



Introduction of the NARA (aircraft) Typhoon Observation and its Model Impact

※ NIMS/KMA Atmospheric Research Aircraft

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Outline



- * **Motivation**
- * **Overview of NARA**
 - Specifications
 - NARA Airborne Observation Strategy
- * **Model Impact**
 - Data Assimilation
 - Forecast Improvement
- * **International Collaboration**



Why Discuss Aircraft Observation Now?



- ❖ Increasing uncertainty in intensity forecast
- ❖ Challenges in predicting rapid intensification
- ❖ Large uncertainty over the open ocean

Aircraft observations help reduce the observation gap over the open ocean.



Overview and Specifications



❖ **KMA established a national airborne observation platform in 2017.**

- **Acquired: Nov 2017**
- **First Flight: Dec 2017**
- **Operated by the NIMS**

Type	Beechcraft King Air 350HW
Engine	Turboprop
Dimensions (L/W/H)	14.22 / 17.65 / 4.37 m
Max. altitude	10 km
Max. endurance	5.5 hours
Crew	2 pilots, 1 researcher, 2 operators

After Modification





A Different Airborne Observation Strategy



Conventional Aircraft	KMA's Platform (NARA)
Large platform Inner-core focus	Small platform Environmental focus
Event-based observation	Sustained airborne observation >> Approximately 300-400 hours per year
Limited sensor diversity	Multi-instrument configuration

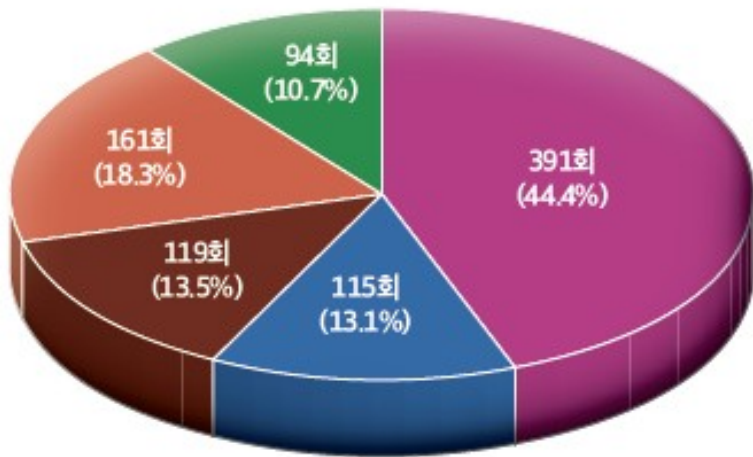
A hybrid operational-research airborne observation program supported by sustained government funding



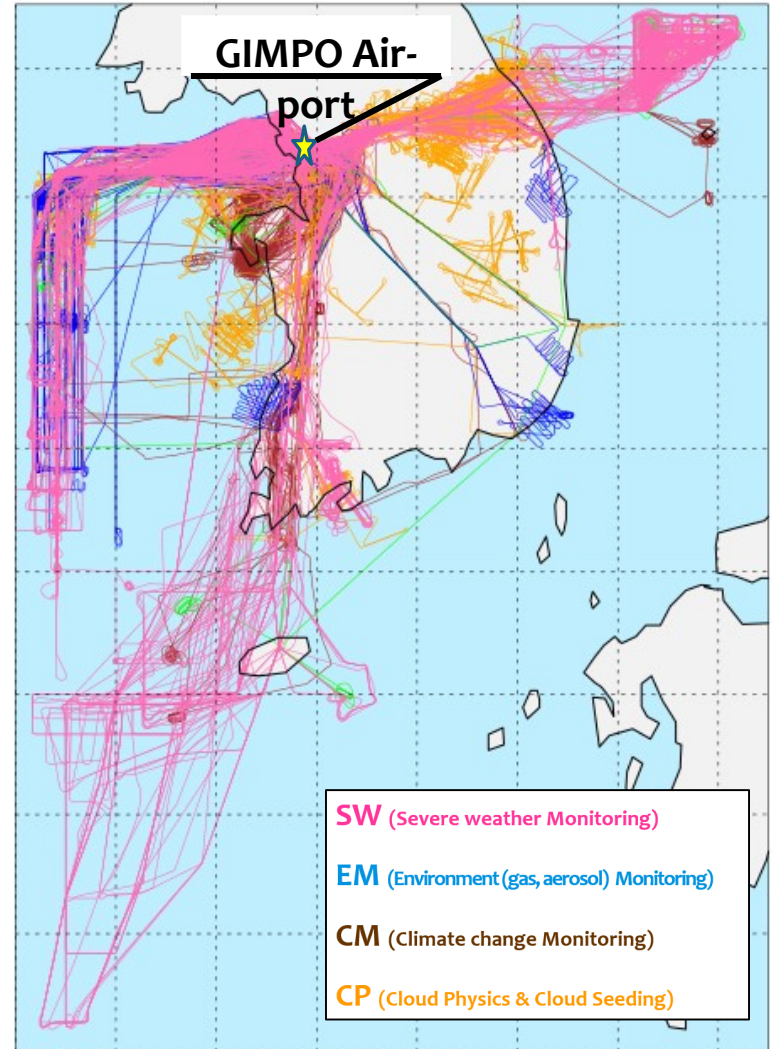
Sustainability as a Core Design Principle



- ❖ Continuous Growth of Operational Flights (2018-2025)
- ❖ Systematic Coverage of the Korean Peninsula and Surrounding Seas



As of Dec 2025





Flight Statistics from 2018 to 2025



❖ **NARA is not a short-term experimental campaign platform.**
 – **It is a sustained national airborne capability.**

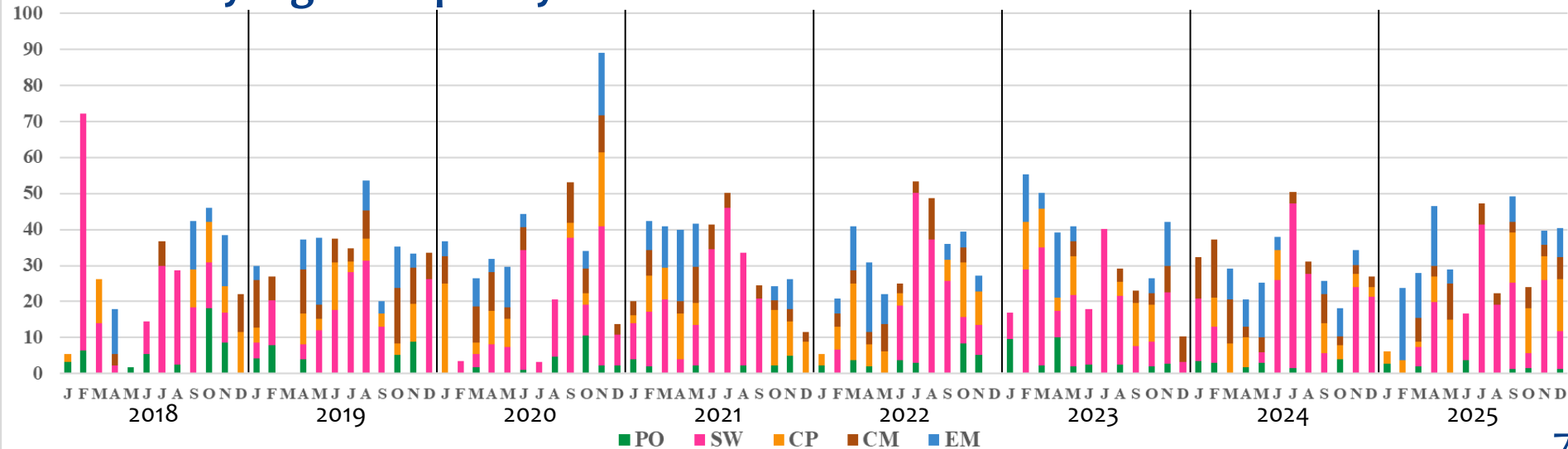
✓ Cumulative Flight Statistics

- Total Flight Hours: **2,999.2 hours** / Annual Average: approximately **300-400 hours**

✓ Statistics of Severe Weather Monitoring

- **Typhoon (#45, 11.5%)**, Rainfall (#193, 49.4%), Snowfall (#62, 15.9%), Others (#91, 23.3%)

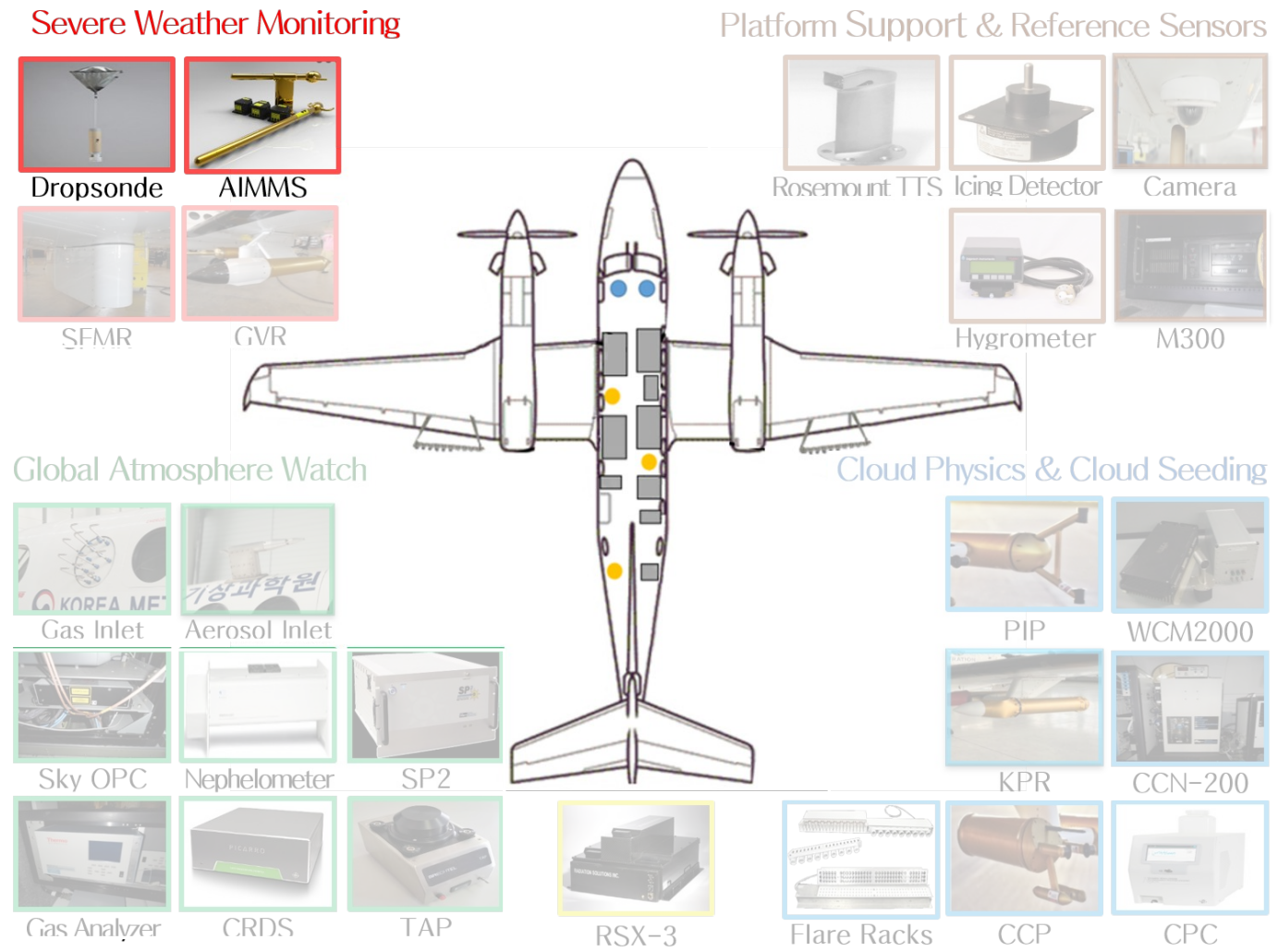
❖ Monthly flight frequency





Multi-mission Platform

❖ A permanently integrated multi-instrument platform designed for sustained and simultaneous multi-mission operations.





Instruments for SW



- ❖ Dropsonde data are directly assimilated into KMA operational NWP model.
- ❖ AIMMS-20 data are also assimilated, currently at the preliminary research stage.

✓ Vertical Observation

Dropsonde

- P, T, RH, WS & WD
- 4 channels



✓ Horizontal Observation

AIMMS-20

(Aircraft Integrated Meteorological Measuring System-20)

- T, P, RH, u, v, w



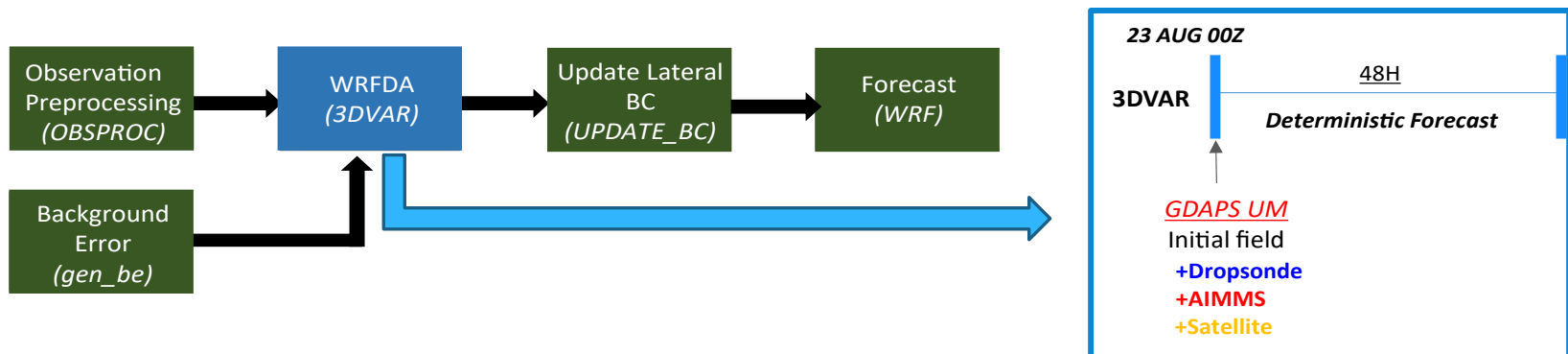


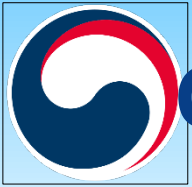
Model Configuration

❖ Regional model configured similarly to KMA operational model (KIM-Meso).

❖ Aircraft observations are included in data assimilation framework.

- WRF V.4.1.2 configured with a physics suite similar to KMA KIM-meso
- Initial/background fields: UM GDAPS, NCEP FNL
- Observations: NCEP Observation (SYNOP, SHIP, SATOB, SOUND, PROFILER, METAR), **Aircraft (Dropsonde, AIMMS)**, Satellite (IASI, AMSU-A, MHS, ATMS, GK-2A, AMSR2)

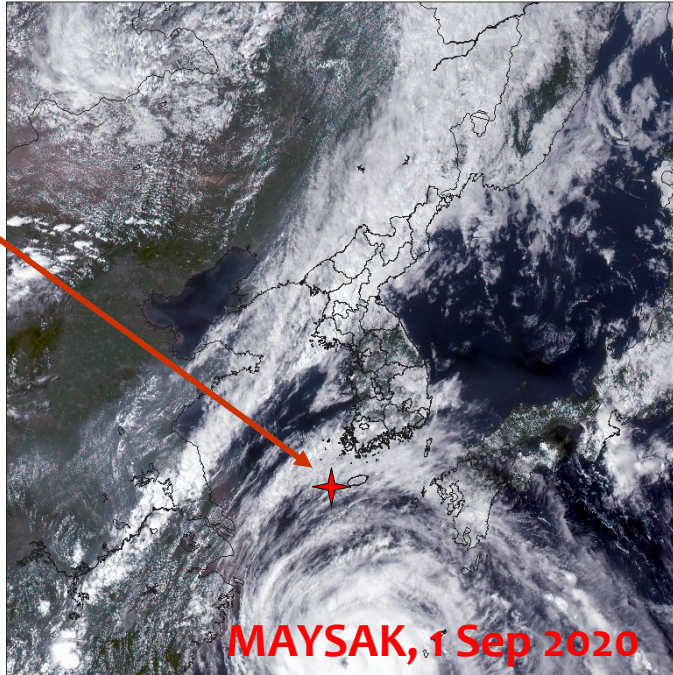




Case Study: Typhoon MAYSAK (2020)

1 Sep 2020

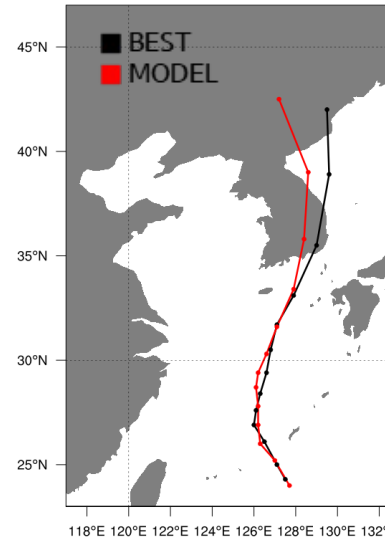
GK2A



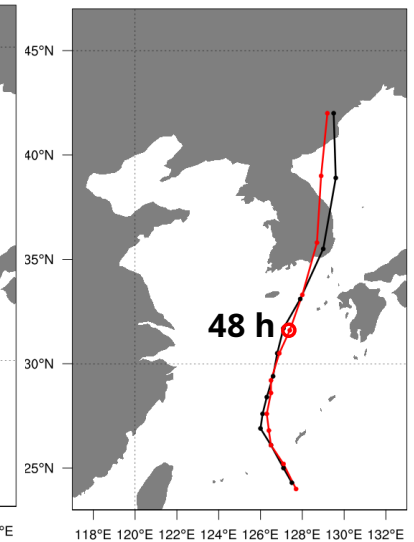
MAYSAK, 1 Sep 2020

- Improved performance after 48-hour forecasts
- Reduction in mean track error: 20 km
- The largest improvement was found at 72-hour forecast lead time (172.5 km).

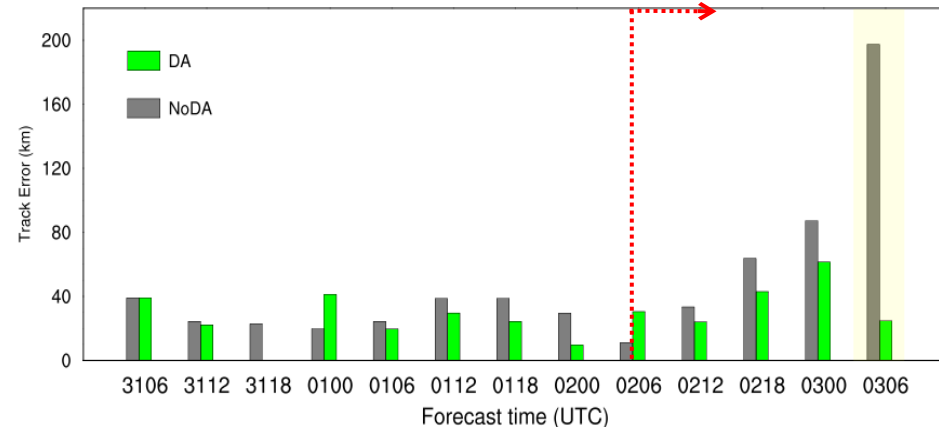
No Data Assimilation (NoDA)



Data assimilation (DA)



<Time series of track simulation error>



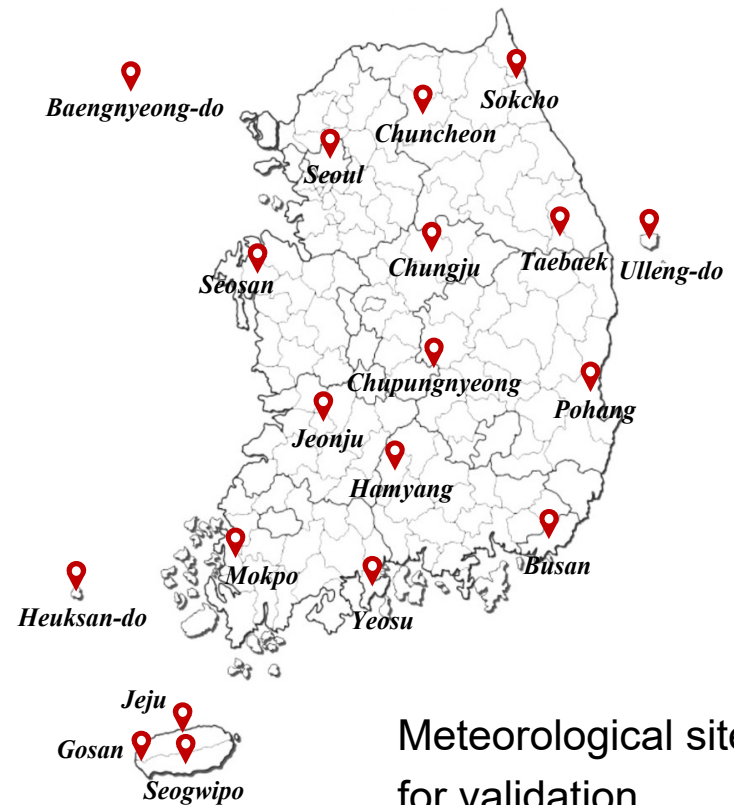
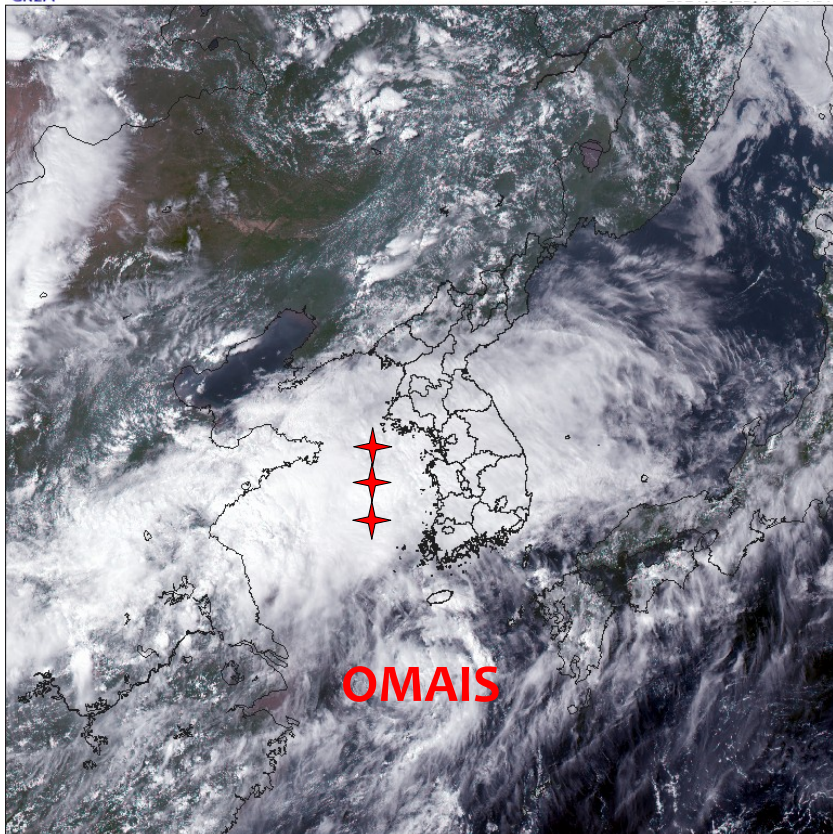


Case Study: Typhoon OMAIS (2021)

- Typhoon: OMAIS (2021)
- Model simulation period: 23 Aug 2021 (48-hour forecast leadtime)
- Data assimilation Input: Dropsonde, AIMMS-20
- Validation : 19-21 surface observation stations

23 Aug 2021

GK2A



Meteorological sites for validation



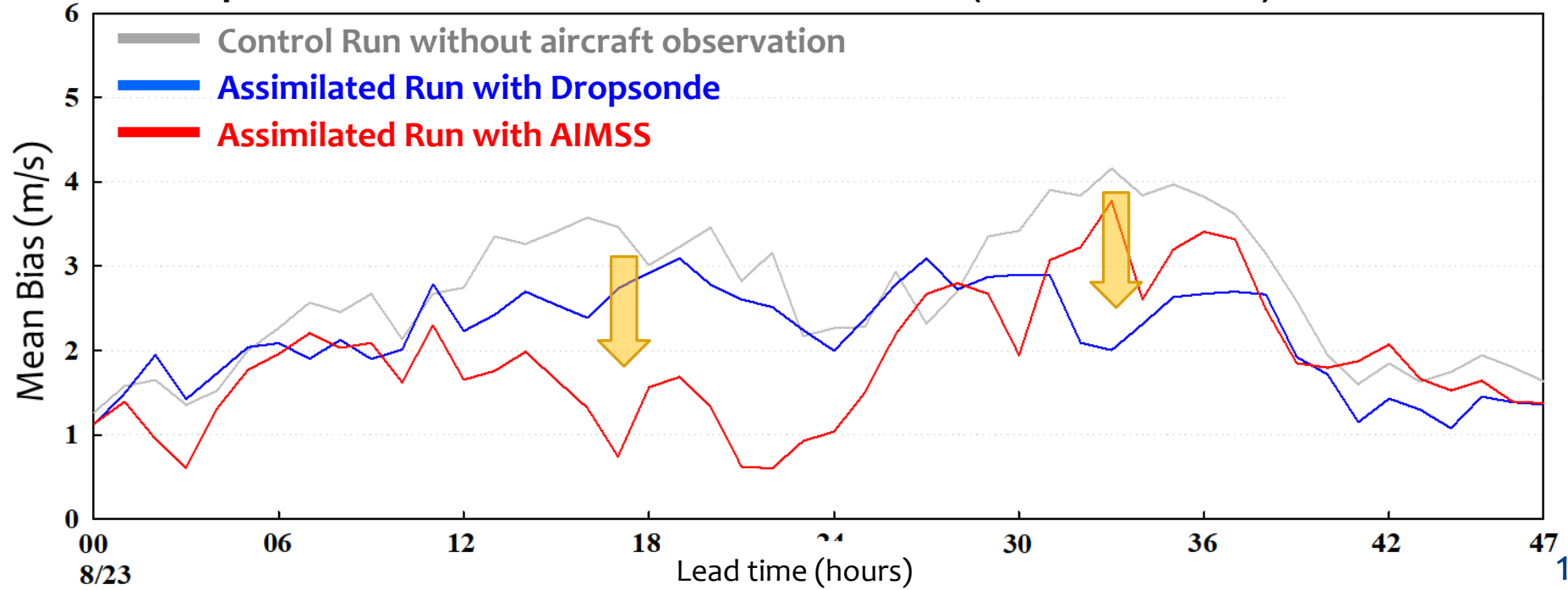
Forecast Improvement for OMAIS



- ❖ 48-hour model simulations with and without airborne data assimilation
- ❖ Data assimilation improves surface wind prediction skill.
 - Mean 48-hour wind speed error reduction: Dropsonde (11.3%), AIMMS-20 (14.4%)

Airborne data assimilation provides measurable forecast improve-

Model-predicted 10m wind – surface observations (mean of 19 sites)





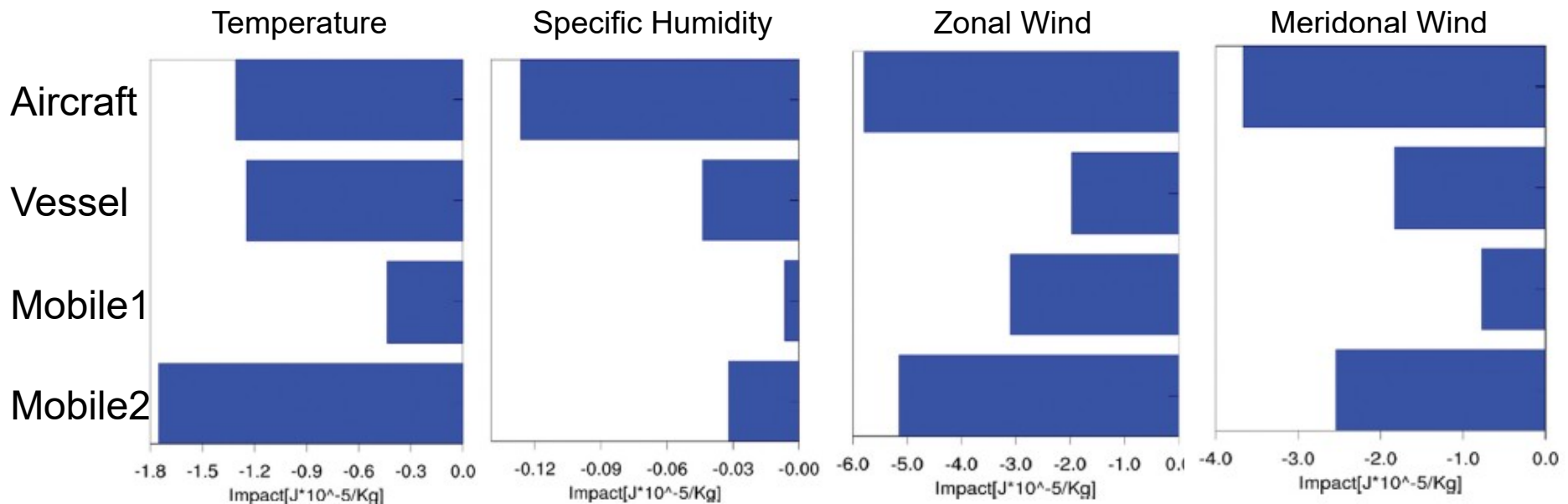
Statistical Impact Assessment (EFSO)

❖ Impact assessment based on ensemble forecast sensitivity to observations (EFSO)

- Summer heavy rainfall season

- Negative EFSO values indicate positive contribution to forecast skill.

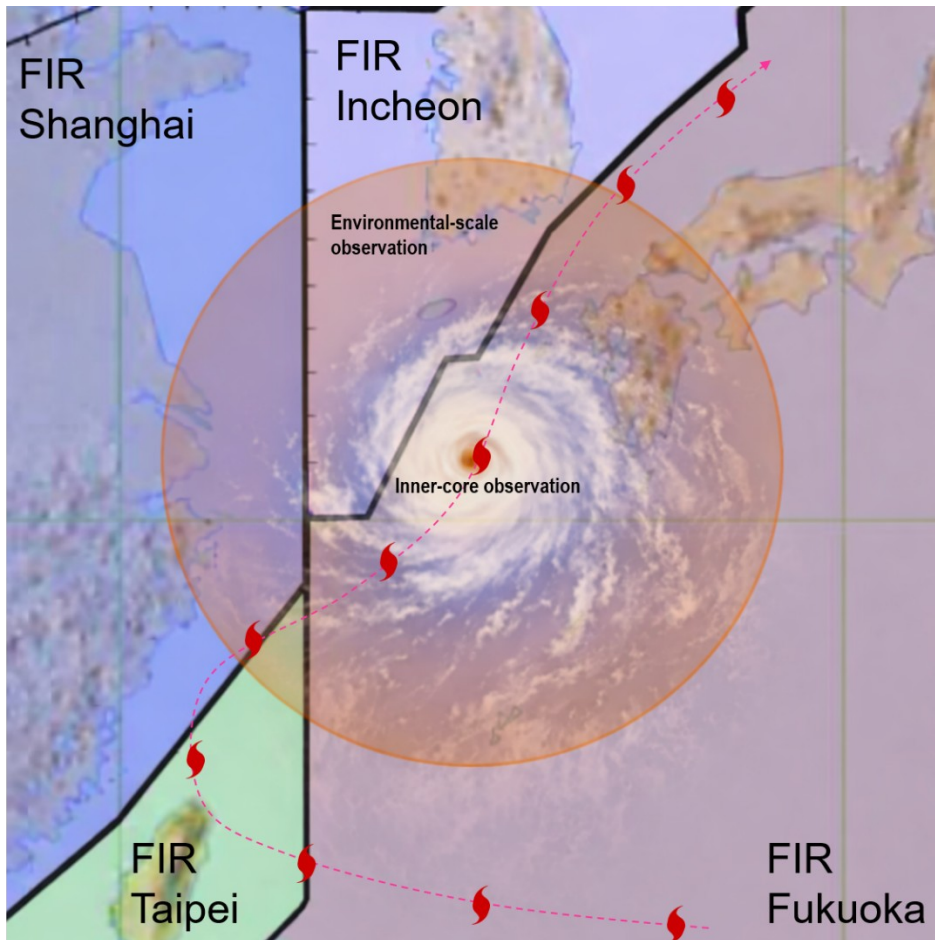
This confirms the operational value of airborne observations beyond typhoon cases.



(Hwang et al., 2025)



International Collaboration



- ❖ Both inner-core and environmental observations are essential.
- ❖ However, the spatial footprint of a typhoon frequently extends across multiple FIRs, highlighting the need for coordinated international observation and data sharing.



Summary



- ❖ Sustained capability
 - Approximately 300-400 flight hours annually since 2018
 - Institutionalized national airborne program
- ❖ Integrated platform for simultaneous multi-mission operation
- ❖ Operational Integration
 - Dropsonde data directly assimilated into operational NWP model
- ❖ Model Impact
 - Demonstrated approximately 5-15% forecast improvement

An integrated and sustained airborne capability
providing measureable operational value



Thank you for your attention!





Dropsonde Statistics from 2018 to 2025



- **Accumulated Quantity : 2,143**
- **Annual Mean Quantity : approximately 250**

