## PEEX implementation plan for Shanghai MegaCity & Yangtze River Delta urban agglomeration

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and many other researchers and students





#### WMO GURME Pilot Project part of Shanghai Multi-Hazard Early Warning System (MHEWS) (by SMB/CMA) => New Fudan Uni & PEEX project: SHANGHAI **Climate Services and Products** Monitoring and METEOROLOGICAL **"PEEX implementation plan** for Health Observations SERVICES FOR PUBLIC for Shanghai MegaCity (& Heat wave/cold spell HEALTH forecasts Meteorological Yangtze River Delta urban Observations Led by Xu Tang, SMB agglomeration )" **UV Exposure Forecast** (temperature, wind, humidity, pressure, cloud, etc.) **Ozone Forecast** Pan-Eurasian Experiment Ultra Violet Radiation Observations Haze Forecast Atmospheric Chemistry MAP-AQ 亚洲区域办公室 ASIAN OFFICE SHANGHAI Observations Forecast Models Monitoring, Analysis, and Prediction of Air Ouality (03, SO2, NOx Aerosols, Pollen Forecast **The First International Conference** Pollen Measurements **Chemical Weather and Chemical Climate (CWCC** (open plate method, microscope Influenza Forecast filter) Integrated Risk Monitoring Heat Index, Sunstroke and (bacterial food poisoning, diarrhea Diarrhea forecast for EXPO diagnostic, trauma, influenza 2010 heatstroke) n 🚓 🖕 🔅 Agiten Thermofisher 🤤 n Metrolm 🦣 🕮

### Main aim and focus of the PEEX Shanghai initiative:

In this study, following by the IPCC AR7 plans, PEEX Science Plan (PEEX SP, 2014; Kulmala et al., 2015, 2016, 2021), its seamless modelling platform (Mahura et al, 2024, Baklanov & Zhang, 2022) and science-based methodology for integrated urban systems (WMO, 2019, 2021, 2023ab, Baklanov et al., 2016, 2020), we will **analyze the recent observations of the climate and atmospheric pollution in Chine's megacities and provide science-based background and methodology for building climate- and environmental- smart, resilient and sustainable cities on example of the Shanghai megacity (as a best-practices demonstration city e.g. for IPCC SR on Climate Chage and Cities**).

#### Strategic goals:

- Intensive urbanization and climate change: interactions, possible consequences, mitigation and adaptation strategy for resilient and sustainable development (on example of Shanghai MegaCity)
- Urban Integrated Field Laboratory (IFS): Observational and modelling platform for studies of urban weather, climate and environment interactions
- Shanghai as a testbed demonstration megacity for climate- and environmental- smart and sustainable development
- Modern science-based education programs and training schools on Urban climate, weather and environment systems for smart cities

#### **Suggested specific research topics and tasks**

- Urban Boundary Layer (UBL) & urban air pollution (UAP) vertical structure observation and urban-and street-scales high-resolution modelling for the Shanghai Tower (626m)
- Study of Urban Effects to the Intensity and Health Impacts of the Record-Breaking 2024 Heatwave over the Yangtze River Delta
- Study of Urban Heat Island (UHI) and UAP interactions and their combined health impacts and risk
- Urban Cooling Mitigations, Adaptation and Action Plan for Shanghai MegaCity
- Towards Carbon-neutral Shanghai MegaCity: scenarios, mitigations, actions plan and their effectiveness
- Shanghai Multi-Hazard Early Warning system, climate service and sci. methodology toward Integrated Urban System and Service (with SMB and WMO GURME SAG)
- Impact of Shanghai MegaCity (& Yangzi River Delta urban agglomeration) on precipitation, cloudness and thunderstorms
- Urban Heat Island (UHI) impact on surface ozone and its vertical distribution (for high floors of skyscrapers) using observation on the Shanghai Tower
- Artificial Intelligence, AI and Machine Learning, ML (including hybrid methods) modeling of AQ and UHI for Shanghai
- Formation of SOA in urban environment and its dependence of and interaction with UBL turbulence (two-ways feedbacks analysis)
- Halogen chemistry in megacities and its contribution to the reactive organic carbon and secondary organic aerosol formation.
- Mass closure and formation mechanisms of airborne nanoparticles in megacities based on molecular-level composition of aerosols and precursors
- Contributions of emitted and airborne nanoparticles to particle mass concentration and cloud condensation nuclei (based on measurements in Shanghai)
- Aerosol source apportionment and formation mechanism in megacities, and interactions with policy-making.
- Influence of climate and weather extremes on aerosol composition and concentration and feedbacks to climate and weather (temperature, cloud etc.).

- Impact of interaction of anthropogenic emission with urban biogenic emissions on urban air quality and urban climate.
- Global Climate change scenarios, their downscaling to regional and urban climate prediction, adaptation scenarios and measures, their effectiveness/efficiency
- Seamless simulation of aerosols and UHI interactions, and feedback aerosols mechanisms, AQ episodes prediction and analysis (Enviro-HIRLAM, WRF/Chem)
- Impact/contribution of remote source regions on urban environment of Shanghai (with FLEXPART)
- Shanghai Urban-SMEAR station: development of atmospheric in situ stations and advanced air quality monitoring in megacity environments
- Nature-based solutions for mitigation and adaptation to climate change for megacities: effectiveness and priorities
- Complex analysis of methodology and KPIs for smart-city requirements and development for Shanghai (following the U4SSC approach with IRDR ICoE team)
- Wetlands and hydrological model integration into atmospheric models for urban areas: study of urban floods modelling (connection to city drainage/sewerage system)
- Long-lived Stably stratified Boundary Layers (BL) and urban BL turbulence mechanisms studies
- Optimizing multimodal traffic management, improving urban mobility, reducing traffic emissions, and finding new solutions towards greener mobility practices, climateneutral and smart cities (on examples of Hangzhou, IMTECC project)
- Interactions between Coastal atmospheric circulations and urban heat island circulation as well as their influence on coastal air quality
- Chemical interactions among anthropogenic emissions and Oceanic natural emissions e.g. Sea salt and DMS and impacts on urban air quality O3 and SOA
- Dynamic impacts of Ship plumes on air quality and human health in coastal cities
- Constraining new particle formation based on observations from Shanghai
- Modeling aerosol formation and growth in the Yangtze River Delta region (grid 2x2.5)
- The impact of anthropogenic and biogenic emissions on new particle formation in Shanghai

#### **Educational activities and Young Scientist Schools:**

- Co-organizing one of the FDU International Summer Schools on Climate Change and Related Risks (FDU long -term project 2024-2034) focusing on climate-smart and sustainable cities (with Shanghai as a demonstration city)
- Organizing a joint MS course on "Urban Meteorology, Environment and Climate: Science, Methodology, Systems and Services"
- In case the PEEX COST Action will be funded, coorganizing 3 PEEX Young Scientist Schools (YSS):
  - 1) Atmospheric observations of aerosols, clouds and trace gases;
  - 2) Advanced Analysis of Atmosphere-Surface Interactions and Feedbacks;
  - 3) Multi-Scales and -Processes Integrated Modelling, Observations and Assessment for Environmental Applications.
- Organizing regular discussions and workshops between students and early-career researchers in Fudan and INAR



Application Link-International Summer School Program 2025

#### Pivotal Contributions of Urban Effects to the Intensity and Health Impacts of the Record-Breaking 2024 Heatwave over the Yangtze River Delta



- The urban effects contribute to about 24% on the elevated daily mean temperature averaged across urban areas, with the LU play a more significant role than the AH.
- At night, urban effects contribute approximately 38% to the elevated surface temperature averaged across urban areas.
- The contribution of urban effects to heat-related morbidity is greater at night than during the daytime, with an average value of 29% across all urban areas and a maximum of 48% in downtown Shanghai at night.

Siyang He, Jiacan Yuan, Chen Liang, Xiangyu Ao, Linhui Li, Alexander Baklanov, Renhe Zhang (2025)



ERA-NET Cofund Urban Accessibility and Connectivity Sino-European call

Integrated systems and analysis of urban Mobility for climateneutral and susTainable Cities in Europe and China (IMTEC)

Meteorological Model

WRF modeling System:

Land-Surface: PX LSM

UNIVERSITY OF COPENHAGEN

Chemical Transport Model

CMAO Modeling System:

Photochemistry: CB05

156 chemical reactions

59 organic and inorganic species,

## IMTECC: The "City Brain" platform for the city of Hangzhou, China

 $\Lambda x=12 \text{ km}$ 

34 lavers

- Developed a comprehensive urban vehicle emission inventory via big traffic data from an intelligent transportation system.
  - This inventory is city-wide pollutants (NO<sub>x</sub>, CO, and HC, CO<sub>2</sub> and CH<sub>4</sub>) from vehicles.
  - This inventory is characterized by high precision with a spatial resolution of 10 m and temporal resolution of 1 minute.

#### > Developed a comprehensive urban air quality model.

- Combines mesoscale and microscale numerical models and considers both meteorological and chemical processes by coupling WRF-CMAQ and AERMOD models.
- Urban form / transport networks; mobility / modal share / congestion / multimodality; local-scale urban-specific climates.



Innovation Fund Denmark

AOPREP

Prepares virtual CMAQ compatible input met. files













#### Recent publications of the team members (not complete):

- Kulmala, M.; Kokkonen, T. V.; Pekkanen, J.; Paatero, S.; Petäjä, T.; Kerminen, V.-M.; Ding, A. Opinion: Gigacity a source of problems or the new way to sustainable development. *Atmos. Chem. Phys.* 2021, 21 (10), 8313-8322. DOI: 10.5194/acp-21-8313-2021.
- Kulmala, M., T. Kokkonen, E. Ezhova, A. Baklanov, A. Mahura, I. Mammarella, J. Bäck, H.K. Lappalainen, S. Tyuryakov, V-M. Kerminen, S. Zilitinkevich & T. Petäjä. Aerosols, Clusters, Greenhouse Gases, Trace Gases and Boundary-Layer Dynamics: on Feedbacks and Interactions. *Boundary-Layer Meteorology*. V. 186, P. 475-503. 2023.
- Lappalainen, H. K., Petäjä, T., Vihma, T., Räisänen, J., Baklanov, A., Chalov, S., ... and Kulmala, M., 2022: Overview: Recent advances in the understanding of the northern Eurasian environments and of the urban air quality in China a Pan-Eurasian Experiment, ACP, 22, 4413–4469, 2022, https://doi.org/10.5194/acp-22-4413-2022,
- Xue Hao, Yan Zhang, Guangyuan Yu, Baoshan He, Fan Yang, Zhong Zou, Cangang Zhang, Xin Yang, Bin Ouyang, Yunhua Chang, 2022: Online vertical measurement of air pollutants: Development of a monitoring platform on a skyscraper and its application in Shanghai, Atmospheric Pollution Research, 13(7), 101477, https://doi.org/10.1016/j.apr.2022.101477
- Huiling Ouyang, Xu Tang, Renhe Zhang, Alexander Baklanov, Guy Brasseur, Rajesh Kumar, Qunli Han & Yong Luo. Resilience Building and Collaborative Governance for Climate Change Adaptation in Response to a New State of More Frequent and Intense Extreme Weather Events. International Journal of Disaster Risk Science. V. 14, P. 162-169. 2023.
- Mahura A., Baklanov A., Makkonen R., Boy M., Petäjä T., Lappalainen H.K., Nuterman R., Kerminen V-M., Arnold S.R., Jochum M., Shvidenko A., Esau I., Sofiev M., Stohl A., Aalto T., Bai J., Chen Ch., Cheng Ya., Drofa O., Huang M., Järvi L., Kokkola H., Kouznetsov R., Li T., Malguzzi P., Monks S., Poulsen M.B., Noe S.M., Palamarchuk Yu., Foreback B., Clusius P., Rasmussen T.A.S., She J., Sørensen J.H., Spracklen D., Su H., Tonttila J., Wang S., Wang J., Wolf-Grosse T., Yu Y., Zhang Q., Zhang W., Zhang We., Zheng S., Li S., Li Y., Zhou P., & Kulmala M. (2024): Towards seamless environmental prediction development of Pan-Eurasian EXperiment (PEEX) modelling platform, *Big Earth Data*, https://doi.org/10.1080/20964471.2024.2325019, 2024
- Linhao Guo, Xuemei Wang, Alexander Baklanov, and Min Shao: PM2.5 Concentration Gap Reduction between Typical Urban and Nonurban China from 2000 to 2023. ACS ES&T Air, DOI: 10.1021/acsestair.4c00208ACS EST Air 2024
- Siyang He, Jiacan Yuan, Chen Liang, Xiangyu Ao, Linhui Li, Alexander Baklanov, Renhe Zhang (2025) Pivotal Contributions of Urban Effects to the Intensity and Health Impacts of the Record-Breaking 2024 Heatwave over the Yangtze River Delta. DOI: 10.2139/ssrn.5080126, In review
- Huiling Ouyang, Alexander Baklanov, Xu Tang, Renhe Zhang, etc. (2025) Urgency and Importance of Local-scale Modeling Tools to Support Climate Adaptation and Sustainable Development. Submitted (in review)
- Alexander Baklanov, Jens H. Christensen, Shaocai Yu, Isabelle Coll, Ma-lo Costes, Pengfei Li, Matthias Ketzel, Sidsel Kjems, Daniel Berthelsen, Artur Elessa Etuman, Camilla Geels, Jibran Khan, Steen S. Jensen, Maher Sahyoun & Roman Nuterman (2025) Integrated systems and analysis of urban Mobility for climate-neutral and susTainable Cities in Europe and China (IMTECC). ITM book (in press)
- Jiesheng Xue, Yuanjian Yang, Yubin Li, Lu Zhang, Linlin Wang, Alexander Baklanov (2025) Characteristics and potential mechanisms of non-stationary turbulence in megacity areas. Submitted to *Geophysical Research Letters* (in review)

# Thank you for the attention! Welcome to join the team of these PEEX-FDU Shanghai studies!!

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