The potential of Deep convective clouds (DCC) for inter-comparison of UVIS hyperspectral measurements

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Content

1. Overview

- Geostationary Environment Monitoring Spectrometer (GEMS)
- Level 0-1 calibration process
- Inter-comparison with GEO & LEOs
- Why DCCs for inter-calibration of GEMS (in UVIS)?
- Sensor specification

2. Collocation & ray-matching method

- LEO-GEO collocation process
- OMPS & GEMS collocation
- Comparison results

3. Relative calibration

- Preliminary results with TROPOMI

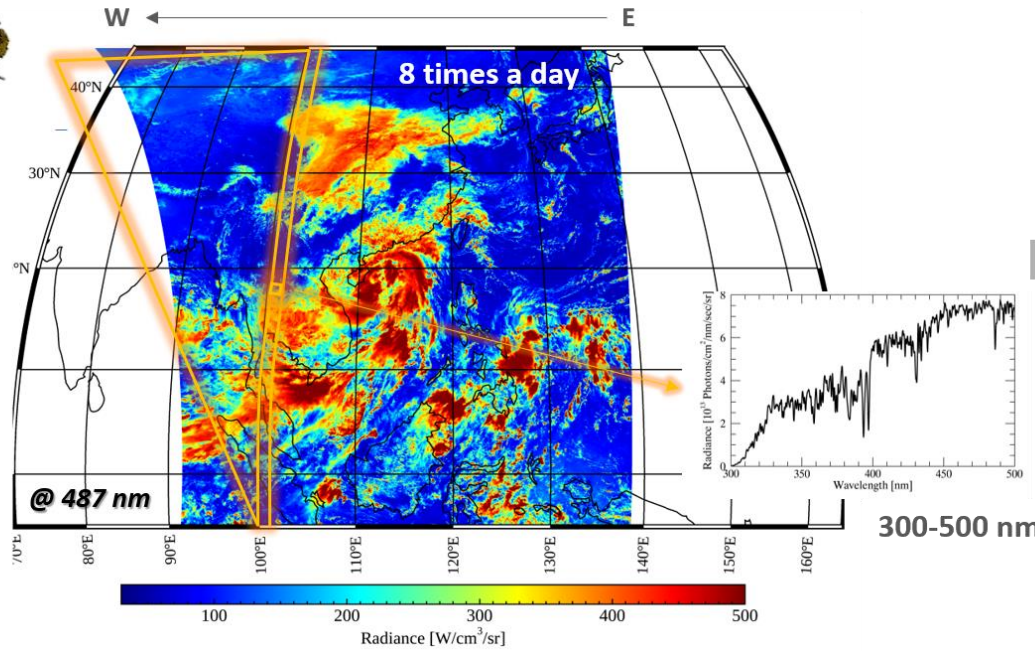
1. Overview

❖ Geostationary Environment Monitoring Spectrometer (GEMS)

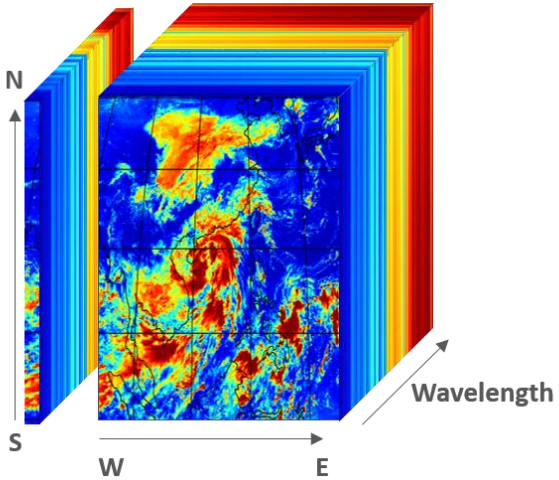
Geostationary orbit

O_3, NO_2, SO_2, HCHO, CHOCHO
& Aerosol properties

hyperspectral imaging



3-dimensional data



300-500 nm (resolution = 0.6 nm)

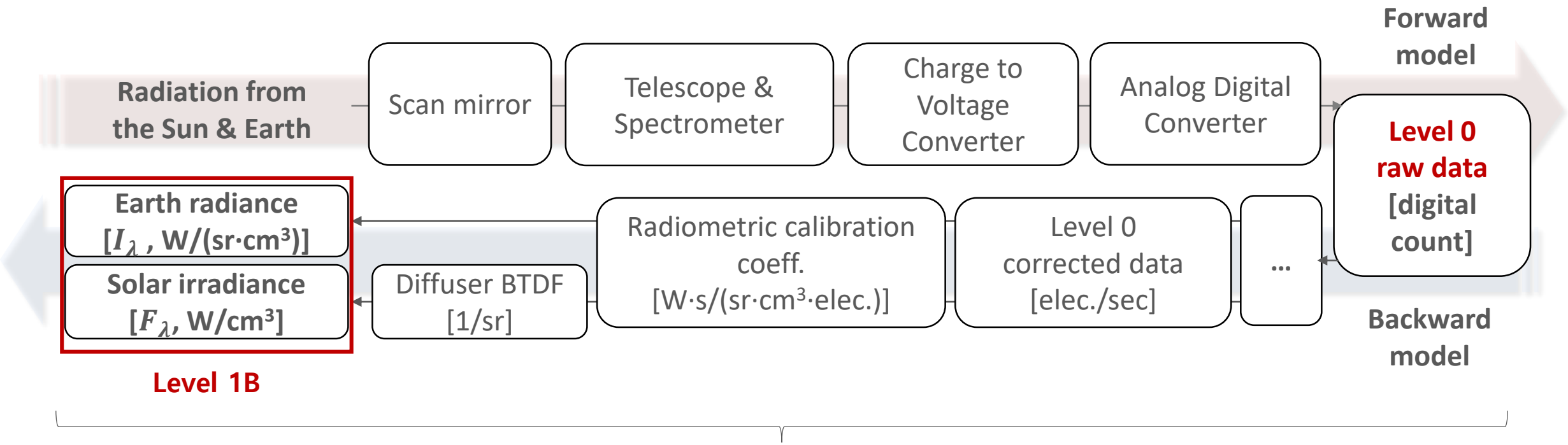
Pre-launch → **In-orbit test (IOT)** → **In operation**

S/C launch in Feb. 2020
Onboard GEO-KOMPSAT-2B (GK-2B)

Finished in Oct. 2020

1. Overview

❖ Level 0-1 calibration process of GEMS



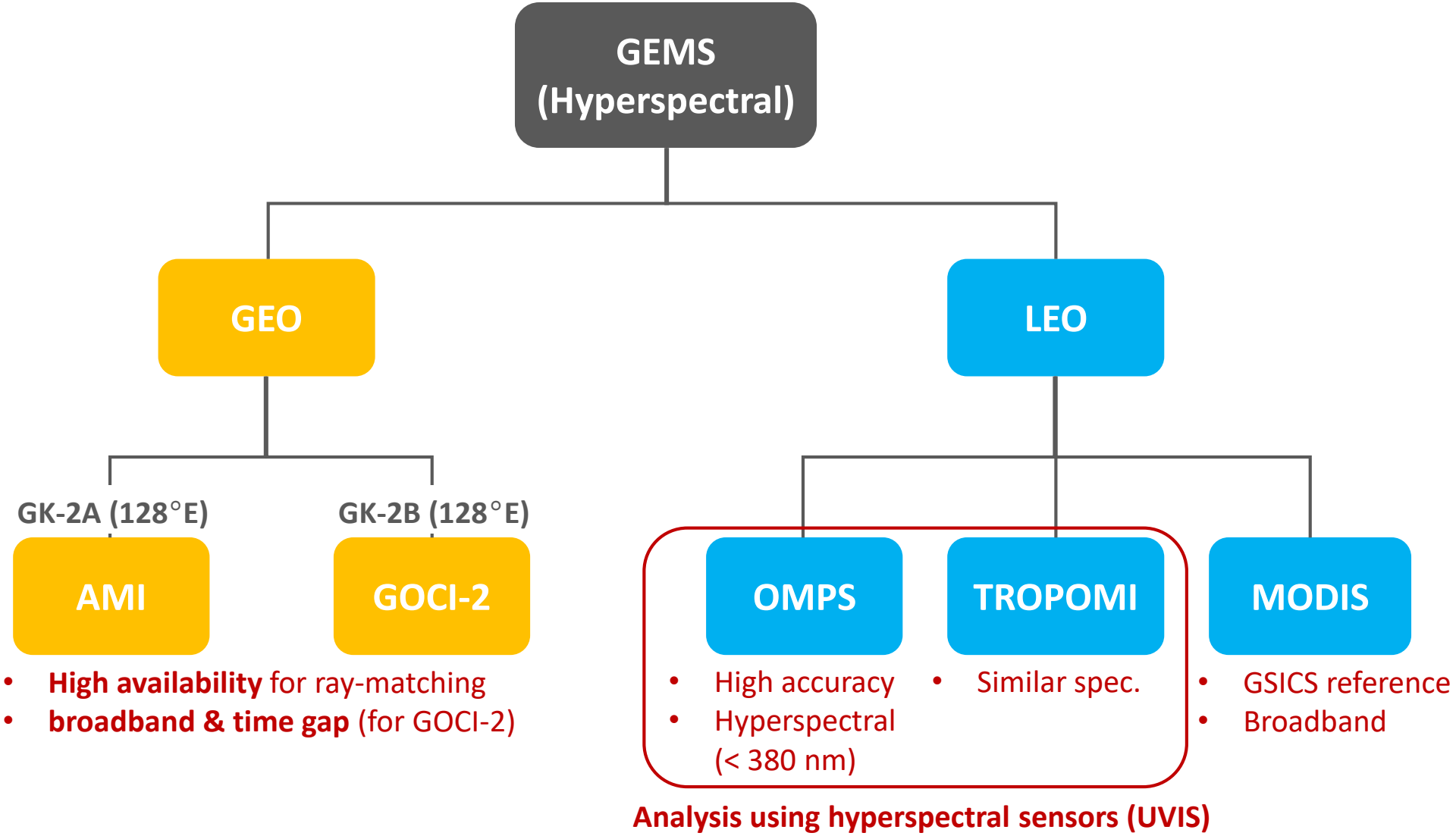
Error

- **Radiance & irradiance calibration error** (on-ground vs. in-orbit)
- **Sensor-specific** (time-dependent) & **degradation**

Error analysis: inter-calibration for GEMS with other satellite sensors (GEO & LEO)

1. Overview

❖ Inter-calibration with GEO & LEOs

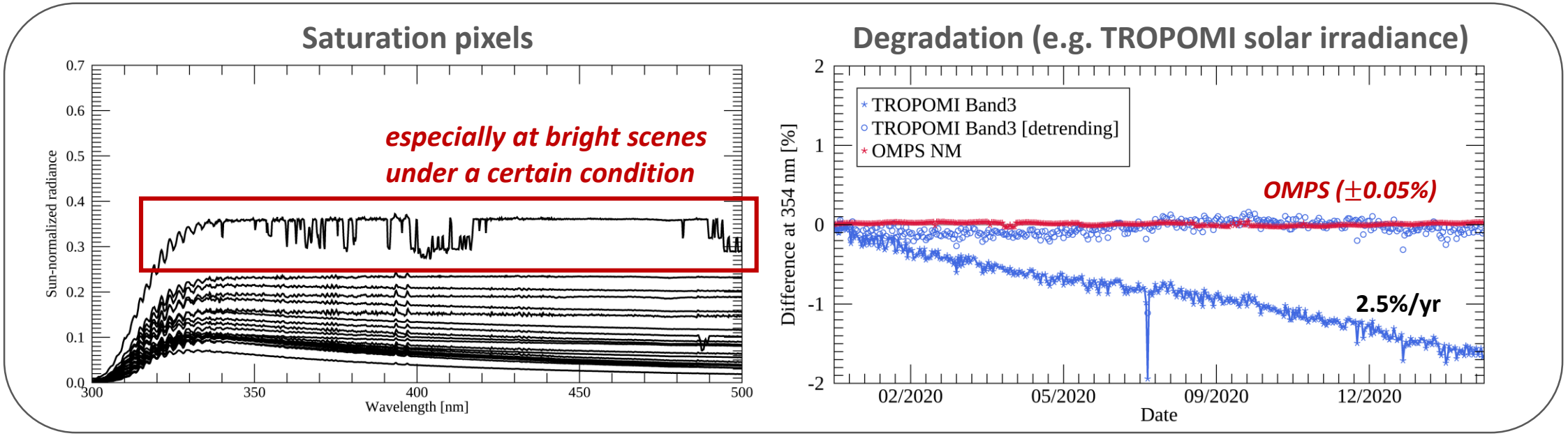


1. Overview

❖ Why DCCs for inter-calibration of GEMS (in UVIS)?

Inter-calibration using DCCs

- **Absolute calibration (ray-matching)**
  - N-S dependence occurred in the **GEMS BTDF**
  - **Saturation / stray light** correction
- **Relative calibration (vicarious calibration)**
  - **Degradation**
  - **Radiometric calibration** coefficient



1. Overview

❖ Sensor specification

6-10% calibration error
& degradation in Band 3-4
(Tilstra et al., 2020)

** **NP**: Nadir profiler*
** **NM**: Nadir mapper*

Sensor	GEMS	TROPOMI			OMPS NPP	
		Band 2	Band 3	Band 4	NP	NM
Orbit type	Geosynchronous (nadir at 128°E)	Sun-synchronous (mean LST 13:35)			Sun-synchronous (mean LST 13:30)	
Spectral range [nm]	**300-500**	300-332	305-400	400-500	250-310	300-380
Spectral resolution [nm]	**< 0.60**	0.55			1.0	1.0
Spectral sampling [nm/pixel]	< 0.20	0.065	0.20			0.42
Spatial resolution [km^2]	**3.5 × 8**	3.5 × 5.5			250 × 250	50 × 50

Reference sensor

2. Collocation & ray-matching method

❖ LEO-GEO collocation process

Target instrument

vs.

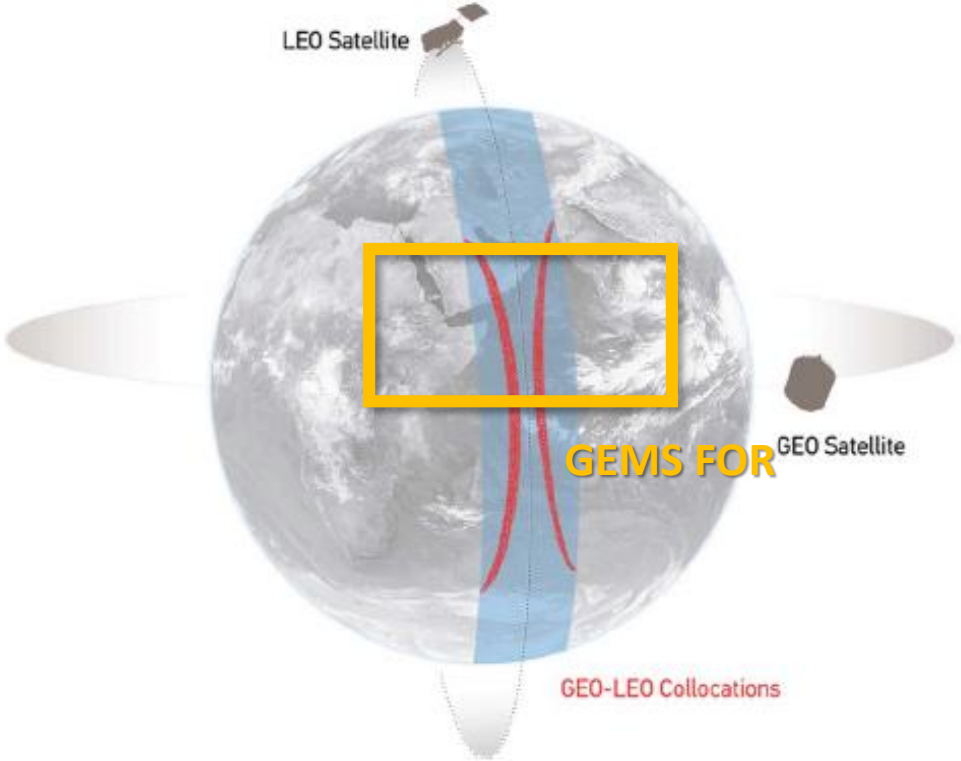
Reference instrument

➡ View an identical target

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

Condition	Threshold
Time	15 minutes
Distance	The half of FOV of LEOs
VZA	1%
Spatial homogeneity	$R_{\sigma,354\ nm}$ <0.03

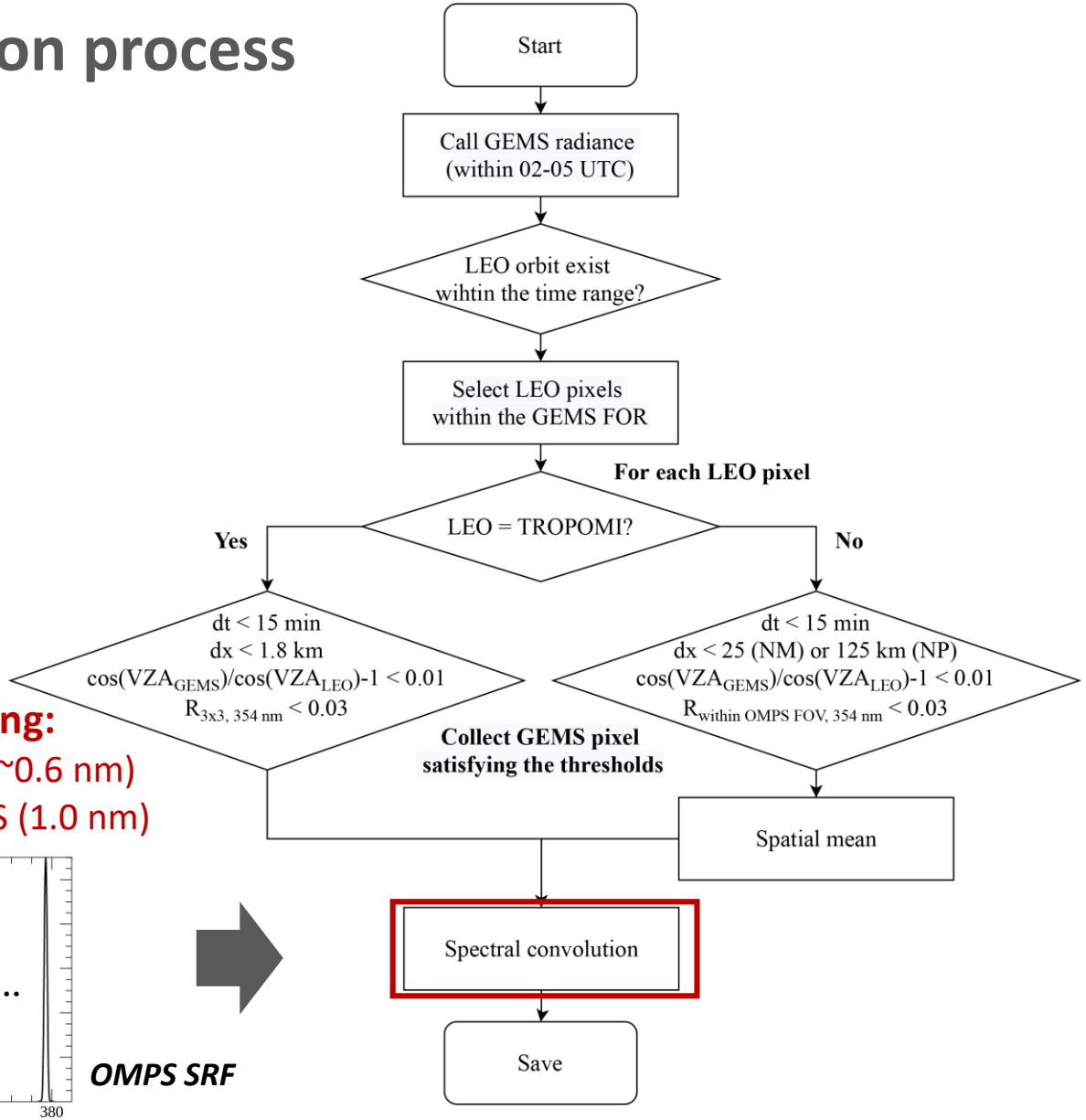
* ***VZA**: Viewing zenith angle*

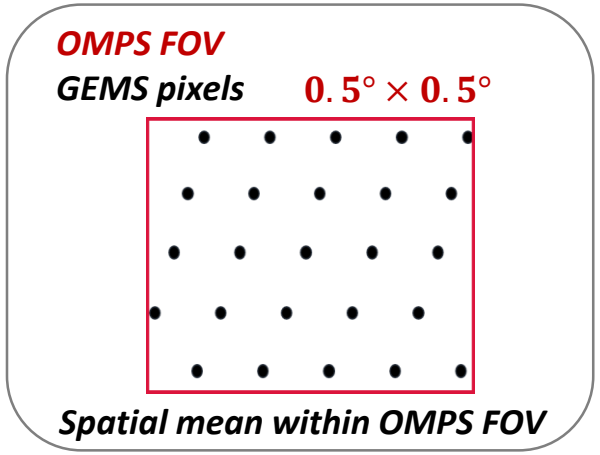


(Hewison et al., 2013)

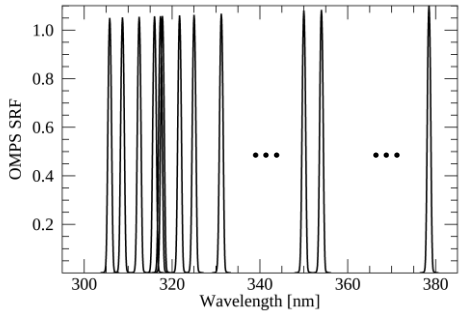
2. Collocation & ray-matching method

❖ LEO-GEO collocation process





Spectral matching:
Convolution of GEMS (~0.6 nm) for matching with OMPS (1.0 nm)



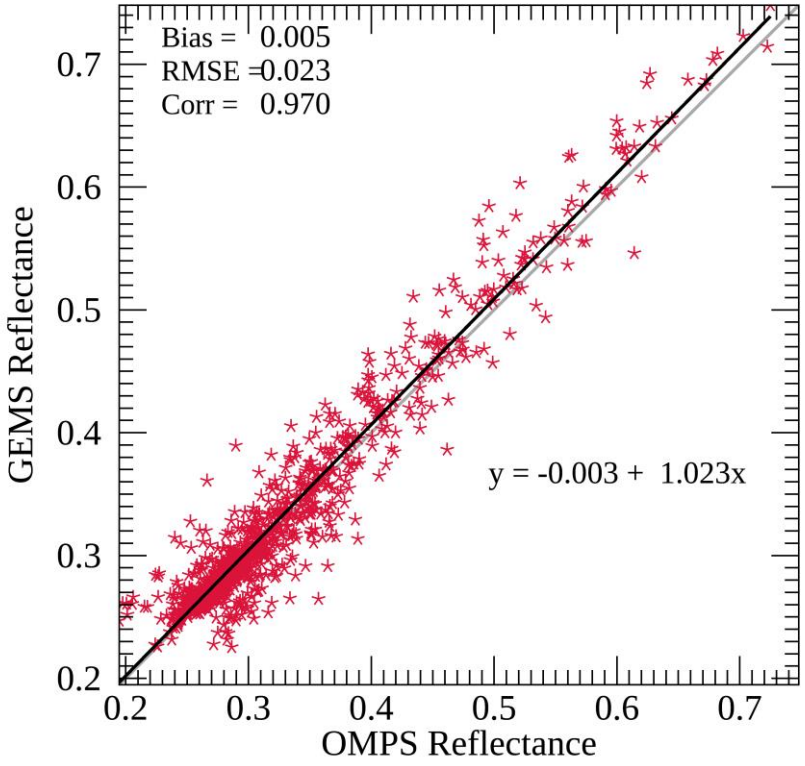
OMPS SRF

2. Collocation & ray-matching method

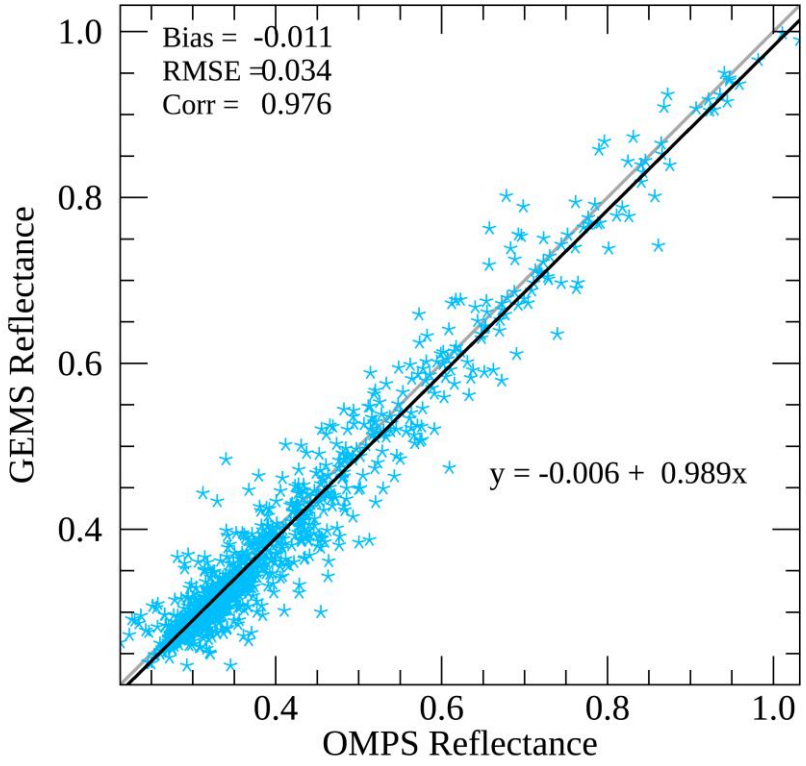
❖ Comparison results – systematic difference

* **Target period**: After the IOT [Nov. 2020-Mar. 2021], **over a thousand spectra satisfying the collocation process**

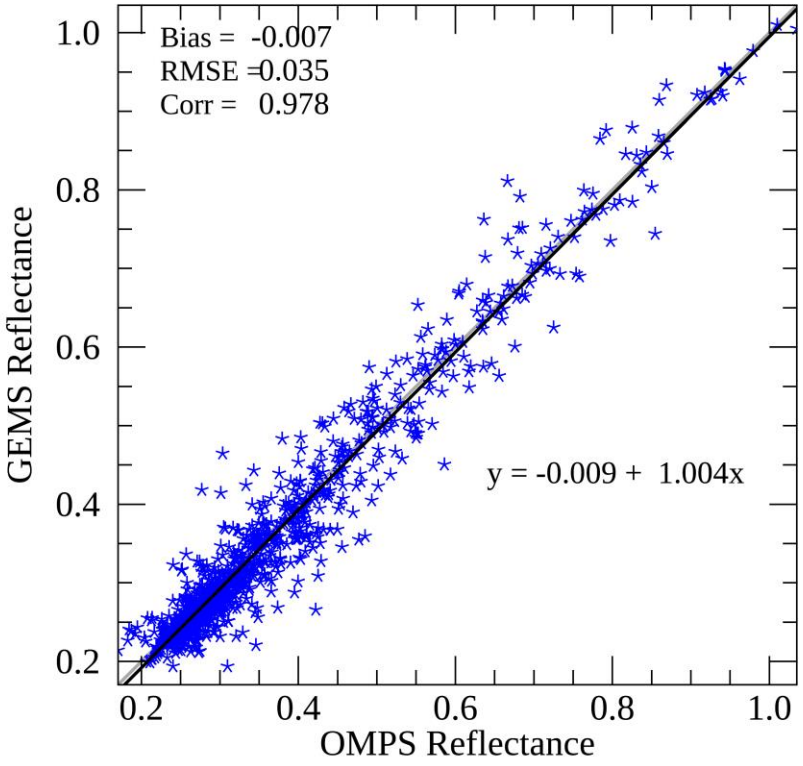
320 nm



354 nm



380 nm

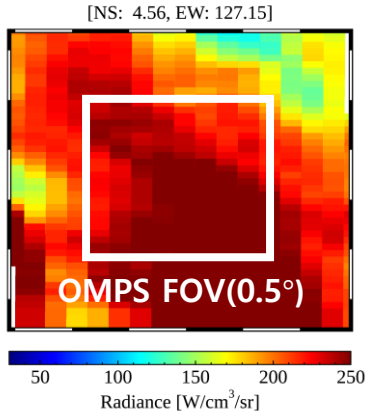


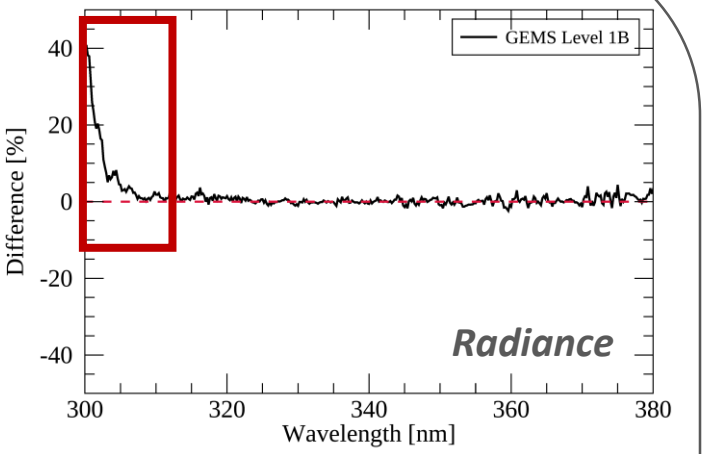
2. Collocation & ray-matching method

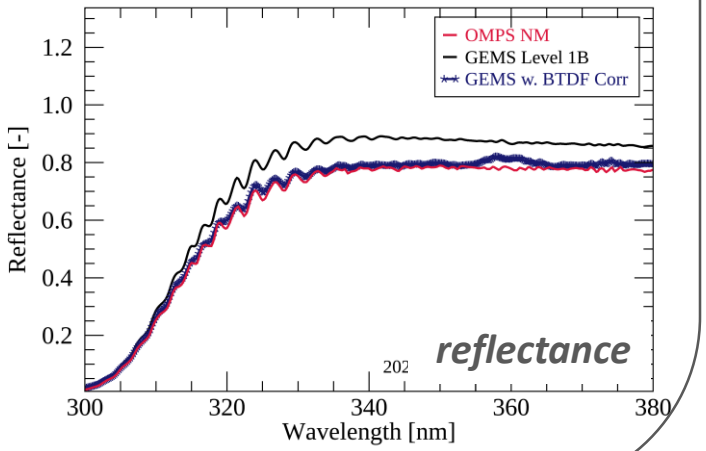
❖ Comparison results – DCCs & Dark ocean

** **VAA**: Viewing azimuth angle*

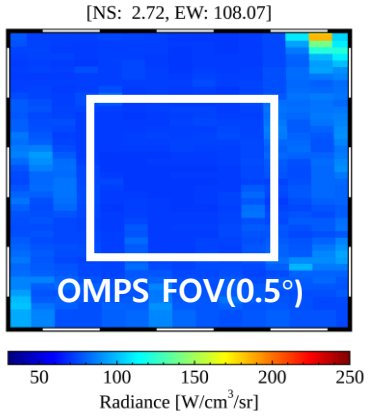
Deep convective clouds (R354 > 0.9)

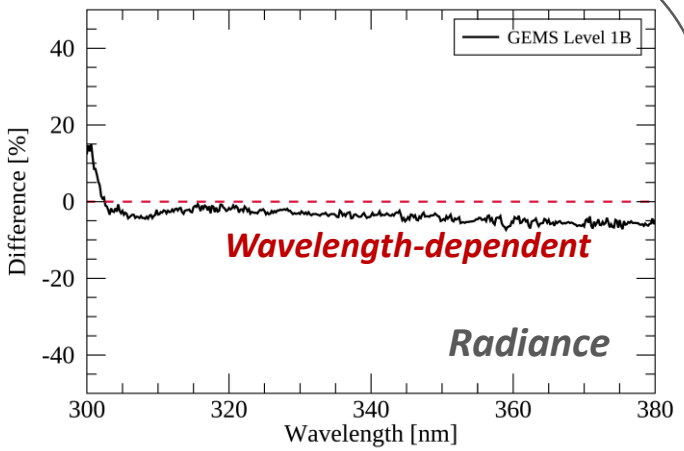




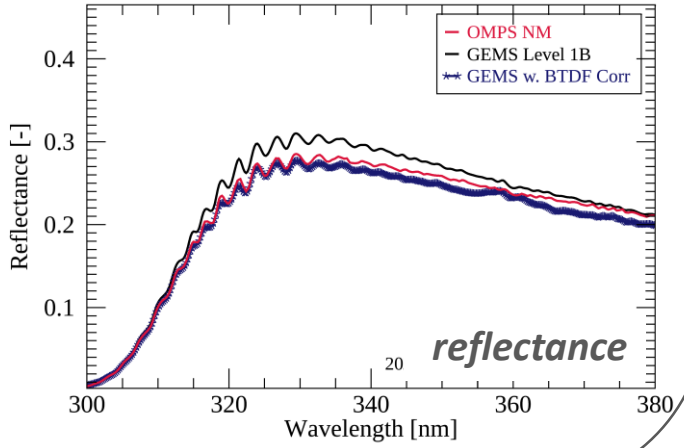


Dark ocean (clear sky)





VAA matching
or
Atmospheric correction



3. Relative calibration

❖ Preliminary results w/ TROPOMI

Stable & time-independent

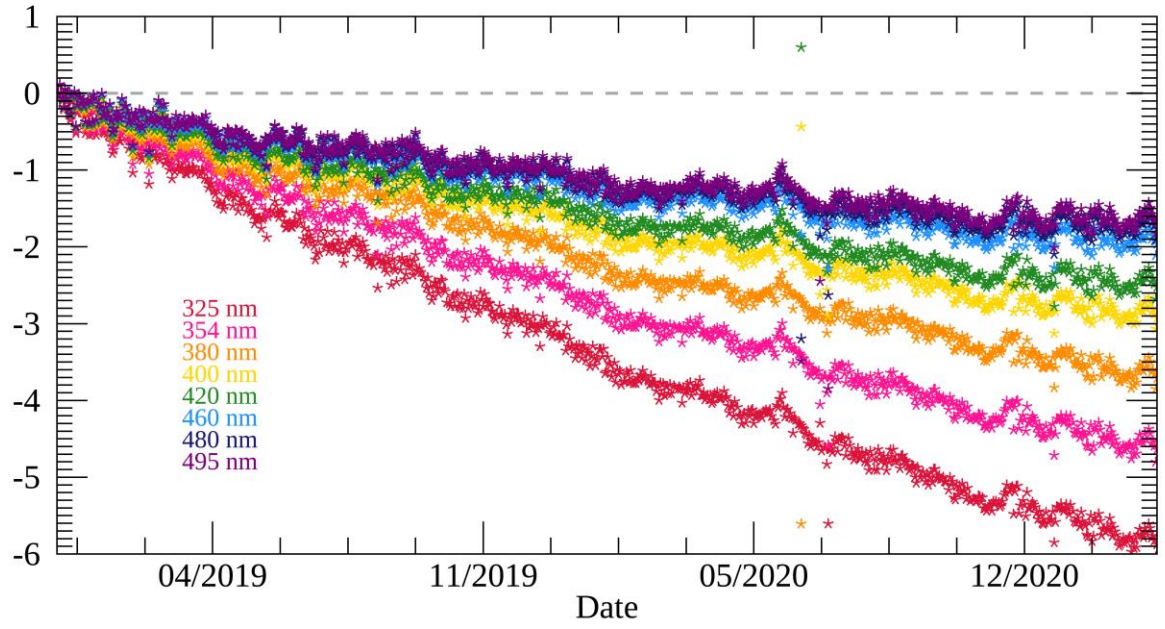
Sun & **DCCs** → Degradation from

- **Solar diffuser**
- **Optical sub-systems**

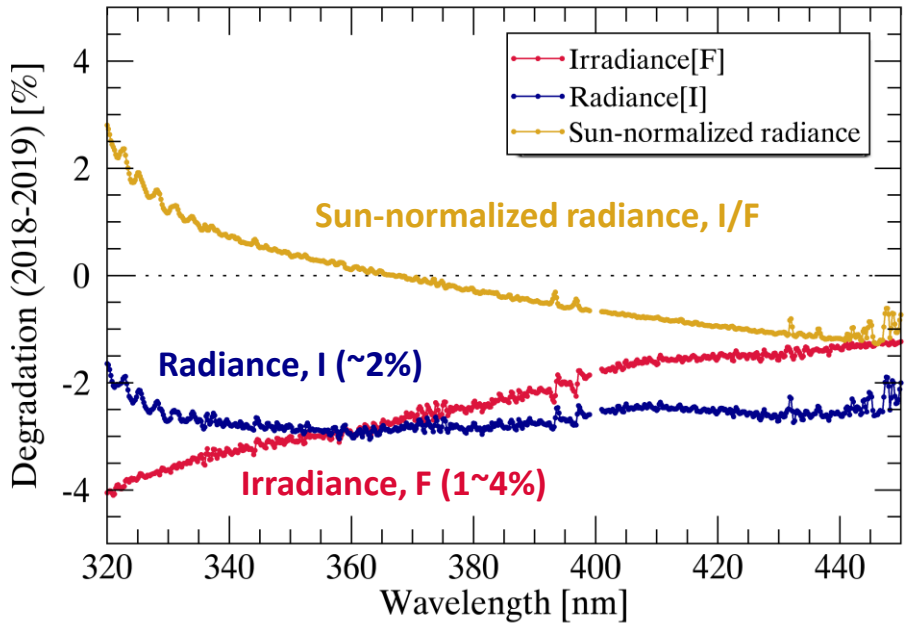
(scan-mirror / telescope / spectrometer / detector /...)

TROPOMI

Solar irradiance



Solar irradiance & DCCs [2018-2019]

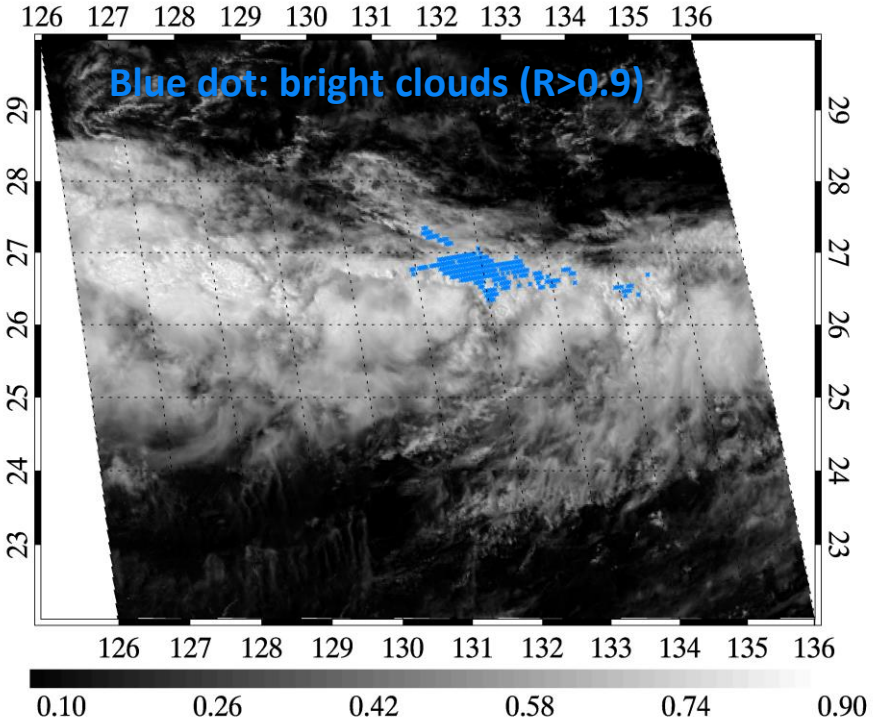


3. Relative calibration

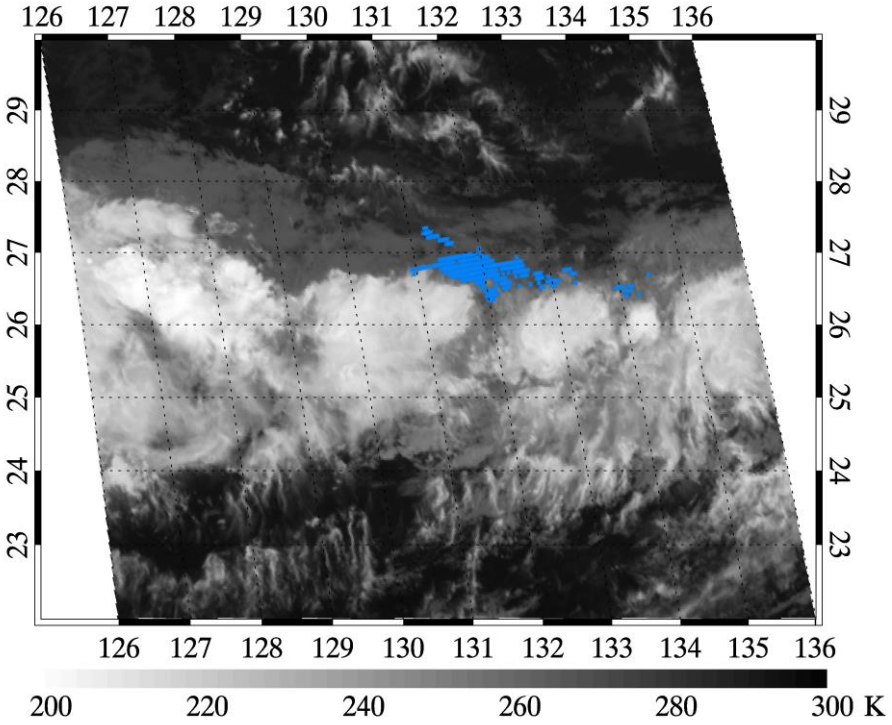
❖ Preliminary results w/ TROPOMI

DCC detection – IR (BT11) & VIS or VIS (R354)

AHI Reflectance (0.47 μm)



AHI Brightness temperature (11 μm)



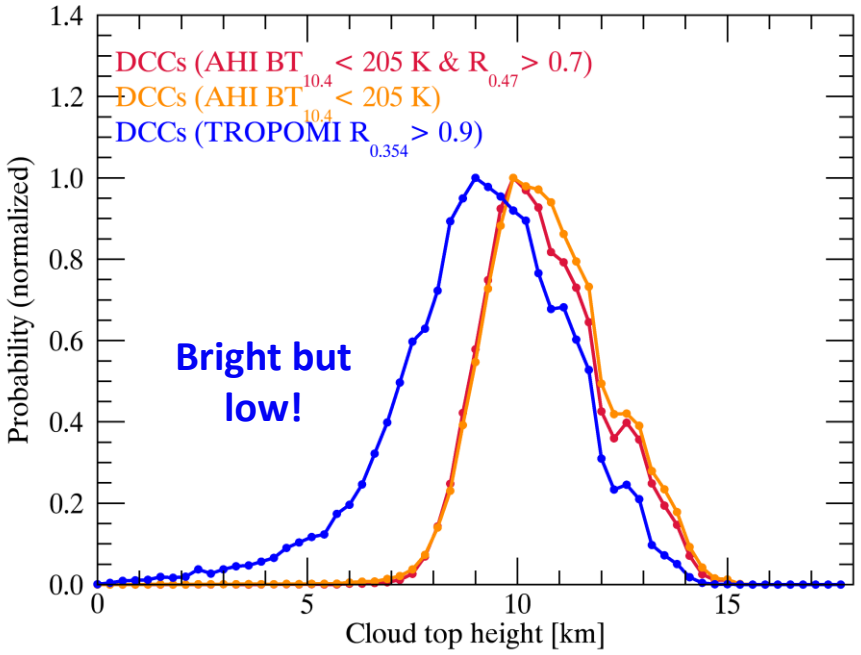
(Lee et al., Remote Sens 2020)

3. Relative calibration

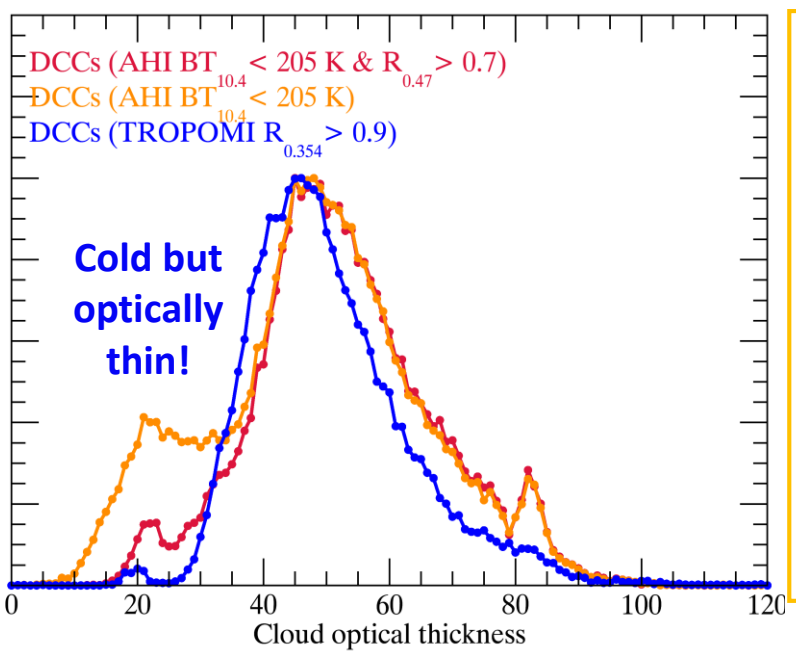
❖ Preliminary results w/ TROPOMI

DCC detection – IR (BT11) & VIS or VIS (R354)

TROPOMI Cloud top height



TROPOMI Cloud optical thickness



Collocation data for DCC detection

AMI (10.5 & 0.47 μm) — GEMS (354 nm)

Detection	Threshold
Brightness temperature ($BT_{10.5}$)	< 205 K
Spatial homogeneity($BT_{10.5}$)	< 2 K
Spatial homogeneity ($R_{0.47}$)	< 0.03
SZA & VZA	< 40°

(Lee et al., Remote Sens 2020)

Summary & future work

- **GEMS was launched in Feb. 2020 and in orbit test (IOT)** was successfully finished **in October.**
- **Errors from the level 0-1B processes** needs to be **separated from each other for correction**, and deep convective clouds would be a useful target for applying inter-calibration with OMPS & vicarious calibration.
- **Collocation between OMPS & GEMS** shows high agreement within 5% difference as prensenting high possibility for absolute calibration with OMPS.

Furtherly,

- **Vicarious calibration using DCCs has some issues to be solved** regarding the DCC detection and spectral coverage between OMPS & GEMS.
- **AMI & GOCI-2 will be used as a reference as well** for inter-calibration together with OMPS for GEMS.

Thank you