Impact of Aeolus DWL Data Assimilation in the JMA's Global Data Assimilation System on Forecasting Skills for Typhoons

Izumi Okabe[1], Kozo Okamoto[1]

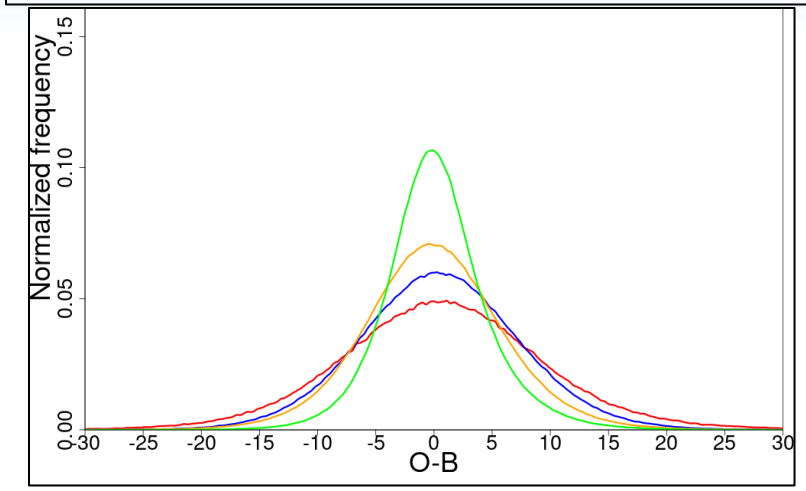
1:Meteorological Research Institute / Japan Meteorological Agency

Contents

1. Assessment of Aeolus HLOS wind data quality
2. Experiment and Result
   - Configuration
   - Fitting of first guess (FG) to other observations
   - Forecasting scores
   - Impact on typhoon track forecasting
3. Case study of Typhoon Hagupit (2004)
   - Improvement of track forecasting
   - Difference of increment
4. Summary

1. Assessment of Aeolus HLOS wind data quality

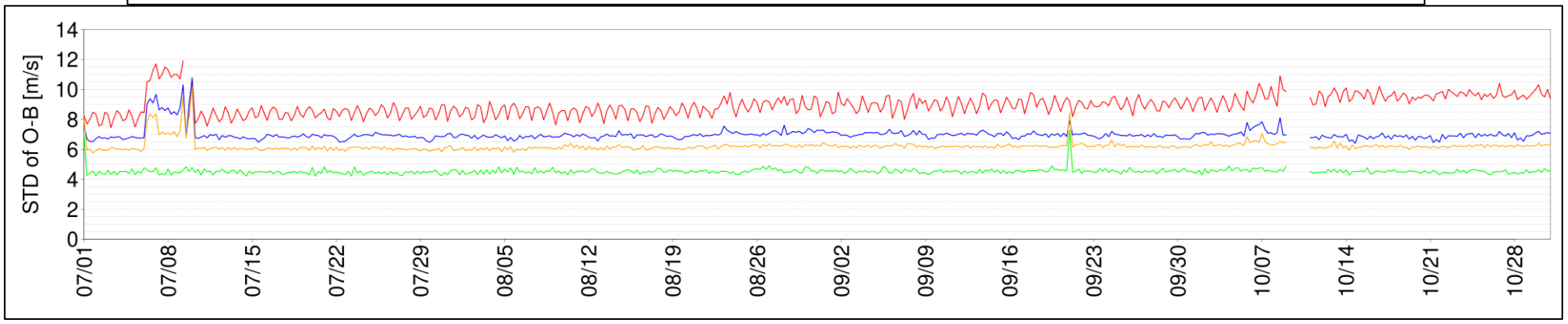
Histograms of O-B (QC pass, August)



Est. error	Bias	STD	Num	
4.8	0.63	8.71	408388	Rayleigh (<90hPa)
4.6	0.49	6.96	1110929	Rayleigh (200-90hPa)
4.1	-0.066	6.14	2259663	Rayleigh (>200hPa)
2.2	0.18	4.54	1494893	Mie

Bias of Mie wind versus FG in GSM is very small (0.18 m/s for Aug.).
The lower level of Rayleigh wind, The smaller of bias.
Histograms follow gaussian distribution very much.

Sequence of standard deviation (STD) of O-B (QC pass, July to October)



Generally stable of STD of O-B.
Luck of data between ver. 10 and 11 (Oct. 9).

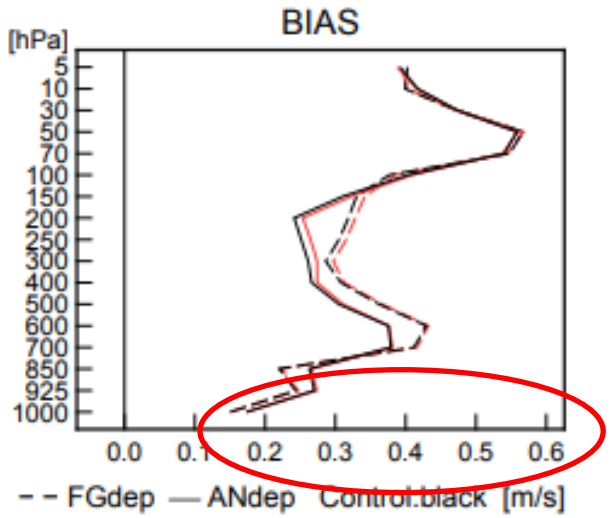
1. Assessment of Aeolus HLOS wind data quality

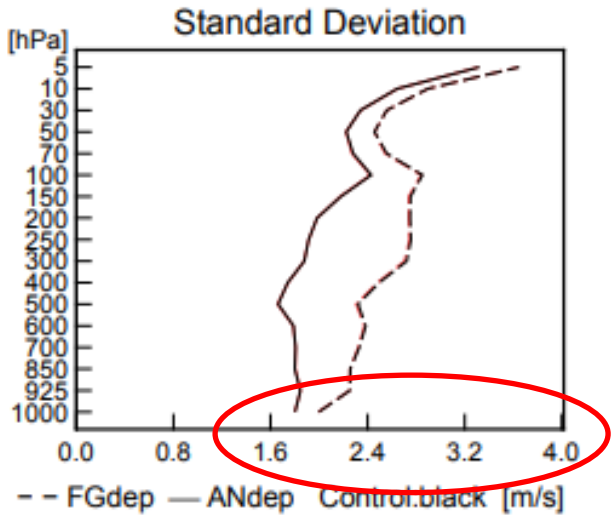
Bias of Aeolus is as small as it of RAOB wind speed. STD of Aeolus is larger than it of RAOB wind speed. (Note that Aeolus data is passively monitored (not assimilated) in this statistics.)

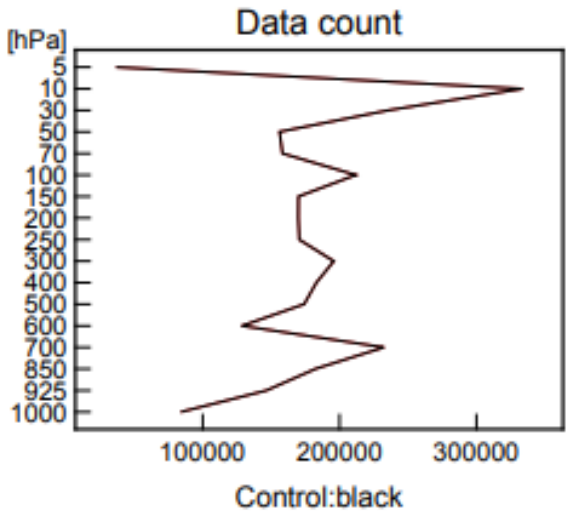
Aeolus HLOS

Bias	STD	Num	
0.63	8.71	408388	Rayleigh (<90hPa)
0.49	6.96	1110929	Rayleigh (200-90hPa)
-0.066	6.14	2259663	Rayleigh (>200hPa)
0.18	4.54	1494893	Mie

RAOB Wind speed







2. Experiment and Result / Configuration

- CNTL : JMA's data assimilation + global spectral model (GSM) as of December 2019.
- TEST : CNTL + Aeolus's Rayleigh wind under clear-sky ＋Mie wind under cloudy condition

- Quality control pass conditions for Aeolus data:

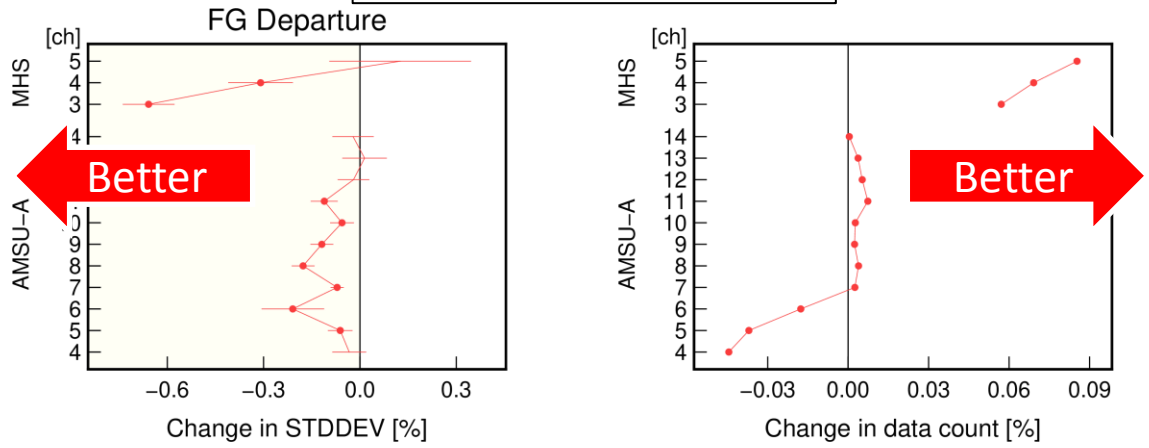
  (ECMWF technical memo 864, The NWP impact of Aeolus Level-2B winds at ECMWF, was referenced.)

  – Limit estimated observation error (EE) and integration length according to Rayleigh and Mie winds.
  – Reported quality check flag = 1
- Observation error (used in assimilation system) for Aeolus data:
  – EE * inflation (inflation = 2.0 at tropics and mid latitude, 3.5 at high latitude)
- Bias correction is NOT applied.
- Experiment term: June 10 to November 11 2020
  – Forecasting models at only 12UTC initials were conducted.

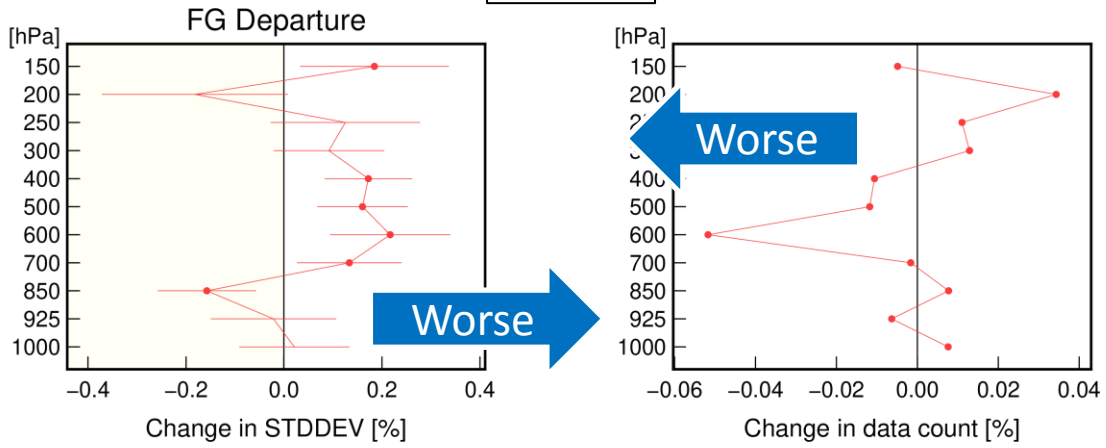
Fitting of FG to other observations

Humidity, temperature and wind fields were suggested to be improved. Fitting to AMVs was exceptionally degraded.

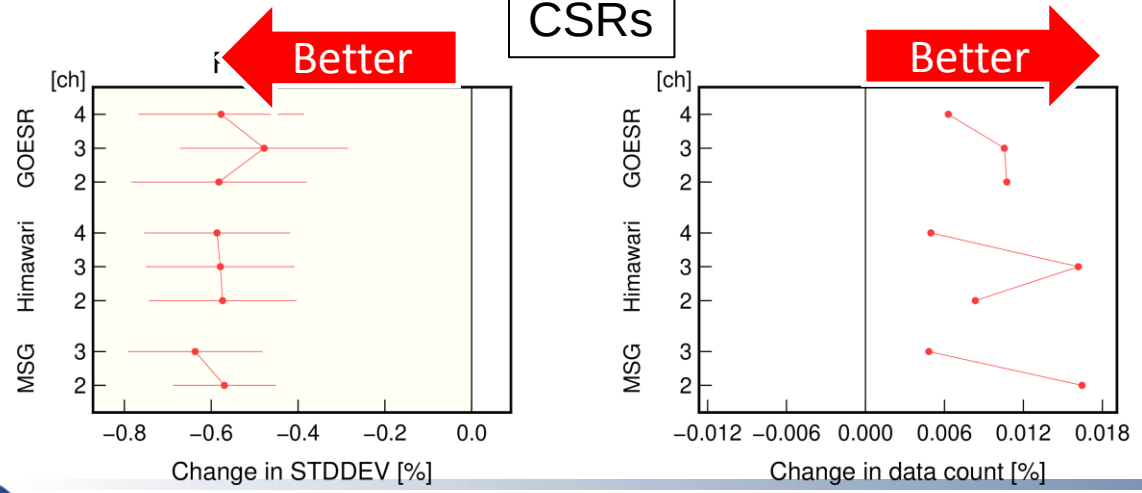
Microwave sounders



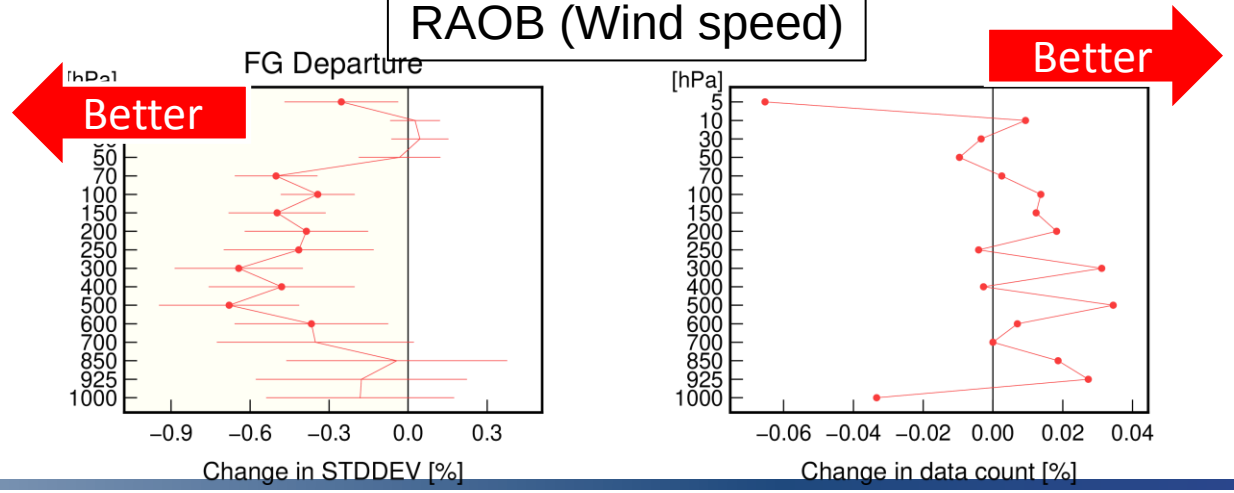
AMVs



CSRs

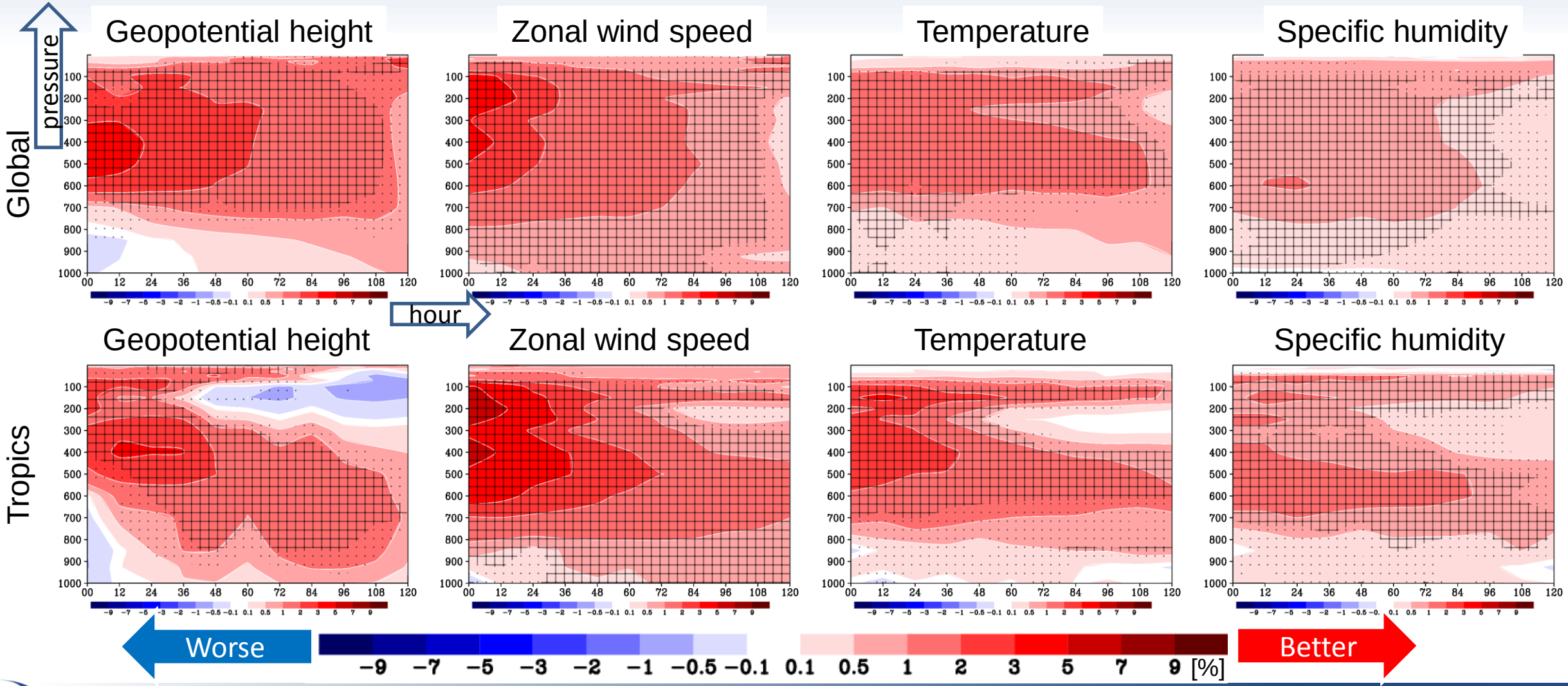


RAOB (Wind speed)



Forecasting scores

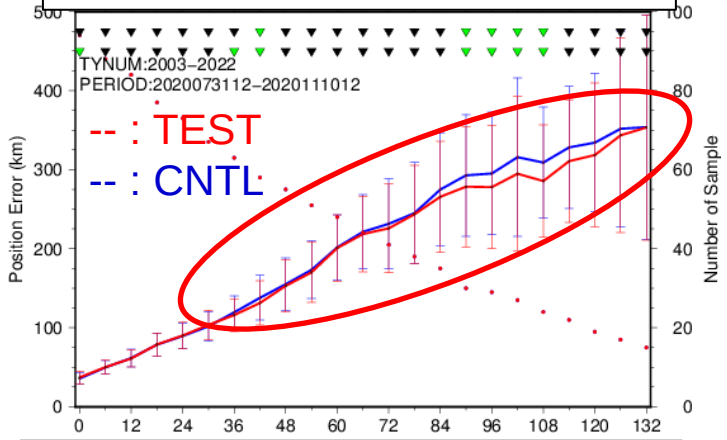
Each element forecasting scores were significantly improved! The improvement was larger at the tropics.



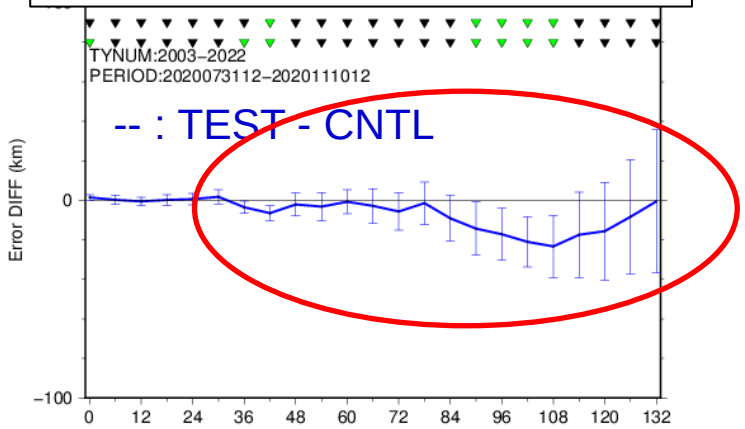
ERA5 analysis was used as reference.

Impact on typhoon track forecasting

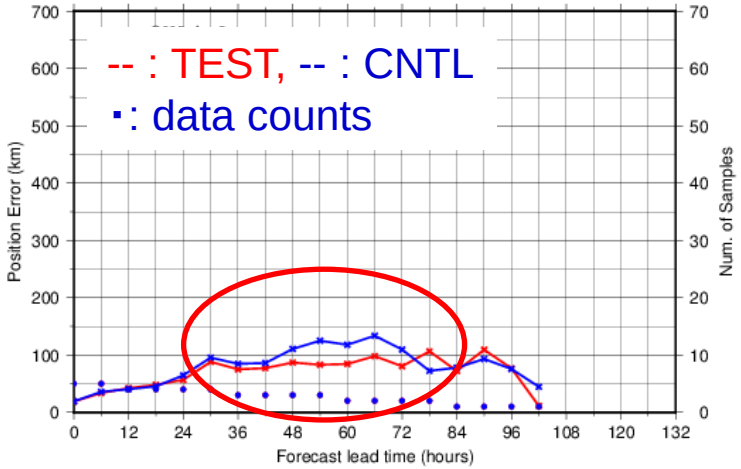
Track forecasting error (typhoon 2003-2022)



Track forecasting error (Diff.)

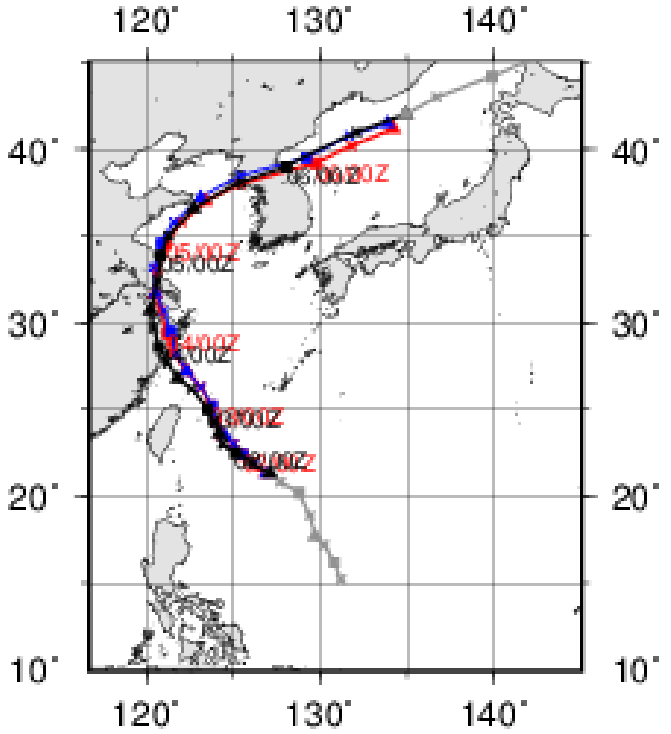


Track forecasting error (Hagupit,2004)



Track forecasting errors after 2 or 3 days were decreased.

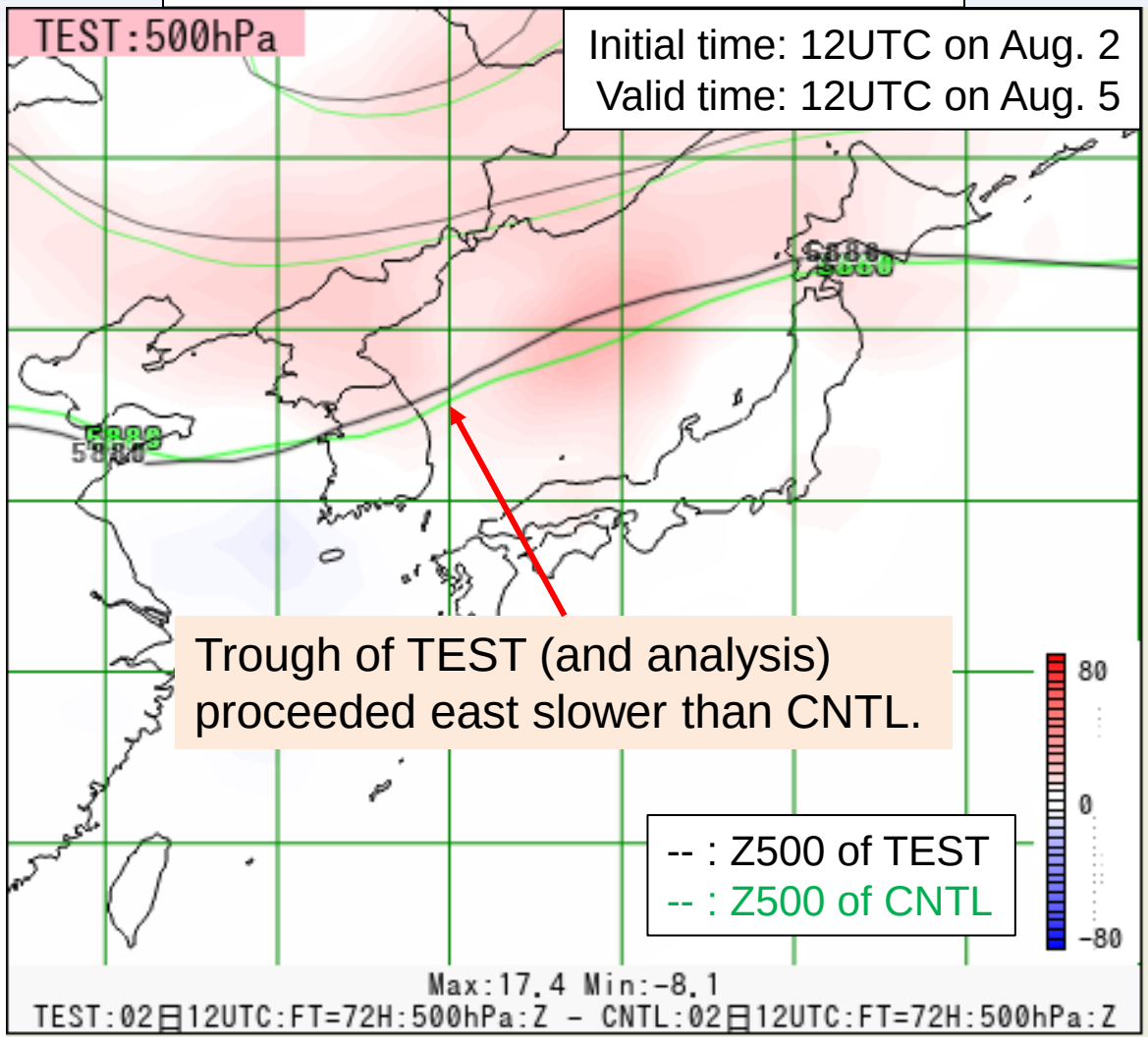
Track forecasting (Hagupit ,2004)



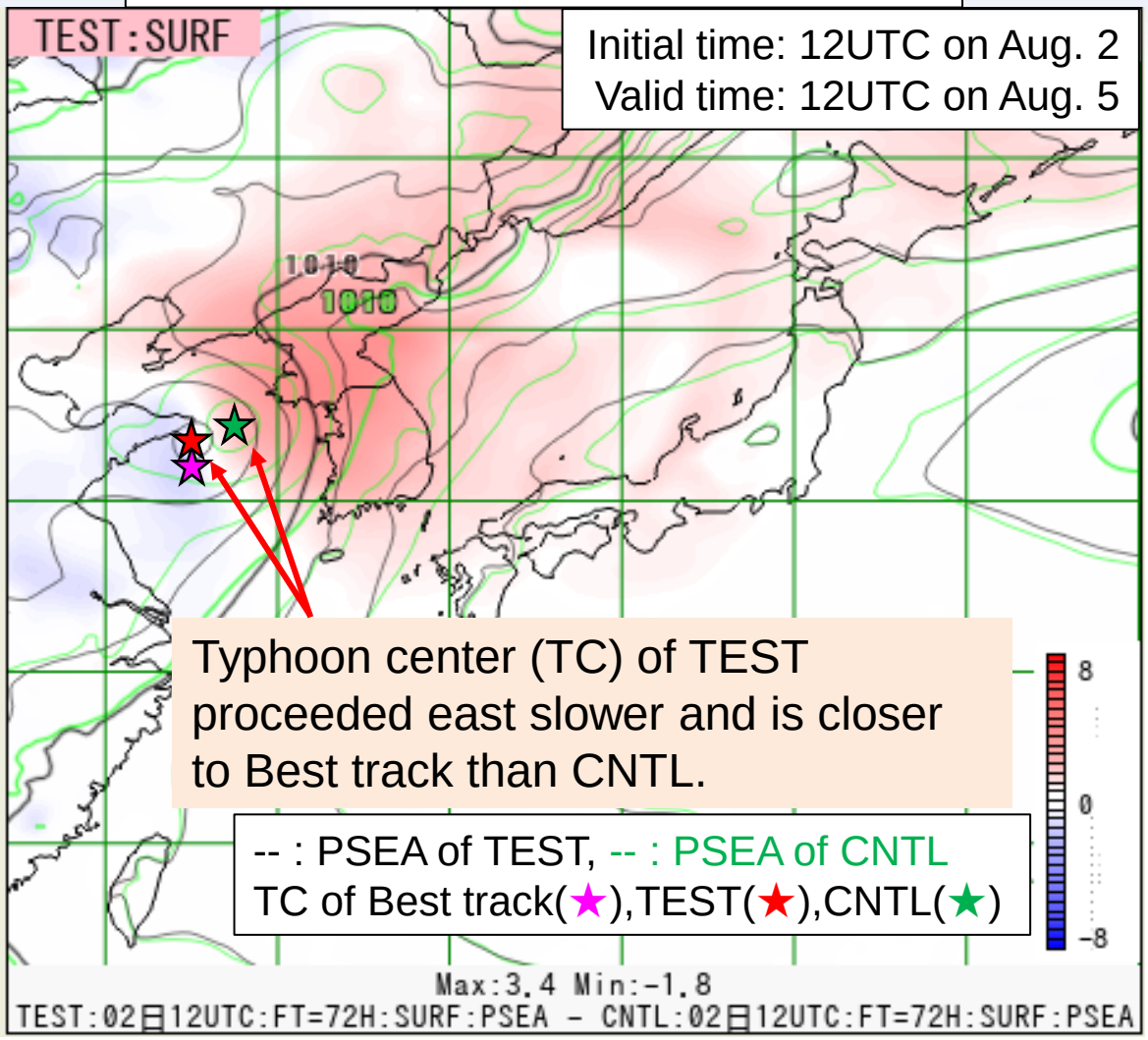
-- : TEST, -- : CNTL, -- : Best track
Forecasting for the initial time of 12UTC on Aug. 1

3. Case study of Typhoon Hagupit (2004)

Z500 (TEST) – Z500(CNTL), FT=72

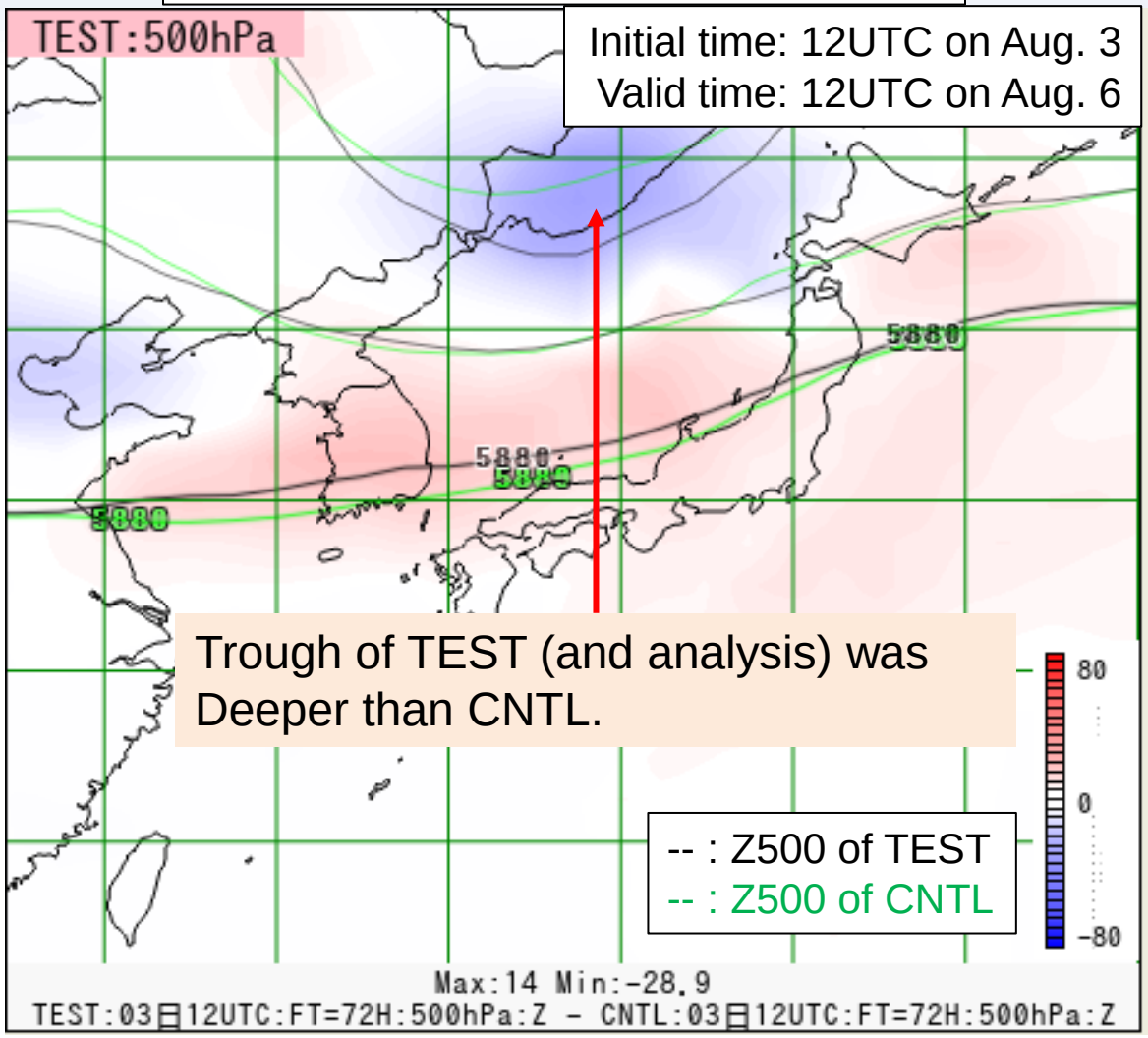


PSEA (TEST) – PSEA(CNTL), FT=72

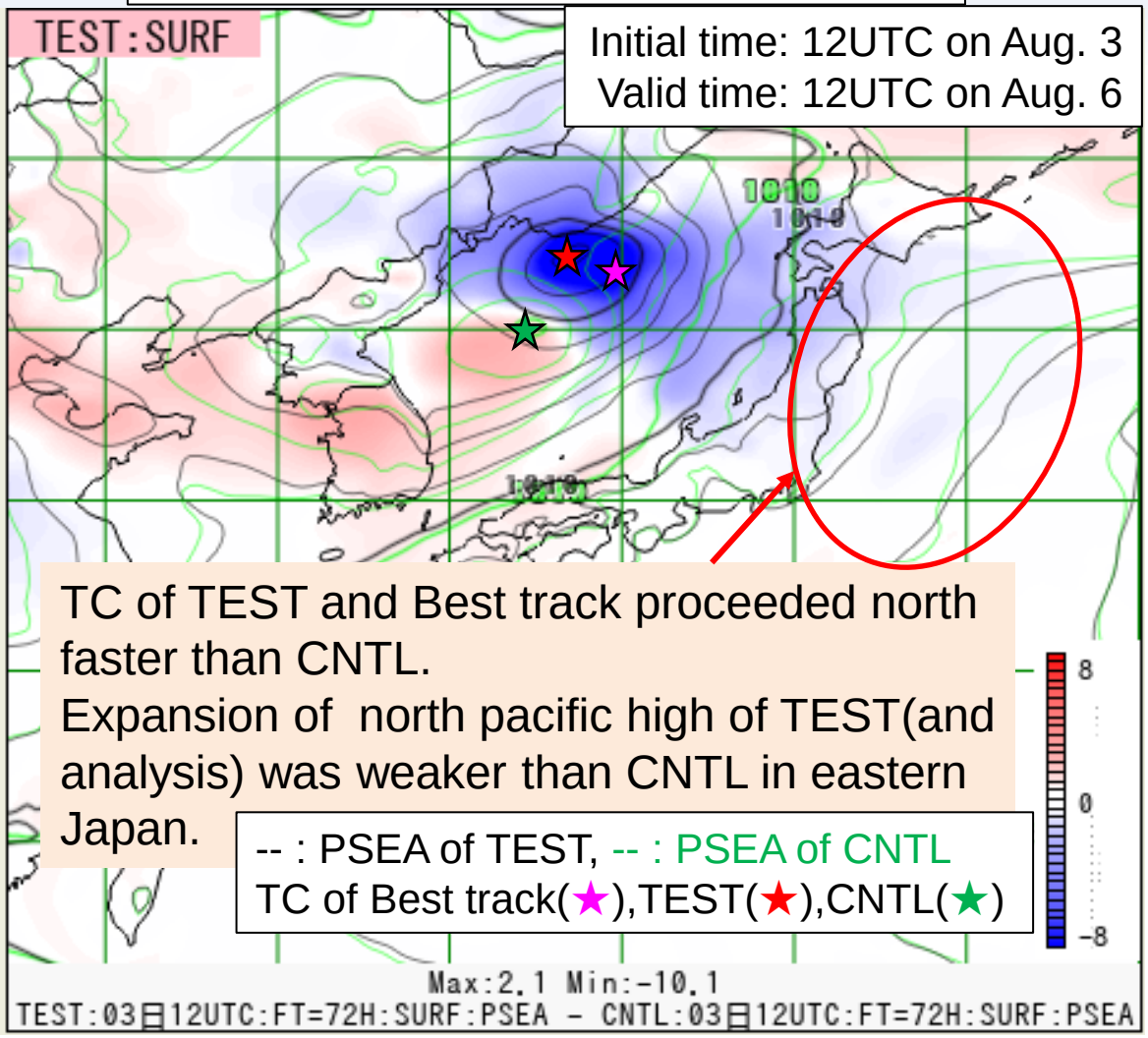


3. Case study of Typhoon Hagupit (2004)

Z500 (TEST) – Z500(CNTL), FT=72

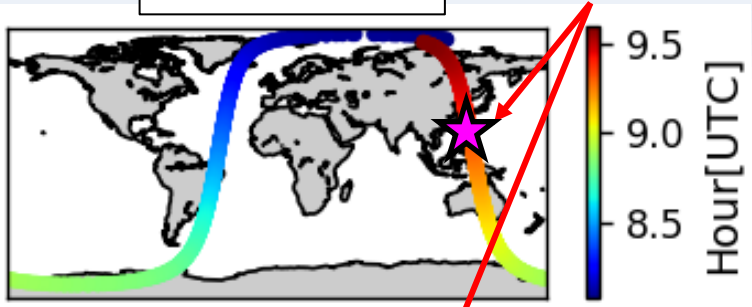


PSEA (TEST) – PSEA(CNTL), FT=72



3. Case study of Typhoon Hagupit (2004)

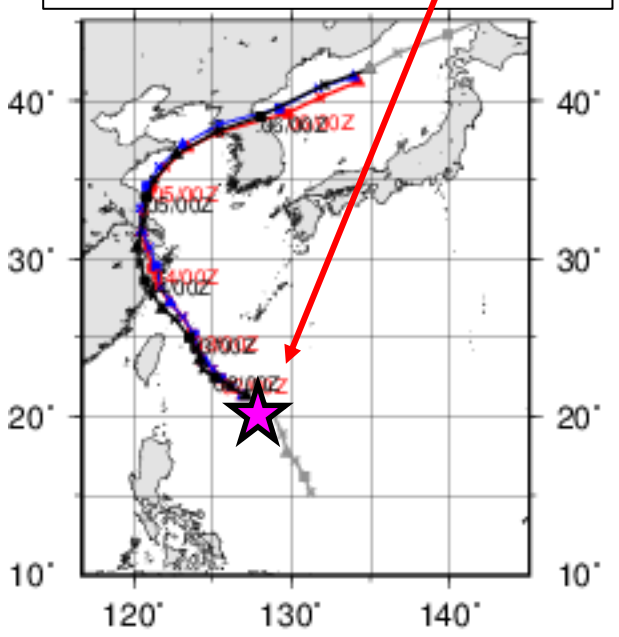
Aeolus track



Aeolus passed over Hagupit about 9:20 UTC.
Pink stars are TCs of Best track at the time.

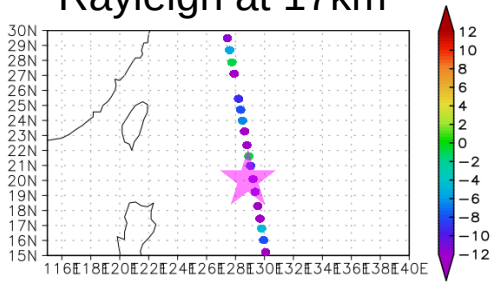
Aeolus succeeded to observe winds over the typhoon.
Less observations at lower troposphere because of thick clouds.

Typhoon track (Hagupit)

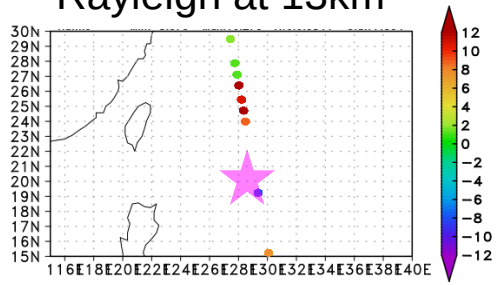


Aeolus observations (HLOS [m/s])

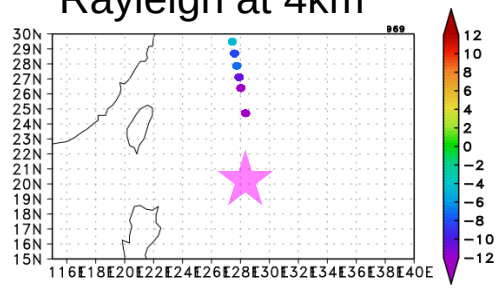
Rayleigh at 17km



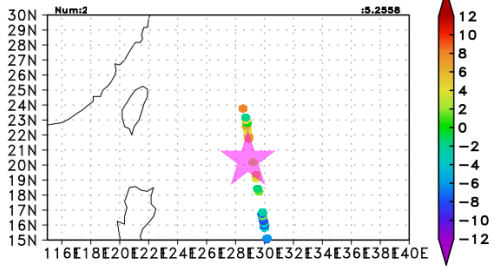
Rayleigh at 13km



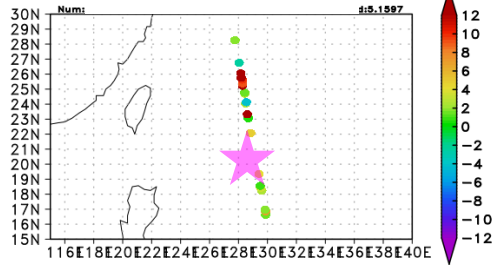
Rayleigh at 4km



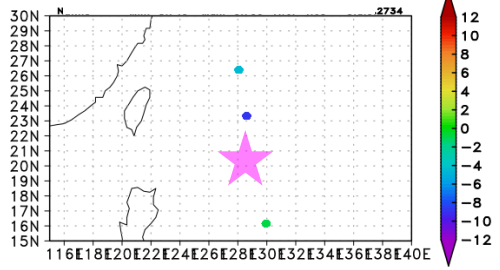
Mie at 15km



Mie at 13km



Mie at 2-10km



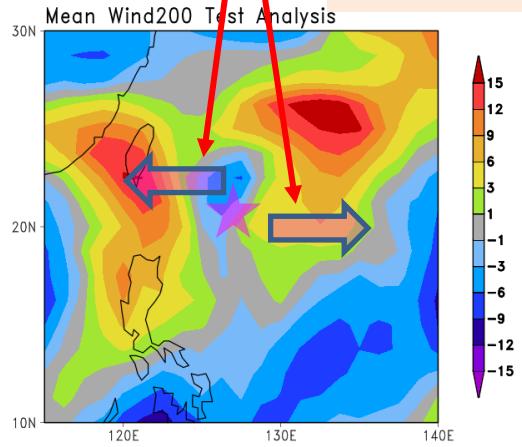
3. Case study of Typhoon Hagupit (2004)

Zonal wind analysis shows a divergence over the top of the typhoon.

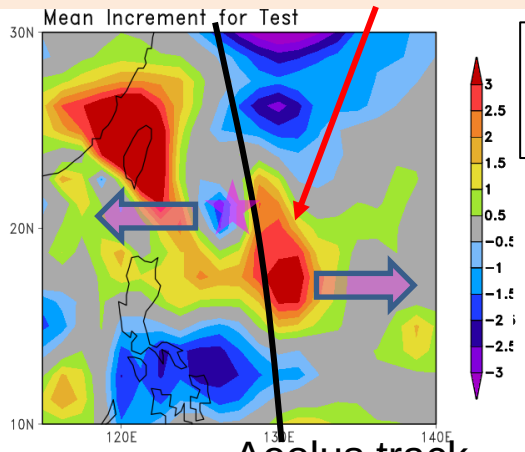
Increment of TEST is larger and more strongly enhances the divergence then CNTL.
(However, few difference between central pressures or max winds of TEST and CNTL)

Zonal wind at 200 hPa analysis

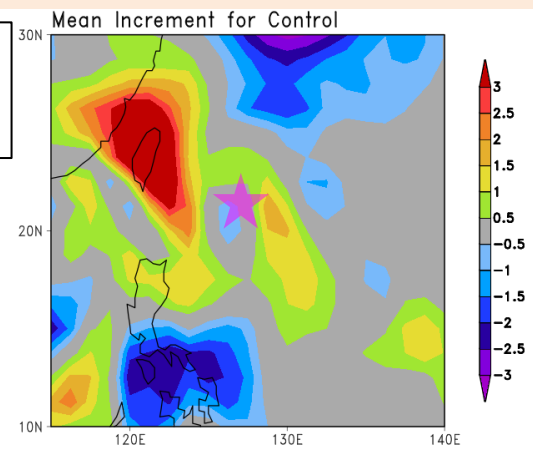
(about at 12km)



TEST Increment

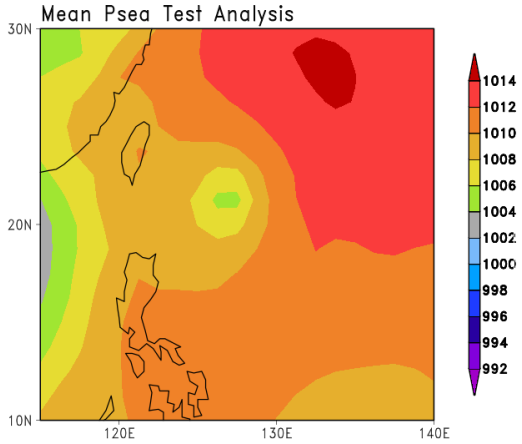


CNTL Increment

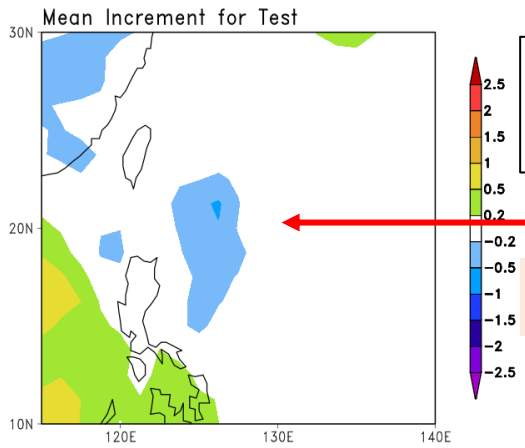


Aeolus track

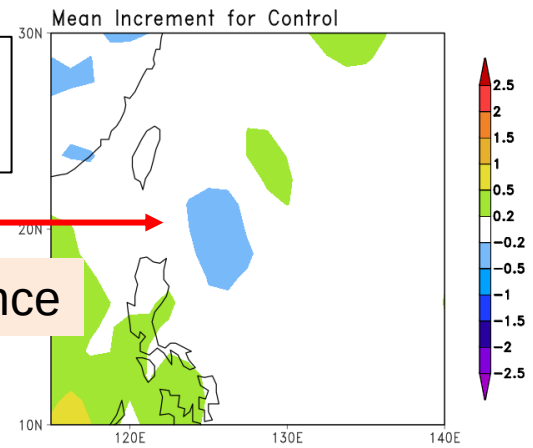
PSEA analysis



TEST Increment



CNTL Increment



No difference

Summary

1. Assessment of Aeolus HLOS wind data quality
   - ✓ As small bias as RAOB wind speed.
2. Experiment and Result
   - ✓ Fitting to most other observations were improved except AMVs.
   - ✓ forecasting scores of wind speed, geopotential height, temperature and specific humidity were improved.
   - ✓ Typhoon track forecasting after 2- or 3-day forecasting was improved.
3. Case study of Typhoon Hagupit (2004)
   - ✓ Improved forecasting accuracy of geopotential height (troughs and PSEA) seemed to contributed the track forecasting improvement.
   - ✓ Direct impact of Aeolus passing over the typhoon center on TC position analysis was not found.

Abstract

- The horizontal line of sight (HLOS) wind data from Aeolus Doppler Wind Lidar (DWL) is available from the European Space Agency (ESA) Earth Online Portal. Assimilation experiments of this HLOS data were conducted using JMA's global data assimilation (DA) system. The experiment term is from July to October 2020 including 18 typhoon events. The result of the assimilation experiments showed positive impacts of Aeolus HLOS wind data on the analysis accuracy and forecasting scores of not only wind speed but also geopotential height, temperature and specific humidity Improvement of typhoon track forecasting was found suggesting the improved environment forecasting. During the experiment term, Aeolus observed wind shears around some typhoons. The Aeolus assimilation seemed to intensify the divergence over the top of typhoons. The details of assessment and assimilation experiments will be shown in the presentation.