Soft Geoengineering: Ice911

Leslie Field

Founder

Ice911 Research Corporation

www.ice911.org

leslie@ice911.org

Consulting Professor

Electrical Engineering – Howe Group

lafield@stanford.edu

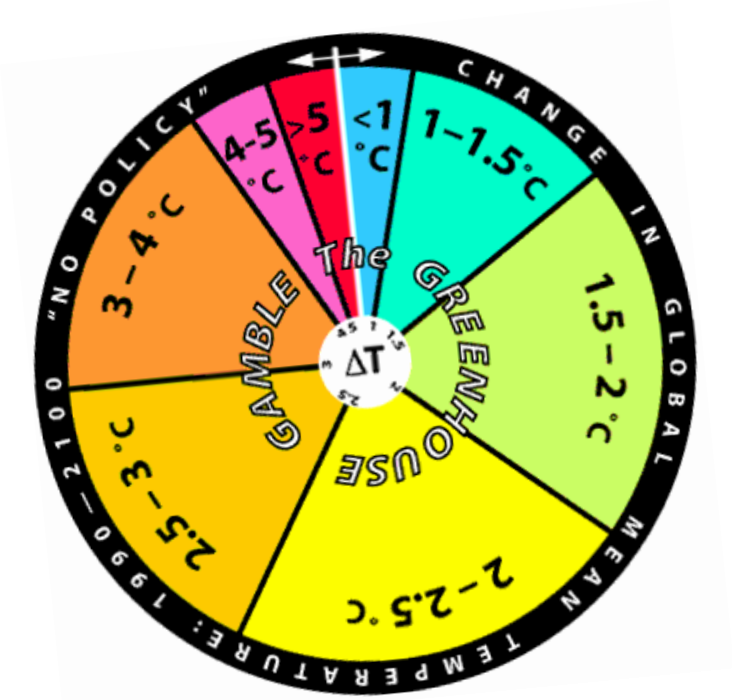
(650) 823-2020

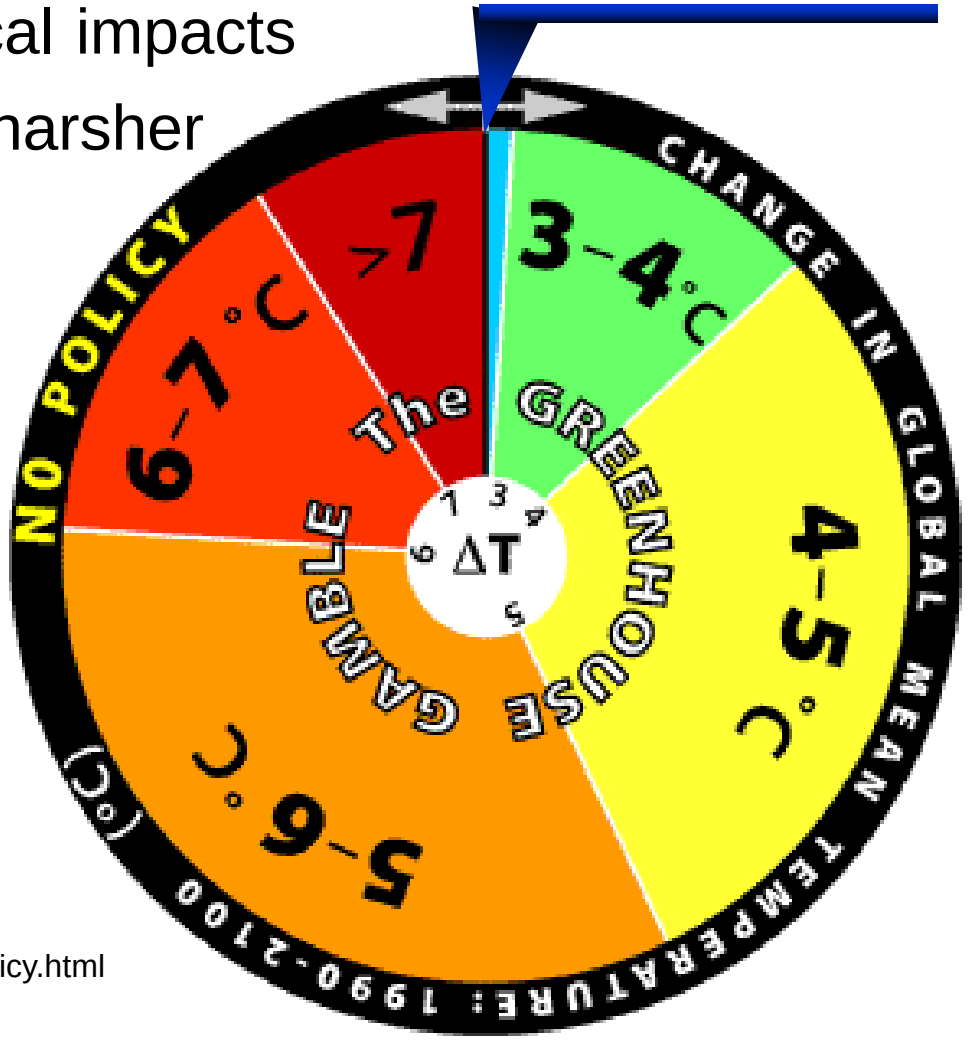
November 8, 2012

MIT's "The Greenhouse Gamble"

Small chance of few ecological impacts

The predictions have gotten harsher





http://globalchange.mit.edu/resources/gamble/no-policy.html

RISING IMPACTS OF GLOBAL WARMING

WITH CONTINUED INTENSIVE RELIANCE ON FOSSIL-FUELS AND EMISSIONS INCREASES

Extinction of more than 40% of known species

2080s

GLOBAL ECONOMIC LOSSES OF UP TO 5% GDP

COMMITMENT TO AT LEAST PARTIAL MELTING OF GREENLAND AND W. ANTARCTIC ICE SHEETS, EVENTUALLY RAISING SEA-LEVEL 13-20 FEET

SUBSTANTIAL BURDEN ON HEALTH SERVICES

GLOBAL FOOD PRODUCTION DECREASES

ABOUT 30% OF GLOBAL COASTAL WETLANDS LOST

2050s

MAJOR CHANGES IN NATURAL SYSTEMS CAUSE PREDOMINANTLY NEGATIVE CONSEQUENCES FOR BIODIVERSITY, WATER AND FOOD SUPPLIES

WIDESPREAD CORAL MORTALITY

MILLIONS MORE PEOPLE FACE FLOODING RISK EVERY YEAR

Greater risk of extinct. for 20-30% of known species

2020s

MOST CORALS BLEACHED

INCREASING MORTALITY FROM HEAT WAVES, FLOODS AND DROUGHTS

DECREASING WATER AVAILABILITY, INCREASING DROUGHT IN MANY REGIONS

INCREASING WILDFIRE RISK, INCREASED FLOOD AND STORM DAMAGE

INCREASING BURDEN FROM MALNUTRITION, DIARHOEAL, CARDIO-RESPIRATORY AND INFECTIOUS DISEASES

NET www.net.org

Source: IPCC Fourth Assessment Report, Working Group II Summary for Policymakers. Timing of temperature increases based on IPCC scenarios that assume continued intensive reliance on fossil-fuels and emissions increases. Emissions reductions would reduce the amount and rate of warming.
Conversion of temperature increases—Celsius to Fahrenheit: 1°C = 1.8°F; 2°C = 3.6°F; 3°C = 5.4°F; 4°C = 7.2°F.

Produced by National Environmental Trust.

Mitigation, Adaptation and Geoengineering

- Mitigation: Conservation, energy efficiency and transition to renewables needed, but may be too slow to prevent major harms
- Adaptation: Designing responses to rising sea levels a current reality in city planning
- Geoengineering: Approaches are possible planetary "bandaid" measures to buy time
  - Possible emergency backup if all else fails
  - Moral Hazard

Another Option

Ecoengineering or Soft Geoengineering

Conservation and renewable energy:

- Conservation and changes to energy mix needed, but too slow.
- Decades to substantially reduce rate of addition of CO_2 to atmosphere

Geoengineering:

- Geoengineering solutions can be rapid
- Can be irreversible, can have unintended ecological effects, can be high costs

Ecoengineering – aka – Soft Geoengineering

- *Ice911 was dubbed Ecoengineering by Prof. Steve Schneider*
- Boundary conditions:
  - Reversible and/or removable
  - As small and local an ecological impact as possible

This presentation describes history and progress towards a **practical engineering solution** to help slow the melt of snow and ice. Technique is also useful for cooling water.

Develop & test suitable materials for local applications.

Determine if this is a useful tool to slow climate change.

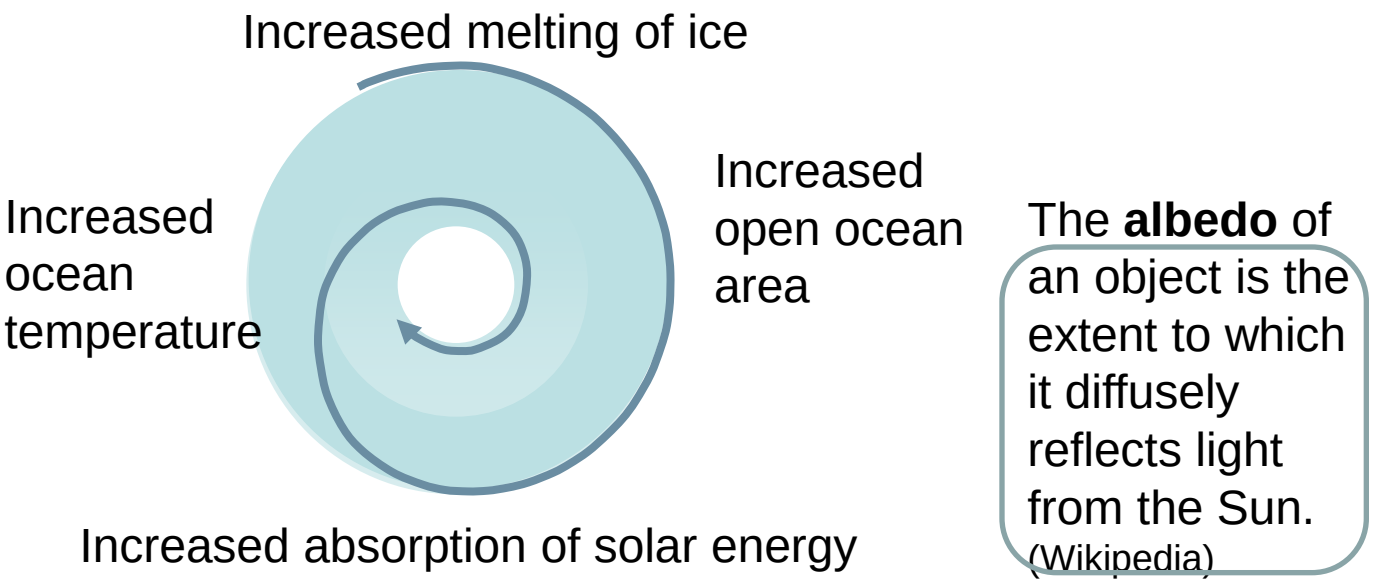
The Ice911 project started in 2006. To date it has been a volunteer effort.

Ice-Albedo Feedback Effect

Polar ice melt is in positive feedback

- the more ice melts, the more radiation is absorbed by larger areas of open ocean
- and the more the ocean heats, the more the ice melts…
- 10% of world's ocean area is in arctic and antarctic

Ice albedo feedback is estimated to increase global rate of warming by 20%

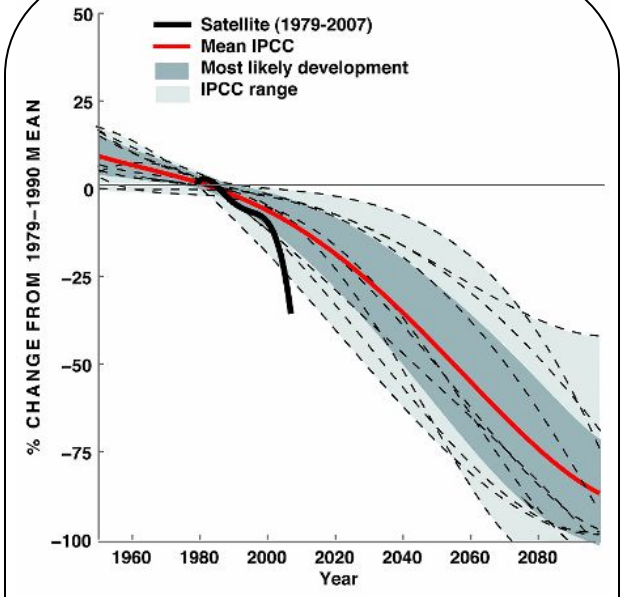


The **albedo** of an object is the extent to which it diffusely reflects light from the Sun. (Wikipedia)

Ice 911: Preserve and Rebuild Ice & Habitat
Rapid Climate Change = Serious Risks

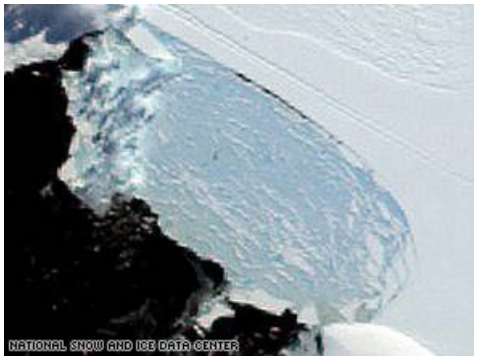
Melting polar ice and glaciers has far-reaching effects

Estimates are 100's of Millions to 1 Billion people depend on glaciers for their drinking water



Arctic sea ice loss compared to IPCC models

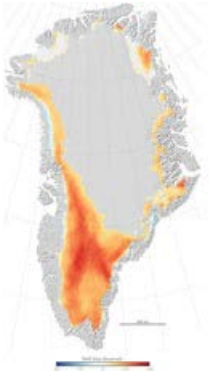
Arctic ice extent loss to September 2007 compared to IPCC modelled changes using the SRES A2 CO2 scenario (IPCC high CO2 scenario). September loss data from satellite observations. Data smoothed with a 4th order polynomial to smooth out the year-to-year variability. Chart courtesy Dr Asgeir Sorteberg, Bjeknes Centre for Climate Research and University Center at Svalbard, Norway. Date: 23 September 2007 www.carbonequity.info/images/seaice07.jpg



Huge Antarctic ice chunk collapses
http://www.cnn.com/2008/TECH/science/03/25/antarctica.collapse.ap/index.html?iref=mpstoryview

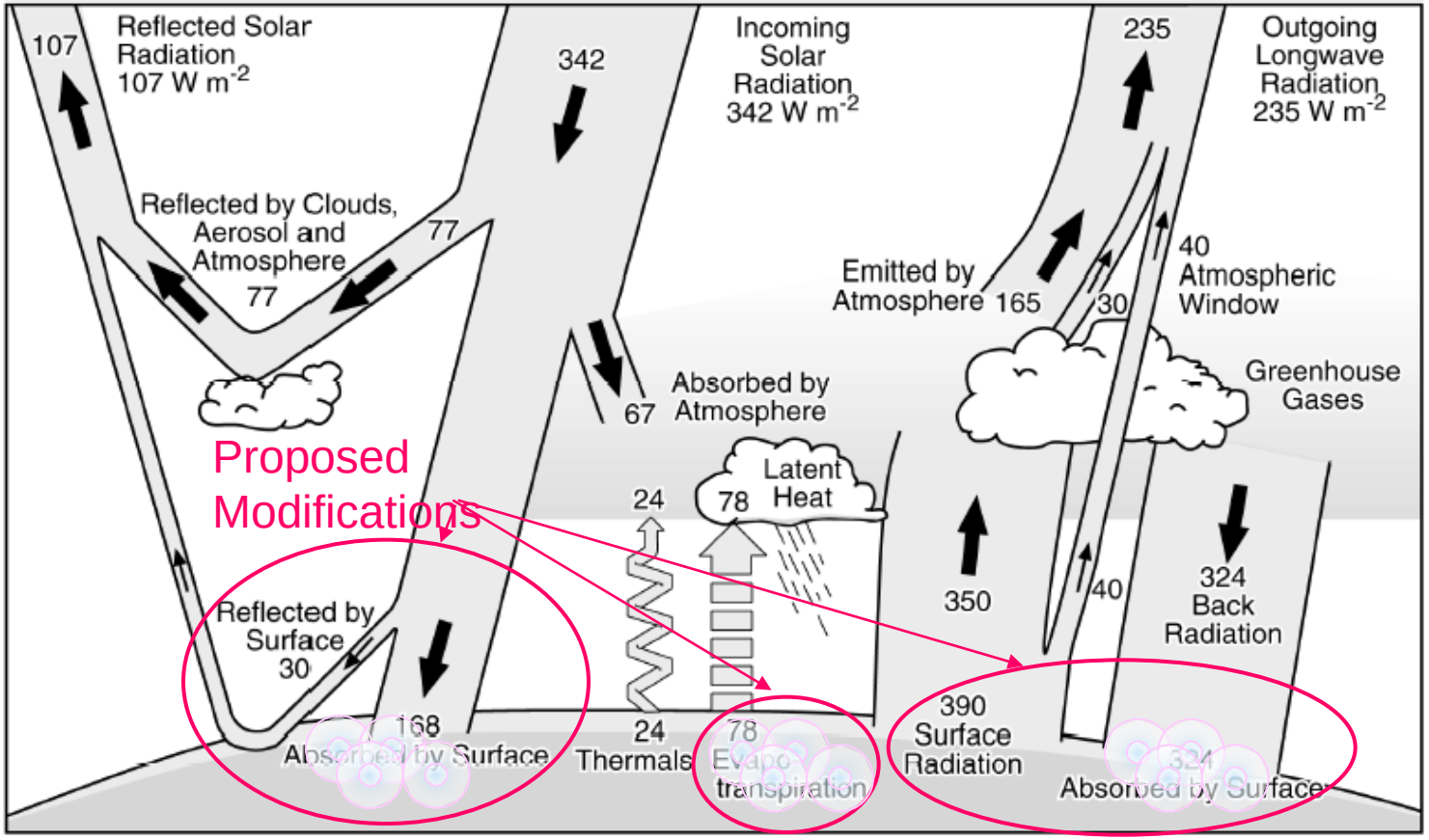
Deep Antarctic waters freshening
http://www.news.com.au/dailytelegraph/story/0,22049,23562427-5001028,00.html ... changes in salinity that could have profound effects on the world's climate and ocean currents.

http://www.independent.co.uk/news/science/solved-mystery-of-the-disappearing-lake-811234.html



Greenland Melting More Than Any Time in 50+ Years
http://www.thedailygreen.com/environmental-news/latest/greenland-melt-47011602
...Greenland ... in 2007… Red indicates 30 days of additional melting.

Earth's Energy Balance With a Localized Tweak



http://stephenschneider.stanford.edu/Climate/Climate_Science/EarthsEnergyBalance.html

Details of Earth's energy balance (source: Kiehl and Trenberth, 1997)

Enhance ice retention with floating, removable materials

Floating materials to change albedo and evaporation rate

Implementation Allows experimentation on relatively small scale

- Instrumented variants in parallel to converge on "best solution"

Allows reversibility if solutions overcompensate

- Or if climate predictions are incomplete

Surface Materials

Protecting Glaciers *and Permafrost?*

Removable, with controlled albedo and porosity

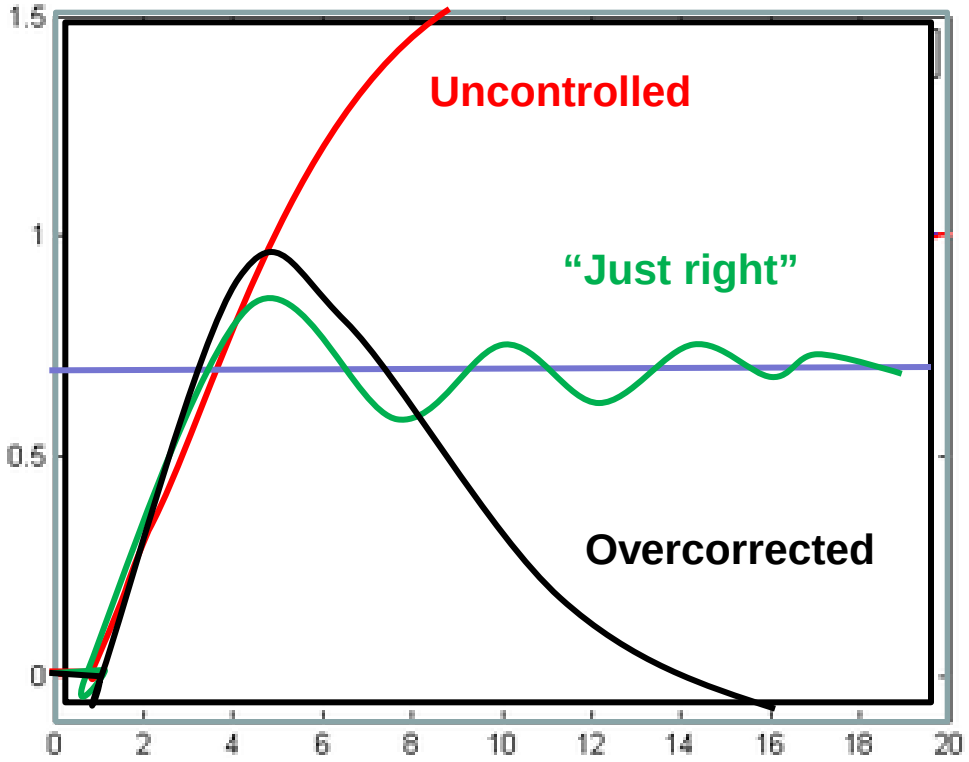
- Reduces solar absorption, allows evaporative cooling
- Protect remaining glaciers, slow the melting, cool and rebuild
- Est. raw material cost is approx $.01/meter^2

EcoEngineering/Soft Geoengineering Control Behavior

Removable and reversible features may be critical

Can ease into solution, reverse if solutions overcompensate

- Or if climate predictions are incomplete



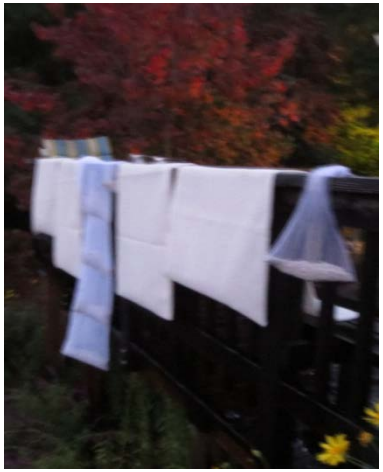
Materials progression over time

- Hollow glass spheres *(including a low cost recycled glass)*
  - Float, inert, high albedo, inexpensive, deployable by helicopter
  - Composite effective for ice retention; Spheres for cooling water in tanks
  - To be able to remove later, need to contain them
  - Need to establish impact, if any, of loose materials on marine ecology

- Sheet materials
  - May not float, inert, high albedo, costly, surface deploy, wind
  - Effective for ice retention
  - Can remove at end of experiment

- Biodegradable modular materials
- Back to low cost floating glass - now in mesh bags
  - May make new ice more like multiyear ice, delaying melt

Deployment is a community affair. Water District gives us permission, and presents to resident's district board. Supportive neighbors stop by to hear updates.







Monday's deployment. Instrument team ran out of time so we had to scale back for now, to not deploy the test from a kayak in the dark, so as to keep our team safe.

Wide-Area Deployment Rough Cost Magnitude

To replace one year's historic (~yr 2000) summer-to-summer ice melt 50,000 km^2:

Low-cost glass sphere diameter (um)	40.00	1000.00
density spheres (kg/m^3) (vendor)	530.00	400.00
weight spheres (gm/m^2) (square lattice)	11.10	209.44
coverage monolayer of spheres (m^2/kg)	90.09	4.77
$ cost/lb (vendor cheaper in large quantities)	0.42	0.42
coverage cost ($/m^2)	0.01	0.19
coverage cost ($/km^2)	10269	193755

50,000 km^2 /yr of ice historical melt

Material cost of $.01/m^2 => $500 Million per year of historic ice replacement

Costs change greatly depending on the diameter of the spheres.
Transportation, deployment, and containment if needed all will add to these costs.
Removing the materials later, or reversing the effects (a little soot ?) would add significant costs.

Ice911 Summary Talking Points

- Why Geoengineering. Geoengineering alternatives.
- Reversible low-impact ways to slow climate change may give a chance to develop longer-term solutions of conservation and energy efficiency
- Ice911 useful for several things, esp targeted to snow and ice preservation as that's a big lever on climate; perhaps permafrost. Working to build back the natural processes of ice and snow formation.
- Young ice melts more quickly than older multi-year ice. Ice911 materials, if taken up in the ice as is forms, may act like multi-year ice, slowing the rapidly increasing spiral from the ice albedo feedback effect.
- Small-scale testing, always removing what we use, complete cleanup – and safety first. Transparent and public. Talks to local community and universities. Updates to Board at lake experimental site.
- Intentional slow and steady progress because cautious and small scale as we proceed to gather data
- Cost and ease of large-scale deployments will depend on how much containment there needs to be. If uncontained OK, least expensive small floating glass materials cost is about 1 cent/m^2