Project Title: High resolution Modeling of Arctic Sea Ice and Currents

FOA/NOFO Research Question(s): Topic 1a, Maritime Risk & Threat Analysis; Topic 2b, Coastal and Marine Modeling and Analysis; Topic 2d, Arctic Analysis. 2d-3-iii: What new technologies can be developed to improve the First Responders ability to conduct search and rescue in extreme conditions?

Project Objectives:

- To support USCG Arctic operators and planners, develop a High-resolution Ice-Ocean Modeling and Assimilation System (HIOMAS) to realistically forecast Arctic sea ice thickness, concentration, and motion, and ocean currents.

Potential Impact:

- Help the Coast Guard to conduct search and rescue missions more safely and reliably; enhance the Coast Guard's ability to prepare for and respond to oil spills.
- Support Arctic stakeholders in planning; modeling feeds ADAC's Arctic Information Fusion Capability (AIFC).

Key Accomplishments:

- Developed HIOMAS based on the well-established Pan-Arctic Ice-Ocean Modeling and Assimilation System (PIOMAS) with high resolution (6 km).
- Conducted model calibration and validation using observations of sea ice thickness, concentration, and motion; carried out HIOMAS hindcast and forecast.
- Configured HIOMAS with even higher resolution (2-4 km); currently testing the 4 km resolution HIOMAS.

Funding:

- Expended to Date by End of Year 2 ……$104,148.00

Key Milestones/Deliverable Schedule:

- Project Start…… Jan 15 √
- Developed and validated 6-km HIOMAS…..... Jun 16 √
- Develop and validate 4-km HIOMAS……. Dec 16
- Conduct hindcast/forecast assessments…… Jun 17
- Project end date…….....Jun 19

Performance Metrics:

- Mean model error in ice concentration: < 30%, achieved.
- Mean model error in ice thickness: < 0.4 m, achieved.
- Mean model error in ice drift: < 0.02 m/s, achieved.

Program Champions:

- LCDR M. Kennedy, HQ USCG CG-751.
- Mr. H. Blaney, HQ USCG, CG-255.

Stakeholders:

- HQ USCG, USCG RDC, USCG Pac Area and USCG D-17.
- NOAA and NWS.

Point of Contact:

- Jinlun Zhang, Univ of Washington, Principal Investigator.

***See PowerPoint Notes for Project Abstract**

Baseline

- There are sea ice-ocean models that are used for Arctic forecast; most of the models have coarse resolution (> 10 km); few have high resolution (< 10 km).
- A rather common difficulty in high-resolution modeling is the overestimation of sea ice thickness in some areas such as the Beaufort Sea, resulting from the simulation of excessive ice deformation.
- Overestimation of ice thickness would affect many other state variables including sea ice movement and ocean currents.
- ADAC is aimed to develop a robust, stable HIOMAS that is able to simulate sea ice without spurious, excessive ice thickness buildup in wrong places in the Arctic.

Year 2 progress highlights (7/2015-6/2016)

- Developed HIOMAS based on the Pan-Arctic Ice-Ocean Modeling and Assimilation System (PIOMAS), with higher horizontal and vertical resolution.
- Initial model horizontal resolution is 6 km for the entire Arctic.
- Assimilated satellite sea ice concentration in HIOMAS to improve initial conditions for forecast.
- Tested HIOMAS configuration, forcing, open boundary conditions etc.
- Calibrated and validated HIOMAS using sea ice observations; no excessive ice thickness buildup in areas such as the Beaufort Sea.
- Conducted experimental forecast driven by the forecast atmospheric forcing from the NCEP Climate Forecast System (CFS).
- HIOMAS forecast data made available online by Rob Bochenek's group in year 3, part of the ADAC AIFC effort.

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Year 3 plan (7/2016-6/2017)

- Refine HIOMAS with even higher horizontal resolution targeting 2-4 km, depending on computer resources.
- Improve HIOMAS model physics and parameterization.
- Expand model calibration and validation using sea ice and ocean observations to reduce model errors.
- Conduct (near) real-time hindcast and daily to seasonal forecast of Arctic sea ice and currents; examine HIOMAS skills in hindcast and forecast and identify areas for further model improvement.
- Seek feedback from Arctic stakeholders (the CG, NOAA, NWS…) to better serve their needs.
- Work with the ADAC AIFC team for improved dissemination of forecast data in support of the CG and other customers (Arctic Environmental Response Management Application, ERMA).

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Year 3 progress to date

- Developed **two new versions of HIOMAS** with higher horizontal resolution; one 2 km resolution & one 4 km.
- The 2 km resolution HIOMAS is computationally time consuming to run on the existing computer; focusing on the 4 km resolution HIOMAS.
- Conducted **model validation** with the 4 km resolution HIOMAS using observations of ice thickness, concentration, and drift.
- It is **straightforward to run** the 2 km resolution HIOMAS on a more powerful computer.

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Science and customer relevance

- What is the relative importance of initial conditions versus atmospheric forcing in the variability and predictability of Arctic sea ice and currents?
- What is the impact of summertime heat storage in the upper ocean on the variability and predictability of sea ice?
- How do Arctic cyclones affect the variability and predictability of sea ice and currents?
- How do multi-year ice and ridged ice distribute and change in space and time? (inspired by field observations of Dr. Phil McGillivary, USCG PACAREA & Icebreaker Science Liaison)

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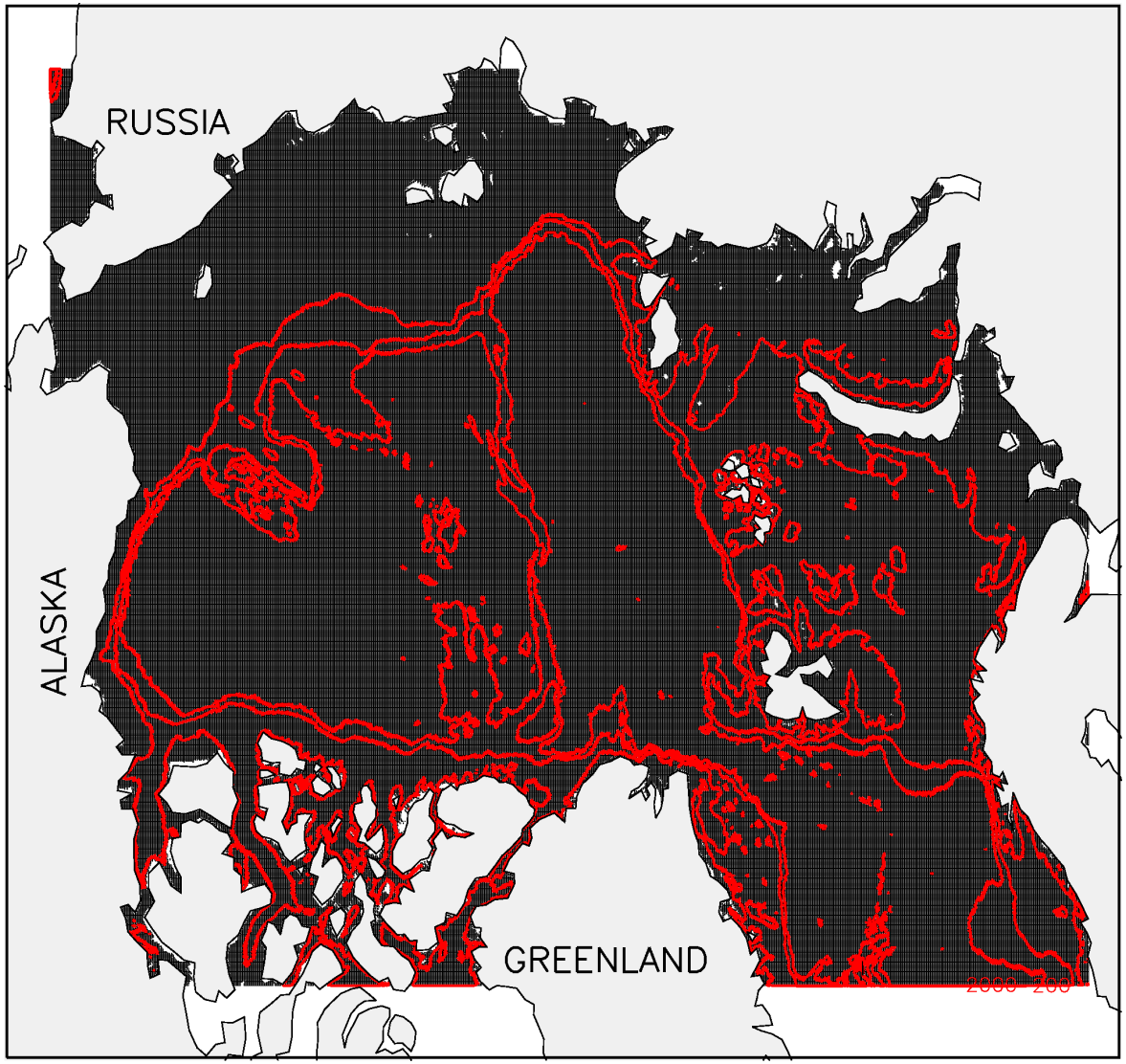
HIOMAS Grid Configuration (4 km resolution)



Red lines represent isobaths of 200, 1000, and 2000 m

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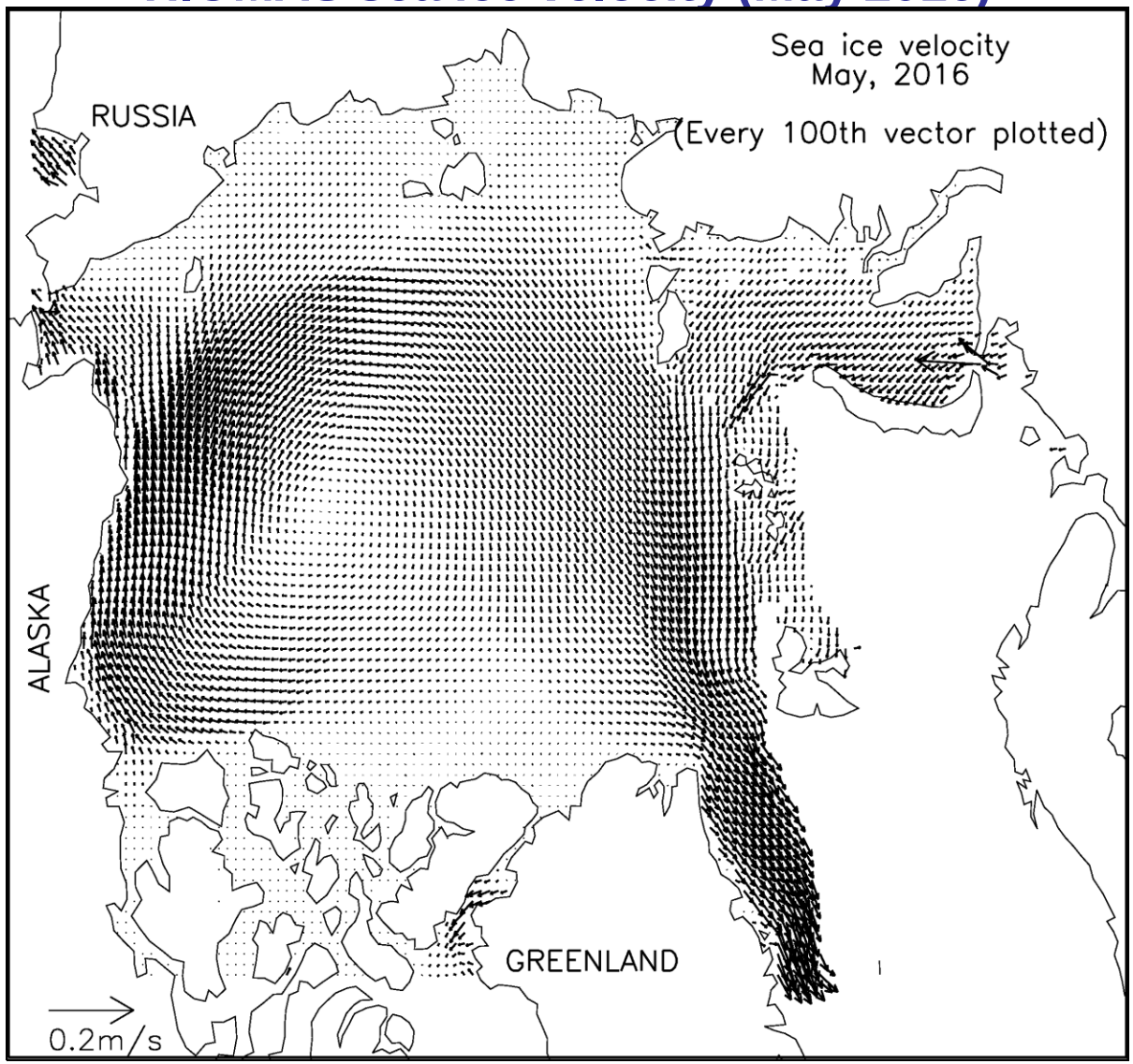
HIOMAS sea ice velocity (May 2016)



One of every 100 velocity vectors is plotted

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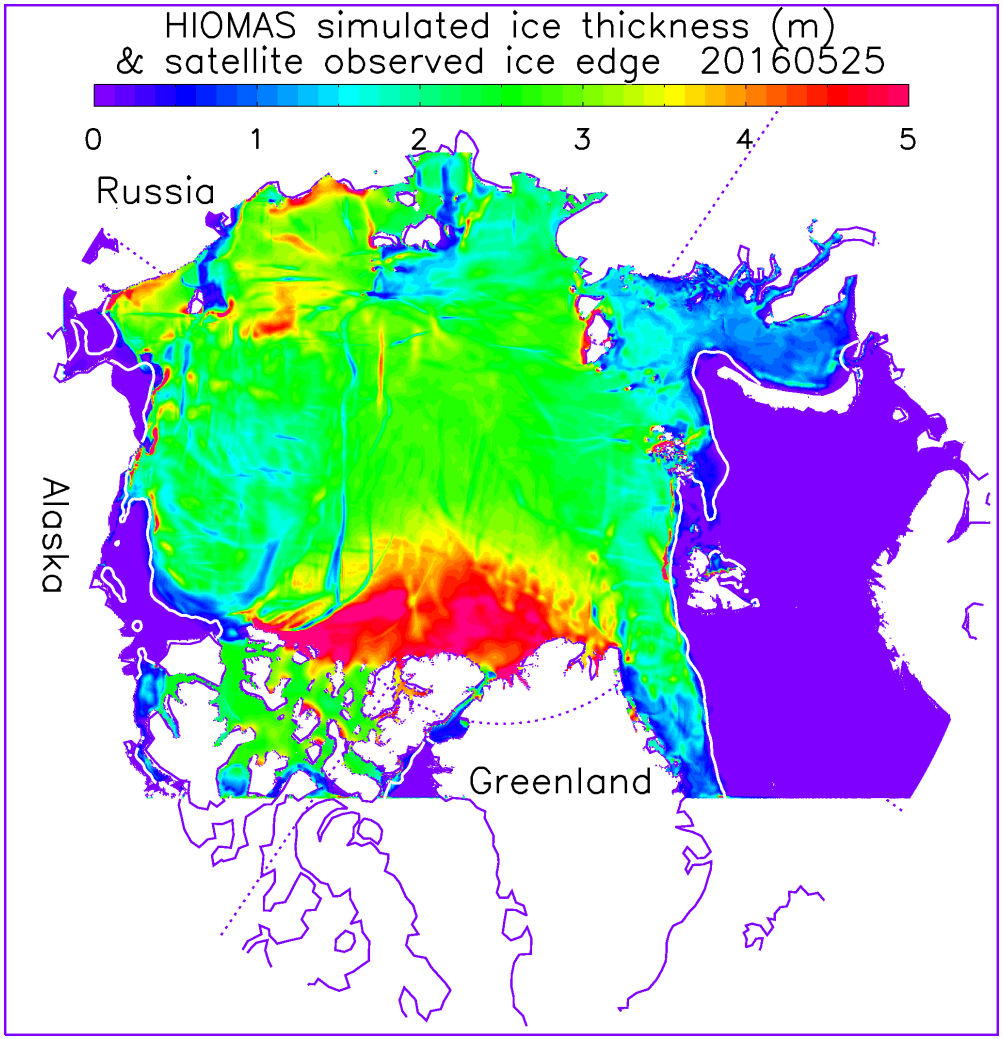
HIOMAS sea ice thickness & satellite observed ice edge – 5/25/2016



White line: satellite ice edge
Ice edge is defined as 0.15 ice concentration

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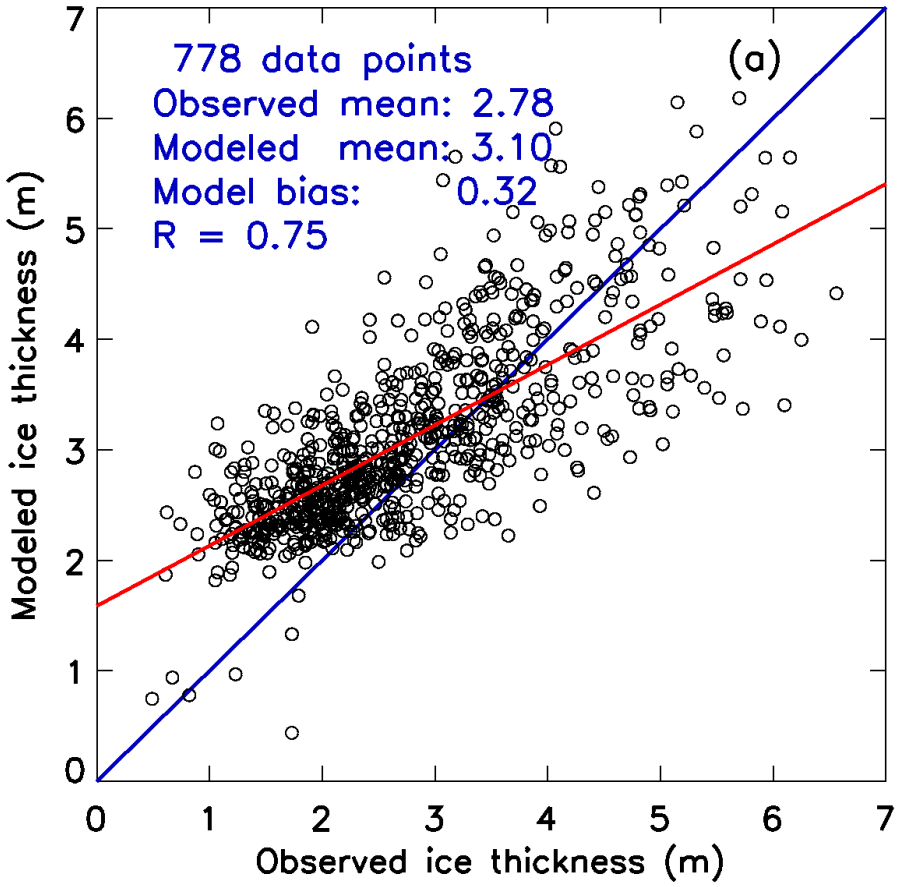
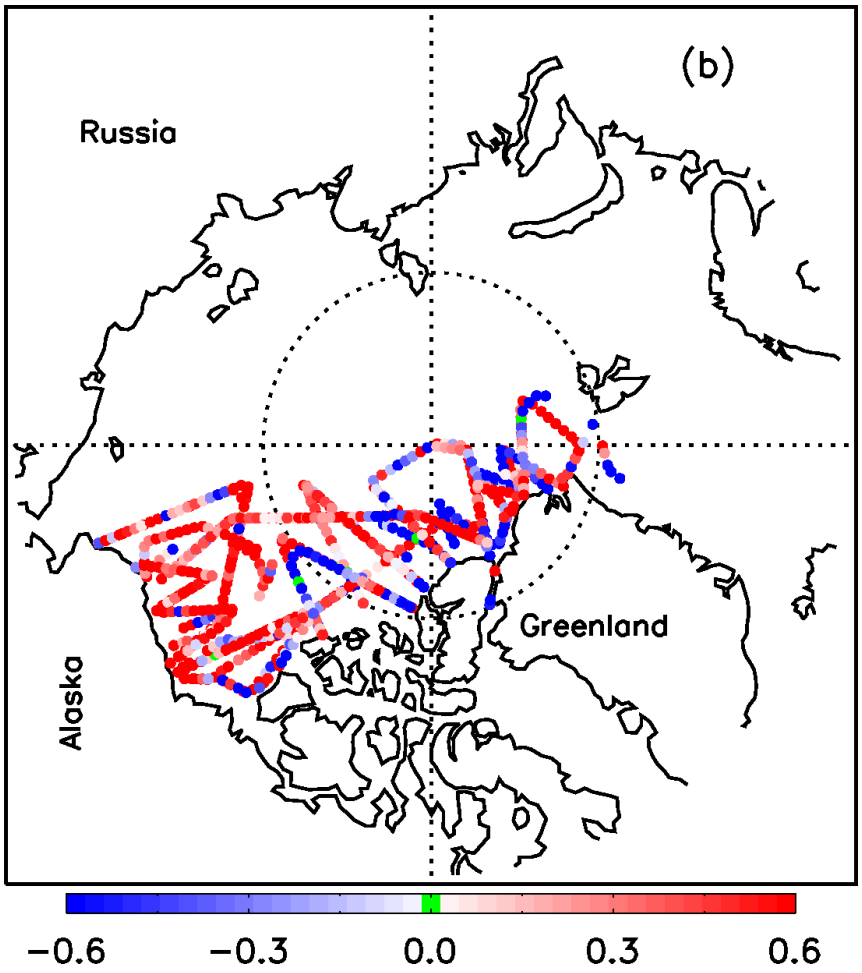
HIOMAS sea ice thickness compared with NASA IceBridge observations, 2013-2015



Thickness difference (HIOMAS – IceBridge)



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HIOMAS sea ice velocity compared with IABP buoy drift velocity data over 2014-2015

Buoy drift velocity data points: 19381

Buoy drift velocity mean: 0.095 m/s

Model ice velocity mean: 0.082 m/s

Model mean bias: -0.013 m/s

IABP: International Arctic Buoy Program

HIOMAS forecast data link:

http://axiomdatascience.com/maps/uaa-dhs?portal_id=85#module-metadata/243d368d-dbf2-4015-88f0-1d2190dfdfc9/7821edec-1504-4577-bda2-fdc0129f0b31

Thank you!

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