Impact of Aeolus horizontal line-of-sight wind observations on Typhoon forecasting in a global NWP system

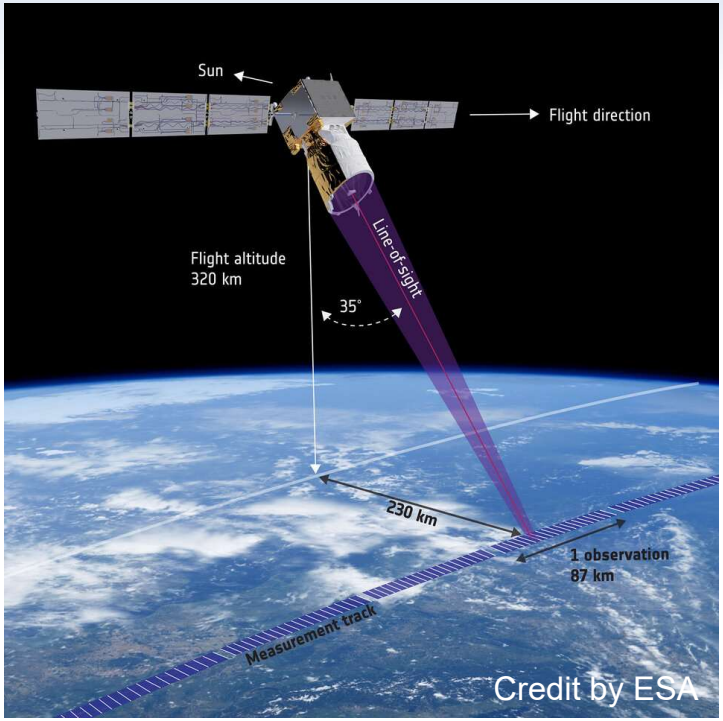
Izumi OKABE[1], Kozo OKAMOTO[1]

1: Meteorological Research Institute of Japan Meteorological Agency

Contents

1. Introduction

- Aeolus is …
  - The first satellite mission to acquire global-scale profiles of Earth's wind launched on 22 August 2018.
  - Orbits Sun-synchronous dusk-dawn plain at the altitude of 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 ☺
- Not observable inside or under thick clouds ☹
- Only almost zonal wind component ☹

What is the assimilation impact on typhoon forecasting?

2. Experiment and Result / Configuration

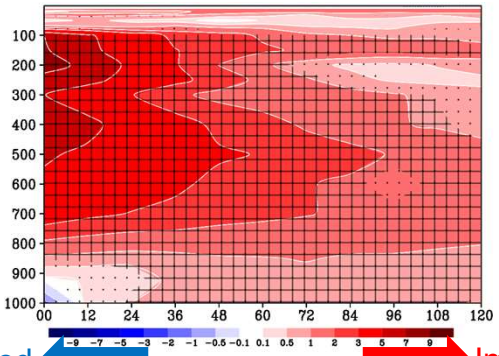
- CNTL : JMA's data assimilation + global spectral model (GSM) as of December 2019.
- TST1 : CNTL + Aeolus's Rayleigh wind under clear-sky ＋Mie wind under cloudy
- TST2 : CNTL + Aeolus's Rayleigh wind under clear-sky ＋Mie wind under cloudy
  Backgrounds from CNTL were used for every analysis.
- Quality control pass conditions for Aeolus data:
  (ECMWF technical memo 864, The NWP impact of Aeolus Level-2B winds at ECMWF, was referenced.)
  - Limit estimated error and integration length according to Rayleigh and Mie winds.
  - Reported quality check flag = 1

  (Additionally, some condition introduced in Okamoto et al. 2018 was applied.)
  - Data outside the range of model's top and bottom, and data at the lowest and highest level was rejected.
- Observation error (used in assimilation system) for Aeolus data:
  - Estimated error × inflation (inflation = 2.0 at tropics and mid latitude, 3.0 at high latitude)
- Bias correction is NOT applied.
- Validation period: August 1 to November 10, 2020.

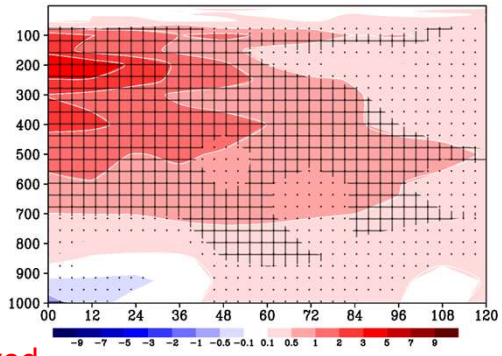
Impact of assimilating Aeolus wind data

TST1 (cycled-analysis) had a greater impact on averaged improvement ratios than TST2 (reinitialized-analysis).
However, the impact on typhoon track forecasting were similar between TST1 and TST2 until 72-hour forecast.

TST1 (U, Tropics)

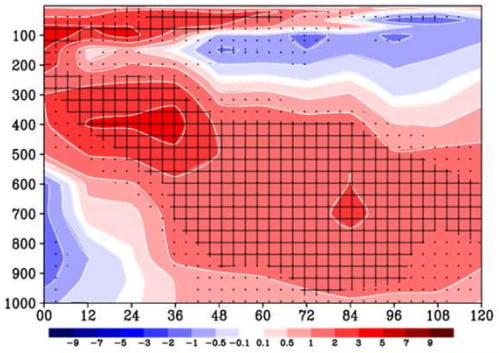


TST2 (U, Tropics)

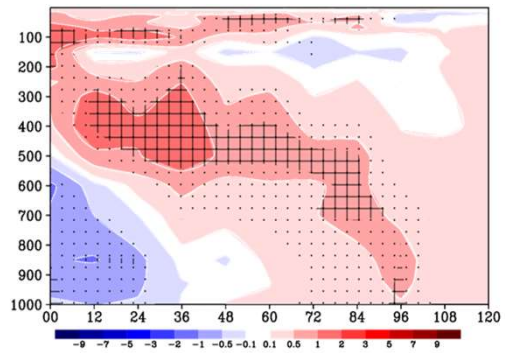


Degraded ← → Improved

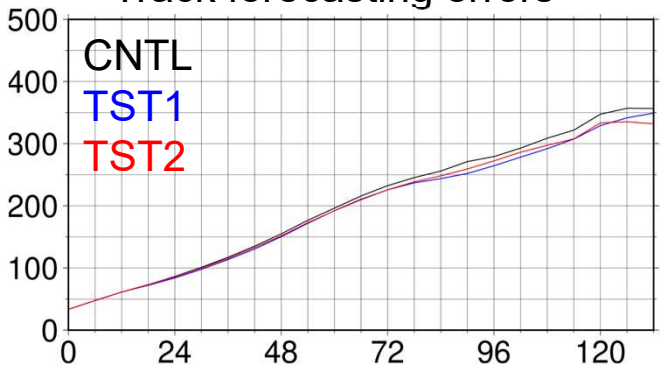
TST1 (Z, tropics)



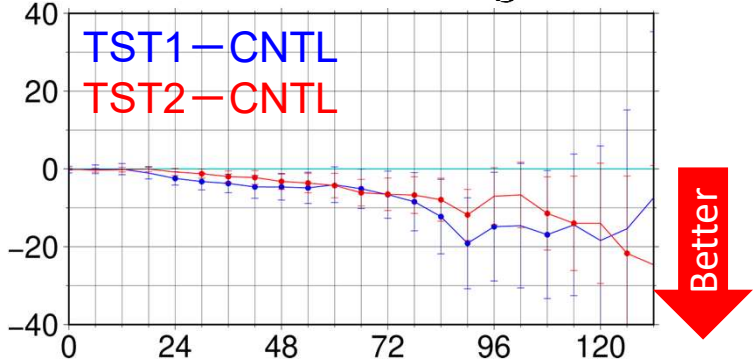
TST2 (Z, Tropics)



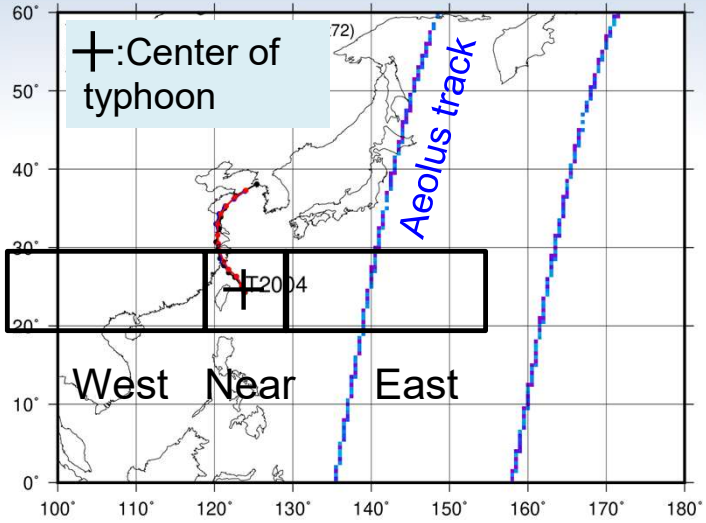
Track forecasting errors



Diff. of track forecasting errors



3. Statistical investigation



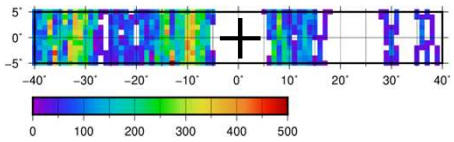
Each analysis was categorized into one of the groups as follows;

Near: Aeolus data used within 5 degree latitudes and longitudes.

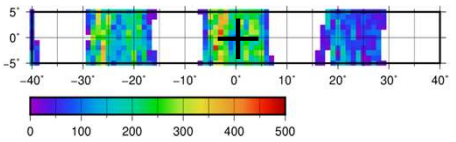
West: The data used in the west of “near” area within 30 degree longitudes.

East: The data used in the east of “near” area within 30 degree longitudes.

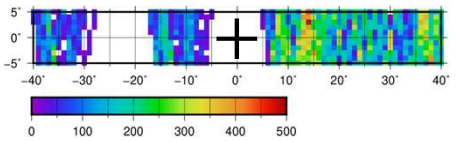
Data counts of West



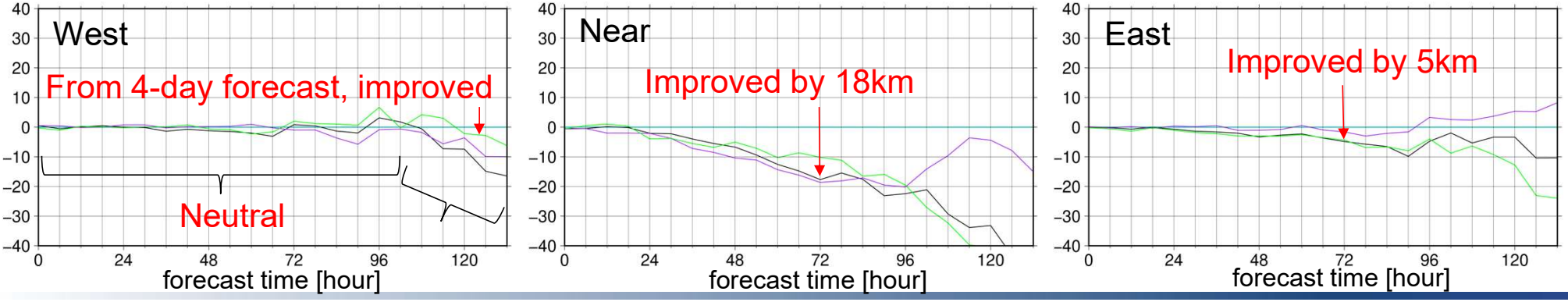
Data counts of Near



Data counts of East

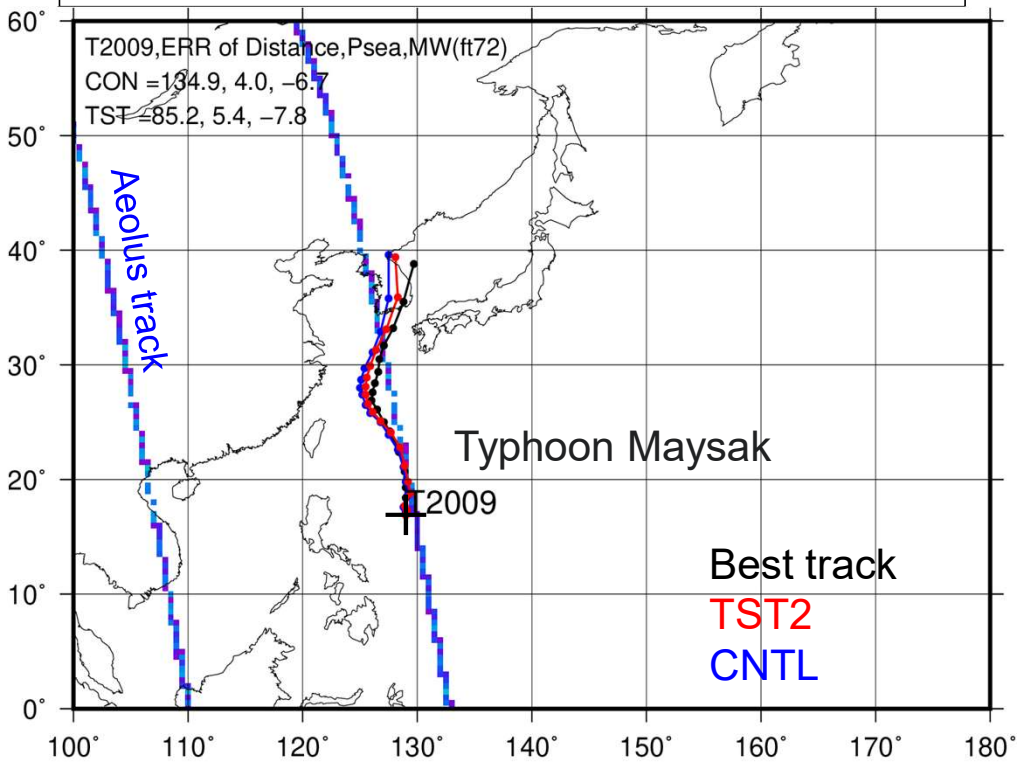


Change in track forecasting error (distance[km] / latitude[0.1deg] / longitude[0.1deg])

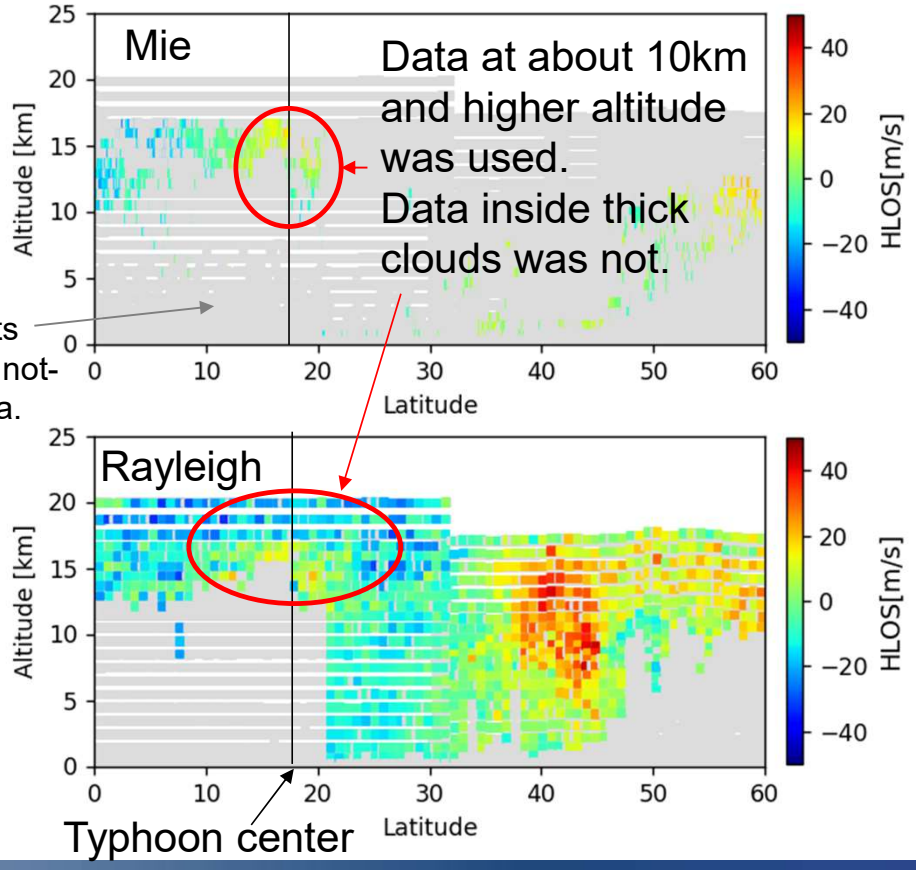


4-1. Case study 1

Near case at 12 Utyphoon on August 29, 2020



Altitude and latitude of used data

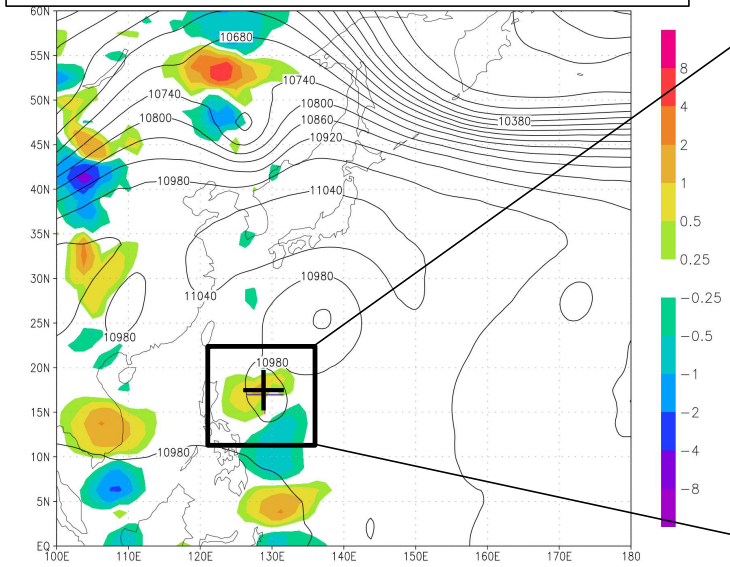


What happens at Aeolus wind assimilation?

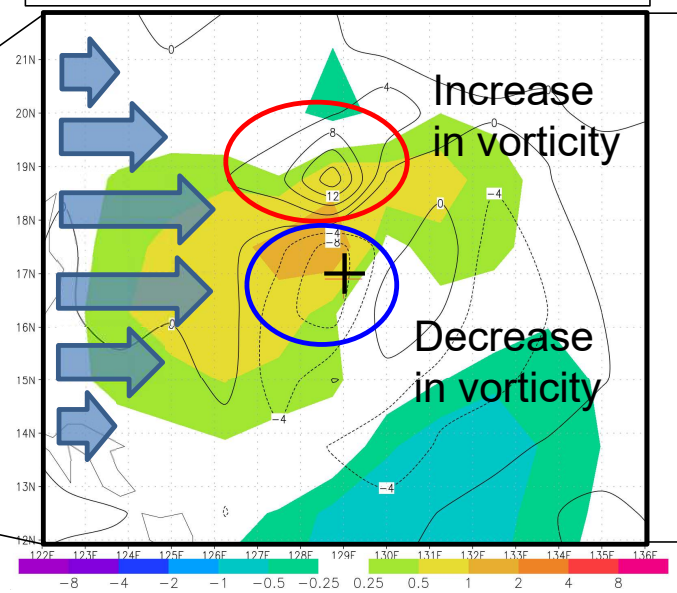
As Aeolus DWL is a single-perspective instrument with 97.2° inclination angle, almost zonal wind component is available.

Difference in analyses of TST2 and CNTL

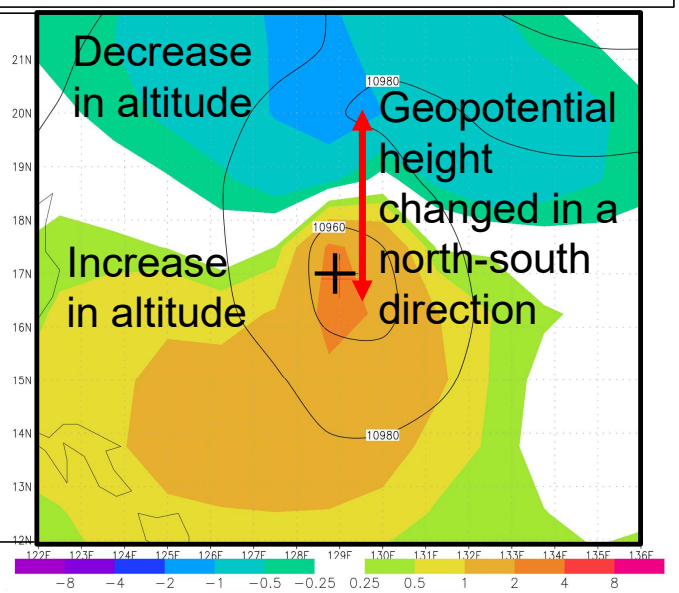
U250(shade),Z250(contour, TST2)



U250(shade),VOR250(contour)



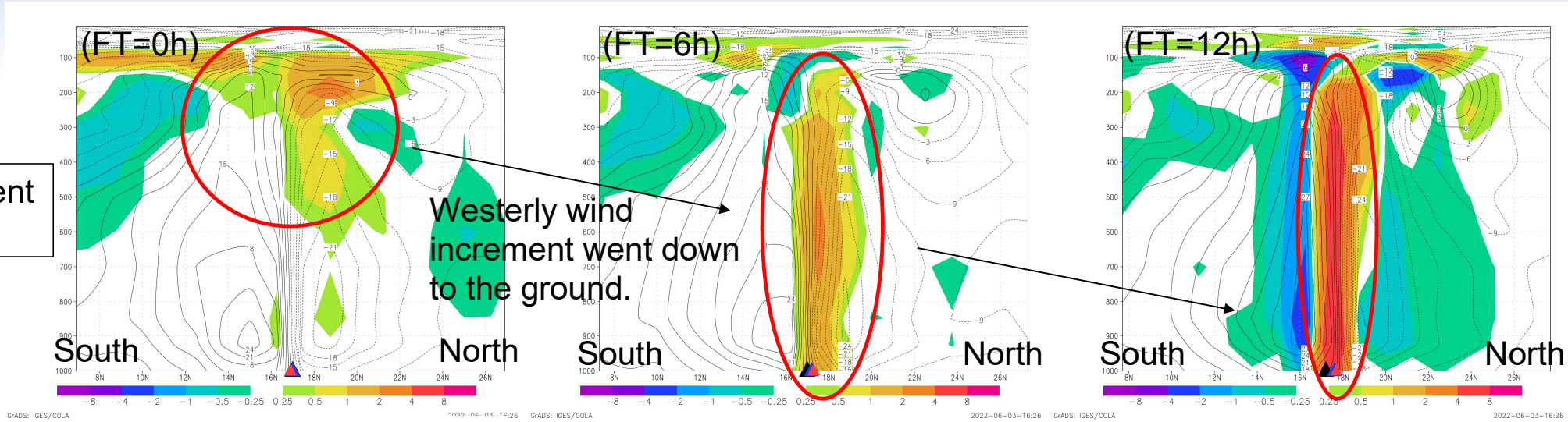
Z250(shade),Z250(contour, TST2)



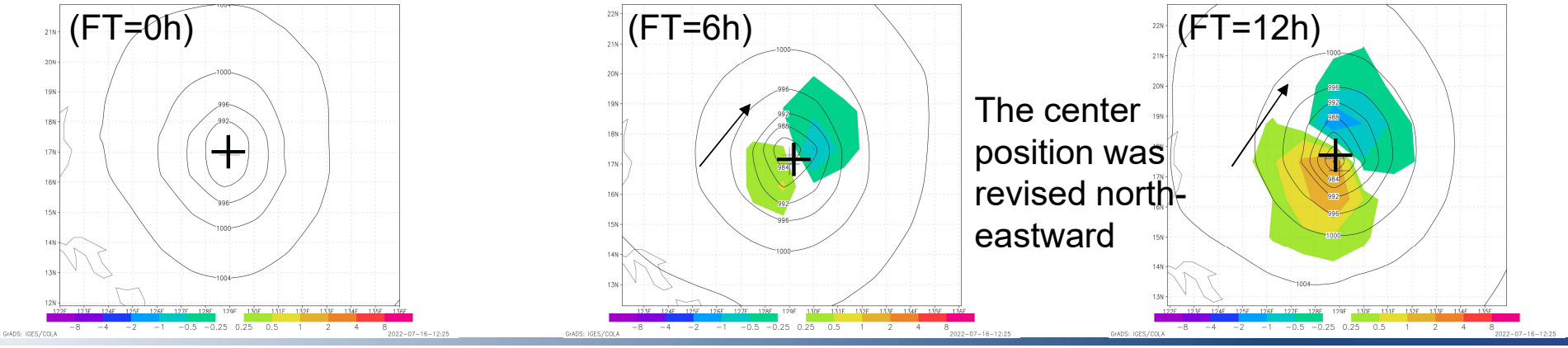
Easterly wind ⟷ Westerly wind

"The increments spread downward and reached the ground level in several hours, after which difference in the typhoon center position began to emerge. This demonstrates how the upper wind observations revised the position of the typhoon center on the ground."

Increment in U

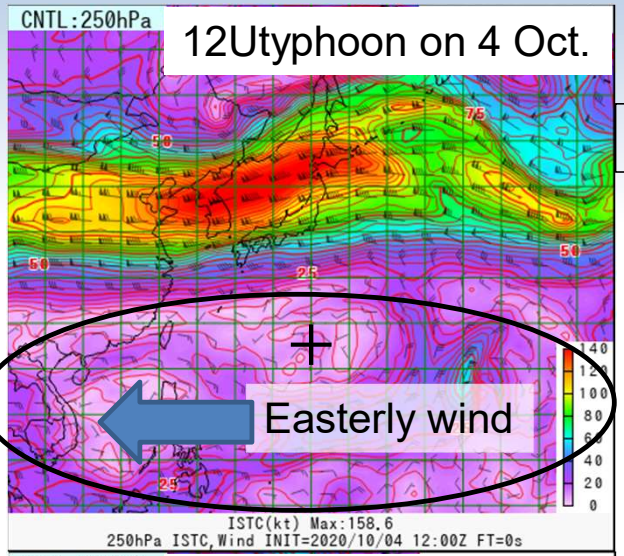


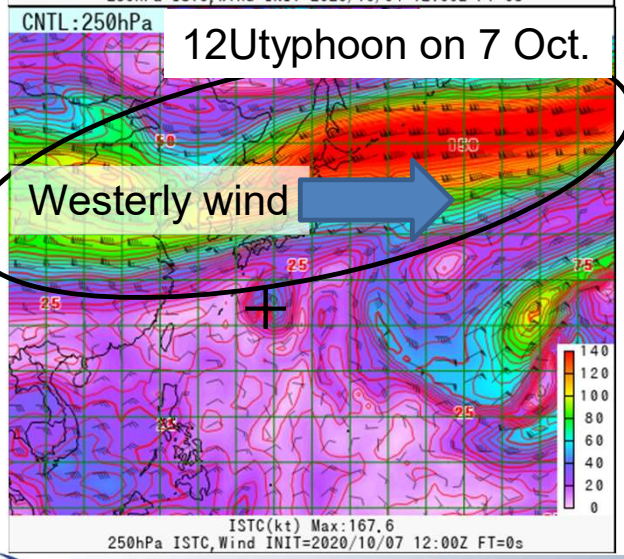
Increment in MSLP



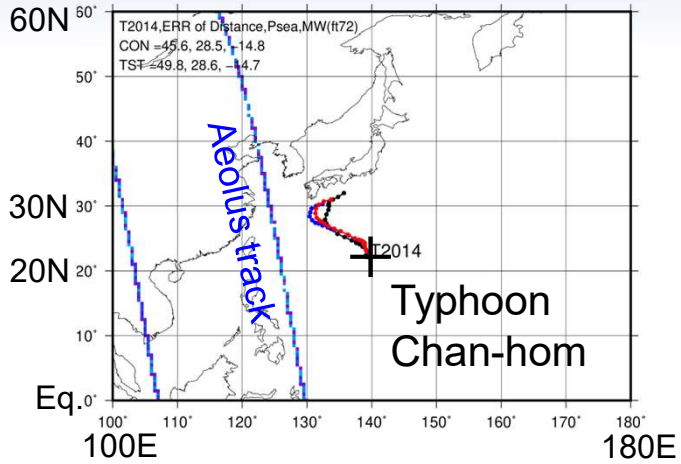
4-2. Case study 2

Wind speed analysis at 250hPa

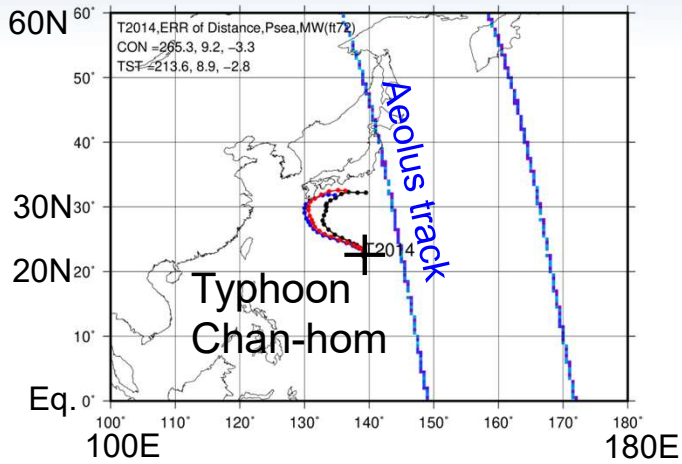




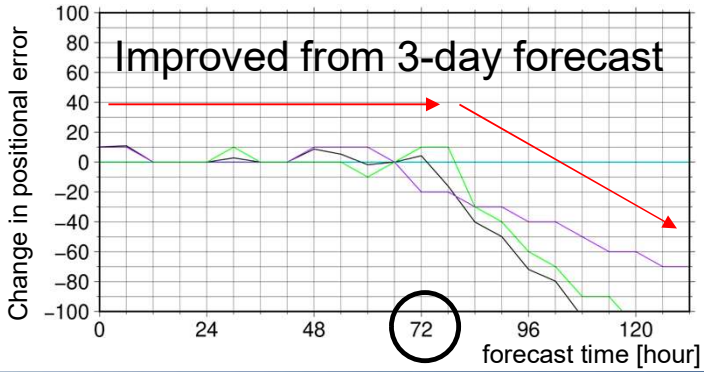
West case at 12 Utyphoon on Oct. 4, 2020

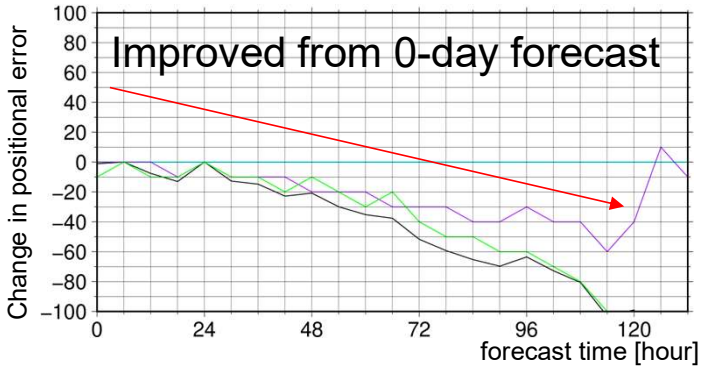


East case at 06 Utyphoon on Oct. 5, 2020



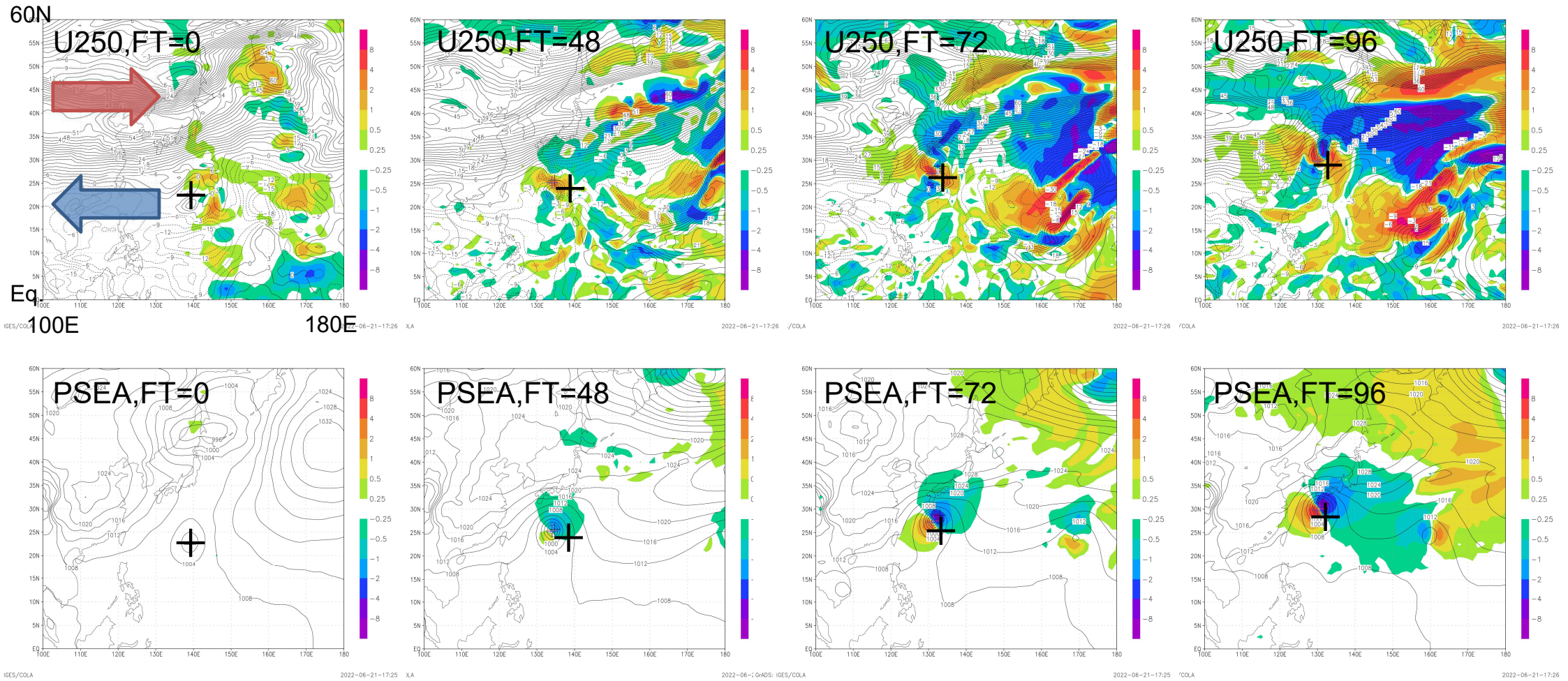
Change in track error (distance[km] / latitude[0.1deg] / longitude[0.1deg])





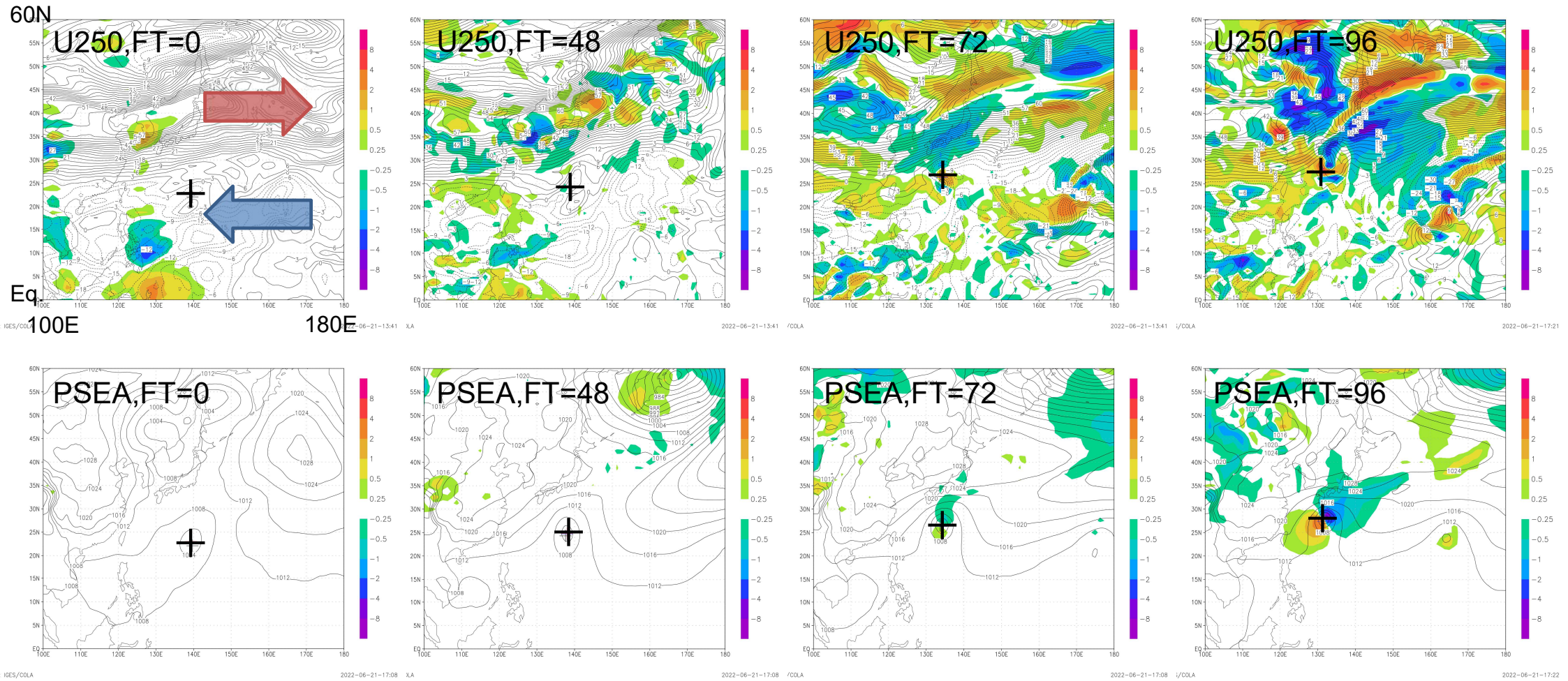
East case

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



West case

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



Summary

- 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 zonal wind component observation.
- In the statistical investigation, each analysis of TST2 was categorized into one of the following groups: Near, West, and East, according to the positional relationship between Aeolus data coverage and typhoon center at the analysis time.
- There were 3 tips given in the statistical investigation and case studies:

1. 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.)
2. A wind observation in the upper troposphere contributes to improve the typhoons' track forecasting, suggesting the importance of the upper troposphere wind as a steering wind of typhoons.
3. The observation data assimilated in the upstream of a typhoon can revise the typhoon's position.