Align with NOAA's mission on
Climate Adaptation and Mitigation
Weather-Ready Nation
Healthy Oceans
Resilient Coastal Communities and Economies
Science Informed Society
Safety and Preparedness
Future Workforce
IPEMF Team

- Brent Lofgren – Climatologist
- Eric Anderson – Hydrodynamic Modeler
- Drew Gronewold – Hydrologist
- Jia Wang – Ice Climatologist
- Craig Stow – Ecosystem Modeler
- Anne Clites – Physical Scientist
- Greg Lang – Physical Scientist
- Tim Hunter – IT Specialist

- Becky Bolinger, Lisi Pei (UCAR PACE fellow)
- Jam Charusombat (NRC postdoc)
- Ayumi Manome, Dima Beletsky, Raisa Beletsky, Haoguo Hu, Andy Xiao, Heather Lucier, Joeseph Smith, James Kessler (CILER)

People first, mission always!

This team is highly skilled with diverse backgrounds and research interest, and are experts in their fields!

Brent is going to talk about Climate-land surface modeling (climate adaptation and mitigation)
Eric will cover the hydrodynamic modeling aspect and extreme event (weather ready nation and healthy ocean)
Drew will talk about hydrologic modeling
Craig will cover ecosystem modeling approaches and nutrient loading
IPEMF Goals

- Conduct innovative research and model development on key processes of the Great Lakes
- Transition research/models/tools/knowledge to operations and applications
- Promote internal and external collaborations
- Data management, data sharing and product dissemination
Climate Modeling – Brent Lofgren

Research and Development

- Climate Weather Research and Forecast Model (WRF) and RegCM4 (Regional Climate Model system) applications
- WRF-Hydro development for the Great Lakes
- Lake surface heat fluxes evaluation and comparison

Products & Services

- Extensive community outreach to decision makers and citizens

NOAA Goals: Climate Mitigation, Weather-Ready Nation
Hydrodynamic Modeling – Eric Anderson

Research and Development
• HAB forecasting
• Contaminant transport
• Meteotsunami & extreme water level events

Research to Operations
• Next-Gen GLOFS to NOS
• LEOFS to NOS in April 2016
• 1 lake/yr for the next 5 years
• 2 RTAP (Research Transition Acceleration Program) funded to speed up transition

NOAA Goals: Weather-Ready Nation, Healthy Oceans, Resilient Communities
Hydrologic Research – Drew Gronewold

Research and Development
- Establish Great Lakes evaporation network
- Develop novel statistical models
- Develop WRF-Hydro framework for the Great Lakes

Transition to Operations (R2O)
- Water level forecast system for Niagara River to NYPA/OPG and NERFC
- AHPS and hydraulic model to USACE & IJC

Products & Services
- Serves on scientific and interagency committees
- Extensive public education and public outreach
- Various hydro-meteorological database and long term water level software applications

NOAA Goals: Climate Mitigation, Weather-Ready Nation, Resilient Communities

AHPS - Advanced Hydrologic Prediction System
NERFC – Northeast River Forecast Center
NYPA - New York Power Authority
OPG - Ontario Power Generation
FVCOM | Finite Volume Community Ocean Model is a modeling tool that enables high resolution (30 meters – 2 km) unstructured grid (i.e., triangular shapes of adaptable size) representation of the coastal system; a better approximation of the integral form of the equations of motion; tracking of seasonal lake level fluctuations; inflows and outflows at major connecting channels; expanded coverage to connecting waterways (Straits of Mackinac, St. Clair River, Lake St. Clair, Detroit River, upper St. Lawrence River).
Ecosystem Research and Modeling – Craig Stow

Research and Development
• Bayesian network
• Ecological modeling
• Model uncertainty analysis

Products & Services
• Great Lakes Water Quality Agreement
  Annex 4 subcommittee on nutrient loading reduction
• OAR Modeling Uncertainty workshop
• Cladophora Workshop

NOAA Goals: Healthy Oceans, Resilient Coastal Communities
Innovative Research

- Improve understanding of the interactions between the physical, biological, and ecological components of the whole Great Lakes ecosystem

- Develop and implement numerical models (climate, atmosphere, lake circulation, hydrology, wave, ice, and ecology) through improved physics, better forcing, higher spatiotemporal resolution
What’s new on the Next-Gen GLOFS?

- Unstructured grid Finite Volume Ocean Model (FVCOM) to resolve complex shoreline, channels and islands
- High spatial resolution (200m) with extended forecast range (120 hours out)
- Improved initial and boundary forcing fields
- Fully-coupled ice module to provide ice guidance

Upgrade from 5km grid to 200 m in the coastal and bay areas.
Original Lake Erie has 1600 grid cells, the new Lake Michigan-Huron has more than 130,000 element!
Great Lakes Operational Forecast System R2O Transition Milestones

- LSOFS 2019
- LMHOFs 2018
- HECOFs 2021
- LEOFS 2016
- LOOFs 2020

Lake Erie HAB tracker to NOS/CO-OPS 2019
Coupled GL Lake-Wave-Ice system to NWS/NCEP 2025
LEOFS transition to NOS in April, 2016

HEC - Huron-Erie Corridor
Collaborating Partners

**NOAA**
NOS: CO-OPS, NCCOS and CSDL  
NWS: NCEP, NWC, WFO and RFC,  
OAR: ESRL, PMEL, NSSL and GFDL

**Other federal government agencies**
Environment Canada, IJC, USACE, USGS, EPA, USCG

**Academic Institutions**

**Stakeholders**
NYPA, OPG, NRC, Limno-Tech, GLOS, and GLIN

UW Madison: Meteotsunamis research. Thesis and dissertation research

MTU: Lake Superior long term climate impact and model coupling research

MSU: Climate-land surface interaction study

U Toledo: Bayseian network approach for nutrient loading

Tulane University: NOAA RESTORE project focusing on Mississippi River and Gulf of Mexico interactions  
Thesis and dissertation committee
What’s Next?

- Continue to conduct innovative research
- Continue to improve model accuracy and extend forecast capability
- Continue to promote collaboration
- Promote environmental data management and data sharing practice
- Rebuild in-house GIS capability

For the last 10-15 years, model improvements pretty much focus on improving model physics, processes, increasing spatial resolutions or improving boundary forcing. Each model (atmos, hydrodynamic, wave, hydrology) are run either loosely coupled or uncoupled mode.

For the next 5-10 years, we plan to apply NOAA’s objective of developing and implement an integrated environmental modeling approach.
An Integrated Environmental Modeling System

- Climate & Meteorological Models
- Wave Models
- Hydrodynamics & Ice Models
- Sediment Transport Models
- Ecological & Food Web Models
- Harmful Algal Bloom & Hypoxia Models
- Land Surface Watershed Hydrologic & Hydraulic Models
This team conducts high quality research, not limited to the Great Lakes, but also throughout other geographic regions, such as the Gulf of Mexico and the Arctic.

The research and products we produce are relevant to NOAA’s mission and are transitioned to NOAA operational line offices and other decision-making agencies.

Images:
Top: Researcher D. Gronewold presentation on Great Lakes water levels at the Thunder Bay National Marine Sanctuary, Alpena, MI.
Bottom: Scientist Anne Clites is interviewed about water levels by Alpena News at Thunder Bay National Marine Sanctuary, June 27, 2013.
We held a community user outreach meeting for the next generation of GLOFS in last October. For years we know the system and products we produced are very popular for commercial and recreational fishermen, and surfers. What we did not expect is the heavy users from the above industry!

What do our product users say

- “We look at GLOFS wind, wave, ice forecasts everyday for search and rescue missions (SAR), GLERL’s products save lives!” Jerry, USCG 9th District Cleveland Office
- “We regularly check GLOFS forecasts for high/low water levels and waves for all the nuclear power plants operation around the Great Lakes!” Jack, Nuclear Regulatory Commission
- “We use GLOFS water level forecasts to determine how much water to release to Niagara River, accurate forecasts save $30M/year!” Peter, (NYPA)
Hold weekly GLOFS conference call between GLERL, CSDL and CO-OPS to discuss status and issues
Quarterly meeting with modeling advisory panels and gateway manager to check progress and milestone schedule
Biannual face-to-face meeting and workshop at Silver Spring

Integrated modeling approach to predict hypoxia, HABs and other ecological and water quality parameters
Brief History of IPEMF’s R2O effort

- 1989: Developed GLFS with OSU
- 1991: First 3-D Lake Erie nowcast on CRAY
- 1992: GLFS workstation version running at GLERL
- 1993: First 3-D forecasts
- 2000: GLFS team won the AMS Special Award
- 2003-2005: Transitioned GLFS to NOS/CO-OPS
- 2016-2021: Next-generation GLOFS being transitioned to NOS/CO-OPS and NWS/NCEP
## Transition to Operations (R2O)

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<tr>
<th>Project/Product</th>
<th>Technical Readiness Level (TRL)</th>
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<tr>
<td>Lake Erie Operational Forecasting System (LEOF)</td>
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<td>Huron Erie Canalway Operational Forecasting System (HECF)</td>
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<td>Lake Michigan-Huron Operational Forecasting System (LHOF)</td>
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<td>Great Lakes PILOT Ice Model</td>
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<td>Lake Ontario Operational Forecasting System (LOOF)</td>
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<td>Short Term River Forecasting System for the Niagara River</td>
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<td>Advanced Hydrologic Prediction System (AHPS)</td>
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<td>Combined Great Lakes Regulation and Routing Model (CGLRMM)</td>
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<tr>
<td>Long Term Water Level Forecast System for the St. Lawrence River</td>
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<td>Lake Erie NRO Operational Forecasting System (LEROF)</td>
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<td>Coupled PILOT-WaveWatch-II for Great Lakes</td>
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### Technical Readiness Level (TRL) Definitions

1. Basic principles have been observed and reported.
2. Technology concept and/or application has been formulated.
3. Analytical and experimental critical function and/or characteristic proof-of-concept.
5. Component/subsystem validation in a relevant environment.
6. System/subsystem model or prototype demonstration in a simulated and/or validated environment.
7. System prototype demonstration in a simulated and/or validated environment.
8. System prototype demonstration in an operational environment.
9. Actual system components and/or prototype deployed and “mission qualified” through field tests and operational assessment.
10. Actual system deployed in a relevant environment.
### Transition to Applications (R2A)

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<td>Biological Oxygen Demand Model (BODM)</td>
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<td>Estuarine Model (ESTM)</td>
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<td>Hydrodynamic Model (HYD)</td>
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<td>Economic Model (EM)</td>
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#### Technical Readiness Level (TRL) Definitions:

1. Basic principles have been observed and reported.
2. Technology concept and/or application has been formulated.
3. Conceptual design has been demonstrated in an operational environment.
4. Operational demonstration has been conducted in a relevant environment.
5. Pre-operational validation has been conducted in a relevant environment.
6. Actual systems have been operational in a relevant environment.
7. Actual systems have been operational in a relevant environment.
8. Actual systems have been operational in a relevant environment.
9. Actual systems have been operational in a relevant environment.
10. Actual systems have been operational in a relevant environment.

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Additional information