Discussion

dust lifetime and size distribution

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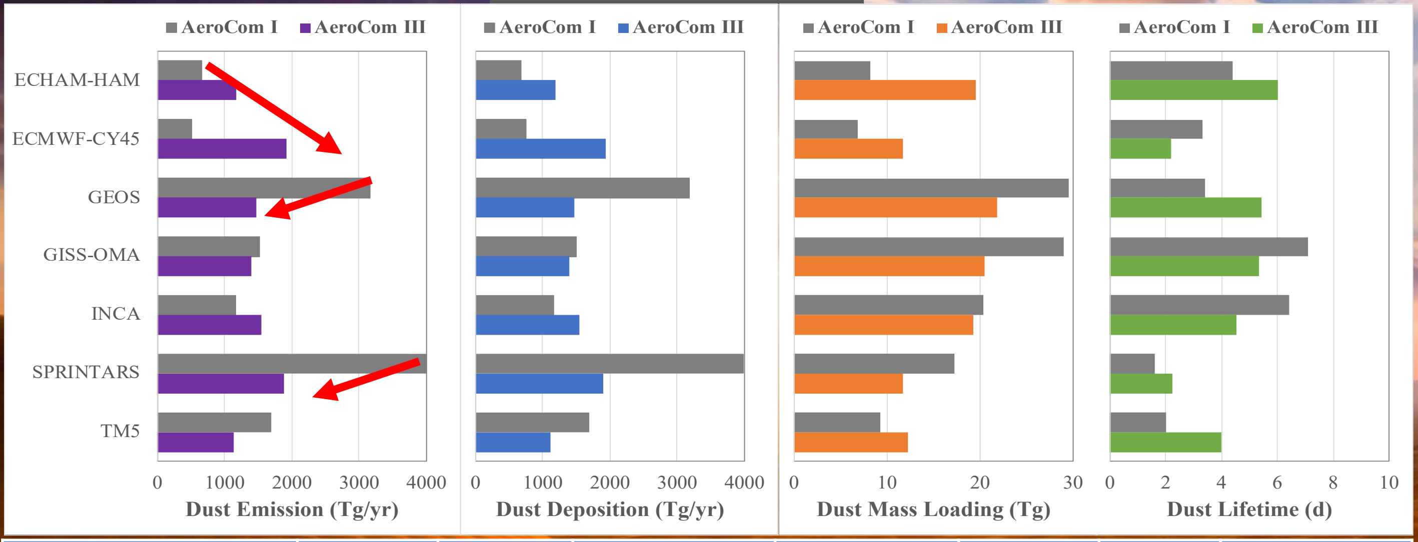
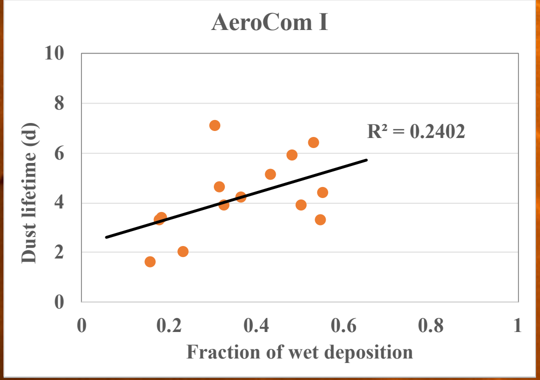
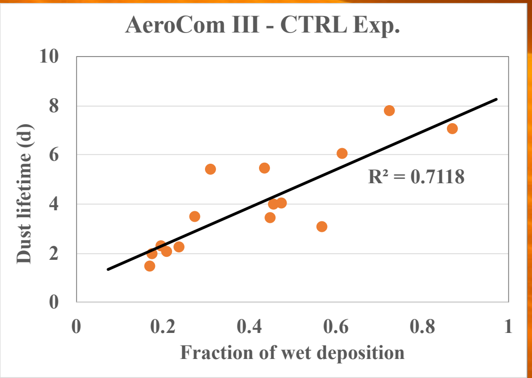
Evolution of dust modeling in AeroCom era

Global dust

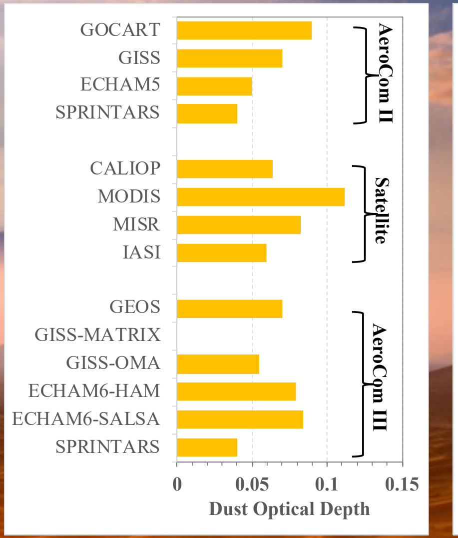


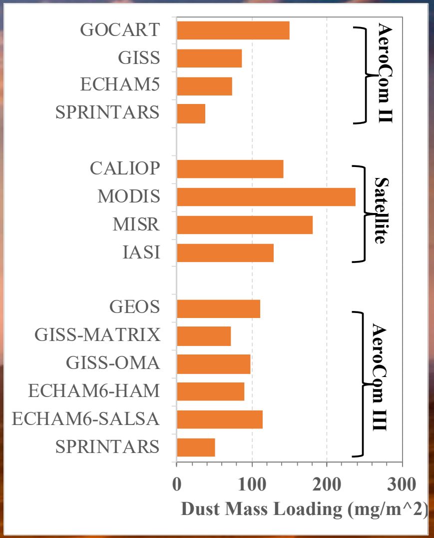
Diversity (%)	Emis.	Load	Wet dep	Dry dep	DOD	MEE	Lifetime
AeroCom I	60	38	54	76	38	49	37
AeroCom III	66	31	43	99	23	41	44

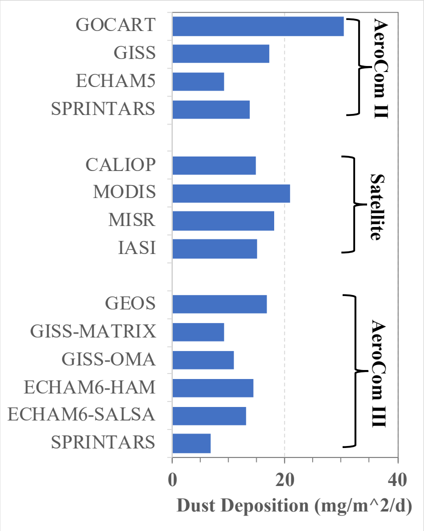


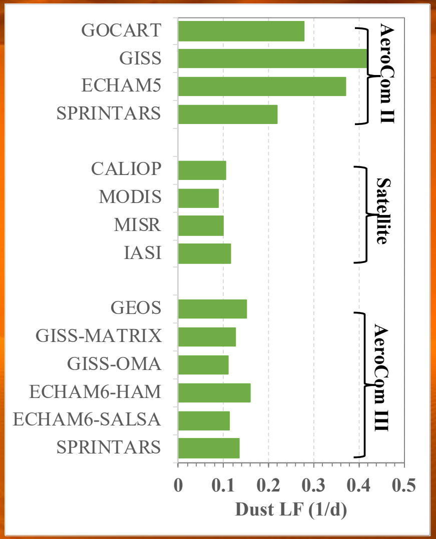


Trans-Atlantic dust



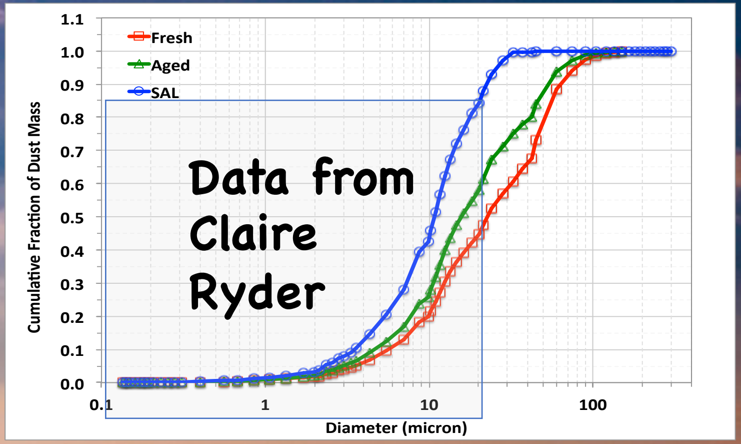


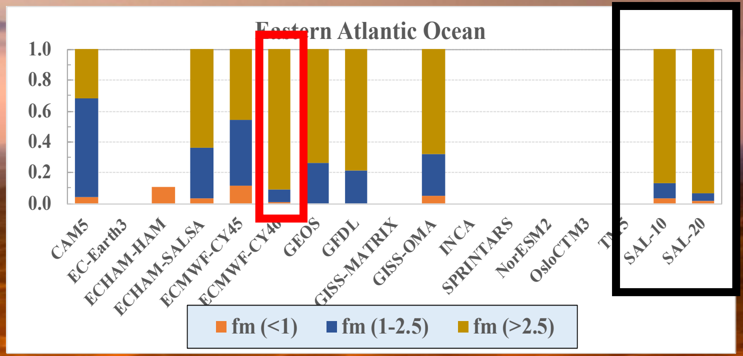


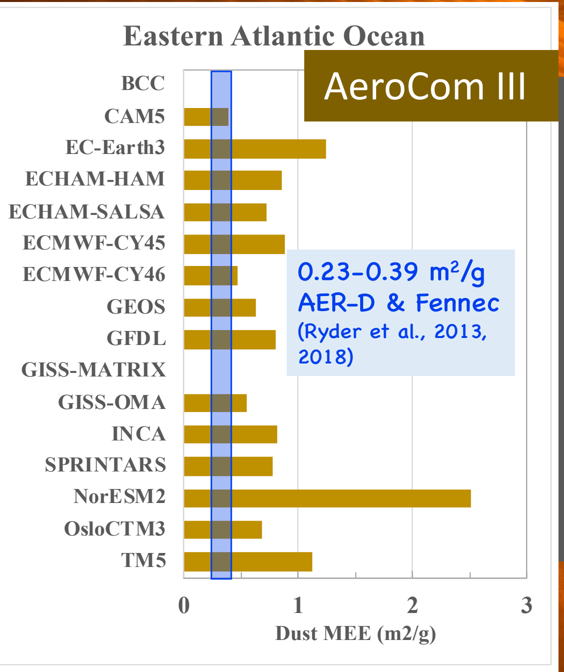


Remaining Issues [1]

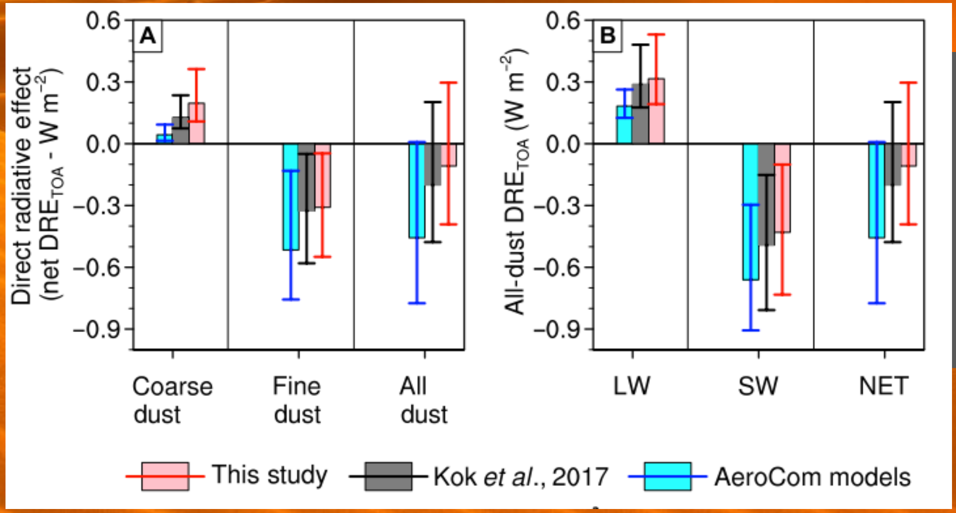
- Giant dust particles (e.g., >20μm) are generally not accounted for in models; some models cut off at ~10μm.
- Modelled dust size is biased to small particles – except ECMWF-CY46.
- How coarse/giant particles can survive for long-range transport remains a mystery.







Mass extinction efficiency biased high (complicating model-satellite comparison)



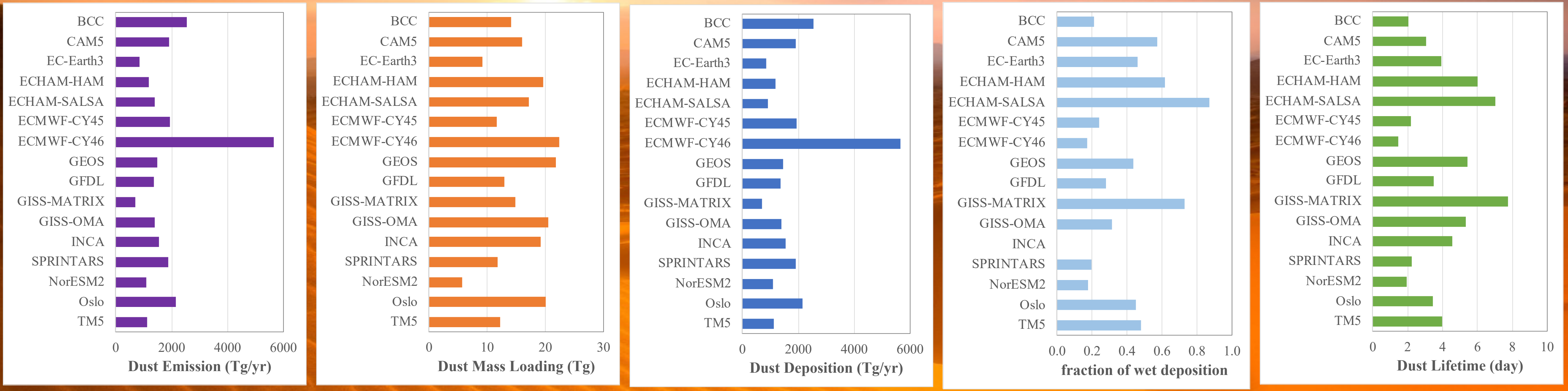
Net radiative effect biased to a stronger cooling

Adebiyi & Kok (2020)

Remaining Issues [2]

Many dust quantities still vary substantially among models

AeroCom III CTRL exp. results – global average

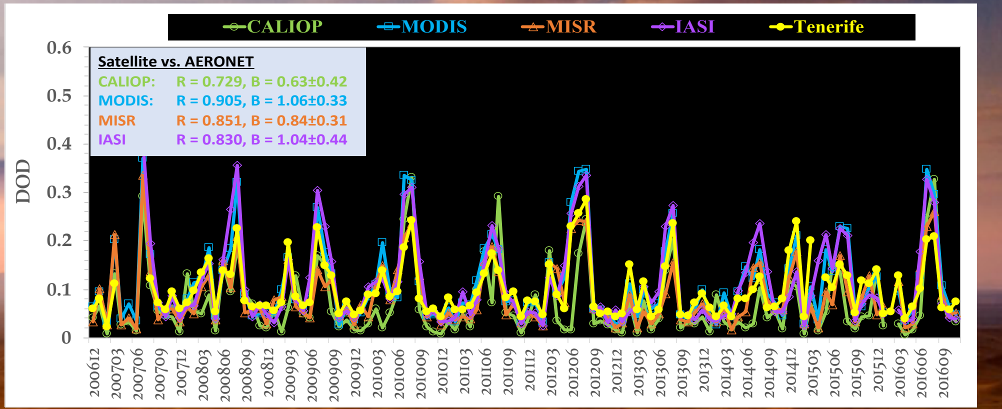


AeroCom III	Emis.	Load	Dep.	Wet dep	Dry dep	fwet	DOD	MEE	Lifetime
Diversity (%)	66	31	68	43	99	48	23	41	44

Evaluation Issues (1)

We don't have and will never have adequate observations to thoroughly evaluate the dust lifecycle. Need to bear in mind the underlying assumptions and uncertainties.

- No size-resolvable dust emissions.
- Coarse particles are under-sampled or not sampled at all by inlets.
- In-situ observations of dust concentration and deposition are scarce.
- Dust optical depth derived from remote sensing observations (e.g., size- or shape-based) is a "proxy", not the ground truth.
- Currently, AOD assimilation doesn't necessarily impose strong constraints on dust.
- Recently, DustCOMM combines AOD reanalysis and constraints of dust size, shape and refractive index to derive mass loading, which would be more reliable in source regions than over oceans.



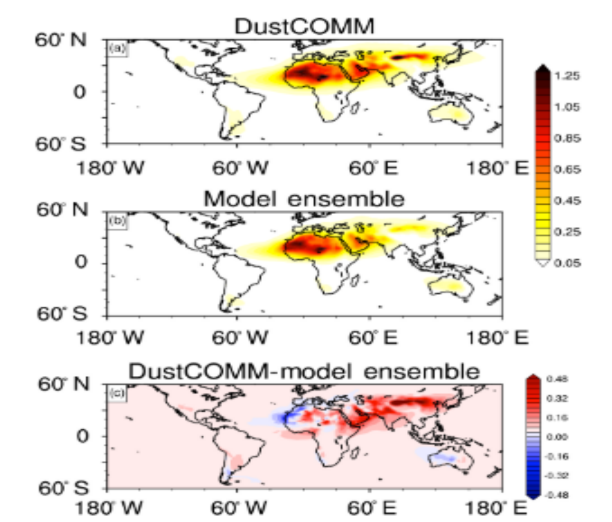
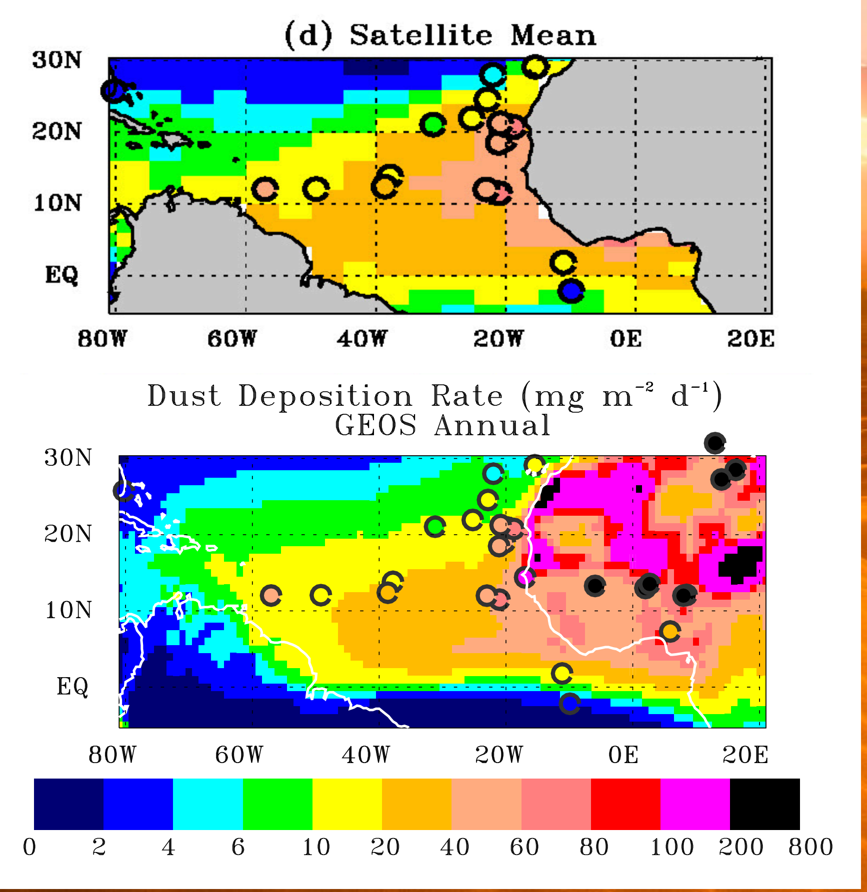


Figure 10. Spatial distributions of the atmospheric dust column loading ($g\,m^{-2}$) for the **(a)** DustCOMM and **(b)** model ensemble estimates and **(c)** the difference between the two (DustCOMM−model ensemble).

Adebiyi, Kok, et al. (2020)

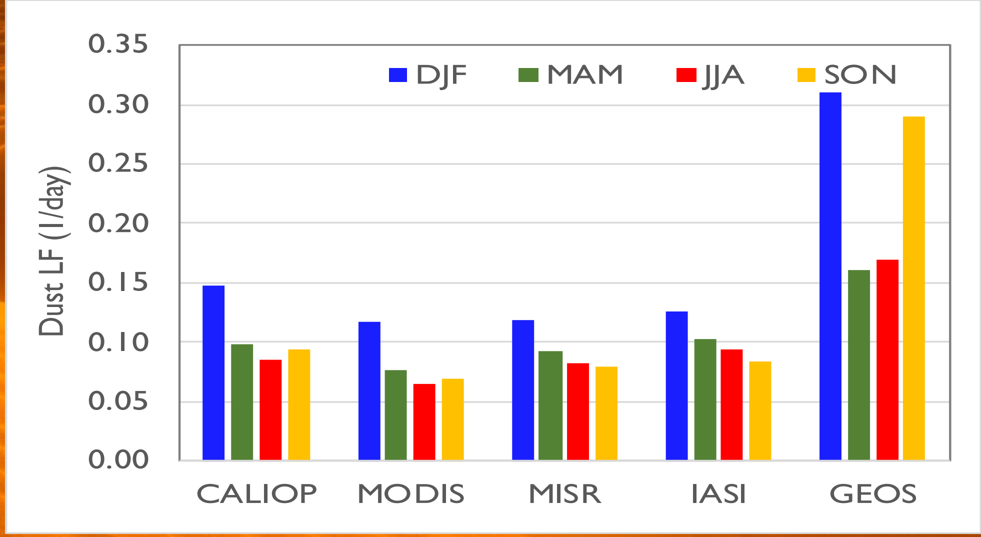
Evaluation Issues (2)

Dust deposition



dust Loss Frequency (LF) = $\frac{\text{Dust Deposition Rate}}{\text{Dust Mass Loading}}$

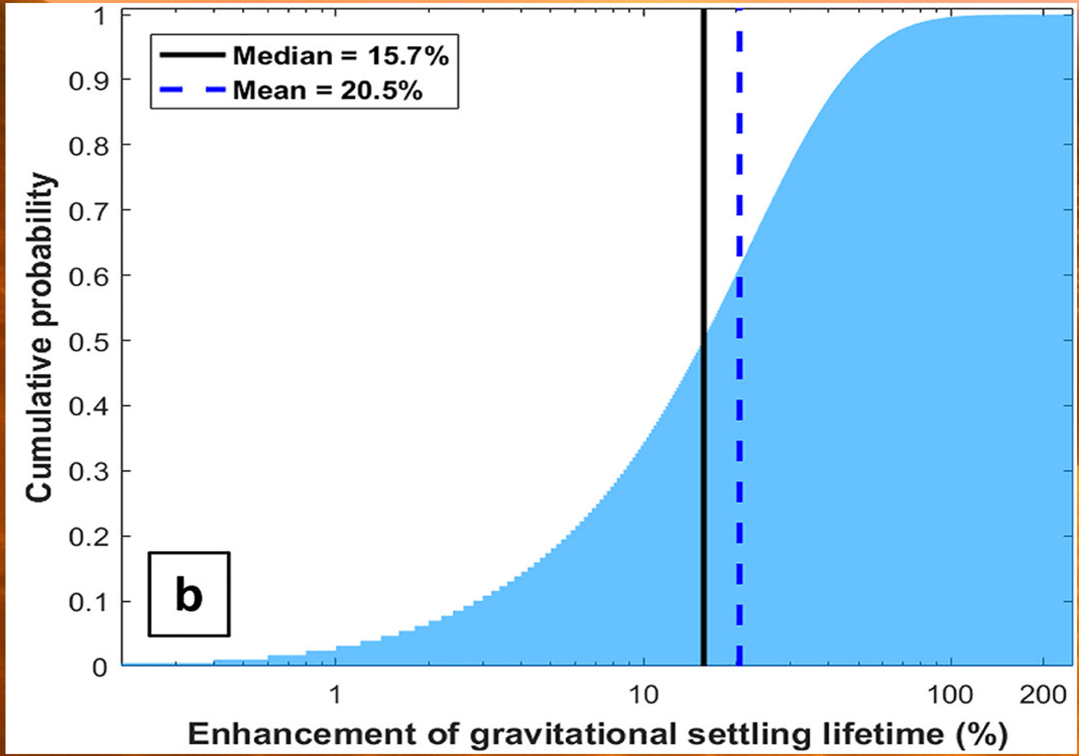
- how fast dust is removed from the atmosphere
- a reciprocal of dust residence time
- more accurate than dust deposition and mass loading
- not available from other means
- useful for isolating uncertainty of transport/removal from that of emissions



Loss frequency for trans-Atlantic dust

Proposed AeroCom Modeling Activities

- ❑ Extend dust cutoff size to 20 or even 30 microns
- ❑ Account for non-spherical shape when calculating gravitational settling *(dry deposition has the highest diversity among AeroCom III models)*



Huang & Kok (2020, GRL)
Accounting for the triaxial ellipsoidal particles (other than spherical or spheroid) could decrease gravitational settling velocity by 15% and increase associated lifetime by 20%.

Aspect Ratio (AR)
Height-Width Ratio (HWR)

❑ Conduct model sensitivity tests on wet removals

GEOS experiments

- Exp4 – f_{con}=1.0, f_{wet}= 0.3
- Exp5 – f_{con}=0.2, f_{wet}= 0.8
- Exp6 – f_{con}=0.1, f_{wet}= 0.5