Potential Impacts of Climate Change on Pathogen and Pesticide Contamination in Coastal Waters

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GLERL
Great Lakes Environmental Research Laboratory

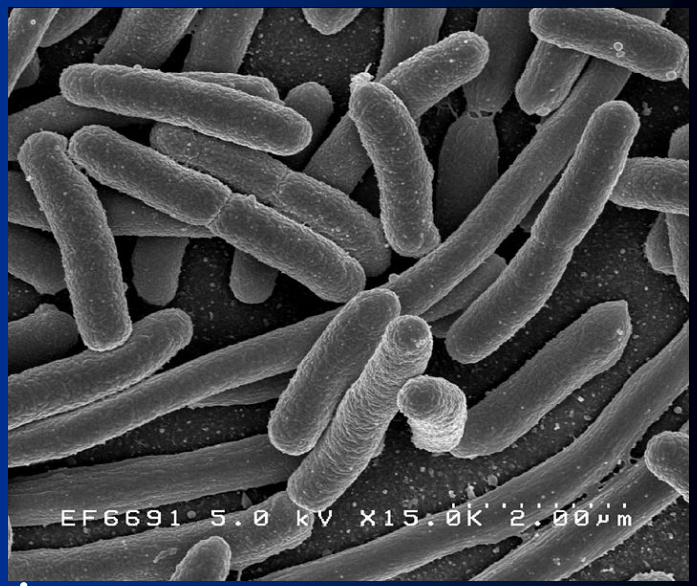
CILER

Overview

- Waterborne pathogens
  - Waterborne pathogen contamination in the Great Lakes
  - Possible impacts of climate change
- Pesticides
  - Pesticide contamination in the Great Lakes
  - Possible impacts of climate change
- Tools for minimizing the effects of increasing contamination

Waterborne Pathogens

- Bacteria
  - Escherichia coli, Aeromonads, Salmonella typhi, Shigella (shigellosis), and Vibrio cholerae (cholera)
- Viruses
  - Hepatitis A virus, Norwalk, rotavirus
- Protozoa
  - Giardia lamblia and Cryptosporidium
- Too many species for testing → Fecal Coliforms



NIH, 2007

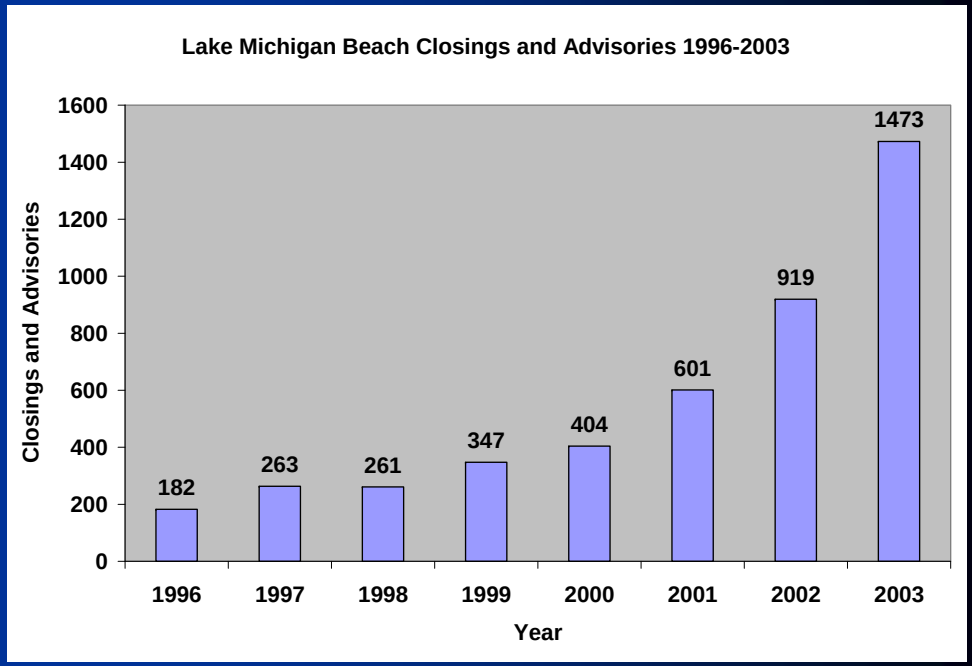
Sources of Waterborne Pathogens

- Storm water (100,000 CFU/100 ml)
- Combined Sewer Overflows (250,000 CFU/100 ml)
- Sanitary Sewer Overflows (500,000 CFU/100 ml)
- Agricultural runoff from fields treated with manure and feedlots (100,000 CFU/100 ml)
- Waterfowl (27,000 CFU/100 ml)
- Other wildlife

GLIN, 2007

Human Exposure to Waterborne Pathogens

- Drinking water
- Seafood and fish consumption
- Consumption of vegetables irrigated with contaminated water
- Recreation in contaminated waters



AGL, 2003

Possible Impacts of Climate Change on Waterborne Pathogen Contamination

- Increasing frequency of intense storms
  - CSOs and runoff from agricultural fields
  - Resuspension of waste in the sediments
  - Increased turbidity
- ? Increasing temperature
  - Coliform presence is more frequent at T>15°C (LeChevalier, 2003)
  - Lower buoyancy and consequently higher particle and pathogen sinking rates (Roesh et al., 2007)
- ? Changes in waterfowl migration patterns
  - No winter migration

Pesticide Contamination of Water

- 1000 million pounds of pesticed were used in the US in 1997
- Herbicides (60%)
  - *Atrazine, simazine, cyanazine, alachlor, metolachlor*
- Insecticides (13%)
  - *Diazinon, carbaryl, chlopyrifos, carbofuran, malathion*
- Fungicides (7%)
  - *Dicarboximide, QoI, Azoxystrobin*
- Rodenticides, fumigants, nematicides (20%)
  - *Nemagon (Fumazone), carbofuran, warfarin, Difenacoum, Bromadiolone*

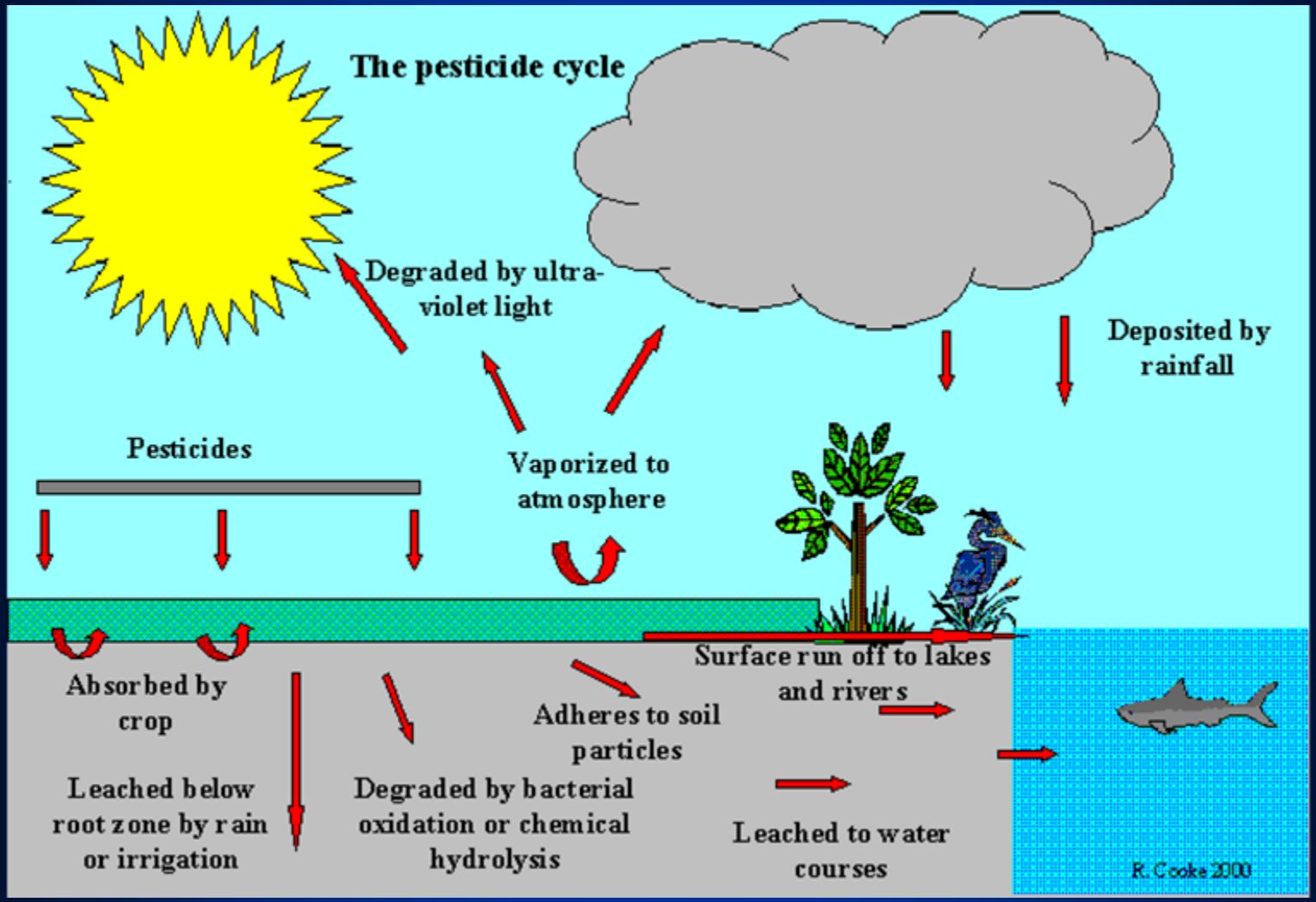
Clay, 2003

Sources of Pesticides

- Agriculture (80%)
  - (Approximately 149 metric tons of Atrazine were used in the Saginaw Bay Basin in 2002)
- Homeowners/gardeners (8%)
- Commercial market (12%)

Clay, 2003; He et al., 2008

The Pesticide Cycle



Exposure to Pesticides

- Drinking water (surface and groundwater)
  - Atrazine may have affected as many as 3,600 drinking water systems throughout the U.S., mainly in the Midwest (Zandonella, 2007)
- Seafood and fish consumption
  - DDT
- Fruit and vegetables
- Recreation in contaminated waters
  - A smaller concern because pesticide levels normally require frequent exposure

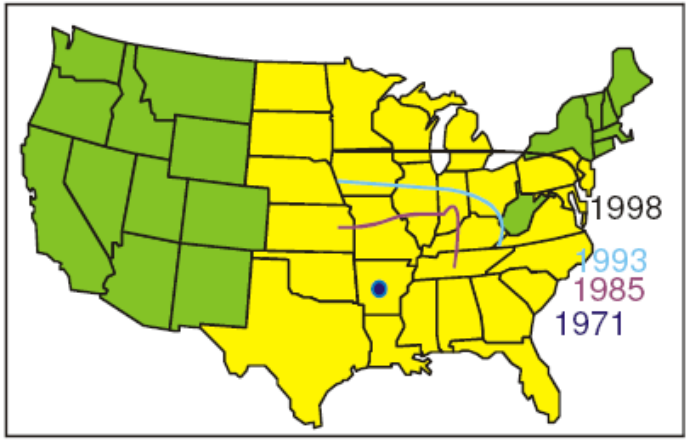
FWS, 2008

Possible Impacts of Climate Change on Pesticide Contamination

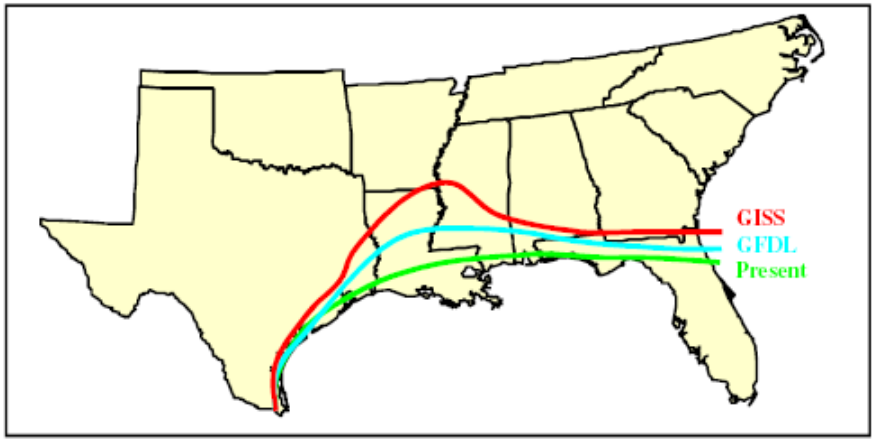
- Increasing humidity, temperature, and CO2
  - Changes in pest patterns
  - Increase in weed infestation
  - Double cropping

Rosenzweig, 2008

Range of expansion of soybean sudden death syndrome (*Fusarium solani* f.sp. *glycines*) in North America. (X.B. Yang).



Overwintering range of potato leafhopper under two doubled $C0_2$ climate change scenarios. (Stinner et al., 1989)



Possible Impacts of Climate Change on Pesticide Contamination

- Increasing Precipitation Intensity
  - Increased runoff from agricultural fields and lawns
  - Increased erosion
  - Increased leaching to groundwater

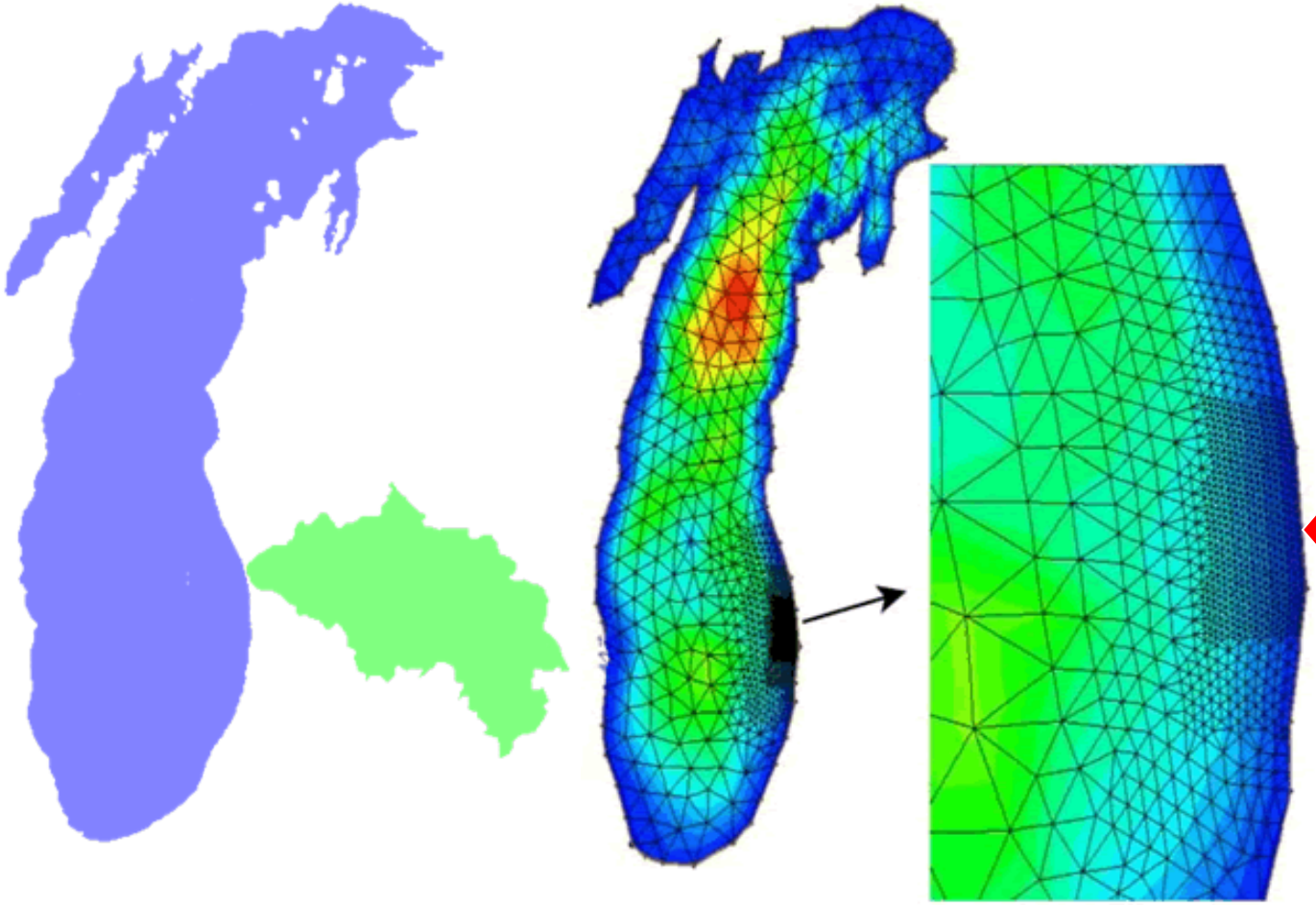
Take Home Message

- Climate change in the Great Lakes region will likely increase human exposure to waterborne pathogens and pesticides

Tools for Minimizing the Effects of Increasing Contamination

- Hardware
  - Expansion of sedimentation basins for storm water, CSOs, and CAFOs
  - Decreased use of pesticides; better pesticides and application techniques
  - Buffers strips, contouring, increased infiltration areas
- Software
  - Better contamination prediction tools

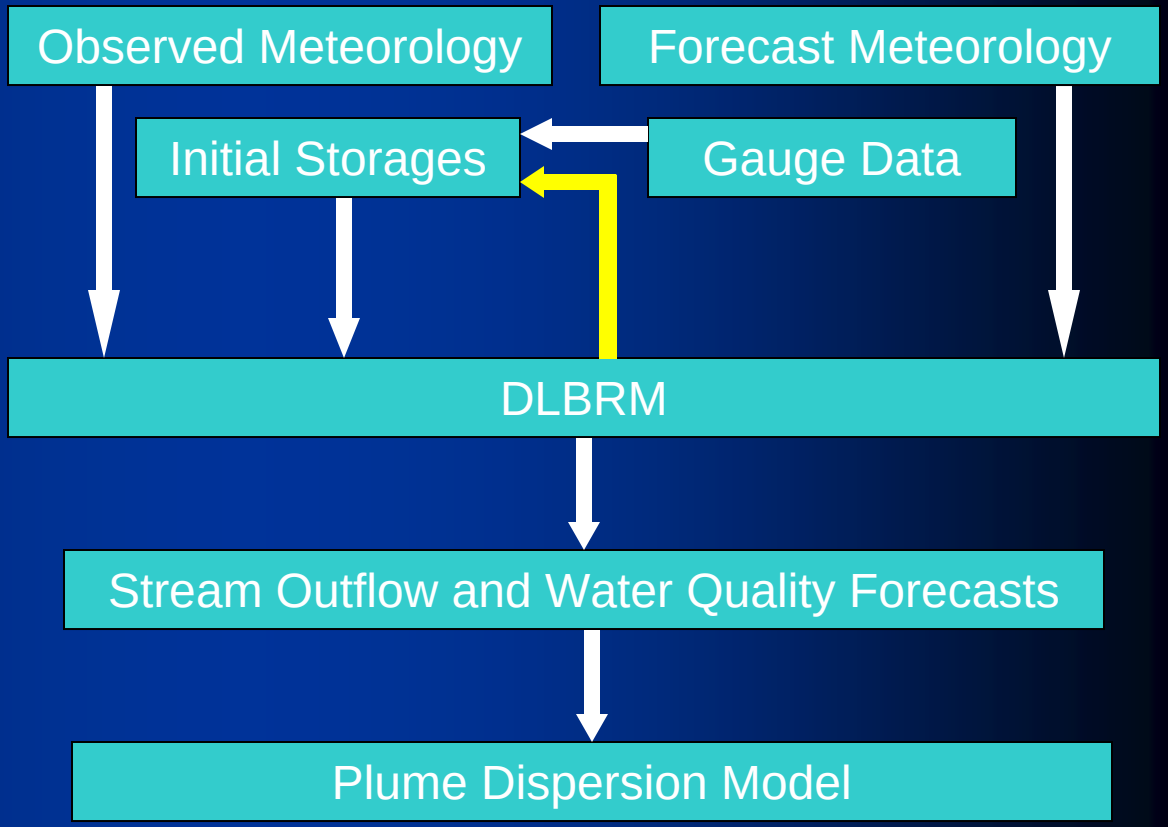
Beach Closure Forecasting
Grand Haven (MI)



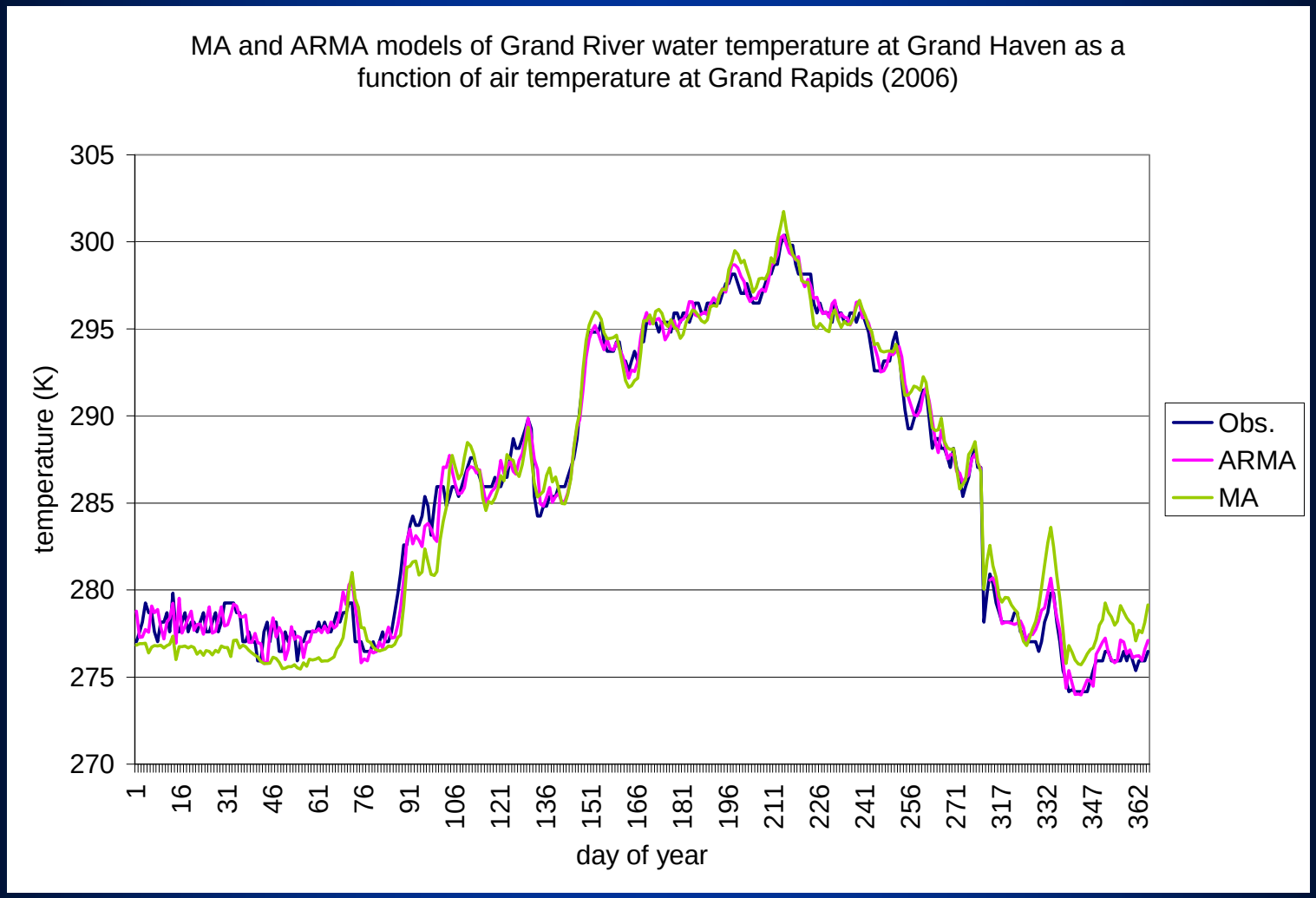
Forecasts for:
- Discharge
- Water Temperature
- Fecal Coliforms
- Sediments
- Other pollutants

GLERL's Short-term Deterministic Outflow Forecast

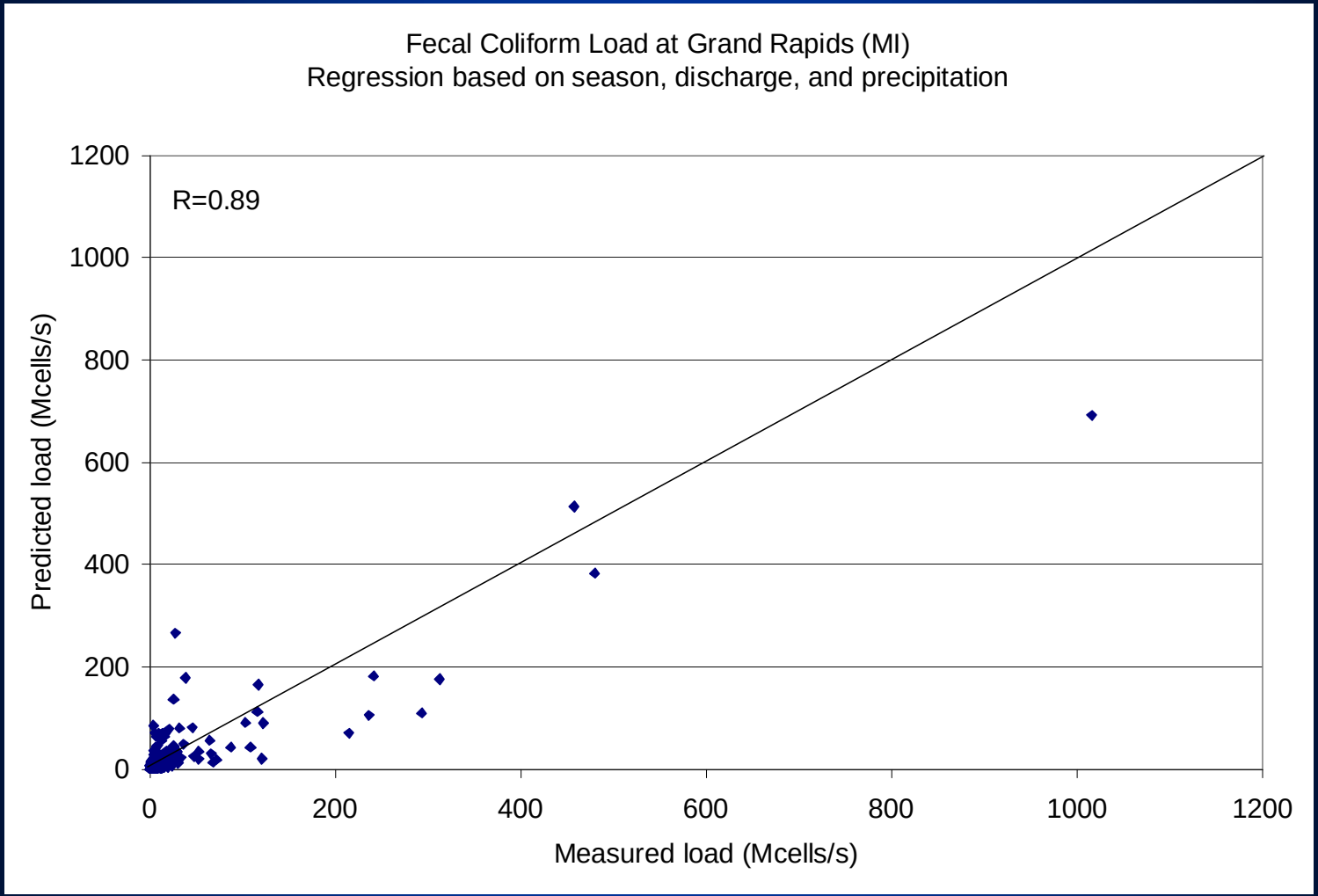
- Distributed Large Basin Runoff Model (DLBRM)
- Observed meteorology for period prior to forecast
- Initial moisture storage conditions for DLBRM
- Forecast meteorology from NWS for forecast period
- Streamflow gauge data from USGS
- Materials transport models



Grand River Water Temperature at Grand Haven



Grand River Fecal Coliform Load at Grand Rapids



Current And Future Research

- Adding pollutant and nutrient transport models
- Improve pathogen forecasting by linking FC to continuously monitored parameters (temperature, discharge, turbidity, DO, NO3, etc.)

- Extending this approach to other areas in the GL and reach to an operational level (NWS, USGS, etc.) will serve present needs and prepare for future problems
- With some exception (Lake Erie), water quality monitoring is poor. Need to improve water quality monitoring/data acquisition to support such extension.

Conclusions

- Coastal waters presently suffer from serious problem of pathogen and pesticide contamination
- Climate change will likely exacerbate these problems via a host of mechanisms
- Minimizing the impact of climate change in these areas will require changes in policies and infrastructure improvement
- Improved forecasting tools will also concur in minimizing the impact of such changes

Thanks for the Attention!

- Questions?
  Comments?
  Suggestions?