# The Tables of Aerosol Optics (TAO) Project

A23P-2576

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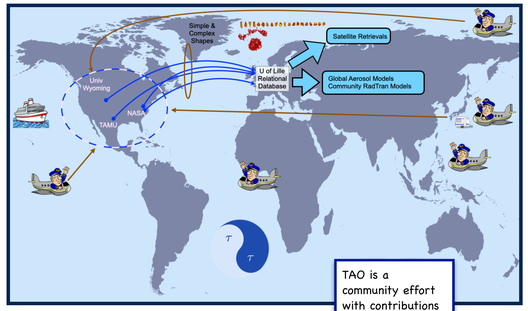
## What TAO has now, and how you can get it

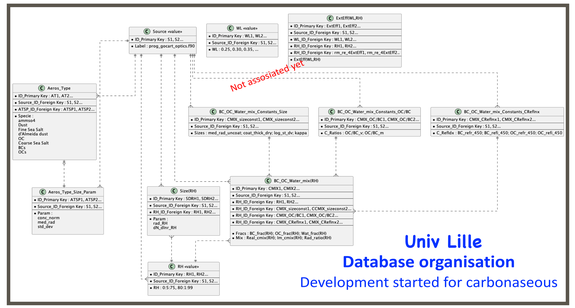
We have created aerosol optical tables that include mass extinction, absorption, and backscatter coefficients, single-scatter albedos, asymmetry parameters, lidar ratios, etc. But we are still building, and we seek your help in establishing a community database.

- Computations at 61 OPAC wavelengths from 0.25 to 40 um and common remote sensing wavelengths.
- We will eventually make recommendations about how to proportion species for the different aerosol types.
- TAO is located on a NASA google drive while we get started. Contact gregory.l.schuster@nasa.gov or mira_crew@lists.nasa.gov for access.

| TAO Aerosol Species | Aerosol Type | | | | | Citations |
|---|---|---|---|---|---|---|
| | Bio Burn | Urban | Dust | Marine | Bckgrnd | |
| Externally-mixed Black Carbon | √ | √ | | | √ | **3 BC SDs & 1 BC Complex RI:** |
| Internally-mixed Black Carbon | √ | √ | | | √ | Schwarz (GRL, 2008), Bond & Bergstrom (AST, 2006) |
| Water-insoluble Brown Carbon | √ | | | | √ | **36 SDs & hygroscopicities:** Rissler (ACP 2006) |
| Water-insoluble White Carbon | √ | √ | | × | √ | **4 complex refractive indices:** |
| Water-soluble Brown Carbon | √ | | | | √ | Sun (GRL 2007), Sutherland and Khanna (AST 1991) |
| Water-soluble White Carbon | √ | √ | | × | √ | Dick (JGR 2000; AST 2007), Dinar (Faraday Discuss. 2008) |
| Sulfates | | × | | × | × | Gosse (Appl Opt, 1997) |
| Nitrates | | × | | | × | Gosse (Appl Opt, 1997), Jarzembski (Appl Opt, 2003) |
| Sodium Chloride | | | | × | × | Irshad (ACP, 2009) |
| Internal mix of clays + $FeO_x$ | | | √ | | | **8 GEOS-GOCART SDs**: Chin (Ann Geophys, 2009) **2 Complex RI and Hexahedras:** Saito (JAS, 2021) |

✓ symbols — at least one calculation available in TAO; X symbols — species that still need to be calculated.




## What is TAO?

- TAO is an extensive set of aerosol single-scatter computations (e.g., Mie theory) that transform particle size and composition into mass-normalized optical properties like extinction, absorption, and angular scattering.
- Global models use such tables to quickly compute upwelling and downwelling radiative flux at wavelengths that range from ~0.25 to 40 um.
- These optical tables must also accommodate the full range of relative humidities for hygroscopic particles.
- The most common optical tables used by modelers today are the Optical Properties of Aerosols and Clouds, or OPAC (Hess etal, BAMS 1993). However, OPAC was published more than two decades ago, so it pre-dates all of the atmospheric measurements obtained in this century.
- TAO is an update to OPAC, but it is not OPAC 2.0 or 5.0. As far as we know, there is no effort to build upon original OPAC no longer has an effort.

## What's new since last year?

- Derimian, Ducos, and Lesueur at University of Lille are building a relational database (initial diagram above).
- Schuster, Stamnes, and Chemyakin at NASA LaRC and Moosmuller at DRI have computed optical properties of bare BC aggregates (discussed in this poster).

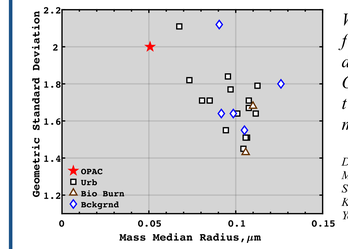
## What TAO seeks from the community

- Measurements of aerosol size distributions and complex refractive indices that are regionally representative.
- Single-scatter computations, especially for complex shapes.
- Special orders — if your favorite model needs something and it is missing in TAO, please let us know!

## Fractal Black Carbon Computations

### Motivation

Long ago, Bond and Bergstrom (AST, 2006) recommended a Mass Absorption Coefficient $MAC_{bc}$ = 7.5±1.2 m²/g for fresh black carbon (BC). Unfortunately, it is not possible to compute $MAC_{bc}(550)$ = 7.5±1.2 using Mie theory with measured BC microphysics (i.e., size distributions and density) and the refractive indices recommended by BB06. Thus, we seek improved MACs by using the publicly available Multi-Sphere T-Matrix (MSTM) code to compute $MAC_{bc}(550)$ BC.




*We computed optical properties for 22 black carbon size distributions. Note that the OPAC SD is smaller and wider than modern SP2 measurements.*

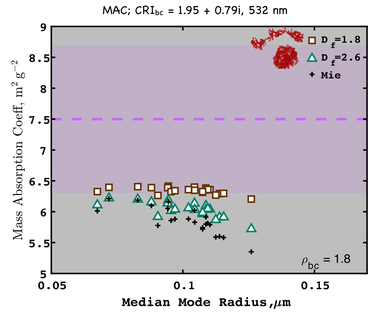
*Data from Hess (BAMS 1998; OPAC), Moteki (GRL 2007), Schwarz (GRL 2008, 2010), Kondo (Aer Sci Tech, 2011), Yoshida (Aer Sci Tech, 2020).*

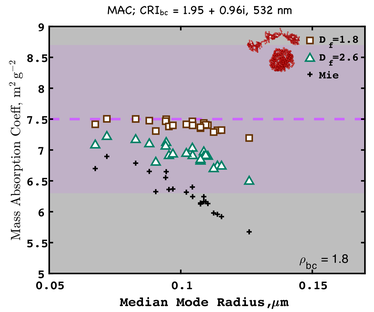
### Methodology

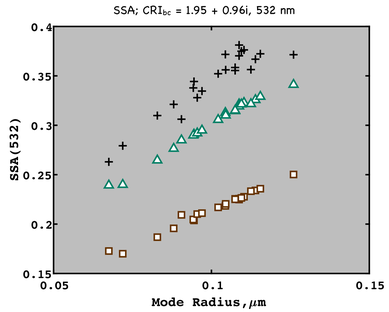
- Assume bare BC particles are aggregates of 20-nm radius spherules.
- Particle-cluster growth
- Two fractal dimensions: $D_f$ = 1.8 and 2.6 for fresh and aged aggregates.
- BC density = 1.8 g/cm³
- 21 measured size distributions, mostly SP2 measurements.
- Two complex refractive indices: 1.95 + 0.79i (BB06) and 1.95 + 0.96 (Moteki, AST 2023).
- Multi-Sphere T-Matrix code (Mackowski & Kolokolova (JQSRT, 2022; https://github.com/dmckwski/MSTM)

### Results

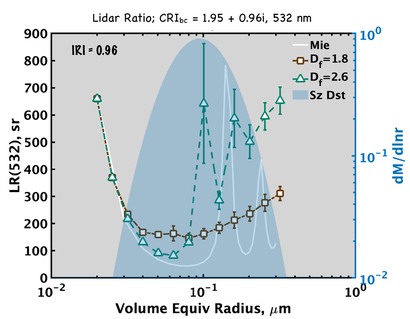
- Although the fractal shape improves the computed MAC, none of the three shapes can produce MAC = 7.5 m2/g using the $CRI_{bc}$ = 1.95 + 0.79i (left panel).
- However, the recent measurements of $CRI_{bc}$ = 1.95 + 0.96i yields MACs consistent with 7.5 m²/g for fresh BC (i.e., Df = 1.8).
- Aged/collapsed aggregates have a decreased MAC, but we have not modeled the coatings that accompany aged BC in this first round.
- Single-scatter albedo of aggregates are significantly lower than Mie theory (right panel).

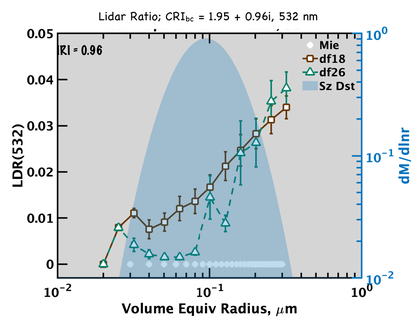



- Significant shape-dependence for lidar ratios of single particles (lower left; not integrated over size, yet).
- Linear depolarization ratios are small for all particle sizes that we computed using $CRI_{bc}$ = 1.95 + 0.96i.




## Goals

- Test sensitivity to spherule size (15-25 nm).
- Test Moteki (JAS, 2010) BC refractive index.
- Then compute optical properties with full phase matrices at 30 remote sensing wavelengths in UV-VIS-NIR.
- Repeat calculations for longwave wavelengths.

Aggregate computations are slow, so this will take a long time. Want to get involved in TAO and help? Contact gregory.l.schuster@nasa.gov or mira_crew@lists.nasa.gov.