# Comparison of Regional Trends in Aerosol Optical Depth from Different Instruments and Algorithms

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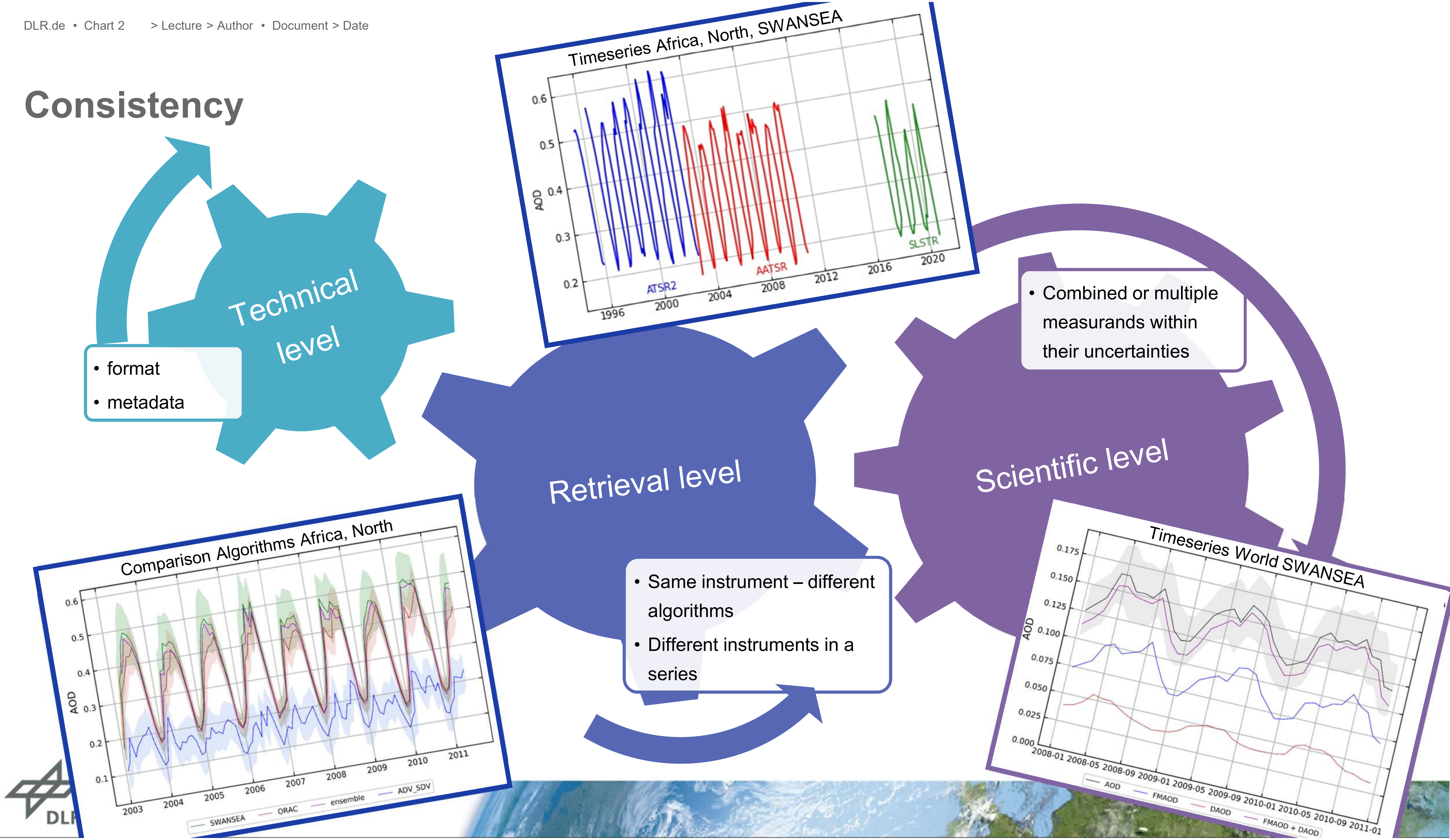
UNIA

# Consistency



Climate
Change

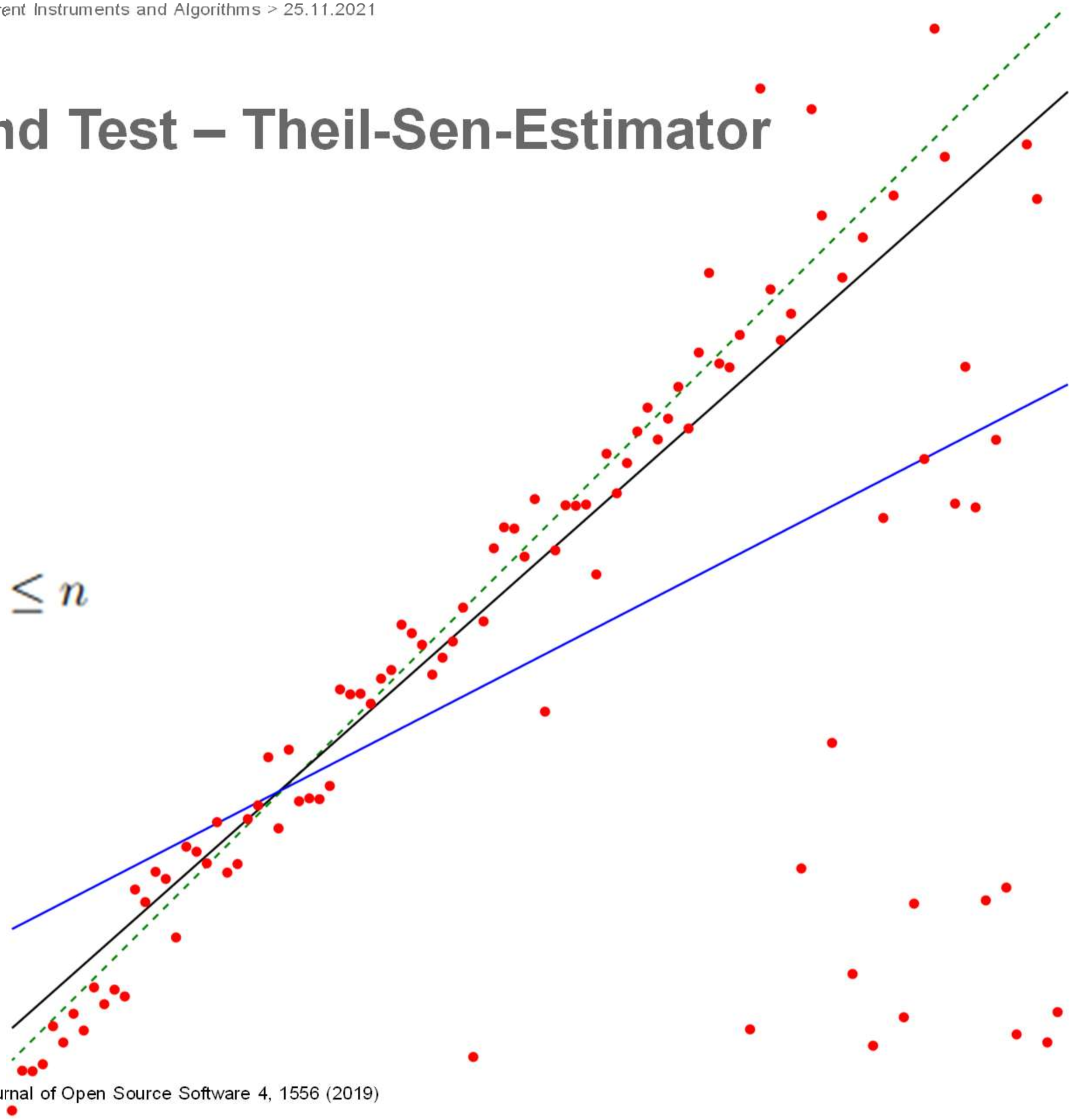
# Aerosol CDRs in the Climate Data Store

| **C3S_312b_Lot2 satellite-based Aerosol Climate Data Records in the Climate Data Store** | | |
|---|---|---|
| Sensor(s) / algorithm(s) | Period | Partner |
| **Dual view radiometer sensor line: AOD, Fine Mode AOD** | | |
| ATSR-2/ADV, AATSR/ADV, SLSTR-3A/SDV | 06/1995-04/2003<br>05/2002-04/2012<br>07/2016-06/2020 | FMI |
| ATSR-2/ORAC, AATSR/ORAC, SLSTR-3A/ORAC | | RAL |
| ATSR-2/OSURAC, AATSR/SU, SLSTR-3A/SU | | SU |
| ATSR-2/ENS, AATSR/ENS, SLSTR-3A/ENS | | DLR |
| **Thermal spectrometer sensor line: Mineral Dust AOD, Dust Layer Height** | | |
| IASI-A/IMARS | 10/2007-06/2020 | DLR |
| IASI-A/MAPIR | | BIRA |
| IASI-A/LMD | | LMD |
| IASI-A/ULB | | ULB |
| IASI-A/ENS | | DLR |
| **https://cds.climate.copernicus.eu/cdsapp#!/dataset/satellite-aerosol-properties?tab=overview** | | |

# Methods – Trends – Mann-Kendall Trend Test – Theil-Sen-Estimator

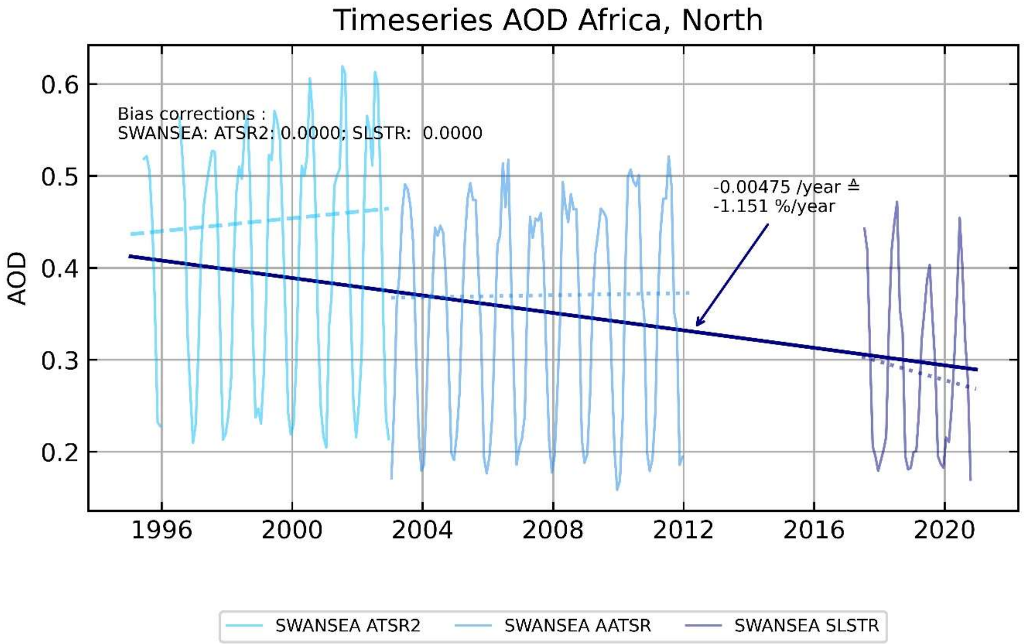
Trend slope b:

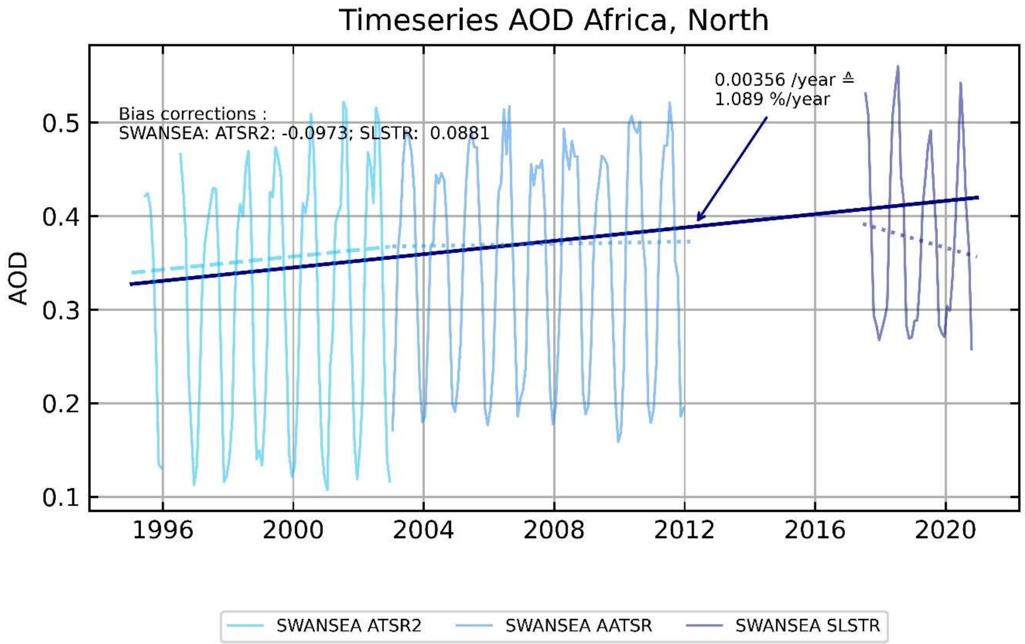
$$b = \mathrm{med}\left(\frac{x_j - x_k}{j - k}\right) \quad \forall \quad 1 \leq k < j \leq n$$



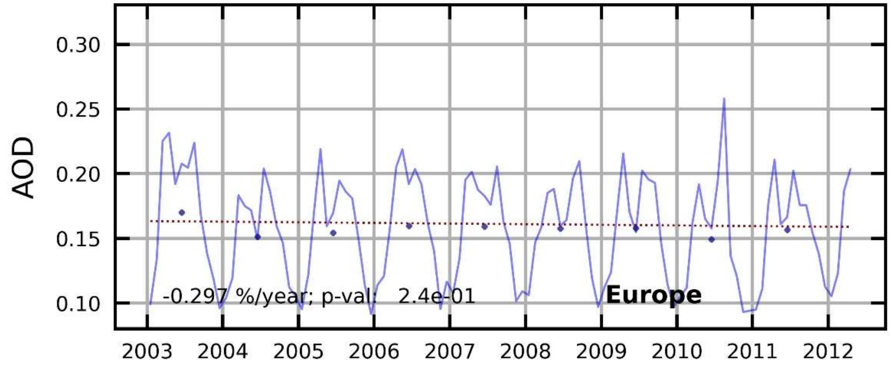
https://en.wikipedia.org/wiki/Theil%E2%80%93Sen_estimator#/media/File:Thiel-Sen_estimator.svg
M. Hussain und I. Mahmud, „pyMannKendall: a python package for non parametric Mann Kendall family of trend tests.“, Journal of Open Source Software 4, 1556 (2019)

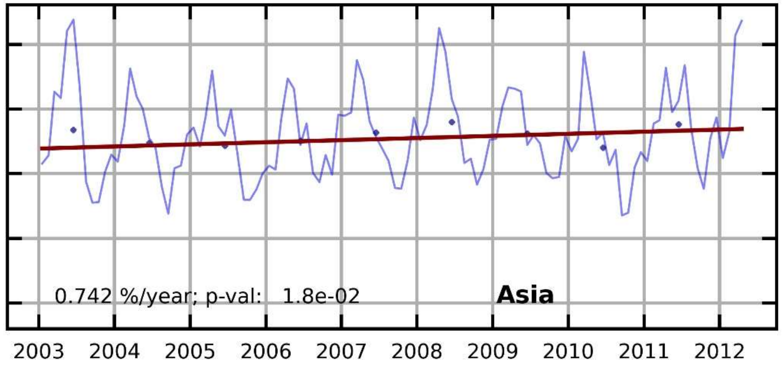
# Bias correction



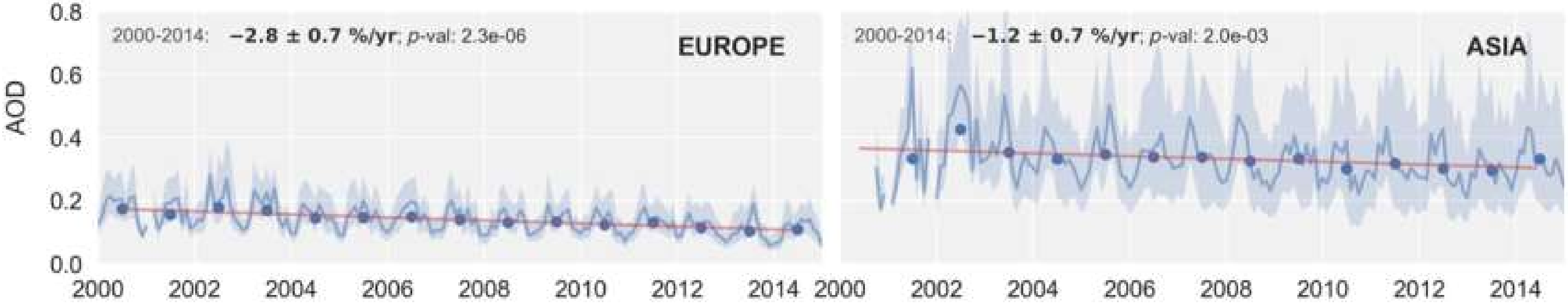



Area



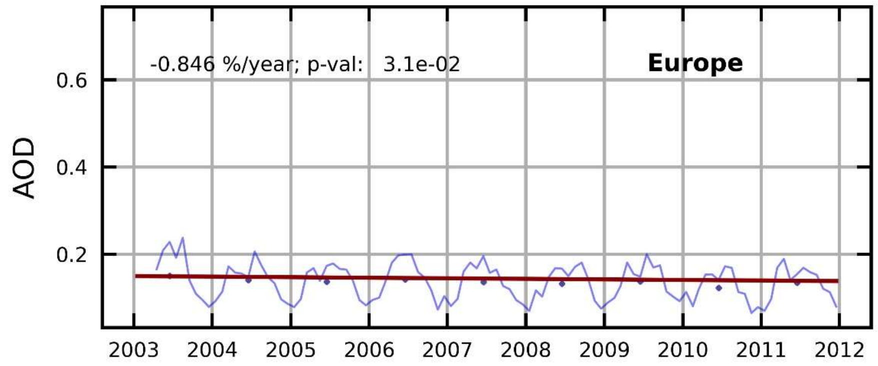



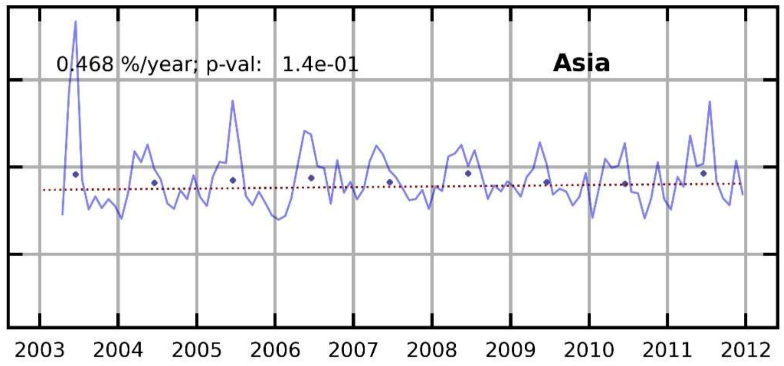

AERONET

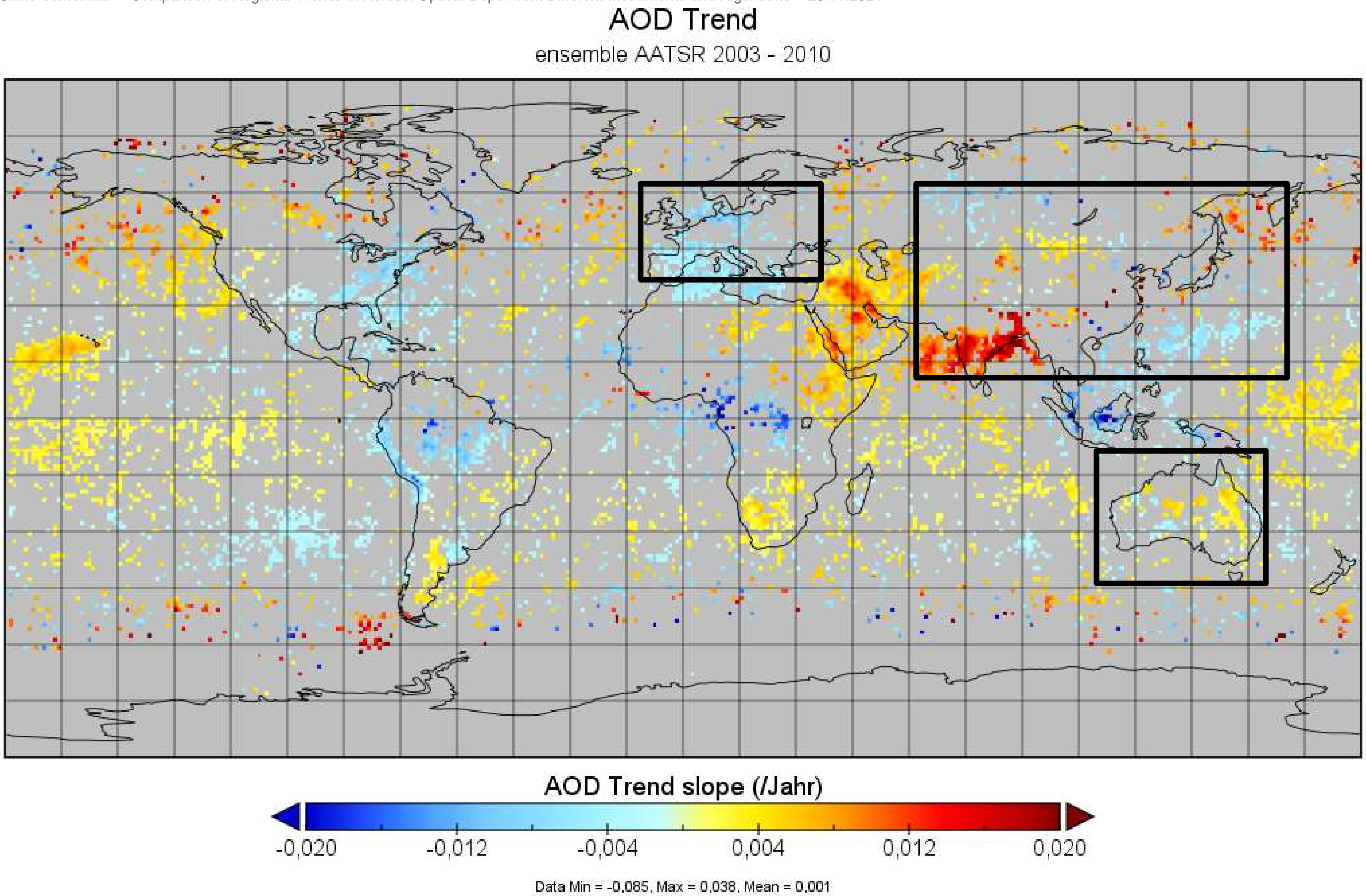


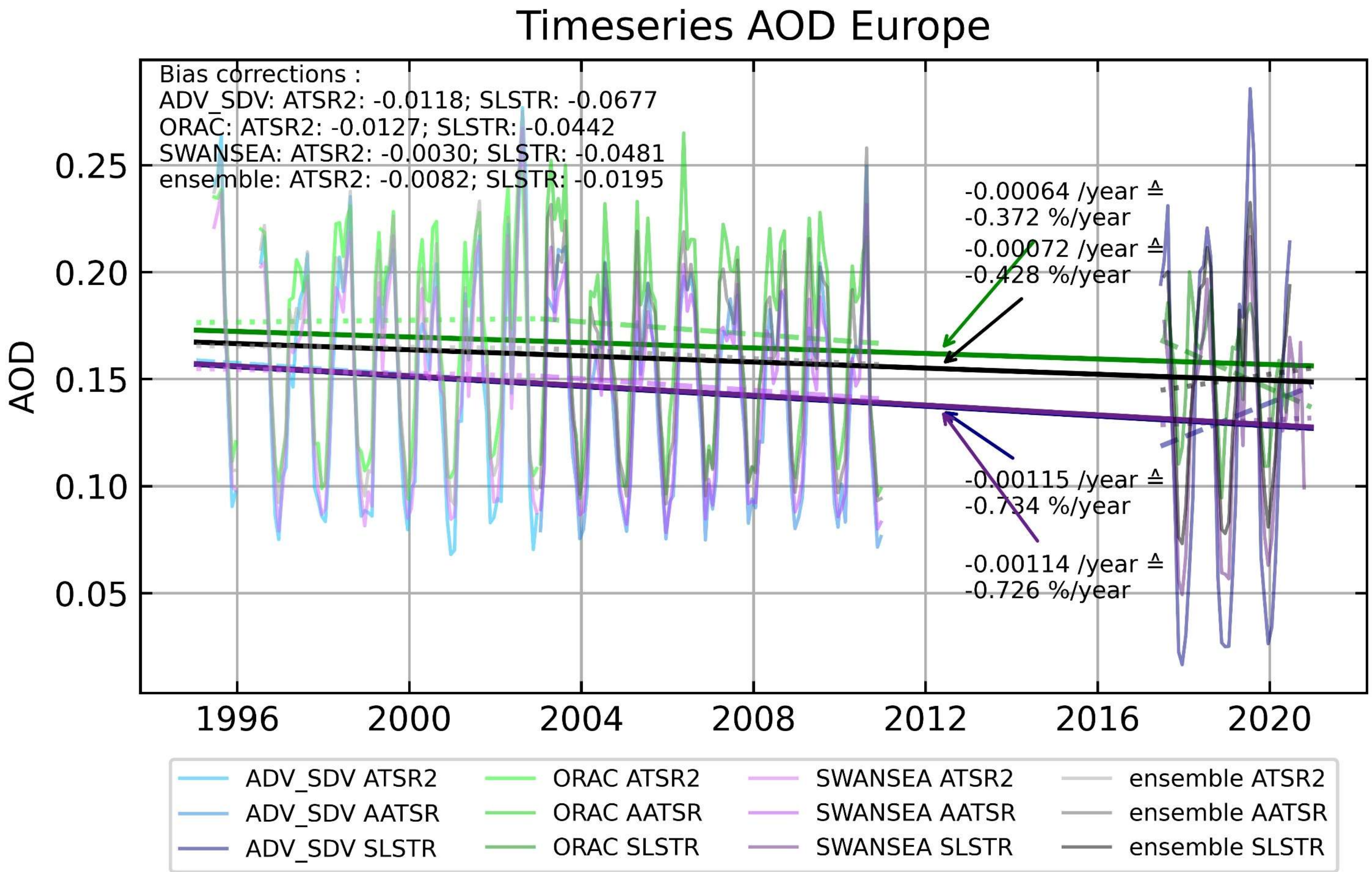

A. Mortier et all (2020)

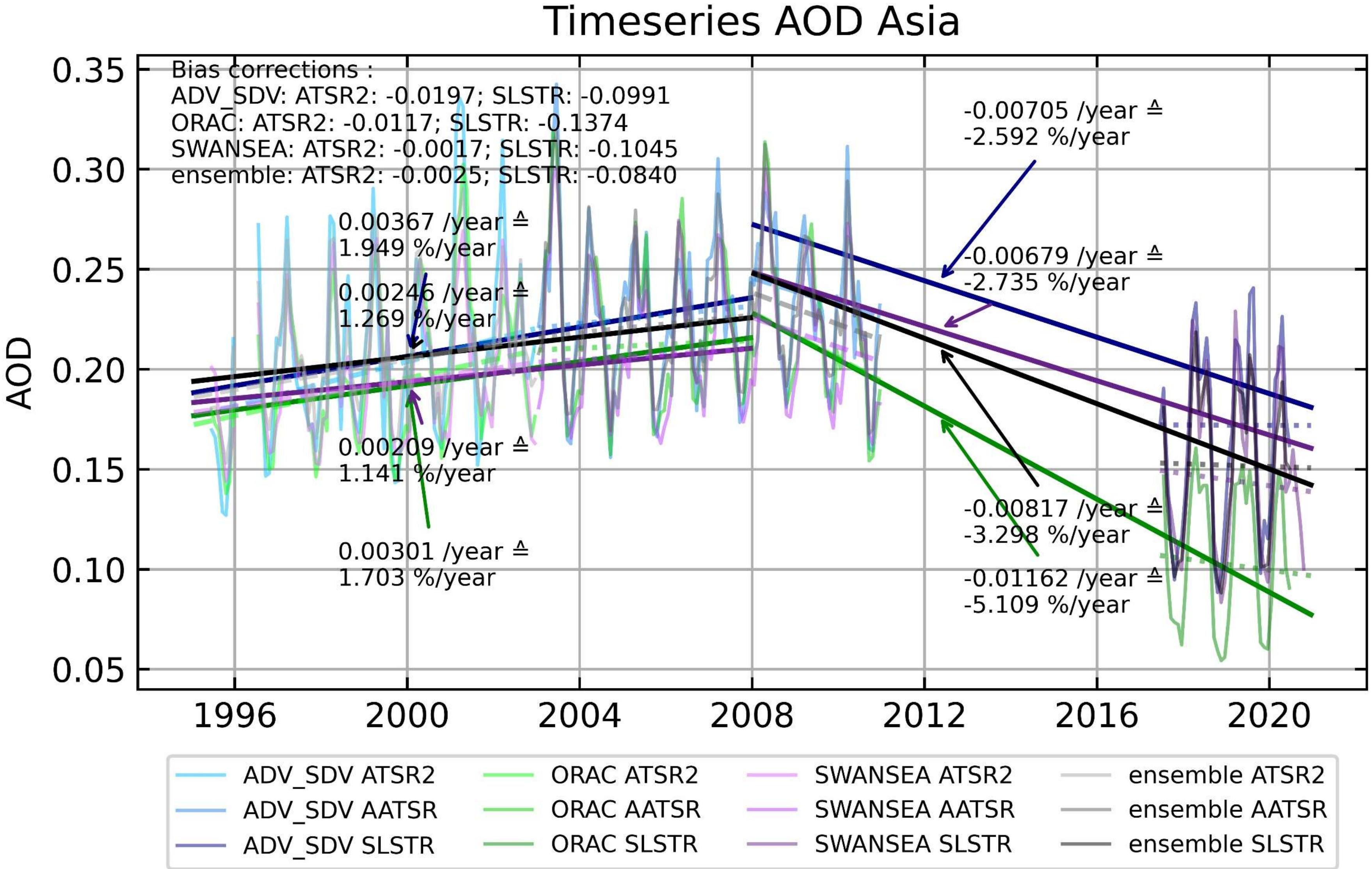
Pixel with AERONET-Stations in Area

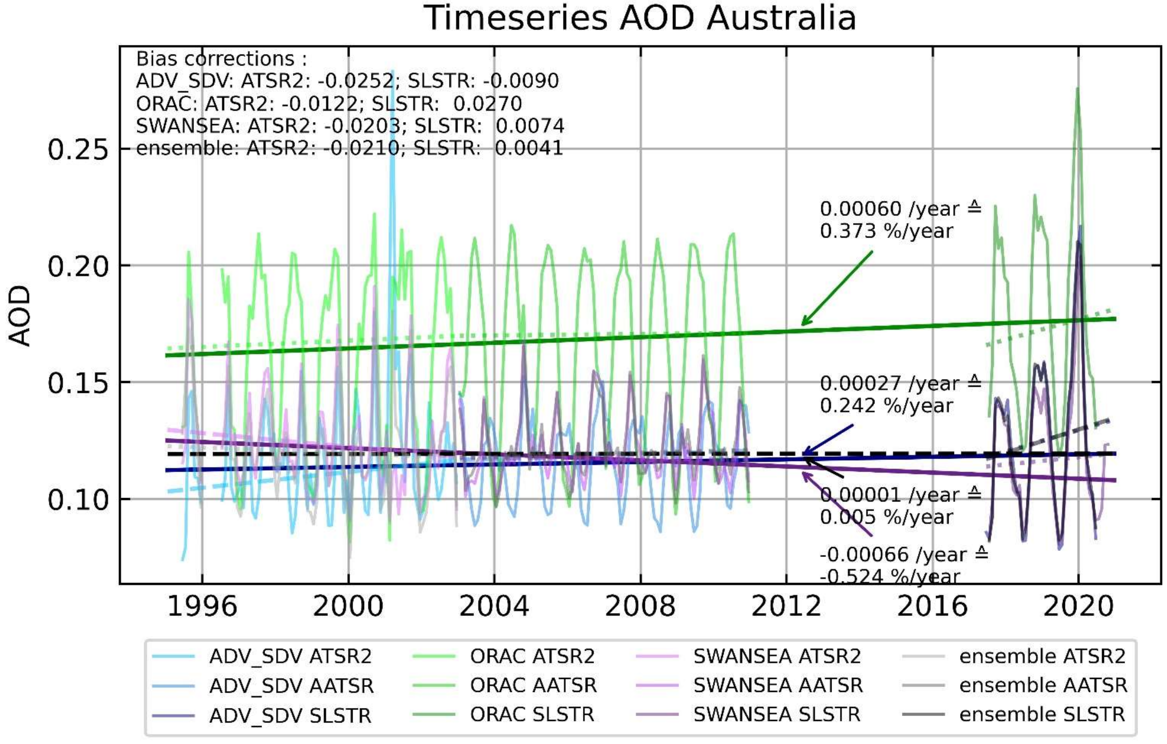


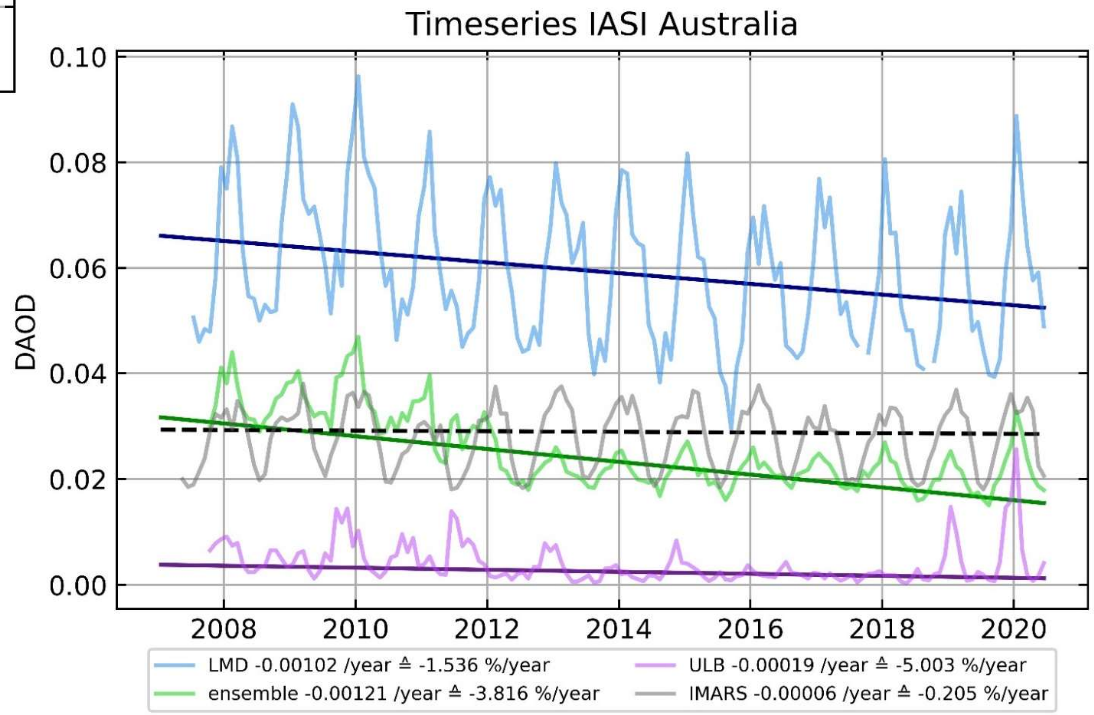



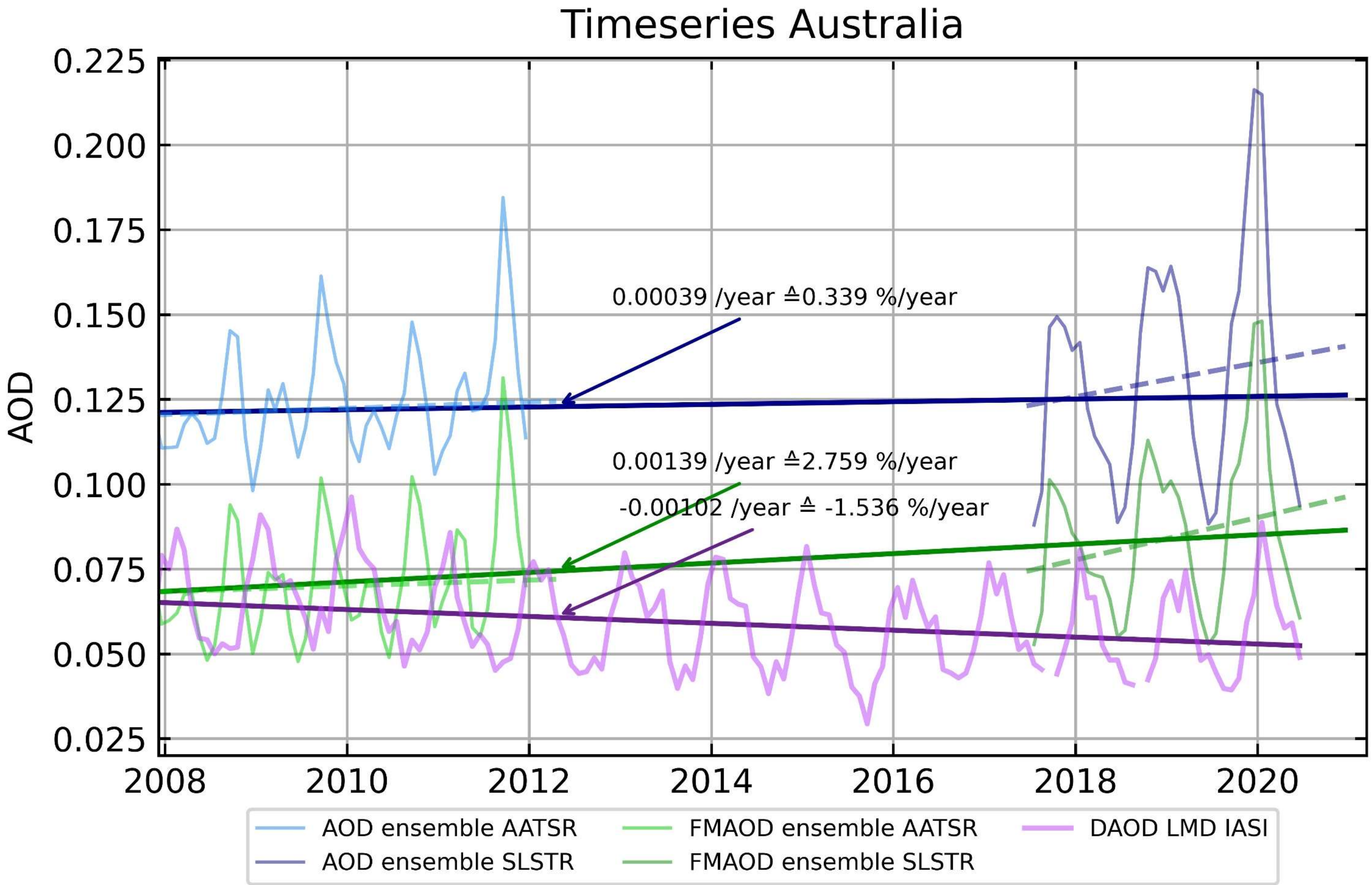

AOD Trend
ensemble AATSR 2003 - 2010
AOD Trend slope (/Jahr)
-0,020
-0,012
-0,004
0,004
0,012
0,020
Data Min = -0,085, Max = 0,038, Mean = 0,001


Timeseries AOD Europe
Bias corrections :
ADV_SDV: ATSR2: -0.0118; SLSTR: -0.0677
ORAC: ATSR2: -0.0127; SLSTR: -0.0442
SWANSEA: ATSR2: -0.0030; SLSTR: -0.0481
ensemble: ATSR2: -0.0082; SLSTR: -0.0195
-0.00064 /year ≙
-0.372 %/year
-0.00072 /year ≙
-0.428 %/year
-0.00115 /year ≙
-0.734 %/year
-0.00114 /year ≙
-0.726 %/year
AOD
0.25
0.20
0.15
0.10
0.05
1996
2000
2004
2008
2012
2016
2020
ADV_SDV ATSR2
ADV_SDV AATSR
ADV_SDV SLSTR
ORAC ATSR2
ORAC AATSR
ORAC SLSTR
SWANSEA ATSR2
SWANSEA AATSR
SWANSEA SLSTR
ensemble ATSR2
ensemble AATSR
ensemble SLSTR


Timeseries AOD Asia
Bias corrections :
ADV_SDV: ATSR2: -0.0197; SLSTR: -0.0991
ORAC: ATSR2: -0.0117; SLSTR: -0.1374
SWANSEA: ATSR2: -0.0017; SLSTR: -0.1045
ensemble: ATSR2: -0.0025; SLSTR: -0.0840
0.00367 /year ≙
1.949 %/year
0.00246 /year ≙
1.269 %/year
0.00209 /year ≙
1.141 %/year
0.00301 /year ≙
1.703 %/year
-0.00705 /year ≙
-2.592 %/year
-0.00679 /year ≙
-2.735 %/year
-0.00817 /year ≙
-3.298 %/year
-0.01162 /year ≙
-5.109 %/year
AOD
0.35
0.30
0.25
0.20
0.15
0.10
0.05
1996
2000
2004
2008
2012
2016
2020
ADV_SDV ATSR2
ADV_SDV AATSR
ADV_SDV SLSTR
ORAC ATSR2
ORAC AATSR
ORAC SLSTR
SWANSEA ATSR2
SWANSEA AATSR
SWANSEA SLSTR
ensemble ATSR2
ensemble AATSR
ensemble SLSTR


Timeseries AOD Australia
Bias corrections :
ADV_SDV: ATSR2: -0.0252; SLSTR: -0.0090
ORAC: ATSR2: -0.0122; SLSTR: 0.0270
SWANSEA: ATSR2: -0.0203; SLSTR: 0.0074
ensemble: ATSR2: -0.0210; SLSTR: 0.0041
0.00060 /year ≙ 0.373 %/year
0.00027 /year ≙ 0.242 %/year
0.00001 /year ≙ 0.005 %/year
-0.00066 /year ≙ -0.524 %/year
AOD
0.25
0.20
0.15
0.10
1996
2000
2004
2008
2012
2016
2020
ADV_SDV ATSR2
ADV_SDV AATSR
ADV_SDV SLSTR
ORAC ATSR2
ORAC AATSR
ORAC SLSTR
SWANSEA ATSR2
SWANSEA AATSR
SWANSEA SLSTR
ensemble ATSR2
ensemble AATSR
ensemble SLSTR


Timeseries IASI Australia
DAOD
0.10
0.08
0.06
0.04
0.02
0.00
2008
2010
2012
2014
2016
2018
2020
LMD -0.00102 /year ≙ -1.536 %/year
ensemble -0.00121 /year ≙ -3.816 %/year
ULB -0.00019 /year ≙ -5.003 %/year
IMARS -0.00006 /year ≙ -0.205 %/year


Timeseries Australia
AOD
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
2008
2010
2012
2014
2016
2018
2020
0.00039 /year ≙0.339 %/year
0.00139 /year ≙2.759 %/year
-0.00102 /year ≙ -1.536 %/year
AOD ensemble AATSR
AOD ensemble SLSTR
FMAOD ensemble AATSR
FMAOD ensemble SLSTR
DAOD LMD IASI

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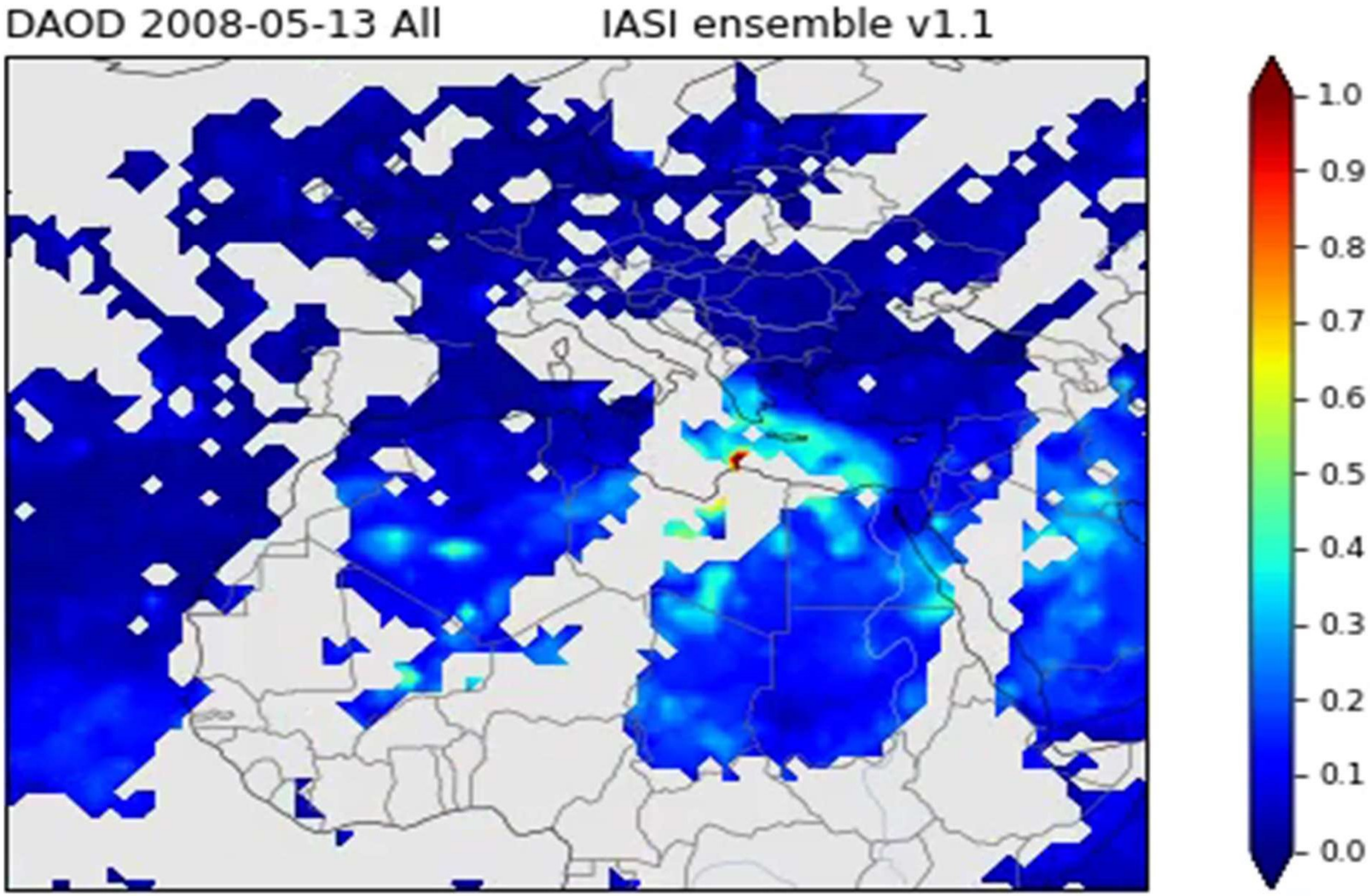
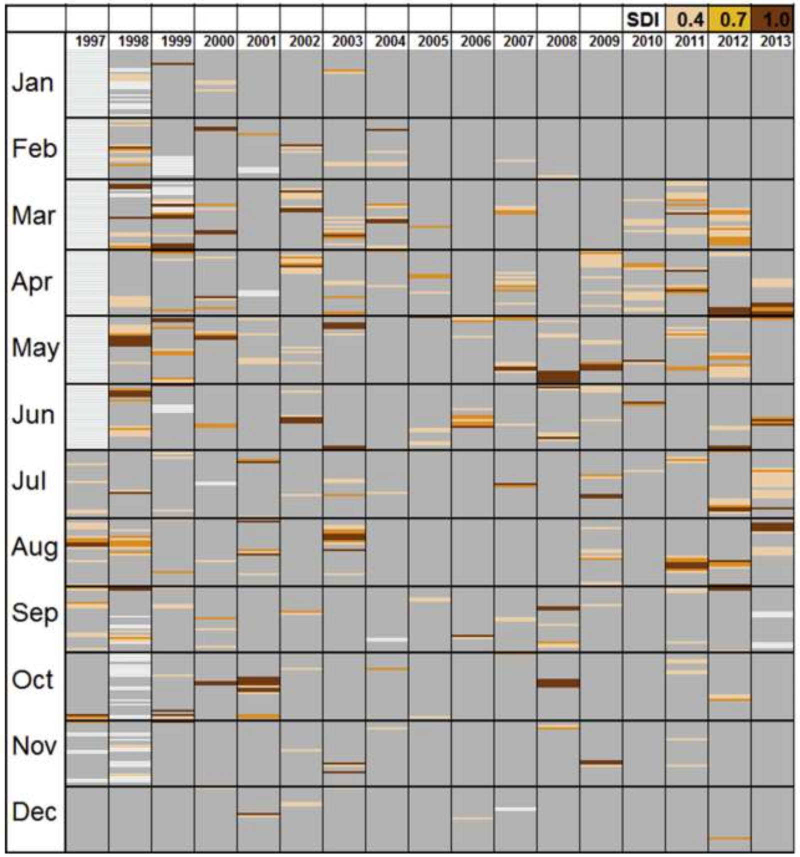
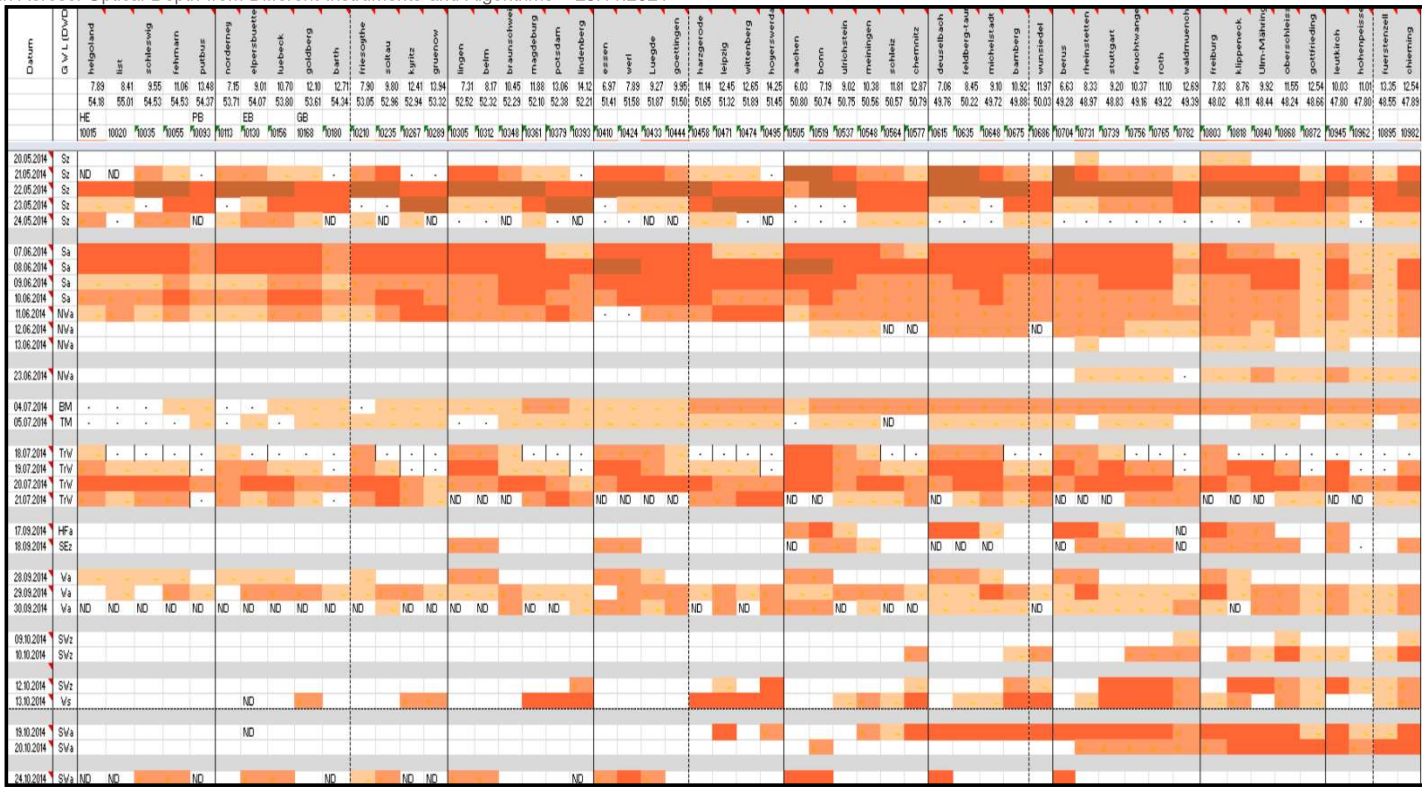
# Sahara Dust Events in Germany



# Sahara Dust Events



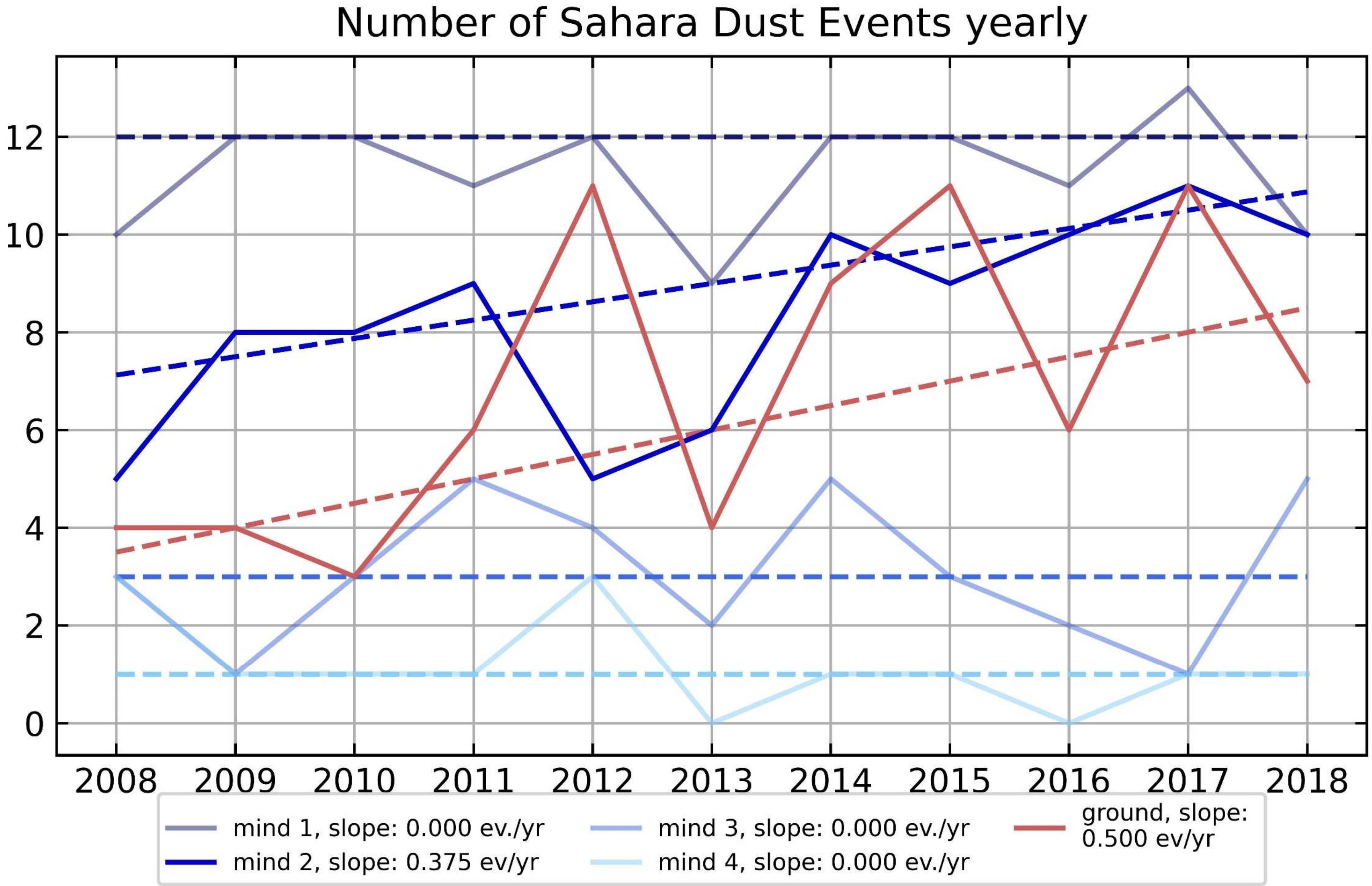



Out of Ceilometer Backscatter profiles calculated optical depth

From daily in-situ measurements of high Ca2 + concentration and large particle volume concentrations with a diameter of 0.5-7 µm

H.Flentje et all. 2015: „Identification and monitoring of Saharan dust: An inventory representative for south Germany since 1997“
G. Müller 2019: „Distribution and intensity of Saharan dust in Germany“

# Sahara Dust Events 2007 - 2018



# Conclusion

- Bias Corrections using trends work well for part of the regions – Validation with AERONET if enough stations in region
- Trends of different algorithms using dual view instruments are mostly consistent – Comparison to AERONET Trends difficult
- Trends of different algorithms using IASI instruments are partly consistent – Here a combination can be useful

Universität Augsburg
Institut für Physik

# Thank you for your attention

Do you have questions?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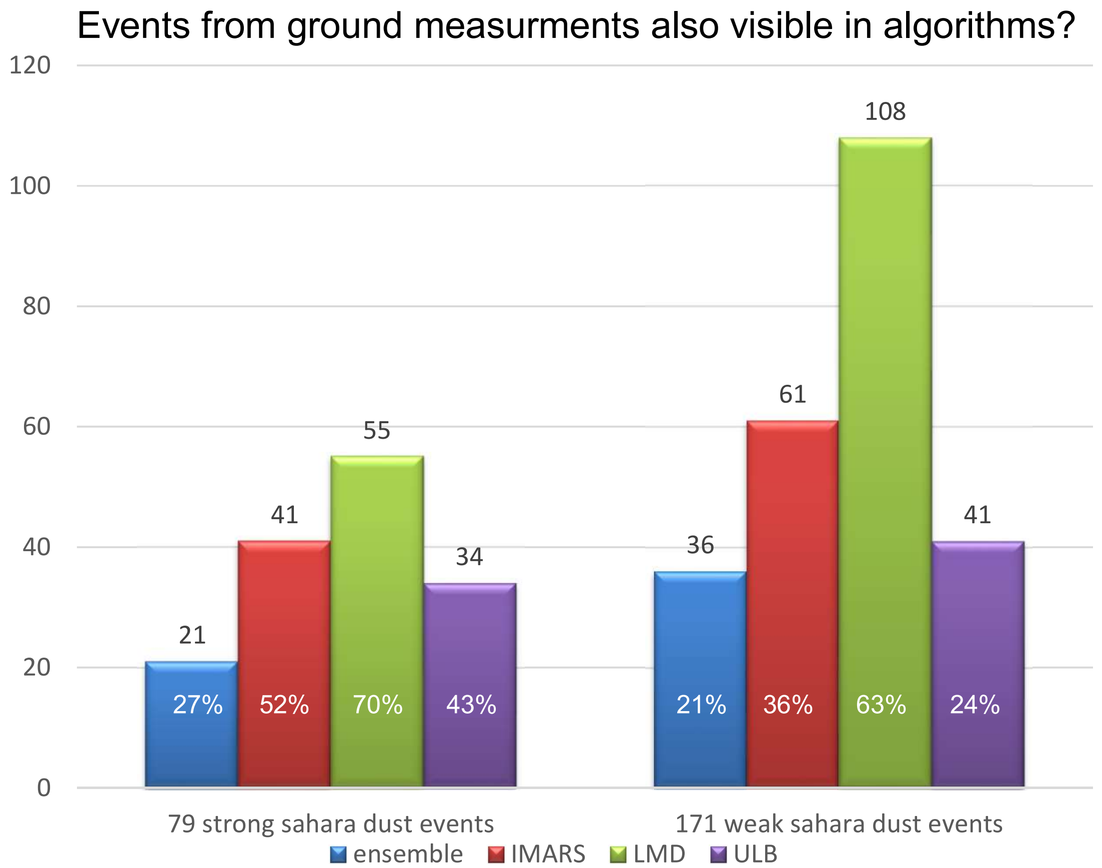
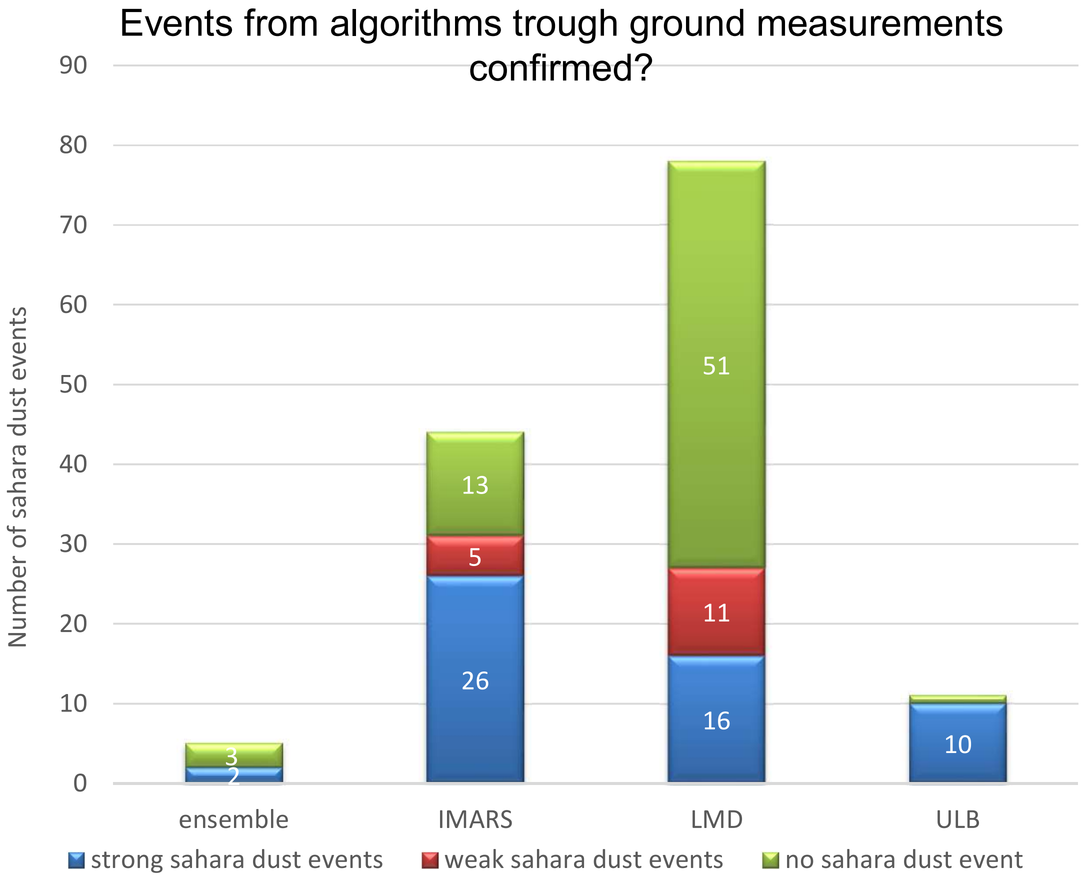
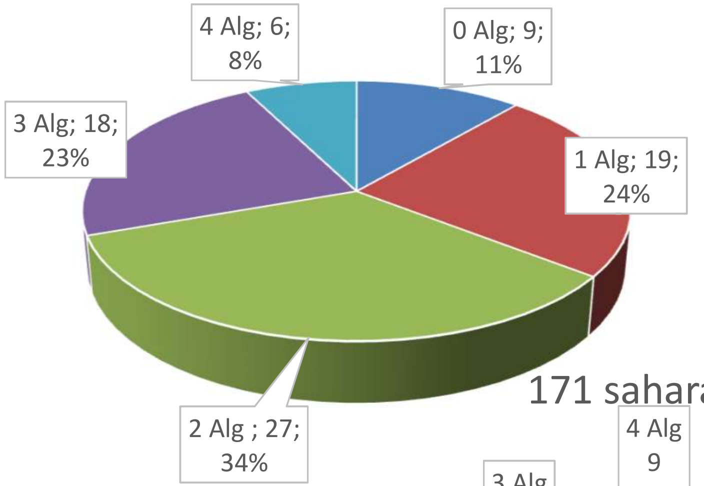
# Sahara dust events in Germany juli 2007 to february 2019

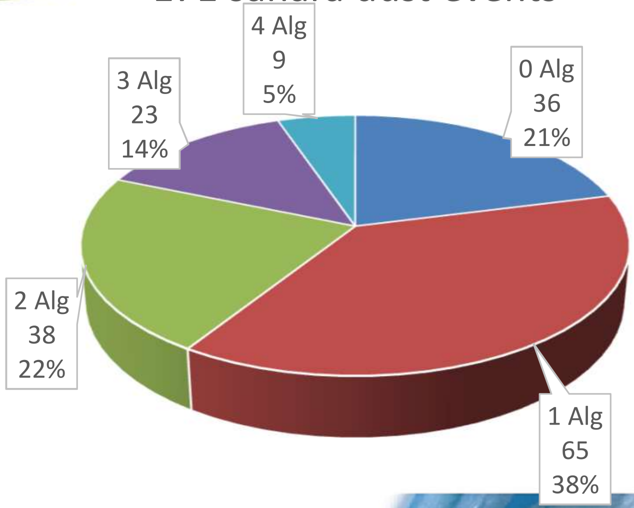


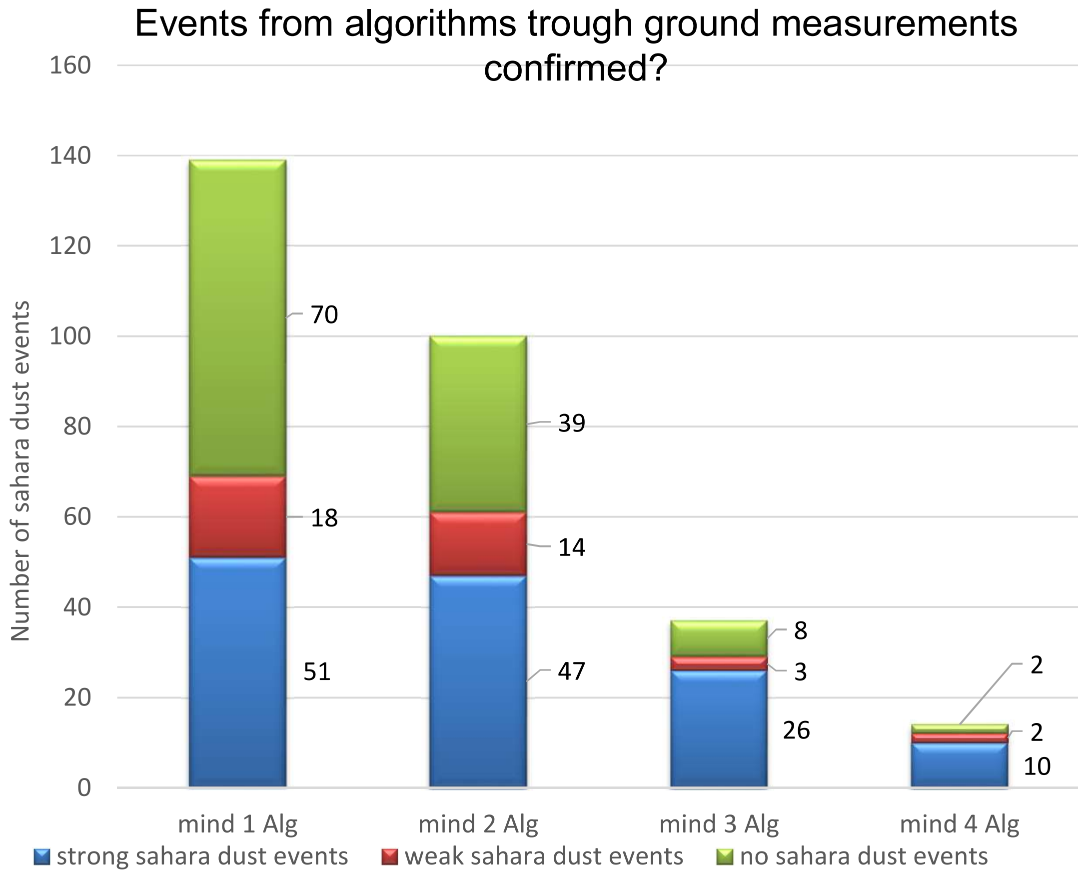



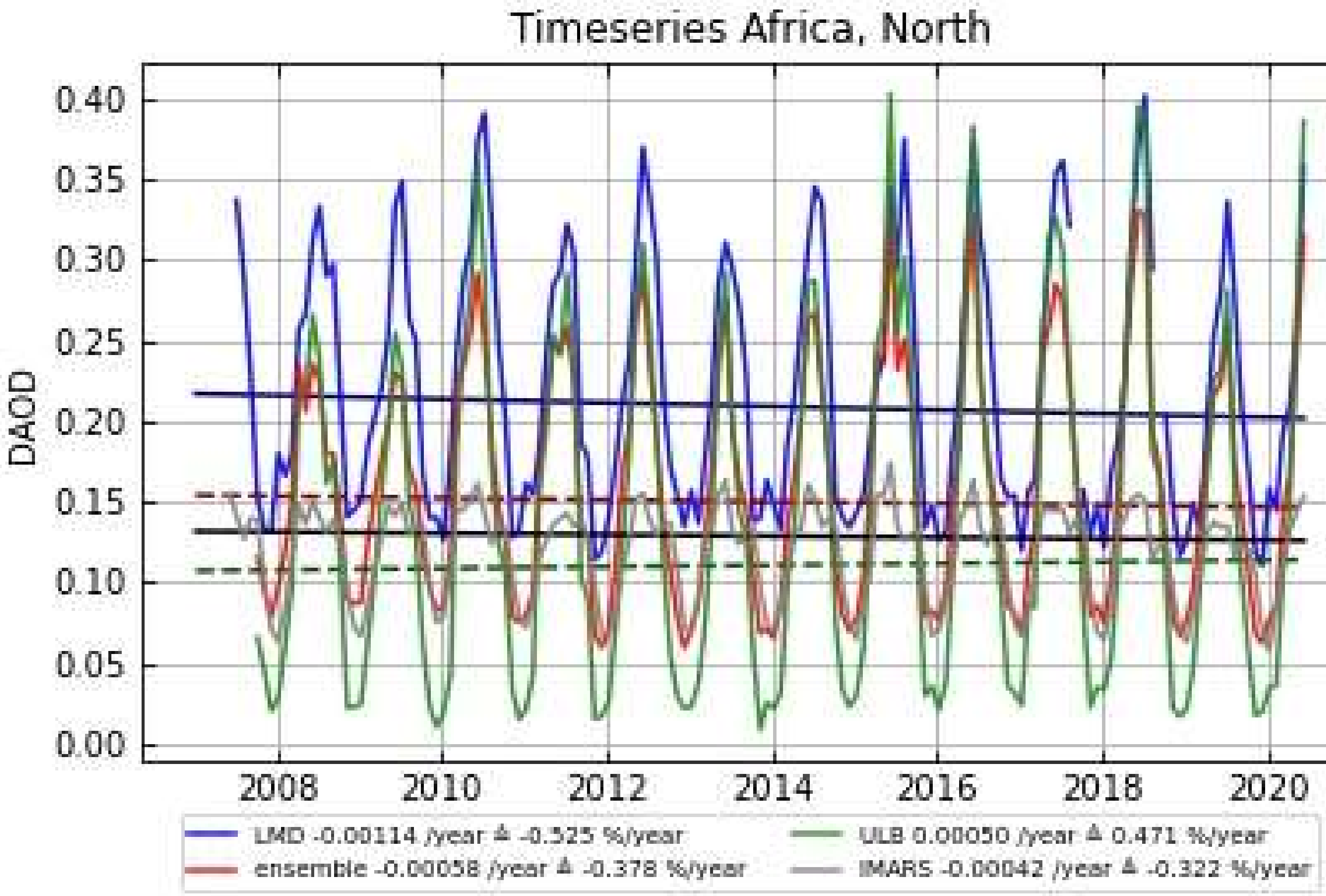

H.Flentje et all. 2015: „Identification and monitoring of Saharan dust: An inventory representative for south Germany since 1997“
G. Müller 2019: „Distribution and intensity of Saharan dust in Germany“

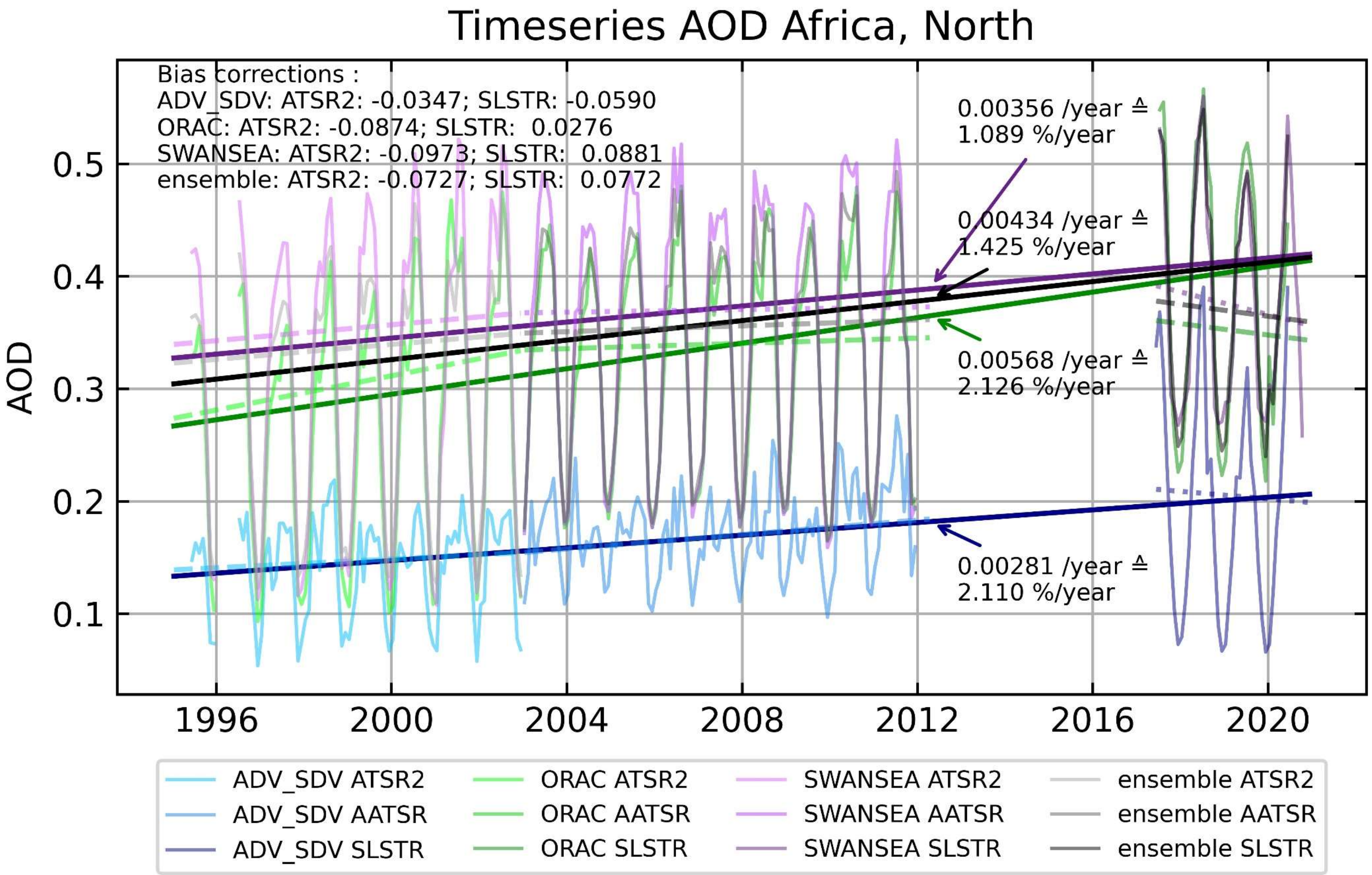
# Sahara dust events in Germany juli 2007 to february 2019




Timeseries Africa, North
DAOD
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
2008
2010
2012
2014
2016
2018
2020
LMD -0.00114 /year ≙ -0.525 %/year
ensemble -0.00058 /year ≙ -0.378 %/year
ULB 0.00050 /year ≙ 0.471 %/year
IMARS -0.00042 /year ≙ -0.322 %/year



Timeseries AOD Africa, North
Bias corrections :
ADV_SDV: ATSR2: -0.0347; SLSTR: -0.0590
ORAC: ATSR2: -0.0874; SLSTR: 0.0276
SWANSEA: ATSR2: -0.0973; SLSTR: 0.0881
ensemble: ATSR2: -0.0727; SLSTR: 0.0772
0.00356 /year ≙ 1.089 %/year
0.00434 /year ≙ 1.425 %/year
0.00568 /year ≙ 2.126 %/year
0.00281 /year ≙ 2.110 %/year
AOD
0.1
0.2
0.3
0.4
0.5
1996
2000
2004
2008
2012
2016
2020
ADV_SDV ATSR2
ADV_SDV AATSR
ADV_SDV SLSTR
ORAC ATSR2
ORAC AATSR
ORAC SLSTR
SWANSEA ATSR2
SWANSEA AATSR
SWANSEA SLSTR
ensemble ATSR2
ensemble AATSR
ensemble SLSTR

## Comparison of Regional Trends in Aerosol Optical Depth from Different Instruments and Algorithms

- **Einleitung**: Aerosols affect climate in several ways. Aerosols together with clouds contribute the largest uncertainties to the Earth's energy budget, according to IPCC. Consequently, accurate retrieval of the Aerosol Optical Depth (AOD) from satellite measurements is important to get more knowledge about aerosols in the atmosphere and the influence of natural and anthropogenic events on the amount of aerosols. Since the retrieval of AOD needs assumptions concerning aerosol properties and the surface of the Earth there are several different algorithms.
- **Welche Daten**: We analyse data from the Copernicus Climate Change Service of retrieved AOD with Dual-View Instruments (Along Track Scanning Radiometer 2 (ATSR2), Advanced Along Track Scanning Radiometer (AATSR), Sea and Land Surface Temperature Radiometer (SLSTR)) and the Infrared Atmospheric Sounding Interferometer (IASI) for the retrieval of Dust AOD.
- For reliable conclusions there should be a **consistency** of these algorithms and between the different instruments.
- In a comparison of AOD trends in different regions we analyse this consistency and the comparability of the different instruments. The trends were calculated by a seasonal Mann-Kendall-trend-test after a bias correction between the different instruments. For further validation we compare the trends to AERONET ground based measurements. Here the distribution of the AERONET stations in the considered region can cause problems, for example when they are not representative leading to opposite trend between AERONET and satellite observations for example in Asia and North Africa.
- Overall, we find good consistency for most regions with few comparisons revealing larger inconsistencies. This will be further explored in the presentation.