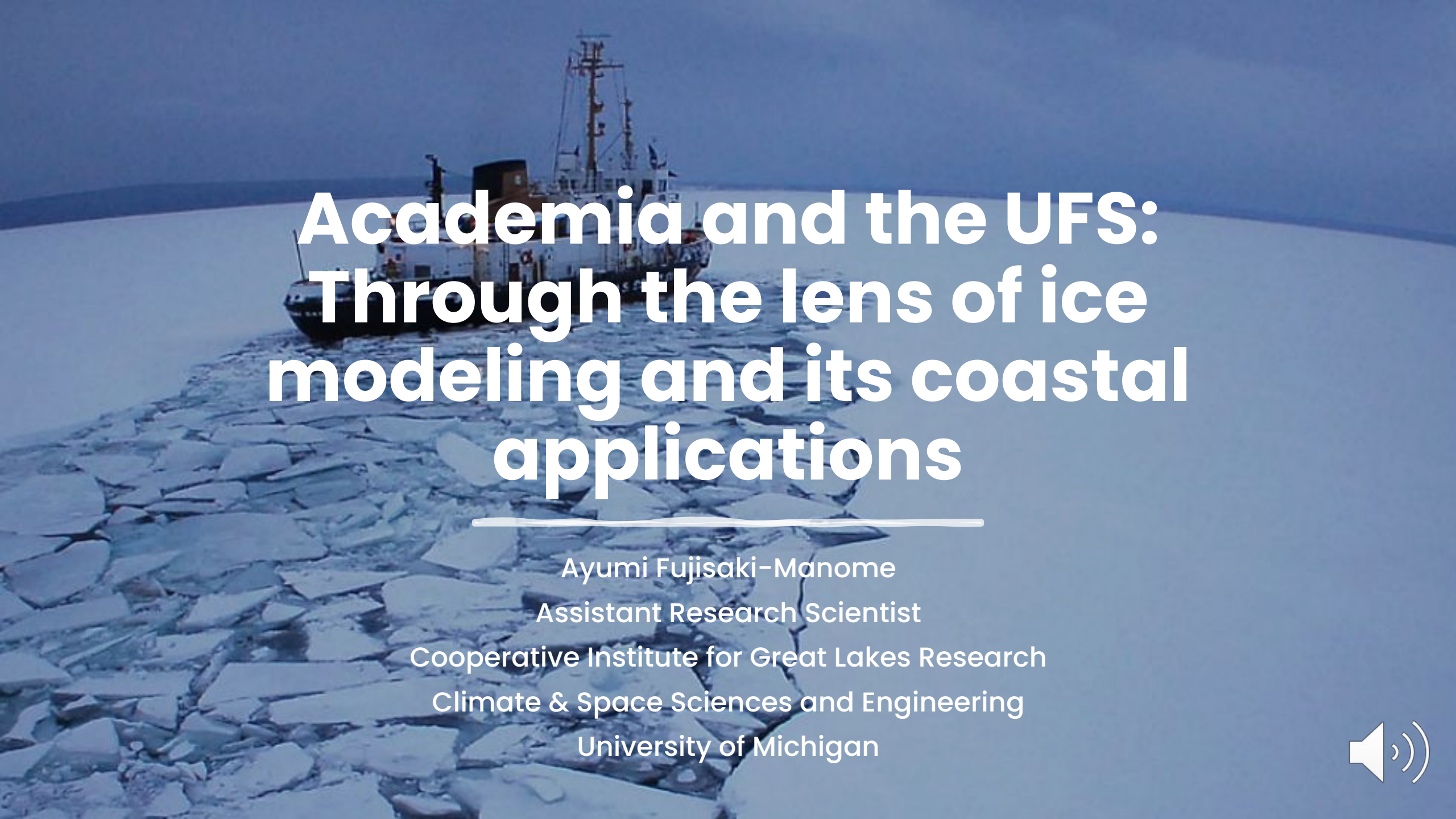


Academia and the UFS: Through the lens of ice modeling and its coastal applications

Ayumi Fujisaki-Manome
Assistant Research Scientist
Cooperative Institute for Great Lakes Research
Climate & Space Sciences and Engineering
University of Michigan

Ice model in Coastal Applications

Direct Impacts

- Severe threats to navigation,
- Resource for winter recreations

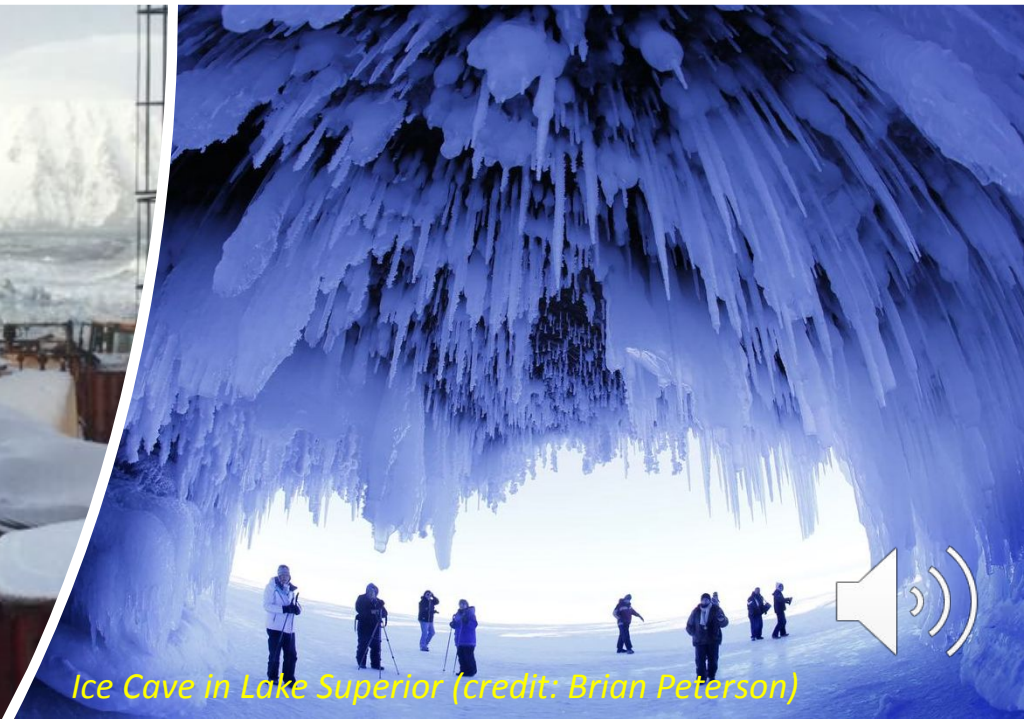
Modifier of heat flux, evaporation, and momentum flux

- Lake-effect snow
- Storm surges
- Thermal structure

Heavy lake effect snow impacting the traffic (credit: Jeremiah William)

USCG ice breaker breaking ice for a freighter (credit: John L. Russell)

Waves hammered the shore in Diomede during a storm on Feb 20. (Photo credit: Frances Ozenna)



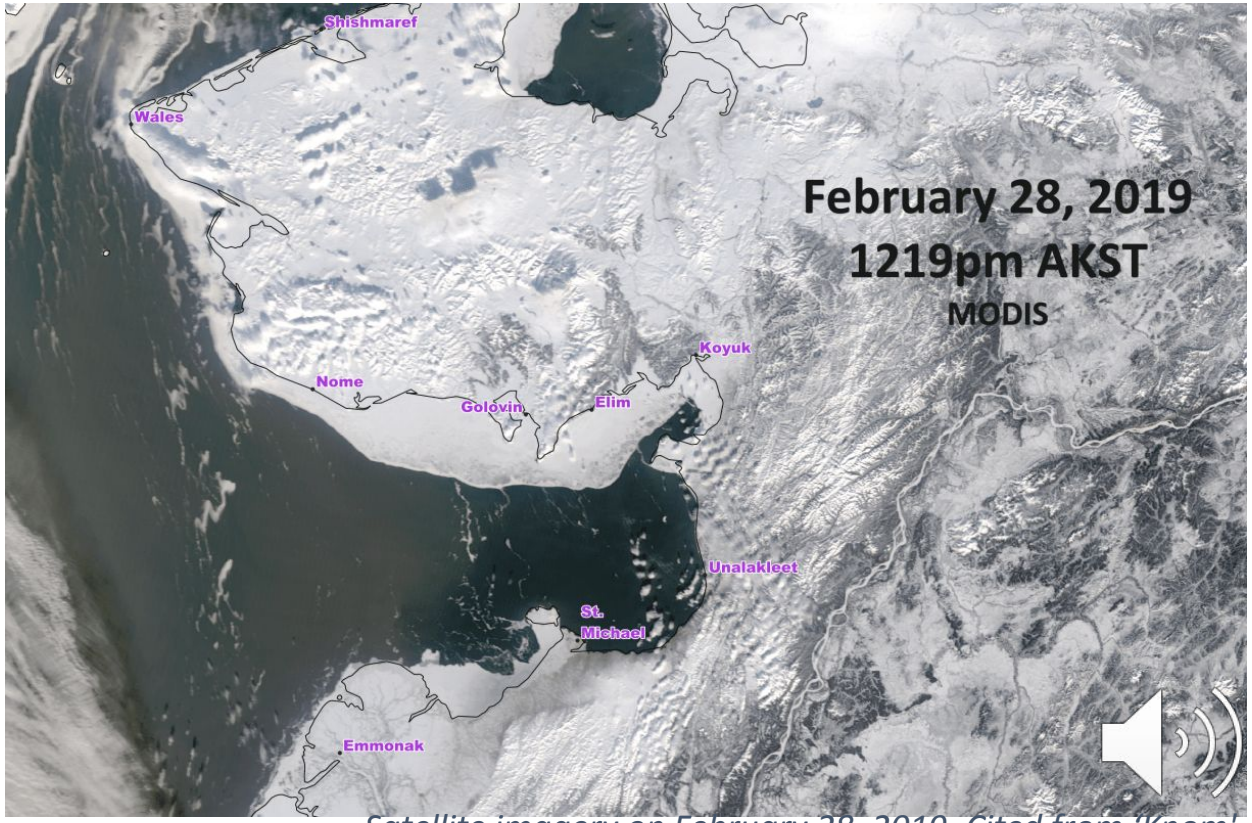
Ice Cave in Lake Superior (credit: Brian Peterson)

Two examples

Ice model in Great Lakes Operational Forecast System (GLOFS)

Photo Credit: NOAA Great Lakes CoastWatch

Ice model in Alaska Coastal Ocean Forecasting System (ALCOFS)



Satellite imagery on February 28, 2019. Cited from 'Knom'.

Ice model in GLOFS

GLOFS Timeline

Time

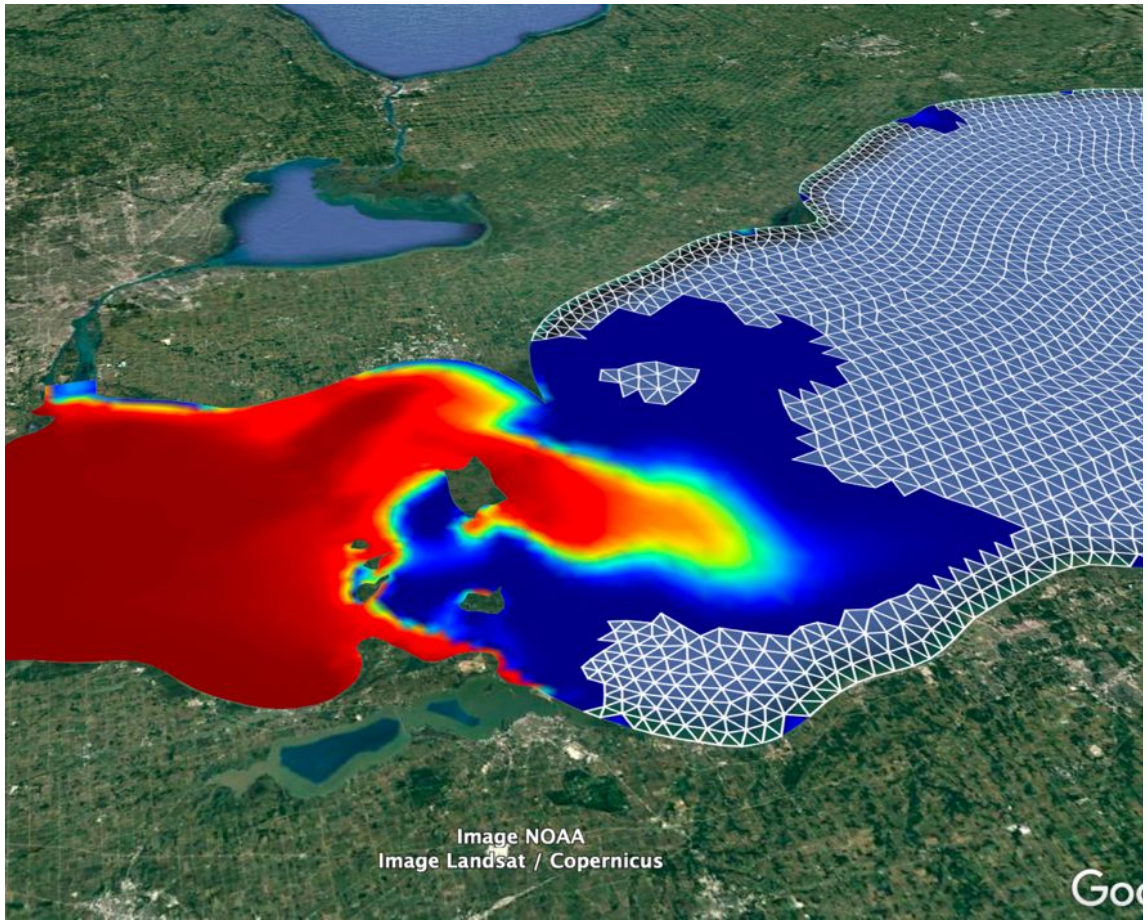
1990 R&D GLERL and Ohio State University

2004-2006 v1 GLOFS (Princeton Ocean Model)
2007 FVCOM application to Freshwater (Great Lakes)

2012 v2 GLOFS (FVCOM upgrade)

- 2016 LEOFS (Lake Erie)
- 2019 LMHOFS (Mich-Huron)
- 2022 LSOFS/LOOFS (Superior-Ontario)
- 2022 GLOFS-Ice (FVCOM-CICE)

Ice model addition



Ice converge simulated in Lake Erie by the Finite Volum Community Ocean Model (FVCOM) and Los Alamos Se Ice Model (CICE).

CICE: Los Alamos Sea Ice Model
RTAP: Research Transition Acceleration Program
HMT: Hydrometeorology Testbed
JTTI: Joint Technology Transfer Initiative

Ice model in GLOFS

- Internal module of FVCOM, based on CICE version 3-4 (old).
- Unstructured mesh
- Updates to include freshwater adjustments and reflect more recent versions of CICE.
- Fortunate funding situation (RTAP, HMT, JTTI) that enabled not only transition work and scholarly outputs
  - 6 publications from GLOFS ice modeling, not including other GLOFS pubs

- Internal, hard-coded model.
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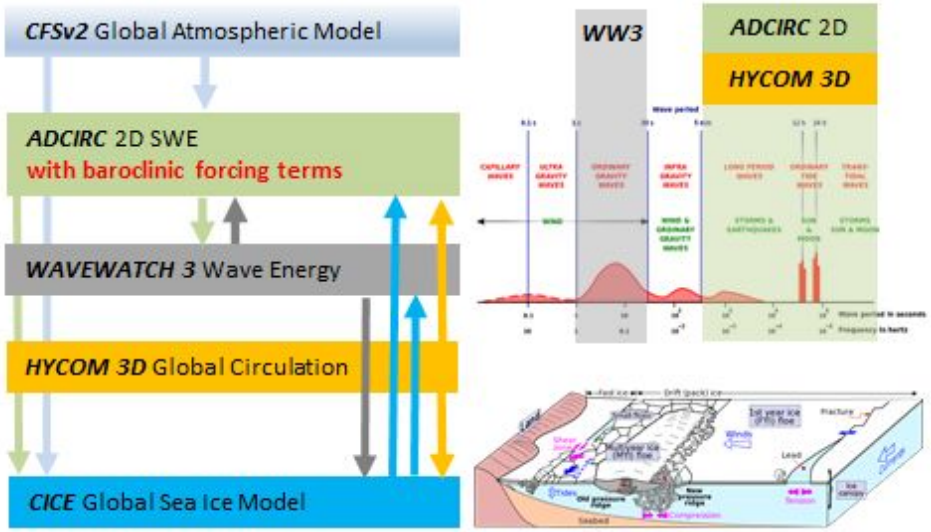
- R&D relies on a few people. → **Potential barrier for**

Ice model in GLOFS - continued

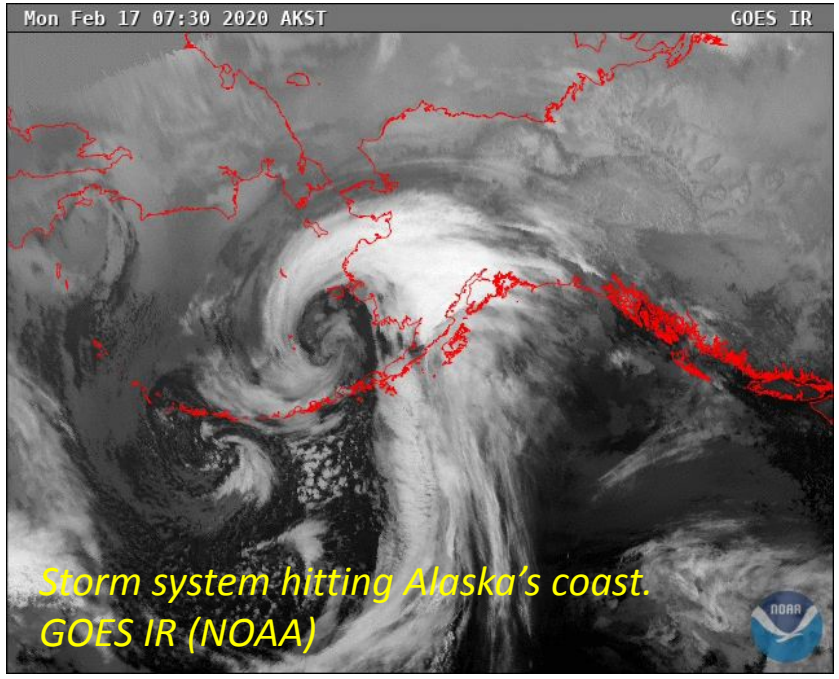
- Migrating to couple CICE6 with FVCOM through EMSF/NUOPC might remove the barriers.
- But challenges are …
  - CICE6 does not offer a dynamical core for unstructured mesh yet.
  - How can we reflect freshwater updates to GLOFS–ice model in CICE6?

Project lead PI: Joannes Westerink (U. Notre Dame)

Alaska ADCIRC+WW3+HYCOM+CICE model



(Source: Alaska Ocean Observing System)



Storm system hitting Alaska's coast. GOES IR (NOAA)

Ice model in ALCOFS

- Funded by IOOS for 2018-2022.
- Led by U. Notre Dame in collaboration with NCEP, NOS, GLERL, U. Texas, Axiom Data Science, U. Michigan.
- Advanced forecasting capability of surge, wave, and ice conditions for Alaska's coast.
- Use of CICE6 (more recent version)
  - high spatial resolution configuration (~3km)
  - detail nearshore physics (landfast ice, form drag parameterization)
- Coupling with storm-surge (ADCIRC) and wave (WAVEWATCH III) model components using the National Unified Operational Prediction Capability (NUOPC) layer.
- Getting help from NUOPC & NEMS experts at NCEP a… NOS.

Ice model in ALCOFS

- Most recent version of CICE (version 6)
- State-of-art physics parameterizations (e.g., form drag, tensile stress)
- NUOPC coupling allows easy migration to newer versions of CICE in the future.

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- Significant undertaking to develop a working app.

Factors for Success

- Stable funding commitment that supported from coding groundwork to innovative modeling & science.
- Connections to the experts at NWS & NOS

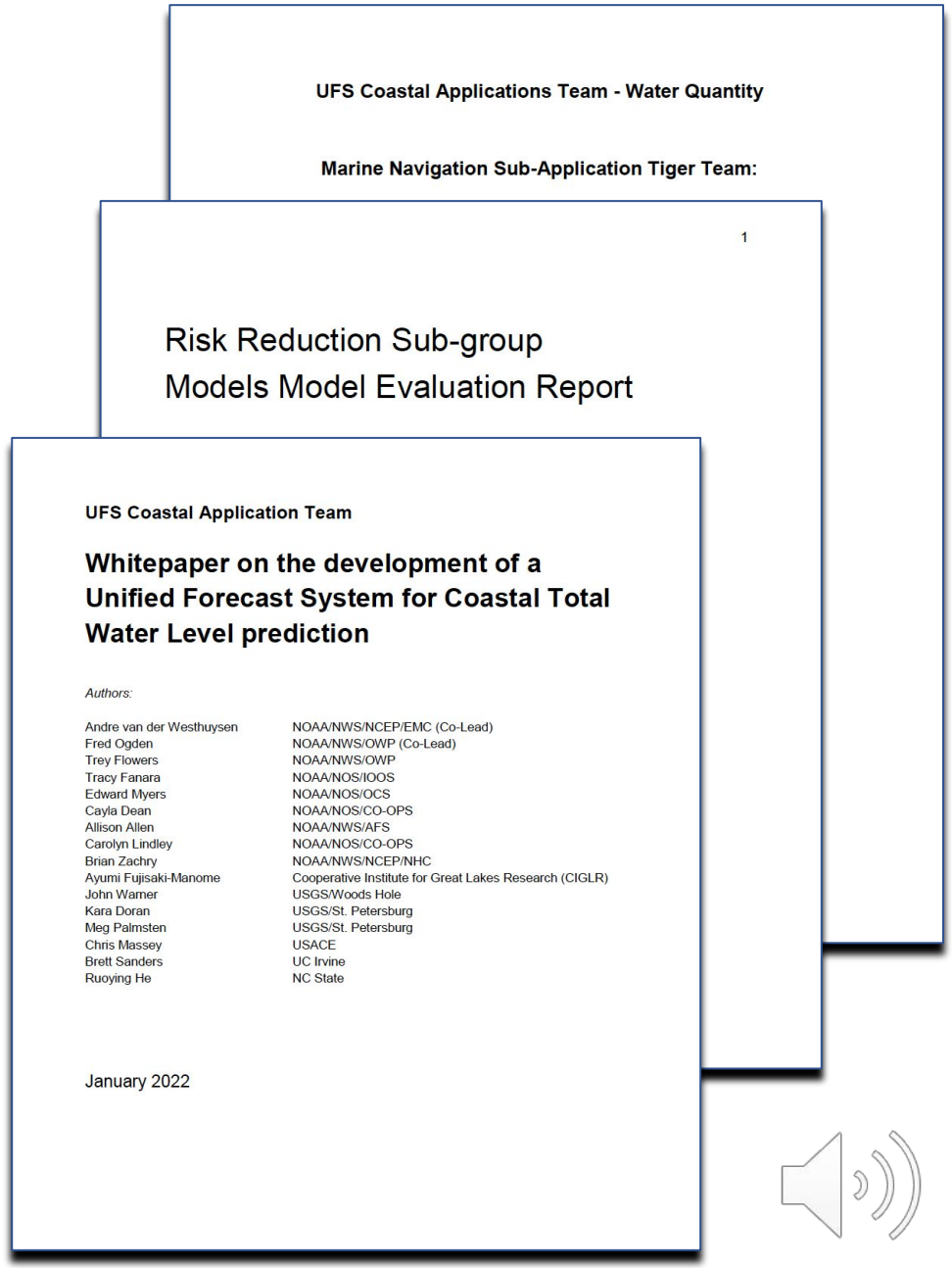
Opportunities, barriers

- UFS may enable better model portability, which may foster innovation.
- Significant coding efforts needed up-front. Not easily lead to publications. Can be a barrier postdocs/students.
- Easily accessible, simple configurations for regional applications (e.g., ICE-ATM-OCN) could save substantial coding groundwork.
- Knowing the right people (e.g., at NOAA, UFS) appears critical. This can be a barrier to academic people who do not have these connections already.

Example participation of Academia in UFS

UFS Coastal Applications Team – Water Quantity

- Academic and government testers evaluate coastal ocean models for three sub-applications
  - Safe, Efficient Navigation
  - Risk Reduction
  - Total Water Level
- Academic testers use common computing platform (TACC), domain & bathymetry, evaluation criteria, etc.




Thank you !