Geophysical Research Abstracts
Vol. 17, EGU2015-9654, 2015
EGU General Assembly 2015

Micromechanics of sea ice gouge in shear zones

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The deformation of sea ice is a key control on the Arctic Ocean dynamics. Shear displacement on all scales is an important deformation process in the sea cover. Shear deformation is a dominant mechanism from the scale of basin-scale shear lineaments, through floe-floe interaction and block sliding in ice ridges through to the micro-scale mechanics. Shear deformation will not only depend on the speed of movement of ice surfaces but also the degree that the surfaces have bonded during thermal consolidation and compaction. Recent observations made during fieldwork in the Barents Sea show that shear produces a gouge similar to a fault gouge in a shear zone in the crust. A range of sizes of gouge are exhibited. The consolidation of these fragments has a profound influence on the shear strength and the rate of the processes involved. We review experimental results in sea ice mechanics from mid-scale experiments, conducted in the Hamburg model ship ice tank, simulating sea ice floe motion and interaction and compare these with laboratory experiments on ice friction done in direct shear, and upscale to field measurement of sea ice friction and gouge deformation made during experiments off Svalbard. We find that consolidation, fragmentation and bridging play important roles in the overall dynamics and fit the model of Sammis and Ben-Zion, developed for understanding the micro-mechanics of rock fault gouge, to the sea ice problem.