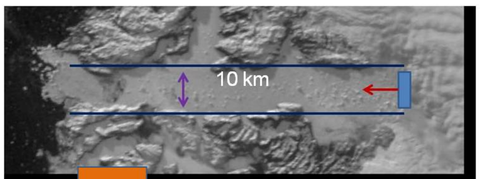
Jamming of Ice Mélange: Using Particle Rafts to Model Ice Mélange

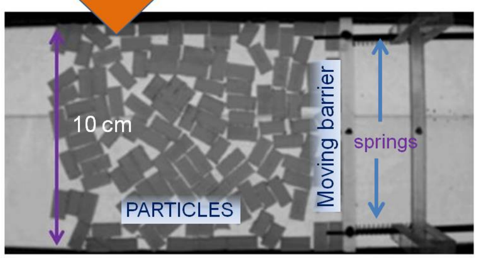
Chin-Chang Kuo, Michael Dennin (U. California, Irvine), Wendy Zhang, Justin Burton, Douglas MacAyeal (University of Chicago) and Jason Amundson (U. of Alaska Southeast)

Introduction

Ice mélange represents a fascinating granular system, as it is a collection of interacting particles on the surface of water that is partially confined between two walls and being driven by a moving glacier into an open reservoir. This represents a fundamentally new system in which to study the *jamming* of granular matter. Jamming refers to a condition in granular matter in which a critical force is required to generate flow. Under conditions of constant driving, a signature of jamming is sudden increases in the force required to maintain the constant driving velocity, followed by sudden releases in the force. Traditional studies of jamming focus on closed geometries or ones with spatial constrictions.



Does this scale?



Experimental Details

We use plastic walls with sandpaper to model the fjord walls. Plastic particles of various shapes are used to model the ice mélange. A pair of plastic bars separated by spring are used to model the glacier driving the flow and measure forces in the system.

Acknowledgments

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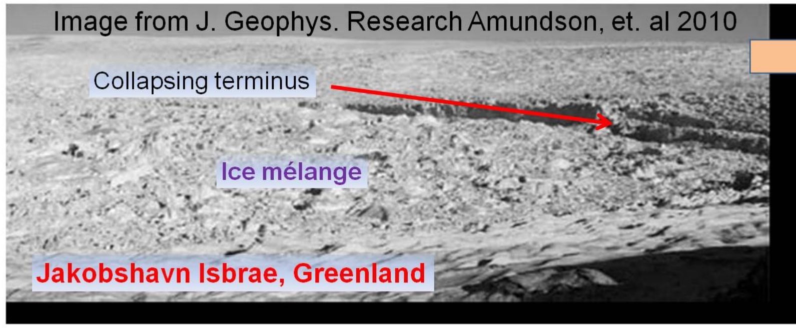


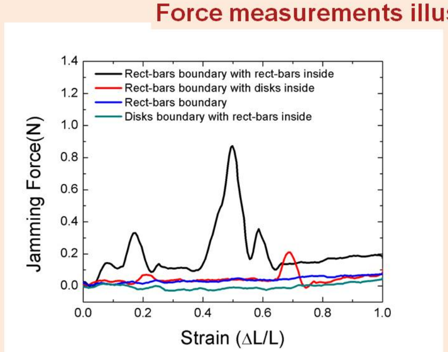
Fjord motivates

Two questions

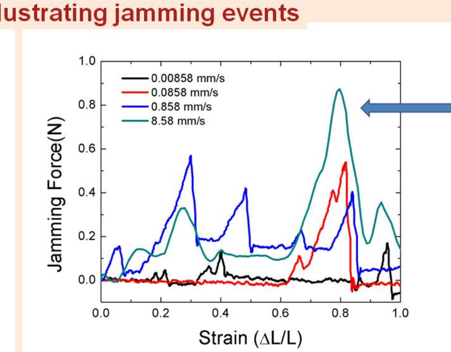
1) Are there new jamming behaviors in the open channel flow of floating, granular particles?
   ANSWER: YES.

2) If there are, are the relevant to the dynamics of ice mélange in fjord?
   ANSWER: subject of future work.

Force measurements illustrating jamming events



Dependence on particle shape

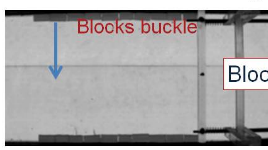


Dependence on driving velocity for system of all rectangular blocks

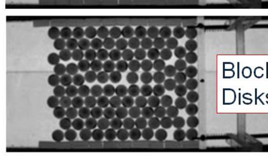
Force Results

The main experimental signature of jamming is the observation of sudden increases in the applied force. The existence of jamming is dependent of the shape of the particle *at the wall of the channel*. We find that when rectangular shaped particles form the boundary layer with the wall, then jamming is observed. If disks form the boundary layer, there is slip at the wall and no jamming occurs. If we place a single layer of rectangular particles at the wall, then buckling of the particles is observed, but no increase in force is measured.

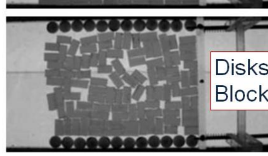
Images of the different Particle systems



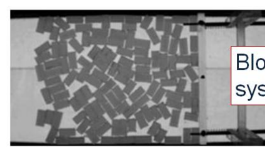
Blocks on wall only



Blocks on wall, Disks in the middle



Disks on wall, Blocks in the middle



Blocks in entire system

Conclusion

We observe a new class of jamming: boundary driven jamming. The jamming requires two steps:

1) Buckling of particles at the wall.
2) The buckling induces density variations in the interior of the system that produces the measured increase in force.

Particle tracking in ice mélange: calving event

Future Work

1) Measure particle dynamics
2) Quantify density variations
3) Develop relevant scaling
4) Connect experiments with glacier data