Radiance biases based on ray-matching for sensors onboard GK-2 series

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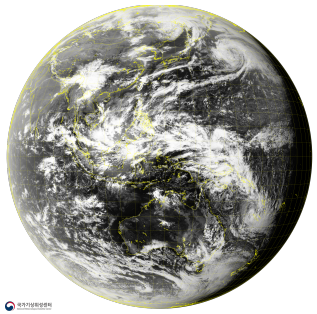
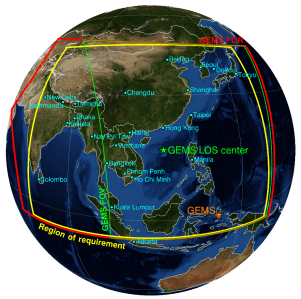
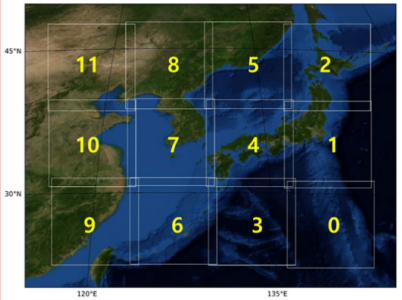
Content

1. Introduction

❖ Geostationary Korean Multi Purpose Satellite -2A/B (GK-2A/B)

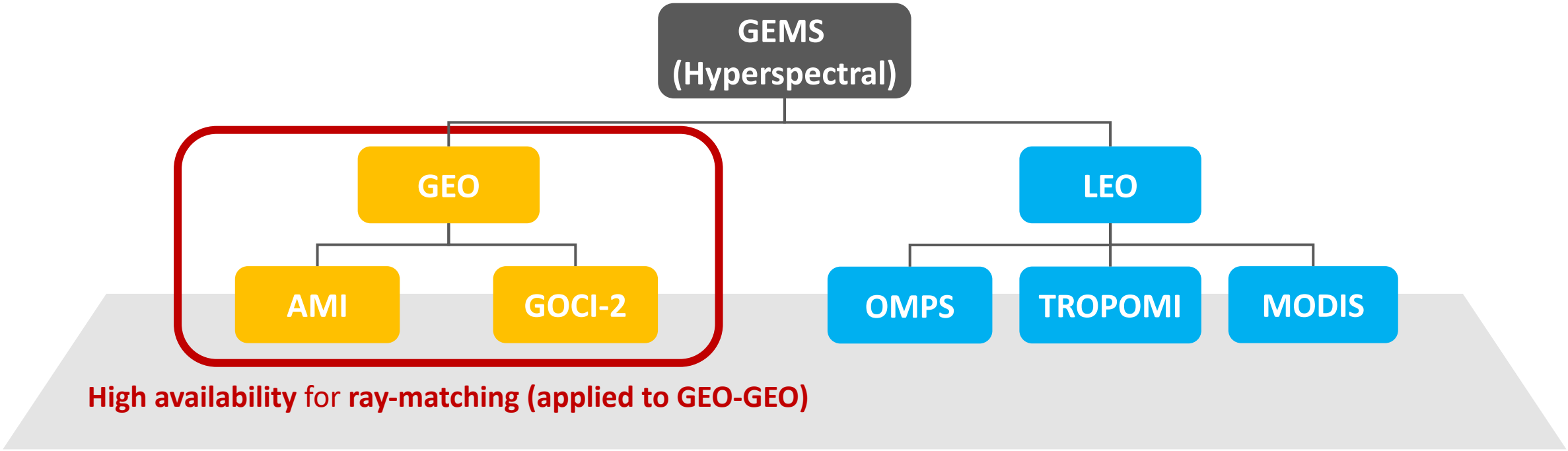
Sensor	AMI	GEMS	GOCI-2
Satellite	GK-2A (Dec. 2018)	GK-2B (Feb. 2020)	
Description	**Meteorological imager (VNIR/IR)**	**Environmental spectrometer (UV/VIS)**	**Ocean color imager (UV-NIR)**
Spectral range	0.47-13.3 μm	300-500 nm (FWHM < 0.6 nm)	380-900 nm
No. of bands	16 (4 VIS & 12 IR)	**Hyperspectral (Δ = 0.2 nm)**	13 (12 VNIR & 1 wide)
Spatial resolution	1 km (VIS), 2 km (IR)	3.5 × 8 km^2	**0.25 km**
Spatial coverage	**Full Disk (10 min.)**  *Credit: NMSC*	5°S-45°N, 75-145°E  *Credit: NIER*	25-50°N, 110-150°E  *Credit: KIOST*

Sub-nadir satellite longitude = 128.2°

Original image Credit: KARI

1. Introduction

❖ GEO & LEO sensors for inter-comparison of GEMS



GEMS

vs.

AMI & GOCI-2

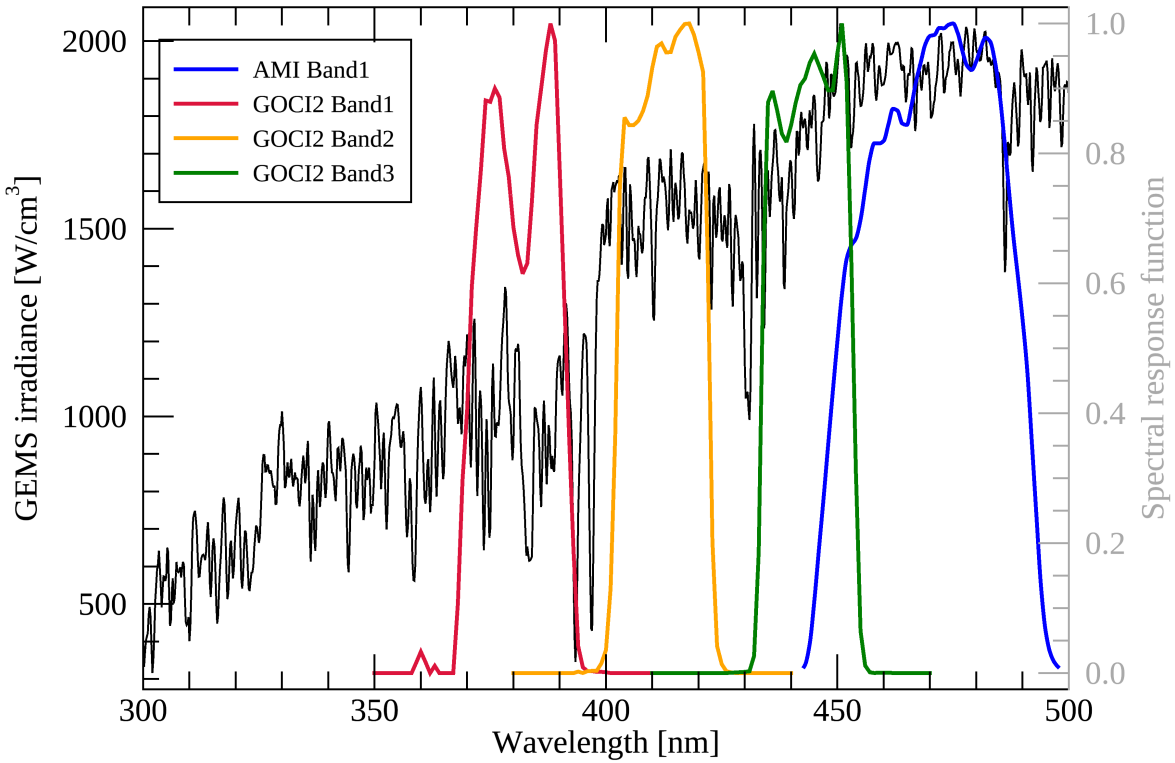
→ View an identical target

- At the same **1) time**
- With same **2) spatial** and **3) spectral response**
- With same **4) viewing geometry** ← **Matched!**

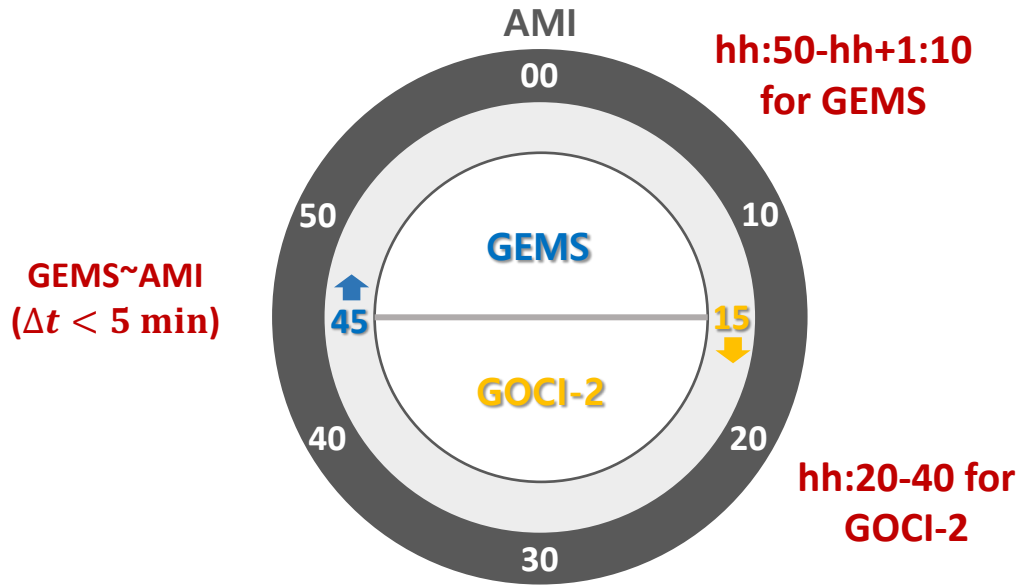
2. Data & methods

❖ Data specification and collocation process

Sensor specification & Spectral Response Function (SRF) of AMI & GOCI-2



- **Spectral matching:** SRF convolution
- **Spatial matching:** 0.1°× 0.1°
- **Time difference:** scene selection



Sensor	AMI	GEMS	GOCI-2
Spectral range [nm]	470 (B1)	300-500 ($\Delta\lambda$=0.2)	380, 412, 443 (B1~B3)
Time interval	**Every 10 minutes**	**hh:45 (00-08 UTC)**	**hh:15 (00-08 UTC)**
SZA & VZA	$\theta < 40°$		

2. Data & methods

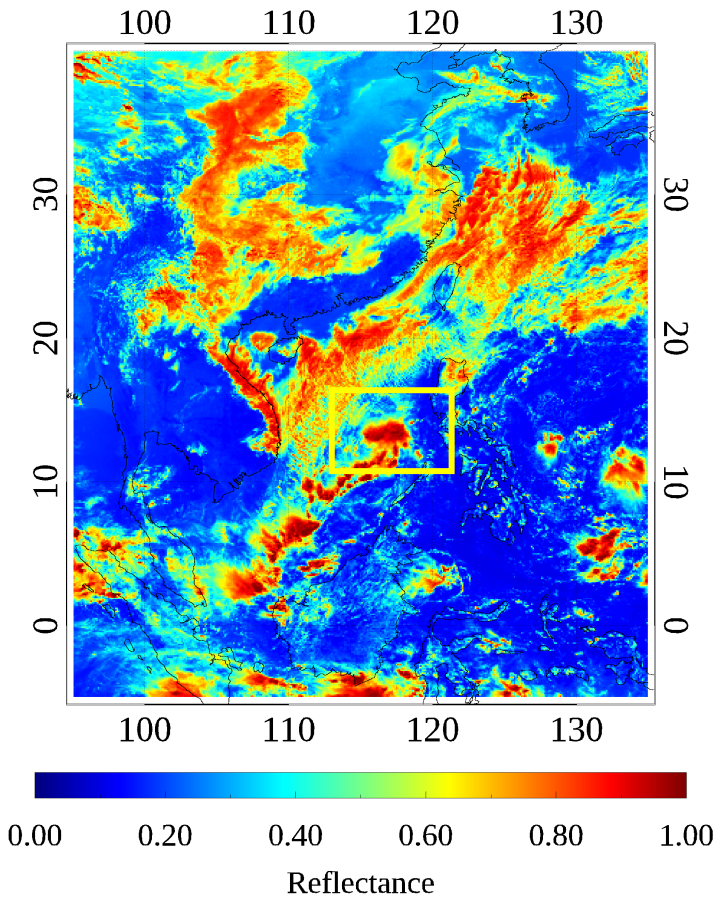
❖ Scene selection with scene homogeneity

** STD: Standard deviation*

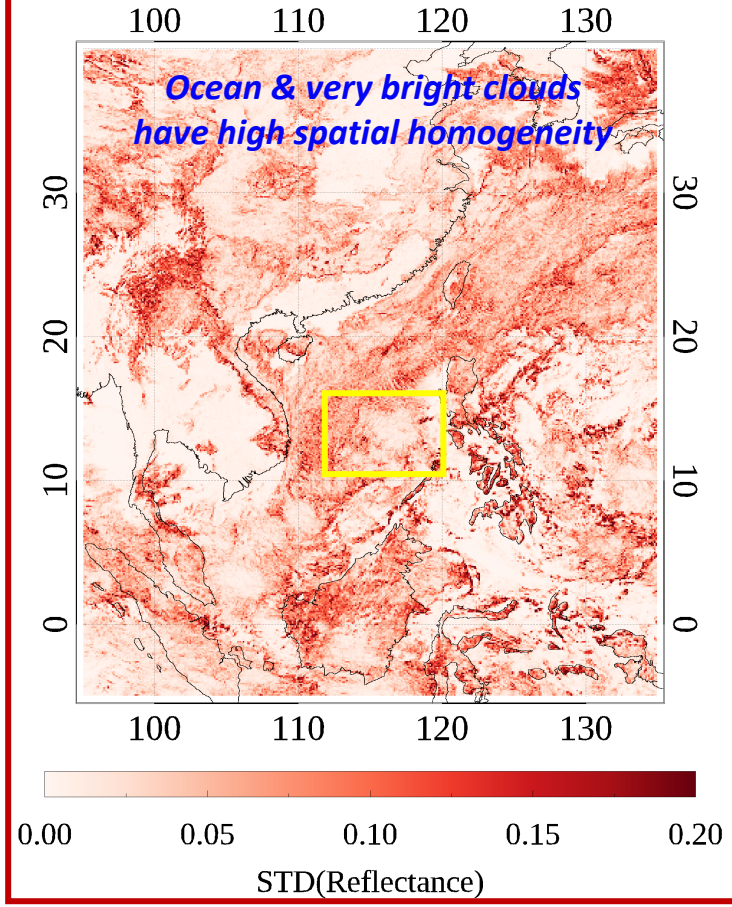
Dec. 15, 2020 (02 UTC)

Spatial & temporal variation calculated w/ AMI $R_{470\ nm}$

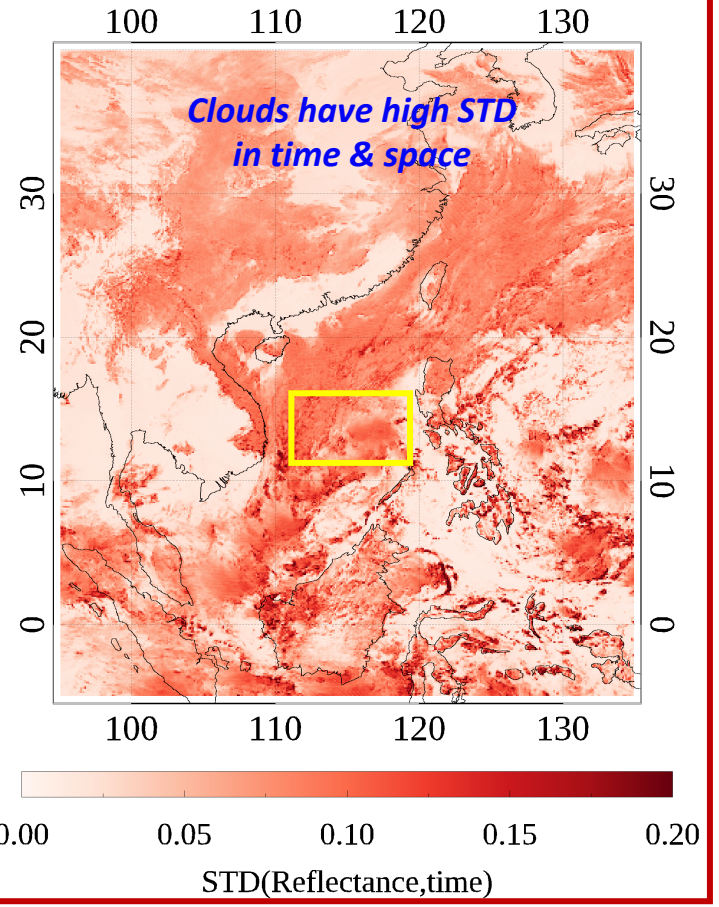
AMI Reflectance (0.1°)



$STD(R_{470\ nm}, \Delta x)$



$STD(R_{470\ nm}, \Delta t)$

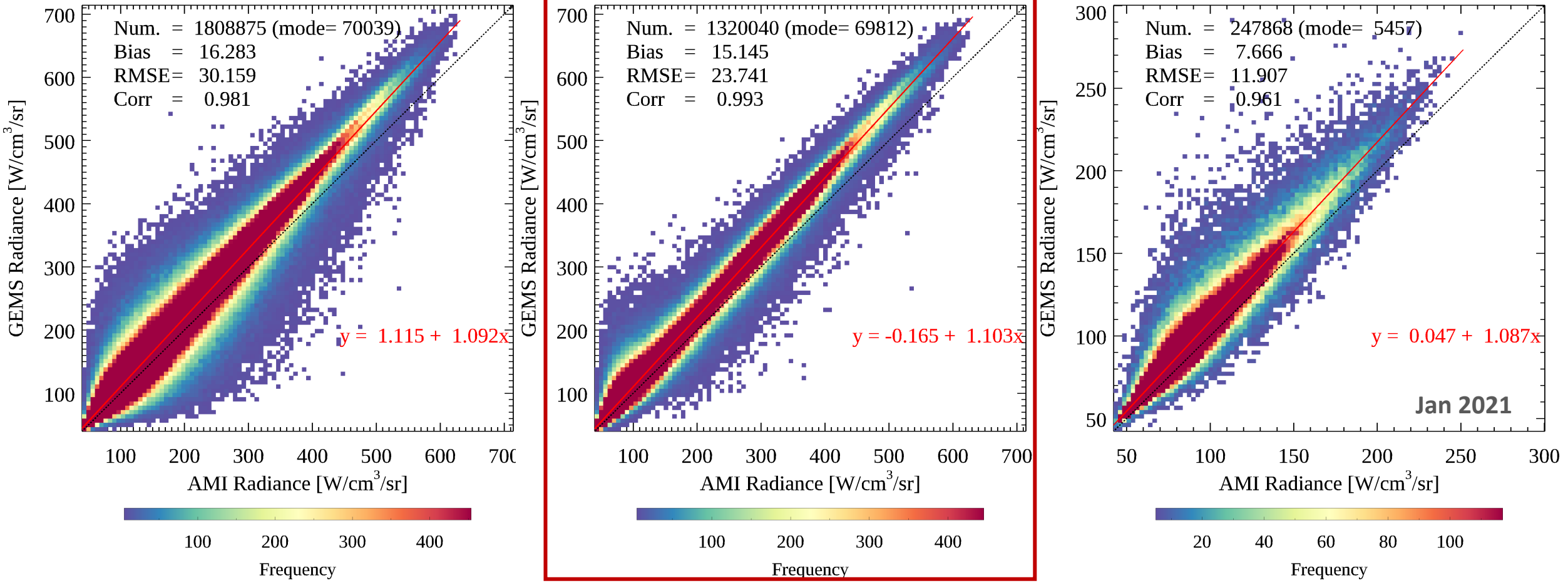


2. Data & methods

❖ GEMS & AMI with temporal & spatial homogeneity conditions (470 nm)

Cover overall dynamic range of signals

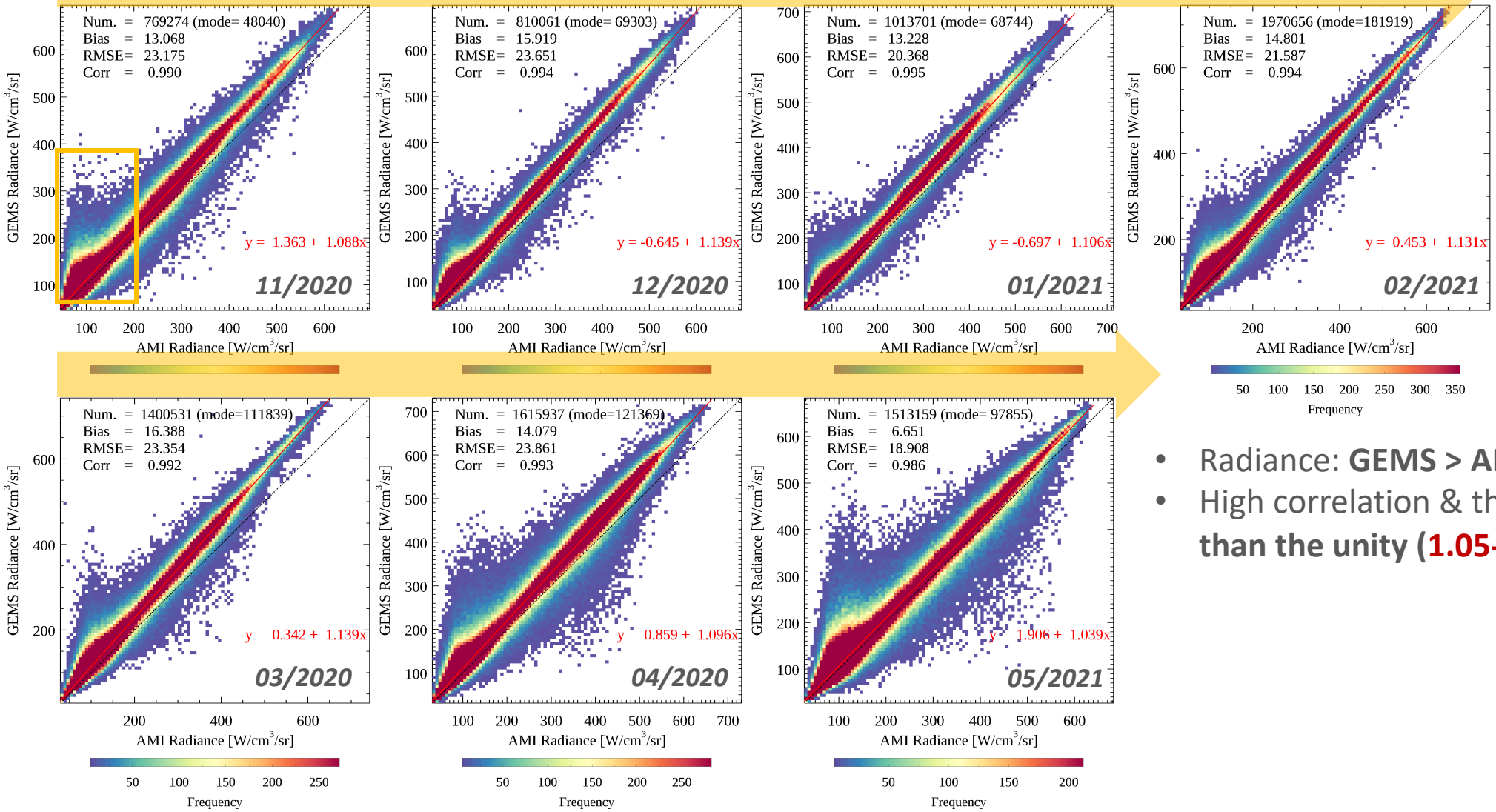
All collocated pixels | Spatial STD($R_{470\ nm}$) < 0.03 | Spatio-temporal STD($R_{470\ nm}$) < 0.03



3. Results & further approach

❖ Seasonal variations (every 10 days, 11/2020-05/2021)

Radiance

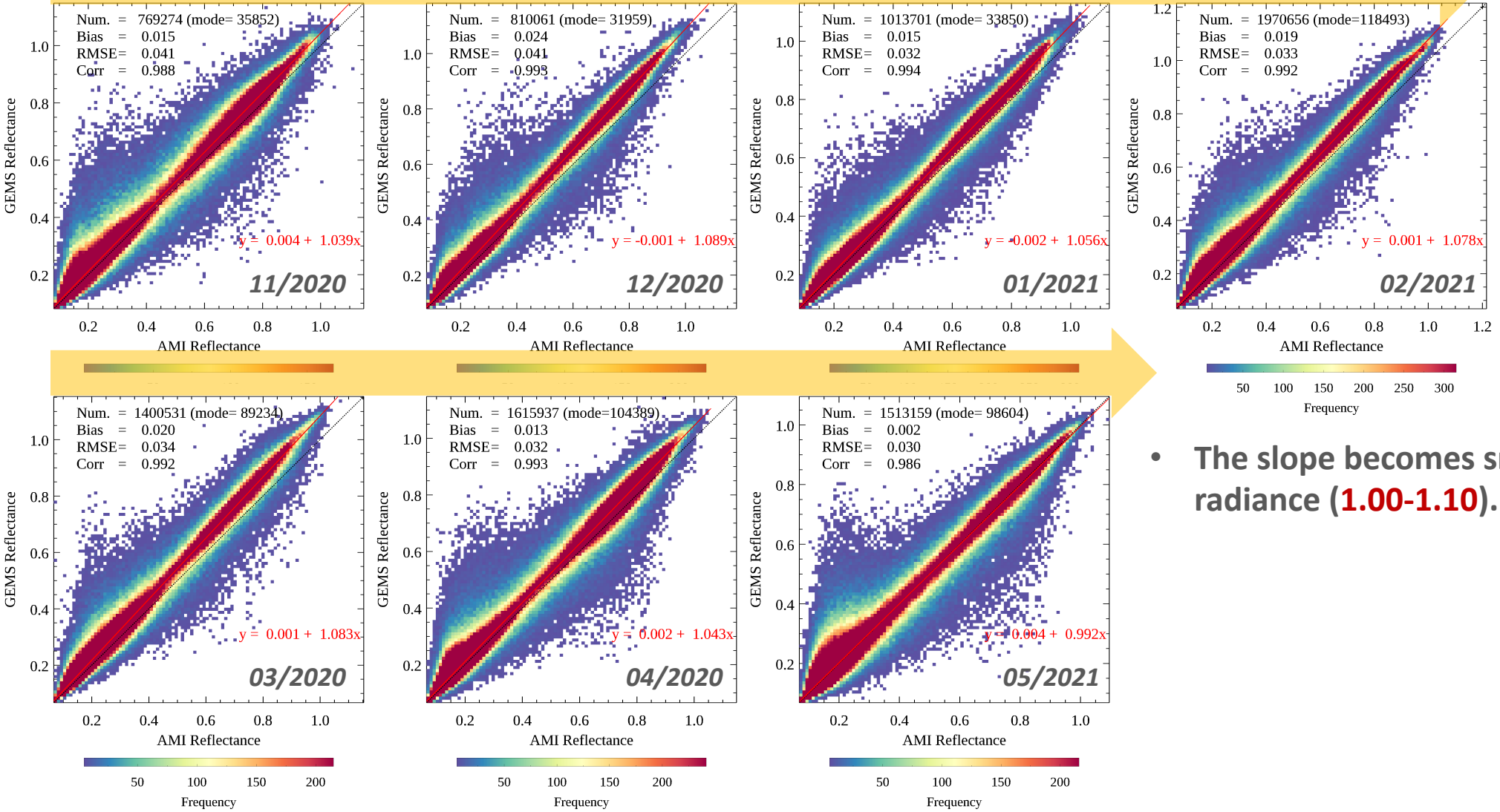


- Radiance: **GEMS > AMI (brighter scenes)**
- High correlation & the linear slope is **larger than the unity (1.05-1.15).**

3. Results & further approach

❖ Seasonal variations (every 10 days, 11/2020-05/2021)

Reflectance



$$R_\lambda = \frac{\pi I_\lambda}{F_\lambda \cos\theta_0}$$

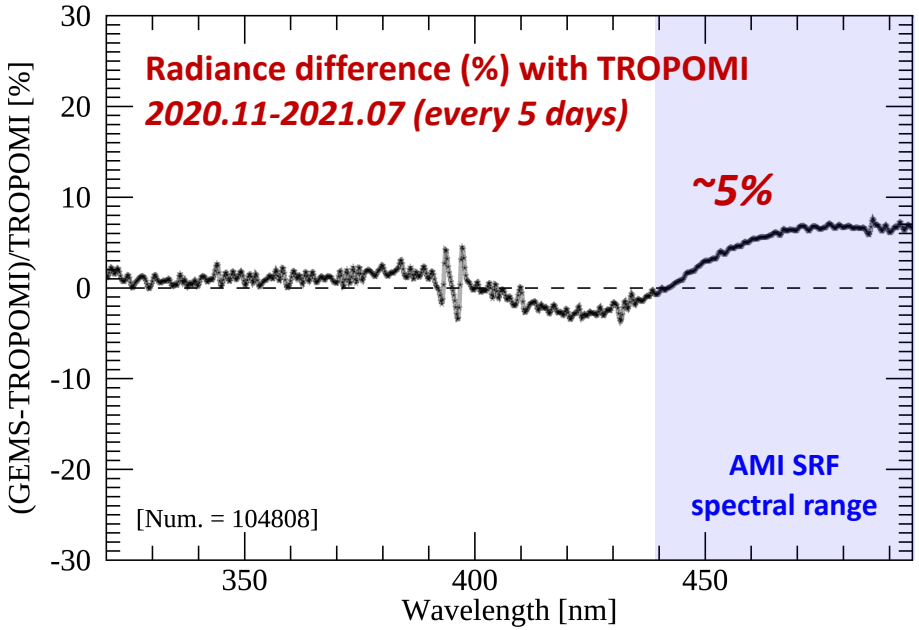
- The slope becomes smaller compared to radiance (**1.00-1.10**).

3. Results & further approach

❖ Seasonal variations (every 10 days, 11/2020-05/2021)

- **Positive bias** becomes **larger at the higher signals**

1) Spectral dependence in GEMS L1B



2) Signal dependence in AMI L1B

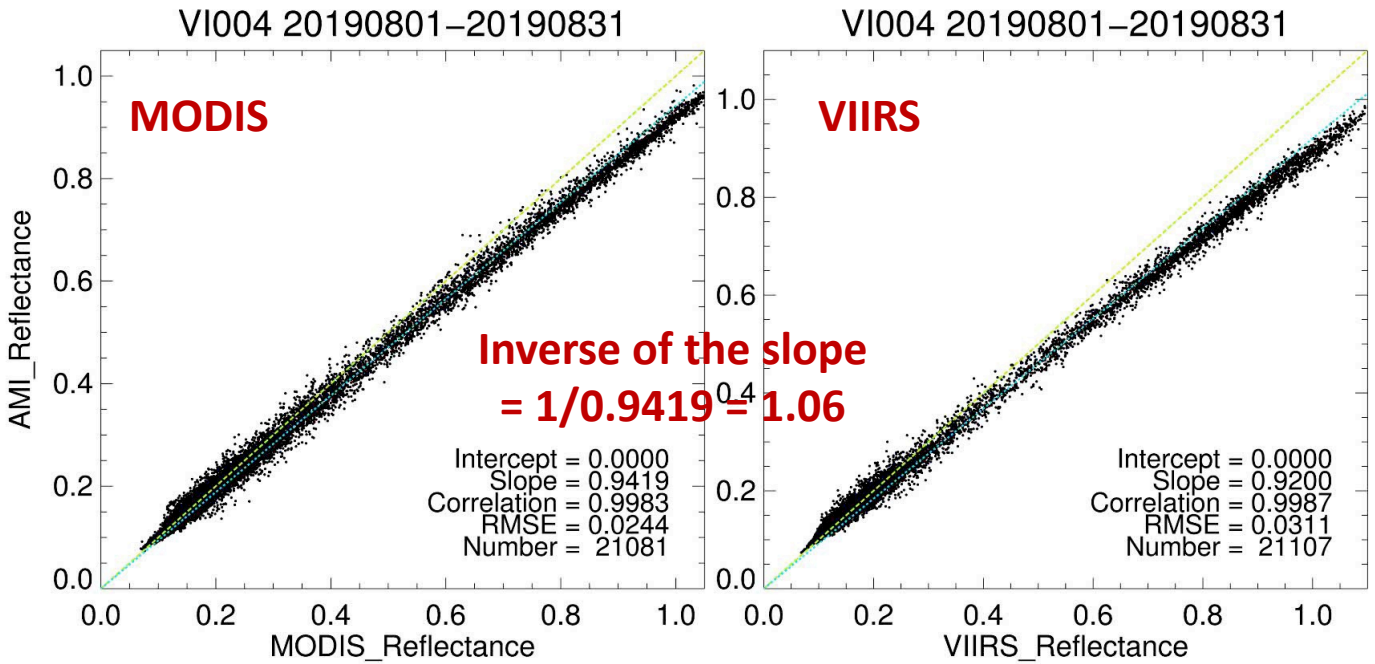


Image credit: Eunkyu Kim (NMSC, GSICS meeting)

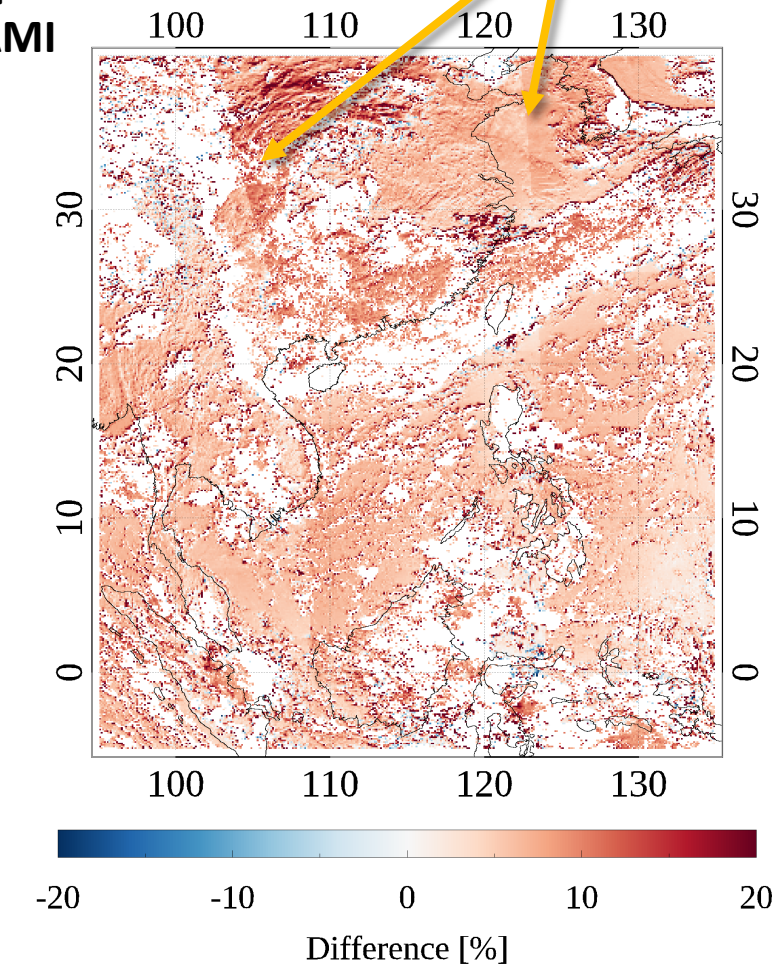
3. Results & further approach

❖ SZA effect in radiance comparison

SZA effect (Discrepancy between AMI images)

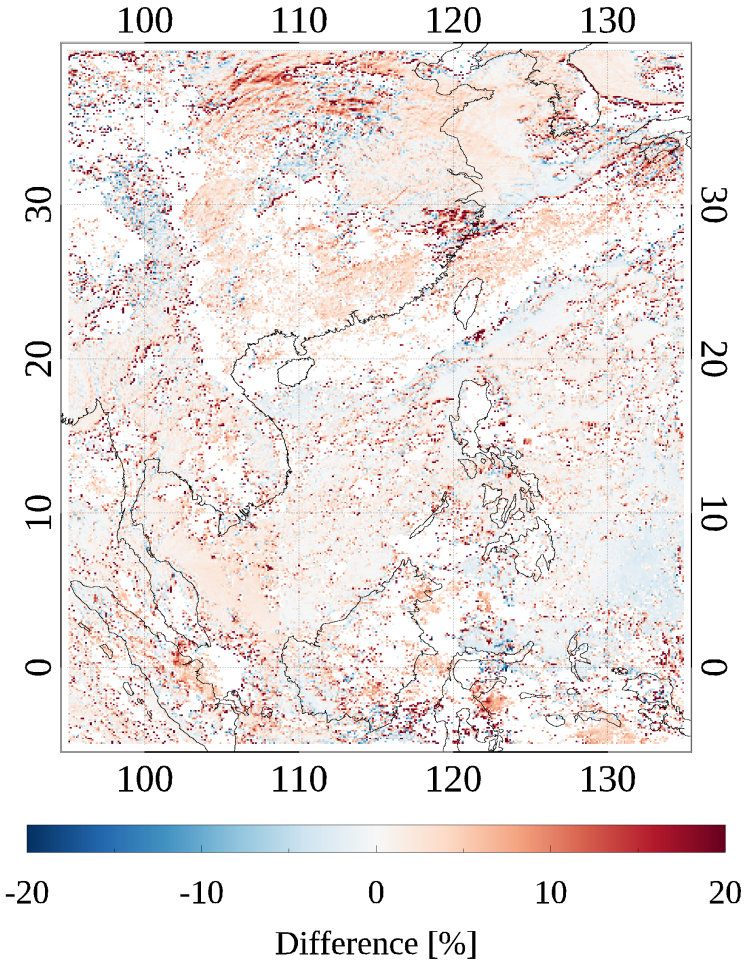
Difference [%]
= (GEMS-AMI)/AMI

Difference (Radiance)

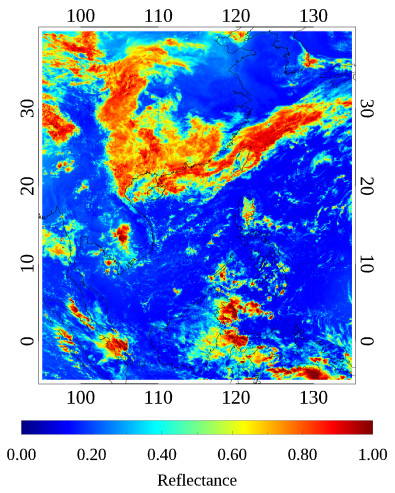


Difference (Reflectance)

$$R_\lambda = \frac{\pi I_\lambda}{F_\lambda \cos\theta_0}$$



AMI reflectance



3. Results & further approach

❖ SZA effect in radiance comparison

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Difference [%]
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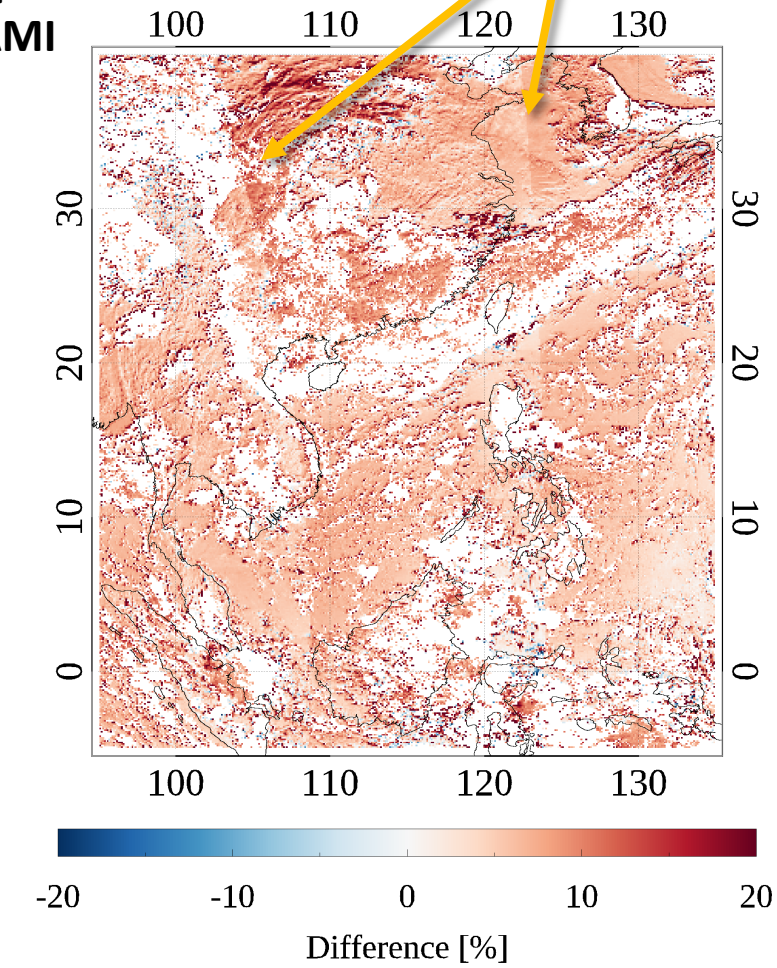
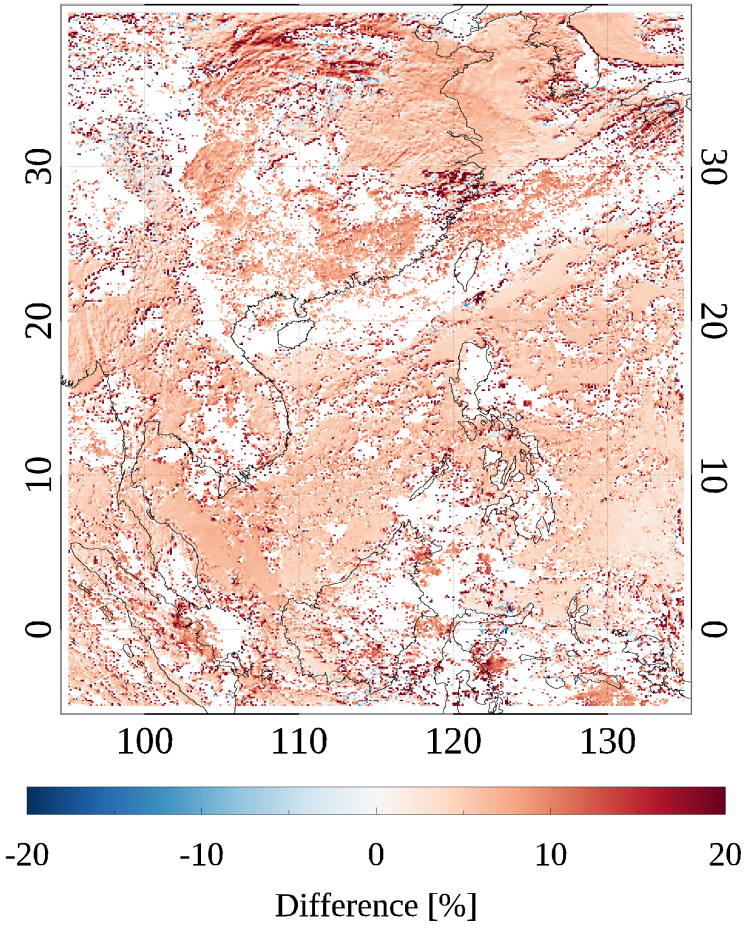
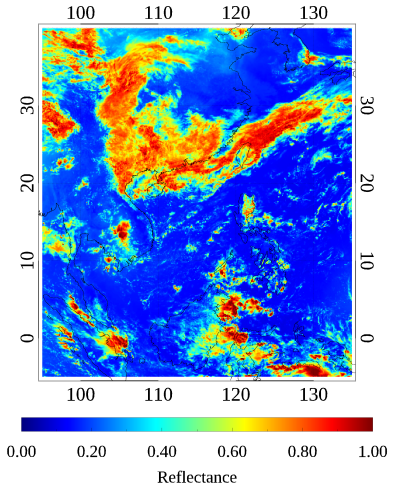


Difference (Radiance)
($cos\theta_0$ correction)

$$I'_\lambda = \frac{I_\lambda}{\cos\theta_0}$$



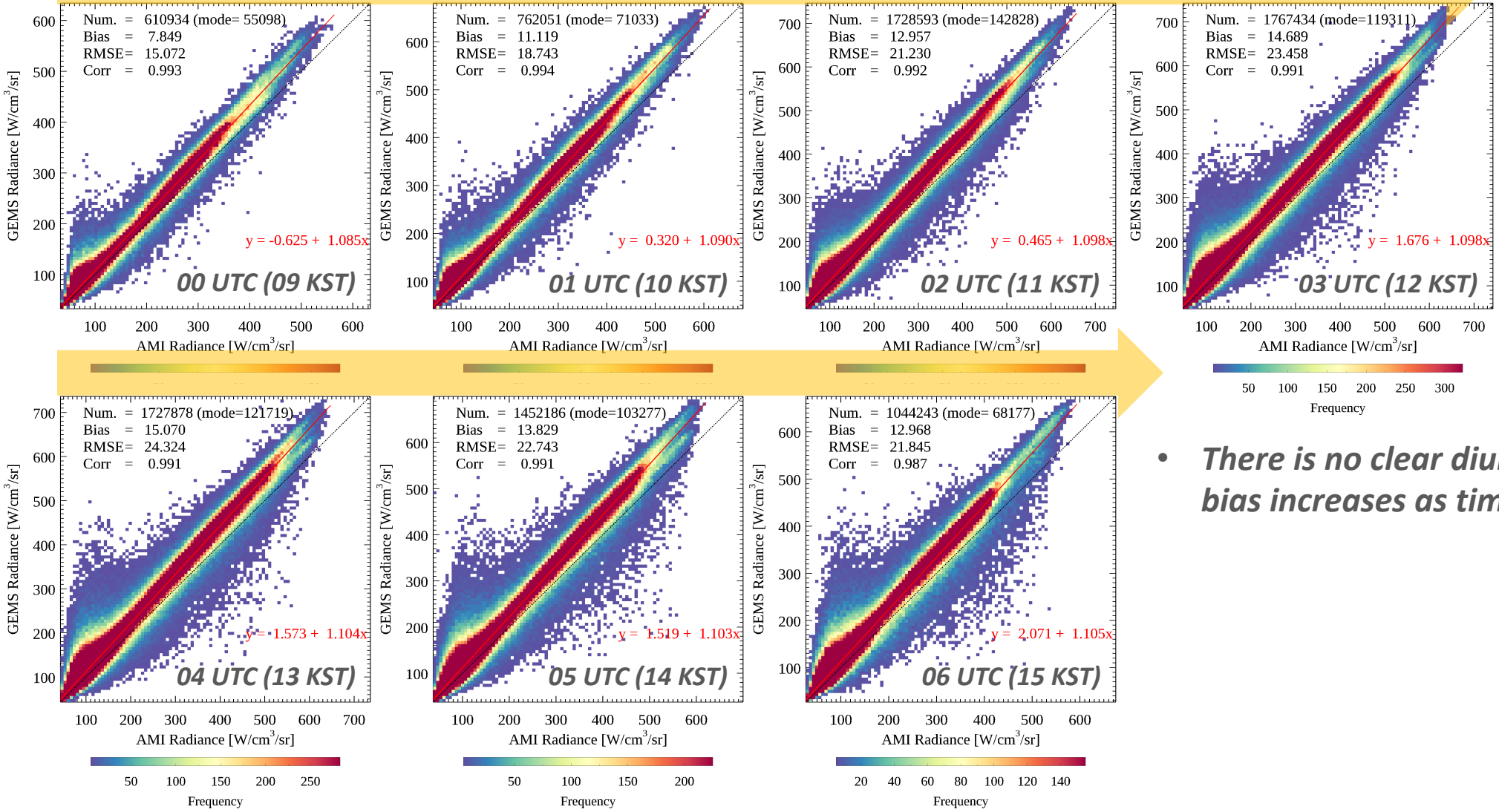
AMI reflectance



3. Results & further approach

❖ Diurnal variations (every 10 days, 11/2020-05/2021)

Radiance

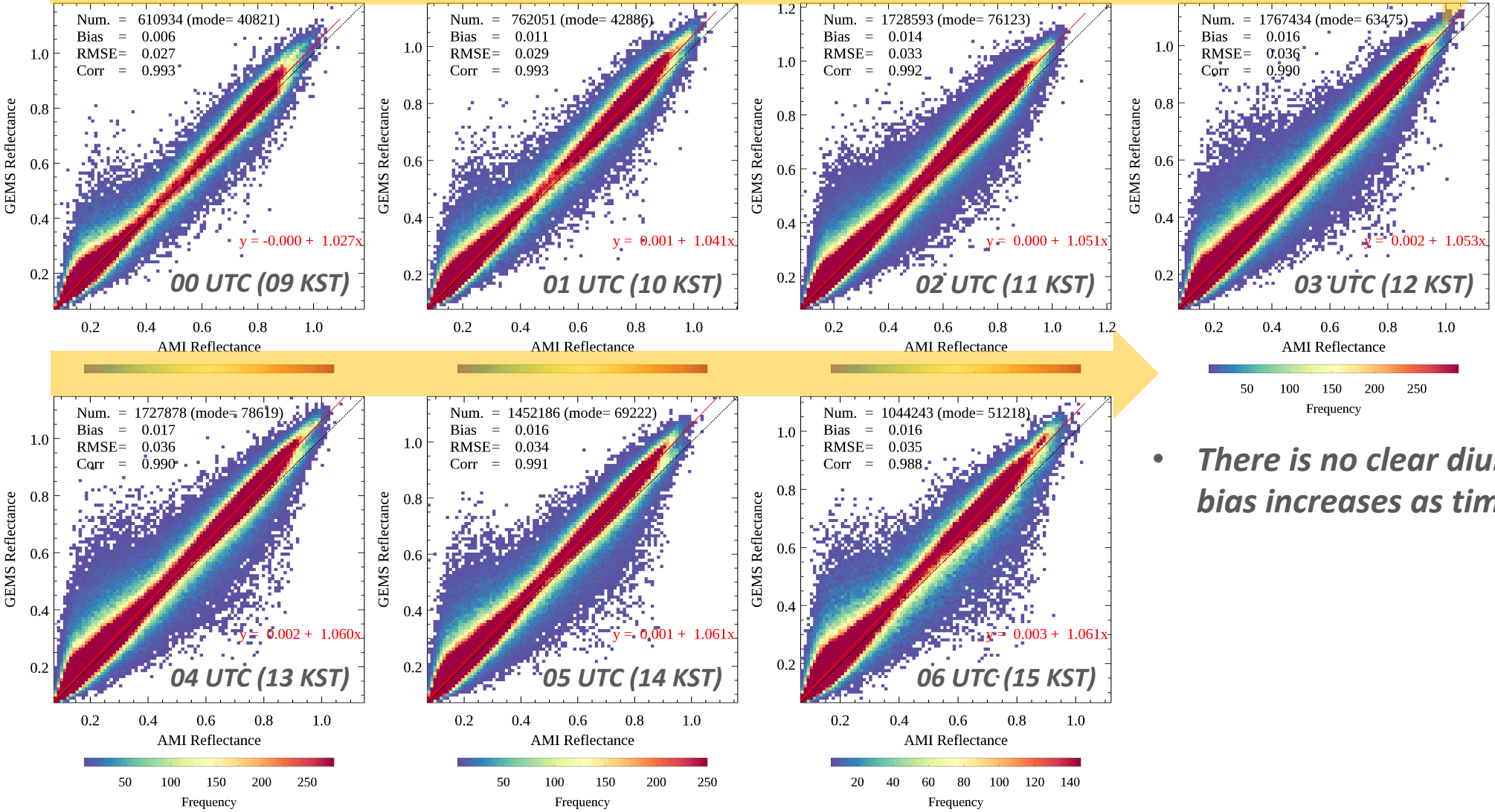


- ***There is no clear diurnal variation, but the bias increases as time goes by.***

3. Results & further approach

❖ Diurnal variations (every 10 days, 11/2020-05/2021)

Reflectance



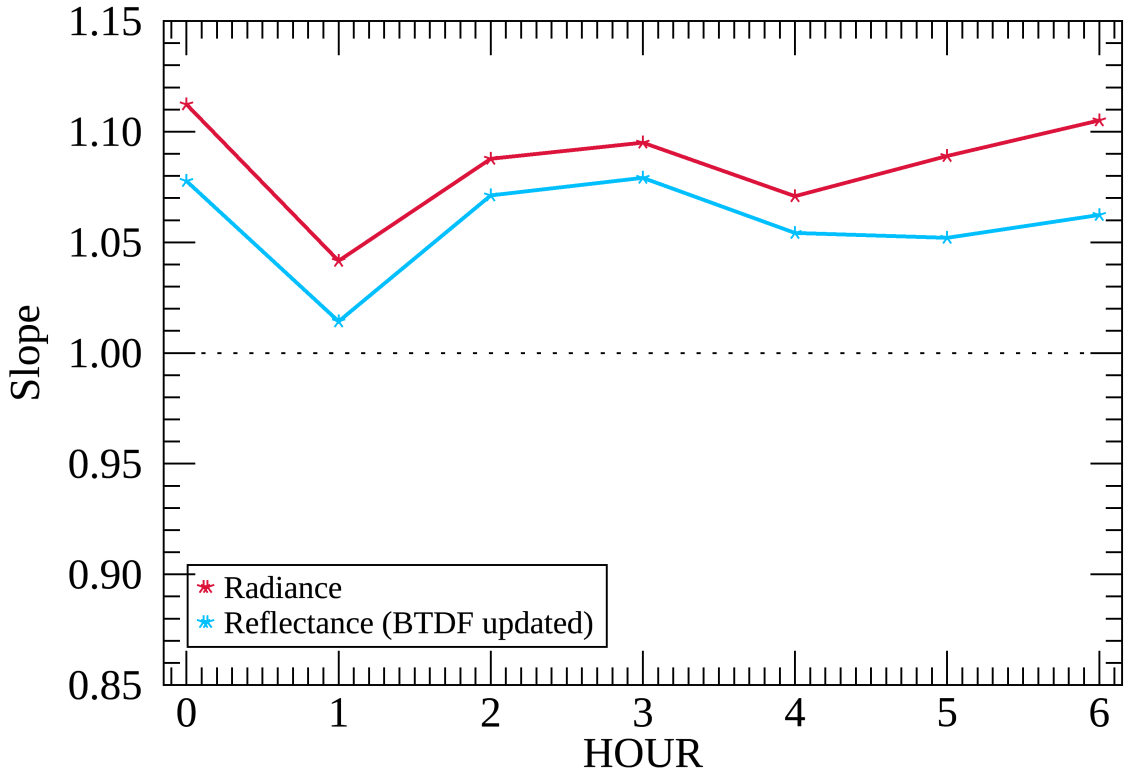
$$R_\lambda = \frac{\pi I_\lambda}{F_\lambda \cos\theta_0}$$

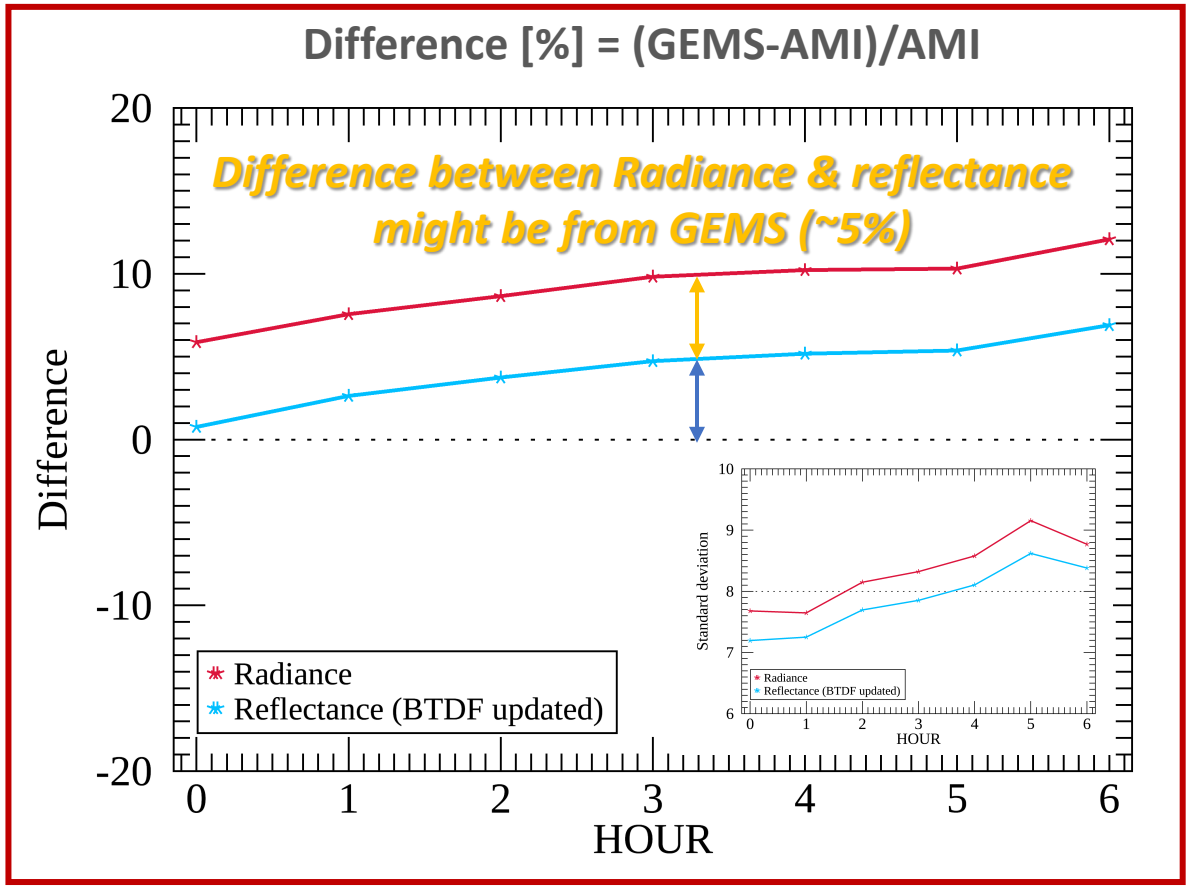
- ***There is no clear diurnal variation, but the bias increases as time goes by.***

3. Results & further approach

❖ Diurnal variations (every 10 days, 11/2020-05/2021)

- Difference between GEMS & AMI increases -> **Difference has clear diurnal variation.**

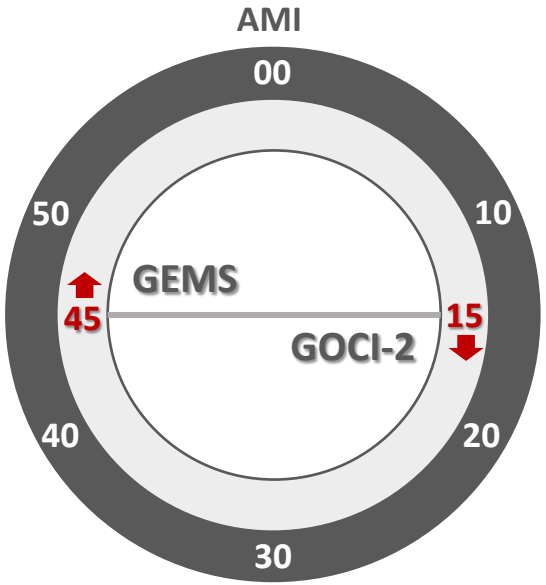




3. Results & further approach

❖ Advantages of using GOCI-2 measurements for inter-comparison

- GOCI-2 has **a narrow band width** and **could cover multiple channels at 380, 412 & 443 nm**.
- Rayleigh scattering effects caused by 30-min time lag between GEMS & GOCI-2 needs to be reduced



GEMS is,
- Darker in the morning
- Brighter bias in the afternoon

GEMS is,
- Brighter bias in the morning
- Darker bias in the afternoon

In the morning	→ Sensor A measures before sensor B	SZA↑	optical path length↑	radiance↓
In the afternoon		SZA↓	optical path length↓	radiance↑

Optical path length correction

$$I'_\lambda = \frac{I_\lambda}{\cos\theta_0}$$

Summary & further study

- **AMI, GEMS and GOCI-2** onboard GK-2A/2B **have an advantage in satisfying ray-matching conditions**.
- **GEO-GEO comparison can provide useful information** as the collocated data could **cover the whole measurement time and angle conditions.**
- **AMI & GEMS show high correlation (~0.99)** with the spatial homogeneity test, but GEMS tends to be **higher for the brighter scenes** and **have overall positive bias**.
- **The positive bias** is attributed to **the spectral dependence in the GEMS measurements** (over 450 nm) and **the stronger bias for brighter scenes** might be caused by AMI.
- **GOCI-2 & GEMS could be compared by reducing the Rayleigh scattering effects** caused by the time lag (~30 min) between sensors with optical path length correction.

Furtherly,

- It is expected that **the GEO-GEO comparison results could support the GEO-LEO comparison**.
- **MTG-FCI & Sentinel 4 (to be launched)** have similar conditions with AMI & GEMS which indicates **the approach also could be applied to the other sensors measuring UV/VIS spectral range**.

Thank you

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