AOMSUC-15 FYSUC-2025

FIFTEENTH ASIA-OCEANIA METEOROLOGICAL SATELLITE USERS' CONFERENCE

THE JOINT 2025 FENGYUN SATELLITE USER CONFERENCE

Enhancing FengYun's Collaborative Observation: The Tianmu-1 Constellation as a Key Partner

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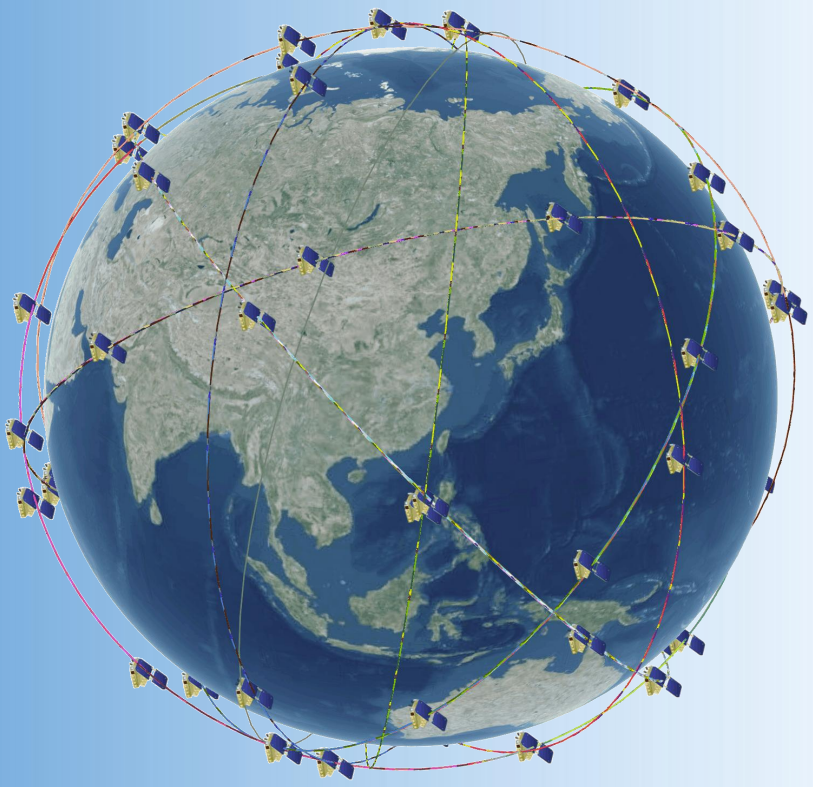
Aerospace Tianmu (Chongqing) Satellite Science and Technology Co., Ltd.



01 The 'Why': The Imperative for Collaboration

02 The 'What': The Tianmu-1 Advantage

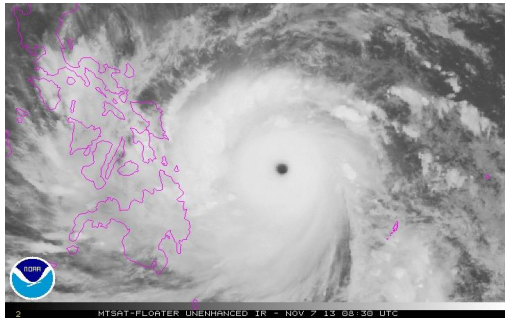
03 The 'How': Synergy in Practice

04 The Future: From Synergy to Integration

01 The 'Why': The Imperative for Collaboration

Evolving Needs in Global Monitoring

- **Increasing frequency and intensity of extreme weather events.**
  - Growing demand for higher spatiotemporal resolution data
  - Need for rapid response and refined forecasting
- **The Gaps**
  - How to complement the robust but broad coverage of systems like Fengyun?
  - How do we fill the gaps in specific areas and moments?



Typhoons

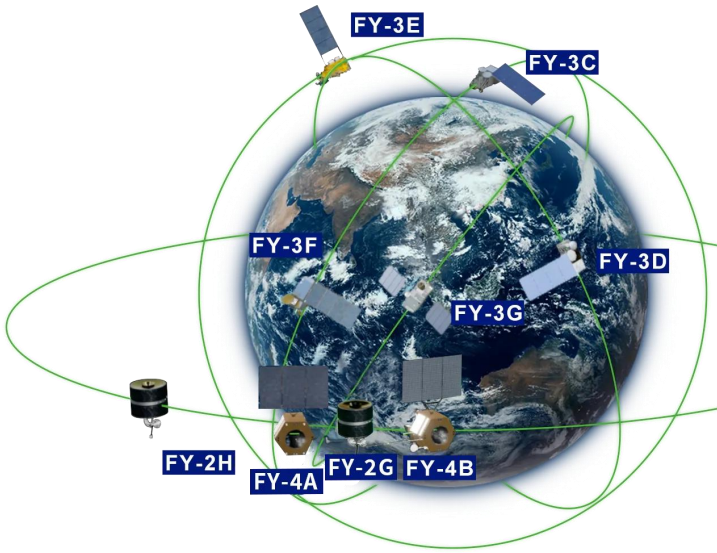
Flood

Heatwave

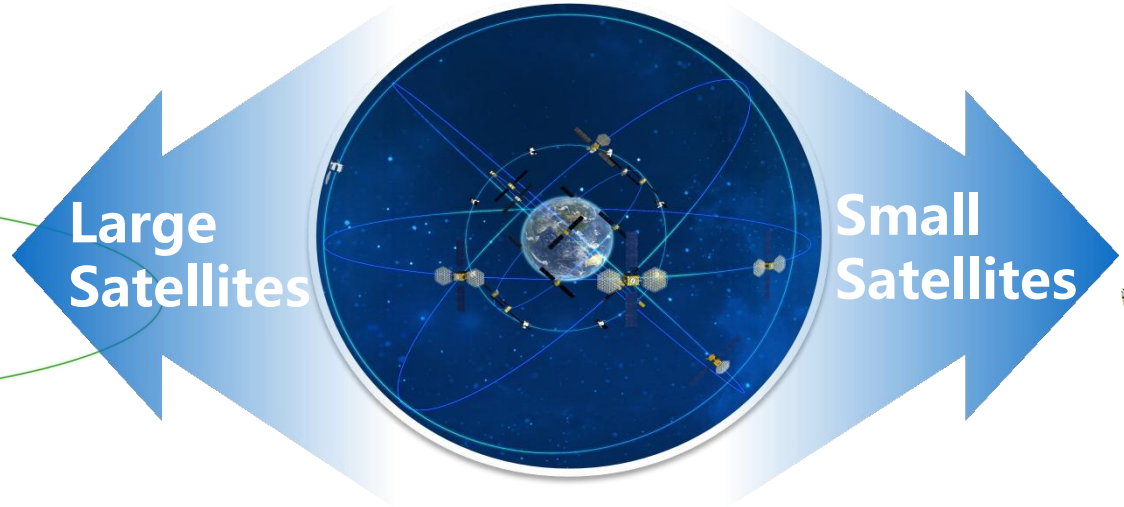
Strong Wind

The Answer is Collaborative: LargeSats + SmallSats

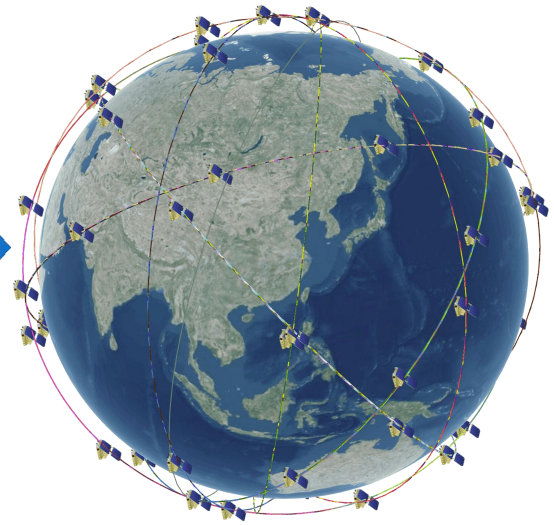
Backbone



stable, long-term coverage
comprehensive benchmark data



Agile Partner



high revisit, high resolution,
targeted and flexible observation

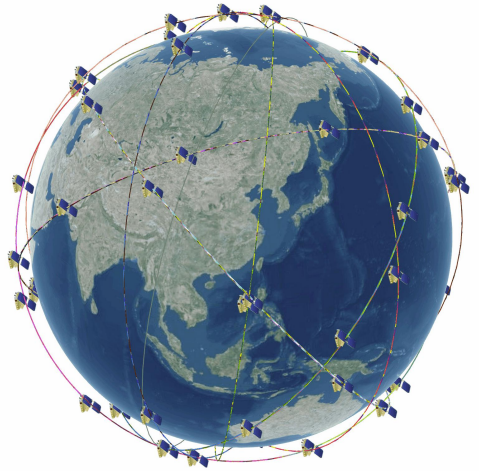
02

The 'What': The Tianmu-1 Advantages

Tianmu-1: A Specialized GNSS Remote Sensing Constellation

Tianmu-1 Constellation

- **Our plan**
  - **72** satellites
  - Sun-Synchronous Orbit (SSO) for global coverage
  - Low-Inclination Orbit for enhanced monitoring over critical tropical and mid-latitude regions



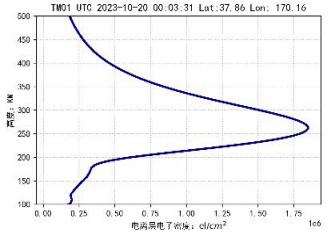
- **Current Status**
  - **23** satellites in orbit
  - **operating stably** and **delivering data operationally**

Dual-Mode GNSS Sensing: GNSS-RO & GNSS-R

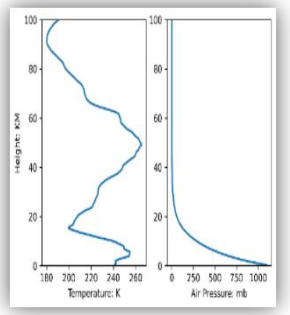
Dual-Mode

- **GNSS-RO**
  - Atmospheric profiles
  - Ionospheric electron density profiles
- **GNSS-R**
  - Sea surface wind,
  - soil moisture
  - sea ice

Ionosphere

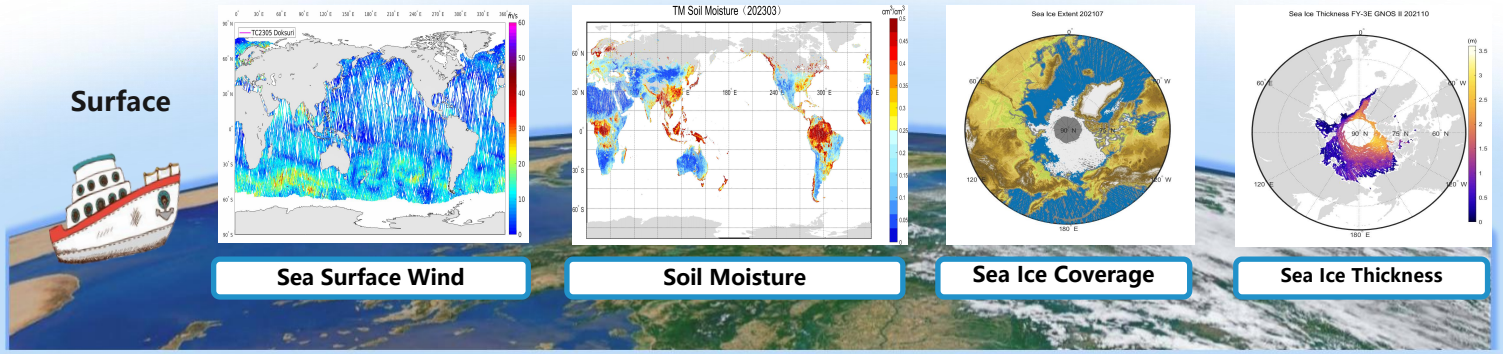


Electron Density Profile



Atmospheric Profile

Atmosphere



Sea Surface Wind

Soil Moisture

Sea Ice Coverage

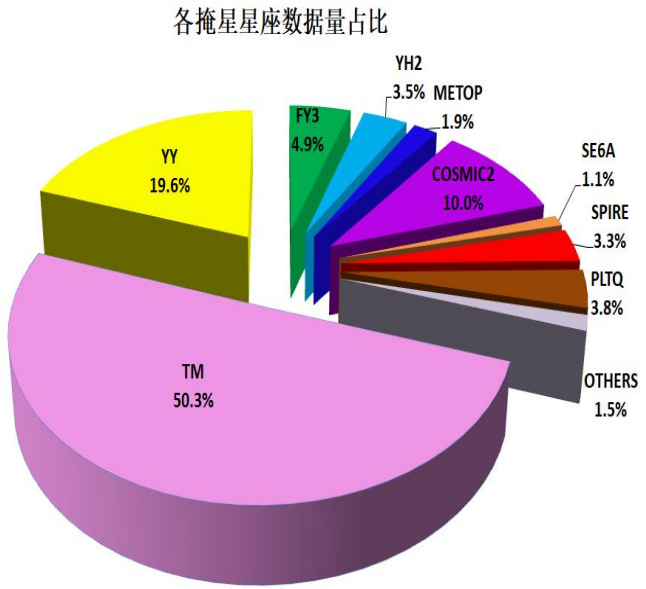
Sea Ice Thickness

Operational Integration & Third-Party Validation

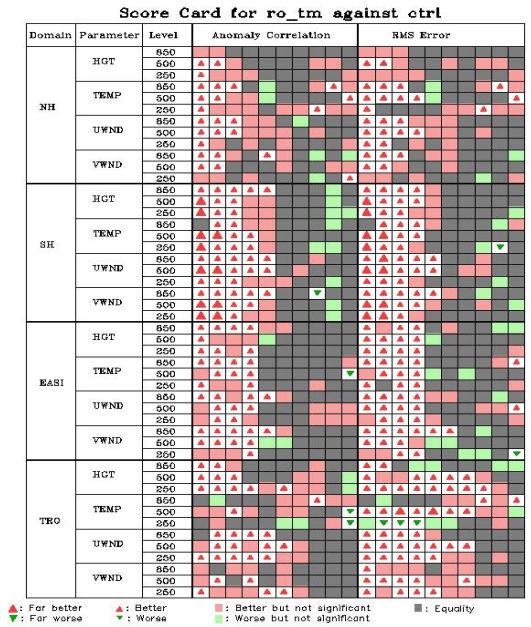
- **Near Real-time Data Dissemination to CMA**
- **Evaluation by CEMC & NSMC**

  Data quality is **high** and has a **positive impact** on forecast accuracy
- **Assimilated into CMA-GFS 4.2**

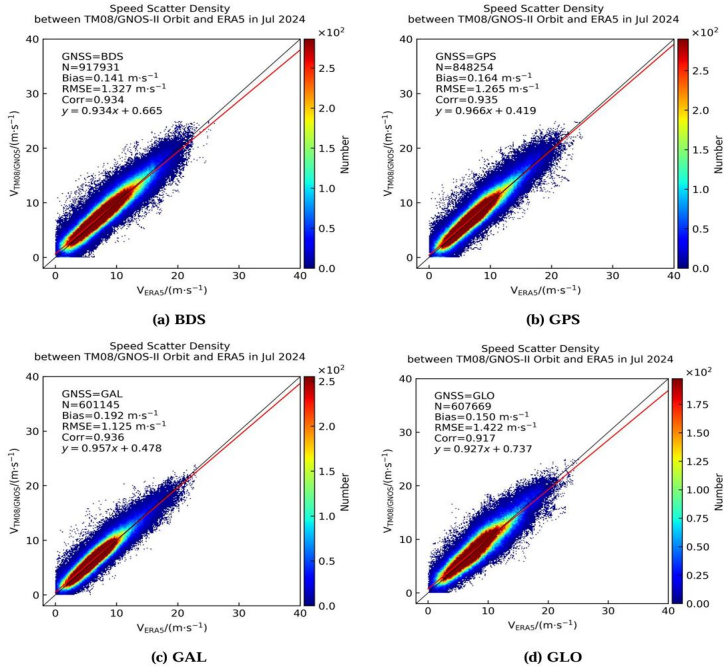
  Tianmu data accounts for **~50%** of all RO data assimilated



Radio occultation data assimilated by the Global Operational System of CMA-GFS 4.2



Contribution to Forecasts (CMA-GFS 4.2)



Scatter Density Plot of TM SWS vs. ERA5

CEMC Evaluation (from CEMC Yan Liu)

NSMC Evaluation (from NSMC Mi Liao)

03

The 'How': Synergy in Practice

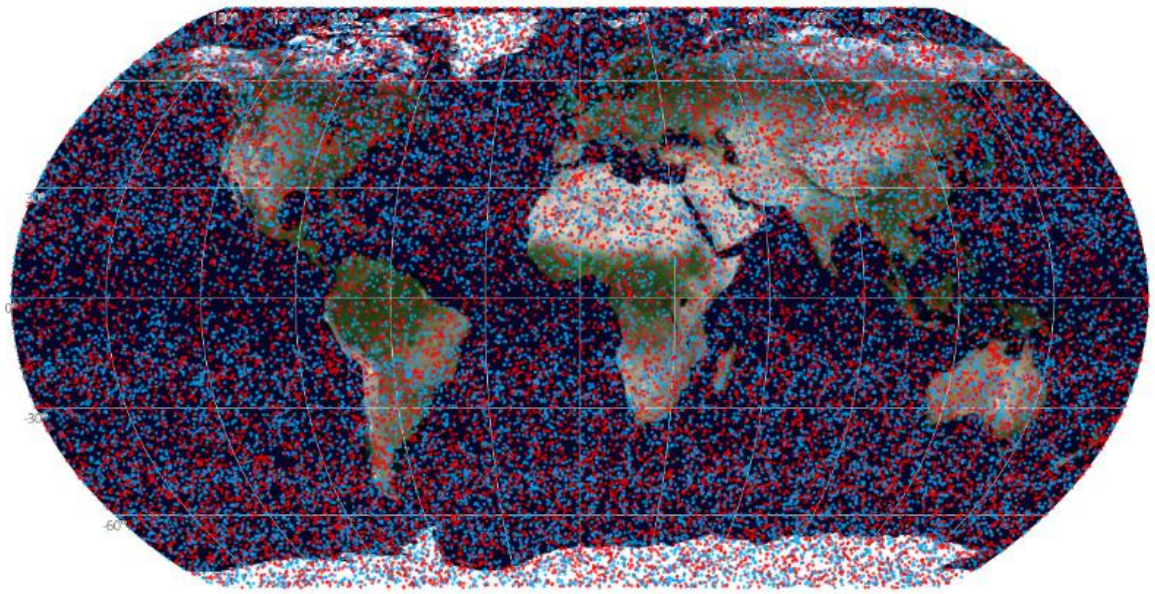
Synergy I: Enhanced Coverage & Resolution

Specialized small-sats (Tianmu-1) complement comprehensive large-sats (FengYun).

① **Coverage Capacity**: Massive Data Volume

Atmospheric Profiles

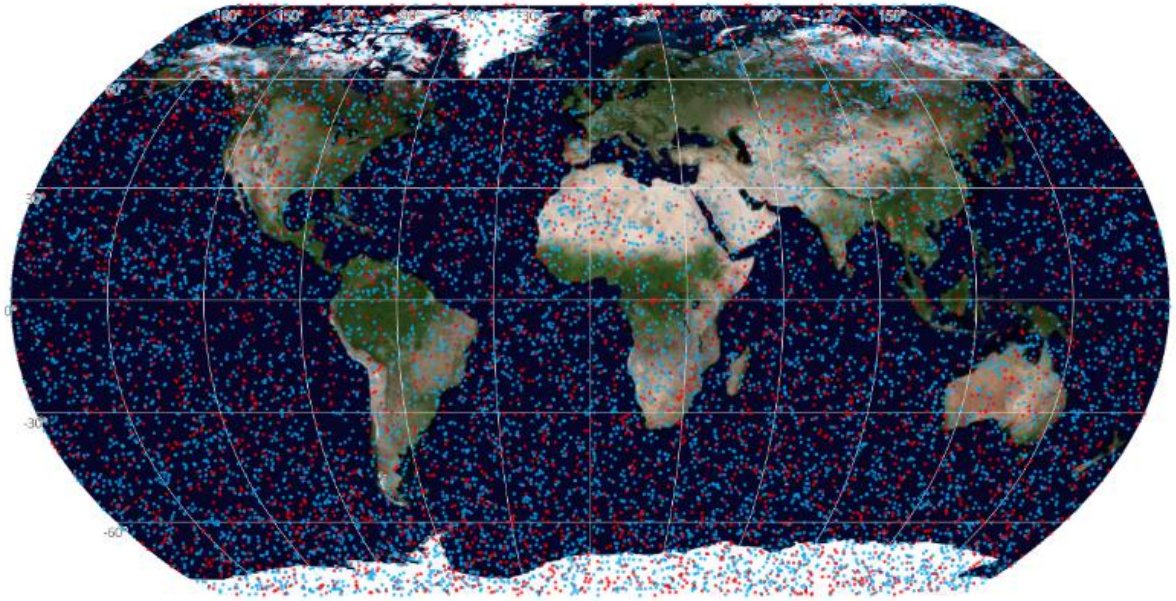
- Reach over **35,000 per day**



Global atmospheric profiles

Electron Density Profiles

- About **15,000 per day**



Global electron density profiles

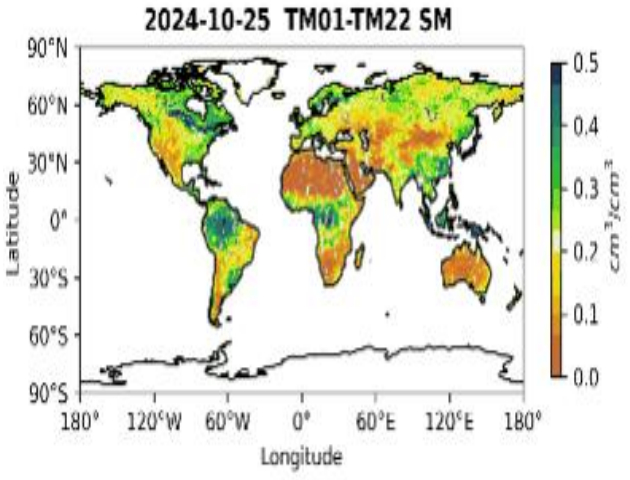
Synergy I: Enhanced Coverage & Resolution

Specialized small-sats (Tianmu-1) complement comprehensive large-sats (FengYun).

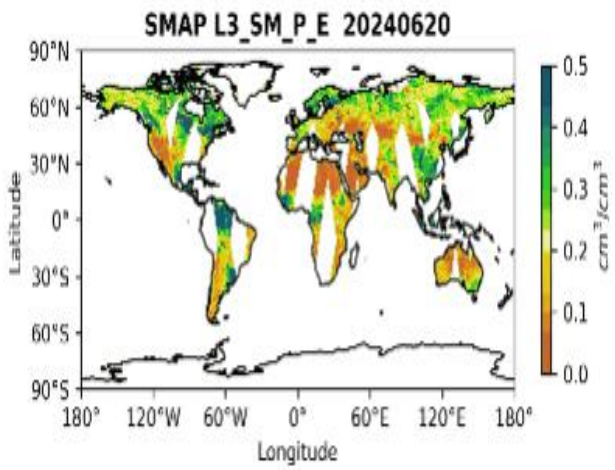
① Coverage Capacity: Massive Data Volume

Soil Moisture

- **1.6 million data points per day**
- **Broader spatial coverage compared to SMAP**



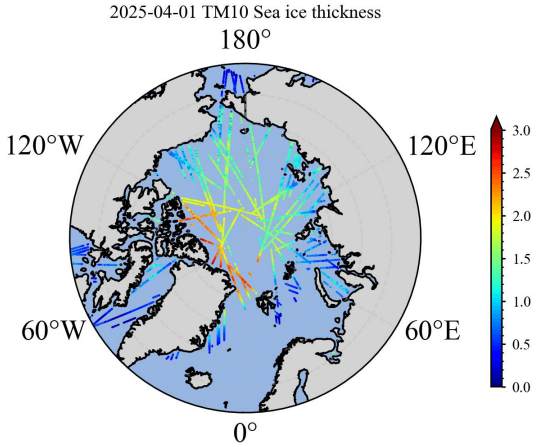
Daily Soil Moisture Distribution of **Tianmu-22 Satellites**



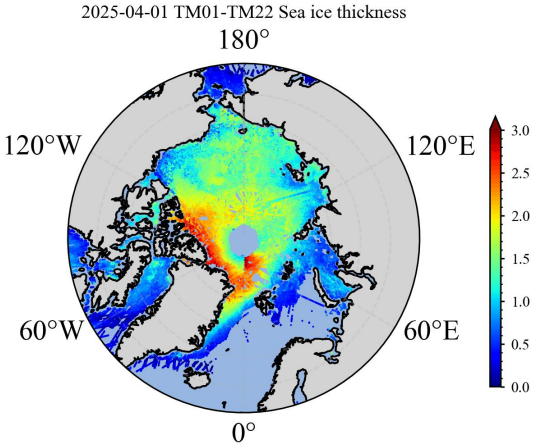
Daily Soil Moisture Distribution of **SMAP**

Sea Ice Thickness

- **150,000 data points per day**
- **enabling detailed polar mapping**



Sea ice thickness of Tianmu (**one** satellite per day)



Sea ice thickness of Tianmu (**22** satellites per day)

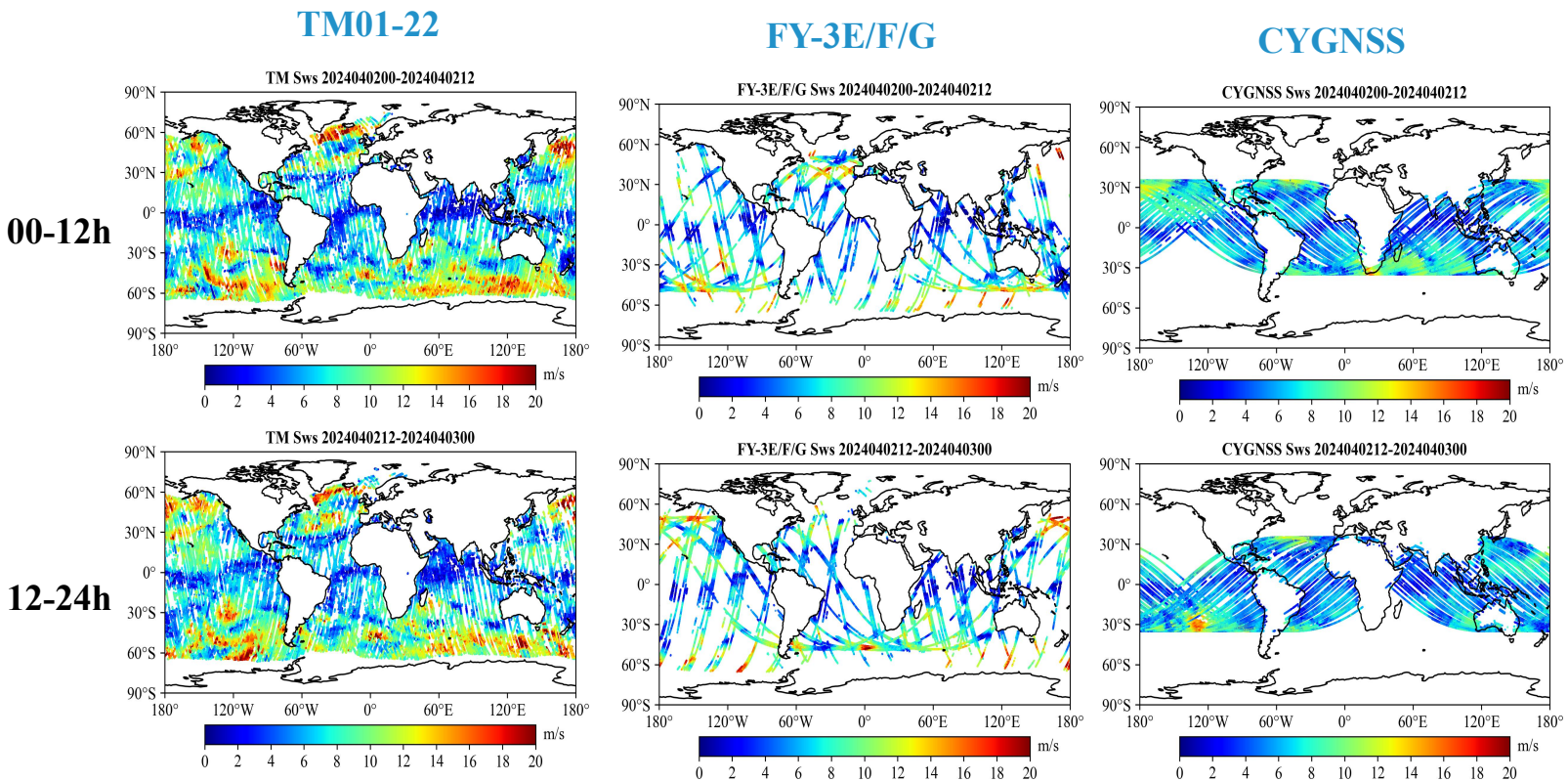
Synergy I: Enhanced Coverage & Resolution

Specialized small-sats (Tianmu-1) complement comprehensive large-sats (Fengyun).

① **Coverage Capacity**: Massive Data Volume

Sea Surface Wind Speed

- **3.5 million data points per day**
- **Latitude coverage advantage**
  - **Tianmu: 67°N to 67 ° S**
  - **CYGNSS: 40 ° N to 40 ° S**

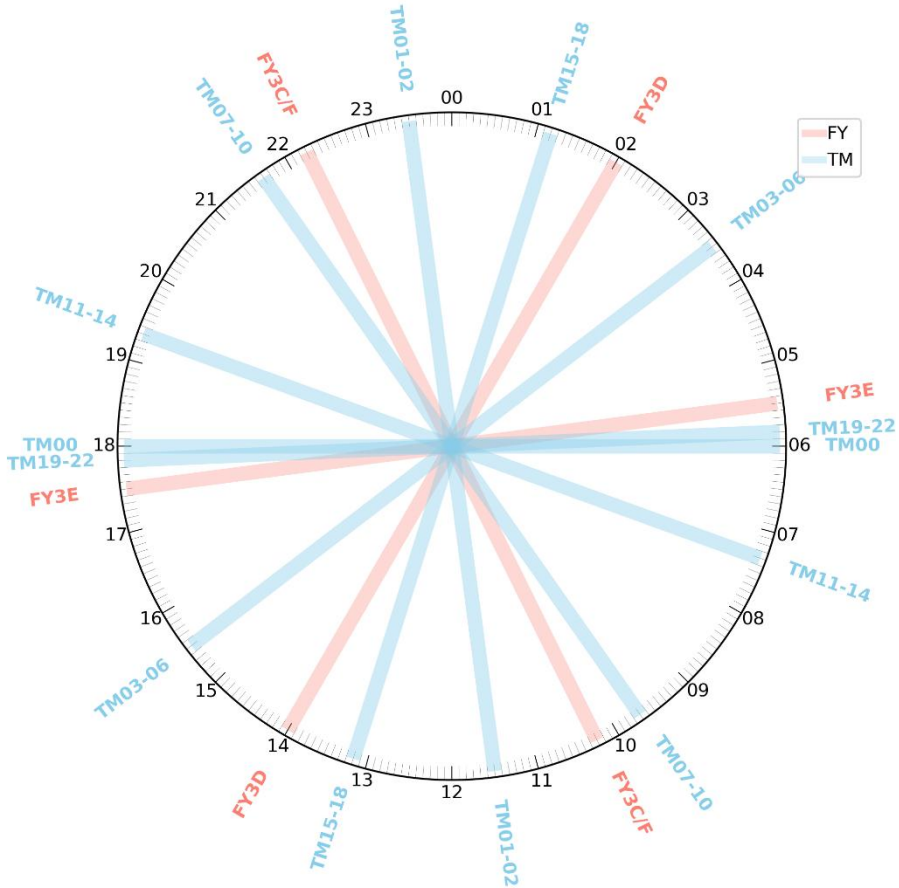


12-hour global sea surface wind distribution of April 2, 2024

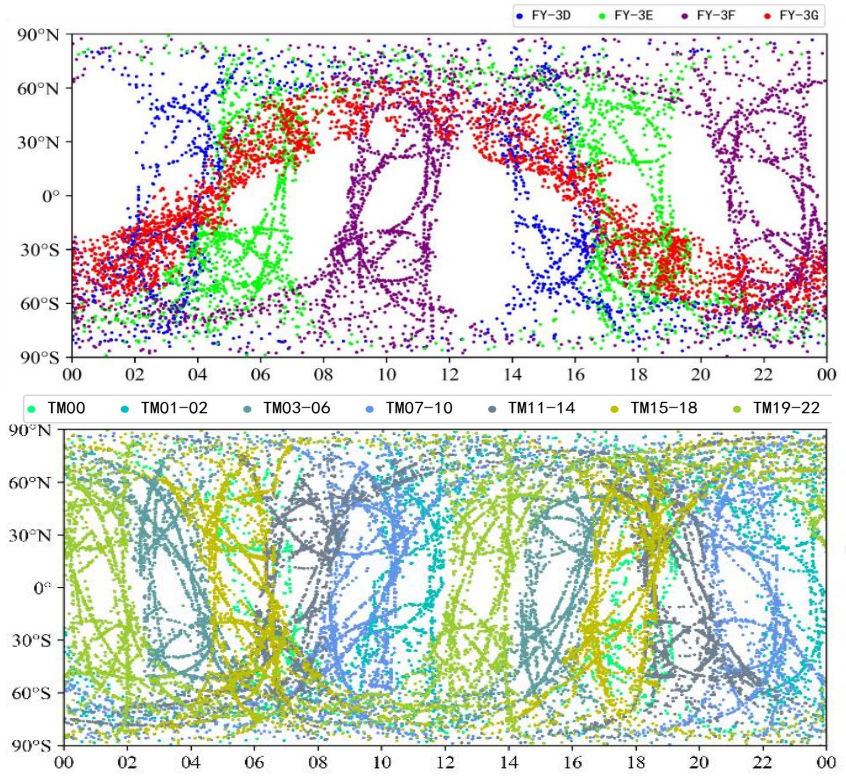
Synergy II: Complementary Local Time Coverage

② Local Time: seven orbital planes, each with a unique local time.

- **Diverse Local Time Coverage**
- **Complements FengYun's coverage:** Early-morning, Mid-morning, and afternoon



FY	TM
	7:20
Early-morning	
5:30	09:40
	11:30
Mid-morning	
10:15	13:10
	15:30
Afternoon	
14:00	17:50
	18:00



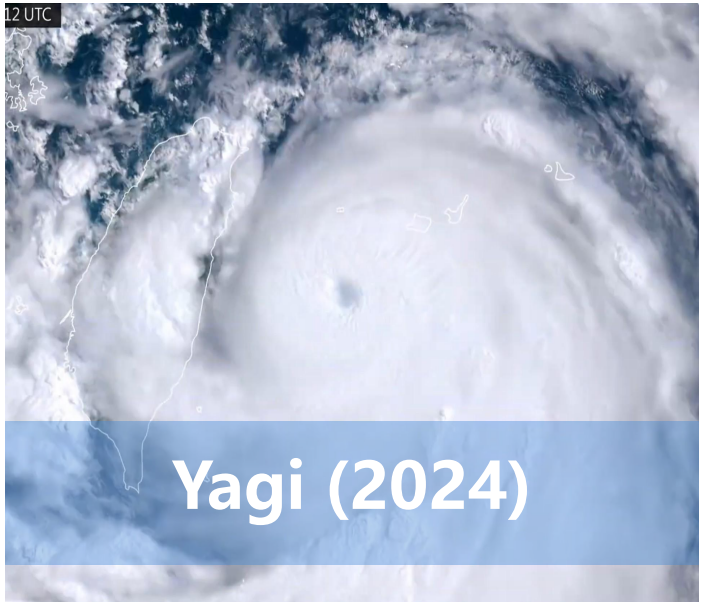
FY

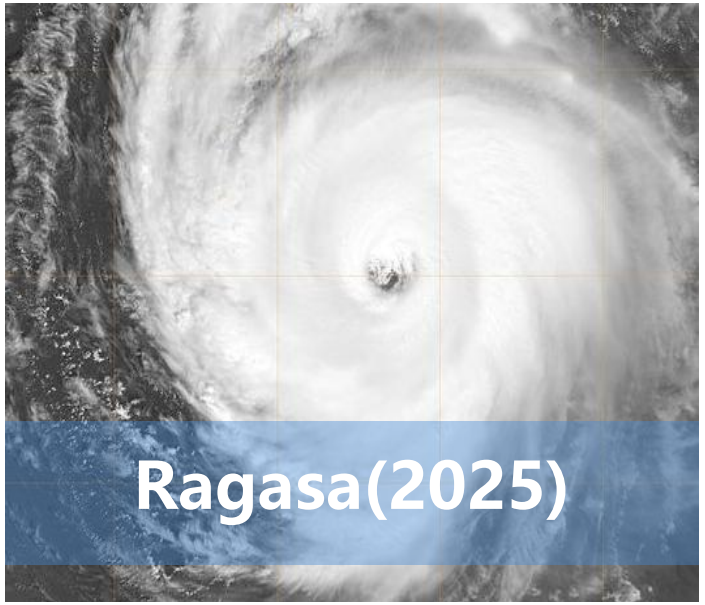
TM

Case Study: Typhoon Monitoring and forecasting - The Power of Synergy

Unaffected by clouds/rain, Tianmu penetrates the eyewall to see the internal typhoon data.

- **Dynamics**: sea surface winds
- **Thermodynamics**: atmospheric profiles





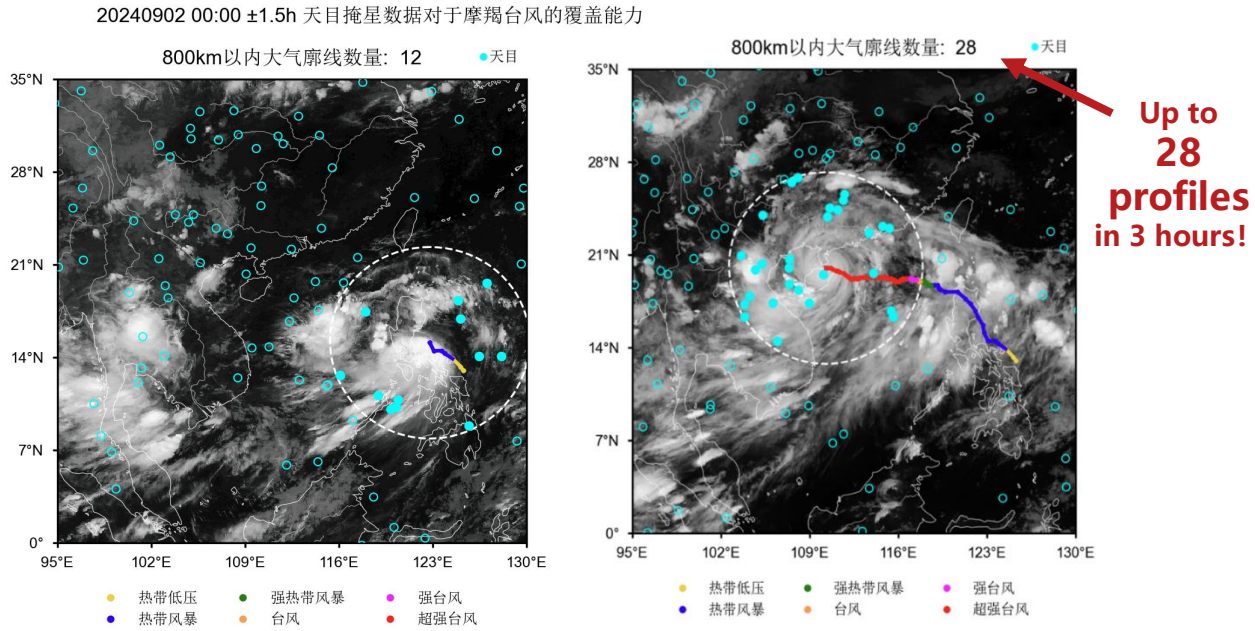
Synergy value

- **This combined view is crucial for accurate intensity analysis and track prediction.**

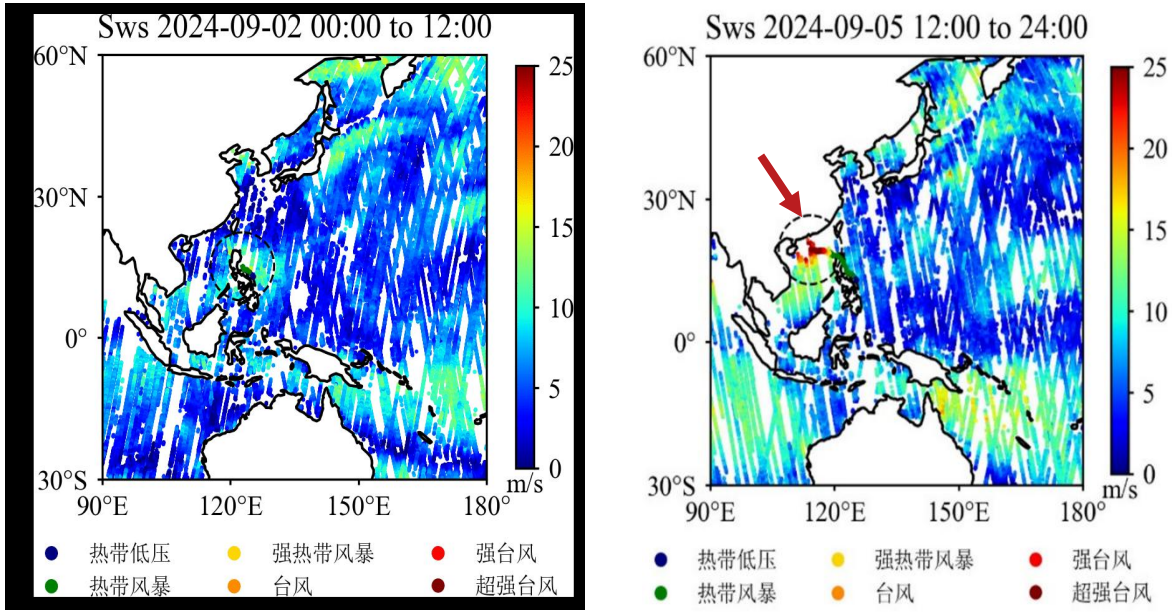
Typhoon Case: Yagi (2024)

Monitoring Capabilities of the Tianmu Constellation for Yagi (2024)

3-hourly distribution of Tianmu atmospheric profiles



12-hourly distribution of Tianmu sea surface wind speed



- Within 800km radius from the eye：
  Up to **28** atmospheric profiles in a **3-hour** window.

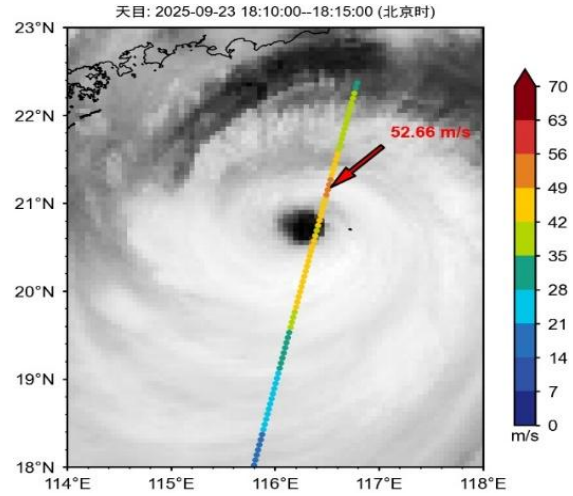
- **Clearly** mapping the evolving wind structure **every 12 hours**.

Typhoon Case: Ragasa(2025)

Monitoring Capabilities of the Tianmu Constellation for Ragasa (2025)

Mapping the Complete Wind Structure

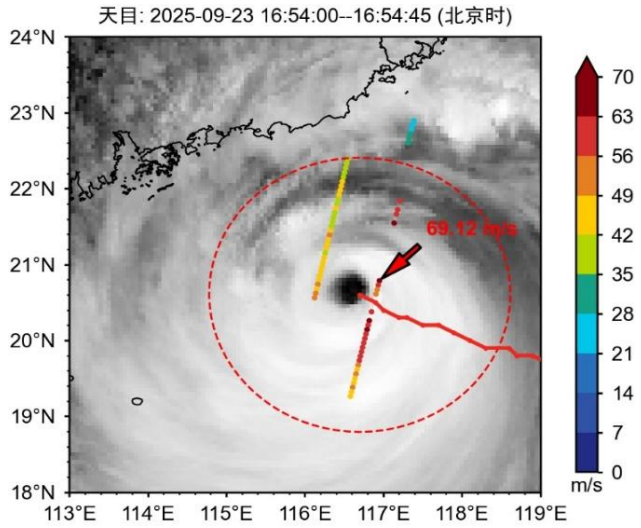
Tianmu SWS & RCM2 SAR



Tianmu SWS & FY cloud image

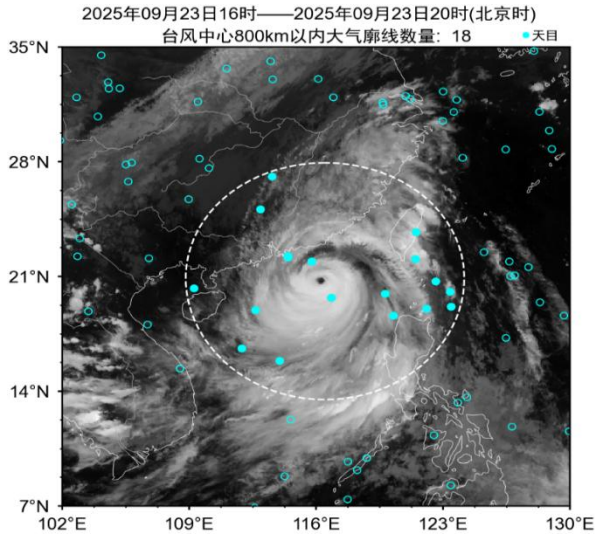
- Captured
  - 52 m/s **in the eyewall**: highly consistent with the 55 m/s reported by CMA
  - the significantly lower wind speeds **in the eye**
- outlines the **full dynamic structure**

Capturing Extreme Wind



- Measured a peak wind speed of **69.12 m/s** right in the eyewall
- provides critical measured data for assessing Typhoon intensity

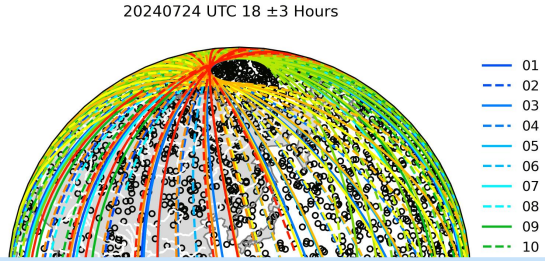
3D Thermal Scanning

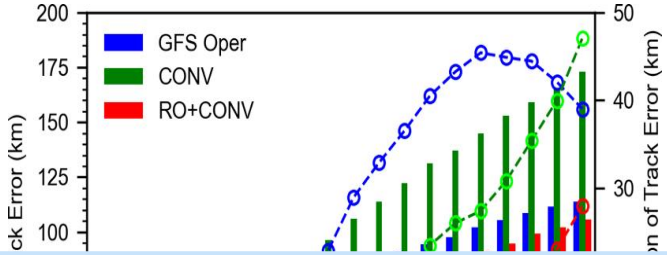


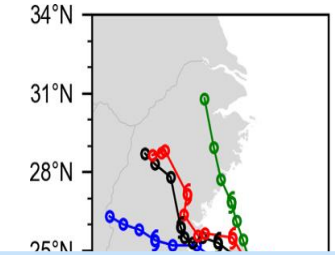
- Obtained **18** atmospheric profiles within 800 km of the eye
- revealing its vertical thermal structure and water vapor transport

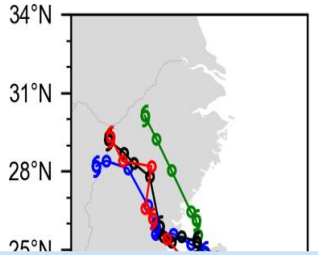
Typhoon Case: Gaemi (2024)

Forcasting Capabilities of the Tianmu Constellation for Gaemi (2024)









- **Highlights the increasing role of commercial RO data in Numerical Weather Prediction (NWP).**
- **As long as there is enough RO data, it can reduce reliance on satellite radiation detection data.**

- **Massive data volume**
  - 7,841 RO profiles in a 6-hour window
  - 6x more than COSMIC-2

- **Forecast Improvement** assimilating Tianmu data
  - reducing 120-hour track errors to under 100 km
  - cutting errors by about 40%, with even greater improvements beyond 48 hours

04 The Future: From Synergy to Integration

Summary: A Validated Partnership

- **Supported by CMA**, Tianmu-1 has proven itself as a Key Partner to the FengYun system.
- The collaborative model has proven its value in **operational applications**.

Tianmu's advantages

- Agility
- Customizability
- Distributive deployment
- …

Enhance

FengYun's capabilities

- Coverage
- Resolution
- Specialized parameters
- …

From synergy to deep integration

- Deeper integration into CMA's ‘Global Monitoring, Forecasting, and Services’ strategy.
- Explore new joint application scenarios and sustainable business models
- Commitment to continuous innovation and collaboration with CMA and global partners.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