TITLE: Sea ice thermodynamic/dynamic observations in the Arctic Ocean

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MEMBERS’ ROLES: Joint drifting buoy deployments, and analysis of mixed layer processes and relation to thermodynamic/dynamic feedbacks in ice. Improved model parameterizations for upper ocean mixing. Monitoring of Arctic sea ice state.
BACKGROUND:

Ice deformation affects ocean stratification (thermo-haline processes), and heat flux to ice (localised kinematic driven upwelling and opening in summer).

Deformation in winter, and summer opening can also impact melt in summer. (a) Early melt of thin lead ice, or opening enhances albedo feedback. (b) Heavily consolidated, ridged ice can survive longer in summer.

Idealised Mixing Processes

Brine rejection at lead

Ridging induced upwelling
**OBJECTIVE:**

- To quantify the dynamic-thermodynamic feedback of the arctic ice pack in recent years. As wintertime ice dynamics precondition the summer ice melt, through control of the sea ice thickness distribution, ice dynamics provide a potential negative or positive feedback to sea ice mass balance.
METHODOLOGY:

Characterize the mass balance of end-of-summer ice pack.

(1) Understand the relationship between sea ice deformation and dynamics, ocean-atmosphere fluxes, and thermodynamic control of the ice mass balance.

(2) Coordinate buoy deployments of IARC ice buoys and JAMSTEC ocean buoys (POPS) in collaboration with ice mass balance buoys from the U.S. Navy Cold Region Research and Engineering Laboratory (CRREL). This will allow a detailed investigation of both the dynamic evolution of sea ice thickness distribution and thermodynamic forcing on the ice.

(3) Develop data (strain rate) driven models of sea ice redistribution that can be used to investigate the relationship between ice deformation and the sea ice mass balance.
**TIME SCHEDULE:**

Spring 2010, 2011, 2012: Collaborative buoy deployments at NPEO

Summer 2010-end 2010: Build data driven drifting station model of ice thickness distribution. This model was used to estimate brine rejection rate to force Kawaguchi’s upper ocean model, and Jin’s POP model.

Spring 2011: Data and model analysis of spring-summer transition. What is the impact of divergence on upper ocean heating? Paper Accepted by Polar Science.

2012: Compile comparative case studies from drifting stations in differing Arctic deformation regimes. Various buoy deployments from 2006-2013.

2013: Model analysis of thermodynamic-dynamic partitioning of influence on mass balance for all case studies. Identifying geographical and seasonal variability in deformation impact on ridging and level ice growth.

2014: Recommendations for future maintenance of buoy deployments and monitoring system. Atlases of ice deformation (1979-present), with report on product error characteristics (funded by NSF). Pan-arctic modeling, and identification of patterns relating sea ice deformation to negative or positive feedback to sea ice mass.
NPEO 2011 Field Campaign

Large Ridging event observed, with coincident upper-ocean warming.
Expected outcome of FY2011:

- Peer reviewed papers: Kawaguchi et al. have a paper accepted in Polar Science (based on 2010 deployment).
  - 3 Papers published/in press, 1 paper submitted

- A better understanding of the interaction between ice divergence and oceanic heat flux to the ice.
  - As outlined in the above paper
Climate model process study: ocean mixing under sea ice.
Jin, Hutchings, Kawaguchi, and Kikuchi

When lead $<<$ climate model grid

When lead $\sim$ climate model grid
Climate model process study: ocean mixing under sea ice.
Ji Hutchings, Kawaguchi, and Kikuchi

Results from 2010 buoys. Kawaguchi et al. (in press).
Practical problem: Funding for equipment
SUMMARY

- Enhanced ice divergence in spring 2010 in Transpolar Drift led to enhanced ice melt and albedo feedback in summer 2010.

- We are continuing our joint buoy deployments through 2012.