Sentinel-2 Level-2 processing: Regional distribution of Sen2Cor performance for AOT and SR retrieval over Europe

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Sen2Cor performance for AOT and SR retrieval over Europe

1. Sen2Cor processing chain
2. Data and test sites
3. AOT retrieval performance — relative to reference data from AERONET
4. SR retrieval performance — relative to pseudo-reference data
5. Conclusions

External links and references:

- L2A core products available on OpenHub:
  - https://scihub.copernicus.eu/dhus/
- Sen2Cor for 'user' processing available at:
  - http://step.esa.int/main/third-party-plugins-2/sen2cor/
- Monthly Sentinel-2 L2A Data Quality Report available at:
  - https://sentinels.copernicus.eu/documents/247904/685211/Sentinel-2-L2A-Data-Quality-Report/

Sen2Cor processing chain

Level-1C

CCI-data

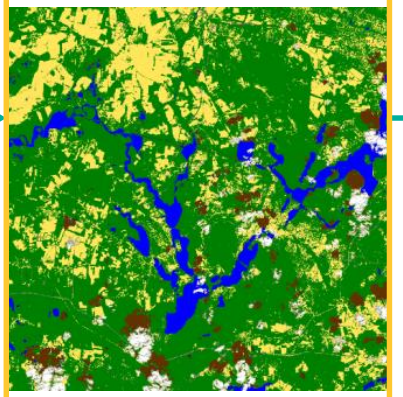
DEM

Radiative Transfer LUT (libRadtran)

optional

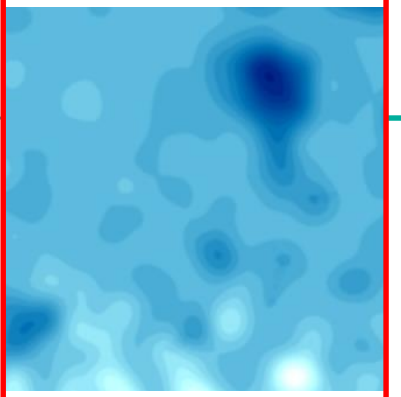
Cirrus Correction

Scene Classification (11 classes) (20m)



series of threshold tests on L1C spectral bands, band ratios and indices

AOT Retrieval (20m)

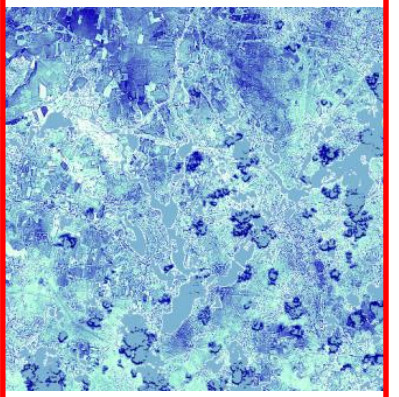


DDV-algorithm
Fall-back:
CAMS data

- terrain correction
- adjacency corr.
- BRDF correction

TOA to BOA conversion

Water Vapour Retrieval (20m)



Atmospheric Pre-corrected Differential Absorption Algorithm (APDA)

Level-2A

10m:
- 4 bands
- AOT, WV maps

20m (60m):
- 9 (11) bands
- SCL, AOT, WV
- cloud probability
- snow probability

Data and test sites

- S2 L1C-products over AERONET sites downloaded from SciHub
- User processing with Sen2Cor 2.80 + CAMS fallback
  (default configuration: SUMMER_RURAL_PlanetDEM90_terrainON_OzoneFromMetadata_cirrusFALSE)
- Site selection:
  - 30 (21) AERONET locations with longest operation time in year **2020**
- Data selection: all products
  - with AERONET data available (level ≥ 1.5)
  - within ±15 min to S2-overpass time
  - still no other data quality check

Data and test sites

Site name	Country	Lat [°N]	Lon [°E]	No.	AOT [min; median; max]	WV [min; median; max]	
Kuopio	Finland	62.892	27.634	20	[0.03; 0.07; 0.21]	[0.2; 0.9; 2.6] g/cm²	Ploar climate
Narsarsuaq	Denmark	61.156	-45.419	35	[0.03; 0.04; 0.09]	[0.1; 0.6; 1.9] g/cm²	
Helsinki	Finland	60.204	24.961	26	[0.03; 0.05; 0.24]	[0.2; 1.3; 3.0] g/cm²	
Lerwick_MO	UK	60.139	-1.185	9	[0.03; 0.07; 0.10]	[0.4; 1.1; 1.6] g/cm²	
Birkenes	Norway	58.388	8.252	15	[0.00; 0.05; 0.24]	[0.4; 1.2; 2.1] g/cm²	Temperate climate
Glasgow_MO	UK	55.907	-4.531	11	[0.05; 0.10; 0.24]	[0.7; 1.0; 2.6] g/cm²	
Minsk	Belarus	53.920	27.601	21	[0.05; 0.10; 0.27]	[0.3; 0.8; 3.2] g/cm²	
Belsk	Poland	51.837	20.792	31	[0.06; 0.12; 0.26]	[0.3; 1.3; 3.5] g/cm²	
Bayfordbury	UK	-0.096	51.776	23	[0.05; 0.11; 0.39]	[0.7; 1.3; 3.4] g/cm²	
Leipzig	Germany	12.435	51.353	43	[0.03; 0.08; 0.35]	[0.2; 1.3; 3.1] g/cm²	
Dunkerque	France	2.368	51.035	24	[0.05; 0.13; 0.36]	[0.3; 1.4; 3.5] g/cm²	

Data and test sites

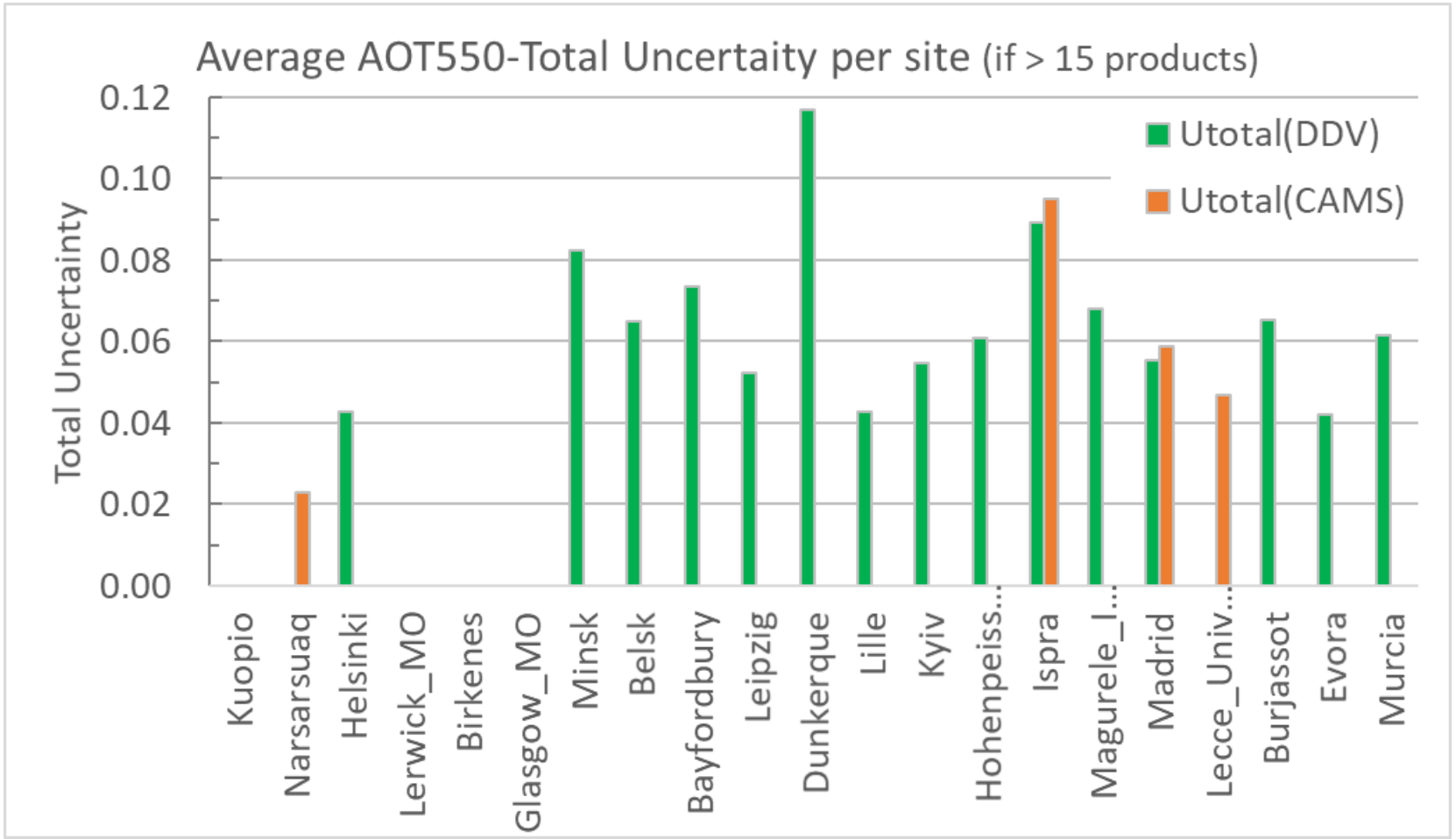
Site name	Country	Lat [°N]	Lon [°E]	No.	AOT [min; median; max]	WV [min; median; max]	
Lille	France	50.612	3.142	26	[0.05; 0.10; 0.22]	[0.3; 1.2; 3.7] g/cm²	Temperate
Kyiv	Ukraine	50.364	30.497	24	[0.04; 0.11; 0.30]	[0.2; 1.6; 2.9] g/cm²	
HohenpeissenbergDWD	Germany	47.802	11.012	47	[0.01; 0.08; 0.30]	[0.2; 0.9; 2.4] g/cm²	
Ispra	Italy	45.803	8.627	45	[0.01; 0.13; 0. 40]	[0.4; 1.4; 4.0] g/cm²	
Magurele_Inoe	Romania	44.348	26.031	34	[0.04; 0.12; 0.29]	[0.3; 1.7; 3.3] g/cm²	Midlatitude North
Madrid	Spain	40.452	-3.724	63	[0.02; 0.08; 0.69]	[0.4; 1.4; 2.4] g/cm²	
Lecce_University	Italy	40.335	18.111	34	[0.06; 0.10; 0.31]	[0.7; 1.7; 3.6] g/cm²	
Burjassot	Spain	39.507	-0.420	40	[0.02; 0.06; 0.24]	[0.4; 1.6; 3.2] g/cm²	
Evora	Portugal	38.568	-7.912	30	[0.03; 0.07; 0.20]	[0.7; 1.4; 2.9] g/cm²	
Murcia	Spain	38.001	-1.171	36	[0.02; 0.07; 0.23]	[0.4; 1.8; 3.7] g/cm²	

Performance metrics applied

- Specifications [Monthly Sentinel-2 L2A Data Quality Report]
  - $|\Delta AOT| \leq 0.1*AOT_{ref} + 0.03$
  - $|\Delta WV| \leq 0.1*WV_{ref} + 0.2$
  - $|\Delta SR| \leq 0.05*SR_{ref} + 0.005$

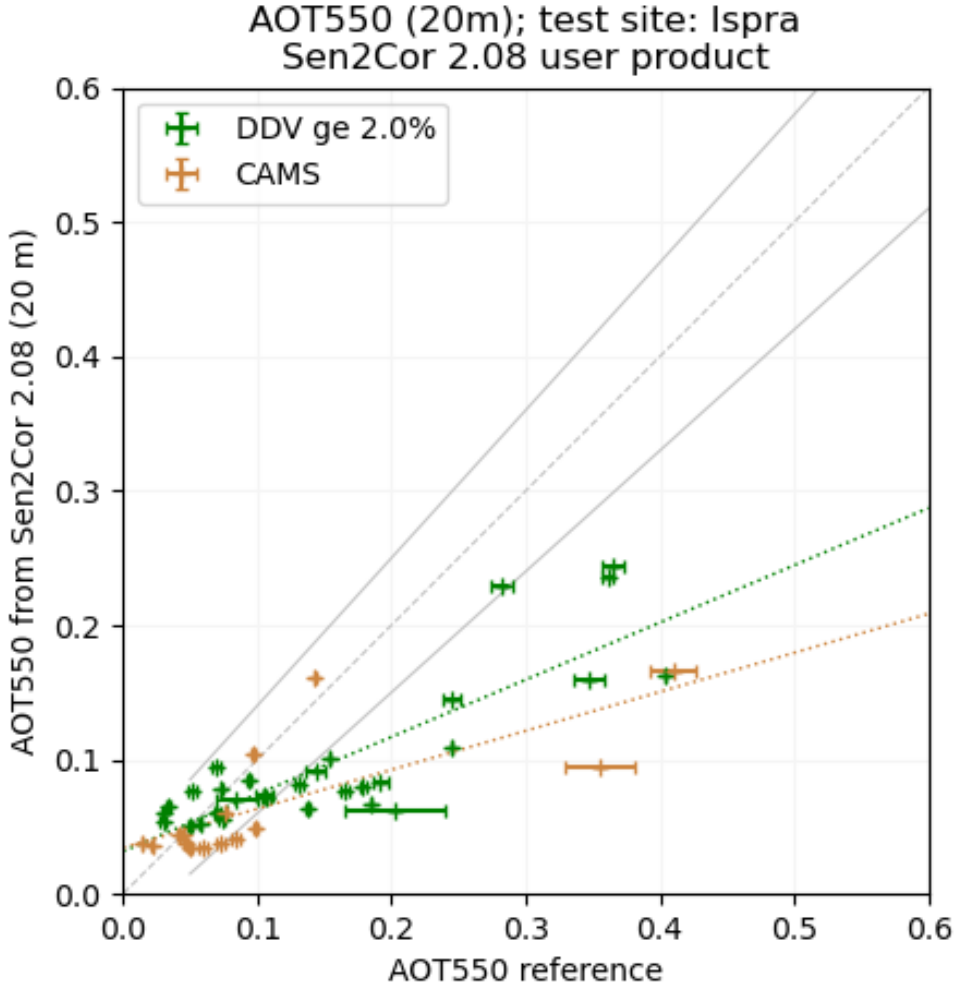
- with $\Delta X = X_{Sen2Cor} - X_{reference}$ and $X = \{AOT, WV, SR\}$
  - Systematic uncertainty: $U_{sys} = \frac{1}{n}\left(\sum_{i=1}^{n} \Delta X\right)$ (Accuracy)
  - Random uncertainty: $U_{random} = \sqrt{\frac{1}{n-1}\left(\sum_{1}^{n} \Delta X - U_{sys}\right)^2}$ (Precision)
  - Total uncertainty: $U_{total} = \sqrt{\frac{1}{n}\sum_{1}^{n}(\Delta X)^2}$ (Uncertainty)

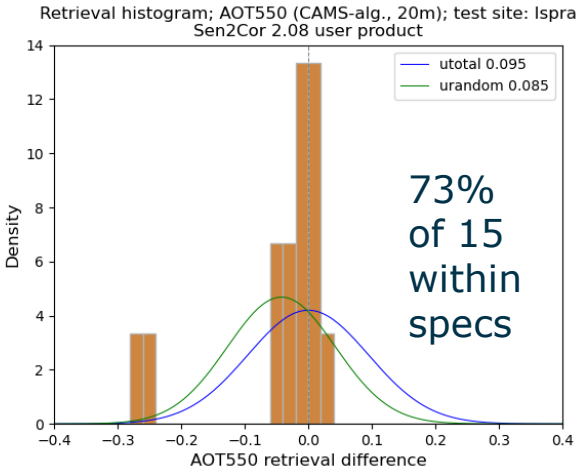
Aerosol Optical Thickness at 550 nm (AOT) retrieval performance

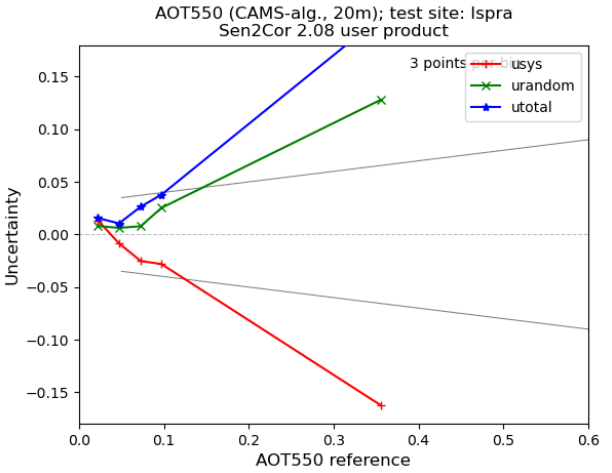


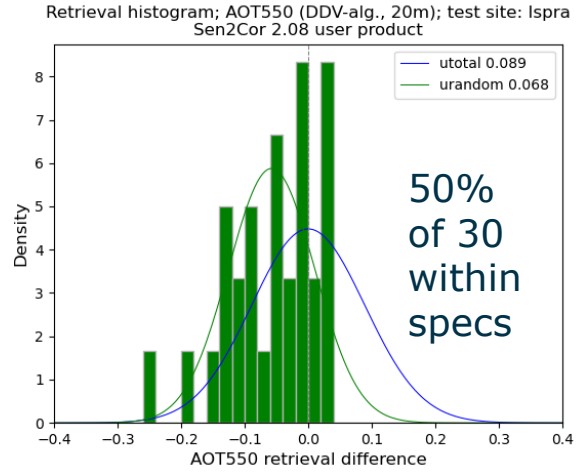
Within specs	DDV	CAMS
Narsarsuaq		90%
Helsinki	**86%**	
Minsk	53%	
Belsk	54%	
Bayfordbury	42%	
Leipzig	69%	
Dunkerque	50%	
Lille	70%	
Kyiv	65%	
Hohenpeissenb.	80%	
Ispra	50%	73%
Madrid	46%	71%
Burjassot	**24%**	

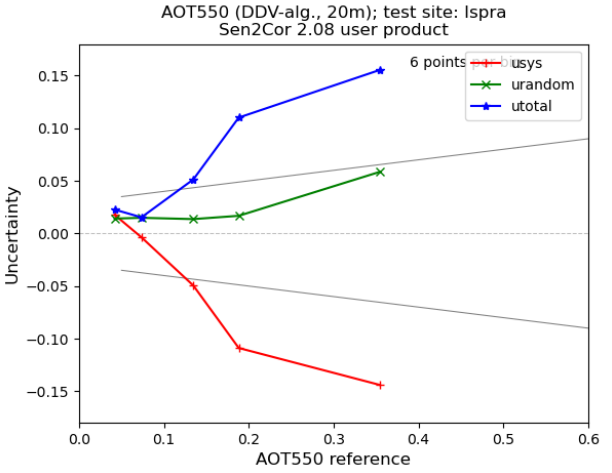
Aerosol Optical Thickness at 550 nm (AOT) retrieval performance, ISPRA





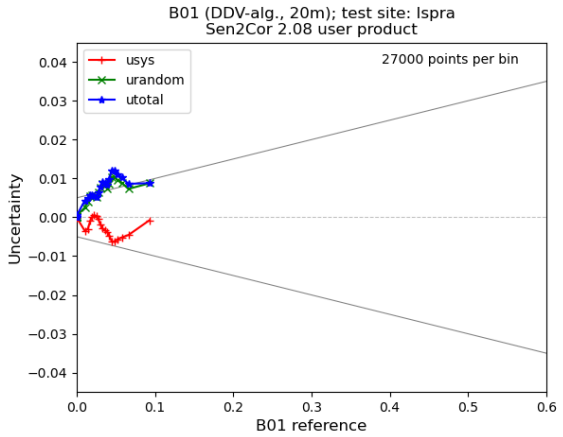


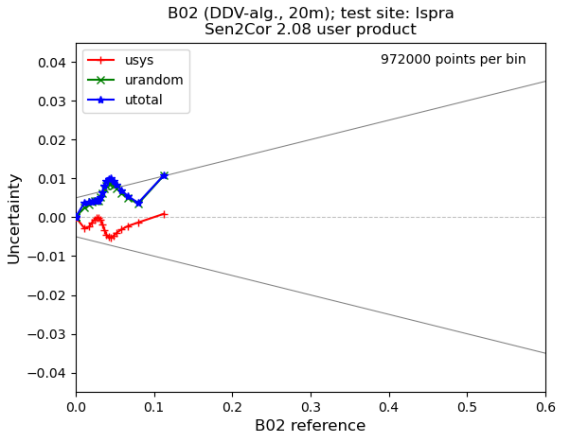


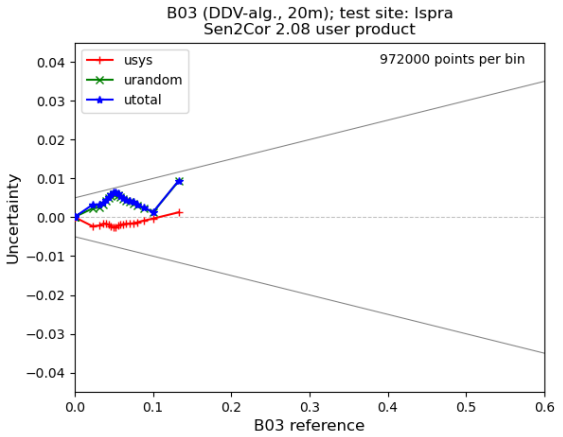


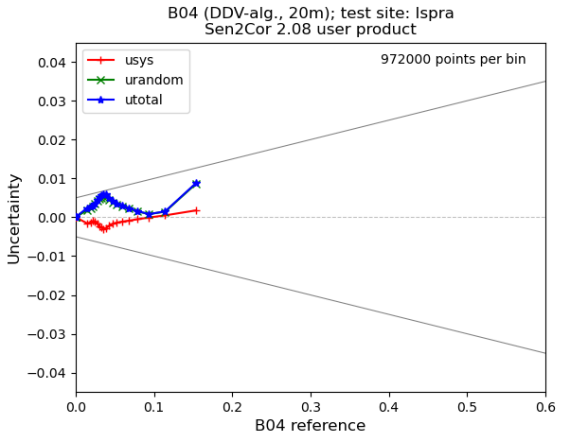
Surface reflectance (SR) retrieval performance, ISPRA, rel. to pseudo reference data

DDV

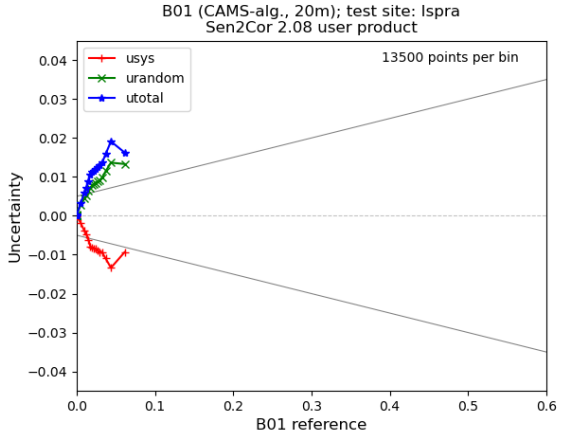


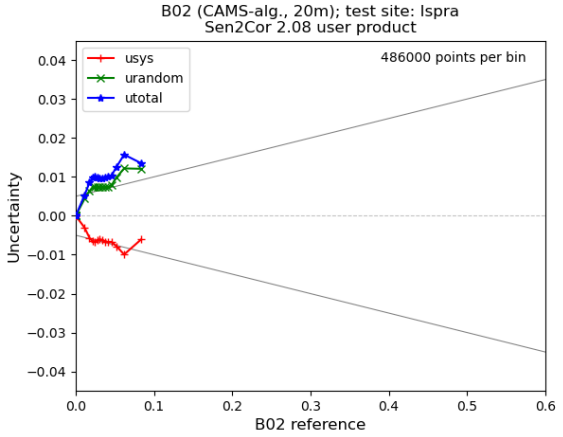


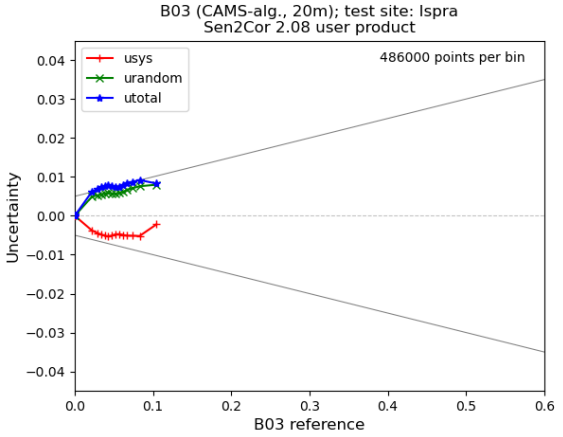


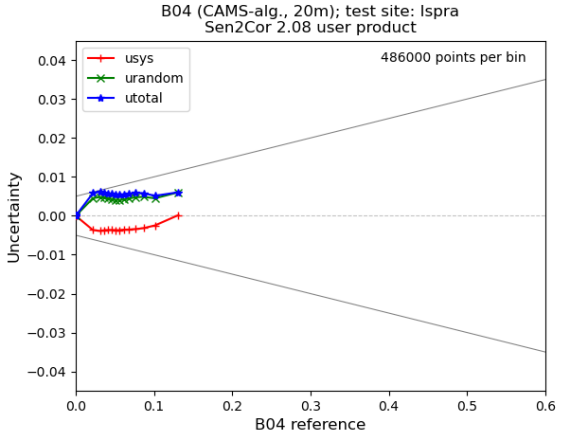


CAMS





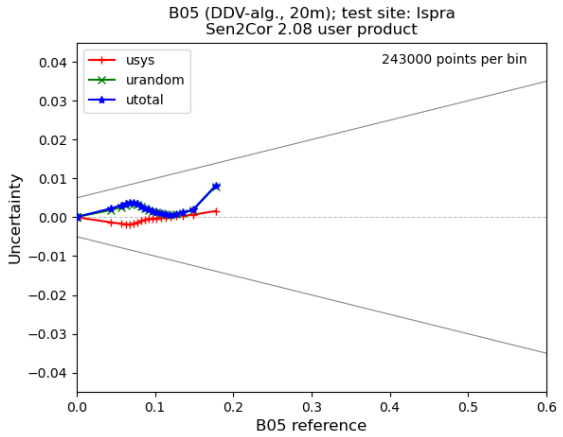


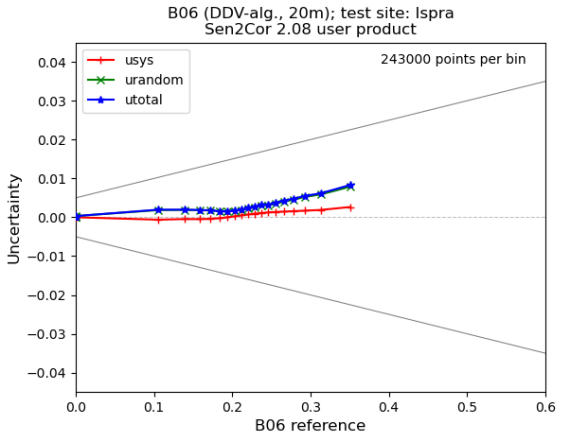


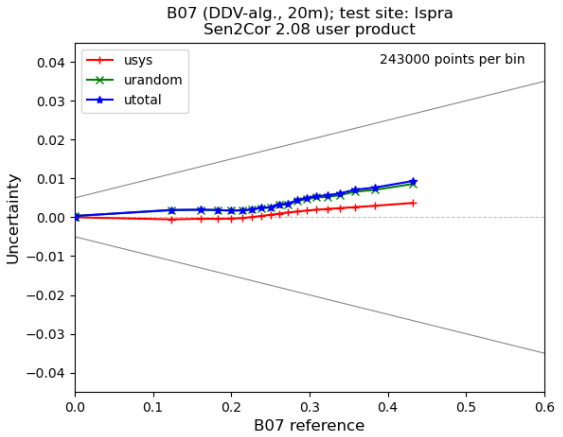
B01 B02 B03 B04

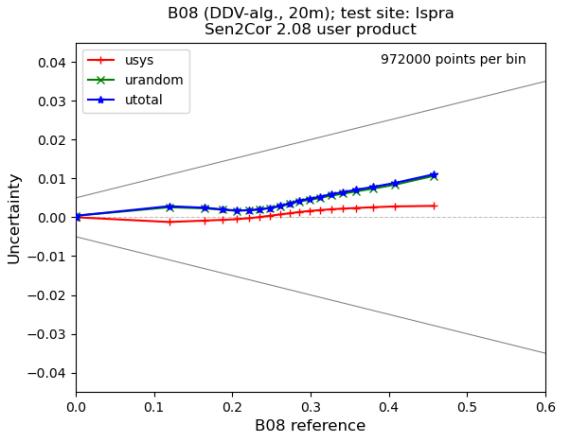
Surface reflectance (SR) retrieval performance, ISPRA, rel. to pseudo reference data

DDV

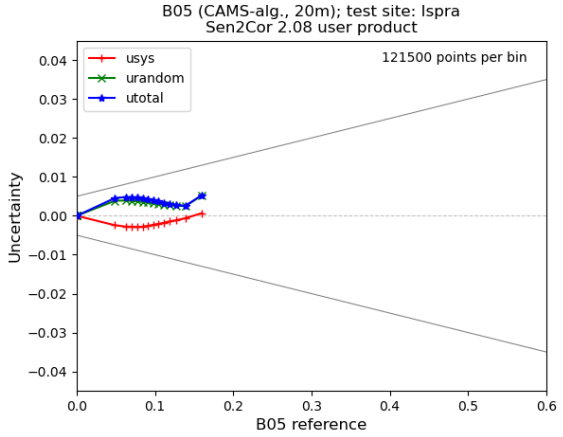


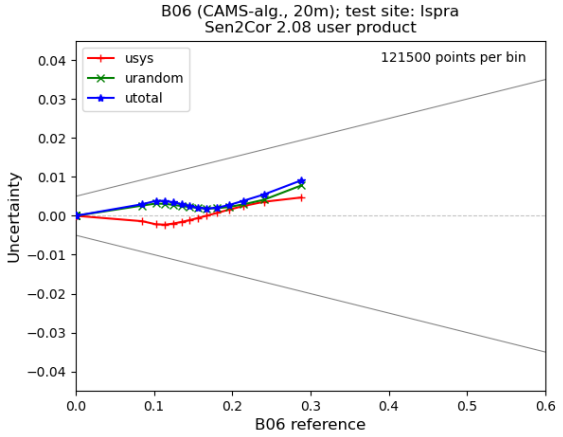


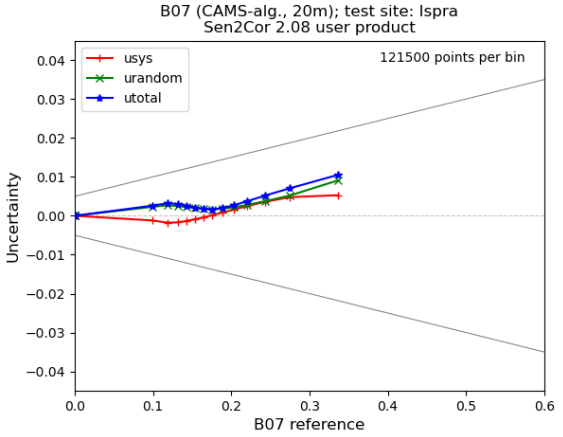


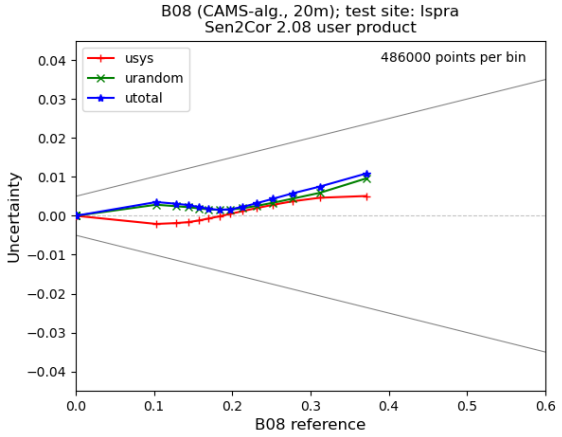


CAMS





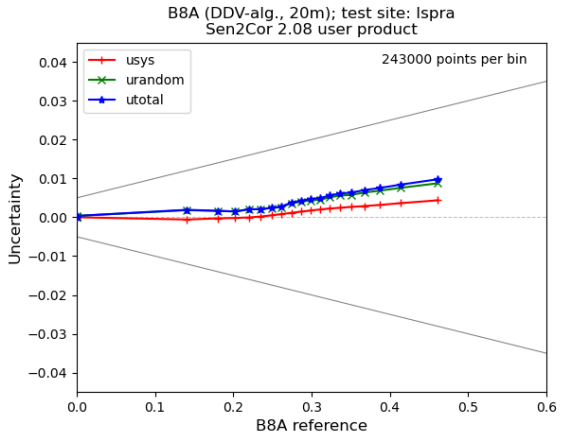


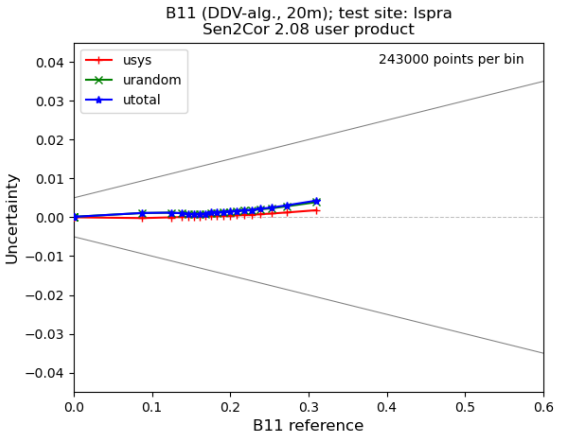


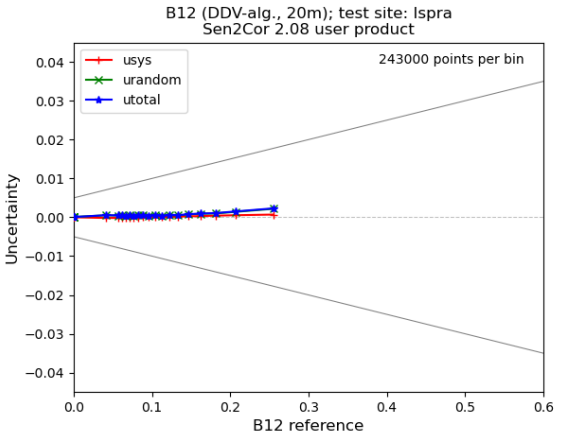
B05 B06 B07 B08

Surface reflectance (SR) retrieval performance, ISPRA, rel. to pseudo reference data

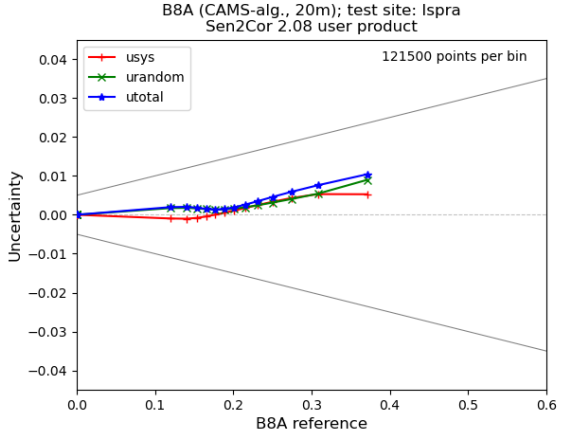
DDV

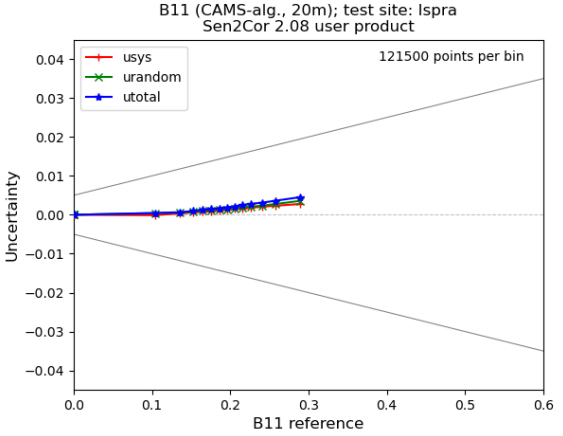


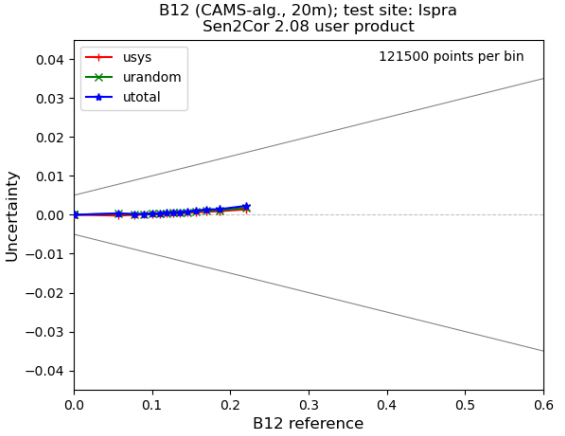




CAMS







B08A B11 B12

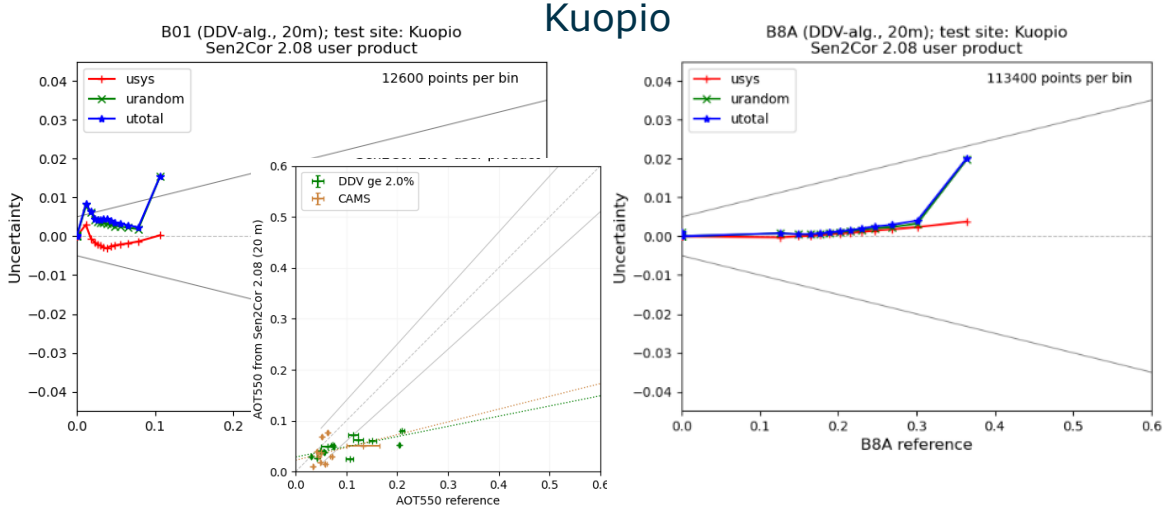
Surface reflectance (SR) retrieval performance, Polar, rel. to pseudo reference data

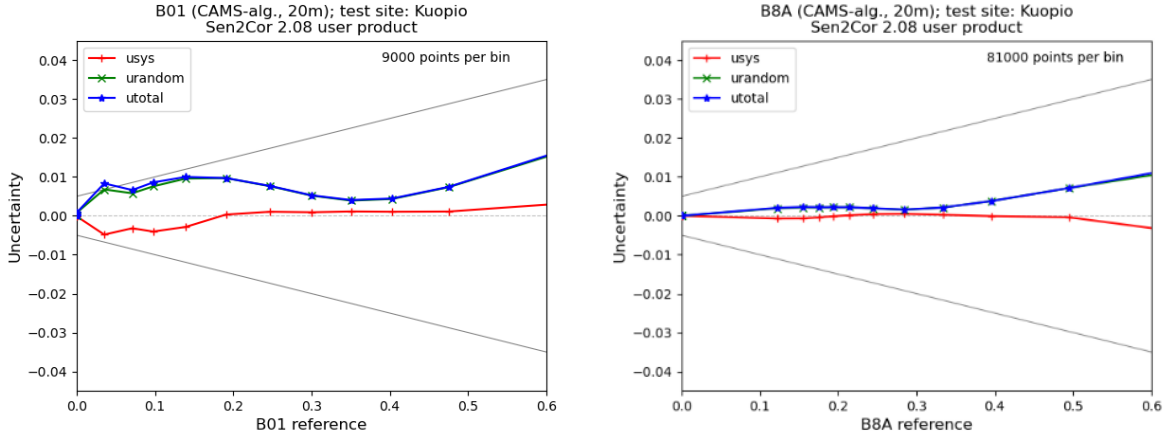
Kuopio

Narsarsuaq

DDV

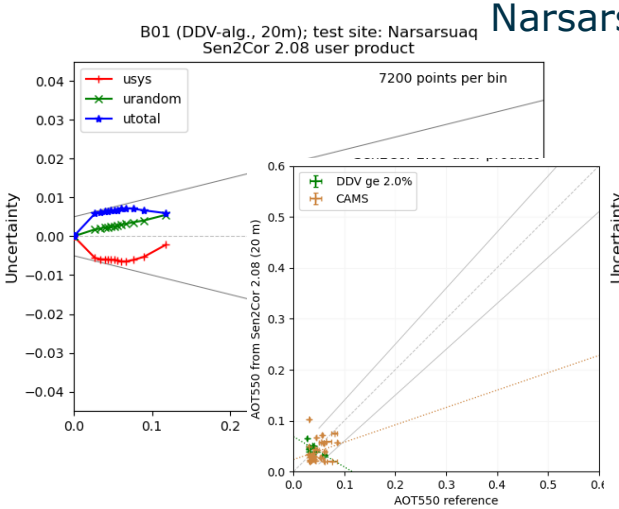
CAMS

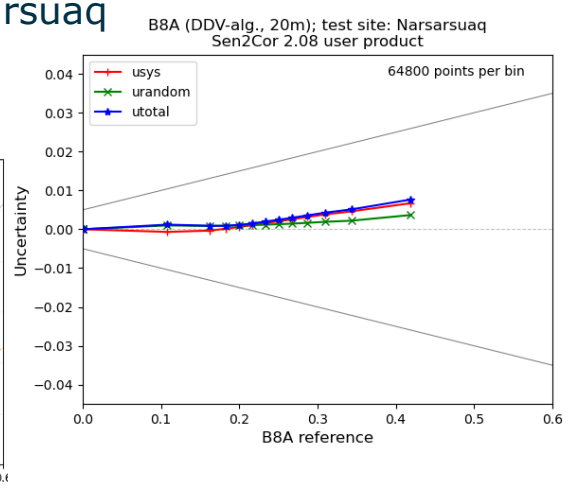


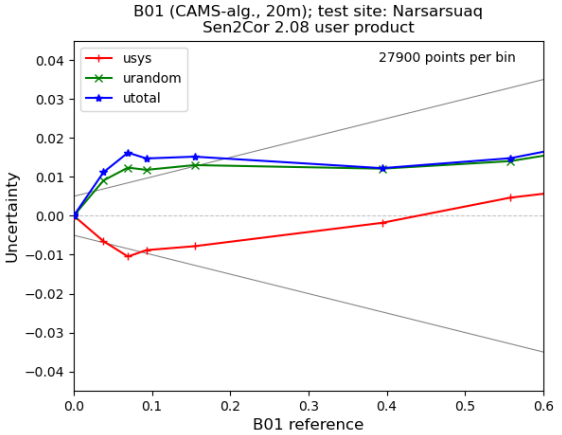


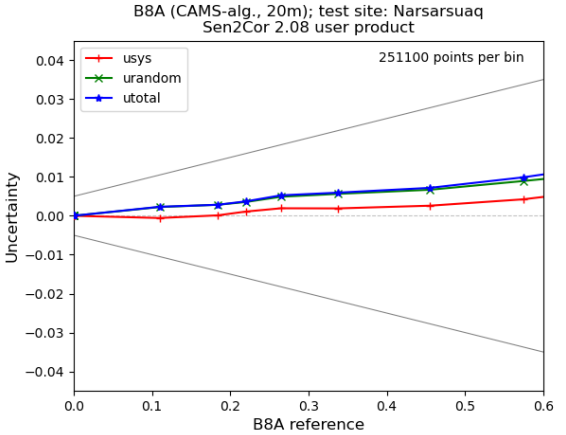
B01

B08A









B01

B08A

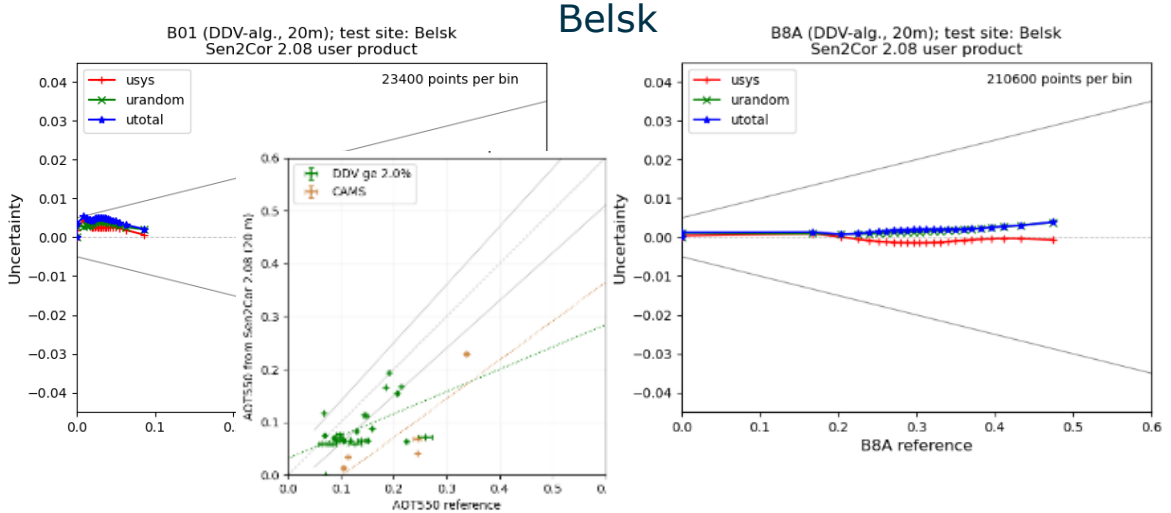
Surface reflectance (SR) retrieval performance, Temperate, rel. to pseudo ref.data

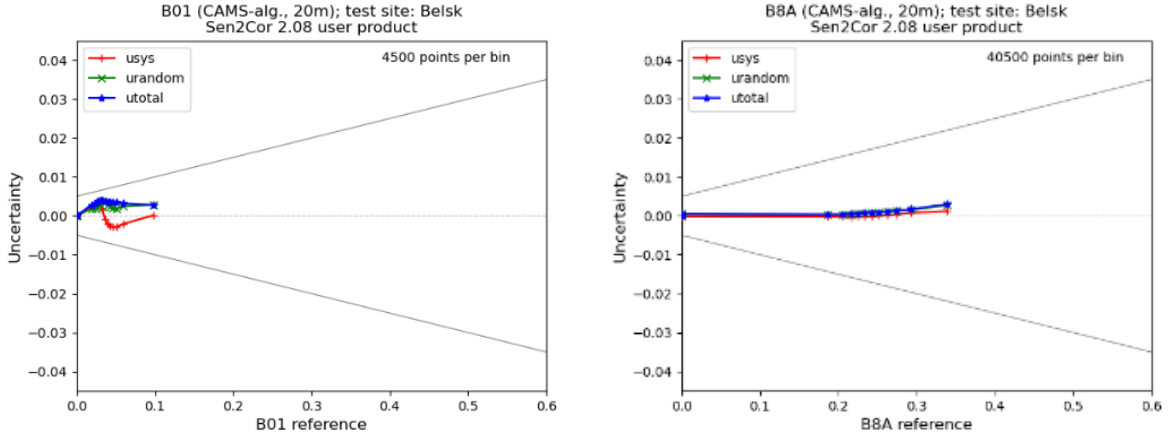
Belsk

Leipzig

DDV

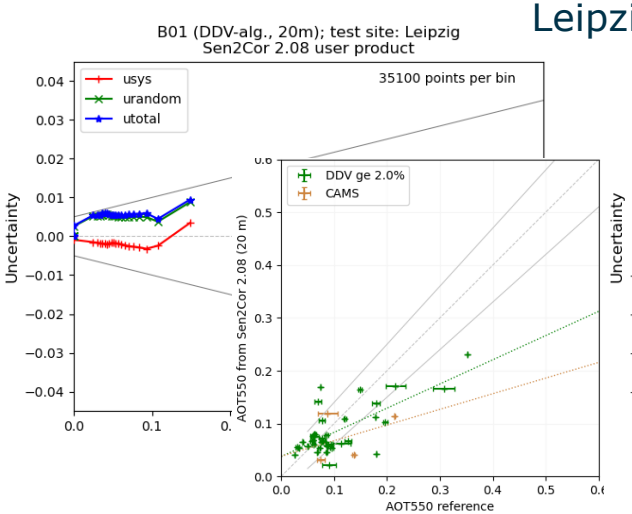
CAMS

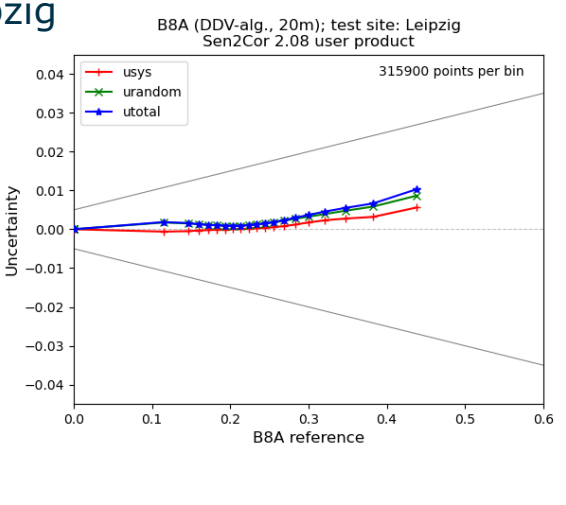


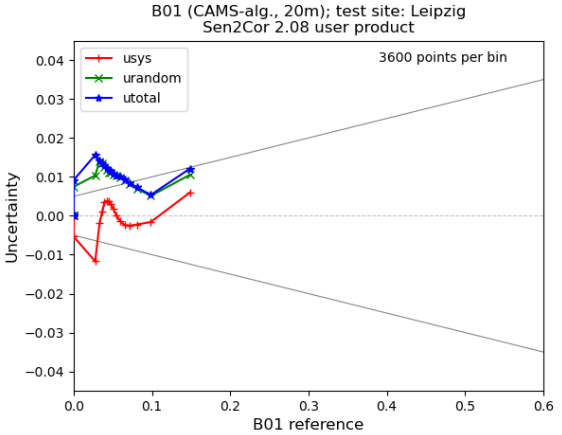


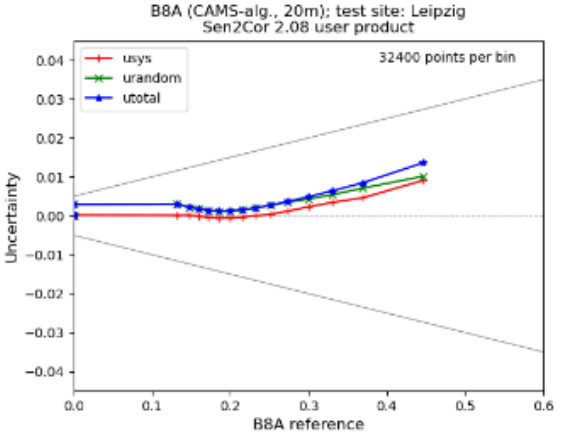
B01

B08A









B01

B08A

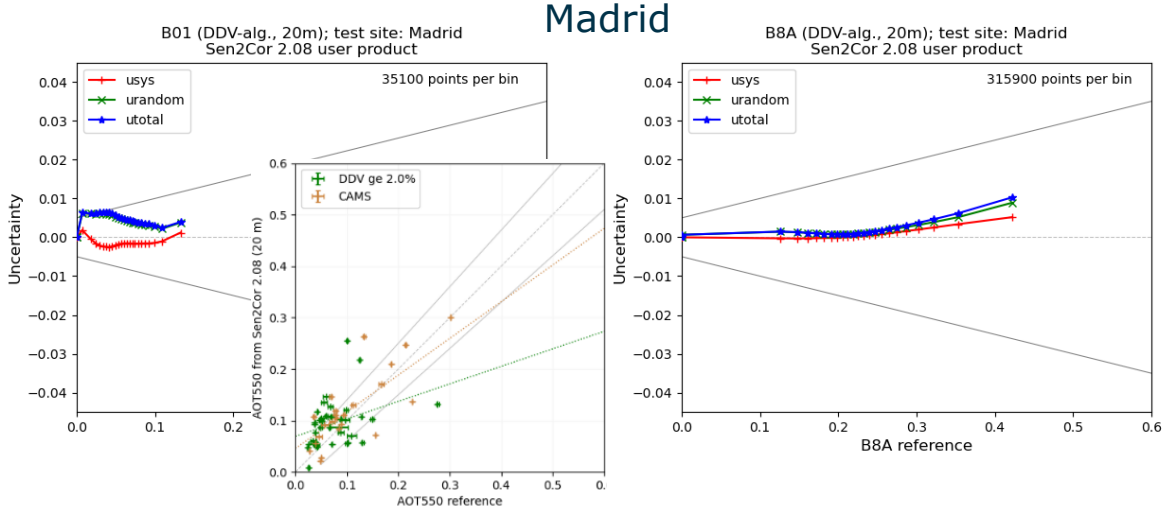
Surface reflectance (SR) retrieval performance, Midlat. N, rel. to pseudo ref.data

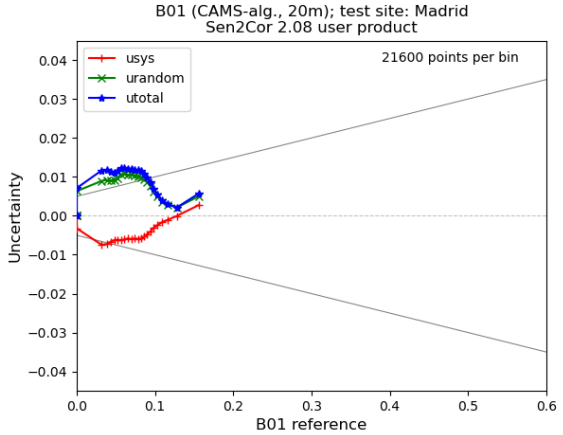
Madrid

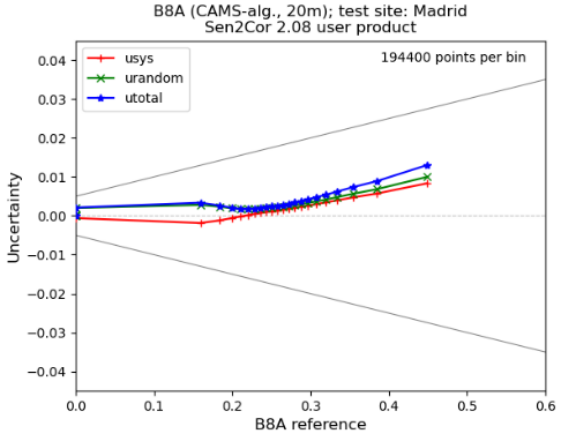
Burjassot

DDV

CAMS

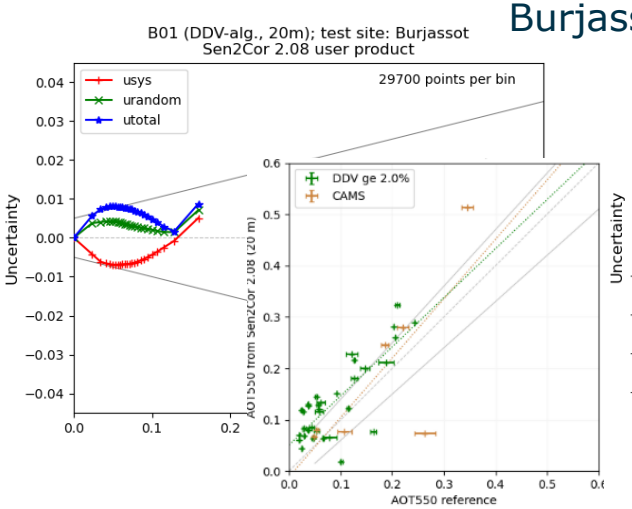


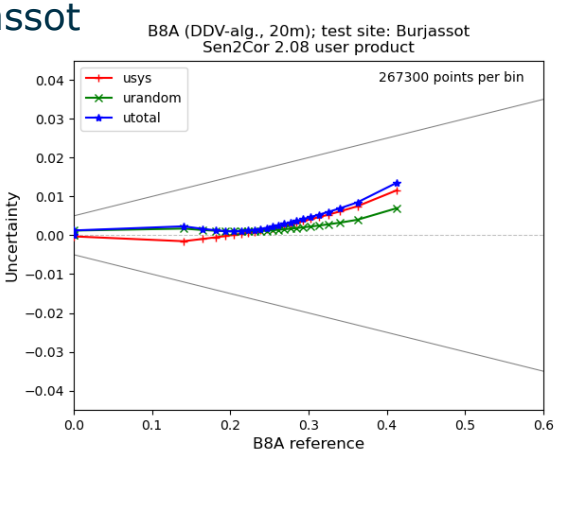


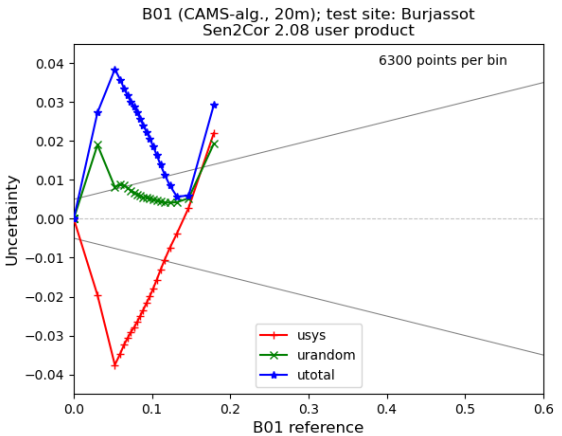


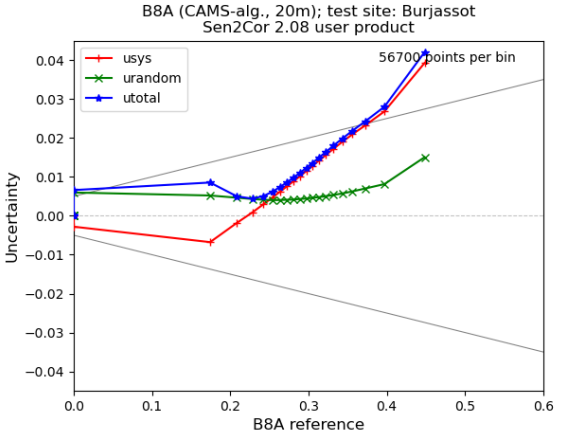
B01

B08A









B03

B08A

Conclusions

- Good Sen2Cor performance for Europe
  - AOT retrieval error has strongest influence on blue bands, not important for NIR and SWIR bands
  - Uncertainty of AOT retrieval gives mostly SR within specs
  - Specification for AOT is stronger than specification for SR

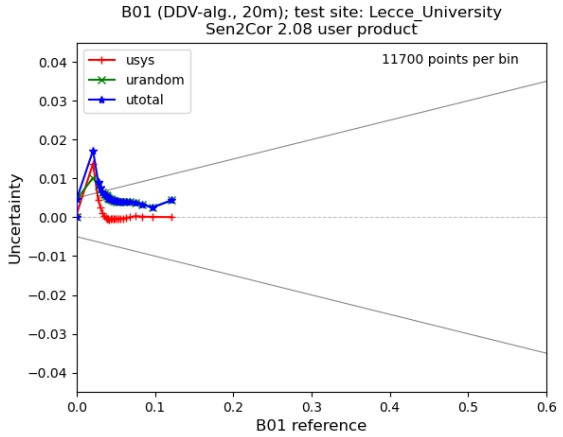
- CAMS data give a good fall-back option for images without DDV
  - Knowledge of CAMS data uncertainty would be valuable

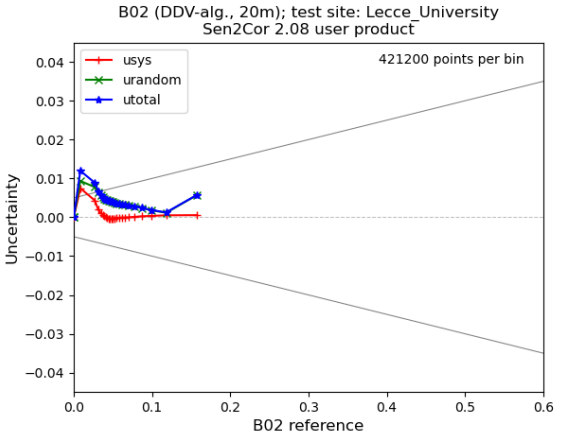
- More detailed analysis is ongoing
  - Find a way to improve AOT-retrieval for higher AOT

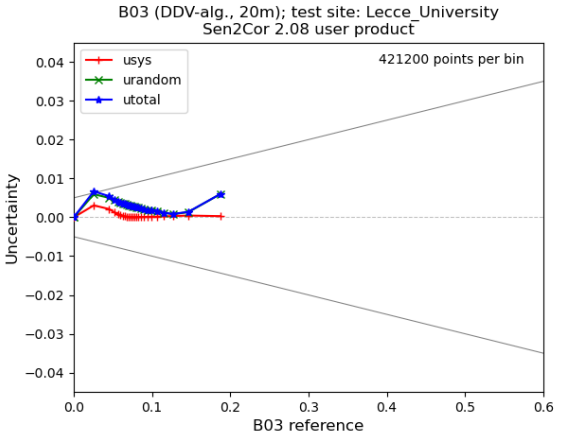
Conatact: bringfried.pflug@dlr.de

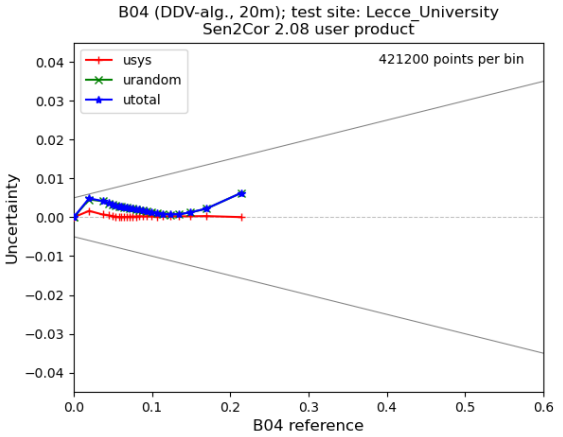
Surface reflectance (SR) retrieval performance, LECCE Univ., rel. to pseudo-ref.

DDV

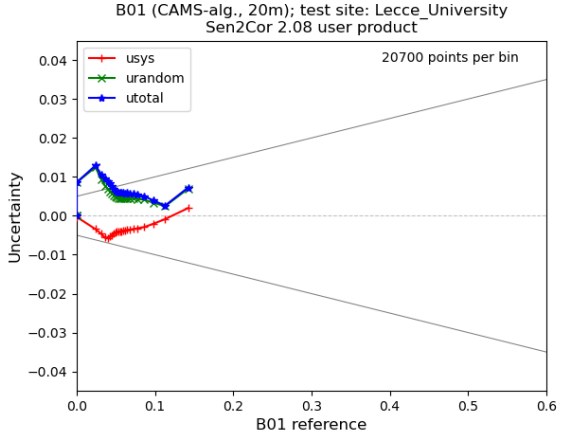


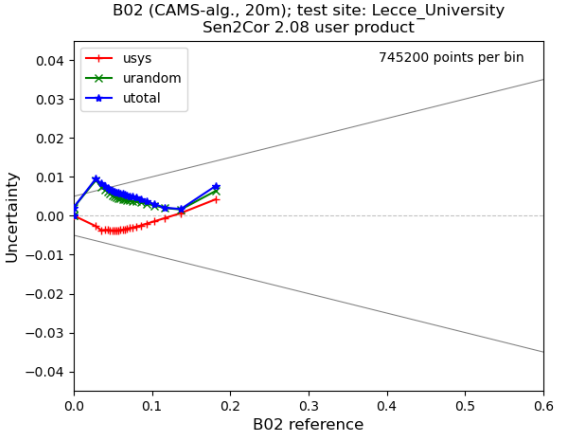


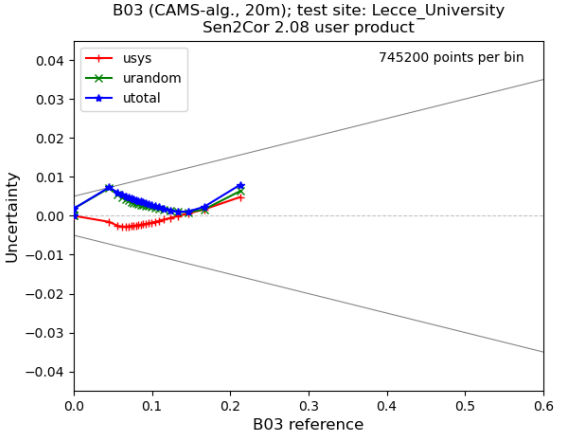


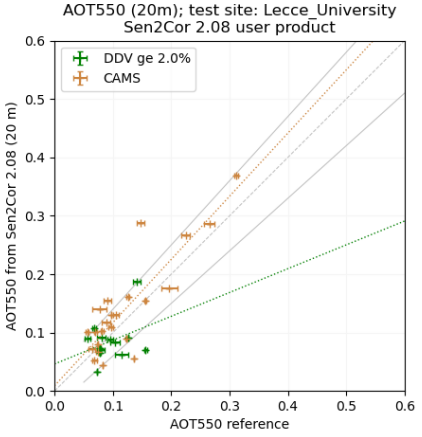


CAMS









B01 B02 B03 B04 / AOT