Mechanism of Tropical Cyclone Frequency Changes Due to Global Warming

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1. Introduction

Recent climate models (high-resolution AGCMs) consistently project that the global tropical cyclone (TC) frequency will decrease in the future greenhouse gas (GHG) warmed climate, but there is a large uncertainty in the regional TC frequency changes (Knutson et al. 2010). In the present study, the mechanism of global and regional TC frequency changes due to global warming is explored.

2. Mechanism of TC Frequency Changes (Hypothesis)

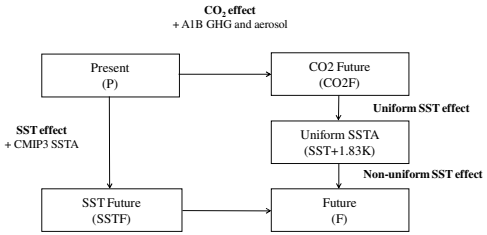
・The changes in global TC frequency are closely related to the changes in upward mass flux.
・Relation between precipitation (P) , upward mass flux (ω) and dry static stability (S):

Thermodynamic equation: $\omega S \approx \alpha P$ (α is a scaling constant), $\frac{\Delta\omega}{\omega} \approx \frac{\Delta P}{P} - \frac{\Delta S}{S}$

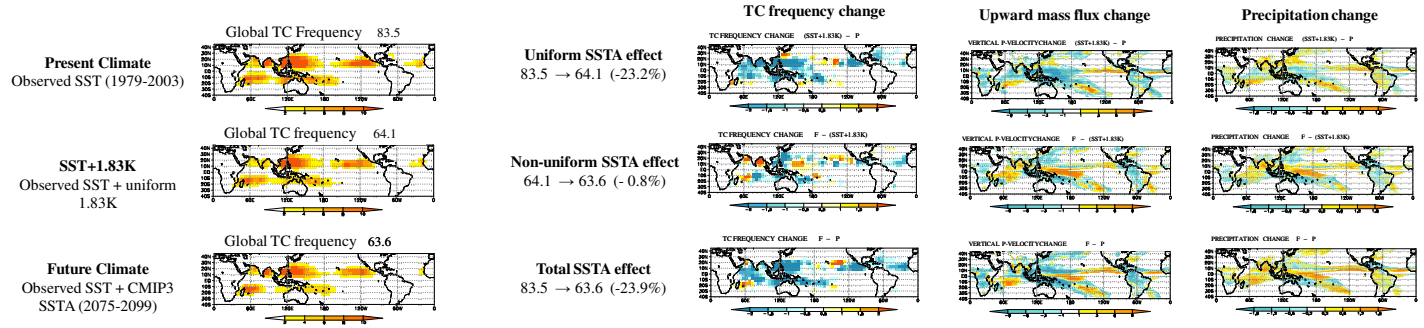
Effect		Global change					Regional change
		Radiative cooling	Precipitation	Stability	Upward mass flux	TC frequency	TC frequency
CO_2	CO_2	Decrease	Decrease		Decrease	Decrease	
	Other GHG	Increase	Increase		Increase	Increase	
SST	Uniform SSTA	Increase	Increase	Increase	Decrease	Decrease	
	Non-uniform SSTA						Shift

3. Model and Experiment

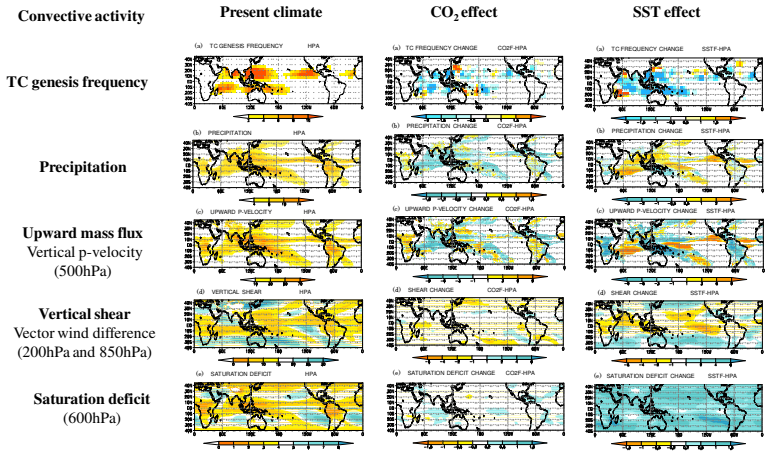
・Five 25year runs are conducted using the MRI-AGCM3.2 with 60km resolution.
・Observed SST (1979-2003) is prescribed for the present climate run, while CMIP3 ensemble mean SSTA (2075-2099) is added for the future climate run.



4. Global Change and Regional Change (Uniform and Non-uniform SSTA effects)



5. CO_2 effect and SST effect



SUMMARY

Global TC frequency reduction

- CO_2 effect and uniform SSTA effect are responsible for the reduction of global TC frequency in the future GHG warmed climate.
- CO_2 effect is a result of overlap effect of CO_2 and water vapor long wave absorption bands, while uniform SSTA effect is a result of increased dry static stability.
- Both CO_2 effect and uniform SSTA effect cause a reduction of upward mass flux, leading to the reduction of global TC frequency.
- Most important remaining question is how the reduction of upward mass flux causes the reduction of TC frequency.

Regional TC frequency change

- Non-uniform SSTA effect (effect of SSTA relative to the tropical mean SSTA) is mainly responsible for the regional TC frequency.
- Non-uniform SSTA effect causes shift of active convection area, leading to the shift of TC genesis area. It causes little change in global TC frequency.

Acknowledgement

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References

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