Early validation of JAXA four-sensor radiation product

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1st ESA-JAXA EarthCARE In-Orbit Validation Workshop

14 – 17 January 2025 | VIRTUAL EVENT

Aims of This Talk

- **To share the development status of JAXA synergy radiation product** (ALL_RAD), which provides fluxes and heating rates derived with 1-D radiative transfer calculations.

- **To present early validation results using the BMA_FLX product** for the SW/LW radiative fluxes at TOA provided by ALL_RAD.

- **To contribute to the improvement of BBR Level-1 and -2 products** through these efforts.

JAXA Four-sensor Synergy Radiation Product (ALL_RAD)

Definition & Features

- Categorized as a JAXA Level-2 standard product and corresponds to ESA ACM-RT
- Description Paper: Yamauchi et al., 2024 AMT
- Generates composite profiles as in ESA ACM-COM using aerosol & cloud properties from three Level-2a single-sensor products (derived from CPR, ATLID, & MSI).

  → At this stage, it does not use aerosol & cloud profiles from synergistic Level-2b products (retrieved by the combined use of CPR, ATLID and MSI Level-1 products)

- Employs 1-D radiative transfer calculations.
- Provides SW/LW radiative fluxes at TOA/BOA with a horizontal resolution of 10 km, along with the CPR footprints.
- Also provides SW/LW radiative heating rate profiles.

◆ Yamauchi et al., 2024: Description and validation of the Japanese algorithm for radiative flux and heating rate products with all four EarthCARE instruments: pre-launch test with A-Train. AMT, https://doi.org/10.5194/amt-17-6751-2024

ALL_RAD Processing

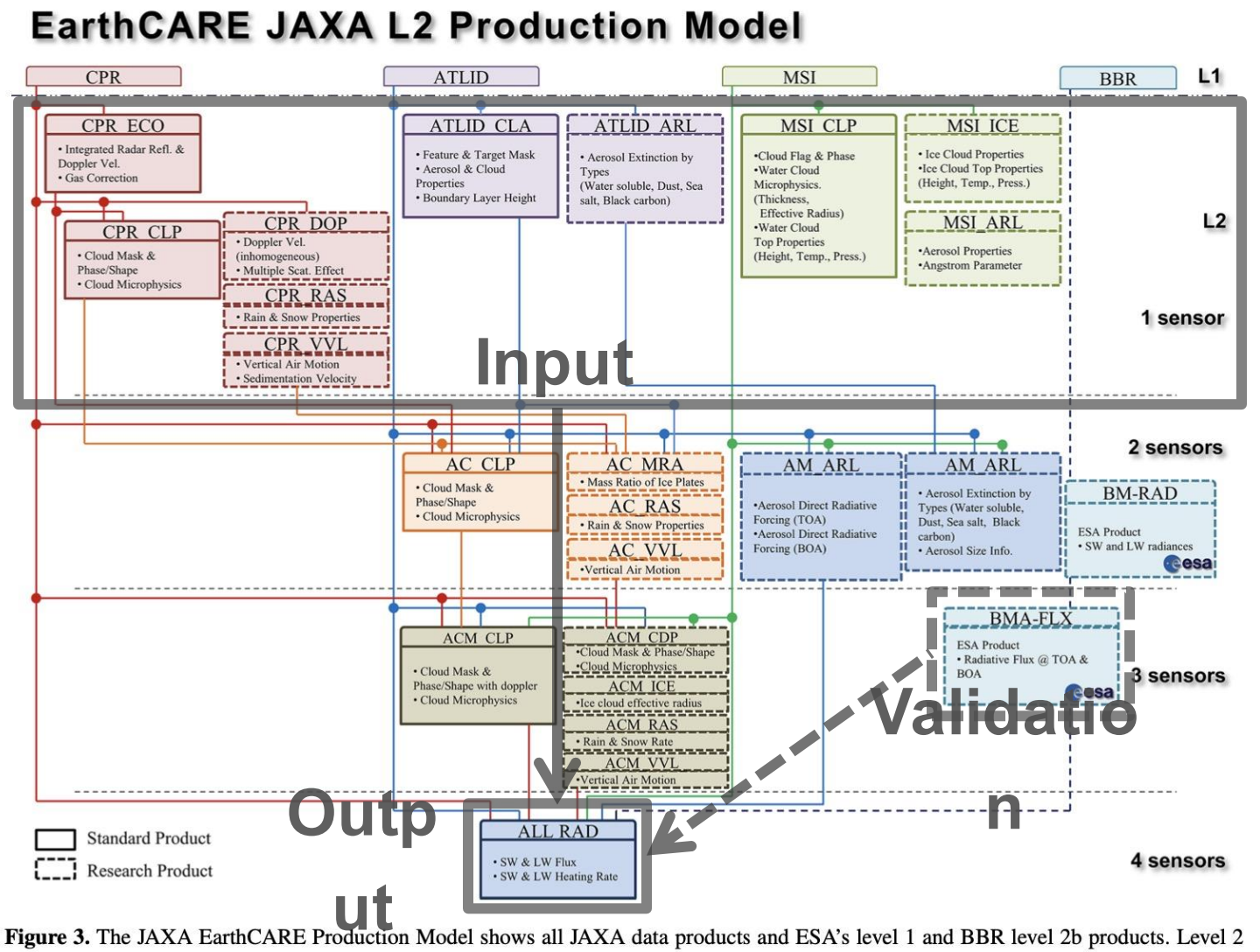


Figure 3. The JAXA EarthCARE Production Model shows all JAXA data products and ESA's level 1 and BBR level 2b products. Level 2 products and their retrieval algorithms (L2a, L2b) are described in this *AMT* special issue according to Table 2 (L2a) and Table 4 (L2b).

- Uses aerosol & cloud properties from single-sensor L2a products (ATLID_CLA, CPR_CLP, MSI_CPR) to generate composite aerosol & cloud profiles
- Performs 1D radiative transfer calculations
- Provides SW/LW fluxes and radiative heating rate profiles
- Validates using BMA-FLX

◆ Eisinger, et al., 2024: The EarthCARE mission: science data processing chain overview. AMT, https://doi.org/10.5194/amt-17-839-2024

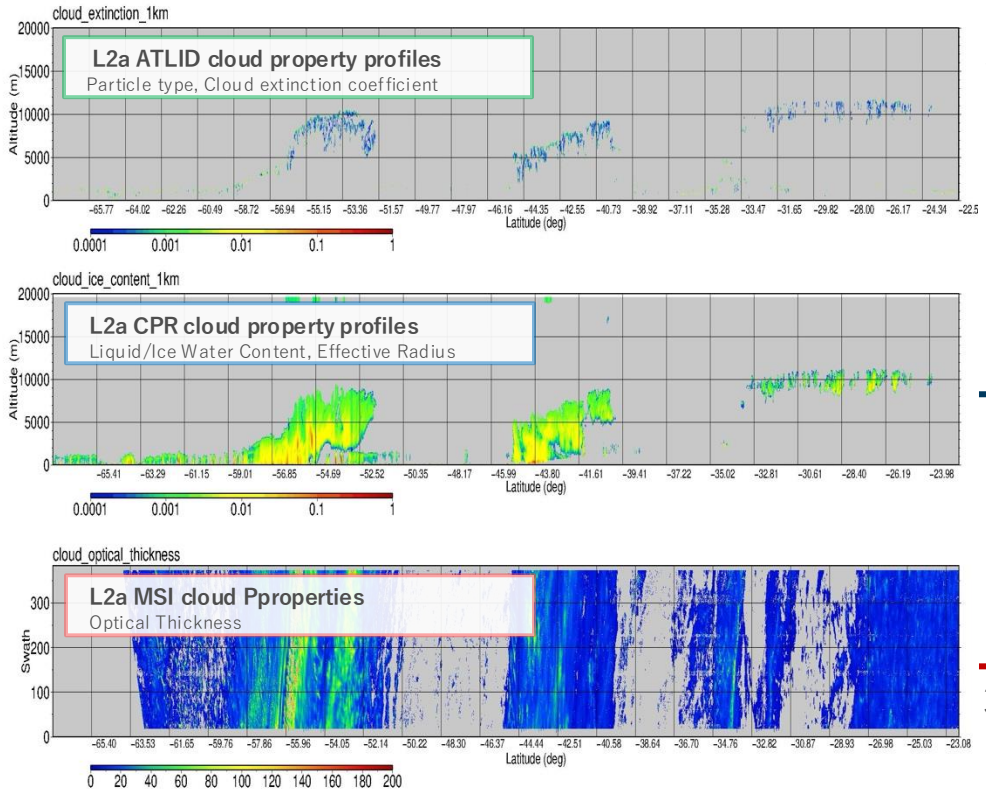
Generating composite aerosol & cloud profiles (as in ACM-COM)

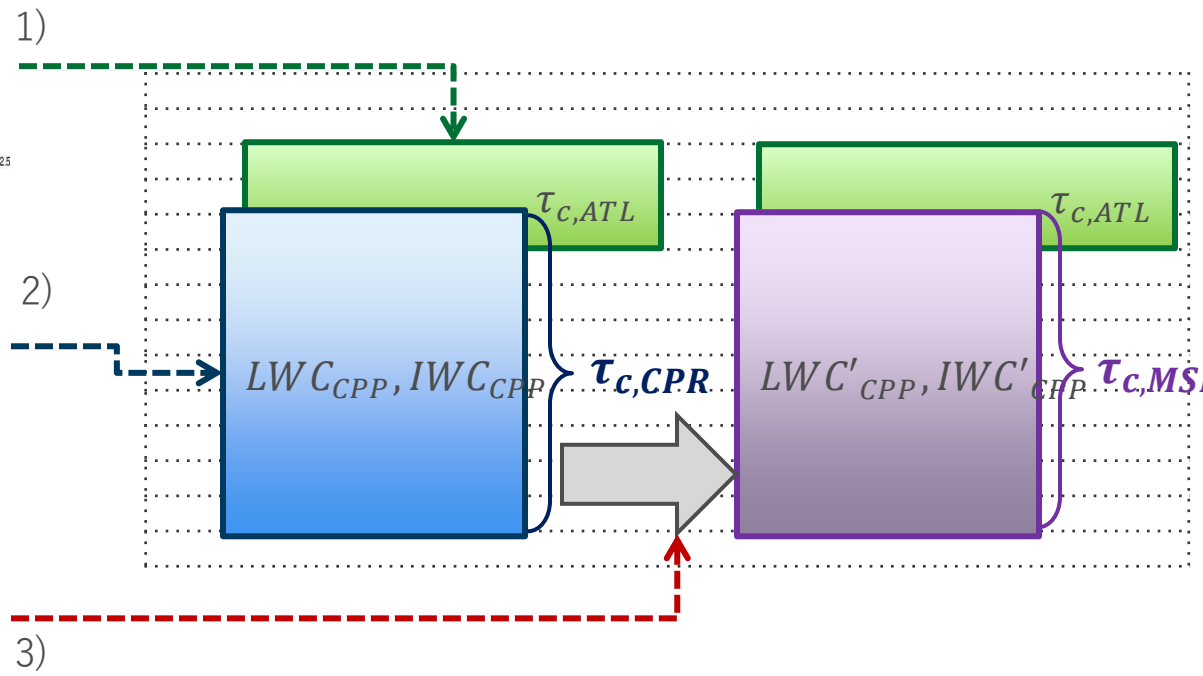
Aerosols

- Uses aerosol type & extinction coefficient profiles from ATLID.
- Does not utilize MSI-based AOT, which is not operationally produced at this time.

Clouds

- Generates a composite cloud profile by combining cloud property profiles from:
  1) ATLID (type & extinction coefficient) and 2) CPR (liquid/ice water content & effective radius)
- Adjusts the WC of each vertical bin in the composite profile to match: 3) the MSI-derived COT.

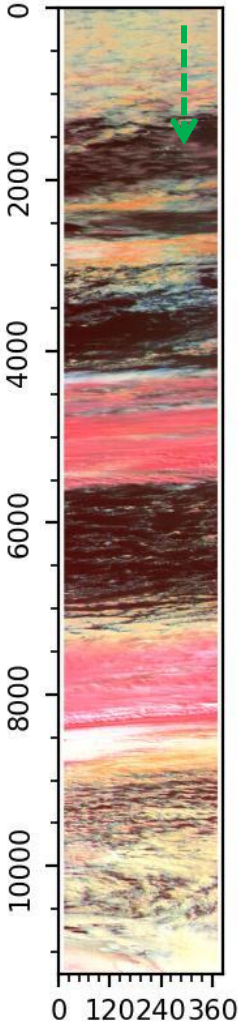




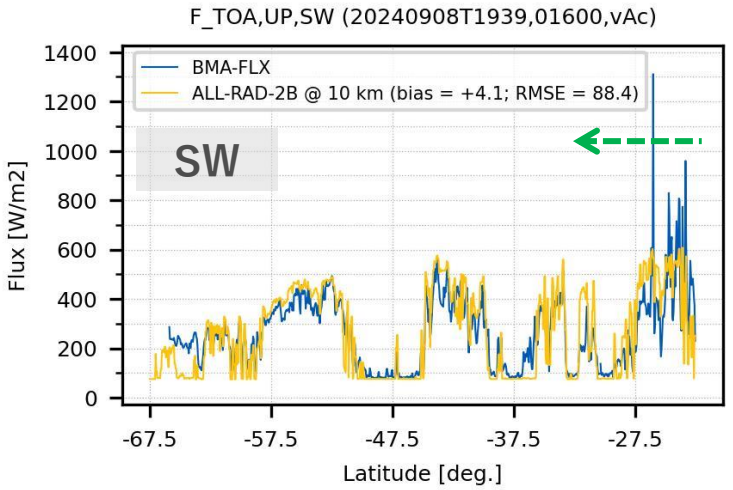
Output Data from ALL_RAD

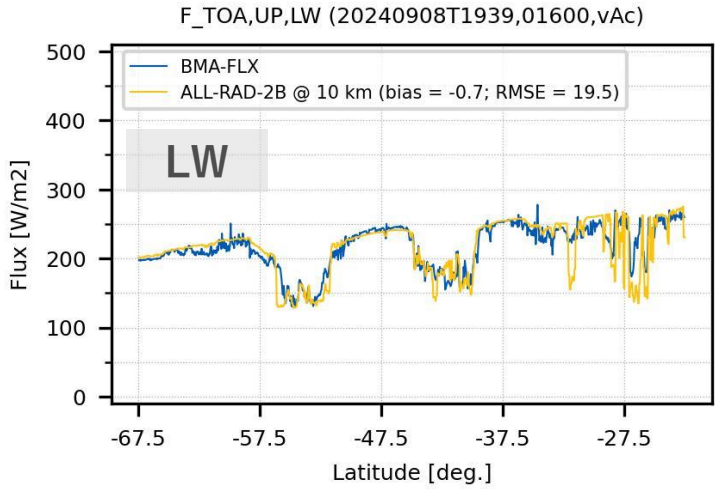
- Performs 1-D RT calculations using the composite profiles with 1 km horizontal × 500 m vertical resolution.
- Provides SW/LW fluxes at TOA/BOA and radiative heating rate profiles averaged over 10 km horizontally.

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

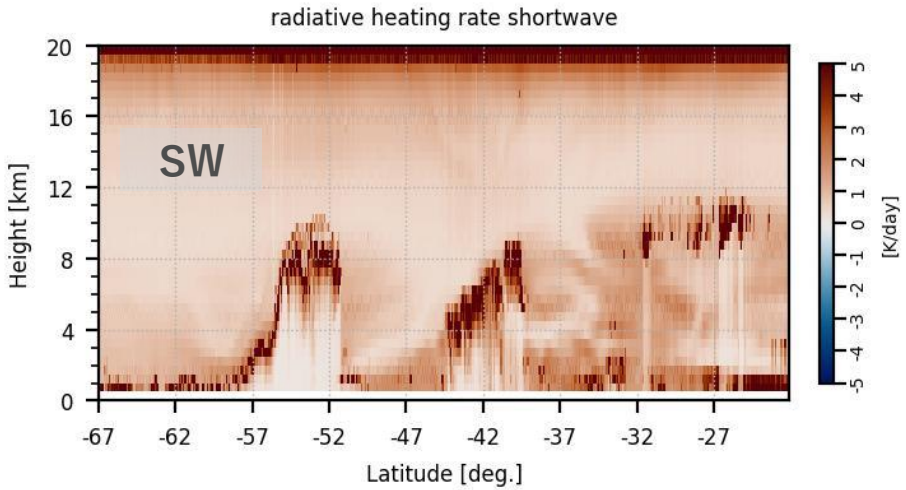


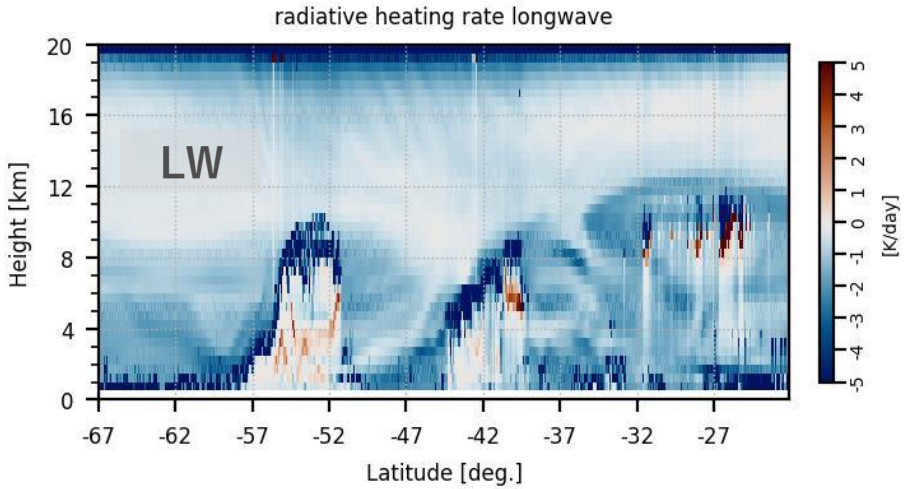
TOA Flux





Radiative heating rate



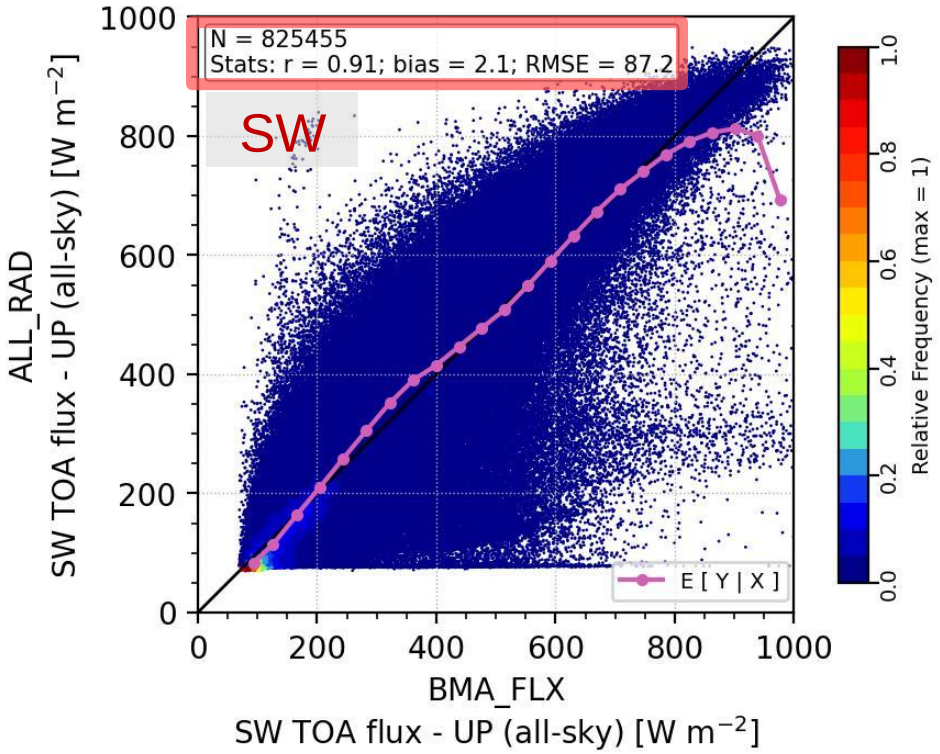


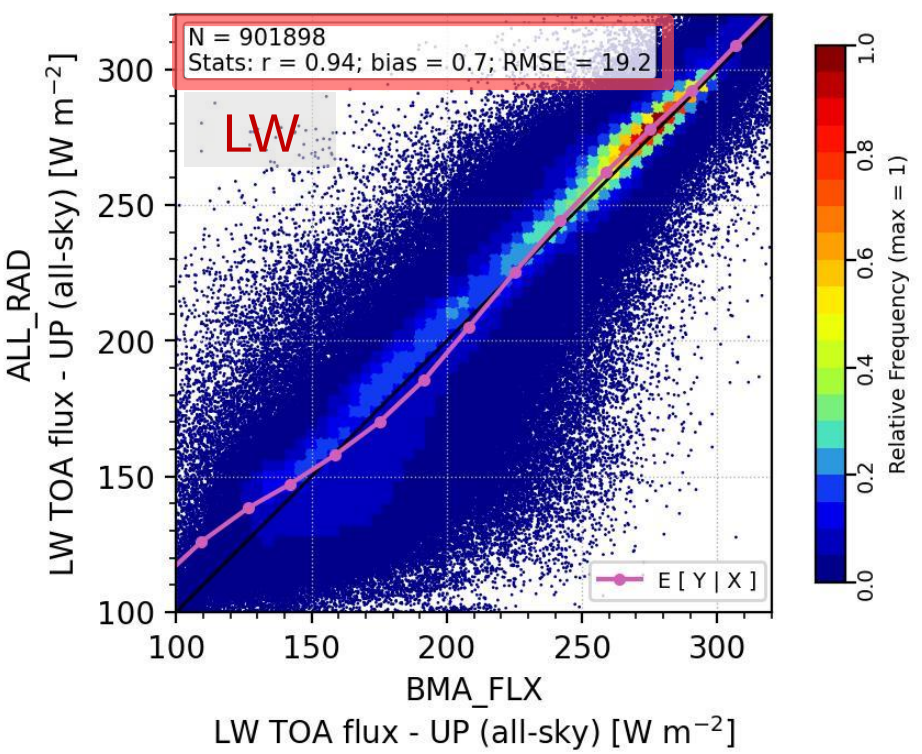
Validation with BMA_FLX

Notes: For this analysis, the JAXA L2a products (CPR_CLP, ATL_CLA, and MSI_CLP), produced using the previous version of the algorithms submitted before launch, were input into ALL_RAD. The latest algorithms, optimized after launch, have been applied since mid-December and were not available.

- Period: September 1 – November 30, 2024

L/W: land & ocean, D/N: daytime (all-sky)





- ✓ Strong correlation
- ✓ Low bias
- ✓ RMSE within the anticipated range

↓

Q: Can such accuracy be consistently expected, anytime & anywhere ?

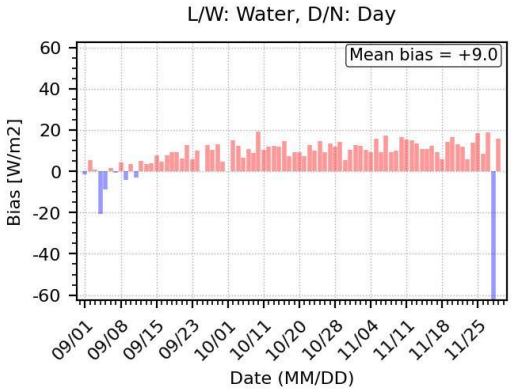
Variables:

- ALL_RAD : radiative_flux_[shortwave, longwave]_upward_toa
- BMA_FLX : StandardResolution/[solar, thermal]_combined_top_of_atmosphere_flux

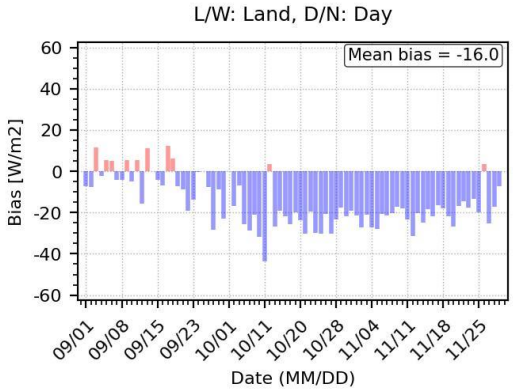
Significant dependence of bias on Land/Water, Day/Night

Bias of **SW** TOA fluxes (**all-sky**)

Water

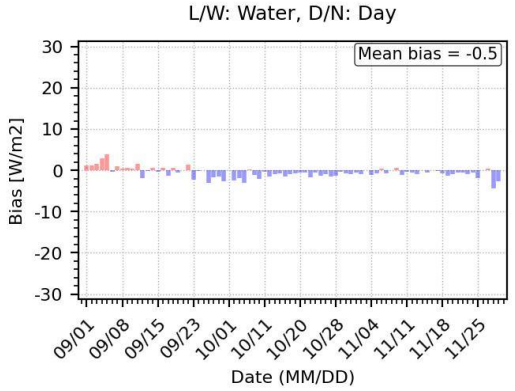


Land

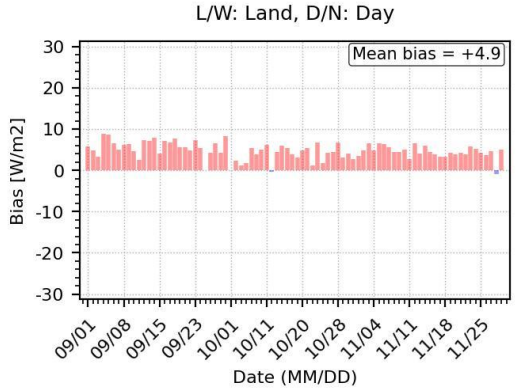


Bias of **LW** TOA fluxes (**all-sky**)

Water

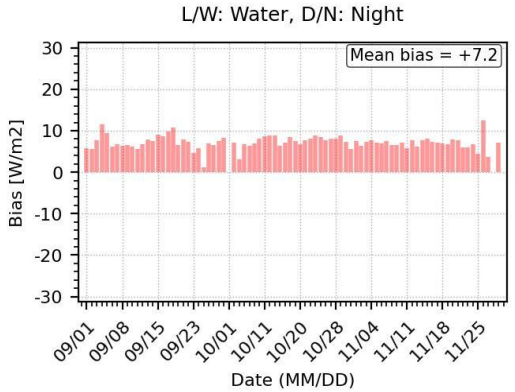


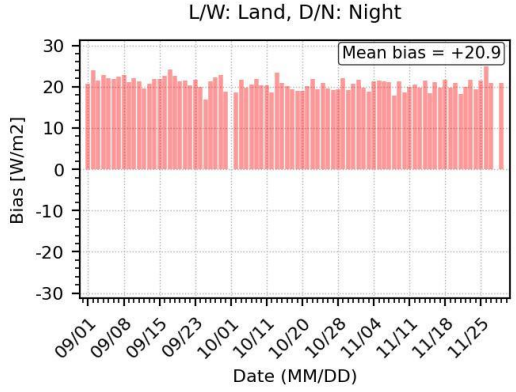
Land



Day

- ✓ Since the end of September (possibly related to the MSI L1 update), the bias trend has been consistent.
- ✓ Biases in ALL_RAD are strongly dependent on ‘Land/Water’ and ‘Day/Night’ conditions.





Night

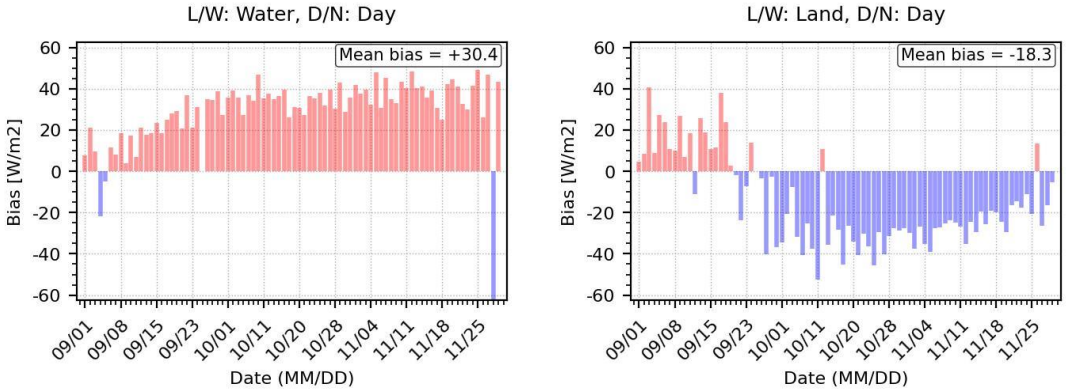
Significant dependence of bias on Land/Water, Day/Night

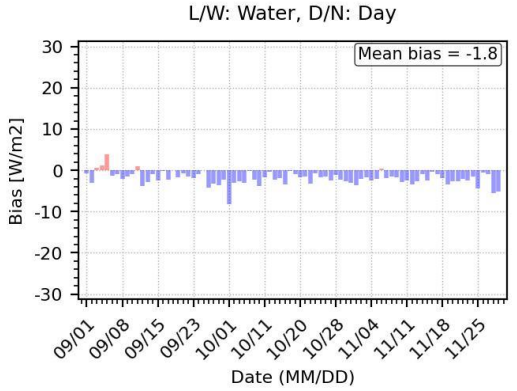
Bias of **SW** TOA fluxes (cloud cover > 80%)

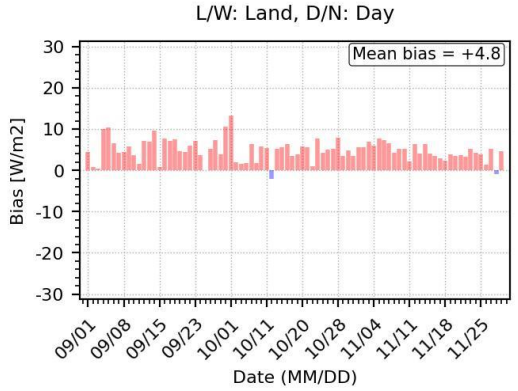
Bias of **LW** TOA fluxes (cloud cover > 80%)

Water **Land** **Water** **Land**

Day

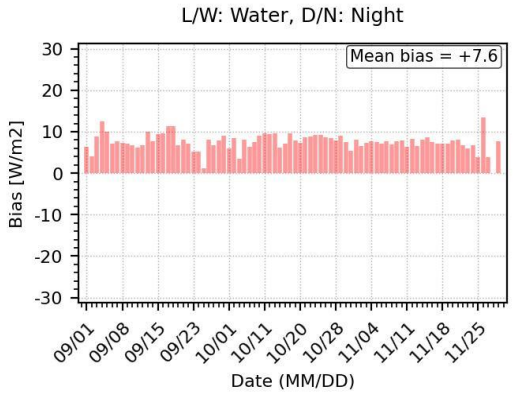


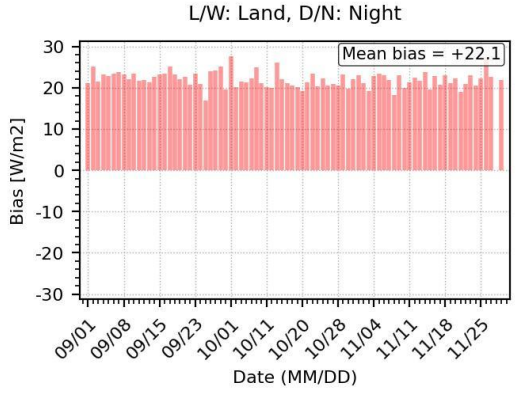




Day

- ✓ Since the end of September (possibly related to the MSI L1 update), the bias trend has been consistent.
- ✓ Biases in ALL_RAD are strongly dependent on ‘Land/Water’ and ‘Day/Night’ conditions.
- ✓ The biases of SW flux are amplified when covered by clouds



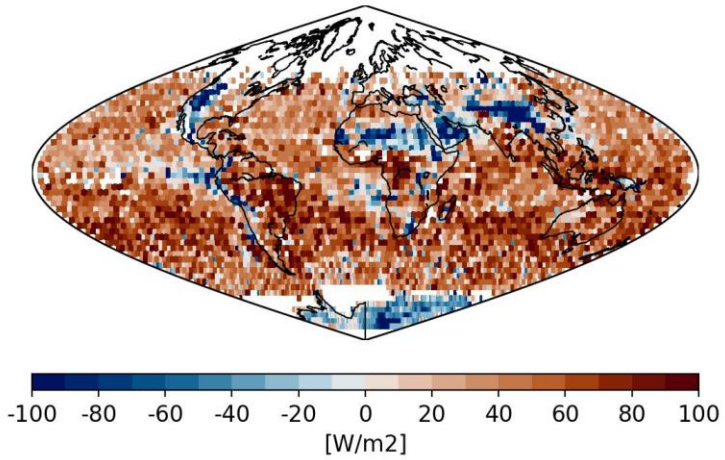


Night

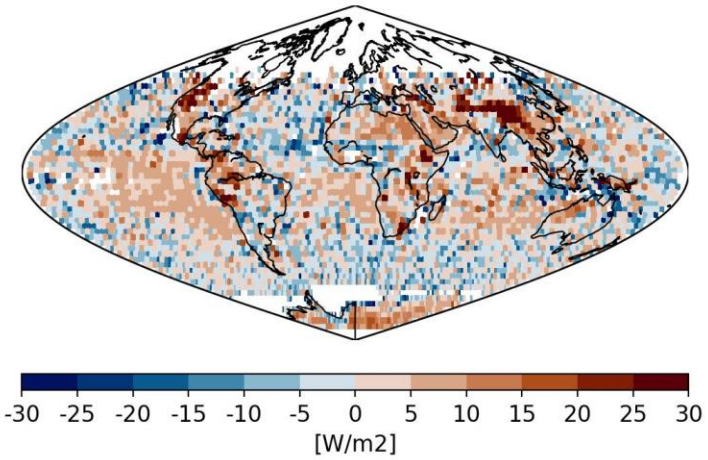
Significant dependence of bias on Land/Water, Day/Night

Bias of **SW** TOA fluxes (cloud cover > 80%)

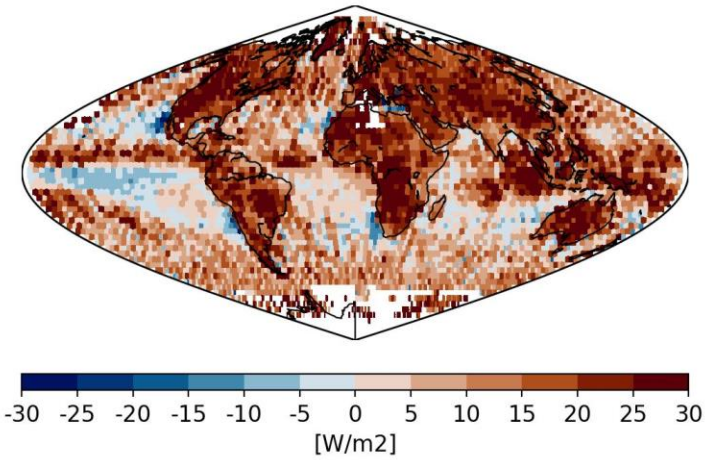
Day



Bias of **LW** TOA fluxes (cloud cover > 80%)



Day



Night

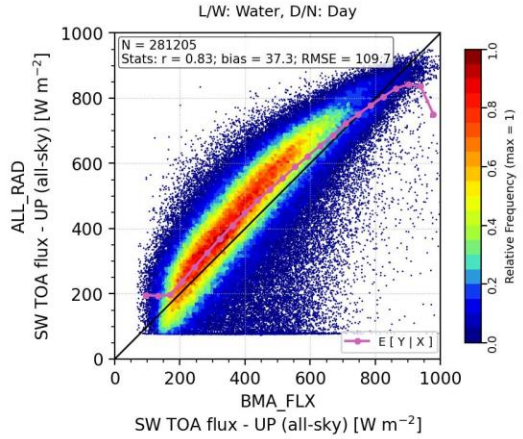
- ✓ Biases in ALL_RAD are strongly dependent on ‘Land/Water’ and ‘Day/Night’ conditions.
- ✓ The biases of SW flux are amplified when covered by clouds

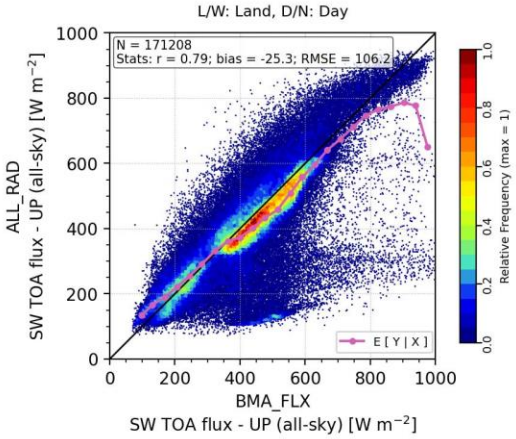
Significant dependence of bias on Land/Water, Day/Night

Bias of **SW** TOA fluxes (cloud cover > 80%)

Water | **Land**

Day

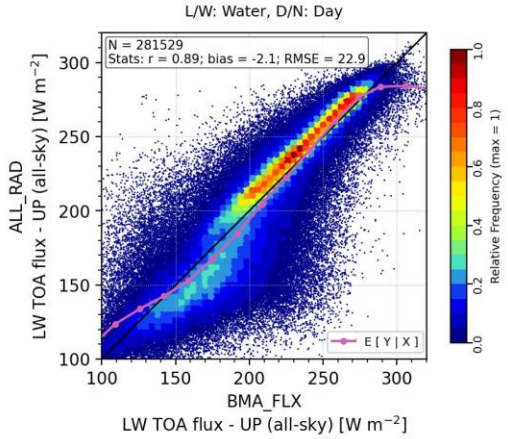


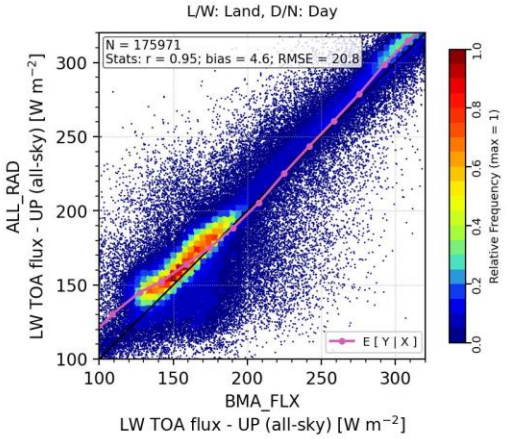


Bias of **LW** TOA fluxes (cloud cover > 80%)

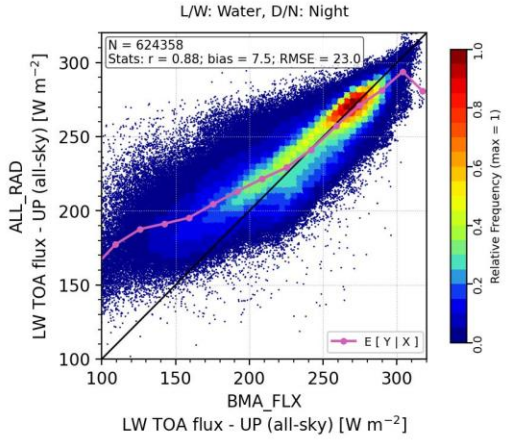
Water | **Land**

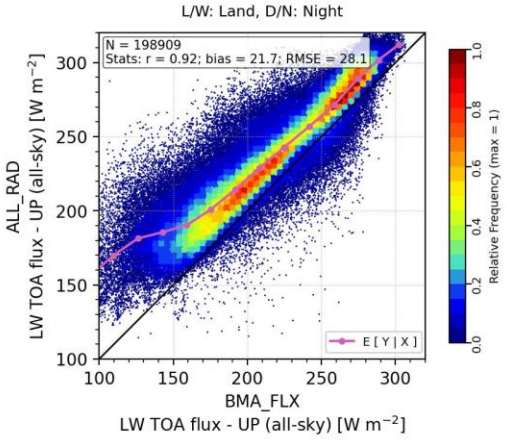
Day





Night





- ✓ Biases in ALL_RAD are strongly dependent on ‘Land/Water’ and ‘Day/Night’ conditions.
- ✓ The biases of SW flux are amplified when covered by clouds

Summary

- We are developing ALL_RAD, JAXA's synergy radiation product.
- In parallel, we are conducting validation using the ESA BMA_FLX product.
- The radiative fluxes from ALL_RAD show a strong correlation with ESA BMA_FLX and exhibit low bias on a global average. However, the bias strongly depends on land/water and day/night conditions, and the bias of SW flux is amplified when covered by clouds
- Further analysis of bias sources is needed, including validation of JAXA L2a single–sensor cloud and aerosol products derived from CPR, ATLID, and MSI.

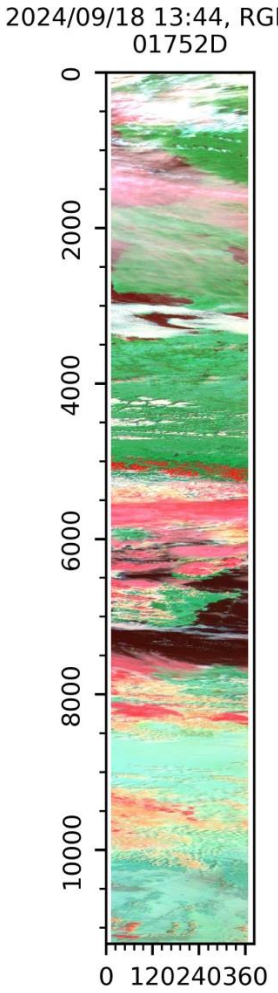
Next Step & Future plans;

- Test ALL_RAD with the latest JAXA L2a products.
- Utilize multi-sensor synergy products: cloud properties from ATLID-CPR-MSI and aerosol properties from ATLID-MSI.
- Incorporate 3D reconstruction and 3D radiative transfer (Okata et al., 2017)

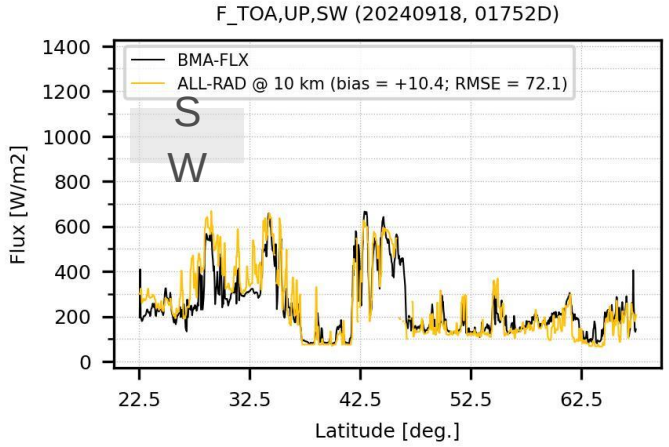
Supplemental slides

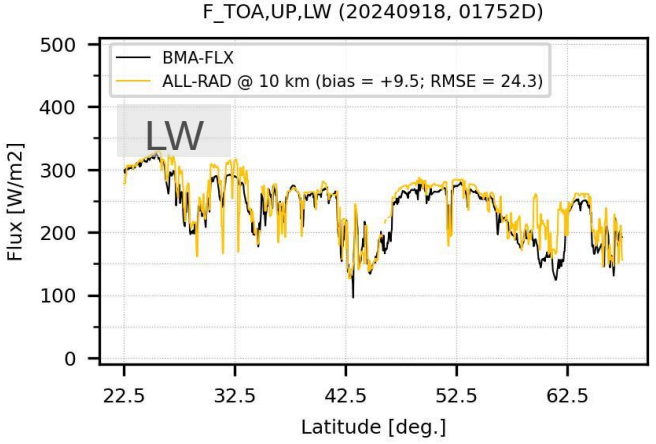
Examples: 2024/09/18 01752[D,E]

MSI L1C (band 1, 3, 4)

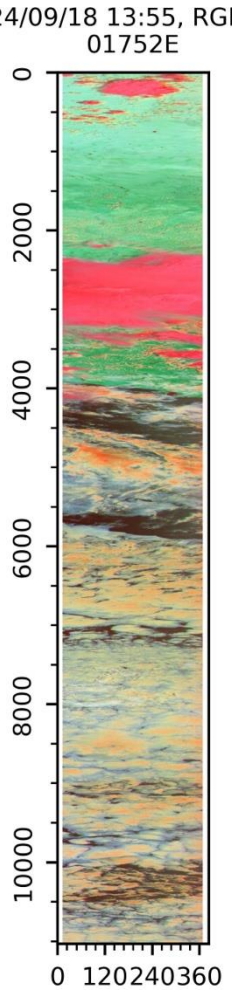


TOA Flux

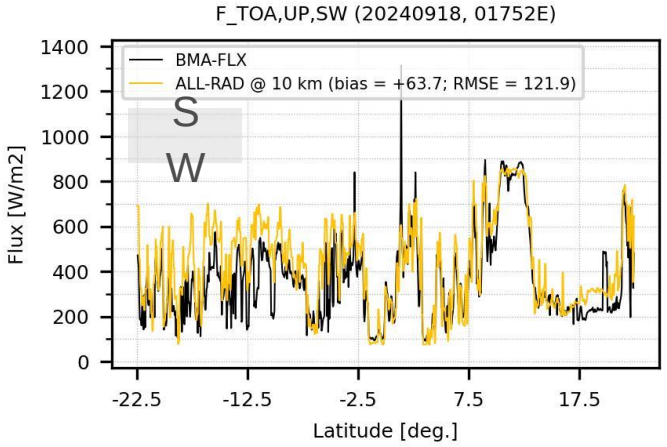


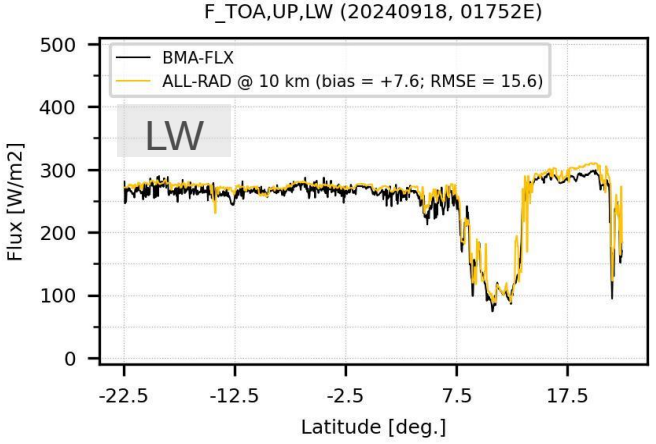


MSI L1C (band 1, 3, 4)



TOA Flux

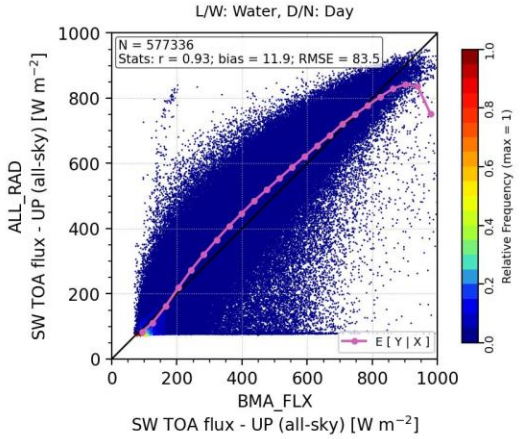




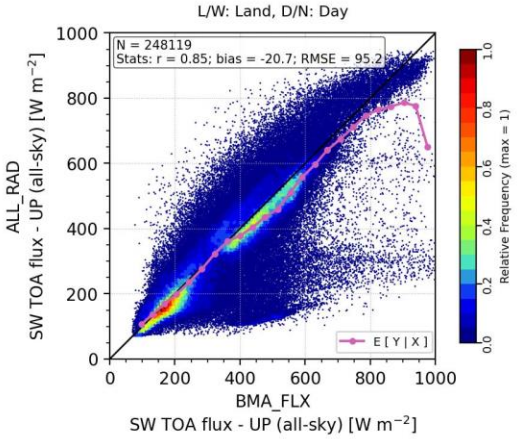
Significant dependence of bias on Land/Water, Day/Night

Bias of **SW** TOA fluxes (**all-sky**)

Water



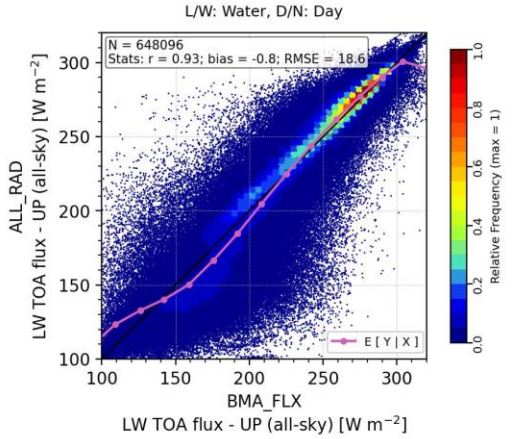
Land



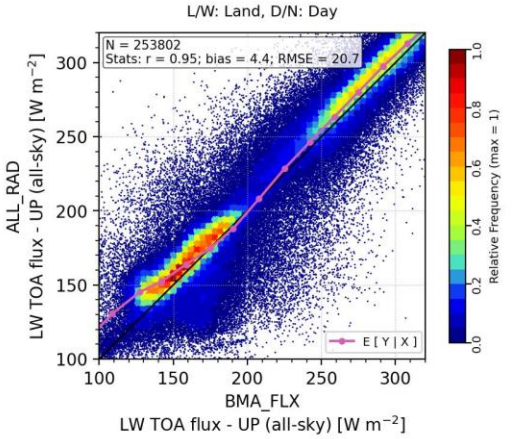
Day

Bias of **LW** TOA fluxes (**all-sky**)

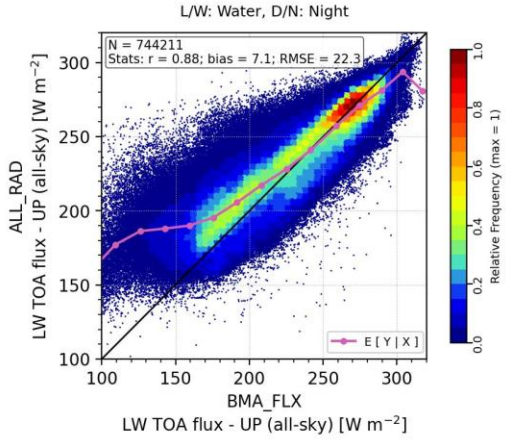
Water

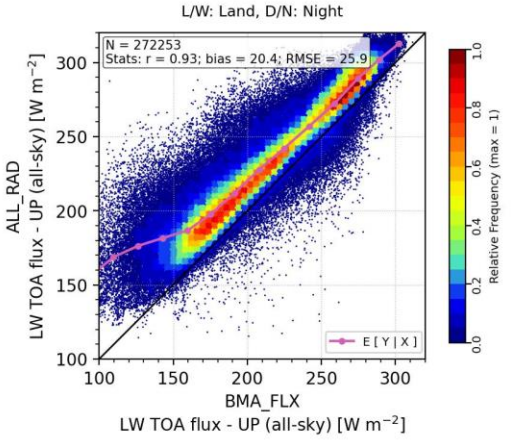


Land



Day





Night

- ✓ Biases in ALL_RAD are strongly dependent on ‘Land/Water’ and ‘Day/Night’ conditions.