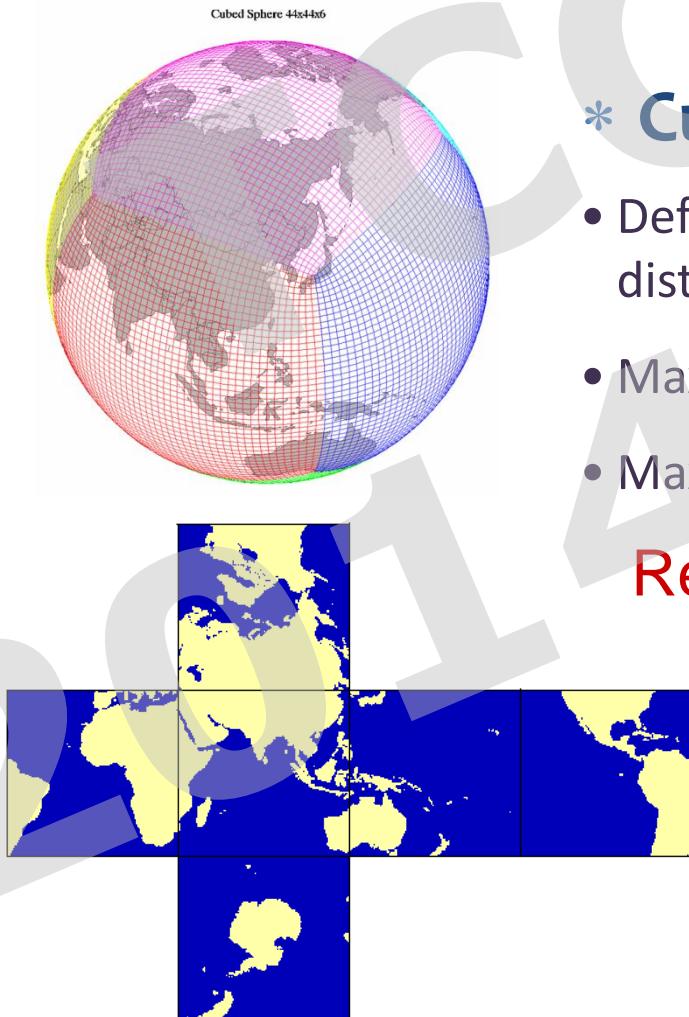


# HiRAM/GFDL

for **high-resolution Time-Slicing Experiments**

Present (1979-2008), near future, end of century (RCP8.5)  
→ TCCIP dynamical downscaling



## \* Cube Sphere Globe (HiRAM)

- Defined by intersects of great circles with equal-distance along 12 edges
- Maximum local grid aspect ratio  $\sim 1.061$
- Maximum global grid aspect ratio  $\sim 1.414$

Resolution:

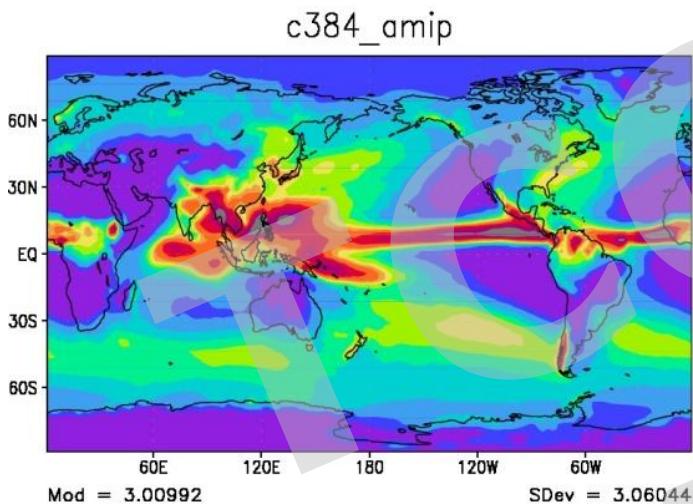
C2000,       $\Delta x = \sim 4.5 \text{ km}$

**C384** ,       $\Delta x = \sim 23 \text{ km}$

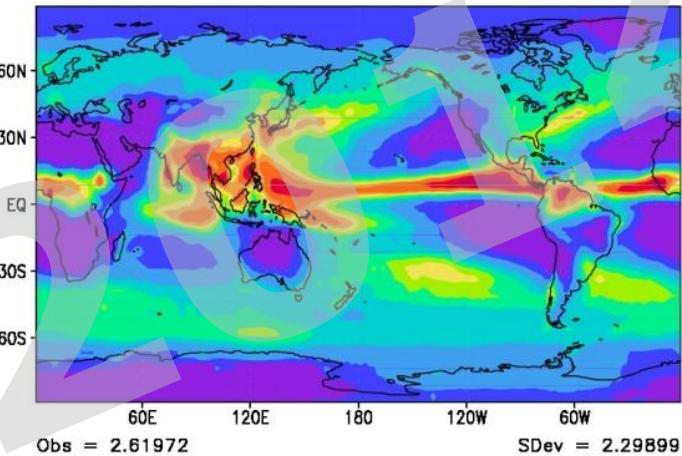
C384R2.5 ,     $\Delta x = 11\text{--}68 \text{ km}$

# JJA Rainfall

JJA PRECIP (mm/d)



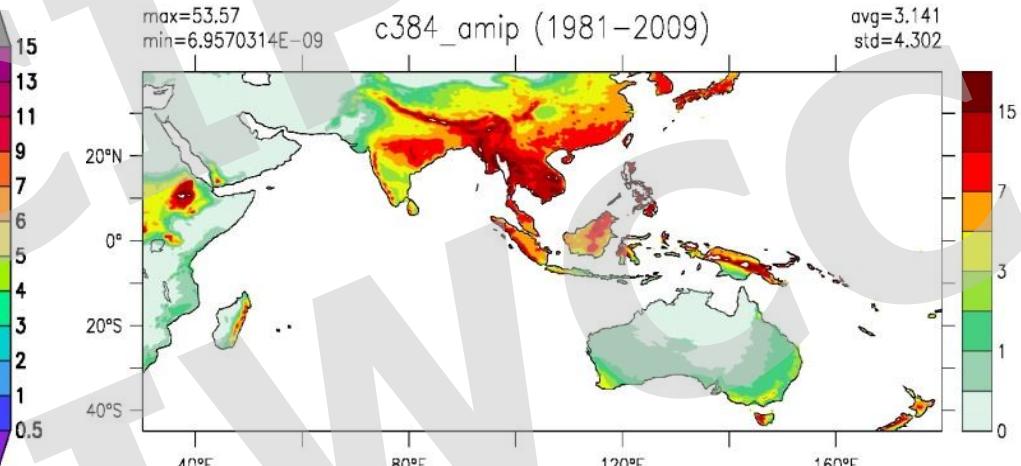
GPCP.v2 sat + gauge ('81-'00)



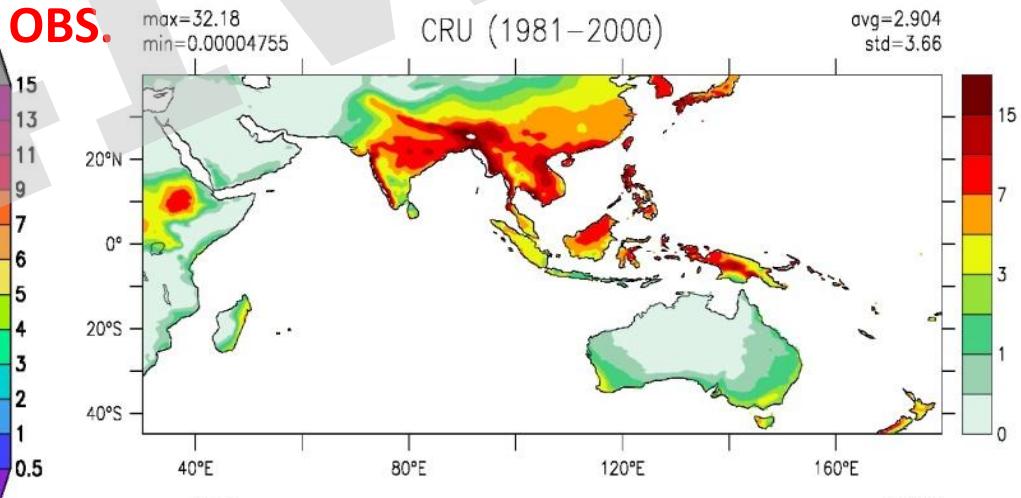
c384\_amip minus GPCP.v2



HiRAM



OBS.



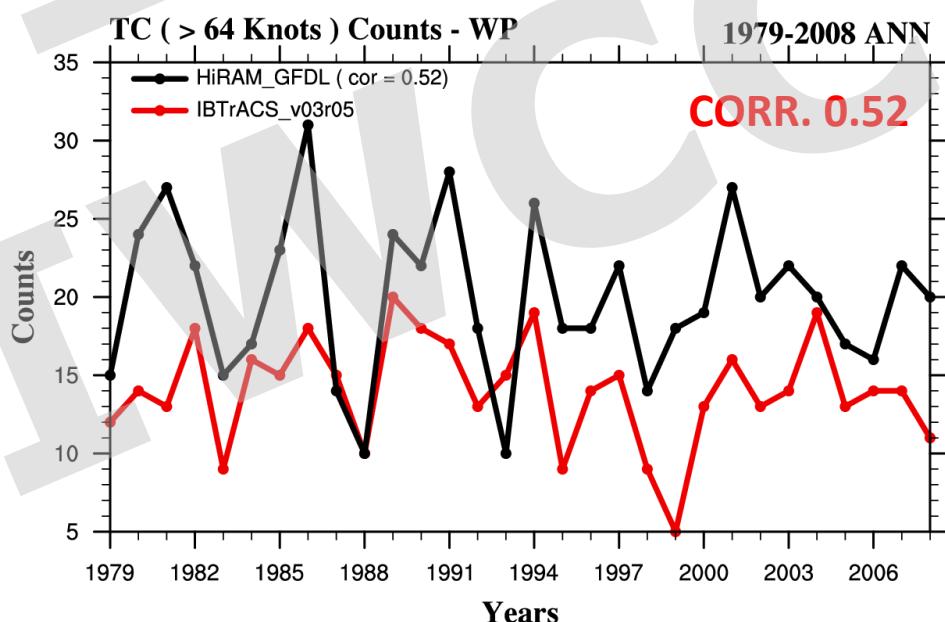
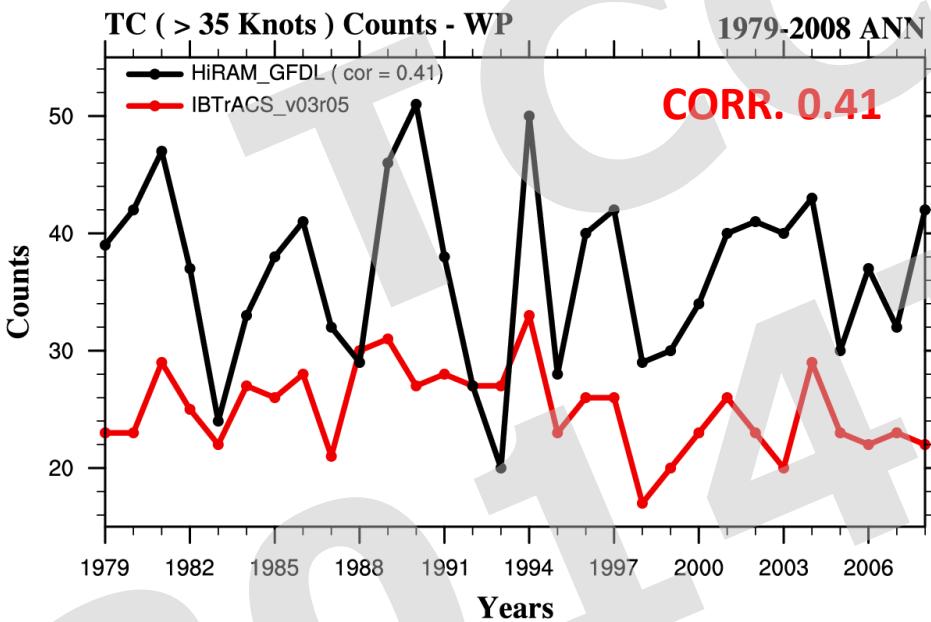
max=45.93  
min=-20.43

avg=0.2374  
rms=2.575



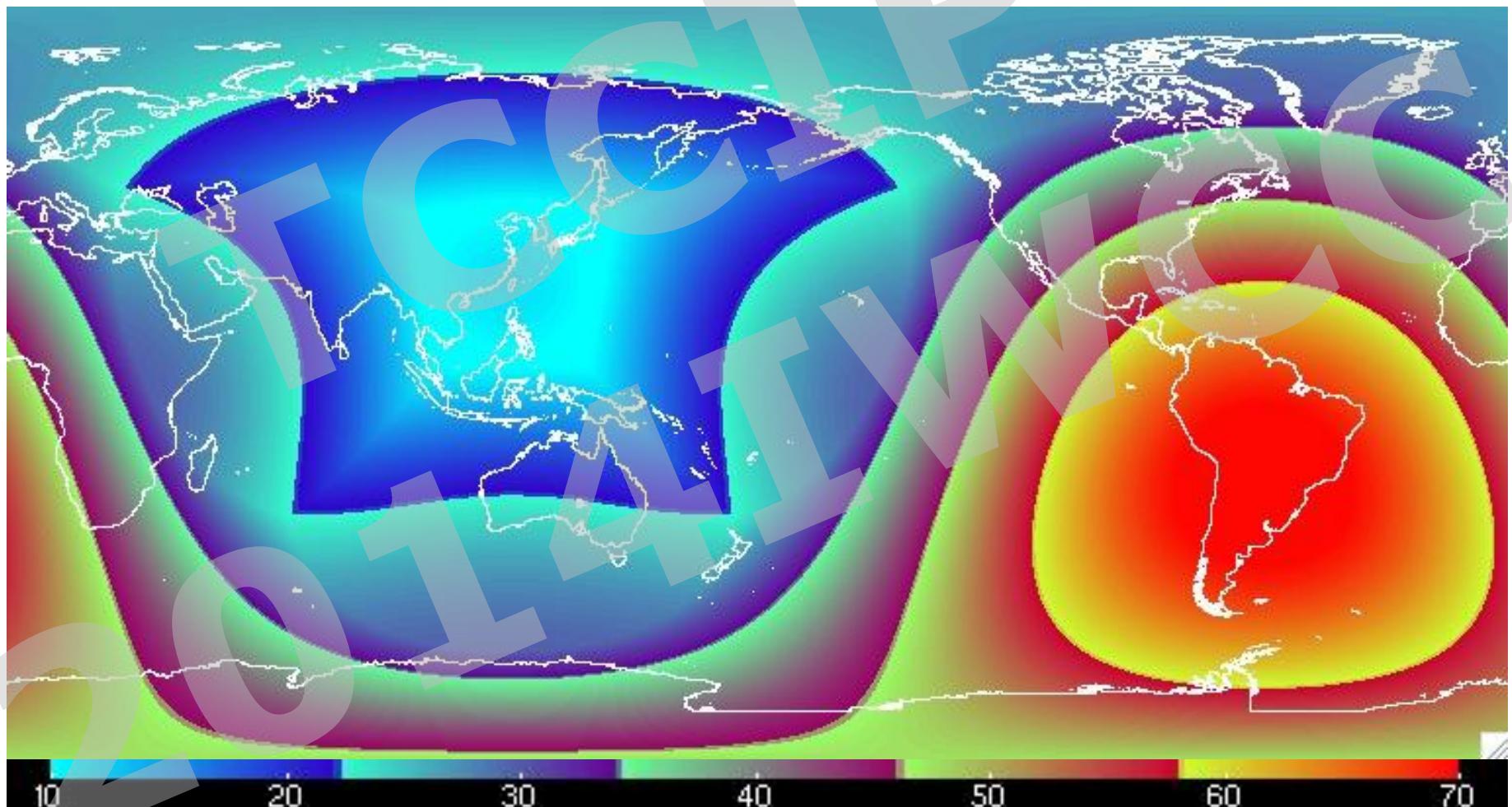
# *HiRAM TC Interannual*

- More TCs but weaker than observed
- Interannual variation marginally OK



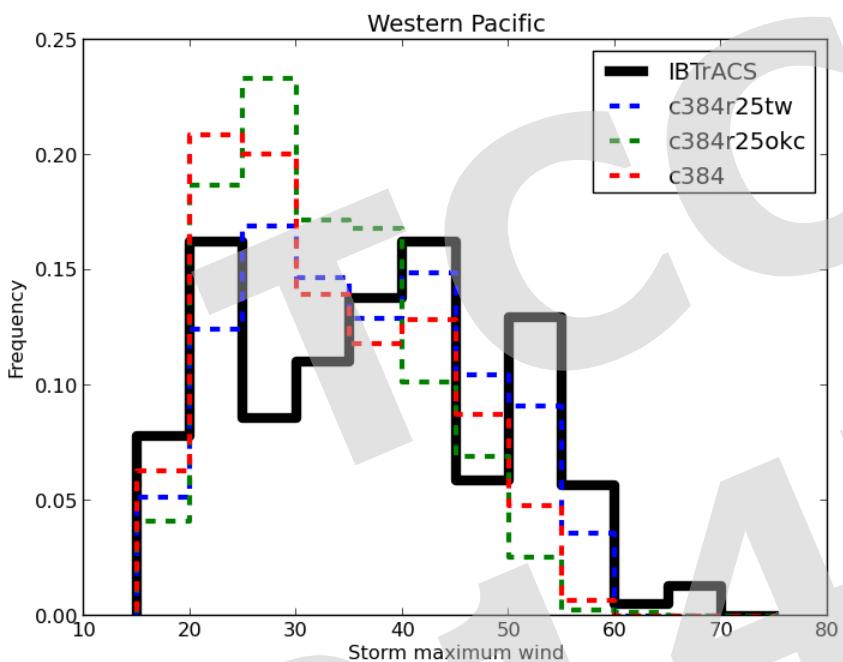
Tropical Cyclone Counts respectively during  
TC (> 35Knots) and Cat-1 (> 64Knots) in Jan-Dec (1979-2008)

# Stretched-grid HiRAM: Grid Size of Stretched Cube Sphere Globe C384R2.5 center @ Taiwan



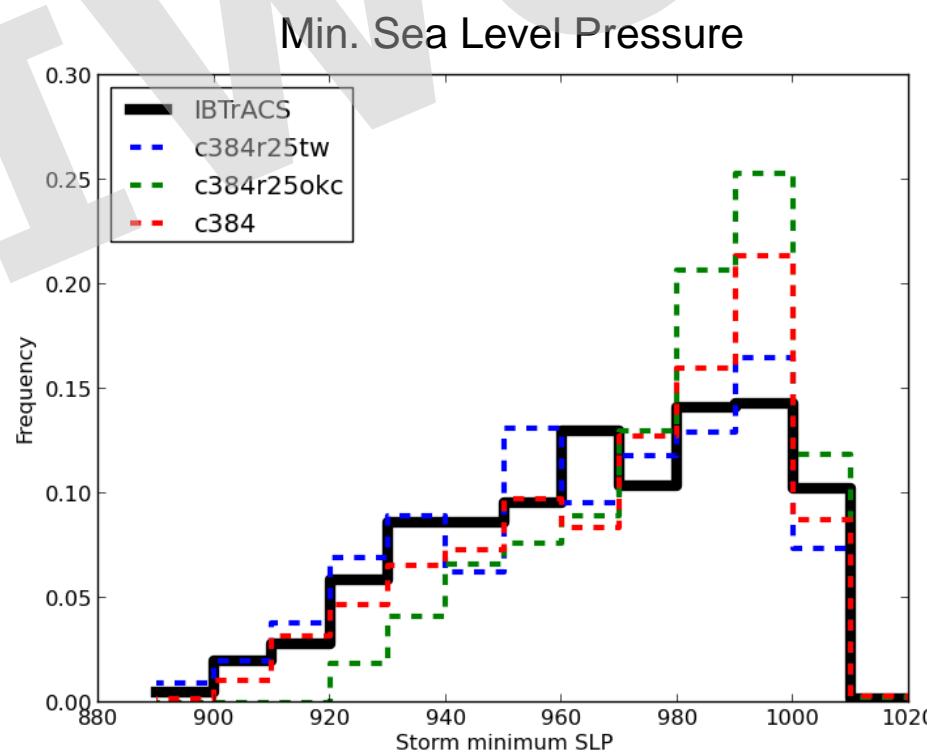
- Grid size for C384R2.5 ranges from around 11km to 68km.

# Typhoons in West. North Pacific



Max. Wind Speed

Improvement:  
Both number and strength  
are closer to the observed.



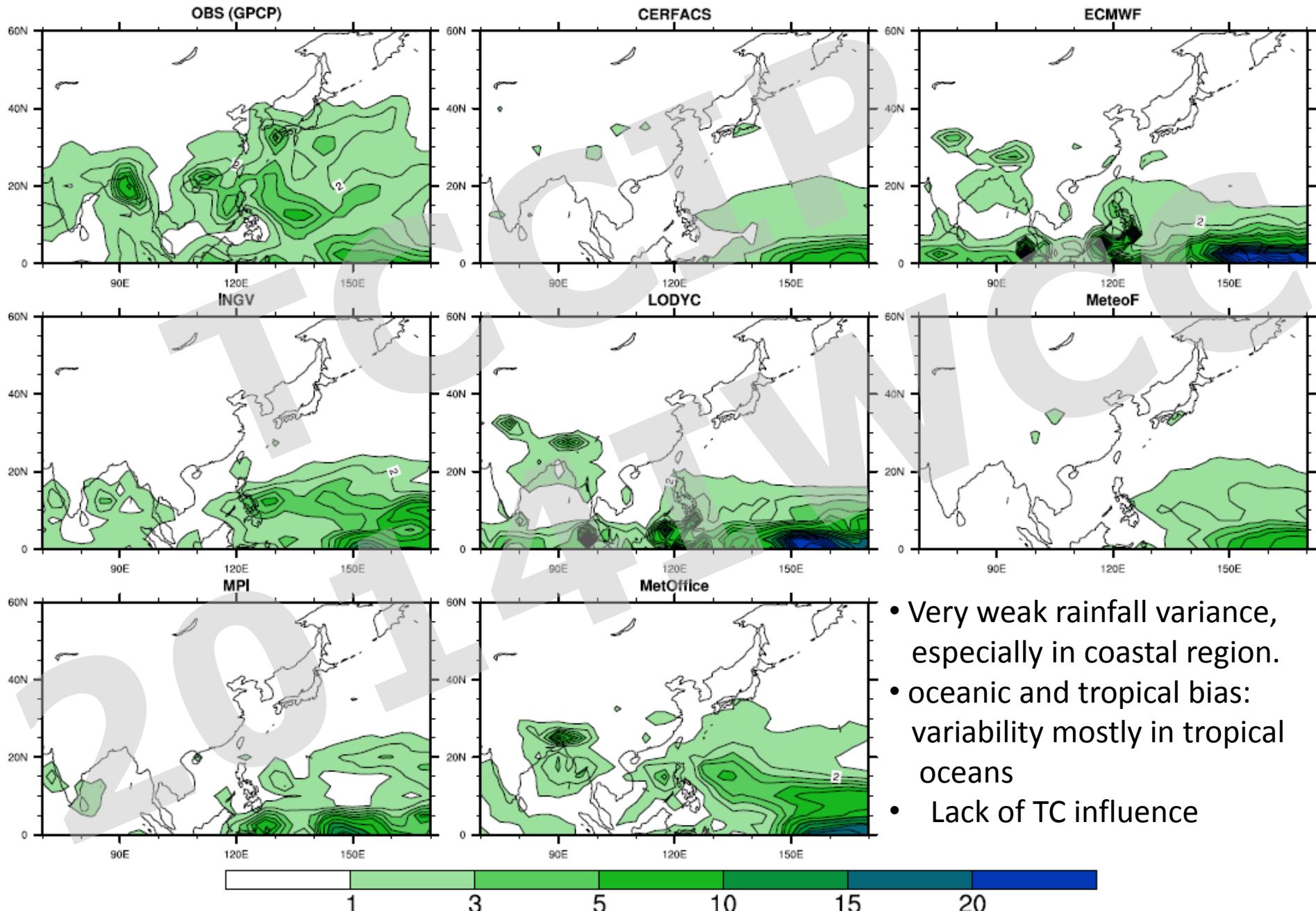


# **Simulation and Projection of Interannual Variability by Seasonal Prediction and CMIP3/5 Models**

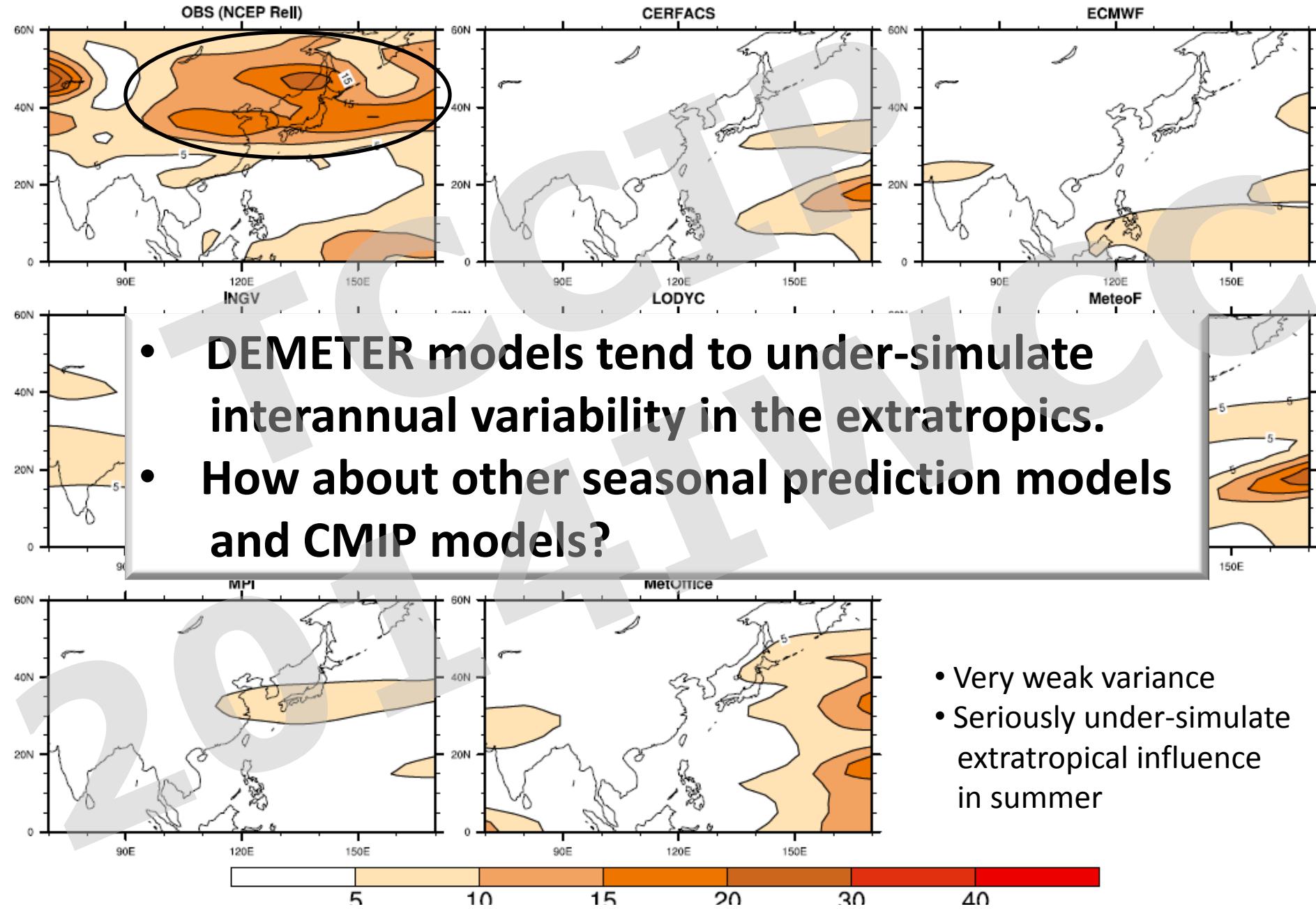
**Huang-Hsiung Hsu, Jung-Kai Yang and Wei-Kai Huang**

Research Center for Environmental Changes, Academia Sinica  
Taipei, Taiwan

# Variance of Precip. of OBS and DEMETER(IC=May,target=JJA)

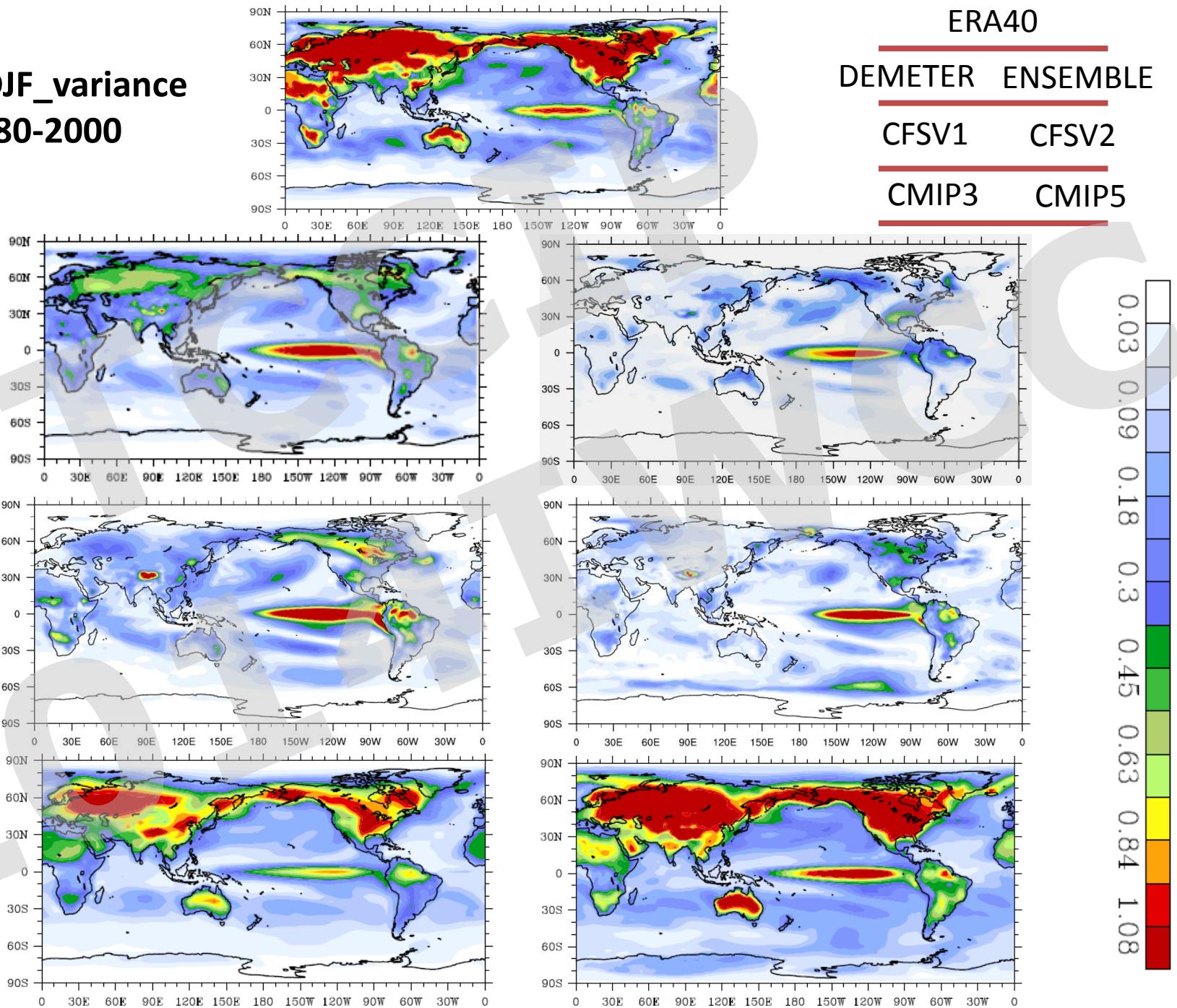


# Variance of U200 of OBS and DEMETER(IC=May,target=JJA)

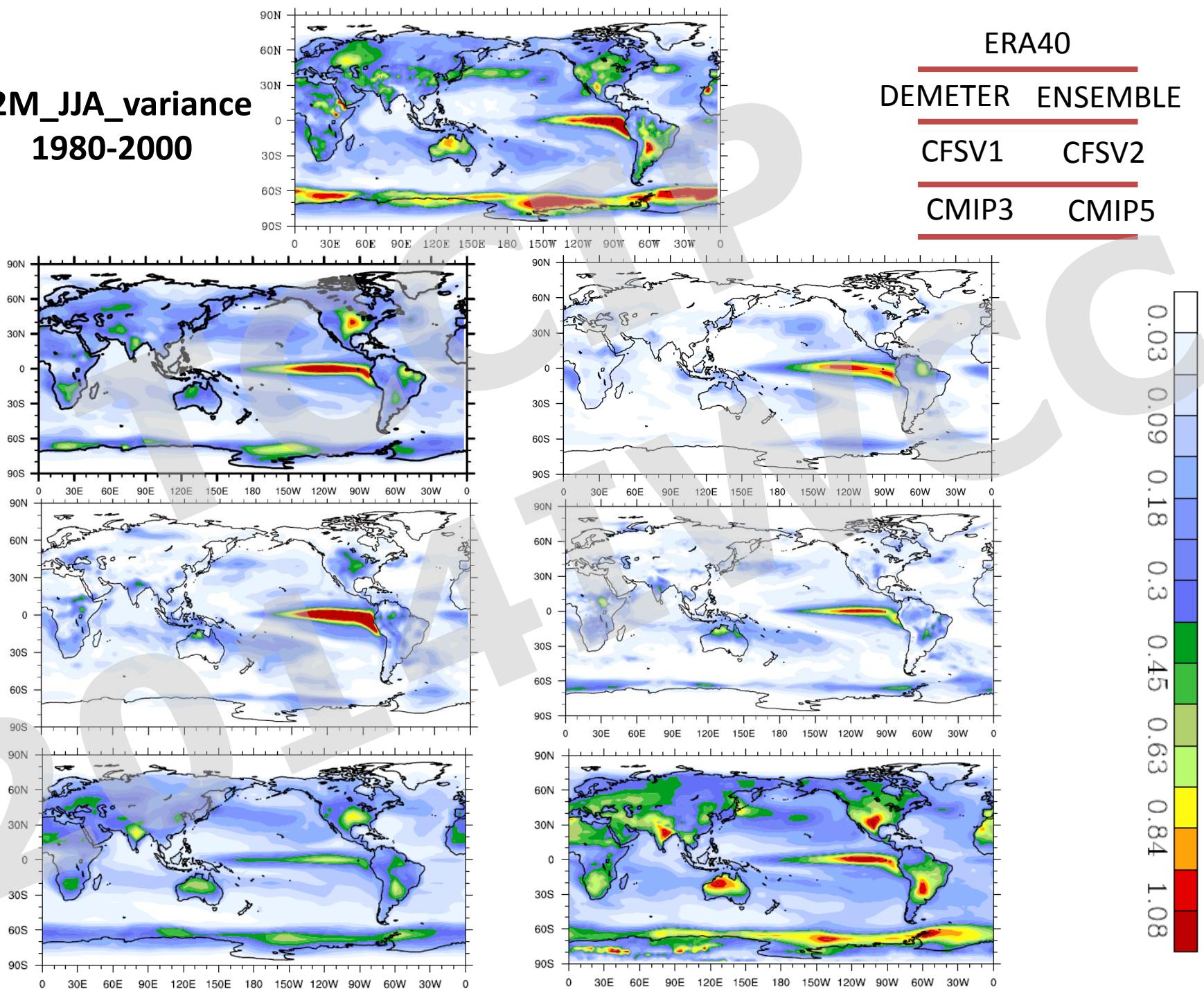


資料名稱	變數	年份
ERA40(144*73)	temperature 、 200hPa U	1980-2000(JJA 、 DJF)
GPCP(144*73)	Precipitation	1980-2000(JJA)
DEMETER(144*73)	temperature 、 precip. 、 200hPa U	1980-2000(JJA 、 DJF)
ENSEMBLE(144*73)	temperature 、 precip. 、 200hPa U	1980-2000(JJA 、 DJF)
CFSv1(192*94)	temperature 、 precip. 、 200hPa U	1980-2000(JJA 、 DJF)
CFSv2(384*190)	temperature 、 precip. 、 200hPa U	1980-2000(JJA 、 DJF)
CMIP3	temperature 、 precip. 、 200hPa U	1980-2000(JJA 、 DJF)
CMIP5	temperature 、 precip. 、 200hPa U	1980-2000(JJA 、 DJF)

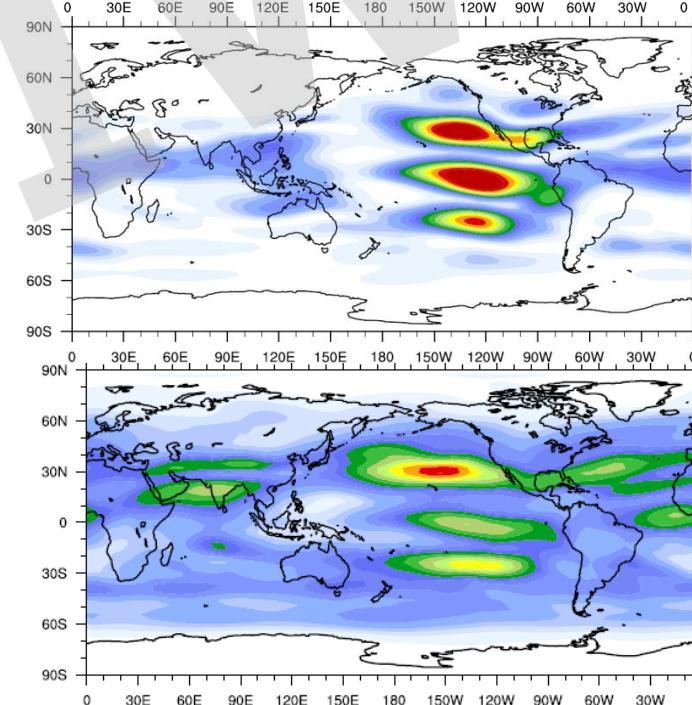
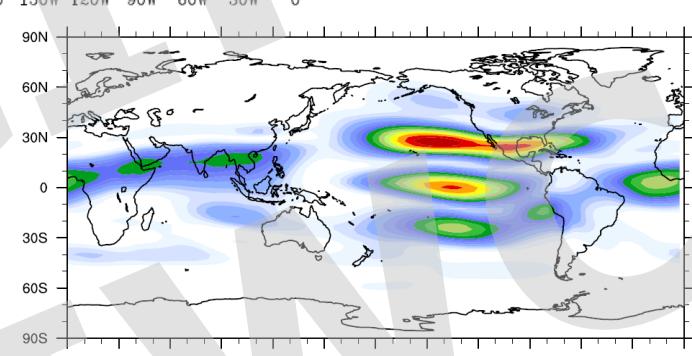
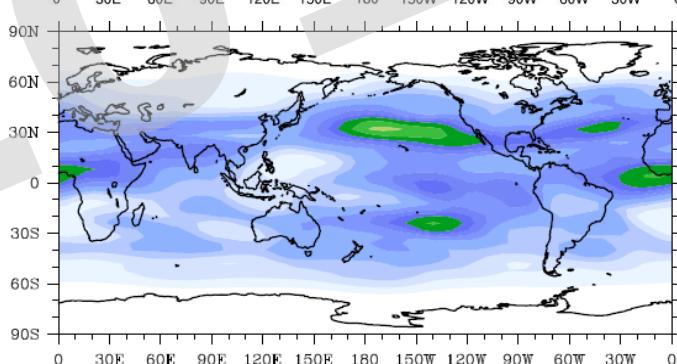
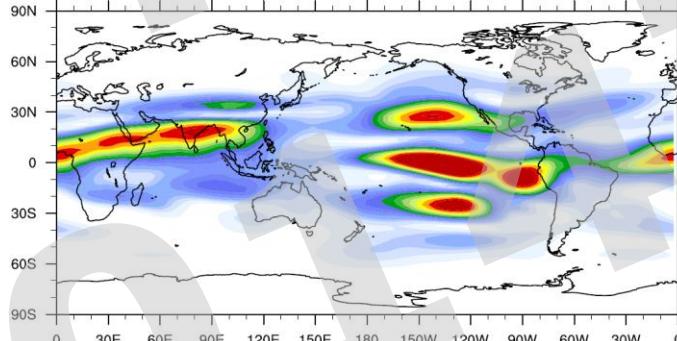
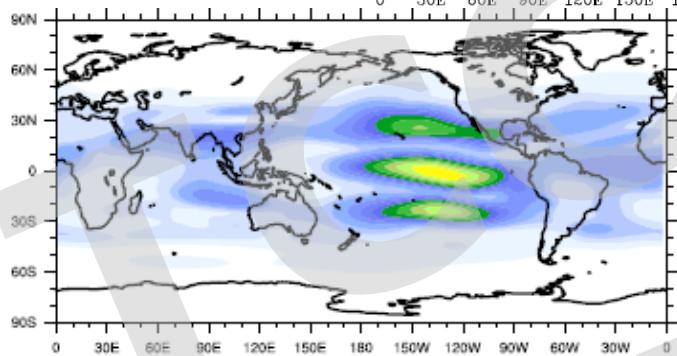
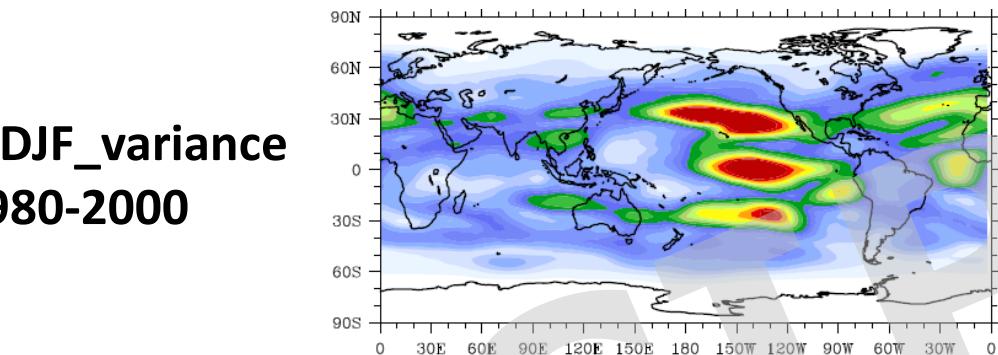
# T2M\_DJF\_variance 1980-2000



# T2M\_JJA\_variance 1980-2000



# U200\_DJF\_variance 1980-2000

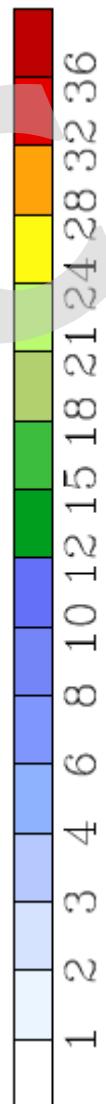


ERA40

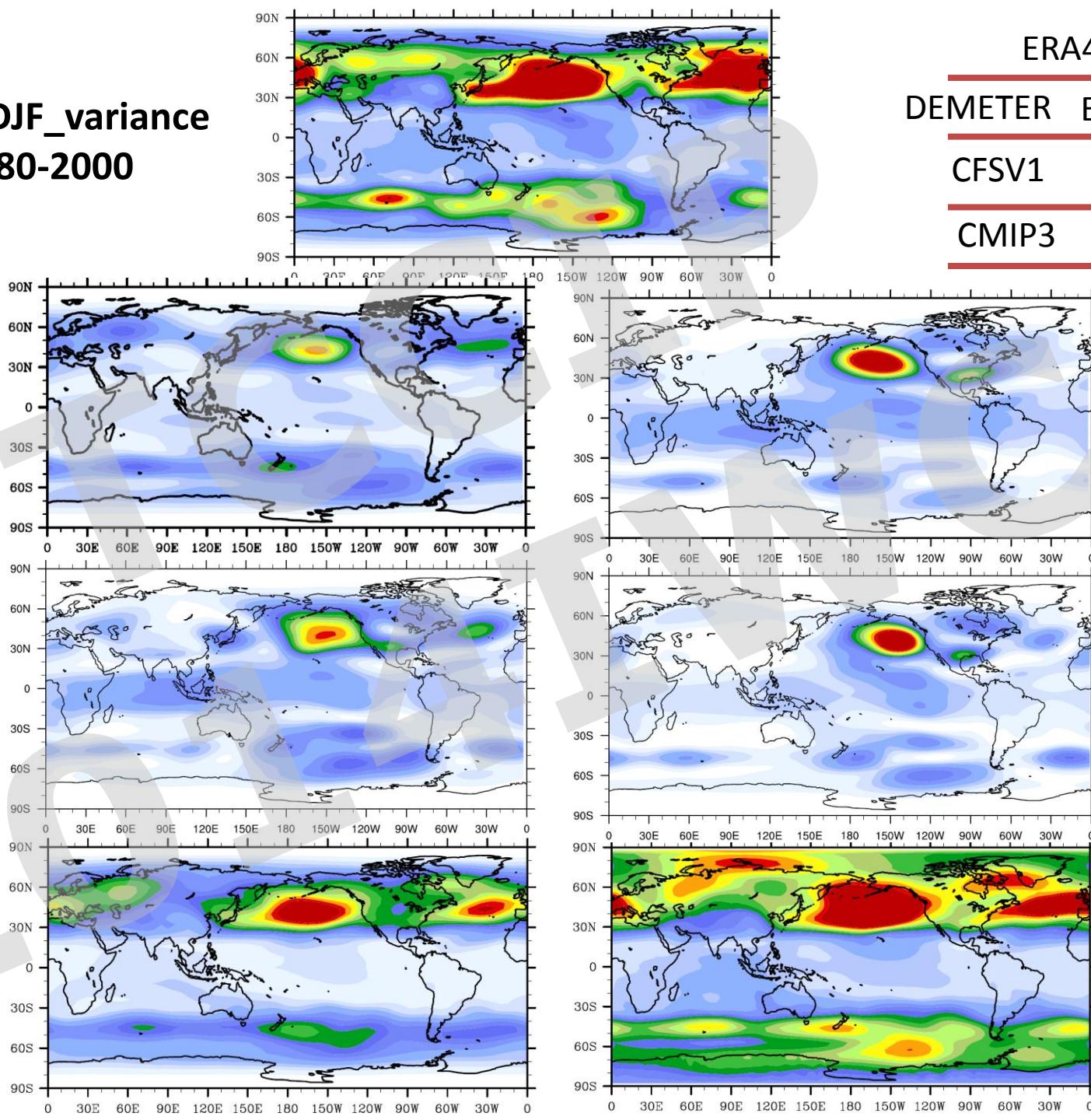
DEMETER ENSEMBLE

CFSV1 CFSV2

CMIP3 CMIP5



# H500\_DJF\_variance 1980-2000



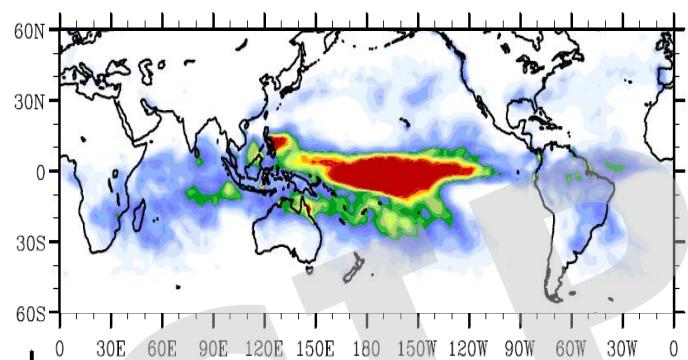
ERA40

DEMETER ENSEMBLE

CFSV1 CFSV2

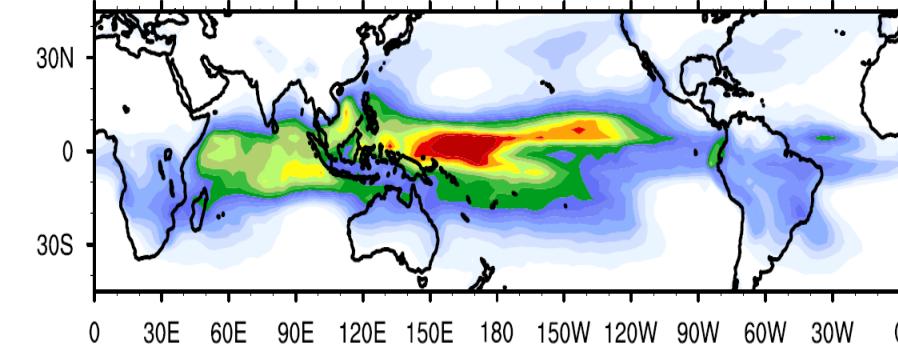
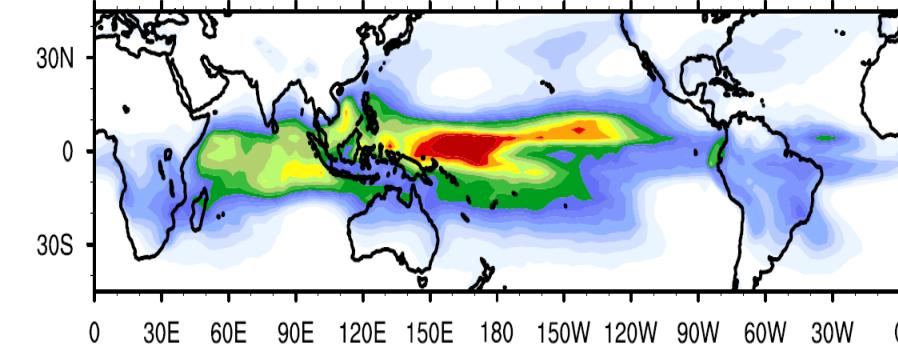
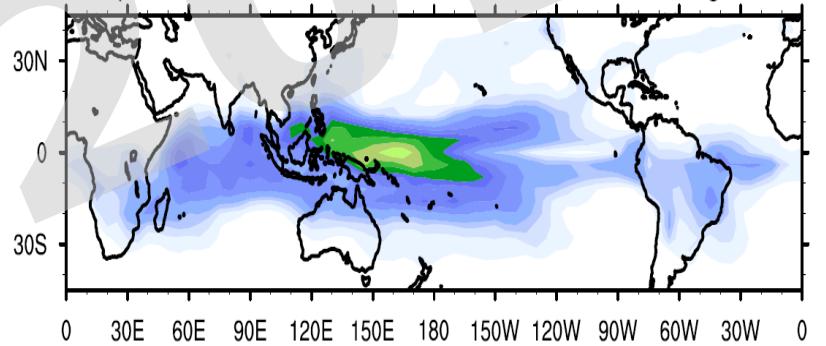
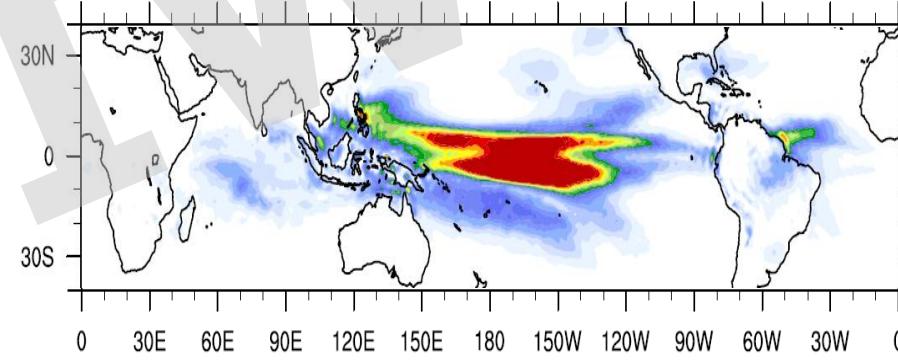
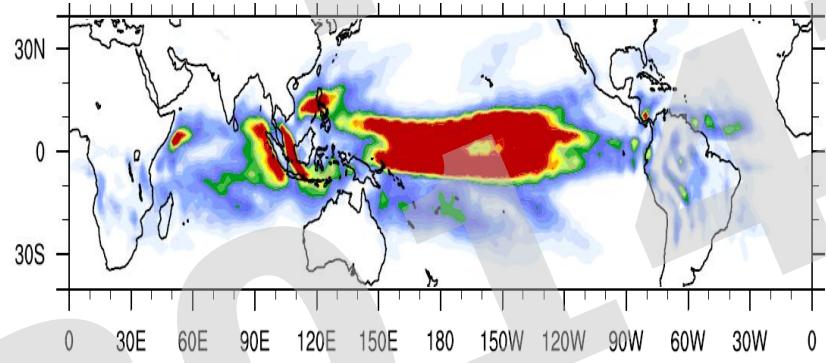
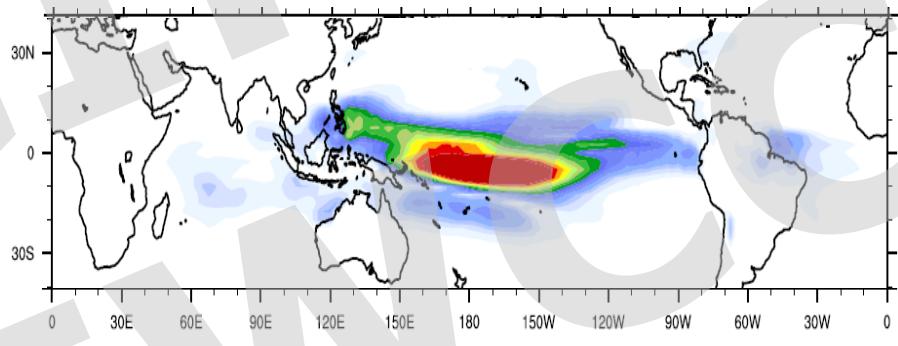
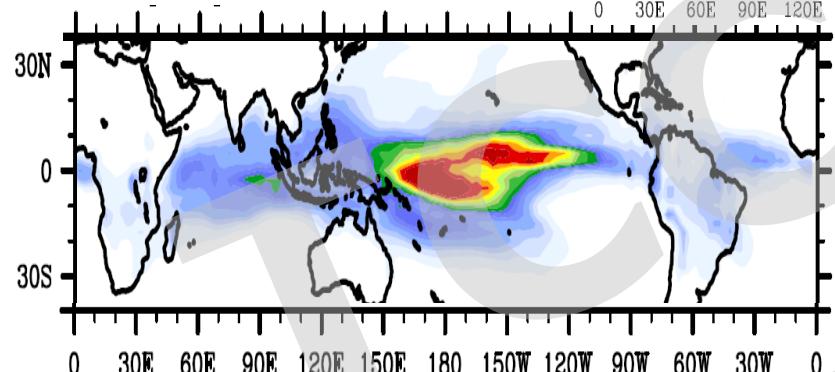
CMIP3 CMIP5

# precip\_DJF\_variance 1980-2000



GPCP

DEMETER ENSEMBLE  
CFSV1 CFSV2  
CMIP3 CMIP5



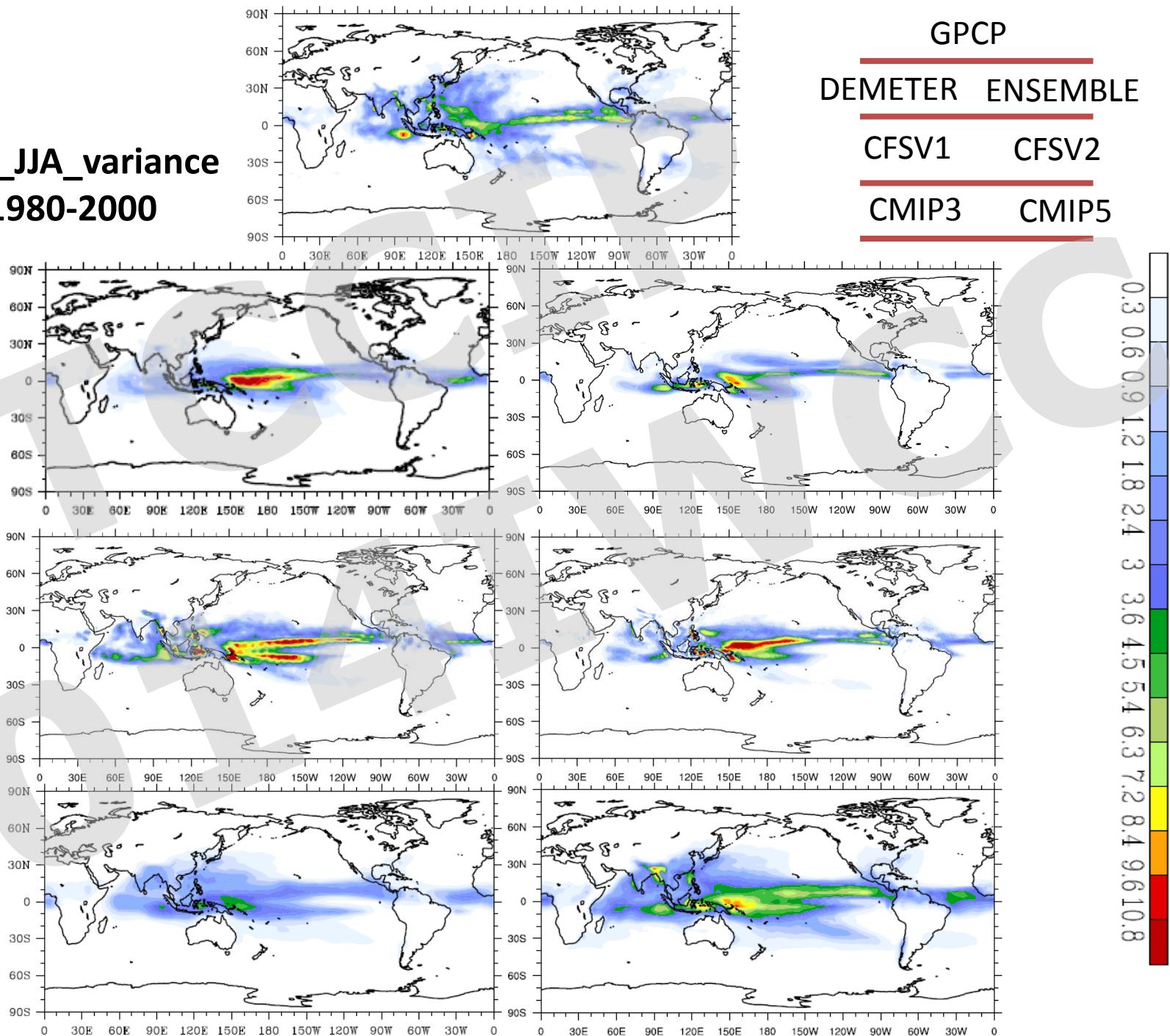
# Rain\_JJA\_variance 1980-2000

GPCP

DEMETER ENSEMBLE

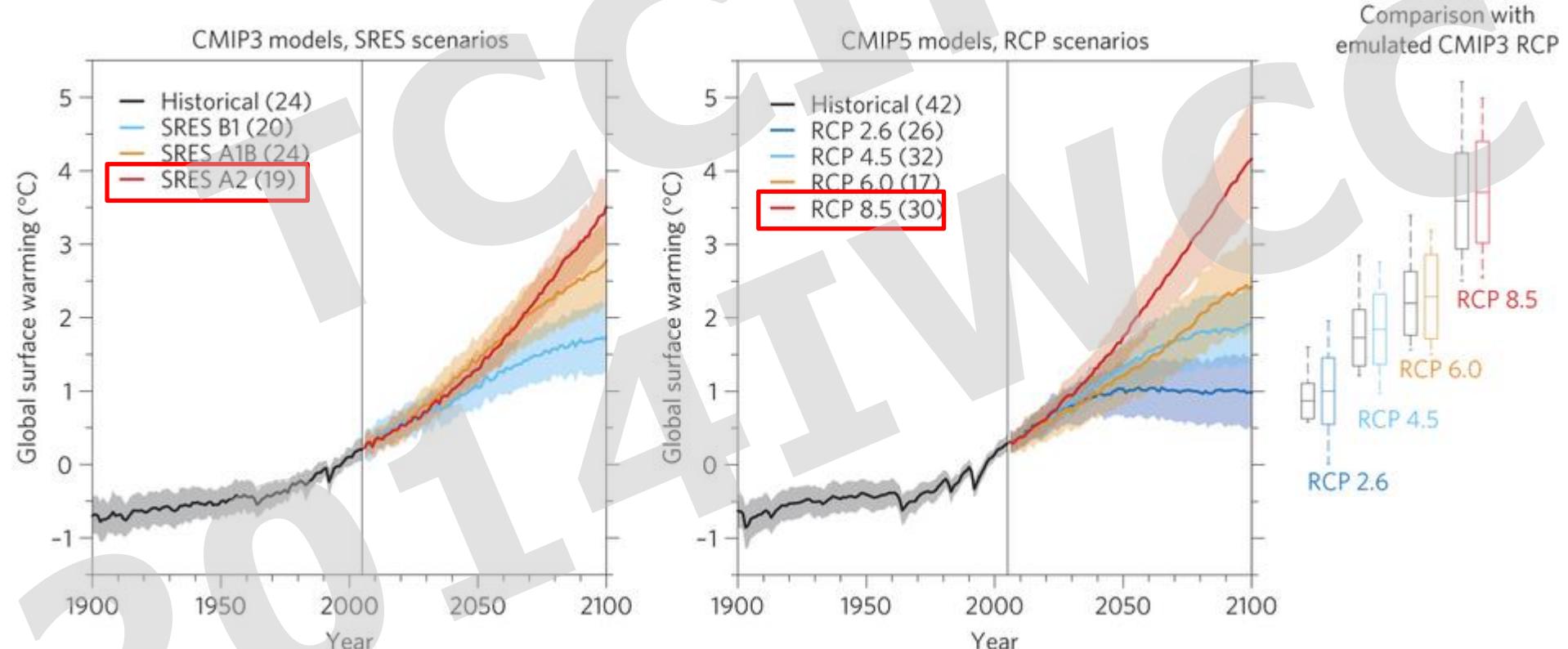
CFSV1 CFSV2

CMIP3 CMIP5



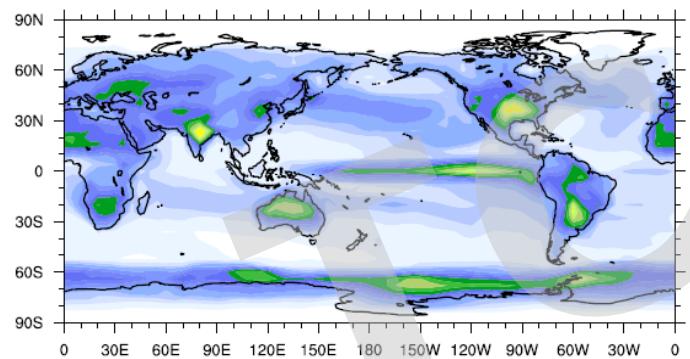
# Future projection?

## CMIP3: SRES A2, CMIP5: RCP8.5

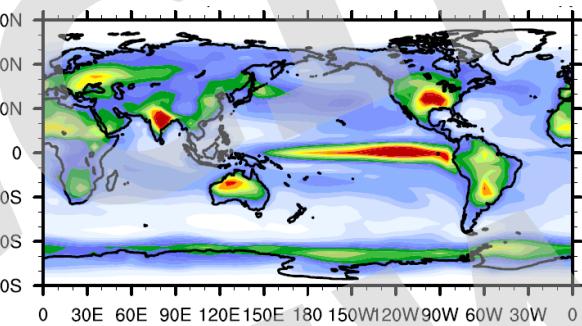


## JJA\_variance\_T2M\_CMIP3

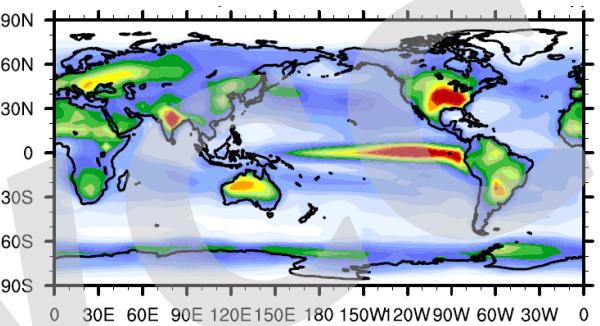
historical1980-2000



CMIP3\_A2\_2041~2070

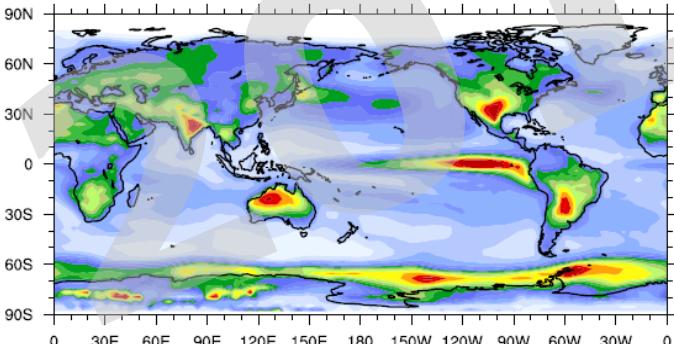


CMIP3\_A2\_2071~2099

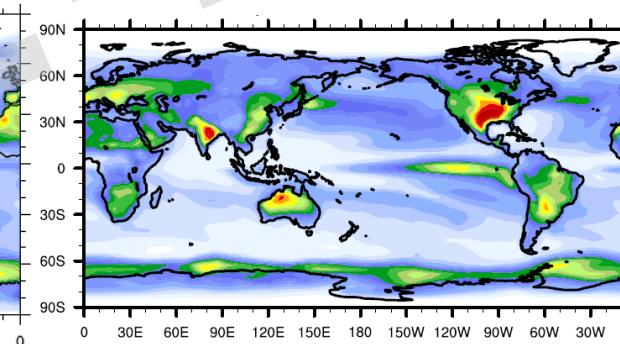


## JJA\_variance\_T2M\_CMIP5

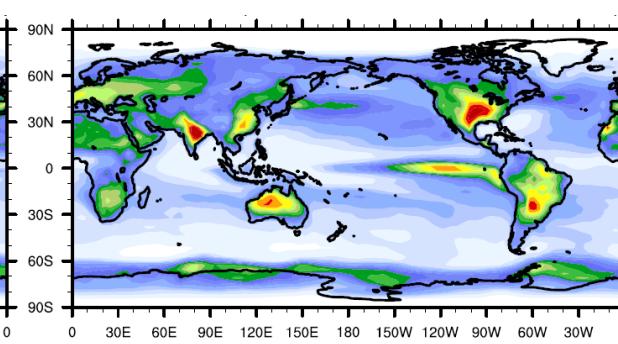
historical1980-2000



CMIP5\_rcp85\_2041~2070

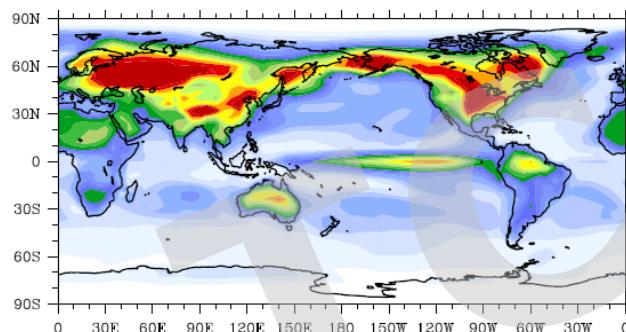


CMIP5\_rcp85\_2071~2099

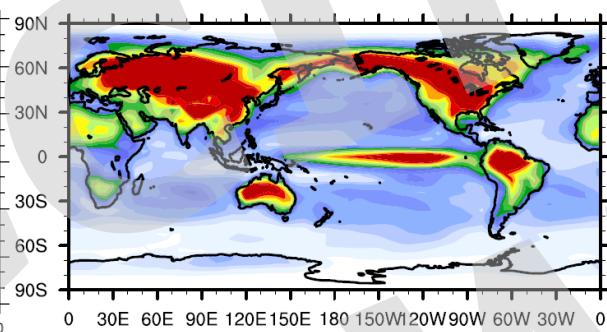


# DJF\_variance\_T2M\_CMIP3

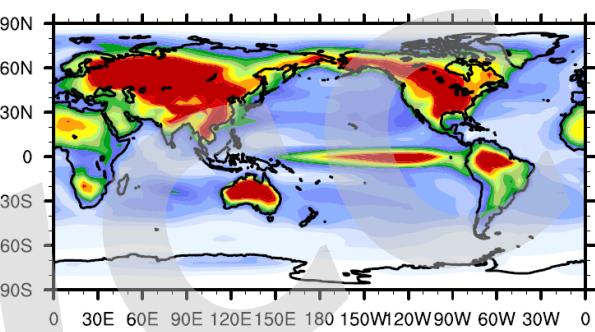
Historical 1980-2000



CMIP3\_A2\_2041~2070

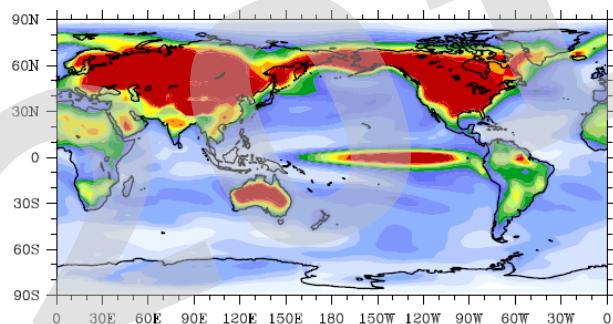


CMIP3\_A2\_2071~2099

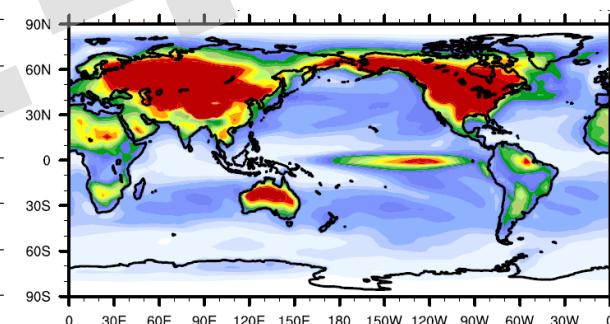


# DJF\_variance\_T2M\_CMIP5

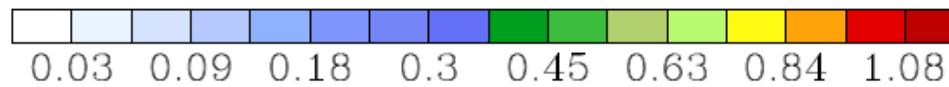
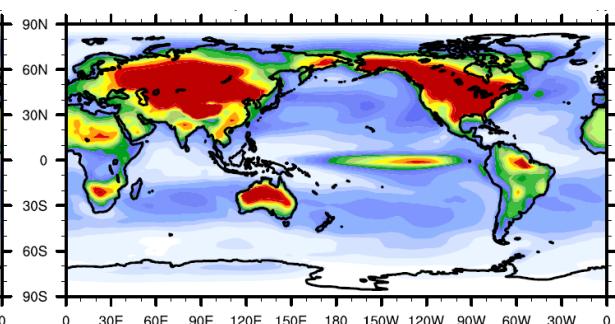
Historical 1980-2000



CMIP5\_rcp85\_2041~2070

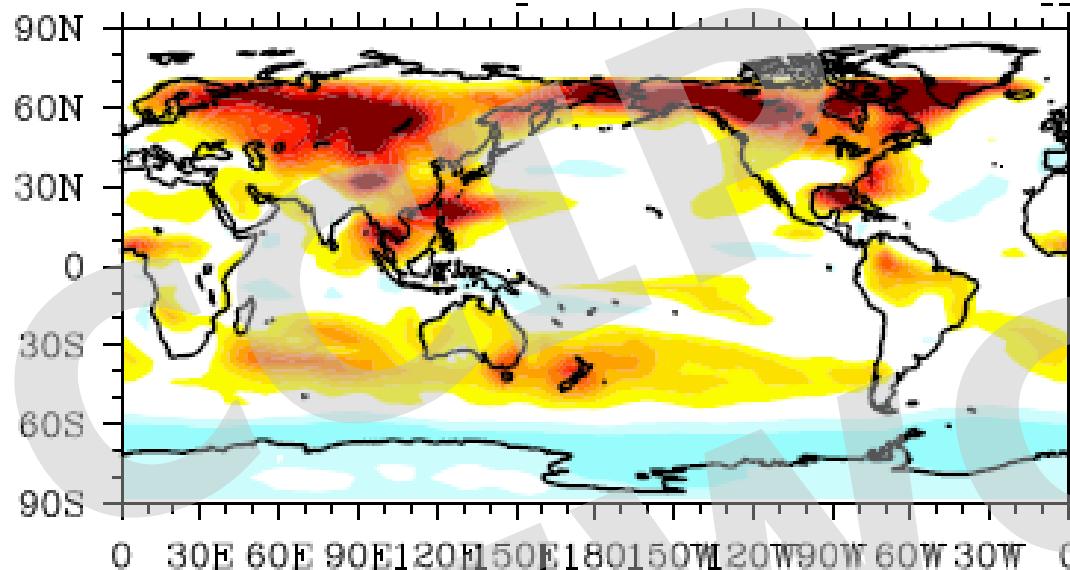


CMIP5\_rcp85\_2071~2099

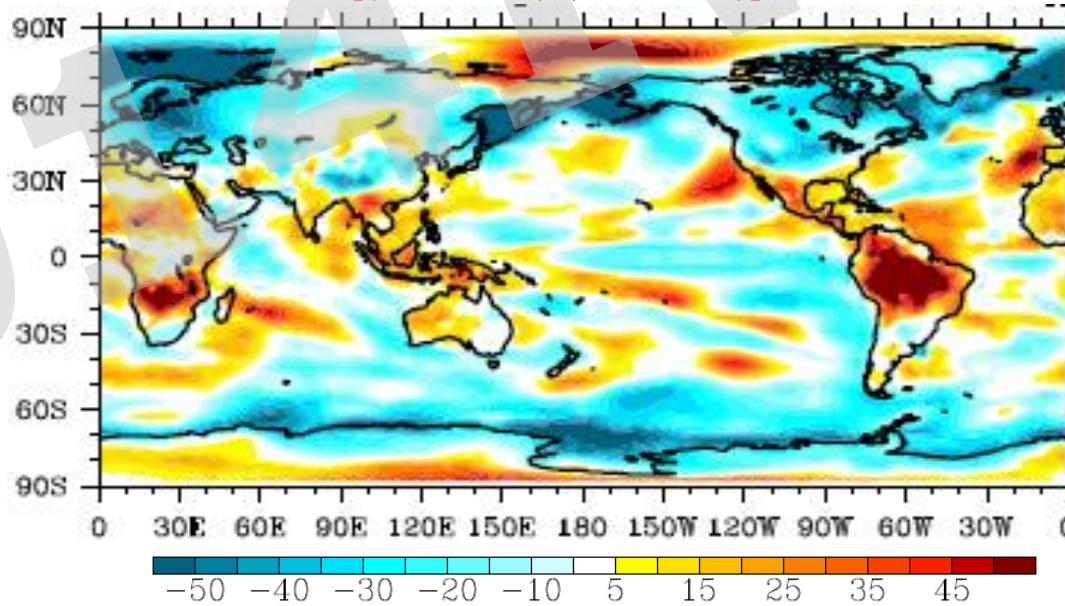


# Change in Ratio DJF

CMIP3\_DJF\_T2M\_var\_  
[(2071-2100)-(1980-2000)]/1980-2000



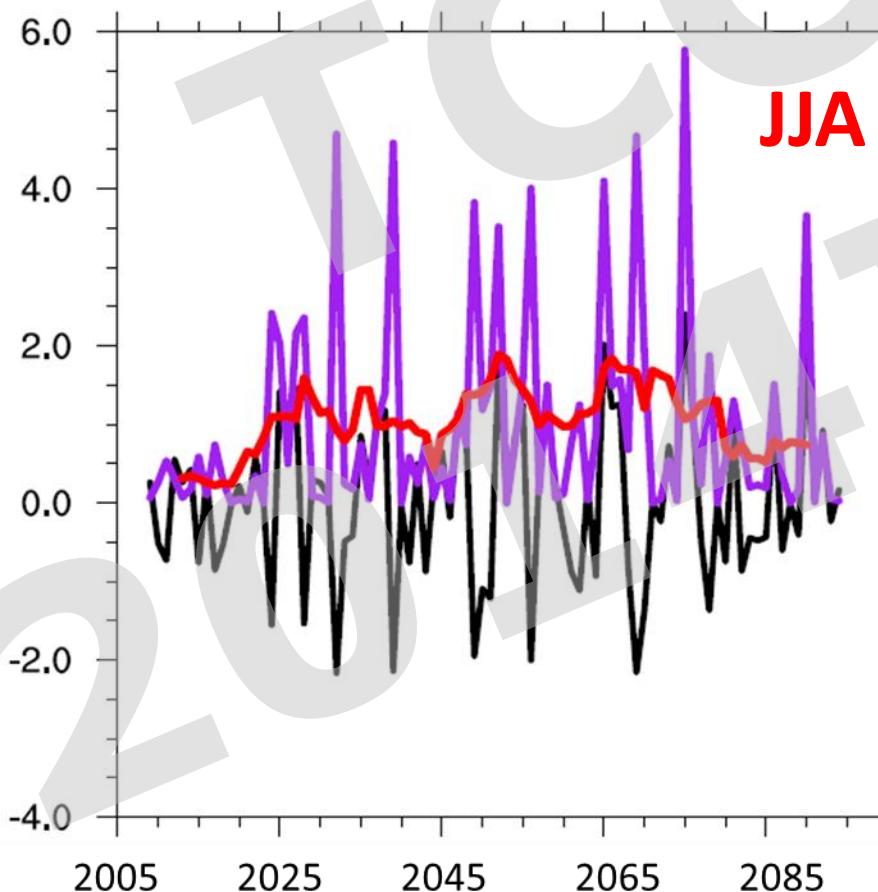
CMIP5\_DJF\_T2M\_var\_  
[(2071-2100)-(1980-2000)]/1980-2000



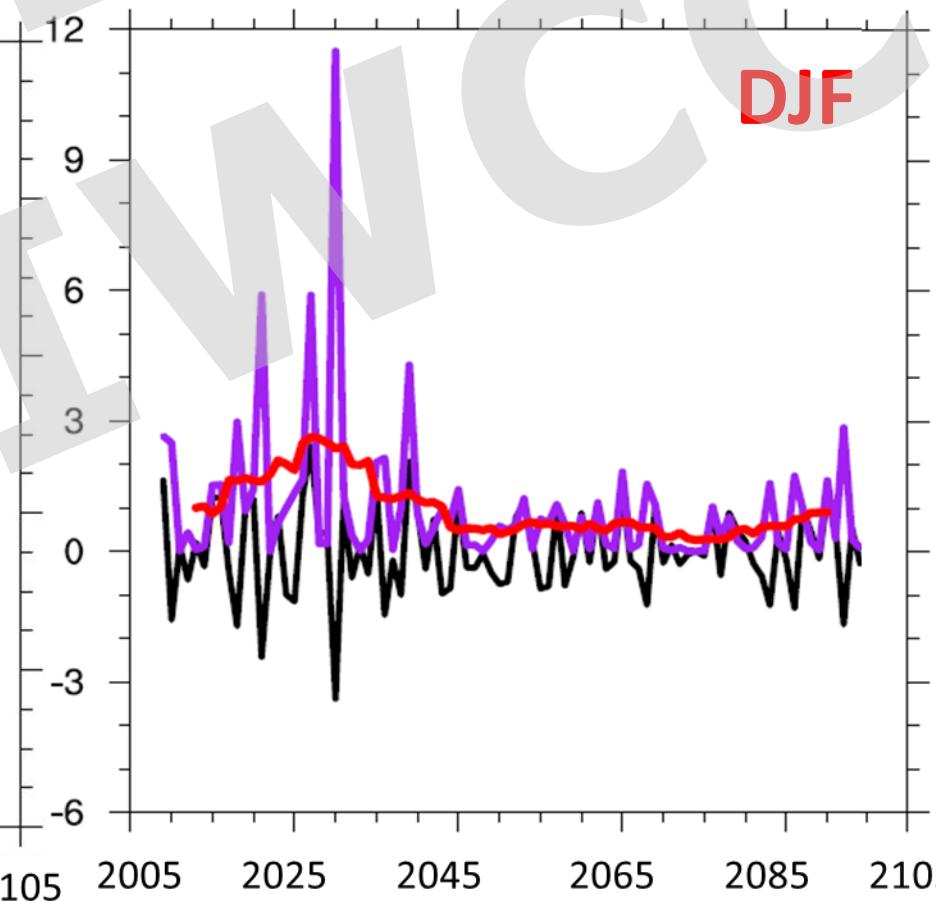
# T2M\_variance\_30N~70N

Black: T2m, Purple: squared T2m,  
Red: 9-year means of purple

CMIP5\_Area\_time series

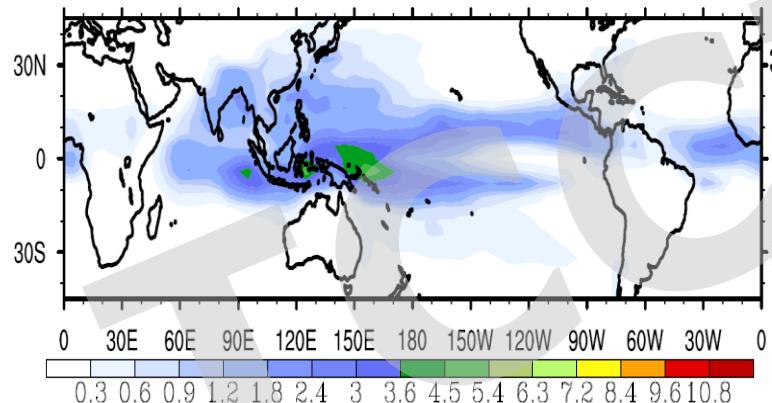


CMIP5\_Area\_time series

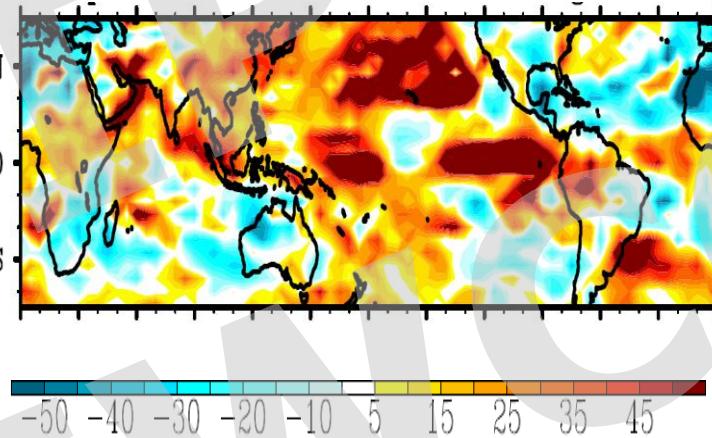


# JJA Rainfall Change

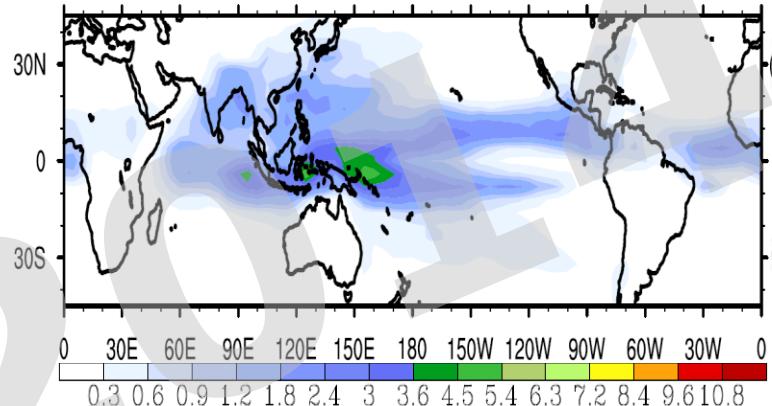
CMIP3\_JJA\_RAIN\_var\_1980-2000



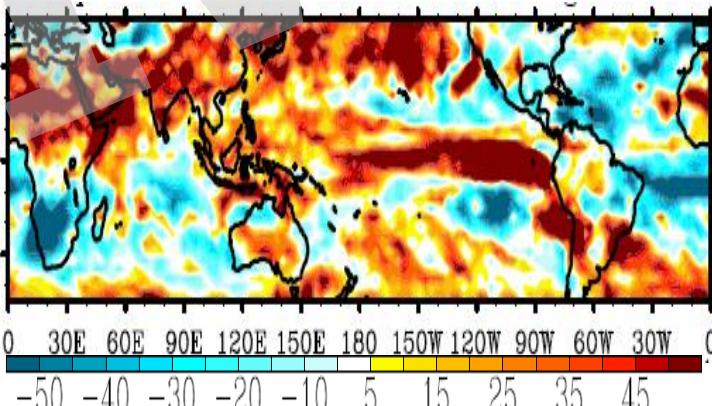
CMIP3\_JJA\_RAIN\_var\_  
[(2071-2100)-(1980-2000)]/1980-2000

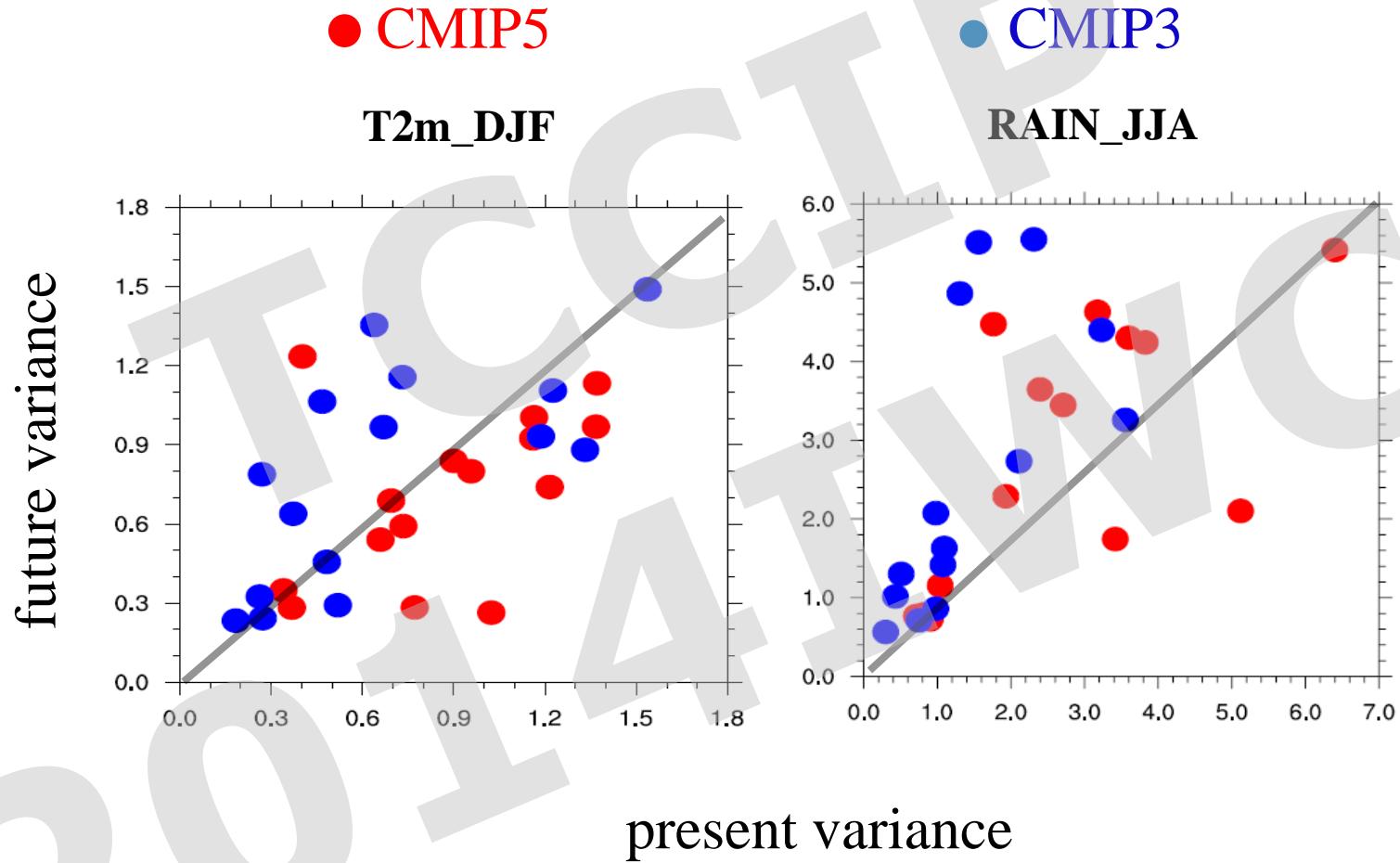


CMIP5\_JJA\_RAIN\_var\_1980-2000



CMIP5\_JJA\_RAIN\_var\_  
[(2071-2100)-(1980-2000)]/1980-2000

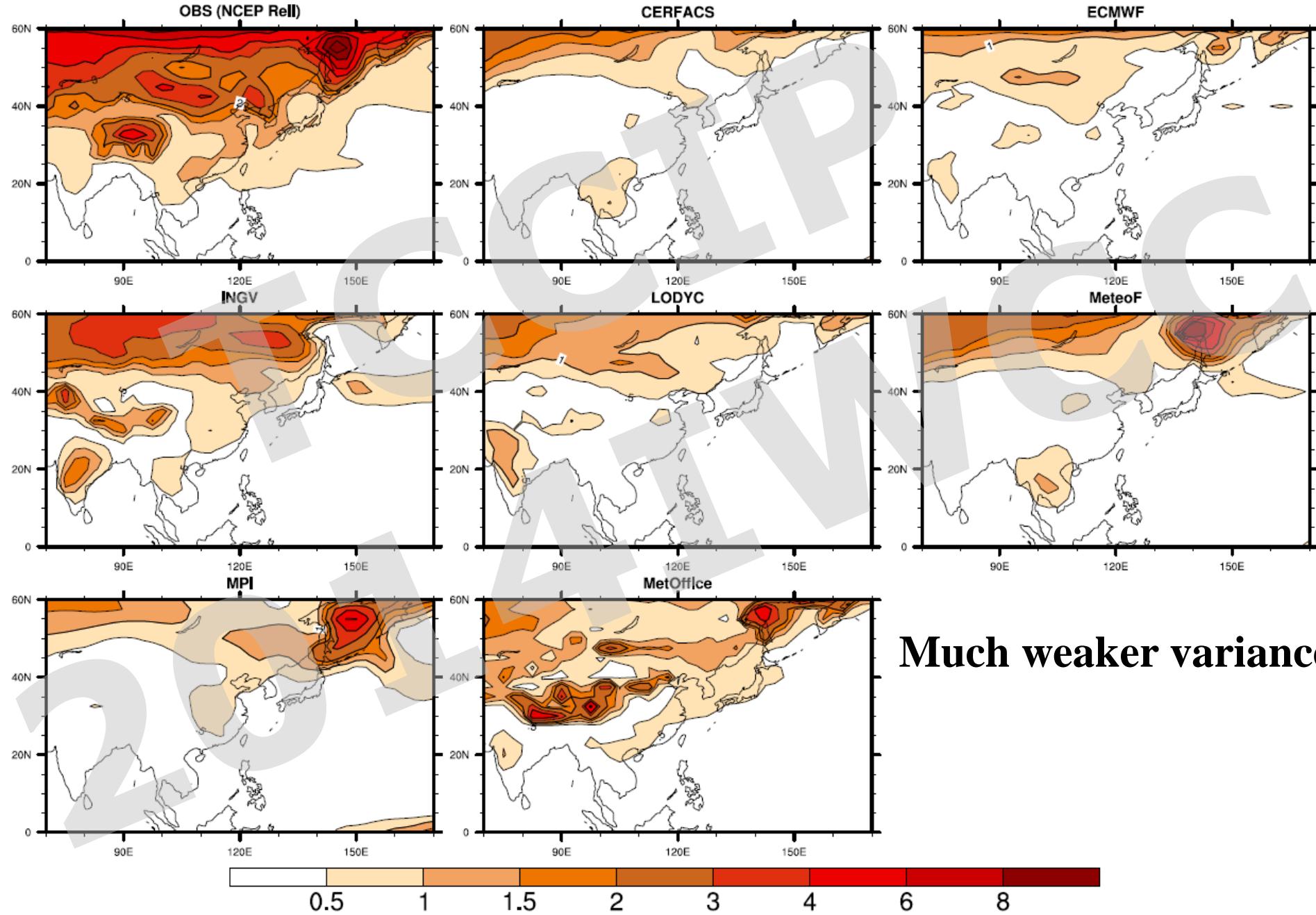




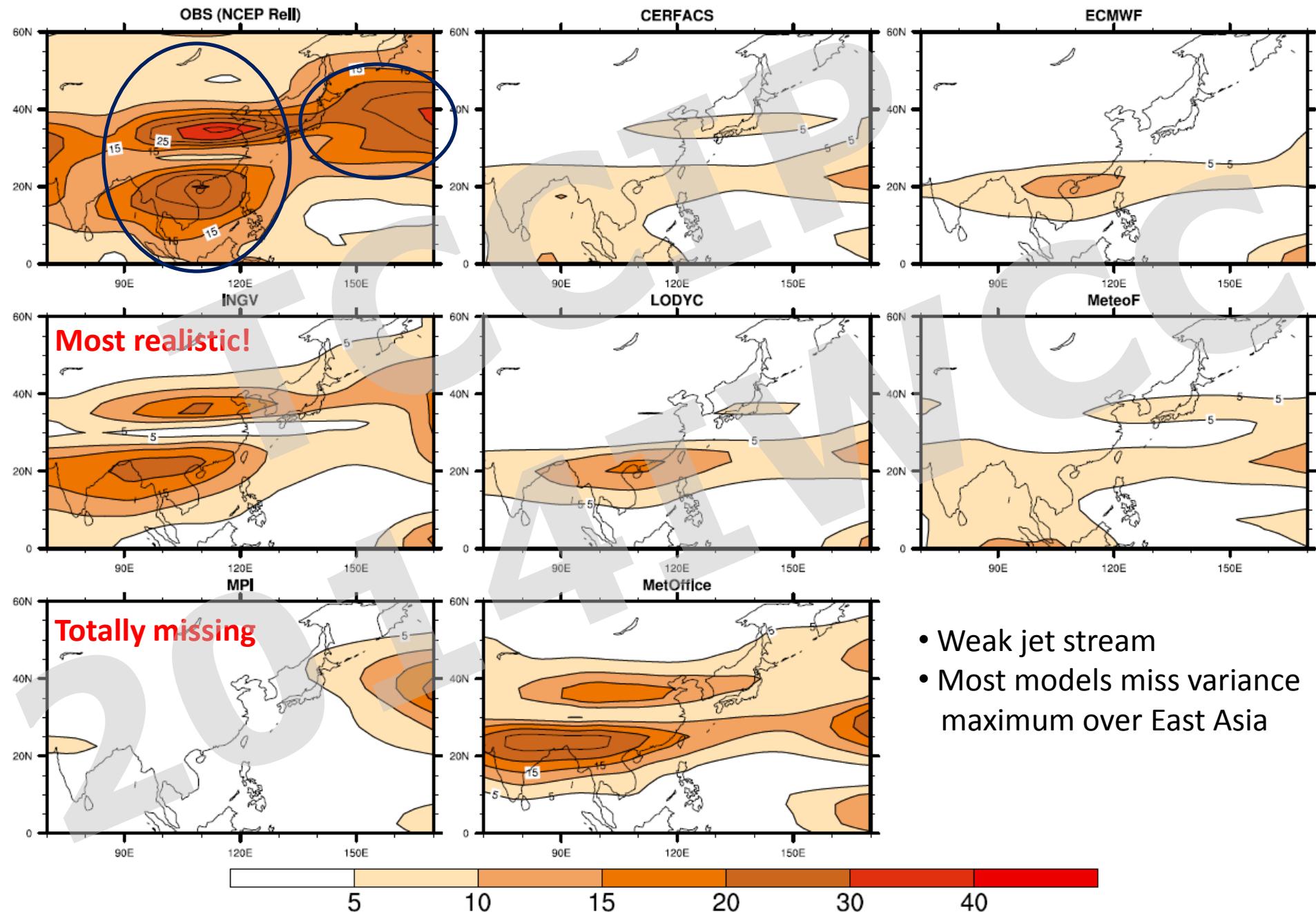
## *Summary*

- *Performance of CMIP5 AOGCMs in simulating present-climate interannual variability has been notably improved over CMIP3.*
- *Seasonal prediction models tended to over-emphasize the ENSO effect on tropical variability but under-simulate extratropical variability, likely due to the nature of seasonal forecast design.*
- *CMIP5 projects weaker interannual variability of winter T2m in the northern extratropics and tropical precipitation in the end of 21<sup>st</sup> century under RCP8.5 scenario. The changes, however, will not be stationary in time.*

# Variance of T2M of OBS and DEMETER(IC=Nov,target=DJF)

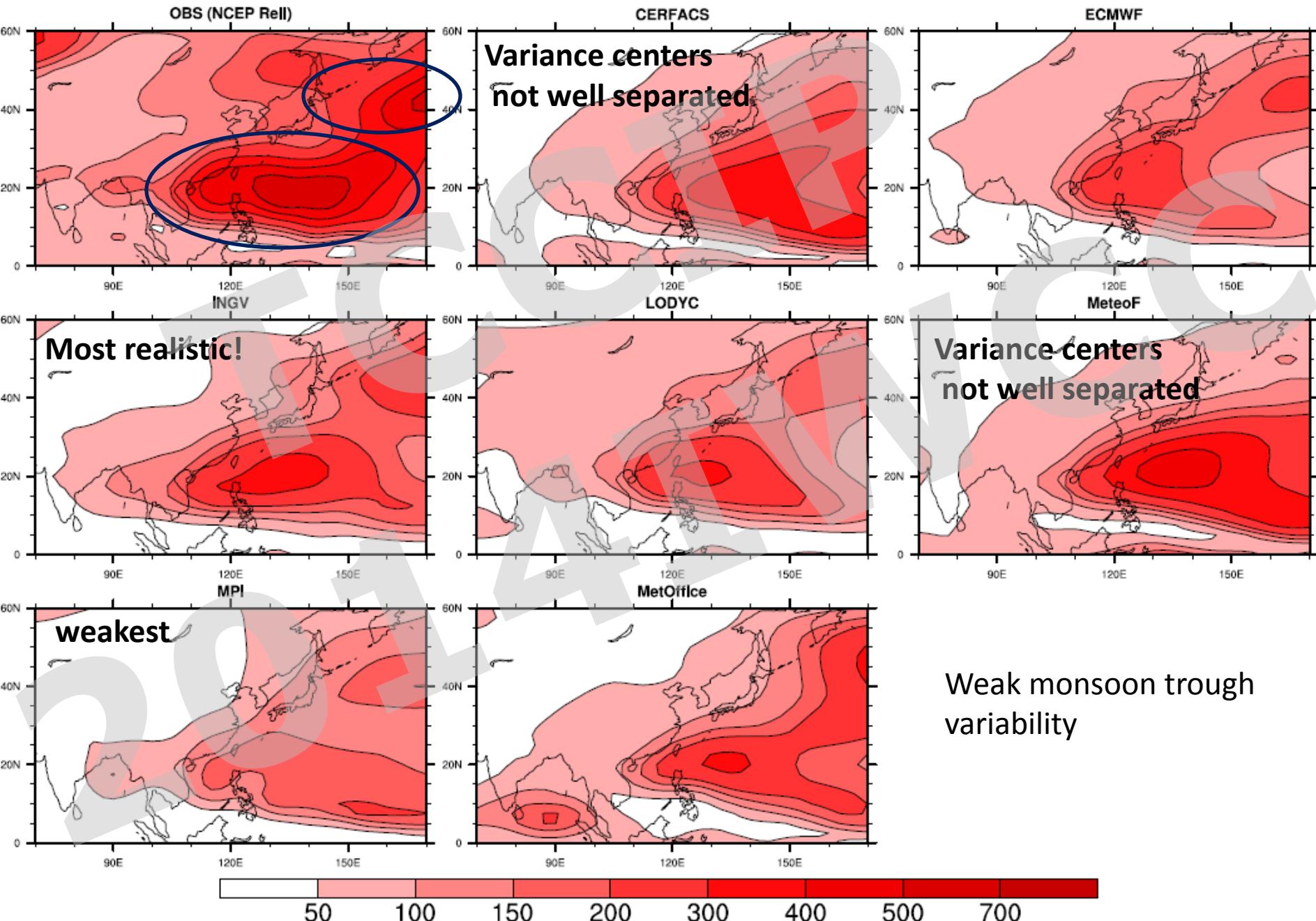


# Variance of U200 of OBS and DEMETER(IC=Nov,target=DJF)

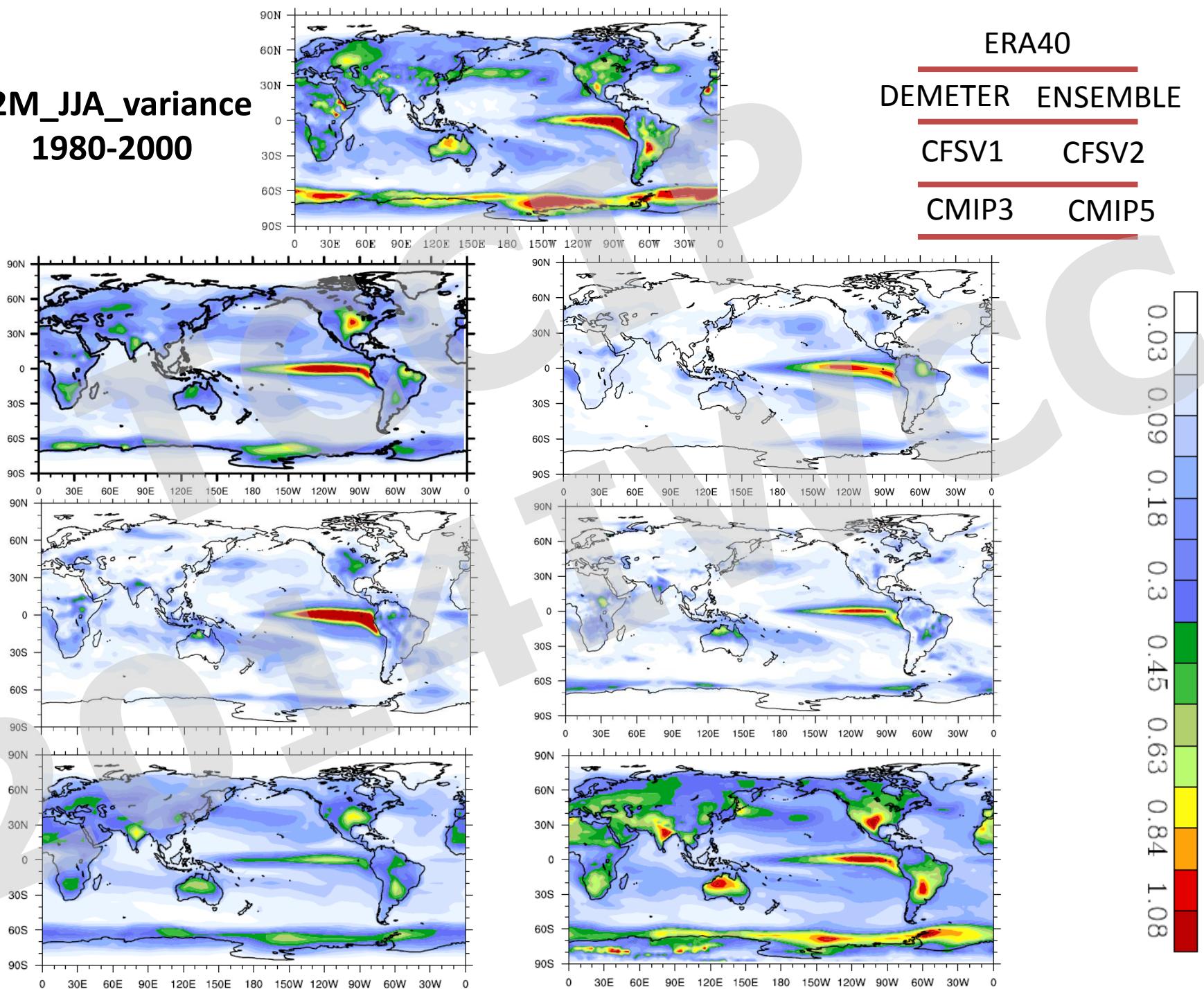


DEMETER	ENSEMBLE	CMIP3	CMIP5	
ECMWF	ECMWF	AUS_CSIRO_MK3	ACCESS1.0	GISS-E2-H
UK, (METO)	UK, (METO)	AUS_CSIRO_MK3.5	ACCESS1.3	GISS-E2-H-CC
France, (CNRM)	France, (CNRM)	CA_CCCMA3.1_T47	BCC-CSM1.1	GISS-E2-R
Germany, (MPI)	Germany, (MPI)	CN_BCC_CM1	BNU-ESM	GISS-E2-R-CC
Italy, (ING)	France, (CERFACS)	FR_CNRM_CM3	CanCM4	HadGEM2-AO
France, (LODYC)		FR_IPSL_CM4.1	CanESM2	HadGEM2-CC
France, (CERFACS)		GFDL_CCM2.0	CCSM4	IPSL-CM5A-LR
Denmark, (DMI)		GFDL_CCM2.1	CESM1-BGC	IPSL-CM5A-MR
		GISS_ER	CESM1-CAM5	MIROC4h
		INGV_ECHAM4	CESM1-CAM5-1-FV2	MIROC5
		JP_CCSR3.2M	CESM1-FASTCHEM	MIROC-ESM
		JP_MRI2.3	CESM1-WACCM	MIROC-ESM-CHEM
		MPI_ECHAM5	CNRM-CM5	MPI-ESM-LR
		NCAR_CCSM3	CSIRO-Mk3.6.0	MPI-ESM-MR
		NCAR_PCM1	FGOALS-g2	MPI-ESM-P
		NW_BCCR_CM2	FGOALS-s2	MRI-CGCM3
		Russia_INMCM3	FIO-ESM	MRI-ESM1
		UKMO_HadCM3	GFDL-CM2.1	NorESM1-M
		UKMO_HadGEM1	GFDL-CM3	

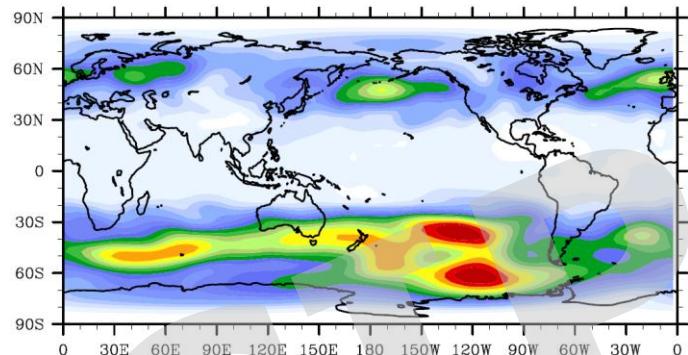
# Variance of PSI850 of OBS and DEMETER(IC=May,target=JJA)



# T2M\_JJA\_variance 1980-2000



# H500\_JJA\_variance 1980-2000

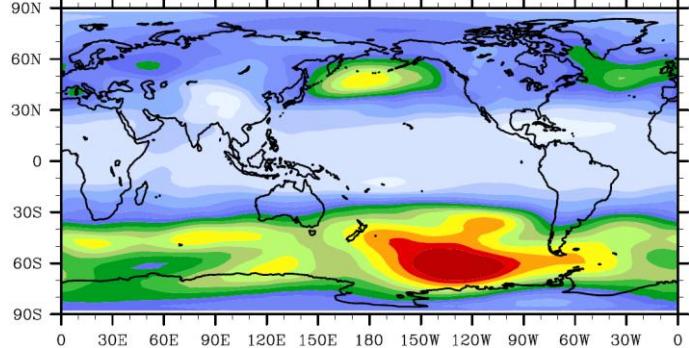
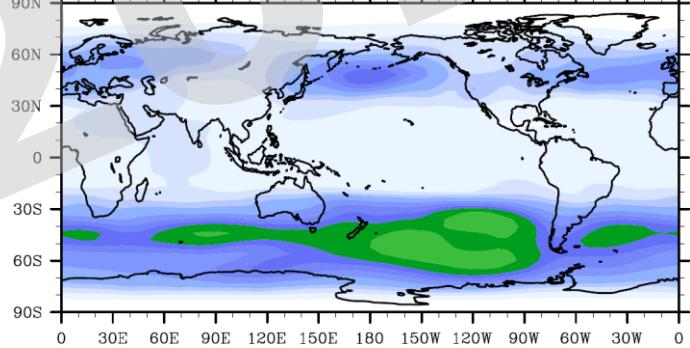
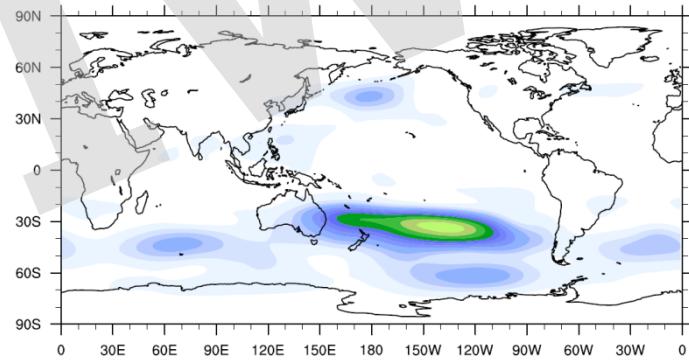
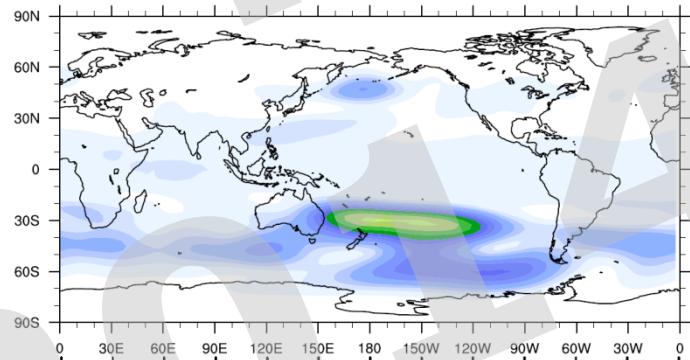
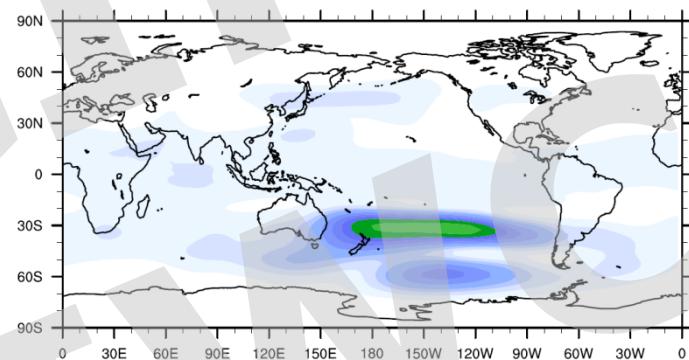
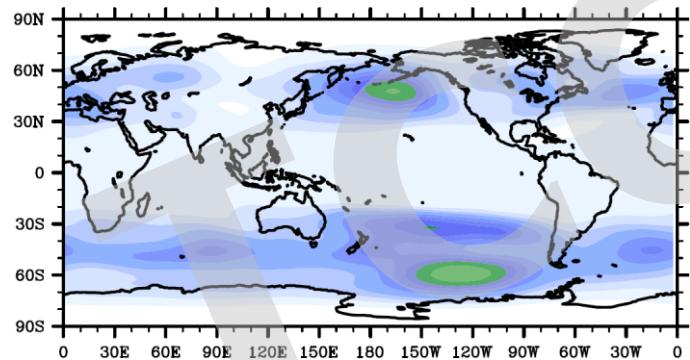


ERA40

DEMETER ENSEMBLE

CFSV1 CFSV2

CMIP3 CMIP5



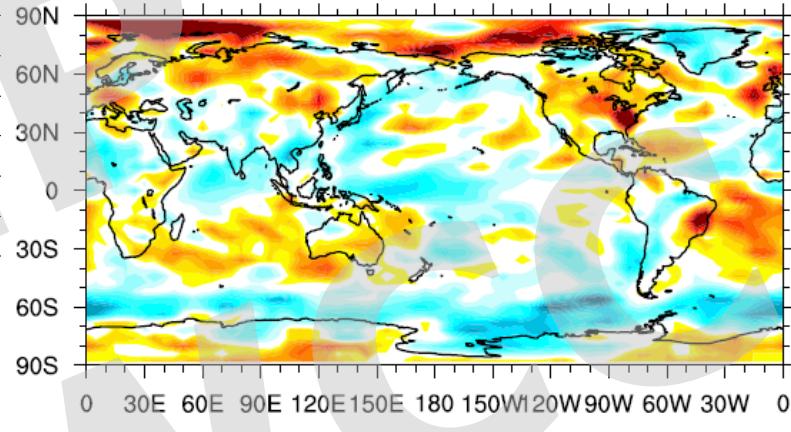
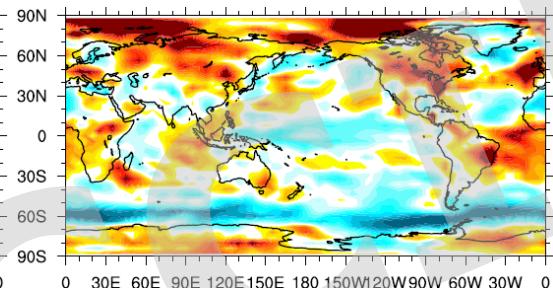
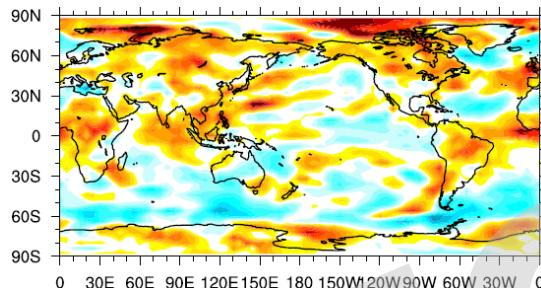
A vertical color bar on the right side of the figure, ranging from light blue at the bottom to dark red at the top. The scale is labeled in increments of 60, starting from 20 and ending at 720. The colors transition through white, yellow, orange, and green.

# CMIP3\_JJA\_variance\_percentage\_T2M

(B-A)/A

(C-A)/A

(C-A)/A -(B-A)/A



A:2011~2040

B:2041~2070

C:2071~2100

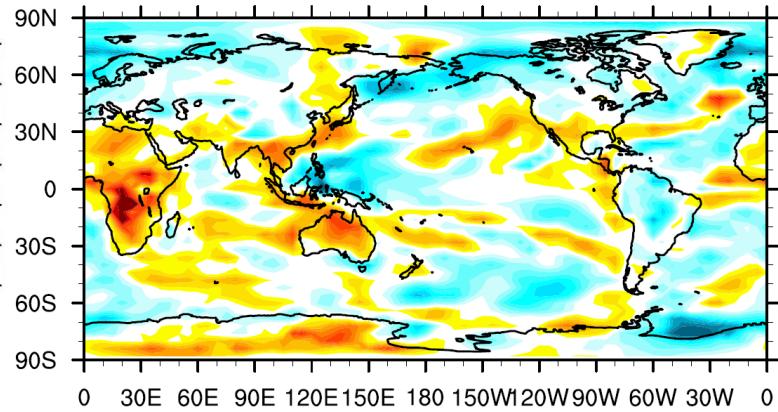
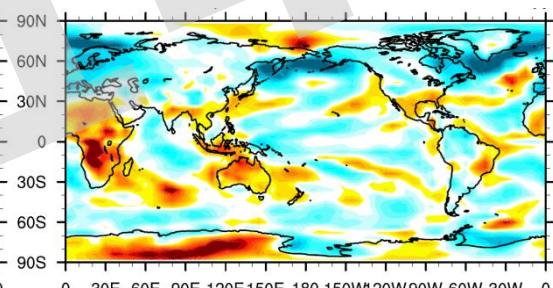
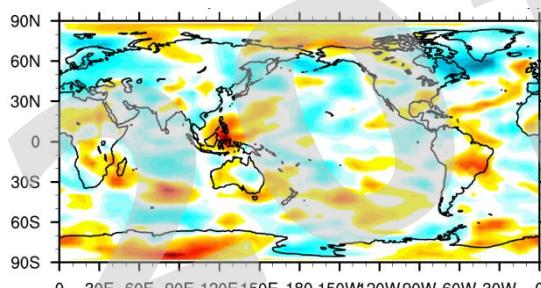


# CMIP3\_DJF\_variance\_percentage\_T2M

(B-A)/A

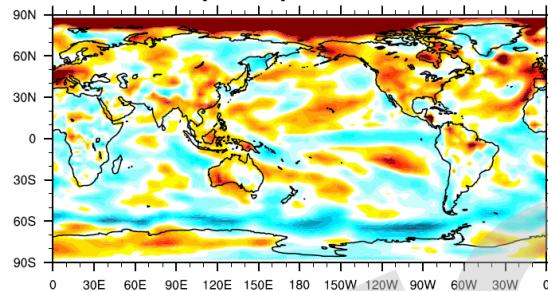
(C-A)/A

(C-A)/A -(B-A)/A

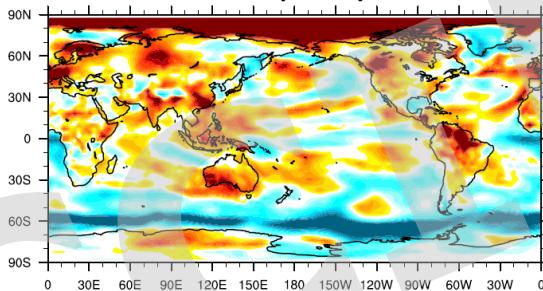


# CMIP5\_JJA\_variance\_percentage

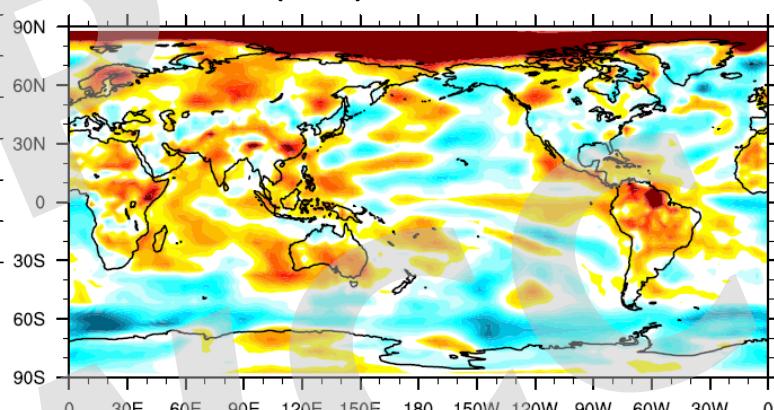
(B-A)/A



(C-A)/A



(C-A)/A -(B-A)/A



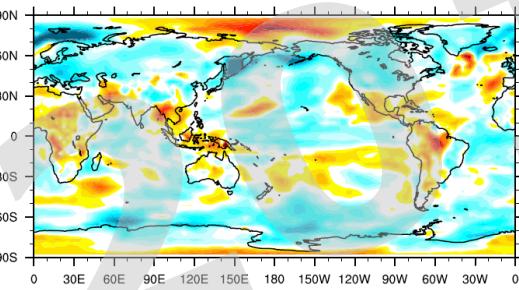
A:2011~2040

B:2041~2070

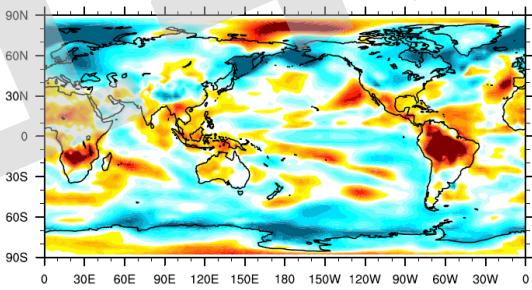
C:2071~2100

# CMIP5\_DJF\_variance\_percentage

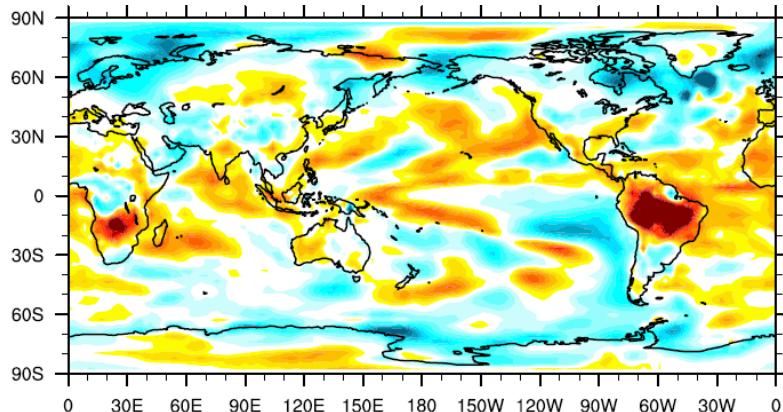
(B-A)/A



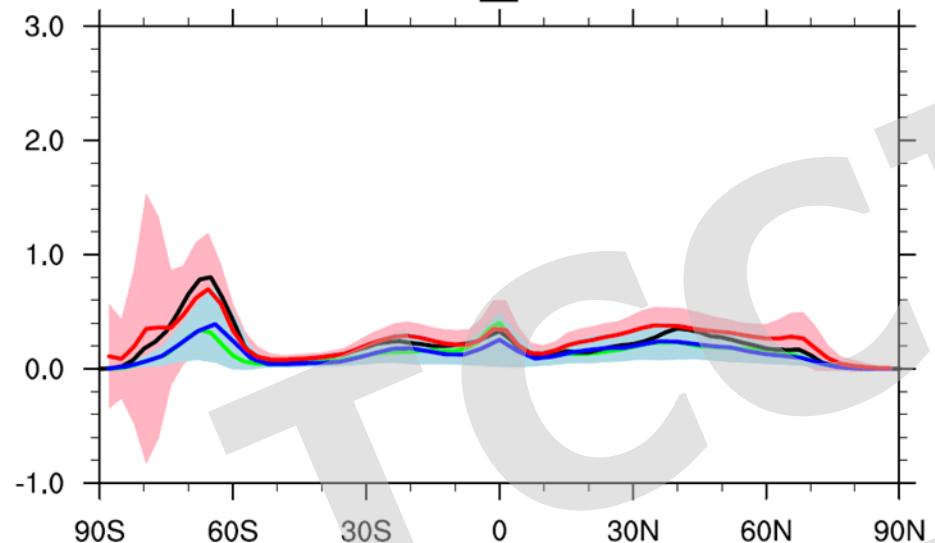
(C-A)/A



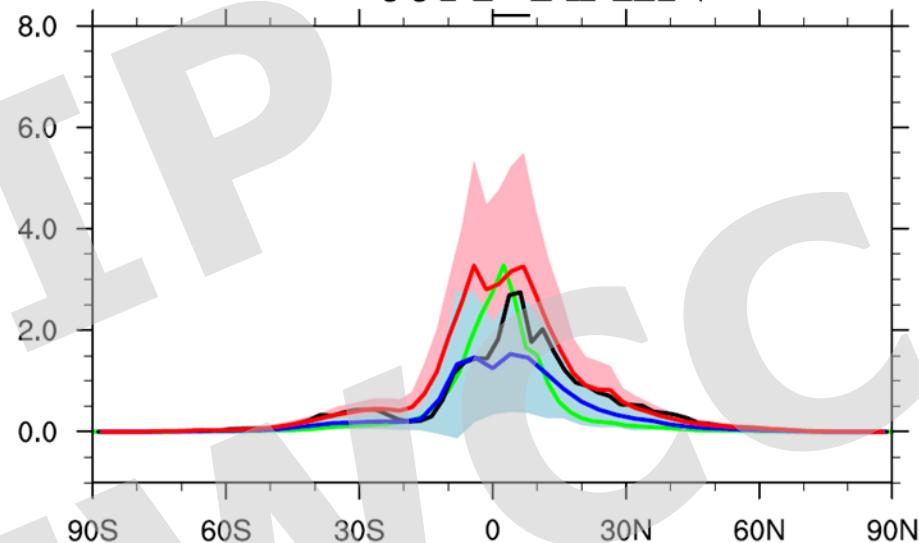
(C-A)/A -(B-A)/A



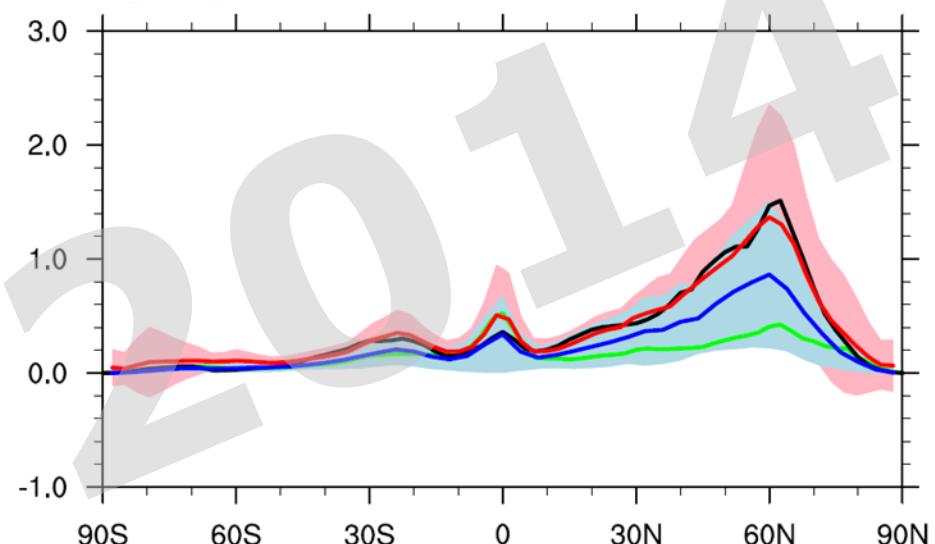
JJA T2M



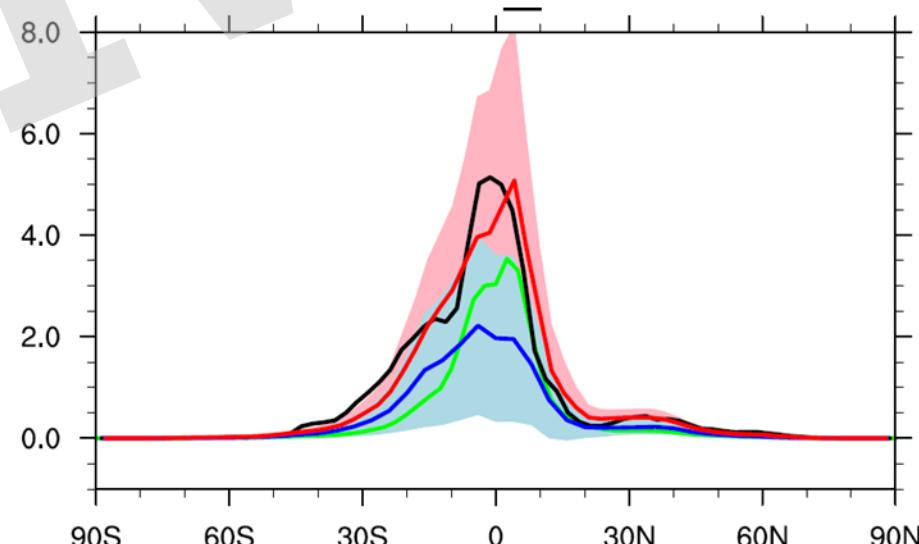
JJA RAIN

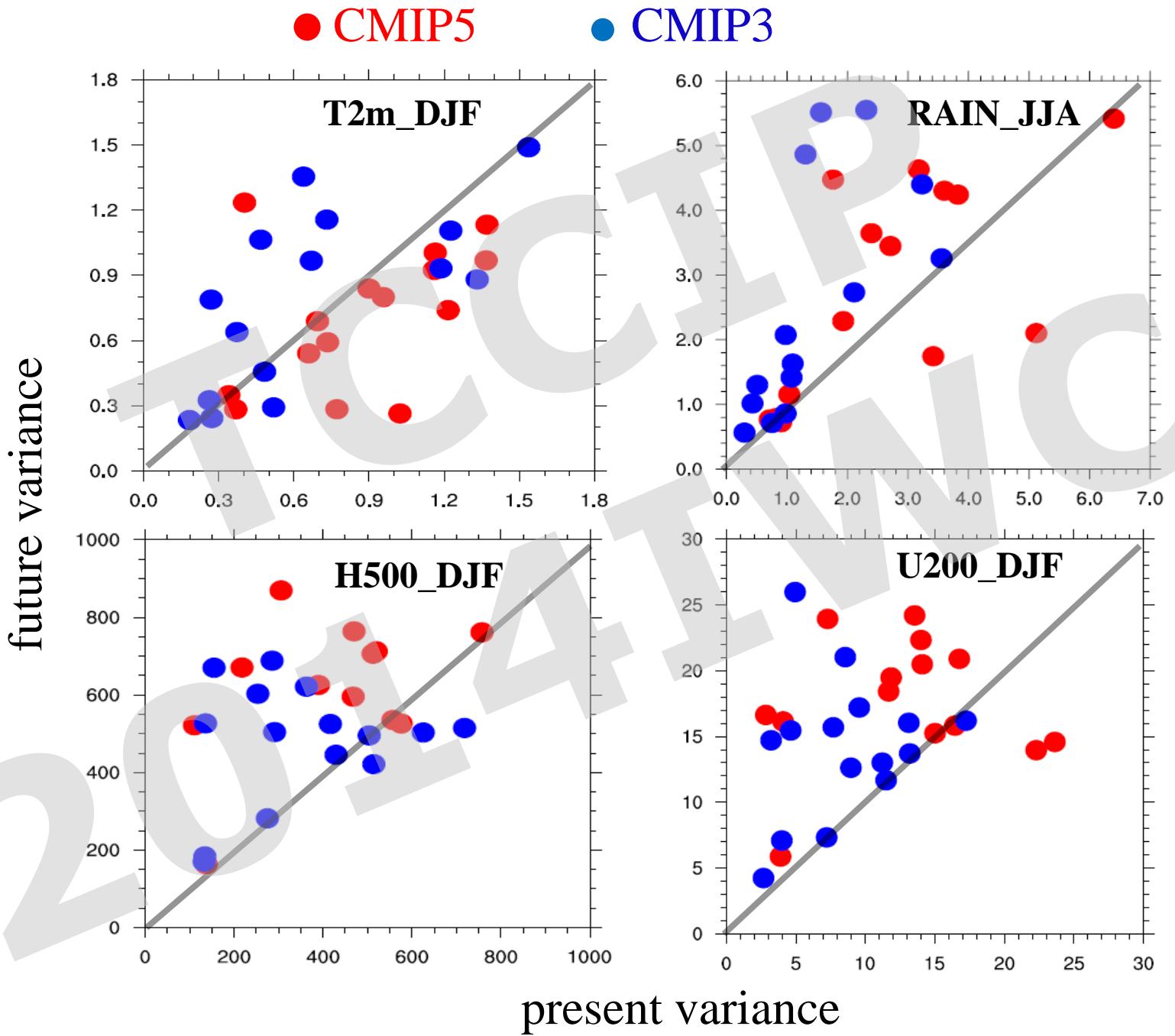


DJF T2M



DJF RAIN

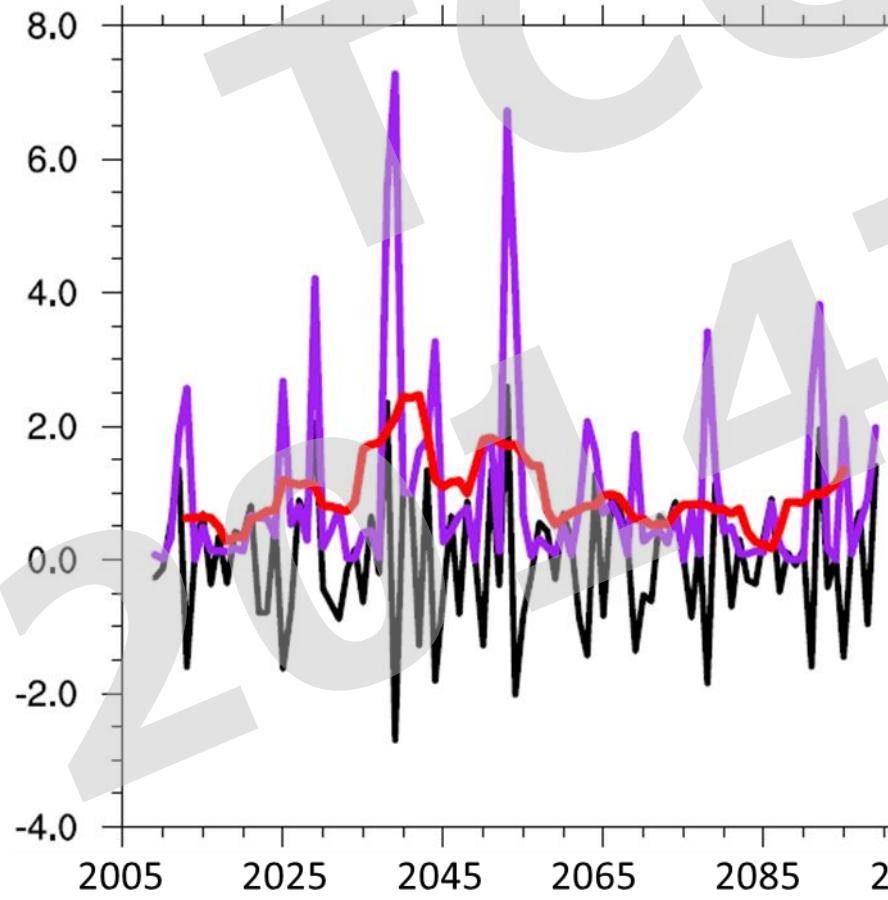




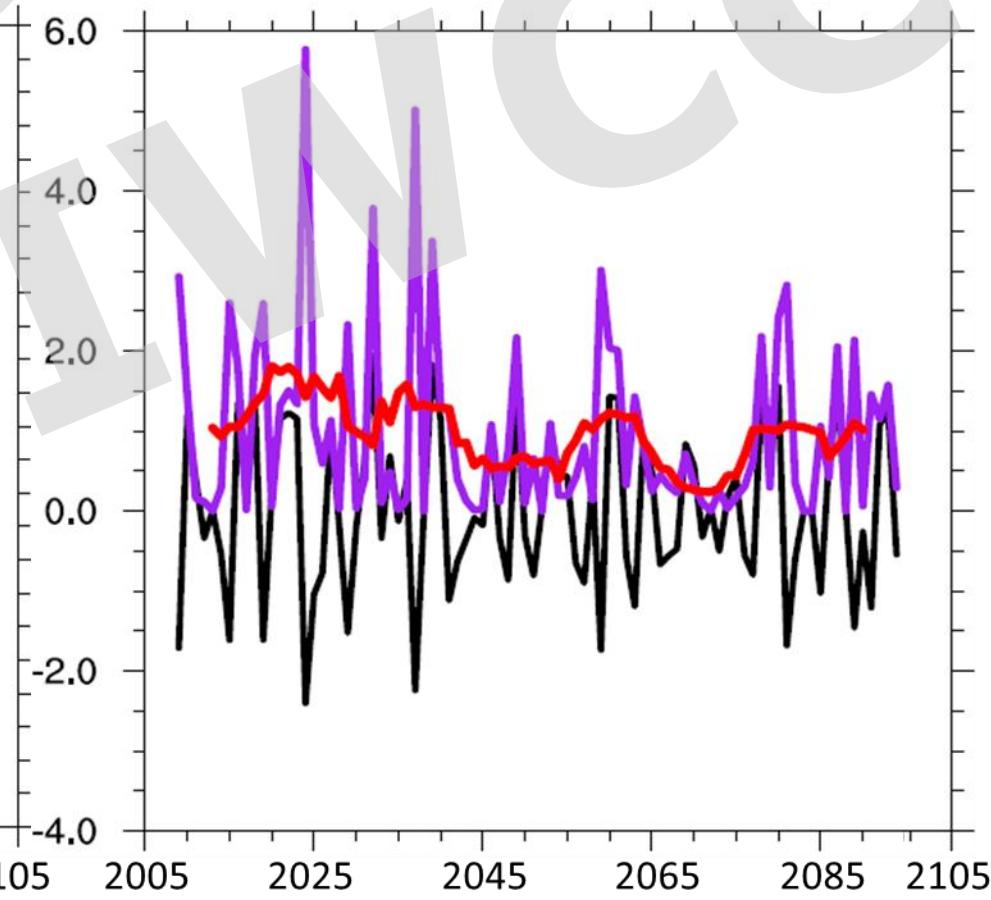
# U200\_DJF\_variance\_60N~60S · 180~90W

**Black: T2m, Purple: squared T2m,  
Red: 9-year means of purple**

CMIP3\_Area\_time series

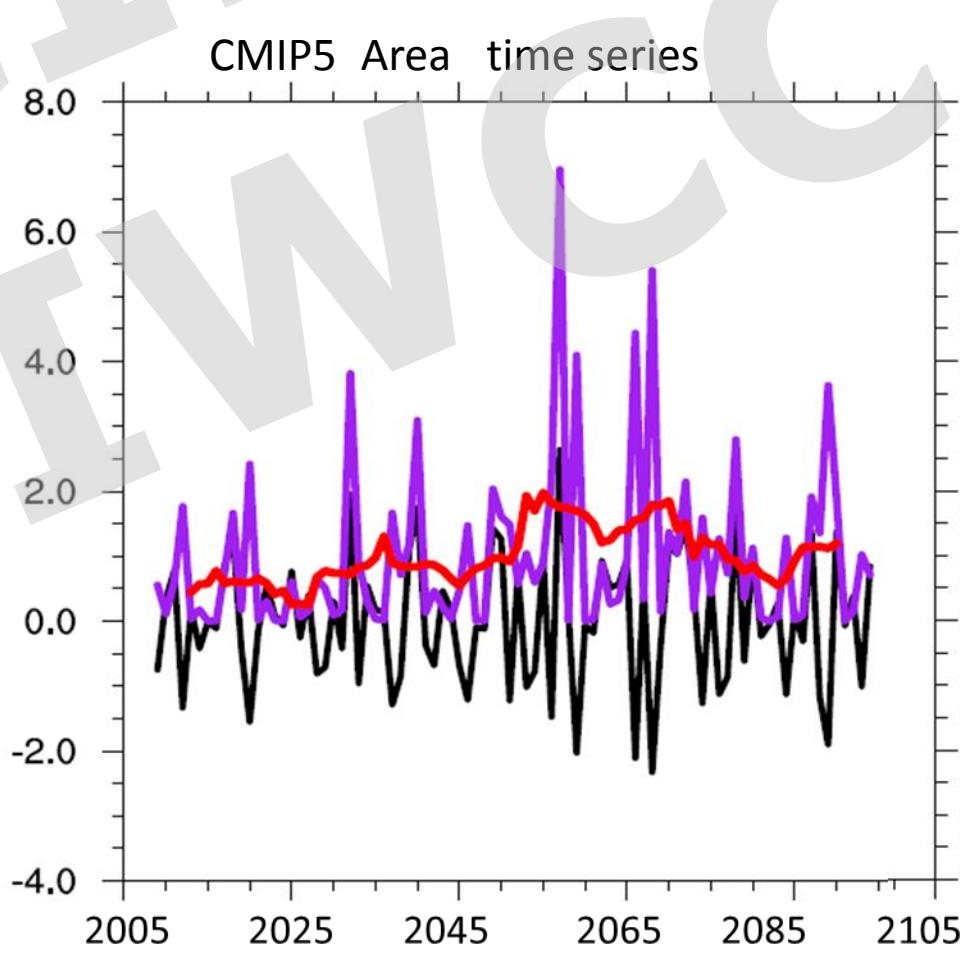
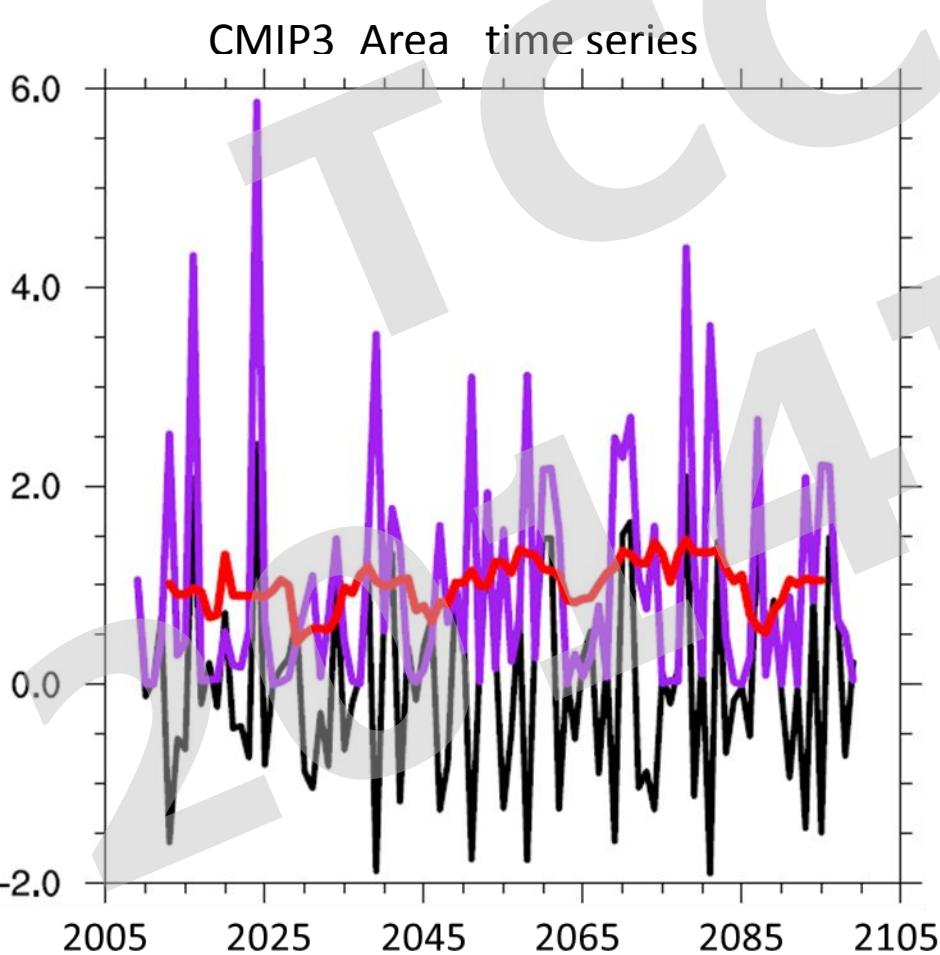


CMIP5\_Area\_time series



# U200\_DJF\_variance\_25N~45N · 180~90W

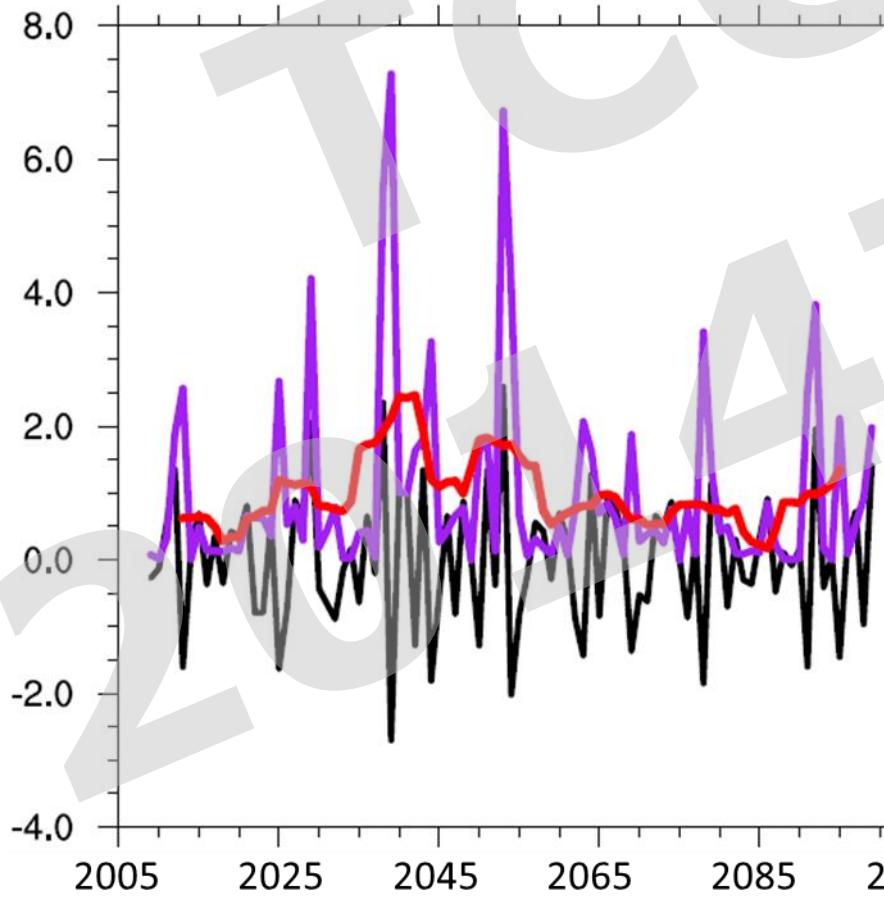
Black: T2m, Purple: squared T2m,  
Red: 9-year means of purple



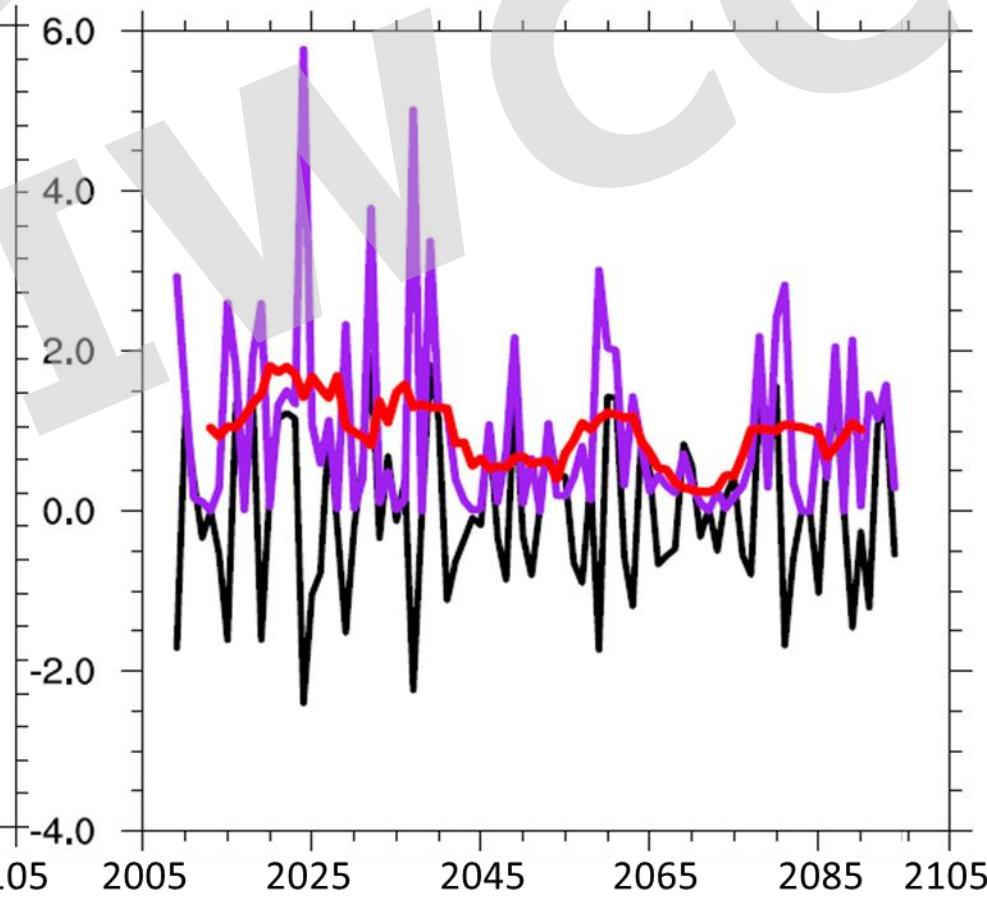
# U200\_DJF\_variance\_60N~60S · 180~90W

**Black: T2m, Purple: squared T2m,  
Red: 9-year means of purple**

CMIP3\_Area\_time series



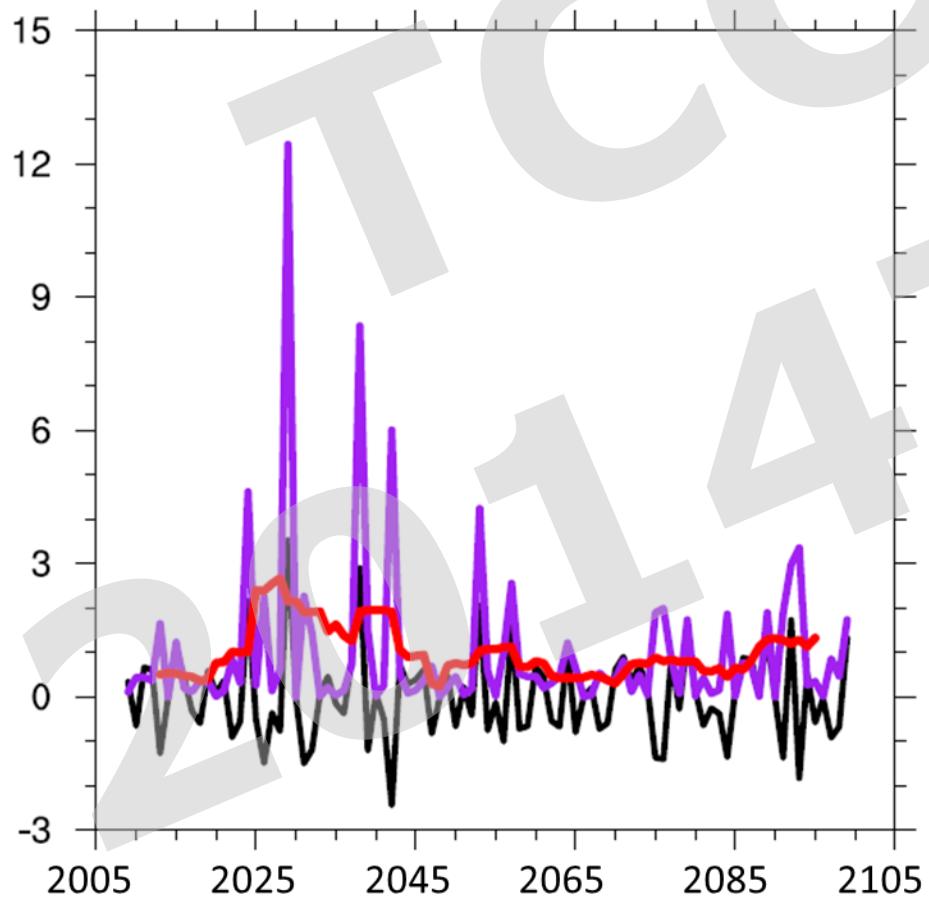
CMIP5\_Area\_time series



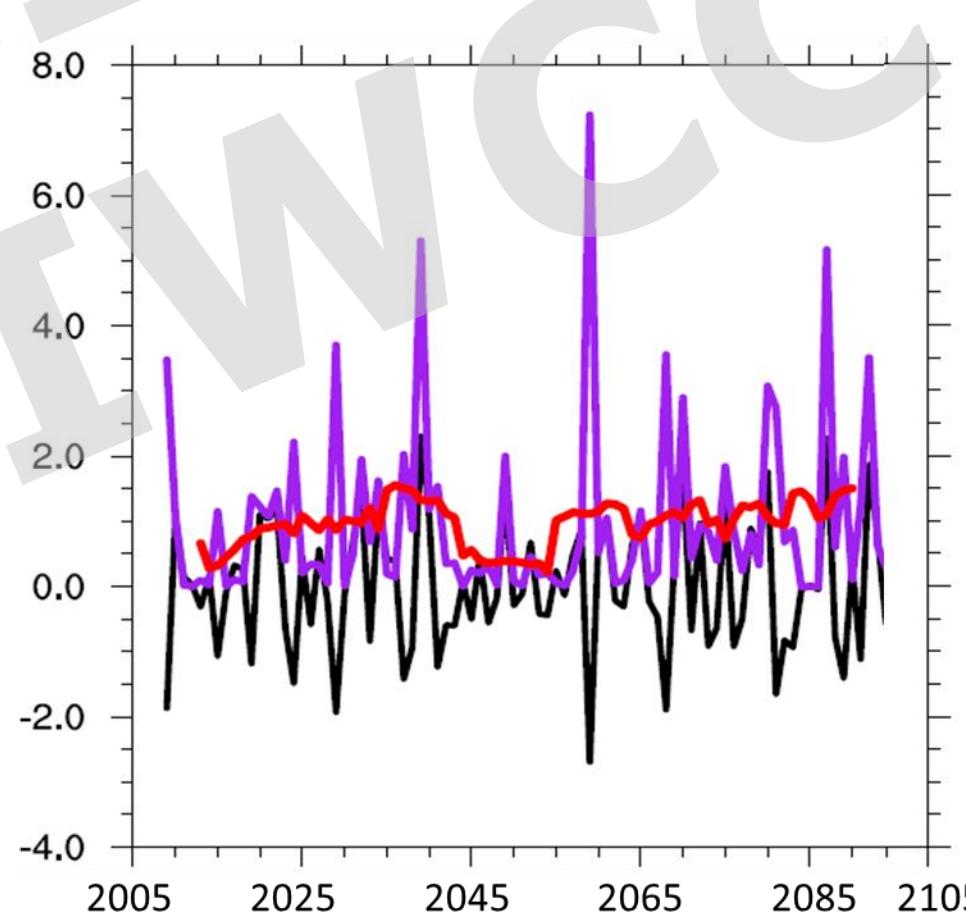
# U200\_DJF\_variance\_60N~60S · 70W~0

**Black: T2m, Purple: squared T2m,  
Red: 9-year means of purple**

CMIP3\_Area\_time series

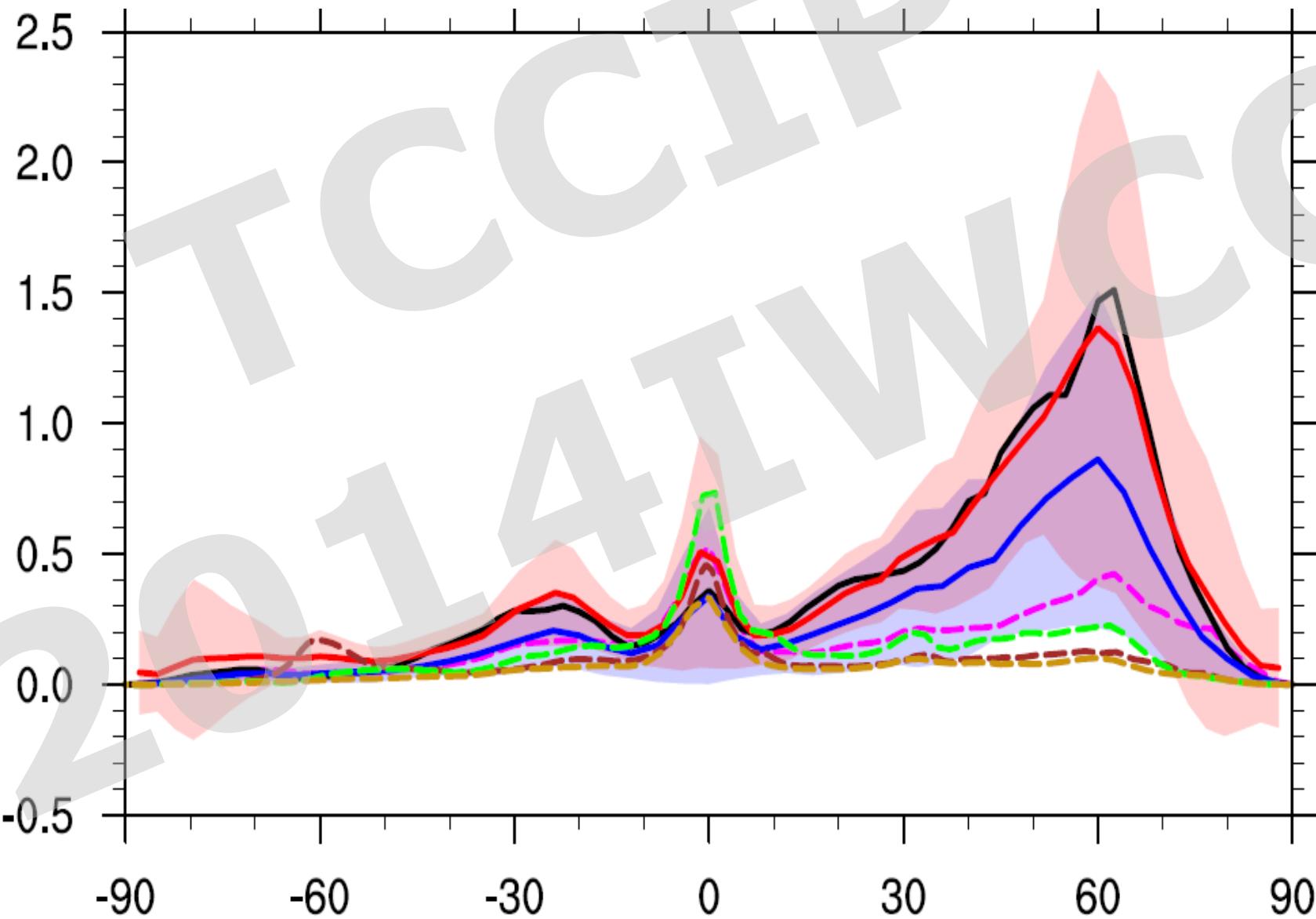


CMIP5\_Area\_time series



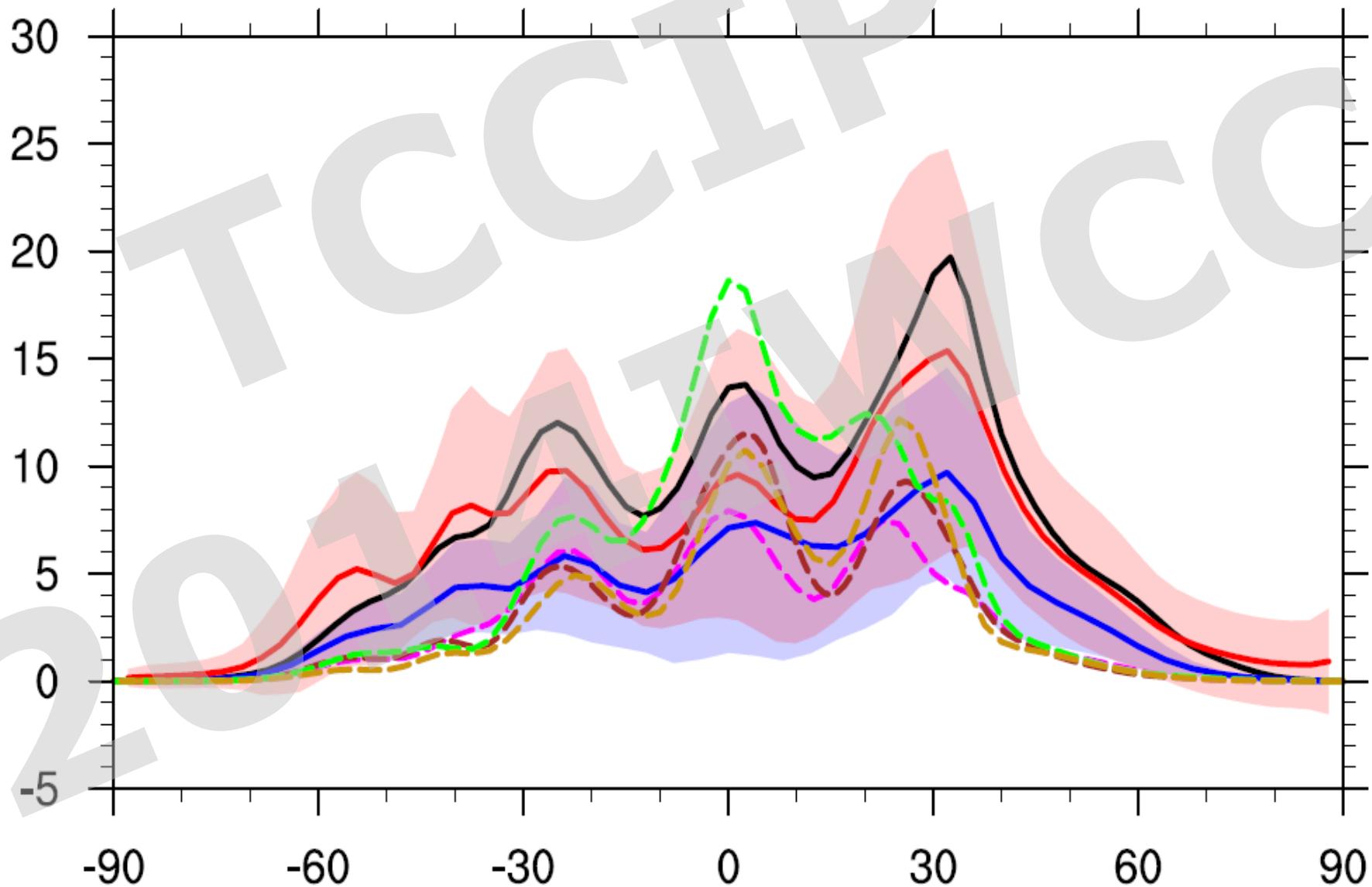
**T2M\_DJF\_variance**  
**1980-2000**

ERA40      DEMETER  
CMIP5      ENSEMBLE  
CMIP3      CFSV1  
            CFSV2



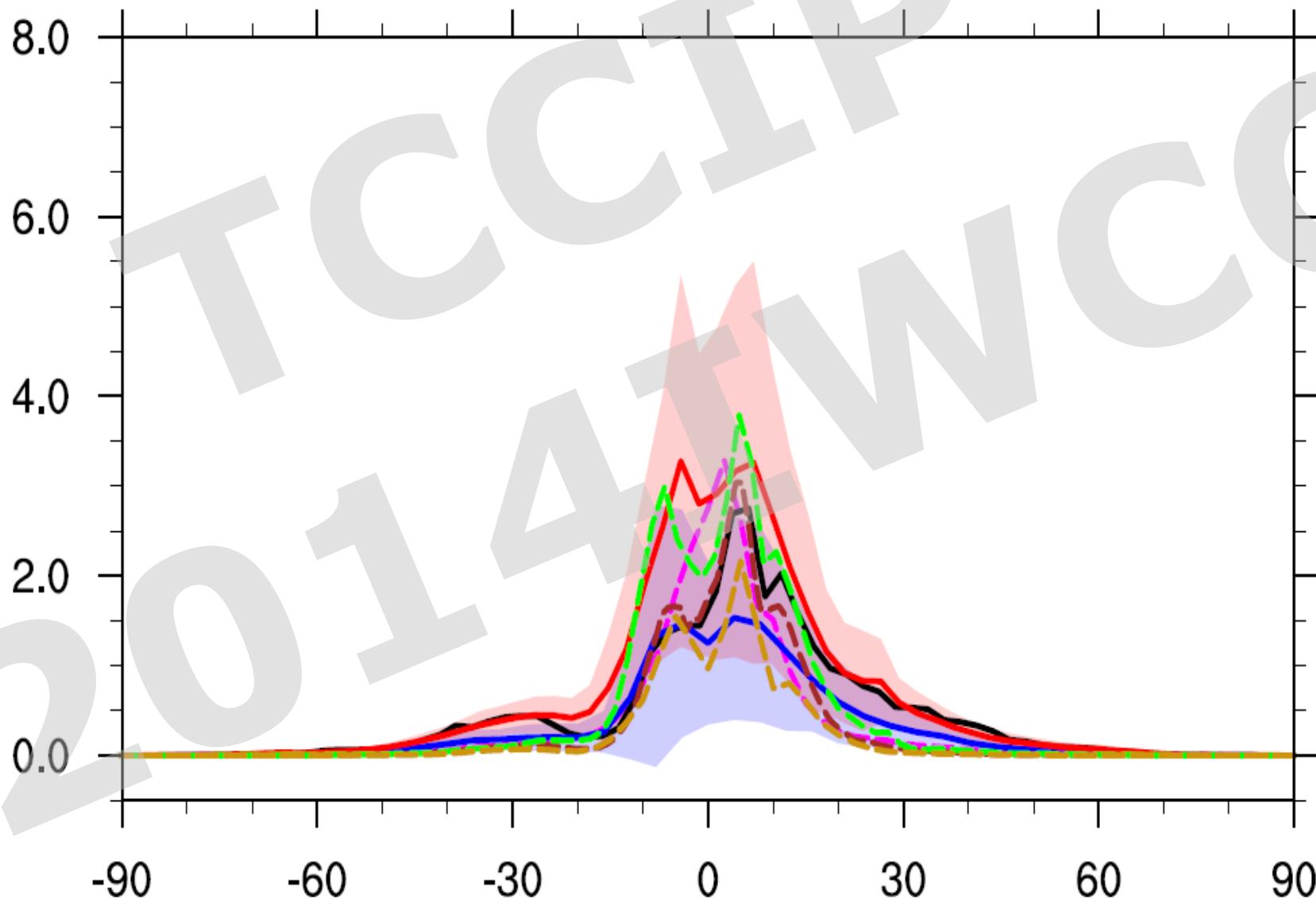
**U200\_DJF\_variance**  
**1980-2000**

— GPCP    — DEMETER  
— CMIP5    — ENSEMBLE  
— CMIP3    — CFSV1  
— CFSV2



**rain\_JJA\_variance**  
**1980-2000**

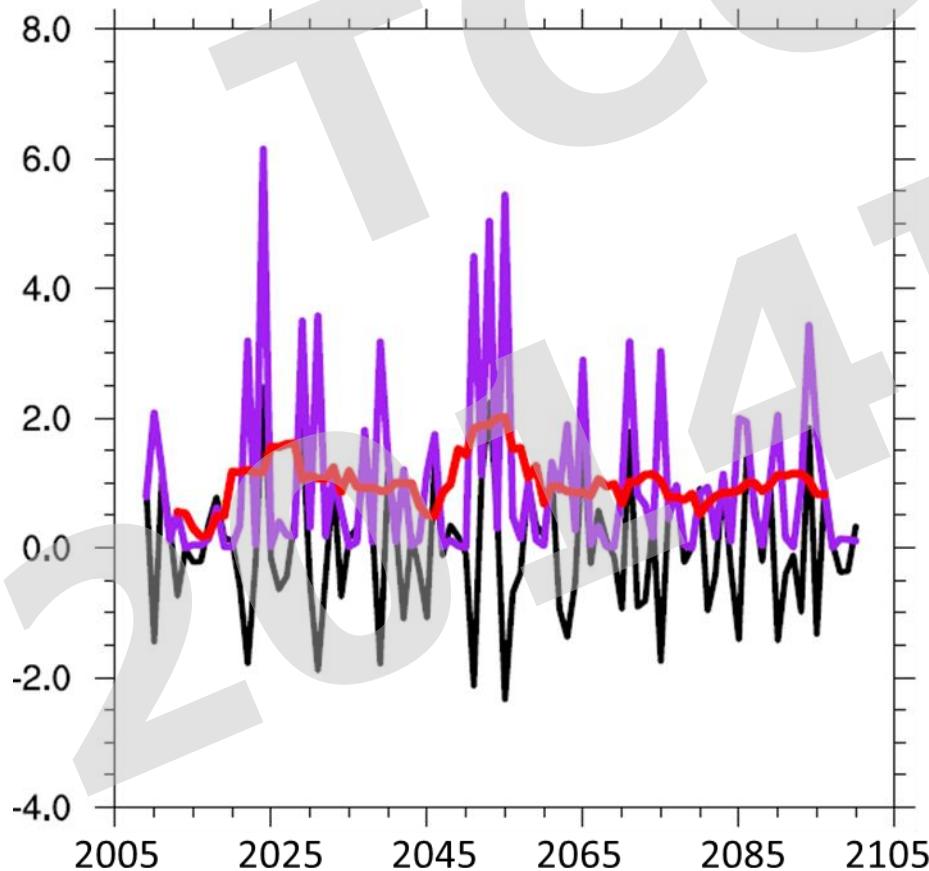
— GPCP    — DEMETER  
— CMIP5    — ENSEMBLE  
— CMIP3    — CFSV1  
— CFSV2



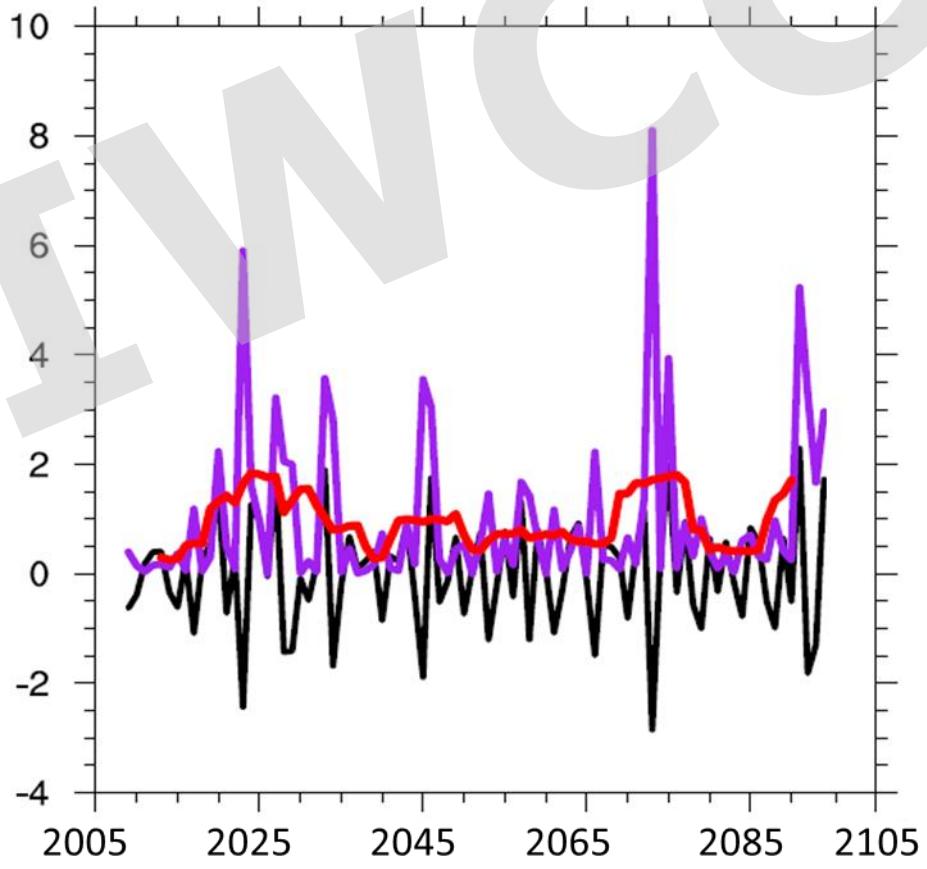
# rain\_JJA\_variance\_10N~10S

Black: T2m, Purple: squared T2m,  
Red: 9-year means of purple

CMIP3\_Area\_time series



CMIP5\_Area\_time series



# TC in HiRAM

C384 wnp olr 2001-11-05-00Z

watts/m<sup>2</sup>

