The 40th annual meeting of the Working Group on Numerical Experimentation (WGNE)

中国气象局地球系统数值预报中心
CMA EARTH SYSTEM MODELING AND PREDICTION CENTRE

Progress of CMA Reanalysis:
From CRA-40 to CMA-RA2 Suite

Lipeng Jiang
(jianglp@cma.gov.cn)

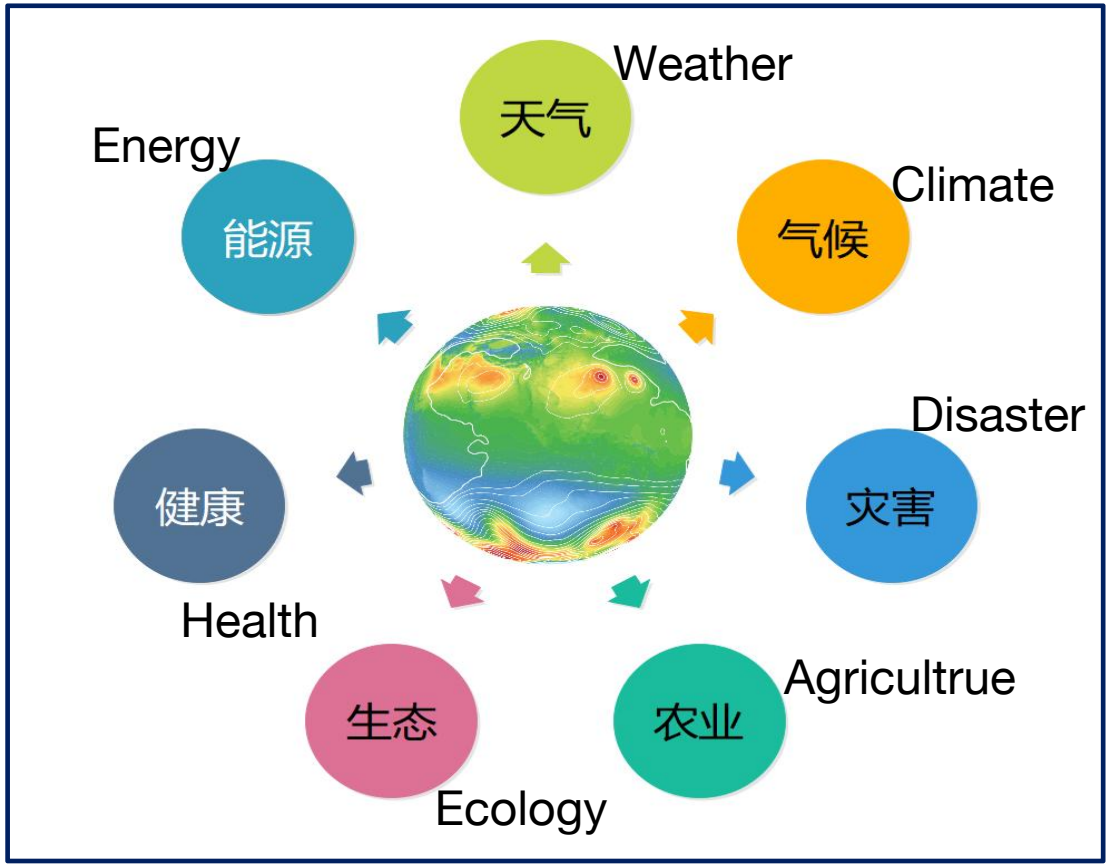
Present for CMA Reanalysis Team

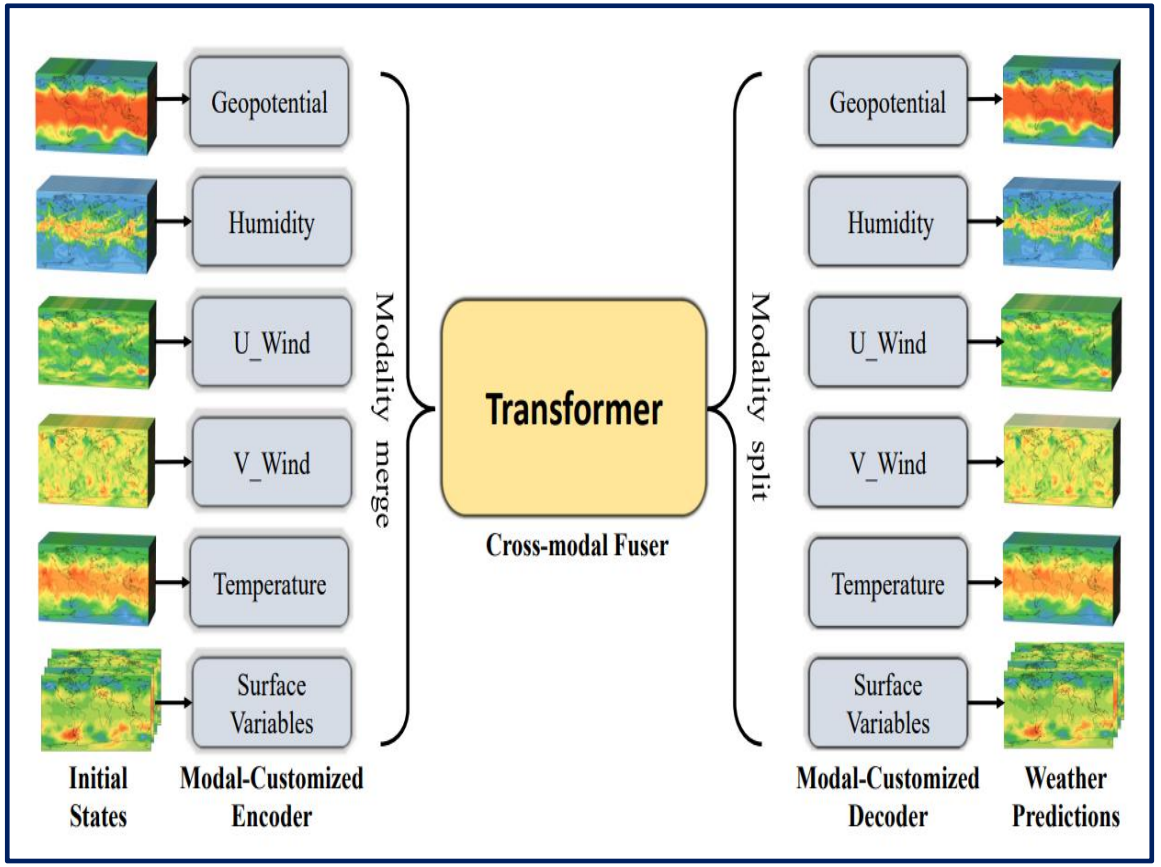
CMA Earth System Modeling and Prediction Center (CEMC)
2025-11-06

The broad use of reanalyses

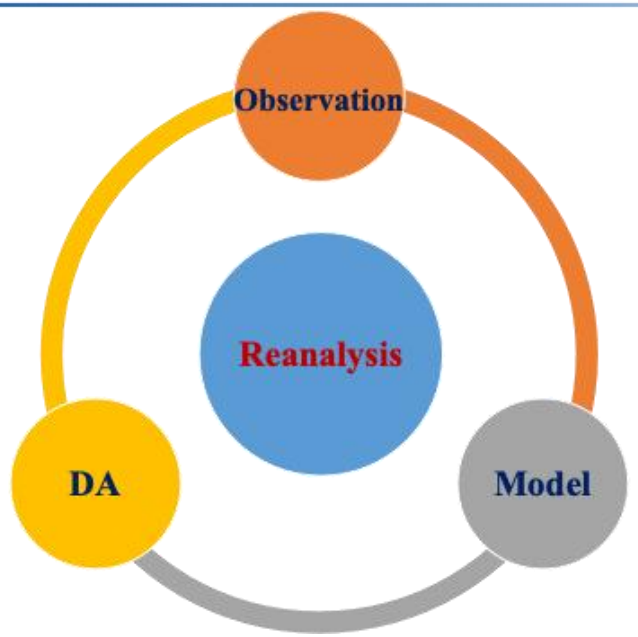
Reanalyses are widely used in weather, climate, and environmental studies, and increasingly in applications such as disaster monitoring, agriculture, energy, and health.

They also provide essential datasets for AI model training and Earth system research.





International Reanalysis Efforts



Reanalysis Exp.

1980s

GFDL FGGE

ECMWF FGGE

The 1st round

1990s

NASA DAO（1980-1995）

2×2.5°, L14

NCEP R1（1948-）

210km, L28

ERA-15（1979-1993）

125km, L31

The 2nd round

2000s

NCEP R2（1979-）

210km, L28

ERA-40（1957-2002）

125km, L60

JRA-25（1979-）

110km, L40

The third round

2010s

CFSR（1979-）

38km, L64

MERRA（1979-2016）

1/2×2/3°, L72

ERA-Interim（1979-2019）

79km, 60L

JRA-55（1957-）

55km, 60L

The fourth round

2020s

ERA5（1950-）

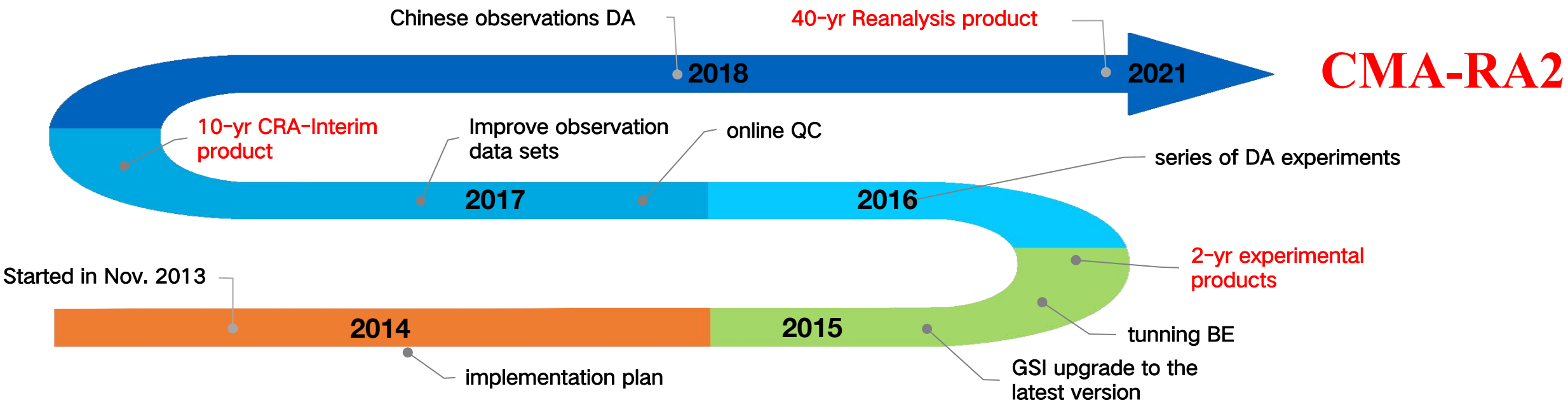
31km, 137L

CMA-RA1（1979-）

34km, 64L

CMA's Efforts in Reanalysis

- CMA launched its global reanalysis project in November 2013.
- The first-generation reanalysis, CMA-RA1, was released in 2021.
- The project has since progressed to the second-generation system, CMA-RA2.



CMA-RA1 configurations

CMA-RA/Atmosphere

- Forecast Model: GSM

- T574 (~ 34km)
- 64 vertical layers with model top at 0.27hPa

- Data Assimilation System: GSI

- 3Dvar-FGAT scheme
- 6 hours assimilation window
- VarBC scheme for aircraft T observations and satellite radiance
- Online CQC procedure for conventional observations

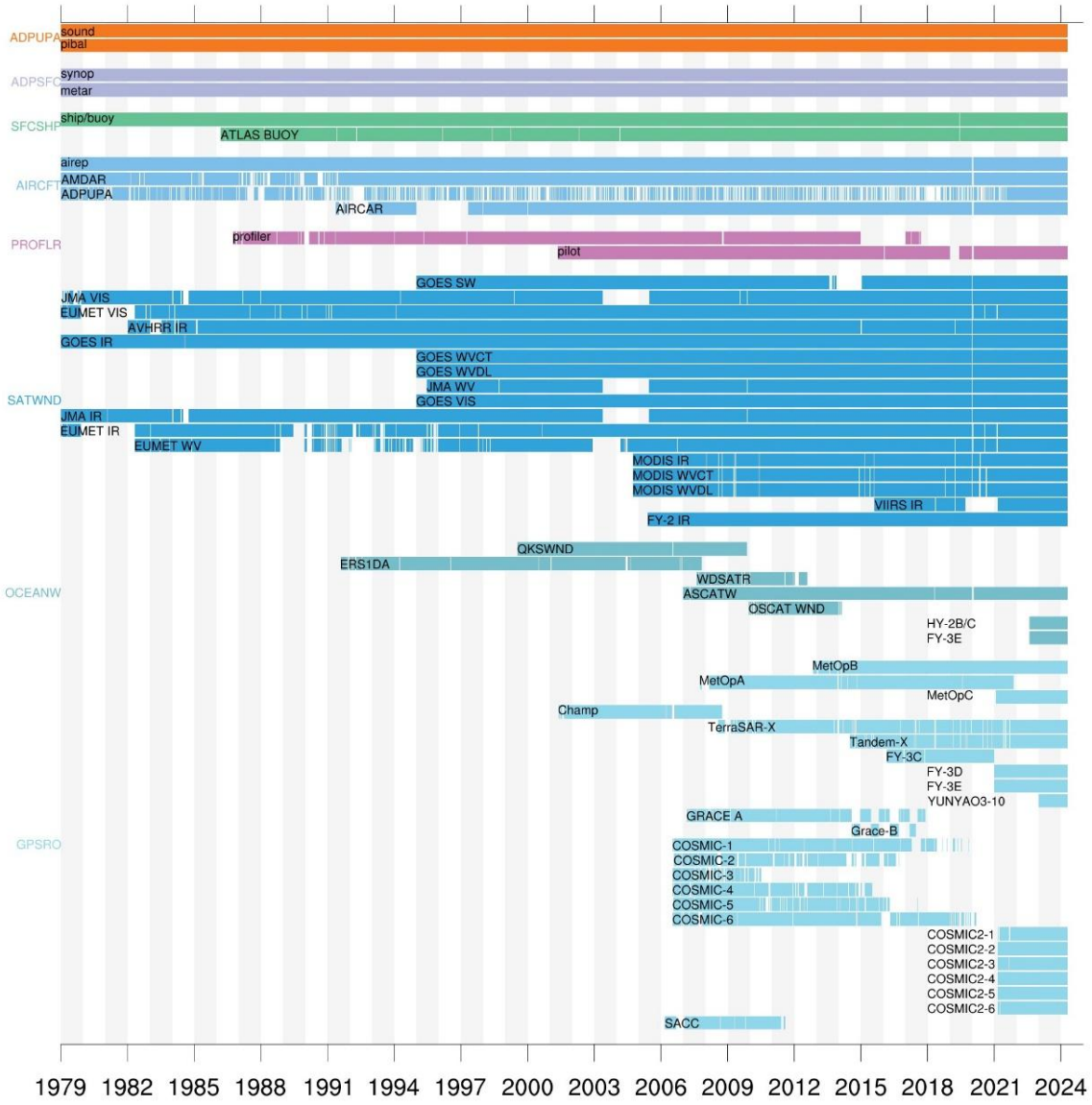
- Production Strategy:

- 10 parallel streams with a 4.5-yr period for each stream (6 month spin-up for each stream)
- 1979.01 – 2018.12 (continues to update in NRT.)

CMA-RA/Land

- Blending T2m, Q2m, U10, V10 model outputs with surface observations using EnOI.
- Blending precipitation with CMAP(5-day, 2.5x2.5) and CPCU (daily, 0.5x0.5) precipitation analysis.
- Noah LSM with 4 soil layers.

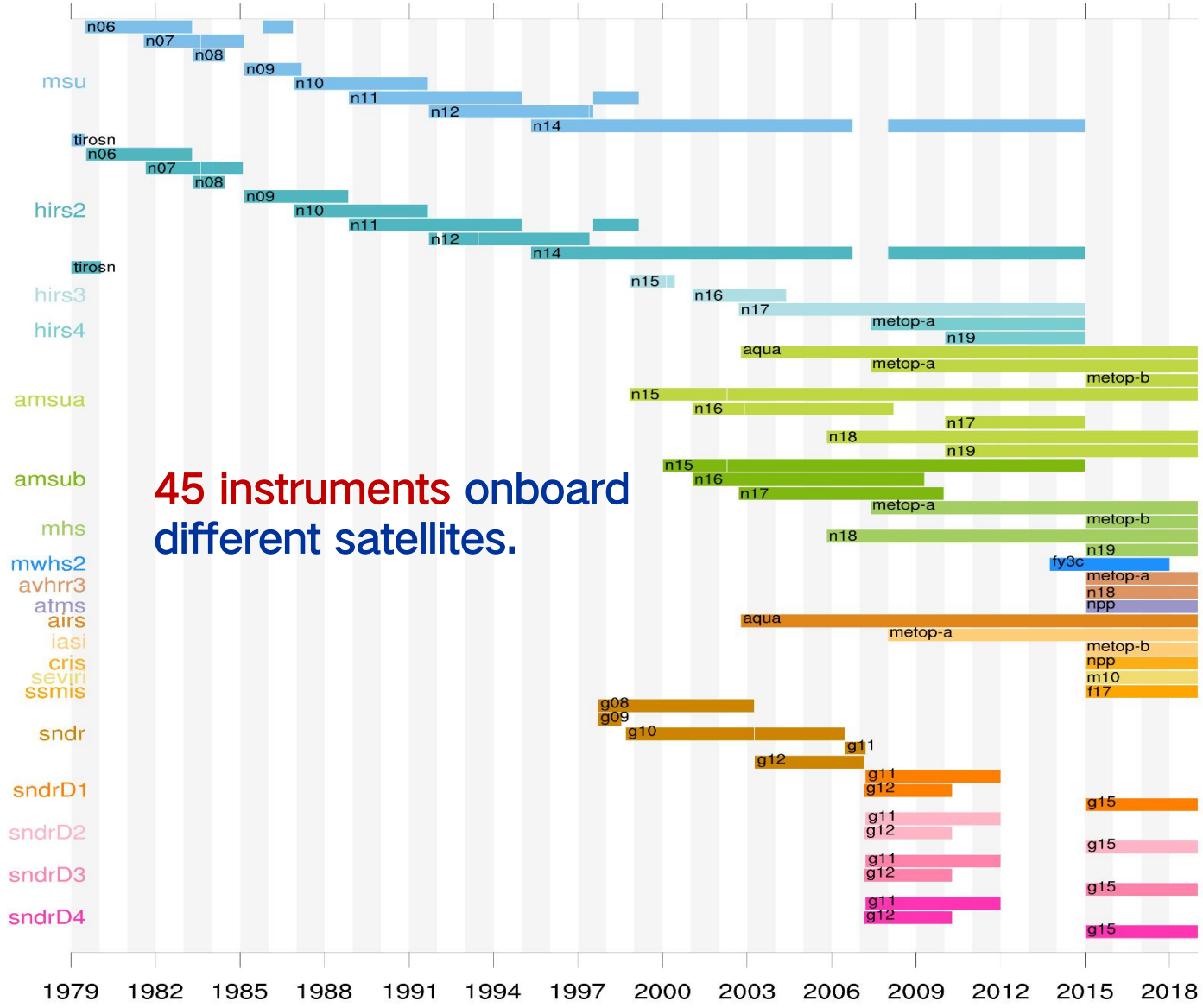
Conventional observations



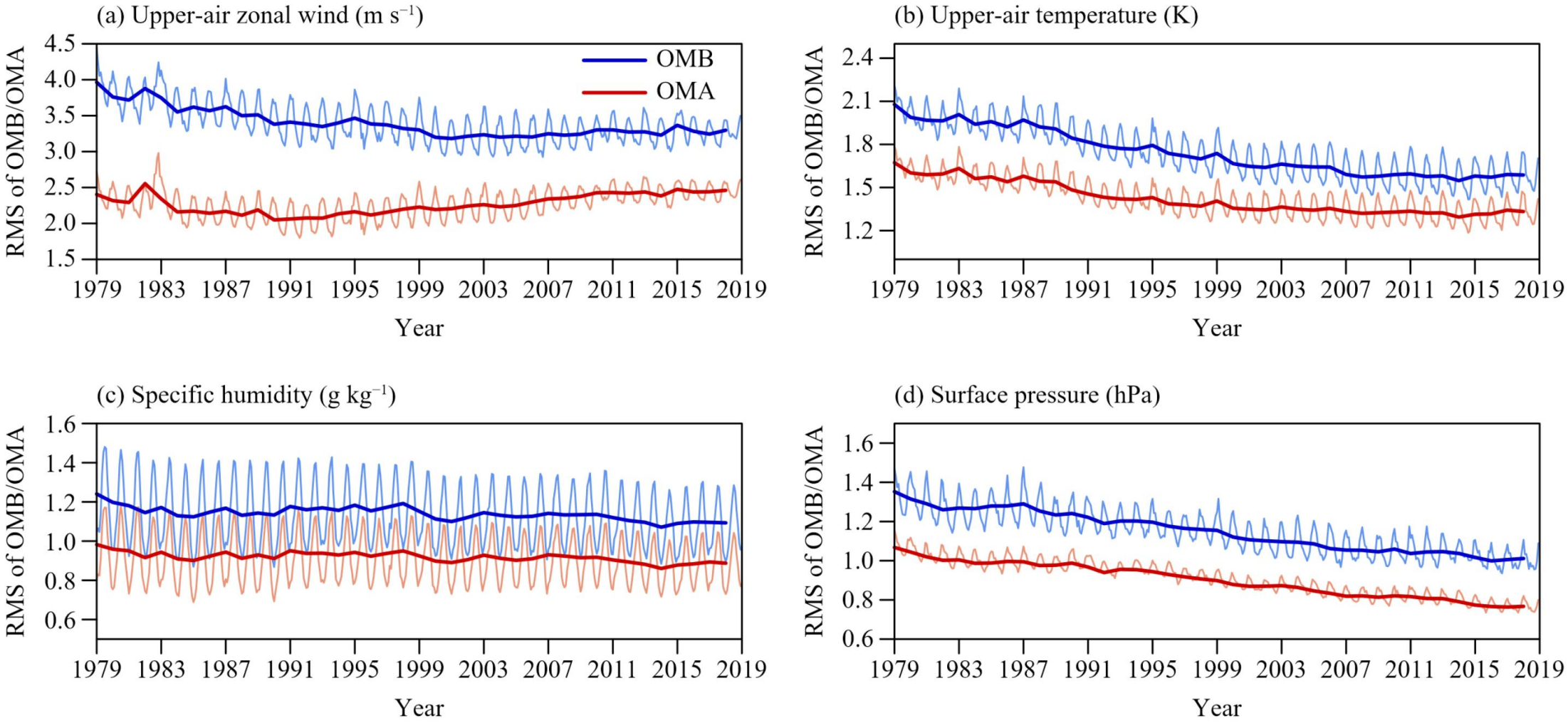
Data Source		Data Type	Period
CMA	Chinese operational observations	SYNOP, radiosonde, and pilot	1979–2023
		Buoy and ship	2013–2023
		Wind profiler	2007–2023
		Aircraft	2003–2023
	Operational GTS data	SYNOP, radiosonde, aircraft, buoy, and ship	1979–2023
	TIPEX III	Radiosonde	2015–2018
NCAR/RDA	ds099.0	SYNOP, radiosonde, pilot, dropsonde, aircraft, buoy, and ship	1979–2014
		Wind profiler over US	1987–2014
	ds735.0	SYNOP, radiosonde, pilot, dropsonde, aircraft, buoy, and ship	2015–2020
	ds351.0	Aircraft	1999–2020
NCEI	ISD	SYNOP and METAR	1979–2020
	IGRA V2.0	Radiosonde	1979–2020
	ICOADS 3.0	Buoy and ship	1979–2020
	DSI-6380	Aircraft	1979–1998
CEDA	AMDAR reports collected by the UK Met Office	Aircraft	2009–2018
JODC	NEAR-GOOS Regional Delayed Mode Data Base	Buoy and ship	1979–2017

Satellite observations

Type	Instrument	Used in CMA-RA
TOVS/ ATOVS	MSU	NOAA 6-8, NOAA 9-14
	AMSUA/ AMSUB/MHS	NOAA 6-8, NOAA 9-14, NOAA 15-19, AQUA, MetOp A/B, FY-3C
	HIRS2/HIRS3/HIRS4	NOAA 6-19, AQUA, MetOp A/B
	ATMS	NPP
Hyperspectral	AIRS	AQUA
	IASI	MetOP
	CRIS	NPP
GPS-RO	GPS-RO	COSMIC reprocessed products, FY-3C
retrieved products	AMV	Reprocessed products, CFSR, FY-2C, FY-2E
	Surface wind	ASCAT、WindSAT、QuikSCAT、ERS-1&2、OSCAT



analysis/background fit to observations



Liu, Z. Q., L. P. Jiang, C. X. Shi, et al., 2023: CRA-40/Atmosphere—The first-generation Chinese atmospheric reanalysis (1979–2018): System description and performance evaluation. *J. Meteor. Res.*, 37(1), 1–19, doi: 10.1007/s13351-023-2086-x.

From CMA-RA1 to CMA-RA2 Suite

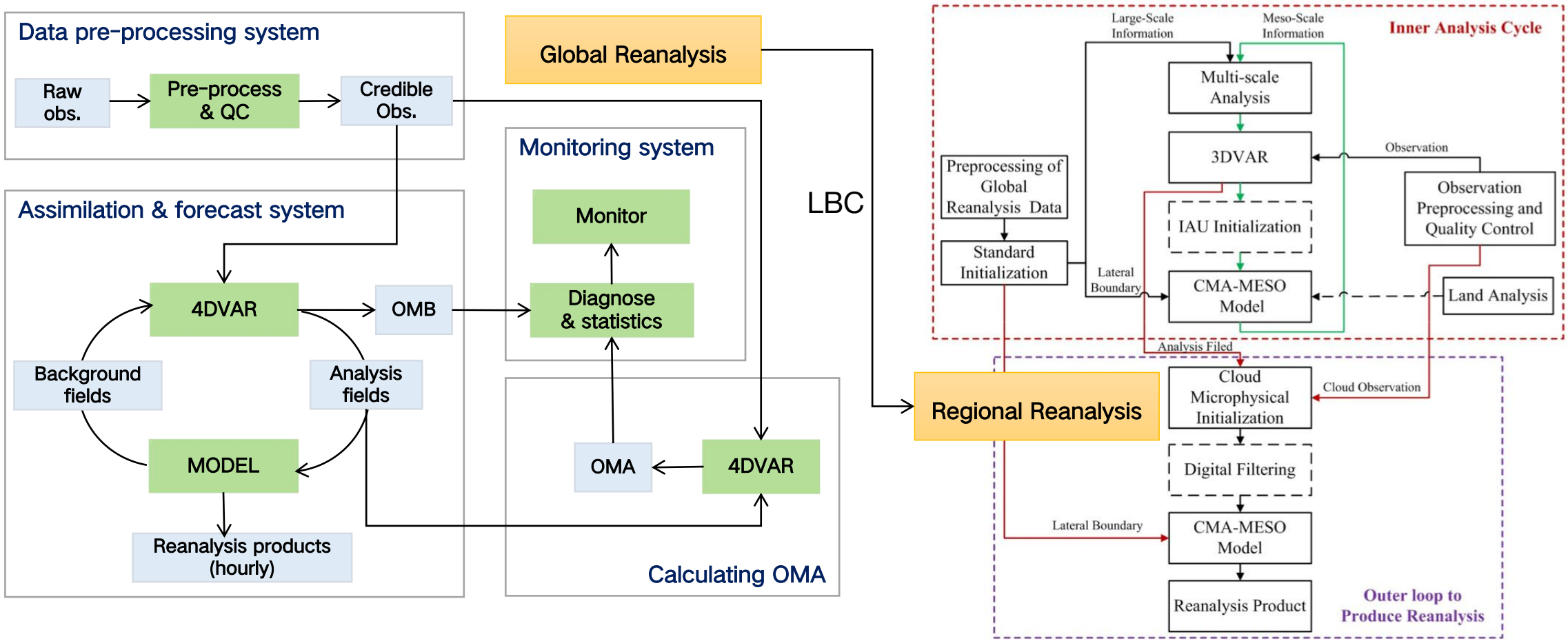
- **Move to CMA-Model based reanalysis**
- **Unified Global and Regional Reanalysis**
- **Research on Meteorology–Chemistry Coupled Reanalysis.**

Indicators	CMA-RA1	CMA-RA2		
		Global	Regional	Chemical Coupled
Assimilation and forecast System	GSI/ 3DVar	CMA-GFS 4DVar	CMA-MESO Hybrid-3DVar	CMA-MESO/CUACE LETKF
Horizontal Resolution	34 km	12.5 km	3 km	10 km
Model Top	0.27 hPa	0.1 hPa	10 hPa	10 hPa
Output Frequency	6 hour	1 hour	1 hour	1 hour

The Global–Regional Unified Atmospheric Reanalysis System

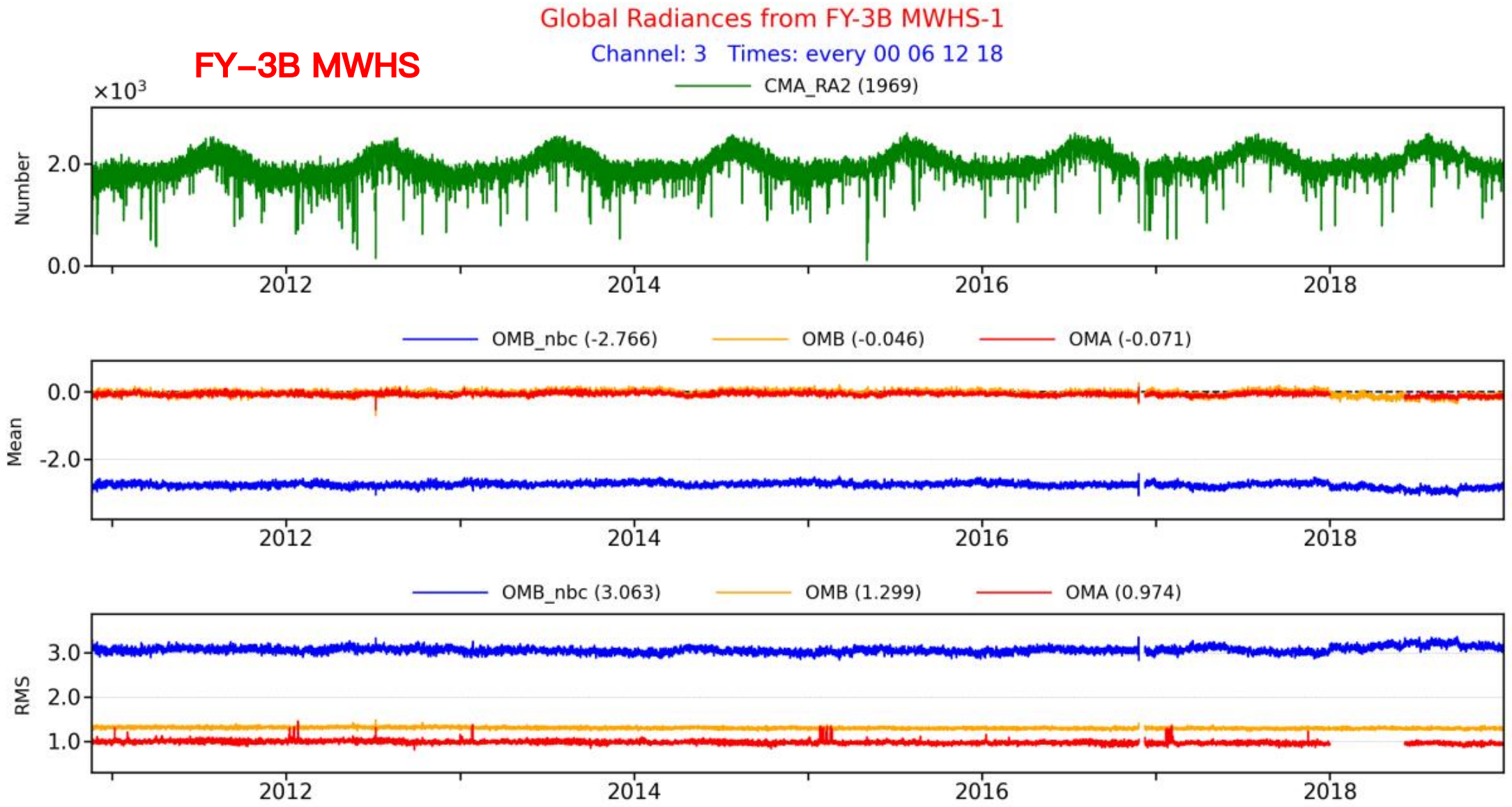
Established the Global–Regional Unified Atmospheric Reanalysis System based on

CMA_GFS v4.2 and CMA_MESO v6.0 (Global: 12.5 km / 87 levels; China regional: 3 km / 70 levels)



Use of reprocessed microwave temperature and humidity sounding obs. from the FY-3 satellite series

FY-3B MWHS

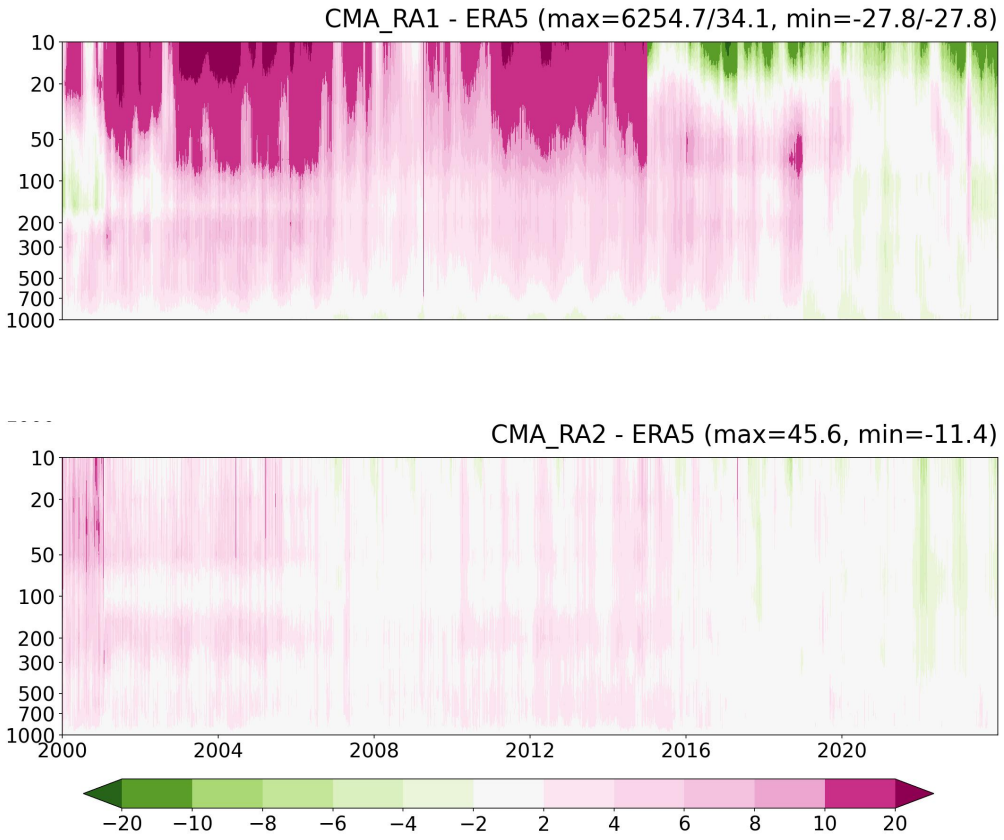


Preliminary Results: Global Mean Bias Relative to ERA5

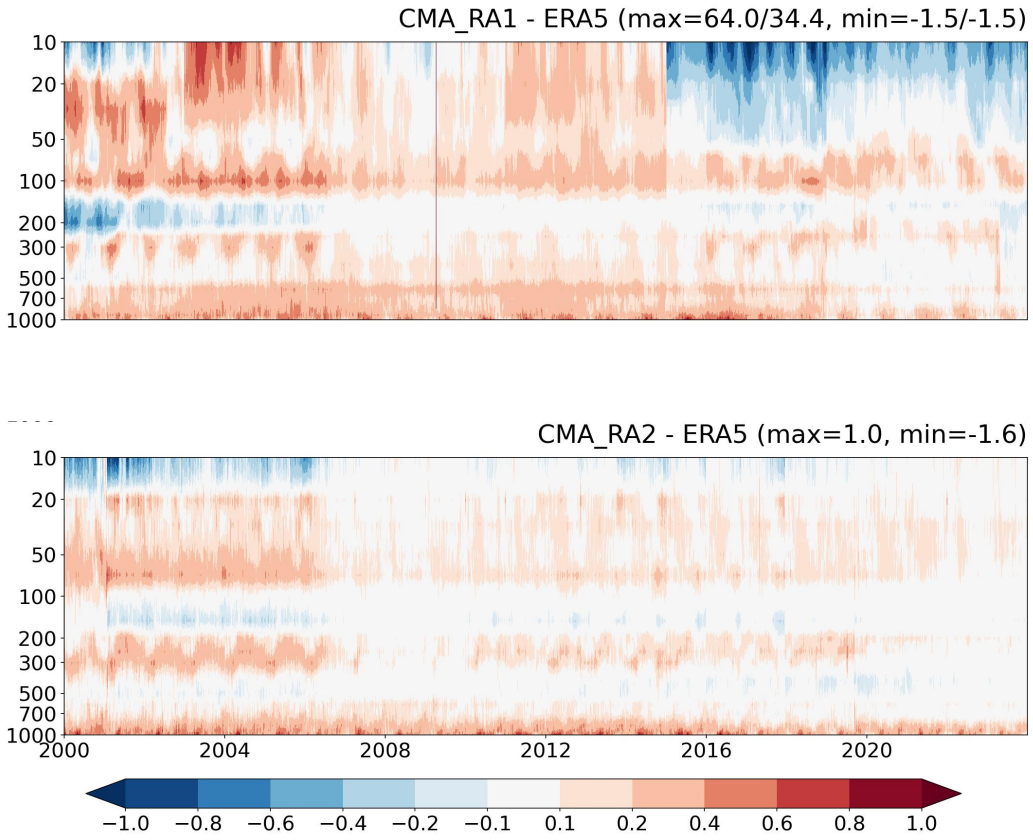
CMA-RA1

CMA-RA2

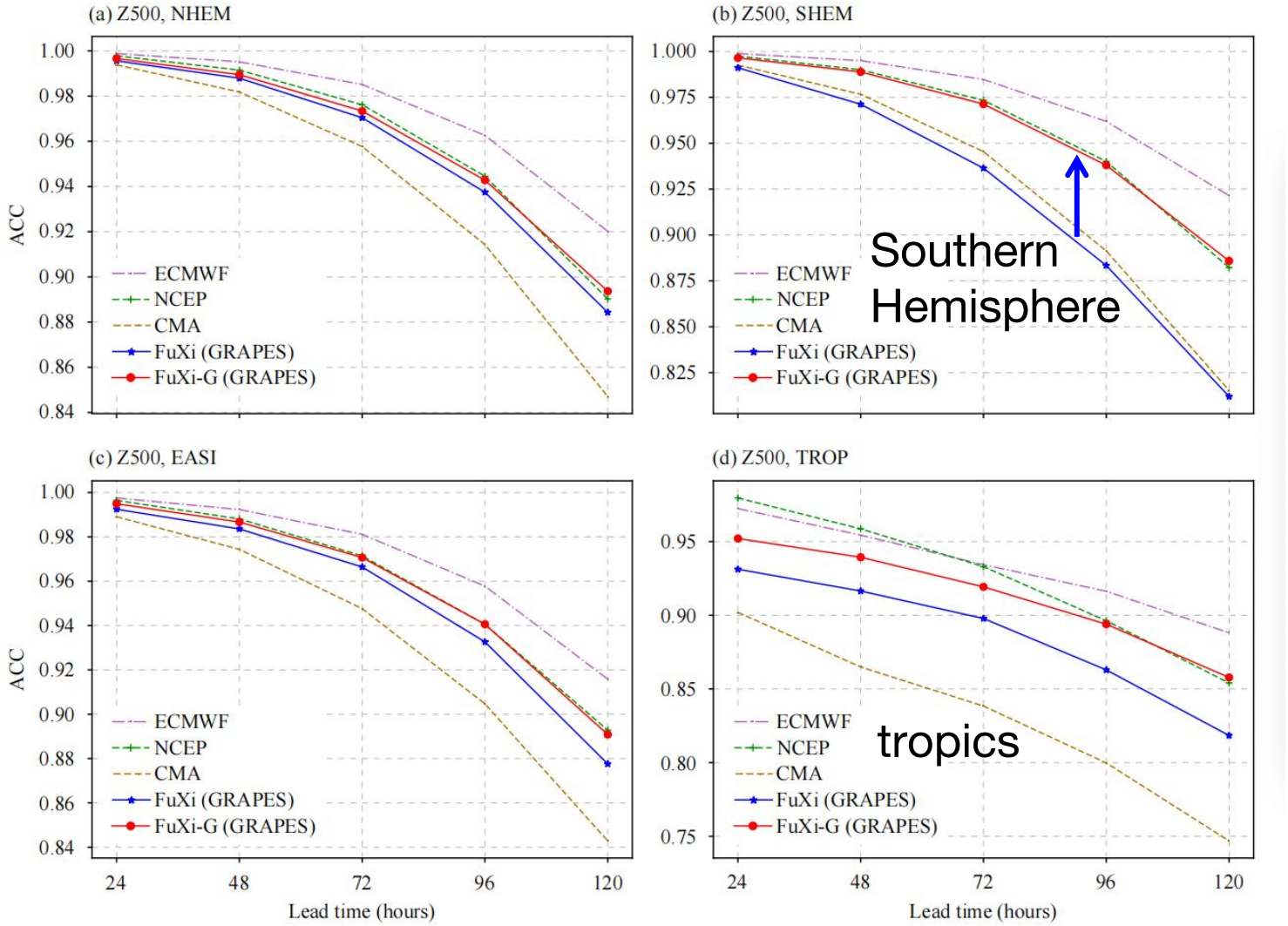
Global: Geopotential Height (gpm)



Global: Temperature (Kelvin)



Improved Fuxi Forecast Skill through Fine-Tuning with CMA-RA2

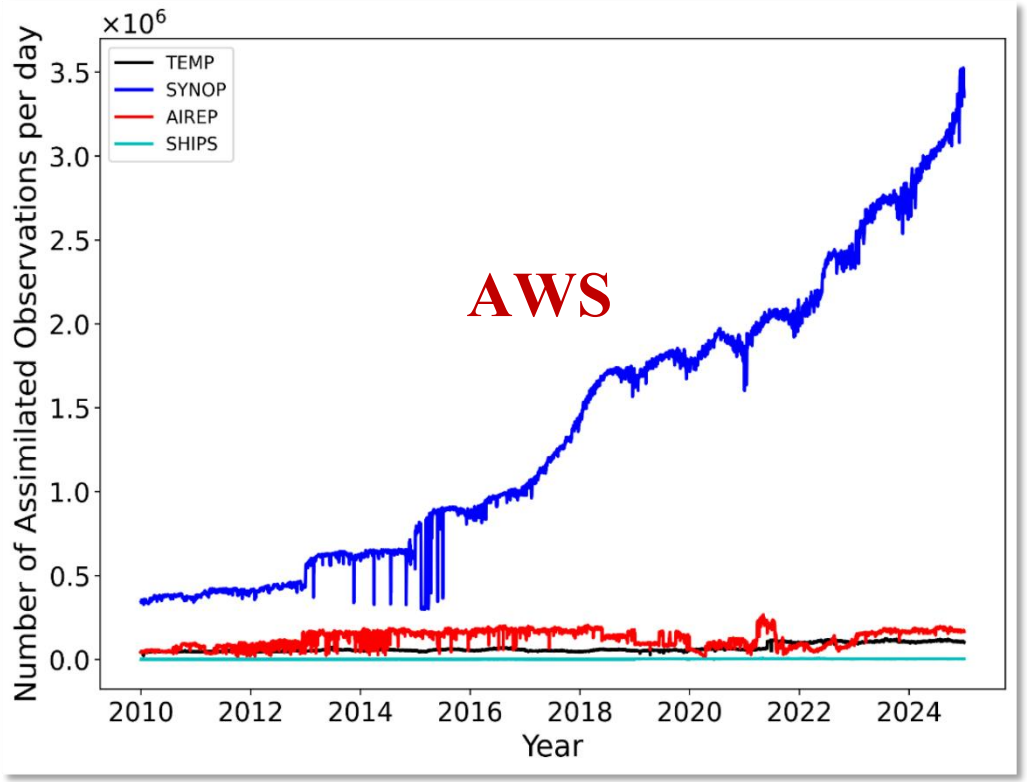


Fine-Tuned FuXi AI model forecasts initialized from CMA-GFS

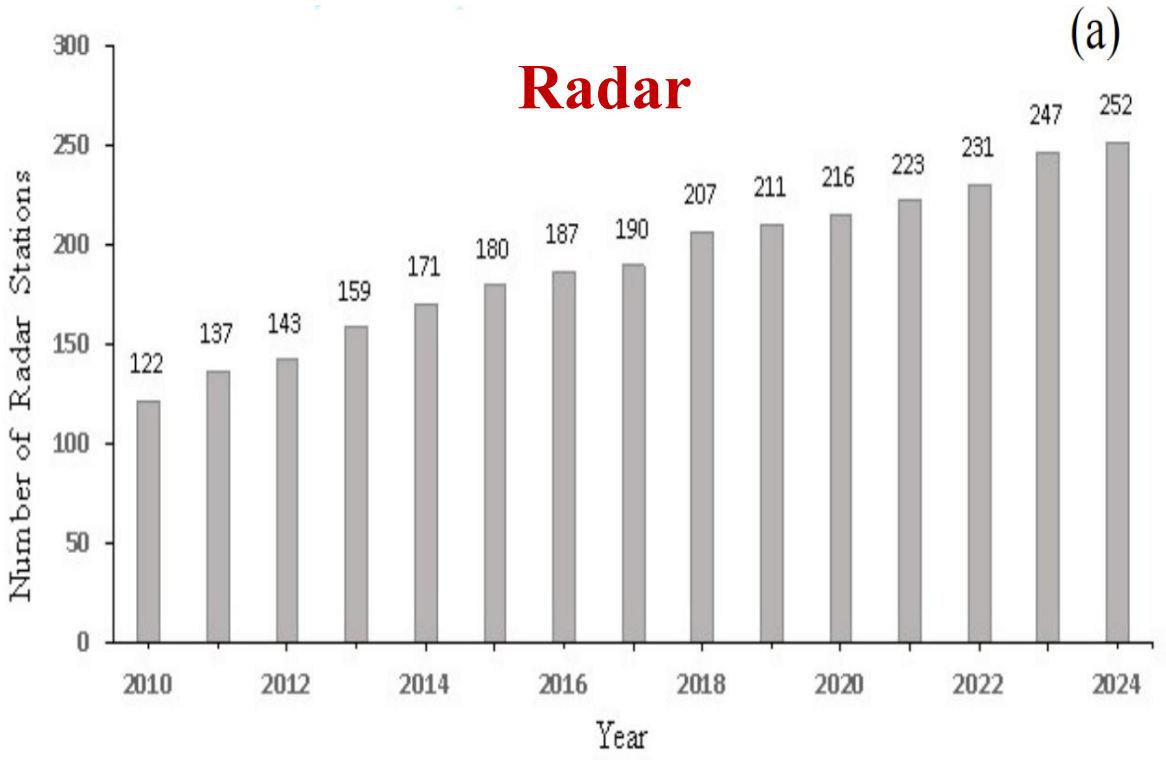
FuXi AI model forecasts initialized from CMA-GFS

Zhang, Z. P., W. Han, L. Chen, et al., 2025: Fine-tuning FuXi with CMA's reanalysis data to improve forecasting. *J. Meteor. Res.*, **39**(x), 1–15, https://doi.org/10.1007/s13351-025-5052-y.

Reprocessed radar reflectivity data and dense automatic weather station (AWS) surface observations were assimilated in the regional reanalysis

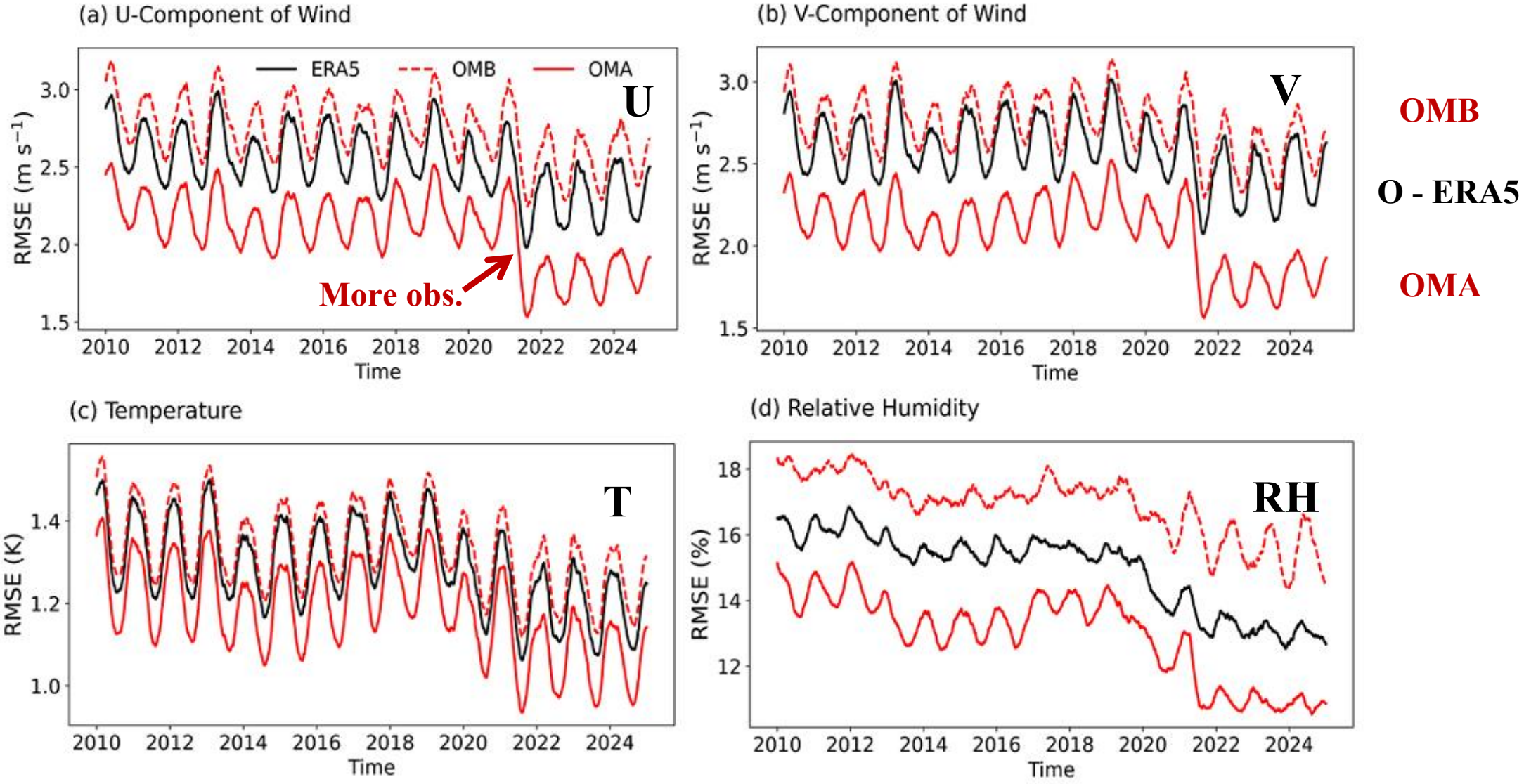


Number of daily observations assimilated in regional reanalysis



Number of weather radar providing 3D reflectivity

Analysis/background fit to radiosondes



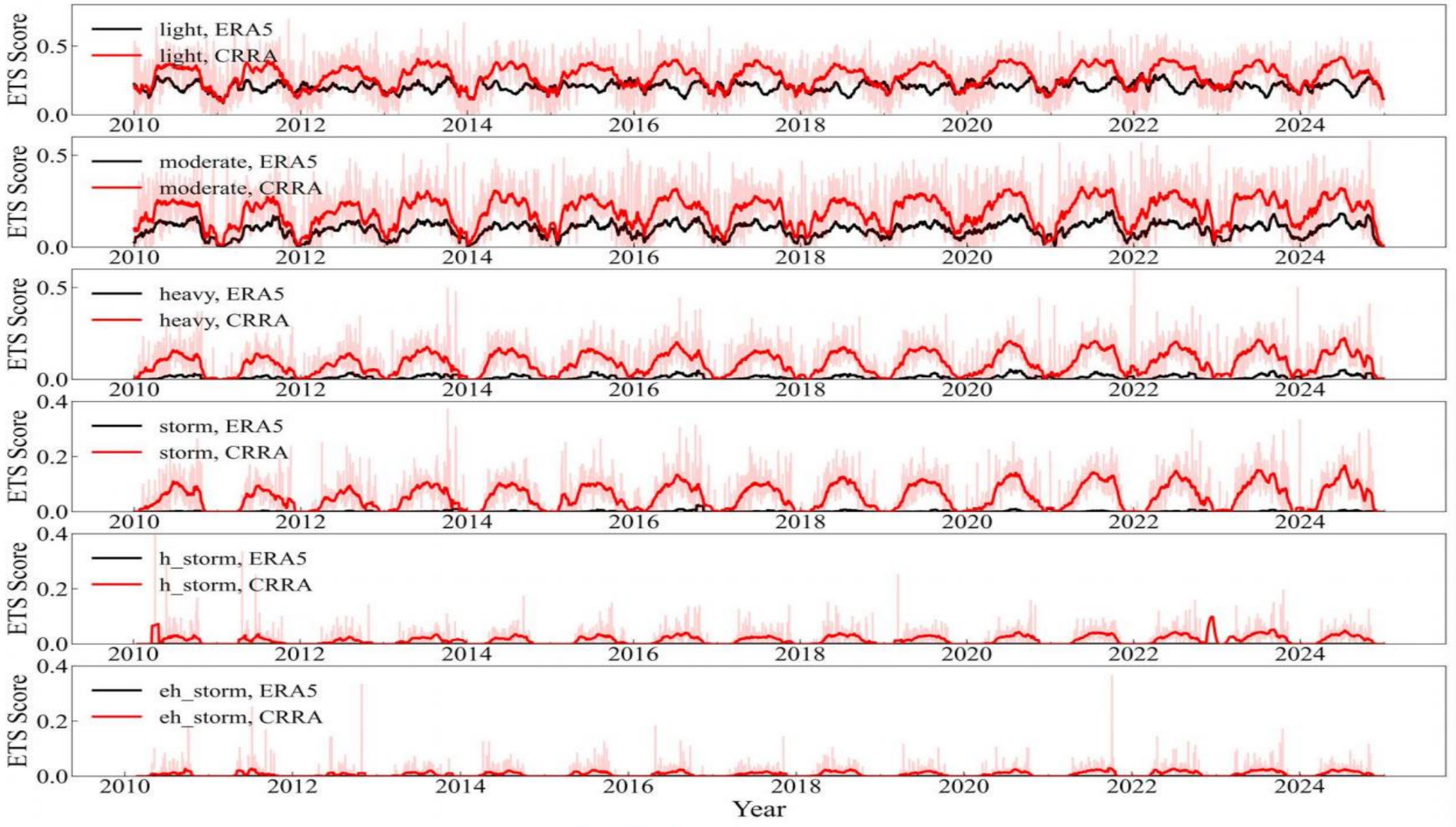
OMB

O - ERA5

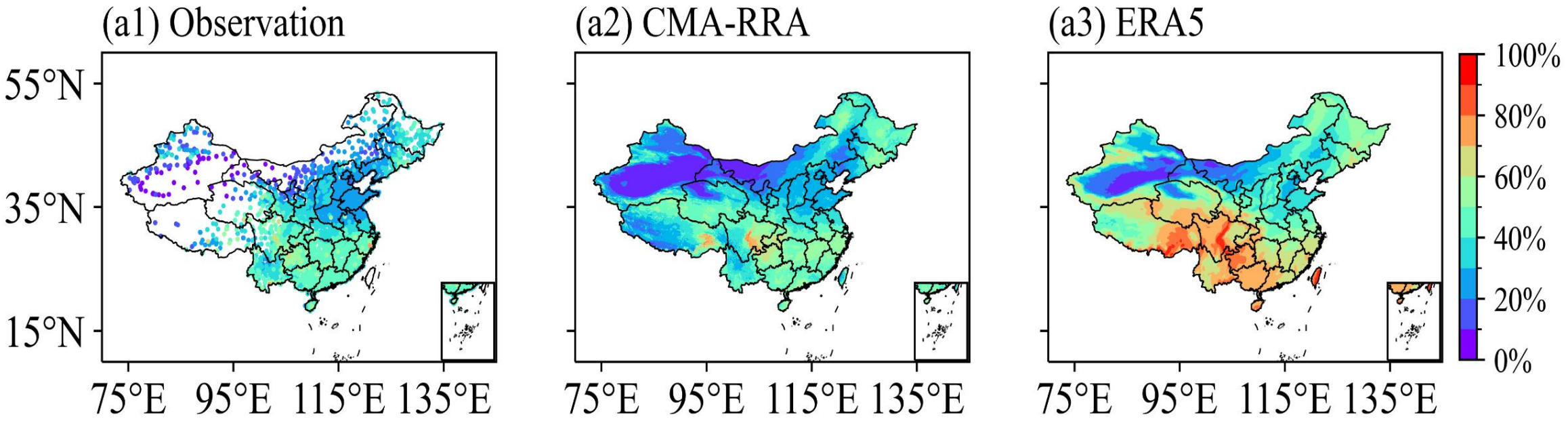
OMA

Precipitation ETS scores

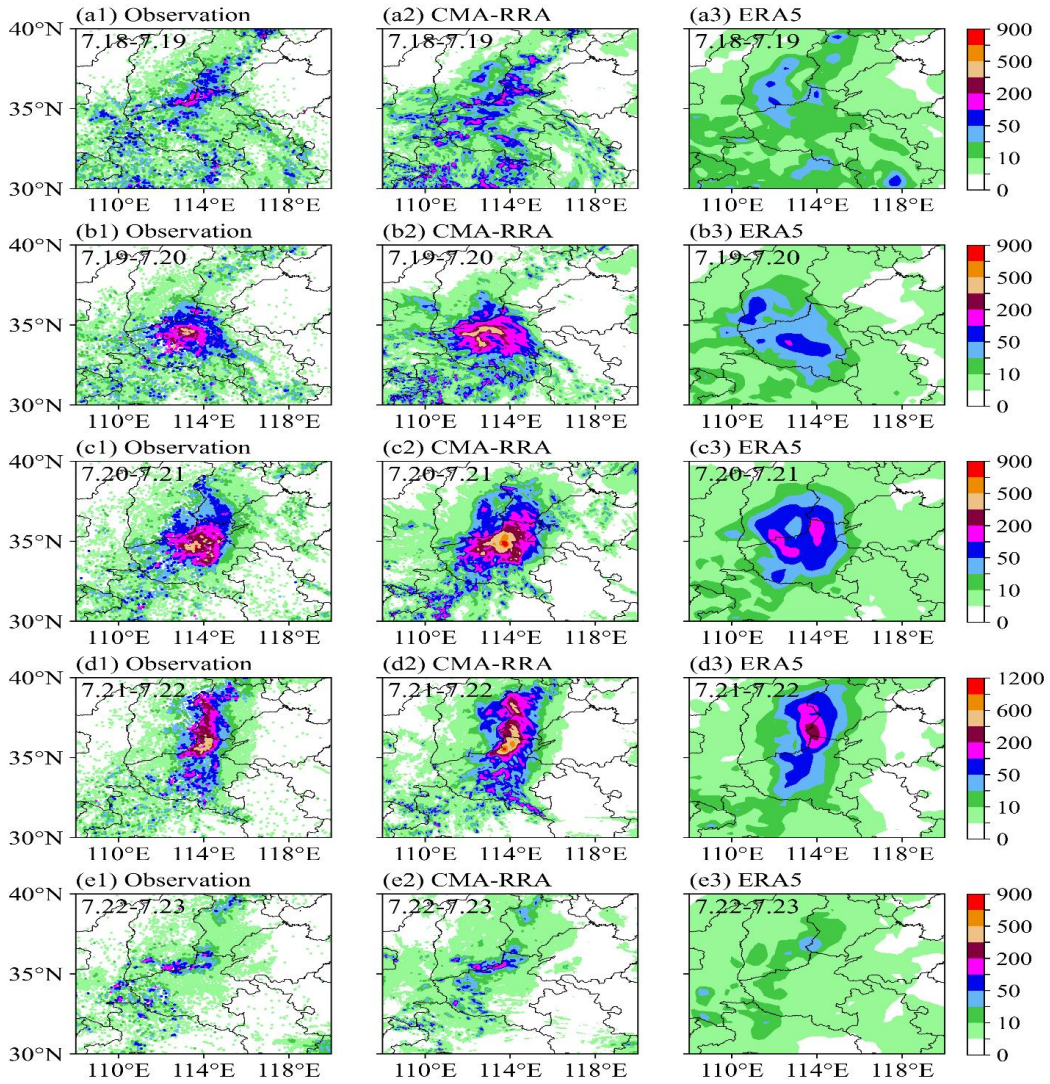
calculated from surface rain gauge observations



Spatial Distribution of Daily Precipitation Frequency from 2000 to 2020 (> 0.1 mm)

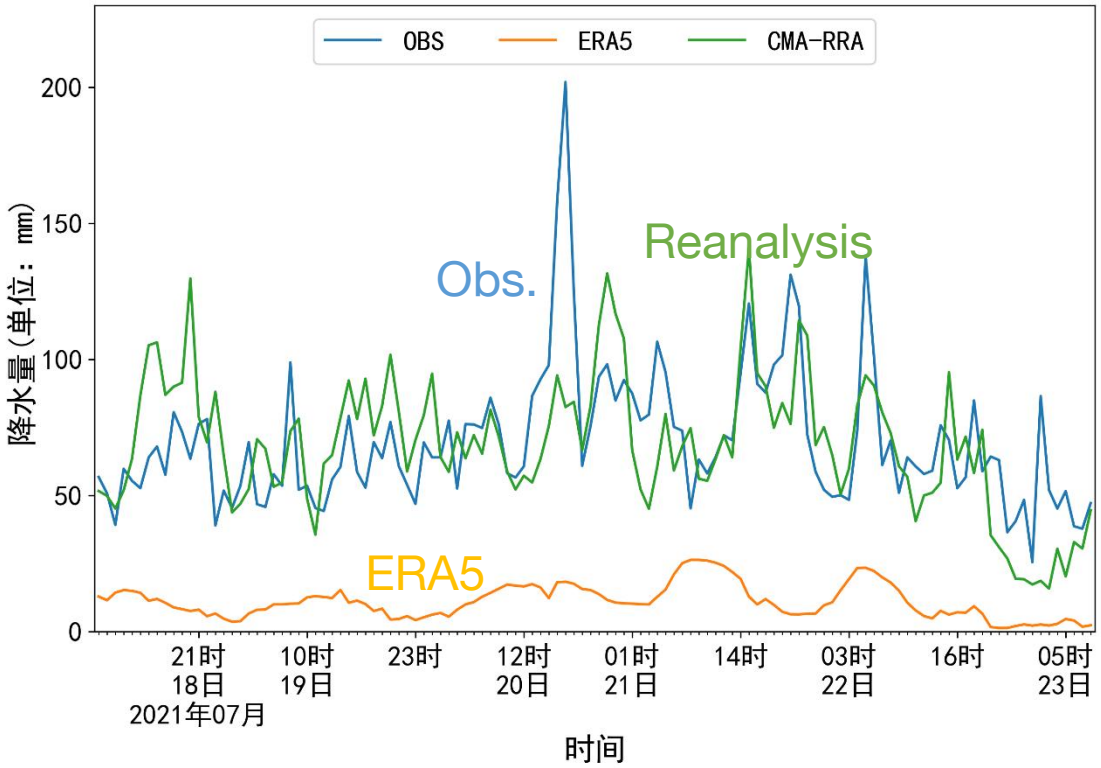


Representation of the July 2021 Henan Extreme Rainfall



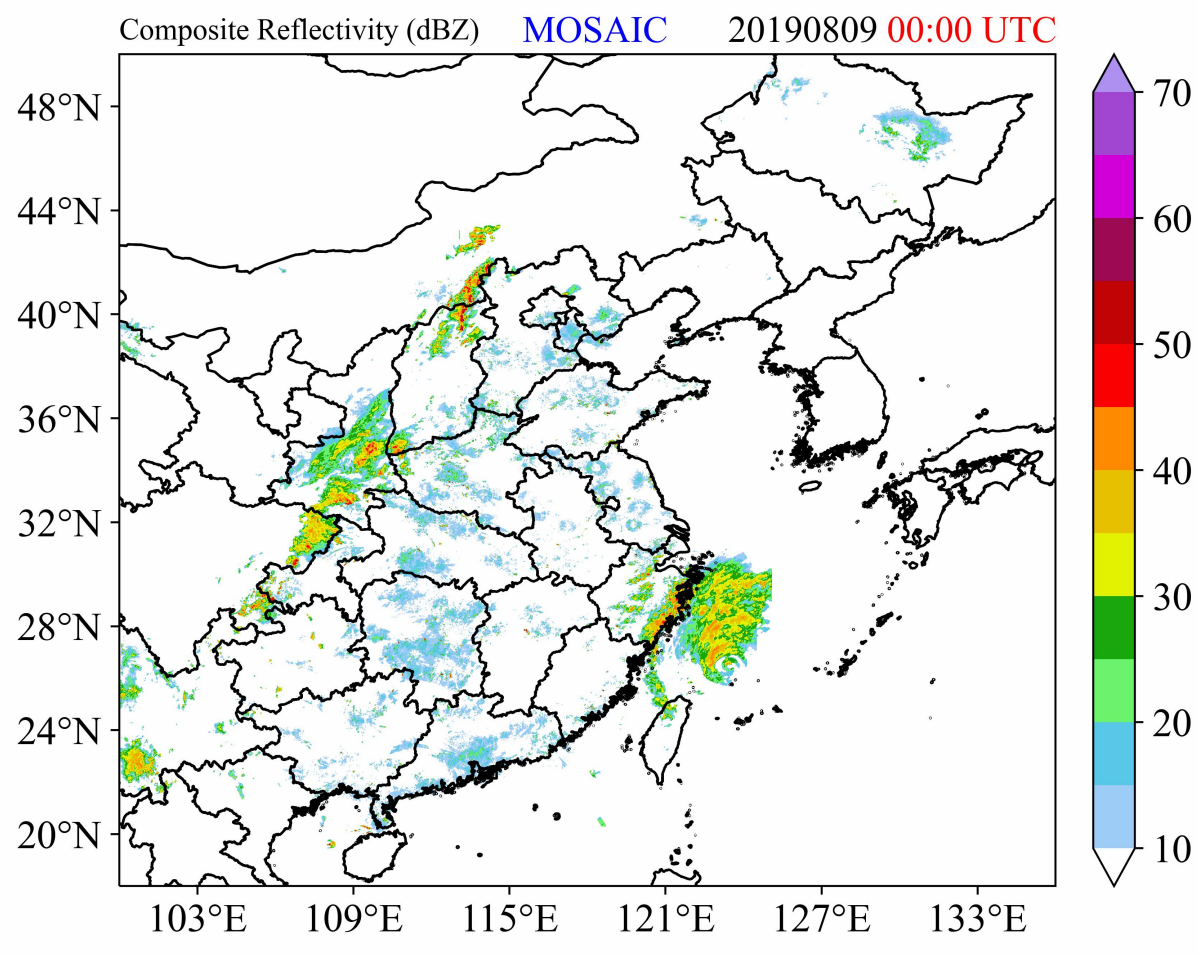
Daily Precipitation

Hourly Maximum Precipitation over the Domain

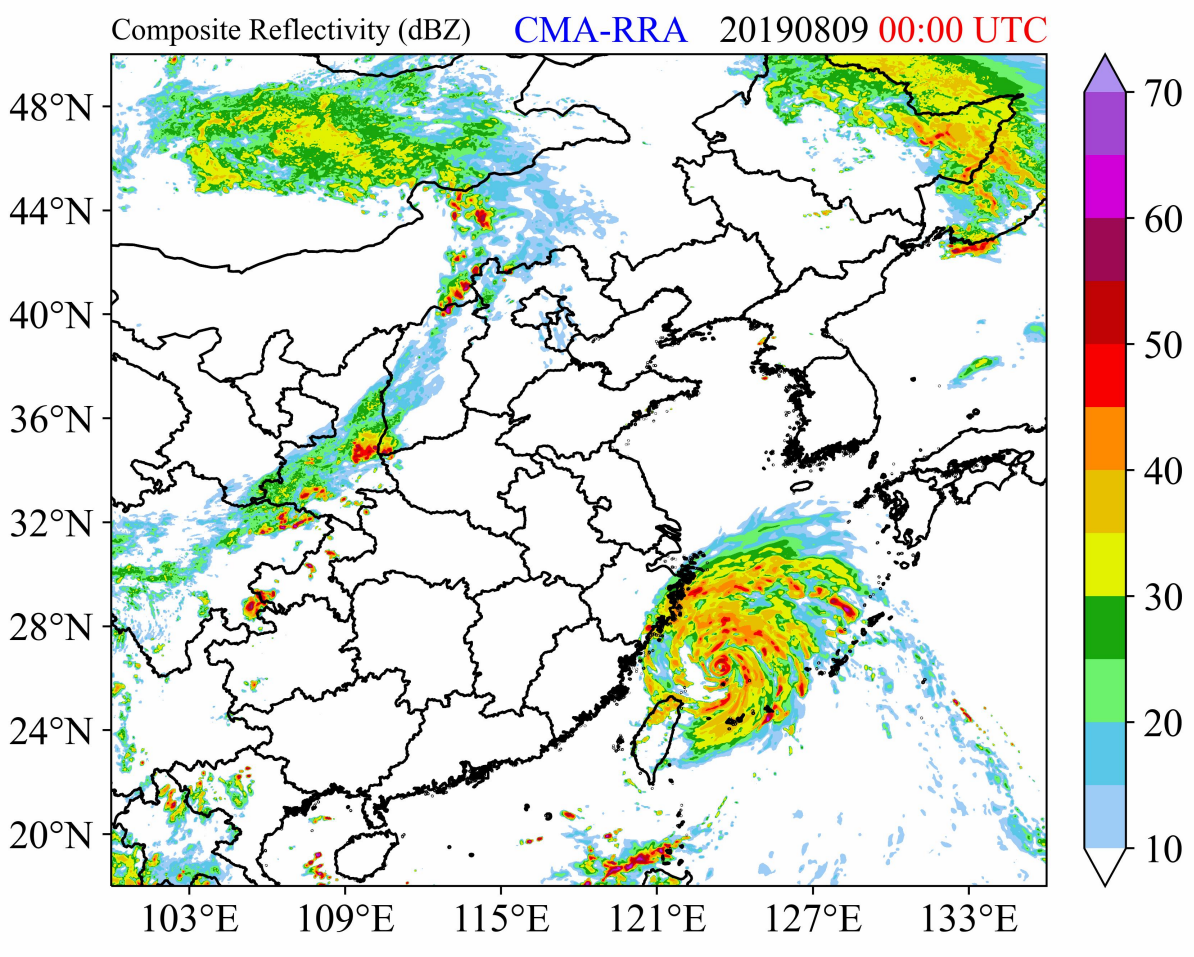


Representation of the Typhoon Lekima (2019)

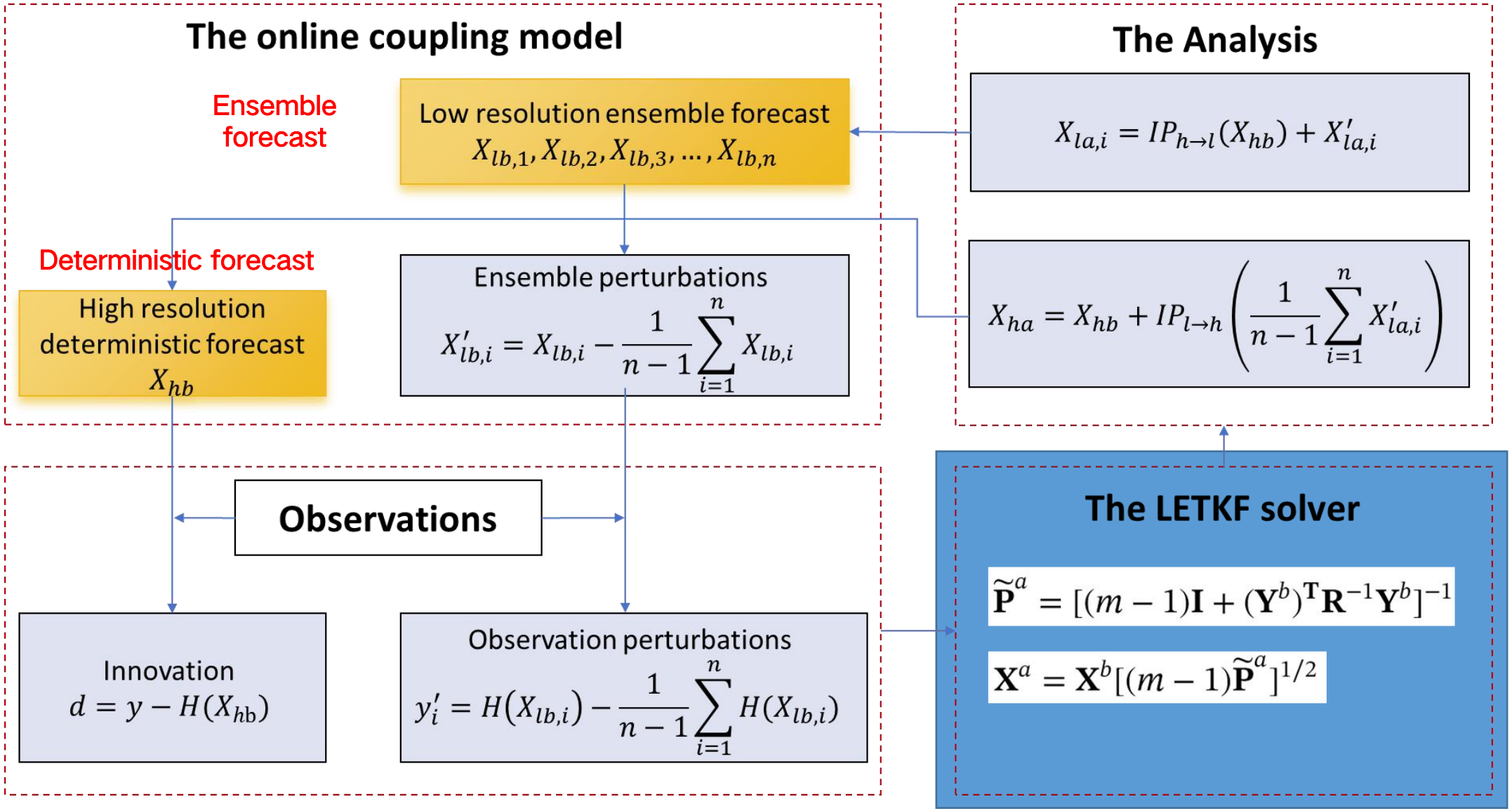
Radar observation



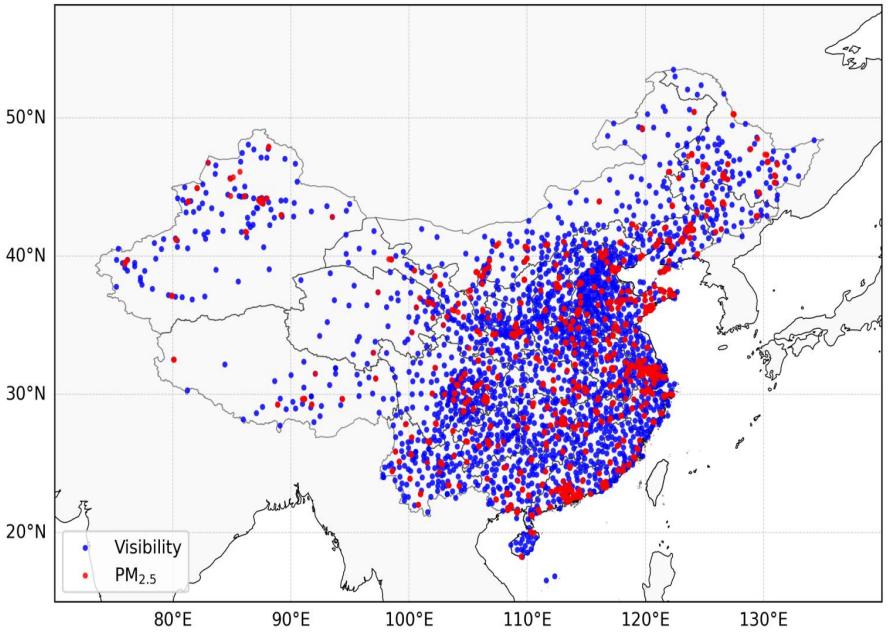
Results derived from reanalysis

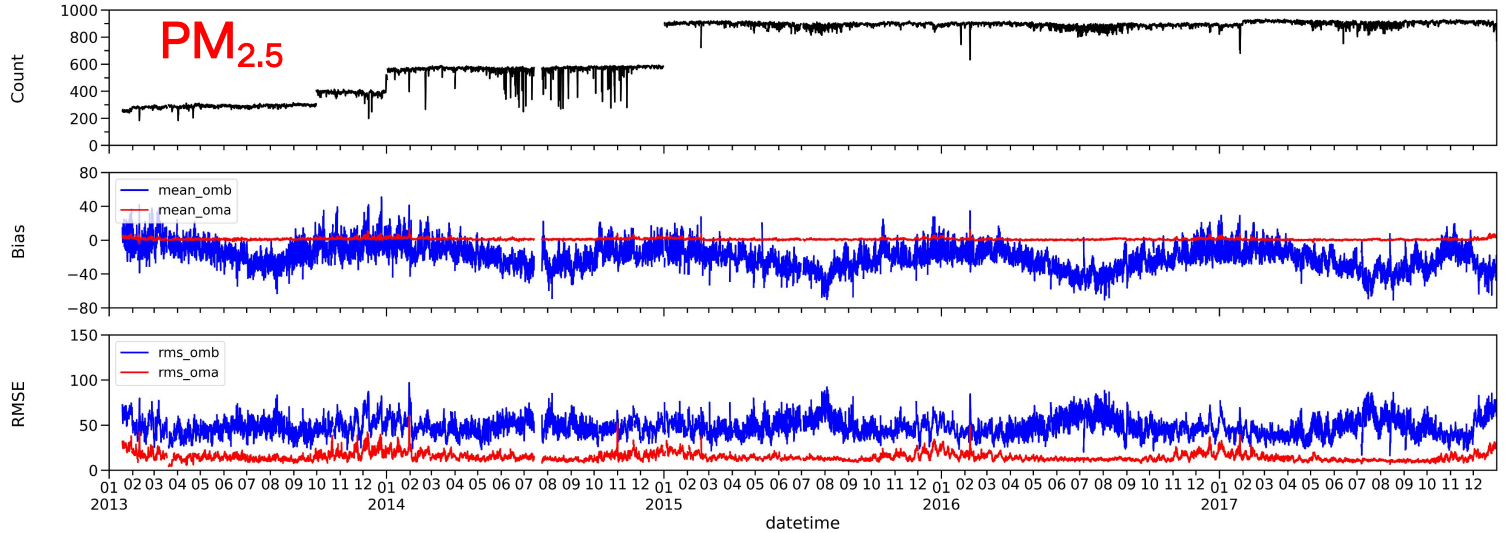


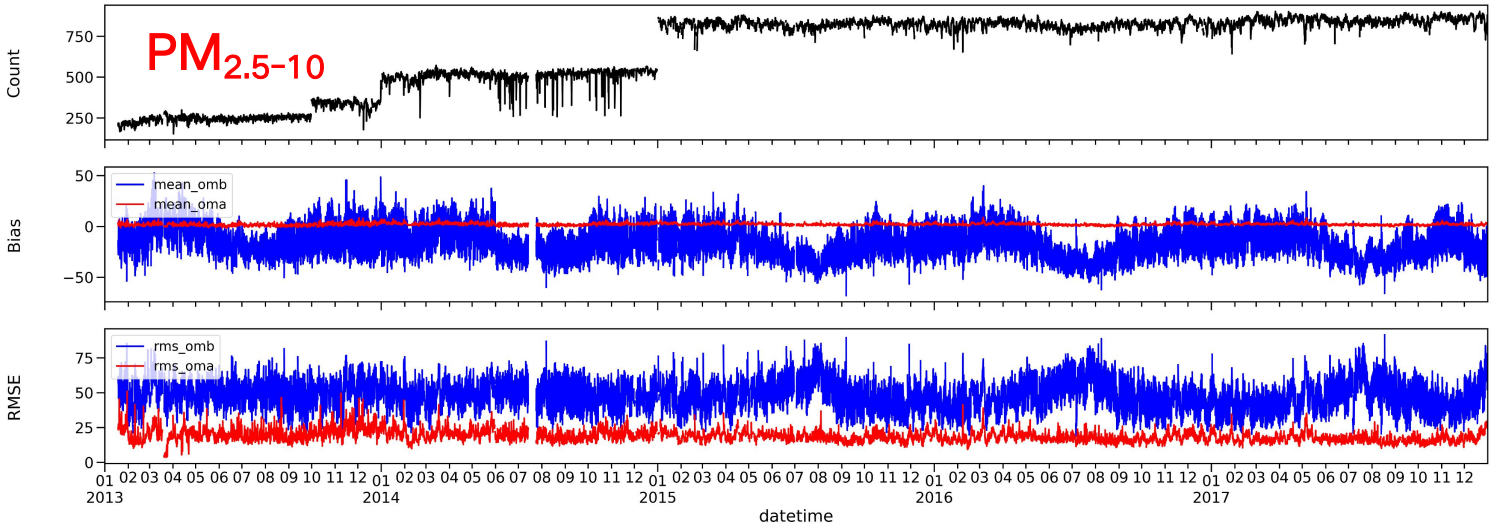
Chemical-Meteorological coupled reanalysis based on CMA-MESO/ CUACE



Chemical-Meteorological coupled reanalysis based on CMA-MESO/ CUACE







Summary and Plan

Summary

- Released CMA Reanalysis Version 1 (Global) in 2021.
- Moved to CMA-Model–based Version 2 Reanalysis (Global and Regional).

Plan

- Complete the production of CMA-RA2 (Global and Regional) next year.
- Continue the development of the Meteorology–Chemistry Coupled Reanalysis.
- Conduct pilot studies of Atmospheric and Coupled Reanalysis Systems based on the MCV Model.

Thank you

JIANG Lipeng

Email： jianglp@cma.gov.cn