Impact de la forme de distribution de taille des gouttelettes sur l'effet radiatif de nuage (dans le spectre solaire)

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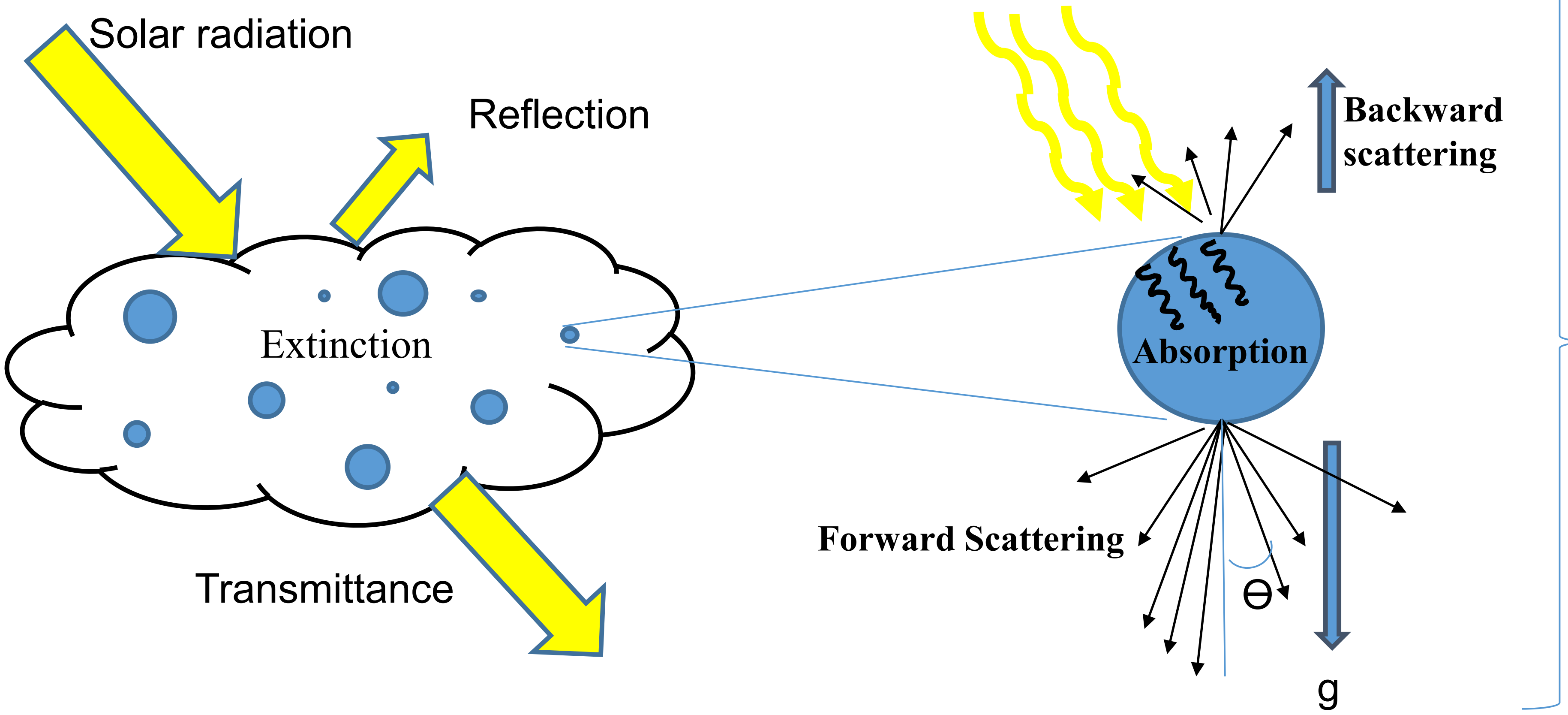
13 Mars 2019
Ateliers de Modélisation de l'Atmosphère



single scattering properties of droplets

Qext→ Extinction Efficiency

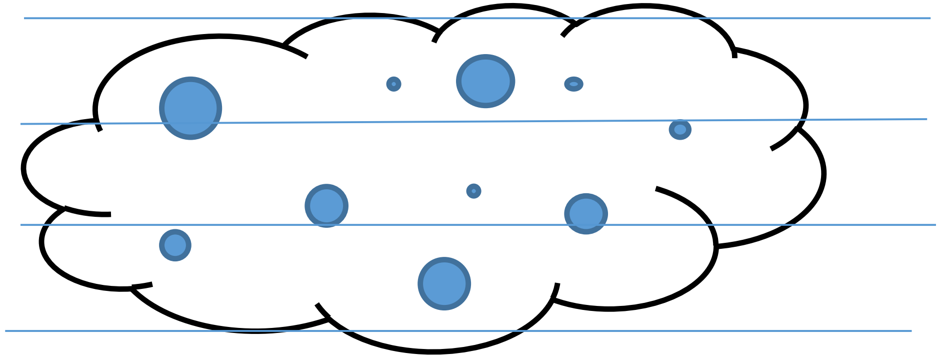
ω:Single Scattering Albedo→ scattering portion of extinction

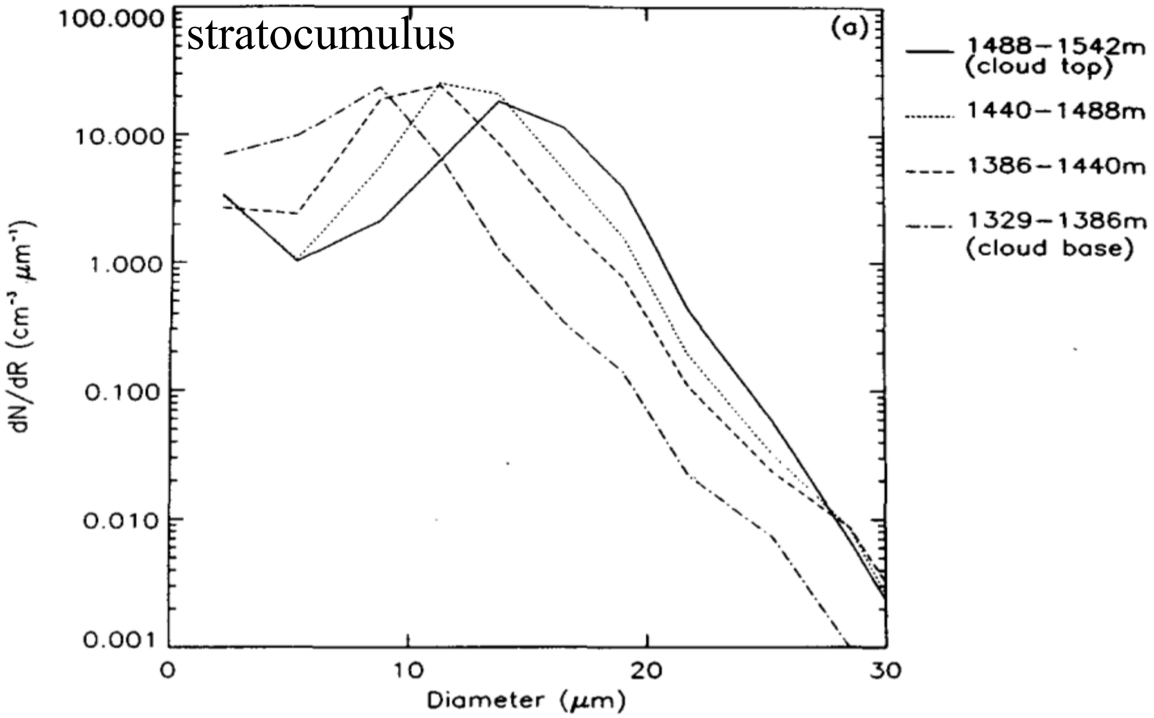
g: asymmetry factor→ Mean of CosΘ the scattering angle

Hypothesis of spherical droplets

Can be calculated by Mie theory for a **defined size spherical particle** for one wavelength

Droplets have various size in each level





Martin et al 1994 .

Estimation of the single scattering properties droplet collection in a cloud???

Application of Mie theory on **Distribution of droplet with different sizes** in a cloud layer → Single scattering properties of that cloud layer

- τ → **optical depth** : Extinction of droplet concentration
- **g_mean** on distribution
- **Mean SingleScatteringAlbedo**

→ Radiative codes in atmospheric models

- Information of droplet size distribution in a cloud is not resolved always in the sub-grid scales
- The Mie approach costs much

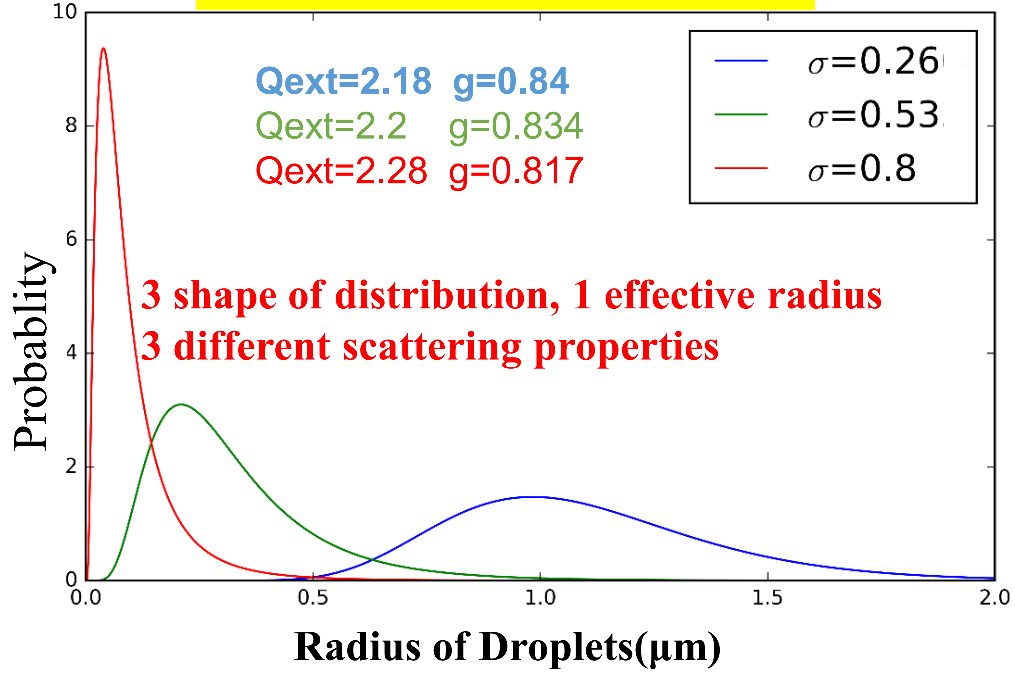
Conventional method of parametrization =effective radius of droplet dependency: $Qext, g, \omega = f(re)$

$$re = \frac{\int_0^{r_{max}} r^3 p(r) dr}{\int_0^{r_{max}} r^2 p(r) dr}$$

Distribution function

Example: Log-normal distribution

For effective radius=8 micron



1. **Is the effective radius sufficient to determine the single scattering properties of a droplet spectra?**
2. **How to account for distribution shape?**

Outline

1. Evaluation of existing conventional parametrizations over the observation

2. Establish a new parametrization which depends on the shape of effective radius + distribution

3. Implementation of this new parametrization in ecRad. Intercomparisons with other parametrizations .

Overview of the Method

- **Dataset for Evaluation:** *Miles et al, 2000* → Droplet size distribution from 94 in situ observations of stratus

- **Existing Parametrizations under evaluation :**
  Nielsen(2014) (IFS radiation code → HARMONIE and AROME)
  SOCRATES *(Edwards and Slingo 1996*) (ecRad code → MesoNH – ECMWF)

- **Choosing Spectral band of interest**

Observed information of distribution function → A reference Method with detailed Mie calculations in each spectral band of interest

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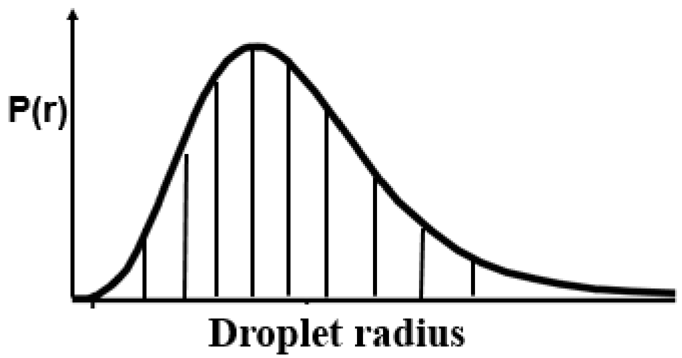
Comparison with the parmaetrizations

Evaluation of existing parametrizations over the observation **Reference calculation method**

Input:Distribution function

1-Averaging on droplet size distribution



Application of **Mie theory** method on each radius bin

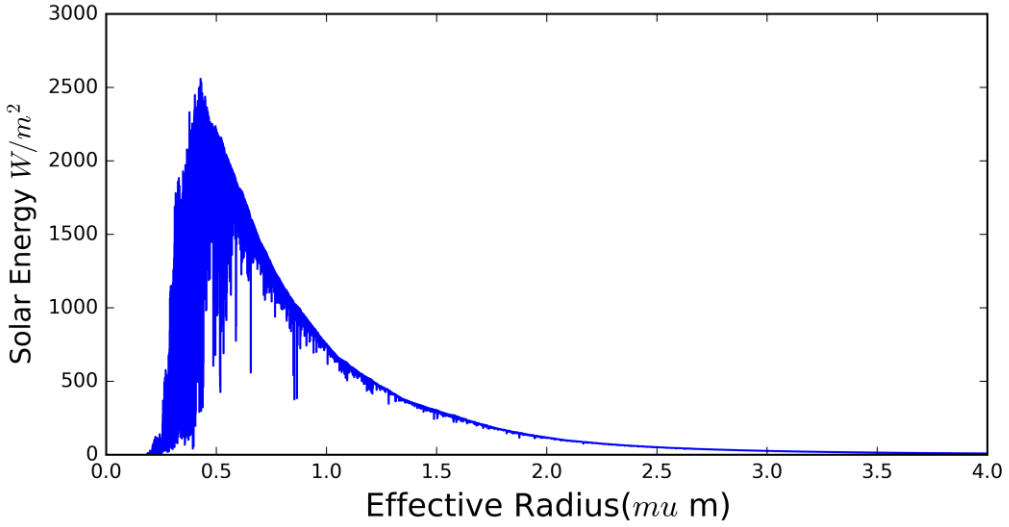
Qext(r), ω(r) ,g(r) for one wavelength

$$Q_{\text{ext}}(\overline{\text{dist}}, \lambda) = \frac{\int_{r_{min}}^{r_{max}} Q_{ext}(r) r^2 p(r) dr}{\int_{r_{min}}^{r_{max}} r^2 p(r) dr}$$

$$g(\overline{\text{dist}}, \lambda) = \frac{\int_{r_{min}}^{r_{max}} g(r) Q_s(r) r^2 p(r) dr}{\int_{r_{min}}^{r_{max}} Q_s(r) r^2 p(r) dr}$$

$$\omega(\overline{\text{dist}}, \lambda) = \frac{\int_{r_{min}}^{r_{max}} Q_s(r) r^2 p(r) dr}{\int_{r_{min}}^{r_{max}} Q_{ext}(r) r^2 p(r) dr}$$

2-Averaging on the bands of wavelength of incident solar radiation



$$Q_{\text{ext}}(\overline{dist}, \lambda) = \frac{\int_{\lambda_{min}}^{\lambda_{max}} Q_{\text{ext}}(\overline{\text{dist}}, \lambda) S(\lambda) d\lambda}{\int_{\lambda_{min}}^{\lambda_{max}} S(\lambda) d\lambda}$$

$$\omega(\overline{dist}, \lambda) = \frac{\int_{\lambda_{min}}^{\lambda_{max}} \omega(\overline{\text{dist}}, \lambda) Q_{\text{ext}}(\overline{\text{dist}}, \lambda) S(\lambda) d\lambda}{\int_{\lambda_{min}}^{\lambda_{max}} Q_{\text{ext}}(\overline{\text{dist}}, \lambda) S(\lambda) d\lambda}$$

$$g(\overline{dist}, \lambda) = \frac{\int_{\lambda_{min}}^{\lambda_{max}} g(\overline{\text{dist}}, \lambda) \omega(\overline{\text{dist}}, \lambda) Q_{\text{ext}}(\overline{\text{dist}}, \lambda) S(\lambda) d\lambda}{\int_{\lambda_{min}}^{\lambda_{max}} omega(\overline{\text{dist}}, \lambda) Q_{\text{ext}}(\overline{\text{dist}}, \lambda) S(\lambda) d\lambda}$$

Output: Mean single scattering properties

Evaluation Method

Distribution function:Lognormal

$$p(r) = \frac{1}{2\pi\sigma}\exp\left(\frac{-[\ln\frac{r}{r_0}]^2}{2\sigma^2}\right)$$

Input to the reference method

94 sets of σ and r0 of observation

$Qext_{MieAdapted}, g_{MieAdapted}, \omega_{MieAdapted}$

$$r_e = r_0 exp(\frac{5}{2}\sigma^2)$$

$$Qext, g, \omega = f(re)$$

$Qext_{Nielsen}, g_{Nielsen}, \omega_{Nielsen}$

$Qext_{SOCRATES}, g_{SOCRATES}, \omega_{SOCRATES}$

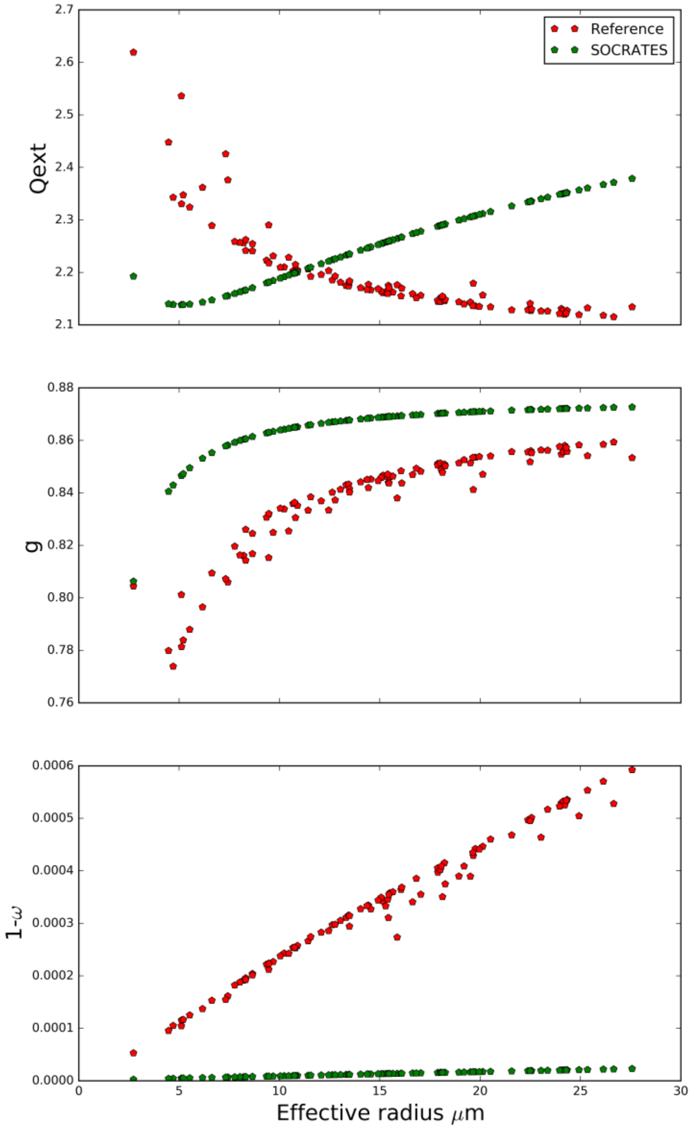
On the same Spectral band

Evaluation of existing parametrizations over the observation **Results**

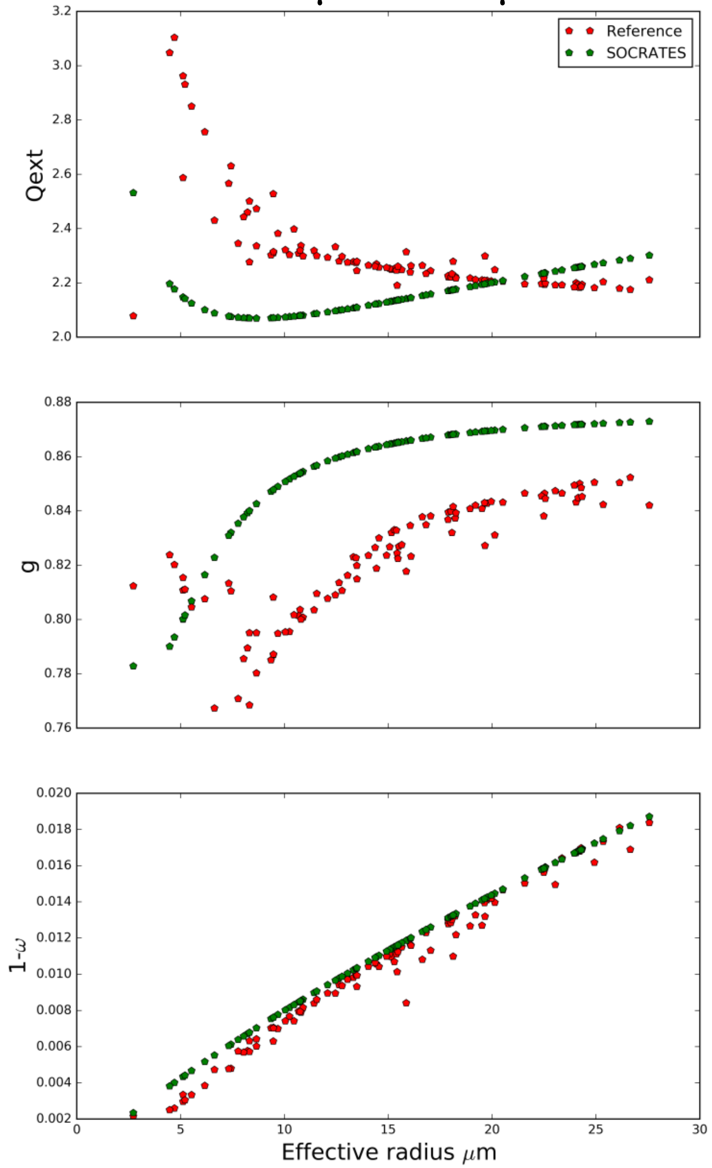
Error on all bands

Band spectral

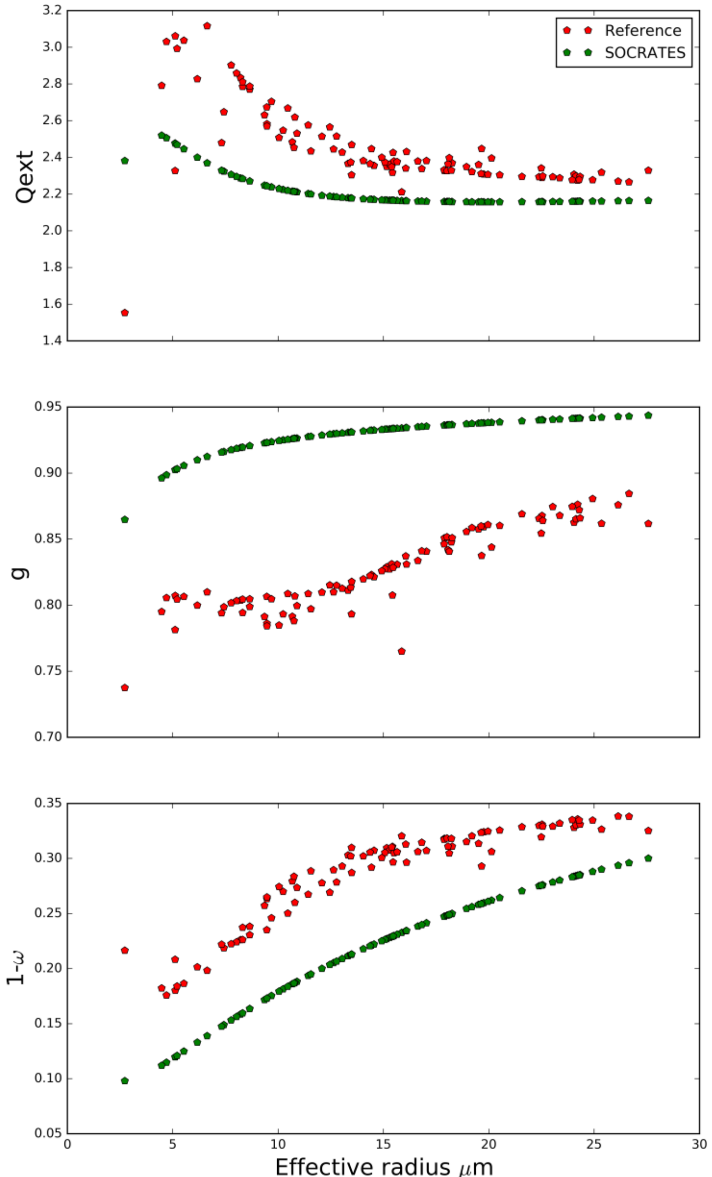
0.625µm 0.778 µm



1.29µm 1.62 µm



2.5µm 3.07 µm



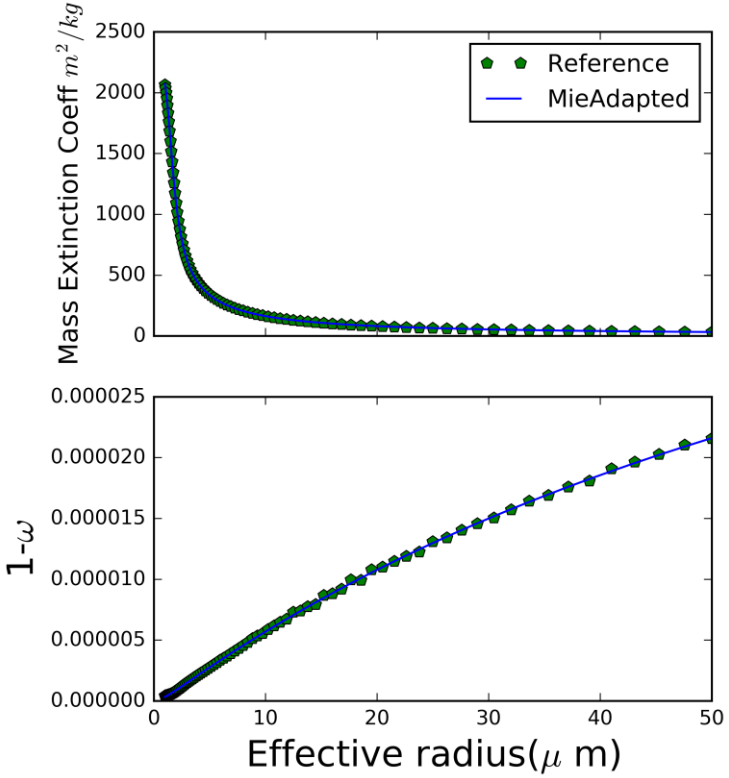
Establishing a new parametrization and some of the fit results

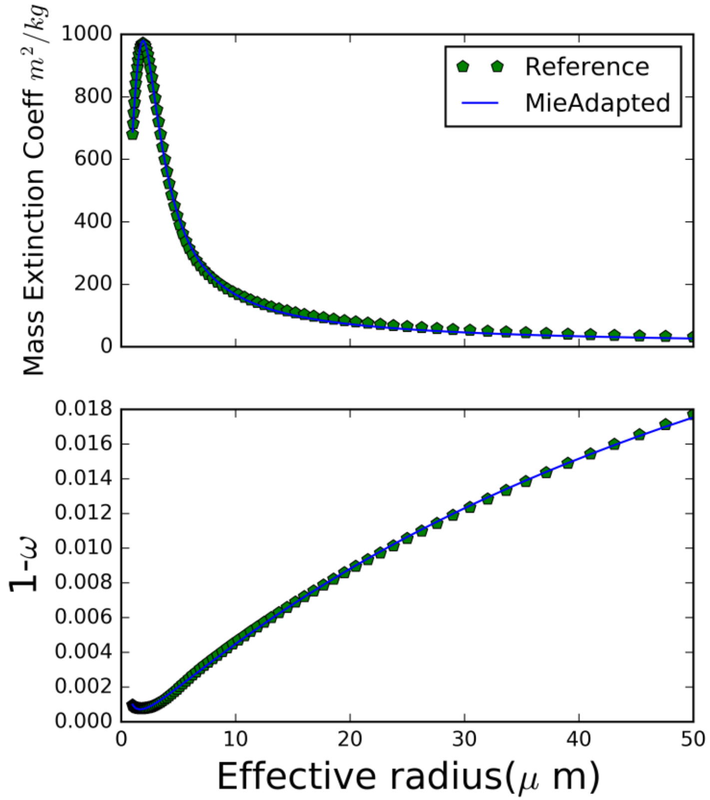
For 4 σ: 0.1 - 0.36 – 0.63 – 0.9
On droplet radii range of 1μm to 50 μm
and All of the ecRad 14 spectral band

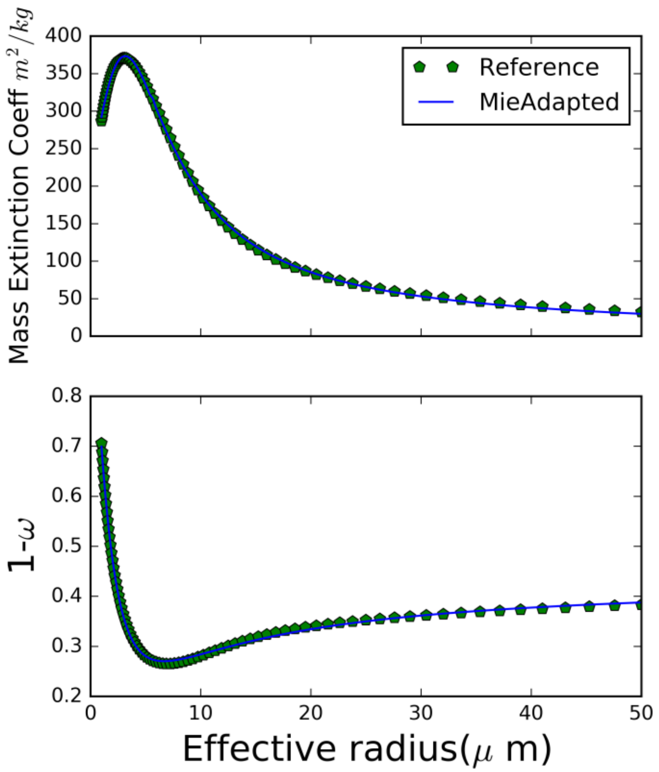
→ Reference calculation and fit on results

→ New parametrization :MieAdapted
$Qext, g, \omega = f(re)$
For each of 4 σ

Fiting results for σ=0.36







Band spectral 0.625μm 0.778 μm 1.29μm 1.62 μm 2.5μm 3.07 μm

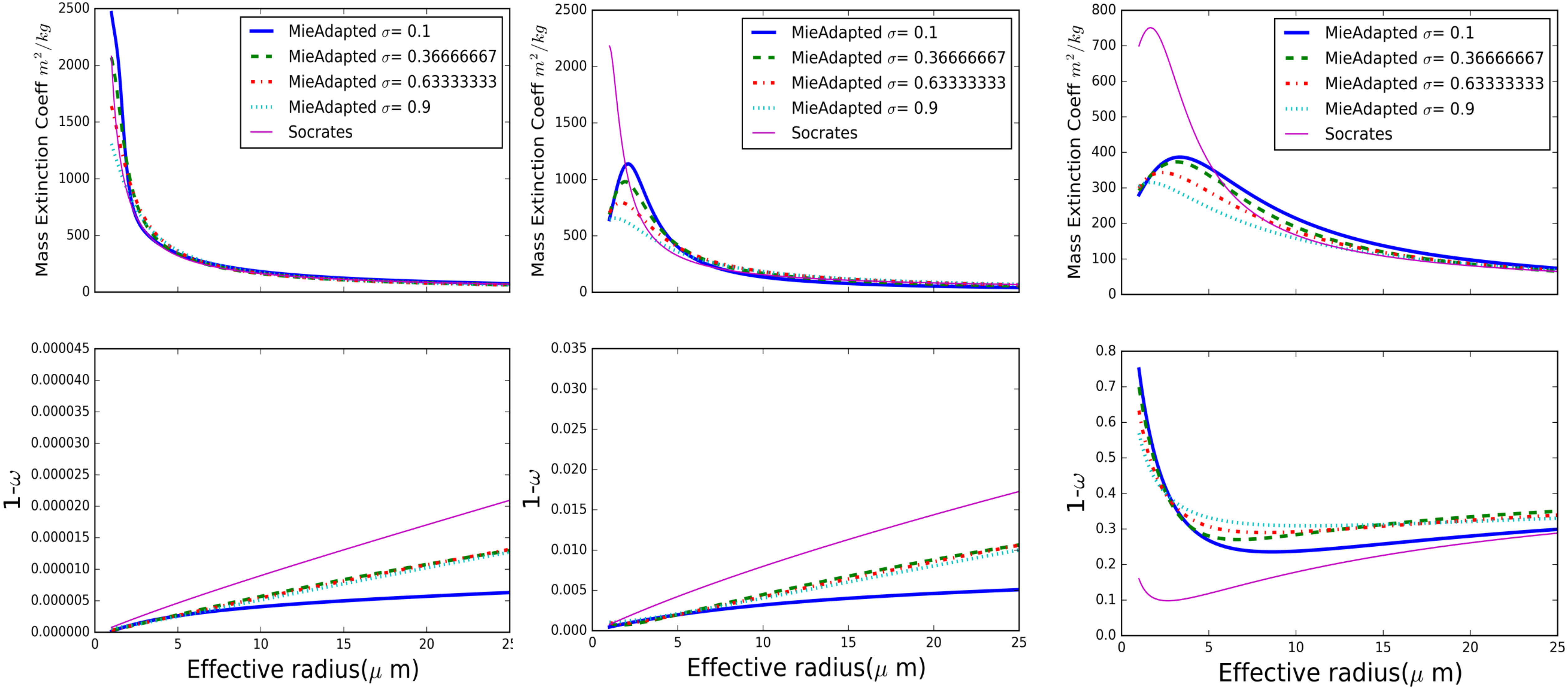
Comparing 4 σ and SOCRATES parametrization

Spectral bands:

0.625µm 0.778 µm

1.29µm 1.62 µm

2.5µm 3.07 µm

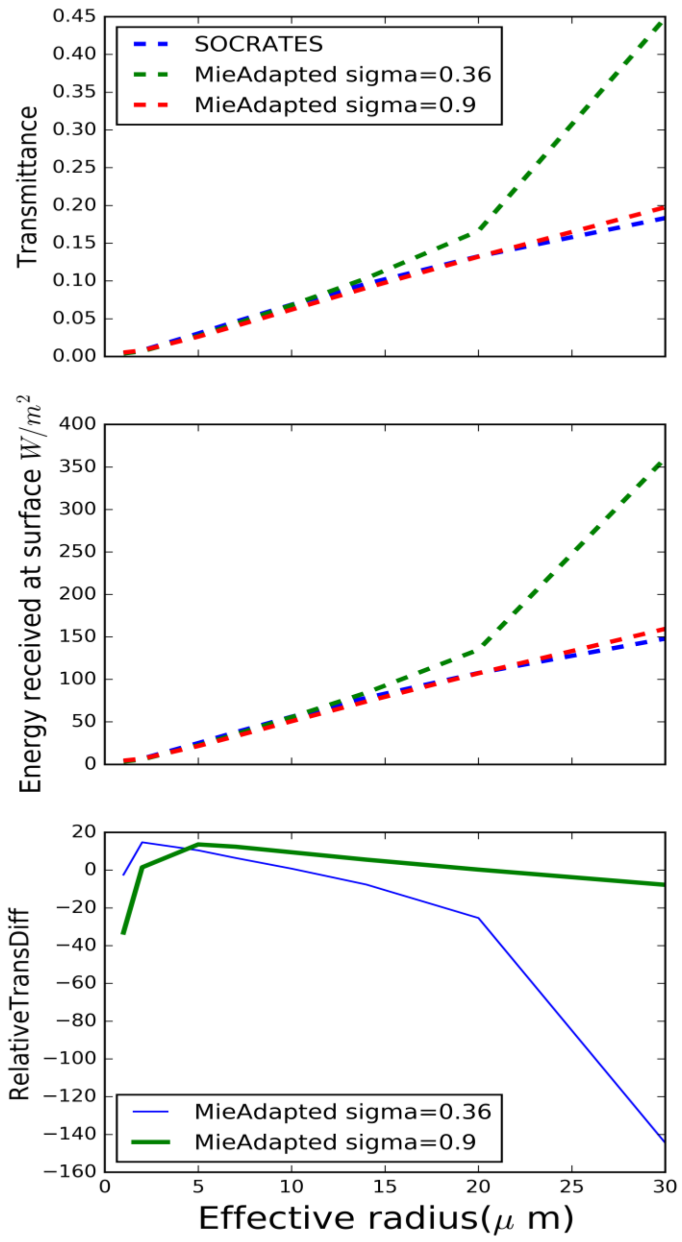


Implementation of new parametrization on ecRad and Intercomparison with SOCRATES

For a cloud with 1400m thickness
And LWP of 1.26 $\frac{kg}{m^2}$

- The results for σ = 0.9 More close to SOCRATES

- Up to 40% difference with Socrates in small particles



Prospective

- Application of different type of clouds and other distribution functions in our method

- Using the a two moment microphysical scheme (LIMA for example)to get more information about σ

Thanks for your attention!