Exploring the resolution dependence of aerosol, cloud, and aerosol-cloud interactions in SD-CAM5

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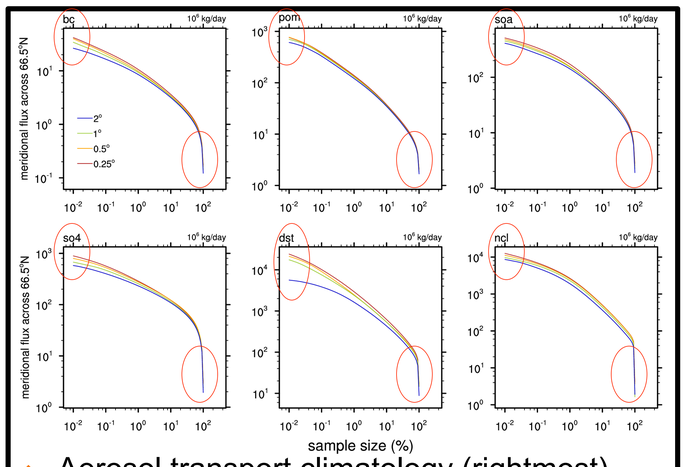
Objectives

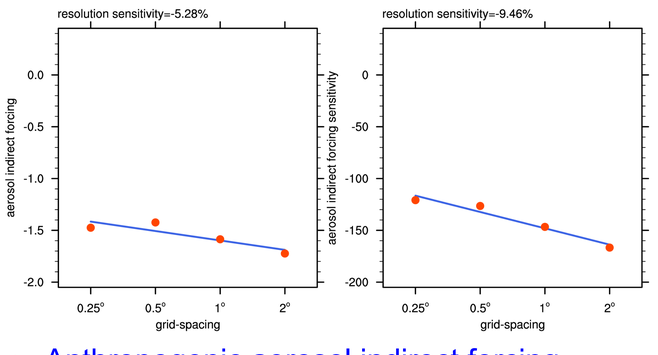
- Explore the resolution dependence of the simulated aerosol and cloud
- Evaluate model simulations against A-train satellite observations
- Investigate the resolution dependence of aerosol forcing and atmospheric response

Aerosol transport into the Arctic



- Aerosol transport climatology (rightmost) increases by 50%.
- Extreme transport associated with transient eddies (leftmost) increases by a factor of 2-10.

Aerosol indirect forcing

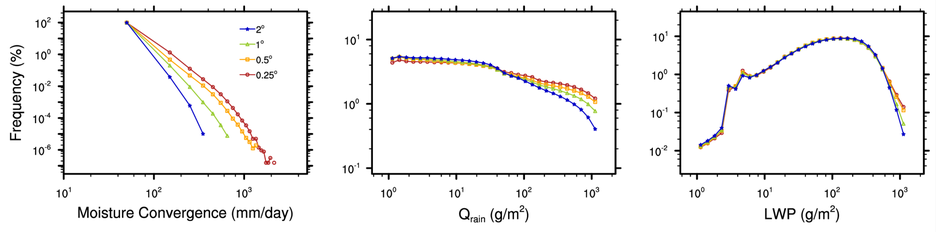


- Anthropogenic aerosol indirect forcing decreases with increasing resolution with a resolution sensitivity of about 5%.
- Aerosol indirect forcing efficiency decreases with increasing resolution with a resolution sensitivity of about 10%.

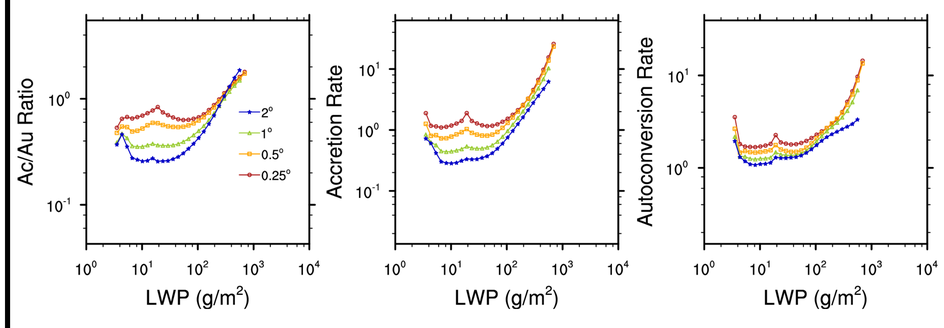
Approach

- Specified dynamics (offline meteorology) methodology
- Year Of Tropical Convection (YOTC) analysis (0.15°), regridded to 2°, 1°, 0.5°, and 0.25° CAM5 grids using mass conservation interpolation
- Model time step and dynamical sub-stepping are kept the same for all resolutions
- Model calibration for aerosol, cloud, and convection parameterizations is first done for the 2° model. Then, all resolutions use the same tunings.
- Surface moisture flux comes from 0.25° SD-CAM5 simulation, scaled to ~2.99 mm/day global annual mean

Precipitation process

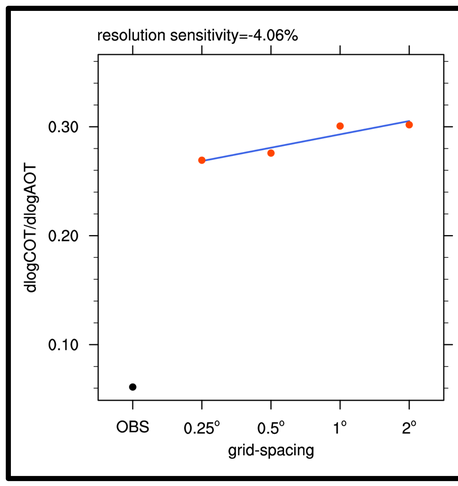


- Increasing resolution leads to more events of strong moisture convergence, which then leads to larger condensation.
- Frequency of occurrence of higher liquid condensate amount (cloud and rain) increases with reducing grid spacing.



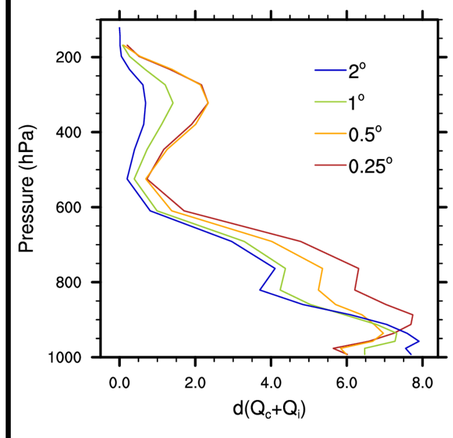
- Increasing resolution results in higher accretion and higher autoconversion process rates, but accretion increases more, shifting the precipitation process towards accretion-dominated regime.
- This is due to more occurrence of high rain water mixing ratio and cloud liquid water path, and can explain the weaker aerosol indirect forcing in high-resolution simulation since clouds are less subject to aerosol processing.
- Some features require further investigation.

Cloud susceptibility evaluated against A-Train satellite observations



- All model simulations overestimate cloud susceptibility
- Increasing resolution reduces the bias with a resolution sensitivity of about 4%.

Aerosol effects on Pacific storm track



- Condensate amount becomes more sensitive to aerosol forcing in the mid- and upper troposphere.
- Condensate amount becomes less sensitive to aerosol forcing in the lower troposphere

Summary

- Increasing resolution reduces some of the model biases (such as high estimate of aerosol indirect forcing, cloud susceptibility, and low aerosol transport into the Arctic).
- Precipitation process is shifted from autoconversion-dominated towards accretion-dominated regime due to stronger moisture convergence that leads to large condensation.
- Pacific storm track is sensitive to aerosol forcing in high-resolution simulations.

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