# Evaluation of Inter-calibration Approaches for GEMS Level 1B Products

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EWHA, THE FUTURE WE CREATE

Geostatidonary Environment Monitoring Spectrometer: GEMS launched in Feb 2020: Operation for over 4 years!

3-dimensional data

@ 487 nm
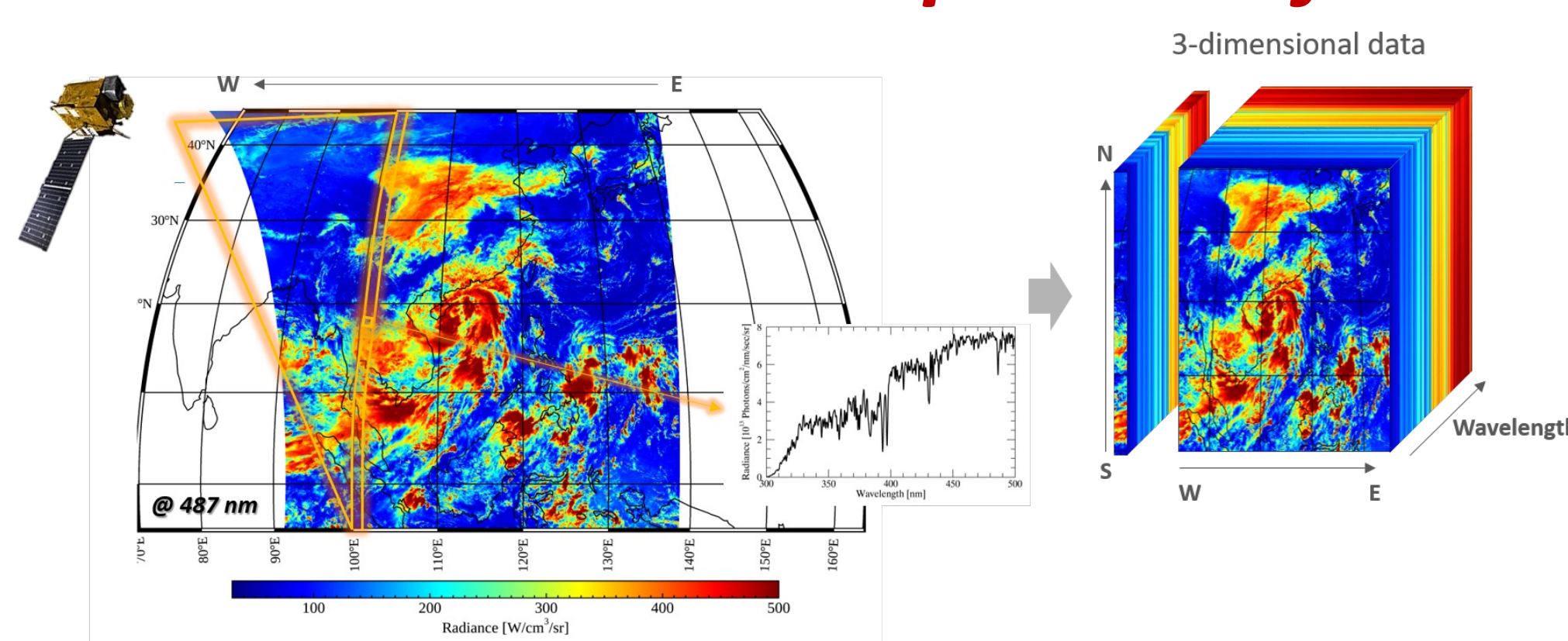
Q. How significantly have the GEMS L1B changed since the IOT and what methodologies can be employed to assess the quality of GEMS L1B data through inter-calibration techniques?

Sensor	AMI Band 1	TROPOMI		OMPS
Spacecraft	GK-2A	Sentinel-5P		S-NPP / N20&21
Orbit	GEO	LEO		LEO
Uncertainty requirement (SNR or %)	261 (@100% albedo)	Band3 Band4 (minSNR)	100-1200 1200	NM NP: F: 7% I: 8% I/F: 2%
Performance	2~3% (negative)	Band3 (ver.2)	F: ~0.5%(Ref.) I: 5%(< OMPS) R: 1-3%(< TOMS)	F: 7% I: 8% I/F: 2%
Approach	Ray-match	Vicarious calibration (DCC)		

Short Summary & future works

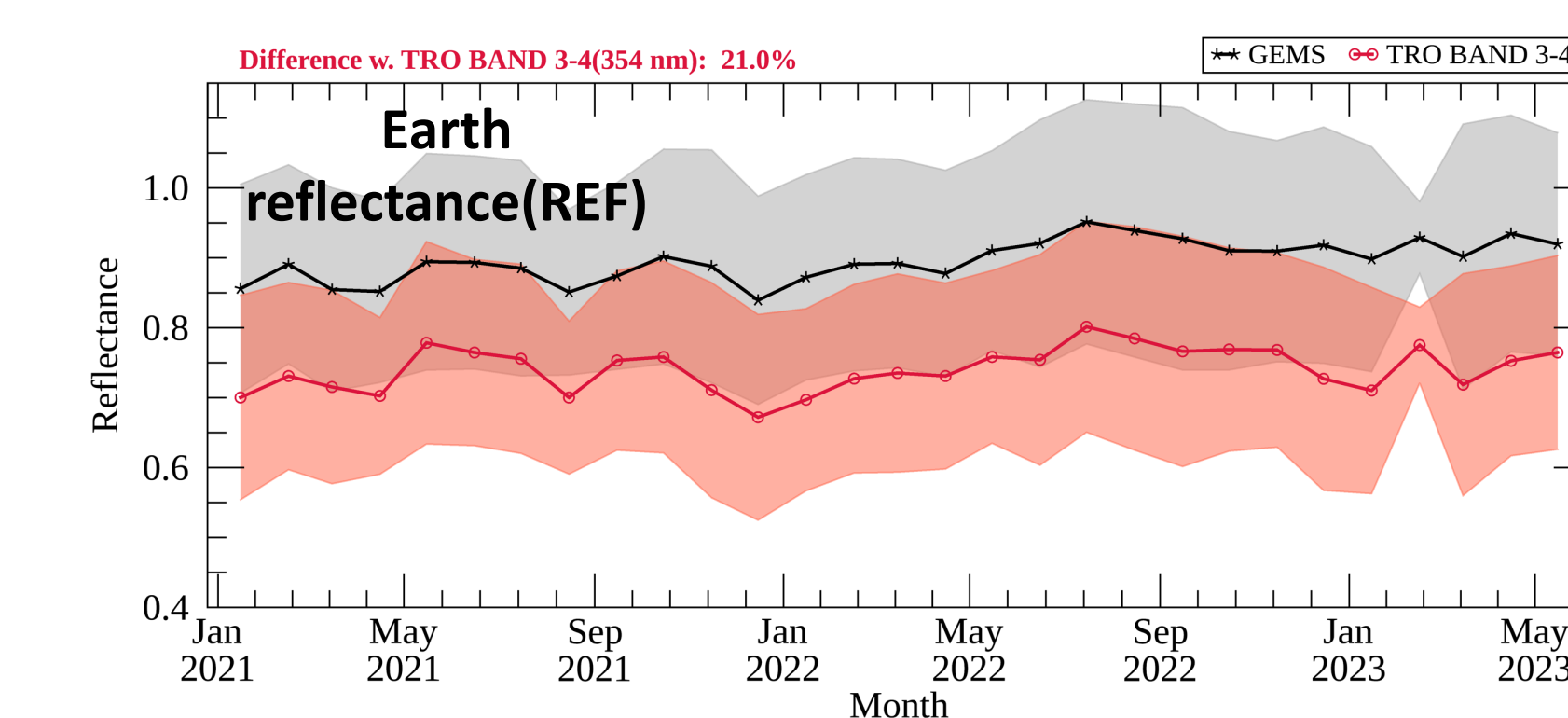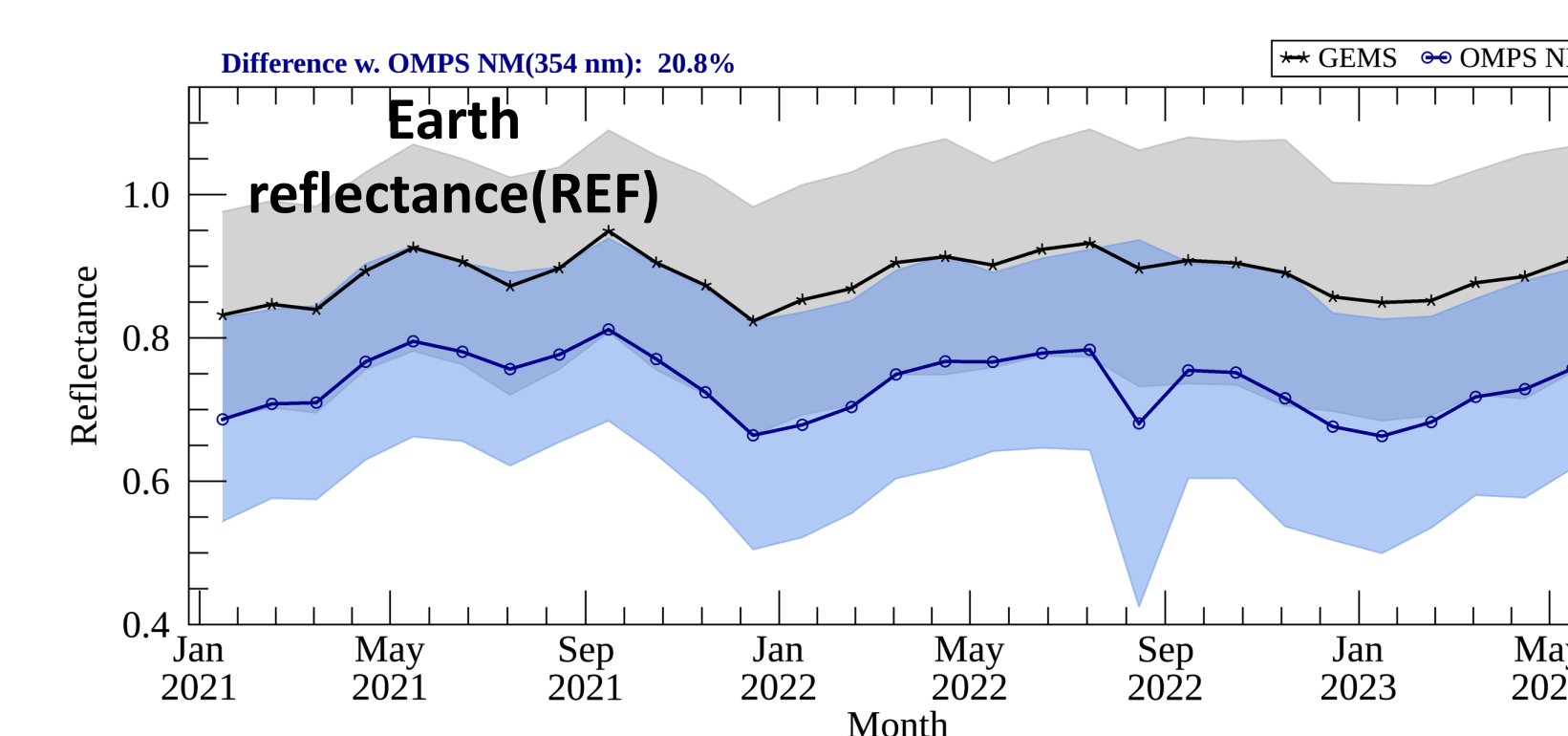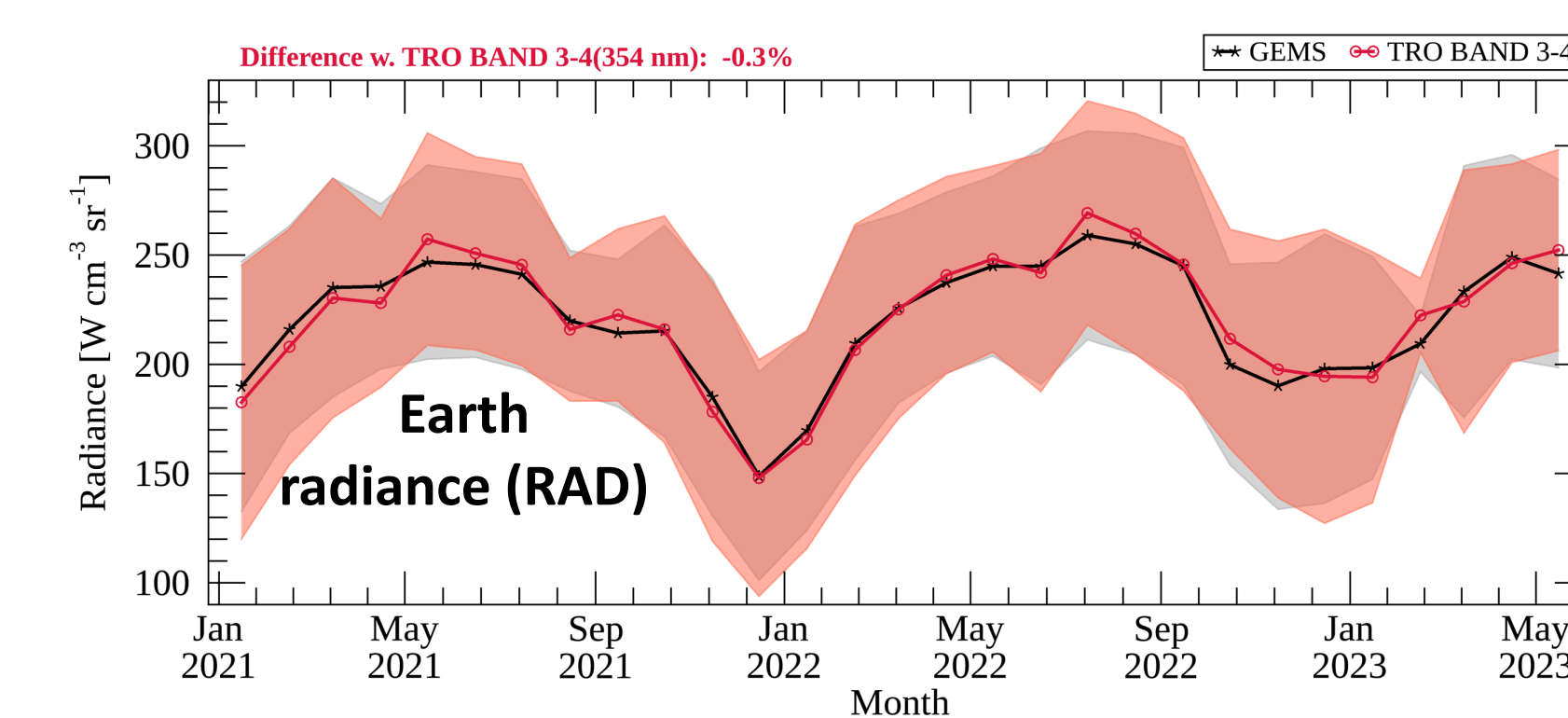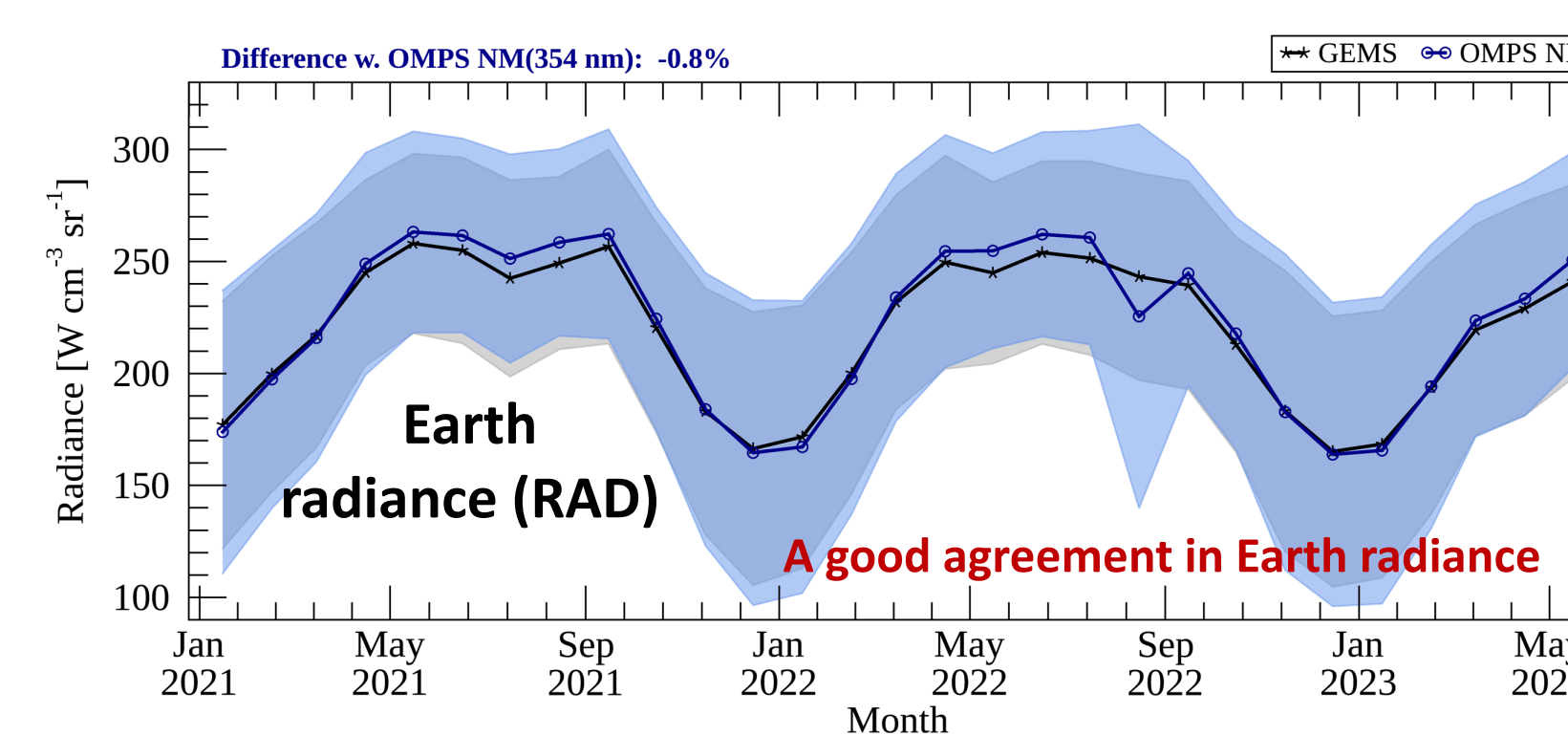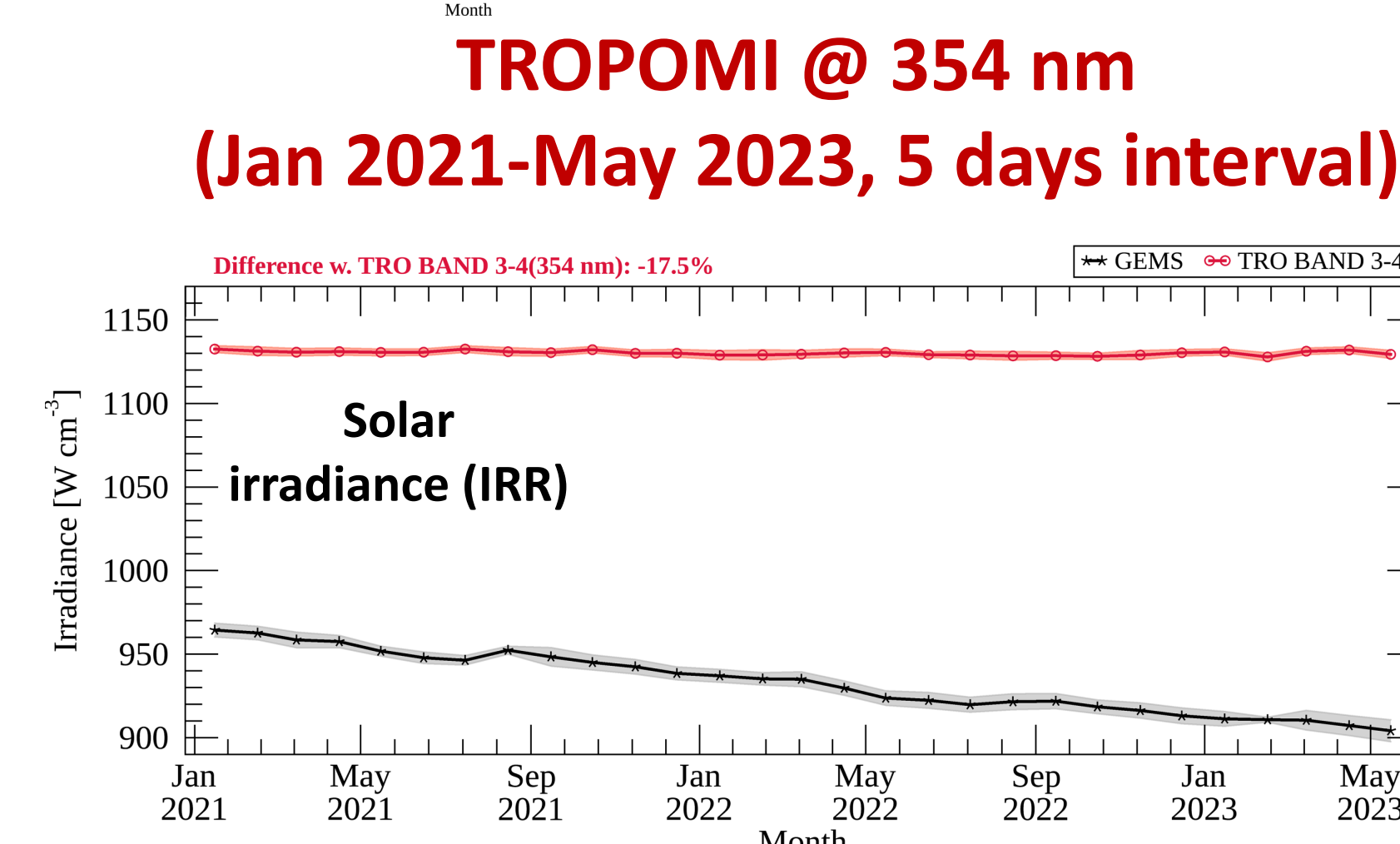Systematic biases of the GEMS Level 1B compared to GEO & LEO are:

OMPS   **IRR:** -17.6% / **RAD:** -0.8% / **REF:** 20.8% (@354 nm)

TROPOMI **IRR:** -17.5% / **RAD:** -0.3% / **REF:** 21.0% (@354 nm)
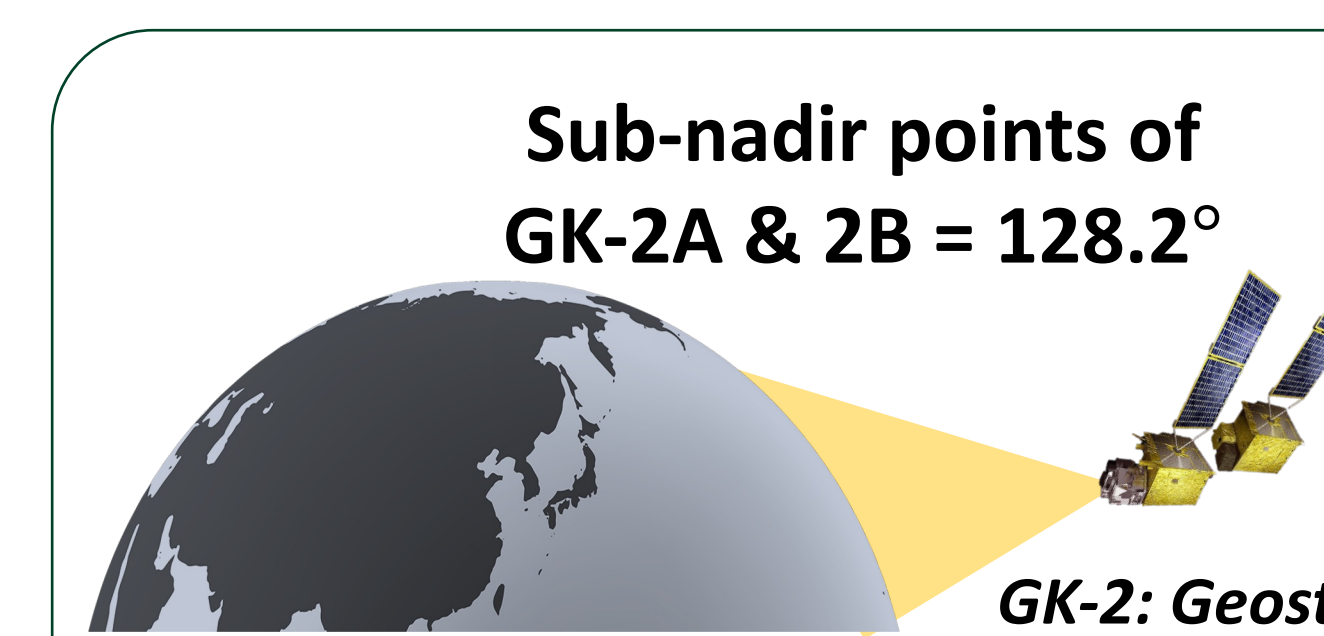
AMI   **IRR:** -   / **RAD:** 7.0%   / **REF:** 15.0% (@470 nm)

- **GEMS L1B products have a negative bias significantly larger in irradiance**, affecting reflectance (**consistent across different sensors**)
- **A significant diffuser degradation and SL effect** has occurred at shorter wavelengths.
- **BTDF update for solar diffusers has resolved the north-south dependence**, while the systematic bias remains in solar irradiances (radiometric cal coeff.).

GEO-LEO (GEMS vs. TROPOMI & OMPS)

<Collocation process>

Start

Call GEMS radiance (within 02-05 UTC)

LEO orbit exist within the time range?

Select LEO pixels within the GEMS FOR

For each LEO pixel

LEO = TROPOMI?

Yes
dt < 15 min
dx < 1.8 km
cos(VZA$_{GEMS}$)/cos(VZA$_{LEO}$)-1 < 0.01
R$_{363, 354 nm}$ < 0.03

No
dt < 15 min dx < 25 (NM) or 125 km (NP)
cos(VZA$_{GEMS}$)/cos(VZA$_{LEO}$)-1 < 0.01
R$_{within OMPS FOV, 354 nm}$ < 0.03

Collect GEMS pixel satisfying the thresholds

Spatial mean

Spectral convolution

Save

Ref. solar (KNMI)

IRR

RAD

REF

Stray light effect (<320 nm)

Spectral analysis (DCCs):
OMPS NM: 300-380 nm
TOMI BD3-4: 320-500 nm

OMPS @ 354 nm (Jan 2021-May 2023, daily interval)

Solar irradiance (IRR)

Earth radiance (RAD)

A good agreement in Earth radiance

Earth reflectance(REF)

TROPOMI @ 354 nm (Jan 2021-May 2023, 5 days interval)

Solar irradiance (IRR)

Earth radiance (RAD)

Earth reflectance(REF)

GEO-GEO (GEMS vs. AMI) onboard twin satellites

<Methodology>

Sub-nadir points of GK-2A & 2B = 128.2°

Similar configuration with FCI (MTG) & UVN (Sentinel 5)

GK-2: Geostationary Korea Multi-Purpose Satellite-2

Advantages of GEO-GEO inter-calibration: Wide spatial & temporal coverage

Ray-matching (GEO-GEO)
- Elimination of sun-glint & land pixels
- SZA & VZA < 60°
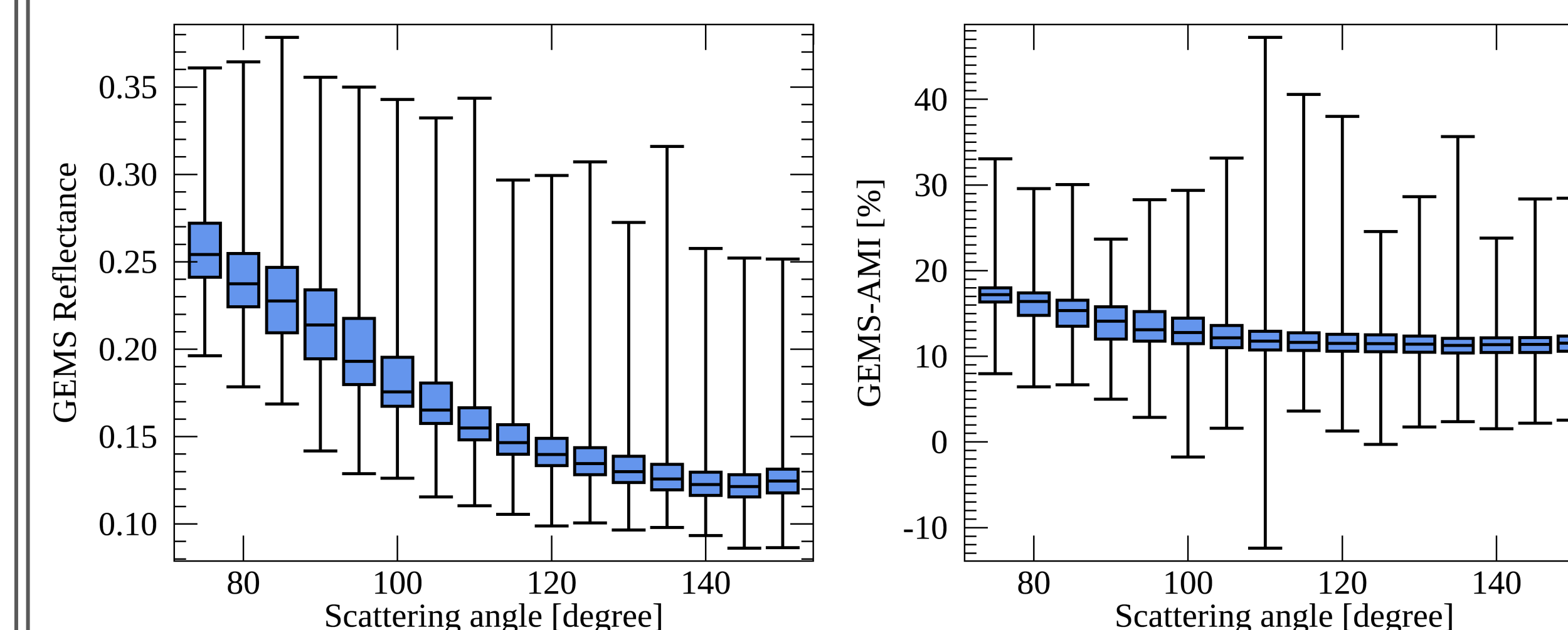- Spatial homogeneity: Scene STD < 5%
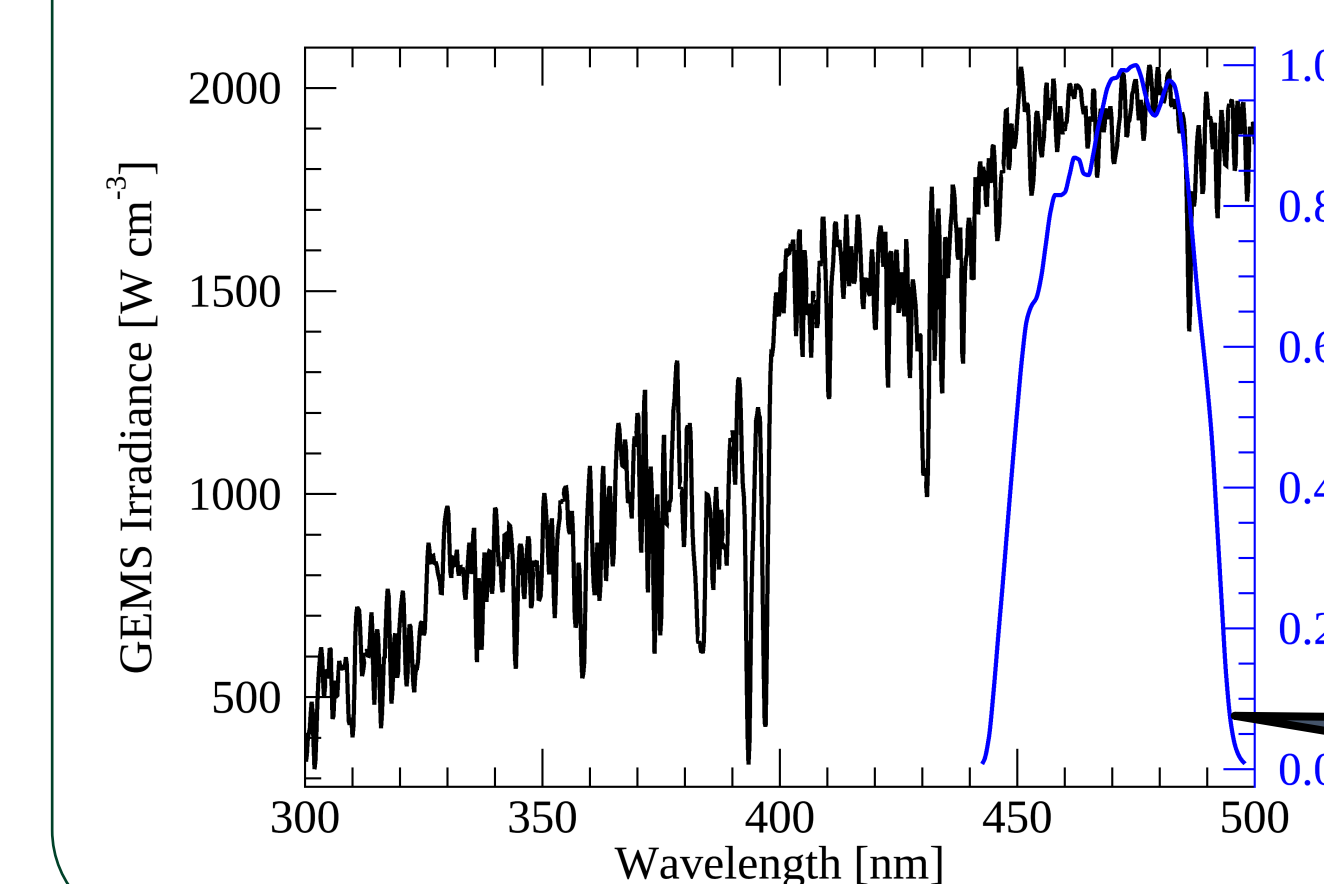
$$L \otimes f = \frac{\int_{\lambda_i}^{\lambda_f} L_\lambda \cdot f_\lambda \, d\lambda}{\int_{\lambda_i}^{\lambda_f} f_\lambda \, d\lambda}$$

$L(\lambda)$: GEMS spectral data
$f(\lambda)$: AMI SRF

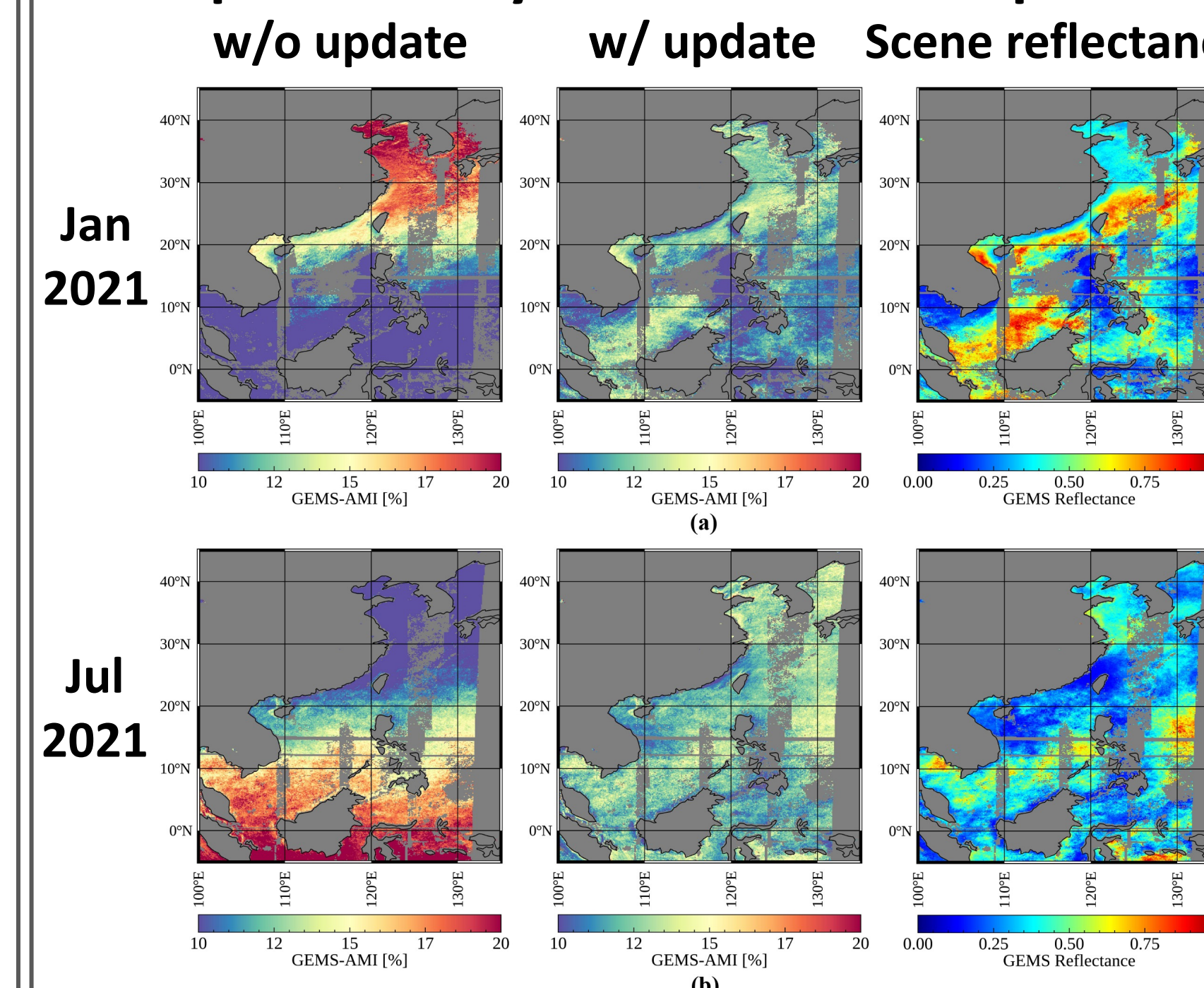**SRF convolution**
Δt < 5 minutes
Spatial average (0.1°)

✓ Scattering angle dependence (dark scenes)

GEMS vs. AMI (over 450 nm)
- Radiance: positive bias (7%)
- Reflectance: positive bias (15%)

✓ Spatial analysis for the N-S dependence

w/o update   w/ update   Scene reflectance

Jan 2021

Jul 2021

✓ Trend analysis

AMI w/ GSICS references : ~2%