기상청 책임운영기관 국립기상과학원

# Incorporating AI/ML into Weather Forecasting

## : Operational use and Forecaster feedback

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# WHY AIphaWeather

Climate Crisis

Consumer Request

Observation Data

New source

NWPs

Extreme Weather

New Request

Weather Forecaster

Weather Forecast

Forecasting Accuracy

Consumer Perception of Accuracy

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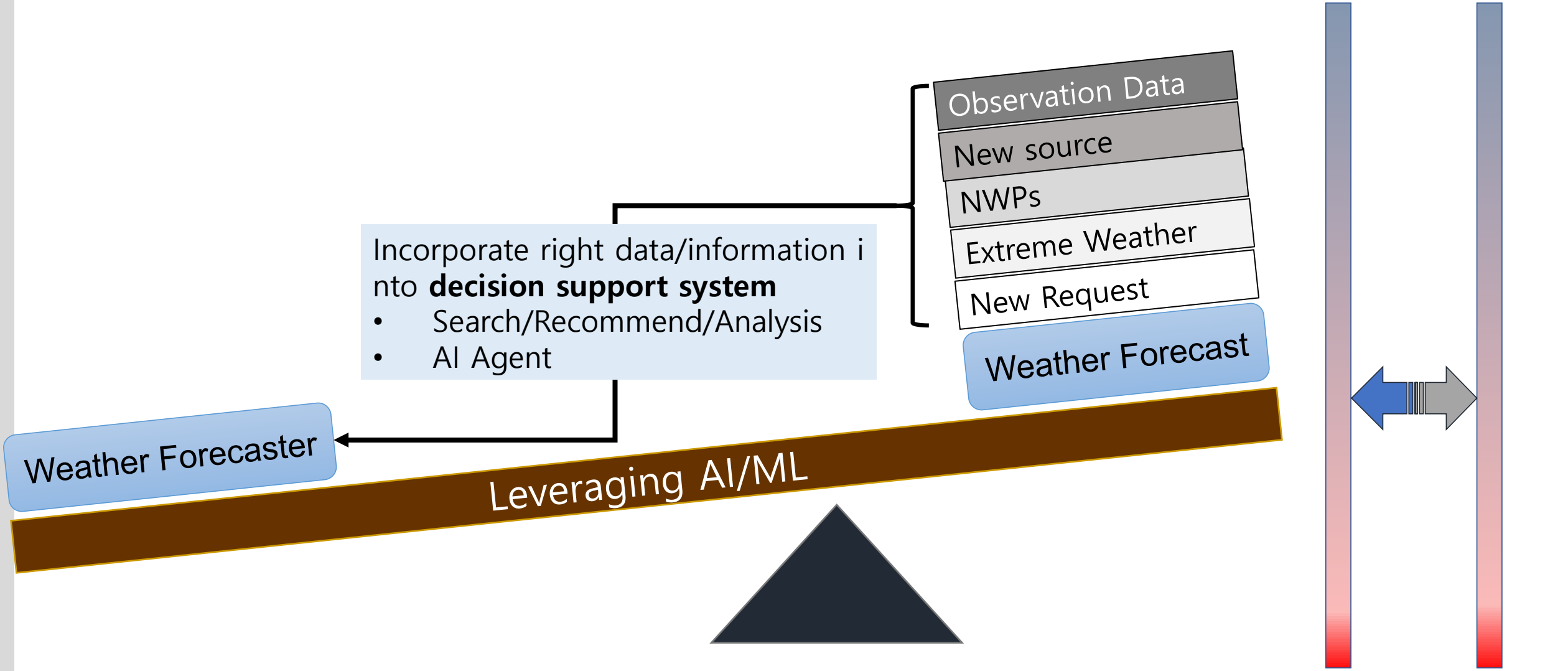
# WHY AIphaWeather

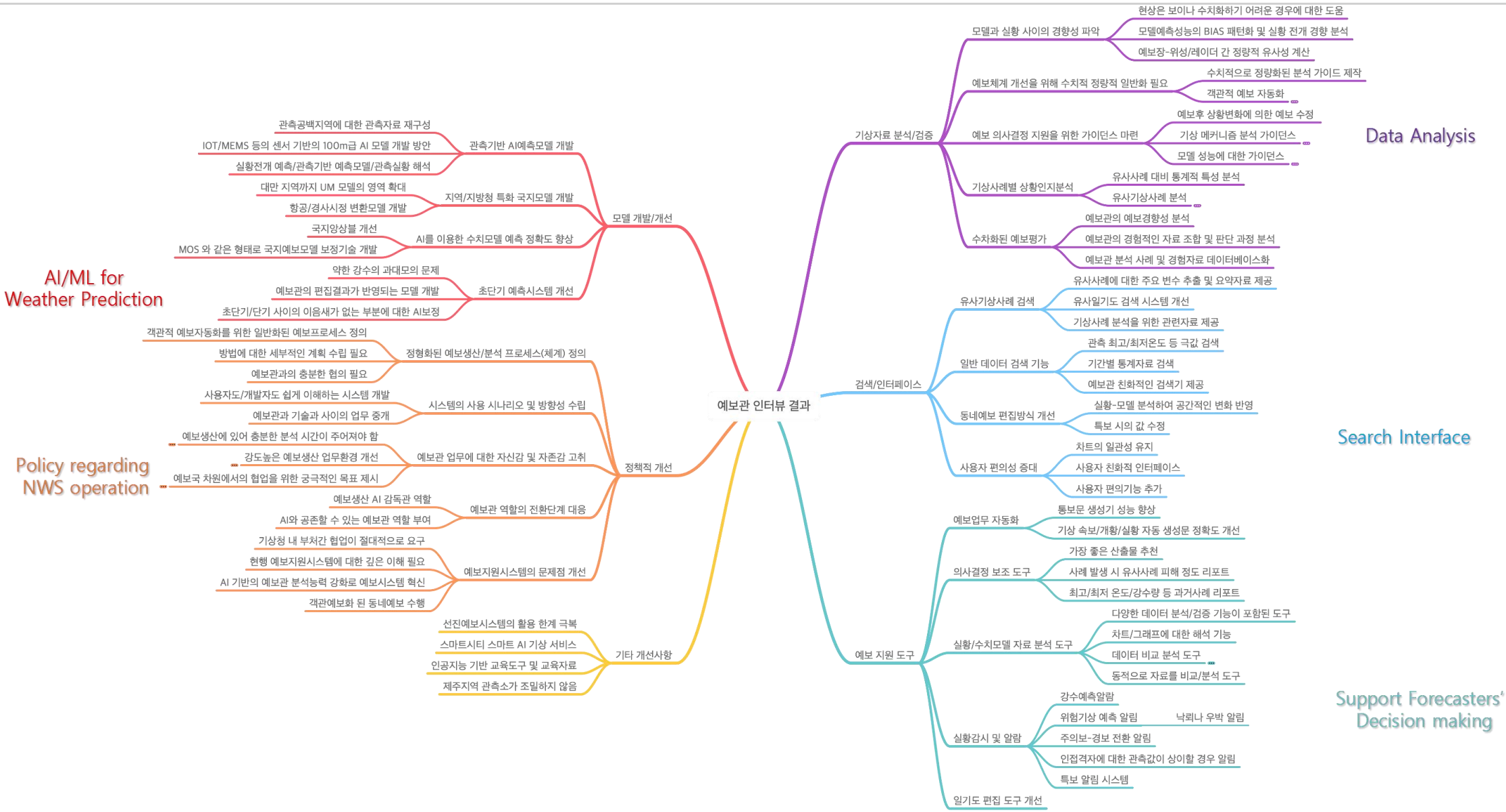


# AIphaWeather is

## Intelligent AI-Agent :

- To be incorporated into
  Next-Generation Forecast Decision Support System of KMA
- To be “3) Quick & 4) Accurate”
- Data/Information 2) Tailor
- Minimization or 1) Automation to support decision-making proces
  s

# Collect the needs from Forecasters



# Collect the needs from Forecasters

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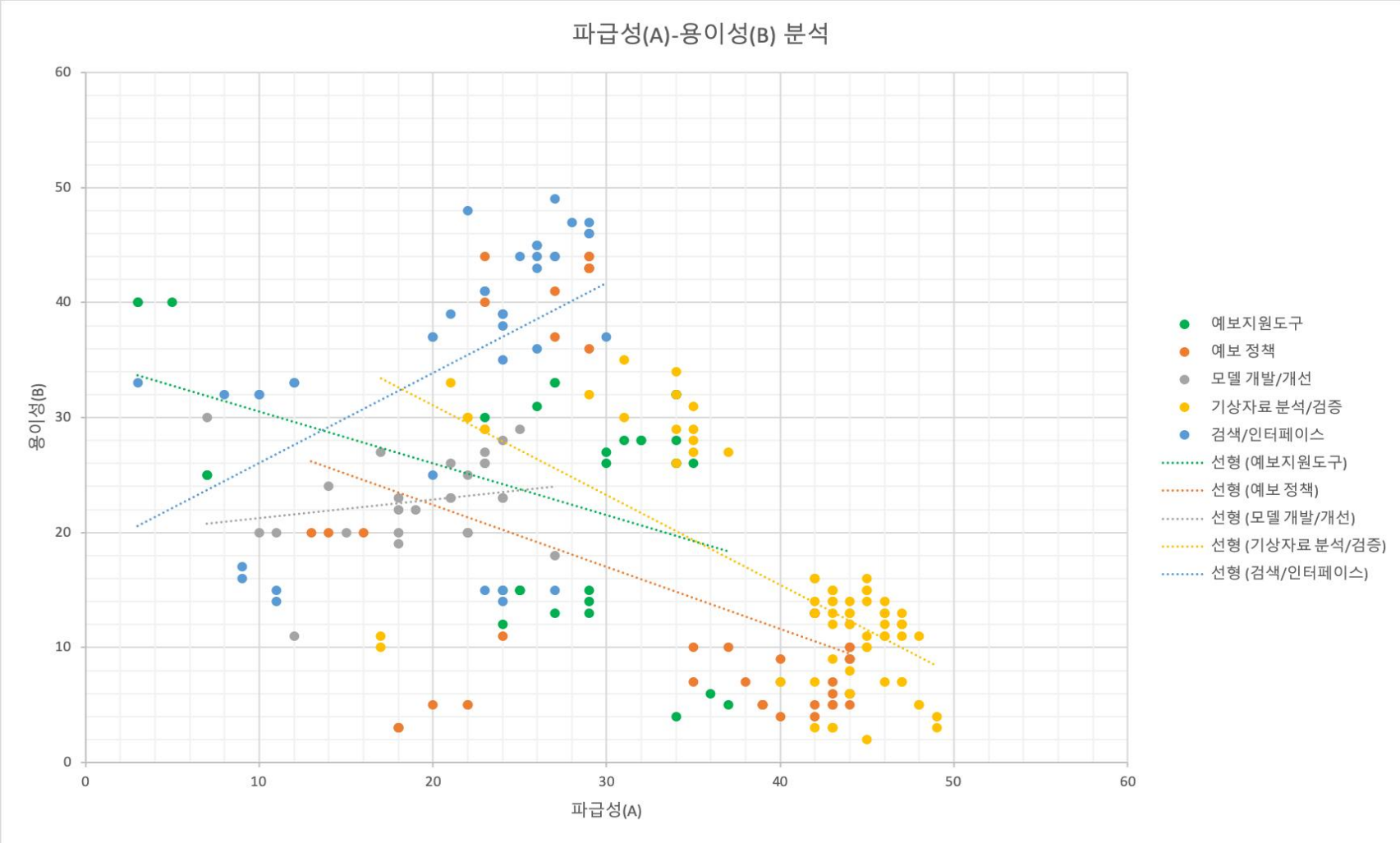
## Ease of doing vs. Impact



# Collect the needs from the field

| | |
|---|---|
| AI/ML for Weather Prediction | Nowcasting, Medium-range forecast , Foundation model |
| Data Analysis | Trend analysis of Bias btw. NWP and Observations |
| Search Interface | Natural Language Processing-based Weather information Retrieval Engine |
| Support Forecasters' Decision making | Similar Case Retrieval System, Interpretable AI model for analyzing Meteorological Mechanism |

# Mid-term('25-'27) Implementation Plan

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## AI-NWP Integrated Technology

1. AI Nowcasting Model
2. Medium-range weather forecasting
3. KIM Regional Reanalysis for EA
4. Ensemble based AI Guidance
5. AI Foundation Model for Weather and Climate

## Intelligent Decision Support for Weather Forecasting

1. AI Agent Technologies for supporting Weather Forecasting
2. Adaptation of LLMs to Weather and Climate
3. Interpretable AI/ML for Weather and Climate

## Governance & Capacity Building

1. Governance for AI Research and Technology Dissemination
2. Capacity building for AI Digital Literacy

**AI-Agent, AlphaWeather**

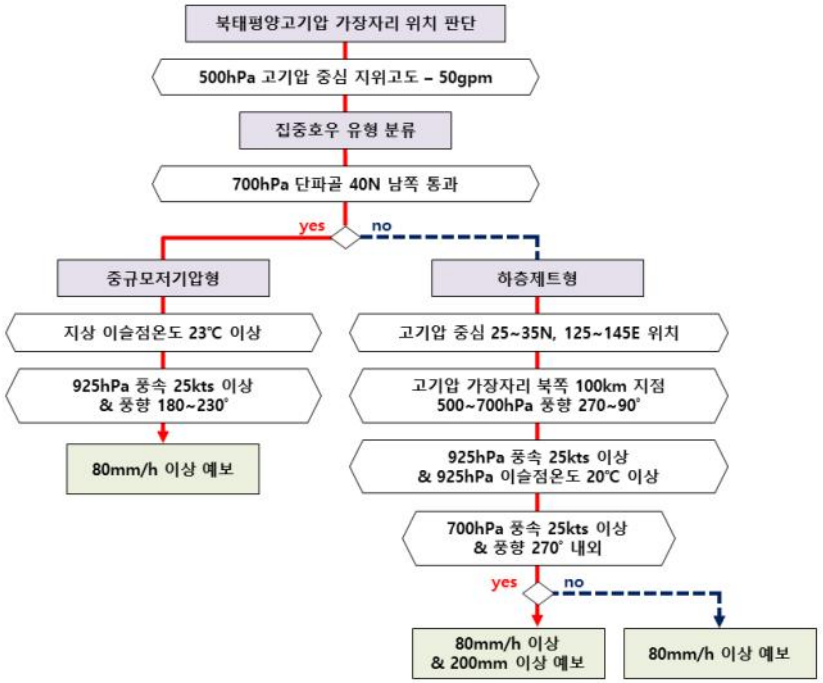
# Intelligent Decision Support for Weather Forecasting

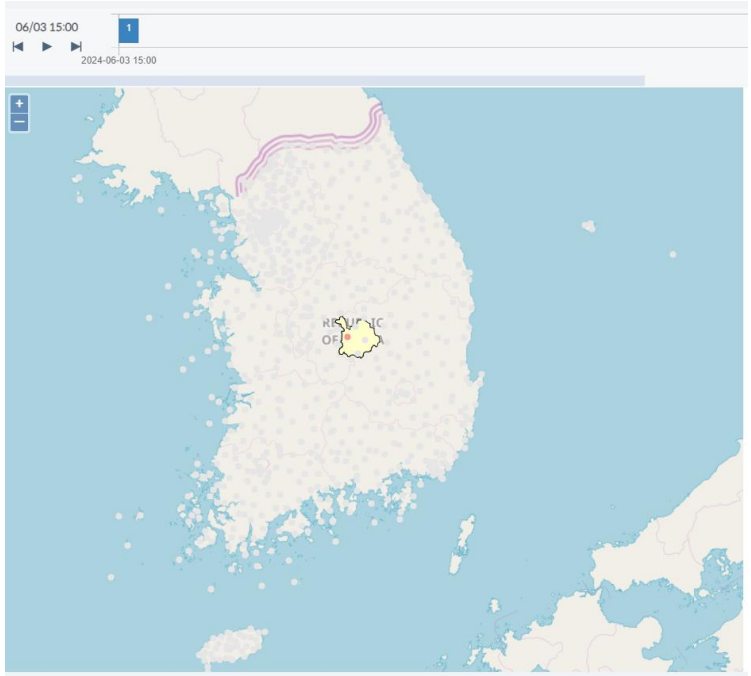
## Selection Criteria of Cognitive Process

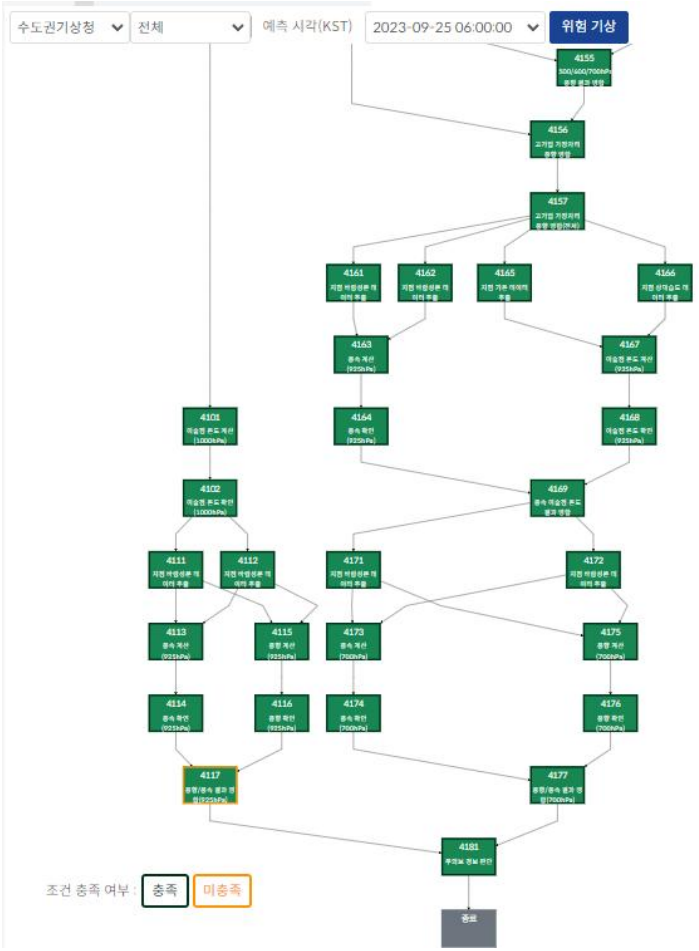
1. **Stability** : Process should NOT change very frequently
2. **Repetitiveness** : Process should REPEAT
3. **Reliability** : Process should be well-structured/-implement/-documented

# Intelligent Decision Support for Weather Forecasting

## Selection Criteria of Cognitive Process

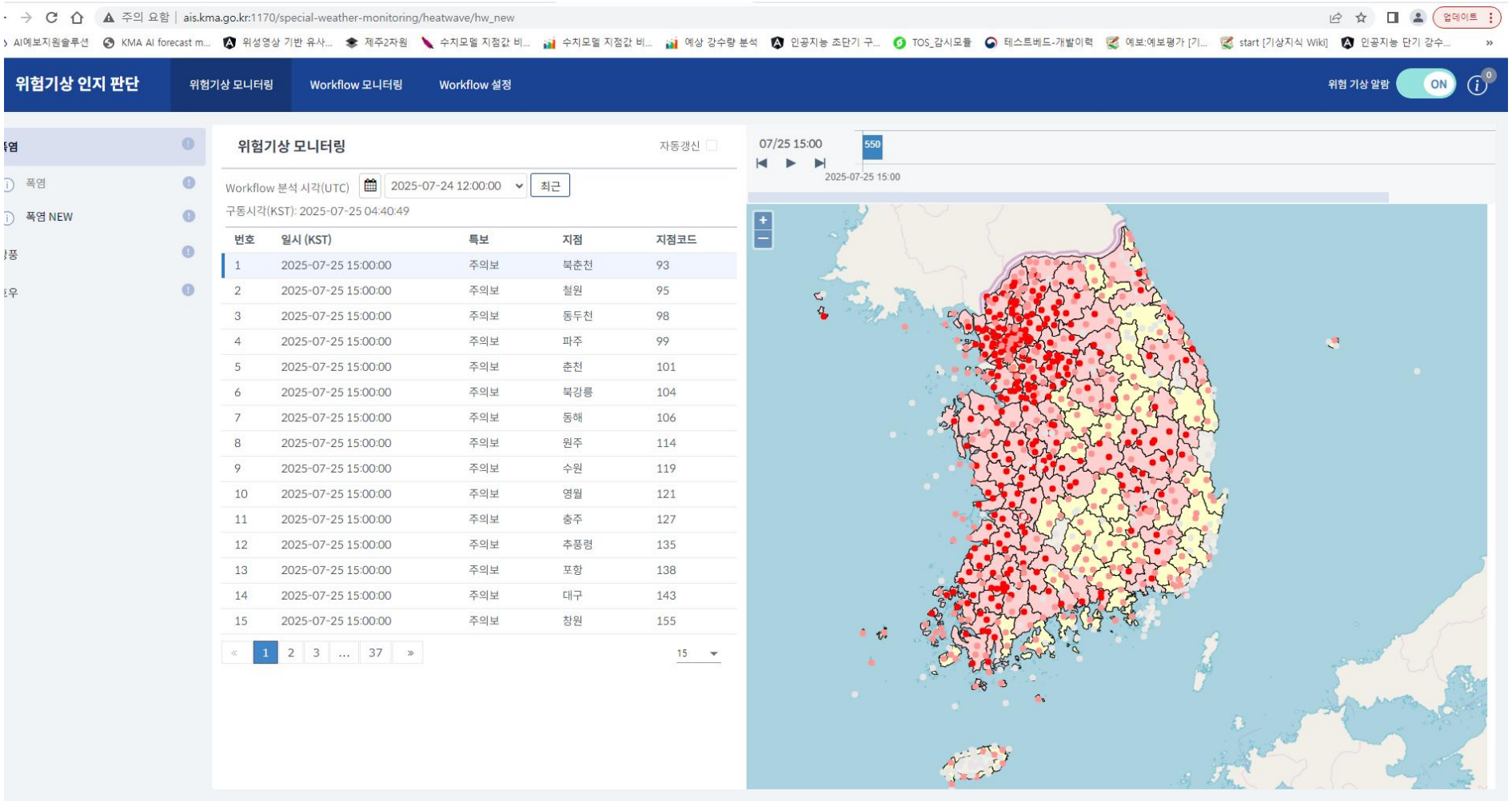


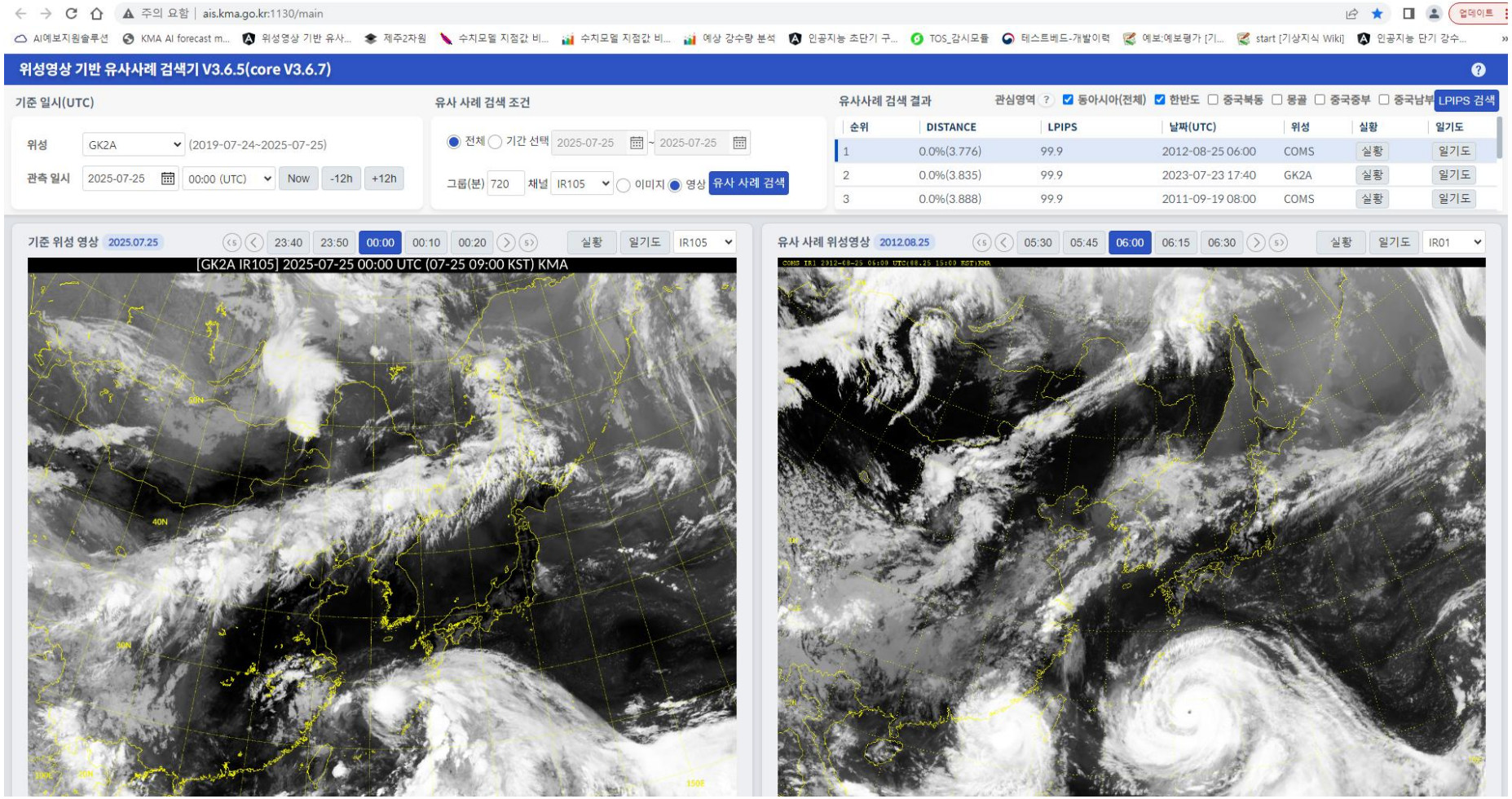
# Intelligent Decision Support for Weather Forecasting

## Selection Criteria of Cognitive Process



# Intelligent Decision Support for Weather Forecasting

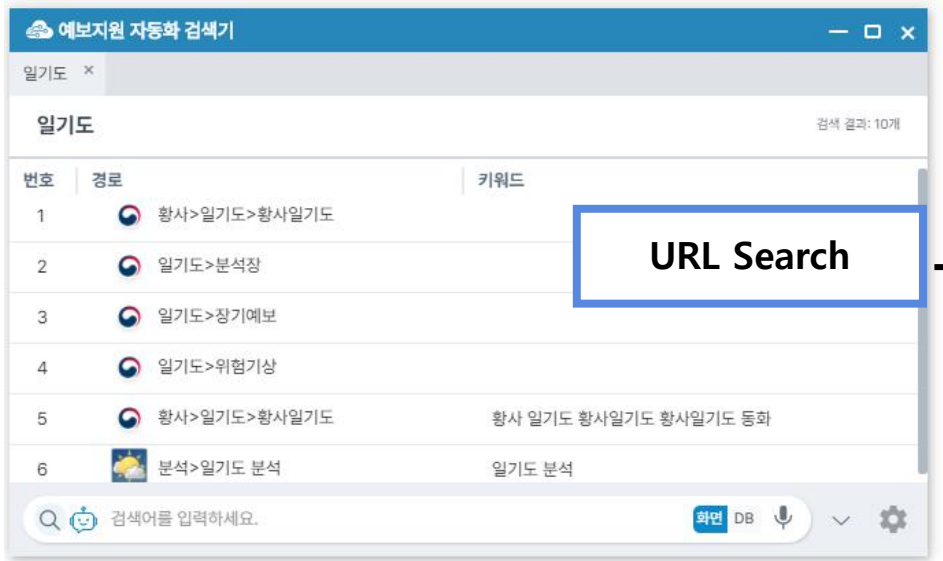
## Selection Criteria of Cognitive Process



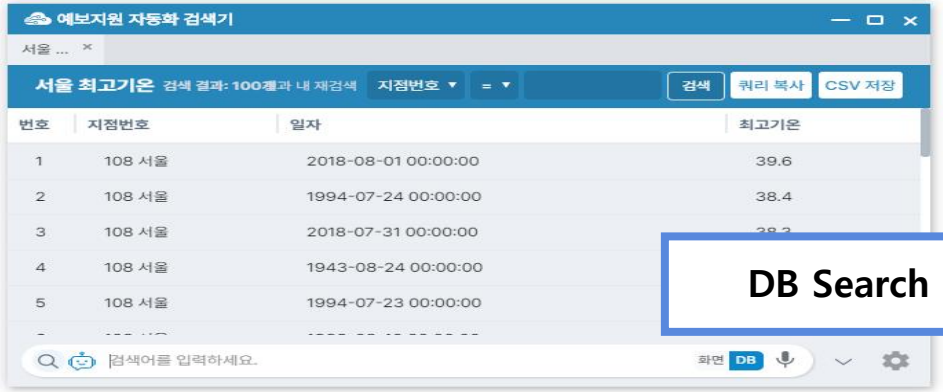
# Intelligent Decision Support for Weather Forecasting


URL & SQL query

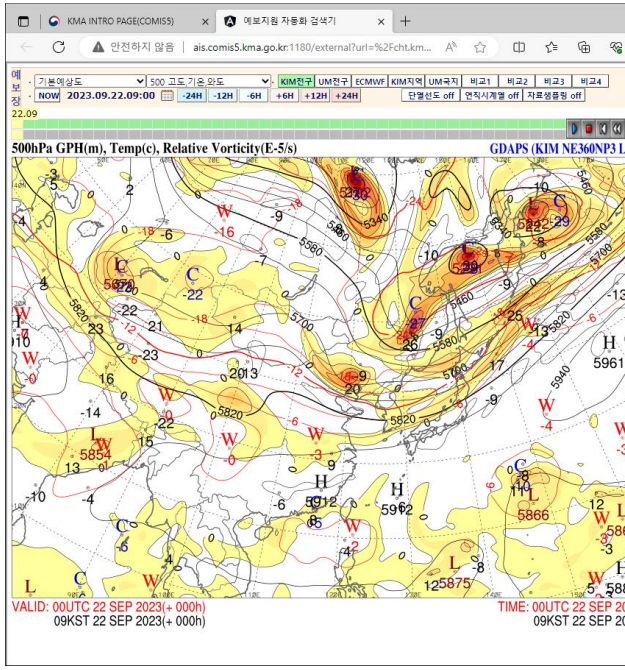
Speech/Text
(Wake up Language:Rabbit)


URL Search




DB Search



# Intelligent Decision Support for Weather Forecasting


| 모델버전 | 파라미터 | 추론시간(s) | 정확도(문항수) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 전체(100) | 1과목(20) | 2과목(20) | 3과목(20) | 4과목(20) | 5과목(20) | 텍스트(94) | 멀티모달(6) |
| Phi-4 (text only) | 14B | 1.70642 | 0.54 | 0.7 | 0.5 | 0.4 | 0.65 | 0.45 | 0.56 | 0.17 |
| Llama-3.3 (text only) | 70B | 1.9664 | 0.65 | **0.8** | 0.6 | 0.45 | **0.9** | 0.5 | 0.66 | **0.5** |
| Llama-3.2-Vision | 11B | 1.37830 | 0.41 | 0.60 | 0.35 | 0.20 | 0.40 | 0.50 | 0.44 | 0.00 |
| | 90B | 2.06714 | 0.62 | 0.65 | 0.6 | 0.55 | 0.75 | 0.55 | 0.66 | 0.00 |
| Llama-3.1 (text only) | 8B | **0.30586** | 0.4 | 0.6 | 0.25 | 0.15 | 0.45 | 0.55 | 0.40 | 0.33 |
| | 70B | 1.96224 | 0.65 | 0.65 | 0.6 | 0.55 | 0.8 | **0.65** | 0.66 | **0.5** |
| Llama-3.1 (text only) (Q) | 70B (8bit) | 1.96423 | 0.65 | 0.65 | 0.6 | 0.55 | 0.8 | **0.65** | 0.66 | **0.5** |
| | 70B (4bit) | 1.96352 | 0.65 | 0.65 | 0.6 | 0.55 | 0.8 | **0.65** | 0.66 | **0.5** |
| Gemma-3 | 27B | 1.7753 | 0.59 | 0.6 | 0.6 | 0.5 | 0.8 | 0.45 | 0.61 | 0.33 |
| Qwen2.5 (text only) | 32B | 1.43841 | 0.6 | 0.7 | 0.55 | **0.6** | 0.6 | 0.55 | 0.62 | 0.33 |
| | 72B | 2.96018 | 0.64 | 0.65 | **0.75** | 0.55 | 0.75 | 0.5 | 0.66 | 0.33 |
| Qwen2.5 (text only) (Q) | 32B | 1.85767 | 0.59 | 0.7 | 0.45 | 0.55 | 0.65 | 0.6 | 0.61 | 0.33 |
| | 72B | 2.83019 | 0.6 | 0.7 | 0.65 | 0.55 | 0.75 | 0.35 | 0.63 | 0.17 |
| **Qwen2.5-VL** | 32B | 1.44588 | 0.61 | 0.65 | 0.55 | 0.55 | 0.75 | 0.55 | 0.64 | 0.17 |
| | **72B** | 3.05231 | **0.68** | 0.7 | 0.7 | 0.55 | 0.85 | 0.6 | **0.70** | 0.33 |
| EXAONE-3.5 | 32B | 2.87324 | 0.58 | 0.6 | 0.65 | 0.4 | 0.7 | 0.55 | 0.61 | 0.17 |
| EXAONE-3.5 (Q) | 32B | 1.58598 | 0.54 | 0.55 | 0.6 | 0.35 | 0.7 | 0.5 | 0.55 | 0.33 |
| DeepSeek-MOE (text only) | 16B | 17.48355 | 0.24 | 0.2 | 0.35 | 0.25 | 0.2 | 0.2 | 0.26 | 0.00 |

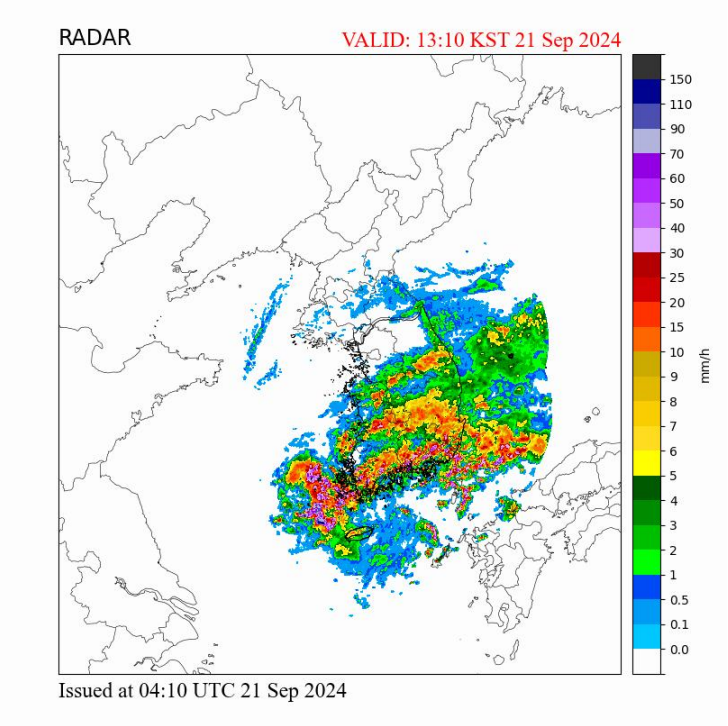
# AI-NWP Integrated Technology : AI Nowcasting

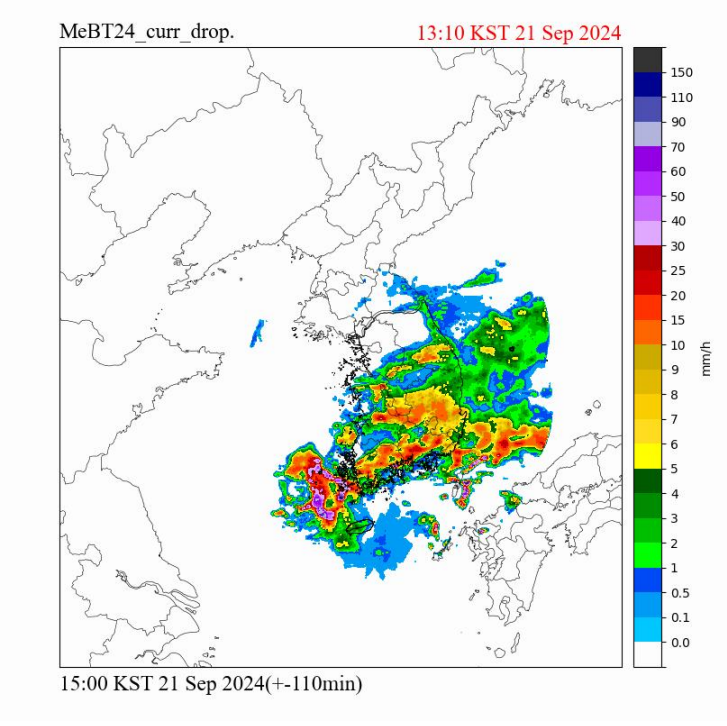
**Custom developed AI model**

Radar $_{t-120:t}$ → VQGAN (Encoding) → Transformer → VQGAN (Decoding)

↳ (CVPR, 2023)

**Observation (Radar)**




**KMA NowAlpha**

**Transition phase (trial use by KMA forecasters, '25.2.~) to Operational use**

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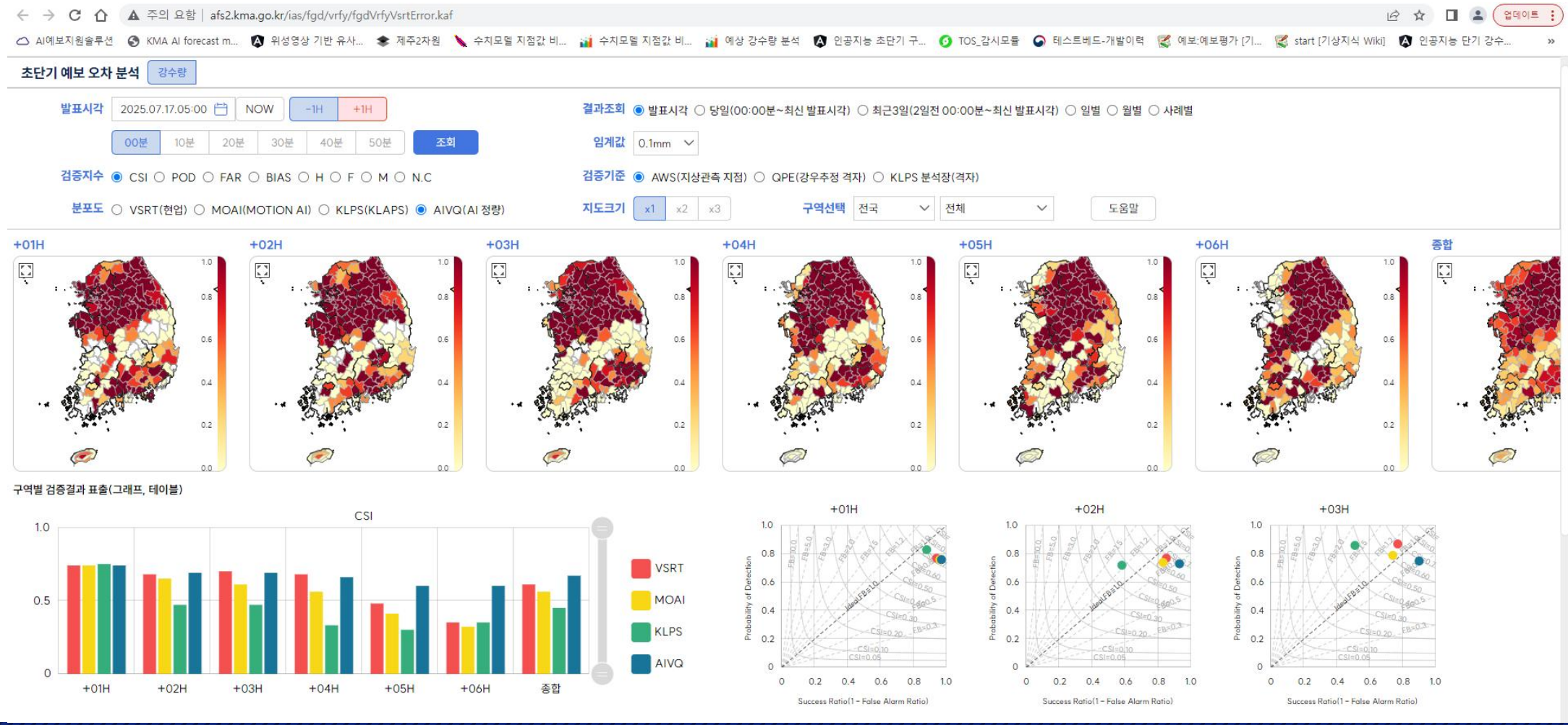
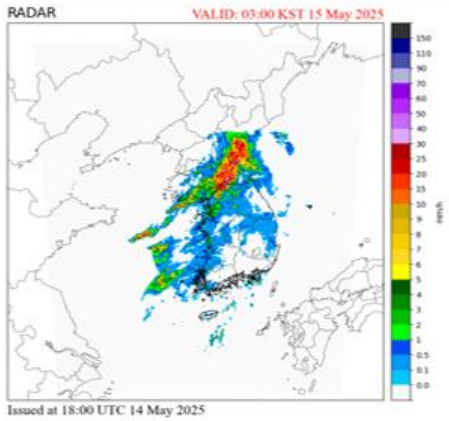
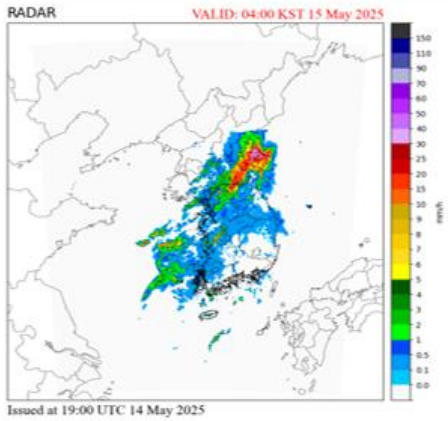
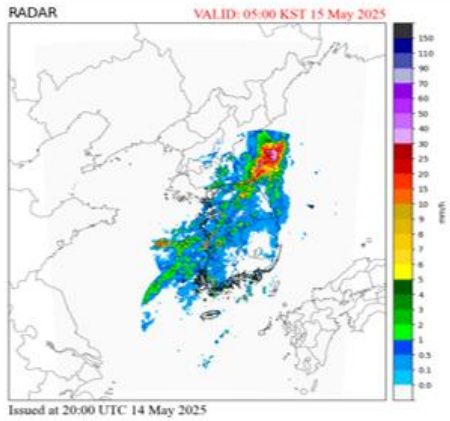
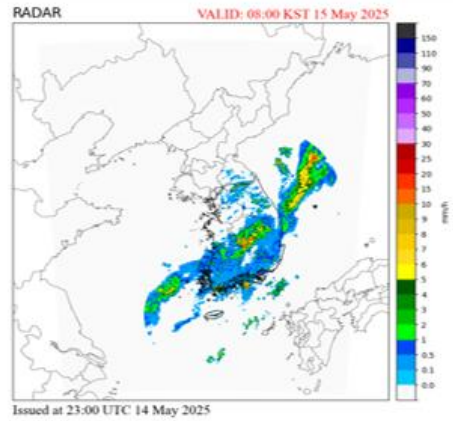
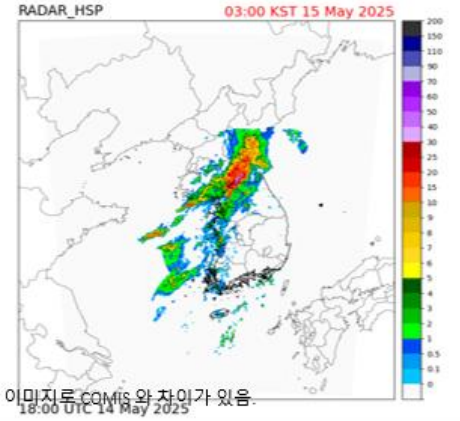
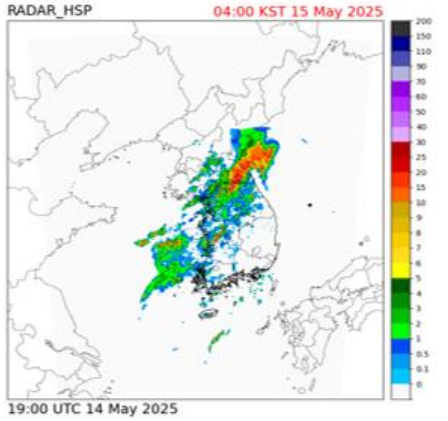
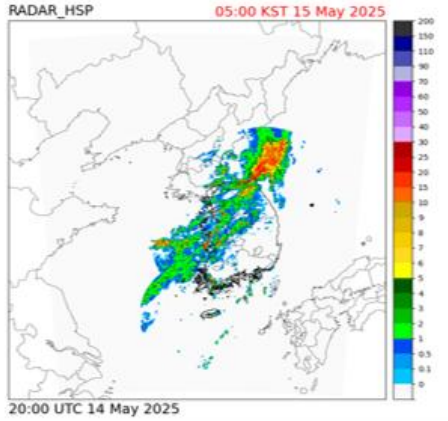
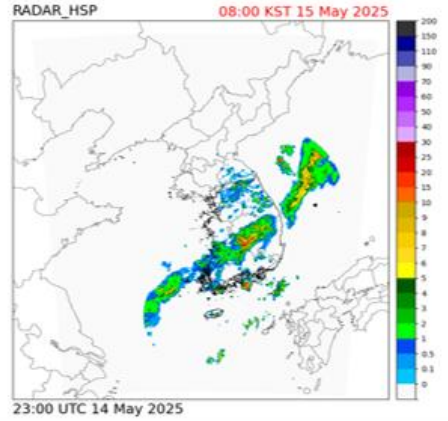
# AI-NWP Integrated Technology : AI Nowcasting




**Transition phase (trial use by KMA forecasters, ‘25.2.~) to Operational use**

# AI Nowcasting Model Drift : Radar QC upgrade

| | 1hr | 2hr | 3hr | 6hr |
|---|---|---|---|---|
| HSR |  |  |  |  |
| HSP |  |  |  |  |

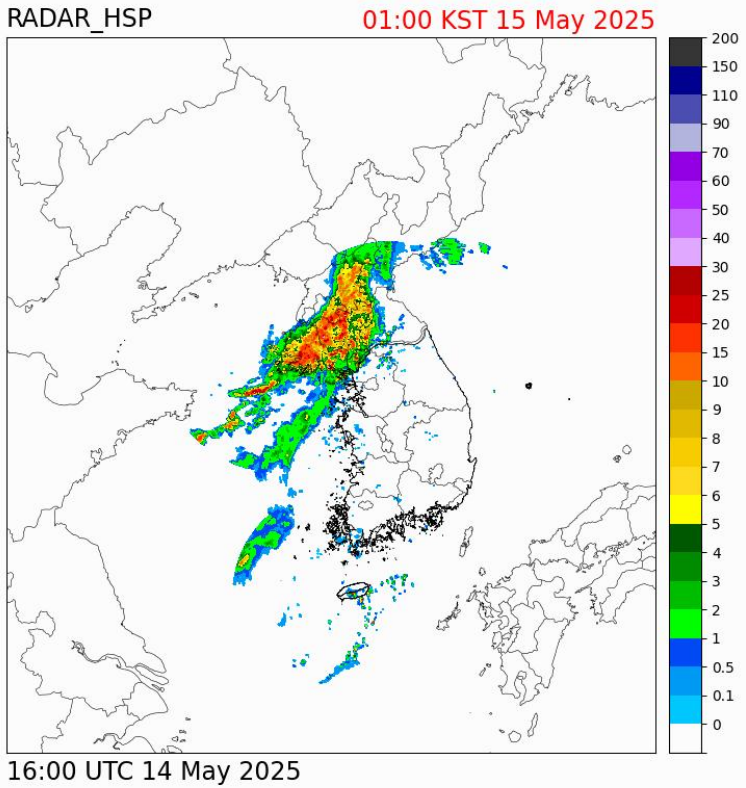


기존 단일 Z-R 로 변환한 이미지로 COMIS 와 차이가 있음.

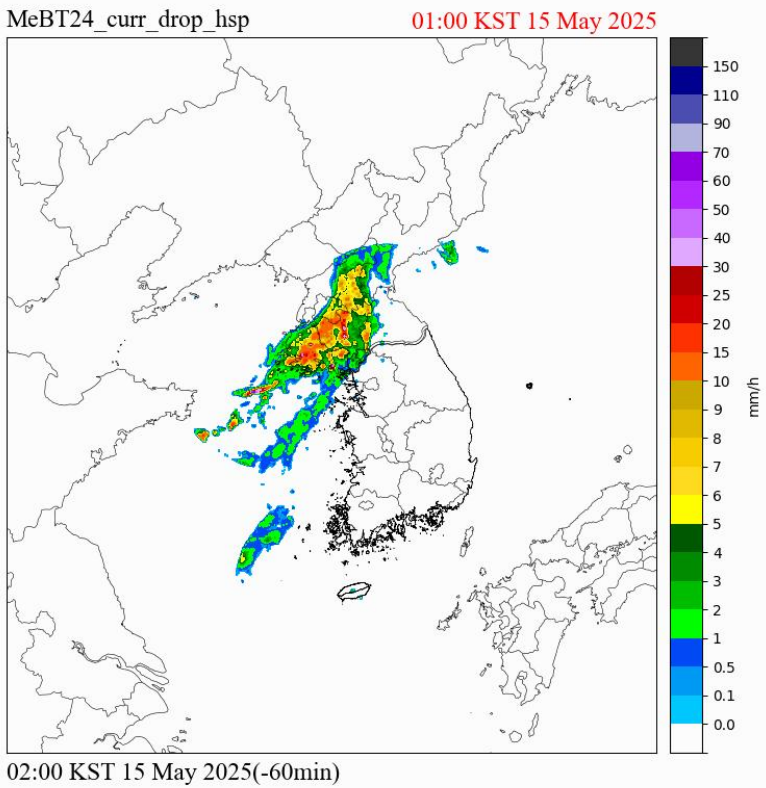
**Transition phase (trial use by KMA forecasters, '25.2.~) to Operational use**

# AI Nowcasting Model Drift : Radar QC upgrade

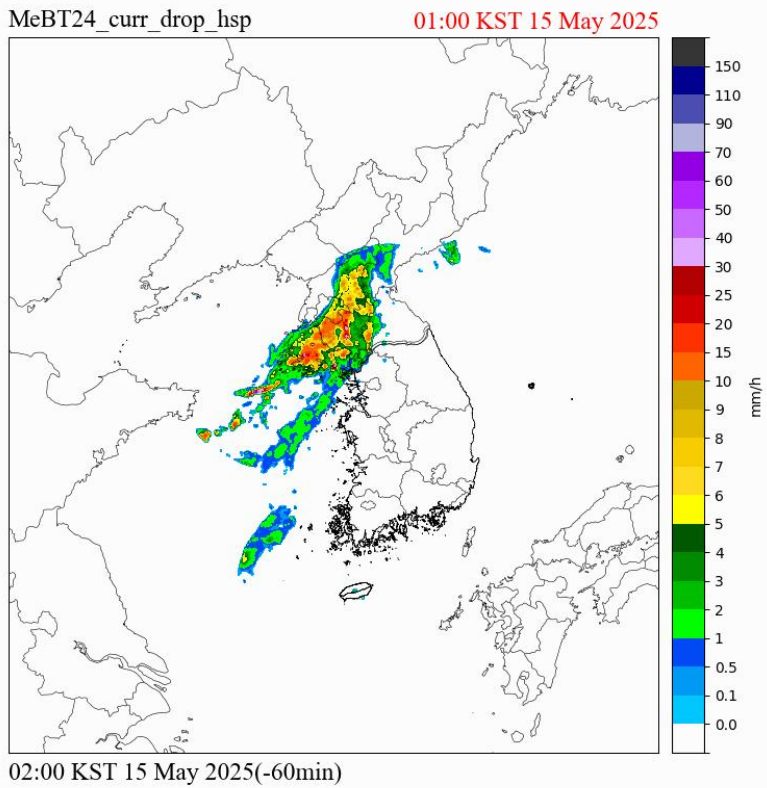
HSP RADAR




HSP AI




HSR AI

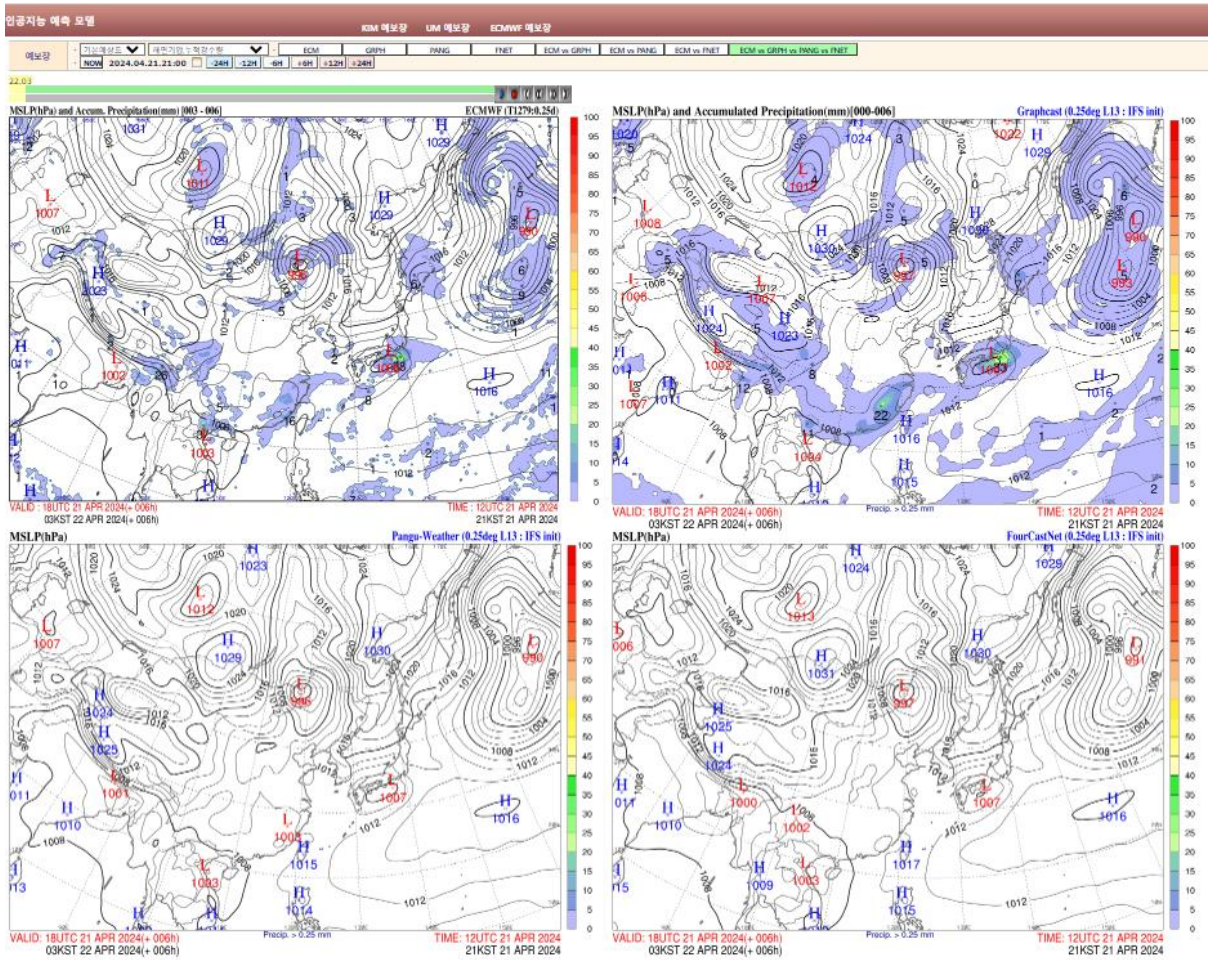



**Transition phase (trial use by KMA forecasters, ‘25.2.~) to Operational use**

# AI-NWP Integrated Technology : Medium-range

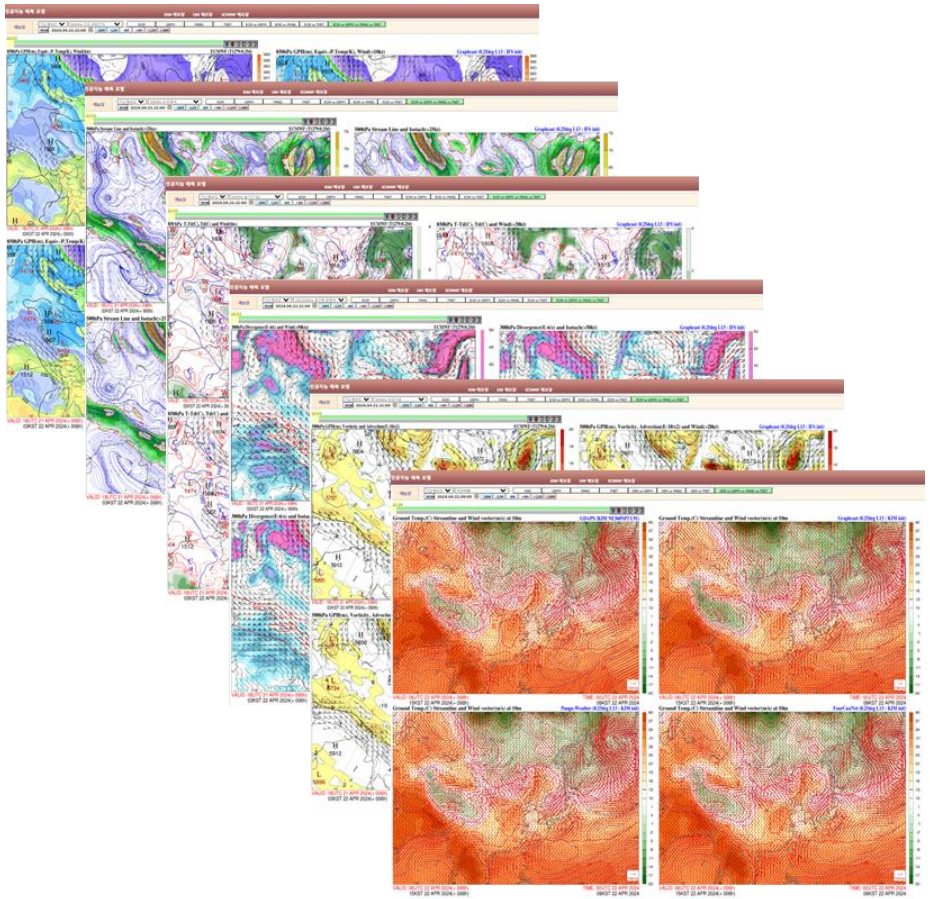
IFS

PW (IFS)



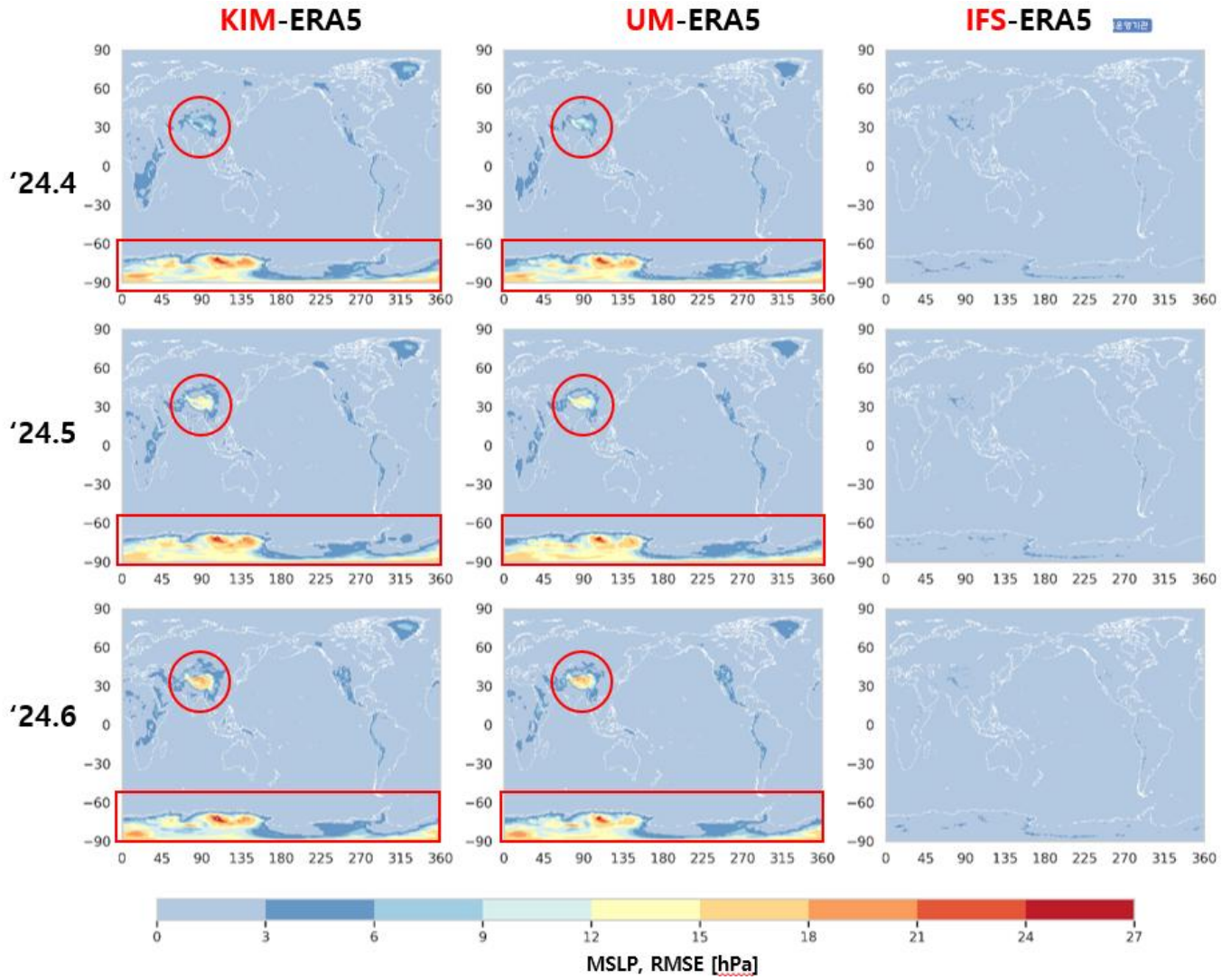

GC (IFS)

FN (IFS)



Example of real-time testbed of AI model

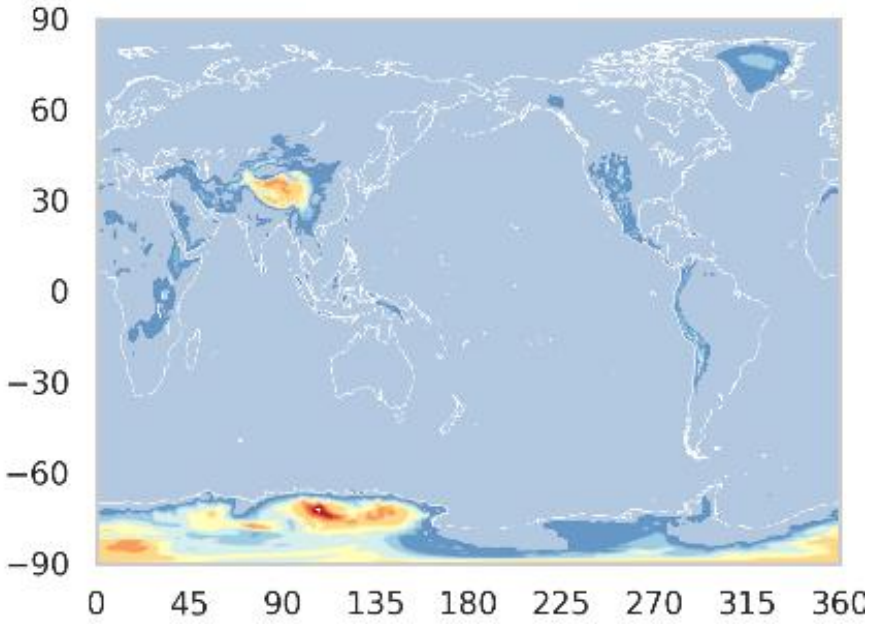
# AI-NWP Integrated Technology : Medium-range

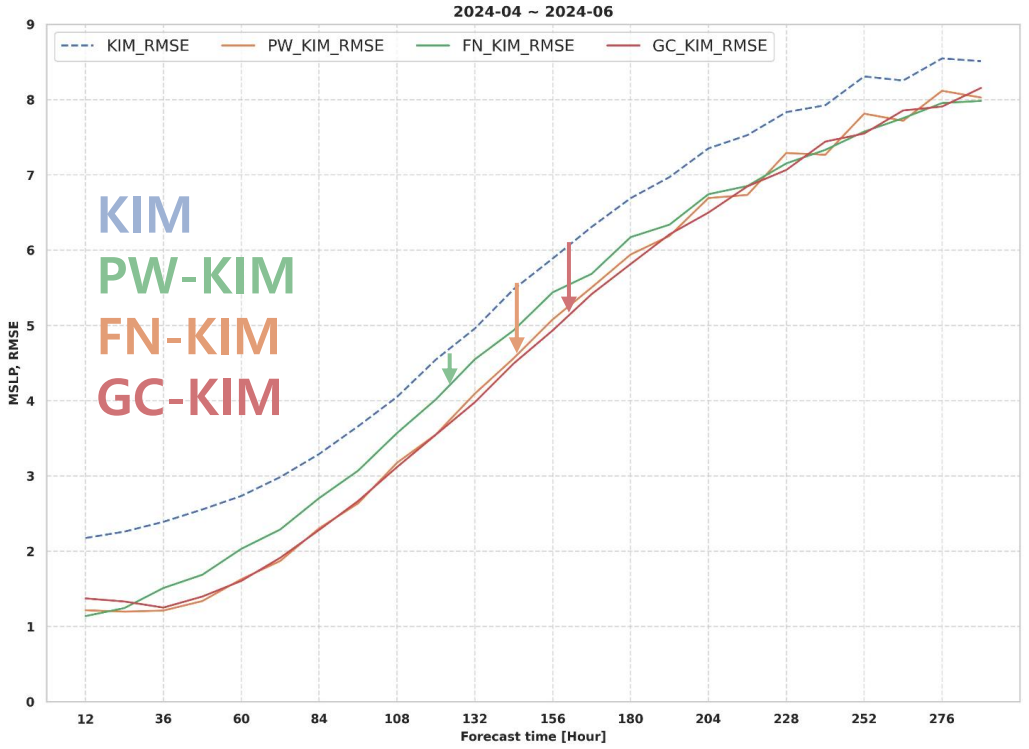


# AI-NWP Integrated Technology : Medium-range

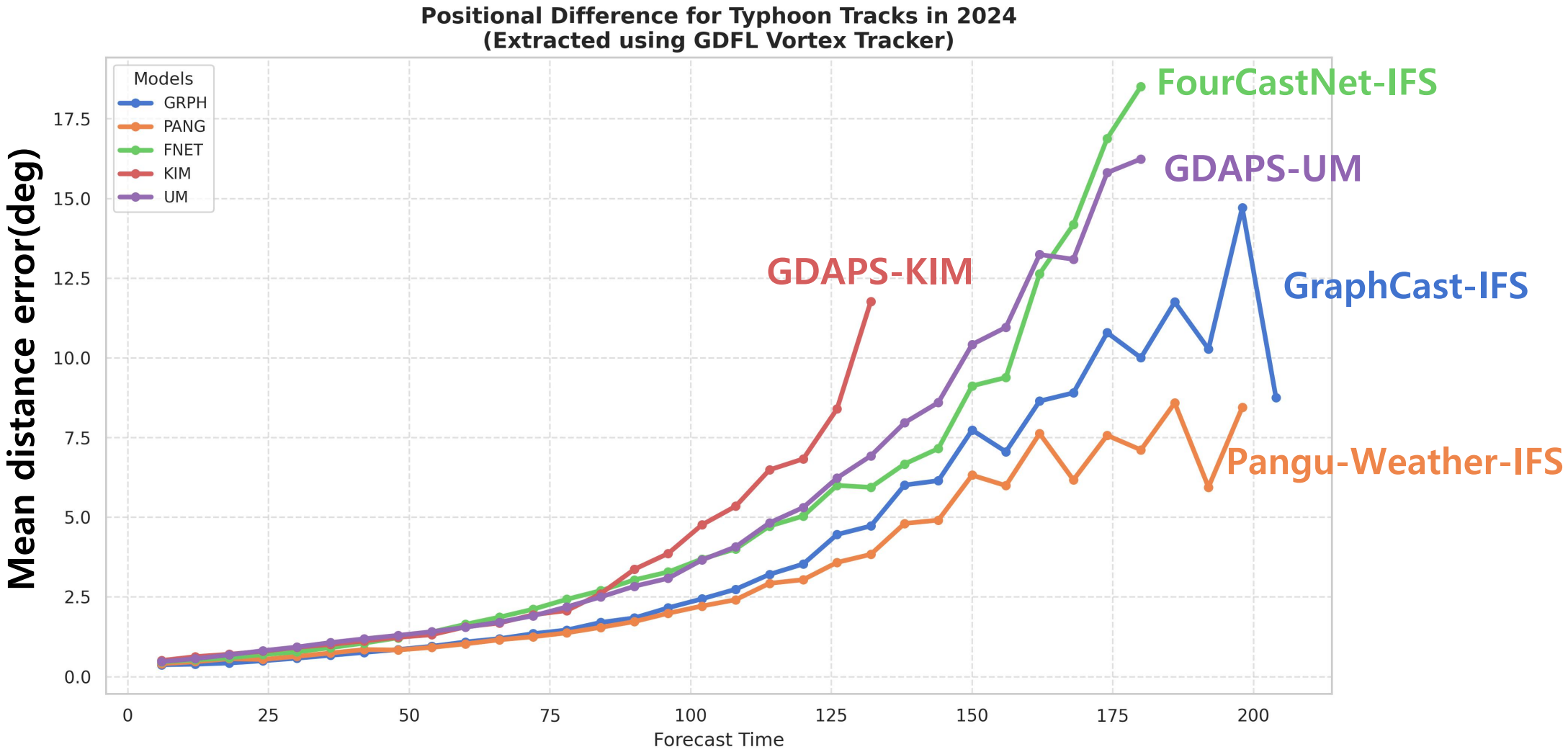
- **Model-wise ability to correcto large error ingested**
  - ✓ **FourCastNet2 < Pangu-Weather ≤ GraphCast**

**KIM-ERA5**

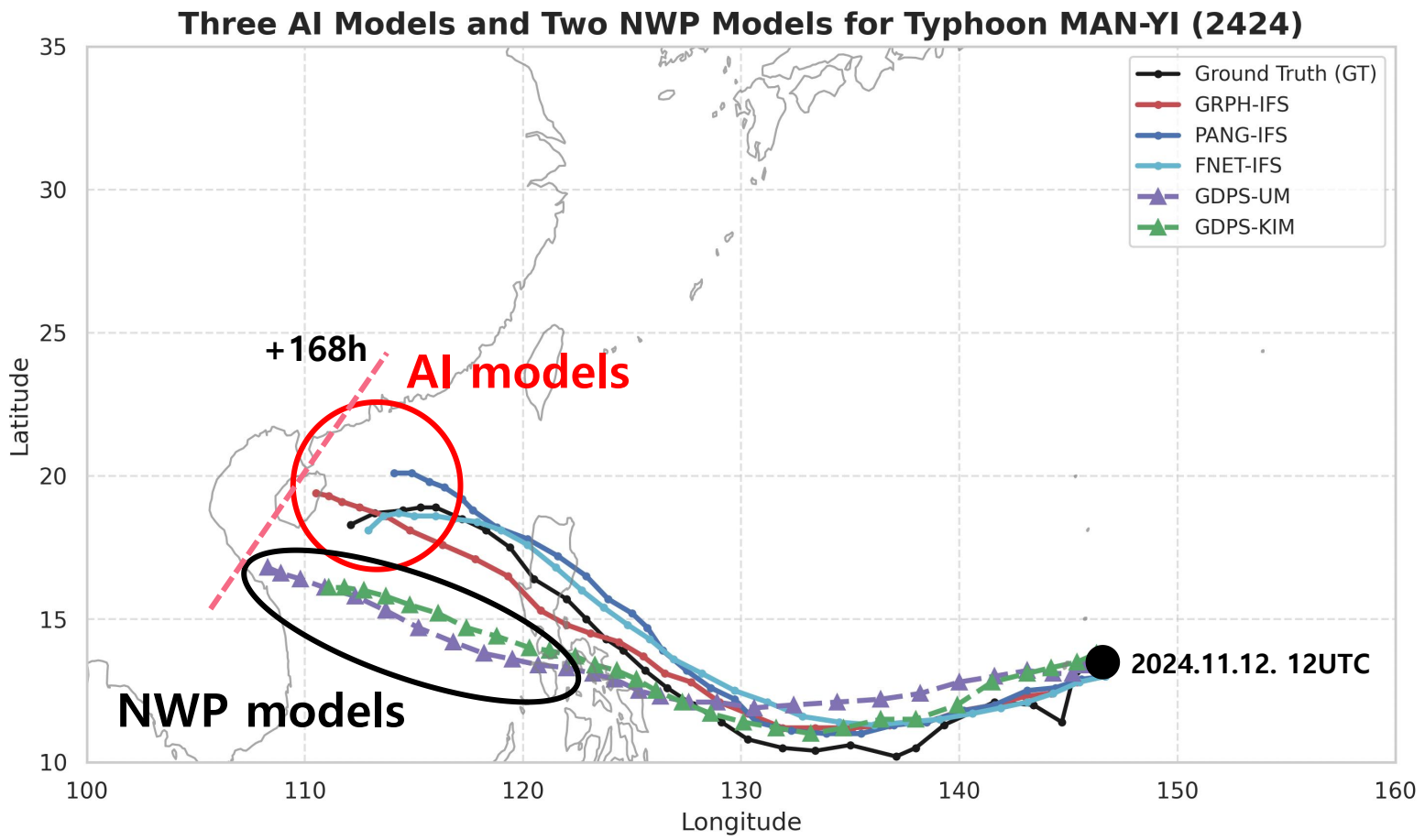


# AI-NWP Integrated Technology : Medium-range



# AI-NWP Integrated Technology : Medium-range



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# Thank You !