Change in the Precipitation Intensity over East Asia and in Tropical Cyclone Frequency in the 228-year Simulations by a Global Atmospheric Model with 60-km Grid Size

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Contents

The 228-year simulations with a global atmospheric model with 60-km grid size

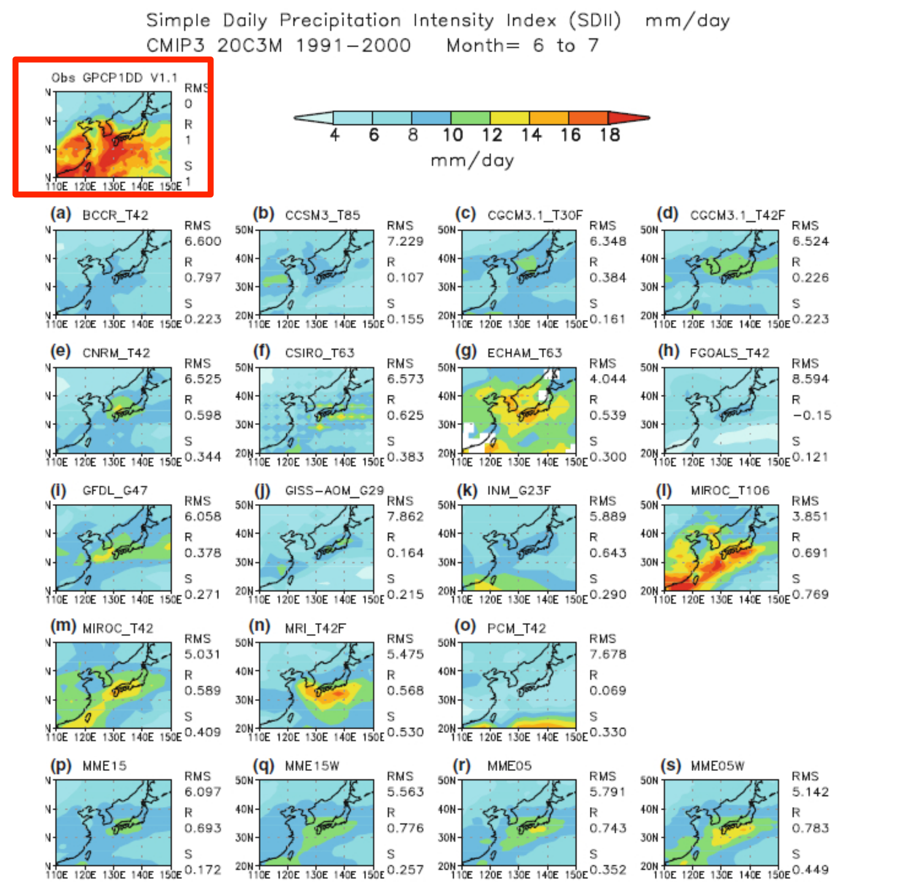
1. Reproducibility and projections in the precipitation intensity over East Asia by Kusunoki and Mizuta (2013) in JGR
2. Decreasing trend in tropical cyclone frequency by Sugi and Yoshimura (2012) in GRL

Background

for reproducibility in the precipitation intensity over East Asia

- Most climate models underestimate precipitation intensity mainly due to low horizontal resolution.
- These systematic biases reduce the reliability of future climate projections with GCMs.

How does a high horizontal resolution model capture the precipitation intensity and project future changes?



e as Fig. 1, but for Simple Daily precipitation Intensity) for June to July. Climatology is calculated only if SDII or whole years of target period at each grid point. No *shading region* denotes missing data. The five best models based on *S* of SDII are model e, f, l, m, and n

Kusunoki and Arakawa (2012, CD)

MRI-AGCM3.2H

Item	Content
Horizontal resolution	60km , TL319
Vertical resolution	64 levels 0.01 hPa top
Time step	15 minutes
Cumulus	Yoshimura (AS/Tiedke hybrid)
Cloud	Tiedtke (1993)
Radiation	JMA (2004r1)
Gravity drag	Iwasaki et al (1989)
Top condition	Rayleigh friction
Sea surface	MRI-scheme + skin SST
Land surface	SiB0109
Boundary layer	Mellor-Yamada Level 2
Aerosol direct	5 species
Aerosol indirect	None

Experimental Setup

<u>Experimental Setup</u>

- Integration period: 1872 to 2099
- Ensemble Size: 3
- Boundary conditions : in the next slide

Boundary conditions and External Forcings

Period	**1872-2000**	**2001-2005**	**2006-2099**
SST and Sea ice	HadISST1		HadISST+CMIP3 Multi-model ensemble, A1B
Sea ice thickness	Observed climatology Bourke and Garrett (1987)		CMIP3 Multi-model ensemble, A1B
Greenhouse Gas	CO2,CH4,N2O,CFC Observation	CO2,CH4,N2O,CFC A1B	
Aerosol	MRI-ESM, 5-year average, A1B - Volcanic eruption: Oct 1986 - Present - Before1970: 1969-1973 average - After 2097: 2092-2096 average		
Ozone O3	MRI-CCM CCMVal , 5-year average, A1B - Before1960: 1959-1963 average		

Precipitation Indices

Name	Variable	Unit
PAVE	Annual precipitation	mm/ day
SDII	Simple Daily precipitation Intensity Index Total precipitation / number of rainy days rainy day : Precipitation >= 1 mm/day	mm/ day
R3d	Maximum 3-day precipitation total	mm
R5d	Maximum 5-day precipitation total	mm
R10d	Maximum 10-day precipitation total	mm

Observational Precipitation data

Name	Period	Horizontal Resolution	Time Resolution	Region
GPCP 1DD v1.1	1997-2008/ 12 years	1.0 deg	Daily	Global
APHRODITE	1951-2007/ 57 years	0.25 deg	Daily	Asia/ Land Only

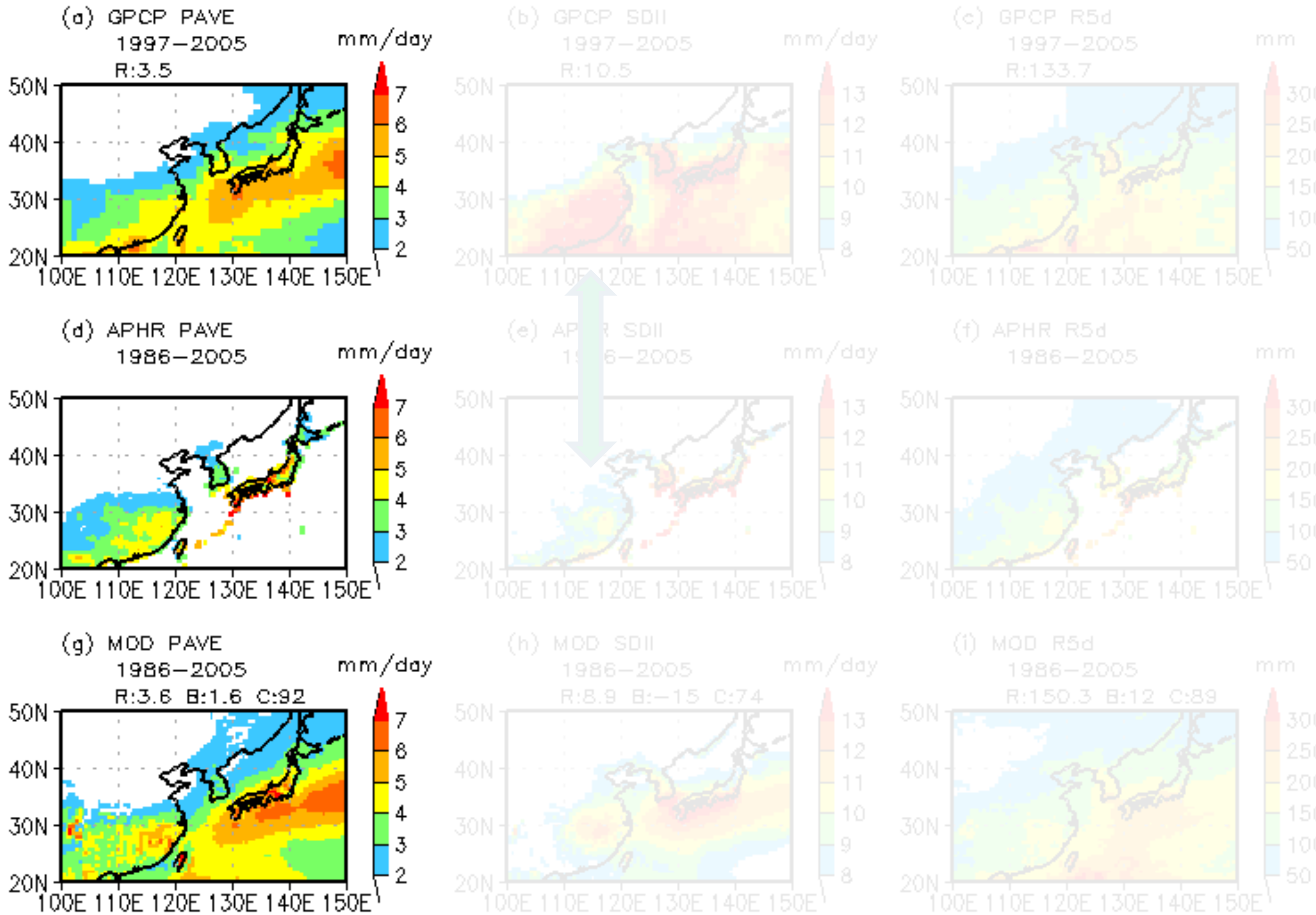
Climatological Index Values

PAVE SDII R5d

GPCP1DD

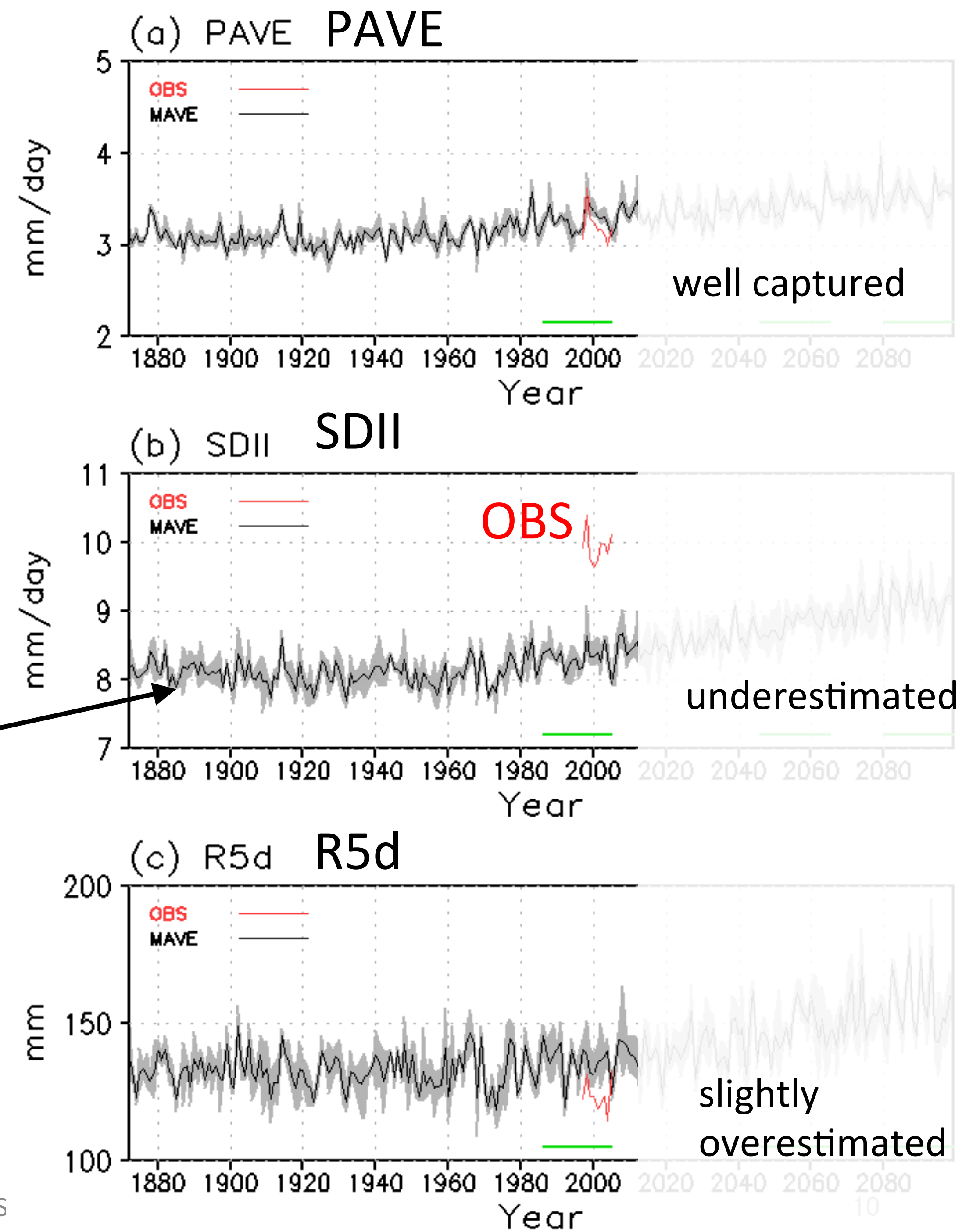
APHRODITE

MRI-AGCM



Kusunoki and Mizuta (2013, JGR)

Regional Average
(100-150E, 20-50N)

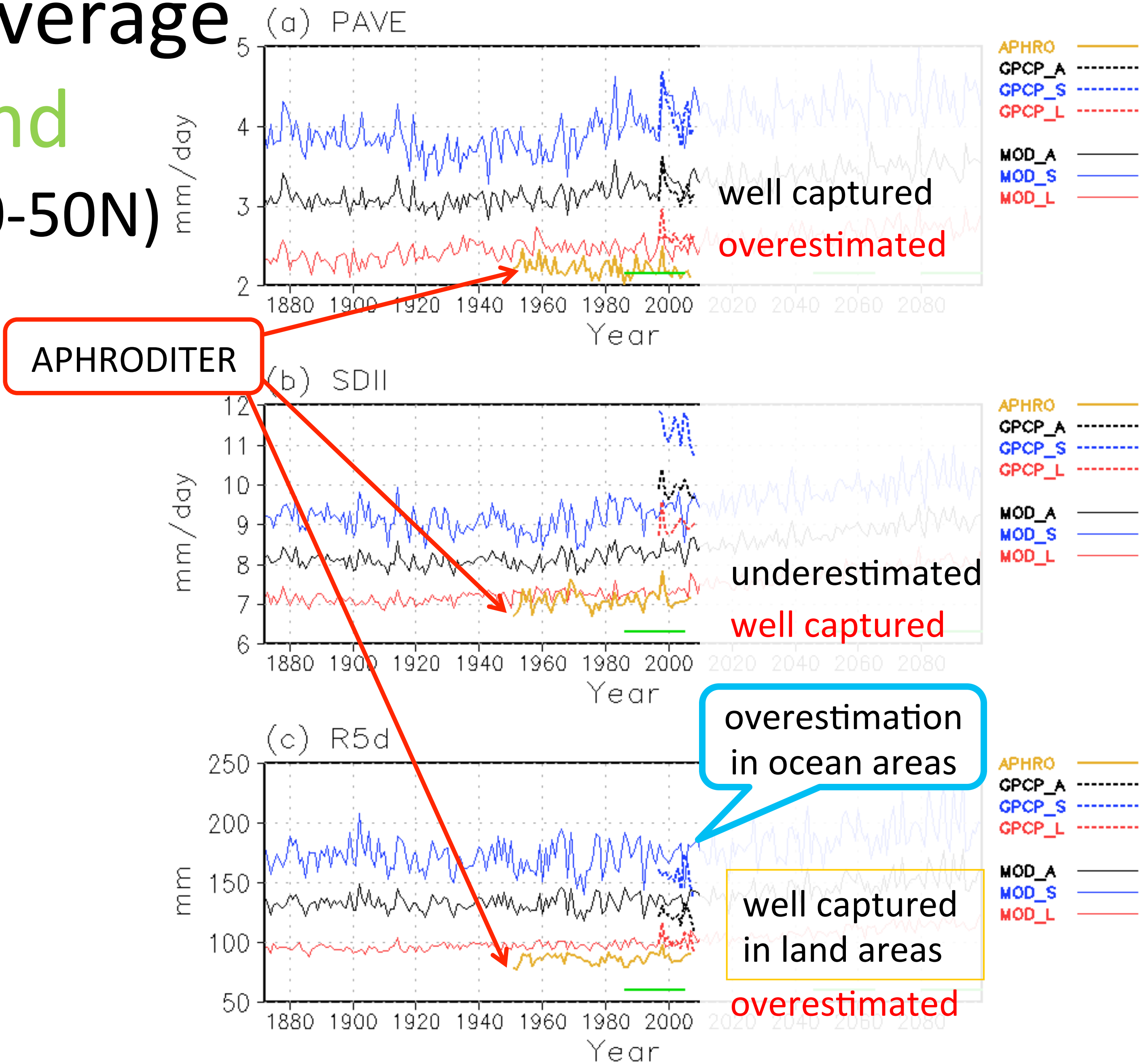


Thick black line: Model Ensemble Average

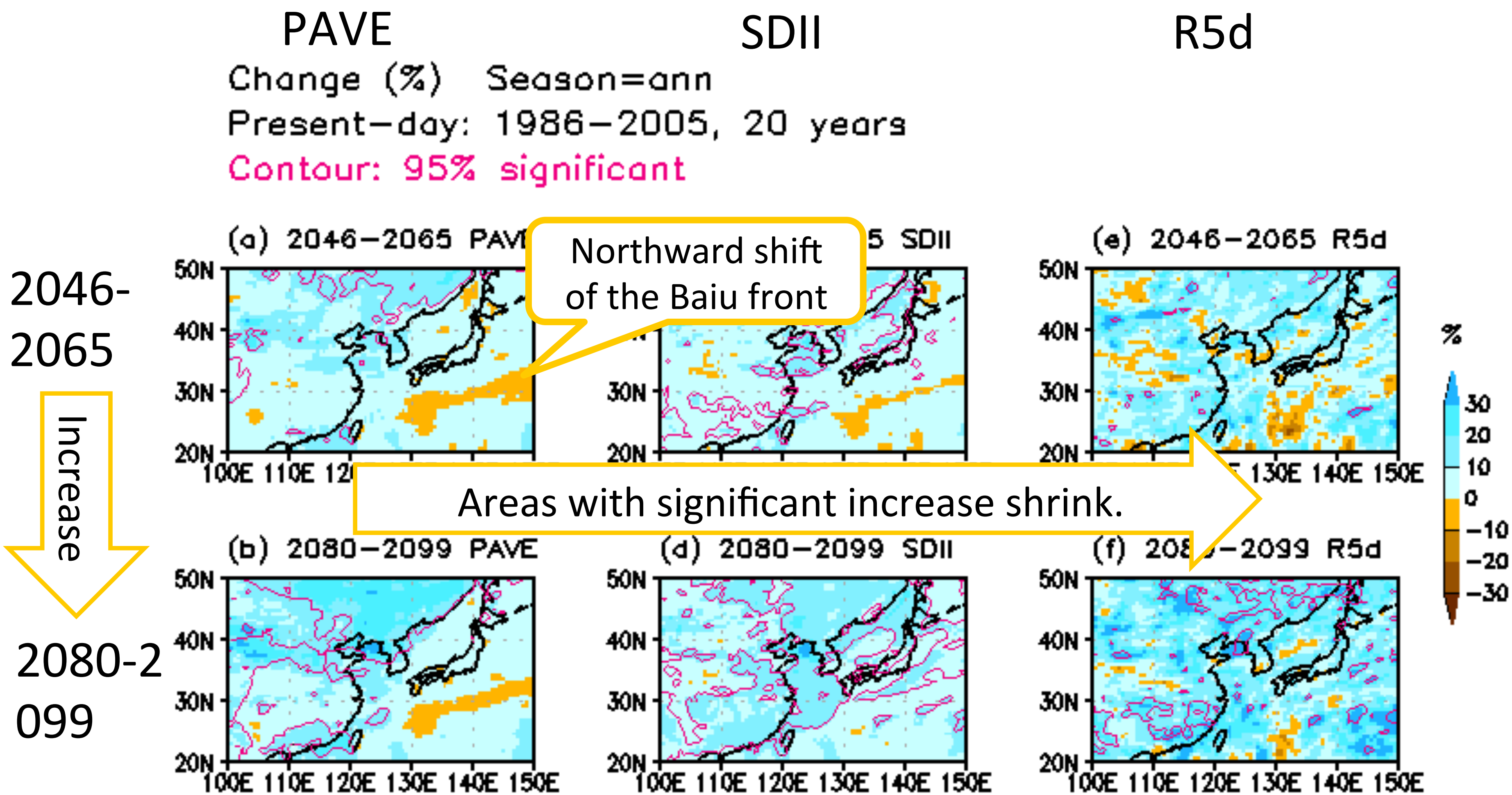
Gray shade: Range of individual runs

Kusunoki and Mizuta (2013, JGR)

Regional Average
All/Sea/Land
(100-150E, 20-50N)



Changes relative to present–day climate: 1986-2005



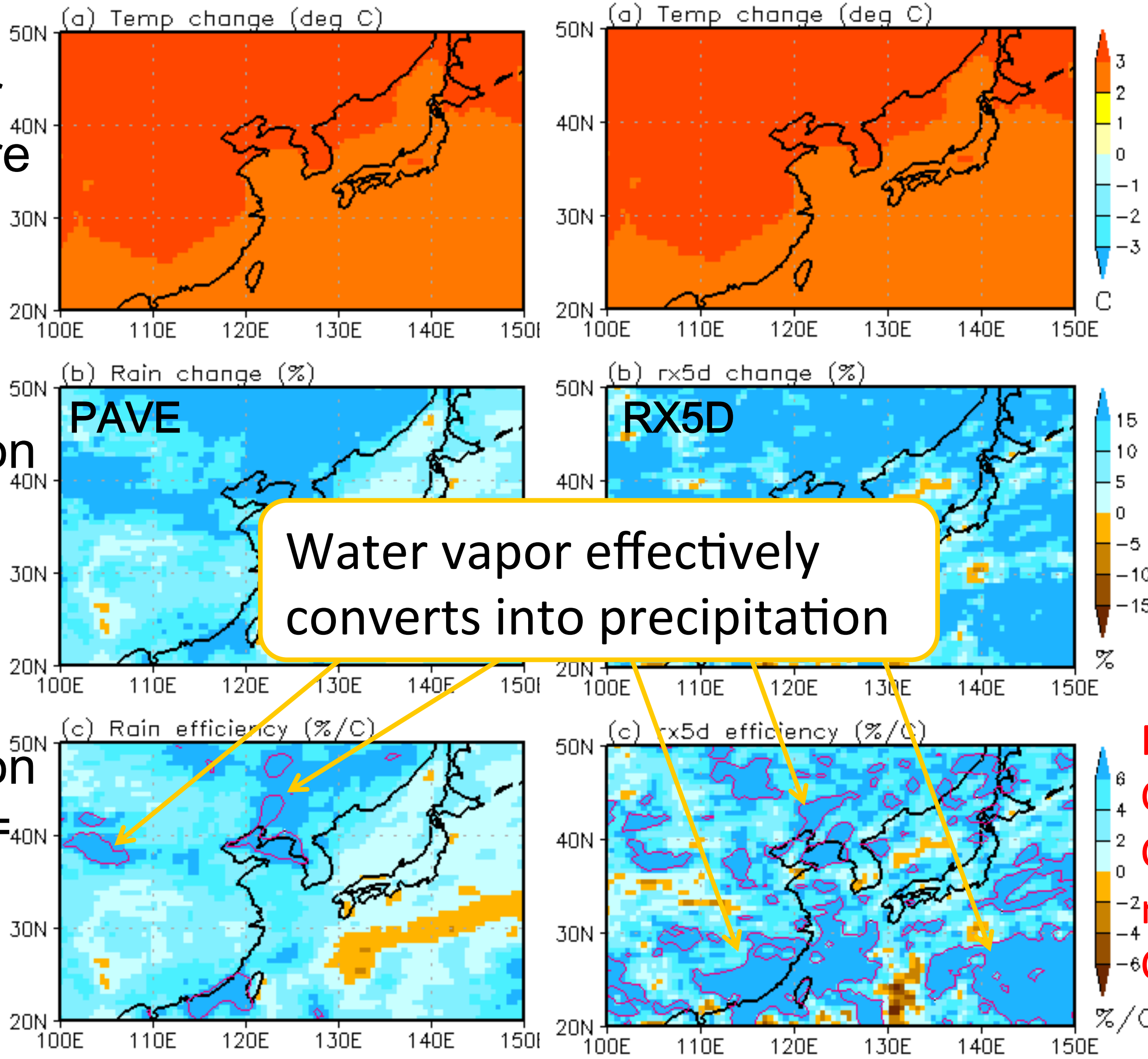
Ensemble average

Change per 1deg C warming

Surface air temperature change

Precipitation change

Precipitation efficiency = $\Delta P/\Delta T$



Present: 1986-2005
Future : 2080-2099

Ensemble average

Red contour : Clausius-Clapeyron relation 7.5 %/C

Precipitation efficiency

East Asia average
(100-150E, 20-50N)

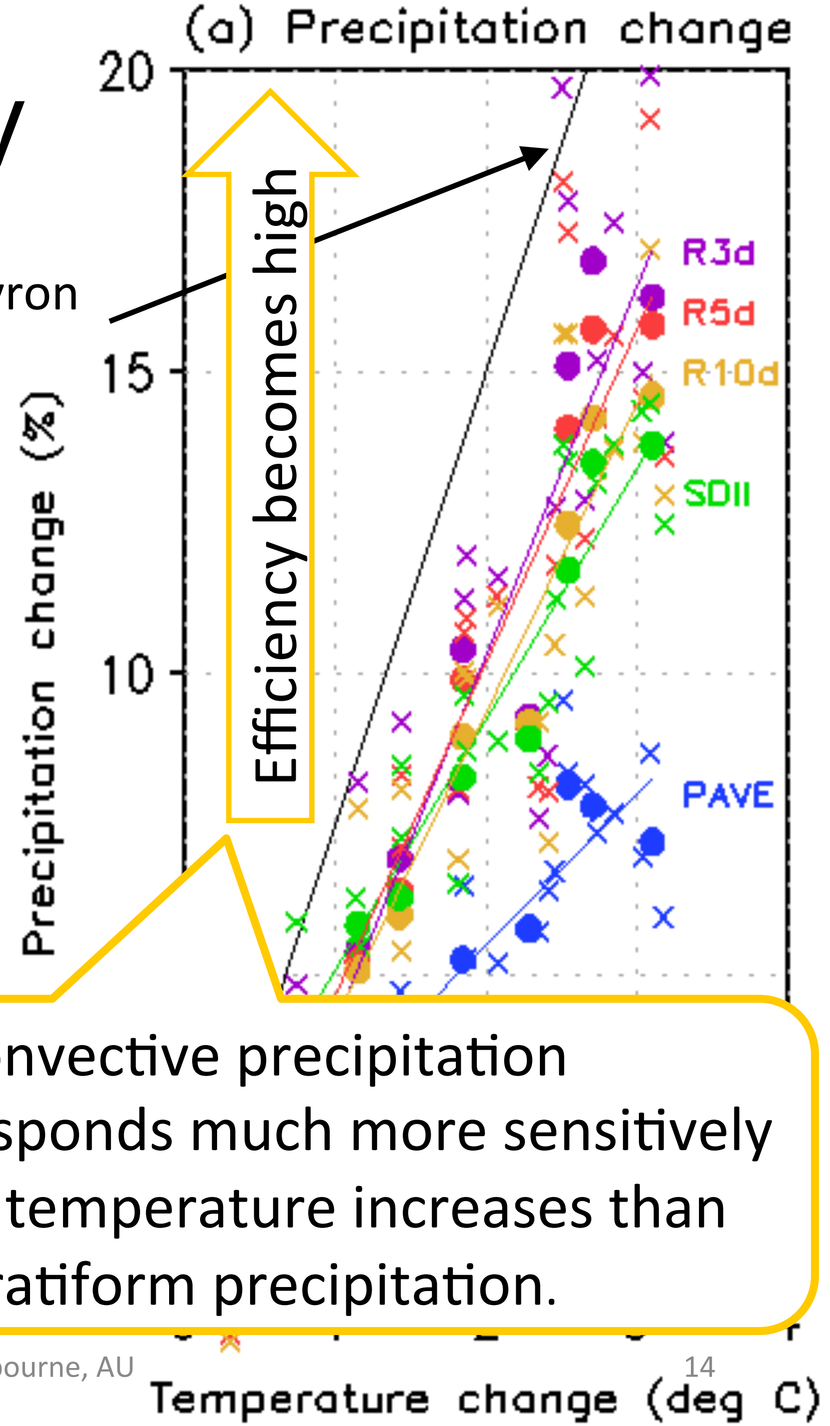
Clausius-Claperyron relation 7.5 %/C

Decadal average
from 2010-2019 up to 2090-2099

X : Individual runs

● Ensemble average

Gradient of line :
Precipitation efficiency =
Precip change / SAT change



Convective precipitation responds much more sensitively to temperature increases than stratiform precipitation.

Summary for Topic 1

1. MRI-AGCM3.2H captures the precipitation indices well in the present-day climate.
2. All the precipitation indices will increase in the 21st century.
3. Conversion of precipitation from water vapor is more efficient for short-term precipitation than long-term precipitation.

Background

for decreasing trend in tropical cyclone frequency

- Observed changes in tropical cyclone (TC) frequency in the 20th century are controversial (e.g. Knutson et al. 2010)
- Recent models consistently project a reduction of global TC frequency in the future due to global warming. (e.g. Sugi et al. 2002; Knutson et al. 2010)

Then, how do the models simulate the past long-term variation of TC frequency?

Long-term variation of TC Frequency

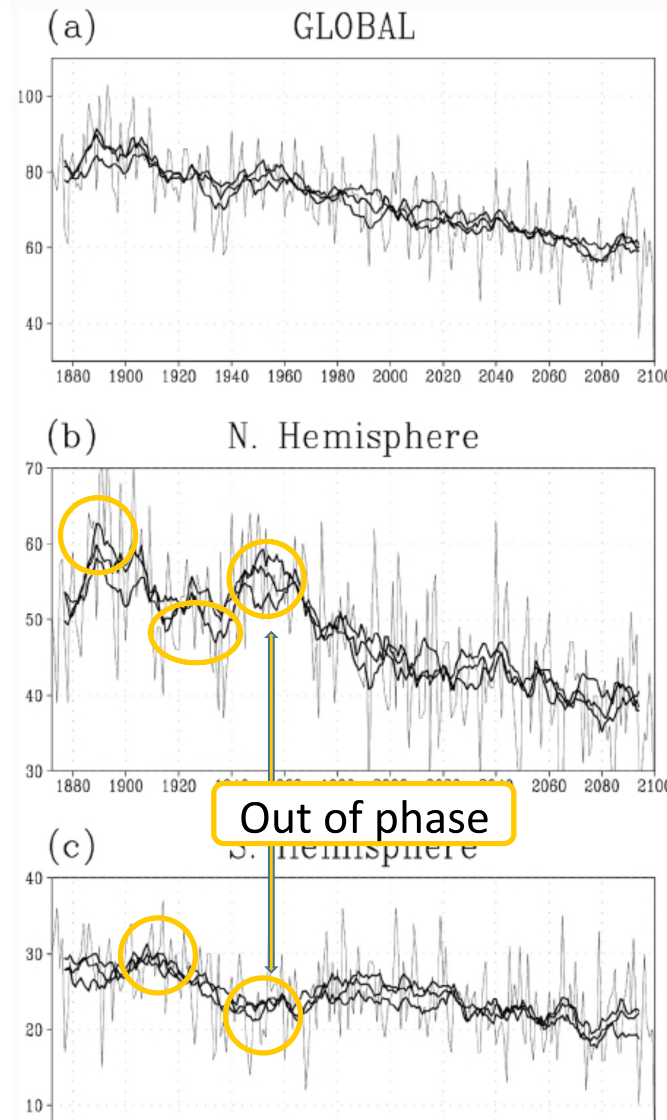
- Clear decreasing trend in both the 20th and 21st century
- Multidecadal variation

  NH: maxima: 1890 and 1950

  minimum: 1920-1940

  SH: maximum: 1910

  minimum: 1950
- Three ensemble member show a considerable difference on a decadal-scale variations



TC frequency is not fully controlled by the SST.

average of the TC counts of each member.

Decreasing trend and decadal variability

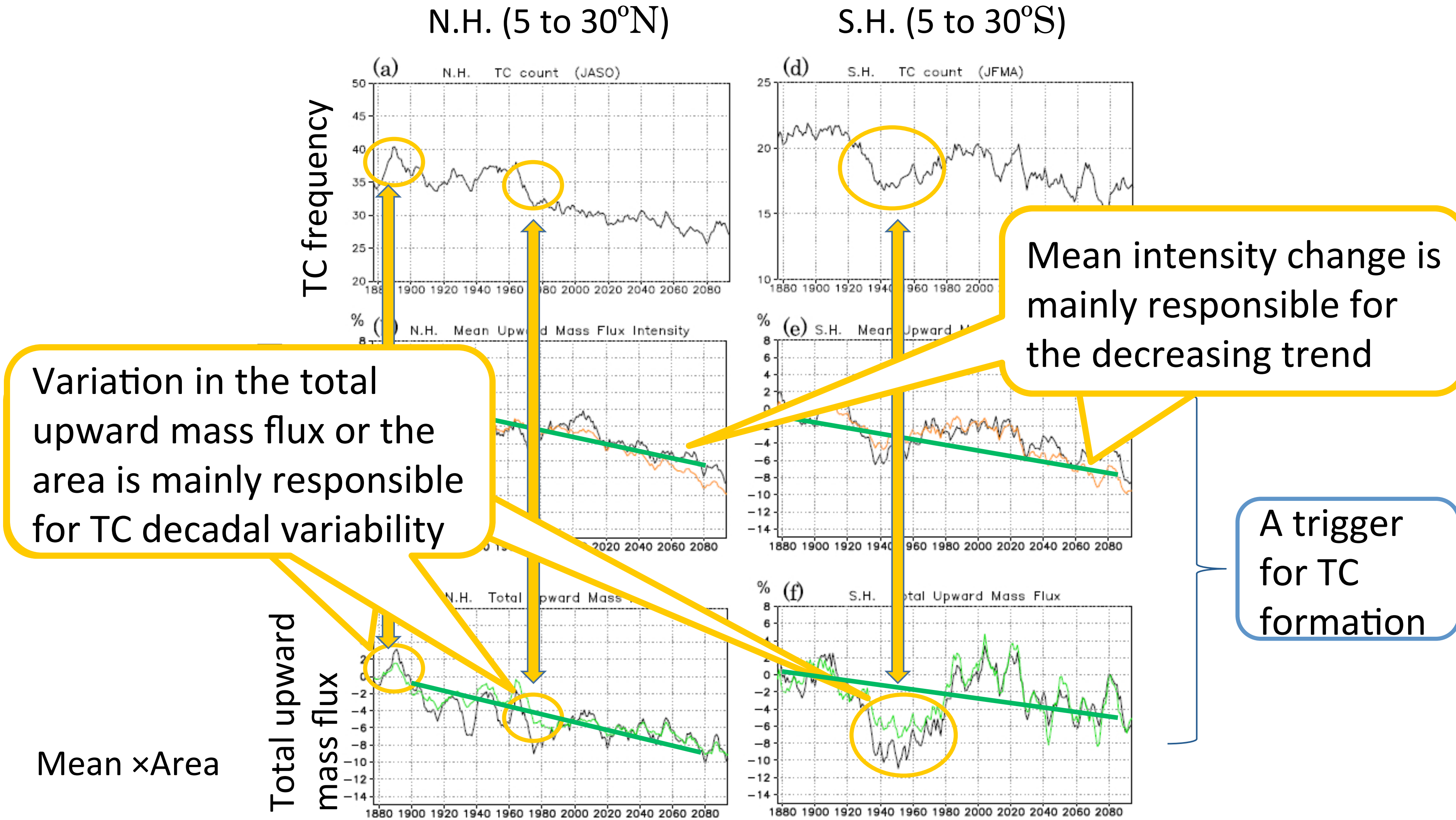
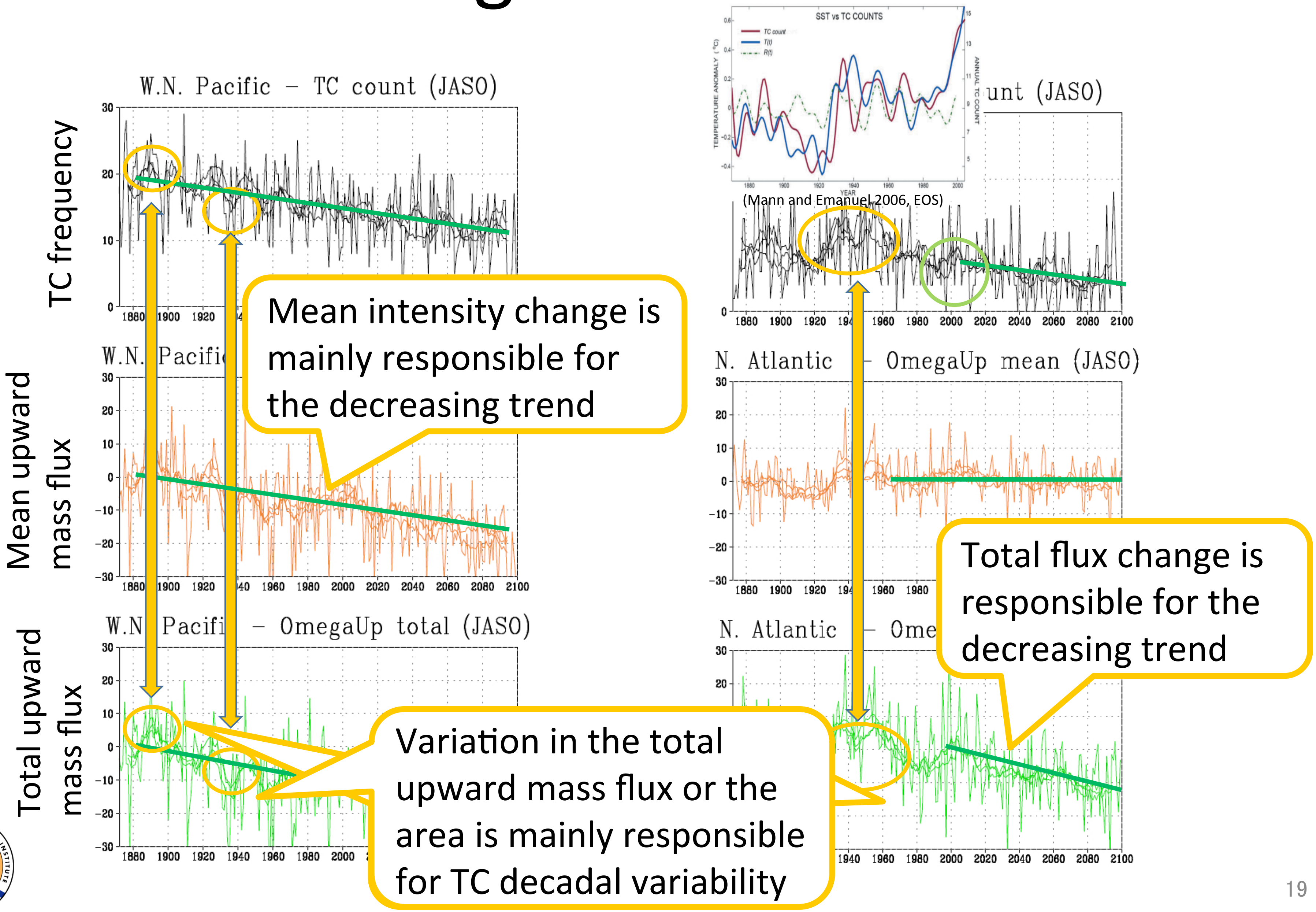
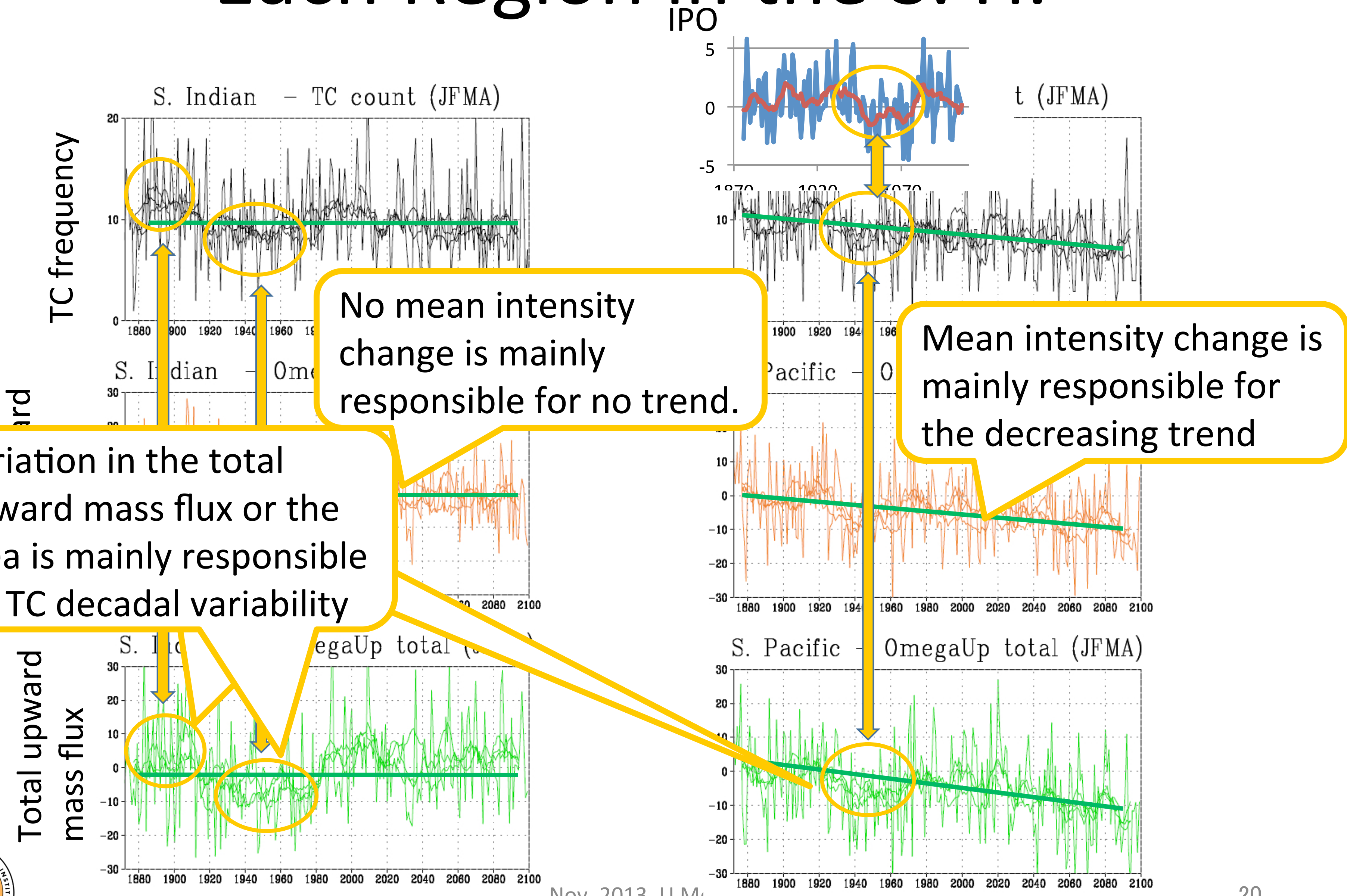


Figure 2. 11-year running average of ensemble mean of (a) TC count for NH TC genesis region (ocean between 5°N and 30°N) and for the active NH TC season (July–October), (b) mean upward mass flux intensity and (c) total upward mass flux. Orange curve in Figure 2b and green curve in Figure 2c indicates upward mass flux calculated by equation (1). (d–f) Same as in Figures 2a–2c but for SH TC genesis region (ocean between 5°S and 30°S) and active SH TC season (January–April).

Each Region in the N. H.



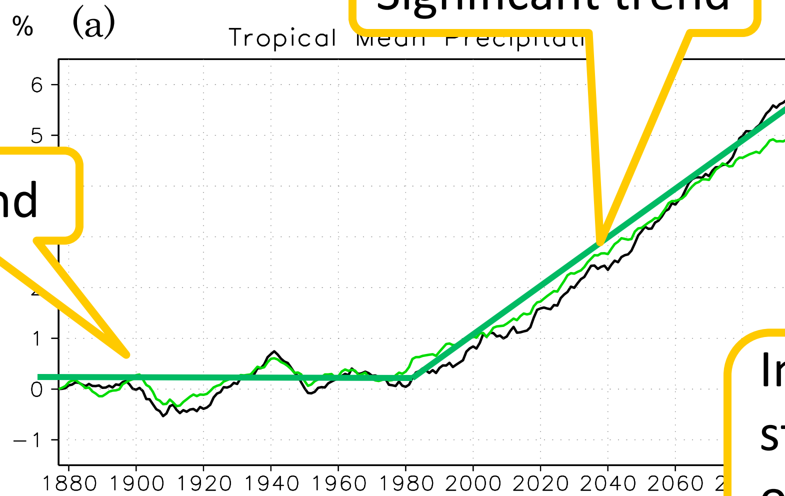
Each Region in the S. H.



Long-term changes in the tropical means

Significant trend

No trend



Long-term changes (11-year running average of anomaly from the first thirty year mean) in the tropics mean precipitation averaged [illegible]

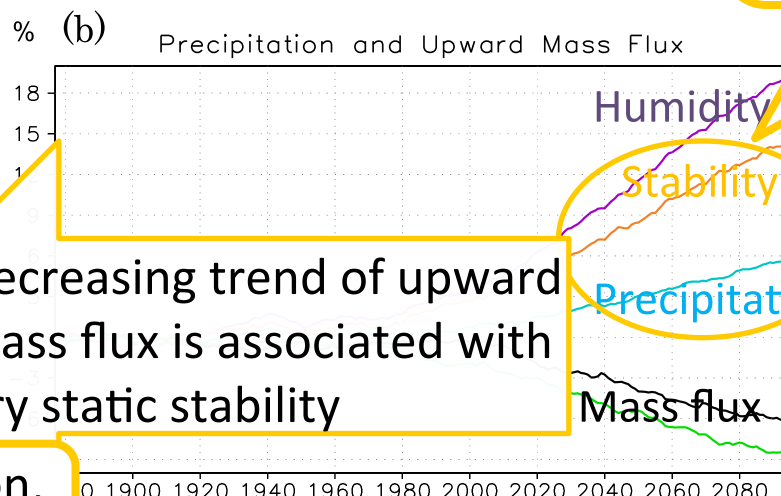
Increasing rate of the dry static stability close to that of humidity is much larger than that of precipitation

Relation in fractional ΔP, ΔS, and Δ ω

$$\frac{\Delta\omega}{\omega} \approx \frac{\Delta P}{P} - \frac{\Delta S}{S}$$

$$\frac{\Delta P}{P} < \frac{\Delta S}{S}$$

$$\frac{\Delta\omega}{\omega} < 0$$



Decreasing trend of upward mass flux is associated with dry static stability

...ges (anomaly from the first thirty year mean, unit is %) in surface specific humidity (purple line), dry static stability (orange line), precipitation (blue line), simulated upward mass flux (black line) and upward mass flux calculated by the Equation (green line).

Trigger of TC formation, Δω, is controlled by ΔS

Summary for TC

1. The decreasing trend and MDV in the long term variation of TC frequency correspond well to a similar decreasing trend and MDV of upward mass flux.
2. Different basins have unique features of the relationship between TC frequency and upward mass flux.
3. The upward mass flux decreases primarily because the rate of increase of dry static stability is much larger than the rate of increase of precipitation.

Key to change in TC frequency