Preparing for ADM cal/val using DAWN and TWiLiTE in two arctic campaigns

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Wind Lidar Working Group Meeting
Boulder, 2015

NASA's PolarWinds and ADM Cal/Val

- Two Campaigns:
  - Campaign 1 November 2014 on UC-12B based Kangerlussuaq, Greenland
  - Campaign 2 May 2015 on DC-8 based Keflavik, Iceland
- Purposes are to conduct basic polar science investigations and to demonstrate technology readiness for ADM Cal/Val
- Critical support from NASA Headquarters (Kakar) and LaRC(Singh)
- Science and Instrument Team
  - Emmitt (SWA) , Principal Investigator
  - M. Kavaya(NASA/LaRC), Technology Lead
  - G. Koch (NASA/LaRC), Instrument Chief Engineer
  - S. Greco (SWA)
  - K.Godwin (SWA)
  - D. Bromwich (OSU)
  - K. Heins (OSU)
  - J. Cassano (CU)
  - R. Foster (U Wash)
  - M. Shapiro (NCAR)
  - D. Winker (NASA/LaRC)
  - B. Gentry (NASA/GSFC), TWiLiTE Lead

Background

- The launch of ESA's wind measuring Atmospheric Dynamics Mission (ADM) is currently scheduled for 2016-2017.
- Although ESA has conducted preliminary studies of the predicted instrument performance utilizing ground-based lidars (2006, 2007) and airborne lidars (2007, 2008, and 2009), they have also expressed a desire for additional pre-launch exercises beginning this spring (2015) that would include joint USA-ESA airborne DWL flights near Iceland/Greenland.
- The combination of ESA's airborne A2D and 2um Doppler lidars coupled with NASA's coherent detection DAWN (Doppler Aerosol WiNd lidar) and direct detection TWiLiTE would provide the critical combination of similar and dissimilar technologies appropriate for cross technology calibrations.

Campaign 1 Objectives

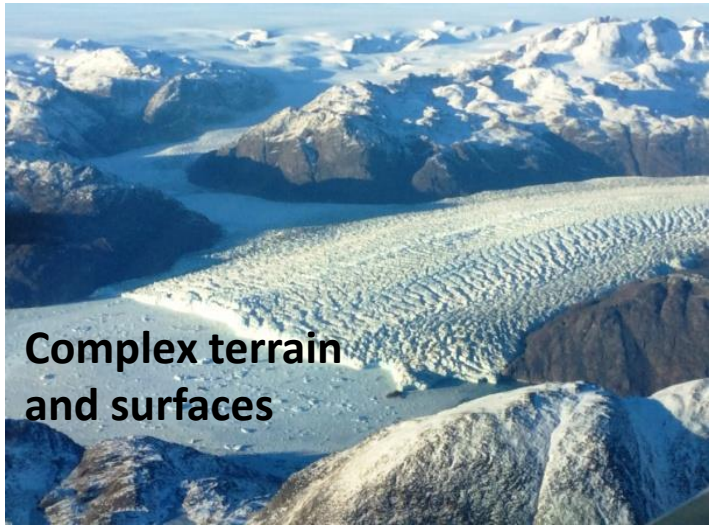
- Demonstrate the readiness of DAWN to participate in the joint ESA/NASA exercises in the spring of 2015
- Conduct underflights of currently orbiting sensors (MODIS, ASCAT and CALIPSO) to refine techniques for cal/val between a space-based lidar and an airborne set of sensors
- Conduct tests to evaluate the optimal scanning configurations of the DAWN to support ADM cal/val questions to be addressed in May 2015.

Tomorrow morning

- Use this opportunity to conduct a subset of the Polar Winds and Arctic science objectives such as model validation and the documentation and analysis of lower level atmospheric phenomenon such as low-level jets, organized large eddies and other boundary layer flows.

ADM/PolarWinds Campaign1 2014

2 um
220 mJ
10 Hz
15 cm



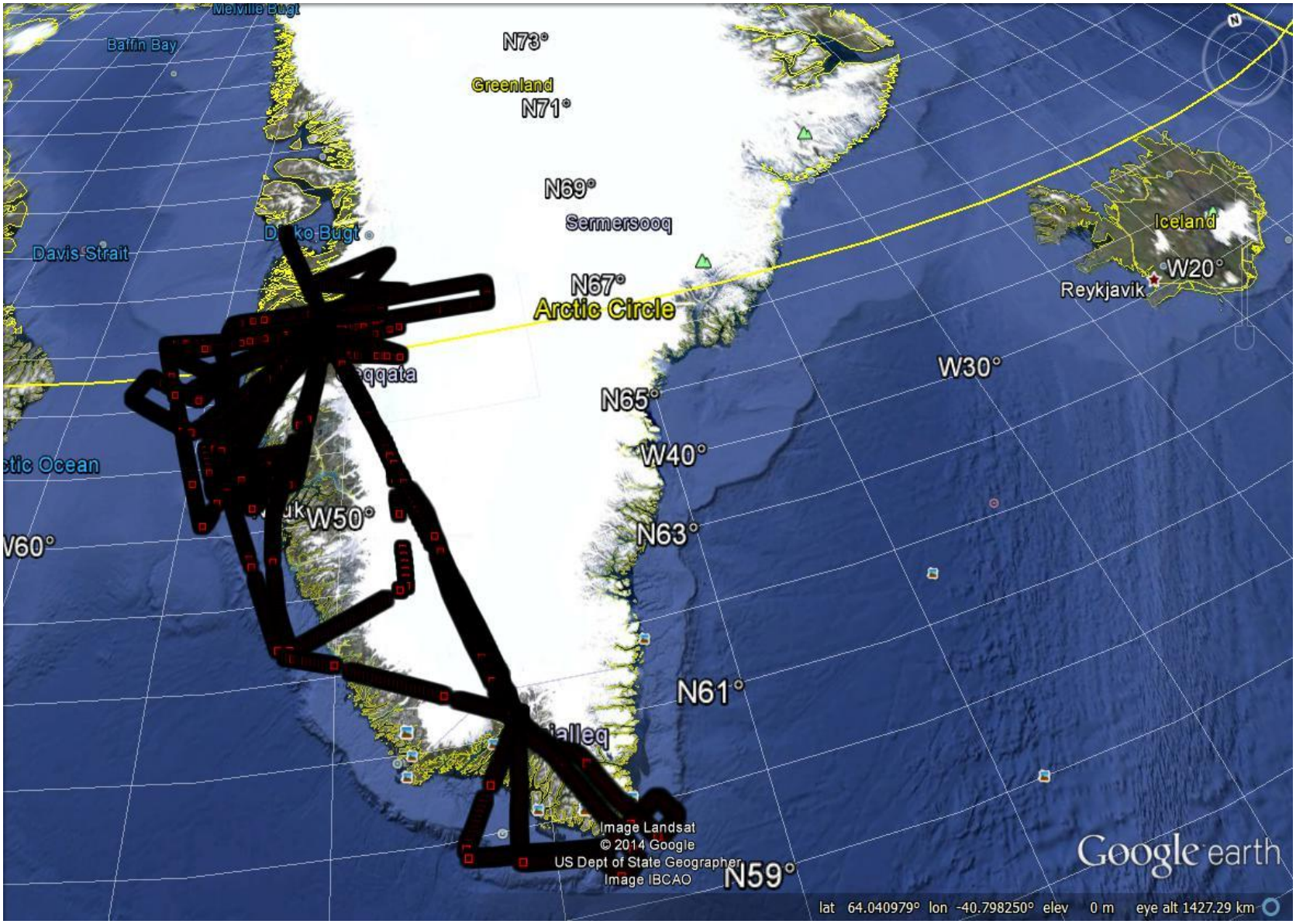
Mission Types

- Satellite Under Pass (SUP) missions
- Model Validation (MVAL) missions
- ADM Cal/Val (ADM_CV) missions
- OLE experiments
- Tip Jet missions
- Ice Cap Missions

General Missions Summary

- 14 flights on 13 days
- ~ 45.5 science flight hours
- 22 ADM simulation segments
- 3 CALIPSO segments
- ~ 10 MODIS segments
- ~ 10 ASCAT segments
- 2 “Tip Jet” missions
- Numerous missions overflying the Ice Cap and regions of BL rolls/waves.

Composite of flight tracks



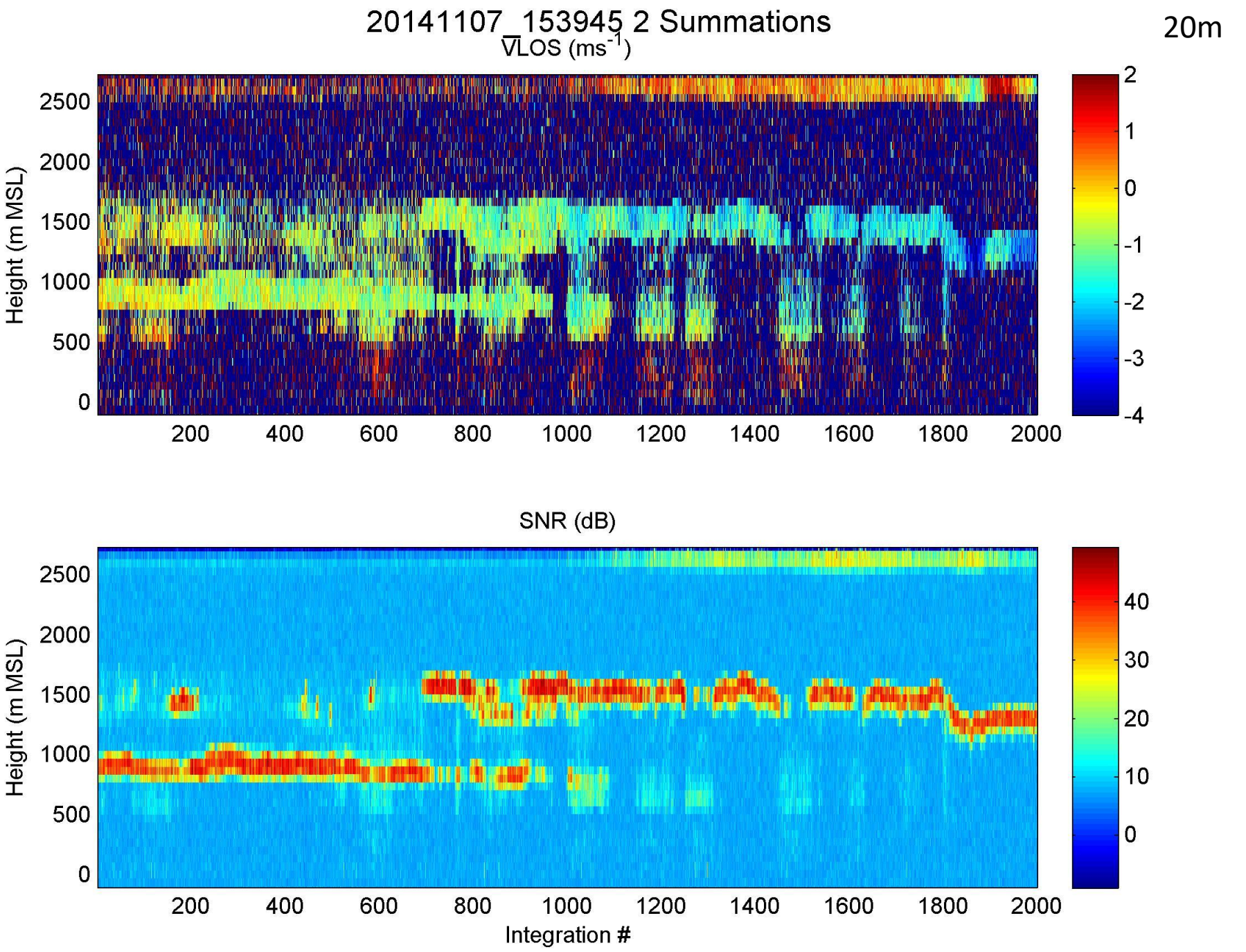
ADM Cal/Val practice

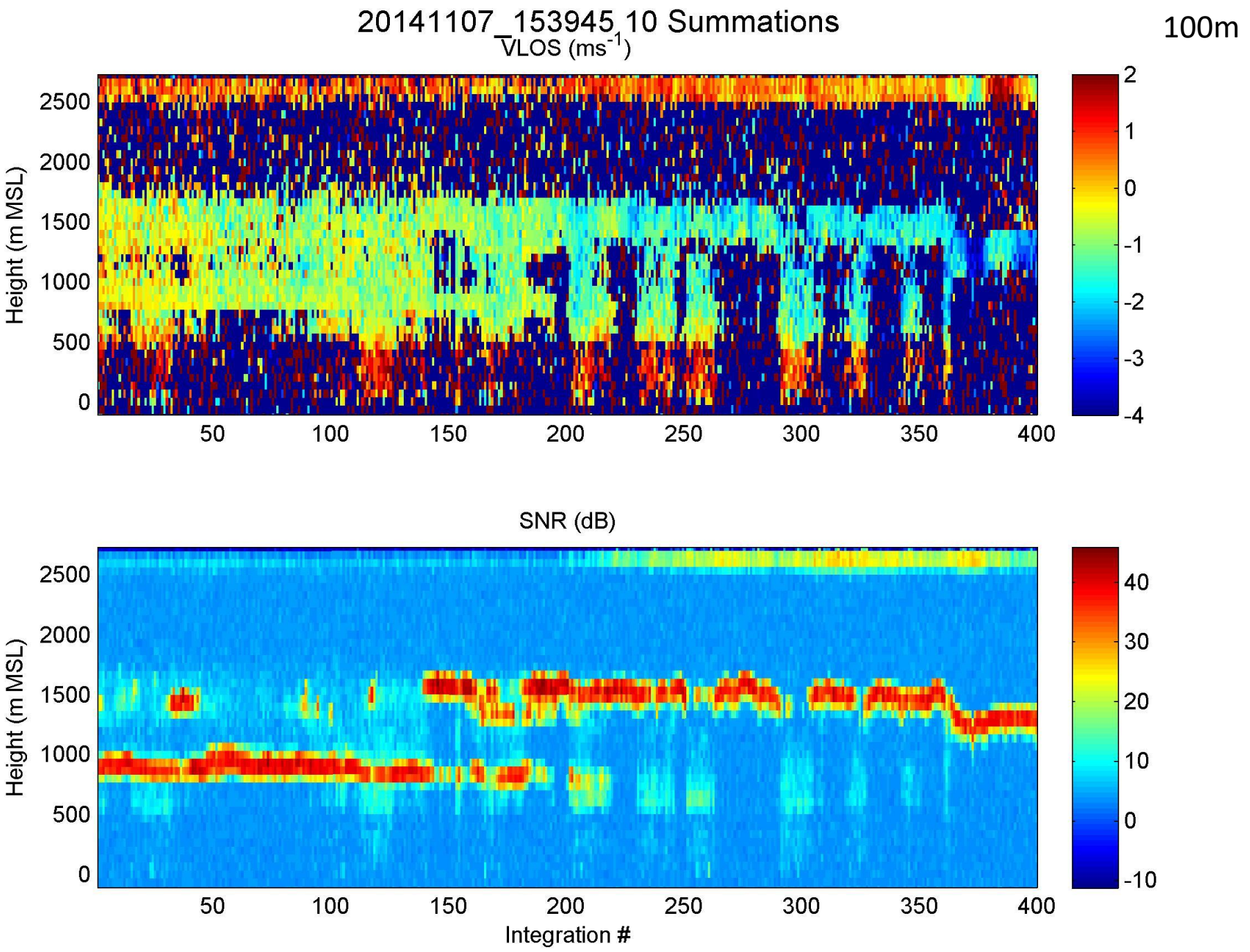
- Primary issues addressed
  - Heterogeneous backscatter situations with wind shear.
  - Blowing snow/ice adjacent to the surface
  - Water/salt sprays adjacent to the sea surface during white cap situations

- 22 cases of 50 -75 km legs with single perspective stare
  - 6 over ice
  - 4 snow/land
  - 12 over water
    - 2 visible cloud free
    - 7 partly cloudy
    - 3 clouds below

Changing integration parameters

- Post flight processing coherent wind observations with a range of vertical and horizontal resolutions.
- Computing average winds over 50 -75 km flight segments in an Aeolus manner and comparing to the non-SNR weighted coherent measurements
  - Coherent (<50m vertical, 200m – 1km horizontal)
  - Direct (250m vertical, 1km -75km horizontal)


20141107_153945 2 Summations
20m
$\overline{V}$LOS (ms^{-1})
Height (m MSL)
2500
2000
1500
1000
500
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2
1
0
-1
-2
-3
-4
SNR (dB)
Height (m MSL)
Integration #
40
30
20
10
0


20141107_153945 10 Summations
100m
VLOS (ms-1)
Height (m MSL)
2500
2000
1500
1000
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150
200
250
300
350
400
2
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-3
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SNR (dB)
Height (m MSL)
Integration #
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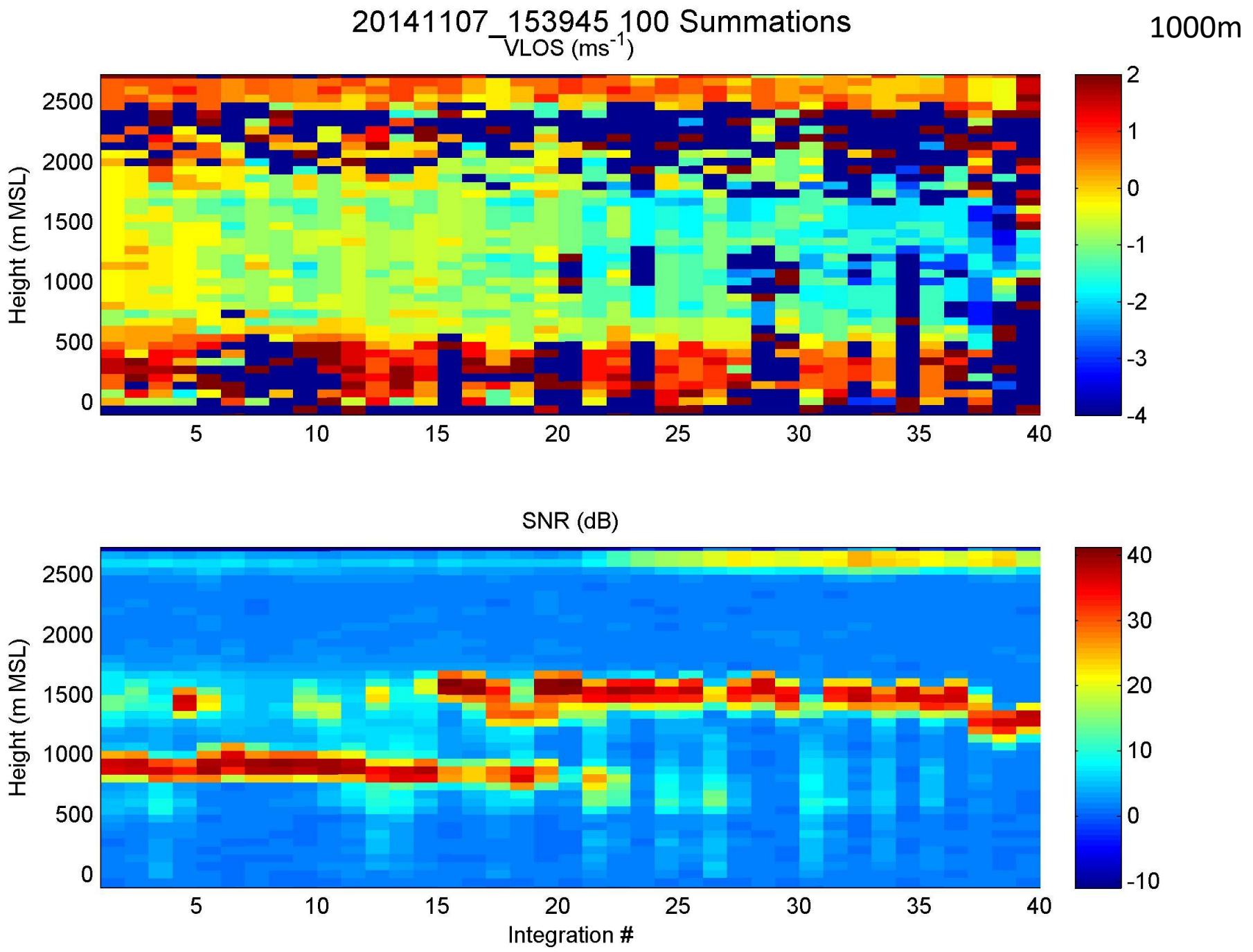
-10


20141107_153945 100 Summations
1000m
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35
40
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SNR (dB)
Height (m MSL)
Integration #
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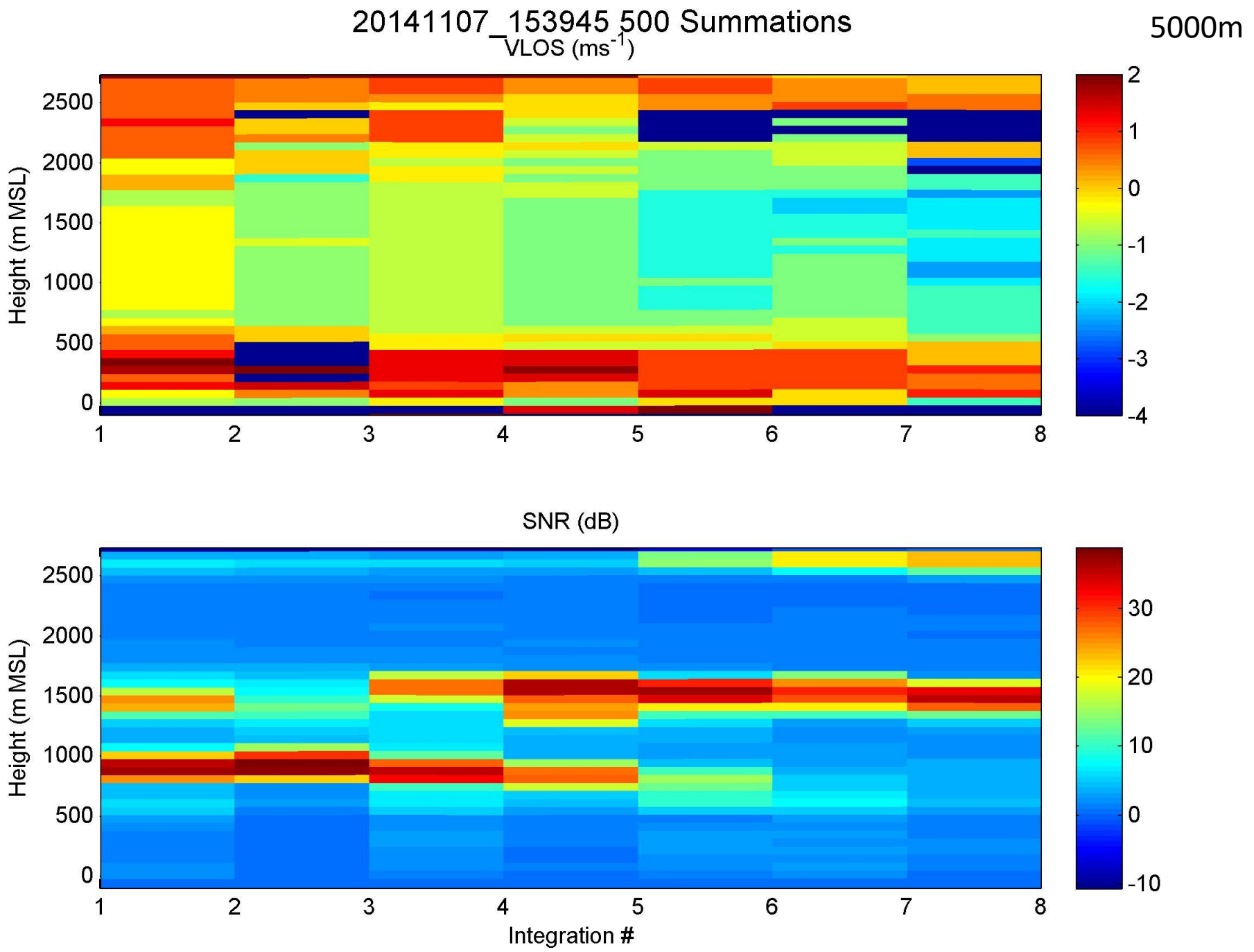
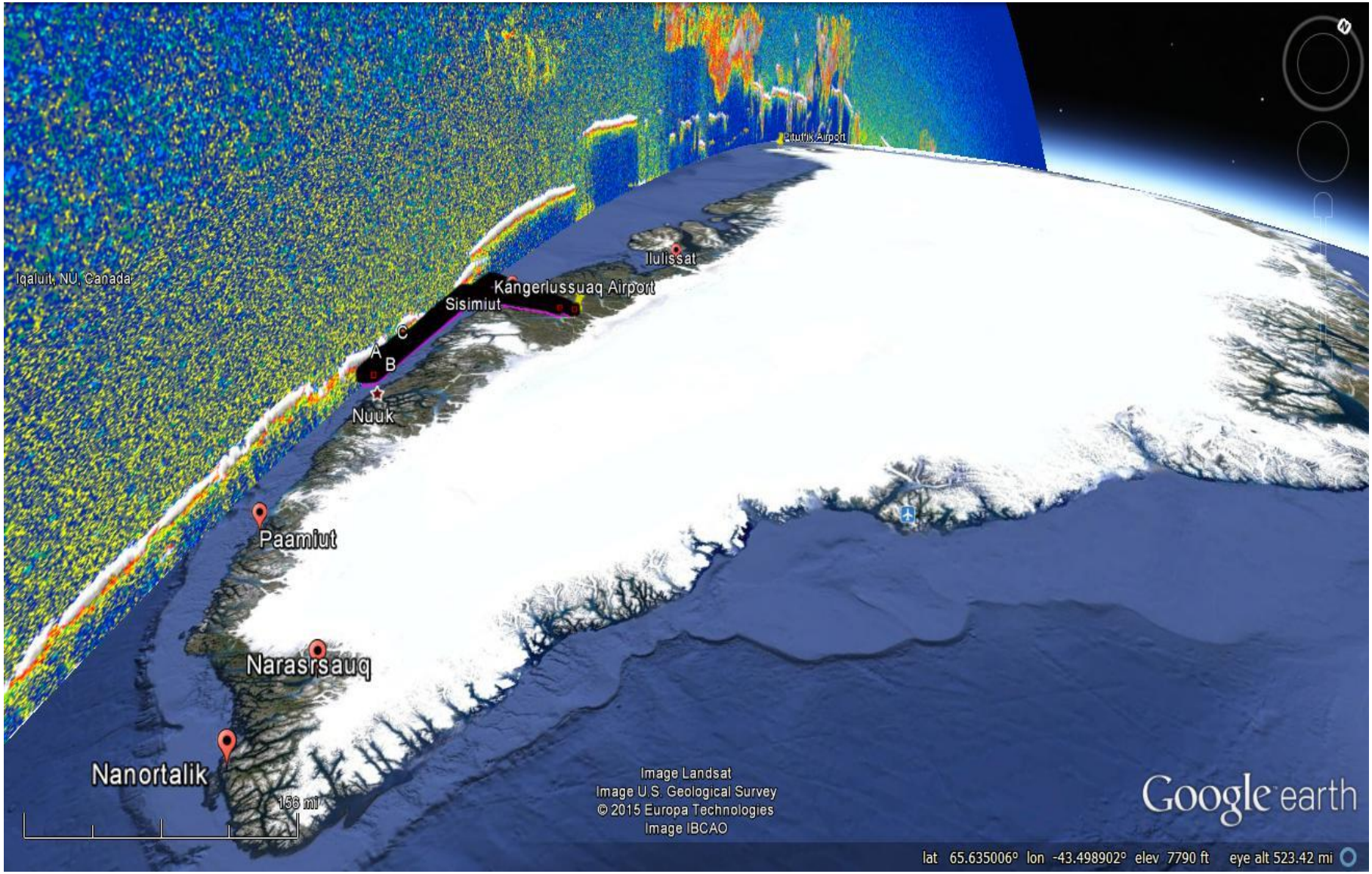

20141107_153945 500 Summations
5000m
VLOS (ms-1)
Height (m MSL)
2500
2000
1500
1000
500
0
1
2
3
4
5
6
7
8
2
1
0
-1
-2
-3
-4
SNR (dB)
Height (m MSL)
Integration #
30
20
10
0
-10

CALIPSO under flights

- Provide near surface winds for comparison with CALIPSO derived wind speeds
- Fly DAWN near CALIPSO track for backscatter comparisons
- Three underpasses during Campaign 1
- Challenges
  - Off shore cloud forecasts (imagery) not reliable
  - Get only “snapshots” (a few seconds) of near coincidence
  - Range of aircraft limited intercepts

CALIPSO Case Study 11/03/15


Iqaluit, NU, Canada
Ilulissat
Kangerlussuaq Airport
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A
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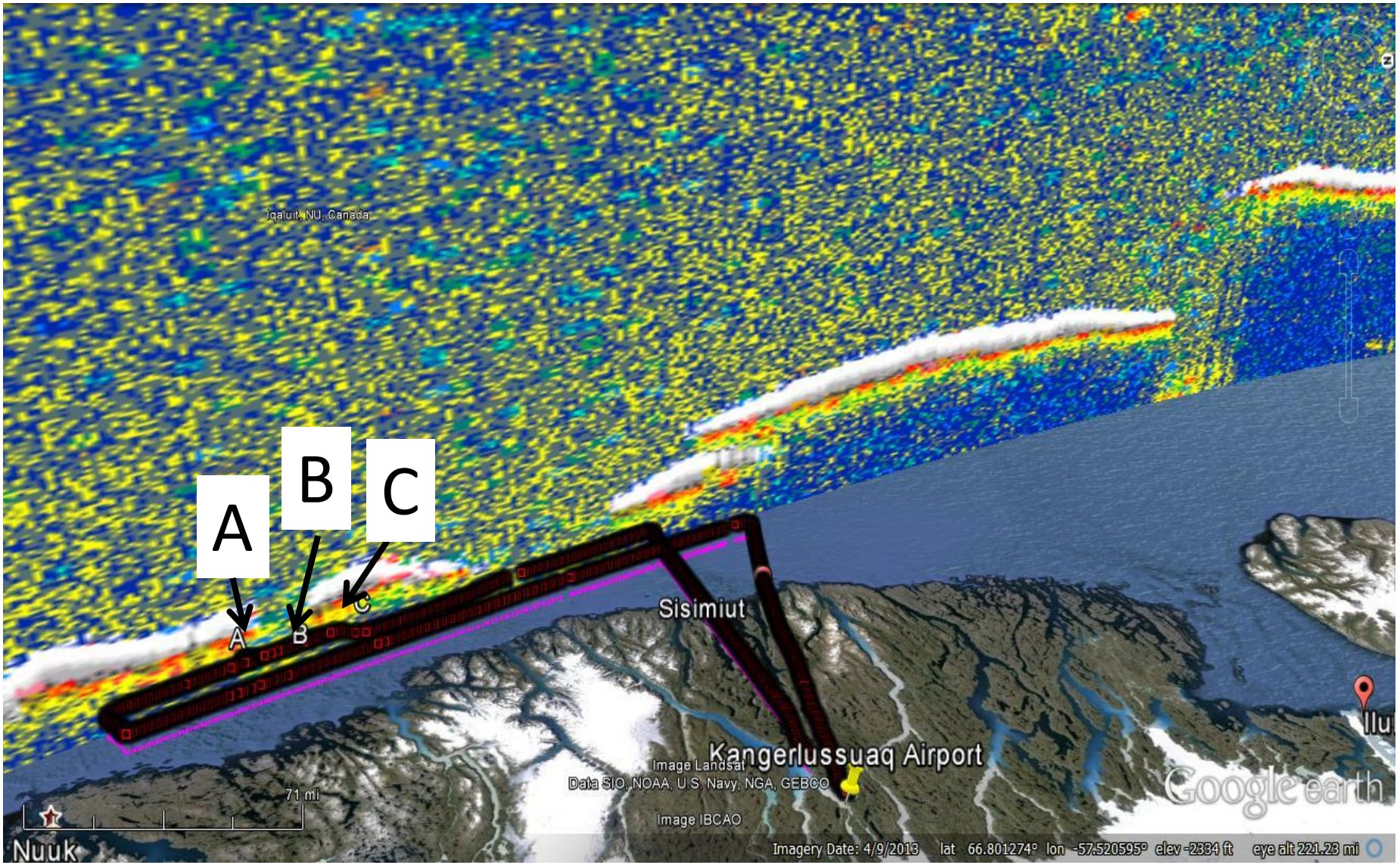
Nuuk
Paamiut
Narasrsauq
Nanortalik
156 mi
Image Landsat
Image U.S. Geological Survey
© 2015 Europa Technologies
Image IBCAO
Google earth
lat 65.635006° lon -43.498902° elev 7790 ft eye alt 523.42 mi


Iqaluit, NU, Canada
A
B
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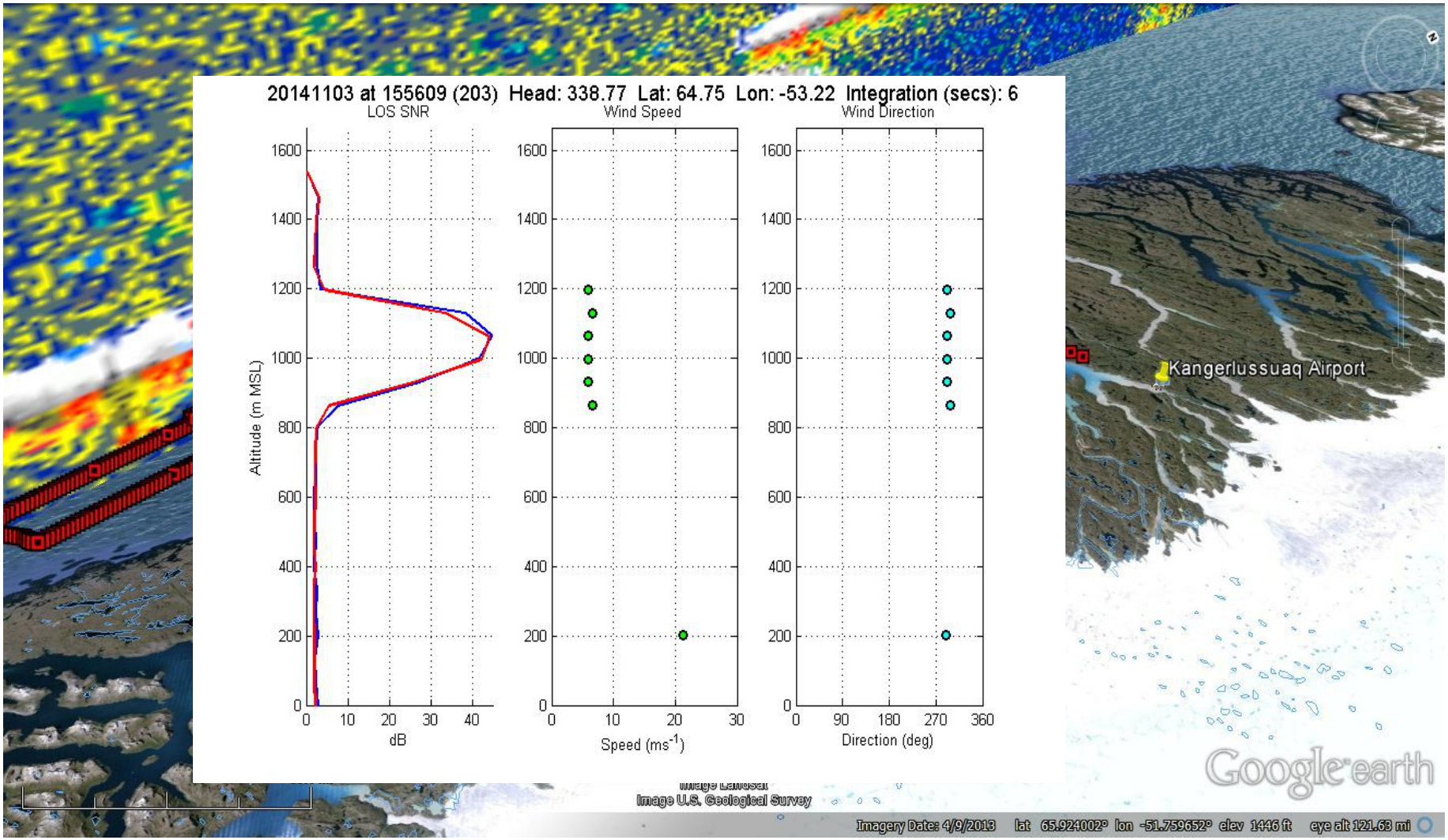
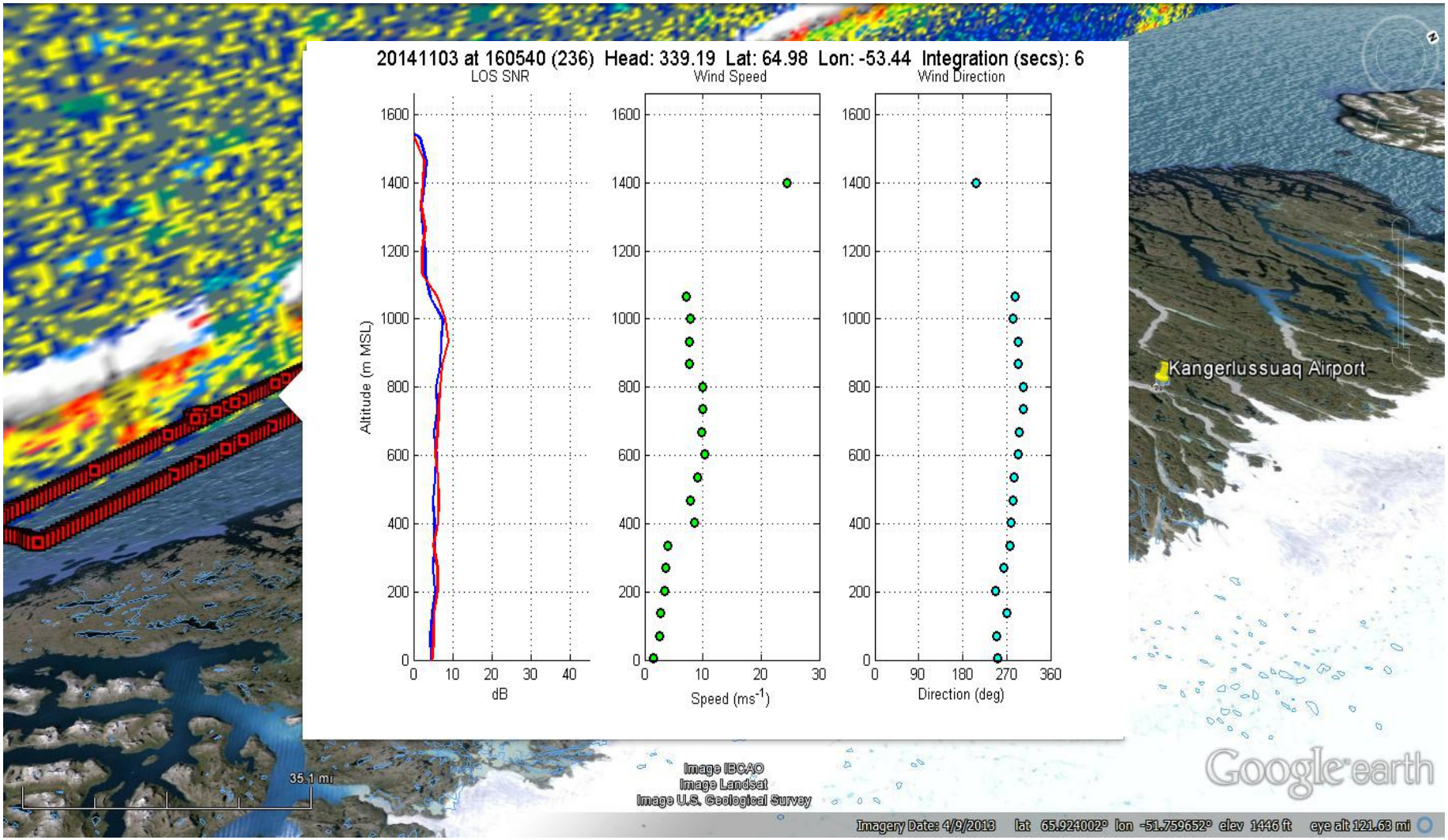
C
Sisimiut
Kangerlussuaq Airport
Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image IBCAO
71 mi
Nuuk
Google earth
Imagery Date: 4/9/2013 lat 66.801274° lon -57.520595° elev -2334 ft eye alt 221.23 mi

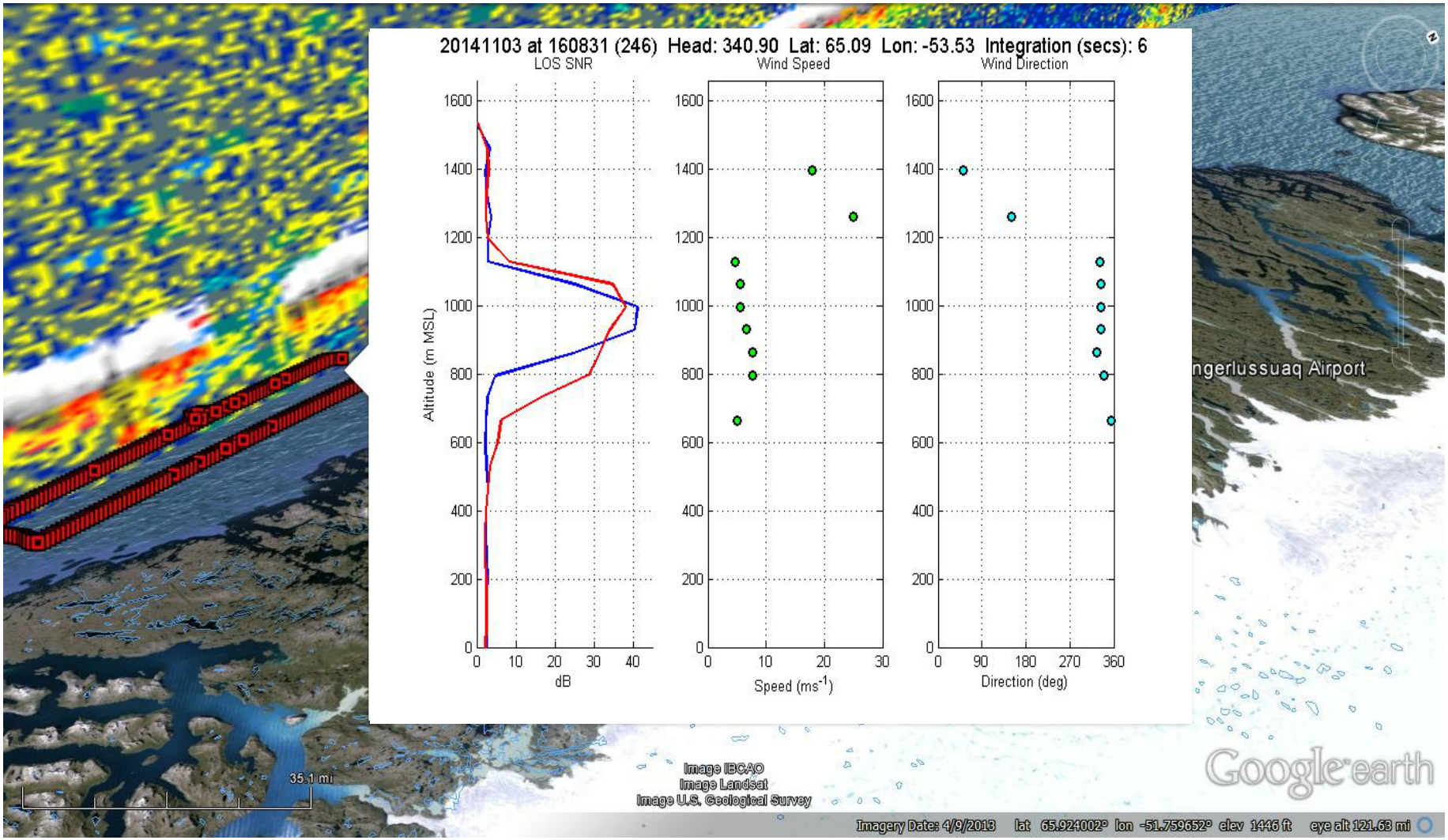
CALIPSO AND DAWN at Point A



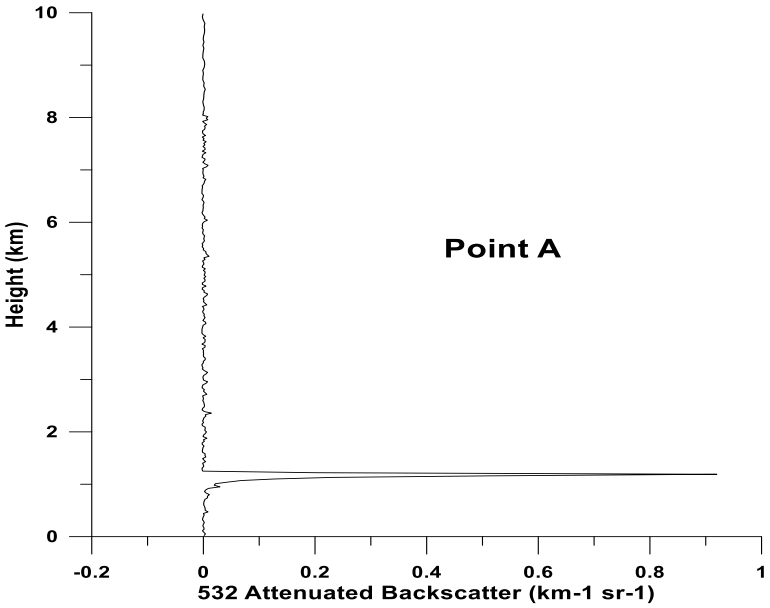
CALIPSO AND DAWN at Point B



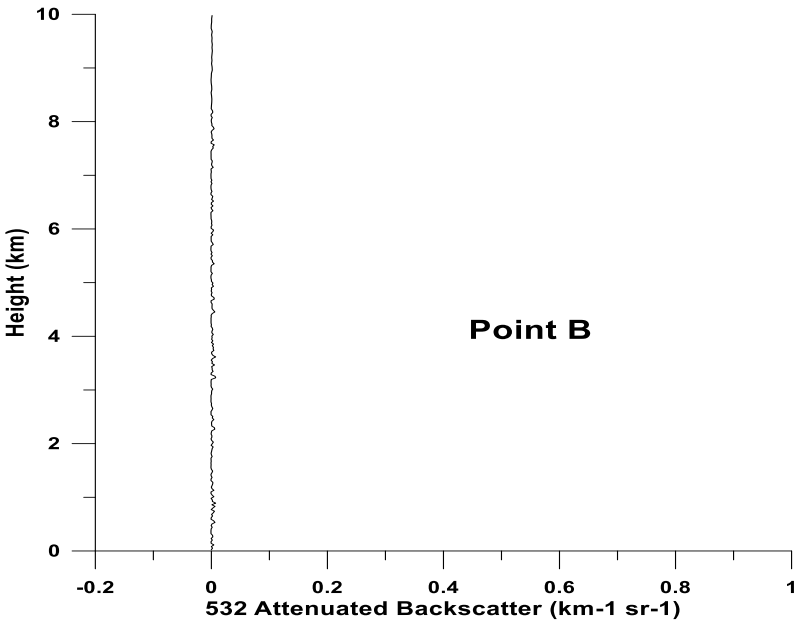
CALIPSO AND DAWN at Point C



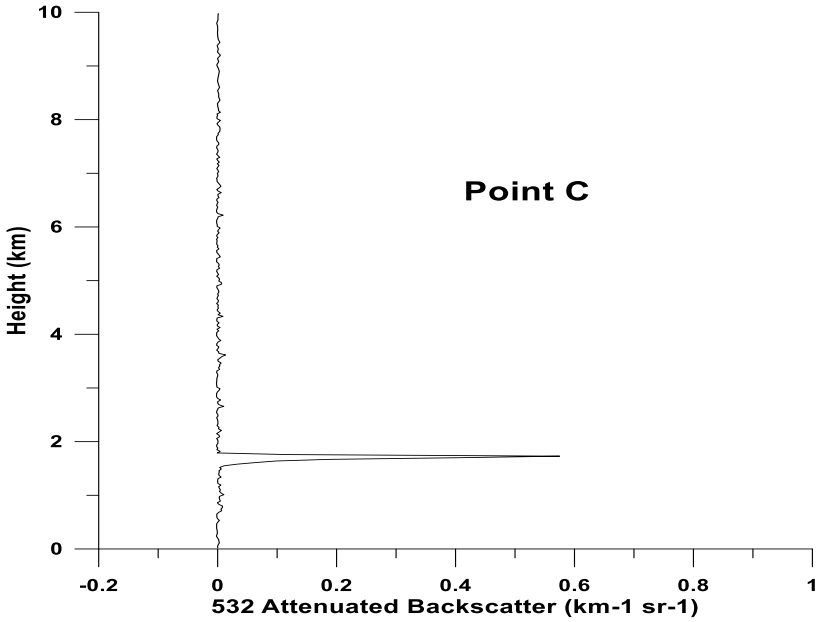
11/03/14 CALIPSO Level 1 532 Attenuated Backscatter



11/03/14 CALIPSO Level 1 532 Attenuated Backscatter



11/03/14 CALIPSO Level 1 532 Attenuated Backscatter

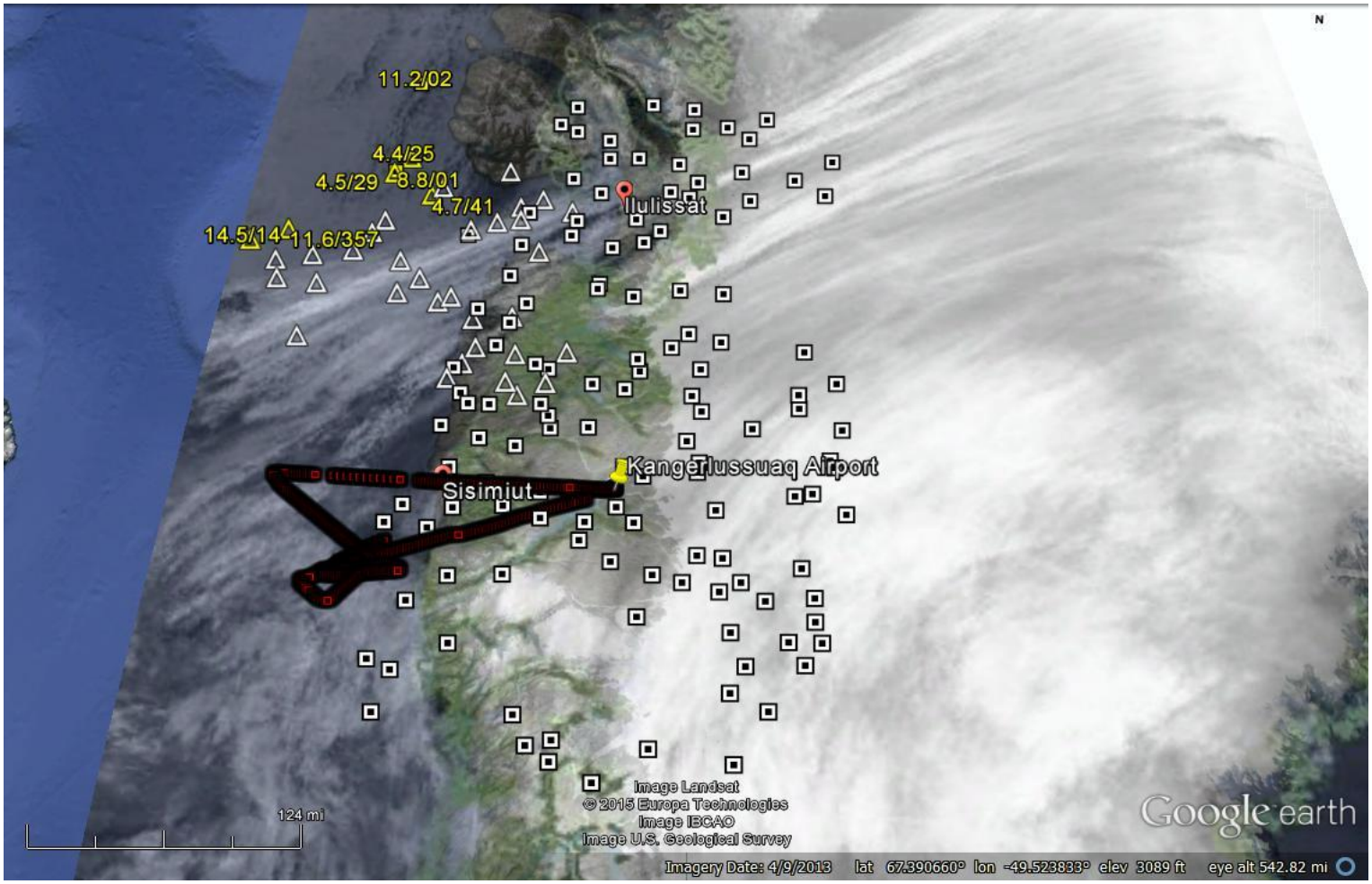


MODIS under flights

- More than 10 under flights
- Both cloud and water vapor AMVs
- Case study 11/07/2014

MODIS AMVs, Aircraft Track and DMI Satellite Imagery 11/07/14

Flight Track: 1420-1650 GMT; DMI Sat: 1528 GMT; MODIS Winds : 1500 – 1600 GMT



Yellow Triangle: AQUA Low; Yellow Square: Terra Low;White Triangle: AQUA High; White Square: Terra High

ASCAT under flights

- More than 11 occasions
- Significant differences found
- Time syncs are difficult
- Near coast environment quite variable
- Footprints are different

NASA's PolarWinds and ADM Cal/Val Campaign 2

- Based out of Keflavik, Iceland
- May 11 – 29, 2015
- NASA DC-8 core instrument suite
  - DAWN (Nadir port 7)
  - Yankee dropsondes (50 -100)
  - TWiLiTE (Nadir port 5)

ADM Cal/Val Campaign 2 Plans

- ADM Calibration/Validation Preparations
  - Coordinated flights with DLR Falcon equipped with Coherent DWL and A2D
  - ADM simulated sampling using fixed starboard stare at 30 degrees off nadir
    - Flight altitude of ~ 35000’
    - Flight legs on order of 250 km
    - Cloud free and partly cloudy conditions
- Under flights of ASCAT, CALIPSO and MODIS as practice for ADM as well building collaborations with these other wind and aerosol instrument teams.
- Detailed mission scenarios available.


DRYDEN FLIGHT RESEARCH CENTER
EARTH SCIENCE

NASA Langley DAWN Wind Profiling Lidar on NASA DC-8

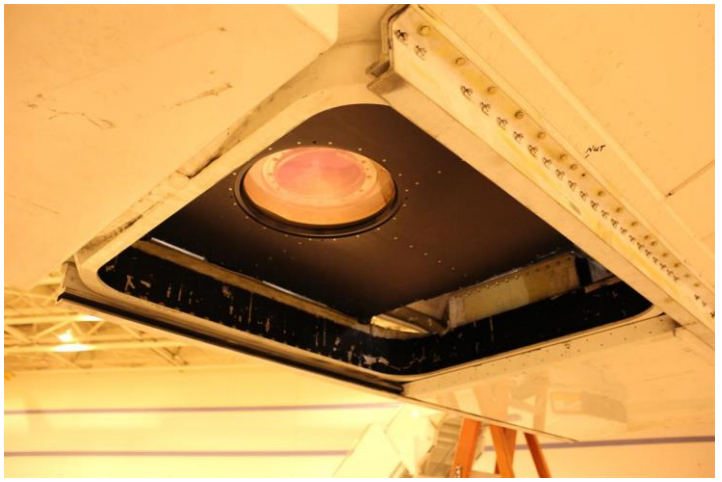
Operator Stations in Passenger Level

Laser Chillers in Passenger Level

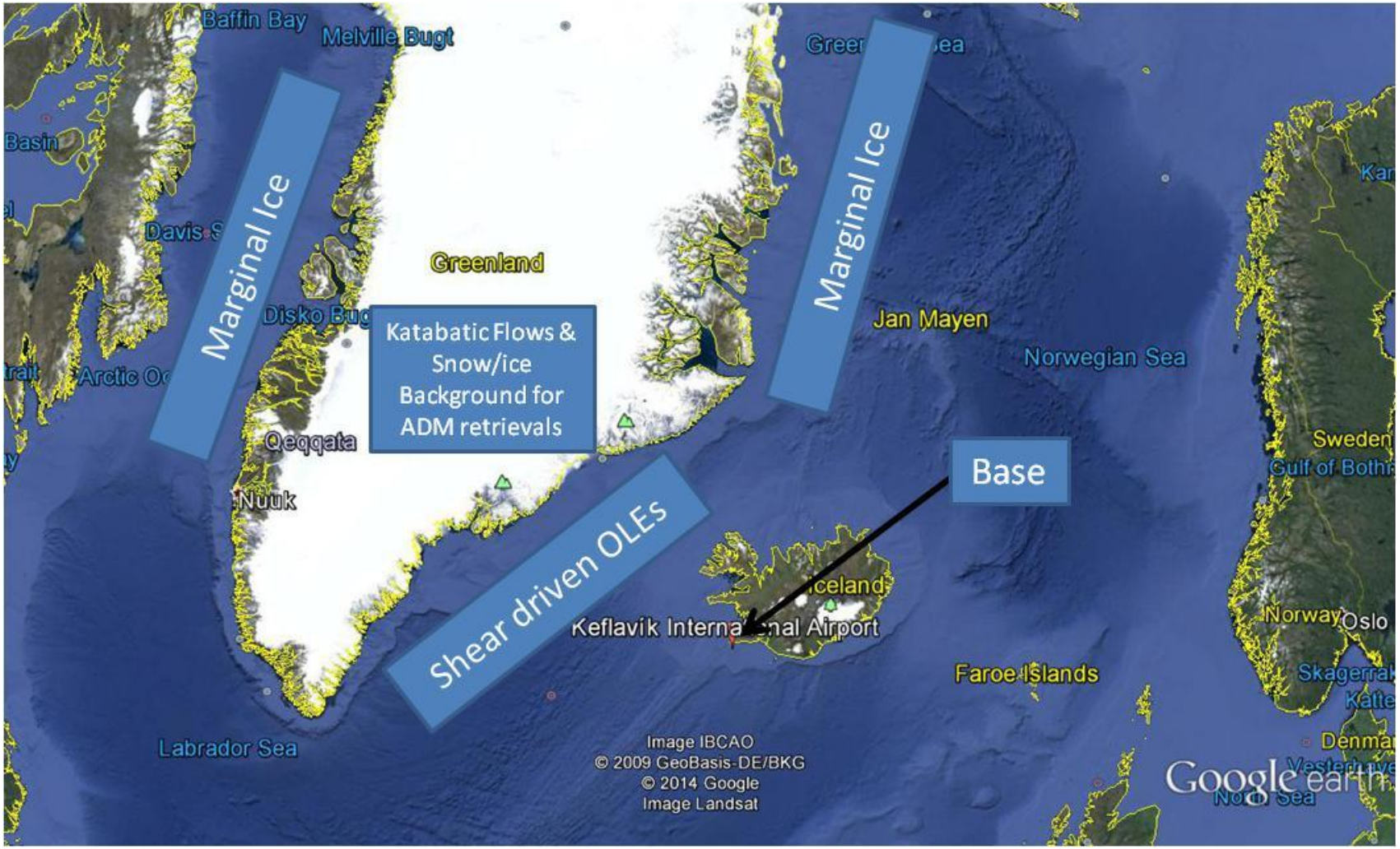
2-micron
Pulsed
MOPA
0.25 J
10 Hz
200 ns
15 cm
Step-stare
conical scan
30-deg nadir
Dual-balanced
heterodyne
detection

Laser, Optics, and Some Electronics in Cargo Level

Centered Nadir Port #7 with Shutter Open



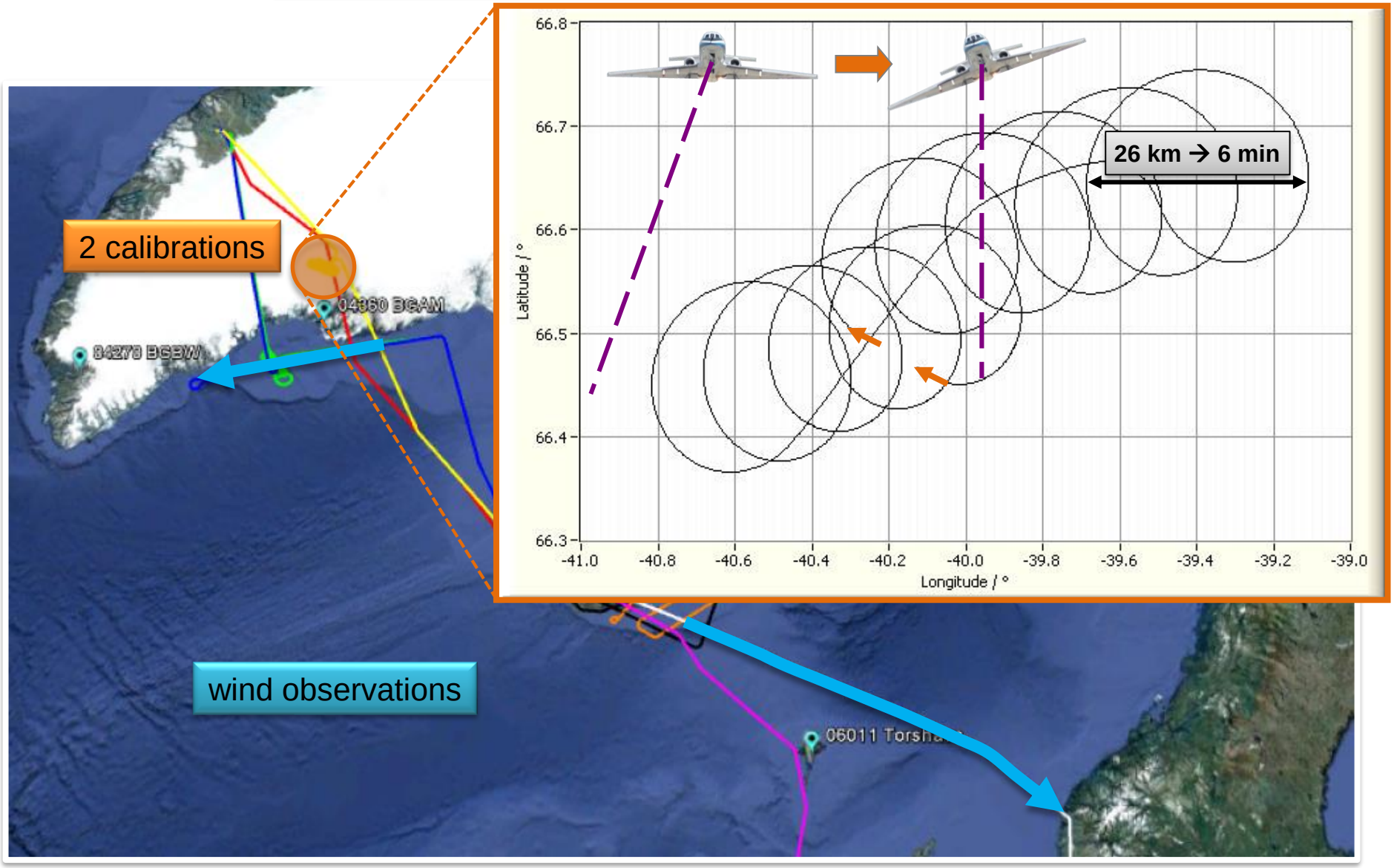
TWiLiTE on ER2


Baffin Bay
Melville Bugt
Marginal Ice
Greenland
Katabatic Flows & Snow/ice Background for ADM retrievals
Marginal Ice
Jan Mayen
Norwegian Sea
Qeqqata
Nuuk
Base
Shear driven OLEs
Iceland
Keflavik International Airport
Faroe Islands
Labrador Sea
Image IBCAO
© 2009 GeoBasis-DE/BKG
© 2014 Google
Image Landsat
Google earth

ADM dedicated missions using both DC-8 and Falcon aircraft

ADM Mission Name	Falcon altitude	DC-8 altitude	Falcon operations	DC-8 operations	Comments
Spiral	38000’	37000’	20 degree bank for > 10 minutes	Race track pattern keeping Falcon within 25 nm	
Instrument comparisons (FL > 35000’)	>35000’	>35000’	Straight and level	Straight and level	Legs > 100km with a dropsonde at each end.
Instrument comparisons (FL ~ 10000 agl)	~ 10000’ agl	~10000’ agl	Straight and level	Straight and level	Legs >100km too low to use dropsondes (?)
Water surface and near surface returns	>35000’	~10000’ agl	Straight and level	Straight and level	Legs > 100 km with no dropsondes
Ice surface and near surface returns	>35000’	~10000’ agl	Straight and level	Straight and level	Legs > 100 km with no dropsondes
Cloud top returns (broken cloud coverage preferred)	>35000’	~10000’ above cloud	Straight and level	Straight and level	Legs > 100 km with no dropsondes

3rd Aeolus Campaign in Sept. 2009



Acknowledgements

- This project is being funded by NASA
  - Ramesh Kakar (PM)
- Credit goes to the DAWN instrument team at NASA/LaRC and the UC-12B crew that flew in challenging weather conditions during Campaign 1