Water and Ice Sheets

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Help From Tim Creyts, Mike Wolovick, Nick Frearson
Science is Collaborative and Global
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Outline

• Water Ice Sheets and Change
  – Melts water and basal melt

• Water at the Ice Sheet Base
  – Why is there water beneath ice sheets?
  – What do subglacial water networks look like?

• The End of Subglacial Water
  – Freeze and Deformation

• Why Refreezing and Deformation Matters

• How to Understand the Fate of Surface Melt
Rare Burst of Melting Seen in Greenland’s Ice Sheet

By KELLY SLIVKA
-50 C @ the Surface but Melting @ Bed
Sept 20

Dr. Robin suggested possible melt-layer at bottom of ice cap

Geothermal heat rise 80% of column

Elevation

Temperature

Melt Layer

1964 Field Notebook
Queen Maud Land Traverse

Gordon Robin
Predicted Melt Beneath East Antarctica
Water beneath Antarctica

- Inventory of subglacial lakes.
- Background shading = balance velocities.
- Many correlate with areas of fast ice flow or the onset of fast flow

Smith et al., 2009
Lake Vostok

Size of NJ
1000m Deep in places
(b) West Antarctica

Grounding Line

Ice Stream

Cascading Ice Stream Lakes

Wet Sediment / Till
Fricker et al, 2007
Some of the surface melt ends up captured in shallow layers of ice sheet.

Forester et al, in review.
Draining Surface Lake Triggers ~24hr Acceleration
Das et al 2008
Some Of The Surface Melt Ends Up At the Base of The Ice Sheet (Das et al)
Ice Sheet Plumbing
Generalized drainage models: analytic flow models

**Fast**
- R-channels
- N-channels
- Broad & Flat channels

**Slow**
- Thin water films
- Linked cavities and macroporous flow
- Porous media
- Canals

From Tim Creyts, Creyts and Clarke 2010, Creyts and Schoof 2009
AGAP EXPEDITION

Nov 2008 – Jan 2009
Water distributions

Map + histogram with depth

- Water is preferentially located in deep valleys
- Very little high in the drainage
- Wolovick et al 2013, Creyts et al in review
Odd Reflectors Emerging from Water
Looks Like........
Flight 4 Dec 26 2008 – EXTRA PEAKS

Flight=04a Line=L280 files=061-080

double peaks close together
Radio fade 68-74

2000m

3000m
Flight 15 Jan 1, 2009 L560
Pointy Mountain???

HUGE mountain, very pointy, can see change in ice surface.
Flight 15 Jan 1, 2009 L580
Dental XRAY???

big mountain

Looks like dental x-rays...
Something Neither Water nor Melt
Often Emerging from Basal Water
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Often Emerging from Basal Water
Water distributions

- Water is preferentially located in deep valleys
- Very little high in the drainage

Map + histogram with depth
Distribution Basal Freeze-on in Greenland on Bed and on water networks

-2011 radar some select 2012
Example from Marginal Radar, Surface, Cartoon Eqip Storsommer
Wolovick et al in prep
Pulses of Flux
Large Bodies
With
Basal
Material
Entrained
NEEM Community Results
Mechanism for Ice Sheets Freeze-on and Deform.... And maybe speed-up?

- Lots of Water – Eqip Margin Ice Sheet
- Variable Water – Deform and Freeze
- Rheology (NEEM Results)
- Changing Basal Conditions – North East Ice Stream
Abrupt Change →
Changing Interior Changing Structure Influence Flux....

• Lots of Water – Eqip Margin Ice Sheet
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ICEPOD Background

- Recovery Act Funding – 5/1/2010-4/30/2015
- Concept: Leverage Defense Department Investment in Technology
- Build Flexible Instrument Package Using Long Range Capabilities LC-130
- Goal Instruments, Data and Platform for Community Use through Piggyback Missions and Dedicated Flights
IcePod
Recovery Act Funding
Goal Instruments, Data and Platform for Community Use through Piggyback Missions and Dedicated Flights
Icepod

A modular approach to Airborne Geophysics.

A Troop Door

An Arm

An LC-130

A Data Acquisition Rack

A Sensor Pod

Some Willing Helpers!
IcePod Instrumentation

- Optical Instruments
  - IR Camera
  - Pyrometer
  - High Res Vis Wave Camera
  - Scanning Laser

- Radar
  - Deep Ice
  - Shallow Ice [100m]

- Georeference
  - GPS
  - IMU
Lab Installation to Flight Ready in 2 days

1. Disassemble and pack system: ~3h
2. Unpack and install system: ~4h
3. Test System: ~2h
First Internal Layers Near Russell
-13.2°C range 1.4°C

IR Camera
300m x 600m

(warm on North Side of Channels)
Capturing The Seasonal Melt Cycle

Piggyback Missions on NYANG Missions

April-August

Benchmark Lines

Summit to the Coast

Jakobshavn

Russell Glacier – Return from Raven

Ice Surface Elevation
Surface Temperature
Surface Imagery
Shallow & Deep Radar
Conclusions

Subglacial Hydrology Complex

Freeze-on and Deformation Key Component

Understand Water Budget and Summer Melt High Resolution Summer Observations - ICEPOD