

CWB FV3GFS積雲參數化方案對於西北太平洋颱風模擬之表現

109 年天氣分析與預報研討會

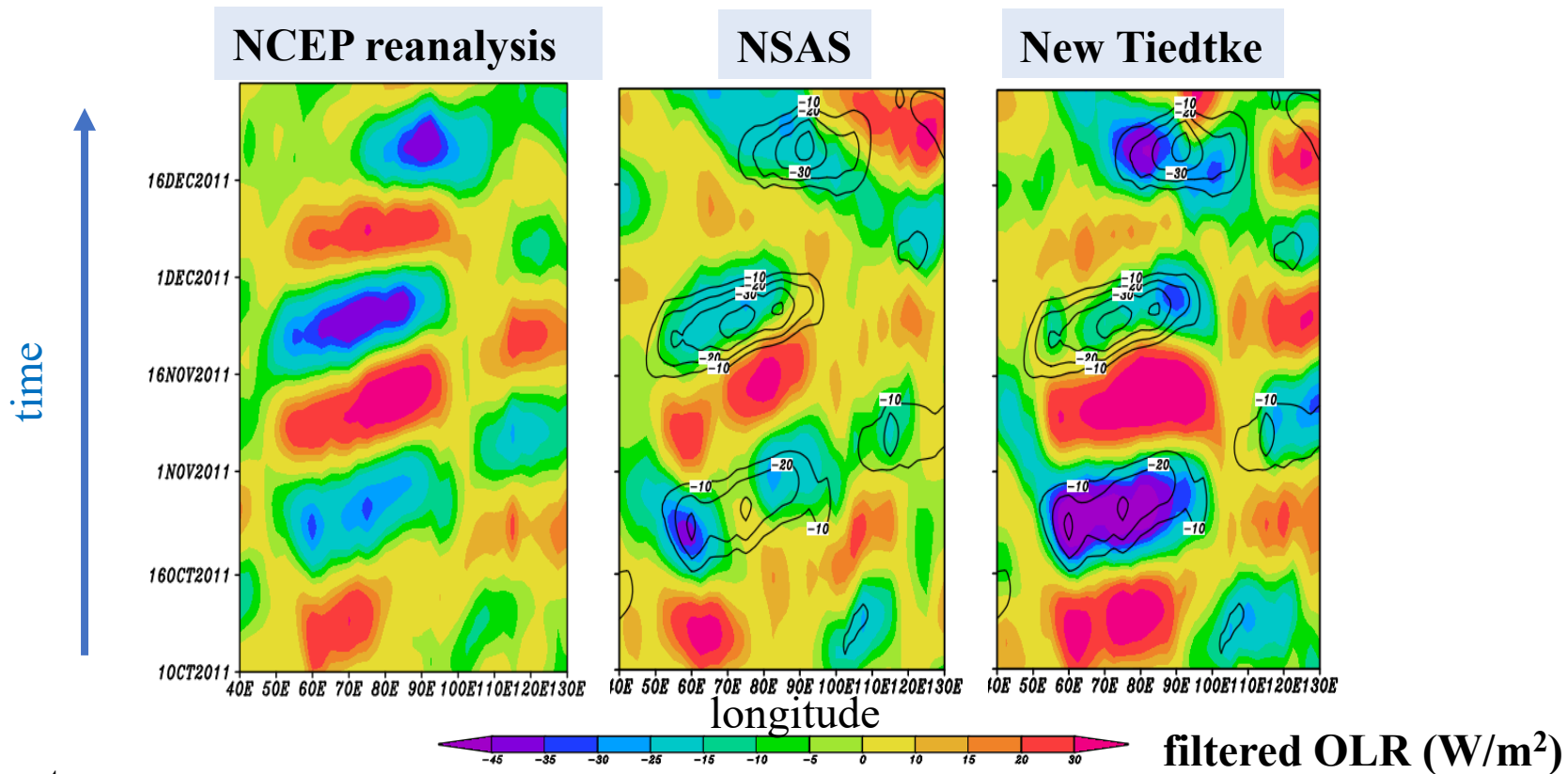
林昌鴻^{1,3} 楊明仁¹ 蕭玲鳳² 陳建河³

國立臺灣大學大氣科學系¹ 中央氣象局科技中心² 中央氣象局氣象資訊中心³

Outline

- Model end experimental setup
- Verification of synoptic environment over East Asia
- typhoon predictions over the Western North Pacific Ocean
 - northward-moving and westward-moving typhoons
 - typhoon forecast track error (along-track and cross-track errors)
 - steering flow
 - three-dimensional structure of typhoon
- summary

- 2) 進行物理參數化法敏感度測試實驗，將積雲參數化法由NSAS改為new Tiedtke 方案後，有助於改善CWB/GFS模式對於MJO現象的預報能力。



contour:

filtered NCEP OLR ≤ -10 W/m²

Model and experimental setup

- Model: CWB FV3GFS (C384T, ~25 km)
- only global domain
- Convective parameterizations:
 - scale-aware New Simplified Arakawa Schubert (NSAS; Han et al. 2017)
 - new Tiedtke (NTDK; Bechtold et al. 2014)
- Other physical parameterizations:
 - grid-scale condensation and precipitation: GFDL MP [Chen and Lin (2011, 2013)]
 - orographic and convective gravity wave drag: Chun and Baik 1994; Kim and Arakawa 1995; Kim and Doyle 2005
 - boundary layer vertical diffusion: EDMF (Han et al. 2016)
 - Rapid Radiative Transfer Model: RRTM; Clough et al. 2005
 - land surface interactions: Noah land surface model (Ek et al. 2003)

- Exp1: 5-day forecasts initialized at 00Z every day in August 2019
- Exp2: typhoon predictions over the Western North Pacific Ocean
- Verification data:

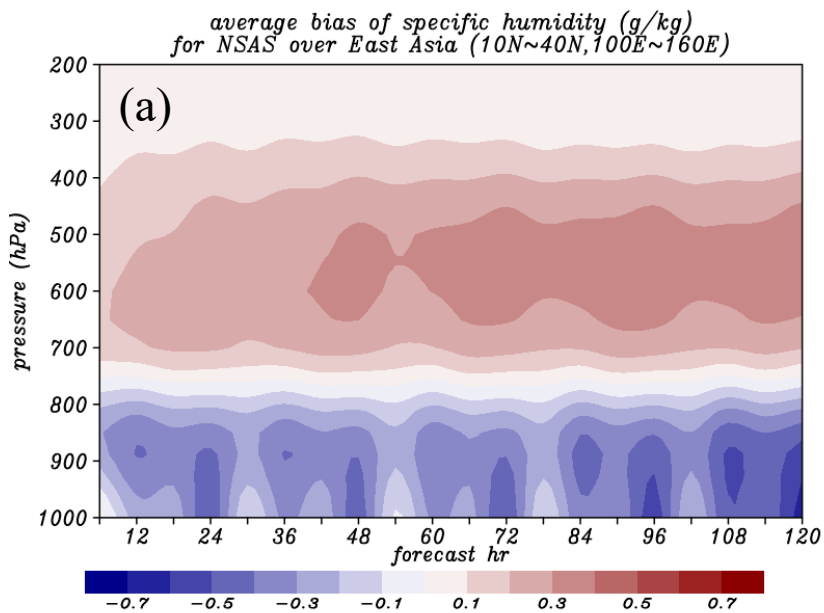
ERA5 (*~31 km, 137 levels, model top at 0.01hPa*)

Exp1: 5-day forecasts initialized at 00Z every day in
August 2019

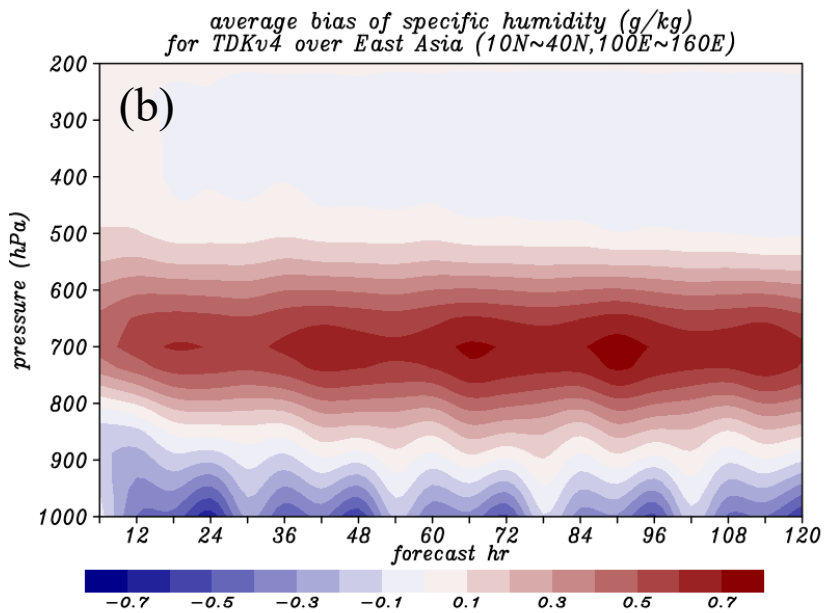
Verification against ERA5 analysis

Specific humidity (g/kg) forecast score averaged over East Asia (10N~40N, 100E~160E)

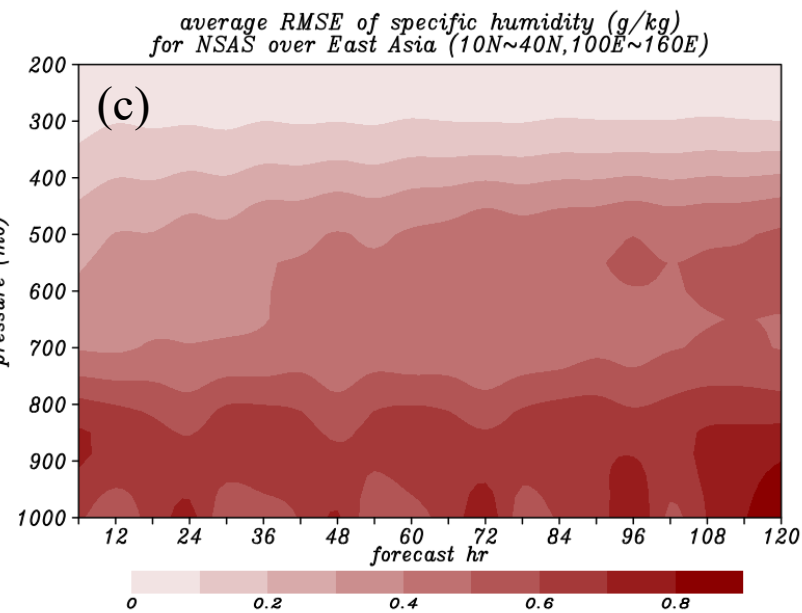
Bias (NSAS)



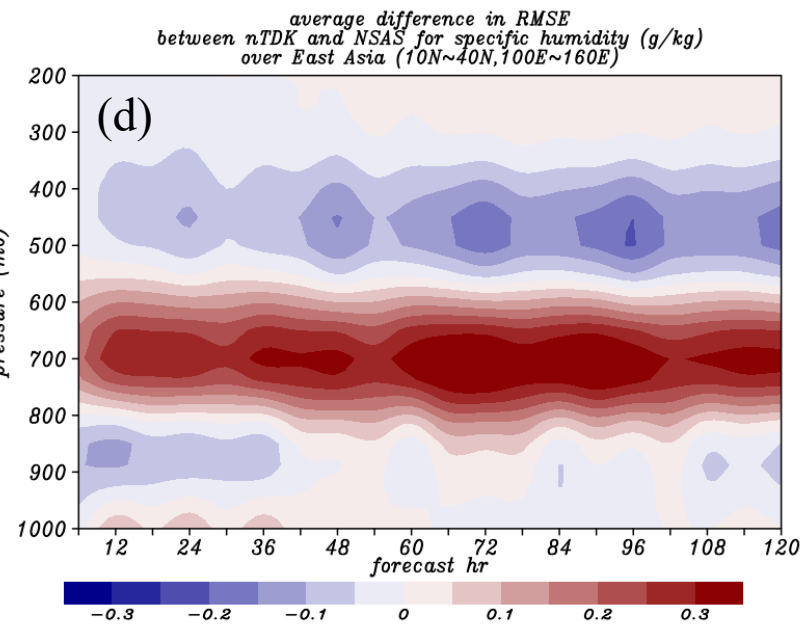
Bias (nTDK)



RMSE (NSAS)

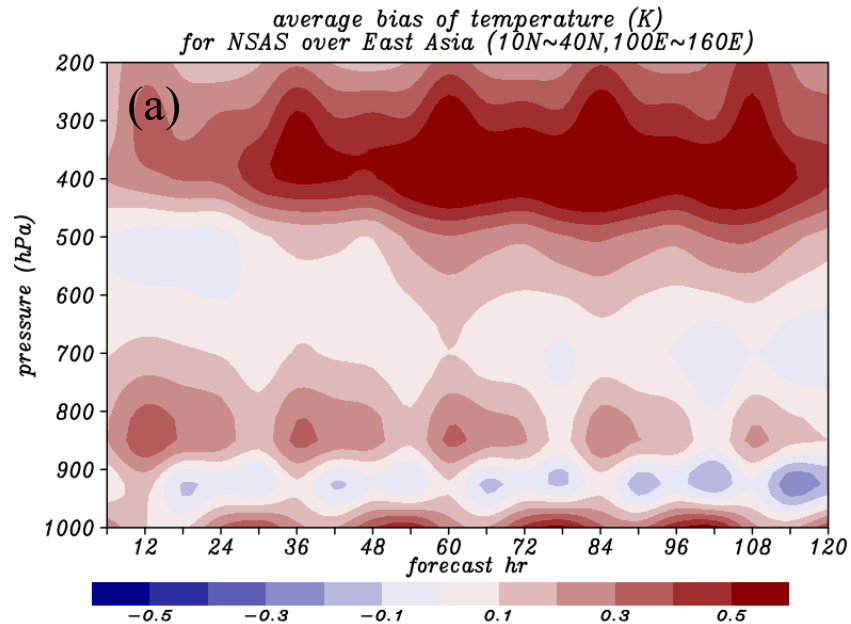


Difference of RMSE
(nTDK-NSAS)

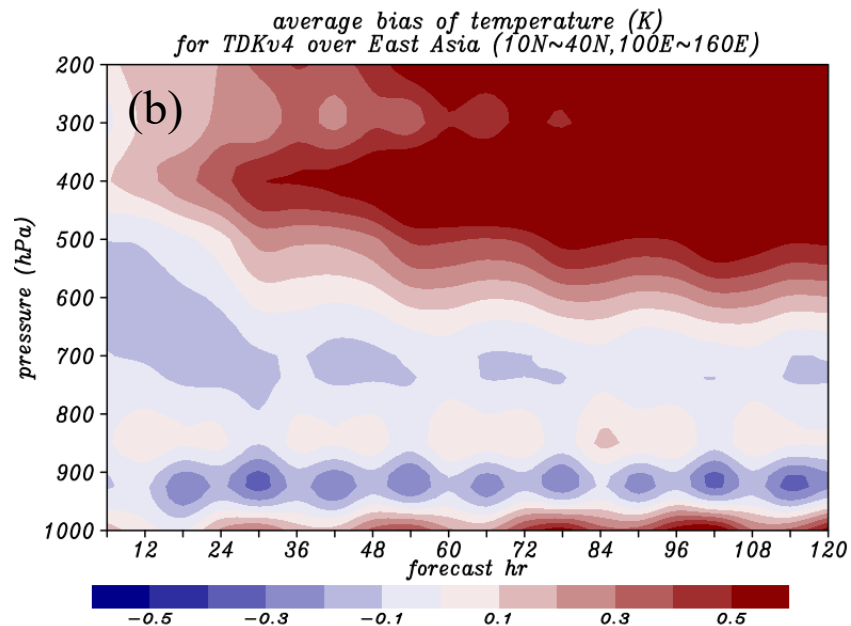


Temperature (K) forecast score averaged over East Asia (10N~40N, 100E~160E)

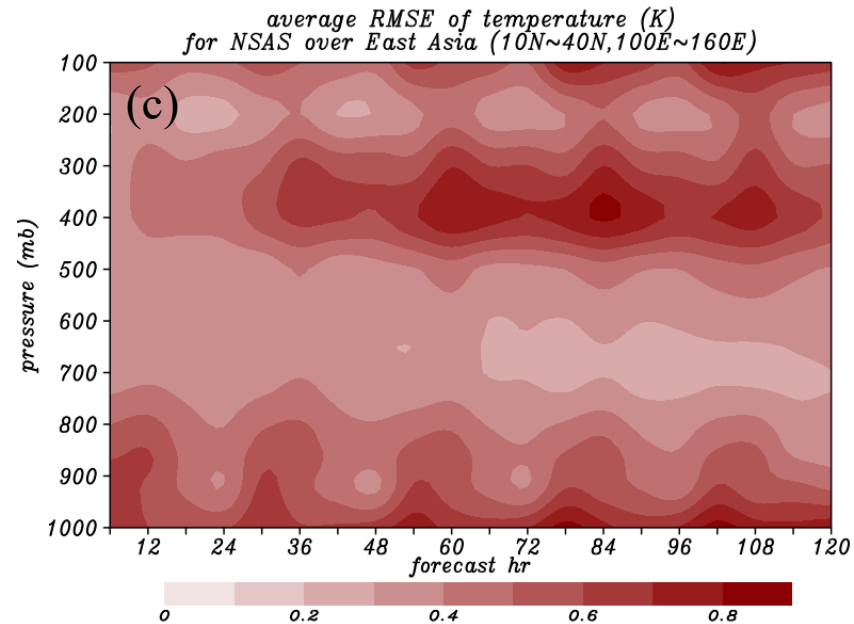
Bias (NSAS)



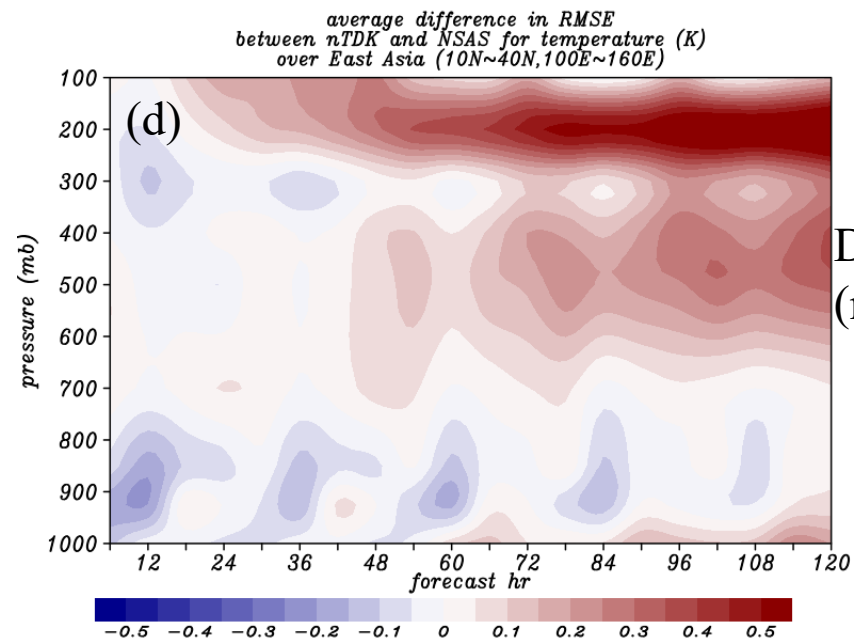
Bias (nTDK)



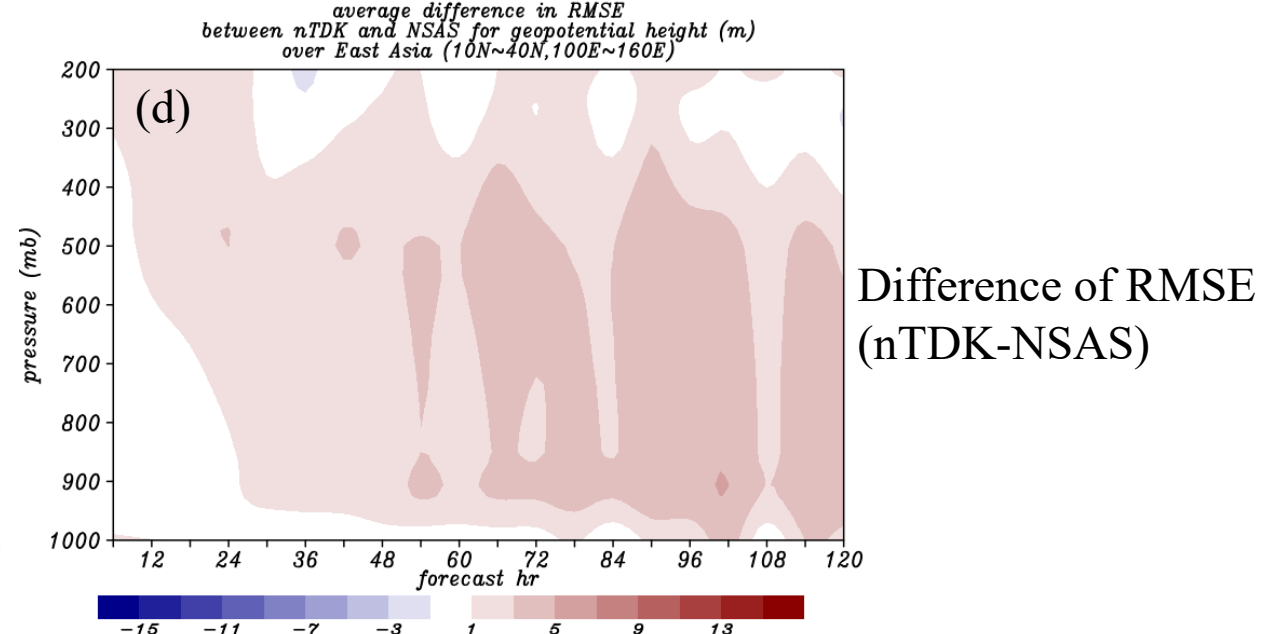
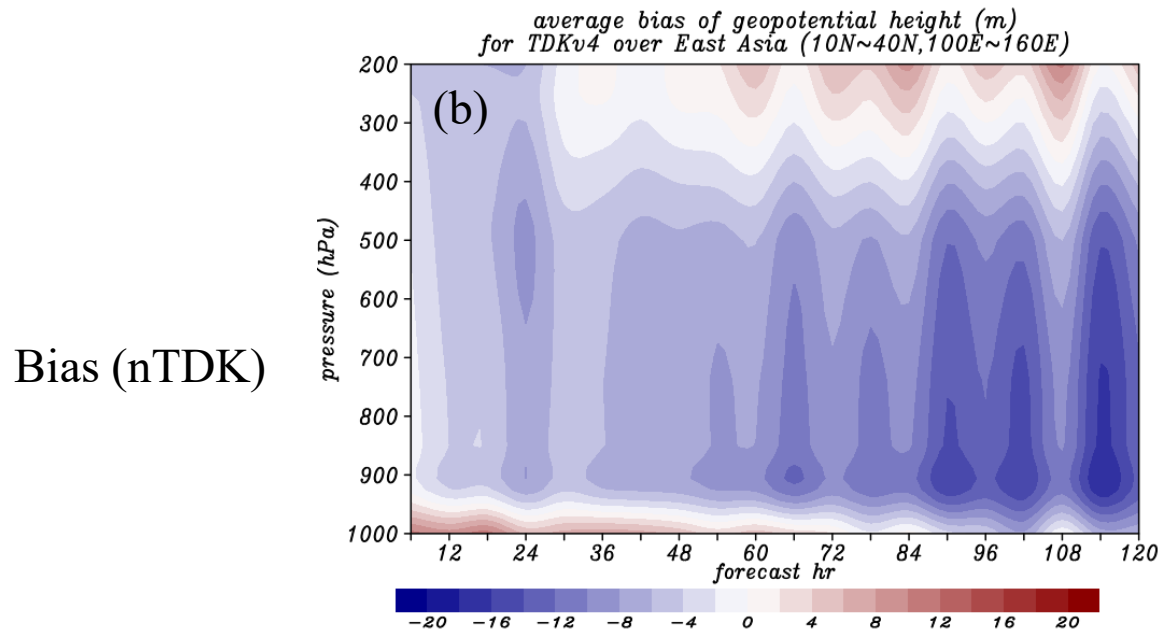
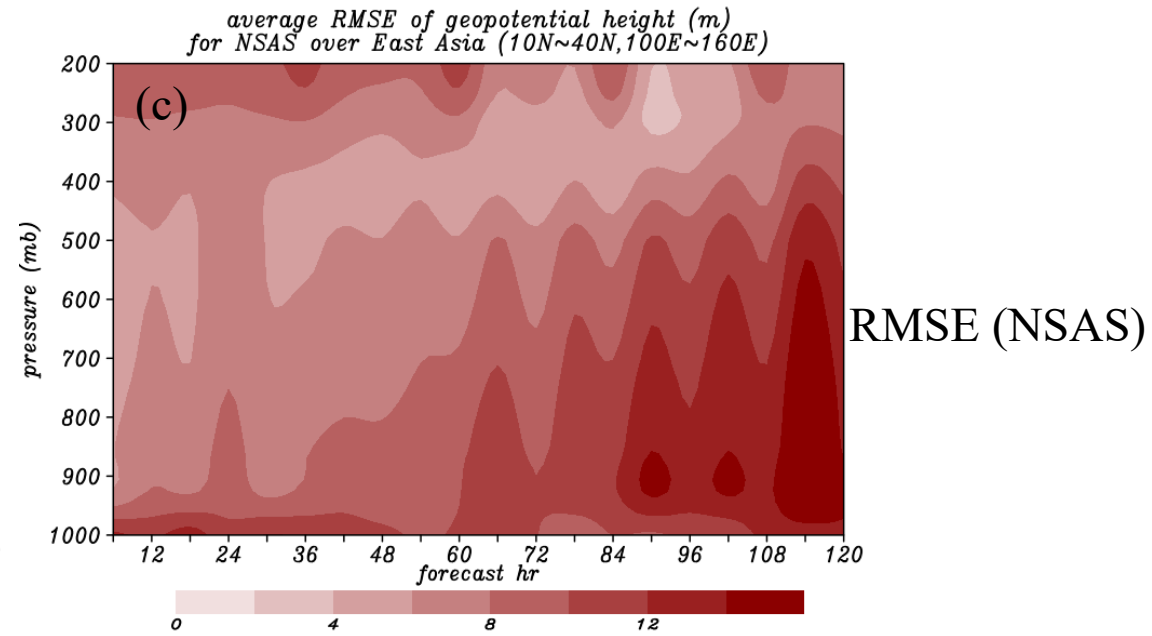
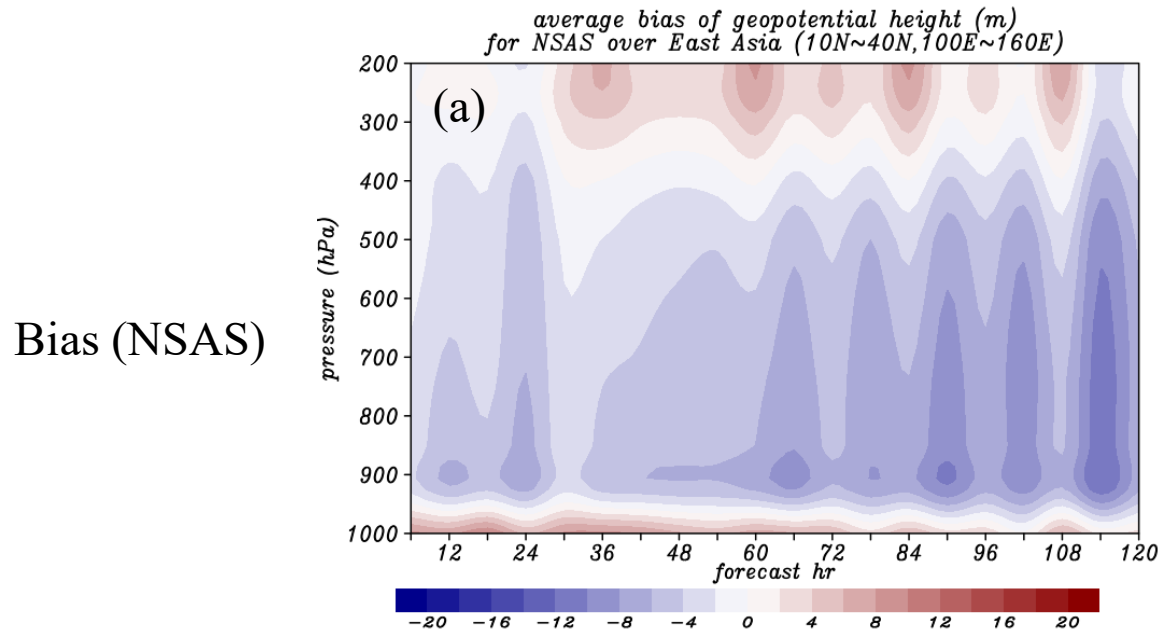
RMSE (NSAS)



Difference of RMSE
(nTDK-NSAS)



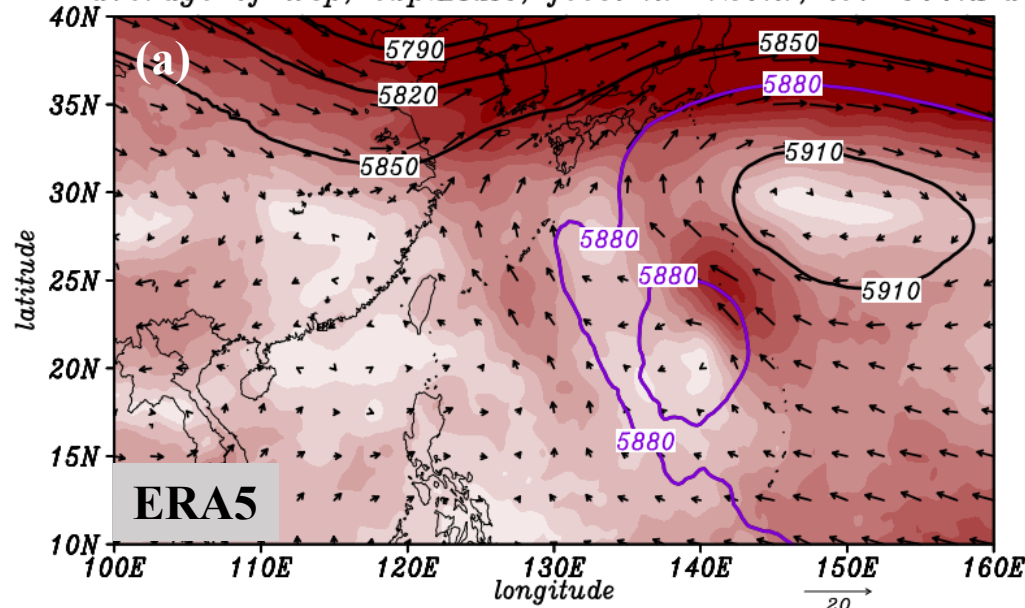
Geopotential height (m) forecast score averaged over East Asia (10N~40N, 100E~160E)



Forecast day 5

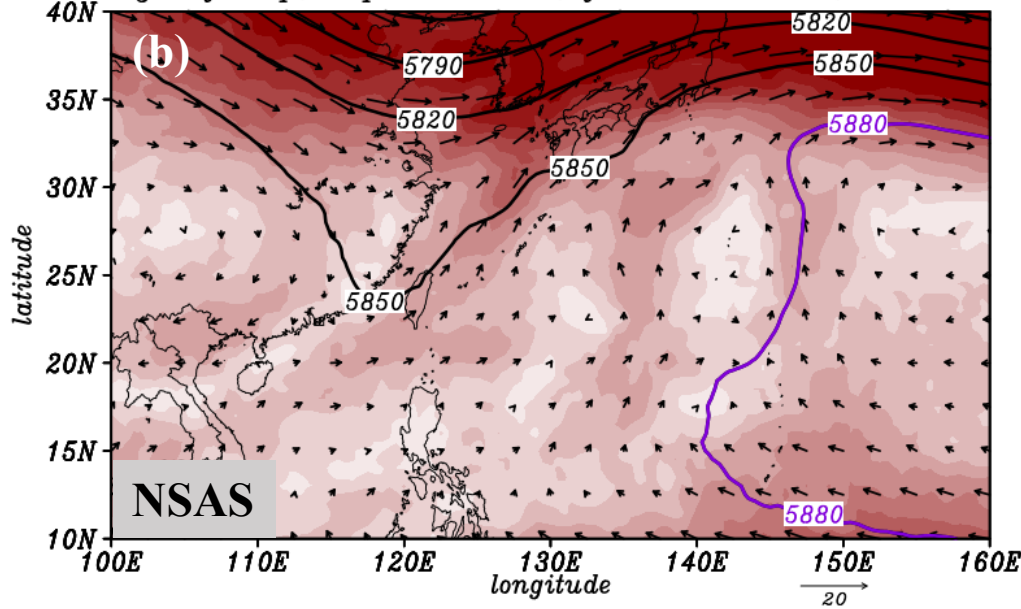
color: 500-hPa wind speed (m/s)
contours: 500-hPa geopotential height (m)

average of wsp, exp:ERA5, fcast hr=120hr, lev=500hPa



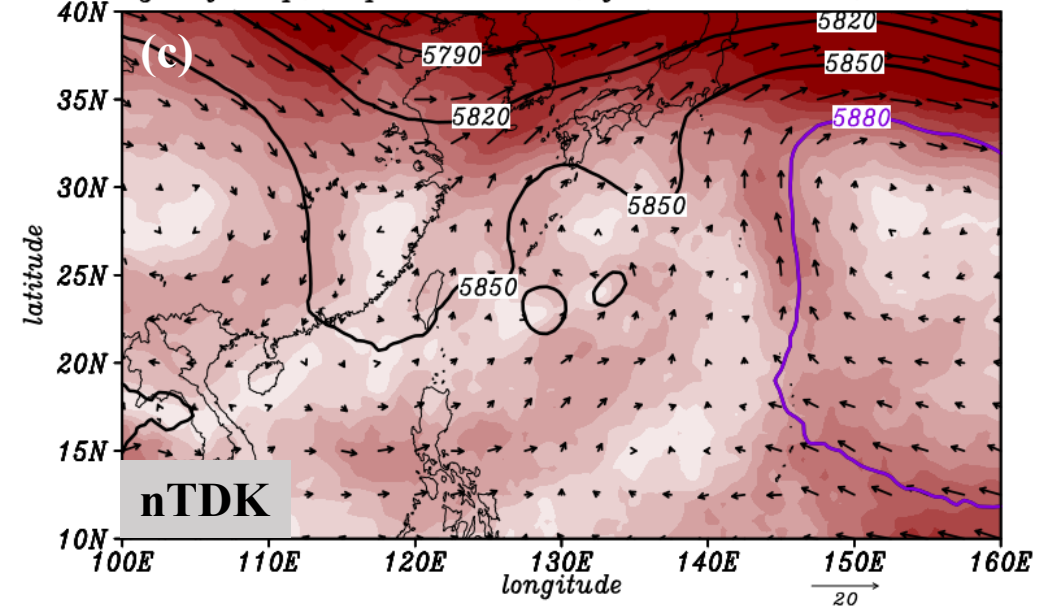
NSAS

average of wsp, exp:FMS.NSAS, fcast hr=120hr, lev=500hPa



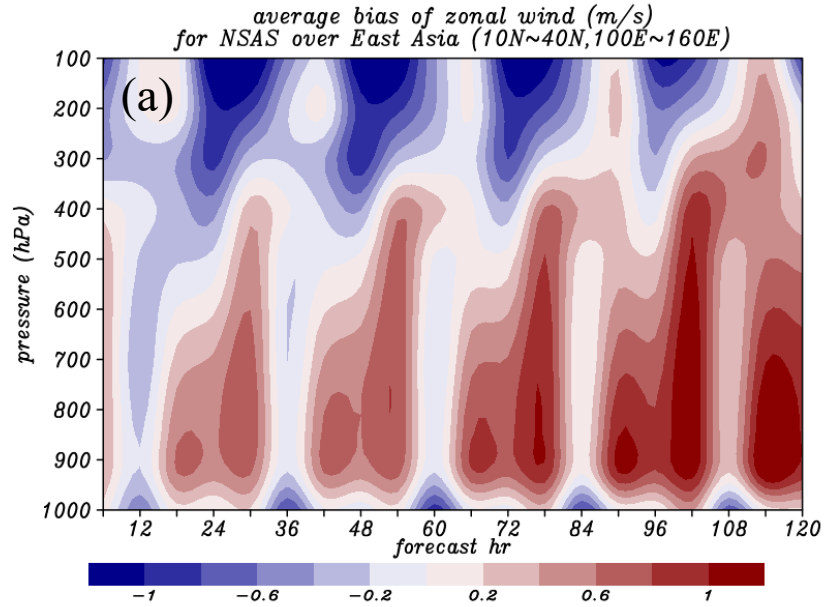
average of wsp, exp:FMS.TDKv4, fcast hr=120hr, lev=500hPa

nTDK

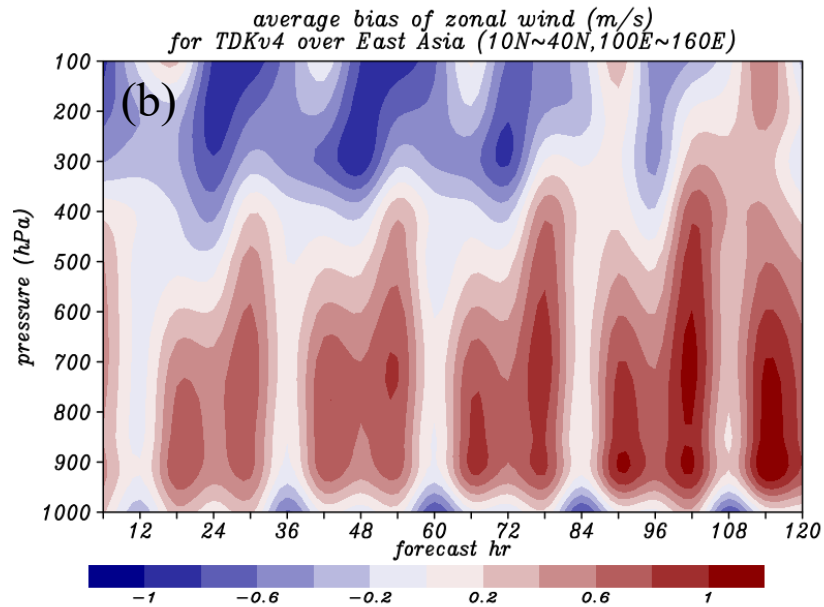


Zonal wind (m/s) forecast score averaged over East Asia (10N~40N, 100E~160E)

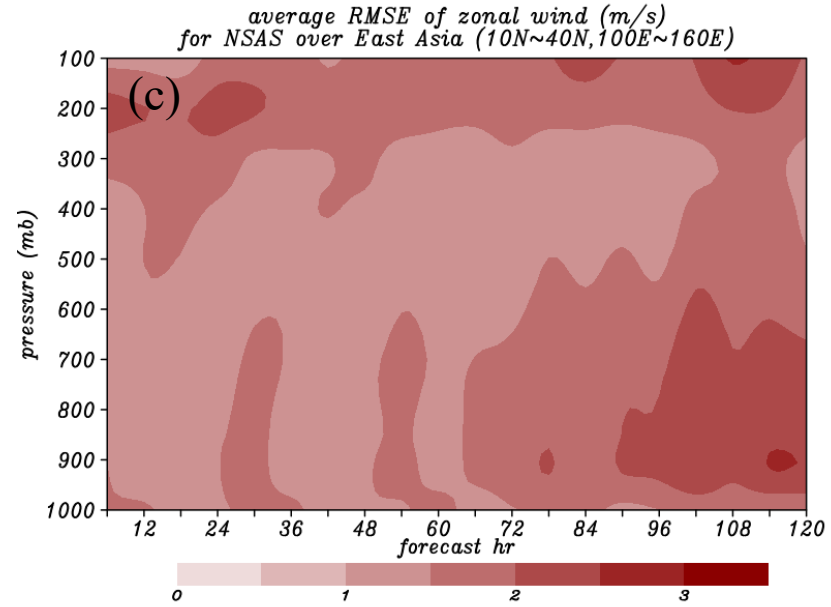
Bias (NSAS)



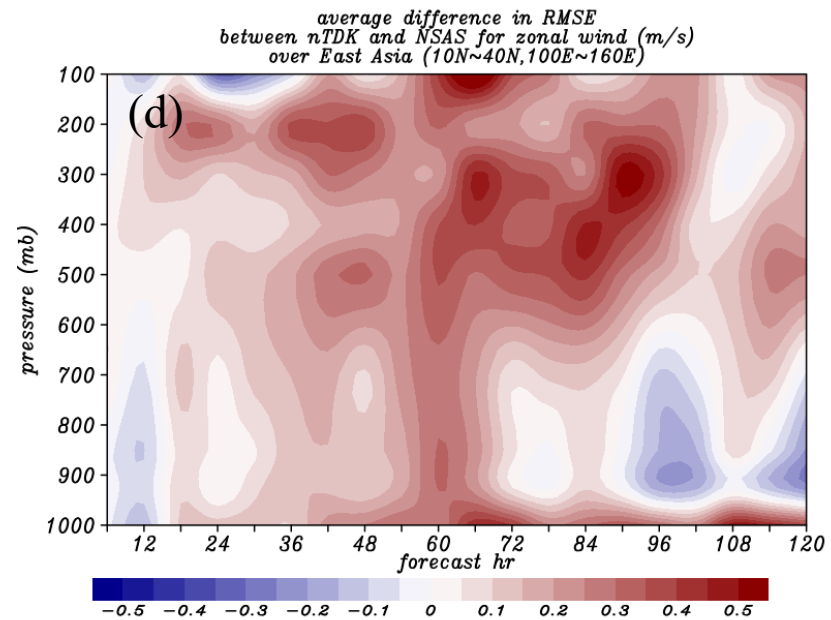
Bias (nTDK)



RMSE (NSAS)

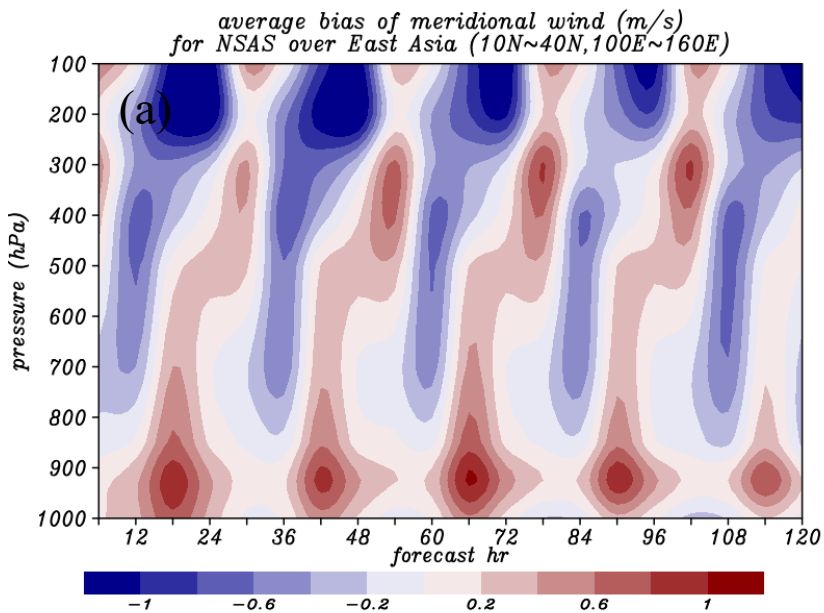


Difference of RMSE
(nTDK-NSAS)

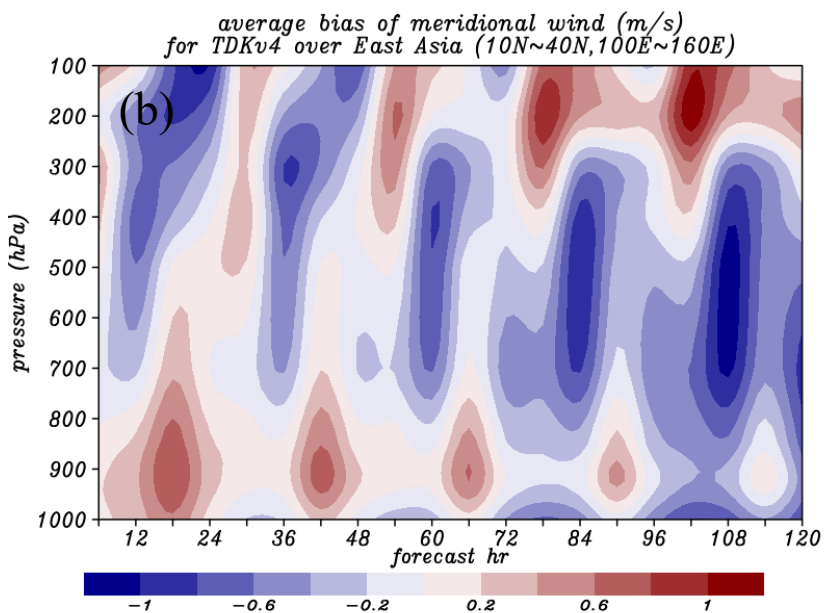


Meridional wind (m/s) forecast score averaged over East Asia (10N~40N, 100E~160E)

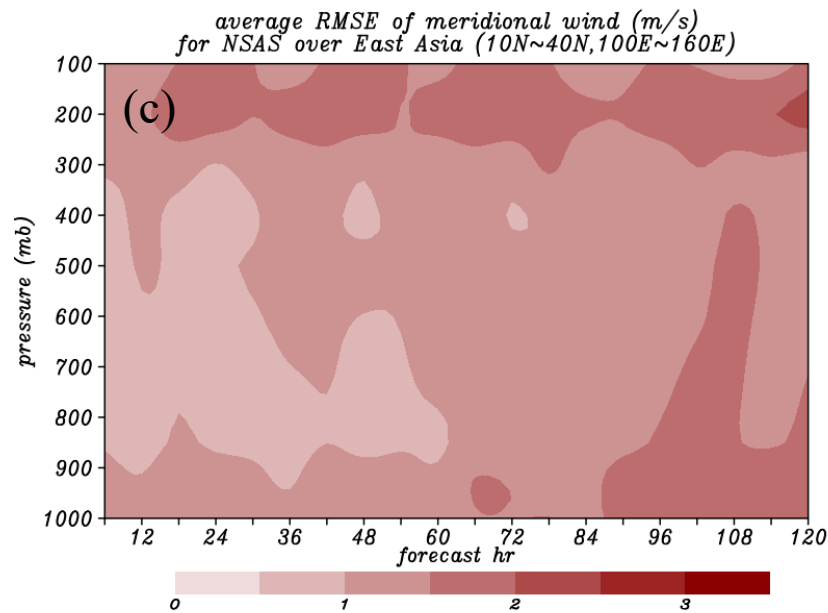
Bias (NSAS)



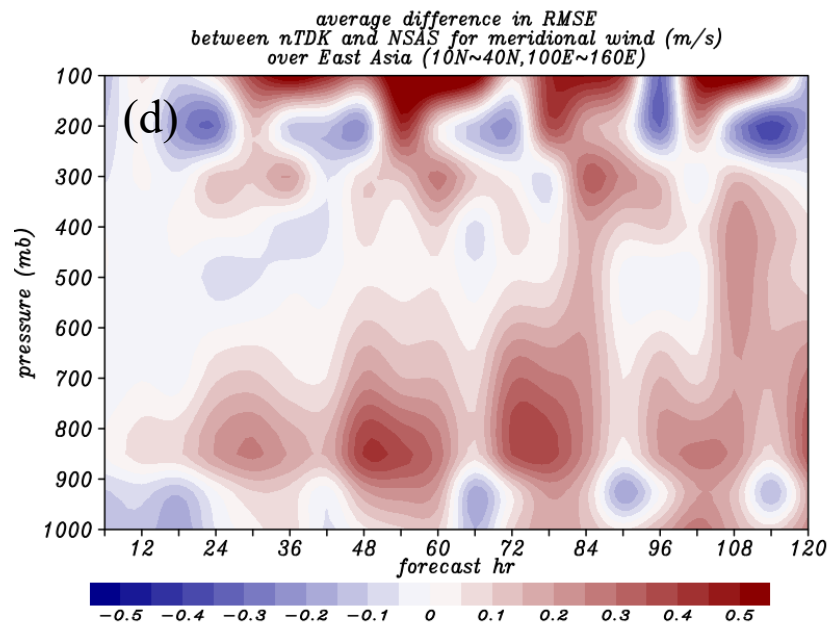
Bias (nTDK)



RMSE (NSAS)



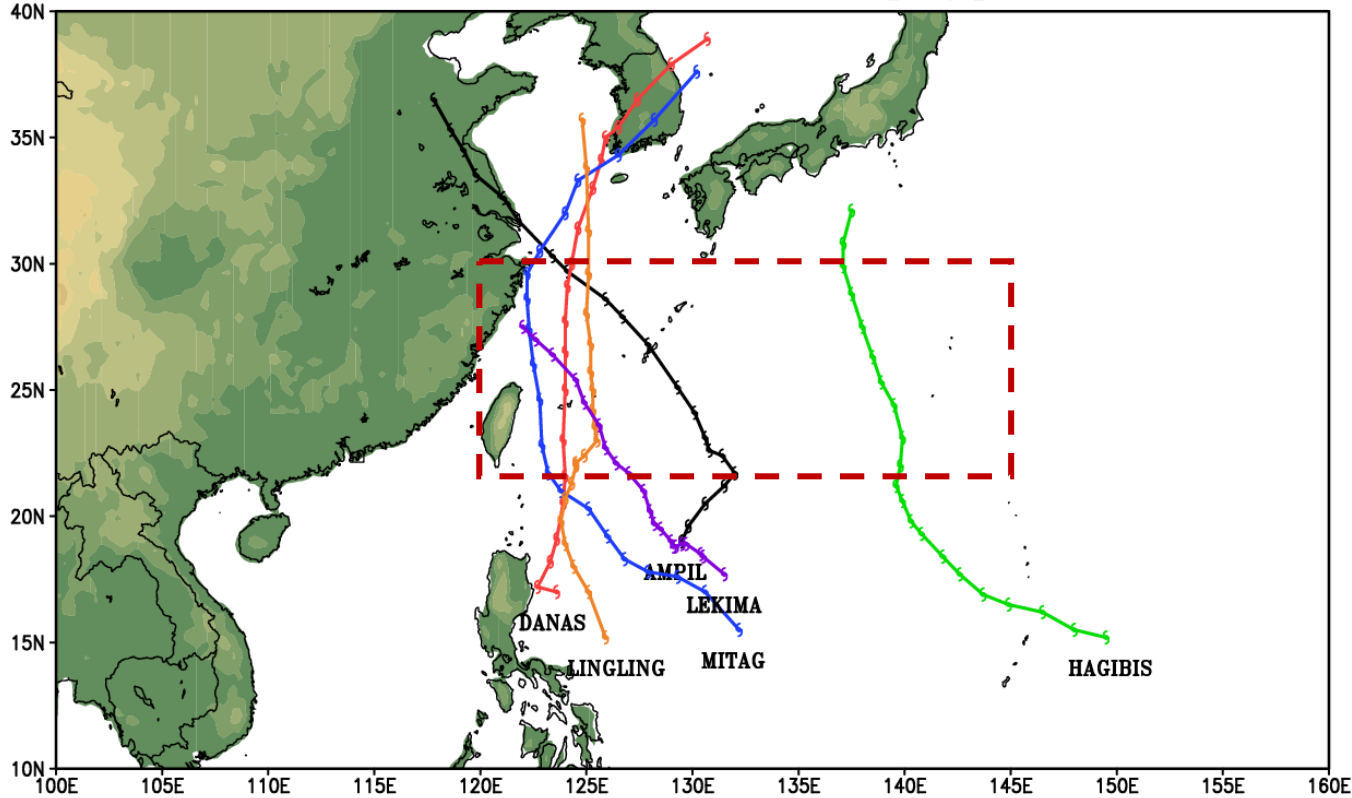
Difference of RMSE
(nTDK-NSAS)



Exp2: typhoon predictions over the Western North Pacific Ocean

Typhoon tracks based on the CWB best track data

tracks of northward-moving typhoons

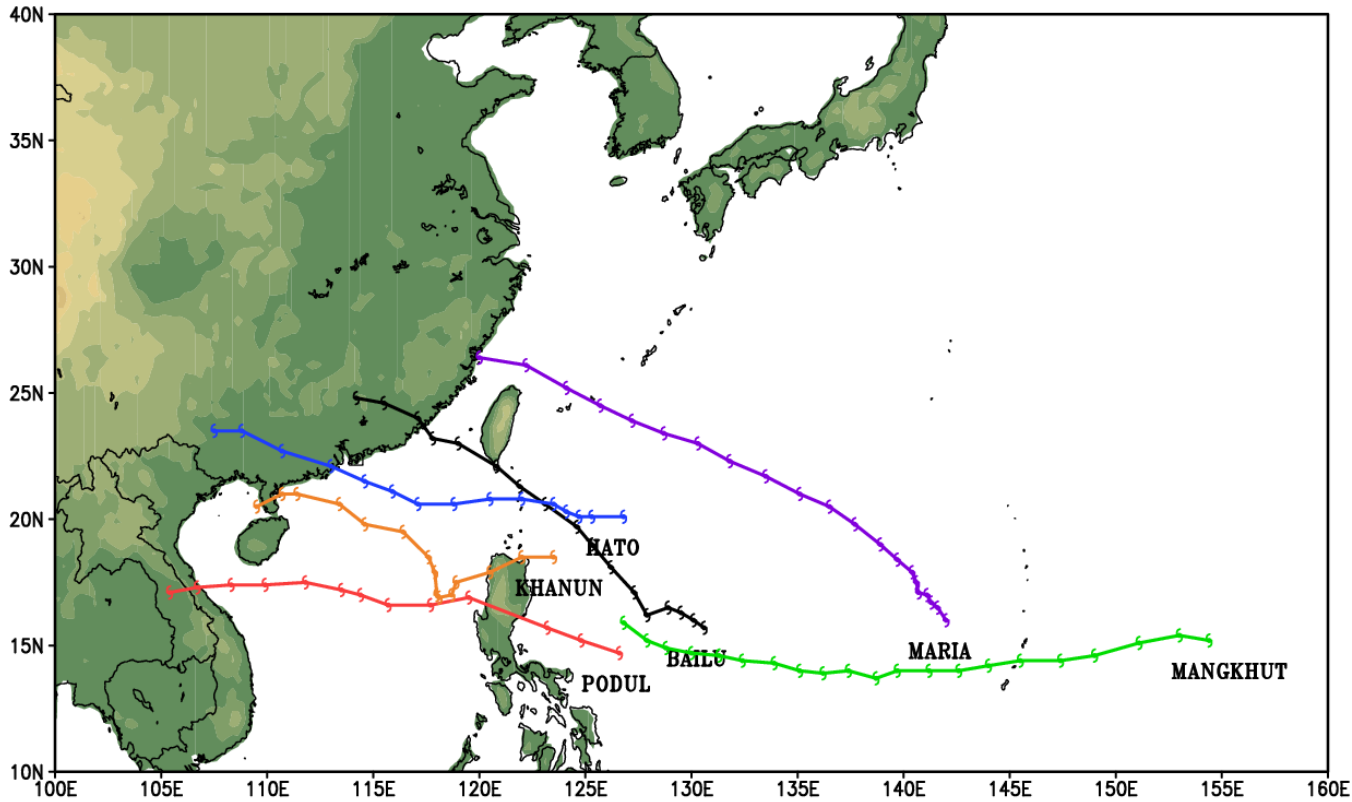


Northward-moving typhoons:

- Defined as the meridional displacement larger than the zonal displacement in the specific area (21N~30N, 120E~145E)
- Life time longer than 4-day
- The period of 5-day forecasts should cover the observed typhoons in mature stage.

intensity	Typhoons	life periods
Sever tropical storms	安比 (Ampil)	2018-07-18 12:00~2018-07-23 18:00
	丹娜絲 (Danas)	2019-07-16 06:00~2019-07-21 12:00
Typhoon(Moderate Intensity)	玲玲 (Lingling)	2019-09-02 00:00~2019-09-08 00:00
	米塔 (Mitag)	2019-09-28 00:00~2019-10-03 06:00
Typhoon(intense Intensity)	利奇馬 (Lekima)	2019-08-04 06:00~2019-08-12 18:00
	哈吉貝 (Hagibis)	2019-10-05 18:00~2019-10-13 06:00

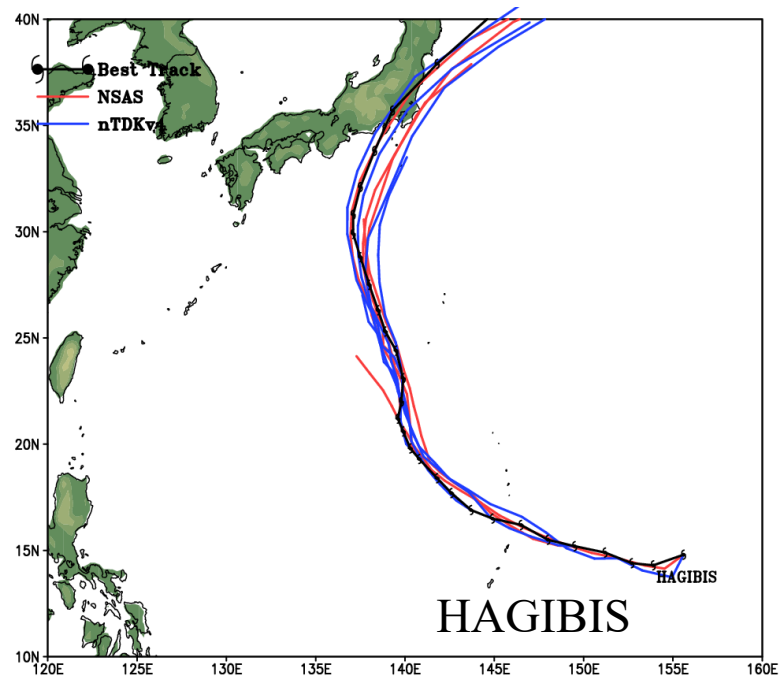
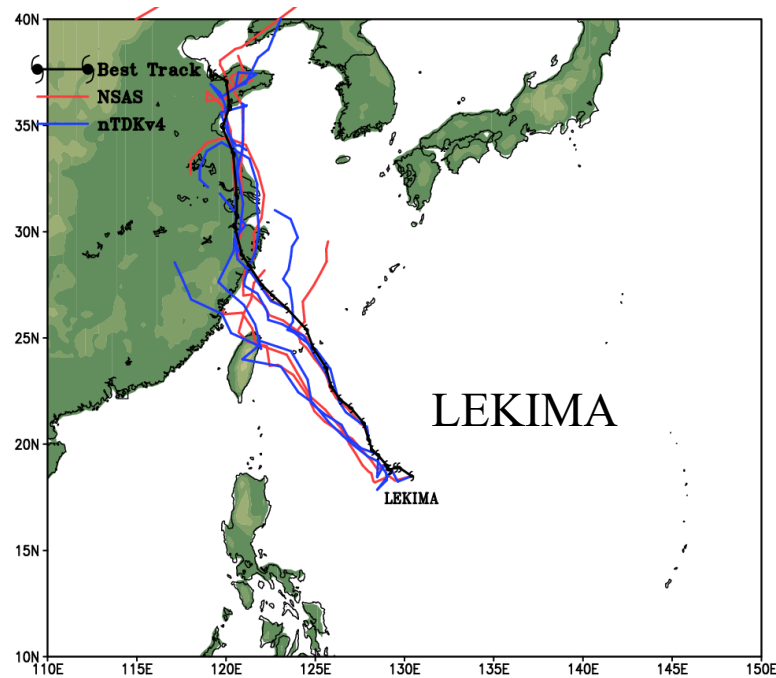
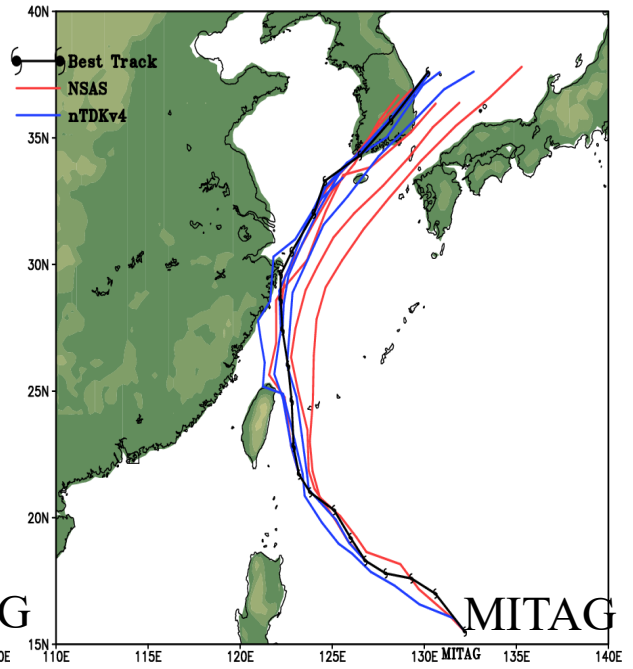
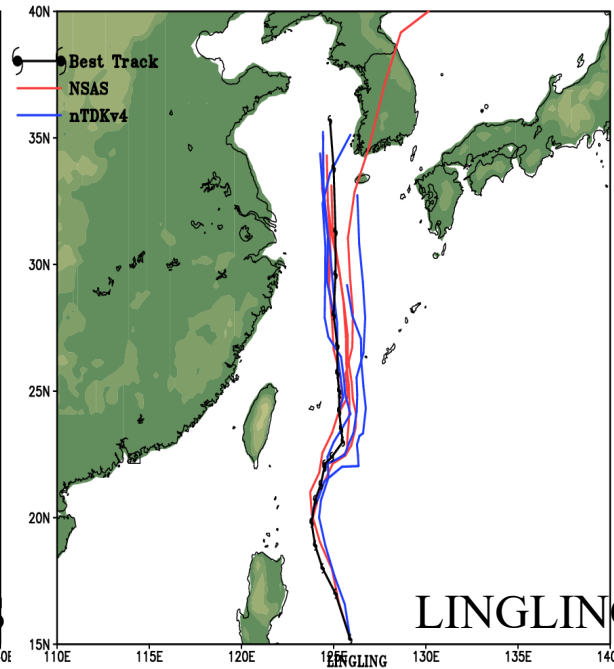
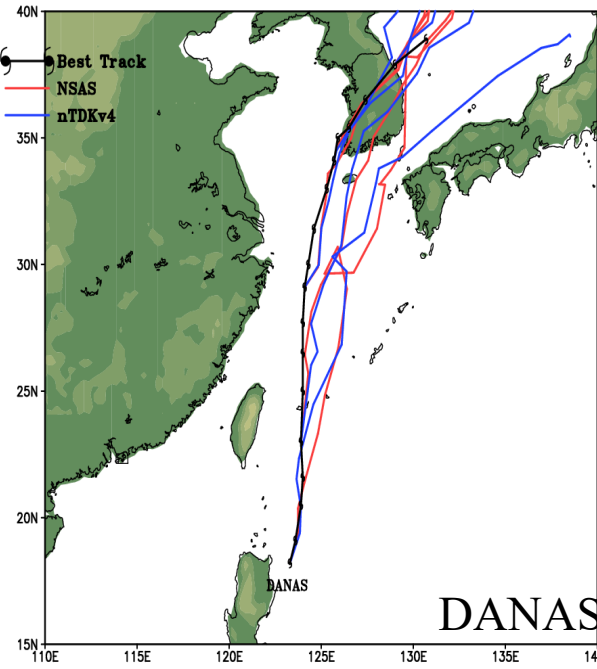
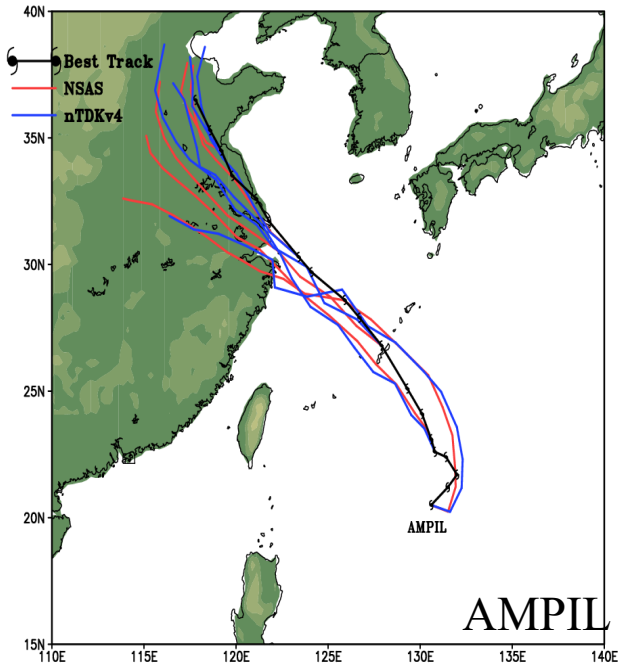
tracks of westward-moving typhoons



westward-moving typhoons:

- The definition is contrary to the northward-moving typhoons.
- Specific area: 10N~30N, 100E~160E

intensity	typhoons	life periods
Sever tropical storms	白鹿 (Bailu)	2019-08-21 06:00~2019-08-25 18:00
	楊柳 (Podul)	2019-08-27 00:00~2019-08-30 06:00
Typhoon(Moderate Intensity)	天鴿 (Hato)	2017-08-20 06:00~2017-08-24 06:00
	卡努 (Khanun)	2017-10-12 12:00~2017-10-16 06:00
Typhoon(intense Intensity)	瑪莉亞 (Maria)	2018-07-04 12:00~2018-07-11 18:00
	山竹 (Mangkhut)	2018-09-07 12:00~2018-09-17 06:00

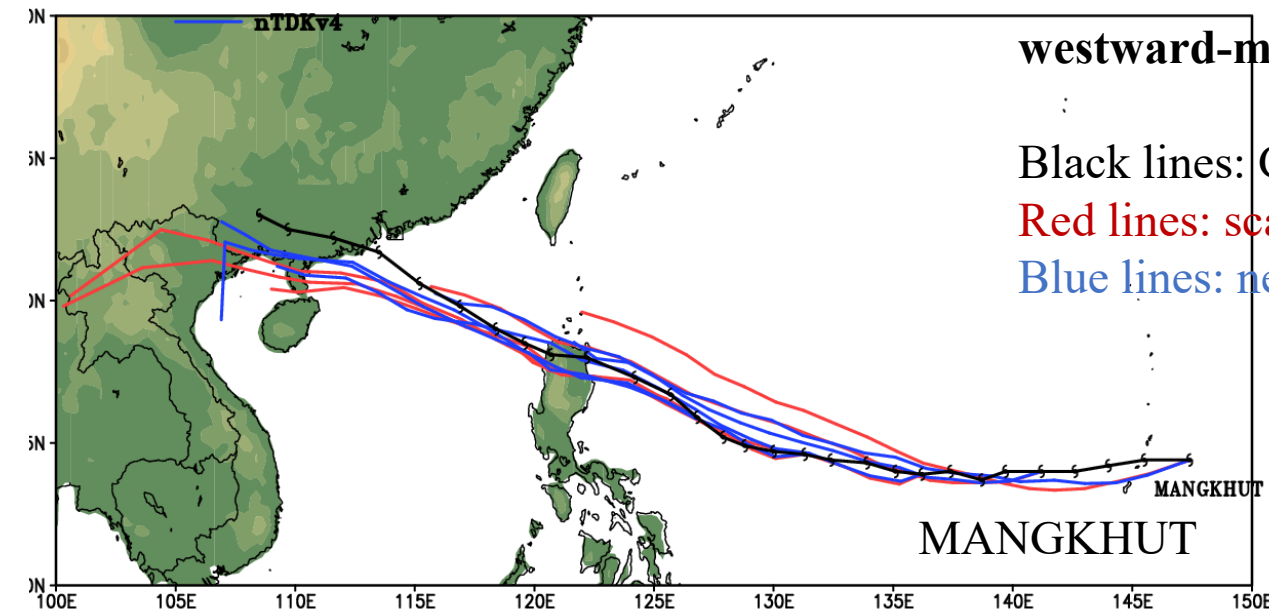
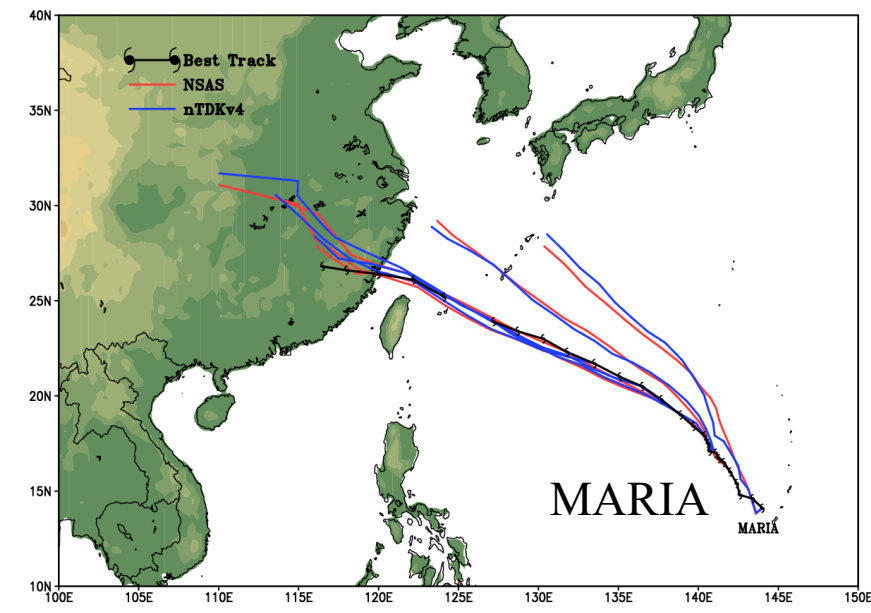
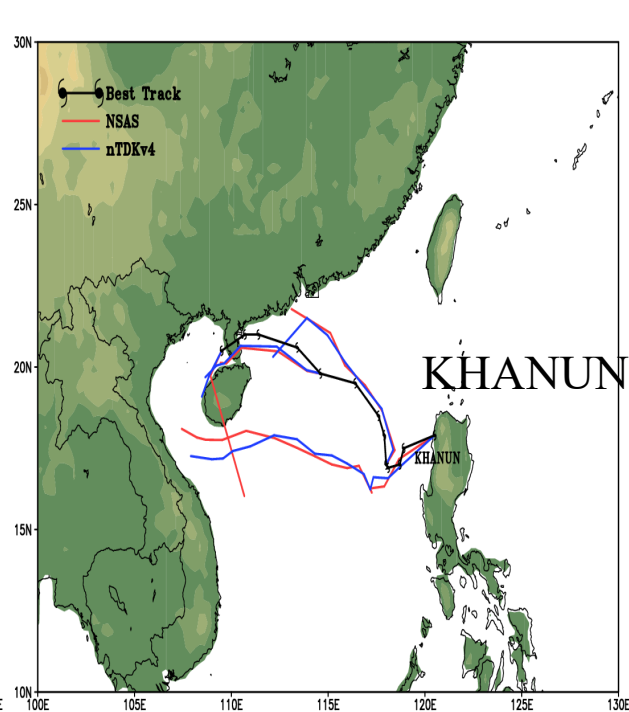
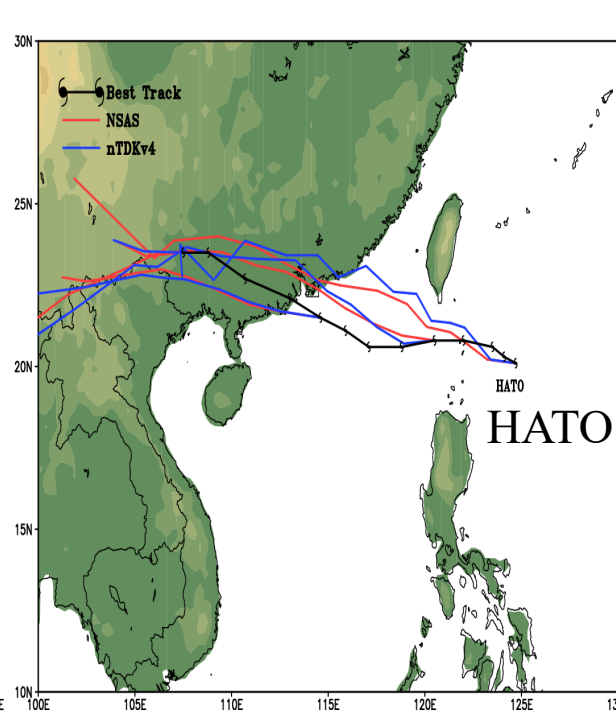
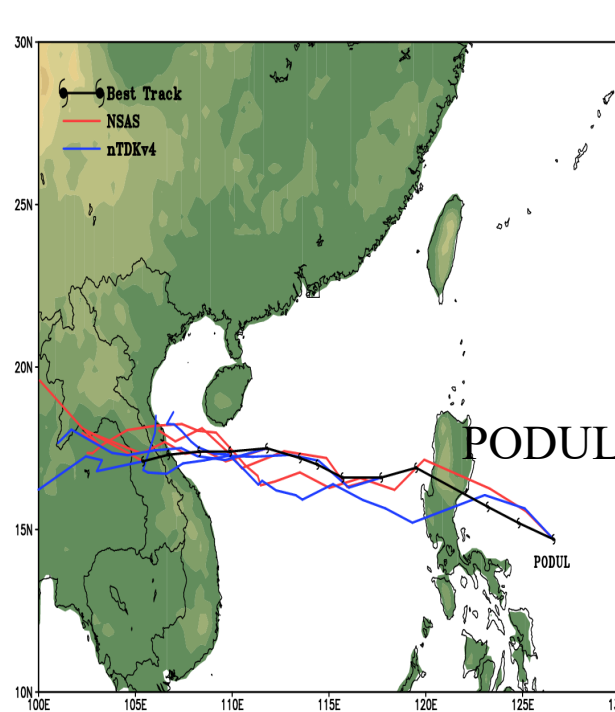
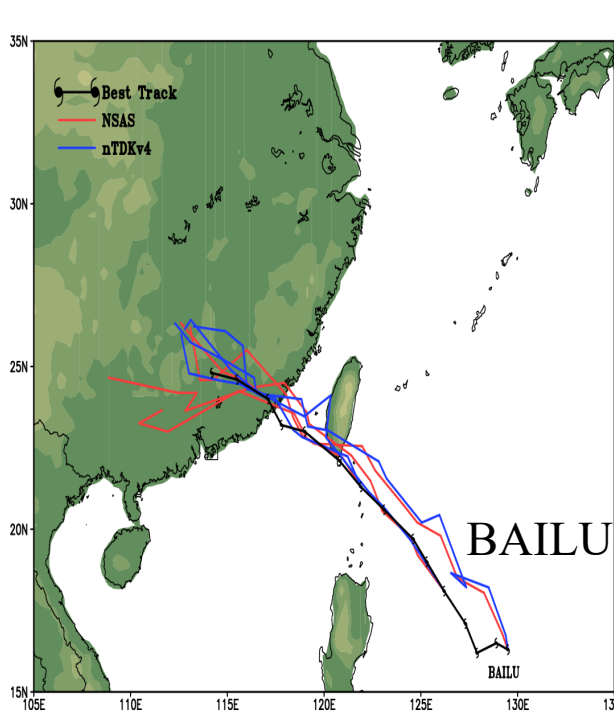


Northward-moving typhoons

Black lines: CWB best track

Red lines: scale-aware NSAS

Blue lines: new Tiedtke

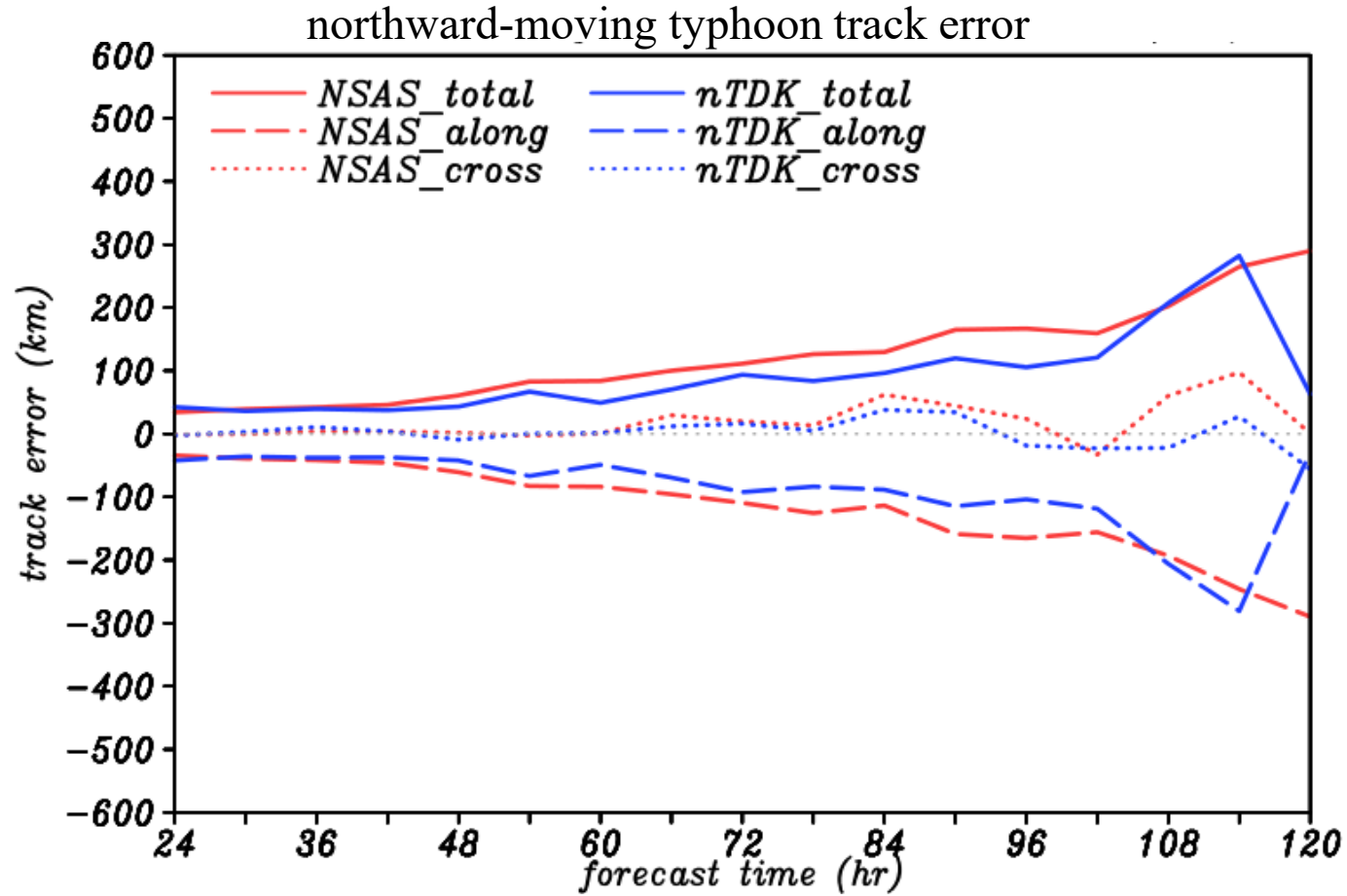


westward-moving typhoons

Black lines: CWB best track

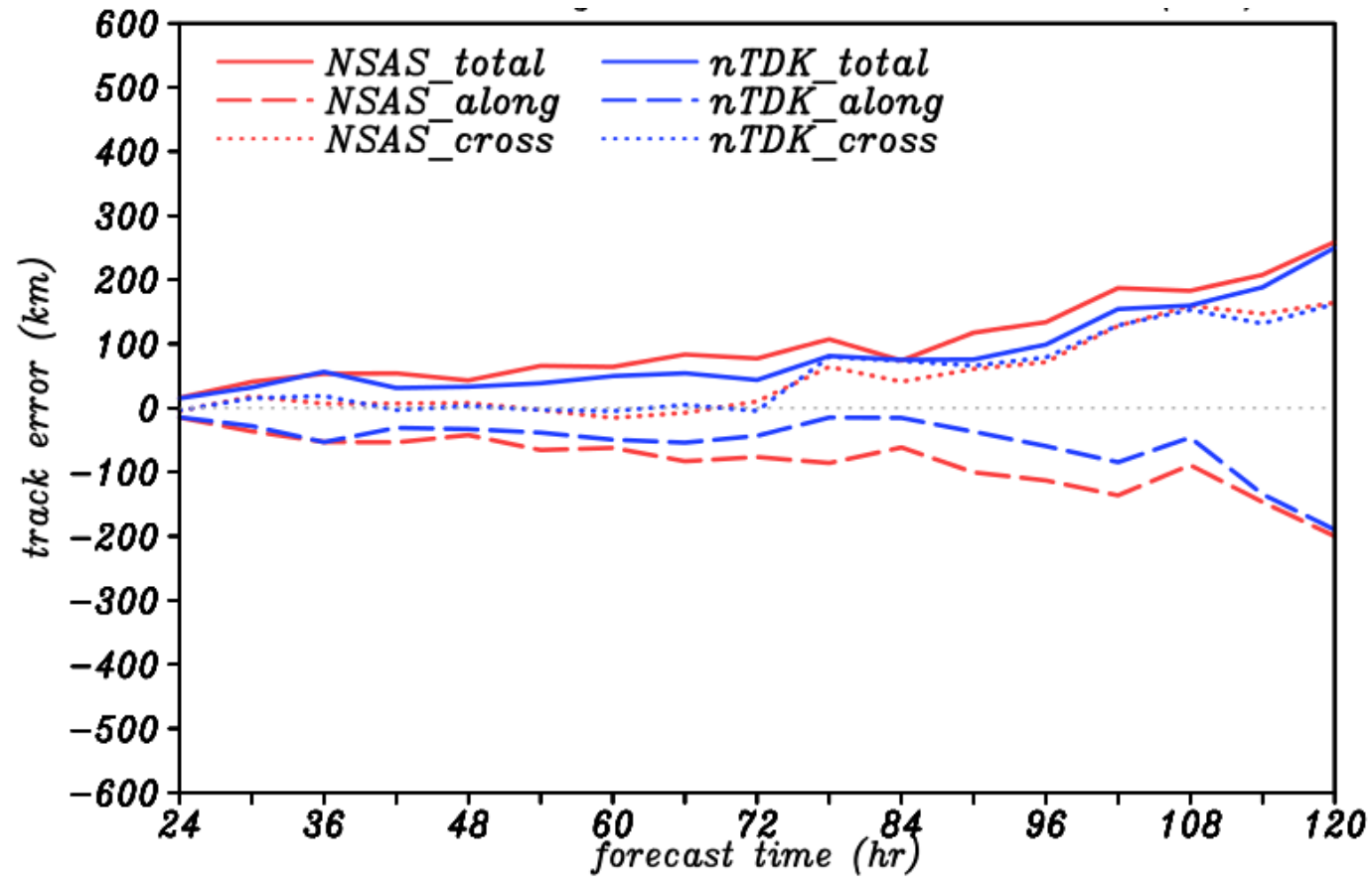
Red lines: scale-aware NSAS

Blue lines: new Tiedtke



Forecast time	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120
Case number	28	27	26	25	24	23	22	21	19	18	16	15	13	12	11	9	7

Westward-moving typhoon track error



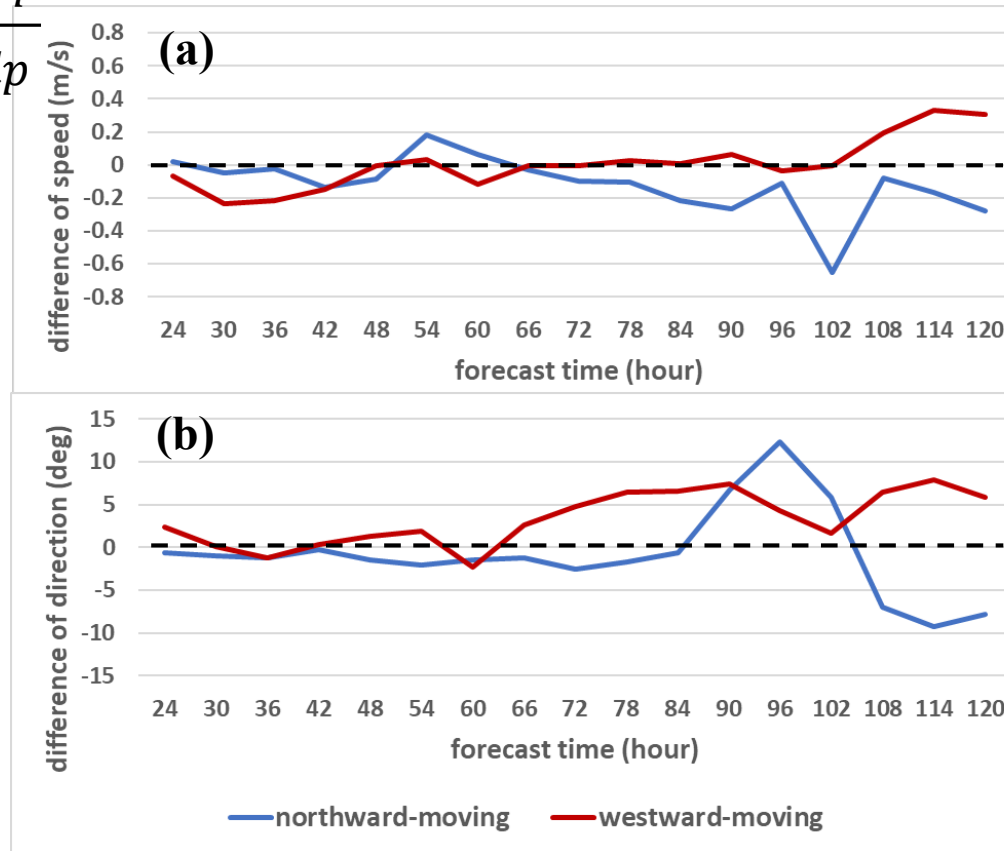
Forecast time	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120
Case number	22	19	19	18	17	15	14	13	13	9	8	7	7	6	5	5	5

Difference of absolute error on steering flow direction between nTDK and NSAS (nTDK-NSAS) (against ERA5 reanalysis data)

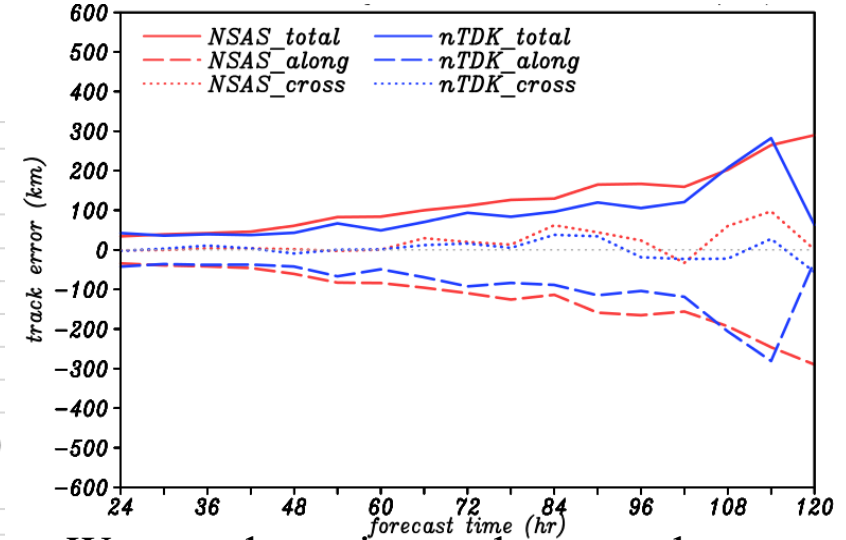
$$\text{steering flow} = \frac{\int_{1000\text{hPa}}^{200\text{hPa}} V dp}{\int_{1000\text{hPa}}^{200\text{hPa}} dp}$$

300~800 km annulus around cyclone center

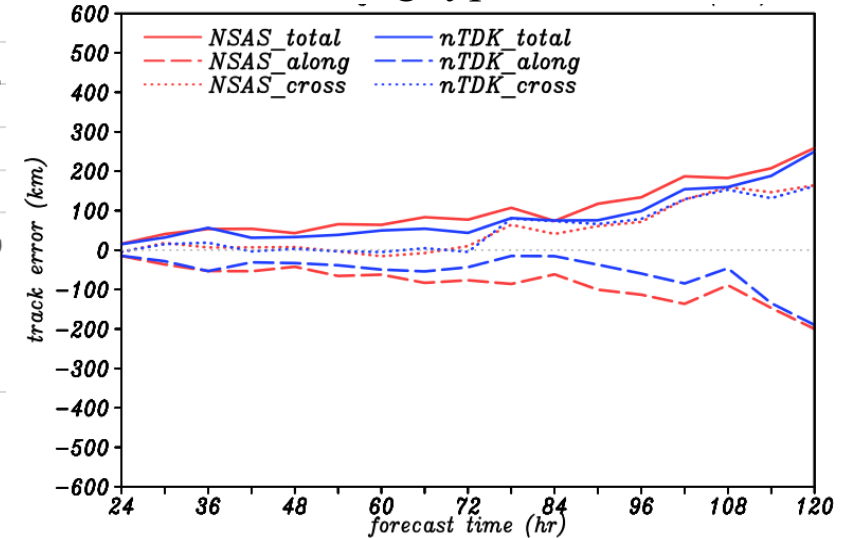
from Reynes A (2003)



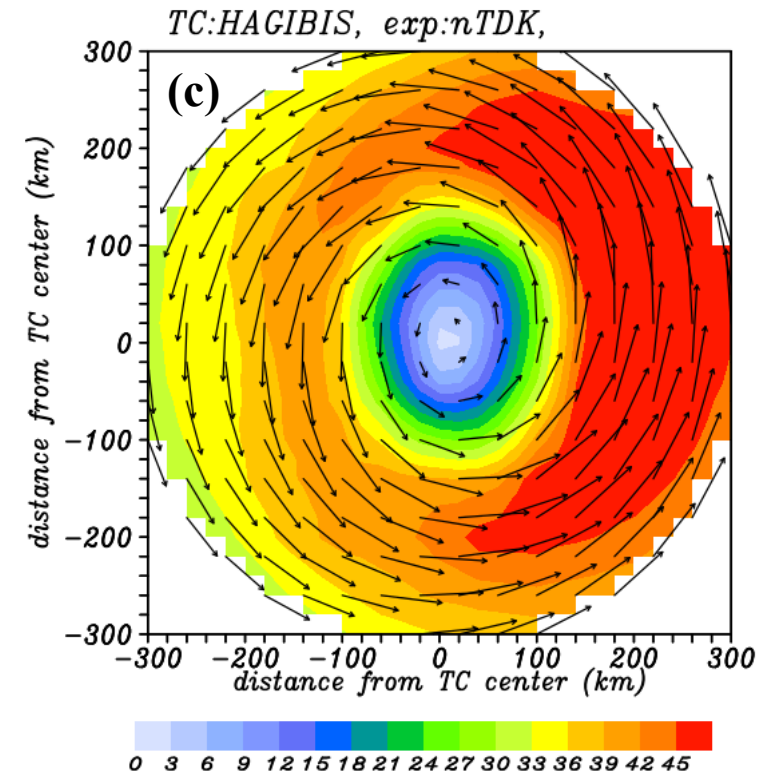
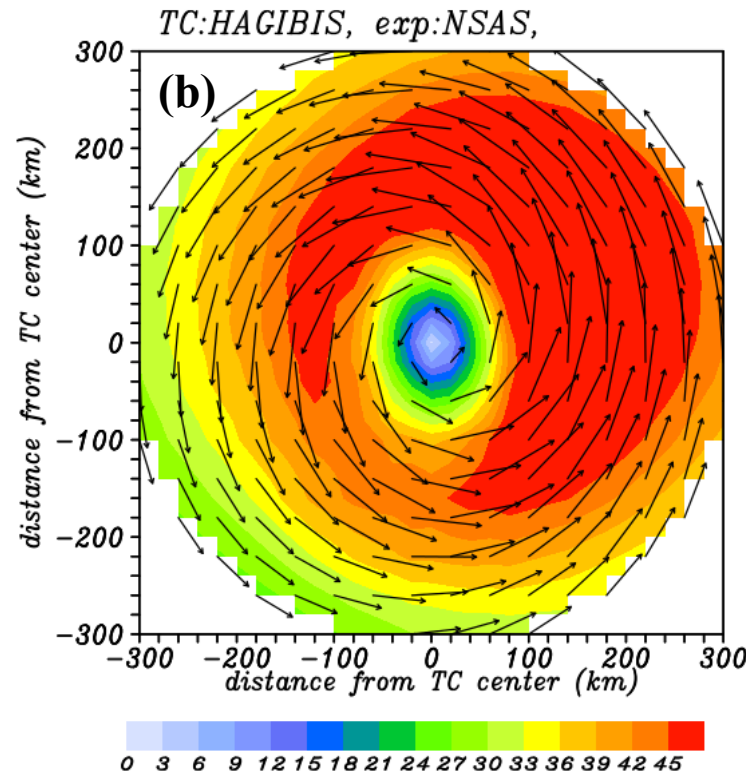
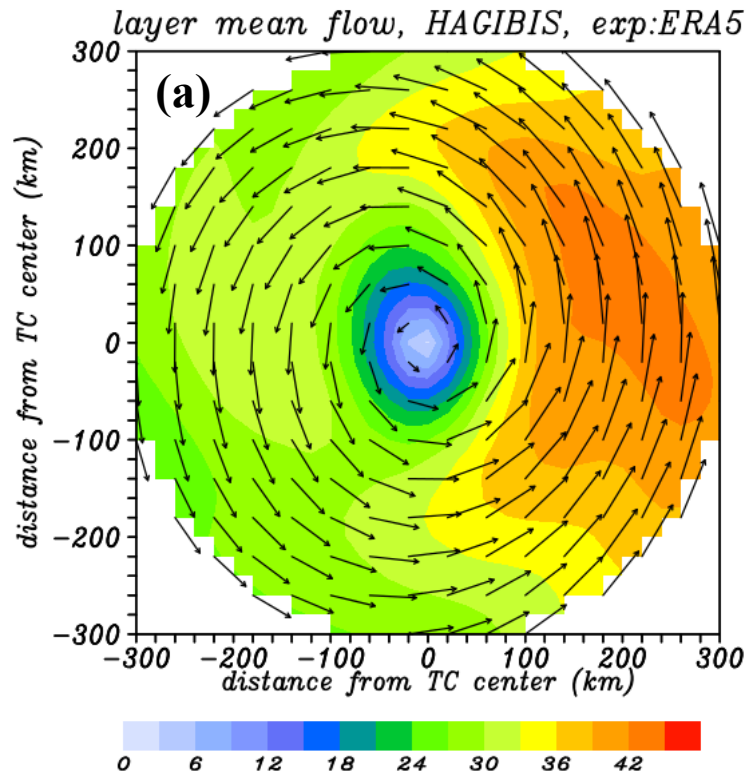
northward-moving typhoon track error



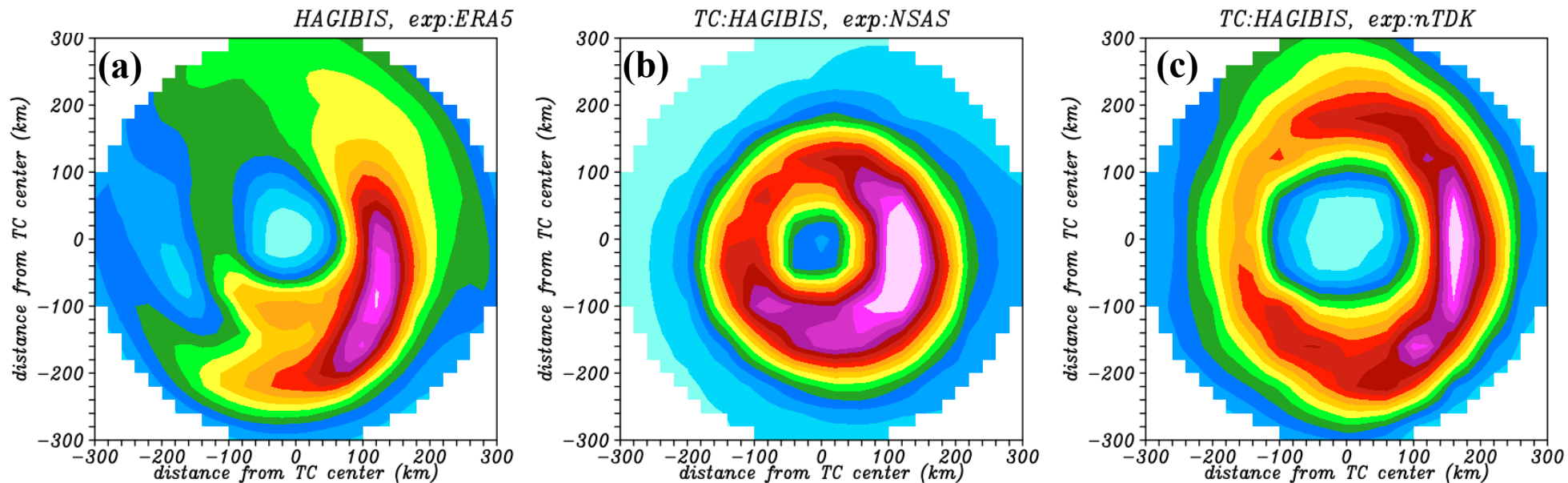
Westward-moving typhoon track error



Layer mean flow averaged during the mature stage of typhoon HAGIBIS



Color : horizontal wind speed (m/s)
Vector: horizontal wind direction (30 m/s)

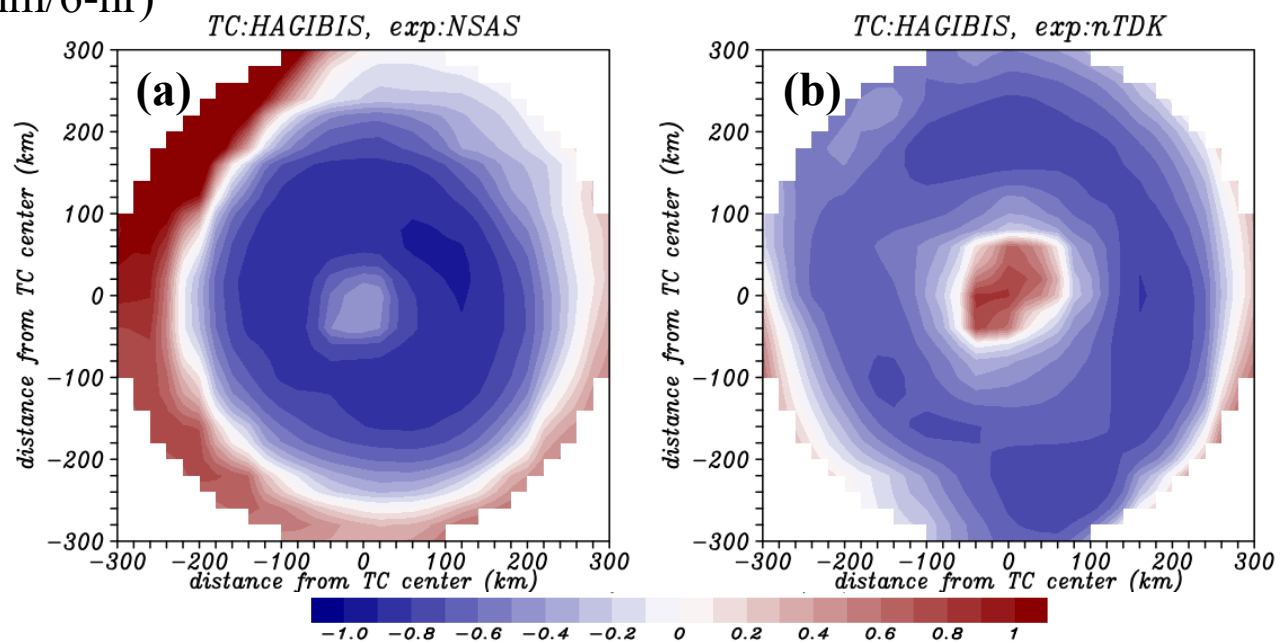


upper panel:

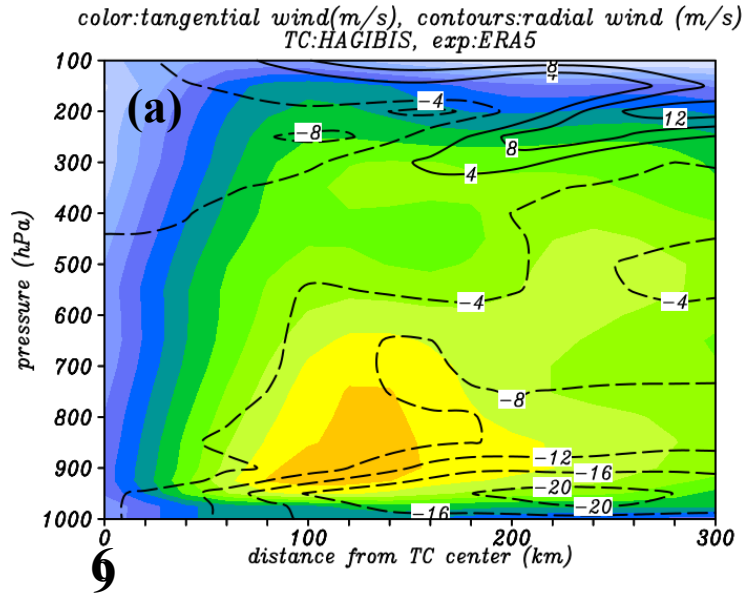
6 hours accumulated precipitation (mm/6-hr)

lower panel:

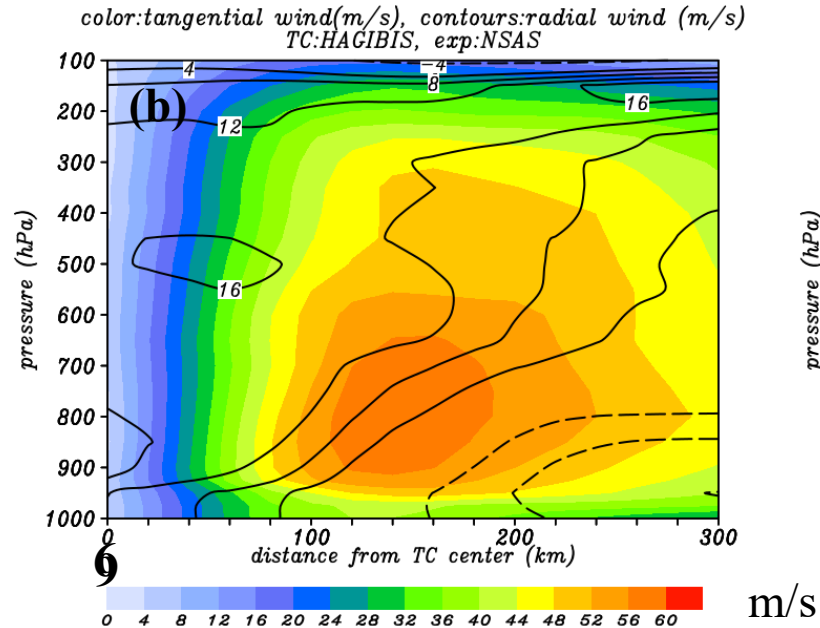
Contribution of total precipitation,
(Subgrid-Resolved Scale)/Total Precipitation



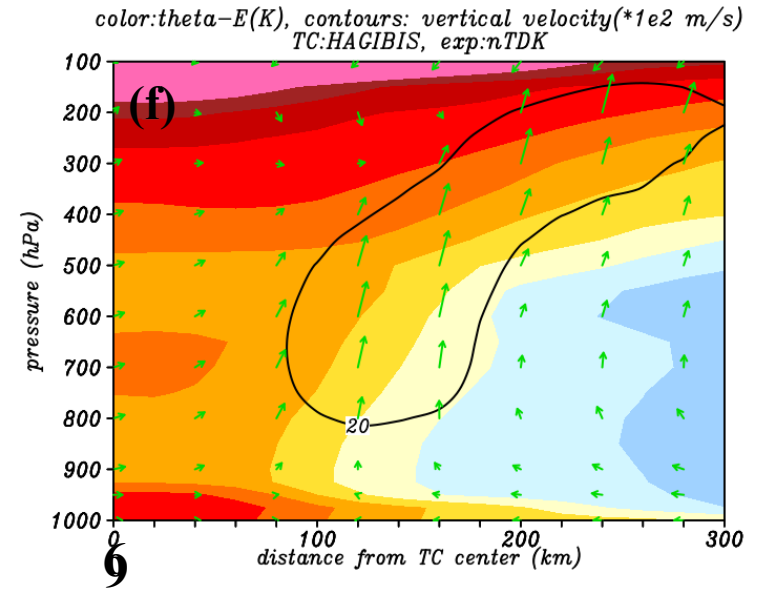
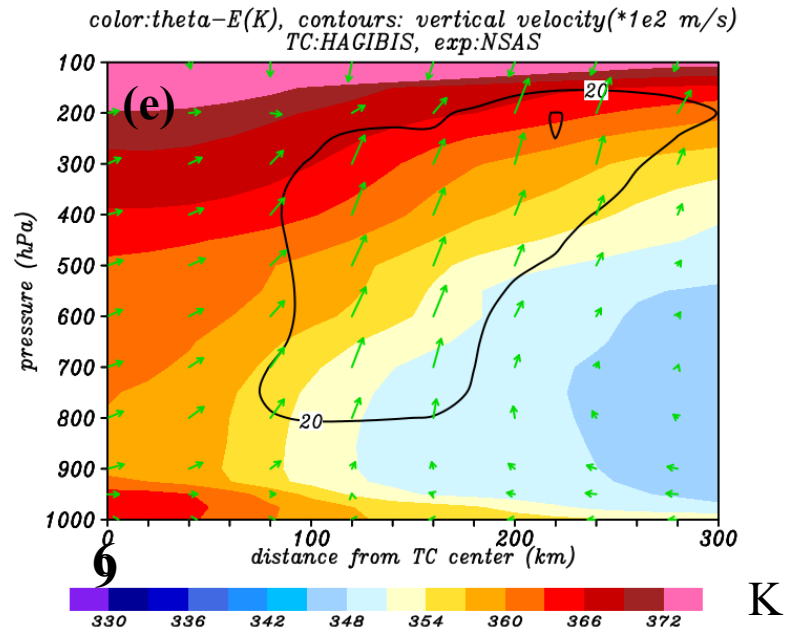
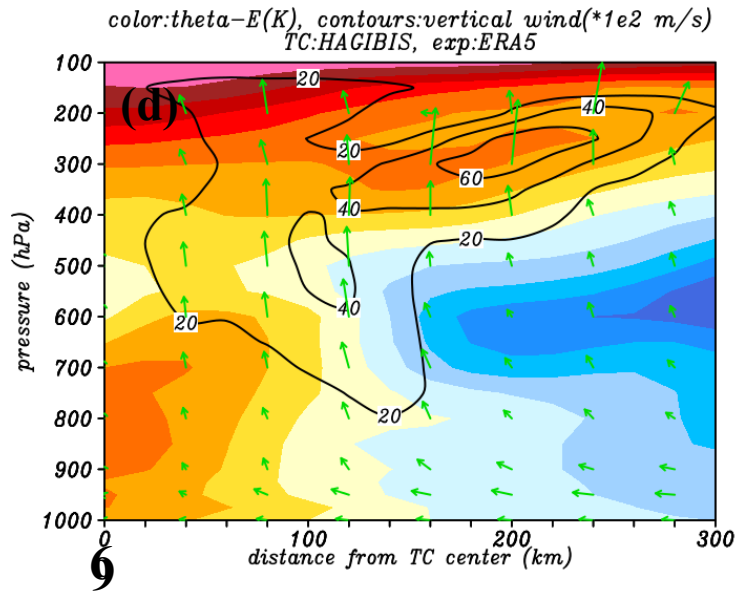
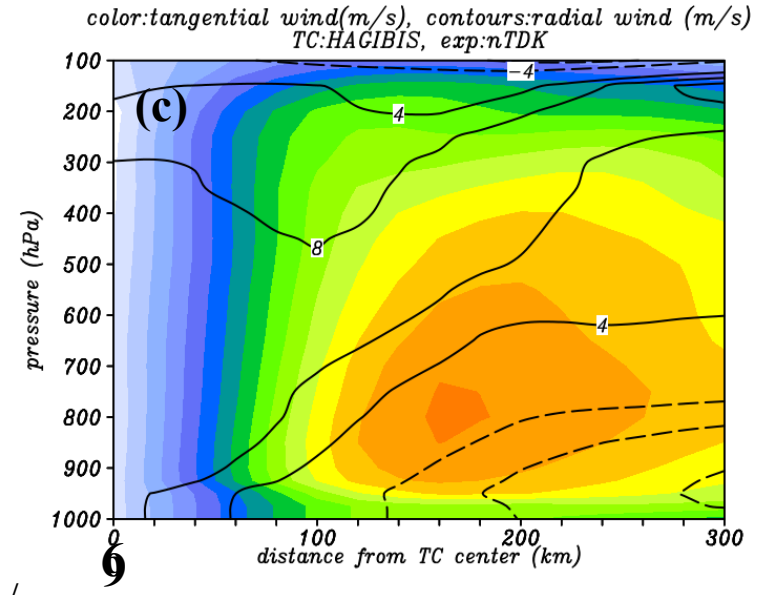
ERA5



NSAS

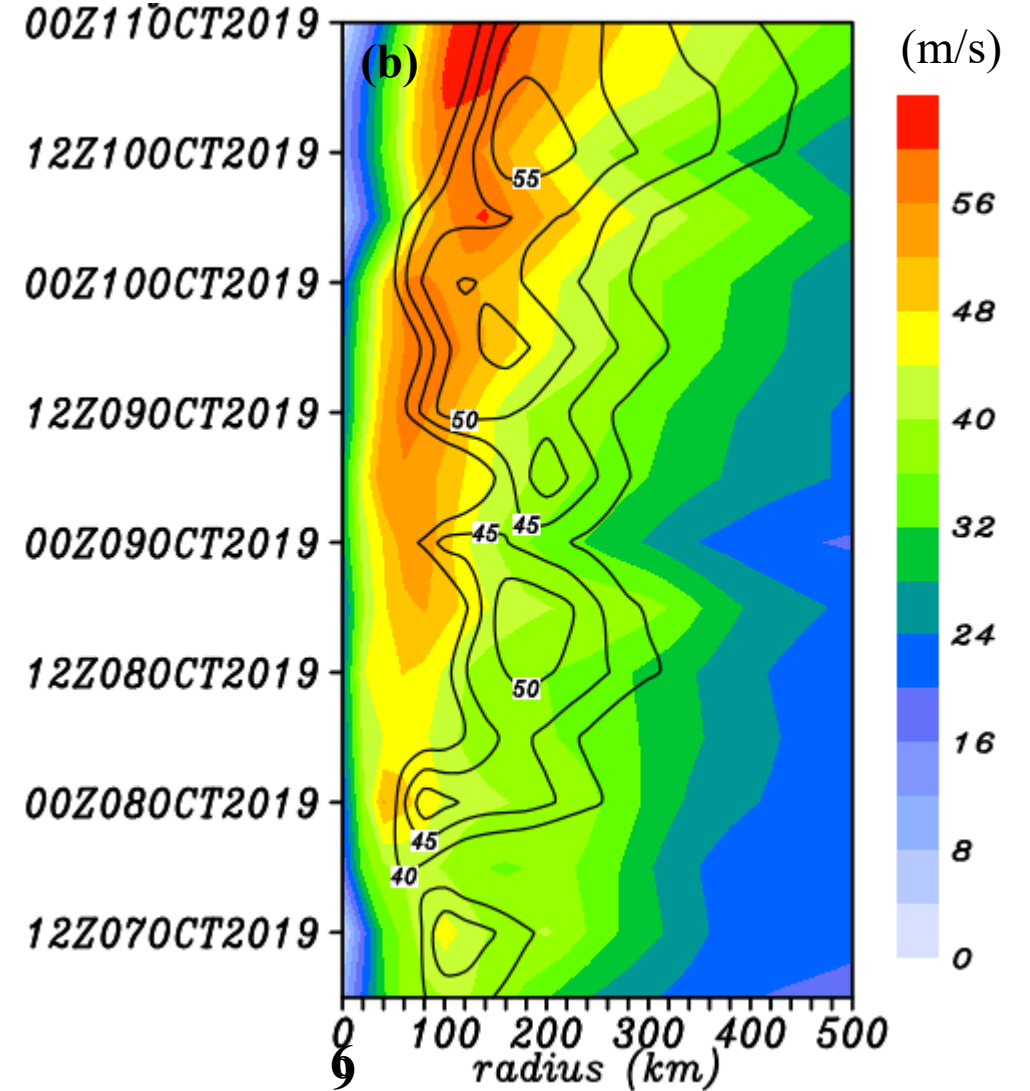
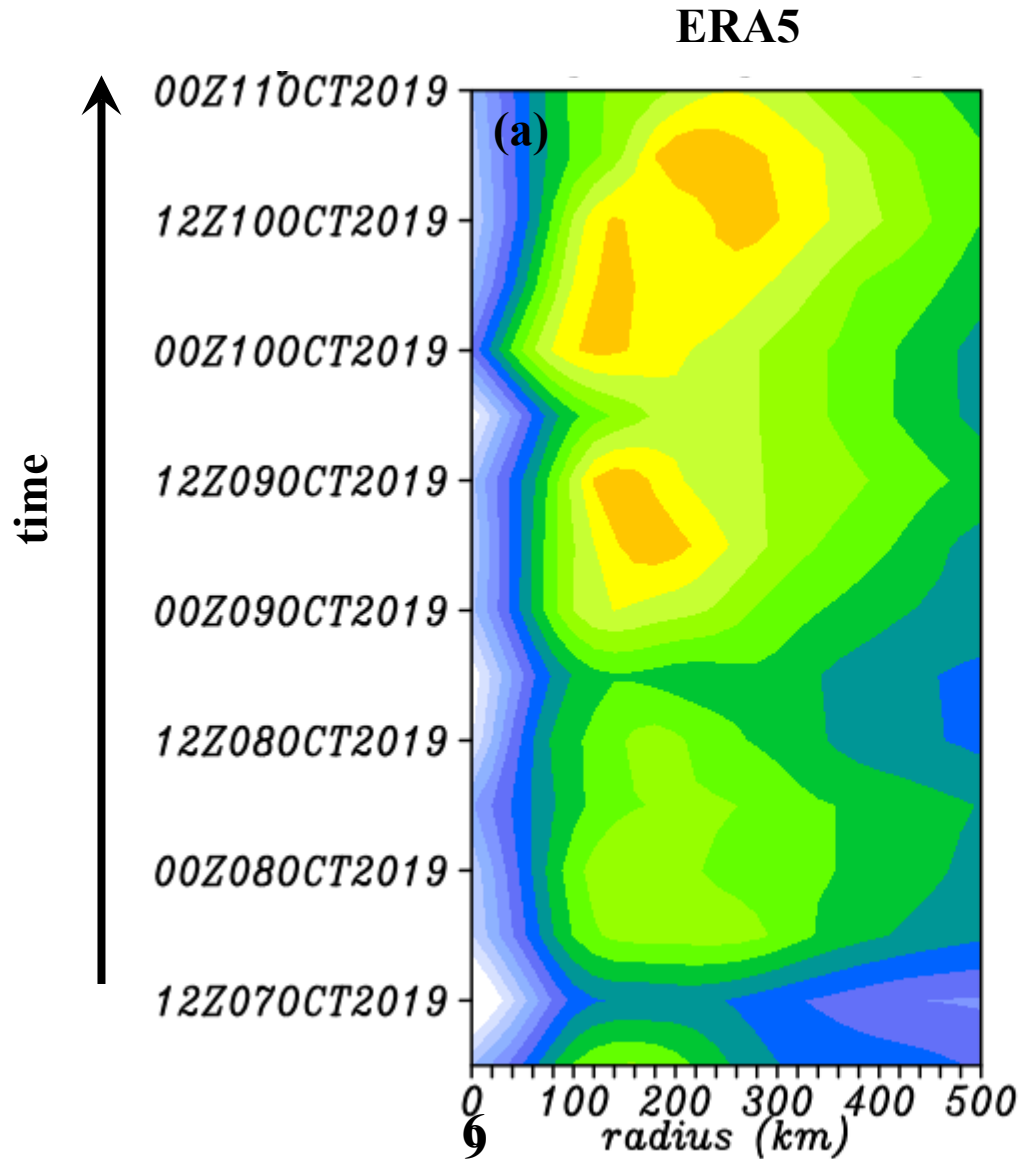


nTDK



Hovmöller diagram of averaged 850 hPa tangential wind

Typhoon HAGIBIS simulations initialized at 2019100700Z
NSAS (color), nTDK (contours, ≥ 40 m/s)



結論

- **綜觀尺度診斷校驗:**

- nTDK方案普遍都比使用NSAS方案的誤差為大 (相較於ERA5再分析資料)
- 西北太平洋高壓偏弱，造成西風偏差
- 北方槽線系統發展偏強，造成較大的北風偏差

- **西北太平洋颱風模擬:**

- 12個包含不同強度的北行或西行颱風個案
- nTDK方案可降低NSAS方案模擬的颱風路徑平均誤差
- nTDK方案主要修正了NSAS方案對於颱風移速偏慢的現象
- 環境駛流場與颱風結構的掌握度方面，nTDK方案皆相較於NSAS方案更為接近於ERA5再分析資料結果

THANK YOU
for your
ATTENTION!

color: wind speed (m/s), contours: geopotential height (m),
lev: 500 hPa, T=2019-10-10 00Z

