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

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Questions to Address

1. **Is there any difference in forecast skills between the GFS four cycles? And Why?**

2. **Most international NWP centers run global medium-range weather forecast two times per day (00Z and 12Z cycles), while NCEP runs GFS four times per day up to 16 days each. Do the 06Z and 18Z cycles provide any extra value for forecasters and downstream jobs?**

Outline

1. **Difference in forecast skills between GFS four cycles (00Z, 06Z, 12Z and 18Z)**

2. **Difference in analyses between the four cycles**

3. **Usage of conventional and satellite data among the four cycles**

4. **The value of GFS 06Z and 18Z cycles**

Outline

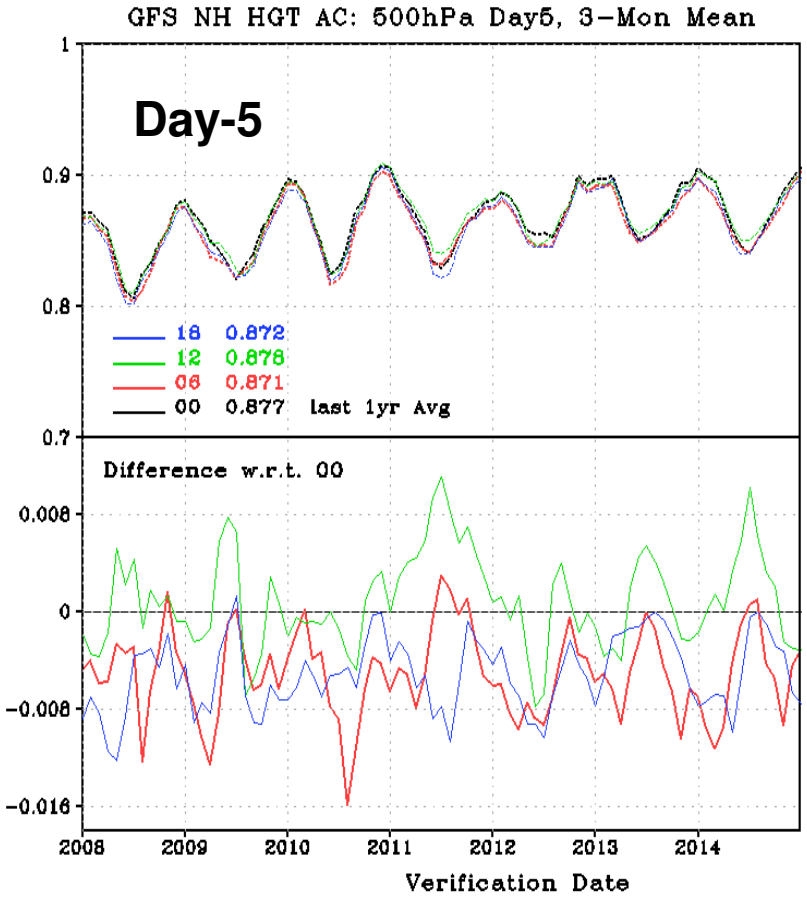
1. **Difference in forecast skills between GFS four cycles (00Z, 06Z, 12Z and 18Z)**

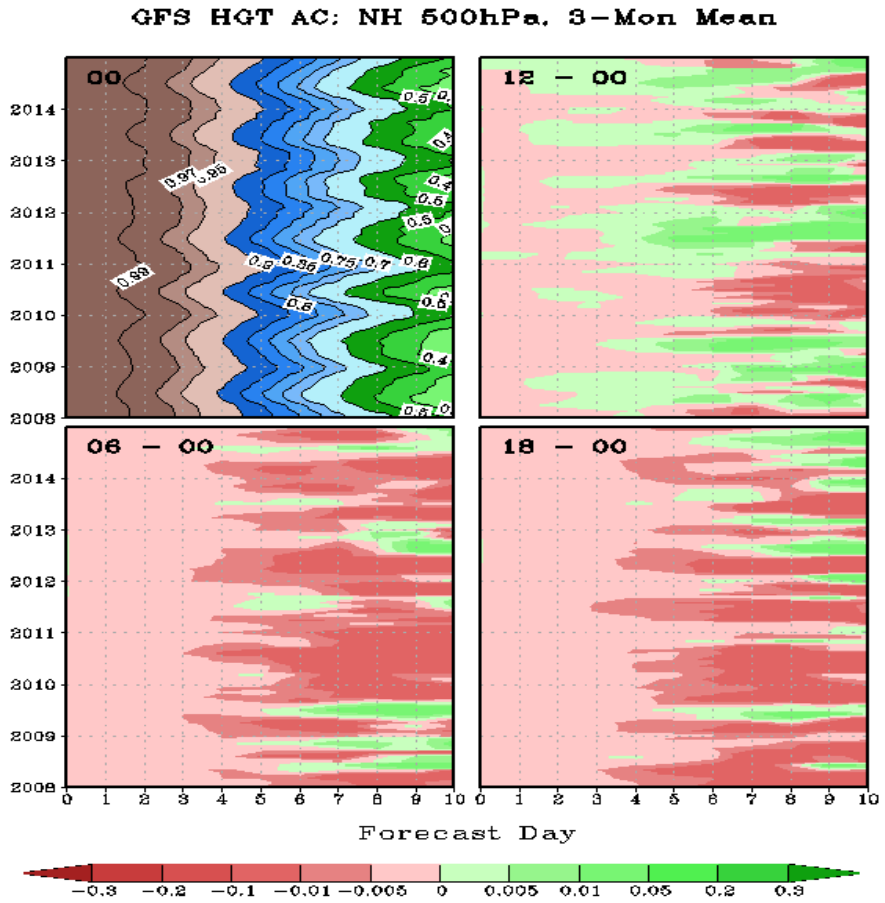
2. Difference in analyses between the four cycles

3. Usage of conventional and satellite data among the four cycles

4. The value of GFS 06Z and 18Z cycles

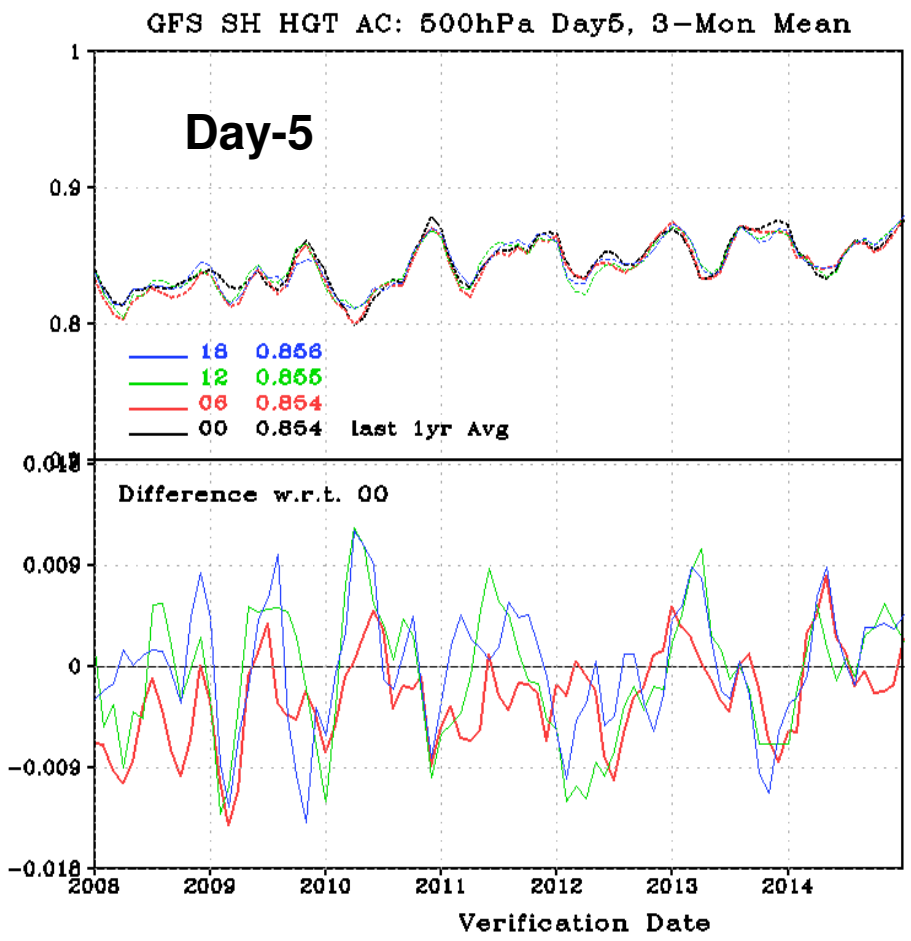
GFS NH 500-hPa HGT Anomaly Correlation Since 2008

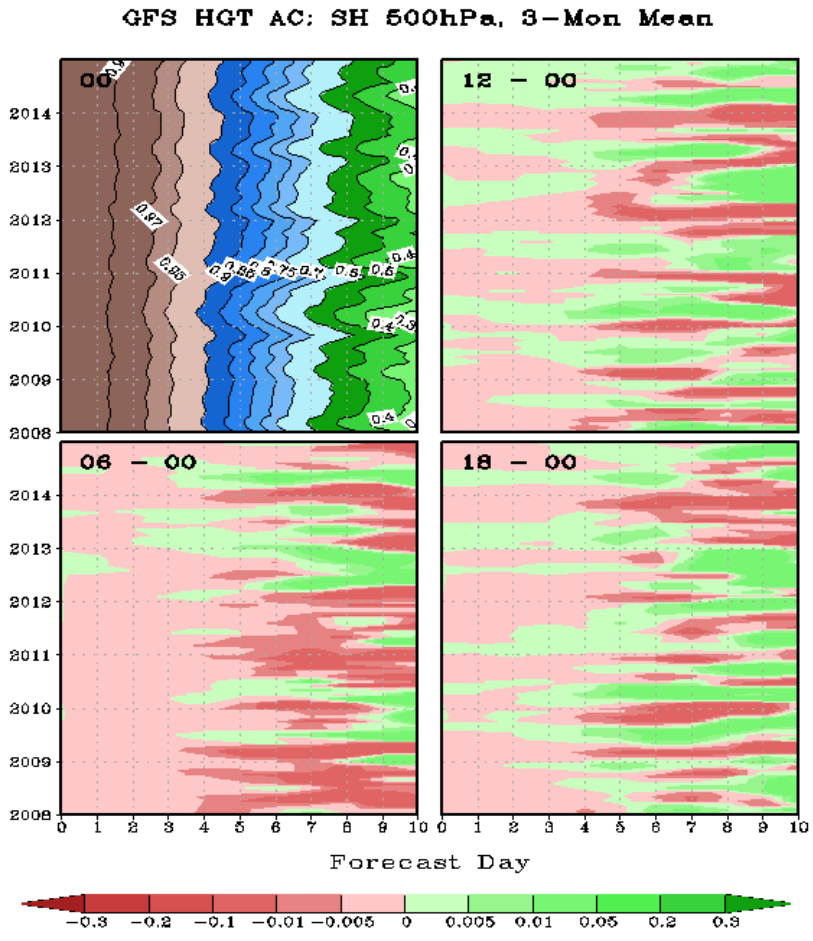




- **All cycles have been steadily improved.**
- **12Z cycle is comparable to 00Z cycle.**
- **06Z and 18Z cycles are consistently worse than 00Z and 12Z cycles**

GFS SH 500-hPa HGT Anomaly Correlation Since 2008



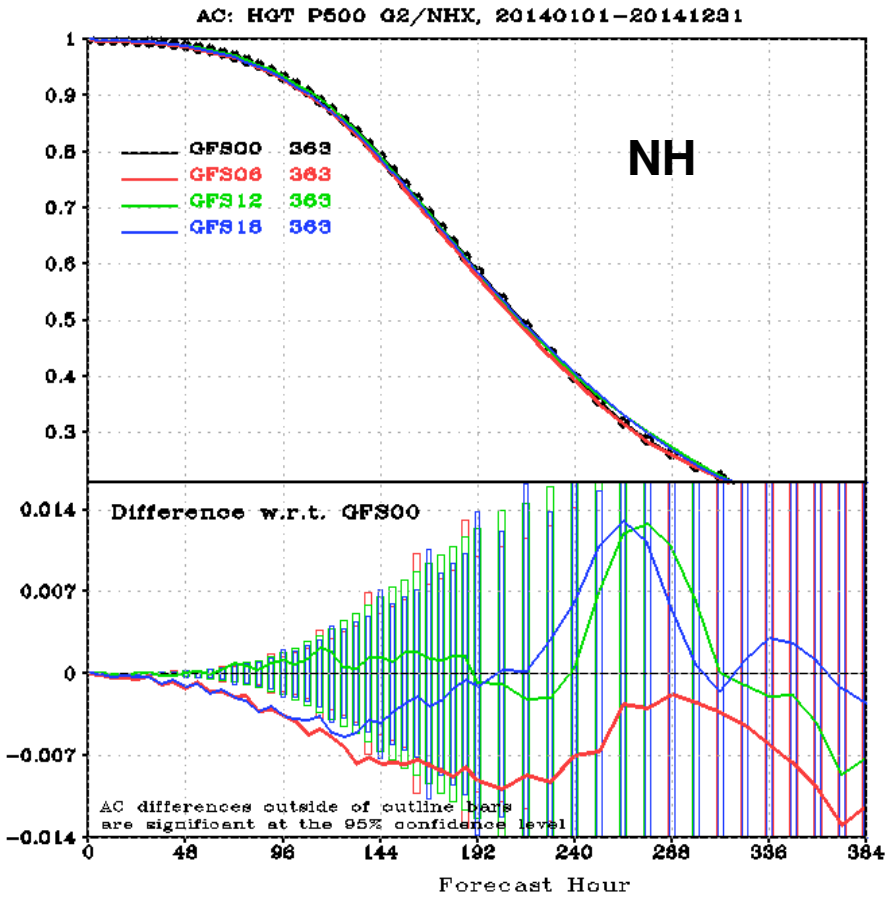


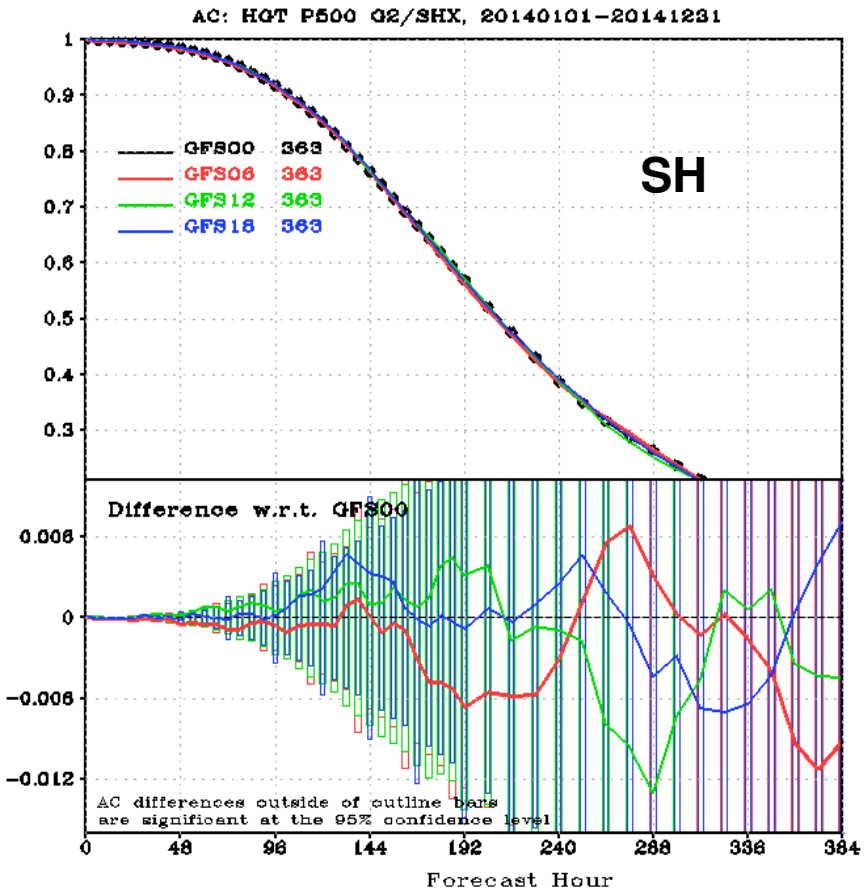
- **All cycles have been steadily improved.**
- **In contrast to the NH, there is no systematic differences between the four cycles except the 06Z cycle is slightly worse.**

Are these differences significant?

Forecasts verified against GFS own analysis

2014 500-hPa AC, 6-hourly verification





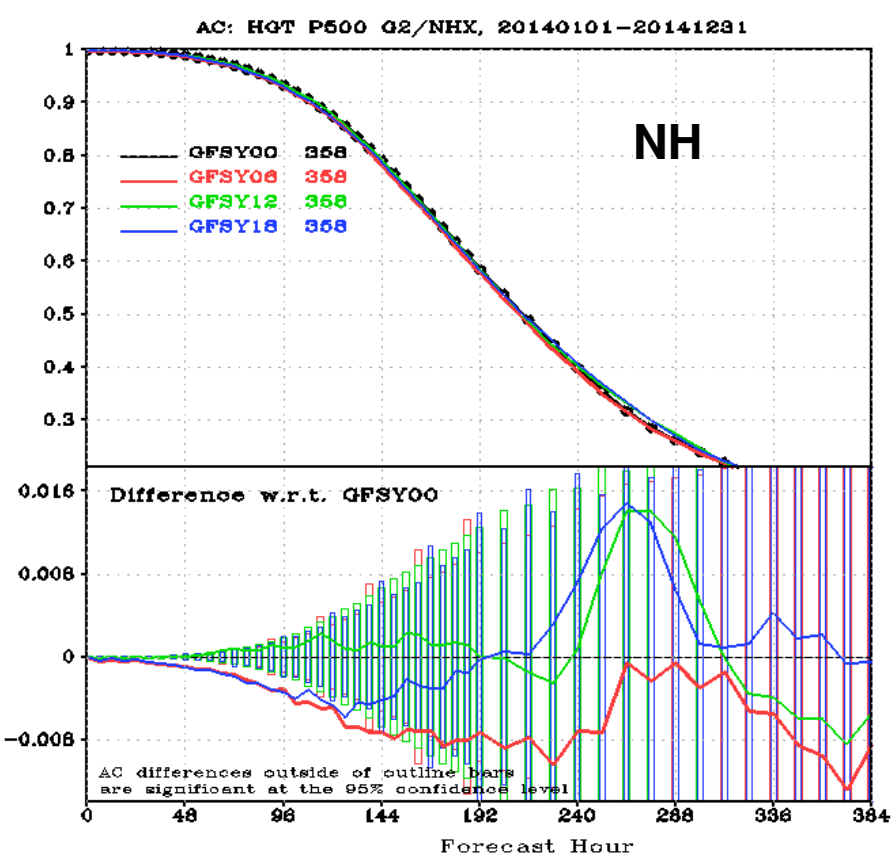
06Z and 18Z cycles are significantly worse than 00Z cycle for forecasts up to 6 to 7 days.

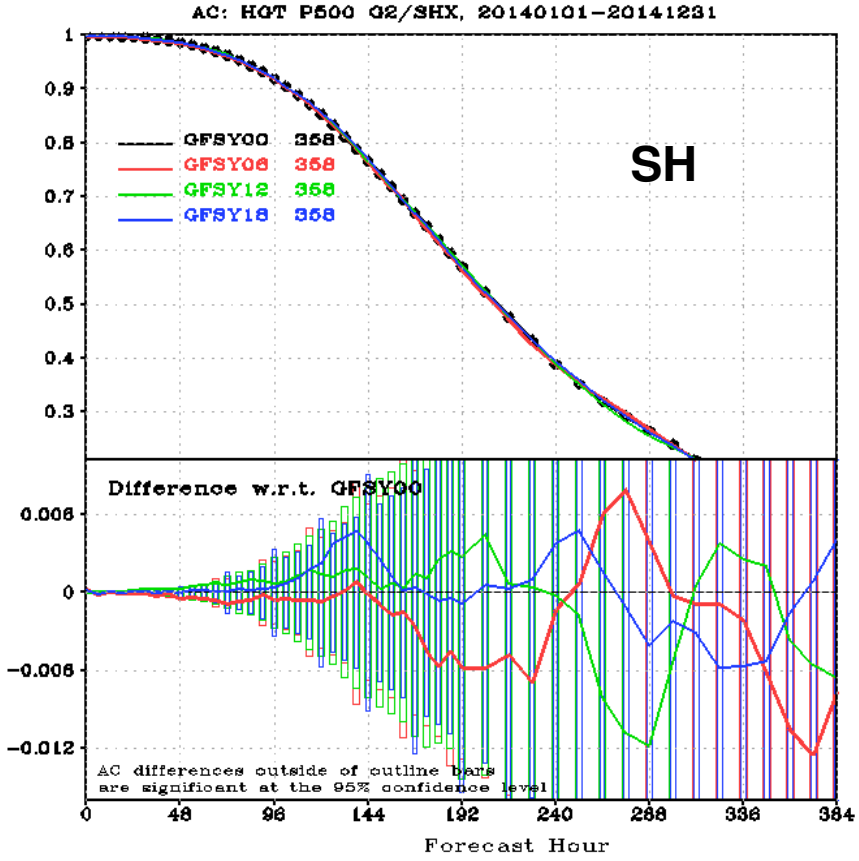
No significant differences between the four cycles

Are these differences significant?

Forecasts verified against ECMWF analyses

2014 500-hPa AC, 6-hourly verification





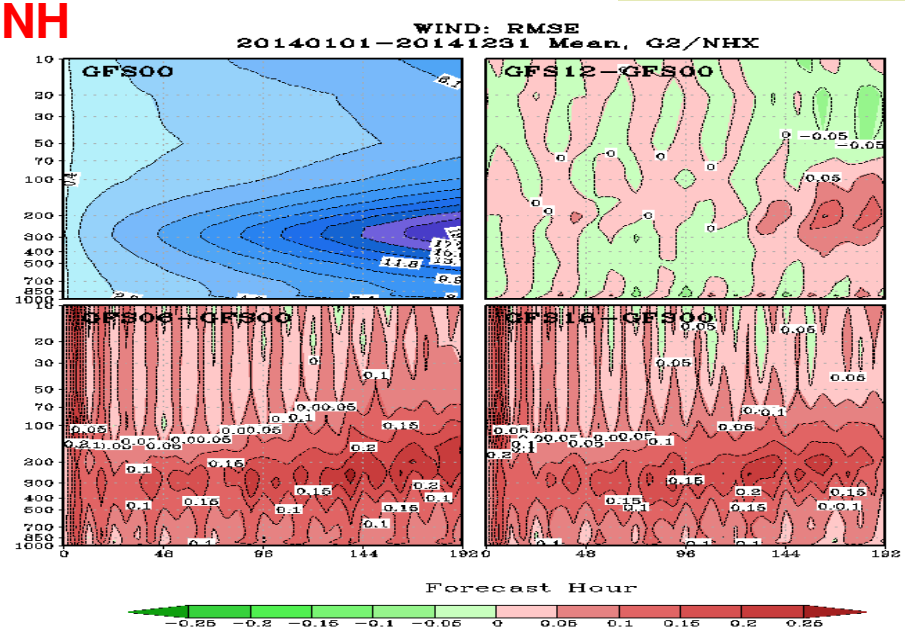
06Z and 18Z cycles are significantly worse than 00Z cycle for forecasts up to 6 to 7 days.

No significant differences between the four cycles

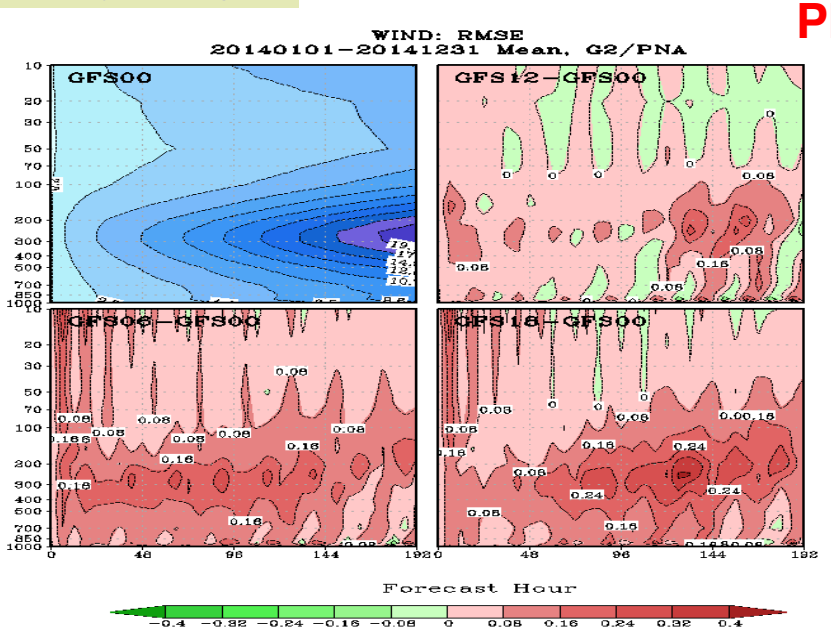
Same as verified against GFS own analyses.

Differences in Wind RMSE

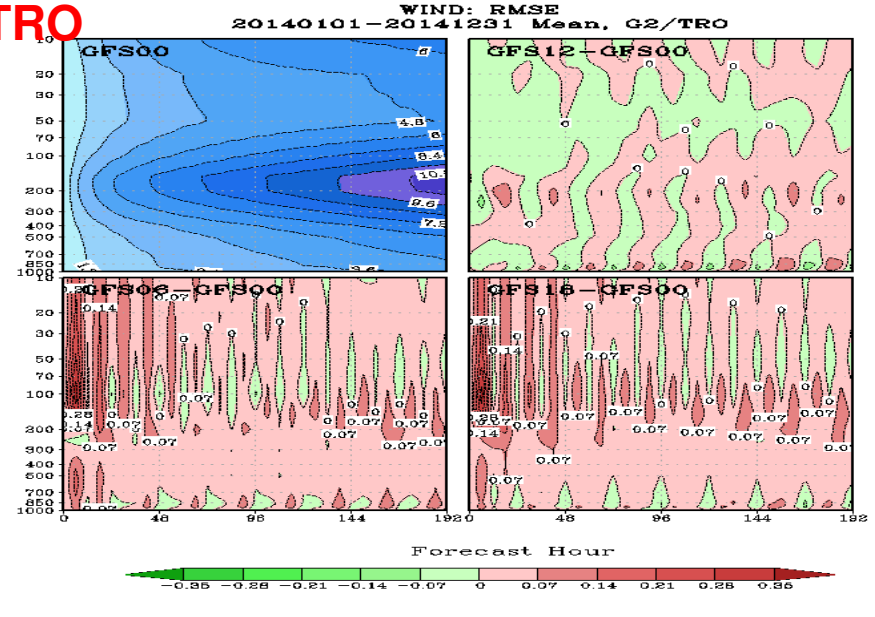
NH



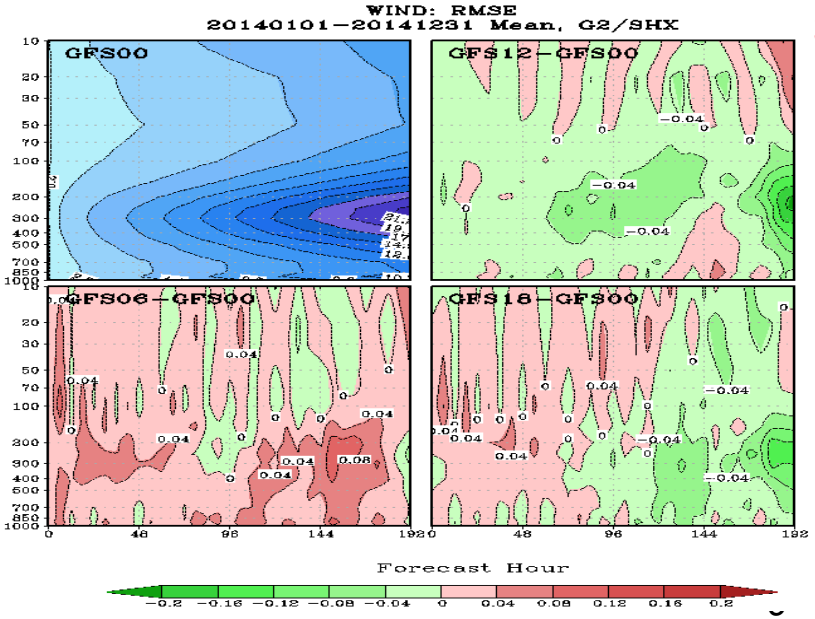
PNA



TRO



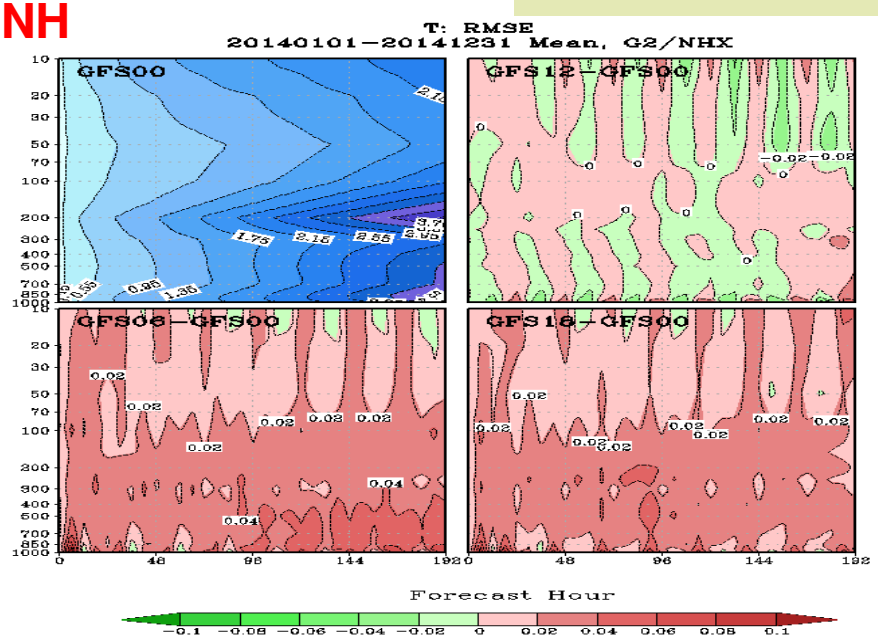
SH



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

Differences in Temperature RMSE

NH



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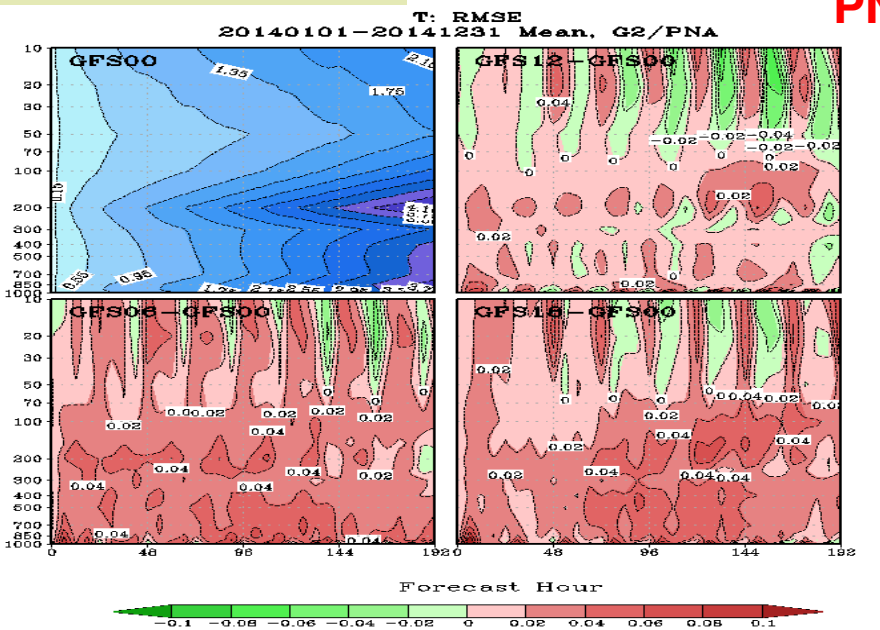

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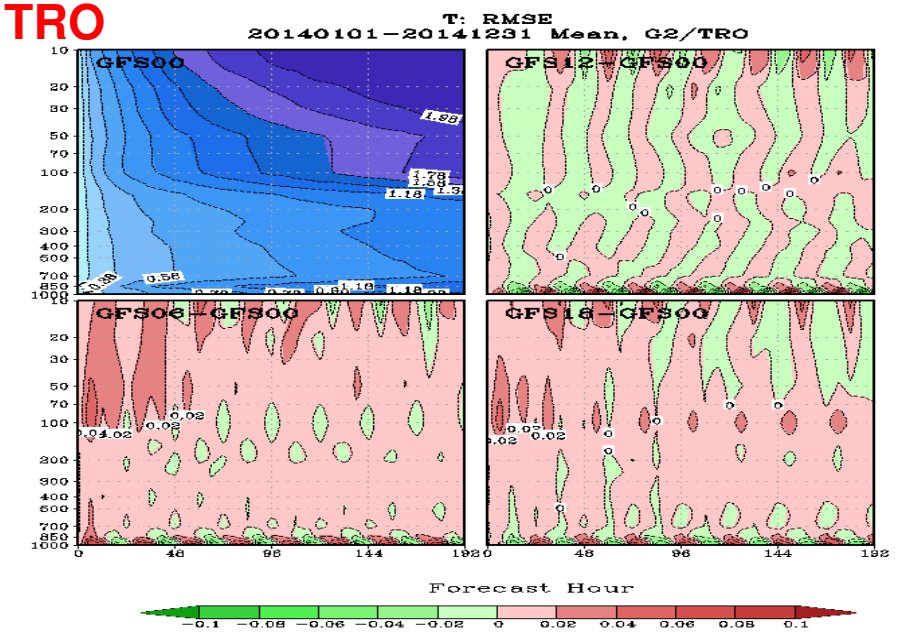
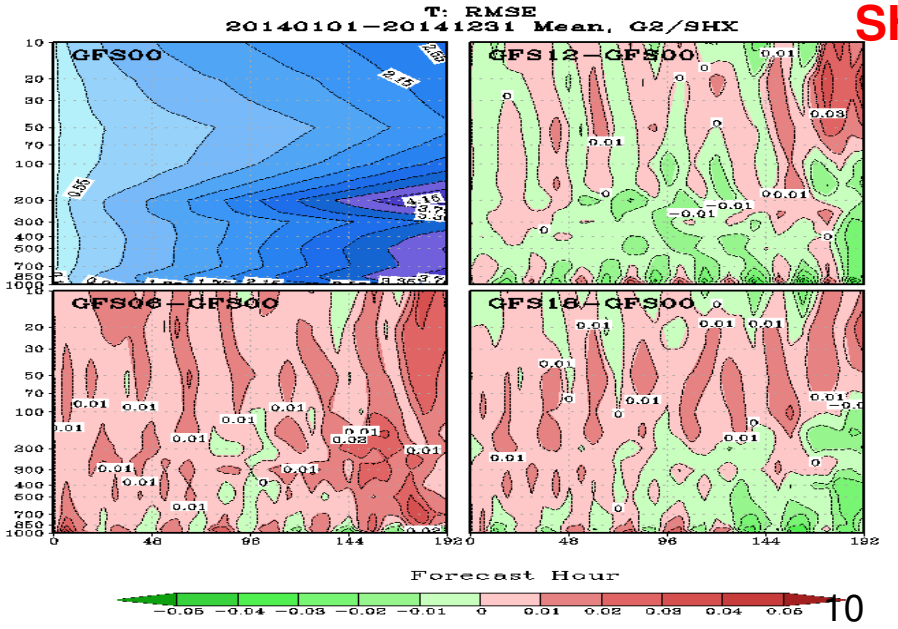
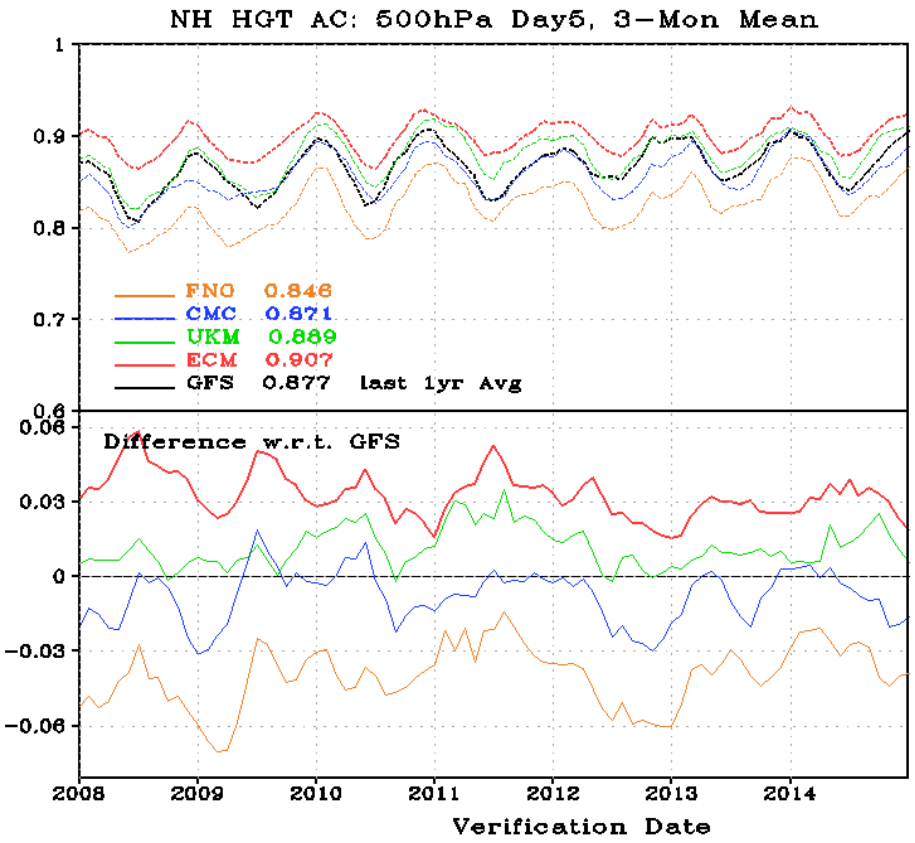


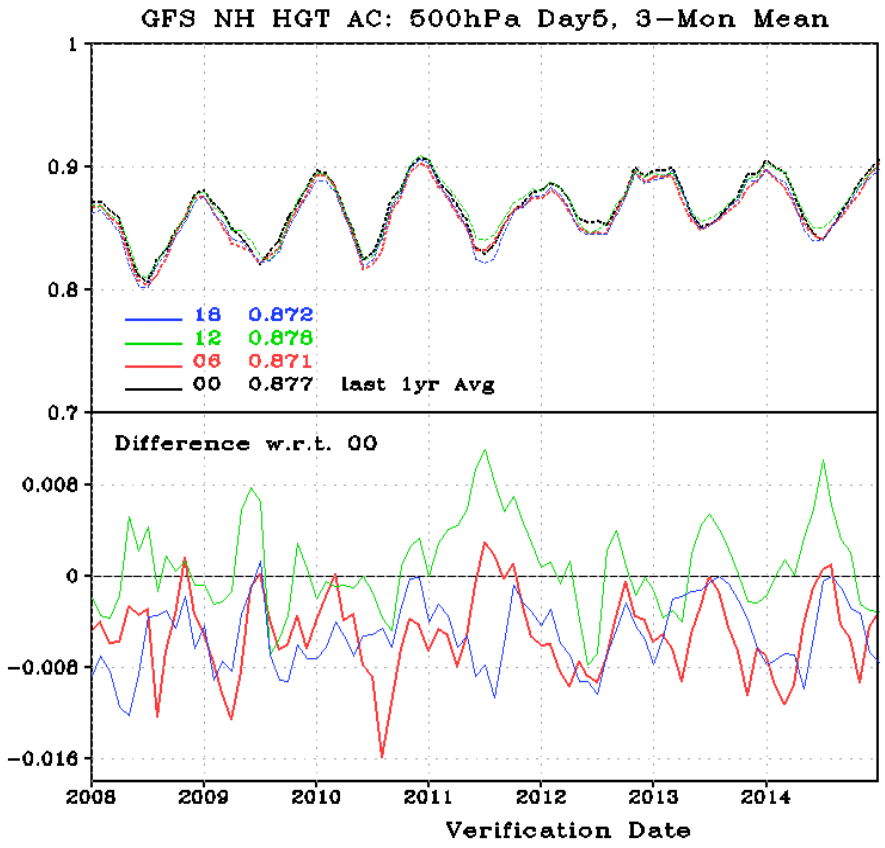
SH



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].

Findings

- **GFS 00Z cycle is the best in all categories. 12Z cycle is close to the 00Z cycle.**
- **GFS 06Z and 18Z cycle are less skillful than the 00Z and 12Z cycles.**
- **The difference in the NH is the largest**
- **Overall, the difference in forecast skills between the GFS four cycles is smaller than that between different NWP models.**

Outline

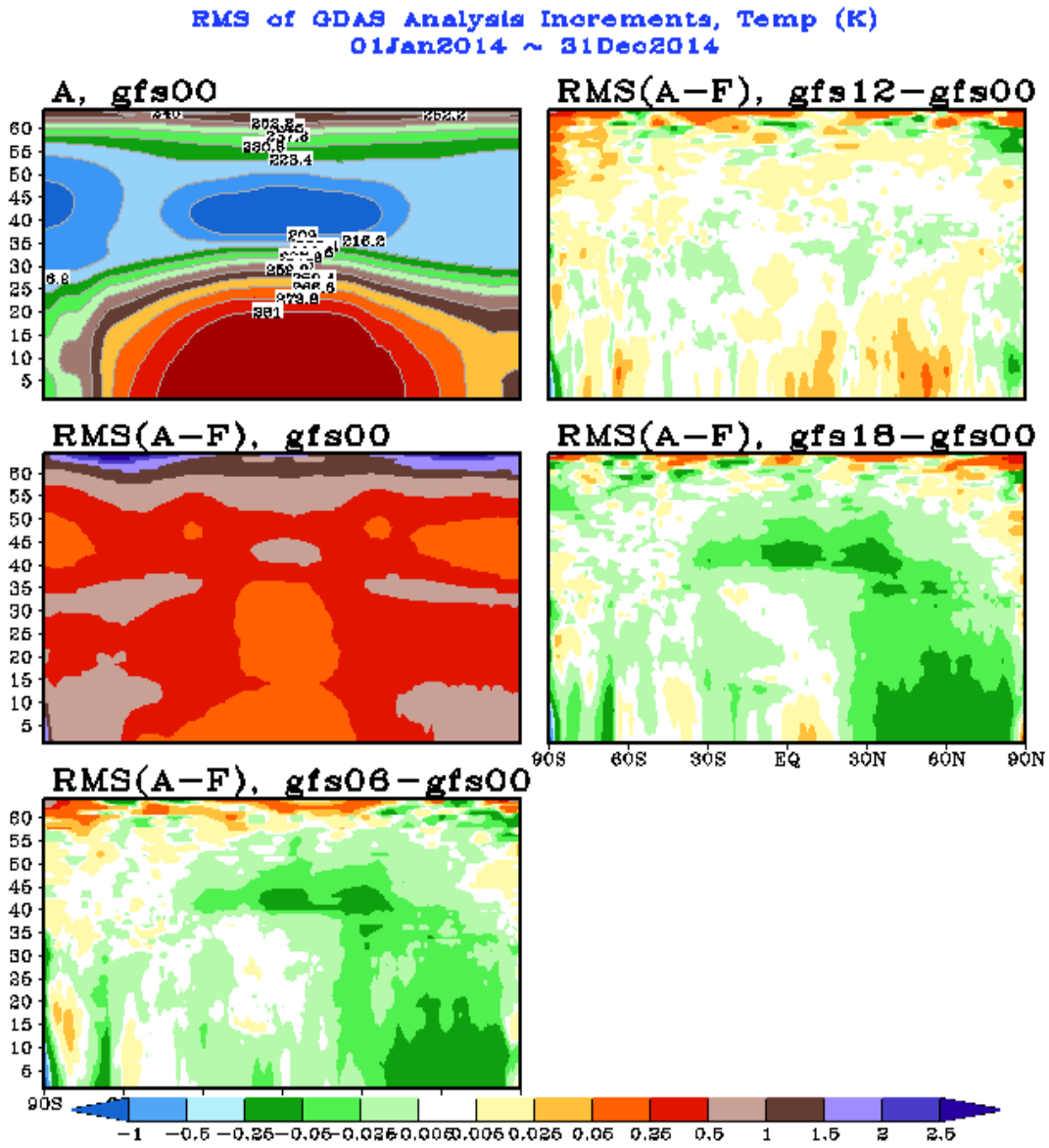
1. Difference in forecast skills between GFS four cycles (00Z, 06Z, 12Z and 18Z)

2. **Difference in analyses between the four cycles**

3. Usage of conventional and satellite data among the four cycles

4. The value of GFS 06Z and 18Z cycles

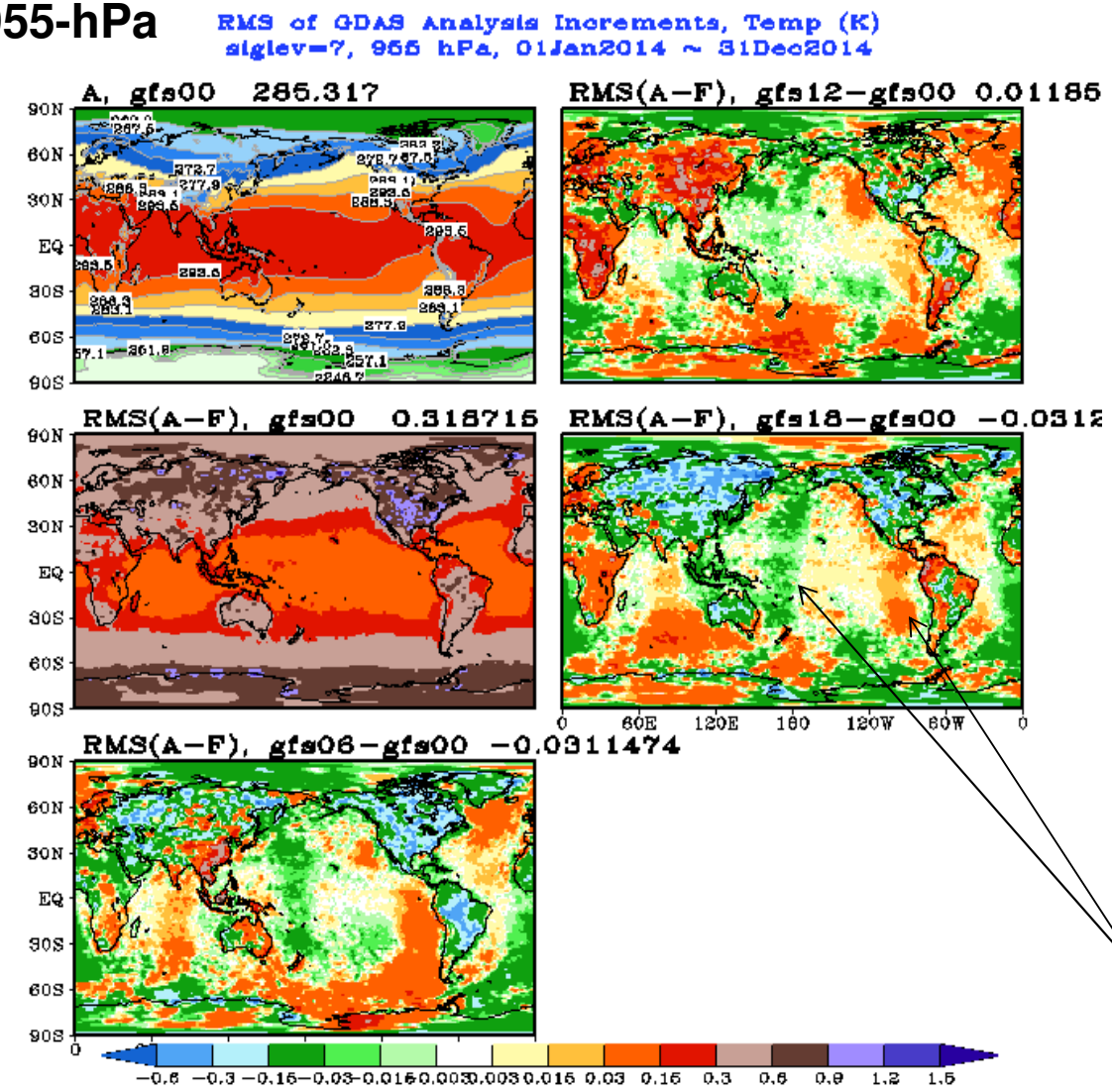
Zonal-Mean RMS of Temperature Analysis Increment (A-B), 2014



- 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.

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

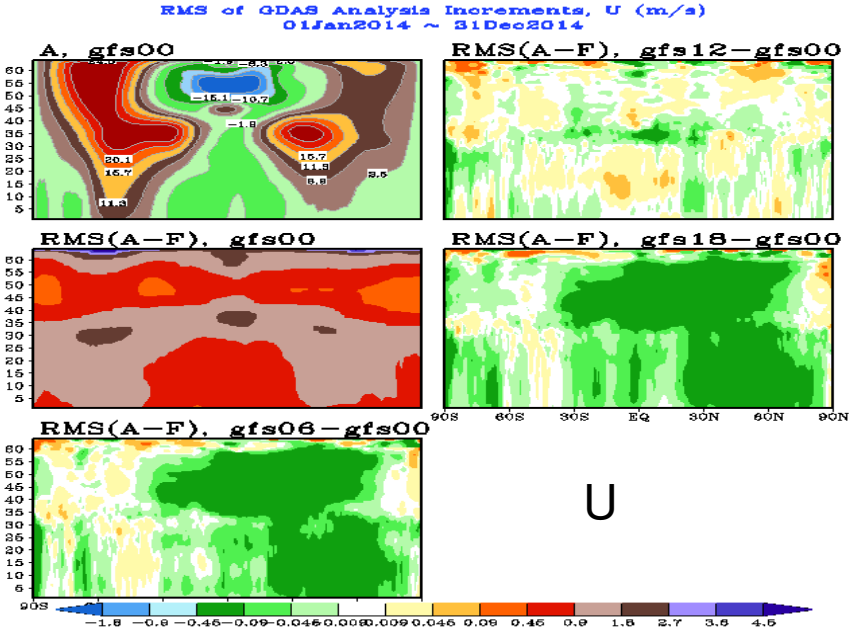
955-hPa

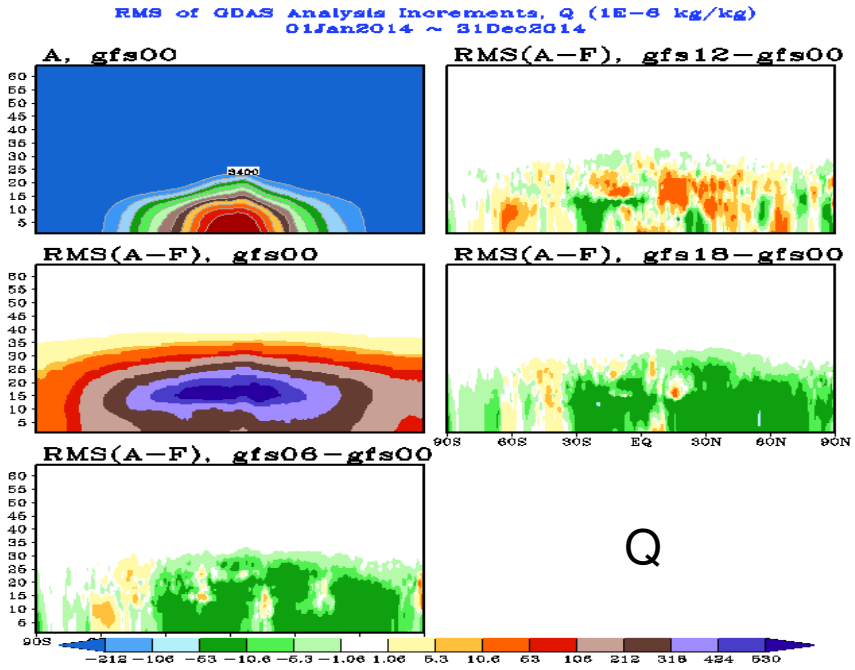


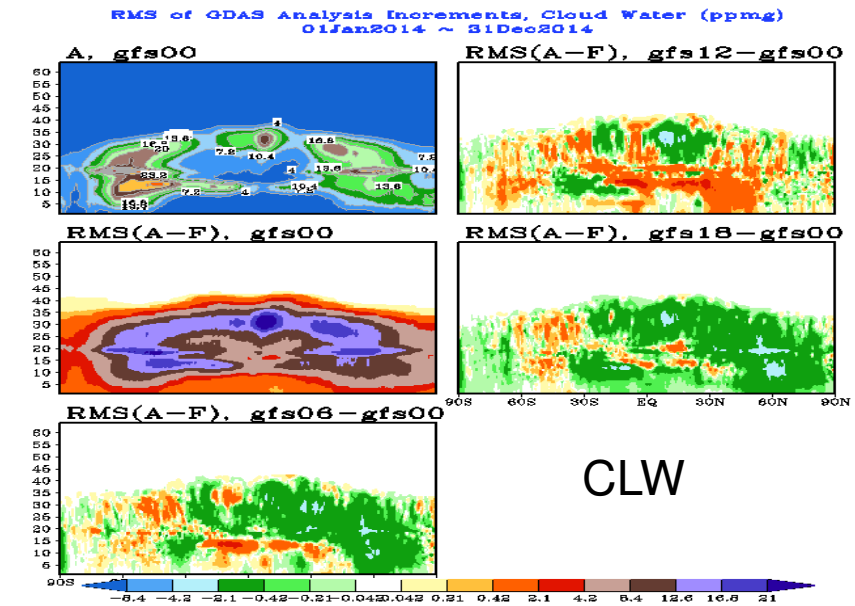
- 12Z cycle has larger increments than 00Z cycle over Eurasia and Africa and smaller increments over American Continents.
- 06Z and 18Z cycles have smaller increments than 00Z cycle over both Eurasia and American Continents.

Footprint of satellite obs

A few more RMSI of interest







Outline

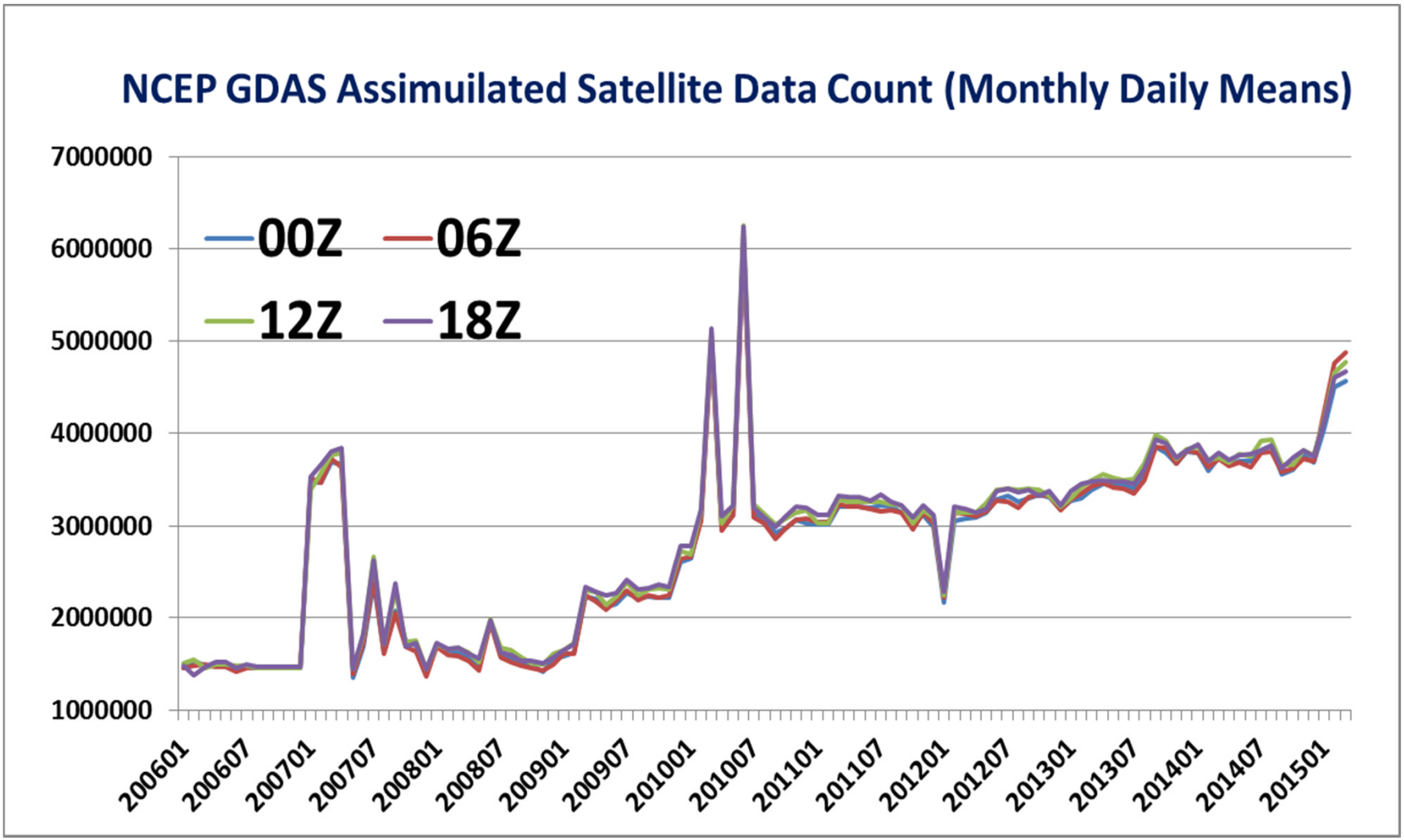
1. Difference in forecast skills between GFS four cycles (00Z, 06Z, 12Z and 18Z)

2. Difference in analyses between the four cycles

3. **Usage of conventional and satellite data among the four cycles**

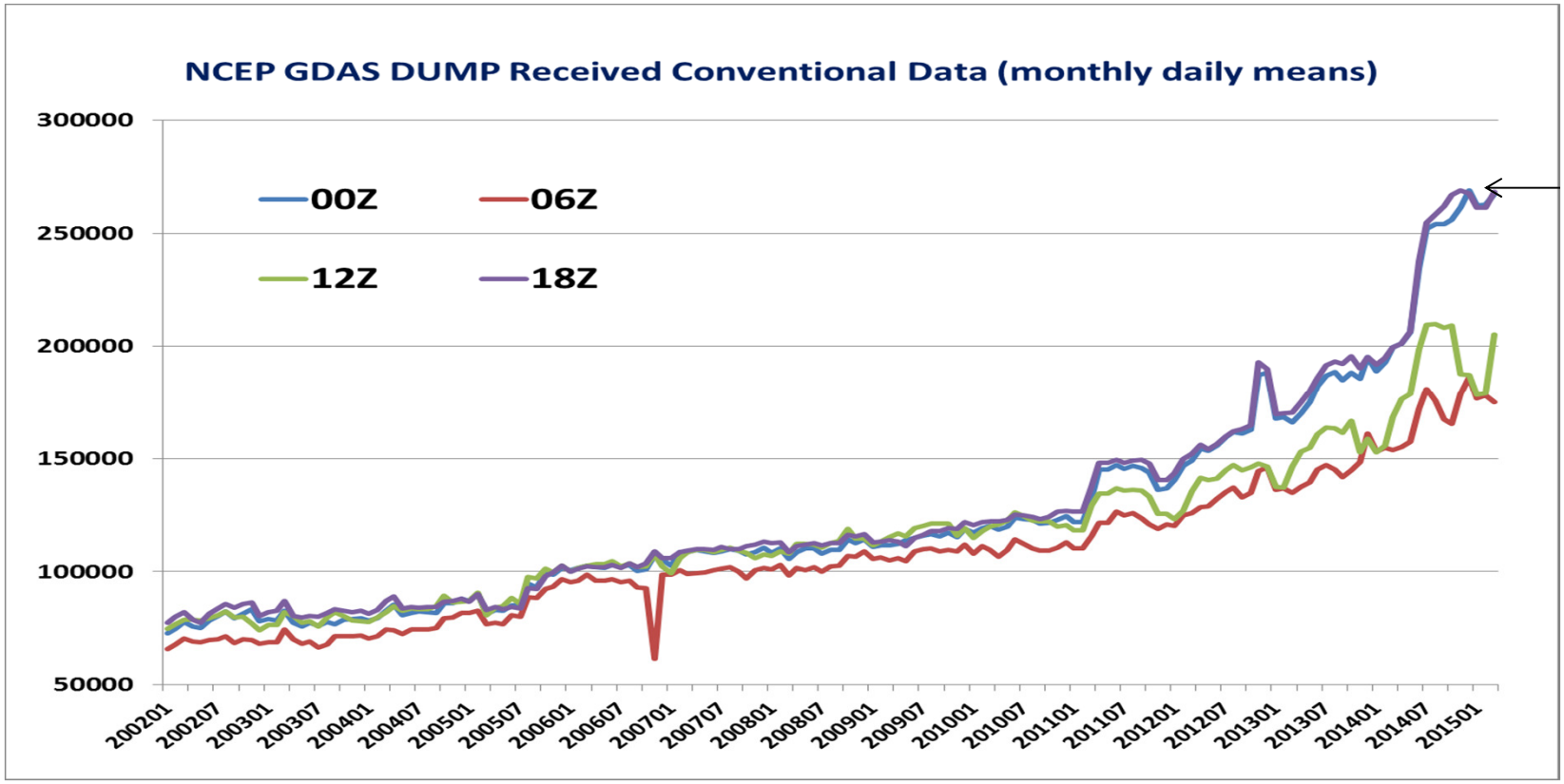
4. The value of GFS 06Z and 18Z cycles

Data Source: http://www.nco.ncep.noaa.gov/sib/counts/



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

Data Source: http://www.nco.ncep.noaa.gov/sib/counts/



ACARS increase

- **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**

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

- **It appears analysis increments of the 06Z and 18Z cycles are much smaller than that of the 00Z and 12Z cycles over the NH land.**

- **The difference in analysis increments and forecast skills are not simplistically explained by the total number of satellite and convectional observations.**

- **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? Data denial experiments need to be conducted to confirm.**
- ***Conventional data are still important.***

Outline

1. Difference in forecast skills between GFS four cycles (00Z, 06Z, 12Z and 18Z)

2. Difference in analyses between the four cycles

3. Usage of conventional and satellite data among the four cycles

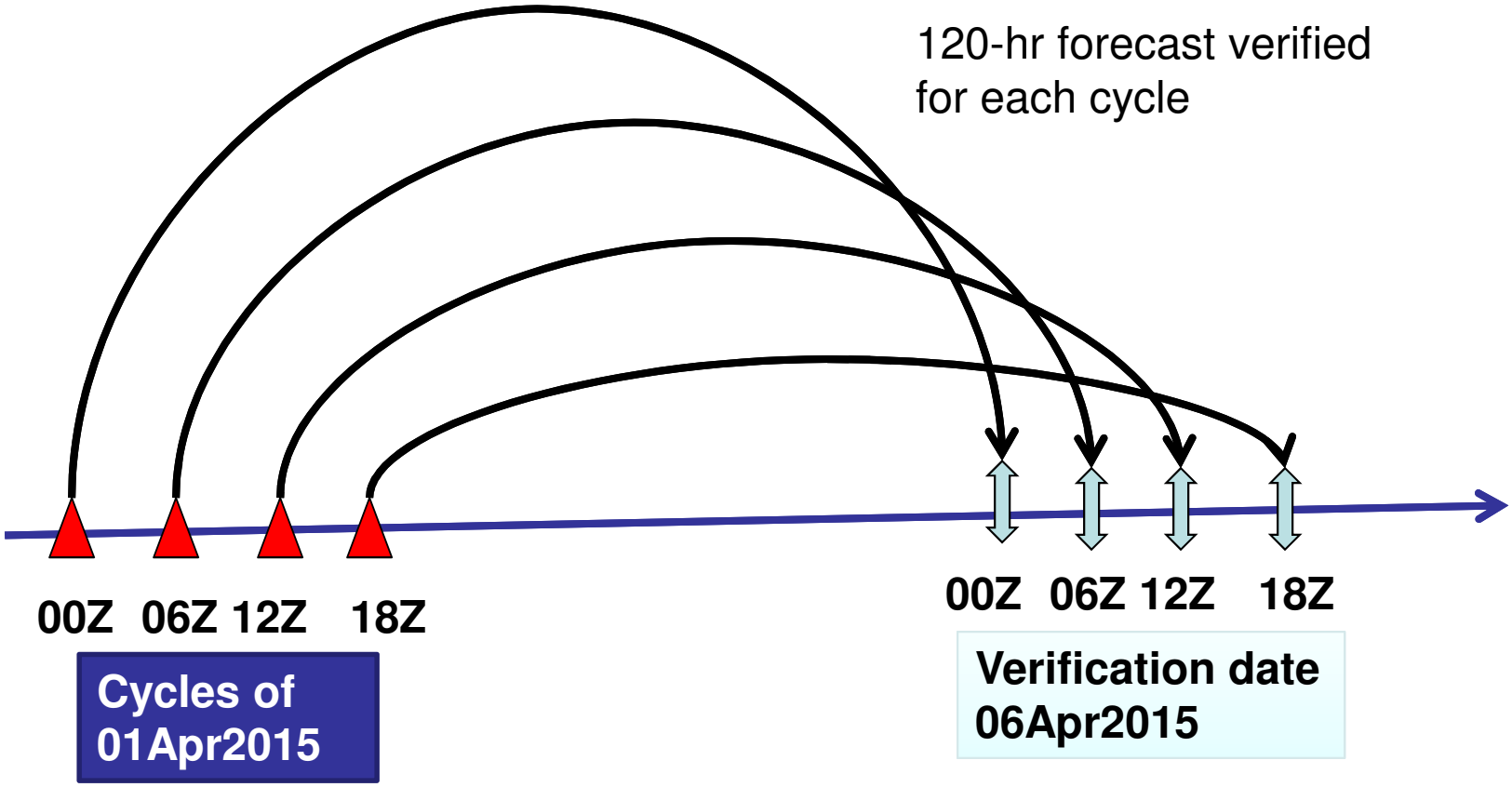
4. **The value of GFS 06Z and 18Z cycles**

1. **Most international NWP centers only run medium-range forecasts for the 00Z and 12Z cycles, even though data assimilation is still carried out for every 6 hours.**

2. **NCEP runs GFS/GDAS data assimilation 4 times per day, and GFS forecasts for all four cycles up to 384 hours.**

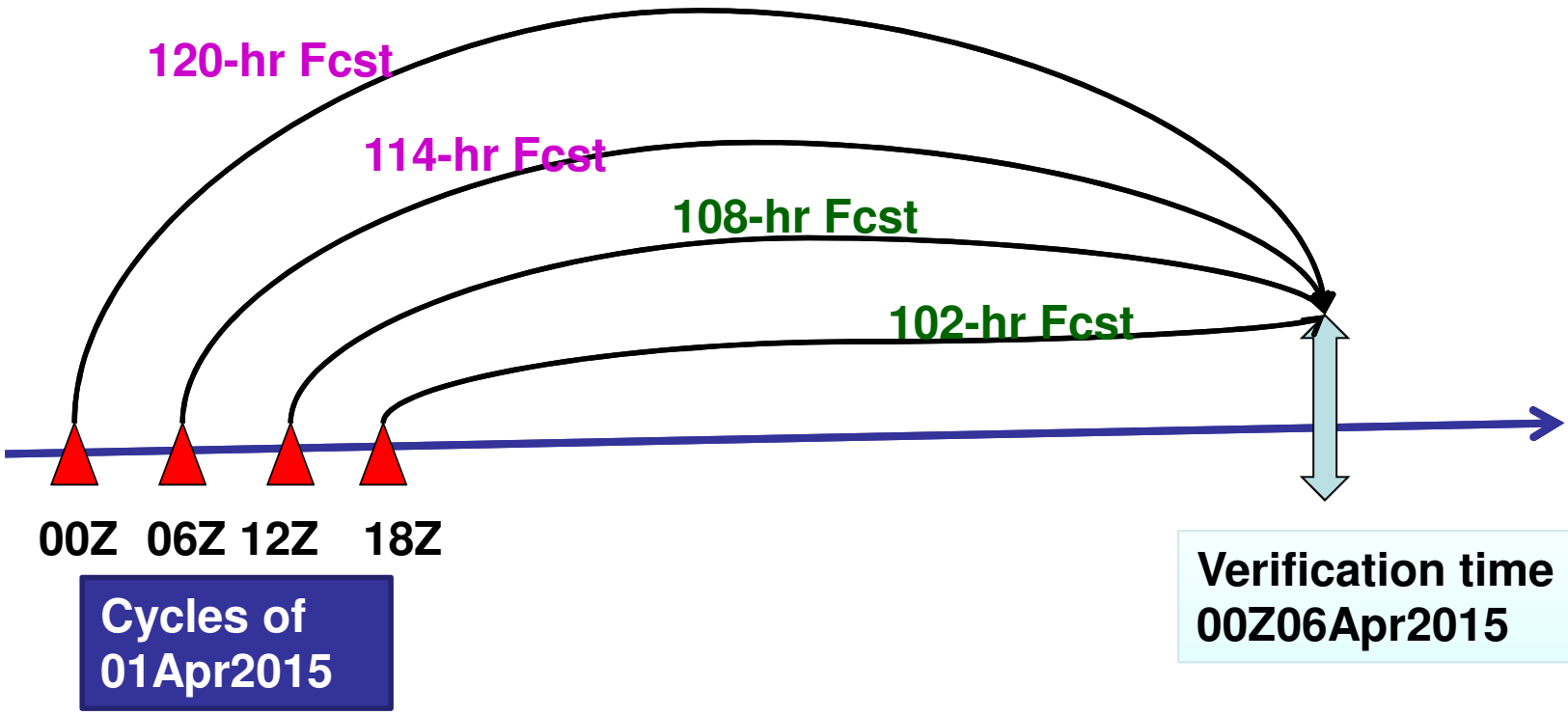
3. **The forecast skills of GFS 06Z and 18Z cycles are not as good as that of the 00Z and 12Z cycles, what are the benefits of running these two extra cycles of forecast?**

NCEP EMC Routine Verification



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

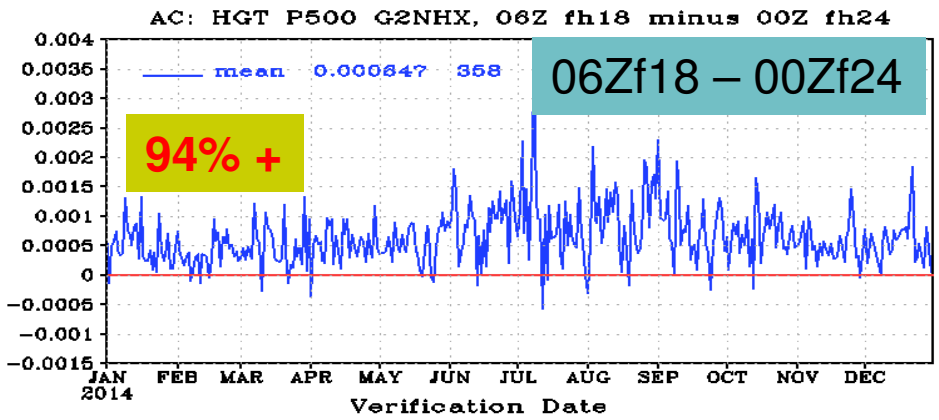
Lagged Verification Statistics

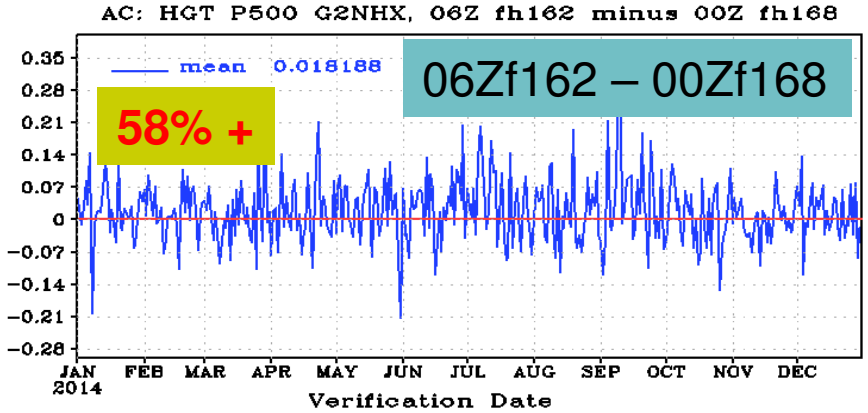


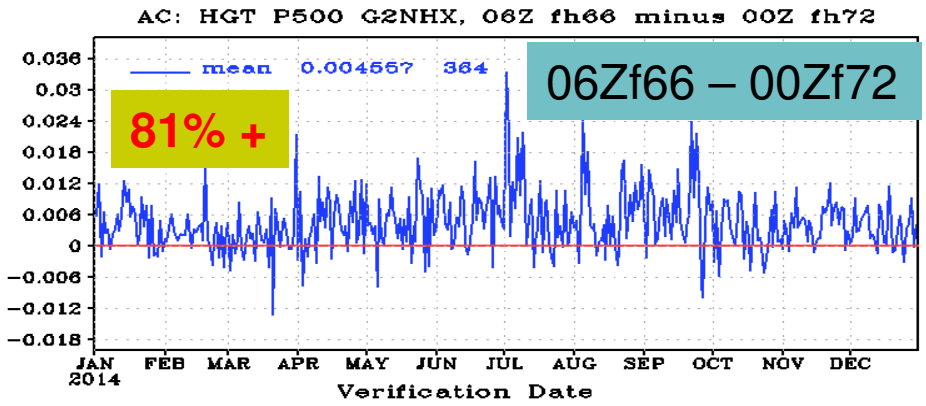
Q: Is the 06Z 114-hr forecast better than the 00Z 120-hr forecast?
Q: Is the 18Z 102-hr forecast better than the 12Z 108-hr forecast?

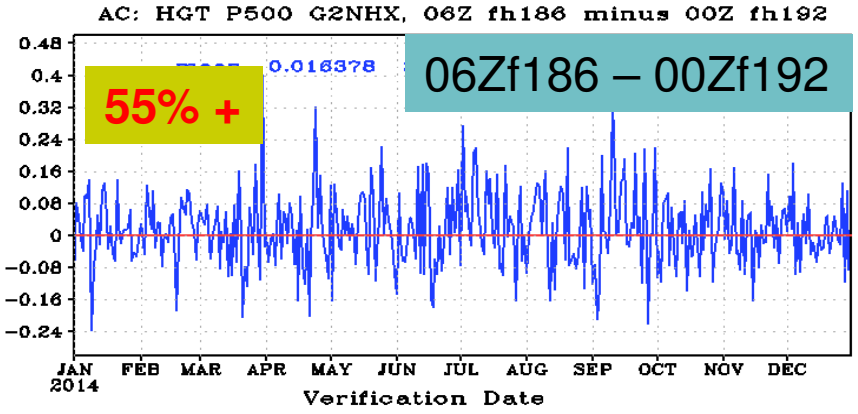
In the following, verification stats computed for every 6-hour forecasts for all days in 2014 are used to address this question.

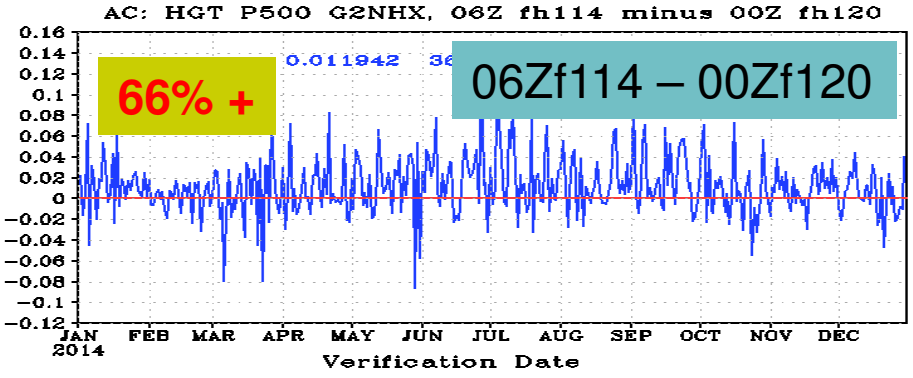
Comparing 06Z Cycle with 00Z Cycle : NH 500-hPa AC





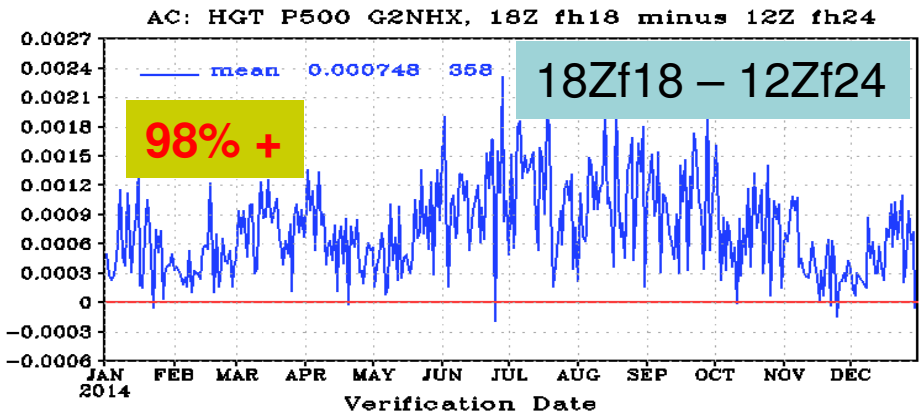


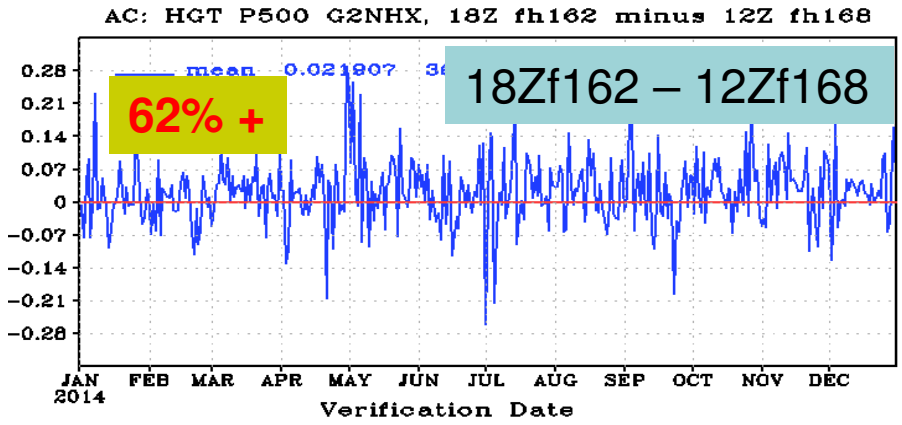


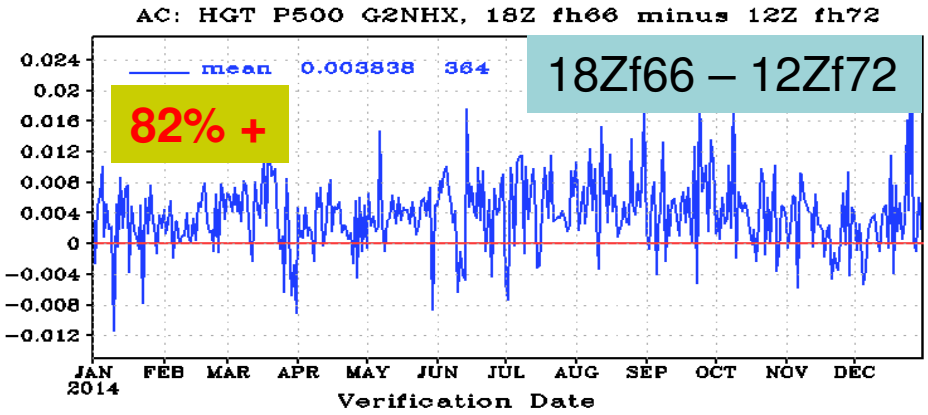


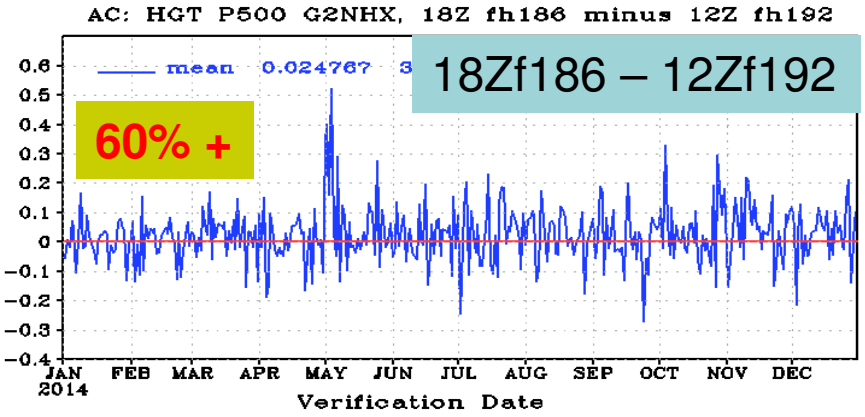
1. **For short-range forecast (~ 3 days), the later 06Z cycle does show better forecast skills than the earlier 00Z cycle when both are validated at the same verification time.**
2. **For medium and longer range forecast, the late 06Z cycle is not always better than the 00Z cycle.**

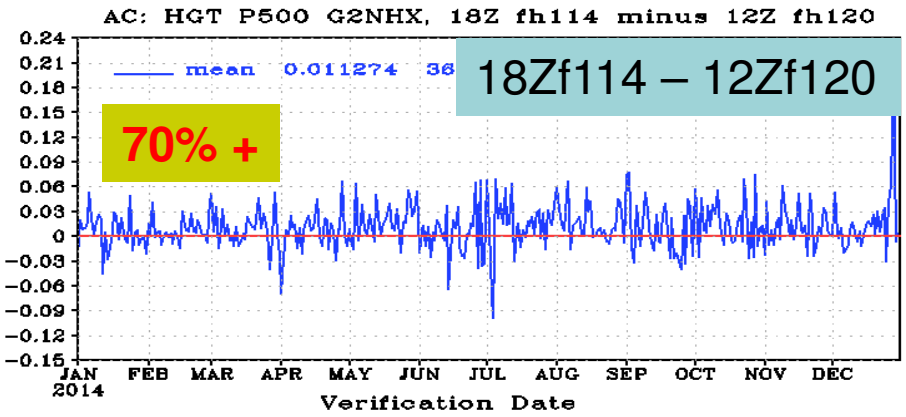
Comparing 18Z Cycle with 12Z Cycle : NH 500-hPa AC





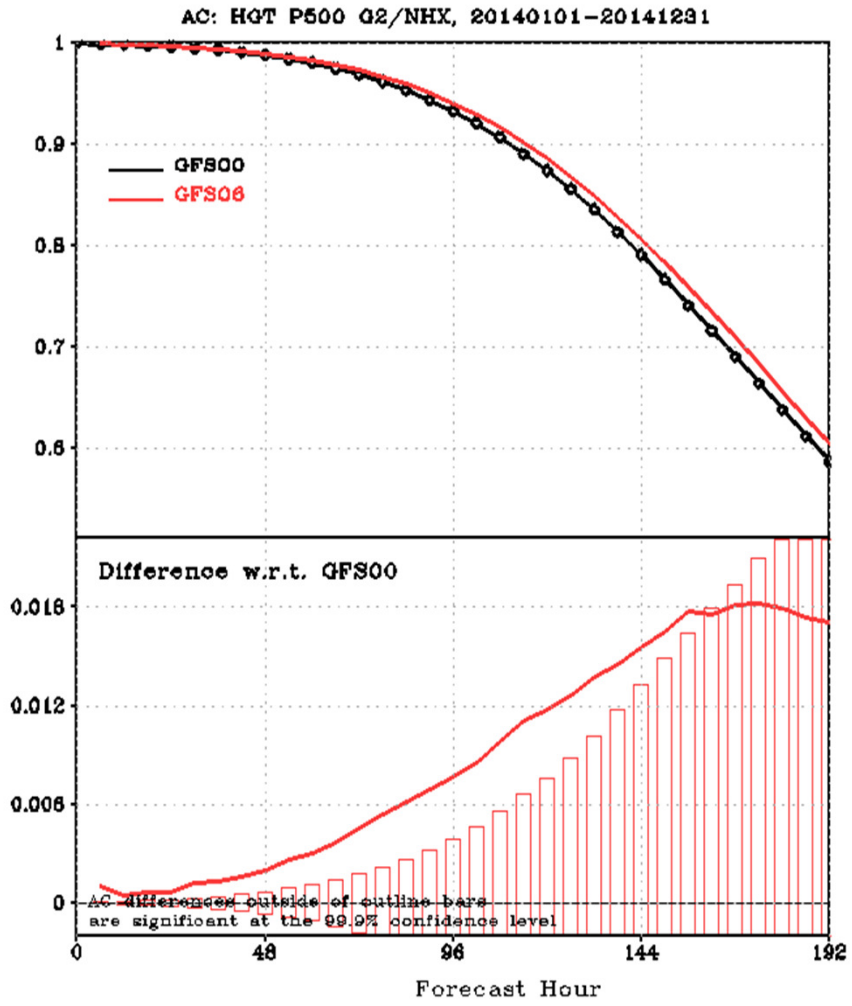


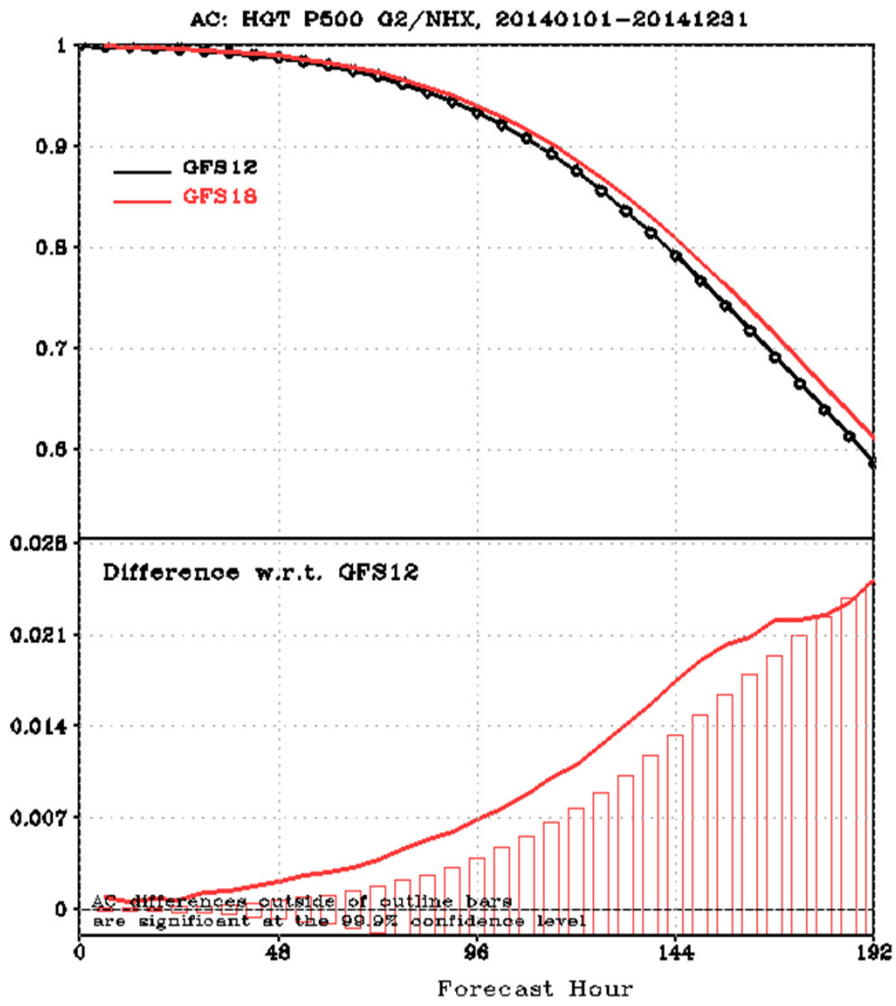




1. **For short-range forecasts, the later 18Z cycle does show better forecast skills than the earlier 12Z cycle when both are validated at the same verification time.**
2. **For medium and longer range forecast, the late 18Z cycle is not always better than the 12Z cycle.**

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 I

- **GFS 06Z and 18Z cycles are less skillful than the 00Z and 12Z cycles in the Northern Hemisphere. There is no significant differences among the four cycles in the Southern Hemisphere.**

- **Analysis increments of the 06Z and 18Z cycles are much smaller than that of the 00Z and 12Z cycles over the NH land.**

- **There is no difference in satellite data count among the four cycles. 18Z and 00Z cycles have the same amount of conventional data, but 18Z cycle has worse forecast skills than 00Z cycle. On the other hand, 12Z cycle has less conventional data than 00Z cycle, but 12Z and 00Z cycles 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?**

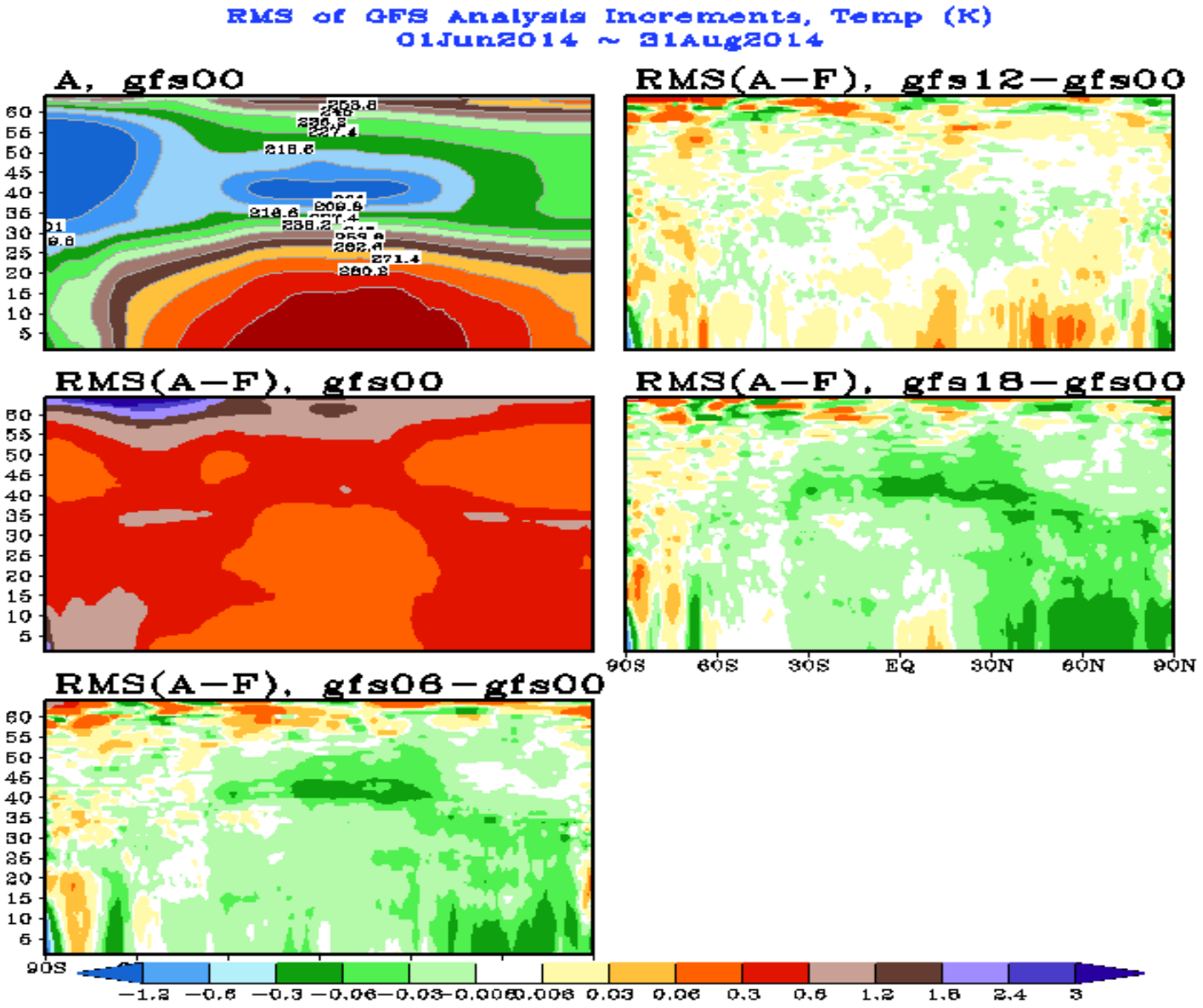
Summary II

- **Even though the 06Z and 18Z cycles are less skillful, when validated at the same verification time the later 06Z (18Z) cycle does show consistent better forecast skills than the earlier 00Z (12Z) cycle for short-range forecasts. For medium and longer-range forecasts, the late cycles are not always better than the early cycles.**

- **Values of the GFS 06Z and 18Z cycles: a) provide updated initial and boundary conditions for down-stream jobs; b) provided users with updated and consistently more accurate guidance than the earlier 00Z and 12Z cycles for short-range (~3 days) weather prediction.**

Extra slides

GFS Analysis Increment RMS, JJA 2014



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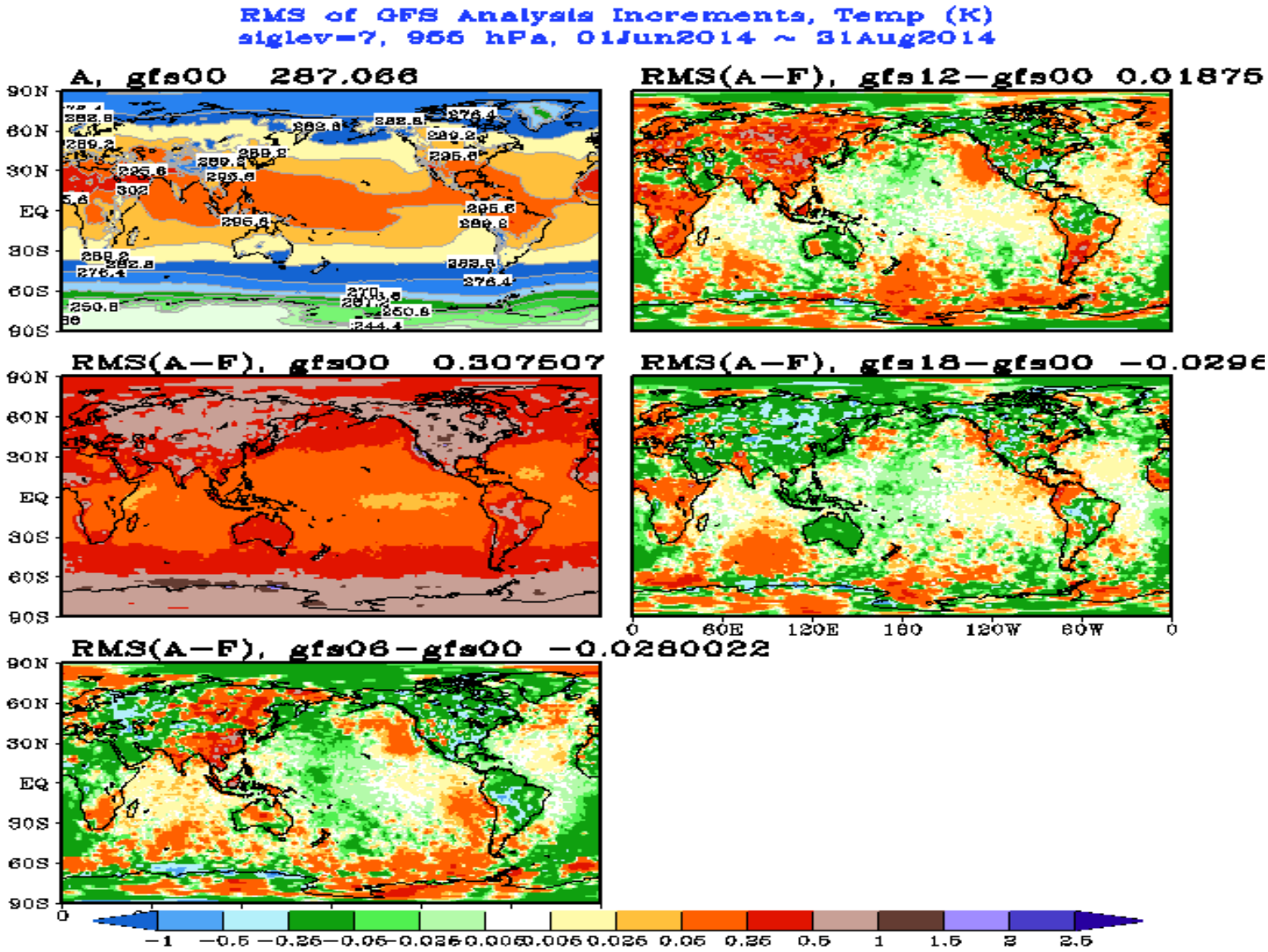

http://www.emc.ncep.noaa.gov/gmb/wx24fy/vsdb/gfs2014_4cyc/