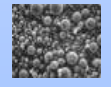
GEMS evaluation using Sentinel-5P products, Sentinel-4 algorithms and ground-based measurements

Diego Loyola, German Aerospace Center (DLR)
Teams from S5P PEGASOS and S4 L2OP

Sentinel-5P five years anniversary
Taormina, 13th October 2022

DLR

Sentinel-4 Copernicus Products and PEGASOS

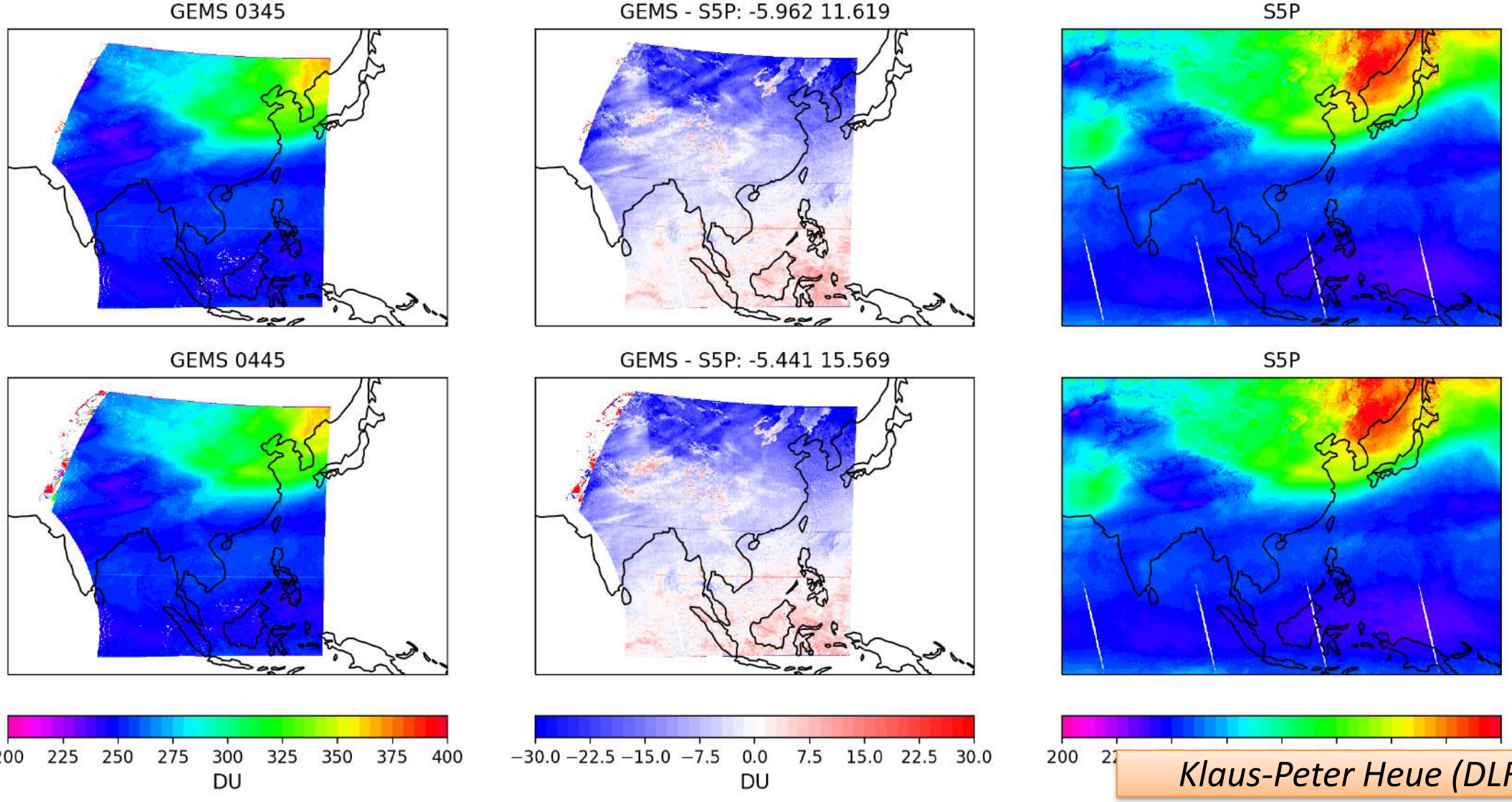
Sentinel-4 Products	
Species	**Parameter**
O_3 	Total column
	Tropospheric column
NO_2 	Total column
	Tropospheric column
SO_2 	Total column
HCHO 	Total column
CHOCHO 	Total column
Cloud 	Cloud fraction
	Optical depth
	Cloud height
Aerosol 	Index
	Optical depth
	Layer Height
Surface reflectance	BRDF and white sky albedo

PEGASOS
Product Evaluation of GEMS L2 via Assessment with S5P and Other Sensors
• Comparison with the operational S5P product • Geophysical validation with ground-based measurements

Total Ozone (O_3) – PEGASOS Sentinel-5P Comparison (DLR)

GEMS 2021-12-01

Sentinel-5P

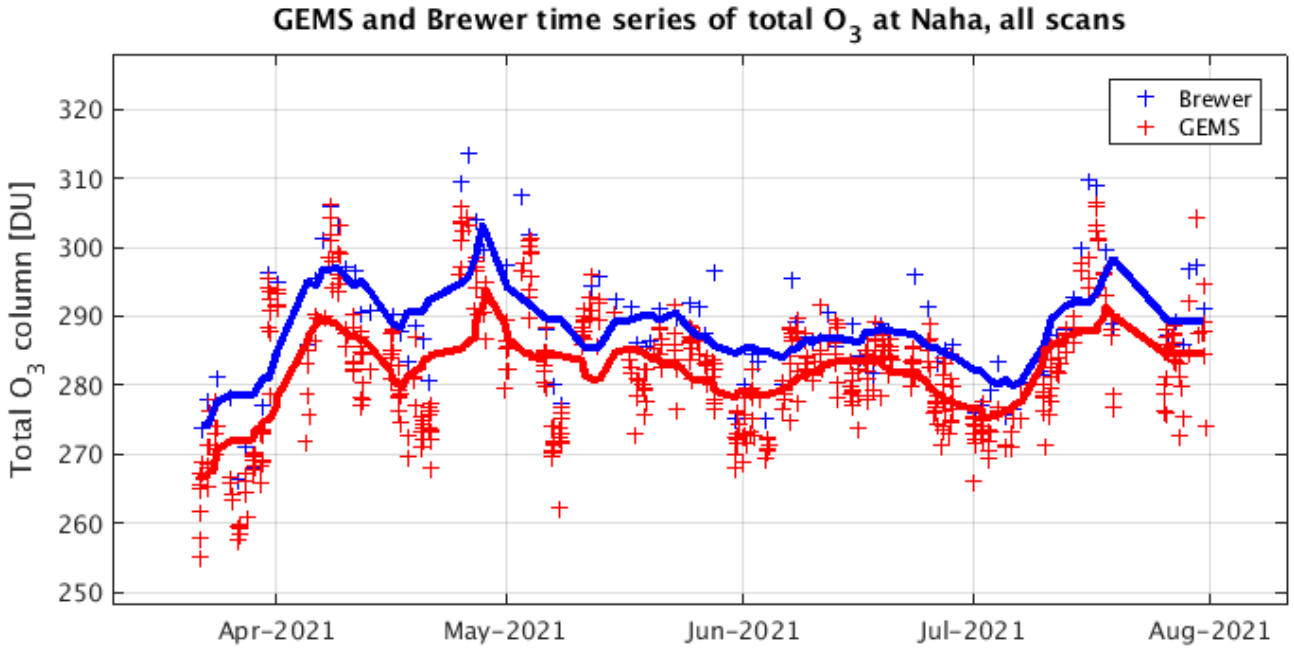


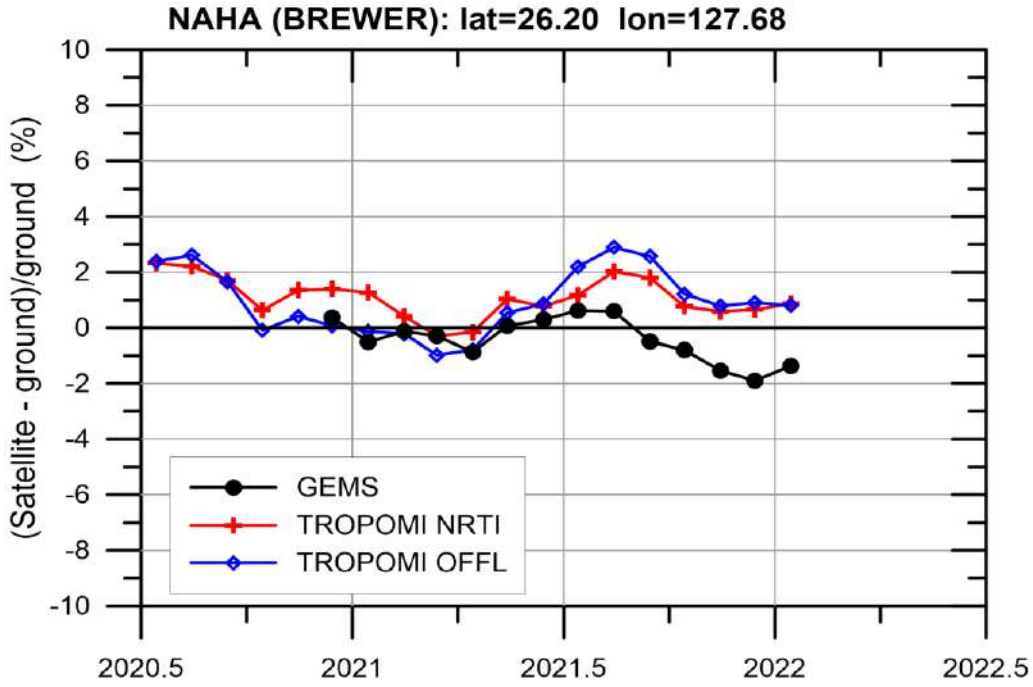
Klaus-Peter Heue (DLR)

Total Ozone (O_3) – PEGASOS Ground-Based Validation

– GEMS tracks Brewer O_3 well, especially in 14-day moving mean

– Small but clear negative bias for GEMS of -6 DU (-2%) and mean relative difference of -2.7%



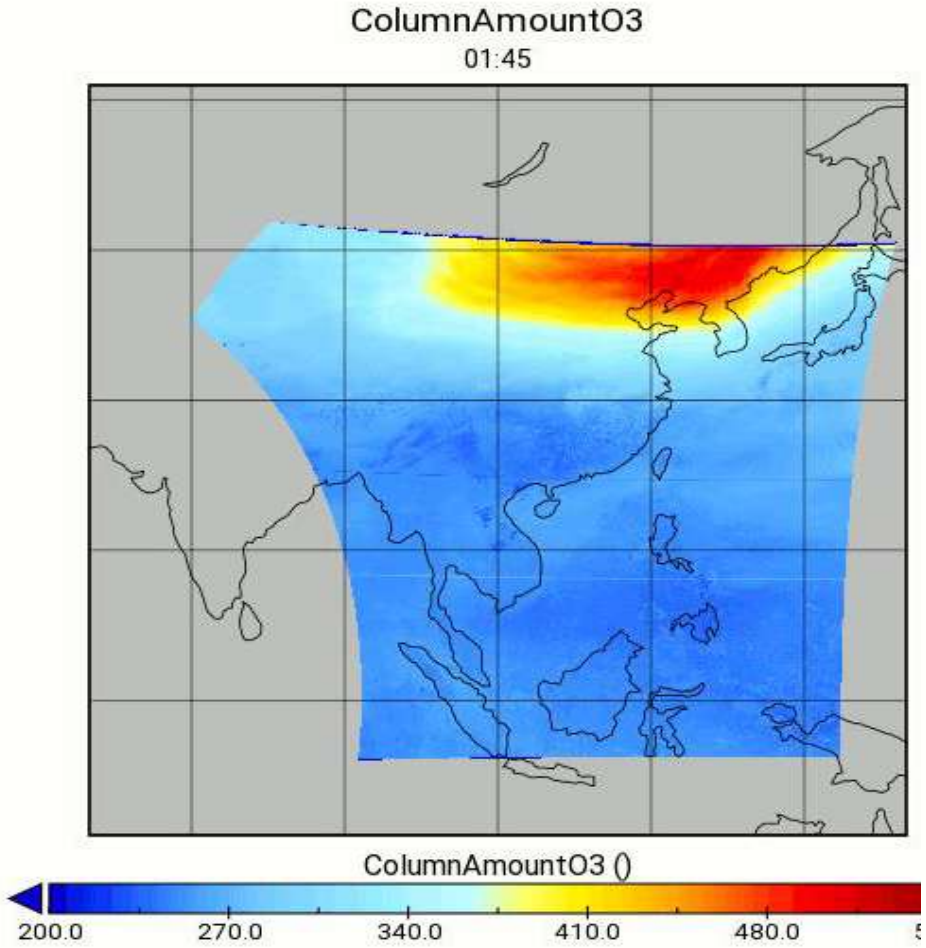


Tijl Verhoelst (BIRA)

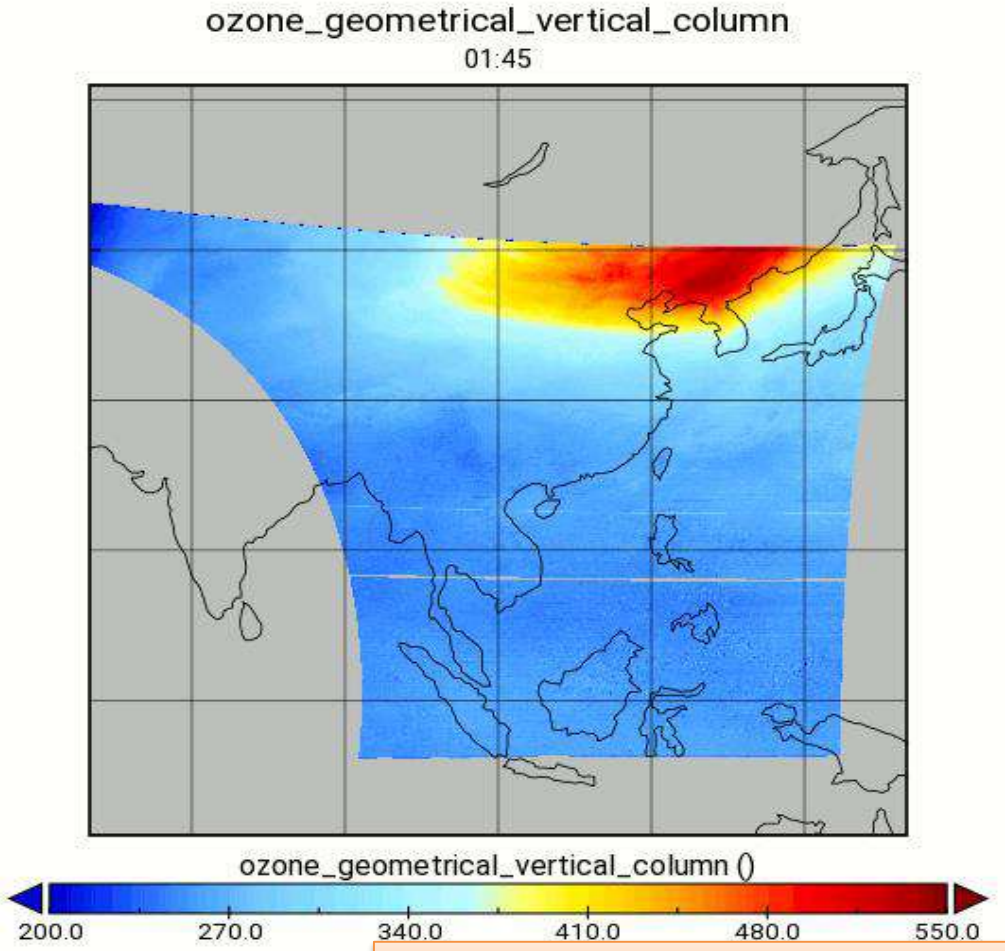
Katerina Garane (AUTH)

Total Ozone (O_3) – Sentinel-4 Algorithm

GEMS 2021-03-21



Sentinel-4 applied to GEMS



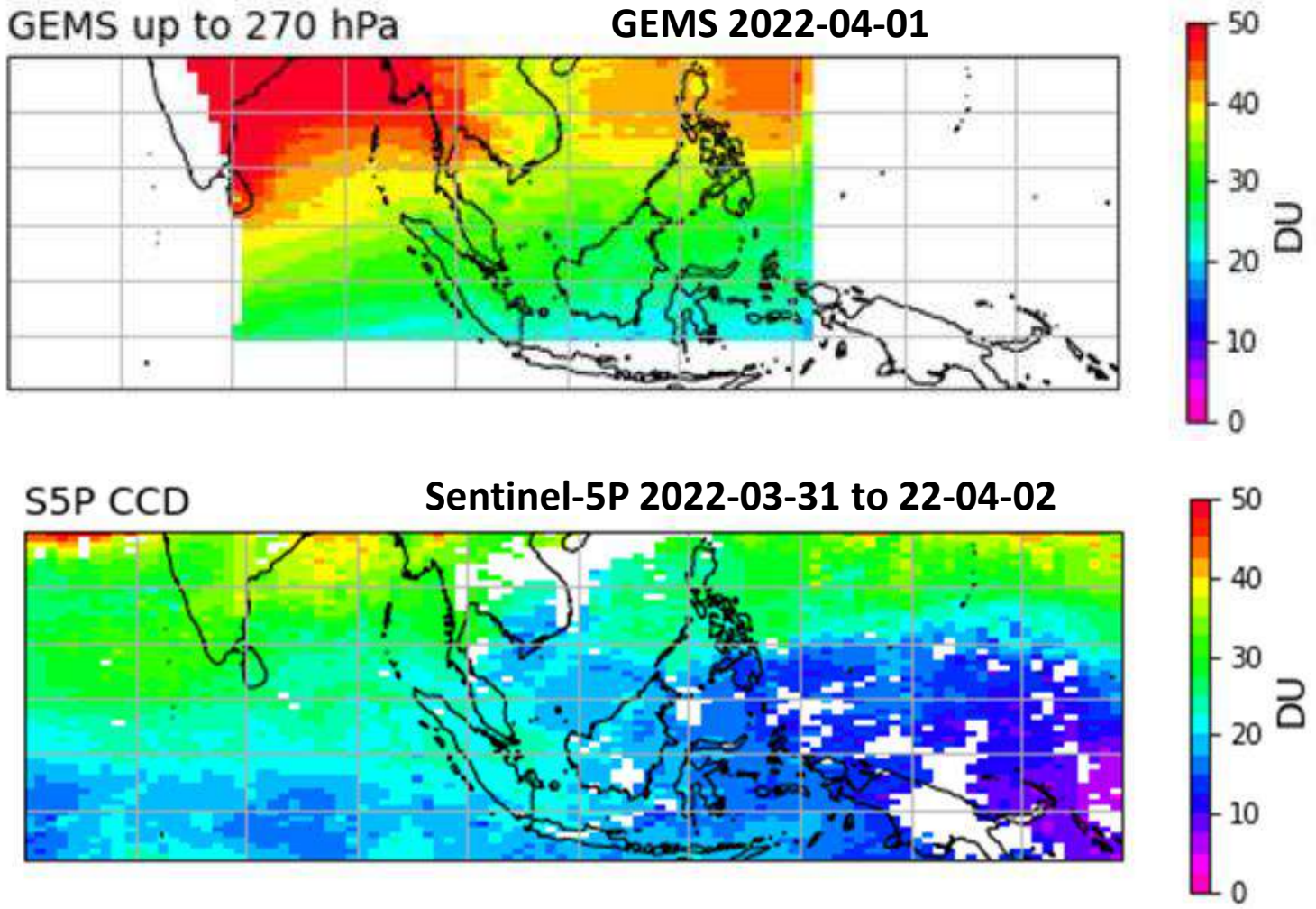
Klaus-Peter Heue (DLR)

Tropospheric Ozone (O_3) – PEGASOS Sentinel-5P Comparison

– GEMS data gridded to S5P CCD resolution of 0.5° x 1° and integrated up to 270 hPa.

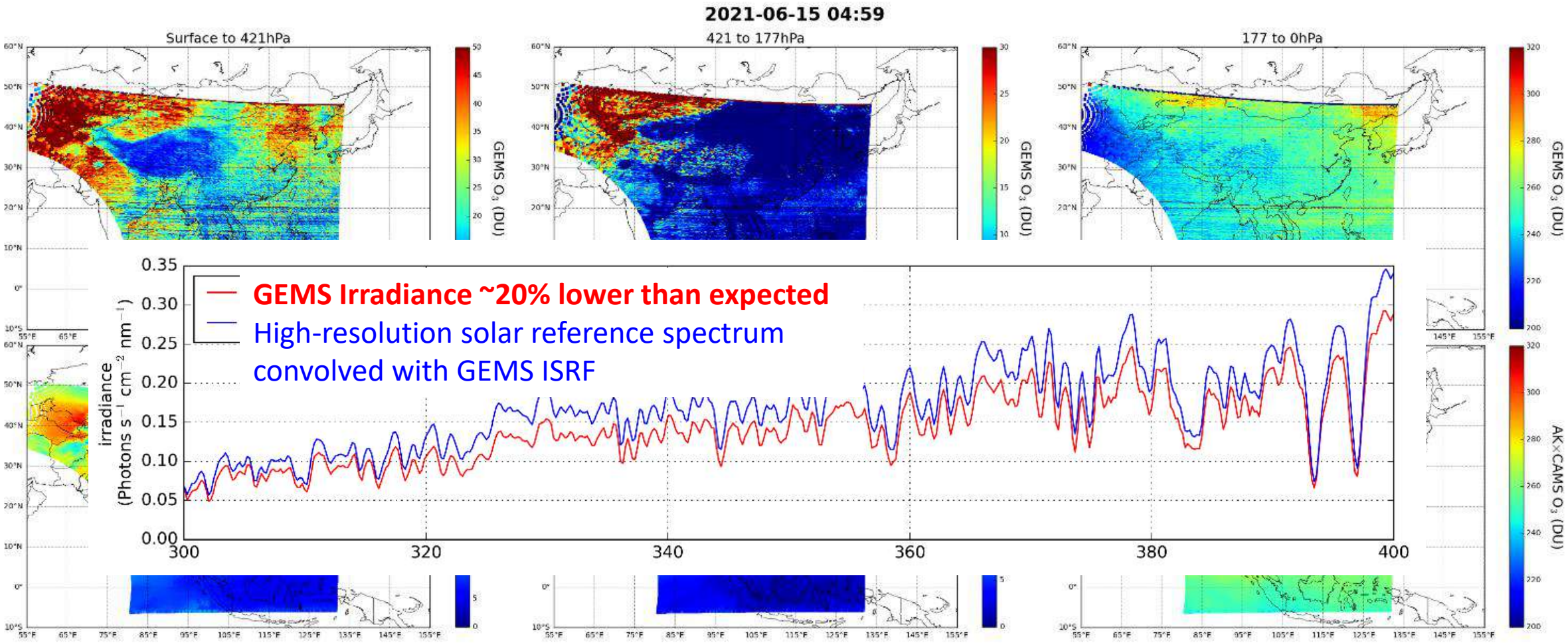
– Mean deviation 12.17 ± 4.75 DU

– Possible issue with altitude pressure and/or vertical integration



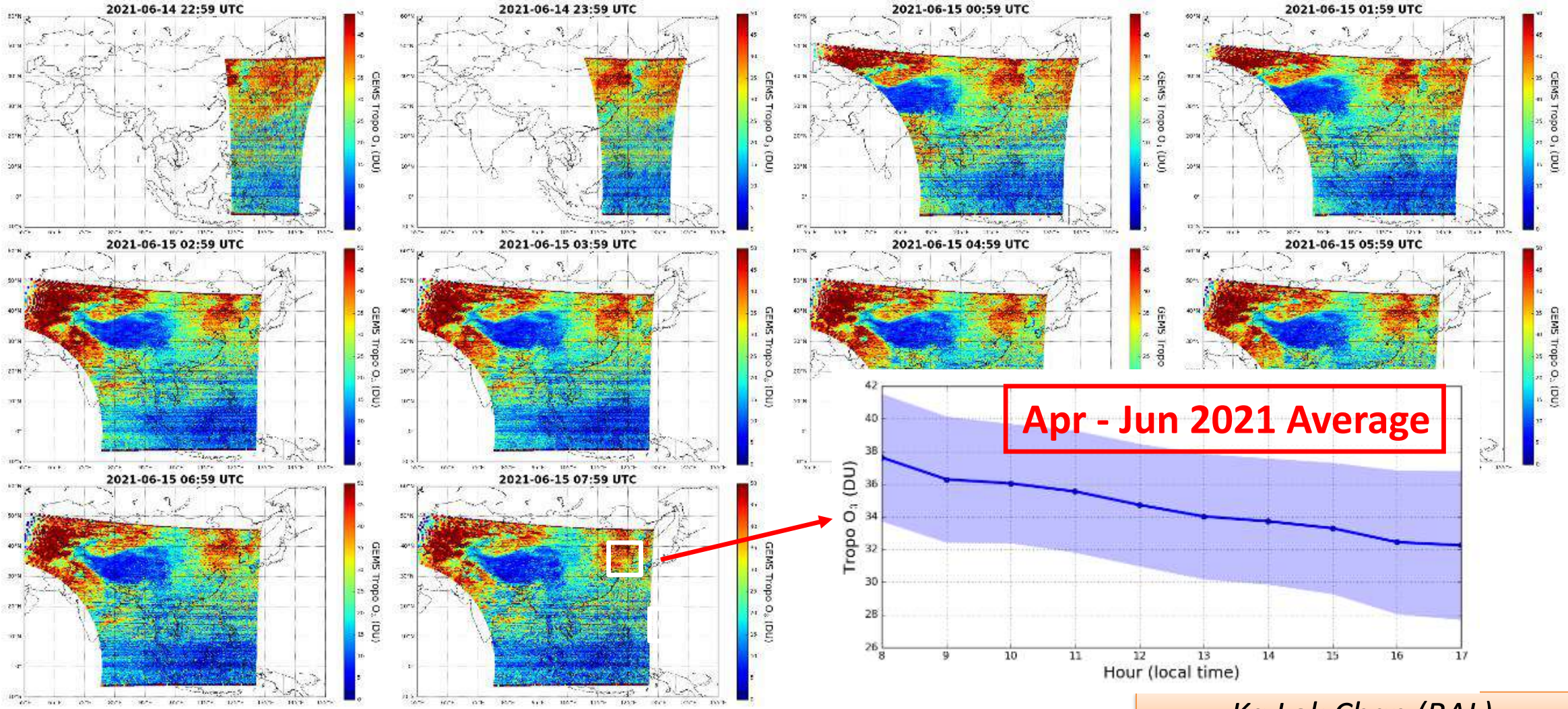
Klaus-Peter Heue (DLR)

Tropospheric Ozone (O_3) – Sentinel-4 Algorithm



Ka Lok Chan (RAL)

Tropospheric Ozone (O_3) – Sentinel-4 Algorithm

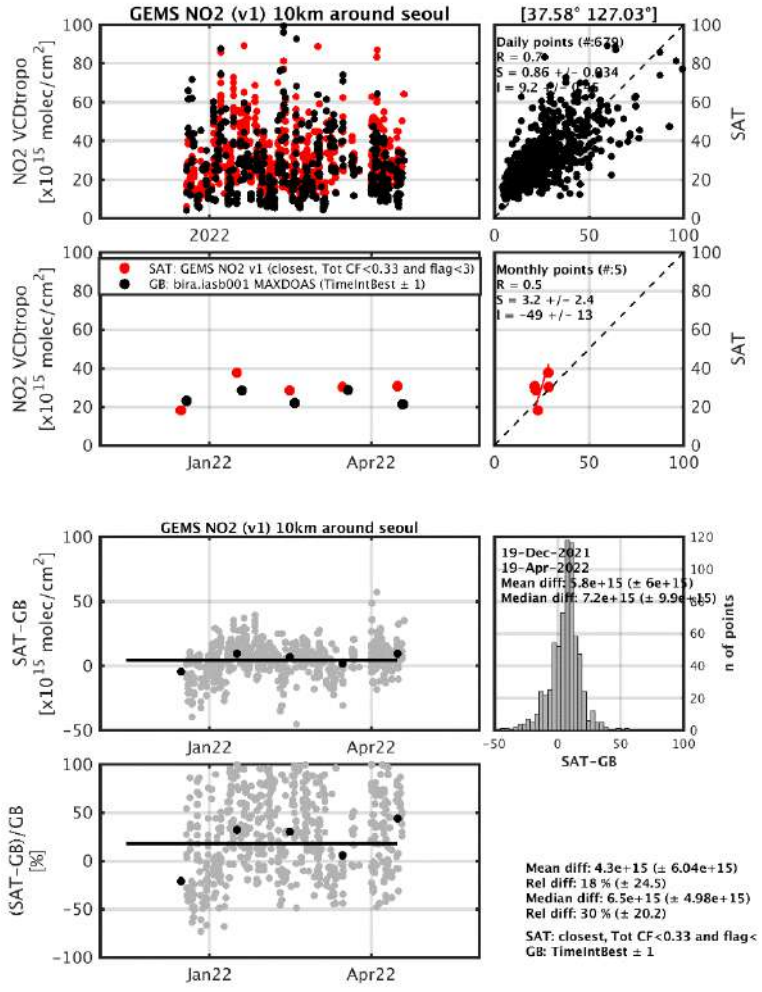


Ka Lok Chan (RAL)

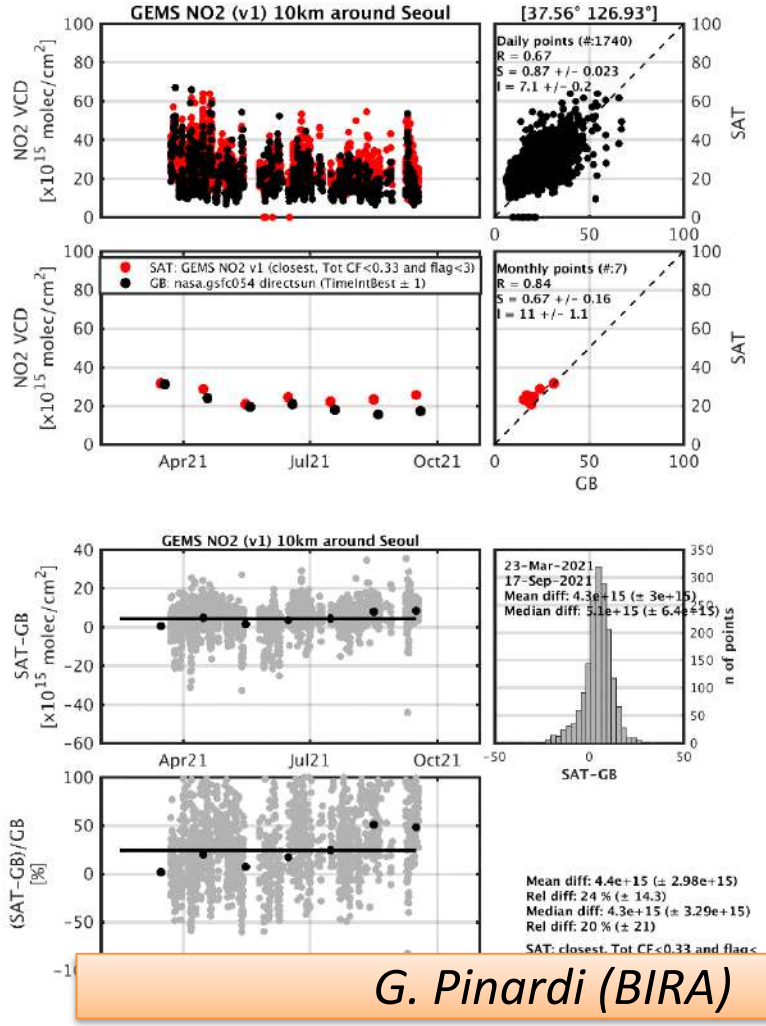
Tropospheric Nitrogen Dioxide (NO_2) – PEGASOS Ground-Based validation

Seoul MAXDOAS BIRA

(part of GMAP'21 campaign)

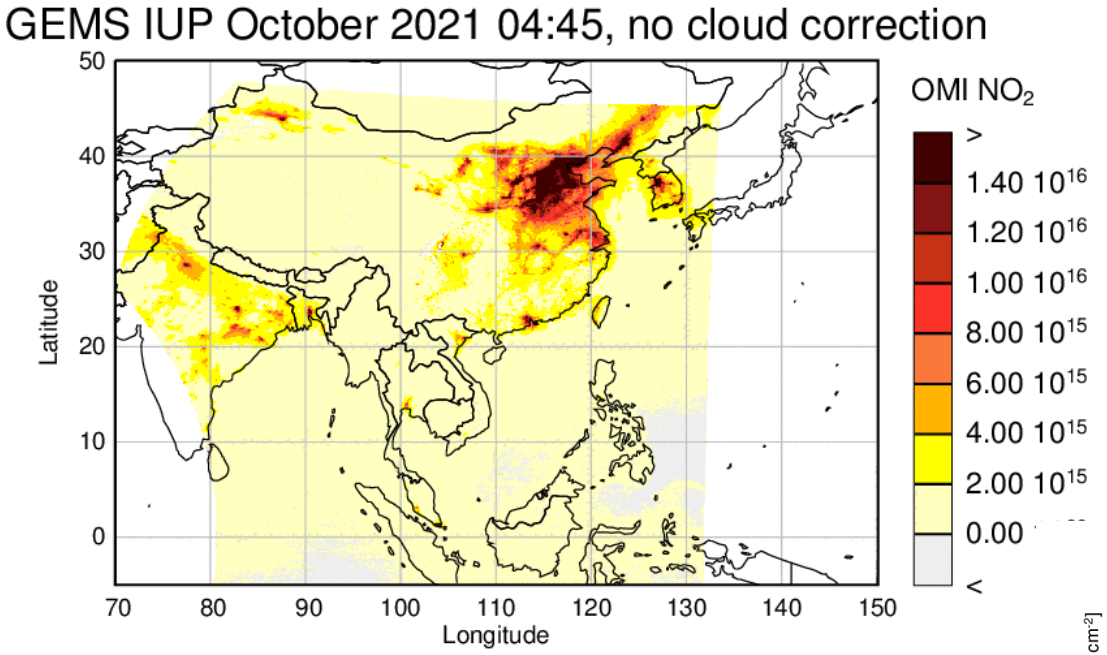


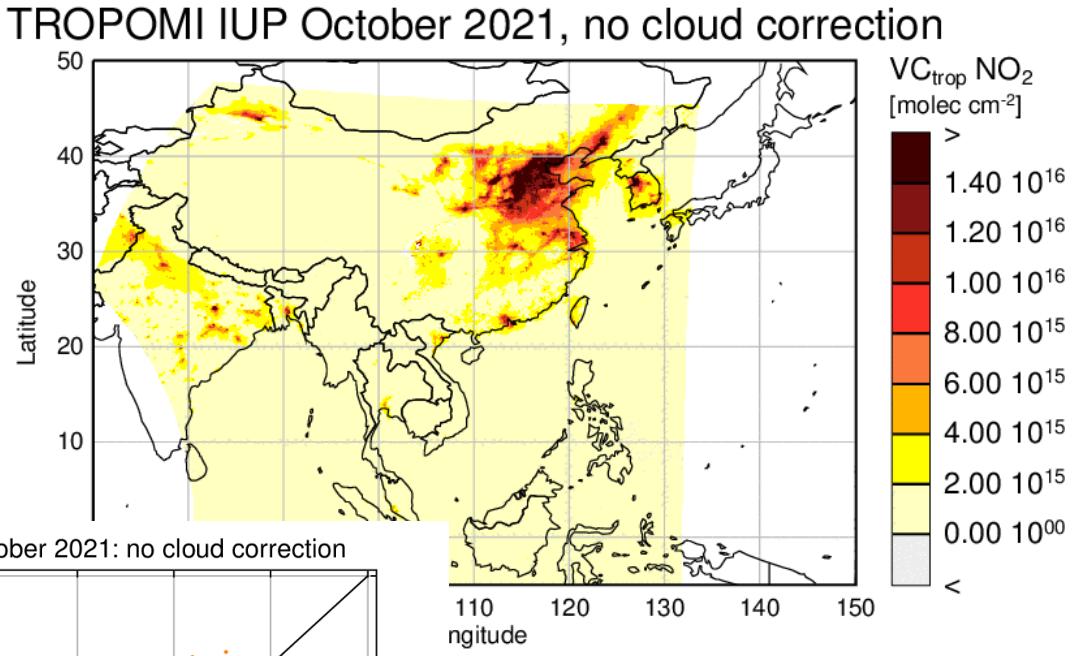
Seoul PNG NASA

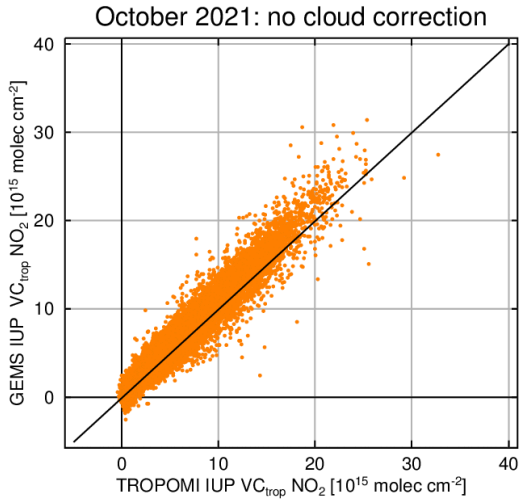


G. Pinardi (BIRA)

Tropospheric Nitrogen Dioxide (NO_2) – Sentinel-4 Algorithm



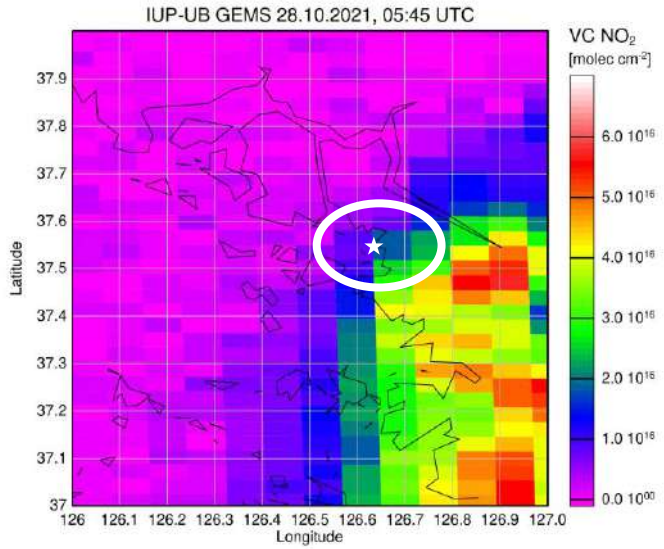




- Excellent agreement of monthly averages
- Only using filtering on cloud radiance fraction:
  - TROPOMI: <= 50% CRF
  - GEMS: <= 60% CRF
- A few percent GEMS overestimation remain

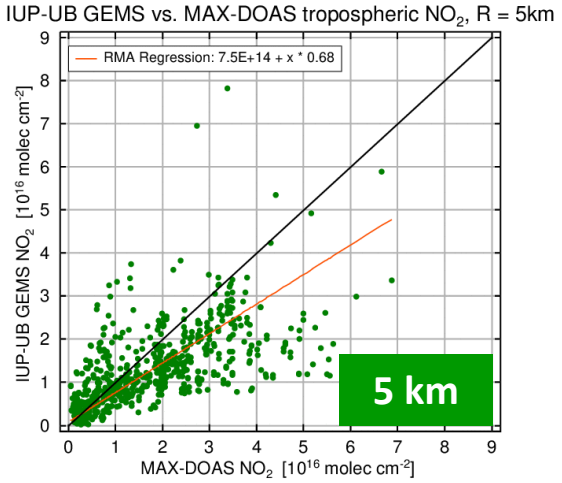
A. Richter (IUP-B) ➽ Oct. 11

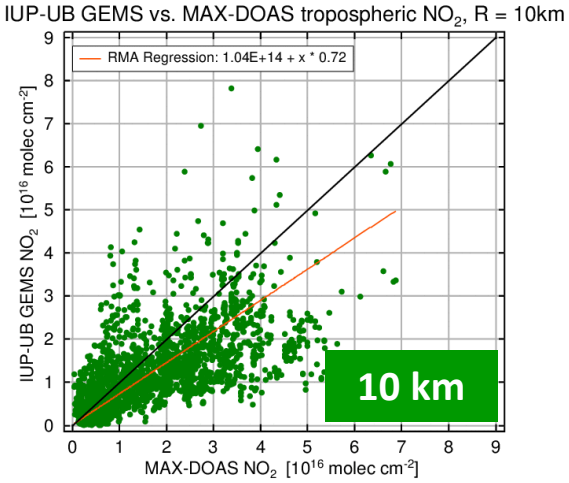
Tropospheric Nitrogen Dioxide (NO_2) – MAX-DOAS Validation in Incheon

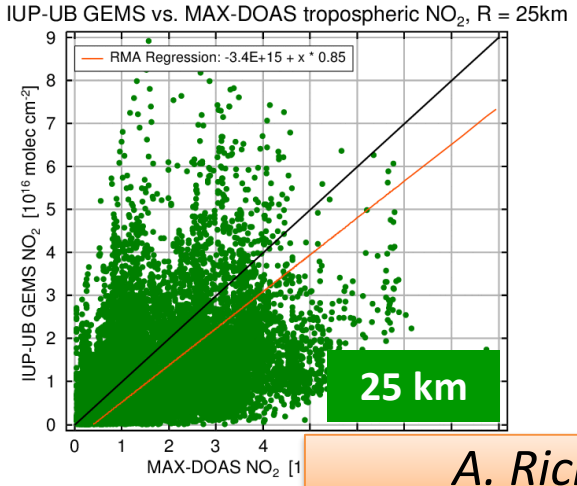


GMAP campaign:

- Roof of NIER building
- Close to Seoul
  => large gradients
- Observations since October 2021
- 5 azimuthal directions



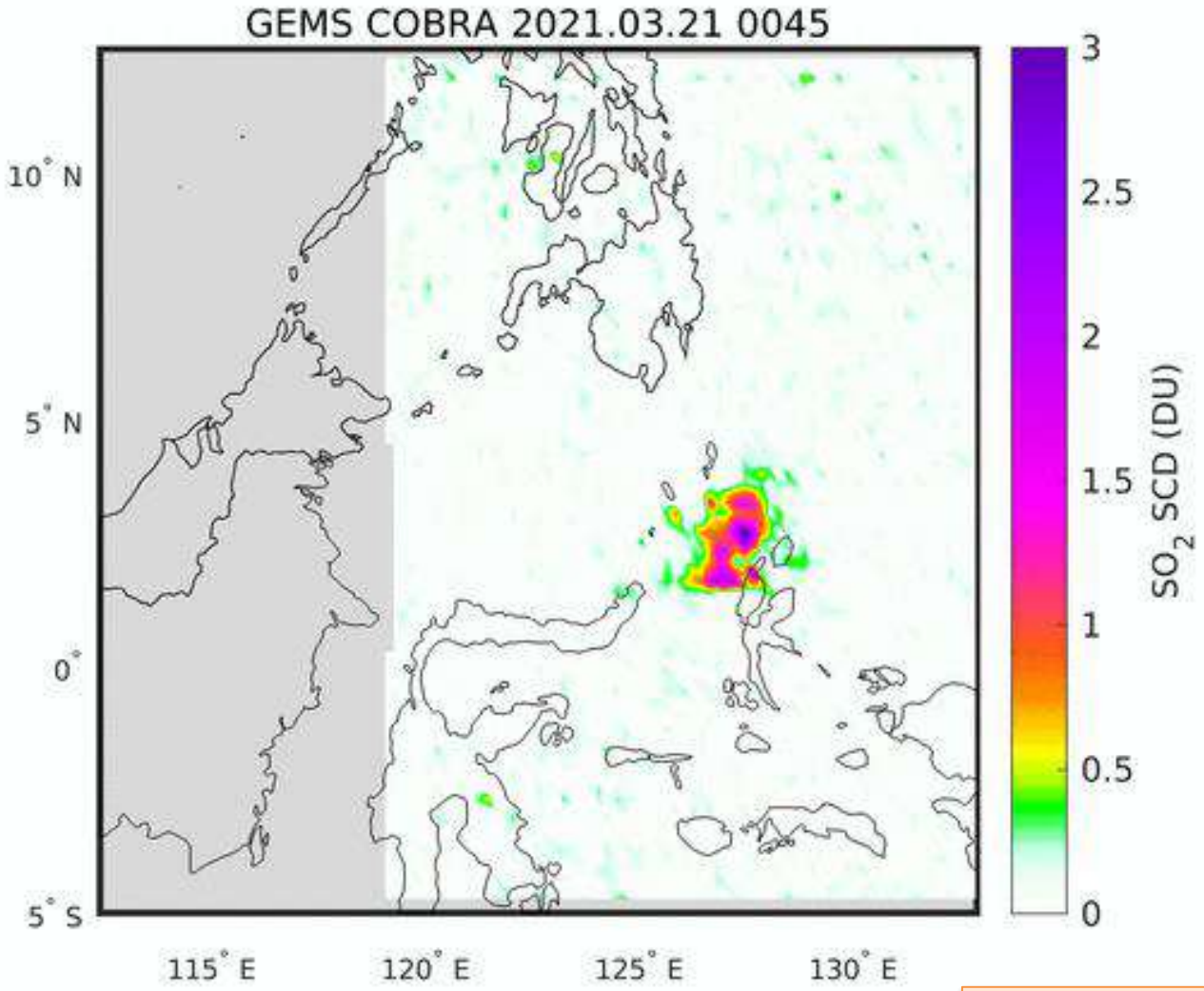




A. Richter (IUP-B)

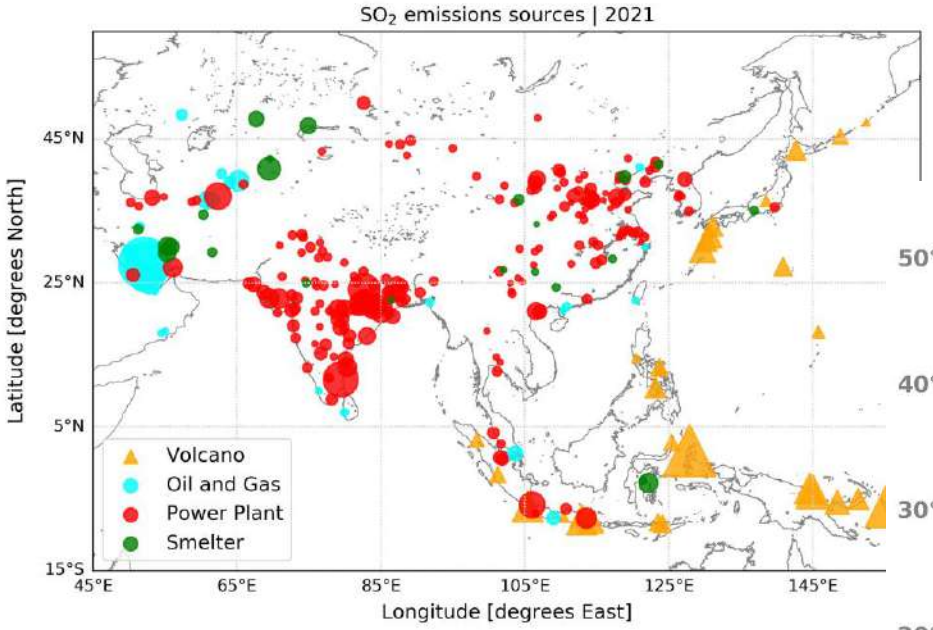
Sulfur Dioxide (SO_2) – Sentinel-4 Algorithm

- S_4 algorithm
  - Operational DOAS
  - Research COBRA



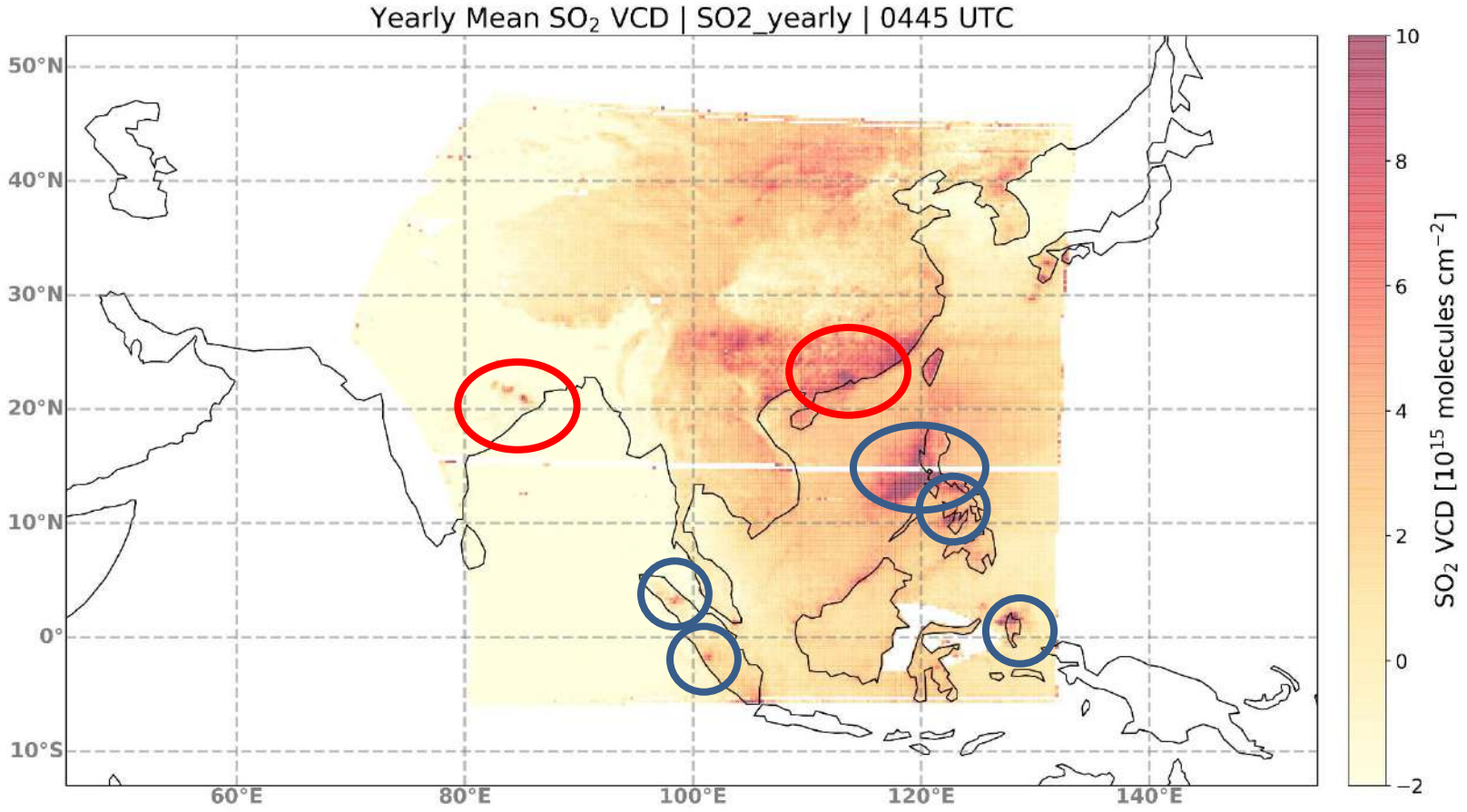
N. Theys (BIRA)

Sulfur Dioxide (SO_2) – PEGASOS Sentinel-5P Comparison



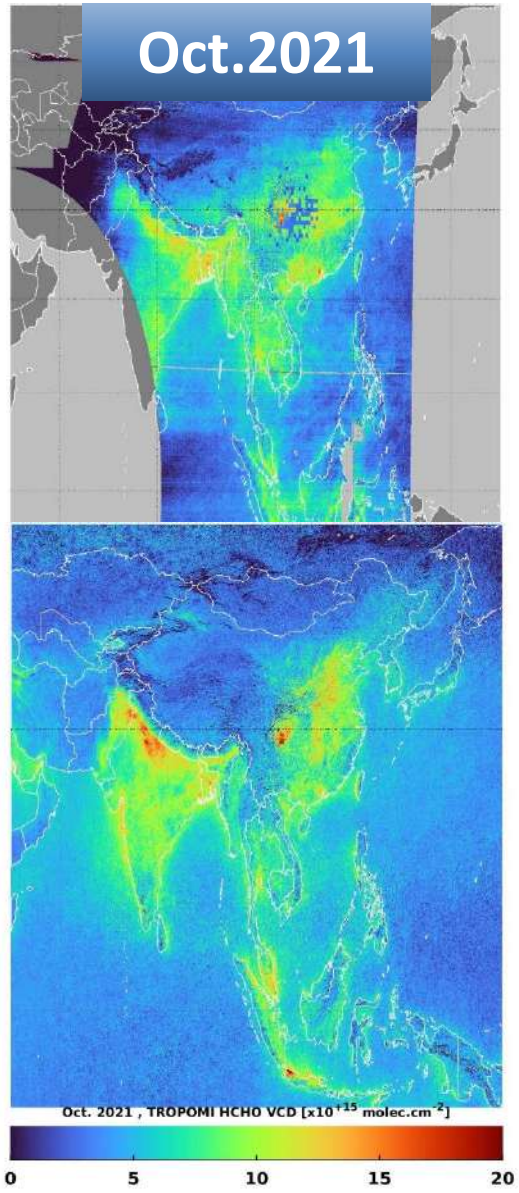
Volcanic

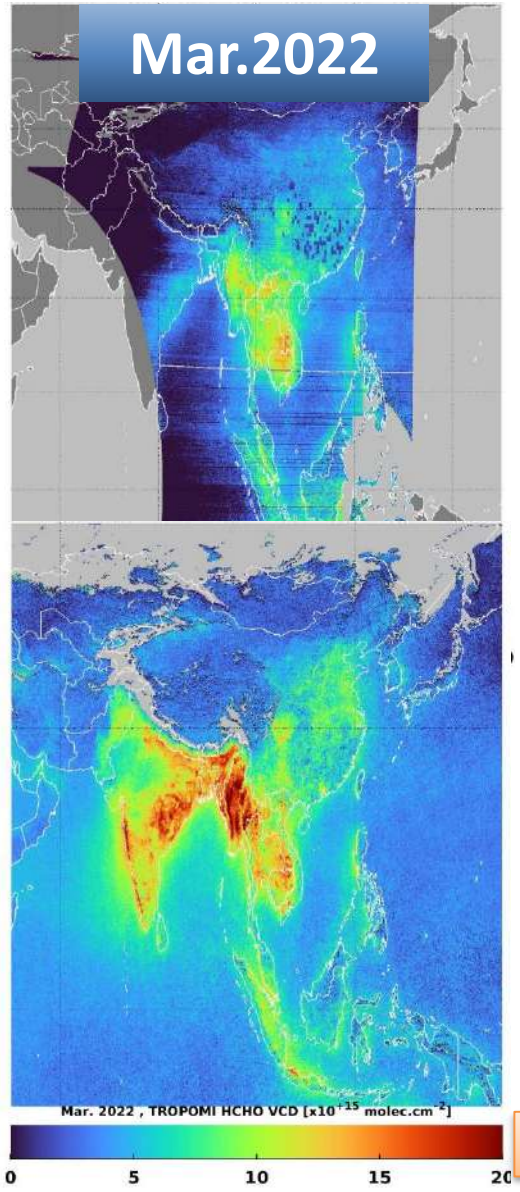
Power Plant

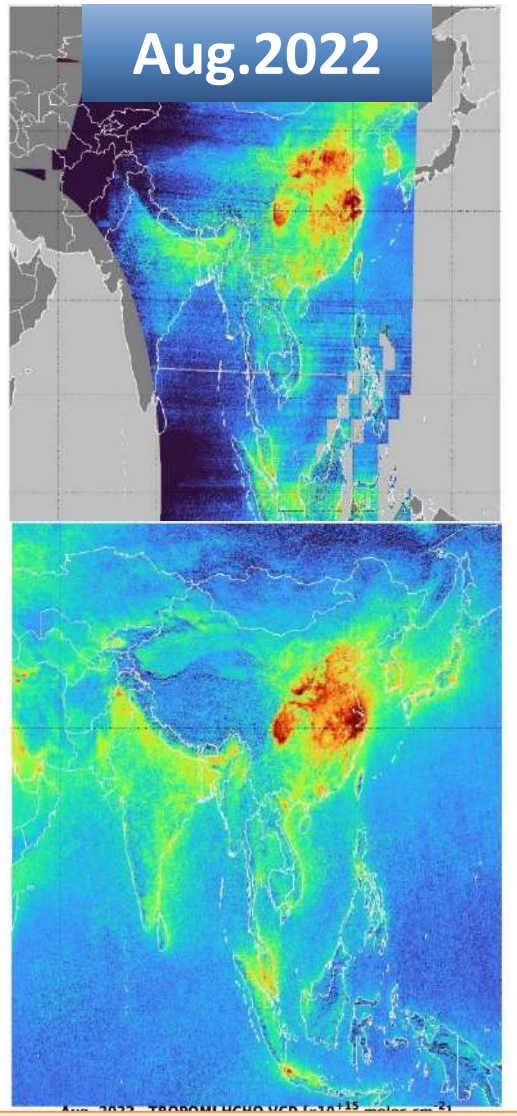


M. Koukouli (AUTH)

Formaldehyde (HCHO) – PEGASOS Sentinel-5 Comparison



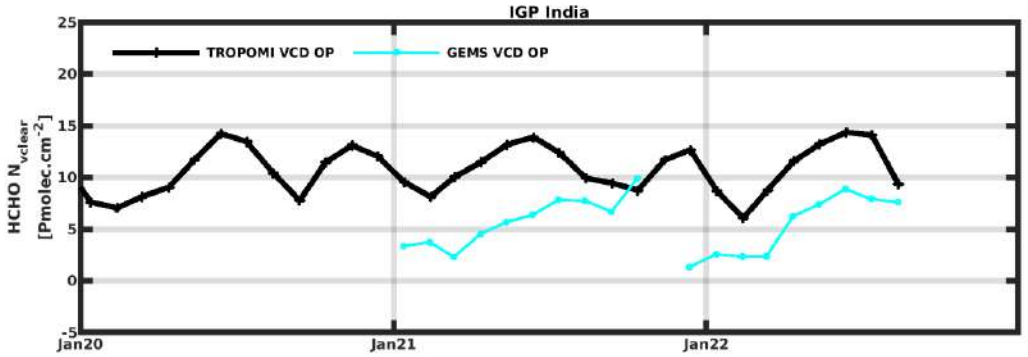




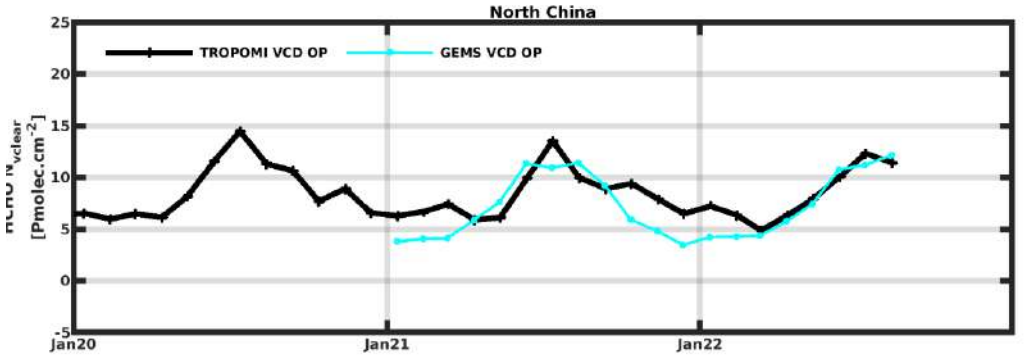
Isabelle De Smedt (BIRA)

Formaldehyde (HCHO) – PEGASOS Sentinel-5P Comparison

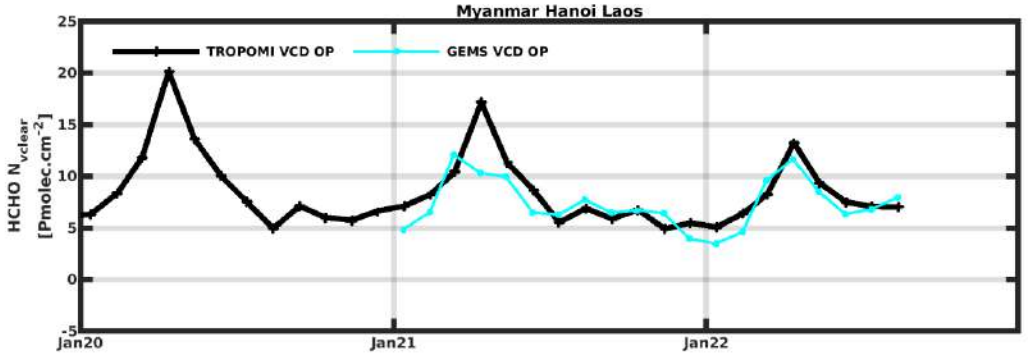
IGP India



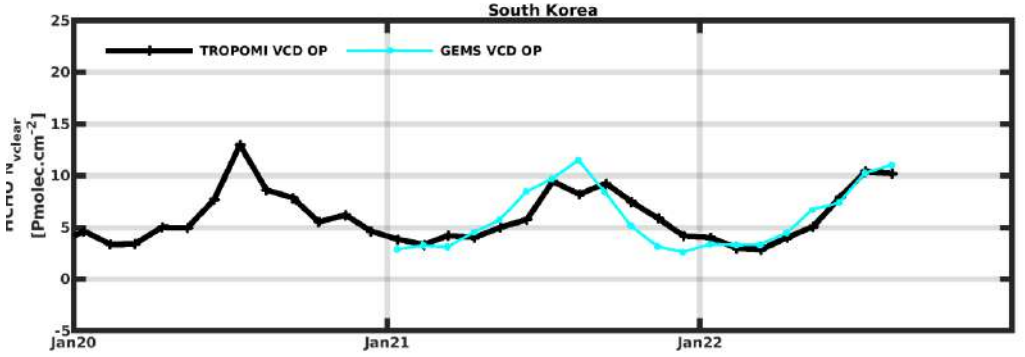
North China



Myanmar Hanoi Laos



South Korea

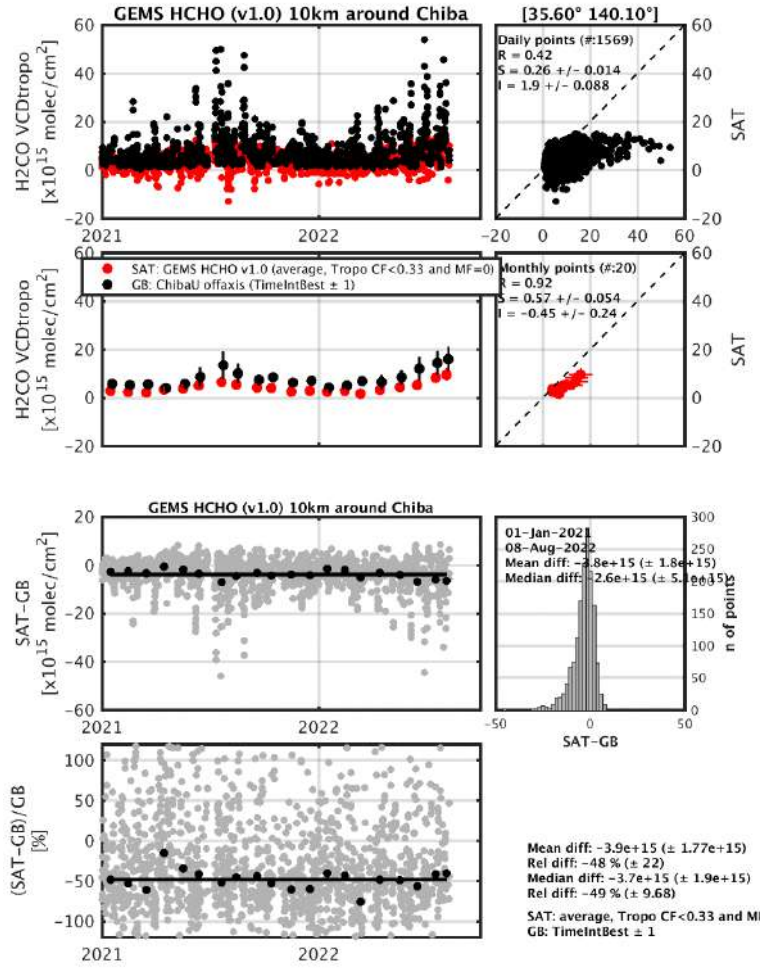


Isabelle De Smedt (BIRA)

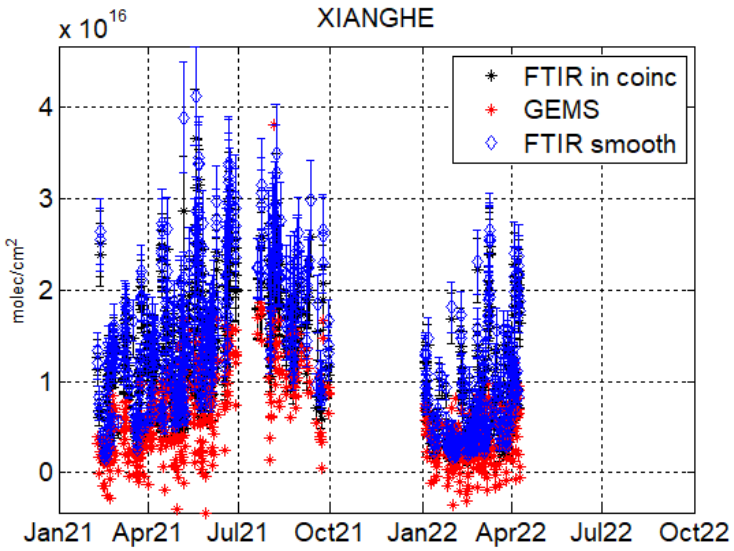
Formaldehyde (HCHO) – PEGASOS Ground-Based validation

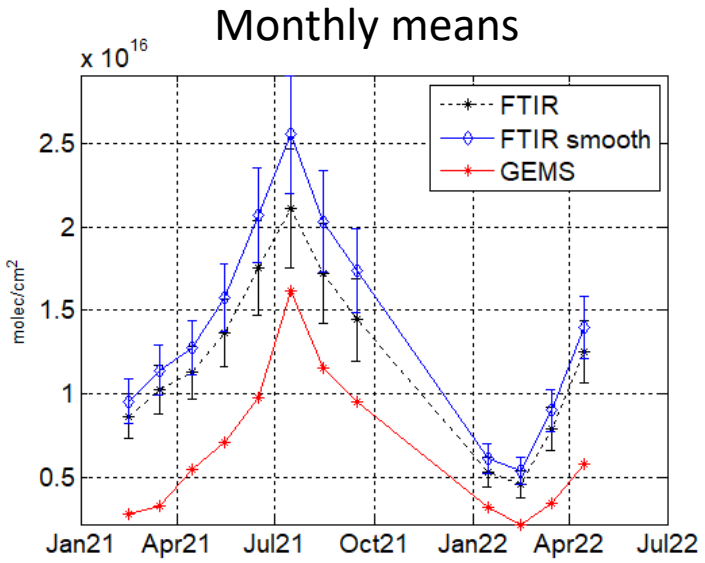
Chiba (Japan) MAXDOAS BIRA

(part of GMAP'21 campaign)



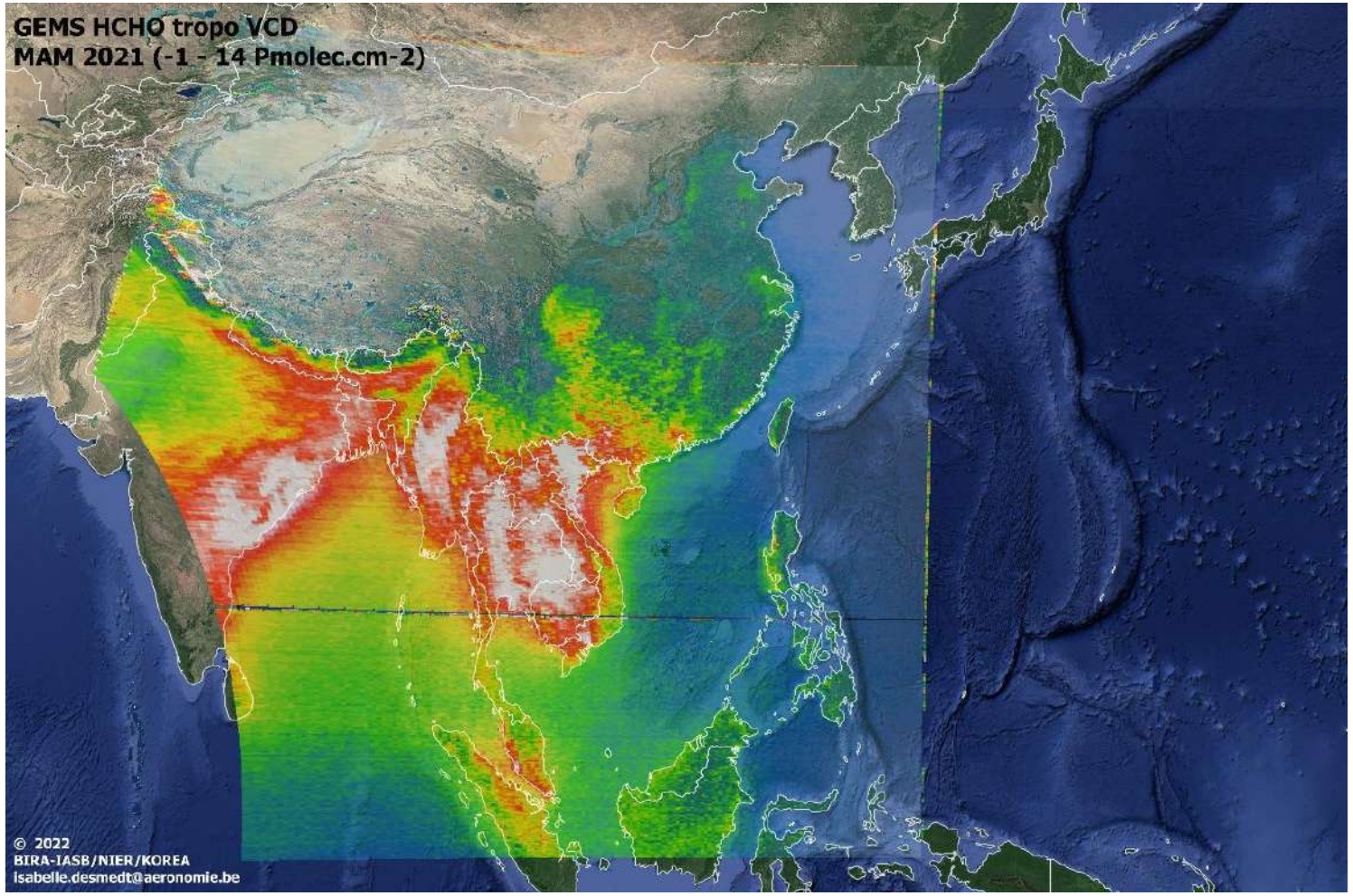
Xianghe (China) FITR BIRA





G. Pinardi & C. Vigouroux (BIRA)

Formaldehyde (HCHO) – Sentinel-4 Algorithms

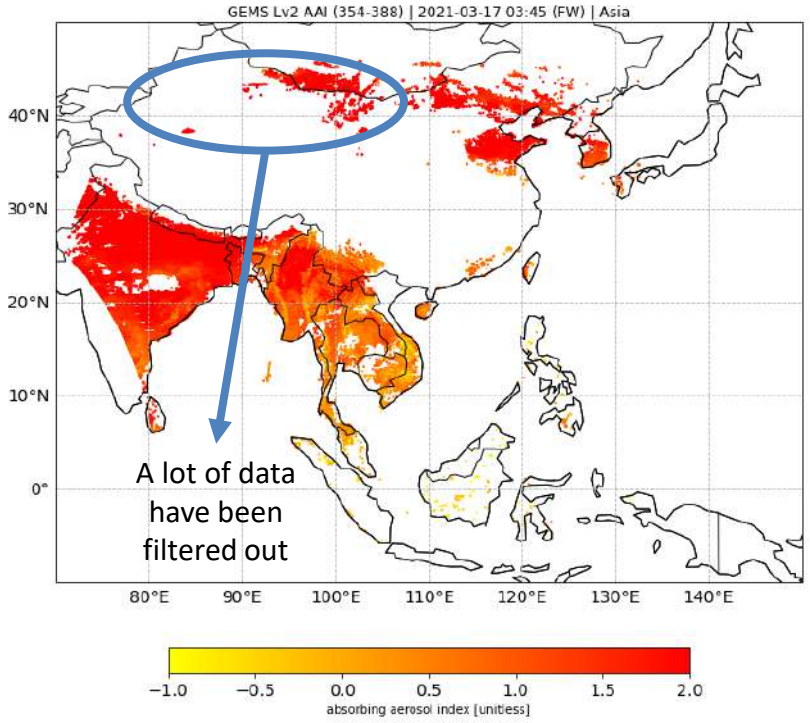


I. De Smedt (BIRA)

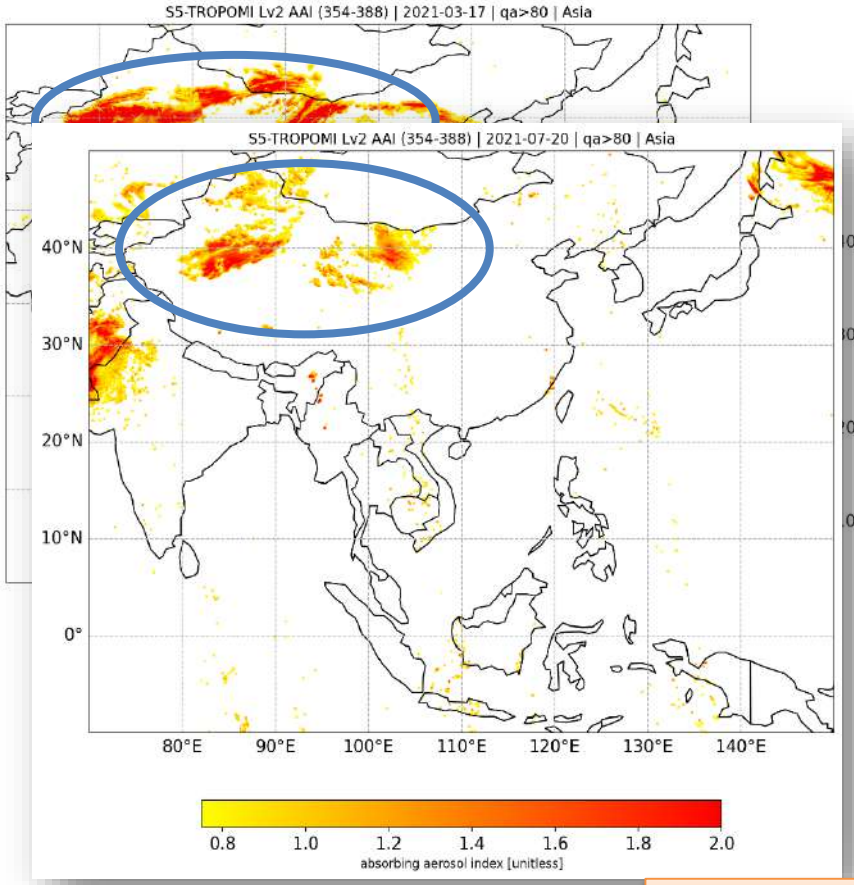
Aerosol Index (AI) – PEGASOS Sentinel-5P Comparison

2021-03-17 | Gobi Desert dust event

GEMS AAI

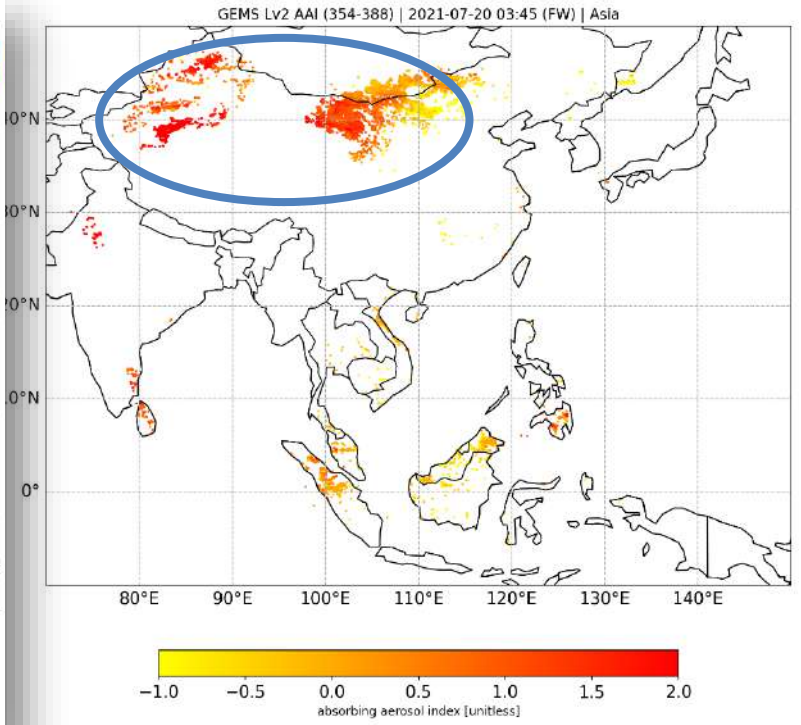


S5P AAI



2021-07-20 | Gobi Desert dust event

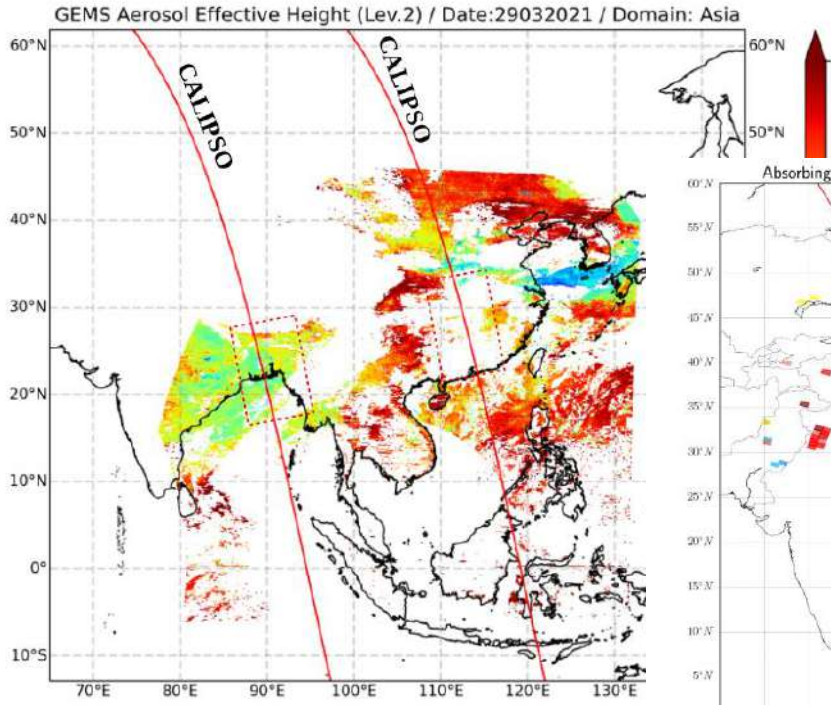
GEMS AAI



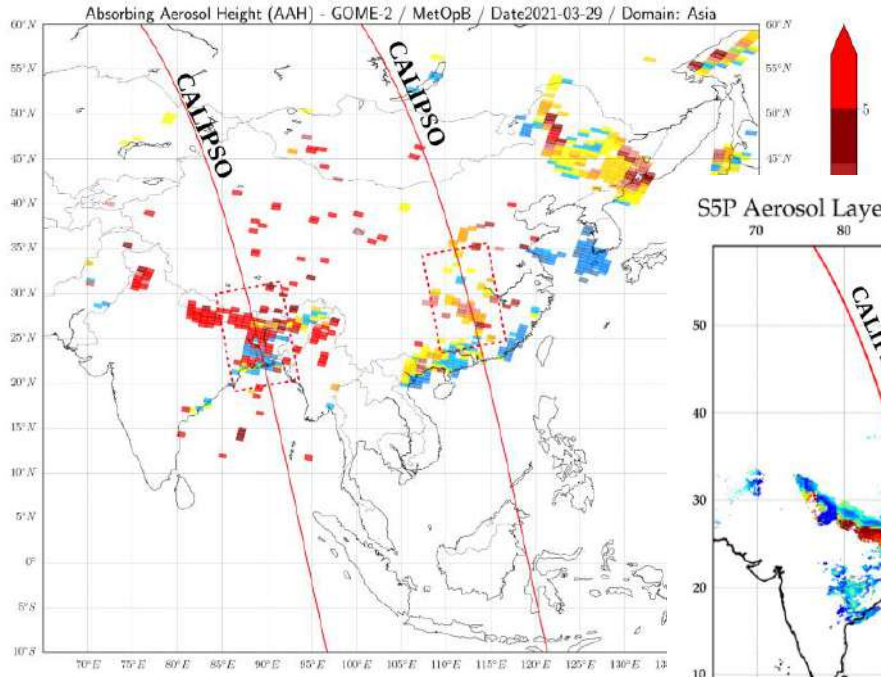
P. Fountoukidis & M. Koukouli (AUTH)

Aerosol Layer Height (ALH) – PEGASOS Sentinel-5P Comparison

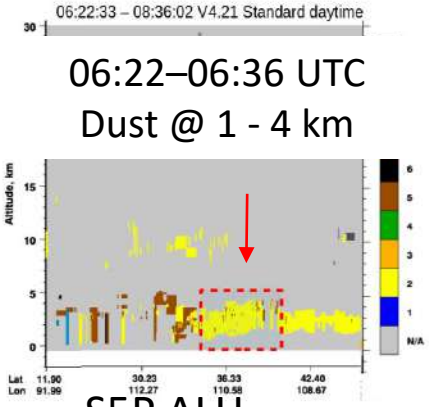
GEMS AEH



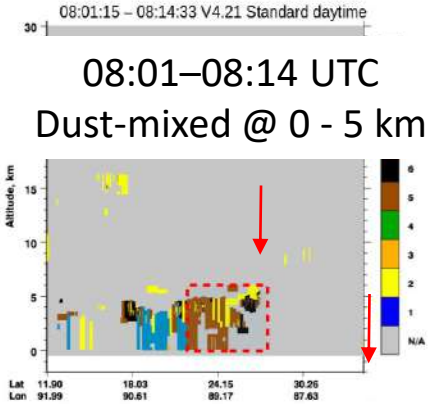
GOME-2B AAH



CALIOP/
CALIPSO

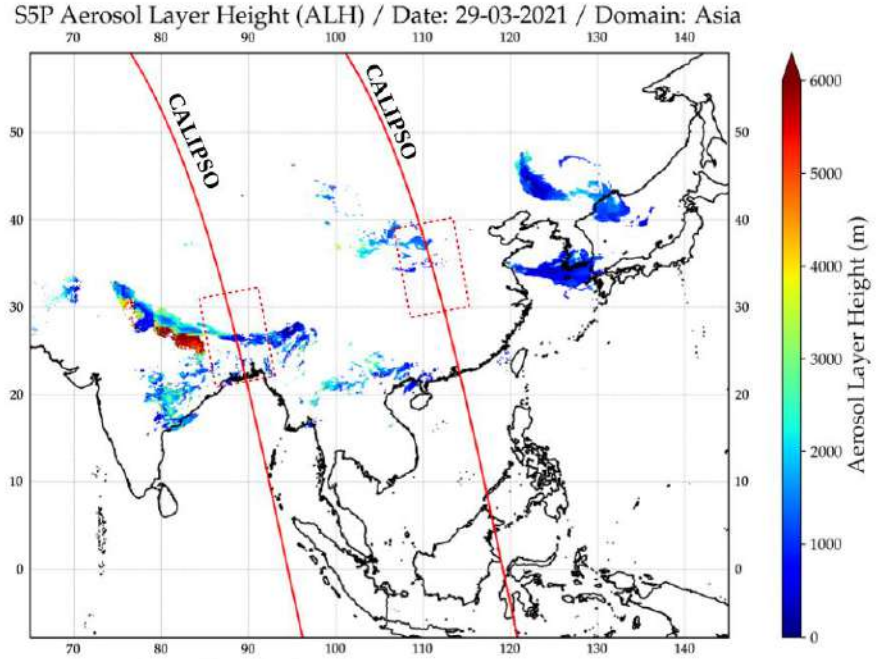


06:22–06:36 UTC
Dust @ 1 - 4 km



08:01–08:14 UTC
Dust-mixed @ 0 - 5 km

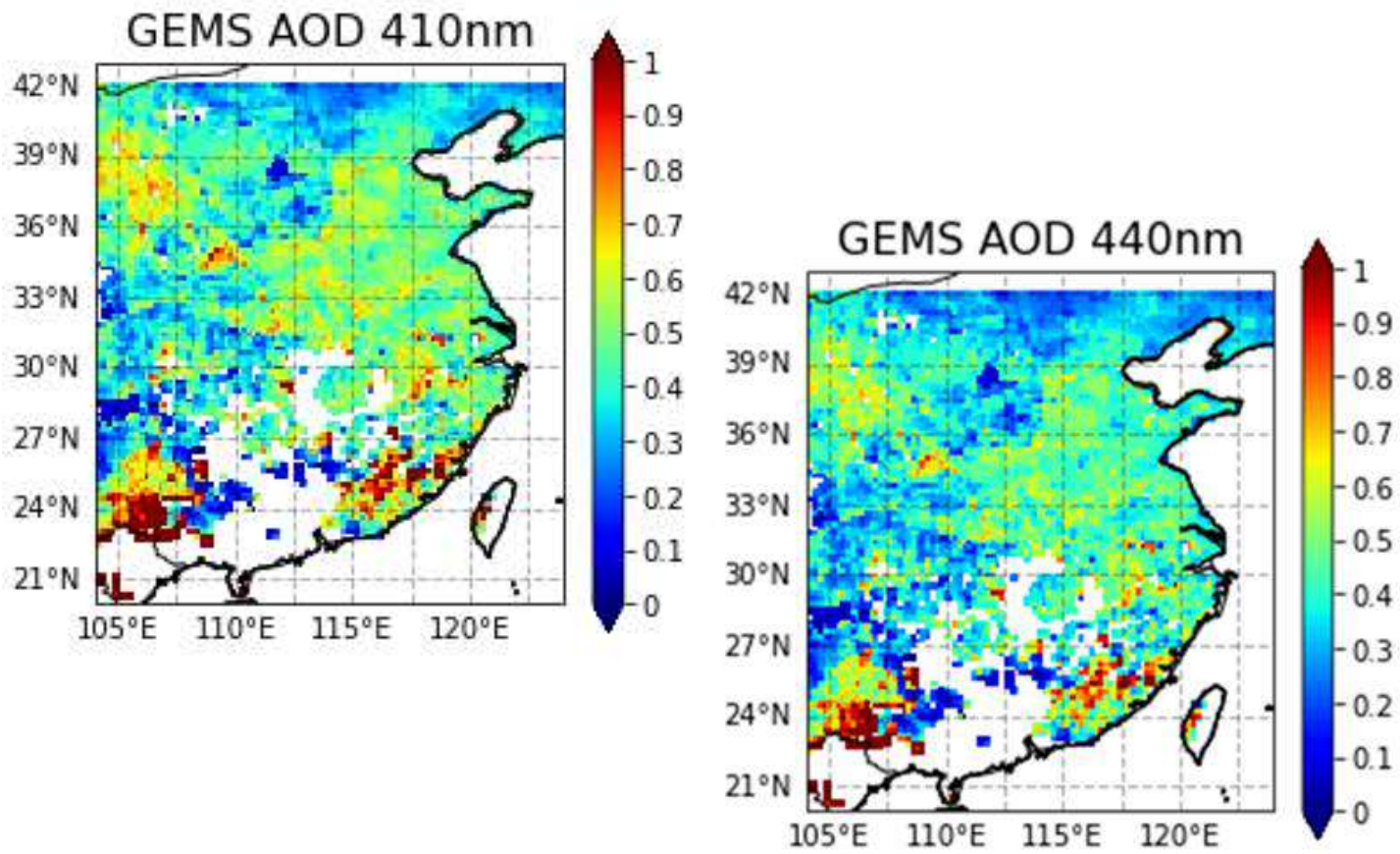
S5P ALH



K. Michailidis & M. Koukouli (AUTH)

Surface Properties and AOD – Sentinel-4 Algorithm

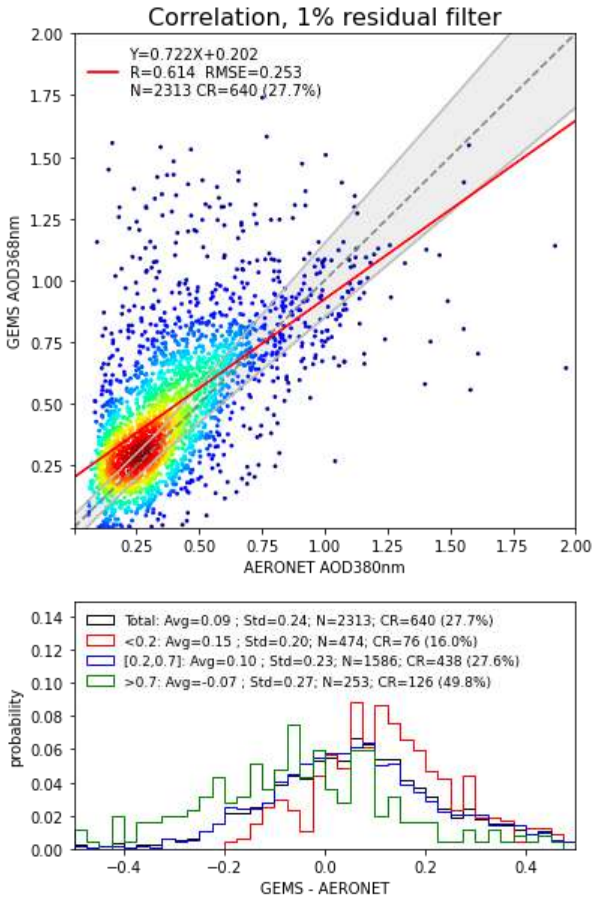
- S4 algorithm
  - Retrieved from several consecutive days and cloud free conditions:
    - Surface Properties (BRF, White Sky Albedo)
    - AOD
    - 342, 367, 410, 443, 490, 755 nm
  - Daily Gapless Surface Reflectance



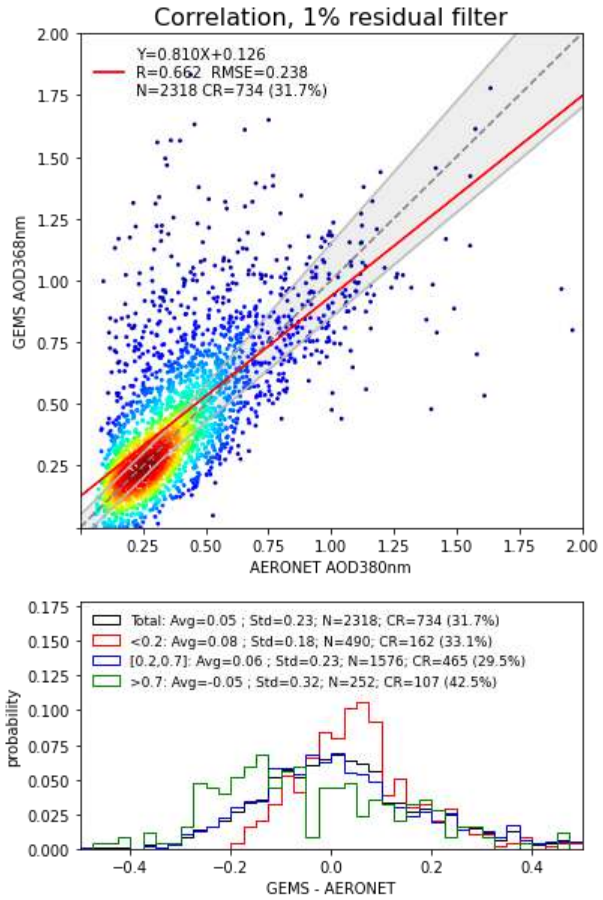
P. Litvinov (GRASP), A. Hangler (CLF), et al.

Surface Properties and AOD – Sentinel-4 Algorithm

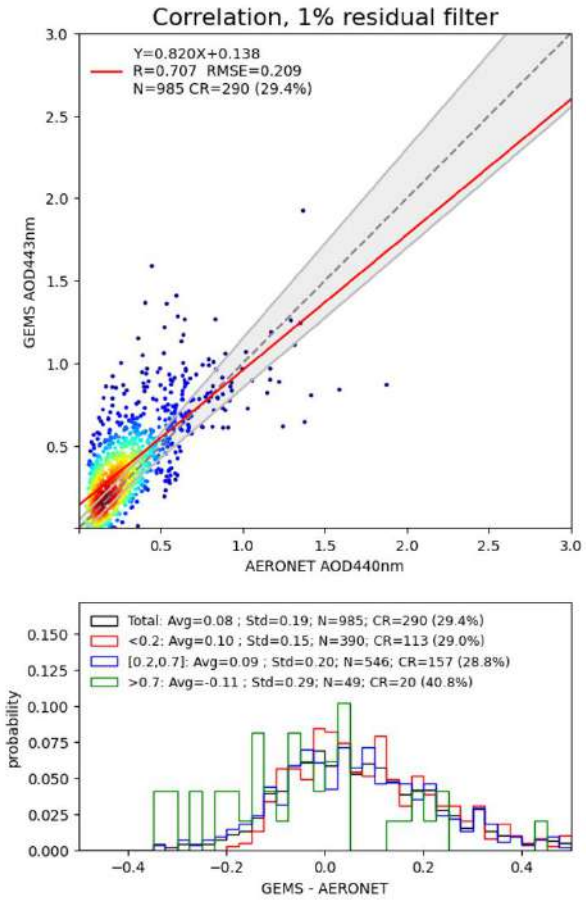
11 AERONET sites, April-May, 2021



Reflectance calibration of 0.92

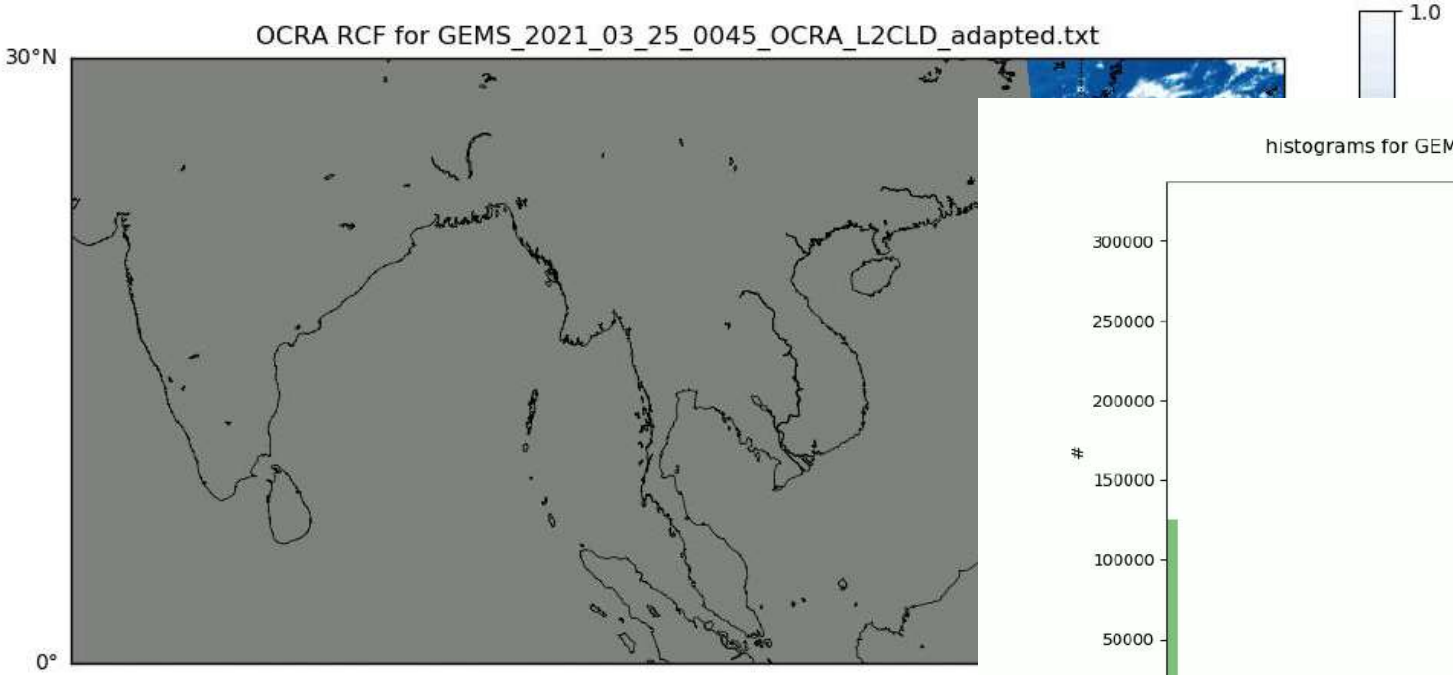


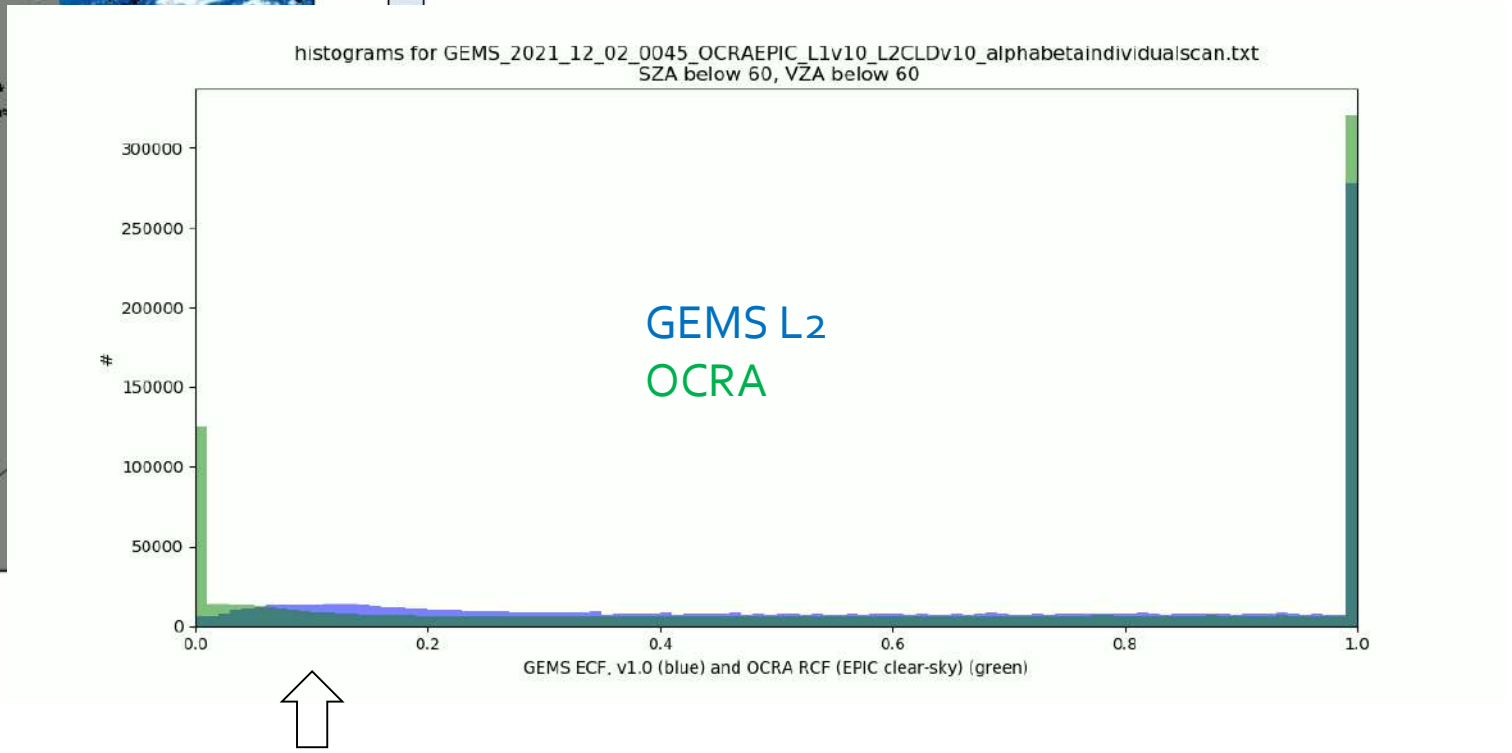
Reference irradiance



P. Litvinov (GRASP), A. Hangler (CLF), et al.

Clouds – Sentinel-4 Algorithm OCRA





GEMS L2 shows very few clear scenes,
but a pronounced peak around 0.1

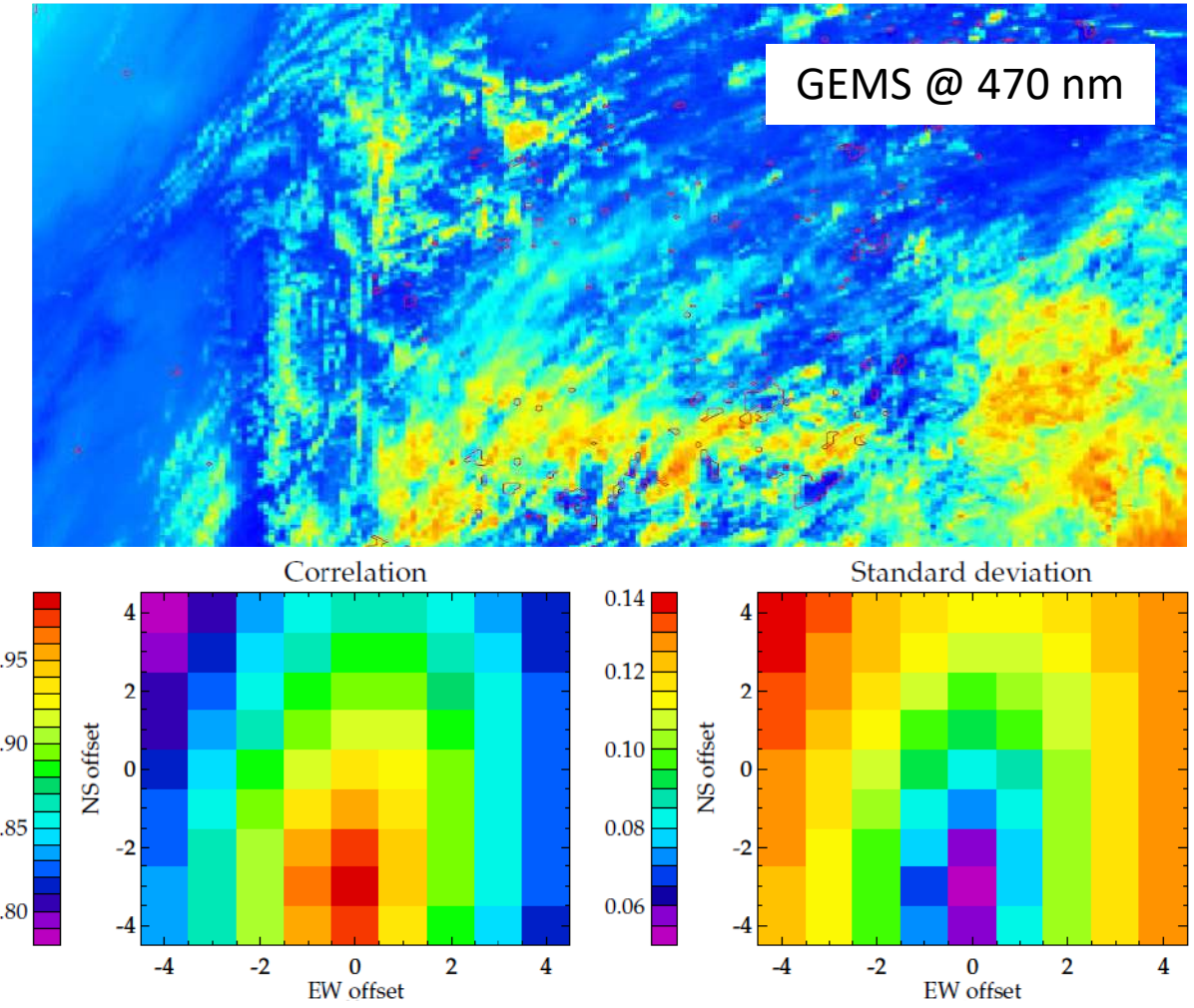
R. Lutz (DLR) ➽ Oct. 13

Regridded clouds from imager – Sentinel-4 Algorithm

RAL Space

- Sentinel-4 algorithm:
  - Cloud data from FCI/MTG will be used for
    - Co-registration of S4 UV and NIR bands
    - S4 and FCI combined cloud masking

- GEMS application:
  - Cloud data from AMI/KOMPSAT used
  - North-South spatial offset (~1 or ~3 GEMS pixels) in the two scenes investigated



R. Siddans (RAL)

Acknoledgments

– NIER for providing the GEMS L1 and L2 products

– EU/ESA for the TROPOMI L2 products

– Ground-based teams