Simulation of Laki eruption and associated issues with aerosol coagulation

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High-Latitude Volcanic Eruptions

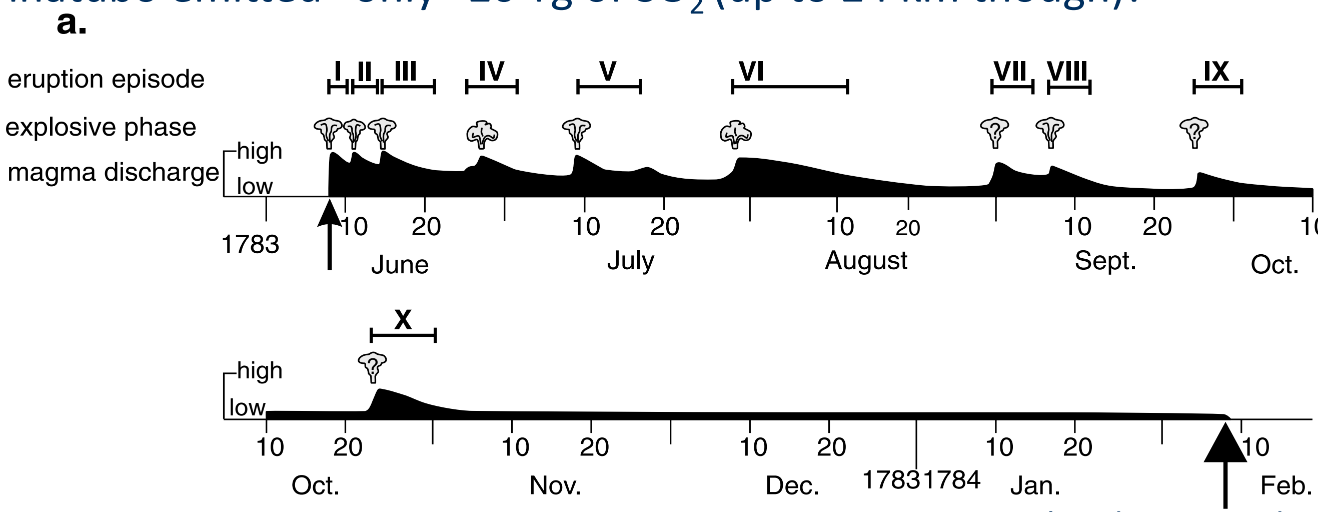
Lakagigar (LAKI) eruption in 1783

Lasted about 8 months from 8 June 1783 to 7 February 1784

Largest basaltic lava flow in historic time

Emitted 122 Tg of SO_2 of which 95 Tg into the LS/UT 9-13 km

- Pinatubo emitted “only” 20 Tg of SO_2 (up to 24 km though)!



Thordarson and Self, 2003

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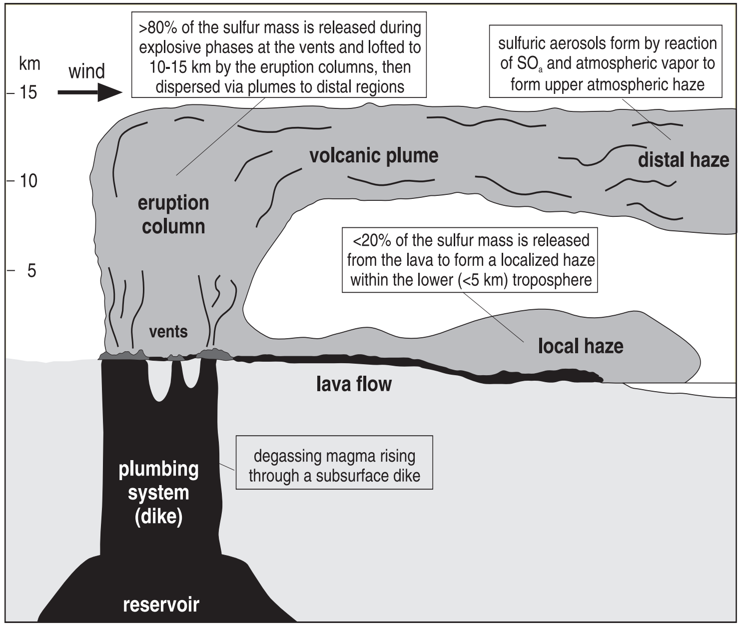

4-month eruption:

100 Tg SO_2

100 Tg Dust

Time distribution:

Not evenly distributed (i.e. 0.83 Tg/day)

Impulses of 5 days every 2 weeks

Stronger the first 2 months (80 %)

Height distribution:

Not evenly distributed

<5km(500mb):	20 Tg
9-13km(300-150mb):	70 Tg
13-15km (150-100 mb):	10 Tg

Eruption date	Jun 1st	Jun 15th	Jul 1st	Jul 15th	Aug 1st	Aug 15th	Sep 1st	Sep 15th
Total SO_2 (Tg)	42	11	11	15	9	5	4	3
$100 < p < 150$ hPa	5	1	1	2	1	0	0	0
$150 < p < 300$ hPa	29	8	8	10	6	4	3	2
$p > 300$ hPa	8	2	2	3	2	1	1	1

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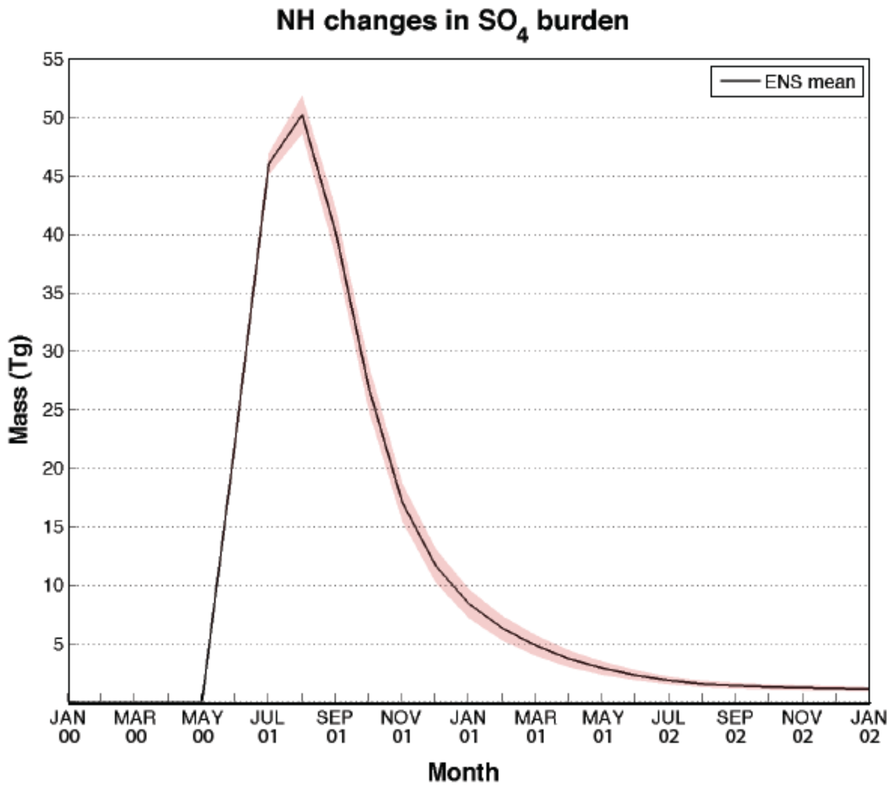
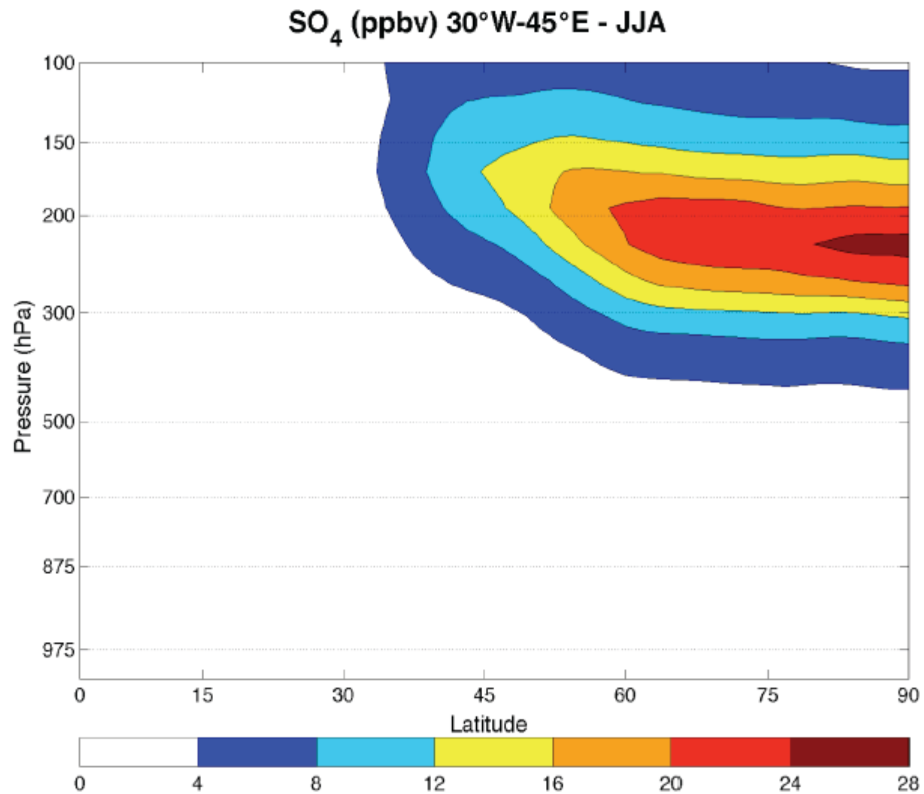
SO_4 burden and concentrations





Ensemble mean change in SO_4 (Tg) mass loading (left) and 30°W to 45°E mean SO_4 concentrations (ppbv) for the summer following the eruption (JJA year 01) over the Northern Hemisphere (NH) from the surface to 100 mbar (right)

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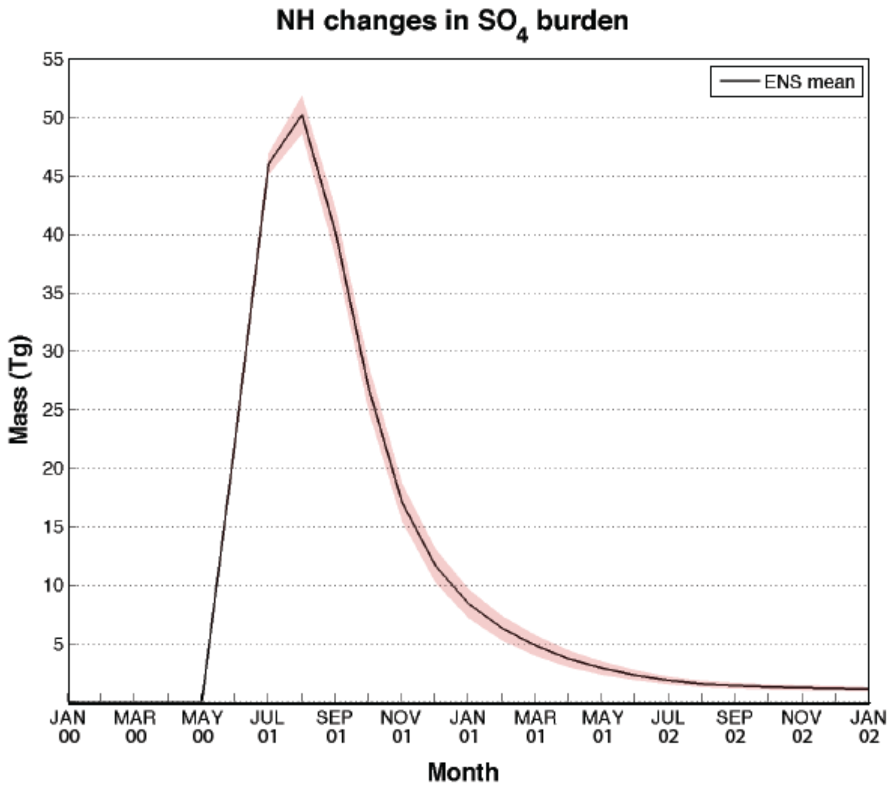
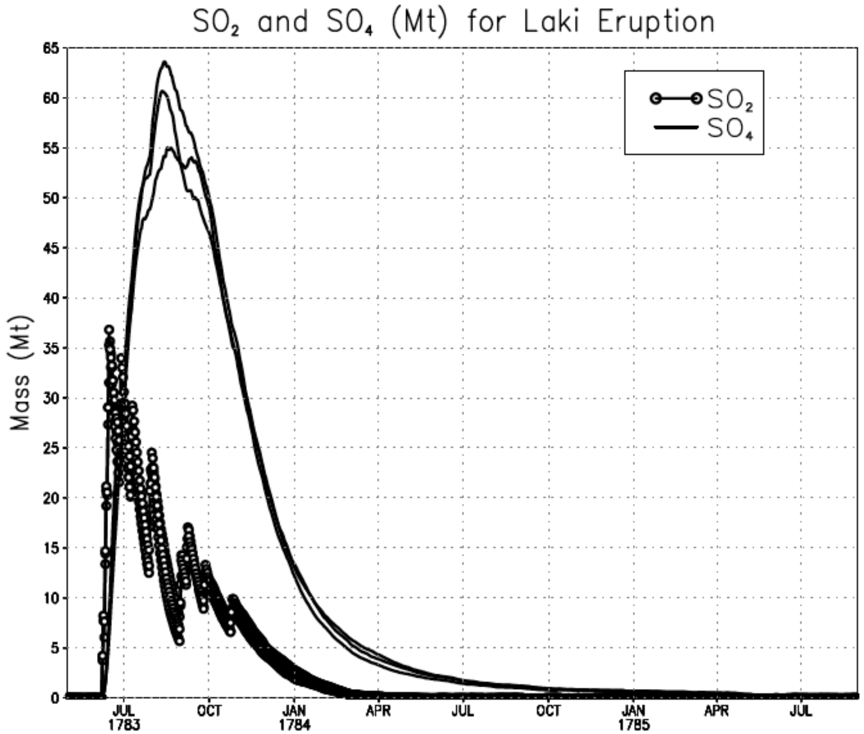


Oman et al. 2006



Ensemble mean change in SO4 (Tg) mass loading for the summer following the eruption (JJA year 01) over the Northern Hemisphere (NH) from the surface to 100 mbar

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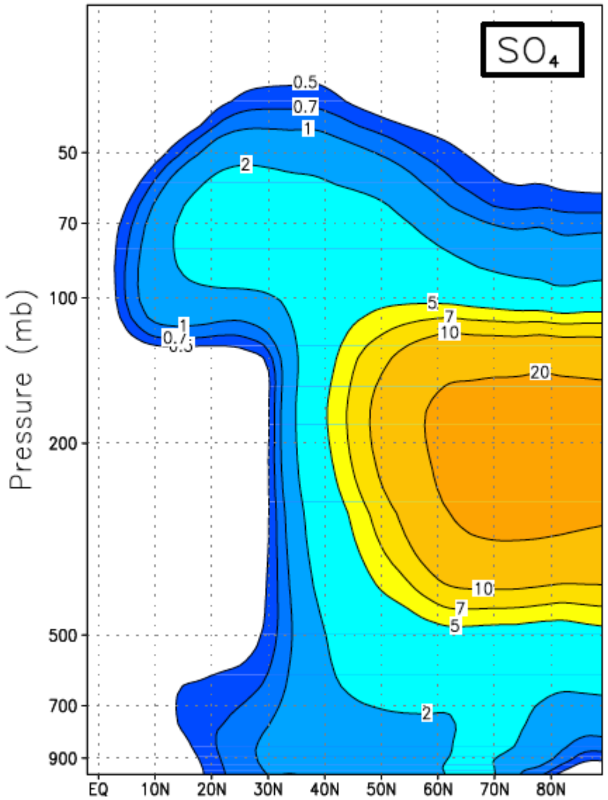

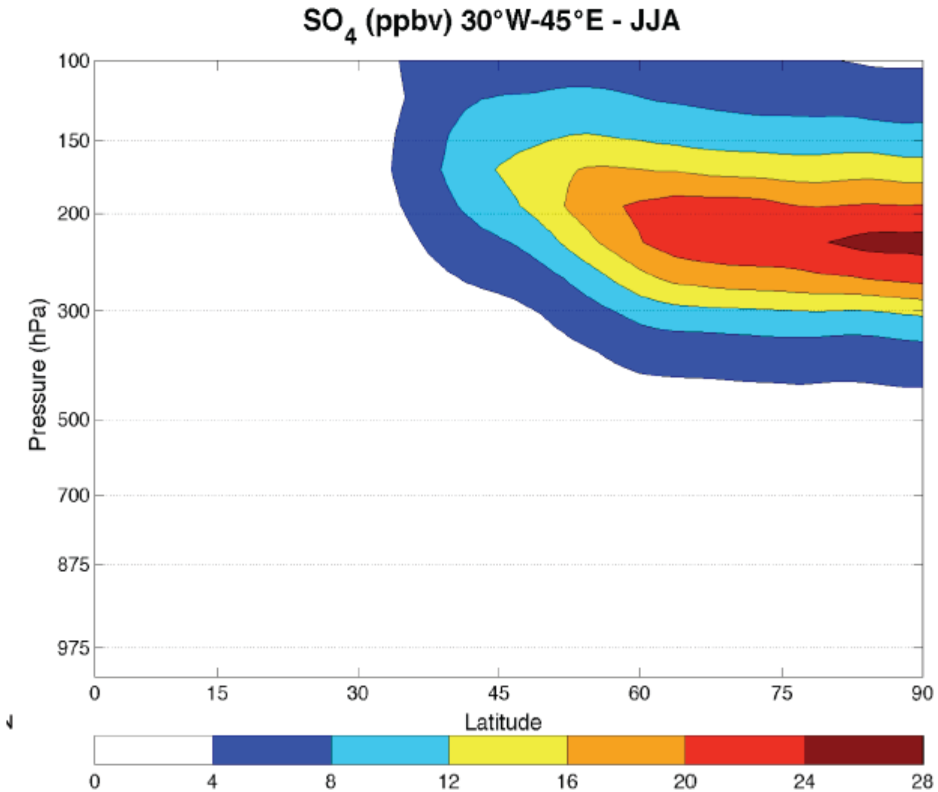

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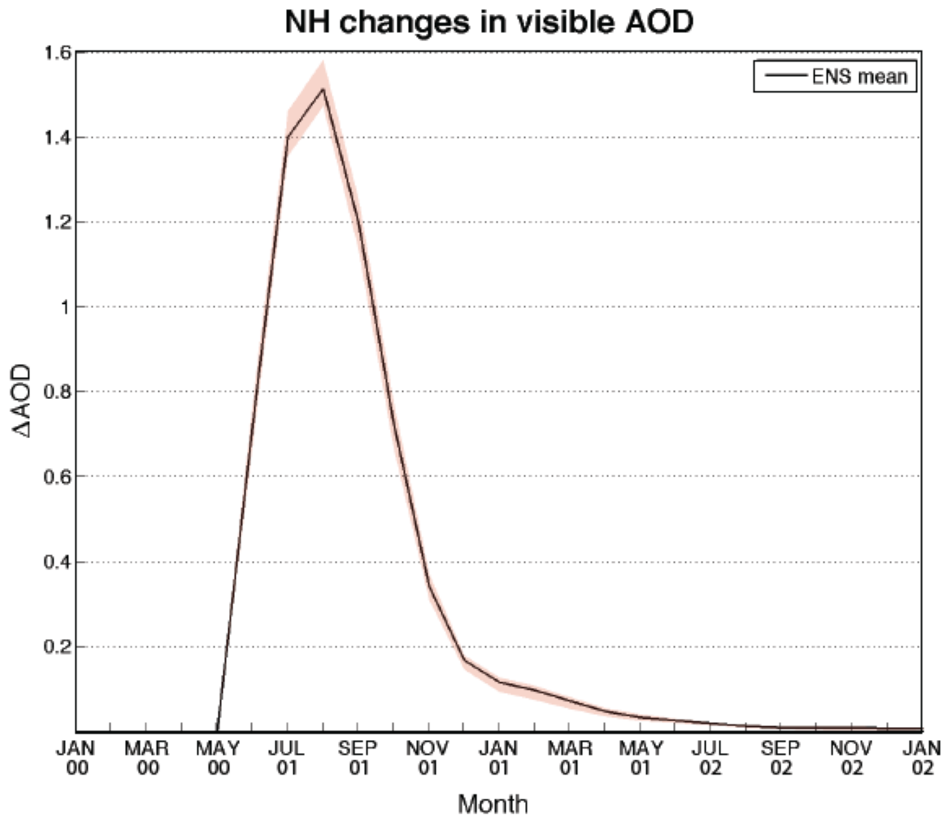
AOD CHANGES



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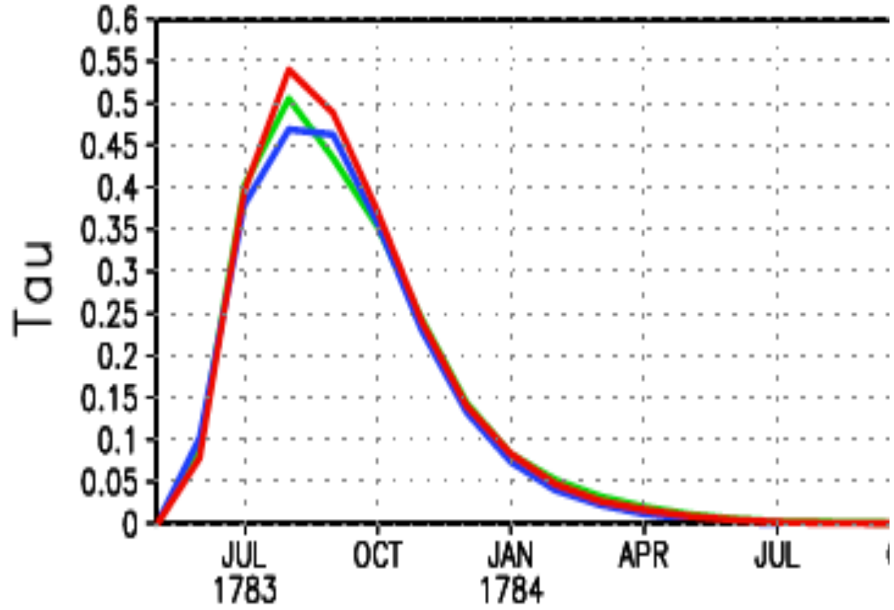

ΔAOD: 1.53 vs. 0.51

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ΔRF: –11 vs. –4 W/m^2

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The differences in the AOD are most likely due to the differences in effective radii: smaller particles scatter light more efficiently

The specific surface area, i.e. surface area seen by radiation goes as the inverse of twice the effective radius (~1/2reff)

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Average effective radius:

0.54-0.61 µm vs.0.2 µm

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Average effective radius:

0.54-0.61 µm vs.0.2 µm

2.5—3 times fewer large particles than in Oman et al. (2006)

greater optical depth by a factor of 2-3

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The reason of such small particles?

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CAM4–Oslo does not simulate growth by self coagulation (coagulation of Aitken-mode particles combining to form larger particles).

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Self-coagulation is an important mechanism after an eruption when a massive amount of sulfate is injected.

In CAM4-Oslo the only growth mechanism is condensation, and intra-modal coagulation is not taken into account.

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To test whether in our model the presence of larger particles would lead to a reduced AOD

we run three additional sensitivity simulations in which:

a) We impose that 2.5% of SO_4 mass is already in the accumulation mode (PCT2.5);

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c) We impose that 25% of SO4 264 mass is already in the coarse mode (PCT25ss).

However, the model does not allow sulfate in the coarse mode. Hence, we emit the primary sulfate as "sea salt" (SS) since coarse sea salt already exists and they are optically similar to sulfate.

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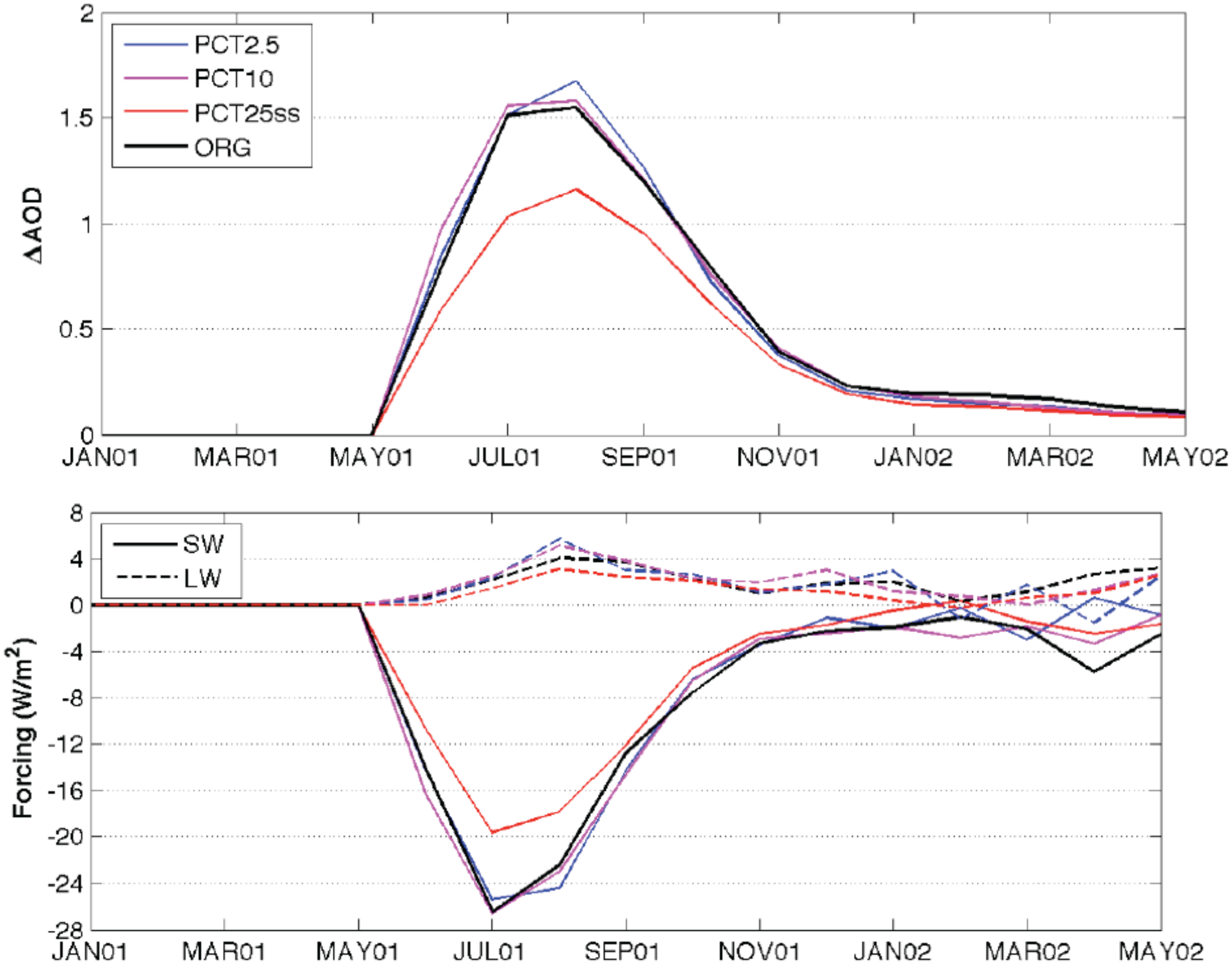

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CONCLUSIONS

NorESM is able to reproduce the correct SO_4 concentrations, whereas it cannot capture the right particle size and consequently the radiative forcing induced by the volcanic SO_2 emission.

The sensitivity tests shows that if our model had included intra-modal coagulation leading to coarse SO_4 particles, the simulated radiative properties would have been more accurate.

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