Measuring the Mendenhall: State of the Glacier

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March 4, 2011
Terminus Changes

- 1.3 miles from Mendenhall Glacier Visitor’s Center to 2010 terminus

- 3.1 miles from 1760 Little Ice Age maximum to 2010 terminus

June 2009 SPOT5 multispectral satellite image
Terminus Changes

- 2009-2010 165 meters, 540 feet (255 meters or 836 feet in the center)

- 1997-2009 52-68 m/yr (170-215 ft)
Mass Balance- Ablation Zone

near terminus

Photo Credits: Michael Hekkers 7/1/10
Mass Balance
Accumulation
Zone
North Branch

Photo Credits: Michael Hekkers 9/12/10
End of Summer Snowline

Equilibrium Line Altitude (m)

South Branch

3,400 feet

Photo Credit: Michael Hekkers 9/12/10
1949-2009

Mean Annual Temperature +3.2°F

Mean Winter (Dec-Feb) Temperature +6.5°F

Mean Summer (Jun-Aug) Temperature +2.3°F

Rick Fritsch, NWS Juneau
Radiocarbon Dates and Stratigraphy
From Relict Little Ice Age Sediments
On Bedrock Peninsula SW of Mendenhall Glacier
Lakefront Terminus
2009-2010

Cathy Connor
02/14/2011
Radiocarbon Sample sites

~2010 TERMINUS

Sediments that survived the Little Ice Age Advance of the Mendenhall Glacier 2,000 years ago.
2,000 Year old Survivor Sediments
UAS Students examine climate evidence recorded in sediments

10-140 AD cal years
(1960 to 1810 years before 1950AD)

340 BC to 20 AD cal yrs
(2150 to 1930 before 1950 AD)

Connor photos 2010
LOWER BED WOOD SAMPLE

Detrital fossil wood
May 14C Sample—Sept Sediment study
MFSR00-6C
35% coarse silt and 50% very fine sand. This is evidence for deposition from slow moving water or lake deposits

MFSR00-6B
45% coarse silt and 48% very fine sand

MRSR00-6A
42% coarse silt and 37% very fine sand

MFSR00 5
28% coarse silt and 55% very fine/fine sand

MFSR00-4C
26% coarse silt and 60% very fine/fine sand

MFSR00-4B
35% coarse silt and 60% very fine/fine sand

MFSR00-4A
31% med-coarse sand and 54% granule/pebble
(This is evidence of faster moving water)

MFSR00-3
56% coarse sand and 37% granule/pebble

MFSR00-2
60% coarse sand and 31% granule/pebbles

MFSR00-1
50% coarse sand and 43% granules/pebbles; Formation of diamictons: Glacial till laid down at the terminus
<table>
<thead>
<tr>
<th>Weight of Total Sample (g)</th>
<th>Description</th>
<th>Sieve Size (mm)</th>
<th>Phi Units*</th>
<th>Sieved Sample Weight (g)</th>
<th>% Mass</th>
<th>Cumulative % Mass</th>
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<tr>
<td>273</td>
<td>3/10Y Dark</td>
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<td>-6.25</td>
<td>12</td>
<td>4.40</td>
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<td>Greenish</td>
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<td>-6</td>
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<td>1.25</td>
<td>1.6</td>
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<td>2.25</td>
<td>0.8</td>
<td>0.29</td>
<td>99.80</td>
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<td>&lt;0.075</td>
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<td></td>
<td>3.25</td>
<td>0.8</td>
<td>0.28</td>
<td>100.08</td>
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</table>

Alex Sargent UAS 2010
Mendenhall Calving Events: A Case Study
Introduction

• On August 18th 2010 Mendenhall Glacier experienced one of the largest calving events of the season which is highlighted in this presentation.
Before Aug 18th

After
Camera on visitor center roof

Hobo in 5/12

Hobo out 9/14

Hobo temperature logger
Since 2000 the deepest portion of the lake has opened up due to terminus retreat.
This new deep basin has increased glacier buoyancy, leading to terminus instability and calving.
The deepest point was measured at 77 meters in 2008 but is slowly decreasing due to increased sedimentation.
• Temperatures of the two meteorological stations, Terminus (red) and the Northstar camp (blue).
• Lower graph highlights the week of 8/15-8/21.
• Temperature reaches almost 65 degrees F before the calving event.
Prior to calving, 2.5 inches of rain fell at the NorthStar camp in a little more than 24 hours.
Summer 2010
Mendenhall Lake Level

- Temperature event (65 °F)
- Precipitation event (2.5 in)
• Deeper Hobos switch from warmest to coldest temps on 8/18 before calving event

• Abrupt increase in deep lake temperatures
Moulins

- A moulin is a narrow chute or crevasse that is a pathway for water to enter a glacier from the surface.
- Moulins can go all the way to the bottom of the glacier.
- They are usually the source of glacial caves and are part of a glacier's internal plumbing system.
Lake Drainage- on the glacier or next to the glacier

- Precipitation and melt water accumulates
- Drains to base of glacier, increases glacier sliding
- Water is discharged at the glacier front and base and is recorded in lake temperatures
- Mendenhall Lake level rises making terminus more buoyant.
- Calving event occurs and is captured on cameras
July Calvings

2nd: East side near the falls
4th: East side, left of the falls, morning
   Center, 1pm
   Large slab, East side, 4:30pm
7th: Small piece of the center nose, 2pm
9th: Medium calving 7pm Right Centre
15th: Calving, right side, ?
17th: Several small calvings, Right side, 8am
18th: New calving overnight @ waterfall
19th: Next to waterfall
20th: 9:00am Centre, right of "nose"
24th: 2:20pm left of waterfall x2
26th: 4:15pm left of previous 2, 4
26th: 11:00am, next to the waterfall, large calving
27th: 5pm, small/medium calvings 3, 5 minutes apart
30th: 3pm - right side, near little waterfalls
Lake Temperature Profile

![Graph showing temperature profile over time with specific dates and temperature readings.]
Conclusion

• The calving event was preceded by a high amount of precipitation and warm temperatures.
• Lake level increases cause strain on the buoyant terminus, allowing the release of the pooled melt water/precipitation.
• Future studies will be done to better understand these calving events before the terminus lifts out of the lake.
Glaciers as a source of freshwater and nutrients to the Gulf of Alaska

- Glaciers cover ~10% of Earth’s surface
- Unique among terrestrial ecosystems
- Undergoing rapid changes (glacier thinning and retreat)
Glacier thinning and recession

Landcover change
Tight terrestrial-marine coupling

Photo: Kevin White
How much do glaciers contribute to freshwater discharge?
## Regional GOA Discharge

<table>
<thead>
<tr>
<th>Region</th>
<th>Area (km²)</th>
<th>Percent GOA Basin Area</th>
<th>Mean Annual Runoff (km³)</th>
<th>Percent GOA Runoff</th>
<th>% from glaciers</th>
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<tr>
<td>Southeast Alaska/Canada</td>
<td>153,884</td>
<td>37%</td>
<td>370 ± 26</td>
<td>42%</td>
<td>26%</td>
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<tr>
<td>Central Coast</td>
<td>55,568</td>
<td>13%</td>
<td>200 ± 14</td>
<td>24%</td>
<td>87%</td>
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<tr>
<td>Copper River Region</td>
<td>65,056</td>
<td>15%</td>
<td>65 ± 5</td>
<td>8%</td>
<td>70%</td>
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<tr>
<td>Prince William Sound</td>
<td>19,898</td>
<td>5%</td>
<td>95 ± 6</td>
<td>10%</td>
<td>57%</td>
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<tr>
<td>W Cook Inlet/Kodiak</td>
<td>42,807</td>
<td>10%</td>
<td>54 ± 3</td>
<td>7%</td>
<td>15%</td>
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<tr>
<td>Knik Arm/Kenai</td>
<td>29,227</td>
<td>7%</td>
<td>36 ± 5</td>
<td>4%</td>
<td>45%</td>
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<td>Susitna River Region</td>
<td>53,789</td>
<td>13%</td>
<td>46 ± 2</td>
<td>5%</td>
<td>26%</td>
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<tr>
<td>Total GOA</td>
<td>420,229</td>
<td>100%</td>
<td>870 ± 61</td>
<td>100%</td>
<td>47%</td>
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</table>

Neal et al., *GRL*, 2010
870 km$^3$ yr$^{-1}$

2x GOA

215 km$^3$ yr$^{-1}$

402 km$^3$ yr$^{-1}$

(410 km$^3$ yr$^{-1}$ from glaciers)

7x GOA

Legend
- Yukon River
- Gulf of Alaska
- Mississippi River
Importance of glacial runoff
Physical Characteristics

Hood and Berner, JGR-B, 2009

Non-glacial Streams

Glacial Streams
Stream temperature

![Graph showing the relationship between water temperature and percentage of glacier, with R squared = 0.92]
Discharge

Non-Glacial

Glacial
Nutrient Export in Rivers

Hood and Scott, 2008
What will happen as glaciers keep melting?

Long term pattern in glacier export

Time (decades)

Material

Current?
Glacier Bay National Park
Thanks

• Former UAS Faculty- Matt Heavner
• Students and alumni: David Sauer, Nick Korzen, Nat Kugler, Benjamin Hoffman (JIRP)
• Ron Marvin, Wayne Ward, Laurie Craig at the MGVC
• Shannon and company at NorthStar Trekking
• ERA Helicopters, Temsco Helicopters, Coastal Helicopters

To find out more about the Mendenhall Glacier go to: uas.alaska.edu/envs/links.html. Click on “Mendenhall Glacier Facts”
Collaborators:
• Andy Vermilyea (UAS)
• Jason Fellman (U. Western Australia)
• Rob Spencer & Peter Hernes (UC Davis)
• Durelle Scott (Virginia Tech)
• Peter Raymond (Yale University)
• Rick Edwards & Dave D’Amore (USFS)
• Ed Neal (USGS)
• Kathy Smikrud (AK Dept of Fish & Game)
• Aron Stubbins (Skidaway Institute of Oceanography)
Funding:

NSF: DBI-0553000 and EAR-0838587

University of Alaska EPSCoR

U.S.D.A. Forest Service, Pacific Northwest Research Station

Geographic Information Network of Alaska

US Geological Survey