Institute of Atmospheric Physics, Chinese Academy of Sciences

Status of Chinese Modeling Groups

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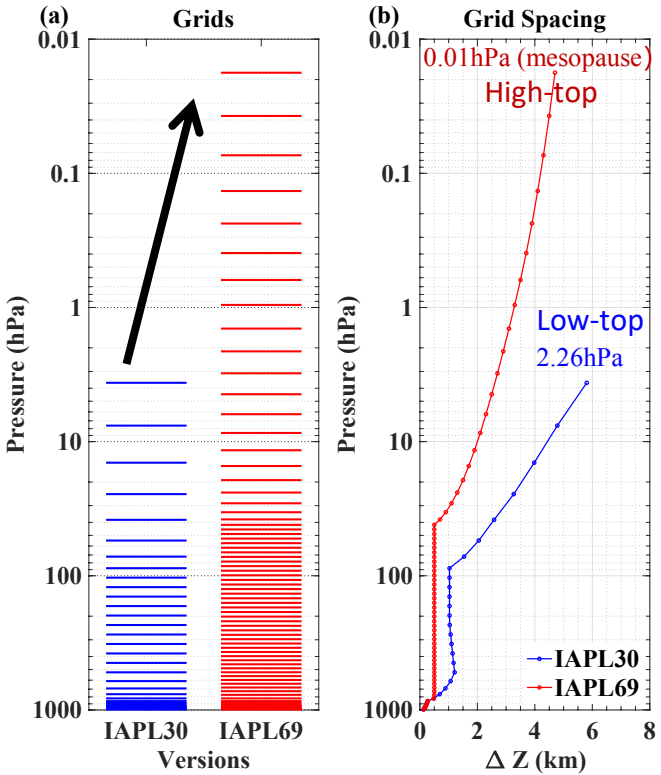
Parts of CMIP6 models

Affiliation	ESM/CSM	AGCM	LSM	OGCM	SIM
Chinese Academy of Sciences	CAS FGOALS-f CAS FGOALS-g	**FAMIL** **GAMIL**	CLM4.5	LICOM3	CICE4.0
	CAS ESM	IAP AGCM4.0	**CoLM +** **IAP DGVM**	LICOM2 + IAP OBGCM	CICE4.0
Universities	CICSM	FDAM/FVAM	CLM4.5	POP2	CICE4.0
	NUIST-CSM	ECHAM –NUIST	Modified ECHAM5.3 Land Model	NEMO 3.4	CICE 4.1
China Meteorology Administration	BCC-ESM BCC-CSM	BCC-AGCM3-Ch BCC-AGCM3-MR BCC-AGCM3-HR	BCC-AVIM2	MOM4 & HAMOCC	CICE5
Ministry of Natural Resources	FIO-ESM	CAM5	CLM4.5 + CN	POP2 + BEC + MASNUM	CICE4

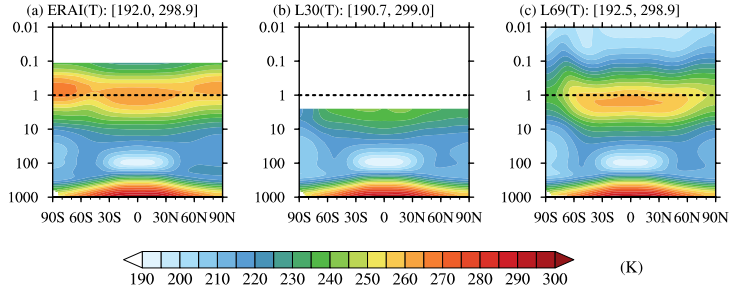
Zhou T. et al. 2020: Development of Climate and Earth System Models in China: Past Achievements and New CMIP6 Results. ***J. Meteor. Res.***, 34(1), 1-19, doi: 10.1007/s13351-020-9164-0

High-top version of CAS-ESM AGCM component

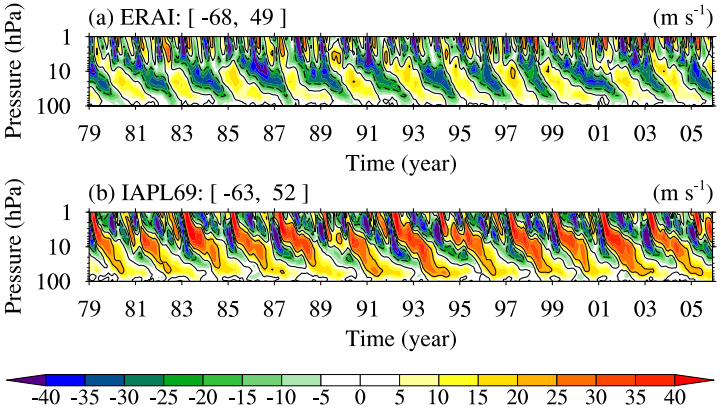
Low-top versus High-top



Temperature



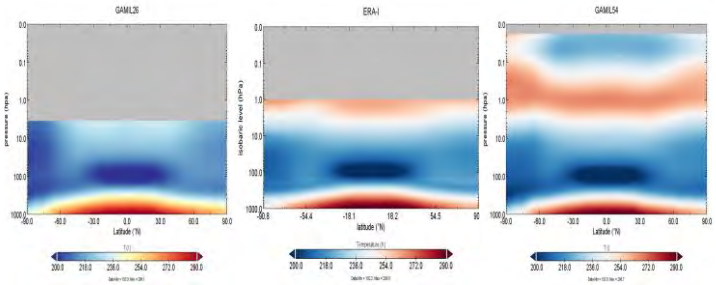
QBO

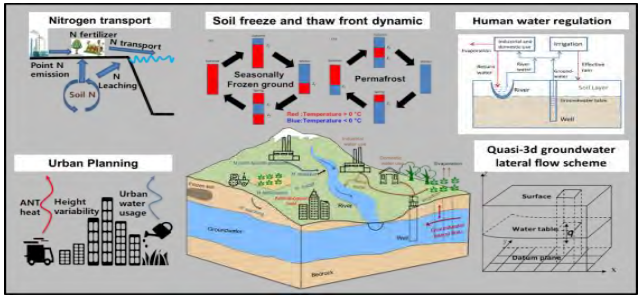


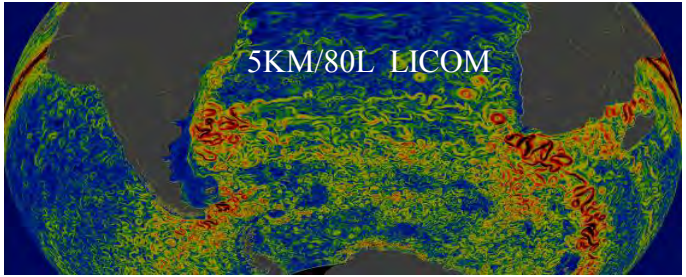
(Courtesy: He Zhang)

Upgrade in FGOALS-g

	FGOALS-g3（CMIP6）	FGOALS-g4
GAMIL (ATM)	200KM/26Layer, top:2hPa	50KM/54Layer, top:0.01hPa
		(New Dynamical core under test) Non-orographic gravity wave drag Improved PBL、convection
CAS-LSM (LND)	Including the effects of groundwater lateral flow, human water use and freeze thaw fronts	Including the effects of river transport, urban planning.
LICOM (OCN)	100KM/30Layer	25KM/55Layer
	TSPAS advection scheme	Sub-mesoscale viscosity scheme Eddy-induced mixing scheme High-order advection scheme
Coupler	CPL7/C-Coupler2	C-Coupler3







(Courtesy: Lijuan LI)

A Systematic Perturbed Parameter Ensemble framework of CAS-FGOALS

Short-term PPE
16 Para & 256 members

PPE for Mean State
34 Para & 1024members

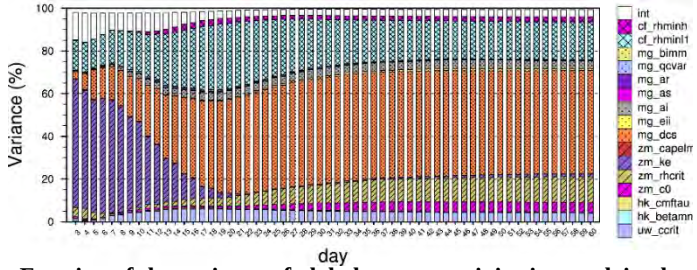
8-year multi-parameter PPE

40 YEARS AMIP PPE
16 Para & 256 members

PPE Strategy

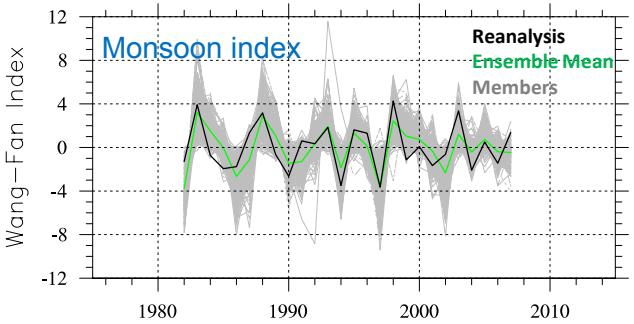
Coupled PPE
16 Para & 256 members

E.g. 1: Base on the short-term PPE: How does the uncertainty of parameter develop?



Fraction of the variance of global-mean precipitation explained by each parameter (color bars) as a function of simulation length

E.g.2 Base on the 40 years PPE: How are the physical processes coordinated with large-scale circulations?



How does parameter uncertainty affect the simulation of radiation, precipitation, circulations and especially East Asian monsoon?

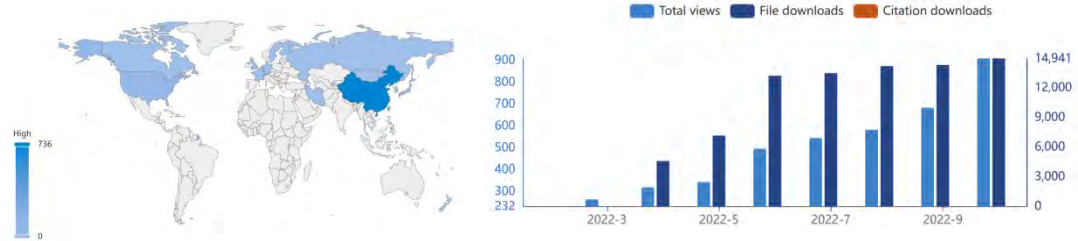
(Courtesy: Zhun Guo, David Sexton, Ben Booth, Saloua Peatier)

Large-ensemble simulations (CAS-FGOALS-g3, historical+SSP5-8.5)

- **Initial condition**: Macro perturbation based on phases of PDO, AMO and AMOC
- **Historical + SSP5-8.5**: 1850-2100
- **110 members**: Largest currently

110 members

Surface temperature change in the 20th centaury



15 countries and regions，15k downloads (up Nov. 2022)

http://cstr.cn/31253.11.sciencedb.01332 **Lin et al. 2022, AAS**

FGOALS experiments for LESFMIP: The Large Ensemble Single Forcing Model Intercomparison Project

Attribution of multi-annual to decadal changes in the climate system

frontiers | Frontiers in Climate

Attribution of multi-annual to decadal changes in the climate system: The Large Ensemble Single Forcing Model Intercomparison Project (LESFMIP)

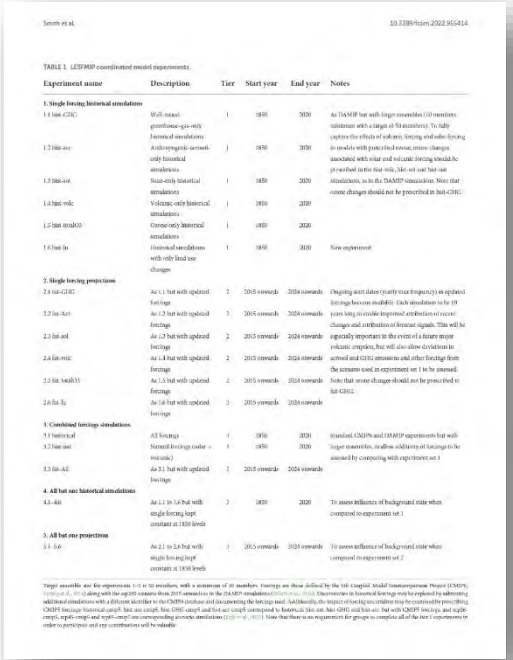


TABLE 1 LESFMIP coordinated model experiments.

Experiment name	Description	Tier	Start year	End year	Notes
1: Single forcing historical simulations					
1.1-hist-GHG	Well-mixed greenhouse-gas-only historical simulations	1	1850	2020	As DAMIP but with larger ensembles (10 members minimum with a target of 50 members). To fully capture the effects of volcanic forcing and solar forcing in models with prescribed ozone, ozone changes associated with solar and volcanic forcing should be prescribed in the hist-volc, hist-sol and hist-sol-volc simulations, as in the DAMIP simulations. Note that ozone changes should not be prescribed in hist-GHG.
1.2-hist-aer	Anthropogenic-aerosol-only historical simulations	1	1850	2020	
1.3-hist-sol	Solar-only historical simulations	1	1850	2020	
1.4-hist-volc	Volcanic-only historical simulations	1	1850	2020	
1.5-hist-nonGHG	Combined historical simulations	1	1850	2020	
1.6-hist-lu	Historical simulations with only land use changes	1	1850	2020	New experiment
2. Single forcing projections					
2.1-hist-GHG	As 1.1 but with updated forcings	2	2015 onwards	2024 onwards	Ongoing start dates (yearly max frequency) as updated forcings become available. Each simulation to be 10 years long to enable improved attribution of recent changes and contribution to forecast signals. This will be especially important in the event of a future major volcanic eruption, but will also allow deviations in aerosol and GHG emissions and other forcings from the scenario used in experiment set 1 to be assessed. Note that ozone changes should not be prescribed in hist-GHG.
2.2-hist-Aer	As 1.2 but with updated forcings	2	2015 onwards	2024 onwards	
2.3-hist-sol	As 1.3 but with updated forcings	2	2015 onwards	2024 onwards	
2.4-hist-volc	As 1.4 but with updated forcings	2	2015 onwards	2024 onwards	
2.5-hist-histNAT	As 1.5 but with updated forcings	2	2015 onwards	2024 onwards	
2.6-hist-lu	As 1.6 but with updated forcings	2	2015 onwards	2024 onwards	
3: Combined forcings simulations					
3.1-hist-all	All forcings	1	1850	2020	Identical CMIP6 and DAMIP experiments but with larger ensembles, to allow additivity of forcings to be assessed by comparing with experiment set 1
3.2-hist-nat	Natural forcings (solar + volcanic)	1	1850	2020	
3.3-hist-All	As 3.1 but with updated forcings	2	2015 onwards	2024 onwards	
4. All but one historical simulations					
4.1–4.6	As 1.1 to 1.6 but with single forcing kept constant at 1850 levels	3	1850	2020	To assess influence of background state when compared to experiment set 3
5: All but one projections					
5.1–5.6	As 2.1 to 2.6 but with single forcing kept constant at 1850 levels	3	2015 onwards	2024 onwards	To assess influence of background state when compared to experiment set 2

The implementation of the project will provide substantial improvements to our ability to understand near-term changes in climate and will support the World Climate Research Program Lighthouse Activity on Explaining and Predicting Earth System Change.

Smith et al. 2022 Frontiers in Climate

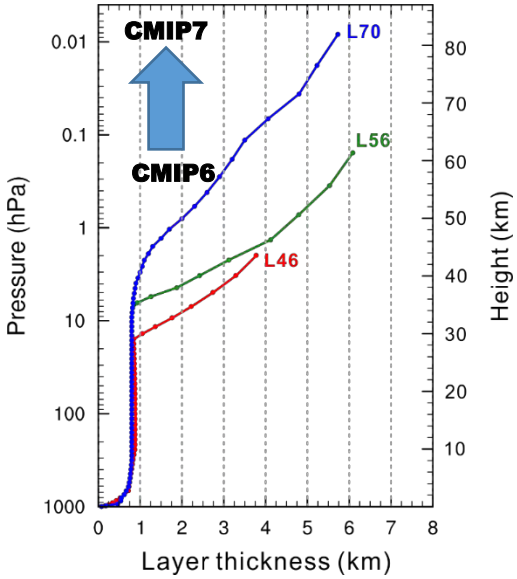
Upgrade in BCC model of CMA

	Model Version	Horizontal Resolution		Atmospheric Model Top/ No. of Vertical Layers
		Atmosphere/Land	Ocean/Ice	
CMIP5	BCC-CSM1.1	T42 (~280 km)	0.3° – 1°	2.917 hPa L26
	BCC-CSM1.1(m)	T106 (~120 km)	0.3° – 1°	2.917 hPa L26
CMIP6	BCC-CSM2-MR	T106 (~120 km)	0.3° – 1°	1.459 hPa L46
	BCC-CSM2-HR	T266 (~45 km)	0.25°	0.1 hPa L56
	BCC-ESM1	T42 (~280 km)	0.3° – 1°	2.917 hPa L26
CMIP7	**BCC-CSM3-MR**	T159 (~75 km)	0.25°	0.01 hPa L70
	BCC-CSM3-HR	T382 (~30 km)	0.25°	0.01 hPa L70
	BCC-ESM2	T159 (~75 km)	0.25°	0.01 hPa L70

(Courtesy: Tongwen Wu)

Improved Simulation of the Middle Atmosphere in BCC-CSM

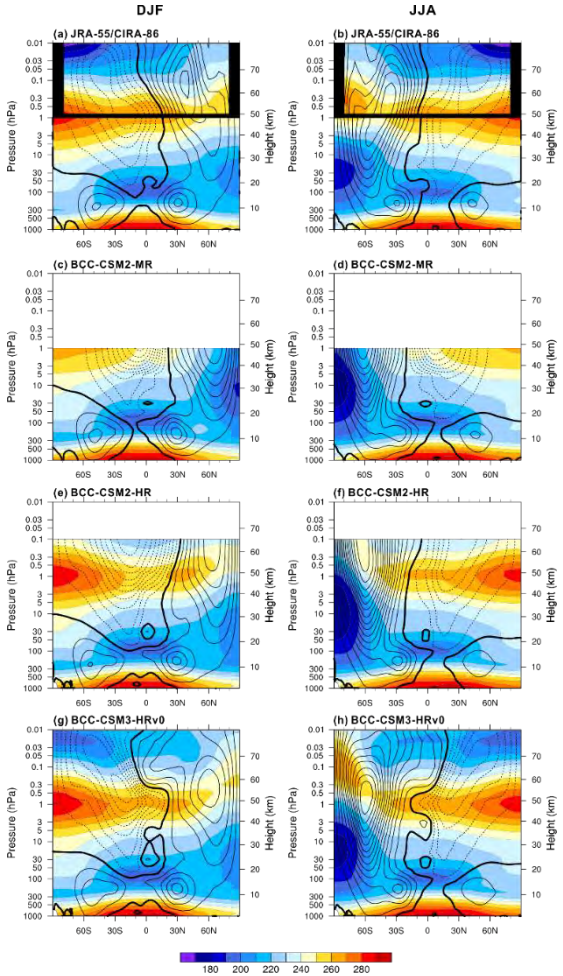
Extended model top and increased vertical layers



OBS

CMIP6

CMIP7 Version

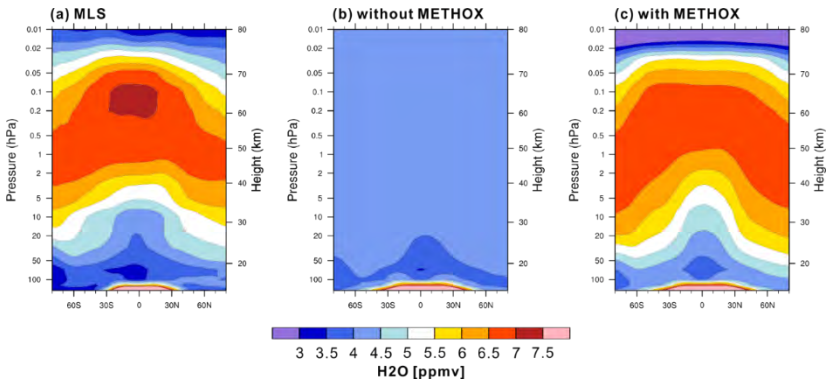


The zonal wind structure and thermal stratification of the upper atmosphere are well reproduced in BCC-CSM with extended model top

(Courtesy: Tongwen Wu)

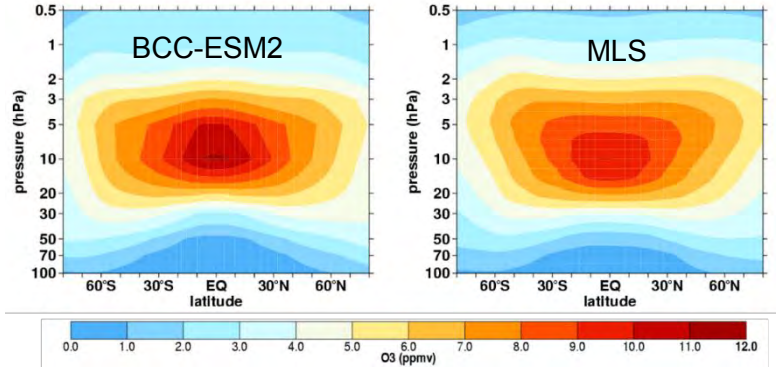
Improved Simulation of the Middle Atmosphere in BCC-CSM

Reasonable representation of water vapor pattern in the upper atmosphere



Relatively higher water vapor is seen in the upper atmosphere. In new version of BCC model with high top, parameterizations of the middle atmospheric water vapor is included, and the water vapor distribution is well reproduced.

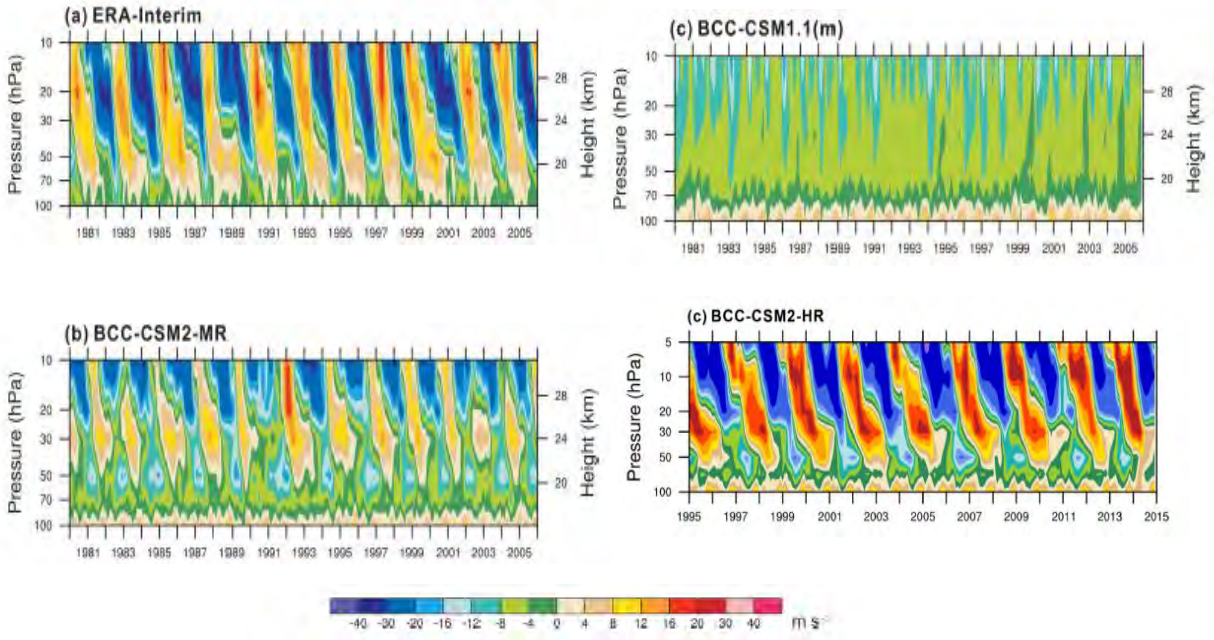
Realistic simulation of the stratospheric O3 chemistry



- CMIP6 version: the stratospheric O3 concentration is prescribed
- New version of BCC-ESM2: the stratospheric chemistry module is included and the O3 distribution is simulated realistically.

(Courtesy: Tongwen Wu)

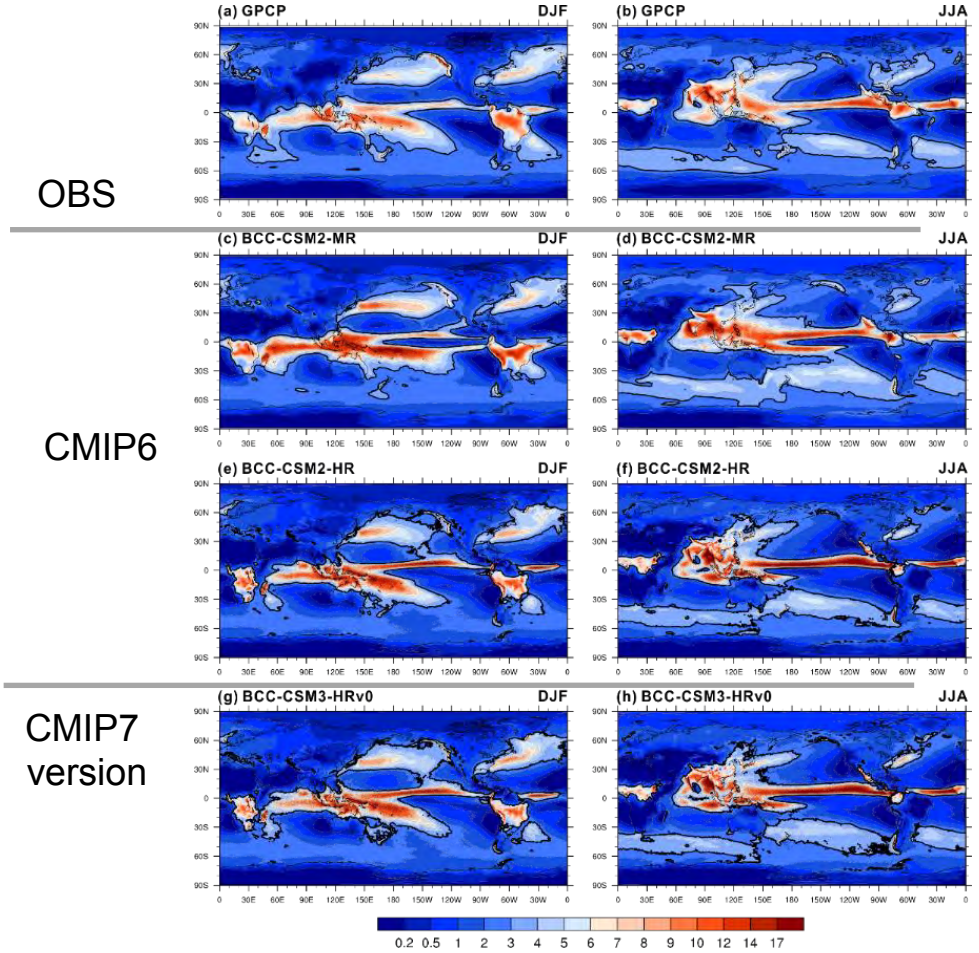
Stratospheric Quasi-Biennial Oscillation (QBO) in BCC-CSM



- Increase in the vertical resolution to better represent large-scale waves, and a mesoscale Gravity Wave parameterization scheme, which is coupled to the convective sources, is implemented to provide unresolved wave forcing of the QBO.
- QBO with realistic periods, amplitudes, and asymmetric features between westerly and easterly phases.

Lu et al. 2020, *JAS*, 77(1): 149-165.

Seasonal mean precipitation rate (mm d^{-1})



ITCZ in BCC-CSM

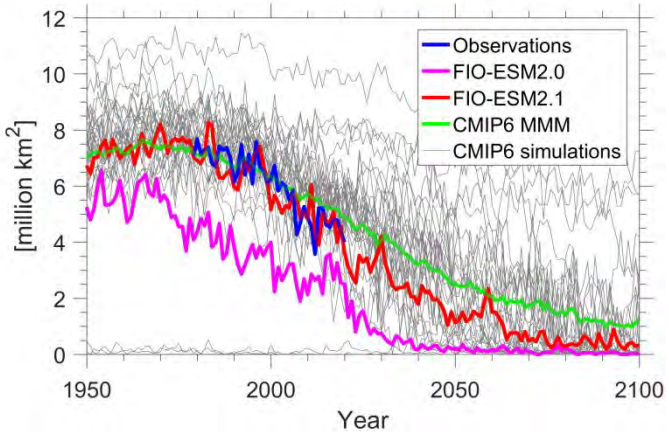
Double ITCZ improvement through tuning of parameterizations of Boundary-Layer Turbulence and Shallow Convection schemes

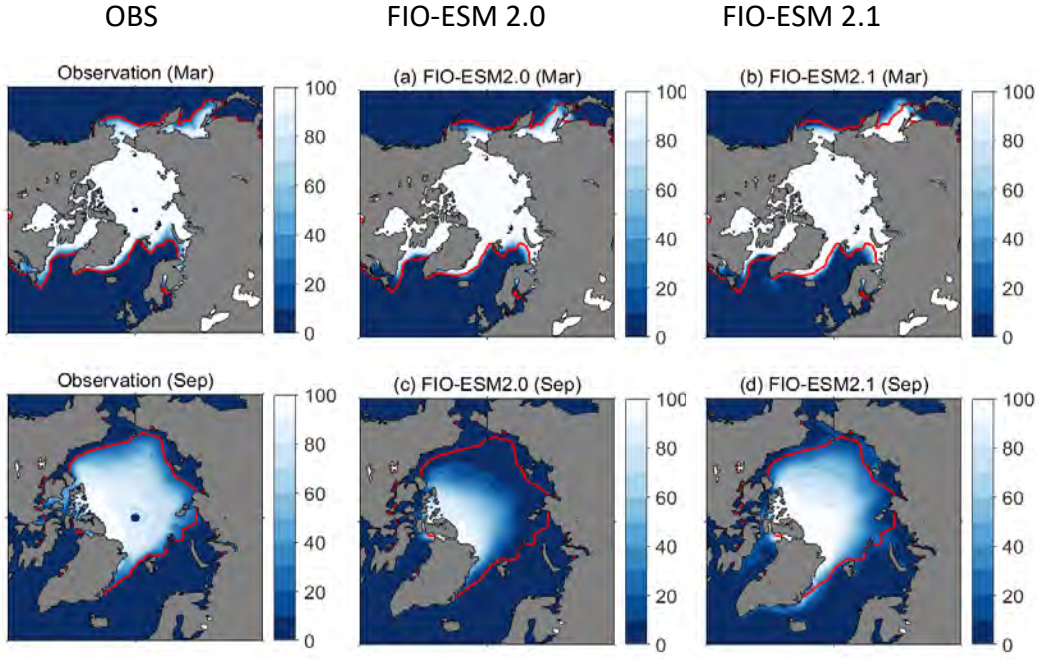
Lu et al. 2021 **Geosci. Model Dev.**, 14, 5183−5204.

Upgrade in FIO-ESM model of Ministry of Natural Resources

Upgraded sea-Ice component and ice-ocean heat flux parameterization scheme

- **FIO-ESM2.0 (CICE4.0)**
- **FIO-ESM2.1 (CICE6.0+3eq)**
- **3eq**: three-equation turbulent ice–ocean heat flux parameterizations





Arctic sea ice concentration (%) in March and September

Shi et al., 2021, GMD; Yu et al., 2022, AAS

THANKS!