Unlocking the Value of Meteorological Data to Promote Digital Transformation and Sustainable Development in Urban Governance

Shanghai Meteorological Service

October 19, 2024

Weather-Data Integration: The Key to Forecasting

天数先知，数据为要

Weather-City Integration: Data Leads the Way

天城合一，数据为先

Data Such as the Atmosphere: Invisible but Valuable

数如大气，无形有价

Weather-Data Integration: The Key to Forecasting

天数先知，数据为要

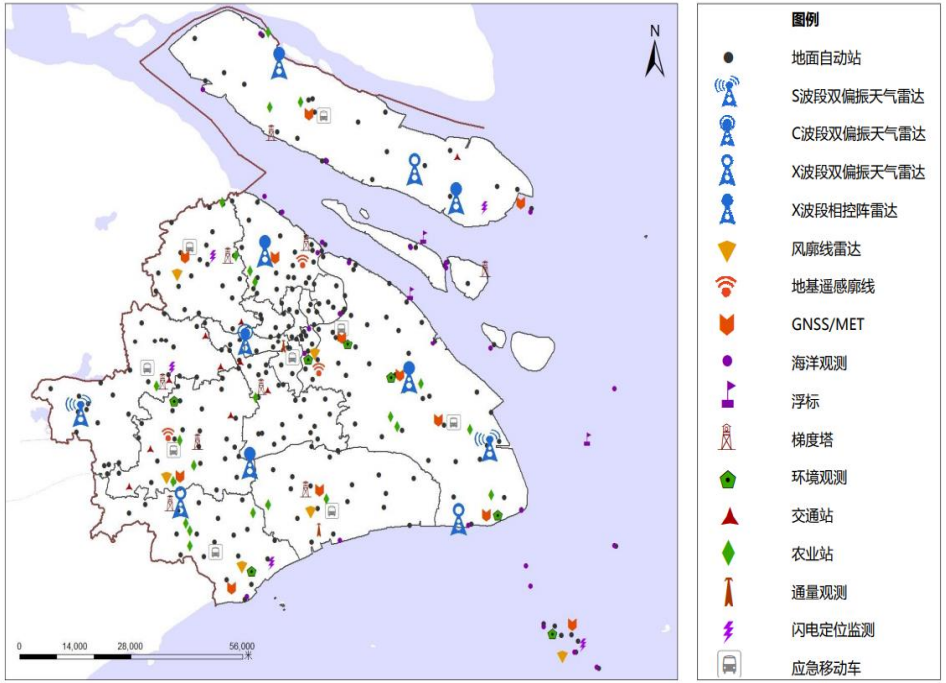
Meteorological data is a national strategic and basic resource, which provides a high-quality and high-value data product system for urban governance.

Observation • Data

Meteorological observation Data: 300+TB, Daily Increment: 230GB

A comprehensive observation system covering *ground-based, space-based, and air-based categories* has been established.

- 315 automatic weather stations;
- 2 fixed Doppler weather radars，3+5 X-band radars;
- 6 wind profilers for atmospheric boundary layer;
- 10 multi-layer gradient meteorological observation systems ranging from 70 to 100 meters;
- 5 Atmospheric composition observation;
- Water vapor observation network of 10 GNSS/MET stations;
- 10 mobile observation vehicles, 14 portable stations, 1 mobile wind profile;
- Fengyun-3 and Fengyun-4 satellite reception systems.



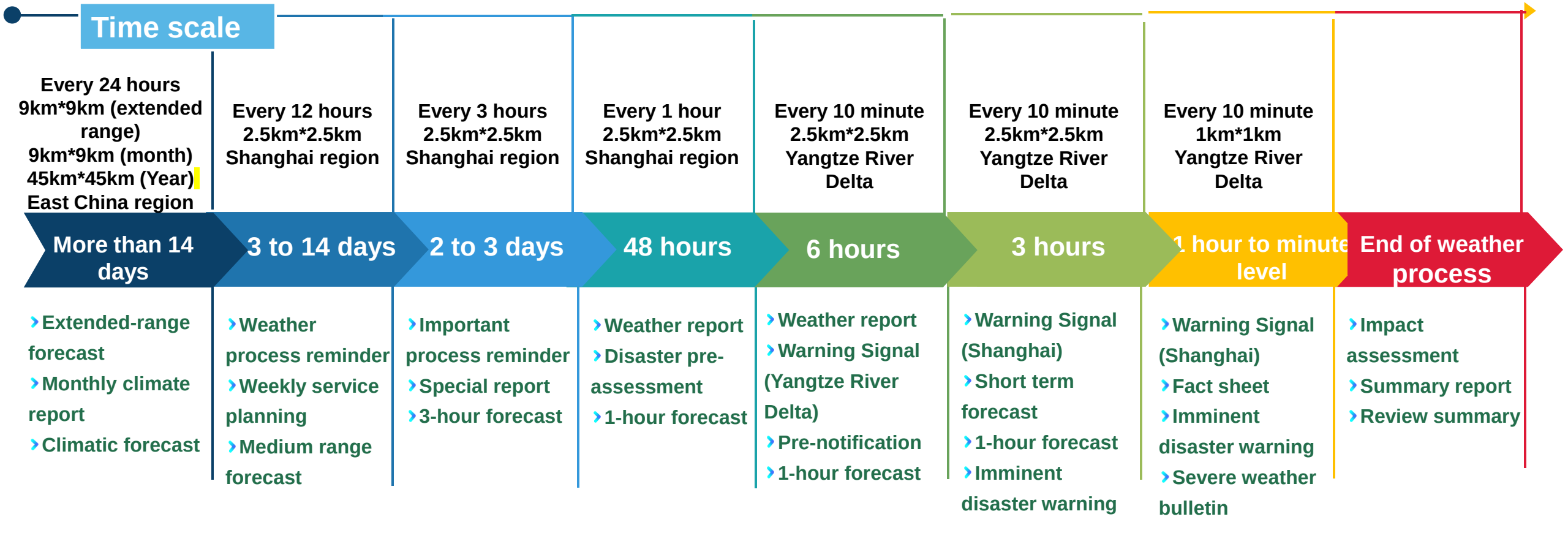
Data • Forecast • Data

Meteorological Forecast Data: 1.7 PB, Daily Increment: 1.2 TB

Time: From 14 days to minute-level precision

Space: 45km / 9km / 2.5km / 1km

Elements: Wind, rain, temperature, humidity

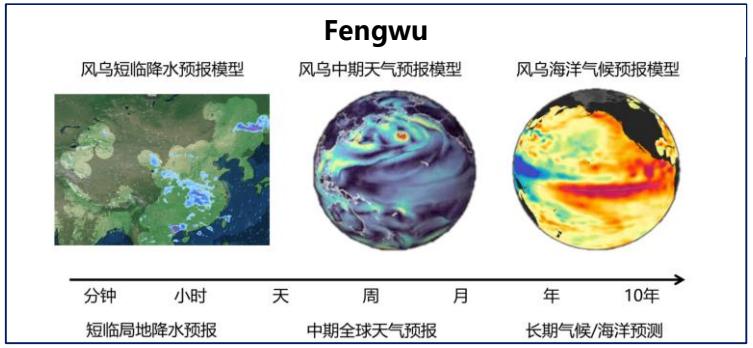


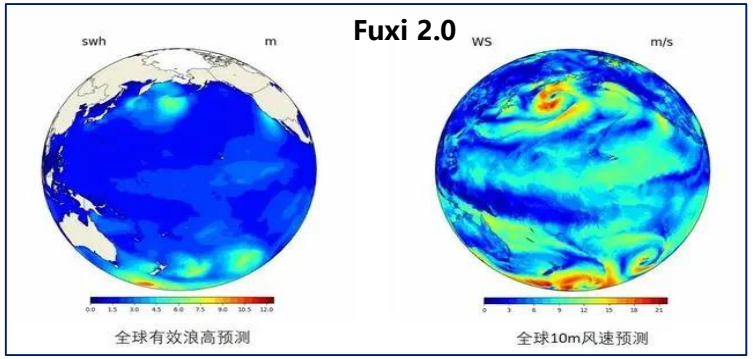
Data • Forecast • Data

Numerical Forecast: Data + Physical Constraints (A Century of Development)

Meteorological Large Models: Data + Machine Learning (Emerging and Thriving)

- Fengqing, Fenglei, Fengshun (China Meteorological Administration)
- Fengwu (Pujiang Laboratory)
- Fuxi (Fudan University)
- Pangu (Huawei)



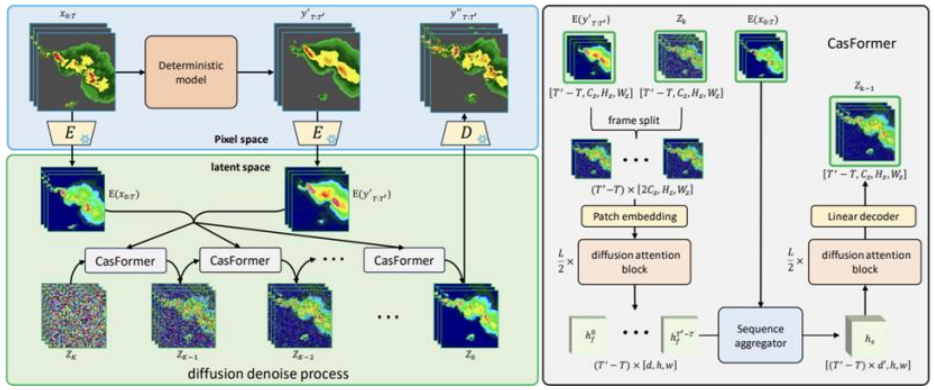


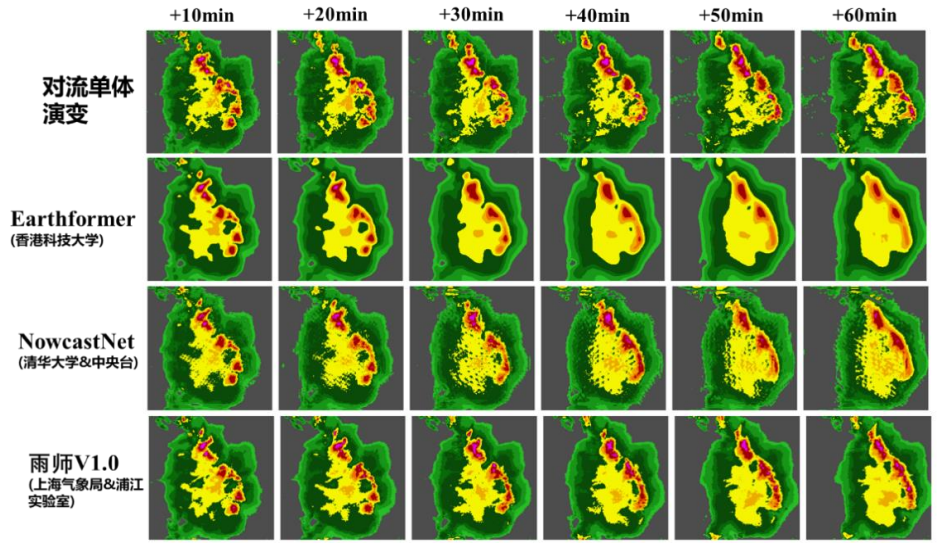
Name		FourCastNet	GraphCast	Pangu	Fengwu	Fuxi
Resolution		0.25°, 6h	0.25°, 6h	0.25°, 1h	0.25°, 6h	0.25°, 6h
Variable	Upper air	4 layers, 5 variables (z/r/t/u/v)	37 layers, 6 variables (z/q/t/u/v/w)	13 layers, 5 variables (z/r/t/u/v)	37 layers, 5 variables (z/r/t/u/v)	13 layers, 5 variables (z/r/t/u/v)
	Ground	5 ariables (t2m/10u/10v/msl/sp)	5 variables (t2m/10u/10v/msl/tp)	4 variables (t2m/10u/10v/msl)	4 variables (t2m/10u/10v/msl)	5 variables (t2m/10u/10v/msl/tp)
Forecast days		7 days	10 days	7 days	10 days	15 days
Model characteristics		A large model for short-to-medium-range forecasting using Vision Transformer for the first time	Large model of short and medium range forecast based on 3D GNN	1.The 3D Transformer forecast model is proposed for the first time; 2. Introduce absolute position coding that is related to latitude and height	1.Multimodal network architecture is applied to deal with different prediction elements; 2. Apply multitasking automatic weight balancing to automatically learn the importance of each variable	Add time dimension to forecast model based on 4D Transformer

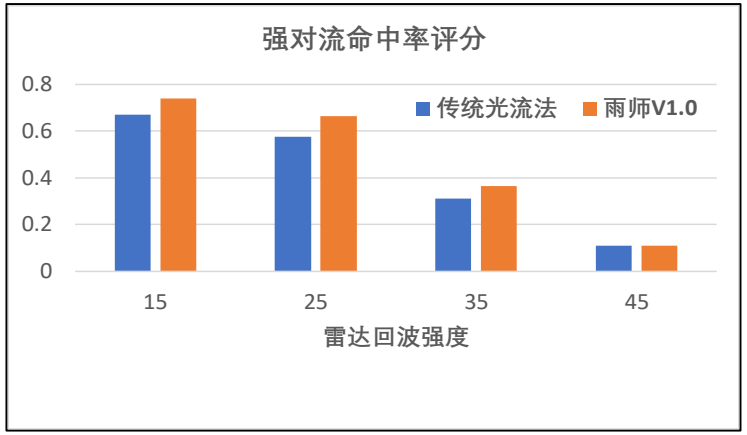
Data • Forecast • Data

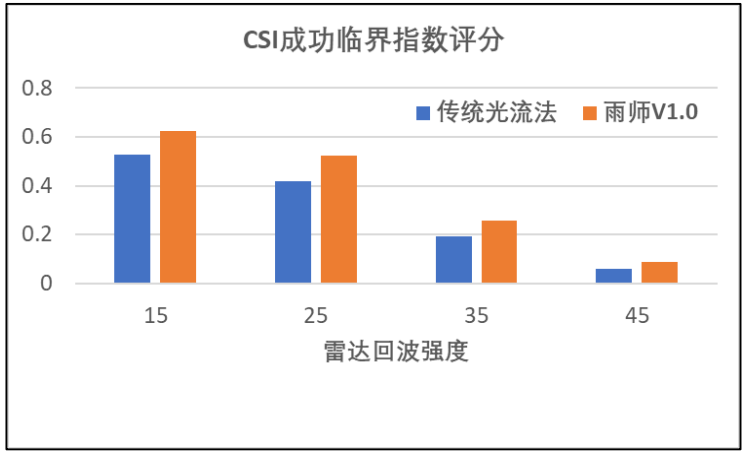
Meteorological Professional Large Model (Yushi) :

Enhanced Data + Physical Mechanisms + Large Model









Meteorological elements, products and services

Meteorological Data Elements × **33 industries (or sectors)**
21 types of data
50+ systems

12 million

Monthly visits of weather plug-in

8 categories

Provided by Shanghai Big Data Center

33 categories

Listed on the Shanghai Stock Exchange

Weather-City Integration: Data Leads the Way

天城合一，数据为先

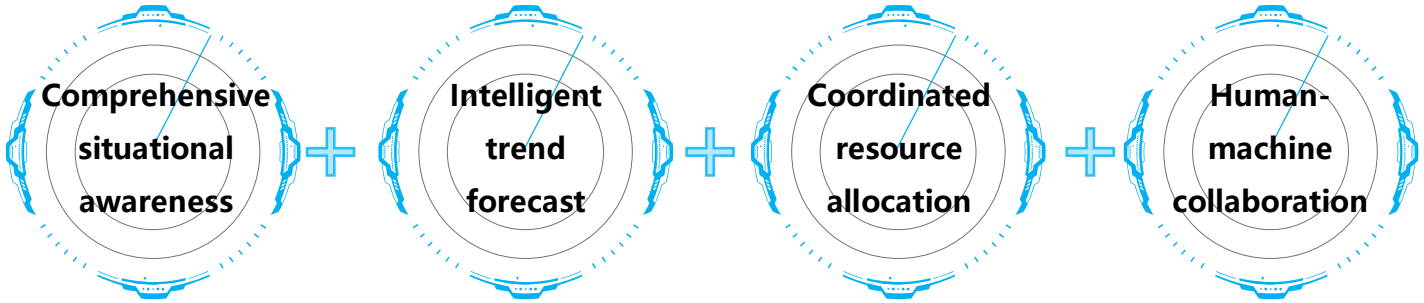
Under the promotion of “One Net for All" in urban operation, meteorological data and urban governance are integrated across borders, and new scenarios for the application of meteorological data elements are continuously expanded.

Urban operations “One Net for AI”

"One Net for All" uses real-time online data and intelligent methods to identify issues in a timely and accurately manner, It addresses the needs, assesses situations and prevents risks at the earliest time with relatively low costs. This solves the most prominent issues to the best outcome and ensures efficient coordination between online and offline governance.

Direction *Modernization of the governance system and its capacities in megacities*

Goal *Explore the world-class urban management model "Shanghai Plan"*



labor-intensive → human-machine interactive

experience-based judgement → data analysis

passive response → proactive discovery

One screen to observe the world

One net to manage the entire city

Six characteristics of megacities

Hyperscale	Megacities have huge markets, complex societies, diverse organizations, massive buildings, with a permanent resident population over 10 million along with a large number of transient residents.
Ultra-high density	The ultra-high density of population, buildings, and capital leads to exceptionally frequent interactions among individuals, between people and organizations, and among organizations, creating new opportunities while also increasing the likelihood of conflicts.
Ultra-high speed	Megacities can be considered living organisms and organic ecosystems with a large volume and rapid flow of people, goods, information, capital. All parts are interconnected and inseparable.
High complexity	Megacities fosters innovation, mergers and cross-sector collaborations with its diversity; however, their high complexity often presents challenging public governance issues.
Uncertainty	Our world today is a society of risk. Governance of megacities requires adequately embracing and responding to uncertainty, and effectively managing risks in urban operations at the same time.
Interaction Effect	In urban society, each individual is a variable. Thus, the interaction among the population of millions creates exponential increase in creativity, complexity and uncertainty.

Weather information is *fully integrated into the urban operation and management command platform (covering the municipal level and all 16 districts).*

The "Cloud" in Shanghai's Urban Operation System
- The Weather Forecaster System

Digital Twin Atmosphere

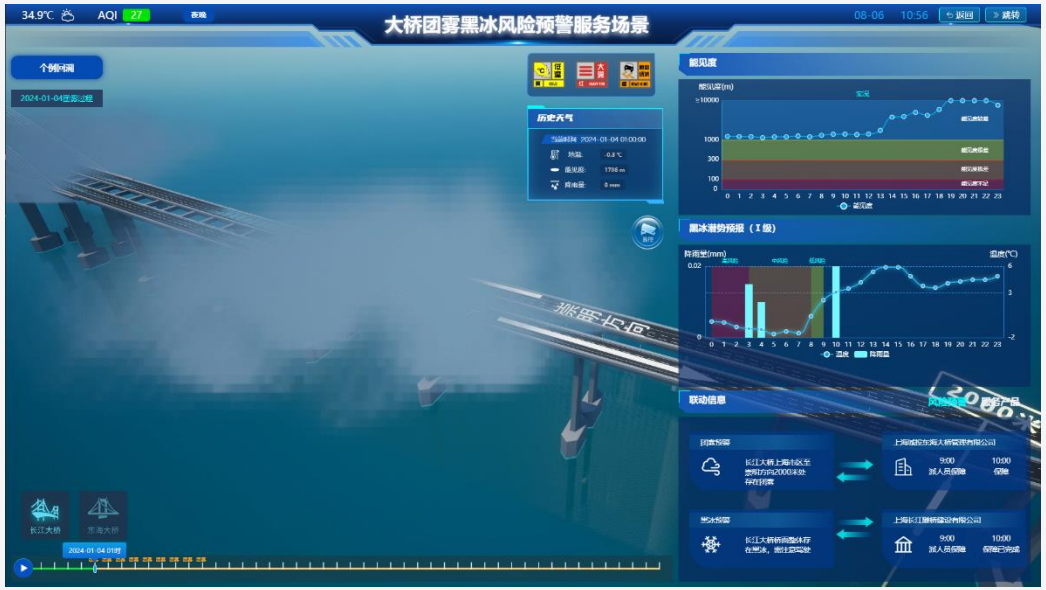
Bridge Data + Meteorological Data = Bridge Meteorological Risk

Observation: visibility, surface temperature observation

Traffic cameras: Video-based visibility inversion

Digital twin: The fog and black ice digital twin

Digital Twin of Bridge Agglomerate fog and Black Ice



Integrate meteorological elements to create a digital twin of the atmosphere and build an application scenario for “one net for all”.

Digital Twin Atmosphere

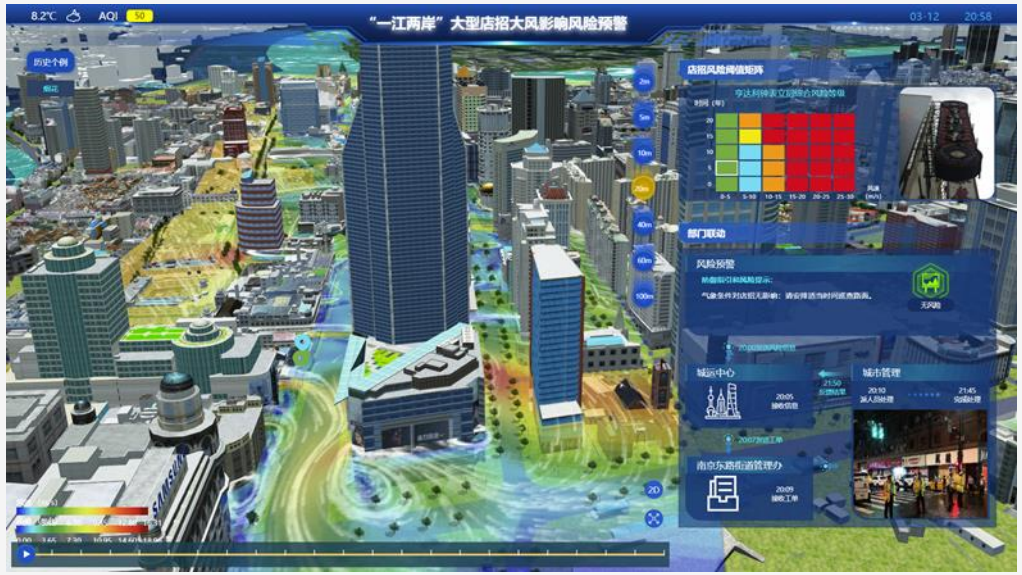
Building Data + Meteorological Data = Urban Wind Field

Observation: Wind speed, wind direction observation and laser wind measurement

Wind field model: three-dimensional wind field model of urban building scale

Digital twin: 3D wind field digital twin

Digital Twin of Urban Block-Scale Wind Field



Integrate meteorological elements to create a digital twin of the atmosphere and build an application scenario for "one net for all".

Weather service and scenario support

Urban Hazard-affected Entities Data + Wind Data at Different Heights = "Overhead Risk" Index

Service Products

- *Create a "Meteorological Risk Map Overhead" to provide decision-making reference for urban management departments such as Housing and Urban-rural Development to organize wind defense work.*

“头顶上的气象风险”
一张图

上海市气象局　　2024年07月25日18时00分

桃美，2024年，上海市数据局、上海市气象局、上海市大数据中心联合组建“气象要素×”工作专班，围绕超大城市“头顶上的风险”建立“头顶上的气象风险一张图”，包括高空作业气象安全风险指数、户外广告牌大风高坠风险指数、玻璃幕墙风险指数、蜘蛛人指数等。针对台风“格美”影响推出“高空作业安全风险一张图”专项产品，后续将继续细化，以期为住建等城市运行管理部门组织大风防御工作提供决策参考。

一、台风实况及大风影响

台风“格美”最新动态：今年第3号台风“格美”（台风级）今天16时其中心位置位于距离福建省福清市面偏东方向约60公里的海面上。预计“格美”将以每小时10～15公里的速度向西偏北方向移动，将于今天18时前后在福建福清到莆岗一带沿海登陆（台风级，12级，33～35米/秒）。之后，经江西和安徽西部北上，强度继续减弱，明后天（26-27日），本市风力将进一步增大到8～9级，高层建筑及沿江沿海地区阵风可达9～10级。

二、“一江两岸”高空作业气象安全风险

受台风“格美”带来的大风影响，“一江两岸”区域的高层建筑高空作业气象安全风险均达到中风险等级以上，其中上海中心大厦、上海环球金融中心、金茂大厦等超高层建筑高空作业气象安全风险均达到高风险等级（见图1和附表）。

图1 台风“格美”影响期间“一江两岸”高空作业气象安全风险预报图

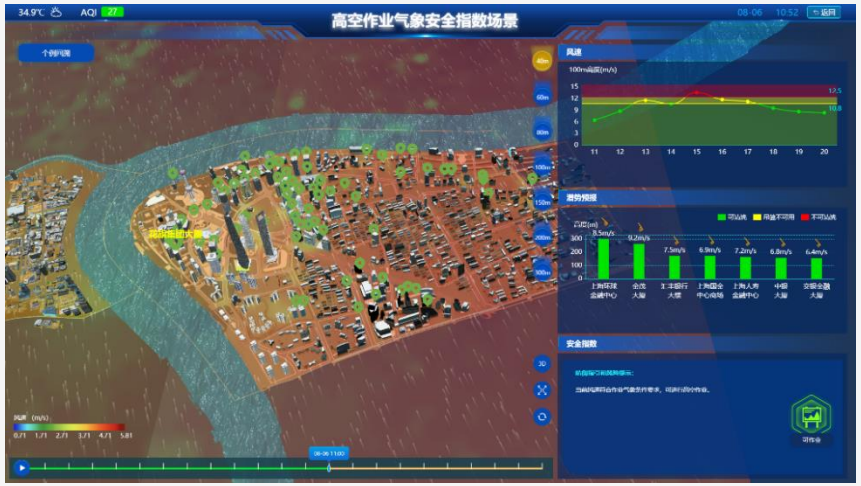
三、全市高空作业气象安全风险

受台风“格美”带来的大风影响，全市40米以上高层建筑风力可达7～9级以上，高空作业气象安全风险除中心城区部分区域为中风险等级，其余均为高风险；全市100米以上超高层建筑风力可达8～10级，部分地区可达11级以上，高空作业气象安全风险均达到高风险等级。

四、高空作业建议

建议作业单位密切关注台风“格美”最新实况及未来预报，建议达到中风险等级的高层建筑停止吊篮作业，达到高风险等级的高层建筑停止所有高空作业。

Service Scenario



- *Meteorological downscaling wind field products*
- *High-altitude work meteorological risk threshold values*
- *Full delivery of risk warning for high-rise buildings in Lujiazui.*

Weather service and scenario support

Urban Geographic Information Data + Drainage Data + Rainfall Data = "Risk Underfoot" Index

Progressive Forecasting and Early Warning

➢ *Meteorological services has been integrated into urban operation and disposal processes and formed "31631" progressive forecasting and warning service, to address the balance between the speed and accuracy of warnings.*

Service Scenario

Disposal Closed Loop

➢ *Integrating weather forecasting mechanisms and city operation response procedures, a closed-loop system is formed from weather risk warning to coordinated response.*

Weather service and scenario support

Early Warning Data + Digital Media = "Risk Among the Crowd" Warning

Innovative Distribution Channels

- *Targeted warning dissemination methods for different groups have been applied, aiming to ensure that everyone receives the warnings.*

Rapid and Precise Delivery of Early Warning Signals

- *Achieve widespread dissemination of early warning information to both the general public and key populations through social media apps.*

Baidu map app

Alipay app

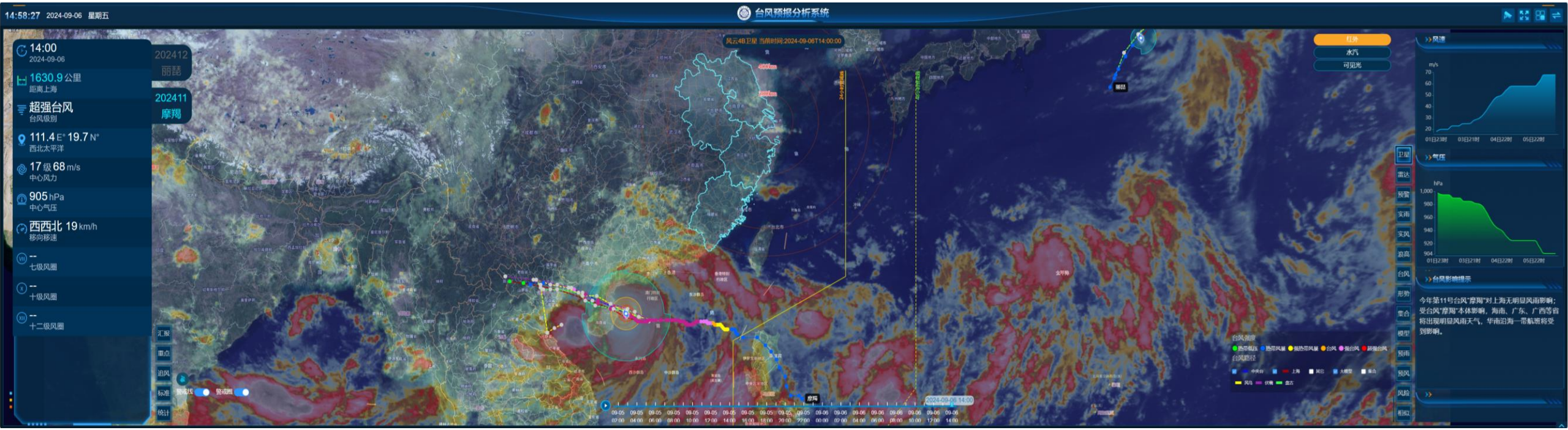
The delivery rider app of Ele.me

Weather service and scenario support

Urban Disaster Chain

(The impact of meteorological disaster on urban operations exhibits a chain-like characteristic)

Establish an Urban Meteorological Disaster Prevention Chain Based on Data Links



Weather service and scenario support

Centered around the practical scenarios of flood control command and dispatch throughout the city, and in conjunction with the operational requirements of flood control in terms of *“observation, management, and prevention”*, we have upgraded and established sections such as *“Monitoring and Analysis” and “Dispatch and Response”*. This has enhanced the dynamic perception capability of flood situations, providing timely and comprehensive information support for leaders' command and decision-making processes.

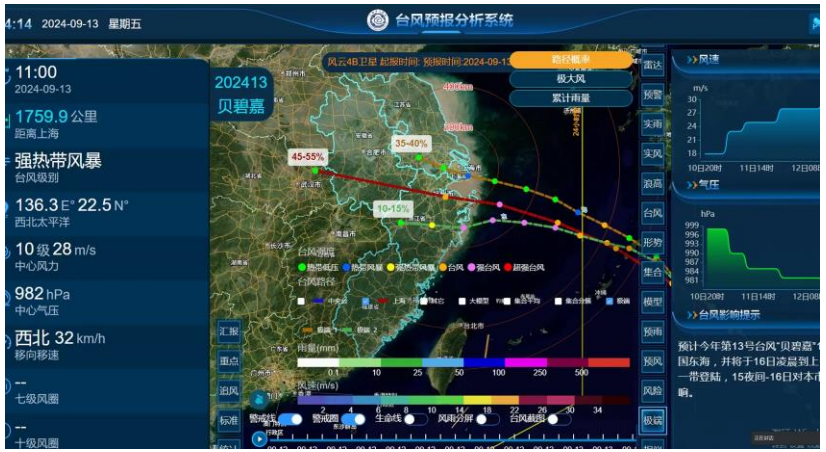
Weather service and scenario support

Digital transformation in response to Typhoon Bebinca

Probabilistic Data on Typhoon Tracks → **Overall Defense Deployment**

Extreme Disaster Data → **Key Defense Content**

Detailed Forecast Data for Wind and Rain → **Detailed Defense Measures**



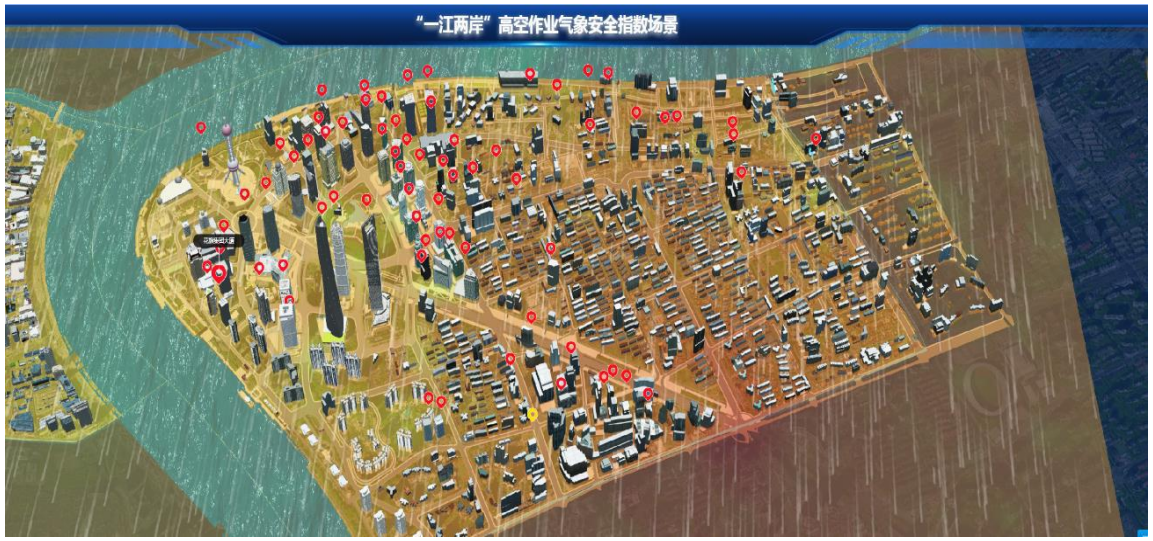
Dynamic Probability Forecast Product for Typhoon Tracks

Refined Matrix-based Wind and Rain Forecast Product

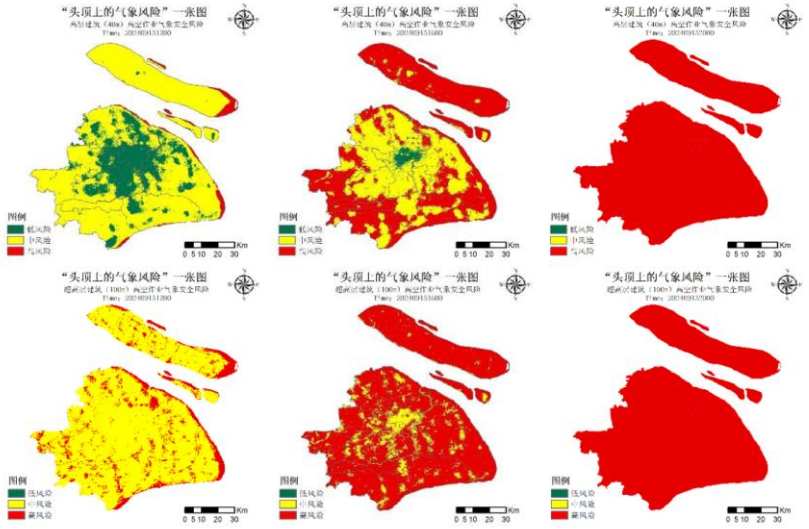
Weather service and scenario support

Digital transformation in response to Typhoon Bebinca

For the core area of the "One River, Two Banks" region and the entire city, a *"Meteorological Risk Map Overhead"* has been developed. This map clearly identifies high-risk levels for buildings *over 40 meters tall* and super high-rise buildings *over 100 meters tall*. It provides decision-making references for urban management departments such as Housing and Urban-rural Development to organize wind defense efforts.



Meteorological Safety Risks for High-Altitude Operations in the Core Area of the "One River, Two Banks" Region



A Comprehensive "Meteorological Risk Map Overhead" for the Entire City

Scenario drives the aggregation of urban operational data

Aggregating 54 categories of data elements from 6 departments in total

Data Such as the Atmosphere: Invisible but Valuable

数如大气，无形有价

Leveraging the multiplier effect of meteorological data to unleash its socio-economic and ecological value as a data element, and providing a demonstration for global data governance.

Meteorological data elements create social value

Shanghai Meteorological Regulations

Chapter 5: Exploitation and Utilization of Public Meteorological Data

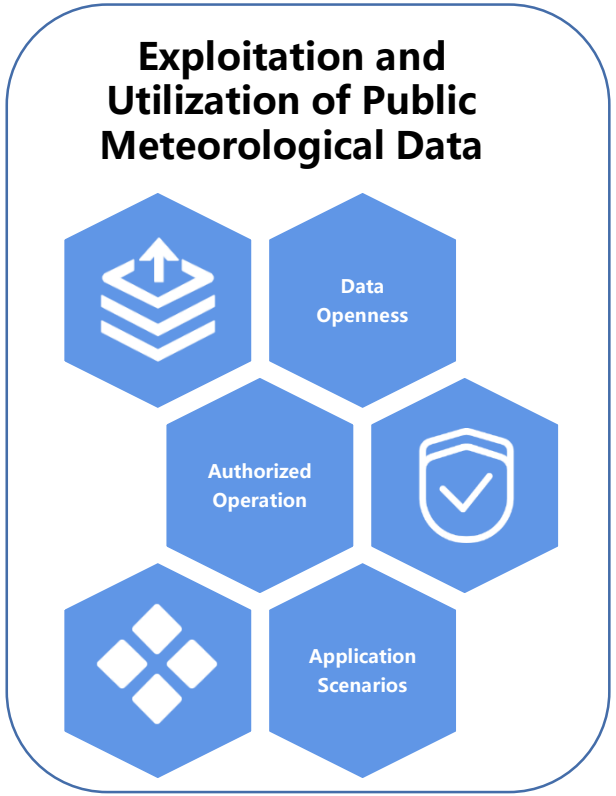
Article 31 (Promotion of the Exploitation and Utilization of Public Meteorological Data)……

Article 32 (Opening Up of Public Meteorological Data)……

Article 33 (Authorized Operation of Public Meteorological Data)……

Article 34 (Requirements for Authorized Operation)……

Article 35 (Data Application Scenarios)……



上海市人大常委会办公厅公告

市十六届人大常委会第十五次会议对《上海市气象条例（草案）》进行了审议。为进一步发扬立法民主，现将条例草案及相关说明在解放日报、上海法治报、东方网（www.eastday.com）、新民网（www.xinmin.cn）、上海人大网、“上海人大”微信公众号上全文公布，向社会广泛征求意见，以便进一步研究修改，再提请以后的常委会会议审议。现将有关事项告知如下：

一、公开征求意见的时间

2024年8月23日至9月7日

二、反映意见的方式

（一）来信地址：上海市人民大道200号，市人大常委会法制工作委员会立法二处；邮政编码：200003

（二）电子邮件：fgwlfec@126.com

（三）传真：63586583

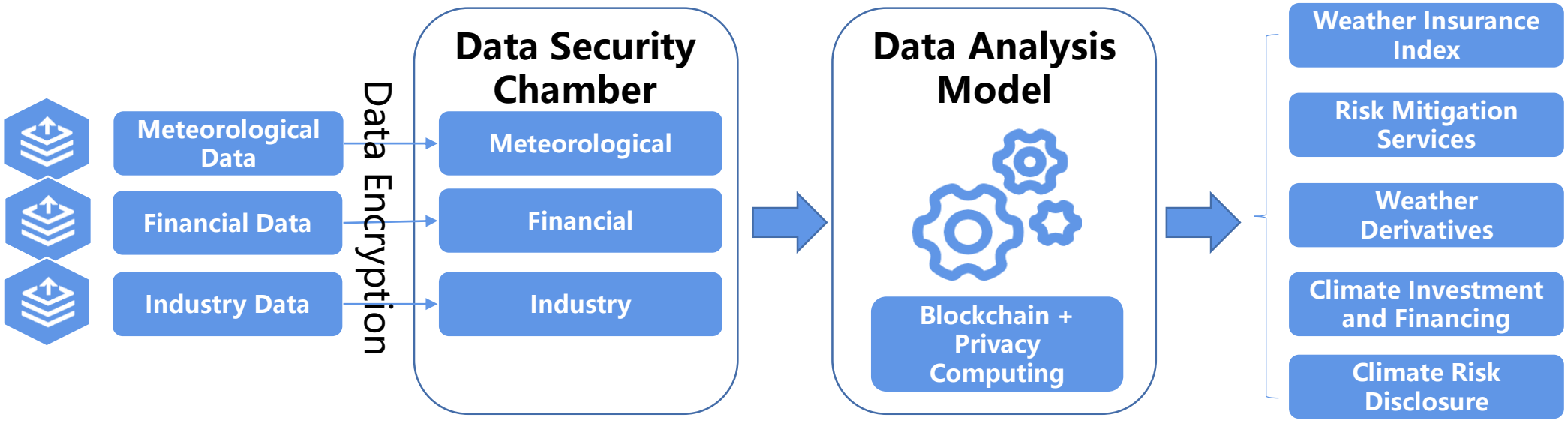
上海市人大常委会办公厅

2024年8月22日

Meteorological data elements generate economic value

The Innovative Platform for "Meteorological Data × Finance"

- Incorporating technologies such as *blockchain, privacy computing, data desensitization, data sandbox, and digital identity*, the "Meteorological Data × Finance" innovative platform establishes a secure and trustworthy environment for processing and operating meteorological data.
- The platform establishes review processes and standard specifications for the circulation of meteorological data, constructs a *regulatory mechanism for meteorological data providers, and develops a cultivation model for such providers*. It promotes the secure, orderly, and effective *market-oriented allocation of meteorological data elements in the financial industry*, driving the market-oriented development of meteorological data elements in Shanghai.



Meteorological data elements generate economic value

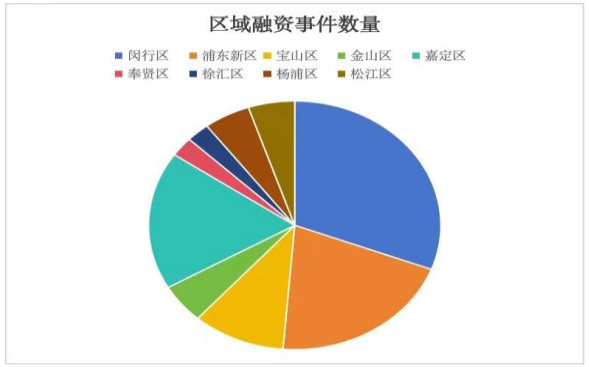
Providing Service Support for the Development of Shanghai's Low-altitude Economy Industry

The potential for Shanghai to develop a low-altitude economy

Policy Foundation

Action Plan for High-Quality Development of Shanghai's Low-Altitude Economy Industry (2024-2027)

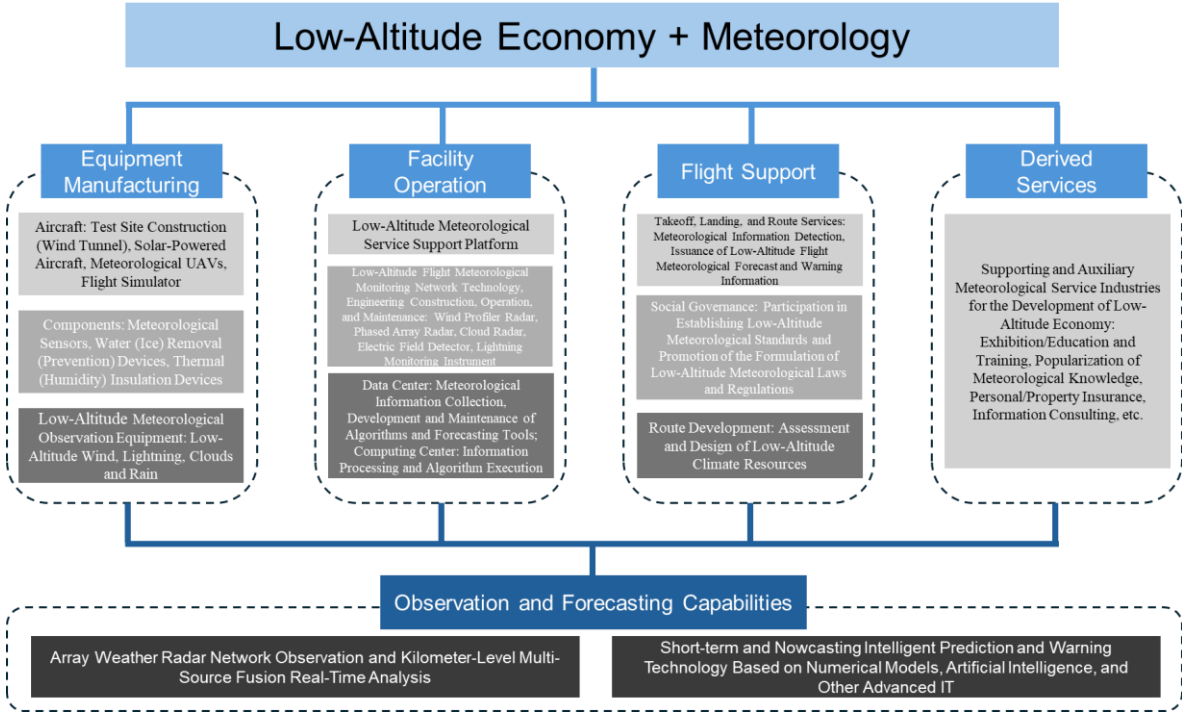
Commercial Foundation



Industrial Foundation

- **JinShan District :** Action Plan of Jinshan District for Promoting High-Quality Development of the UAV Industry and Enhancing the Construction of the East China UAV Base (2023-2025)
- **Minhang District:** An aviation industry alliance consisting of more than 20 upstream and downstream enterprises in the aviation industry has been formed.

Development strategy for meteorological service support



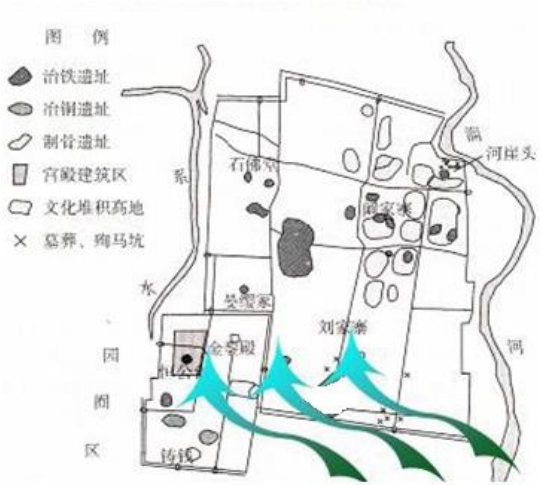
- **Carry out research on key technologies and the development of important equipment/systems for meteorological monitoring, early warning, and services for low-altitude flight.**
- **Formulate/amend a series of local and industry standards for integrated space-air-ground meteorological precision services related to the low-altitude industry.**

Meteorological data elements empower ecological governance

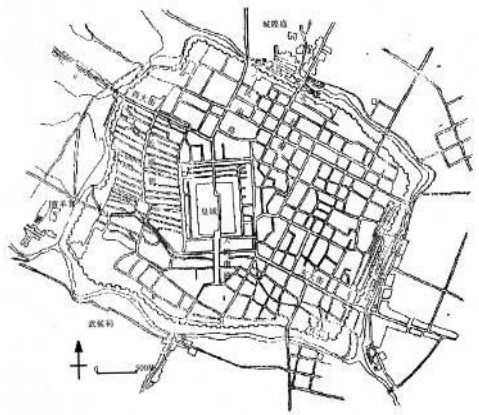
"Harmony between Man and Nature" Ecological Philosophy: Integrating with the Local Climate for a Harmonious Coexistence between Humans and Nature

“天法道，道法自然。”其一焉。人法地，地法天，亦大，域中有四大，而王居“故道大，天大，地大，王”《道德经》（二十五章）

“大人者与天地合其德，与日月合其明，与四时合其序，与鬼神合凶吉，先天而天弗违，后天而奉天时”。《周易·乾卦·文言》



The ancient Linzi City had its smelting workshops built in the downwind direction.

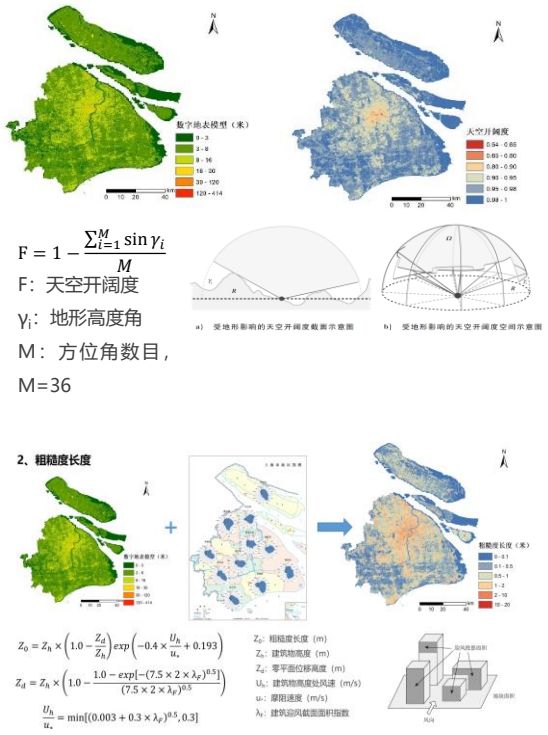


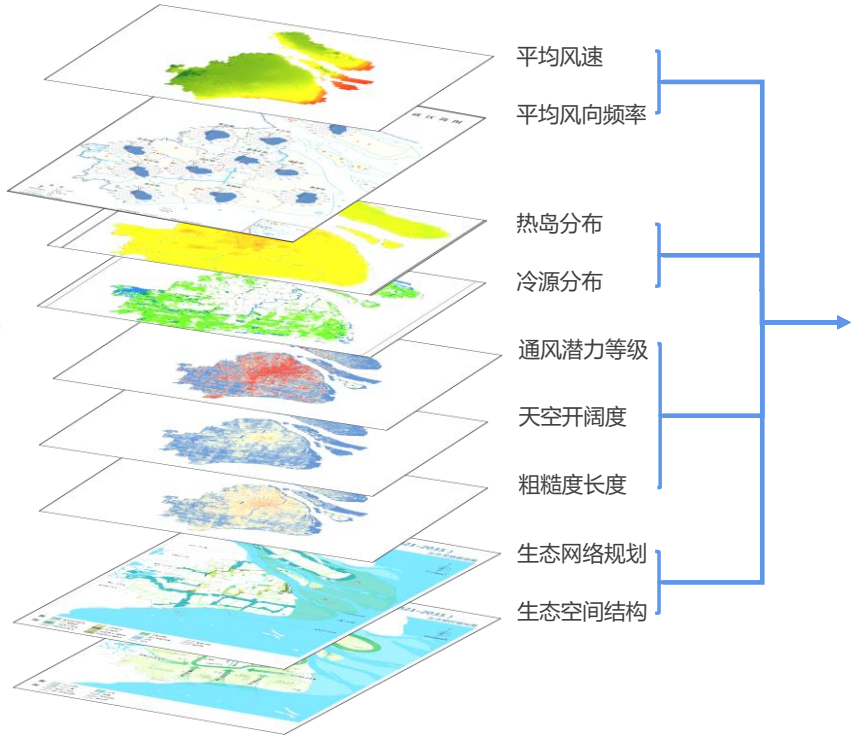
In ancient Chengdu, the streets were oriented in a northeast-southwest direction, which was consistent with the prevailing wind direction.

Meteorological data elements empower ecological governance

Digital Twin Atmosphere
+
Digital Twin City

Based on an analysis of current urban issues, it is essential to *respect the existing urban layout, take into account overall planning and design, and harness ecological cooling resources*. Efforts should primarily focus on improving the urban ventilation environment, mitigating the urban heat island effect, and enhancing air quality. By thoroughly implementing the concept of ecological civilization, we can address issues such as *poor ventilation, heat islands, and pollution*.





Digital Twin Atmosphere: Tracing the Origin of Wind

Understanding the Urban Dynamics: Where the Wind Goes

Meteorological data elements empower ecological governance

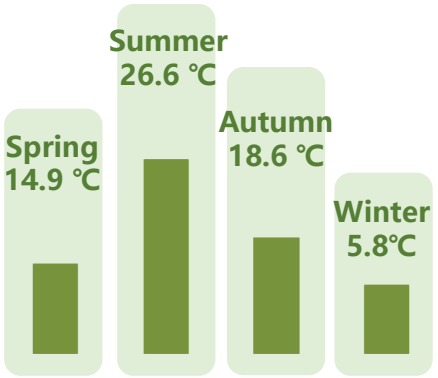
land-based observation → Temperature, precipitation, and negative oxygen ions…

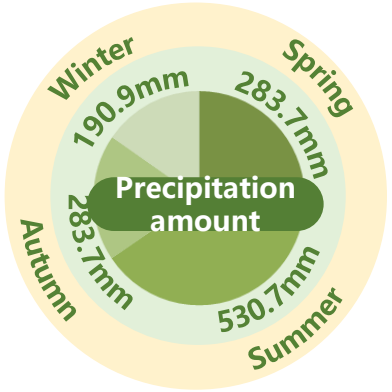
space-based observation → Aerosol and vertical profiling

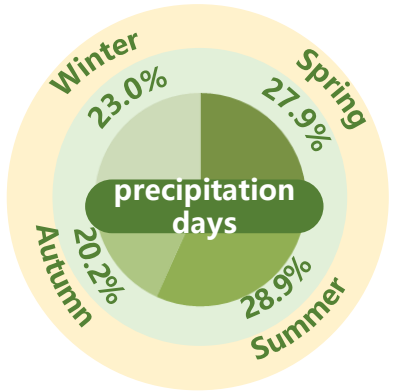
air-based observation → Vegetation cover and ecological quality

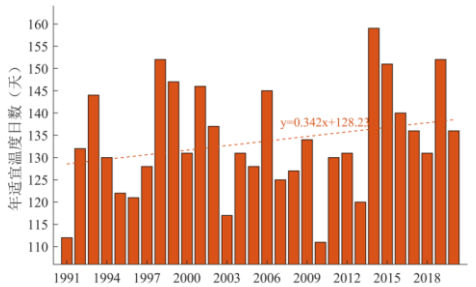
Shanghai's Chongming District Has Been Awarded the Titles of "China's Natural Oxygen Bar" and "China's Climatically Habitable City (County)"

Shanghai's Fengxian District Has Been Awarded the Title of "China's Climatically Habitable City (County)"

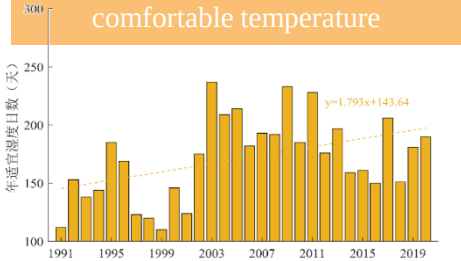




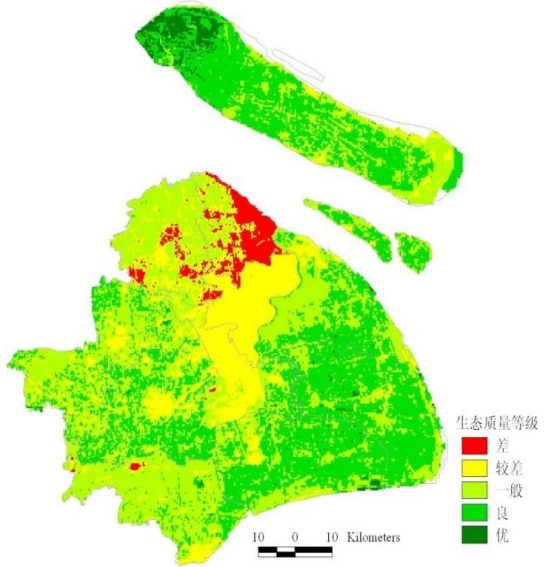




annual number of days with comfortable temperature



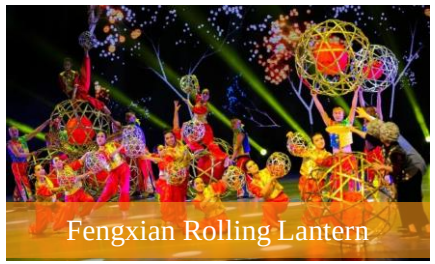
annual number of days with comfortable humidity



Comprehensive Ecological Quality Assessment

Dongtan International Important Wetland

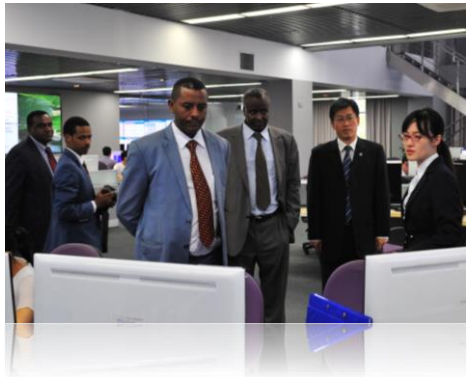
The Yangtze Estuary Chinese Sturgeon International Important Wetland



Fengxian Rolling Lantern

Meteorological data elements provide a model for global data governance

Since 2006 to 2024, the Shanghai UMHEWS practices have been shared with many Members through international workshops and training courses.



2006 — Demonstration project for UMHEWS

2010 — MHEWS supported Shanghai Expo 2010

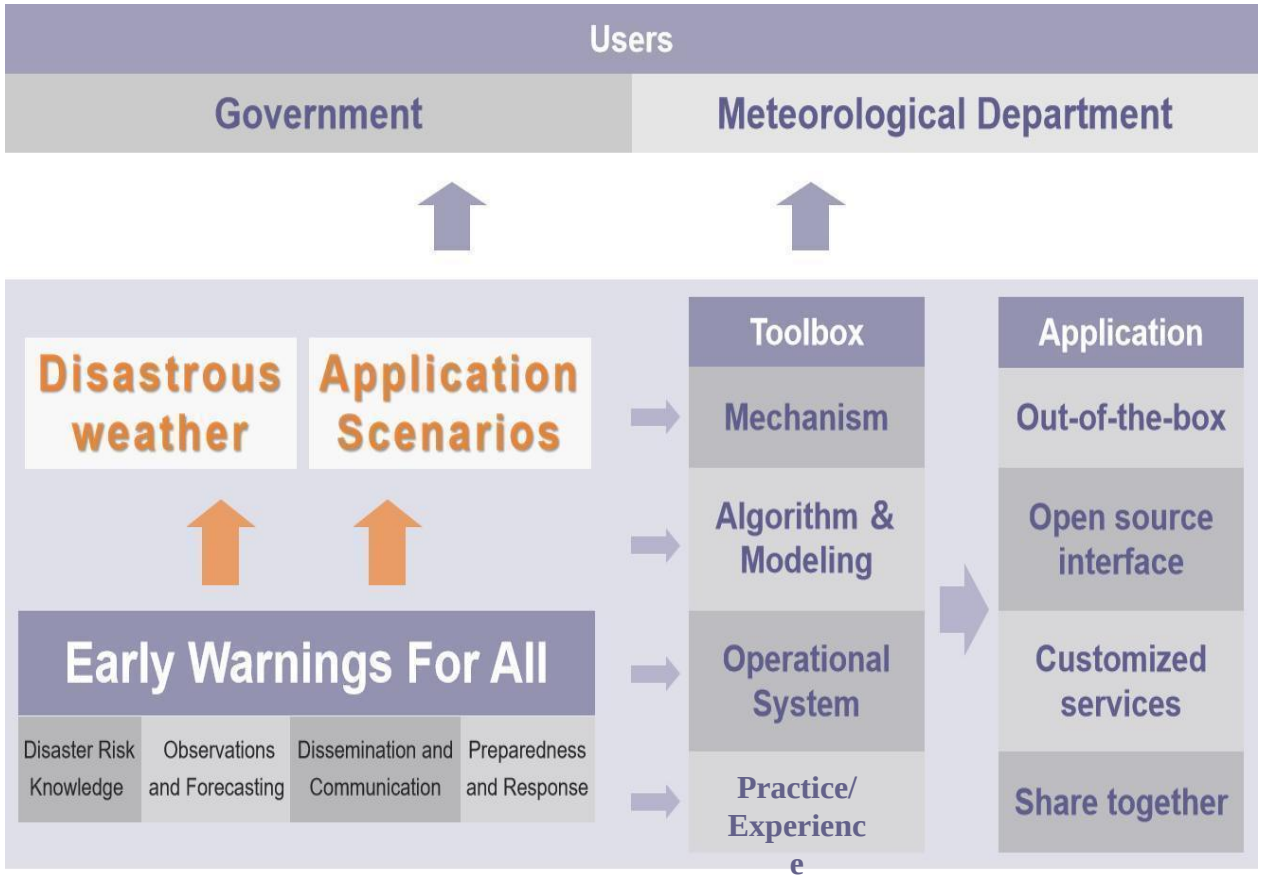
2016 — Guidelines for Meteorological Impact Forecasting and Risk Warning in Shanghai

2023 — UMHEW Toolbox

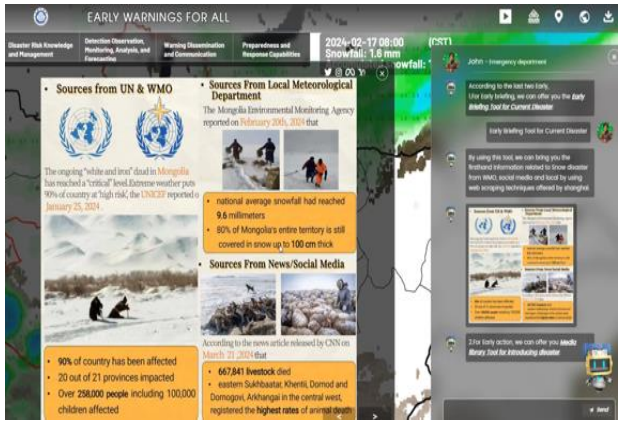
2024 — UMHEW-CoE

Meteorological data elements provide a model for global data governance

Based on the 4 pillars， serving 2 types of users, supporting 4 access methods. Currently, the toolbox is being trialed in Karachi, Macau(China), and Ulaanbaatar.



Tools will be provided based on different data conditions

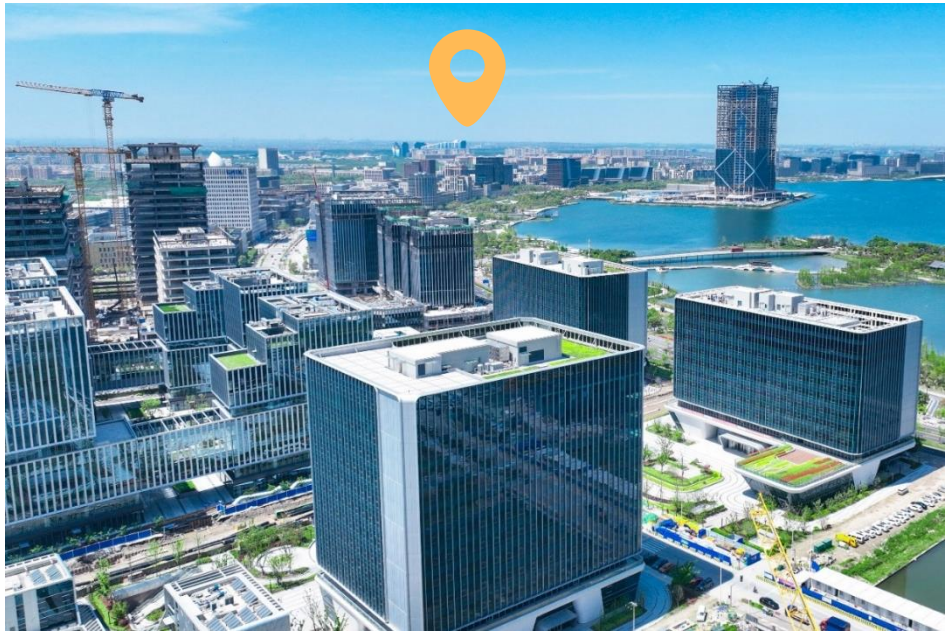


Ulaanbaatar

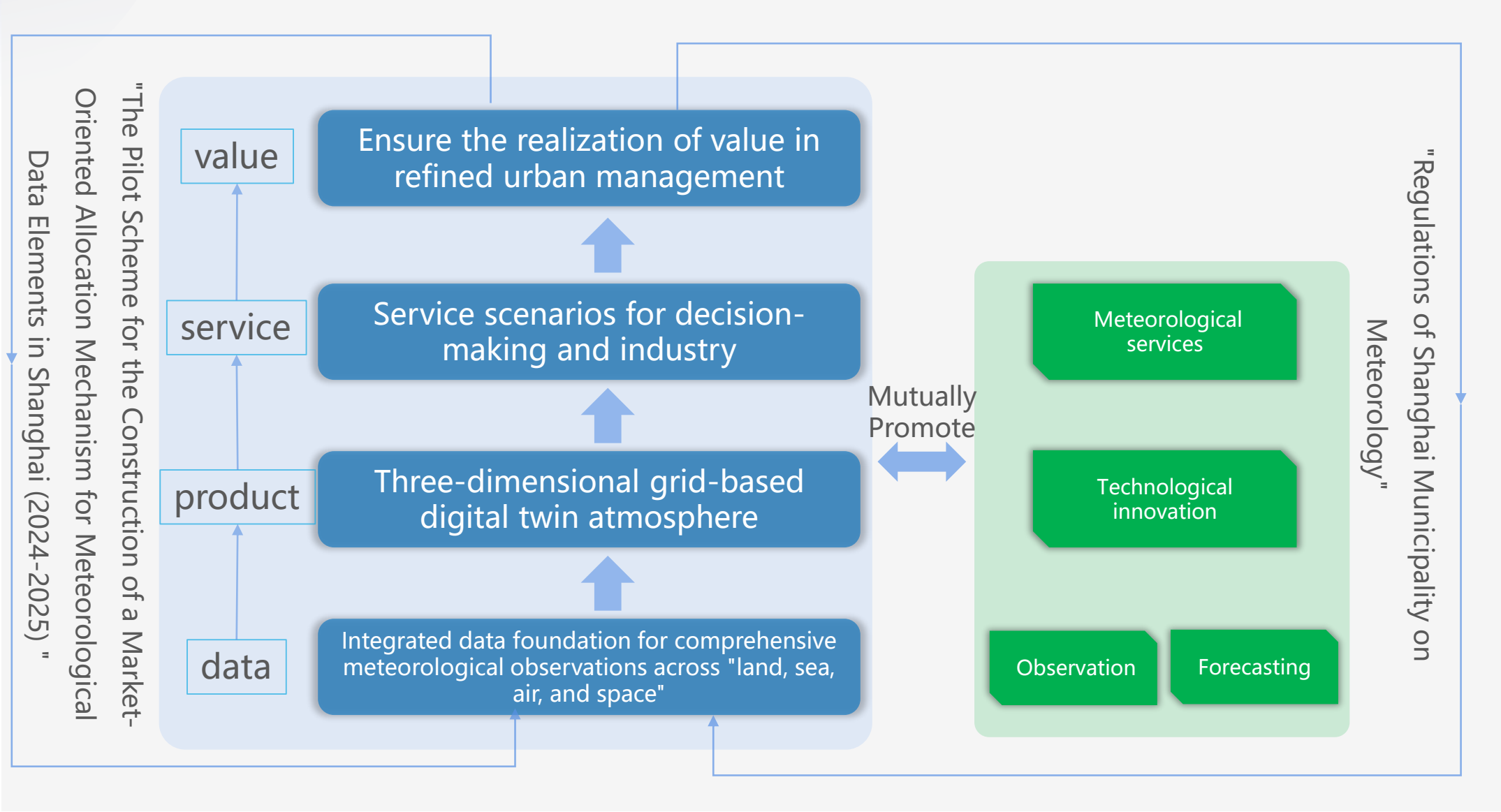
Karachi

Meteorological data elements provide a model for global data governance

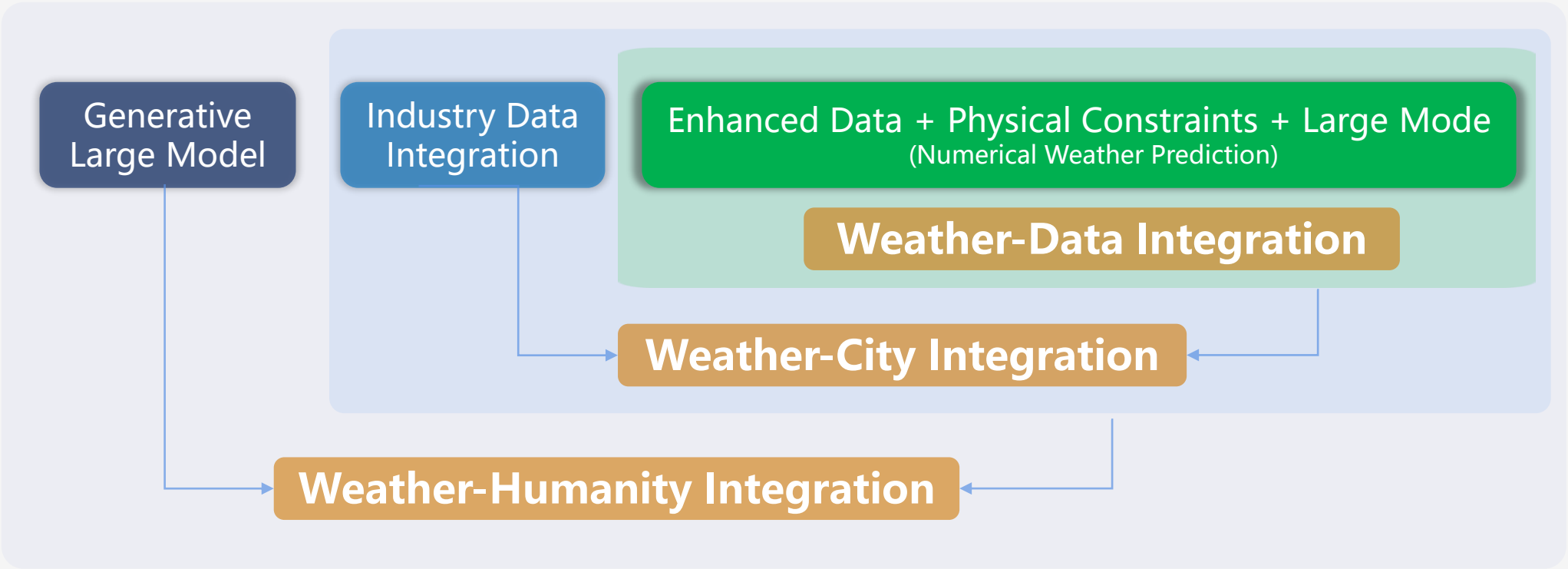
With the strong support of the World Meteorological Organization (WMO), China Meteorological Administration (CMA), and the Shanghai Municipal Government, Shanghai meteorological Service is actively preparing for the establishment of the *WMO Center of Excellence (CoE) on Urban Multi-hazard Early Warnings in Shanghai*. Upon completion, this center will provide technical support for multi-hazard early warning to cities that are members of the WMO, friendly cities of Shanghai, and cities along the Belt and Road Initiative route. It will also conduct regular training to continuously enhance the multi-hazard early warning capabilities of cities in other countries.



Realization Pathways for the Value of Meteorological Data Elements



Implement the Shanghai Plan for "Meteorological Data Elements ×"



Shanghai Plan for "Meteorological Data Elements ×"

Going Forward without Stopping,
the Future is Promising