The Los Alamos Sea Ice Model (CICE5)

David Bailey and Marika Holland, NCAR
Jennifer Kay, CU
Nicole Jeffery, Elizabeth Hunke, and Adrian Turner, LANL
Andrew Roberts, NPS
Anthony Craig, FA
CICE5

- Same infrastructure as CICE4
- New thermodynamics, dynamics, melt pond, and BGC options.
- Initial configuration will be same as CICE4 and will be in cesm1_3_beta16. Many thanks to Tony Craig!
- Not bfb, but same climate as CICE4.
PCWG Priorities

- New mushy-layer (ML) thermodynamics (Turner and Hunke, submitted)
- Elastic-Anisotropic (EAP) dynamics (Tsamados et al. 2012)
- Form drag at atmosphere-ice interface (Hunke et al.)
- Snow on sea ice processes
- Ponds
- Vertical levels and subgridscale categories.
\begin{equation}
\rho c \frac{\partial T}{\partial t} = \frac{\partial}{\partial z} \left( K \frac{\partial T}{\partial z} \right) + F,
\end{equation}

where \( z \) is the vertical coordinate, defined to be positive downward with \( z = 0 \) at the top surface, \( \rho \) is a fixed sea-ice density, \( c \) is the specific heat of sea ice, \( K \) is the thermal conductivity of sea ice, \( F \) is the absorbed shortwave radiation. The specific heat, \( c \), is given by the approximation of Ono [1967]

\begin{equation}
c(T, S) = c_0 + \frac{L_0 \mu S}{T^2},
\end{equation}

where \( c_0 \) is the specific heat of fresh ice at 0°C, \( L_0 \) is the latent heat of fusion of fresh ice.
ML Thermo

ANN Mean

grid cell mean ice thickness

b.e13.B1850C5CN.f09_g16.cice5.004 - b.e13.B1850C5CN.f09_g16.cice5.001

Yrs 1023 - 1047

grid cell mean ice thickness

b.e13.B1850C5CN.f09_g16.cice5.004 - b.e13.B1850C5CN.f09_g16.cice5.001

Yrs 1023 - 1047

grid cell mean ice thickness

b.e13.B1850C5CN.f09_g16.cice5.004 - b.e13.B1850C5CN.f09_g16.cice5.001

Yrs 1023 - 1047

grid cell mean ice thickness

b.e13.B1850C5CN.f09_g16.cice5.004 - b.e13.B1850C5CN.f09_g16.cice5.001

Yrs 1023 - 1047

grid cell mean ice thickness

b.e13.B1850C5CN.f09_g16.cice5.004 - b.e13.B1850C5CN.f09_g16.cice5.001

Yrs 1023 - 1047
Elastic-Anisotropic Sea Ice
EAP Dynamics

[Image of maps showing grid cell mean ice thickness for different regions with color scales indicating ice thickness in meters.]
Snow patchiness

\[
\text{snow\_fraction} = \min\left(\frac{hs}{hs0}, 1.0\right)
\]

\text{hs0} = 0.1

\text{hs0} = 0.03
Snow patchiness

NH

SH

hs0 = 0.1

hs0 = 0.03
Summary

- Sensitivity with CAM5.1 in 1850 controls. What about CAM6? Transient?
- EAP tends to thicken the thicker ice by slowing it down. Better for higher resolution simulations.
- CESM1.3 will have CICE5 configured the same as CICE4, but with the optional physics.
- While ML tends to thicken ice, it is better physics. More stable solution and needed for BGC.
- Salinity dependent freezing point, salt exchange
- Natural boundary conditions; Z*