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OPT-MPC WG Atmospheric correction:
Validation practice of Copernicus Sentinel-2 and Sentinel-3 missions

OPT-MPC
Optical Mission Performance Cluster

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[1] German Aerospace Centre (DLR) , [2] ACRI-ST, [3] Brockmann Consult GmbH, [4] Telespazio France, [5] Swansea University, [6] STFC Rutherford Appleton Laboratory, [7] Finnish Meteorological Institute , [8] VITO Remote Sensing, [9] European Space Agency (ESA-ESRIN)

The Copernicus program is a European initiative for the implementation of information services dealing with environment and security, mainly based on observation data received from Earth Observation (EO) satellites. In the frame of this program, ESA launched the Copernicus Sentinel-2 and Sentinel-3 optical imaging satellites. These satellites deliver a new generation of optical data products designed to directly feed downstream services mainly related to land and ocean monitoring, emergency management and security. To ensure the highest quality of Earth Observation data from the Copernicus Sentinel-2 and Sentinel-3 optical missions, ESA set up the Optical Mission Performance Cluster (OPT-MPC) supported by several Expert Support Laboratories (ESL) and working groups (WG). The WG on atmospheric correction in the OPT-MPC brings together the experience of the former separated S2 and S3 Mission Performance Centers for validation of atmospheric correction products.

Copernicus Sentinel-2

Products to validate:

❖ Aerosol Optical Thickness at 550 nm (AOT550) — 20 m
❖ Water Vapour (WV) over land surface — 20 m
❖ Surface reflectance (SR) per band (hemispherical-directional reflectance factor) — 10, 20, 60 m

Used reference data measurements:

❖ AOT from AERONET
❖ WV from AERONET
❖ SR from RadCalNet and ad-hoc campaigns
➢ Lack of sufficient number of SR measurements for variation of surface types, of atmospheric conditions, of observation geometry …
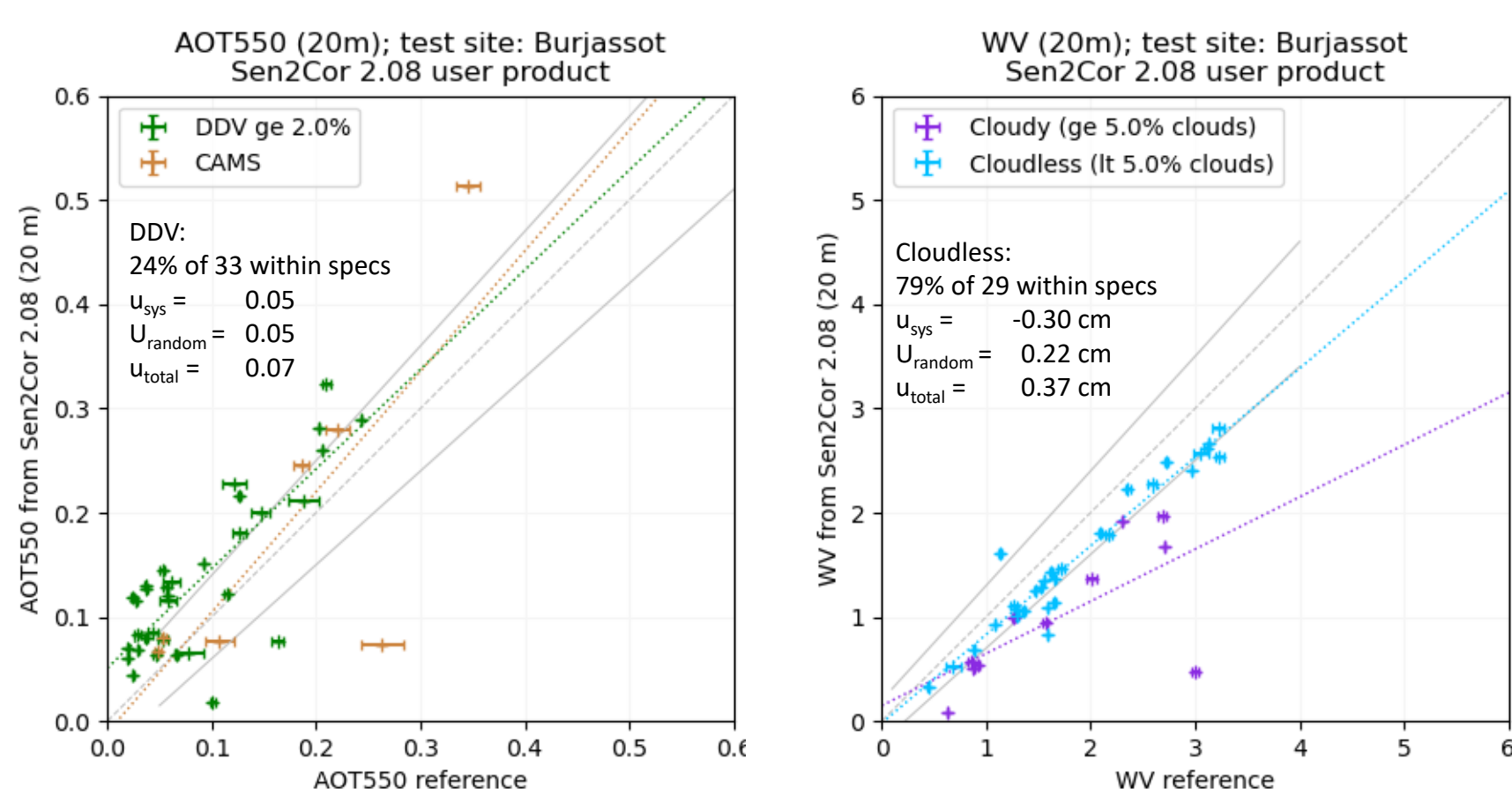
Alternative data for quality assurance of atmospheric correction:

❖ Computed SR reference data
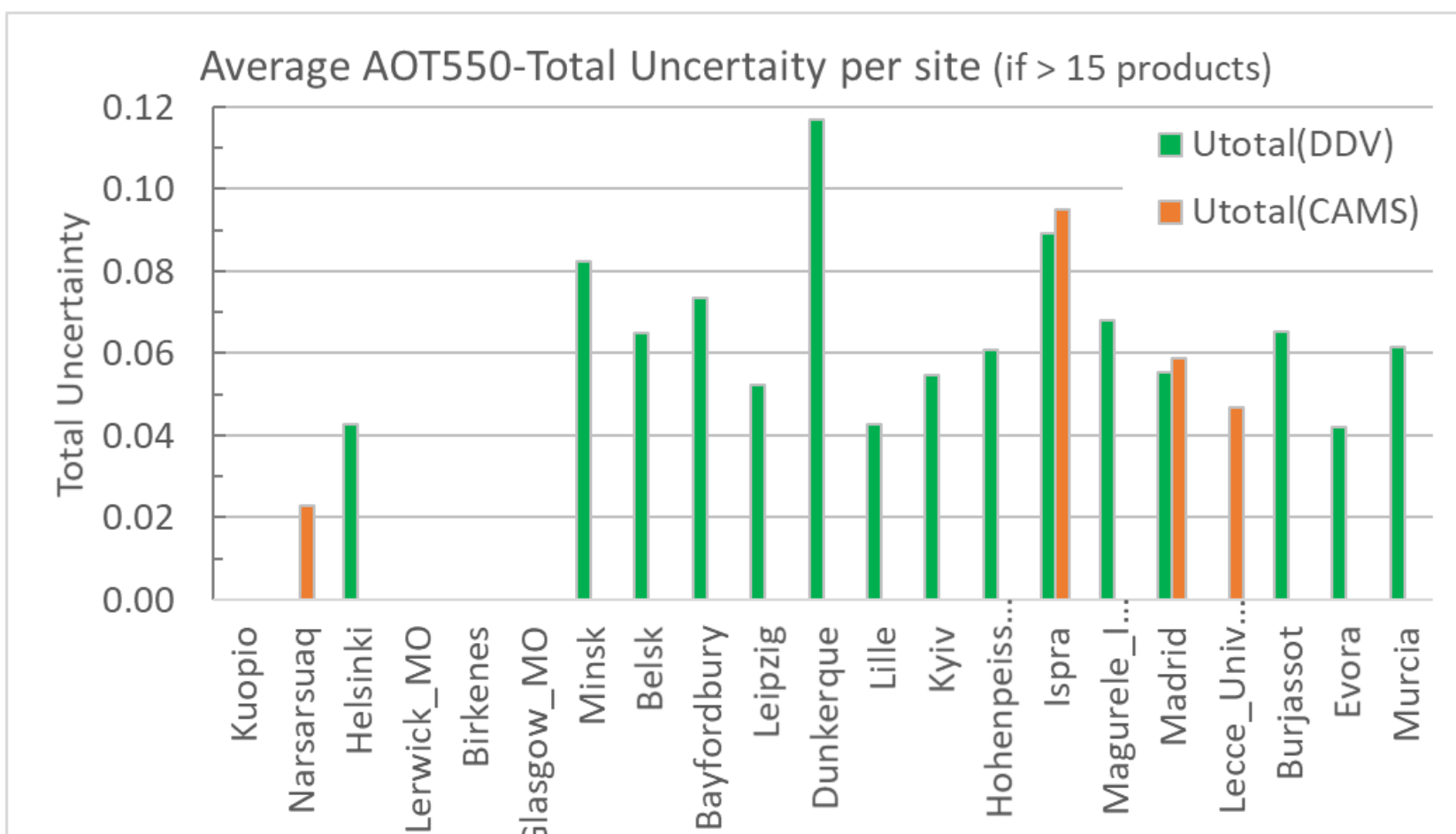❖ Inter-comparison with other optical remote sensing missions

Uncertainty specifications for products to validate:

○ $|\Delta AOT| \leq 0.1*AOT_{ref} + 0.03$
○ $|\Delta WV| \leq 0.1*WV_{ref} + 0.2$
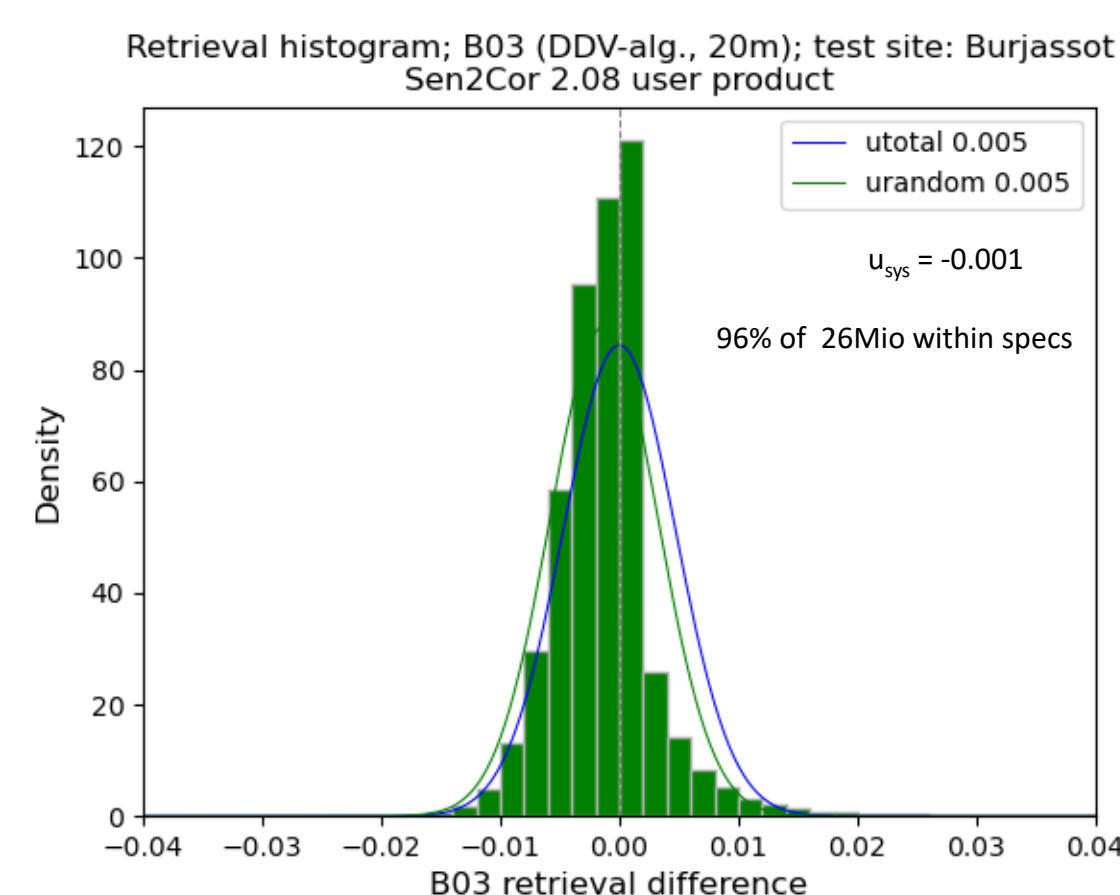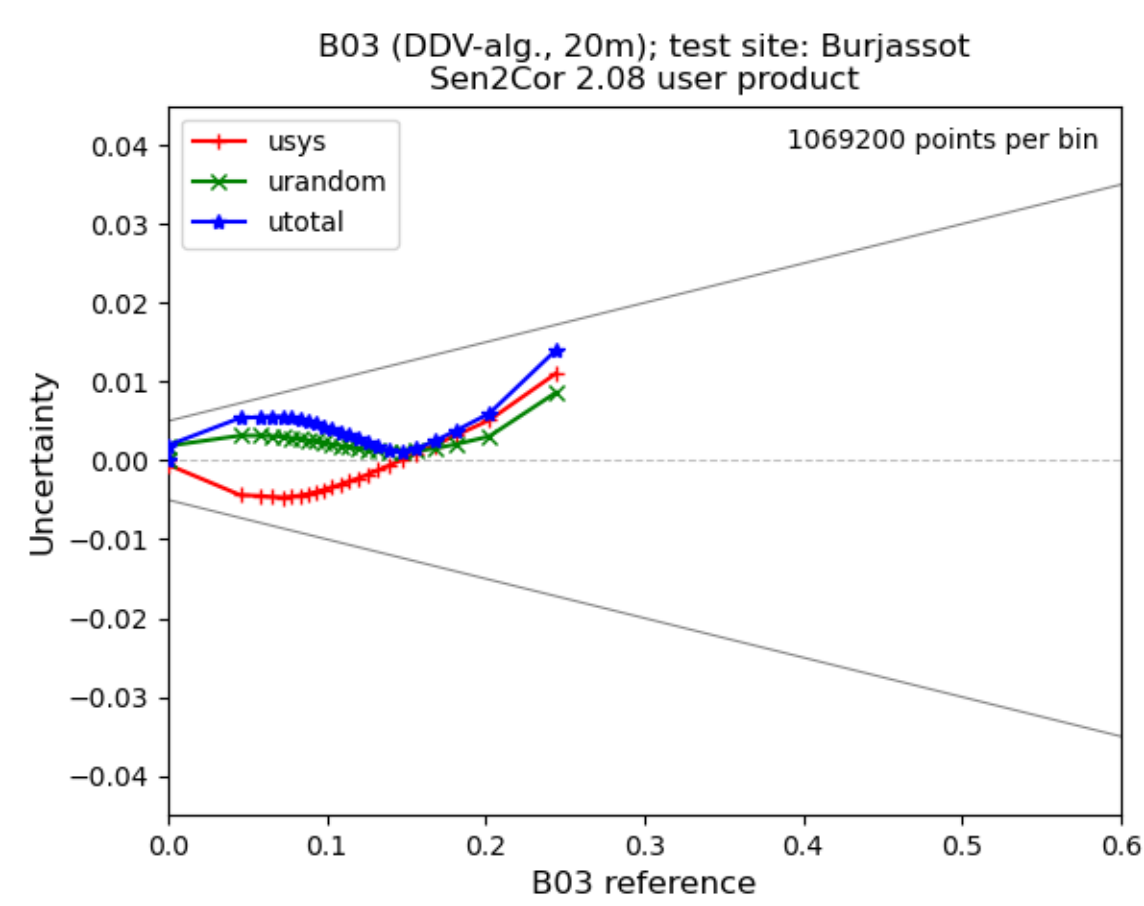○ $|\Delta SR| \leq 0.05*SR_{ref} + 0.005$

Reporting validation results:

Correlation plot of the AOT550 and WV retrieval with reference data from AERONET

Histogram plot of SR retrieval difference to pseudo-reference data processed with input AOT550 from AERONET for B03

Uncertainty of AOT retrieval (DDV-algorithm) and fall-back solution (CAMS data) relative to AERONET data

APU-plot of SR retrieval uncertainties for B03 relative to pseudo-reference data processed with AOT550 from AERONET

Copernicus Sentinel-3 OLCI and Synergy

Products to validate:

❖ AOT at wavelengths (442.5, 555, 659, 865, 1610 and 2250) nm — 4500 m
❖ Integrated Water Vapour (IWV) over land and water surface — 300 m
❖ Surface Directional Reflectance (BRF) at wavelengths (442.5, 555, 659, 865, 1610 and 2250) nm — 4500 m / 300 m
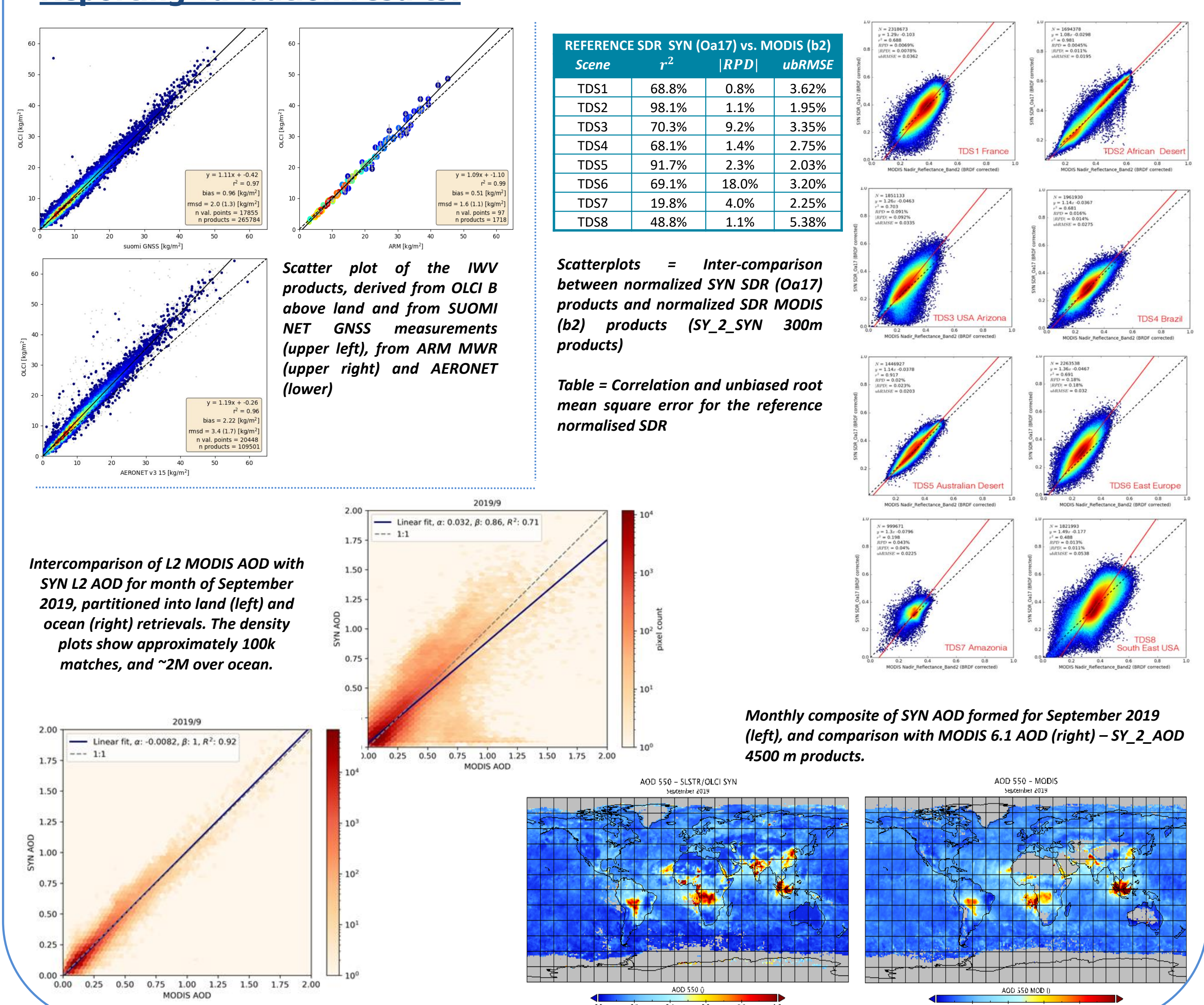❖ Aerosol Angstrœm Exponent at 550 nm and other Aerosol parameters — 4500 m

Used reference data measurements:

❖ AOT from AERONET and MODIS
❖ WV from AERONET, SUOMI NET GNSS and ARM MWR
❖ SR from MODIS
➢ Lack of sufficient number of SR measurements for variation of surface types, of atmospheric conditions, of observation geometry …

Alternative data for quality assurance of atmospheric correction:

❖ Computed SR reference data
❖ Inter-comparison with other optical remote sensing missions like PROBA-V

Reporting validation results:

REFERENCE SDR SYN (Oa17) vs. MODIS (b2)			
Scene	r²	|RPD|	ubRMSE
TDS1	68.8%	0.8%	3.62%
TDS2	98.1%	1.1%	1.95%
TDS3	70.3%	9.2%	3.35%
TDS4	68.1%	1.4%	2.75%
TDS5	91.7%	2.3%	2.03%
TDS6	69.1%	18.0%	3.20%
TDS7	19.8%	4.0%	2.25%
TDS8	48.8%	1.1%	5.38%

Scatter plot of the IWV products, derived from OLCI B above land and from SUOMI NET GNSS measurements (upper left), from ARM MWR (upper right) and AERONET (lower)

Scatterplots = Inter-comparison between normalized SYN SDR (Oa17) products and normalized SDR MODIS (b2) products (SY_2_SYN 300m products)

Table = Correlation and unbiased root mean square error for the reference normalised SDR

Intercomparison of L2 MODIS AOD with SYN L2 AOD for month of September 2019, partitioned into land (left) and ocean (right) retrievals. The density plots show approximately 100k matches, and ~2M over ocean.

Monthly composite of SYN AOD formed for September 2019 (left), and comparison with MODIS 6.1 AOD (right) – SY_2_AOD 4500 m products.

Outcome

We have in both missions
  ❖ Similar tasks
  ❖ Similar products to validate
  ❖ Lack of SR reference data
  ❖ Different ways to report results
  ❖ Different terminology
  ❖ Different spatial scales

➢ The main objective of the working group on atmospheric correction within OPT-MPC is to employ synergies across the missions on surface reflectance (SR), aerosol optical thickness (AOT) and water vapour (WV) validation. Harmonization of validation practices, approaches, metrics, terms and definitions will support inter-operability among missions. This can also result in a guideline for good validation practice for other optical remote sensing missions in the Copernicus program and worldwide.
Eventually the WG can give recommendations for atmospheric correction algorithm improvements.