Synergistic impacts of population growth, urbanization, and climate change on watersheds and coastal ecology of the northeastern United States

A new three-year research project funded by NASA's Interdisciplinary Research in Earth Science Program

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Overall goal of project

Quantify the impacts of human population growth and associated land-use changes on the biogeochemistry and ecology of the Chesapeake and Delaware estuaries and the adjacent continental shelf waters

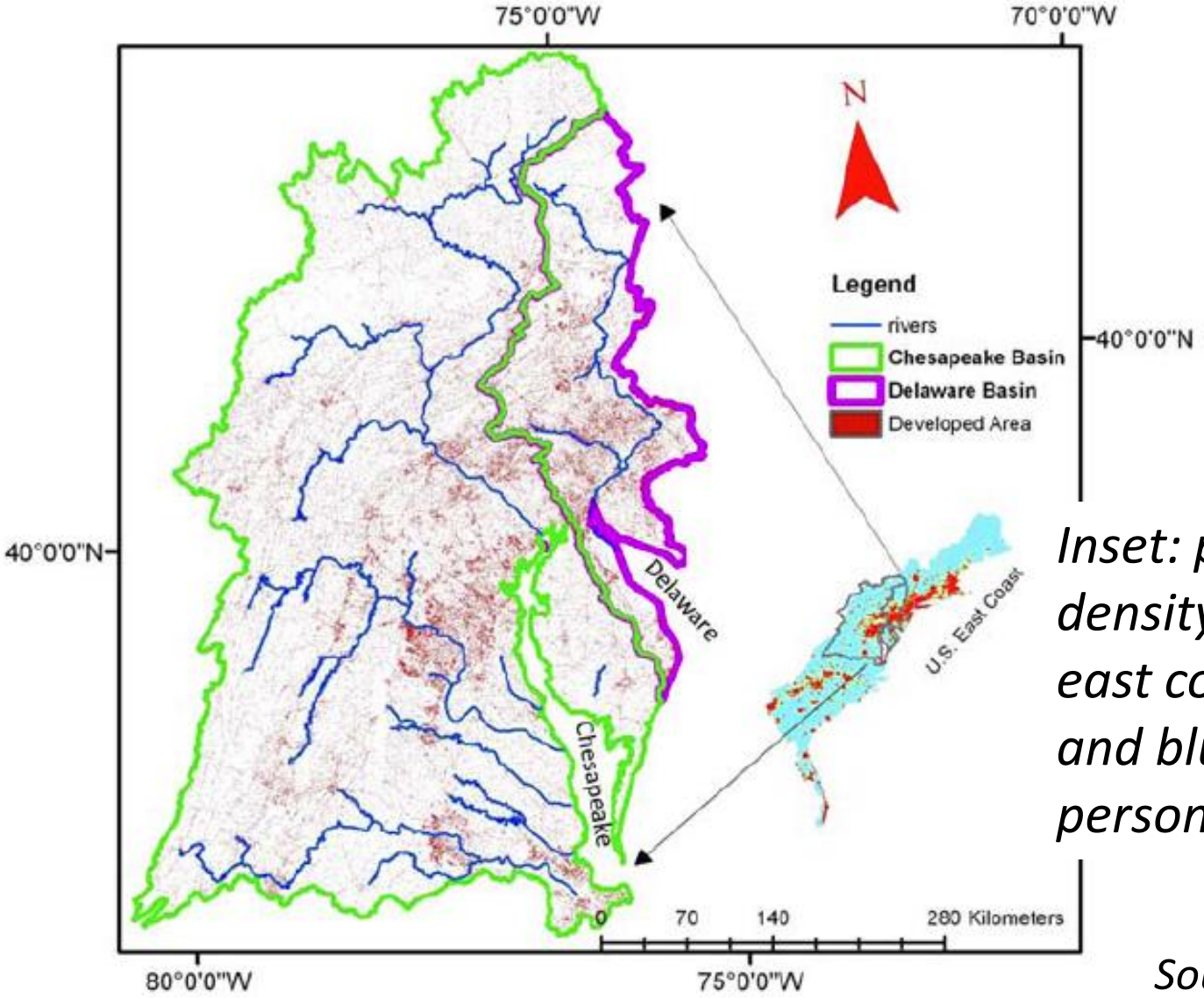
Ecological endpoints considered

(1) Phytoplankton speciation, representing the base of the coastal food web;

(2) Eastern oysters and Atlantic surfclams, upper-trophic keystone species for the region's estuaries and shelf waters, respectively; and

(3) Hypoxia, representing an index of threats to the overall health of the region's ecology

Chesapeake and Delaware Bays, their watersheds, and associated developed areas



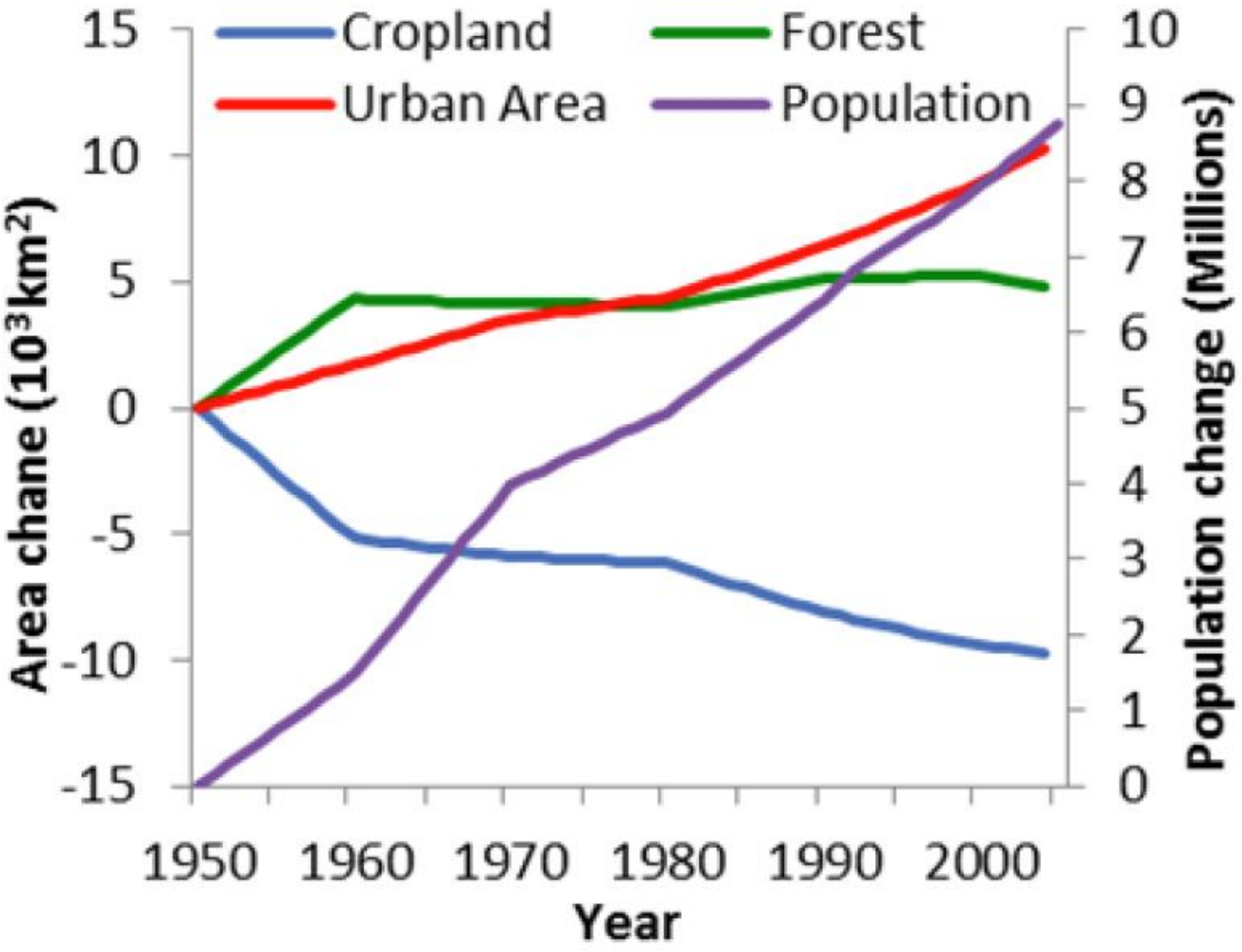
Inset: population density along U.S. east coast (red > 2000 and blue < 500 persons km^{-2})

Source: Hanqin Tian

Changes in population and land use in the Chesapeake Bay watershed

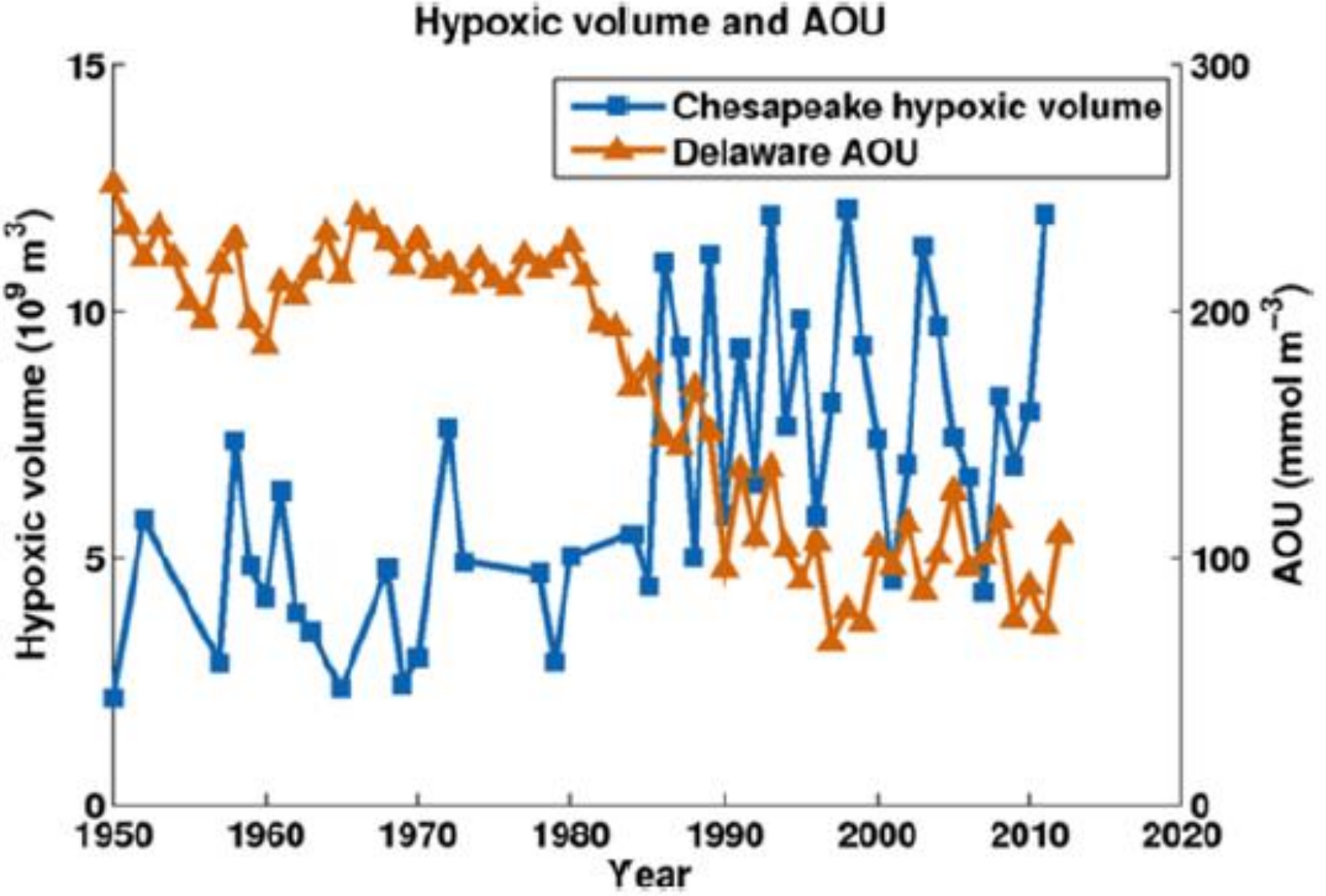
Watershed area = 166 x 10^3 km^2

Similar trends seen in the Delaware Bay watershed



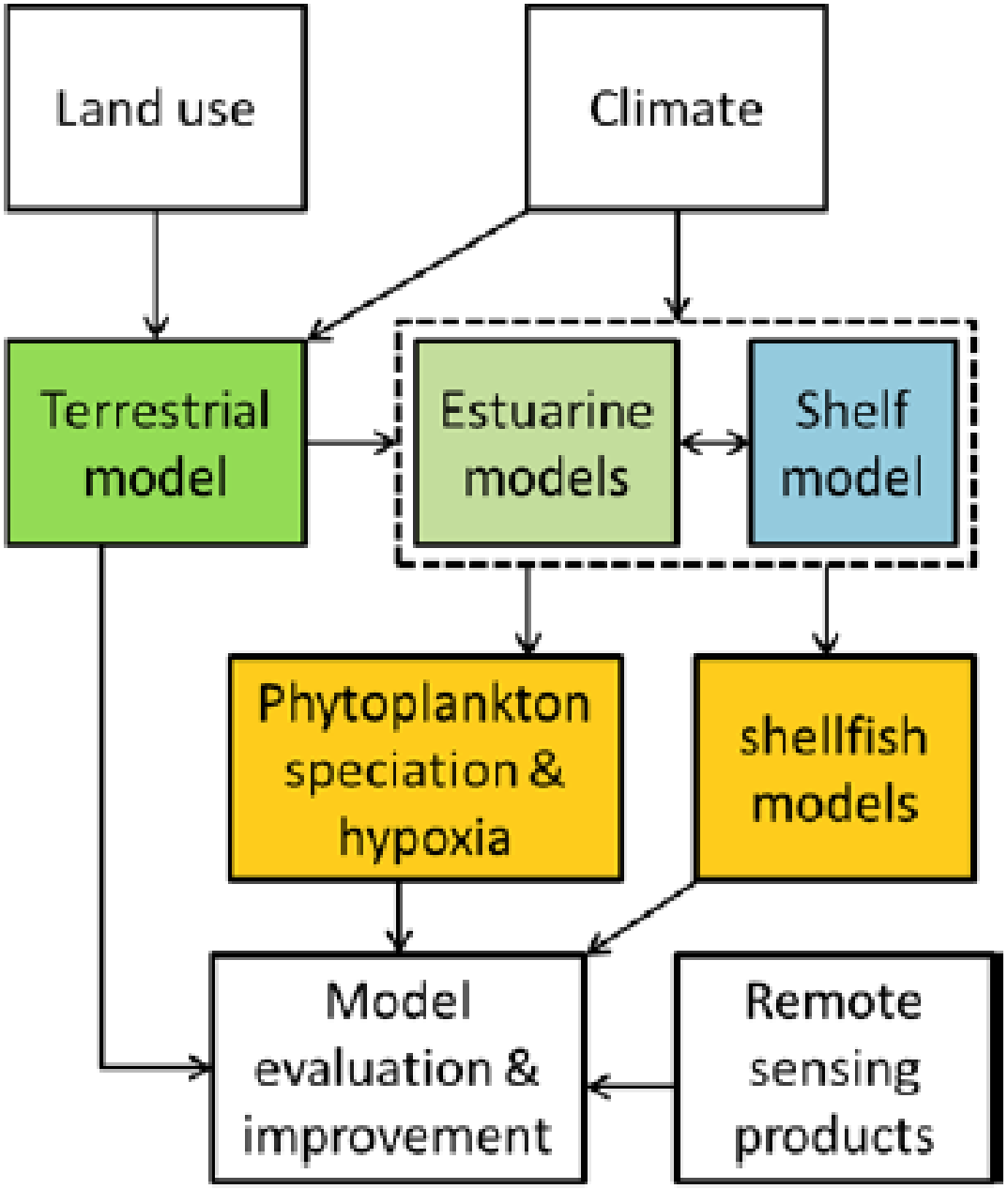
Source: Hanqin Tian

Measures of low-oxygen conditions in the Chesapeake and Delaware estuaries



Sources: Dan Tomaso, Bever et al. (2013), Hagy et al. (2004)

Overall framework



Approach

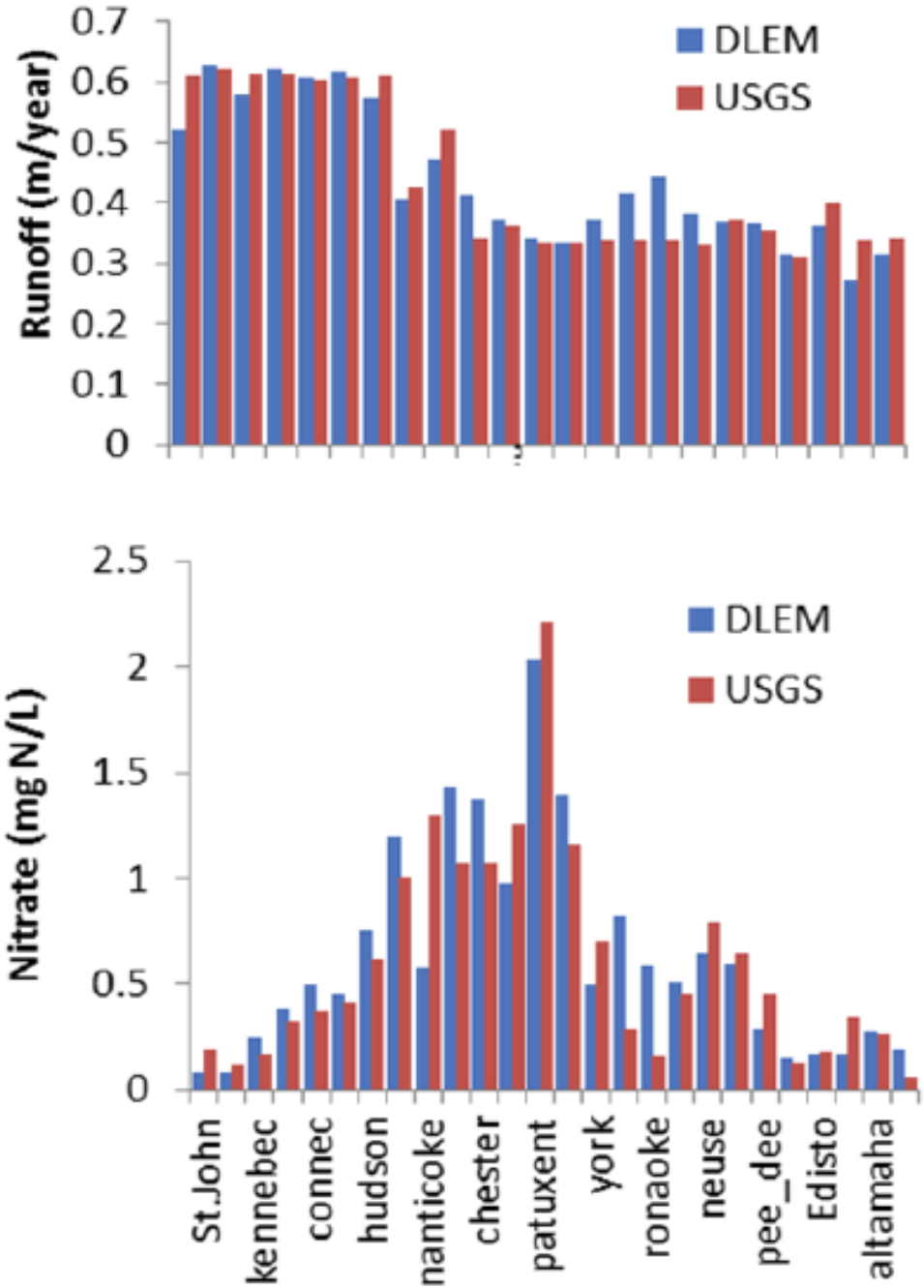
(1) Refine and link models for

(a) terrestrial biogeochemistry

(b) estuarine-coastal biogeochemistry

(c) Eastern oysters and Atlantic surfclams

Evaluation of runoff and nitrate concentration in The Dynamic Land Ecosystem Model (DLEM) along the US East Coast



Source: Hanqin Tian

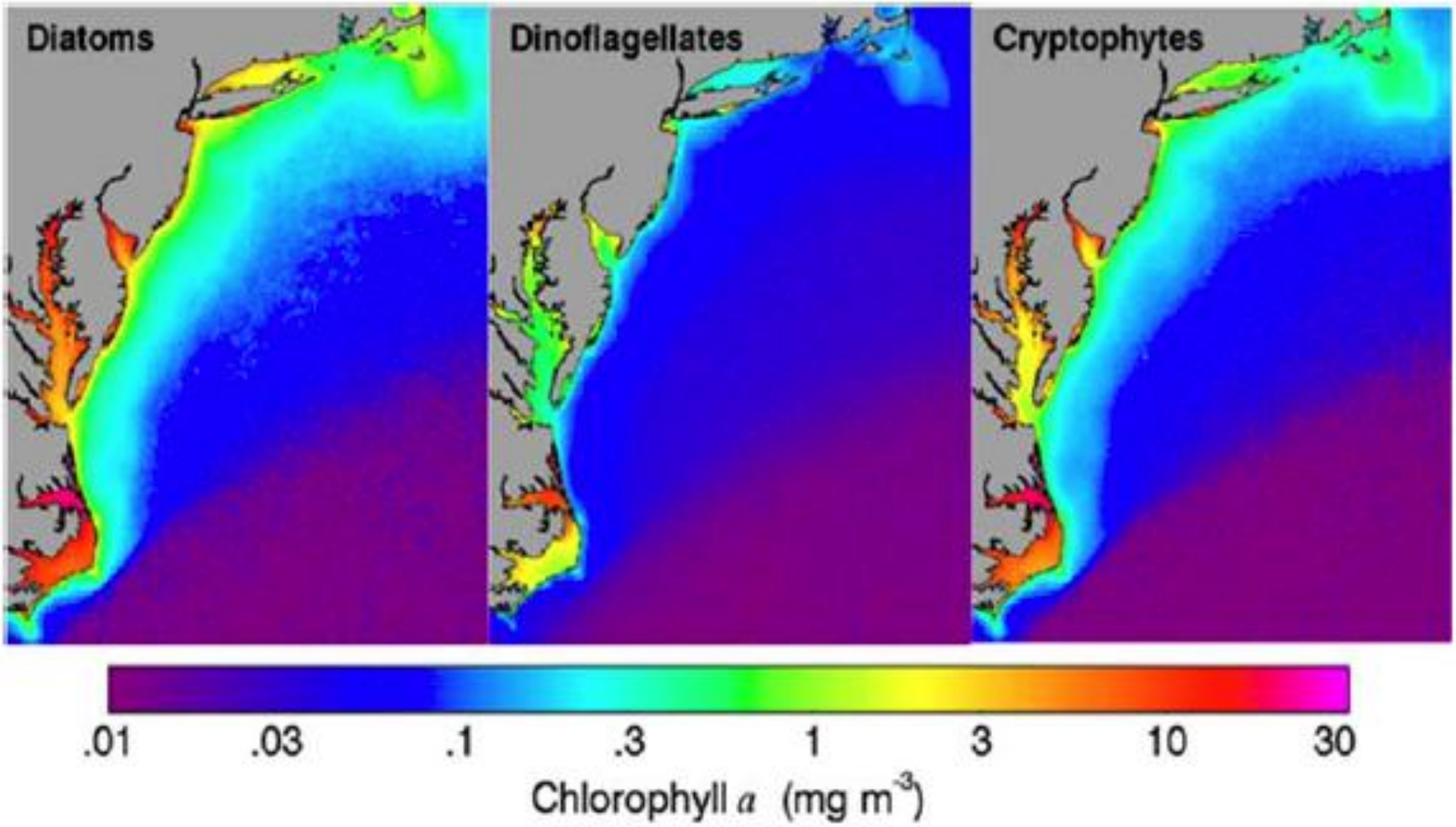
(2) Develop new remote sensing products for model evaluation:

(a) phytoplankton functional types

(b) optical properties

(c) organic carbon cycling

1998-2007 mean chlorophyll concentrations associated with three phytoplankton groups



Sources: Kim Hyde, Pan et al. (2011)

(3) Generate four simulations, 1950s to present:

(a) All forcings

(b) Only climate change

(c) Only changes in land cover and management

(d) Only changes in nitrogen inputs

Foci of new work

- Remote sensing: extend prior work on continental shelf and lower estuaries to turbid portions of estuaries
- DLEM: implement new input data sets and new module for urban processes
- Ocean model: develop two-way nested model of estuaries and continental shelf, include multiple phytoplankton groups in estuarine models, and improve dissolved oxygen module
- Shellfish models: Implement existing models of oysters and surfclams to simulate impact of changes in coastal water quality from 1950 to the present

Thank you! Questions and comments?