Development of size-resolving aerosol microphysics scheme for use in a global non-hydrostatic model

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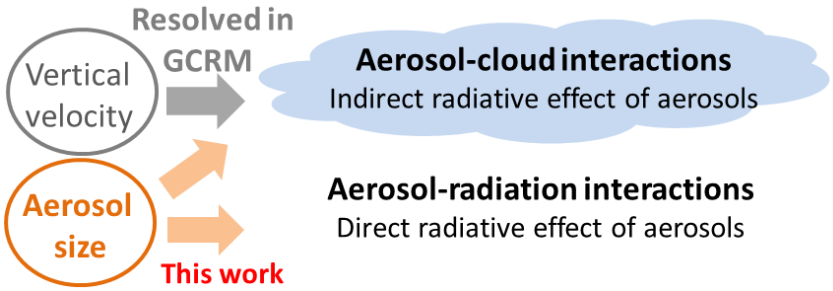
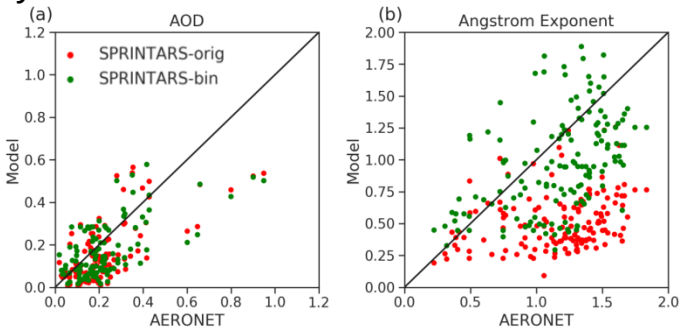
(Cheng and Suzuki, JMSJ revised)





- A sectional aerosol model is implemented in NICAM-SPRINTARS
- Original SPRINTARS model (bulk scheme) underestimates
  - Angstrom Exponent (AE) at AERONET sites
  - Number concentrations at GAW & EUSAAR
- Compared to original model, the sectional model produces
  - Similar AOD & aerosol masses
  - Higher AE & number concentrations
  - ➢ Higher correlations to AERONET/GAW values
  - Number concentration of coarse particles still underestimated

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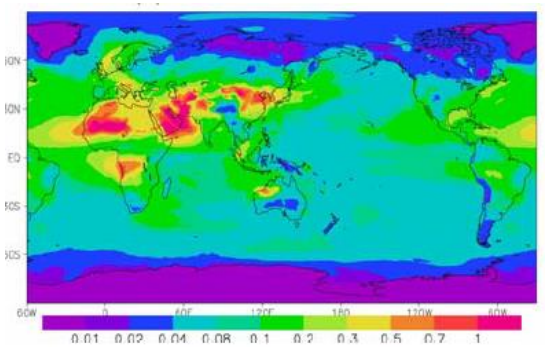
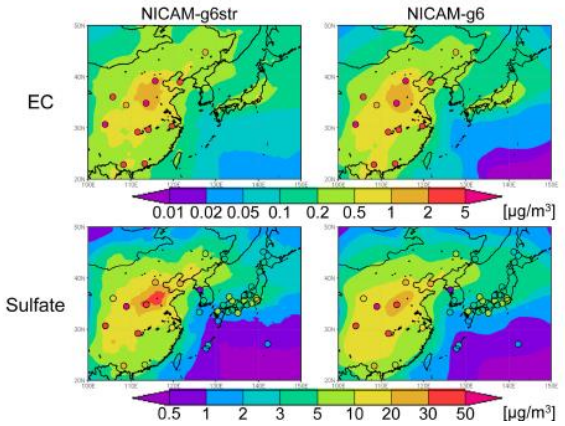
NICAM-SPRINTARS: Global-to-regional model

NICAM (Global non-hydrostatic model, Satoh et al., 2014)
+ SPRINTARS (Aerosol model, Takemura et al., 2000)

- NICAM-SPRINTARS can be run on different grid resolutions seamlessly depending on the objective
  - Suzuki et al., 2008 : 7 km (8 days)
  - Goto et al., 2015 : 223 km (Month-long)
  - Dai et al., 2018 : 223 km (5 years)
  - Goto et al., 2019 : 11 km over Japan (regional, 1 month)
  - Goto et al., 2020 : 14 / 56 km (3 year)
- At high resolution:
  Can simulate deep convective circulations without cumulus parameterizations



Suzuki et al., 2008



Goto et al., 2015

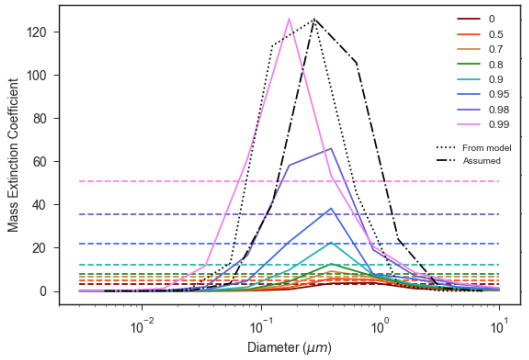
Size-dependent aerosol microphysics & properties

- Nucleation & initial growth (Sulfate)
- Condensation (Sulfate) & coagulation

Added

- CCN activation
  → In-cloud scavenging, re-emission from raindrops
- Optical properties
- Terminal velocities
  → Gravitational settling, Sub-cloud scavenging

Modified



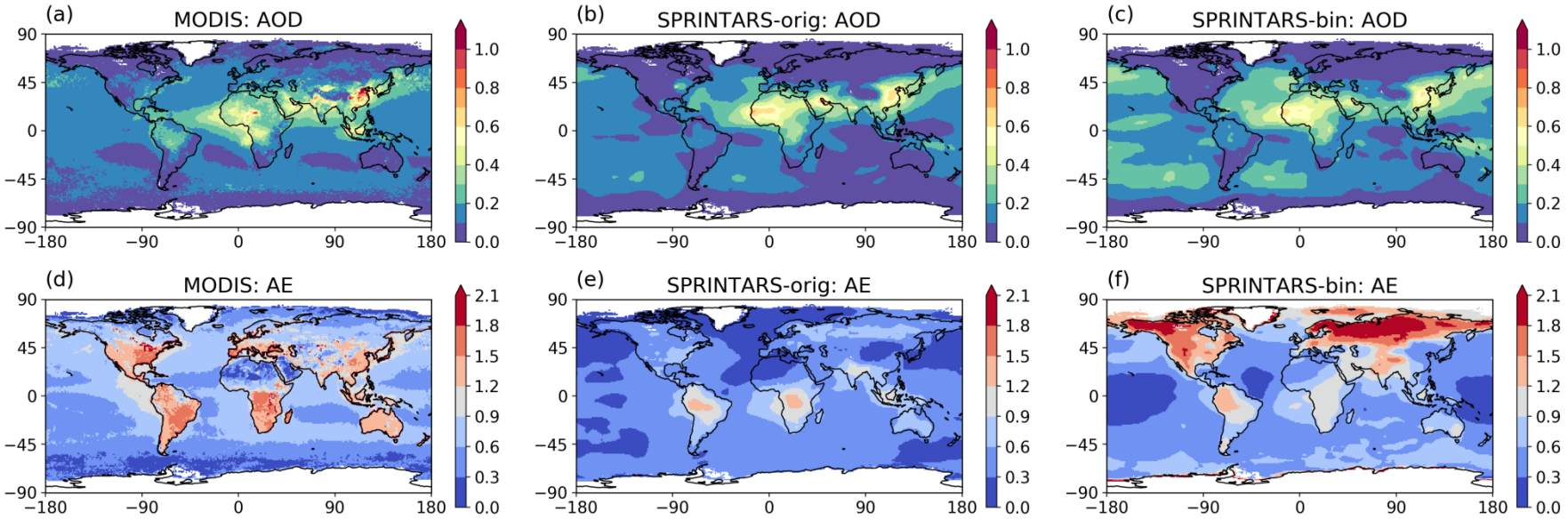
Simulation setup

Target Compare only the influences of size-resolved microphysics

Resolution	gl05 (dx ~ 200 km), dt = 1200 s
Simulation period	Year 2006 (Spin-up: Jul-Dec 2005)
Nudging	Air temperature, wind (6 hr) Sea surface temperature (daily)
CCN scheme	Simple
Cloud microphysics	Large scale condensation
Cumulus parameterizations	Arakawa-Schubert
Cases	**SPRINTARS-orig**: Original version **SPRINTARS-bin**: Size-resolved version, 20 bins
Source functions	Dust: Interpolation from original Salt: Monahan 1998 Carb (OC, BC, SOA): Log-normal, modal radius as in original

Optical properties: AOD & AE

MODIS: Level 3 monthly products (Platnick et al., 2015)

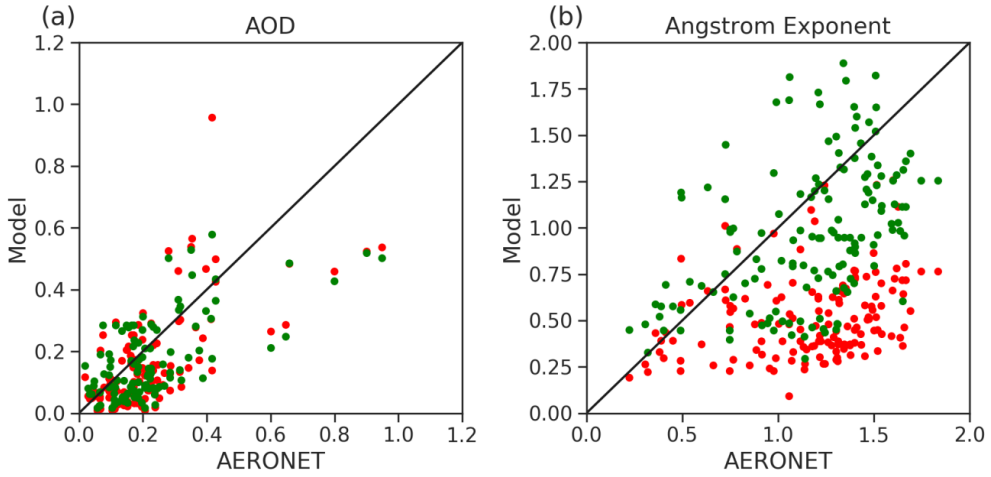


Values at AERONET sites

Level 2 daily average product, #rec > 150 (Holben et al., 1998)

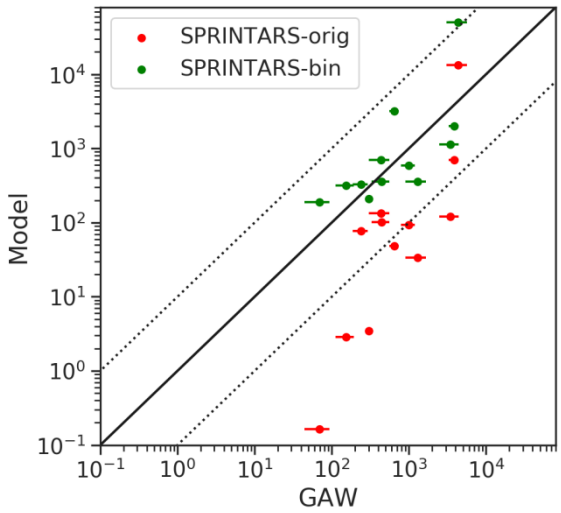
Correlations

	AOD	AE
SPRINTARS-orig	0.65	0.29
SPRINTARS-bin	0.64	0.45



Total number concentrations vs GAW

GAW: Global Atmosphere Watch

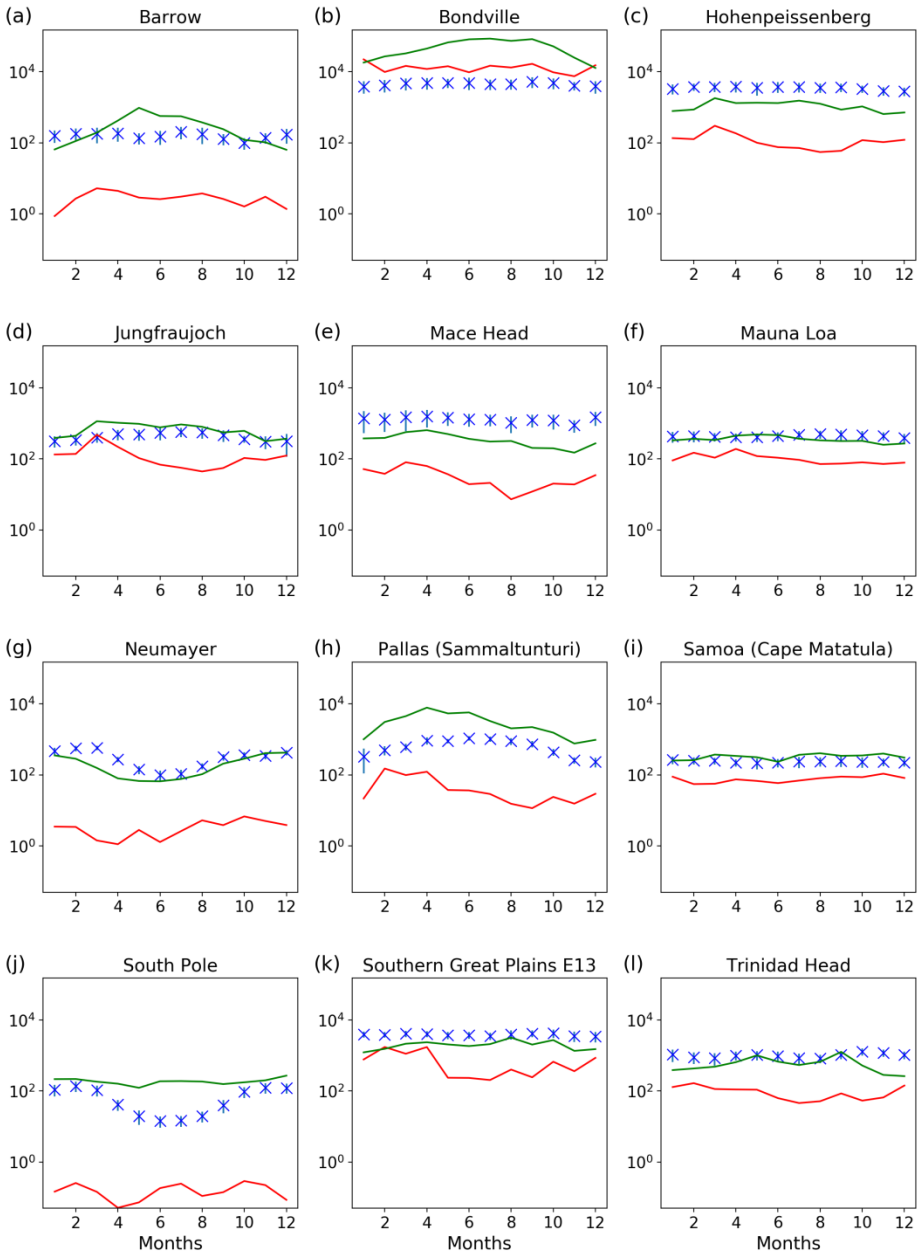


SPRINTARS-orig

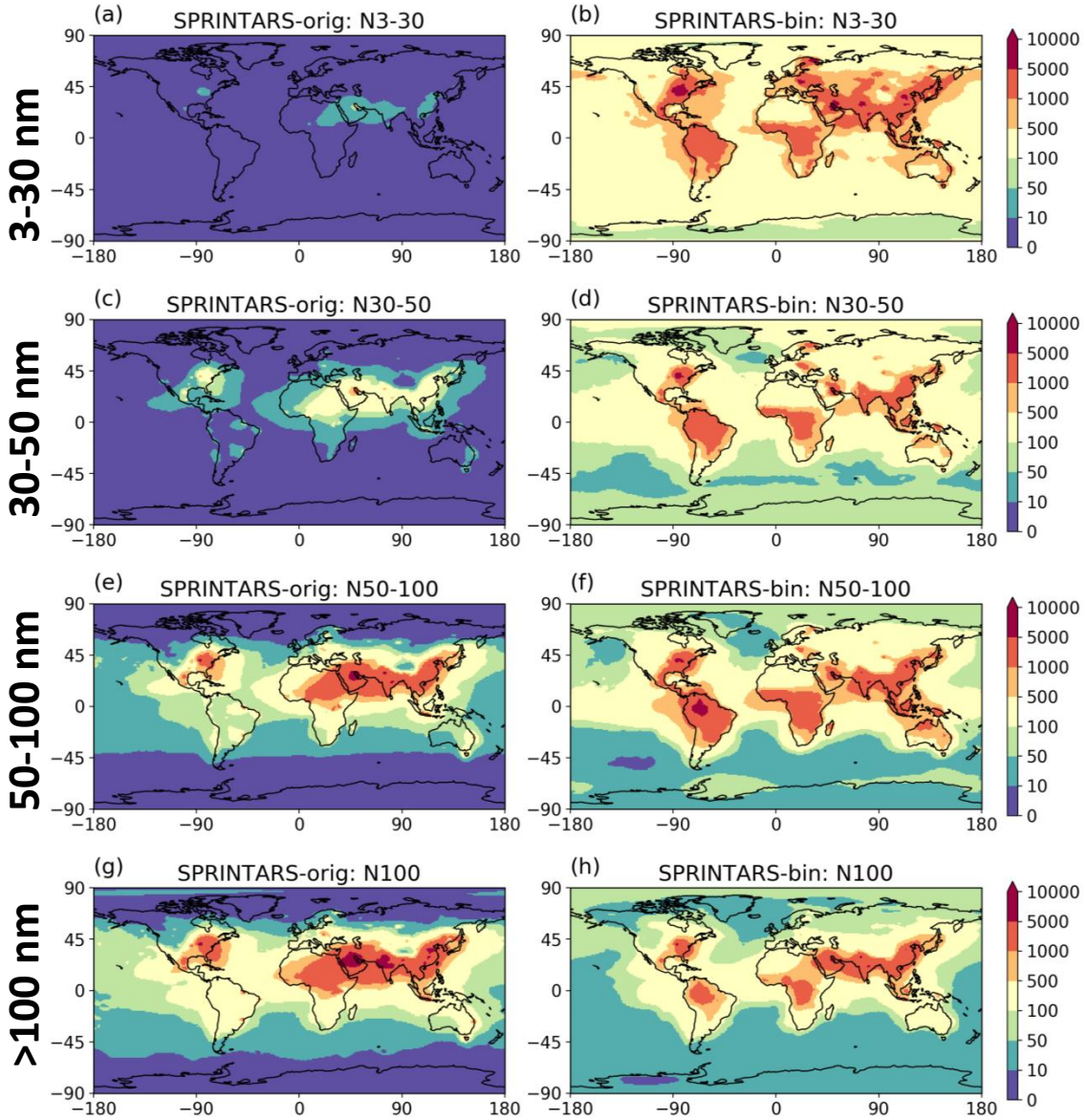
- Values underestimated at most stations

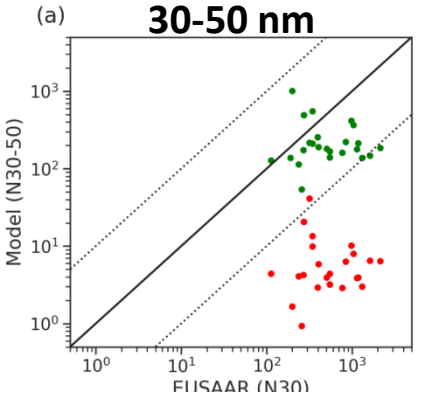
SPRINTARS-bin

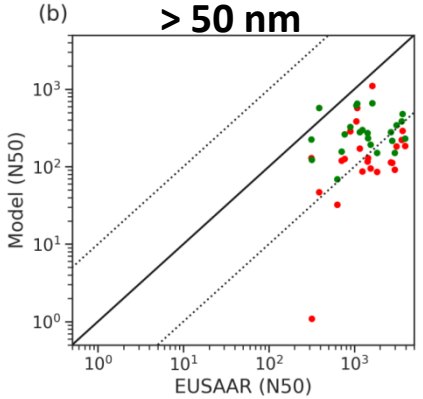
- Annual averages within one order of magnitude
- Seasonality reproduced in some stations

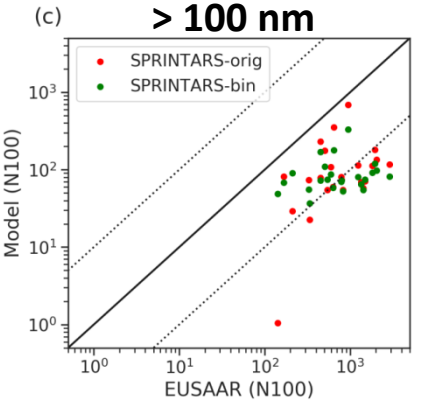


Size-resolved number concentrations









EUSAAR: European Supersites for Atmospheric Aerosol Research, 24 sites in Europe (Asmi et al., 2012)