

Present simulation and future projection of tropical storm activity over the western North Pacific in 20-km HiRAM and MRI Climate Model

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Introduction

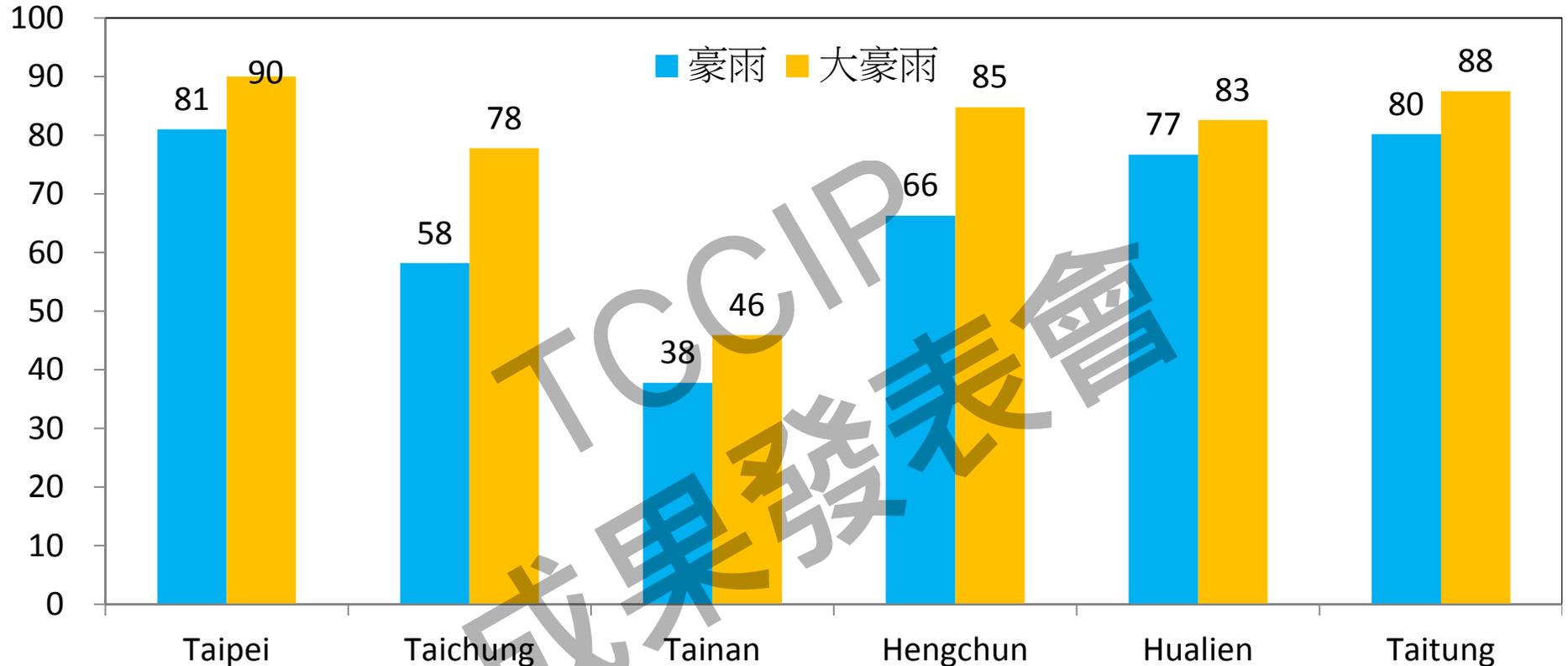


圖1. 1960-2010年臺灣六測站6-11月，侵台颱風佔豪雨與大豪雨事件之次數比例(單位: %)。侵台颱風表示豪雨發生當日(或前後一日)，中央氣象局有發布颱風警報。根據中央氣象局定義，豪雨為 >130 mm/day，大豪雨為 >200 mm/day。

Introduction

*CMIP5 Coupled Models : coarse resolutions

Underestimate the numbers and intensity of tropical storms

*Dynamic Downscaling

* High Resolution AGCMs : expensive

* Regional Climate Models : limited domains,

The remote forcing may be neglected.

High resolution AGCMs **HiRAM** and **MRI** are used in this study .

Model Setting

	HiRAM C384-TW	MRI-AGCM 3.2
Horizontal Resolution	23 km	20 km
Vertical Resolution	32 layers	64 layers
Boundary data	AMIP CMIP5 RCP 8.5	AMIP CMIP5 RCP 8.5
Integration	1979-2005 2075-2099	1979-2005 2075-2099

Cumulus	non-intrusive shallow convective scheme (Chen and Lin 2011)	Yoshimura cumulus scheme (Yoshimura et al. 2011)
Micro-physics	6-category bulk cloud microphysics (Chen and Lin 2011)	Tiedtke cloud scheme (Tiedtke 1993)
	Boundary layer	

TS simulation and future Projection

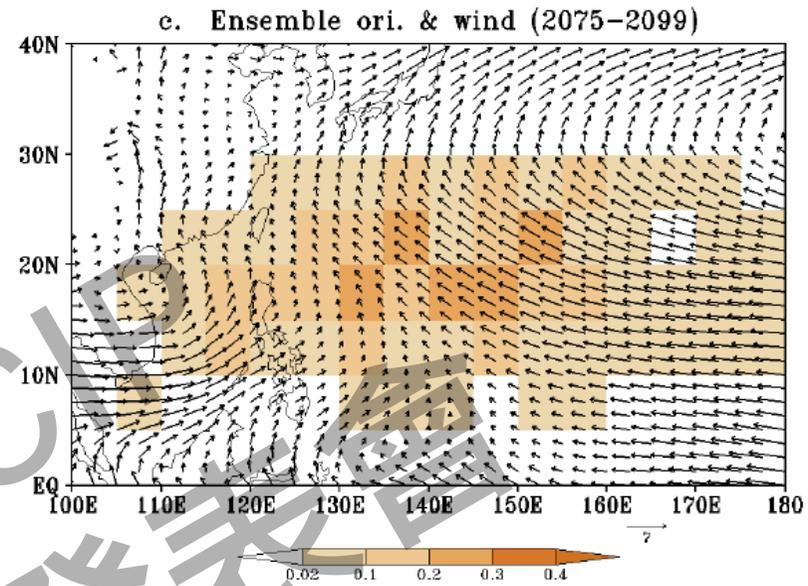
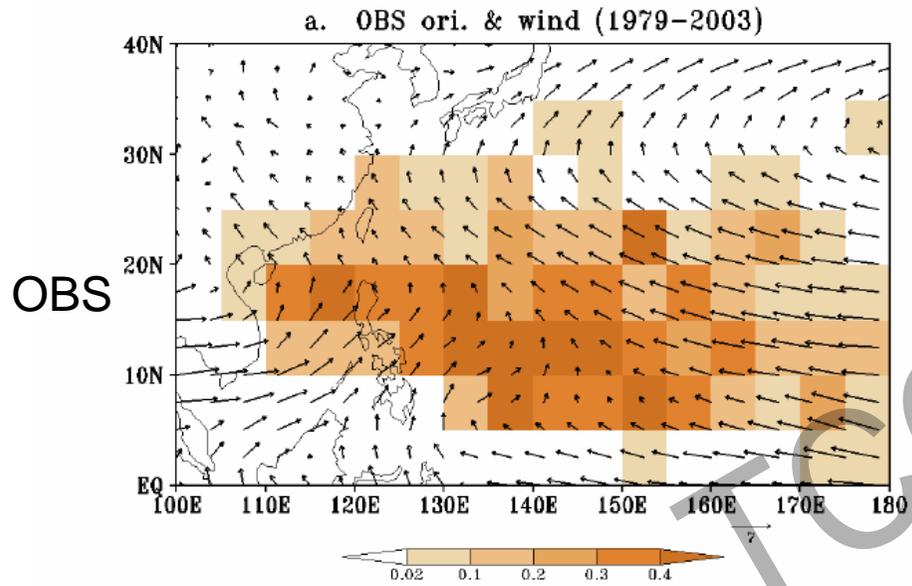
TCCIP
成果發表會

Table 1. Observed and simulated TS activity

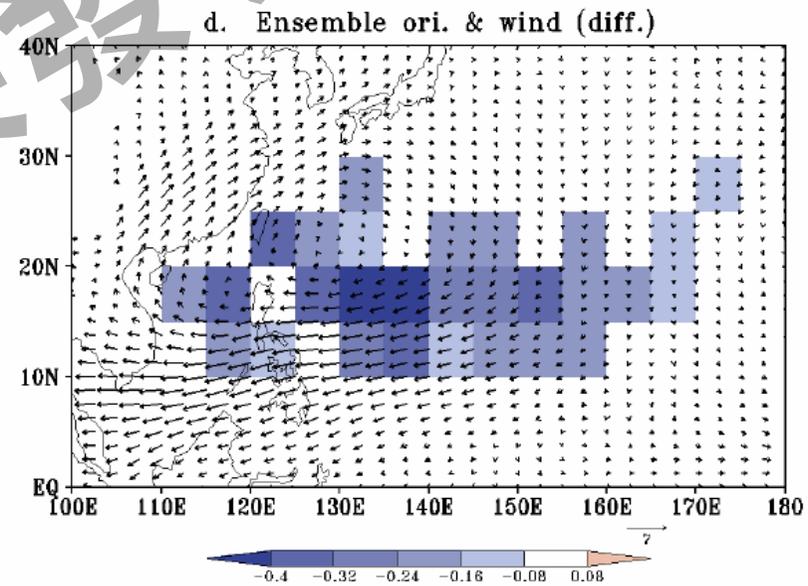
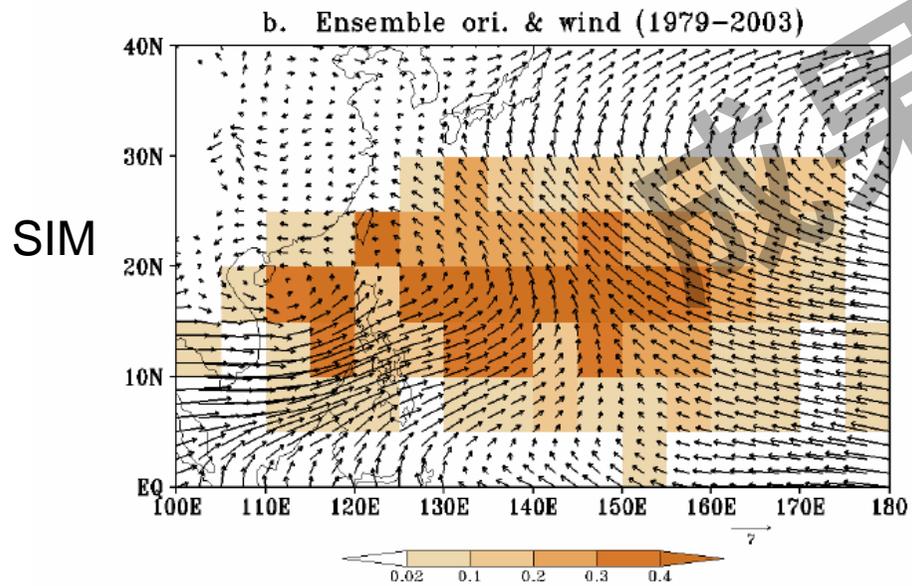
WNP	TS Num. (Num/yr)	PC
JTWC	22.6	
HiRAM	27.0	0.83
MRI	20.1	0.83
Ensemble	23.5	0.87
2075-2099 (Ensemble)	-11.8 (-50 %)	

*PC is the pattern correlation coefficient between simulation TS frequency and observation (110°-180°E, 0°-40°N).

TS formation frequency (shaded), and 850 hPa winds (ms^{-1})



2075-2099



DiF.
(2075-2099
-
1979-2003)

Table 1. Observed and simulated TS activity

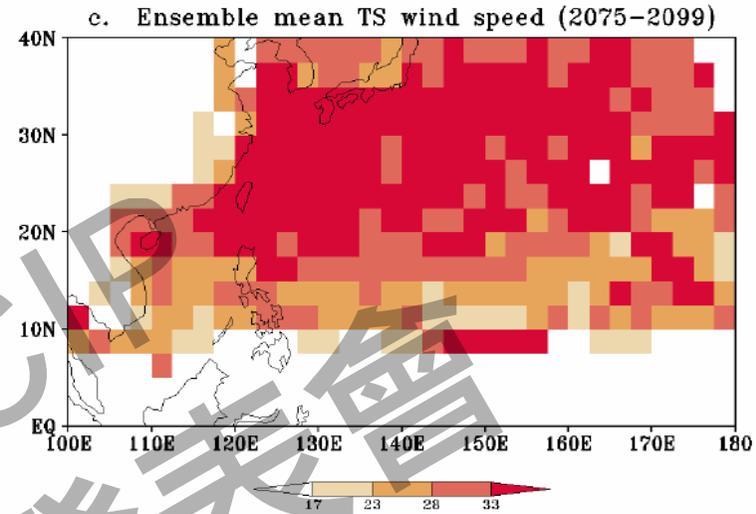
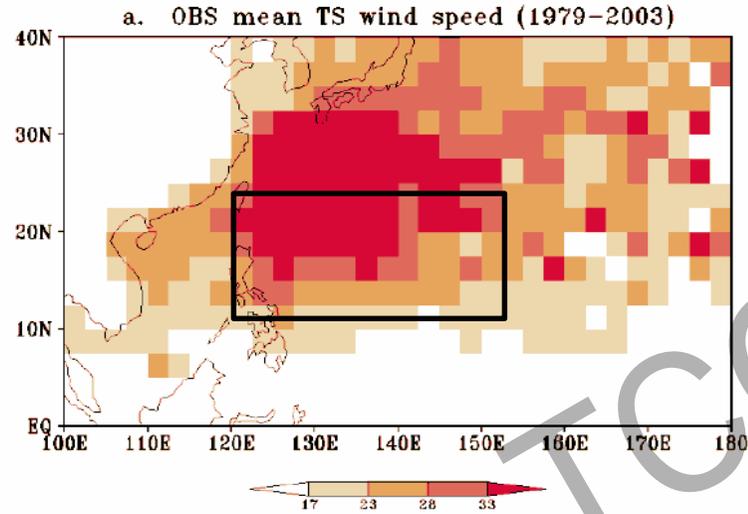
WNP	TY1 & TY2 (Num/y r)	TY4 & TY5 (Num/yr)	Mean LMI (m s ⁻¹)	MP (mm day ⁻¹)
JTWC	7.2	5.6	43.3	79.6
HiRAM	12.8	0.1	37.2	95.6
MRI	4.7	5.8	44.0	110.5
Ensemble	8.8	2.9	40.6	103
2075-2099 (Ensemble)	-5.4 (-62 %)	-0.7 (-22 %)	3.2 (8 %)	36.5 (35 %)

*LMI the maximum intensity achieved during a storm's lifetime.

*Maximum precipitation rate (MP) is the average rain rate within 200 km of the storm center at the time of the LMI.

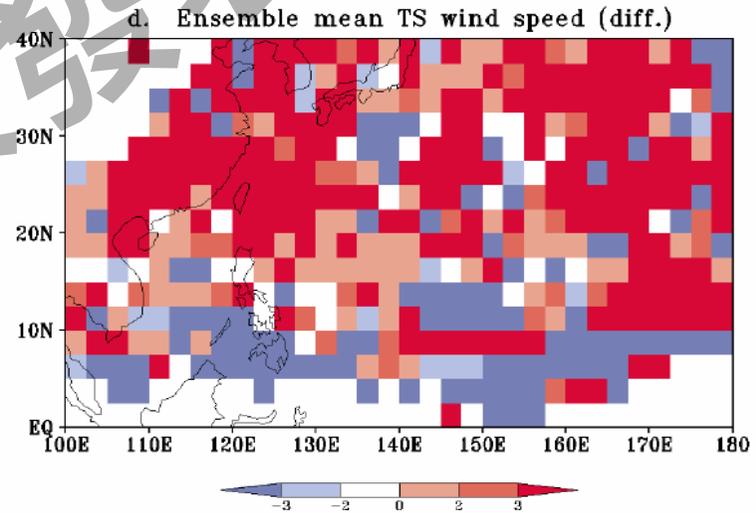
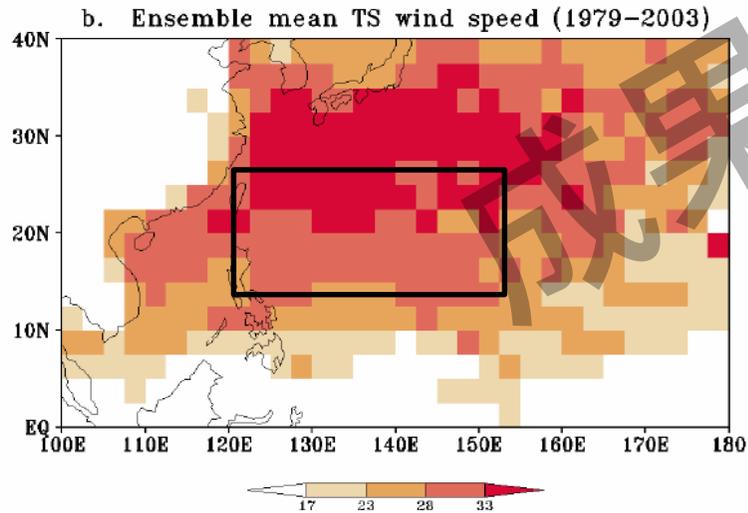
TSs mean wind speeds (ms^{-1})

OBS

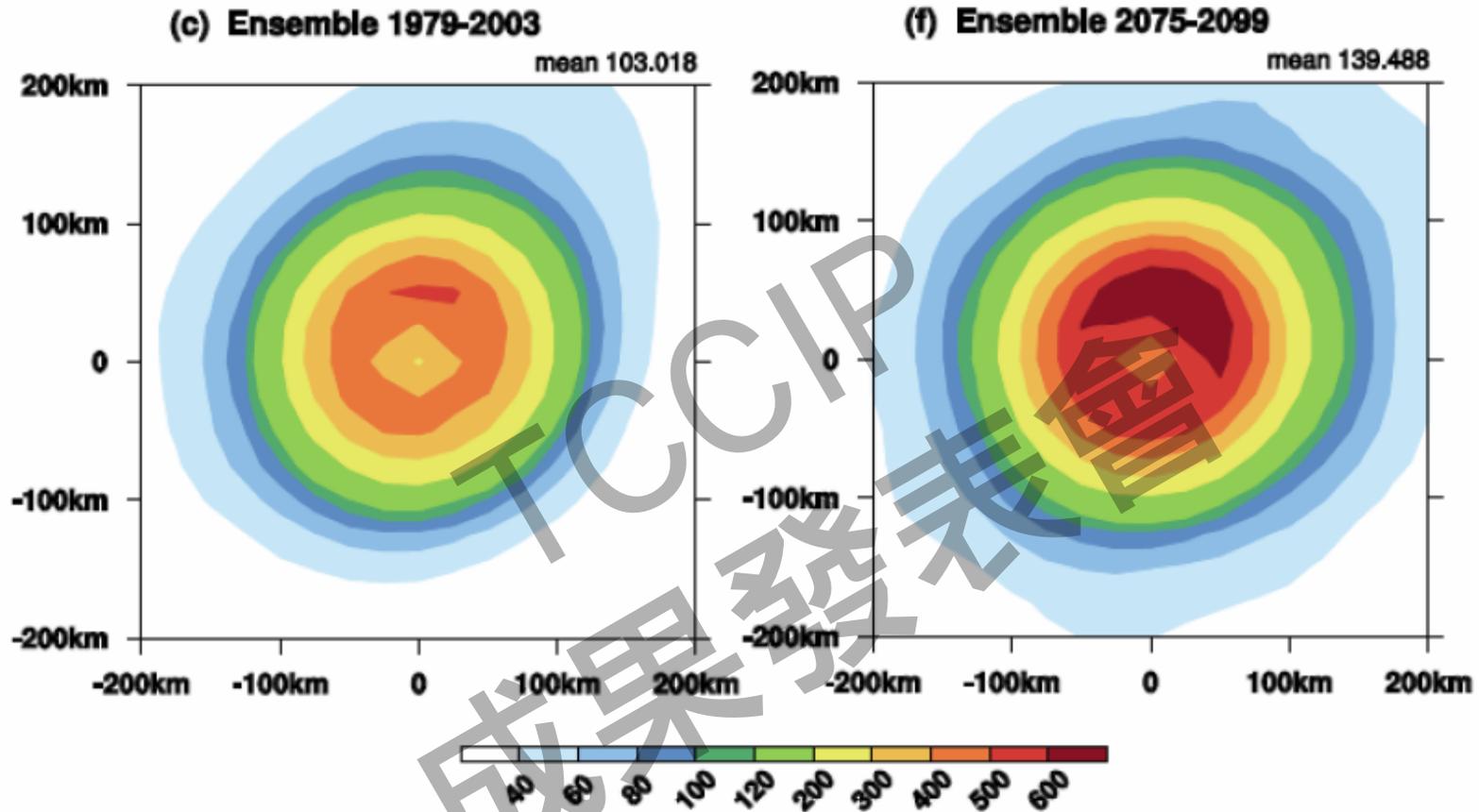


2075-2099

SIM

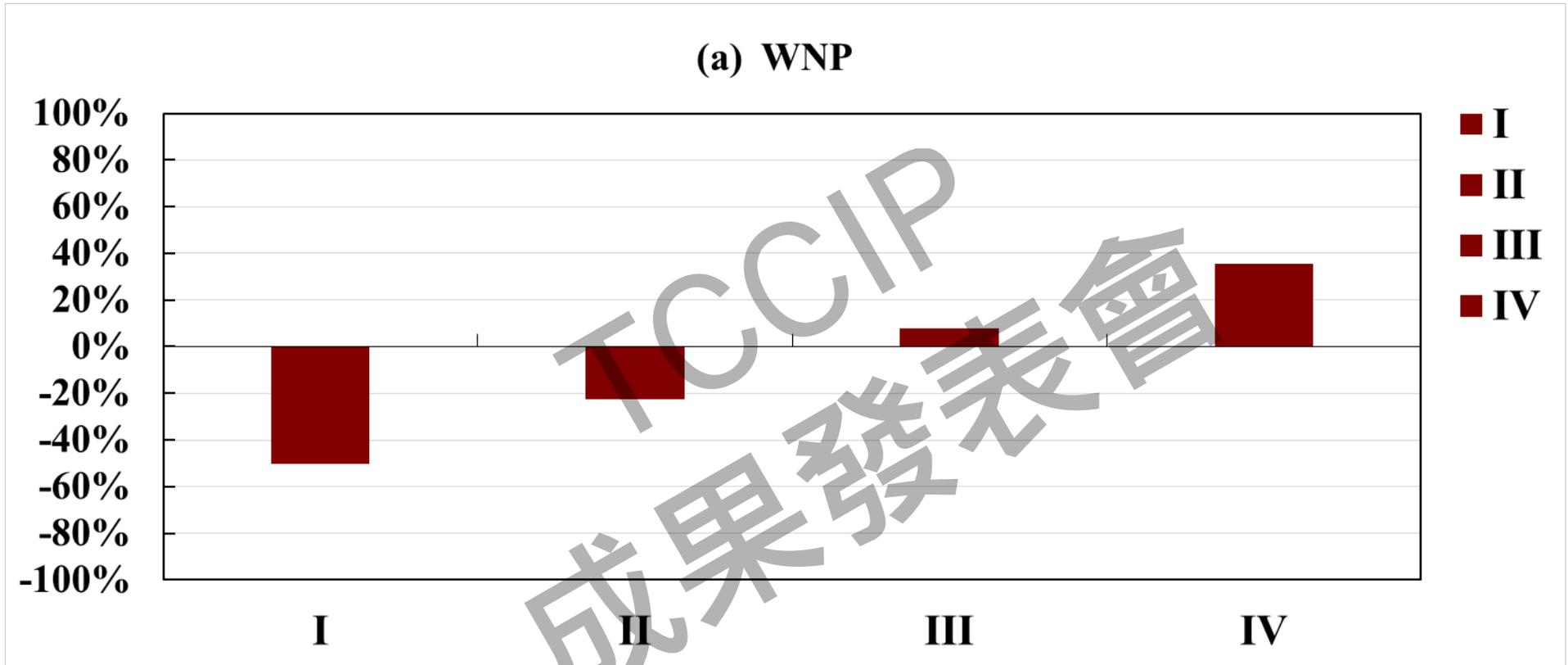


DiF.
(2075-2099
-
1979-2003)



- FIG.3 Composite of the maximum precipitation rate for all TSs within 200 km of the storm center at the time of the LMI during JJASON for the period (a) 1979-2003. (b) 2075-2099. LMI the maximum intensity achieved during a storm's lifetime.

Future projection

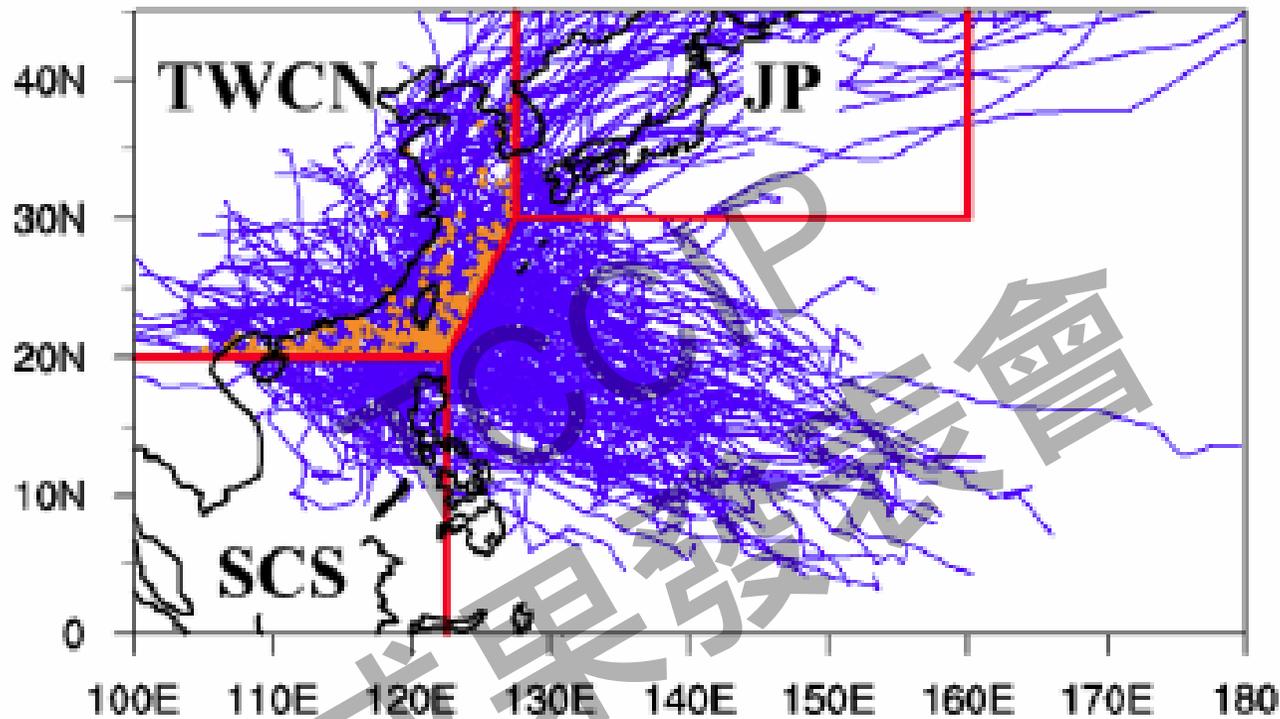


IPCC AR5 四個指標：(I)西北太平洋地區颱風總數目，(II) 颱風強度等級4及5之颱風數目，(III) 颱風平均最大強度，(IV) 颱風達到最大強度時，颱風中心200公里內的平均降雨量。

TW/CN Results
Mean Circulation and TS formation

HIRAM (1979-2003)

JJASON



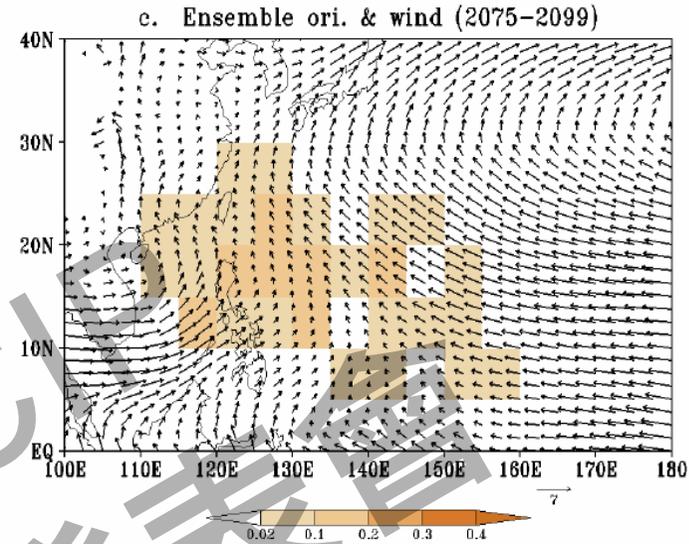
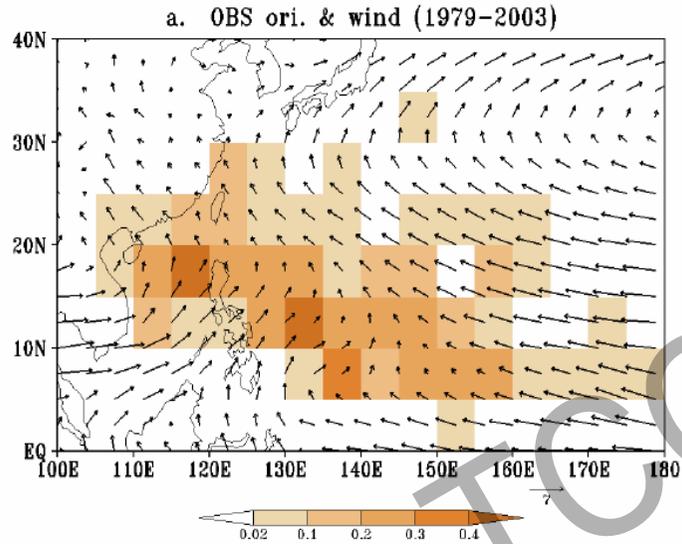
影響區域示意圖(紅線)與影響臺灣華南地區颱風軌跡。橘點為 RMI 位置。

TWCN TS simulation

TWCN	TS Num.	PC	TY1 & TY2	TY4 & TY5	Mean RMI (m s ⁻¹)	RMP (mm day ⁻¹)
JTWC	8.9		3.4	0.8	35.5	70.2
HiRAM	8.5	0.87	3.8	0.04	33.8	94.7
MRI	4.6	0.86	1.3	1.1	43.5	125.8
Ensemble	6.5	0.89	2.5	0.6	38.6	110.3

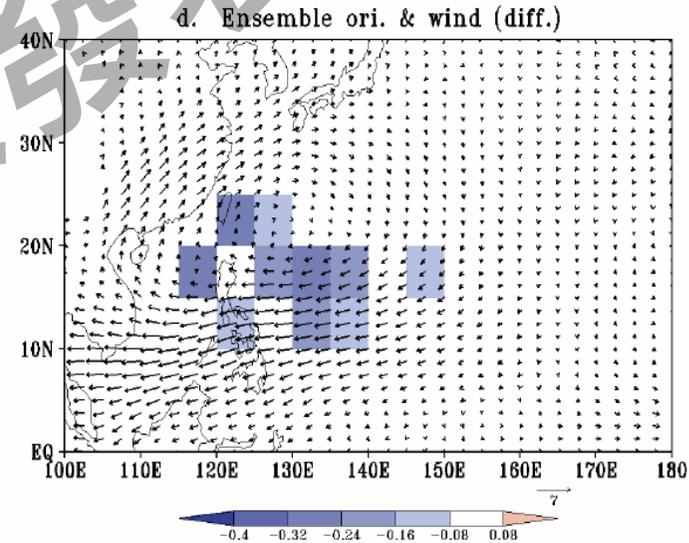
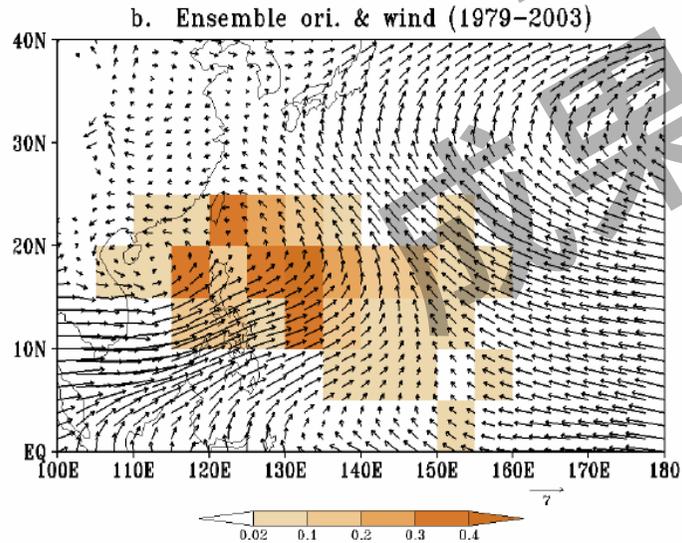
TS formation frequency (shaded), and 850 hPa winds (ms^{-1})

OBS



2075-2099

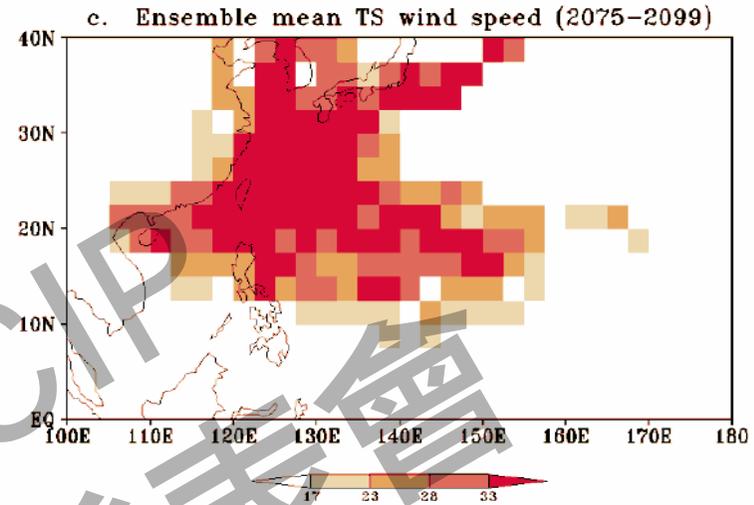
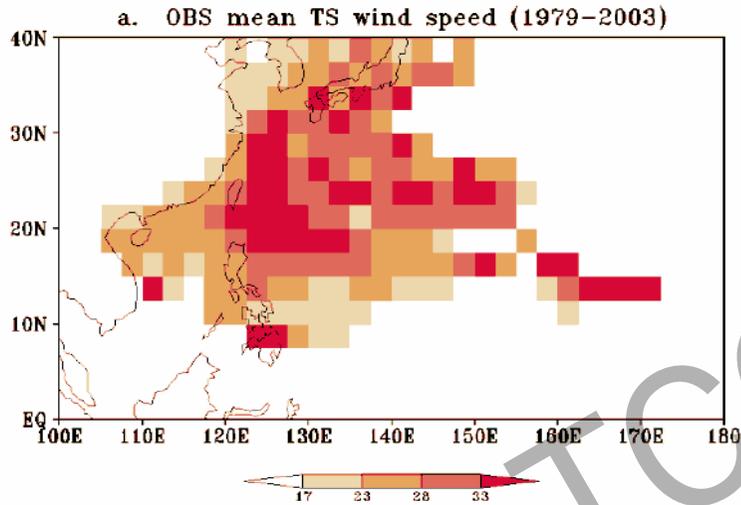
SIM



DiF.
(2075-2099
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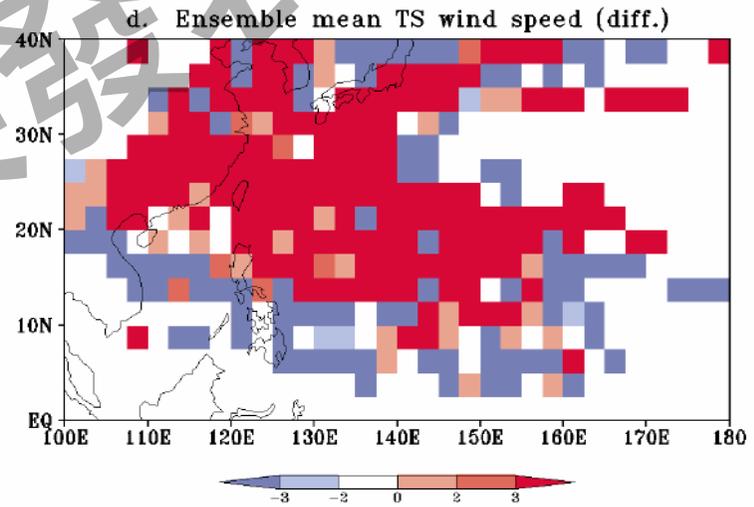
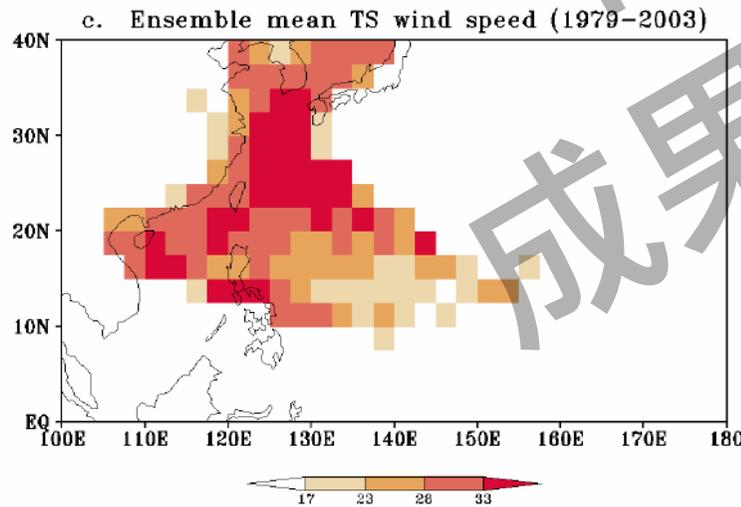
TSs mean wind speeds (ms^{-1})

OBS

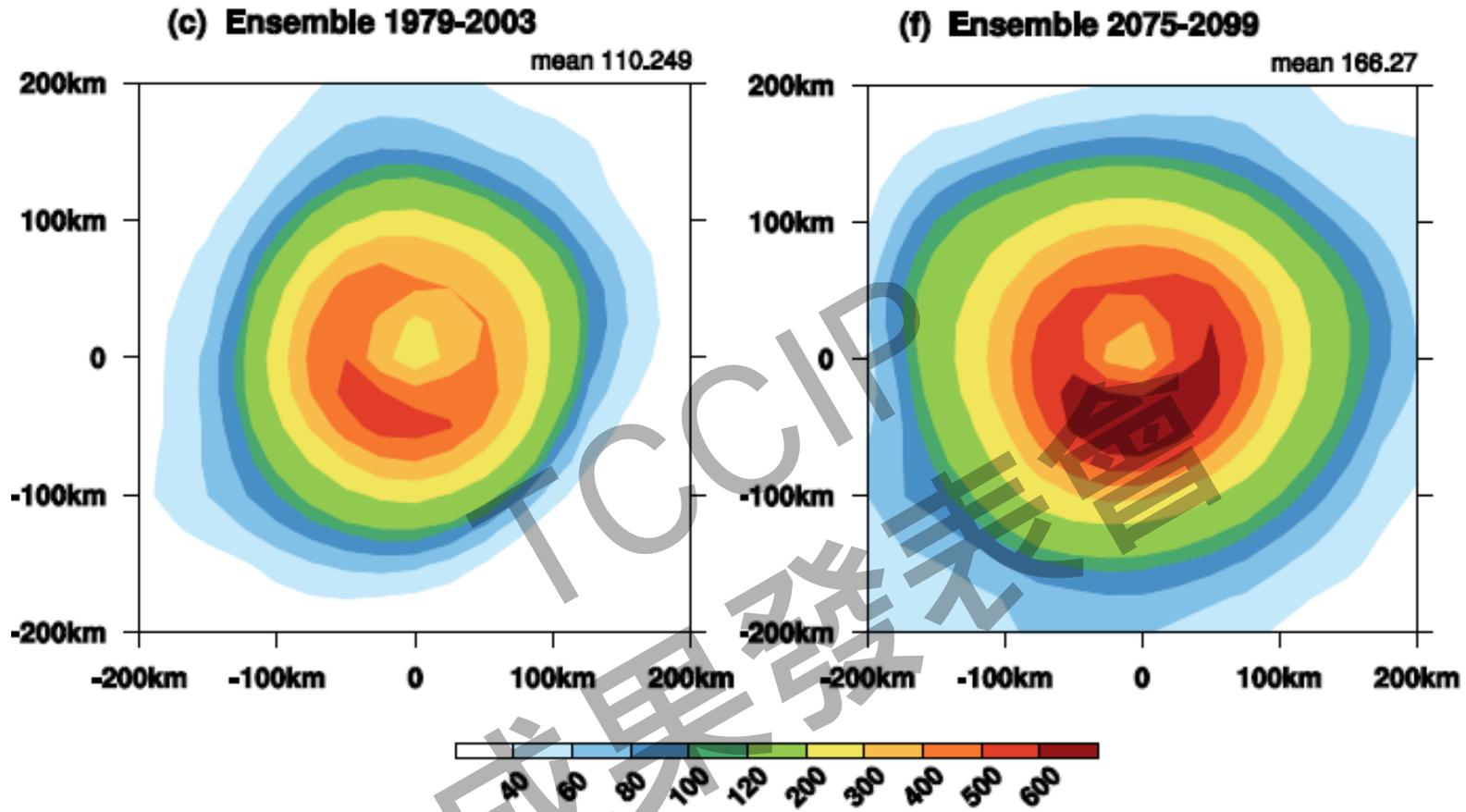


2075-2099

SIM



DiF.
(2075-2099
-
1979-2003)



- FIG. Composite of the maximum precipitation rate for all TSs within 200 km of the storm center at the time of the LMI during JJASON for the period (a) 1979-2003. (b) 2075-2099. LMI the maximum intensity achieved during a storm's lifetime.

(b) TWCN

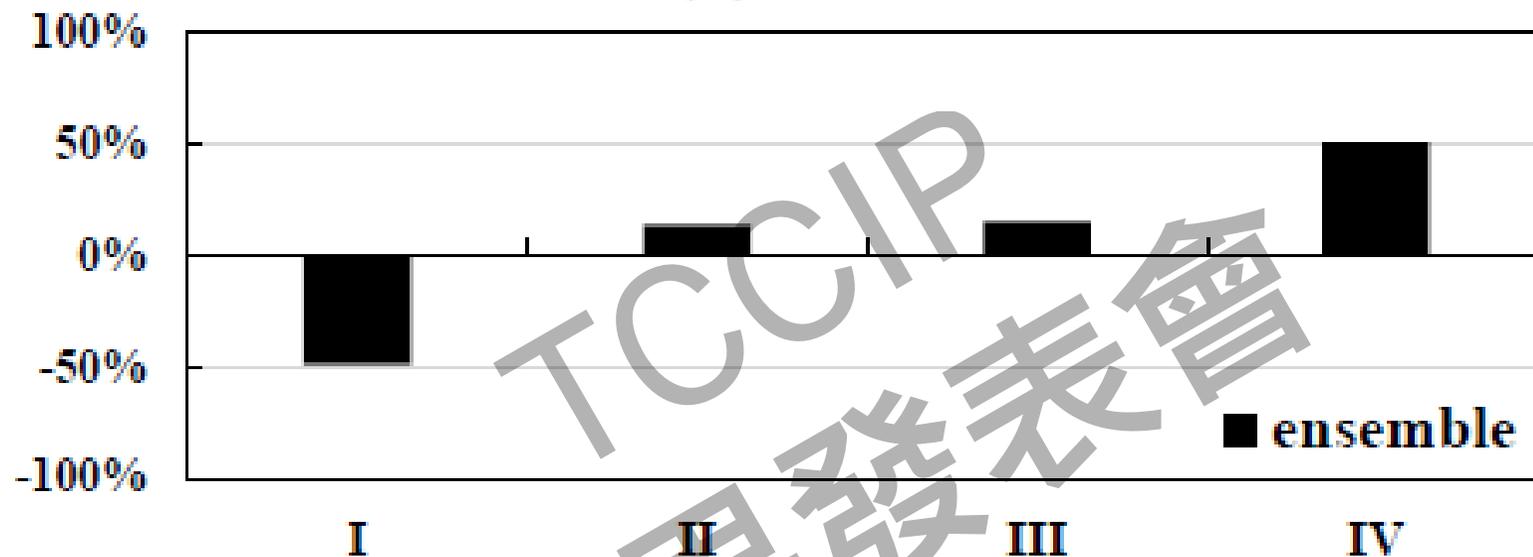
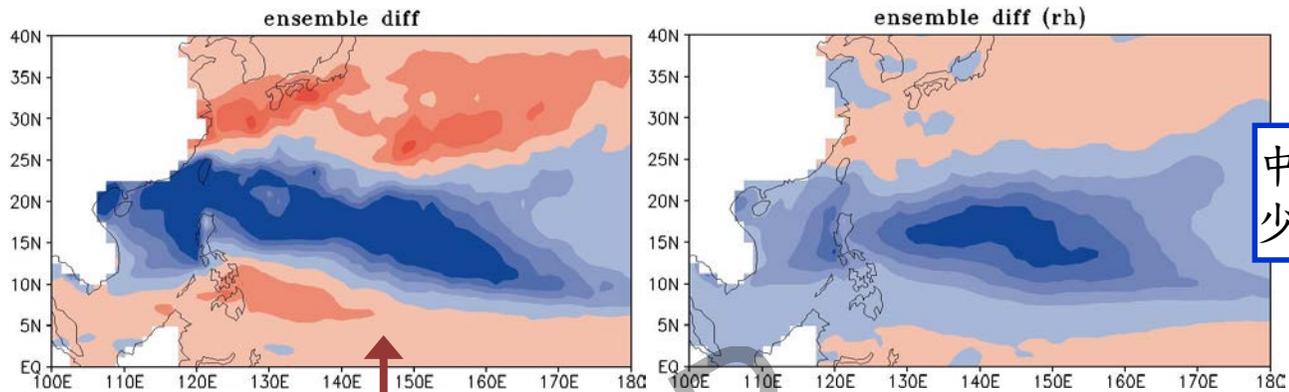


圖3. 高解析度模式系集推估未來影響TWCN地區之颱風活動的變化百分比。四個指標：(I) 影響TWCN地區颱風總數目，(II)強烈TY4和TY5颱風數目，(III)平均區域最大強度 (RMI)，(IV)達到區域最大強度時，颱風中心200公里內的降雨量。

利用GPI和季內震盪
探討影響未來颱風生成數目變遷機制

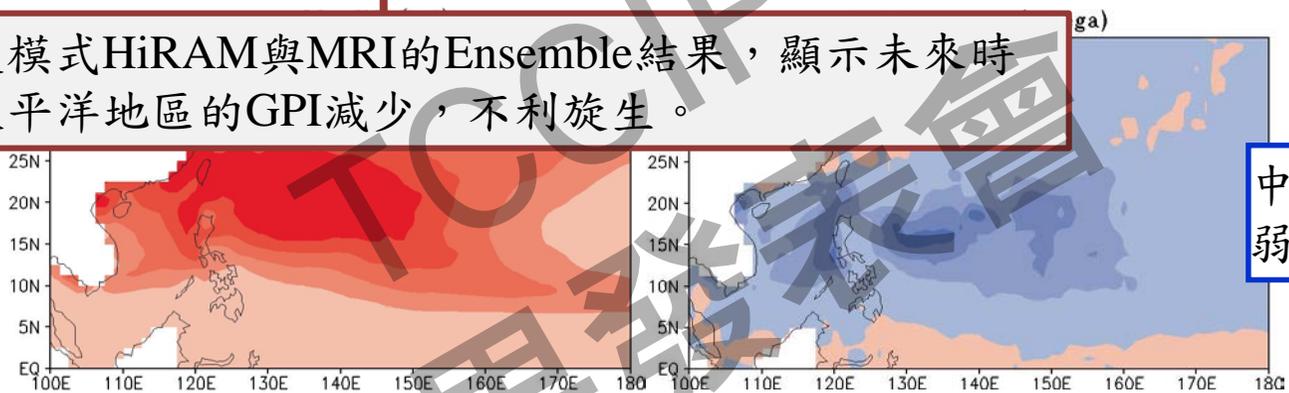
TOPIC
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GPI

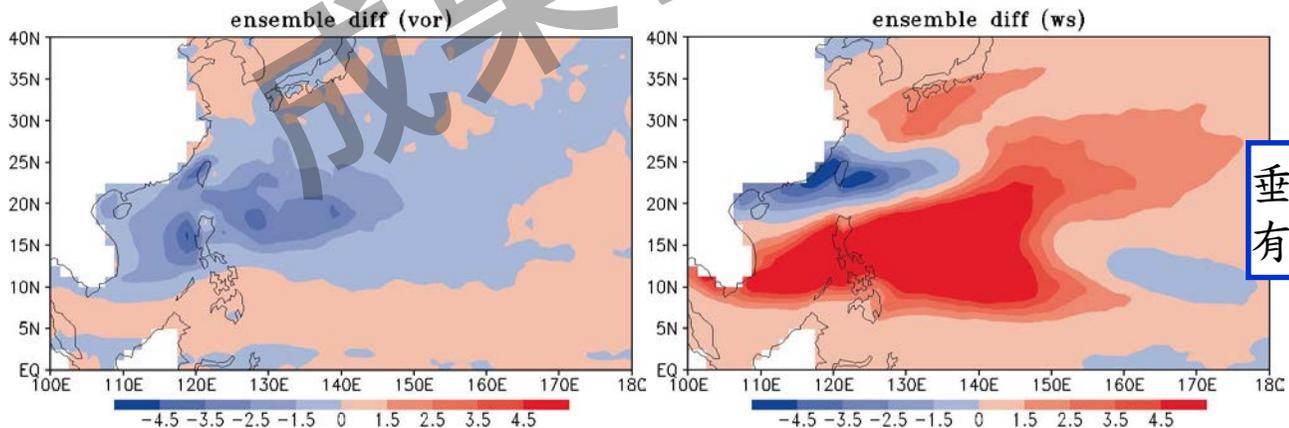


中層相對濕度減少，不利旋生。

高解析度模式HiRAM與MRI的Ensemble結果，顯示未來時期西北太平洋地區的GPI減少，不利旋生。



中層垂直速度變弱，不利旋生。



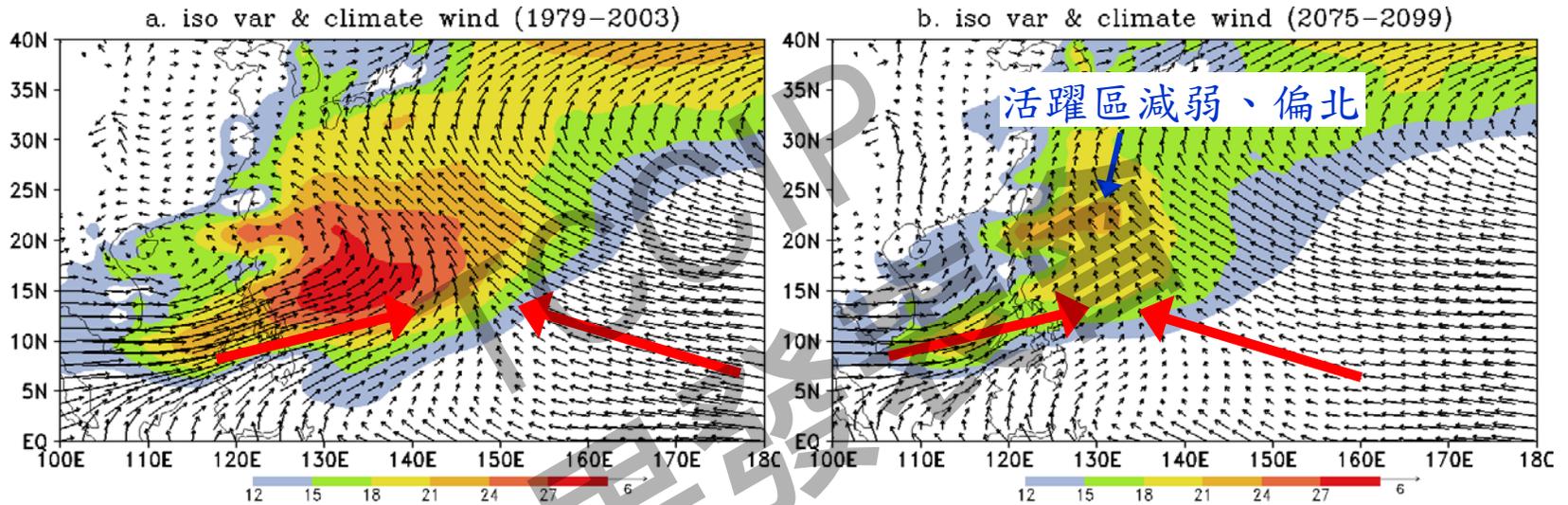
垂直風切變小，有利旋生。

海溫增暖使得GPI增加，有利旋生。

季風槽減弱使低層相對渦度減弱，不利旋生。

圖：HiRAM與MRI的Ensemble之2075-2099年7-9月GPI，減去1979-2003年之差值圖。

ISO & Wind

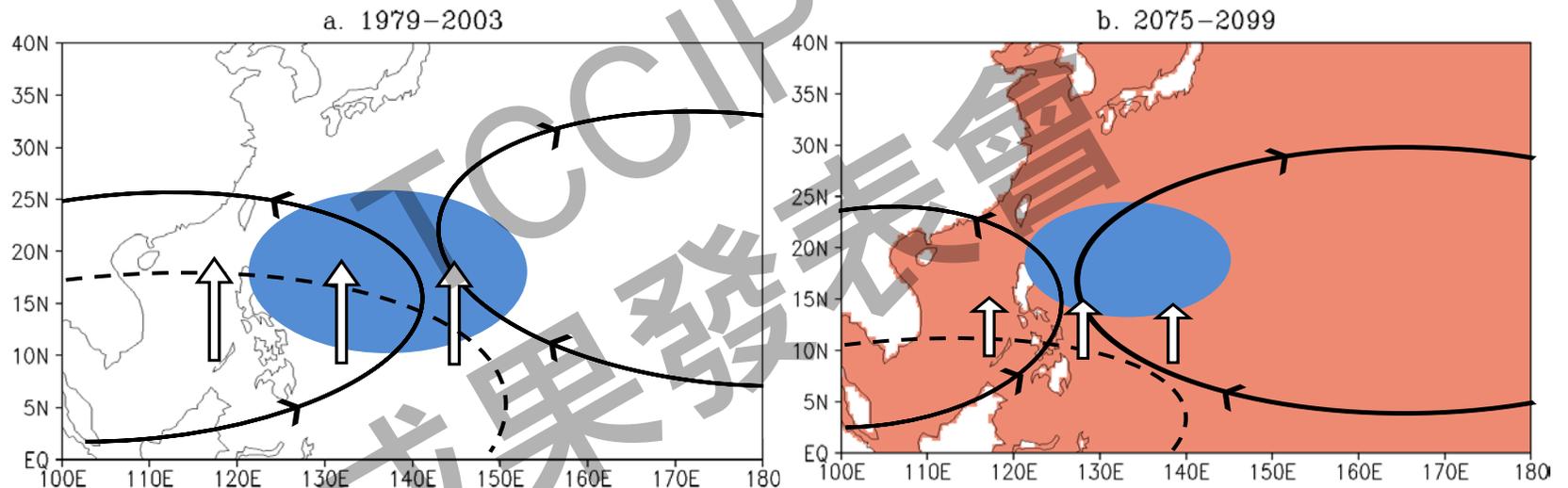


圖：HiRAM與MRI的Ensemble之(a)1979-2003年7-9月，850 hPa東西向風場之10-90天季內震盪變異數(陰影)與850 hPa氣候風場。(b)2075-2099年。

季風槽減弱，太平洋副高增強，與季內震盪變異量減弱，因此較不利於西北太平洋之颱風生成。

示意圖

在世紀末時期，雖然海溫增高有利颱風生成數目，但季內震盪和季風槽減弱、相對濕度減少與垂直速度變弱則使颱風生成數目減少。



圖：影響西北太平洋颱風軌跡機制之示意圖。(a)1979-2003年，(b)2075-2099年。紅色陰影表示海溫增暖。藍色陰影為季內震盪活躍區域。實線為大尺度環流場，分別為副高與季風槽。虛線為600 hPa相對溼度75%等值線。白色箭頭為500hPa垂直運動。

Summary

- HiRAM與MRI高解析度模式，成功模擬影響TWCN地區的颱風生成與軌跡的氣候特徵，系集模擬優於各別模式模擬。
- 高解析度模式HiRAM與MRI的Ensemble結果，推估世紀末時期，侵襲臺灣華南地區的颱風數目減少-48%。
(Mechanisms: 季內震盪和季風槽減弱、相對濕度減少)
- 強颱風(TY4及TY5)數目增加14%。
- 達到RMI時，颱風中心200公里內降雨量增強50%。
- Mechanisms ?

Thanks

TOGCIP
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TS Detection and tracking methodology

HiRAM	<ul style="list-style-type: none">(1) 850 hPa relative vorticity max exceeding 1.5×10^{-4}(2) warm core(3) max wind speed at surface ≥ 17 (m/s)(4) storm exist at least 3 days <p style="text-align: right;">Chiu (2013)</p>
MRI	<ul style="list-style-type: none">(1) 850 hPa relative vorticity max exceeding 2×10^{-4}(2) warm core(3) max wind speed at 850hPa ≥ 17 (m/s)(4) the wind speed at 850hPa ≥ 17 (m/s) at least during 1.5 days (not necessarily consecutive) <p style="text-align: right;">Mizuta et al (2012)</p>

Observation Data: Validation

NCEP-CFSR : wind

6hr data

1979-2010 June-November

JTWC: TS information

(a) TS frequency: total number of TC occurrence in a
5*5 box

(b) TC genesis: first time when the wind speed of TC > 25
knots