



Initial Validation of JAXA's Four-Sensor Synergy Radiation Budget Product: ALL_RAD

Takashi M. Nagao¹ and Kentaroh Suzuki¹

¹ Atmosphere and Ocean Research Institute, The University of Tokyo, Japan

JAXA's Four-Sensor Synergy Radiation Product: ALL_RAD

Definition & Features

- Categorized as **JAXA's L2b synergy standard product**, planned for release in Dec. 2025.
- **Generates composite aerosol & cloud profiles** by integrating three L2a single-sensor products from CPR, ATLID, and MSI.
- Employs **1-D radiative transfer calculations** to estimate radiative properties.
- Provides **SW & LW radiative fluxes at TOA & BOA** with a horizontal resolution of 10 km, aligned with the CPR footprints.
- Additionally, provides **SW & LW radiative heating rate profiles**.
- Currently, **being validated against BMA_FLX & BSRN**

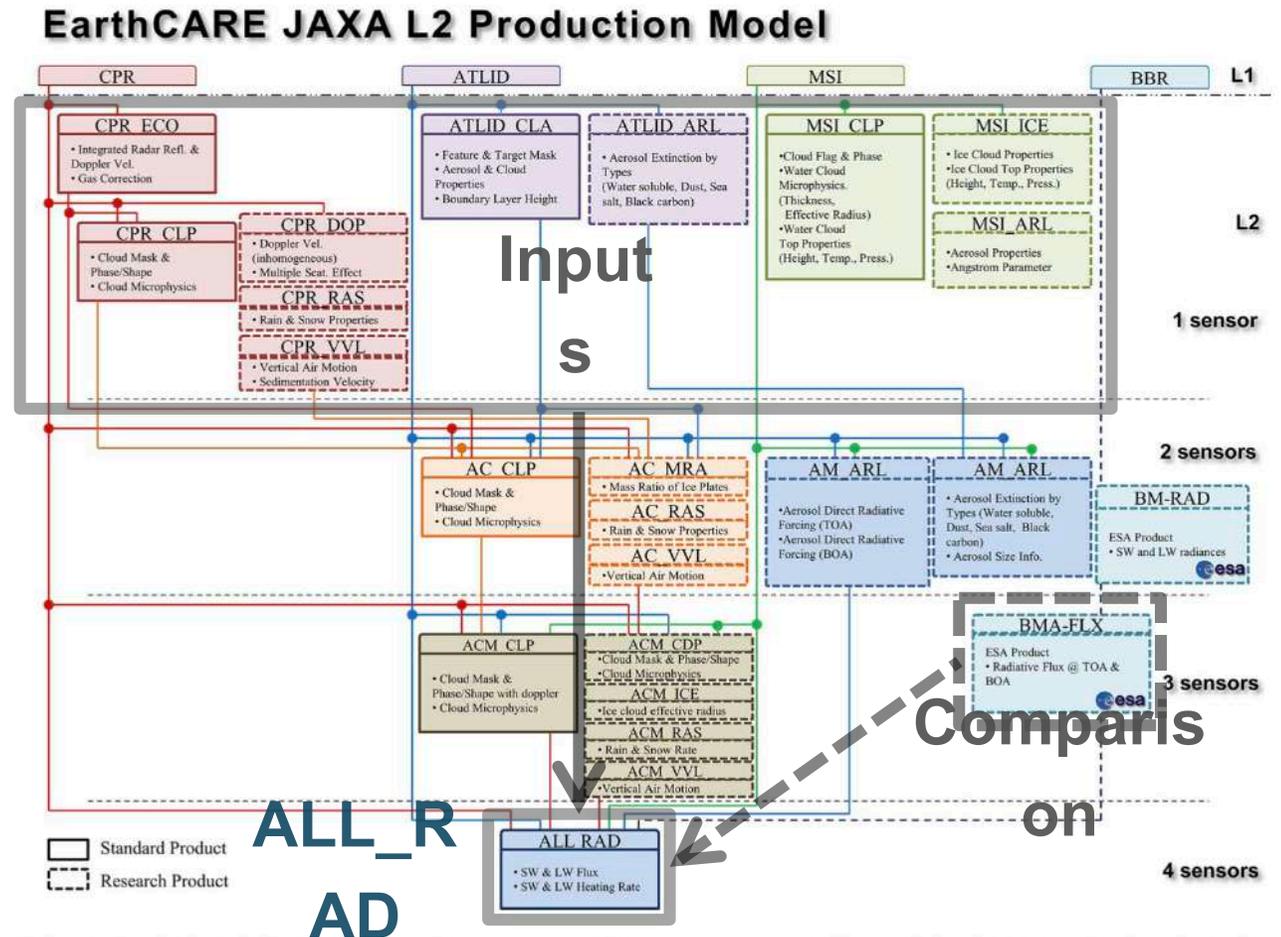
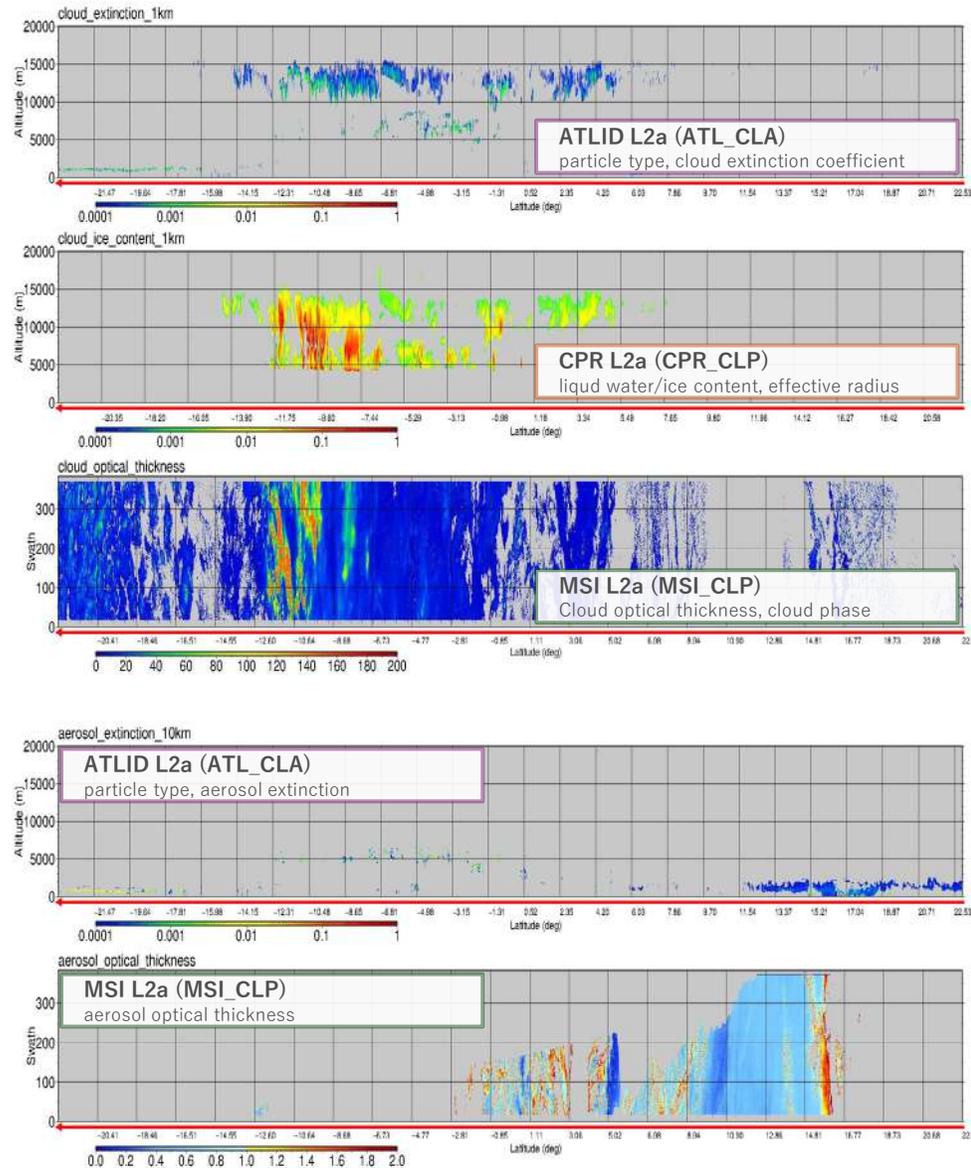


Figure 3. The JAXA EarthCARE Production Model shows all JAXA data products and ESA's level 1 and BBR level 2b products. Level 2 products and their retrieval algorithms (L2a, L2b) are described in this AMT special issue according to Table 2 (L2a) and Table 4 (L2b).

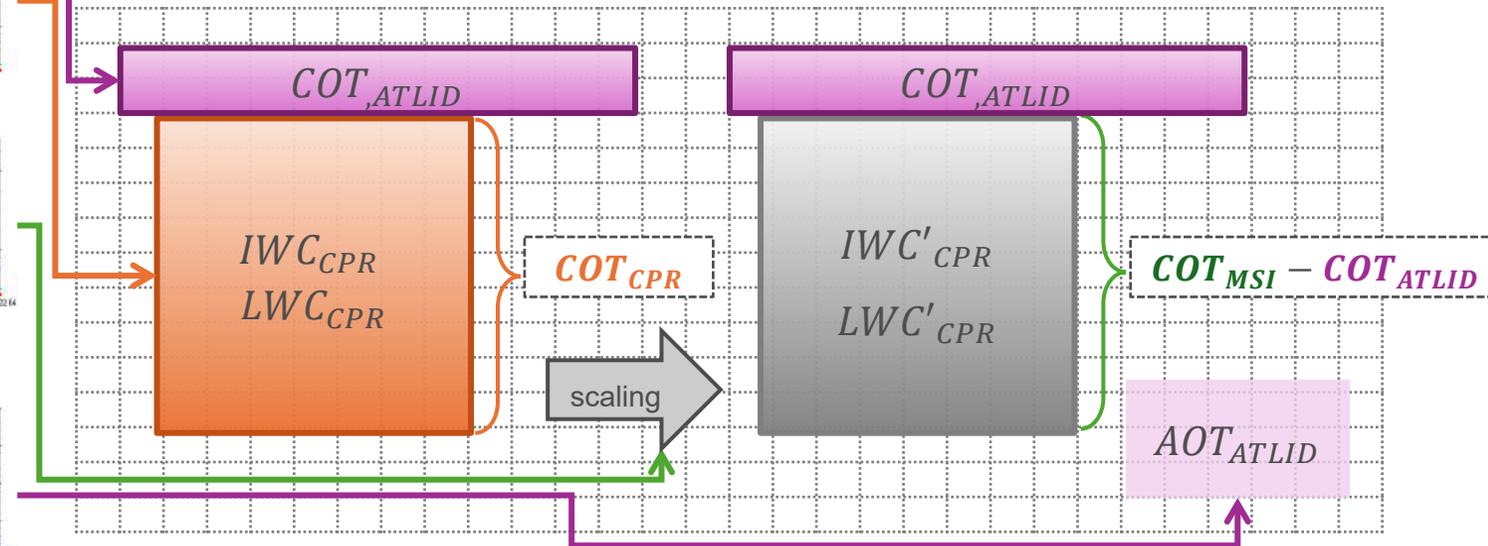
Adapted from Eisinger et al., 2024 AMT

Generating Composite Cloud and Aerosol Profiles



[For cloud properties]

1. Combines cloud information derived from **ATLID** & **CPR** to generate composite cloud profiles
2. If available, uses **MSI COT** to adjust the **LWC/IWC** of each vertical bin so that total COT matches MSI-observed COT



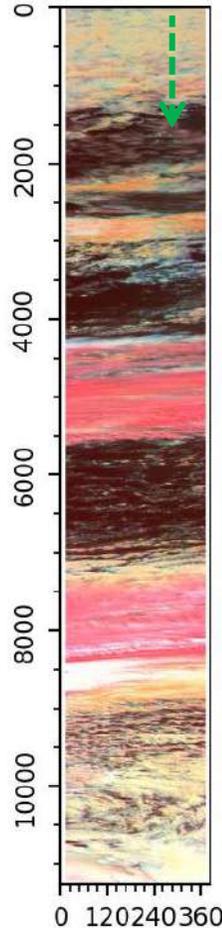
[For aerosol properties]

1. Uses aerosol type & extinction coefficient from **ATLID**
2. MSI-based AOT is not used at this time

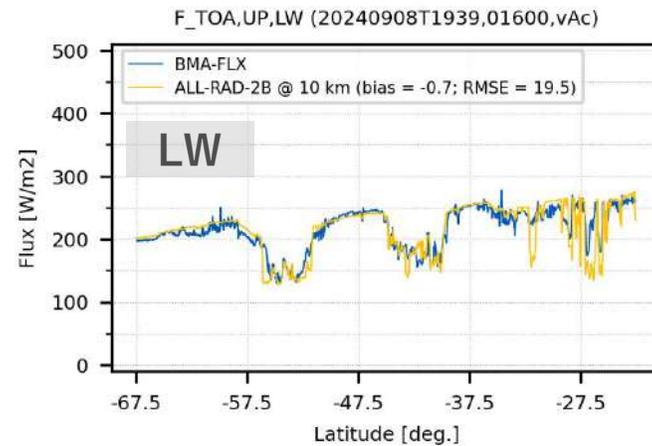
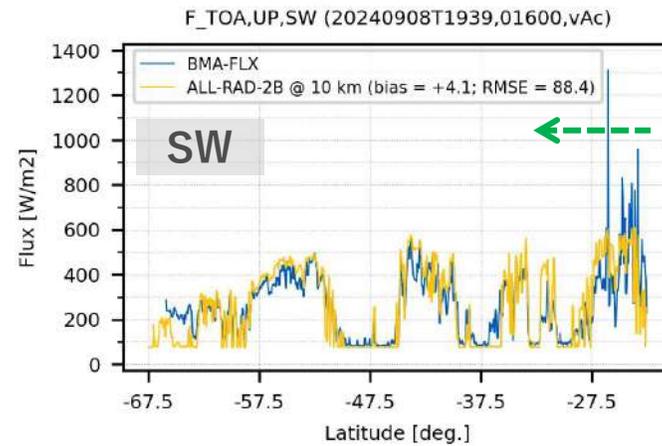
ALL_RAD Output Data

- Performs **1-D RT calculations** using the composite profiles with 1 km horizontal resolution.
- Provides **SW/LW fluxes at TOA/BOA** and **radiative heating rate profiles** averaged over 10 km horizontally.

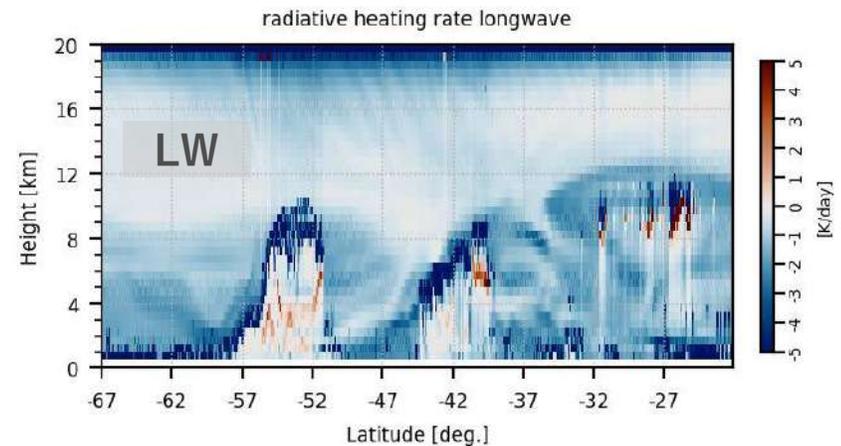
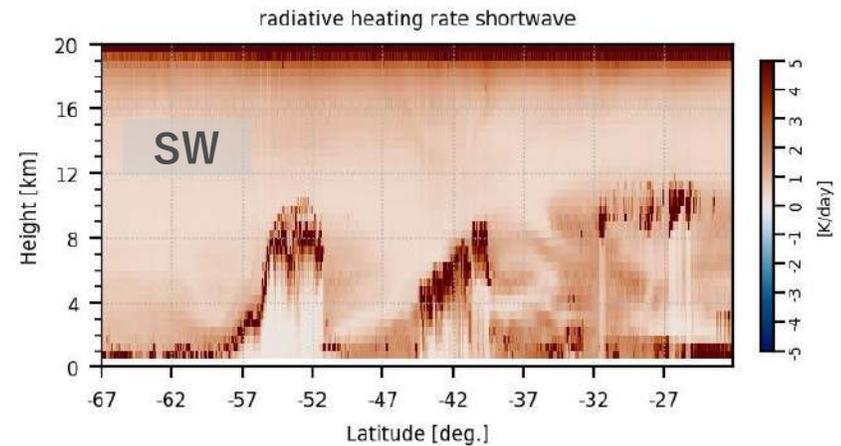
MSI L1C (Band 1, 3, 4)
2024/09/08 19:39, RGB@SW



TOA Flux



Radiative heating rate



ALL_RAD Validation Strategy & Initial Validation Activities

1) Validation of **upward SW/LW fluxes at TOA using BMA_FLX**

- Period: Jan. 14 – Feb. 14, 2025 (introduced in this talk)
- Inputs: JAXA's L2a ATL_CLA, CPR_CLP, MSI_CLP (vAc)

2) Validation of **downward SW/LW fluxes at surface using BSRN ground measurements**

- Currently in preparation
- However, demonstrated using A-Train data during the pre-launch period (Yamauchi et al., 2024 AMT)

3) **Intercomparison with ACM_RT**

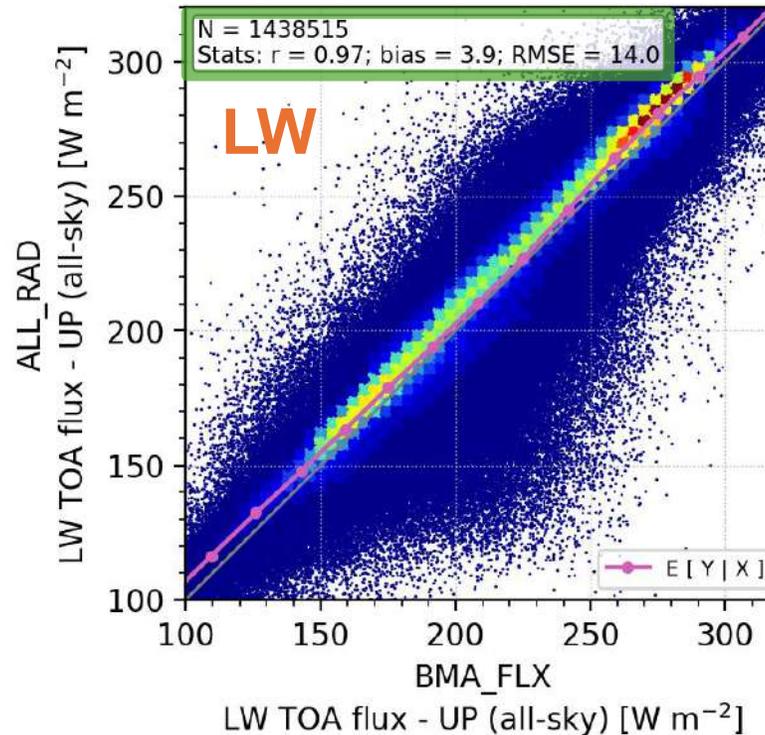
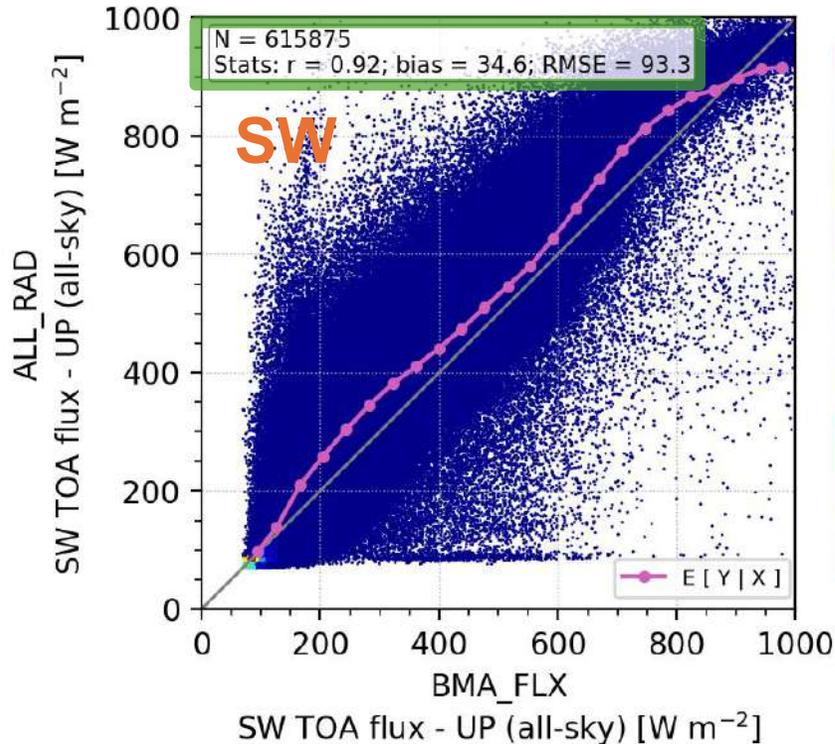
- In collaboration with J. Cole
- Discussed in J. Cole & K. Suzuki's Talk

ALL_RAD Evaluation Using BMA_FLX Comparison

ALL_RAD Algorithm v0.7

- Results using v0.7 were presented in JAXA Tanaka-san's talk on Day 1
- **SW**: Shows a very high correlation (0.92) but exhibit a **significant positive bias** (+34.6 W/m²)
- **LW**: Shows a very high correlation (0.97) with a low bias (+3.9 W/m²)

Land & ocean, Daytime (all-sky)



Q. What are the possible causes of the positive bias in SW?

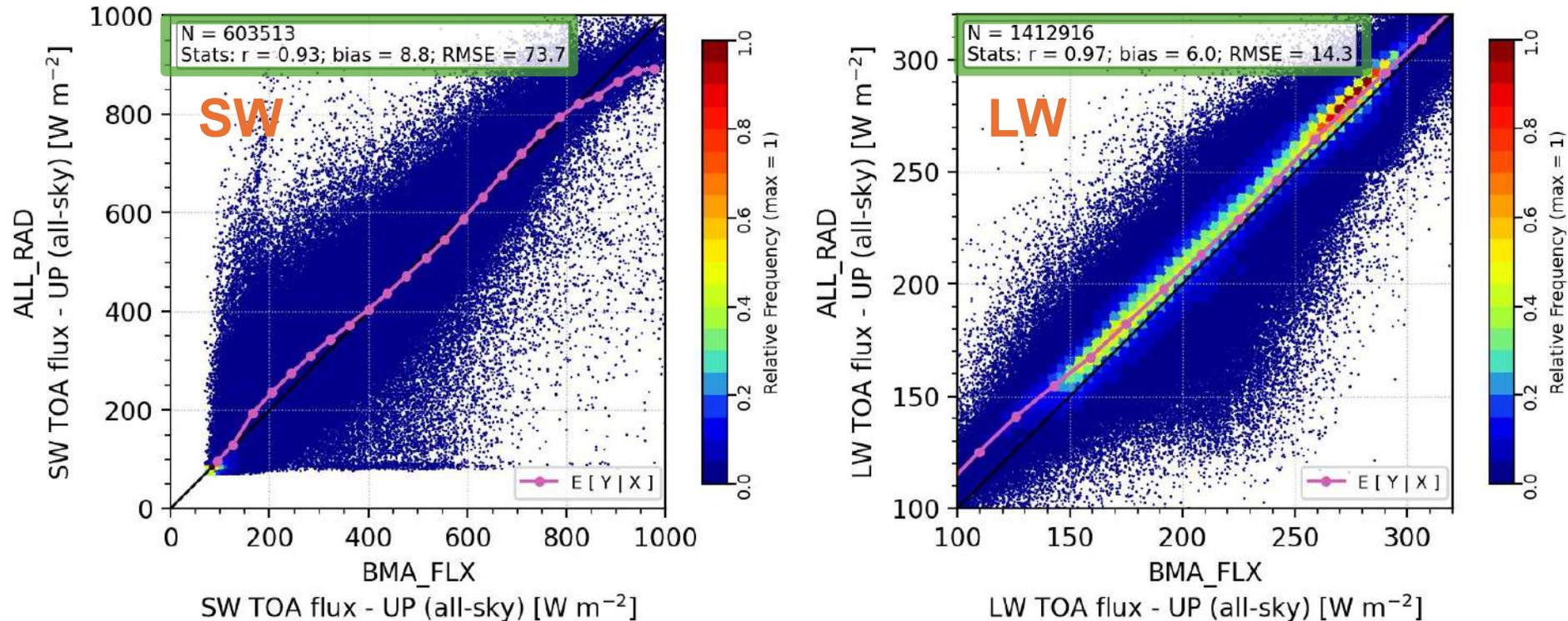
- Bias in MSI COT? (This will become clearer through their cal./val. activities.)
- Focus on any issues in ALL_RAD algorithm

ALL_RAD Evaluation Using BMA_FLX Comparison

ALL_RAD v0.8 (in Progress)

- Found an inconsistency between ice particle scattering used in the 1D-RTs of MSI_CLP & ALL_RAD
- Tested an updated ALL_RAD where ice cloud scattering quantitatively matches MSI_CLP
- The SW bias was significantly reduced from +34.6 W/m² to +8.8 W/m².

Land & ocean, Daytime (all-sky)



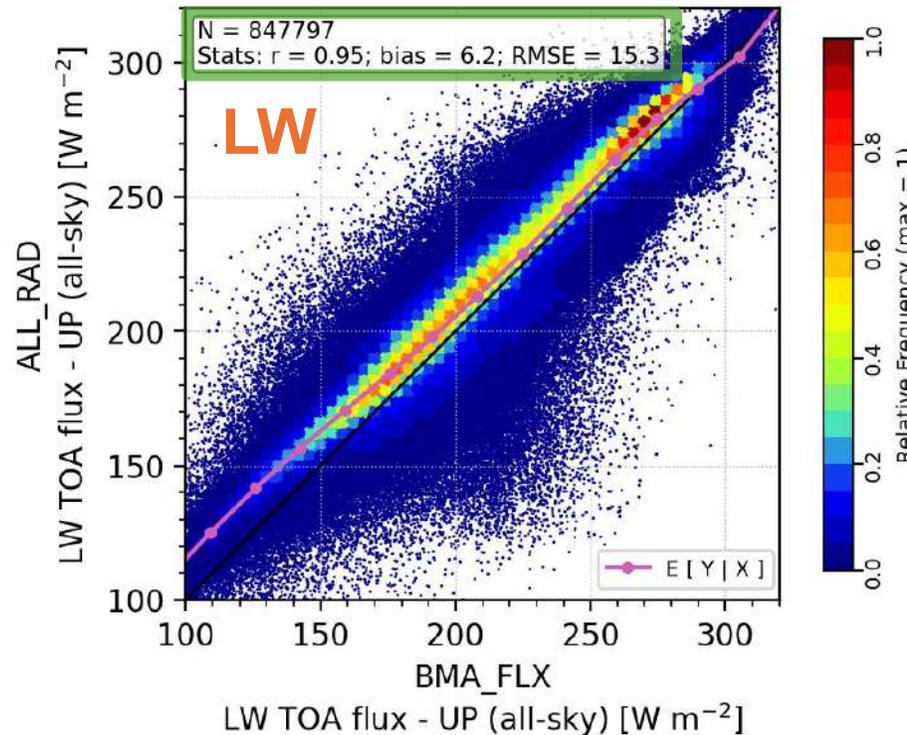
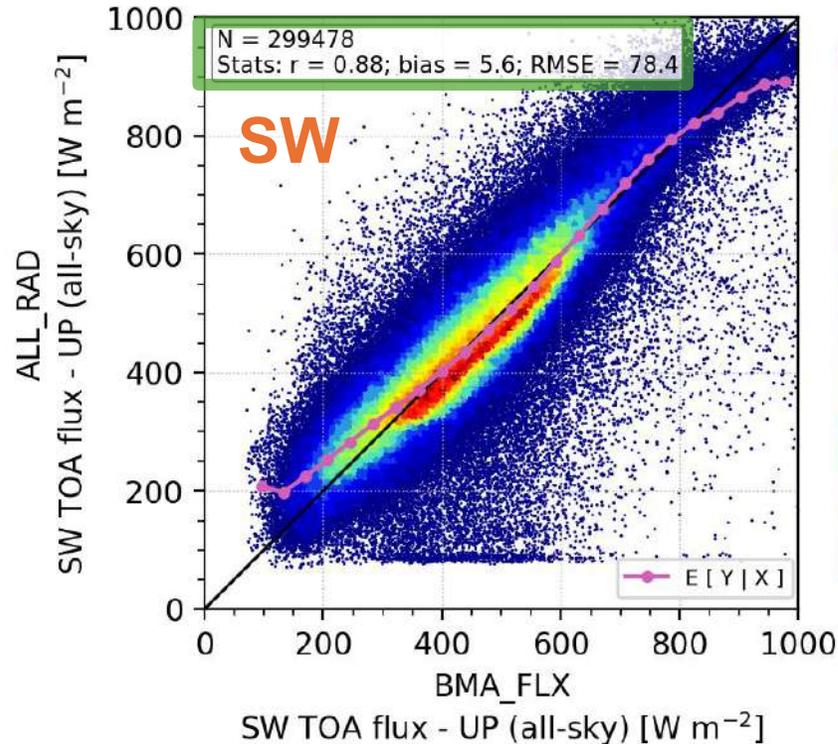
ALL_RAD Evaluation Using BMA_FLX Comparison

ALL_RAD v0.8 (in Progress)

(Data extracted with cloud cover > 90%)

- Found an inconsistency between ice particle scattering used in 1D-RTs of MSI_CLP & ALL_RAD
- Tested an updated ALL_RAD where ice cloud scattering quantitatively matches MSI_CLP
- The bias in SW is significantly reduced to +5.6 W/m², even if limit to cloud pixels.

Land & ocean, Daytime (all-sky)



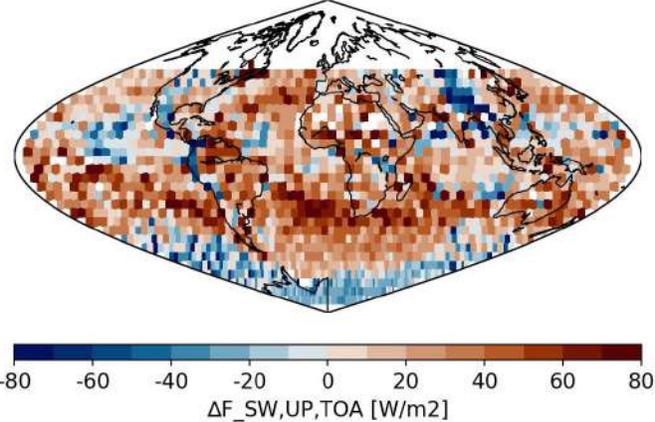
Q: Can such accuracy be consistently expected, anywhere ?

Error Characteristics: Spatial Distribution of Bias (For cloudy pixels)

Base on MSI
observation

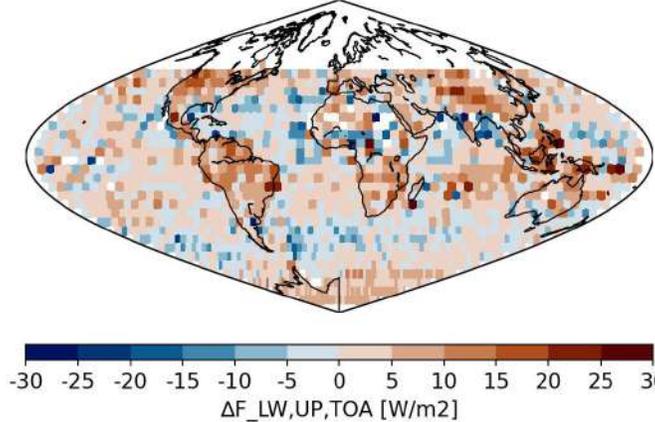
SW, Day

Day, Cloud cover > 90 % (+3.5 W/m²)



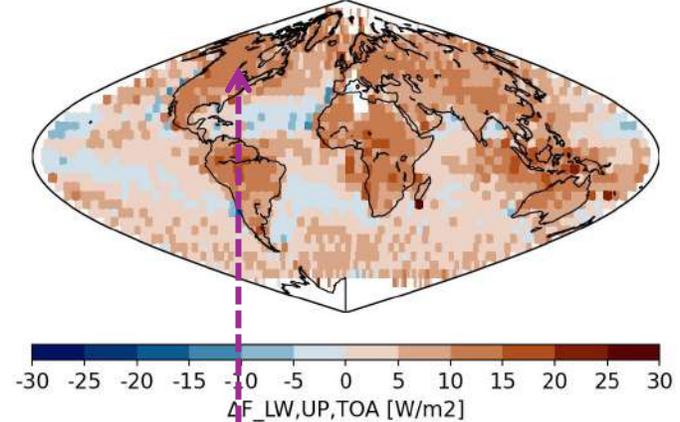
LW, Day

Day, Cloud cover > 90 % (+5.3 W/m²)

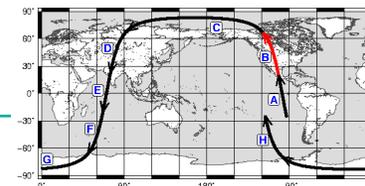
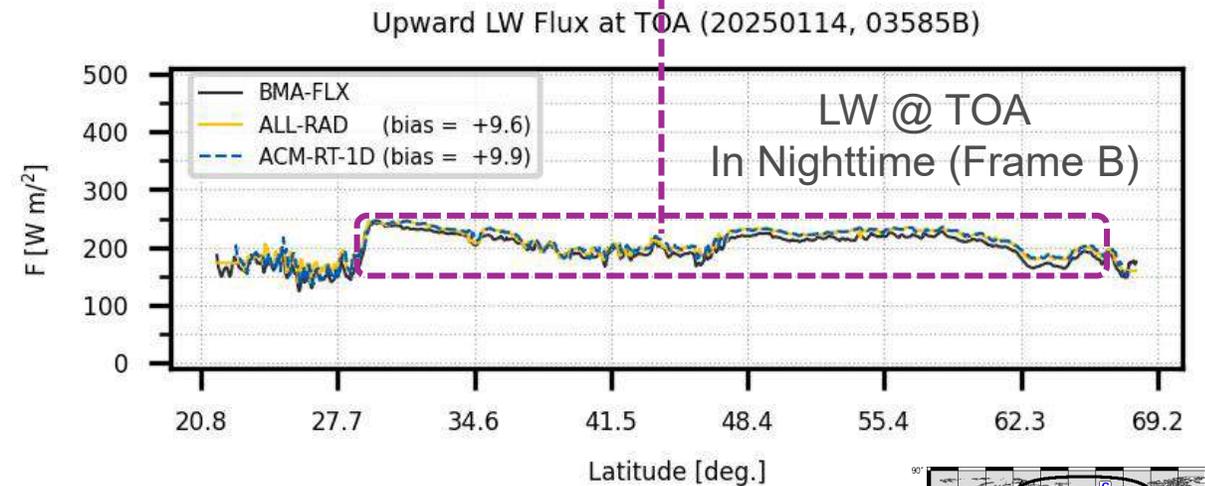


LW, Night

Night, Cloud cover > 90 % (+9.8 W/m²)



- SW: The bias varies geographically, and its variation is much larger than the total bias. However, (un)fortunately, positive and negative cancel each other out, resulting in a small total bias (+3.5 W/m²).
- LW: The total positive bias arises from positive biases over land areas, which are amplified at nighttime (+5.3 W/m² → 9.8 W/m²).

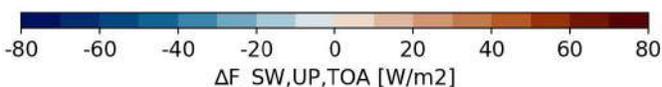
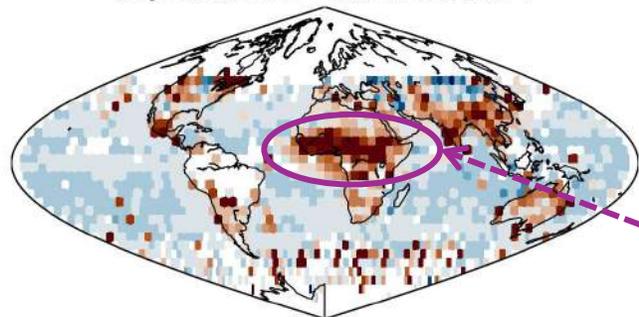


Error Characteristics: Spatial Distribution of Bias (For clear pixels)

Base on MSI observation

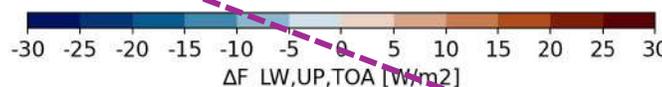
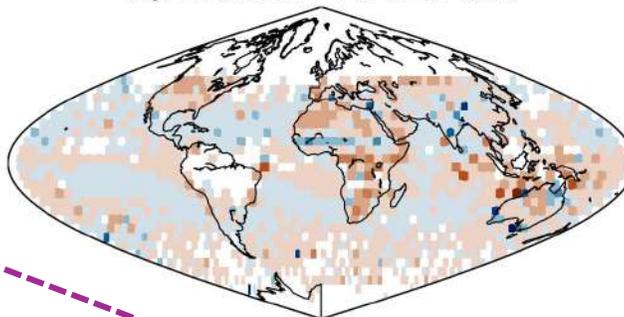
SW, Day

Day, Cloud cover = 0 % (+28.0 W/m²)



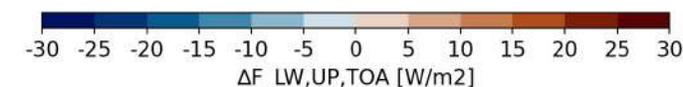
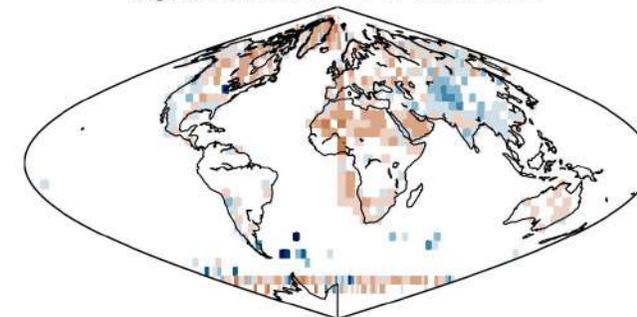
LW, Day

Day, Cloud cover = 0 % (+1.3 W/m²)



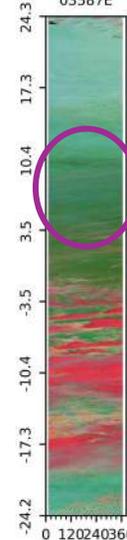
LW, Night

Night, Cloud cover = 0 % (+1.6 W/m²)

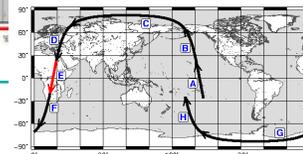
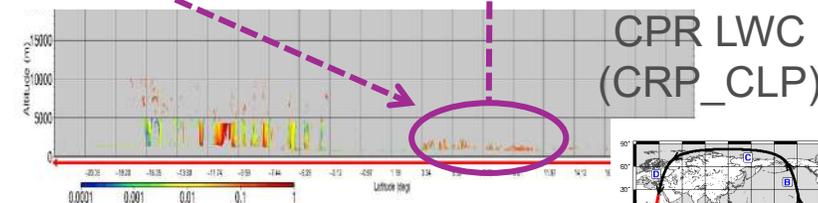
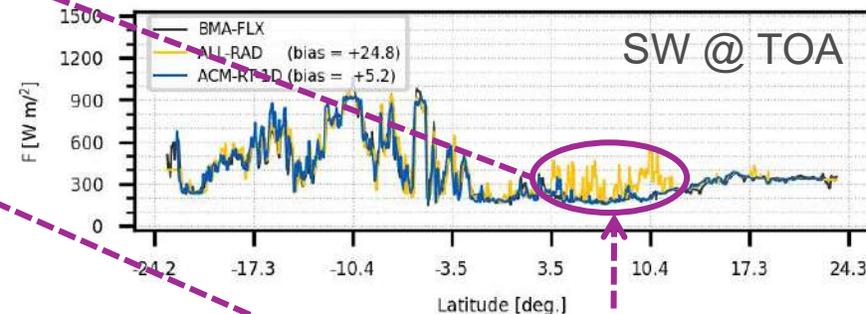


- SW: Significantly large positive biases are observed over land areas, particularly central Africa region
- Due to issues in the composite process of ALL_RAD, it failed to mask uncertain cloud properties near the ground surface originated from the CPR cloud product.

2025/01/14 12:14, RGB@03587E



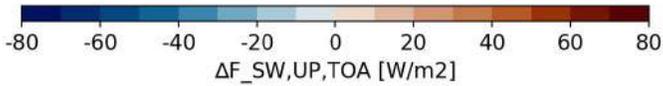
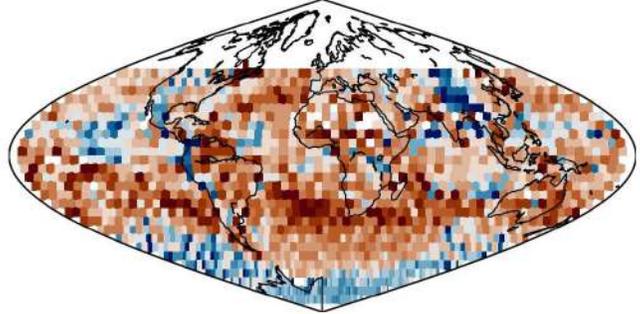
Upward SW Flux at TOA (20250114, 03587E)



Error Characteristics: Dependence on Cloud Properties

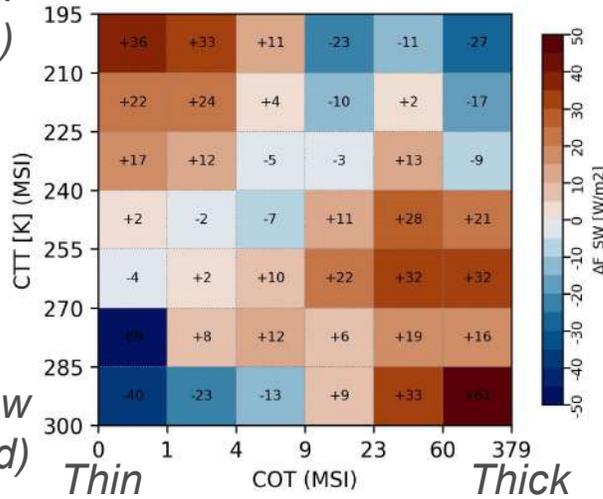
SW, Day

Day, Cloud cover > 90 % (+3.5 W/m²)



High
(ice)

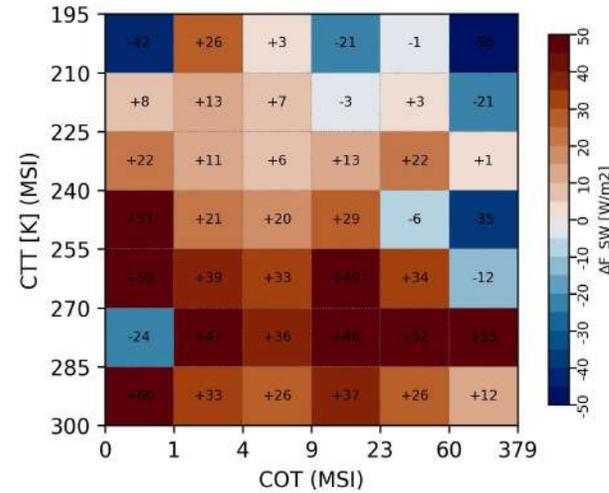
Ocean



Low
(Liquid)

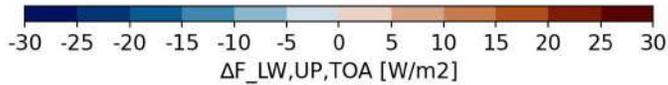
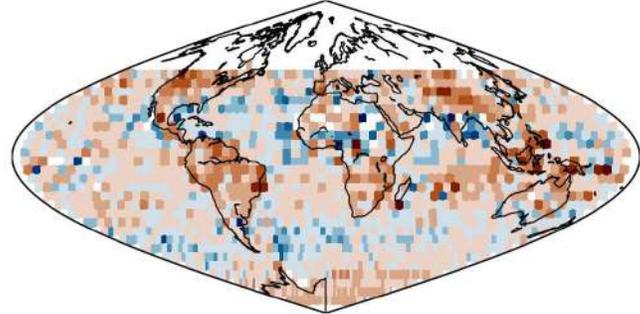
Thin Thick

Land

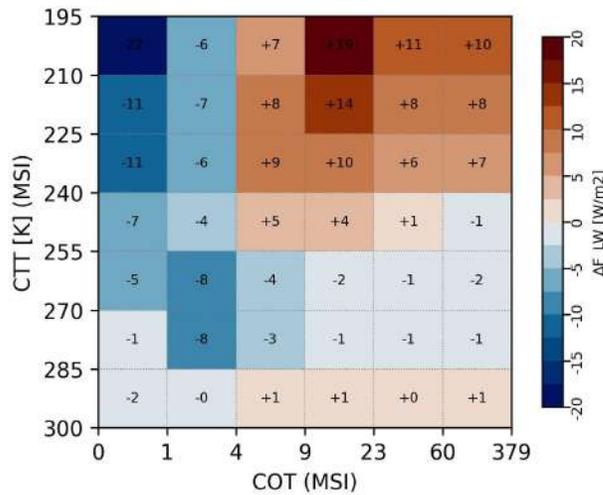


LW, Day

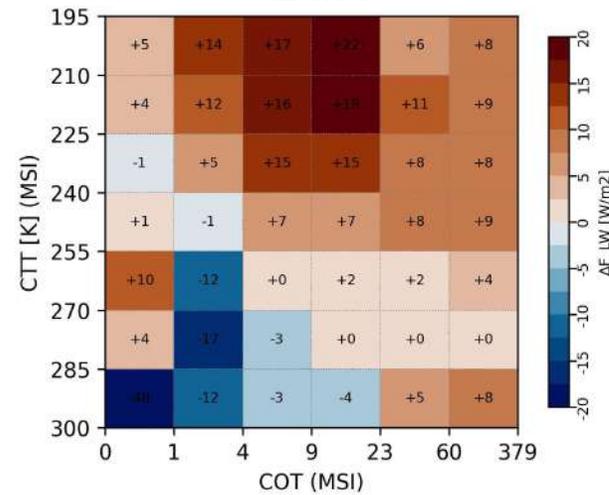
Day, Cloud cover > 90 % (+5.3 W/m²)



Ocean



Land



✓ Both SW/LW biases vary depending on COT & CTH, Their variation are much larger than total mean bias.

Summary

- **ALL RAD**: JAXA's L2b synergy product, which provides SW & LW radiative fluxes at TOA & BOA and radiative heating rate profiles.
- **Initial validation**: ALL_RAD is being validated through comparisons with BMA_FLX. SW & LW flux exhibits high correlation and low bias after corrected the inconsistency of ice particle scattering properties used in 1D-RTs of MSI cloud retrieval algorithm and ALL_RAD.
- **Known issues**: The biases varies geographically. For SW, positive and negative cancel each other out, resulting in a small total bias. For LW, the total positive bias arises from positive biases over all land areas, which amplified at nighttime.
- **Towards the release**: The ALL_RAD still has several issues within its own algorithm that need to be resolved. Additionally, the quality of ALL_RAD products is expected to improve as the quality of the input products improved. Therefore, we will continuously conduct such validations and provide feedback to the developers of the Level-2 products.