# EXPLOITATION OF AI/ML TO ENHANCE ACCESSIBILITY AND USABILITY OF SATELLITE DATA BY USERS

# JMA'S CHALLENGES FOR AI/ML UTILIZATION

Presented to CGMS-51 Plenary, agenda item ### (JMA-WP-09)

*Japan Meteorological Agency*

Coordination Group for Meteorological Satellites

# INTRODUCTION

- JMA is focused on significant improvement of the accuracy of weather observation and forecast with a target date of 2030.
- JMA have been conducting joint research with the RIKEN Center for Advanced Intelligence Project (RIKEN AIP Center) since 2019 toward the development of related technology.
- JMA seeks to apply AI/ML to NWP and quality control for surface meteorological observation data and ground-based remote sensing data in the joint research.
- Results have highlighted the potential for improved accuracy of NWP and data quality, along with collaborative learning in the field of AI/ML.
- Against this background, JMA's **Meteorological Satellite Center (MSC)** and its **Office of Meteorological Analysis and Application Development (OMAAD)** use AI/ML to develop satellite products.

# OUTLINES OF HIMAWARI PRODUCTS DEVELOPMENT

- MSC and OMAAD of JMA work together to develop satellite products.
- In this presentation, Himawari products developed by using AI/ML technology are outlined as below.

*MSC developing products*

- Cloud mask
- RGB imagery-based products
- Atmospheric profiles from infrared sounder

*OMAAD developing products*

- Convective Cloud Information
- Clear Air Turbulence potential analysis
- Icing potential analysis

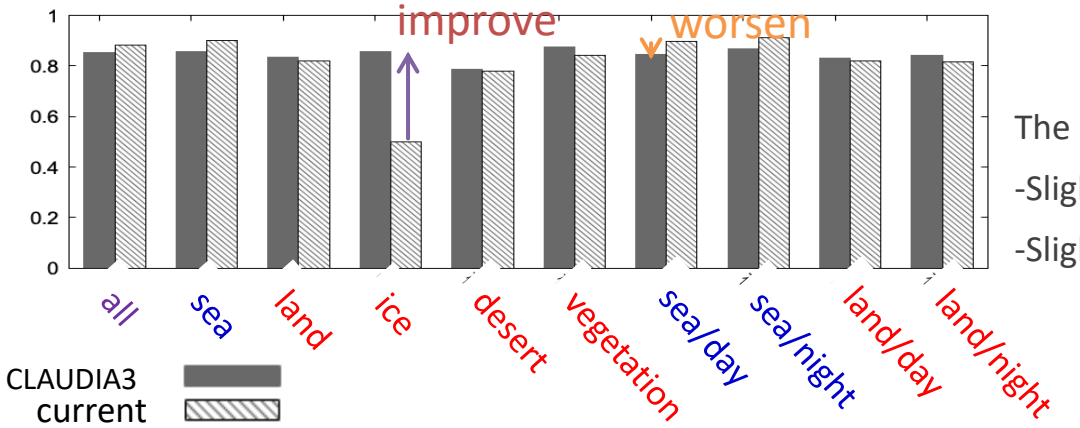
# Cloud mask

- **CLAUDIA3** (Ishida et al. 2018) is a cloud detection algorithm using **Support Vector Machine** originally developed by the **Meteorological Research Institute** of JMA.
- MSC is working on the introduction of the CLAUDIA3 for the Himawari-8/9 cloud mask product.
- The use of CLAUDIA3 data to calculate threshold values is expected to improve accuracy by eliminating this dependence on NWP.

**Hit ratio with MODIS cloud product**

✓ Training data : January 2023

✓ Evaluation data : December 2022




The accuracy of CLAUDIA3 is

-Slightly higher than the current cloud mask over land

-Slightly lower than the current cloud mask over sea

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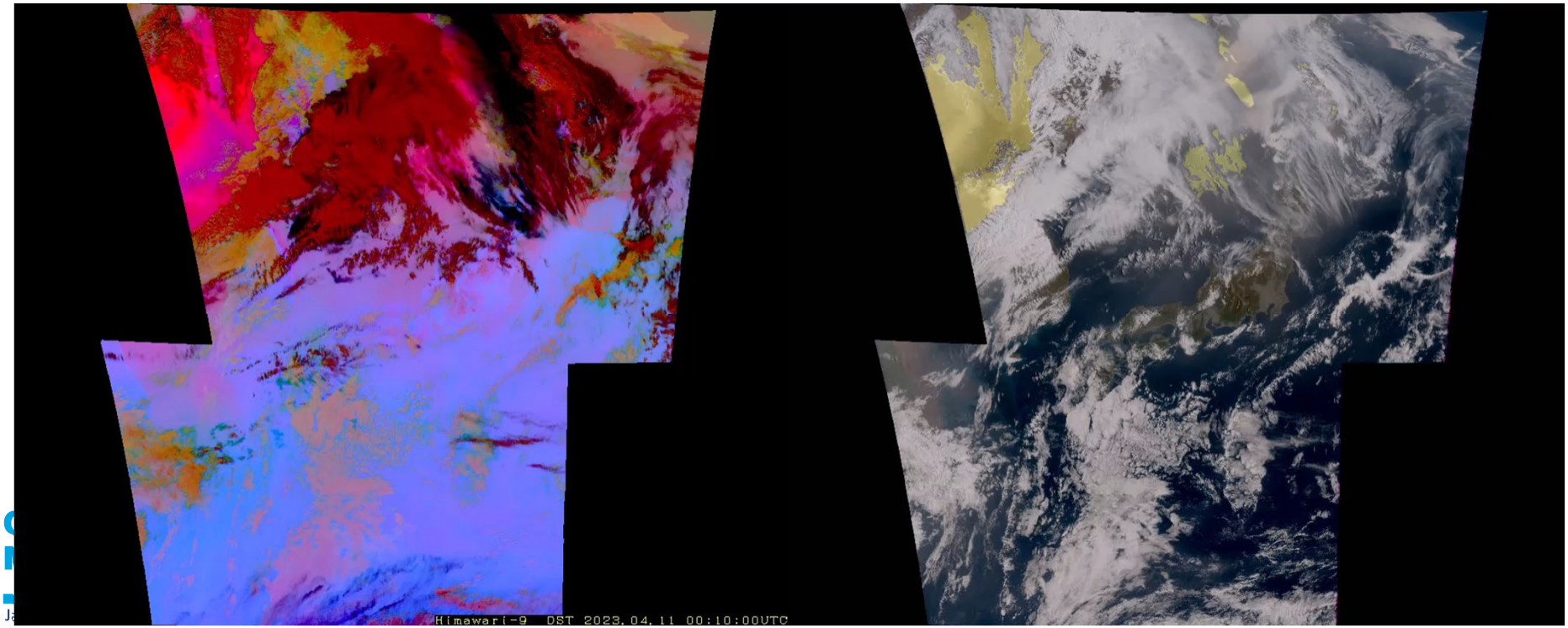
# RGB imagery-based products

- Due to the difficulty of collecting observation data with appropriate quality and quantity, MSC is currently developing an **AI approach with RGB image pixel values as input and phenomena classes as output** to support an environment in which **RGB specialists interactively create training data**.
- RGB interpretation is left to AI trained using expert-validated data, and the results are used exclusively to **eliminate the need for end-user RGB interpretation training**.

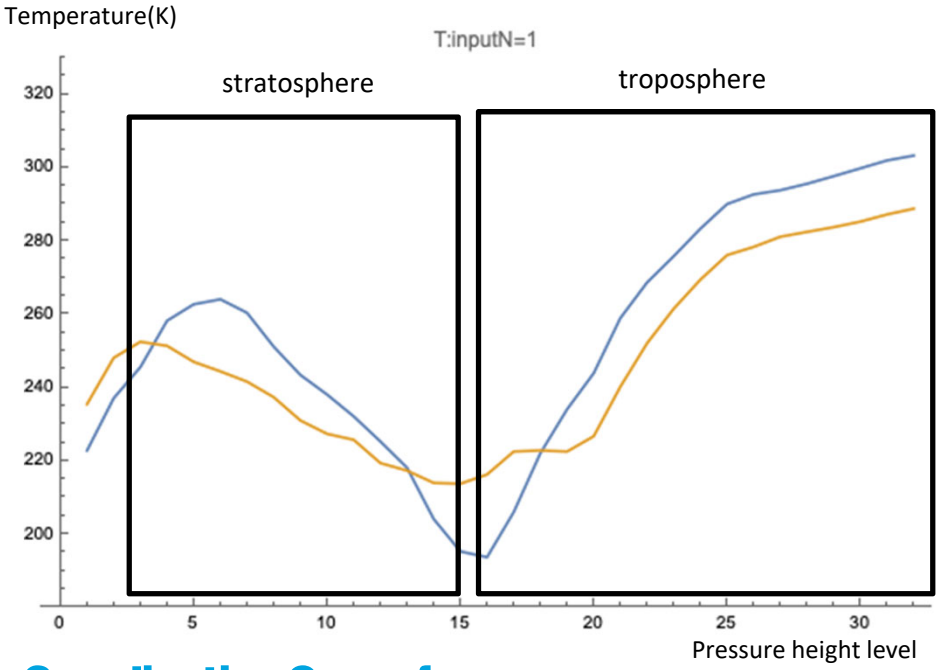
Dust RGB imagery

Dust area (yellow)



# Atmospheric profiles from infrared sounder

- The hyperspectral infrared sounder on Himawari-10 will provide vertical **profiles of atmospheric temperature, water vapor** and other variables..
- MSC's research on machine learning in this context involves the use of neural networking using **Long Short-Term Memory (LSTM)** and **Attention** from sequential infrared sounder input data in wavenumber order.




LSTM can store information that has been input in the past. It is intended to be designed in such a way that (I) only noteworthy new information that has not been previously input (and is already in its possession) is passed on to subsequent generations, and that (2) each time successive inputs are made, and that (3) the output profile is successively modified.

Animation on the left shows how the **retrieved vertical temperature profile (yellow)** changes when the simulated sounder data is input to the network sequentially in wavenumber order. **True values are shown in blue**.

As the number of bands that have been submitted increases, we can see how the retrieved temperatures are approaching the correct values.

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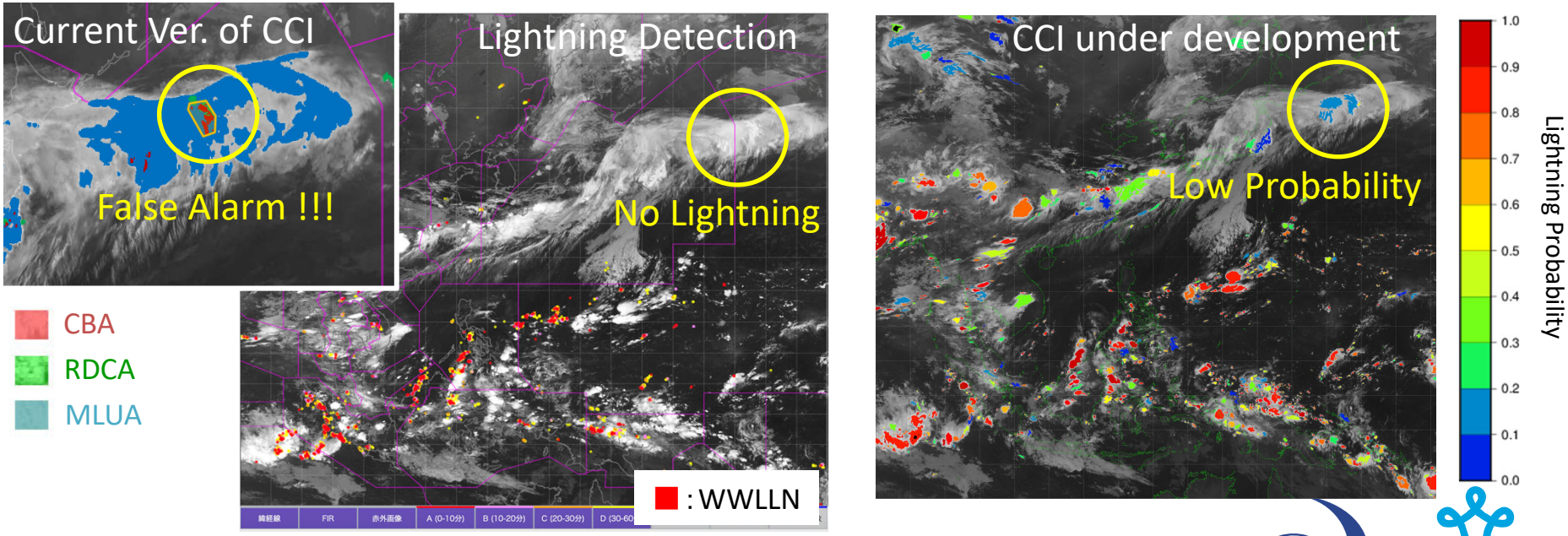
# Convective Cloud Information

- OMAAD is working on improving the accuracy of the Convective Cloud Information (CCI) (Sumida et al. 2017) product with **Convolutional Neural Network-based Deep Learning**.
- Preliminary results suggest reduced false alarms in upper dense cloud regions with the new algorithm.




55°N-15°S, 85°E-180°E
1700UTC on 6 June 2020

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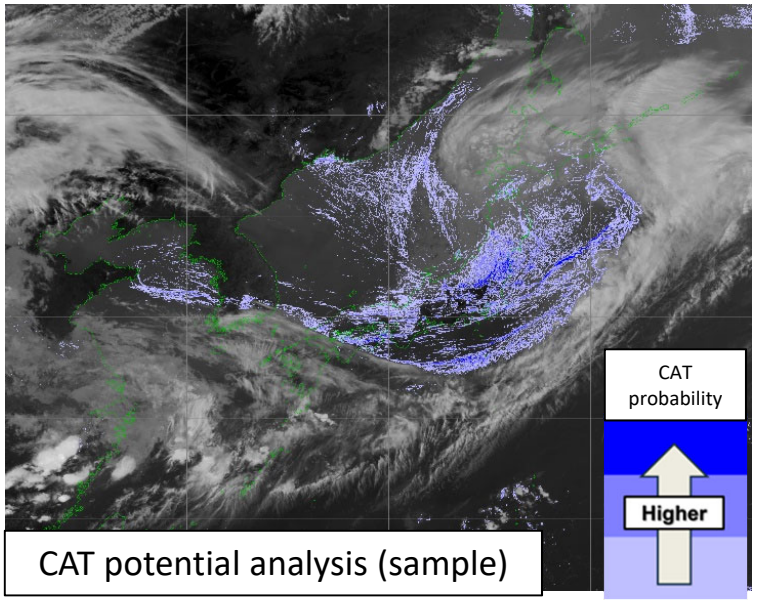
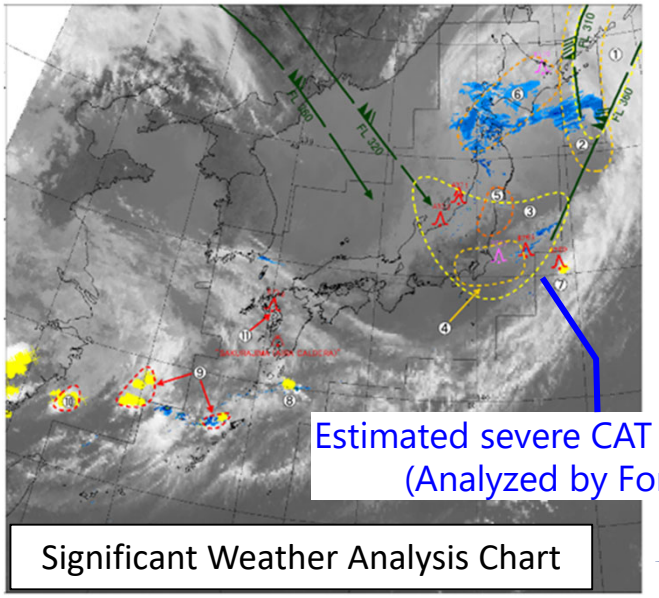
# Clear Air Turbulence potential analysis

- OMAAD is researching estimation to determine the probability of Clear Air Turbulence (CAT) from Himawari-8/9 imagery using **Neural Networking**.
- Analysis involves both brightness temperature and related **Sobel-filtered values** for edge detection-related CAT variables such as atmospheric gravity waves.
- Early results indicate close correspondence between areas of high CAT probability in analysis and CAT area in significant weather chart analyzed by forecaster.




CAT potential analysis (sample)



Estimated severe CAT potential area
(Analyzed by Forecaster)

Significant Weather Analysis Chart

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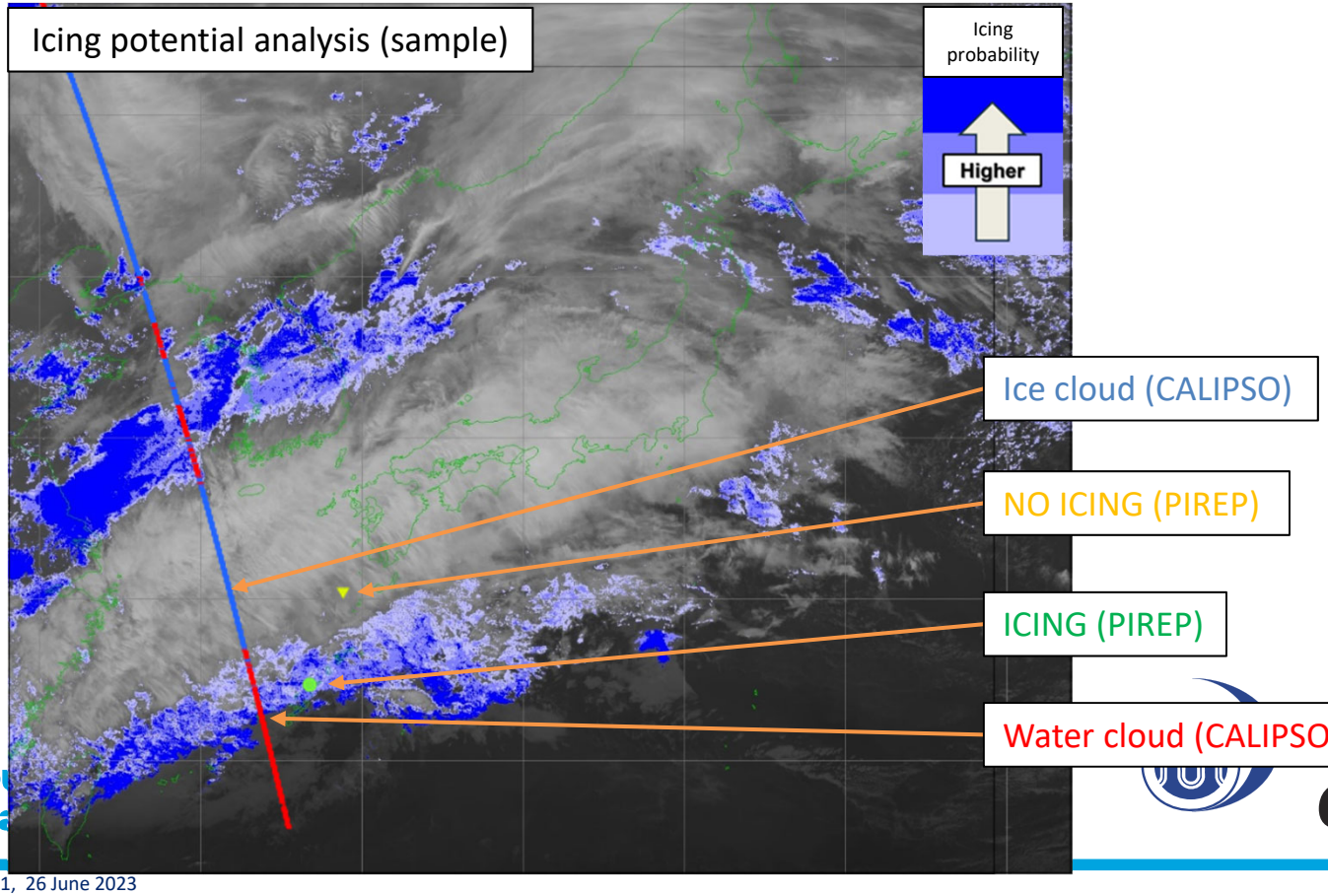
# Icing potential analysis

- OMAAD is researching estimation to determine the probability of icing from Himawari-8/9 imagery using **Neural Networking** based on CALIPSO/CALIOP cloud phase for truth data.
- In areas where icing probability is high, CALIPSO shows water clouds and PIREP shows icing, indicating good correspondence..



# CONCLUSION

- Collaboration with the RIKEN AIP Center allows JMA to assimilate cutting-edge AI/ML information on optimization of existing and new methods, as well as related application to meteorological services.
  - *A new partner's limited expertise in meteorology gives rise to a need for appropriate explanation, interaction and coordination in future collaboration.*
  - *JMA's limited expertise with AI/ML technology requires ongoing development of human resources of AI/ML experts and related information sharing within JMA.*
  - *Issues in actual development using this technology include a need to secure computational resources for learning and storage of teaching data, as well as identification of optimal training data.*

- The examples outlined in this presentation highlight efforts to develop Himawari satellite products utilizing AI/ML under JMA's MSC and OMAAD.