

PEEX Seminar at the ACCC Impact



Research and Educational Activities Department of Atmospheric and Oceanic Sciences(AOS) & Institute of Atmospheric Sciences (IAS) Fudan University



Outline

✓General Introduction

√Our researches

√Discussions



Fudan historical landmarks





Multi-disciplinarily world-class university

6 disciplines rank top 1‰ in the world



21 disciplines rank top 1% in the world



Data from Essential Science Indicators SM Database, Clarivate Analytics, updated on Mar, 2023

Establishment of AOS/IAS

Prof. Renhe Zhang and Prof. Mu Mu joined Fudan University in Mar 31st 2016



Institute of Atmospheric Sciences was established in April 29th 2016





Department of Atmospheric and Oceanic Sciences was established in April 20th 2018

□ Faculty and Staff



2016	5+2	
2017	12+4	Chair professors 17
2018	20+7	Academician of Chinese Academy of Sciences 2
2019	25+ <mark>8</mark>	
2020	32+ <mark>9</mark>	
2021	36+11	
2022	44+12	
2024	46+13	
Now	48+15	

Platforms

Key laboratories/research centers

- CMA-FDU Joint Laboratory of Marine Meteorology
- Shanghai Frontiers Science Center of Atmosphere-Ocean Interaction
- Shanghai Key Laboratory of Ocean-land-atmosphere Boundary Dynamics and Climate Change
- Key Laboratory of Polar Atmosphere-ocean-ice System for Weather and Climate, Ministry of Education



Platforms



International Centers

- World Meteorological Organization(WMO) Fudan University MoU
- Integrated Research on Disaster Risks (IRDR) International Center of Excellence research and educational activities
- WMO Monitoring, Analysis and Prediction of Air Quality









CFFF: Computing for the Future at Fudan

Inspire the innovation of artificial intelligence, biomedicine and integrated circuit

Promoting the transformation of scientific research paradigms

Cultivate new AI talents to drive the KCAL cluster Accelerate the construction of "The First Fudan University"

Research and Development of large models in multi-modal scientific fields

Life Science

Integrated Circuit

Physical Science

Atmospheric Science

CFFF: the largest scientific research intelligent computing cluster on the cloud of Chinese universities

Large scale GPU/CPU Heterogeneous clusters High performance distributed hierarchical storage High speed communication

AI autonomous chip compatible

Support KCAL cluster for research and development of large model with 100 billion parameters





Build up the whole education system from BSc to PhD

From march 2017, undergraduate student	From July, 2017 Graduate student	From May, 2019 Postdoc	From January , 2025 Atmo. + Al Double Bachelor
≈25 students per year	≈ 100 master and PhD students per year	39	14

Ocean science is still going on....

International Summer School Program on Climate Change and Related Risks

2024 ISS: Climate change and Air Quality is the 1st School of the long-term Climate Change and Related Risks Summer School Program

Near 100 students and young scientists from 14 countries participated in the School

17 top-level international scientists and leaders (from UN and 7 countries) together with a great team of Fudan University professors and scientists provided lectures, discussions, mini-projects and other events during the last 3 weeks



7 Open Ceremony speakers:



9+ School key lectors / speakers:



Climate Change and Related Risks International Summer School Program 2025 Session: Human Activities and Extreme Events

Hosted by: Fudan University and WMO

Organized: Department of Atmospheric and Oceanic Sciences & Institute of Atmospheric Sciences, Fudan University,

Co-Organized: WMO/GAW, FDU-IRDR-ICoE, MAP-AQ Asian Office Shanghai

Theme: Climate Change and Extreme Events Dates: June 30 – July 18, 2025 (June 29 for registration) Venue: Jiangwan Campus, Fudan University, Shanghai, China Format: Courses + Tour visit + Discussion + Mini-project

Focus on: Impact of Human Activity on Extreme Weather/ Climate events under Global Warming Background **Course Modules:**

- (1) Weather/climate extremes under global warming
- (2) Impact of human activity, including anthropogenic greenhouse gases and aerosols, urbanization, land-use change
- (3) Impact of interactions among land, ocean and atmosphere under global warming
- (4) Risks interconnectivity, mitigation and adaptation

PEEX Participation



Memorandum of Understanding on Cooperation

between

Institute for Atmospheric and Earth System Research (INAR) at the University of Helsinki and "Atmosphere and Climate Competence Center (ACCC)" and "Pan-Eurasian Experiment (PEEX) Program" coordinated by INAR

and Department of Atmospheric and Oceanic Sciences (AOS), Institute of Atmospheric Sciences (IAS), Fudan Integrated Research on Disaster Risks International Center of Excellence (FDU IRDR ICOE) FUDAN UNIVERSITY

MoU was signed in August 2024

- $\checkmark\,$ Establishing institute contact point for the collaboration
- ✓ Actively participating in the relevant PEEX labelled activities, such as PEEX meetings and conferences, working groups and new funding proposals, and FDU International Summer School on Climate Change and Related Risks (FDU long -term project 2024-2034)
- Making PEEX Program visible in their countries through development and implementation of relevant mega-city pilot/demonstration projects
- ✓ Exchange visiting scholars and students regularly.

Outline

√General Introduction

√Our researches

√Discussions

□ Four major research directions



- Meteorology and air pollution
- Climate variability and climate change
- Physical and Chemical processes in Atmosphere
- Marine meteorology and Physical Oceanography

Integrated observation system in Shanghai megacity and Yangtze River estuary



Observations: Pacific and Indian Ocean air-sea interactions



Observations: Development of high precision monitoring system of ozone depletion substances (ODS) and fluorinated greenhouse gases (F-gas) and monitoring network







Forecast systems: Ocean model and data assimilation









Weather Forecast system: FuXi (伏羲)

The variable we use

Short Name

R

T2M

U10

V10

MSL

TΡ

Name

Geopotentia

Temperature

U component of wind

V component of wind

Relative humidity

2 metre temperature

o metre u wind componen

o metre v wind component

Mean sea level pressure

Total precipitation(6h)





大气与海洋科学系 DEPARTMENT OF ATMOSPHERIC AND OCEANIC SCIENCES FUDAN UNIVERSITY



The <u>first</u> machine learning forecasting system with comparable performance to <u>ECMWF</u> ensemble mean for 15-day global weather forecast

Dataset

ERA5

- · ECMWF 5th generation reanalysis dataset
- 13 pressure level and 1 surface level
- Training set: 1979–2016
- Validation set: 2017
- Test set: 2018

Results

The ground truth for HRES and EM

- HRES-fc0: the first time step of HRES forecast
- · ENS-fc0: the first time step of ensemble control forecast

The overall performance of FuXi



Predicting accuracy in 10 days

- Comparison with GraphCast:
 - Both FuXi and GraphCast outperform HRES significantly.
 - FuXi is close to GraphCast within 7 days, and outperforms GraphCast significantly after 7 days.



0.4 1 2 3 4 5 6 7 8 9 20 0.4 1 2 3 4 5 6 7 8 9 20 0.2 1 2 3 4 5 6 7 8 9 20 0.2 1 2 3 4 5 6 7 8 9 20

0.4 1 2 3 4 5 6 7 8 6 20 0.4 1 2 3 4 5 6 7 8 6 20 0.2 1 2 3 4 5 6 7 8 6 20 0.2 1 2 3 4 5 6 7 8 6 10 0.2 1 2 3 4 5 6 7 8 6 10

1 2 3 4 5 6 7 8 9 10 Lead Time (days)

234567891

12345678930

Predicting accuracy in 15 days

- Comparison with ECMWF Ensemble Mean
- · Fuxi is better than ECMWF EM within 9 days, and slightly inferior to ECMWF EM after 9 days:
- Overall, the 15-day prediction accuracy of Fuxi is comparable to that of ECMWF EM. On the combination of 240 time and variables evaluated, FuXi outperforms EM by 67.92% in accuracy and 53.75% in RMSE.

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Distribution of error

The distribution of RMSE of Z500

 The error of Fuxi is small than ECMWF HRES in most areas with in 10 days, and overall, comparable with that of ECMWF EM.



Fuxi model architecture

- Cube embedding
- U-Net style block: Down & Up Block
- 48 Swin Transformer blocks
- Prediction Layer



Type

Atmospheri

variables

Surface

variables



12345678910

Observations of organic aerosol in various environment

- Motivation:
 - Molecular composition and source of OA in many regions are not clear.
- Investigation:
 - Measured OA chemical composition on molecular level in urban, rural, mountain and remote sites (Shanghai, Zhejiang, Tibet etc.) and did source apportionment.

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C10H14N2





- Findings:
 - Measured >1000 compounds.
 - Identified new species and sources, e.g. plasticizers, highly oxygenated compounds in biomass burning, and cigarette smoking OA, cooking OA.
 - Identified new processes, e.g. nighttime NO₃ oxidation of alkenes.



Weather/Climate Effect on Air Quality



Rapid increase in perfluorinated GHG emissions



NF₃ and PFC-318 not included in National inventory GWP values used in National Inventory are lower than our study: CF₄ 6500 vs 7380, PFC-116 9200 vs 12400, SF₆ 23900 vs 24300

An, Yao et al. 2024@Nat. Commun. Wang, Yao et al., 2024@EST An, Yao et al. 2024@PNAS Weng, Yao et al., 2024@ESTL

Discussions

- Our department has made some significant progresses in faculty recruitments, education, platforms, international cooperation and researches...
- We expect international collaborations in more research fields such as observations, modelling and forecast of chemical weather and chemical climate.

Warmly welcome to Fudan University

THANKS FOR YOUR ATTENTION!