Remotely Piloted Aircrafts for Arctic Environmental Monitoring

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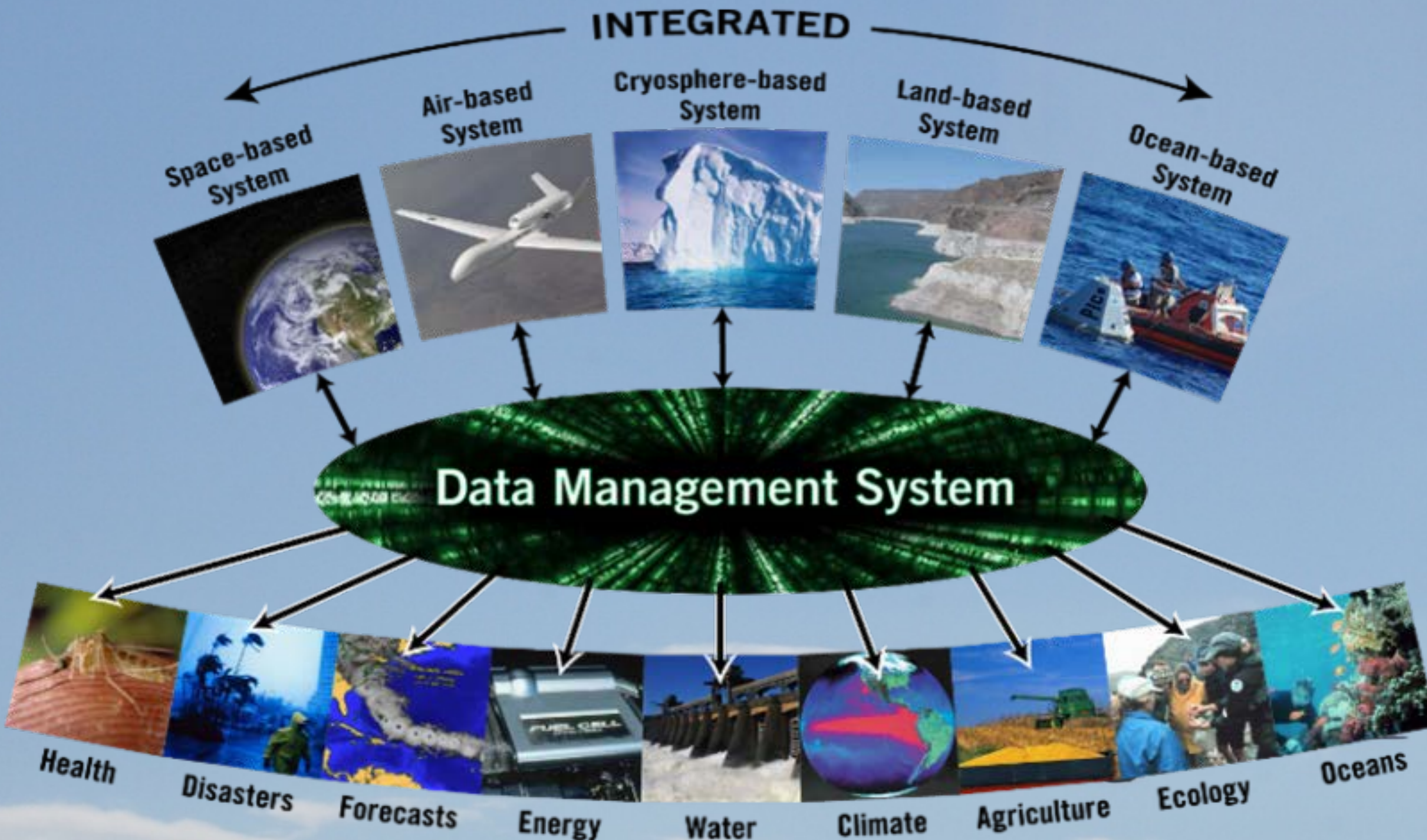
EMS2014 “Environmental Monitoring and Surveillance: Challenges, Solutions and Opportunities
December 4th and 5th
Porto, Portugal

Earth Observation Systems



Some UAS Systems Previously Used in the Arctic

Noruts CryoWing UAS Fleet

CryoWing Micro (2012)
MTOW: 2-3 kg
Wingspan: 1,2 m
Range: 100 km
Telemetry: UHF
Payload Capacity: 0.8 kg
Fuel: Li-Pol Battery

CryoWing Mk 1 (2007)
MTOW: 32 kg
Wingspan: 3.8 m
Range: 400/800 km
Telemetry:
3G/GSM Iridium, UHF
Payload Capacity: 10 kg
Fuel Capacity: 4.5 kg petrol

CryoWing Mk 2 (2012)
MTOW: 60 kg
Vingespenn : 5.2 m
Range: 1600 km
Telemetry:
3G/GSM, Iridium, UHF
Payload Capacity: 15 kg
Fuel Capacity: 15 kg petrol

CryoCopter (2013)
MTOW: 6-7 kg
Range: 2 km
Telemetry: UHF and C-Band
Payload Capacity: 3 kg
Fuel : Li-Pol Battery

Available Instrumentation

Current:

Imaging Spectrometer 256 channels 400-700 (950) nm wavelength (Fred Sigernes, UNIS)

Digital camera (Canon or Nikon SLR)

C-band radar sounder (5.3 GHz)

Laser profiler (20-60 mm rms, max 2KHz)

Meteorological instr. package (Temp, hum, press, wind)

Laser-scanner 12500 pts/s 10cm accuracy

Turbulent heat flux sensors (Temporary loan, Univ. of Braunschweig)

SST meter (IR thermometer)

Trios Ramses spectrometer (up and down looking)

GRIM OPS particle sampler (Volcanic Ash)

Under development:

Synthetic aperture radar (Ku-band, 15GHz)

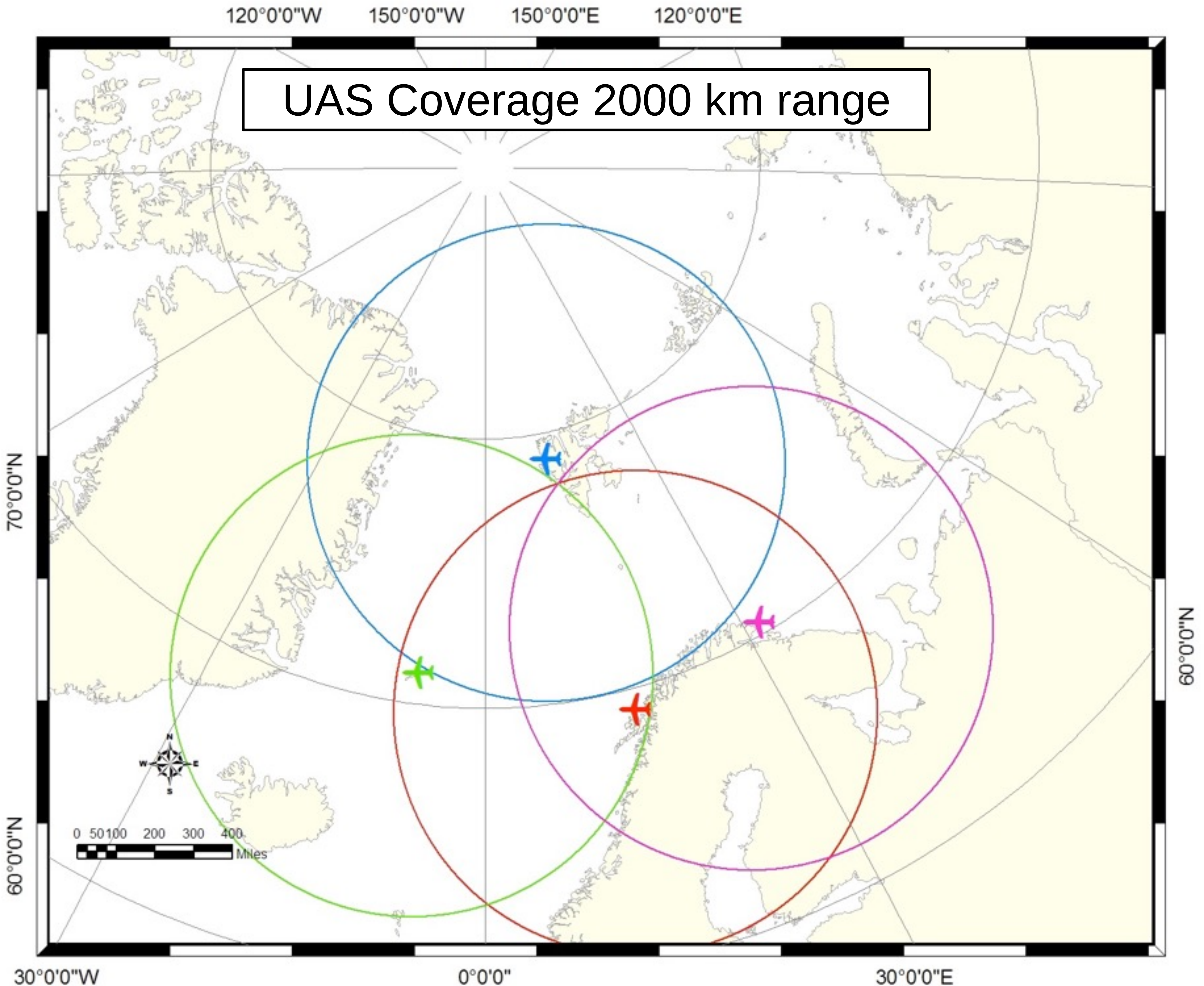
Drop sonde, met. and oil “fingerprint” lab on a chip

Planned:

Methane sensor

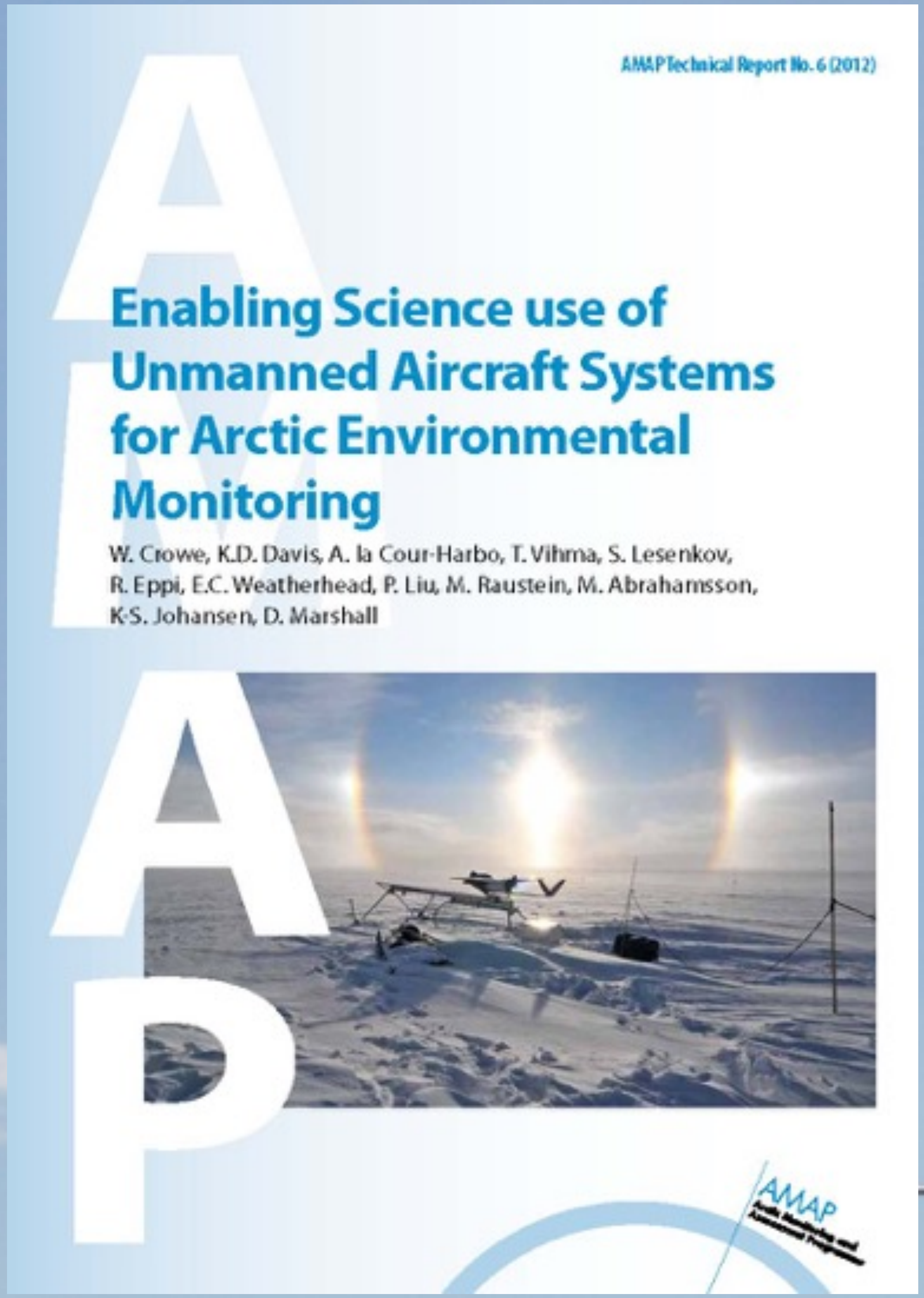
Wanted:

Standardized met. sensor package


UAS Coverage 2000 km range
120°0'0"W
150°0'0"W
150°0'0"E
120°0'0"E
70°0'0"N
60°0'0"N
60°0'0"N
30°0'0"W
0°0'0"
30°0'0"E
0 50 100 200 300 400
Miles
N
W
E
S

Science data gaps filled by UAS and associated challenges

Electronic copy at
www.amap.no

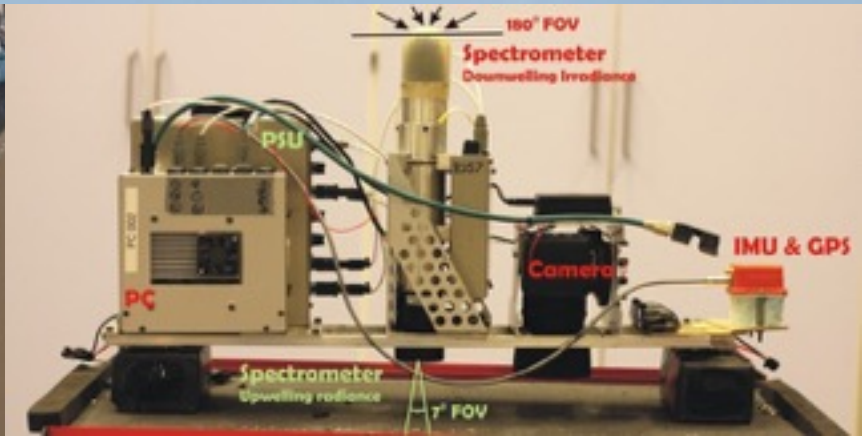


Key Arctic Science Topics

Where UAS could play a future vital role

- ***Arctic lower atmosphere - boundary layer system; Dynamical and radiation feedback systems***
  Aerosols and BC, clouds, surface energy fluxes, meteorology
- ***Oceanic and sea-ice processes***
  Ice fraction, ice thickness, ice albedo, melt pond fractions, ice mechanics, ice classification, snow on ice, ocean winds and waves.
- ***Marine transport of energy, nutrients and pollution***
  Ocean color (chlorophyll-A, algae), surface temperature and currents
- ***Glacier and ice cap mass balance and dynamics***
  Mass balance, glacier dynamics and facies characterization
- ***Greenhouse gas processes and feedbacks in the Arctic climate system***
  Measurements of methane, ozone, CO_2, N_2O and other trace gases
- ***Arctic ecosystem resilience to climate variability and change***
  Vegetation mapping, phenology and population estimation



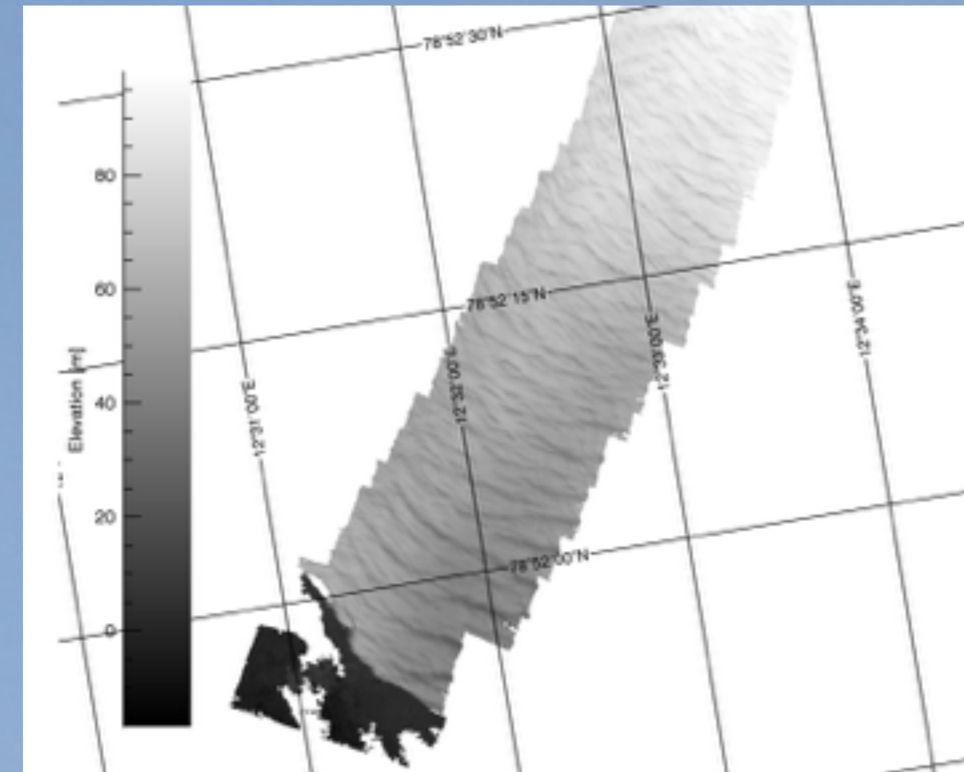
Other Key "Arctic" Topics

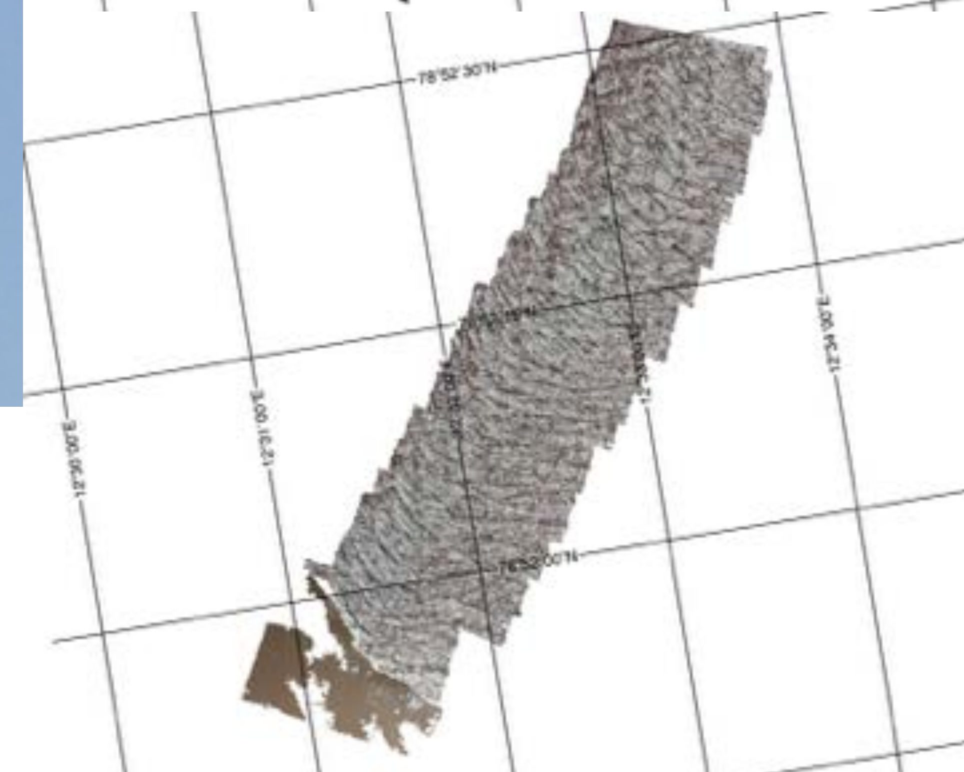
Where UAS will play a future vital role

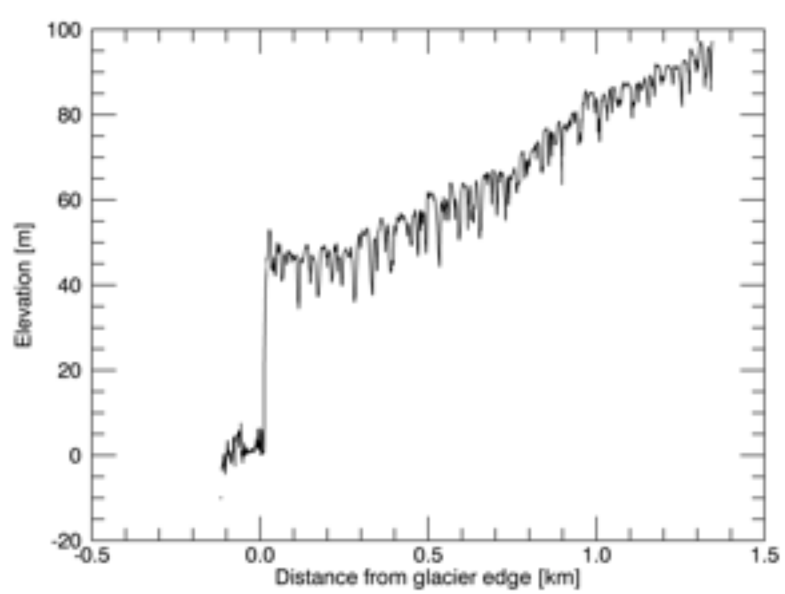
- ***Search and Rescue***
  - *Search part, MOB, Mountain Rescue, ship accidents.*
- ***Operational Support Oil and Gas Industry***
  - *Sea-ice surveillance*
  - *Ice-berg detection and tracking*
  - *Marine mammal detection*
- ***Operational Support Maritime Industry***
  - *Sea-ice properties, pirates, SAR*
- ***Emergency Preparedness and Response***
  - *Oil spill detection, distribution and tracking*
  - *Volcanic ash concentration*
  - *Plume monitoring industrial accidents (Nuclear, chemical)*
- ***Resource management***
  - *Marine mammal population estimation (seals, whales, polar bears)*
  - *Reindeer management (population management, food access)*
- ***Renewable energy support***
  - *Hydroelectric power*
  - *Wind power*

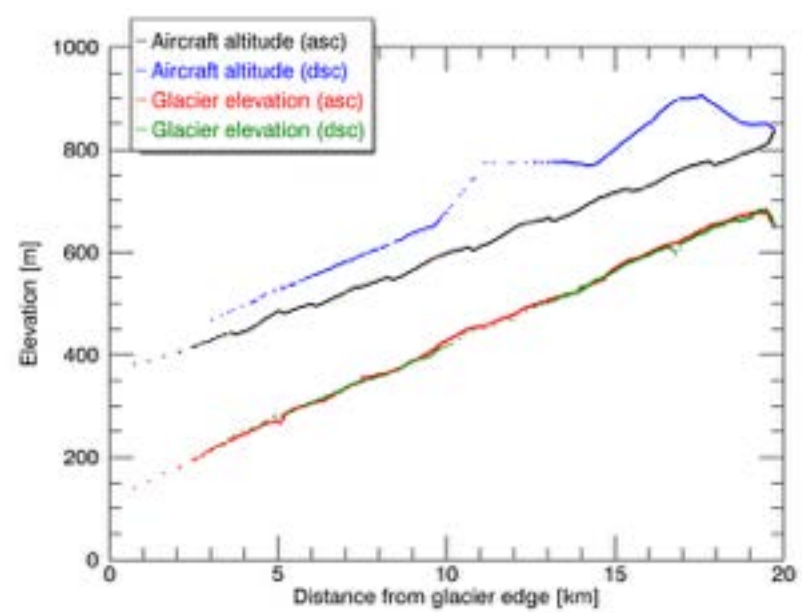
Glaciology

Kronebreen and Kongsvegen Glaciers





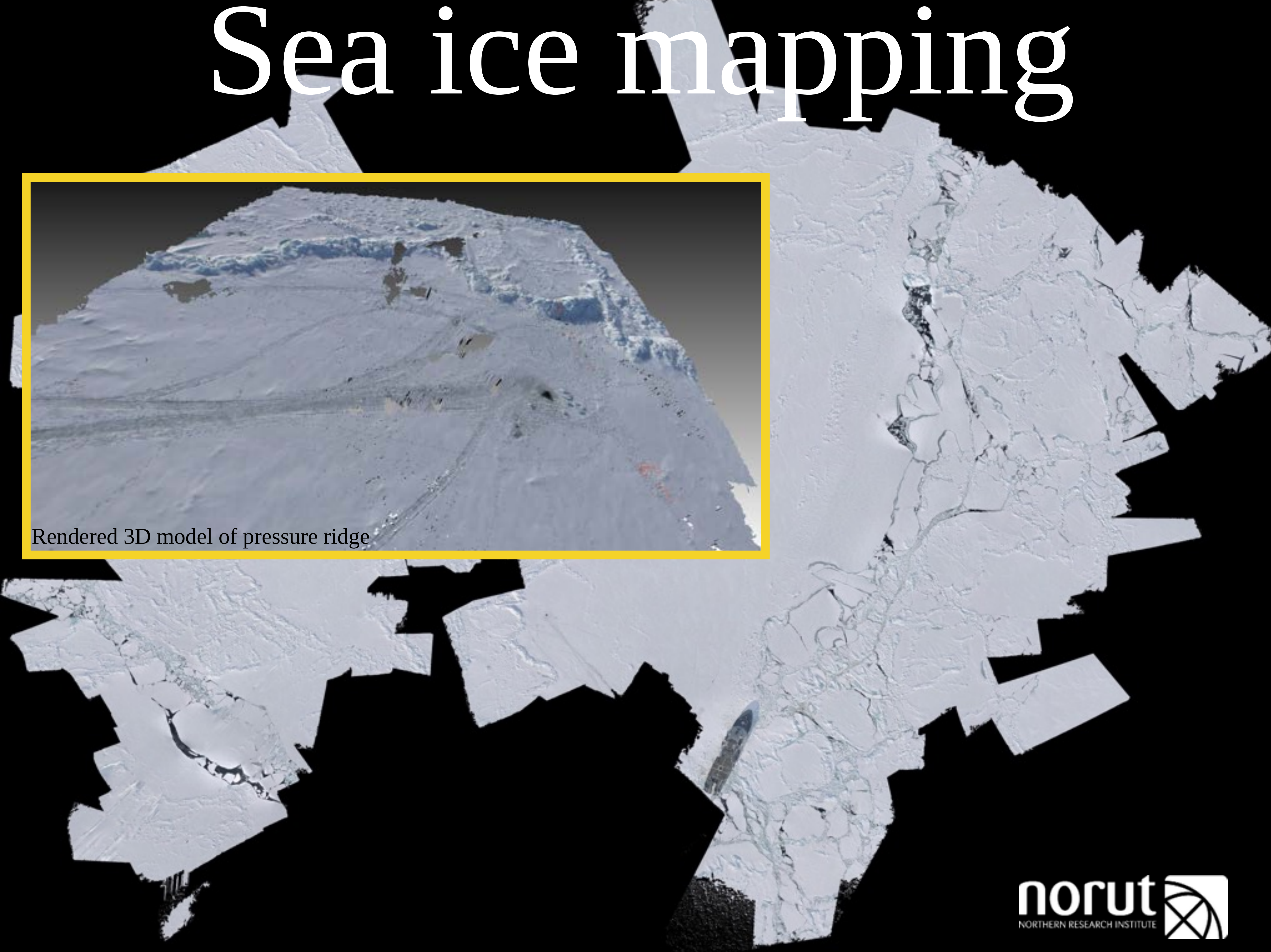




Glacier and ice cap mapping

UAS measurements of Kongsvegen/Kronebreen Augus 2014

Sea ice mapping



Rendered 3D model of pressure ridge

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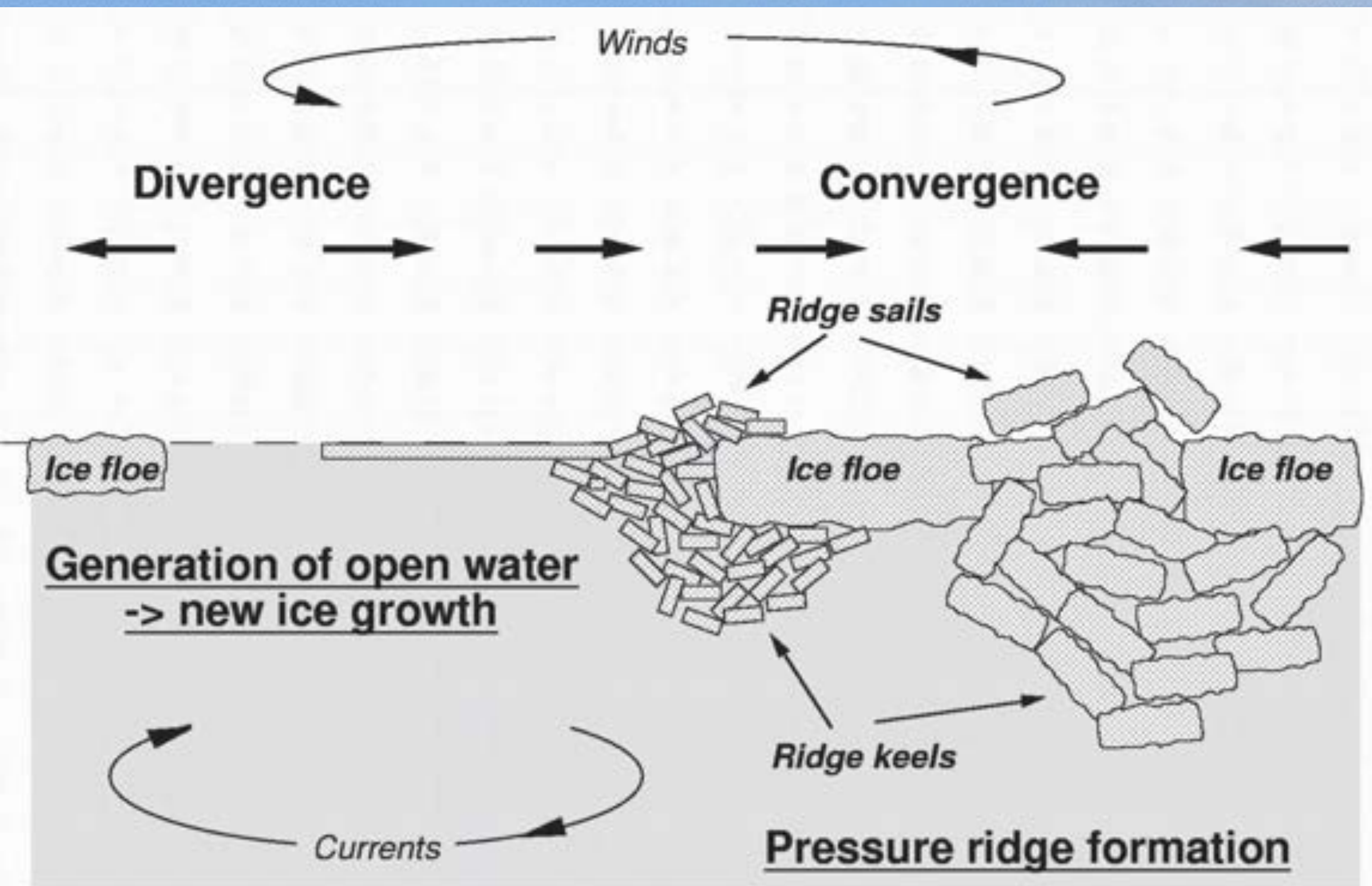
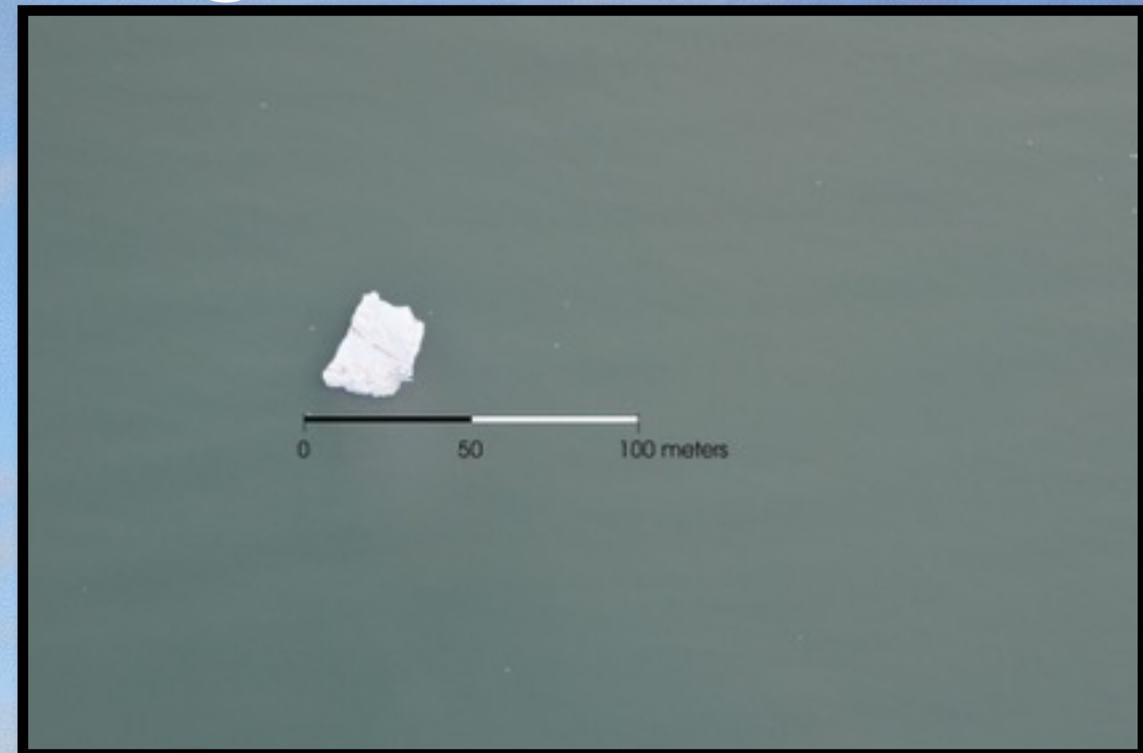
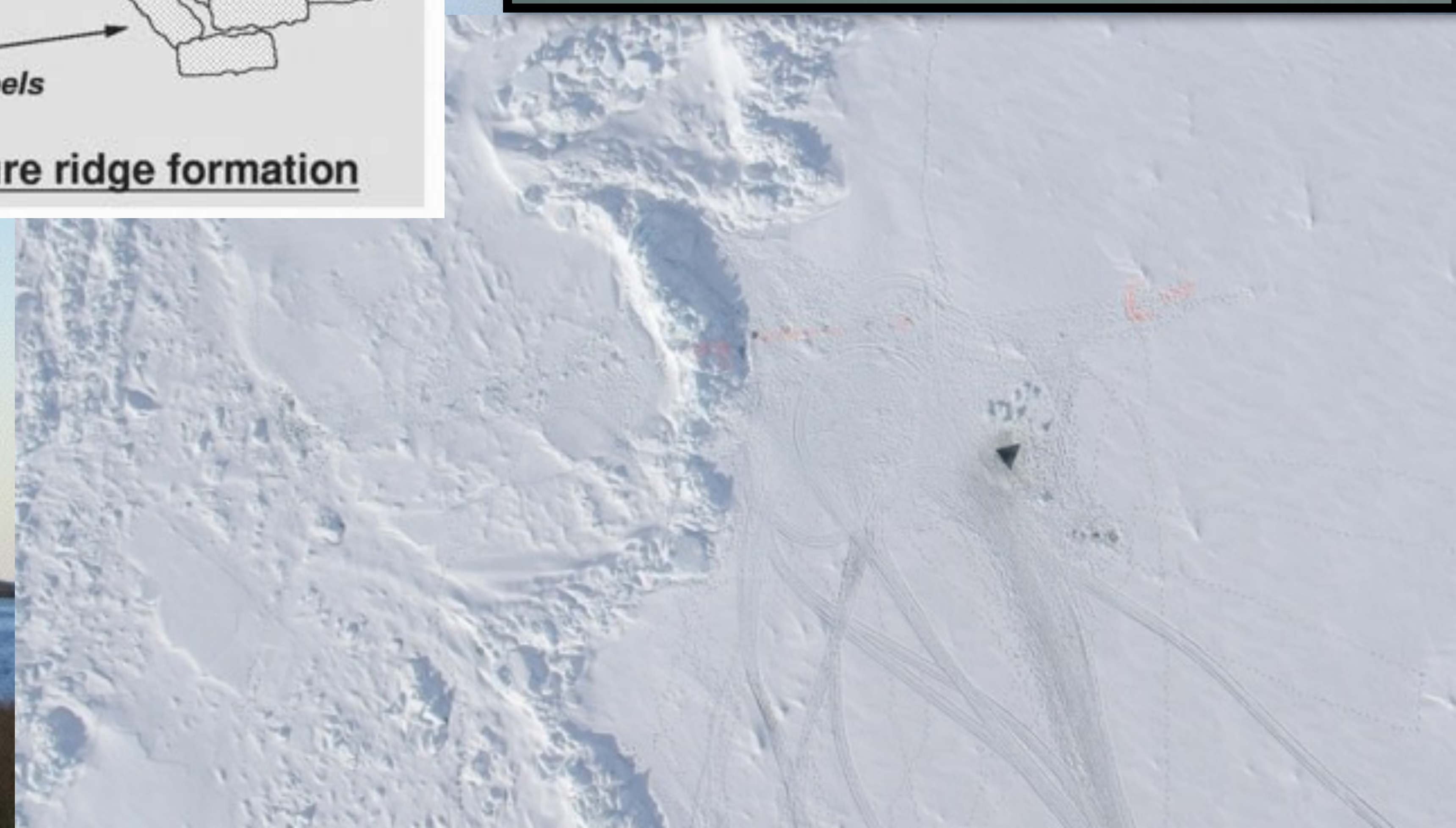
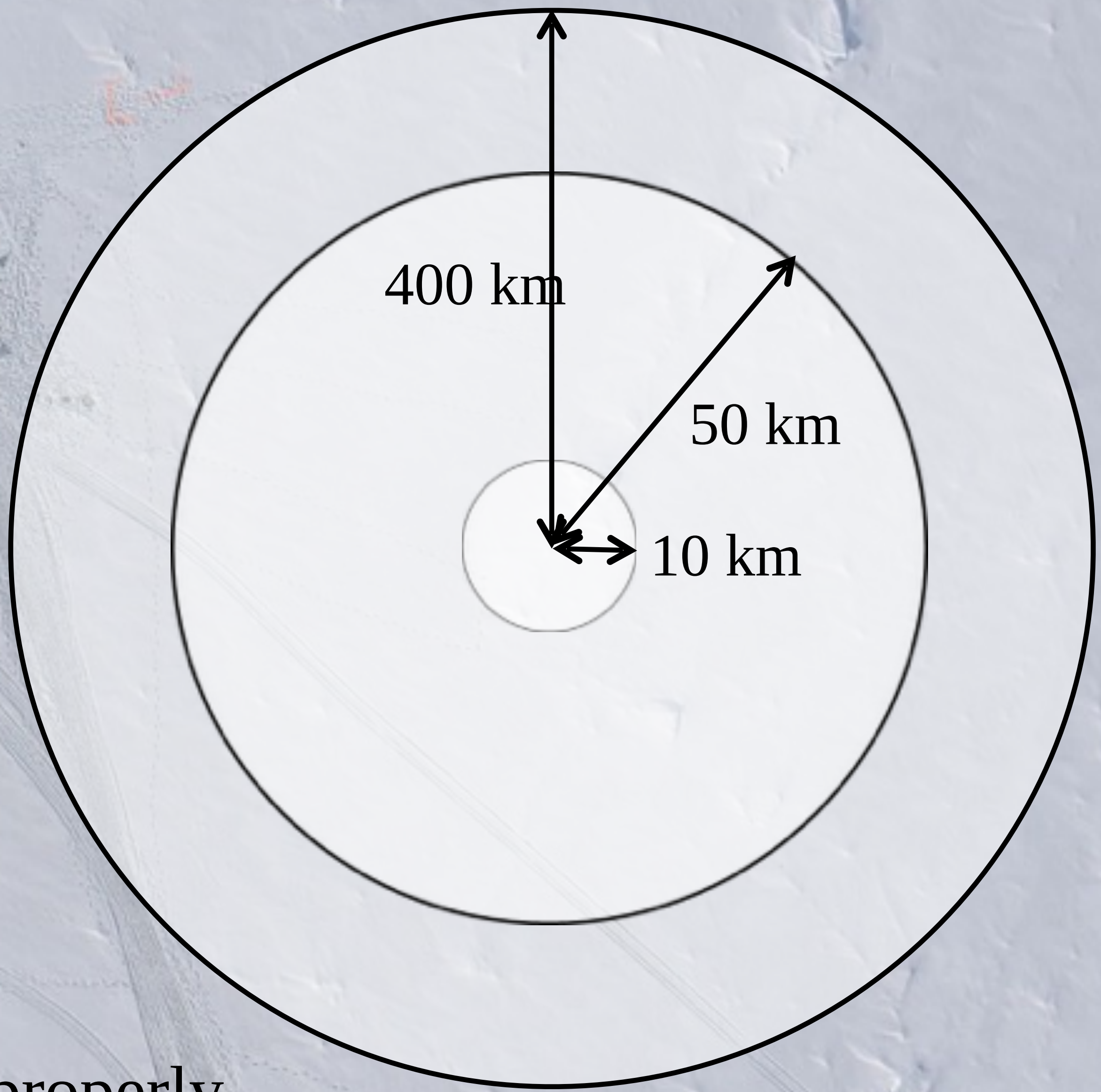
Ice and Icebergs







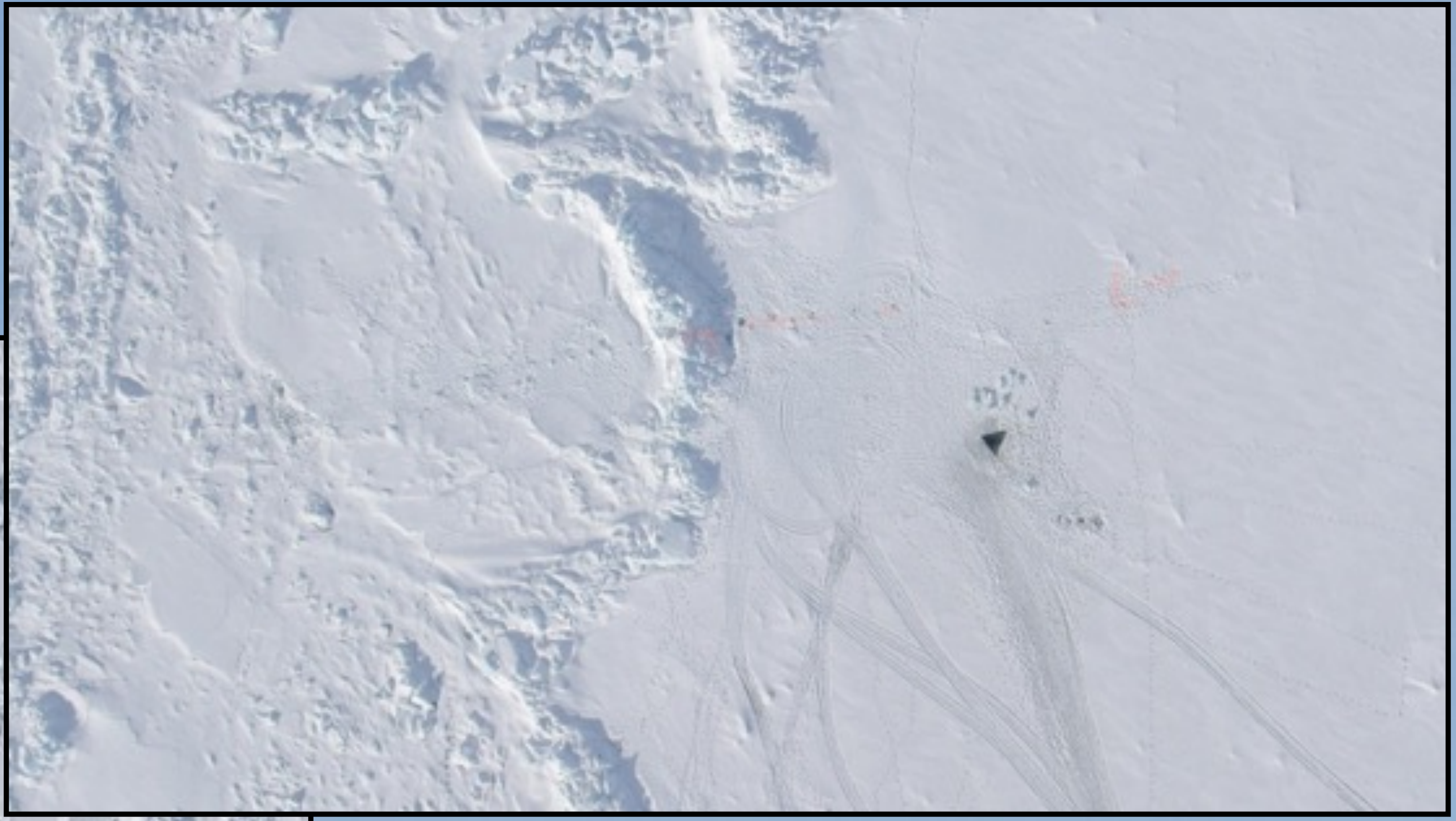
Ice Management

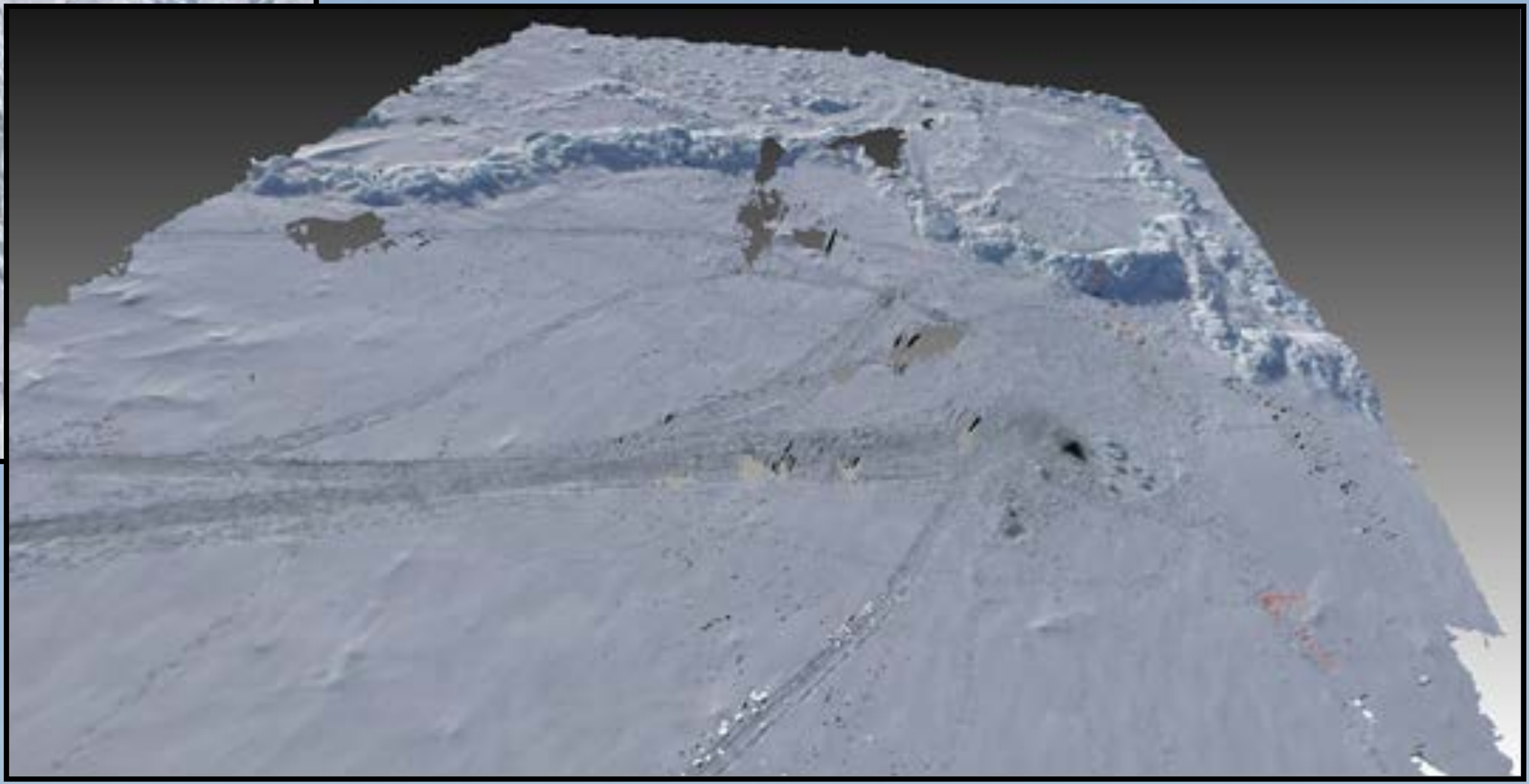


Need 6 hours to decouple from drill string properly
Can be done in 30 minutes, but then coupling back on takes time

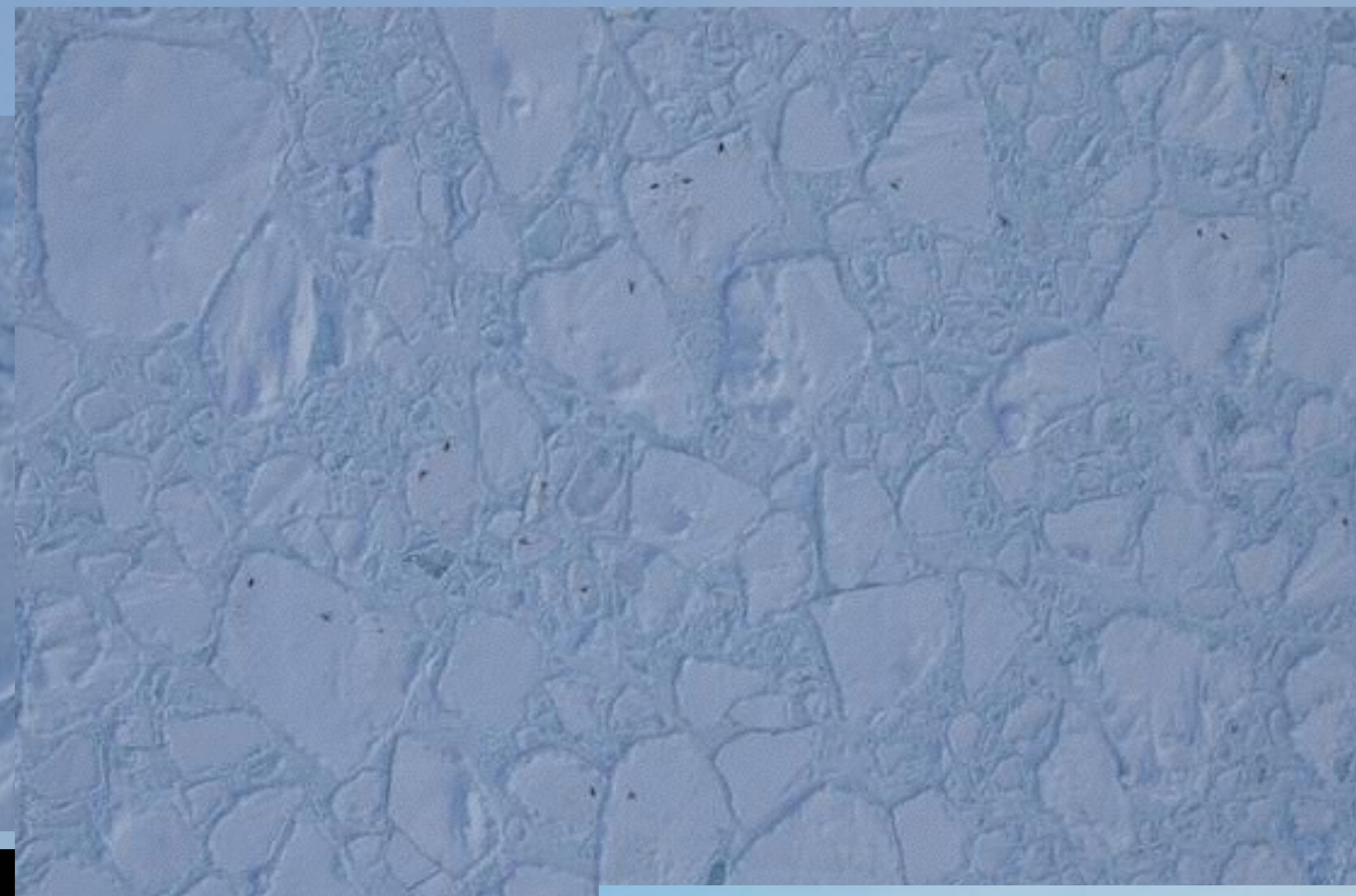
Ice drifts with speeds up to 25 km in 24 hrs. not uncommon.
Ice thickness distribution, drift and concentration determines loads.
Reduced downtime = $$$

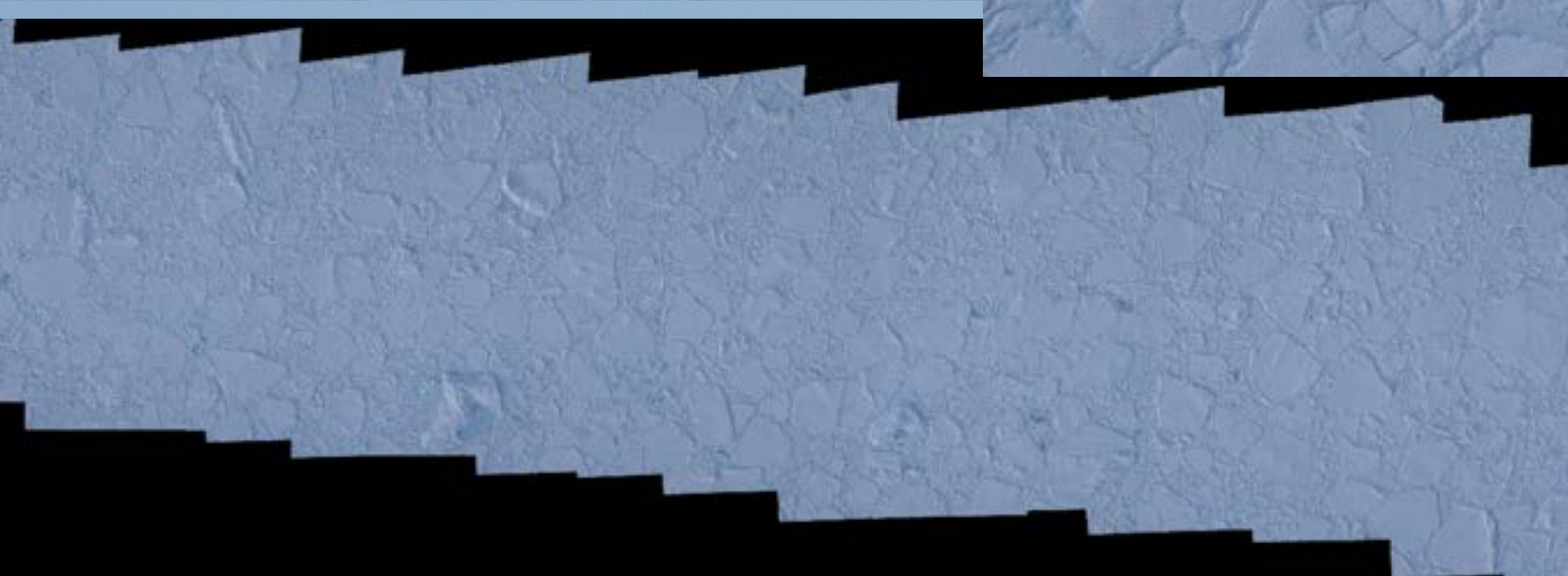
KV Svalbard April-May 2013



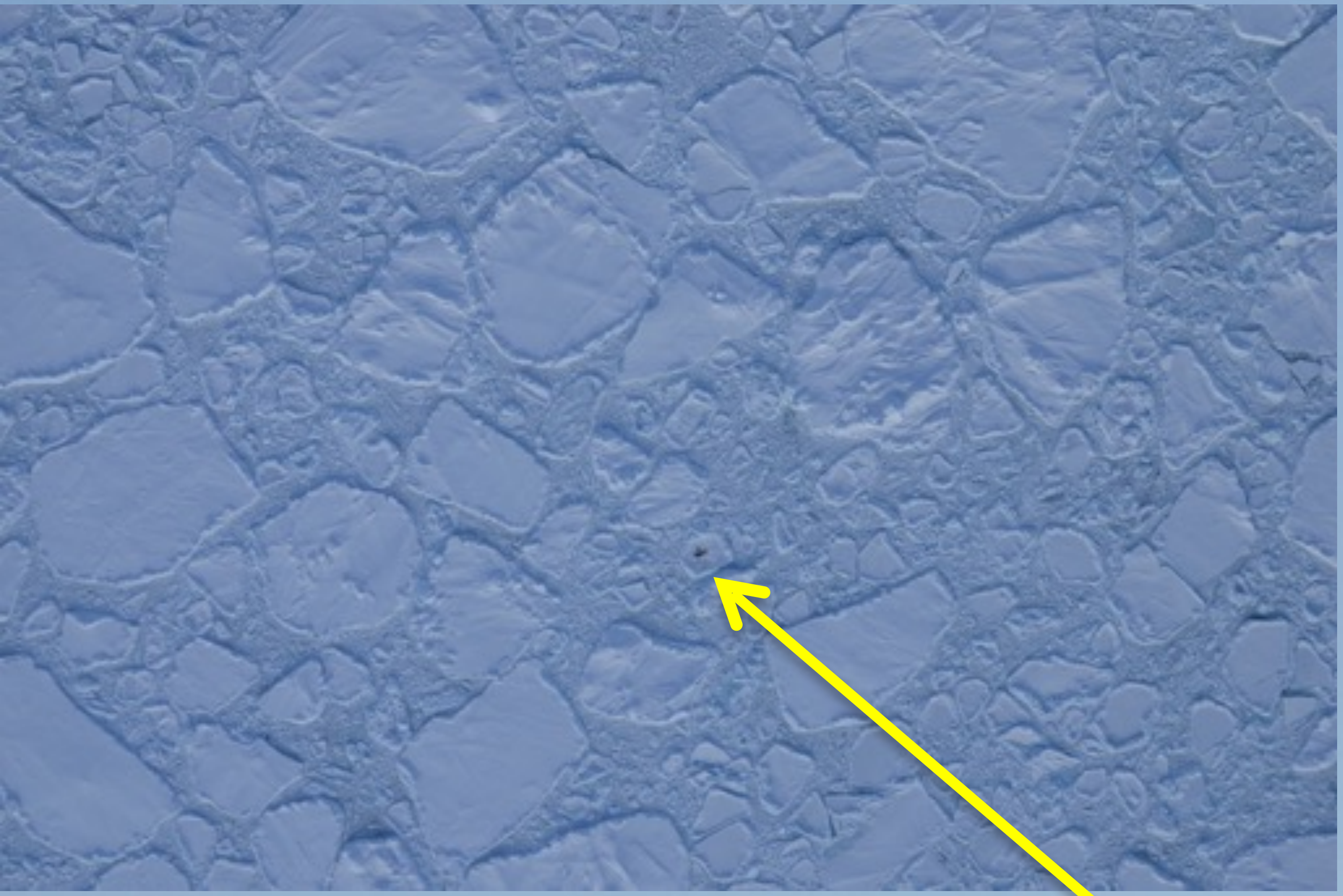


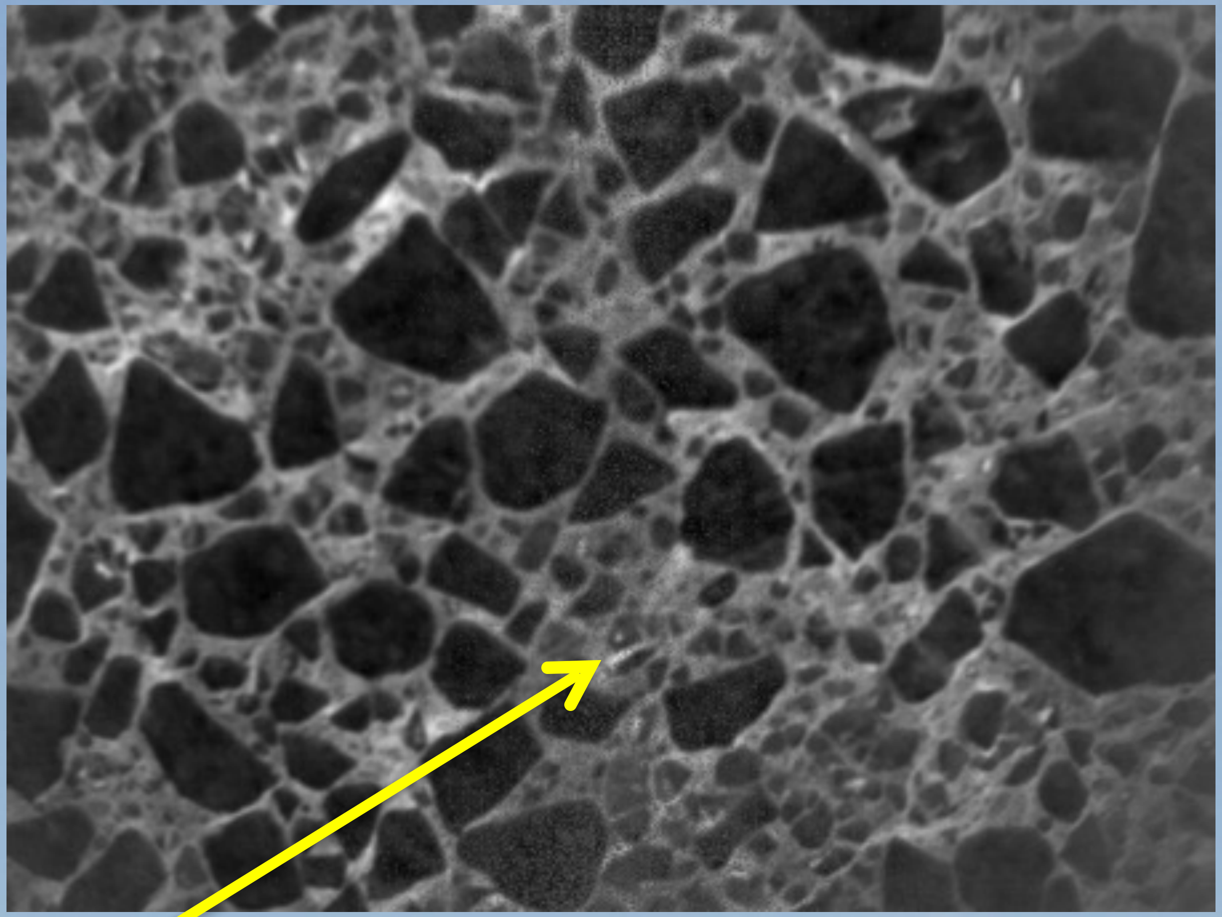
Counting Seals





Simultaneous visible and IR





Seal on ice floe

Marine Mammals

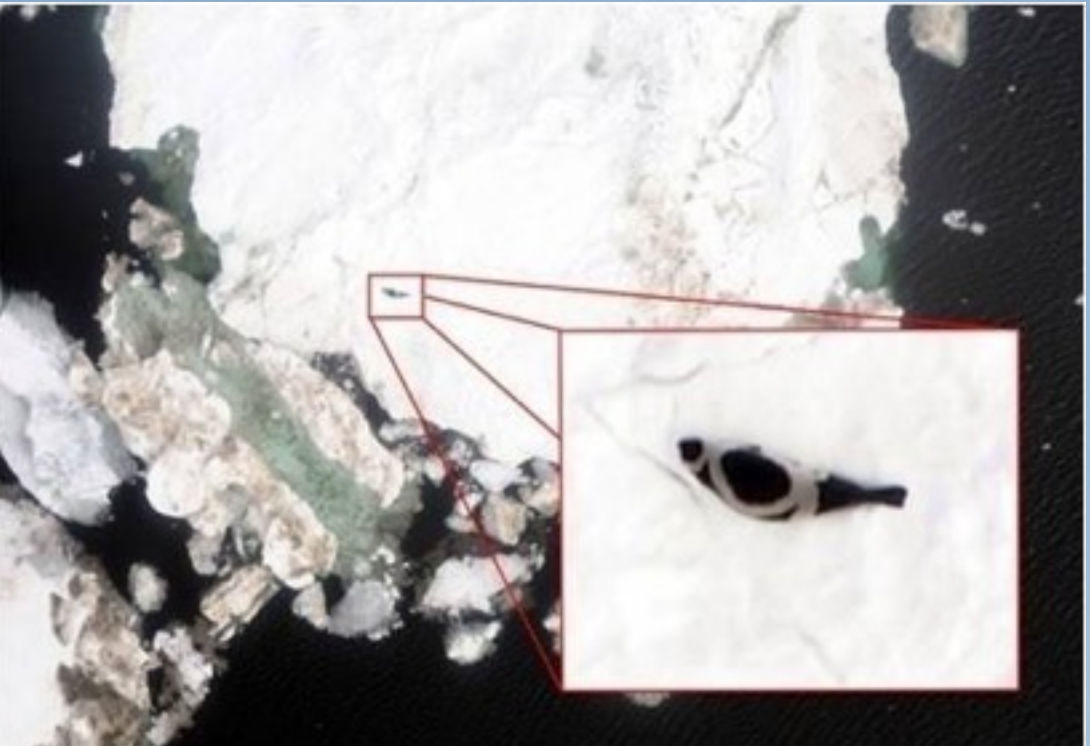
Marine Mammals

Seismic and sonar activities might impact whales and seals

- ***Monitoring for whales is required***
- ***Impact poorly understood, huge differences in requirements***
- ***Behavioral studies needed***

Measurements

- ***Detection (IR and visible imagery)***
- ***Identification, size estimation***



Marine Mammals

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A team of Norut scientists has just finished counting penguins in Antarctica!

Mapping vegetation stress due to ATV traffic. Breivikeidet

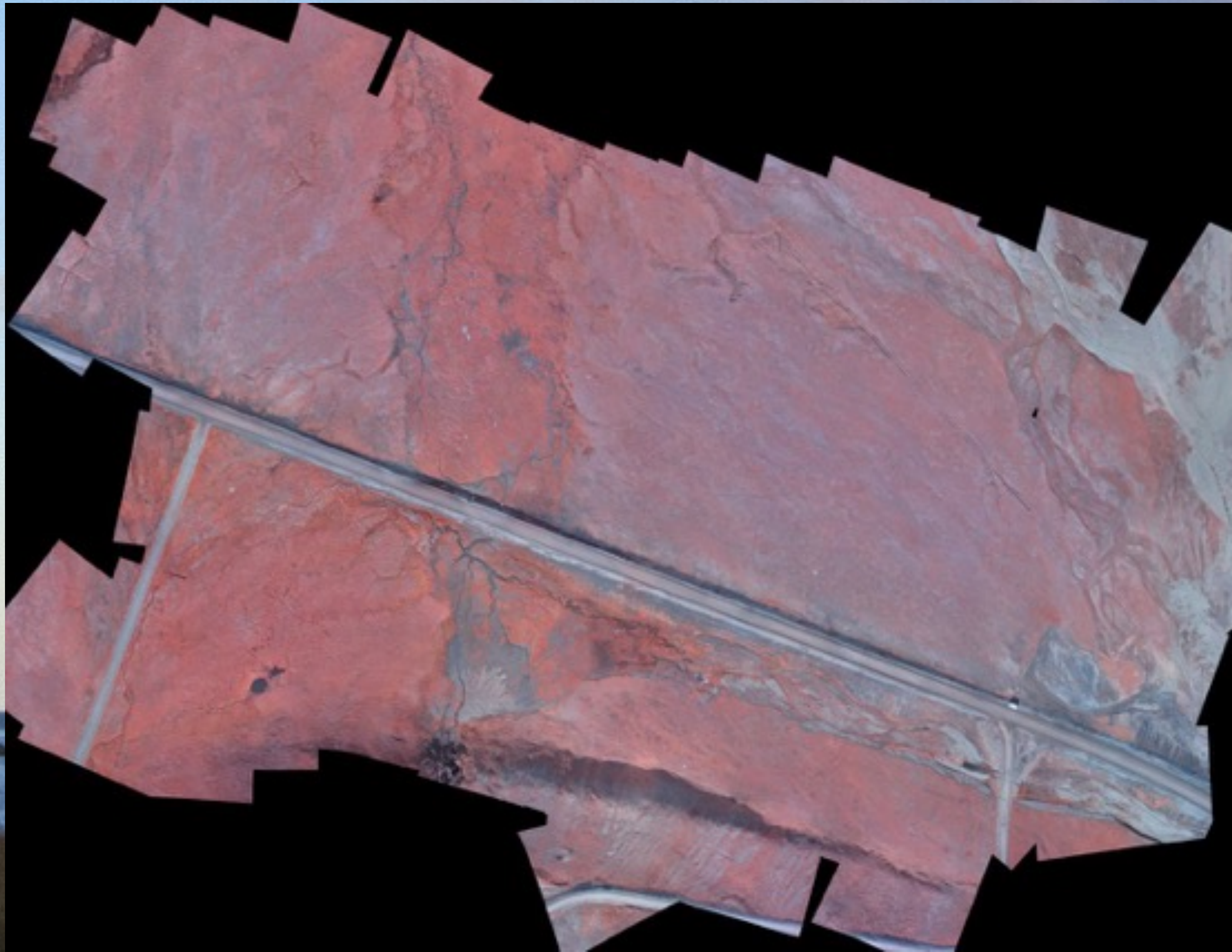
Snowmobile tracks on tundra in Advent Valley

Vegetation Mapping and Scaling

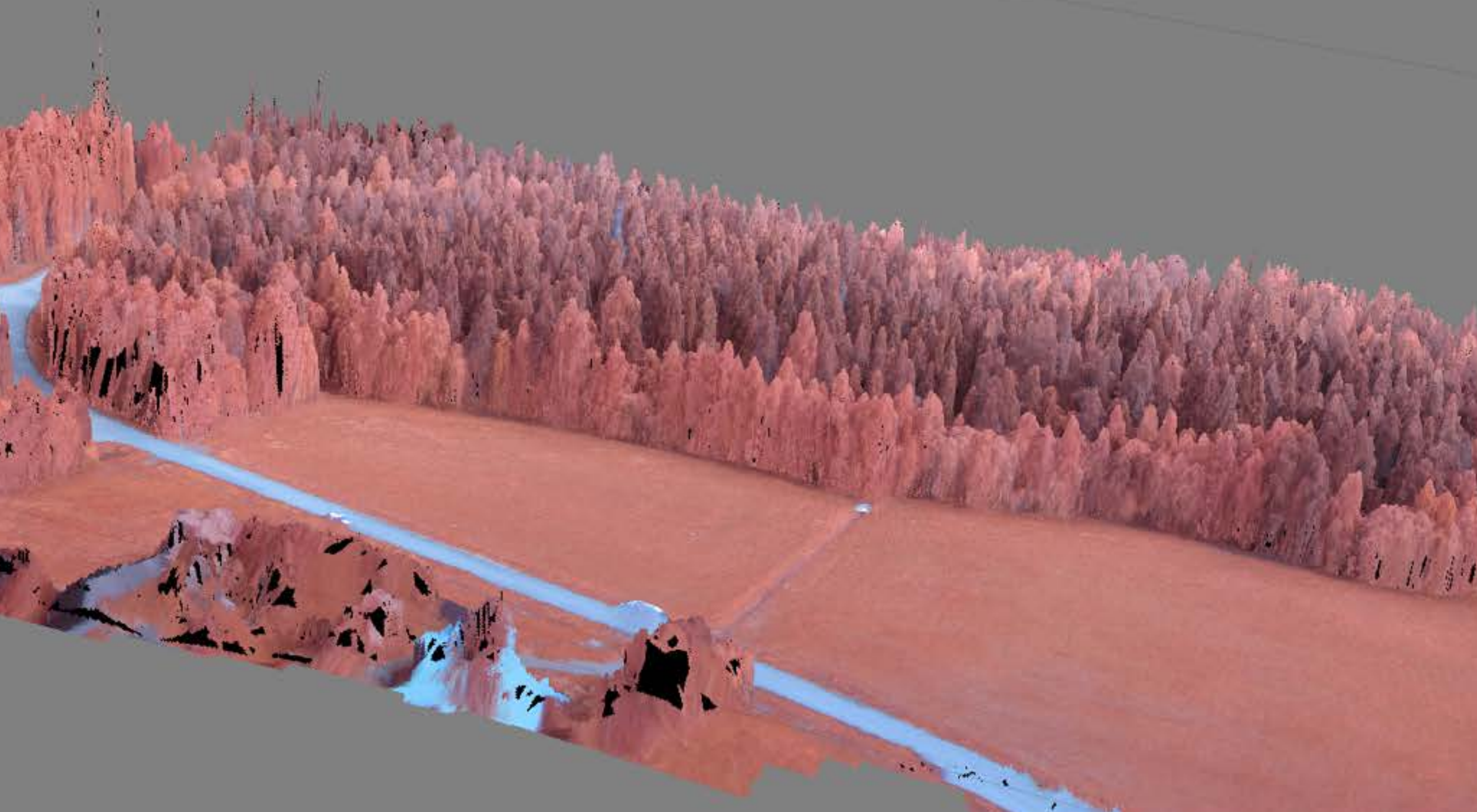
Svalbard Science forum project 2013/14
Low impact measurements for mapping of vegetation, biomass and phenology
Sensors:
Camera, Visible and NDVI

Challenges:
Very high resolution may be required for some applications.
Absolute reflectance measurements are challenging due to high attitude dependency and BRDF effects

NDVI mosaic Adventdalen



3D processing of NDVI data

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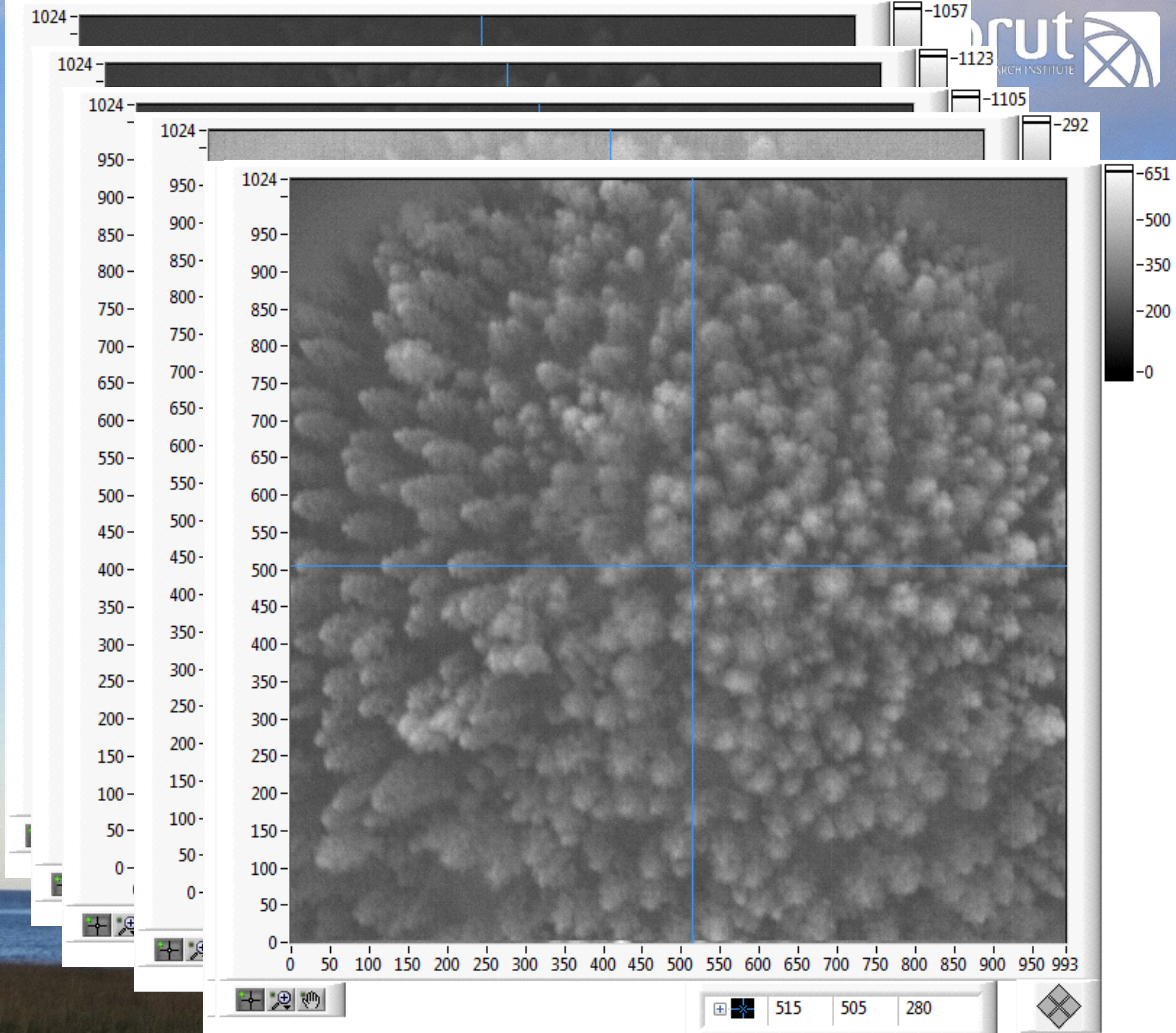
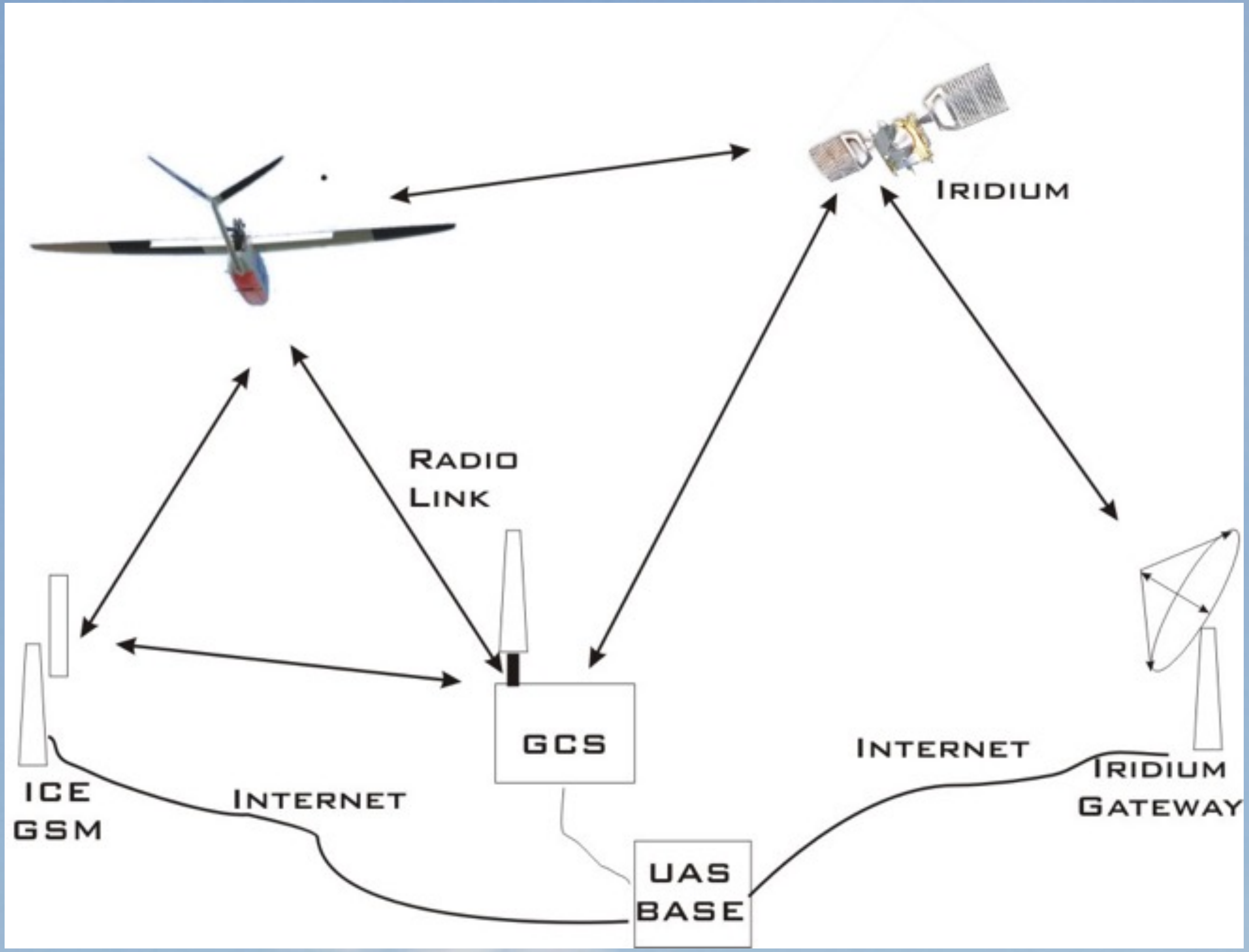
Channels
500
510
531
570
645
700
710
720
730
745
750
760
775
790
858
5ms int



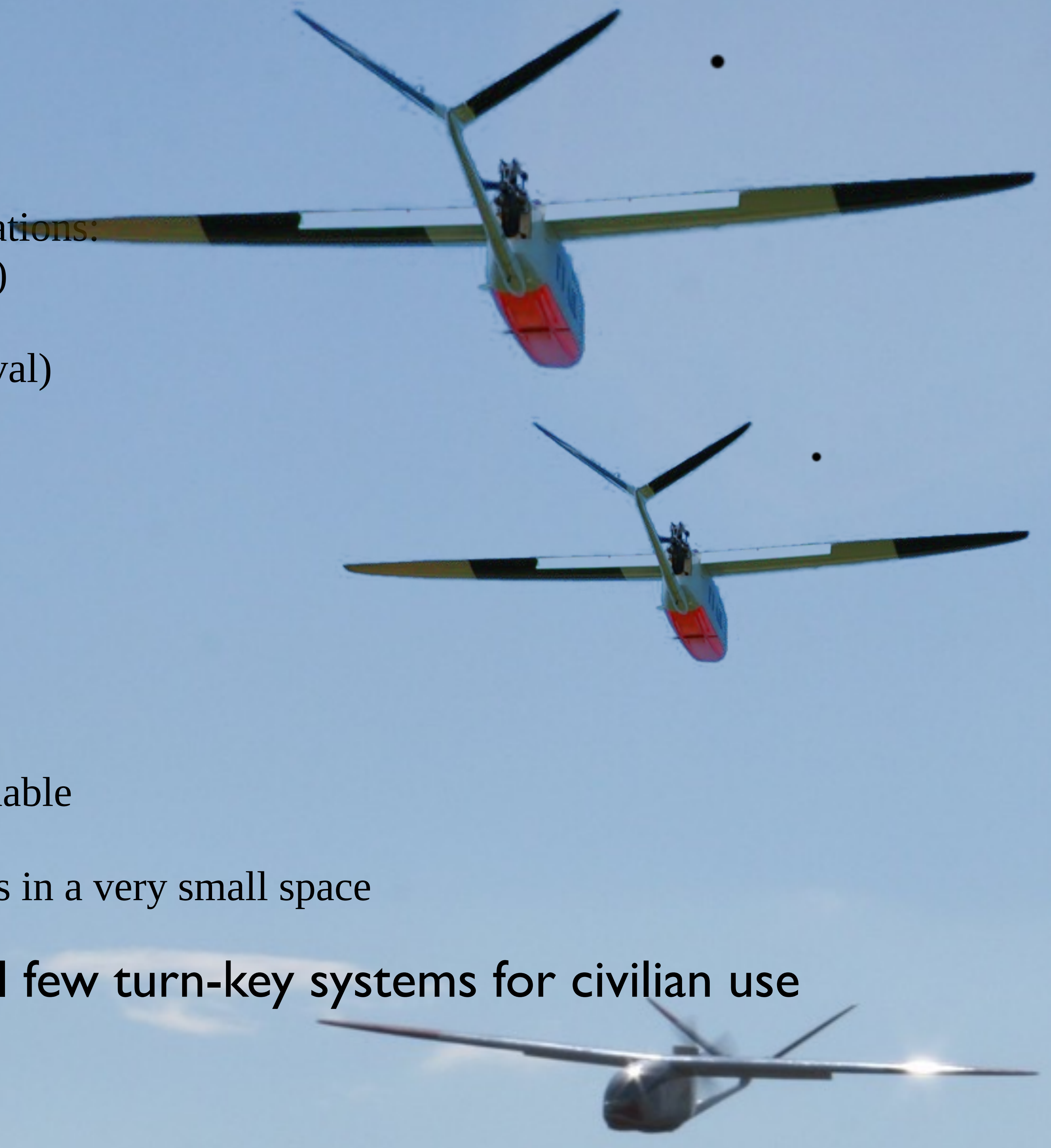
Communications Challenges

- Communication System:
  - Ideally a 10 mbps link that is always up
  - Reality: BRLOS in the Arctic 2kbps Iridium with 2-5 second delay and shaky handover from satellite to satellite every 10-20 minutes. Limitations of 80 handsets within a 100 km radius.



Platform Challenges

- **Propulsion System:**
  - Fuel efficient Engine
  - Heavy fuel (shipping advantages)
- **Environmental Robustness**
  Ideally all weather proof, but real life limitations:
  - Winds (control system hardware design)
  - Turbulence (control system robustness)
  - Icing (ice detection, avoidance and removal)
  - Carburetor icing
  - Water intrusion
  - Visibility
- **Vibrations**
  - Disturb sensors and measurements
  - Wears airframe
- **Power System**
  - Generator based
  - Clean, robust, multiple output, programmable
  - Battery backup
- **RF Noise**, up to 6 active and passive antennas in a very small space

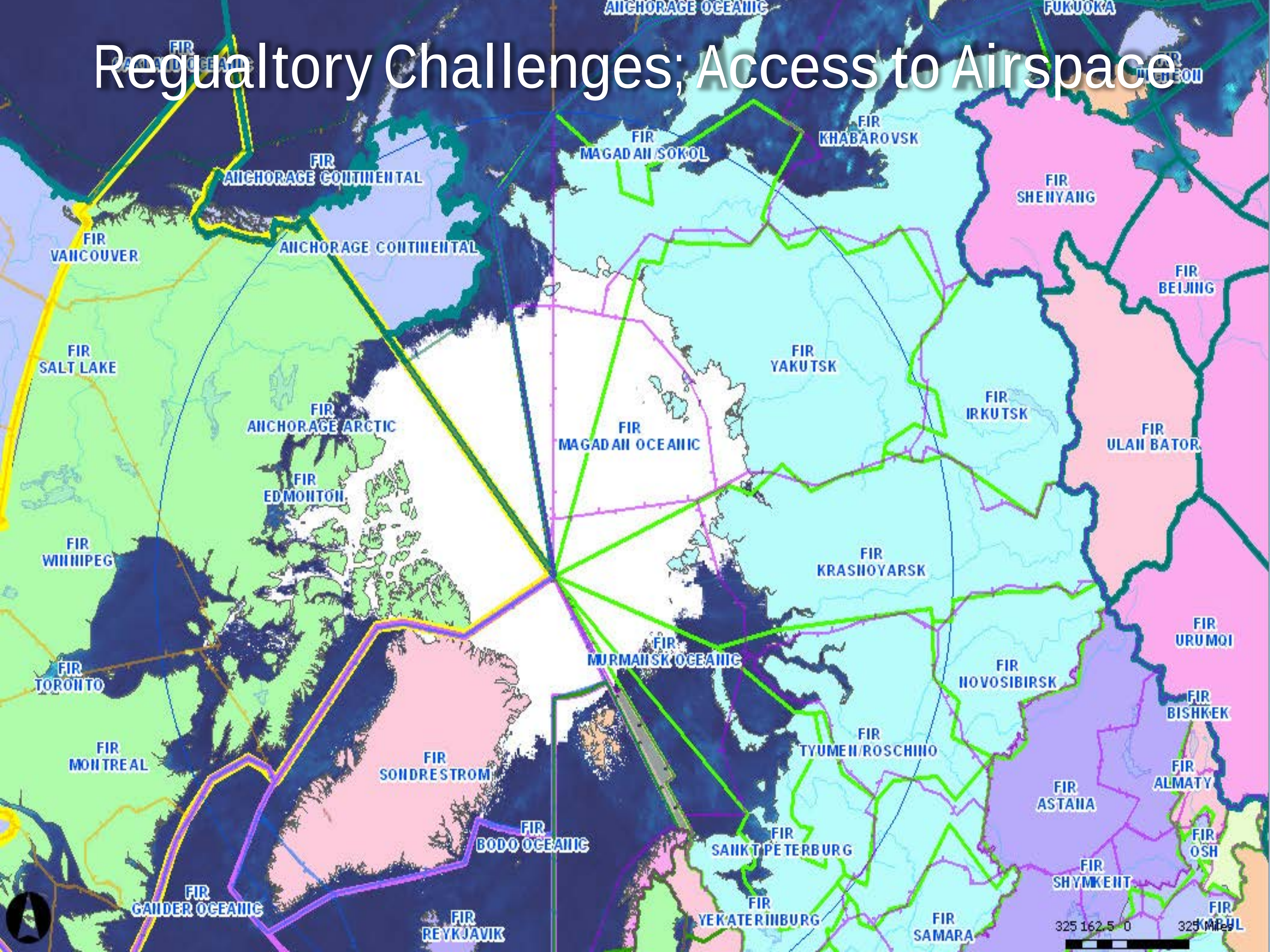


Many airframes on the market, but still few turn-key systems for civilian use

UAS come in all sizes

- There is a lack of small/medium sized turn-key systems for ship based operations on a "civilian" budget
- Oil/seismic companies request ship based UAS capacity for detection of icebergs and crawlers. 24/7!

Regualtory Challenges; Access to Airspace



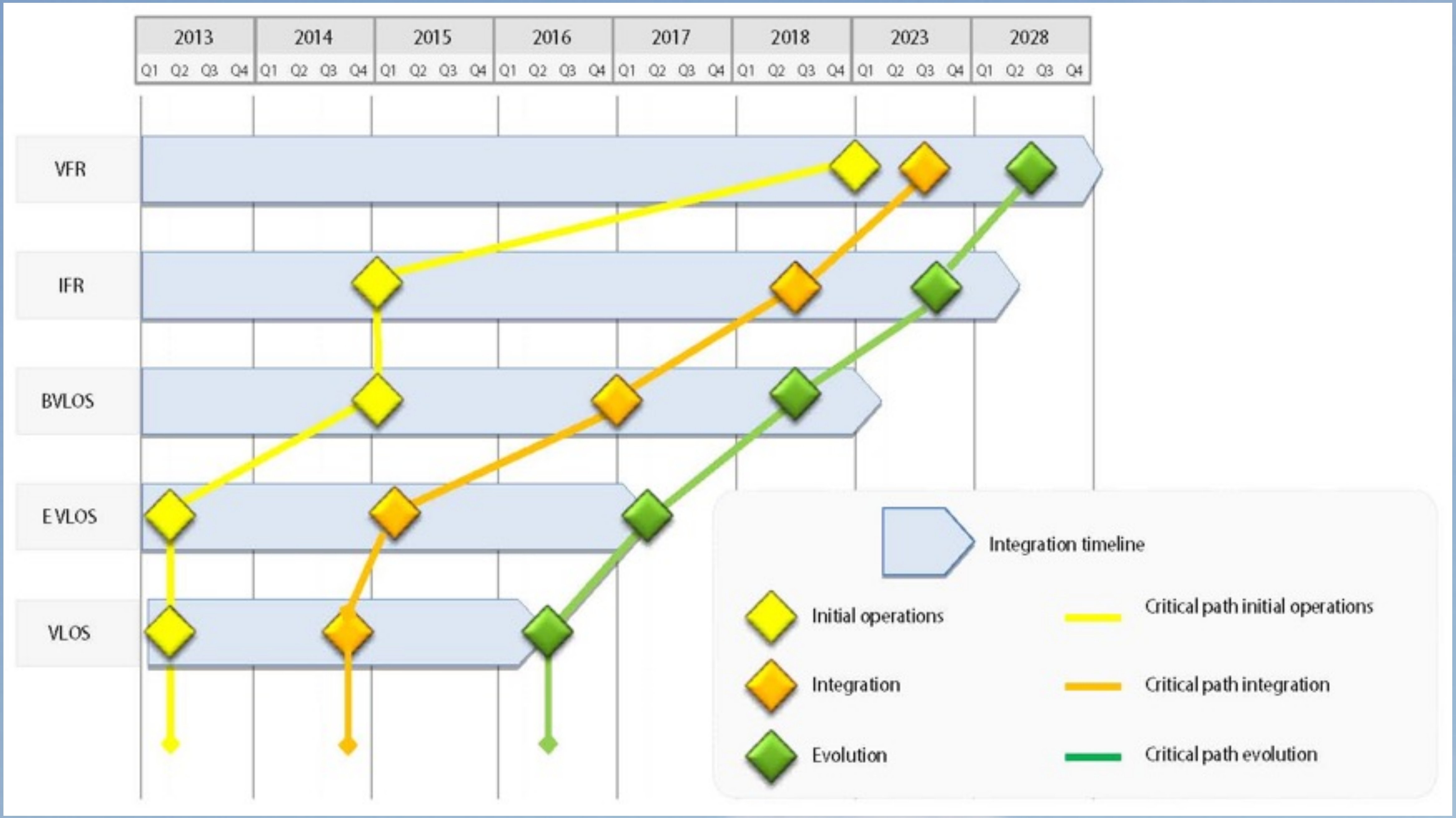
Technology Use and Sharing Challenges

Sensitive technologies with potential dual use purposes.
Export restrictions.

Consistent Pan Arctic datasets requires:

- Inter-comparison and inter-calibration campaigns. Aircraft part of the sensor.
- Open data policy, including flight data.
- Multilateral collaboration and coordination of data collection activities
- Sharing of sensor technologies and analysis techniques

ICAO Regulation Roadmap



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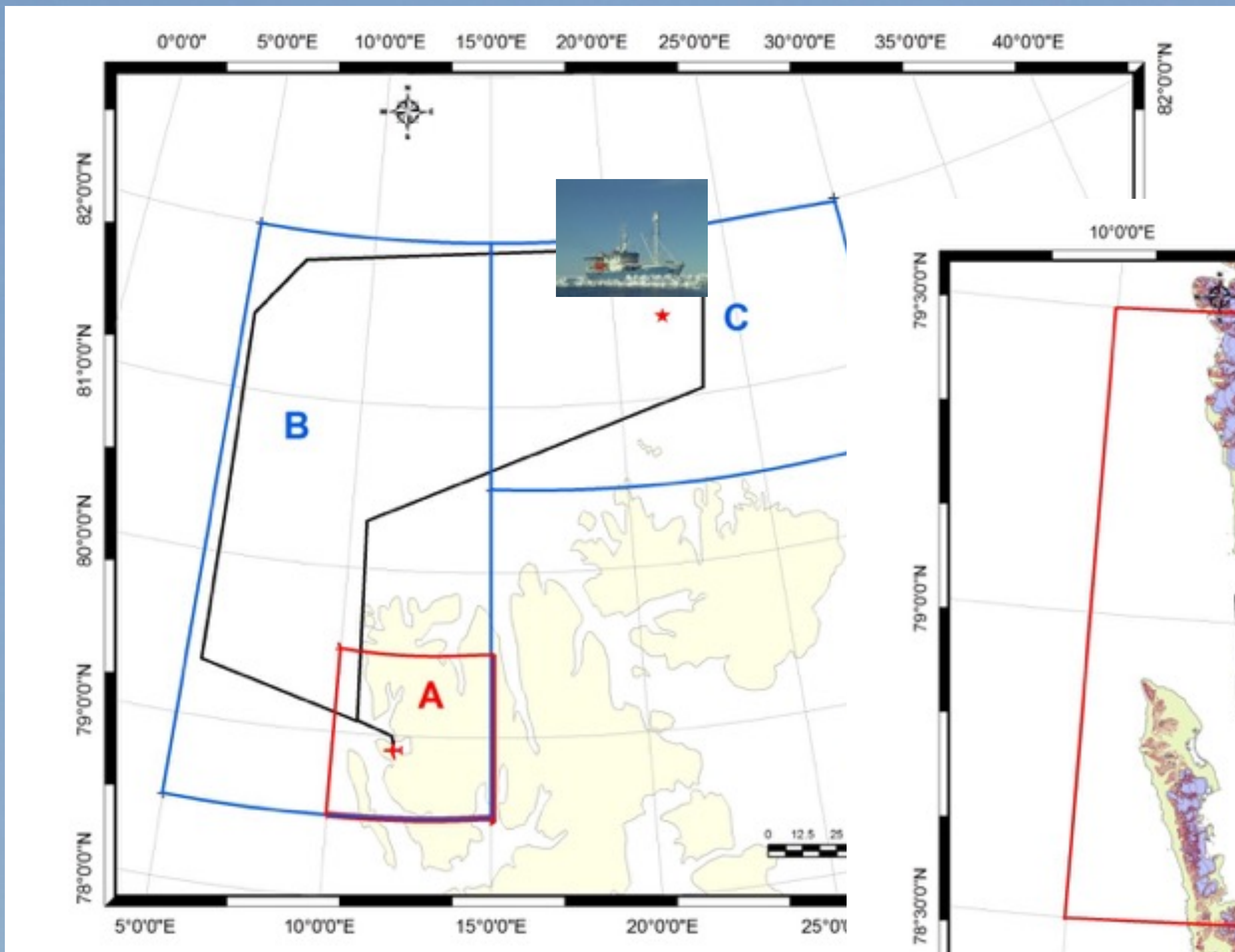
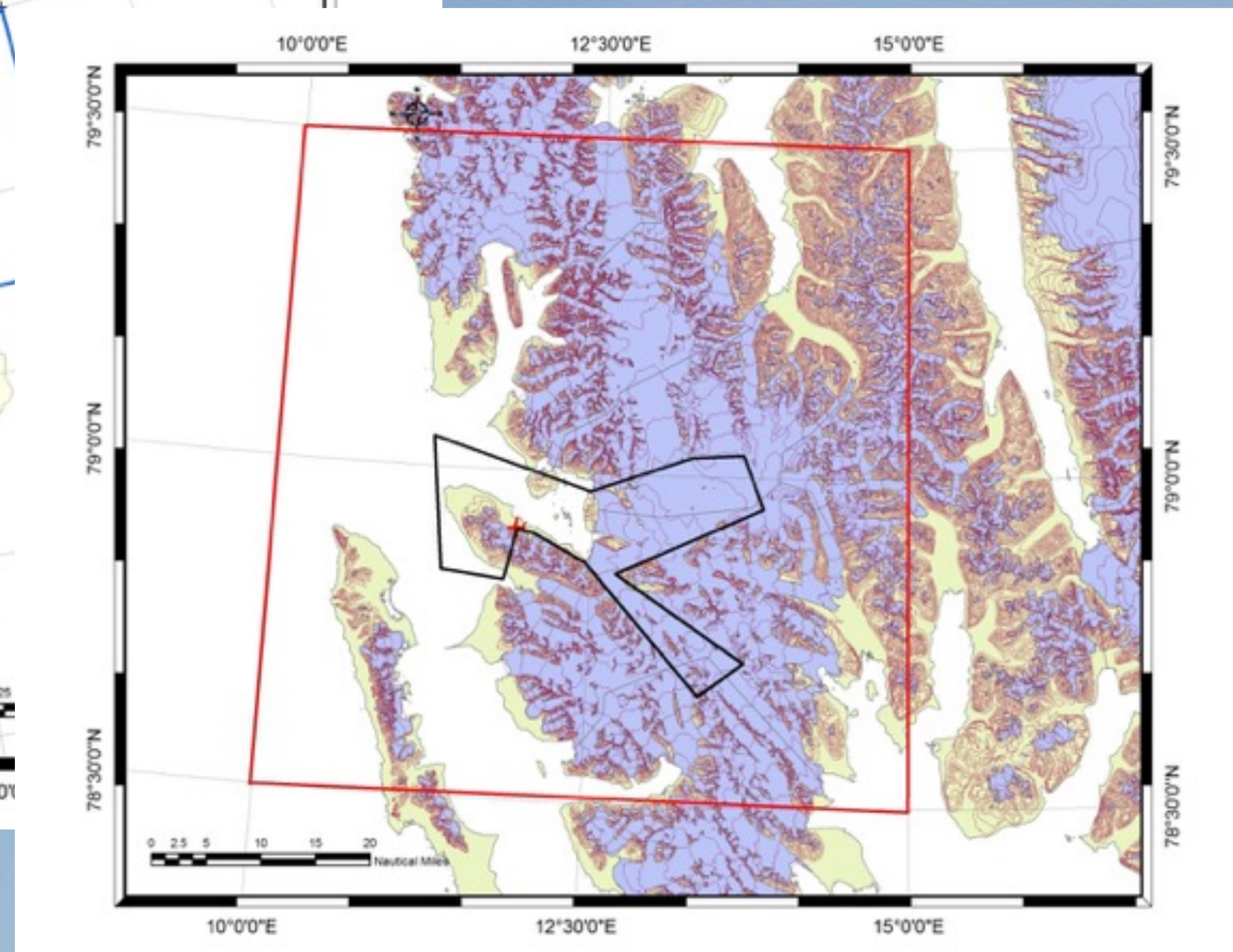
Flight Permitting





Thank you for you attention

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Kjell Sture Johansen, Andreas Tøllefsen,
Rune Storvold, Stian Solbø, et al.