UFS – Arctic: *A pan-Arctic Regional Application of the UFS*

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NOAA GLOBAL OCEAN MONITORING & OBSERVING

CIRES

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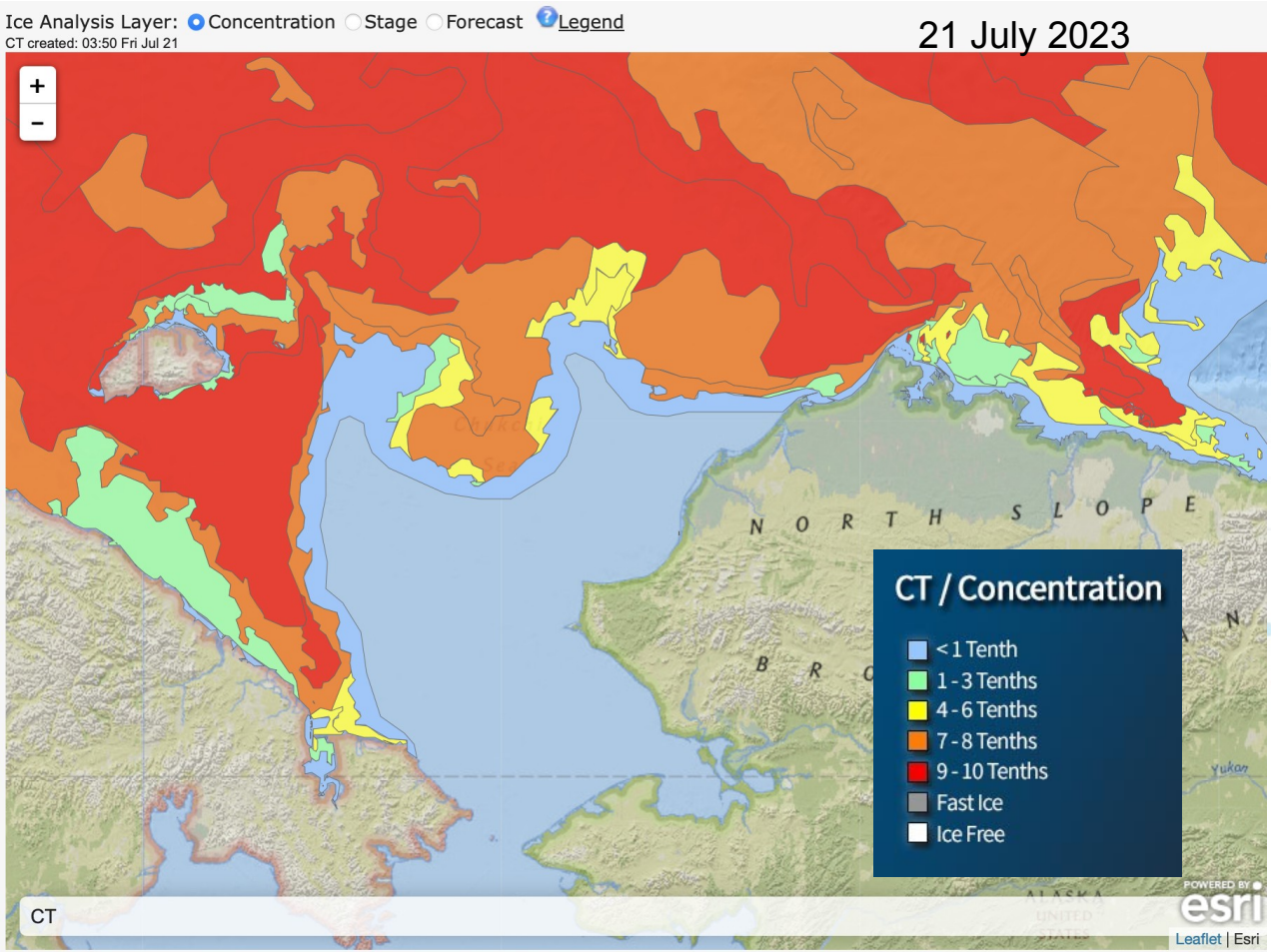

NWS
Alaska Sea Ice Program (ASIP)

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NOAA Sea Ice Modeling Collaboration (SIMC) Workshop

Boulder, CO, 25-27 April 2023

SIMC Overview

55 participants (34 in-person, 21 virtual attendees)

- NOAA OAR (PMEL, PSL, GLERL, GFDL, ARP), NESDIS (STAR), NWS (EMC, CPC, Alaska Region WFO), NOS (OR&R)
- Other agencies (DOE, NIC, NSIDC)
- Research universities (UAF, CU, UW, OSU, CO Mines, UMD, Brown, U Mich, etc.)
- International entities (AWI, Environment Canada)

Workshop outcomes included:

- Prioritized approaches for intra-OAR & cross-NOAA sea ice modeling collaborations
- Recommendations on prioritized & targeted model development projects with NOAA partners
- Transition opportunities & priorities for advancing NOAA's sea ice forecasting efforts

SIMC Themes

(just some example priorities identified)

- Sea Ice Model Development & Innovative Solutions

Implementation and evaluation of landfast ice parameterizations; water mass properties; floe size distribution; surface fluxes (thermodynamics); wave-ice interactions.

- Novel Ways of Evaluating the Sea Ice & Coupled Models

Process-oriented evaluation and tools; leveraging in situ observations

- New Opportunities for Advancing the Models Products/Target Applications

"UFS-Arctic"; develop evaluation plan between NWS users and OAR/partners via Alaska Testbed project

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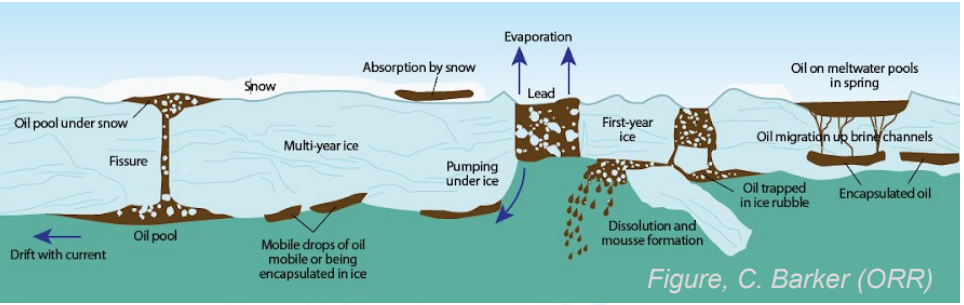
Detailed & specific needs: small scale, short lead



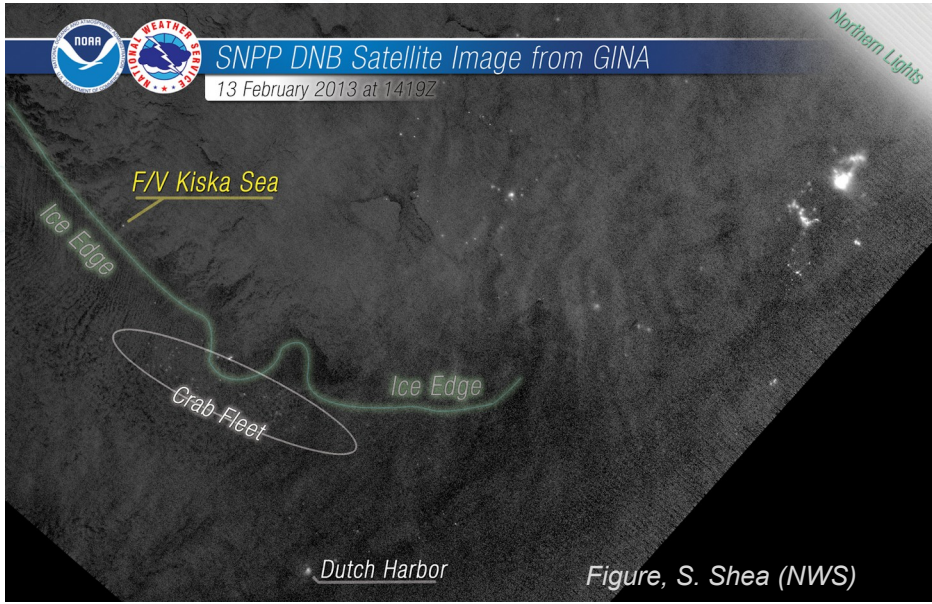
Figure, C. Barker (ORR)

From NOS ORR Oil Response (C. Barker):

“Could models provide more now?” Floe size distribution; ice bottom roughness; lead locations; keels.

From NWS Alaska Region (S. Shea): e.g.,

“Form and nature of the ice/ice edge is also a problem. While we can use the concentration data for the ice edge, what form it takes is important to us as well. Is there new ice growing out from the edge? Or is older ice stripping away from the pack?”

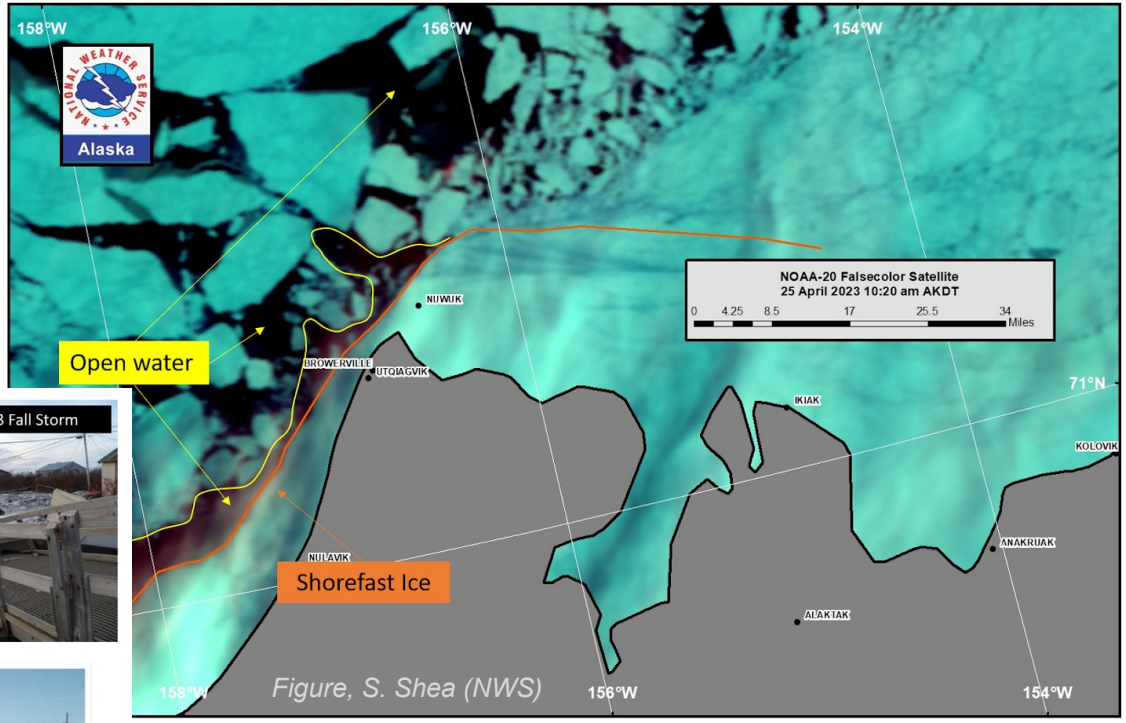


Figure, S. Shea (NWS)

Detailed & specific needs: coastal

Products related to landfast ice and near shore ice concentration & areas of open water.

Subsistence hunting; ice travel; runup/erosion; river breakup…



Figure, E. Petrescu (NWS)

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Detailed & specific needs: regional

e.g., development of Bering Sea cold pool:
critical for fisheries management.

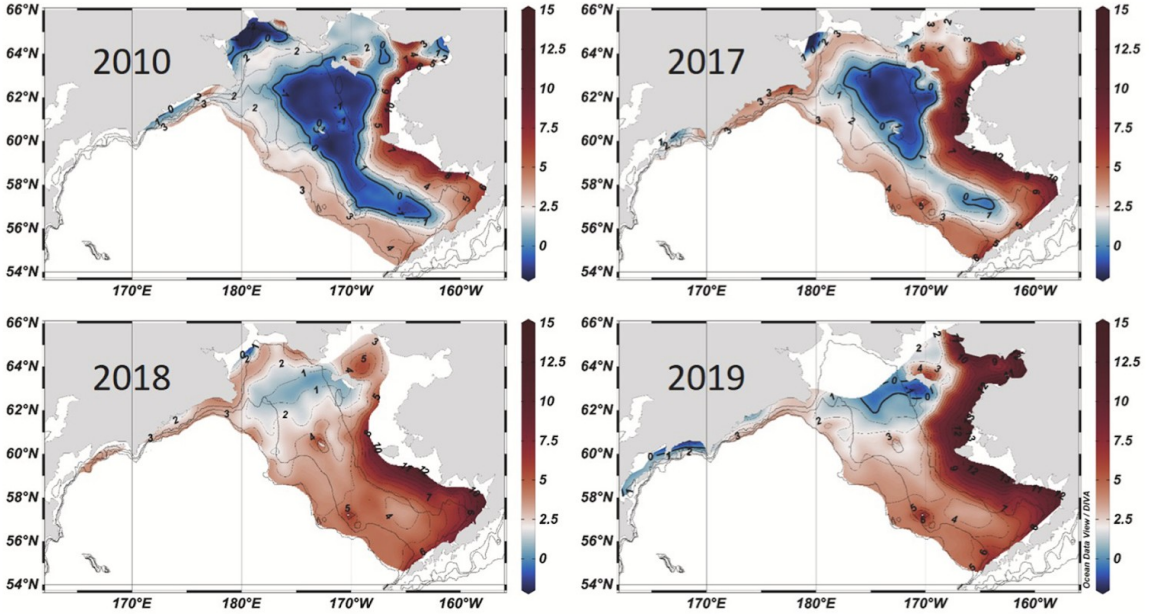

Fig. 4. Bottom temperatures from summer fisheries oceanography surveys for 2010, 2017, 2018, and 2019, normalized to July 15. The cold pool (<2 °C) is designated by blue with the 0 °C contour designated by the bold line. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Eisner et al. 2020 Deep Sea Res II

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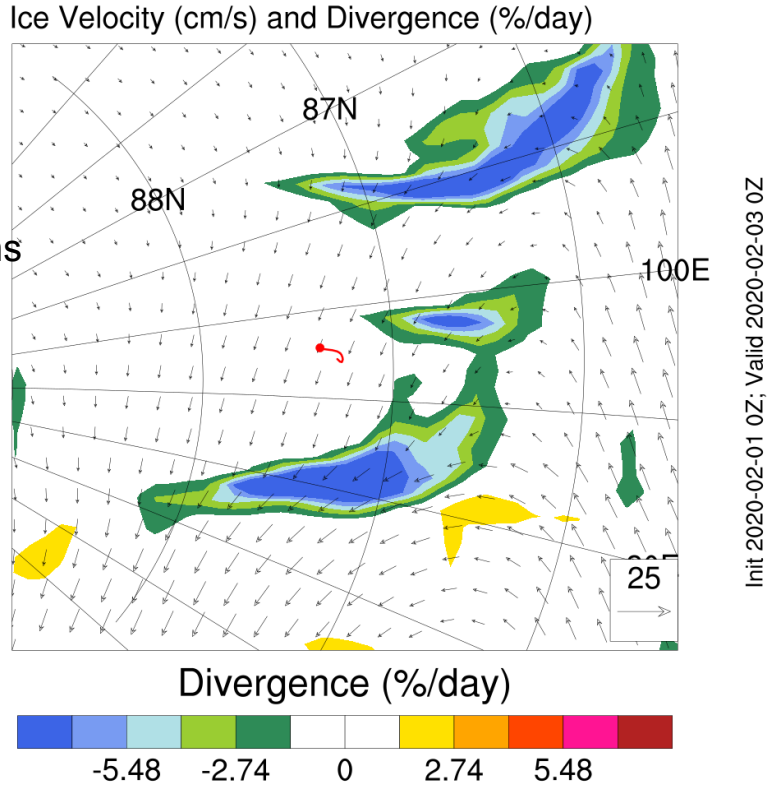
Detailed & specific needs: navigation

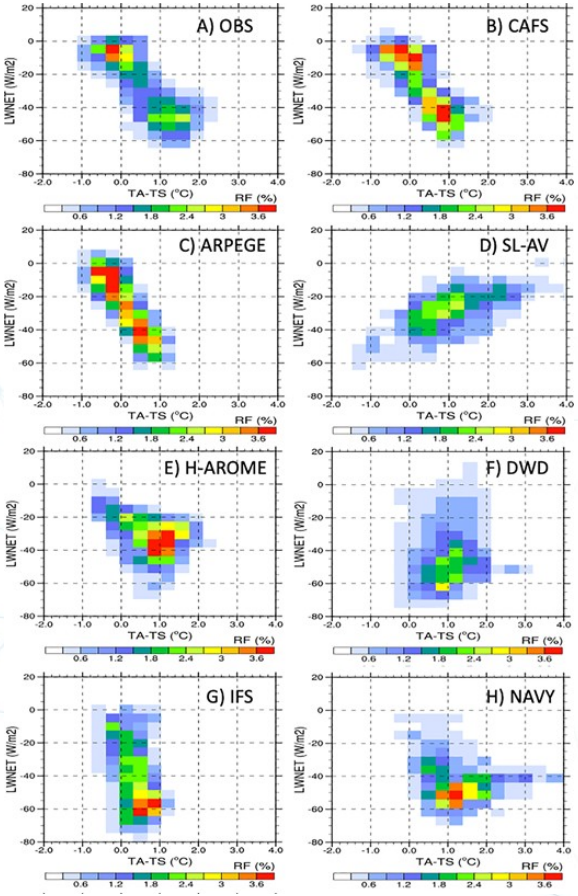
In addition to sea ice concentration and thickness…

Snow depth; internal stress; divergence; lead locations



e.g. Ice divergence forecasts provided to vessels during MOSAiC expedition, 2019-2020 by PSL

There are lots of issues affecting coupled sea ice modelling



Solomon et al. (2023)

For example…

- Model error in boundary-layer stratification frequently linked to inability to correctly simulate liquid-bearing clouds.
- Subgrid heterogeneities in surface roughness.
- Assumptions about subgrid deformation processes.
- Errors in ice drift when ocean processes dominate.
- Biases in snow conductivity, albedo, precipitation, snow depth…

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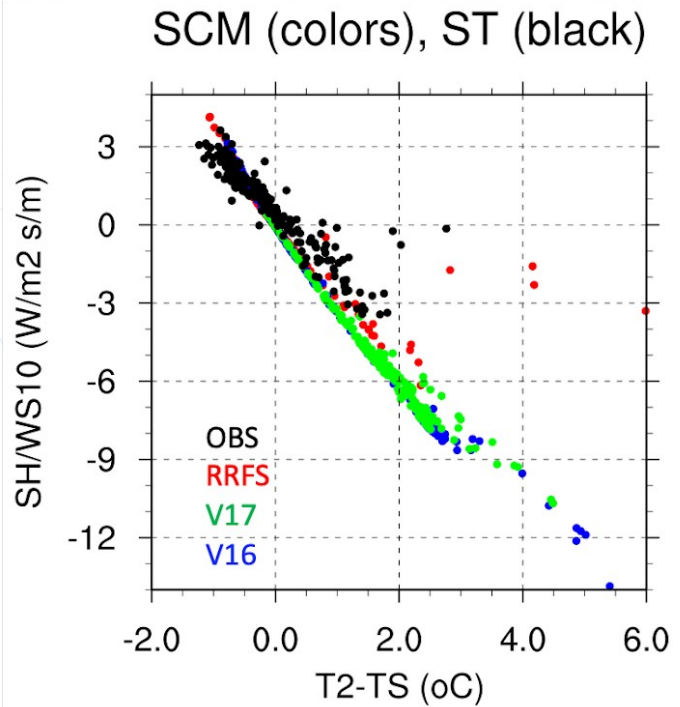
Work within the Physical Sciences Lab

Using the UFS-SCM to improve UFS Arctic Forecasts

- Focus on unique aspects of Arctic climate such as cloud water phase partitioning and strongly stably stratified boundary layers (and the coupling between these processes)
- Setup standard Arctic cases for SCM studies using MOSAiC observations and CAFS forecasts
- Evaluate parameterizations to be used in the new NCEP Forecast System

An example of a diagnostic to evaluate turbulence parameterizations



Work within the Physical Sciences Lab

- A community tool for regional modeling of the Arctic within the UFS:
  - PSL and EMC are beginning work to build capabilities to enable regional modelling of the Arctic in the UFS: “UFS-Arctic”.
  - Streamline R2O
    - Build capability that could be adopted as a future operational regional application.
    - Testbed for developing new products (e.g., related to shore fast ice, cold pool development, navigation…), parameterizations, and diagnostics.

From HAFS-MOM6 to UFS-Arctic: Some goals

FY2023

- Coupled MOM6/WW3/FV3
- Roving/telescoping nesting capabilities (for atmosphere) (carried over from HAFS workflow)
- Establish a new regional grid for Arctic for use with UFS
- Develop workflow for regional Arctic
- Test coupled configurations on case study

FY2024-2025

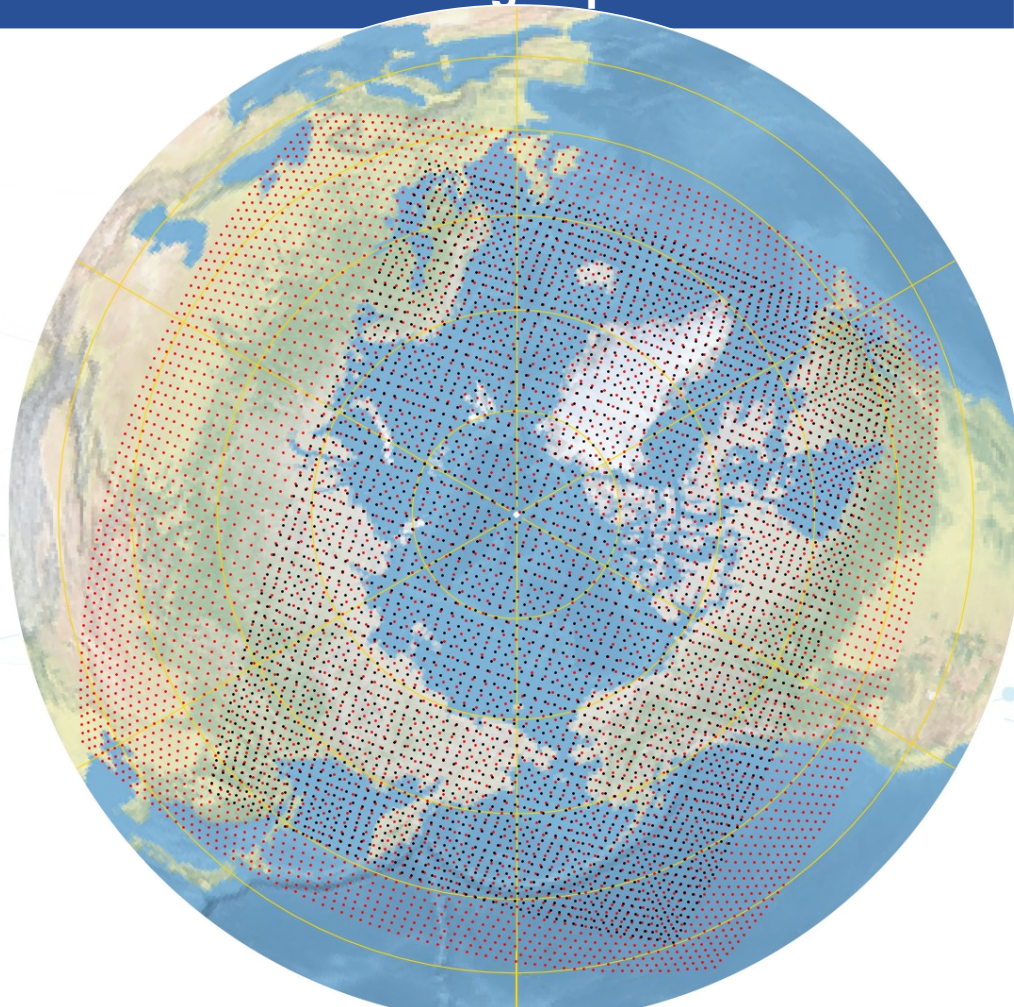
- UFS-MOM6/CICE6 Coupling
- In coordination with UFS physics development team, and CCPP physics management team, add microphysics used by PSL's CAFS model: Morrison et al. double-moment microphysics scheme (or coordinate with UFS physics team on inclusion of PUMAS)
- Develop and add "COARE-ice" surface-aware air-ice interactions (leverage with MOSAiC campaign data)
- Analyze subgrid parameterization of heterogeneity in mixed-phase cloud processes (leverage MOSAiC)
- Develop Process Oriented Diagnostics (POD) tools

Thinking ahead

- Coupled nesting capabilities to CICE?
- Forecast product development

From HAFS-MOM6 to UFS-Arctic: Domain advantages/plans

- Shared by non-UFS regional modeling within OAR (mostly BGC) (partner K. Hedstrom, UAF):
  - Climate Ecosystem and Fisheries Initiative (CEFI) eco modeling at GFDL
  - Bering Sea modeling at PMEL
- Coverage includes southern tip of Greenland and Alaska Fisheries regulatory areas.
- No ice at lateral boundaries.
- ~5 km resolution.



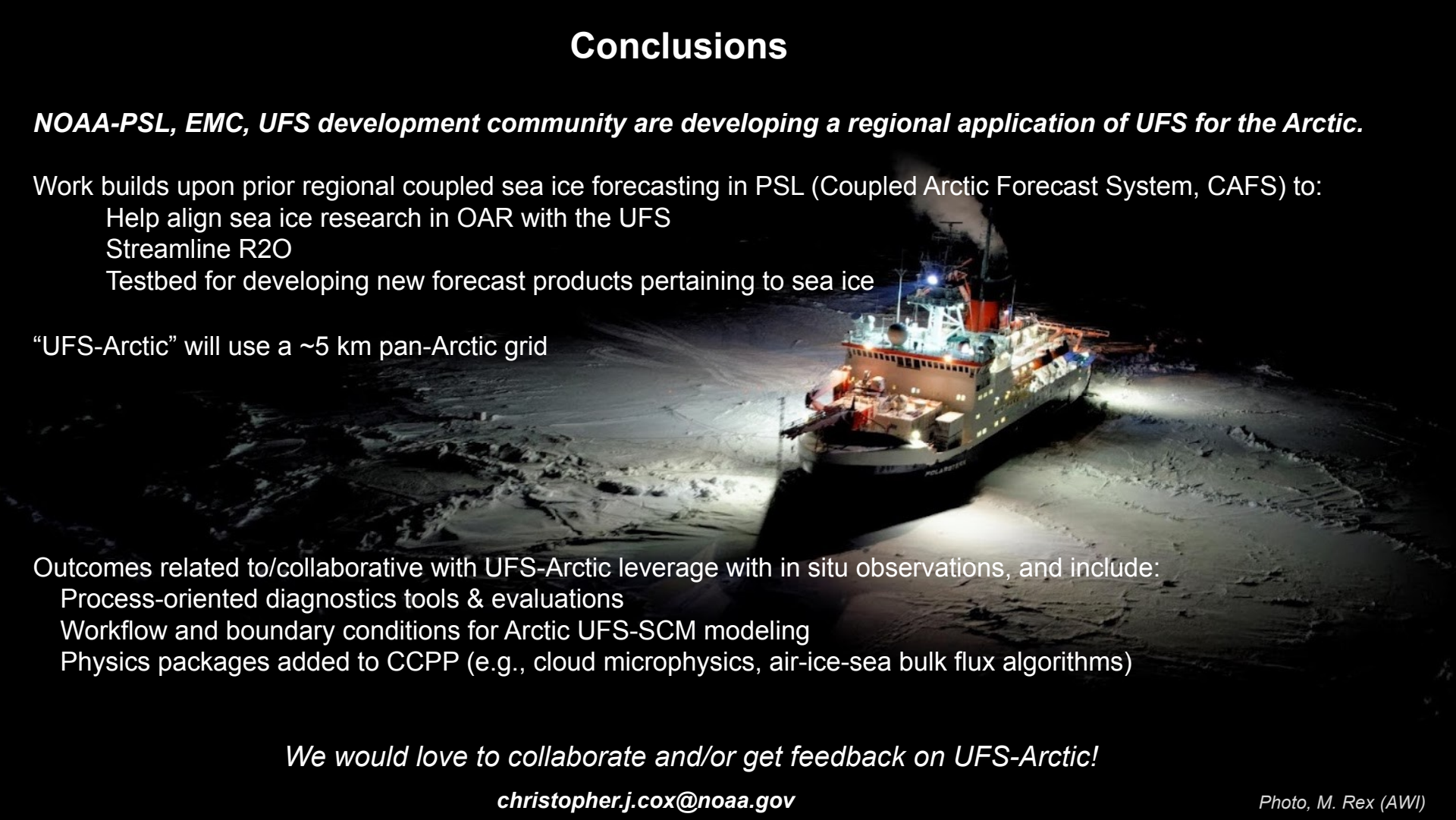
Conclusions

NOAA-PSL, EMC, UFS development community are developing a regional application of UFS for the Arctic.

Work builds upon prior regional coupled sea ice forecasting in PSL (Coupled Arctic Forecast System, CAFS) to:

- Help align sea ice research in OAR with the UFS
- Streamline R2O
- Testbed for developing new forecast products pertaining to sea ice

"UFS-Arctic" will use a ~5 km pan-Arctic grid



Outcomes related to/collaborative with UFS-Arctic leverage with in situ observations, and include:

- Process-oriented diagnostics tools & evaluations
- Workflow and boundary conditions for Arctic UFS-SCM modeling
- Physics packages added to CCPP (e.g., cloud microphysics, air-ice-sea bulk flux algorithms)

We would love to collaborate and/or get feedback on UFS-Arctic!

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Photo, M. Rex (AWI)