Modeling Isotopes in Sea Ice

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CESM Sea Ice Component

- Los Alamos sea ice model (CICE4)
- Fully prognostic dynamic-thermodynamic sea ice.
- Multiple-scattering shortwave radiation scheme.
- Tracers in the sea ice are affected by transport, mechanical redistribution, subgridscale thickness distribution, snow ice formation, etc.
- Tracers: Black carbon, dust, melt ponds, and iron.

Black Carbon Aerosol

Figure 3: The concentration of black carbon in the interior snowpack over sea ice in ngC/g in April for (a) the 1xCO2 and (b) the 2xCO2 control integration.

Figure 7: The mean annual cycle of (a) Northern Hemisphere ice area in 10^6 km^2 and (b) Arctic Ocean averaged ice thickness in meters for the control run (solid), the run which excludes aerosols (No_A, dotted), and the run which excludes aerosols and melt ponds (No_A & P, dashed). All simulations shown use 1xCO2 forcing.
Observations of Isotopes in Sea Ice

Pfirman et al. 2004
Plan

- Three new isotope tracers in the sea ice: mass/concentration of HDO, $H_2^{16}O$, and $H_2^{18}O$. Ratio $(R, \delta)$ instead?

- A diagnostic variable for history will be the $\delta$ ratios.

- Initially keep track of concentration of isotopes in snow and sea ice. Add vertical profiles later.

- Handled as passive tracers in the sea ice.

- Parameterize the sources and sinks, e.g. fractionation during freezing, precipitation, evaporation, meltwater.
Isotopes in Sea Ice

- Precipitation: $< -10 \text{‰}$
- Evaporation/Sublimation: $R_{\text{evap}} = R_{\text{ice/snow}}$
- Snow: $-4 \text{‰}$
- Sea Ice: $-3$ to $+3 \text{‰}$
- Meltwater: $-3$ to $+3 \text{‰}$
- Ocean: $-5$ to $+1 \text{‰}$
- Frazil fractionation: $< 0.1\text{‰}$
- Columnar fractionation: $> 2 \text{‰}$
Summary

- Additional tracers added to CICE code.
- Work in progress to implement sources, sinks, and exchange between snow and sea ice.
- Open to ideas on ways to parameterize fractionation (freezing, evaporation).
- NASA GISS model has done this.