 18Z-cycle forecast score is worse than that of the 00Z cycle, 18Z conventional data count is not less than 00Z data count!**

Snapshot of Conventional Data Count

January 2014

category	T00Z	T06Z	T12Z	T18Z
Land Sfc (Metar/Synoptic)	61263	63004	65188	63604
Marine Sfc (Ship/ Buoy/Gauge etc)	21487	21686	21796	21510
Land Soundings (RAOB/dropsonde/Pibal/Profiler /NEXRAD etc)	2173	1607	2118	1615
Aircraft (ACARS/AMDAR/AIREP etc)	104207	66860	63538	105077
Total	189130	153157	152640	191806

Fixed Land RAOB	625	52	626	33
Pibal	77	106	72	58
Profiler	45	44	44	43
NEXRAD Wind	1422	1404	1369	1480

Note even though the total number of land soundings is almost the same among the four cycles, 06Z and 18Z have much less land RAOBs than the 00Z and 12Z cycles !

- Among the four cycles, there is no difference in land Sfc and Marine Sfc data counts.
- 18Z has the same amount of Aircraft data as the 00Z does, but has worse forecast skill scores.
- 12Z has less Aircraft data than 00Z, but has similar forecast skill scores to 00Z.
- Difference in Aircraft data cannot explain forecast skill differences between 00Z/12Z and 06Z/18Z cycles.

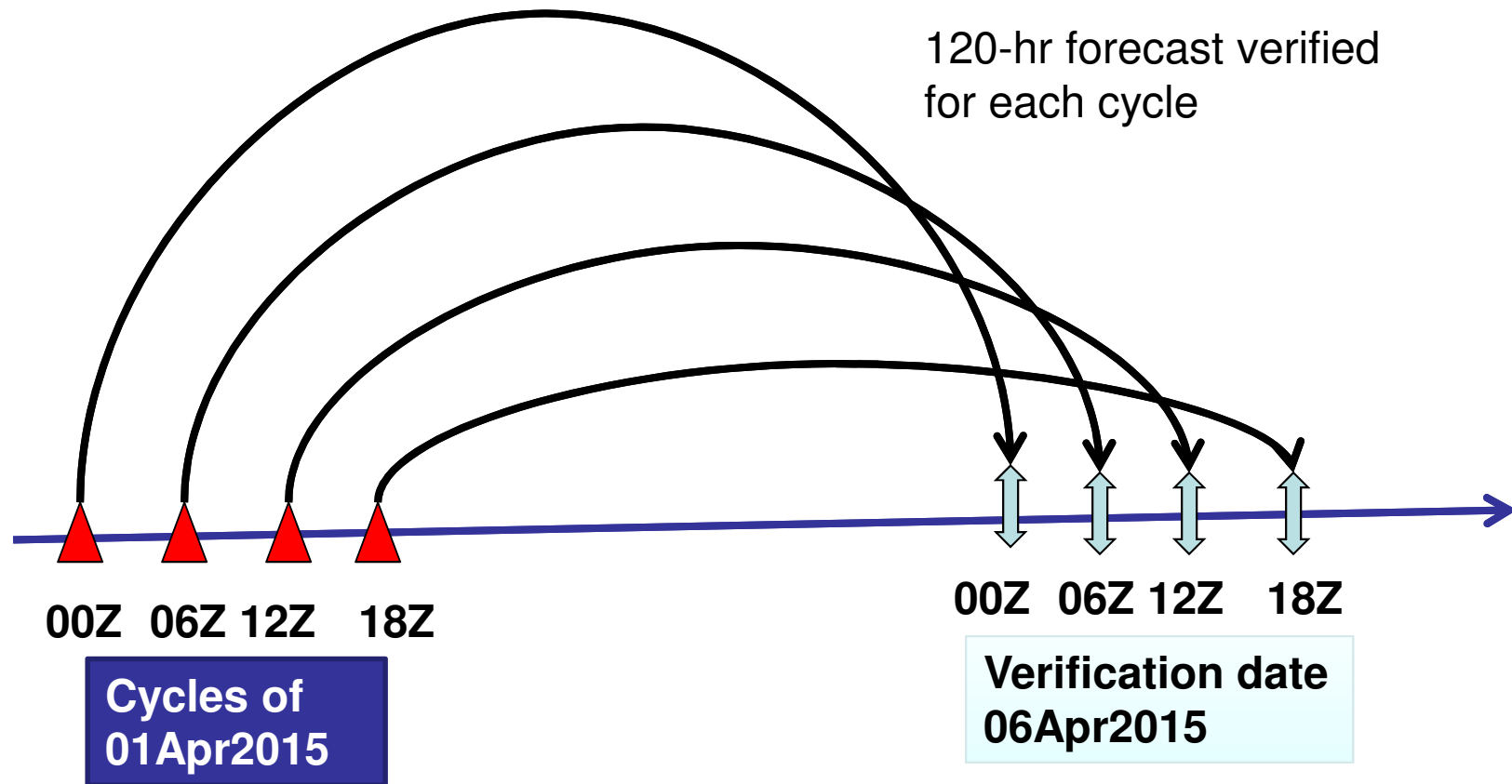
Findings

- There is no difference in satellite data count among the four cycles.
- 18Z and 00Z have the same amount of conventional data, but 18Z has worse forecast skills than 00Z. On the other hand, 12Z has less conventional data than 00Z, but 12Z and 00Z have similar forecast skills.
- 06Z and 18Z cycles have 10 to 20 times less land rawinsonde observations than the 00Z and 12Z cycles. Is the lack of RAOBS responsible for the lower forecast scores of the 06Z and 18Z cycles? More investigation is required to understand its impact.
- Conventional data are still important

The forecast skills of GFS 06Z and 18Z cycles are not as good as that of the 00Z and 12Z cycles.

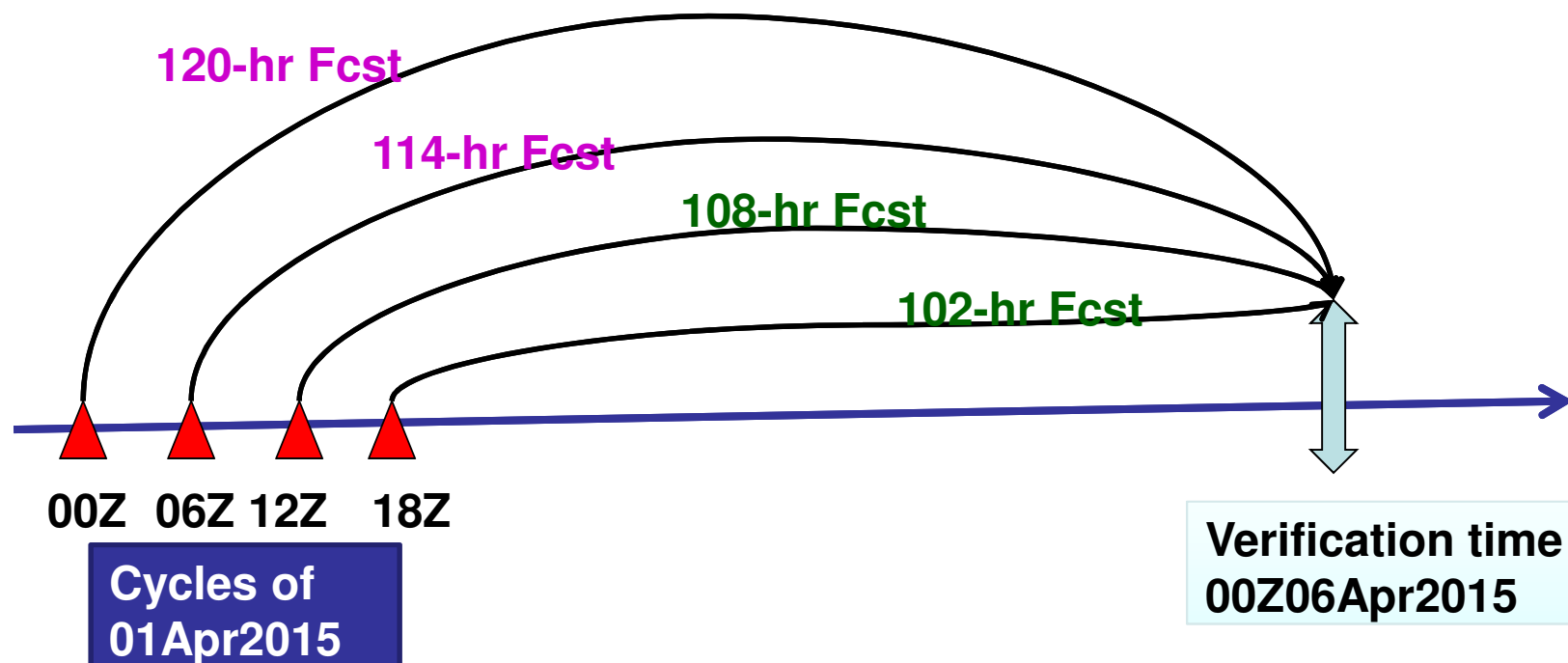
what are the benefits of running these two extra cycles of forecast ?

NCEP EMC Routine Verification



- Equal forecast length verification, fair for all cycles.
- Forecast output at 6-hour intervals are used for verification.

Lagged Verification Statistics

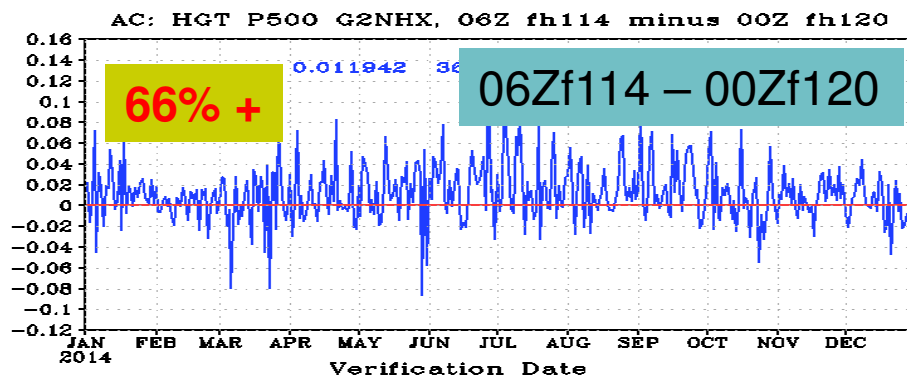
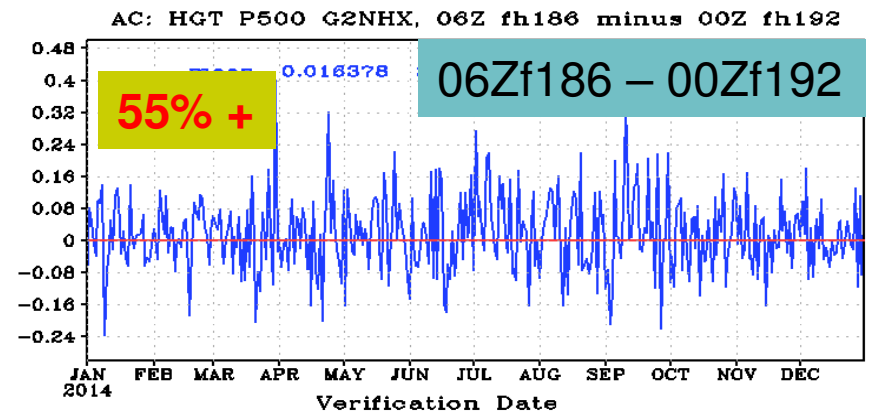
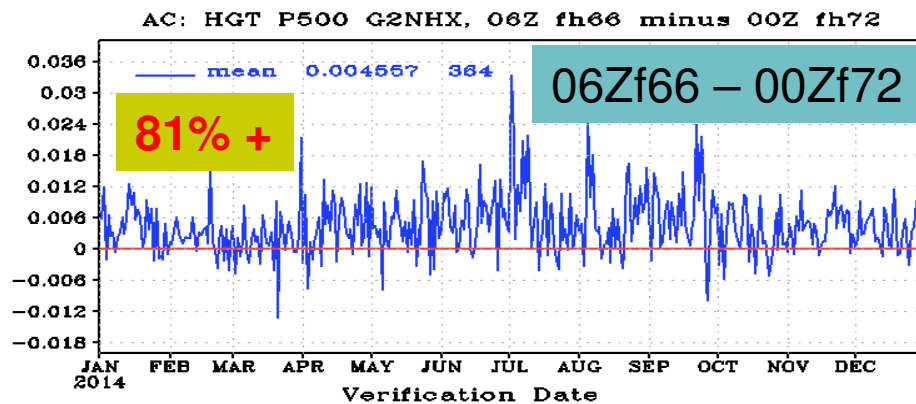
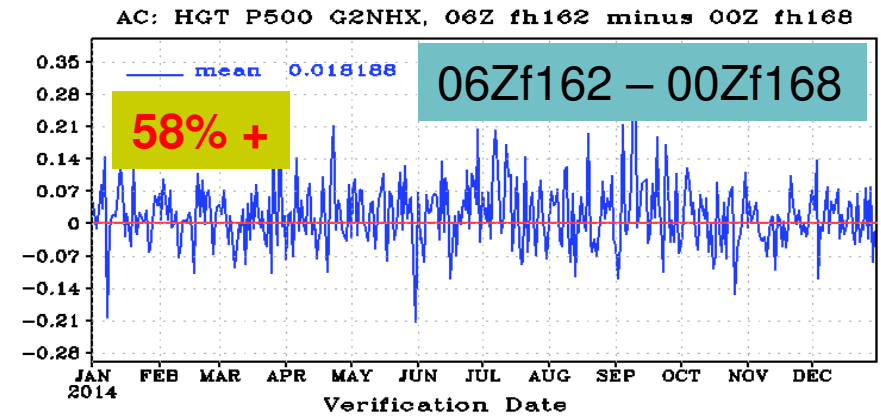
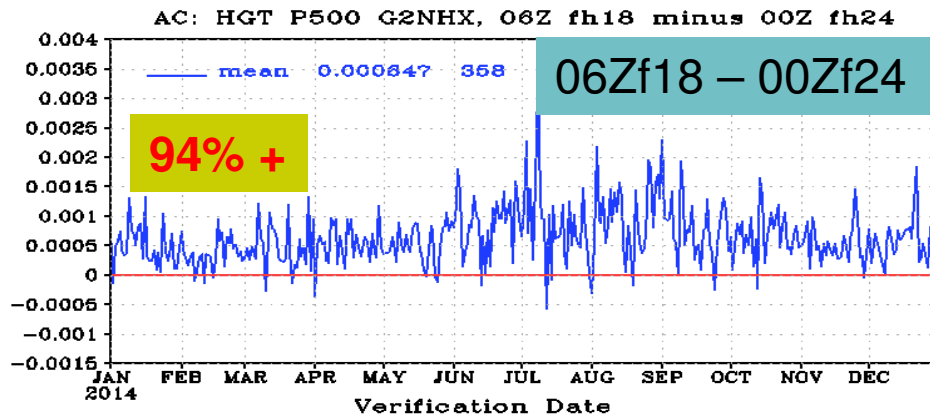


Q: Is the 06Z 114-hr forecast better than the 00Z 120-hr forecast?

Q: Is the 18Z 102-hr forecast better than the 12Z 108-hr forecast?

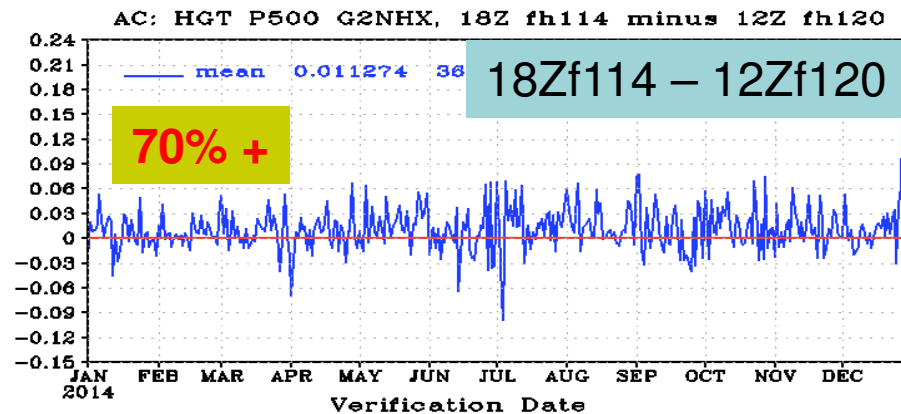
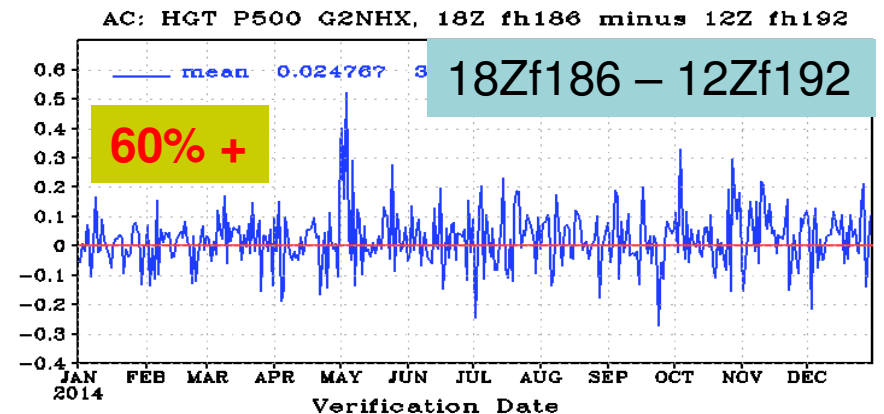
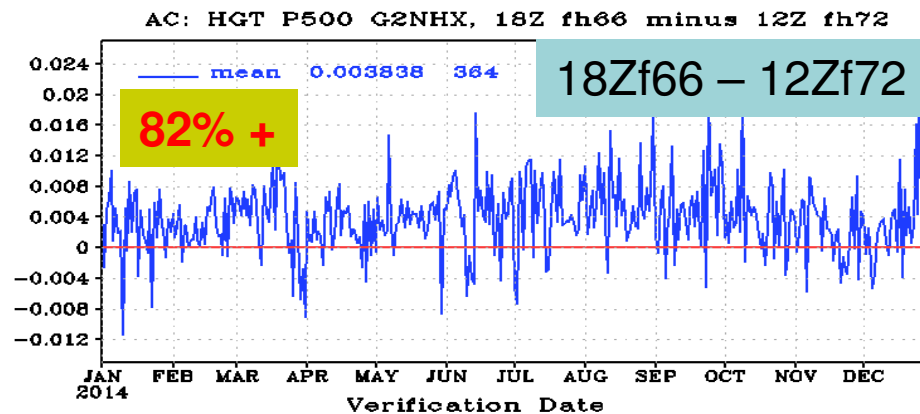
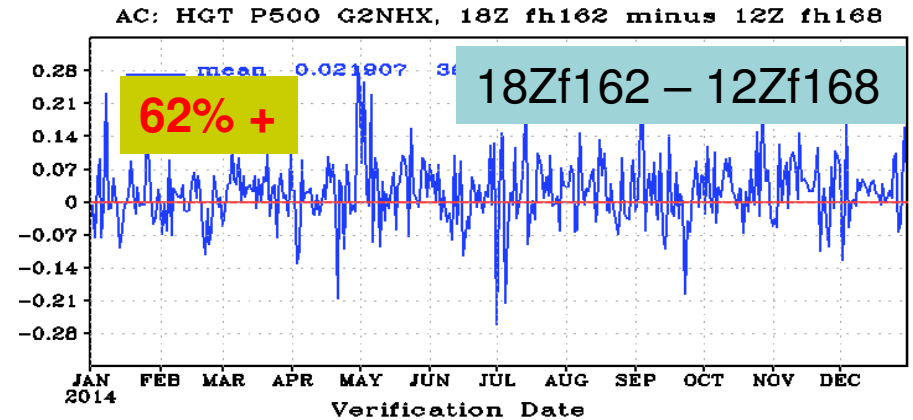
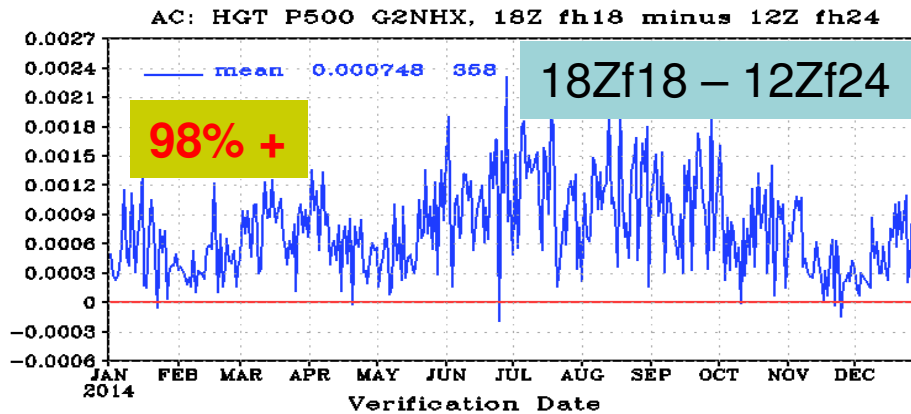
In the following, verification stats computed for every 6-hour forecasts for all days in 2014 are used to address this question.

Comparing 06Z Cycle with 00Z Cycle : NH 500-hPa AC



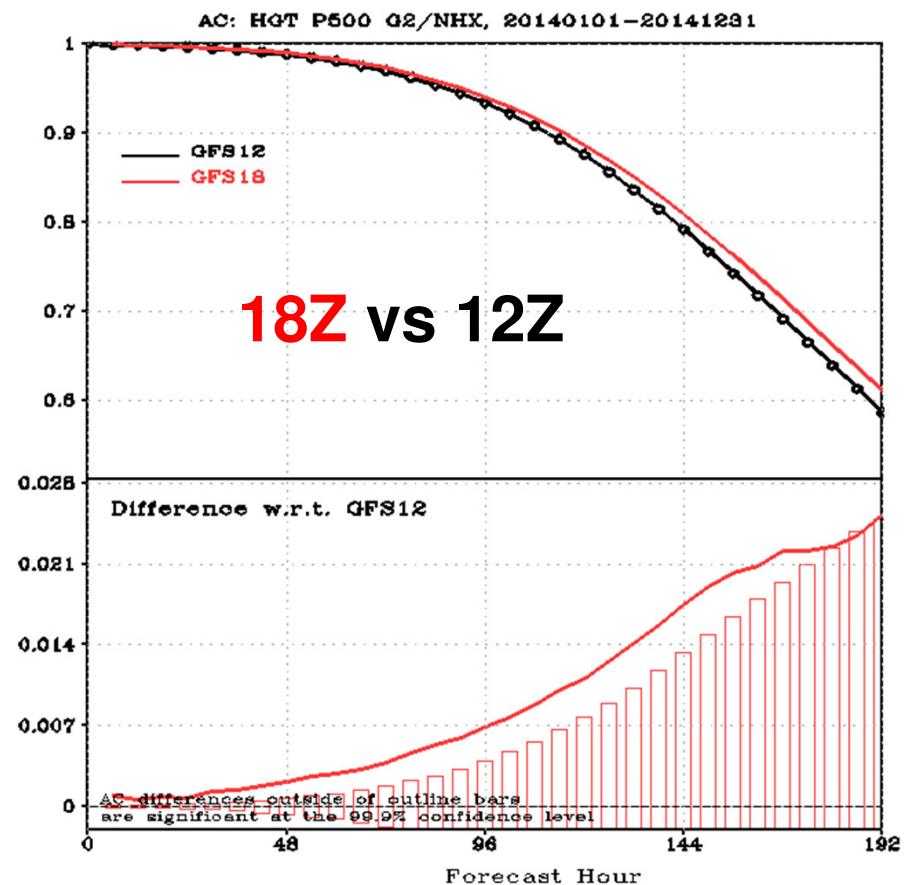
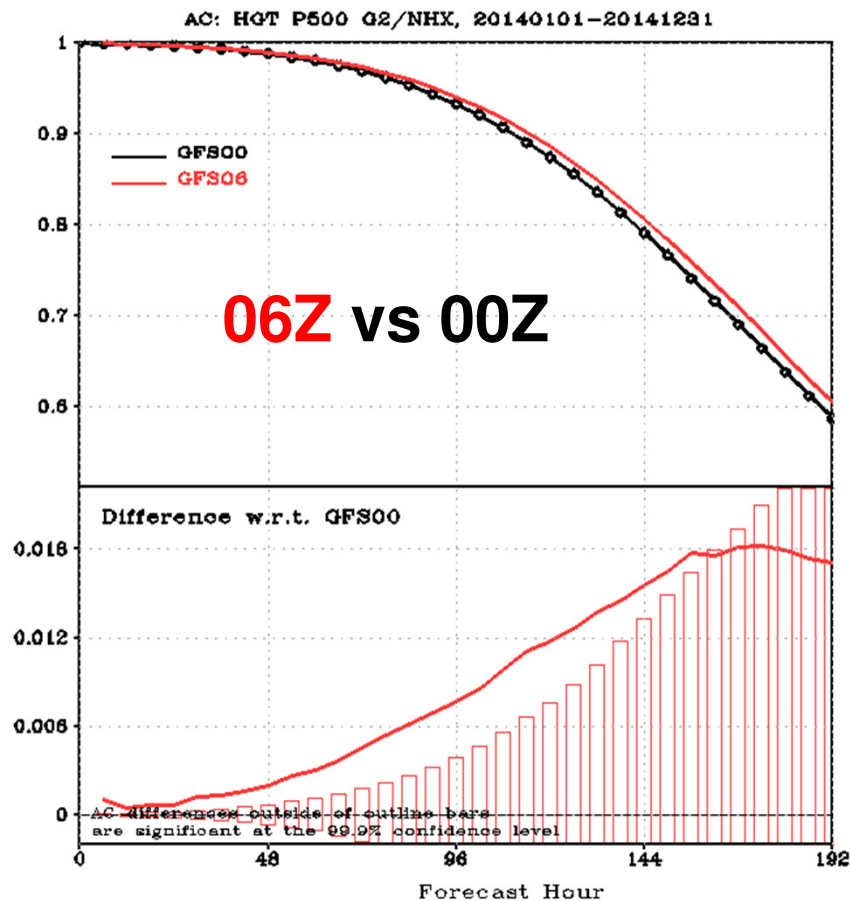
For short to medium-range forecasts, the later 06Z cycle does show better forecast skills than the earlier 00Z cycle when both are validated at the same verification time.

Comparing 18Z Cycle with 12Z Cycle : NH 500-hPa AC



For short to medium-range forecasts, the later 18Z cycle does show better forecast skills than the earlier 12Z cycle when both are validated at the same verification time.

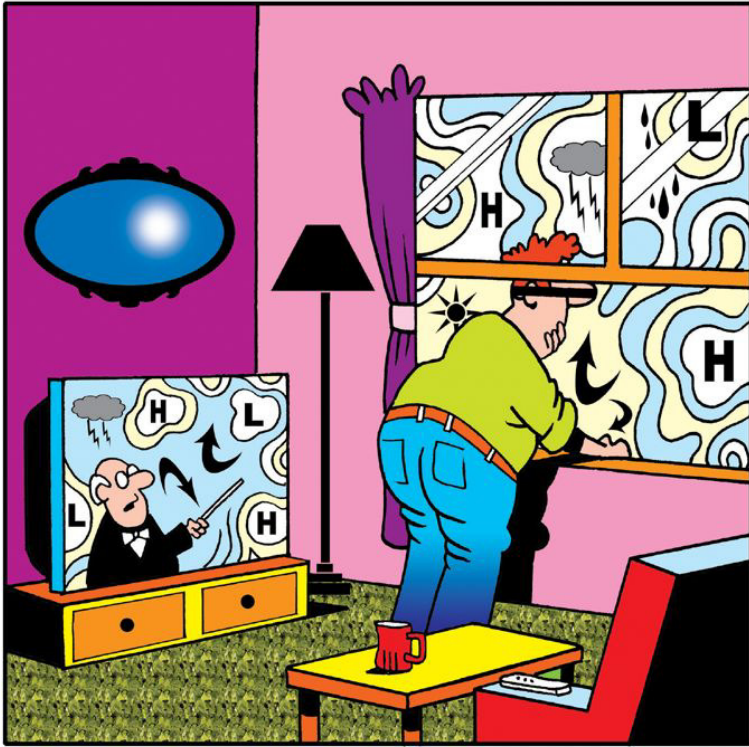
2014 Annual Mean Scores, NH



Annually averaged, forecast scores of the later 06Z (18Z) cycle are significantly better than that of the 6-hour earlier 00Z (12Z) cycle for forecast up to 6 (7) days, if both are validated at the same verification time.

Summary

- GFS 06Z and 18Z cycles are less skillful than the 00Z and 12Z cycles in the Northern Hemisphere. There is no significant difference among the four cycles in the Southern Hemisphere.
- 06Z and 18Z cycles have 10 to 20 times less land rawinsonde observations than the 00Z and 12Z cycles.
- Even though the 06Z and 18Z cycles are less skillful, when validated at the same verification time the later 06Z (18Z) cycle does show consistently better forecast skills than the earlier 00Z (12Z) cycle for short to medium-range forecasts.
- **Value of the GFS 06Z and 18Z cycles:** a) provide updated initial and boundary conditions for down-stream jobs; b) provide users with updated and more accurate guidance than the earlier 00Z and 12Z cycles for short to medium-range weather forecast.



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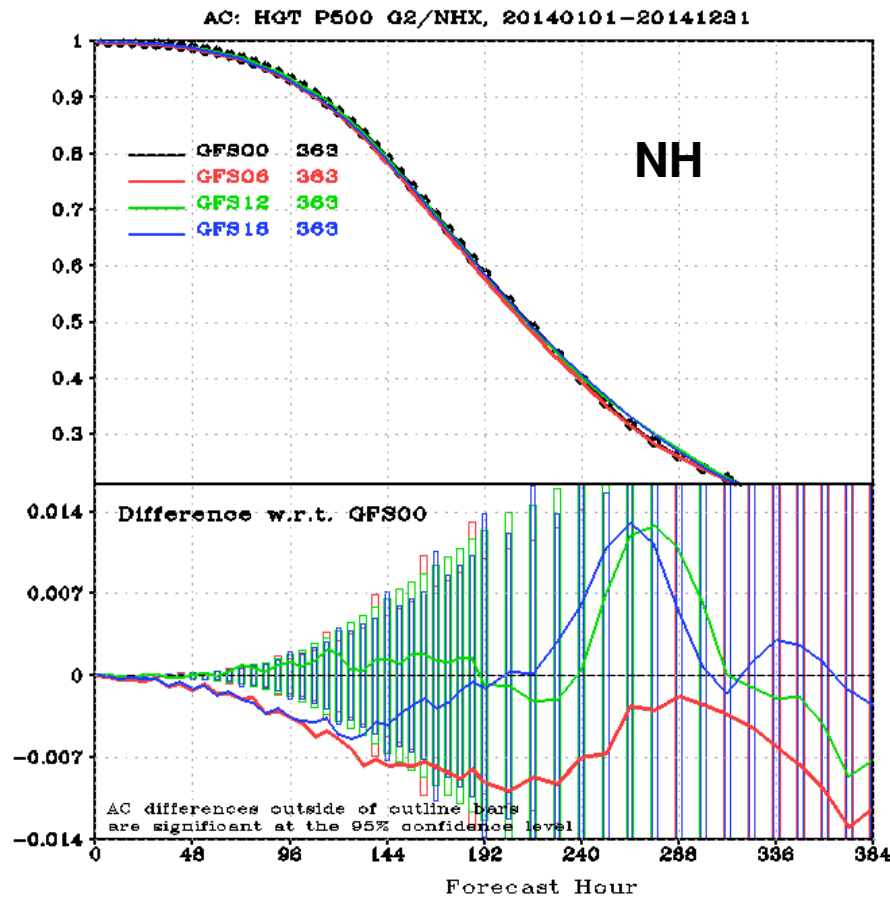


Extra slides

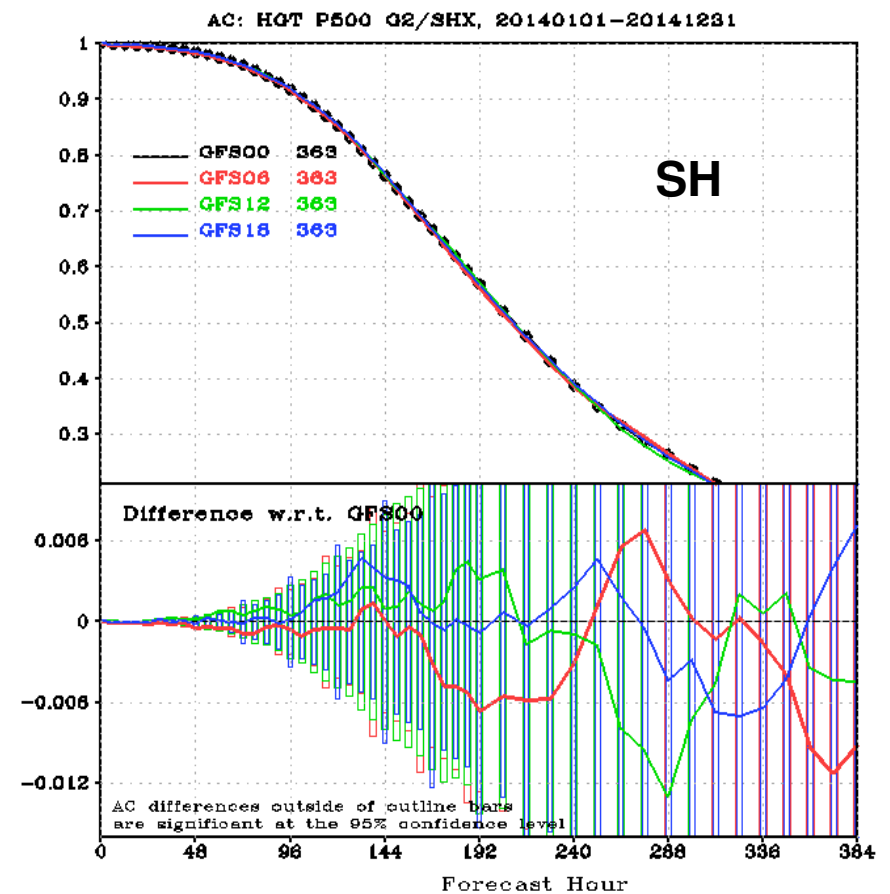
Are these differences significant?

Forecasts verified against
GFS own analysis

2014 500-hPa AC, 6-hourly verification



06Z and 18Z cycles are **significantly worse** than 00Z cycle for forecasts up to 6 to 7 days.

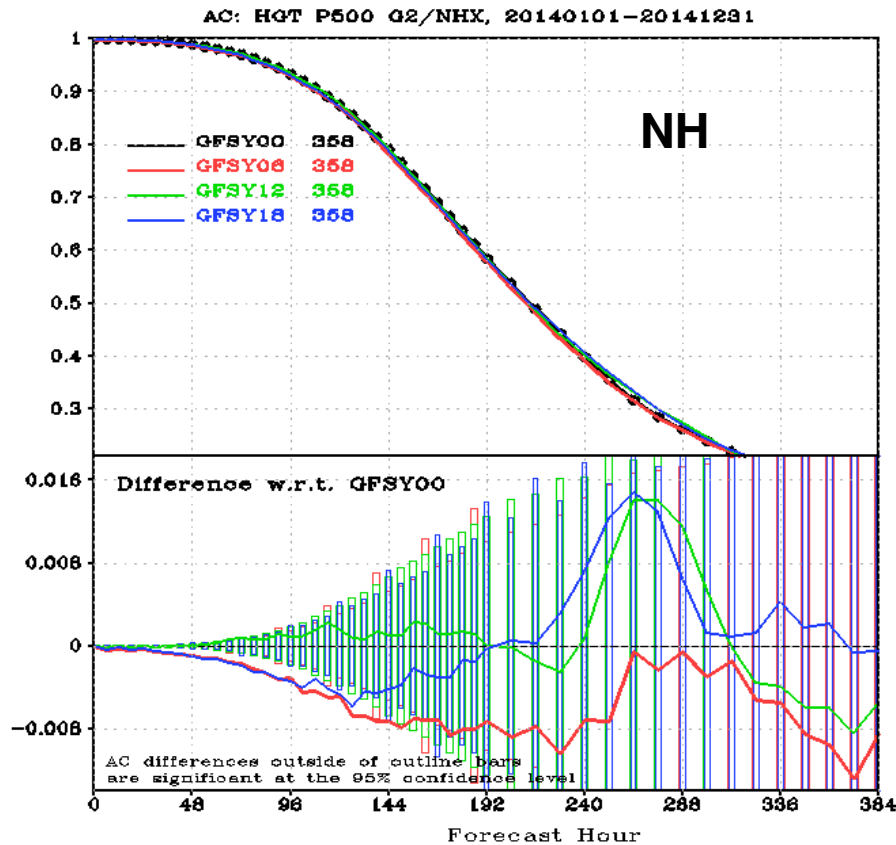


No significant differences between the four cycles

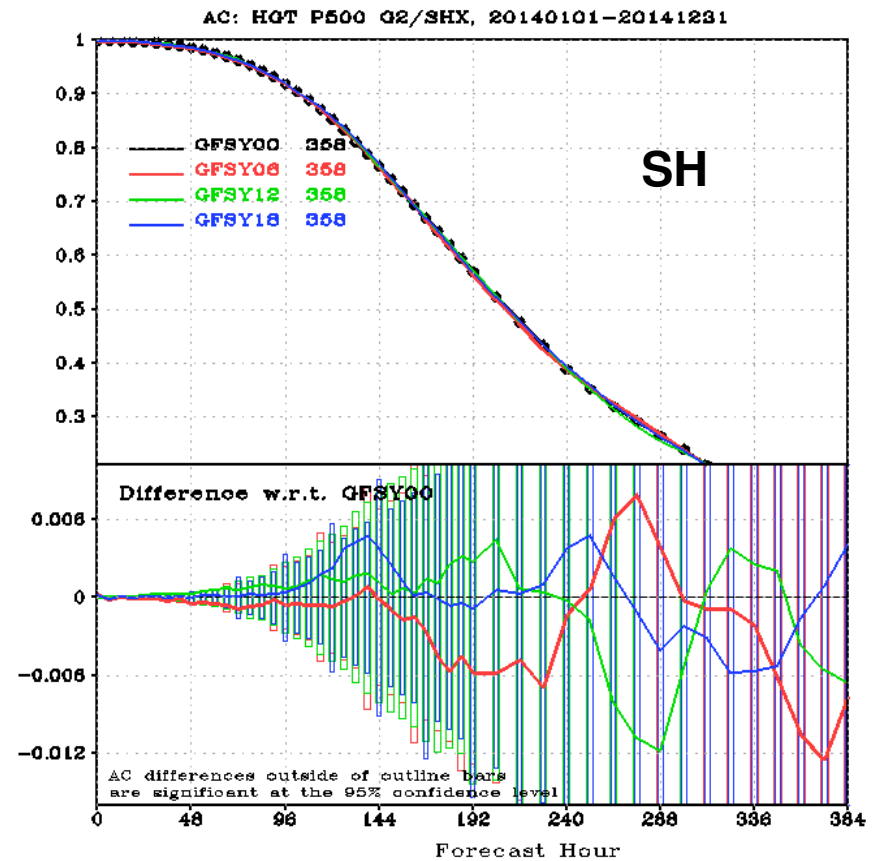
Are these differences significant?

Forecasts verified against
ECMWF analyses

2014 500-hPa AC, 6-hourly verification



06Z and 18Z cycles are **significantly worse** than 00Z cycle for forecasts up to 6 to 7 days.



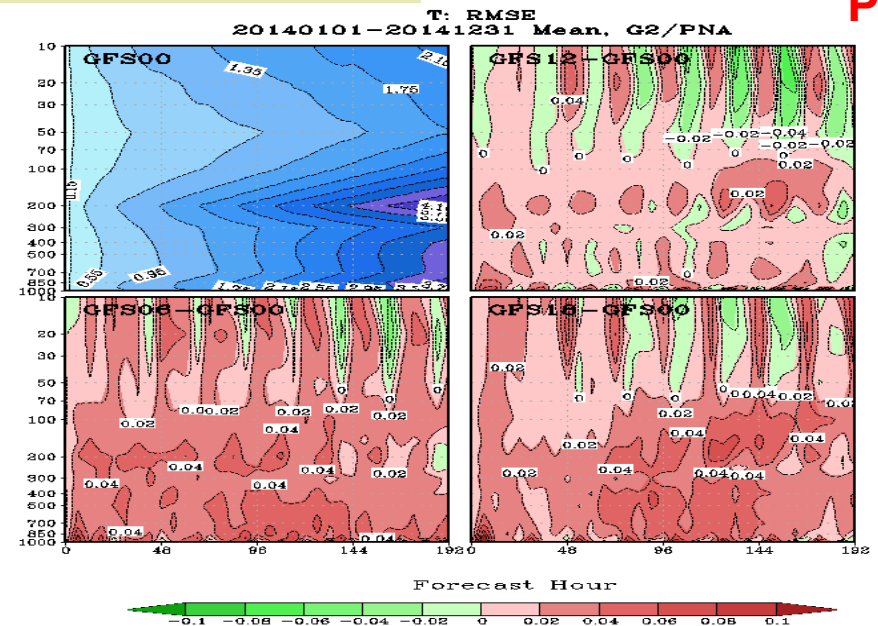
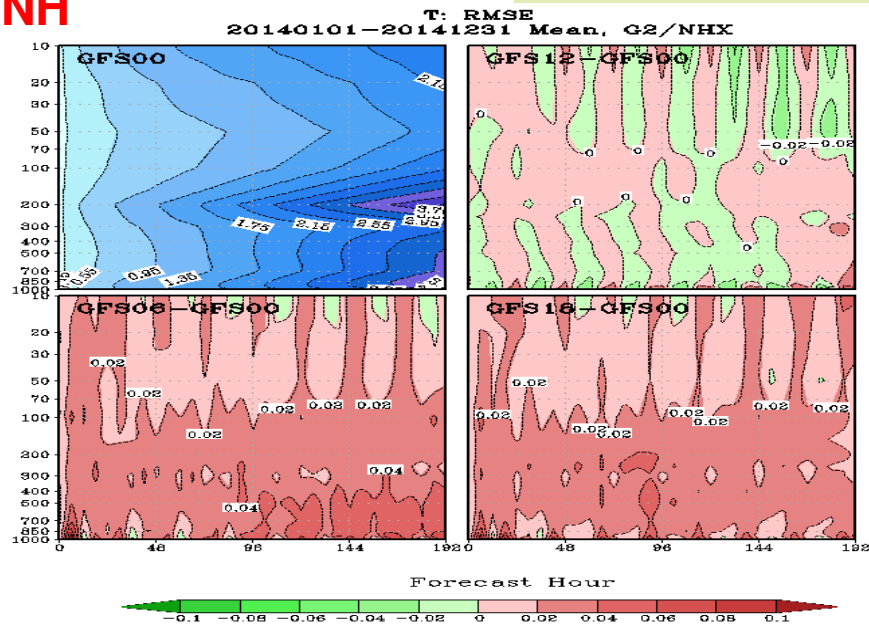
No significant differences between the four cycles

Same as verified against GFS own analyses.

Differences in Temperature RMSE

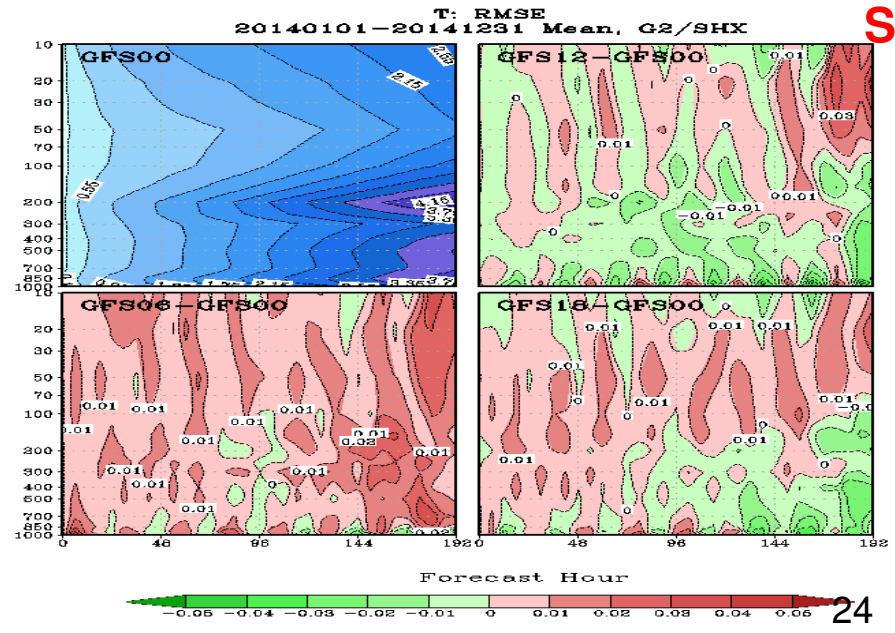
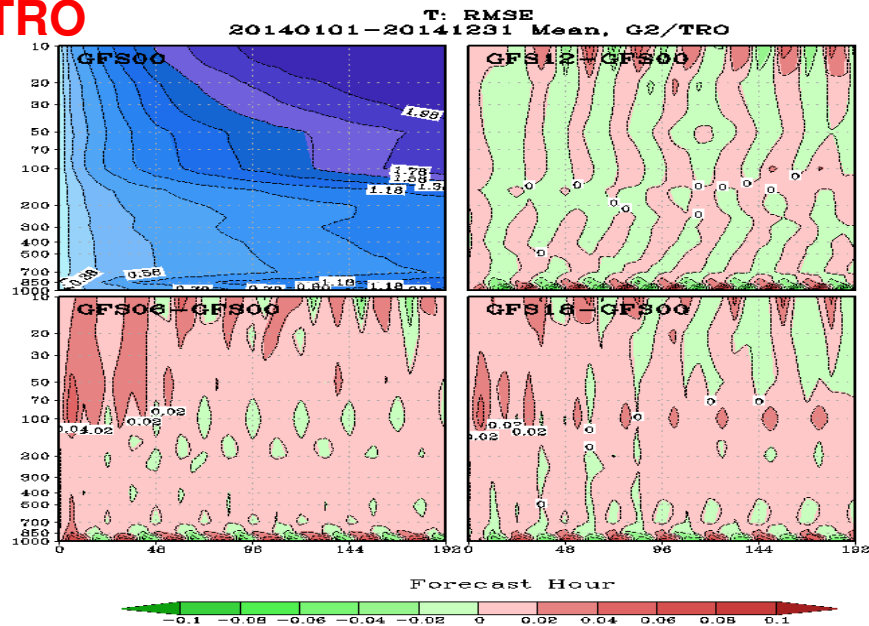
NH

PNA



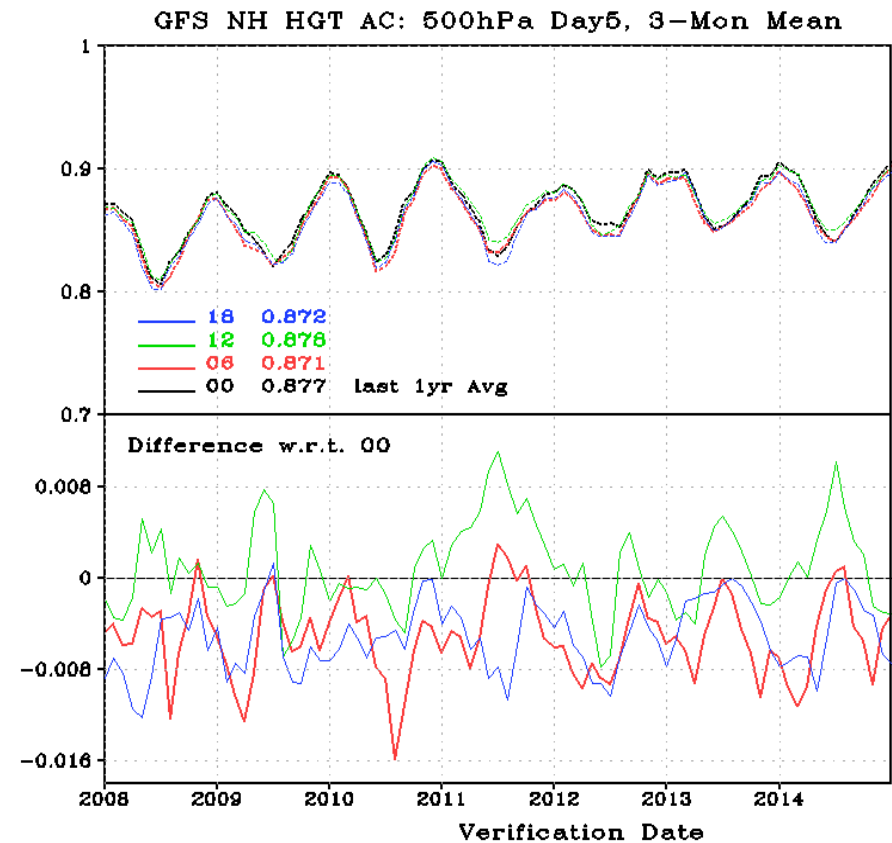
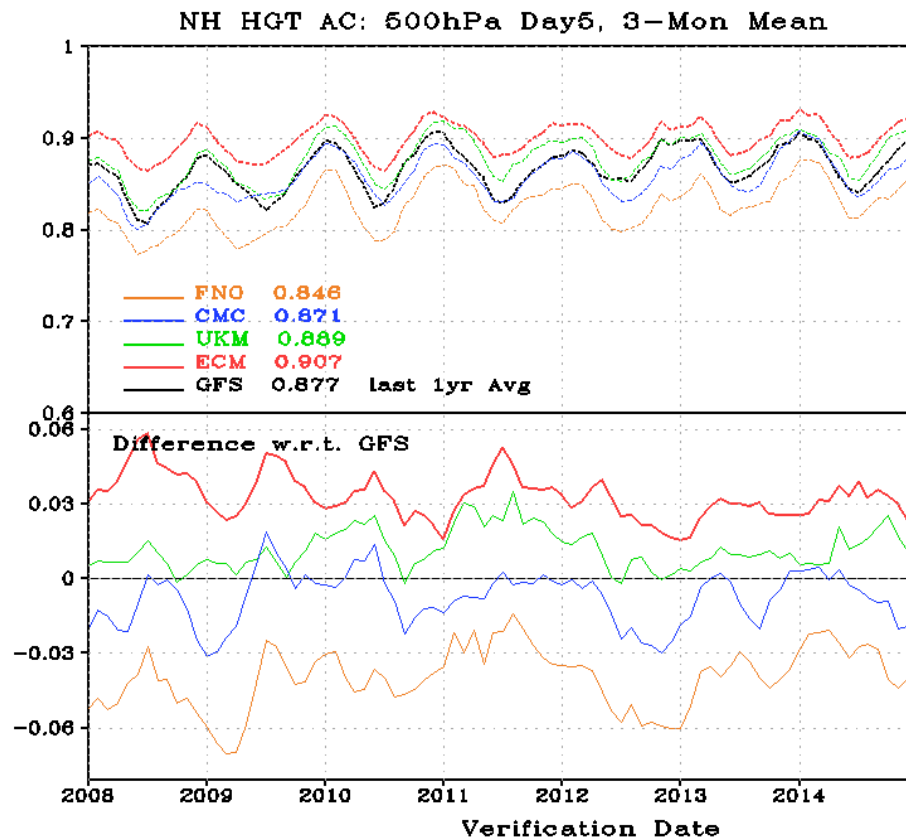
TRO

SH



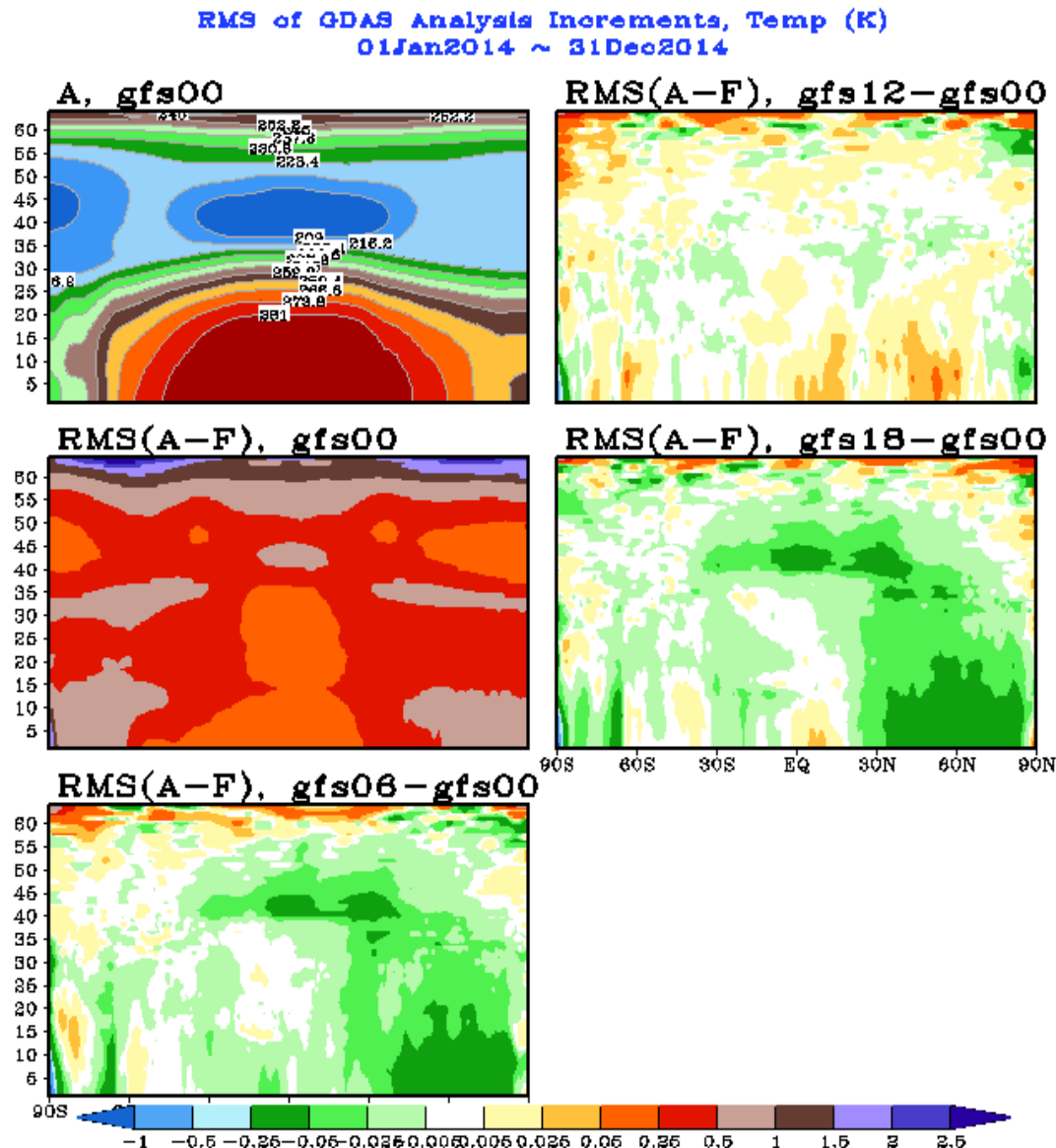
The largest difference is found in the NH 06Z and 18Z cycles

Comparison with other NWP models



The difference between the GFS four cycles **[-0.016 to 0.008]** is much smaller (~five times) than that between different NWP models **[-0.06 to 0.06]**.

Zonal-Mean RMS of Temperature Analysis Increment (A-B), 2014

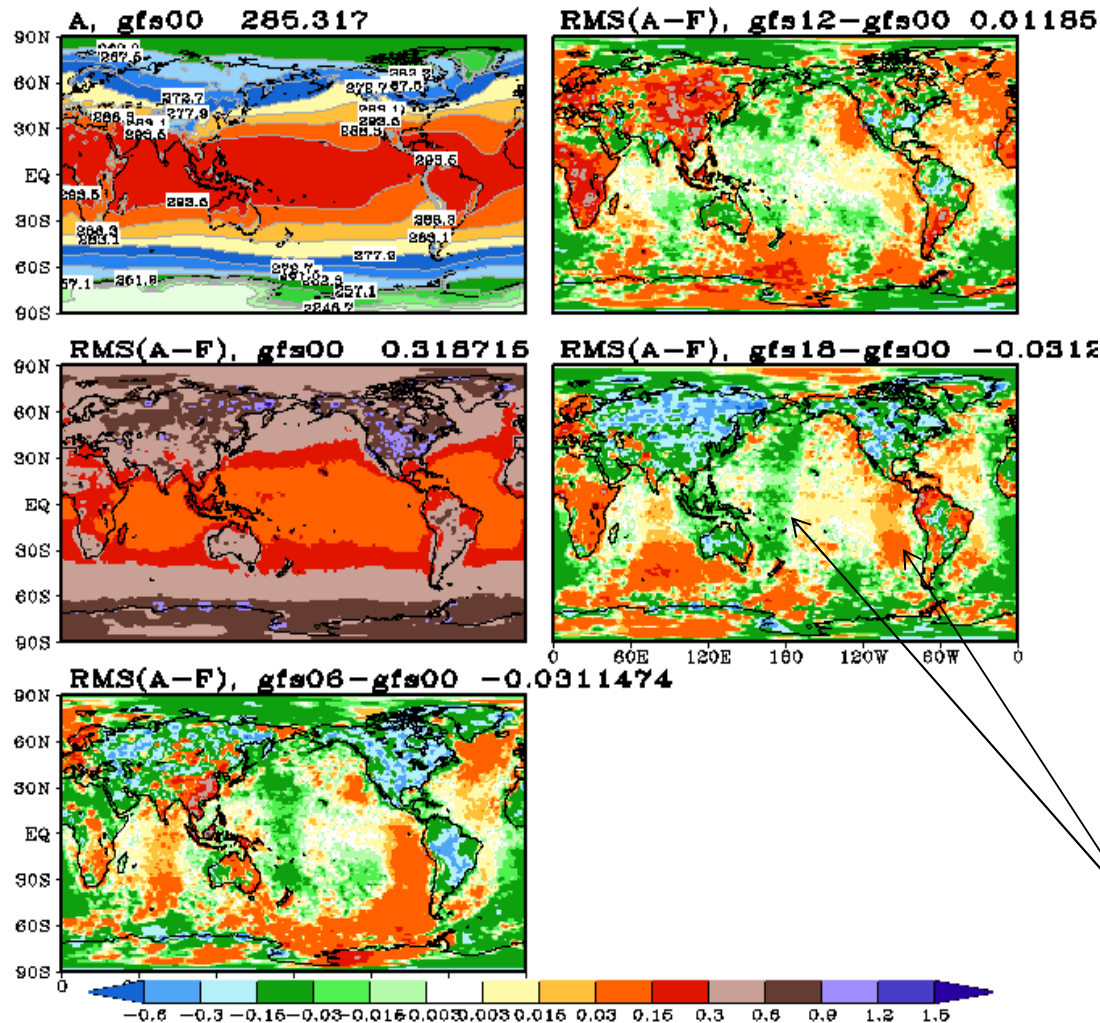


- 12Z cycle has similar increments to the 00Z cycle through the atmosphere
- 06Z and 18Z cycles have smaller increments than 00Z cycle in the NH troposphere and near the tropical tropopause, and similar increments to the 00Z cycle in the SH.
- The difference is likely caused by different number of conventional observations among the cycles.
- In SH, satellite observations dominate, which do not change much from cycle to cycle. 26

Lat-Lon RMS Distribution of Temperature Analysis Increment (A-B), 2014

955-hPa

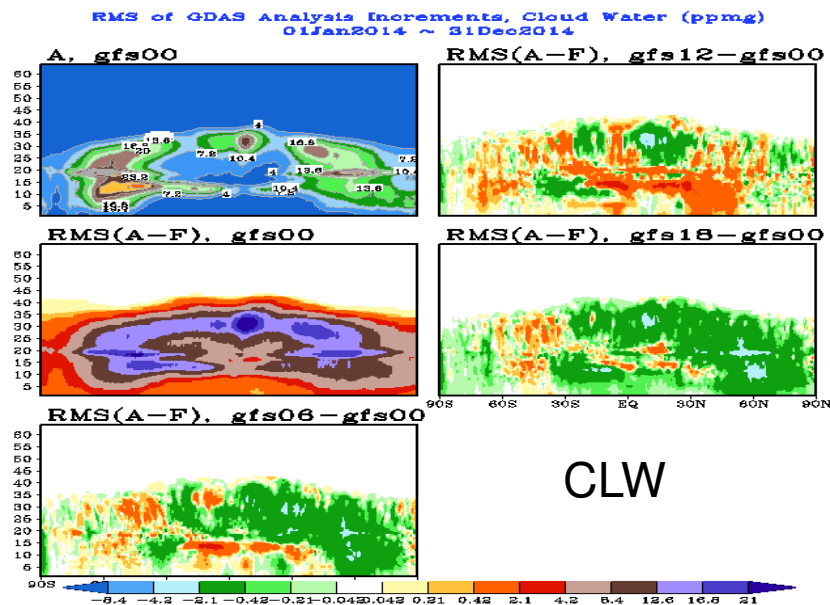
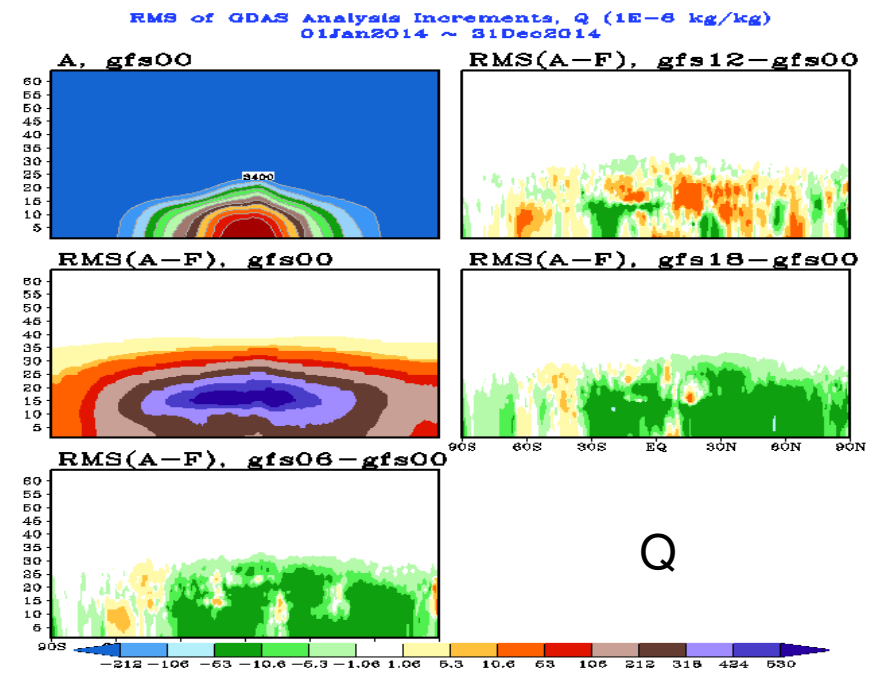
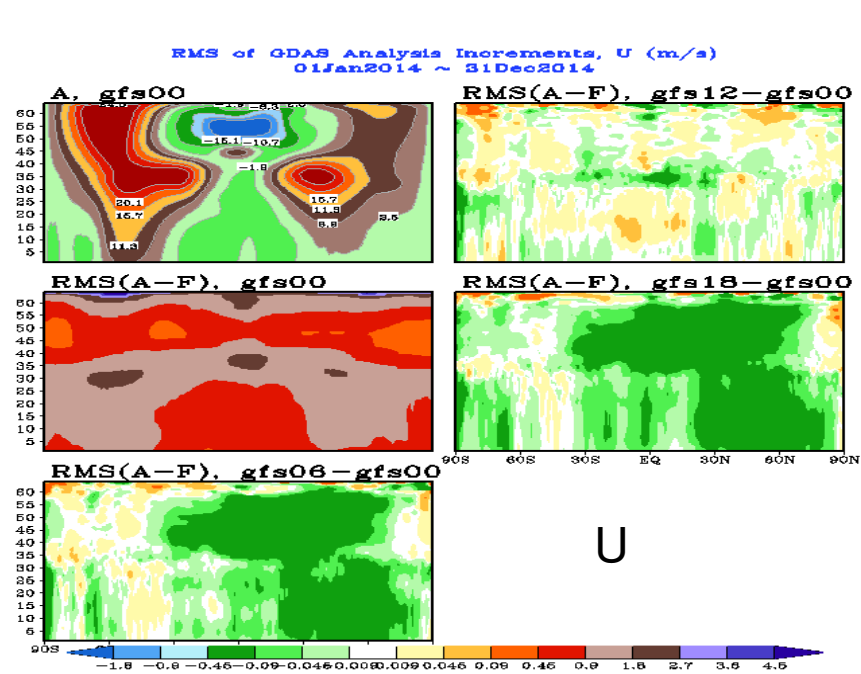
RMS of GDAS Analysis Increments, Temp (K)
siglev=7, 955 hPa, 01Jan2014 ~ 31Dec2014



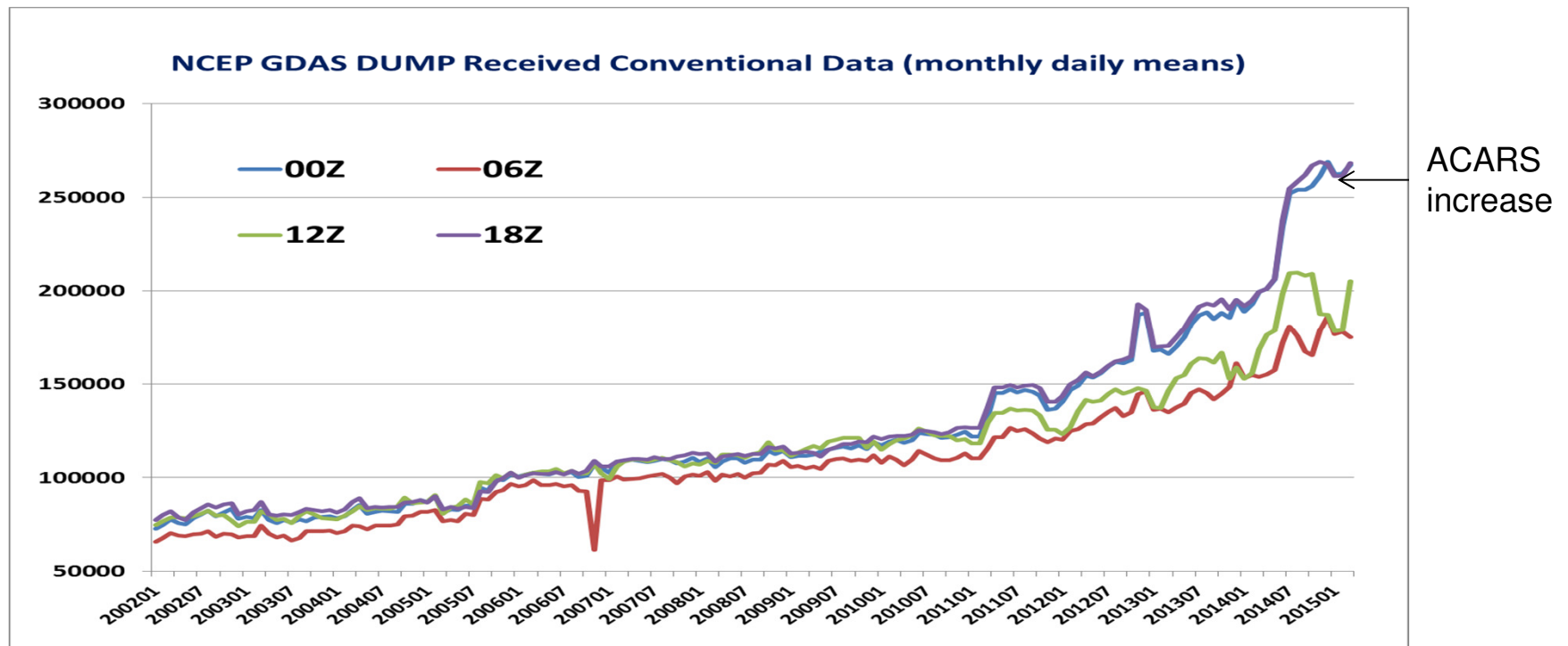
- 12Z cycle has larger increments than 00Z cycle over Eurasia and Africa and smaller increments over American Continents.
- 06Z and 18Z cycles have smaller increments than 00Z cycle over both Eurasia and American Continents.

Footprint of satellite obs

A few more RMSI of interest

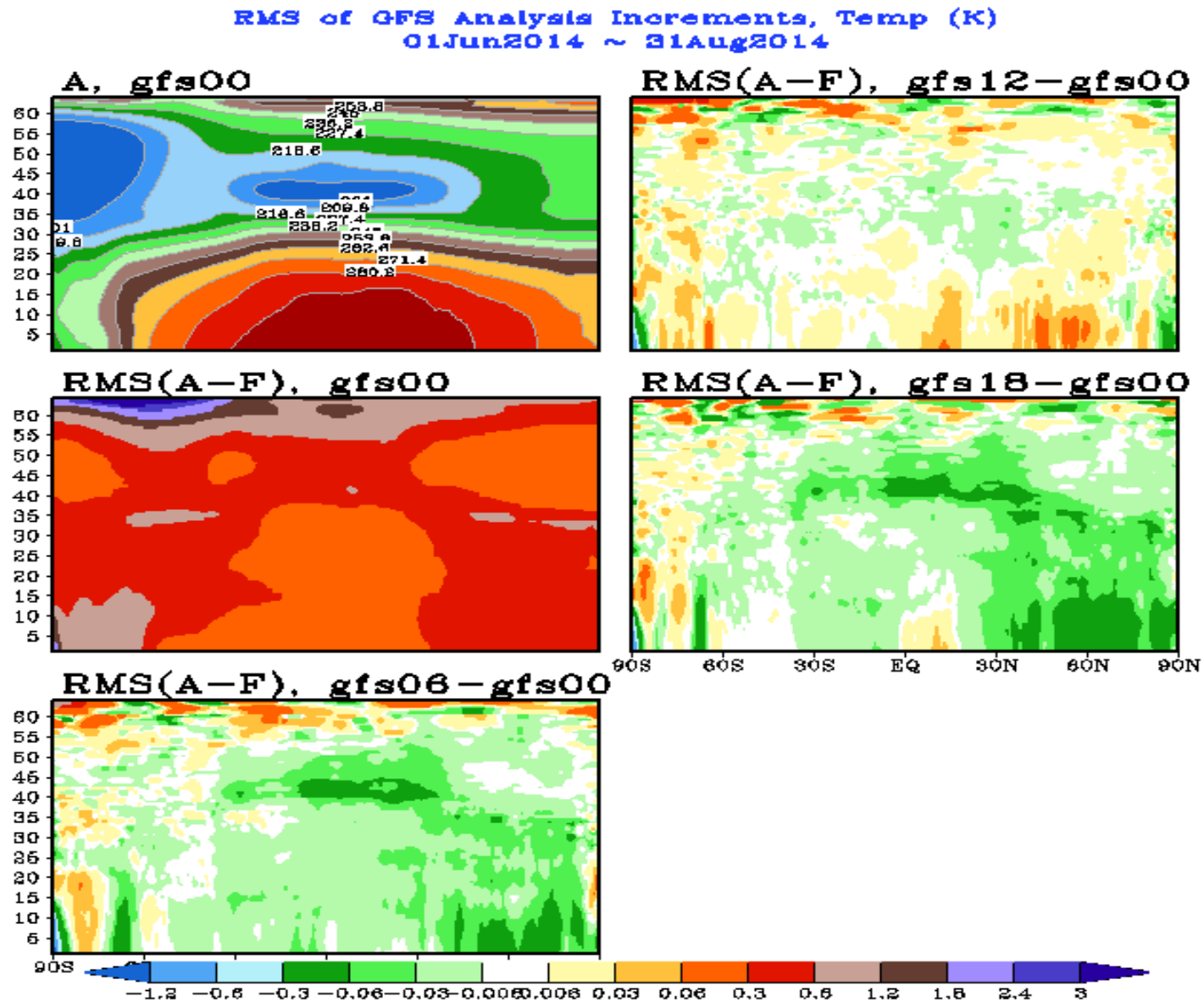


Conventional Data

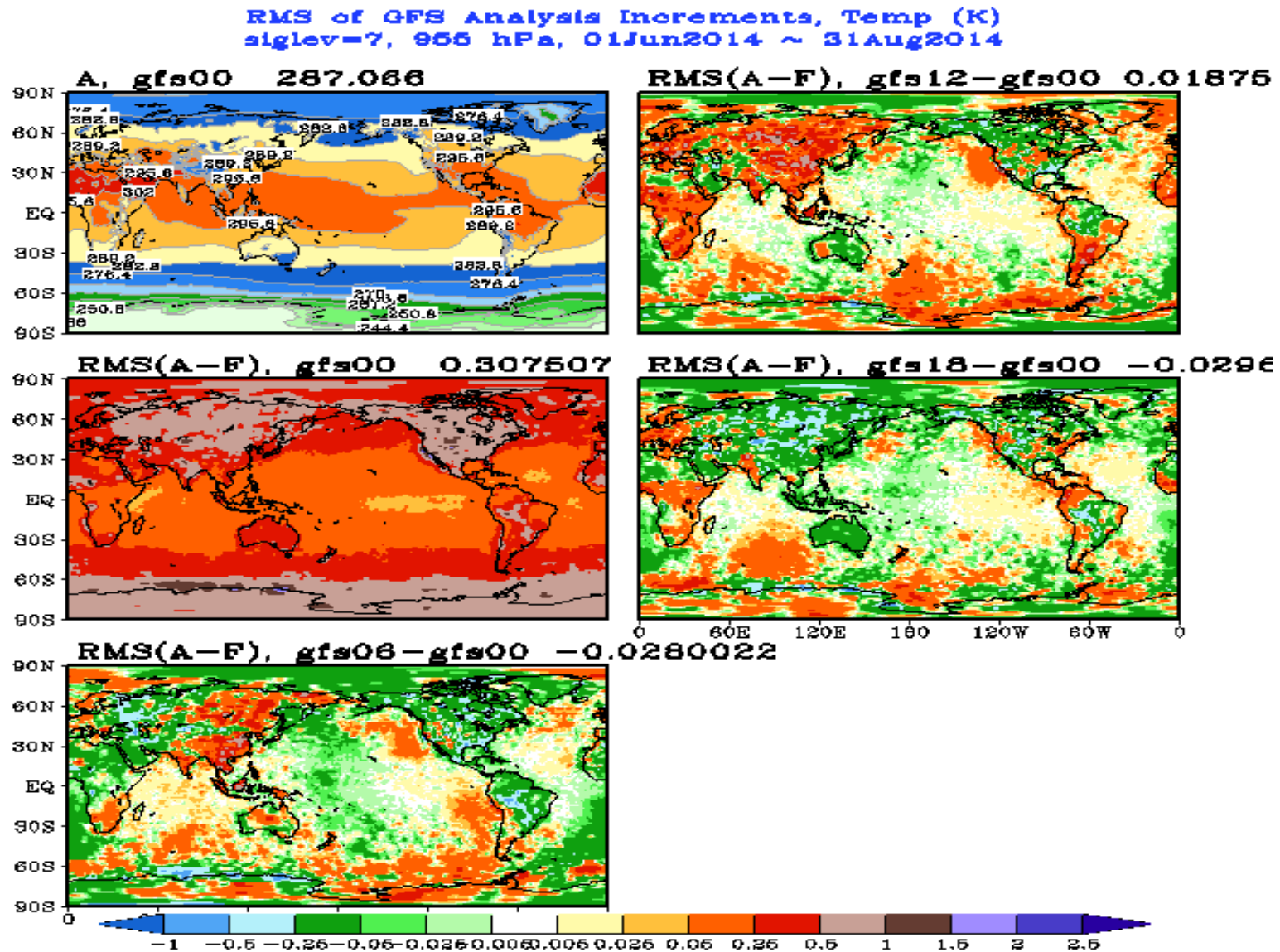


- **06Z data count is always less** (10~30%) than other cycles.
- Even though the 18Z-cycle forecast score is worse than the 00Z-cycle score, **18Z conventional data count is not less than 00Z !**
- 12Z data count started to deviate from the 00Z and 18Z cycles after 2011.
- Increase of 06Z and 18Z data after 2014 is primarily due to ACARS data

GFS Analysis Increment RMS, JJA 2014



GFS Analysis Increment RMS, JJA 2014



http://www.emc.ncep.noaa.gov/gmb/wx24fy/vsdb/gfs2014_4cyc/