Unmanned Aerial Vehicle Flights over Terra Nova Bay, Antarctica During September 2009

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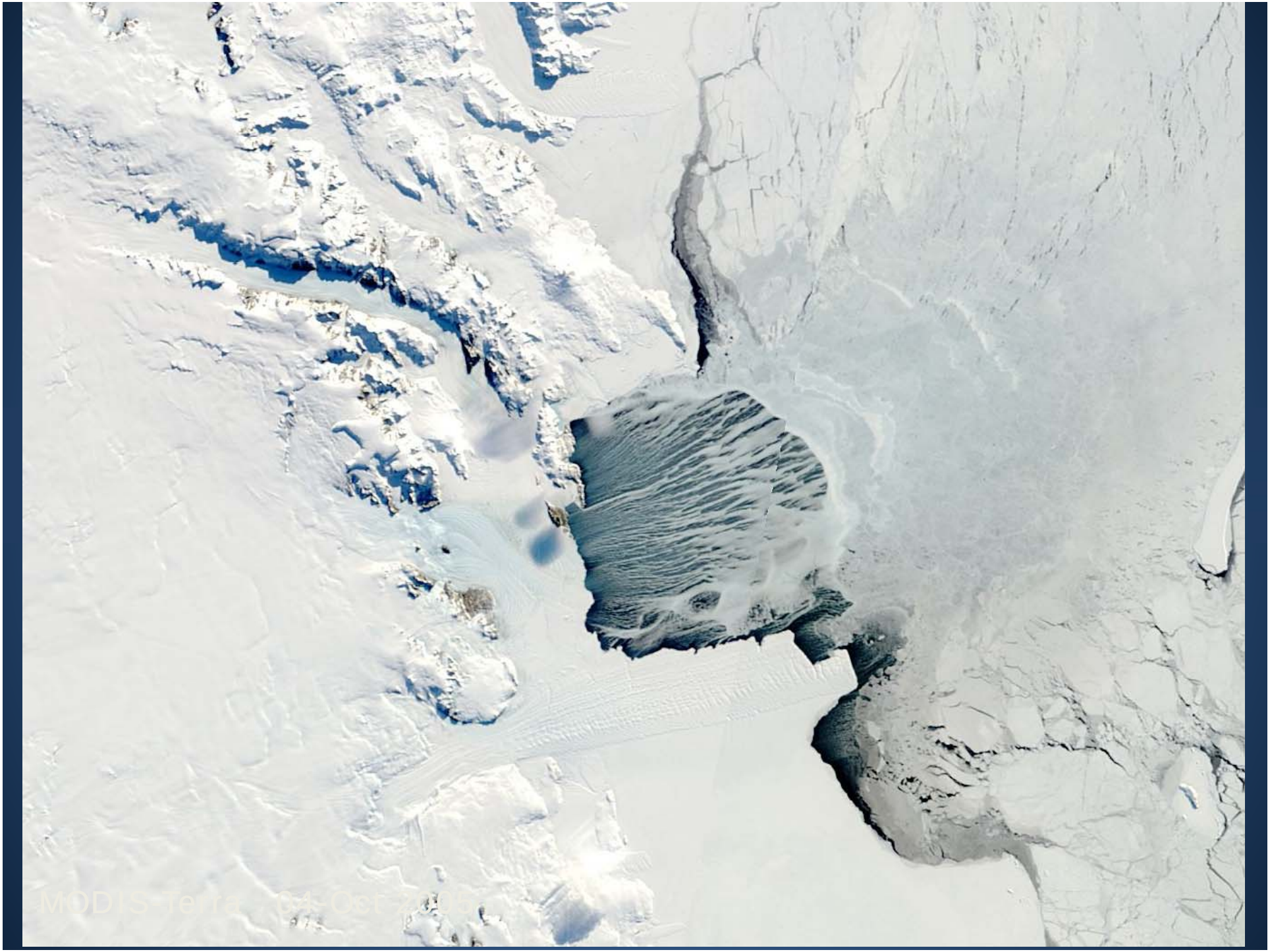
Project Overview

- Use Aerosonde unmanned aerial vehicles (UAVs) to make meteorological measurements in the vicinity of Terra Nova Bay
- Why Terra Nova Bay?
  - Location of recurring polynya
  - Region of strong katabatic winds
  - Source region for Antarctic bottom water
- Prior to this project there were no in-situ atmospheric measurements of the wintertime atmosphere over the Terra Nova Bay polynya



Science Questions

- What atmospheric processes control the size of the Terra Nova Bay polynya?
  - Winds?
  - Surface energy budget?
- How do changes in the atmospheric state alter the amount of heat and moisture removed from the ocean in the polynya?
- How does the presence of the polynya modify the katabatic airstream as it passes over the polynya?

Aerosonde UAV

- 16 flights
  - 8 science flights to TNB
- 11000 km (7000 miles)
- 130 flight hours

Aerosonde UAV

Wingspan	3 meters
Weight	15 kg
Payload Capacity	2-5 kg
Endurance	12-17+ hrs
Range	1000+ km
Altitude	100-6000 m

Communications via 900 MHz radio and Iridium

Flies in fully autonomous mode with user-controlled capability

Aerosonde Measurements

Wind Speed/Direction	Pitot with GPS
RH/Temp/Pressure	Standard Radiosonde Met Sensors
Ocean /Ice Skin Temperature	Infrared Thermometer
Ocean/Ice Visible Imagery	Still Digital Camera
Net Shortwave Radiation	Pyranometer
Net Longwave Radiation	Pyrgeometer
RH/T/P/wind profiles	Dropsondes
Altitude and Surface Waves	Laser Altimeter

The Challenges

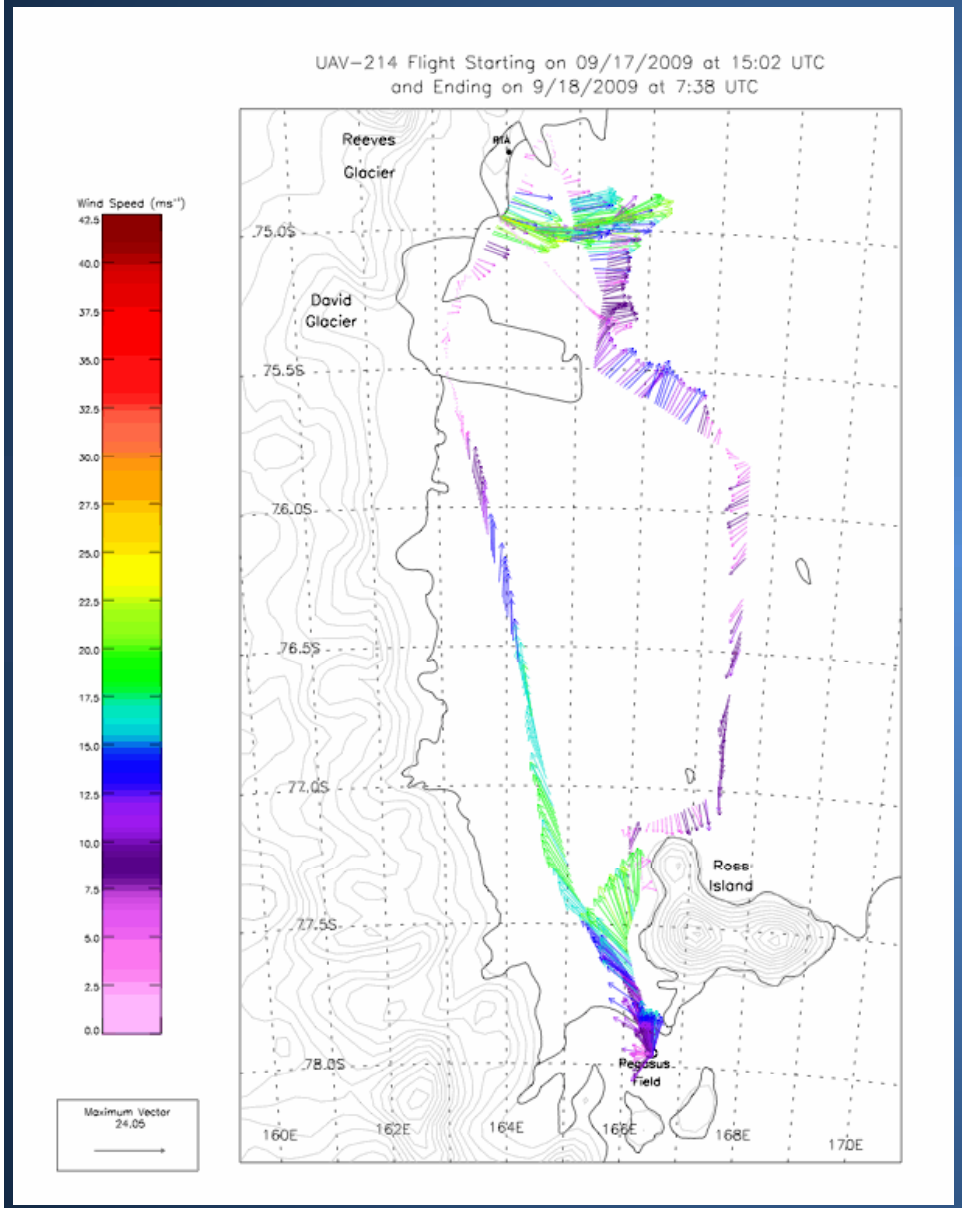
- Cold temperatures
  - Impacted:
    - Engine
    - Parts failure
- Communication failures
- Wind
  - Take-off / landing
  - In flight winds
- Aircraft icing

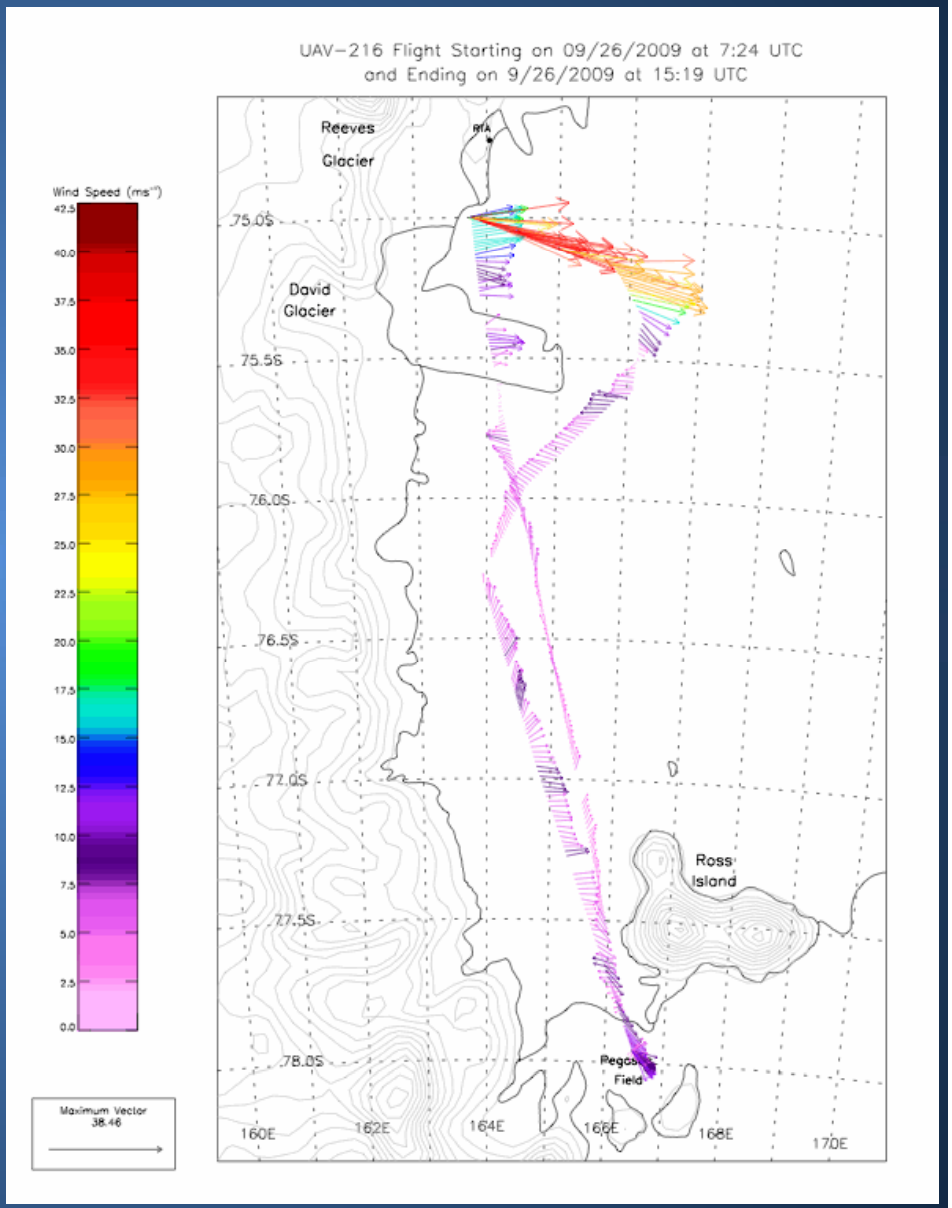
Aerosonde Launch

Pegasus Runway (14 Sept 2009)

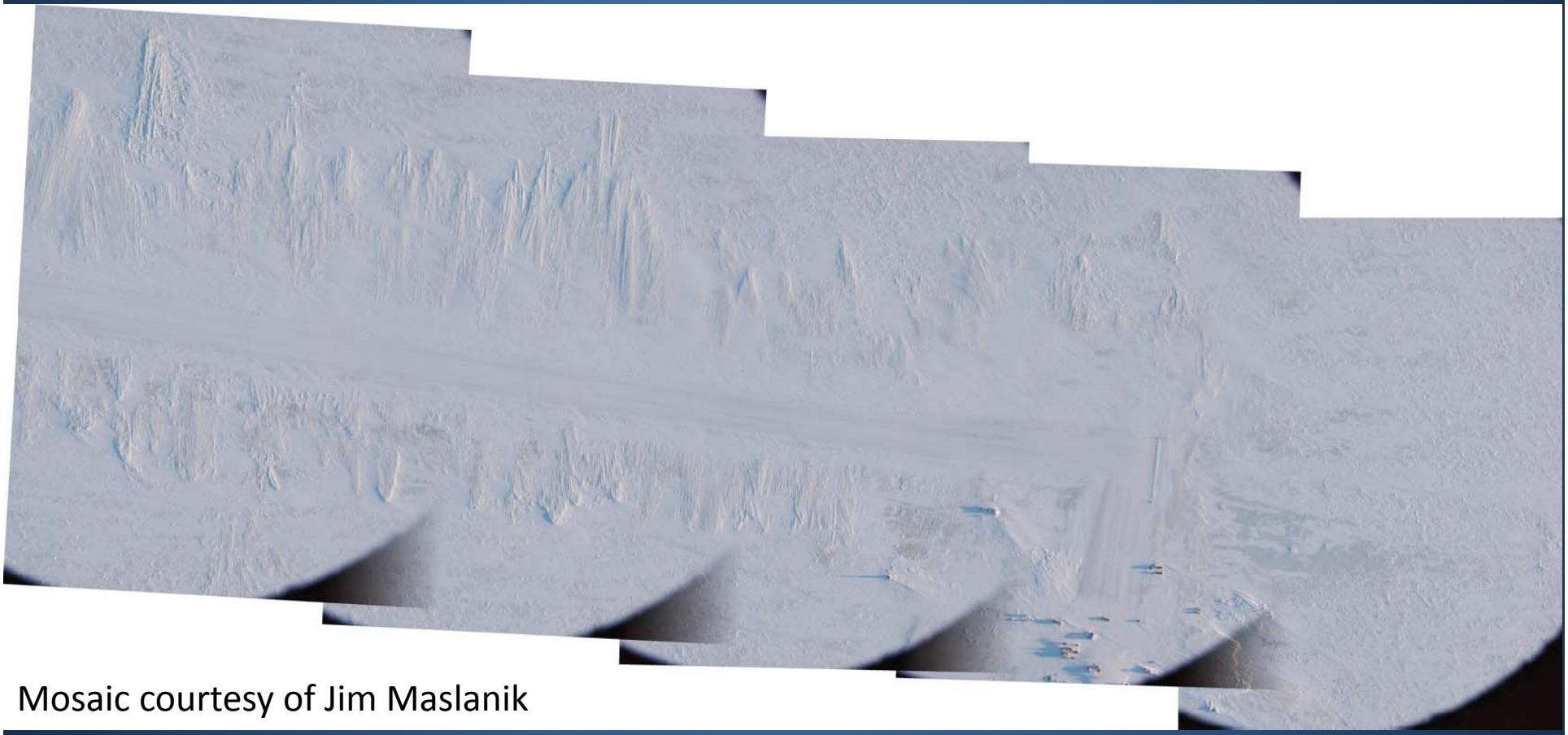
Aerosonde Recovery

Pegasus Runway (7 Sept 2009)


UAV–214 Flight Starting on 09/17/2009 at 15:02 UTC
and Ending on 9/18/2009 at 7:38 UTC
Wind Speed (ms⁻¹)
42.5
40.0
37.5
35.0
32.5
30.0
27.5
25.0
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
Maximum Vector
24.05
Reeves
Glacier
RTA
David
Glacier
75.0S
75.5S
76.0S
76.5S
77.0S
77.5S
78.0S
Ross
Island
Pegasus
Field
160E
162E
164E
166E
168E
170E


UAV–216 Flight Starting on 09/26/2009 at 7:24 UTC
and Ending on 9/26/2009 at 15:19 UTC
Wind Speed (ms⁻¹)
42.5
40.0
37.5
35.0
32.5
30.0
27.5
25.0
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
Maximum Vector
38.46
Reeves
Glacier
RTA
David
Glacier
75.0S
75.5S
76.0S
76.5S
77.0S
77.5S
78.0S
Ross
Island
160E
162E
164E
166E
168E
170E

Pegasus Runway



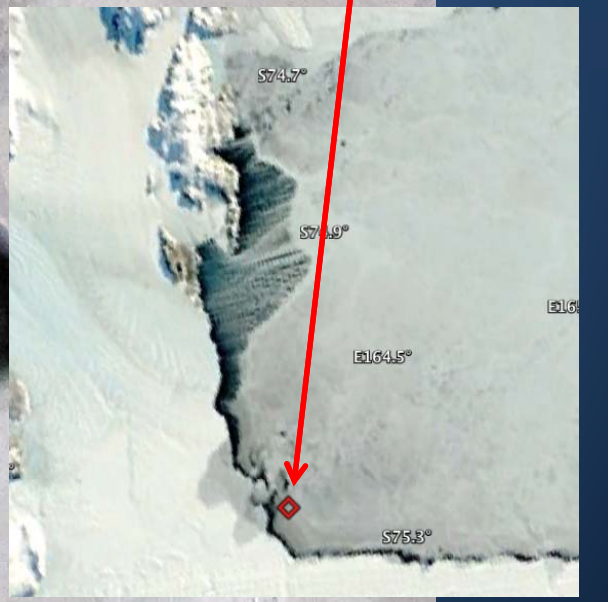
Mosaic courtesy of Jim Maslanik

9 September 2009
1000 m alititude

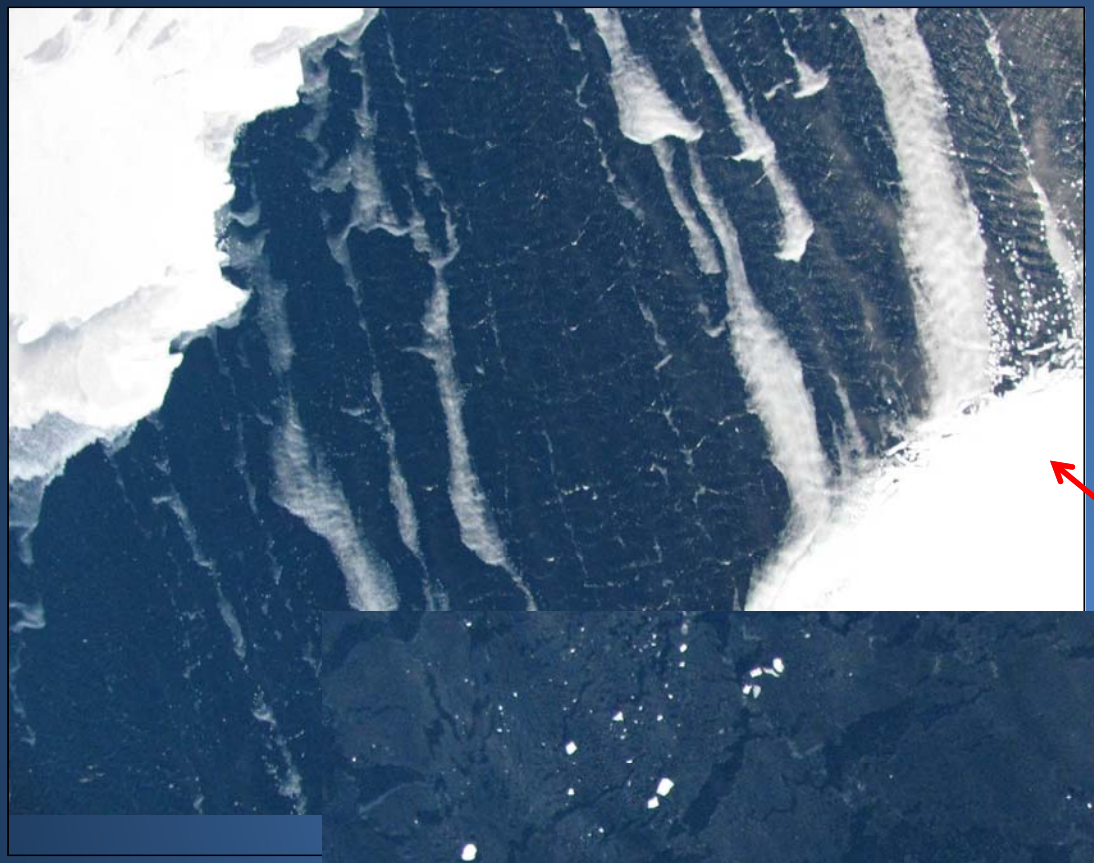
Complex rafting and finger rafting: Produces accumulation of ice mass within thin-ice locations

Image width: 70m

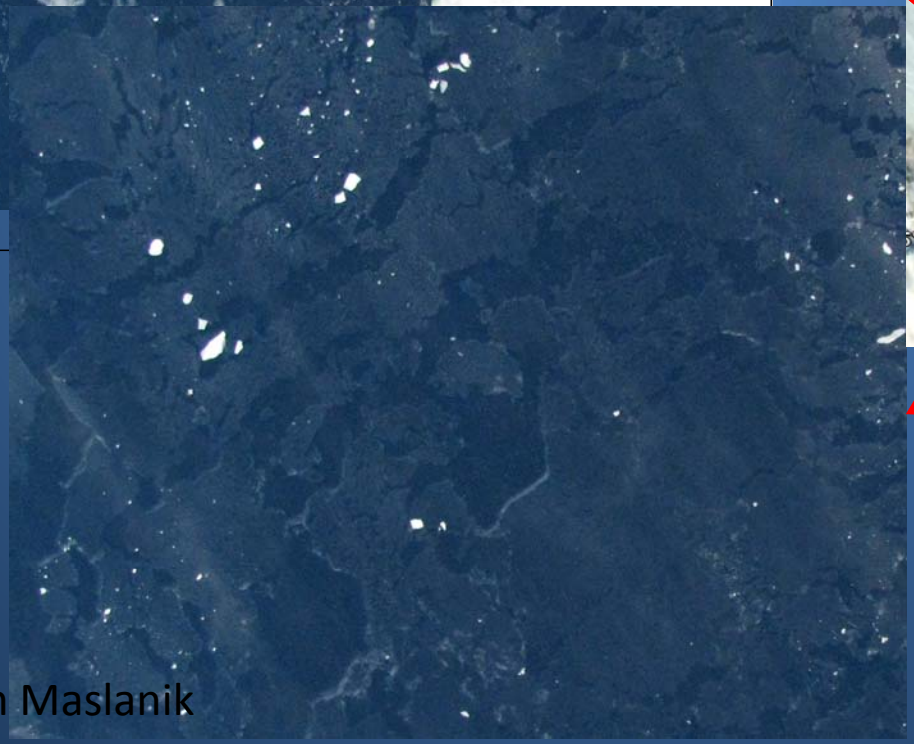
Photo location shown in MODIS satellite image



Courtesy of Jim Maslanik



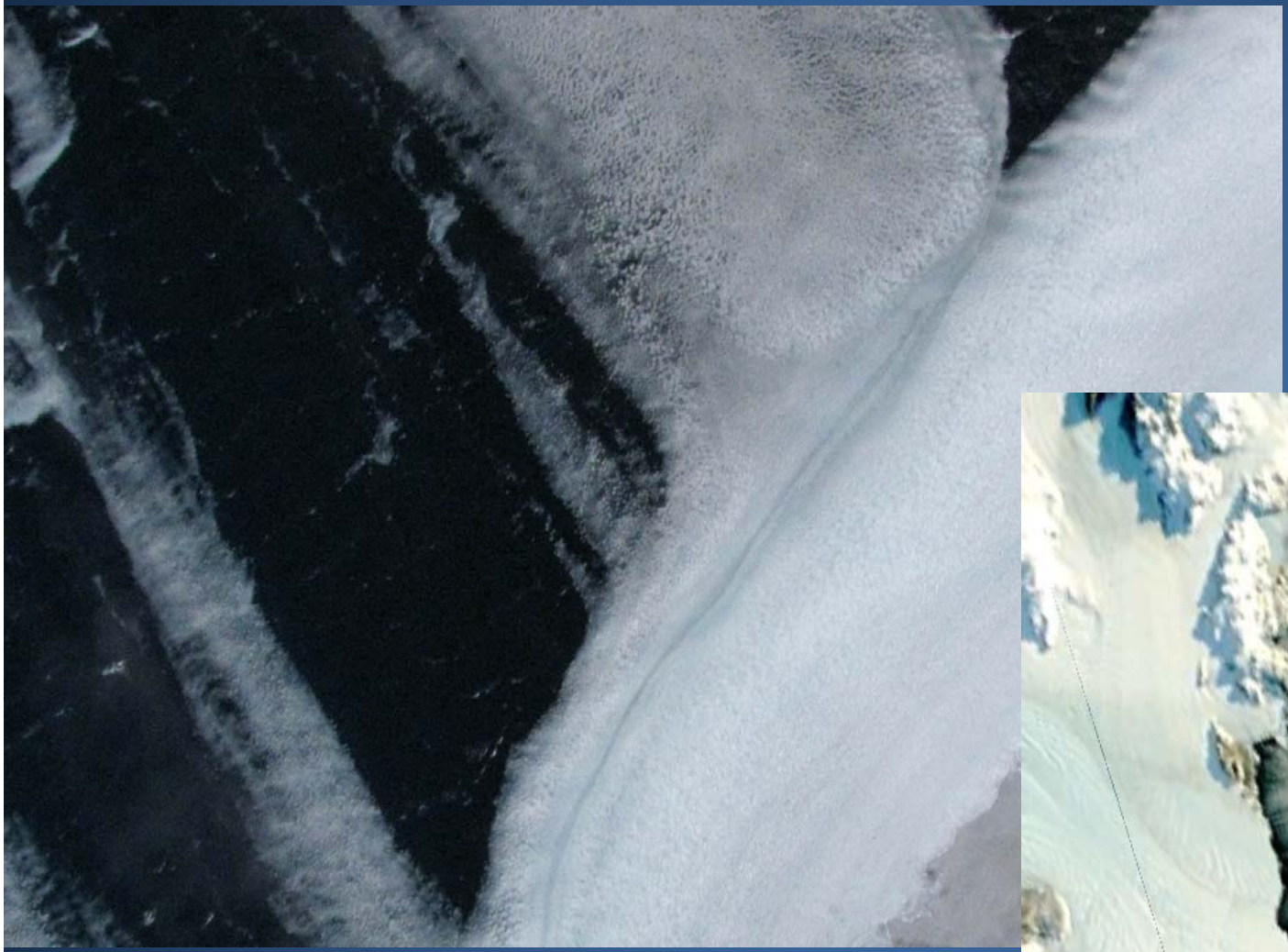
Frazil ice in location of strong winds, including waves with white caps.

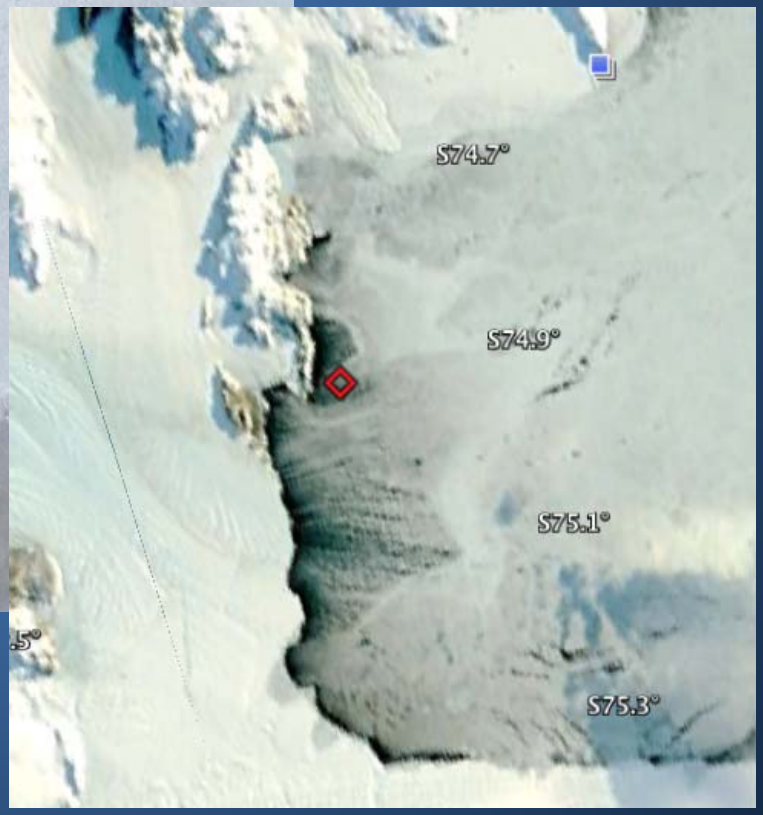


Nilas ice forming in area of relatively calm winds. Sea smoke is also present.

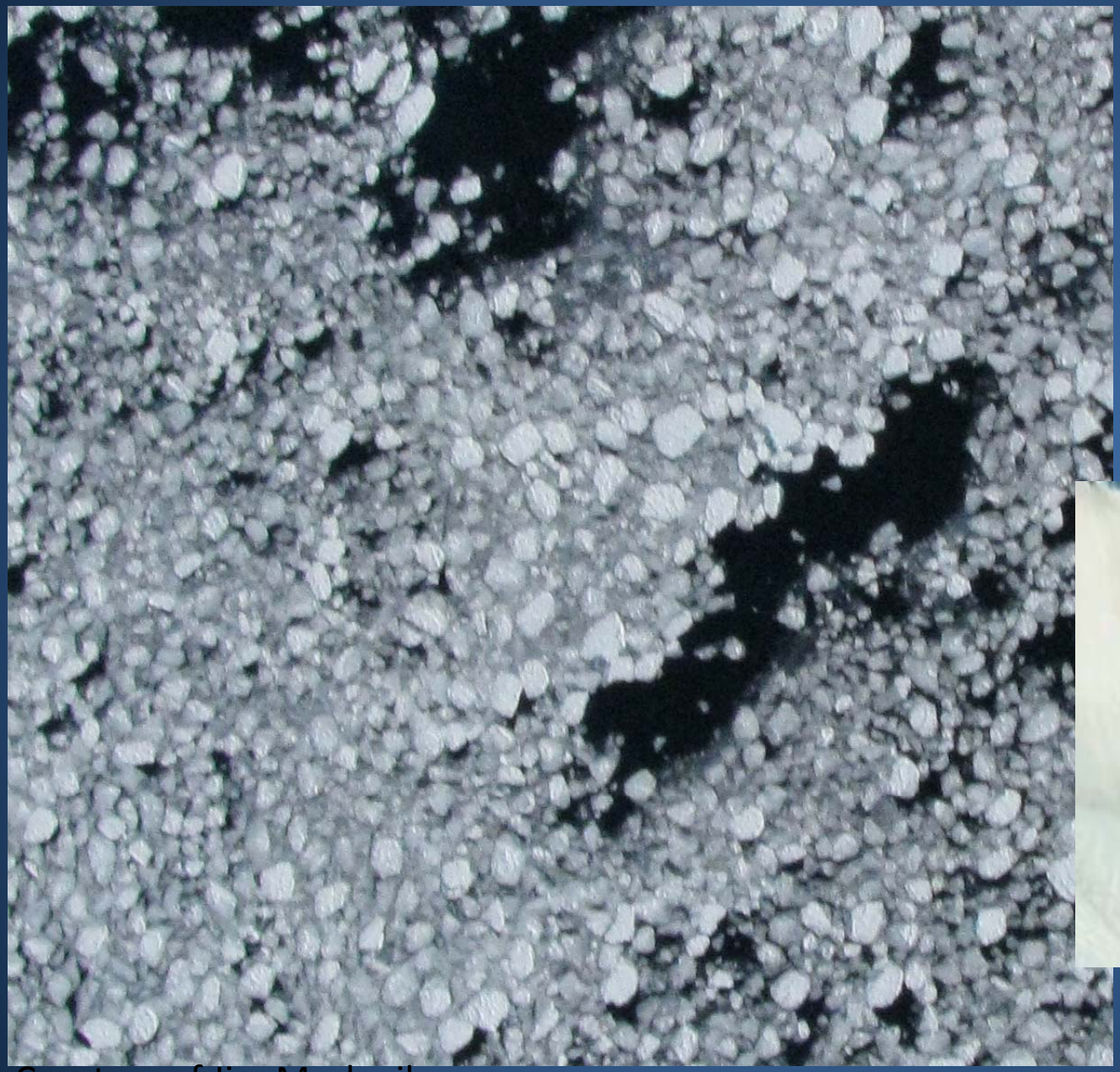
Courtesy of Jim Maslanik

Frazil and pancake ice accumulating to form a band of thicker ice



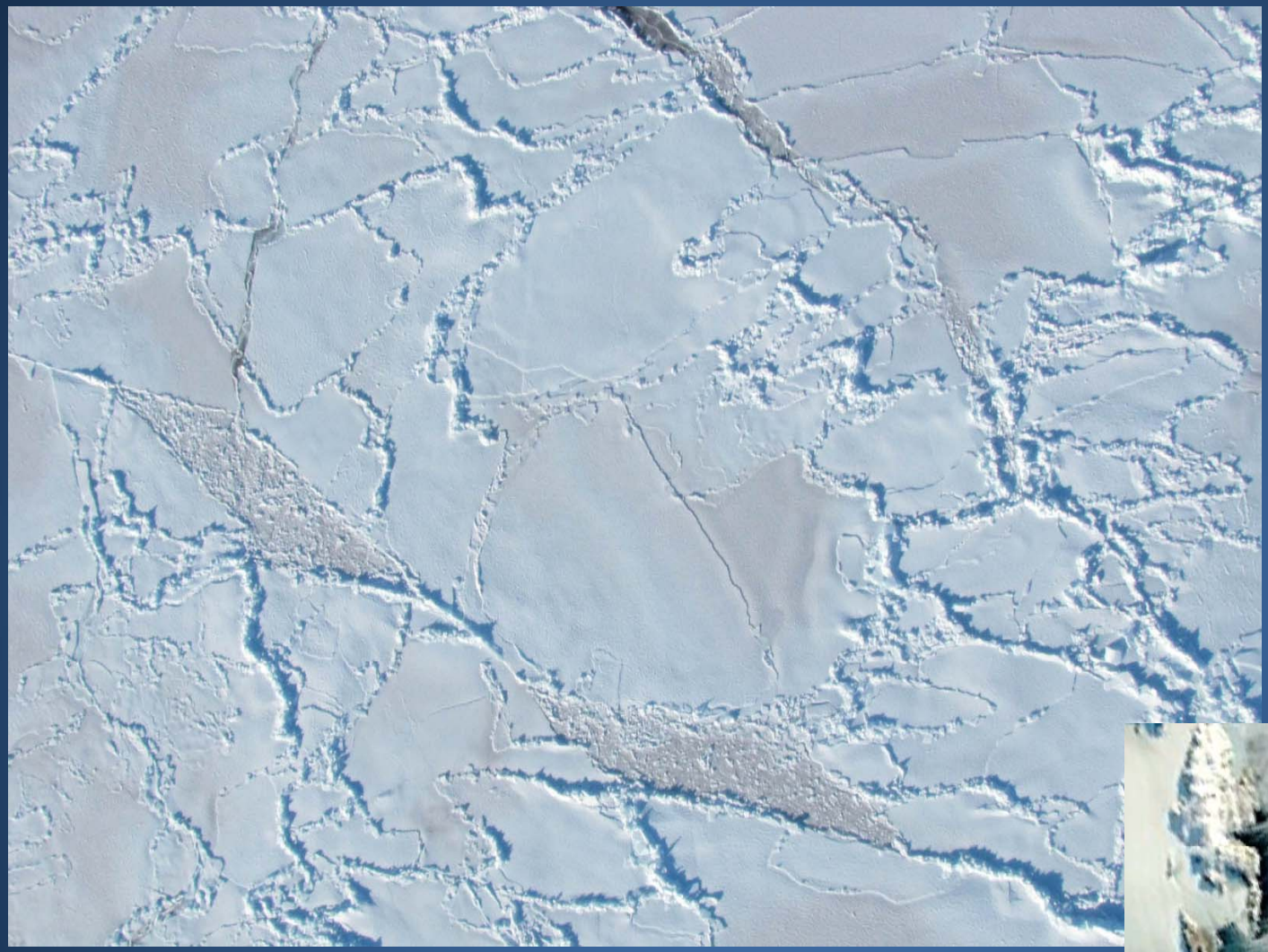


Courtesy of Jim Maslanik



Courtesy of Jim Maslanik

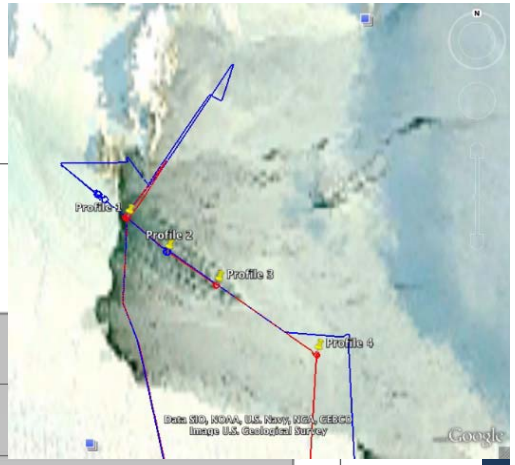
Pancake ice, with largest floes averaging about 2m diameter

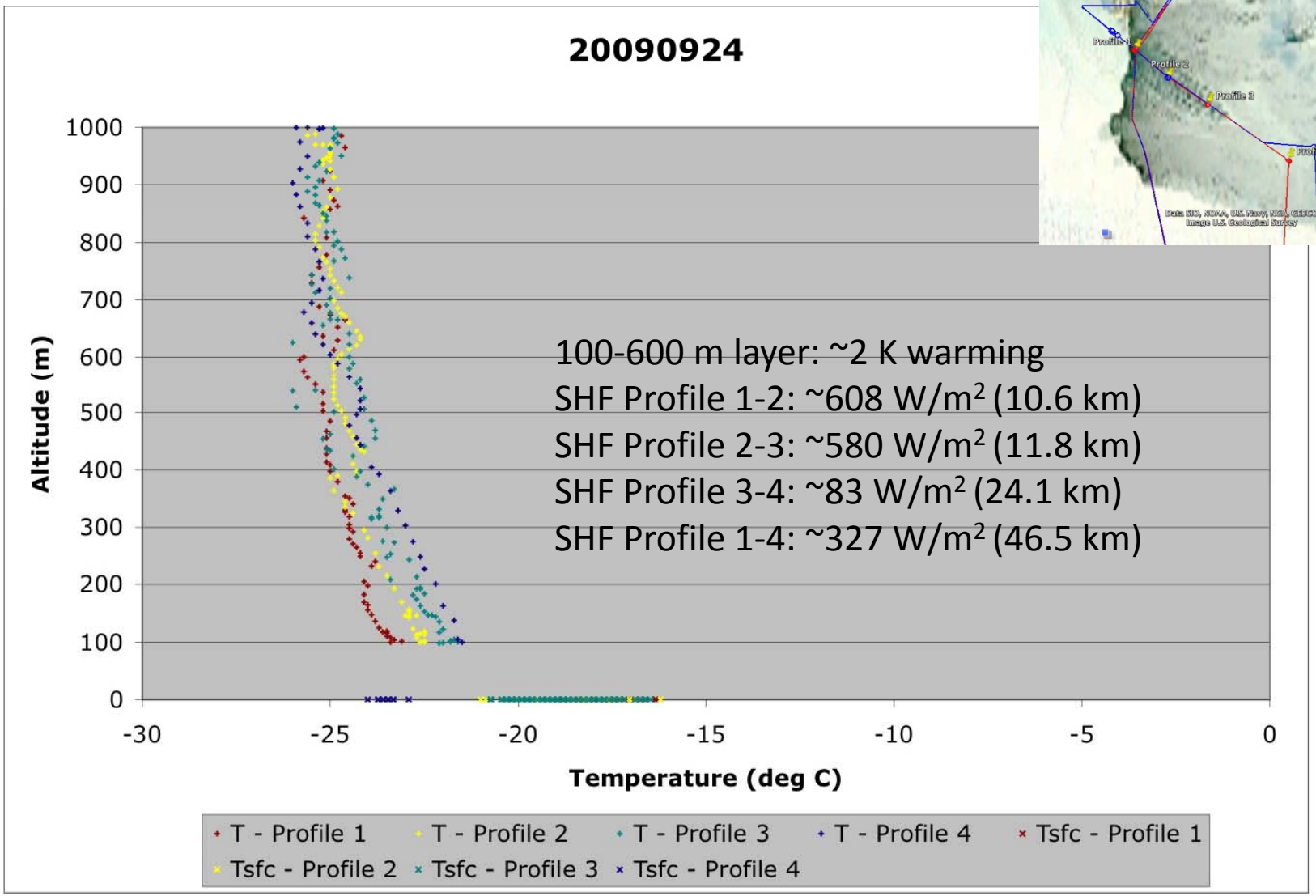


Ridging within consolidated pack ice. Ridging indicates thicker ice compared to locations with rafted ice.

Courtesy of Jim Maslanik

Temperature





100-600 m layer: ~2 K warming

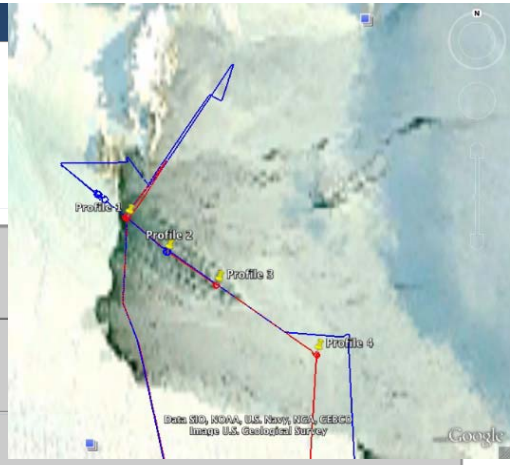
SHF Profile 1-2: ~608 W/m^2 (10.6 km)

SHF Profile 2-3: ~580 W/m^2 (11.8 km)

SHF Profile 3-4: ~83 W/m^2 (24.1 km)

SHF Profile 1-4: ~327 W/m^2 (46.5 km)

Relative Humidity



100-600 m layer:

125% inc. in specific humidity

LHF Profile 1-2: ~63 W/m^2 (10.6 km)

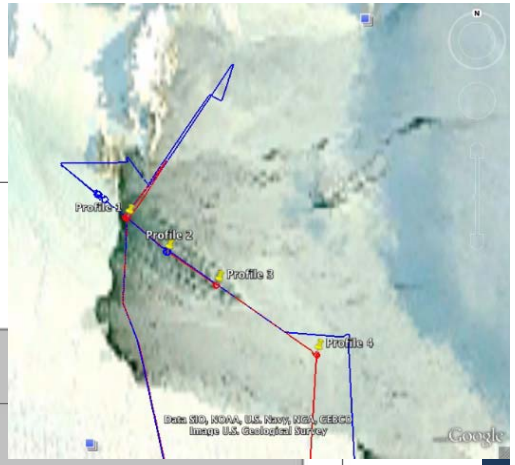
LHF Profile 2-3: ~161 W/m^2 (11.8 km)

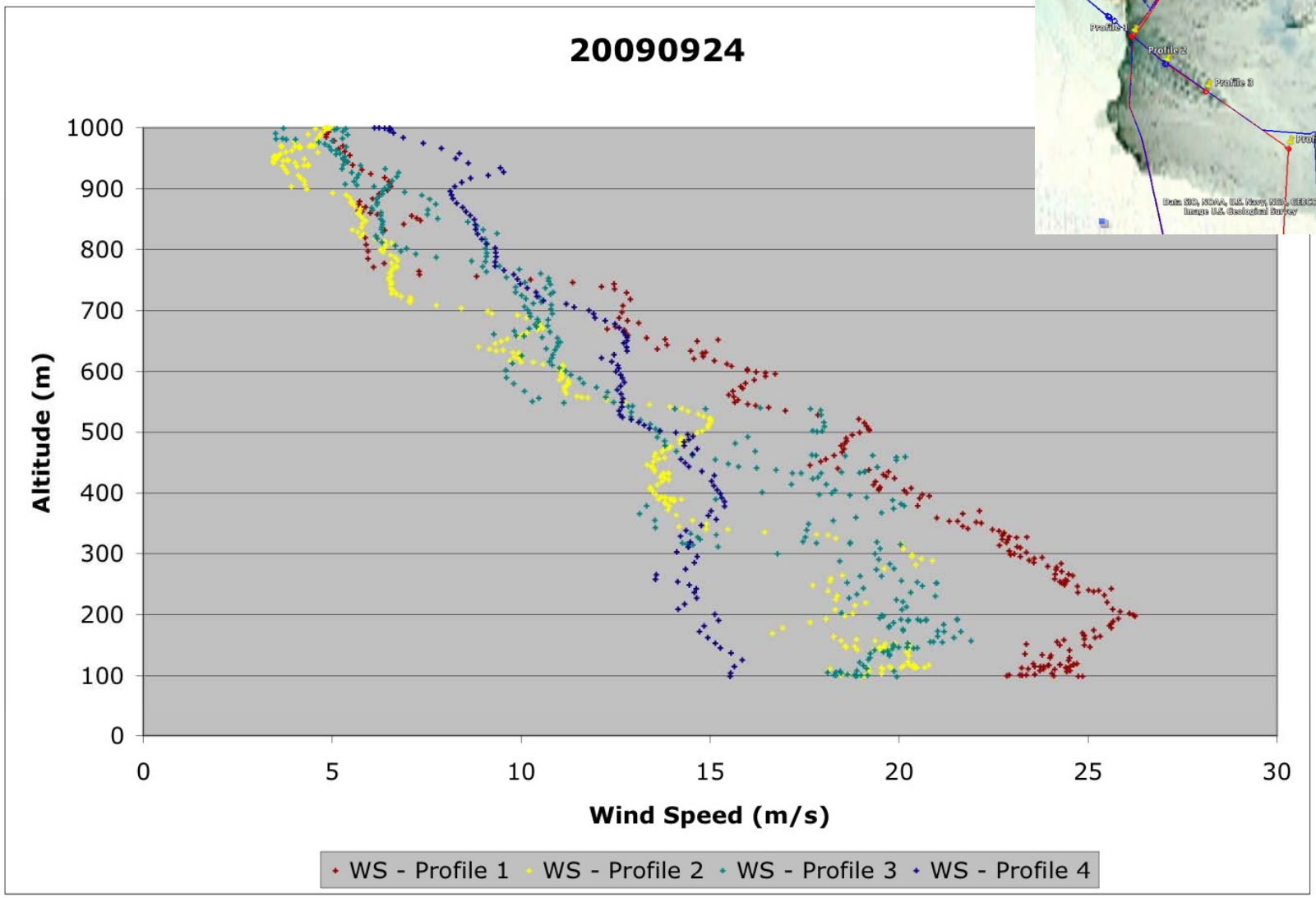
LHF Profile 3-4: ~86 W/m^2 (24.1 km)

LHF Profile 1-4: ~101 W/m^2 (46.5 km)

24 September 2009

Wind Speed


Profile 1
Profile 2
Profile 3
Profile 4
Google

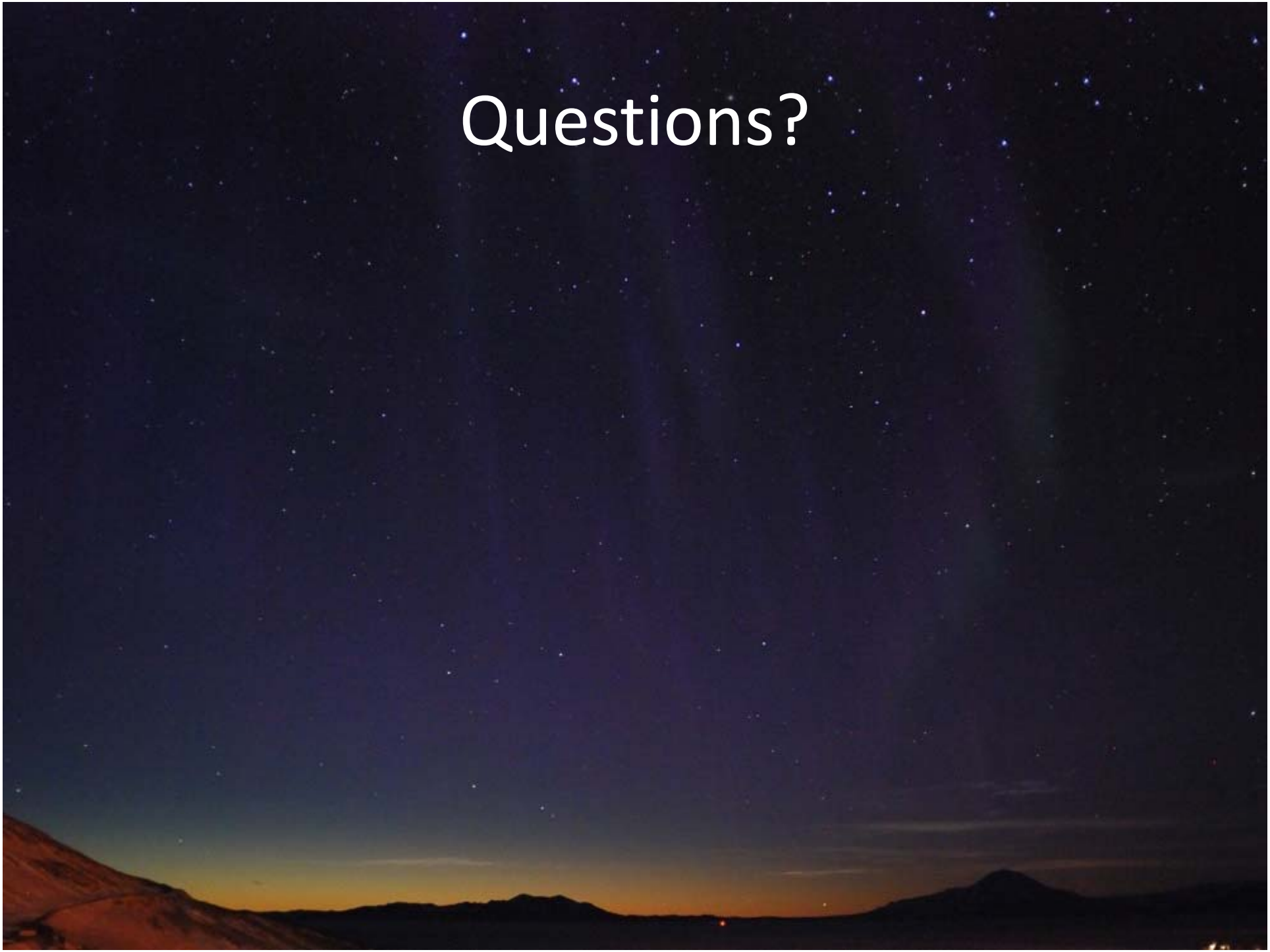

20090924
Altitude (m)
1000
900
800
700
600
500
400
300
200
100
0
0
5
10
15
20
25
30
Wind Speed (m/s)
WS - Profile 1
WS - Profile 2
WS - Profile 3
WS - Profile 4

Future Work

- Estimate the sensible and latent heat fluxes
- How does the momentum budget change over the polynya?
  - Momentum fluxes
  - Horizontal pressure gradient force
- Vertical and horizontal structure of katabatic jet?
- Is polynya opening / closing driven by winds or changes in the surface energy budget?
- Repeat UAV observations when high vertical resolution mooring is present in TNB

SUMO operation

- Low cost, inexpensive UAVs (0.8 m wingspan, 0.6 kg)
- Flights at Tall tower site and terrain near McMurdo
- Examine boundary layer structure and evolution
- Determine feasibility for use in Antarctic


Questions?