Potential and limitation of remote sensing observations to monitor super coarse particles of ambient aerosol

Oleg Dubovik, Anton Lopatin, Masahiro Momoi, Alexander Sinuyk, Elena Lind, Tatyana Lapyonok, Tom Eck, Alexander Smirnov, Marcos Herreras Giralda, Pavel Litvinov, and Carlos Perez

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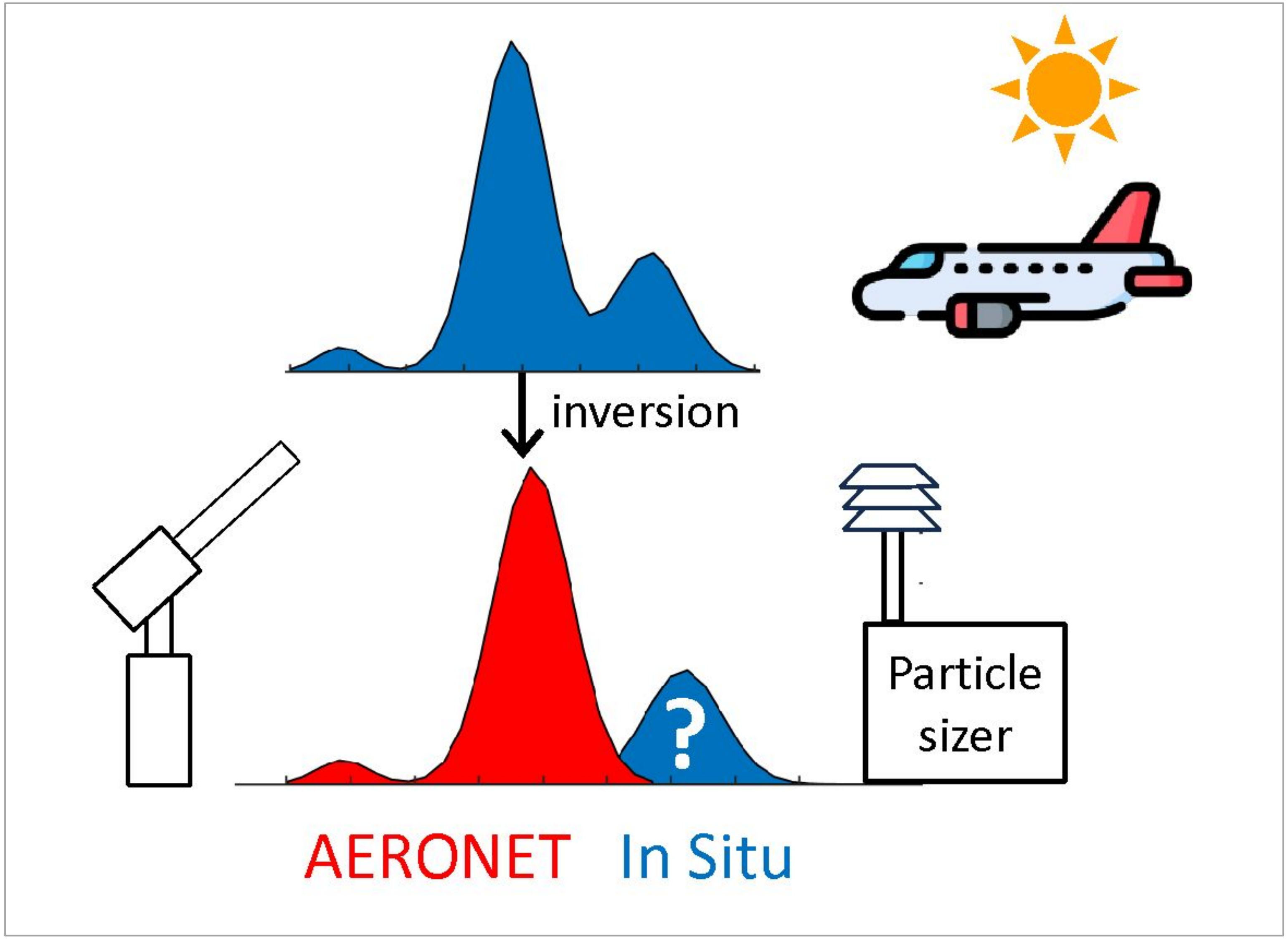
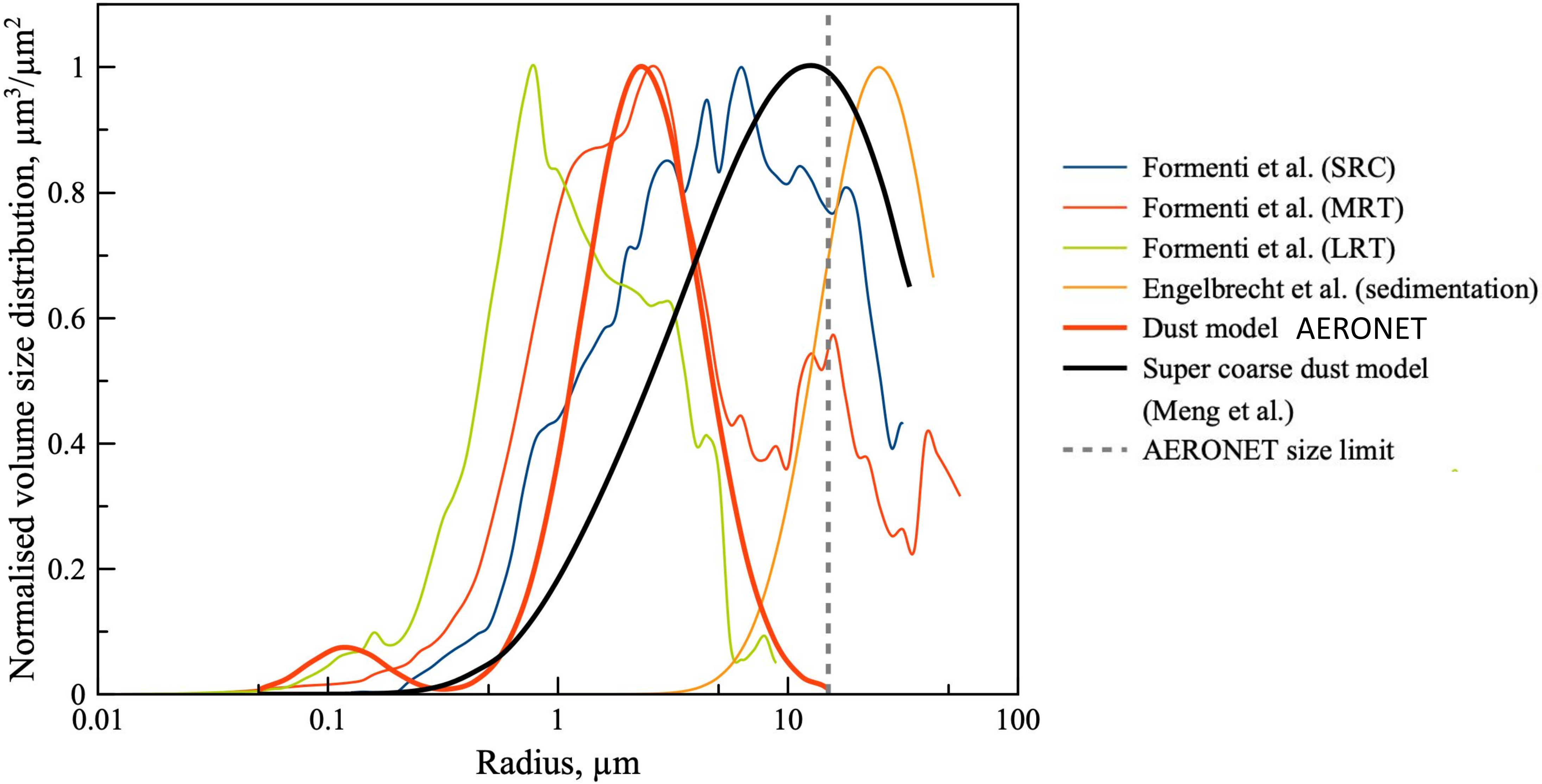
Are super coarse particles visible from remote sensing ?



Super coarse dust and its modelling



Study Concept and Scope:

AERONET observations:

✔ **Optimizing retrieval algorithm:**

- extending particle size range in the size distribution retrieval;
- relaxing a priori constraints on the size distribution extremity;

✔ **Increasing information content of observations:**

- extending spectral coverage (SWIR 1.64 and 2.2 μm);
- extending aureole measurement to the smaller scattering angles;
- adding polarization observations;

Observations beyond AERONET:

✔ **Observations with extra sensitivities and synergies:**

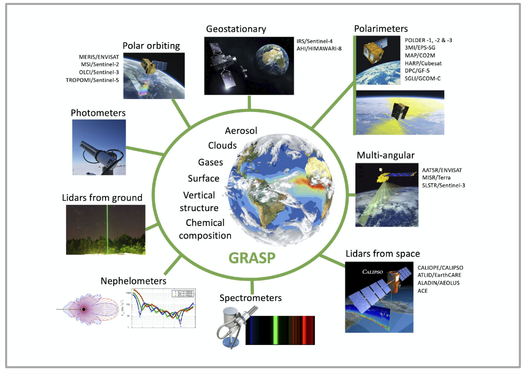
- active (lidars); - passive + active (lidars);
- passive + active (lidars) + in situ;
- SWIR + TIR observations;

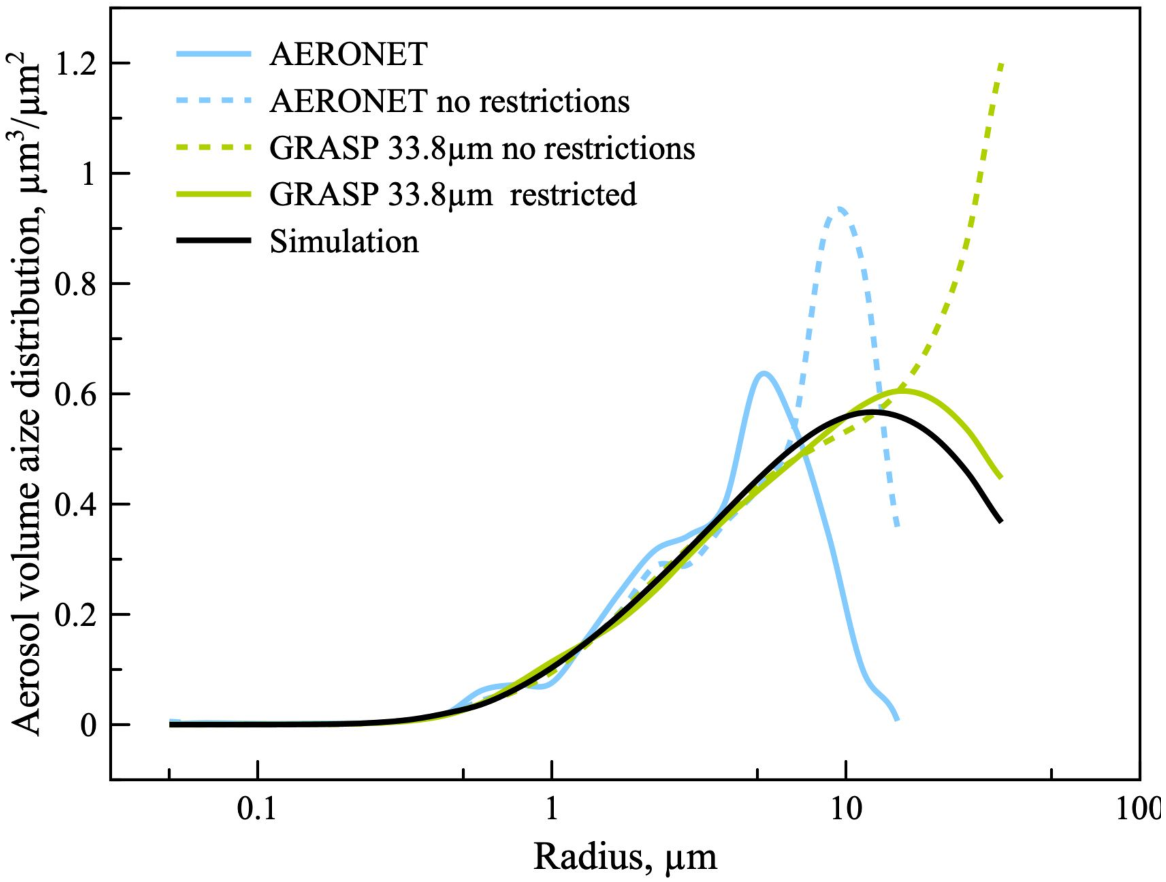
Extensive numerical tests

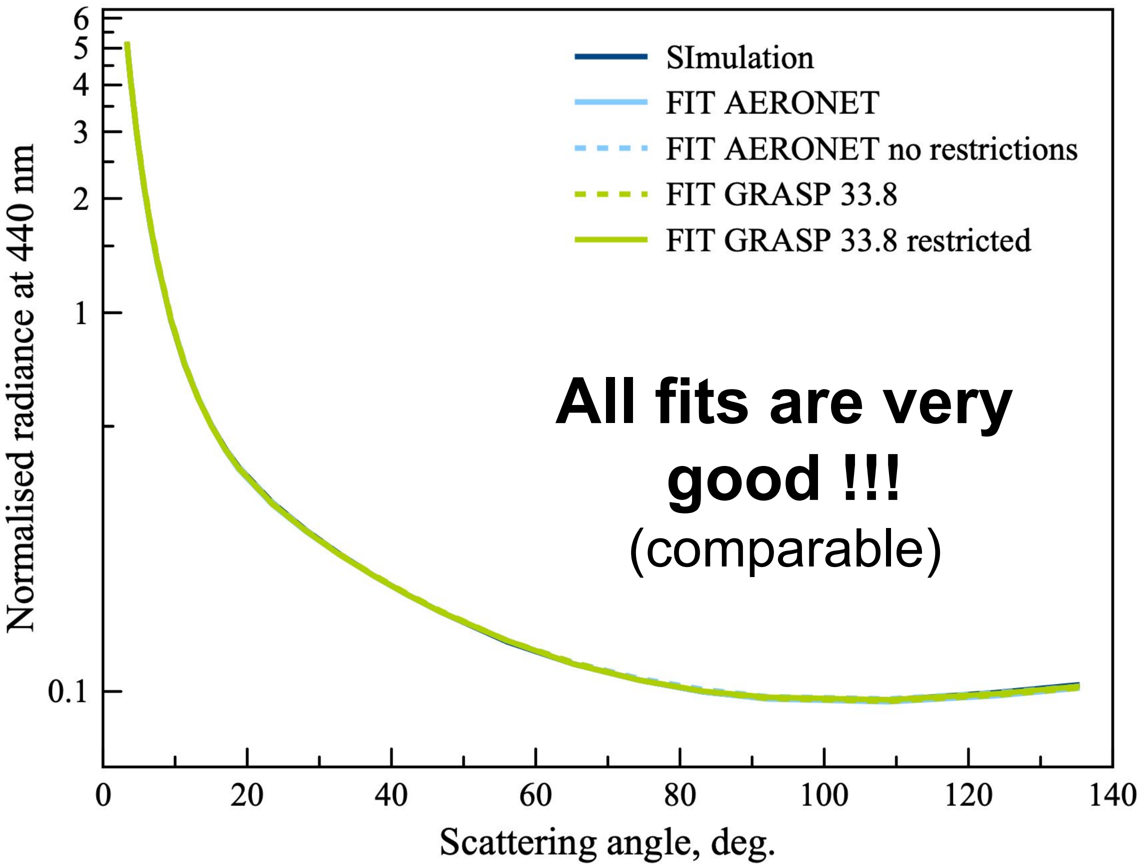
&

Real data analysis

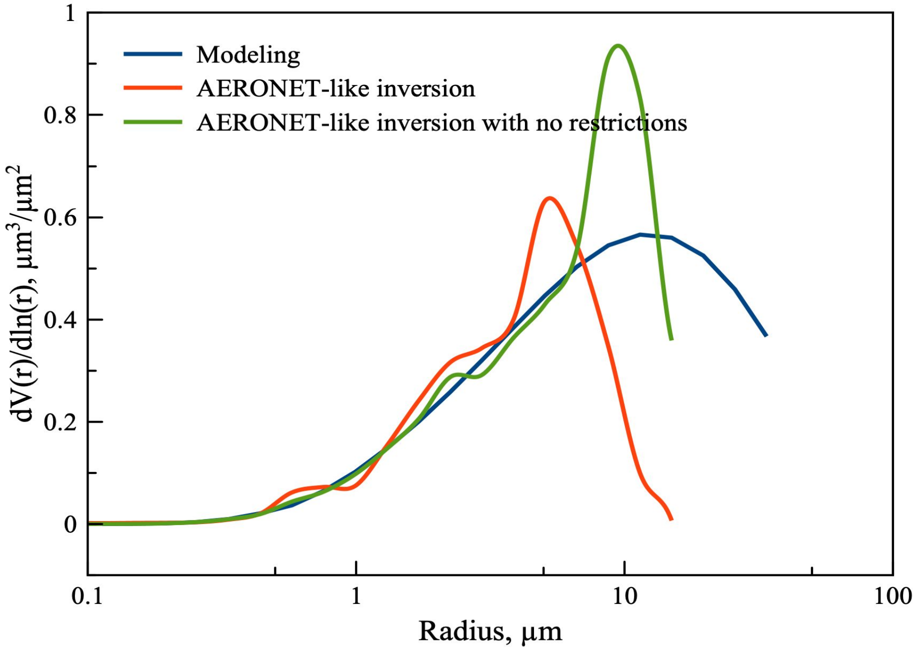
Effect on SD edge restrictions:
Sensitivity study

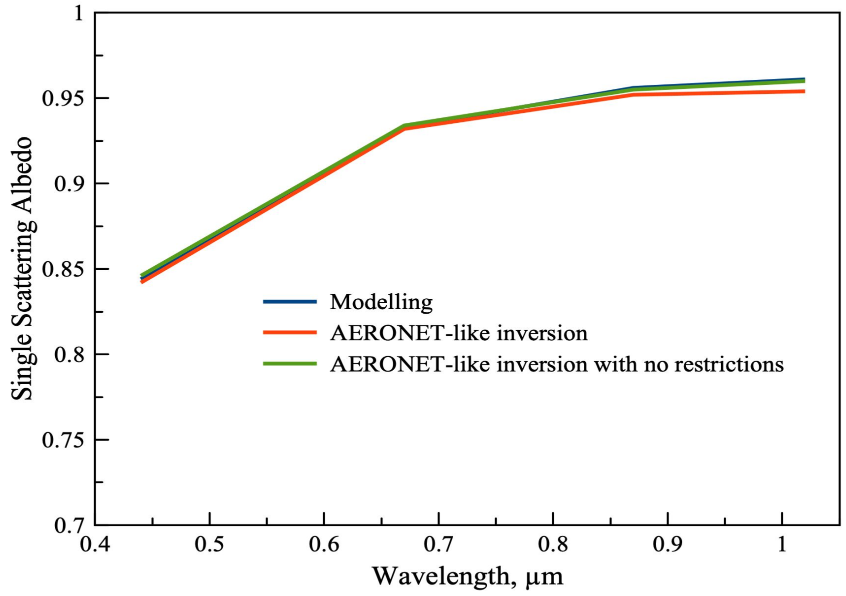


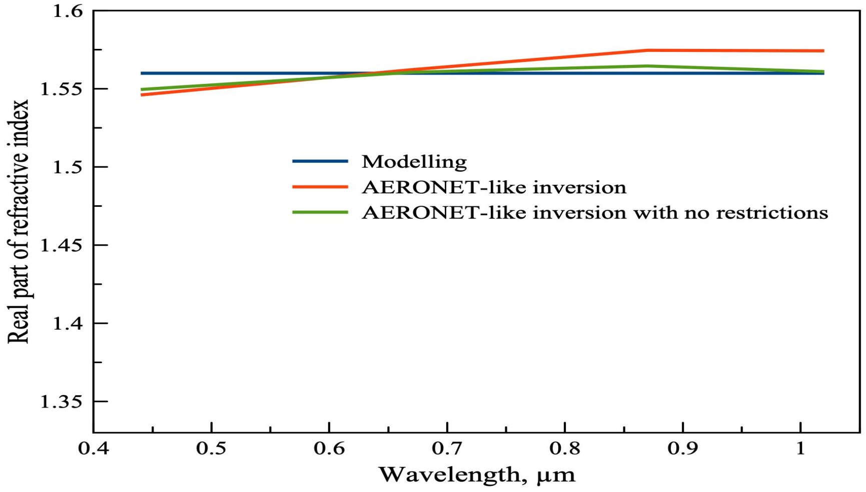


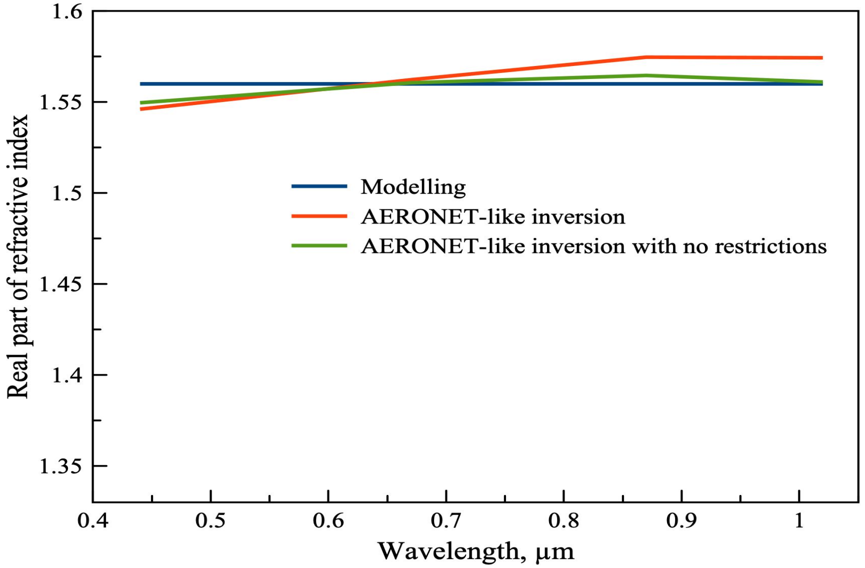


AERONET retrieval: Sensitivity study



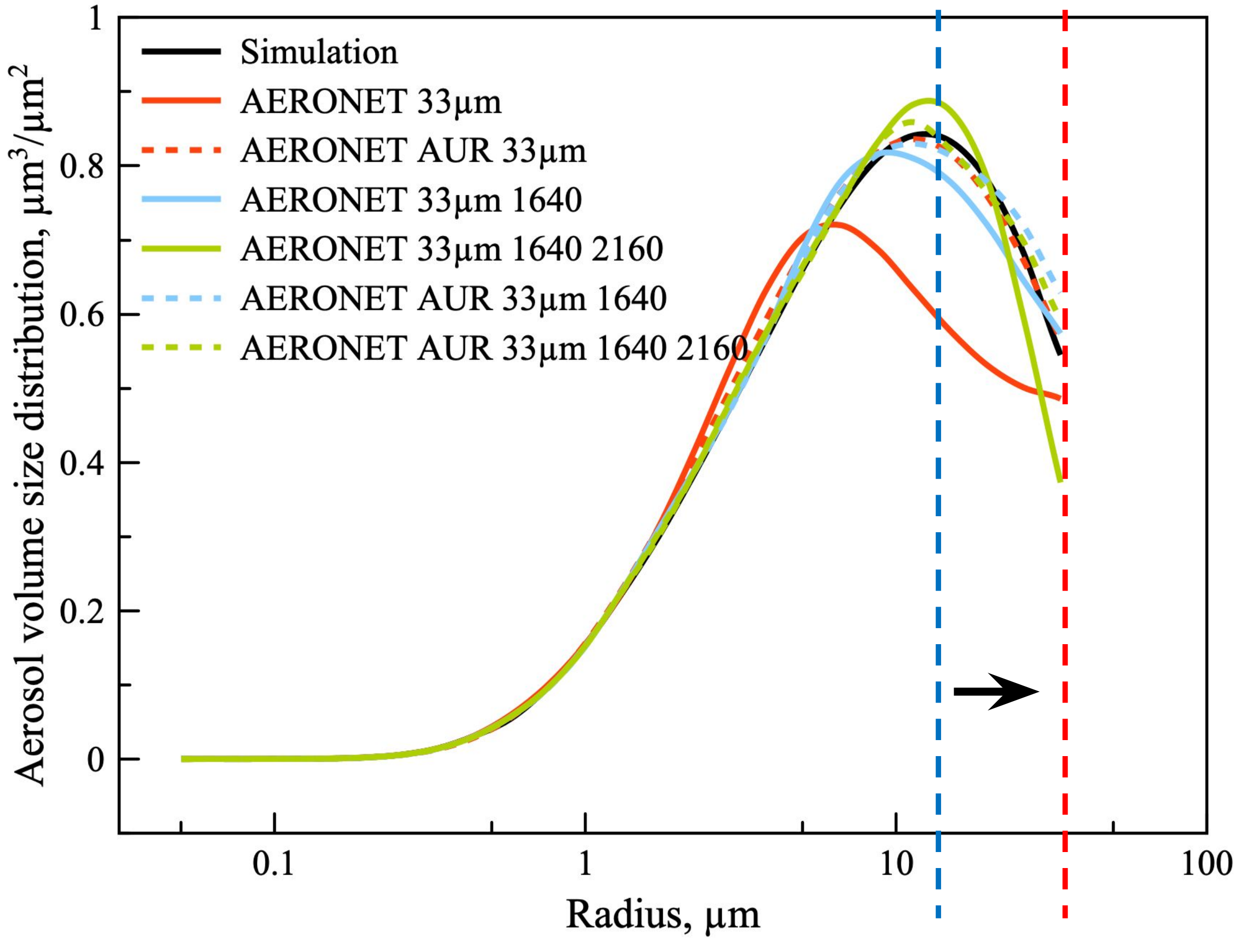




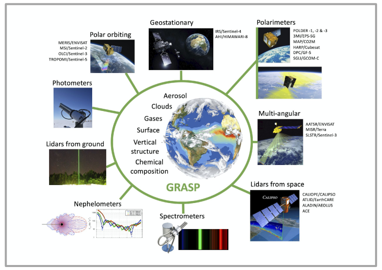


Feasibility study to retrieve particles > 15µm (~30)

- extending spectral coverage (SWIR 1.64 and 2.16 µm);
- extending aureole to the smaller



AERONET SD limit



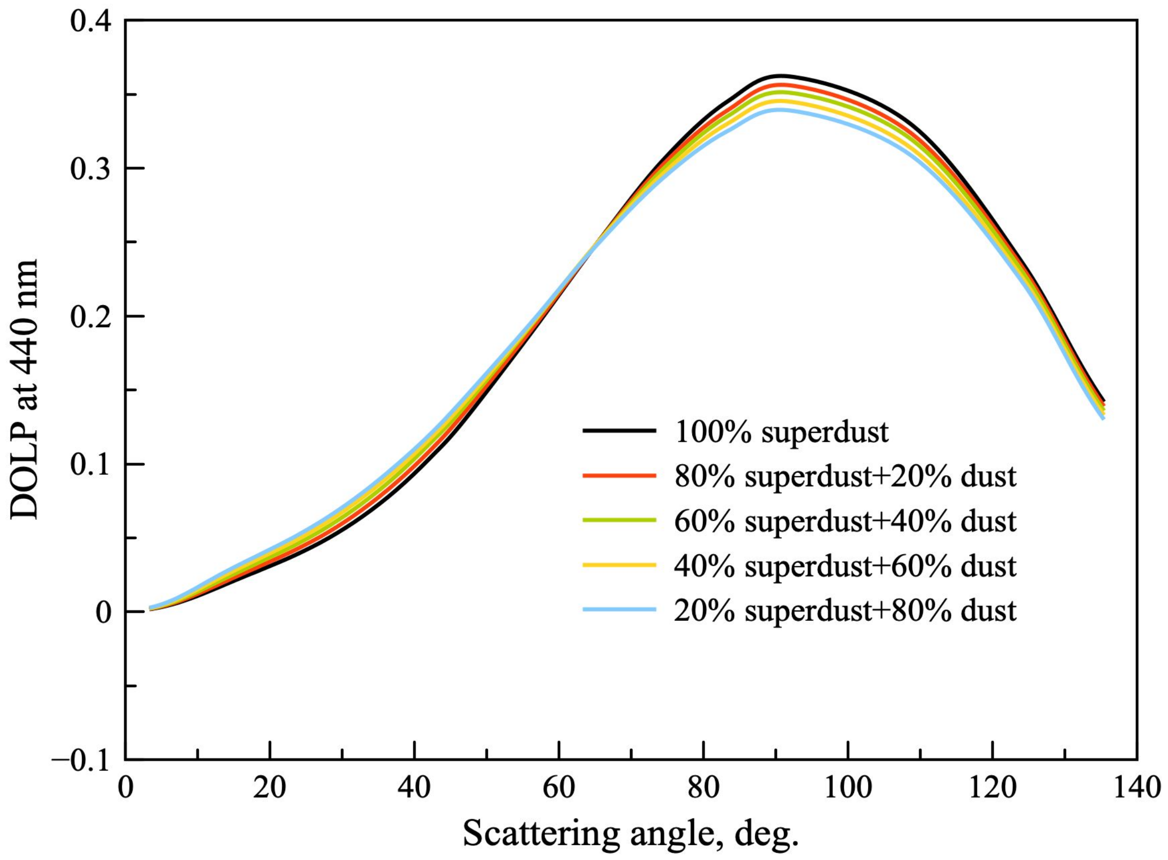
Conclusions:

- The lager particles **can be retrieved** for sizes larger than 15 microns,

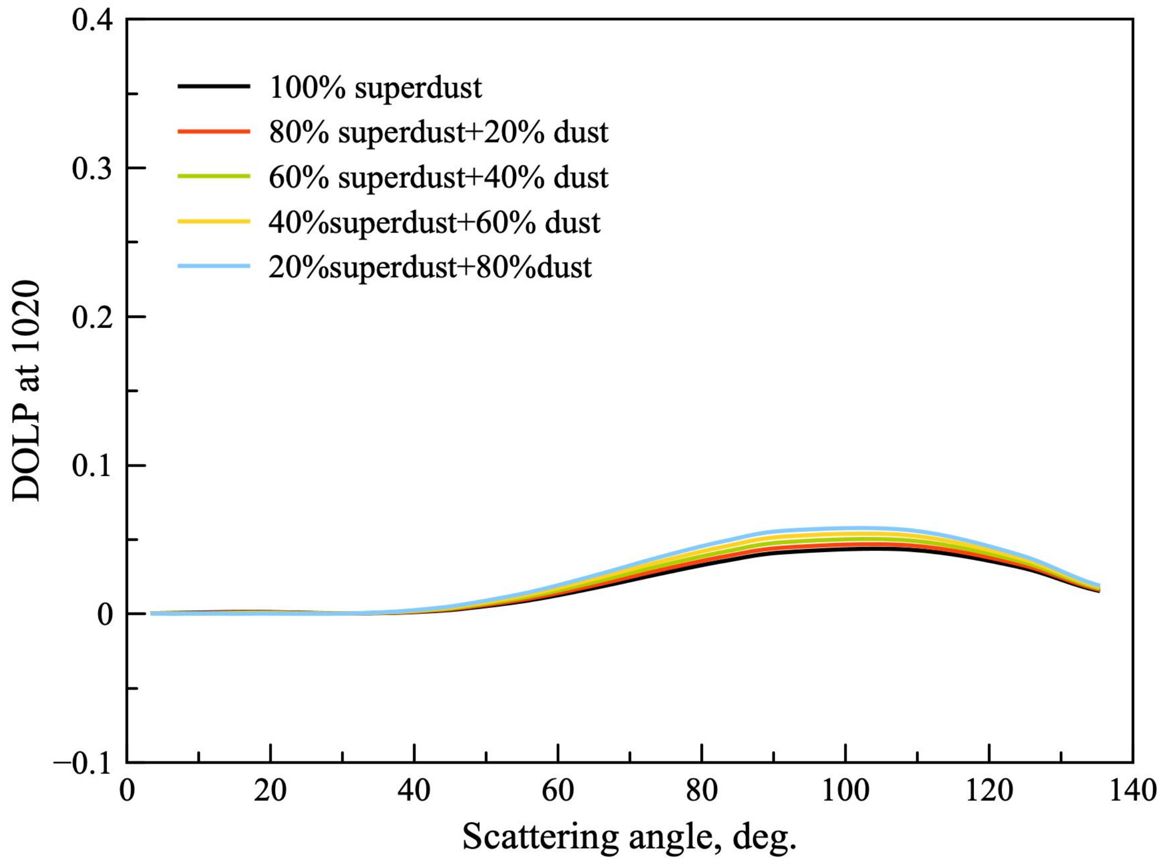
- Adding aureole, at measurements at longer wavelength **1640**, **2160** improves the sensitivity.

Adding polarization: forward modelling

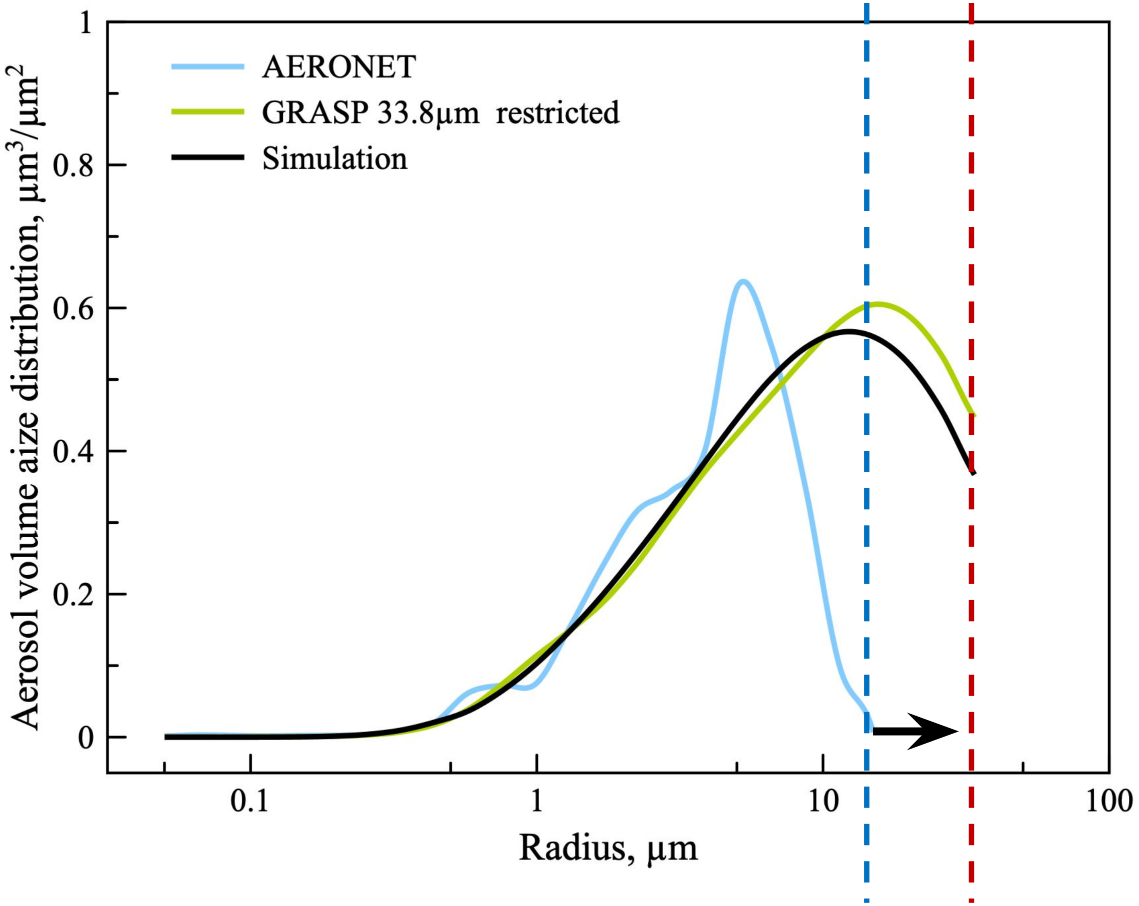
P/I(440)



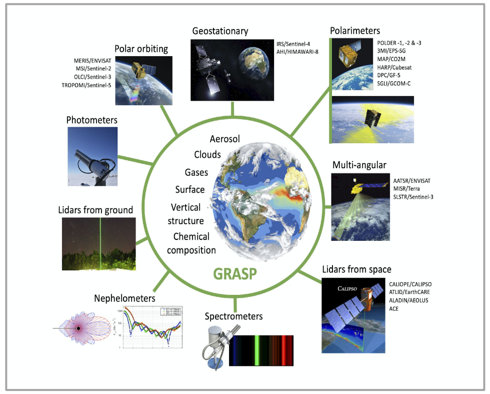
P/I(1020)



Feasibility study to retrieve particles coarser than 15μm, up to ~30.

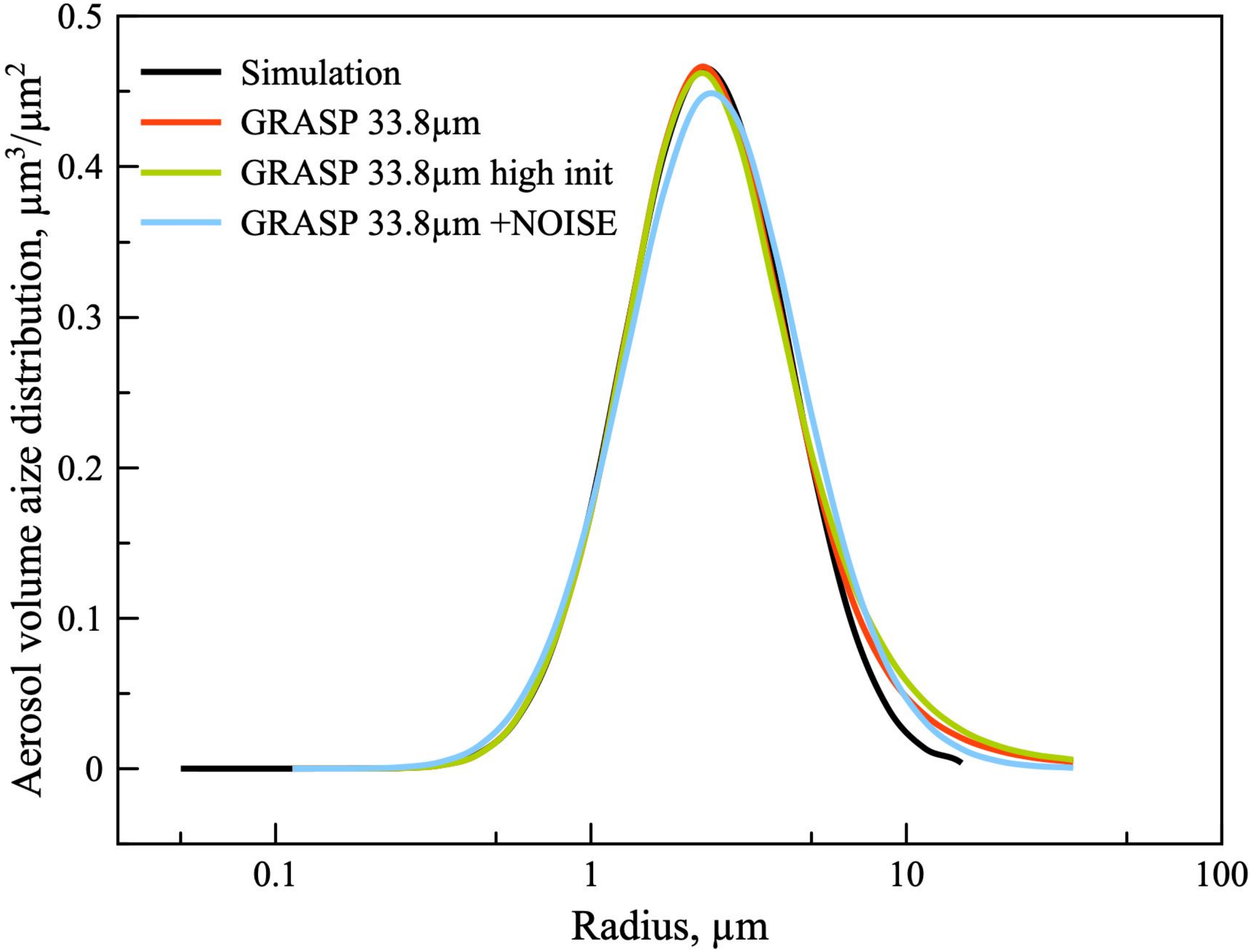


AERONET SD limit



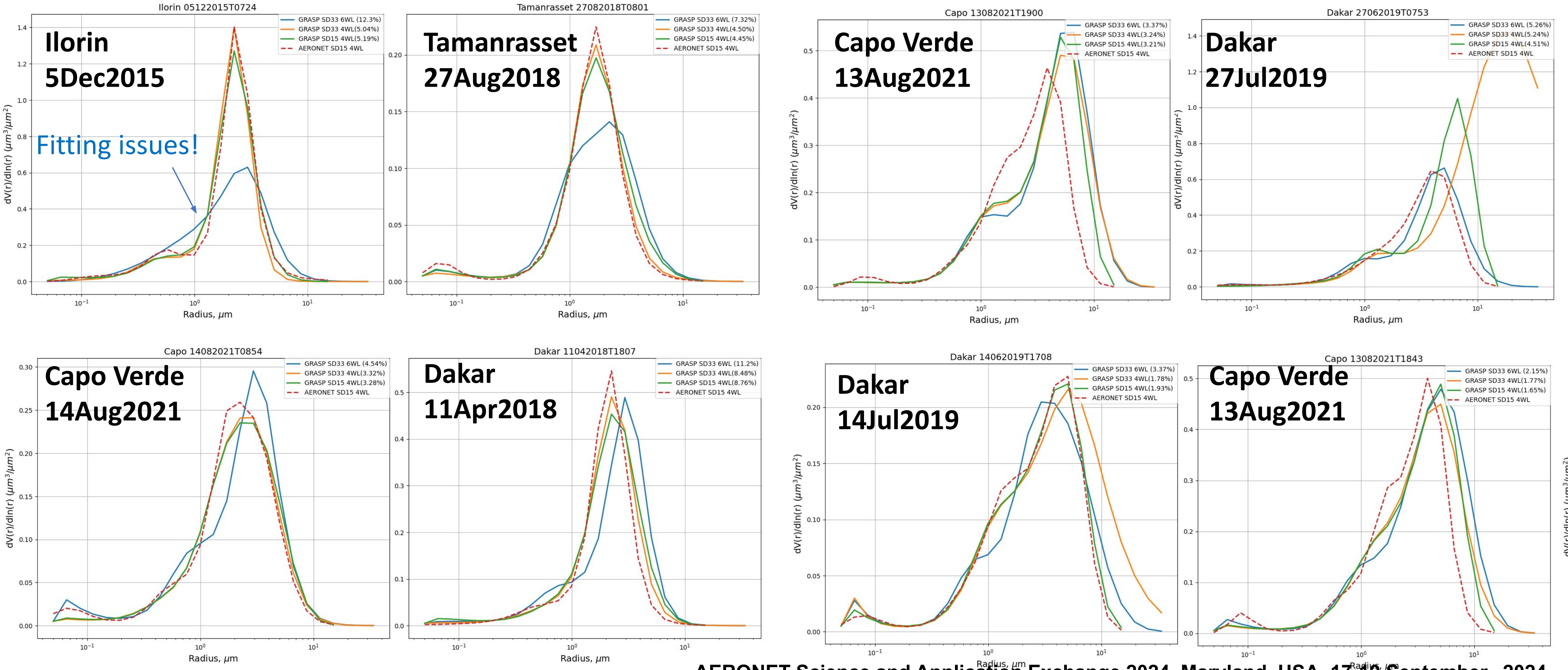
The sensitivity studies suggest the usefulness of extending maximum size to retrieved particles to 30 μm

Stability of retrieval tests: retrieving dust with extended range (up to ~30 μm)



Allowing coarser particles
doesn't change
the results !!!

Real observations (4&6 wavelengths): low AE cases with size distribution 15.0μm and extension to 33.8 μm



Real observations processing: selection of very low AE cases with 1.64 μm

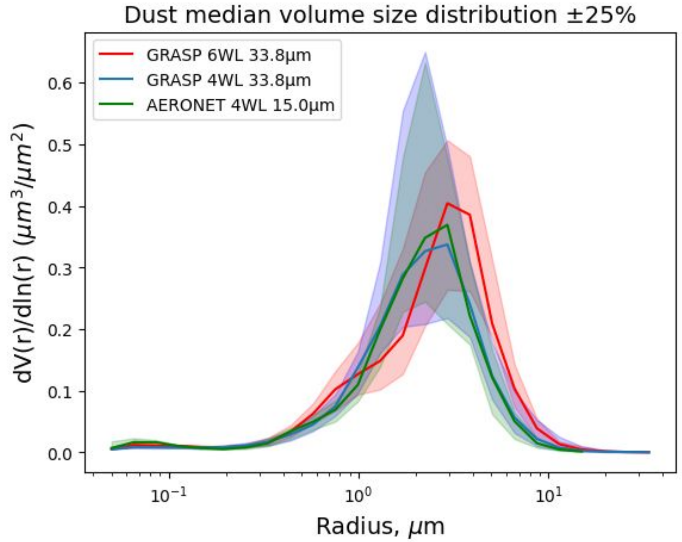
43 meticulously selected candidate cases of **super coarse dust** presence:

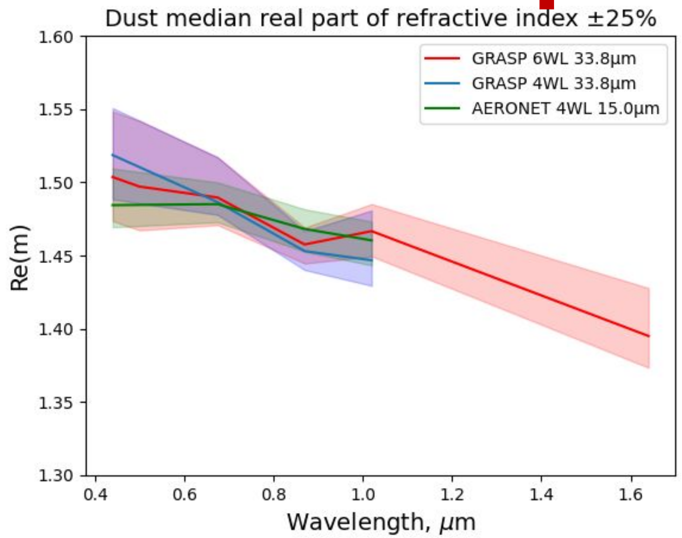
- **Dakar**, **Ilorin**, **Tamanrasset** and **Capo_Verde** AERONET "dust belt" sites

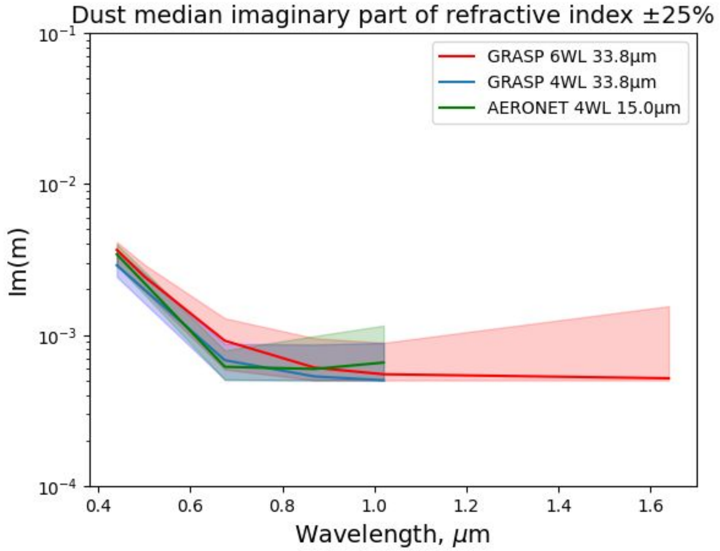
Criteria:

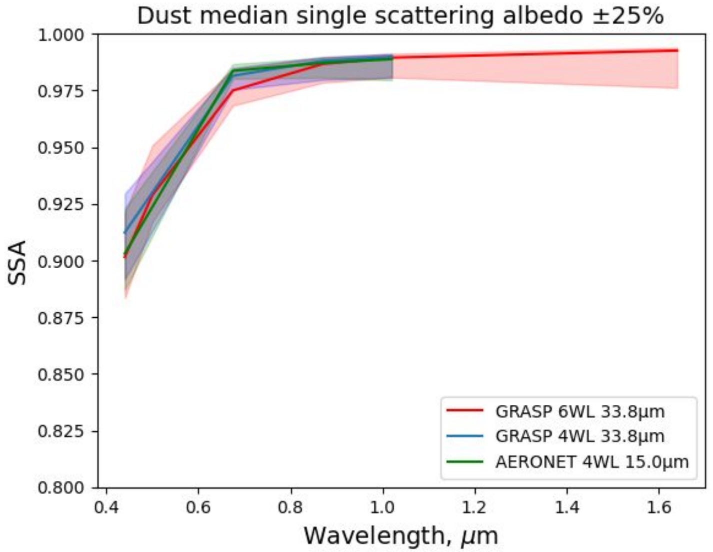
- L2 data with 1640 channel availability
- Average AOD 0.8, min 0.32
- AE below 0.17, min -0.02
- Sphericity fraction <2%

Real observations processing: selection of very low AE cases with 1.64 µm



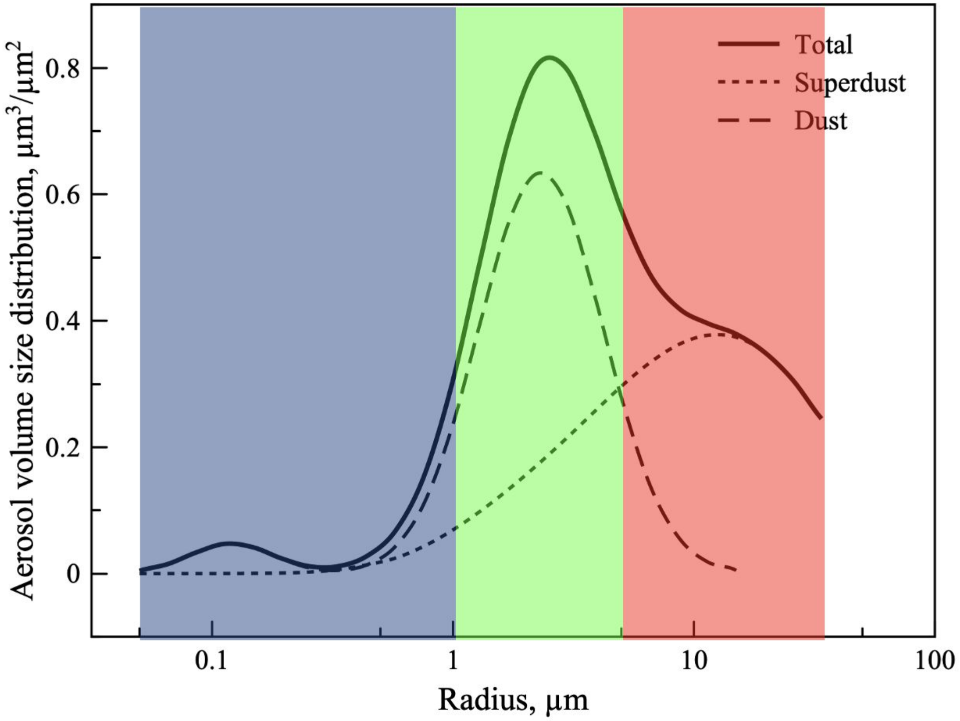




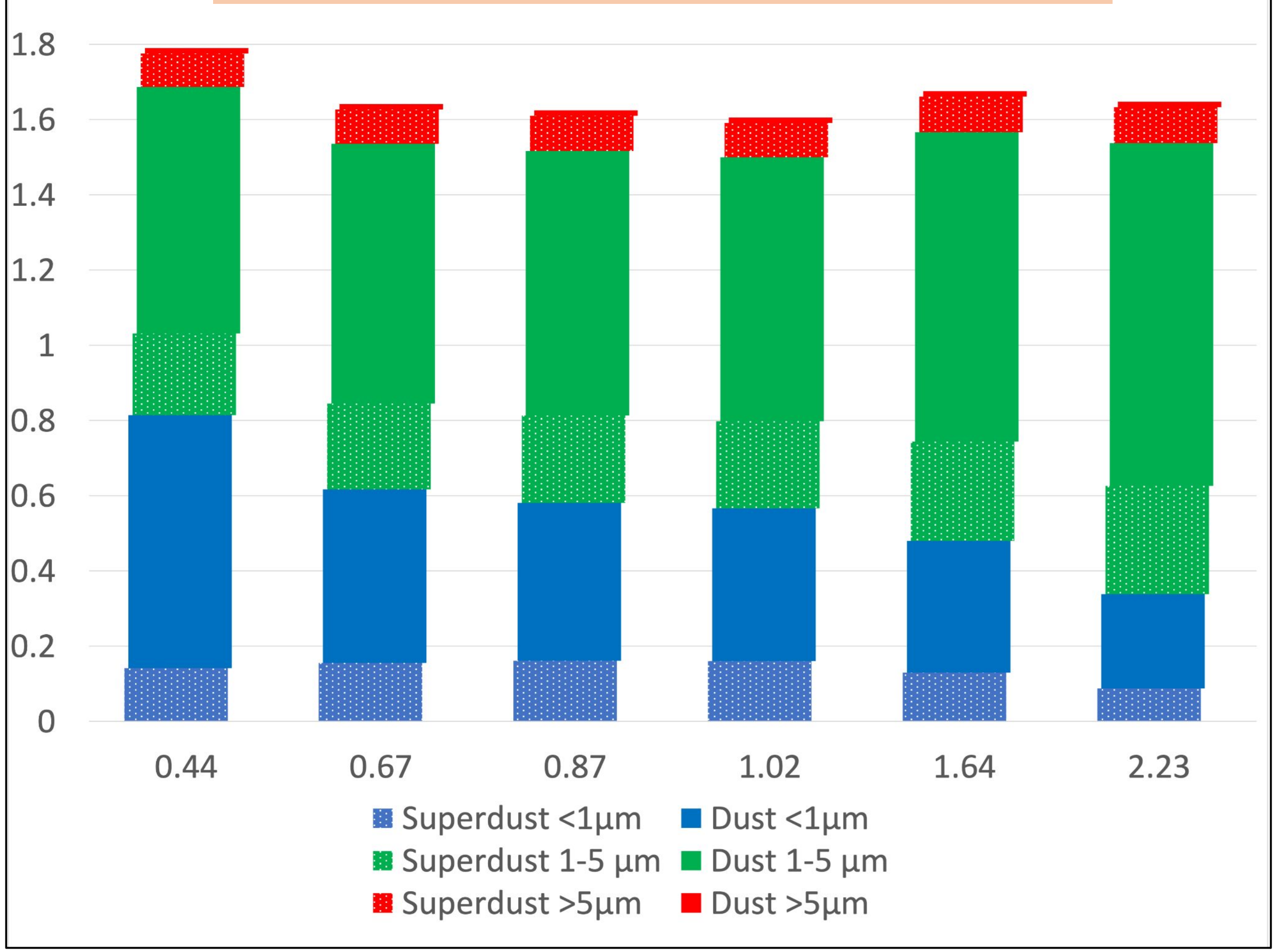


Contribution of different size ranges to AOD

Mixture of regular dust and super coarse dust with equal volume concentration



~ 5% contribution of super coarse dust with radius > 5 μm



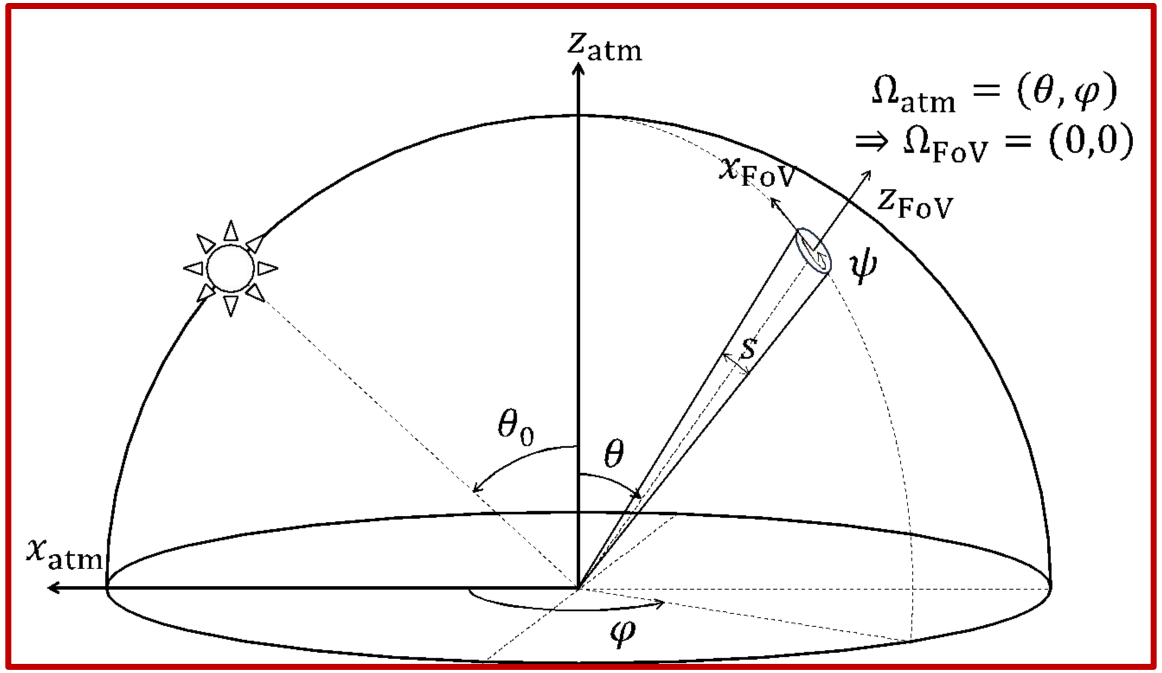
Field-of-View effect on AERONET products:

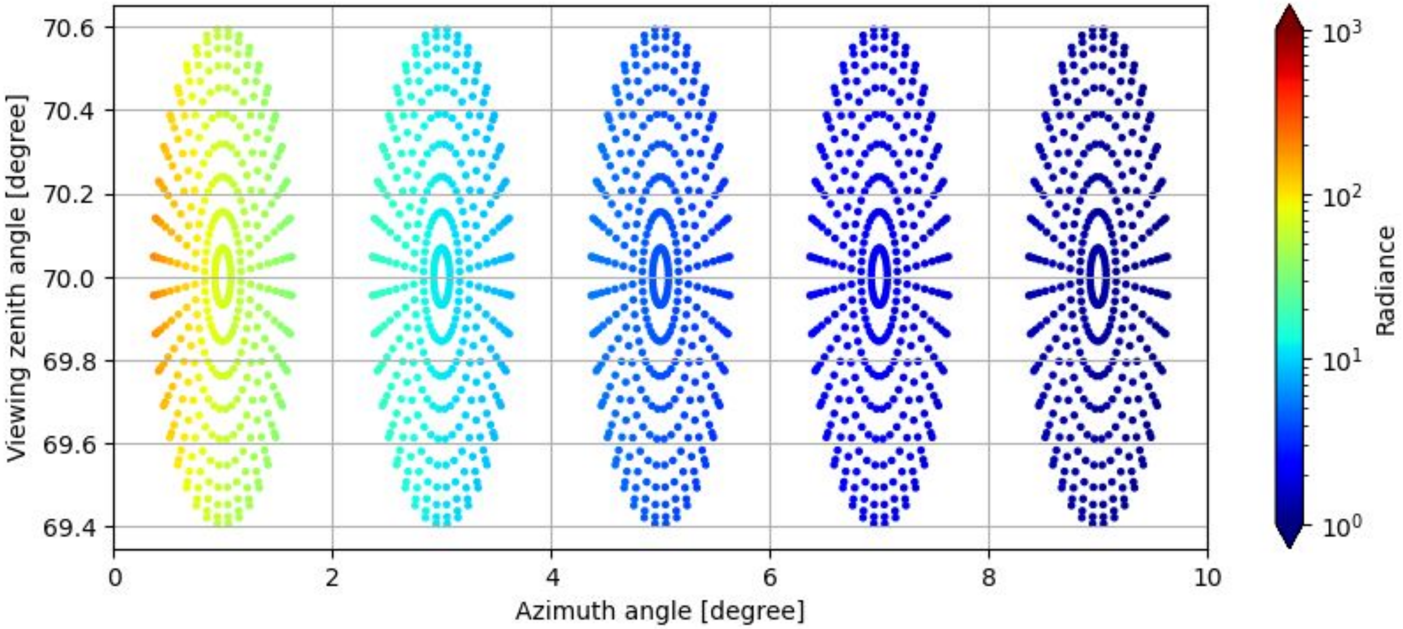
Due to high anisotropy of radiances in the aureole, FOV effect may be essential in presence of super coarse dust and have an effect on:

- Measurement of sky-radiance;

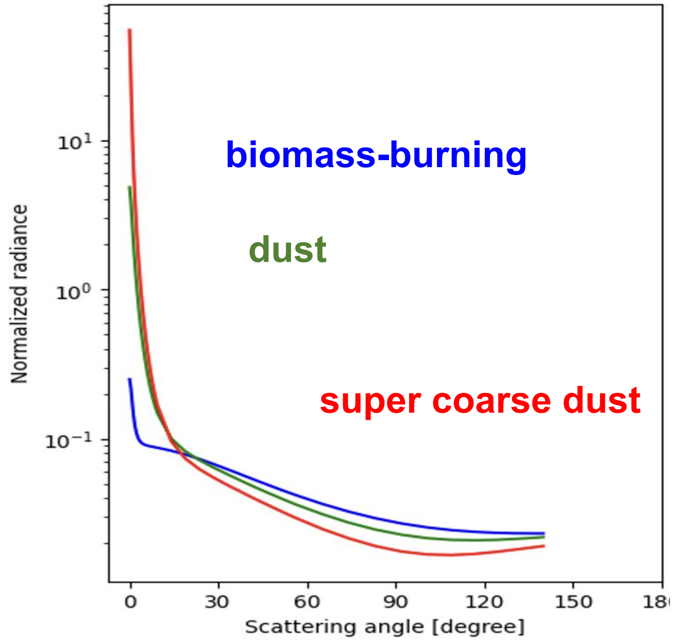
- Measurements of AOD;

- Retrieval of size distribution and SSA.

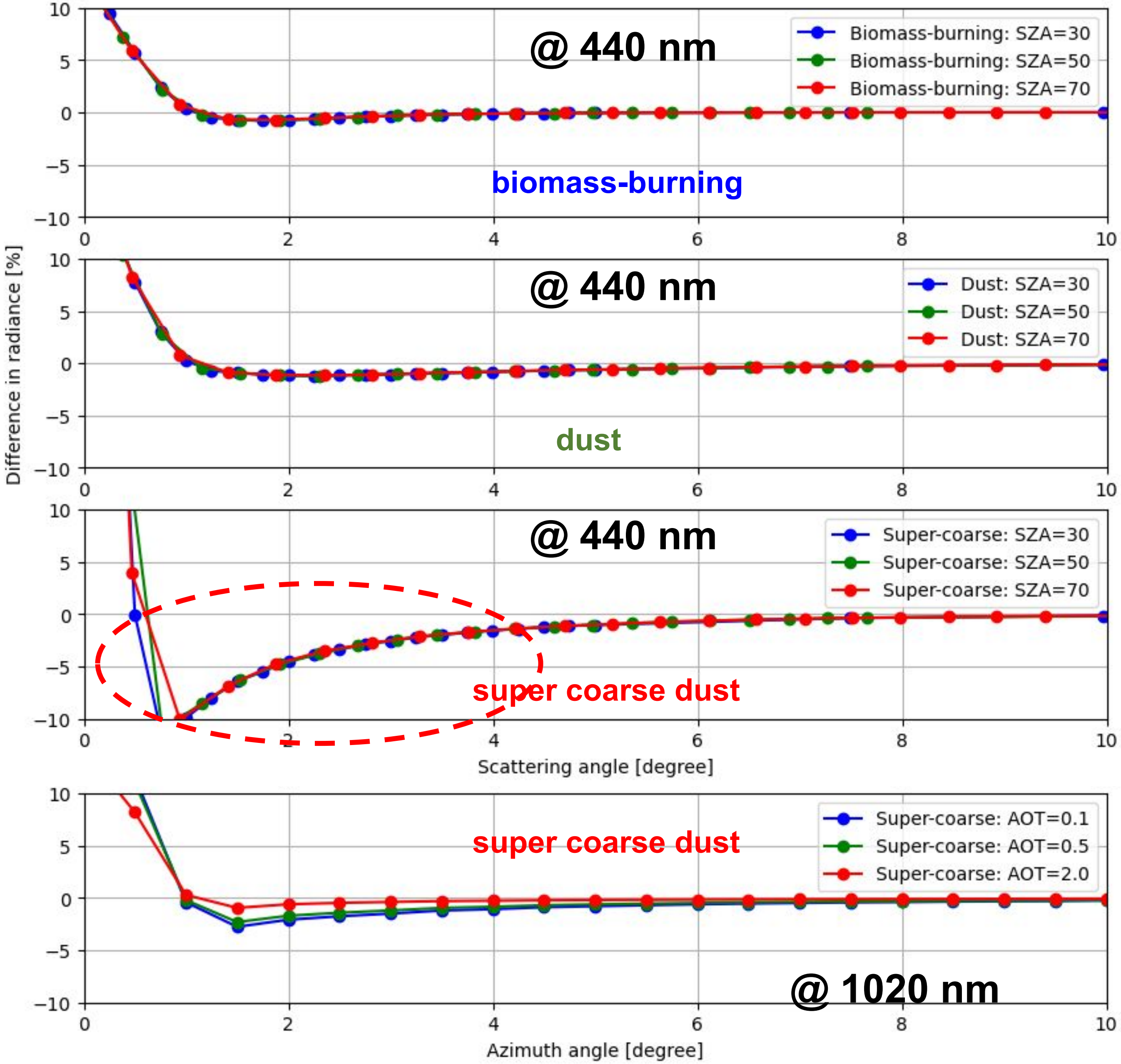




Field-of-View effect on radiance distribution



$$diff = \frac{u - u_{\mathrm{FoV}}}{u_{\mathrm{FoV}}} \times 100\ [\%]$$

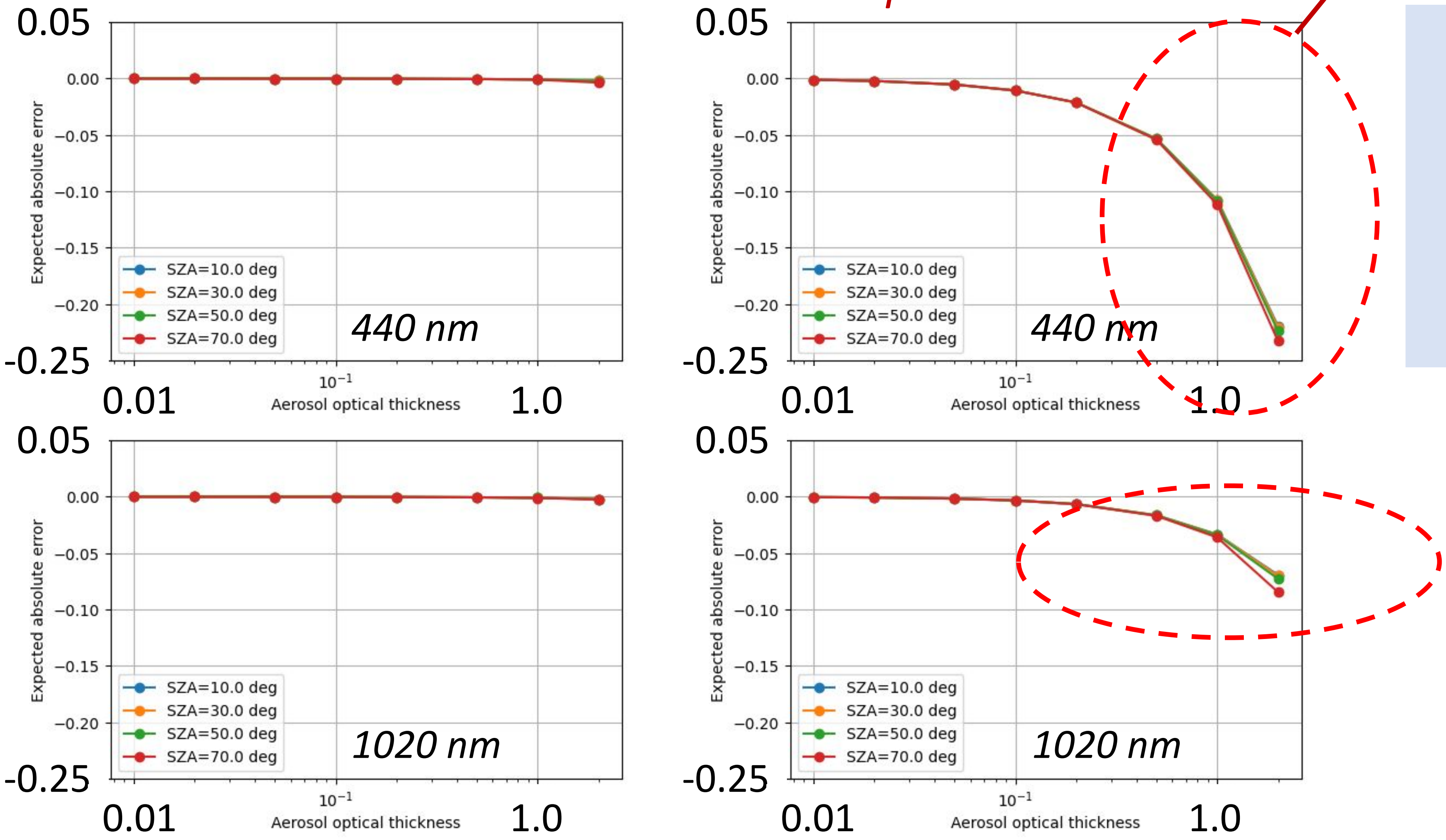


FoV effect

1. **is larger**
   - in forward direction;
   - for larger particles;
   - at Lower AOD;
2. **is *weaker***
   - *at longer wavelengths;*
3. **is independent** on solar zenith

FoV effect on direct solar measurements

Biomass burning *Super coarse dust*



~ **10%** underestimation

~ **3%** underestimation

Direct sun measurement:

$$R(\theta_0, 0, s) = \frac{F(\theta_0, 0, s)}{F_0}$$

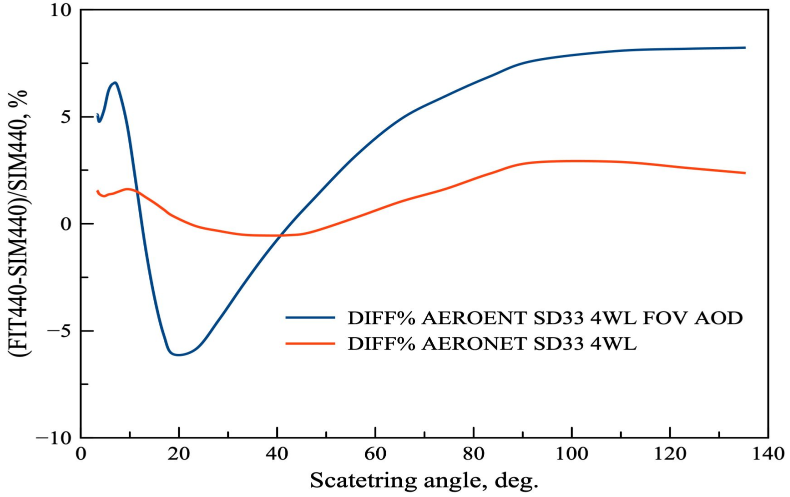
$$= T_{ds}(\theta_0) + \bar{u}(\theta_0, 0, s) \cdot \Delta_\Omega(s)$$

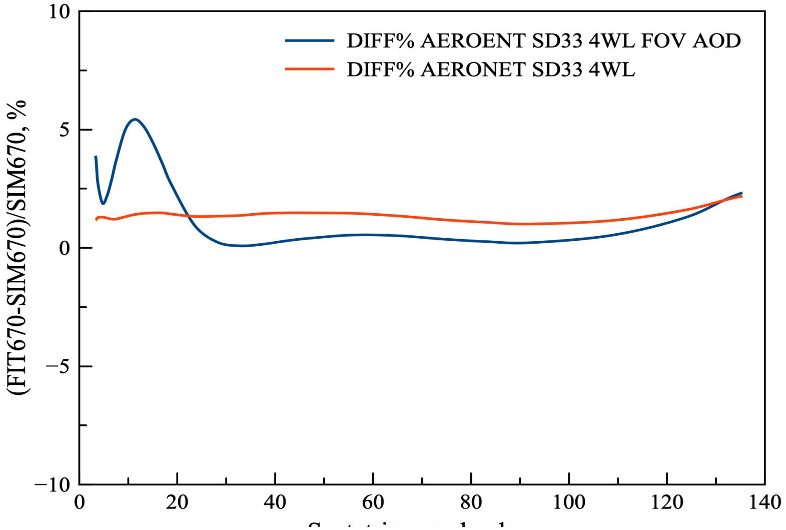
Sun transmittance FoV effects

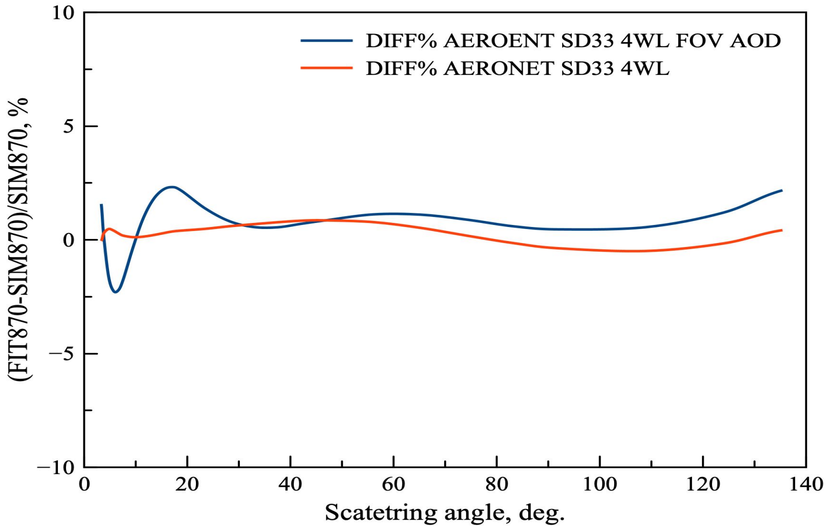
Error affected by FoV:

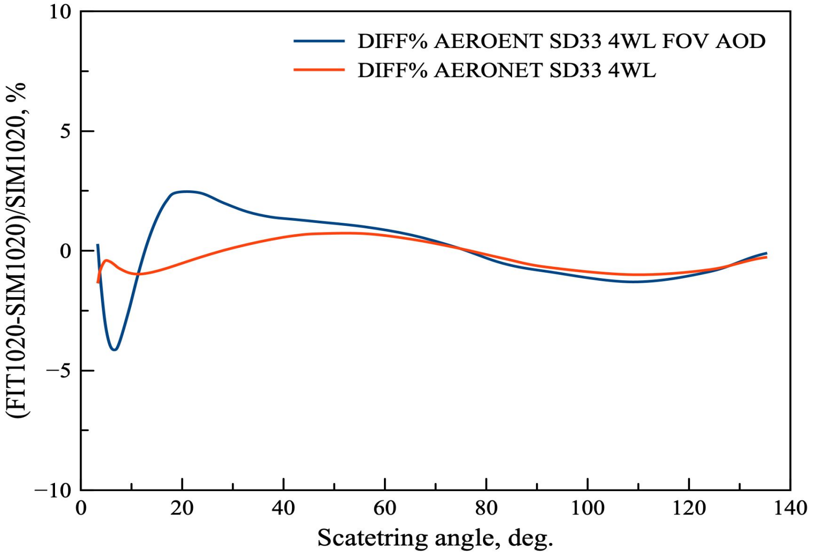
$$\varepsilon_{\text{eff}} = -\cos\theta_0 \cdot \log R - \tau$$

Field of view forward scattering effect on AOD: sky-radiance fits

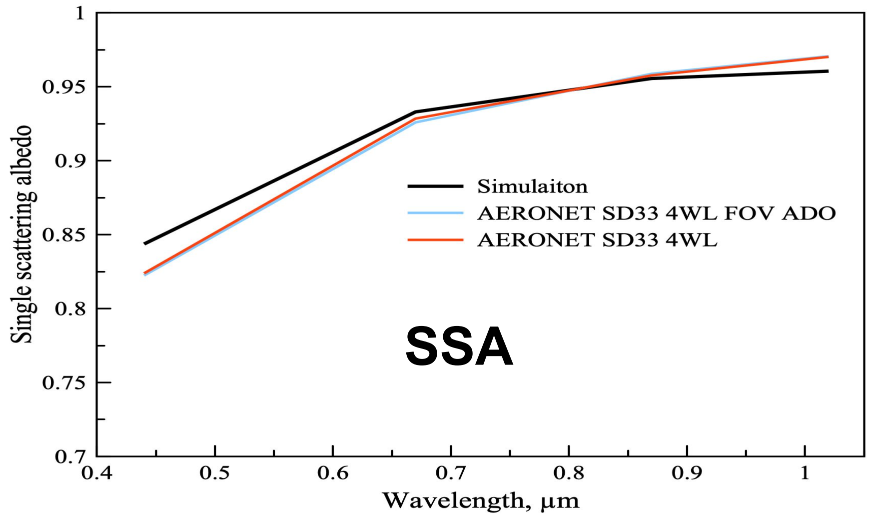


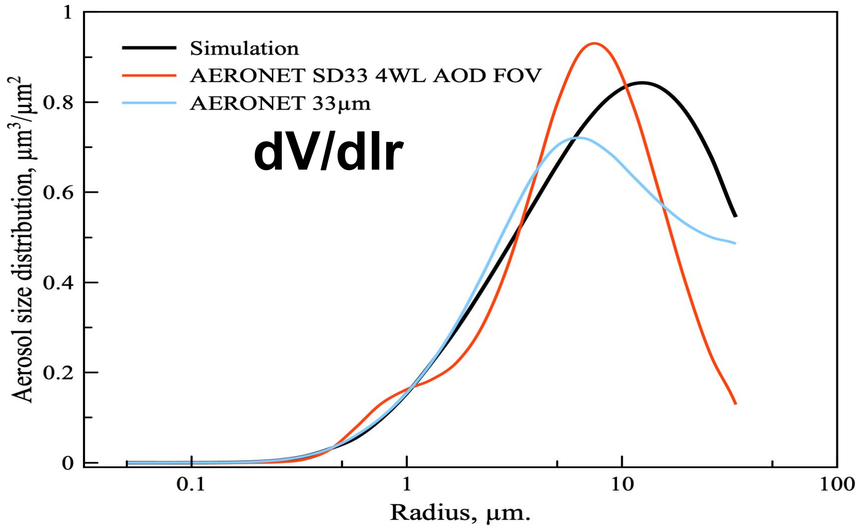


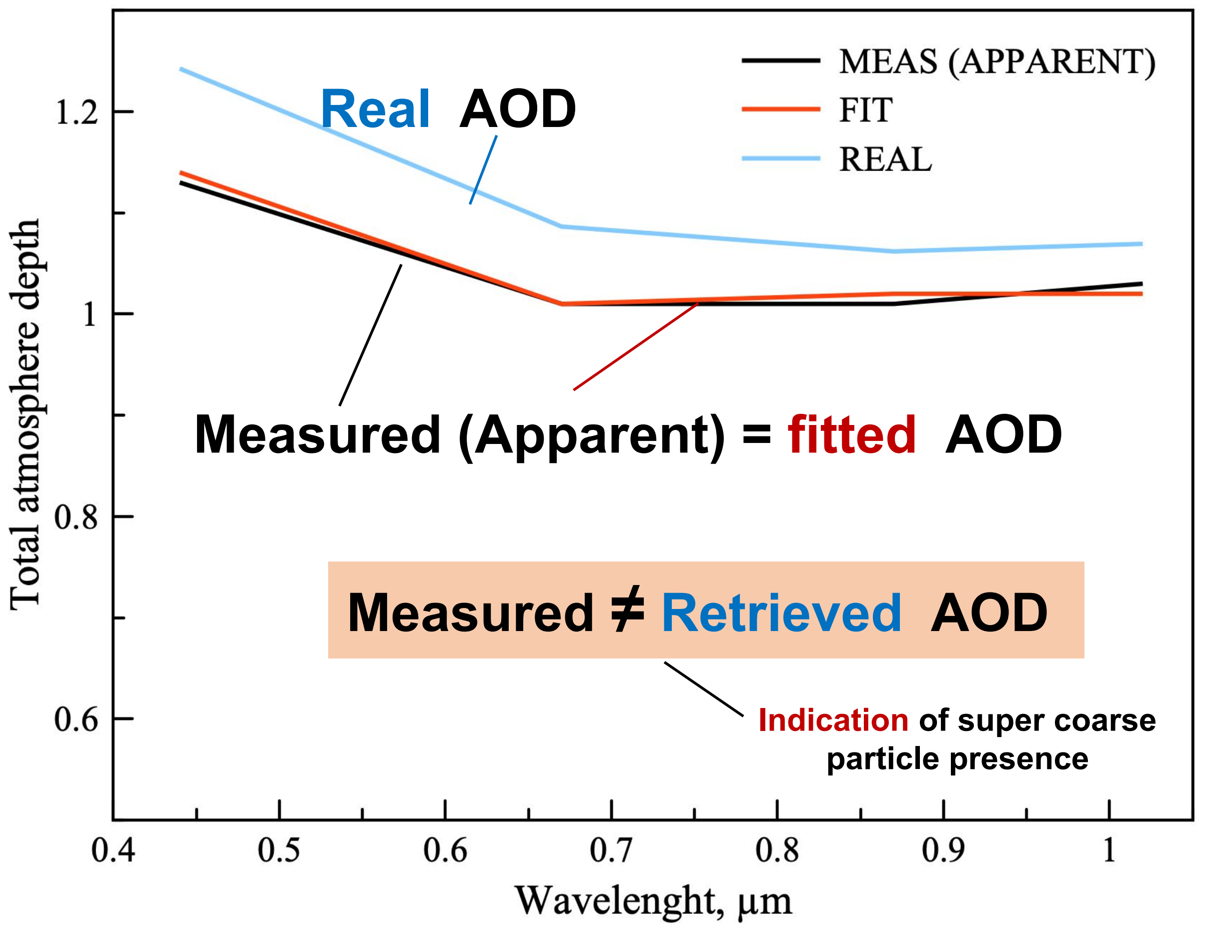




Field of view forward scattering effect on AOD: Size Distribution and SSA







Preliminary conclusions:

- ✔ There is some sensitivity for observing super coarse dust;
- ✔ 1.64 and 2.2 μm and aureole increase sensitivity to super coarse particles;
- ✔ Shape of particle size distribution for extreme sizes remains uncertain;
- ✔ Extending max size in retrieval from 15 μm to ~ 35 μm can be recommended;
- ✔ Analysis of AERONET observations of extreme dust events didn't suggest significant presence of super coarse particles;
- ✔ AOD correction for forward scattering is important and can be indication of super coarse dust presence

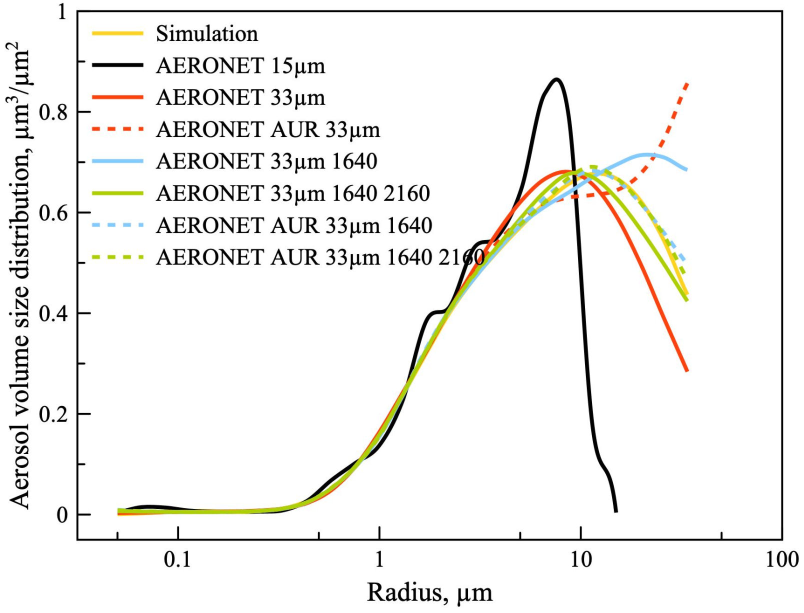
Observations beyond AERONET:

- ✔ Observations with extra sensitivities and synergies:
  - active (lidars); - passive + active (lidars);
  - passive + active (lidars) + in situ;
  - SWIR + TIR observations;

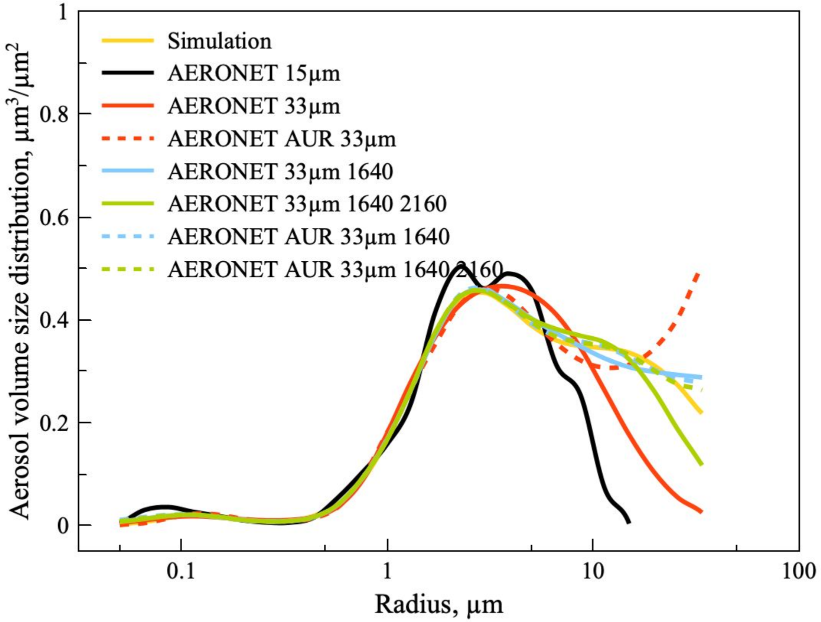
To be completed !!!

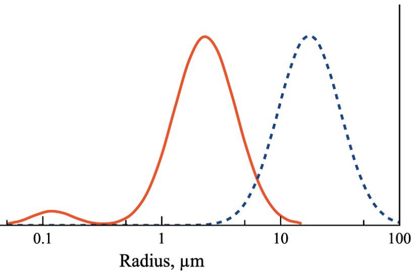
Super coarse dust and dust mixtures retrievals

80% super coarse
+
20% dust

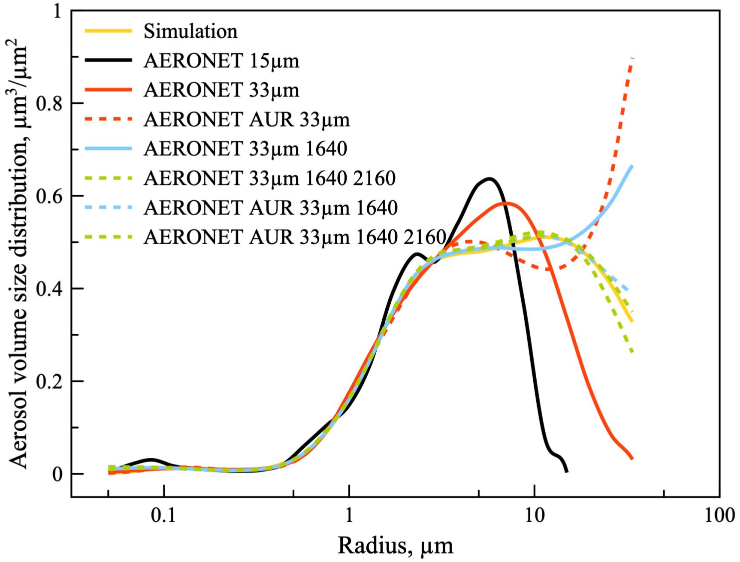


60% super coarse
+
40% dust

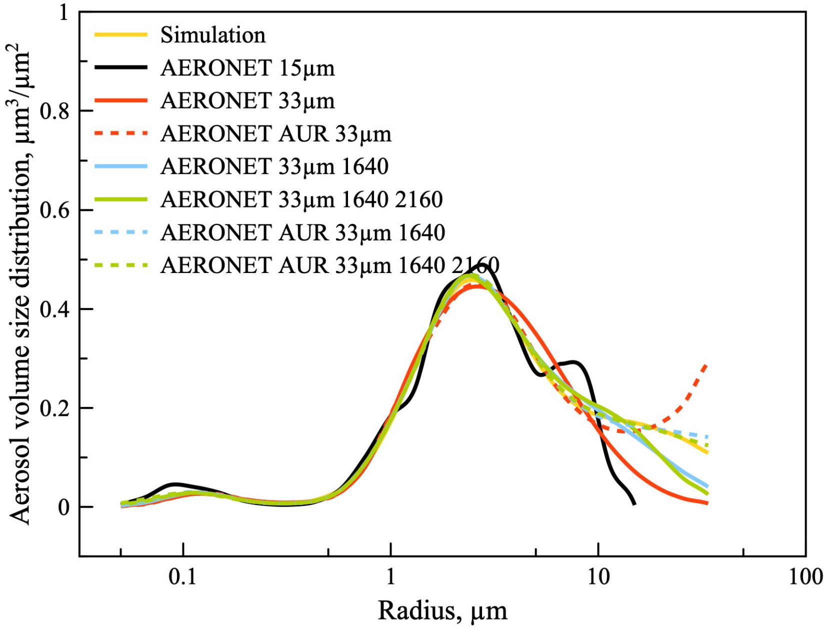




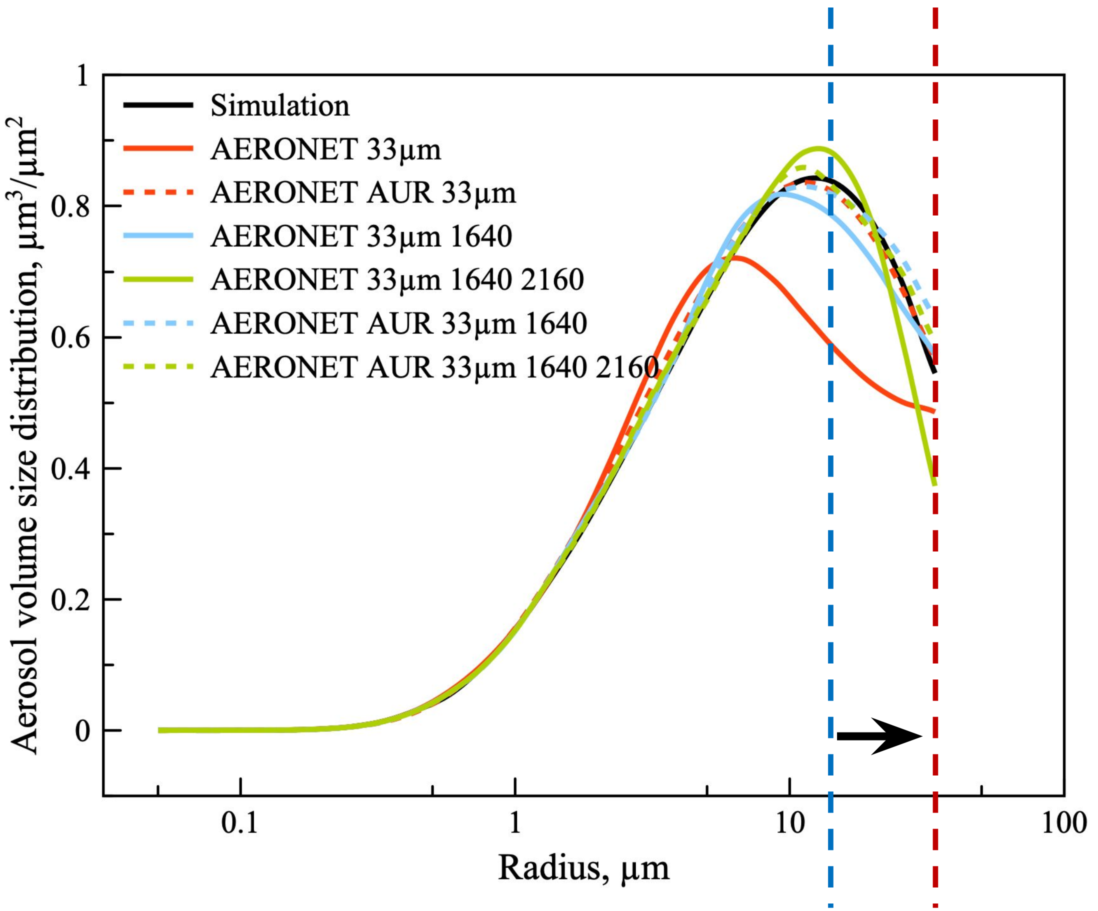
40% super coarse
+
60% dust



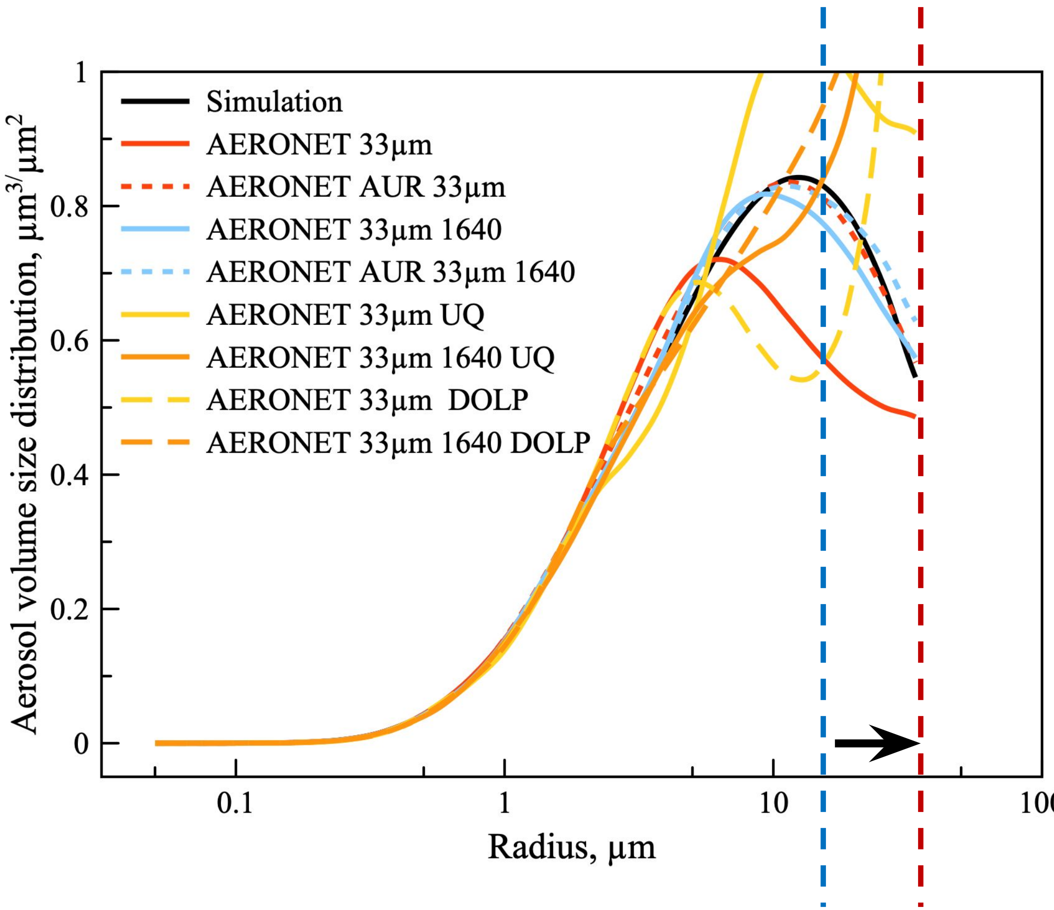
20% super coarse
+
80% dust



Feasibility study to retrieve particles coarser than 15μm (~30), polarization effect



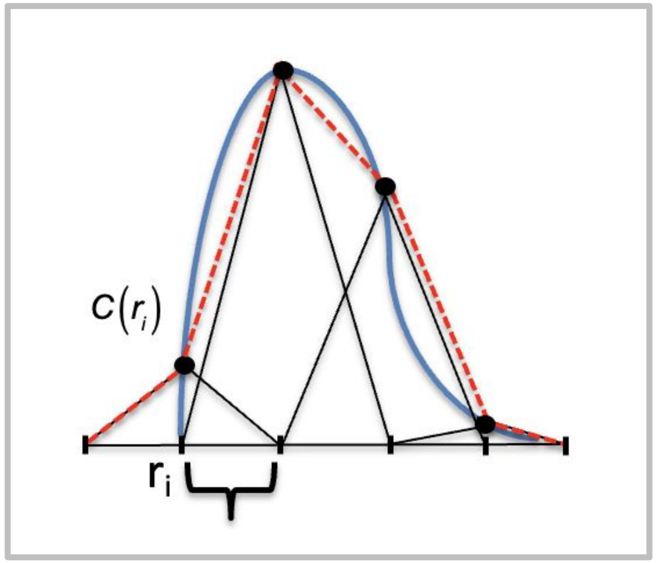
AERONET SD limit



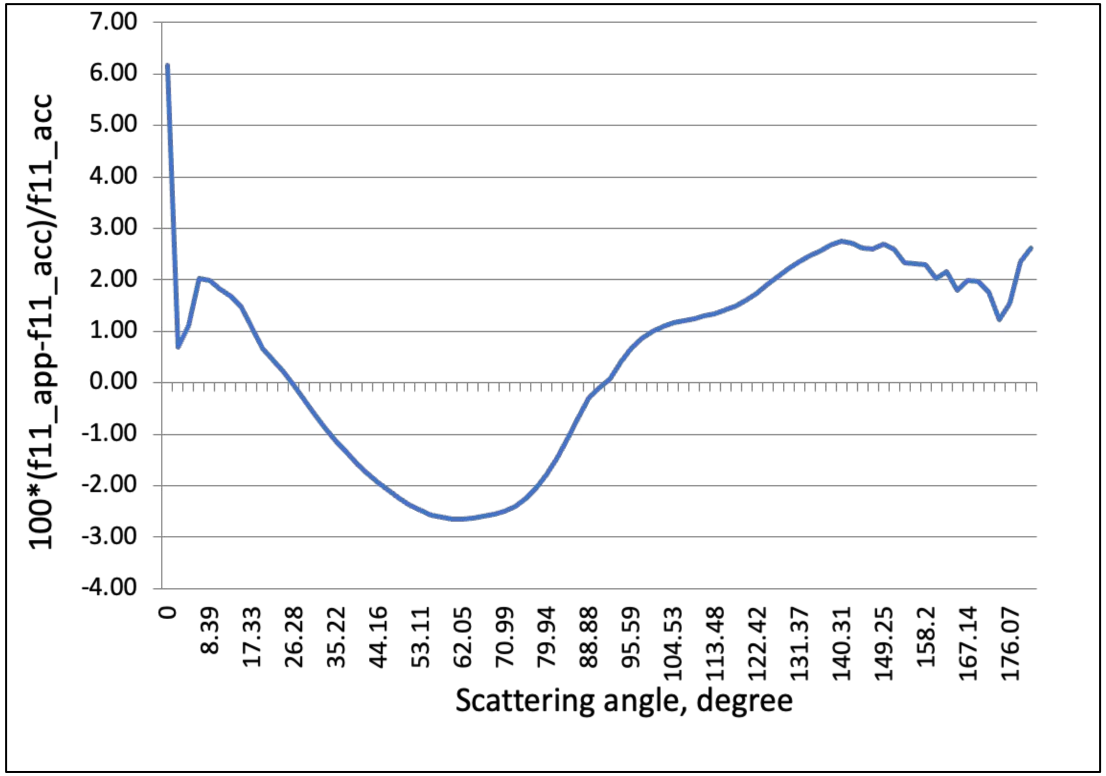
AERONET SD limit

GRASP

Effect of **kernel approximation** on F11: Comparison with Mie



Continental



Dust