



# Performance of Copernicus Sentinel-2 Level-2A processor Sen2Cor dependent on cloudiness



Mission Performance Centre

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Many earth remote sensing applications rely on time series of satellite data. However at many locations on the globe it is almost impossible to build time series relying only on cloudless data due the cloudiness of the region. Generally time series get denser if they can include data containing some clouds. However, how accurate and reliable are L2A satellite products of cloudy images? To answer this question, the presentation is focused on providing Sen2Cor performance in dependence of cloud cover of the images. Sen2Cor performance of Aerosol Optical Thickness (AOT) and Water Vapour (WV) retrieval is analyzed by direct comparison of Sen2Cor outputs with reference data provided by AERONET sunphotometers. AOT and WV are the parameters having largest influence on SR retrieval accuracy.

## Sen2Cor<sub>(1)</sub>:

- Single mission atmospheric correction processor tailored to Sentinel-2 data, extension to Landsat-8 data processing in preparation.
- was implemented on basis of ATCOR by TPZ-D, TPZ-F and DLR on behalf of ESA
- Is used for global L2A-processing by Sentinel-2 PDGS
- can be obtained for user processing from <http://step.esa.int/main/third-party-plugins-2/sen2cor/>

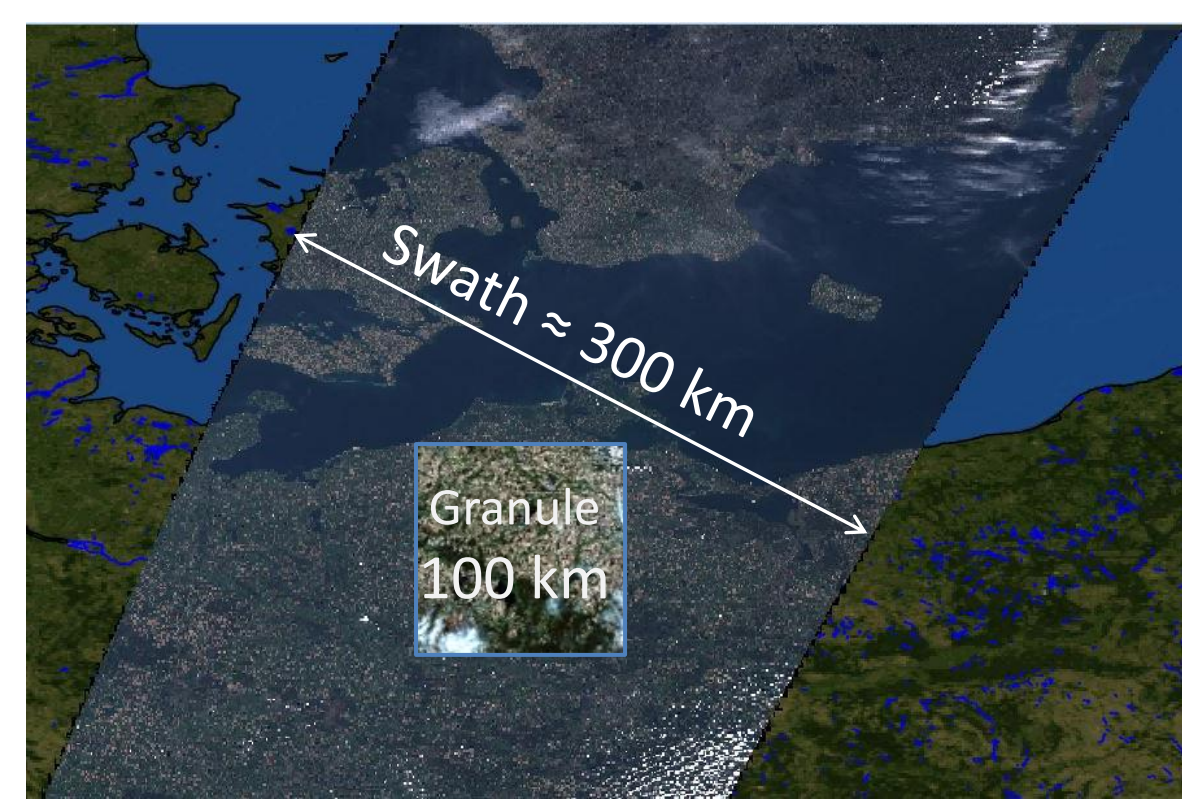
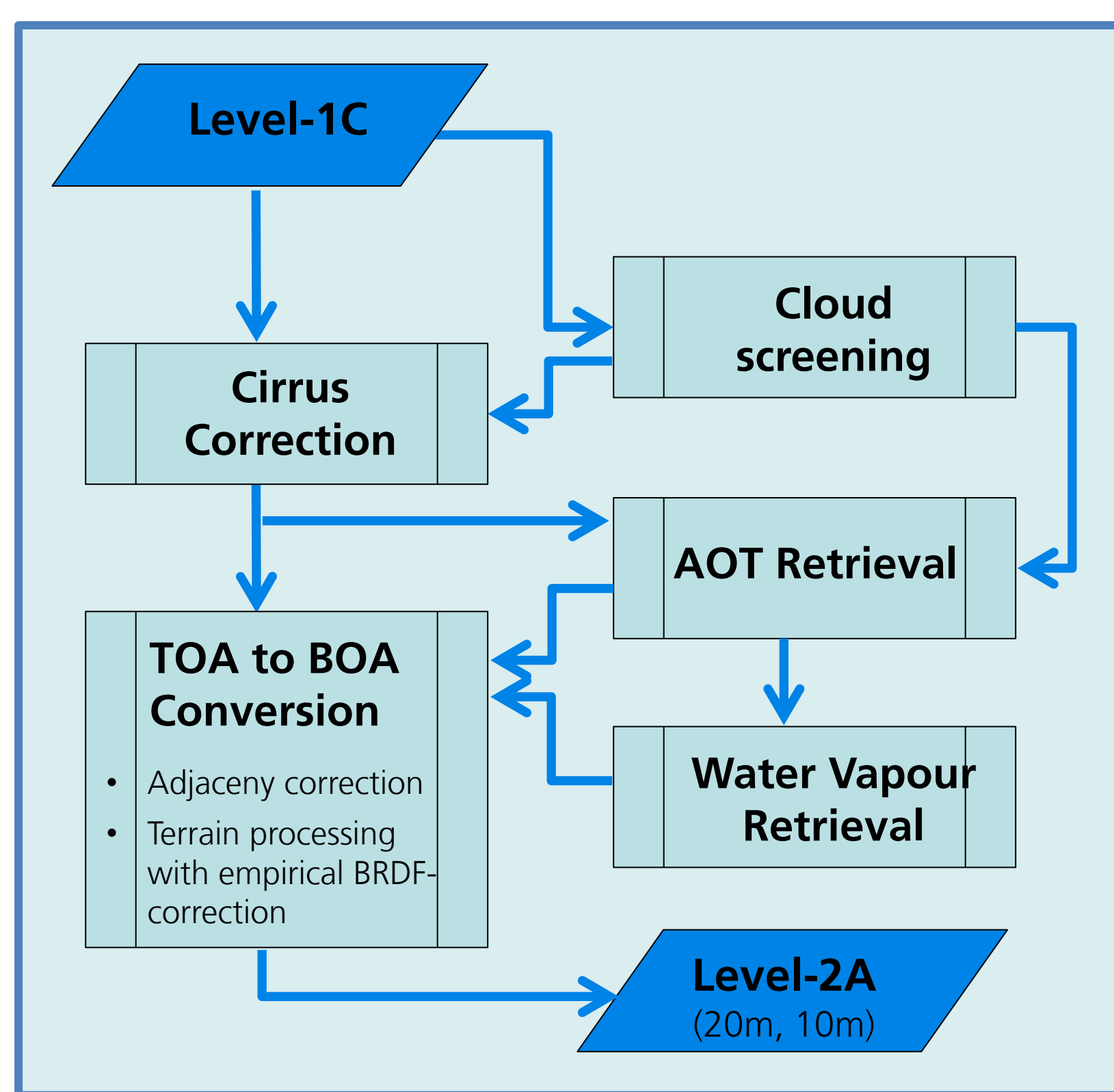


Figure 2: Processing on granule level

(1) Richter, R.; Louis, J.; Müller-Wilm, U. Sentinel-2 MSI—Level 2A Products Algorithm Theoretical Basis Document. 2012, S2PAD-ATBD-0001, Issue 2.0.

Figure 1: Sen2Cor processing

## Analysis procedure

Retrievals from satellite data are directly compared with AERONET data as reference

Analysis steps include:

- ➔ Select Sentinel-2 acquisitions with AERONET data within ±15 min of satellite overpass time
- ➔ Spectral interpolation of AERONET AOT-spectra by a (geometric) fit to  $AOT_{550} = a0 \cdot 0.55^{a1} + a2$
- ➔ Temporal average of  $AOT_{550}$  and WV reference data
- ➔ Spatial average of  $AOT_{550}$  and WV from Sentinel-2 data over 9x9 km<sup>2</sup> subset around sunphotometer location
- ➔ Compute AOT-/ WV retrieval statistics and create plots with mask ('vegetation' or 'not vegetated') dependent on cloud cover

$$X = AOT_{550}; WV \quad ;(\rho_{i\lambda})$$

$$\Delta X = X_{SEN2COR} - X_{AERONET}$$

Precision (P)  
rms around mean value

$$P = \sqrt{\frac{1}{(n-1)} \sum_{i=1}^n (\Delta X_i - A)^2}$$

Accuracy (A) and Deviation (D)  
mean difference to reference value

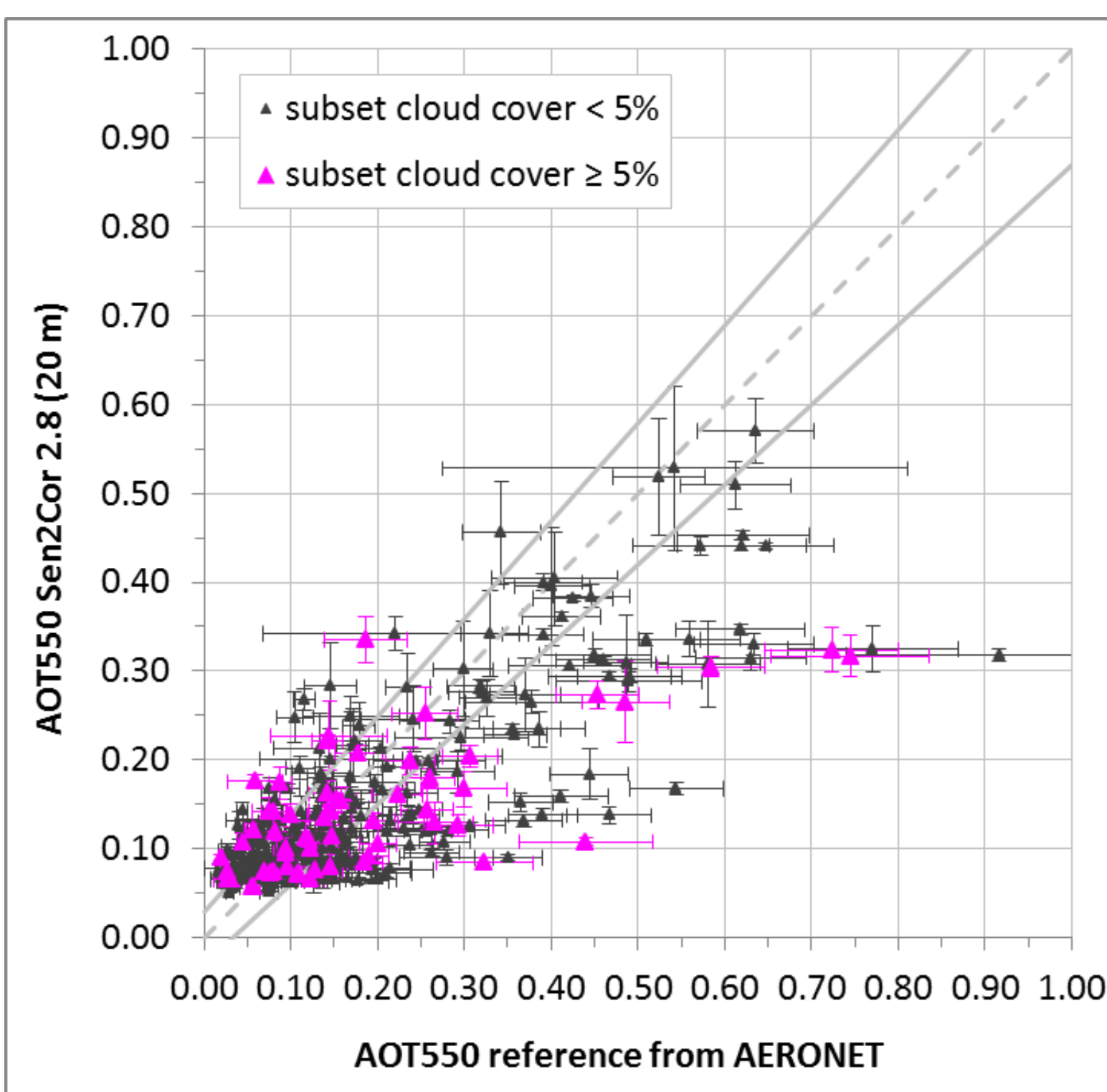
$$A = Median_{i=1}^n (\Delta X_i)$$

$$D = Median_{i=1}^n (|\Delta X_i|)$$

Uncertainty (U)  
rms around reference value

$$U = \sqrt{\frac{1}{n} \sum_{i=1}^n (\Delta X_i)^2}$$

## Performance of AOT retrieval



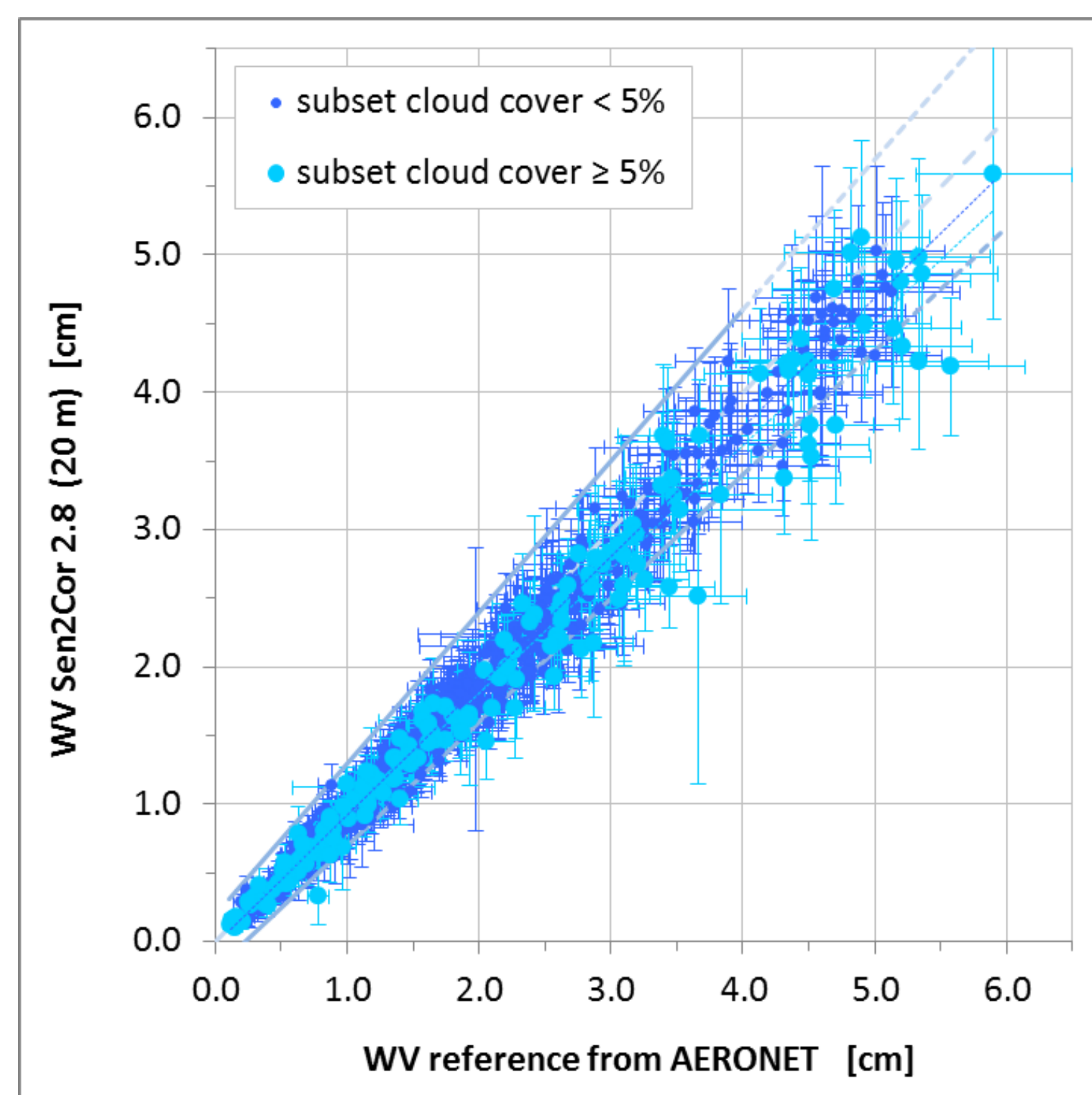
- ➔ **Solid lines:** Accuracy requirement  $|\Delta AOT_{550}| \leq 0.1 \cdot AOT_{550,ref} + 0.03$
- ➔ **Dashed line:**  $Sen2Cor\_output = Reference$
- ➔ **Black triangles:** near cloudless images
- ➔ **Magenta triangles:** cloudy images
- ➔ **Error bars:** have to use total uncertainties

$$u_{total} = \sqrt{u_{statistical}^2 + u_{systematic}^2}$$

$$u_{systematic} = \{0.1 \cdot AERONET; \sigma^{AOT}(Granule)\}$$

Figure 3: Correlation plot for AOT@550nm (20m) retrieval over reference from AERONET

## Performance of WV retrieval



- ➔ **Solid lines:** Accuracy requirement  $|\Delta WV| \leq 0.1 \cdot WV_{ref} + 0.2$
- ➔ **Dashed line:**  $Sen2Cor\_output = Reference$
- ➔ **Dark blue circles:** near cloudless images
- ➔ **Cyan circles:** cloudy images
- ➔ **Error bars:** have to use total uncertainties

$$u_{total} = \sqrt{u_{statistical}^2 + u_{systematic}^2}$$

$$u_{systematic} = \{0.1 \cdot avg(WV(ROI)); \sigma^{WV}(Granule)\}$$

Figure 5: Correlation plot for WV (20m) retrieval over reference from AERONET

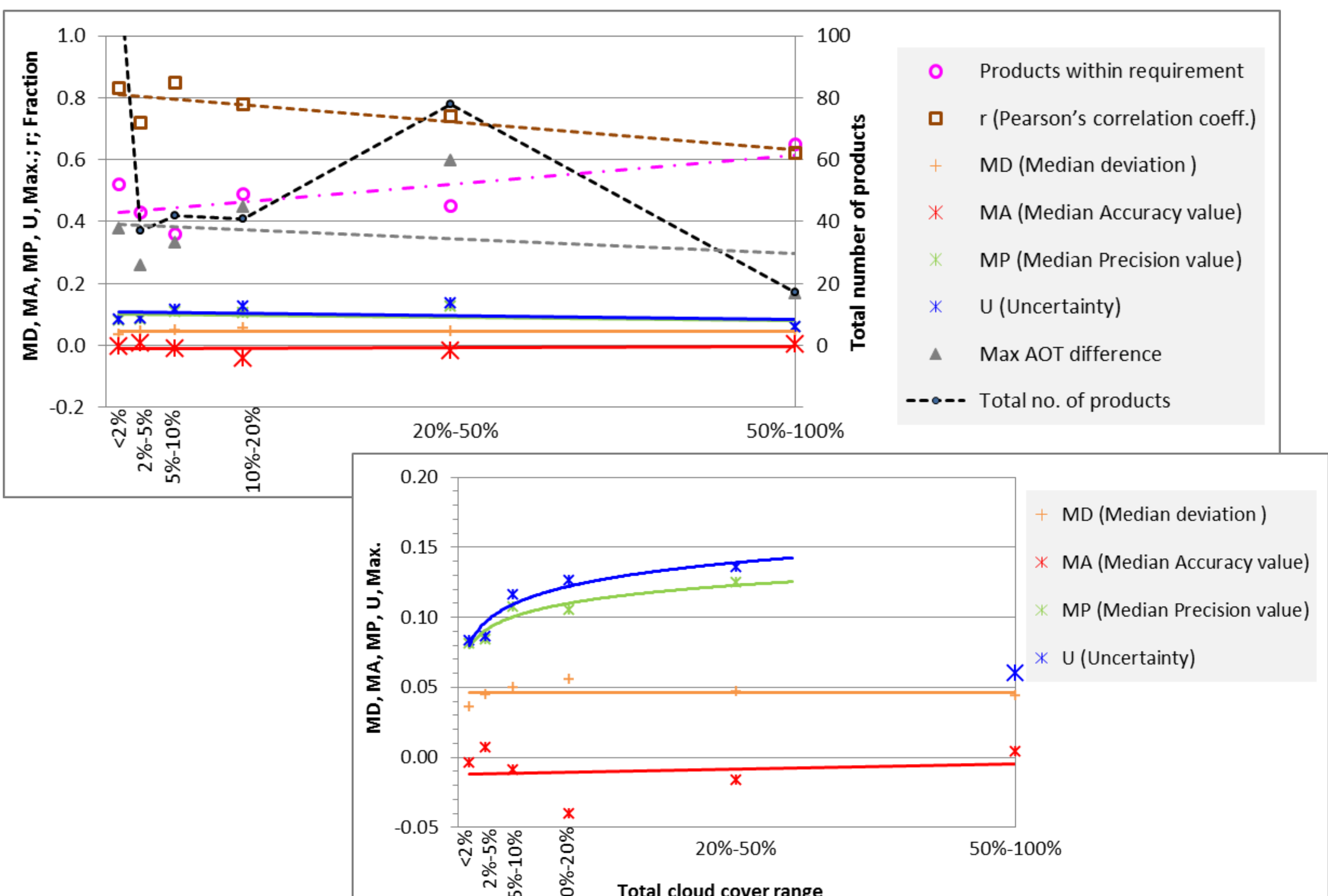


Figure 4: Performance measures for AOT<sub>550</sub> retrieval as function of 9x9 km<sup>2</sup> granule cloudiness

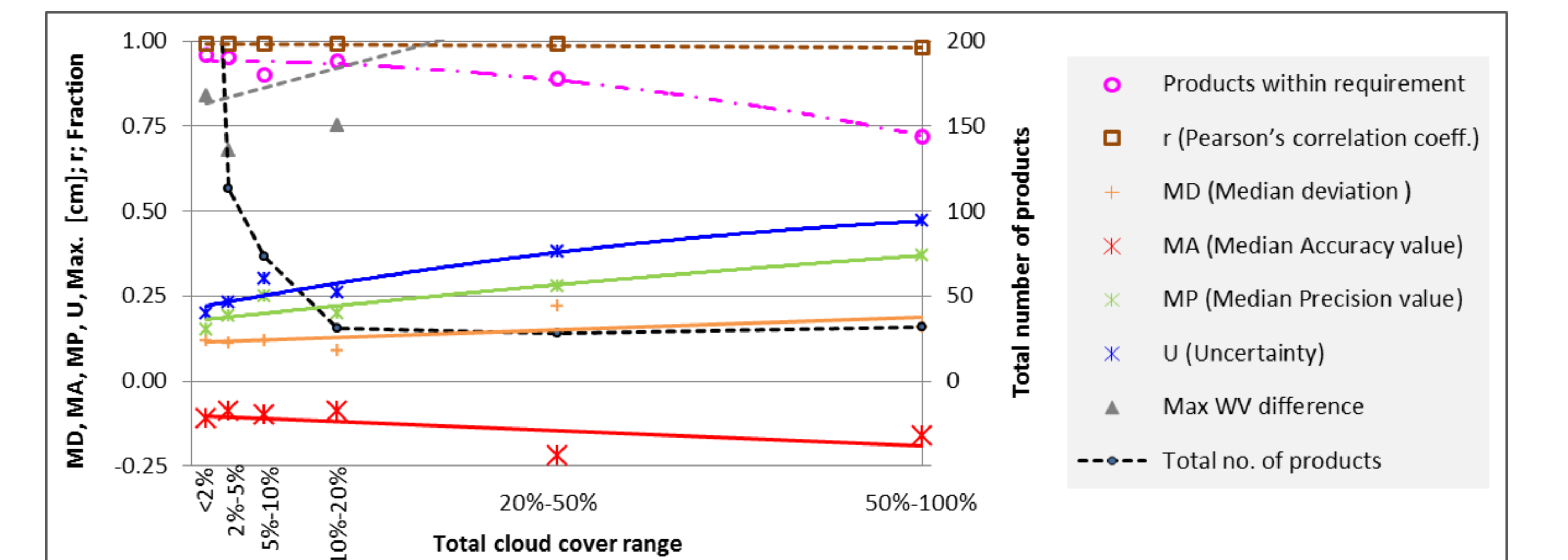


Figure 6: Performance measures for WV retrieval as function of 9x9 km<sup>2</sup> subset cloudiness

## Outcome and credits

There are quite cloudy L2A-products with good retrieval performance. On average cloud cover shows negligible influence on median accuracy, however increasing precision and uncertainty. Recommendation is to avoid products with more than 5% cloudiness.

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