Impact of Aeolus wind data assimilation on typhoon track forecasting

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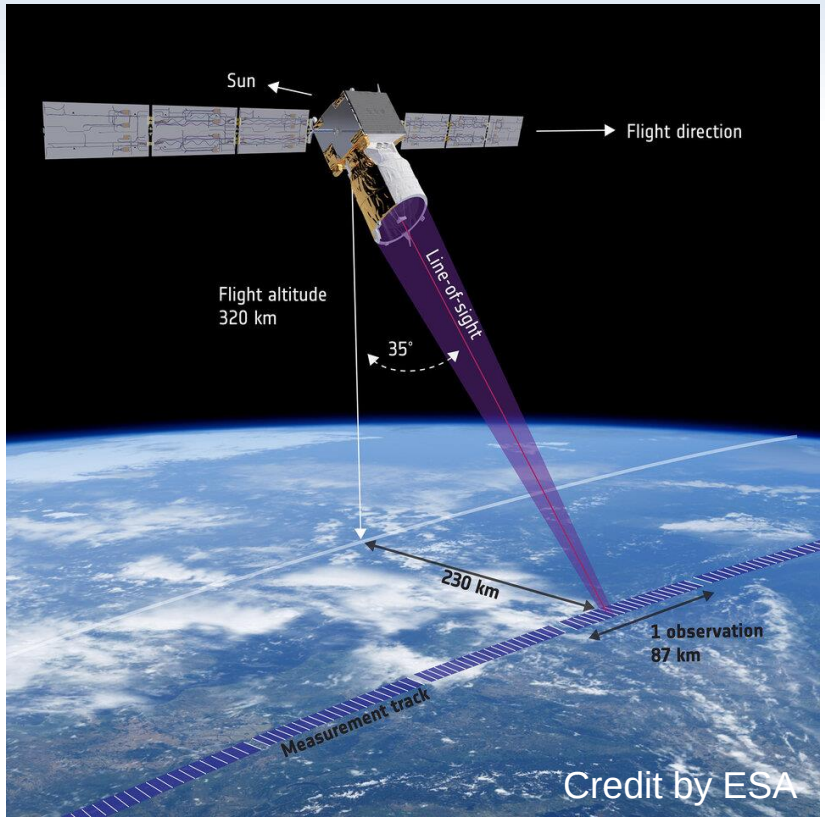
1. Introduction

- Aeolus is …
  - The first satellite mission to acquire profiles of Earth's wind on a global scale launched on 22 August 2018.
  - The orbits in a Sun-synchronous, dusk/dawn orbit, 320 km above Earth.
- The Doppler Wind Lidar (DWL) is …
  - a single-perspective instrument.
  - Rayleigh wind at 24 levels from the doppler shift of the molecular scattering.
  - Mie wind at 24 levels from the doppler shift of scattering from aerosols and water droplets.



- Observable under clear and thin cloudy condition ☺
- Observable over land and oceans ☺
- Only almost zonal wind component ☹
- Not observable inside or under thick clouds ☹

What is the assimilation impact on typhoon forecasting?

2. Experiment and Result / Configuration

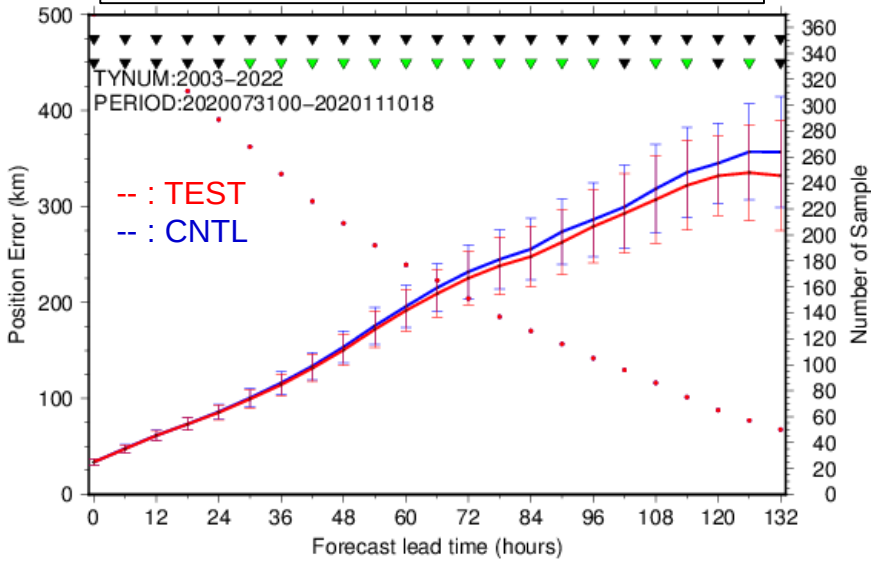
- CNTL : JMA's data assimilation + global spectral model (GSM) as of December 2019.
- TEST : CNTL + Aeolus's Rayleigh wind under clear-sky ＋Mie wind under cloudy condition. Backgrounds from CNTL were used for every analysis.
- Quality control pass conditions for Aeolus data:

  (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.
- Validation period: July 30 to November 10, 2020.

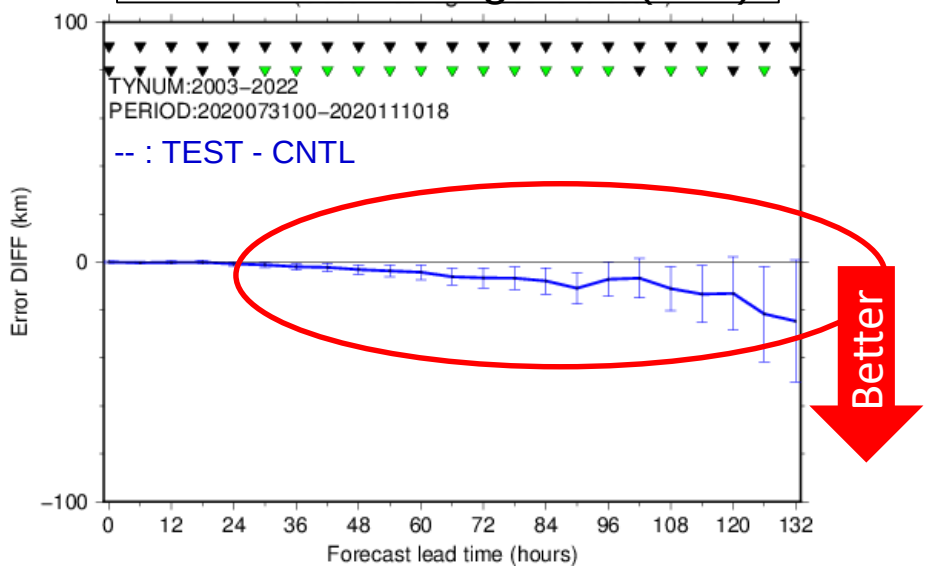
Impact on typhoon track forecasting

Track forecasting errors were significantly decreased.

Track forecasting error

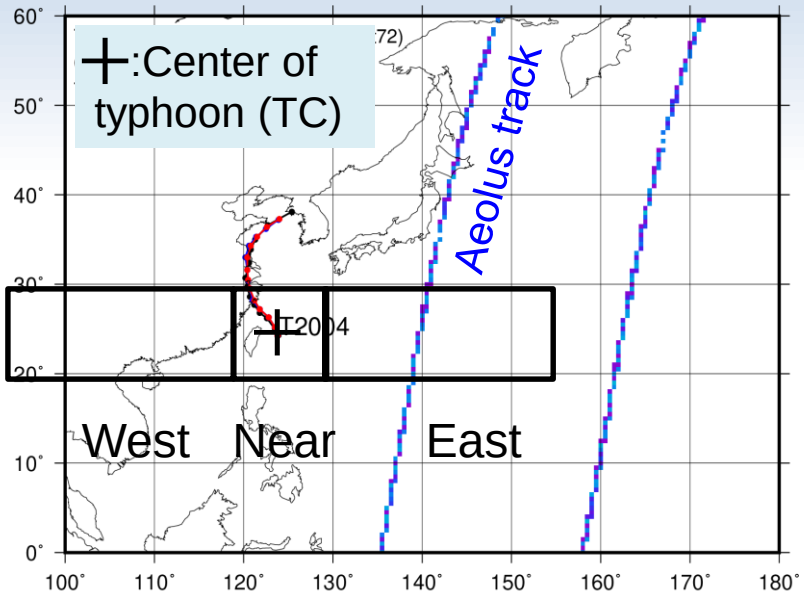


Track forecasting error (Diff.)



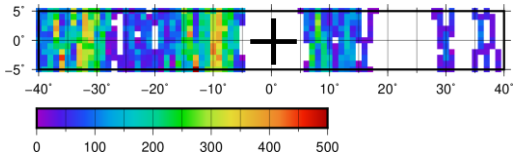
Statistical period: 31 July to 10 November 2020
JMA's best track was used as reference.

3. Statistical investigation

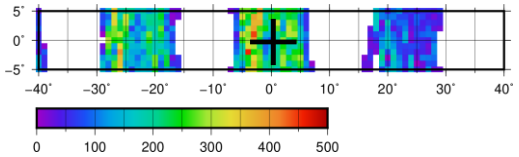


All analysis in the validation period of 2020 were checked weather it can be classified into the 3 groups as follows;
Near: Aeolus data used within 5 degree latitudes and longitudes.
West: The data used in the west of “near” area within 30 degree longitudes.
East: The data used in the east of “near” area within 30 degree longitudes.

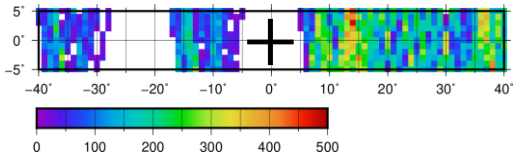
Data counts of West



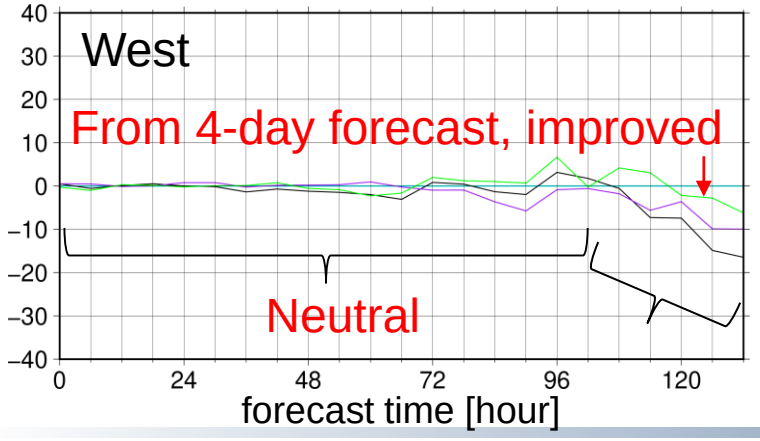
Data counts of Near

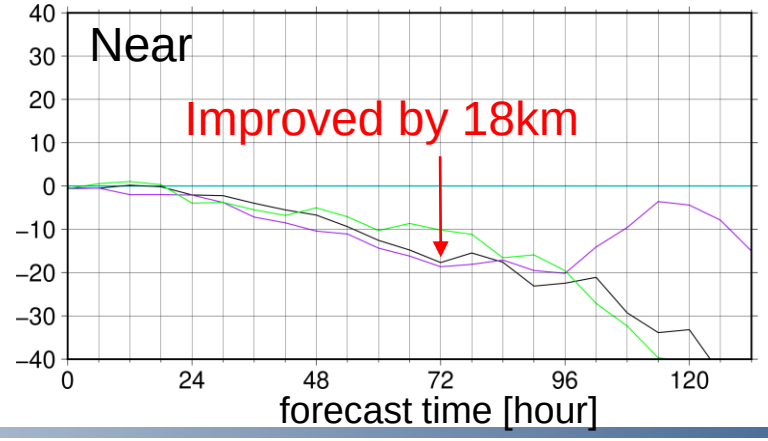


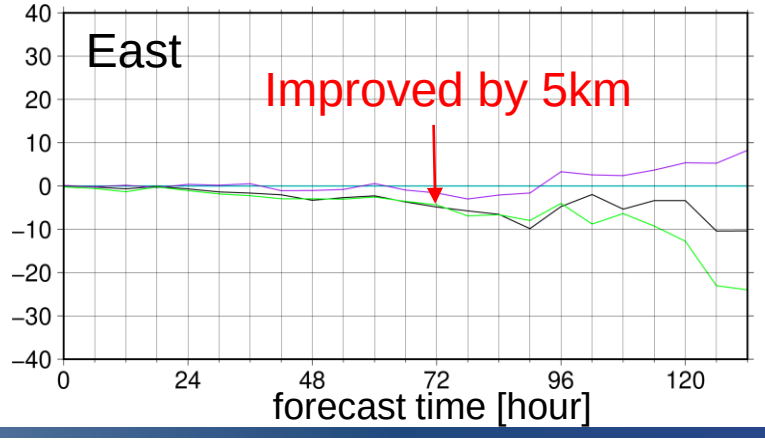
Data counts of East



Change in positional error (distance[km] / latitude[0.1deg] / longitude[0.1deg])

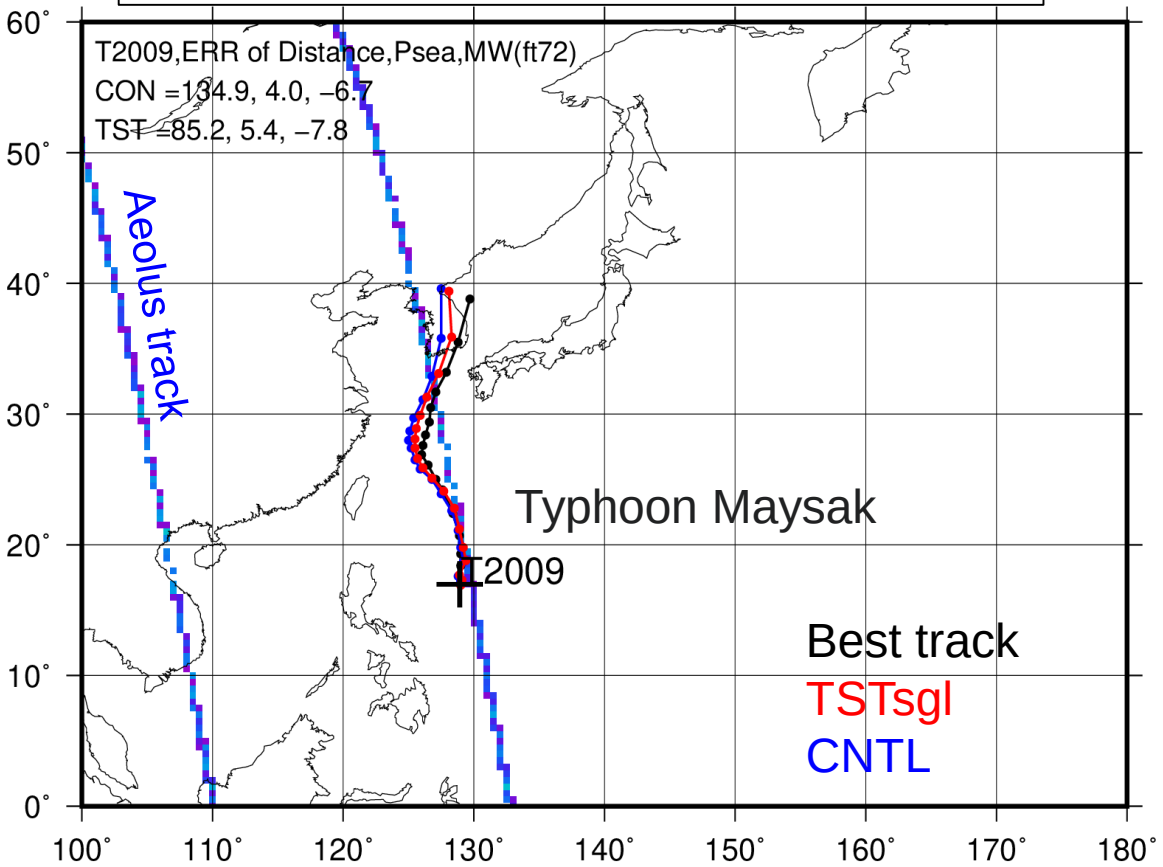




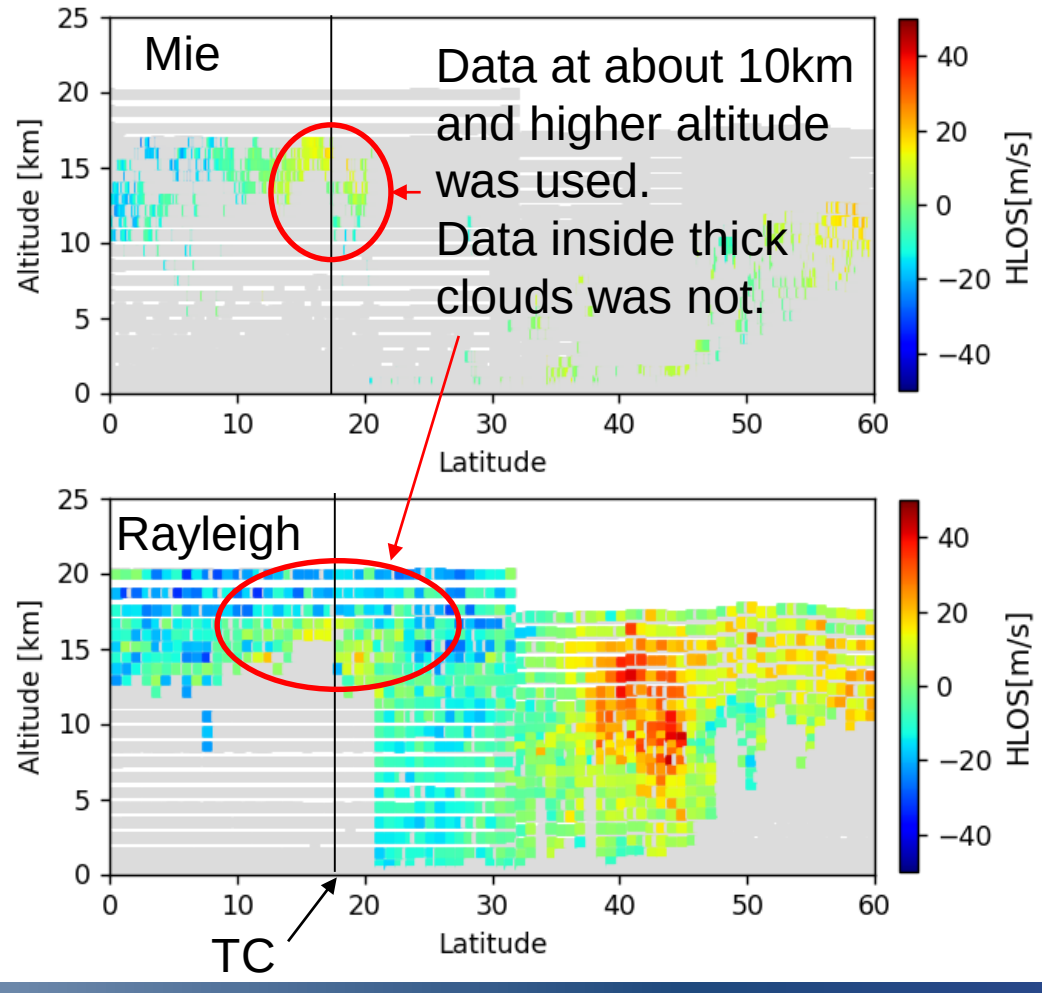


4. Case study 1

Near case at 12 UTC on August 29, 2020



Altitude and latitude of used data

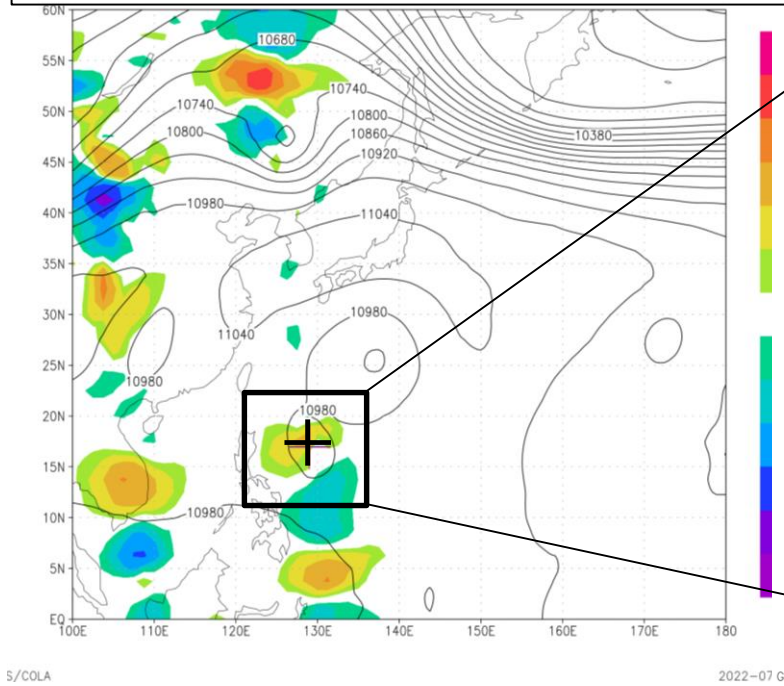


What happens at Aeolus wind assimilation?

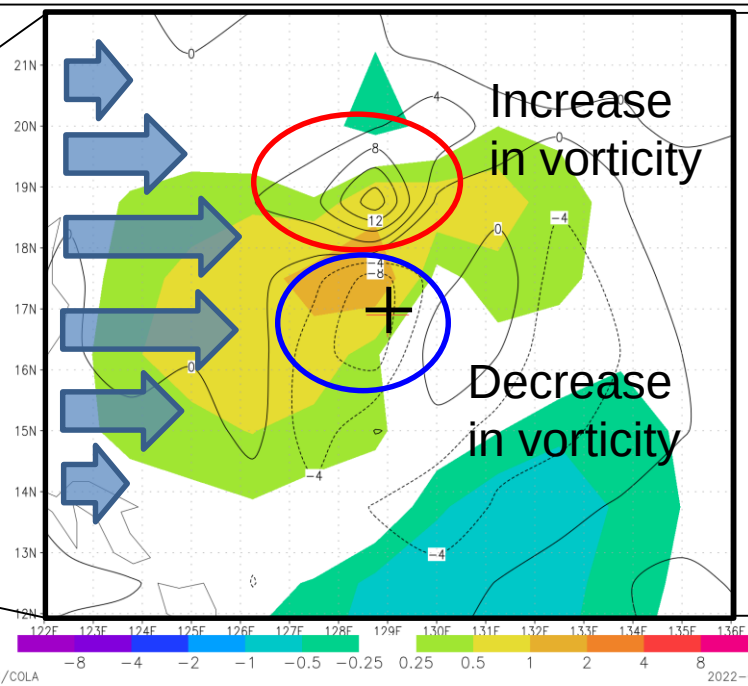
As Aeolus DWL is a single-perspective instrument with 97.2° inclination angle, almost east-west direction's wind component is available.

Difference in analyses of TEST and CNTL

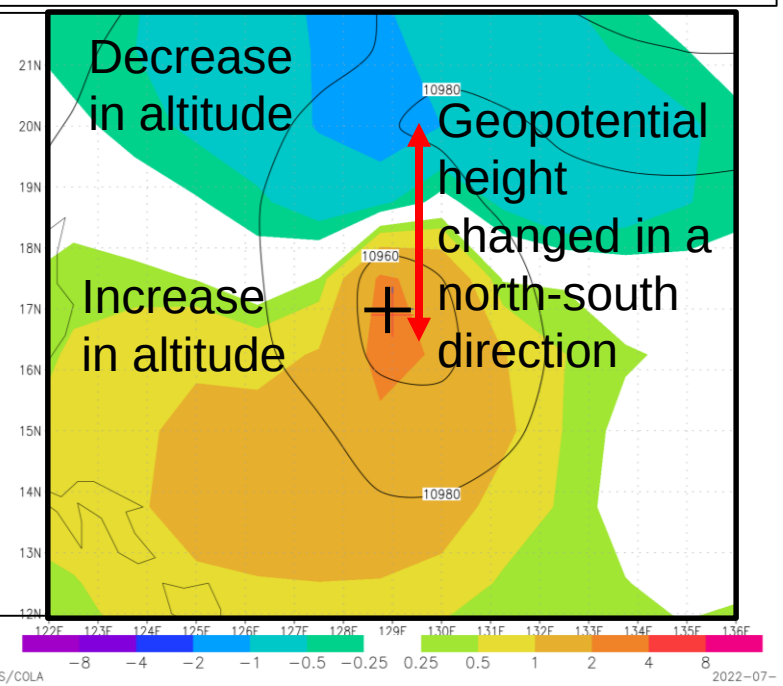
U250(shade),Z250(contour, TEST)



U250(shade),Vorticity250(contour)

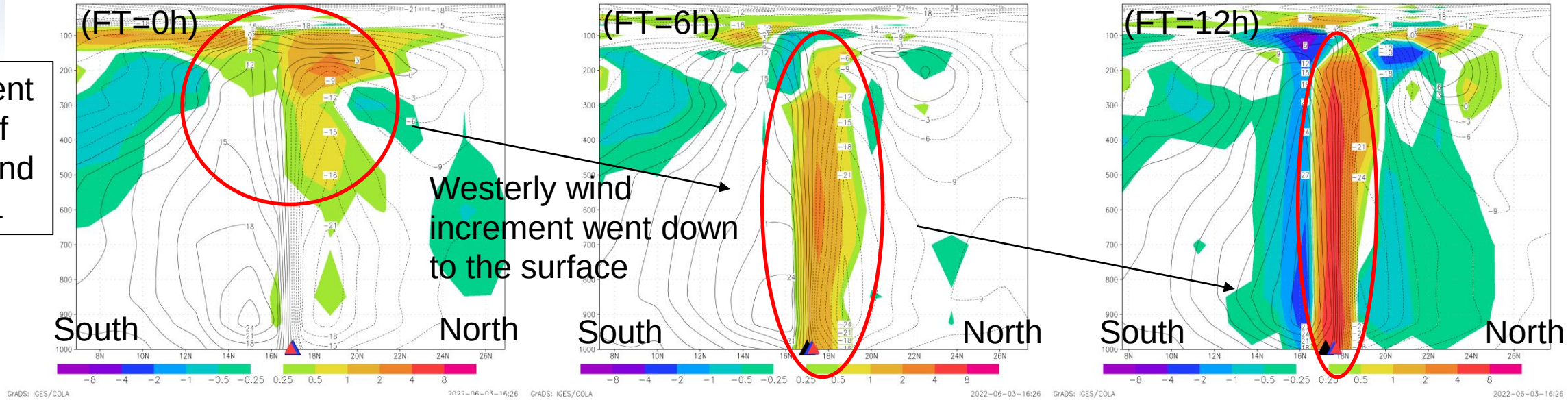


Z250(shade),Z250(contour, TEST)

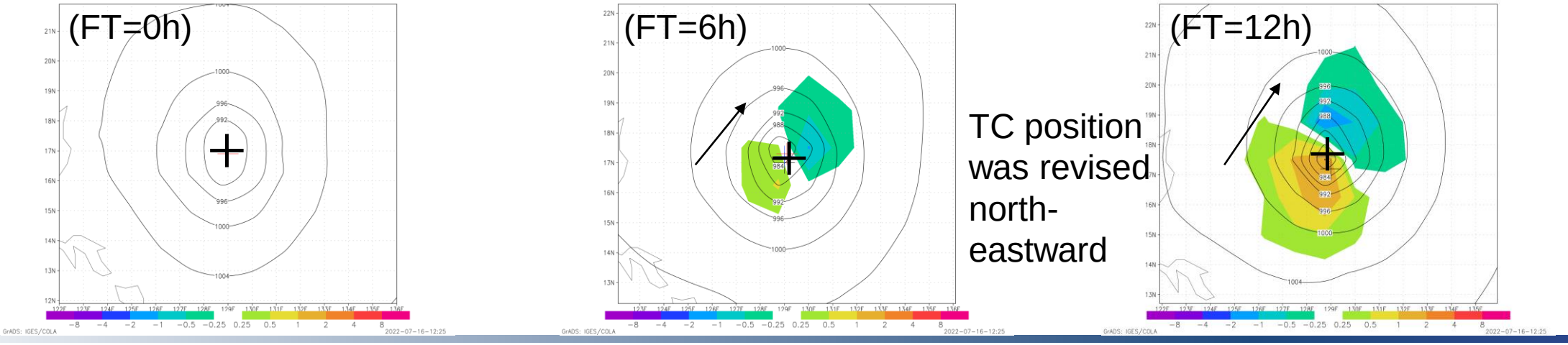


Increment spread downward, and reached to the earth's surface in several hours.
And then, Change in TC position started to extend.
Upper wind observation contributed to reduce the positional errors of typhoon forecast.

Increment in U of TEST and CNTL

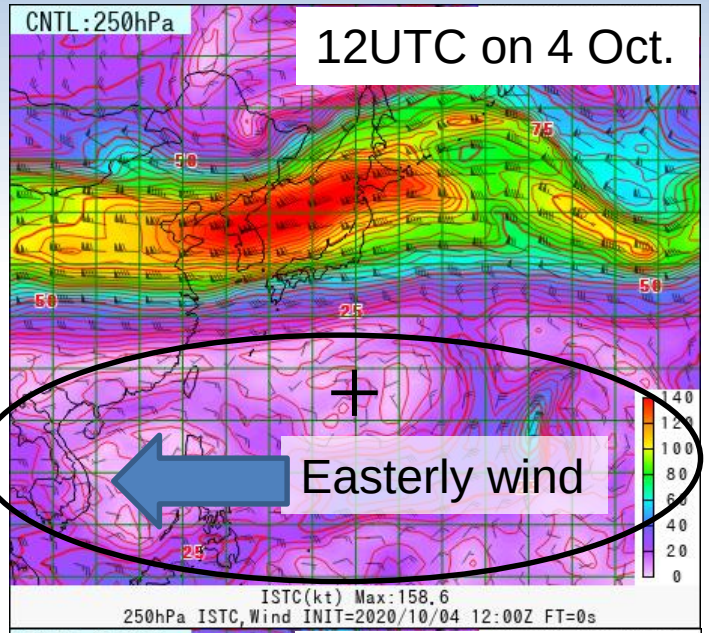


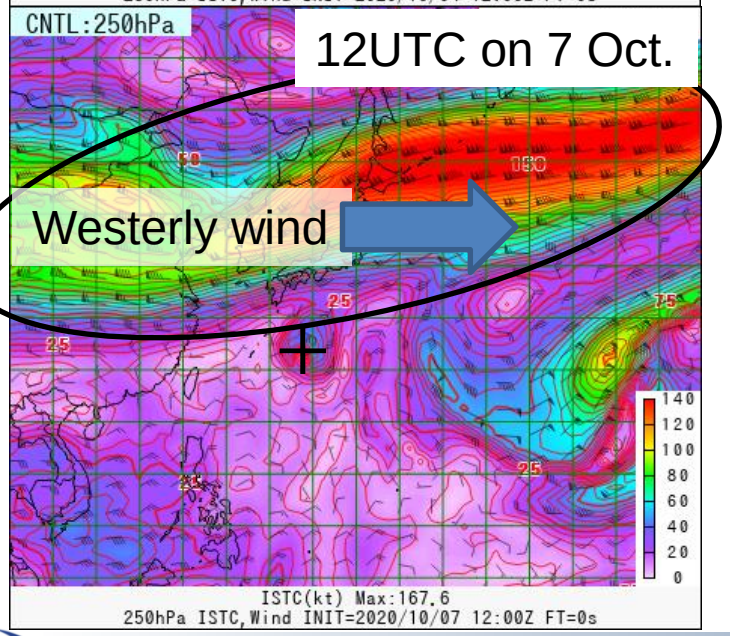
Increment in PSEA of TEST and CNTL



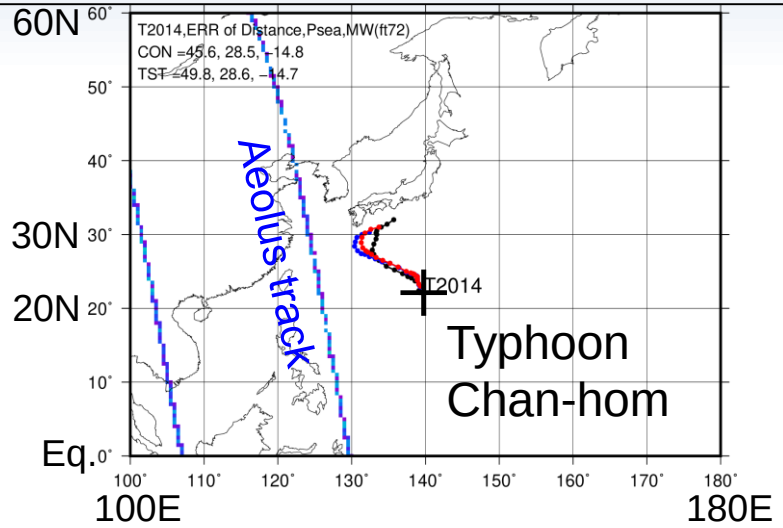
4. Case study 2

Wind speed at 250hPa

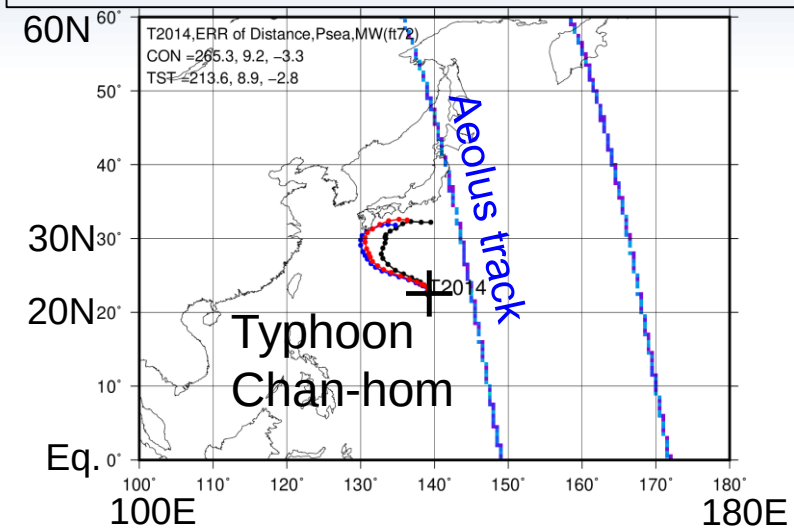




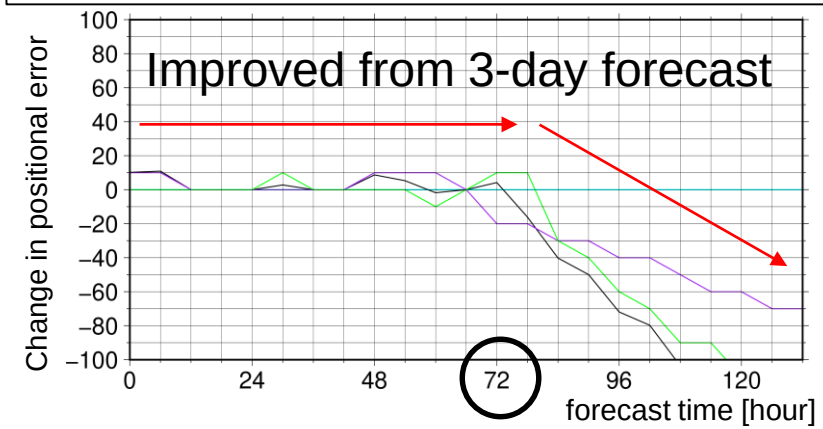
West case at 12 UTC on Oct. 4, 2020

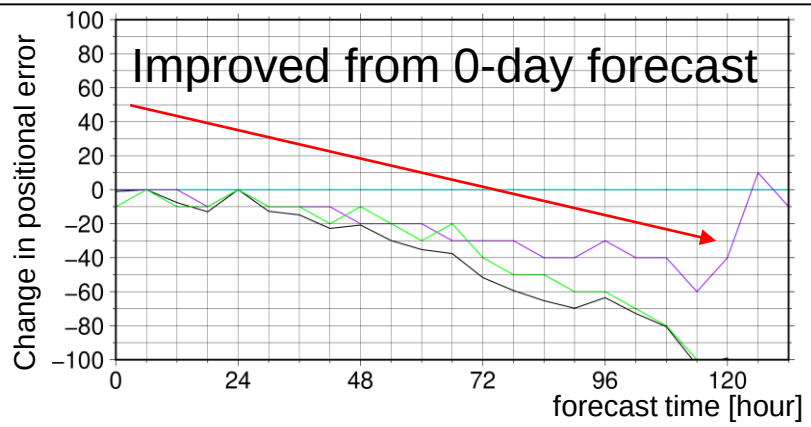


East case at 06 UTC on Oct. 5, 2020



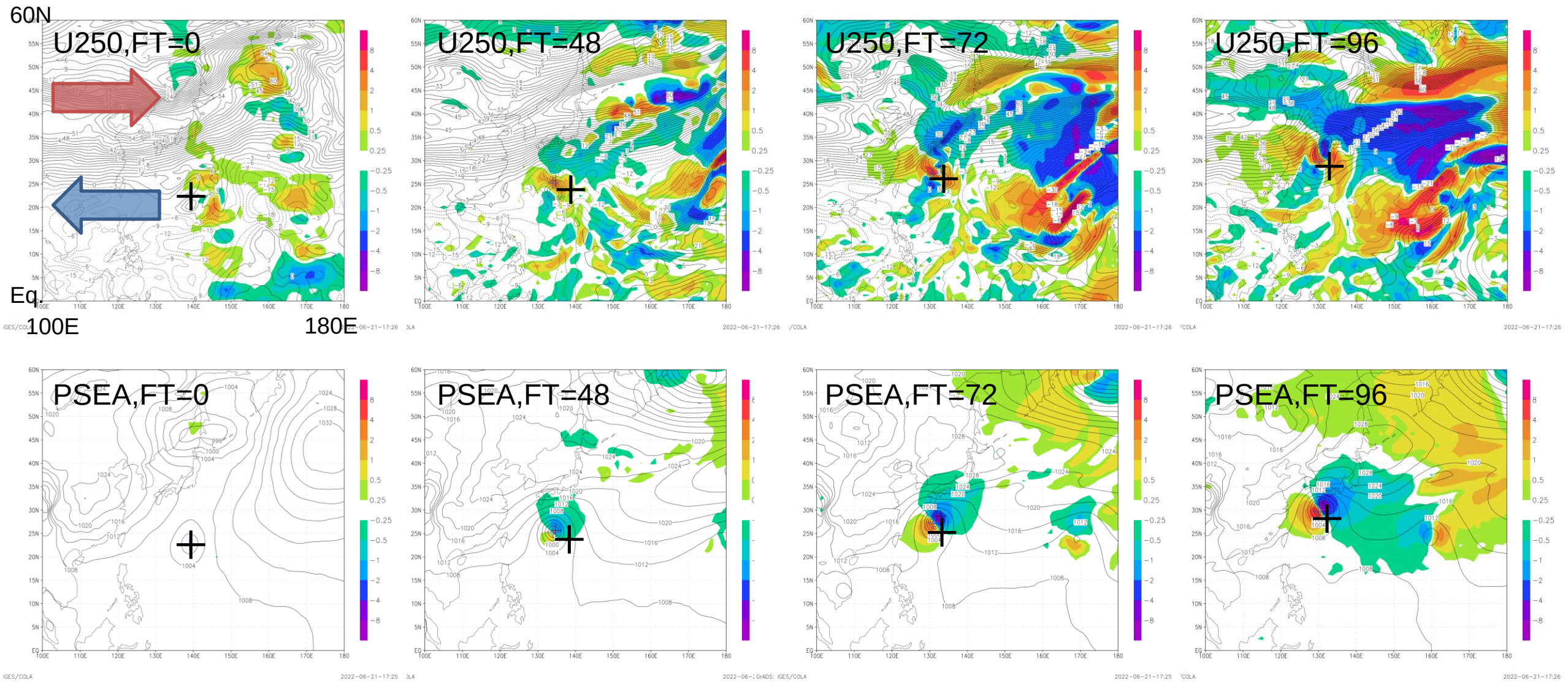
Change in positional error (distance[km] / latitude[0.1deg] / longitude[0.1deg])





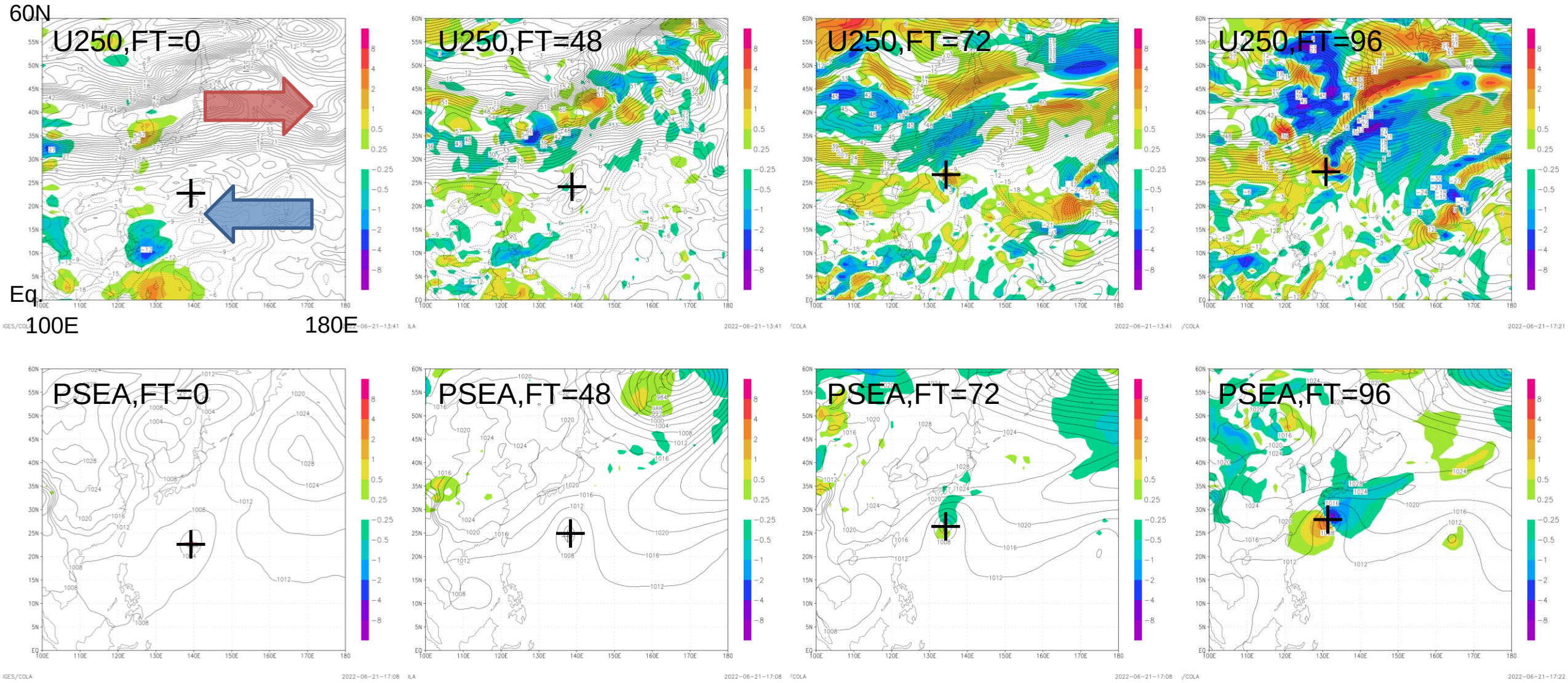
East case

The increment was brought to TC in a day by the easterly wind, and started to revise TC position.
The change in TC position spread over forecast time.



West case

The increment was brought away from TC by the Easterly wind up to 3-day forecast.
When TC closed to the subtropical jet, it's position was started to be revised.



Summary and future work

- Aeolus DWL data assimilation impact on typhoons' track forecasting was investigated in detail.
- Aeolus DWL provides a single-perspective horizontal wind data, and it is almost east-west wind component observation.
- In the statistical investigation, the improvement in the track forecasting was checked for the 3 groups of analyses, Near, West, and East, that is defined base on the positional relationship between Aeolus data coverage and typhoon at the analysis time.
- There were 3 tips given in the statistical investigation and case studies.

1. A wind observation in the upper troposphere contributes to improve the typhoons' track forecasting. This suggests the importance of the upper troposphere wind as a steering wind of typhoons.
2. A single-perspective wind observation contributes to improve the typhoon's track in both east-west and north-south directions. This supports the Aeolus's value for numerical weather prediction.
3. The observation data assimilated in the upstream of a typhoon can revise the TC's position.

Future works;

- How the upper vortex's positional revision influences on the lower vortex's position and intensity.
- Impact on intensity forecasting of typhoons.