

Projection of Tropical Cyclones near Taiwan in high-resolution AGCMs and Their Further Dynamical Downscaling

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Outline

- Modeling Frame work and experiments (High-resolution global AGCMs and RCM downscaling)
- C projections of super-high resolution AGCM (∆ x=20-25km)
- ⇒ TC projections of MRI-AGCM3.2S (∆x=20km) ensemble
- ⇒ TC projection of HiRAM c192 (∆x=50km) ensemble



AGCM & RCM for CMIP5



4 SST in JJASON of the end of 21st century











TCs of Northwest Pacific



Northwest Pacific TCs

AGCM	Period	Number	# percentage (%)			
			TS	Cat <3	Cat≥3	
OBS	1979-2003	641	43%	44%	13%	vent/v
MRI-	1979-2003	688	49 %	30%	25%	e) vor
RCP8.5	2075-2099	365 (-47%)	36 %	29%	36%	BUIE
HiRAM-	1979-2003	918	44%	48%	7%	T Y Fr
RCP8.5	2075-2099	537 (-42%)	47%	39%	13%	



III

VIV

II Category 4-5 TC freq III Lifetime Maximum Iı IV Precipitation rate

Reasonable seasonal cycle for TC genesis
MRI-AGCM (HiRAM) overestimate (underestimate) strong TC #
End of 21st century (RCP8.5)

- TC # reduces ~45%
 - Ratio of intense ones increases



PDF of grid rainfall extremes associated with TCs



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Composite Rainfall Distribution from Center of Tropical Cyclones



Composite of Projected Change in ω Vertical Velocity Distribution from Center of Tropical Cyclones



TC Affecting Taiwan



	AGCM	Period	Number	# percentage (%)			
	ACCIN	renou	Number	TS	Cat <3	Cat≥3	
	OBS	1979-2003	115	30%	53%	17%	
	MRI- RCP8.5	1979-2003	87	28%	40%	32%	
		2075-2099	48 (-45%)	17%	42%	42%	
	HiRAM-	1979-2003	128	50%	50%	0.00	
	RCP8.5	2075-2099	65 (-49%)	38%	46%	15%	

- ⇒ MRI underestimated TC # by 35%.
- Strong TC # was underestimated by HiRAM but overestimated by MRI-AGCM
- End of 21st century (RCP8.5):
 - Total # reduces 45~49%
 - ratio of intense TC increases significantly in the future .



- Downscaling can reduce the over/underestimation. Results are closer to observation.
- Ratio of strong TC increase in future

Total Typhoon Prec. of Present



SDII of Present



Fewer TC in MRI results in less rainfall amount.

Rainfall intensity are similar.





TC Affecting Taiwan HiRAM OBS _ MRI Present Present Present HIRAM HIRAM Future Future MRI 1 4 7 10 13 16 19 22 25 (RCP8.5 (RCP8.5 **TC** tracks is highly uncertain in a small domain 120E 125E

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TC # in MRI-AGCM ensemble

MRI 20km	Northwest Pacific TCs				Ratio to Taiwan	TCs Affecting Taiwan				
member	Total #	TS	Cat1-2	Cat 3-5		Total #	TS	Cat1-2	Cat 3-5	
1979-2003										
OBS	641	43%	44%	13%	18%	115	30%	53%	17%	
Present	688	49%	30%	25%	13%	87	28%	40%	32%	
2075-2099										
CO	365(-47%)	36%	29%	36%	13%	48 (-45%)	1 <mark>7%</mark>	42%	42%	
C1	299(-57%)	37%	26%	37%	9%	27 (-69%)	26%	19%	56%	
C2	454(-34%)	34%	29%	37%	14%	65 (- <mark>25%</mark>)	15%	32%	52%	
C3	312(-5 <mark>5</mark> %)	40%	28%	32%	16%	50 (-43%)	34%	28%	38%	

- Future TC # all decrease:
 - Northwest Pacific TC #: c2 > c0 > c3 > c1
 - Taiwan TC #: c2 > c3 ~ c0 > c1.

Again, ratio of strong TC increase in all members.











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TC # in HiRAM ensemble

HiRAM C192	Northwest Pacific TC				Ratio to Taiwan	TC Affecting Taiwan				
member	Total #	TS	Cat1-2	Cat 3-5		Total #	TS	Cat1-2	Cat 3-5	
1979-2003										
OBS	641	43%	44%	13%	18%	115	30%	53%	17%	
Present	1035	76%	24%	0%	15%	150	69%	31%	0%	
2075-2099										
С0	634(-39%)	74%	<mark>26%</mark>	0%	12%	74 (-56%)	<mark>68%</mark>	32%	0%	
C1	620(-40%)	75%	25%	0%	12%	77 (-52%)	69%	31%	0%	
C2	7 <mark>31(-29%)</mark>	72%	28%	0%	12%	89 (- <mark>50%</mark>)	55%	45%	0%	
C3	607(-4 <mark>1</mark> %)	70%	30%	0%	13%	81 (-51%)	54%	46%	0%	

Future TC # all decrease:

- Northwest Pacific: TC # c2 > c0 > c1 > c3.
- Taiwan: TC # c2 > c3 > c1 > c0 (c1, c2, c3 are close)

Difficult to tell intensity changes.

TC in RCM vs. AGCM





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Summary

- ⇒ TC projections of super-high resolution AGCM (∆x=20-25km) : Although HiRAM overestimates and MRI underestimates TC #, similar future change features are found.
 - Future TC # in both models are reduced, associated with smaller low-level vorticity, and mid-level RH & W.
 - TC # reduction rate are similar (~45%) in both models.
 - Ratio of strong TC increases significantly in the future.
 - Model simulated rainfall extremes associated with TC are stronger than TRMM. The projected change of TC rainfall near the center are much stronger than the moisture increase due to additional dynamical effect.

TC projections of MRI-AGCM3.2S ($\Delta x = 20$ km) ensemble:

- Subtropical high over NW Pacific intensified more in c1 & c3, associated with fewer TC in northwest Pacific.
- Northwest Pacific TC #: c2 > c0 > c3 > c1
- Taiwan TC #: c2 > c3 ~ c0 > c1.
- Again, ratio of strong TC increase

Summary

TC projection of HiRAM c912 (Δx =50km) ensemble:

- Subtropical high over NW Pacific also intensified more in c1 & c3, associated with fewer TC in northwest Pacific.
- Northwest Pacific: TC # c2 > c0 > c1 > c3.
- Taiwan: TC # c2 > c3 > c1 > c0 (c1, c2, c3 are close)
- Difficult to tell intensity changes.
- Downscaling can effectively increase insufficient TC intensity in HiRAM c192

Dynamical downscaling for Taiwan area

- More realistic terrain-circulation interaction results in better rainfall distribution in RCM.
- Downscaling also can reduce the TC intensity bias. Results are closer to observation.
- Total TC rainfall amount decrease because of decreased TC frequency.
- Most rainfall intensity increase. Spatial distributions of rainfall intensity changes are affected by the uncertainty in TC track projection.

