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Overview of Chinese Contribution to CMIP6: Status and challenges

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Thanks for inputs from model groups' contacts

Pan-WCRP modelling, Met Office, Exeter, Oct 9th-13th, 2017

Outline

- Overview of the models and commitments
- Model changes compared to CMIP5
- Status and planning to submit model outputs
- First results from CMIP6 simulations
- Additional feedback to the WGCM and CMIP Panel

Nine Model Groups

Group name	Affiliation	Model name
IAP/CAS	Institute of Atmospheric Physics (IAP), Chinese Academy of Sciences (CAS)	CAS FGOALS
		CAS ESM
CESS/THU	Center for Earth System Science (CESS), Tsinghua University (THU)	CICSM
BNU	Beijing Normal University (BNU)	BNU-ESM
NUIST	Nanjing University of Information Science and Technology (NUIST)	NUIST-CSM
BCC	Beijing Climate Center (BCC) / China Meteorological Administration (CMA) Chinese Academy of Meteorological Science (CAMS) / CMA	BCC-ESM/CSM
CAMS		CAMS-CSM
FIO	First Institute of Oceanography (FIO) / State Oceanic Administration (SOA)	FIO-ESM
RCEC	Research Center for Environmental Changes, Academia Sinica	TaiESM

FGOALS: Flexible Global Ocean-Atmosphere-Land System   CICSM / CIESM: Community Integrated CSM / ESM

Model Names

Affiliation	ESM/CSM	AGCM	LSM	OGCM	SIM
CAS	CAS FGOALS-f CAS FGOALS-g	FAMIL GAMIL 3	CLM4.5	LICOM3	CICE4.0
	CAS ESM	IAP AGCM4.0 + AACM	CoLM + IAP DGVM	LICOM2 + IAP OBGCM	CICE4.0
Universities	CICSM	FDAM/FVAM	CLM4.5	POP2	CICE4.0
	BNU-ESM	CAM4	CoLM + improved biogeochem schem	MOM4p1 + Dynamic ecosystem- carbon scheme♪	CICE4.1♪
	NUIST-CSM	ECHAM –NUIST	Modified ECHAM5.3 Land Model♪	NEMO 3.4♪	CICE 4.1♪
CMA	BCC-ESM BCC-CSM	BCC-AGCM3-Ch BCC-AGCM3-MR BCC-AGCM3-HR	BCC-AVIM2	MOM4- HAMOCC	CICE5
	CAMS-CSM	ECHAM5.0	CoLM	LICOM2	CICE4.0
SOA	FIO-ESM	CAM4 / CAM5	CLM4.5 + DGVM	NEMO3.6 + OCMIP-2 + MASNUM	CICE5
Academia Sinica	TaiESM	CAM 5.3	CLM4.0	POP2	CICE4.0

Model Resolutions

Affiliation	ESM/CSM	AGCM / LSM	OGCM/SIM
CAS	CAS FGOALS	C96(1^ox1^o), C384(0.25^ox0.25^o); L32 for FAMIL 2^ox2^o, 1^ox1^o; L26 for GAMIL	1^o x 1^o (0.5^o near EQ) L80
	CAS ESM	1^ox1^o; L26	1^o x 1^o (0.5^o near EQ) L30
Universities	CICSM	1^ox1^o; L30	1^o x 1^o (0.5^o near EQ) L30
	BNU-ESM	FV144x96; L30	360x200 L50
	NUIST-CSM	T63 L47 / T31 L31	~1^o L46 / ~2^o L31 Sea ice: 1^o x 0.5^o
CMA	BCC-ESM / BCC-CSM	T42 L26 for ESM1-LR T106 L46 for CSM2-MR T266 L26 for CSM2-HR	1/3 ^{o} in 50S-50N 1/3-1^o in 50N-60N 1^o in high latitudes
	CAMS-CSM	T106 L31	1^o x 1^o (0.5^o near EQ) L30
SOA	FIO-ESM	100 km; L26	100 km; L75 WAV: 100km
Academia Sinica	TaiESM	0.9°×1.25° and 1.9°×2.5°; L30	1^o x 1^o ; L70

Model Groups' Commitments to participate in each MIP

	MIPs	CAS		Universities			CMA		SOA	Academia Sinica	Total
		FGOALS	CAS ESM	THU	BNU	NUIST	BCC	CAMS	FIO	RCEC	
0	DECK	Participating	Participating	Participating	Participating	Participating	Participating	Participating	Participating	Participating	10
1	AerChemMIP	Not Participating	Participating	Not Participating	Not Participating	Not Participating	Participating	Not Participating	Not Participating	Not Participating	2
2	C^4MIP	Not Participating	Participating	Not Participating	Not Participating	Not Participating	Participating	Not Participating	Participating	Not Participating	3
3	CFMIP	Participating	Not Participating	Participating	Participating	Not Participating	Participating	Participating	Not Participating	Participating	6
4	DAMIP	Not Participating	Not Participating	Not Participating	Not Participating	Participating	Participating	Not Participating	Not Participating	Not Participating	2
5	DCPP	Not Participating	Not Participating	Not Participating	Not Participating	Participating	Participating	Not Participating	Participating	Not Participating	3
6	GeoMIP	Not Participating	Not Participating	Not Participating	Participating	Not Participating	Not Participating	Not Participating	Not Participating	Not Participating	1
7	GMMIP	Participating	Participating	Participating	Participating	Participating	Participating	Participating	Participating	Participating	10
8	HighResMIP	Participating	Participating	Not Participating	Not Participating	Not Participating	Participating	Participating	Not Participating	Not Participating	4
9	LS3MIP	Not Participating	Not Participating	Not Participating	Not Participating	Not Participating	Participating	Not Participating	Not Participating	Not Participating	1
10	LUMIP	Not Participating	Not Participating	Not Participating	Not Participating	Not Participating	Participating	Not Participating	Not Participating	Participating	2
11	OMIP	Participating	Not Participating	Participating	Not Participating	Not Participating	Participating	Not Participating	Participating	Not Participating	4
12	PMIP	Participating	Not Participating	Not Participating	Not Participating	Participating	Not Participating	Not Participating	Not Participating	Participating	3
13	RFMIP	Not Participating	Not Participating	Not Participating	Not Participating	Not Participating	Participating	Not Participating	Not Participating	Not Participating	1
14	ScenarioMIP	Participating	Participating	Participating	Participating	Not Participating	Participating	Not Participating	Participating	Participating	7
15	SIMIP	Not Participating	Not Participating	Participating	Not Participating	Not Participating	Not Participating	Not Participating	Participating	Not Participating	2
16	CORDEX	Not Participating	Not Participating	Participating	Not Participating	Not Participating	Not Participating	Not Participating	Not Participating	Not Participating	1

Not Participating
Participating

Model Groups' CMIP5 Experiences: *5 new faces*

Group name	Affiliation	Model name
LASG/IAP	Institute of Atmospheric Physics (IAP), Chinese Academy of Sciences (CAS)	CAS FGOALS
IAP/CAS		CAS ESM
CESS/THU	Center for Earth System Science (CESS), Tsinghua University (THU)	CICSM
BNU	Beijing Normal University (BNU)	BNU-ESM
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CAMS		CAMS-CSM
FIO	First Institute of Oceanography (FIO) / State Oceanic Administration (SOA)	FIO-ESM
RCEC	Research Center for Environmental Changes, Academia Sinica	TaiESM

Participating CMIP5 (green)

No Experience of participating CMIP5 (yellow)

Outline

- Overview of the models and commitments
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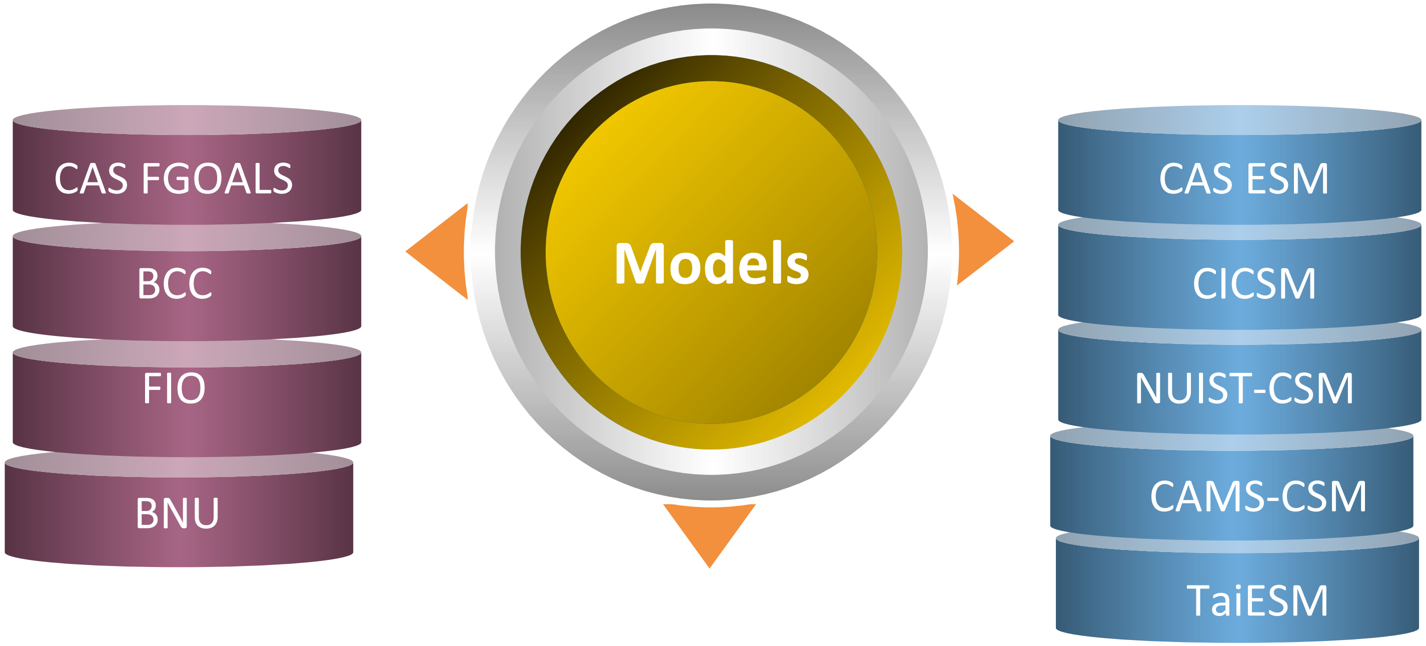
With CMIP5 experiences

New faces in CMIP6



10 models/versions from 9 centers

Main changes in FGOALS-g

	CMIP5 FGOALS-g2	CMIP6 FGOALS-g3
GAMIL	128x60 latxlon grid L26 TSPAS advection K-profile boundary layer processes Based on LTS stratocumulus E-Q deep convection closure none	180x80 latxlon grid L26/L29 Improved TSPAS advection Adding entrainment and longwave radiative cooling (Sun et al., 2016, Sci China Earth) Based on EIS stratocumulus(Guo et al., 2014, Sci China Earth) Hybrid deep convection closure Including stratospheric aerosols
LICOM	360x190 latxlon grid L30 Explicit momentum time integration none Central tracer advection Redi+GM90 isopycnal mixing	1degree/0.1 degree tripole grid L30/L55/L80 Implicit momentum time integration Tidal mixing Preserved shape tracer advection Redi+GM90 with N^2 thickness diffusivity isopycnal mixing
CPL	CPL6	CPL7

Main changes from FGOALS-s to FGOALS-f

	CMIP5 FGOALS-s2	CMIP6 FGOALS-f
AGCM	SAMIL: Spectral on lon-lat grid, R42(2.81*1.66) L26	FAMIL: Finite Volume on Cubed-sphere grid C96(1*1） L32 C384(0.25*0.25) L32
OGCM	LICOM2: 360x190 lat*lon grid L30	LICOM3: 1degree/0.1 degree tripole grid L30/L55/L80 Implicit momentum time integration Tidal mixing Preserved tracer advection with N**2 thickness diffusivity isopycnal mixing
Coupler	CPL6	CPL7

Main changes in FGOALS-f

	CMIP5	CMIP6
Name	FGOALS-s2	FGOALS-f
Atmosphere	SAMIL	FAMIL
Dynamic core	Spectral on lon-lat grid (Wu et al 1996; Bao et al., 2010)	Finite Volume on Cubed-sphere grid (Lin 1996,2004; Zhou et al. 2015)
Resolution	R42(2.81*1.66) L26	C96(1*1） L32 C384(0.25*0.25) L32
Radiation	Edwards J. M. and A. Slingo, 1996 Sun, Z., 2005	RRTMG (Clough et al, 2005)
Convection	Mass-flux Tiedtke, 1989;Nordeng,1994	The Resolving Convective Precipitation
Microphysics	None	One-moment bulk (Lin et al,,1983) Two-moment (Chen and Liu, 2004)
Boundary Layer	Non local (Holtslag and Boville, 1993)	UW (Bretherton and Park,2009)

BCC Models for CMIP5

Model versions	Model components	Resolutions
BCC-CSM1.1	BCC-AGCM2.1,BCC-AVIM1 MOM4-L40v1, SIS	Atmos: T42L26, Top: 2.19 hPa Ocn: 1/3° in 30S-30N and 1/3-1° in 30-90 N/S
BCC-CSM1.1(m)	BCC-AGCM2.2,BCC-AVIM1 MOM4-L40v2,SIS	Atmos: T106L26, Top: 2.19 hPa Ocn: 1/3° in 30S-30N and 1/3-1° in 30-90N/S

BCC Models for CMIP6

Model Versions	Model Components	Resolutions	MIP
BCC-ESM1	BCC-AGCM3-Chem BCC-AVIM2 MOM4-L40v3 SIS	Atmos: T42L26, **Top: 2.19 hPa** Ocn: 1/3 ° in 30S-30N and 1/3-1° in 30-60 N/S, and 1° in high latitudes	AerChemMIP
BCC-CSM2-MR	BCC-AGCM3-MR BCC-AVIM2 MOM4-L40v3 SIS	Atmos: T106L46, **Top: 1.46 hPa** Ocn: 1/3 ° in 30S-30N and 1/3-1° in 30-60 N/S, and 1° in high latitudes	**C4MIP,DCPP,CFMIP, DAMIP,GMMIP,LS3MIP, LUMIP,** RFMIP, ScenarioMIP
BCC-CSM2-HR	BCC-AGCM3-HR BCC-AVIM2 MOM4-L40v3 SIS (CICE5 an option)	Atmos: T266L56, **Top: 0.1 hPa** Ocn: 1/3 ° in 30S-30N and 1/3-1° in 30-60 N/S, and 1° in high latitudes	HighResMIP

FIO-ESM: From V1 to V2

Component		CMIP5: FIO-ESM v1	CMIP6: FIO-ESM v2
ATM	Model	CAM3	CAM5
	Resolution	H: 300km; V: 26 level	H: 200, 100 and 50 km; V: 26 level
LND	Model	CLM3.5	CLM4.5
	Resolution	300km	200, 100, and 50 km
OCN	Model	POP 2	NEMO3.6
	Resolution	H: 100km V: 40 level C: 24hrs	H: 100, 50, and 25 km; V: 75 level C: 3hrs
ICE	Model	CICE4	CICE5
	Resolution	100km	100, 50, and 25 km
WAV	Model	MASNUM Wave model	MASNUM Wave model
	Resolution	200km	200, 100, and 50 km
COUPLER		CPL6	CPL7

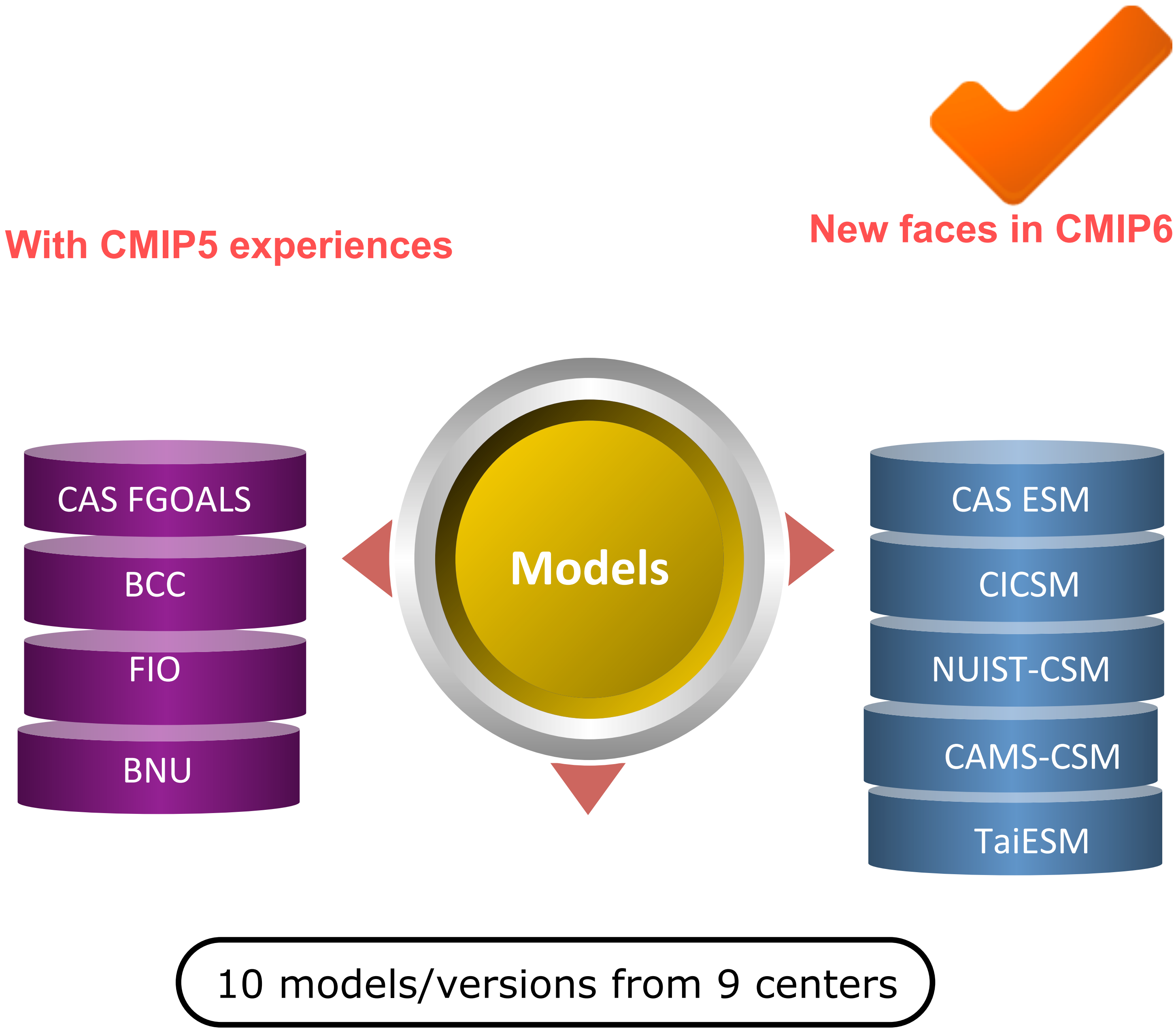
Main changes in BNU-ESM

	CMIP5 BUM-ESM1.0	CMIP6 BUM-ESM1.1
AGCM	CAM4 + revised Zhang-McFarlane scheme Resolution: T42(128x64) L26	CAM4 + revised Zhang-McFarlane scheme Resolution: FV(144x96) L26
OGCM	MOM4P1 with idealized ocean biogeochemistry (iBGC) Resolution: 360x200 (~1/3^o 10^{o}S-10^{o}N) L50	MOM4P1 with a new dynamic marine ecosystem-carbon scheme Resolution: 360x200 (~1/3^o 10^{o}S-10^{o}N) L50
Land	CoLM with carbon cycle Resolution: T42(128x64) L10	CoLM with carbon-nitrogen interactions Resolution: FV(144x96) L15
Sea ice	CICE4.1 Resolution: 360x200	CICE4.1 Resolution: 360x200

The global biogeochemical cycle schemes have been improved:

1)Terrestrial biogeochemical scheme with carbon-nitrogen interactions

2)Dynamic marine ecosystem-carbon scheme



With CMIP5 experiences
New faces in CMIP6
CAS FGOALS
BCC
FIO
BNU
Models
CAS ESM
CICSM
NUIST-CSM
CAMS-CSM
TaiESM
10 models/versions from 9 centers

CAS-ESM: Developed by multi-institutions in China led by the Institute of Atmospheric Physics (IAP) in CAS

AGCM	IAP4 AGCM (Zhang et al. 2013 MWR) finite difference; 1.4°or 0.5° horizontal resolutions; 30 and 51 levels. For CMIP6, the 1.4° and 30 level version will be used except for the HiresMIP, in which the 0.5° version will be used. IAP AACM for atmospheric aerosol and chemistry (Cheng et al., 2015, ACP)
OGCM	LICOM2 OGCM (Lin et al. 2016, JMR): 0.5° to 1.0°, 30 levels IAP OBGCM for ocean-biogeochemistry (Xu et al. 2009, AAS)
Land	CoLM Land Model (Dai et al. 2003, JCL; Zhu et al. 2017 JGR) IAP DGVM for dynamic vegetation (Zeng et al. 2016 AAS)
Sea ice	CICE4.0 with improvements by J. Liu & M. Song
Coupler	CESM Coupler 7 (He et al., 2012 JAMES)

THU CIESM: Community Integrated Earth System Model developed in Tsinghua University

Components	Model Physics
AGCM	CAM5 Modified Zhang-McFarlane (ZM) scheme A single ice double moment cloud microphysics (Zhao et al. 2017, JAMES) A new PDF cloud fraction and cloud macrophysics scheme (Qin et al., 2017, JAMES, in revision) Four stream shortwave radiative calculations Subgrid-scale Orographic Form Drag （Liang et al. 2016, Climate Dynamics）
OGCM	POP2 with a 0.5 degree Schwarz-Chrsitoffel ocean/sea ice model grid (Xu et al. GMD, 2015) and a P-CSI barotropic solver (Huang et al. GMD, 2016)
Land	CLM4.5
Sea ice	CICE4.0, with Schwarz-Chrsitoffel mapping based ocean/sea ice model grid (Xu et al. GMD, 2015), floe-size dependent sea Ice lateral melting parameterization
Coupler	C-Coupler (Liu et al. GMD 2014)

CAMS-CSM: Chinese Academy of Meteorological Sciences, CMA

Components	Model Physics
AGCM	ECHAM5.4,with modifications on: Water vapor advection: Two-step Shape Preserving Advection Scheme (TSPAS) (Yu 1994) Radiation scheme: BCC_RAD (Zhang et al. 2006) Resolution: T106, L31
OGCM	MOM4 Resolution: 1˚ longitude, 1/3˚(equator) ~ 1˚latitude, 50 layers
Land	CoLM (Dai 2005) from Beijing Normal Univeristy
Sea ice	FMS SIS

NUIST-ESM v3

	Model Physics
AGCM	ECHAM v6.3 (T63L47/T31L31) a. Incorporating a improved convective parameterization (Yang et al. 2017) - Moisture trigger function (Tokioka et al. 1988) - Entrainment rate considering moisture (Kim and Kang 2012) - Mass flux closure for shallow cloud (Yang et al. 2014) - Introducing downdraft based on cloud ice/snow/mass flux & bulk cold pool dynamics b. Implementing a diffusion type of shallow convective scheme (Tietdke et al. 1988) with enhanced mixing of BL and lower atmosphere. c. Adding a stratocumulus cloud parameterization over EP (Slingo 1987) d. Incorporating low cloud parameterization over Southern Hemisphere e. Calibrating parameters of cloud microphysics based on TOGA CORE experiment
OGCM	NEMO v3.4 a.Incorporation of the brine rejection in ocean model due to sea ice freezing/melting in the mixed layer (Smith et al., 2010) b.Improved freshwater/salt fluxes (Madec et al., 2016) c.Modification of isopycnal and thickness diffusivities (Ferreira et al., 2005; Danabasoglu and Marshall, 2007) d.Calibrating latitude-depent background of eddy diffusivity (Jochum, 2009) e.Incorporating a “stiffer” oceanic equation of state (Dukowicz, 2001)
Land	JSBACH Dyn. Veg., a.Adding surface albedo considering soil moisture (Bonan et al. 1993) b.Introducing trigger and entrainment for better land precipitation and surface fluxes
Sea ice	CICE v4.1
coupler	OASIS3-MCT3

TaiESM: developed on the basis of CESM 1.2.2 with the following modifications

	CESM 1.2.2	TaiESM
Deep convection	Zhang-McFarlane scheme (Neale et al. 2008)	ZM + triggering function of SAS (Wang et al. 2015)
Cloud macrophysics	Park et al. (2011)	Wang et al. (2017)
Aerosol	MAM3 (Liu et al. 2012)	SNAP (Chen et al. 2013)
Topographic effect on solar radiation	(None)	Lee et al. (2013)

Other components kept unchanged: POP2, CICE4, CLM4

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Status and planning for submitting model outputs

	Model	Simulation started	Date for submitting DECK	Date for submitting CMIP6 historical	Date for submitting MIPs
1	**BCC-CSM**	DECK, CMIP6 historical	Dec 2017	Mar 2018	5 MIPs by June 2018; 2 MIPs by Dec 2018; 4 MIPs by June 2019
2	**BCC-ESM**	AerChemMIP, DECK, CMIP6 historical,C4MIP	Dec 2017	Mar 2018	
6	**BNU-ESM**	Under tuning	Sep 2018	Sep 2018	*Pending on progress*
3	**CAS FGOALS-g**	informal CMIP6 Historical done, Code frozen by Dec 2017	May 2018	July 2018	Oct 2018
4	**CAS FGOALS-f**	Informal DECK,CMIP6 historical done, Code frozen by Dec 2017	May 2018	July 2018	Oct 2018
5	**FIO-ESM**	Code frozen by Feb 2018	June 2018	June 2018	*Pending on progress*
8	**CAMS-CSM**	Under tuning, informal DECK and CMIP6 Historical done	Mar, 2018	May, 2018	Aug 2018
7	**CAS ESM**	DECK, Historical with CMIP5 forcing	Aug 2018	Aug 2018	Dec 2018
10	**CIESM**	Under tuning	June 2018	June 2018	Oct 2018
9	**NUIST-CSM**	DECK, CMIP6 Historical	Dec 2017	Dec 2017	DAMIP, ScenatioMIP: Mar 2018; GMMIP, VolMIP, GeoMIP: Jun 2018; DCPP, PMIP: Sep 2018
11	**TaiESM**	Code frozen by Dec 2017	May 2018	May 2018	CFMIP, GMMIP, LUMIP, PMIP, and ScenarioMIP : Sep 2018; AerChemMIP: Dec 2018

CMIP5 & CMIP6 models

CMIP6 models

No models have started filling the ES-DOC questionnaire: drafts under revision.

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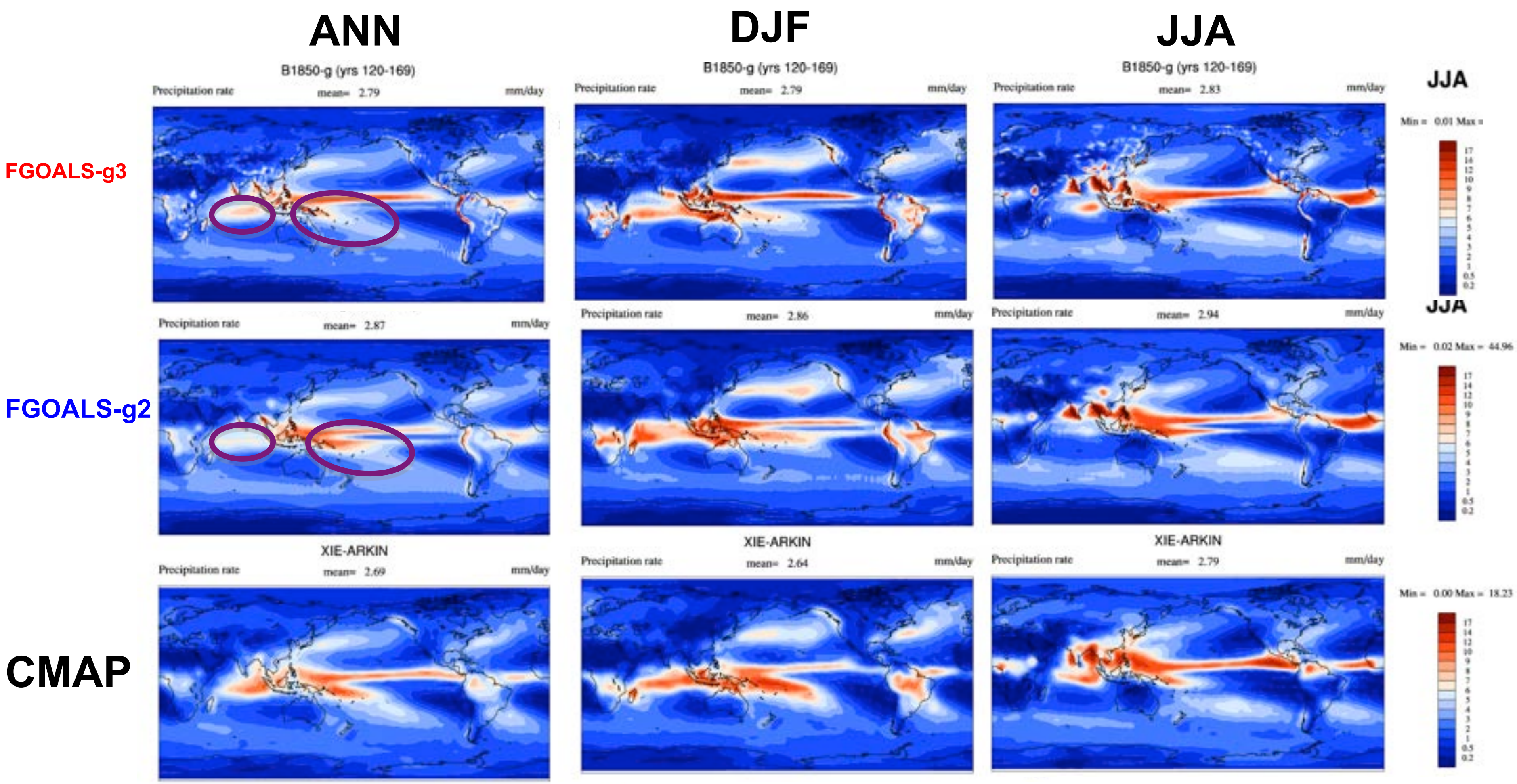
Climate mean precipitation



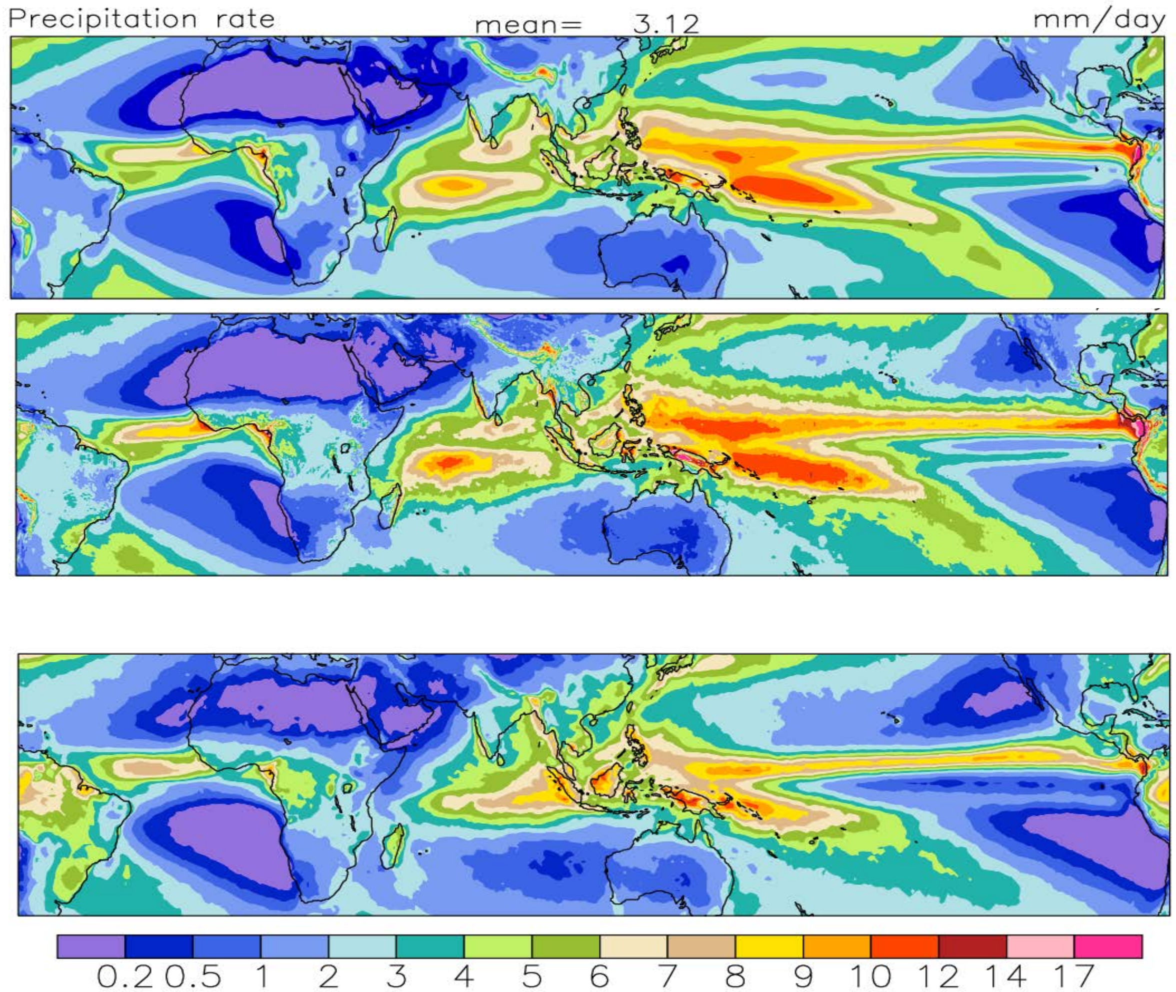
The rainfall over the Indian ocean and the "double ITCZ" are improved in the new version

Annual mean precipitation in FGOALS-f

C96 (1°)

C384 (0.25°)

TRMM

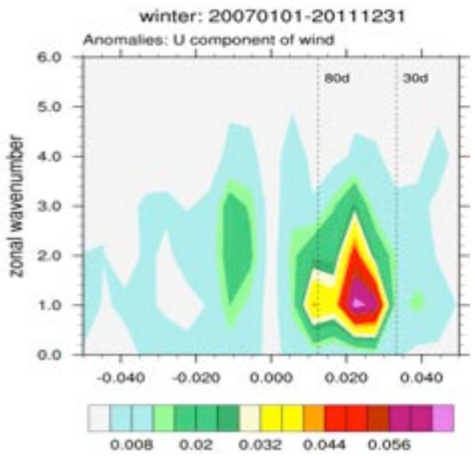


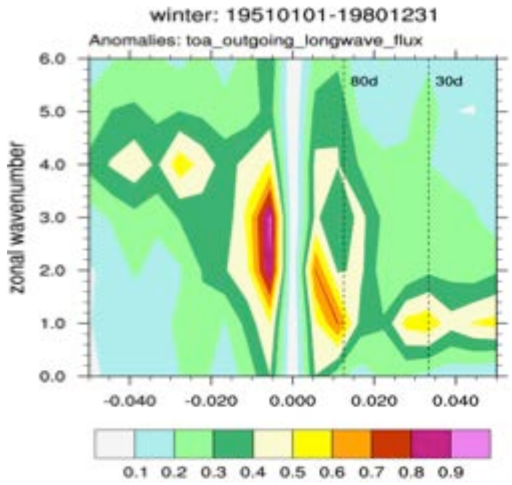
The “double ITCZ” bias is improved

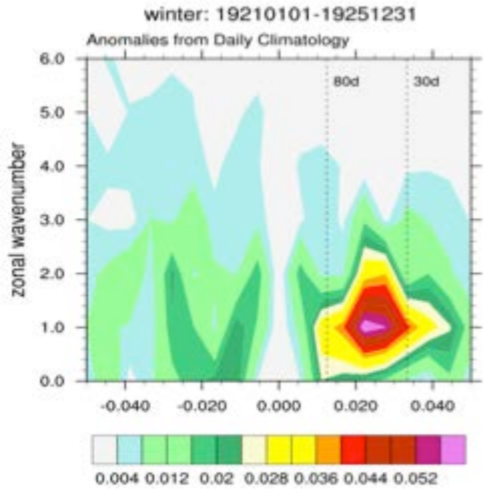
MJO features of 10S-10N averaged OLR and U850

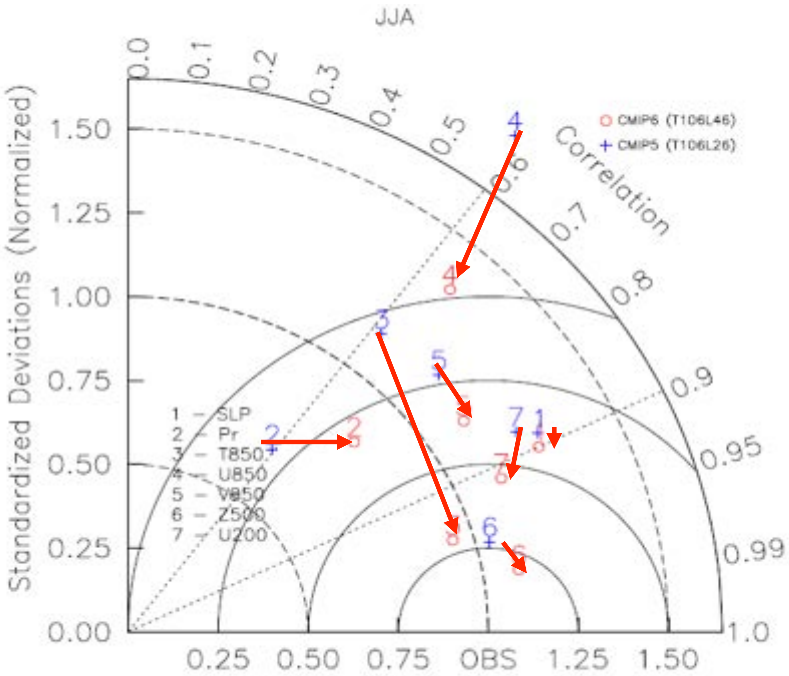
OBS | BCC-CSM1.1m (CMIP5) | BCC-CSM2-MR (CMIP6)

U850





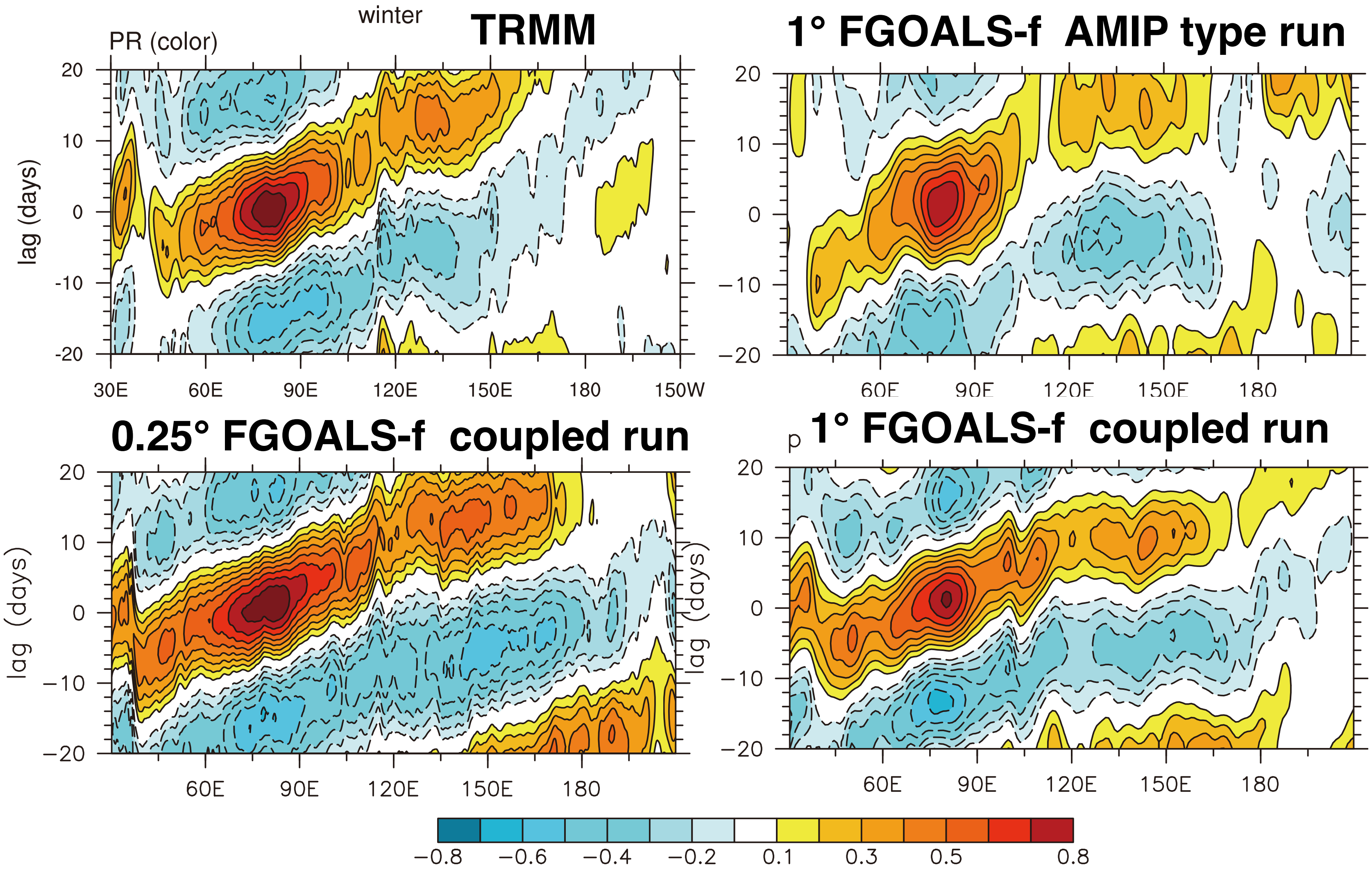




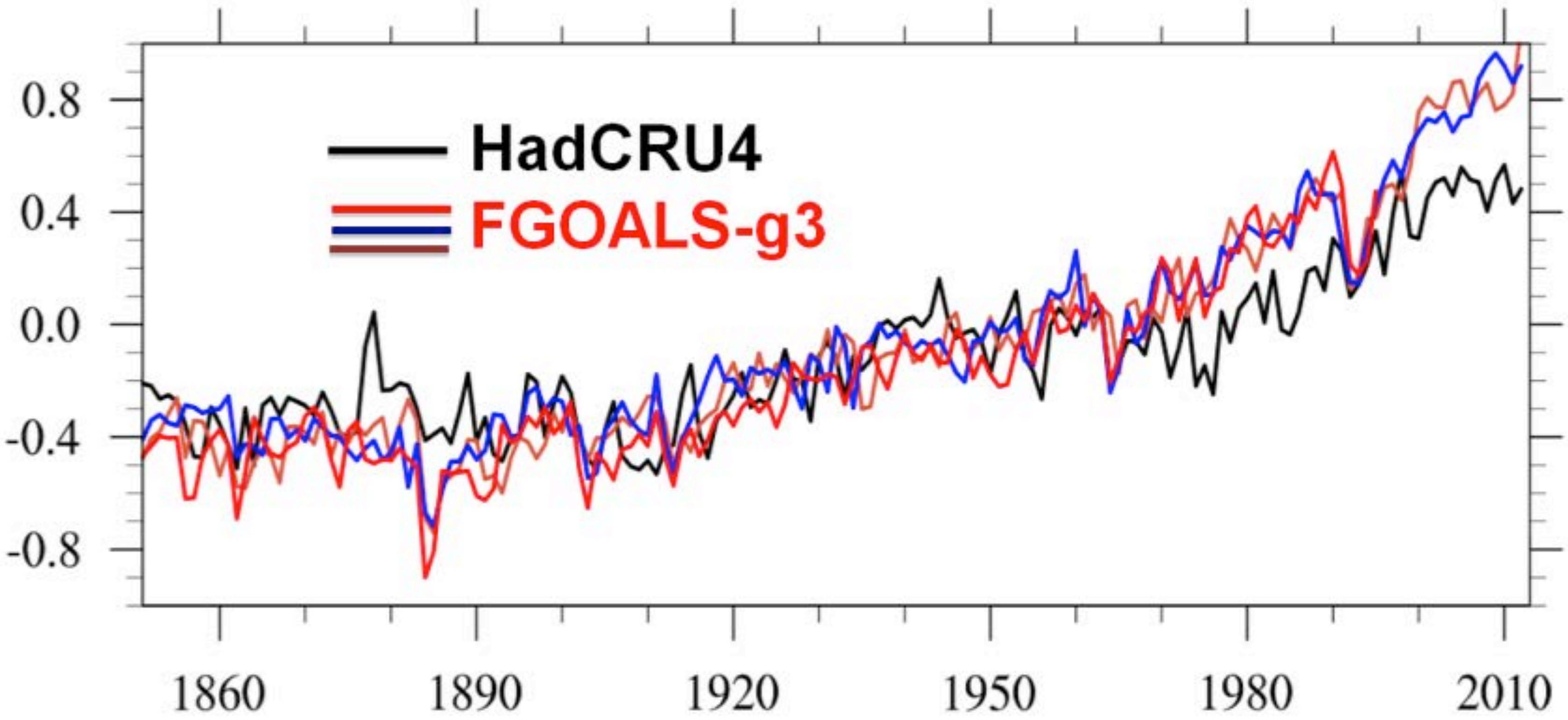
Evident improvements from CMIP5 to CMIP6 for East Asian (20^{o}N-50^{o}N, 100^{o}E-140^{o}E) climatology in JJA

Mean of 1981-2000

MJO over the equatorial eastern Indian Ocean in boreal winter: FGOALS-f

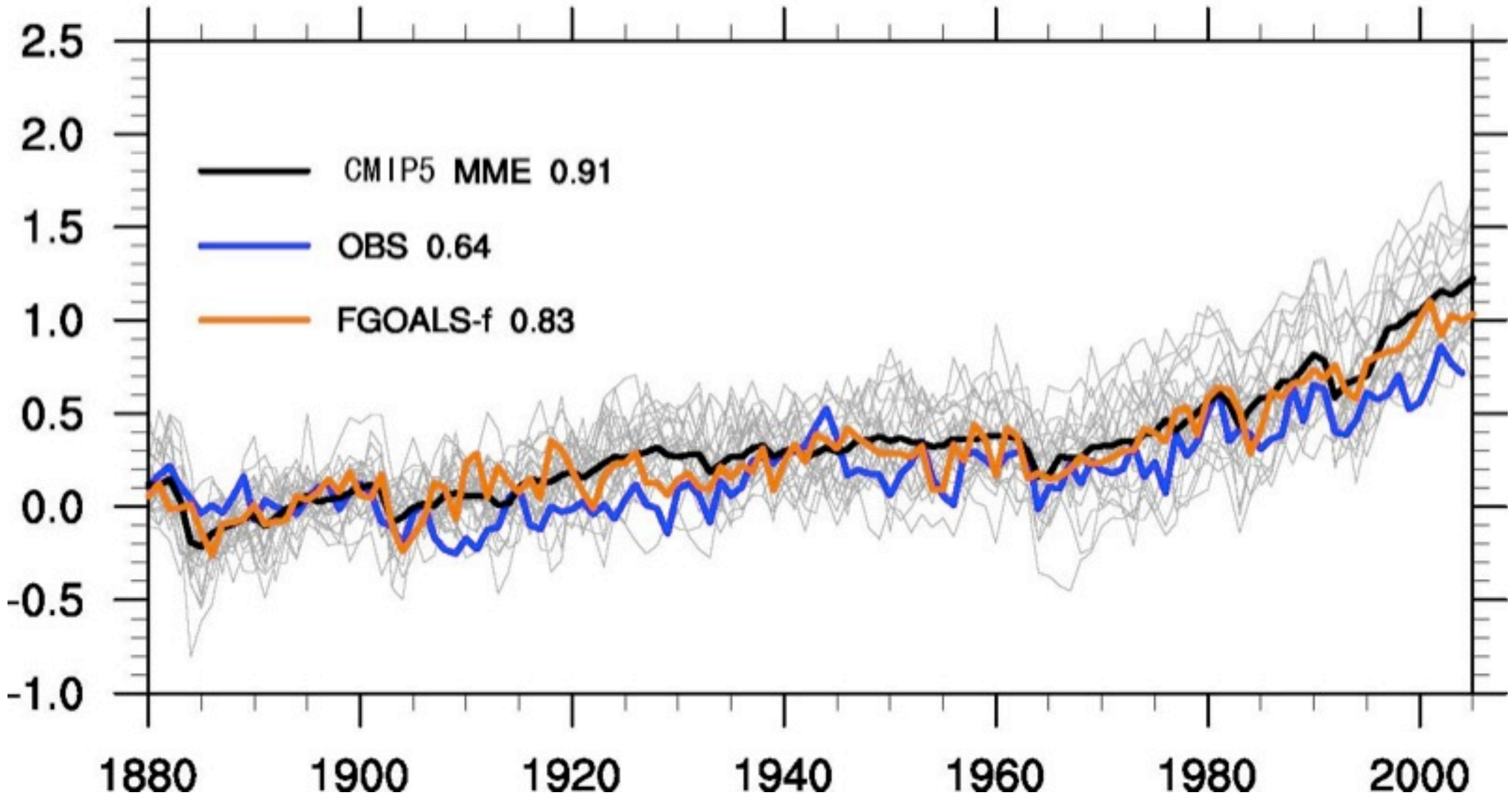


Global mean SAT time series: FGOALS-g3



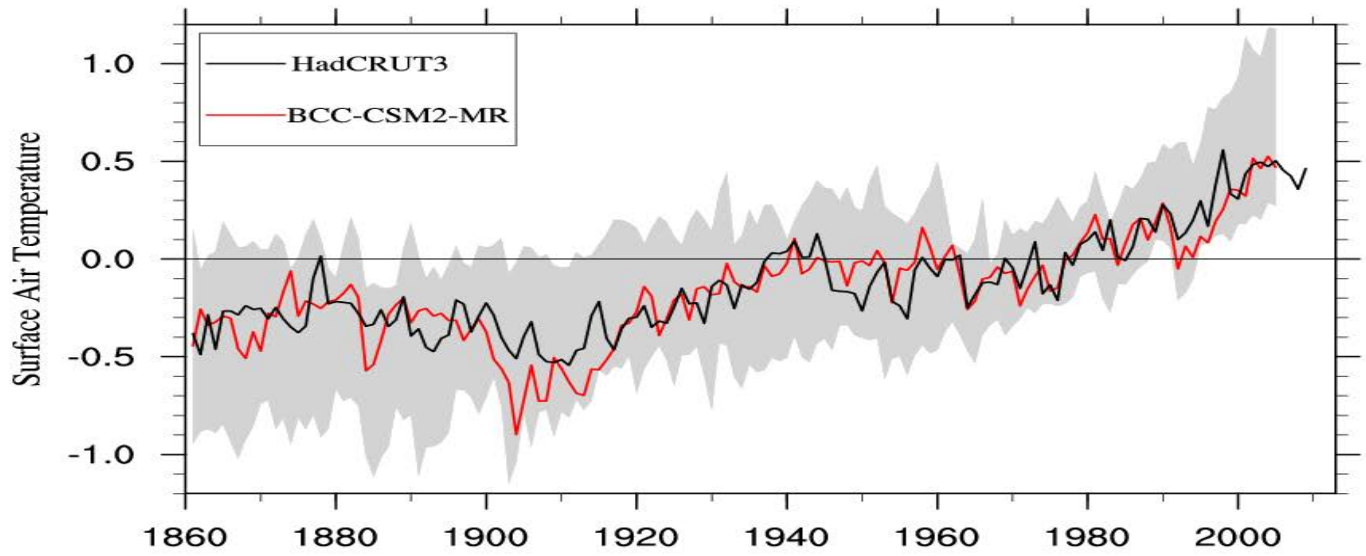
Forcing data: v6.1.0(17th May 2017)
Compared to the HadCRU4, the model reproduces the warming from 1910-1940, but overestimates the warming since 1970.

Global mean SAT time series: FGOALS-f

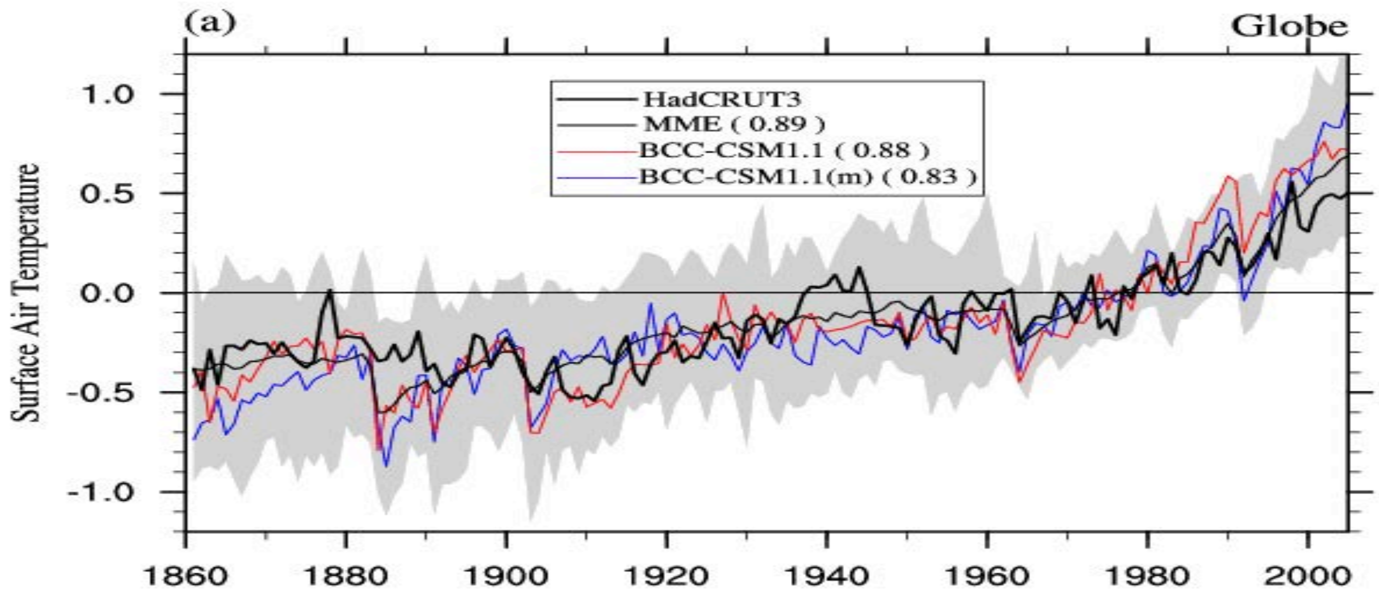


Without aerosol-indirect effect; Overestimates of the warming since 1970

Global mean SAT time series: BCC-CSM

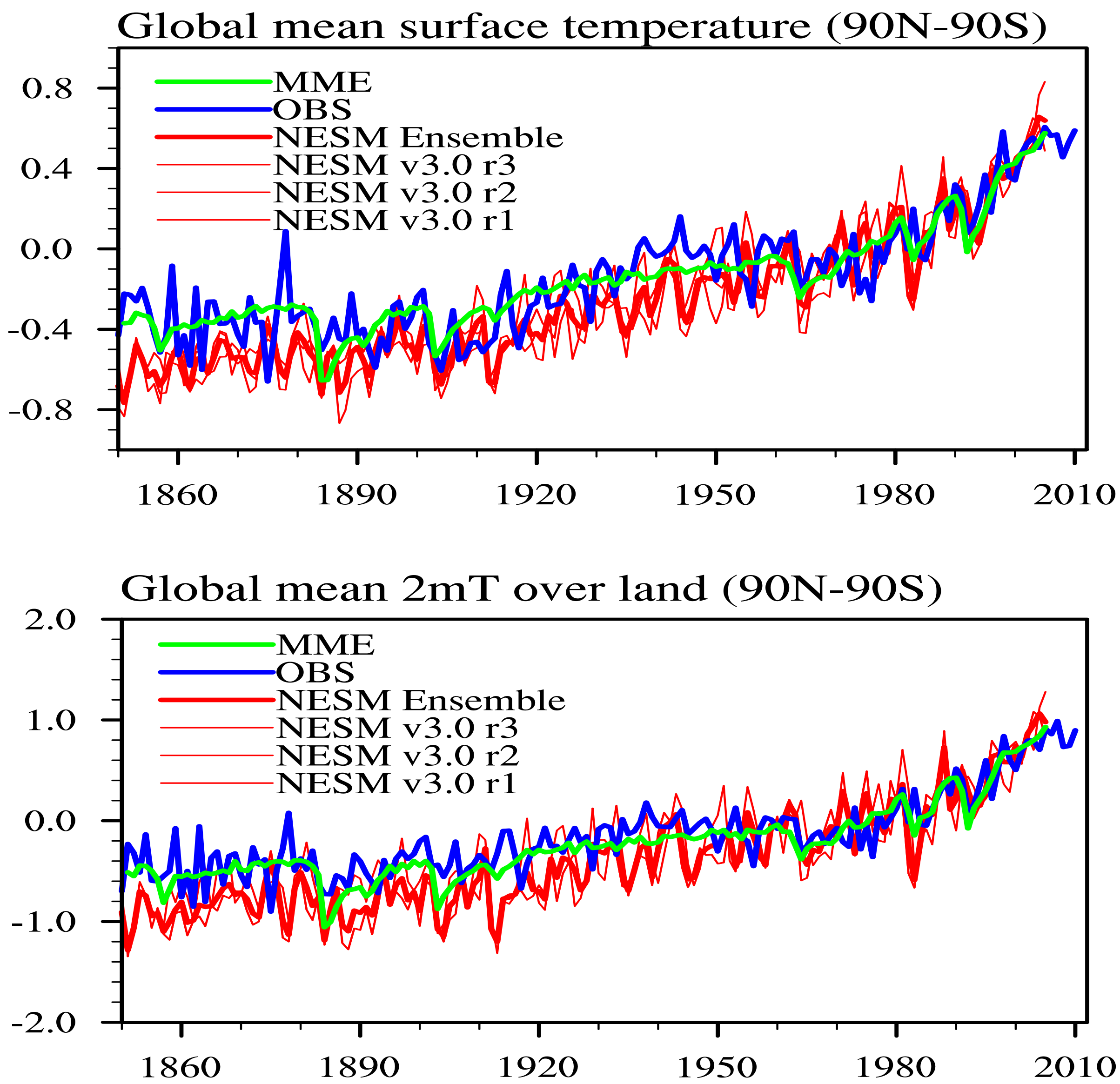


BCC-CSM2-MR
(CMIP6 simulation)



CMIP5 simulations

Global mean SAT time series: NUIST-CSM



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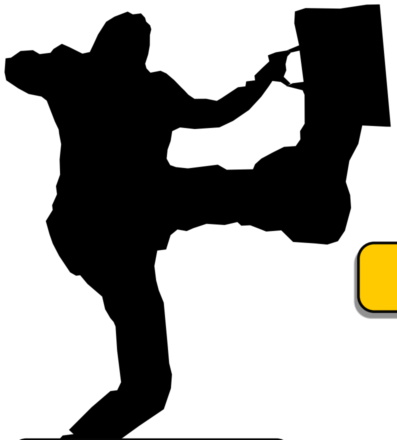


Step 1

- More universities/institutions have interests to CMIP
- Good for students & young scientists training at a cost of more resources

Step 2

- Traditional modeling centers engaged in model development
- New centers generally employ a hybrid model policy
- Clear documentations for model family tree are needed.
- To develop a CMIP6 hybrid model inter-comparison project ?

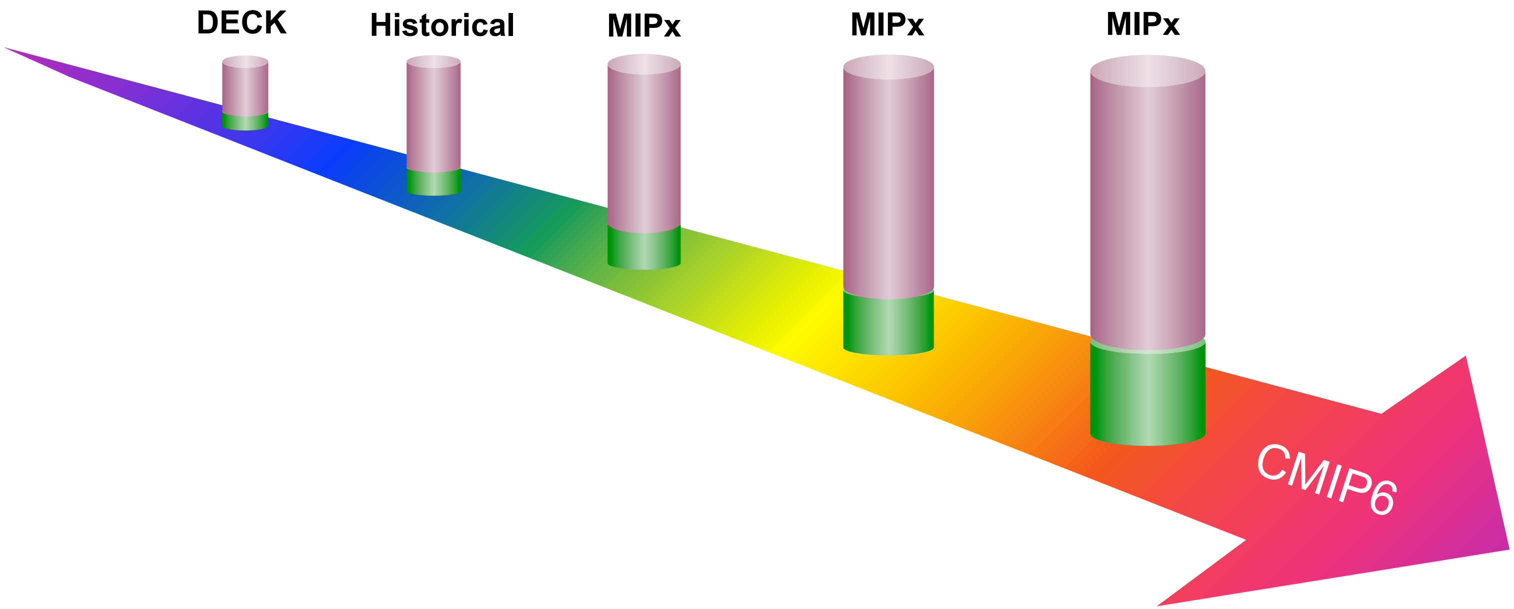
Step 3

- ~ Half a year delay in CMIP6 Exp progress
- Consistent forcing data needs to be highlighted, coordination with DAMIP ect.

Step 4

- CMIP6: More models' outputs
- CMIP7: new & essential technical entry card for models?

Thanks for your attention



Status of BCC CMIP6 experiments

	Short name of MIP	Model version	Started ?	Planning date to submit
1	DECK	BCC-ESM1 and BCC-CSM2-MR	Yes	Dec, 2017
	CMIP6 historical	BCC-ESM1 and BCC-CSM2-MR	Yes	Mar, 2018
2	AerChemMIP	BCC-ESM1	Yes	Jun, 2018
3	C4MIP	BCC-CSM2-MR	Yes	Jun, 2018
4	CFMIP	BCC-CSM2-MR	Test	Jun, 2018
5	DAMIP	BCC-CSM2-MR	Test	Jun, 2018
6	GMMIP	BCC-CSM2-MR	Test	Jun, 2018
7	LS3MIP	BCC-AVIM2, BCC-CSM2-MR	Test	Dec. 2018
8	LUMIP	BCC-CSM2-MR	Test	Dec. 2018
9	DCPP	BCC-CSM2-MR	Not yet	Jun, 2019
10	RFMIP	BCC-CSM2-MR	Not yet	Jun. 2019
11	ScenarioMIP	BCC-CSM2-MR	Not yet	Jun. 2019
12	HighResMIP	BCC-CSM2-HR	Not yet	Jun. 2019

Not yet started filling the ES-DOC questionnaire.

CMIP6 forcing preparation

Model Name: NUIST-ESM; Institution: NUIST

Forcing Dataset	Will be used	Pre-industrial	Historical
Land-use	*YES*	OK	OK
GHG concentrations	*YES*	OK	OK
Ozone concentrations	*YES*	OK	OK
Solar	*YES*	OK	OK
Stratospheric aerosol	*YES*	OK	OK
Anthropogenic aerosol	*NO*		OK
AMIP SST and SIC	*YES &OK*	OK	OK

KEY:	OK	Testing	Preliminary	Unknown

Note: On Sep. 21, the CMIP 6 volcanic forcing is changed, we are testing the new forcing.

The CMIP6 forcing is more sensitive than the CMIP5 forcing in the recent 20 years (eg: 1990-2015)

Climate sensitivity Exp of FGOALS-f

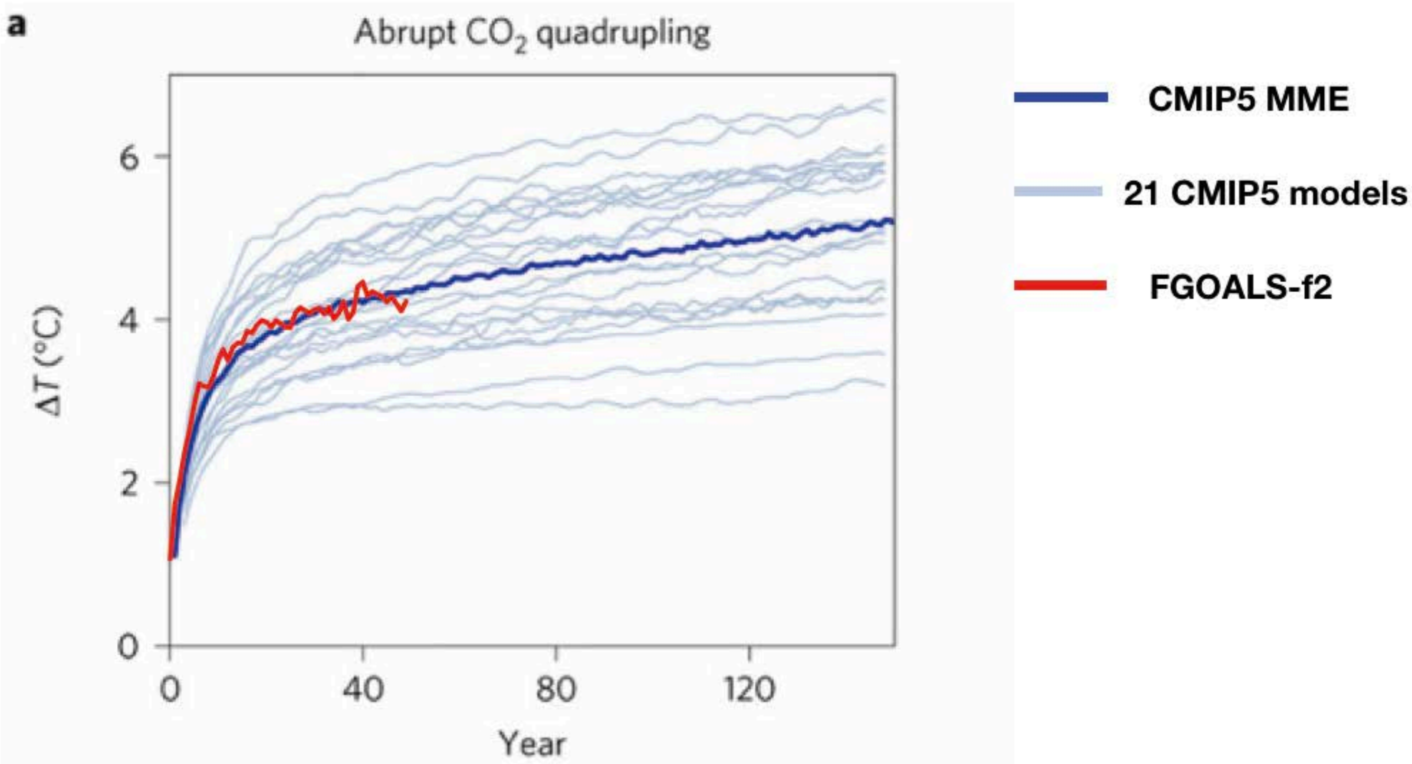


Figure 1: Inconstancy of feedbacks in CMIP5 abrupt CO2 quadrupling and 1% yr-1 CO2 ramping simulations.

From

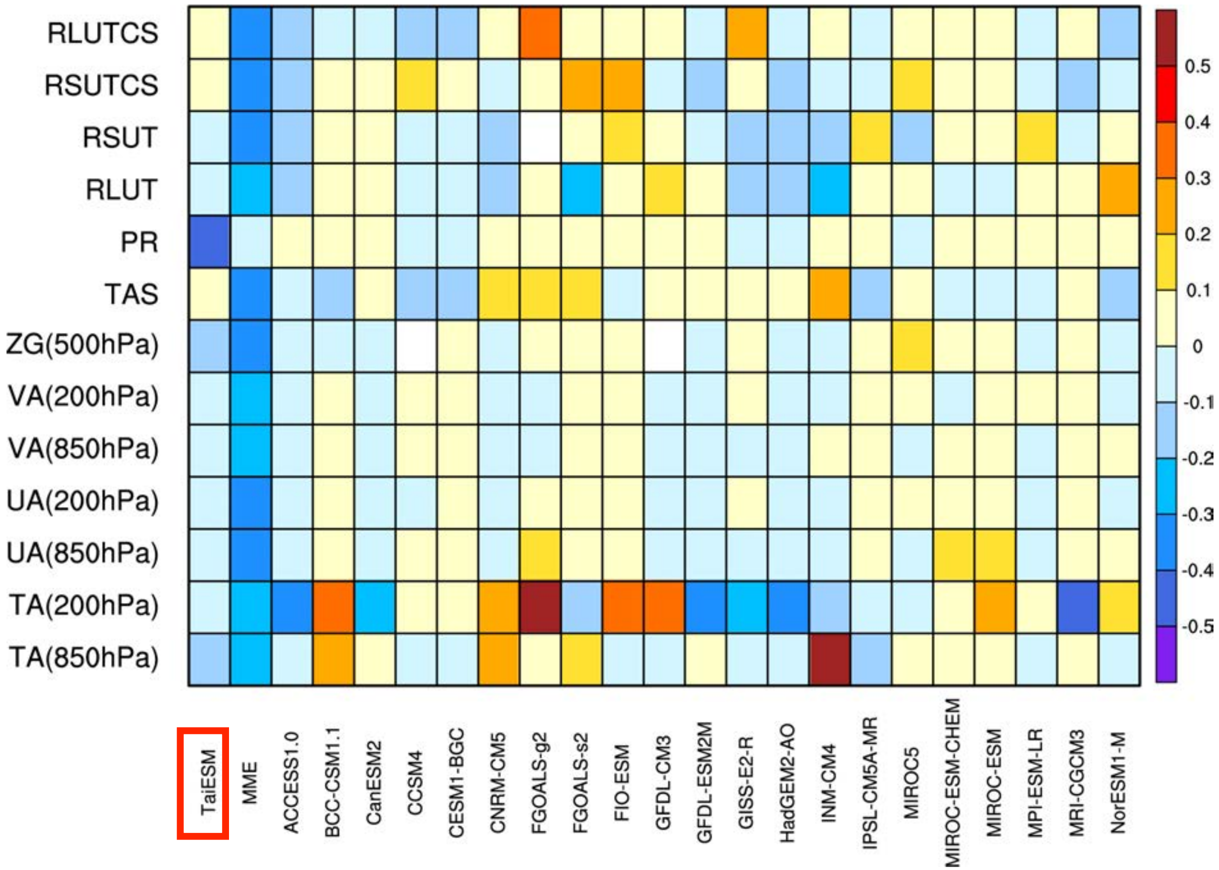
Energy budget constraints on climate sensitivity in light of inconstant climate feedbacks

- Kyle C. Armour

Nature Climate Change **7**, 331–335 (2017) doi:10.1038/nclimate3278

Performance of TaiESM

Comparison of TaiESM and CMIP5 models with JRA-55 reanalysis data for 1980-2005



Pros:

- Improved precipitation spatial distribution, especially for the Asian monsoon
- Improved diurnal cycle of precipitation
- Better MJO simulation

Cons:

- Too cold global mean surface temperature
- Too strong ENSO variability and too concentrated period at 4 years
- Too much low cloud globally, probably caused by too strong aerosol-cloud interaction