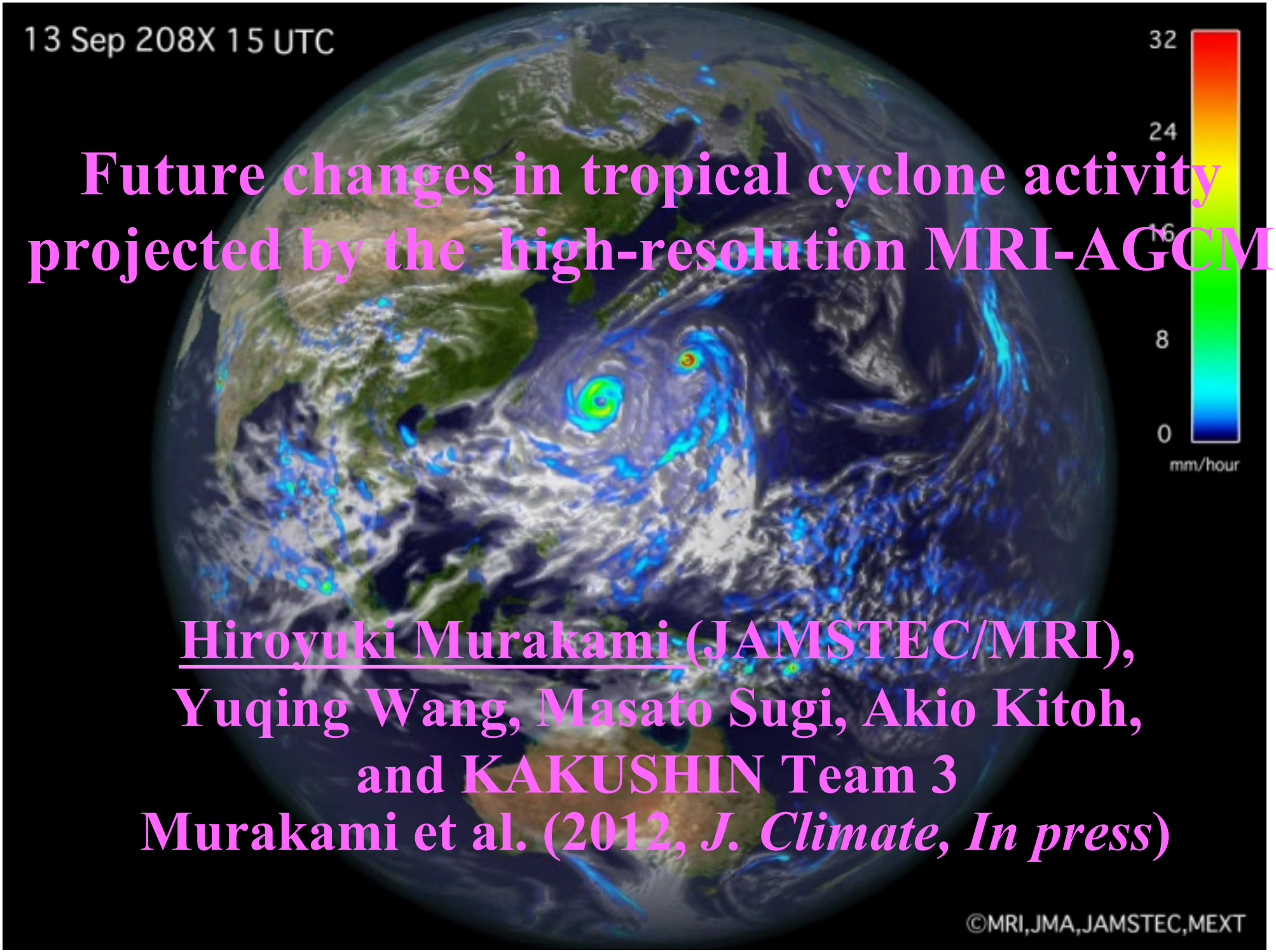

Future changes in tropical cyclone activity projected by the high-resolution MRI-AGCM

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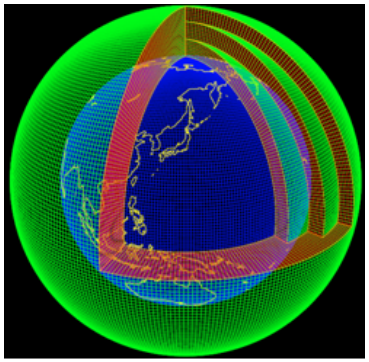
and KAKUSHIN Team 3

Murakami et al. (2012, *J. Climate*, *In press*)

Outline

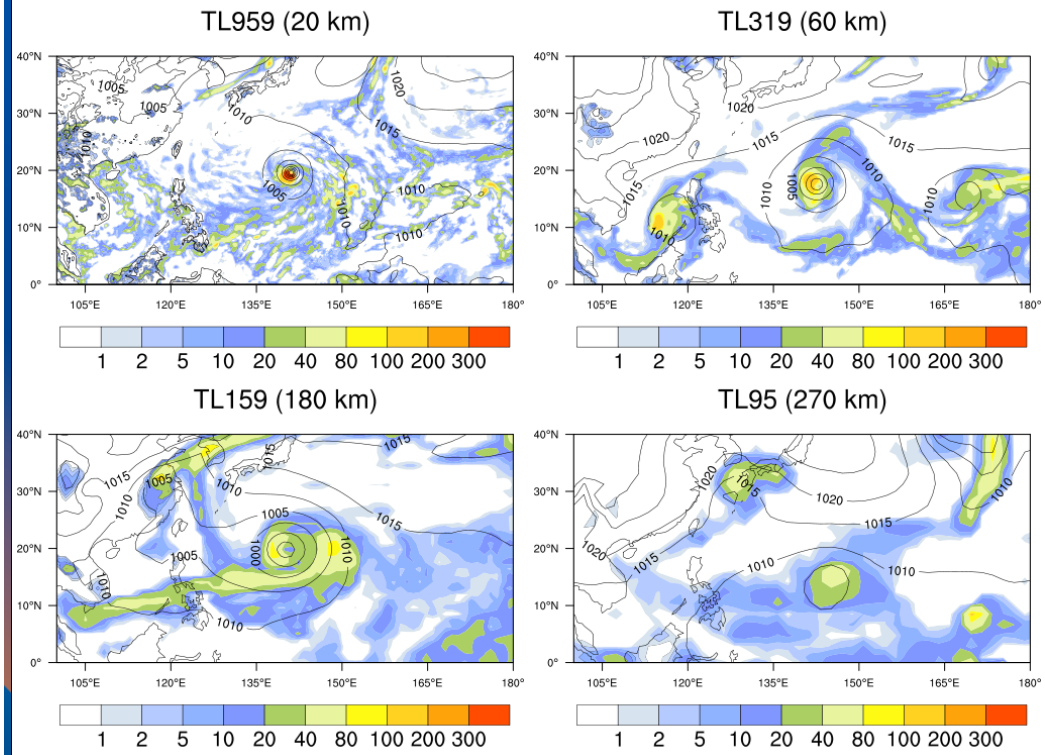
- History of development of 20-km-mesh MRI-AGCM
- New high-resolution (20-km-mesh) MRI-AGCM and projected future change in TC activity
- Summary



20 km-mesh grids

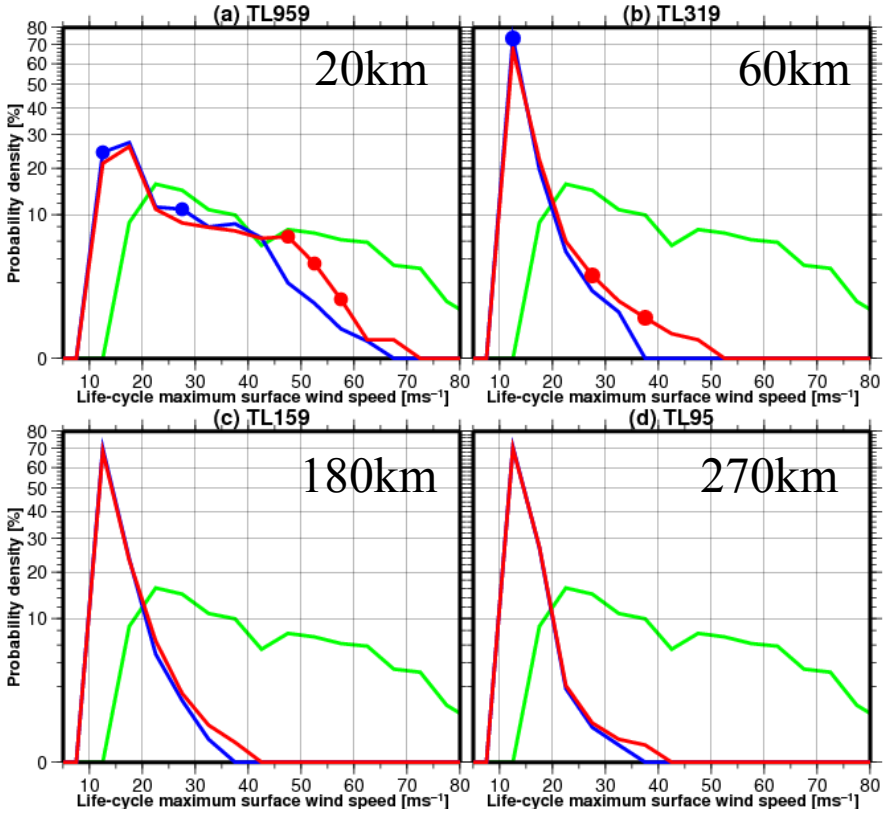
Why do we need a high resolution model?

·Projections by previous climate models are not reliable because the models are too coarse to resolve TC structures.



<u>High resolution model yields realistic TC structures.</u>

·Only models finer than 60 km-mesh show future increase in intense TCs (Knutson et al. 2010; Murakami and Sugi, 2010).



Observations (1979-2003)

Present 25year (1979-2003)

Future 25year (2075-2099)

● : significant increase at 95% level

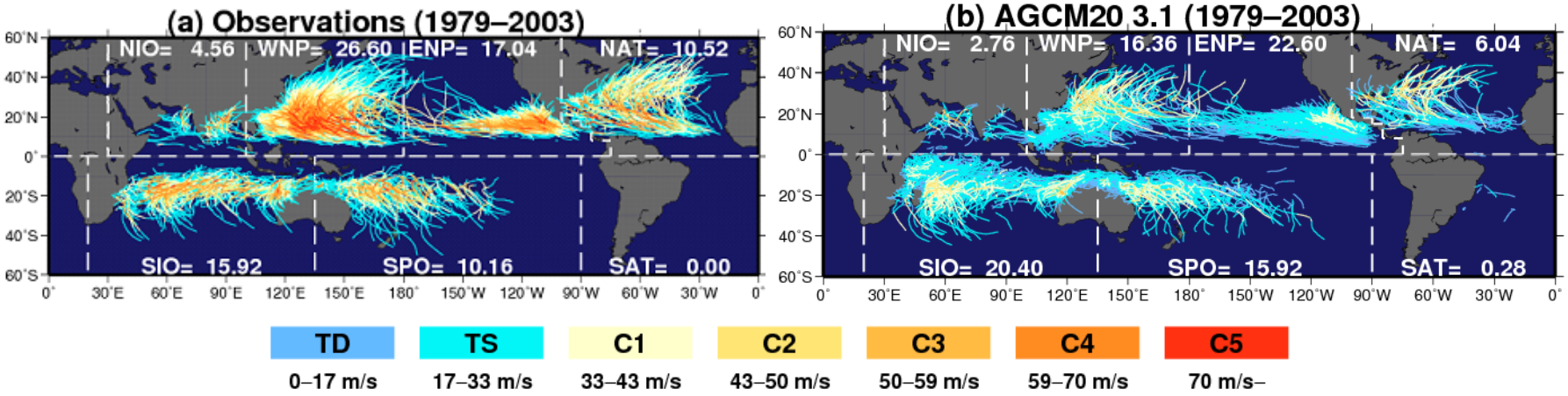
● : significant decrease at 95% level

History of 20-km-mesh MRI-AGCM

MRI-AGCM3.1 (since 2007) Previous version

This model was developed from JMA operational NWP model.
First 20-km mesh global model which simulates for multi decades (Oouchi et al. 2007; Kitoh et al. 2009; Murakami and Wang 2010)

The version had marked biases in geographical distribution of TCs and TC intensity.



MRI-AGCM3.2 (since 2009) New version

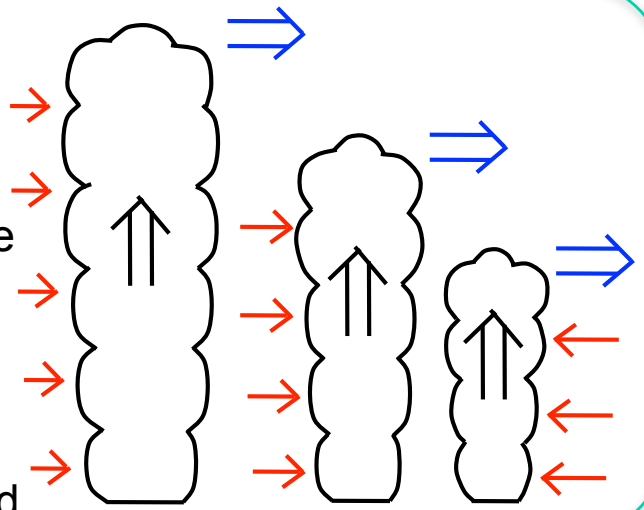
AMIP-type 25 years experiments are conducted using observed SST for the present-day climate.
Future projections of 25 years are conducted by prescribing CMIP3 ensemble mean SST and clustered SSTs.

Comparisons between v3.1 and v3.2 MRI-AGCMs

	Previous version (contributed to IPCC AR4)	New version (for IPCC AR5)
	MRI-AGCM 3.1 (Mizuta et al. 2006, *JMSJ*)	MRI-AGCM 3.2 (Mizuta et al., 2012)
Horizontal resolution	TL959 (20km)	
Vertical resolution	60 levels (top at 0.1hPa)	64 levels (top at 0.01hPa)
Time integration	Semi-Lagrangian	
Time step	6minutes	10minutes
Cumulus convection	Prognostic Arakara-Schubert	Yoshimura (Tiedtke-based)
Cloud	Smith (1990)	Tiedtke (1993)
Radiation	Shibata and Aoki (1989) Shibata and Uchiyama(1992)	JMA (2007)
GWD	Iwasaki et al. (1989)	
Land surface	SiB ver0109(Hirai et al.2007)	
Boundary layer	MellorYamada Level2	
Aerosol (direct)	Sulfate aerosol	5 species
Aerosol (indirect)	No	

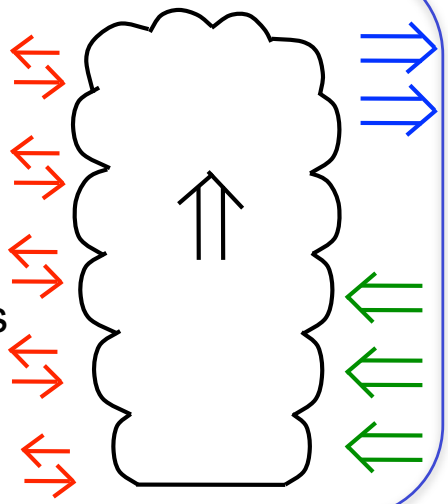
Arakawa-Schubert

Multiple convective updrafts with different heights depending on entrainment rates explicitly calculated

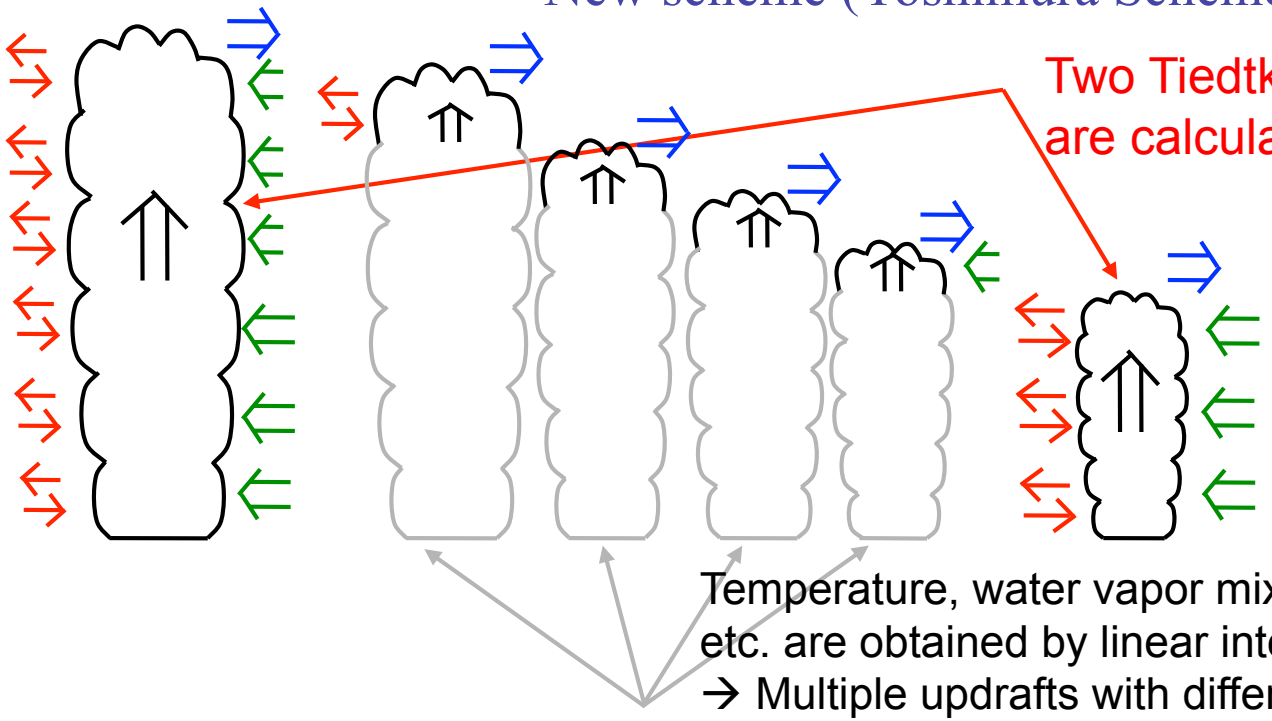


Tiedtke

Only a single convective updraft but represented as a more derailed entraining and detraining plume



New scheme (Yoshimura Scheme; Yukimoto et al. 2011)

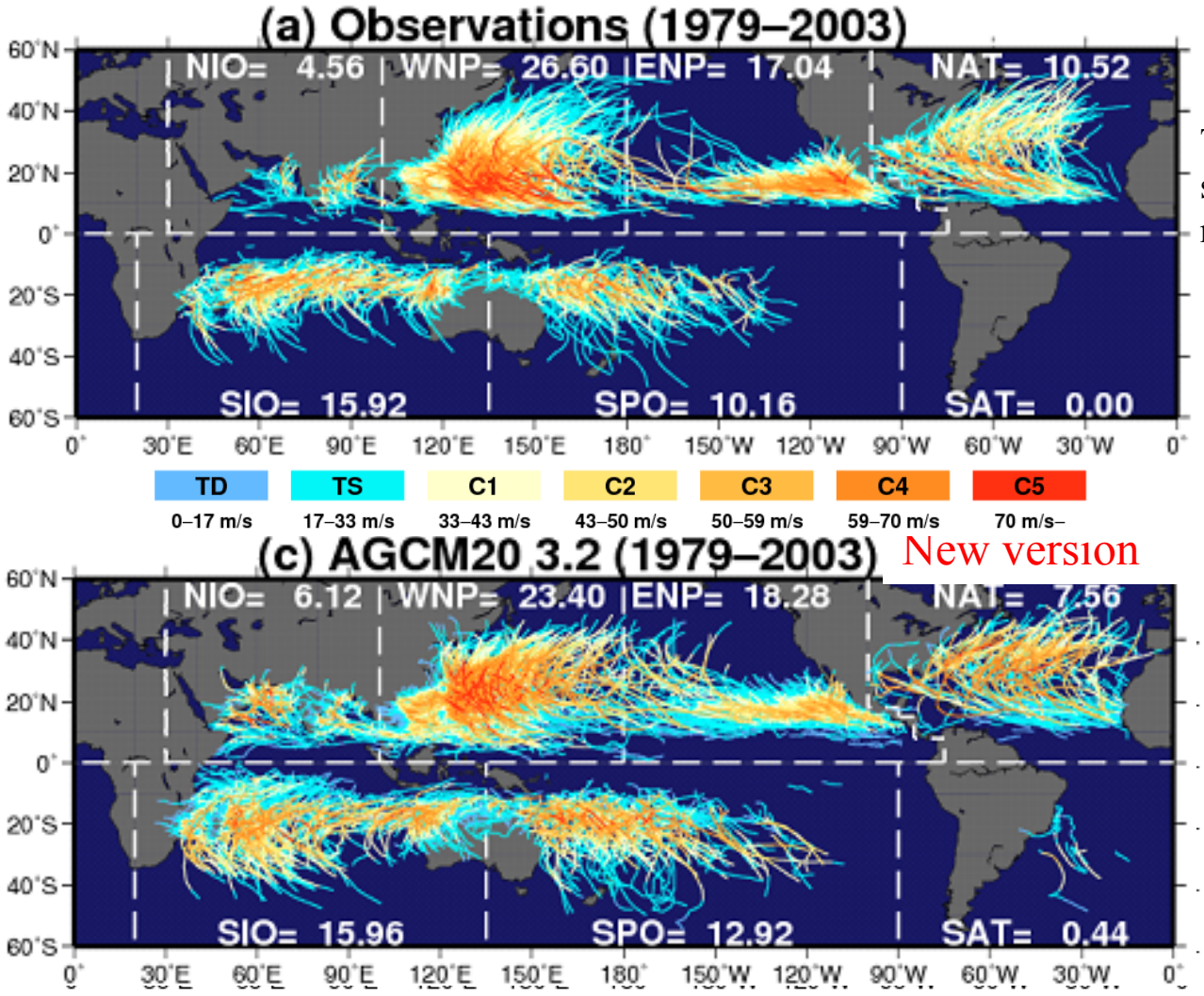


Two Tiedtke-type updrafts are calculated

Updrafts between min. and max. rates are assumed to be continuously present.

Temperature, water vapor mixing ratio, entrainment rate etc. are obtained by linear interpolation between the two.
→ Multiple updrafts with different heights are represented.

Improvements in TC climatology by the new 20-km mesh MRI-AGCM



The number for each basin shows annual mean number of TCs.

·Predicted TC number in the WNP is underestimated. Improved

·TC intensity is weak compared with observations Improved

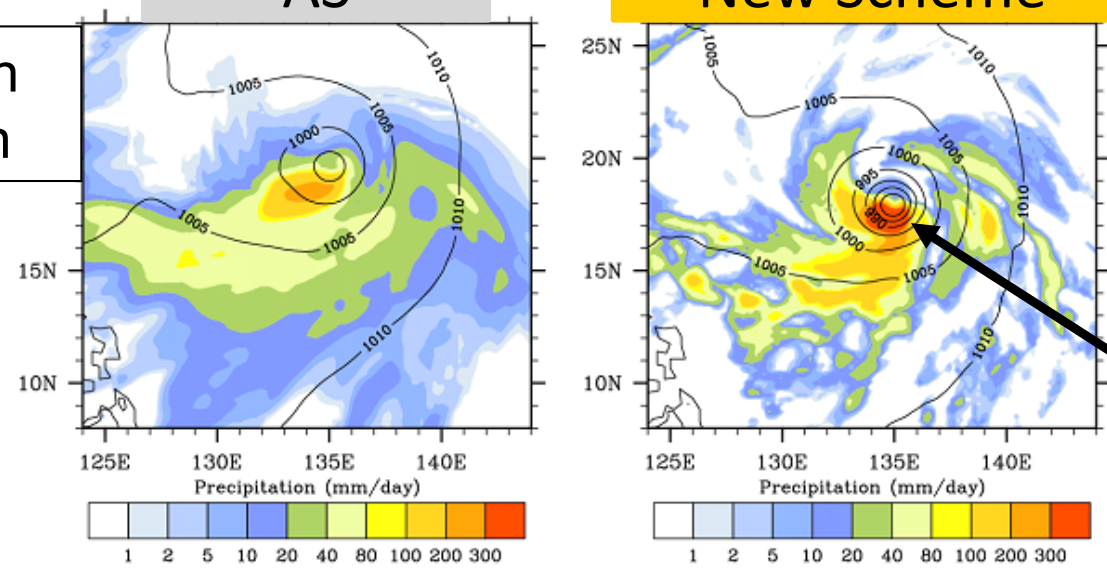
TC Structure

Snapshots of two 48-h simulations using different cumulus convection schemes

AS

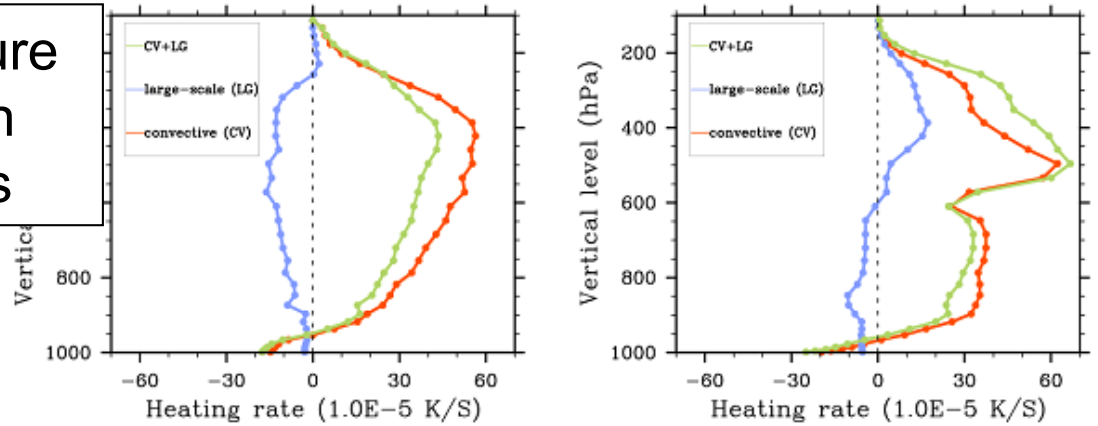
New Scheme

1-hour mean precipitation

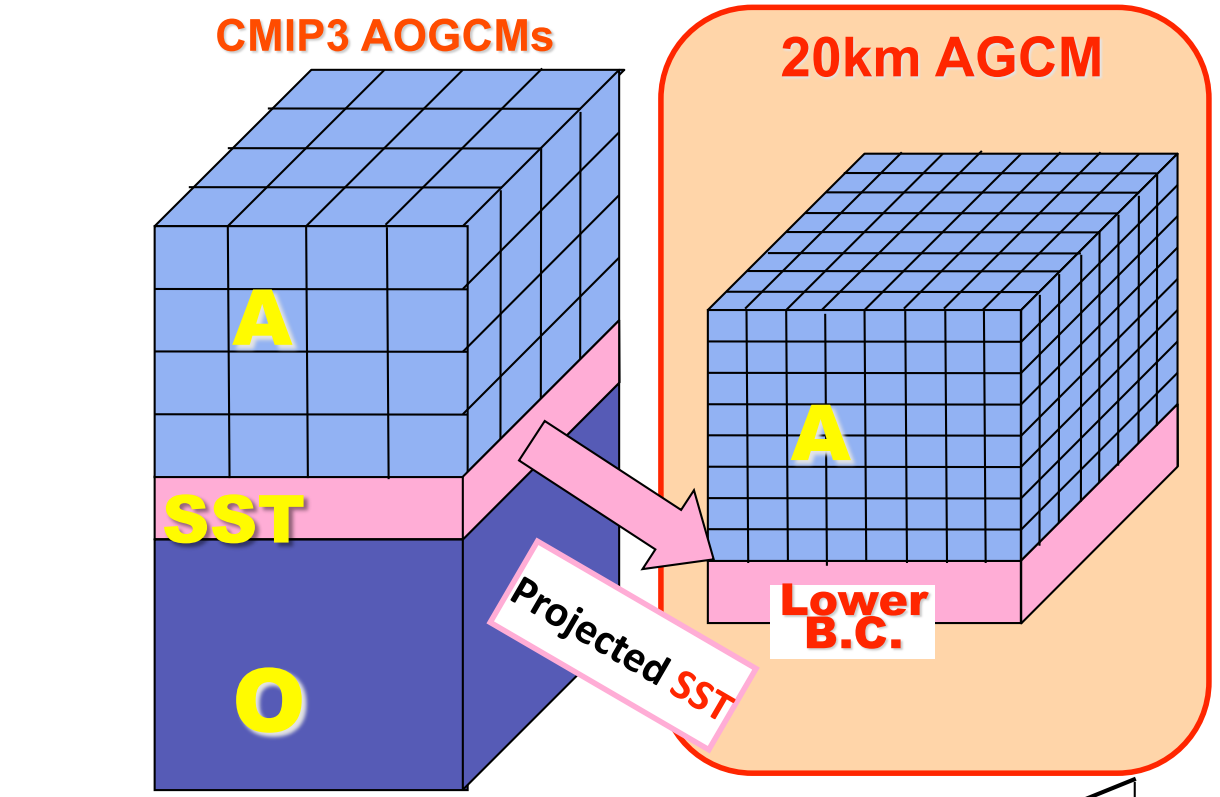


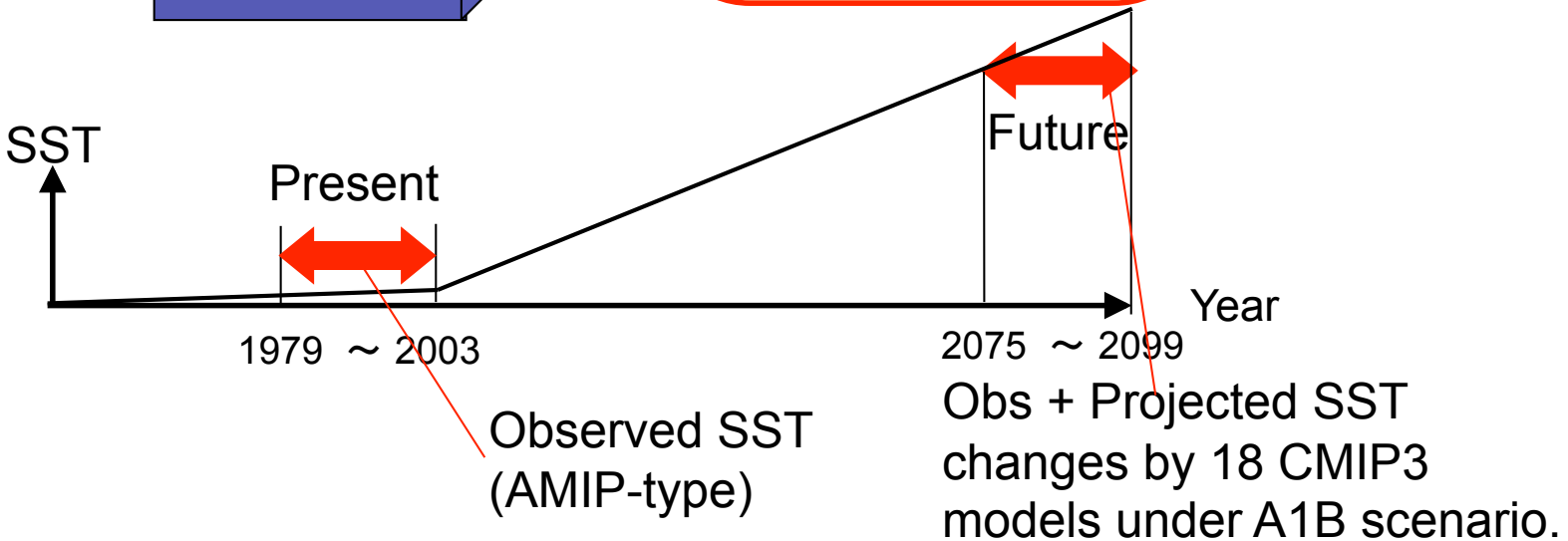
Precipitation is intense within the eyewall region using the new scheme.

Vertical structure of area mean heating rates



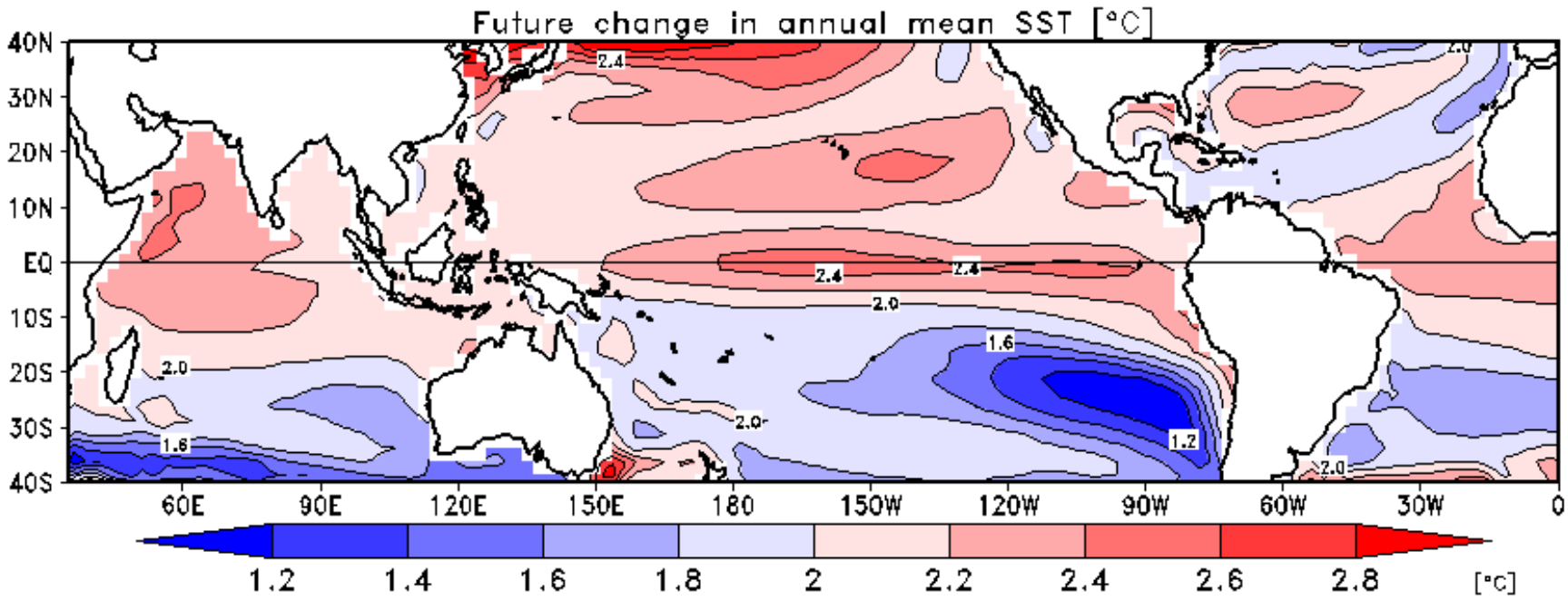
Time-slice Experiment





Spatial pattern of prescribed future changes in SST

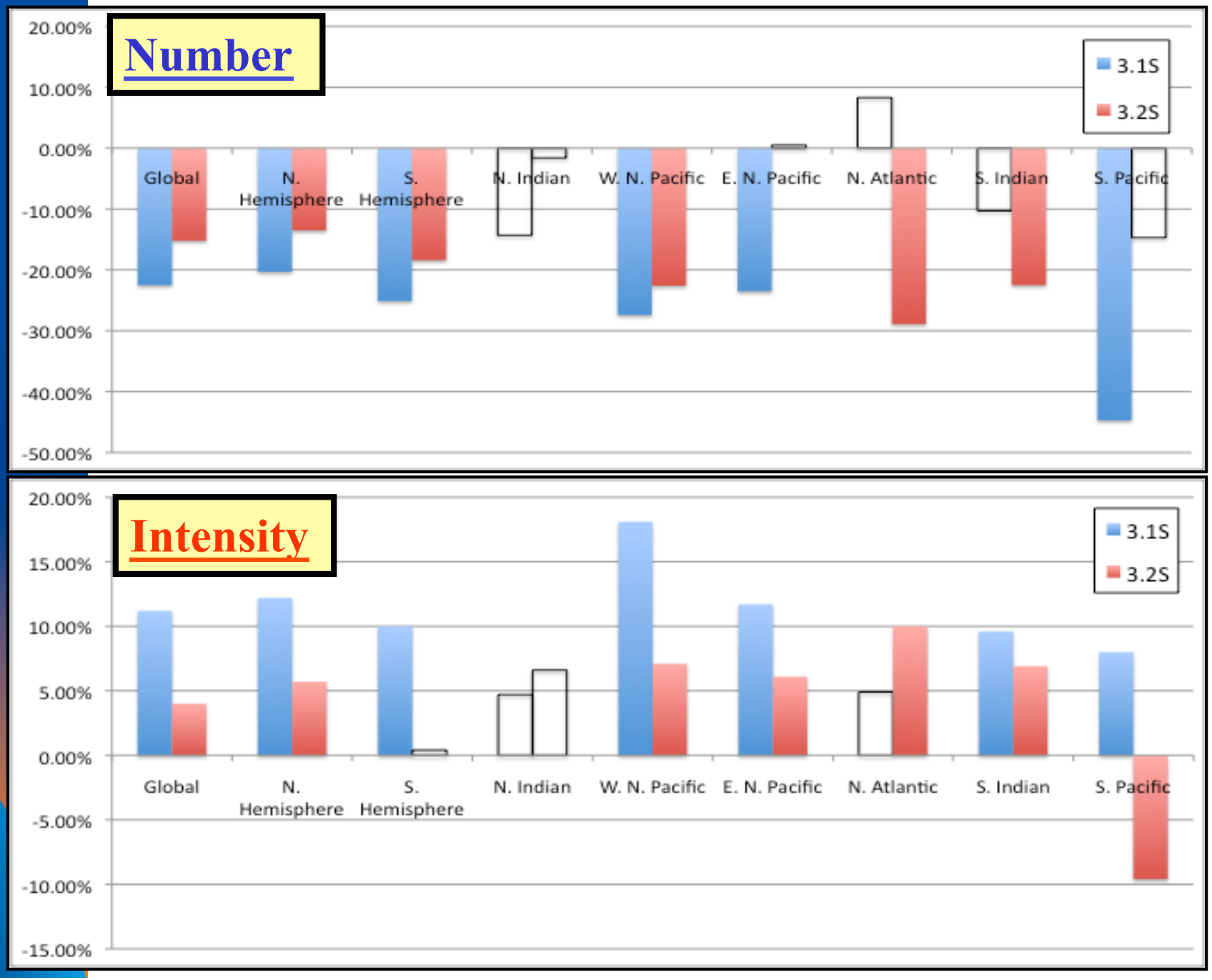
21st (2075–2099) – Present (1979–2003)



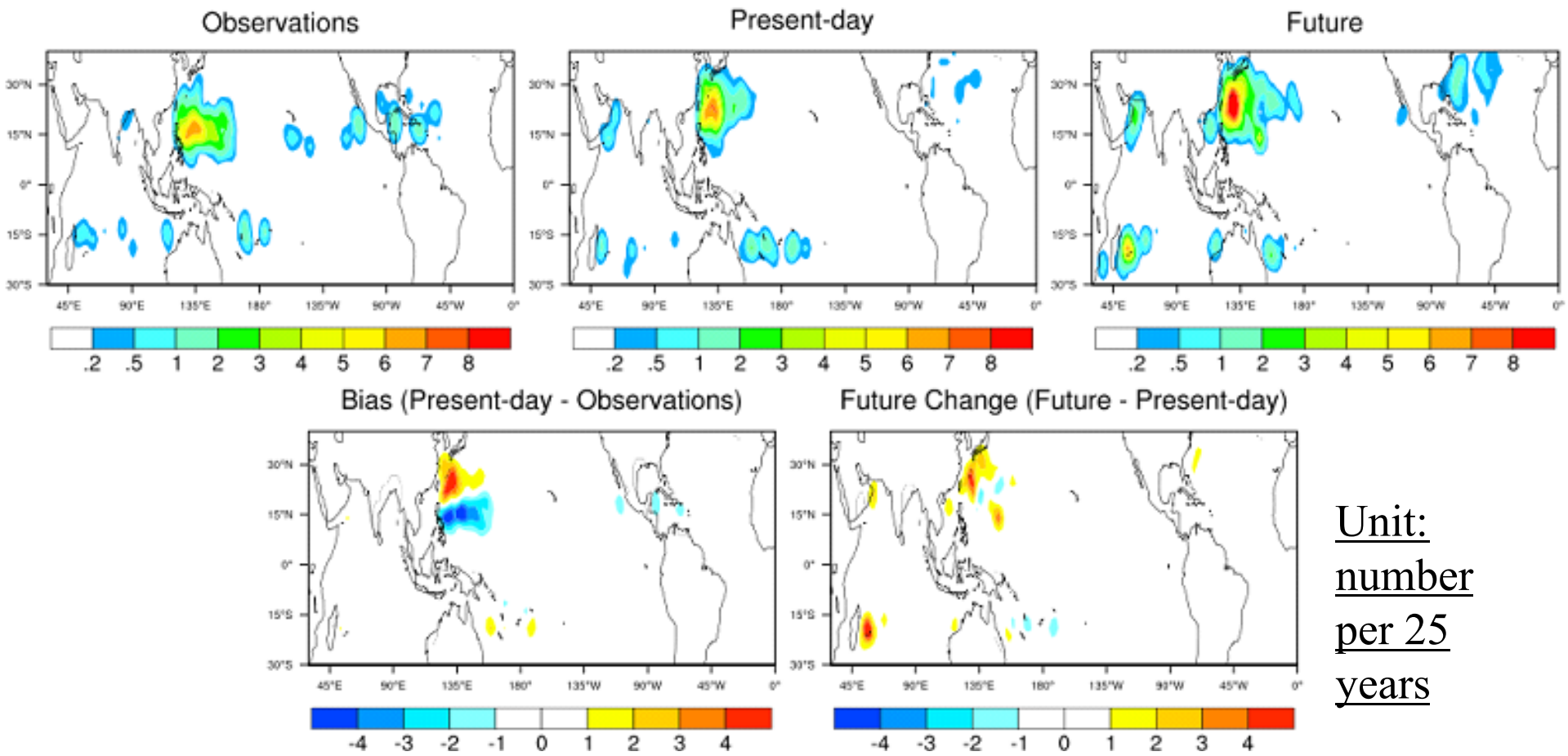
- Relatively larger increase in SST in the Northern Hemisphere than in the Southern Hemisphere.

- The SST increase is the largest in the tropical Central Pacific (Xie et al. 2010).

Future changes in TC number and intensity



Future change in frequency of Category 5 (C5) occurrence



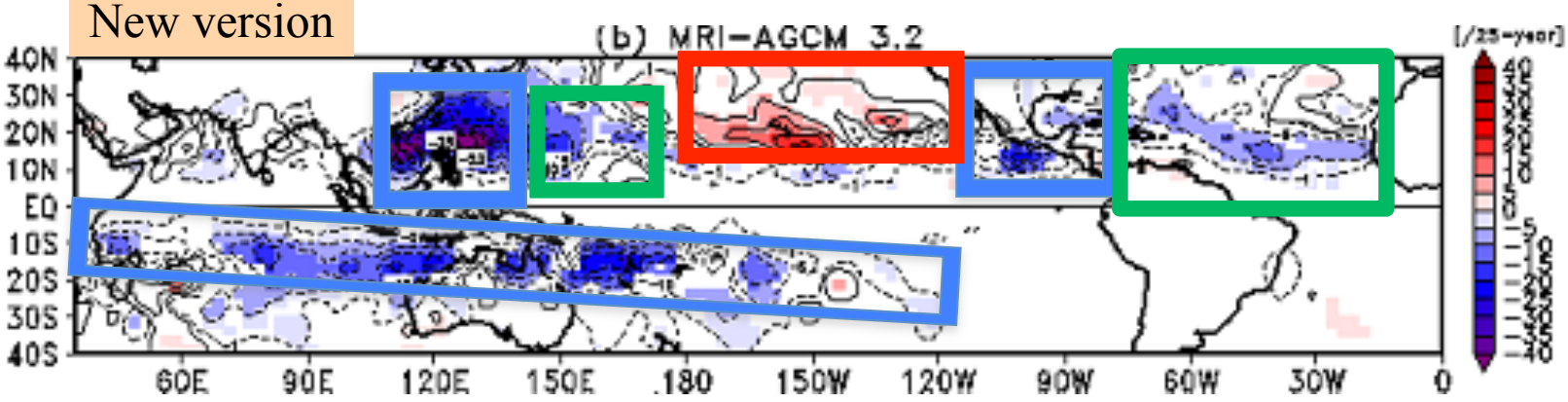
Unit: number per 25 years

·The frequency of C5 TCs appears to increase in the northern portion of the WNP basin.

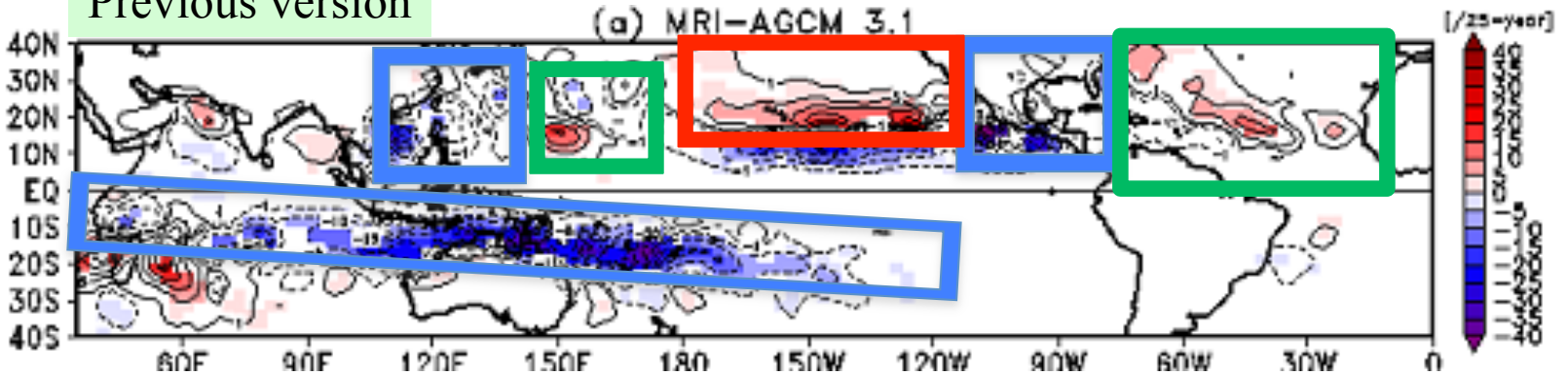
·Note that the tracks of C5 TCs in the present-day simulation show a northward shift relative to observations. This bias should be taken into account and corrected when interpreting the results.

Comparison of projected future changes in TC frequency between versions

New version



Previous version



·Both versions show significant decrease in TC frequency over the South Pacific and western portion of WNP.

·Both versions show significant increase in TC frequency over the central Pacific.

·Inconsistent in the eastern quadrant of WNP and NAT.

Summary

We have developed a new 20-km-mesh high-resolution AGCM for addressing future changes in TC activity. New findings are as follows.

(a) Compared with the previous version, the new version yields a more realistic global distribution of TCs. Moreover, the new version is able to simulate extremely intense TCs (Categories 4 and 5).

(b) Future projections consistently suggest a significant decrease in TC genesis number in global, both hemispheres, western WNP, and SPO, whereas they suggest pronounced increase in the Central Pacific.

(c) A significant increase in the frequency of intense TCs with global warming occurs in both versions. However, the increase is smaller in the new version than in the previous version. New version also projects a marked decrease in mean intensity in South Pacific Ocean.

(d) Future changes in TC frequency at regional scales are inconsistent among the ensemble experiments. These discrepancies highlight continuing uncertainties in the future changes in regional TC activity. Further study is needed to explore the uncertainties.