Fire and Ice: Measuring Antarctica’s Frozen Sea

Dr. Cindy Furse, Dr. Ken Golden
David Lubbers, Dr. Joyce Lin Christian Sampson
Our expedition was a key activity in a 4 year interdisciplinary, international project:

U. of Utah - Math: Ken Golden PI
Elena Cherkaev, Jingyi Zhu
ECE: Cindy Furse
U. Alaska Fairbanks – Geophys. Inst.: Hajo Eicken

Co-PI’s

UTAH MATH: Joyce Lin, NSF Postdoc, Grad students Adam Gully, Christian Sampson, Senior Kyle Steffen
UTAH ECE: Seniors David Lubbers, Erik Gamez, Jake Hansen
UAF: Grad student Marc Mueller-Stoffels
VUW: Grad students Keleigh Jones, Sean Buchanan

National Science Foundation
Collaborations in Mathematical Geosciences

Develop electromagnetic methods to monitor sea ice processes which are critical to understanding climate and improving global climate models.
Team Members

• Jake Hansen
  o Intro, Background, Key Properties
  o Procedures/Methods

• Erik Gamez
  o DC Measurements and Results

• David Lubbers
  o Anisotropic Measurements
  o AC Measurements and Results
Why Study Sea Ice?

- **Winter:** 7-10% of the Earth’s surface
- **Cycle of formation and degradation impactful**
- **Boundary:** sunscreen and blanket
- **Albedo:** ratio of reflected sunlight to incident sunlight
- **Climate and ocean life**
- **Most sensitive regions on Earth**
Sea Ice and Climate Change

- Sea ice as the boundary layer between the ocean and atmosphere
- Nearly 40% loss

From: Don Perovich
Arctic meltdown
Summertime Arctic sea ice pack is declining, and thicker, multiyear ice is being replaced by thinner first year ice.

IPCC (Intergovernmental Panel on Climate Change) projections
Global climate models underestimate observed decline in summer Arctic sea ice extent.

Change in summer Arctic sea ice extent

Arctic sea ice loss compared to IPCC models

September 2007

March 2009

Boé, Hall, Qu 2009
Properties of Sea Ice

- Sea ice: simply frozen ocean water
- Sea ice is heterogeneous
- Composite: pure ice with inclusions of liquid brine, air pockets, and solid salts
- Most influential variable: Temperature

Courtesy of Dr. Ken Golden
Brine channels in the ice allow transport of sea water, forming snow ice and affecting heat exchange and melt pond evolution.
Why Study Sea Ice?

Why Study Sea Ice?

Global Temperature

Resistivity of Sea Ice
Why Study Sea Ice?

Global Temperature

How?

Resistivity of Sea Ice
Amount of Sea Ice

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From: Don Perovich
Why Study Sea Ice?

Global Temperature ➔

Amount of Sea Ice
Melt Ponds

Melt Ponds/ Albedo

Why Study Sea Ice?

Global Temperature

Amount of Sea Ice

Melt Ponds
Brine Channels/Percolation

Properties of Brine

- Brine: Salt water
- Host extensive algae and bacterial communities
- Facilitates the flow of salt water through sea ice
- Mediates the growth and decay of seasonal ice
Brine Inclusions

Courtesy of Dr. Ken Golden
Fluid Transport Occurs

From Previous Work: Dr. KM Golden
From Previous Work: Dr. KM Golden, Dr. Hajo Eicken
Rule Of Fives (cont.)

\[ T = -5^\circ \text{C} \]

\[ \Phi = .05 \]

\[ S = 5 \text{ ppt} \]
Anisotropy

- The property of being directionally dependent
- Modeling is very difficult due to the anisotropic nature of sea ice
Why Study Sea Ice?

Global Temperature

Amount of Sea Ice

Melt Ponds

Percolation Rate
Resistivity of Sea Ice
Why Study Sea Ice?

Global Temperature

Amount of Sea Ice

Melt Ponds

Percolation Rate

Resistivity of Sea Ice
Sea Ice Cores (2.5 meters deep)
Sea Ice and Climate Change

- Columnar ice

Courtesy of Dr. Pat Langhorne
Sea Ice and Climate Change

- Platelet ice – deep

Courtesy of Dr. Pat Langhorne
• Columnar ice

Courtesy of Dr. Pat Langhorne
Developing a Method
Sea Ice Cores (2.5 meters deep)
Measuring Resistance
Vert. Resistance
Vert. Resistance
• Corrosion

• The sun is an enemy

• Real ice is not the same as homegrown
Horiz. Resistance (Fail)
Horiz. Resistance (Fail)
Horiz. Resistance (Fail)
Horiz. Resistance (Less Fail)
Vert. Capacitance (Fail)
Horiz. Capacitance (Less Fail)
Vert. Capacitance Success!
Crooked Coring: A Good Idea
Crooked Coring: A Good Idea
Crooked Cores
Proving Anisotropy
The Lesson

• **Things go wrong!**

  • *When it goes wrong, fix it*
  
  • *When your fix didn’t work, fix it again*

  • **Perservere**
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