



ATMOS 2021

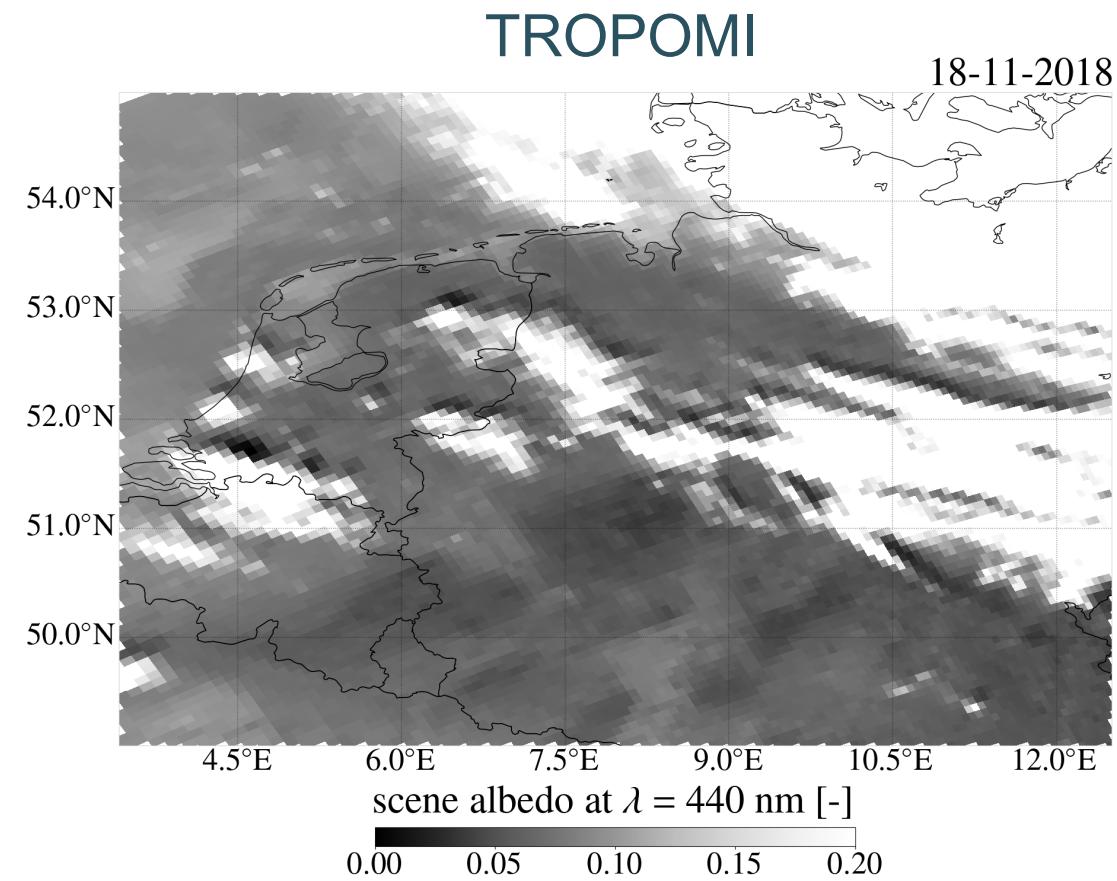
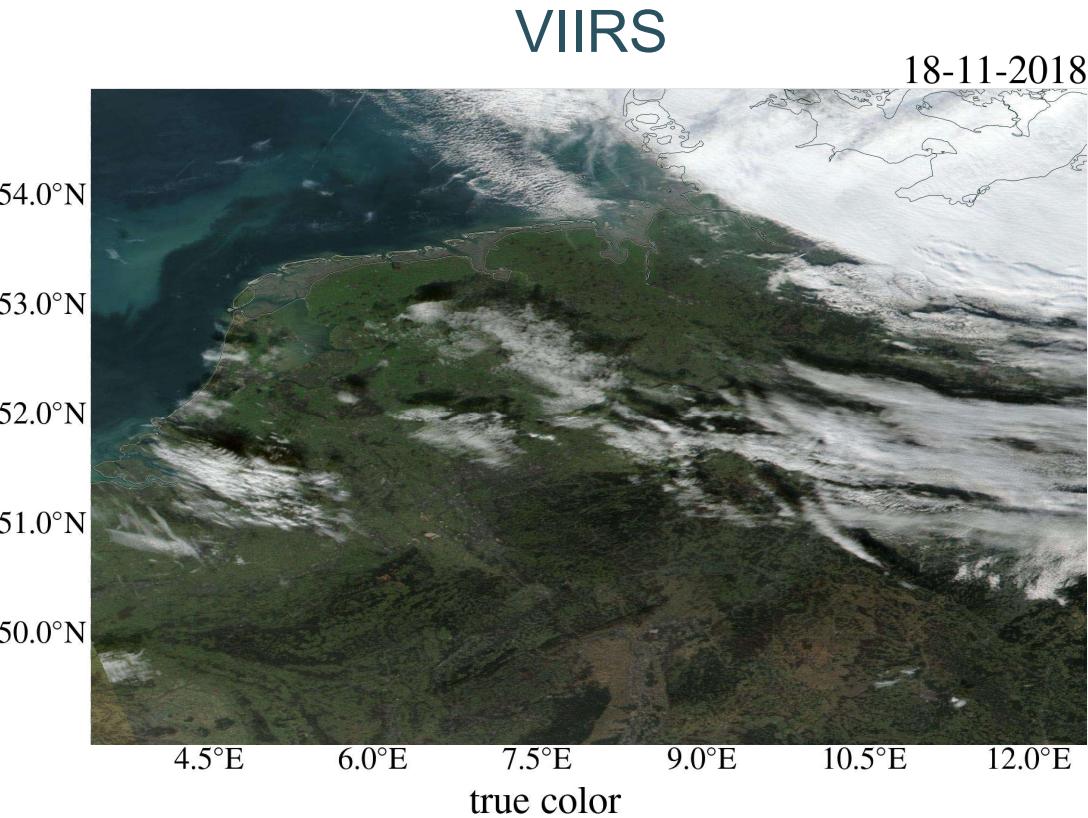
DARCLOS: a cloud shadow detection algorithm for TROPOMI

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26/11/2021

Cloud Shadow Detection with TROPOMI



Cloud Shadow Detection with TROPOMI



Cloud shadows are not taken into account in atmosphere models for air quality retrieval.

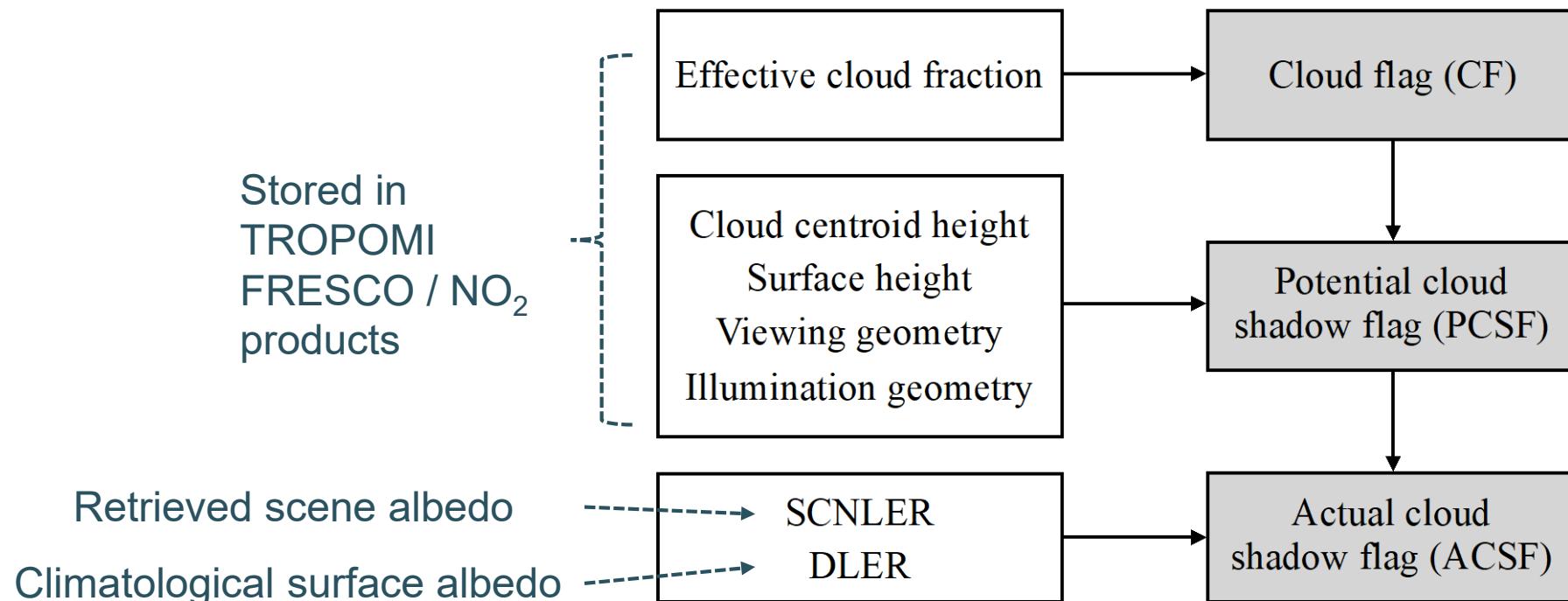
Automatic cloud shadow detection is needed for:

- **removal** of the cloud shadow contamination.
- **analysis** of the cloud shadow contamination.
- **correction** of the cloud shadow contamination.

Cloud Shadow Detection with TROPOMI



Detection AlgoRithm for CLOud Shadows (DARCLOS)

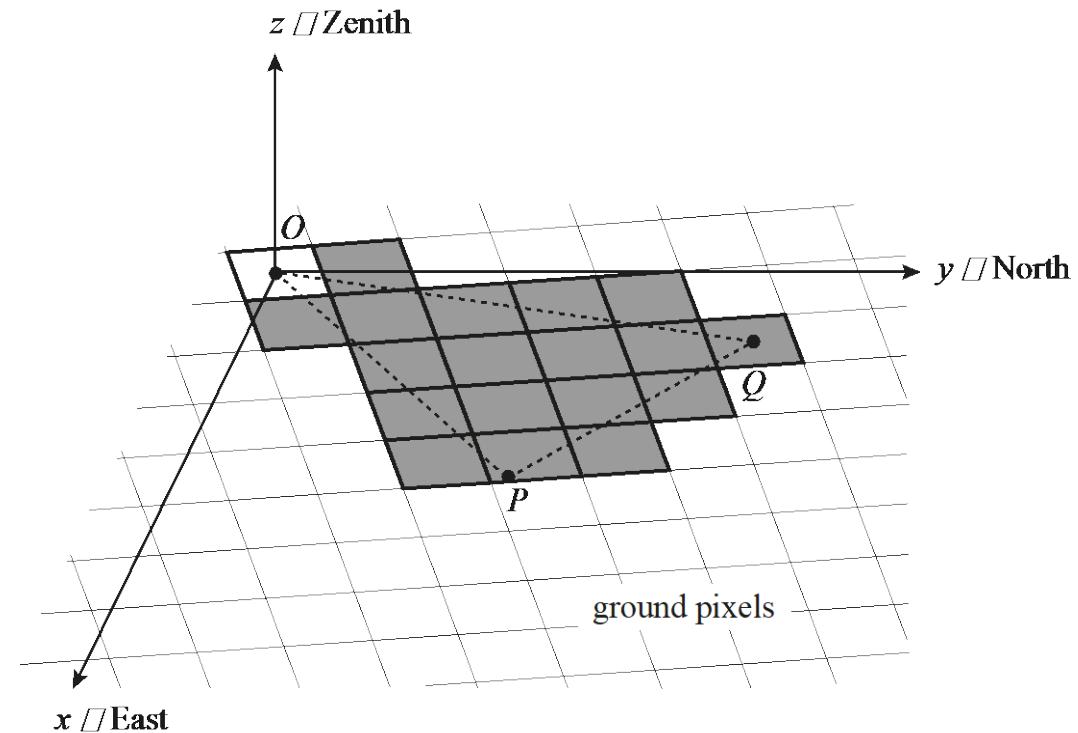
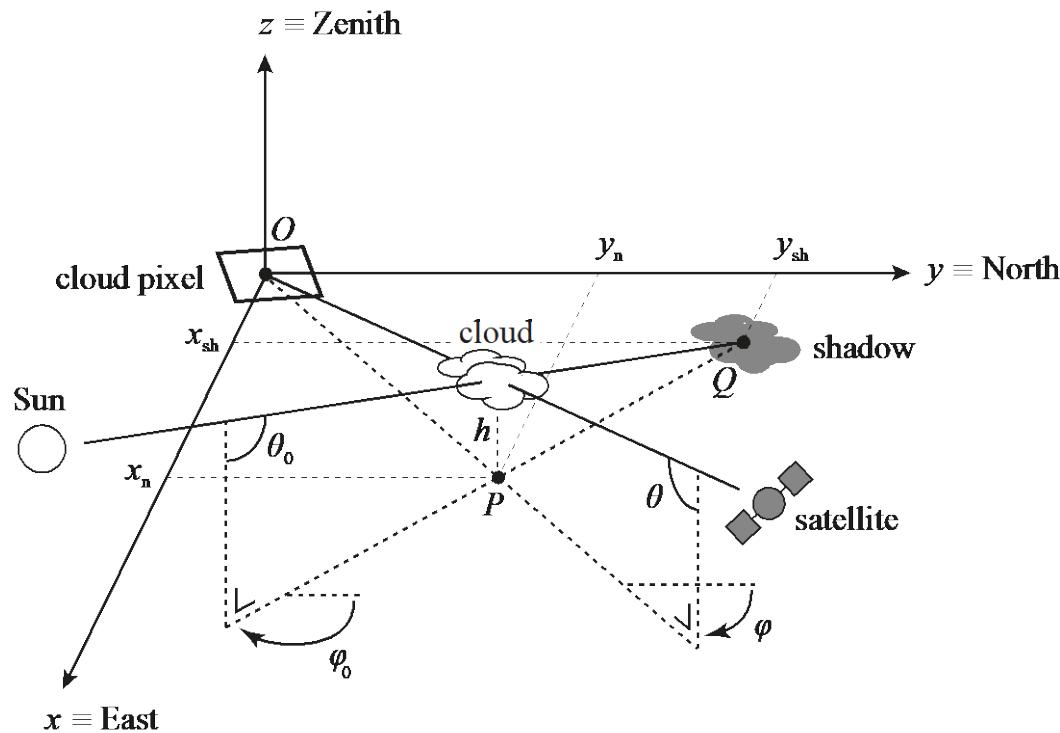


Trees et al. (2021), submitted to AMT

Cloud Shadow Detection with TROPOMI



Potential Cloud Shadow Flag (PCSF)

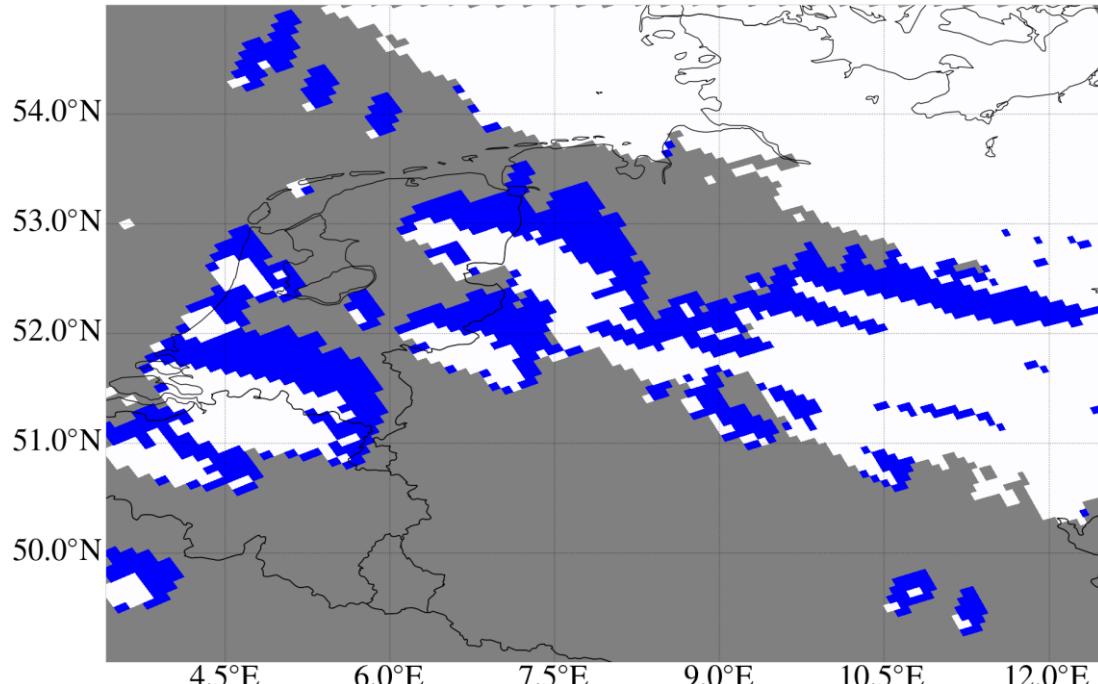


Trees et al. (2021), submitted to AMT

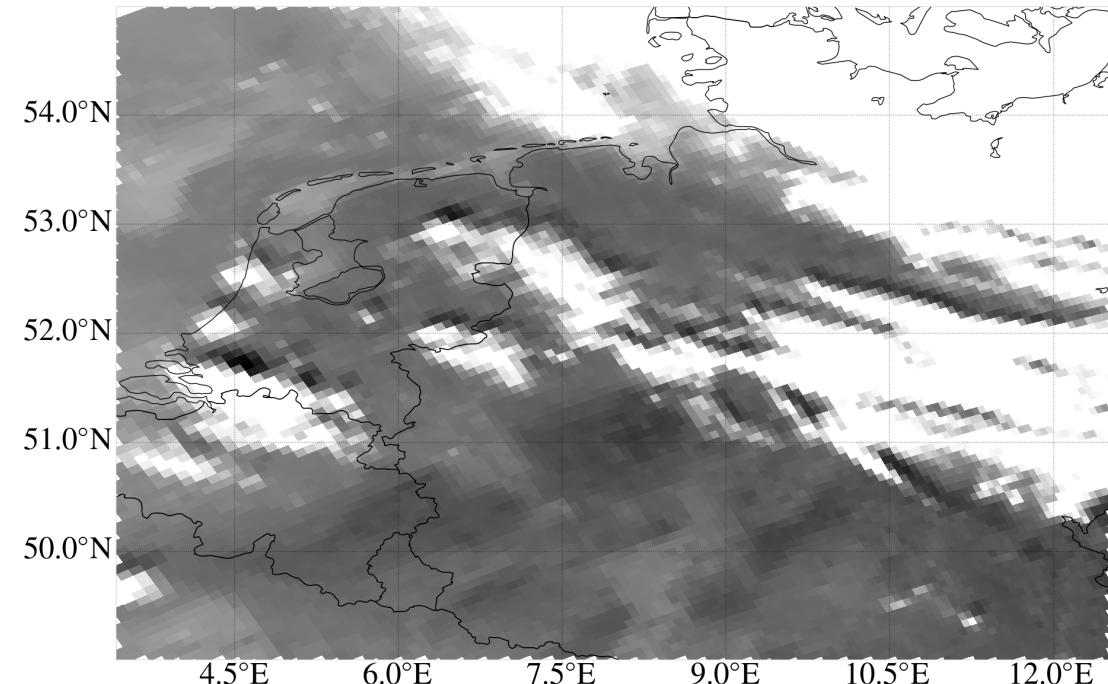
Cloud Shadow Detection with TROPOMI



Potential Cloud Shadow Flag (PCSF)



- potential cloud shadow flag (PCSF)
- cloud flag (CF)
- cloud- and shadow-free



scene albedo at $\lambda = 440$ nm [-]
0.00 0.05 0.10 0.15 0.20
Trees et al. (2021), submitted to AMT

Cloud Shadow Detection with TROPOMI



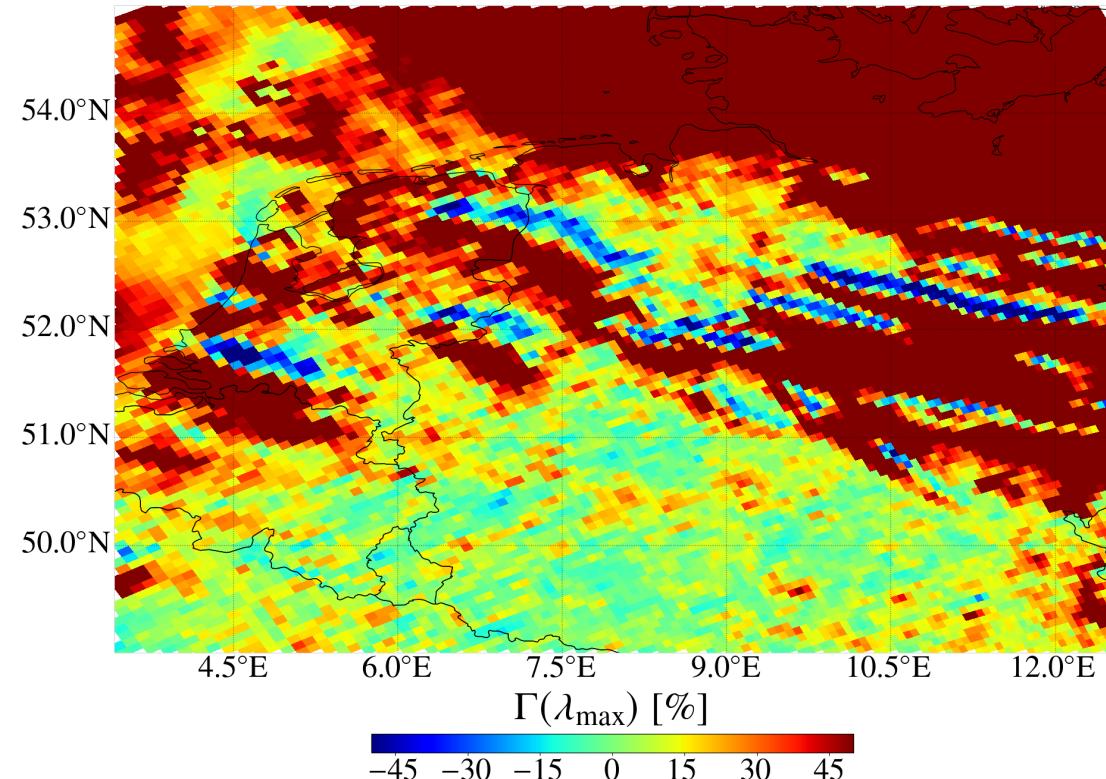
Actual Cloud Shadow Flag (ACSF)

$$\Gamma(\lambda) = \frac{A_{\text{scene}}(\lambda) - A_{\text{DLER}}(\lambda)}{A_{\text{DLER}}(\lambda)} \times 100\%$$

$$\lambda_{\max} = \underset{\lambda}{\operatorname{argmax}} \ A_{\text{DLER}}(\lambda)$$

Raise ACSF for:

$$\Gamma(\lambda_{\max}) < -15\%$$

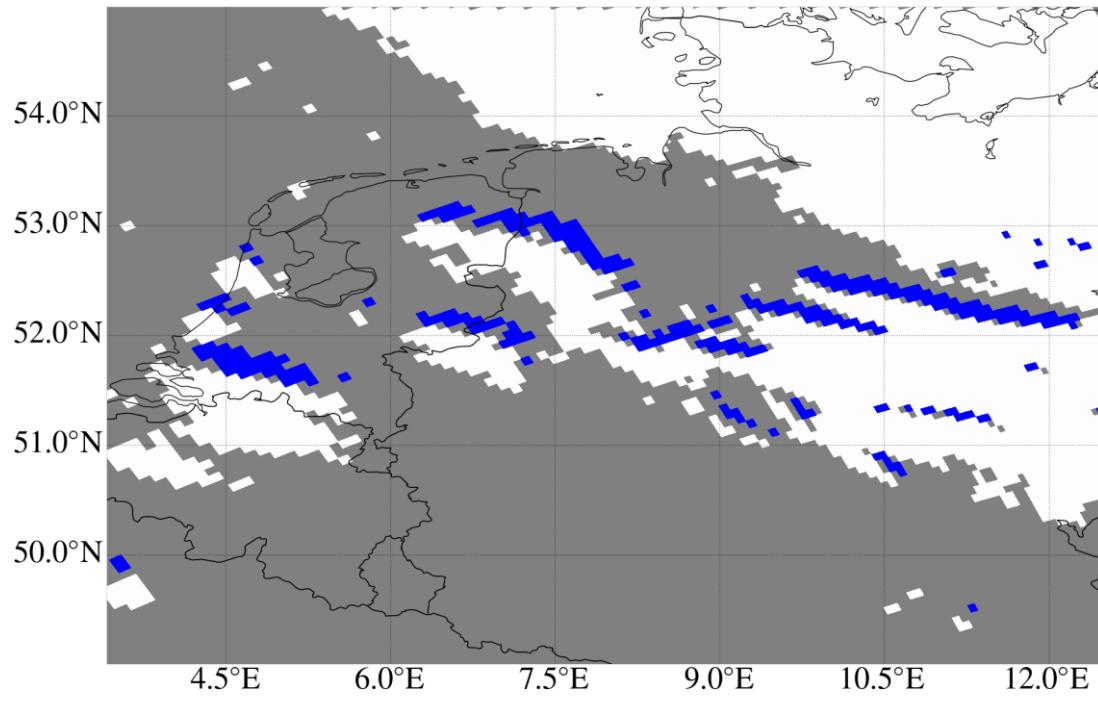


Trees et al. (2021), submitted to AMT

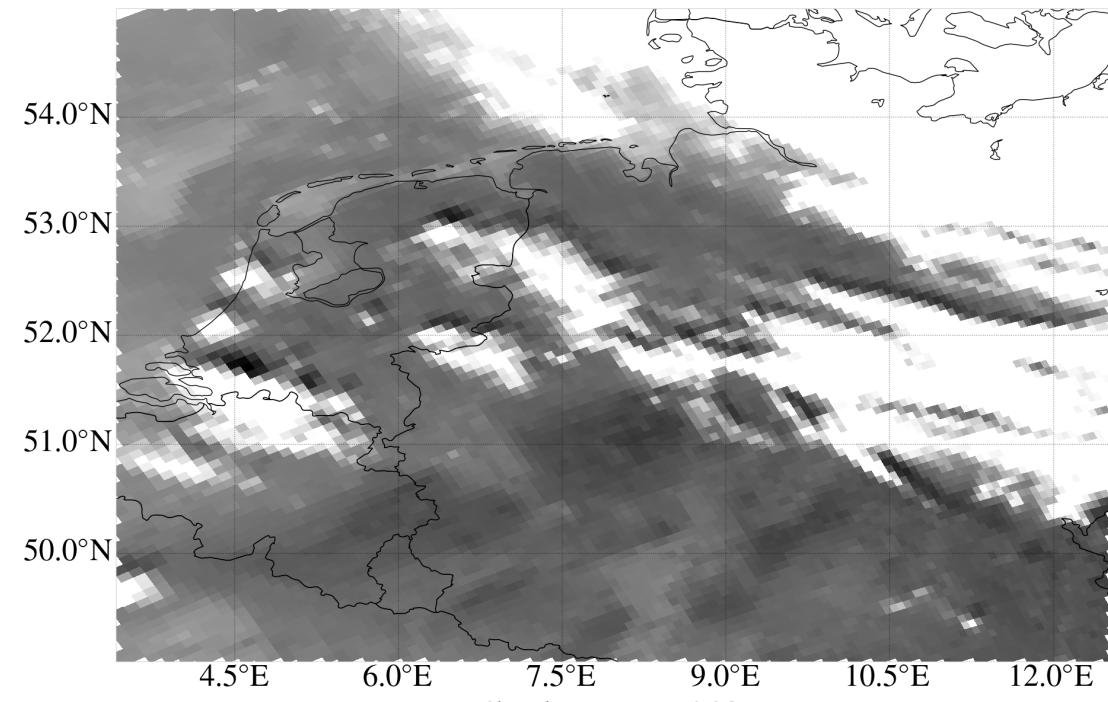
Cloud Shadow Detection with TROPOMI



Actual Cloud Shadow Flag (ACSF)



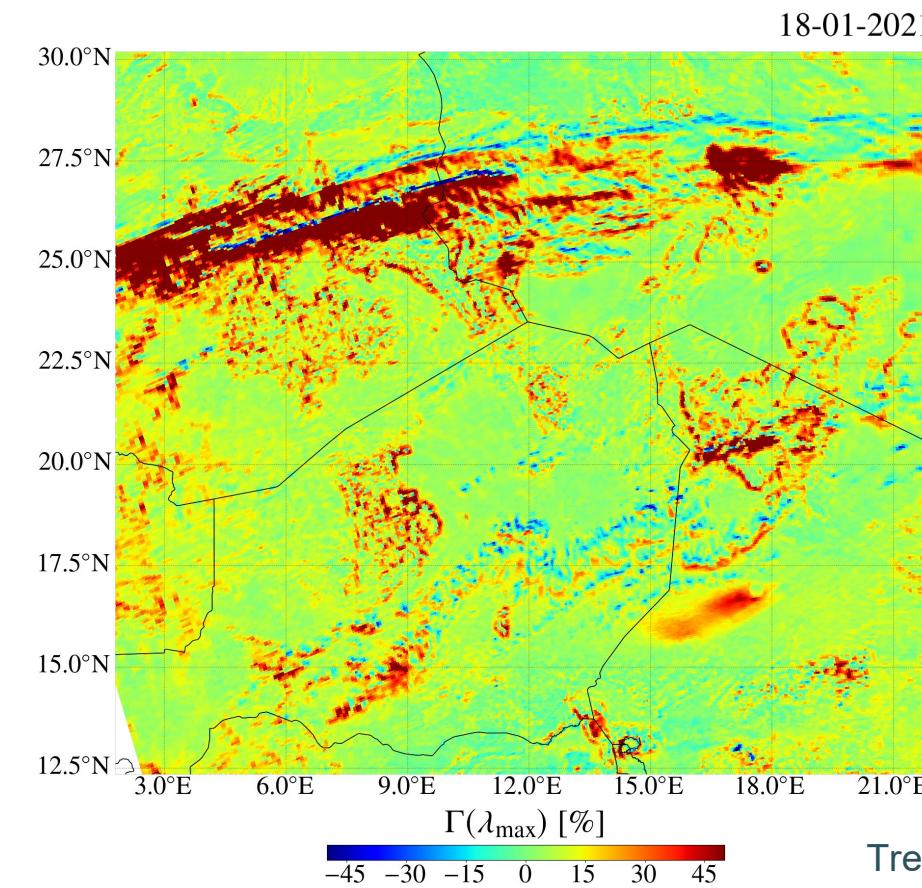
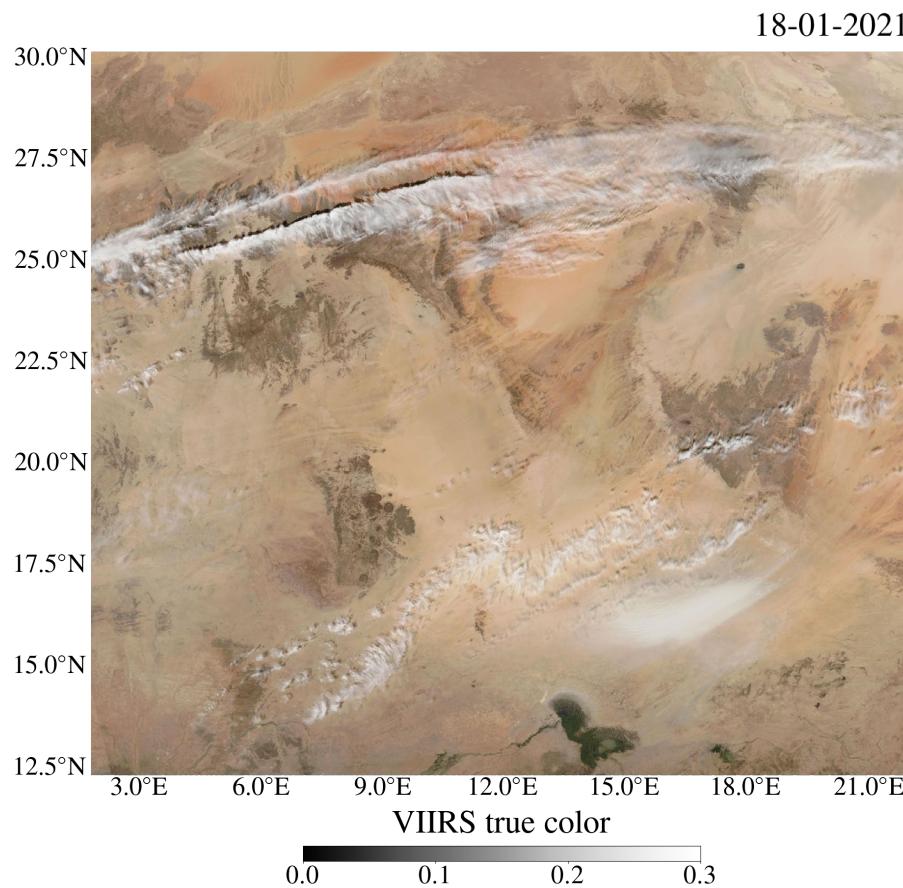
- actual cloud shadow flag (ACSF)
- cloud flag (CF)
- cloud- and shadow-free



scene albedo at $\lambda = 440$ nm [-]
0.00 0.05 0.10 0.15 0.20

Trees et al. (2021), submitted to AMT

Cloud Shadow Detection with TROPOMI

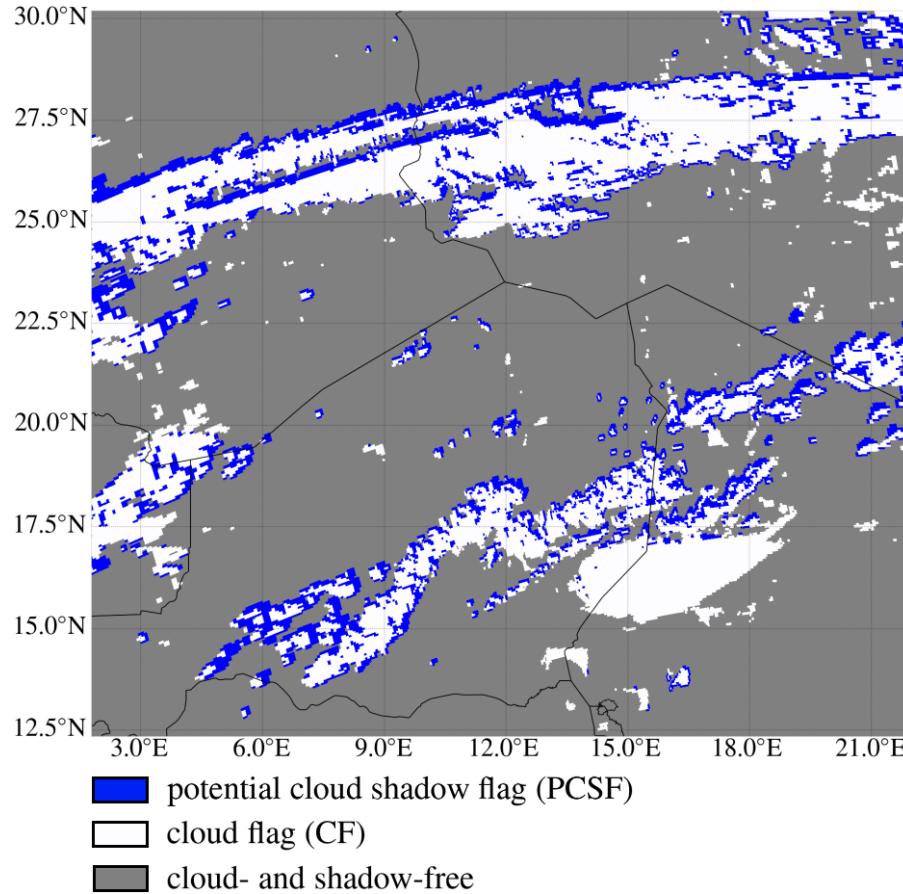


Trees et al. (2021),
submitted to AMT

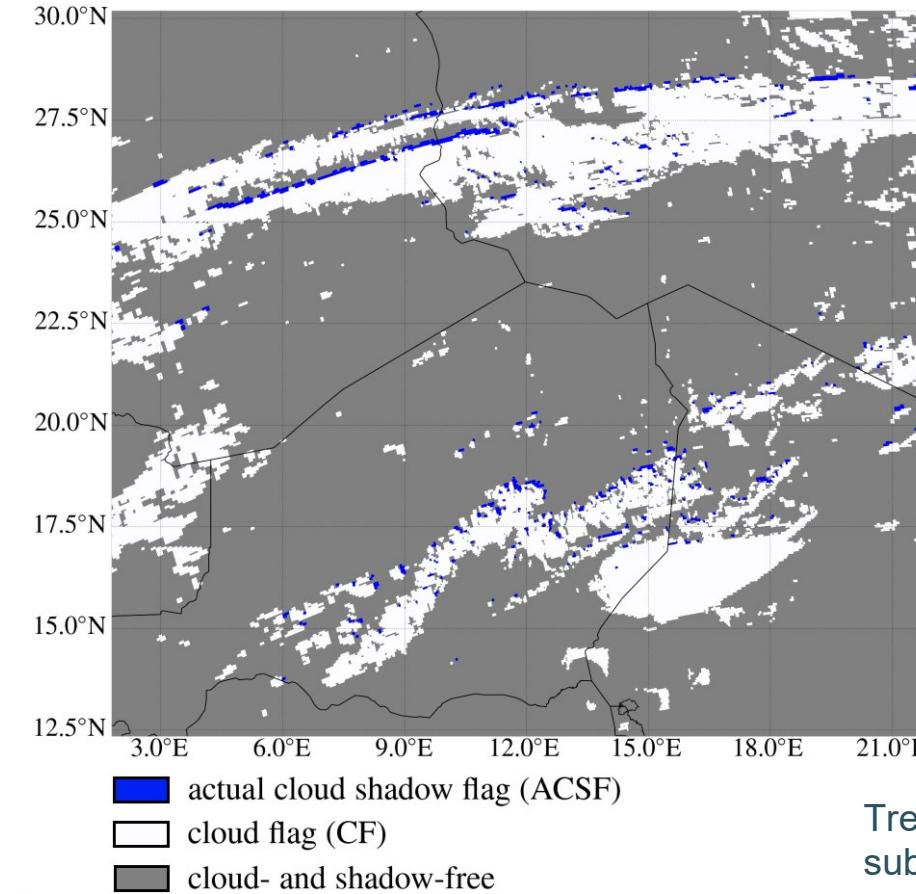
Cloud Shadow Detection with TROPOMI



Potential Cloud Shadow Flag (PCSF)



Actual Cloud Shadow Flag (ACSF)



Trees et al. (2021),
submitted to AMT

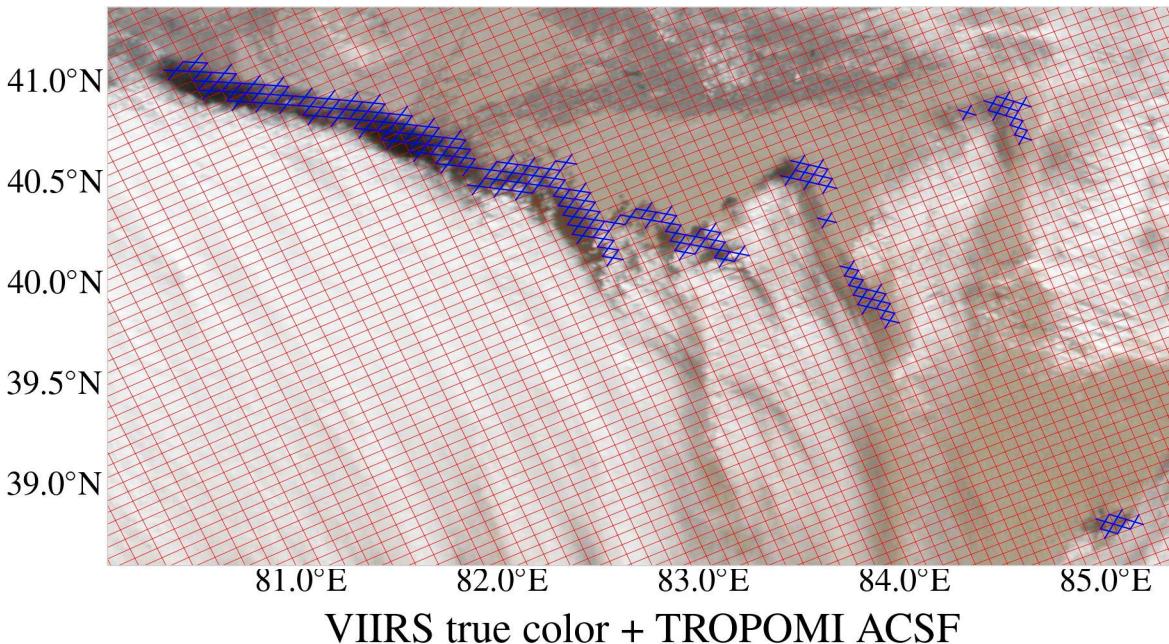
Cloud Shadow Detection with TROPOMI



Validation

F_1 score = 0.76

22-12-2019



$$\epsilon_C = \frac{N_{FP}}{N_{TP} + N_{FP}}$$

$$\epsilon_O = \frac{N_{FN}}{N_{TP} + N_{FN}}$$

$$F_1 \text{ score} = \frac{2(1 - \epsilon_C)(1 - \epsilon_O)}{(2 - \epsilon_C - \epsilon_O)}$$

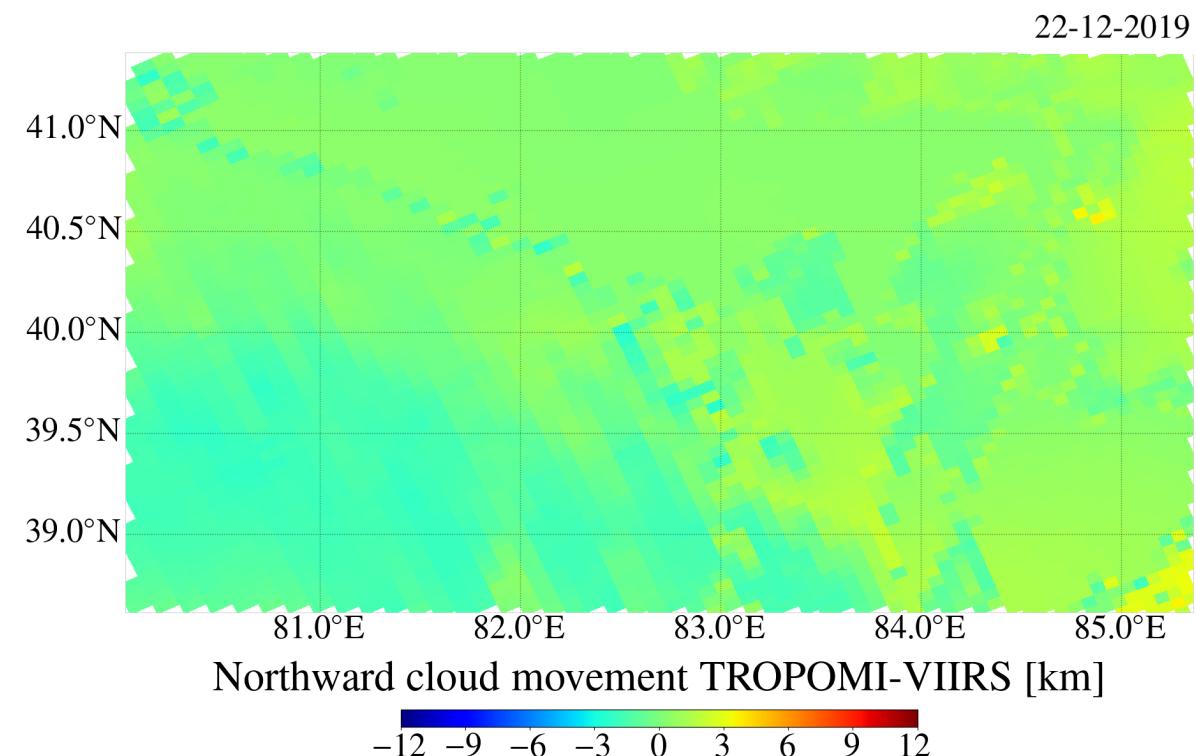
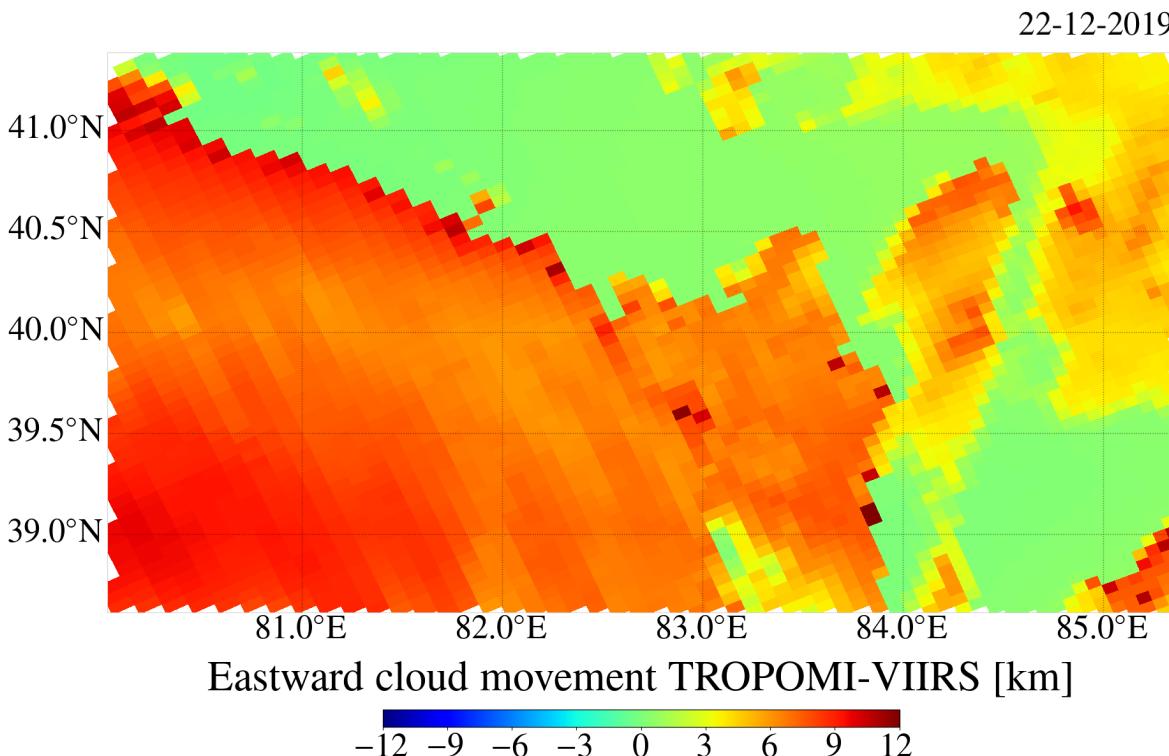
	VIIRS shadow	VIIRS no shadow
TROPOMI shadow	True positive (TP)	False positive (FP)
TROPOMI no shadow	False negative (FN)	True negative (TN)

Trees et al. (2021), submitted to AMT

Cloud Shadow Detection with TROPOMI



Validation



Trees et al. (2021), submitted to AMT

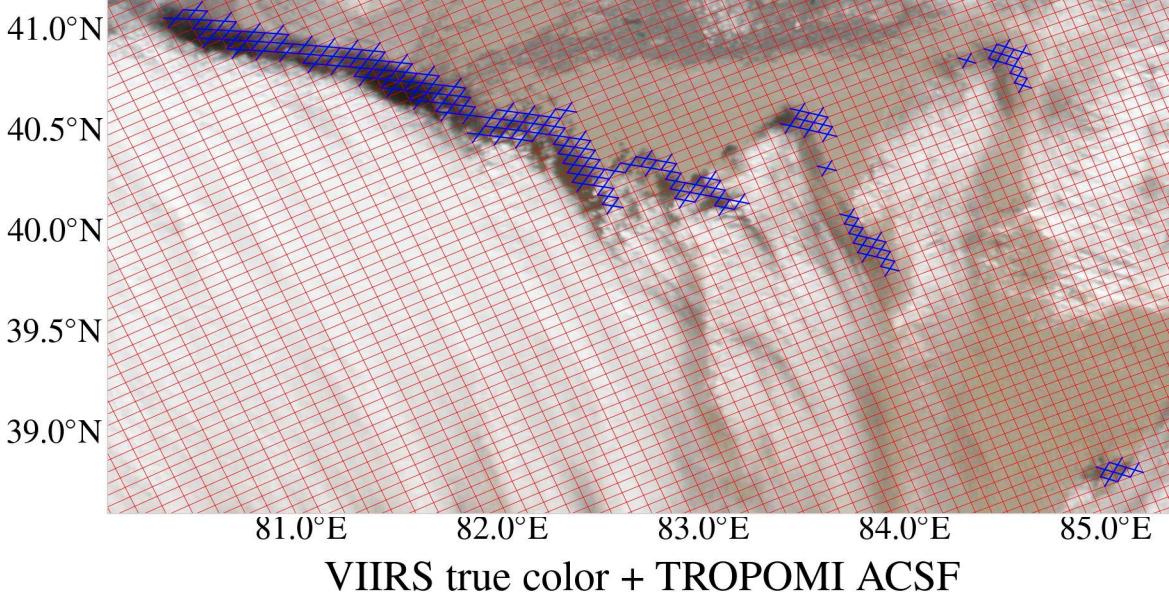
Cloud Shadow Detection with TROPOMI



Validation

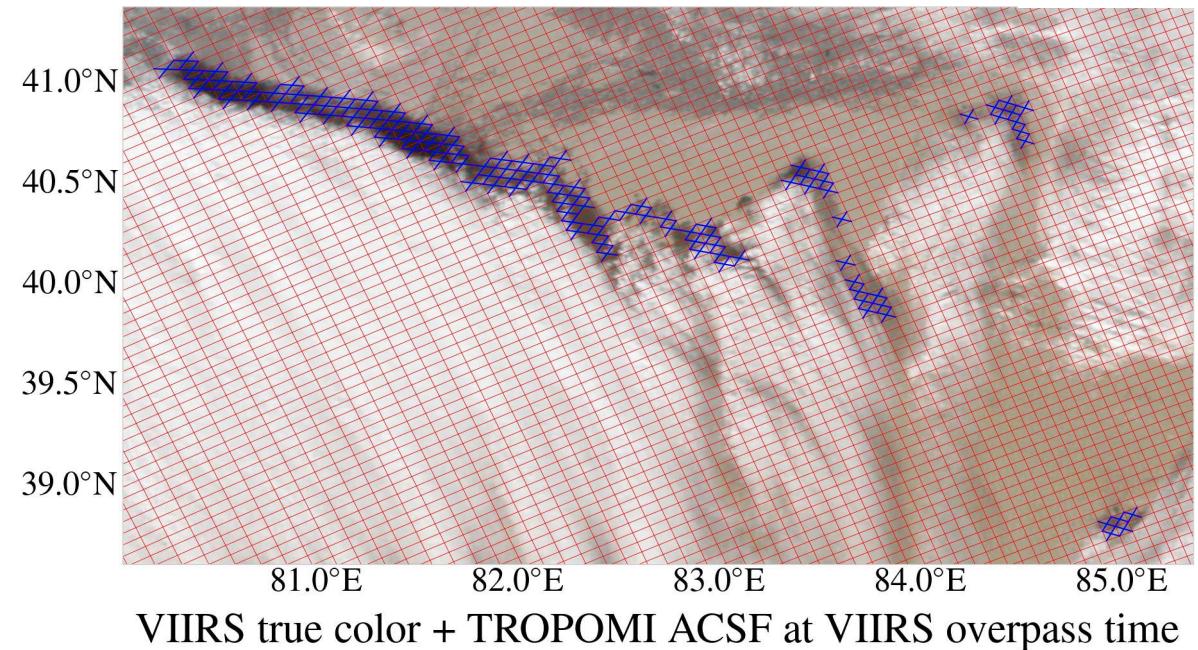
F_1 score = 0.76

22-12-2019



F_1 score = 0.95

22-12-2019



Trees et al. (2021), submitted to AMT

Cloud Shadow Detection with TROPOMI



Validation

Example	Coordinates	Date	Orbit	F_1 score ACSF
Southern Chile and Argentina	53.528-49.626 °S 73.047-62.418 °W	03-08-2019	9355	0.94
The Netherlands and Germany	49.004-54.991 °N 3.4119-12.5062 °E	18-11-2018	5690	0.90
Sahara desert, North Africa	24.802-27.400 °N 3.506 - 12.011 °E	18-01-2021	16927	0.84
Taklamakan desert, China	36.500-43.000 °N 76.000-88.000 °E	22-12-2019	11348	0.95
The Netherlands, Belgium and Luxembourg	48.995-55.004 °N 2.000-8.000 °E	09-10-2018	5123	0.86
Taklamakan desert, China	37.006-42.005 °N 80.005-88.007 °E	21-12-2020	16527	0.88

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Cloud Shadow Detection with TROPOMI



We suggest

- using the DARCLOS **Potential** Cloud Shadow Flag (PCSF) to **remove** cloud shadow contamination from TROPOMI data.
- using the DARCLOS **Actual** Cloud Shadow Flag (ACSF) to further **analyze** cloud shadow effects on TROPOMI data.

Lesson:

TROPOMI cloud shadow validation with VIIRS images is limited by cloud motion and cloud evolution during the TROPOMI-VIIRS measurement time difference.