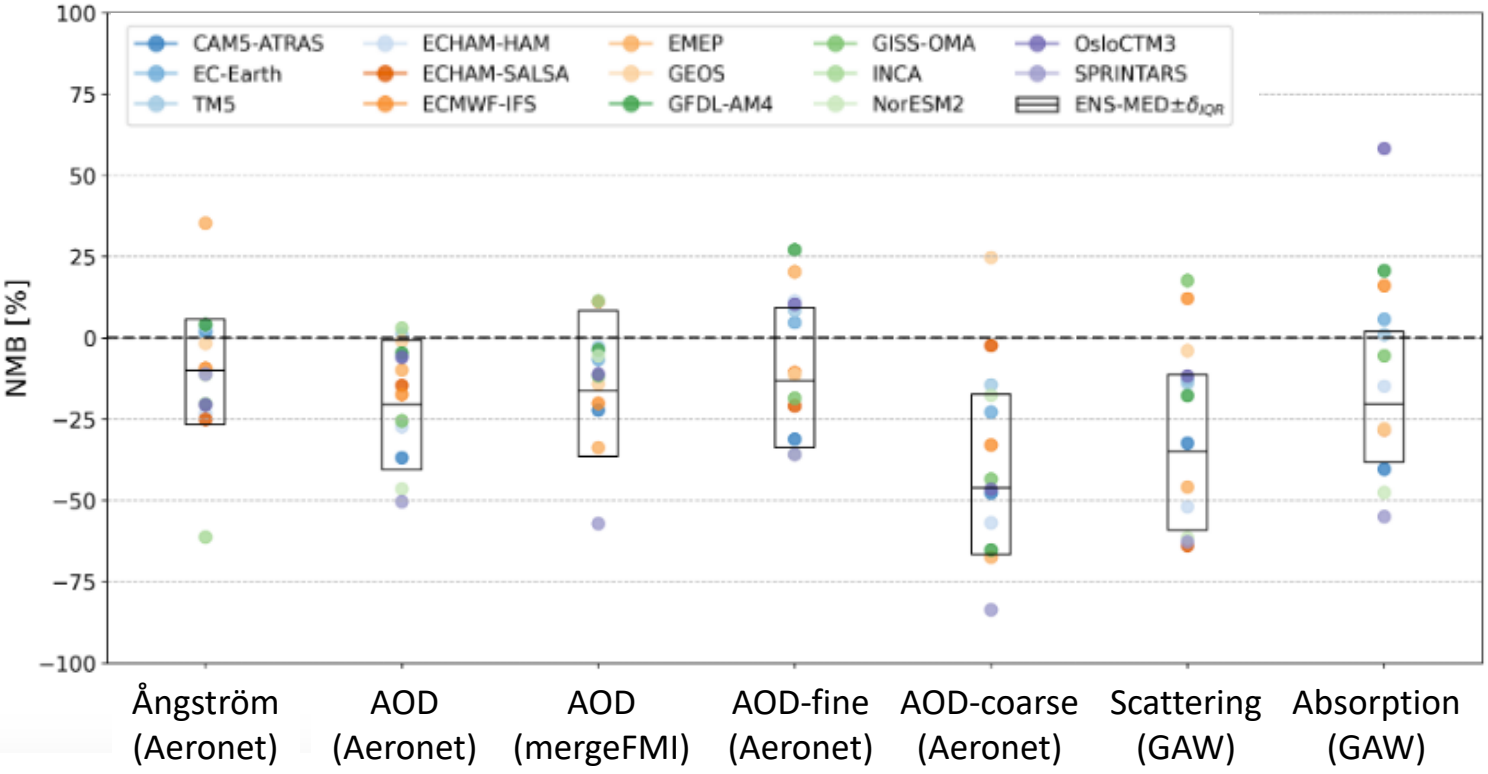
Aerocom Phase III evaluation with optical property observations

Gliss et al., 2020 (in review for ACP)

AP3 models tend to underestimate all aerosol optical properties investigated:

- AOD (total/fine/coarse)
- column extinction Ångström exponent,
- In-situ aerosol surface scattering and absorption coefficients (low RH ("dry"))



Betsy Andrews (presenter)

Implication: If fine mode AOD is a proxy for present day aerosol forcing estimates

→models underestimate aerosol forcing by circa -15% (IQR: -35% and +10%)

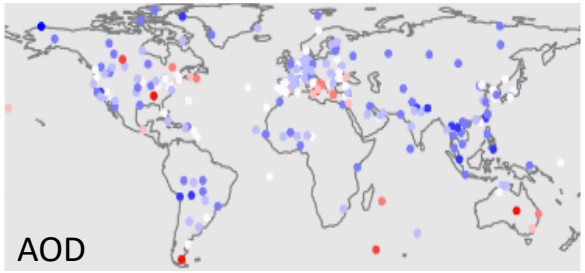
Size matters

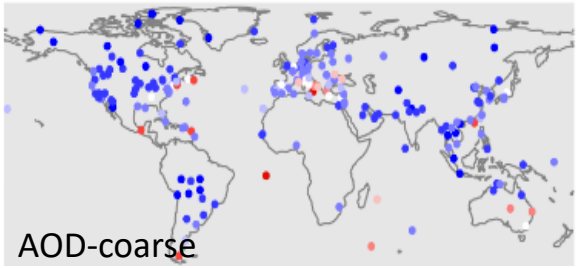
Model over/underestimates of AOD (tot/fine/coarse) and Ångström exponent are site-specific.

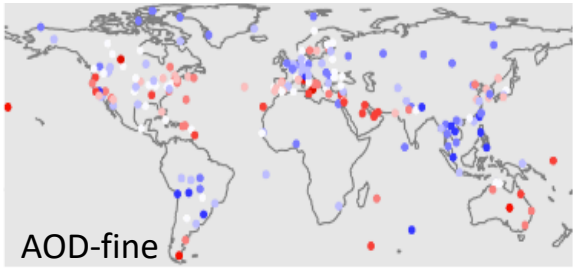
But – *in general* – for the ensemble model*:*

- Underestimate of AOD-coarse is larger than model underestimate of total AOD
- AOD-fine underestimate is similar to the total AOD underestimate

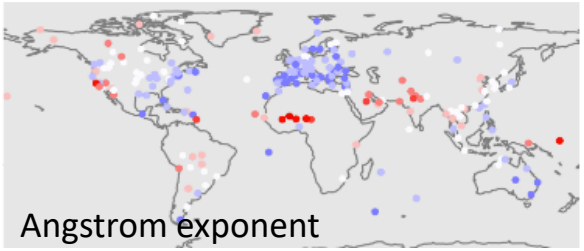
→suggests models underestimate coarse mode aerosol.







Ensemble model underestimate AE by about 10-20%
→suggests models overestimate large aerosol contribution.



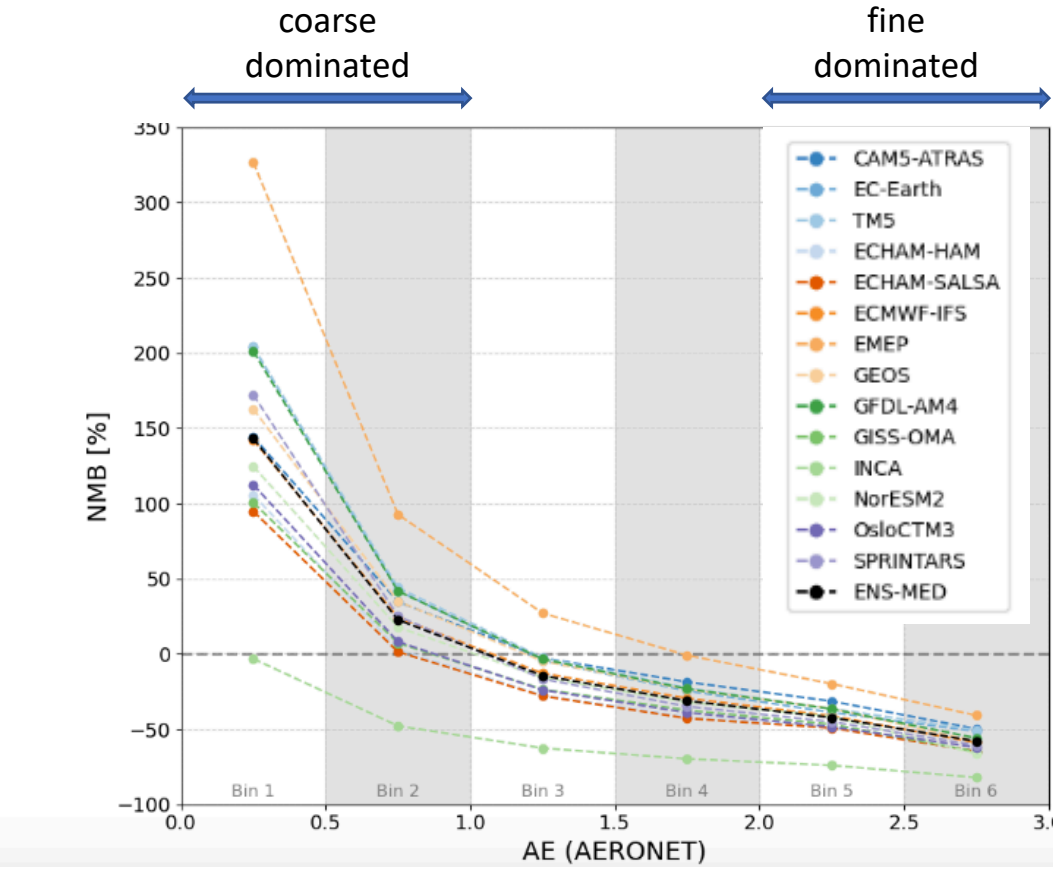
More work is needed:

- Complex interplay between AE and multimodal size distributions (e.g. Schuster et al. (2006))
- Discrepancies in definitions of fine and coarse mode splits for models and observations
- Explore individual site patterns as function of aerosol type

Model biases as a function of observed AERONET Ångström exponent

- Coarse mode dominated regimes: models simulate not enough coarse particles (or overestimate the contribution of fineaerosol to extinction).

- Fine mode dominated regimes: models overestimate size (or underestimate the fine mode fraction)



- Are hydrophobic dust and sea salt particles too small?

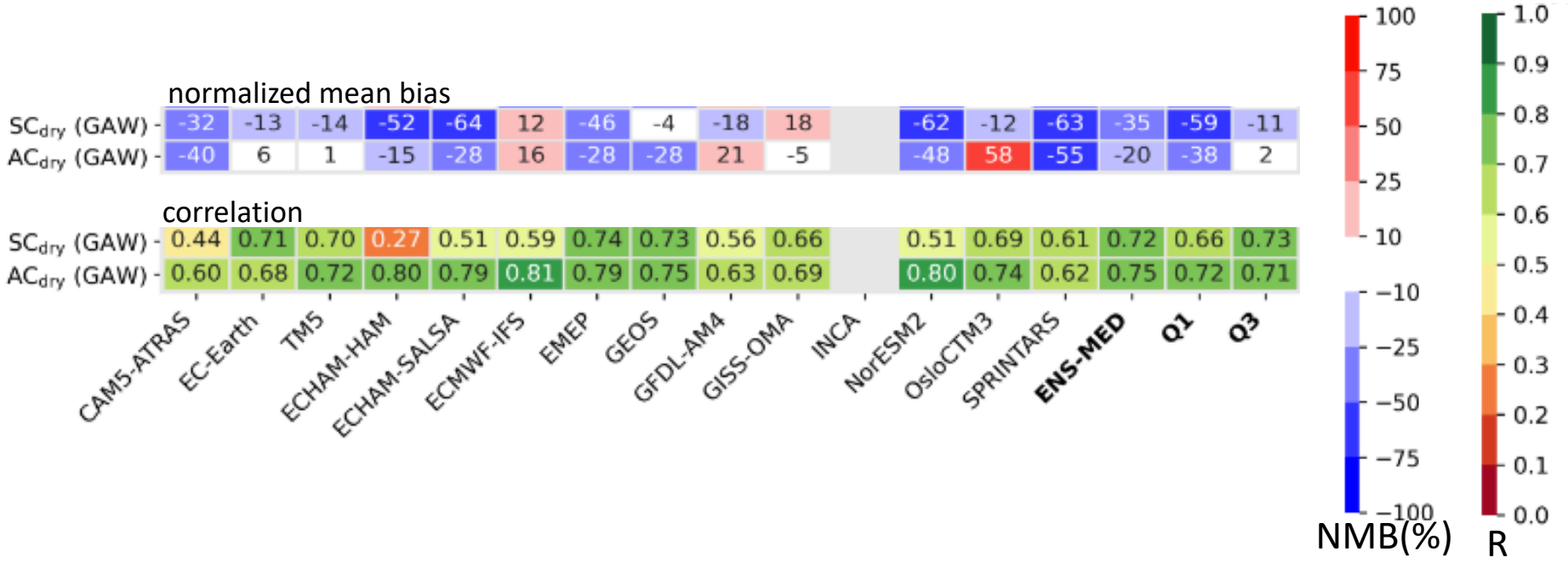
- Is this related to overestimation of hygroscopic growth?
  → more growth needed to get AOD where needed
  → hygroscopicity effect stronger for fine particles

Caveat: AERONET AE measurements are mostly land based

What's going on at the surface?

Models underestimate of aerosol scattering (-35%) more than surface absorption (-20%).
→Model single scattering albedo (darker aerosol) lower than surface in-situ observations.

Models generally well correlated with observations, but do better at absorption



Some of scattering underestimate may be due to definition of dry (Burgos presentation).

- Model dry = 0% RH
- Observation 'dry' = RH<40%.

Limited number of sites (39), primarily in Europe & N America so take with grain of salt (dust)?

Conclusions

- Models underestimate the aerosol parameters considered.
- AeroCom median ensemble model is overall best comparison with observations when all parameters considered.
- Models (still) simulate too fine dust aerosol or overestimate the fine mode fraction of coarse dominated aerosol
- Aerosol water is an important component that deserves more attention both in column and at surface.

Future work and recommendations

- INSITU – look at Angstrom (scattering and absorption), SSA, FMF and temporal variations
- Investigate impact of model resolution (particularly vertical)
- Explore profile extinction data and column water content (to assess hygroscopic growth)
- Delve into the details of assumed size distributions, particularly for natural aerosol
- Utilize mass concentration measurements to determine if models are missing mass or if assumptions about optical properties are causing the model loading underestimates