Analysis of Altimetry and Imagery Data and Comparison to CICE Results

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CASIE Analysis: Altimetry and Imagery

Objectives of Ice Classification

(1) Characterization of ice provinces: Establish a unique quantitative description of each ice type

(2) Classification: Assign a given object to a surface class, using the characterization

(3) Segmentation: Create a thematic map by applying the classification operator in a moving window

Transfer to Modeling

(1) Parameterization of spatial sea-ice properties, based on characterization

(2) Summarize properties of ice types, based on classification

(3) Simplify regional ice-type distributions for model input at larger/ regional scale, based on segmentation

CASIE Experiment 2009
Fram Strait

CASIE – Characterization of Arctic Sea Ice Experiment

July/ August 2009 from a base in Nye Alesund, Svalbard

Objective: Collection of high-resolution microtopographic and roughness data

SIERRA UAV, NASA AMES Research Center: Matthew Fladeland and collaborators

Experiment science: Jim Maslanik (P.I.), Ute Herzfeld (Co-I.), David Long (Co-I.), R. Kwok (Co-I.), Ian Crocker, K. Wegrezyn

NASA IPY sea-ice roughness project: J. Maslanik, U. Herzfeld, J. Heinrichs, D. Long, R. Kwok

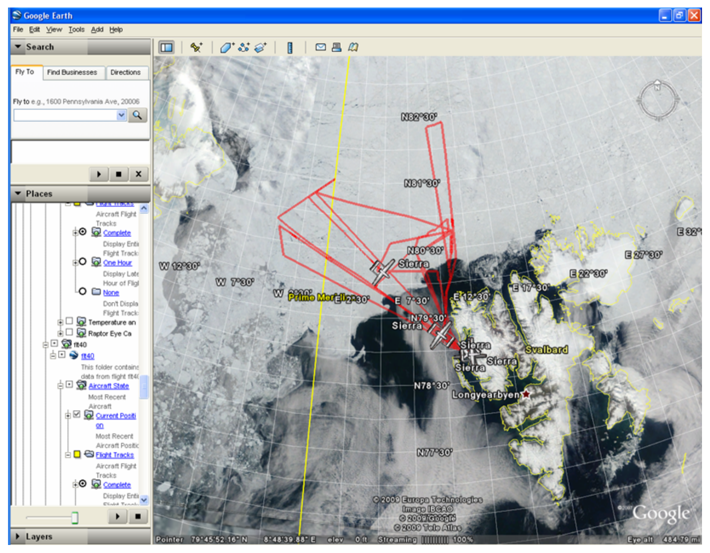
NASA AMES SIERRA: Cold-Weather System Test with CU-ULS (March 2009)

photograph by Don Herlth

BYU mSAR panels integrated in SIERRA

NASA AMES SIERRA: Ny Alesund, Svalbard

photograph by Ian Crocker



flight tracks

What is spatial surface roughness?

- a derivative of (micro)topography
  $\rightarrow$ characterization of spatial behavior

Why do we need spatial surface roughness?

- sub-scale information for satellite measurements
- indicator variable for other, harder to observe processes
- parameterization of sub-scale features or processes

(4.) How do we analyze surface roughness?

The analytically defined spatial derivative needs to be calculated numerically from a data set.

One way to do this:

$$\lim_{x \to x_0} \frac{z(x_0) - z(x)}{x_0 - x}$$

surface slope in a given location x_0

To characterize morphology, better use averages...

Definition of Vario Functions

$$V = \{(x, z) \text{ with } x = (x_1, x_2)\epsilon\mathcal{D} \text{ and } z = z(x)\} \subseteq \mathcal{R}^3$$

discrete-surface case or

$$V = \{(x, z) \text{ with } x\epsilon\mathcal{D} \text{ and } z = z(x)\} \subseteq \mathcal{R}^2$$

discrete-profile case

Define the first-order vario function v_1

$$v_1(h) = \frac{1}{2n}\sum_{i=1}^{n}[z(x_i) - z(x_i + h)]^2$$

with $(x_i, z(x_i)), (x_i + h, z(x_i + h))\epsilon\mathcal{D}$ and n the number of pairs separated by h.

Higher-Order Vario Functions

The first-order vario-function set is

$$V_1 = \{(h, v_1(h))\} = \underline{v}(V_0)$$

Then: get V_2 from V_1 in the same way you get V_1 from V_0. The second-order vario function is also called varvar function.

Recursively, the vario function set of order $i + 1$ is defined by

$$V_{i+1} = \underline{v}(V_i)$$

for $i \epsilon \mathcal{N}_0$.

Geostatistical Classification Parameters

significance parameters:

slope parameter:

$$p1 = \frac{\gamma_{max_1} - \gamma_{min_1}}{h_{min_1} - h_{max_1}}$$

relative significance parameter:

$$p2 = \frac{\gamma_{max_1} - \gamma_{min_1}}{\gamma_{max_1}}$$

pond – maximum vario value

mindist – distance to first min after first max

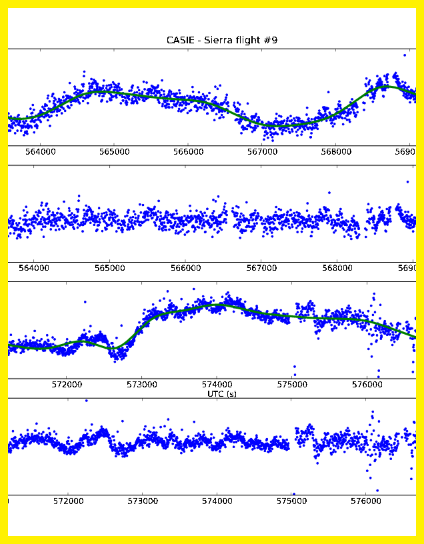
$$avgspac = \frac{1}{n} \sum_{i=1}^{n} \frac{1}{i} \; h_{min_i}$$

typically for $n = 3$ or $n = 4$

Roughness length approximation:

$$arl = \frac{1}{2}\sqrt{2pond}$$

Laser altimeter data — correction method



Correction ingredients

(1) 1 Hz GPS data, collected on-board SIERRA

(2) cubic splines to correct for longer range aircraft motion

(3) altimetry / geolocation residuals wrt to fitted splines

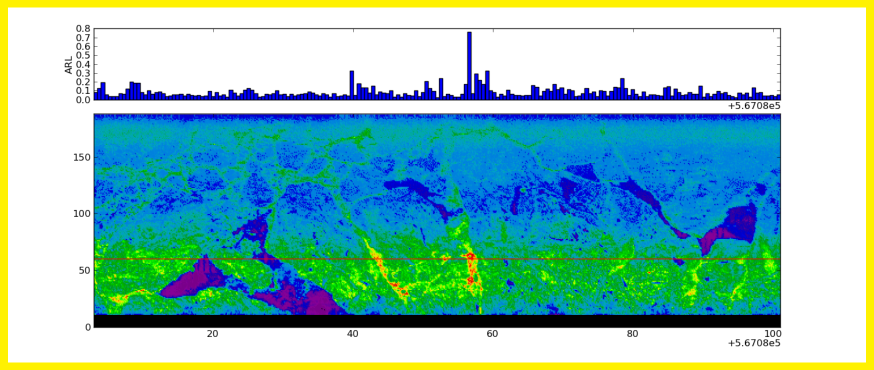
Shown at left: 2 segments with double tracks, altimetry over microASAR

Top: Segment 1, Flight 9

Bottom: Segment 2, Flight 9

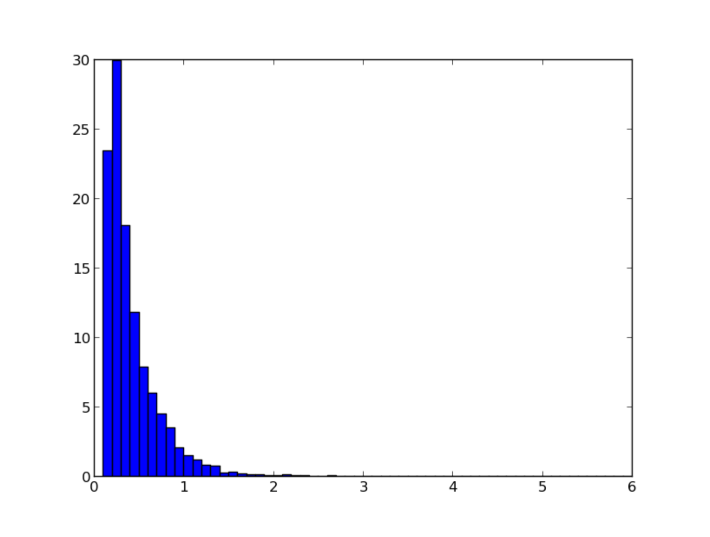
2009-07-25

ARL from altimetry and matching microASAR data



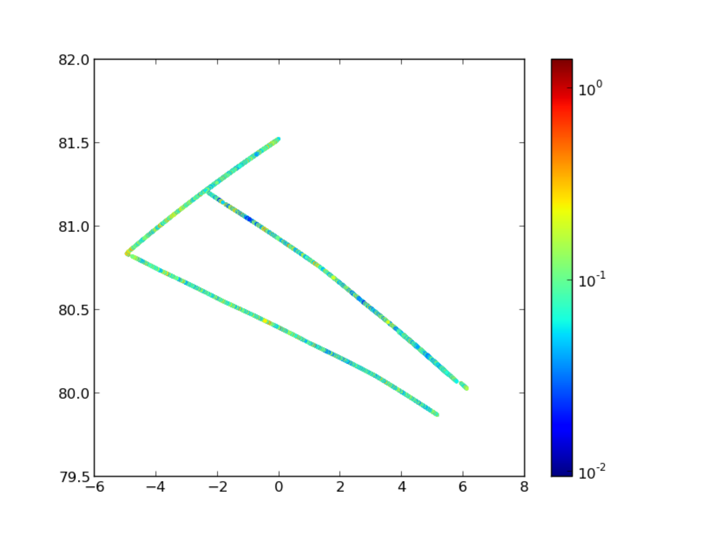
Segment 1 (msar104), Flight 9, 2009-07-25, CASIE 2009

ARL Histogram from CASIE Laser Data

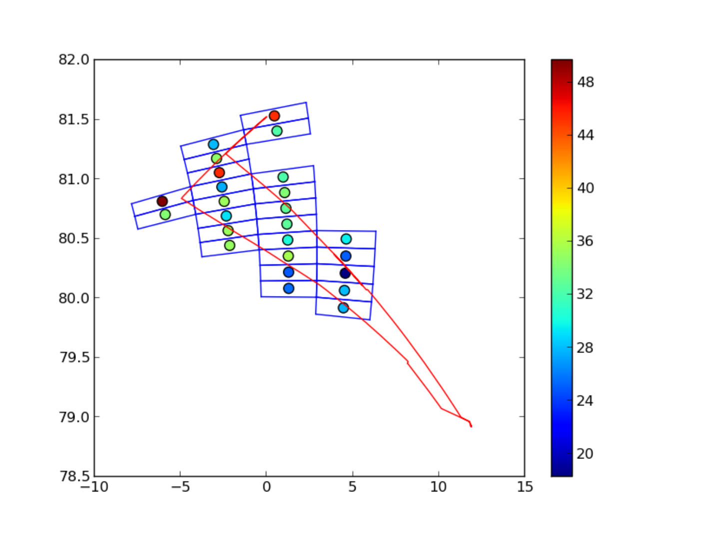


CASIE ULS ARL Histogram

Along-track ARL - CASIE July 2009 - Over Ice

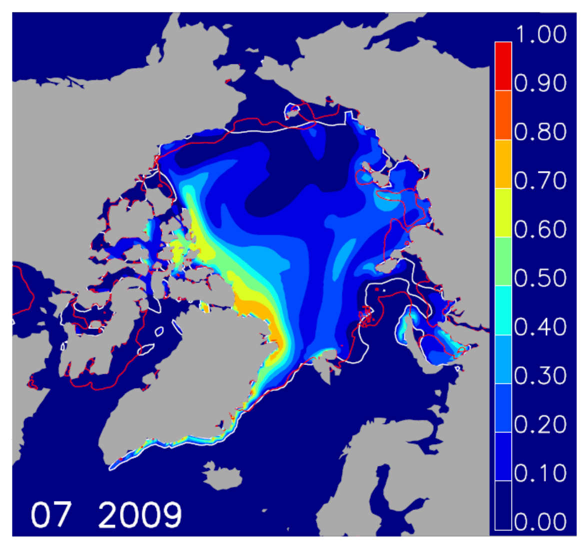


ARL CASIE Laser Data - Flight Track

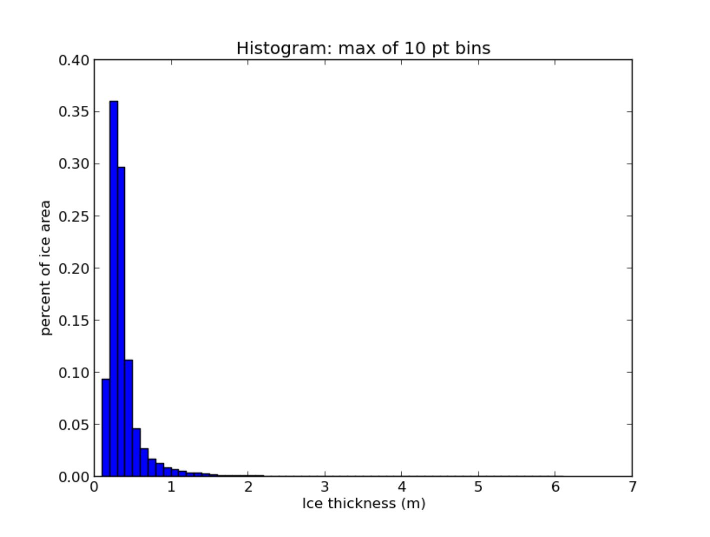


CASIE ULS Flight Track

CICE Model Run For CASIE Flight 09 Time Deformed Ice Area Fraction – July 2009

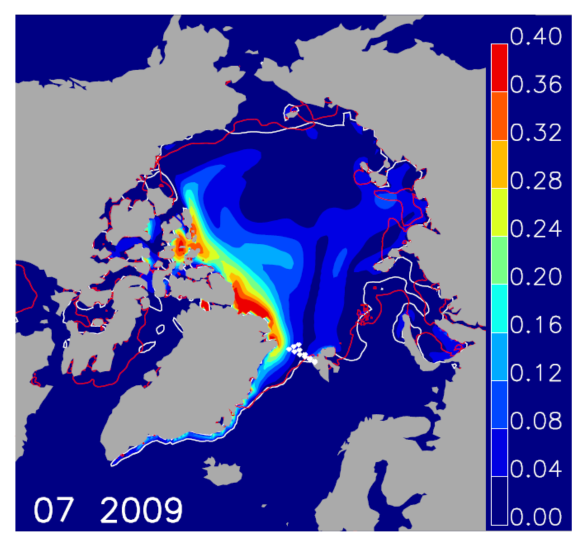


Sail Height Histogram from CASIE Laser Data



CASIE ULS Sail Height Histogram

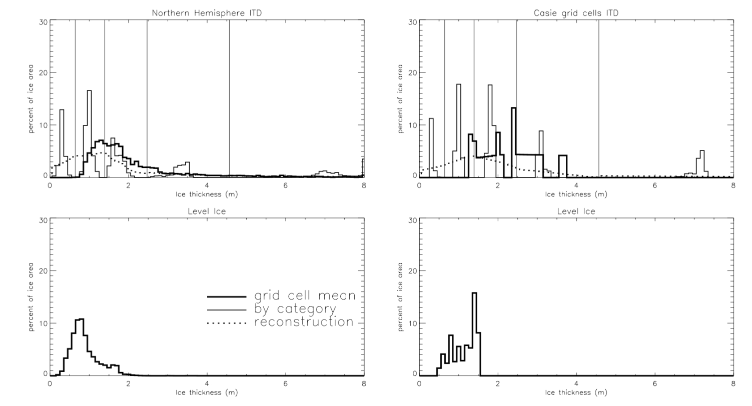
CICE Model Run For CASIE Flight 09 Time Sail Height – July 2009



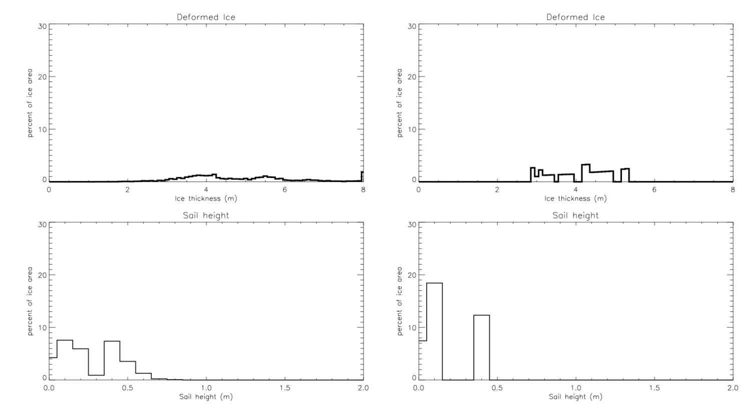
Deformed Ice Dependent on CICE Model Parameters

Parameter	Northern Hem.	Casie Mask (35 Nodes)
orginal	31.1634	38.1931
astar.03	32.4175	45.5128
astar.07	30.9051	39.2194
maxraft.17	33.0950	41.8181
maxraft2	30.7335	37.6406
murdg4	24.6877	27.6685
murdg5	20.2645	21.2877
Cf10	41.5542	63.9714
Cs.5	36.6809	50.2486

Model Results

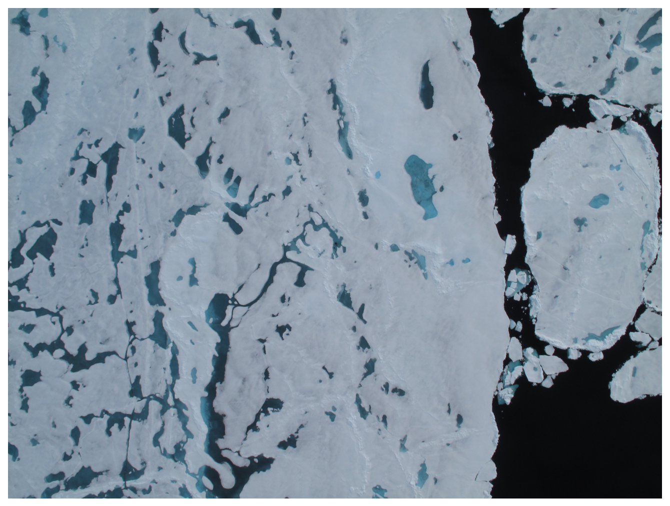


Model Results



Definition revisited

What do we actually call "deformed sea ice"?

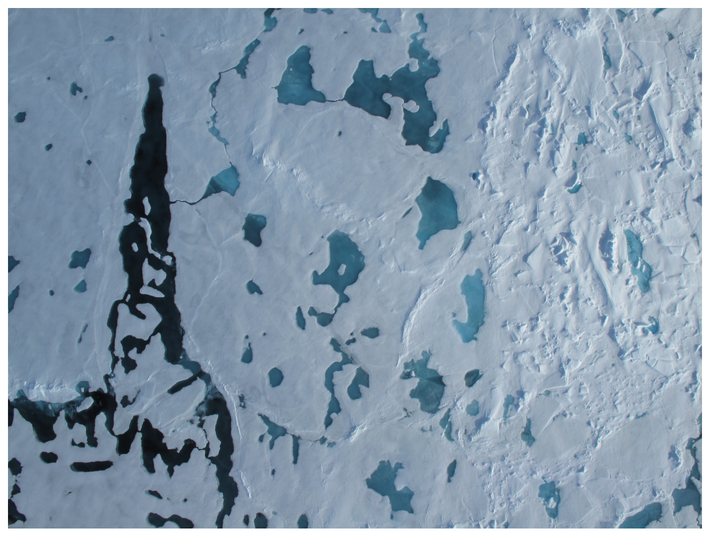


CASIE image 1-20090725-10-33-55-IMG-4580-R.jpg

Approach for measuring deformed sea ice areas from imagery

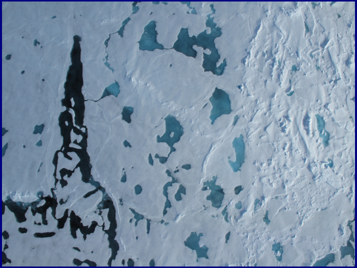
- Use high-resolution CASIE imagery
- Geo-reference all images individually using GPS data
- Define a *pond*-filter that identifies ridge areas
- Apply this to images in all grid cells

To Do: Compare that to ARL

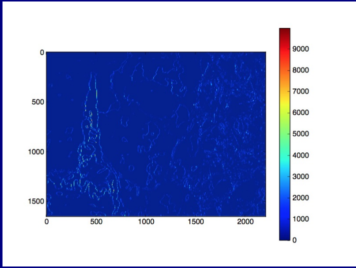


CASIE image 20090725-15.36.22-IMG-9080.jpeg

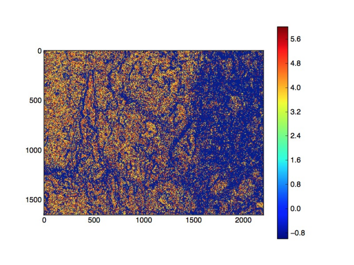
Geostatistical Classification Parameters Applied To Sea-Ice Image



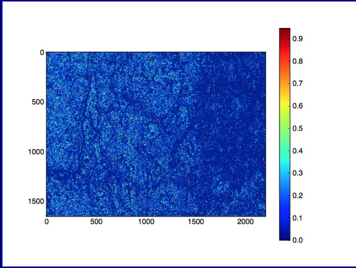
image



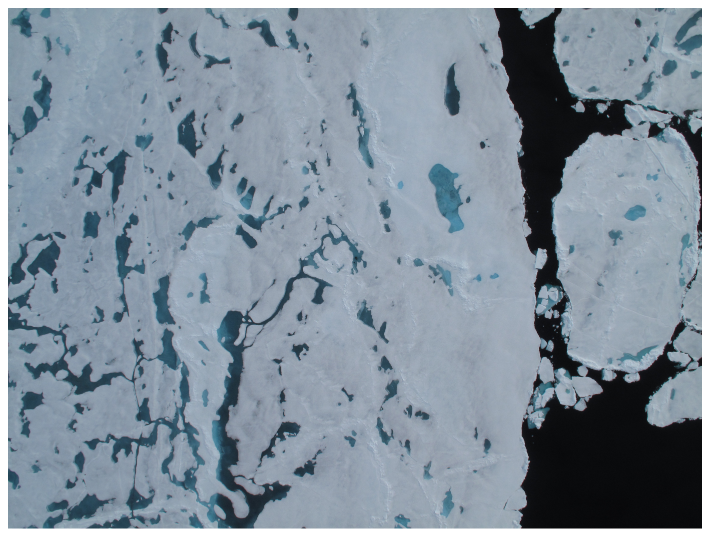
pond



mindist

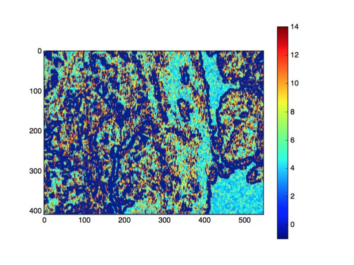


p2

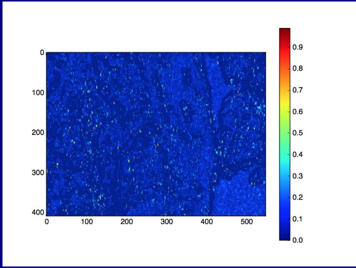


CASIE image 1-20090725-10-33-55-IMG-4580-R.jpg

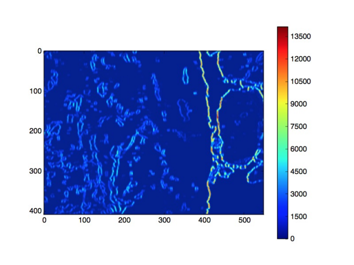
Determination of Deformed Ice Area Using Geostatistical Classification



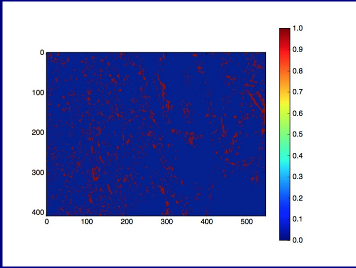
mindist



p2



pond



pond filtered: $60 \leqslant pond < 200$

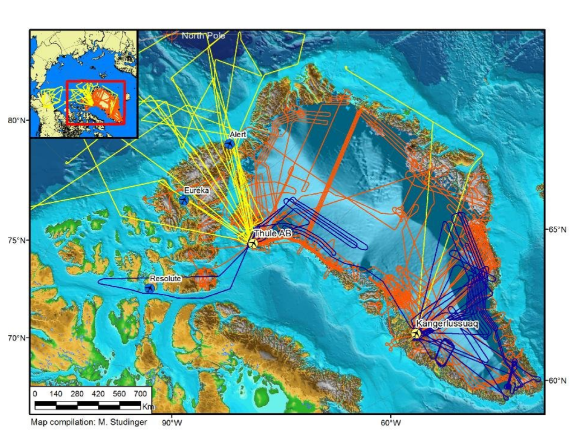
Deformed Ice from CASIE Images (*pond*)

Latitude	Longitude	% Ridged Ice
80.06551361	4.50762939	9.46214414035
80.08296967	1.27127075	11.6643353086
80.21040344	4.5546875	13.6099826824
80.2192688	1.26473999	12.3897421788
80.35453033	4.58929443	11.8910531342
80.35469818	1.24539185	12.0757602732
80.44387054	-2.15808105	16.299423827
80.48925018	1.21295166	14.1650751776
80.49788666	4.6111145	10.9840662275
80.56816101	-2.25061035	18.5388512147
80.62290192	1.16702271	14.1661271789
80.69143677	-2.35668945	21.4184618124
80.70297241	-5.90551758	23.4446026942
80.75563049	1.10736084	15.0469354395
80.81368256	-2.47665405	23.4854014599
80.81427002	-6.0753479	18.4906210044
80.88742828	1.03353882	19.9097706637
80.93487549	-2.61074829	23.9840593802
81.01826477	0.94525146	13.8140709211
81.05499268	-2.75927734	17.2569472543
81.17401123	-2.92260742	17.0840548983
81.29190826	-3.1010437	14.5342062246
81.40483093	0.58953857	19.6372618836
81.53162384	0.43930054	16.6952595206

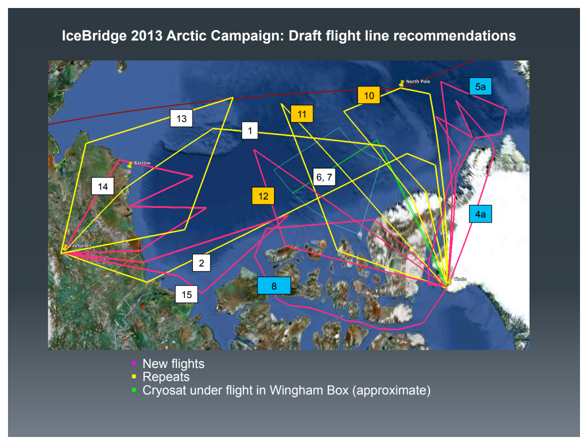
- from 25 nodes (ice-covered regions only)

- threshold for classification: $60 < pond < 200$ to determine ridged ice areas

NASA Operation Ice Bridge — Flight Tracks

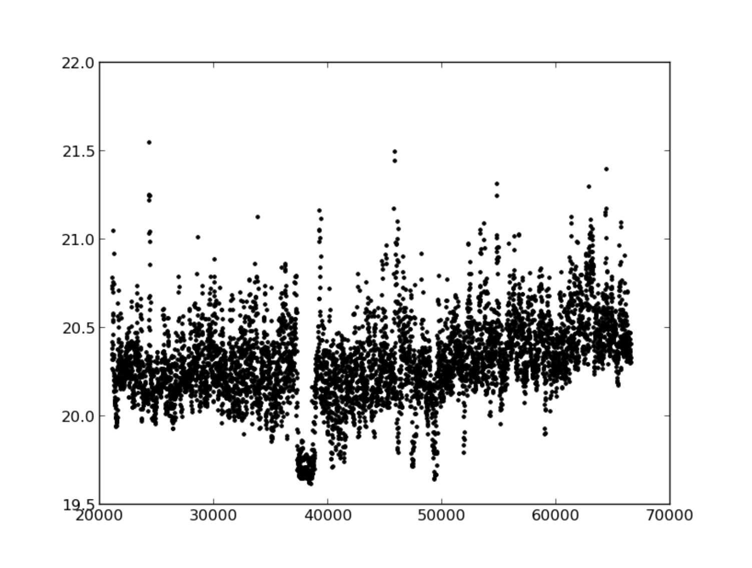


NASA Operation Ice Bridge — Flight Tracks

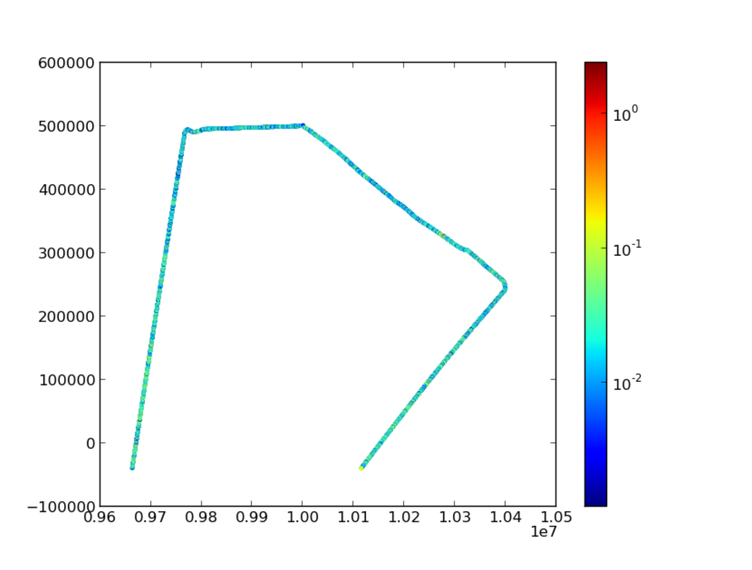


from Jackie Richter-Menge, Feb 11, 2013

OIB data



OIB data


600000
500000
400000
300000
200000
100000
0
−100000
0.96
0.97
0.98
0.99
1.00
1.01
1.02
1.03
1.04
1.05
1e7
10^{0}
10^{-1}
10^{-2}

Conclusions and Future Work

- Definition of Ridge
- Expand Analysis for More Coverage
- Reflecting Results in Models

Questions?