

# **Numerical Climate and Weather Modeling on the China Earth System Simulator**

**Presenter: Yongqiang YU**

**Contributors: China Earth System Simulator Team**

**LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences**

**May 9, 2022**

# Outline

- 1. Brief Introduction to the China Earth System Simulator
- 2. Global Climate Modeling
- 3. Regional Weather and Air Pollution Modeling
- 4. Support and Manage System
- 5. Forthcoming Plans

# **Construction History of China Earth System Simulator**

- 
- A vertical blue line with circular markers at each year, pointing downwards to indicate the progression of time.
- 2008 – China Earth System Simulator was first proposed**
  - 2013 - The construction plan was listed in the 12<sup>th</sup> National Five-Year Plan**
  - 2015 – Developed prototype system (14 million EUR).**
  - 2017 – China Earth System Simulator was preliminary approved.**
  - 2018 - China Earth System Simulator was finally approved (180 million EUR)**
  - 2020 - completion of infrastructure.**
  - 2021 - trial operation**
  - 2022 Oct- Final evaluation**

# Scientific Objectives

Explore the interaction among the components of earth system



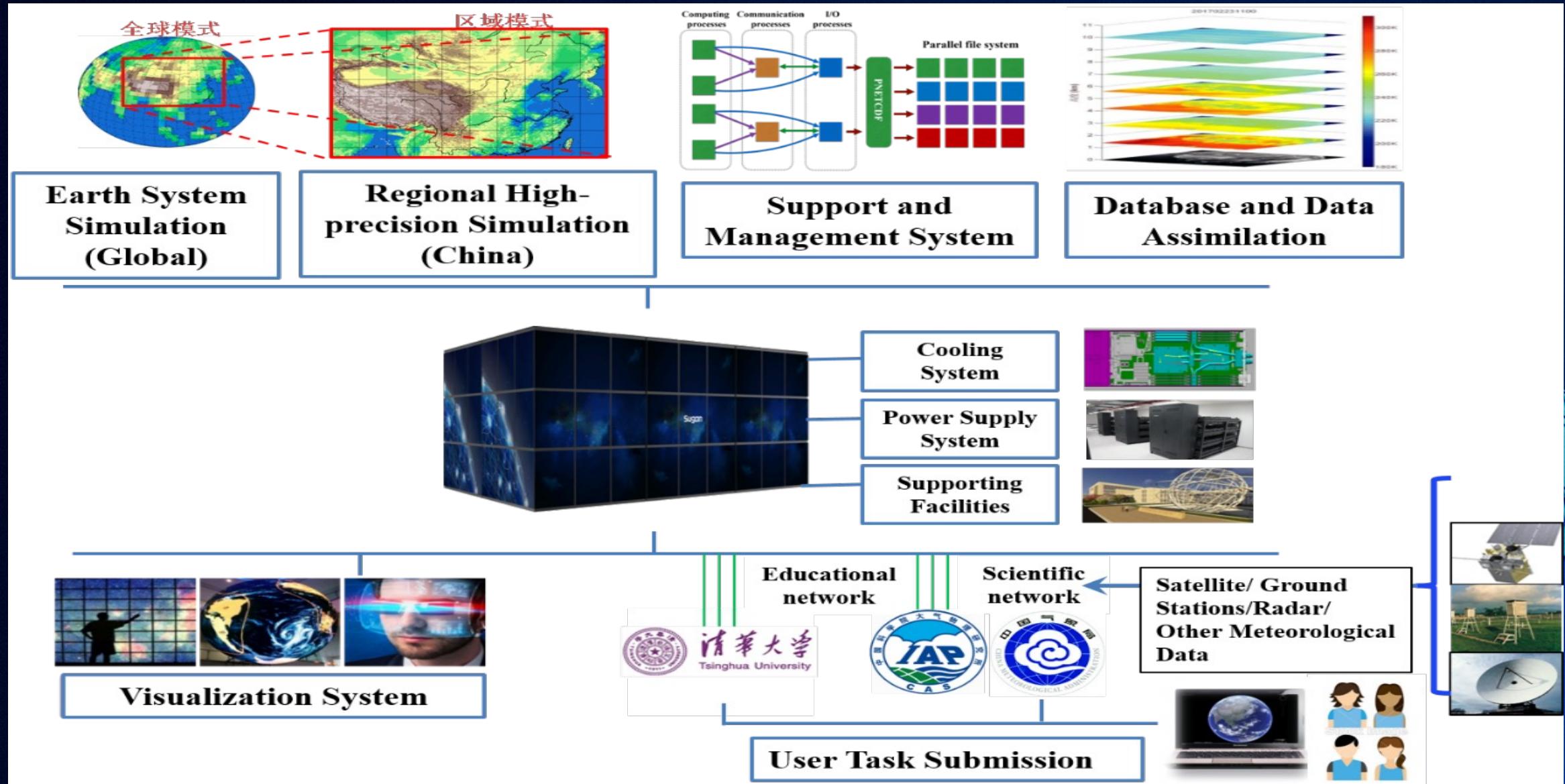
Improve prediction skill of earth system



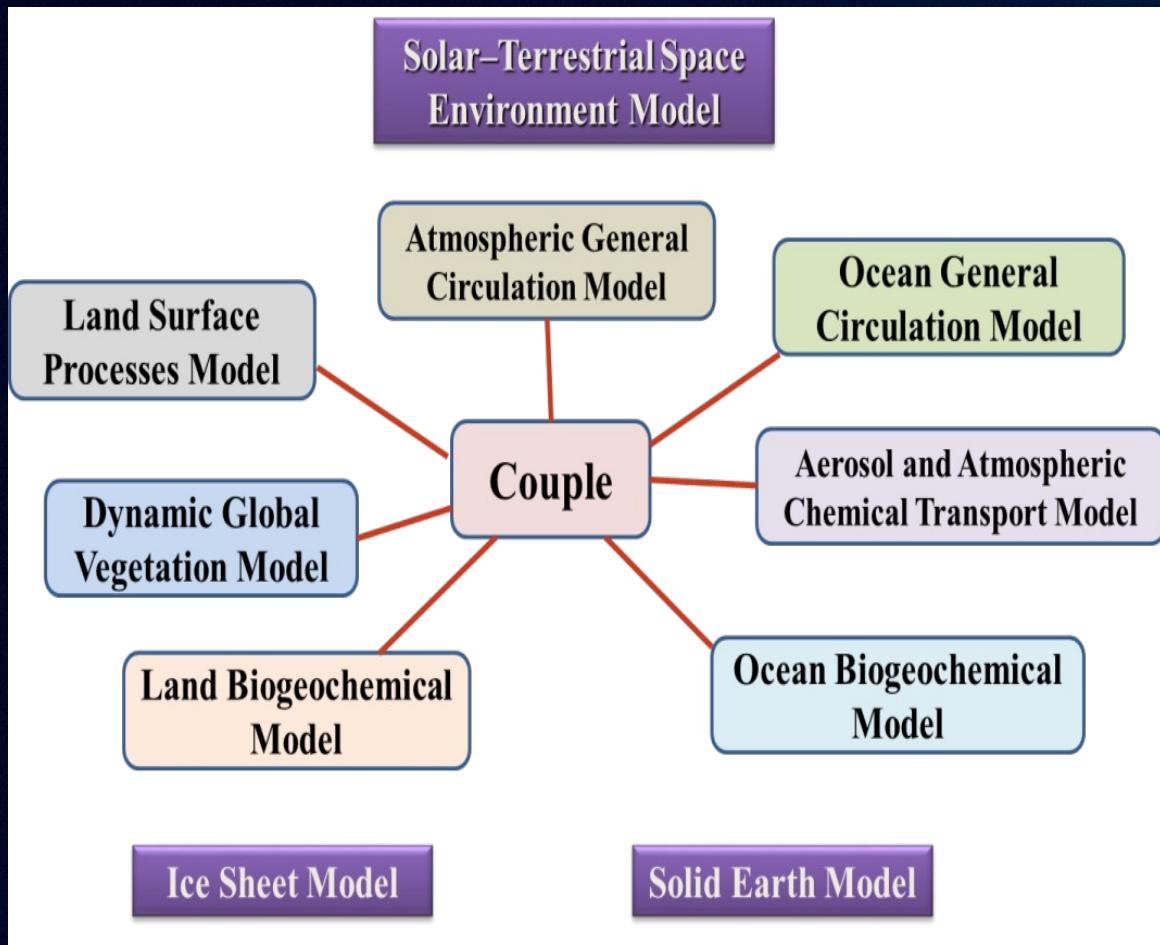
Support the policy development for climate and environment changes, natural disaster etc.



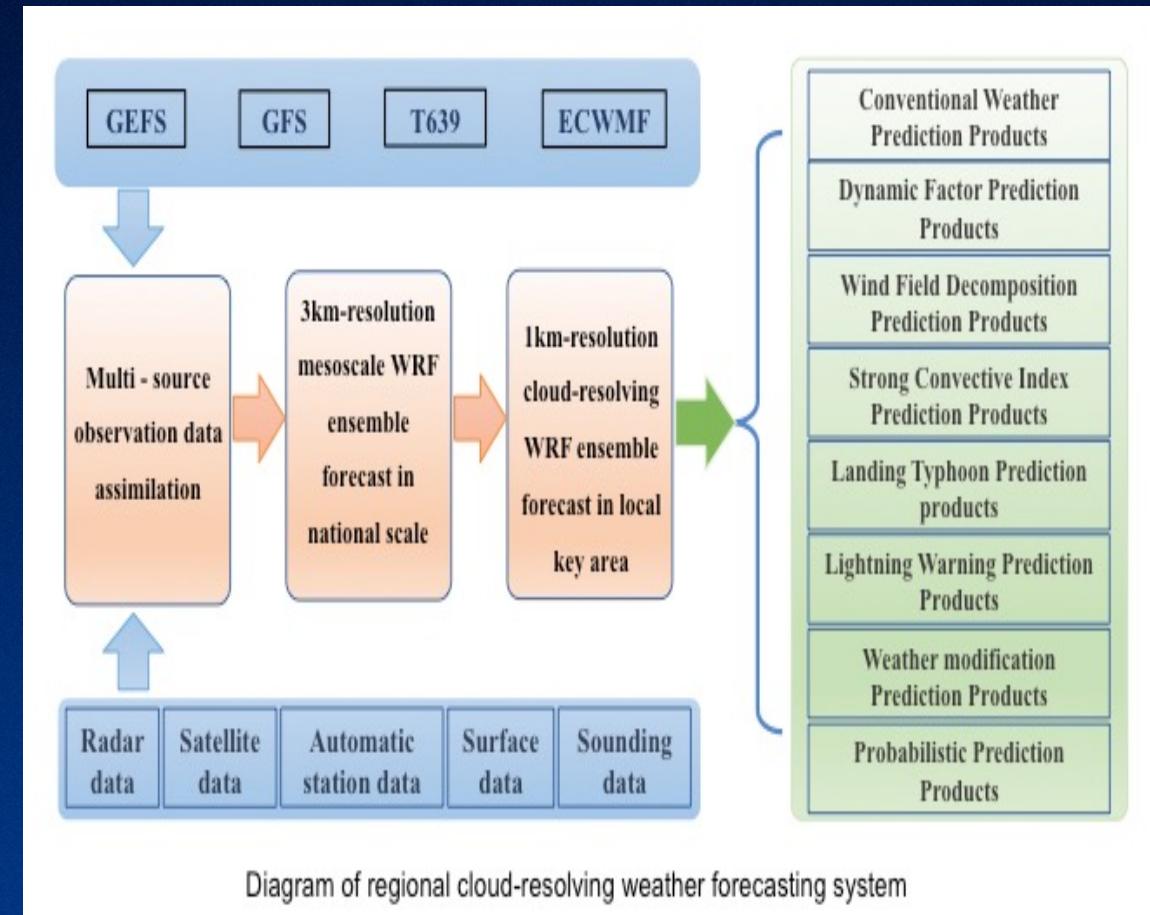
# Earth System Science Numerical Simulator Facility



# Global Model

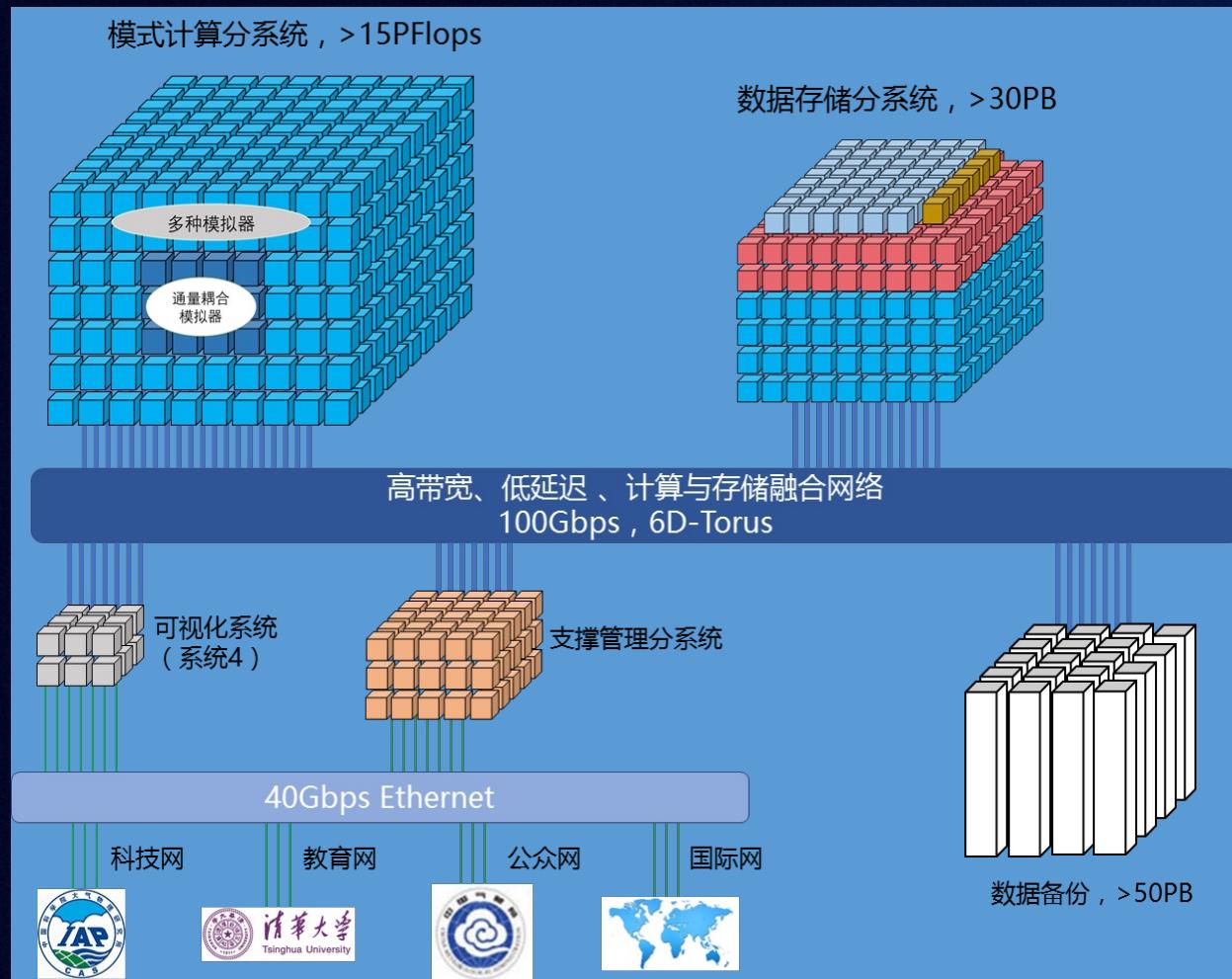


# Regional Model



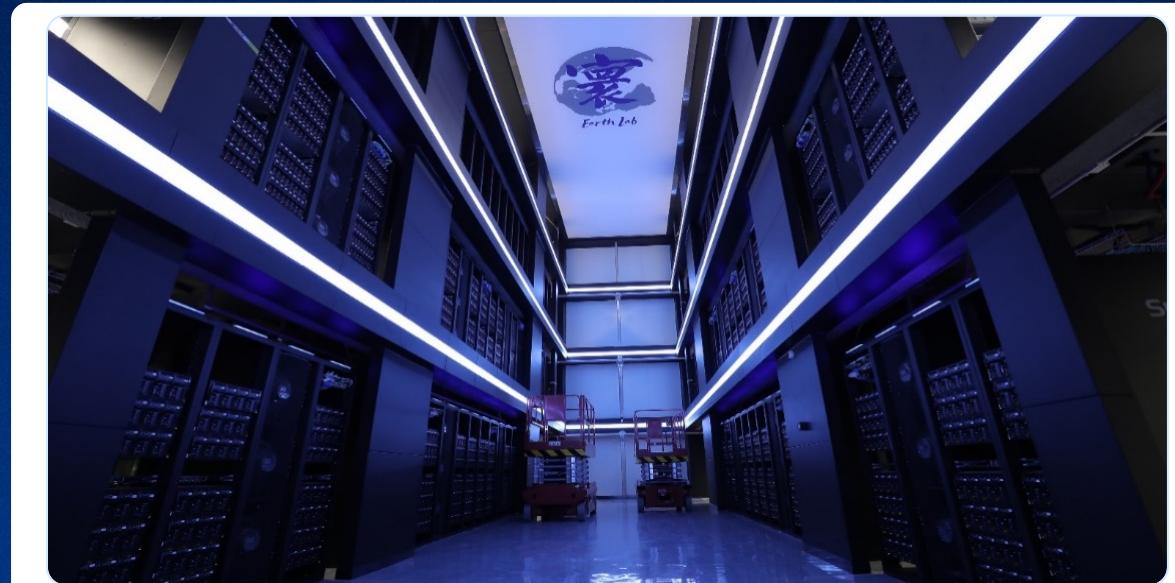
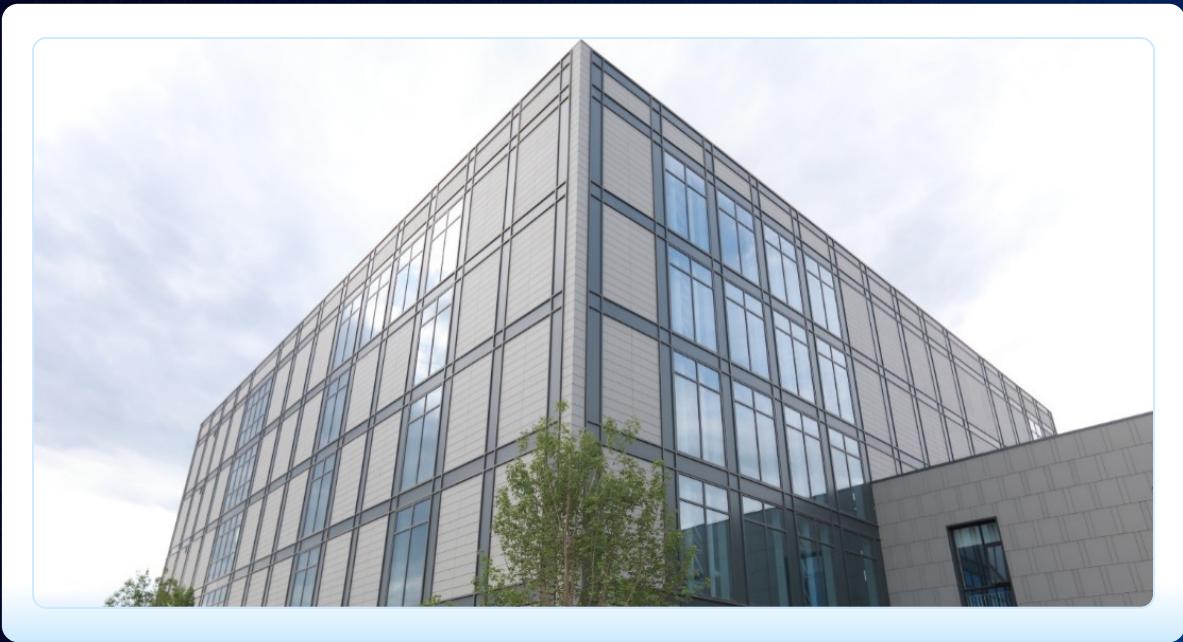
# High Performance Computer

# Scientific Visualization





*Earth Lab*



Total Budget: 180 million EUR (2018-2022)

# Outline

- 
- 1. Brief Introduction to the China Earth System Simulator**
  - 2. Global Climate Modeling**
  - 3. Regional Weather and Air Pollution Modeling**
  - 4. Support and Manage System**
  - 5. Forthcoming Plans**

# CAS-ESM2.0

# CAS-FGOALS3.0



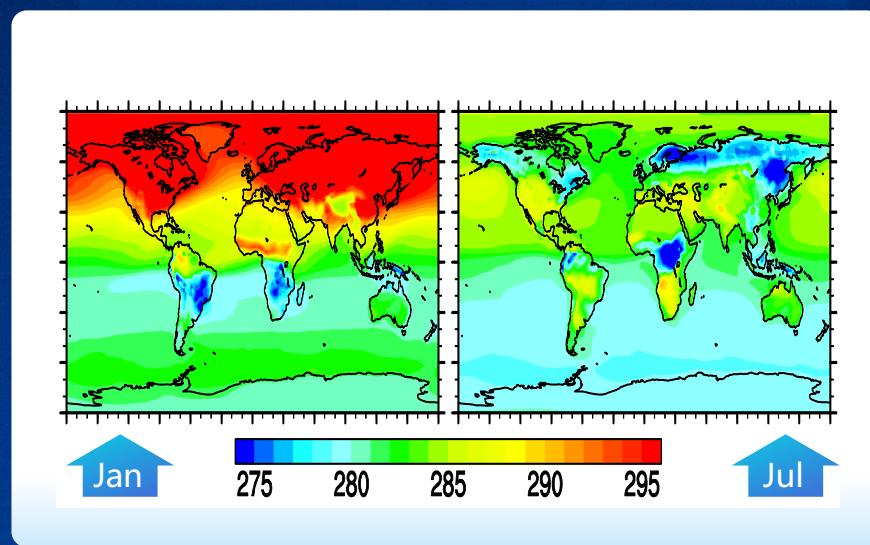
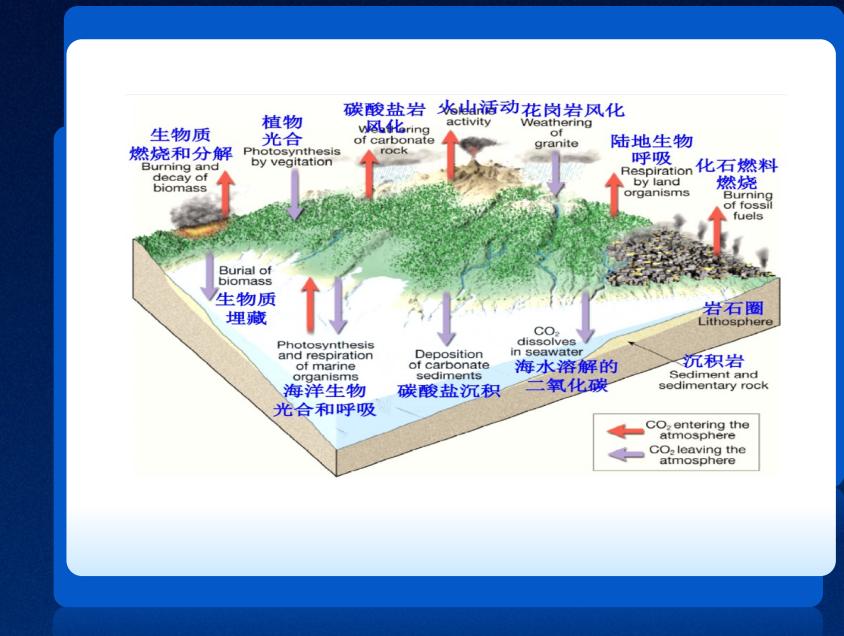
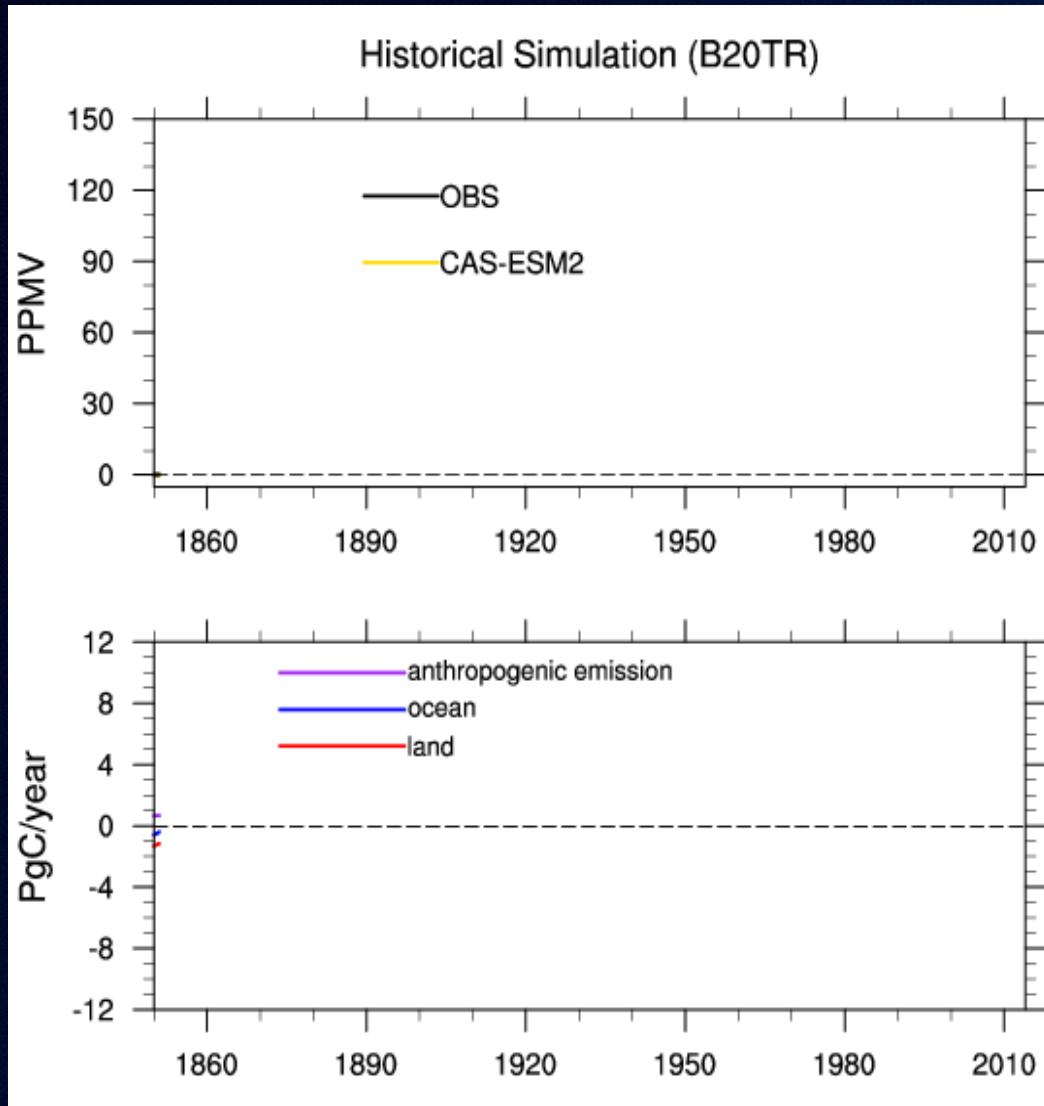
# CMIP6 Experiments: DECK, ScenarioMIP, HiresMIP etc

The screenshot shows the WCRP CMIP6 Data Node Status interface. The left sidebar contains dropdown menus for MIP Era, Activity, Model Cohort, Product, Source ID, Institution ID (selected), Source Type, Nominal Resolution, and Experiment ID. The main area displays a search bar with 'Enter Text:' and search options for 'Search', 'Reset', 'Display 10 results per page', and 'More Search Options'. Below the search bar are checkboxes for 'Show All Replicas', 'Show All Versions', and 'Search Local Node Only (Including All Replicas)'. The search results show a total of 4414 results for 'FOGOALS-f3-H' experiments. The first seven results are listed:

1. CMIP6.GMMIP.CAS.FGOALS-f3-Lampip-TIP.r1f1p1f1.Amon.rdscls.gr  
Data Node: esg.lasg.ac.cn  
Version: 20190422  
Total Number of Files (for all variables): 1  
Full Dataset Services: [ Show Metadata ] [ List Files ] [ THREDDS Catalog ] [ WGET Script ] [ LAS ] [ Show Citation ] [ PID ] [ Further Info ]
2. CMIP6.GMMIP.CAS.FGOALS-f3-Lampip-TIP.r1f1p1f1.Amon.rdscls.gr  
Data Node: esg.lasg.ac.cn  
Version: 20190422  
Total Number of Files (for all variables): 1  
Full Dataset Services: [ Show Metadata ] [ List Files ] [ THREDDS Catalog ] [ WGET Script ] [ LAS ] [ Show Citation ] [ PID ] [ Further Info ]
3. CMIP6.GMMIP.CAS.FGOALS-f3-Lampip-TIP.r1f1p1f1.Amon.rlutscls.gr  
Data Node: esg.lasg.ac.cn  
Version: 20190422  
Total Number of Files (for all variables): 1  
Full Dataset Services: [ Show Metadata ] [ List Files ] [ THREDDS Catalog ] [ WGET Script ] [ LAS ] [ Show Citation ] [ PID ] [ Further Info ]
4. CMIP6.GMMIP.CAS.FGOALS-f3-Lampip-TIP.r1f1p1f1.Amon.rlds.gr  
Data Node: esg.lasg.ac.cn  
Version: 20190422  
Total Number of Files (for all variables): 1  
Full Dataset Services: [ Show Metadata ] [ List Files ] [ THREDDS Catalog ] [ WGET Script ] [ LAS ] [ Show Citation ] [ PID ] [ Further Info ]
5. CMIP6.GMMIP.CAS.FGOALS-f3-Lampip-TIP.r1f1p1f1.Amon.rlus.gr  
Data Node: esg.lasg.ac.cn  
Version: 20190422  
Total Number of Files (for all variables): 1  
Full Dataset Services: [ Show Metadata ] [ List Files ] [ THREDDS Catalog ] [ WGET Script ] [ LAS ] [ Show Citation ] [ PID ] [ Further Info ]
6. CMIP6.GMMIP.CAS.FGOALS-f3-Lampip-TIP.r1f1p1f1.Amon.rlut.gr  
Data Node: esg.lasg.ac.cn  
Version: 20190422  
Total Number of Files (for all variables): 1  
Full Dataset Services: [ Show Metadata ] [ List Files ] [ THREDDS Catalog ] [ WGET Script ] [ LAS ] [ Show Citation ] [ PID ] [ Further Info ]
7. CMIP6.GMMIP.CAS.FGOALS-f3-Lampip-TIP.r1f1p1f1.Amon.prsn.gr  
Data Node: esg.lasg.ac.cn

Model	Atm.	Ocn.
AWI-CM-1:	25km	25km
BCC-CSM:	40km	25km
CMCC:	25km	25km
CNRM:	50km	25km
EC-Earth:	25km	25km
GFDL CM5:	50km	25km
FGOALS-f3-H:	25km	10km
HadGEM3:	25km	10km
MPI-ESM:	50km	40km
NCAR-CESM:	25km	10km

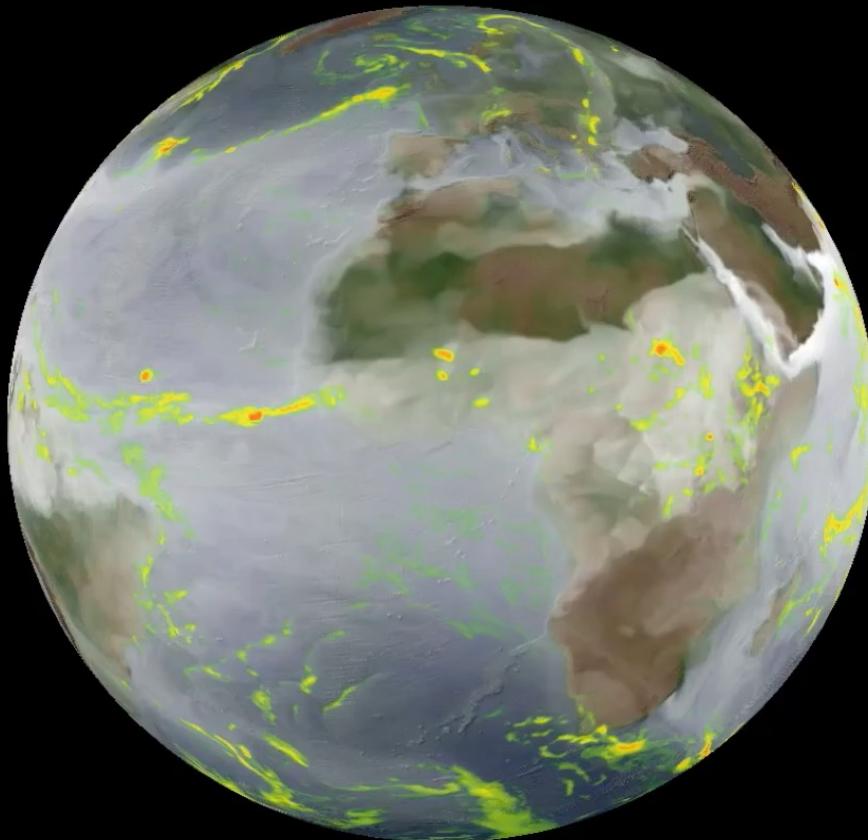
# Carbon Cycle in CAS ESM



FAMIL



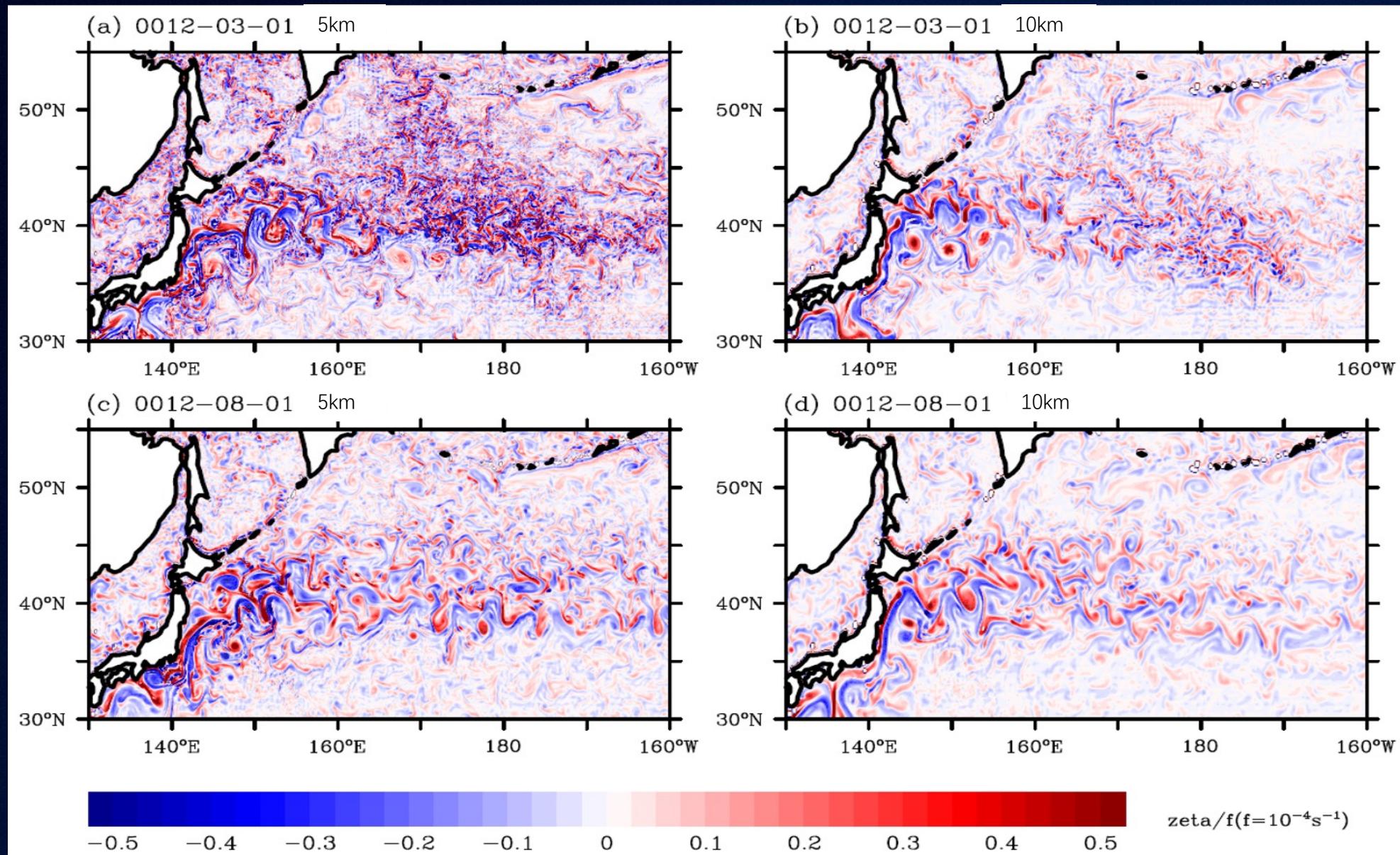
State Key Laboratory of Numerical Modelling for Atmospheric Sciences  
and Geophysical Fluid Dynamics(LASG)  
Institute of Atmospheric Physics Chinese Academy of Sciences

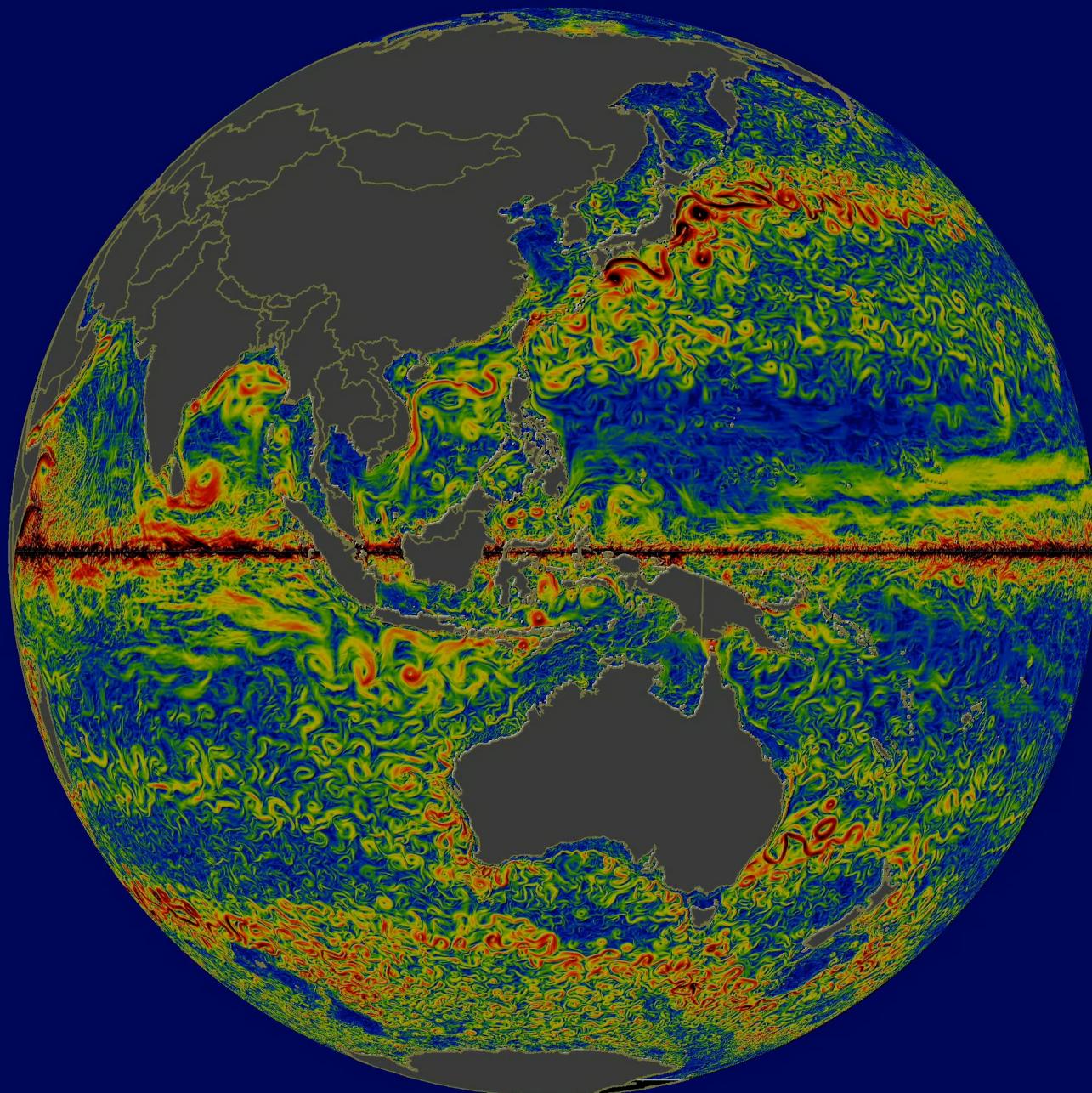


高分辨率大气模式FAMIL模拟的全球降水

Daily Precipitation from 25km AGCM

# Oceanic Eddies from 10km and 5km OGCM

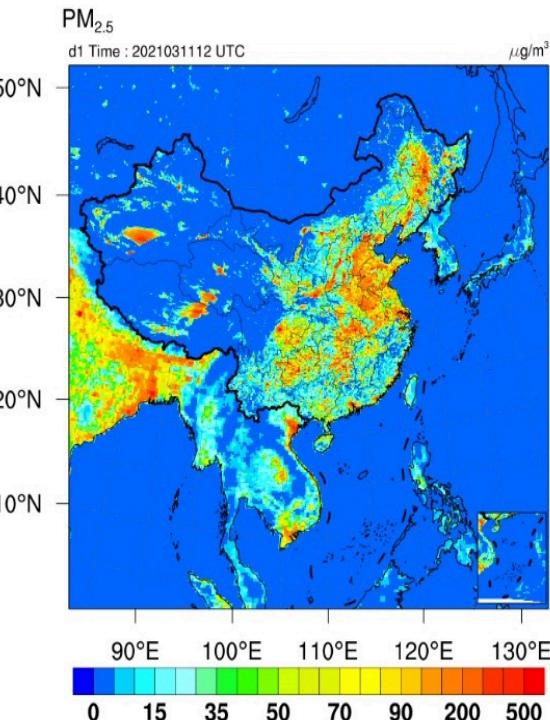
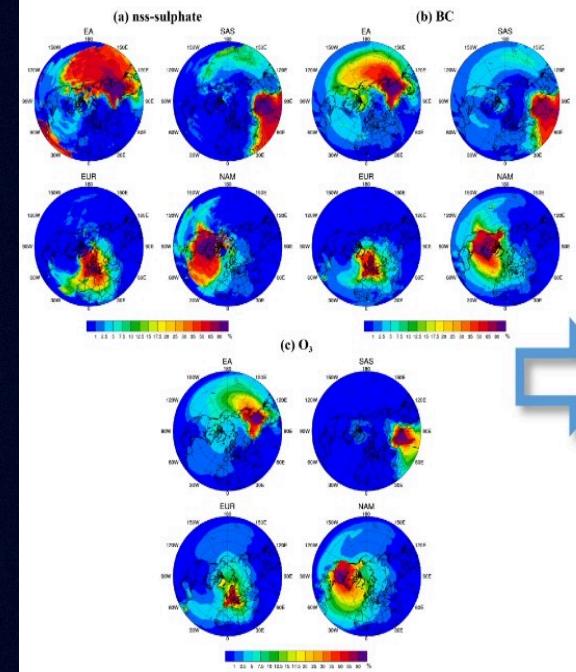




# Outline

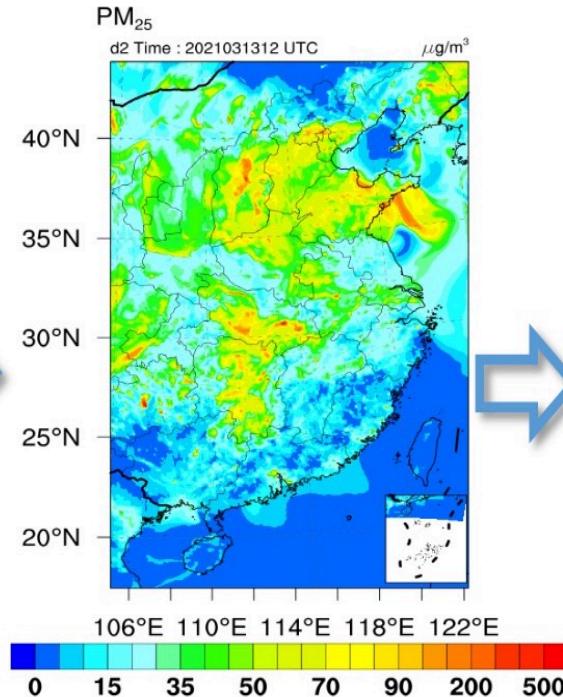
- 
- 1. Brief Introduction to the China Earth System Simulator**
  - 2. Global Climate Modeling**
  - 3. Regional Weather and Air Pollution Modeling**
  - 4. Support and Manage System**
  - 5. Forthcoming Plans**

# High-Precision Regional Simulation System

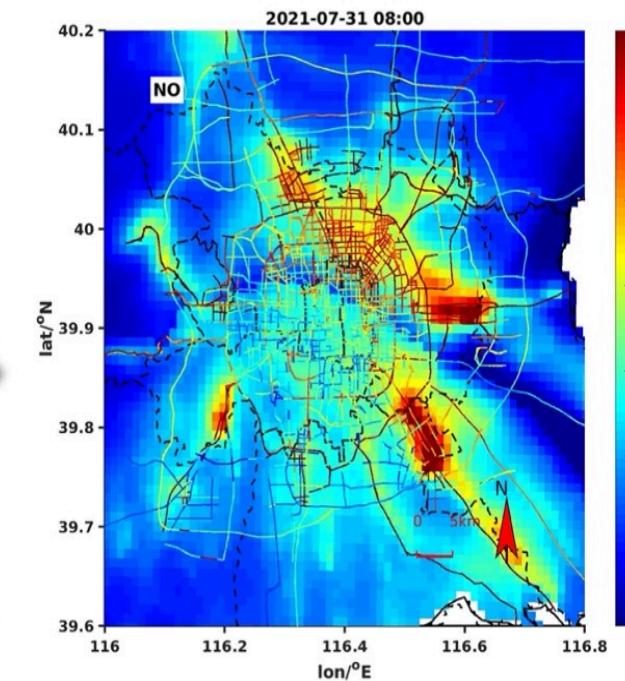


全球 : 0.5度

中国 : 3公里



中东部 : 1公里



街区 : 50米

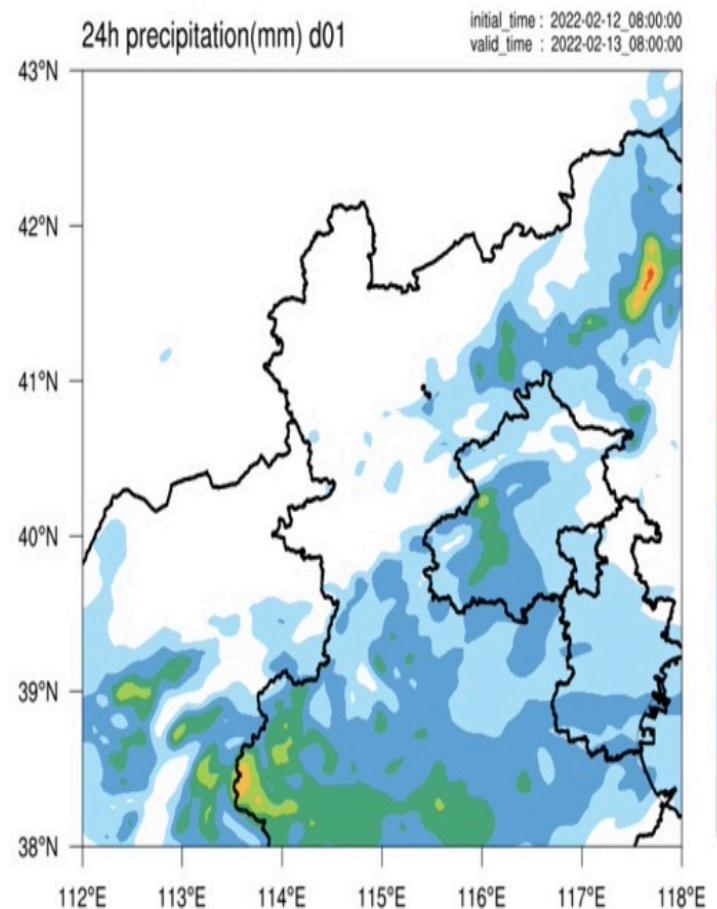
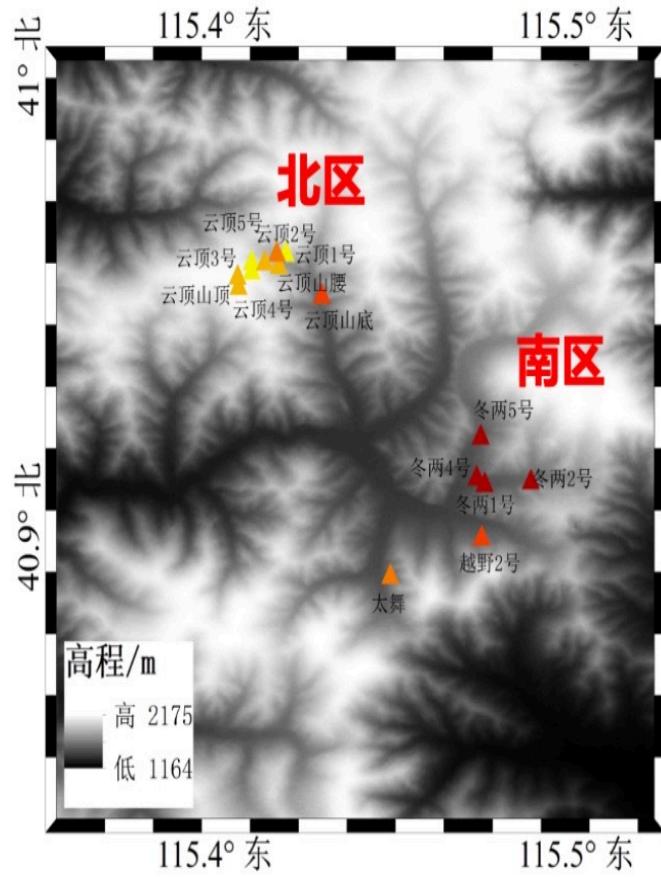
Global: 0.5degree.

China : 3km.

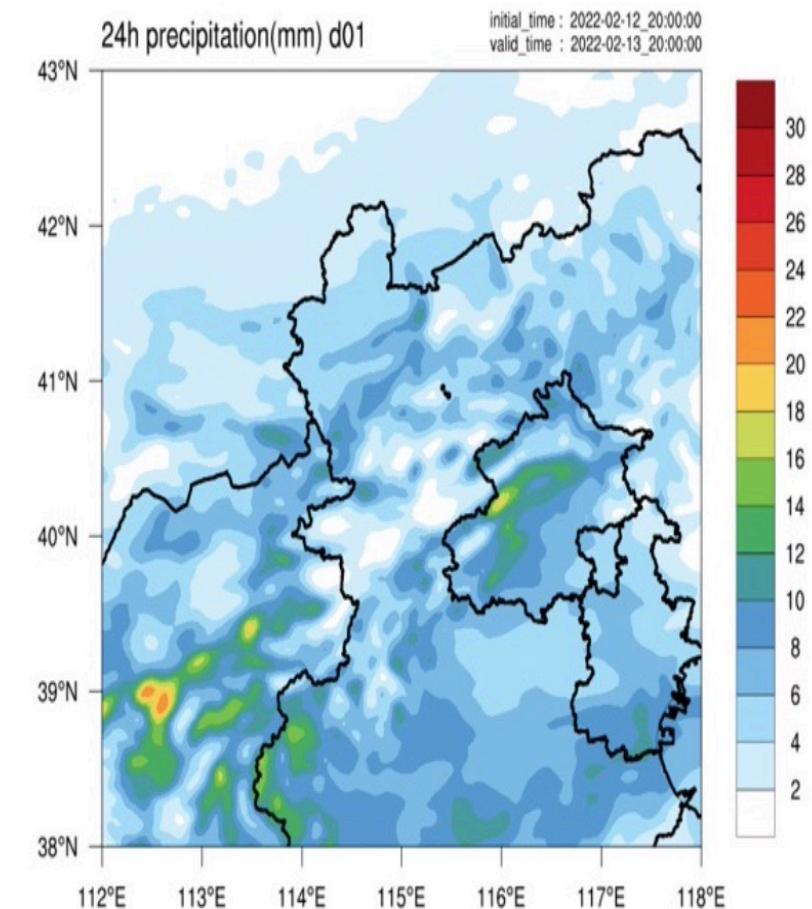
East China: 1km

Street : 50m

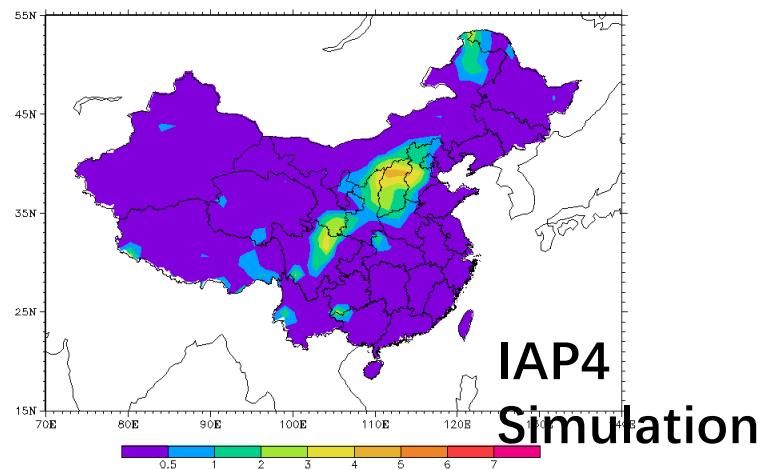
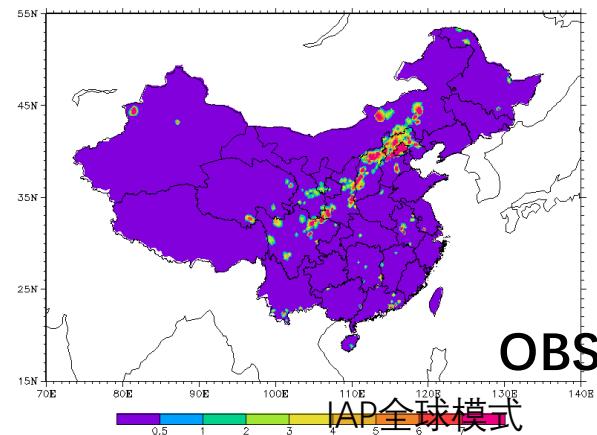
# 100m weather forecast system with 9600 CPU cores for Winter Olympic Games in 2022



12日08时-13日08时

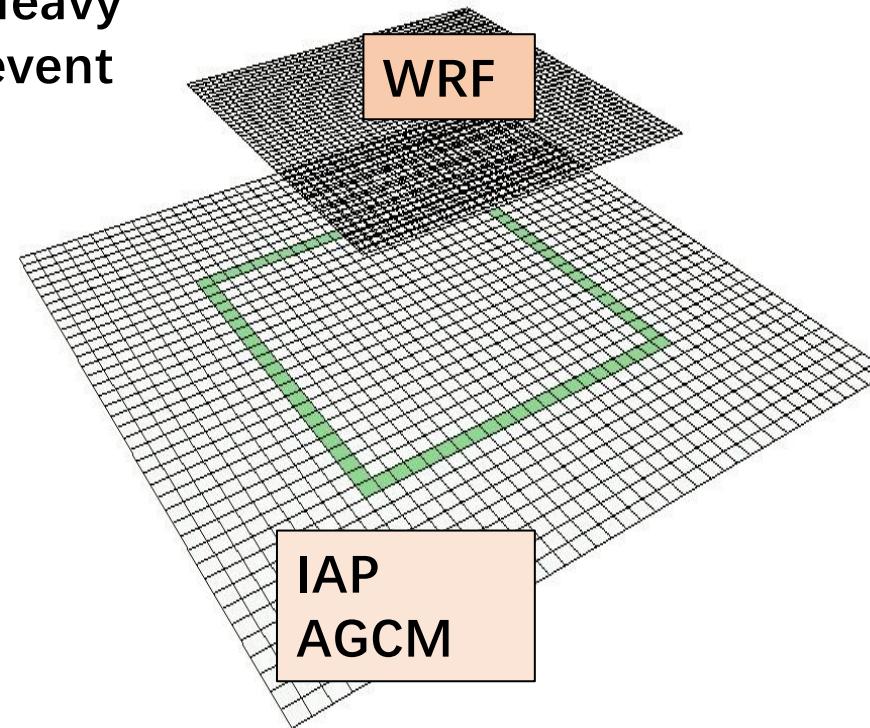


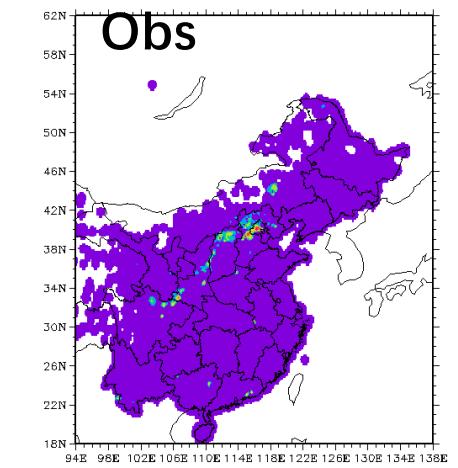
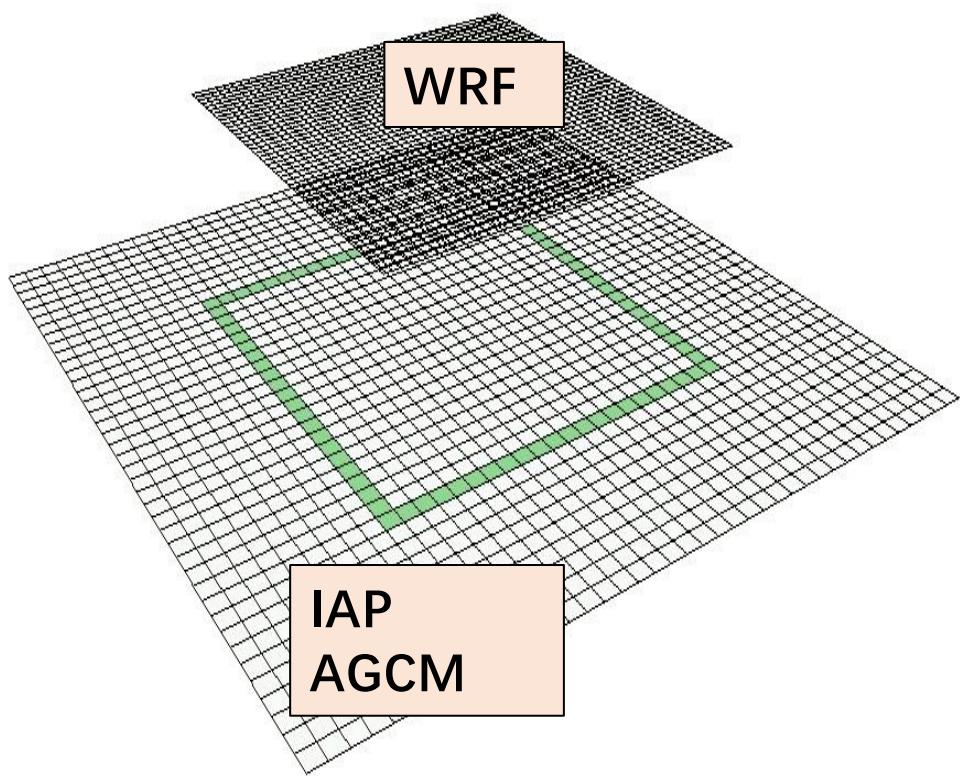
12日20时-13日20时



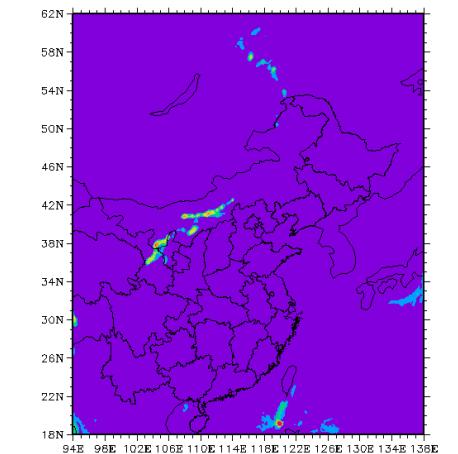
台站资料

2012 July 21 Heavy  
Precipitation event

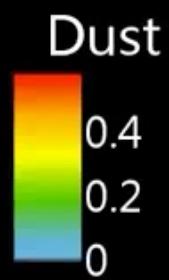
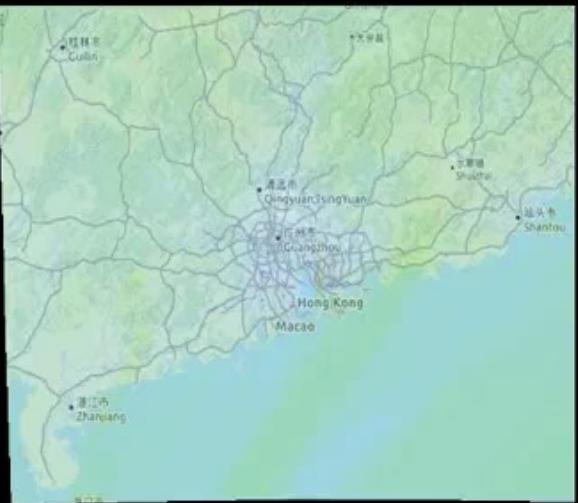
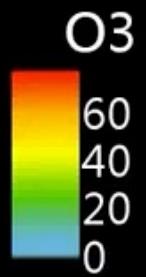
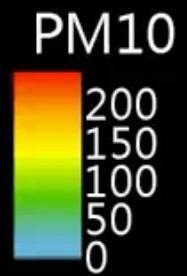
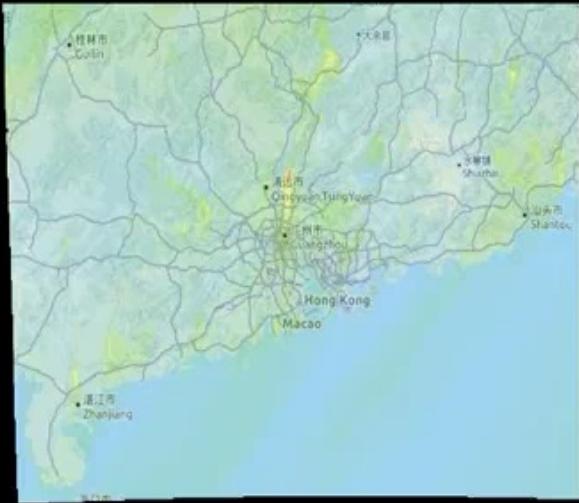
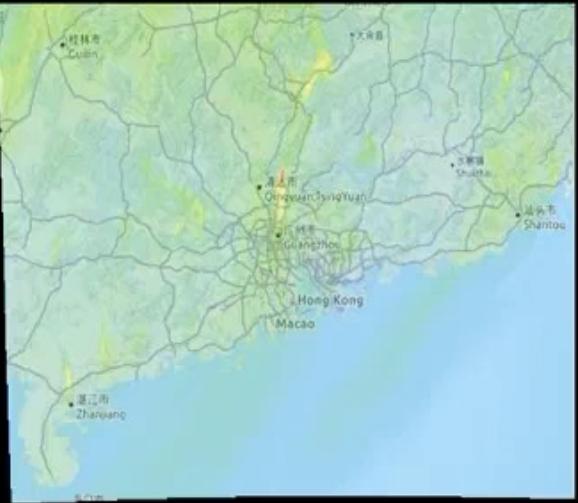
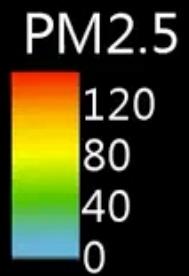




**WRF Nested in IAP4 AGCM**



00-20130112

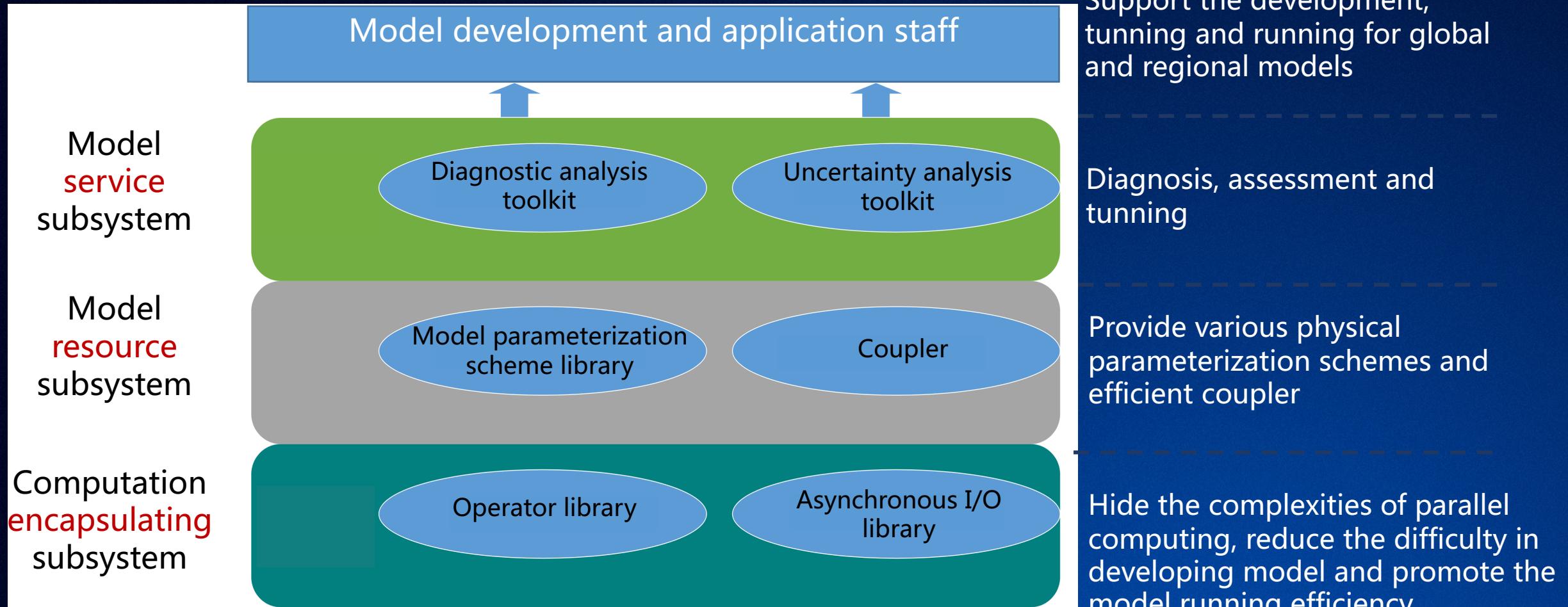


# Outline

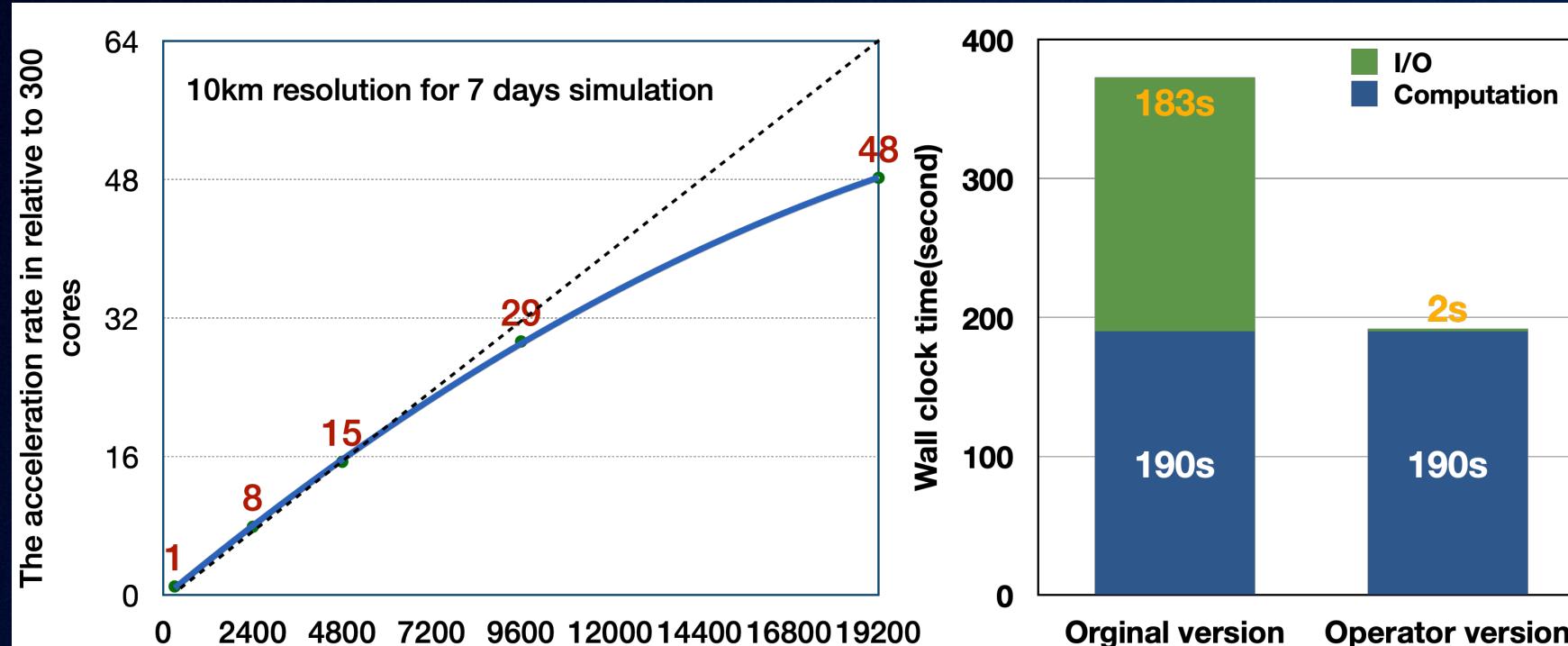
- 1. Brief Introduction to the China Earth System Simulator**
- 2. Global Climate Modeling**
- 3. Regional Weather and Air Pollution Modeling**
- 4. Support and Manage System**
- 5. Forthcoming Plans**



# Super simulation support and management system



# Speedup on the Earth System Numerical Simulation Facility

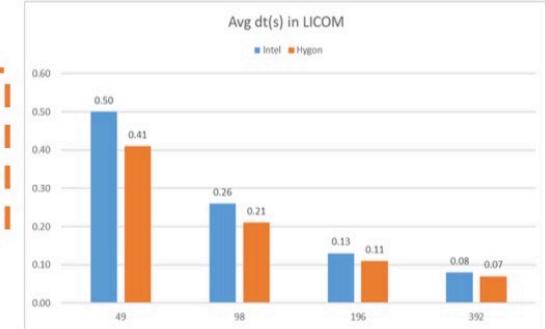


The LICOM3 global ocean model: 19200 CPU cores, 75% parallel efficiency. I/O time was reduced from 183 seconds to 2 seconds, resulting in an overall model acceleration of 1.94x.

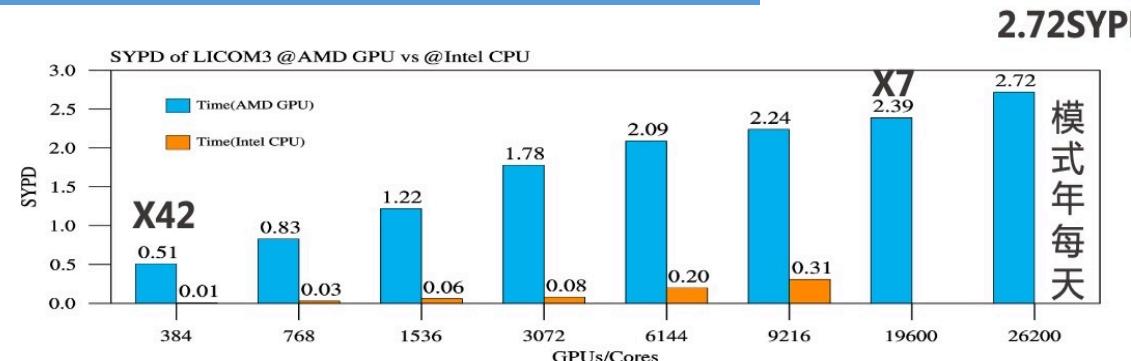
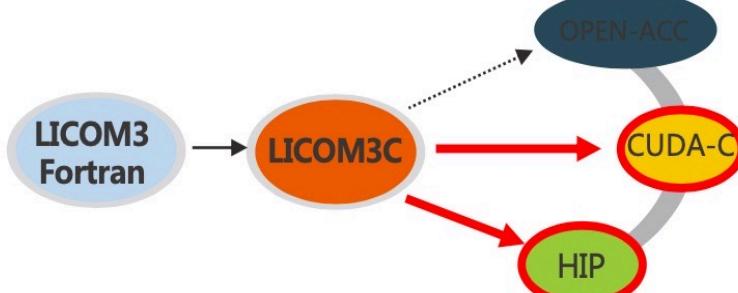
## Optimization of LICOM3(1/20°) for AMD and Intel CPU

CPU Type	Nodes	49	98	196	392
Intel Xeon Gold 6142 (16 Cores, 2.6GHz)	Cores	1470	2940	5880	11760
	Avg dt(s)	0.50	0.26	0.13	0.08
Hygon Dhyana 7185 (32 Cores, 2.0GHz)	Cores	2940	5880	11760	23520
	Avg dt(s)	0.41	0.21	0.11	0.07

- 相同节点数，Hygon平台比Intel平台性能更高
- 392节点Hygon平台比Intel平台快12%



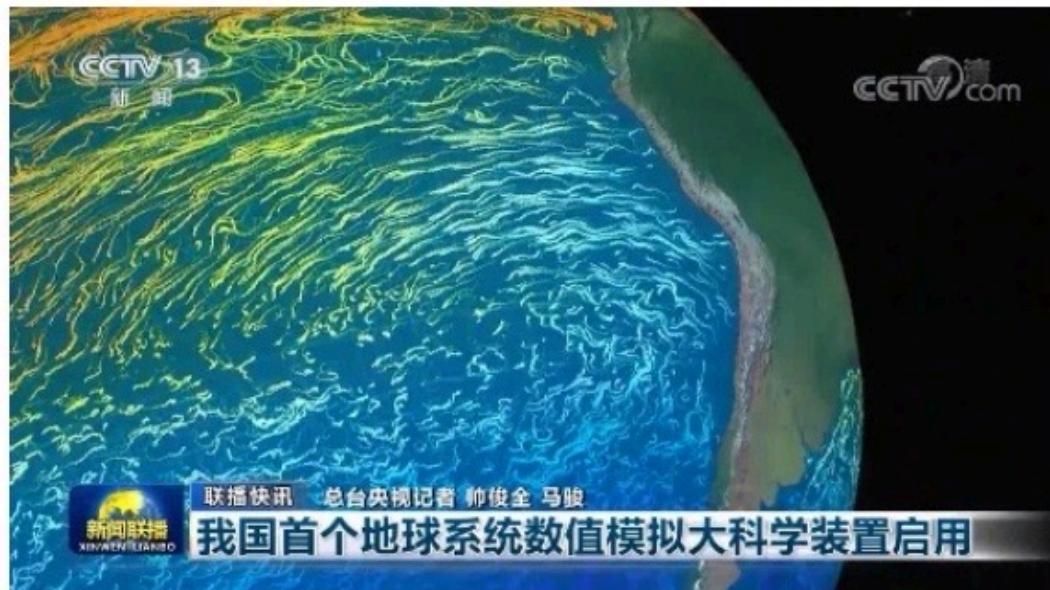
## Heterogeneous optimization of LICOM3(1/20°) for AMD GPU



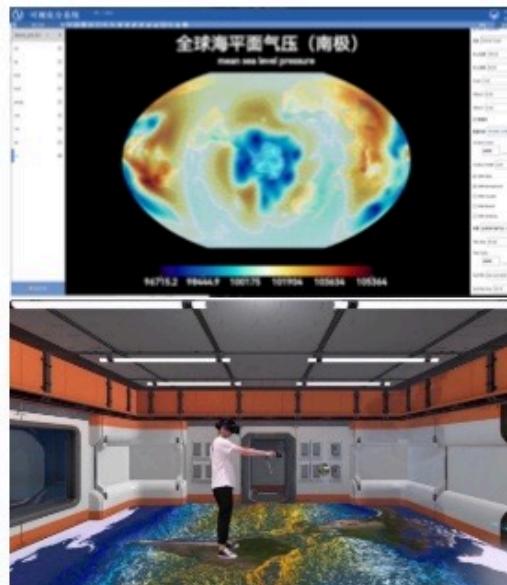
LICOM3(1/20°) can be run more than 1 million GPU cores, speeded up to 2.72SYPD



# Visualization system includes virtual reality (VR) machines and Spherical LED display system for professional study as well as science popularization and publicity



可视化系统支持装置宣传工作  
图为央视新闻联播新闻报道画面



可视化系统  
支持模式数据分析



支持装置科普工作

# Outline

- 1. Brief Introduction to the China Earth System Simulator**
- 2. Global Climate Modeling**
- 3. Regional Weather and Air Pollution Modeling**
- 4. Support and Manage System**
- 5. Forthcoming Plans**



# Forthcoming Plans

- Further increase spatial resolution: 2-3km for global OGCM, 5-10km for AGCM
- Improve the earth system model, i.e. introduce new component model such as icesheet model etc.
- Develop coupled data-assimilation and climate prediction system
- Both computer and software including model and supporting system will open to all scientists over the world.

# Supercomputer for Earth System Modeling in the World

Peak FLOAPS: 15PF  
Storage: 80PB

