

# Development of an Experimental Harmful Algal Bloom Forecast for Saginaw Bay

Mark D. Rowe, Eric J. Anderson, Henry A. Vanderploeg  
NOAA Great Lakes Environmental Research Lab

Richard P. Stumpf  
NOAA National Ocean Service

# Outline

- NOAA information products for Lake Erie HABs
- Experimental Lake Erie HAB Tracker
- Proposed Experimental Saginaw Bay HAB Tracker

# NOAA National Ocean Service HAB Information Products

## Lake Erie Harmful Algal Bloom Seasonal Forecast 12 July 2018

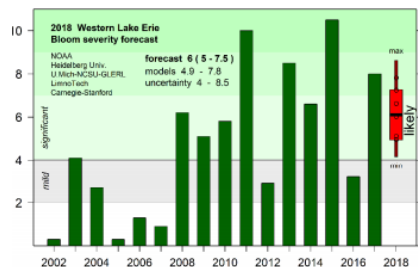


Figure 1. Bloom forecast compared to previous years. The wide bar is the range of likely severity (5-7.5). The narrow bar captures the maximum uncertainty in all the models.

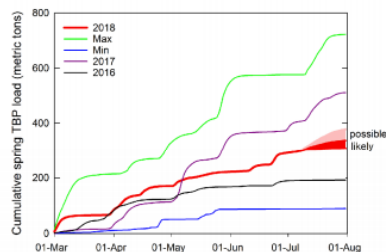


Figure 2. Cumulative total bioavailable phosphorus (TBP) loads for the Maume River (based on Waterville). Each line denotes a different year. 2018 is in red through July 18, the solid line is the measured load. Loads over the remainder of July will have a negligible impact on the bloom size.



## Lake Erie Harmful Algal Bloom Bulletin 30 July, 2018, Bulletin 12

### Analysis

The *Microcystis* cyanobacteria bloom continues in the western basin. Recent satellite imagery (7/29) indicates the bloom is present in Maumee Bay, extending north alongshore the Michigan coast to Brest Bay, east towards the Bass Islands, and along the Ohio coast to Catawba Island. Observed winds yesterday (7/29) reduced mixing and may have lead to scum formation. Measured toxin concentrations are detectable at all samples sites, but still below the recreational threshold throughout most of the bloom extent. *Keep pets and yourself out of the water in areas where scum is forming.* The persistent cyanobacteria bloom in Sandusky Bay continues.

### Forecasts

Forecast winds (5-11 kn) tomorrow through Thursday (7/31-8/2) will promote slight mixing of surface waters and eastward transport of surface *Microcystis* concentrations. --Davis, Keeney

The images below are "GeoPDF". Please visit <https://go.usa.gov/xReTC> for instructions on viewing longitude and latitude.

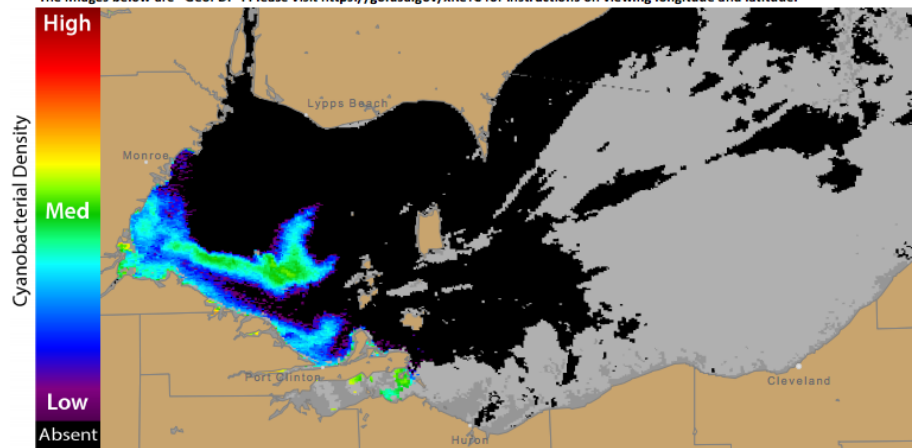
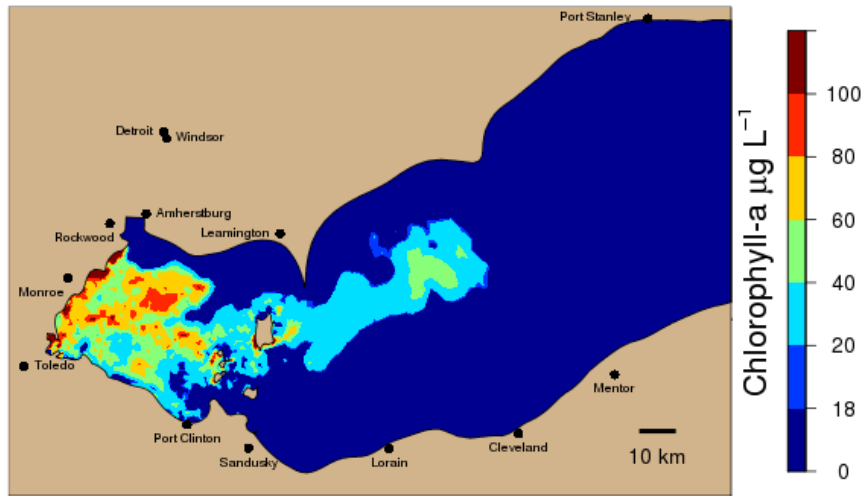


Figure 1. Cyanobacterial Index from modified Copernicus Sentinel 3 data collected 29 July, 2018 at 11:19 EST. Grey indicates clouds or missing data. The estimated threshold for cyanobacteria detection is 20,000 cells/ml

# Concept of the short term HAB forecast

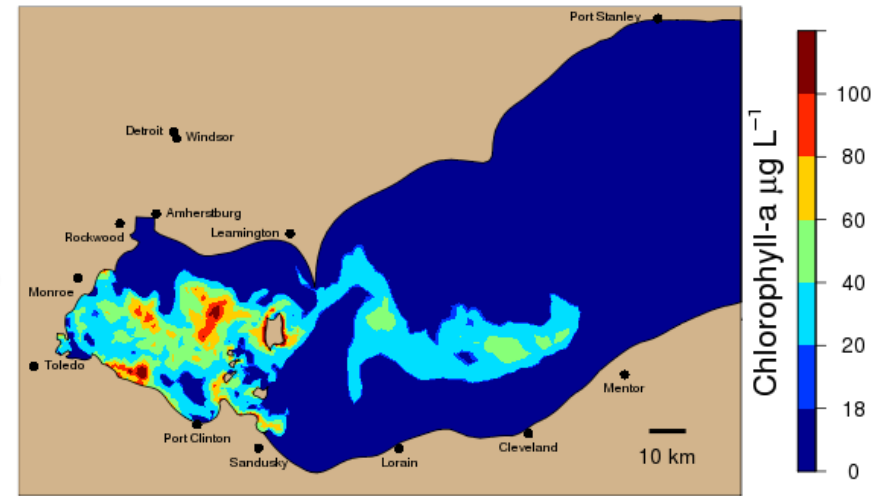
## Nowcast

2015-08-23 20:00 EDT



## Five-day forecast

2015-08-29 21:00 EDT



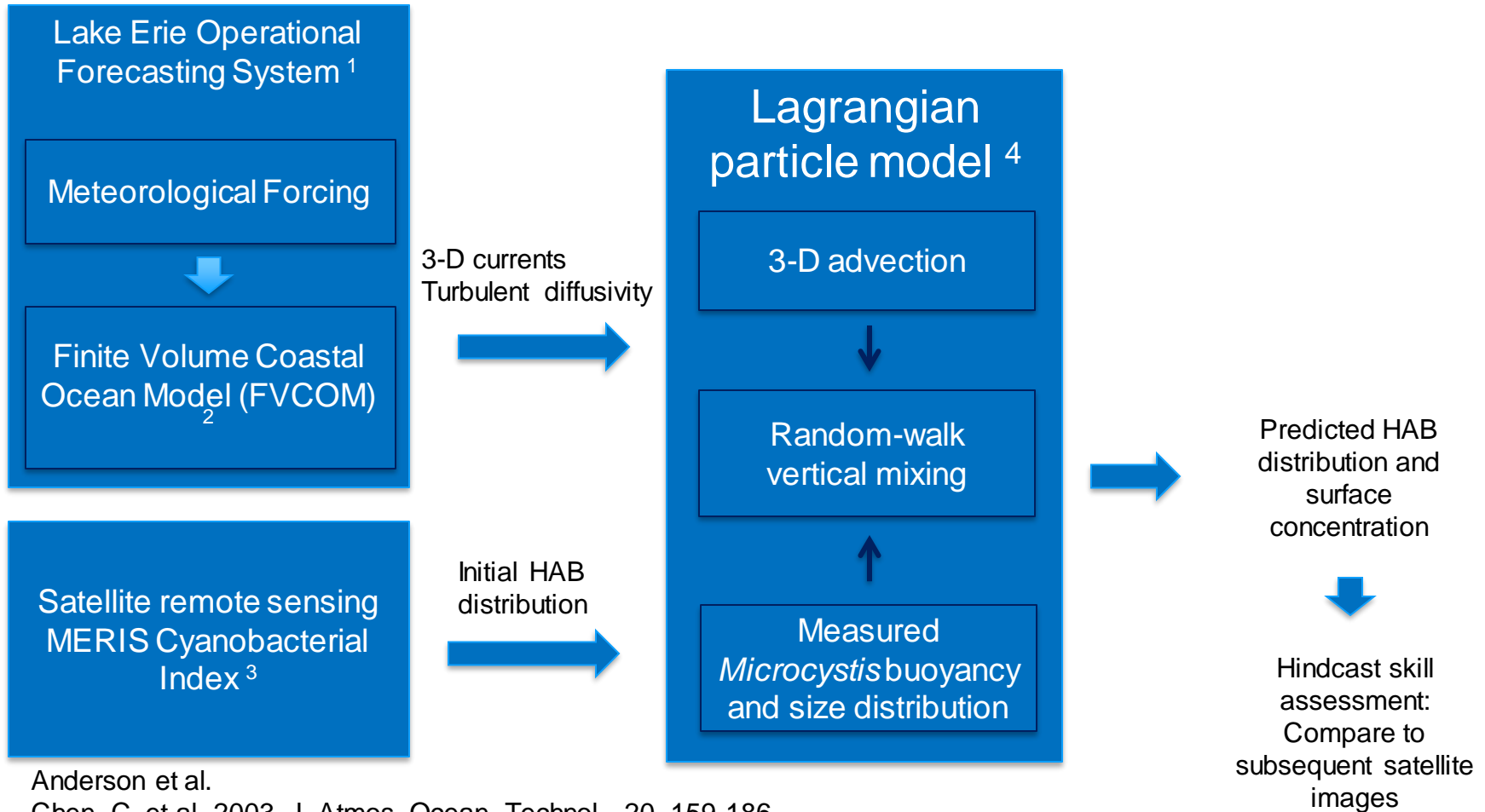
Initialize bloom location and intensity in a model based on satellite remote sensing imagery



Five-day forecast of bloom intensity and location based on

1. Forecast meteorology
2. Currents from a hydrodynamic model
3. Lagrangian particle tracking model

# Components of the Lake Erie HAB Tracker



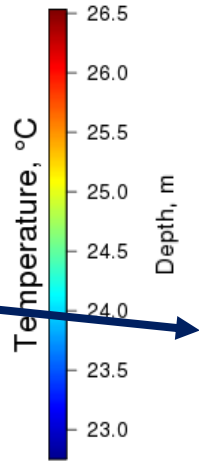
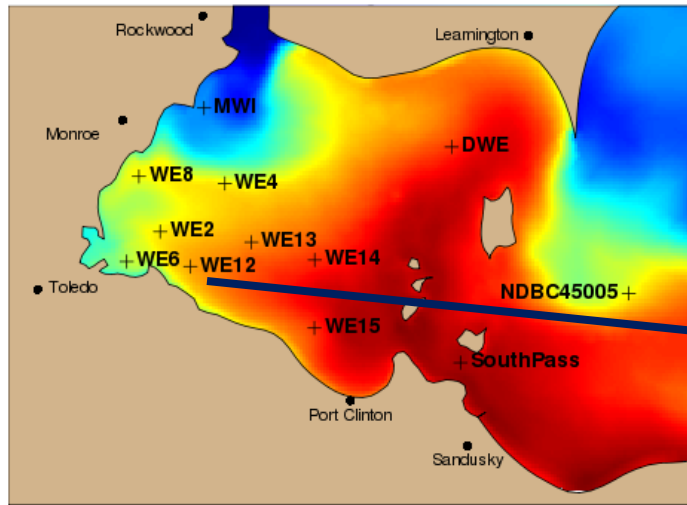
1. Anderson et al.
2. Chen, C. et al. 2003. J. Atmos. Ocean. Technol., 20, 159-186.
3. Wynne et al. 2010. Limnol. Oceanogr. 55(5), 2025-36
4. Gilbert, C.S. et al. 2010. Prog. Oceanogr., 87: 37-48.

# Prediction of surface scums

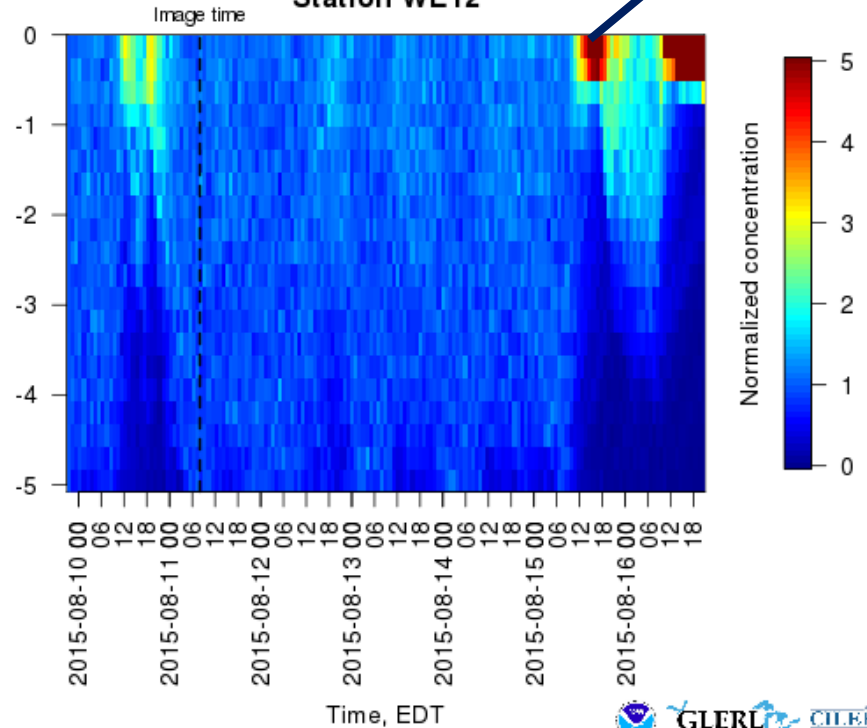


## Vertical Mixing Analysis

2015-08-11 12:00 GMT



Station WE12

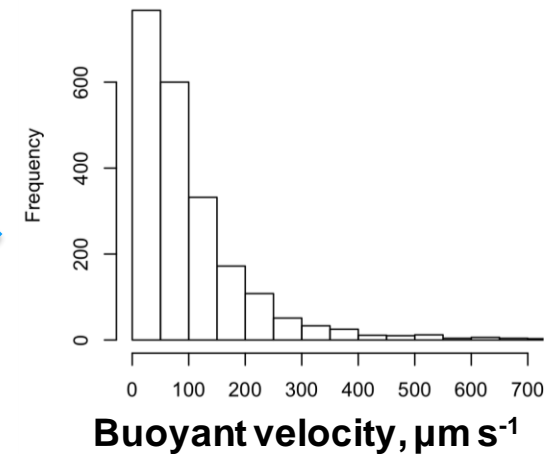
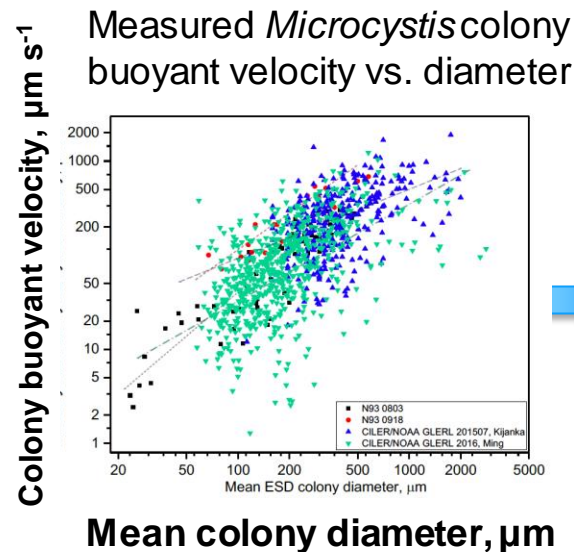
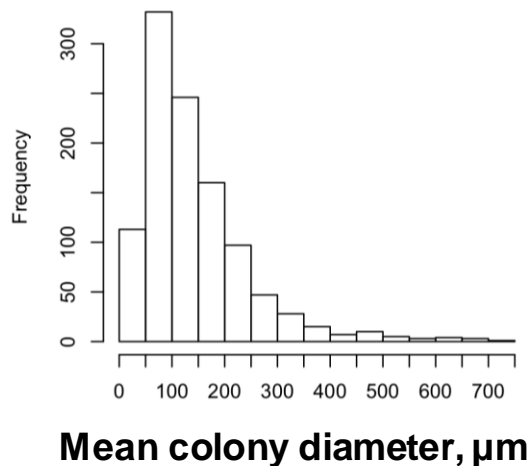


# Measurement of *Microcystis* colony buoyancy and size distribution



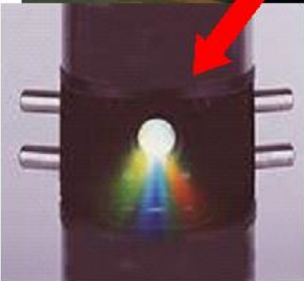
*Microcystis* colony size distribution measured by FlowCam, Lake Erie, August 4, 2014

Source: David Fanslow, NOAA GLERL



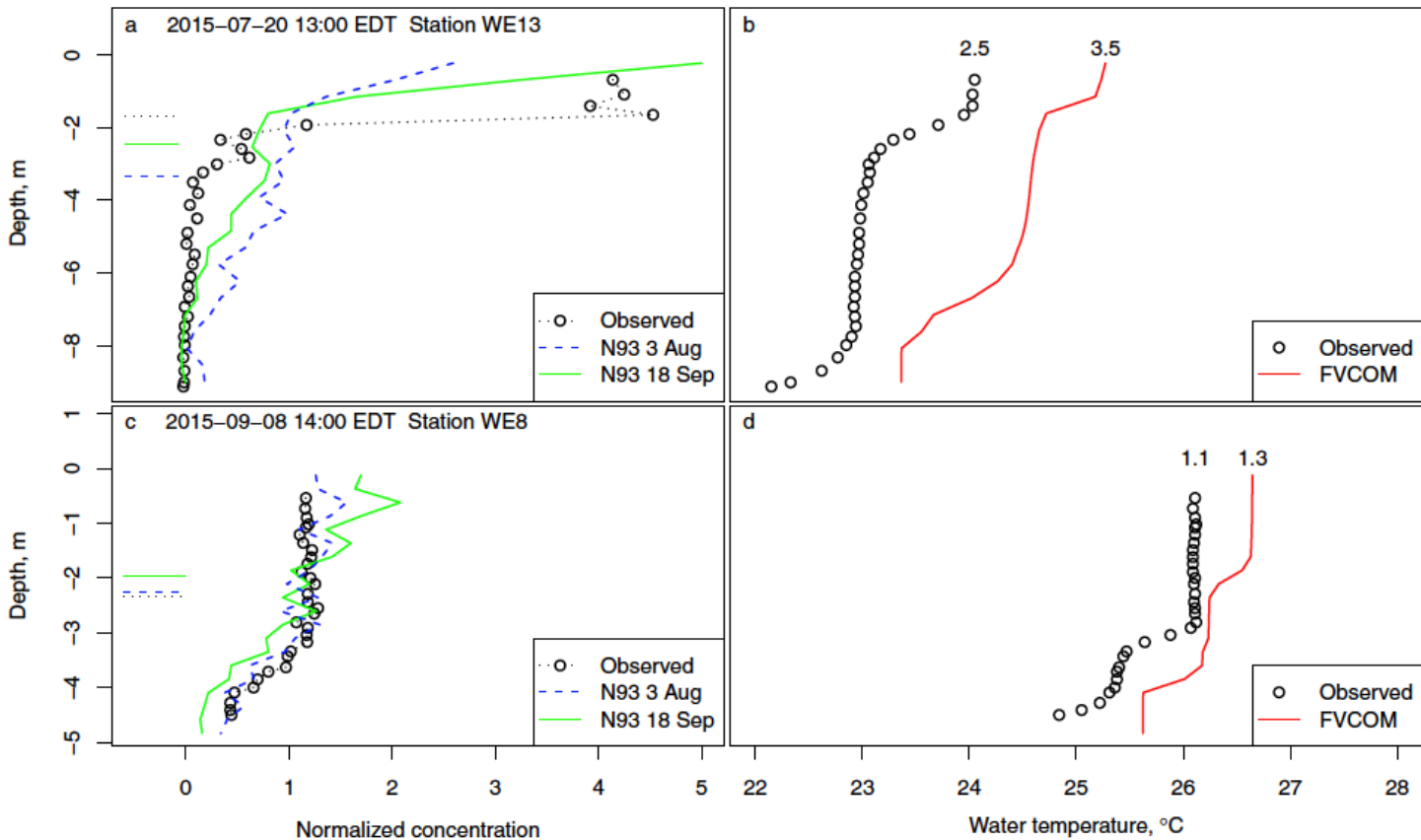


# Vertical profiles of cyanobacterial chlorophyll concentration were collected with the fluoroprobe





# Model assessment of predicted *Microcystis* vertical distribution



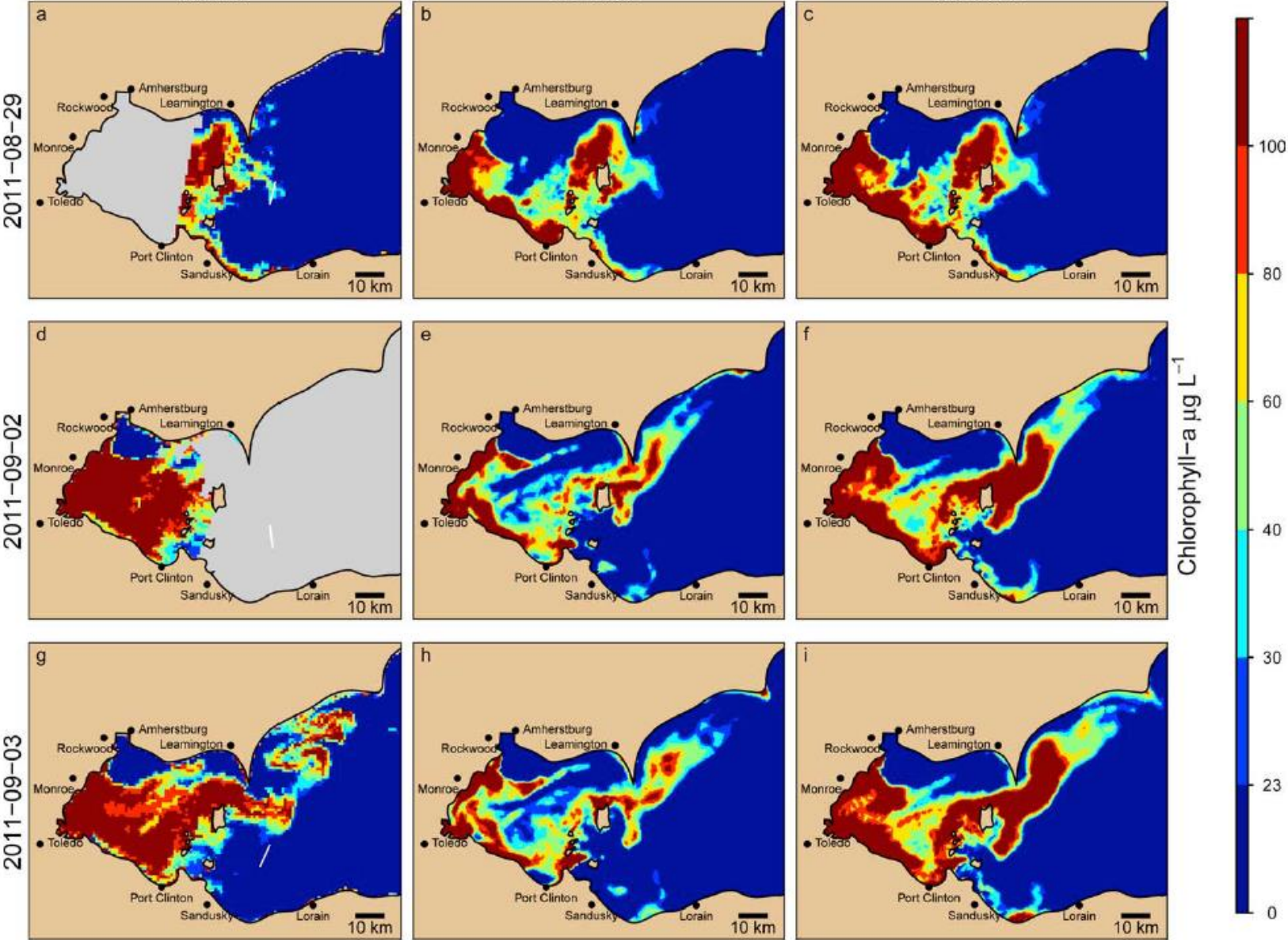
Rowe et al. 2016. J. Geophys. Res. Oceans, 121, doi:10.1002/2016JC011720.

# Model assessment

Satellite observed

2D simulation

3D simulation





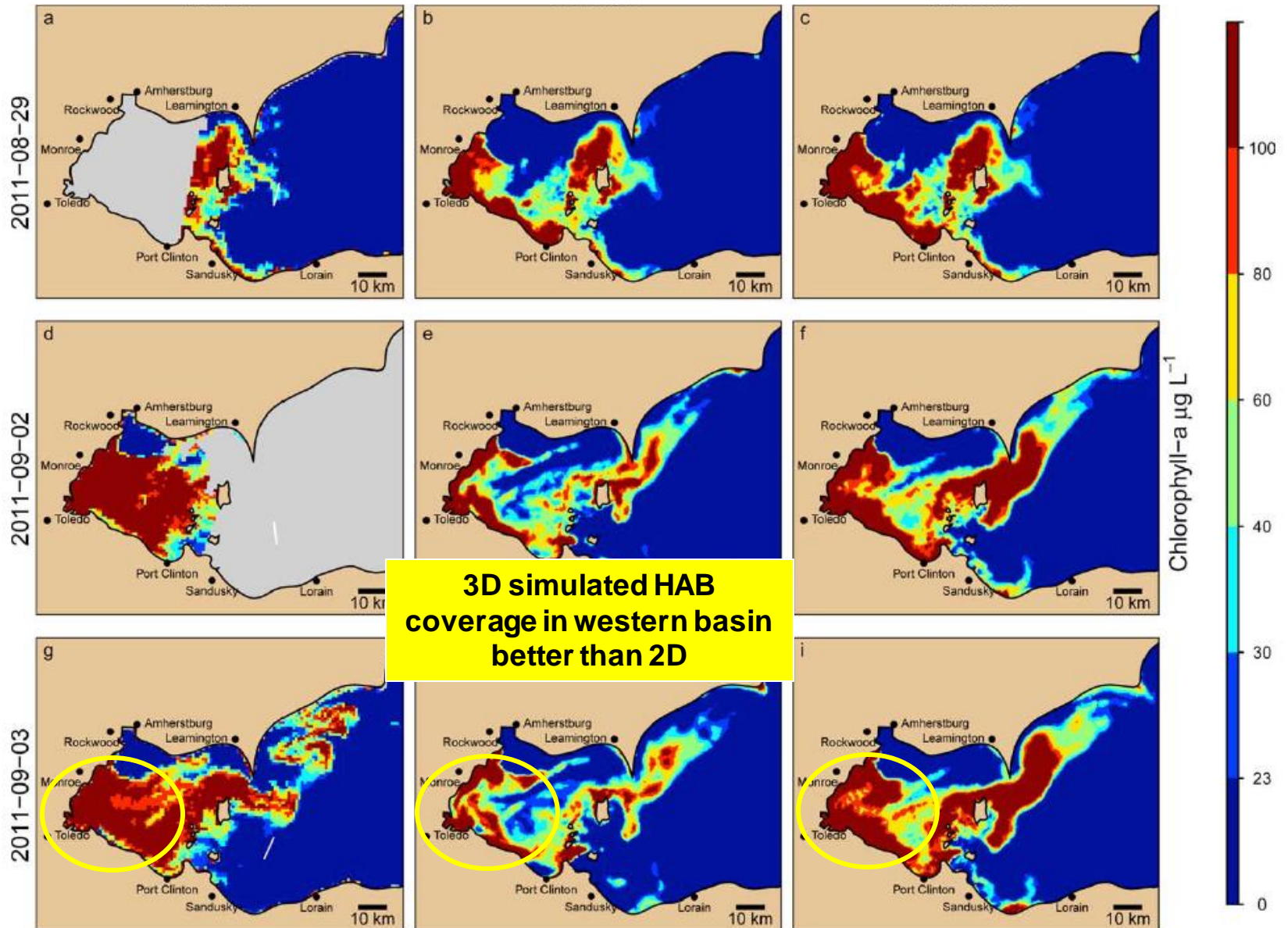


# Model assessment

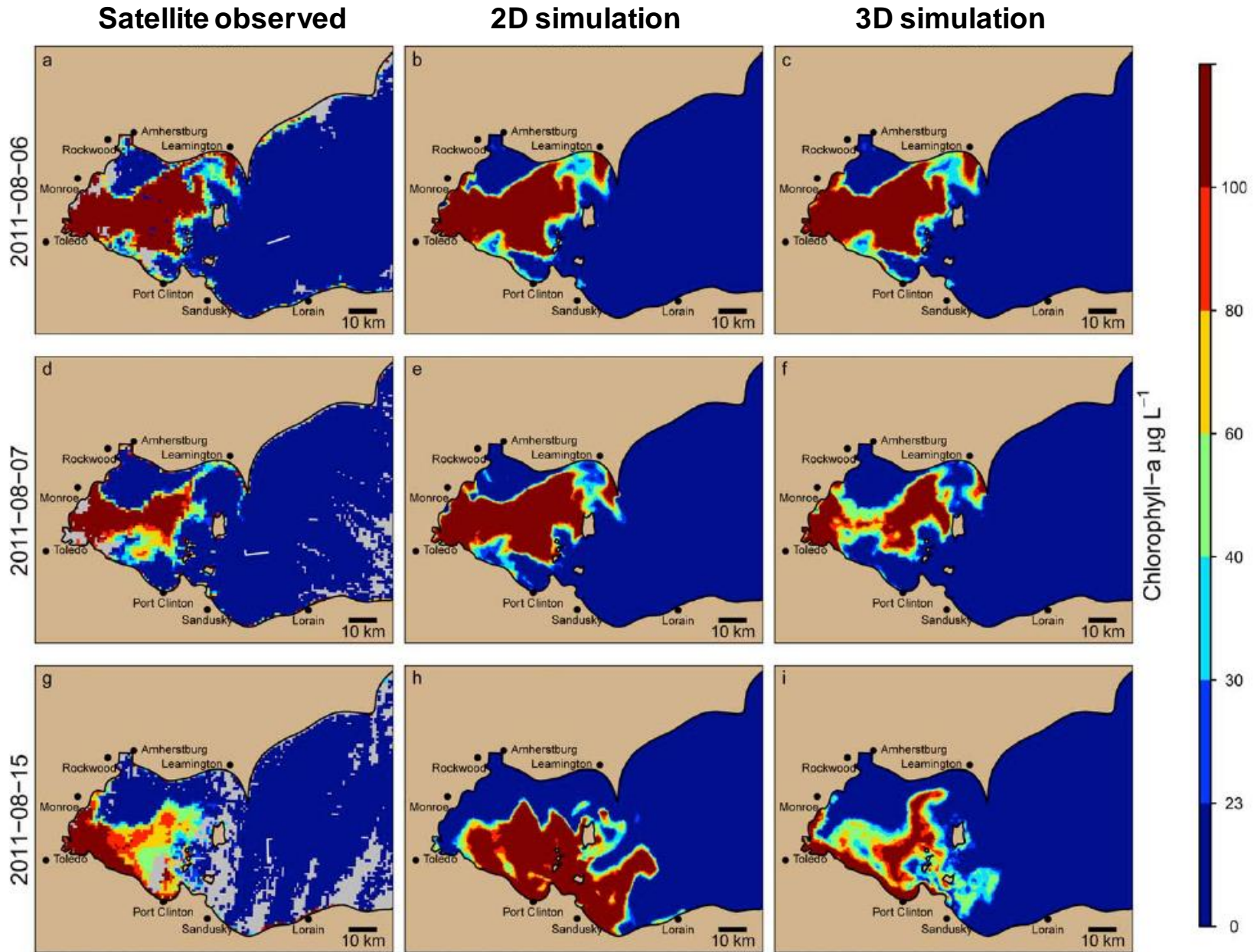
Satellite observed

2D simulation

3D simulation

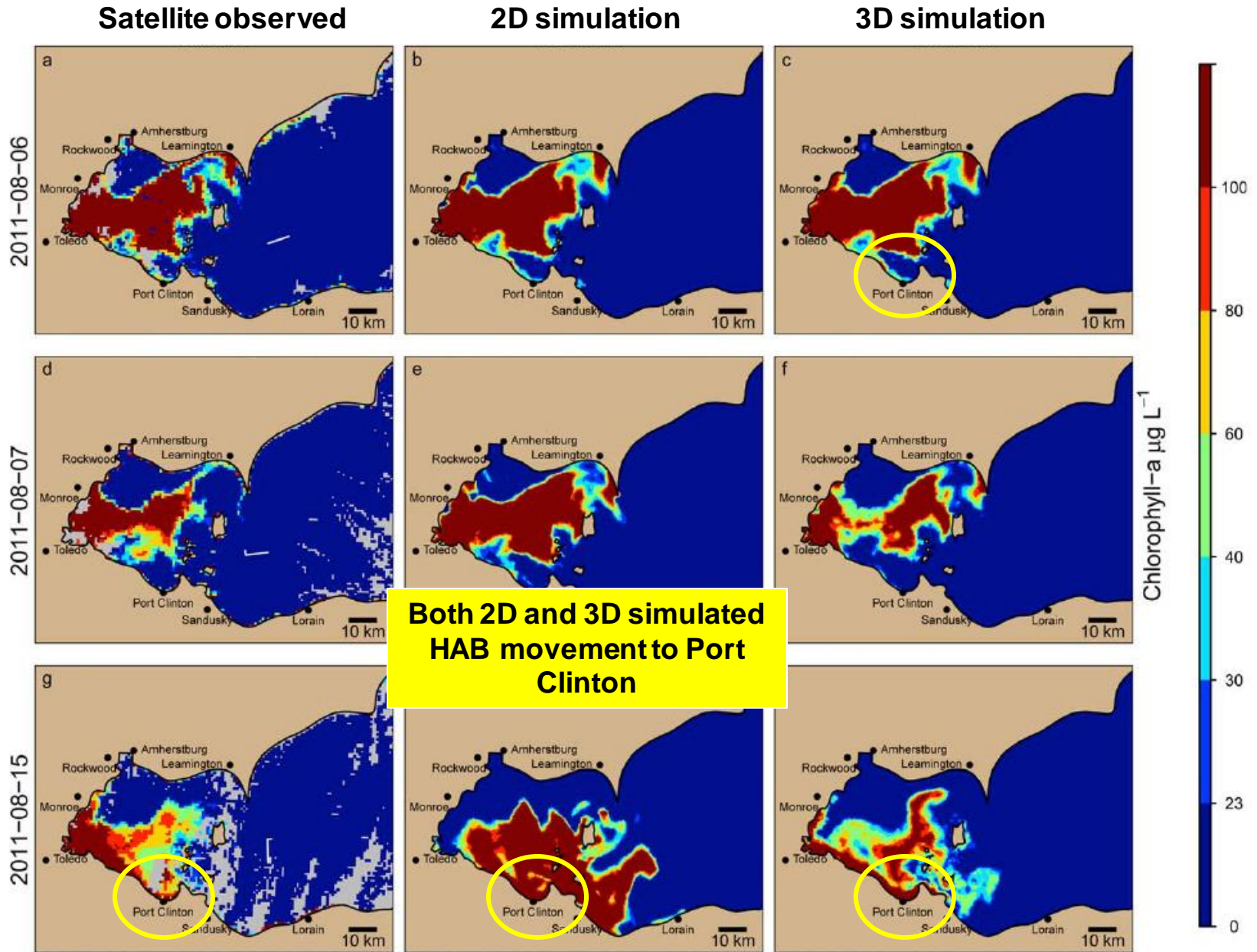


# Model assessment



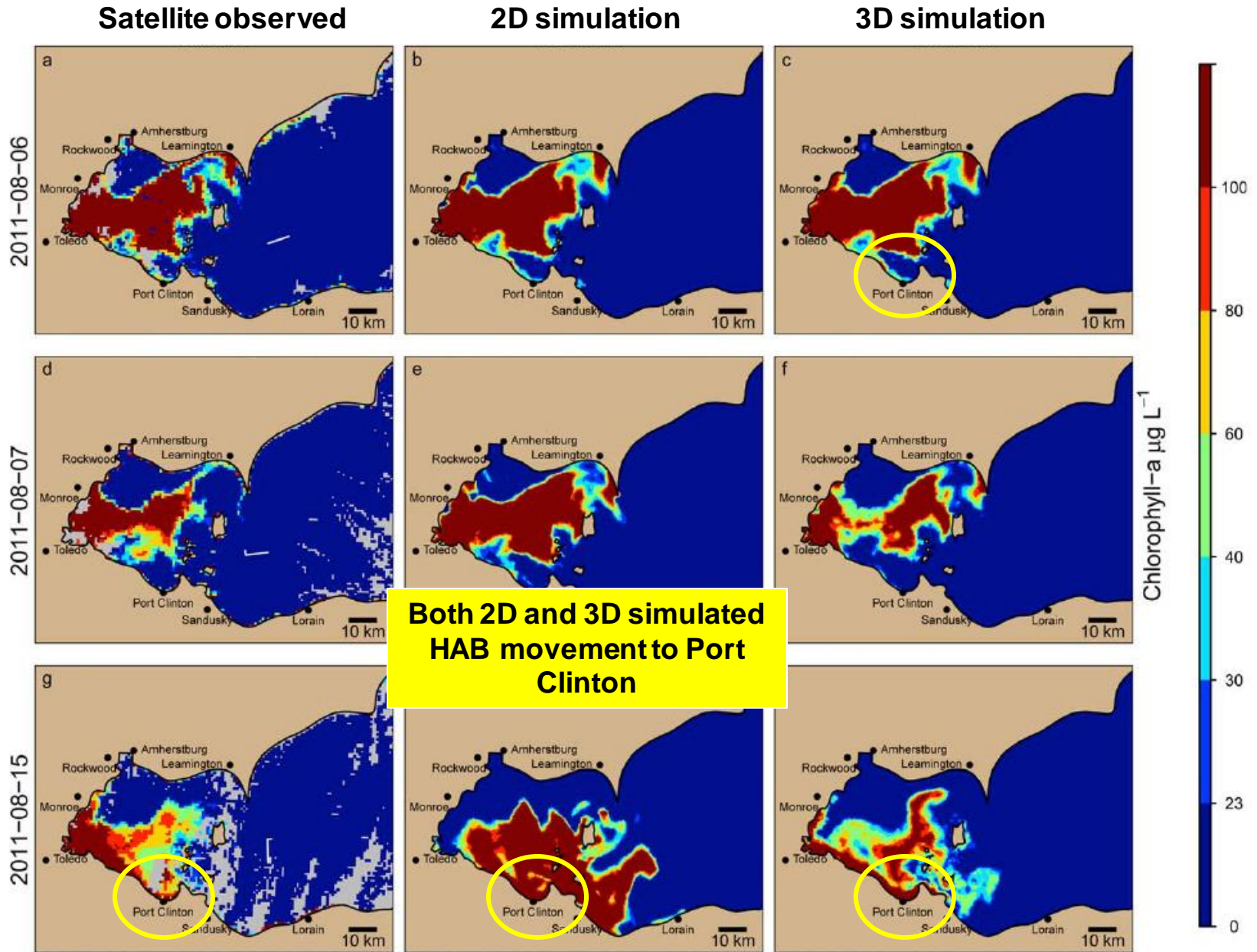


# Model assessment



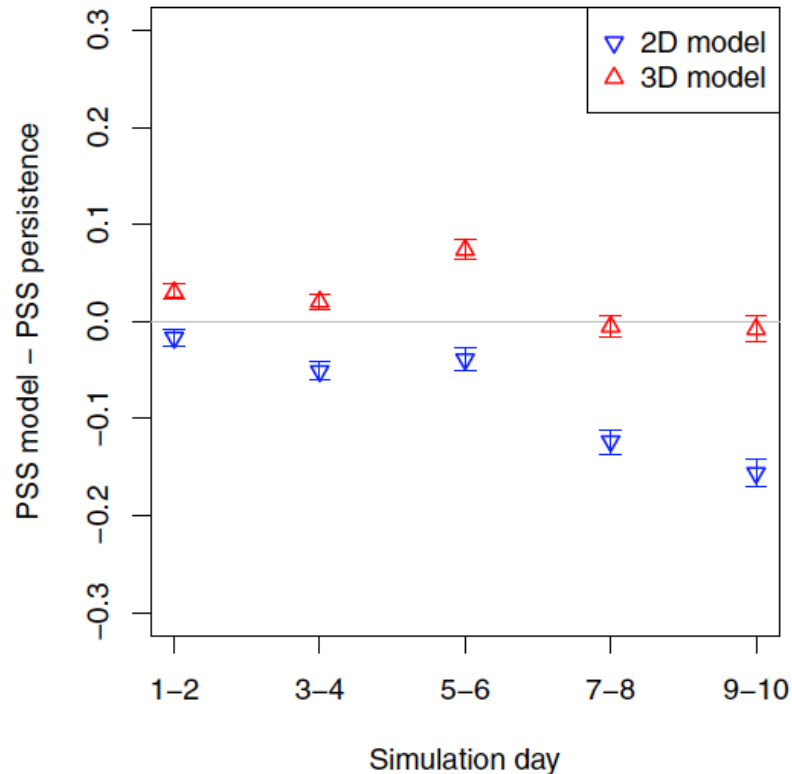


# Model assessment



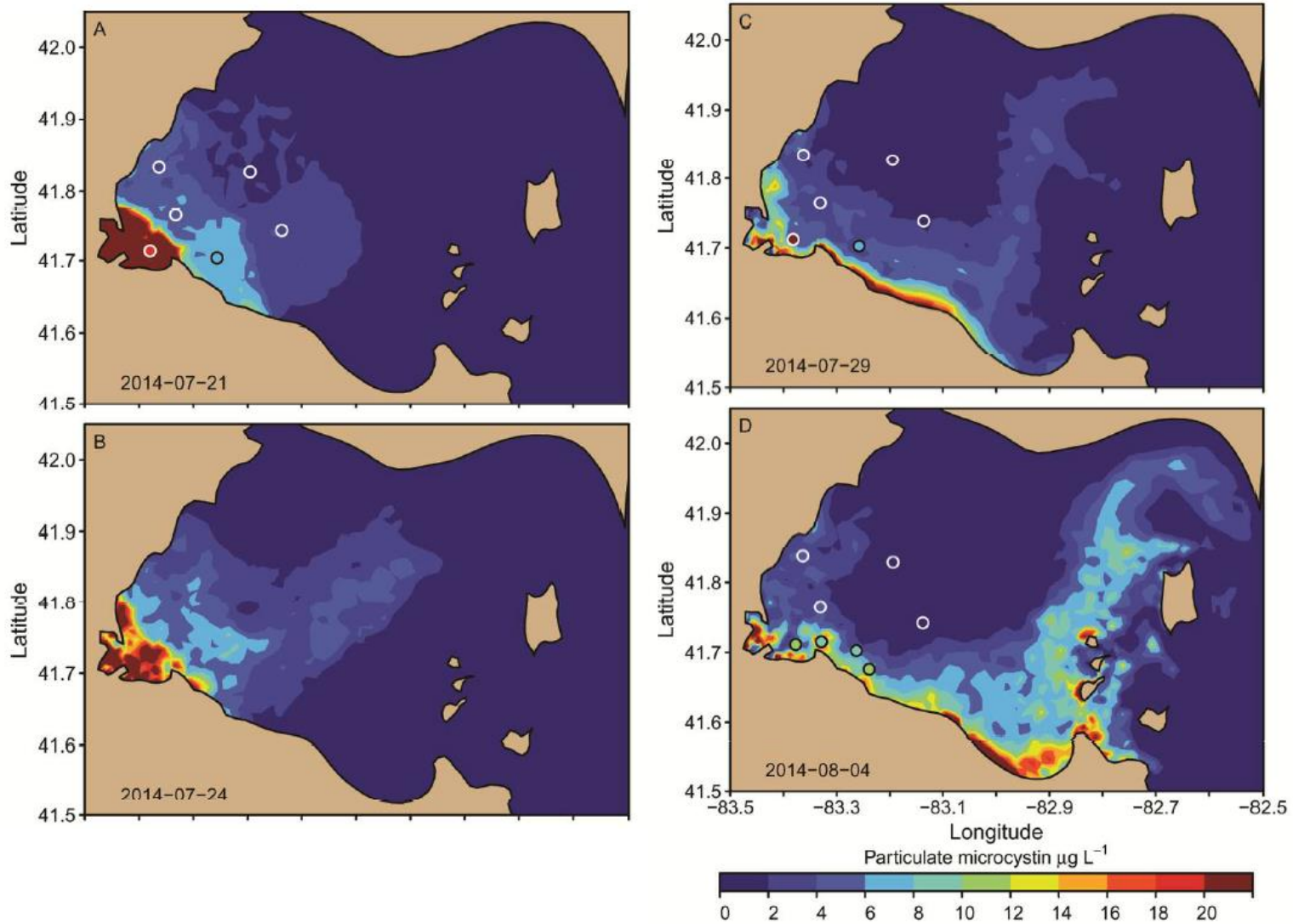


# Improved prediction statistics relative to previous model and “persistence forecast”



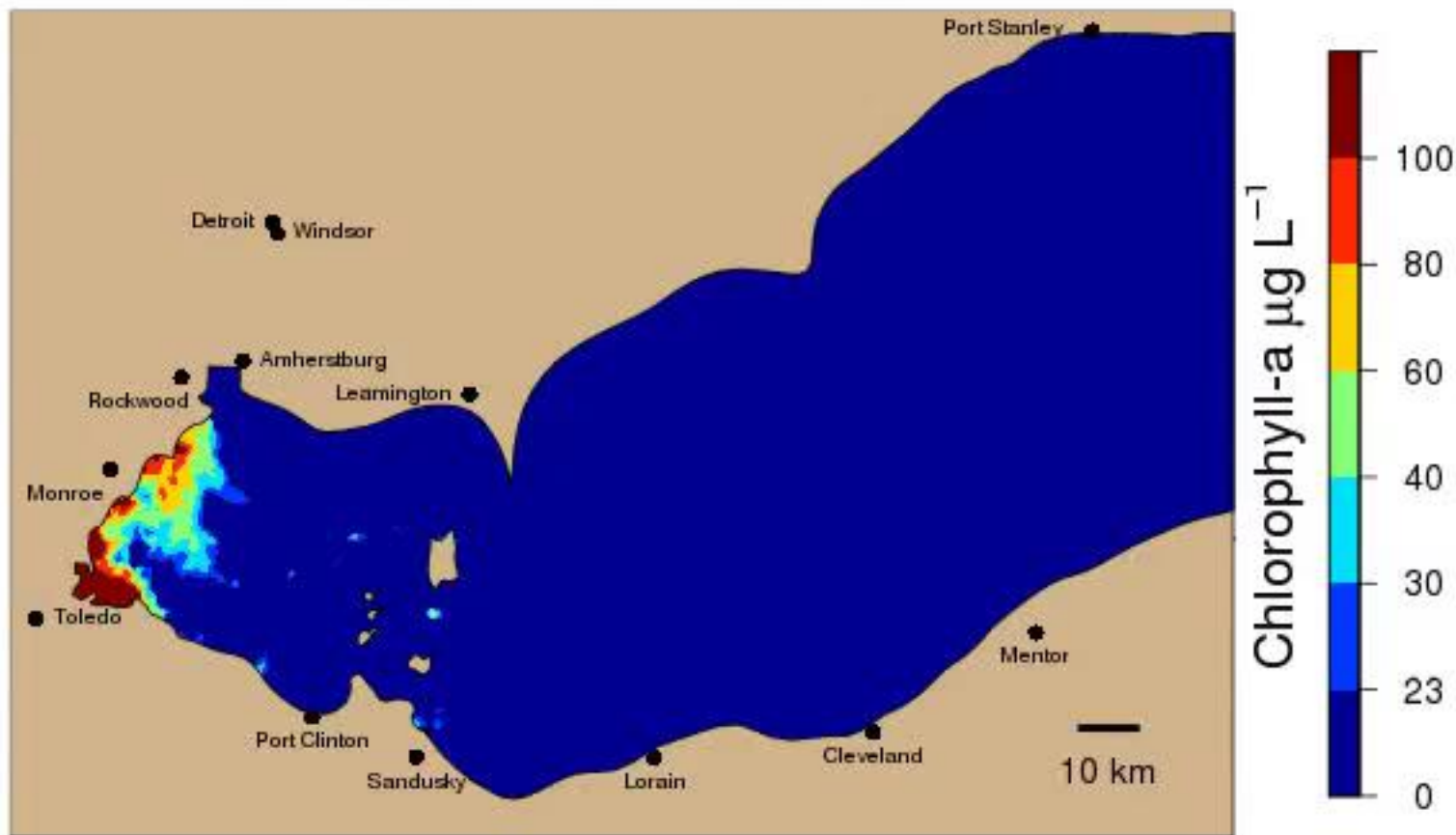
Rowe et al. 2016. J. Geophys. Res. Oceans, 121, doi:10.1002/2016JC011720.

# Modeled transport of algal toxins out of Maumee Bay during 2014 Toledo water crisis event





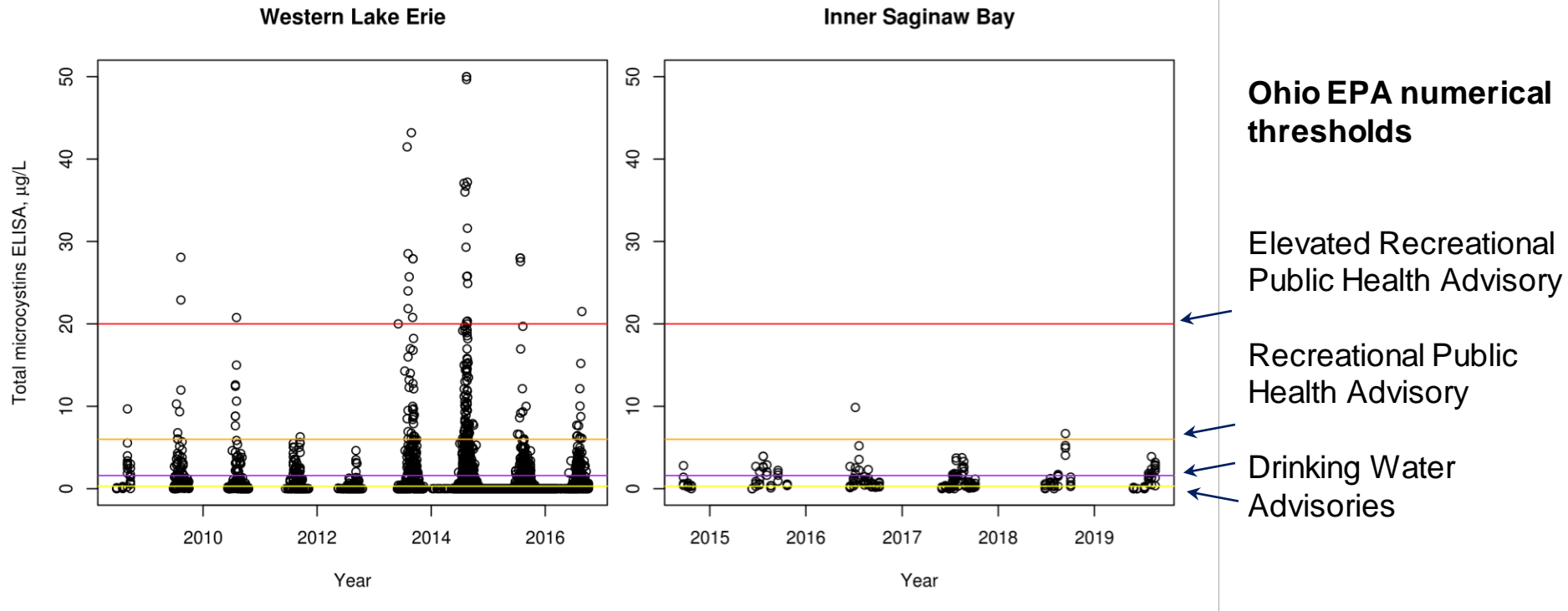
2016-08-18 13:00 EDT



# Background and Motivation for an Experimental Saginaw Bay HAB Tracker



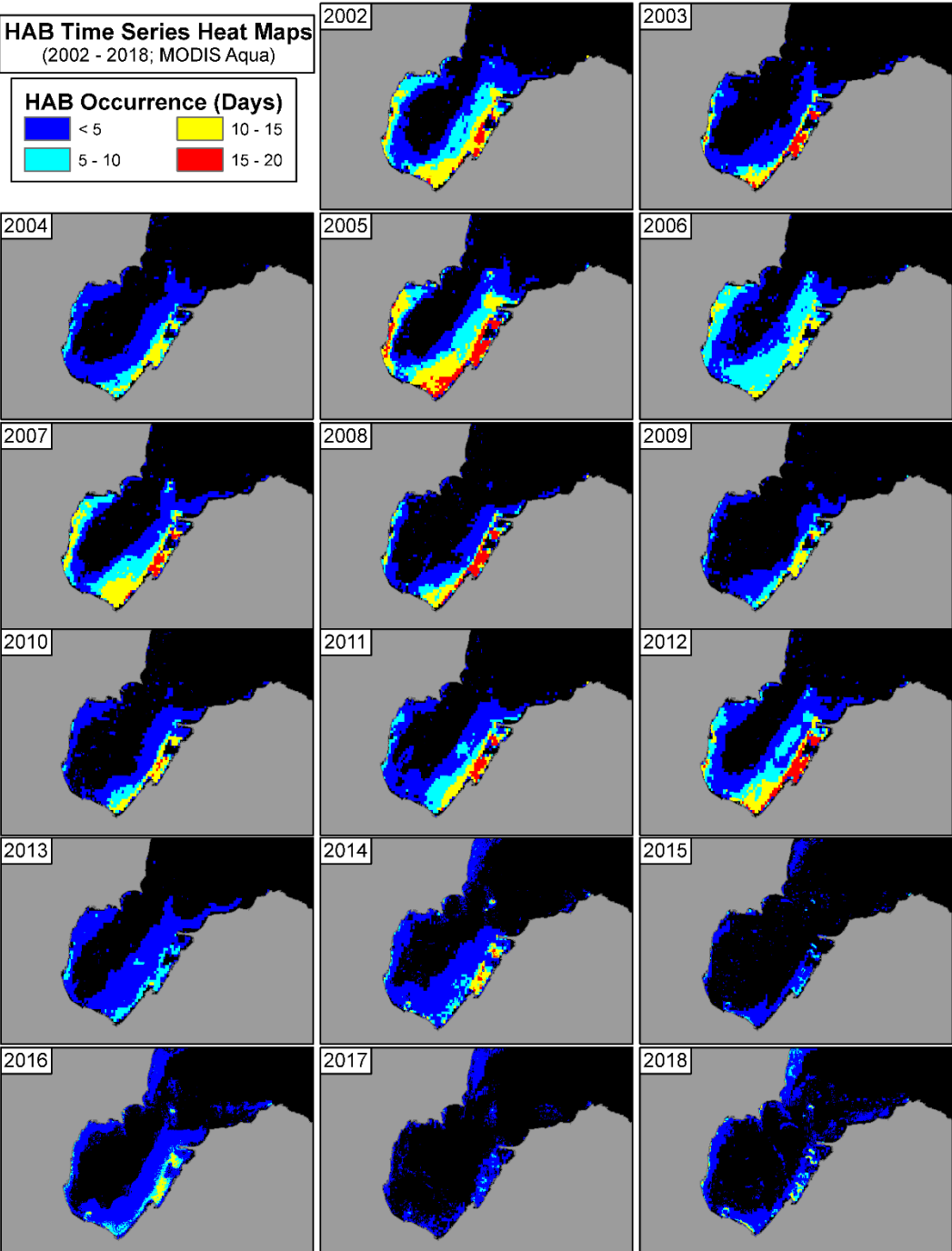
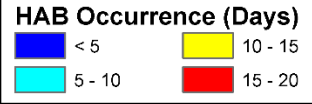
# Microcystin toxin concentrations in inner Saginaw Bay and western Lake Erie



Data source: NOAA GLERL, CIGLR

# Saginaw Bay HAB spatial patterns

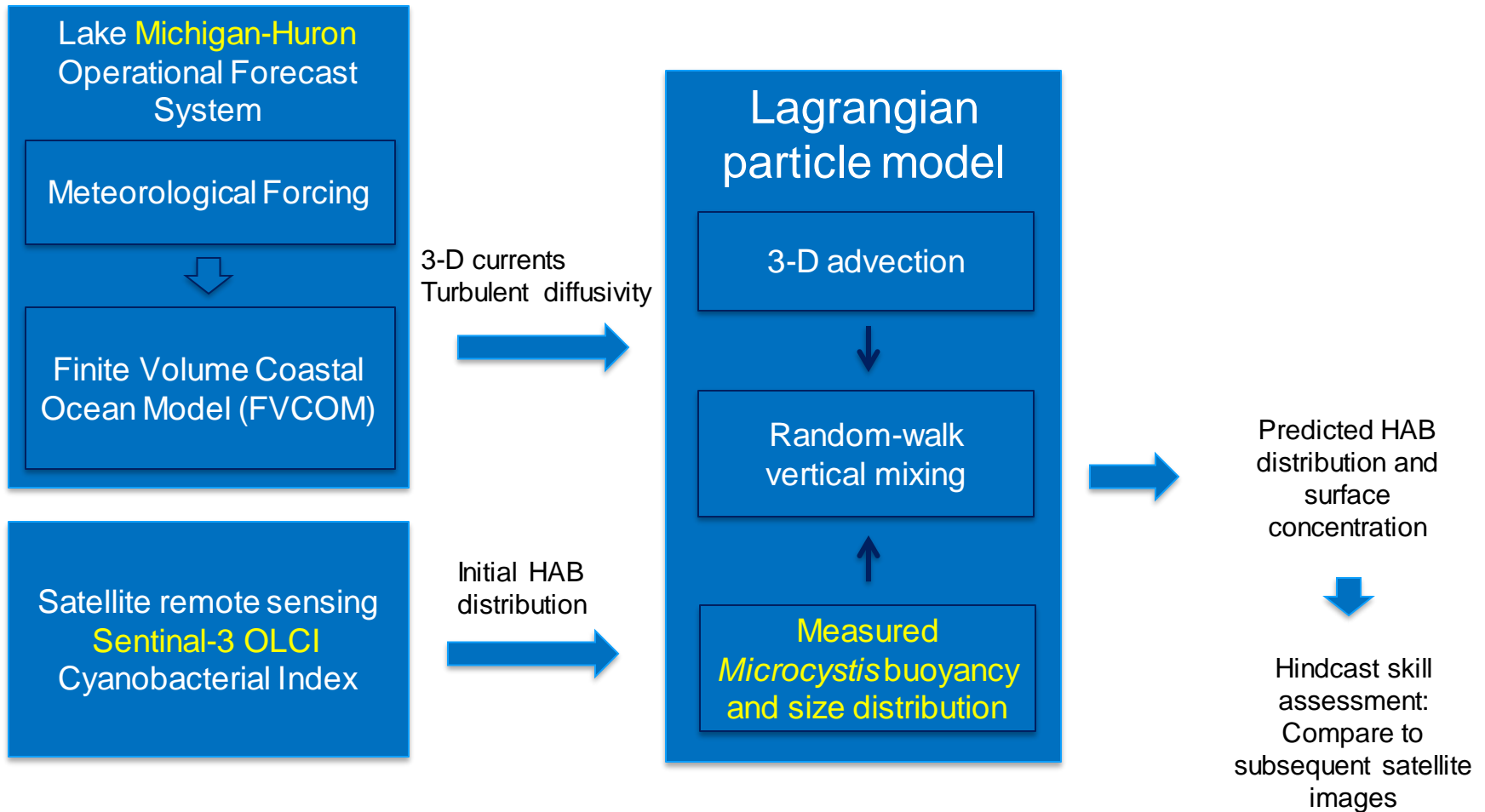
HAB Time Series Heat Maps  
(2002 - 2018; MODIS Aqua)



Courtesy of  
Michigan Tech  
Research Institute

# Proposed Experimental Saginaw Bay HAB Tracker

# Components of the Saginaw Bay HAB Tracker



# Great Lakes Operational Forecast System (GLOFS)

- Upgrade to **FVCOM & CICE**
- **200m coastlines**
- **30m tributary resolution**

**LSOFS  
2020**

**LOOFS  
2020**

**LMHOFS  
2019**

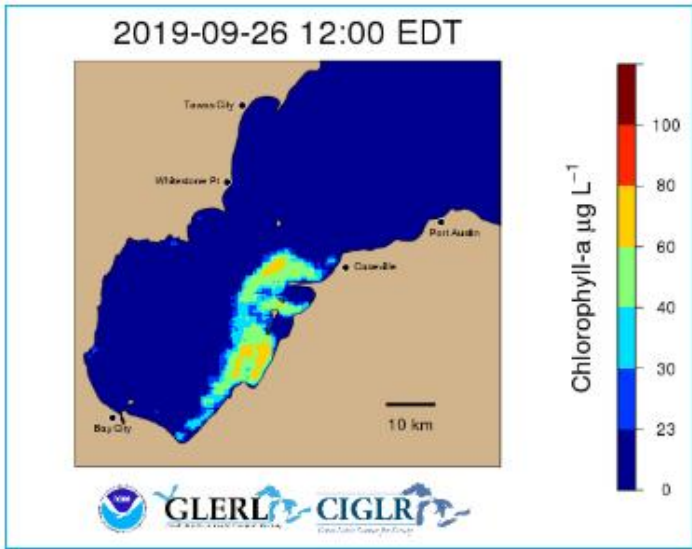
**HECOFS  
>2021**

**LEOFS  
2016**

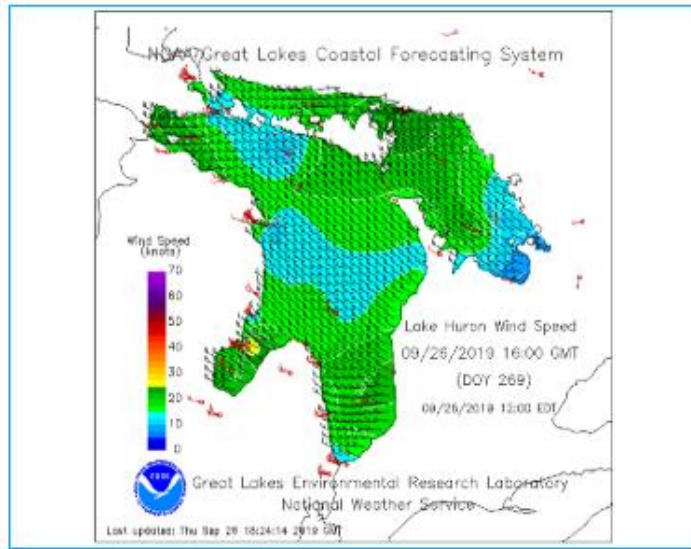
Data Sources: NOAA/GLERL FVCOM grid

Basemap: Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community

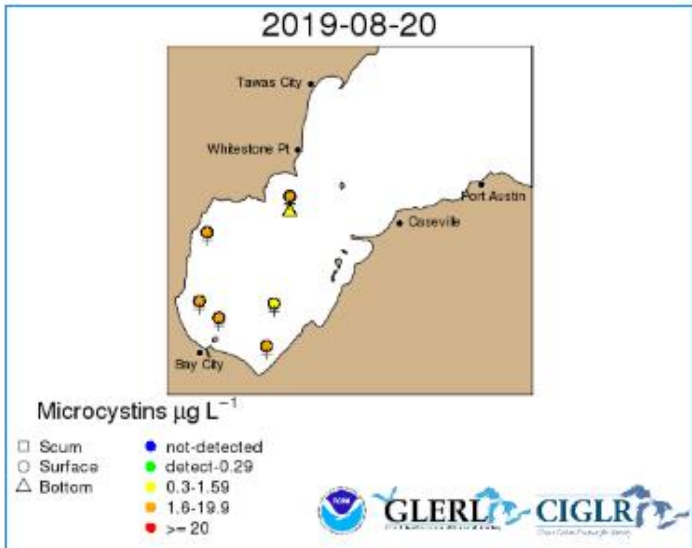
### HAB Tracker forecast



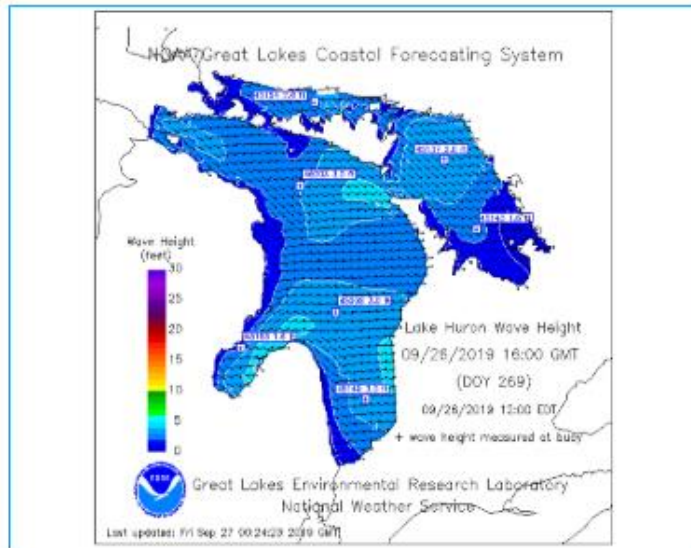
### GLCFS nowcast & 5-day wind speed forecast



### Latest reported microcystins concentrations



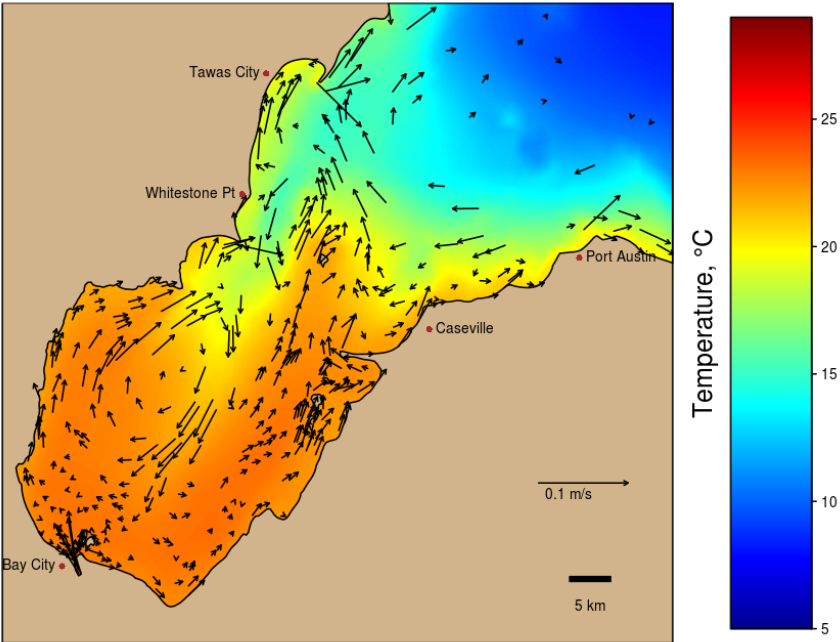
### GLCFS nowcast & 5-day wave height forecast



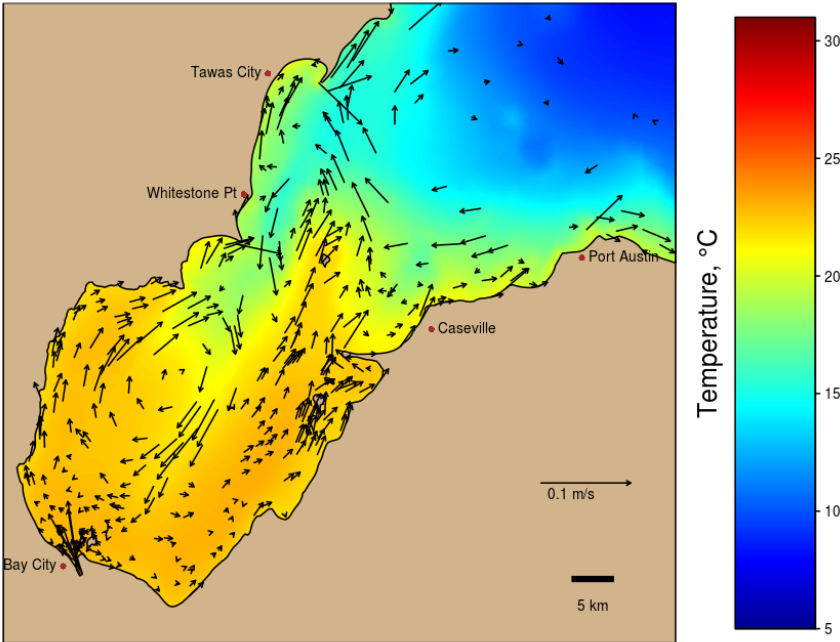


# Saginaw Bay mean circulation

2019 July-September mean

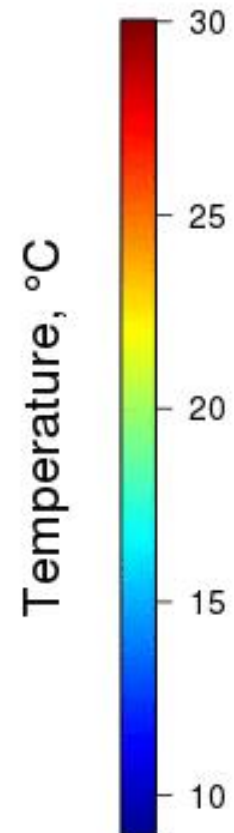
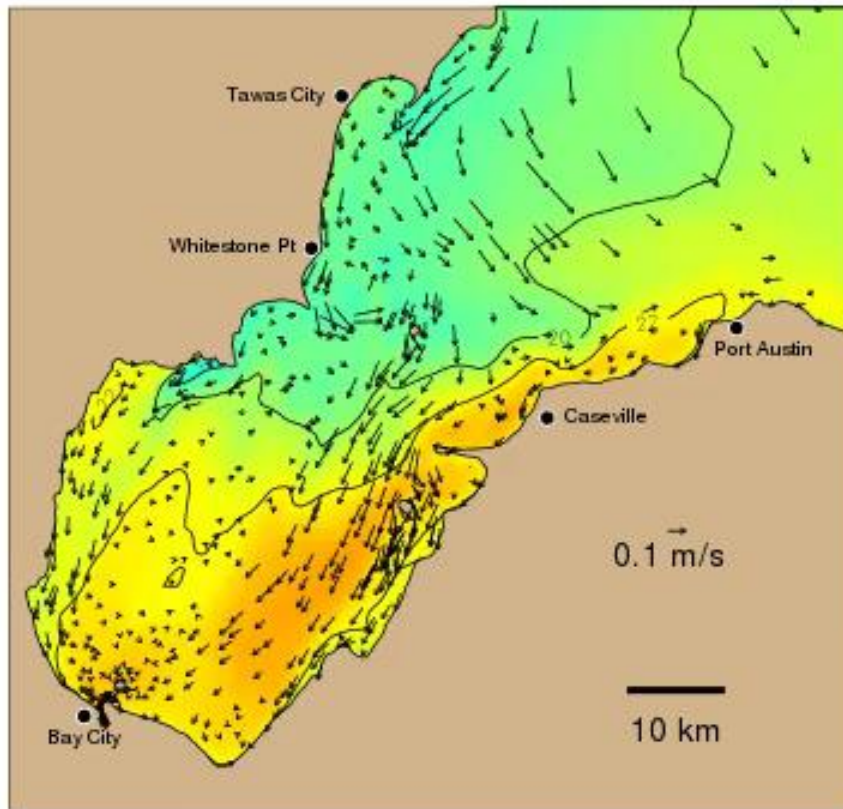


2018 July-September mean

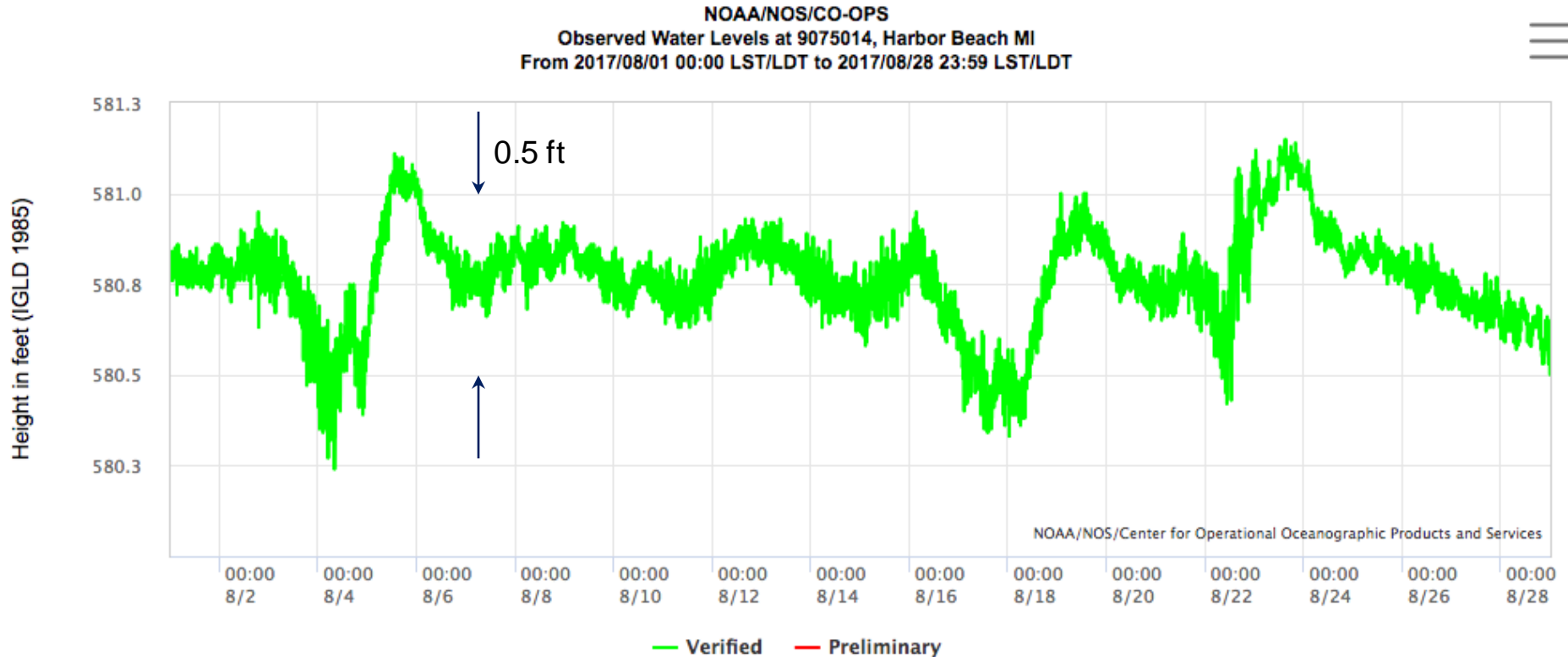


LMHOFS model vertically averaged circulation and temperature

2017-07-15 01:00:00



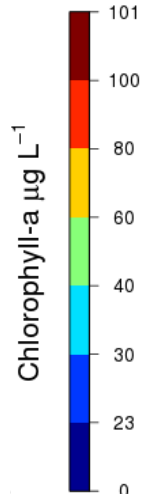
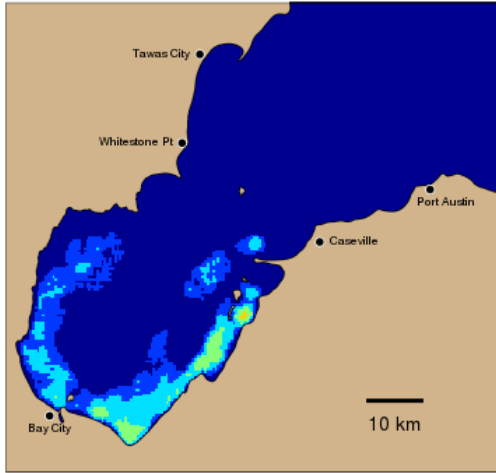
# Water level varies due to seiche, causing flow in or out of Saginaw Bay



<https://tidesandcurrents.noaa.gov/waterlevels.html>

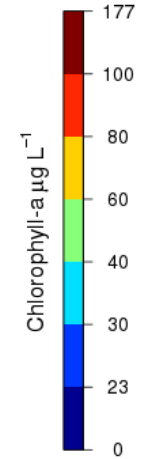
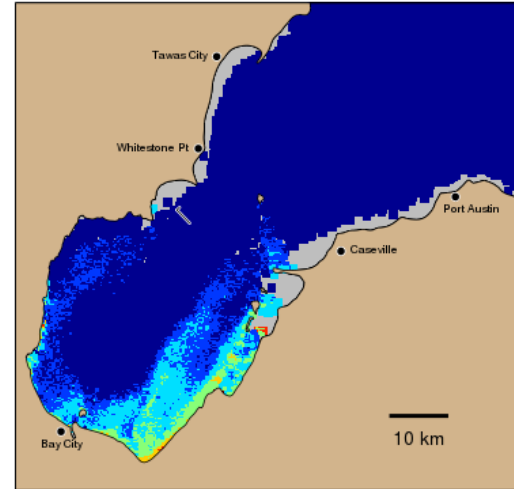
### Satellite observed

2017-08-15 12:00 EDT



### Model

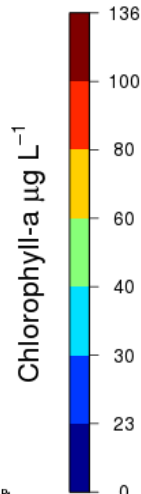
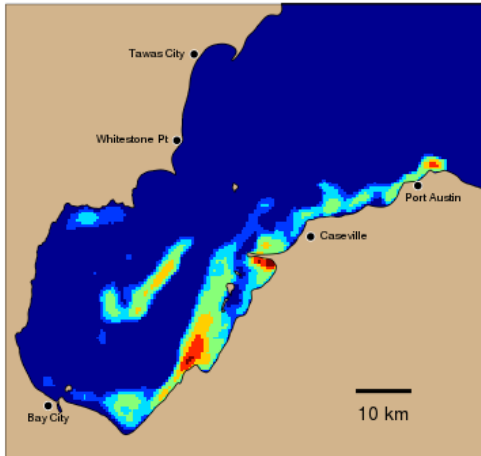
2017-08-15 11:44 EDT



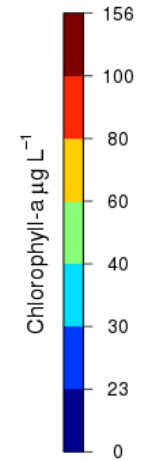
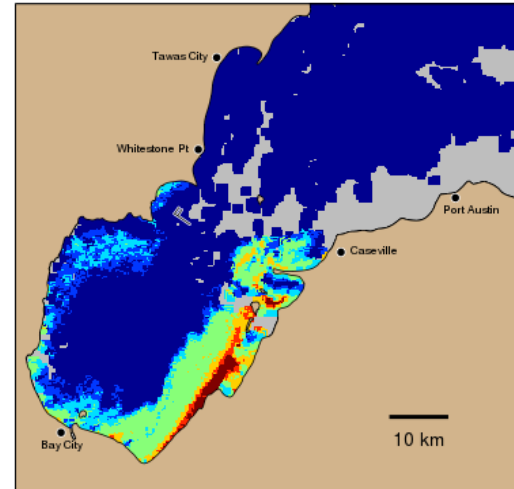
pct good = 87.6    pct HAB = 16.5    pct > Chl threshold = 16.5

Initial condition

2017-08-19 11:00 EDT



2017-08-19 11:40 EDT



pct good = 76.6    pct HAB = 21.4    pct > Chl threshold = 21.4

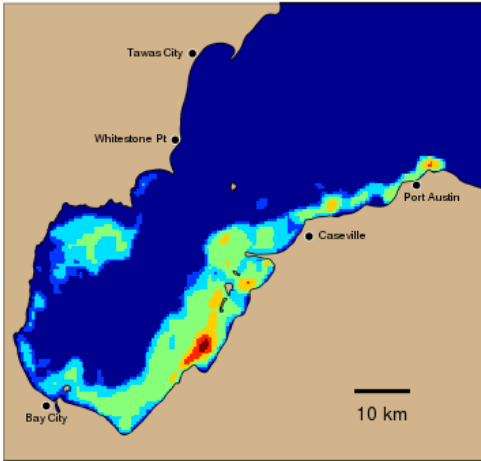
Predicted day 4

nObsHab	nObsNoHab	nPredHab	nPredNoHab	pctAccHab	pctAccNoHab	pctAccAll	chlPctBias	chlRmse	chlCor	Pt
2257	2961	1957	3261	73	90	83	-32	19	0.77	Pt
2257	2961	1509	3709	53	89	73	-26	21	0.65	

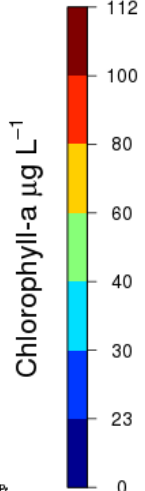
### Satellite observed

2017-08-19 11:00 EDT

Initial condition

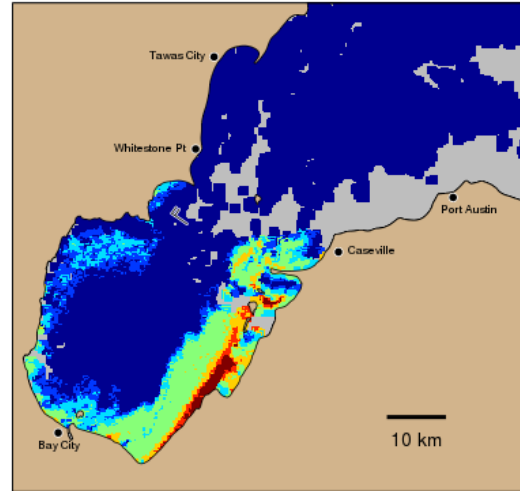


nObsHab	nObsNoHab	nPredHab	nPredNoHab	pc1AccHab	pc1AccNoHab	pc1AccAll	ch1PctHab	ch1PctNoHab	ch1PctAll	ch1Rmse	ch1Cor
2257	2961	2254	2964	99	99	99	-2	5	0.98		
2297	2991	2378	2940	94	92	93	-4	10	0.92		

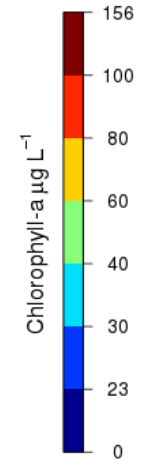


### Model

2017-08-19 11:40 EDT

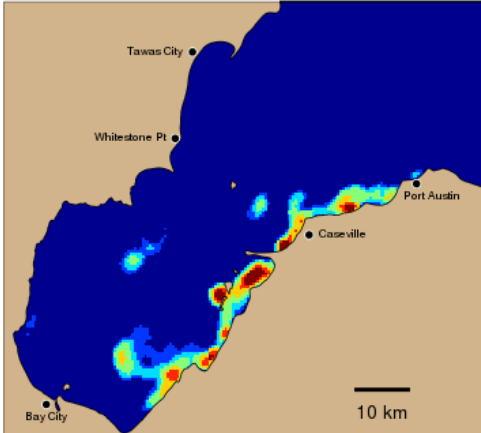


pct good = 76.6    pct HAB = 21.4    pct > Chl threshold = 21.4

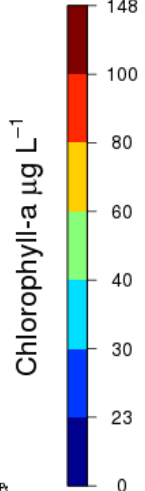


2017-08-23 11:00 EDT

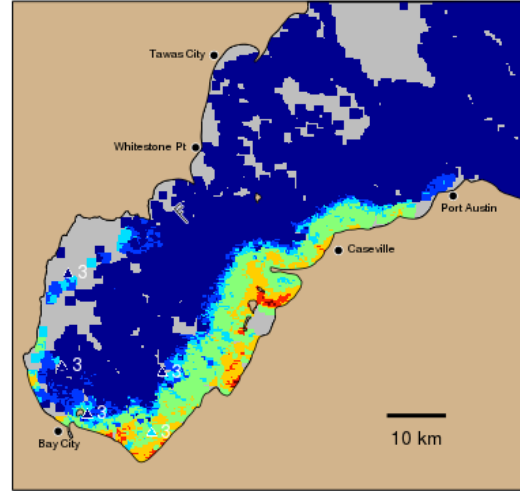
Predicted day 4



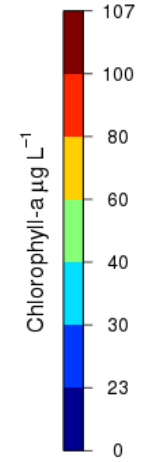
nObsHab	nObsNoHab	nPredHab	nPredNoHab	pc1AccHab	pc1AccNoHab	pc1AccAll	ch1PctHab	ch1PctNoHab	ch1PctAll	ch1Rmse	ch1Cor
1933	2940	1708	2893	81	95	89	-11	16	0.82		
1933	2940	841	3732	35	94	69	-37	25	0.52		
1	4	3	2	100	90	90	8	12	0.90		
1	4	1	4	0	75	60	-47	12	0.54		



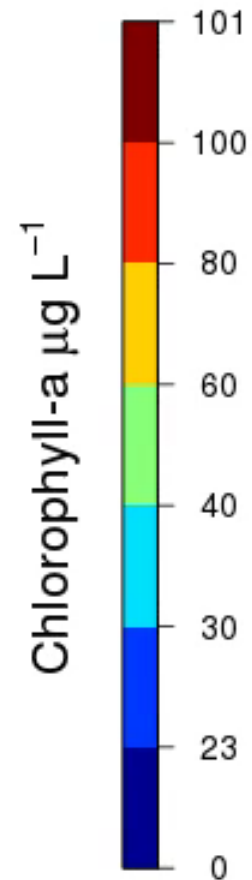
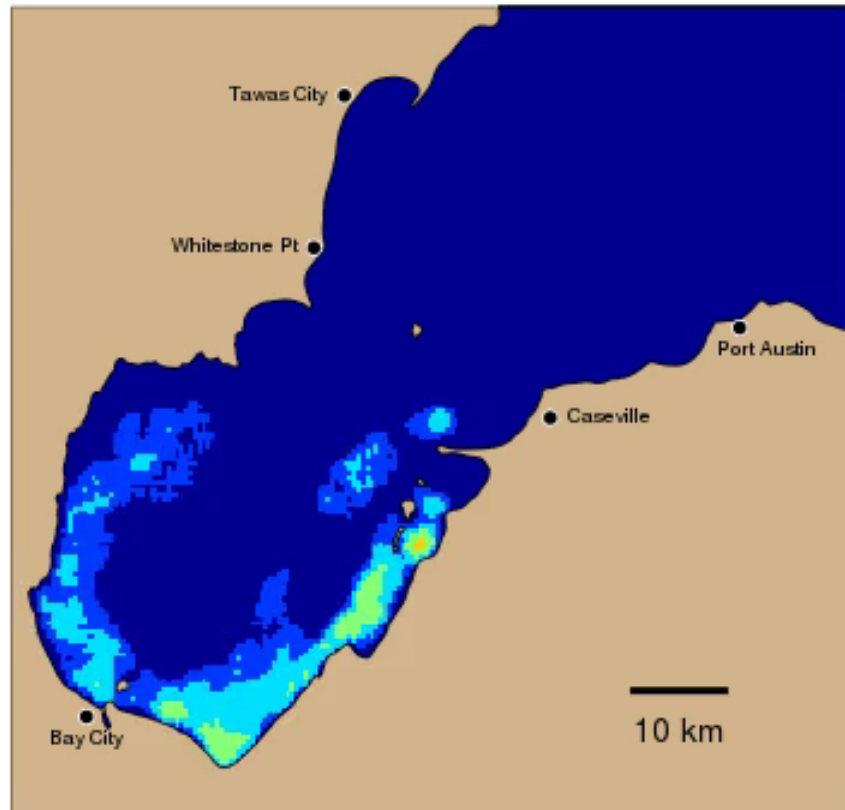
2017-08-23 11:36 EDT



pct good = 70.4    pct HAB = 20.8    pct > Chl threshold = 20.8



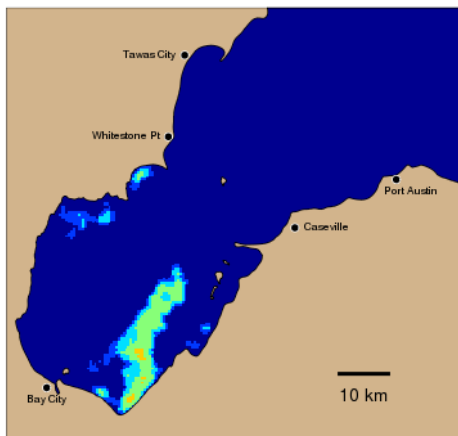
2017-08-15 12:00 EDT





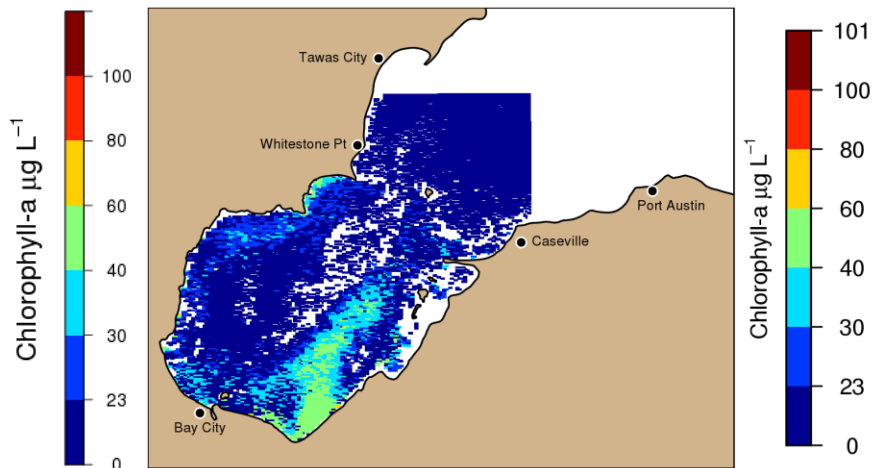
## Model

2019-09-07 12:00 EDT



## Satellite observed

2019-09-07 11:00 EDT



Wind speed

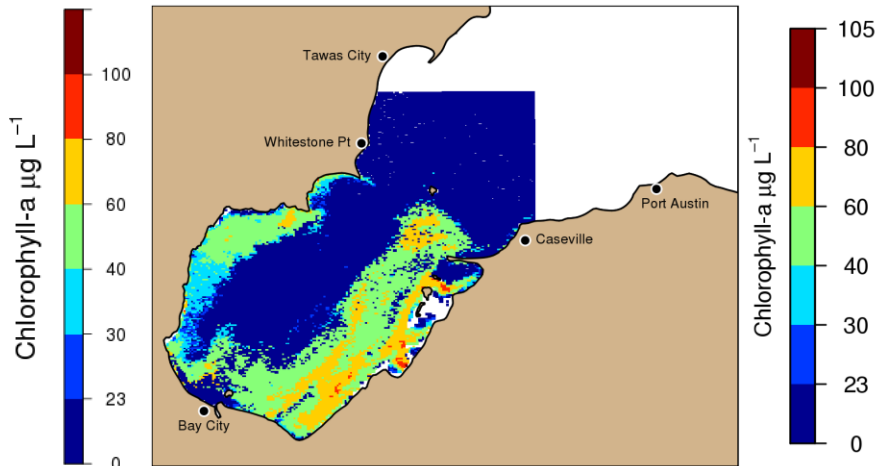
8.1 kt

Initial condition

2019-09-14 11:00 EDT



2019-09-14 11:00 EDT



13.7 kt

GLOS buoy  
45163  
preceding 24 hr  
mean

Predicted day 7

# Summary

A short-term forecast for HAB distribution and movement could be adapted to Saginaw Bay, making use of the new Lake Michigan-Huron Operational Forecast System, and Cyanobacterial Index from new Sentinel-3 satellite.