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Evaluation of aerosol properties over China using multiple satellite instruments (MarcoPolo)

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AERO_SAT, Beijing, 22-24 September 2016

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MarcoPolo project objectives

Improve **air quality** monitoring, modelling and forecasting over **China** by:

- Construction of an **emission database** using satellite-based emission estimates together with information from ground-based measurements
- Satellite observations provide information on:
  - aerosols,
  - NO_x,
  - SO_2,
  - biogenic gases;
- Inverse modeling;

In this contribution we focus on the occurrence of aerosols over China.

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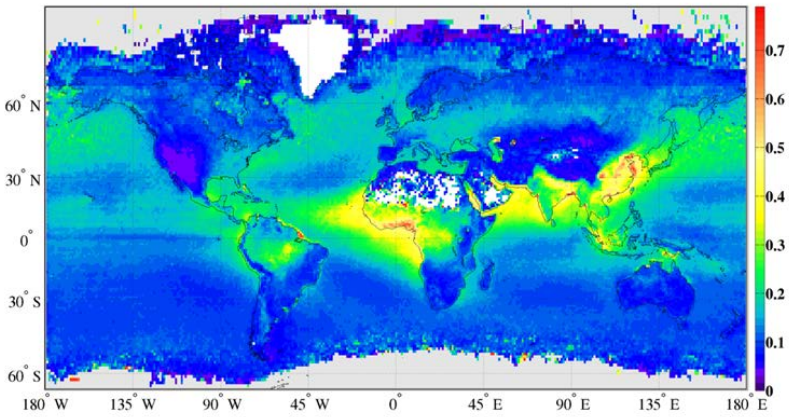
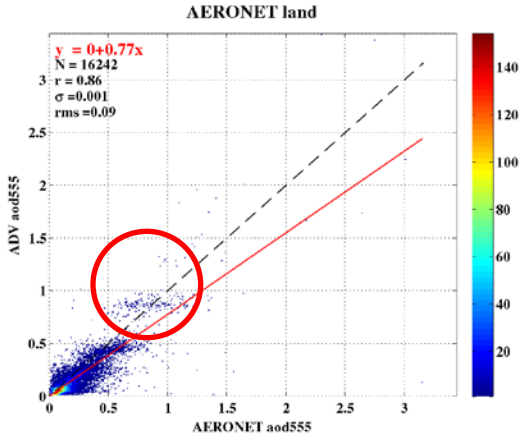
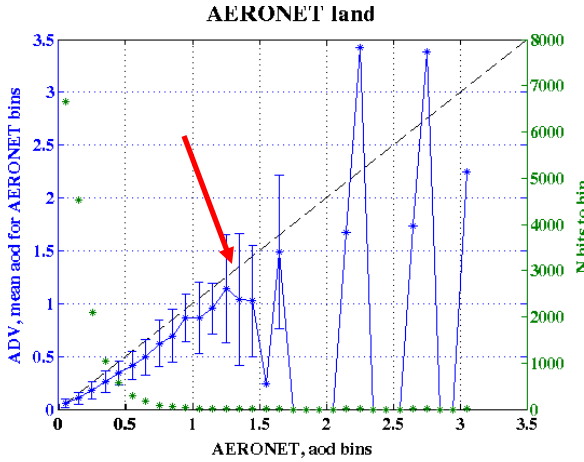
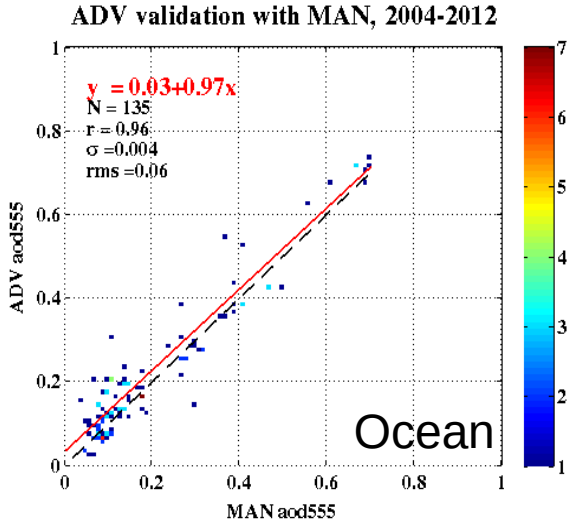
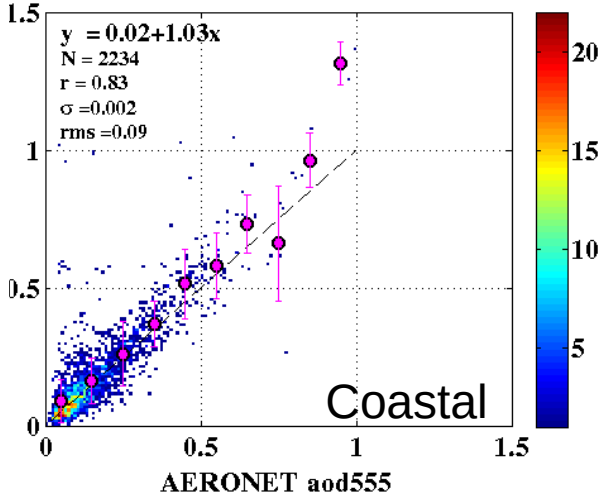
AATSR (2003-2011) aggregated AOD550 & validation

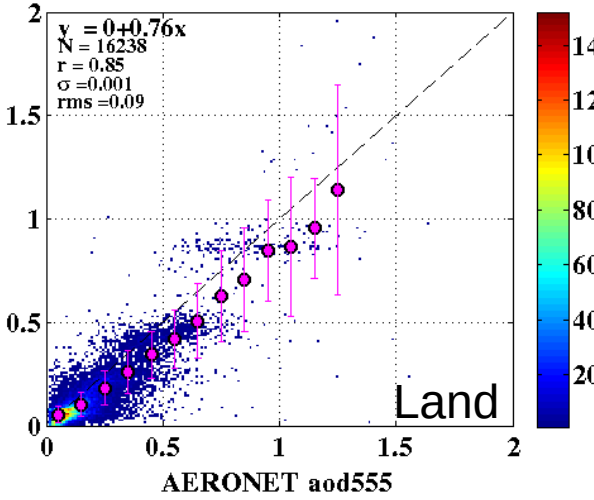












Kolmonen et al., IJDE, 2016

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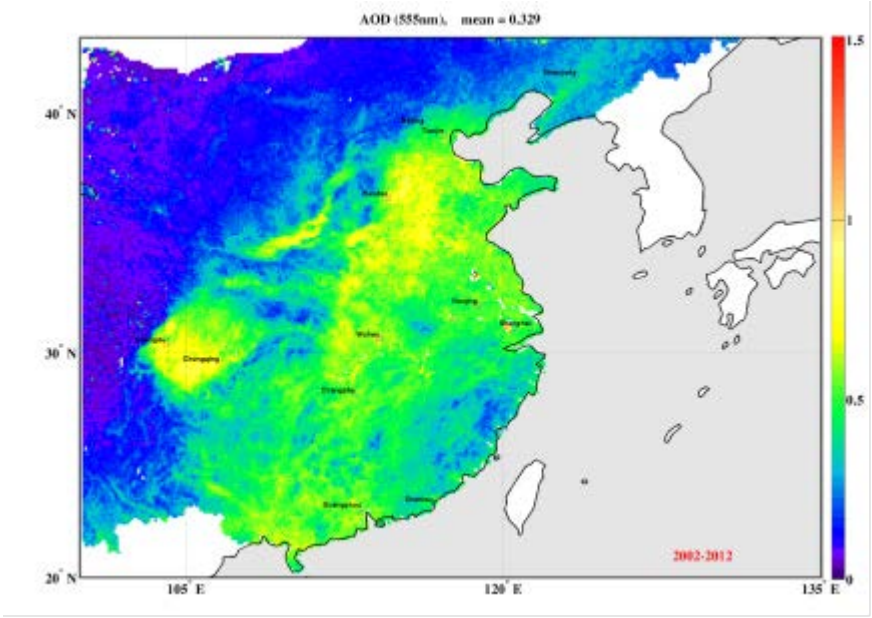
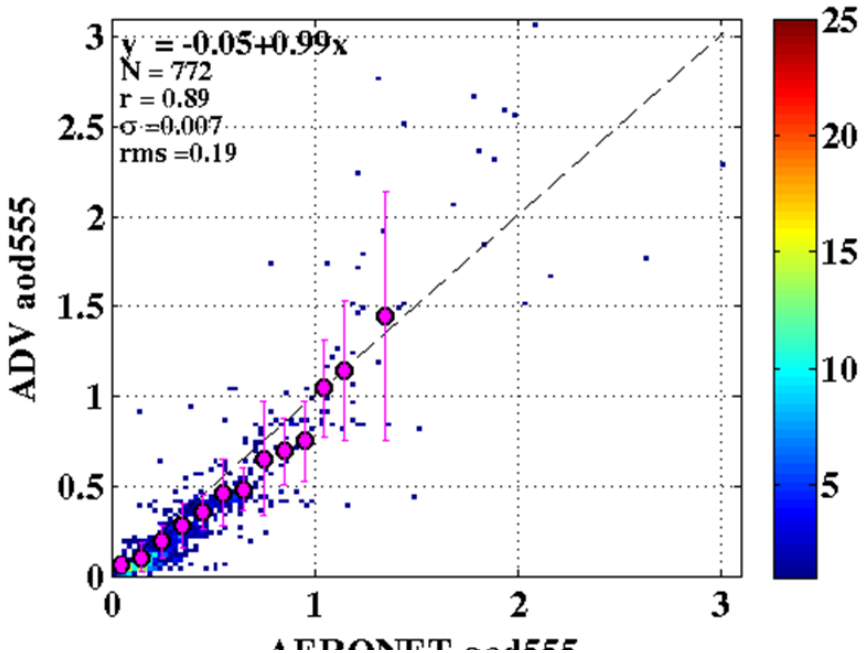
AOD over China

AATSR AOD(555µm) 2003-2011 level 2



AOD AATSR validation against Aeronet 2003 -2011



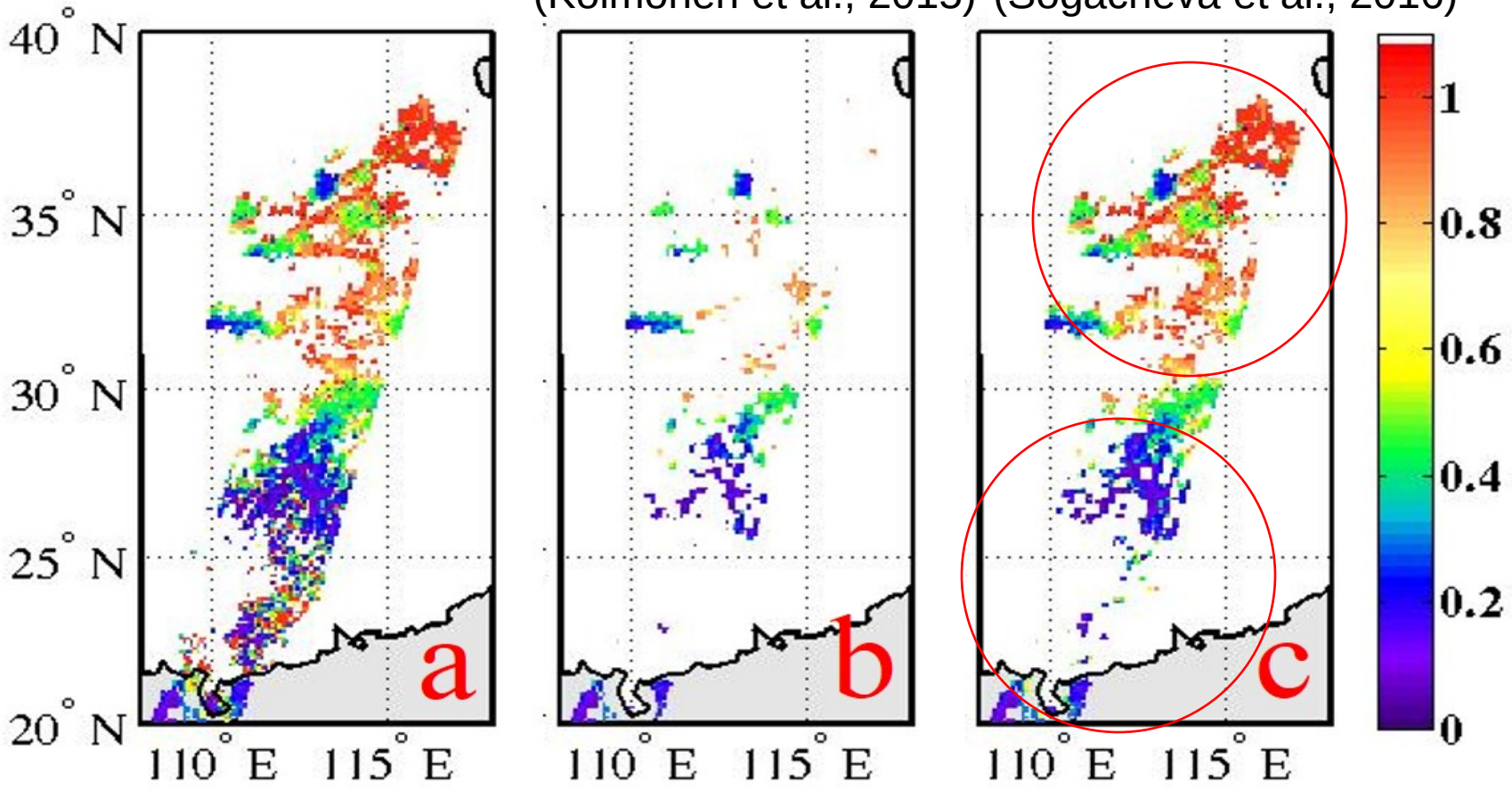
Aerosol retrieval can usually only be done for clear sky. Therefore strict cloud detection is needed while also aerosol scenes should not be flagged as cloudy. At FMI a cloud post-processing scheme has been developed which removes a priori undetected clouds while retaining valid aerosol pixels (Sogacheva et al., ACPD, 2016).

Problems in existing cloud post-processing

All pixels retrieved

Pixels left with existing cloud post-processing (Kolmonen et al., 2015)

Pixels left with improved cloud post-processing (Sogacheva et al., 2016)



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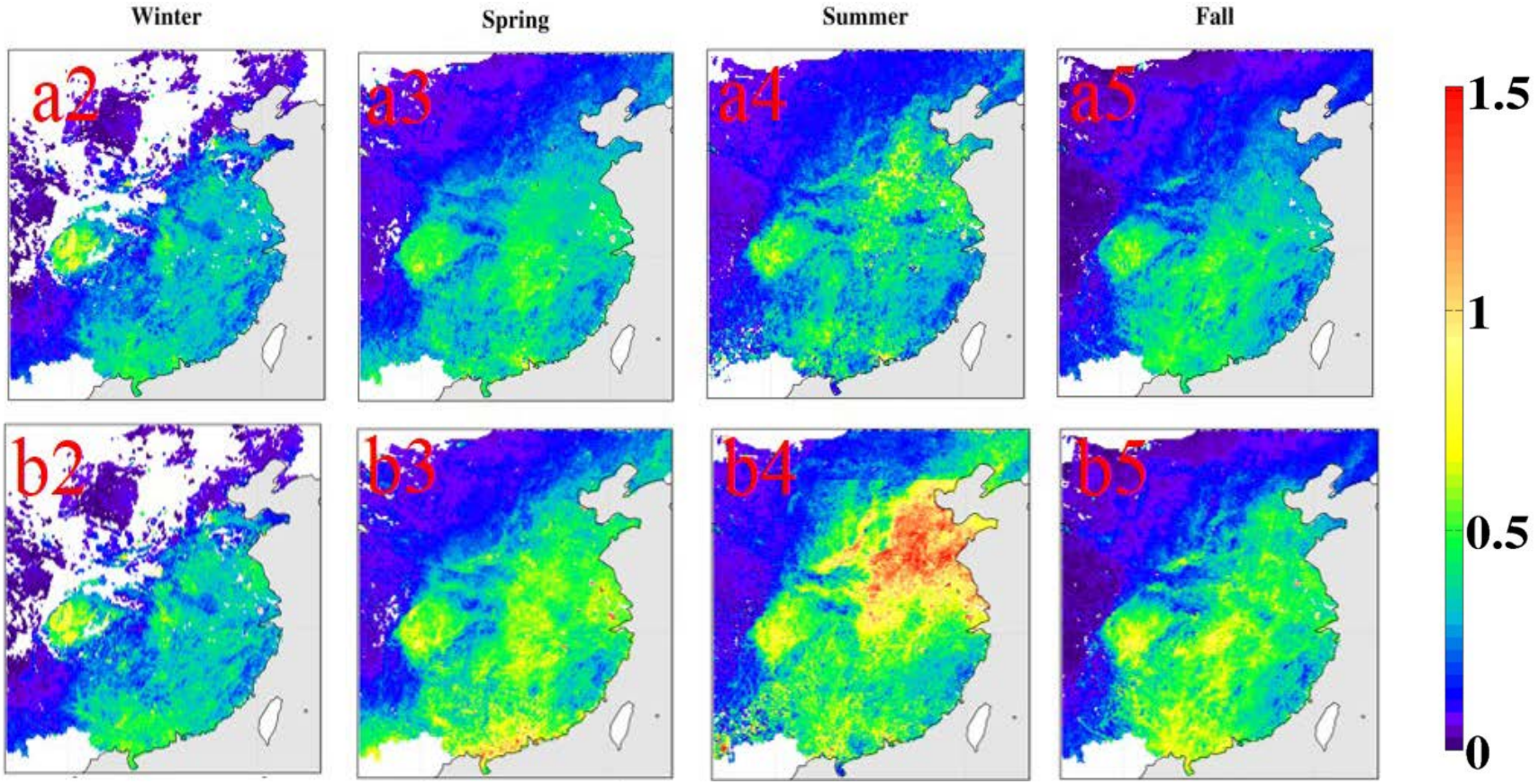
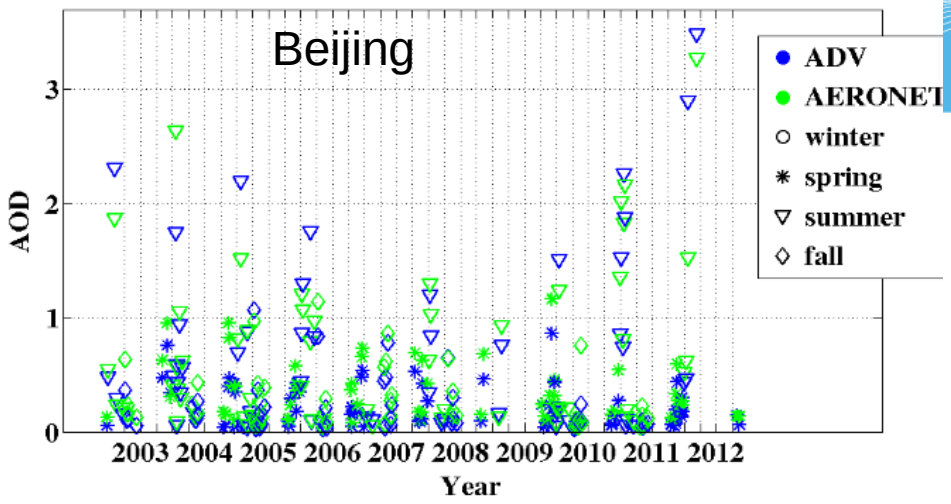
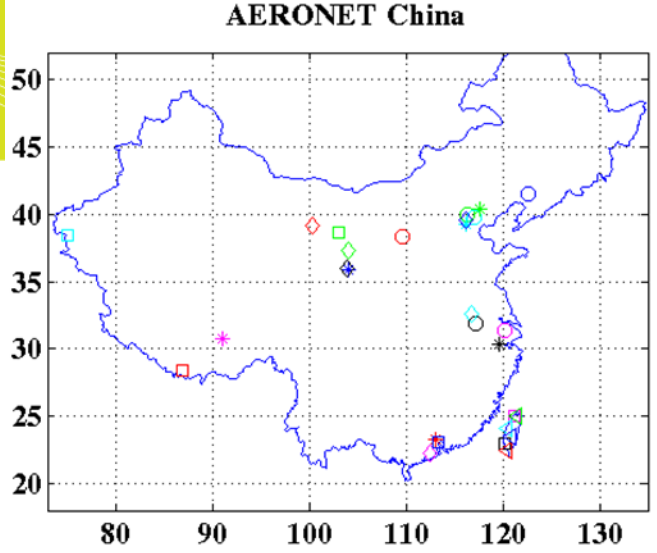
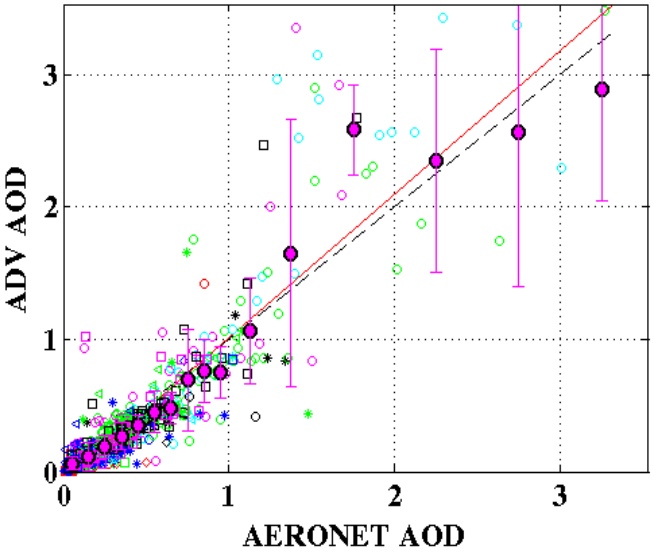
Seasonal AATSR ADV AOD 2003-2011

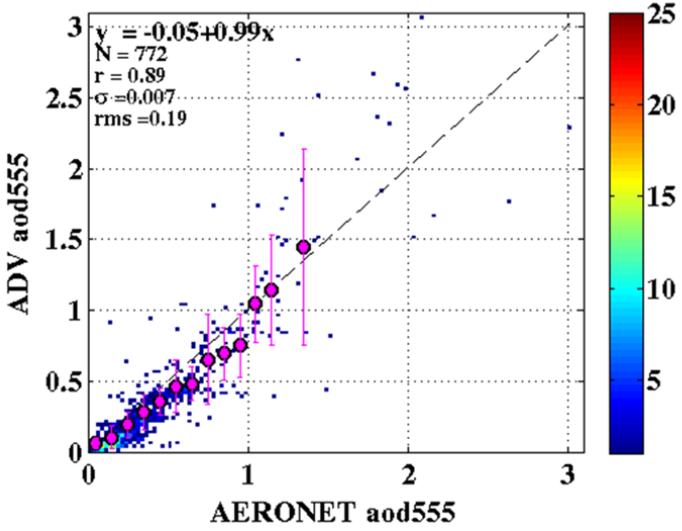
Before(top) and after (bottom) new cloud post- processing implementation











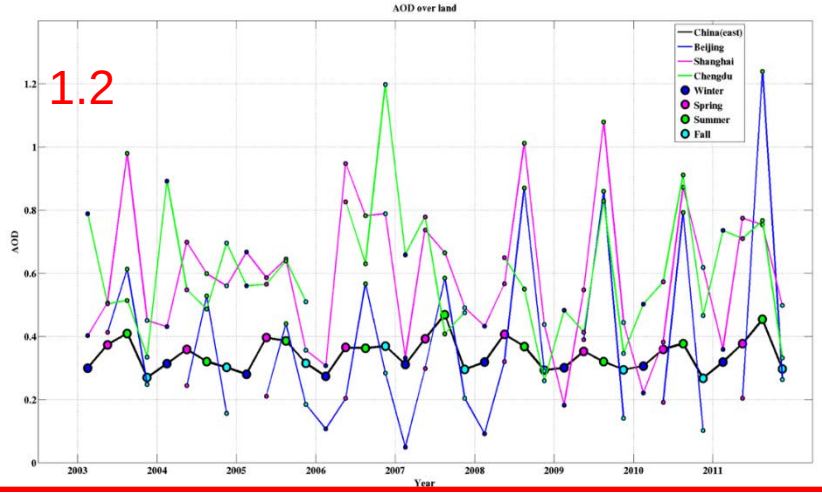
We do see high AOD: do we see it all? > how much confidence can we have, how much do we miss? What are the consequences?

AOD time series (ATSR, 17 years)

Top: comparison AOD 17 years time series over china with Europe and global

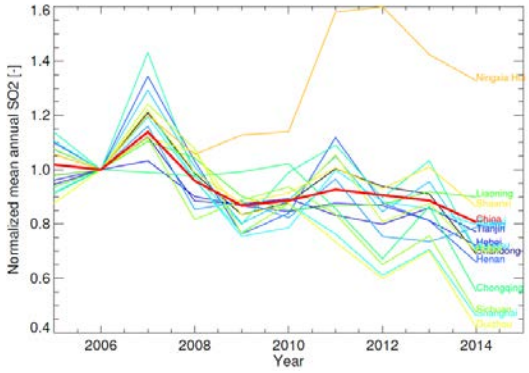
Right: China and 3 cities

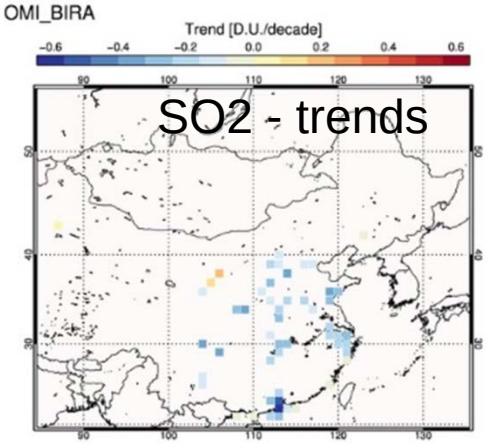
Note different vertical scales

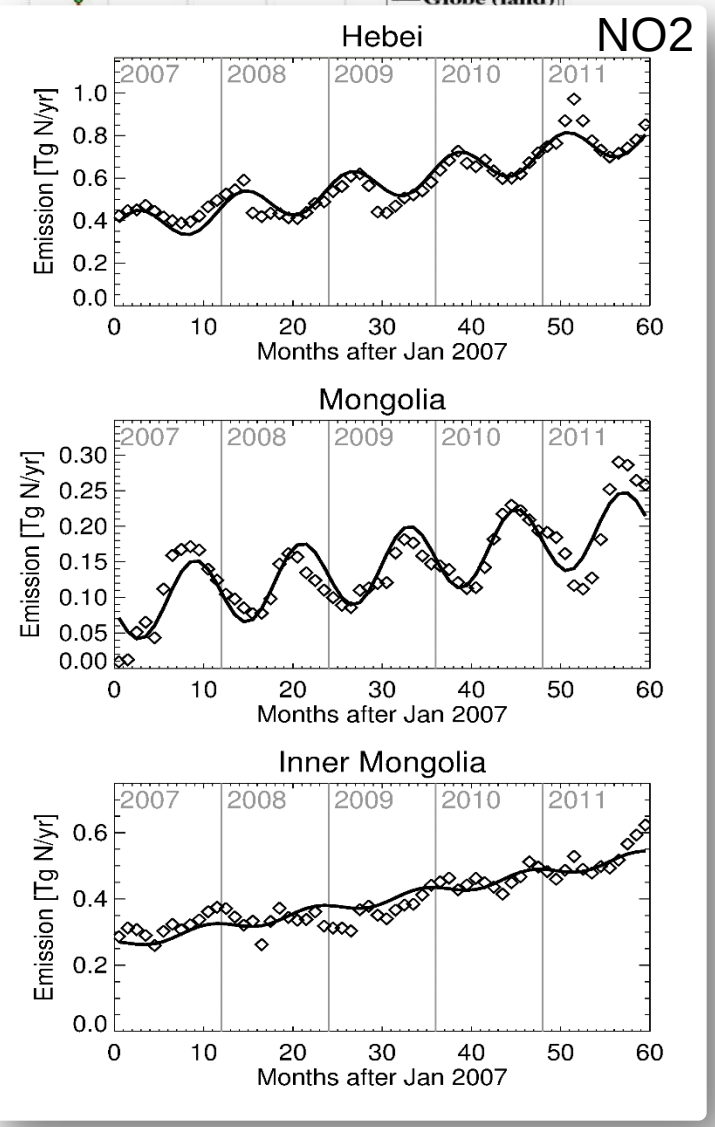


Strong seasonal variations! Why? Could it be a satellite sampling problem?

AOD time series (ATSR, 17 years)







17 years AOD time series: can we now do trends?

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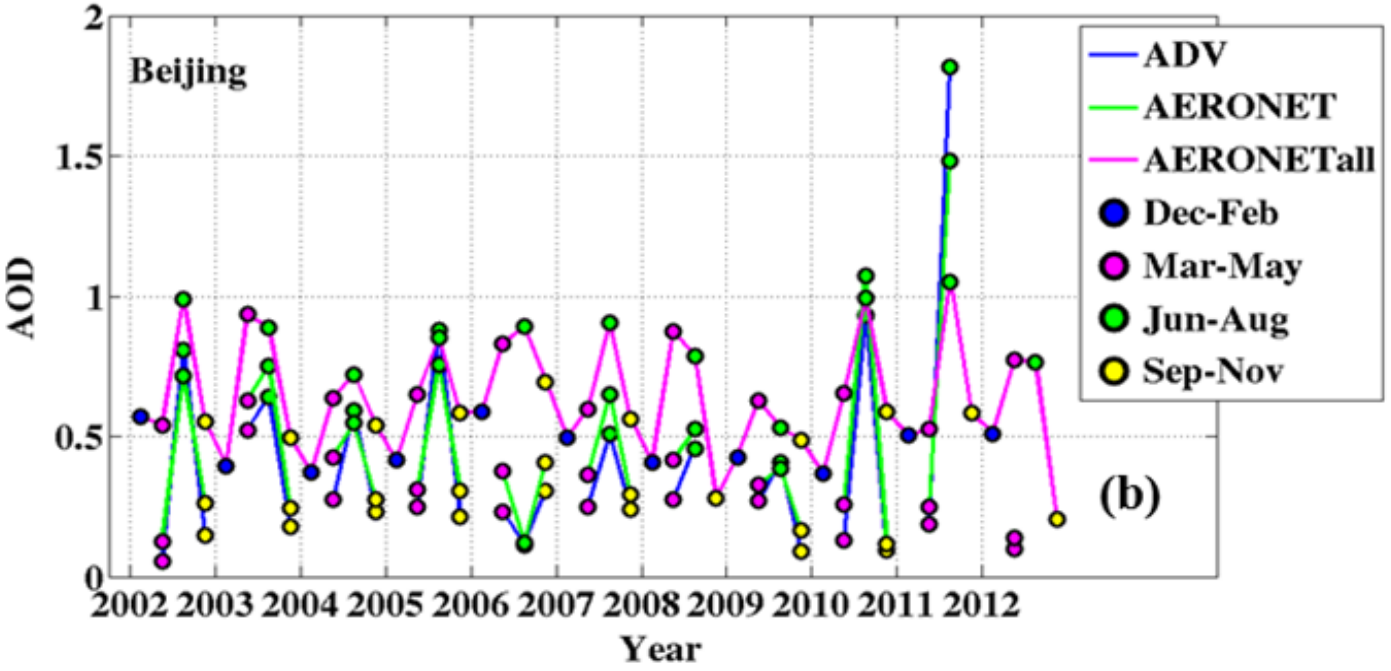
AATSR and AERONET AOD over Beijing:

winter minima and summer maxima; diurnal variations



Time series for seasonally (coloured dots) averaged AOD-ADV (blue line), AOD-AERONET in the time window ±30 min from AATSR over path (green line) and whole day AOD-AERONET (magenta line).

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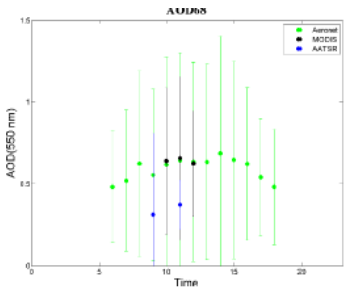
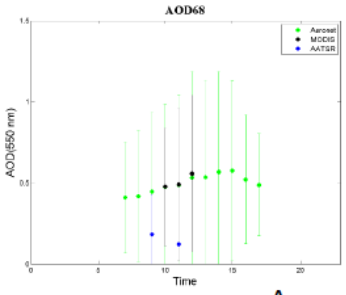
Mean (2002-2012) hourly AOD over Beijing AERONET

Mean



Mar



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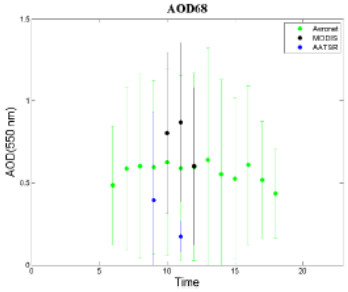
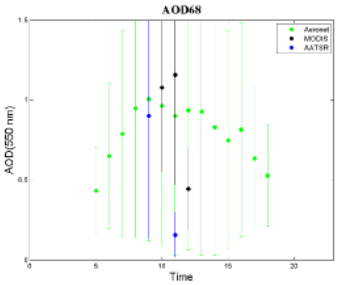


May



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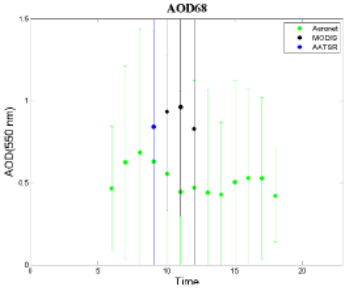

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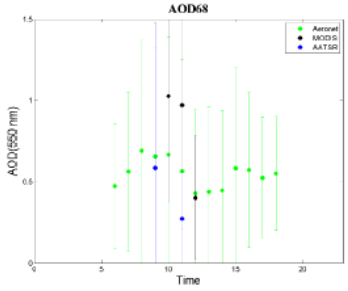

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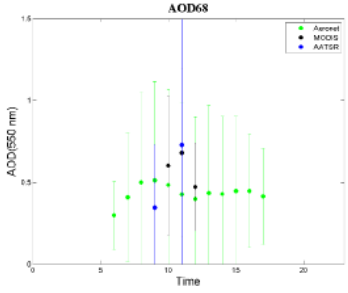

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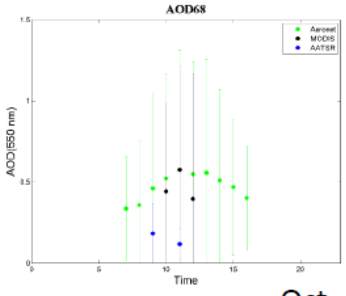
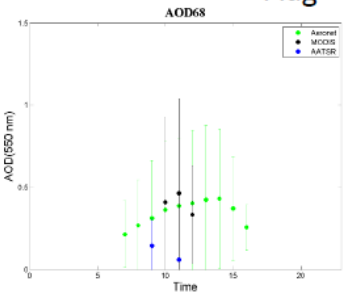


Oct



Nov

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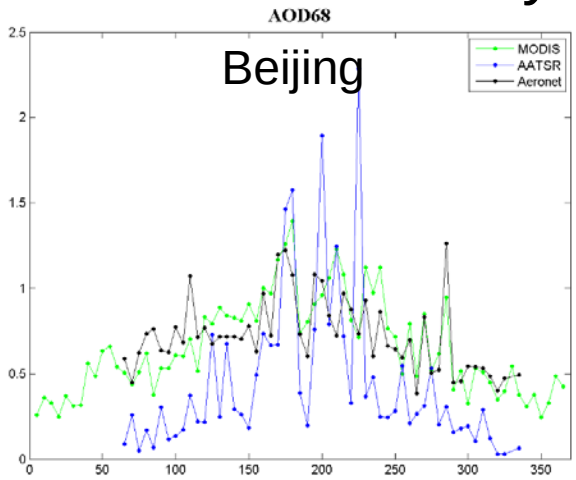
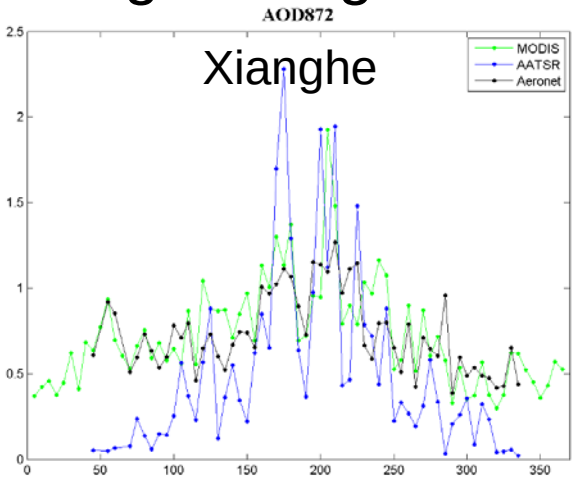
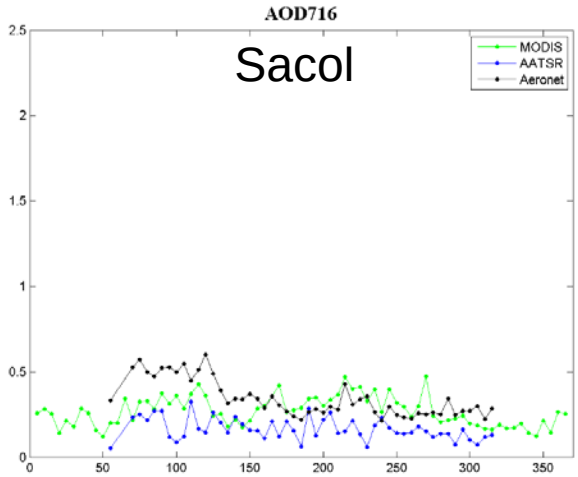
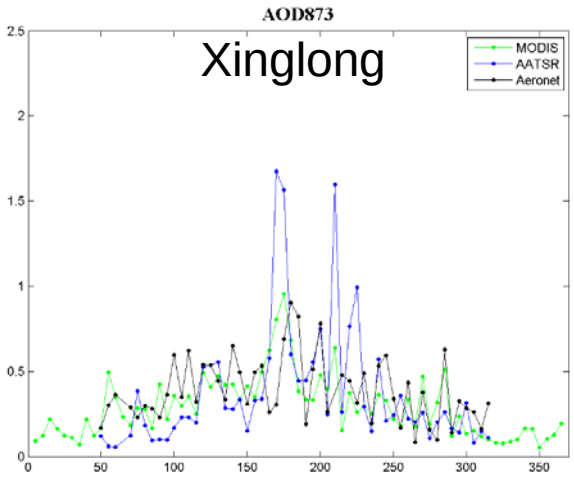
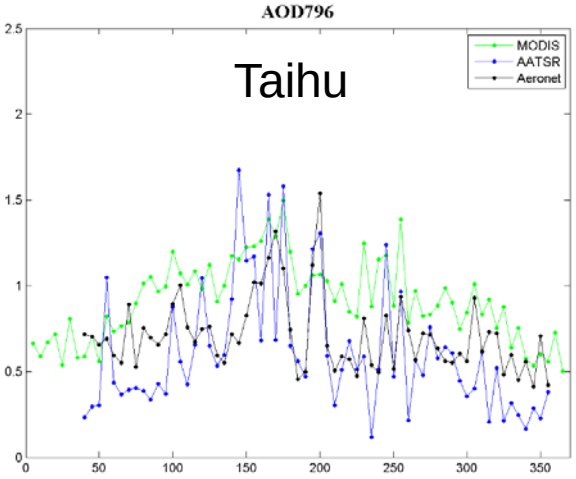
Seasonal variation AERONET, MODIS, AATSR: 5 day running avarage 2002-2012

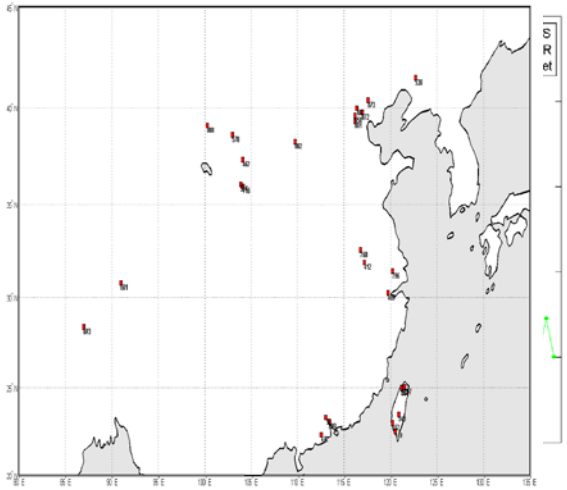












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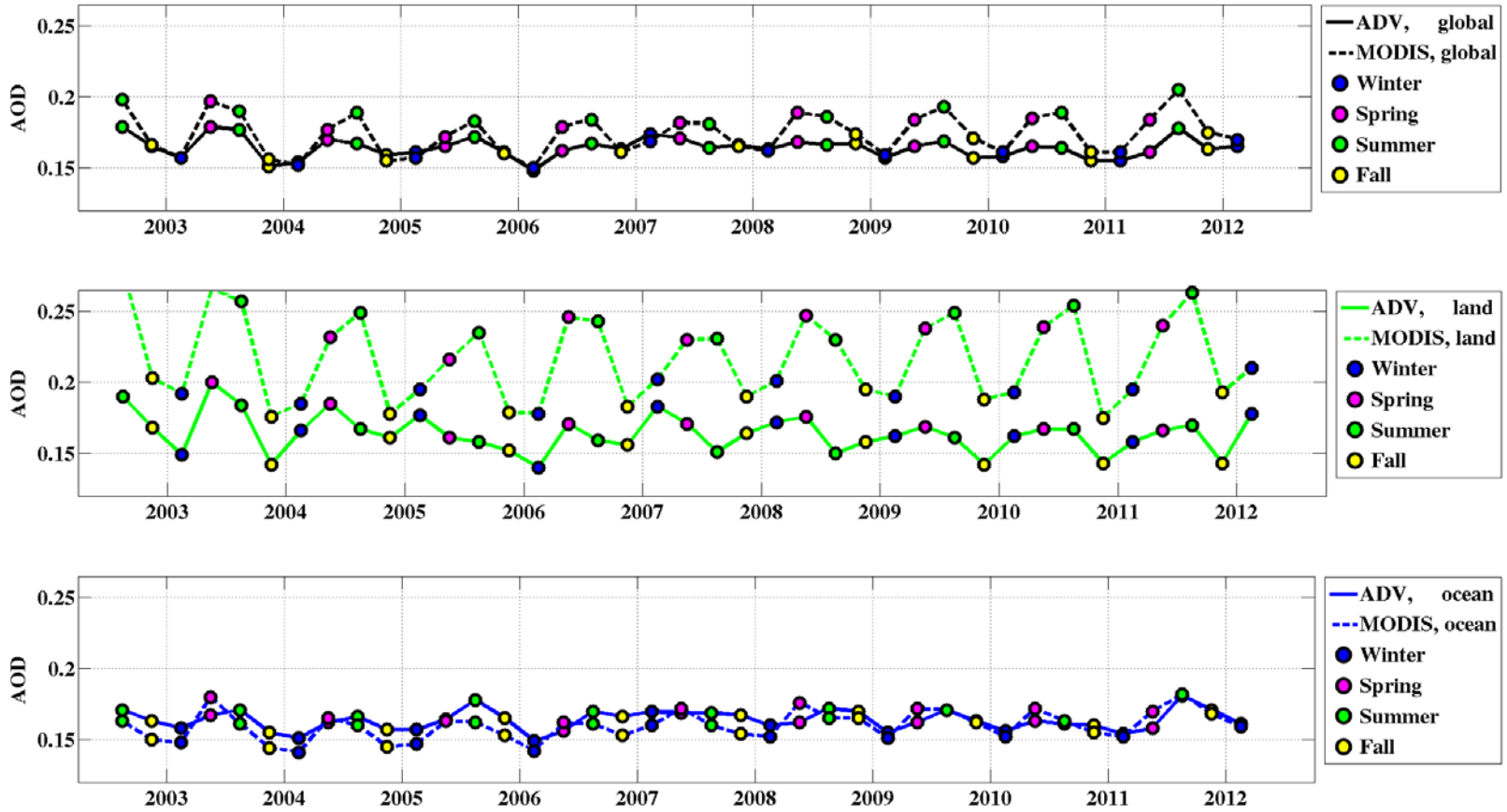
ADV and MODIS (DT&DB) : all pixels retrieved



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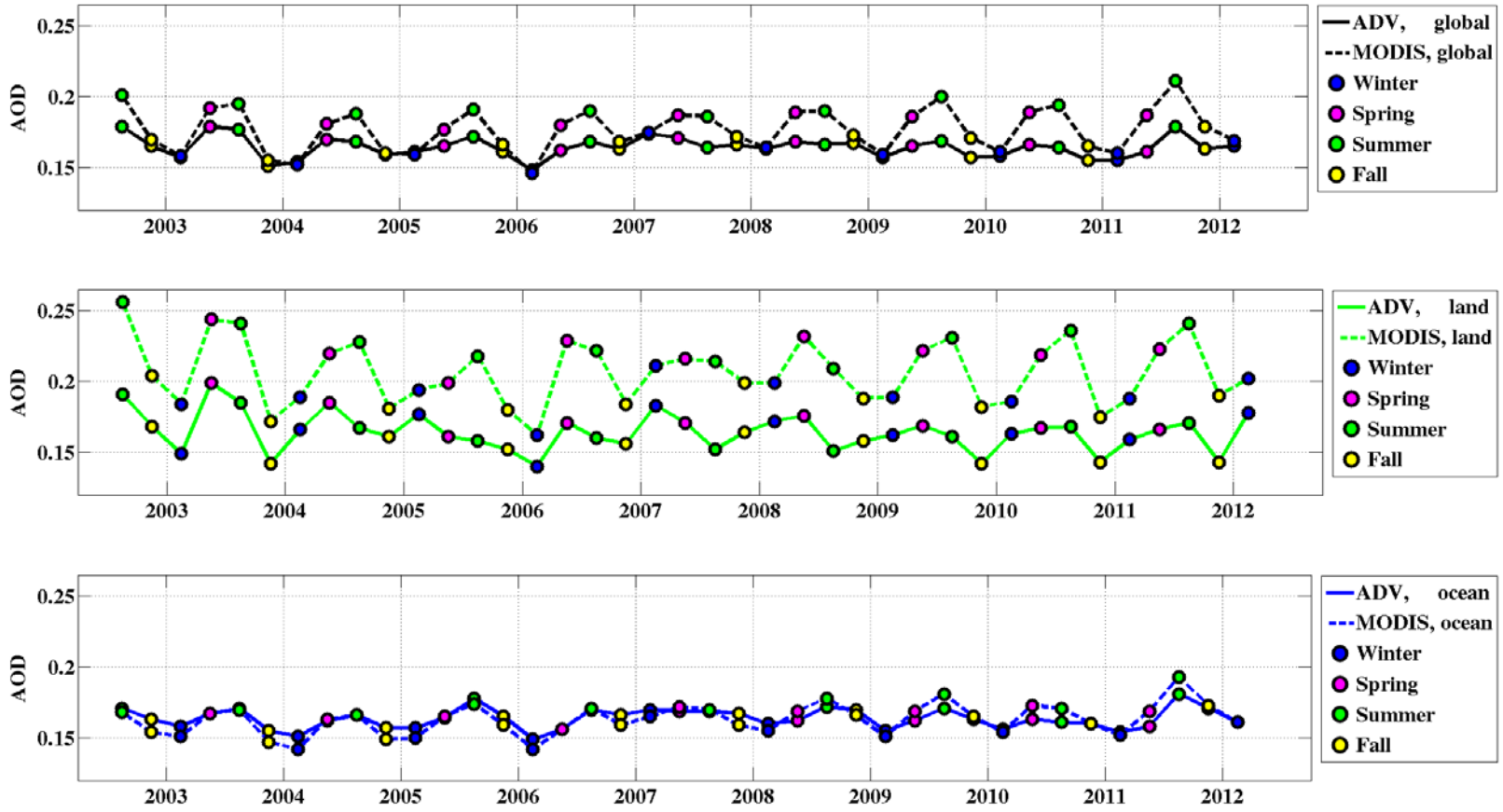
ADV and MODIS (DT&DB) : collocated pixels



Difference between AATSR and MODIS mainly over land: MODIS higher AOD and larger seasonal differences; co-location reduces these differences but does not eliminate them

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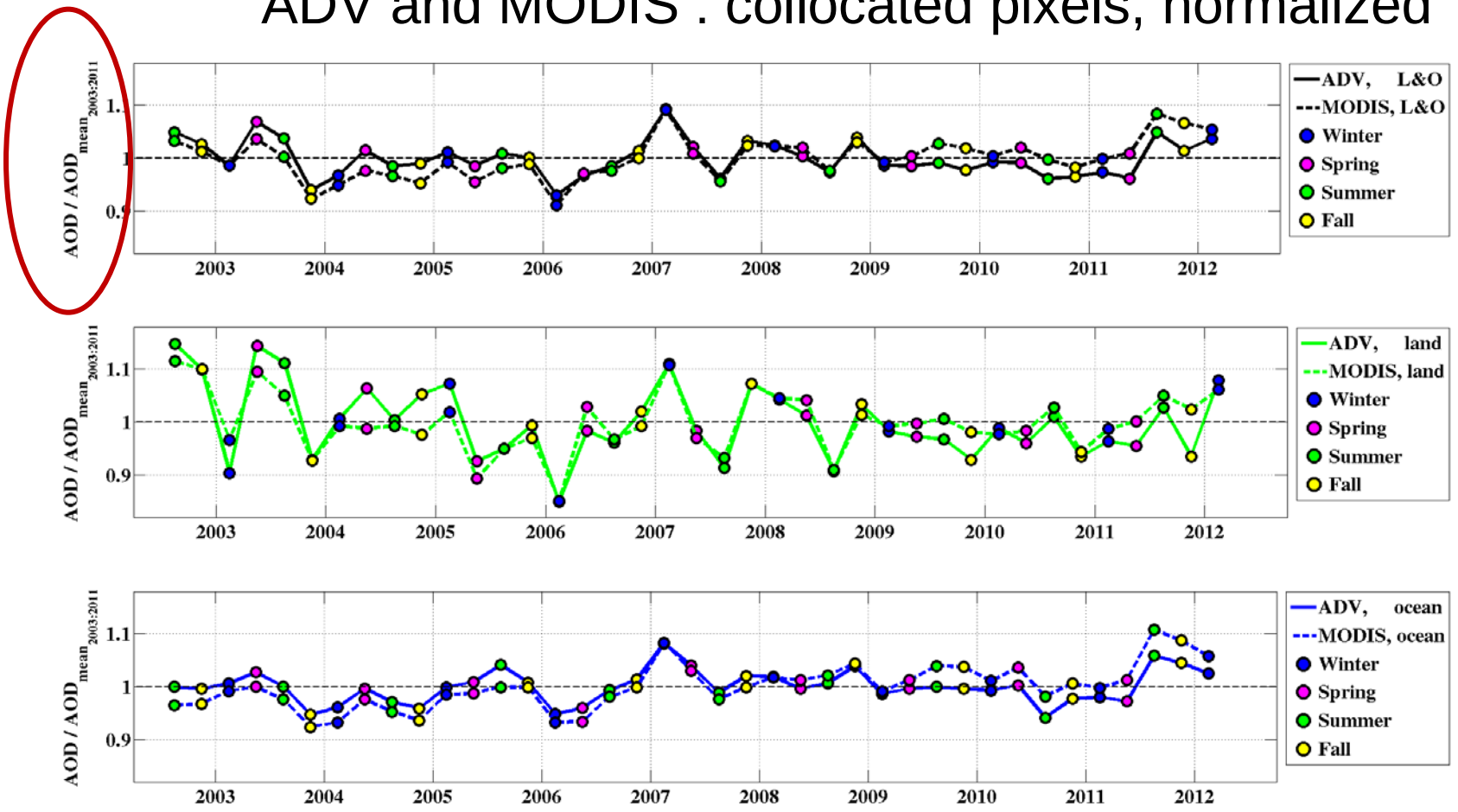
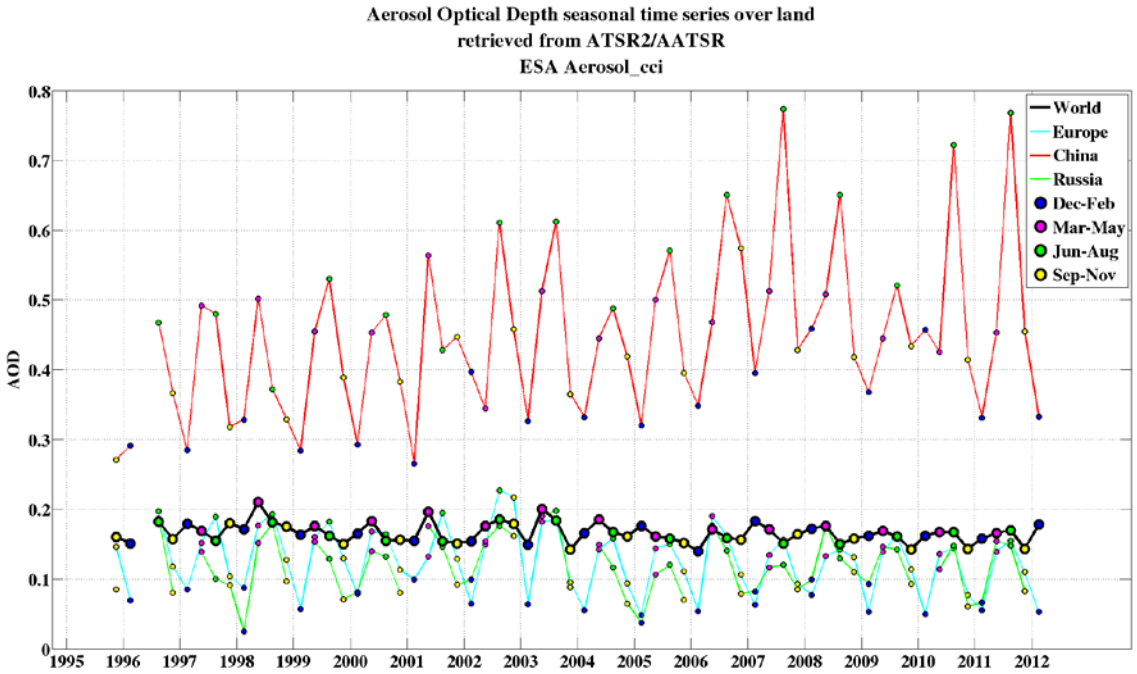
ADV and MODIS : collocated pixels, normalized



Normalisation to global mean for the study period (2003-2011) reduces the difference in seasonality

AOD time series over several regions



Seasonal and diurnal variations are commonly observed, however over China:

- AOD peaks in summer, while PM2.5 peaks in winter
- For AQ studies: column AOD and surface PM are often correlated, albeit that relations vary with location and time

What do I **NOT** understand?

- Dry PM vs in situ AOD?
- Vertical structure and disconnected layers: AOD, RH, Chemistry?
- Mixing? Is aerosol near the surface different from elevated?

PM2.5

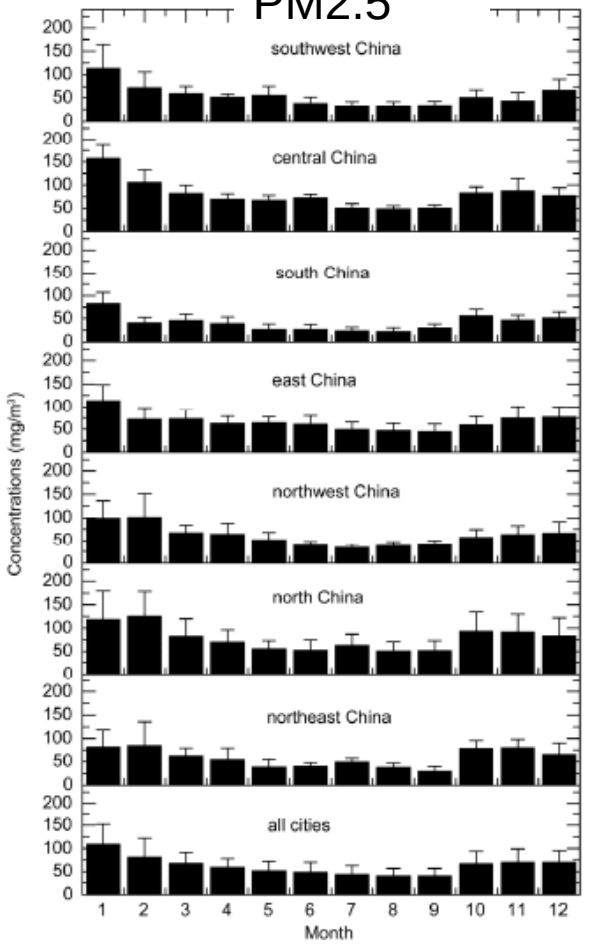


Figure 3 Monthly averaged $PM_{2.5}$ mass concentrations for all cities and the seven geographic divisions of China.

Wang et al. (2015), Science China Chemistry

Boundary layer height

Spatial distributions of the seasonal mean of ERA-BLH (color shaded) and CMA-BLH (color dots, radiosondes) at 1400 BJT in (a) spring, (b) summer, (c) fall, and (d) winter

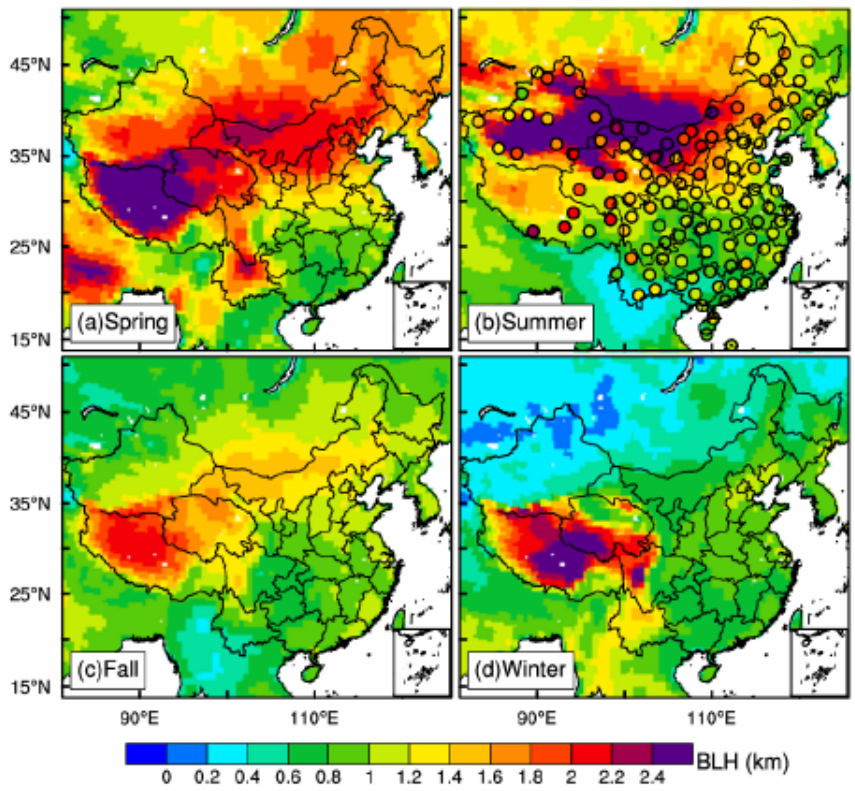


Figure 9. Same as Figure 7, but for the spatial distribution of BLHs at 1400 BJT.

- Can a factor of 2 explain the different AOD/PM behaviour?
- Need to include mixing (stability)
- Can CALIOP help out here?
- What can we learn from model exps?

(Guo et al., ACPD 2016)

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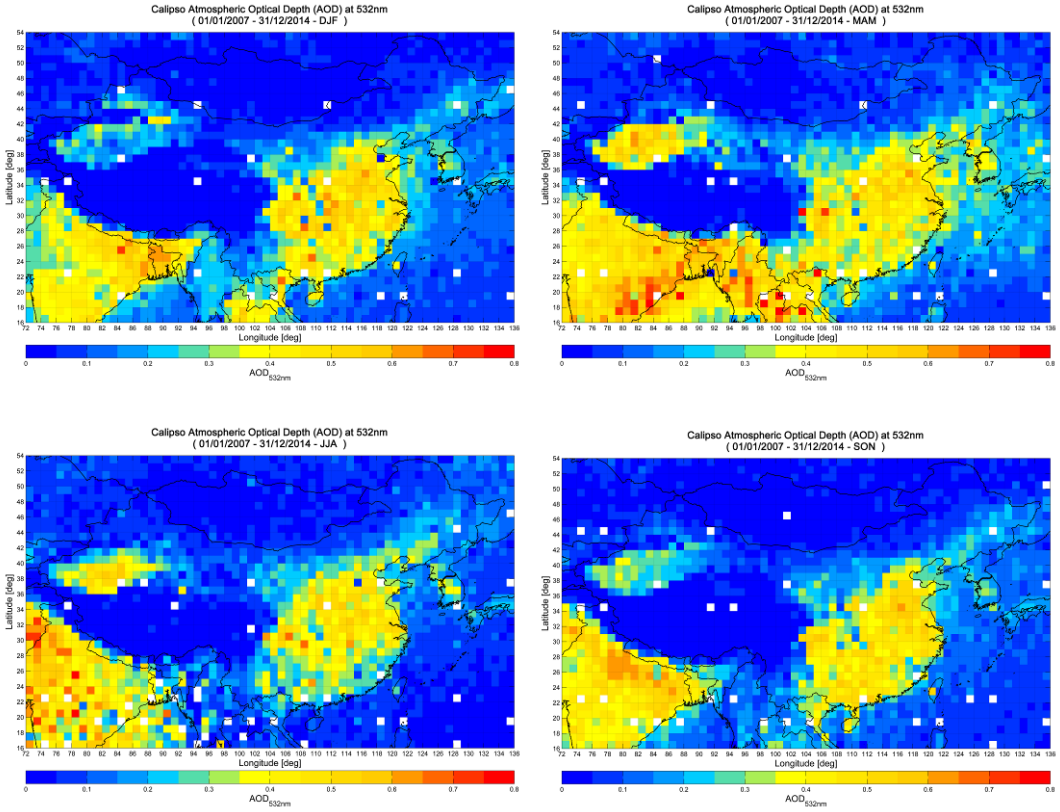
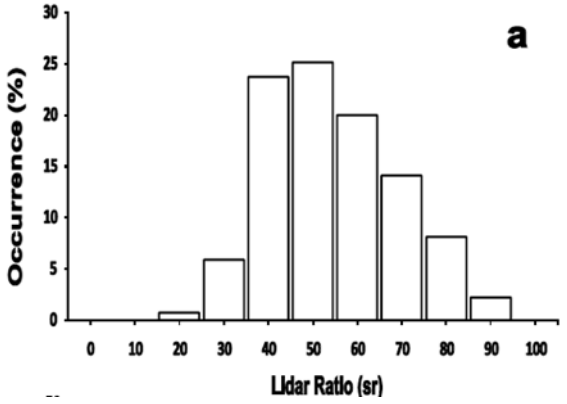
Seasonal total AOD from CALIOP based on 2007 to 2014

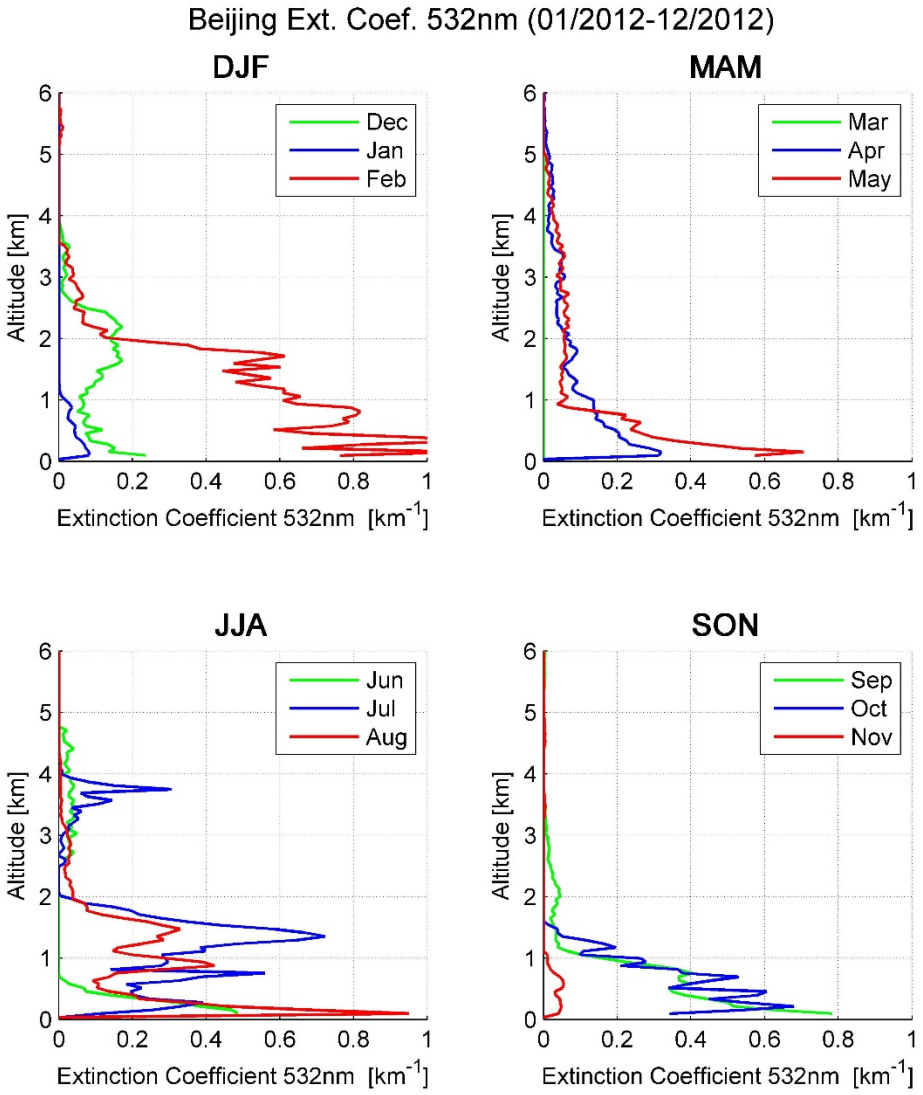


Appropriate Lidar Ratio for China is needed from ground-based lidar measurements



Hänel et al. 2012

CALIOP: Mean extinction profiles



Large variability in monthly avaraged extinction profiles for 2012:

- Profile shape
- Extinction value
- BLH
- Elevated layers

Near surface features? Most profiles seem not well-mixed

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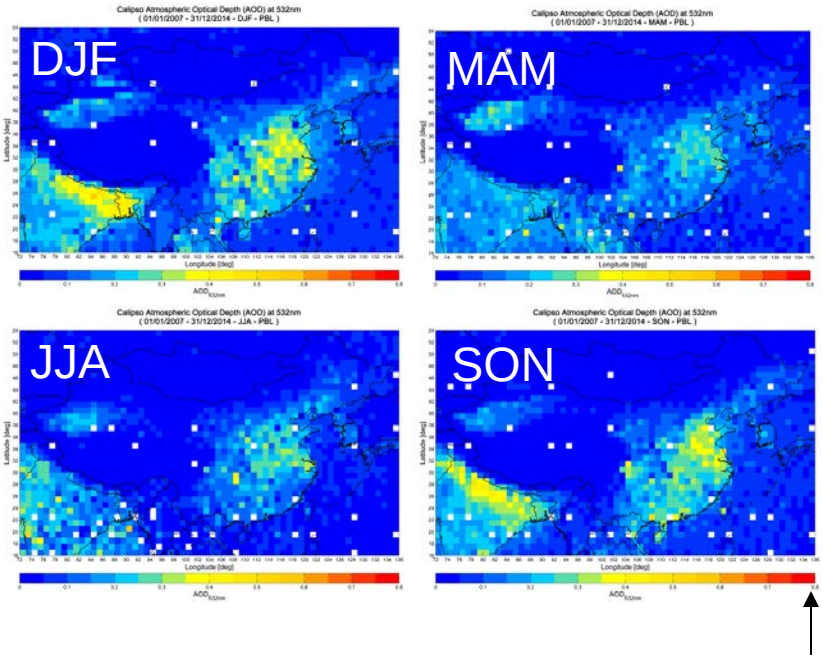
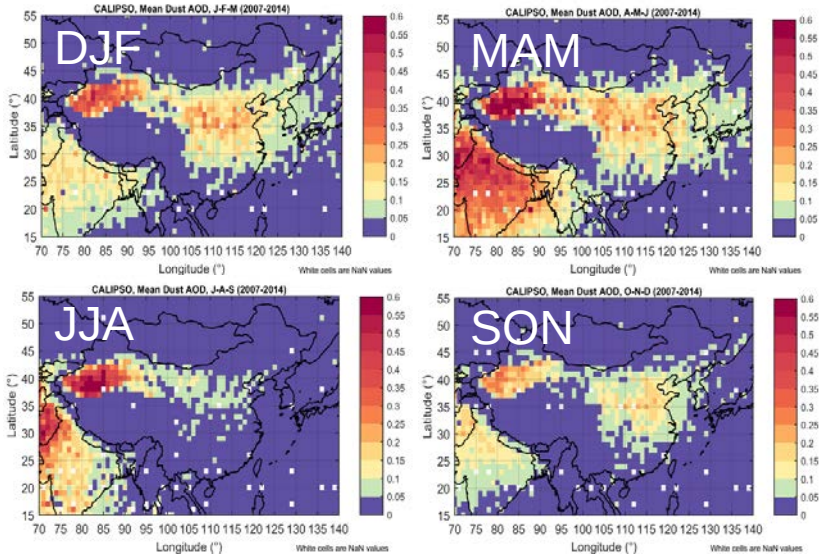
Seasonal total AOD from CALIPSO for altitudes 0-1km above mean ground level in 1x1 degree (left), and pure dust (right) based on 2007 to 2014.

AOD, H> 1 km



0.8

Dust



0.8

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Conclusions and outlook

- Satellites provide the spatial, vertical and temporal distribution of aerosols
- This information is used for inverse modelling to determine emissions
- Temporal trends show yearly and seasonal variation, anti-correlated with PM, could be caused by :
  - Sampling, not conclusive
  - Aerosol physics, chemistry, meterology: tbd
- Models may help to better understand
- These data need to be further analysed and interpreted, together with that from precursor gases, using models and information on emission sources to better understand the spatial and temporal variations

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Acknowledgements

- Marco Polo is an EU FP7 project
- ATSR algorithm ADV/ASV) development is supported by ESA as part of the Climate Change Initiative (CCI) project Aerosol_cci