(Very) Preliminary Evaluation of CESM-CARMA with ACCLIP Airborne Observations

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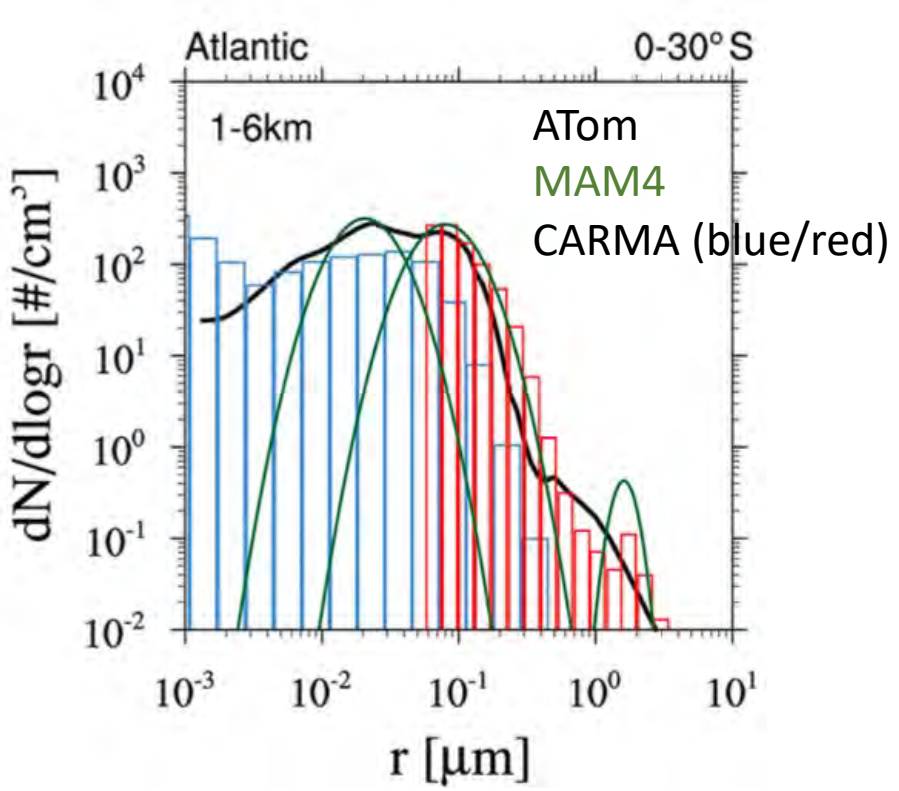
Model Simulations used for this study

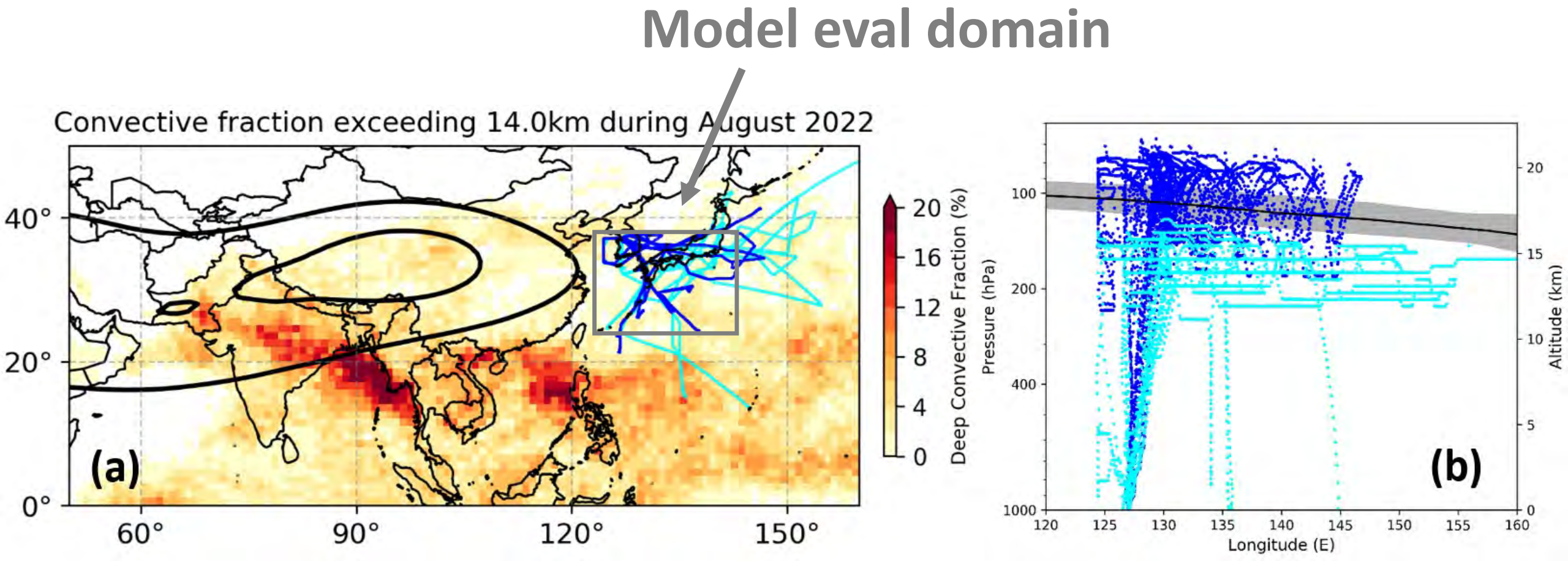
Model configuration	CAMchem	CAMchem
Horizontal resolution	0.9 × 1.25	0.9 × 1.25
Top of model	42 km	42 km
Chemistry	TS1	TS1
Aerosol	CARMA	MAM4
Number of aerosol tracers	220	27
Throughput	2.6 years per day	3.6 years per day
Model cost (core hours per year)	31 K	7.5 K
Nucleation scheme	Zhao	Vehkamäki

CARMA: 2 groups with each 20 bins
Pure sulfate: sulfate
Mixed aerosol: sulfate, primary/ secondary organics, black carbon, sea-salt, dust

MAM4: Aitken, primary carbon, accumulation and coarse mode
Mixed aerosol: sulfate, primary/ secondary organics, black carbon, sea-salt, dust

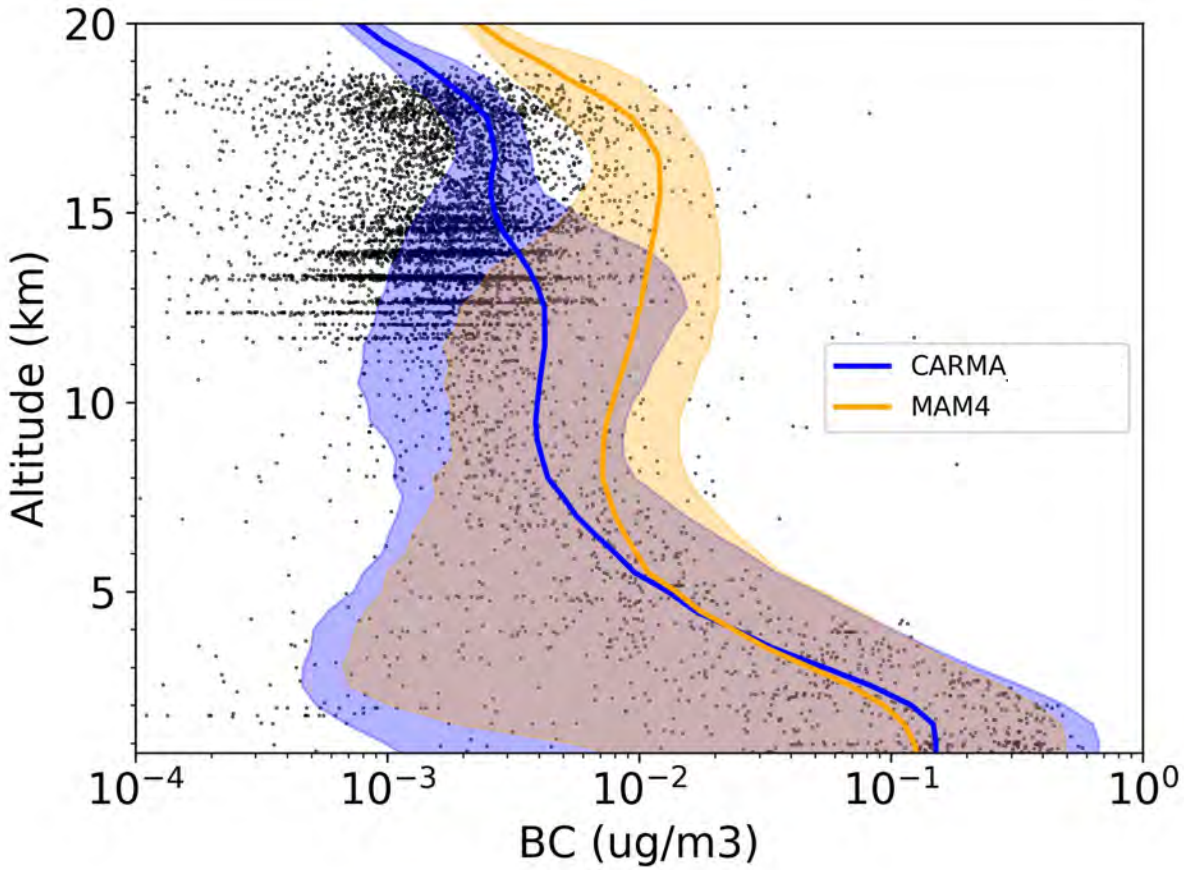


Evaluation of CARMA and MAM4 against ACCLIP (2022) observations

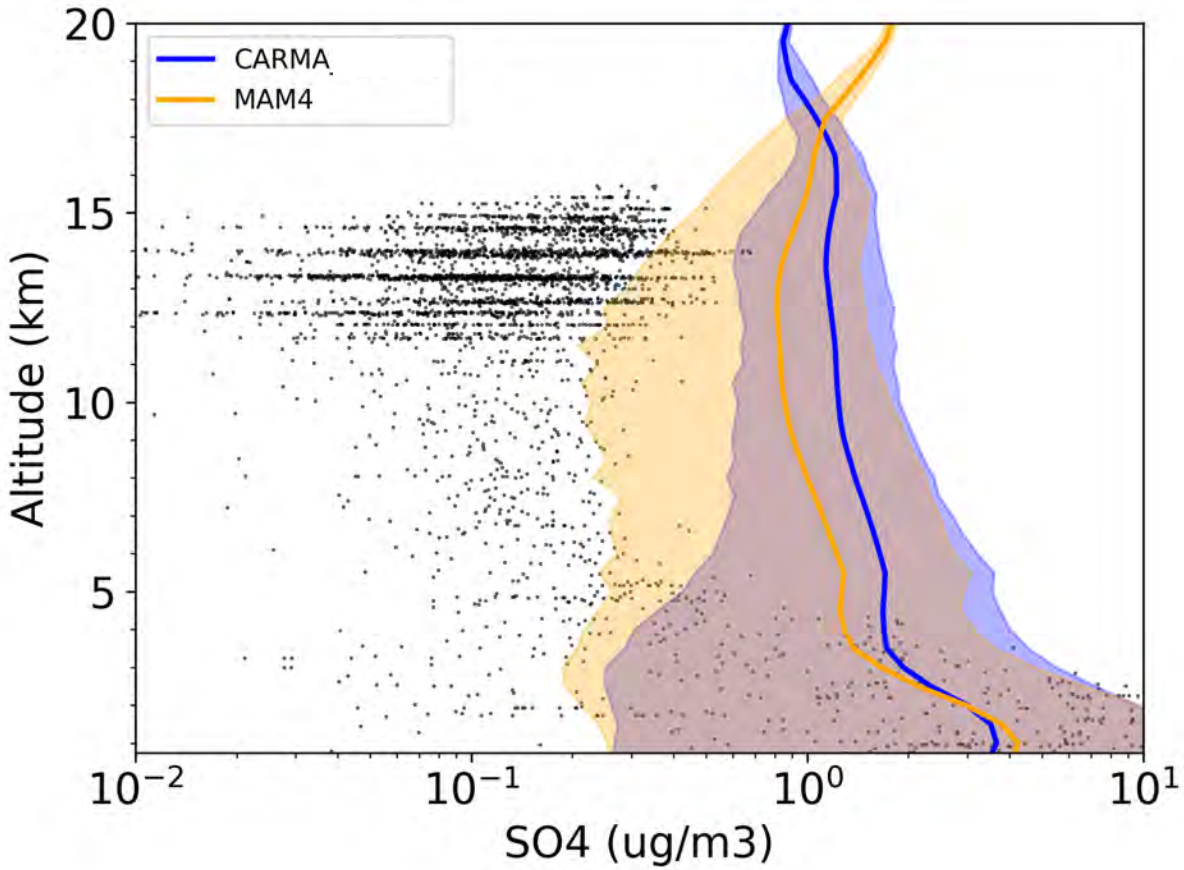


(We note these comparisons have also been performed along the flight tracks, and the results are not substantially impacted)

Model-obs profile comparisons



Black carbon looks great for CARMA!

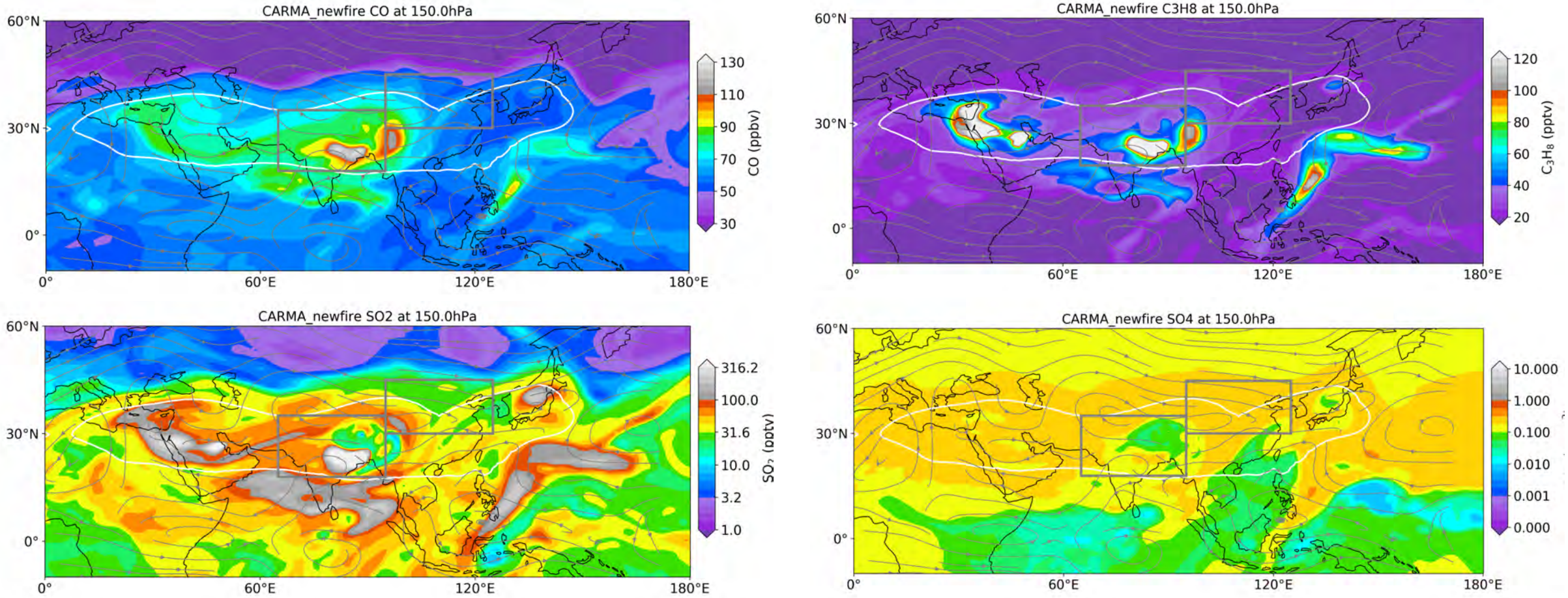


Sulfate is about an order of magnitude too high

BC courtesy of SP2 team
Sulfate courtesy of ERICA team

Goal: try to figure out what's going on with sulfate

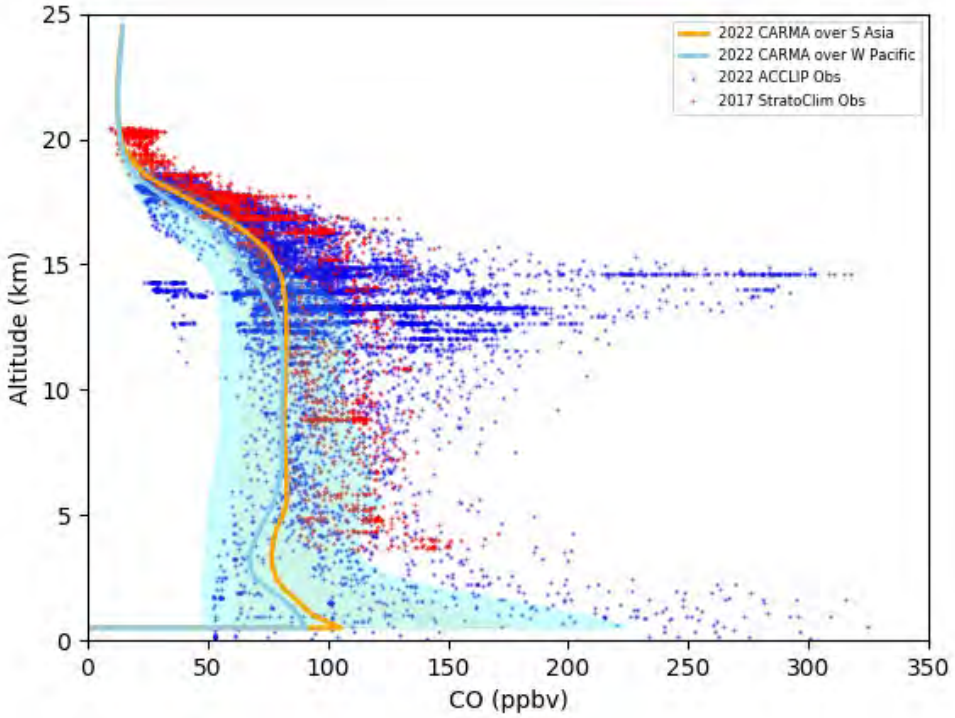
Investigation #1: Is there a problem with model convection?



Examples for August 1 2022, 0Z at 150 hPa. Clear evidence of convective transport over northern India. CO, SO2 and propane are all enhanced. Sulfate is diminished in the same place, suggesting that there is not a primary aerosol source from beneath

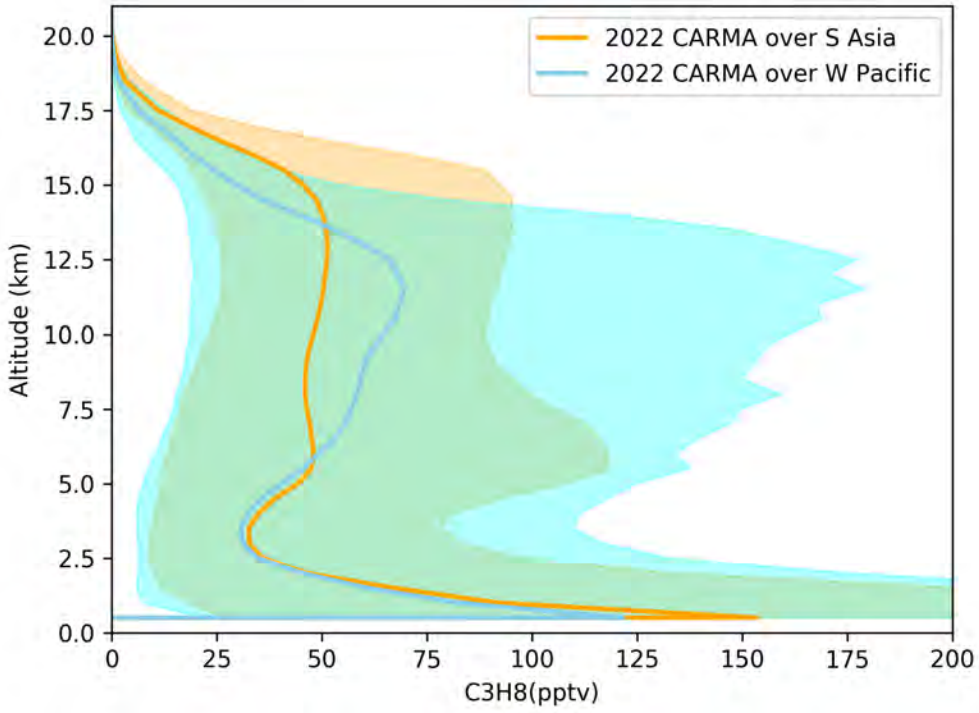
Convection is the dominant process up to ~15km altitude over southern Asia, with a lower top over eastern Asia. CESM-CARMA represents this behavior

CO with airborne observations



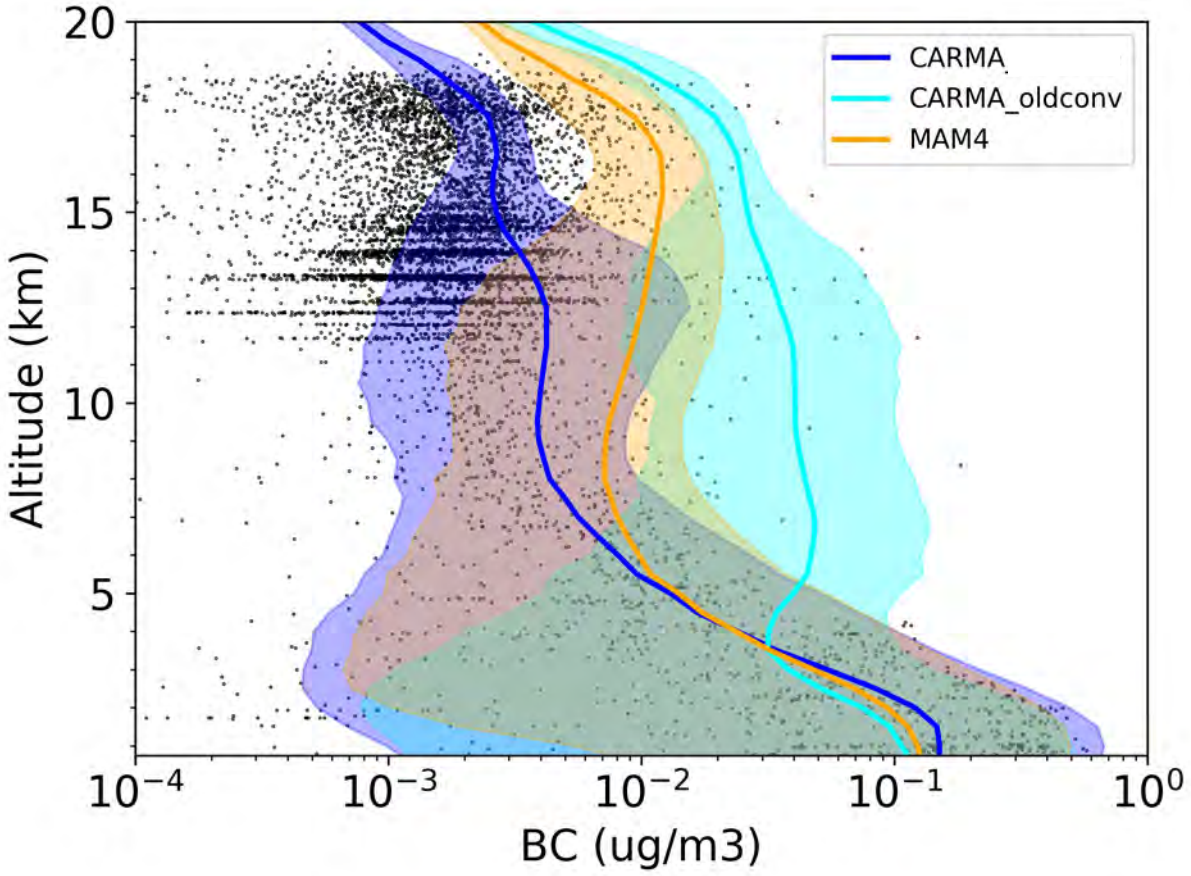
CO courtesy of COLD2 instrument team (StratoClim & ACCLIP WB-57) and T. Campos (ACCLIP GV)

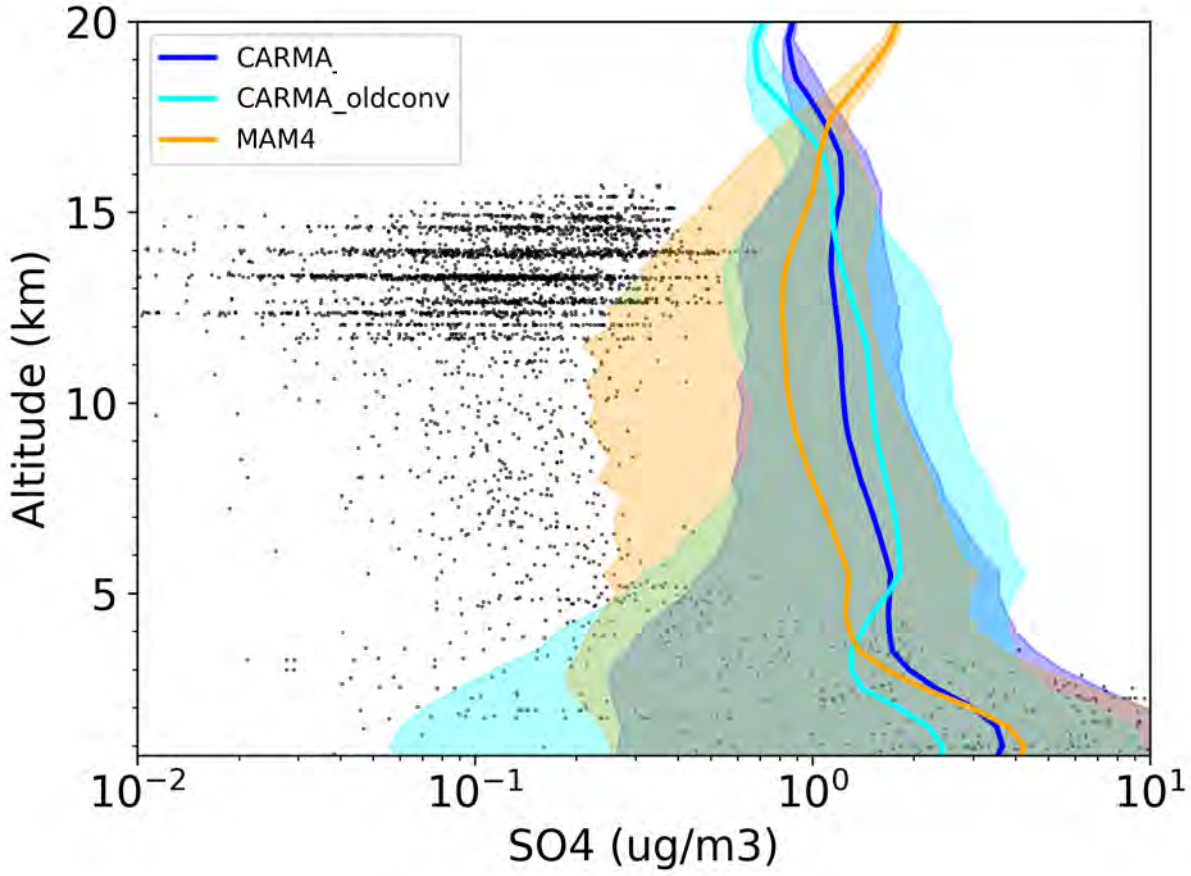
Propane



Ran out of time to add propane obs from WAS….

The new (current) model convective removal scheme allows BC to be represented correctly

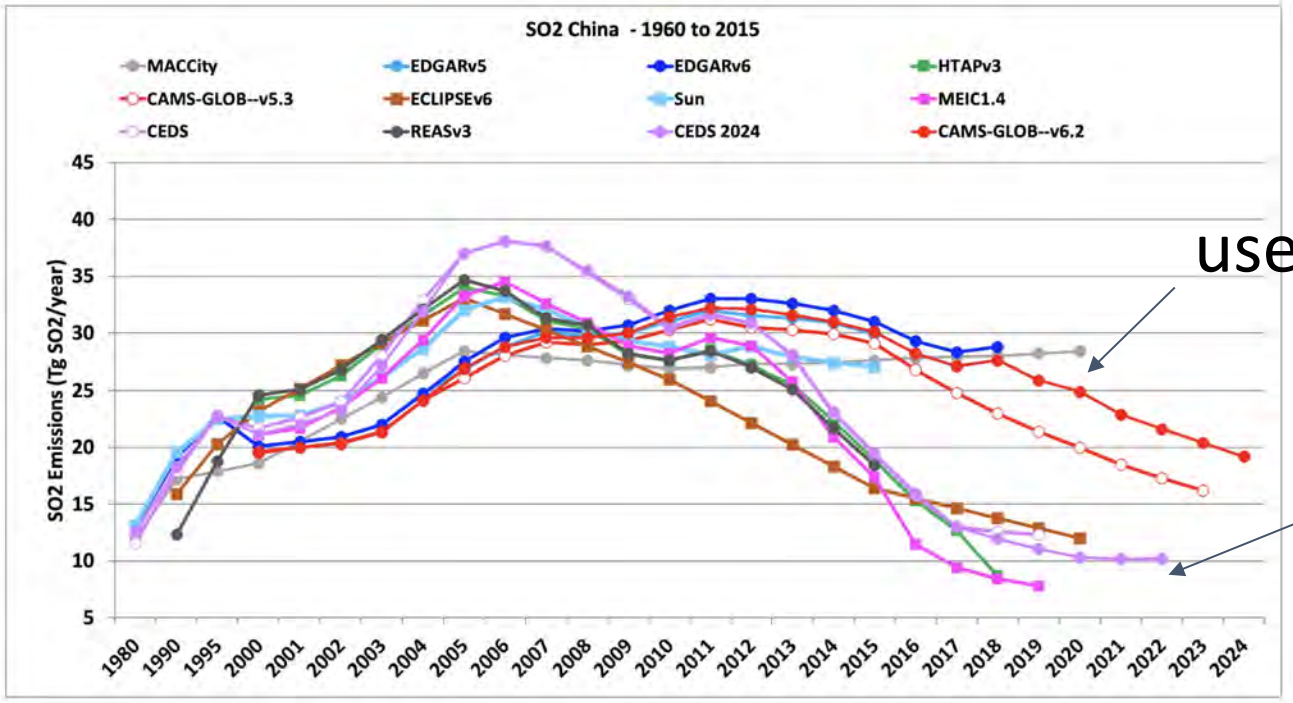




BC courtesy of SP2 team
Sulfate courtesy of ERICA team

With all this in mind, convection and wet removal are not likely to be the issue with SO4

Investigation #2: Bias in model SO2 emissions



China SO_2 emissions

used for this study

more realistic estimate

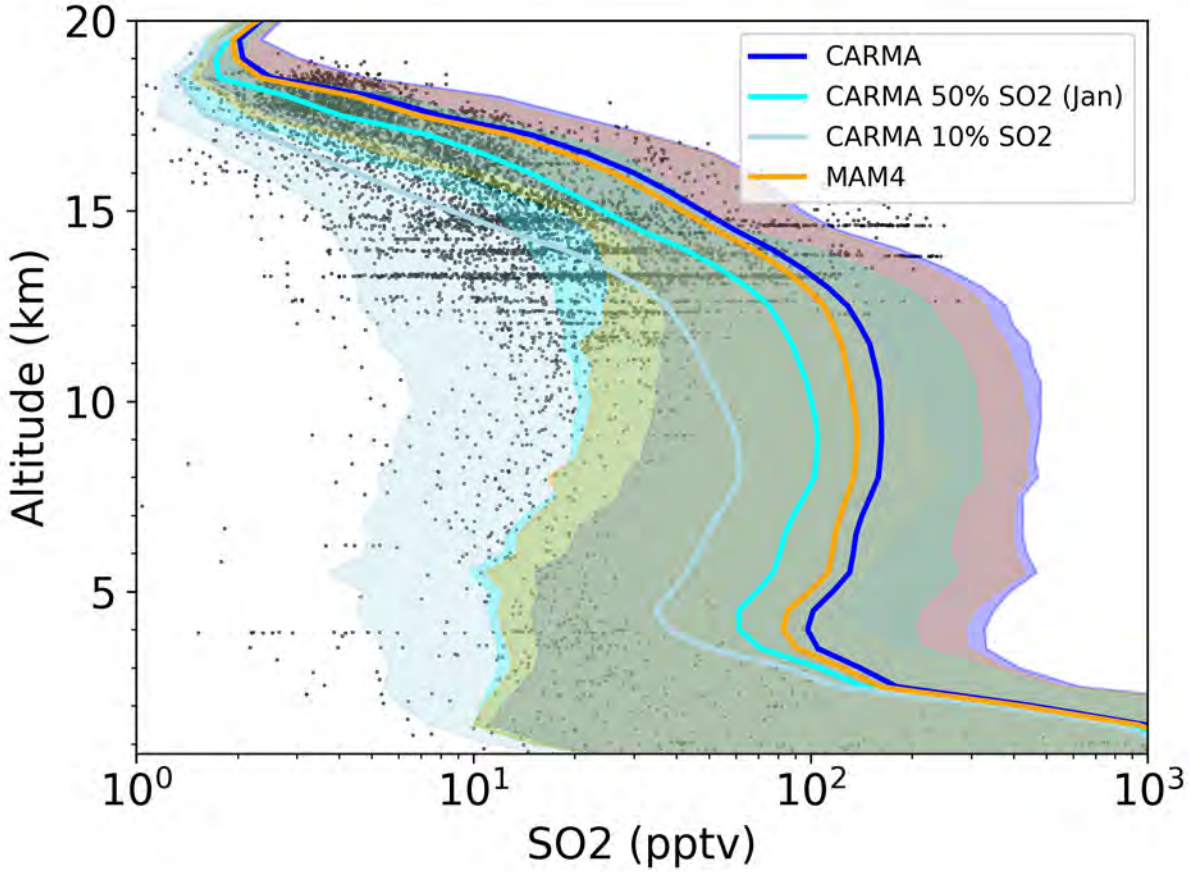
Personal communication with Claire Granier, and Canthy Li

- China SO2 emissions have dropped significantly in the last 10 years.
- Other SO2 emissions have also dropped over the US and shipping emissions
- Many inventories do not follow the declining trend compared to regional Chinese inventories as used in this study
- CAMS v5.1 used here may cover some of the trend but not all

Since we don't have an updated emission inventory (work in progress), we just performed 2 sensitivity Studies: 50% anthropogenic SO_2, 10% anthropogenic SO_2

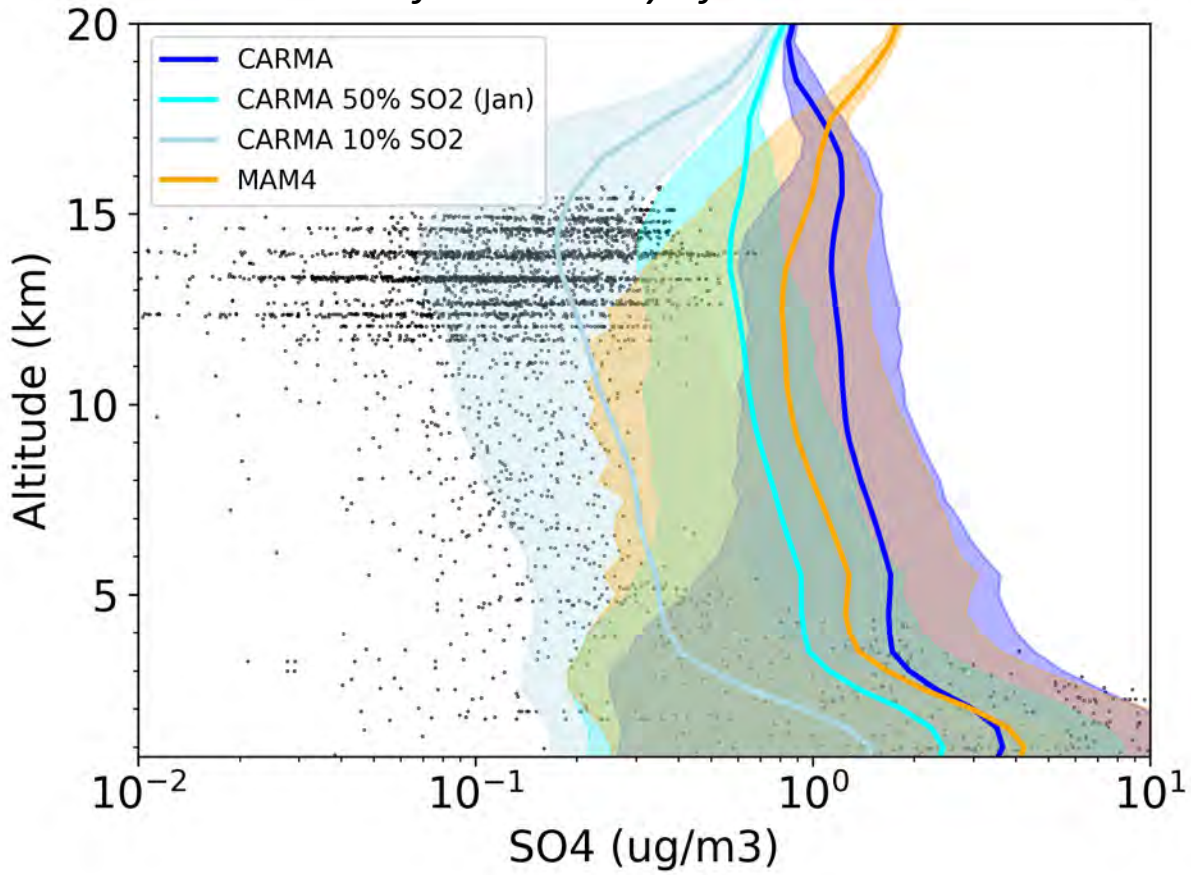
Investigation #2: Bias in model SO2 emissions

SO2 courtesy of LIF (WB-57) and GT-CIMS (GV) teams



Default SO2 emissions indeed appear to be too high over Asia. Reductions appear to match more reasonably

Sulfate courtesy of ERICA team



Reducing SO4 emissions (eventually) results in realistic SO4 mixing ratios

Summary:

- CESM-CARMA has excellent agreement with black carbon. Updated convective removal scheme considerably improves its representation
- Issues with sulfate appear to be (mostly) explainable by model emissions being too high over Asia

Future work:

- Size distribution comparisons using the NMASS / UHSAS airborne observations and balloon-borne POPS observations
- Expand analysis to DCOTSS and/or SABRE for evaluating different emission regimes, and dominant transport processes

A new modeling capability may better represent the environment sampled during ACCLIP