

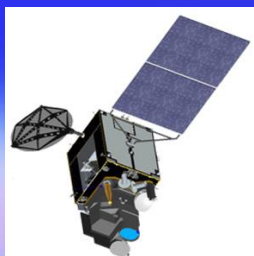


AOMSUC-15 FYSUC-2025

FIFTEENTH ASIA-OCEANIA METEOROLOGICAL SATELLITE USERS' CONFERENCE
THE JOINT 2025 FENGYUN SATELLITE USER CONFERENCE

Development of a new cloud mask of the Fundamental Cloud Product derived from Himawari-8/-9

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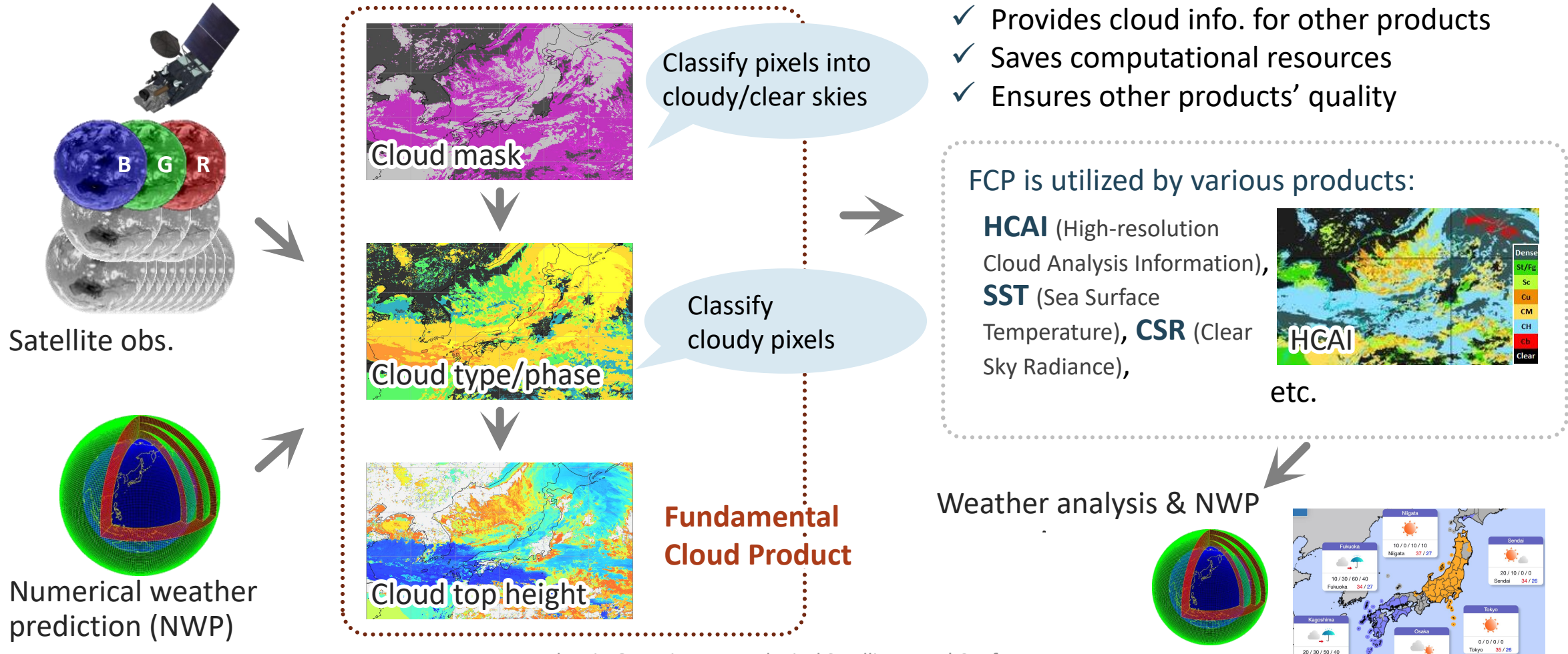
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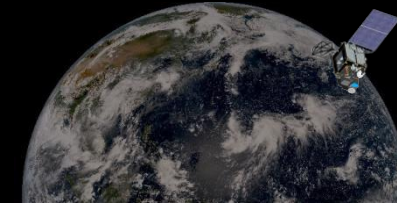
Overview of the current FCP



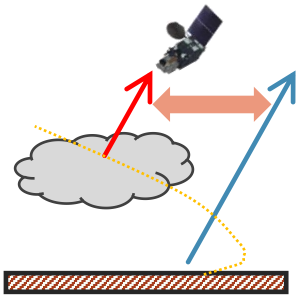
Fundamental Cloud Product (FCP) is a basic satellite level-2 product by JMA



Methodology of the current FCP's cloud mask



Cloud mask → Cloud type /phase → Cloud top height

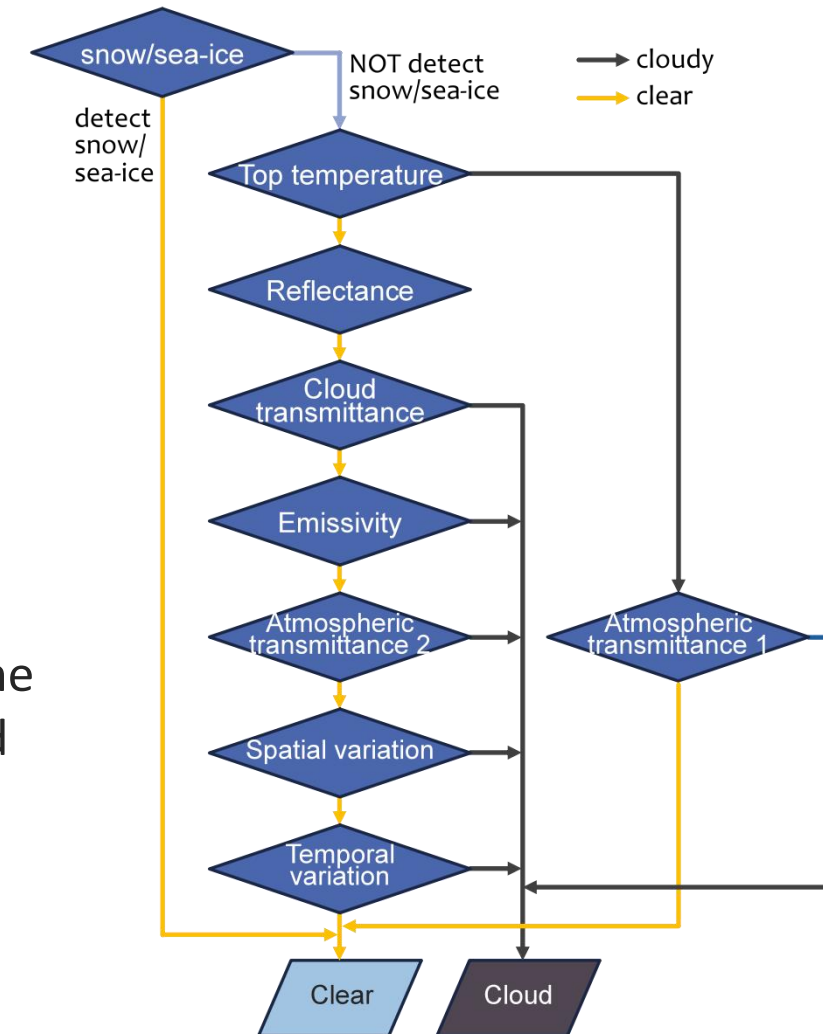


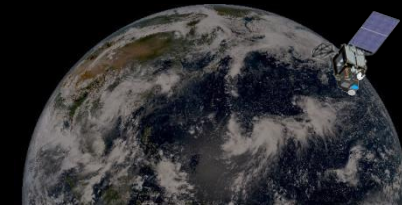
↑ **Obs:** Observed Tbs, spatial distribution of Tbs, etc.

↑ **Cal:** Estimated clear-sky threshold **by NWP data**

- ✓ **Multiple inequalities** are applied to determine whether observed scene includes clouds or not.
 - $Obs. < Cal. + offset$
 - If the “Obs.” of a pixel is smaller than the threshold ($Cal. + offset$), the pixel is classified as “cloudy”.
 - The offset values were determined so as to lessen misclassifications against MODIS Cloud Mask.
- ✓ The Algorithm was created from the combination of the different two algorithms developed by NWC-SAF^[1] and NOAA/NESDIS/STAR^[2] respectively.

References: [1] [Meteo-France, SAF/NWC/CDOP2/MFL/SCI/PUM/01, Issue 3, Rev. 2.3 \(2014\).](#), [2] [A. Heidinger and W. C. Straka III, Algorithm Theoretical Basis Document ABI Cloud Mask \(2012\).](#)





Why is a new cloud mask required?

Problems with the **current FCP's cloud mask**

- ✓ Low accuracy in certain areas such as snow and ice areas
- ✓ Estimated results of the cloud mask are dominated by specific threshold tests
- ✓ Influenced by data other than satellite observations (e.g. NWP data and radiative transfer model)

Objectives of the **new FCP's cloud mask**

- ✓ Improve accuracy
 - Increase independence as a satellite product by generating cloud mask w/o NWP data
- ✓ Output probability of clear/cloudy conditions
 - Satisfy users' needs flexibly
- ✓ Accelerate calculations



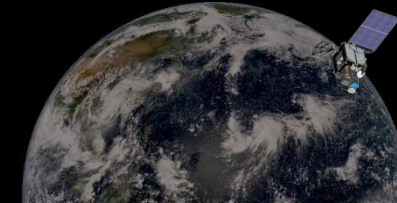
Introduce AI/ML technique



Approach (First step)

Reproduce the current FCP's cloud mask from Himawari observation data only

- ✓ Learning methods
 - Random forests (RF) and neural networks (NN)
 - * use default model parameters of Scikit-learn
- ✓ Training data
 - Training labels : current FCP's cloud mask (clear/cloudy)
 - * adjust the numbers of clear/cloudy data almost same
 - * random sampling
- ✓ Training period
 - 03, 09, 15, 21UTC on 1st of each month in 2023
- ✓ Input/Output
 - Input : All Himawari observation bands (16 bands)
 - Output : binary classification of clear or cloudy



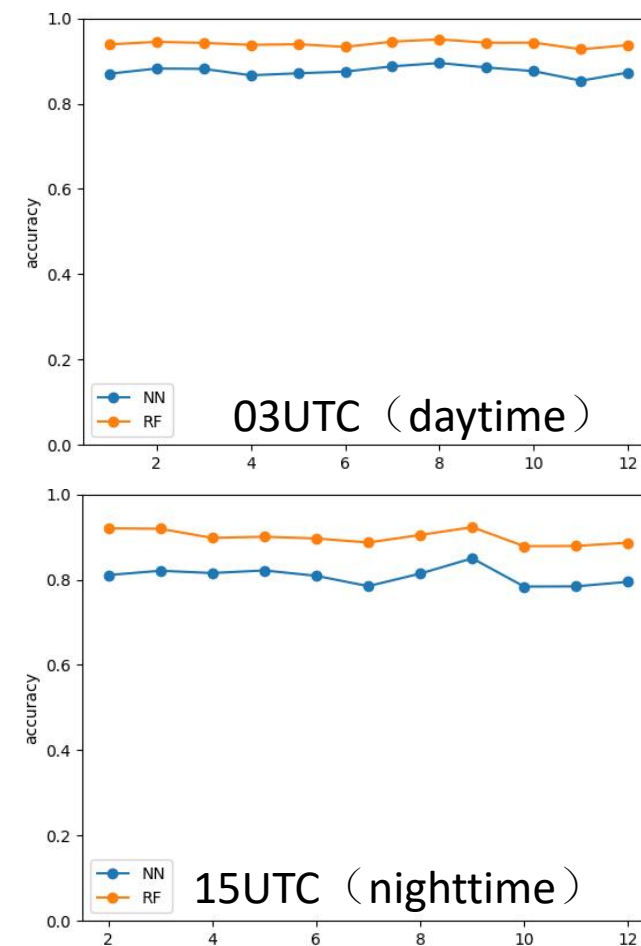
Accuracy with respect to the current FCP

03, 15UTC on 15th of each month in 2022

- ✓ Both models (RF/NN) achieved over 80% accuracy throughout the year for both daytime and nighttime.
- ✓ The cloud mask of the RF model was closer to the current FCP's cloud mask than that of the NN model.

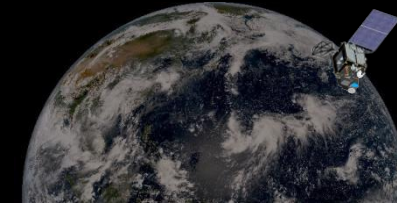
$$\text{Accuracy} = (A + D) / (A + B + C + D)$$

		current FCP	
		clear	cloudy
RF/NN	clear	A	B
	cloudy	C	D



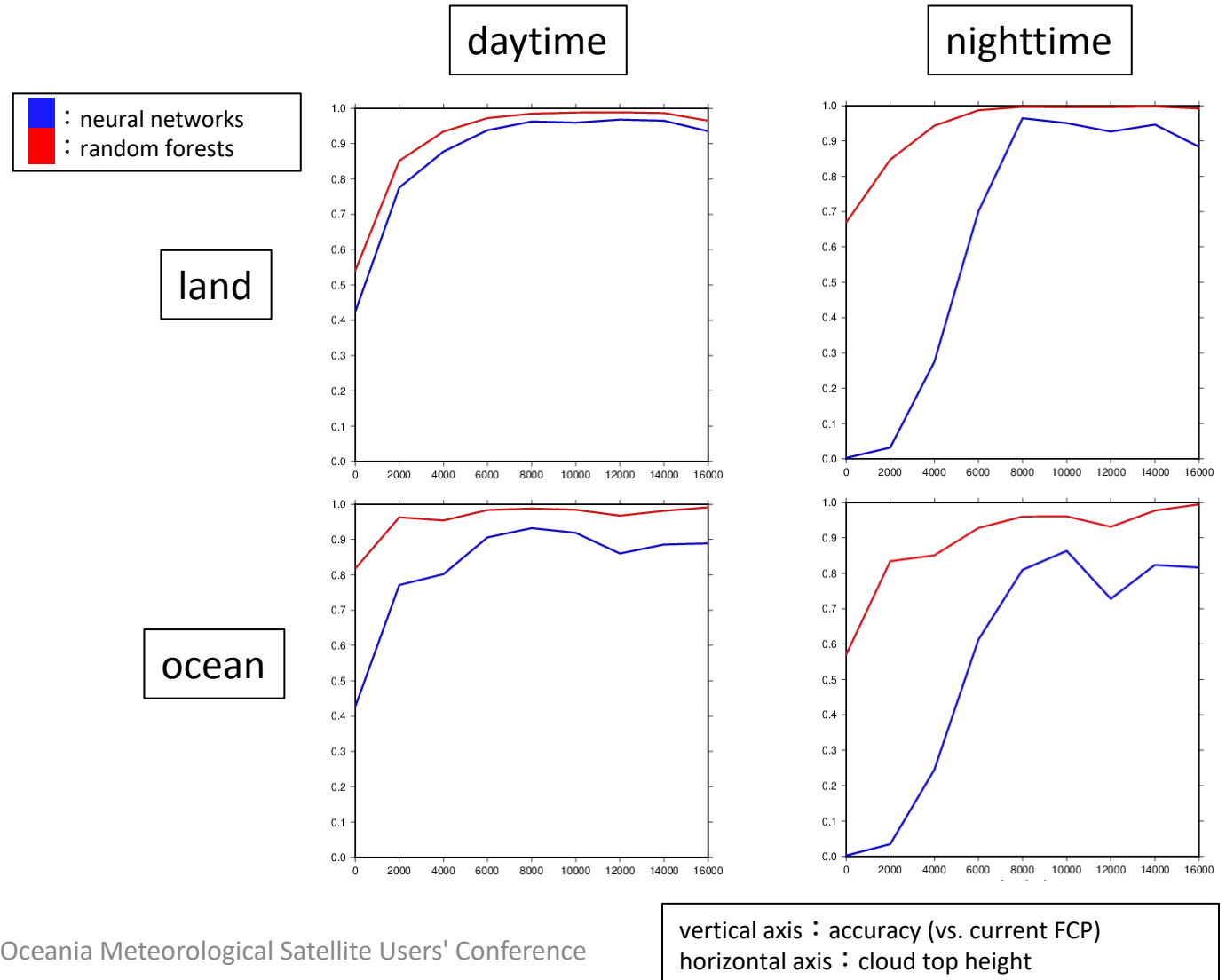
vertical axis : accuracy (vs. current FCP)
horizontal axis : month

Accuracy with respect to the current FCP

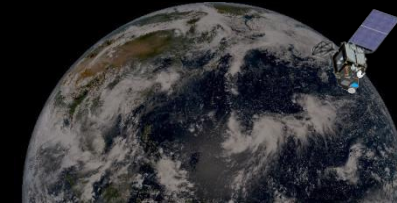


16th of each month in 2024

- ✓ Calculated the accuracy of the cloud masks by the current FCP's cloud top height.
- ✓ A tendency of discrepancy was found in low cloud cases even between the RF model and the current FCP.



Accuracy with respect to MODIS



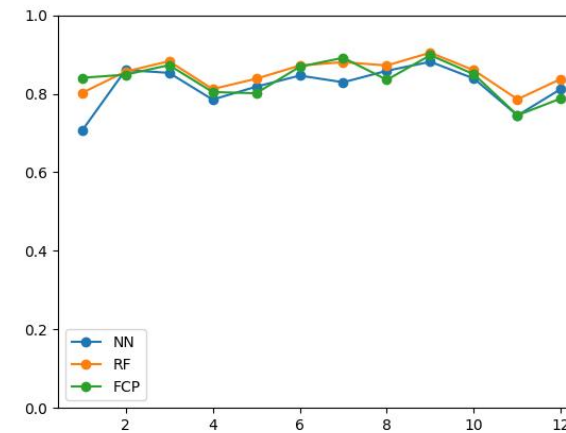
16th of each month in 2024

- ✓ The accuracy of the cloud mask of the RF model was slightly higher than the current FCP over land, while lower over sea.
- ✓ The accuracy of the cloud mask of the NN model was particularly low over sea in the nighttime.

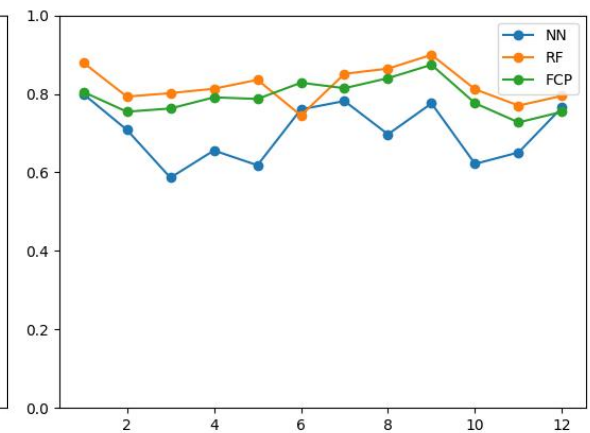
■ : neural networks
■ : random forests
■ : current FCP

land

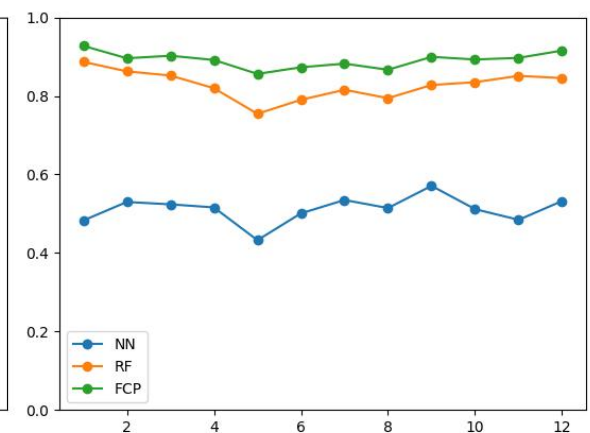
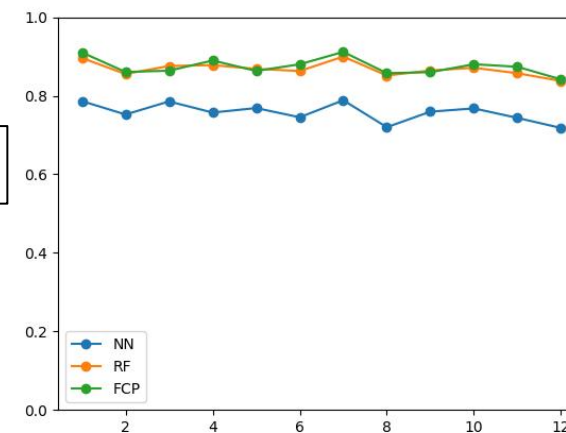
daytime



nighttime

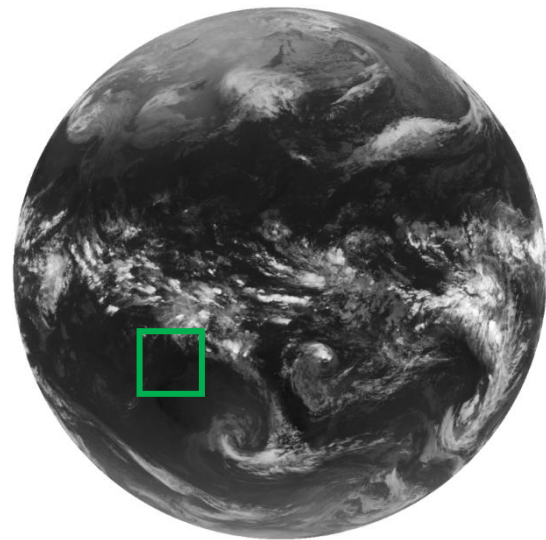


ocean

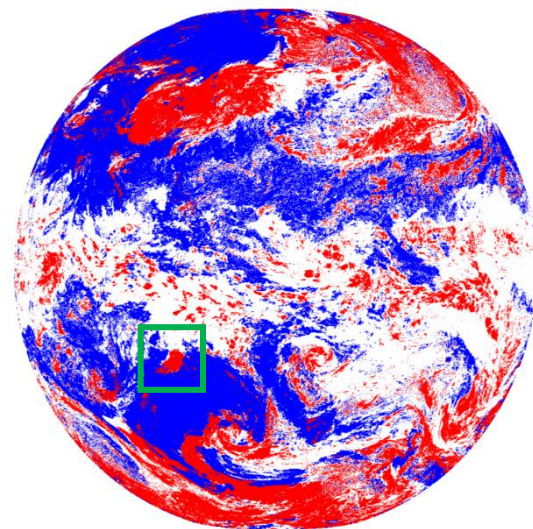


Case study

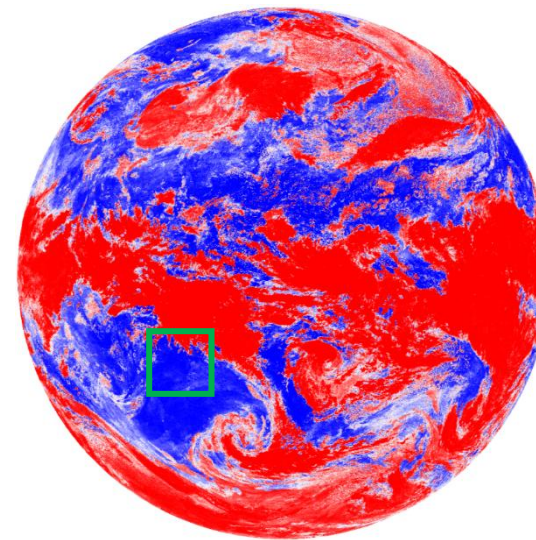
12UTC, 11th December 2023



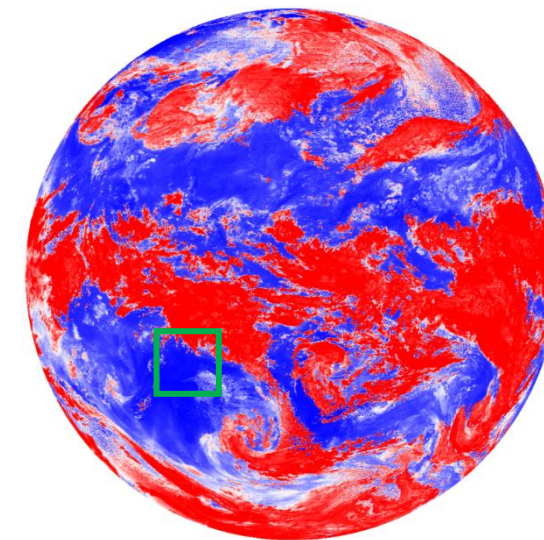
IR image (B13)



current FCP



RF



NN

cloudy

mix

clear

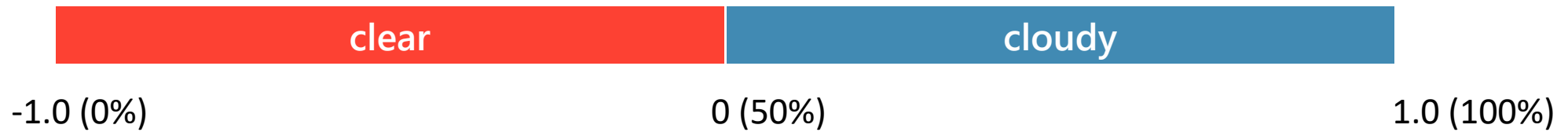
- ✓ The current FCP indicates cloudy conditions over the ocean northwest of Australia (green rectangle), but RF/NN indicates clear conditions.
- ✓ RF/NN model results looks more accurate than that of the current FCP.
- ✓ The current FCP may have mistaken a dust area for a cloud area in this case.

Adjusting the threshold for clear/cloudy

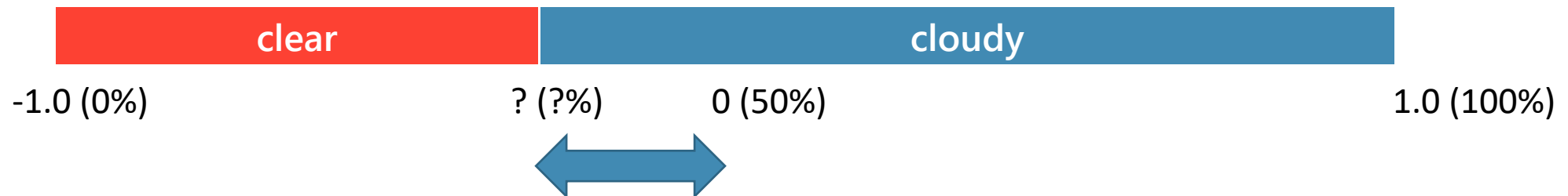


- ✓ Model output of cloud probability ranges from -1 (clear) to 1 (cloudy).
- ✓ Default threshold dividing clear/cloudy conditions is 0 (50%).
- ✓ Adjusting the threshold to maximize accuracy.

Default threshold



Adjusted threshold



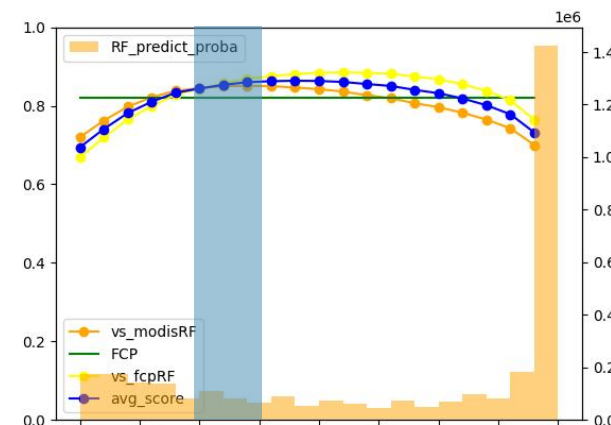
Maximizing accuracy

16th of each month in 2024

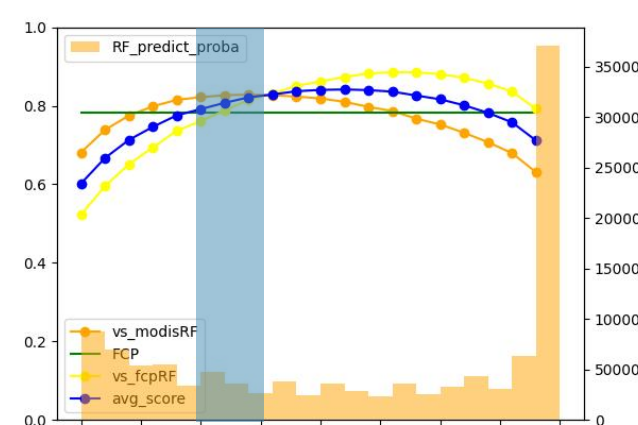
- ✓ The accuracy can be maximized by appropriately adjusting the threshold for clear/cloudy conditions.
- ✓ Blue banded range (-0.5 ~ -0.25) seems to be suitable.

land

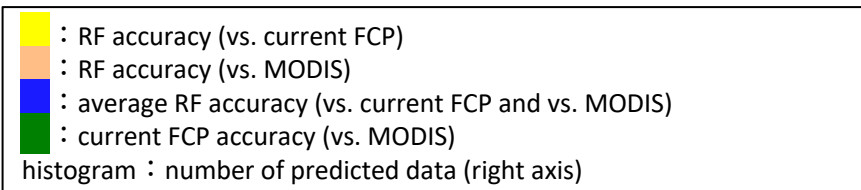
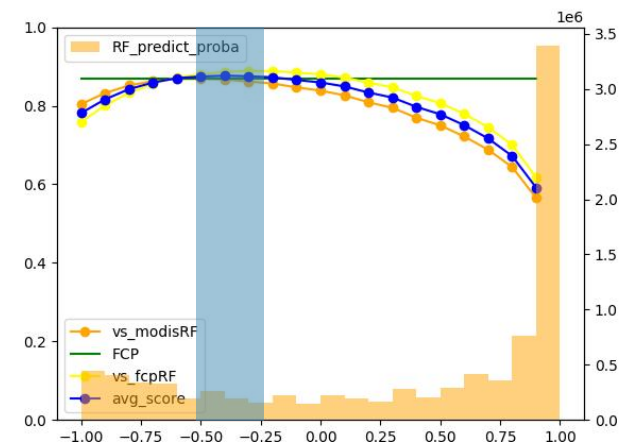
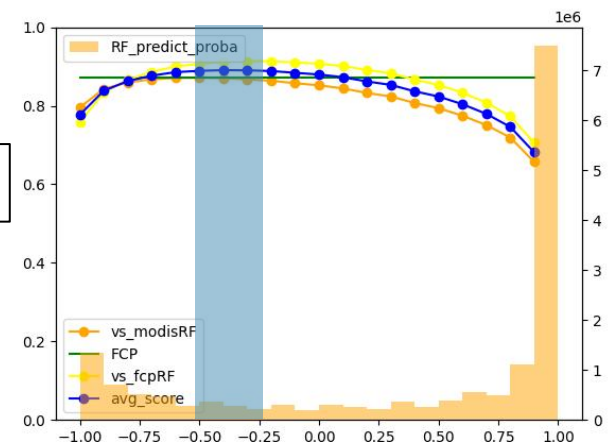
daytime



nighttime



ocean



vertical axis : accuracy
horizontal axis : cloud probability (-1 ~ 1)

Future plans (Next step)



- ✓ Explore other methods (U-Net, etc.)
- ✓ Adjust model setting
- ✓ Consider true value (current FCP? MODIS? other data?)
- ✓ Add training data
- ✓ Continue evaluation

Summary



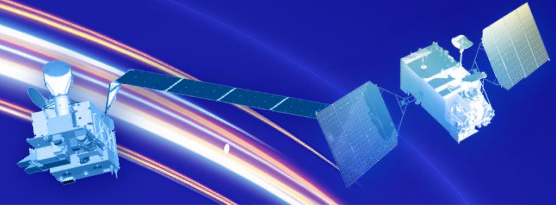
MSC/JMA is currently developing a new FCP's cloud mask

- ✓ In order to improve the accuracy of the cloud mask, MSC examined the use of random forests (RF) and neural networks (NN) for a new FCP's cloud mask.
- ✓ Evaluation results showed that the cloud mask of the RF model was closer to the current FCP's cloud mask than that of the NN model.
- ✓ With reference to the MODIS cloud mask, the accuracy of the cloud mask of the RF model was slightly higher than the current FCP over land, while lower over sea.
- ✓ Some case studies showed that the cloud detection by the RF/NN model was more accurate than that of the current FCP.



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Thank you for your attention !