Atmospheric Chemistry in DOE-ACME

Philip Cameron-Smith (LLNL)



Ozone Hole

[Cryosphere v1]

- · Antarctic ozone-hole affects ice-sheets.
 - Ozone hole -> surface winds (SAM) -> ocean upwelling -> ice-sheet melting.
- Interannual variability of ozone hole may affect likelyhood of ice-sheet melting.
 - Implement in ACME-atm using Linoz (1 tracer),
 - ~1% computational cost.

[BGC, v2]

- Methane is 2nd most important greenhouse gas.
 - Emissions -> atmospheric chemistry -> concentrations
 - Highly non-linear function of: clouds, water vapor, temperature, other chemicals.
- Implement with chemical solver and ~30 tracers.
- Dependent on:
 - Methane module in land BGC group,
 - Model top and vertical grid.

Sulfur Cycle

[Hydro, BGC, Cryo, v2]

- Sulfur is top uncertainty in 20th-Century forcing, & therefore climate sensitivity [Carslaw, 2013].
- Dimethyl sulfide (DMS) affects climate:
 - Ocean ecosystem -> DMS emissions -> atm chem -> sulfate aerosols -> clouds -> climate.
 - Major aerosol source in pre-industrial and in future.
 - 4-6 W/m² global-mean in CESM1.2.2.
- In 1850, DMS contributes ~6 W/m2 of cooling to base state of our model.



Change in reflective shortwave due to DMS in 1850



Methane

celerated Climate Modeling

For additional information, contact: Philip Cameron-Smith Task Leader: Atmospheric Chemistry Lawrence Livermore National Laboratory (925) 423-6634 pjc@llnl.gov

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Ozone Hole Impacts Antarctic Winds

Ozone Hole

Antarctic ozone-hole affects Southern Annular Mode (SAM).



Accelerated Climate Modeling for Energy For additional information, contact: Philip Cameron-Smith Task Leader: Atmospheric Chemistry

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[Cryosphere v1]





Antarctic Winds Affect Temperature Next to Ice-Sheets

Ozone Hole

- Interannual variability of ozone hole may affect likelyhood of ice-sheet melting.
 - Implement in ACME-atm using Linoz (1 tracer),
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80°S 60° S 40° S Reduced cloud Regional and seasonal differences in sea-ice response cover ai Rising air Subsiding Rising air 0 Atmospheric boundary layer Ekman layer MLD Enhanced upwelling of carbon-rich deep water [Thompson, et al., Nature Geo, 2011] Density surfaces Barotropic flow 💽 Antarctica Weak return flow Deep ocean Surface fluxes, Ekman transport and MLD changes act in concert to produce SST response. Eddy heat fluxes act in the opposite sense. Increased eastward wind/current Heat fluxes Increased westward wind/current Eddy response



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[Cryosphere v1]

DMS Impacts TOA Reflected Shortwave



Reflected Shortwave shifts polewards, and decreases in magnitude to due competition with anthropogenic aerosols.

ACCINE Accelerated for Energy

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DMS Impacts Surface Temperature



Ice albedo feedback works in both directions.



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Short-wave sensitivity is only slightly higher than observations





Observed Shortwave Sensitivity to Aerosols McCoy, Burrows et al. (2015, submitted)

-5 -10-15 Wm⁻² А Μ J -5 -10-15 Wm⁻² Μ J А -5 Lat -50 -10-60-70 -15 Wm⁻² D М A M J

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SO4 higher than reference from Simone. Maximum error at surface.



SO4 ANN

super fast MAM3 origi Sulfur DOE 2000 2deg v2 - f2000.e122 mam4.STRATMAM3.f19.f19.003



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SO4 higher than reference from Manish. Maximum error aloft.

SO4 (ANN) (ng/kg)





Diagnostic package from Po-Lun



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- 1. AMWG diagnostic with chemistry installed at ORNL (major credit to Simone).
 - a. Now works on machines other than Yellowstone.
 - b. Now works when output variables are not available
 - c. Fixed a few bugs in tables and plots.
 - d. Need many additional output variables.
 - a. Will get many of those needed with history_aerosol=.true.
- 2. Don't use default lightning scaling.
 - a. Caught error by using diagnostic package.
 - b. It isn't added to cam_nl, unless specified.
 - c. Default is lght_no_prd_factor = 1
 - d. For 2 degrees, use lght_no_prd_factor = 3



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