

Exploring future typhoon change using Pseudo Global Warming (PGW) scenarios

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Introduction

- Motivation : Typhoon-induced extreme rainfall and strong wind usually cause severe disasters, casualties, and economic losses. To explore the understanding of typhoon changes under global warming, this study selected four typhoons that had brought severe disasters in Taiwan and investigated their changes in idealized pseudo-global warming experiments.
- Data : 1. NCDR_PGW (Pseudo Global Warming) historical, +2°C and +4°C scenario 2. JTWC - Western North Pacific Best Track Data

TC name	Morakot		Herb		Mindulle		Nari		Morakot	Herb	
Time	2009/8/6 18:00- 2009/8/9 18:00		1996/7/31 03:00- 1996/8/1 06:00		2004/6/30 12:00- 2004/7/2 18:00		2001/9/15 00:00- 2001/9/19 18:00		32°N 30°N - 28°N - 26°N -	2°N 0°N 8°N 6°N	
Landfall time	2009/8/07 23:00		1996/7/31 14:00		2004/7/01 22:00		2001/9/16 21:00		24°N - 22°N - 20°N -	4°N - 2°N - 0°N -	
Data	CWB	PGW histo	CWB	PGW histo	CWB	PGW histo	CWB	PGW histo	18°N 114°E 116°E 118°E 120°E 122°E 124°E 126°E 128°E 130°E Mindulle 30°N - 46.09 km	B°N 114°E 116°E 118°E 120°E 122°E 124°E 126°E 128°E 130°E Nari 30°N 30°N 144.36 km	
Minimum pressure	955hPa	945hPa	920hPa	927hPa	942hPa	957hPa	960hPa	950hPa	28°N - 26°N - 24°N - 22°N - 20°N - 22°N - 22°N - 20°N - 20	28°N - 26°N - 22°N - 20°N - 22°N - 22°N - 20°N - 22°N - 20°N - 22°N - 20°N - 22°N - 20°N - 20	
Maximum wind speed	40 m/s	61 m/s	53 m/s	70 m/s	45m/s	56 m/s	40 m/s	56 m/s	20°N - 18°N - 114°E 116°E 118°E 120°E 122°E 124°E 126°E 128°E 130°E	20°N - 18°N - 114°E 116°E 118°E 120°E 122°E 124°E 126°E 128°E 130°E	

Changes in TCs structure

- Less change in TCs tracks in PGW experiments. (Fig. 1)
- In the +4 °C scenario, minimum pressure decreases about 5-10 hPa. (Fig. 2)
- Compared with +2 °C PGW, the +4 °C scenario projects stronger wind speed and further enhanced precipitation in the eye wall, except Typhoon Morakot.



Figure 1. TCs tracks and their averaged changes in (a) Morakot, (b) Herb, (c) Mindulle, and (d) Nari. Black lines are TCs tracks in historical scenario, yellow and red lines are those in +2°C and +4°C, respectively. Numbers denote the averaged changes in TCs tracks in +2°C and +4°C experiments.





Figure 4. (a) Averaged wind speed (m/s, vectors and shading) before TC make landfall in the historical scenario in Morakot. Differences between PGW and historical experiments in (b) +2°C and (c) +4°C scenarios. Same as (a-c), but for the result in (d-f) Herb, (g-i) Mindulle, and (J-I) Nari.







Figure 5. Same as Fig. 4, but for averaged hourly precipitation (mm) before TCs make landfall in historical scenario.

Dynamic and thermodynamic factors

- The 850hPa water vapor increases about 10% in +2°C scenario and 20% in +4°C scenario. And we can know that when the water vapor increases by 7%, the amount of rain can increase about 100-270% (Take Morakot for example).
- Except for Typhoon Morakot, the required increase of vertical velocity when increasing the same rainfall in $+4^{\circ}C$ scenario is less than $+2^{\circ}C$ scenario.

Precipitation in Taiwan





Figure 6. Dependence of changes in (a) 850hPa water vapor and (b) vertical velocity at 500hPa versus precipitation change in historical and PGW experiments.

Figure 7. (a-c) Accumulated precipitation in Taiwan (mm) in (a) Morakot, (b) Herb, and (c) Mindulle . (d-f) Timing diagram of the areas with the highest accumulated precipitation (mm). (g-i) Cumulative Distribution Function (CDF) of hourly precipitation (mm). Black lines are TCs tracks in historical scenario, yellow and red lines are those in +2°C and +4°C, respectively.

- The precipitation in +4°C scenario is 82.95-182.9mm higher than in historical scenario(Fig. 7(d-f)).
- Heavier precipitation occur more frequently in PGW scenarios.