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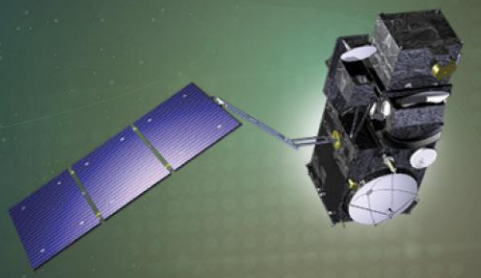

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Extended validation and evaluation of the OLCI-SLSTR Synergy aerosol product (SY_2_AOD) on Sentinel-3

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Introduction

In the context of remote sensing

- Validation refers to the process of quantifying the accuracy of satellite retrieved products by assessing the uncertainty of the derived products by analytical comparison to reference data, which is presumed to represent the true value of an attribute
- Validation shows the maturity of the satellite derived product and, thus, provides a conclusion on the mission success.
- Validation may also reveal a degradation of the instrument or potential drift
- Common validation principles and approaches should be followed to allow the inter-comparison.
- General validation is product-specific, while detailed validation is instrument-specific.
- Validation requires an expertise on instrument, processing, and application, and a good understanding of limitations; thus general validation approaches have to be adapted considering specifications of particular products (e.g., temporal, spatial, radiometric resolutions).
- Validation results should be used in quality assurance reporting together with product details, calibration characterisation, retrieval algorithm description, and uncertainty characterisation.

SY_2_AOD product

Ground-based AOD
AERONET
SURFRAD
SKYNET

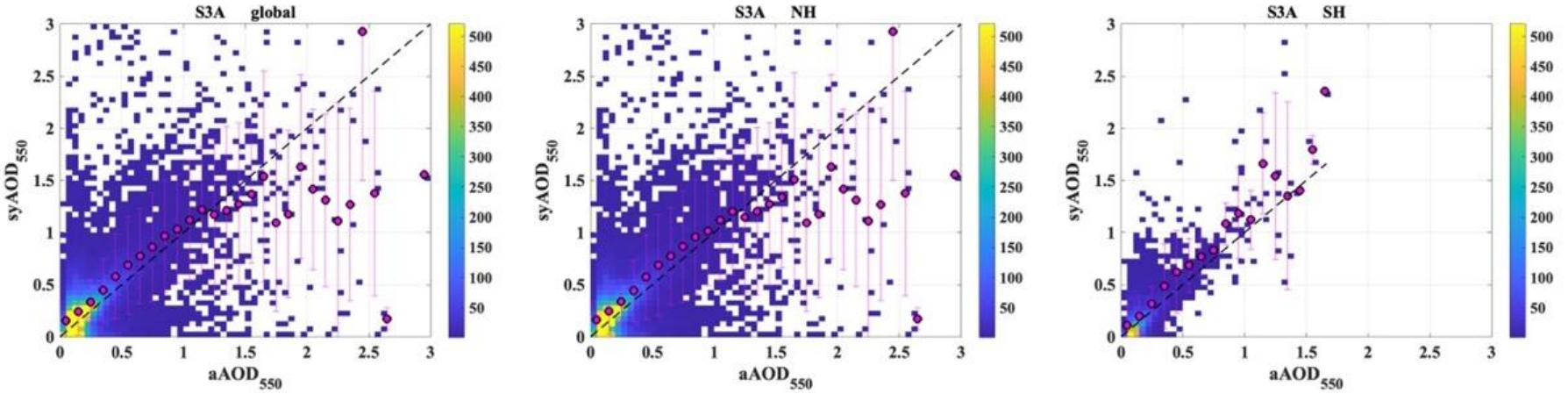
Satellite AOD
MODIS

Name	Description
AOD440	Aerosol optical depth at 442.5nm
AOD550	Aerosol optical depth at 550nm
AOD670	Aerosol optical depth at 659nm
AOD865	Aerosol optical depth at 865nm
AOD1600	Aerosol optical depth at 1610nm
AOD440_uncertainty	Uncertainty of aerosol optical depth at 442.5nm
AOD550_uncertainty	Uncertainty of aerosol optical depth at 550nm
AOD670_uncertainty	Uncertainty of aerosol optical depth at 659nm
AOD865_uncertainty	Uncertainty of aerosol optical depth at 865nm
AOD1600_uncertainty	Uncertainty of aerosol optical depth at 1610nm
SSA440	Aerosol single scattering albedo at 442.5nm
SSA550	Aerosol single scattering albedo at 550nm
SSA670	Aerosol single scattering albedo at 659nm
SSA865	Aerosol single scattering albedo at 865nm
SSA1600	Aerosol single scattering albedo at 1610nm
AAOD550	Aerosol absorption optical depth at 550nm
FM_AOD550	Fine-mode aerosol optical depth at 550nm
ANG550_865	Aerosol Angstrøm parameter between 550nm and 865nm
D_AOD550	Dust aerosol optical depth at 550nm

Matchups
ACRI

https://law.acri-st.fr/home

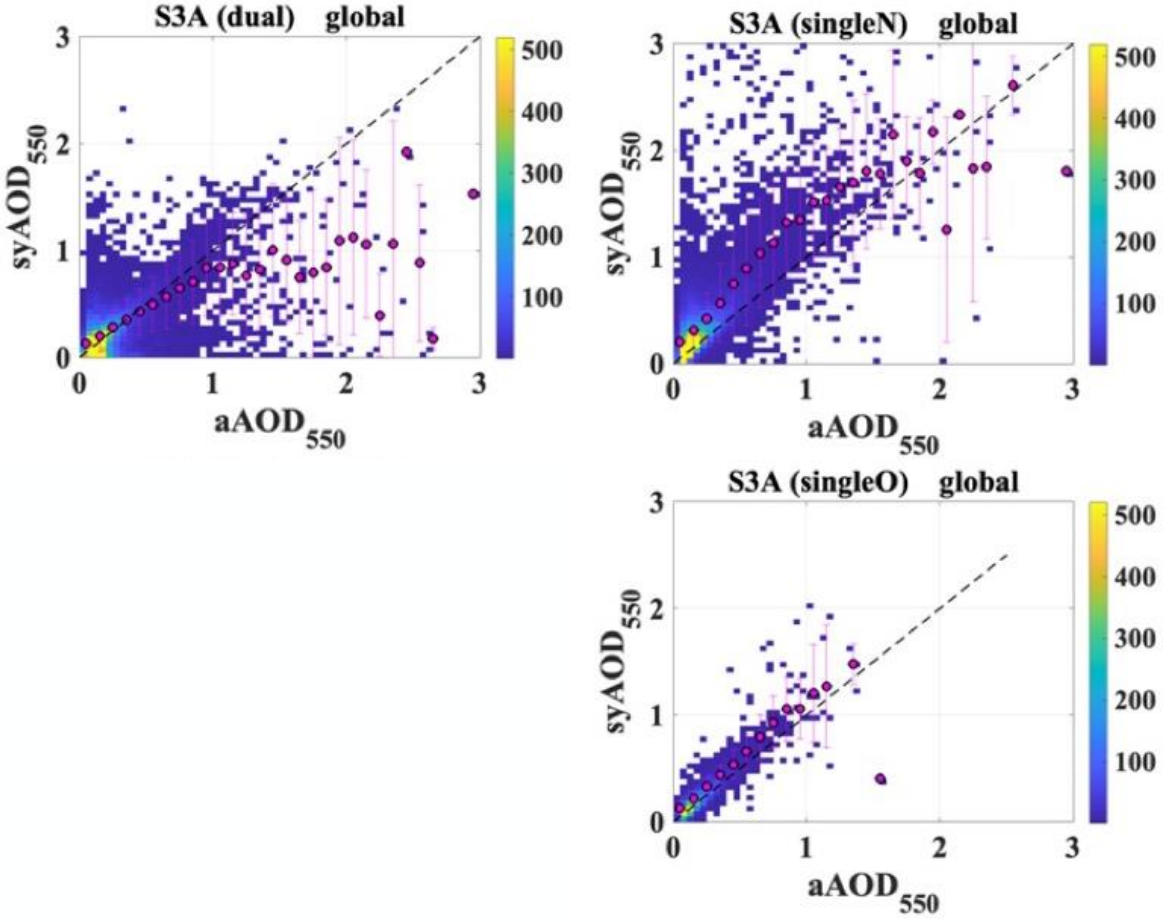
AOD_{550}



- for aAOD <0.3, syAOD is slightly overestimated; if aAOD >1.5, syAOD is often underestimated.
- For S3A, linear regression: r=0.6, rms = 0.28, offset = 0.12, slope = 0.89. 51.4% of matchups fit in the MODIS EE
- SYN AOD_{550} product shows better performance in the SH
- global validation results are slightly better than those for the NH
- validation statistics for S3B are slightly better

Validation of dual and single processors

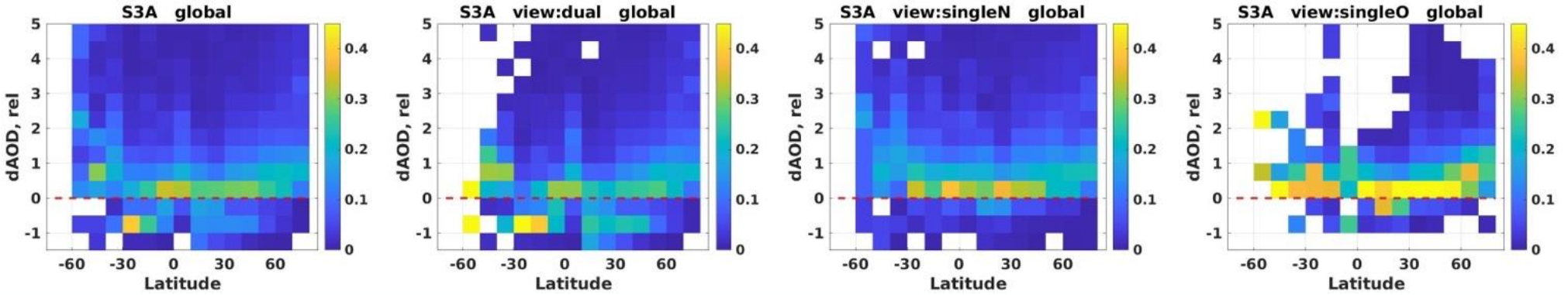
- Most of the negative syAOD outliers are retrieved with dual view processor
- Most of the positive syAOD outliers that we recognised during the validation of the whole SY_2 AOD product, are retrieved with single processor applied to the nadir view
- Validation results for dual view processor are slightly better than for the whole product
- rms is highest, number of pixels in EE is lowest for single processor applied to the nadir view; for that group of pixels, binned syAOD is considerably higher than aAOD for aAOD<1.5



AOD offset as a function of …..

- Latitude

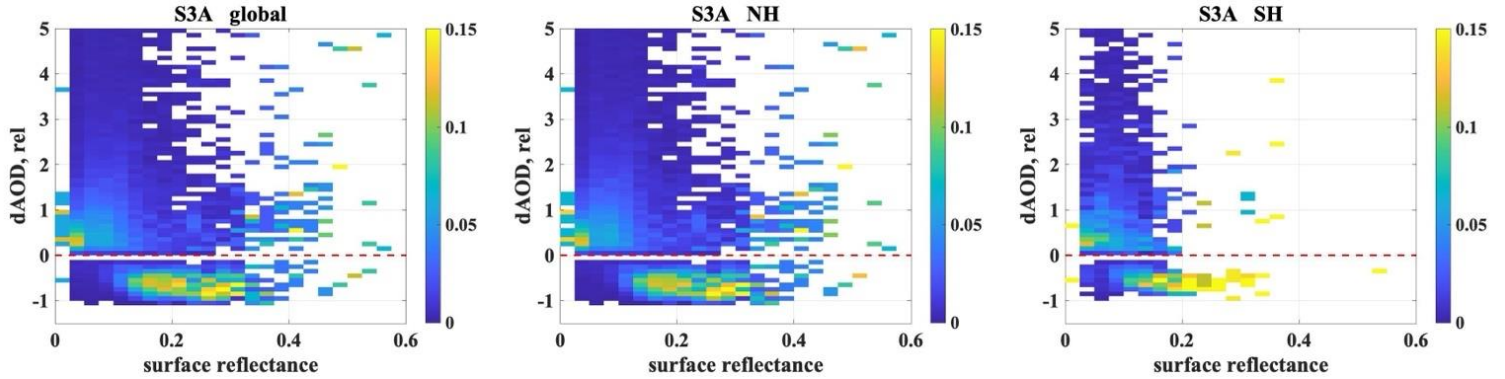
  syAOD offset increases towards poles



- Surface reflectance

  For low (<0.1) SR, dAODrel is mostly slightly (<0.5) positive.

  At SR>0.4, both positive and negative dAODrel offsets are observed



AOD offset as a function of …..

- Raz

  In the NH, positive dAODrel is increasing for Raz in [50° 80°] and in [100° 140°].

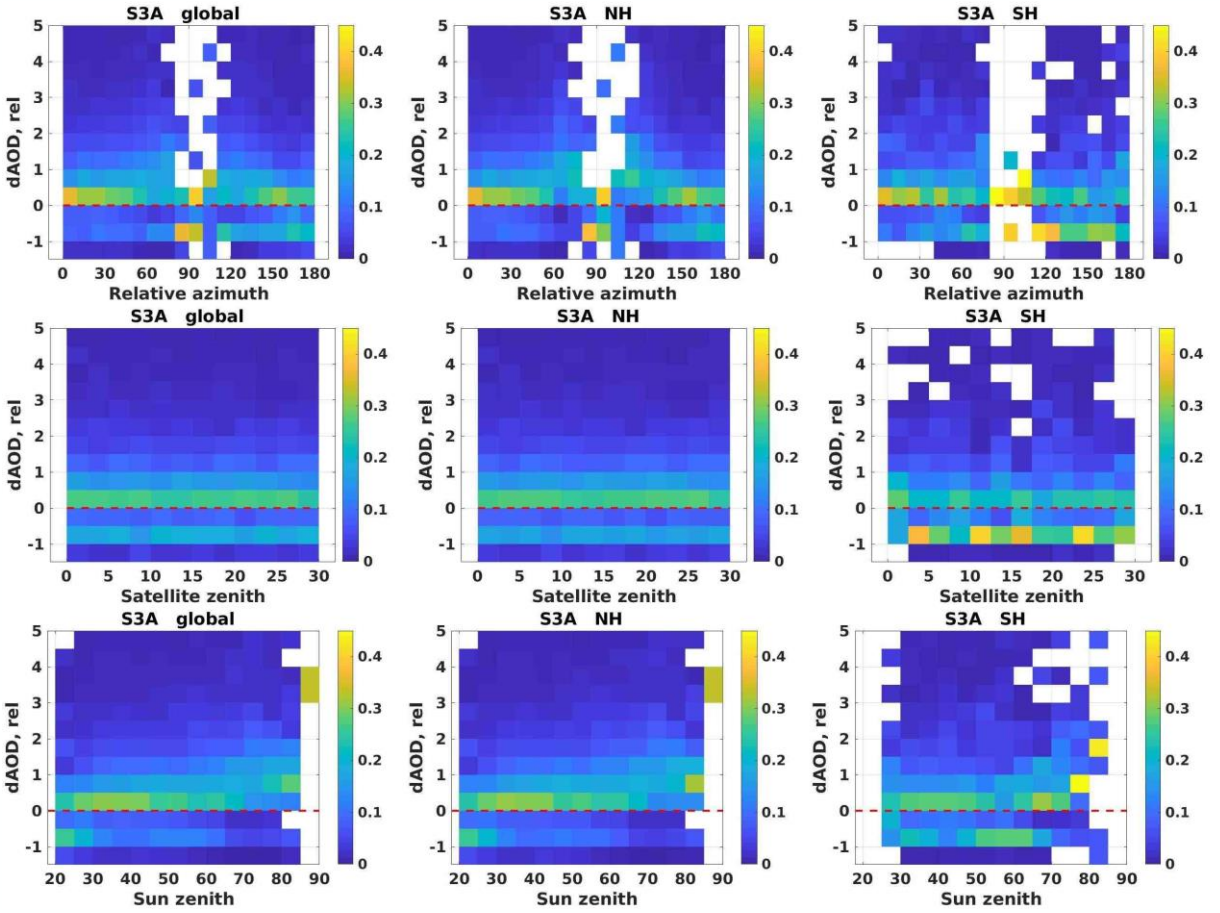
  In the SH we see the similar dependence of dAODrel for Raz in [50° 80°].

- SatZA

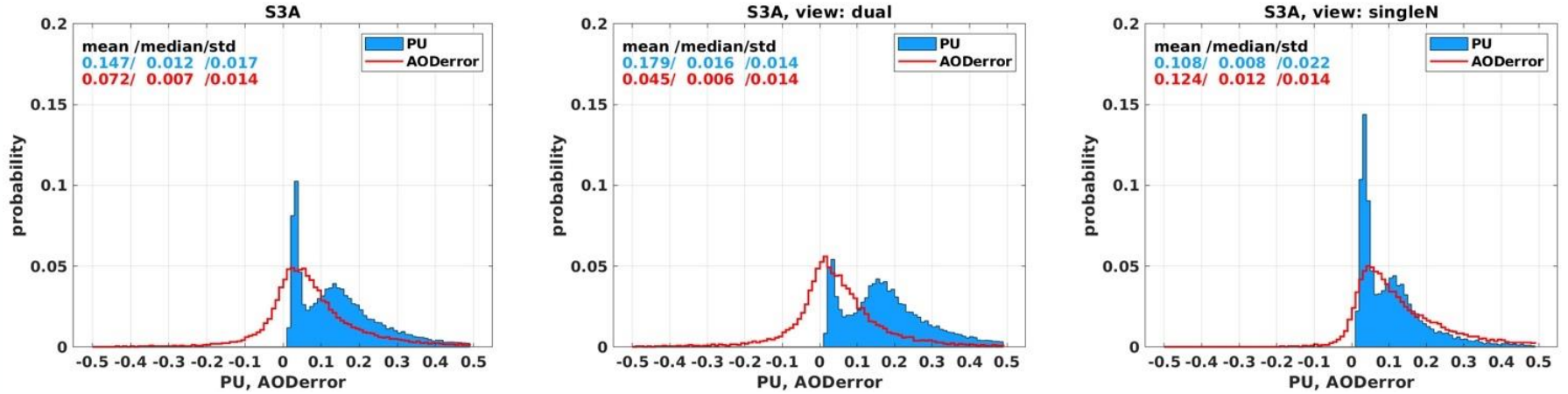
  No significant dependence of dAODrel on the SatZA have been observed.

- SunZA

  For SunZA>80°, the percentage of higher positive dAODrel, [0.5 1] increases

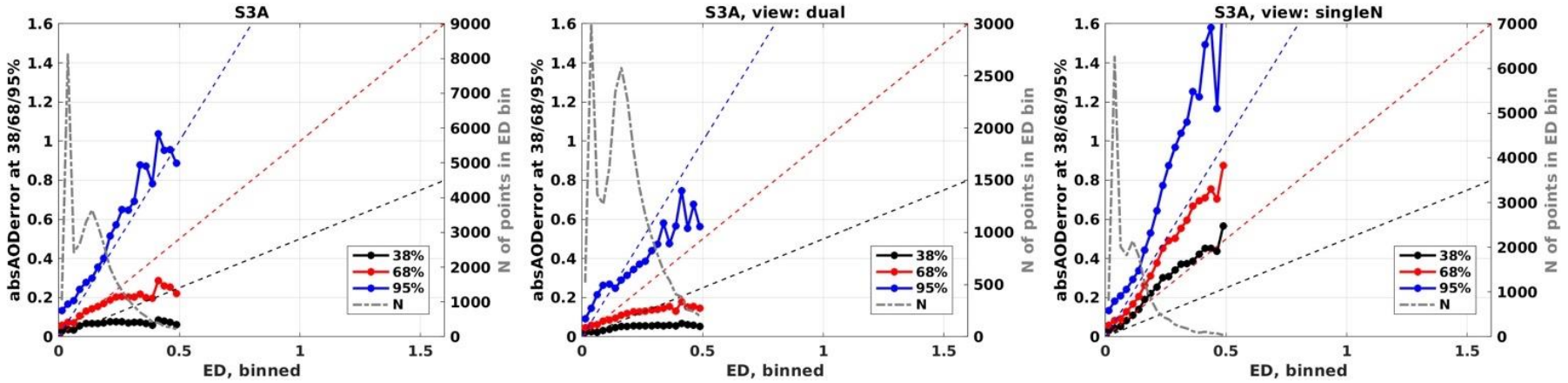


AOD uncertainties: provided uncertainties vs AOD error



- For low AOD error, prognostic uncertainties are overestimated in singleN product
- For high AOD error, prognostic uncertainties are overestimated dual product

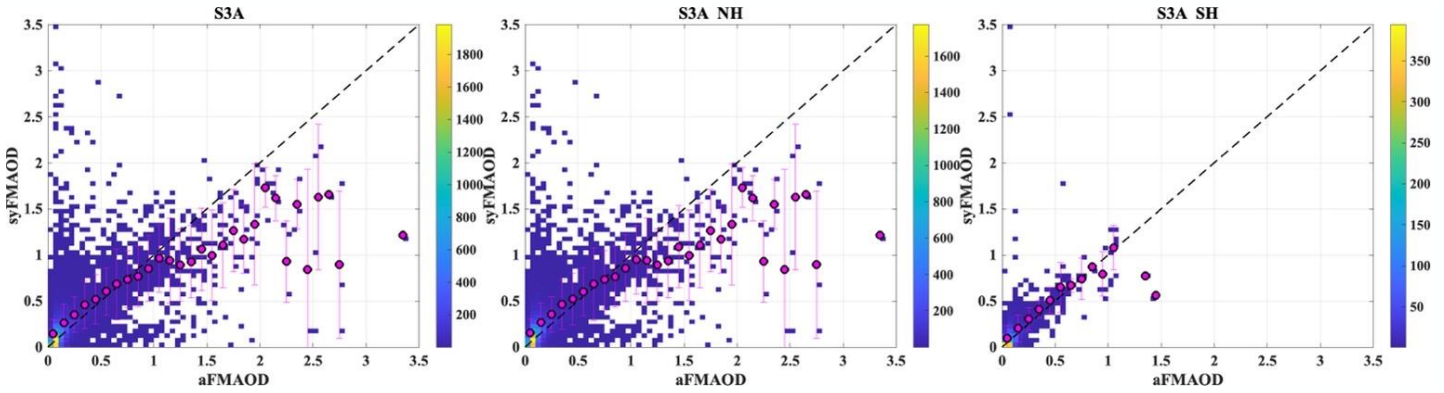
AOD uncertainties: Potential of the expected discrepancy



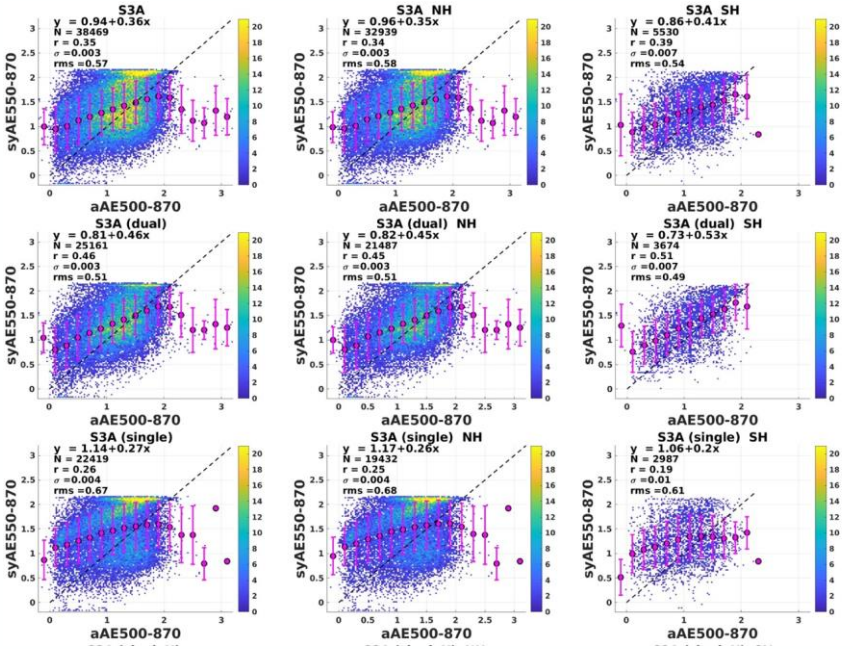
- The percentile plots show a reasonable agreement (within statistical noise) with the theoretical lines of 38% and 68% for majority of the validation points in the lower range of ED (up to 0.05-0.1) for all groups. 98% show the overestimation of ED.
- For higher uncertainties the error values for all and dual groups are clearly below the expected lines, which means that ED is too large.
- For singleN, ED>~ 0.2 is underestimated.

Fine mode AOD

- An agreement between $syFM_{550}$ and aFM_{550} is close to 1:1 line for FM_{550} < 0.6-1; for higher FM_{550}, $syFM_{550}$ is lower than the corresponding reference.
- Validation statistics are slightly better in the SH for both S3A and S3B.
- Clear $syFM_{550}$ outliers are observed mostly for cases when syAOD is strongly under-/overestimated

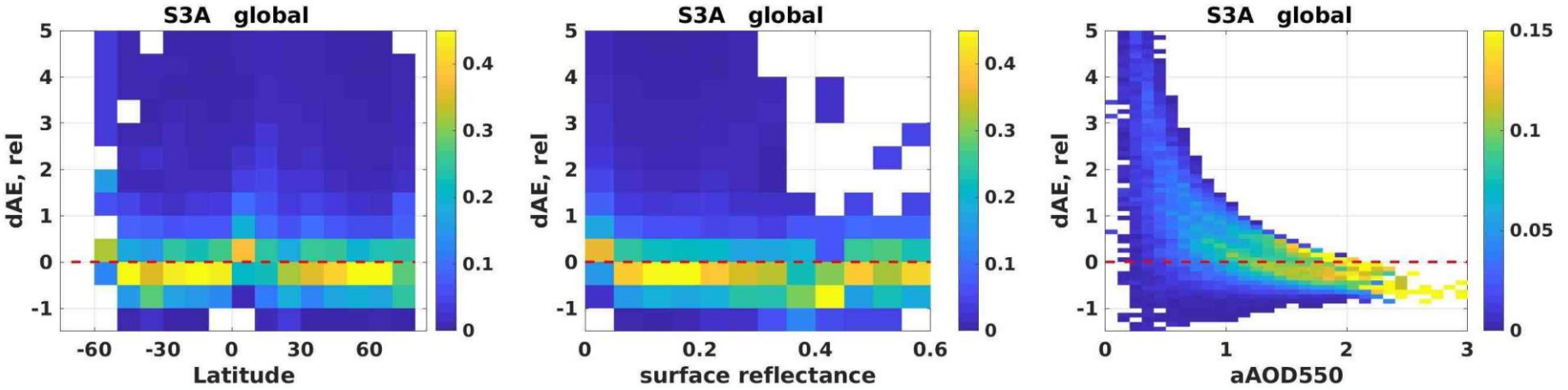


Angström exponent



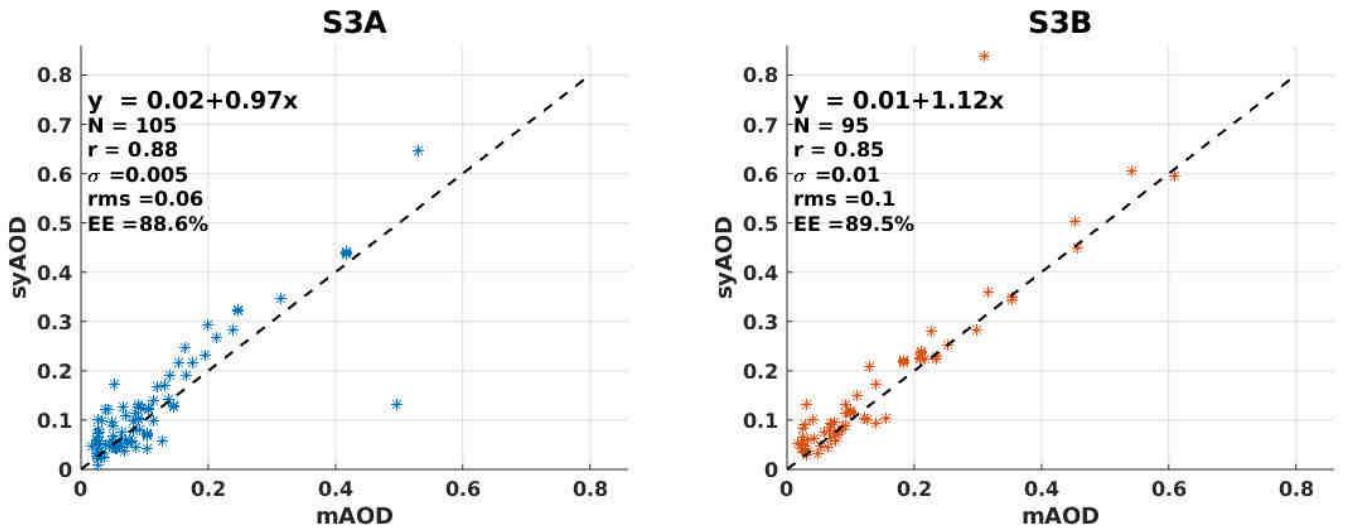
- For the whole global product, correlation coefficients between $sAE_{550\text{-}870}$ and $aAE_{500\text{-}870}$ are quite low, 0.35/0.34, rms is high, 0.57/0.58 for S3A/S3B, respectively.
- Validation statistics are slightly better for dual product. SingleO product shows better correlation, but worse rms and std.
- Validation statistics are better in the NH for the whole and dual products. For single group, now difference in validation results was revealed between the NH and SH.

AE relative error dependence on ….



- No clear dependence of dAErel on latitude has been revealed
- dAErel is mostly positive at SR<0.05, negative at SR in [0.35 0.45]. dAErel is in [1 5] at SR<0.35, for most of the cases.
- dAErel is decreasing with increasing aAOD; for aAOD>2 aAErel is negative

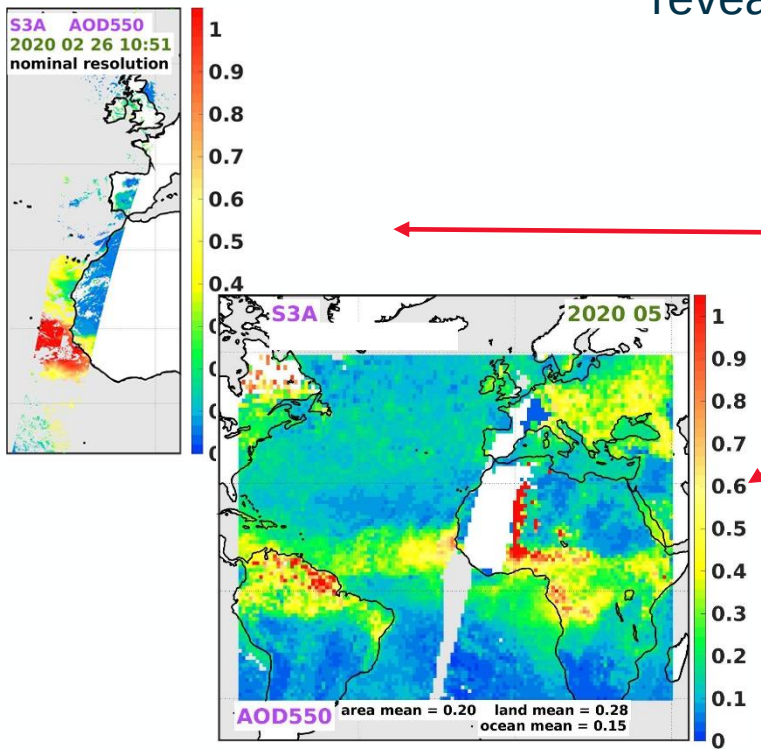
SY_2_AOD validation with MAN

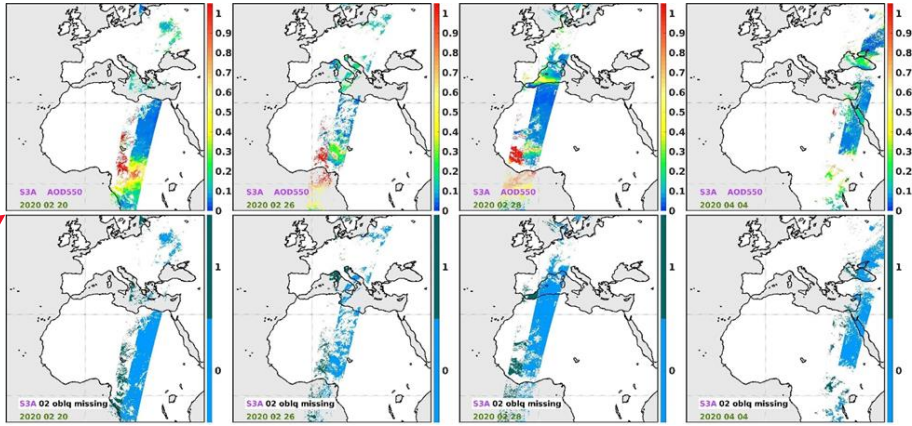


- Results for both instruments confirm a good performance of the retrieval algorithm over ocean.
- For S3A/S3B, correlation coefficient is 0.88/0.85, EE is 88.6/89.5 %.
- An offset with AERONET is slightly higher for S3A.

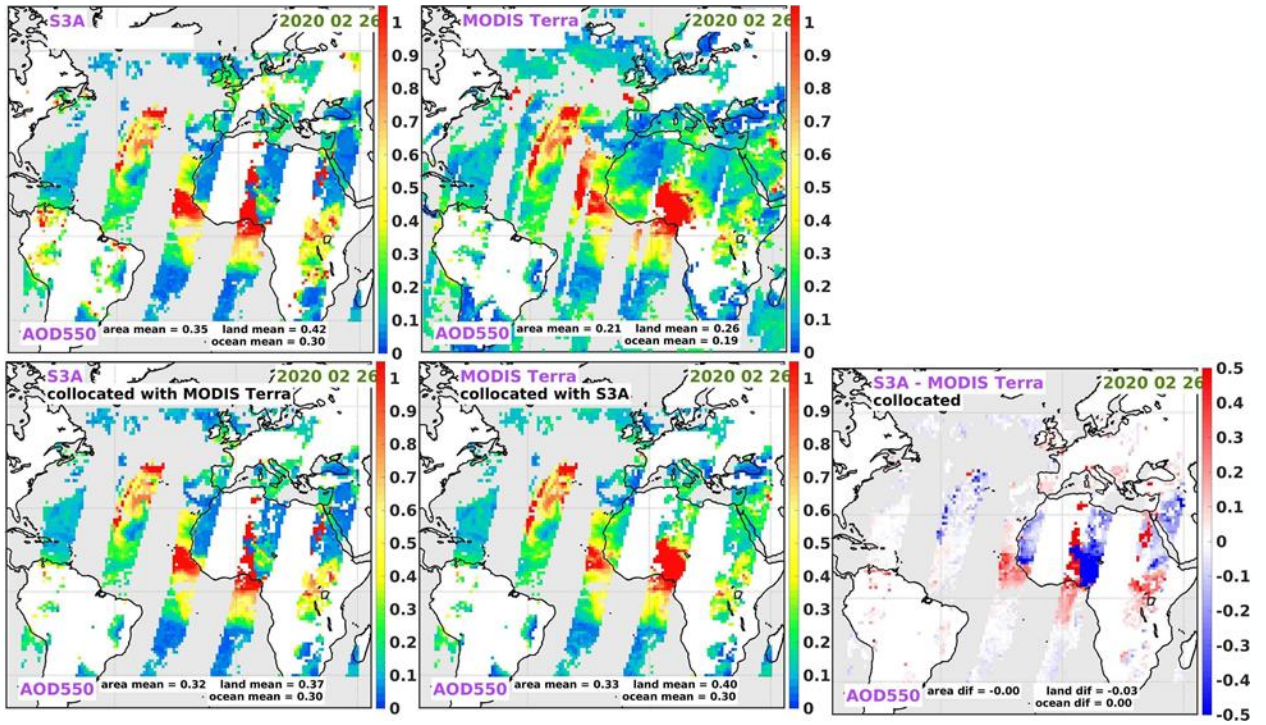
Visual inspection

- In general, AOD and AE spatial distribution looks reasonable
- However, the following problems were revealed:
  - Discontinuity in AOD retrieved with single and dual retrieval
  - Discontinuity in AOD retrieved over land and ocean
  - No-data area over the Northern Africa

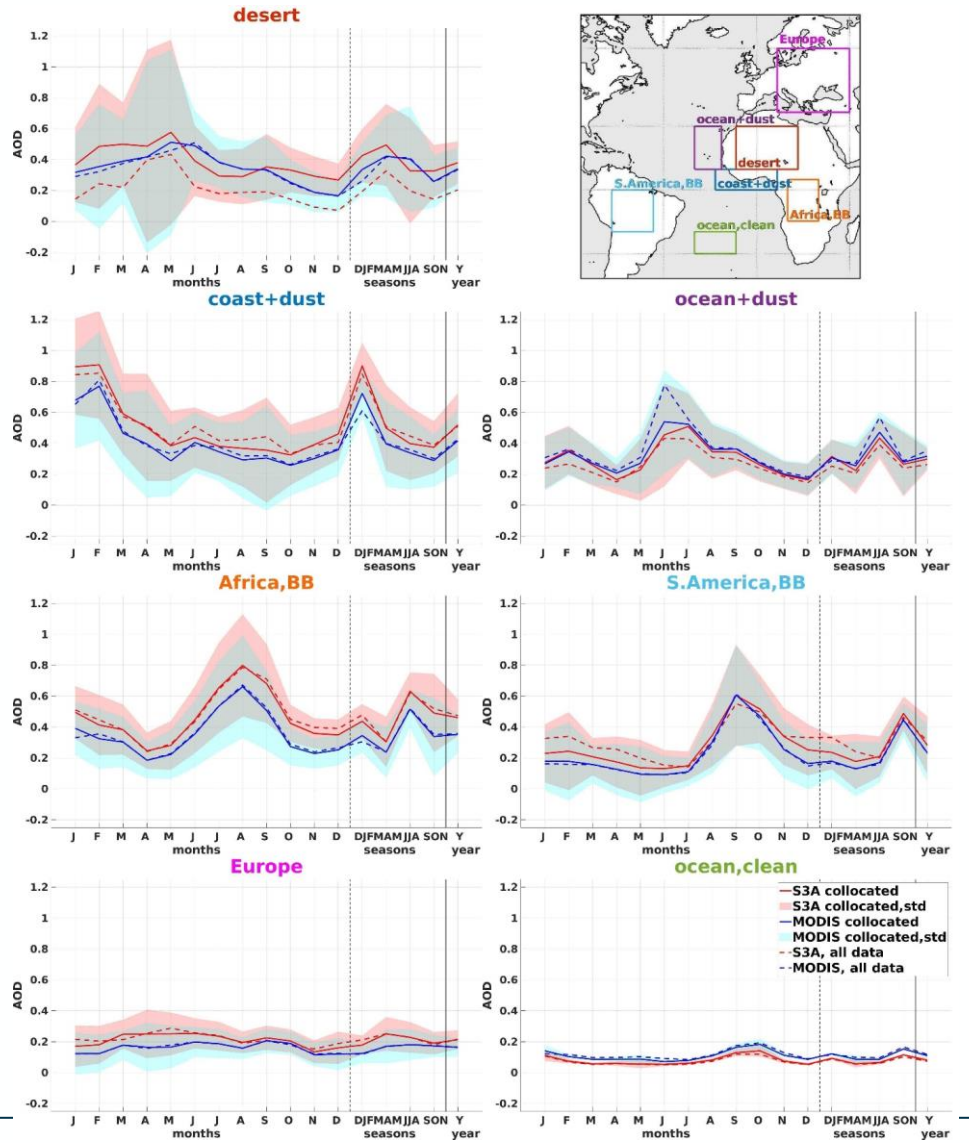




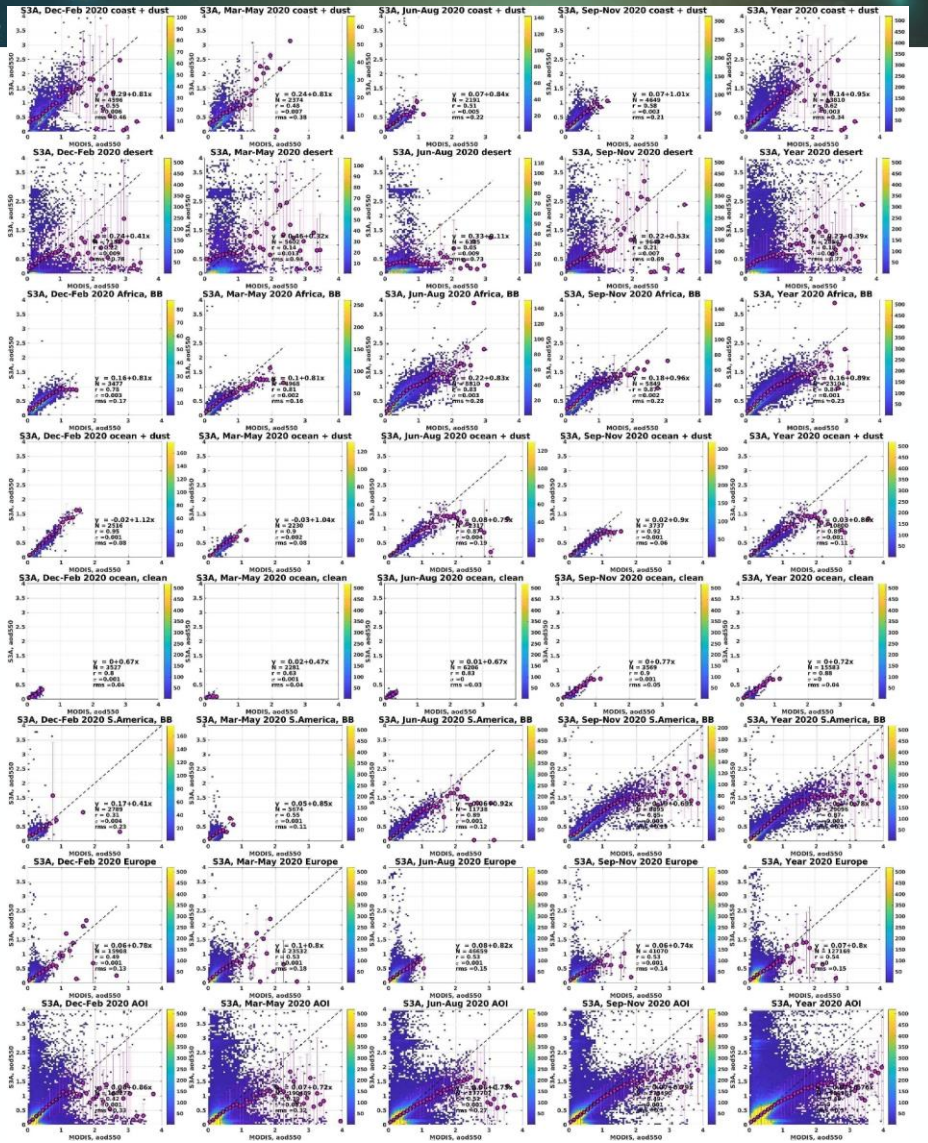
Inter-comparison with MODIS daily AOD



Regional inter-comparison with MODIS AOD: monthly, seasonal, annual

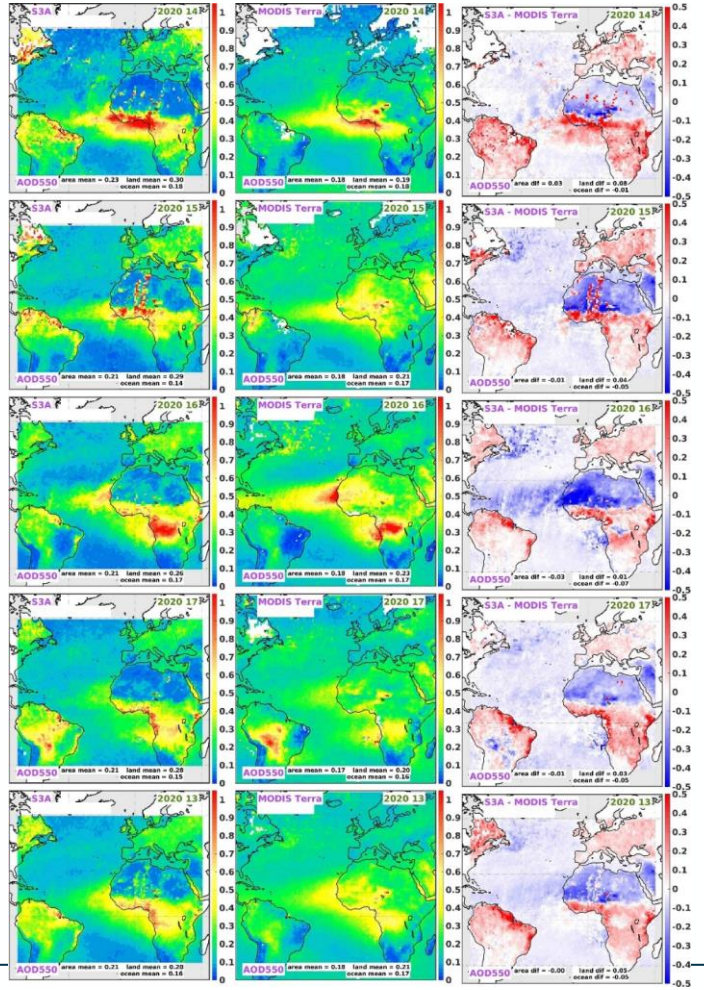


Pixel-by-pixel inter-comparison with MODIS daily AOD Seasonal aggregates

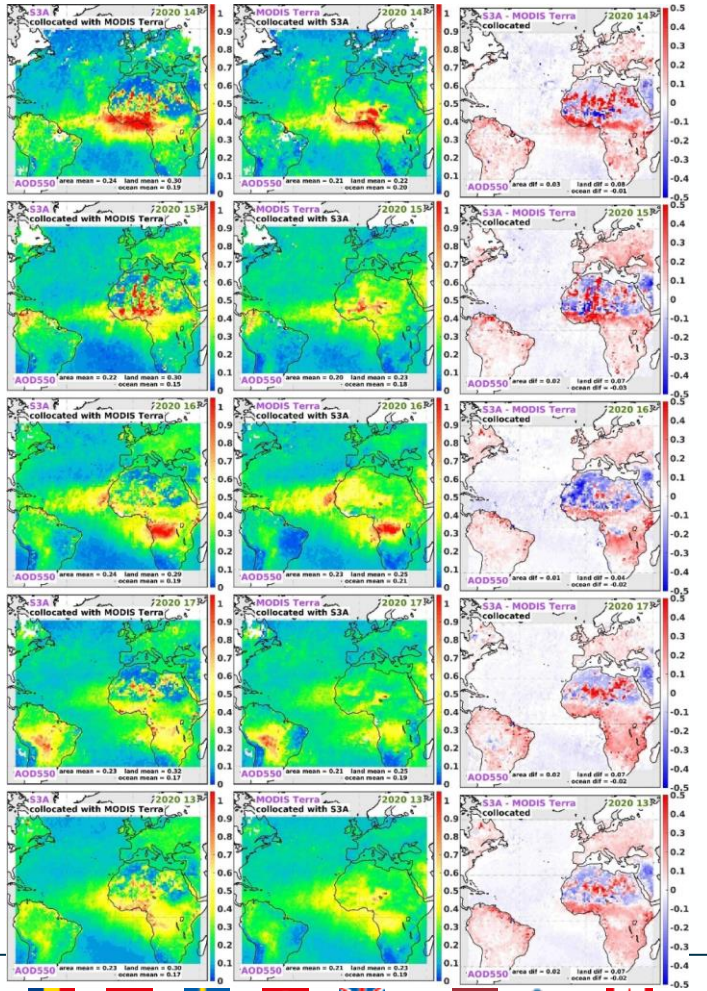


Inter-comparison with MODIS seasonal AOD

All pixels



Collocated pixels



Evaluation of cloud screening and other reasons for missing data with AERONET

- 20-30% of syAOD is not available (cloud screened, not retrieved, or rejected)
- Low NDVI, failed uncertainties and zero AOD are the main reasons for flagging out AOD or not perform the retrieval. Note, that snow and twilight zone flags are not considered in the current analysis (planned to be included when available in matchup files)
- Cloud screening in SY_2 shows a good performance. In general, for 1-2% of satellite/AERONET collocations SY_2 AOD is cloud screened, while aAOD is available. Over bright surface the percentage of the cloud screened pixels is a bit higher (3-5%). The percentage of cloud screened pixels is higher over coastal areas and in high latitudes – often snow-covered areas.

Standard AOD validation approach:

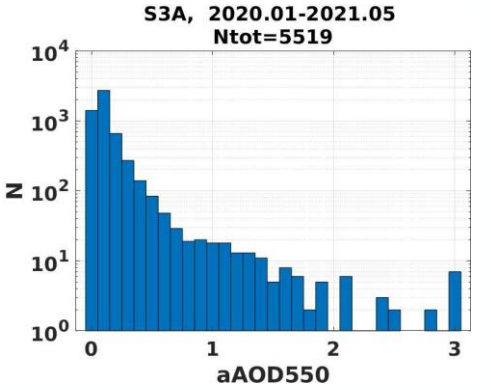
Cloud screening evaluation approach:

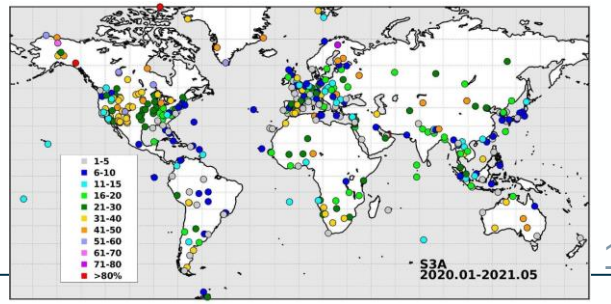
Case 1: — V

-> satellite cloud screening is too strict

Case 2: V —

-> satellite cloud screening is too relaxed





Main conclusions

- Over ocean, the performance of SYNERGY retrieved AOD is good and consistent with reference MAN dataset (rms ~0.05), although the MAN validation has a limited set of higher AOD examples.
- Over land overall performance has very high rms error, above 0.25 when compared to AERONET. This is higher by a factor of approximately 2 than comparable global products, and indicates the product needs significant improvement for widespread acceptance. Overall AERONET correlation is also low ~0.6. The poor performance is caused by a large number of outliers.
- The causes of outliers over land should be further investigated and rectified, and action taken to lower rms and increase correlation with reference data.
- It is clear that retrievals using dual view give higher quality, making use of more information to allow less reliance on surface spectral assumptions.
- Retrieval over land surface in the Northern Hemisphere shows generally higher retrieval error, in some cases, this will be due to weak masking of snow and ice cover,
- The presence of retrievals made at high solar zenith angles (over 70°) should be re-considered.

Paper in AMT
https://amt.copernicus.org/articles/15/5289/2022/amt-15-5289-2022-discussion.html

LAW final validation report,
Match-ups data base
https://law.acri-st.fr/home

Thank you for your attention!