Surface and aerosol retrieval from S5P using GRASP: baseline requirements and expected performance

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GRASP/S5p products

Sentinel-5p and S4 instruments provide hyperspectral measurements in UV, VIS and infrared spectral range. Though the main purpose of the instruments is the trace gases characterization, they provide essential piece of information about aerosol and surface properties.

Here, on the basis of GRASP inversion results from S5p measurements, we discuss how expected accuracy of AOD and BRDF retrieval from the spectrometers meet the baseline requirements for climate studies.

1. Requirements on AOD and BRDF products

The requirements on quality of aerosol characterization for climate studies are formulated by the climate organizations and groups (GCOS, 2011 (Global Climate Observing System), CMUG, 2015 (Climate Modelling User Group), ESA aerosol CCI, 2019 (Climate Change Initiative). They were used as a basis to formulate requirements on quality of AOD and BRDF retrievals from S4 and S5p instruments. In particular, in the frame of ESA S5p+Innovation AOD/BRDF project the requirements are specified for two main cases:

1. Target: requirements for aerosol and surface product of moderate quality, which is expected to be suitable for most of applications.
2. Optimal: the requirements for highly accurate AOD and BRDF retrieval.

These requirements are collected in Tables below.

Requirements BRDF/albedo	Uncertainties	
	Albedo <= 0.03	Albedo > 0.03
Target	0.04	0.03 or 10%
Optimal	0.02	0.01 or 5%

Requirements AOD	Uncertainties
Target	0.05 or 20%
Optimal (GCOS+ESA CCI)	0.04 or 10%

2. Surface reference dataset from combined AERONET+SP retrieval

During a few last decades AERONET direct measurements and inversion products are the main validation dataset for satellite aerosol retrieval. Despite of big request on the reference dataset for surface reflectance, it still does not exist.

Enhancement of the surface retrieval accuracy can be achieved by inverting simultaneously AERONET and satellite measurements. This is due to the fact that AERONET measurements constrain aerosol well while satellite observations are very sensitive to the surface reflectance. In the frame of S5P+I BRDF/AOD project this approach was applied to combined inversion of AERONET and S5P measurements. This resulted in generation of surface reference database over selected AERONET stations, which was used for validation of GRASP/S5P surface product.

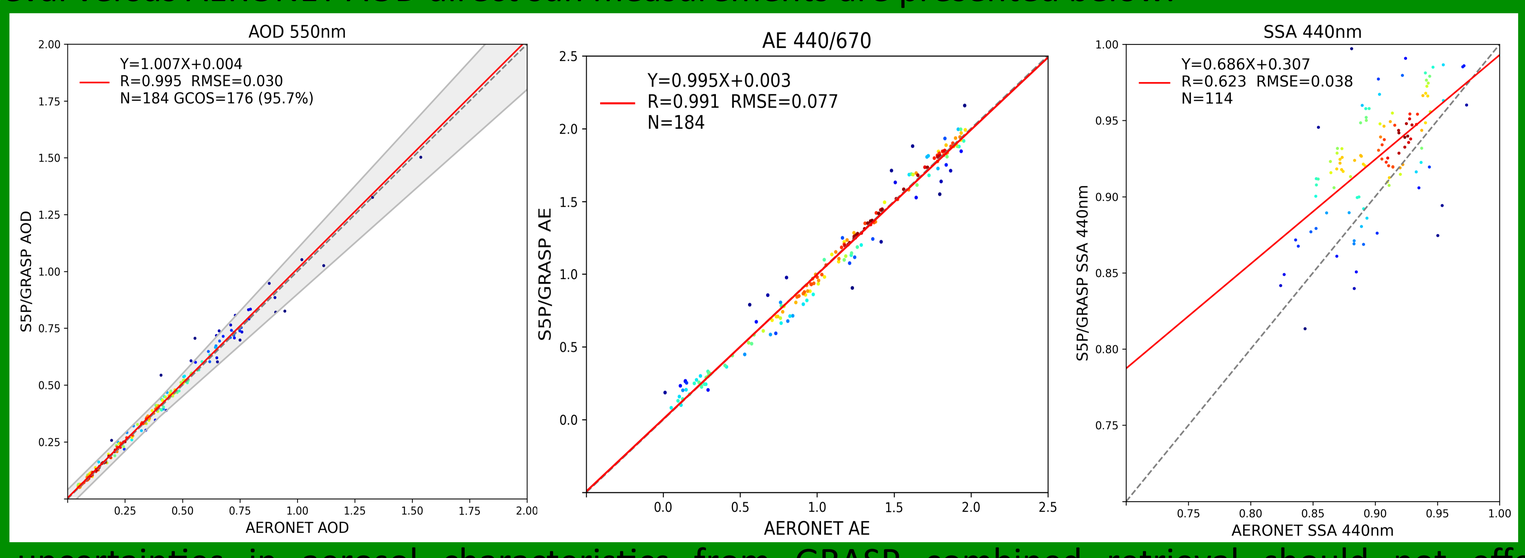
Concept of combined AERONET + Satellite retrieval

I. **Input**:
1. AERONET Almucantar + TOD (direct sun) measurements nearest to S5p measurements
2. S5P measurements

II. The accurate surface product from the combined AERONET + satellite retrieval can be obtained under the following **conditions**:
1. Aerosol properties are retrieved correctly by GRASP from the combined retrieval.
2. The inversion is converged and the fitted residual is sufficiently small (smaller than required accuracy of the surface product).
3. Instruments are well calibrated.

III. **Output**: Surface reflectance database over AERONET stations.

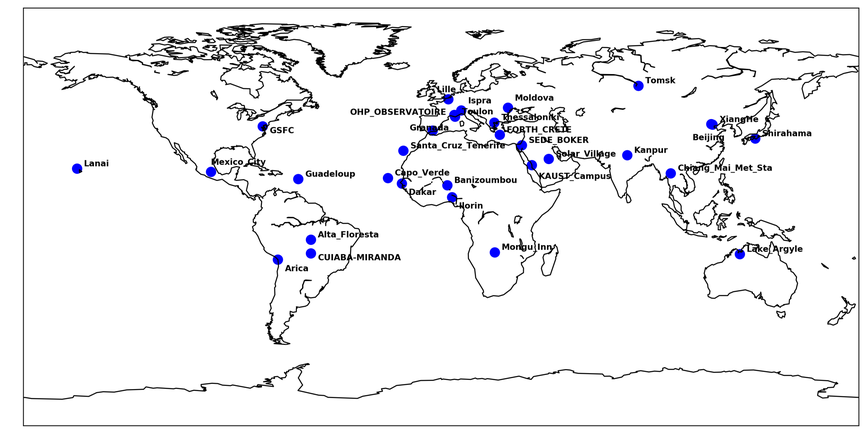
The results of GRASP AOD, Angstrom Exponent (AE) and SSA from combined GRASP AERONET+S5P retrieval versus AERONET AOD direct sun measurements are presented below.

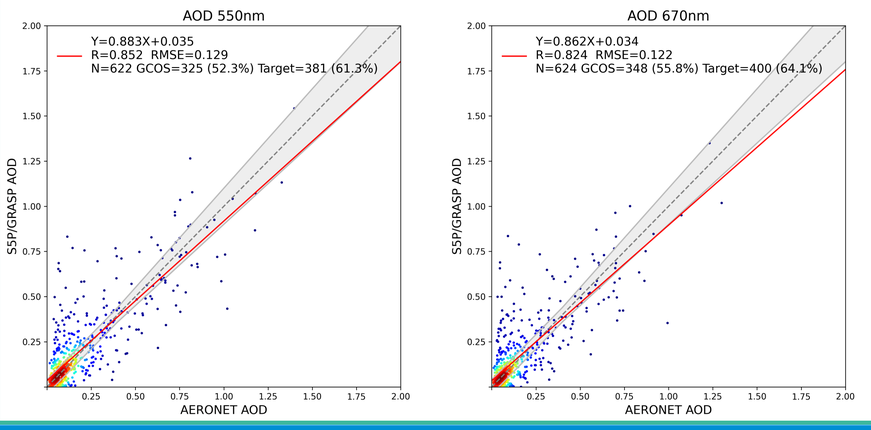


The uncertainties in aerosol characteristics from GRASP combined retrieval should not effect essentially the accuracy of the surface reference dataset

4. GRASP/S5p AOD validation

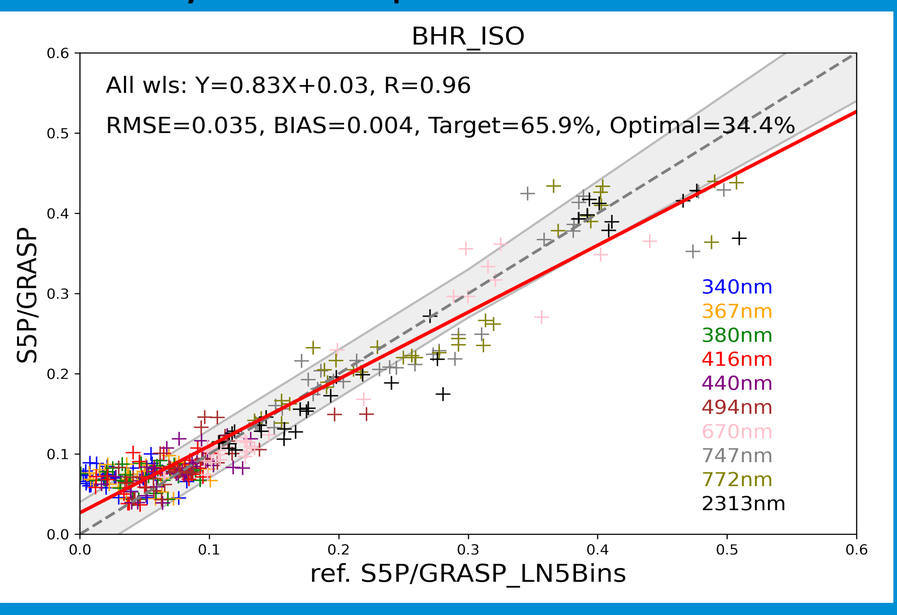
30 AERONET stations, 1 year of S5p measurements (June, 2018 –June, 2019)



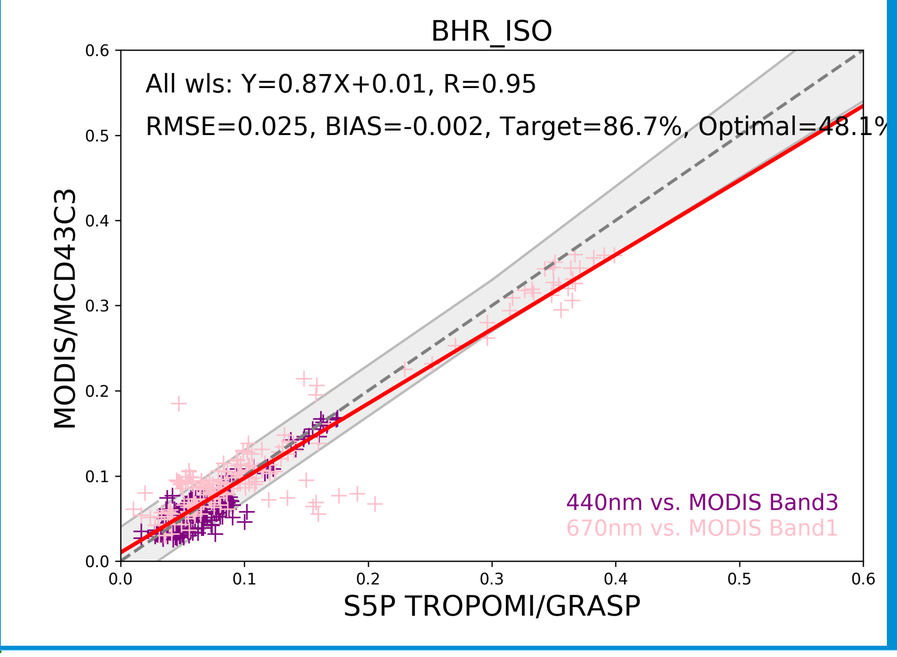


5. GRASP/S5p BRDF validation

Validation vs. surface reference dataset, 1 year of S5p measurements



Inter-comparison with MODIS



Summary

The validation results show solid performance of GRASP/S5P aerosol and surface products:

1. Low bias vs. reference.
2. High correlations with reference.
3. High percentage of the retrievals, which meet the AOD and BRDF requirements.