Artificial Intelligence (AI)-Enhanced Space Surveillance for Sea Resources Safety

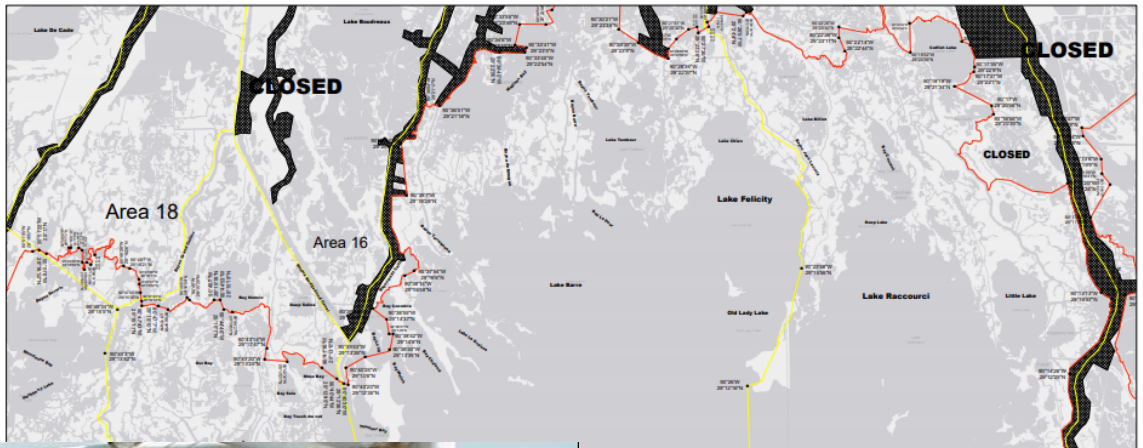
Zhiqiang Deng
Department of Civil & Environmental Engineering
Louisiana State University
E-mail: zdeng@lsu.edu

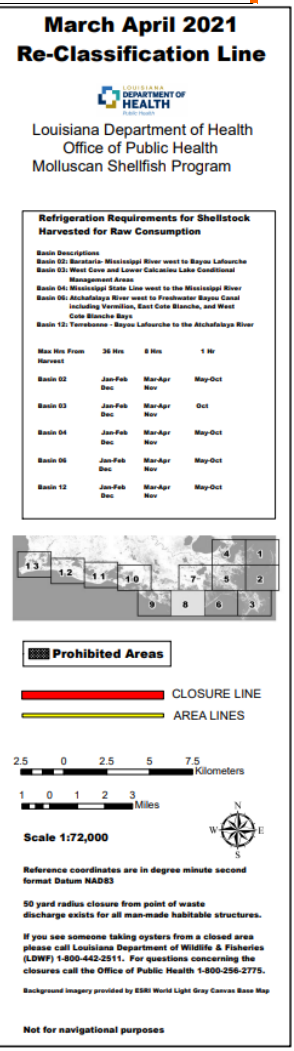
Outline

- Background: Sea Resources Safety Issues
- Important Indicators of Sea Resources Safety
  - Sea Surface Temperature (SST)
  - Sea Surface Salinity
  - Solar Radiation
  - Chlorophyll-a Concentration
- Artificial Intelligence-Enhanced Space Surveillance
  - Oyster Norovirus Outbreaks
  - Vibrio Concentration in Oysters
  - Harmful Algal Blooms
- Conclusions

Sea Resources Safety Issues

- Monthly Monitoring vs Daily Harvest of Oysters





Sea Resources Safety Issues

Shutc

Norovirus Outbreak in Washington Associated with Raw Oysters

ears

March 29, 2017 by Linda Larsen

Chris Kirkham

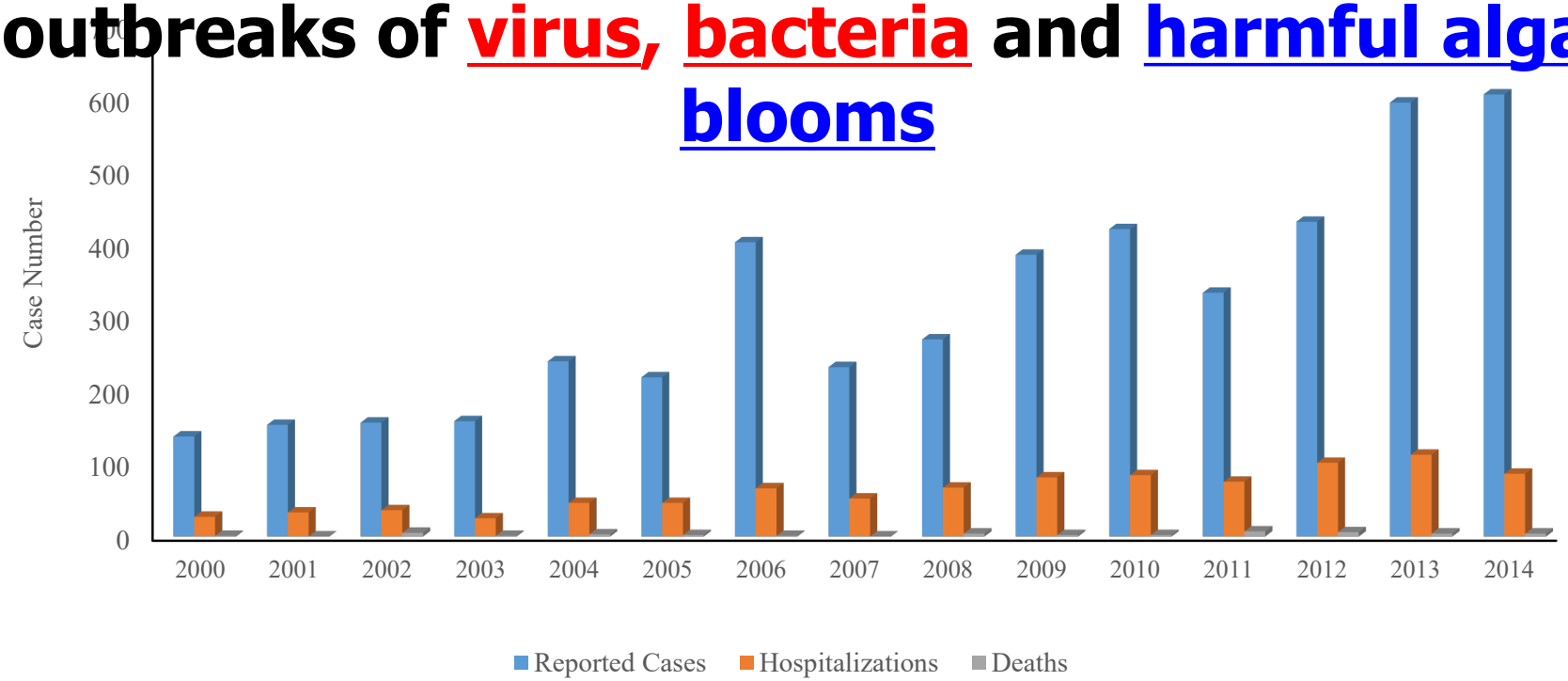
Public health officials in Seattle and King County are investigating multiple reports of a norovirus-like illness in people who ate raw oysters. Since January, officials have received reports that as many as 39 people were sickened after eating that shellfish. Illnesses have been reported during the time period ranging from January 10 through March 20, 2017.

oysters-shu

It was reported that "some of the larger recalls have been in the millions of dollars" (http://www.nola.com/environment/index.ssf/2013/01/oysters_soon_might_never_cause.html).

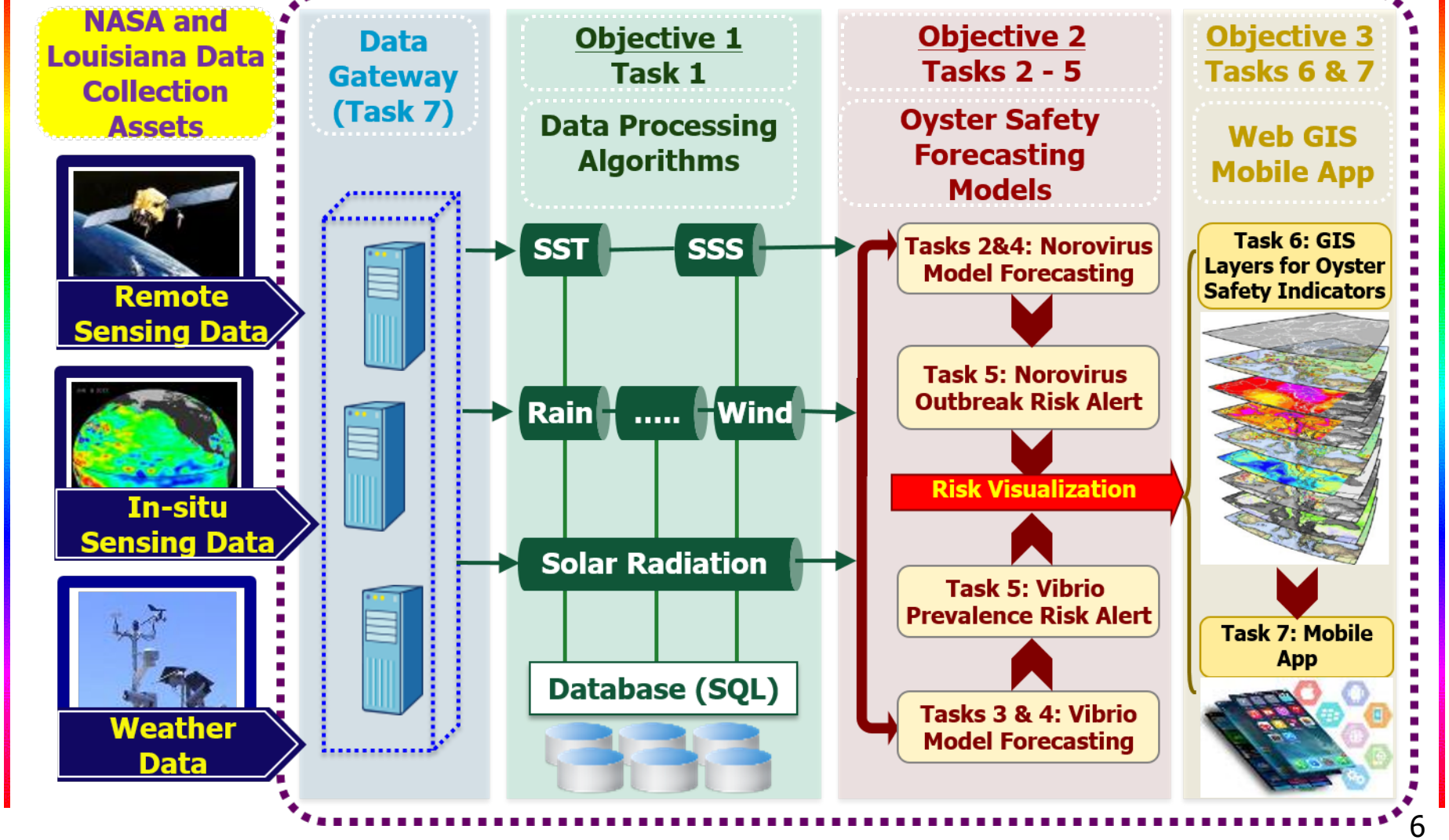
Sea Resources Safety Issues

There is growing concern about safety of sea resources (particularly seafood) due to outbreaks of virus, bacteria and harmful algal blooms



The number of *V.p* infections, hospitalizations, and death cases reported to COVIS (Cholera and Other *Vibrio* Illness Surveillance system) during 2000-2014 in the USA (http://www.cdc.gov/Vibrio/surveillance.html)

Artificial Intelligence (AI)-Enhanced Space Surveillance



AI-Based Forecasting Models for Oyster Norovirus Outbreaks

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Development of artificial intelligence approach to forecasting oyster norovirus outbreaks along Gulf of Mexico coast

Shima Shamkhali Chenar, Zhiqiang Deng*

Department of Civil and Environmental Engineering, Louisiana State University, Baton Rouge, LA 70803, United States

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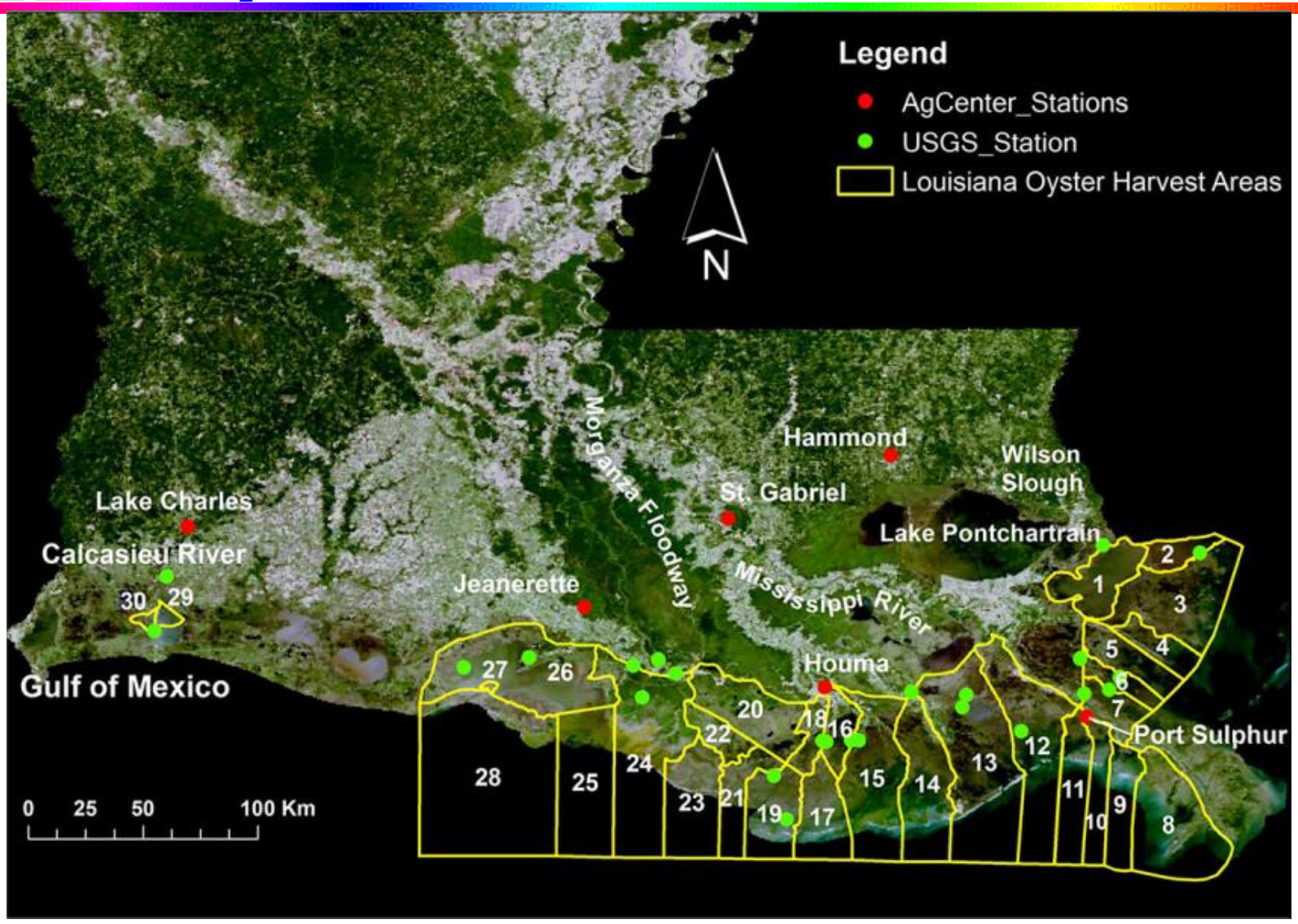
ABSTRACT

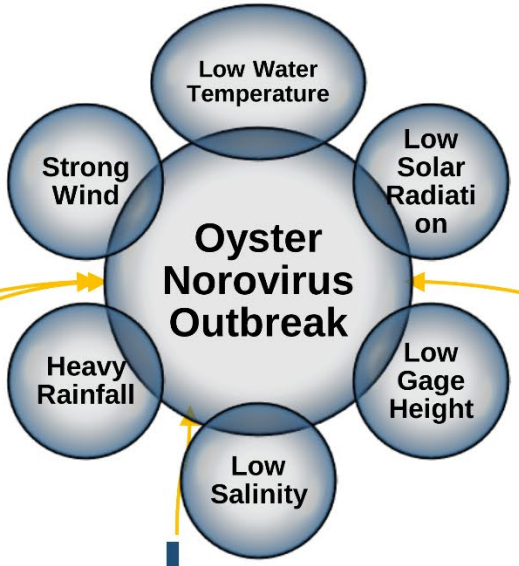
This paper presents an artificial intelligence-based model, called ANN-2Day model, for forecasting, managing and ultimately eliminating the growing risk of oyster norovirus outbreaks. The ANN-2Day model was developed using Artificial Neural Network (ANN) Toolbox in MATLAB Program and 15-years of epidemiological and environmental data for six independent environmental predictors including water temperature, solar radiation, gage height, salinity, wind, and rainfall. It was found that oyster norovirus outbreaks can be forecasted with two-day lead time using the ANN-2Day model and daily data of the six environmental predictors. Forecasting results of the ANN-2Day model indicated that the model was capable of reproducing 19 years of historical oyster norovirus outbreaks along the Northern Gulf of Mexico coast with the positive predictive value of 76.82%, the negative predictive value of 100.00%, the sensitivity of 100.00%, the specificity of 99.84%, and the overall accuracy of 99.83%, respectively, demonstrating the efficacy of the ANN-2Day model in predicting the risk of norovirus outbreaks to human health. The 2-day lead time enables public health agencies and oyster harvesters to plan for management interventions and thus makes it possible to achieve a paradigm shift of their daily management and operation from primarily reacting to epidemic incidents of norovirus infection after they have occurred to eliminating (or at least reducing) the risk of costly incidents.

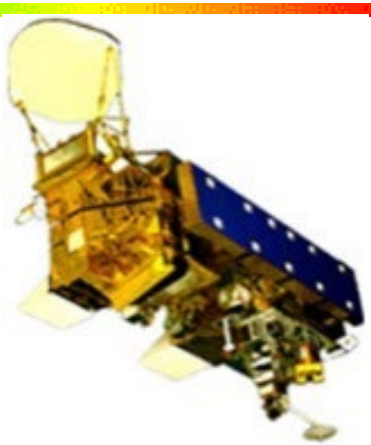
AI-Based Forecasting Models for Oyster Norovirus Outbreaks



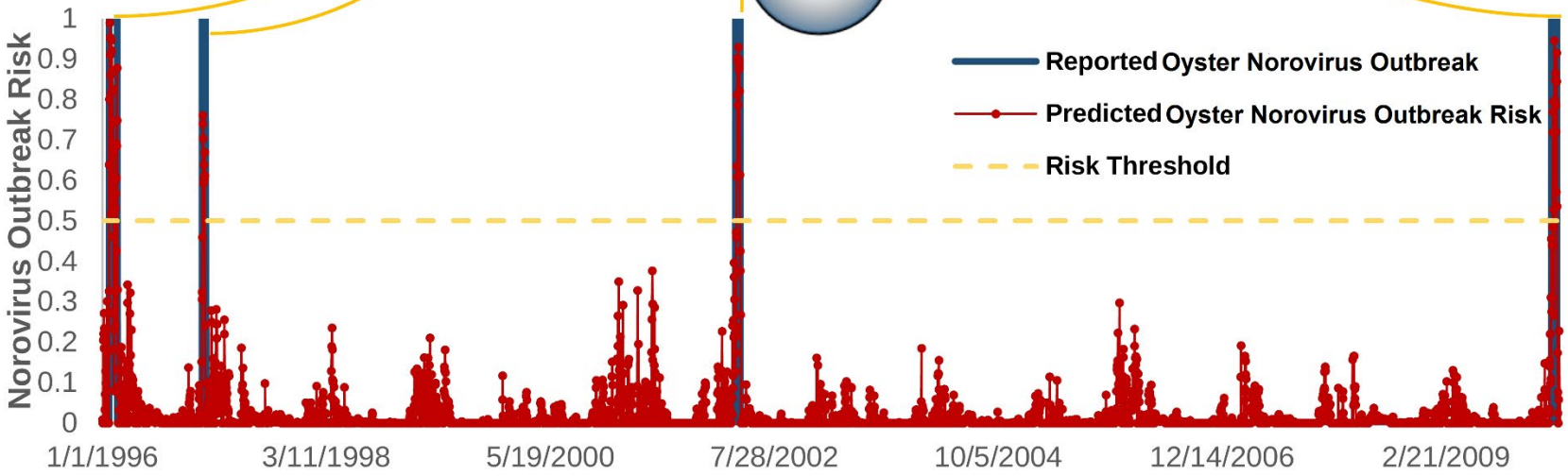
AI-Based Forecasting Models for Oyster Norovirus Outbreaks

NASA GPM Satellite

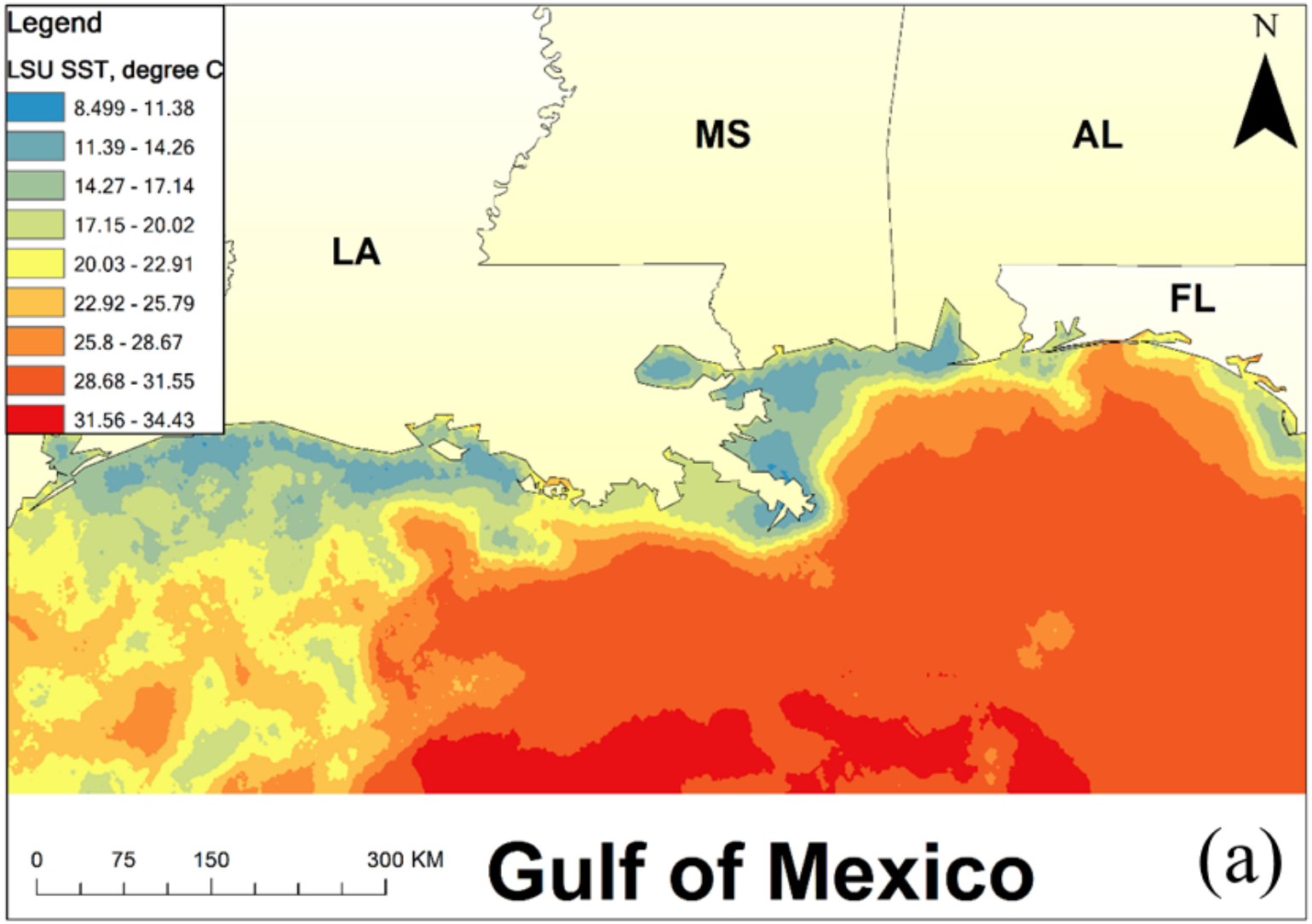




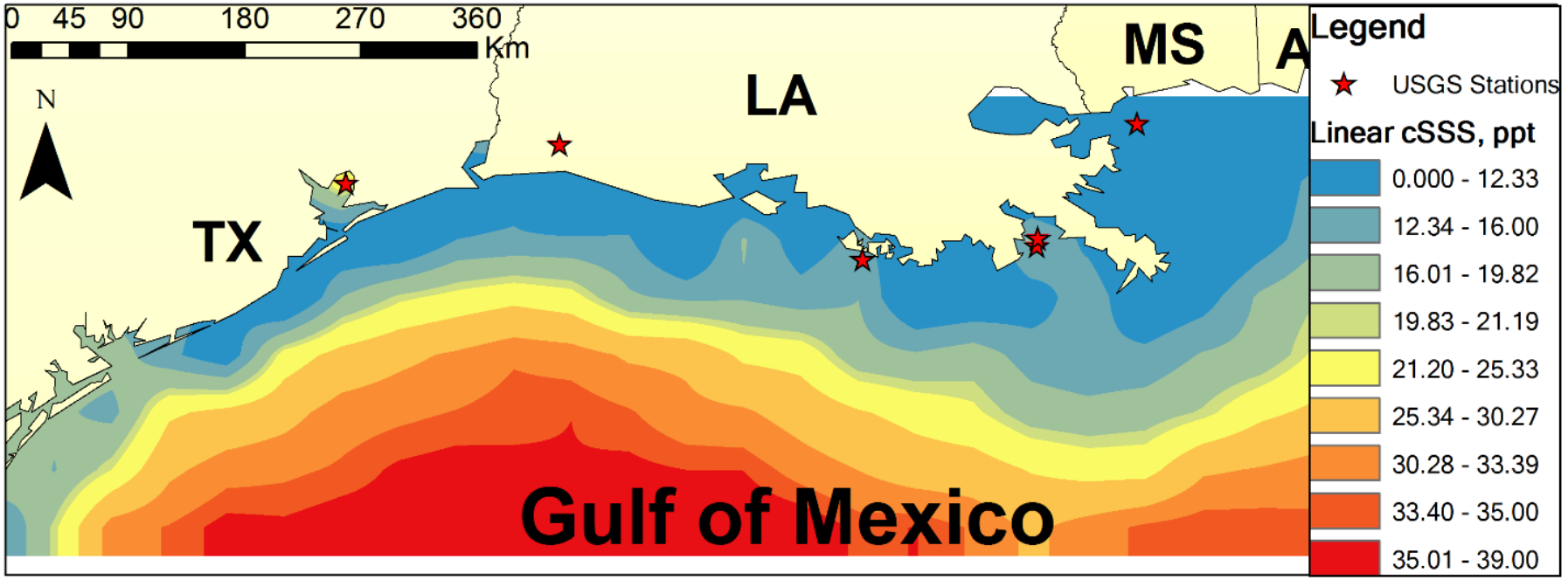
NASA Aqua satellite: (https://modis.gsfc.nasa.gov/about/).



AI Enhanced Remote Sensing:
LSU Algorithm for Nearshore Water Temperature



AI Enhanced Remote Sensing:
LSU Algorithm for Nearshore Sea Surface Salinity



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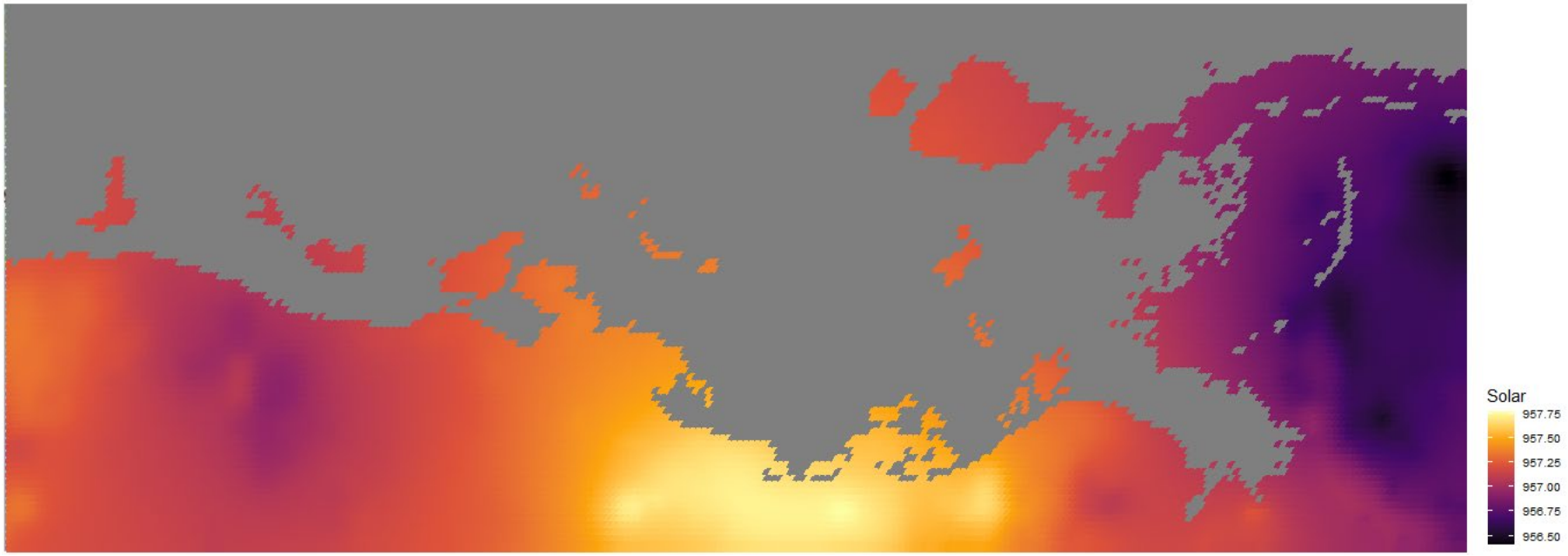
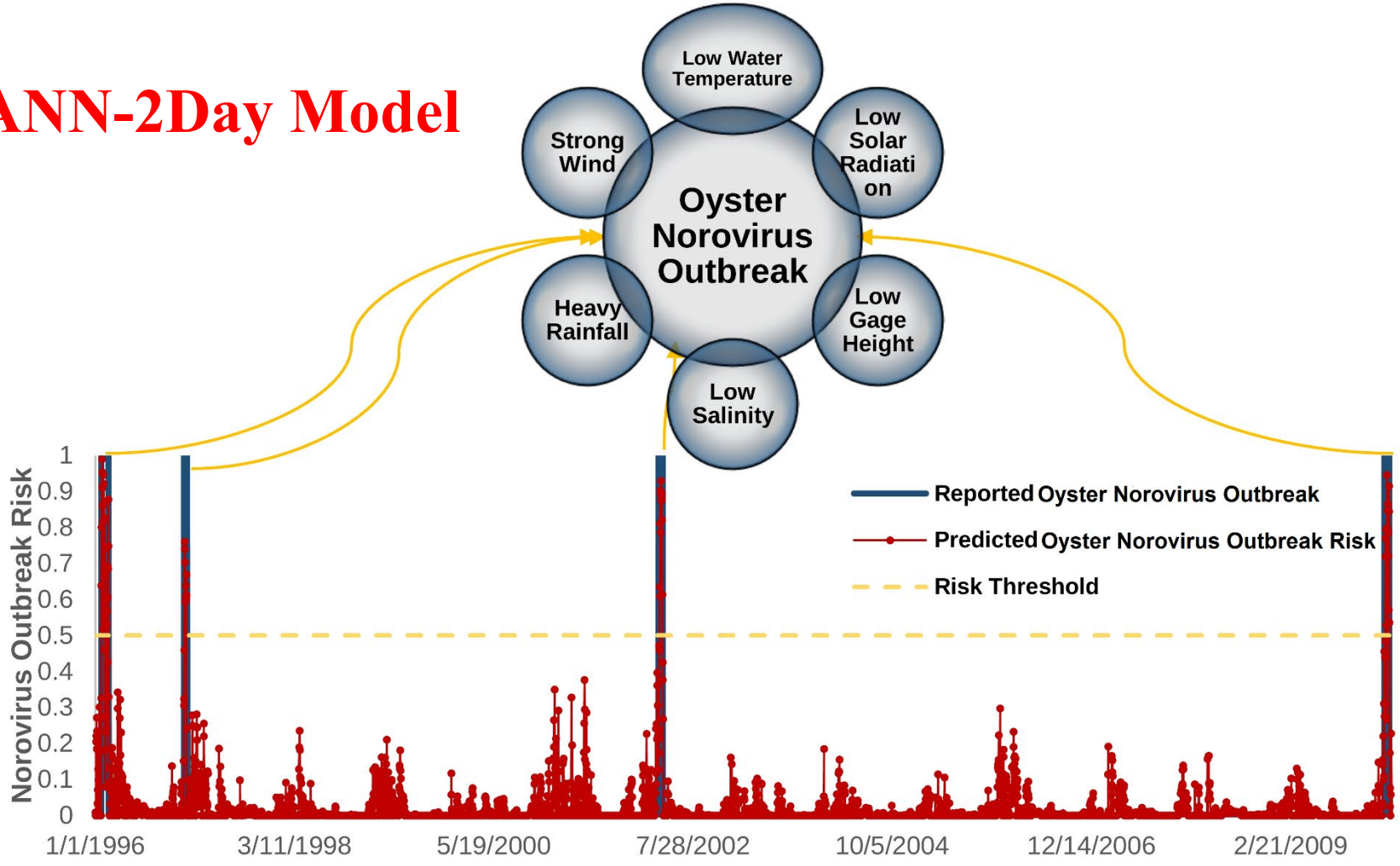
AI Enhanced Remote Sensing:
LSU Algorithm for Solar Radiation

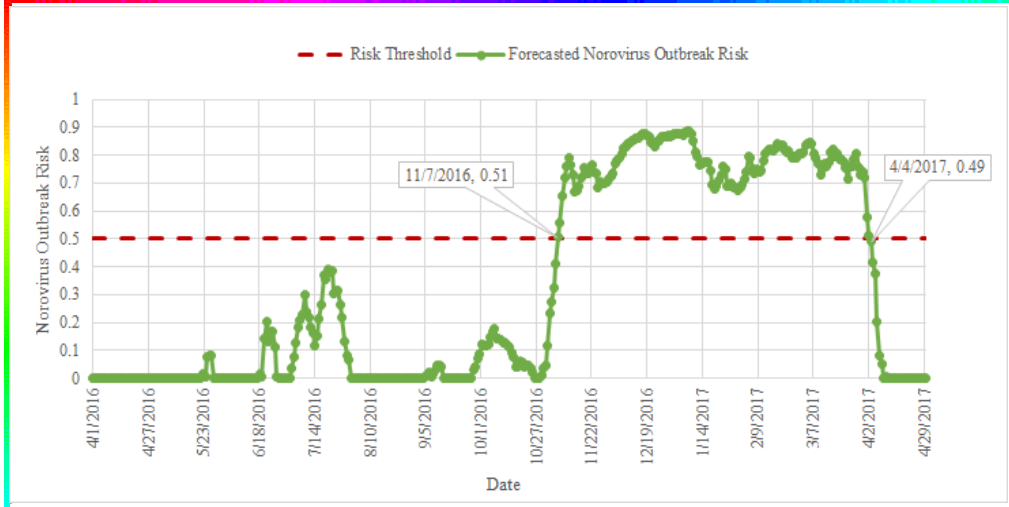


AI-Based Forecasting Models for Oyster Norovirus Outbreaks

ANN-2Day Model

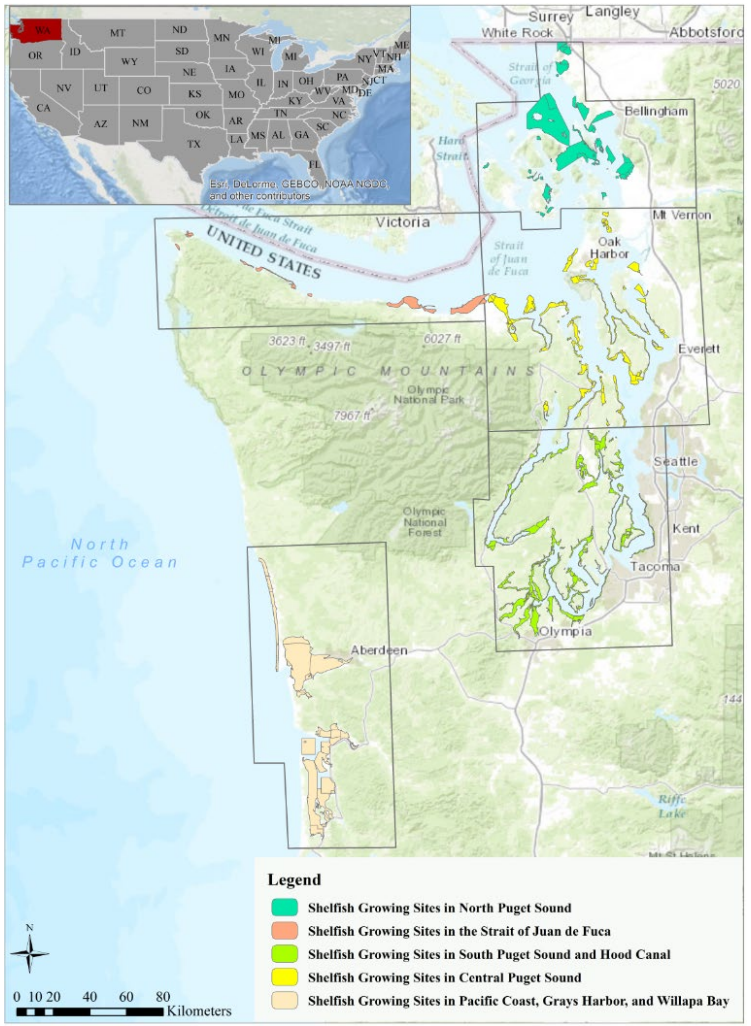


AI-Based Forecasting Models for Oyster Norovirus Outbreaks



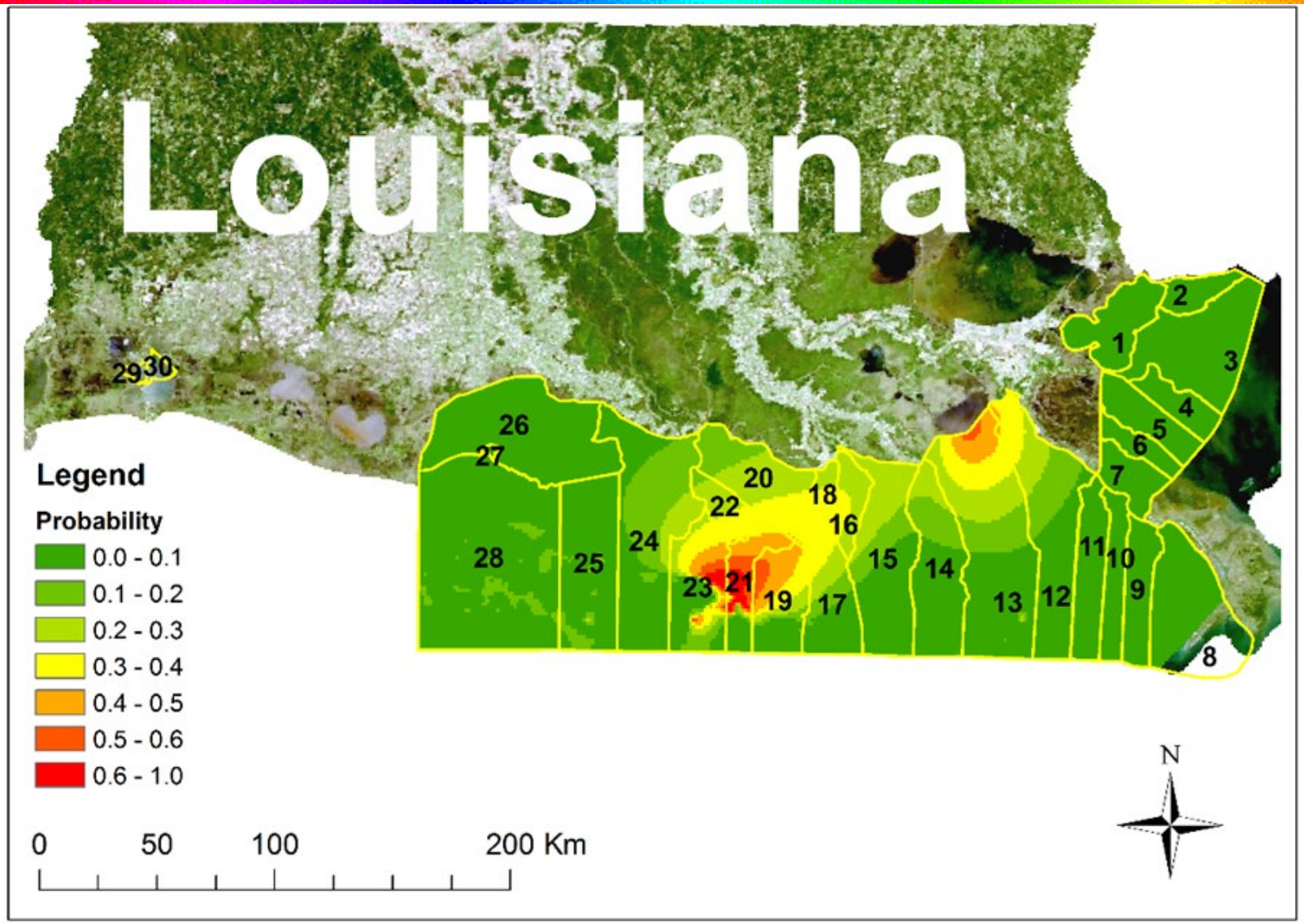
Risks of norovirus (NoV) outbreaks in Puget Sound oyster growing areas, WA, forecasted with the ANN-2Day model.

According to the figure, a series of oyster norovirus outbreaks in the Puget Sound started on November 7, 2016 (risk > 0.5 – risk threshold for oyster norovirus outbreaks) and ended on April 3, 2017. The model predicted end date of April 3, 2017 is almost the same as that (4/05/2017) confirmed by the Washington State Department of Health. While the model predicted onset date of 11/07/2016 is earlier than January 11 when the oyster growing areas were first closed, the onset date is consistent with the media report that "the norovirus contamination of oysters appears to span the Salish Sea, and was first linked to illness in British Columbia in **November**…… The implicated oysters come from all over the Puget Sound – from down near Olympia to all the way up in Belllingham/Samish Bay" (https://kingcountywtd.com/2017/03/31/norovirus-outbreak-in-oysters-unrelated-to-west-point-overflow/).

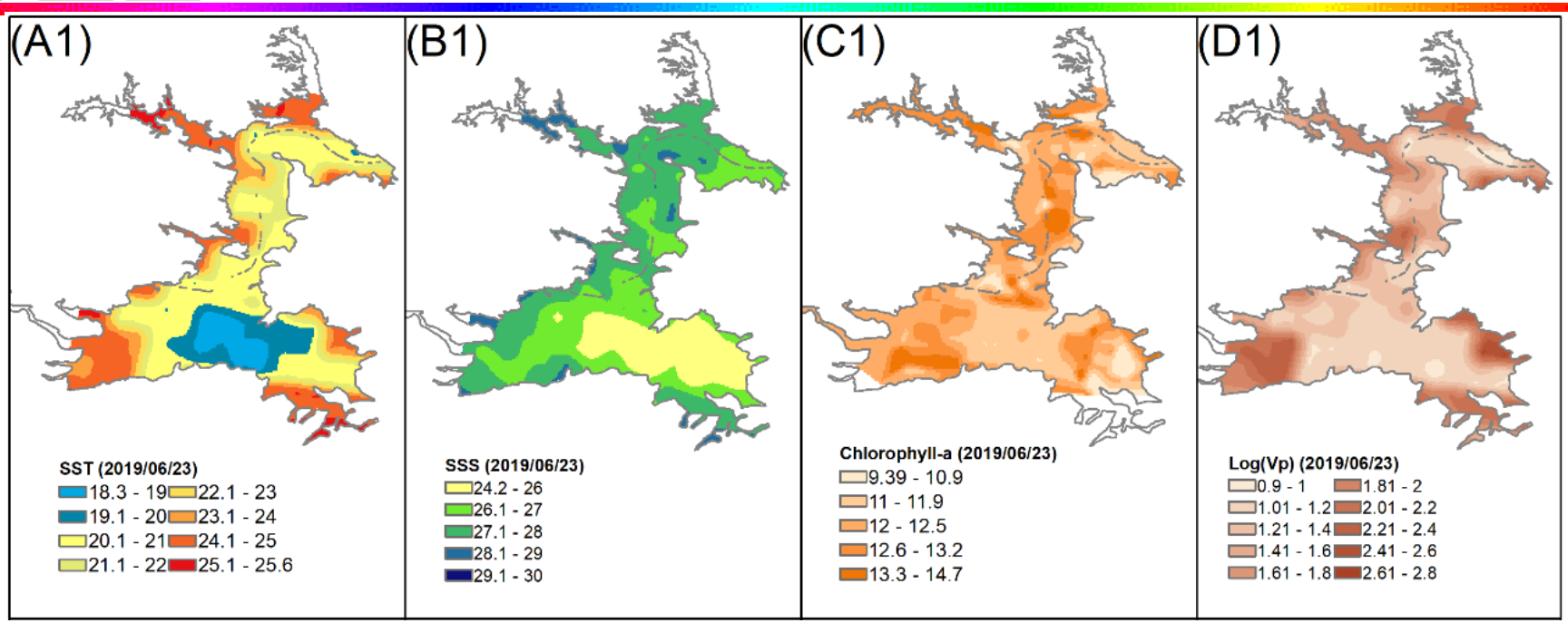


Five major oyster growing areas along the Pacific Coast of Washington State.

AI-Enhanced Space Surveillance for Oyster Norovirus Outbreak



AI-Enhanced Space Surveillance for Vibrio Concentration



By using Sentinel-3 SLSTR and OLCI bands we also created Remote Sensing Algorithms for Retrieving SST, SSS, Chlorophyll-a Concentration, and Vibrio parahaemolyticus (*V.p*) concentration in Great Bay, NH

AI-Enhanced Space Surveillance for Vibrio Concentration in Oysters

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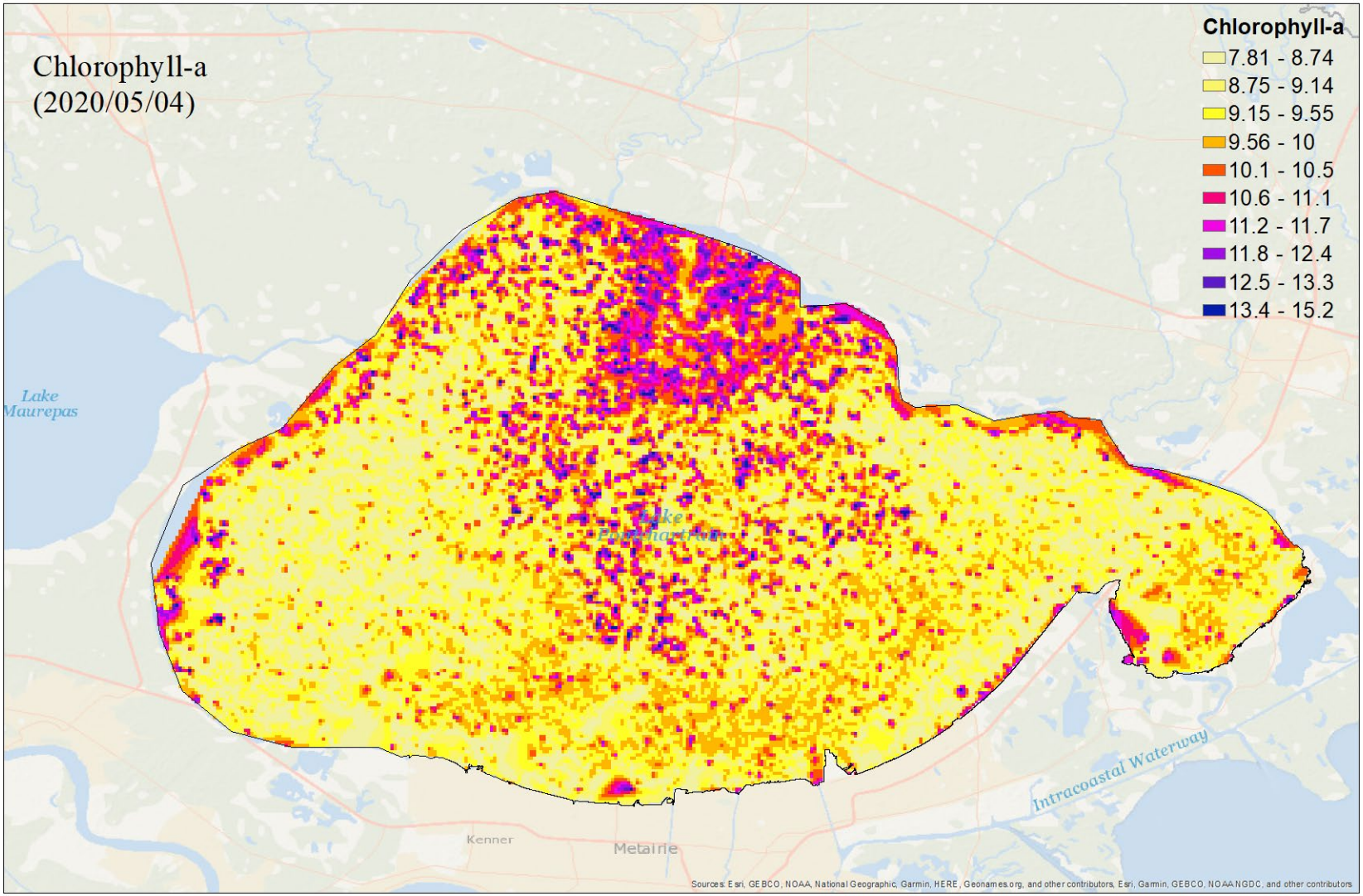
Modeling and Forecasting Vibrio Parahaemolyticus Concentrations in Oysters

Peyman Namadi, Zhiqiang Deng

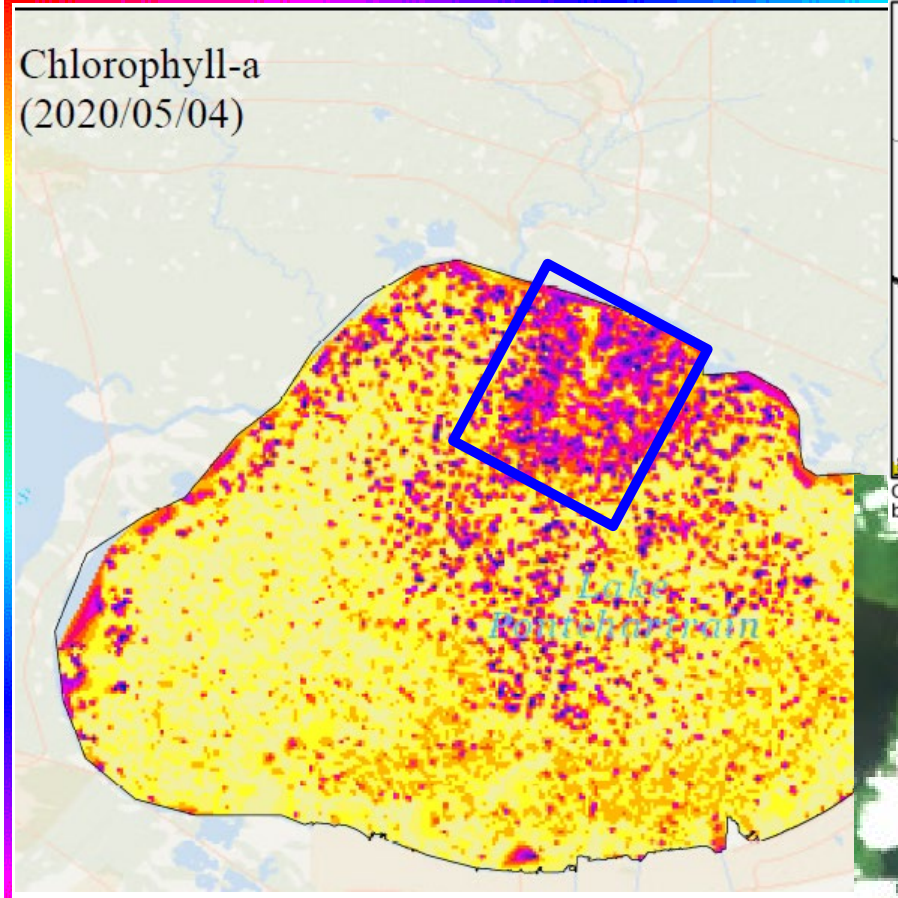
Model Assessment	RF-1Day Model	RF-2Day Model	RF-3Day Model	RF-4Day Model
True Positive Rate	0.83	0.80	0.75	0.73
True Negative Rate	0.94	0.92	0.95	0.92
Accuracy	0.90	0.88	0.88	0.85
Error Rate	0.10	0.12	0.12	0.15

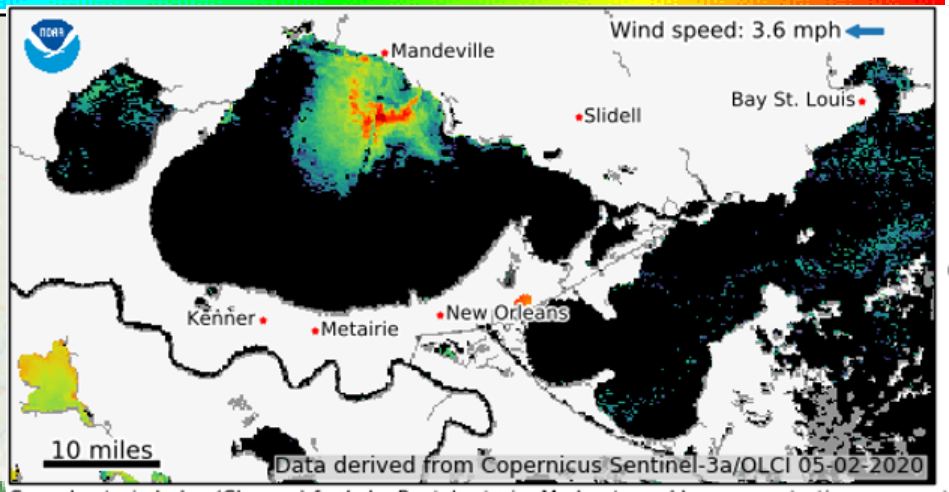
- *V.p* abundance depends on antecedent environmental conditions 1–11 days before
- The environmental conditions can be described with time-lagged

AI-Enhanced Space Surveillance for Harmful Algal Blooms



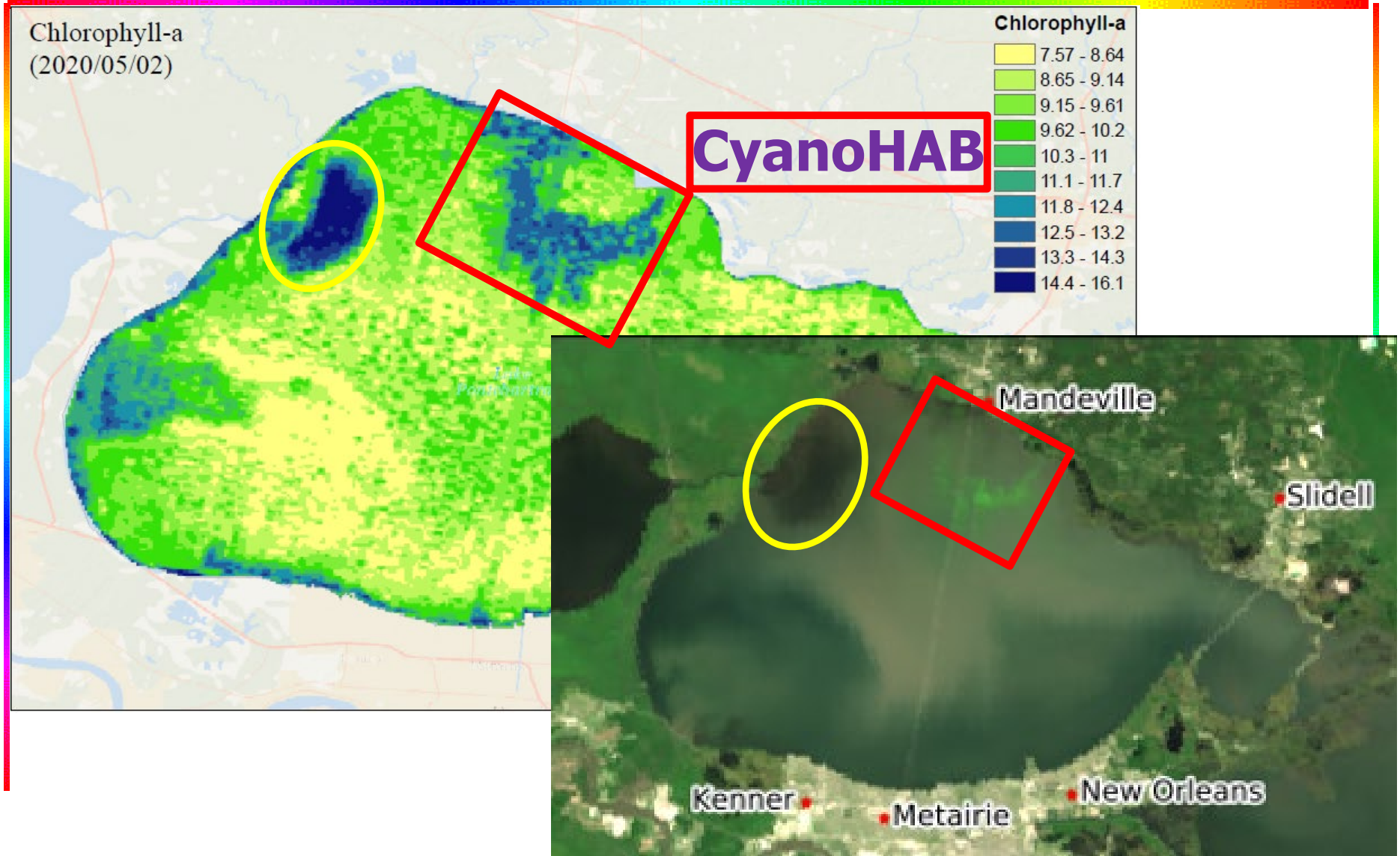
AI-Enhanced Space Surveillance for Harmful Algal Blooms



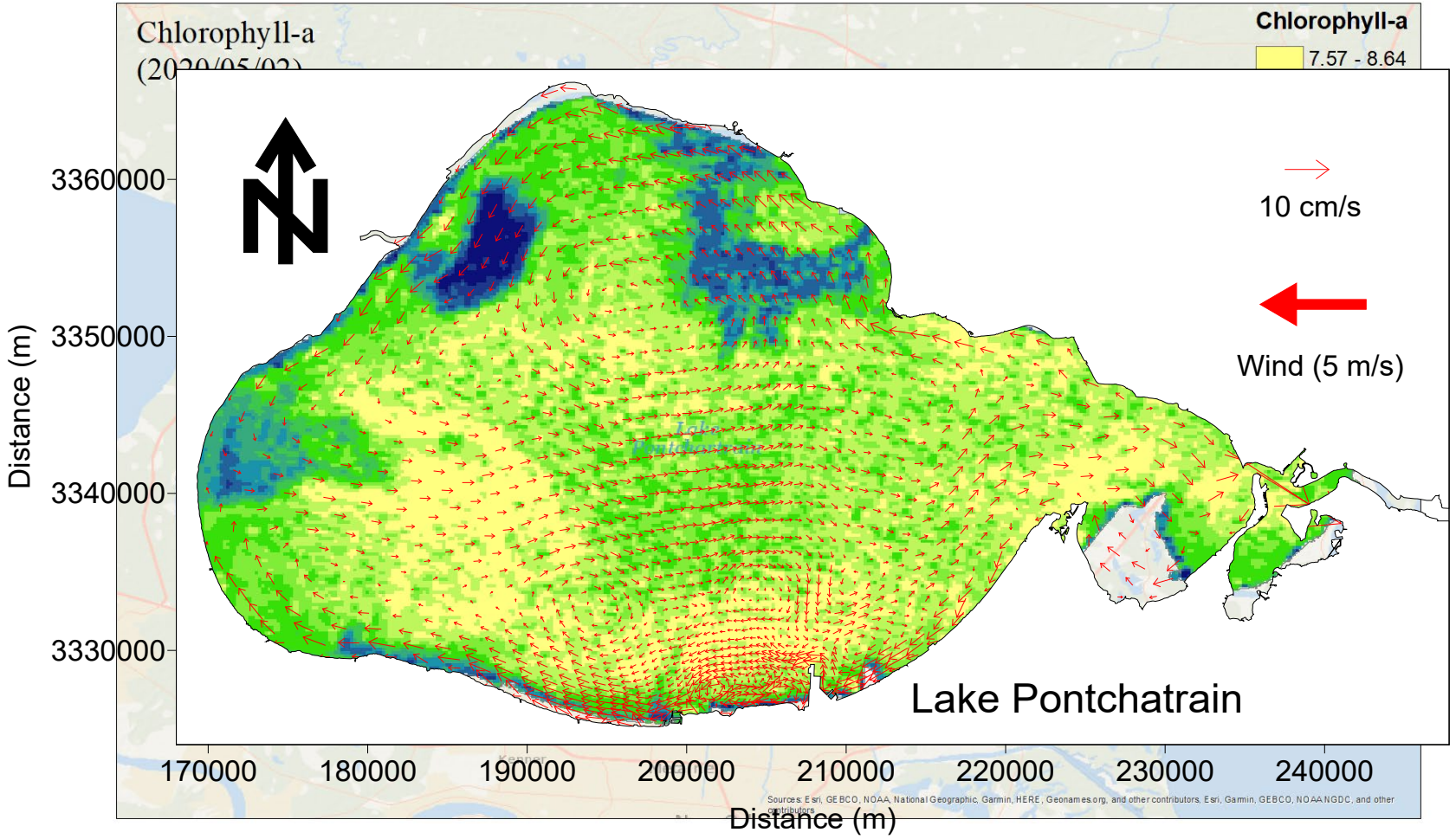


Cyanobacteria Index (CIcyano) for Lake Pontchartrain. Moderate and low concentrations may not be obvious to the eye. Winds from NOAA NDBC station FREL1.

AI-Enhanced Space Surveillance for Harmful Algal Blooms



AI-Enhanced Space Surveillance for Harmful Algal Blooms



Conclusions

- The SAFE Oyster system is designed to synergistically combine spatially distributed satellite remote sensing data, AI-based modeling tools, and GIS-based mapping methods within an automated cyberinfrastructure system.
- The SAFE Oyster system could significantly expand the spatial coverage of existing oyster safety monitoring program.
- The SAFE Oyster system could change the temporal frequency of oyster safety monitoring from current 30 days to 1 day, enabling managers to reduce the decision-making time from current 2 – 3 months to 1 day (daily) based on daily Earth observations and associated model predictions.
- The automated SAFE Oyster system is particularly important during holiday seasons when oyster safety risks are elevated while decision-makers are not available due to holiday breaks.

Conclusions

- The SAFE Oyster system enables public health agencies and oyster harvesters to focus more on preventing oyster contamination events, rather than relying on reacting to problems after they have occurred, greatly reducing the risk of oyster contamination to human health and the risk of economic loss to the seafood industry.

Acknowledgments

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