



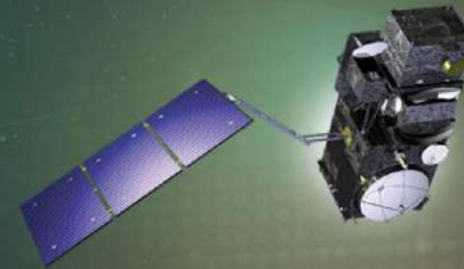
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# 7<sup>th</sup> Sentinel-3 Validation Team Meeting 2022

19-20 October 2022 | ESA-ESRIN | Frascati (Rm) Italy

## Towards harmonization of the (A)ATSR and SLSTR AOD CDRs

Larisa Sogacheva<sup>1</sup>, Kevin Pearson<sup>2</sup>, Peter North<sup>2</sup>, Véronique Bruniquel<sup>3</sup>, Thomas Popp<sup>4</sup>,  
Pekka Kolmonen<sup>1</sup>, Timo H. Virtanen<sup>2</sup>, and Antti Arola<sup>1</sup>

<sup>1</sup>FMI <sup>2</sup>SU <sup>3</sup>ACRI-ST <sup>4</sup>DLR

[larisa.sogacheva@fmi.fi](mailto:larisa.sogacheva@fmi.fi)

*contact:*





## MOTIVATION

- ATSR and S3 are instruments from the “same family” with main difference in viewing geometry -> AOD products of similar quality are expected
- ATSR and S3 are not overlapping -> to reveal an offset between ATSR and S3 AOD products a reference (satellite) AOD product is required



## Questions to be answered

**Q1:** for which purposes the corrected product can be utilized (in other words, why do we need to perform the correction)

**A1.1:** to continue ATSR AOD time series

**A1.2:** to have comparable statistics for ATSR and S3 periods

**Q2:** Which product should be corrected, ATSR or S3A?

**A:** ATSR

In general, S3A product should be more reliable (better coverage)

We correct ATSR once; in case of S3A correction to ATSR, we will need to continue S3A correction

For the next generations of Sentinels the correction to the previous product should be simpler than for 2-generations back product

**B:** SLSTR

ATSR product looks a bit more "reliable"

S3 v1.12 product needs improvements of the the bright surface (v1.14) and low AOD (positive bias)

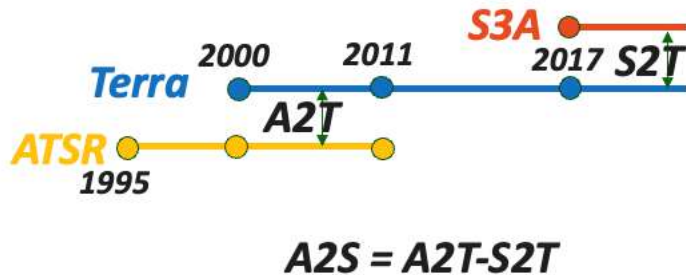
**Q3:** Method

**Q4:** What to do for the "bridging" (2012-2017) period?



## General approach

- Calculate ATSR and S3 offsets to the reference product
- Calculate total offset (A2S)
- CDRs harmonization: Apply total offset to ATSR or S3 products



### Acronyms:

**A2T** – ATSR offset to Terra

**S2T** – SLSTR offset to Terra

**A2S** – offset between ATSR and SLSTR

## • Input

L3 monthly  
AOD



## Input products

### (A)ATSR/S3

#### ▪ (A)ATSR : ESA CCI

##### ❖ SU, v4.33

- ATRS-2 (06.1995-2002), AATSR (08.2002 -03.2012)
- CDS <https://cds.climate.copernicus.eu/cdsapp#!/dataset/satellite-aerosol-properties?tab=overview>

#### ▪ SLSTR NTC : COPERNICUS Lot5, Lot2

##### ❖ SU, v1.12

- S3A (07.2017-12.2021), S3B (05.2018-12.2021)
- CDS <https://cds.climate.copernicus.eu/cdsapp#!/dataset/satellite-aerosol-properties?tab=overview>

### Reference products

#### ▪ MODIS Terra: NASA

##### ❖ C6.1, MOD08\_M3

- 2000->
- LAADS

#### ▪ MISR: NASA

##### ❖ V32

- 2000->
- <https://asdc.larc.nasa.gov/data/MISR/MIL3/MAEN.004/>

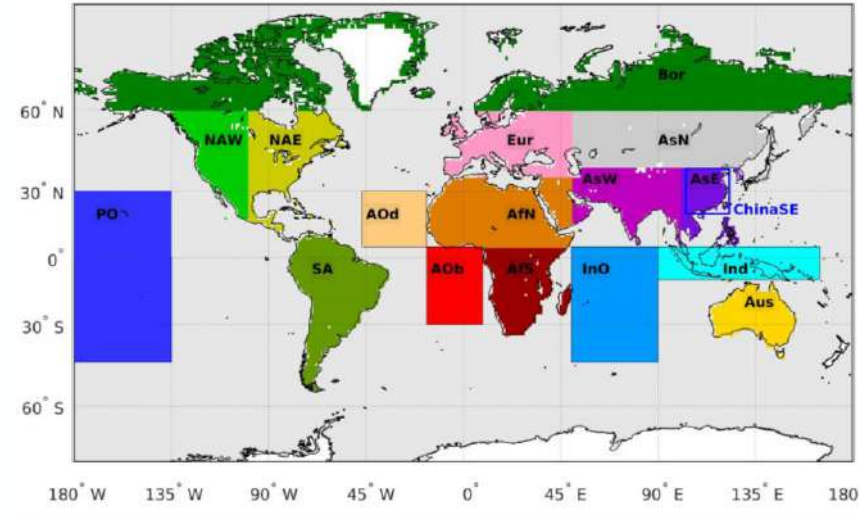
#### ▪ Merged AOD product : FMI V1.0

- 1995-2017
- [https://nsdc.fmi.fi/data/data\\_aod](https://nsdc.fmi.fi/data/data_aod)



## Regional analysis

- Algorithm performance is different in different aerosol conditions (sea/land, low background, dust, biomass burning, anthropogenic emissions, etc)



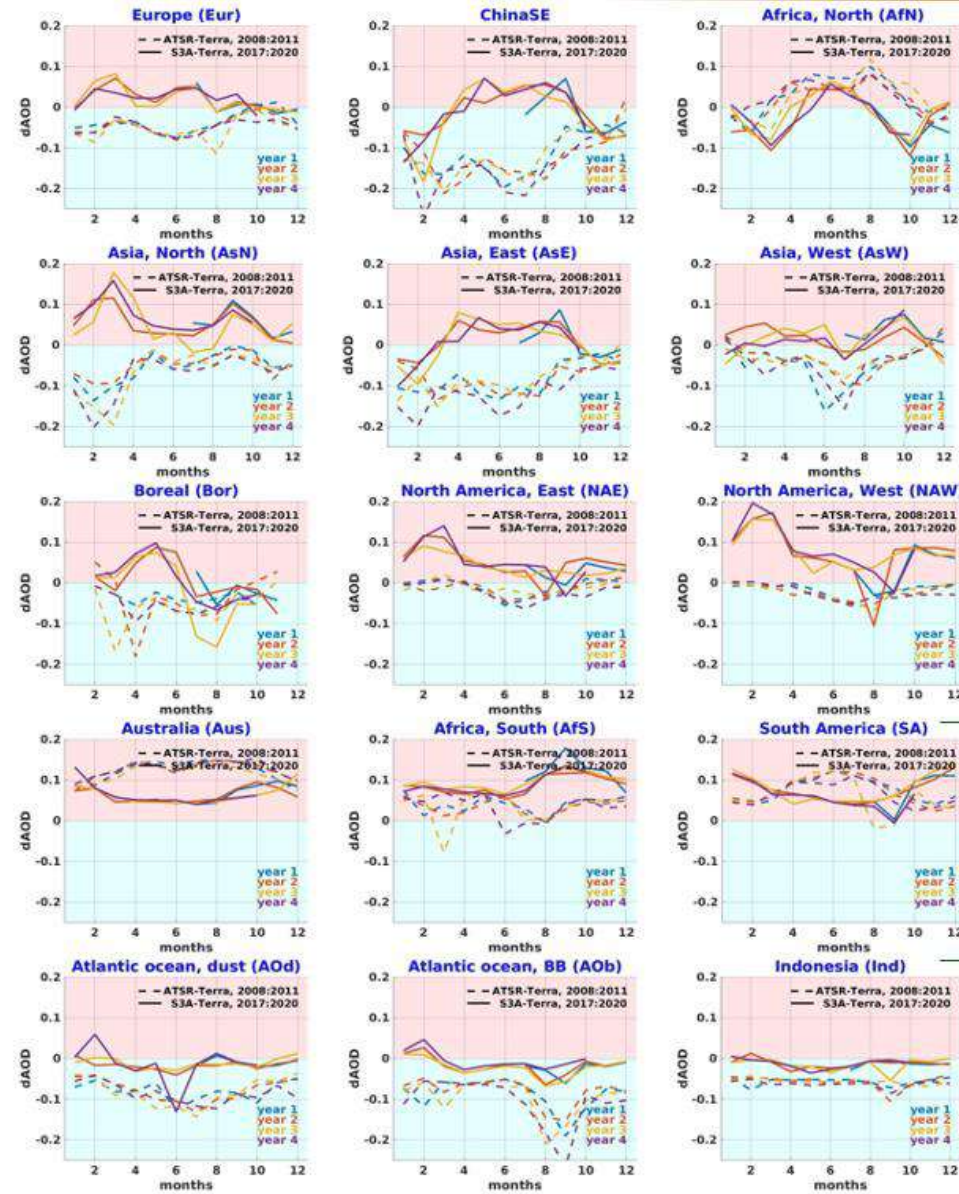


## Intra- and inter-annual regional offsets

4 tested years are chosen:

- ❖ AATSR years 2008-2011
- ❖ SLSTR years 2017-2020

- Regional differences are higher than global
- S2T is lower than A2T over ocean
- Clear seasonality is observed
- Both A2T and S2T are positive (with few exceptions) in the SH



NH

SH

ocean, land+ocean





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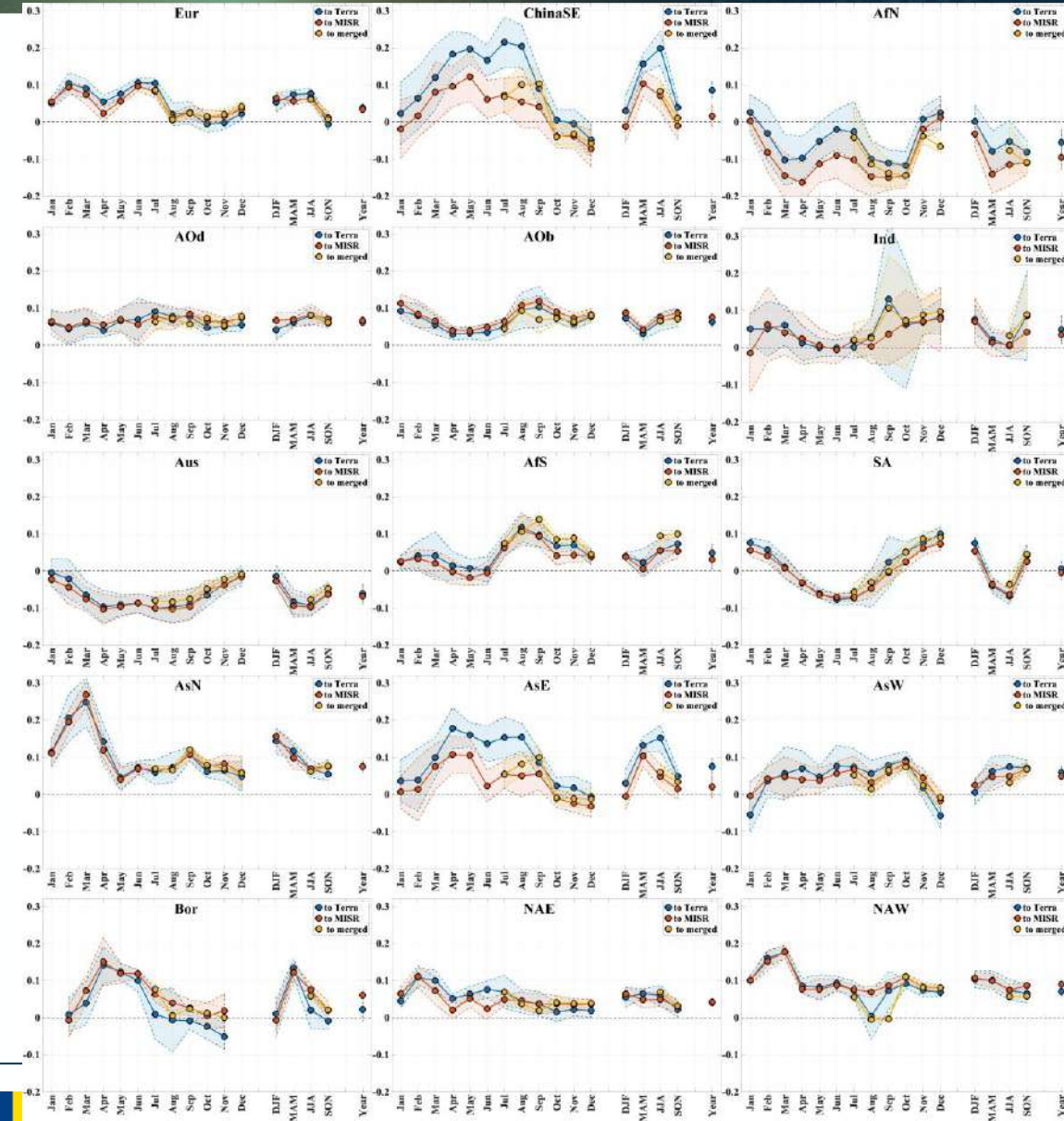
## Regional absolute AOD OFFSET between S3A and ATSR (S2A)

S3A to Terra (S2T) - ATSR to Terra (A2T)

S3A to MISR - ATSR to MISR

S3A to merged- ATSR to merged

- S3A to ATSR offset has similar intra-annual variations regardless of which satellite products is considered as a reference





## Method

- ❖ **M1: L3m AOD pixel correction** with **absolute offset**,  $AO$  (monthly, averaged over the region)

$$A_{pix,corr} = A_{pix} + AbsO_{reg,mon} \quad (1)$$

$$AbsO_{reg,mon} = \frac{1}{N_{years}} \sum_{y=1}^{y=N_{years}} (ST_{y,reg,mon} + AT_{y,reg,mon}) \quad (2)$$

- Is not working properly; negative AOD is obtained in case the correction calculated over the region is bigger than pixel AOD

- ❖ **M2: L3m AOD pixel correction** with **relative offset** (monthly, averaged over the region)

$$AT\_RelO_{reg,mon} = \frac{1}{N_{years}} \sum_{y=1}^{y=N_{years}} \frac{(A_{y,reg,mon} - T_{y,reg,mon})}{T_{y,reg,mon}} \quad (3)$$

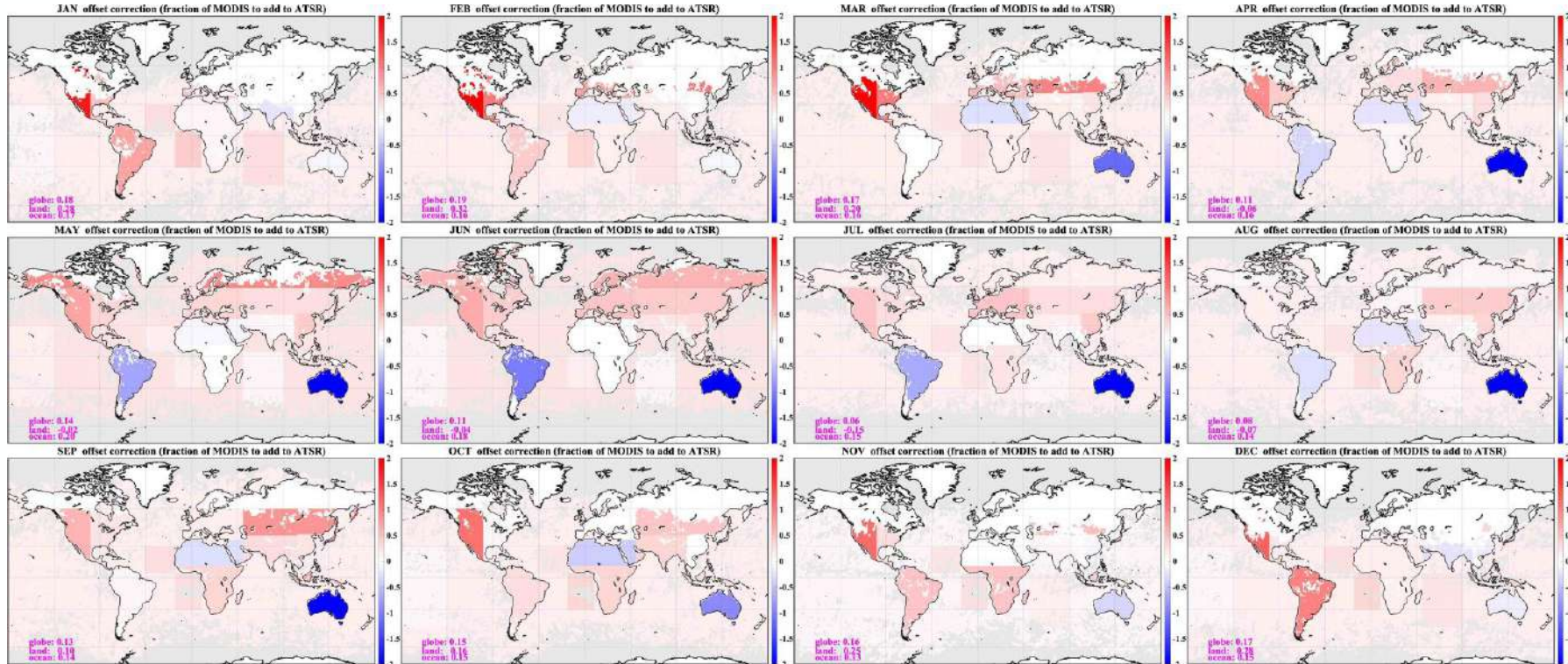
$$sum\_RelO_{reg,mon} = AT\_RelO_{reg,mon} - ST\_RelO_{reg,mon} \quad (4)$$

$$A_{pix,corr} = A_{pix} + sumRelO_{reg,mon} * T_{L3m,pix,mon} \quad (5)$$

**M2 method correction:** Terra data ( $T_{L3m,pix,mon}$ ) does not exist for the period 1995 – 1999.

$T_{mean(2000-2020),pix,mon}$  was used instead.

## Regional mean monthly relative offsets



Next steps were:

- Regional monthly corrections factors were applied to original L3 monthly products
- Corrected products were validated with AERONET
- Regional means for the corrected products were calculated

- Clear seasonality (offset is bigger in winter)
- Difference between NH (offset is mostly positive) and SH (offset is mostly negative)
- “sharp” transition between regions



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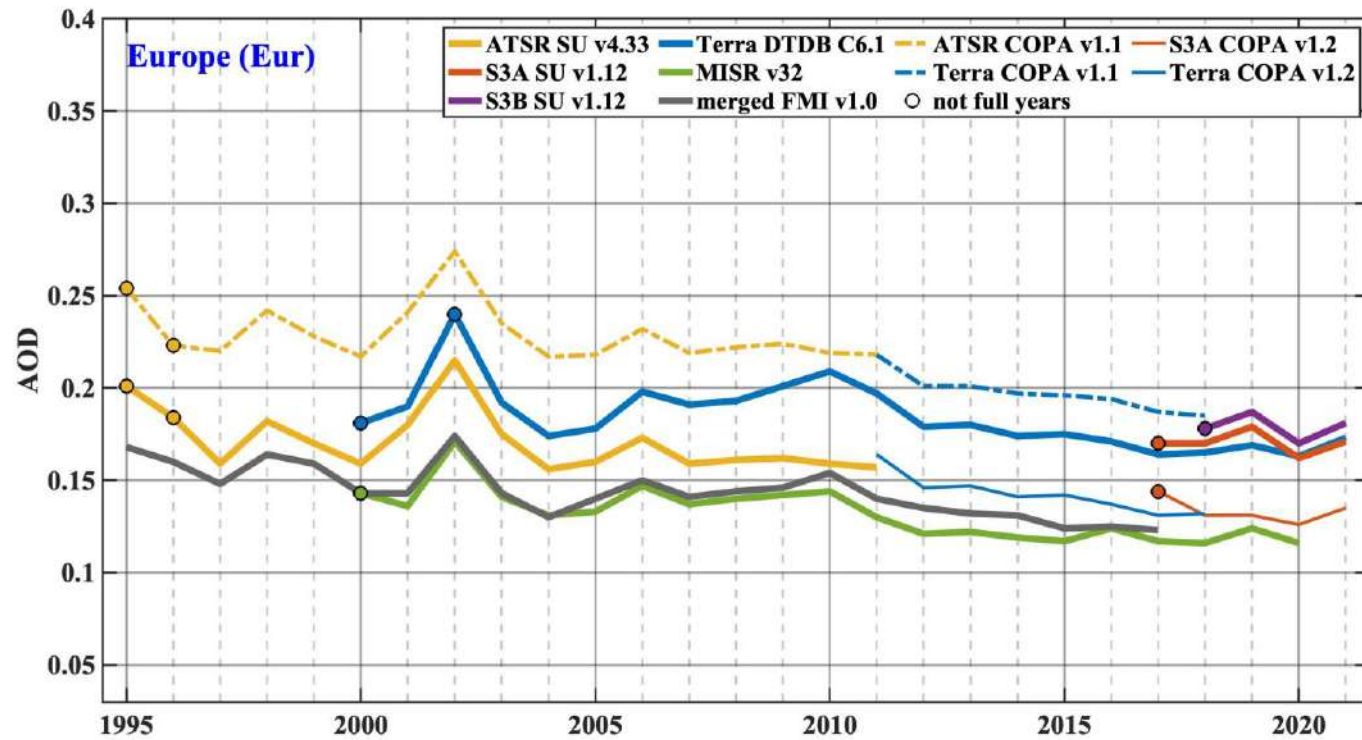
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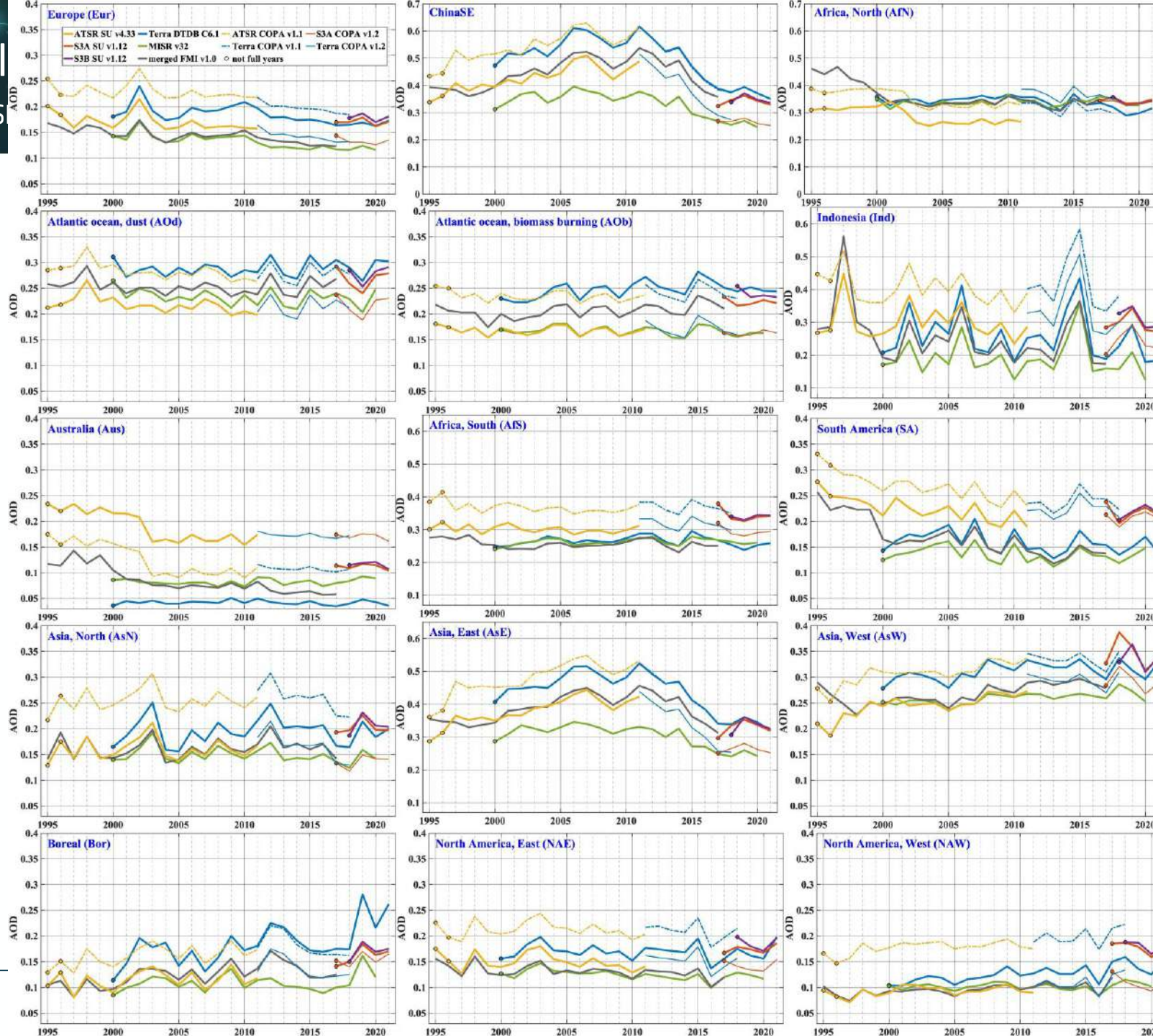
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## AOD time series: Original products ATSR and Terra corrected to S3A S3A and Terra corrected to ATSR

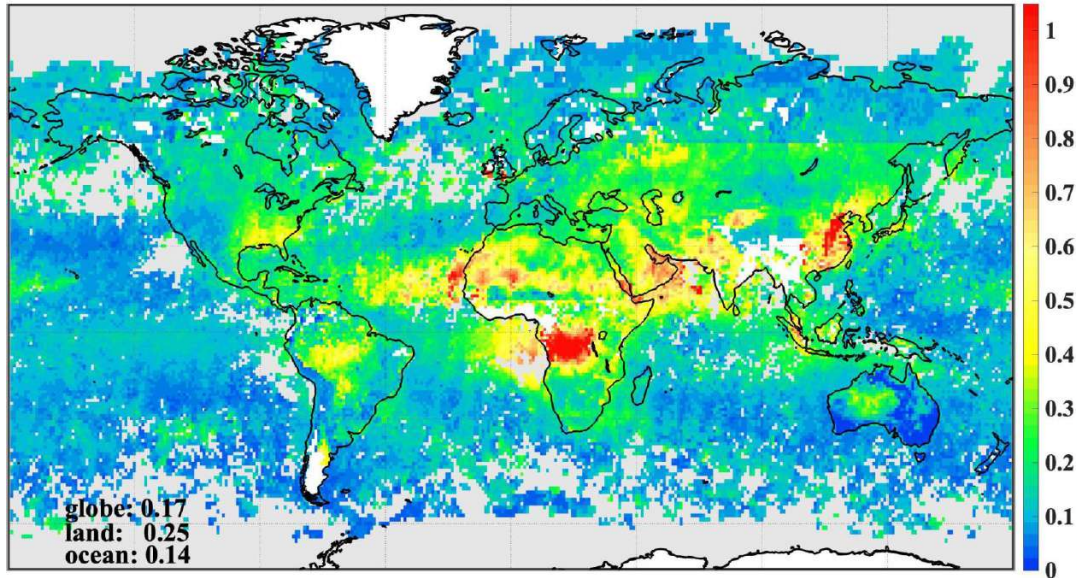


# Regional AOD time series

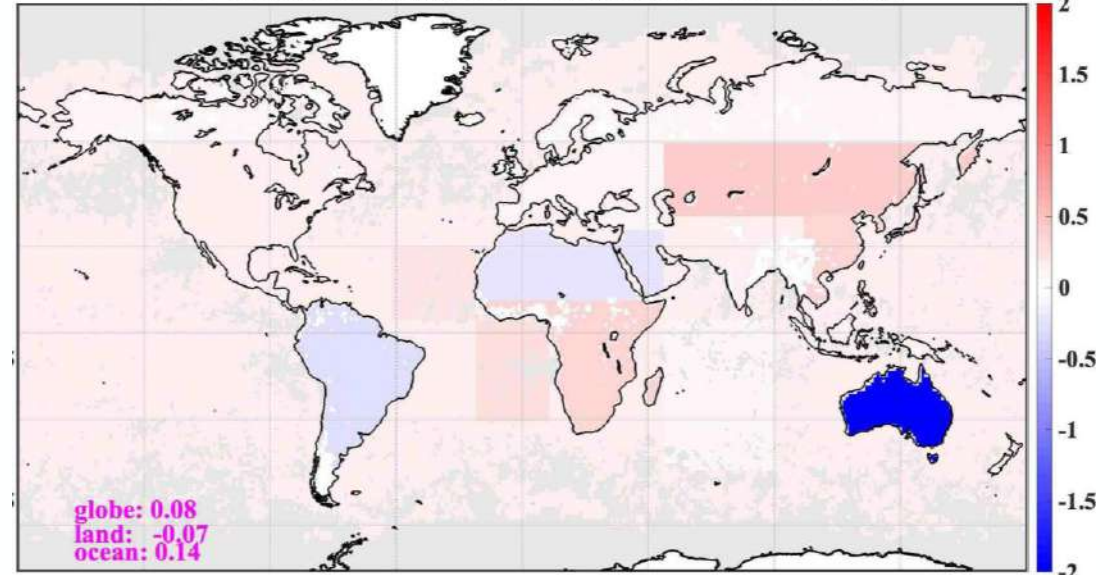


## Problem: discontinuity in the AOD field

2008 AUG ATSR2S3ATerra COPA v1.1



AUG offset correction (fraction of MODIS to add to ATSR)



- Reason – regional offset correction approach
- Possible solution – pixel offset correction approach

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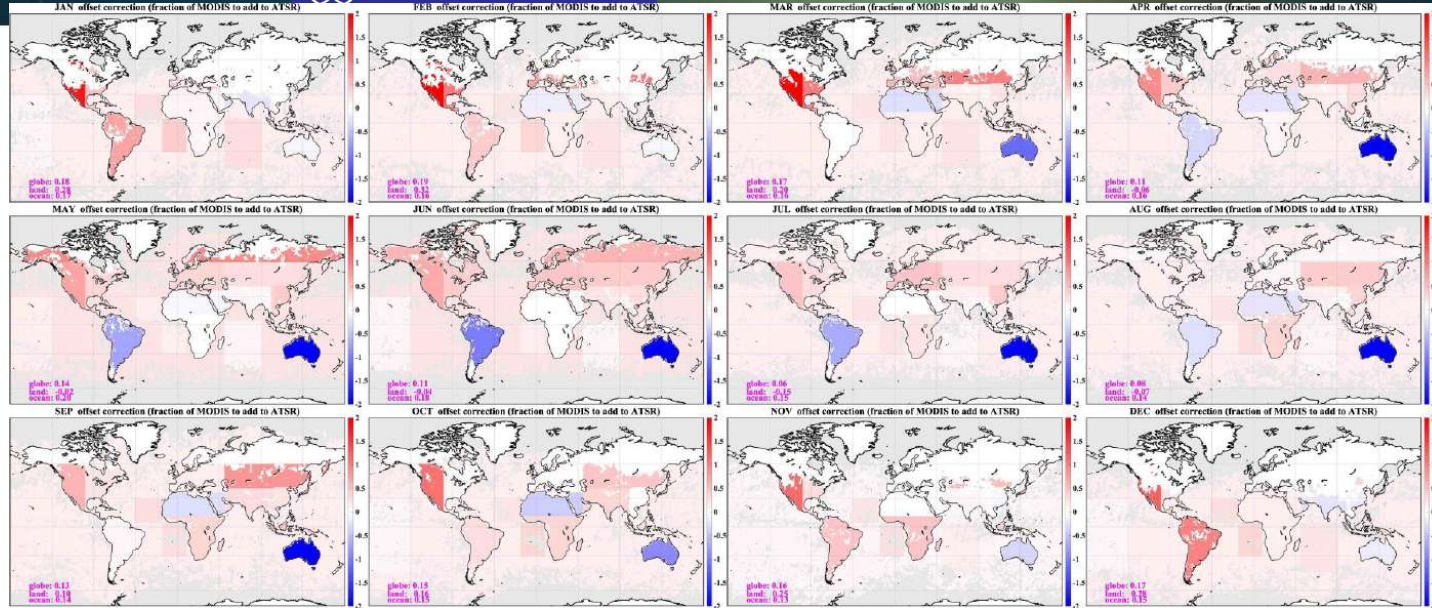
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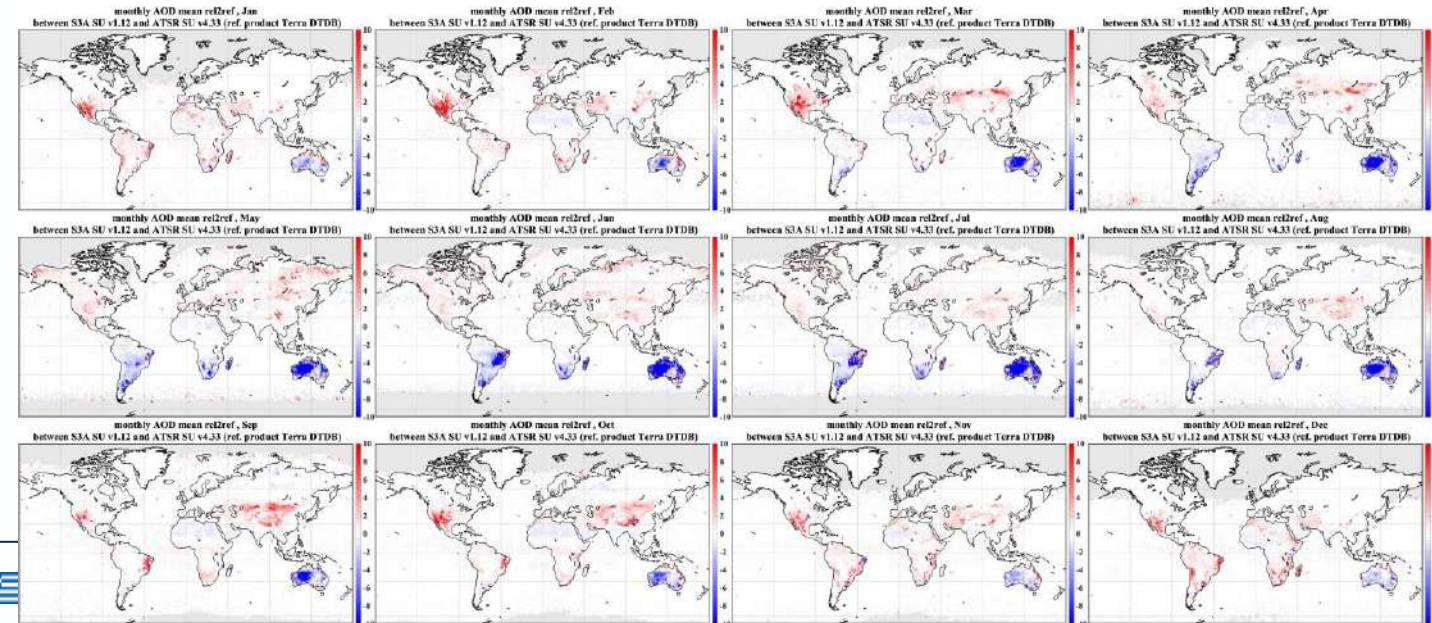
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## Correction factors for different approaches

Regional approach

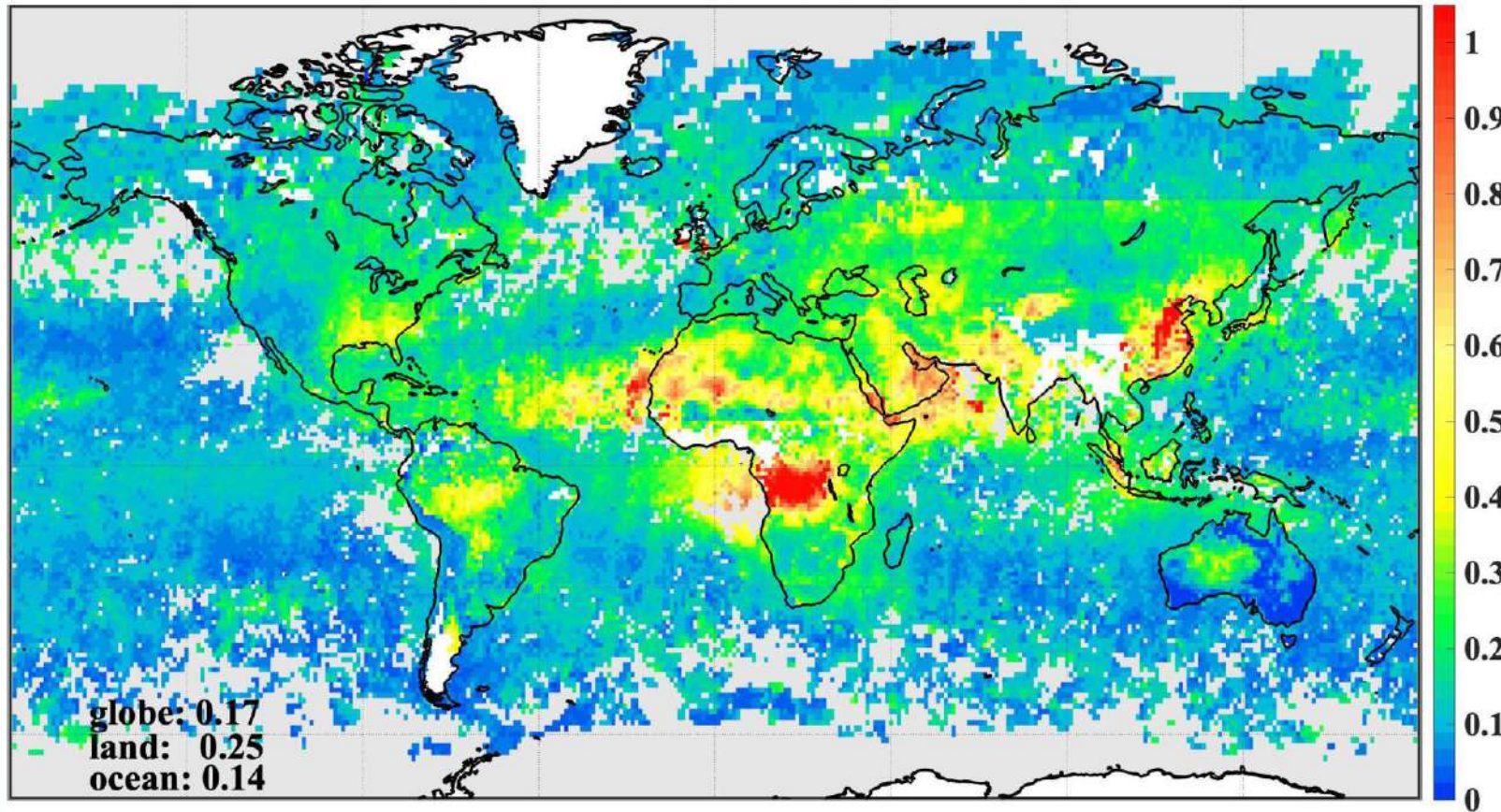


Pixel approach



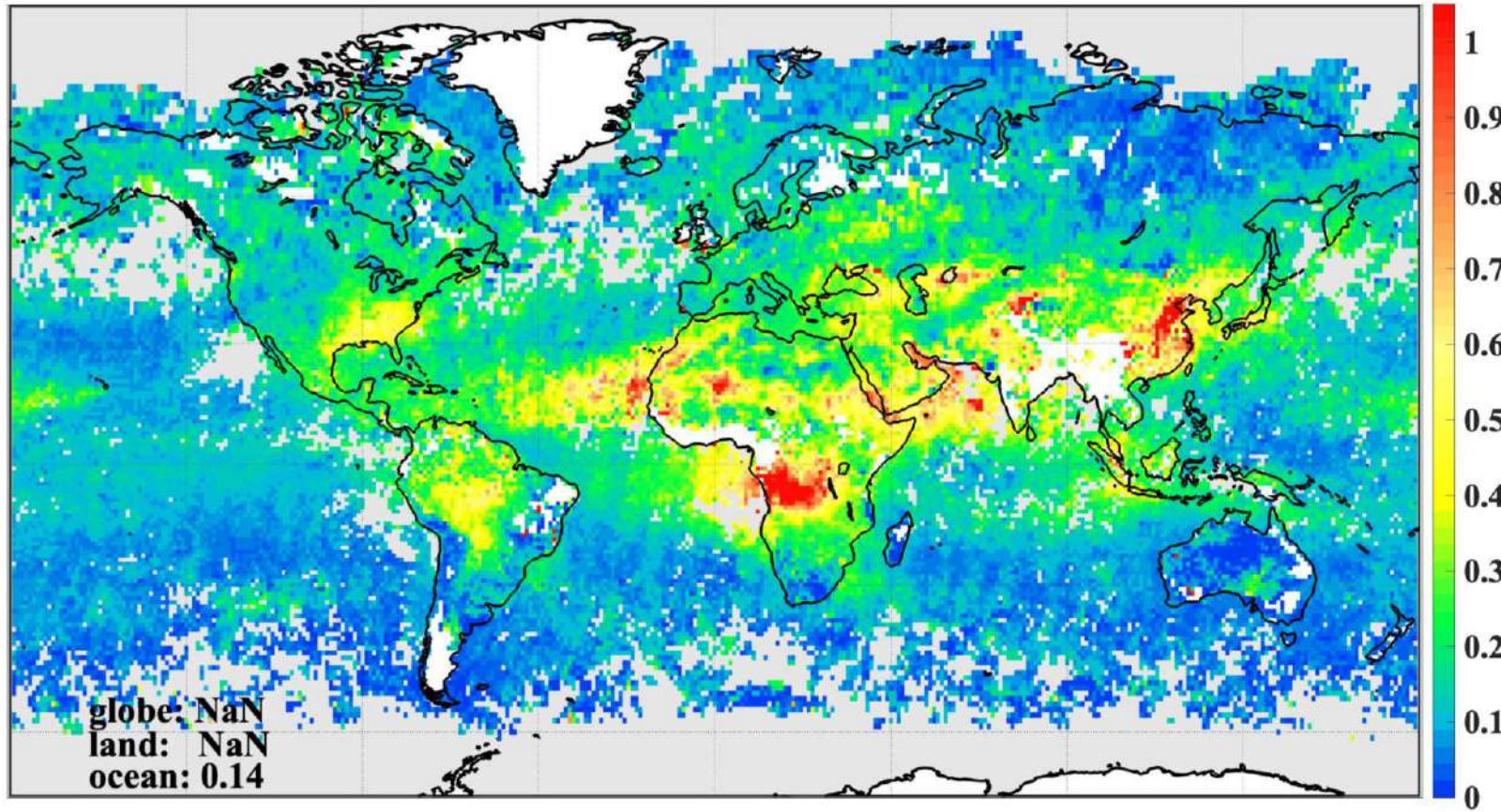
## Regional approach

2008 AUG ATSR2S3ATerra COPA v1.1



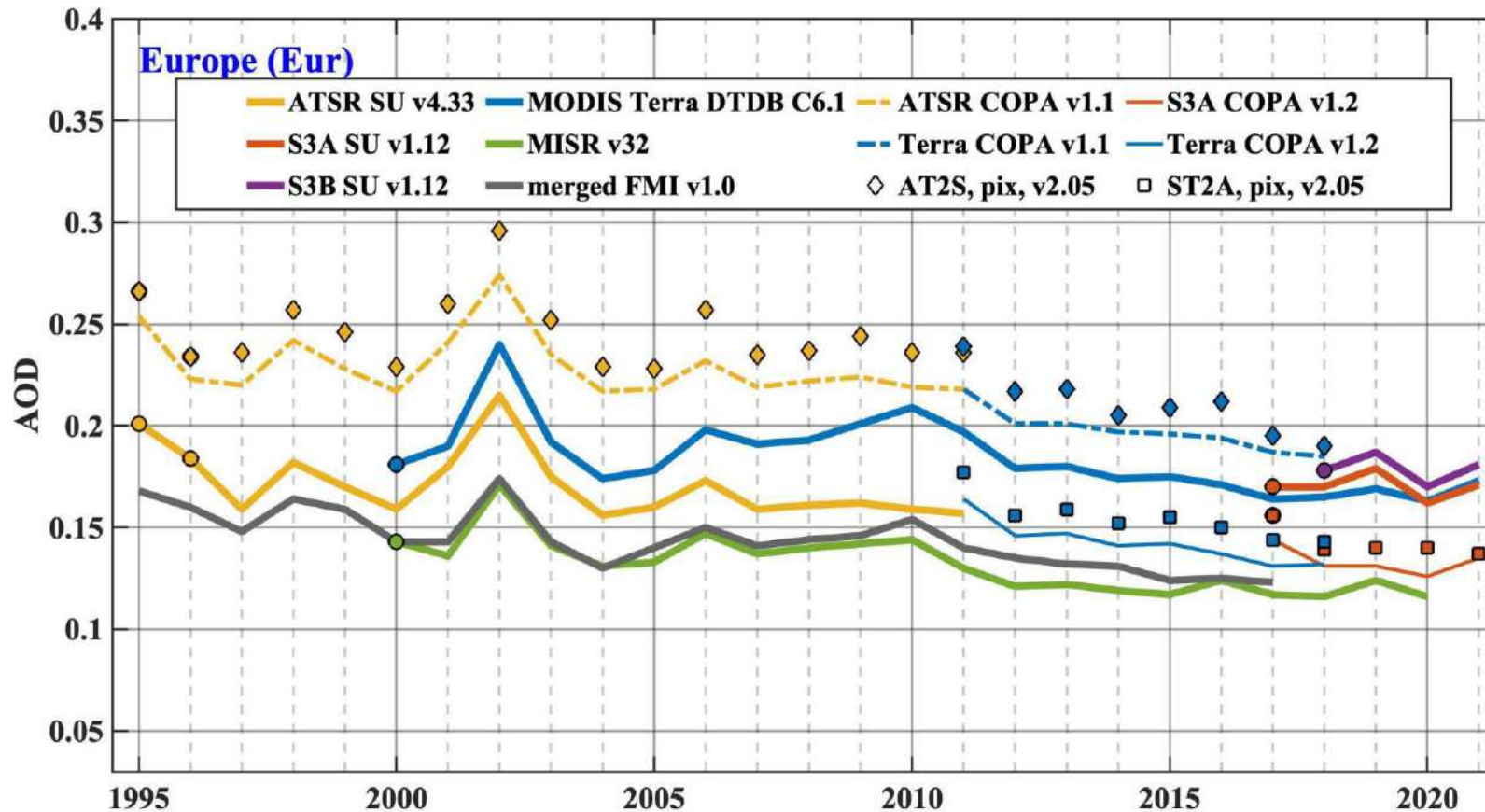
## Pixel approach

ATSR2S3A SU-FMI v2.04 2008 AUG

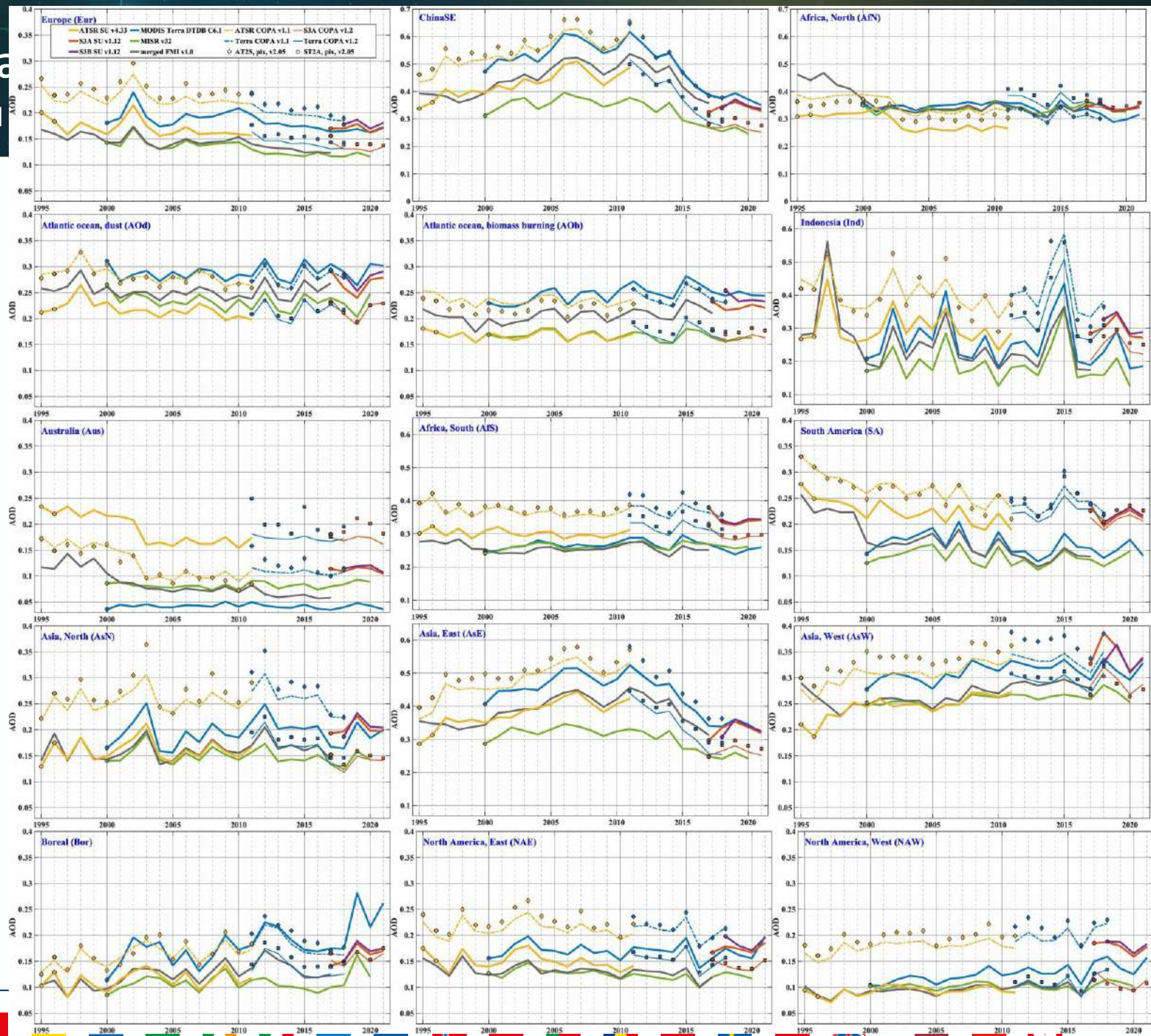




## AOD time series: Europe, regional vs pixel approach

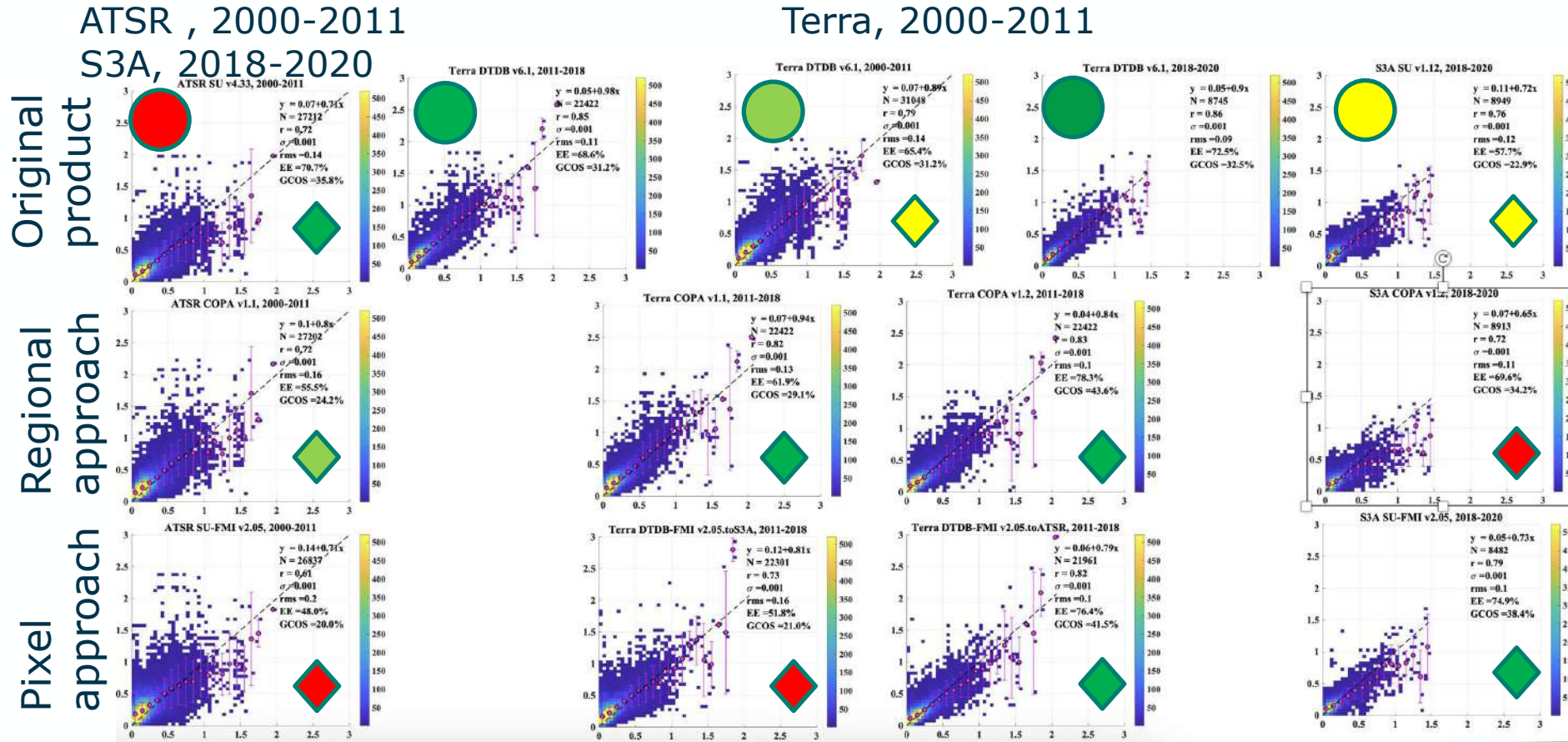


## Regional results





## Validation with AERONET



## Conclusions

- Work in progress
- Suggested approaches produce reasonable results
- Method has to be further developed for regions with the highest difference between the product to be harmonized and the reference product

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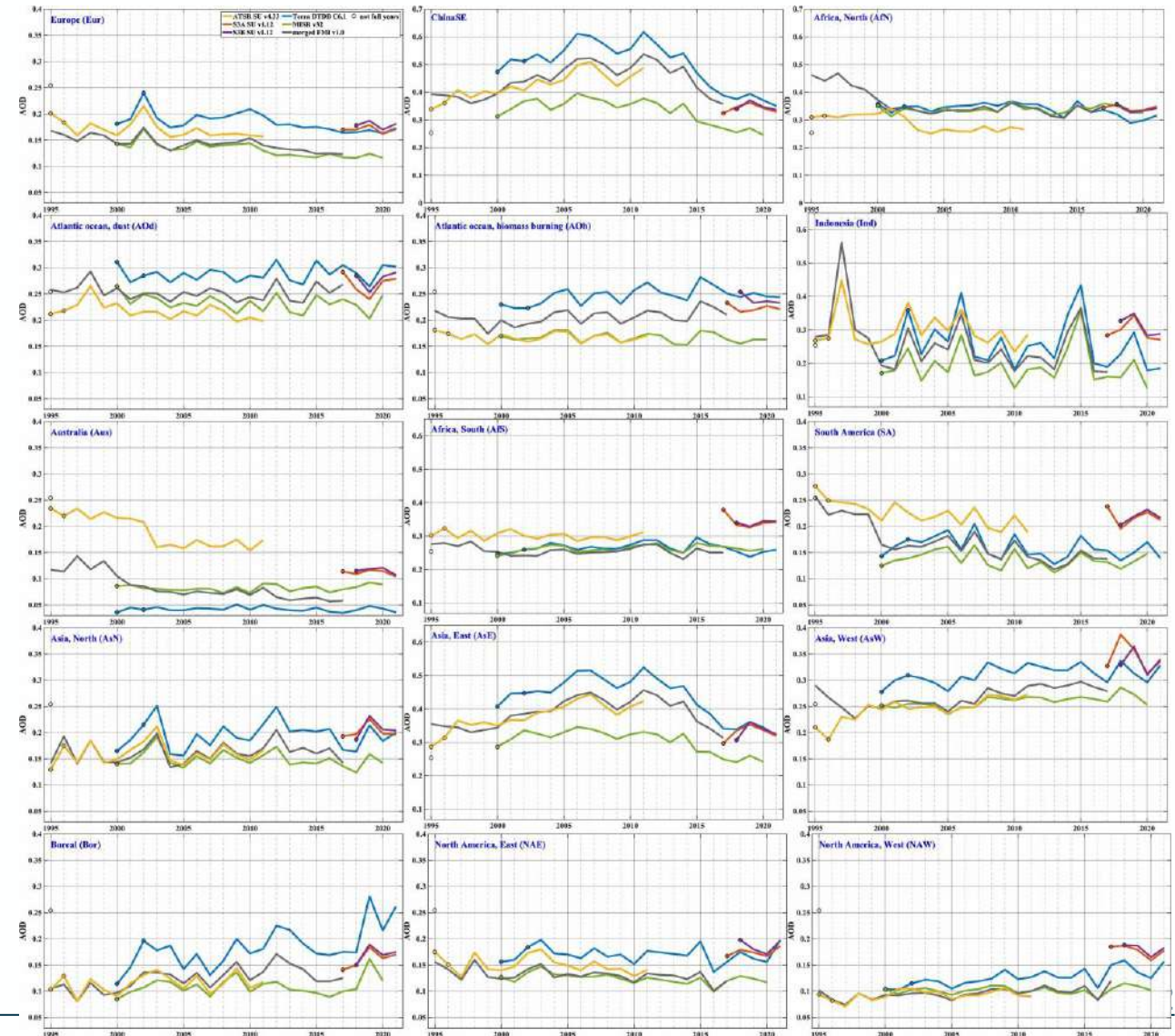
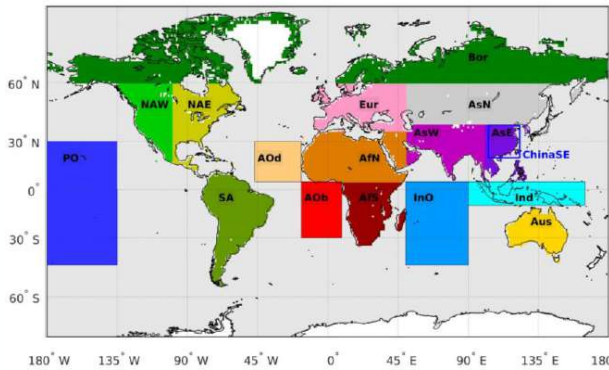


Thank you for your attention



## Regional time series

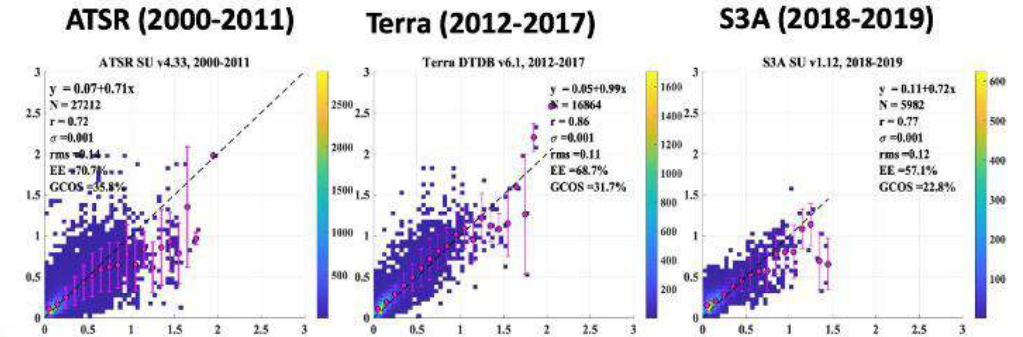
- Algorithm performance is different in different aerosol conditions (sea/land, low background, dust, biomass burning, anthropogenic emissions, etc)



## Validation with AERONET



### Validation results for original products

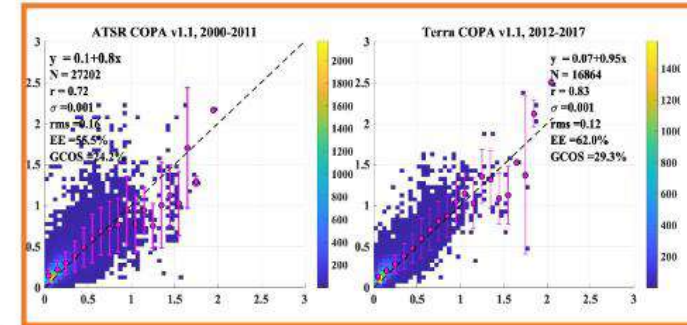


### For ATSR COPA v1.1 product

- ❖ r is the same
- ❖ EE and GCOS fractions are lower
- ❖ Offset, rms is higher

### For Terra COPA v1.1 product

- ❖ All statistics are worse



AT2S COPA v1.1  
ATSR, TERRA  
corrected to S3A

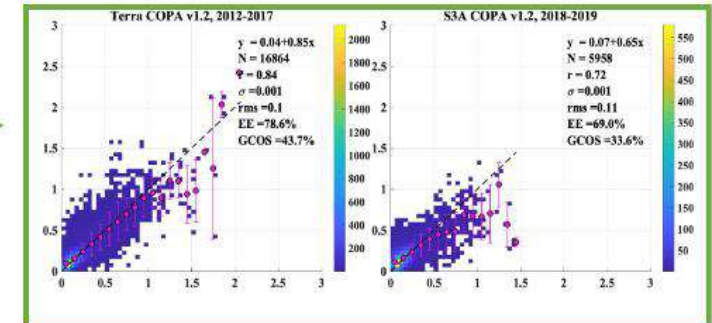
### For S3A COPA v1.2 product

- ❖ r is a bit lower
- ❖ EE and GCOS fractions are higher

### For Terra COPA v1.2 product

- ❖ r is a bit lower
- ❖ EE and GCOS fractions are higher

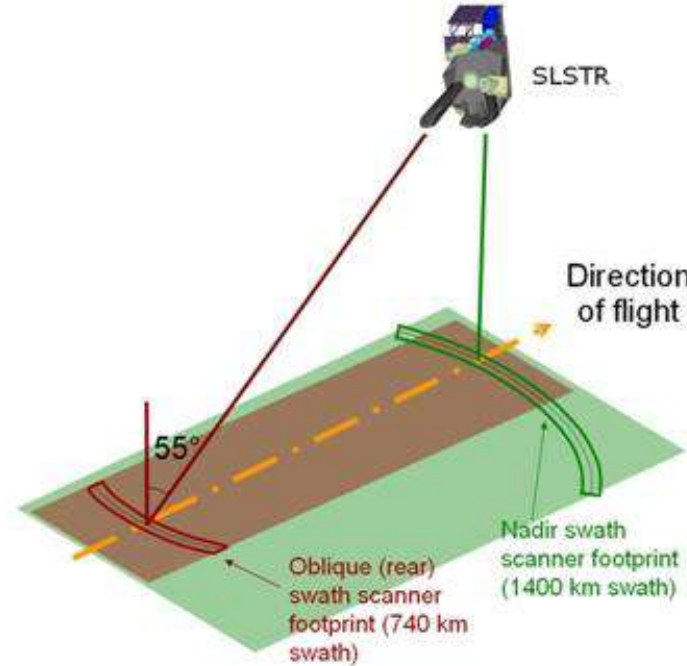
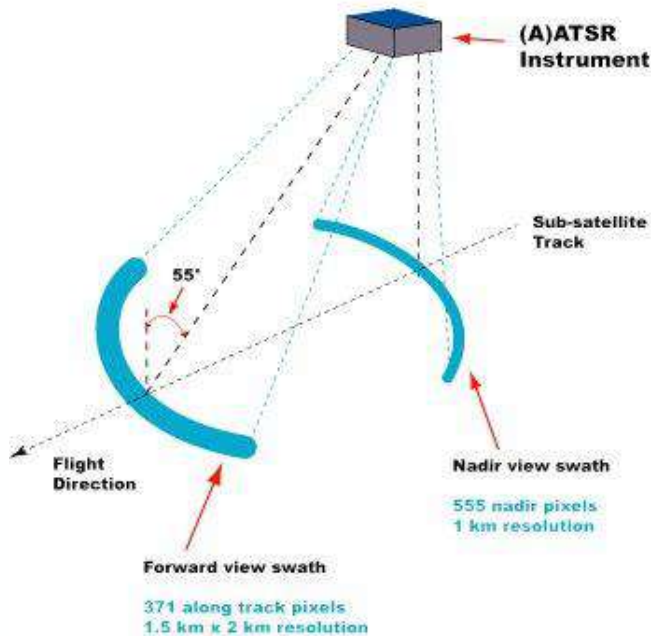
ST2A COPA v1.2  
TERRA, S3A  
corrected to ATSR



## (A)ATSR 1995-2002

VS

## SLSTR 2017->



- Increase of the dual view swath width from 500 to 740 km
- Enlarged single view swath width of 1470 km
- An on-ground resolution of 0.5 km at nadir (instead of 1 km) for all VIS and SWIR channels.
- Two added channels (at wavelengths of 2.25 and 1.375 microns) in the SWIR band to allow improved cloud and aerosol detection to give more accurate SST/LST retrievals.