Potential Impact of Aeroclipper Observations on a Tropical Cyclone Analysis in a Global Model

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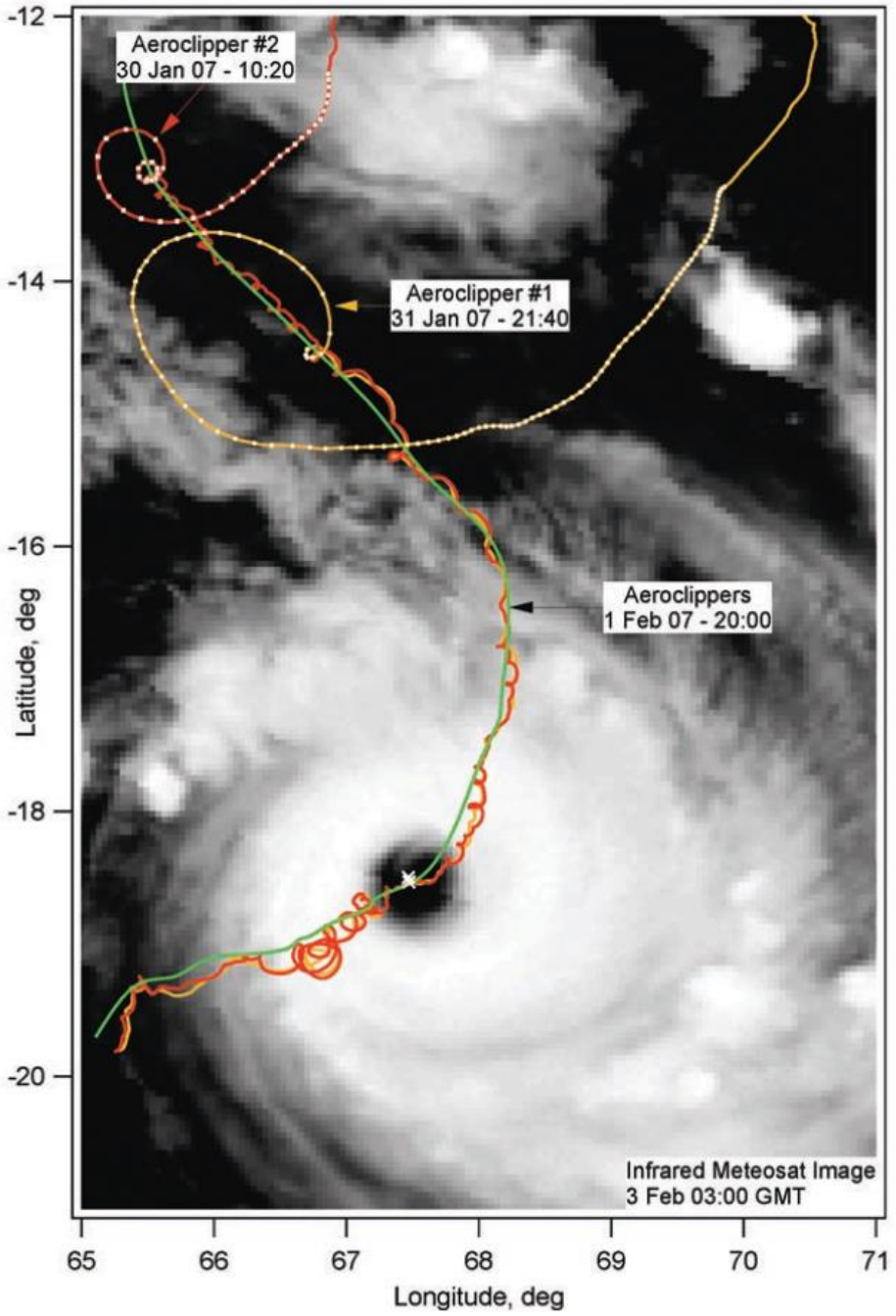
Aeroclipper : a new meteorological observation equipment drifting by the surface wind

Pressure, Temperature, Humidity, Wind,
Position(GPS), SST(infrared sensor)
data is transferred every minute using IRIDIUM satellite communication system
Flight duration：20～30 days

~30m

ARCEO campaign in Guam 2017



During VASCO experiment in 2007, two Aeroclippers (1 and 2) accidentally converged into TC Dora.

Both Aeroclippers trapped within the eye of the cyclone a few days after the launch and remained within the eye the following days.

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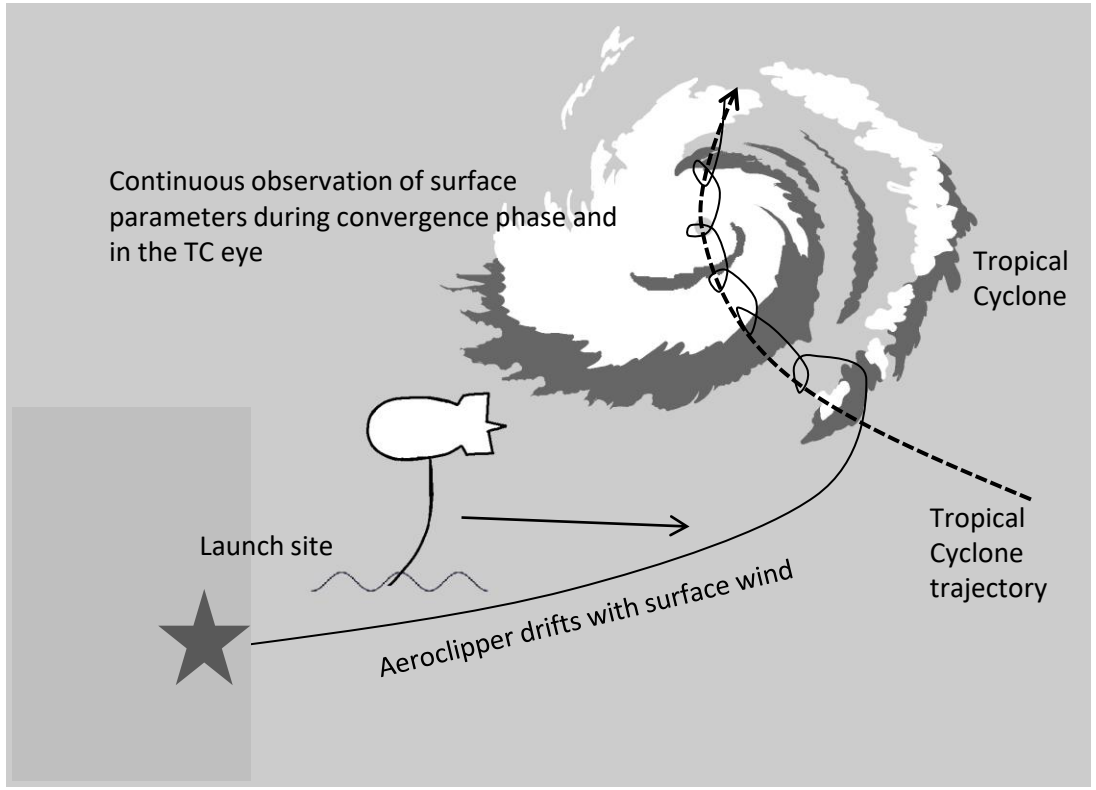
we can chase TC by Aeroclipper observation

Duvel et al. 2009

TC observation

- TC nowcasting
- Dvorak technique validation
- evaluate Assimilation impact on TC analysis and forecasts



Credit: H. Kenehisa

Purpose

To investigate the impact of the Aeroclipper observations on the analysis of TC by the data assimilation

No real observation data

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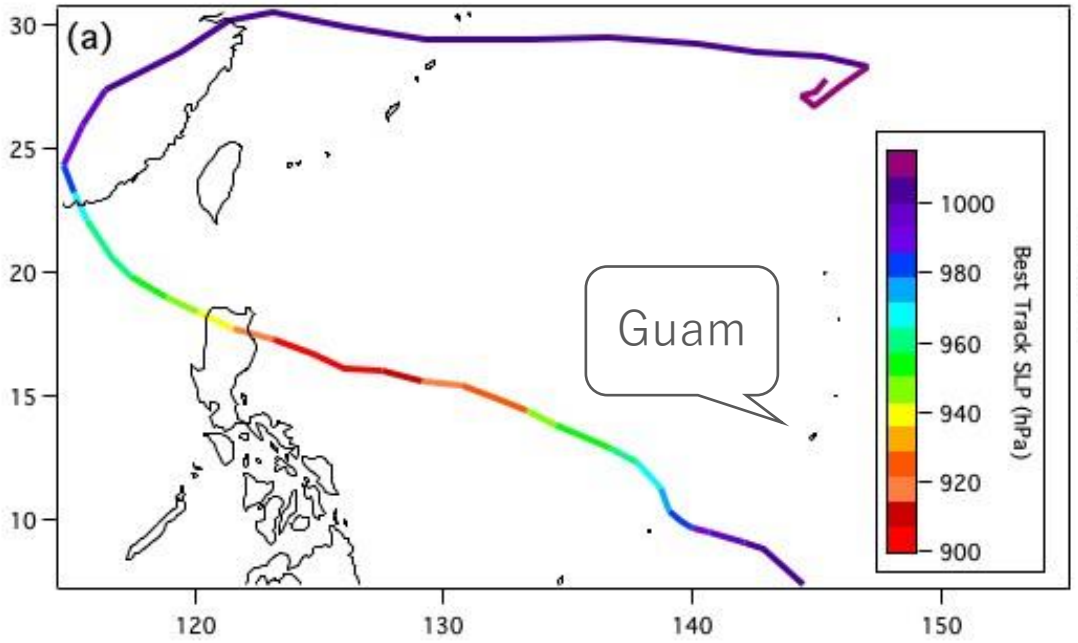
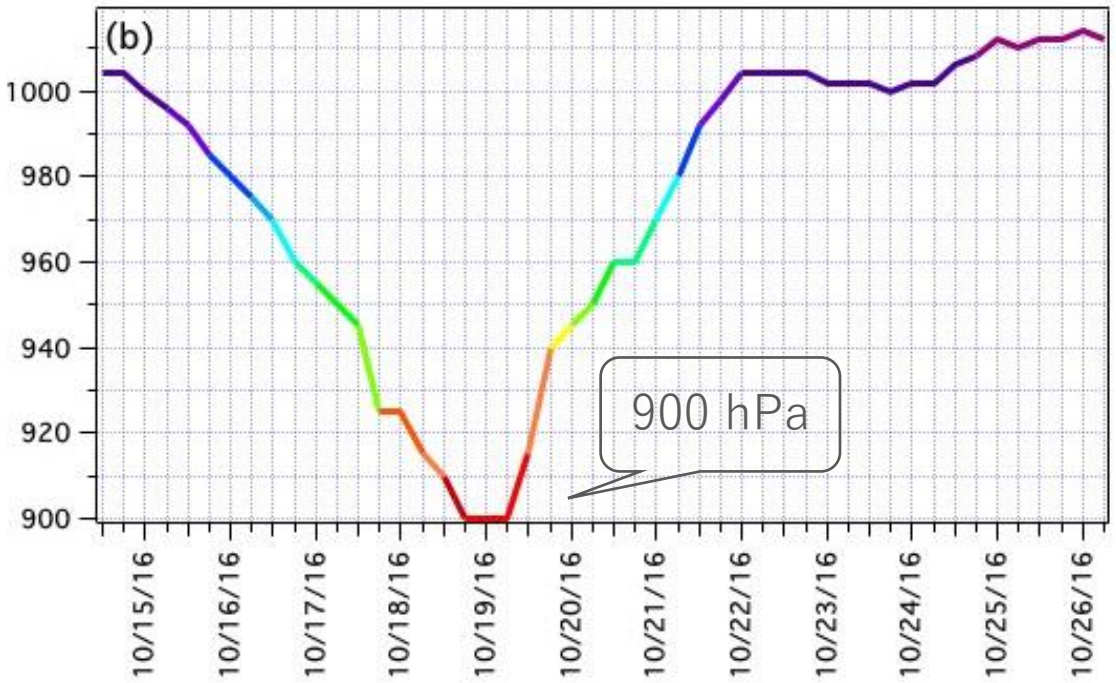
Virtual Observing System Experiment using artificially generated Aeroclipper observation data of SLP

This is neither OSE nor OSSE

TC Haima (201622)



6-hourly trajectory.



6-hourly central SLP (hPa) time series.

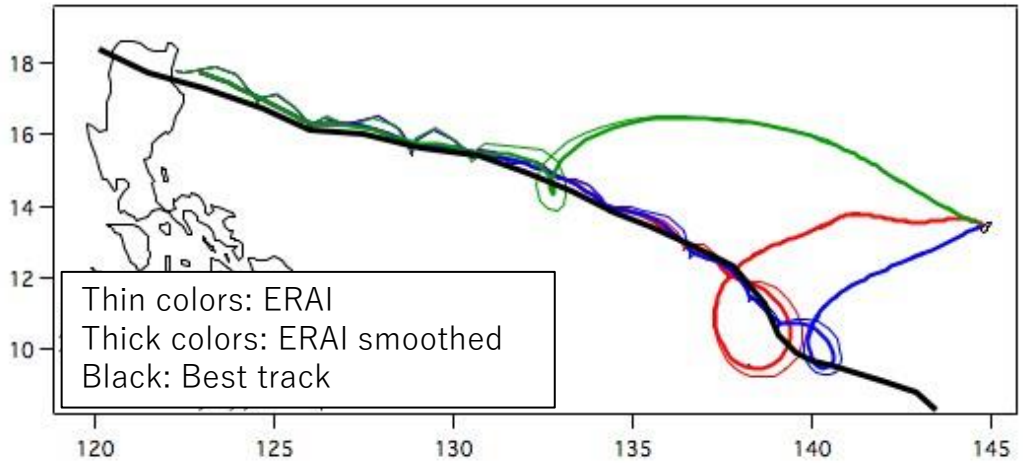
Virtual aeroclipper observation: trajectories

3 virtual aeroclippers are released from Guam on
2016 October 11th (0000GMT), 13th (1200GMT) and 15th (1200GMT).

Their velocity (V_{AEC}) is computed from ERA-Interim 10 meters wind vectors (V_{10}) following an empirical relationship derived from VASCO experiment (Duvel et al. 2009) :

$$V_{AEC} = 0.3\|V_{10}\|^{1.34}\frac{V_{10}}{\|V_{10}\|}$$

V10 is interpolated from 6h to 5min time resolution and bi-linearly interpolated at the position of the aeroclipper.

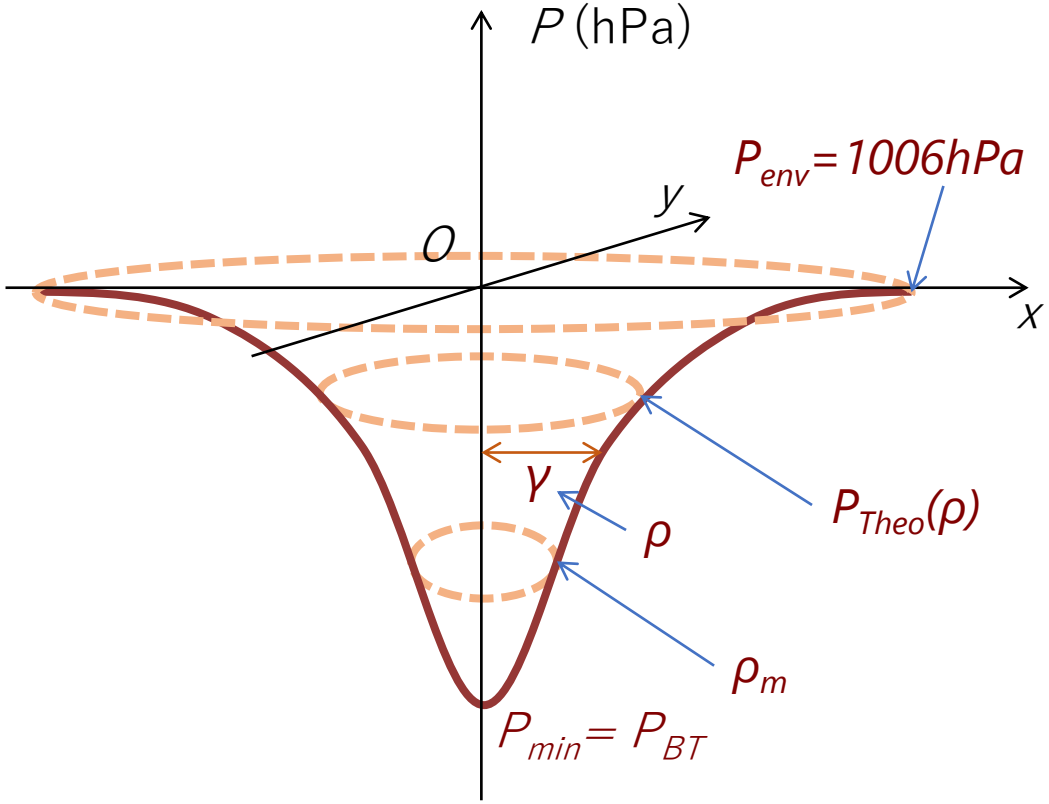


Trajectories are smoothed with a 12h binomial smoothing filter
(Marchand and Marmet 1983)

The aeroclippers are destroyed when reaching a coast using ERA-I sea-land mask.

Virtual aeroclipper observation: Sea Level Pressure

obtain synthetic SLP time series taking advantage of the best track analysis



Theoretical pressure in the TC: $P_{theo}(\rho)$

$$P_{Theo}(r) = P_{env} + (P_{BT} - P_{env}) \frac{1}{\sqrt{1+2(r/r_m)^2}}$$

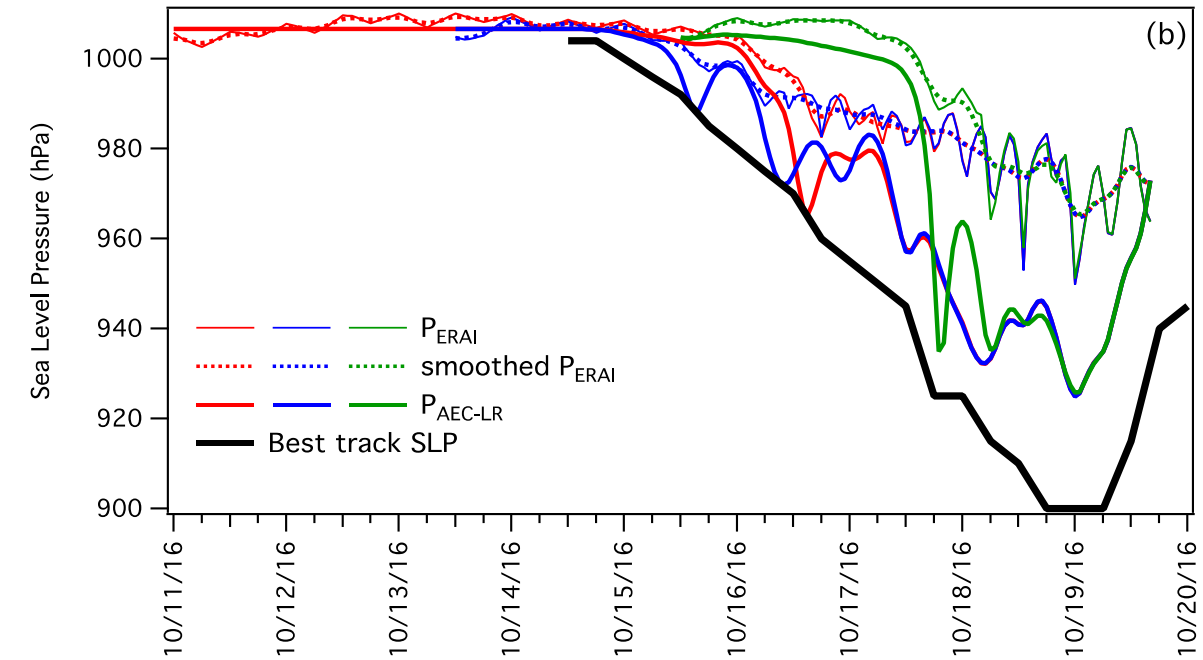
(Fujita 1952, Ma et al. 2012)

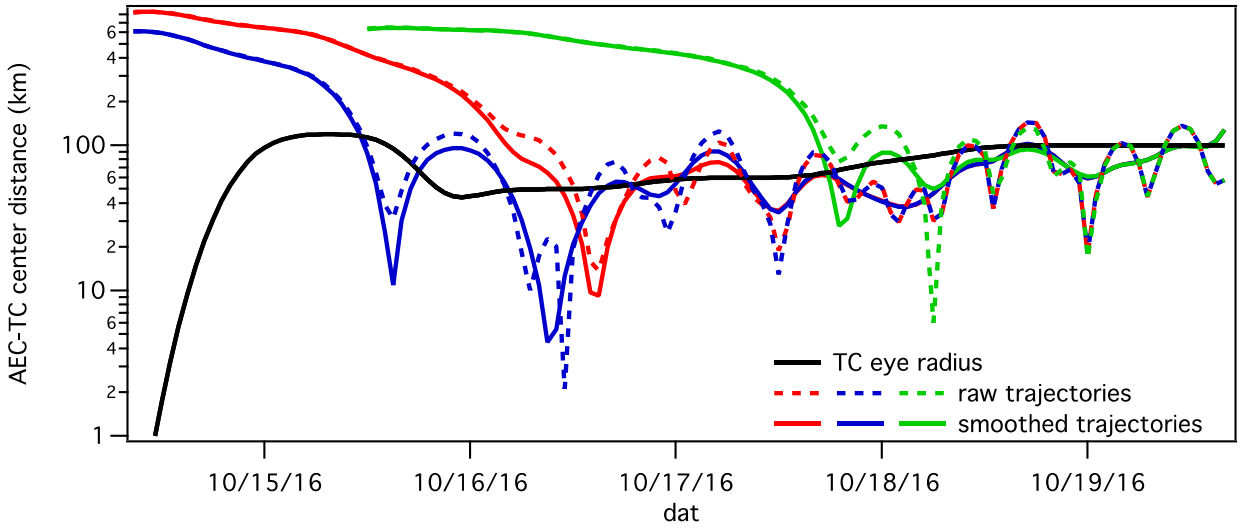
P_{env} is the environmental pressure at outside the TC: set to 1006 hPa.

P_{BT} the minimum pressure: it is provided by the best track estimate (6 hourly).

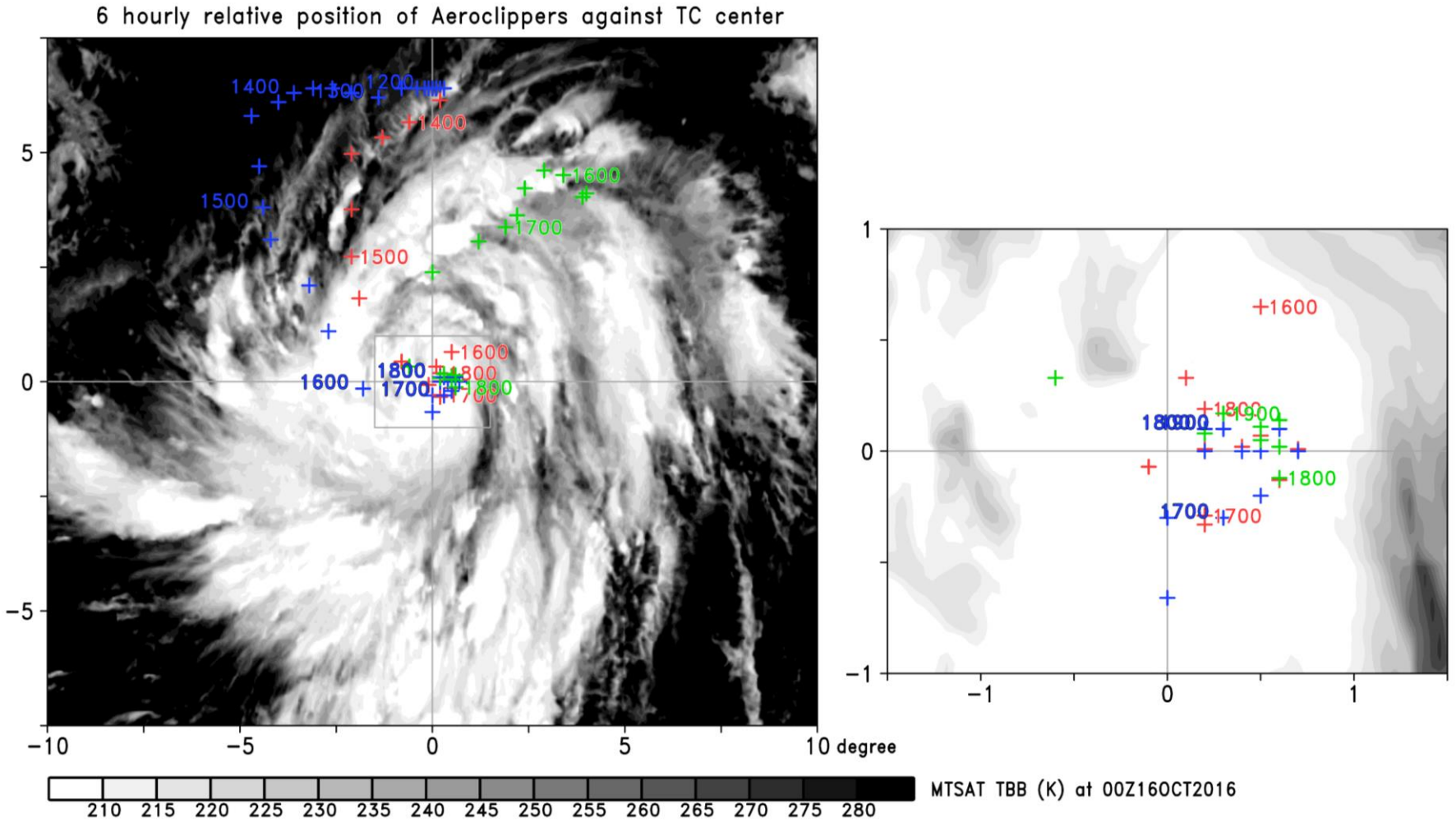
ρ_m is the radius of maximum wind: it is a smoothed blending of radii of 30knt and 50knt winds speed provided by best track data.

Virtual aeroclipper observation: Sea Level Pressure time series





Virtual aeroclipper observation



Note that this is not an assimilation of the best track data that is the extreme value on the center of TC but an assimilation of distributed observations including the data outside of TC.

virtual OSE using ALEDAS2

AFES-LETKF ensemble data assimilation system

	ALEDAS2
AFES version	3.6
Resolution	T119L48
Ensemble size	63+1
Covariance localization	400 km / 0.4 ln p
Spread inflation	10%
Observation	NCEP PREPBUFR

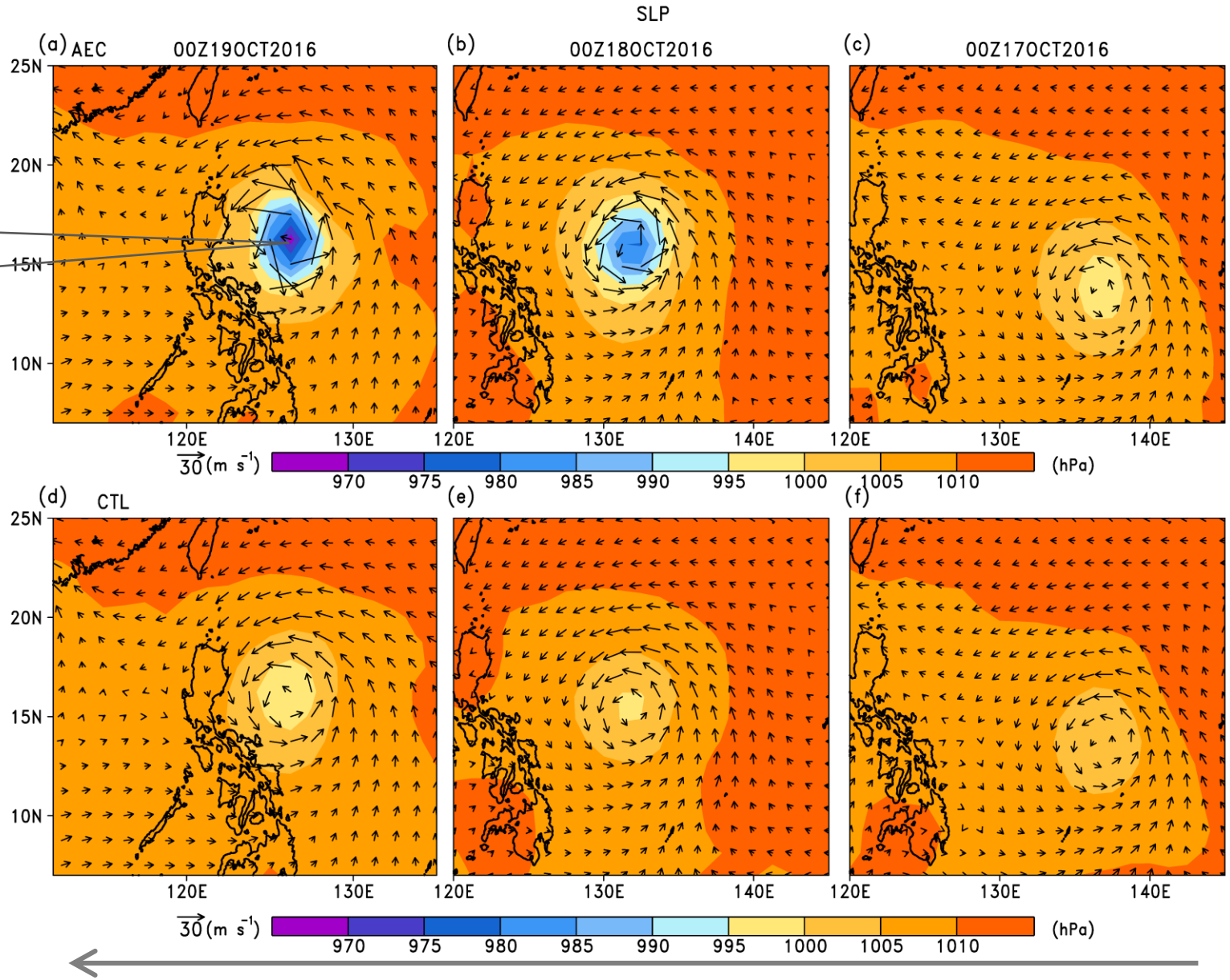
virtual OSE period: 09–24 Oct. 2016

CTL: without the aeroclipper obs.

AEC: with the virtual aeroclipper obs.

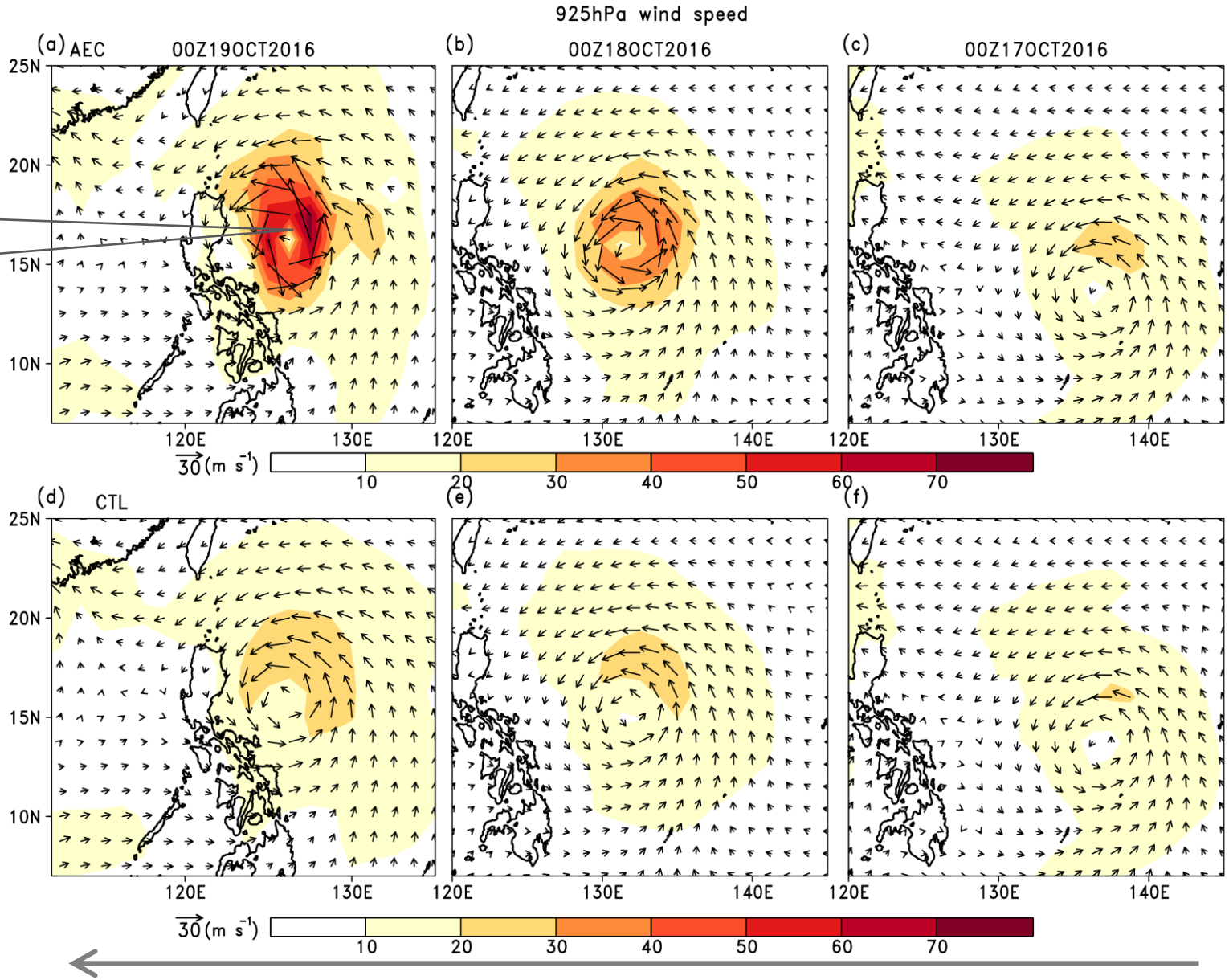
Impact of the Aeroclipper observations on the analysis of TC

SLP:
970 hPa



Difference of SLP between AEC and CTL is getting larger as TC develops and as aeroclippers are assimilated continuously.

Impact of the Aeroclipper observations on the analysis of TC

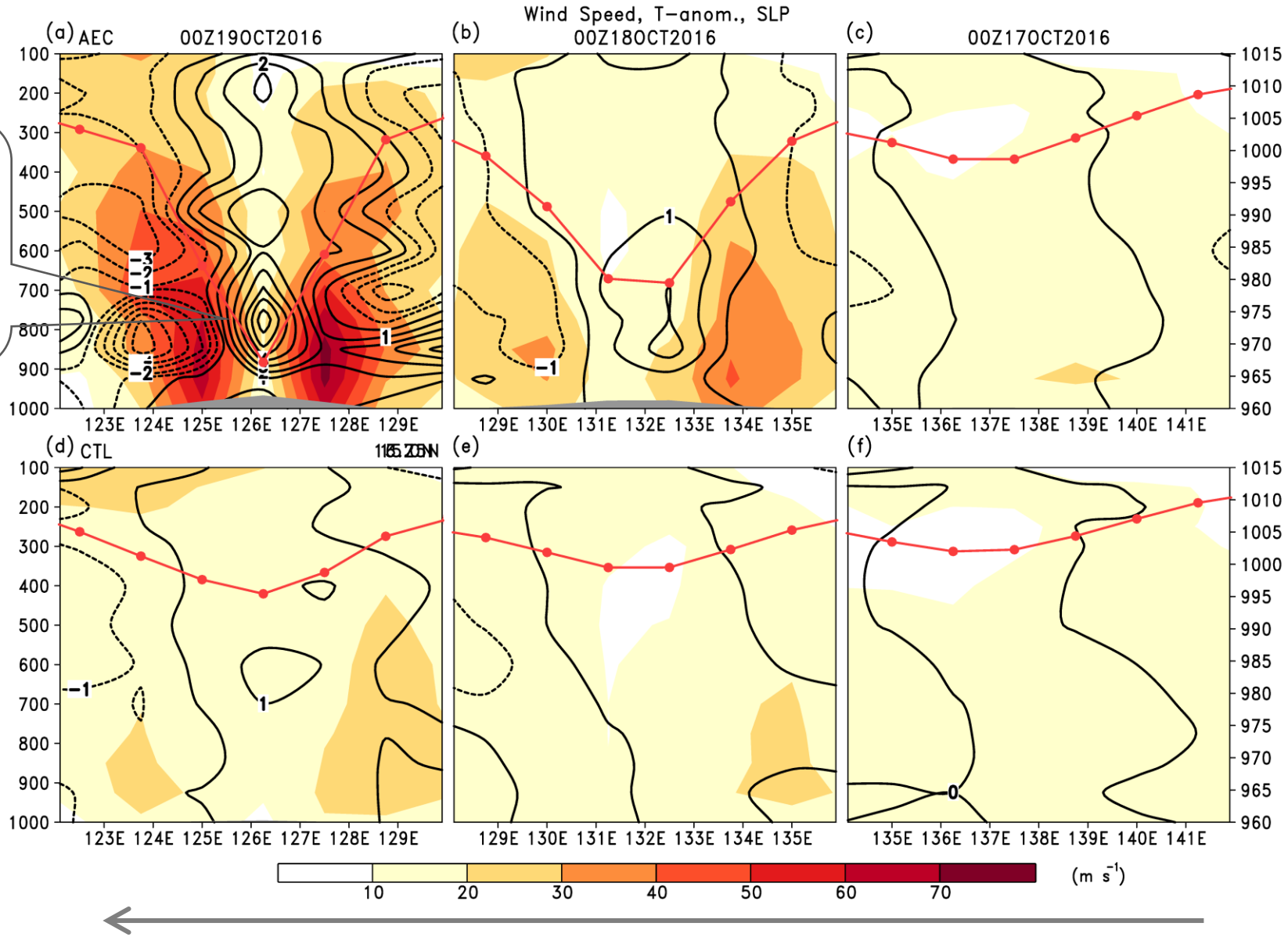


Wind speed:
60 m/s

As the assimilation continues and the TC develops, the strength at the center of TC is analyzed more remarkable.

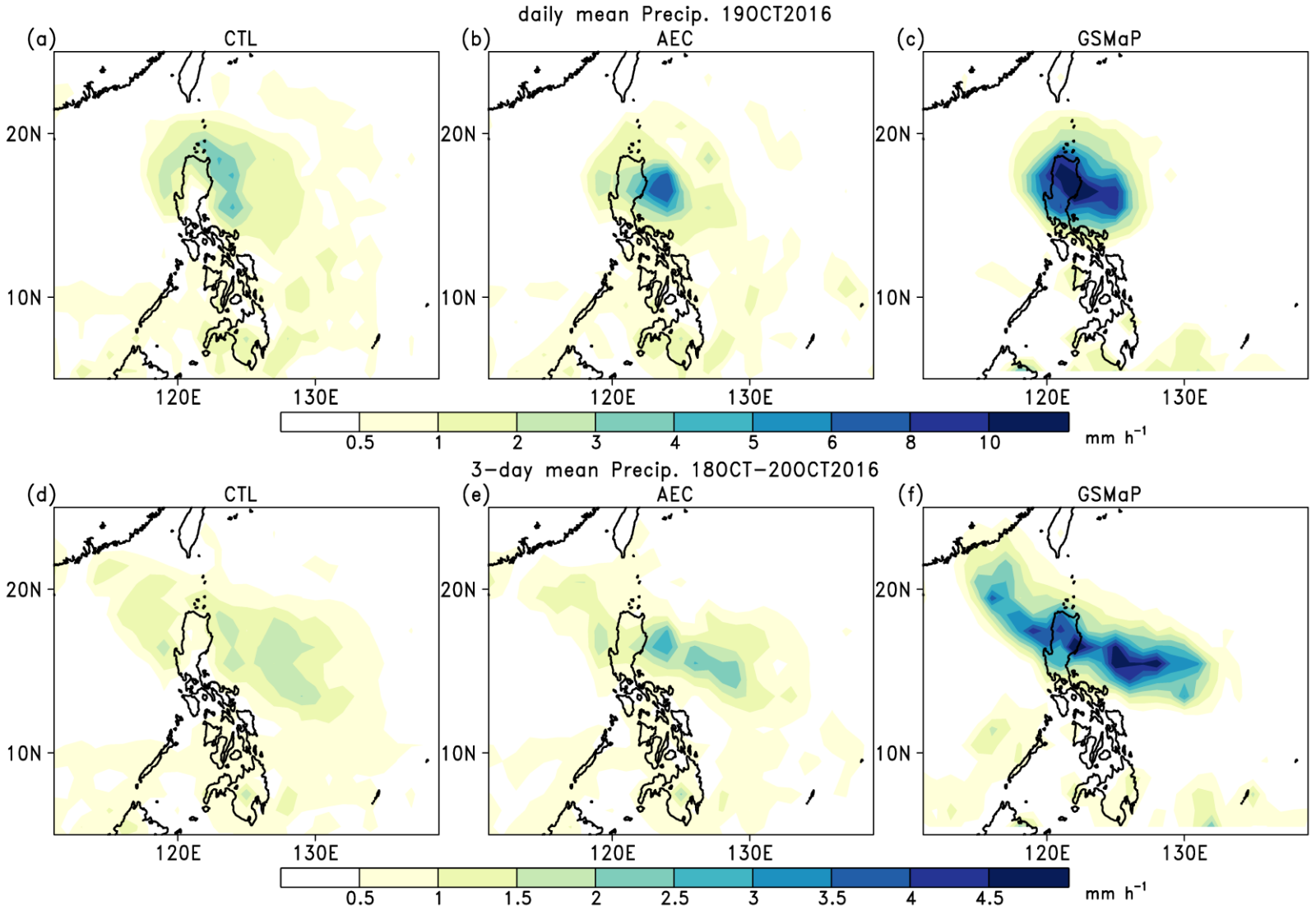
Impact of the Aeroclipper observations on the analysis of TC

Warm core:
+7 °C
Minimum
Pressure:
970 hPa



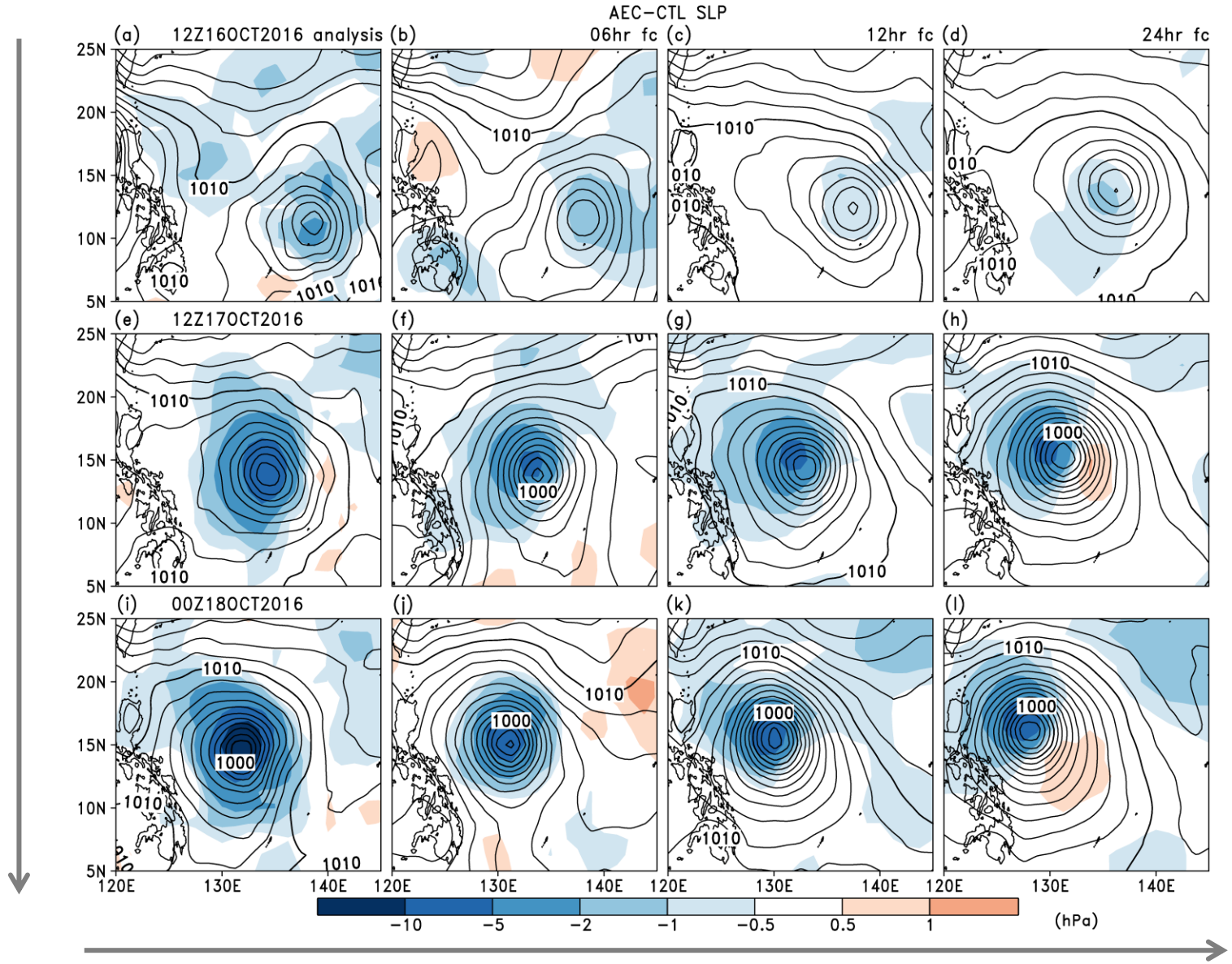
Assimilation of the virtual Aeroclipper observations reproduced the detailed structures of TC.

Impact of the Aeroclipper observations on the analysis of TC



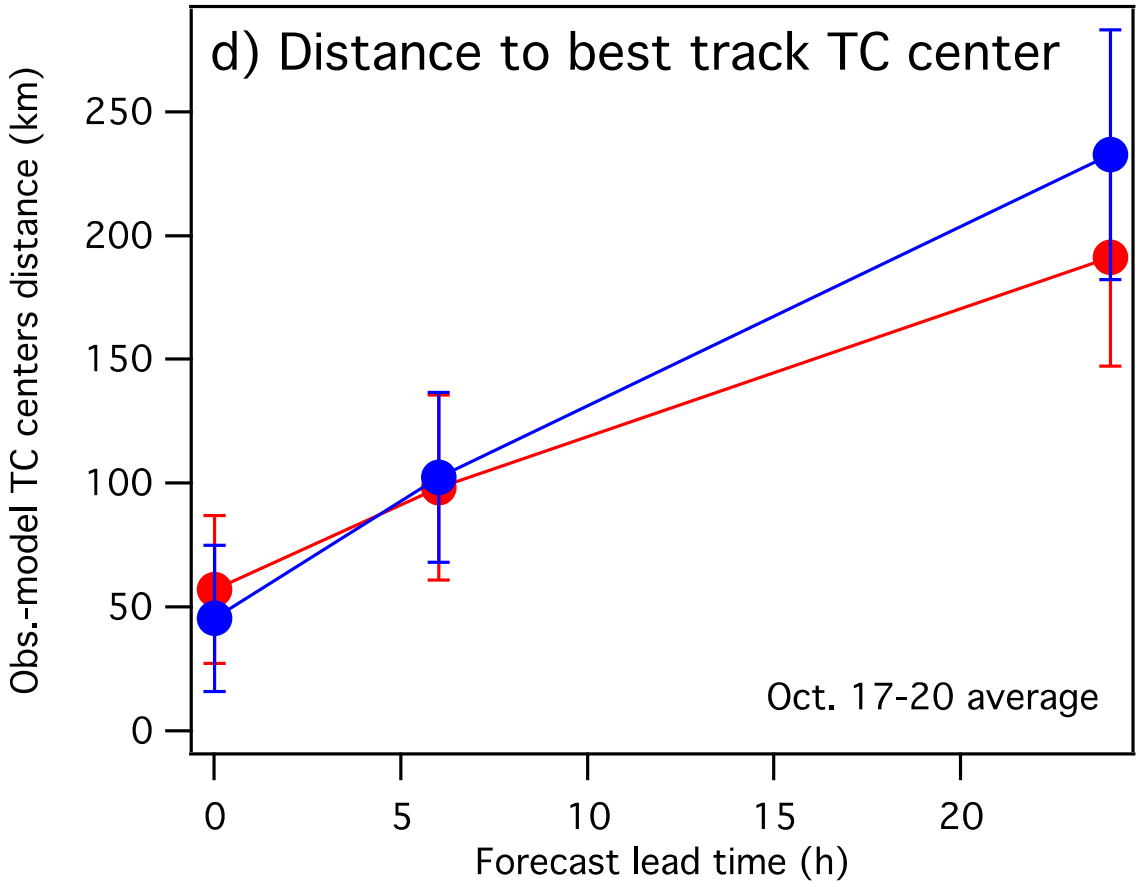
Although the difference from the observation is still large due to the resolution of the model, but it is clear that AEC experiment has more precipitation than CTL.

Impact of the Aeroclipper observations on the forecast of TC



The longer the forecast time, the smaller the difference between AEC and CTL.
As the forecast time progresses, the differences in TC position appear.

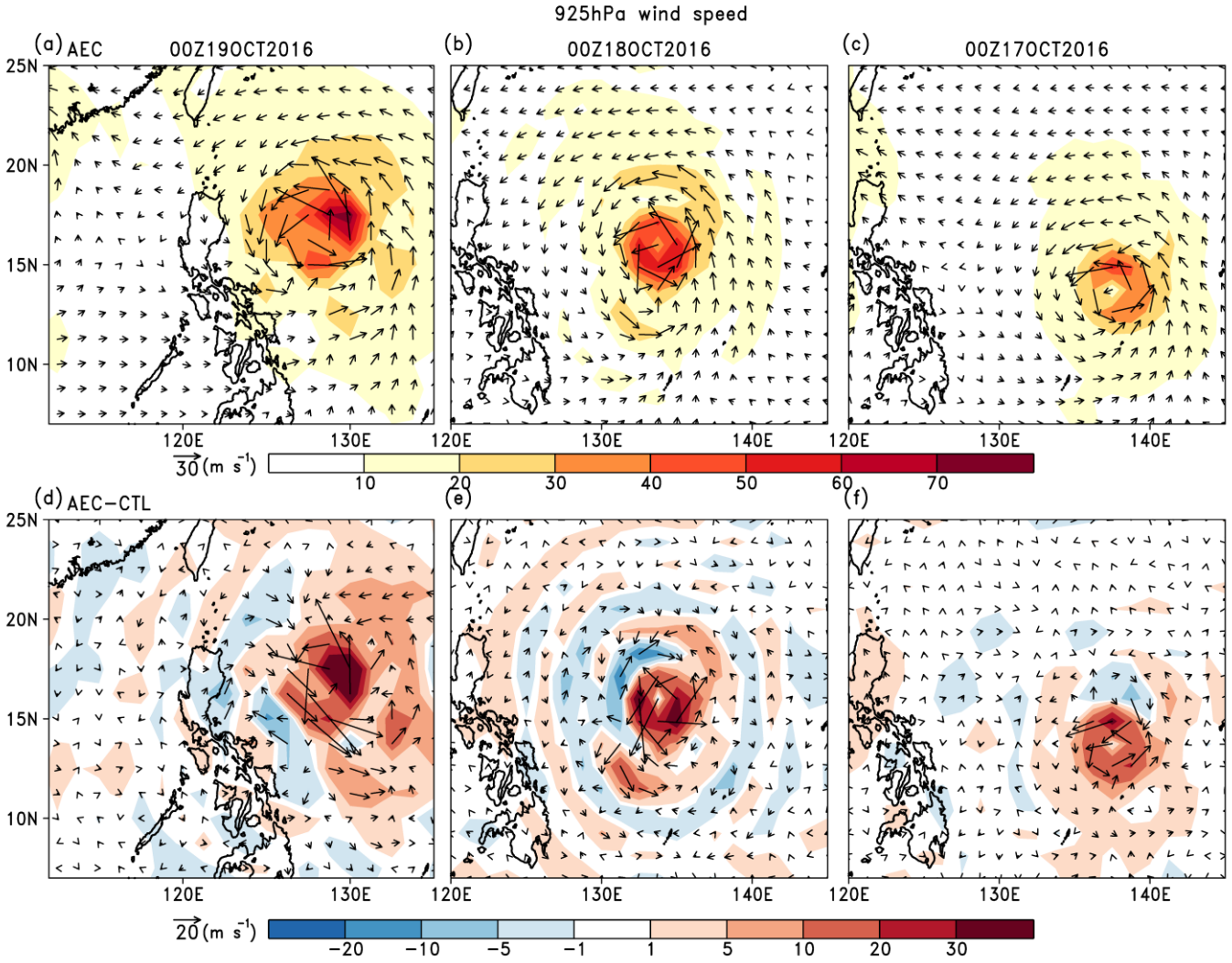
Impact of the Aeroclipper observations on the forecast of TC



As the forecast time increases, the position of TC in AEC is closer to the best track data than that in CTL.

Effects of distributed observations

best track SLP assimilation



TC is strongly reproduced from the early stage.

lack of uniformity is appeared

The distributed AEC observations have the effect of mitigating the ununiformity caused by the extreme data assimilation in the low-resolution model by assimilating not only the central extreme data but also the surrounding observations.

Summary:

The potential impact of the Aeroclipper observations on the analysis and forecast of TC Haima was investigated by the virtual observing system experiment using ALEDAS2 data assimilation system.

The fundamental structure of TC Haima is well represented even in the lower resolution (T119) model. The forecast of the precipitation and the TC position have also improved.

It is suggested that surface pressure observations by the Aeroclipper could benefit not only high-resolution models used to predict TC evolution but also low-resolution models used to produce global (re)analysis products.

In the near future, actual observation in the western Pacific is planned, and if successful, we will conduct OSE using real Aeroclipper data.