Five years of excellent performance of the TROPOMI-SWIR module

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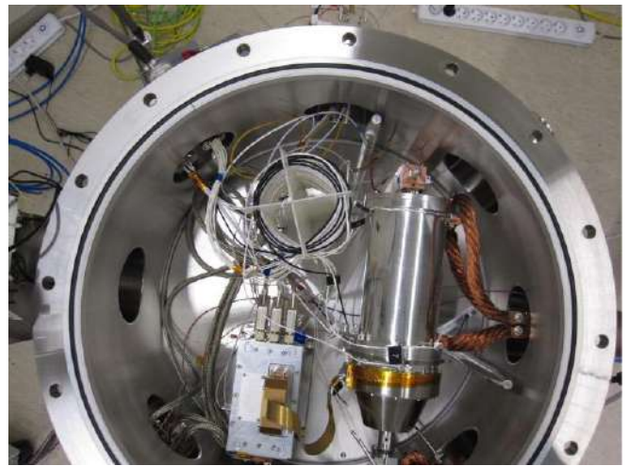
TIM ROTMANS, FILIPPO OGGIONNI (TU DELFT)

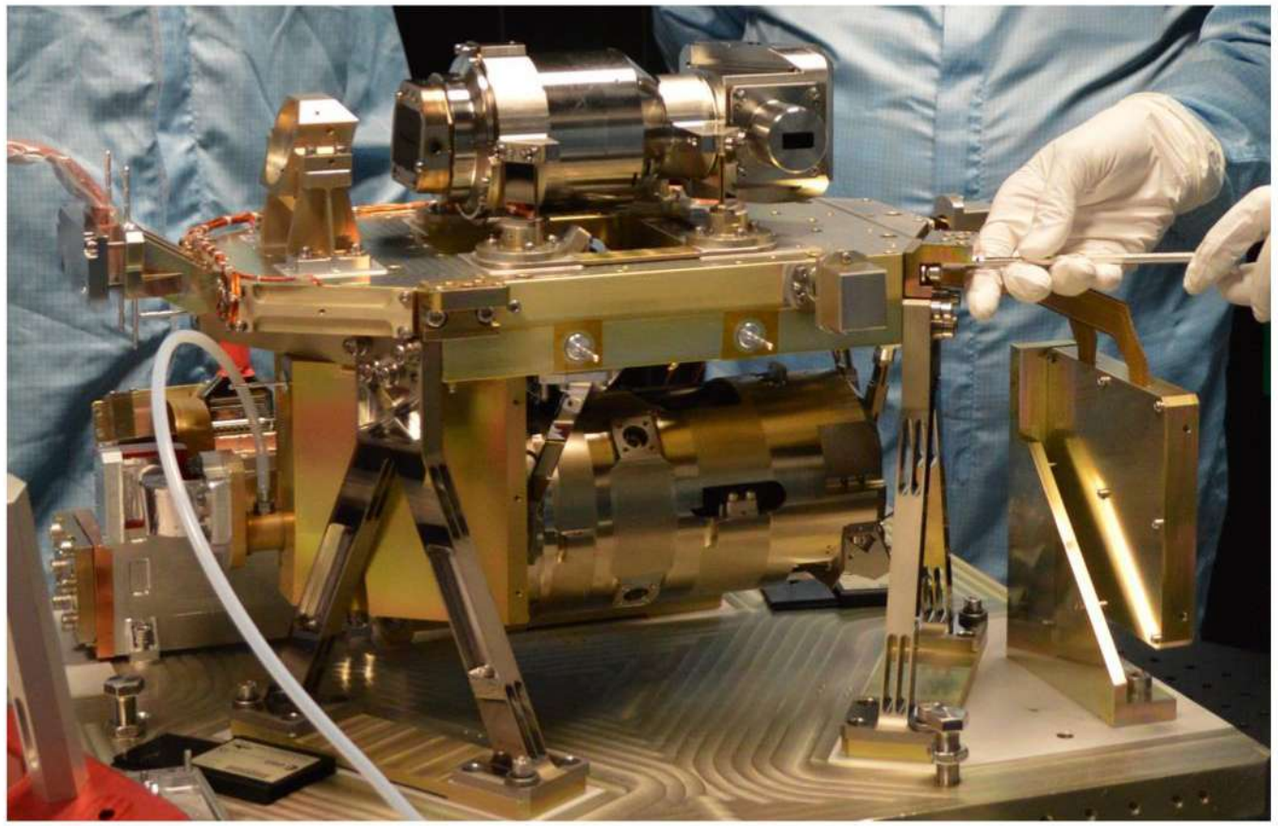
MARINA LOBANOVA (LEIDEN UNIVERSITY)

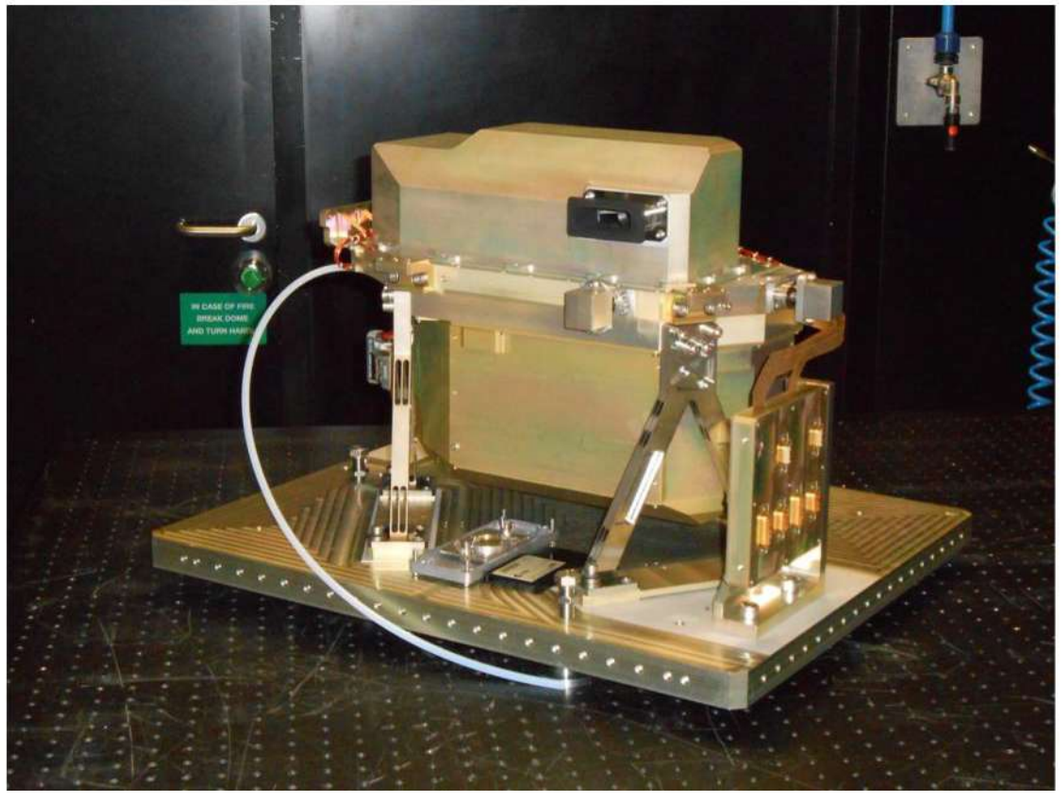
THANKS TO C. BRUEGGE, R. ROSENBERG (JPL) FOR RRV DATA

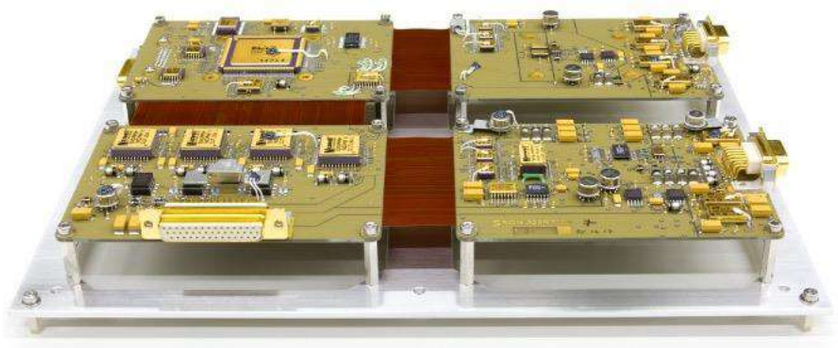
Tropomi is a project in partnership between Airbus Defence and Space, KNMI, SRON and TNO, commissioned by NSO and ESA. Airbus Defence and Space is the main contractor for the construction phase. KNMI and SRON are responsible for the scientific management. TROPOMI is funded by the following ministries of the Dutch government: the Ministry of Economic Affairs and Climate Policy, the Ministry of Education, Culture and Science, and the Ministry of Infrastructure and Water Management.

Final TROPOMI-SWIR Flight Model





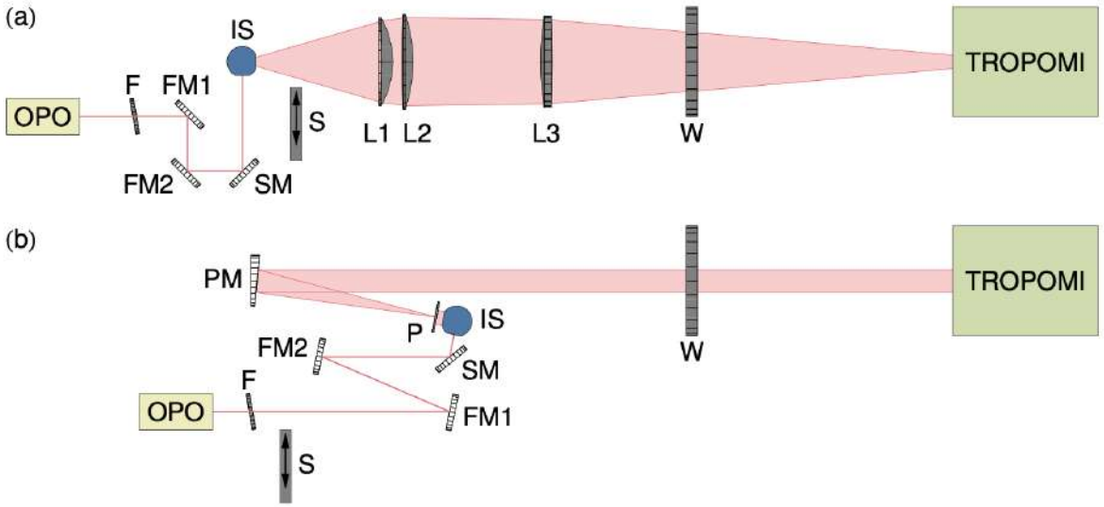




PICTURES OF
RUUD HOOGEVEEN (SRON)
~2012-2014

Ground Campaign @ CSL

- TROPOMI was placed in a 6.5m vacuum chamber inside a clean room with light sources placed in front of the vacuum window.
- Sources included spectral line sources, sun simulators, gas cells and different lasers. Internal sources were also used

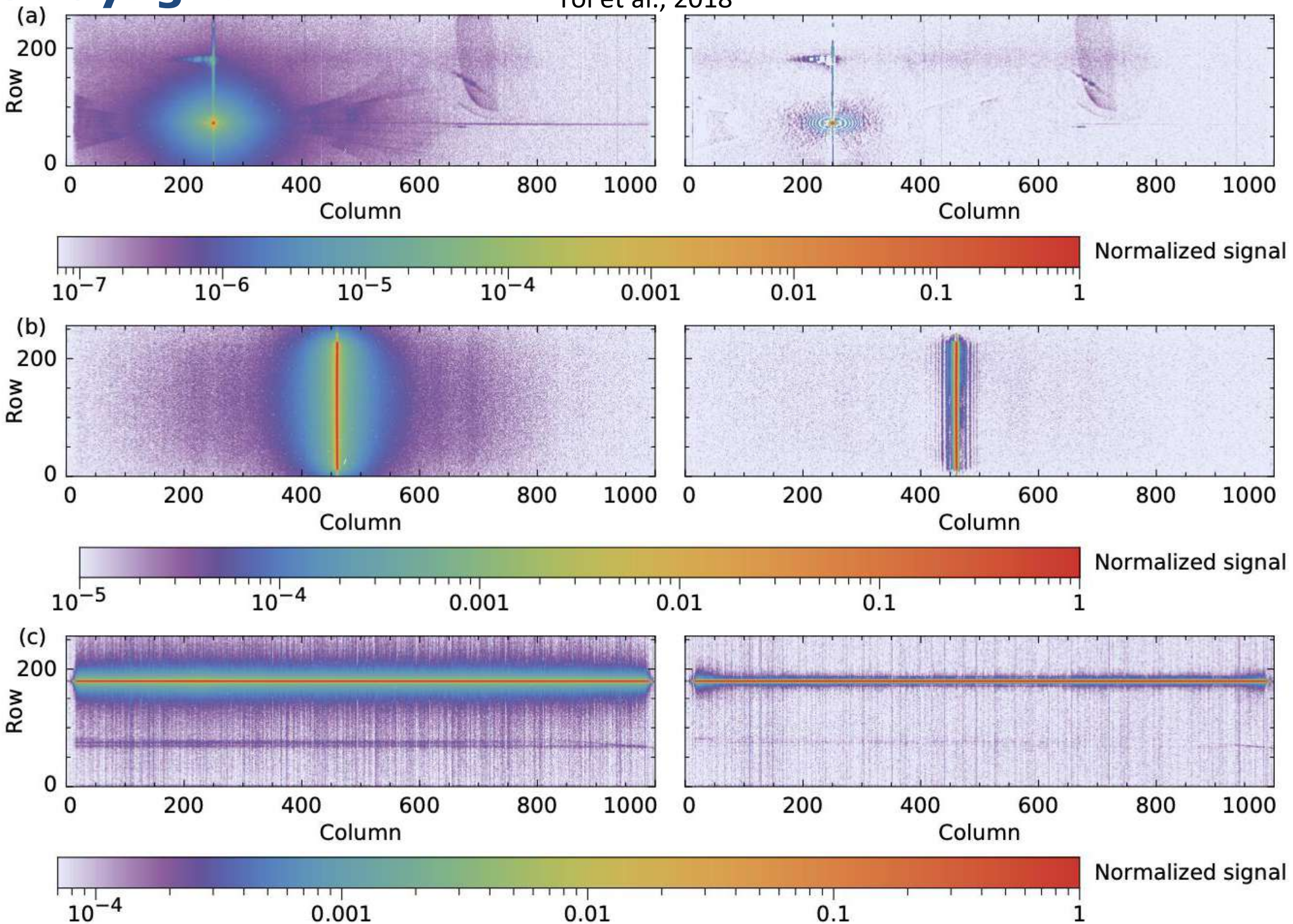


Van Hees et al., 2018
Tol et al., 2018
Kleipool et al., 2018

SRON

Straylight

Tol et al., 2018



OCTOBER 13TH 2017
S5-P LAUNCH FROM
PLESETSK, RUSSIA

Can someone turn off the light in Basra?

icalnotes_basra.pdf — Open with Preview

SRON TROPOMI SCIENCE	TECHNICAL NOTE	Doc. no.: Issue : 0.4 Date : 19 November 2017 Page : 70 of 92

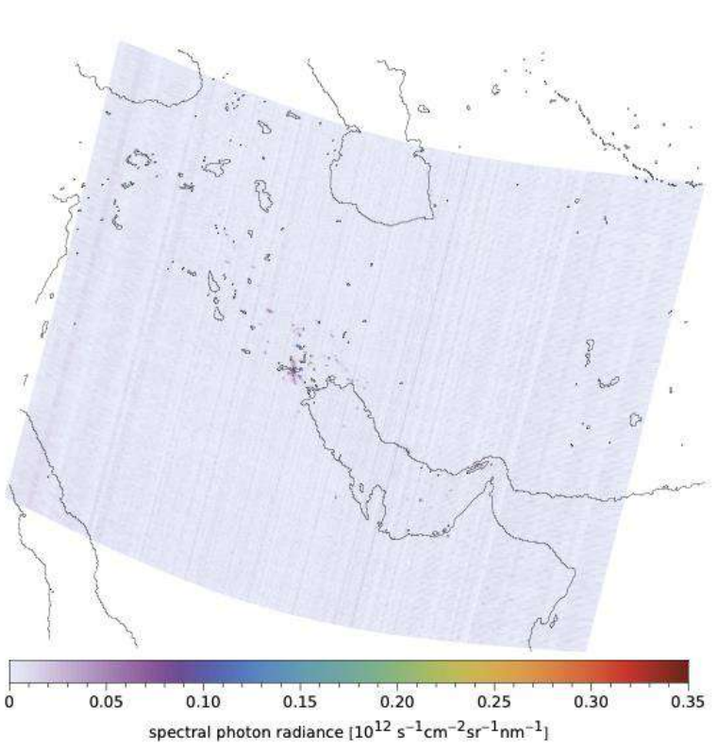


Figure 10: Spectral radiance at the SWIR continuum around the Persian Gulf at night in revolution 390.

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Kan iemand het licht uit doen in Basra?

Paul Tol <P.J.J.T... Sunday, 19 November 201...

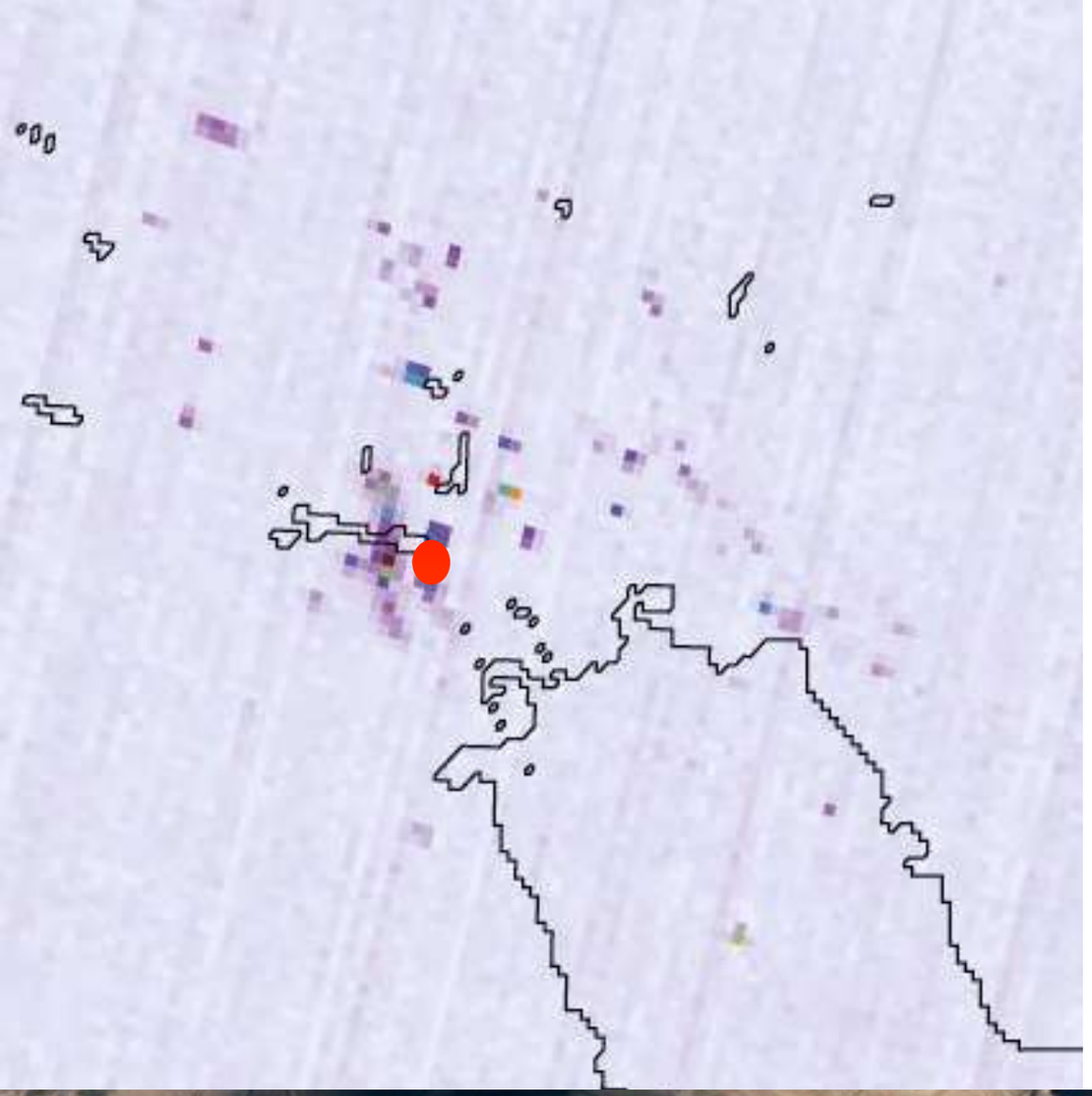
To: Ilse Aben; Ruud Hoogeveen; Richard van Hees; Tim van Kempen

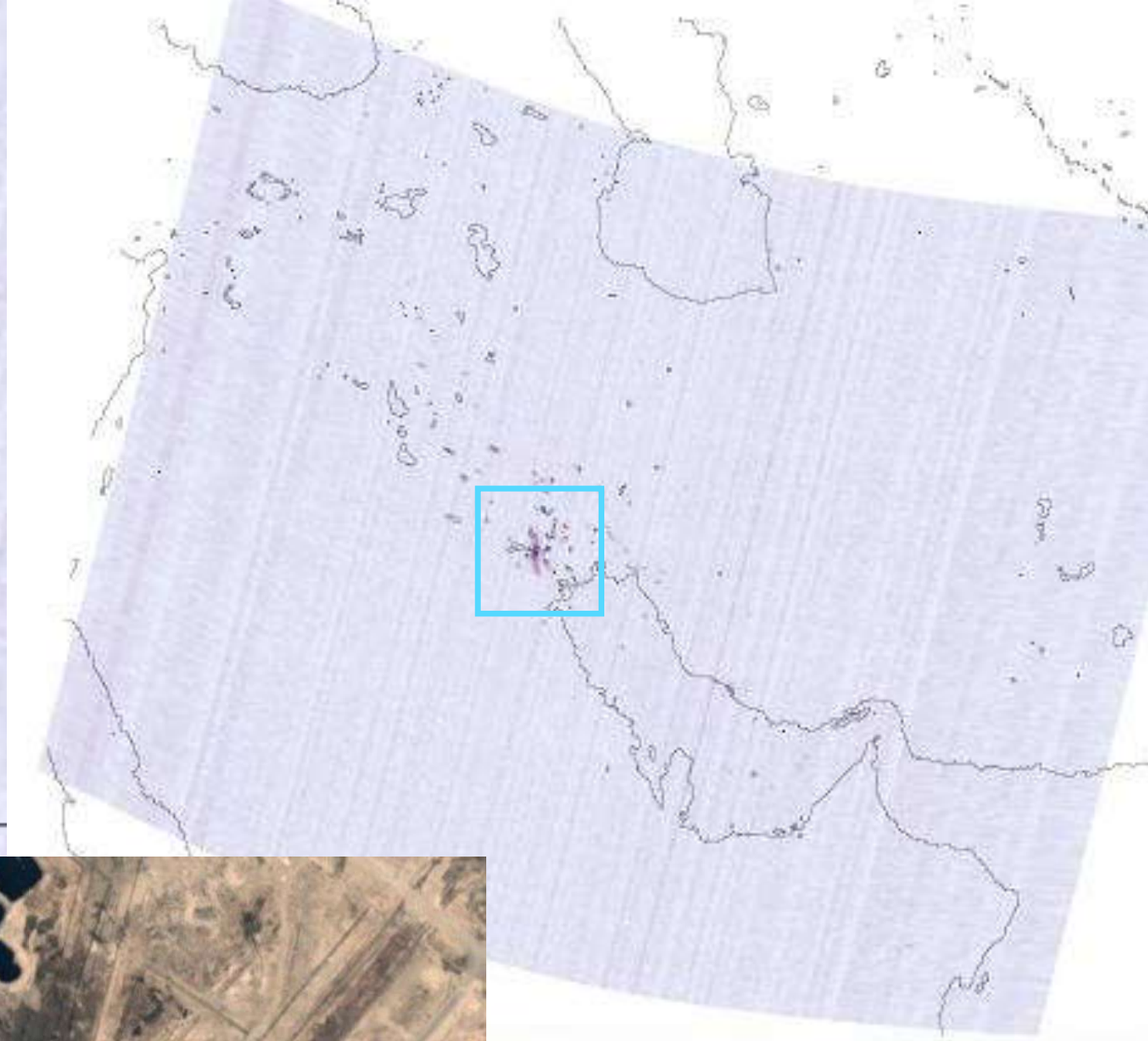
icalnotes_basra.pdf
1,8 MB

Download All • Preview All

Hier is een plot van de radiantie 's nachts rond de Perzische Golf.
Bij Basra is de intensiteit 3% van de felste Sahara overdag.

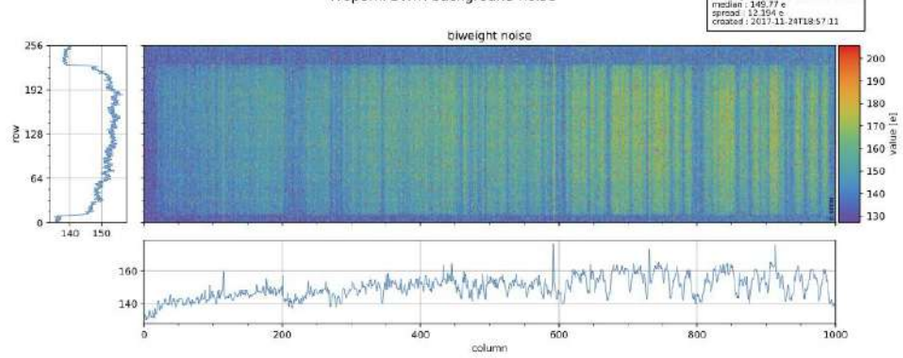
Paul

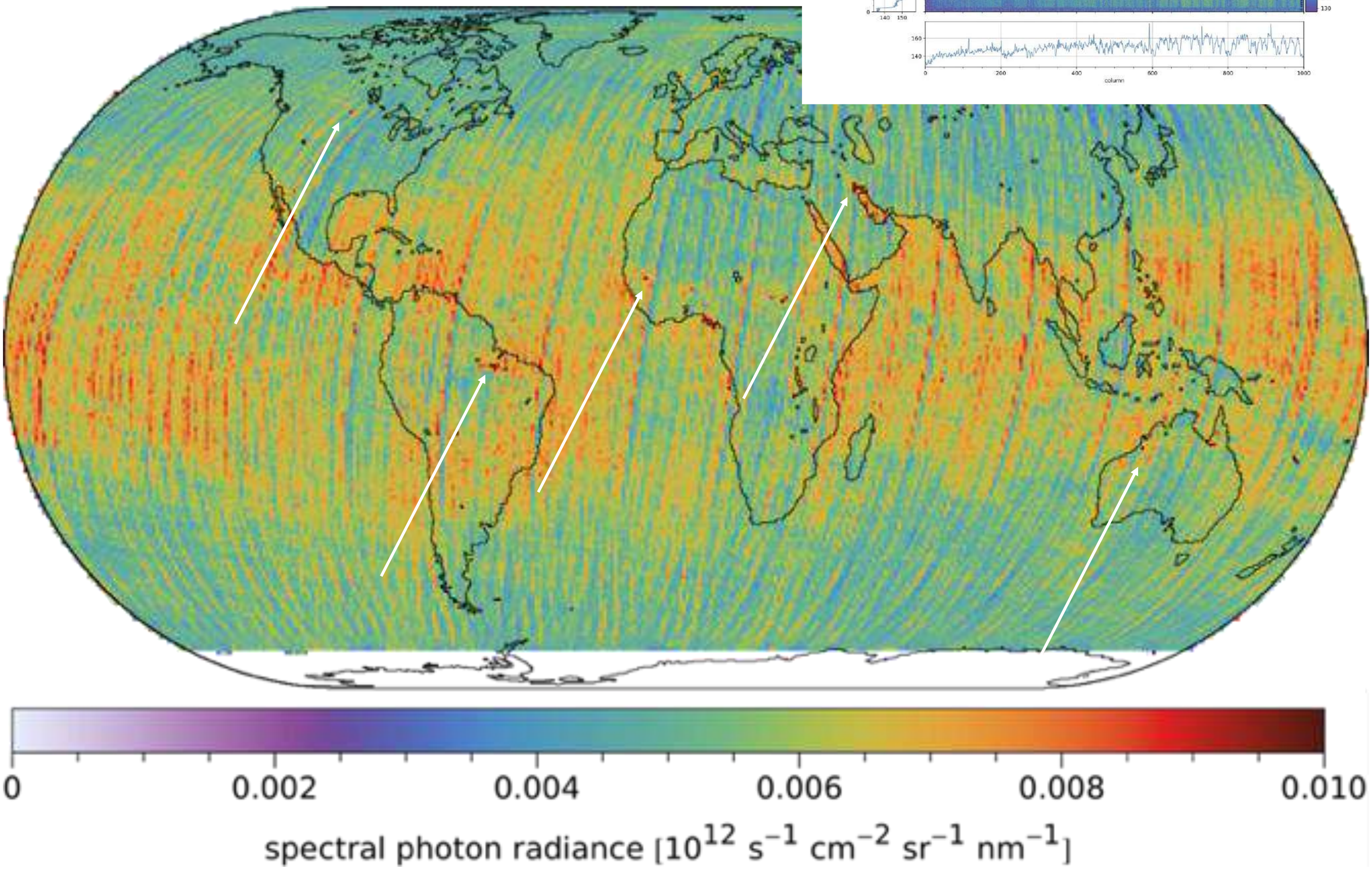




Oil fields around city of Basra, Iraq

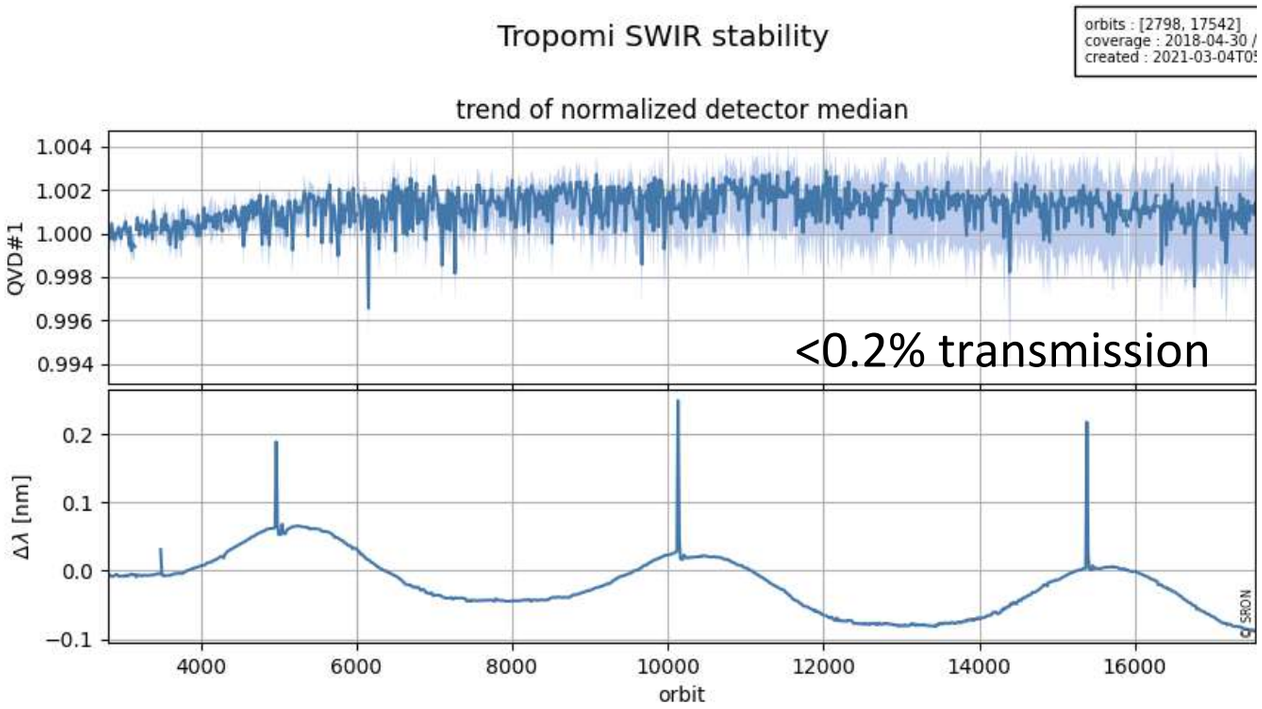
19 Nov - 10 Dec

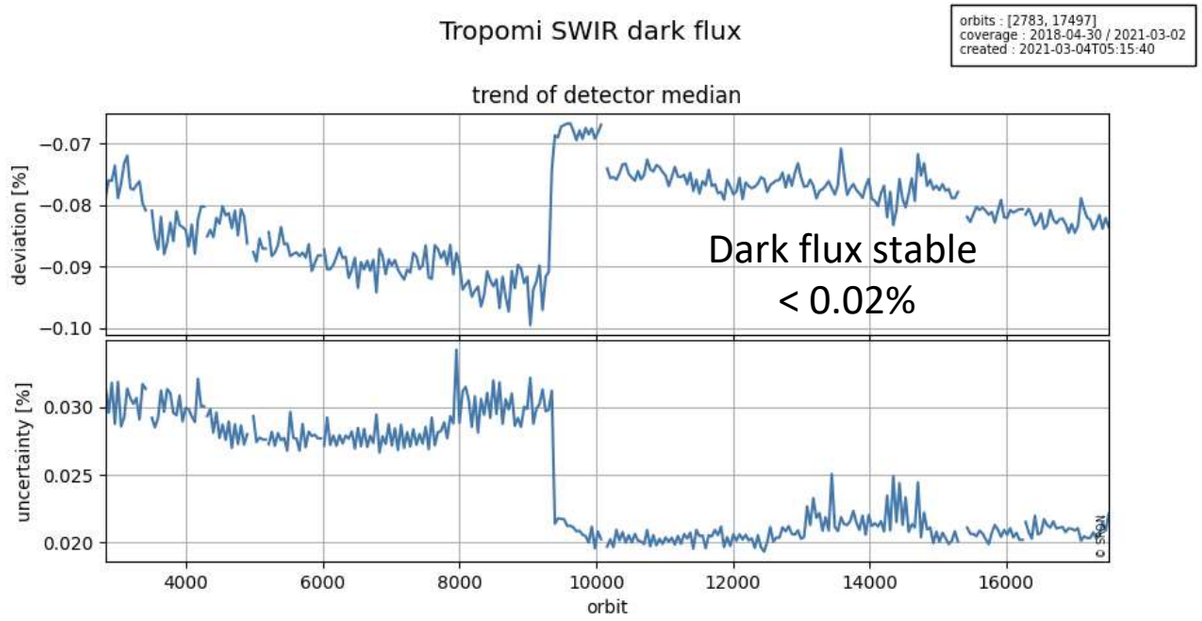


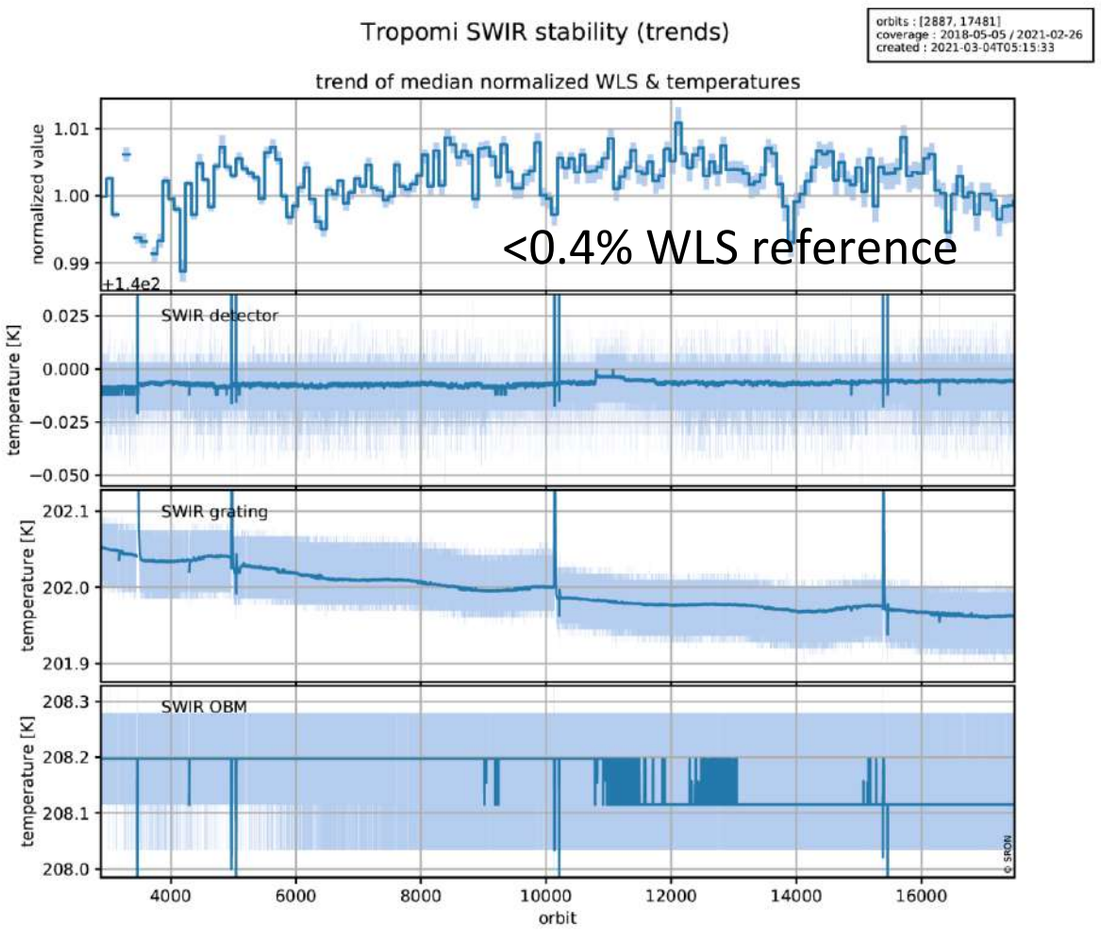


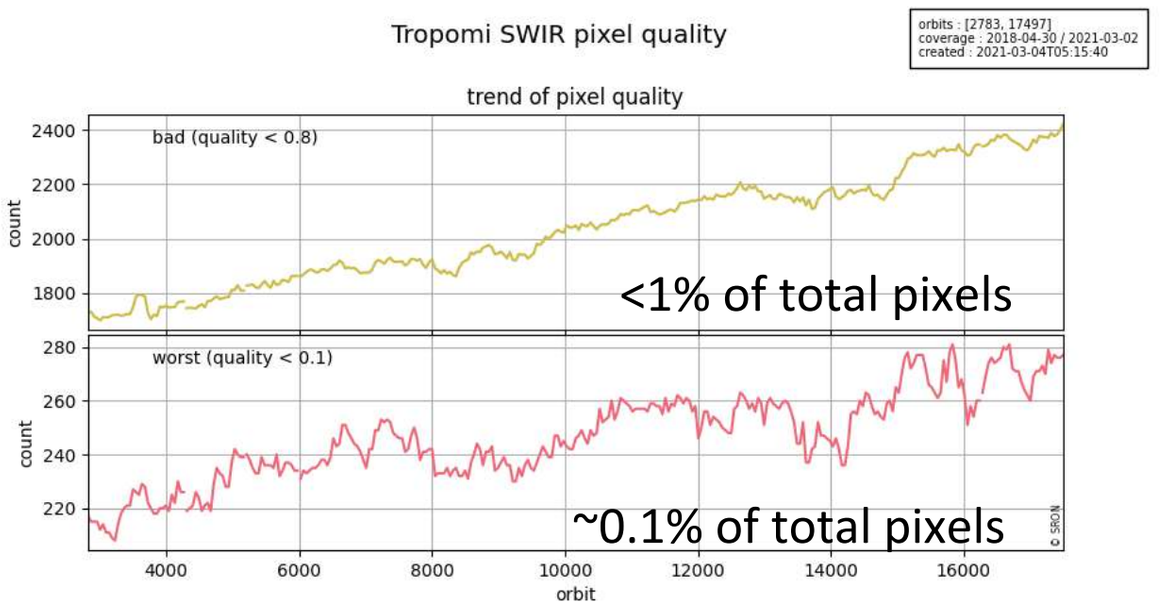
The Earth is not dark enough (!)

Monitoring (1st year) (https://www.sron.nl/tropomi-swir-monitoring)



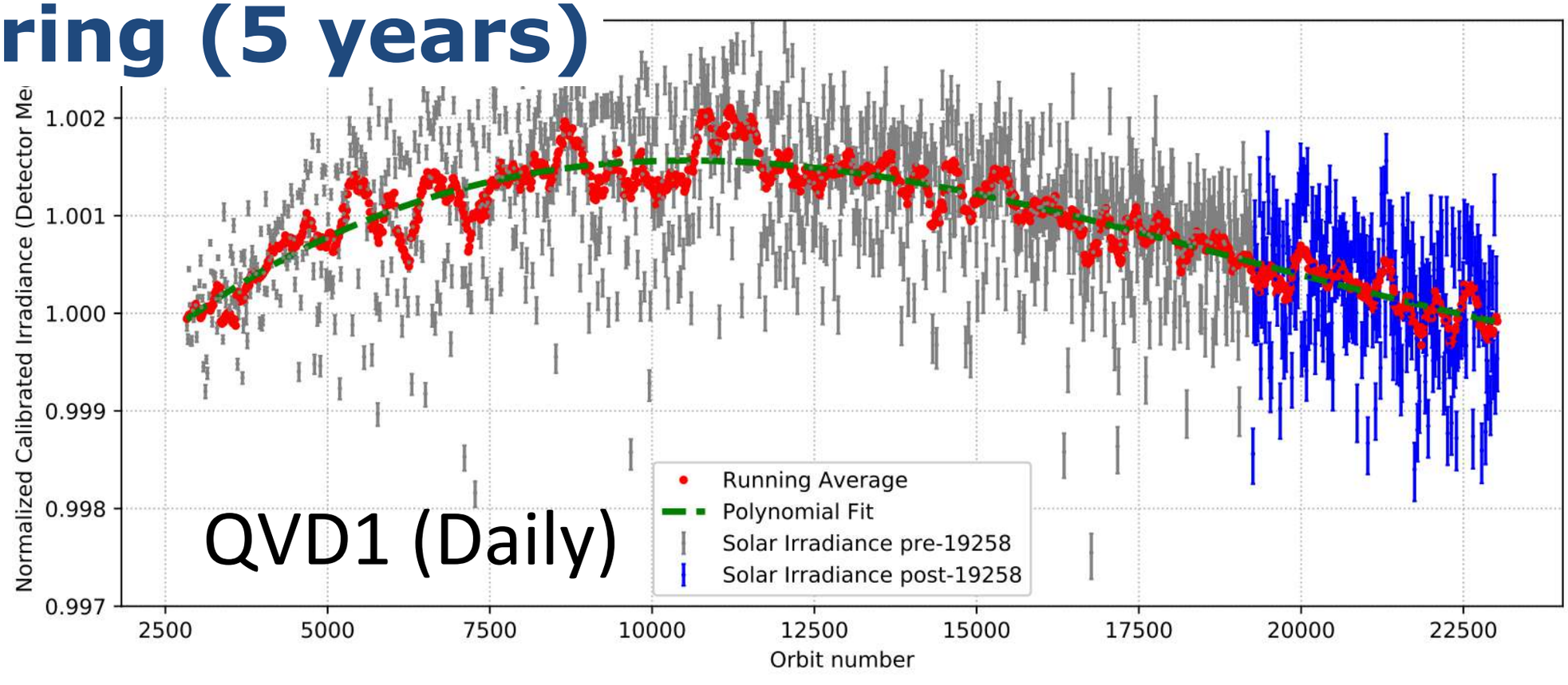


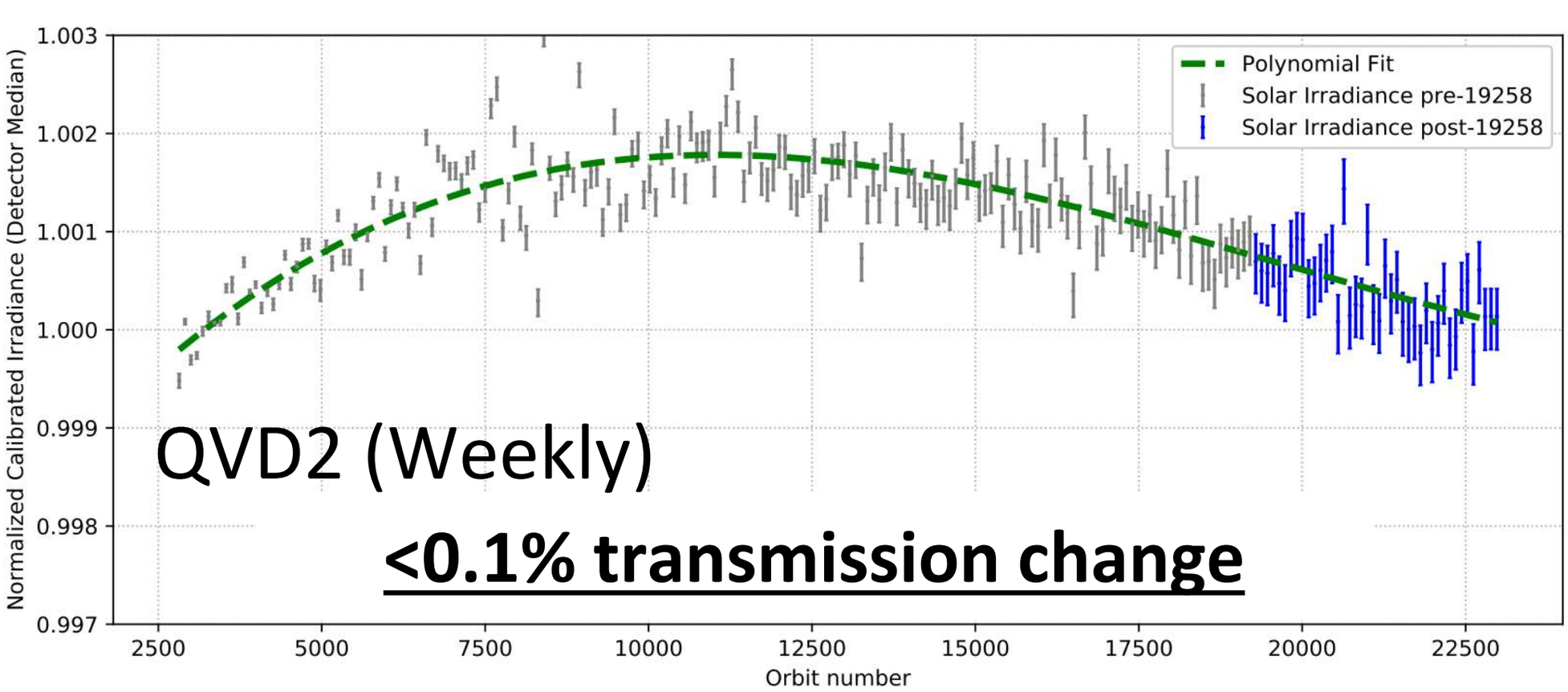




Van Kempen et al., 2019, AMT, 12, 6287
Ludewig et al., 2020, AMT, 13, 3561

Monitoring (5 years)

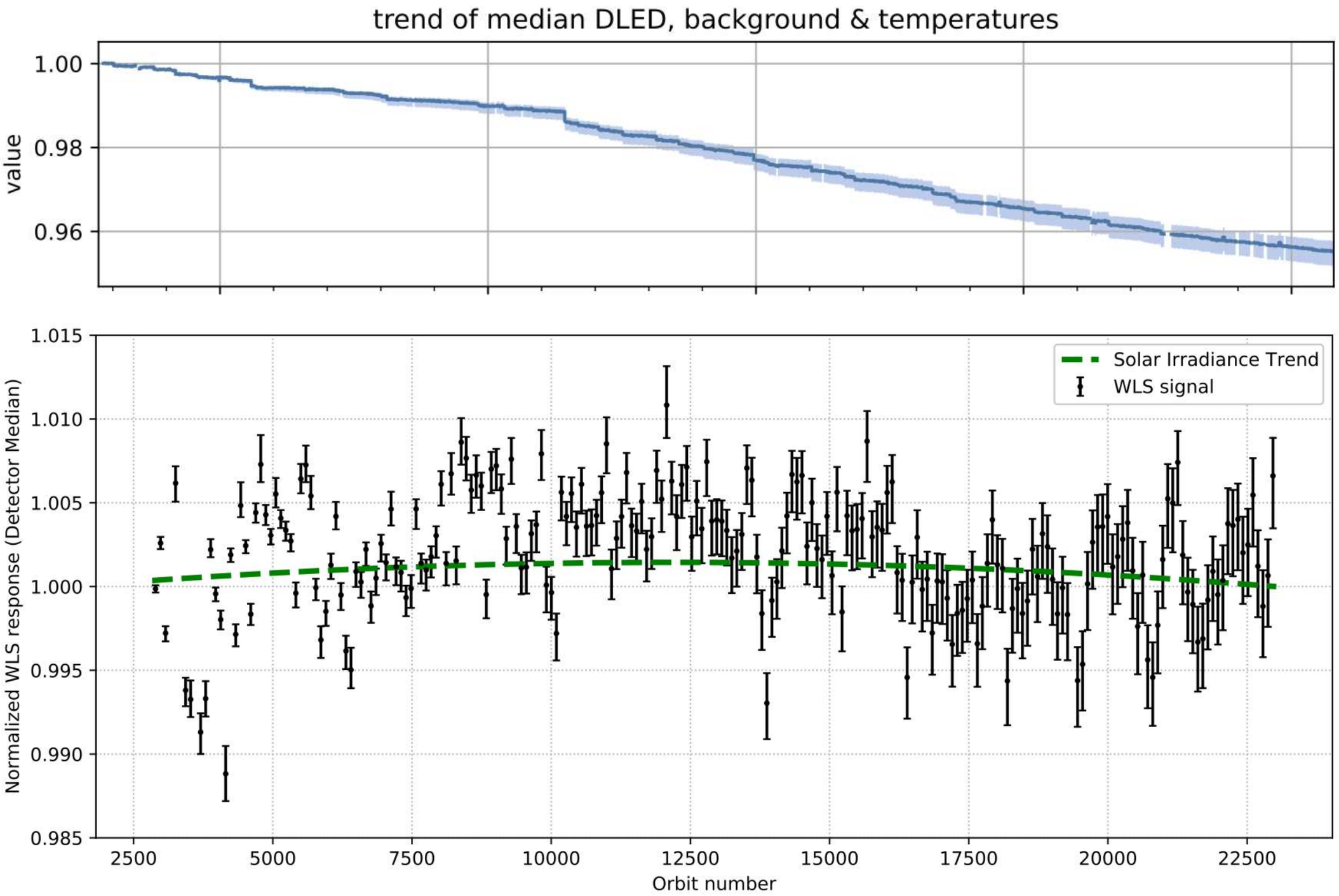




<0.1% transmission change

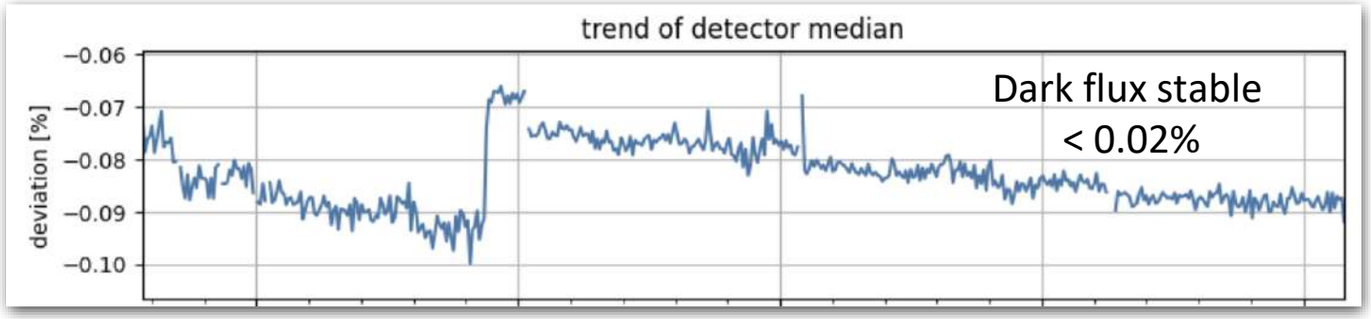
Van Kempen et al., 2022 in prep

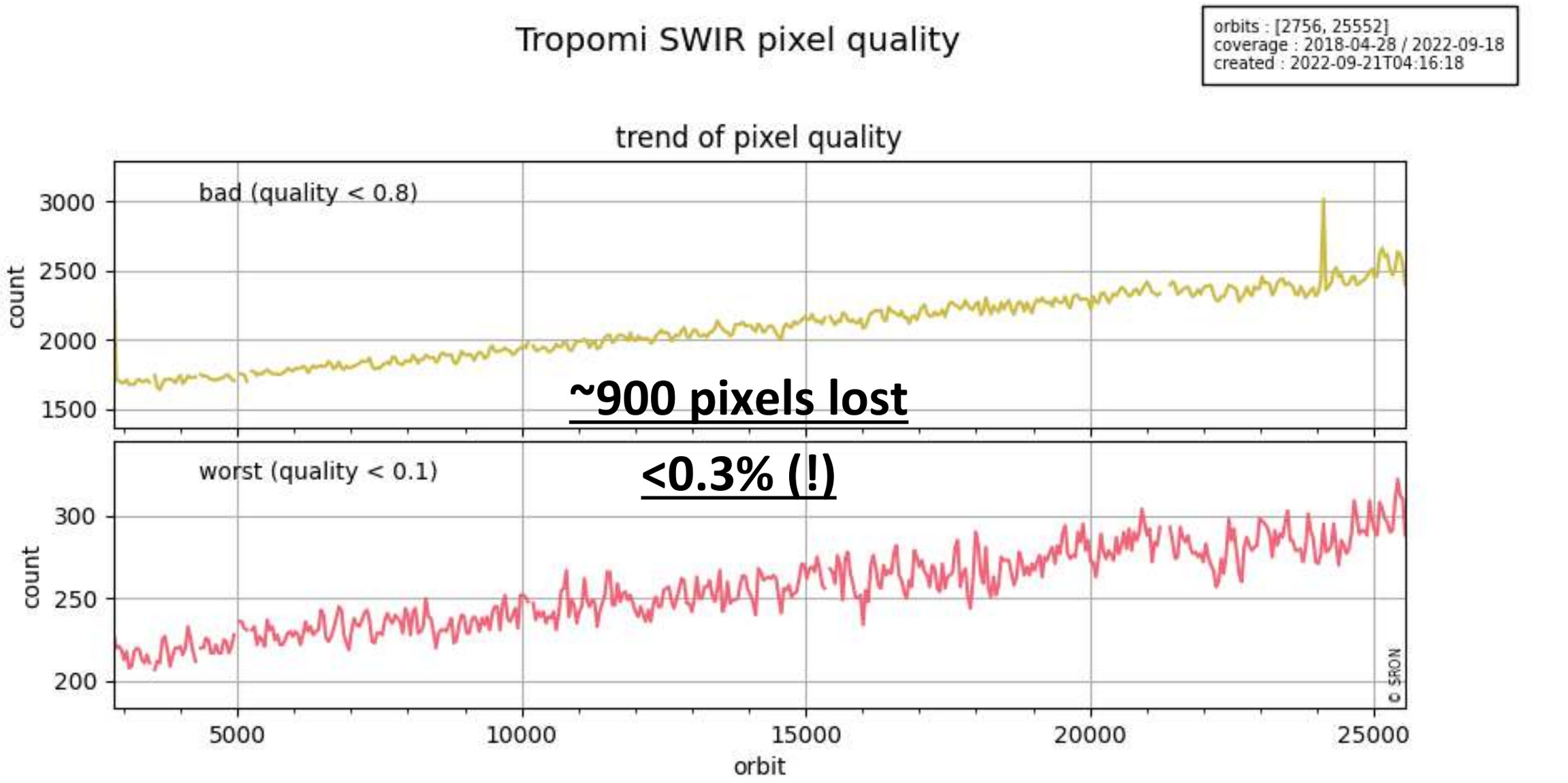
Transmission (DLED + WLS)



Van Kempen et al., 2022 in prep

Detector degradation



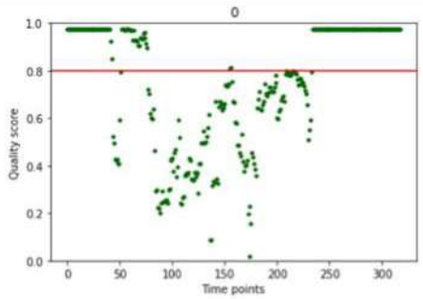


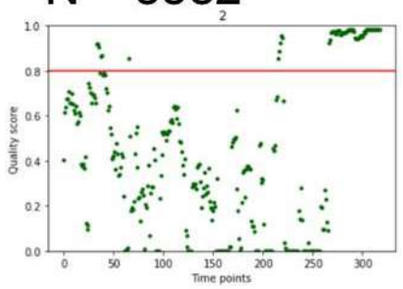
SRON

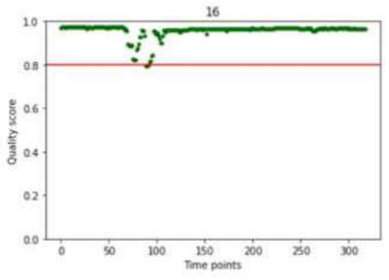
Van Kempen et al., 2022 in prep

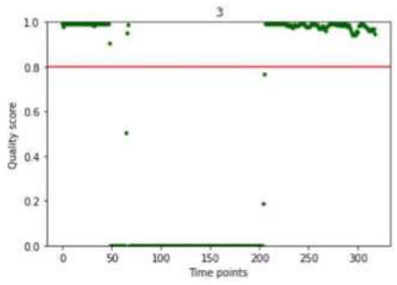
Reliable (green) and Unreliable quality progression plots

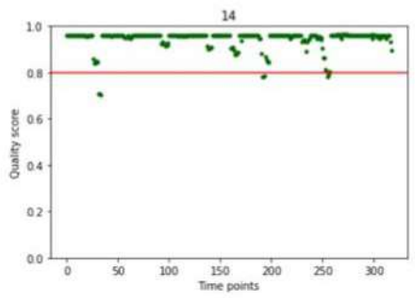
N = 3382

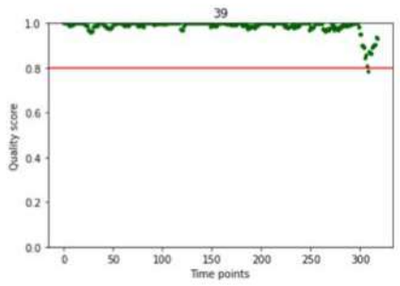


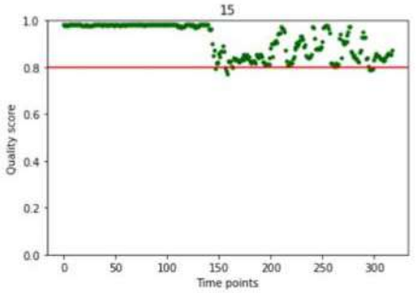


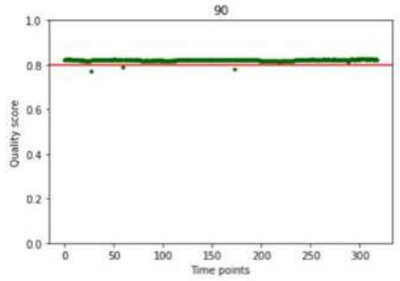


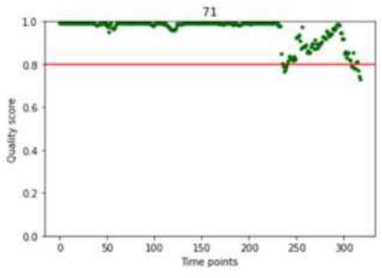












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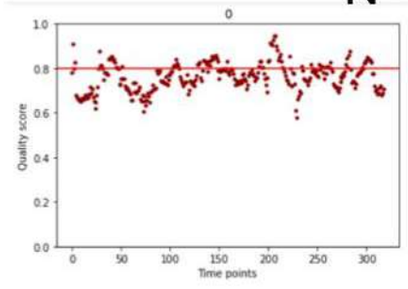
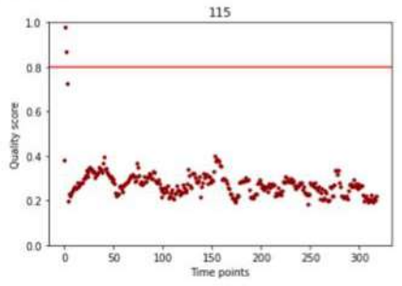
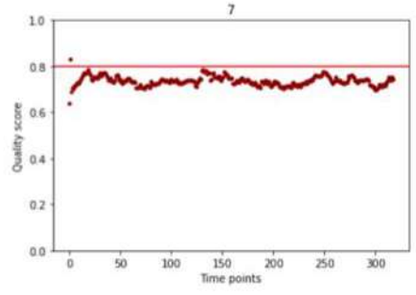
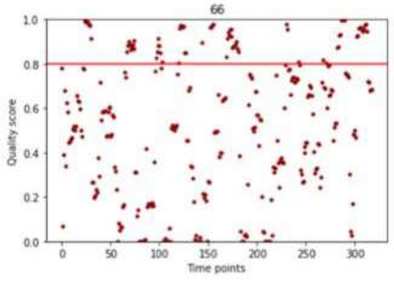
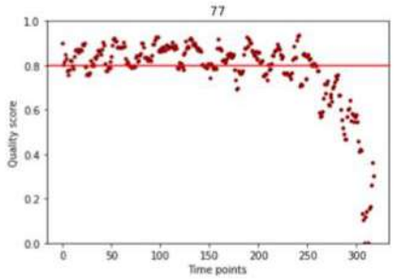
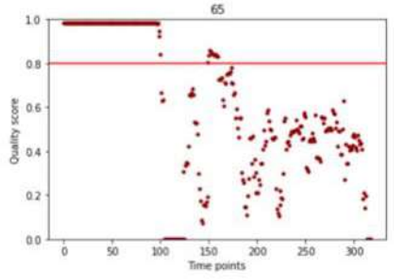


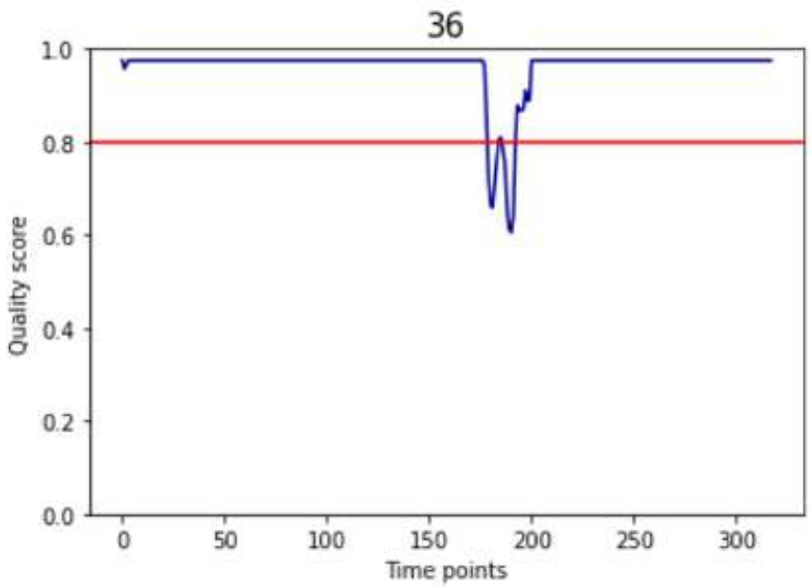












Naff = 1

Nrec = 1

Nbad = 12

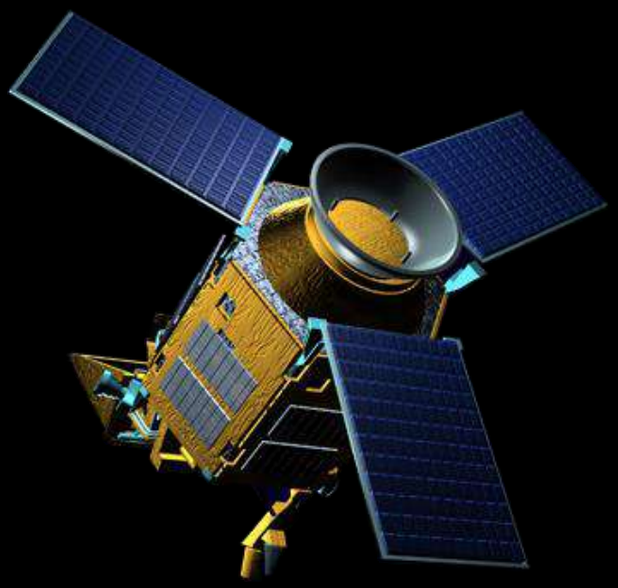
- Small number permanently lost (~0.05% vs 0.3%)
- Recovery 0.25%
  'average' = 54 days

Lobanova & van Kempen, memo

Van Kempen & Hoogeveen, 2024+

SRON

AMAZING STABILITY !
IS IT TRUE?
PROBABLY…
BUT WE WANT TO BE (MORE) SURE



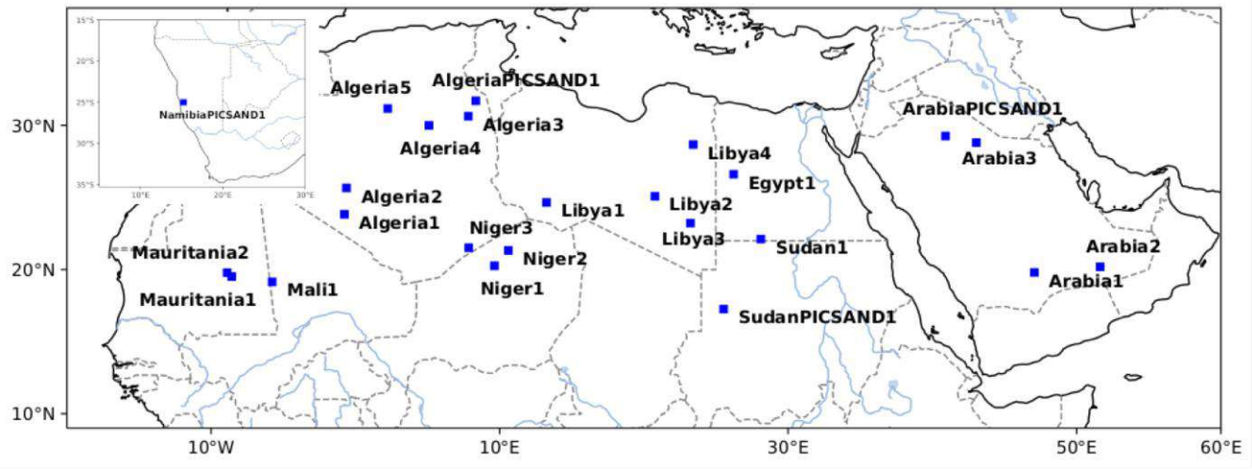
VICARIOUS CALIBRATION

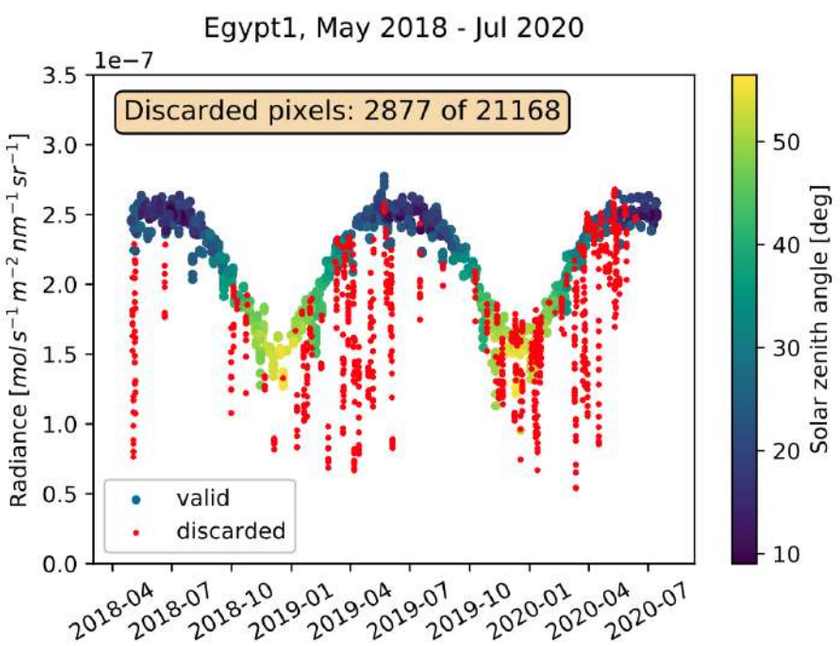
INDEPENDENT *L1B* VALIDATION

source:
Lacherade et al., 2013, Bacour et al., 2019

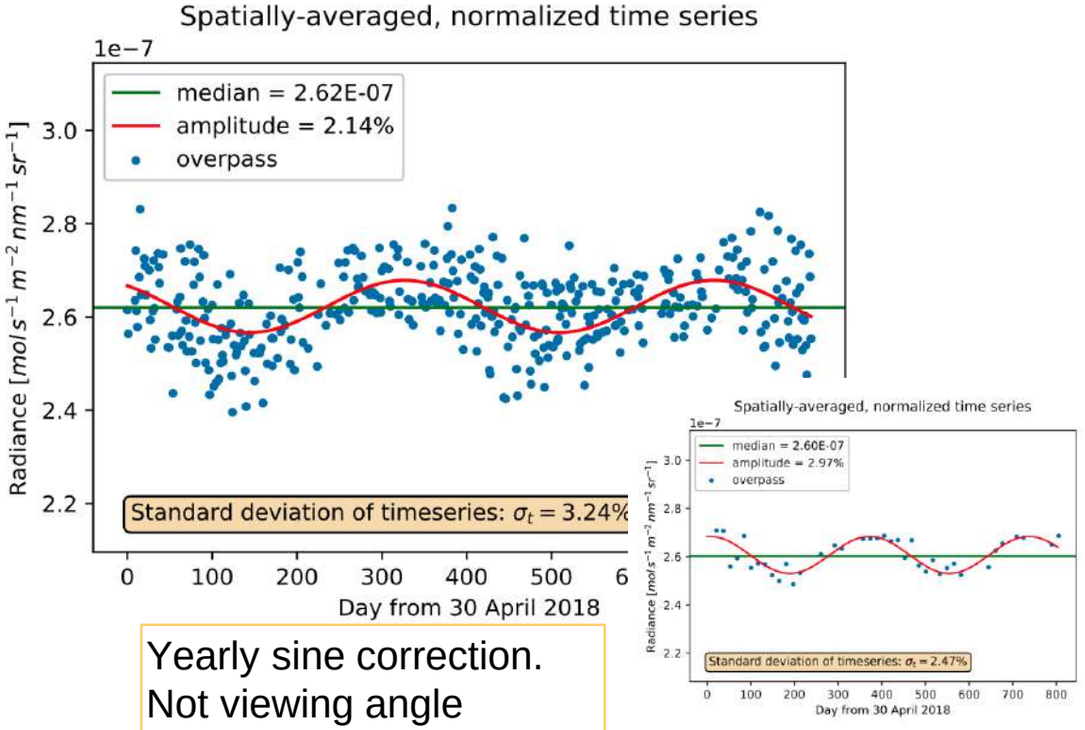
Monitoring of ‘Saharan’ desert sites

- 23 PICS (*Bacour et al., 2019*)
- **GOALS**
  - Monitor TROPOMI-SWIR stability using 2312.8 nm continuum from o L1b radiance
  - Validate Calibration and Instrument Stability from SRON monitoring program (within XX%)
  - Develop monitoring program for next-gen small-sat missions
  - Evaluate stability/quality of sites at SWIR wavelengths





SZA normalisation
Cloud filter
High SZA filter
High IZA filter
Assume Lambertian surface

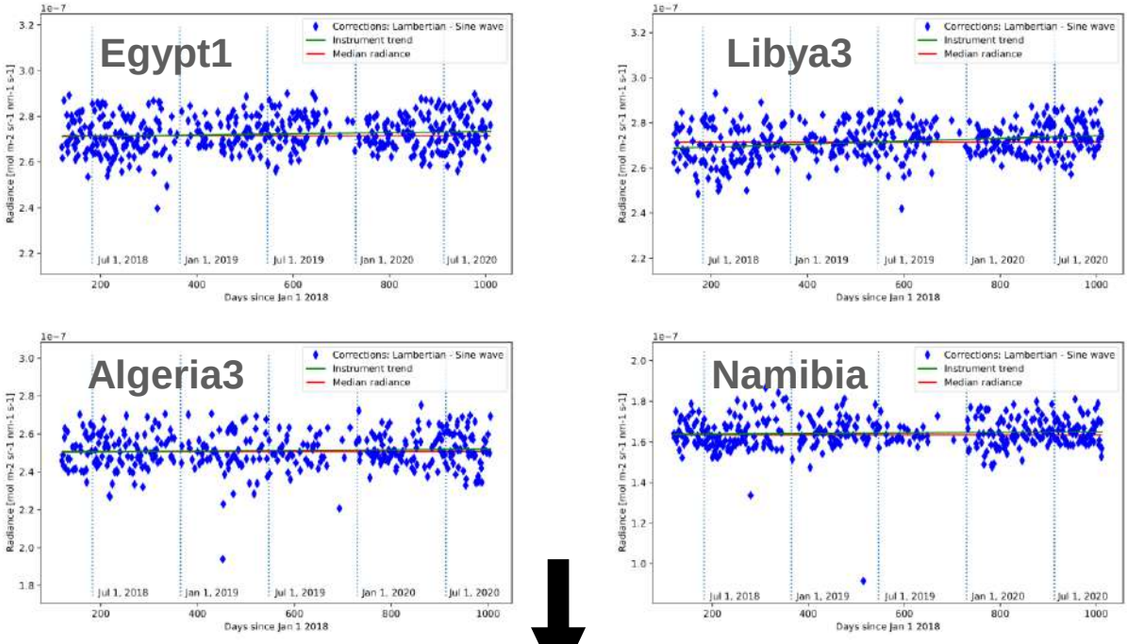


Yearly sine correction.
Not viewing angle dependent!

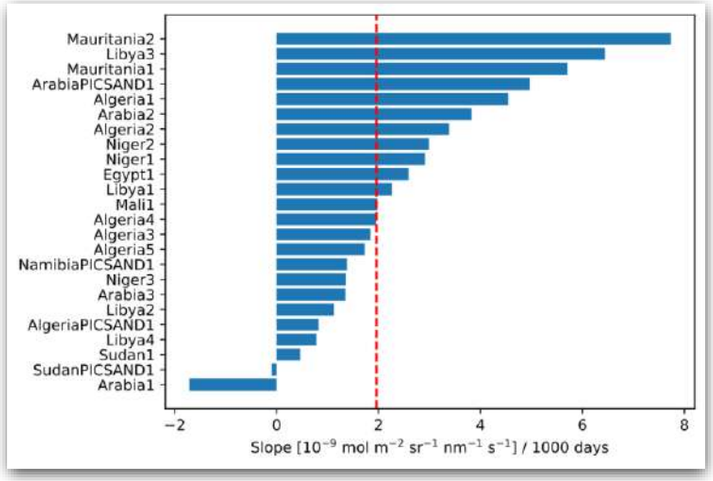
SRON
Netherlands Institute for Space Research

Van Kempen, Oggionni & van Hees, 2021

Validation of L1b SWIR calibration and instrument monitoring (~0.8%)

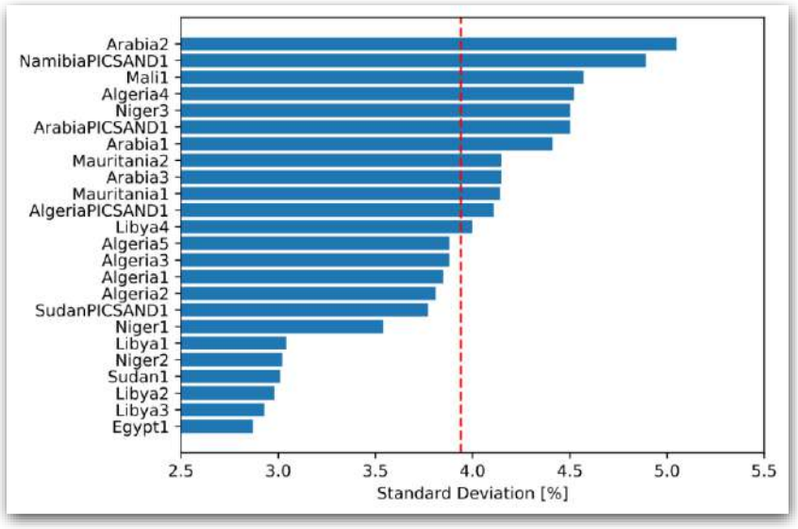


Slope of Linear fit

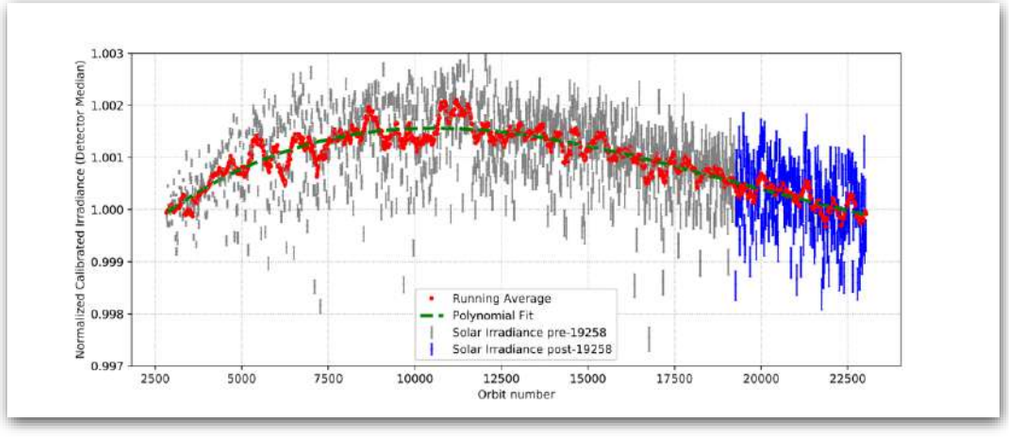


Instrument degradation < 0.8 %

Standard Deviation



Mean for STDEV 4-5%
Selected sites < 3 %



Instrument degradation ~ 0.1 %

SRON
Netherlands Institute for Space Research

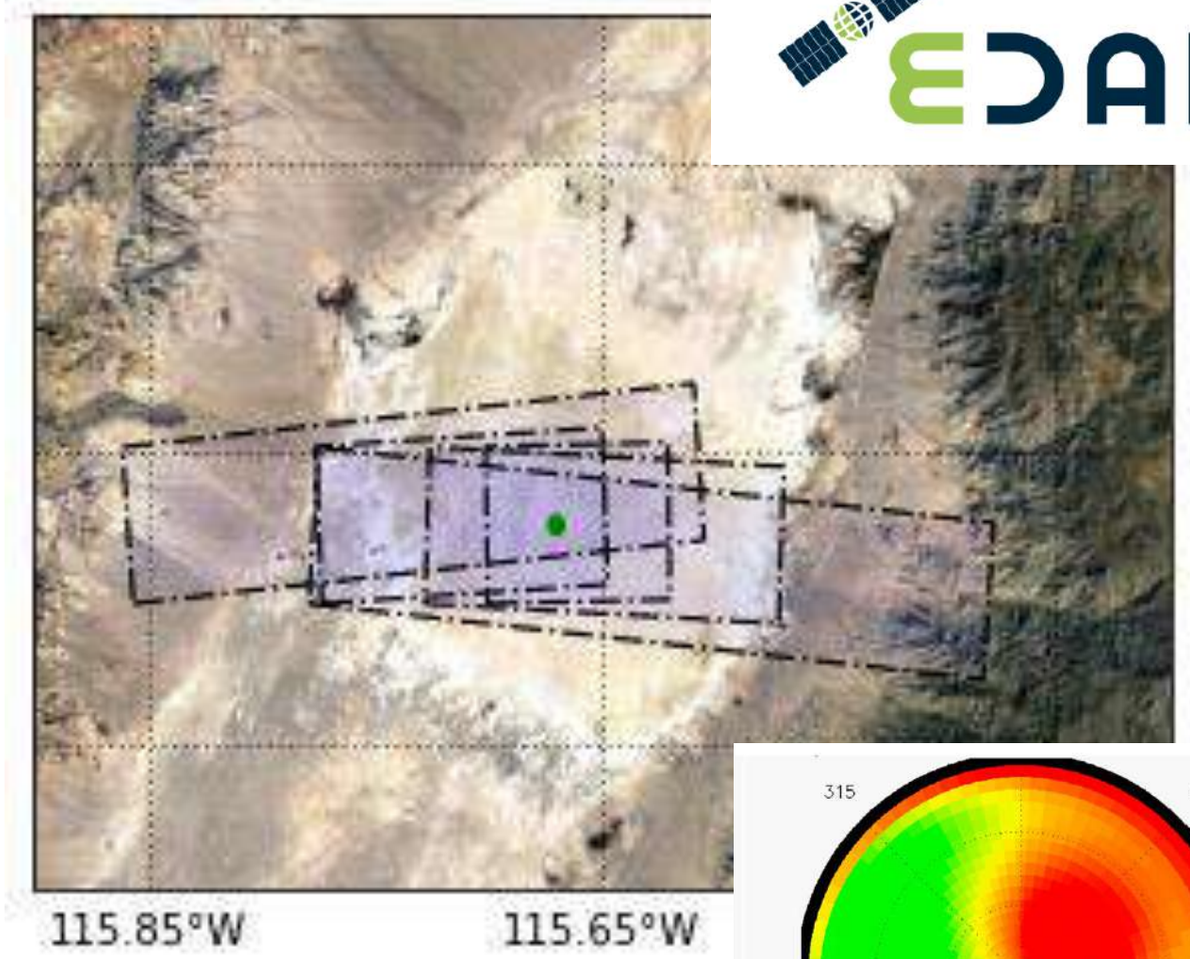
Van Kempen, Oggionni & van Hees, 2021

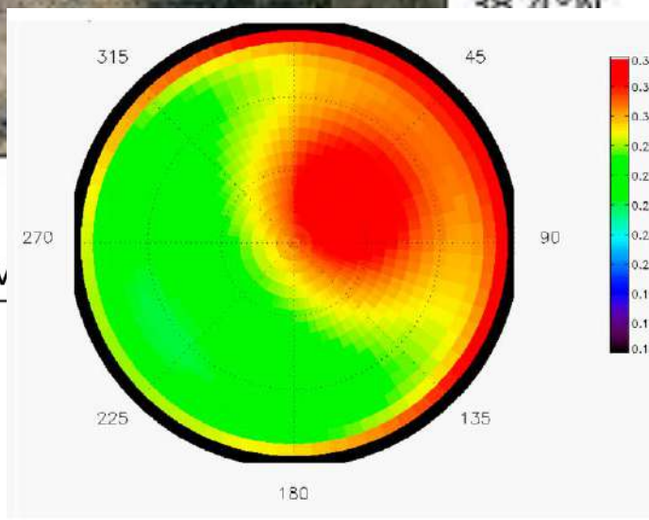
Railroad Valley Playa

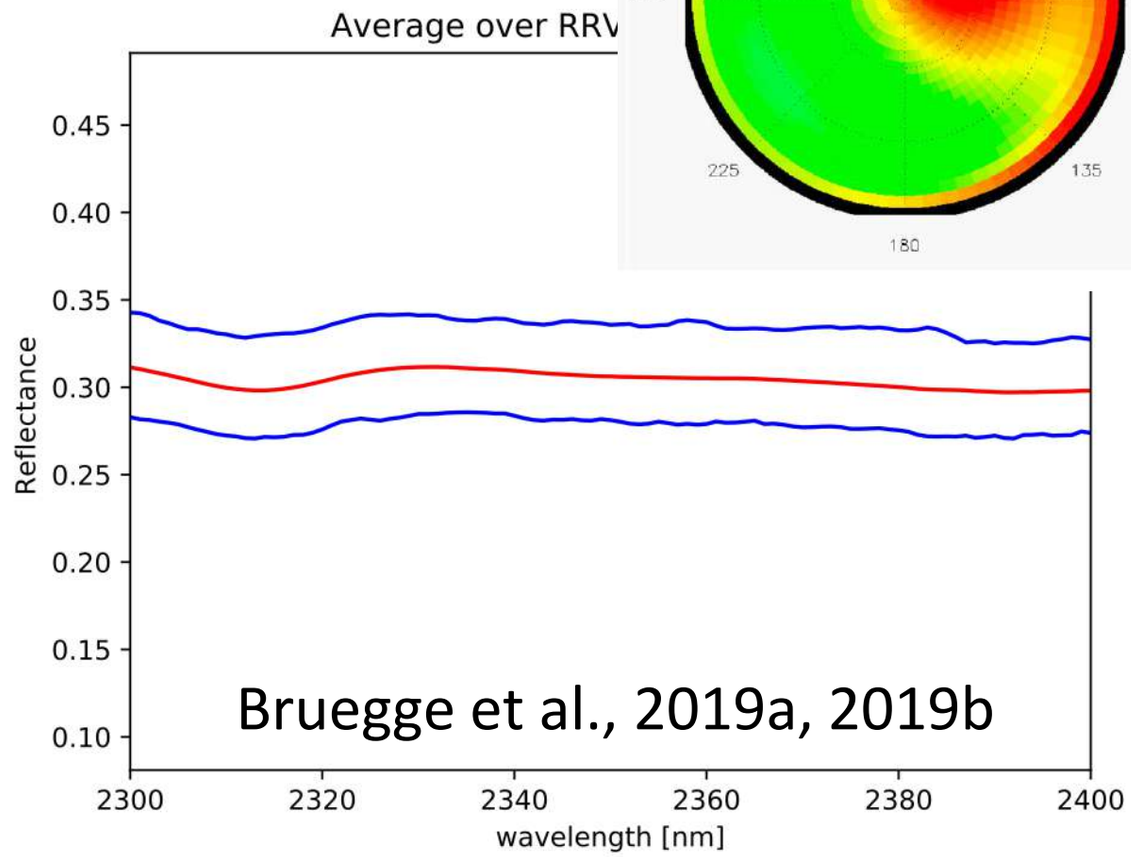
- TROPOMI-SWIR has **daily** overpasses over RailRoad Valley (RVUS) Playa in central Nevada, ranging from 66 East to 66 West viewing zenith angles
- TROPOMI pixel is rectangular and large
  - Pixel size depends on viewing angle and scan time
  - 5.5x7 to 7x26 km^2

- Flat salt basin
  - No vegetation.
  - Low aerosol optical depth
  - *Non-Lambertian surface*

- ~Yearly campaigns
  OCO-2 + GOSAT teams.

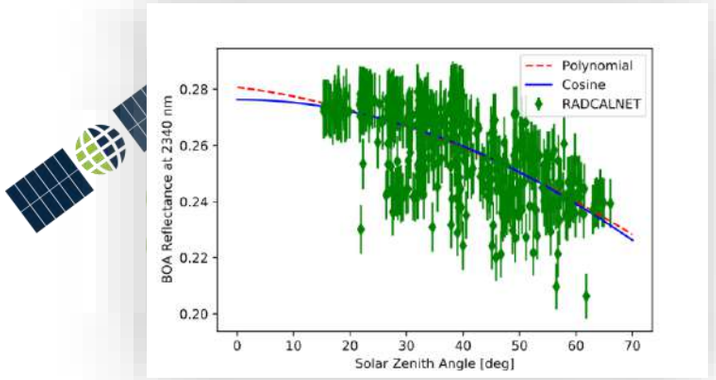


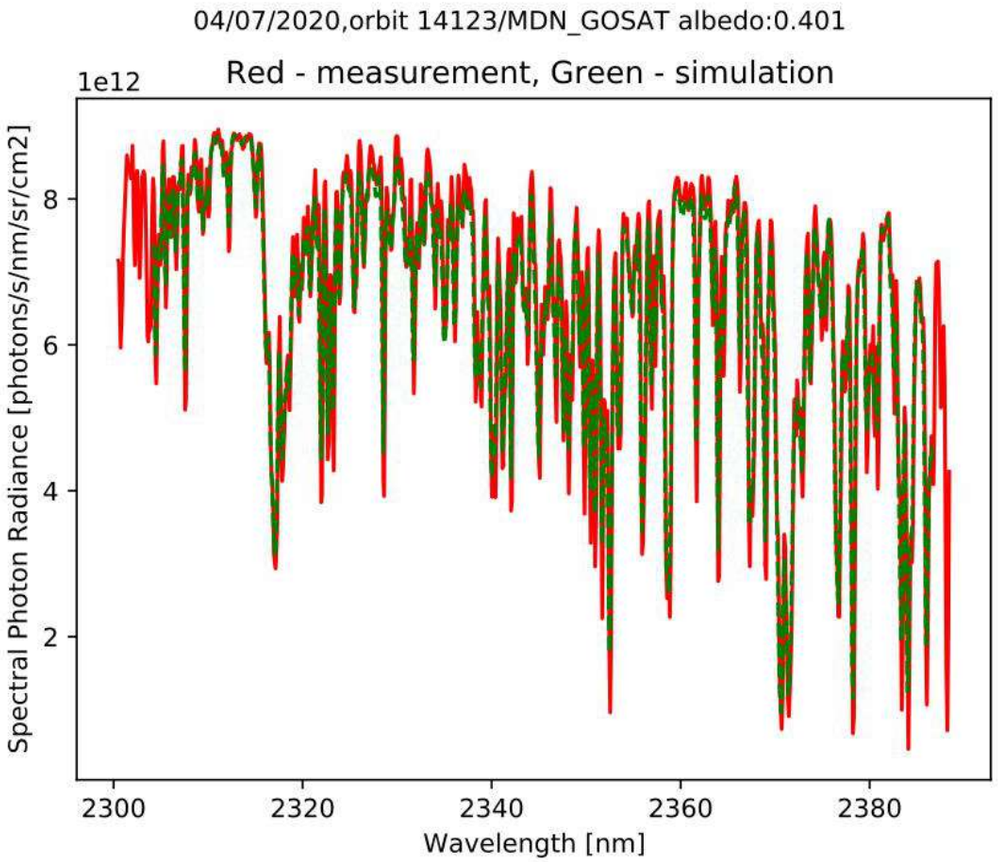




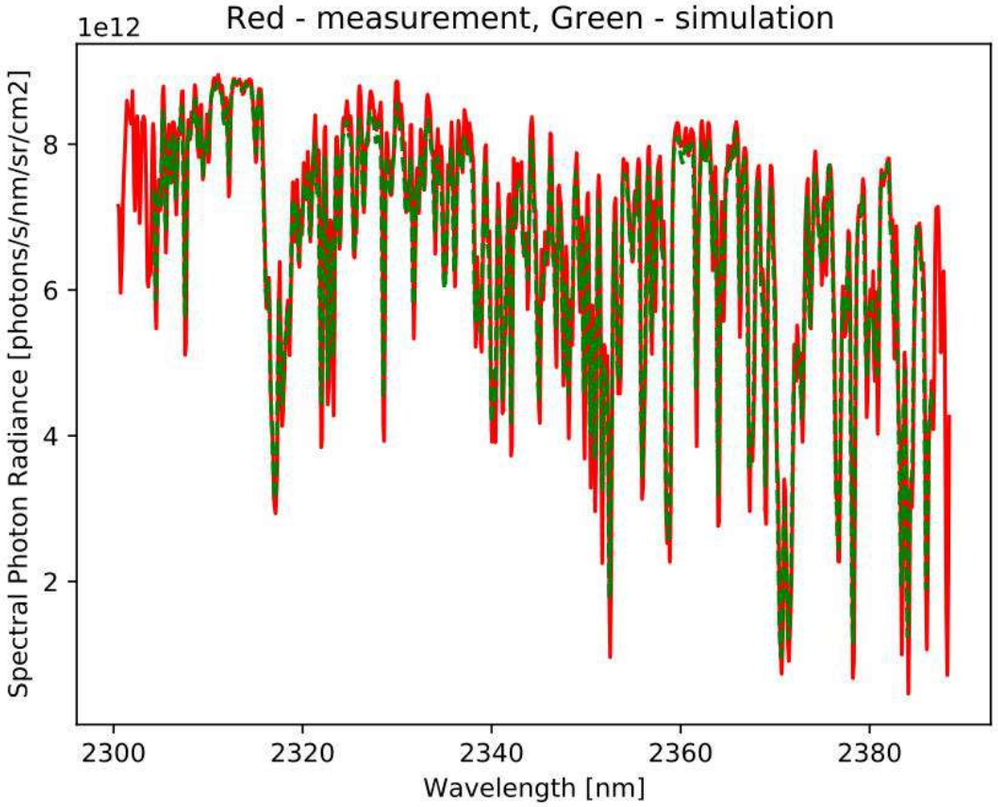
Bruegge et al., 2019a, 2019b

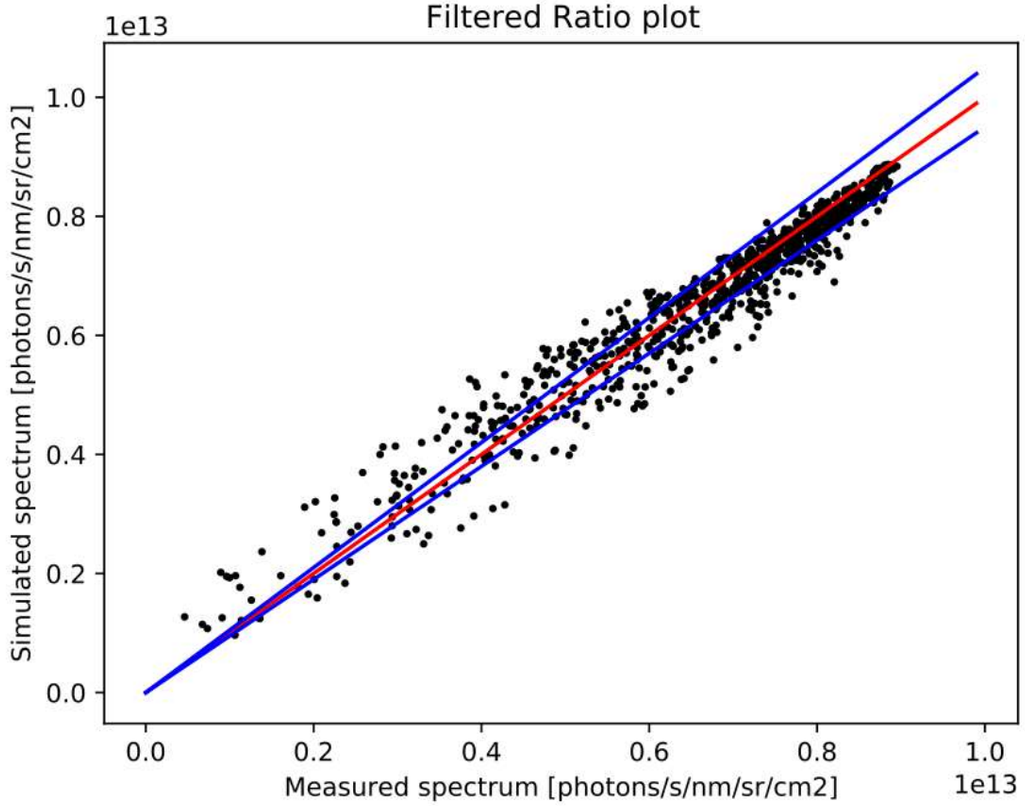
Example orbit July 4th 2020 - Two ground measurements





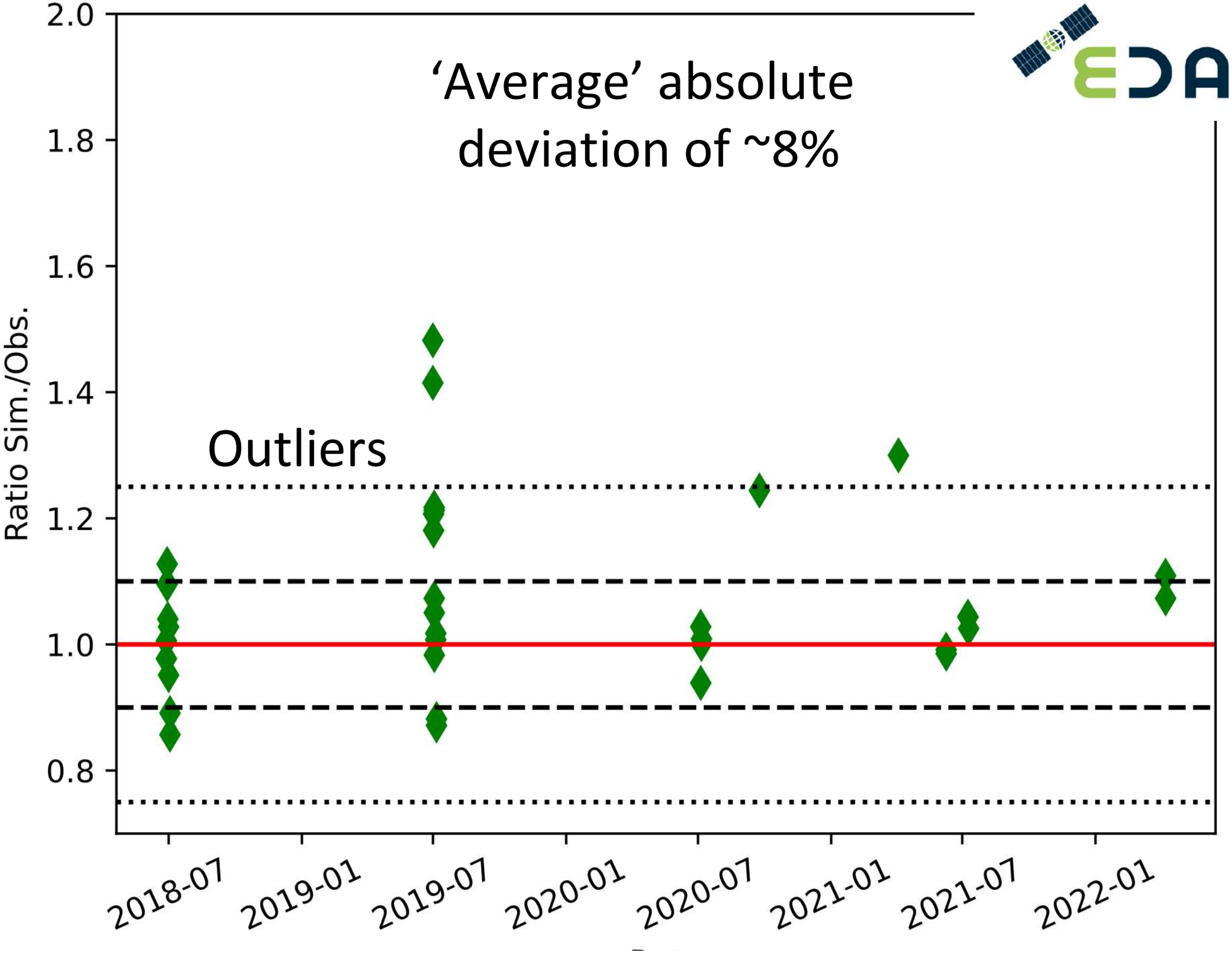
Input	
Reflectance	0.369 (2.3 μm)
norm_BRF (mRPV method)	1.081
AOD	0.02 (at 760 nm)
SZA	21.1
SAZ	-126.54
IZA	**35.12**
IAZ	-95.18



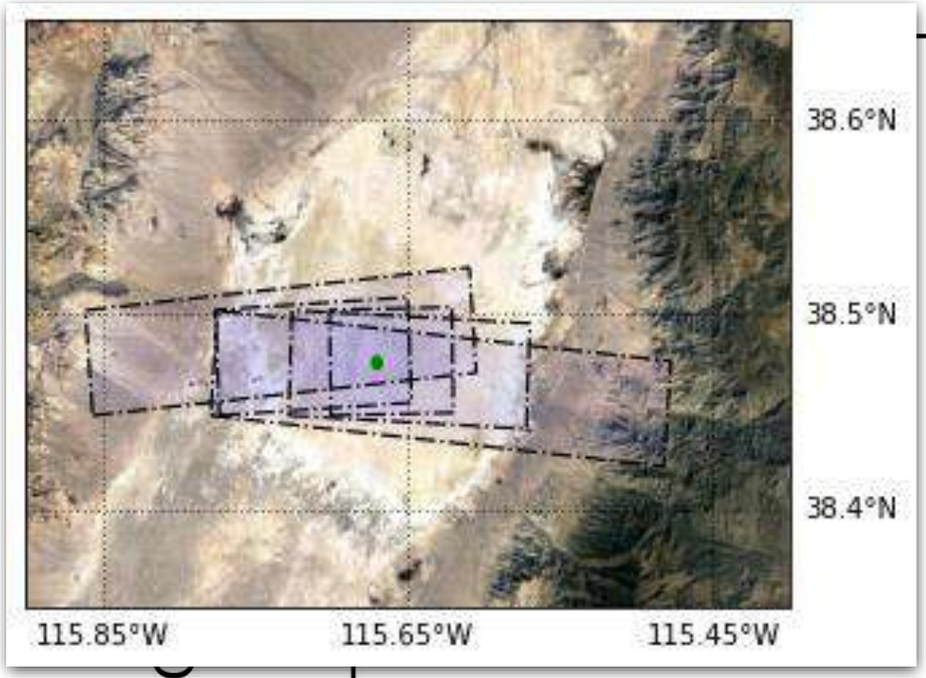


‘Average’ absolute deviation of ~8%

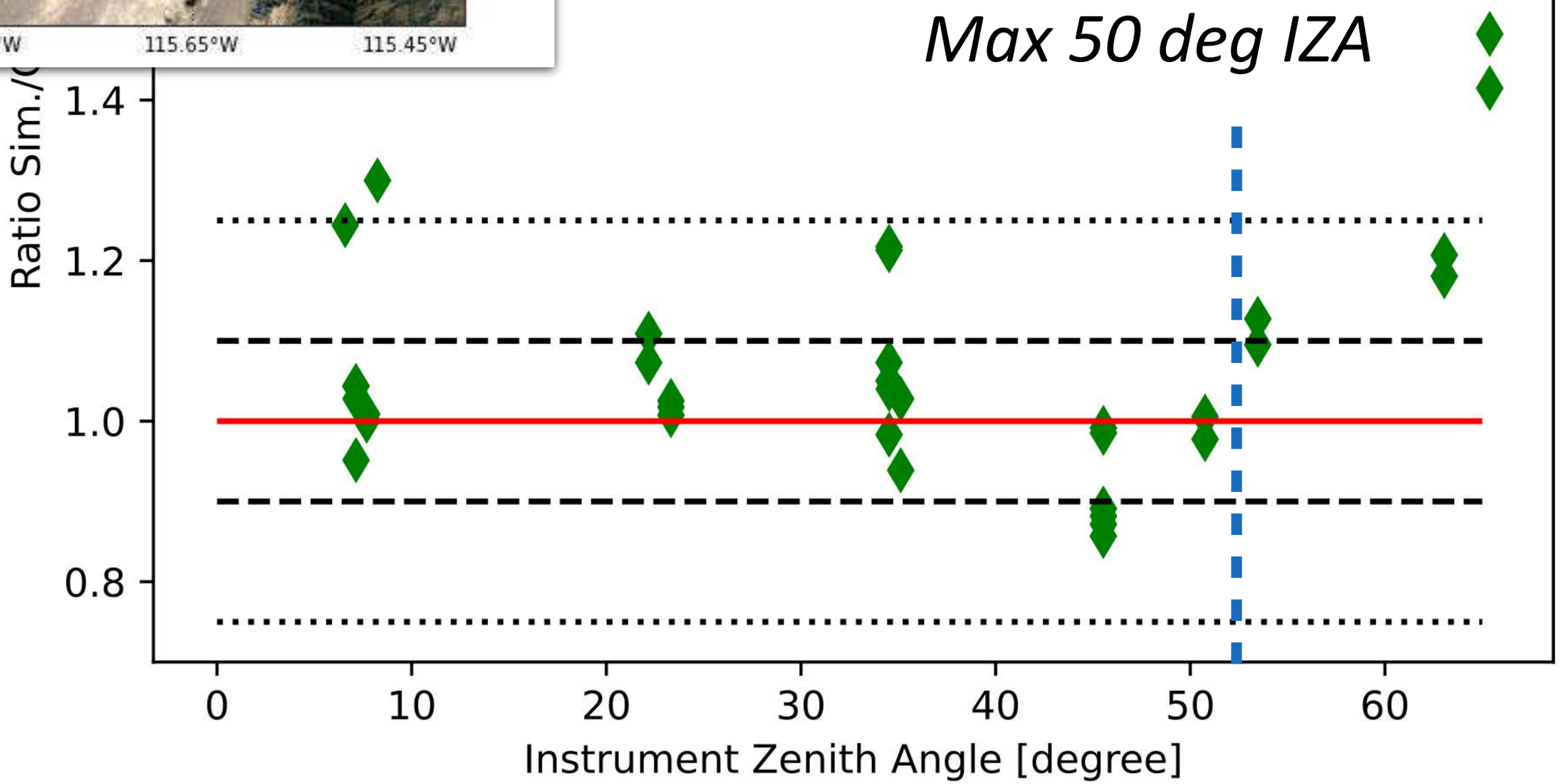
Outliers



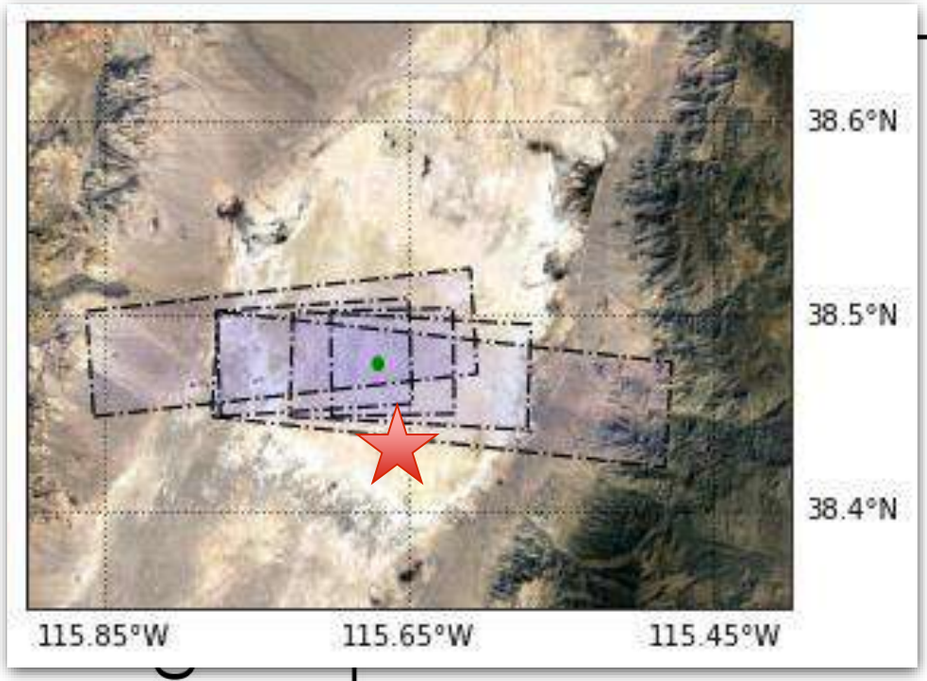
Van Kempen, et al., 2022, in prep



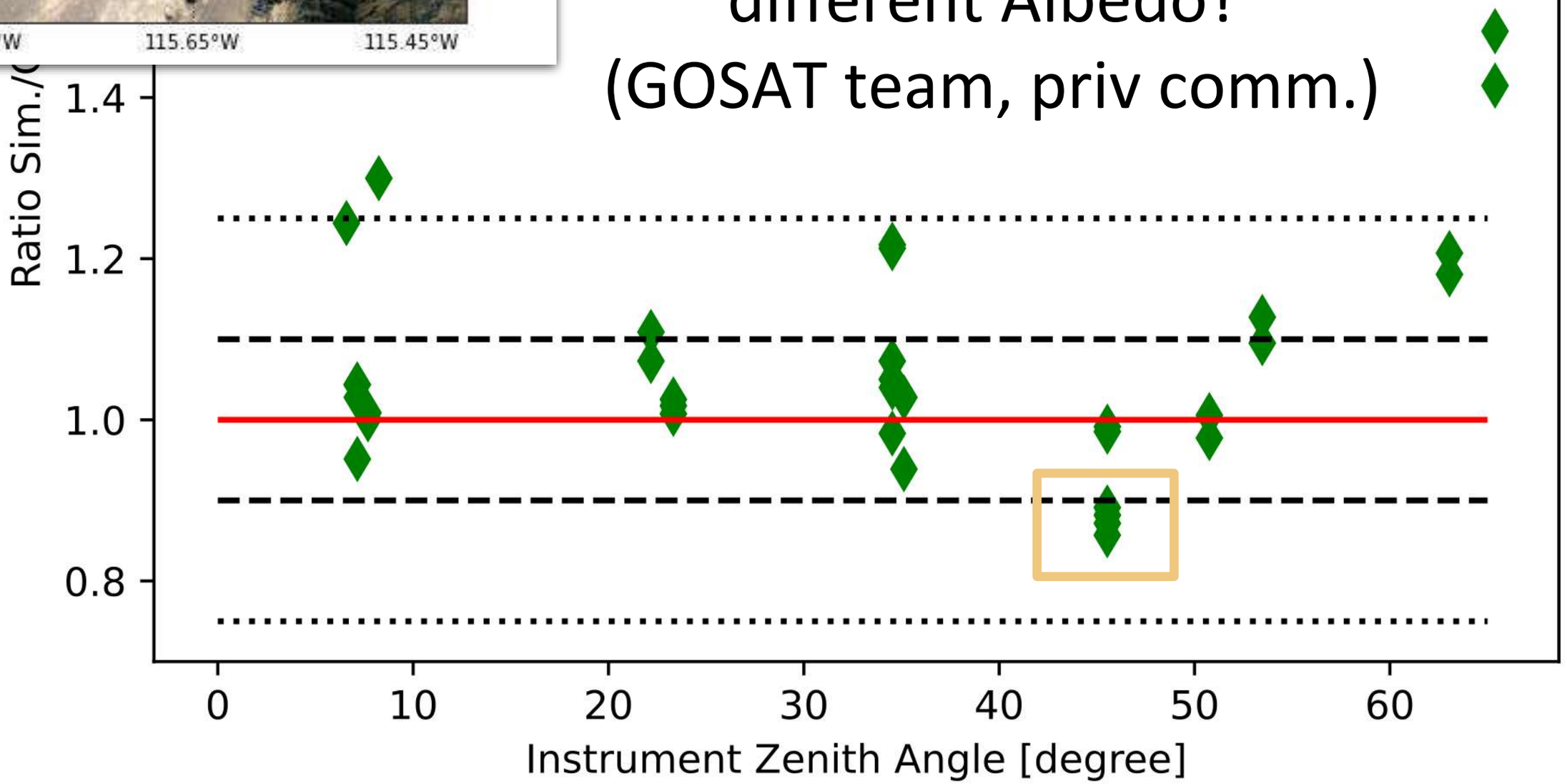
Max 50 deg IZA



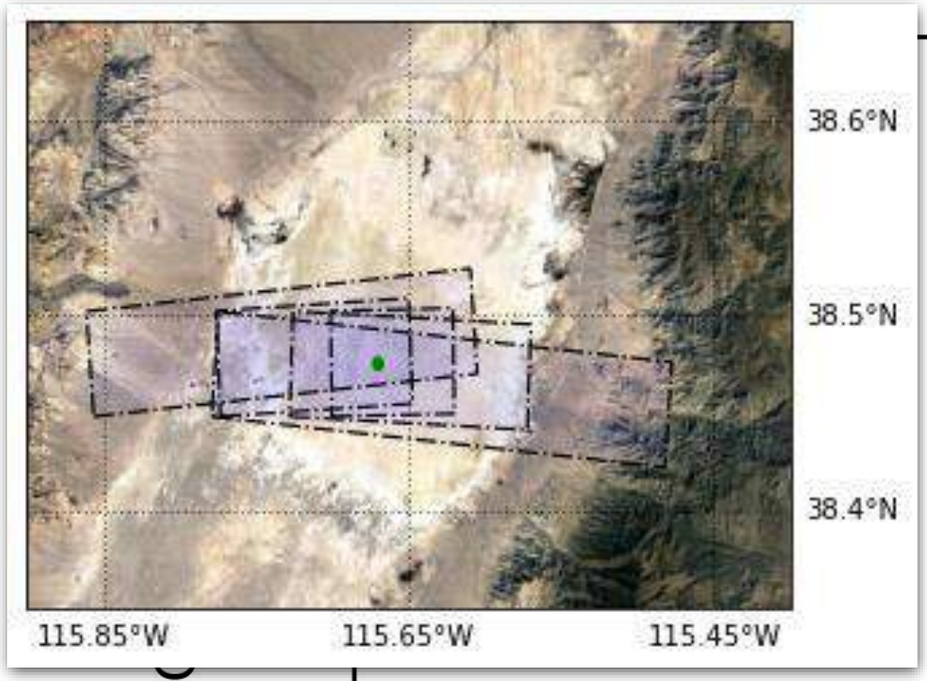
Van Kempen, et al., 2022, in prep



RRV south,
different Albedo?
(GOSAT team, priv comm.)



Van Kempen, et al., 2022, in prep



Fall/winter 2020 ?

Ratio Sim./O

1.4
1.2
1.0
0.8

0 10 20 30 40 50 60

Instrument Zenith Angle [degree]

Van Kempen, et al., 2022, in prep

Conclusions 5 years TROPOMI-SWIR

- TROPOMI-SWIR module is extremely stable
  - <0.1 % degradation in transmission
  - ~0.3 % pixel loss
    Continuation of 1 year conclusions to 5 years
    if trends continue: SWIR easily good for another 5-15 years

- Vicarious Calibration
  - Limited results. TROPOMI-SWIR might be 'too good'
  - Sahara Desert: Instrument degradation < 0.8%
  - RRV : Radiometric calibration ~8-10%, 'biased' ~5%
    - Large pixels (IZA dependent)
    - *BRDF (5-10%)*
    - Time (2nd order, 3-4%)
    - Reference Measurement uncertainty (2-3%)
    - TROPOMI Solar Irradiance product (<1%)
    - Solar Irradiance lines (<1%)

Five years of excellent performance of the TROPOMI-SWIR module

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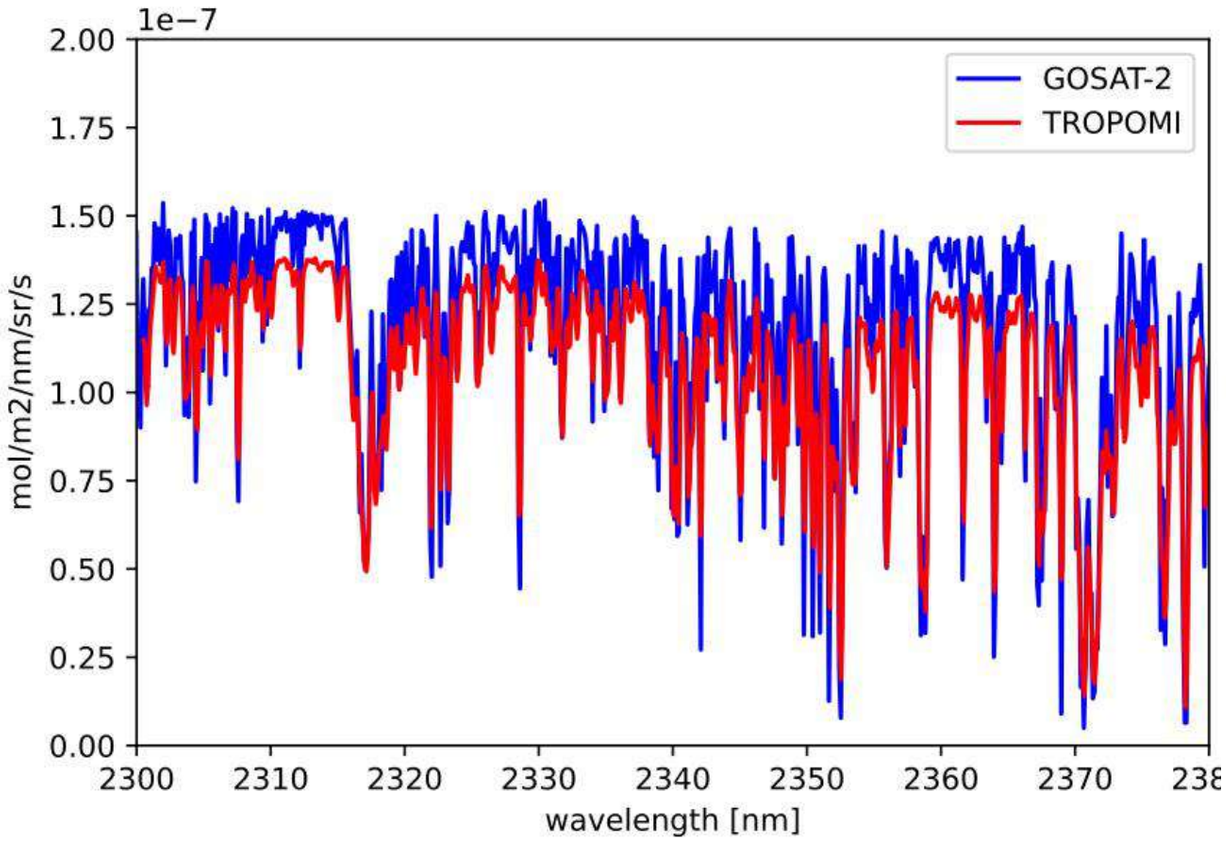
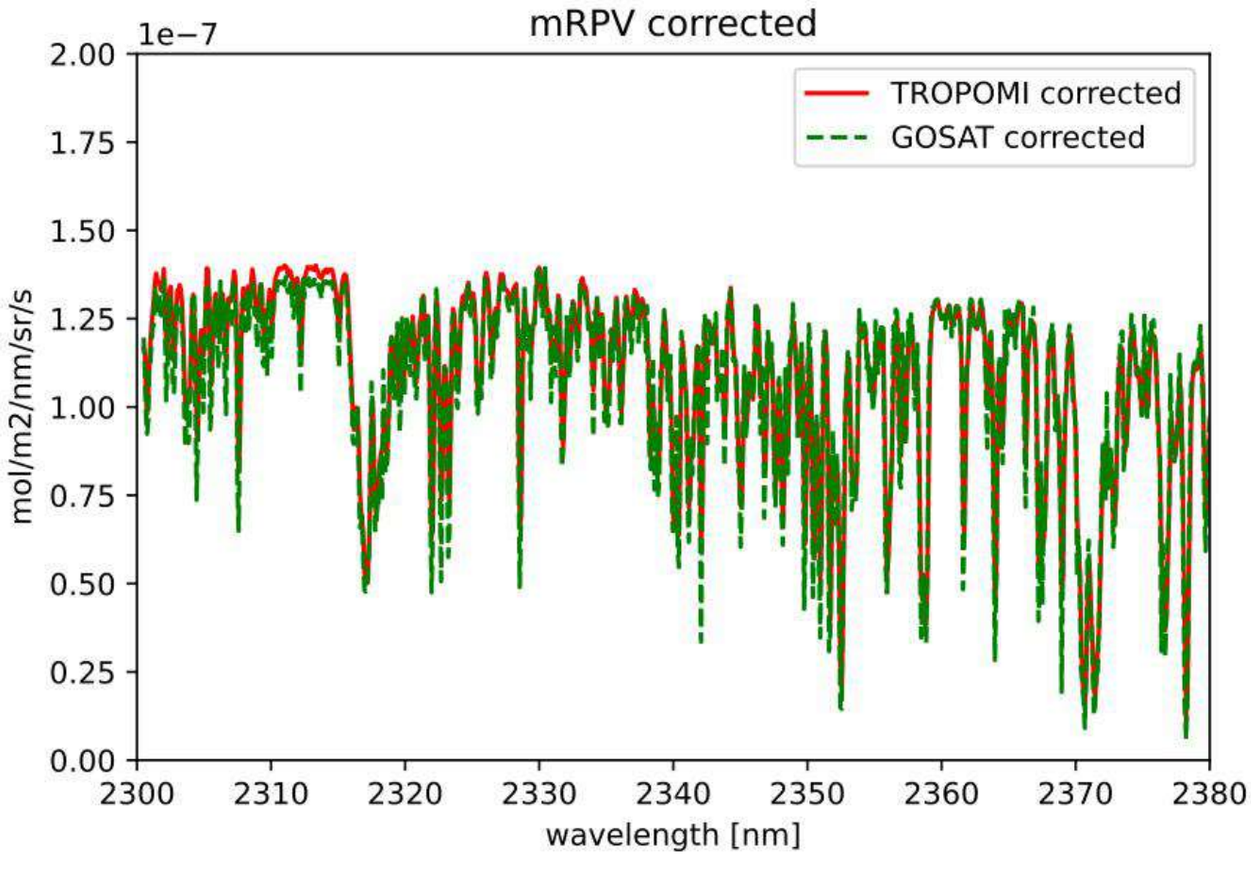
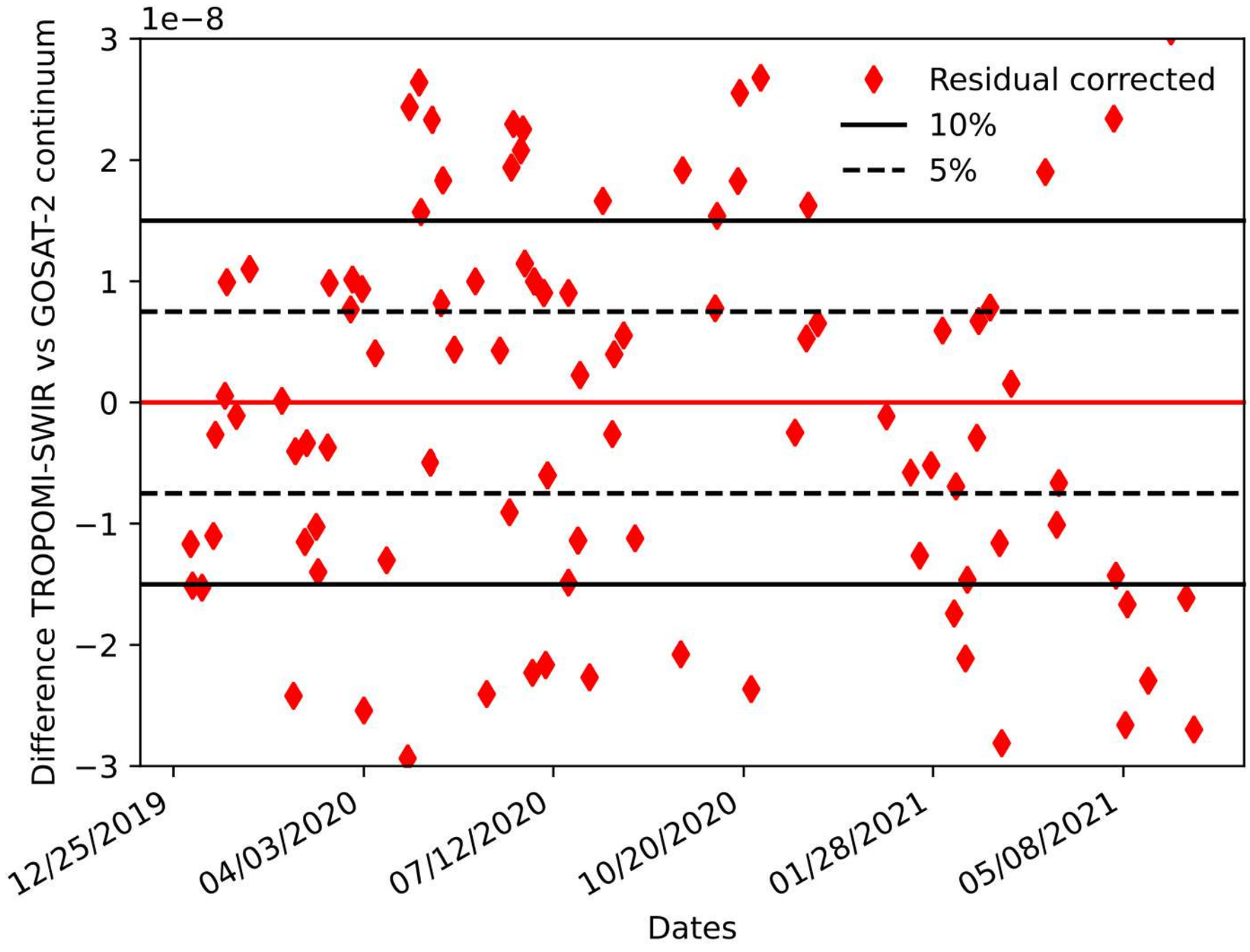
Current work in progress





GOSAT-2 vs TROPOMI L1 (BRDF corrected) 2019 - 2021

Continuum channels 2312.7-2313.1



Median absolute difference : 5.1%

RRV may not be ideal target for cross-calibration