Deformation parameters derived from suborbital remote sensing observations, compared to CICE parameters

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CESM Polar Climate Working Group — NCAR 2016-Feb 10

Thanks to our collaborators and students ...

CICE: Bill Lipscomb
CASIE and SeaiceIPY: James Maslanik (CCAR, CU Boulder), Ron Kwok (JPL), John Heinrichs (†, Ft. Hays State Univ, KS), David Long (BYU Provo), Matt Fladeland and SIERRA Team at NASA Ames Research Center
Geomath Team and former Geomath Team: Jessica Bobeck, Lukas Goetz-Weiss, Aris Sheiner, Jeff Jennings, Katherine Schneider, Phil Chen, Ian Crocker (now NEON), Maciej Stachura, Alex Weltman, Lance Bradbury, Alex Yearsley, Griffin Hale, SeanOGrady, Steve Sucht, Scott Williams (now google)

... and for support through

- NASA Cryospheric Sciences
- Los Alamos Institute of Geophysics and Planetary Physics
- University of Colorado Undergraduate Research Opportunity Program

Models and Observations (Sea-Ice Example)

- Comparison between model results and observations
  $\rightarrow$ Validation of physical concepts
- History
  - physical understanding of sea-ice processes was ahead of observation technology for decades
  - new remote-sensing technology now yields data which facilitate insight in sea-ice processes ("now" - in the last few years)
- Bridging the data world and the modeling world is not trivial:
  - requires parameterizations from data that match models
  - scale matching: high-resolution observations — models run on relatively low-scale grids
  - spatial coverage and generalization: models cover entire ocean or hemisphere — observation campaigns often localized
  - time scale: observations happen at a short, specific time frame — models cover decades or centuries
- Comparison can lead to
  - either validation of physical concepts
  - or need to include different physical concepts in sea-ice models
  - sometimes different parameterizations in models are sufficient

Topics

- Arctic sea ice coverage continues to decrease
- Change from a perennial sea-ice cover to a seasonal sea-ice cover? (ice-free summers in the Arctic)
  $\rightarrow$ Consequences for Arctic ecology and human living, for weather and climate everywhere
- Loss of old ice
- Need to study the more complicated processes and properties of Arctic sea ice:
  - Deformation processes
  - Ridged ice (and rafted ice)
  - Melt-pond formation and localization
  - Relationships and interactions of the above processes

– Results from a collaborative project *Parameterization of Ridges and Other Spatial Sea-Ice Properties From Geomathematical Analysis of Recent Observations for Improvement of the Los Alamos Sea Ice Model, CICE*

CASIE Experiment July/Aug 2009 – Fram Strait

Characterization of Arctic Sea Ice Experiment

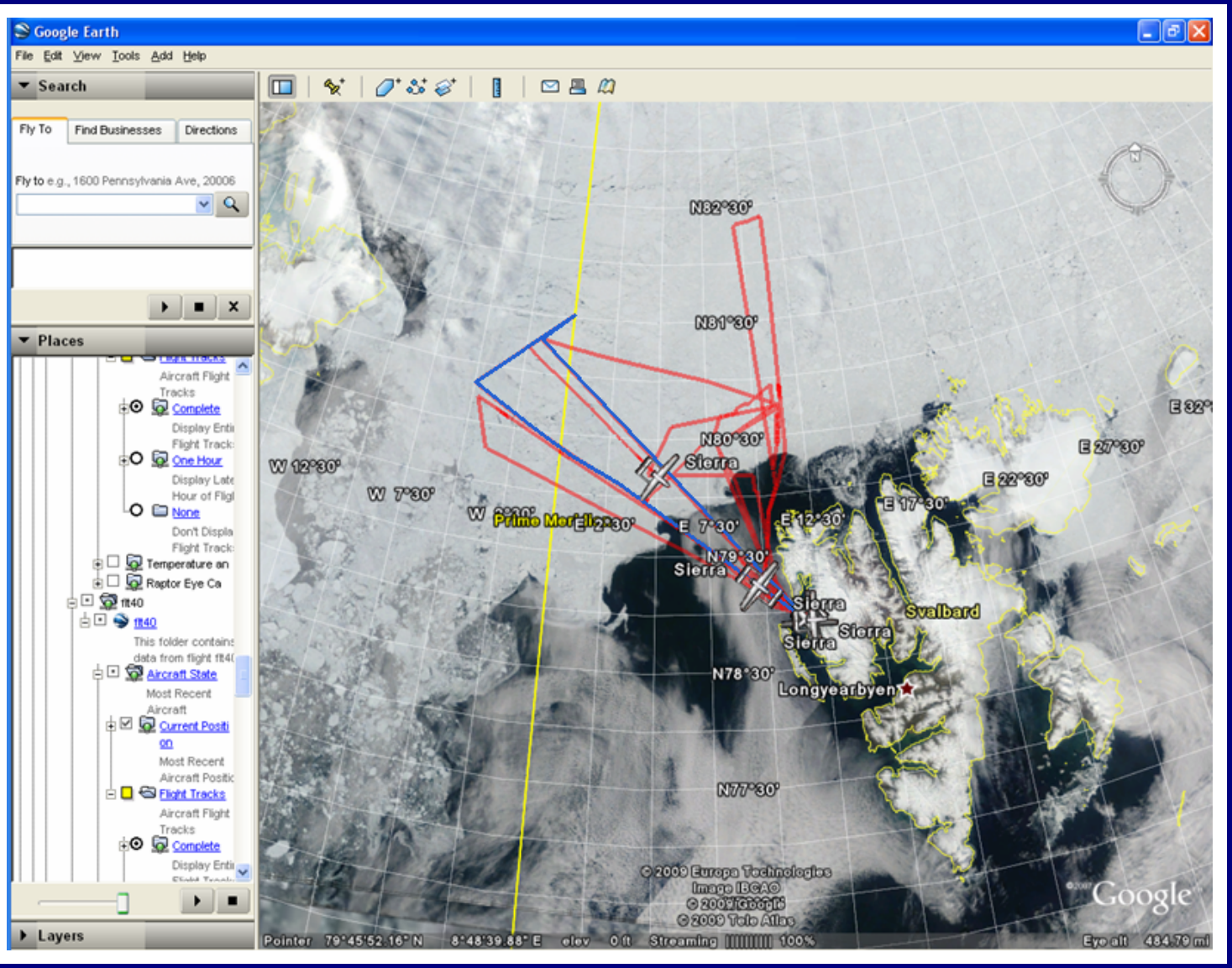
NASA AMES SIERRA: Ny Alesund, Svalbard (photograph by Ian Crocker)

Objective: Collection of high-resolution microtopographic and roughness data: laser altimetry, imagery, microASAR

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

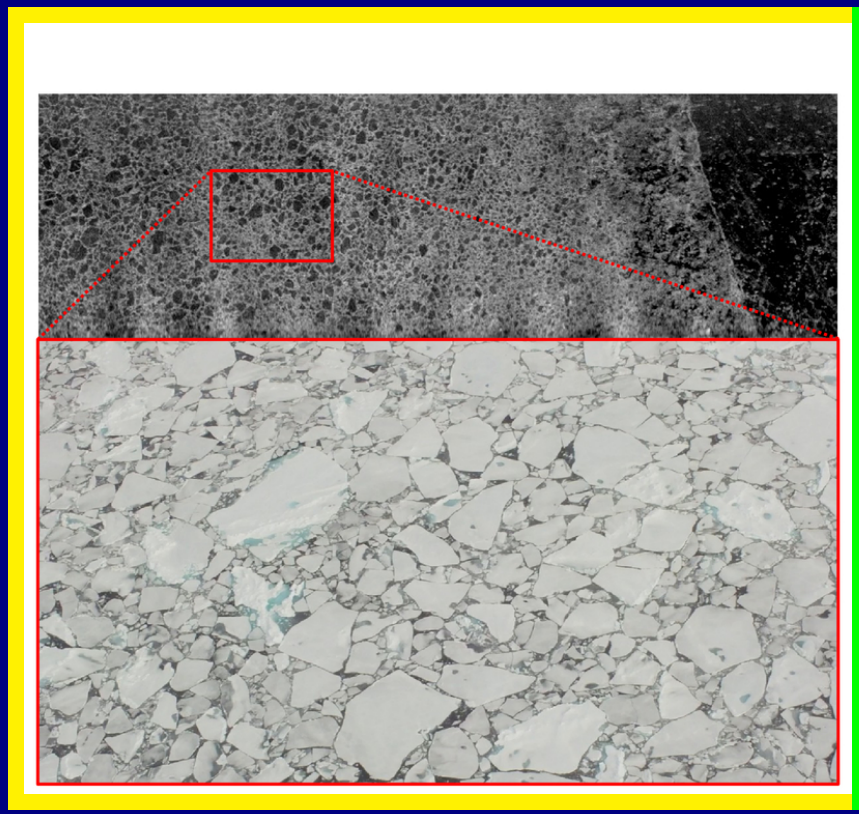
NASA IPY sea-ice roughness project: J. Maslanik, U. Herzfeld, J. Heinrichs, D. Long, R. Kwok



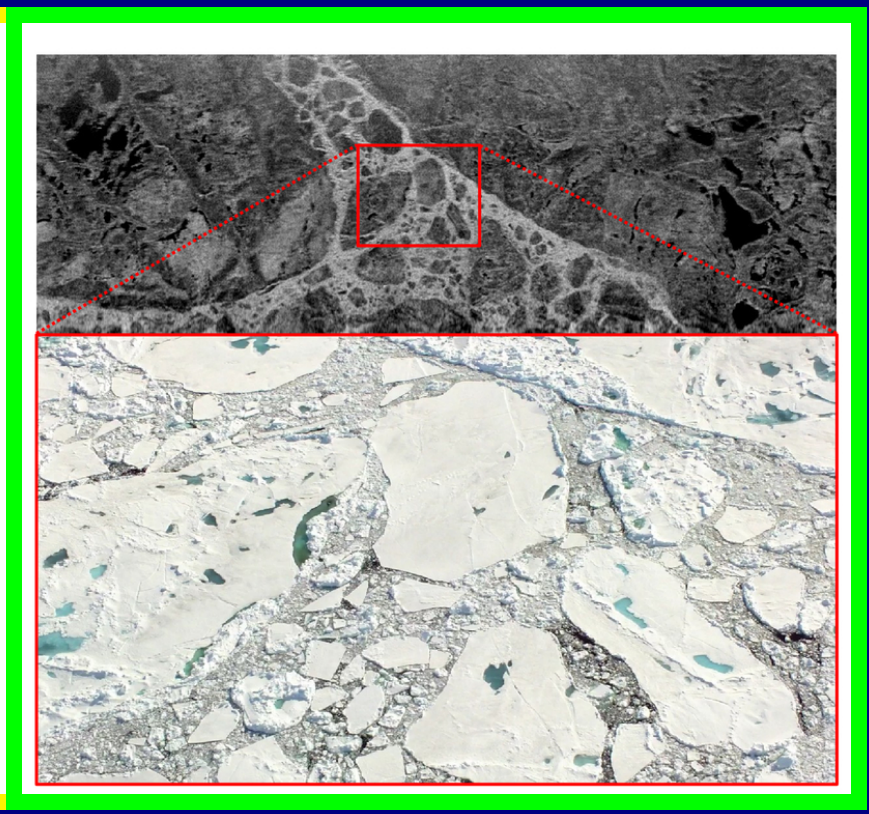
Flight tracks of the CASIE Experiment July/August 2009.

Data used here stem from flight 9 (marked blue).

Sea Ice Types — Fram Strait, from CASIE 2009

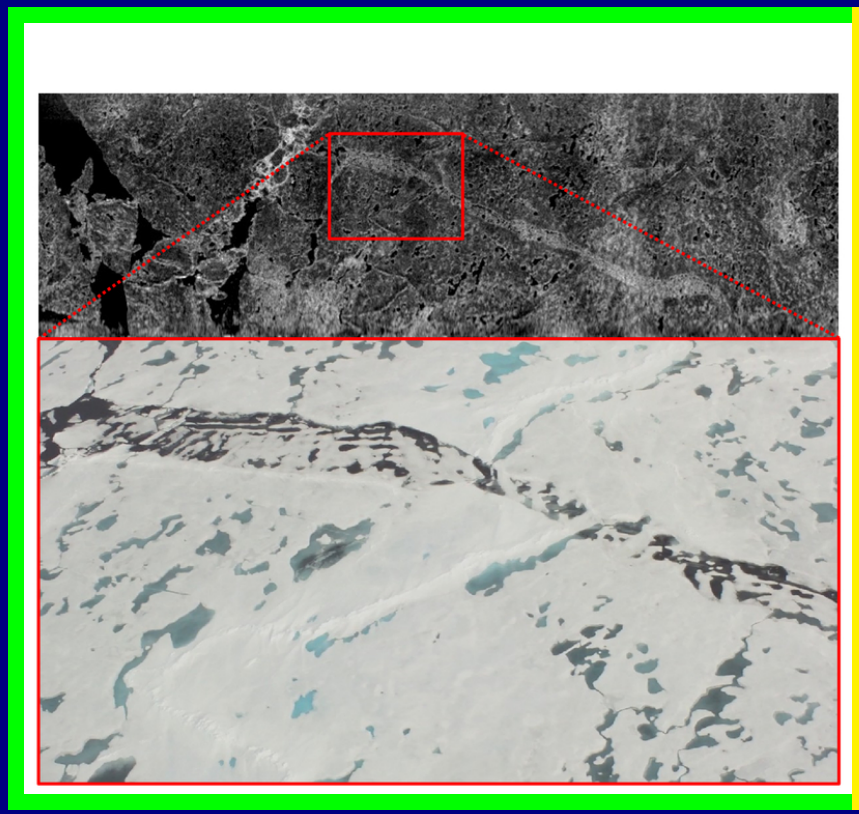


(a) near ice edge

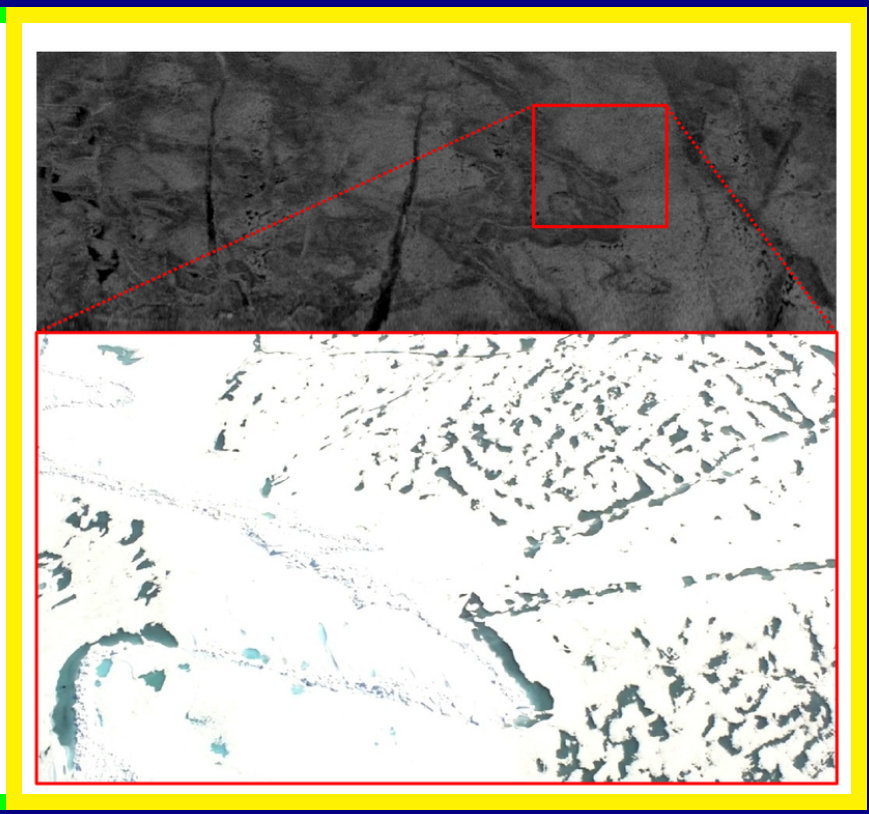


(b) rubble – lead – floes

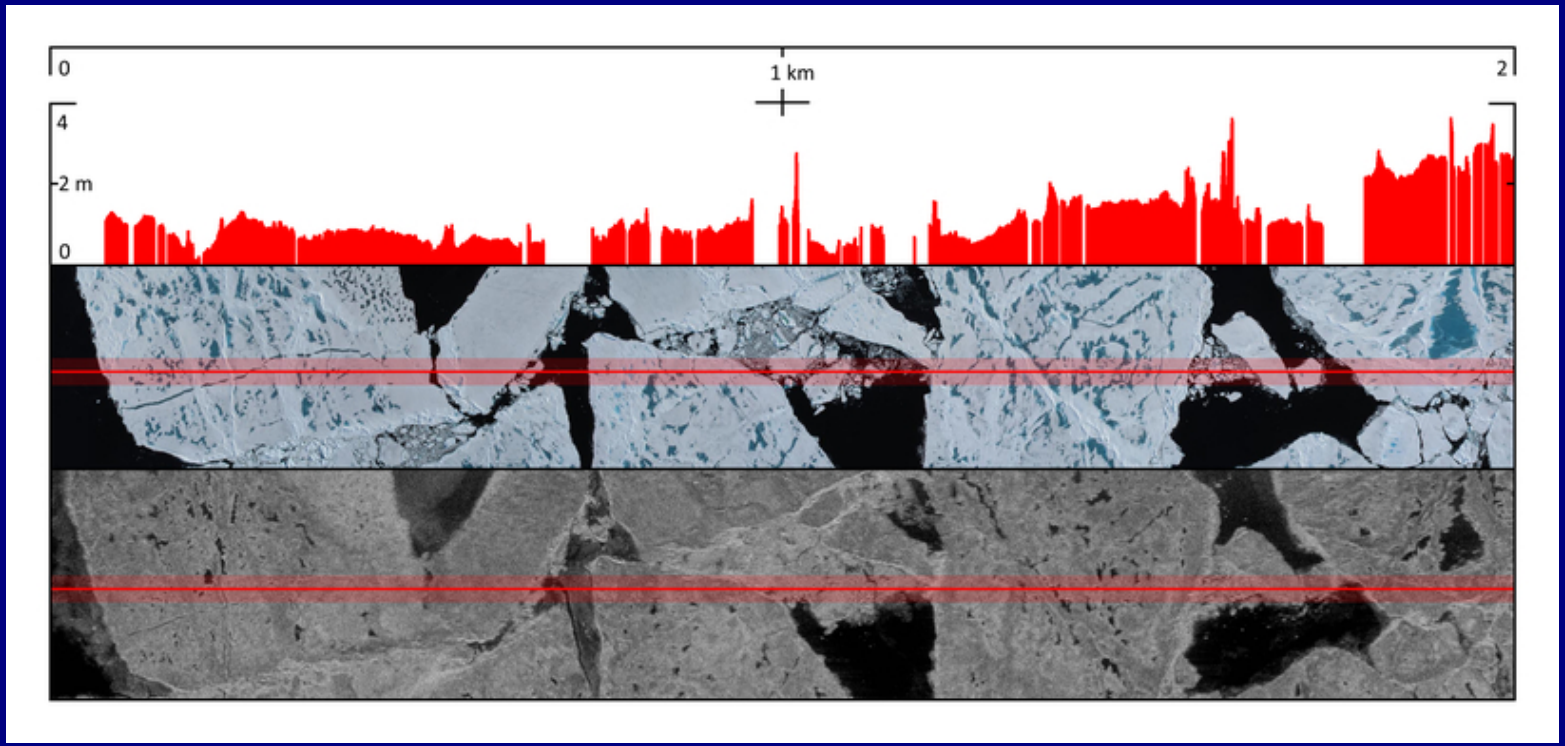
Sea Ice Types — Fram Strait, from CASIE 2009



(c) refrozen lead

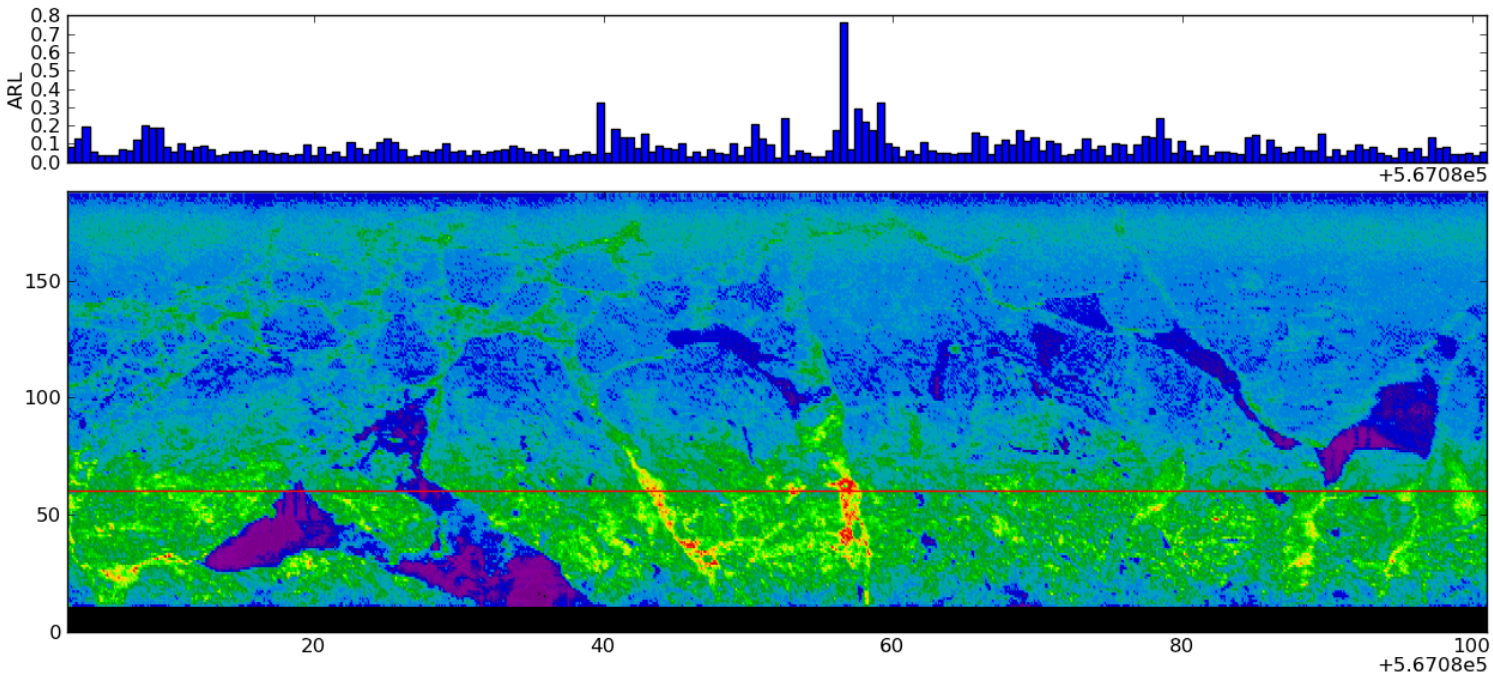


(d) flooded floes – ridging



Laser altimeter data, videographic data and microASAR data from CASIE

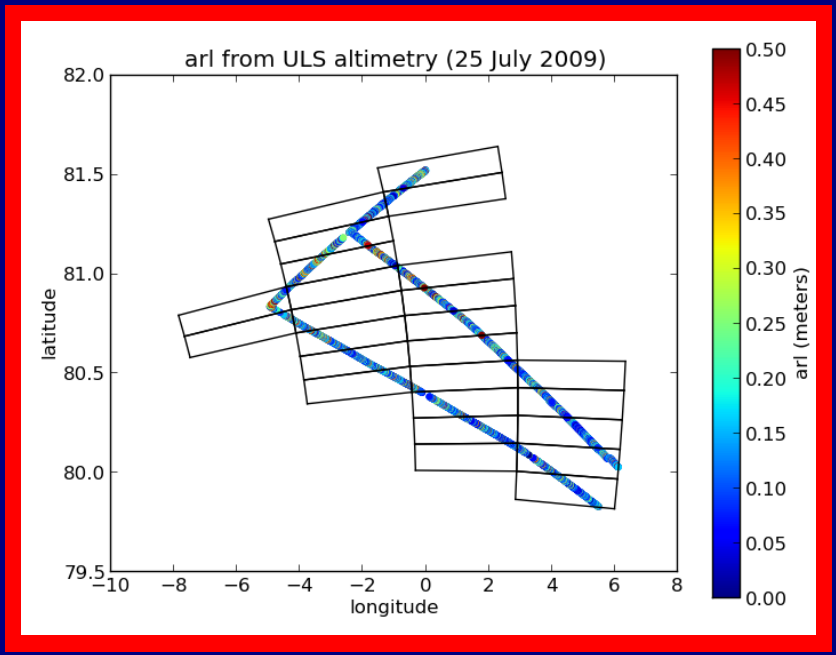
ARL from altimetry and matching microASAR data

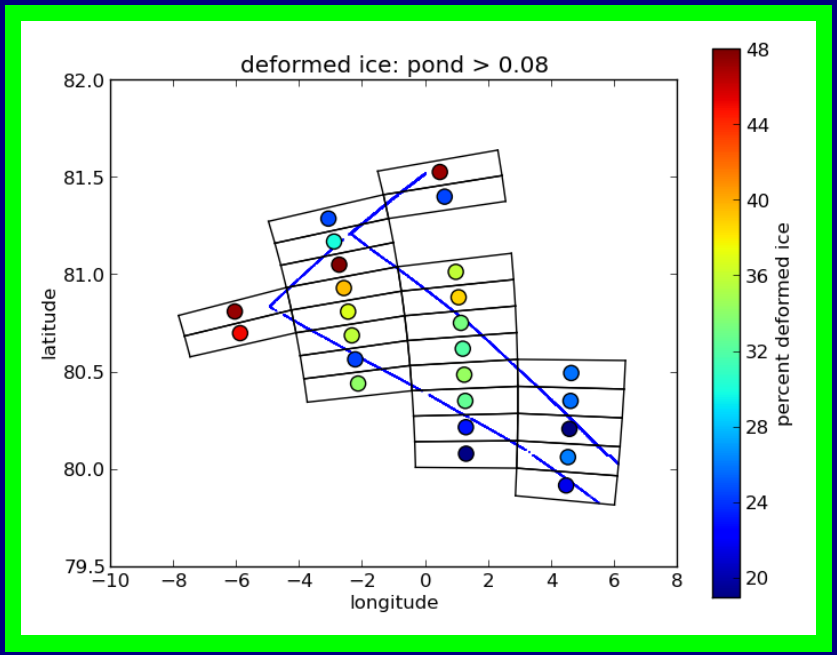


Segment 1 (msar104), Flight 9, 2009-07-25, CASIE 2009

CICE-CASIE Comparison:

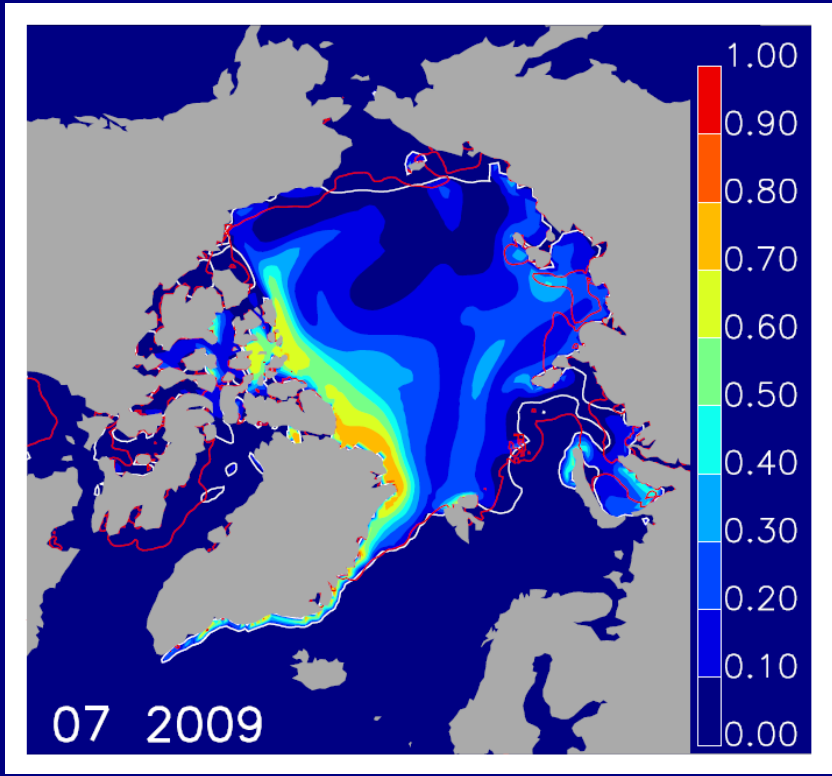
Ice-Surface Roughness (arl) and Percent Deformed Ice Area from Laser Altimetry



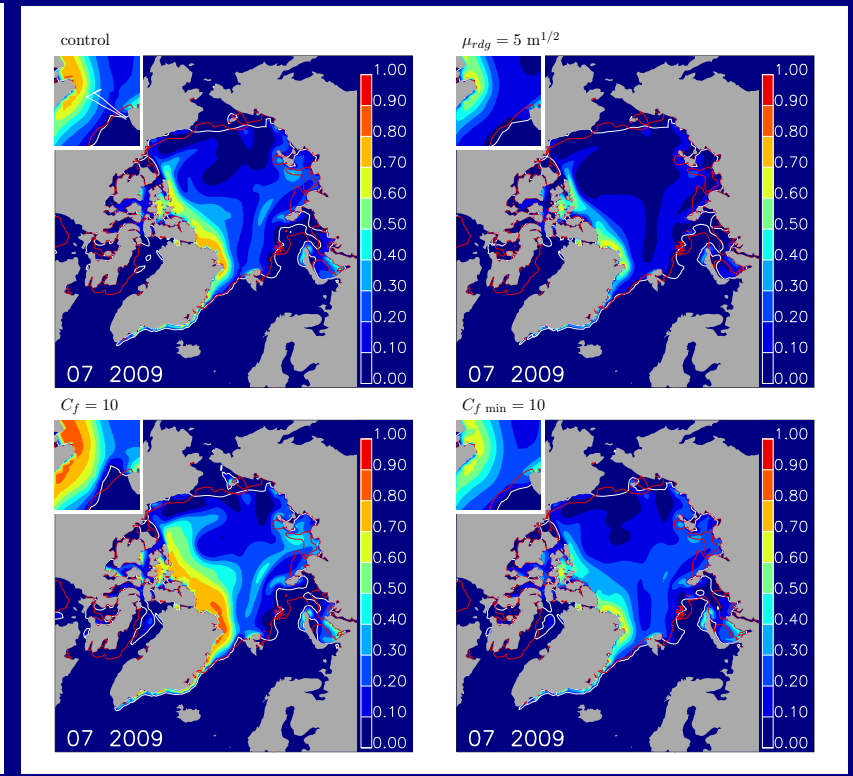


25 CICE grid nodes over sea ice; sea-ice water boundary determined using returned-signal counts

CICE Model Runs For CASIE Flight Time (July 2009)
Deformed Ice Area Fraction

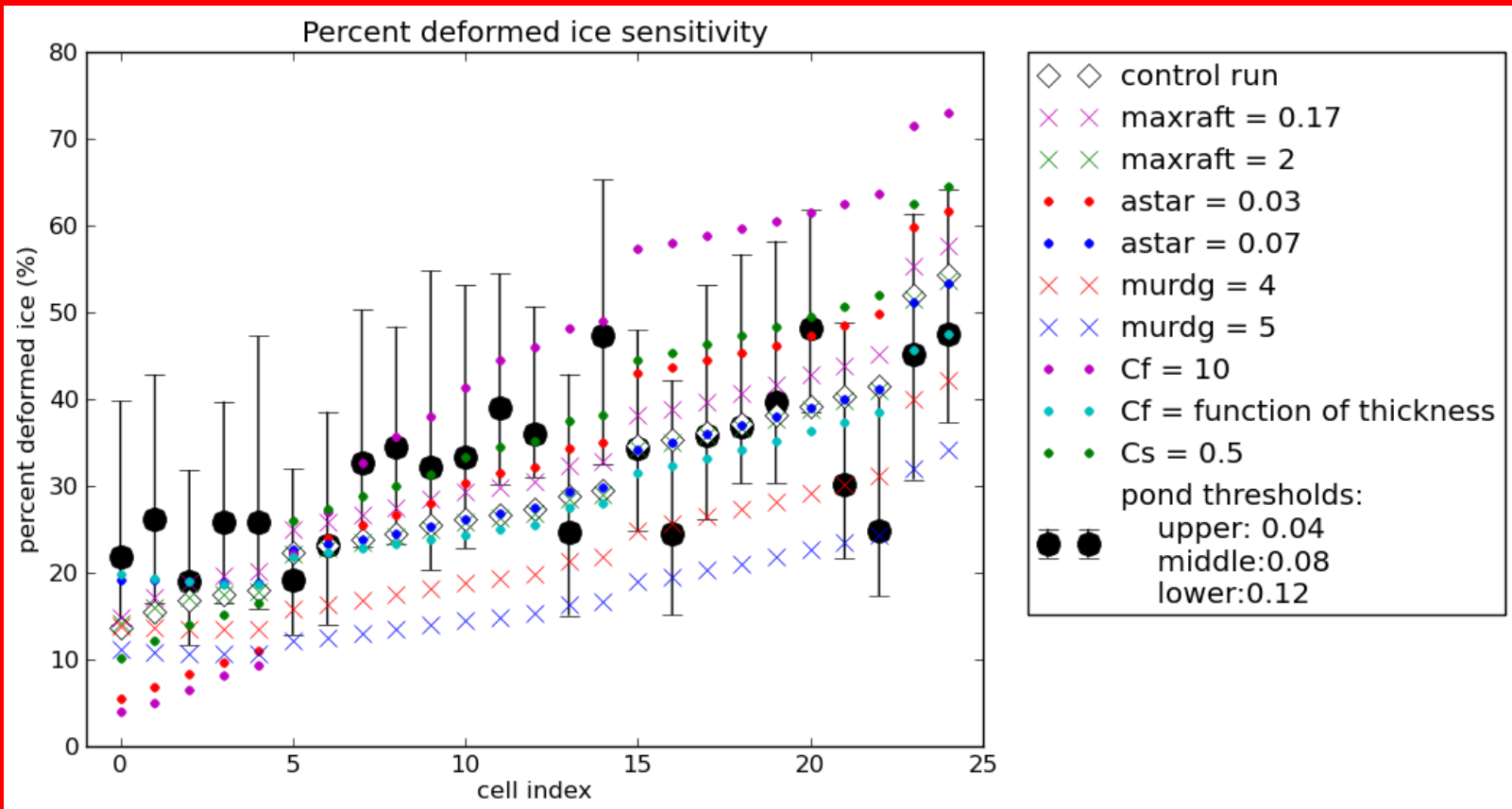


(a) Control Run



(b) Sensitivity Study

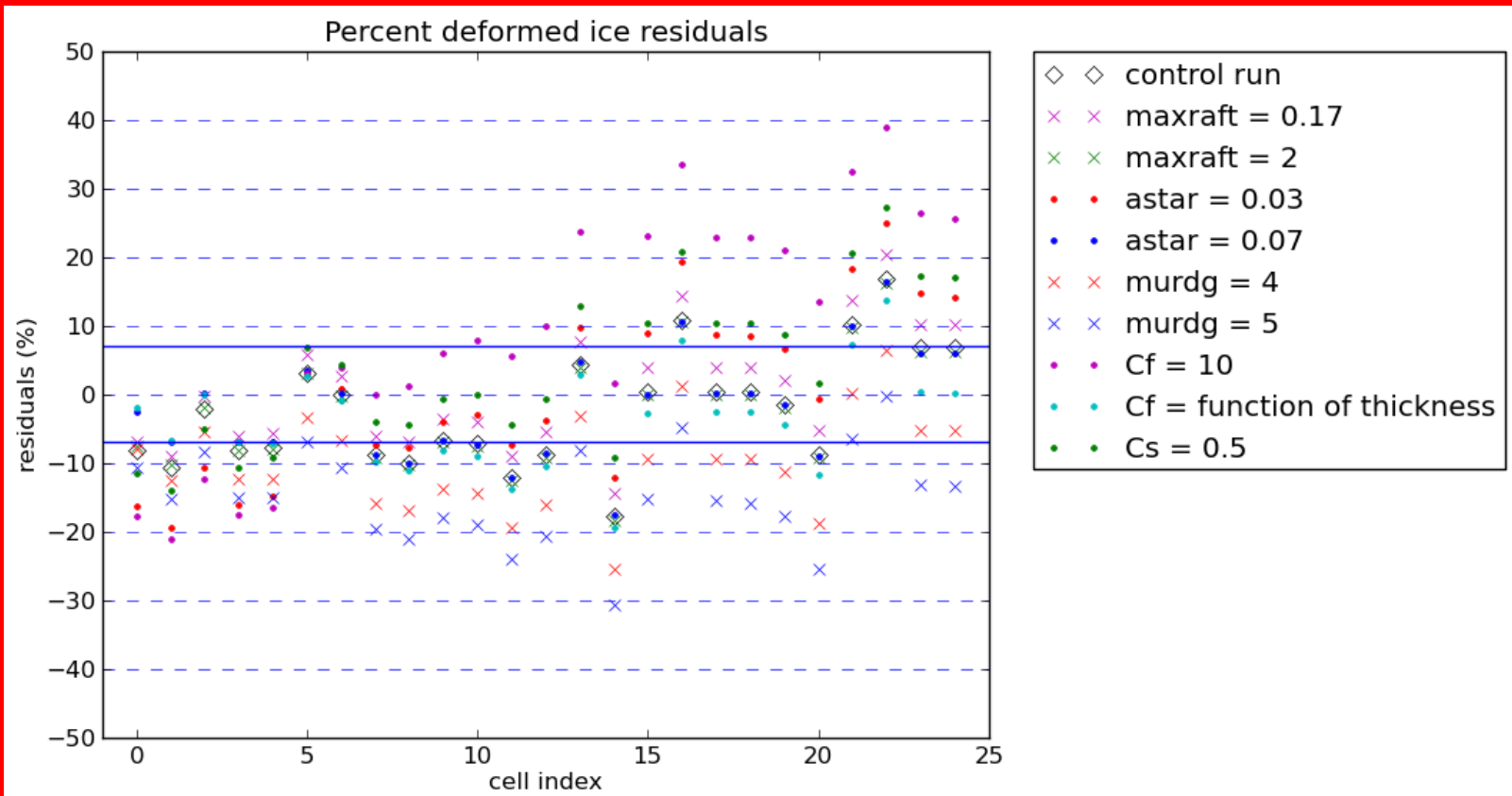
CICE-CASIE Comparison: Sensitivity Studies
Percent Deformed Ice Area from CICE and CASIE



25 CICE grid nodes over sea ice

(Herzfeld, Hunke, McDonald , Wallin, CRST, 2015)

CICE-CASIE Comparison: Sensitivity Studies
Percent Deformed Ice Area from CICE and CASIE



25 CICE grid nodes over sea ice

(Herzfeld, Hunke, McDonald , Wallin, CRST, 2015)

A Method for Calculation of Ridged Sea-Ice Areas from Imagery and Comparison to Results from Sea-Ice Modeling

Geostatistical Classification Parameters

significance parameters:

slope parameter:

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

relative significance parameter:

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

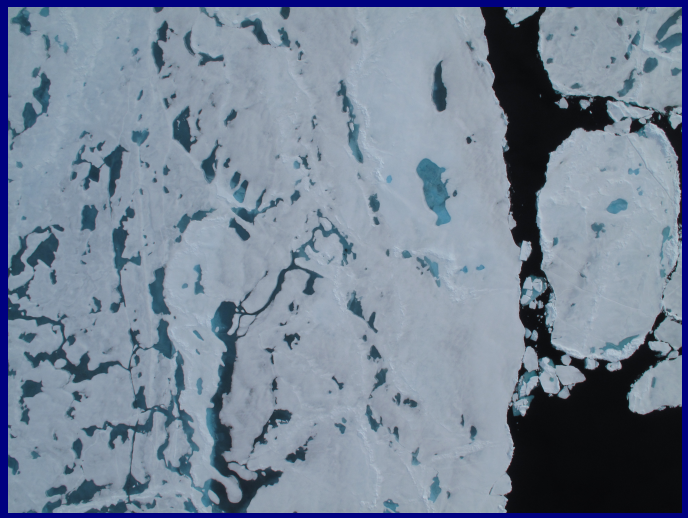
pond – maximum vario value

mindist – distance to first min after first max

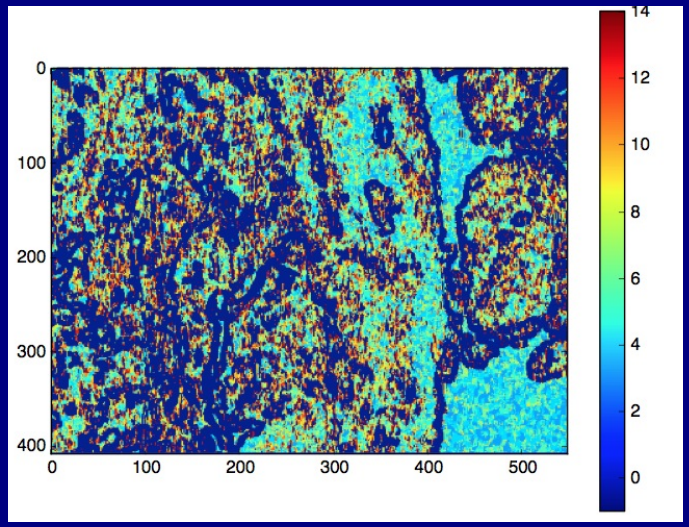
Roughness length approximation:

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

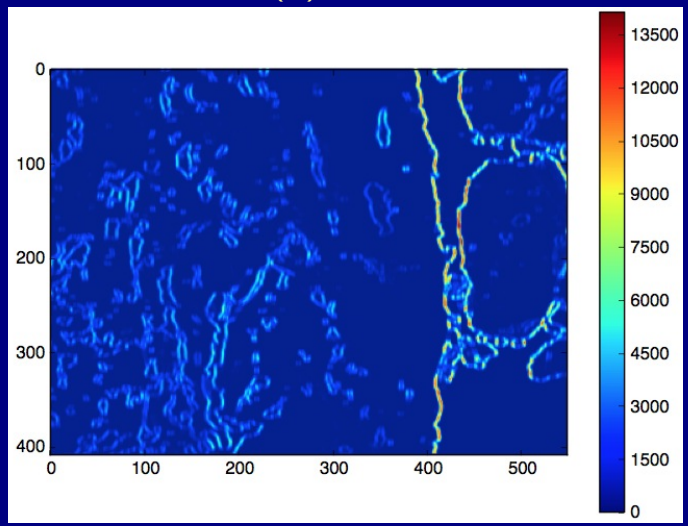
Geostatistical Sea-Ice Image Characterization



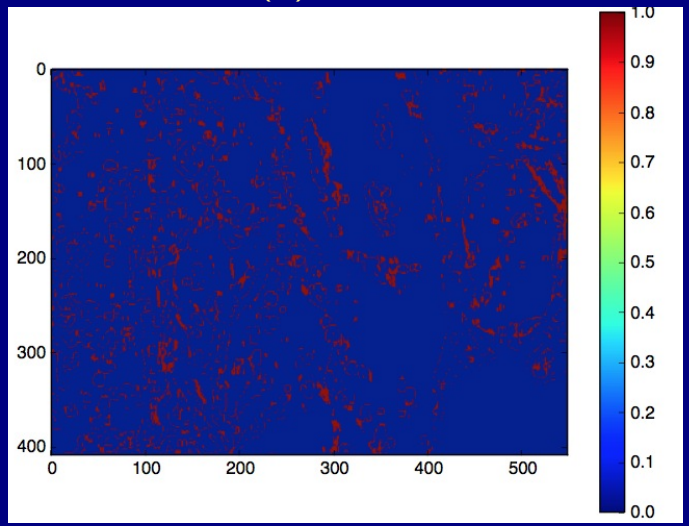
(a) image



(b) mindist

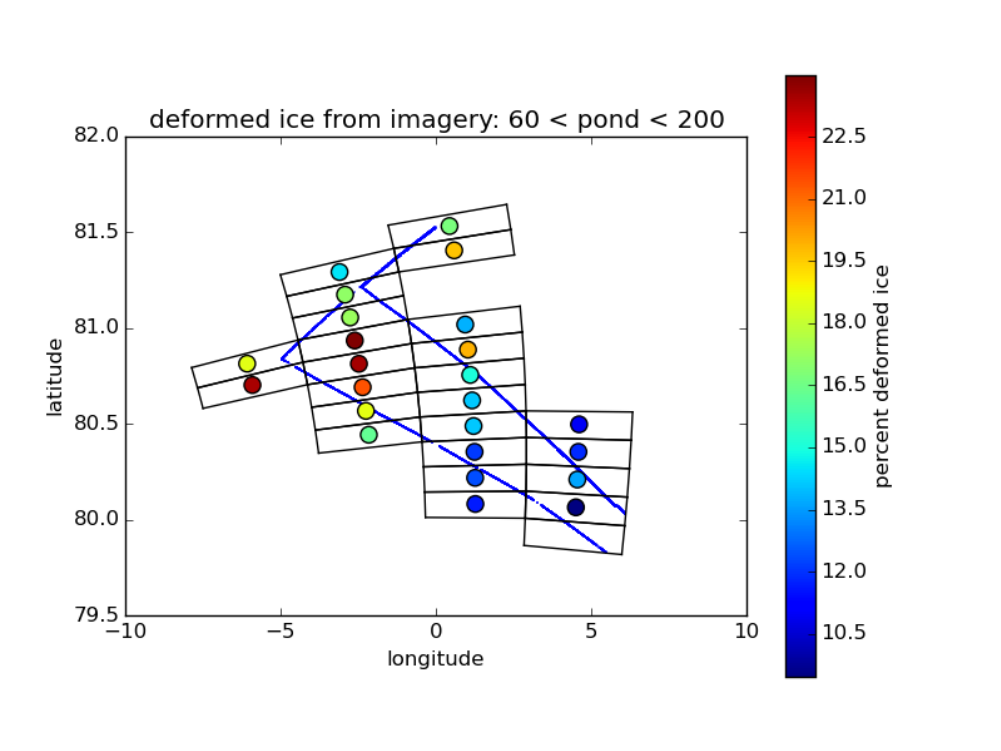


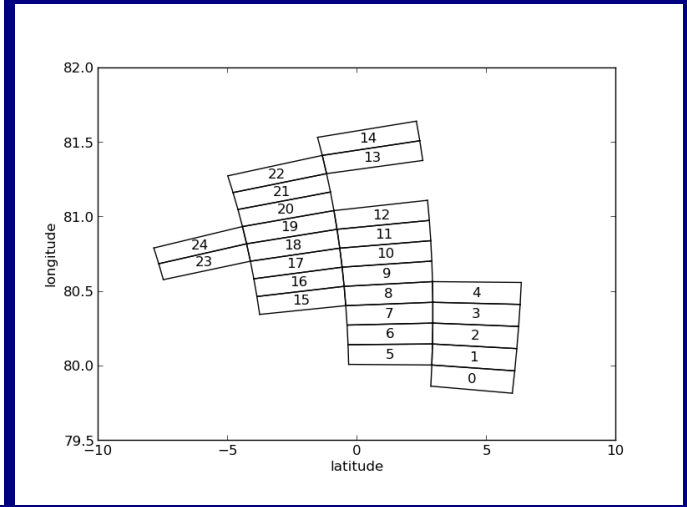
(c) pond



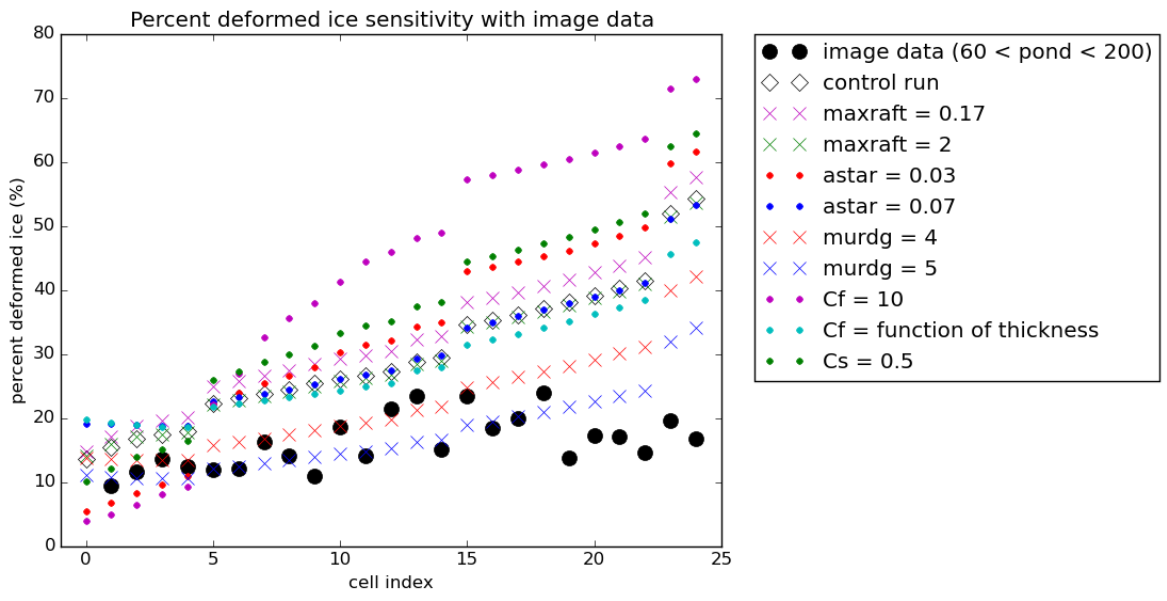
(d) ridges: pond filtered: $60 < pond < 200$

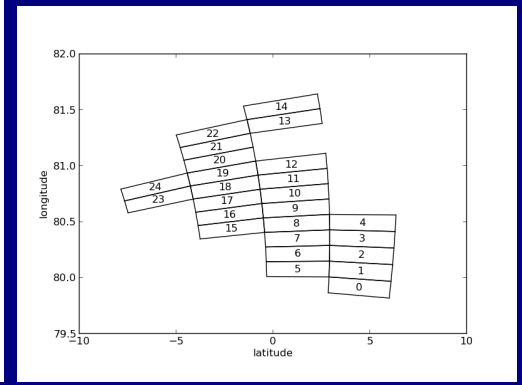
CICE-CASIE Comparison: Ridged area percentages from imagery



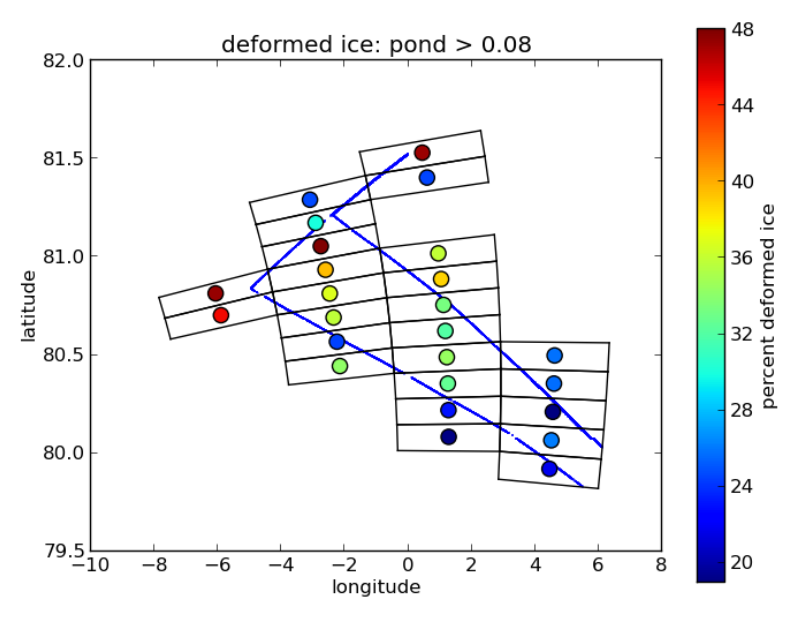


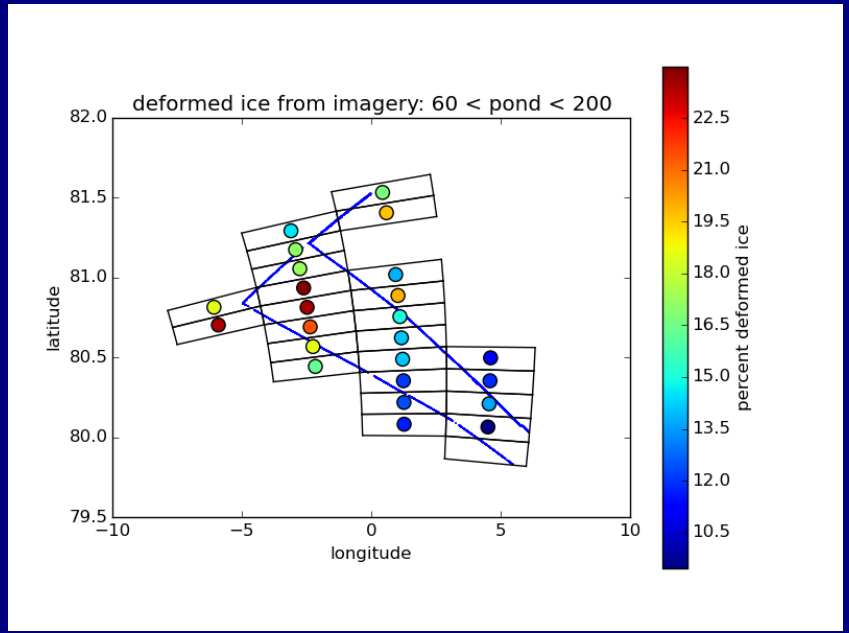
CICE-CASIE Comparison:
CICE Sensitivity study with imagery analysis results



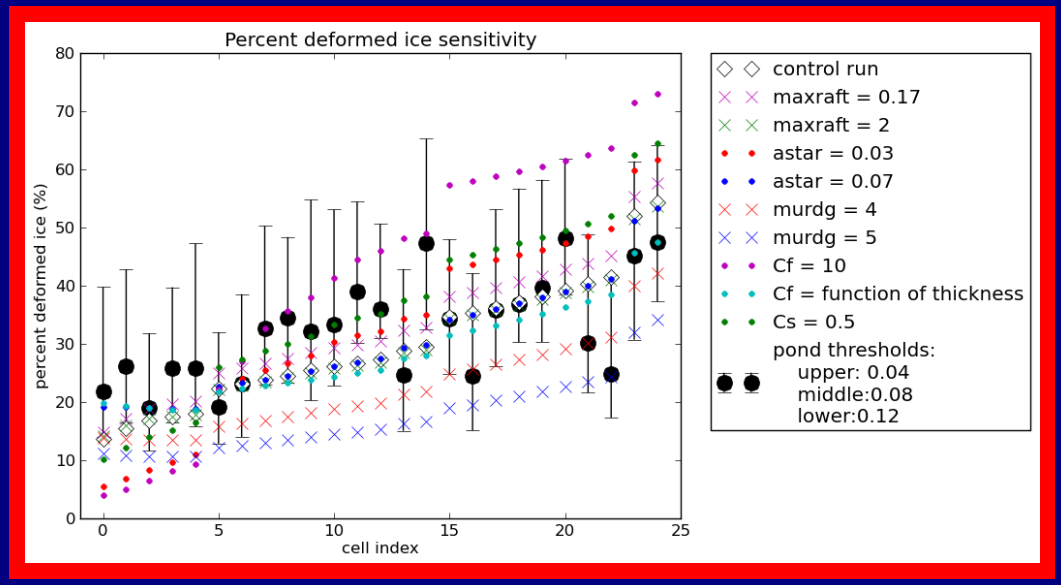


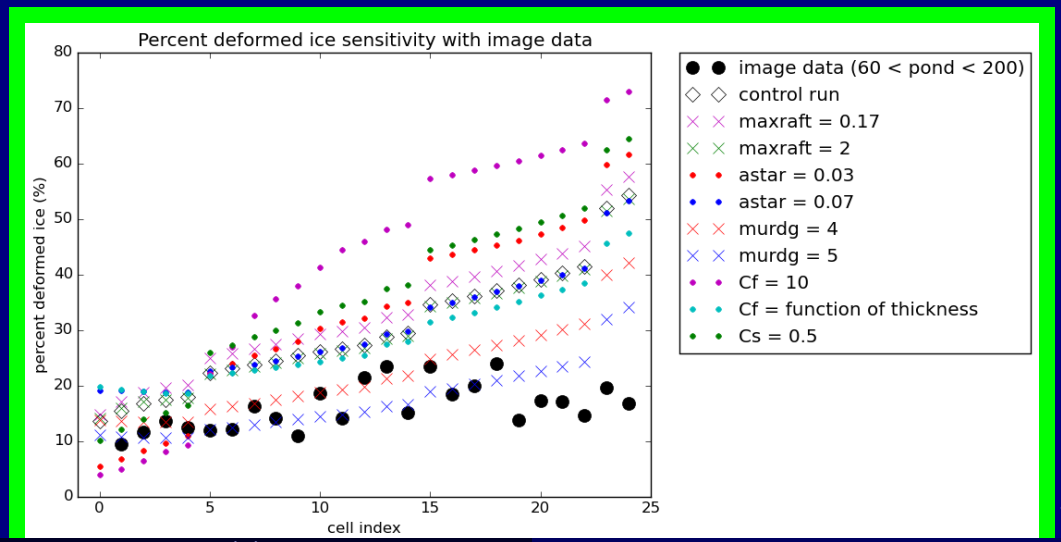
CICE-CASIE Comparison: Altimetry results versus imagery results



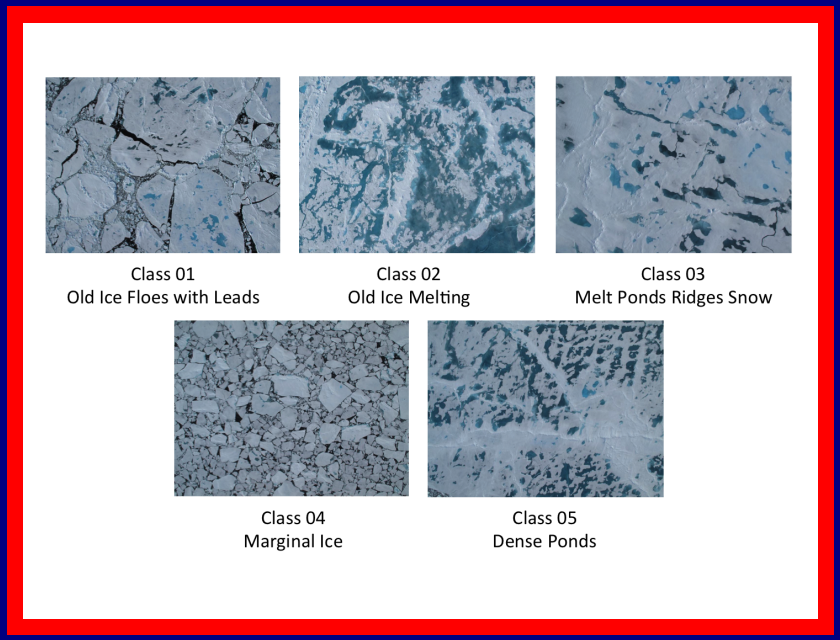


CICE-CASIE Comparison:
CICE Sensitivity: altimetry versus imagery results

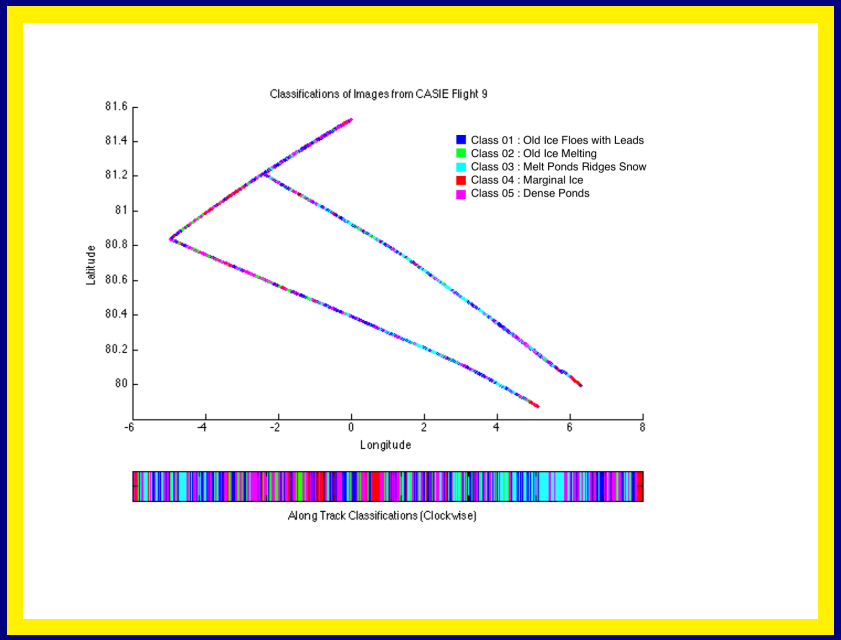




Sea Ice Image Classification - CASIE July 2009



(a) Sea Ice Classes



(b) Classification