Recent Polar Instrumentation Developments Using Low Cost, New Access Methods via Iridium Short Burst Data (SBD)

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Thoughts about Presentation

- **New concepts are being/have been developed for the polar environment remote sensing investigations (15 listed)**

- **The common model is to work with the Science PI (Ahlstrom, Benn, Kohler, Steffen, Kamb, Englehardt, Carsey, Box, Fahnestock, Truffer, Zwally, Slawek, Fricker, Holland, Lane, Tedesco, Parish, Bromwich. Howat, Finnegan, Bindschladler, Tedesco, Adler, Smith, Kyle, as well as Danish Polar Inst., Norwegian Polar Institute, British Antarctic Service, Australian Antarctic Division, UNAVCO) to solve a needed measurement challenge.**

- **In addition new technology applicable to polar investigations is introduced to Science PI's (Workshops, PTC, IASC, WAIS, PARCA, AGU, EGU, etc.)**
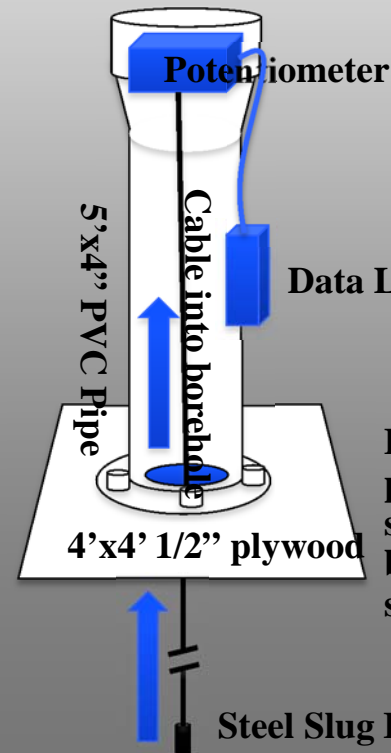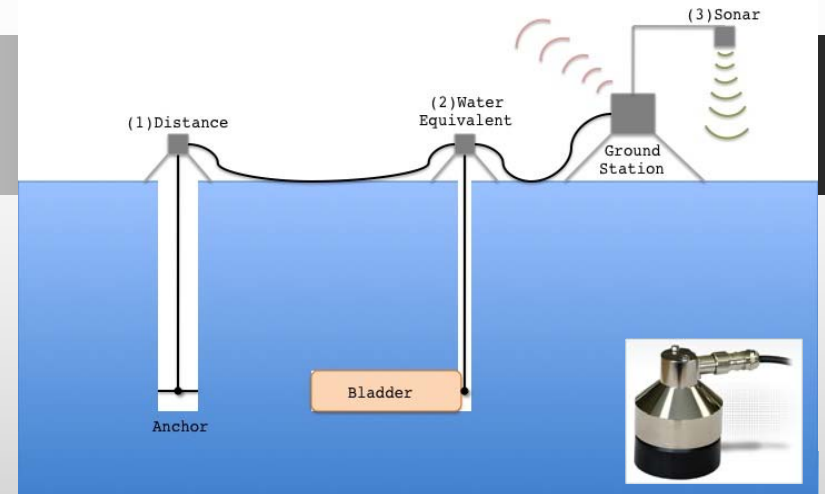
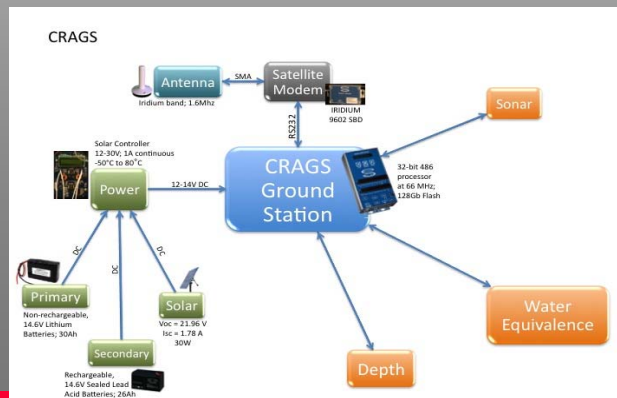# CRAGS - Compaction Reconnaissance of Arctic Glacial Snow System Interfaces

- Purpose: to monitor the amount of snow compaction occurring on the Greenlandic glacier

- Benefit: In situ sensor packages that will aid the deconvolution of surface change observations.

- System: Each sensor package will consist of a device for measuring deep-firn compaction, a snow pillow for measuring accumulation mass, and an echo sounder for measuring accumulation thickness

- Plan: Two stations put in 2015 above Jakobshavn Isbrae in the west, and another above Helheim Glacier in the southeast; two regions undergoing substantial dynamic changes. (Test system Apr. 2014)

- Goal: to provide a foundation for a more extensive operational system in concert with the launch of ICESat-2 planned for 2016

CRAGS

(1)Distance (2)Water Equivalent (3)Sonar

Ground Station

Anchor Bladder

Potentiometer

Data Logger

5'x4" PVC Pipe

Cable into borehole

4'x4' 1/2" plywood

Platform installed on previous summer surface & buried because this area has surface melt.

Steel Slug Frozen to Bottom

CRAGS

Antenna — Satellite Modem
Iridium band; 1.6Mhz
IRIDIUM 9602 SBD

Solar Controller
12-30V; 1A continuous
-50°C to 80°C

Power — 12-14V DC — CRAGS Ground Station
32-bit 486 processor at 66 MHz; 128Gb Flash

Primary
Non-rechargeable, 14.6V Lithium Batteries; 30Ah

Solar
Voc = 21.96 V
Isc = 1.78 A
30W

Secondary
Rechargeable, 14.6V Sealed Lead Acid Batteries; 26Ah

Sonar
Water Equivalence
Depth

Moball-Buoy Network: A Near-Real-Time Ground-Truth Distributed Monitoring System to Map Ice, Weather, Chemical Species, and Radiations, in the Arctic

System Purpose: (multiple low-power, low-mass systems allows)

• To quickly map several relevant environmental parameters over the Arctic-wide area.

• To map a wide range of environmental factors such as the ice, surface water, and weather conditions

• To detect chemical species, radiations, precipitation, cloud coverage, electromagnetic fields

• And detect other secondary factors such as human presence and activity

Communication System Purpose: (distributed network allows)

• To reliably assess the measurements by cross-referencing readings from multiple nearby Moball- Buoys

• To share tasks intelligently in order to optimize movement and monitoring efforts based on available resources (i.e. presence of energy, winds, memory, bandwidth constraints, science goals)

• To robustly respond to system degradation by reconfiguring

• To provide real-time, map updates of ice topography &weather patterns, for enhancing predictive climate models

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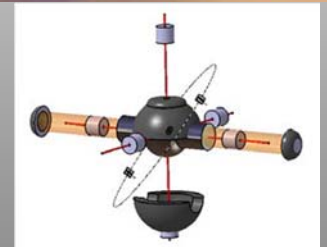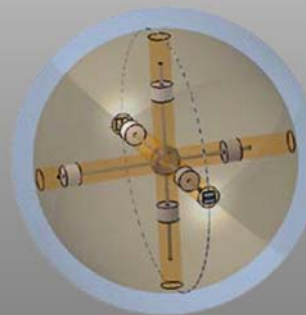
Fjord Drifters

- **Jakobshavn Glacier rapidly receding**
- **Unknown water depth in fjord**
- **Area inaccessible by boats**
- **Data is vital to update glacier flow models**
- **Measure 1-km depth**
  - **Transducers hang 3-ft below surface**
- **Data transmitted via Iridium network**
- **Back up: Tracked by Spot GPS transmitters**
- **Cage frames for ease of recovery**
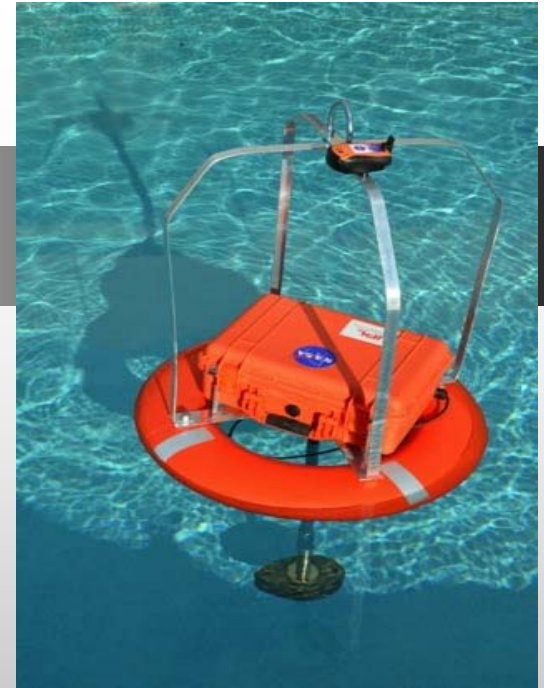
Greenland Fjord Depth Trackers

The bathymetry of tidewater glacier fjords is a key boundary condition for models of ocean water circulation and ice flow, as well as calculations of ice discharge and mass loss. The water depth near the ice fronts of rapidly calving glaciers, such as Jakobhavn Isbrae, is almost completely unknown due to the presence of a perennial ice mélange (floating mixture of icebergs and bergy bits), making ship-based surveys either impossible or extremely dangerous. It is precisely these glaciers, however, where water depth information is most critical. We have therefore designed a drifting buoy system that is embedded into the mélange as close to the ice front as possible and records bathymetry and other parameters as it drifts with the ice, transmitting its data via satellite link.

This investigation is conducted by Dr. Ian Howat of Ohio State University using depth drifting buoys developed by Dr. Alberto Behar. This work is funded through generous support from Tom Wagner, NASA's Cryosphere program and Renee Crain, Office of Polar Programs, NSF.
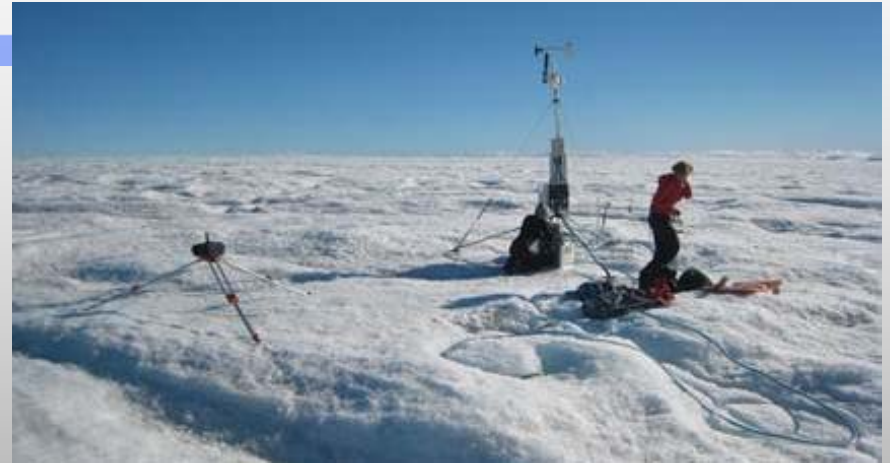

Albert

Snow Ablation Monitor

- **Portable system that can monitor the rate at which snow melts at the dispatched location**

- **System has a fluid tube that contains glycol and is put in a 2 inch diameter hole, 10m depth**

- **The current version has been designed to measure ambient atmospheric pressure, temperature and pressure from water level in a tube.**

- **Sends data real-time using the iridium constellation of satellites.**

- **It also reports internal system health data like battery voltage and internal micro-controller temperature**

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Iceland Hengil Volcano BENTO

Satellite-linked data collection system for volcano monitoring

BENTO: Behar's Environmental Networking, Telemetry, and Observation Box, *BTW, not coined by me*.

Unit deployed on Hengil Volcano, Iceland

- Data collected every hour (normal mode)
- "Burst mode" = collection every min/5 mins
- 1 year lifetime (normal mode)
- Records Chlorine, Flourine, Bromine, SO2, CO2, Pressure, Temp, Humidity, Precipitation

-4 more systems going in July 2014 (2 seismic, 1 Cold hardened Gas Monitor, One for Erebus in Dec. 2014
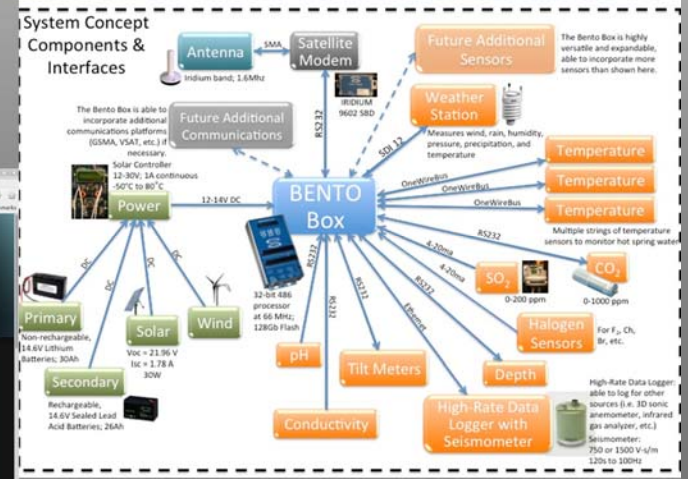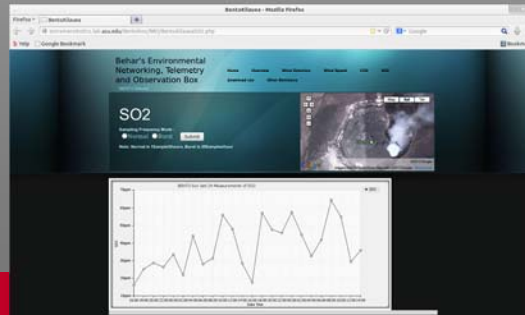
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Glacier Motion and Iceberg Satellite Tracker

- 20+ units functioning around Greenland
- Uses Iridium Satellite Network
- Two way comms. for setting any update rate
- Cost: Unit ~3K, Subscription $30/month
- Long Life (years, depending on update rate)
- Display software interfaces with Google Earth
- Can download positions
- Updates can arrive via email (human readable)
- Can be used to track icebergs or monitor events
- Newer version can interface to many new sensors: temp, pressure, radiation, depth, snow height, wind speed/dir, humitidy, snow compaction rate, etc.

Picture Courtesy:
Soren Nielsen, (c) GEUS, July 27, 2010

Glacial Runoff Depth Measurements

Units send water depth and atmos. pressure of glacier runoff in a West Greenland fjord

Remote Unit Details:

1. Recording Frequency: Pressure data: once per 2 hours, ~32 bytes
2. Data per day: 360 bytes (Depth Reading, Temp, Atmos Pressure, System Voltage)
3. Download/receive frequency: Once per day
4. Connection Method: Iridium Modem, 9601 SBD Transceiver
5. Number of stations: 2 separate locations each with its own comm. capability.

Operations base Details:

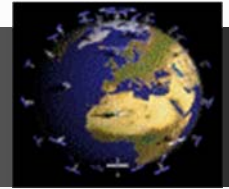1. Communication with Iridium Network is via MIME Email Attachment.

Lagoon from river before reaching De Quervain Harbor
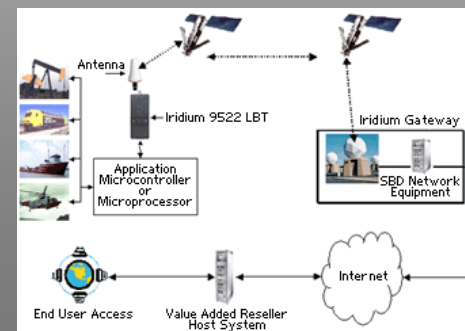

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Geodetic Data via NetRS to SBD Iridium
4 units built (3 Greenland, 1 Antarctica)

- Streams GPS position data (BINEX open format) from a Trimble NetRS to a microcontroller + Iridium modem that sends data through the Iridium Network to an operations base where it is repackaged to look like the original stream

- Remote Unit Configuration:
    - Records position every 30 sec, 35kb/hour
    - 7200 epochs/day, (100-220bytes/epoch) ~1mbyte/day
    - Download/receive frequency: Every 4-5 mins.
    - Receiver and Format: Trimble NetRS in BINEX, 9600bps
    - Connection Method: Iridium Modem, LBT9522 with DOD Sim card

- Operations base Details:
    - PC Computer located at UNAVCO, Boulder, Colorado
    - Communication with Iridium Network is via TCP/IP Direct IP Sockets.
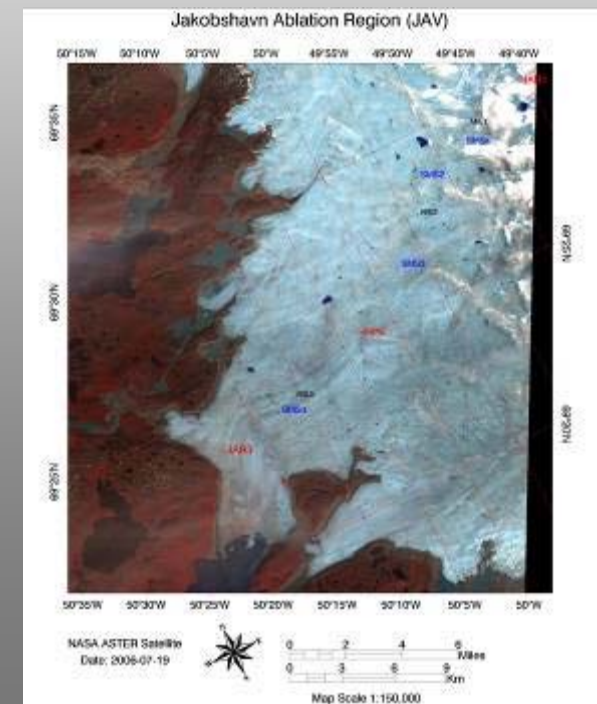   - Runs a Linux simple application (shell script) that reassembles the data into 24hr UTC break files.
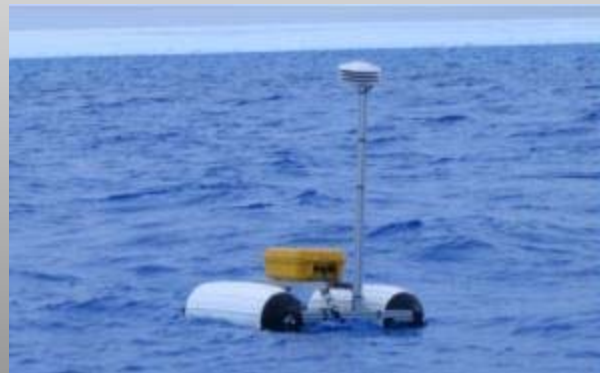
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Surface Lakes Depth Measurements

Units (Buoys) to send water depth/temp profile of surface lake in West Greenland fjord

Remote Unit Details:

1. Recording Frequency: Pressure data: once per hour, ~32 bytes
2. Data per day: 360 bytes (Depth Reading, Temp (9), System Voltage)
3. Download/receive frequency: Once per day
4. Connection Method: Iridium Modem, 9601 SBD Transceiver
5. Number of stations: 2 separate locations each with its own comm. capability.

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Jakobshavn Ablation Region (JAV)

NASA ASTER Satellite
Date: 2008-07-19

Map Scale 1:150,000

Greenland Moulin Stream Path and Motion Sensor

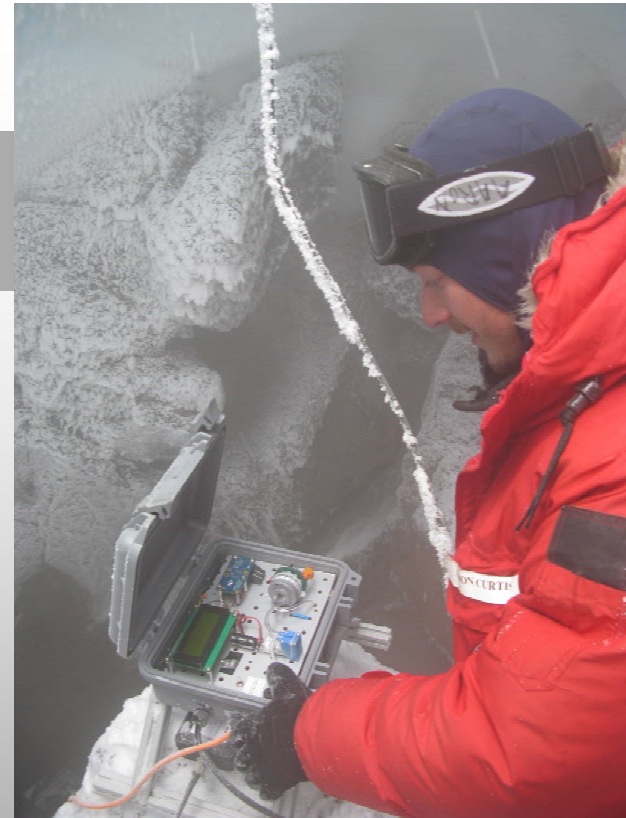
- Contains Iridium Tracking GPS
- Contained in a Pressure Vessel
- Follows water pathway
- Sends Postion/Velocity
- Buoyant/Robust Shell

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Mt Erebus Volcano
Ice Cave Monitor

- **Self-contained sensor and comms. package**
  - **Sensor – CO_2, SO_2, Viasala Weather Station, (Wind speed/direction temperature, pressure, humidity)**

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Supra-Glacial Lakes Characterization

- **Interest in Characterizing Supra-Glacial Lakes and cheaply determining depth profiles**
- **Leads are Larry Smith et. al.**
- **Deployed July, 11 near Kanger**
- **Uses Off the Shelf Bait Boat**
- **Shark Technologies Depth Sounder**
- **Records and send every few seconds, via Iridium 9602 and Voyager Modem Carrier (has gps, accelerometer, analog to digital converter)**
- **Controlled from the shore**
- **All data gets recorded and maps/graphs made automatically to websites**

9602VG-D15 Side View

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Supra-Glacial Streams Profiles

- **Interest in Characterizing Supra-Glacial Rivers and determining their flow rates and elevation change**

- **Leads are Larry Smith et. al.**

- **First deployed July 11 near Kanger, again Aug. 2014**

- **Uses Off the Shelf Boat Bumper Float**

- **Records and sends every few seconds, via Iridium 9602 and Voyager Modem Carrier (has gps, accelerometer, analog to digital converter)**

- **All data gets recorded and maps/graphs made automatically to websites**

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Glacier Front Water Monitor

- **Currently in tests for a monitor/measuring system that can characterize volume of water in glacier front crevasses**
- **Leads are Jason Box (GEUS) & BBC, Doug Benn (Svalbard), Andreas Ahlstrom (Danish Polar Institute)**
- **Would be deployed on glacier edge**
- **Contains three pressure sensors, (ambient, water level, water depth)**
- **Is retrievable and re-deployable**
- **Records and reports every hour**
- **Controllable to change reporting rate**

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Glacier Front
Strain Monitor

- **Currently in tests for a monitor/measuring system that can characterize changes in opening in glacier front crevasses**

- **Leads are Jason Box (US) & BBC, Doug Benn (Svalbard), Andreas**

- **Would be deployed on glacier edge**

- **Contains Linear Distance Change sensor**

- **Is retrievable and re-deployable**

- **Records and reports every hour**

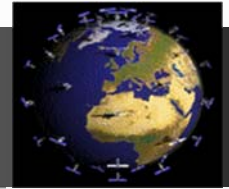- **Controllable to change reporting rate**

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Questions?
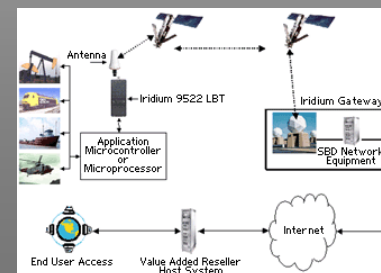
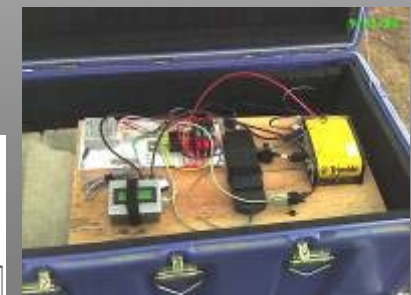**Looking forward to future collaborations…**

Please contact me at: <u>alberto.behar@jpl.nasa.gov</u>
Or +1-818-687-8627

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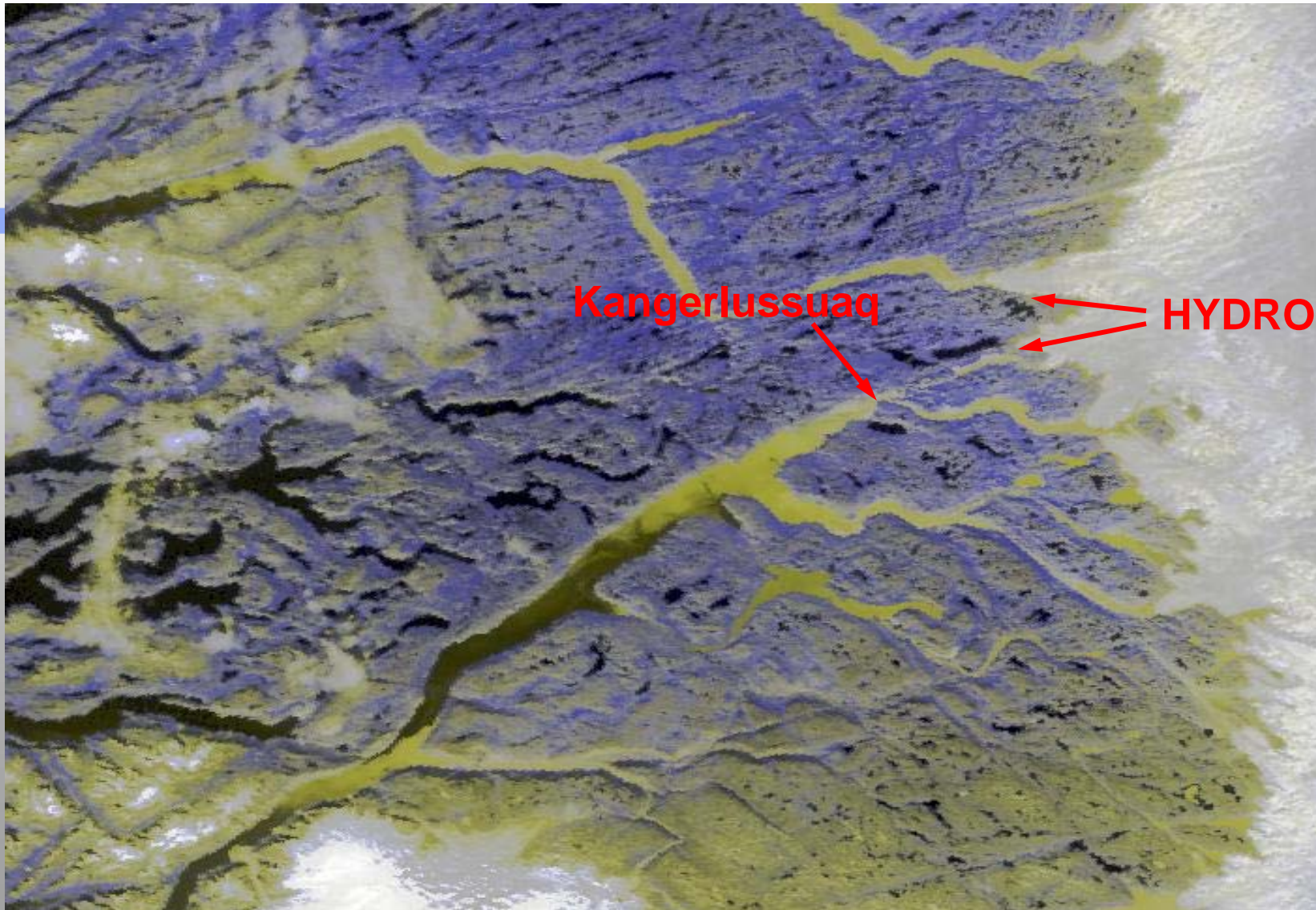
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Greenland Nikon Cameras (Weather and Health Data)

5 camera health data units that record Temp/Humidity & Battery Voltage readings every two hours and send once a day

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Kangerlussuaq

HYDRO

July 7, 2007   MODIS 250m

Ice-sheet hydrology from rivers (Larry Smith, UCLA)