# Validation of POLDER/ GRASP 10 km product and Assessment of multi-angular polarimetry potential

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***Details in:*** *Chen, Dubovik, Fuertes, et al., Earth Syst. Sci. Data Discuss, 2020.*

**The study includes**:

- Introduction of POLDER/GRASP 10km products;
- Validation of 9-year POLDER products against AERONET;
- Comparisons of the AOD results with validation results of 3 MODIS products against AERONET;
- Global pixel – to pixel comparisons of POLDER and MODIS AOD 10 km products.

**Conclusions/Discussions**:

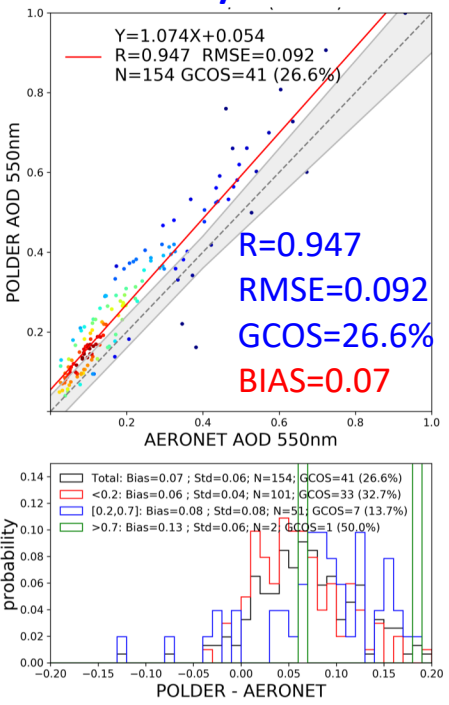
- Both over land ocean **total AOD** from MAP is, at least, of the similar quality as from SVR;
- Properties - **AE, fine /coarse AOD** (ocean), from MAP generally higher quality than from SVR;
- Detailed properties - **fine /coarse AOD** (land), **SSA, AAOD** are available from MAP and generally not from SVR;
- The algorithm for MAP are very complex, and may need **specific tuning for different products**

**MAP** – *Multi Angular Polarimeter ("POLDER")*

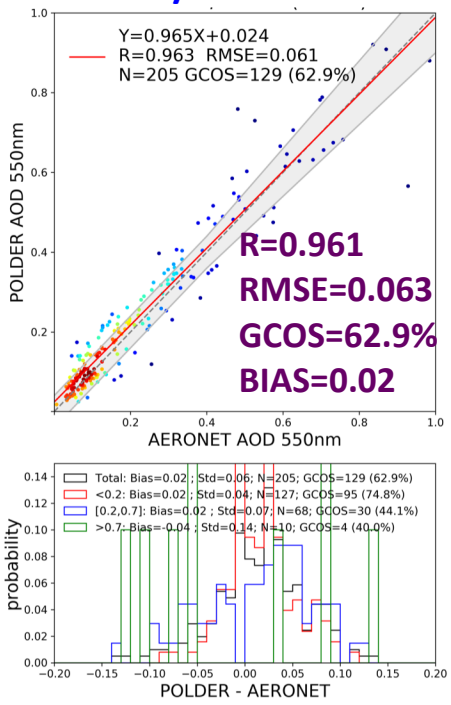
**SVR** – *Single View Radiometer ("MODIS")*

# Validation, all AERONET sites (Ocean), 2008

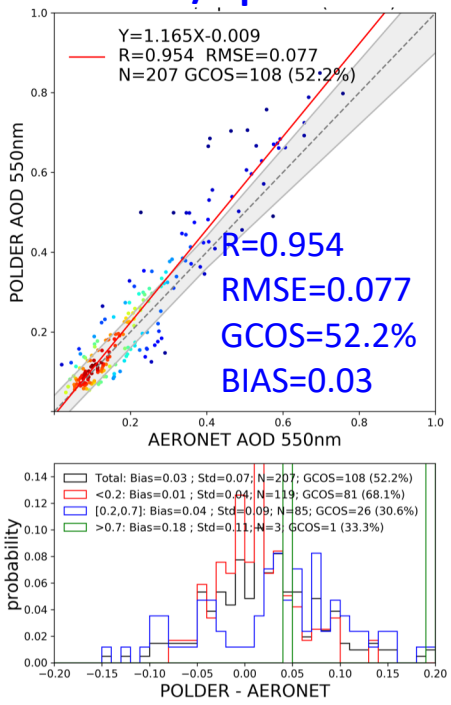
**POLDER/GRASP-HP**



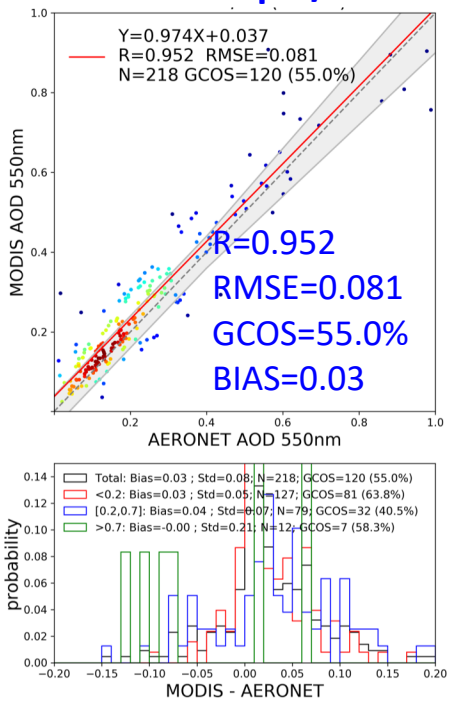

**POLDER/GRASP-Models**




**POLDER/Operational**



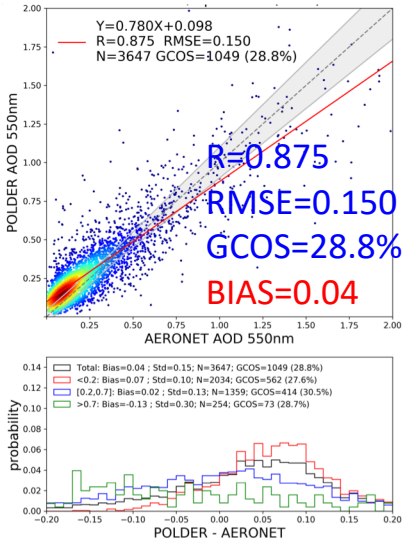

**MODIS-Aqua/DT**



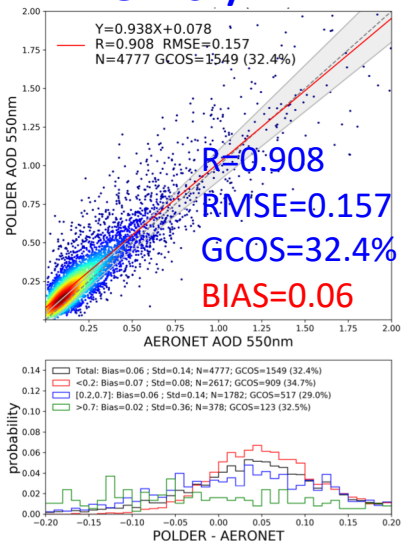

| | N | R | RMSE | BIAS | BIAS (τ<0.2) | BIAS (0.2≤τ≤0.7) | BIAS (τ>0.7) |
|---|---|---|---|---|---|---|---|
| DT vs. Models | 32 486 105 (130) | 0.92 (0.97) | 0.05 (0.05) | -0.01 (-0.01) | 0.00 (-0.02) | -0.04 (-0.01) | -0.06 (-0.04) |
| HP vs. Models | 65 551 501 (300) | 0.94 (0.97) | 0.09 (0.10) | 0.05 (0.06) | 0.05 (0.05) | 0.07 (0.06) | 0.16 (0.11) |
| Operational vs. Models | 5 988 842 (91) | 0.94 (0.99) | 0.04 (0.09) | 0.01 (0.05) | 0.01 (0.04) | 0.03 (0.03) | 0.10 (0.24) |

# Validation, all AERONET sites (Land), 2008

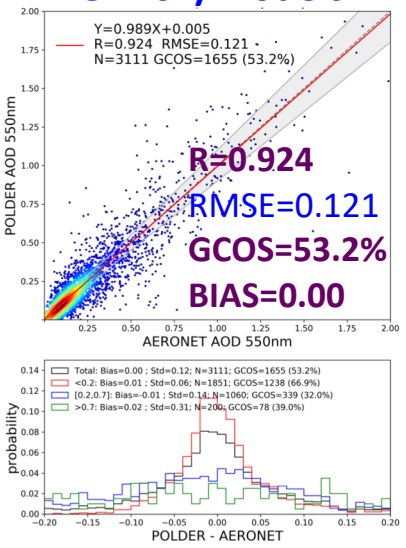
## GRASP/Optimized




## GRASP/HP




## GRASP/Models

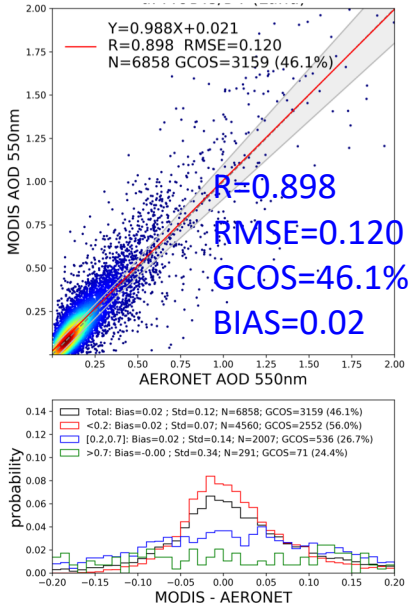



1. 0.05~0.07 bias for Optimized and HP

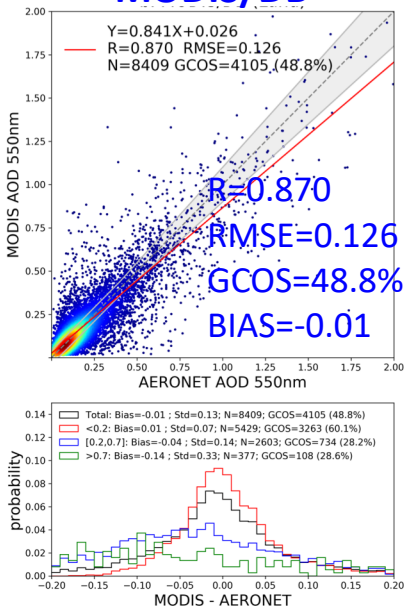
2. ~0.00 bias for Models, R~0.92, GCOS~53%

3. Stricter filter to generate Models products; do not work for the others

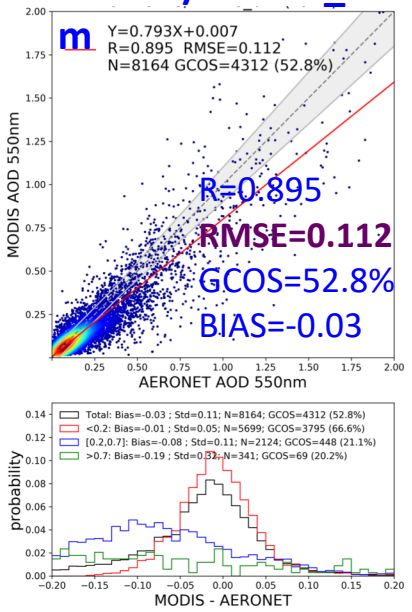
## MODIS/DT



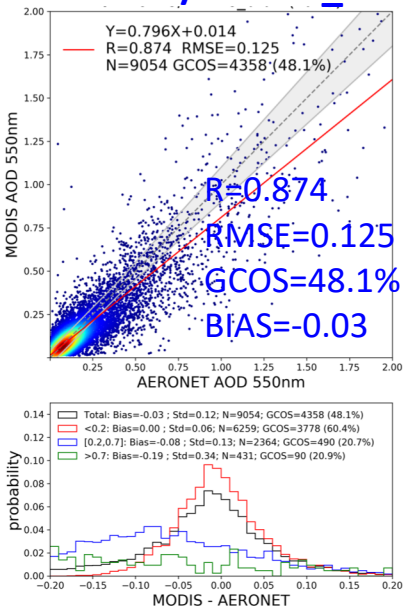

## MODIS/DB



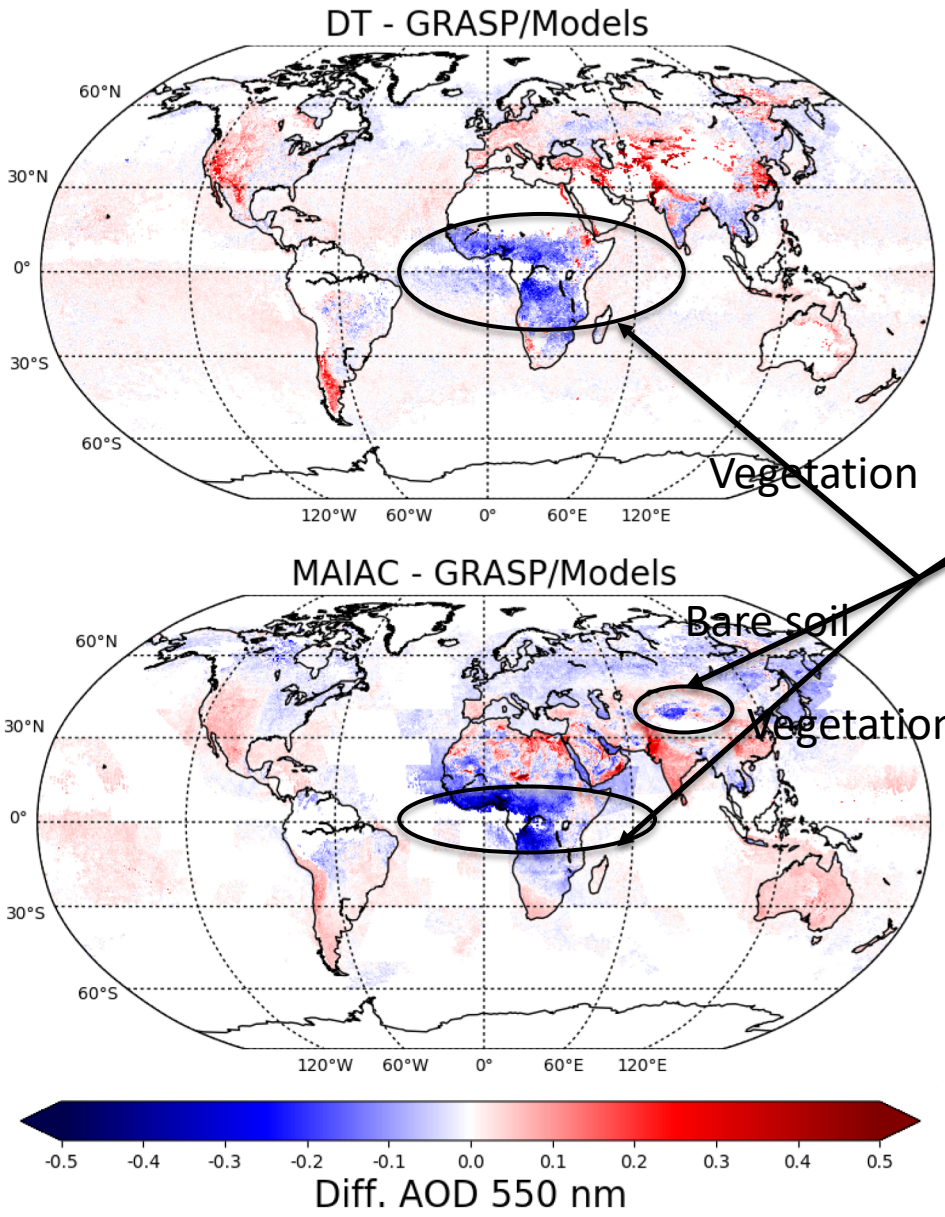

## MODIS/MAIAC_1km



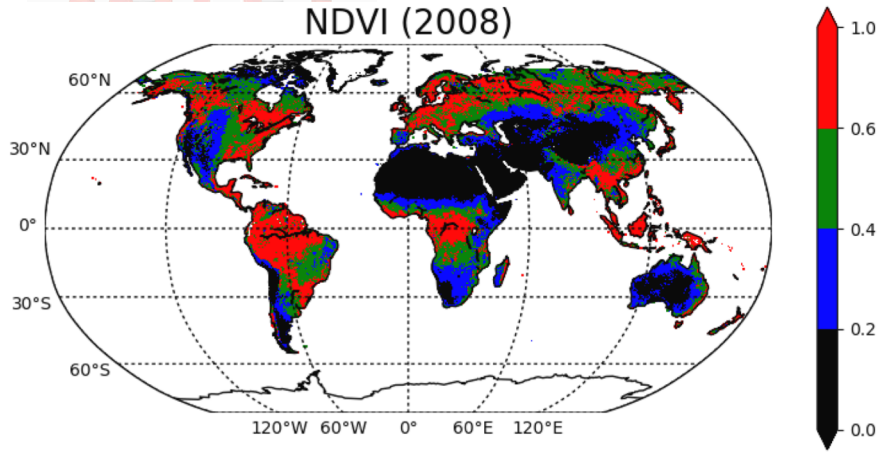

## MODIS/MAIAC_0.1



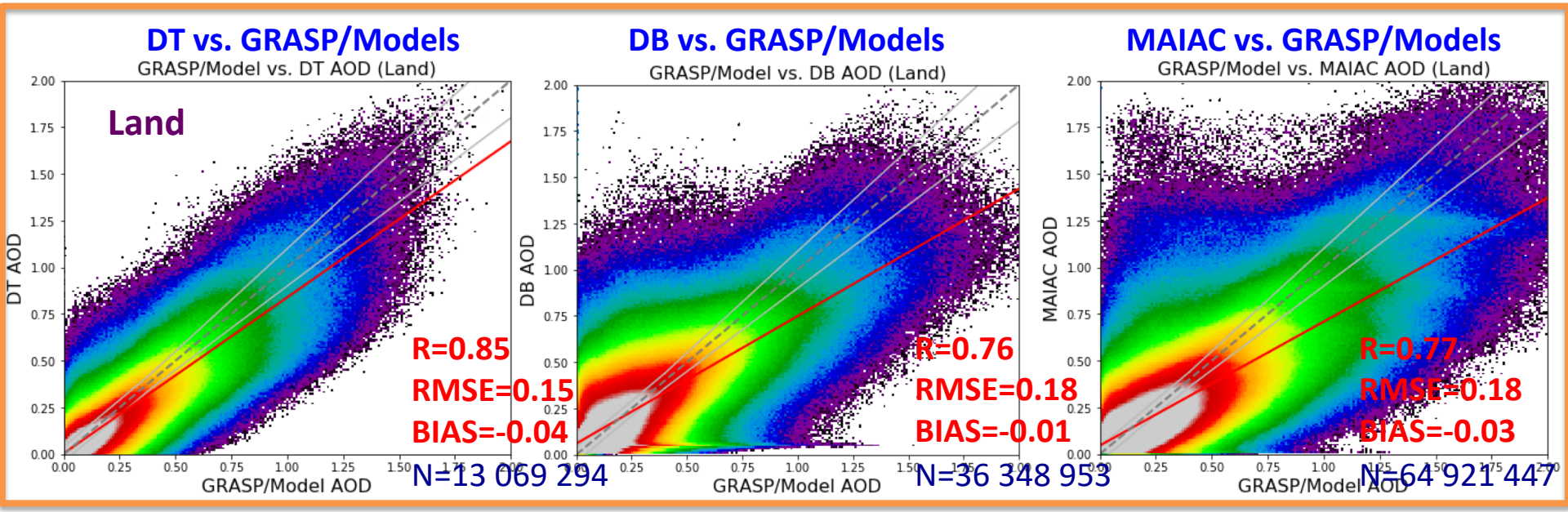
# AOD differences between products at 0.1 degree

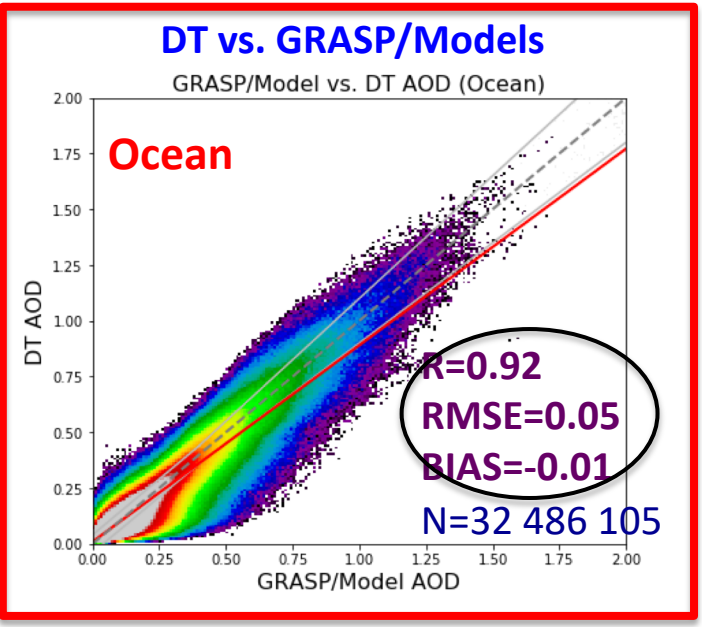






# Global AOD between products at **0.1** degree, 2008



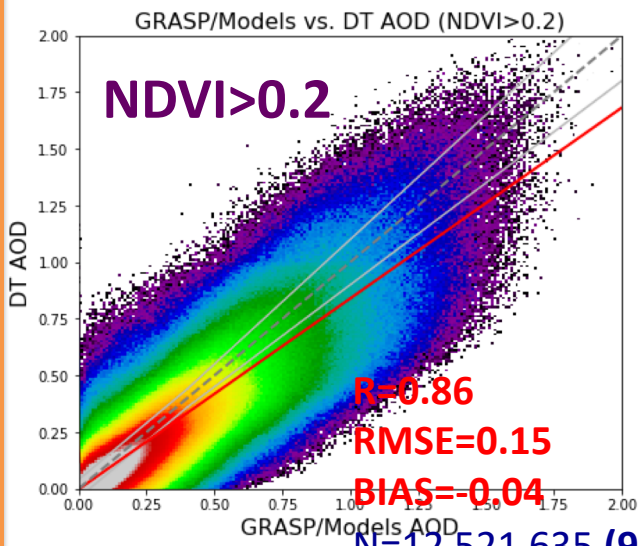




Over ocean, DT vs. Models, R~0.92, Diff~-0.01, RMSE=0.05, >32 millions points

Over land, Models vs. **DT** (R=0.85, **RMSE=0.15**), in contrast, Models vs. **DB** (R=0.76, **RMSE=0.18**), vs. **MAIAC** (R=0.77, **RMSE=0.18**)

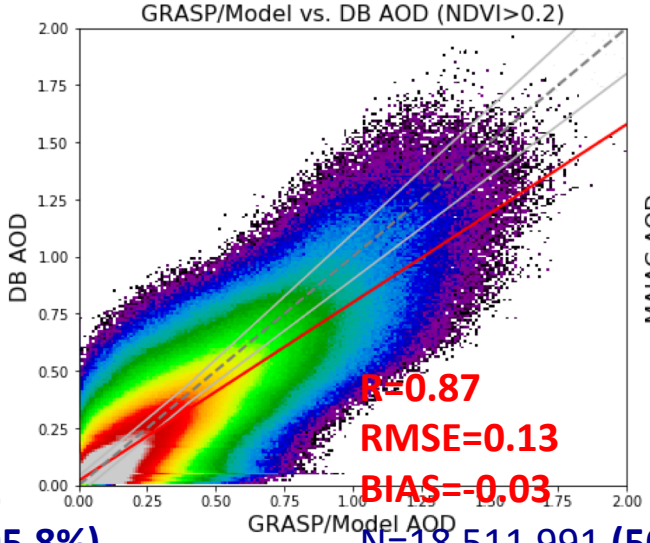
# **0.1** degree AOD classified with NDVI, 2008

## DT vs. GRASP/Models



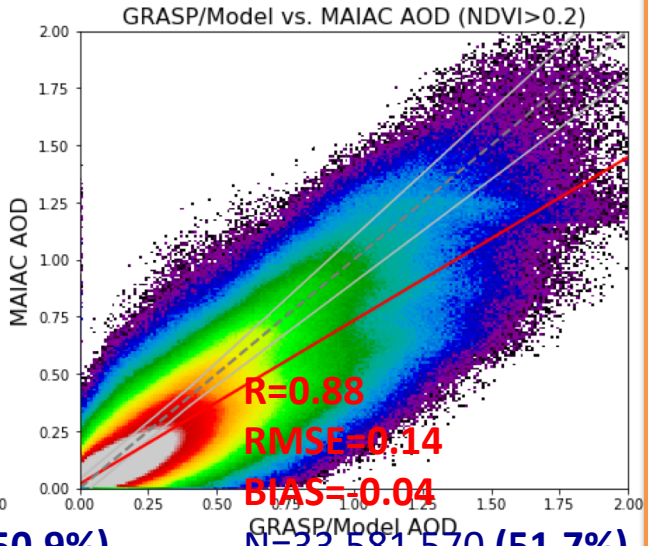

N=12 521 635 **(95.8%)**

## DB vs. GRASP/Models

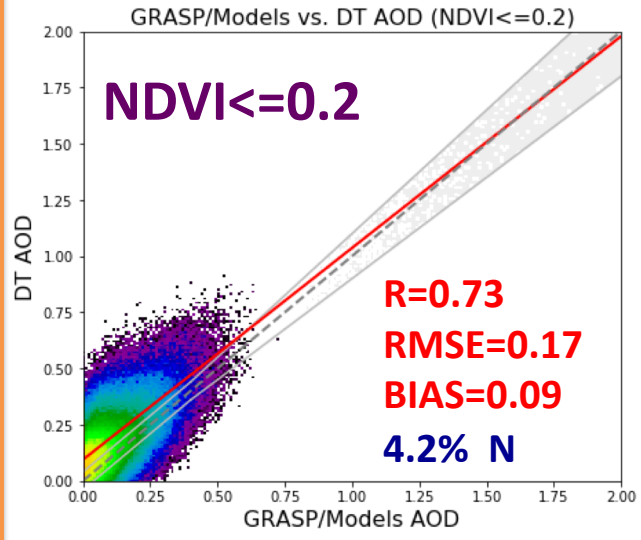


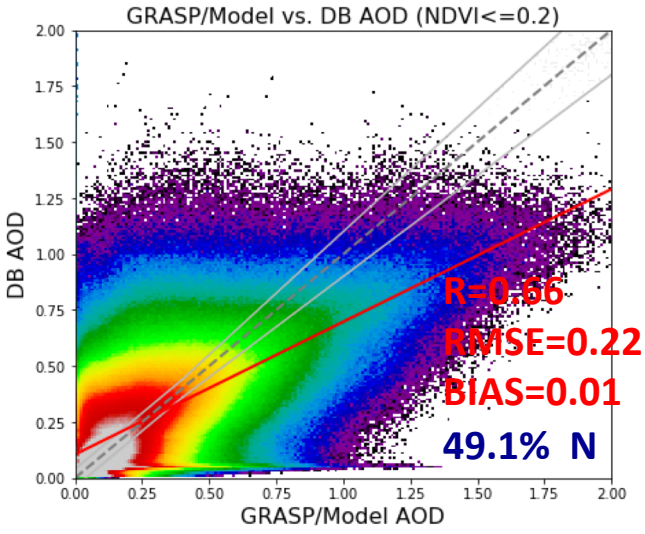

N=18 511 991 **(50.9%)**

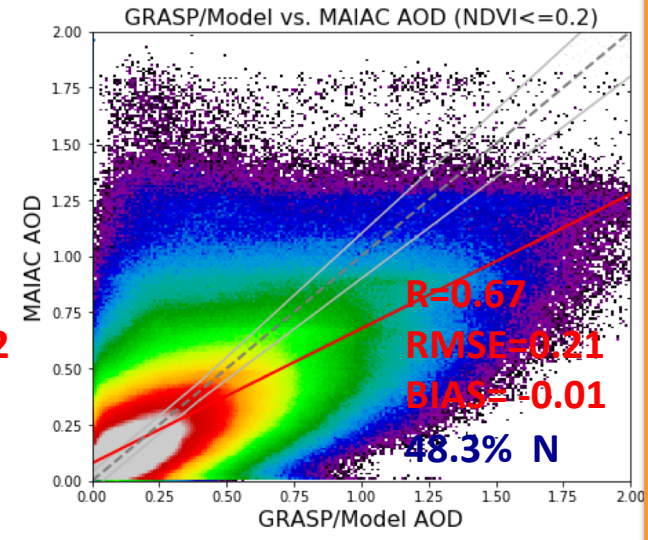
## MAIAC vs. GRASP/Models




N=33 581 570 **(51.7%)**



# Validation metrics classified by NDVI

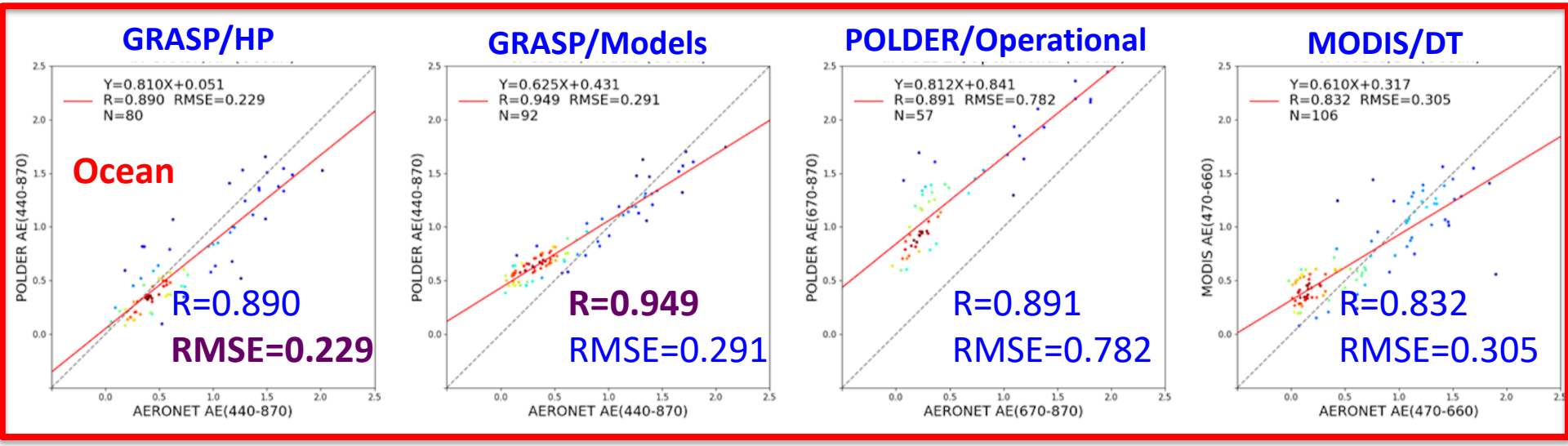
| | Products | R | RMSE | GCOS (%) | BIAS | BIAS (τ<0.2) | BIAS (0.2≤τ≤0.7) | BIAS (τ>0.7) |
|---|---|---|---|---|---|---|---|---|
| NDVI<0.2 | HP (1410) | **0.915** | 0.155 | 26.0 | 0.06 | 0.09 | 0.05 | -0.03 |
| | Models (786) | 0.873 | 0.159 | 39.8 | **-0.01** | **0.01** | **-0.03** | **0.01** |
| | DB (1327) | 0.845 | 0.153 | **44.2** | **-0.01** | 0.03 | -0.05 | -0.16 |
| | MAIAC_0.1 (1853) | 0.883 | **0.139** | 42.4 | -0.03 | 0.02 | -0.09 | -0.22 |
| 0.2<=NDVI<0.4 | HP (1479) | 0.928 | 0.145 | 39.4 | 0.05 | 0.05 | 0.06 | **-0.03** |
| | Models (1020) | **0.953** | **0.125** | 52.7 | **0.00** | **0.00** | **-0.01** | 0.04 |
| | DT (1847) | 0.895 | 0.145 | 40.6 | 0.02 | 0.03 | **0.01** | -0.05 |
| | DB (2204) | 0.888 | 0.142 | 46.3 | -0.02 | **0.00** | -0.05 | -0.09 |
| | MAIAC_0.1 (2049) | 0.901 | 0.133 | **53.9** | -0.04 | -0.01 | -0.11 | -0.18 |
| 0.4<=NDVI<0.6 | HP (1249) | 0.903 | 0.173 | 33.2 | 0.07 | 0.06 | 0.07 | 0.12 |
| | Models (1074) | **0.920** | **0.086** | **61.5** | **0.00** | **0.01** | **0.00** | -0.04 |
| | DT (2702) | 0.907 | 0.112 | 46.6 | 0.01 | **0.01** | 0.02 | **-0.01** |
| | DB (2718) | 0.866 | 0.120 | 50.0 | -0.01 | **0.01** | -0.03 | -0.20 |
| | MAIAC_0.1 (2193) | 0.911 | 0.093 | 53.5 | -0.04 | -0.03 | -0.07 | -0.19 |
| NDVI>=0.6 | HP (194) | 0.853 | 0.160 | 21.3 | 0.11 | 0.10 | 0.11 | 0.10 |
| | Models (786) | **0.910** | 0.083 | 61.9 | 0.03 | 0.02 | 0.07 | 0.06 |
| | DT (943) | **0.910** | 0.076 | 55.0 | 0.01 | **0.01** | **0.03** | 0.17 |
| | DB (907) | 0.855 | 0.076 | 60.2 | **0.00** | **0.01** | -0.04 | 0.07 |
| | MAIAC_0.1 (651) | 0.826 | **0.063** | **66.2** | -0.02 | -0.02 | -0.06 | **-0.04** |

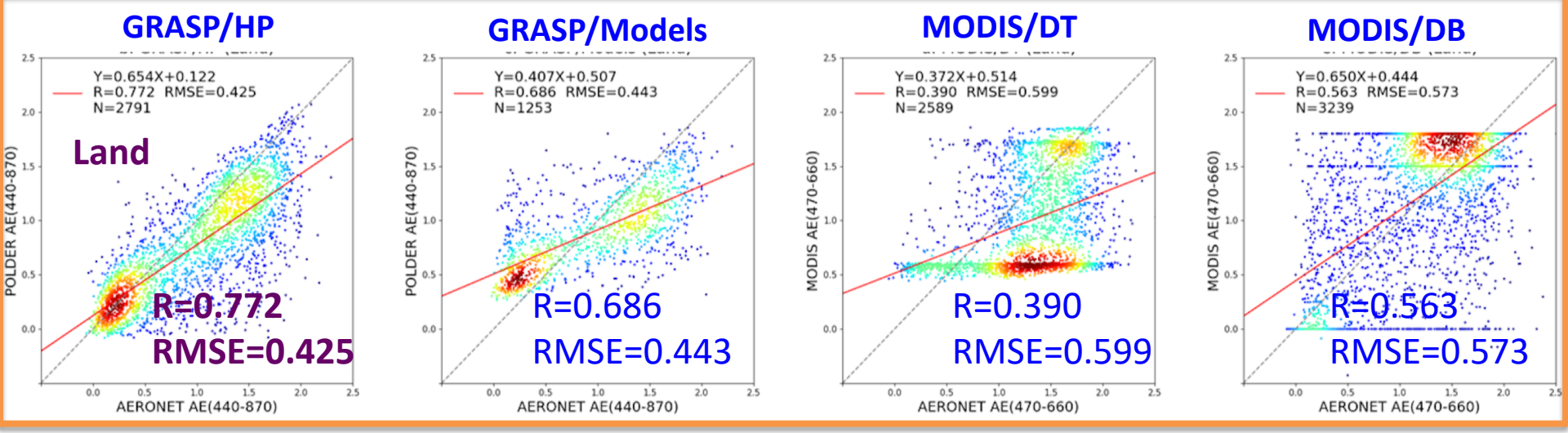
- ✓ All products perform less good over bare soil (NDVI<0.2) than the rest of surface types
  - ✓ DB and MAIAC overestimate (0.03-0.05) for low AOD and underestimate for medium and high AOD may result in differences over Sahara and Taklimakan

- ✓ AOD products show good performance for NDVI (0.2<=NDVI<0.6), GCOS>~45%, R>0.87
  - ✓ HP AOD has a positive bias 0.05-0.07, which is non-negligible
  - ✓ Models AOD: R>0.92, GCOS>92%, BIAS = 0.00

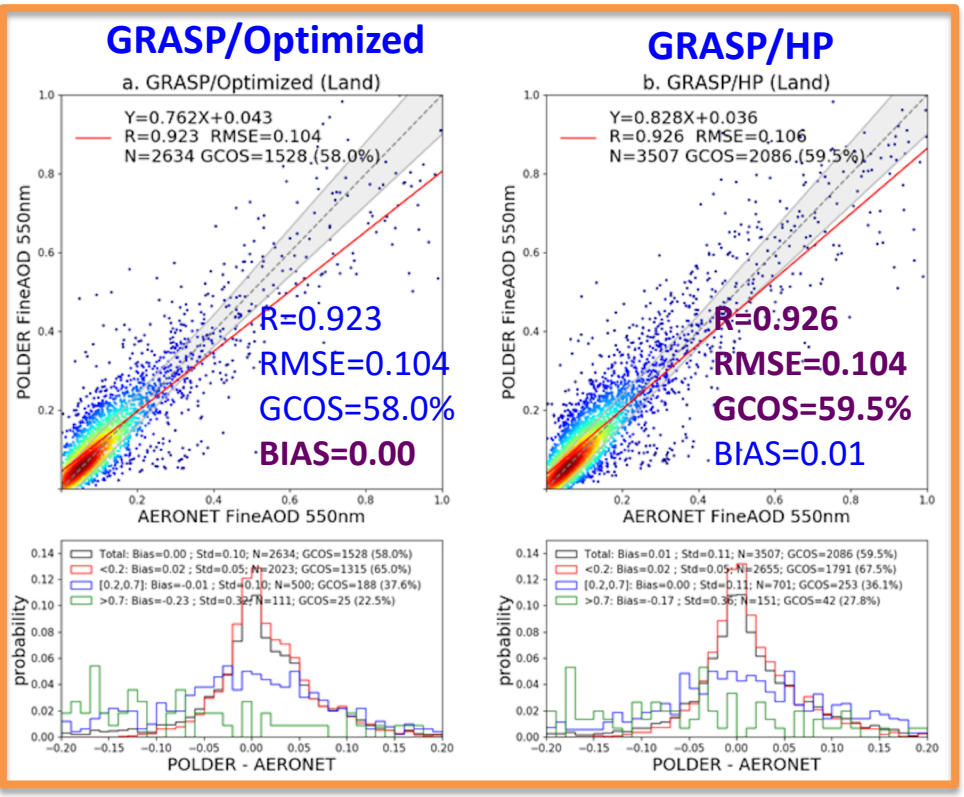
- ✓ Over dense vegetation (NDVI>=0.6), good GCOS for Models and MODIS (>55%), and low RMSE <0.085; However, the BIAS shows different story.
  - ✓ Models and DT show positive bias for all AOD ranges. In total, 0.01 -0.03, and Models is higher than DT.
  - ✓ DB overall bias is 0.00, and positive for small AOD and high AOD, while underestimate for medium AOD
  - ✓ MAIAC shows negative -0.02.
  - ✓ The different signs of bias for products may worsen the discrepancy.

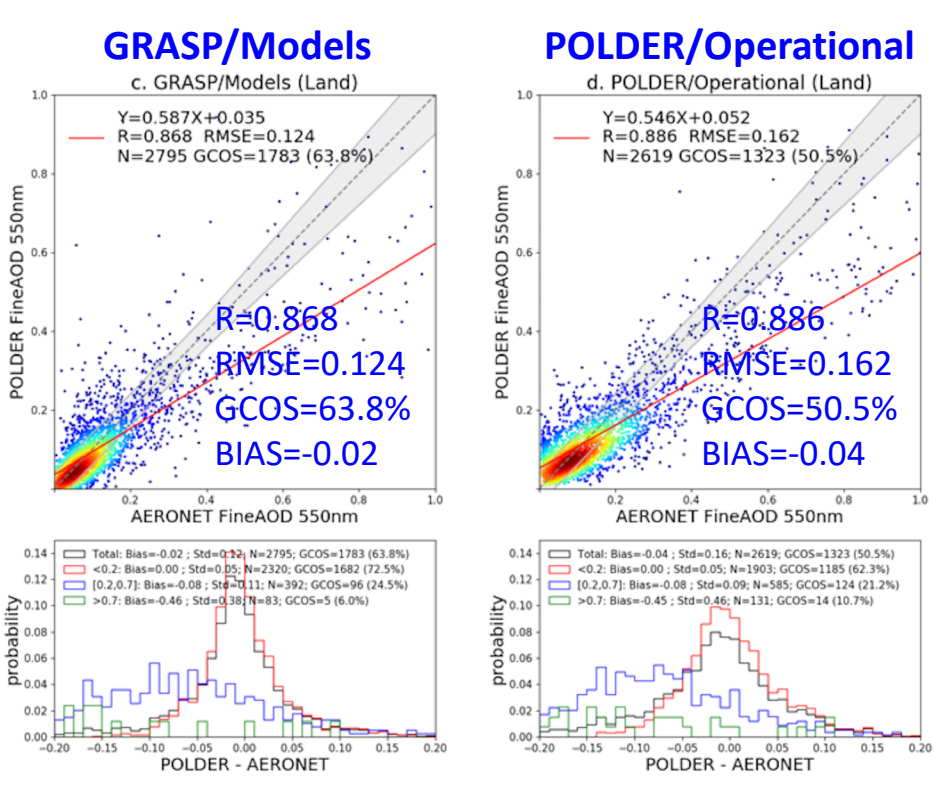
# AE Validation, all AERONET sites (Land/Ocean), 2008



# Fine AOD Validation, all AERONET sites (Land), 2008




1. Fine AOD over land is only available from multi-angular polarimetry (MAP), e.g. POLDER

2. Fine AOD from more complex retrieval, e.g. GRASP/Optimized and GRASP/HP, show solid quality, R>0.92 and BIAS<0.01 over land.

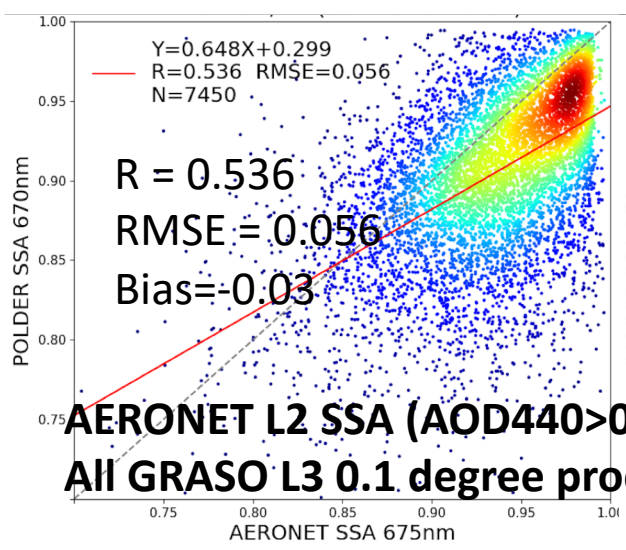
3. The AOD 0.05~0.07 bias for Optimized and HP are mainly from coarse mode AOD over land.

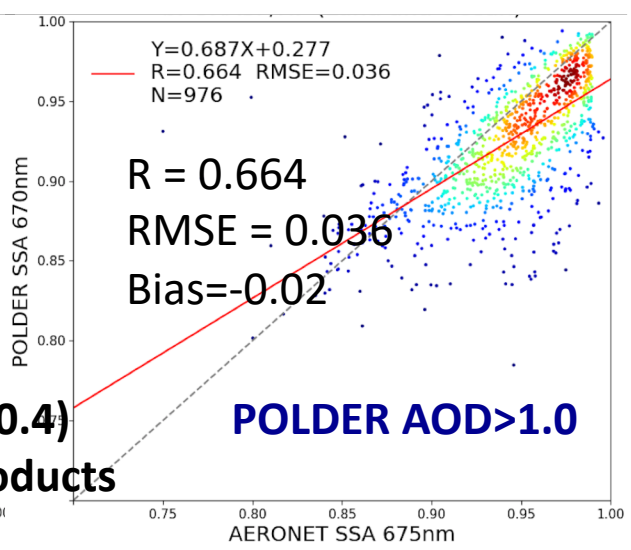
# Aerosol absorption: spectral SSA and AAOD

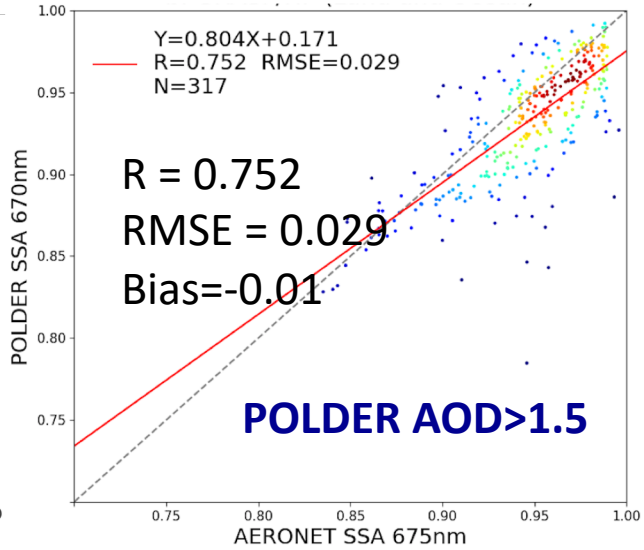
1. The GRASP/Modesl spectral **AAOD** bias against AERONET are ~zeros, R is low

| wls | N | R | RMSE | BIAS |
|---|---|---|---|---|
| 440 nm | 8046 | 0.54 | 0.04 | **0.00** |
| 670 nm | 8046 | 0.48 | 0.02 | **0.01** |
| 865 nm | 8046 | 0.44 | 0.02 | **0.00** |
| 1020 nm | 8046 | 0.41 | 0.02 | **0.00** |

2. The **SSA** quality against AERONET improves with AOD filter



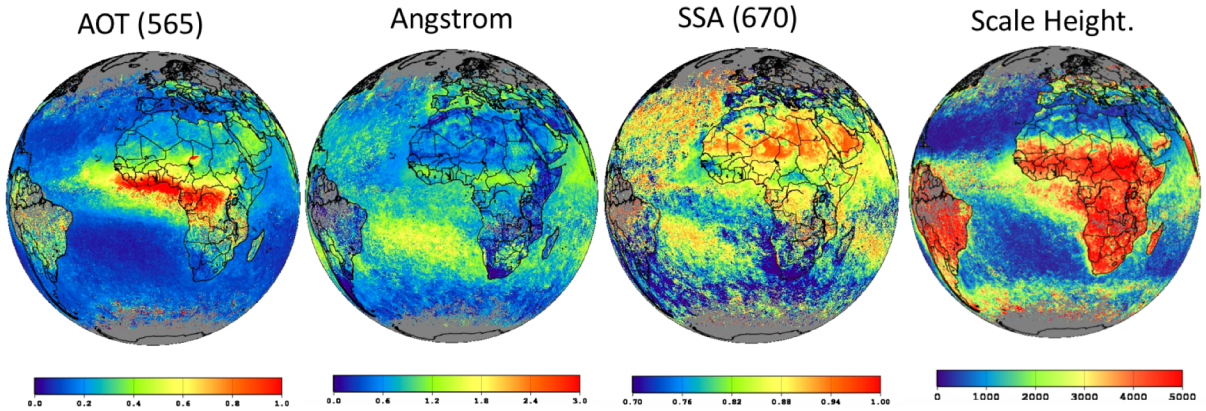



# POLDER-1, -2, -3/ GRASP products are available

**1996- 1997, 2003, 2004 – 2013** :
**Aerosol** (land and ocean):
AOD (λ), fine/coarse AOD(λ);
AE, SSA(λ), AAOD(λ), Scale height, size, etc.

**Surface:** (land and ocean):
BRDF (λ), BPDF (λ),




www.grasp-open.com/products, https://www.aeris-data.fr/icare

- **Full archive of POLDER-1,-2,-3 /GRASP** is available ;

**Conclusions from the data analysis**:

- Both over land ocean **total AOD** from MAP is, at least, of the similar quality as from SVR;
- Properties - **AE, fine /coarse AOD** (ocean)**,** from MAP generally higher quality than from SVR;
- Detailed properties - **fine /coarse AOD** (land), **SSA, AAOD** are available from MAP and generally not from SVR;
- The algorithm for MAP are very complex, and may need **specific tuning for different products**

**MAP** – *Multi Angular Polarimeter ("POLDER")*

**SVR** – *Single View Radiometer ("MODIS")*