FINNISH METEOROLOGICAL INSTITUTE

AeroSat Session14
Climate Data Records (CDR)

Chair: Gerrit de Leeuw / FMI
Notes: tbd

Seed talks:

Tom Eck: AERONET v3 update and including AERONET inversion uncertainties

Ellsworth Welton: NASA Micro Pulse Lidar Network: Overview of the new Version 3 Product Suite

Greg Schuster: Laboratory Evaluation of the AERONET and GRASP Retrieval Algorithms

Other records (AVHRR, TOMS/OMI) and next years progress

Aerosol CDR in AeroSat

Starting points:

- GCOS requirements
- Uptake of aerosol CDRs in climate studies
- Aerosol CDR quality
- Users' needs

✓ 2014, Steamboat:
Introduction Pinnock; Objectives WG and Workplan, Inventory of potential aerosol CDRs, QA, combined products, CDR criteria, satellites vs models

✓ 2015, Frascati:
Introduction Pinnock + 4 talks (MODIS/VIIRS; Meteosat; Reanalysis; AVHRR); Validation pre-AERONET, AAI TOMS, working group/workshop older sensors?

✓ 2016, Beijing:
Introduction Popp + 3 talks (MODIS/VIIRS; MISR; ATSR);consistency, deterioration, similar instruments, like instruments, validation, gridding, missing high AOD, etc., stability and trends in satellite data records, (regional) differences between algorithms

FOCUS on Satellites and algorithms!

✓ 2017, Helsinki:

Focus on ground-based remote sensing and evaluation / validation

Some reflections

For the construction of CDRs we need:

- Long-term and consistent measurements of high quality
- Retrieval algorithms taking care of the directional surface contributions to the TOA radiances, cloud detection and screening, aerosol models

However:

- Instruments have a limited lifetime, and even like instruments show differences (e.g., MODIS Terra vs Aqua; vs VIIRS)
- Different algorithms? (e.g., ATRS in cci: ADV, ORAC, SU)
- Different instruments? (e.g., MODIS, MISR, …)
- Gaps between instruments (e.g., ATSR, SLSTR)
- Design of instrument for the complex problem of aerosol retrieval: wide variety of aerosol properties: size distribution, chemical properties as f(size), vertical distribution, absorbing aerosol, non-sphericity (e.g., POLDER)
- A wide variety of surface properties
- Pixel resolution and variability of scattering surfaces

➢ To what degree are satellite observations suitable for constructing CDRs?
➢ How should we use ground-based instruments? What are the limitations of ground-based instruments?

Ground-based measurements?

What are the limitations of ground-based instruments?

- Local point measurements
- Representative for the area where they are used
- Large parts of the world are not covered, and some do not provide open access
- Vertical resolution (for column measurements)
- Representiveness near-surface layer (certain lidar measurements)
- Representativeness of retrieved aerosol properties given high-AOD is required for retrieval

What are the advantages of ground-based instruments?

- No surface interference
- Direct sun and angular scattering
- Combination with instruments measuring other relevant parameters (closure)
- High temporal frequency throughout the daylight hours (plus nighttime for lidars)
- Very high accuracy for AOD measurement (it is not an retrieval from sunphotometry as it is from satellite)
- Less surface interference than most satellite observations

What are other issues with ground-based measurments?

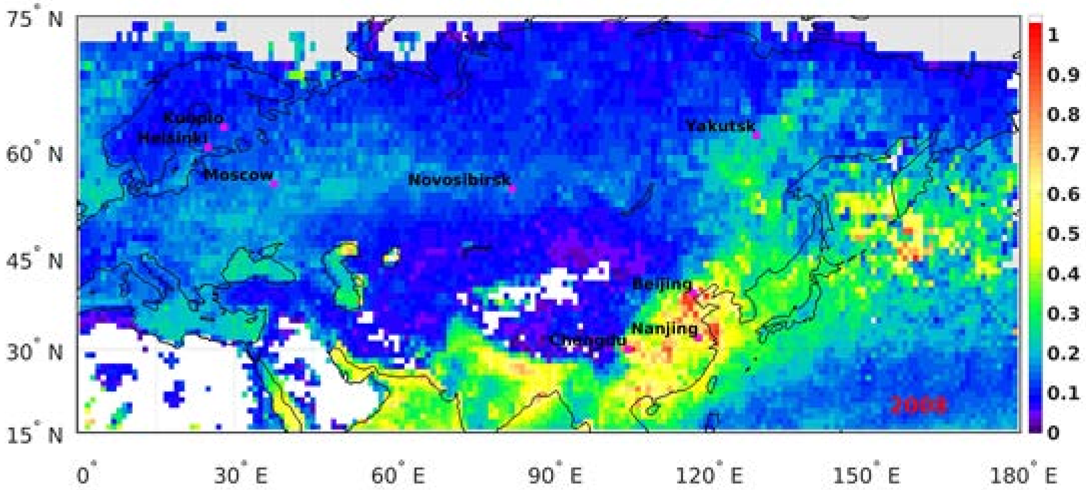
- Traceability?
- Instrument lifetime, evolution, replacement, upgrades?
- Calibration?
- Cloud screening
- Calibration and drift

What can we learn from ground-based remote sensing to improve satellite remote sensing and learn about atmospheric processes?

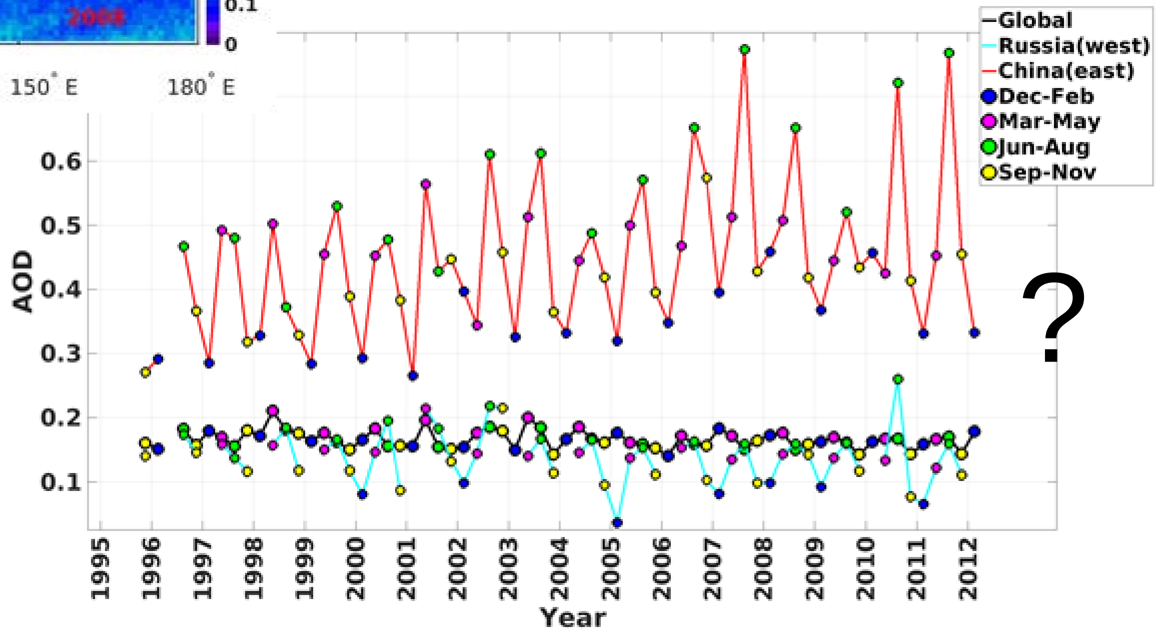
Other records (AVHRR, TOMS/OMI) and next years progress

1. **ATSR-2 & AATSR (1995-2012) & SLSTR (2016- …)**
2. **MODIS (1998 / 2000 - …) & VIIRS**
3. **AVHRR (Xue et al. 2017; Hsu / Sayer et al., 2017) (>35 years)**
4. **TOMS/OMI (>35 years)**

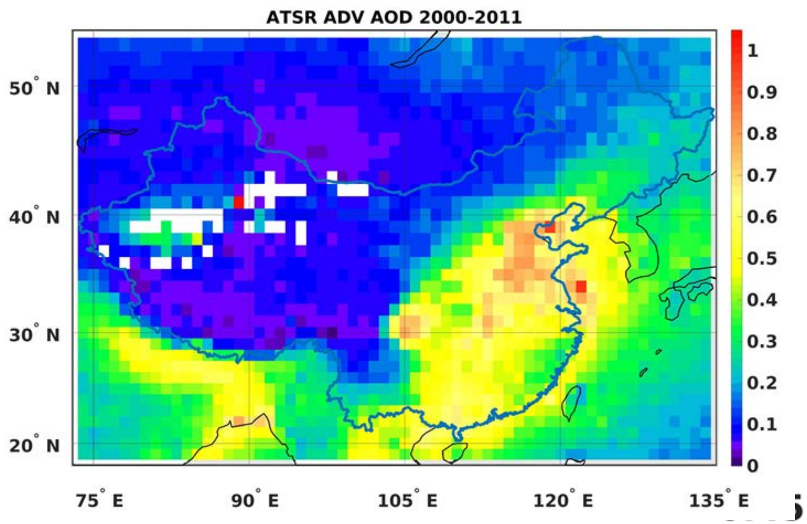
AOD over the PEEX study area (2008) spatial& temporal variations



AOD retrieved from
AATSR/ENVISAT
L1 data, using ADV v2.31



AOD over Mainland China from ATSR-2, AATSR and MODIS: time series 1995-2015

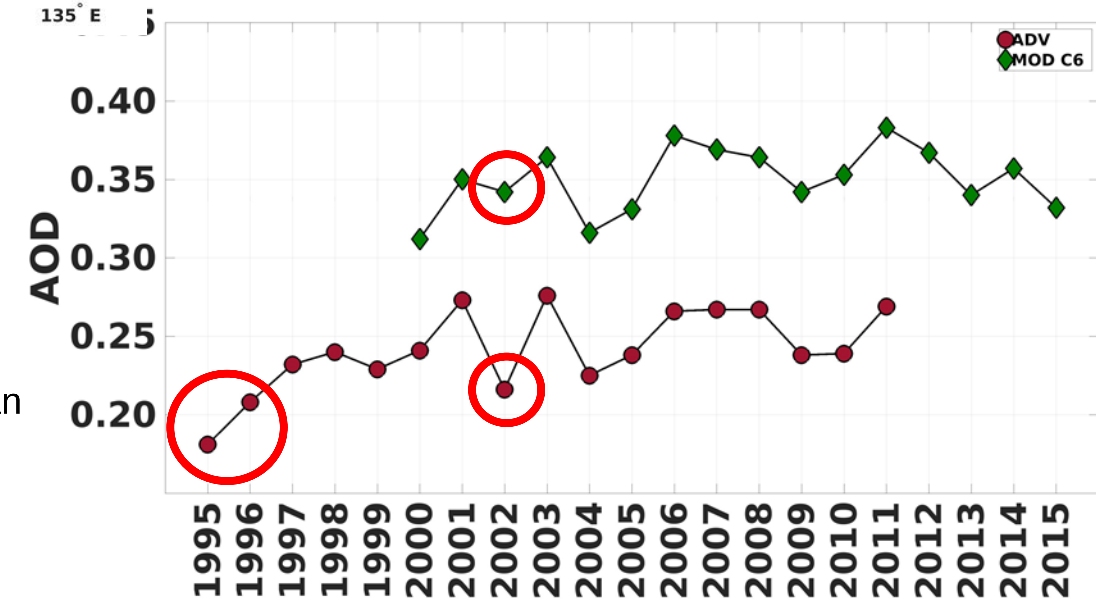


Mainland China: yearly AOD

ATSR-2 + AATSR 2000-2011
L3 (1^o x 1^o)

ATSR & MODIS/Terra C6 are complementary:

- ATSR shows the AOD increase before the EOS era
- MODIS/Terra shows the AOD decrease after ENVISAT, in response to emission reductions



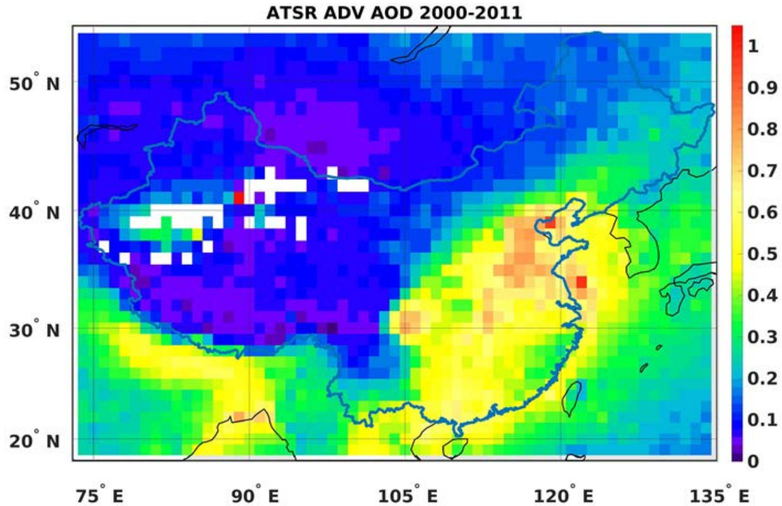
Two questions:

1) ATSR&MODIS are substantially different, can they be used together?
2) How effective are emission reductions?

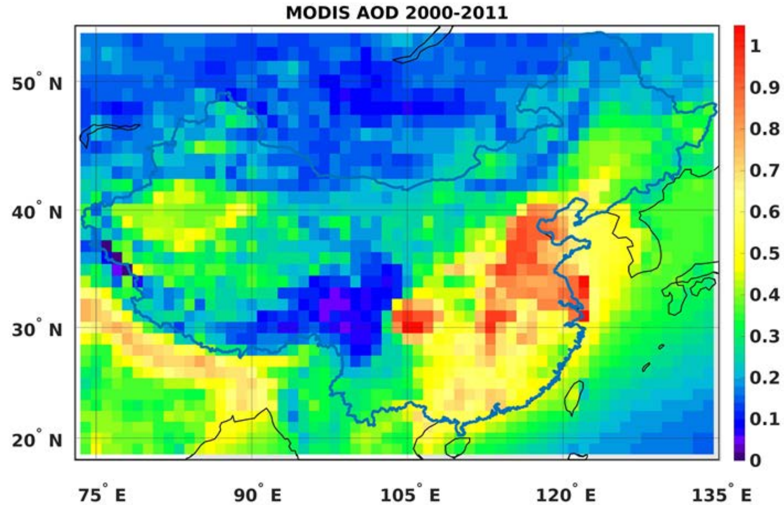
de Leeuw et al., submitted

C6 DT expected error over land: $\pm(0.05+0.15\tau_{AERONET})$

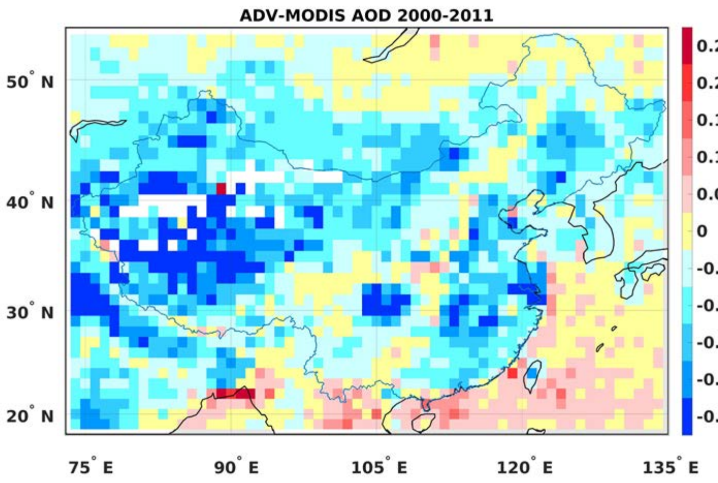
Comparison ATSR and MODIS

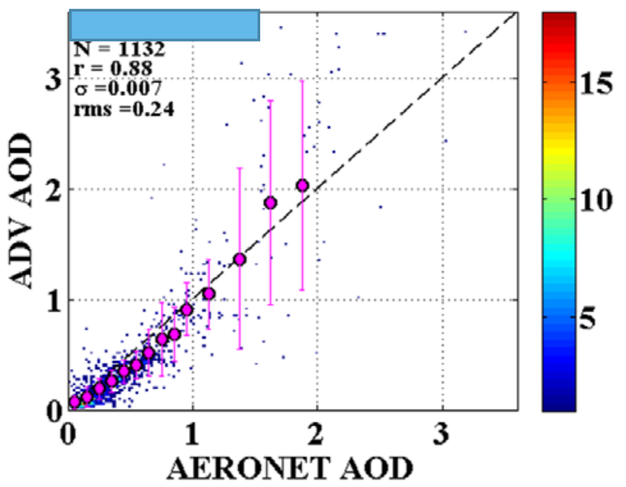


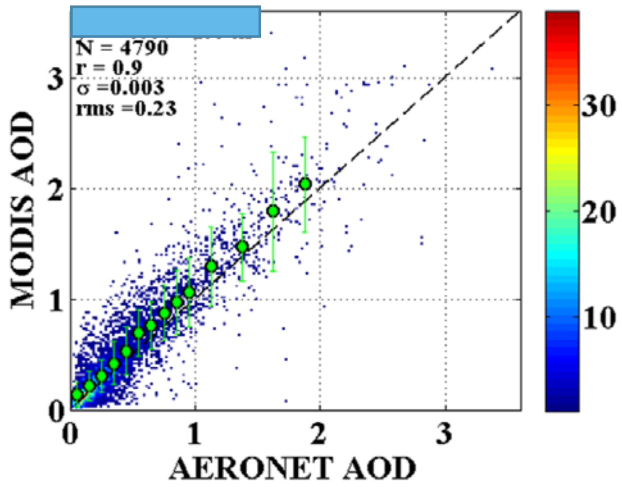
ATSR ADV v2.31



MODIS/Terra C6 DTDB merged



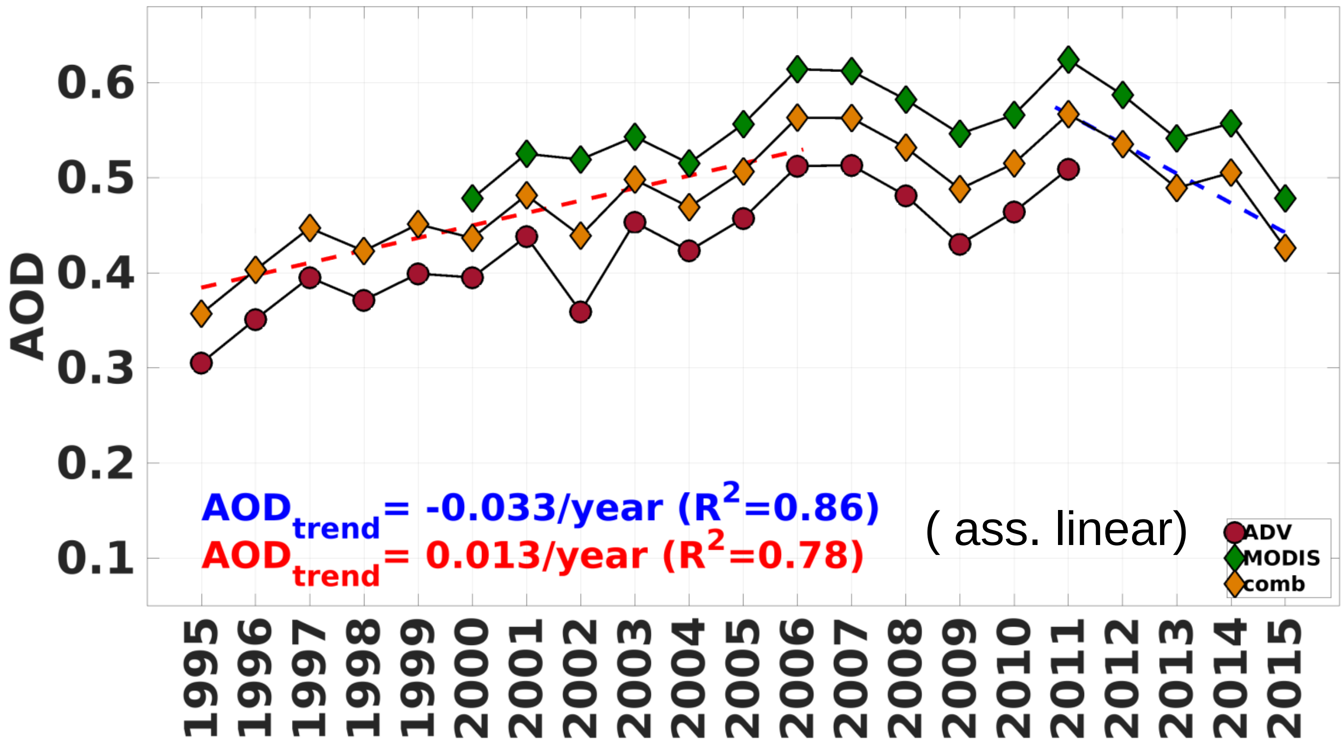




de Leeuw et al., submitted

C6 DT expected error over land: $\pm(0.05+0.15\tau_{AERONET})$

AOD over SE China from ATSR-2, AATSR and MODIS: combined time series (1995-2015)



Initial increase
Followed by a decrease from ~2011

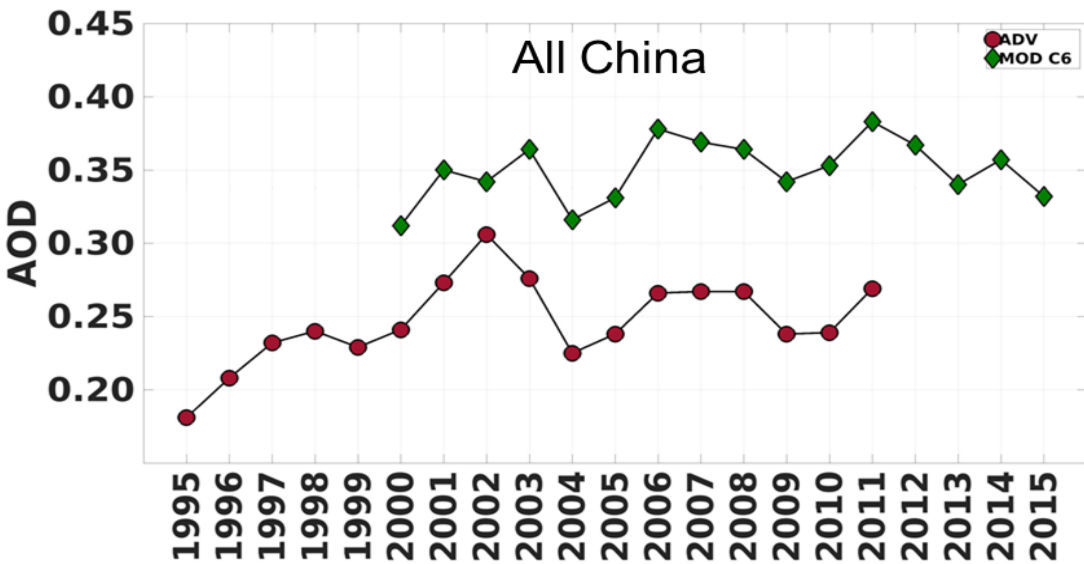
Linear fits?

Several reasons for non-linear behaviour:
. Emission reductions
. Meteorology and large scale variations

Sogacheva poster nr X

Sogacheva et al., in prep.

AOD time series: 1995-2011-2015 Annual means



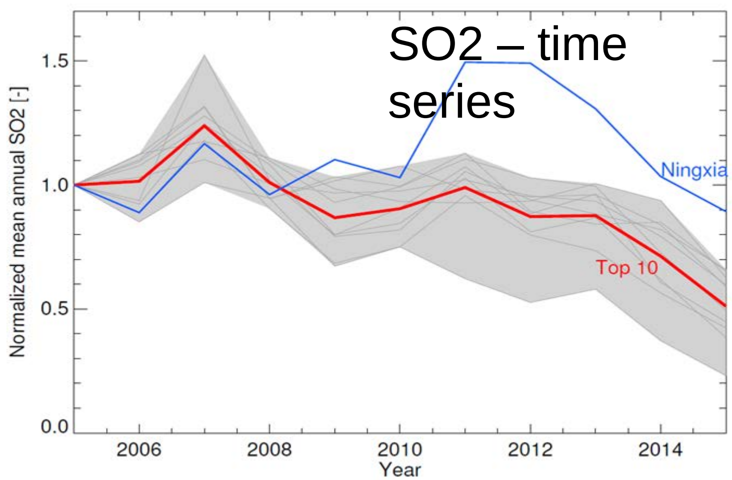
Discussion:

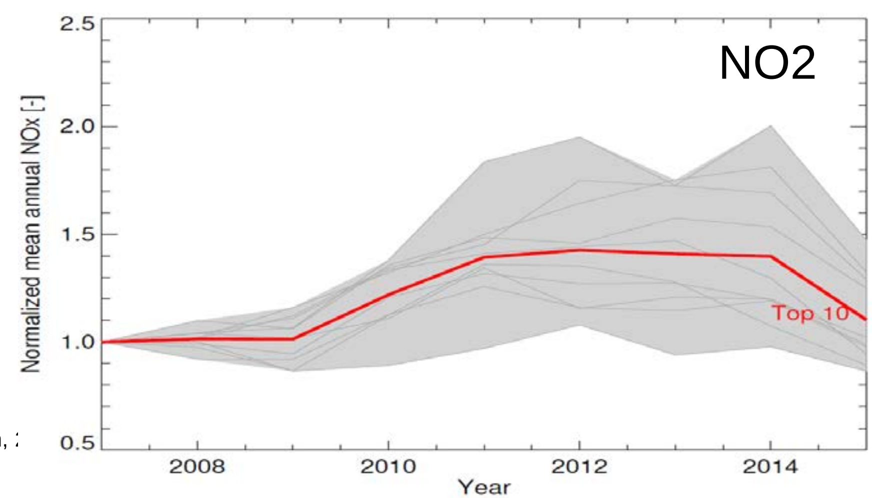
Trends???:

- 2006-2008 pivot point (refs)
- 2011 pivot point (refs)
- Economic recession end 2008(refs)
- Emission policy (refs)

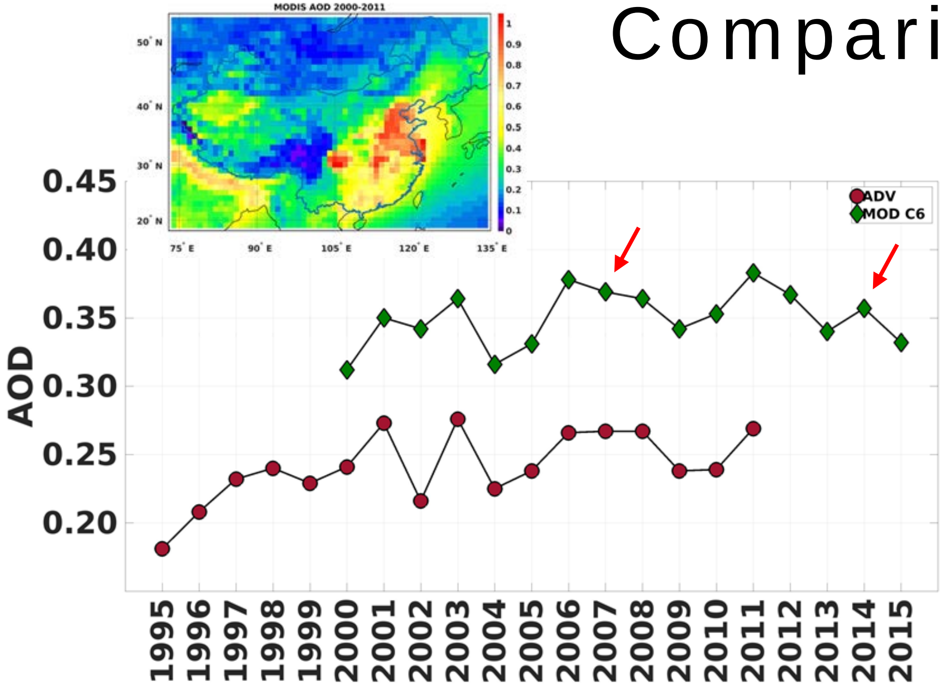
Natural variability:

- Natural emissions (e.g. dust, natural fires, VOCs)
- Meterological factors and large scale circulation





AOD time series: 1995-2015 Annual means Comparison with precursor gases



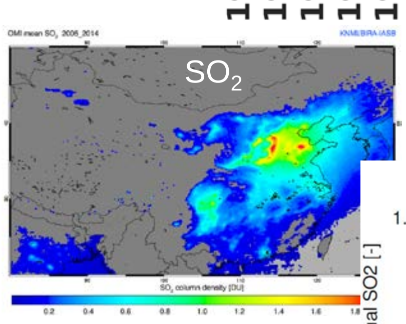
Discussion:

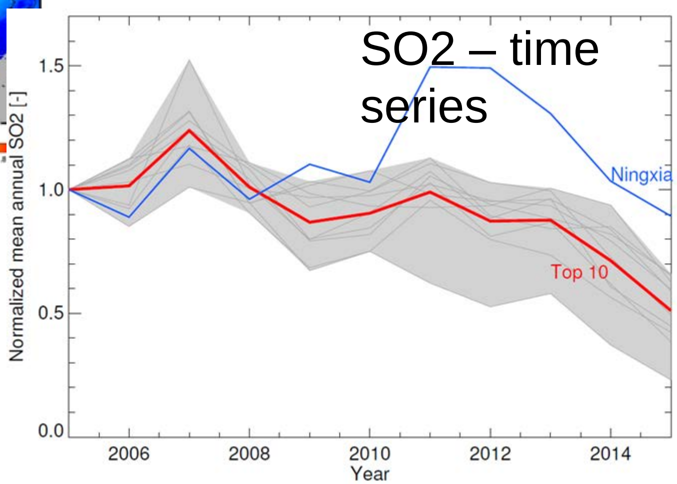
Trends ????:

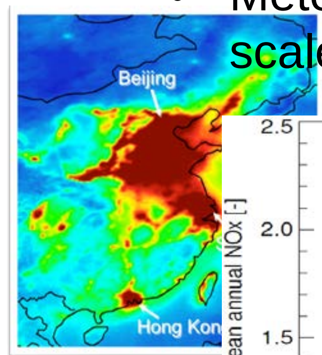
- 2006-2008 pivot point (refs)
- 2011 pivot point (refs)
- Economic recession end 2008(refs)
- Emission policy (refs)

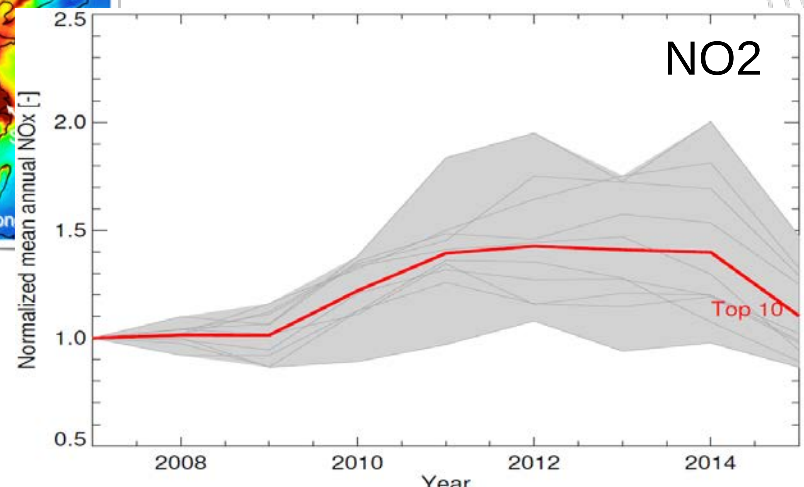
Natural variability:

- Natural emissions (e.g. dust, natural fires, VOCs)
- Meterological factors and large scale circulation





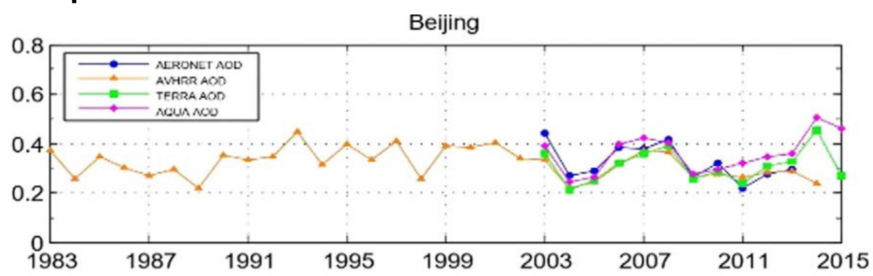


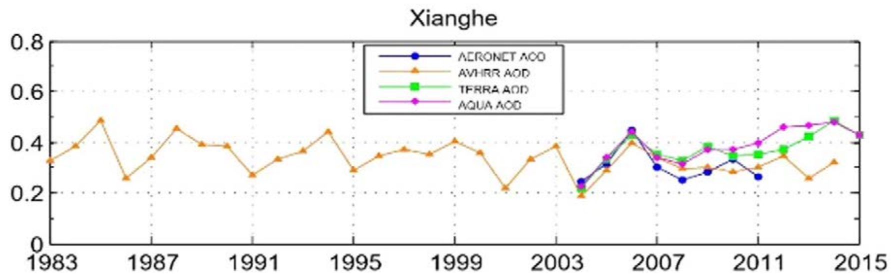


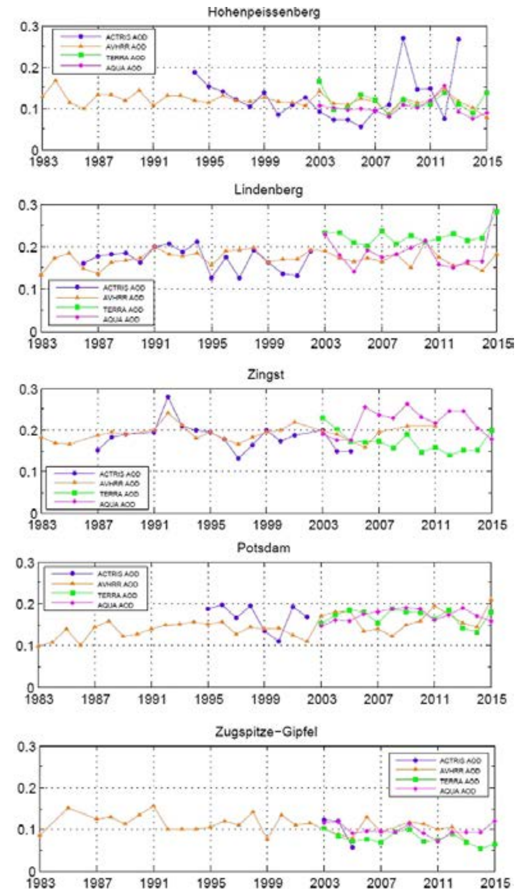
2 September 2017

AVHRR: long time series: ca. 1980 -present

(Xue et al., 2017): NE China and Central Europe, 1983-2015

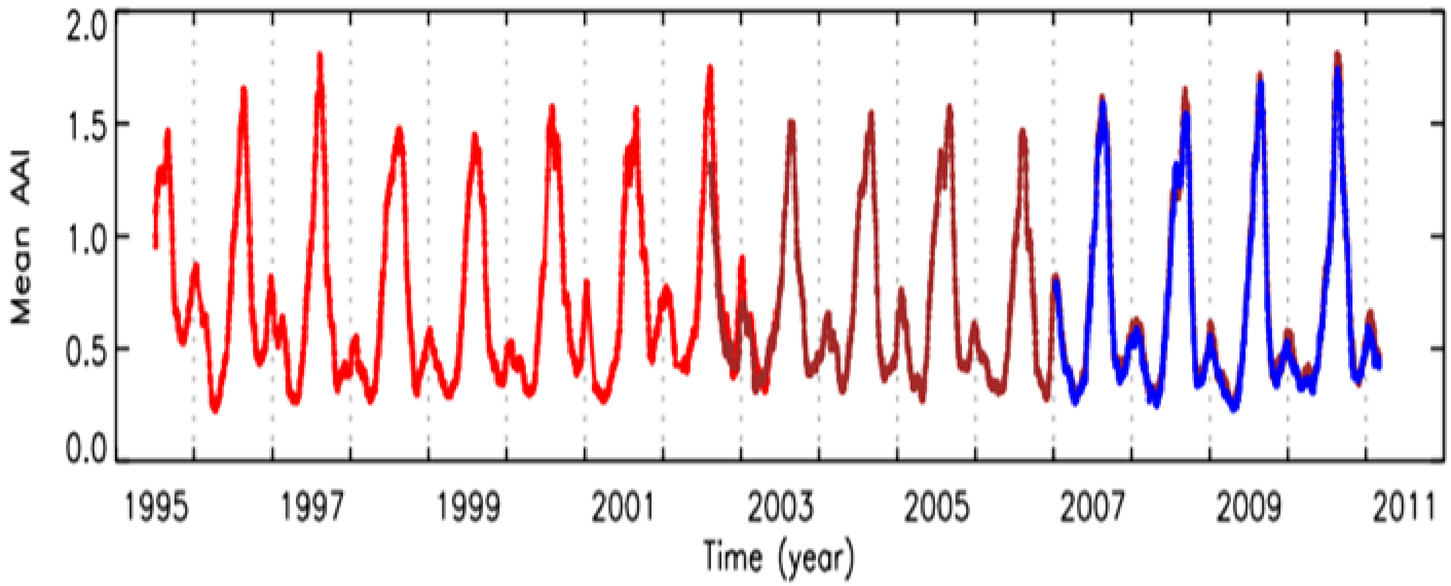




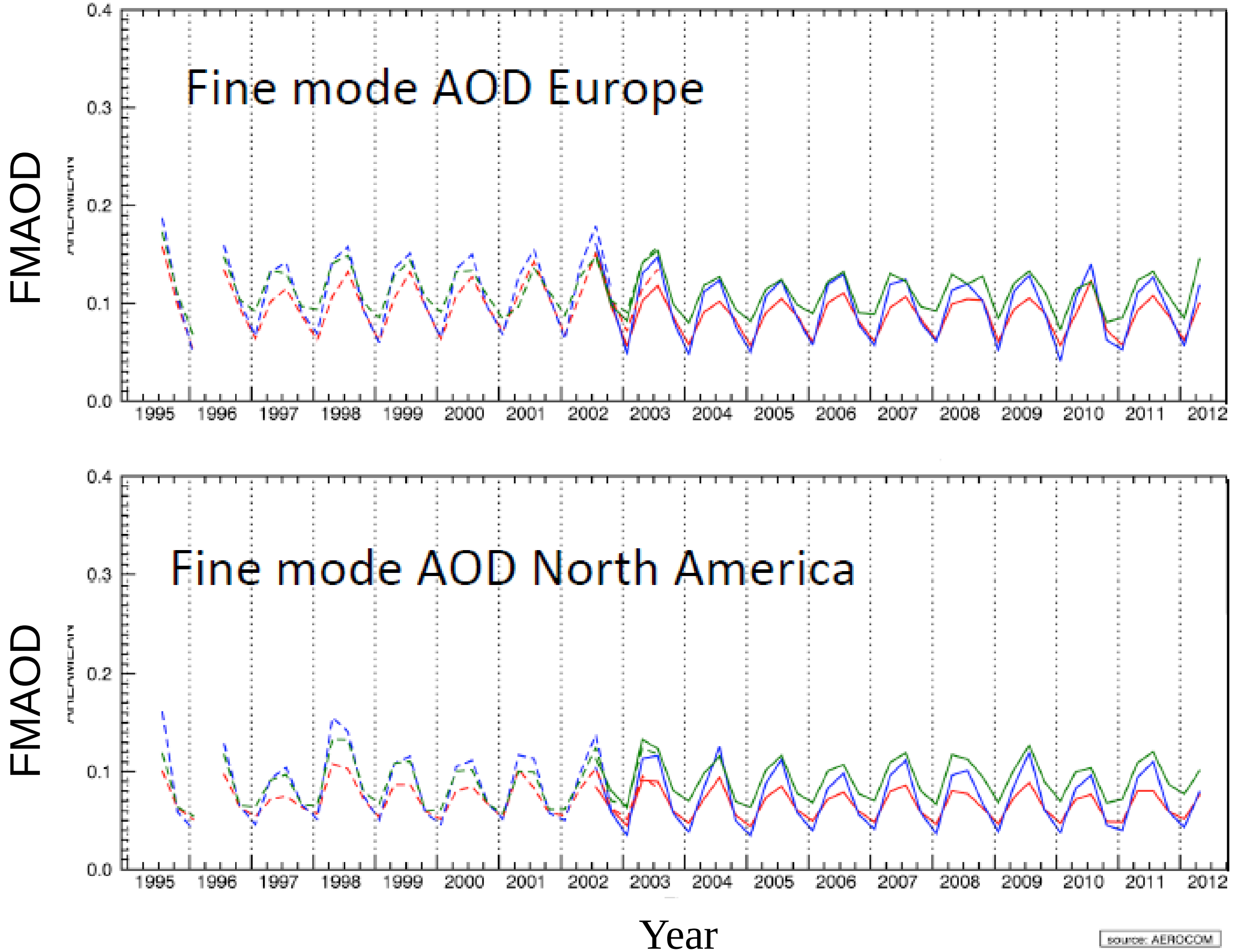


Hsu/Sayer, et al AVHRR global data set

AAI record for West-Africa (Tilstra et al., 2011). Red GOME-1, Brown SCIAMACHY blue GOME-2A



------ ATSR-2 ------ | ----------- AATSR ----------



ATSR ADV v2.30
ATSR SU v4.21
ATSR ORAC v3.02

regional
consistent overlap
biases ~0.02

- **To what degree are satellite observations suitable for constructing CDRs?**
- **How should we use ground-based instruments? What are the limitations of ground-based instruments?**

What can we learn from ground-based remote sensing to improve satellite remote sensing and learn about atmospheric processes?