A Cryospheric Sensor Web Use Case on a Small Temperate Glacier

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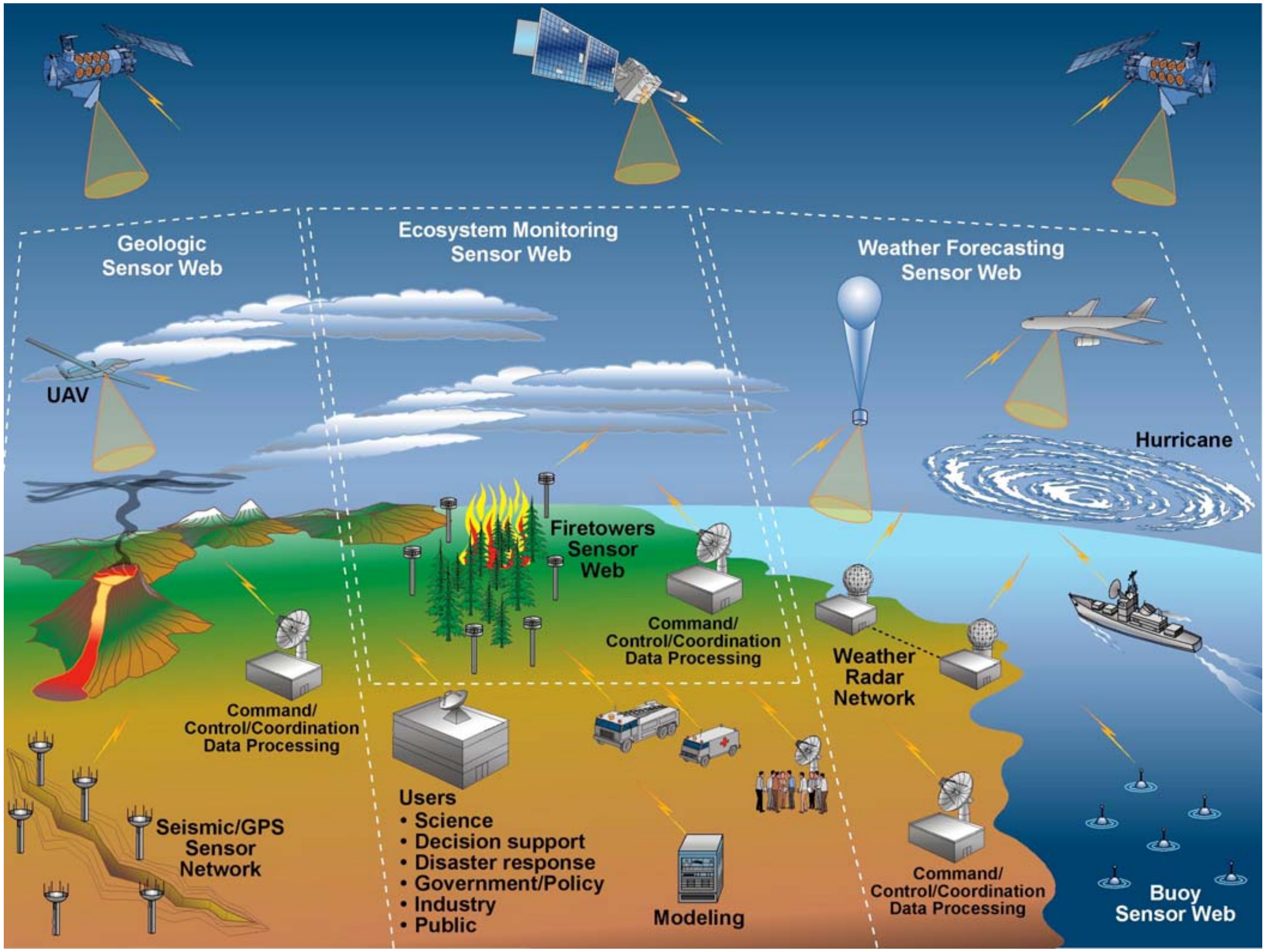
http://seamonsterak.com

Outline

- Sensor Web
- Science Motivation
- SEAMONSTER Components
- SEAMONSTER Sensor Web
- Findings, Results, Status
- Sensor Web Testbed

Sensor Web Concept



Southeast Alaska

SEAMONSTER

SouthEast
Alaska
MOnitoring
Network for
Science
Technology
Education and
Research

Tlingit carving of Gunakadeit, the seamonster, in downtown Juneau.

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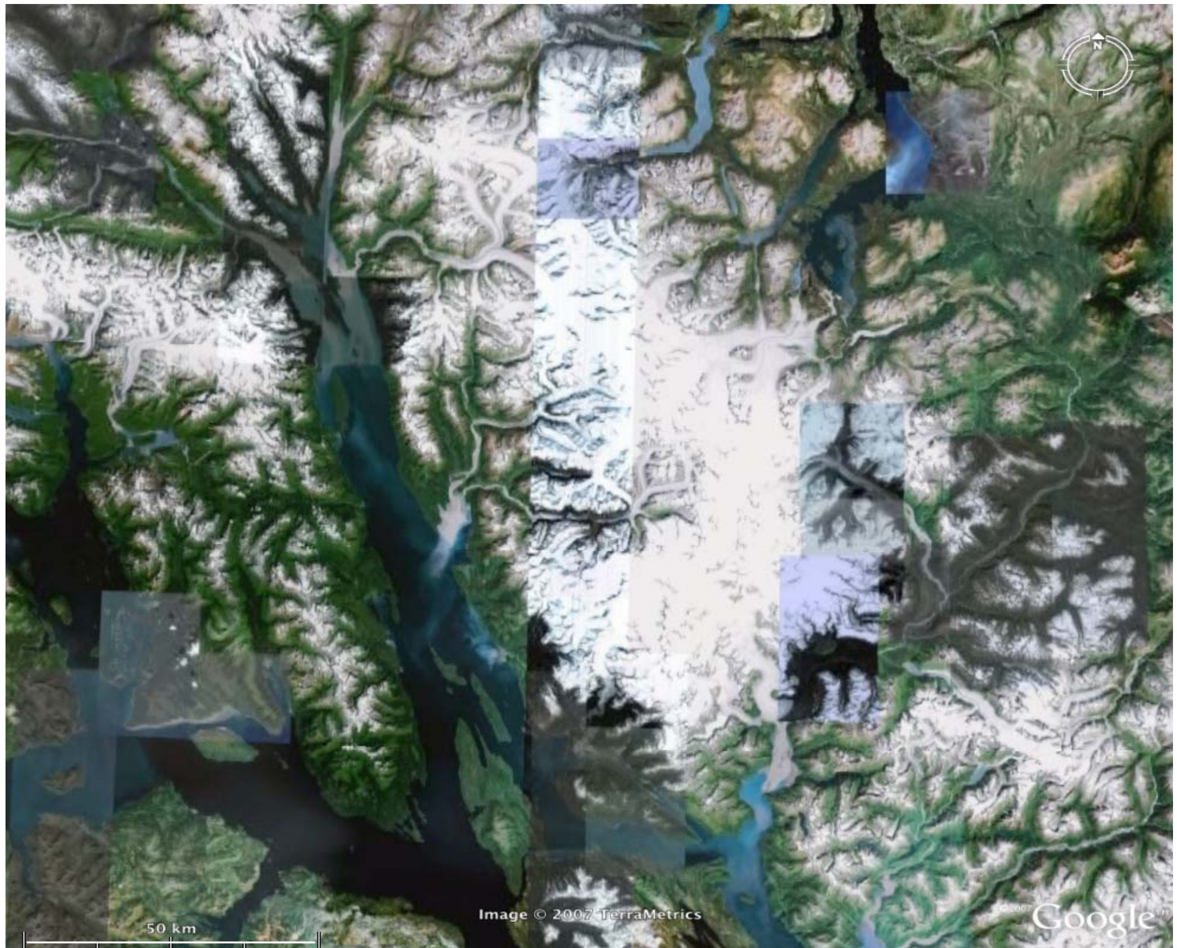
SEAMONSTER

- Scientifically Motivated Technology Development funded by NASA ESTO AIST
- Testbed Sensor Web
  - MACRO
  - SnoMotes
- Path for Technology Infusion
  - Scientific Collaborations

Scientific Motivation, 1

Long term monitoring of the Juneau Icefield to observe watershed and ocean ecological impacts of glacial recession



50 km

Scientific Motivation, 1

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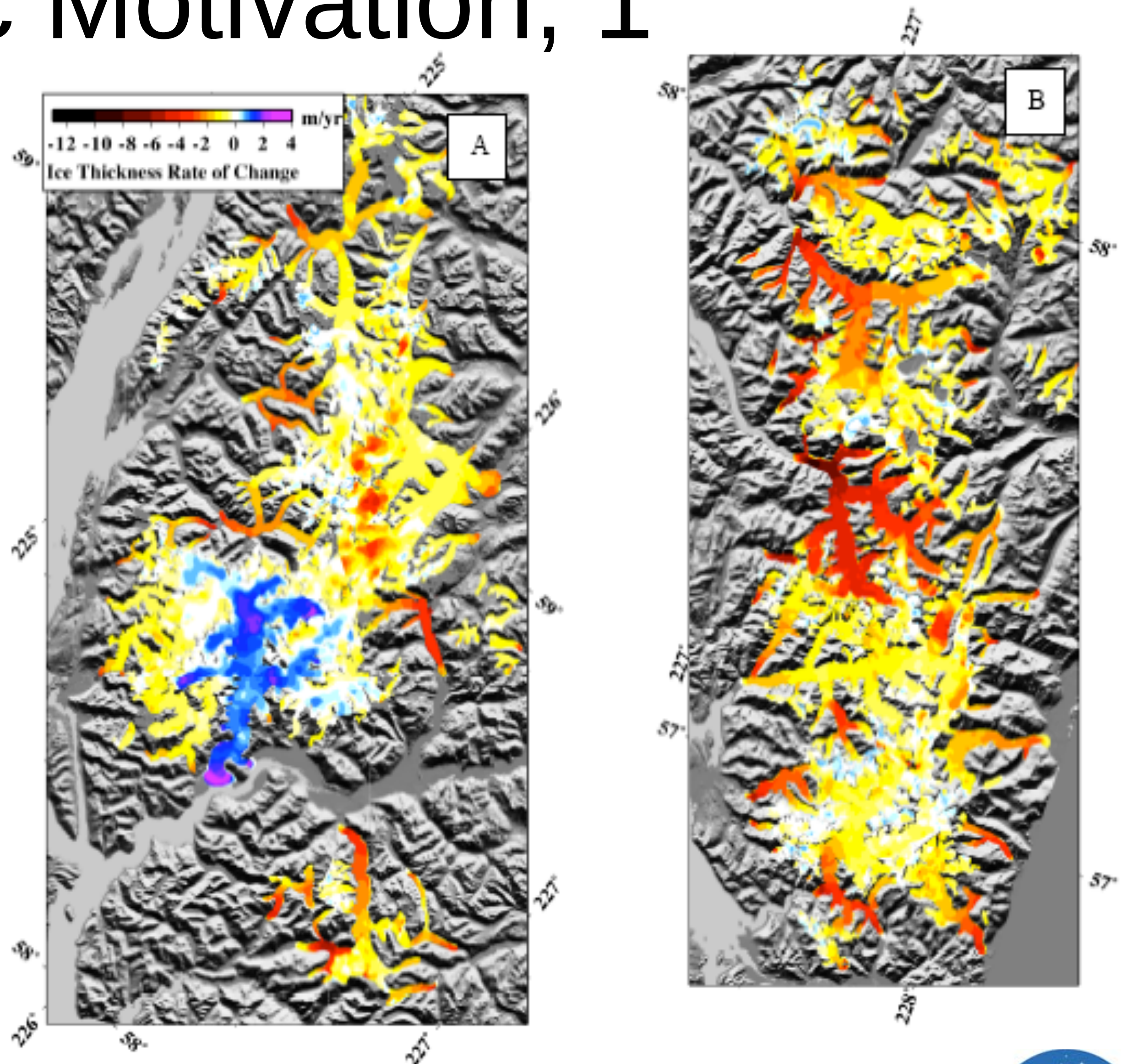


Larsen *et al*, 2007

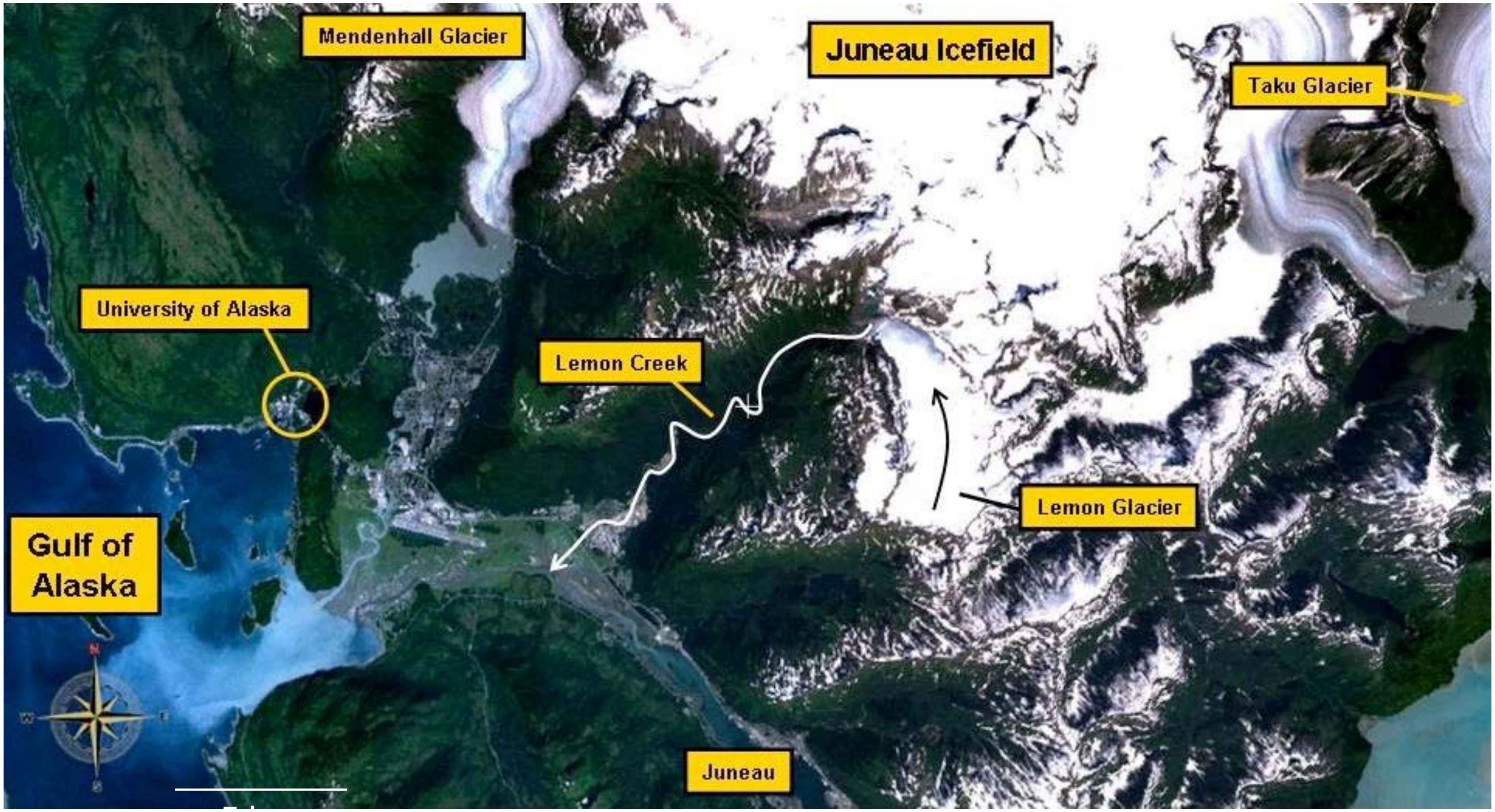
Scientific Motivation, 2

Detection of transient glacial lake outburst floods and observation for watershed impacts

Lake pre-drainage

Lake post-drainage

Lemon Creek Watershed



The University of Alaska Southeast has (relatively) easy access to these areas. The initial watershed of interest is the Lemon Creek watershed (fed by Lemon Glacier) which can be entirely accessed via hiking. Lemon Glacier was monitored as part of IGY (1957-58) and is again being studied for IPY (2007-8).

SEAMONSTER Use Case Research Questions

How does runoff from the Lemon Glacier affect:

- Physiochemical properties of Lemon Creek (aquatic habitat)
- Sediment transport
- Streamwater nutrient loads
- Ocean Impacts

Preliminary Science Results

- Seasonal Changes
- Diurnal Patterns

April

June

July

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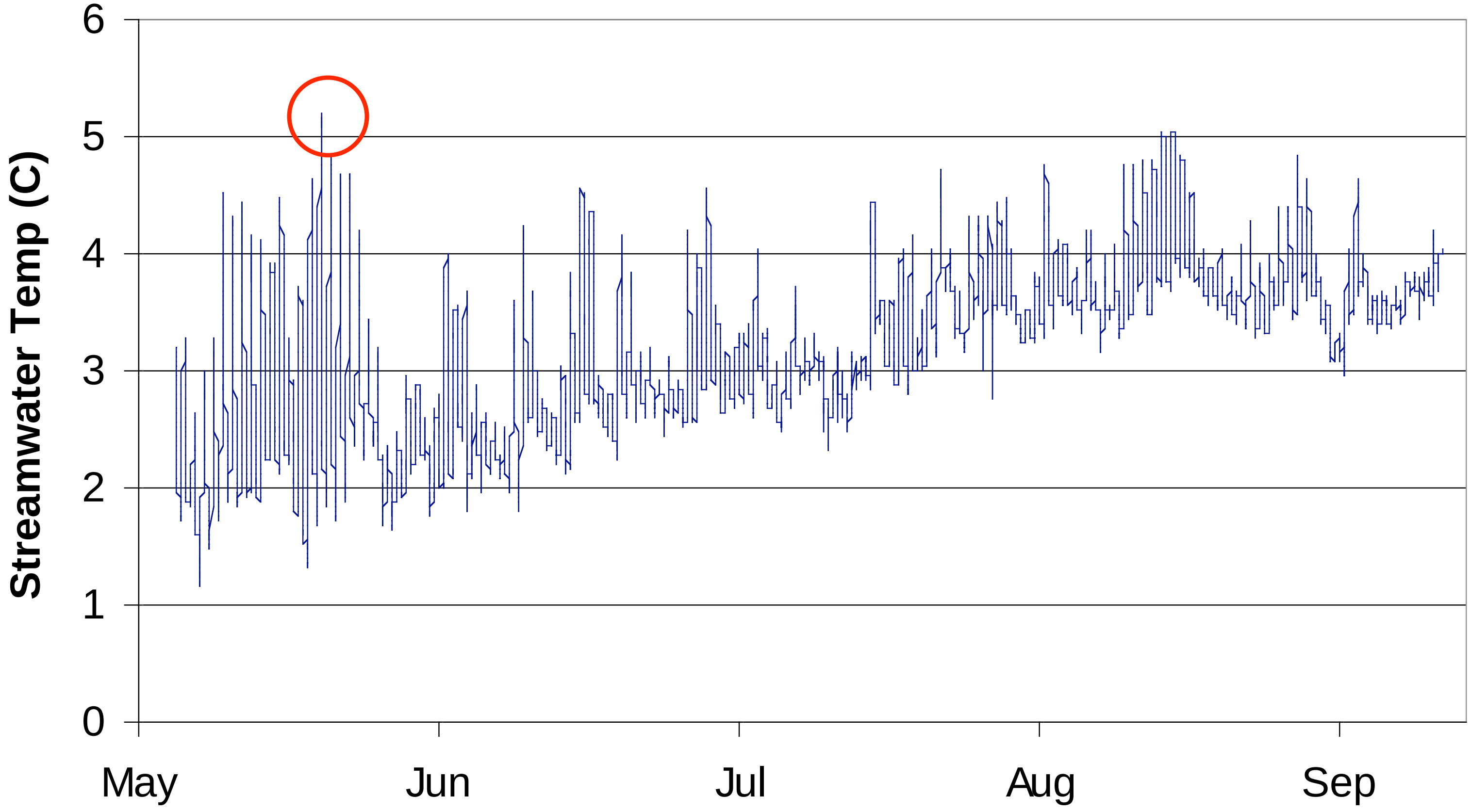
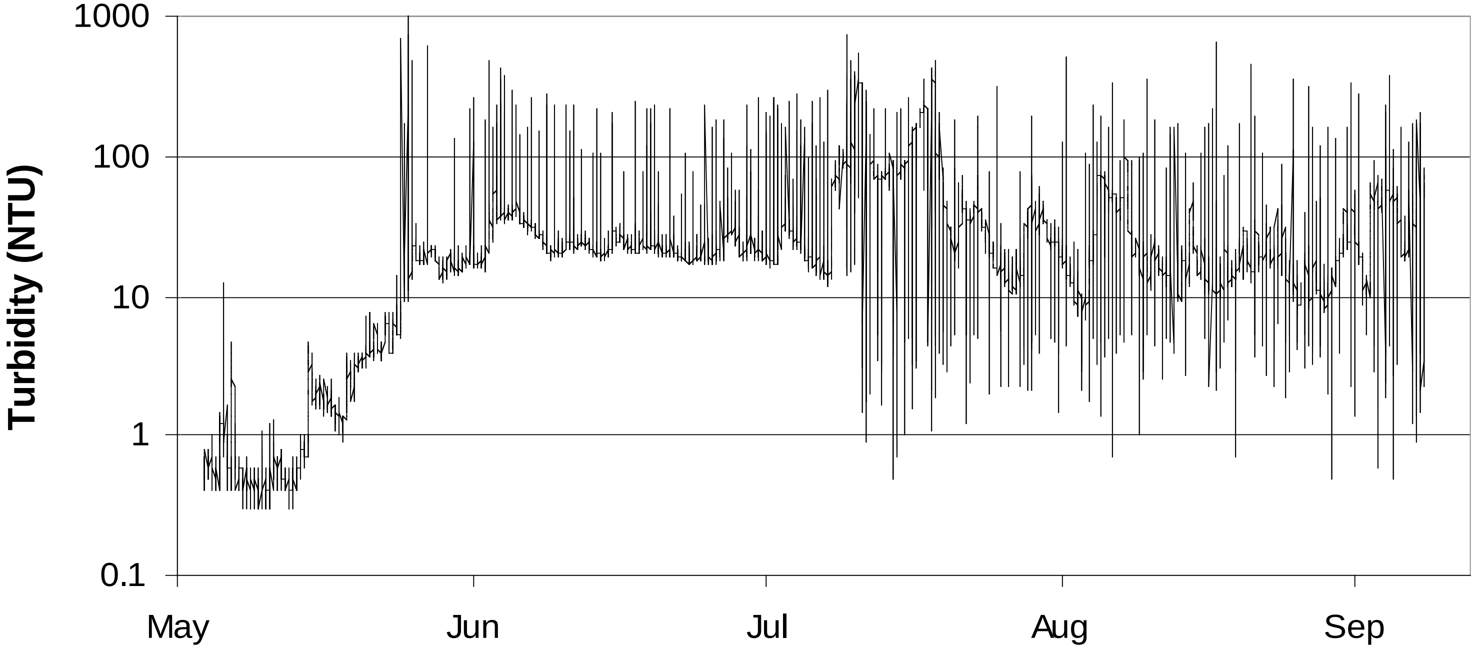
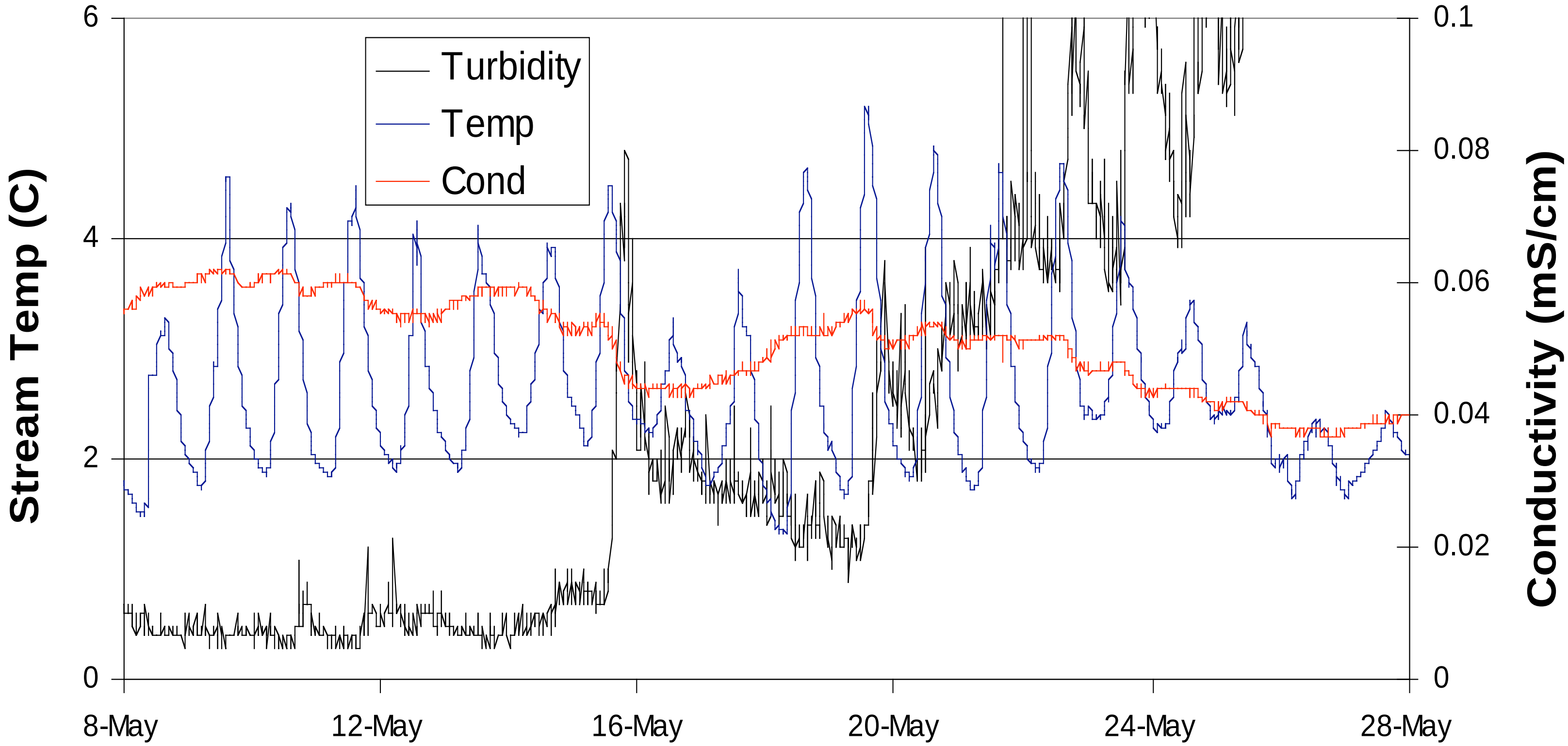
Seasonal Temp



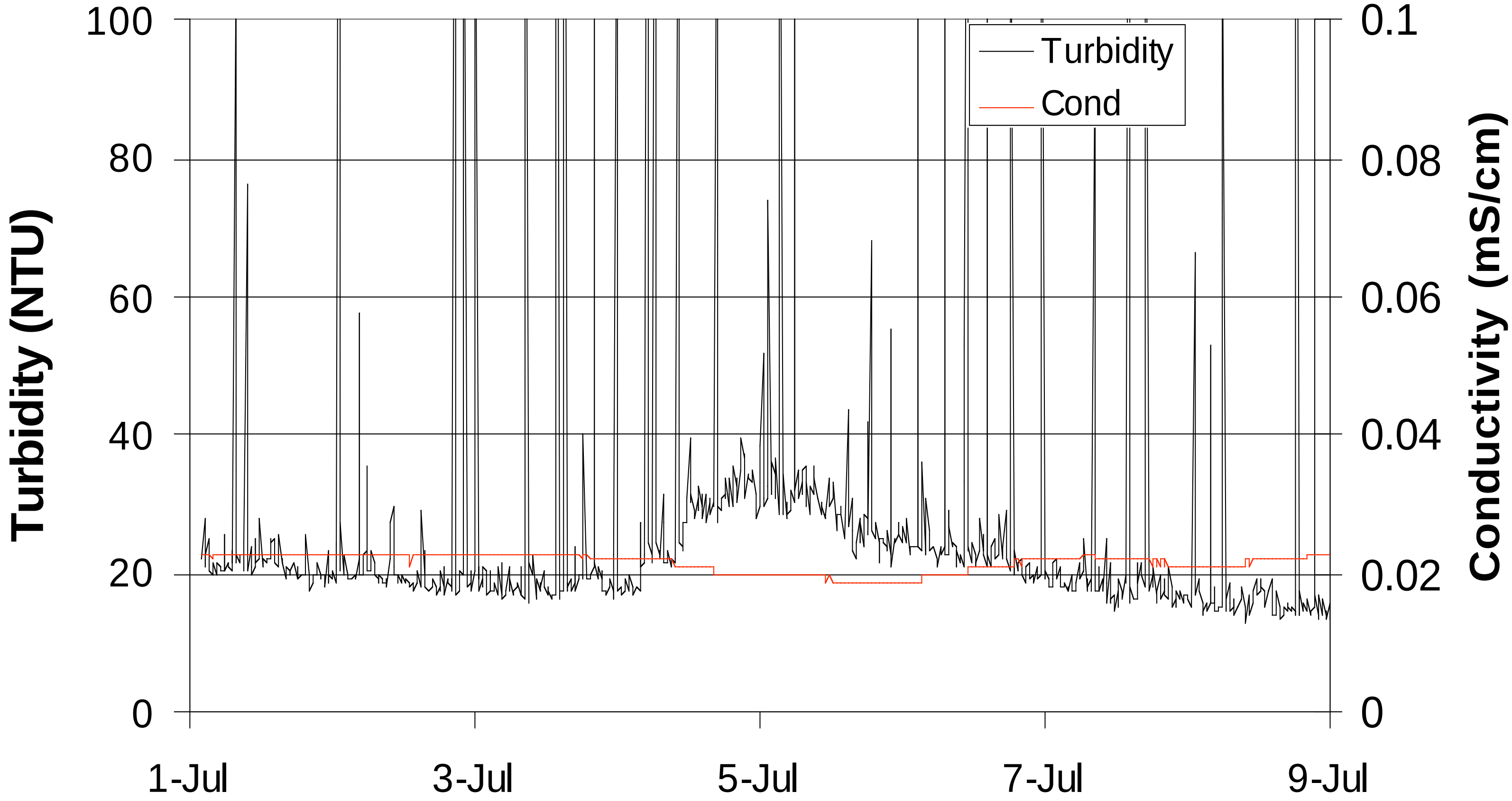
Seasonal Turbidity



Early Season: May



Mid-Summer: July



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Seasonal Changes in Water Quality

Winter Season:
- Very low discharge
- Cold water temps
- Clear Water
- Low diurnal variability

Fall/Spring Transition Period:
- Lower discharge
- Warmer water temps
- Clear water
- High diurnal variability

Summer Melt Season:
- High discharge
- Colder water temps
- Turbid water
- Low diurnal variability

Changes with Climate Warming?

Lemon Creek Glacier Instruments


Pressure Transducer


GPS and Seismic


Met Station


Dipa/Pan-Tilt-Zoom Camera

User controllable camera

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Lemon Creek Instruments

Hydrological Parameters:

Temp, DO, pH, Turbidity, Conductivity

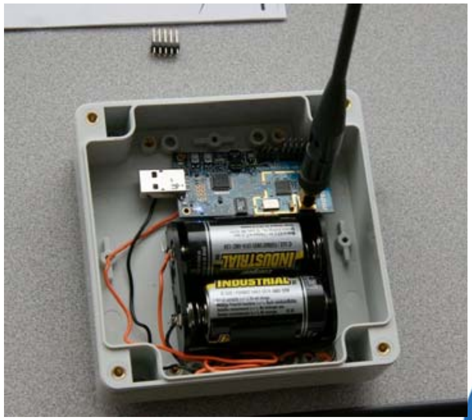
15 min data (May-Sept)

Platforms

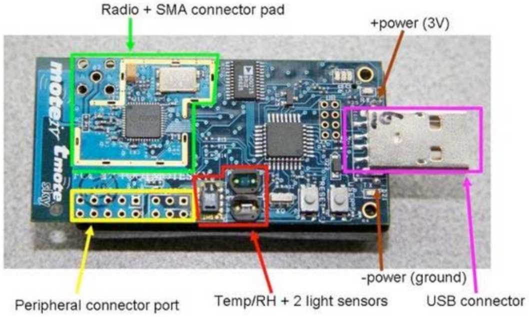
Vexcel Microserver, Linux

Linksys NSLU-2, a UAS testbed platform, Linux

Deployment-ready tmote



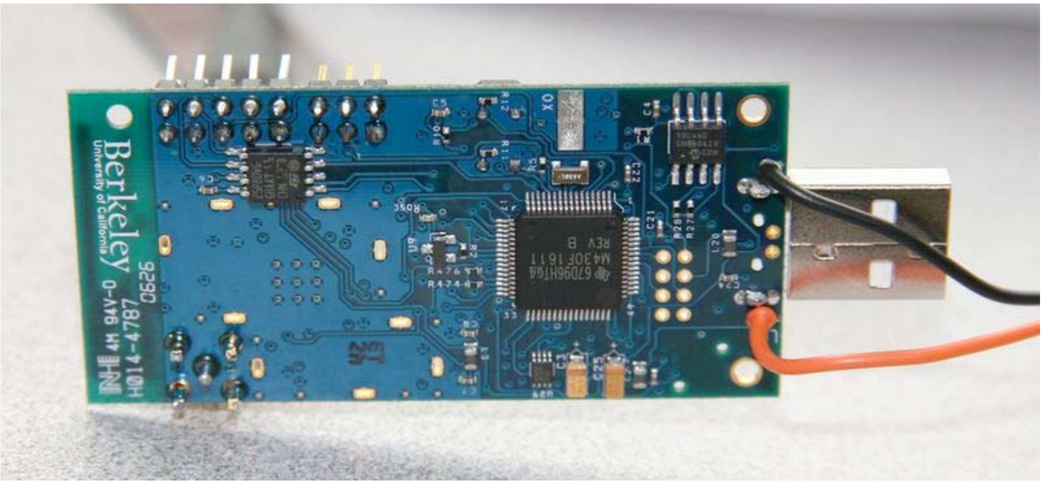
There are three different platforms in use, with relative computation, storage, and sensing capabilities as well as power requirements and cost.

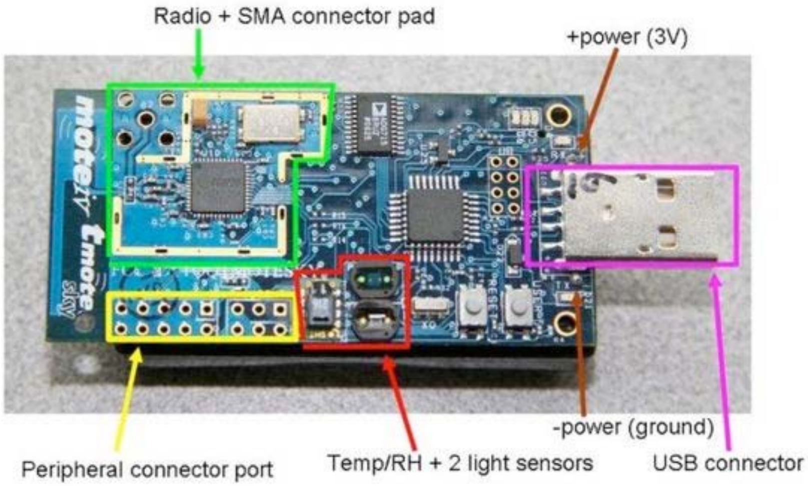


Tmote, tinyOS

Mote Hardware

The TinyOS complex programming model makes mote development an involved proposition.





Field Motes

Deployment Test
Determine range, connectivity, *etc*

Mote Deployment

Accessibility is necessary
Managed deployment:
Base station dwells in site

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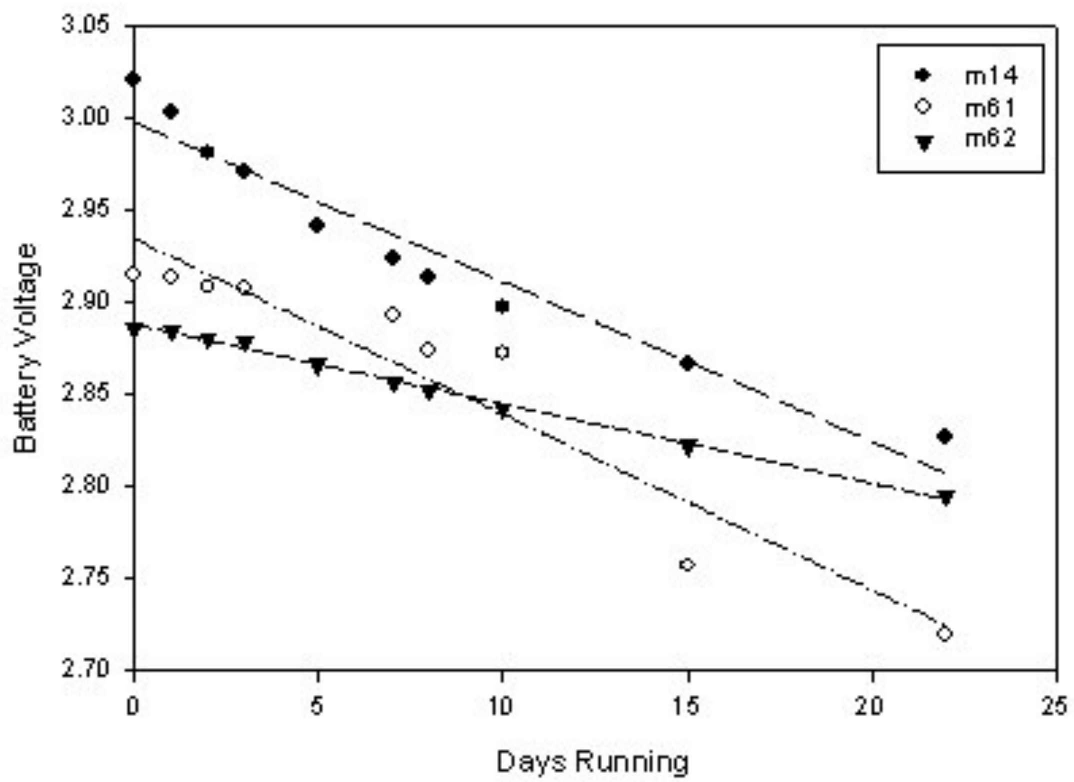
SOUTHEAST

June 26, 2008

Microserver/Mote Power Consumption Tests

Sept - Dec 2007: 3 Motes + Microserver Deployed to UAS Rooftops

Real-time data into SEAMONSTER database

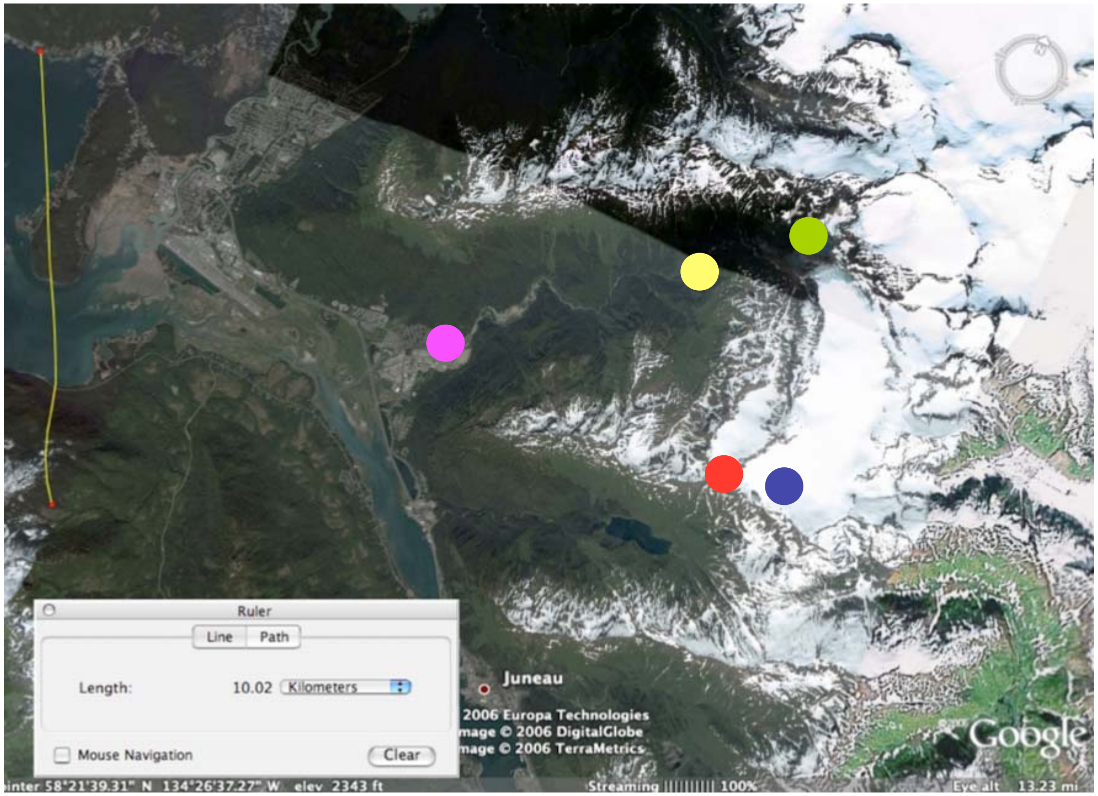


http://robfatland.net/seamonster/index.php?title=Fun_with_Motes%2C_Bricks%2C_and_Modems

Communication

- 802.11g
- 900 MHz
- 802.11n
- Iridium
- 802.15.4 (Zigbee)

Lemon Creek Sensor Web



- Met Station, Web Cam, Comm Hub (red)
- Lake Level, GPS, Geophone (blue)
- Met Station, Web Cam (green)
- Water Qual, USGS Gauge (yellow)
- Water Qual (magenta)

Communication between the nodes enables the Sensor Web. Ex: pressure transducer (●) detects lake drainage and passes the message reconfiguring other sensor behavior.

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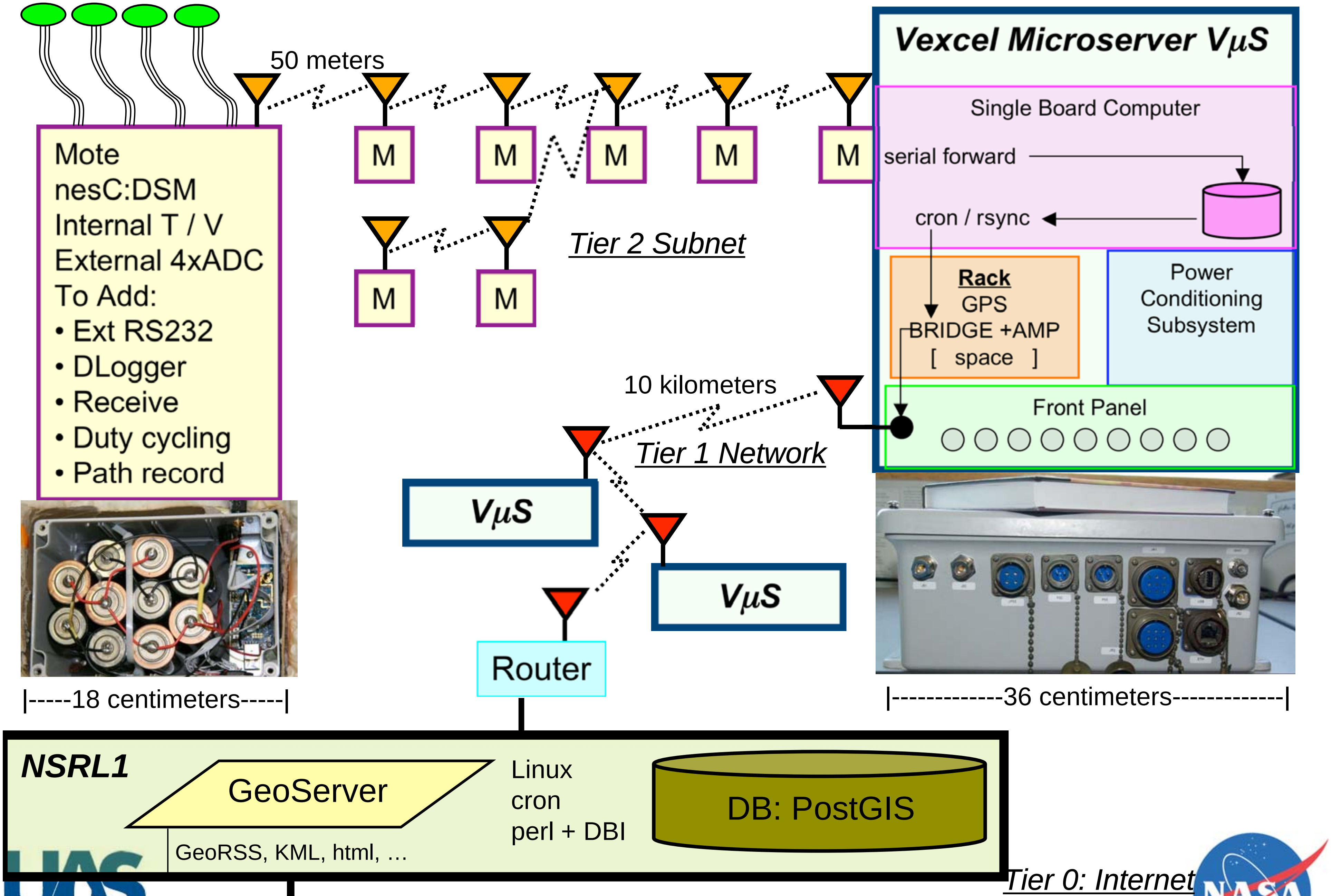
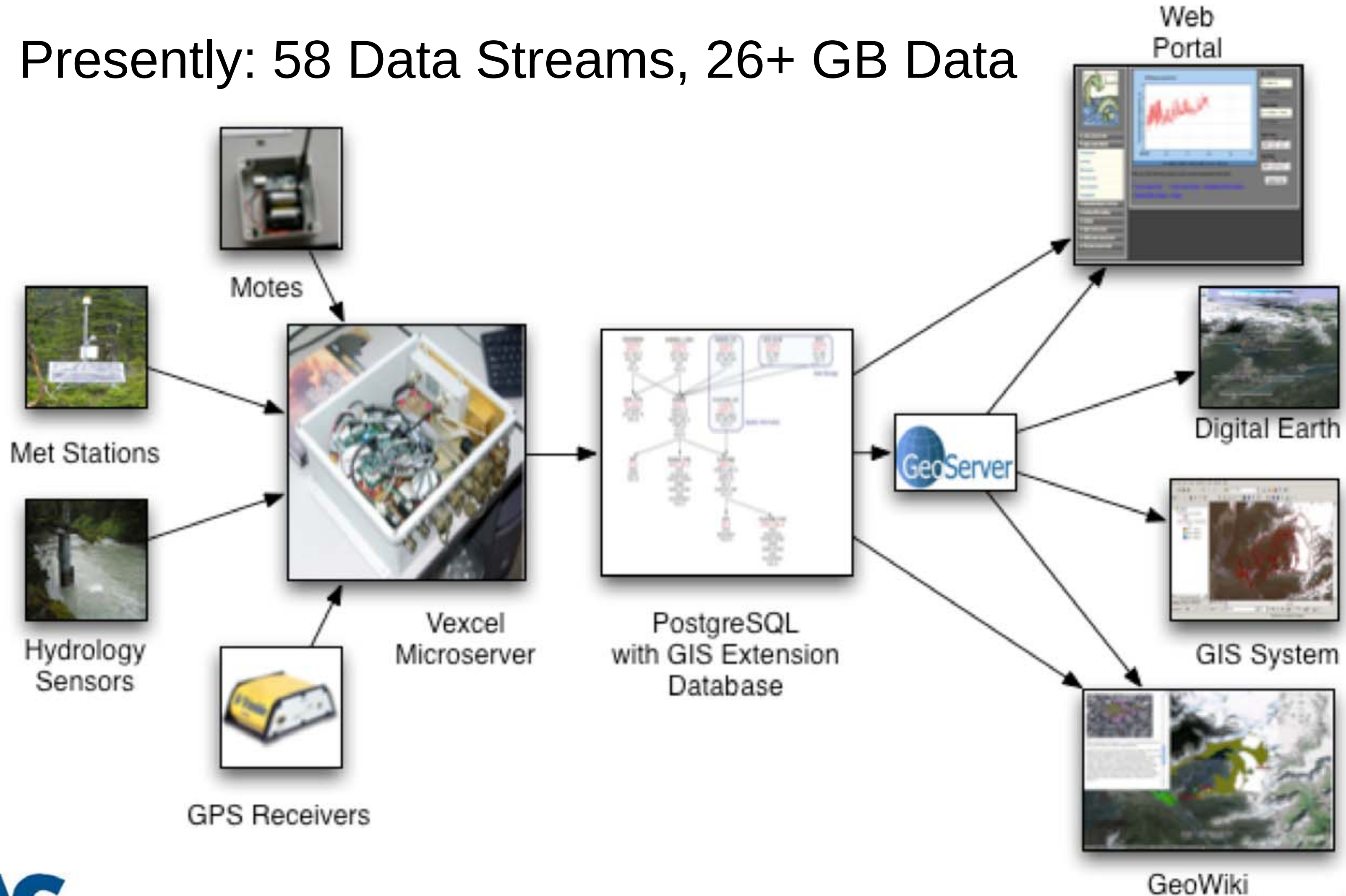

50 meters
Mote
nesC:DSM
Internal T / V
External 4xADC
To Add:
• Ext RS232
• DLogger
• Receive
• Duty cycling
• Path record
M
M
M
M
M
M
M
Tier 2 Subnet
Vexcel Microserver VμS
Single Board Computer
serial forward
cron / rsync
Rack
GPS
BRIDGE +AMP
[space]
Power
Conditioning
Subsystem
Front Panel
10 kilometers
Tier 1 Network
VμS
VμS
Router
|-----18 centimeters-----|
|------------36 centimeters------------|
NSRL1
GeoServer
GeoRSS, KML, html, …
Linux
cron
perl + DBI
DB: PostGIS
Tier 0: Internet

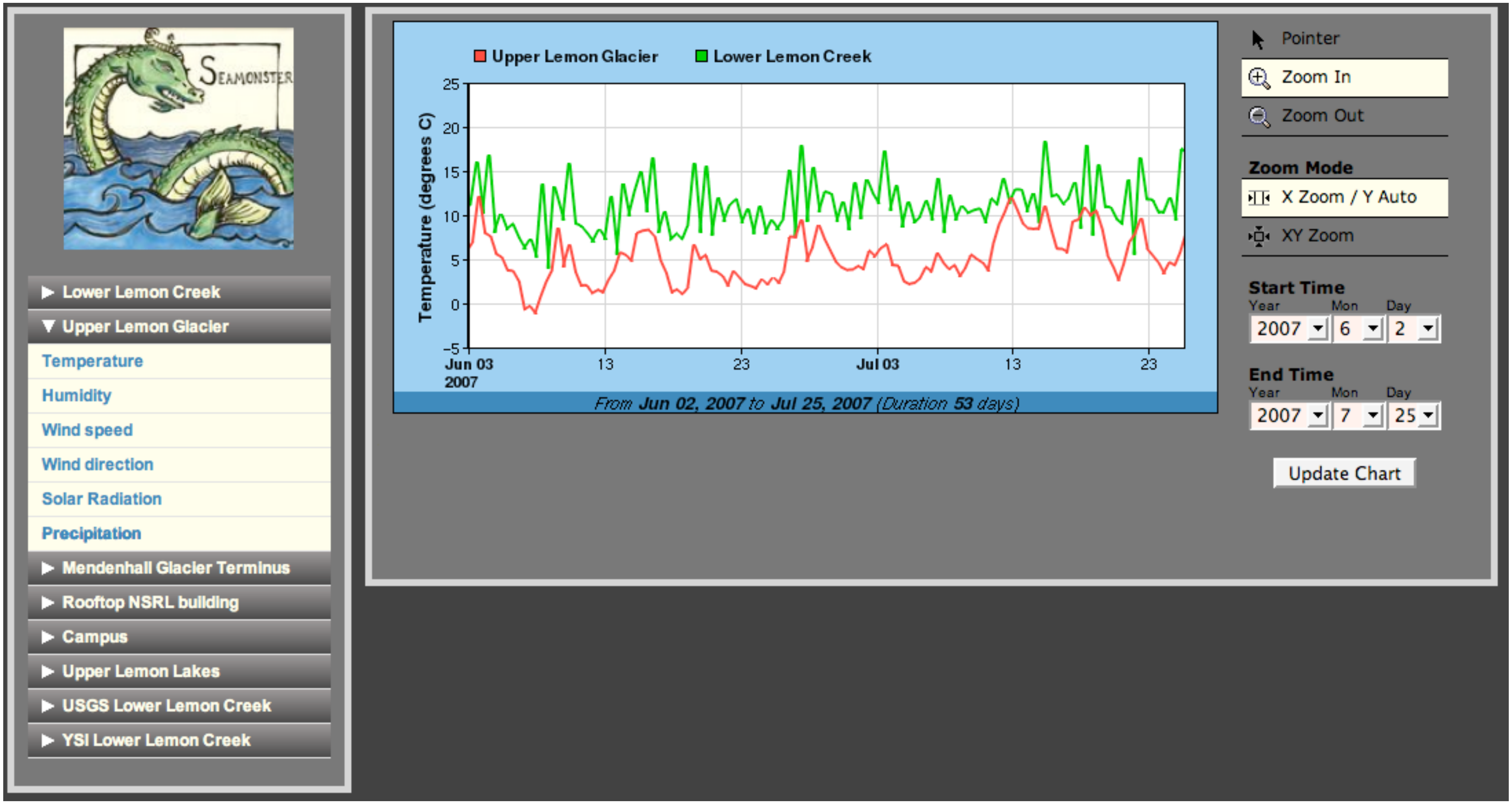
Database and Access

http://seamonster.jun.alaska.edu:8080/geoserver/mapPreview.do

Presently: 58 Data Streams, 26+ GB Data



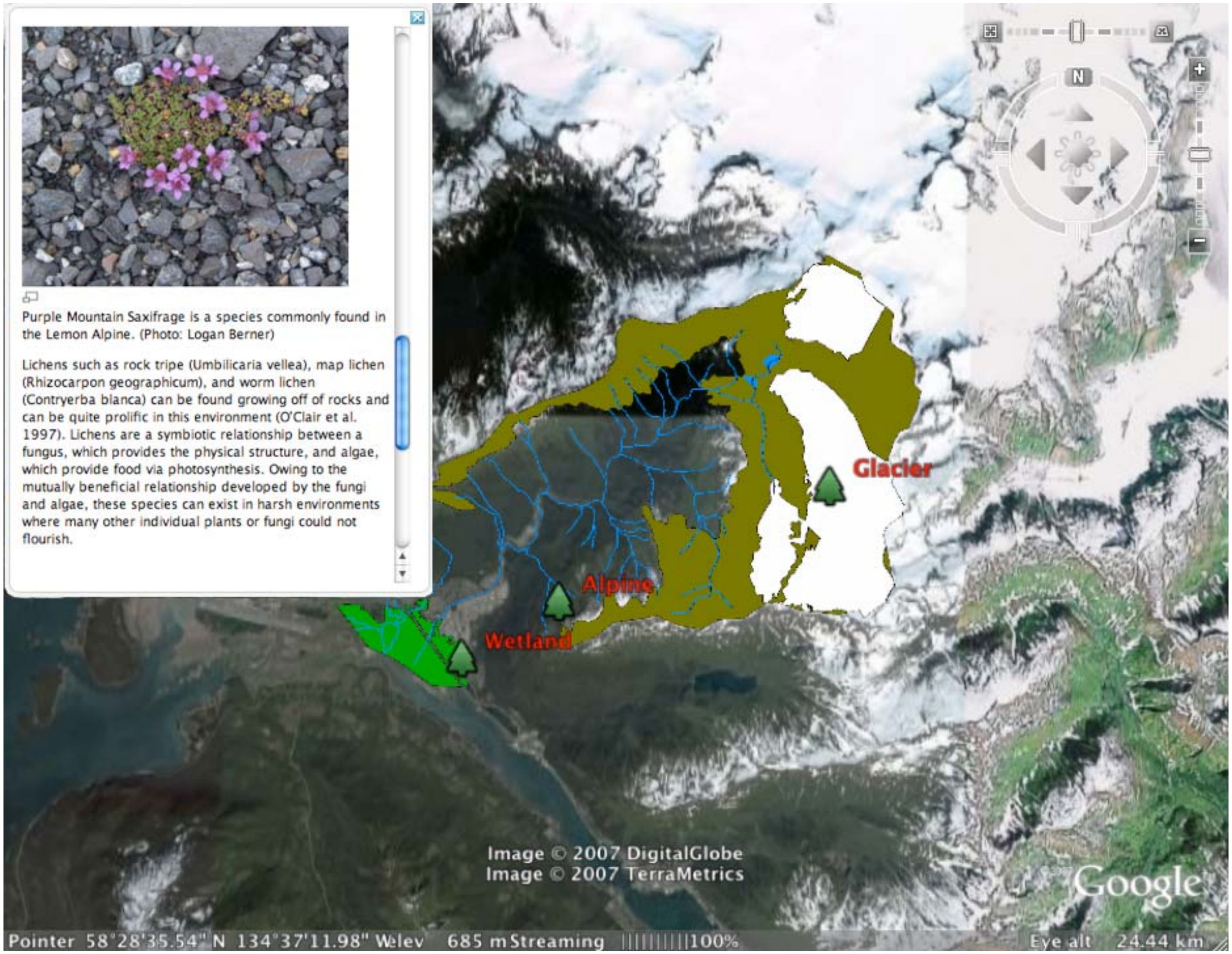
Data Browser



http://seamonster.jun.alaska.edu/browser/

GeoWiki

http://seamonster.jun.alaska.edu/geowiki/index.php/Tour_Main_Page



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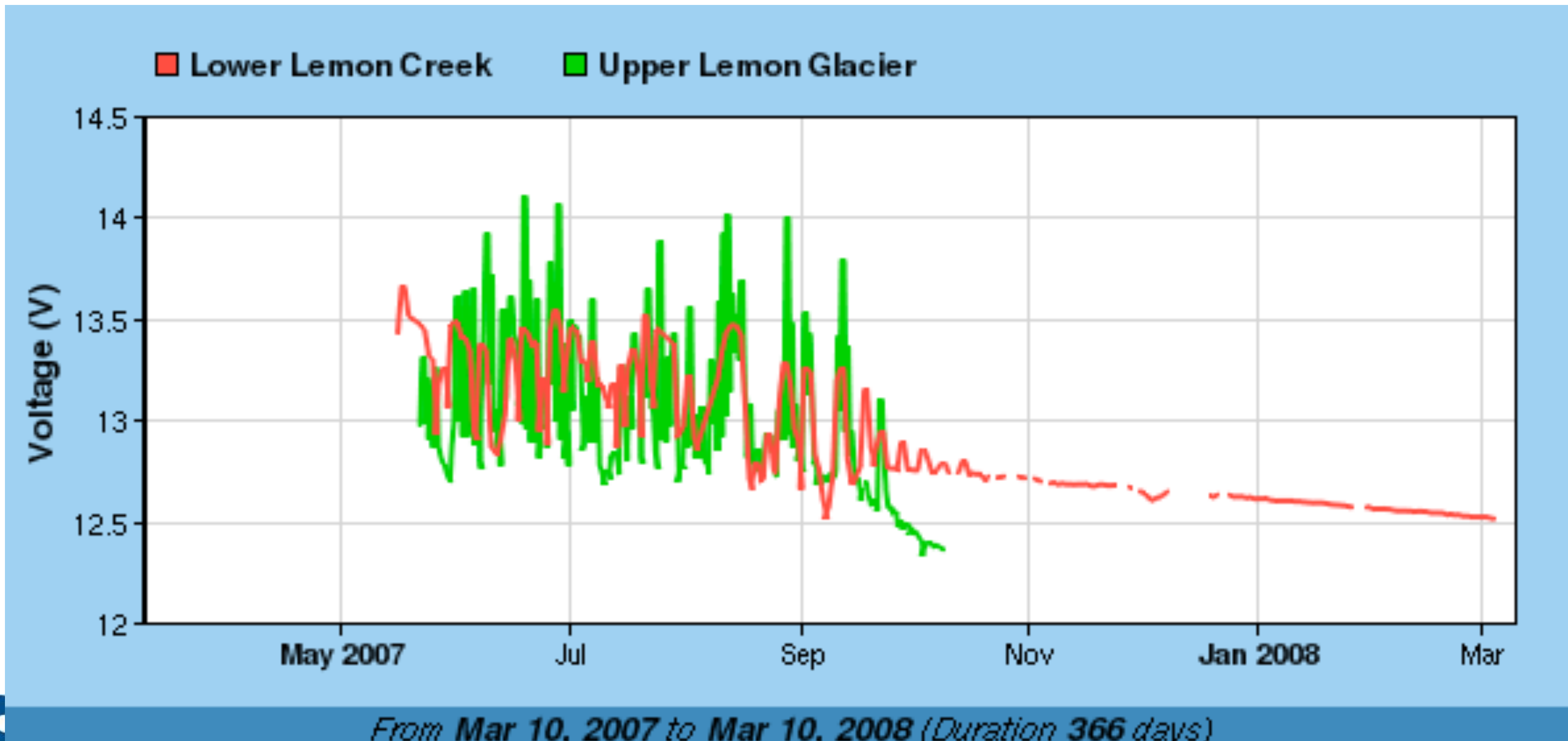
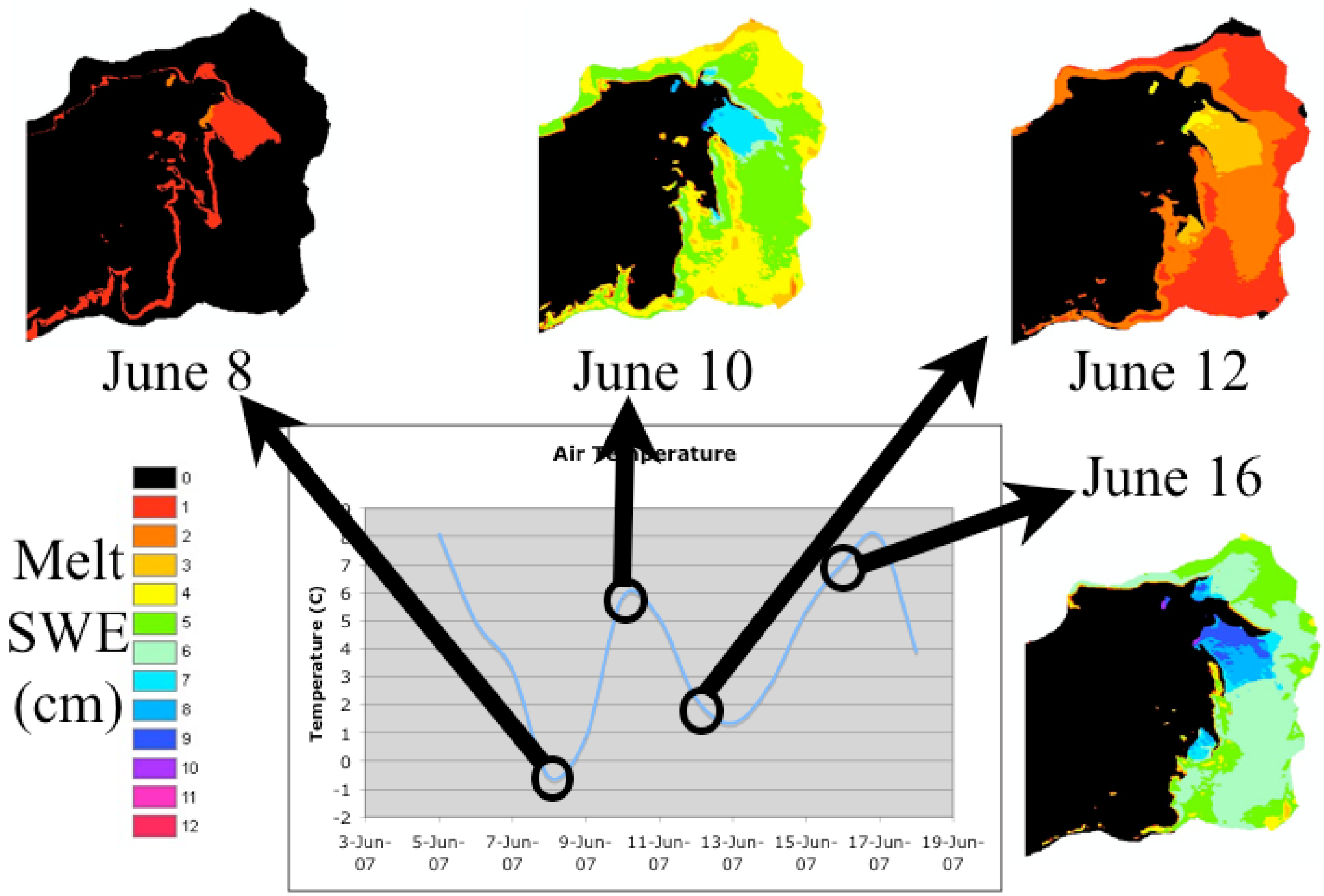
Project Challenges (Sensor Web Use Case)

- Resource management
  - Power constrained (batteries and solar)



Role of Models in Sensor Web



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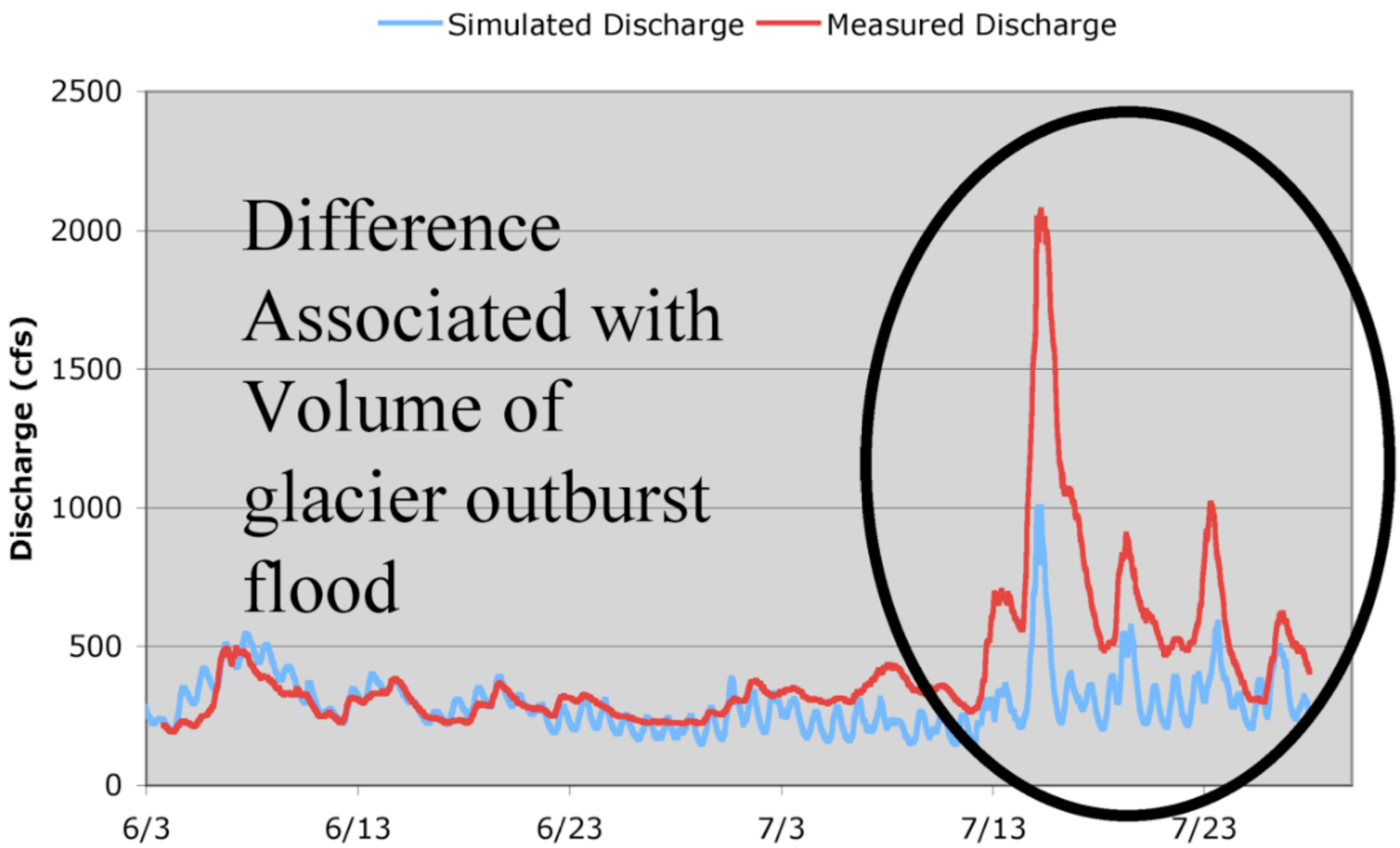

Project Challenges (Sensor Web Use Case)

- Resource management
  - Power constrained (batteries and solar)
  - Also: storage, bandwidth
- Different sampling requirements
  - Long term monitoring
  - Transient, rapidly evolving events

➢**NEED SEMI-AUTONOMY or AGENTS**

Agents' Role

Agents are needed to reconfigure data acquisition based on observations and power states.

Ex1: Battery voltage driving platform is decreasing towards a critical value

Ex2: If the lake pressure transducer measures a drop in lake level:

1. Retask the camera to focus on the lakes
2. Alert systems down glacier to collect (relax power management)

Minimal Agent Solution

Need: **Software agents** to reconfigure data acquisition based on observations and sensor web state.

Specifically: If the lake pressure transducer measures a drop in lake level:

1. Retask the camera to focus on the lakes
2. Alert systems down the watershed to collect (relax power management)

```perl
#!/usr/bin/perl -w
# SEAMONSTER "Agent" v 0.8: receive PDX data, find drop, send message
$| = 1; # non-blocking I/O
$initial_pressure = 0;
$last_pressure = $initial_pressure;
open(ALARM,">>alarm.txt");
while ($latest_pressure = `tail -1 pressure.txt`) {
    chop $latest_pressure;
    print "$latest_pressure $last_pressure\n";
    if ($latest_pressure - $last_pressure < -0.3) {
        print ALARM "lake_drain = 1\n"; }
    $last_pressure = $latest_pressure;
    sleep 1;  }
```

Our Solution:
Conceptual, minimal implementation

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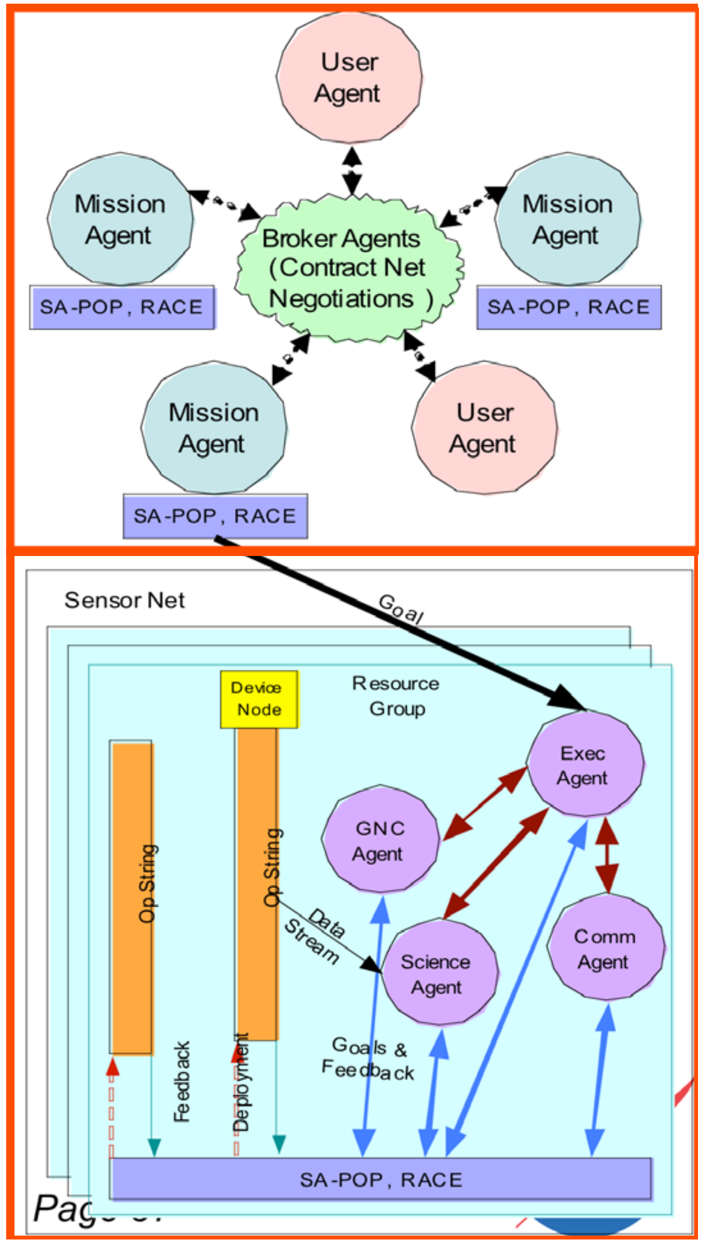
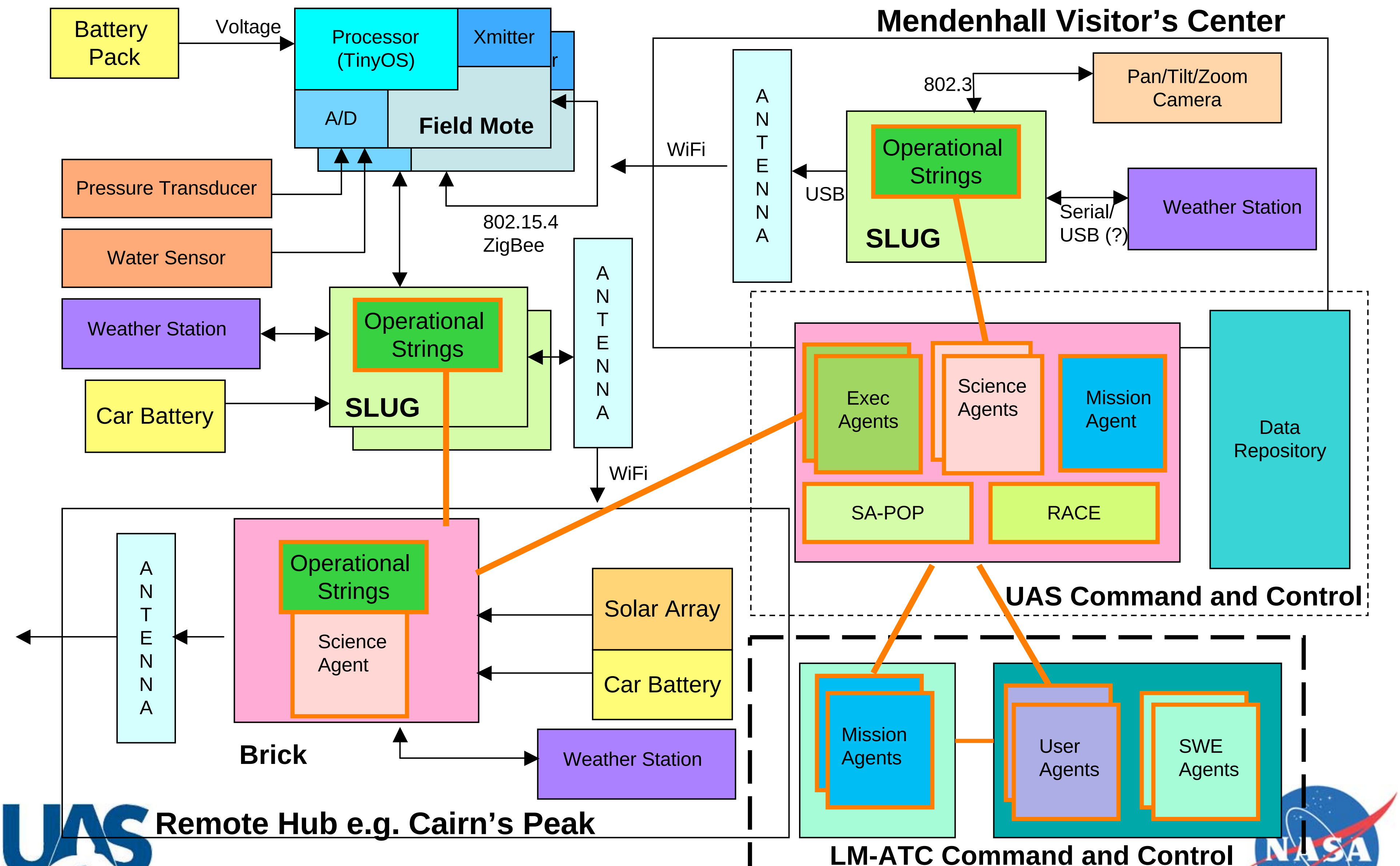
MACRO Agents

- Mission level
  - Mission agents control a sensor net (set of distinct Resource Groups)
  - User agents provide interface for applications and scientists
  - Brokers mediate contract net negotiations
- Resource Group level
  - Exec agent in overall control
  - Other agents as necessary for specific resource group



MACRO/SEAMONSTER Mapping



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SnoMotes

Collaboration Tools

- SVN Code Repository

http://seamonster.jun.alaska.edu/websvn/

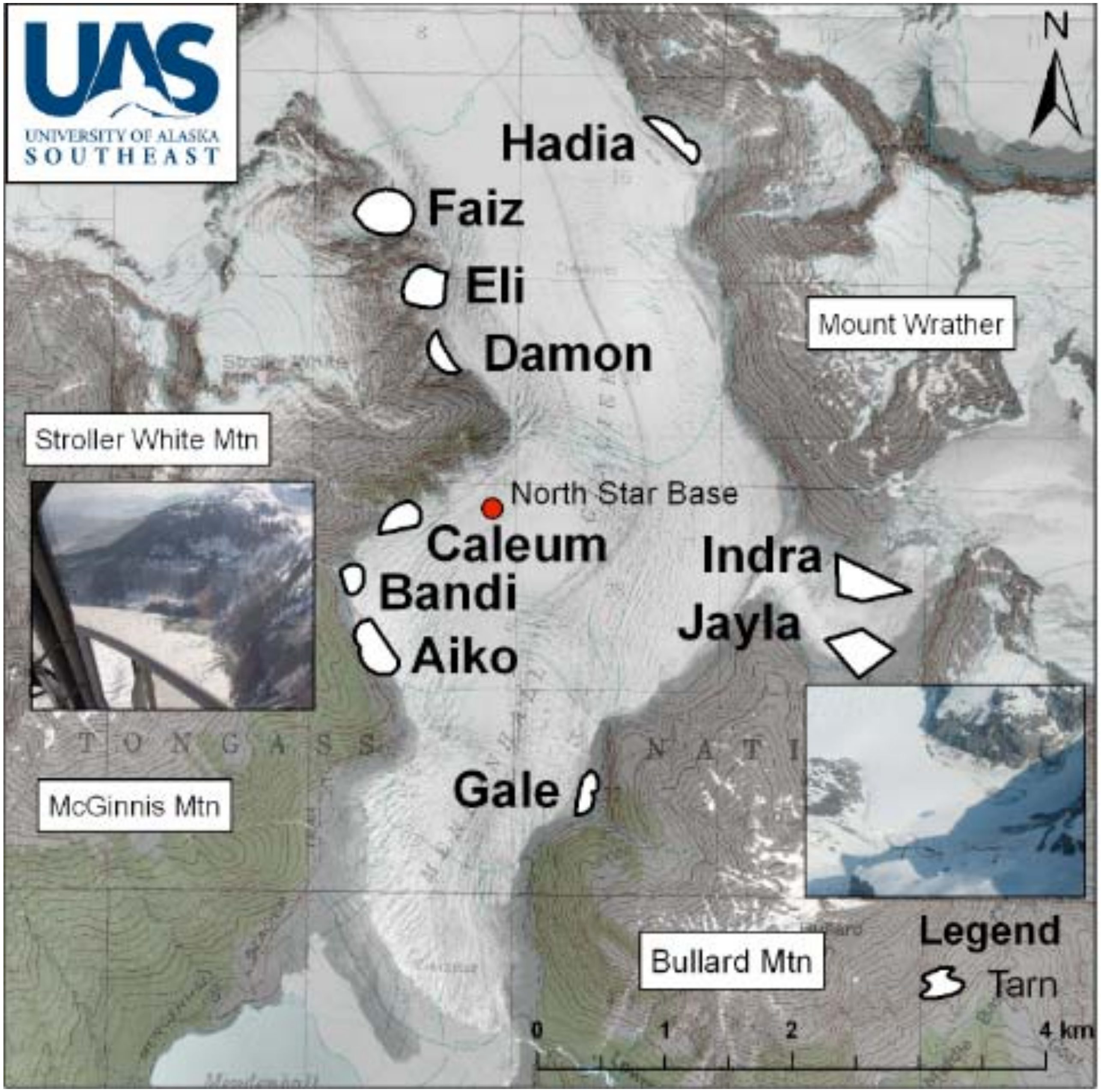
- Project wiki

http://robfatland.net/seamonster

Future

- Increase OGC usage
- Additional Sensor Web Testbed Hosting
- Add sensor data streams
- Expand Spatial Coverage


Mendenhall Glacier



UAS
UNIVERSITY OF ALASKA
SOUTHEAST
N
Hadia
Faiz
Eli
Damon
Mount Wrather
Stroller White Mtn
North Star Base
Caleum
Indra
Bandi
Jayla
Aiko
TONGASS
NATI
Gale
McGinnis Mtn
Bullard Mtn
Legend
Tarn
0
1
2
4 km

Summary

SEAMONSTER presents a scientifically motivated Sensor Web use case scenario which is directly linked to the NASA Decadal Survey (Primary Productivity in light of Climate Change) and has very strong potential for technology infusion with both technologists and scientists.

Acknowledgements

- NASA ESTO AIST
- North Star Trekking, Era Helicopters
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- Numerous UAS students

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Acknowledgements

Acronyms

ACE Adaptive Comunications Environment
ANA Adaptive Network Architecture
CCM CORBA Component Model
CIAO Component Integrated ACE ORB
CORBA Common Object Request Broker Arch
CoSMIC Component Synthesis with Model Integrated Computing
DAnCE Deployment & Configuration Engine
DO Dissolved Oxygen
DRE Distributed Real Time Engine
IGY International Geophysical Year ('57-8)
IPY International Polar Year (2007-8)
MACRO Multi-agent Architecture for Coordinated, Responsive Observations
MGVC Mendenhall Glacier Visitor's Center
MSR Microsoft Research
OCG Open Geospatial Consortium
ORB Object Request Broker
PCS Power Control Subsystem
PICML Platform Independent Component Modeling Language
RACE Resource Allocation and Control Engine

ReDAC Real-Time Deployment & Configuration
SA-POP Spreading Activation Partial Order Planner
SBC Single Board Computer
SEAMONSTER Southeast Alaska Monitoring Network for Science, Telecommunications, Education, and Research
SRTM Shuttle Radar Topography Mission
SWE Sensor Web Enablement
TAO The ACE ORB
UAS University Alaska Southeast
UA-GI Univeristy Alaska Geophysical Institute
VuS Vexcel Microserver
WCS Web Coverage Service
WMS Web Mapping Service