Surface and aerosol characterization from S5P/TROPOMI: validation, inter-comparison and expected performance

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Aerosol and surface product S5p+I AOD/BRDF project

Sentinel-5p+ Innovation

ESA EOP-SDR initiative (IT)

AEROSOL OPTICAL DEPTH AND BIDIRECTIONAL REFLECTANCE DISTRIBUTION FUNCTION

GRASP Catalysts

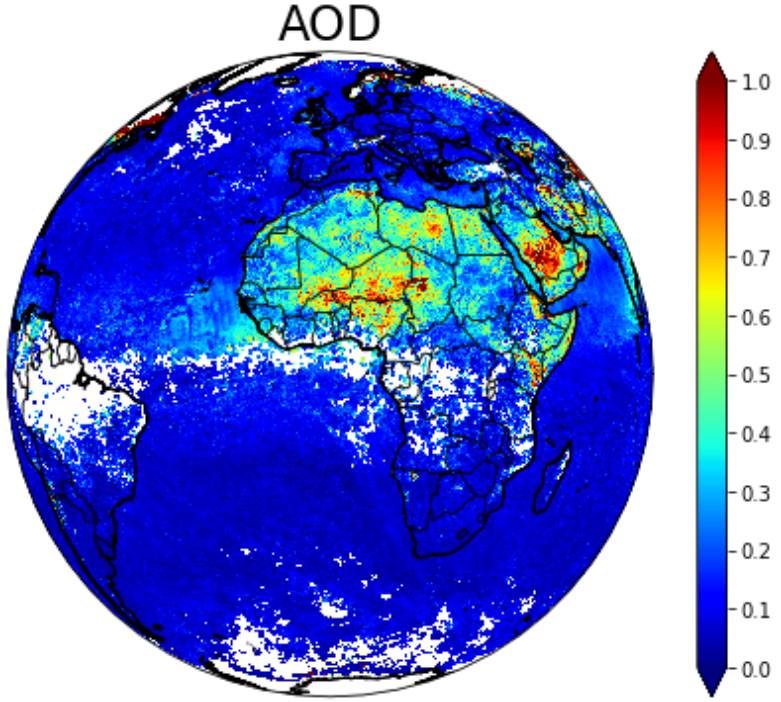
Royal Netherlands Meteorological Institute
Ministry of Infrastructure and Water Management

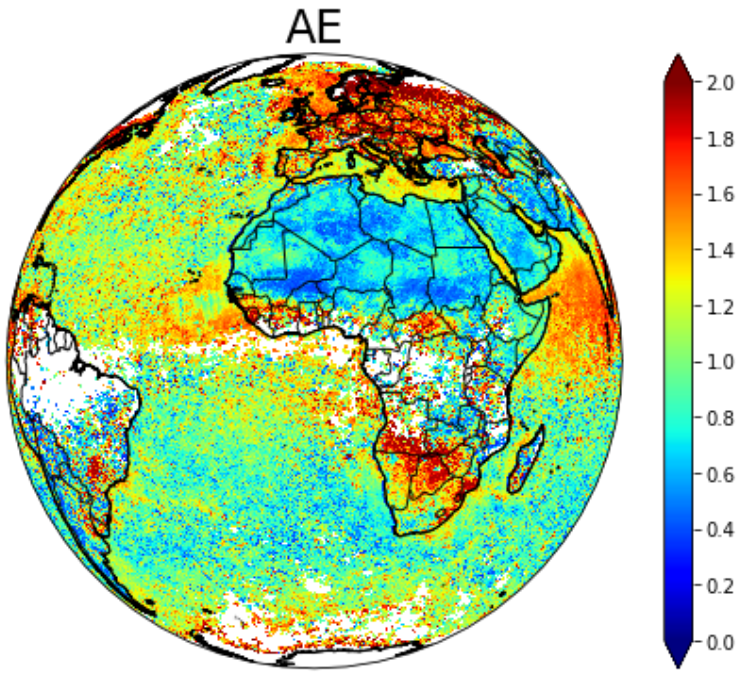
esa

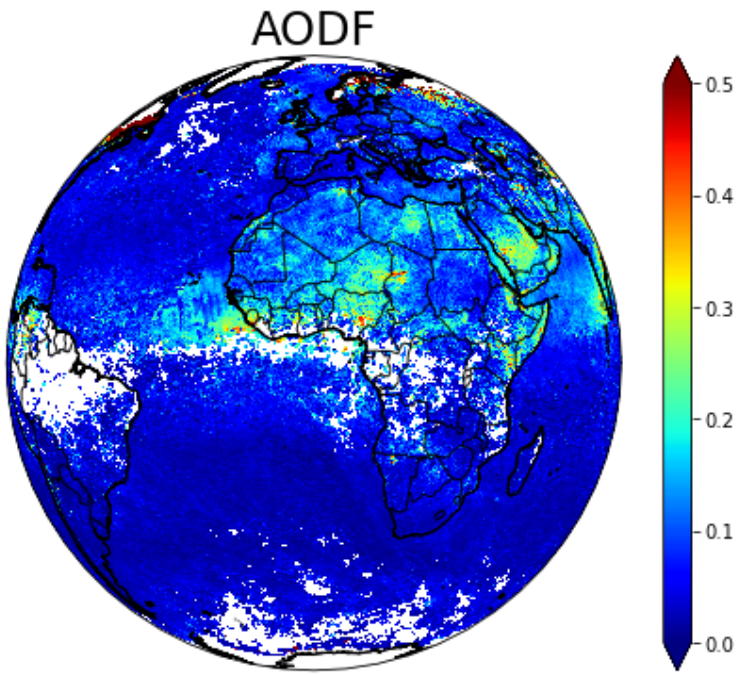
www.grasp-sas.com/projects/aod-brdf_sentinel-5p-innovation/

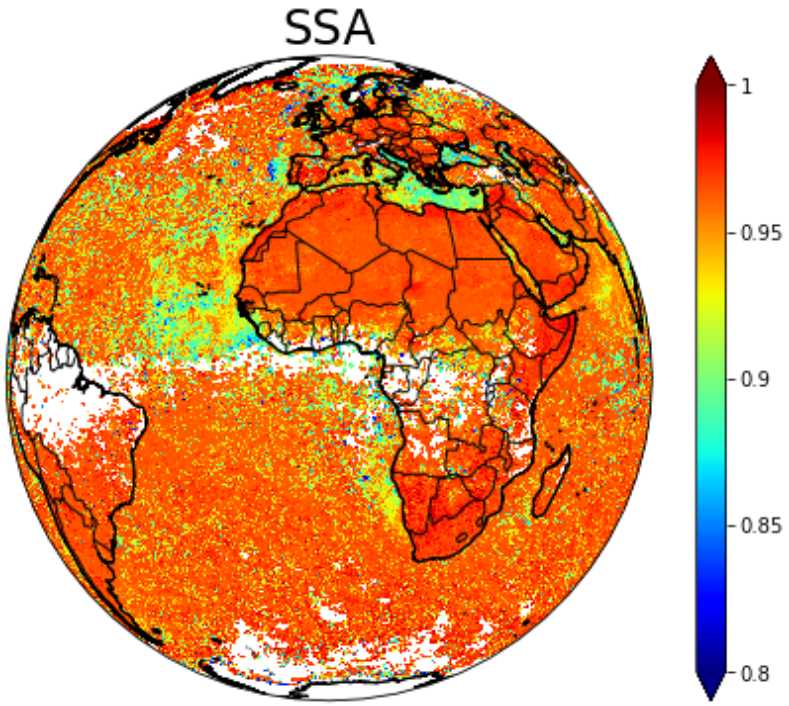
1. GRASP aerosol and surface BRDF products
2. KNMI surface DLER and OMI-heritage AOD products

Two products complement and extend each other







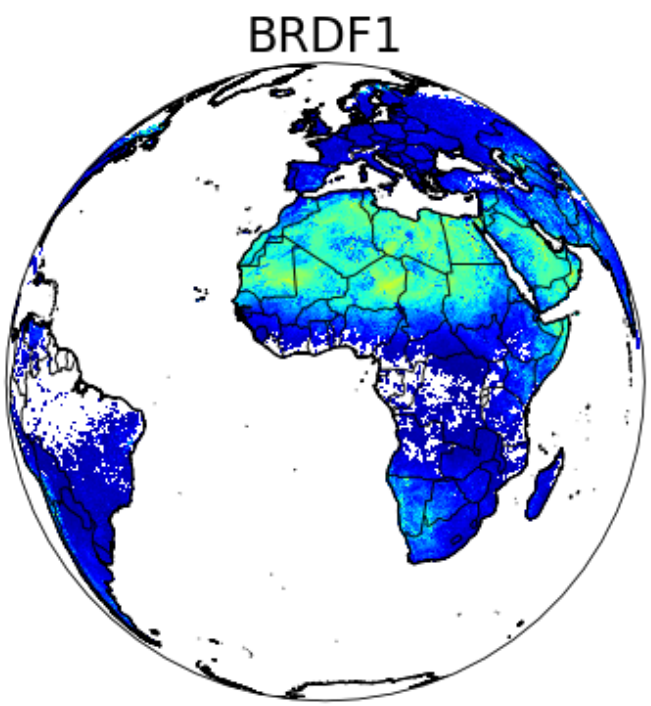


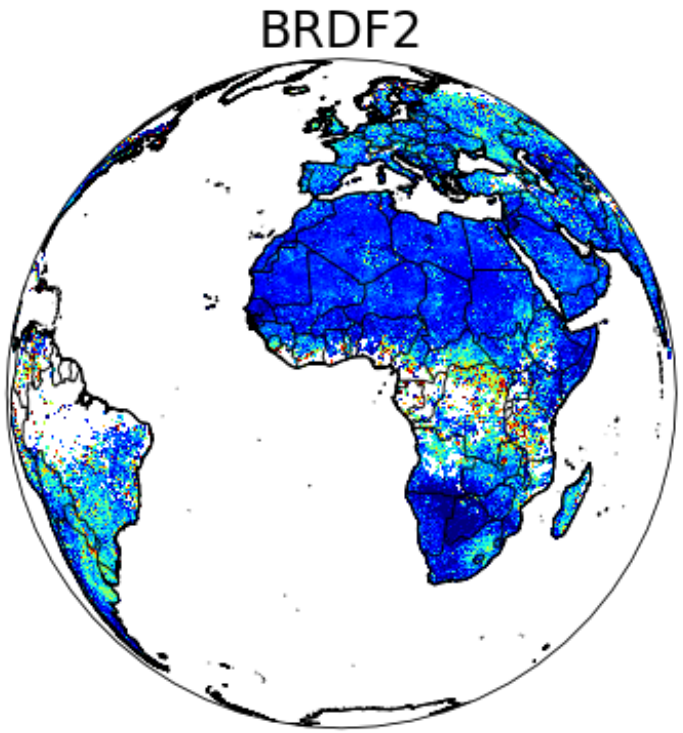
GRASP aerosol products

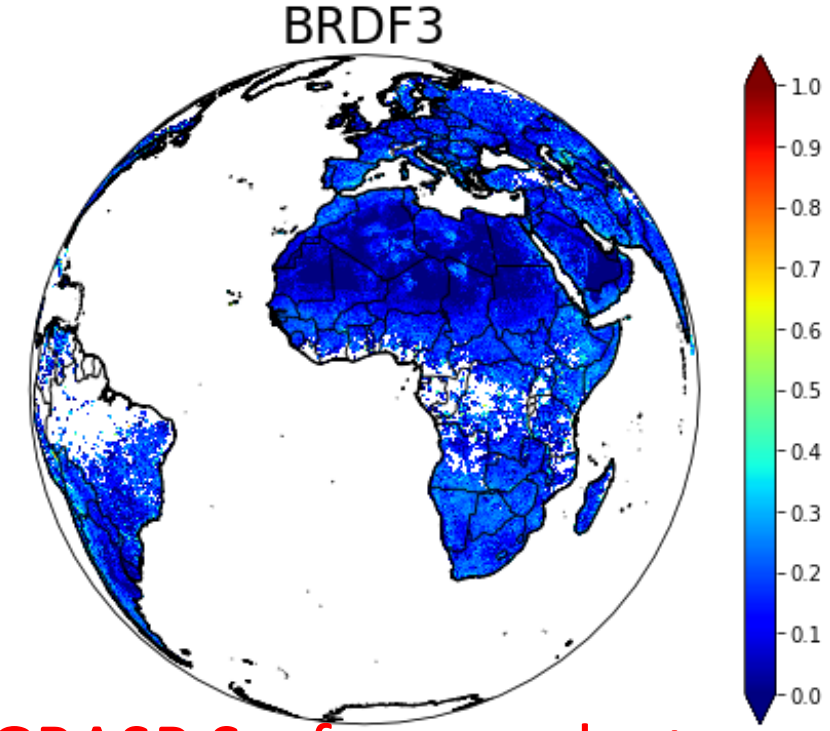
10 wavelengths:

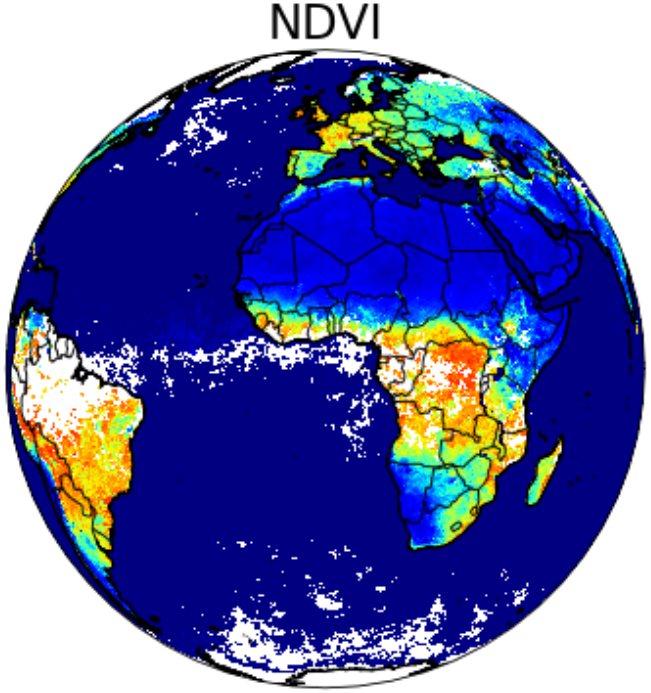
0.340 0.367 0.380 0.416 0.440 0.494 0.670 0.747 0.772 2.313

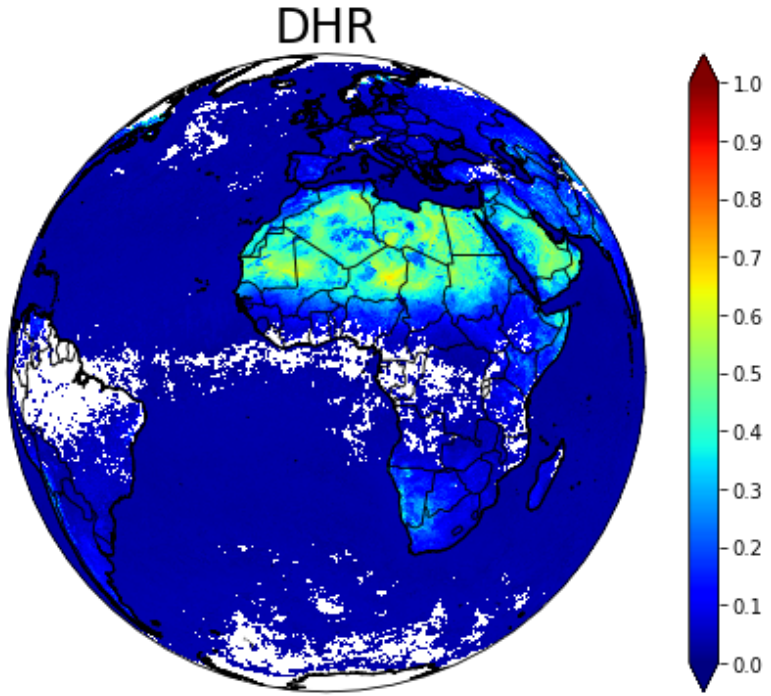
1. Spectral AOD, AE, AODF and AODC
2. Spectral AAOD
3. Spectral SSA
4. 4 aerosol model concentrations











GRASP Surface products

10 wavelengths:

0.340 0.367 0.380 0.416 0.440 0.494

0.670 0.747 0.772 2.313

1. Spectral BRDF1 (land)
2. BRDF 2nd and 3rd parameters (land)
3. NDVI
4. Spectral water body reflectance (sea/ocean)
5. Spectral DHR, BHR_iso

Specified requirements on aerosol (ESA S5p+I AOD/BRDF)

Characteristic	Required Uncertainty	
	Based on GCOS and aerosol CCI	Target: relaxed
AOD	0.04 or 10% (whatever is bigger)	0.05 or 20% (whatever is bigger)
Fine mode AOD (AODf)	0.04 or 10% (whatever is bigger)	0.05 or 20% (whatever is bigger)
SSA	0.02 - 0.03	0.04 - 0.05

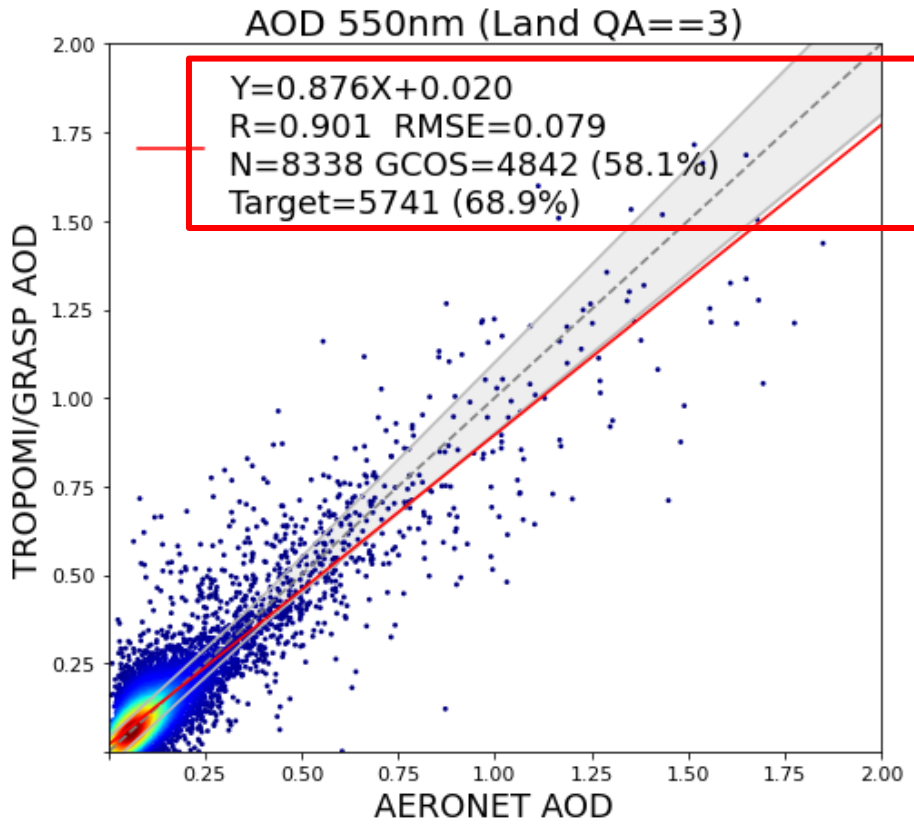
Requirements on surface (ESA S5p+I AOD/BRDF)

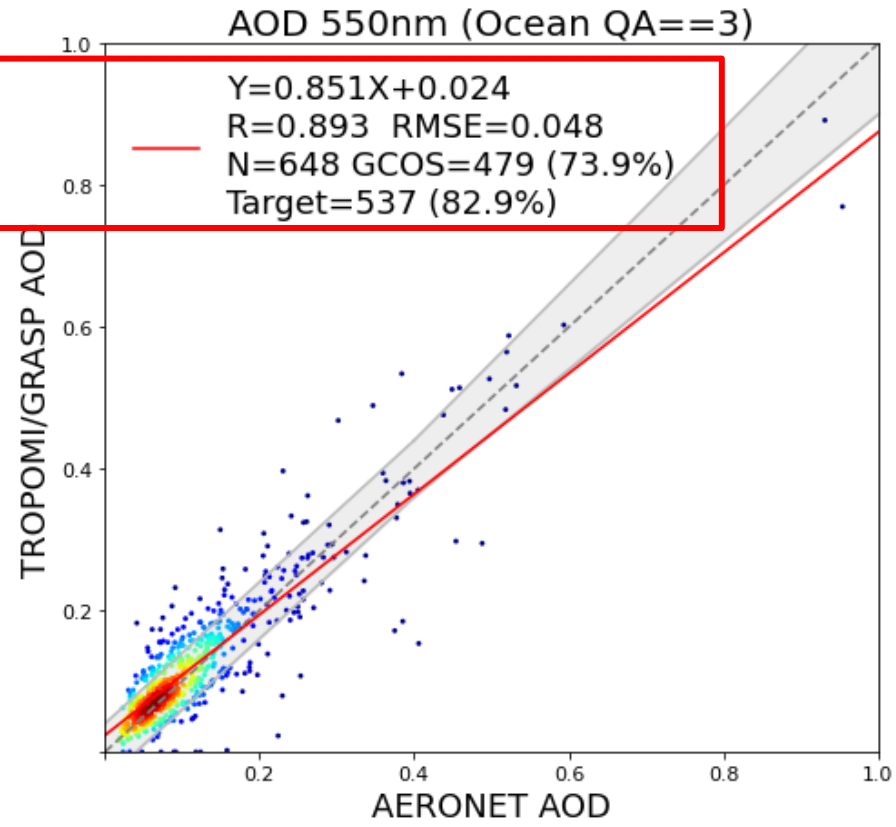
Requirements BRDF/albedo	Uncertainties	
	Albedo <= 0.03	Albedo > 0.03
Target	0.04	0.03 or 10% (whatever is bigger)
Optimal	0.02	0.01 or 5% (whatever is bigger)

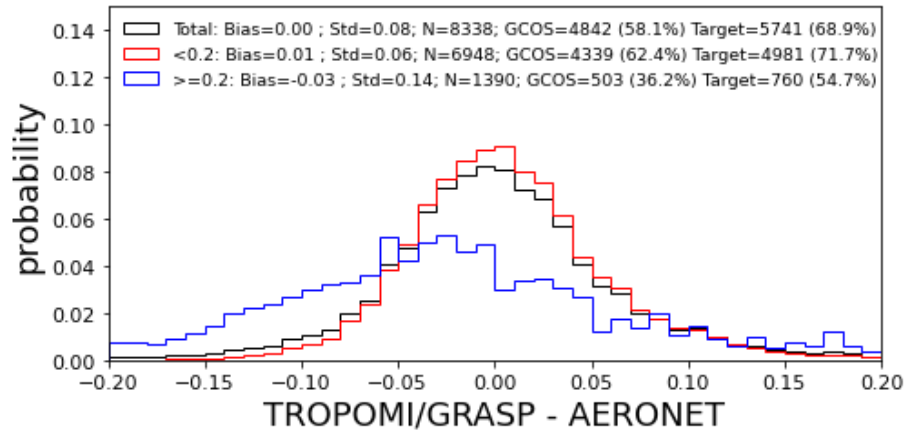
Aerosol product validation.

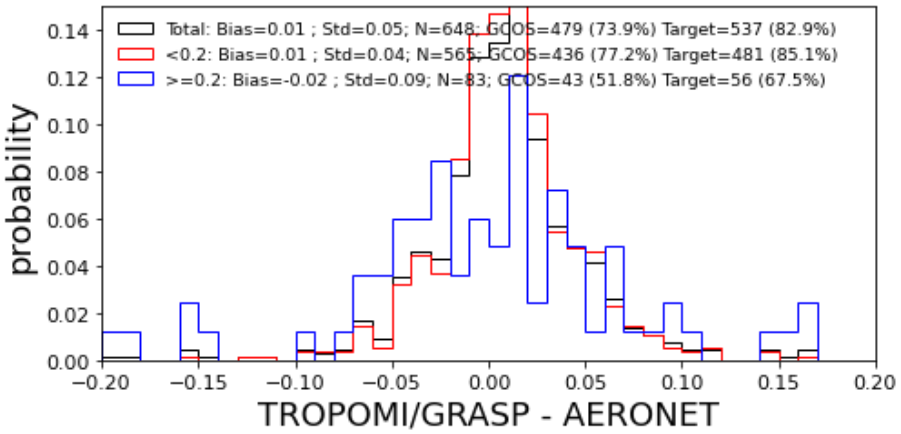
AOD

GRASP/S5p vs AERONET

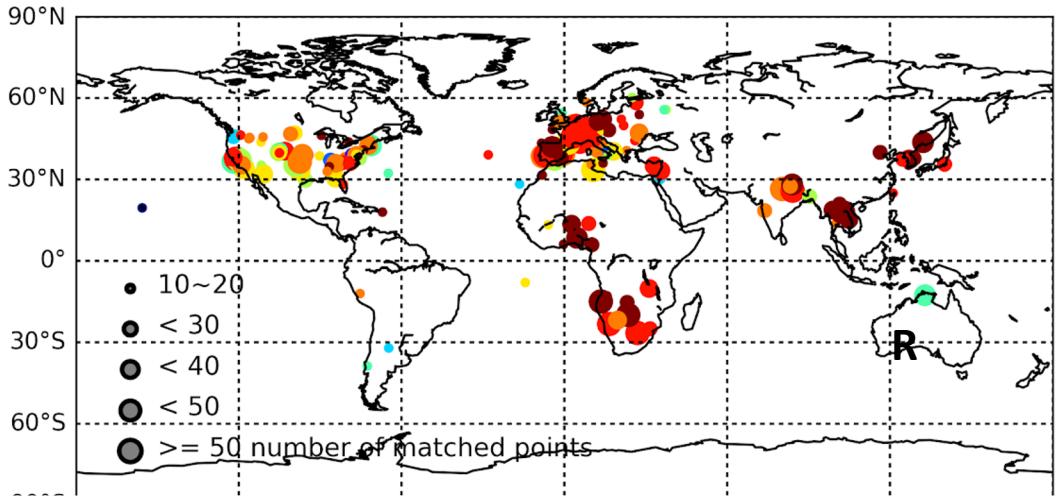


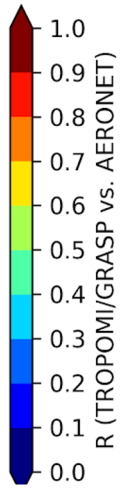


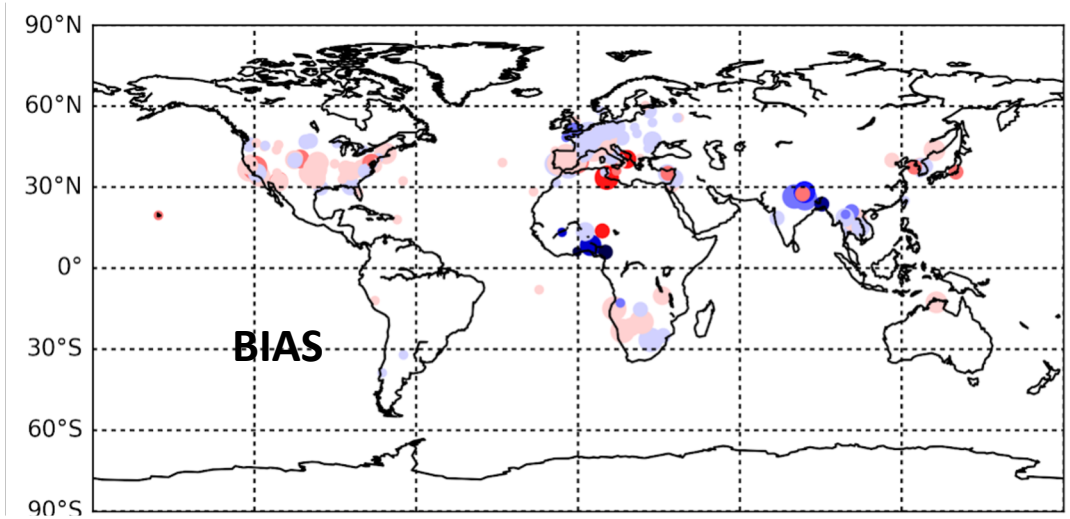


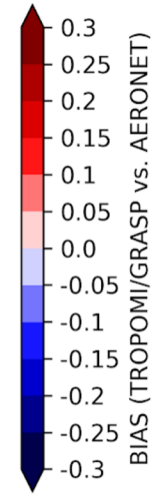


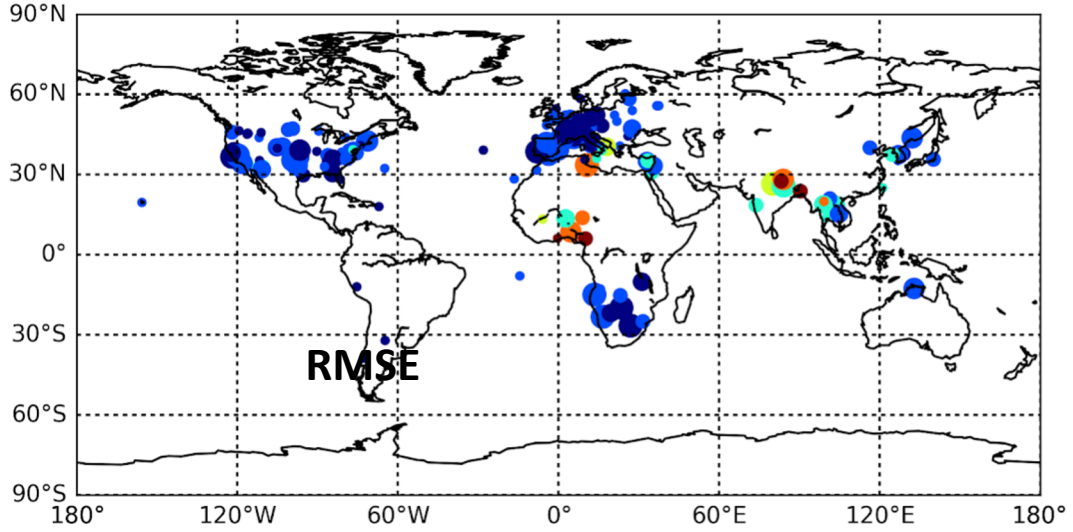
Site by site validation statistics of GRASP/S5p AOD 550nm

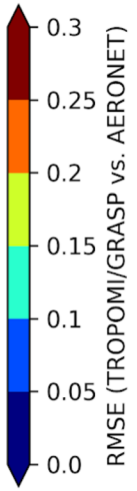


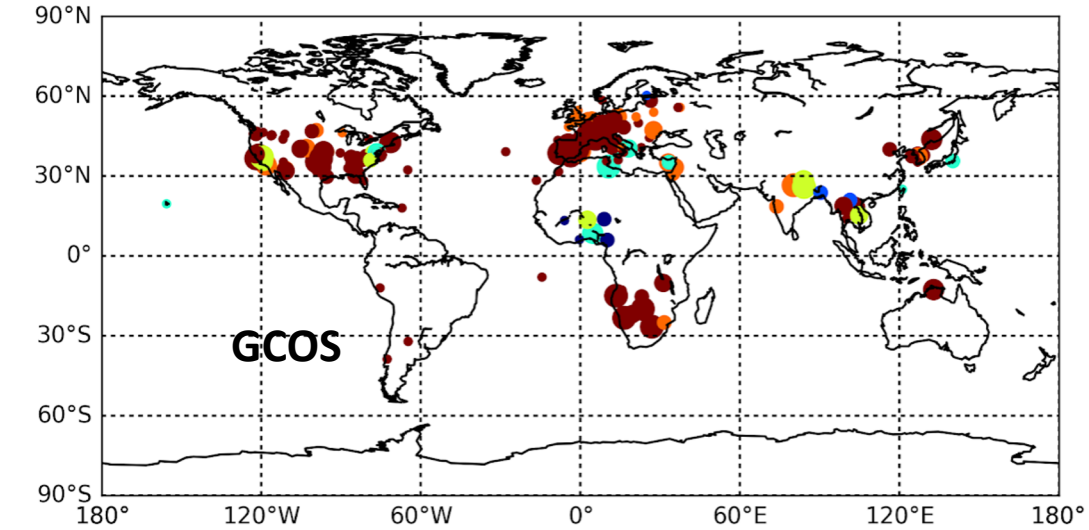


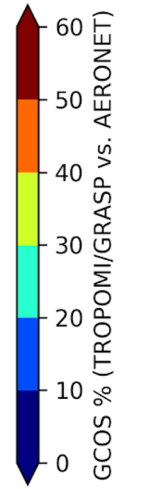




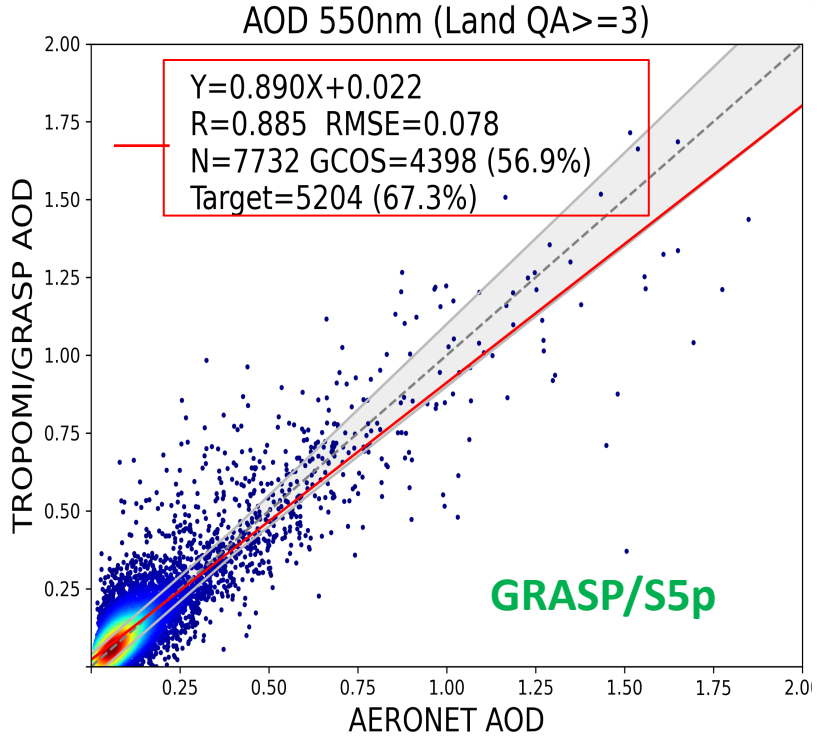


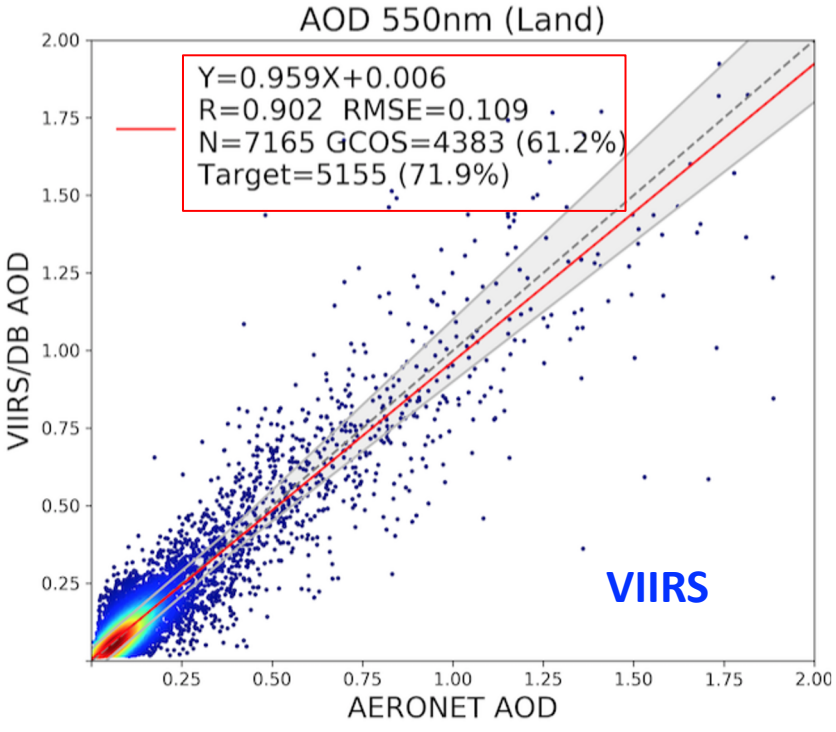


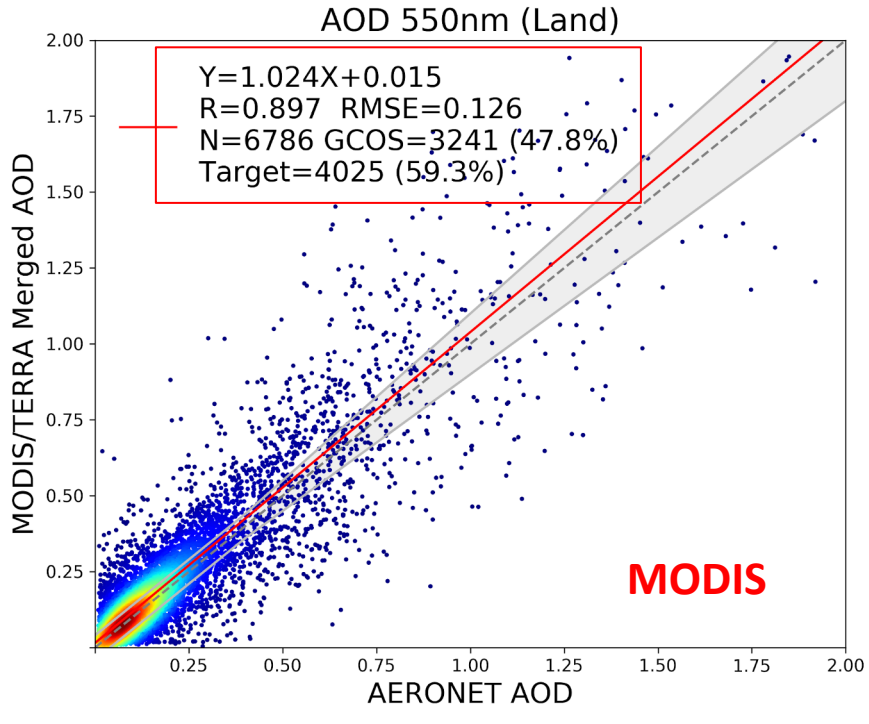


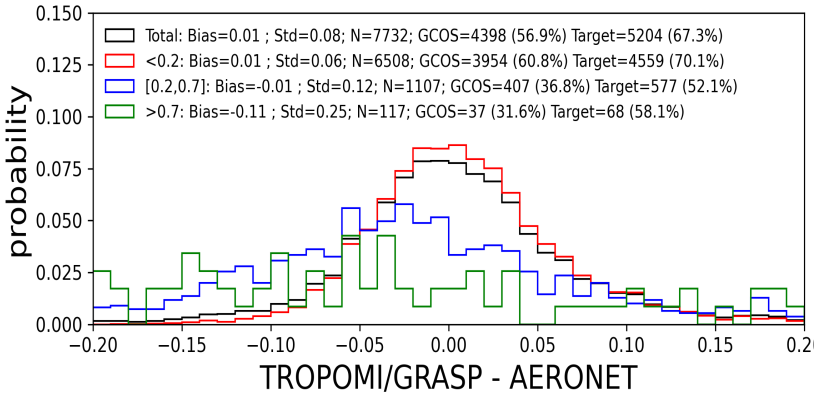


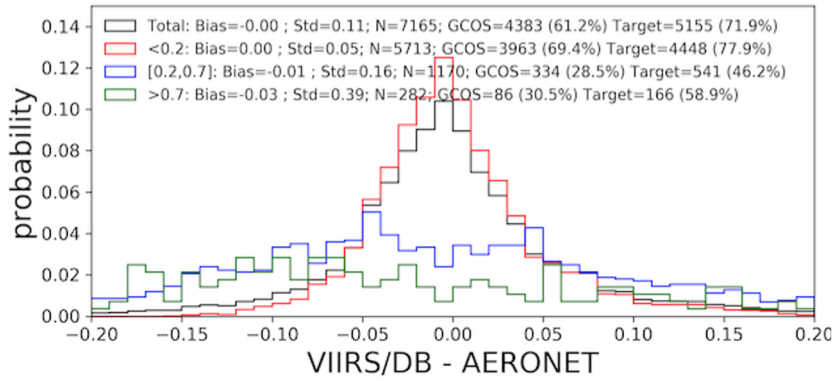
Inter-comparison over AERONET: GRASP/S5p, VIIRS, and MODIS. 550nm

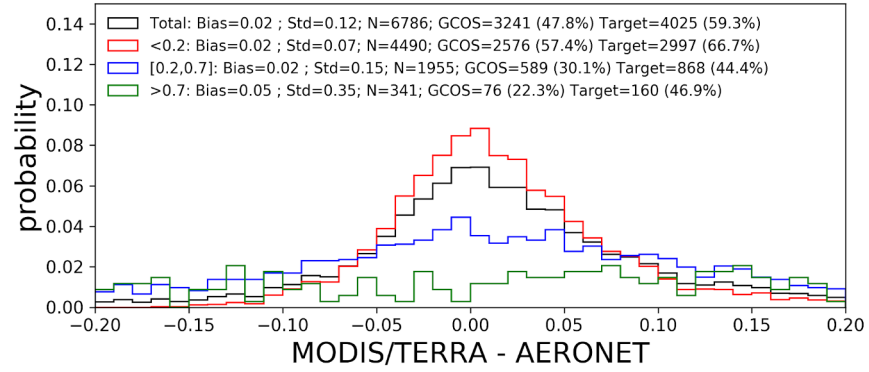






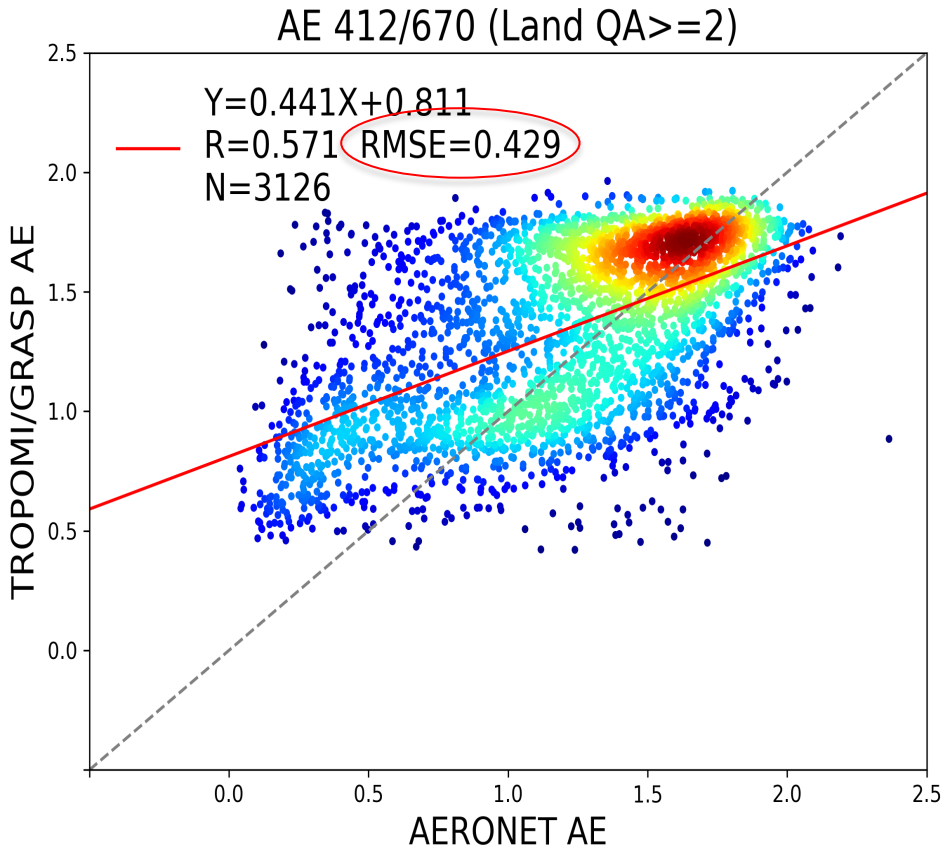


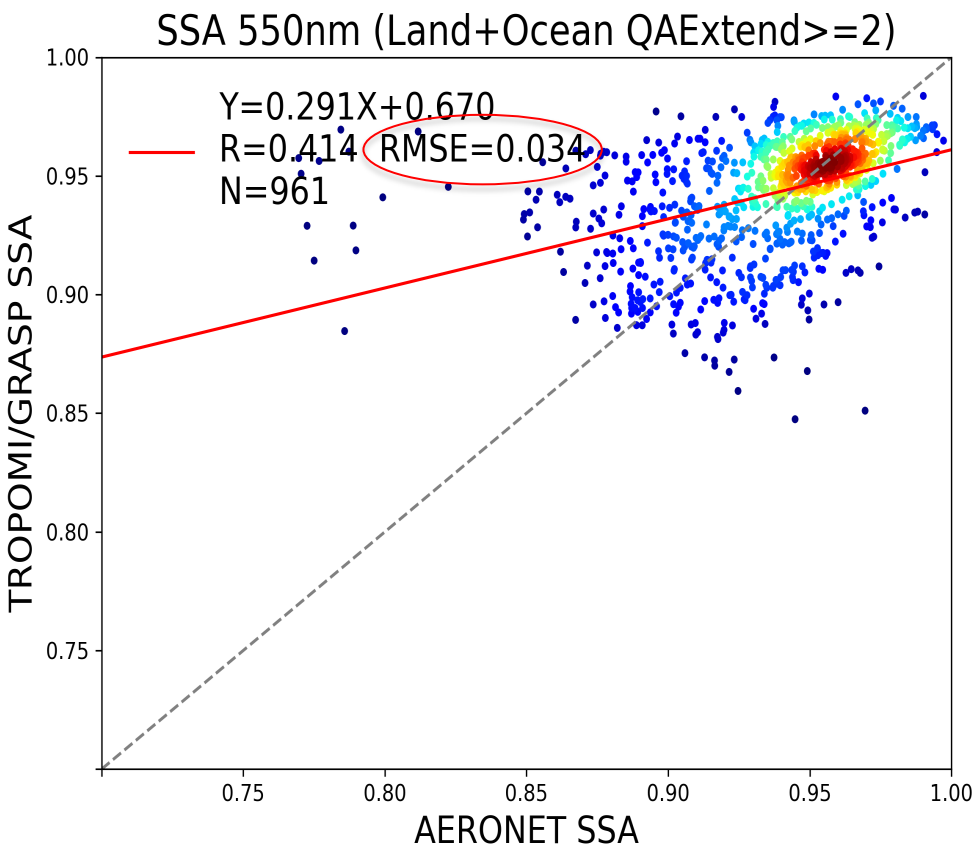


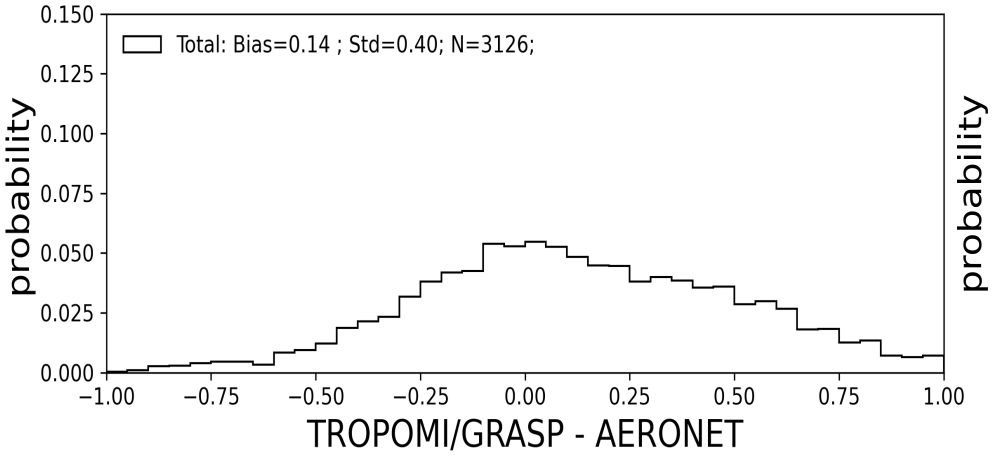


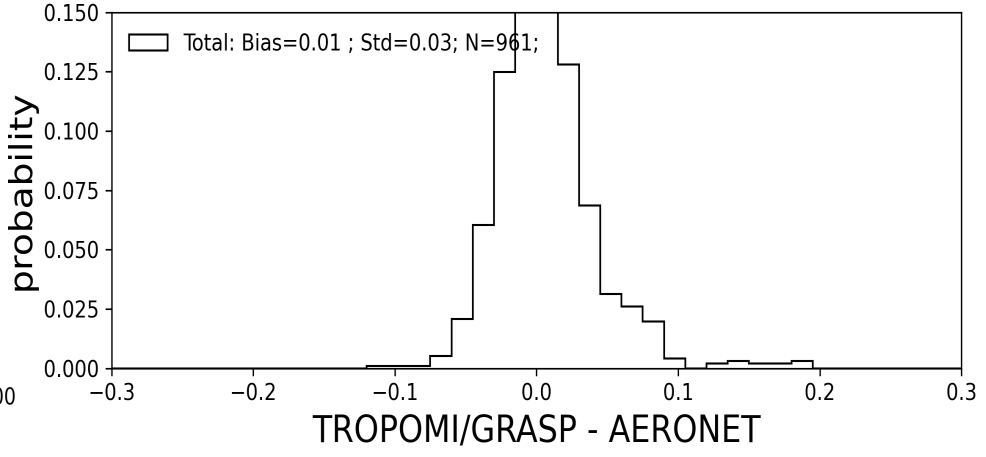
Beside AOD, GRASP/TROPOMI provides extended aerosol properties!

Aerosol product validation. Aexp and SSA GRASP/S5p vs AERONET



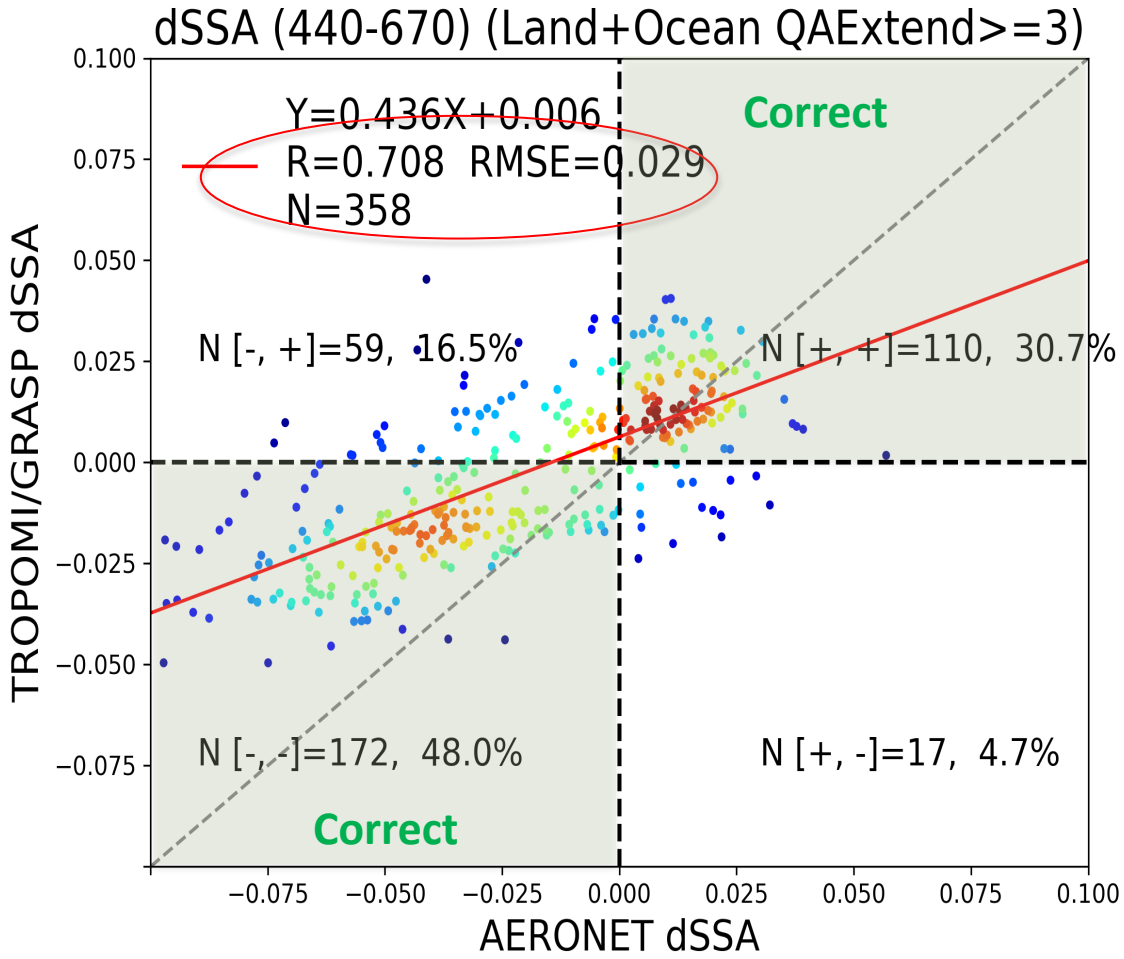


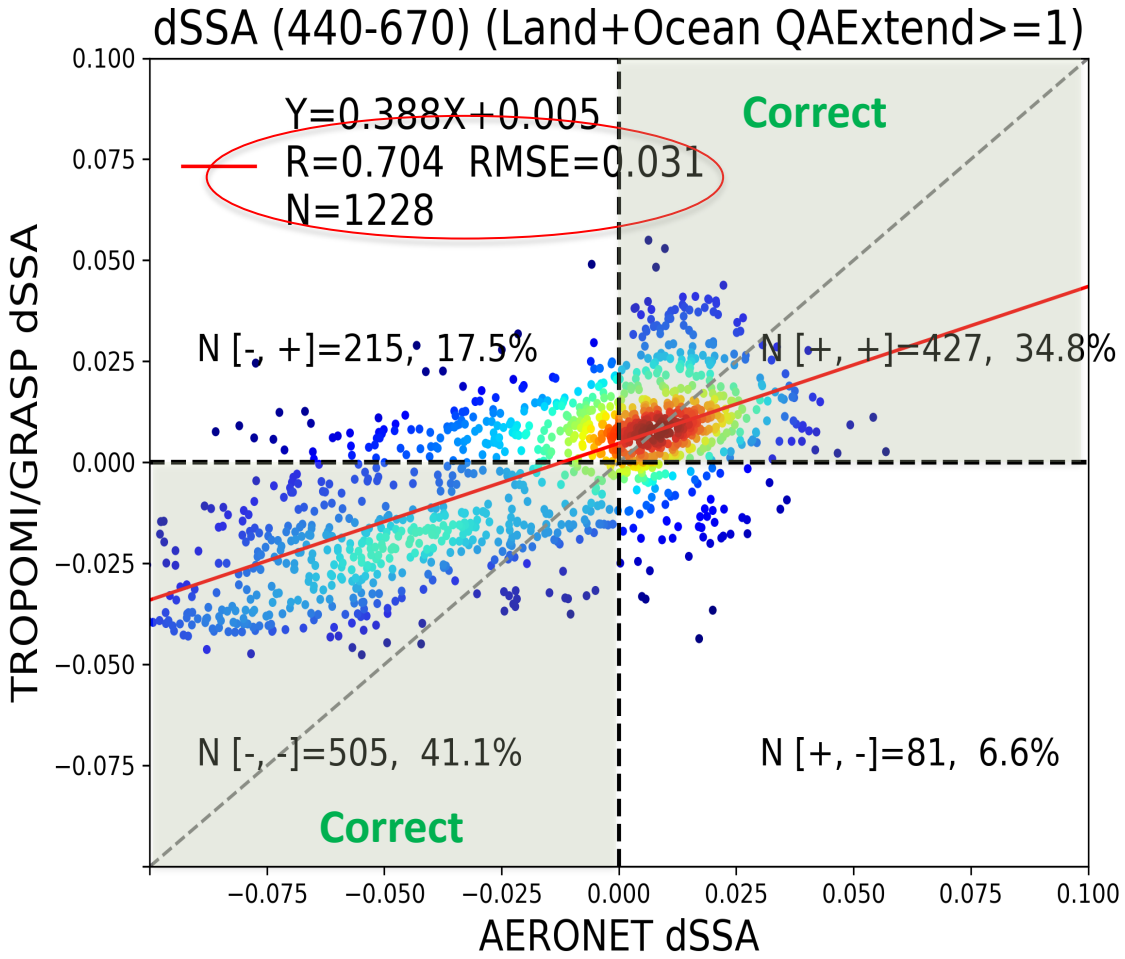




Aerosol product validation. Spectral dependence of SSA

GRASP/S5p vs AERONET



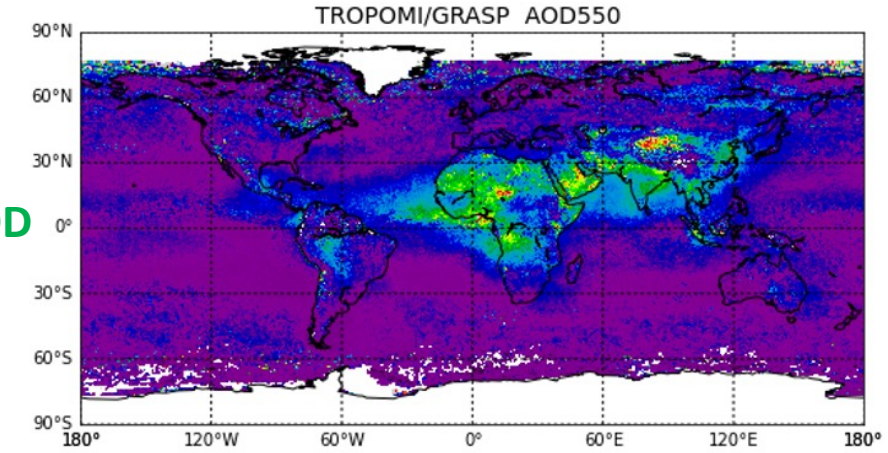


Spectral dependence of SSA (dSSA) sensitive to aerosol type.

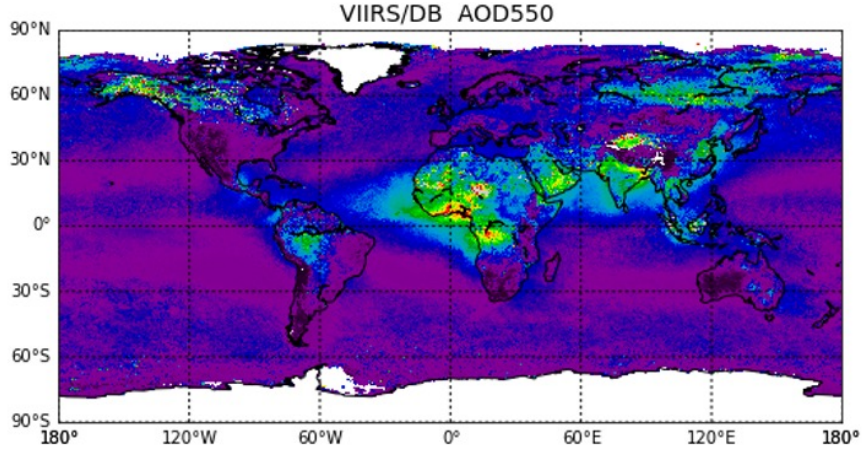
In GRASP/S5p product **dSSA** depends **less** on “quality” assurance index than **AExp** and **SSA**.

Global inter-comparison. AOD. GRASP/S5p vs VIIRS and MODIS

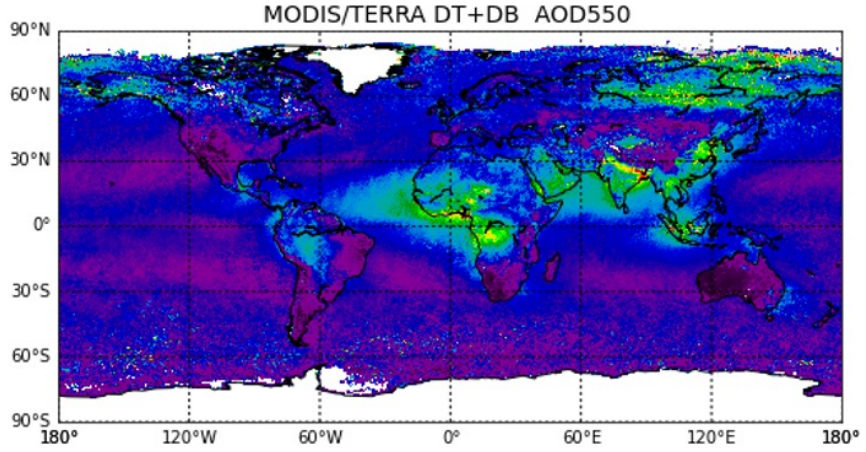
GRASP/S5p AOD

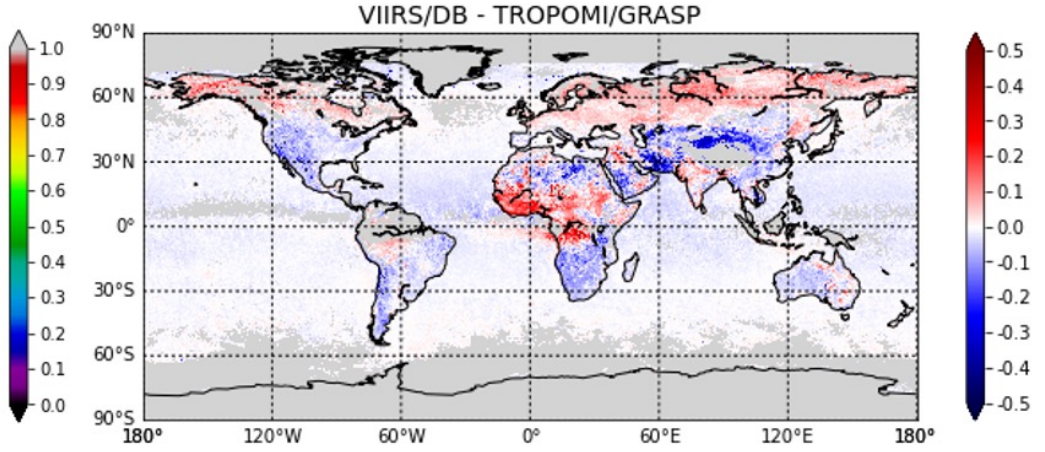


VIIRS AOD



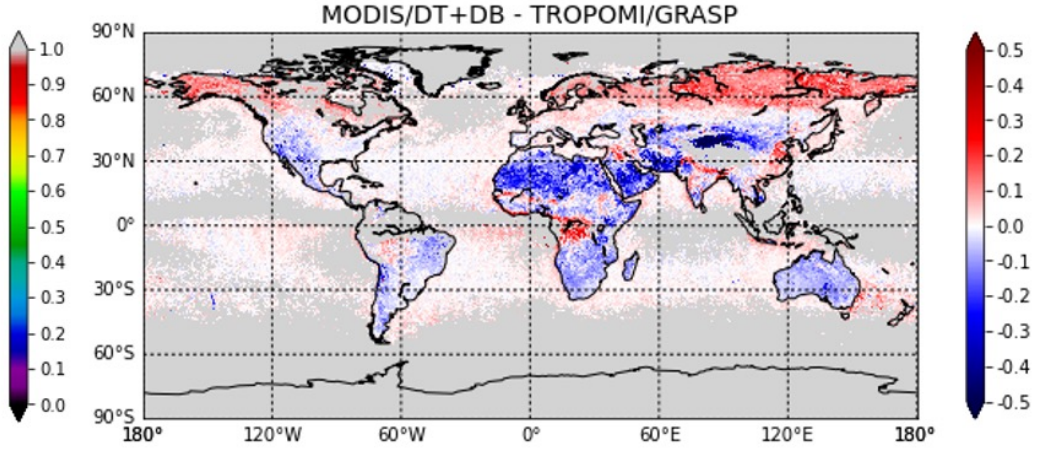
MODIS AOD





VIIRS - GRASP

The differences in AOD are mainly over land



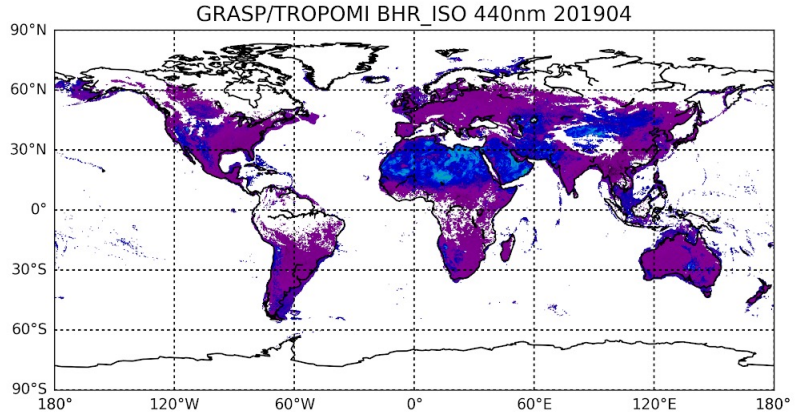
MODIS - GRASP

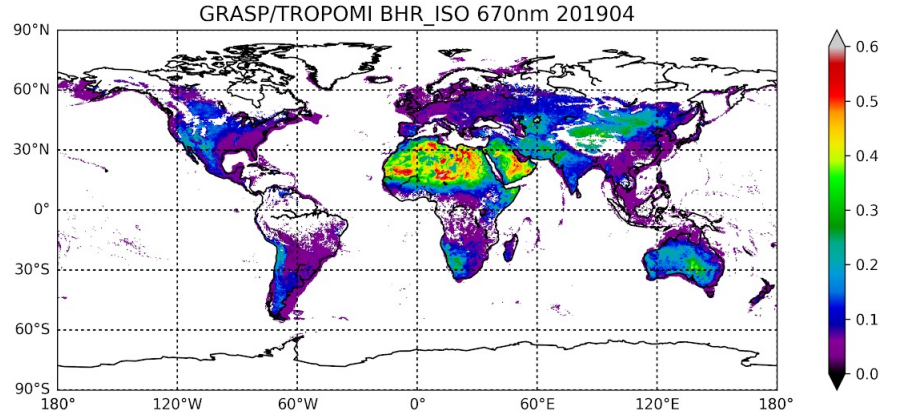
Global inter-comparison. Surface. GRASP/S5p vs MODIS

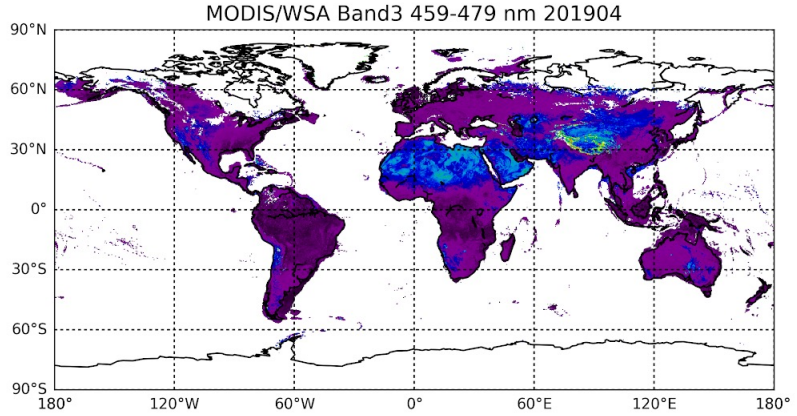
GRASP (BHR_iso)

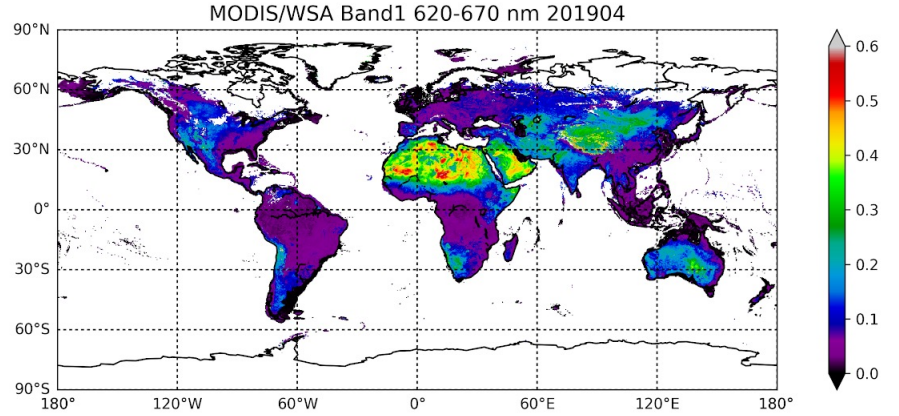
MODIS (White Sky Albedo (WSA) MCD43C3)

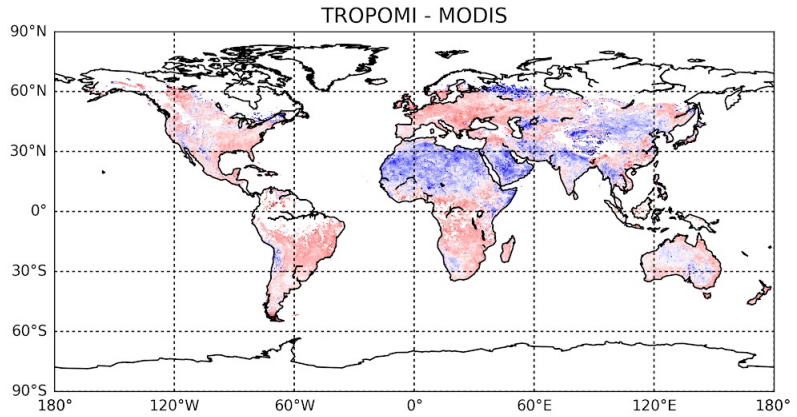
GRASP - MODIS

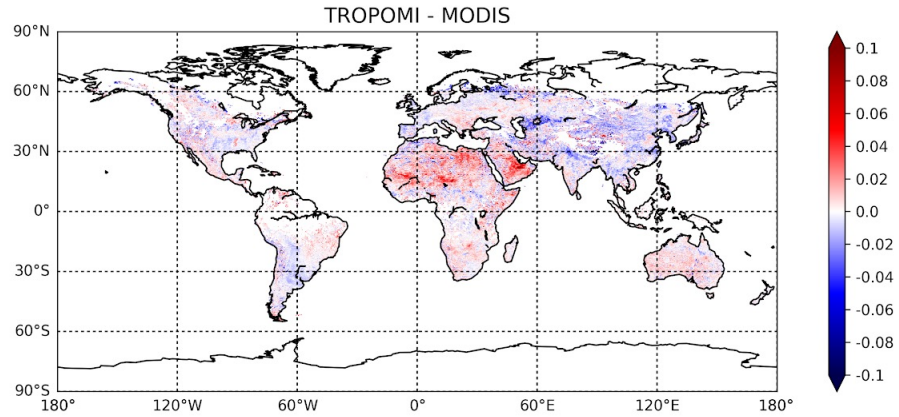








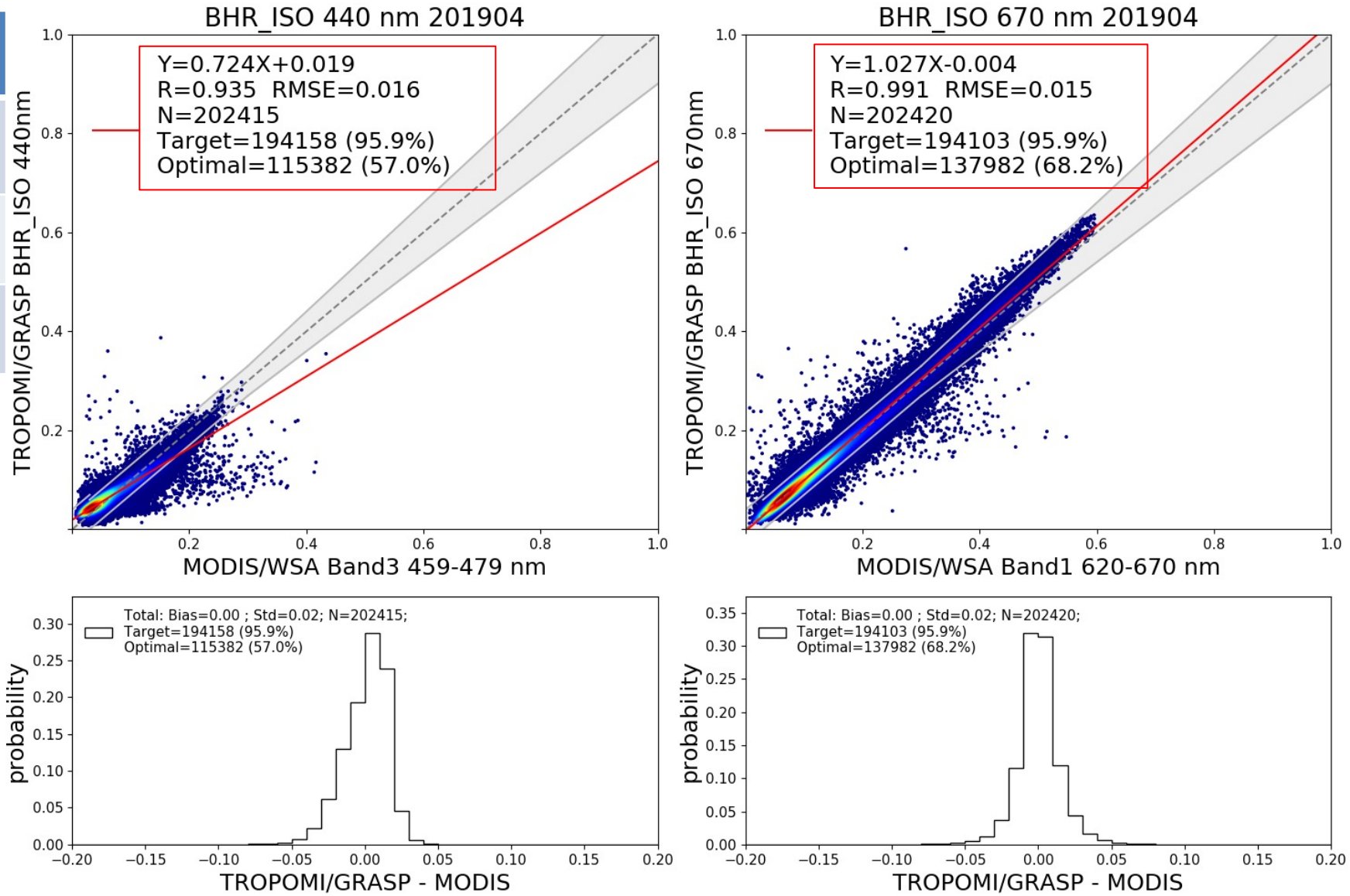




GRASP/S5p (BHR_ISO) vs MODIS (MCD43C3 WSA)

Requirements BRDF/ albedo	Uncertainties	
	Albedo <= 0.03	Albedo > 0.03
Target	0.04	0.03 or 10% (whatever is bigger)
Optimal	0.02	0.01 or 5% (whatever is bigger)

Good correspondence between GRASP and MODIS surface products globally!



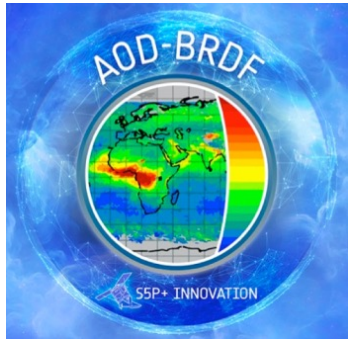
Summary. GRASP/S5p+I product

- ✓ Global aerosol product of high quality (daily, monthly)

- ✓ New information from GRASP/S5p:
  - AOD in UV, VIS and SWIR
  - Aerosol size (**AEexp, AODF, AODC**)
  - Absorption properties (**SSA, dSSA, AAOD**)

} Required information for aerosol type

- Full BRDF, Black Sky (DHR) and White Sky (BHR_iso) albedos from S5p/TROPOMI of high quality (daily, monthly).



GRASP/S5p+I products. Expected performance

Surface GRASP/S5p+I product (10 wavelengths: 0.340 0.367 0.380 0.416 0.440 0.494 0.670 0.747 0.772 2.313)

	UV	VIS	NIR	SWIR	Coverage	Uncertainties	
						Target requirements	Optimal requirements
BRDF	✓	✓	✓	✓	Daily / Monthly	0.03 or 10% **(60 - 95%) depending on spectral band**	0.01 or 5% **(50 - 80%) depending on spectral band**
Albedos	✓	✓	✓	✓			

Aerosol GRASP/S5p+I product (10 wavelengths: 0.340 0.367 0.380 0.416 0.440 0.494 0.670 0.747 0.772 2.313)

	UV	VIS	NIR	SWIR	Coverage	Uncertainties	
						Target: 0.05 or 20%	Optimal: 0.04 or 10%
AOD, AODF	✓	✓	✓	✓	Daily / Monthly	**Ocean: 65 - 90% Land: 45 – 80%**	**Ocean 60-85 % Land: 40-70 %**
SSA, AAOD	✓	✓	✓	✓		**< 0.05** (for AOD > 0.3)	
Aerosol type, aerosol height						Under validation	

Conclusions and Outlook

- **S5p+I AOD/BRDF studies show rich information content** of S5p/TROMOMI for aerosol and surface characterization.
- **Wide TROPOMI swath (Global daily coverage)** provides the possibility of detailed surface characterisation:
  - Full BRDF characterisation.
  - Possibilities for accurate separation of the atmosphere and surface signals.
- **Wide spectral range + global daily coverage** provide new possibilities for extended aerosol characterisation:
  - Aerosol absorption properties (SSA, dSSA, AAOD etc)
  - Aerosol size (fine and coarse AOD, AExp etc)
- **In combination with GRASP retrieval algorithm** aerosol and surface products of high quality can be derived from S5p/TROPOMI measurements:
  - Good agreement with AERONET.
  - Good global agreement with well-validated aerosol and surface products (MODIS, VIIRS).
- **Operational generation** of advanced aerosol and surface products **from S5P/TROPOMI** should advance global climate studies and can be used in different climate applications.