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EXPLOITATION OF AI/ML TO ENHANCE ACCESSIBILITY AND USABILITY OF SATELLITE DATA BY USERS
JMA'S CHALLENGES FOR AI/ML UTILIZATION

Since 2019, the Japan Meteorological Agency (JMA) has conducted cutting-edge research with the RIKEN Center for Advanced Intelligence Project on Artificial Intelligence/Machine Learning (AI/ML) for weather observation and numerical forecasting toward related learning and application.

Against this background, JMA's Meteorological Satellite Center (MSC) and its Office of Meteorological Analysis and Application Development (OMAAD) apply AI/ML technology to develop and improve various satellite products. MSC is improving Cloud mask products, considering RGB imagery-based products and developing Atmospheric profiles using infrared sounder data from the Himawari-10 satellite. The OMAAD is now improving the Convective Cloud Information, and newly developing the Clear Air Turbulence potential analysis and the Icing potential analysis. The outlines of these products in the development stage are shown in this Working Paper.

Action/recommendation proposed: None

1 INTRODUCTION

The Japan Meteorological Agency (JMA) has long used traditional machine learning (ML) for Numerical Weather Prediction (NWP), observation data quality assurance and other purposes, and is focused on significant improvement of the accuracy of weather observation and forecast with a target date of 2030. To this end, JMA have been conducting joint research with the RIKEN Center for Advanced Intelligence Project (RIKEN AIP Center; a national center for AI/ML development) since 2019 toward the development of related technology. In this joint research, JMA seeks to apply AI/ML to NWP and quality control for surface meteorological observation data and ground-based remote sensing data. Results have highlighted the potential for improved accuracy of NWP and data quality, along with collaborative learning in the field.
JMA also focuses on internal sharing of AI/ML technology toward. The development of human resource of AI/ML experts is also important for JMA as exemplified by a March 2023 face-to-face/online presentation headed by external AI/ML experts that was heavily attended by staff from HQ and regional/local observatories.
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 as described below.

2 HIMAWARI PRODUCT DEVELOPMENT USING AI/ML

The MSC and OMAAD work together to develop satellite products. In this section, Himawari products developed by using AI/ML technology are outlined. Using these technologies, MSC develops cloud mask (2.1), RGB imagery-based products (2.2) and atmospheric profiles from infrared sounder data (2.3), while OMAAD develops Convective Cloud Information (2.4), Clear Air Turbulence potential analysis (2.5) and Icing potential analysis (2.6). These organizations collaborate on product development, hold regular discussions, and interact on AI/ML technology, as well as actively engaging in personnel exchanges.

2.1 Cloud mask

MSC is working on the introduction of the ML CLAUDIA3 cloud detection algorithm (Ishida et al. 2018) for the Himawari-8/9 cloud mask product. The algorithm is used to support vector-based machine developed by JMA's Meteorological Research Institute which is basically an organization to conduct fundamental research. Cloud mask results from the current MSC algorithm for Himawari-8/9 data currently depend on NWP output, but the use of CLAUDIA3 data to calculate threshold values is expected to improve accuracy by eliminating this dependence. For more accurate cloud detection, appropriate training data and feature selection should be applied for re-training.

2.2 RGB imagery-based products

RGB imaging is extremely useful for analyzing phenomena, but appropriate interpretation requires user expertise. RGB imagery-based satellite product development also requires large amounts of reliable training data. 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. Here, 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.

2.3 Infrared sounder atmospheric profiles

The Himawari-10 satellite will be equipped with a hyperspectral infrared sounder providing 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, originally used in natural-language processing, from sequential infrared sounder input data in wavenumber order. The profiles derived can be used for other products such as 3D-Winds. At this stage, simulated MTG-IRS data calculated from NWP data are used in development research.

2.4 Convective Cloud Information

OMAAD is working on improving the accuracy of the Convective Cloud Information (CCI) (Sumida et al. 2017) product with AI/ML. Using B13 (10.4 μm) satellite imagery from Himawari-8/9 as input, the product is based on calculation of lightning probability within an hour via convolutional neural network-based deep learning. Training and validation data from the WWLLN (World Wide Lightning Location Network) of Washington University are used as a truth metric here. Preliminary results suggest reduced false alarms in upper dense cloud regions with the new algorithm.

2.5 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 based on PIREP for truth data and B08/B13 data from Himawari-8/9 for CAT probability determination. 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.

2.6 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 and all Himawari bands to estimate icing probability in development. In areas where icing probability is high, CALIPSO shows water clouds and PIREP shows icing, indicating good correspondence.

3 CONCLUSION

Collaboration with the 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. However, a new partner's limited expertise in meteorology

gives rise to a need for appropriate explanation, interaction and coordination in future collaboration.
Conversely, 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 here highlight efforts to develop Himawari satellite products utilizing AI/ML under JMA's MSC and OMAAD.

4 REFERENCE

Ishida, H. et al., 2018: Development of a support vector machine based cloud detection method for MODIS with the adjustability to various conditions. Rem. Sens. Environ., 205, 390-407. https://doi.org/10.1016/j.rse.2017.11.003

Sumida, Y. et al., 2017: Convective Cloud Information derived from Himawari-8 data. MSC technical note, 62, 19-37