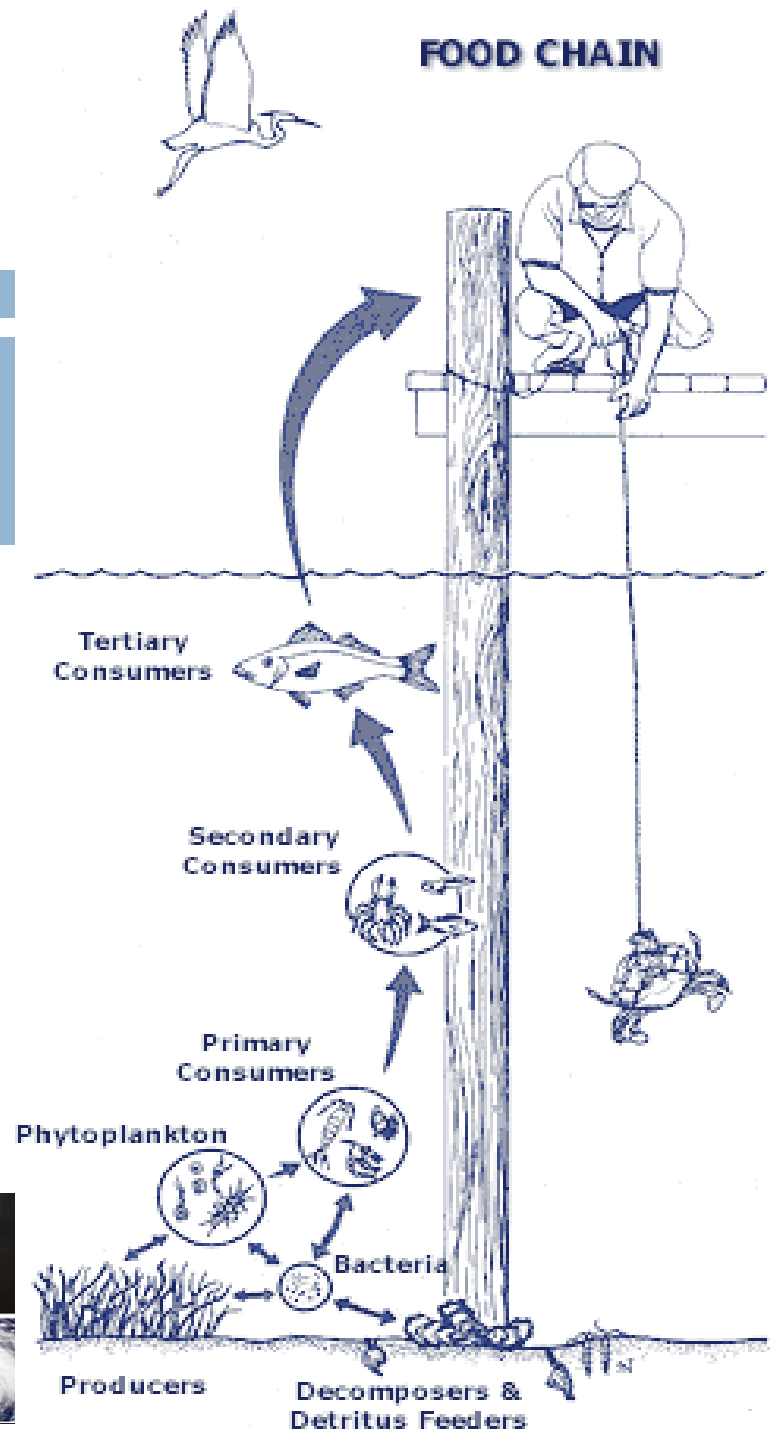


Pathogens, HABs, Swine Flu

What can CTB do?

Raghu
Murtugudde



Partners

UMCP: J. Strack, M. Bala Prasad, C. Anderson, A. Sood, G. Constantin de Magny, K. Mohan

NOAA: C. Brown, H. Meng, F. Aikman

- HPL: W. Long, V. Coles, E. North, R. Hood, M. Li
- UMIACS: D. Zotkin, A. Varshney, R. Duraiswami, B. Vasan
- SPH: A. Sapkota
- NASA: G. McConaughy, M. Seablom, H. Mitchell
- NCSU: L. Pietrefesa, M. Zhang
- NOAA Oxford Lab: B. Wood, X. Zhang, J. Jacobs
- EPA: G. Shenk, L Linker
- DNR: C. Wazniak, B. Michael, P. Tango

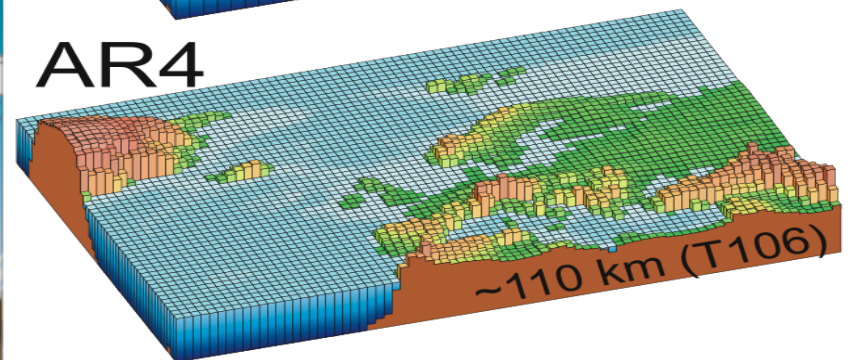
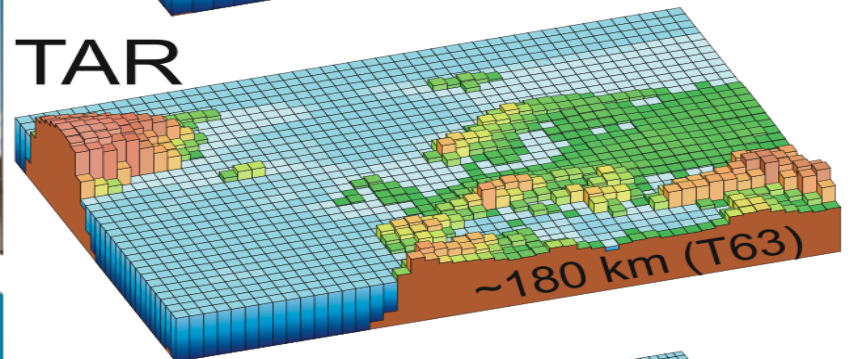
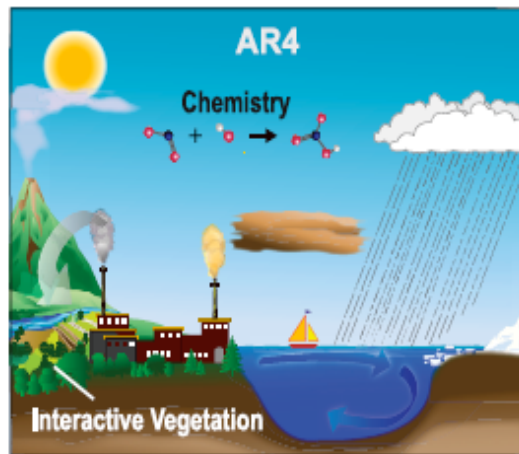
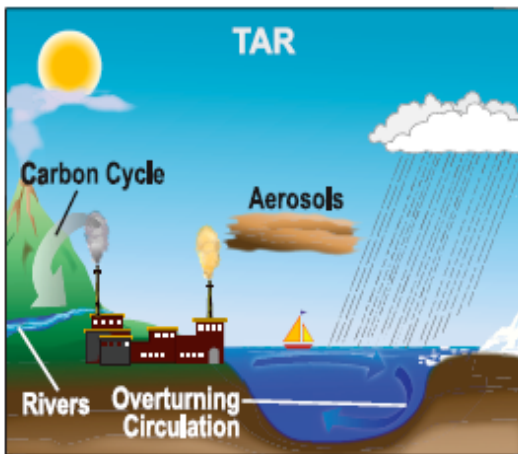
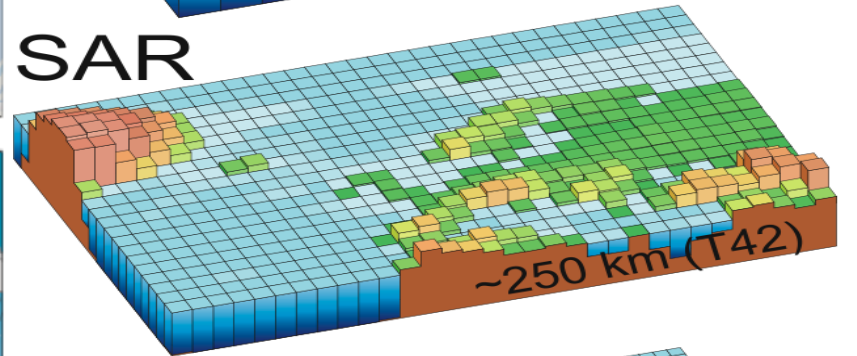
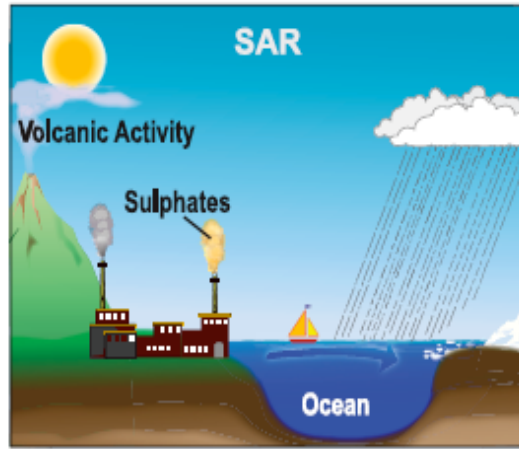
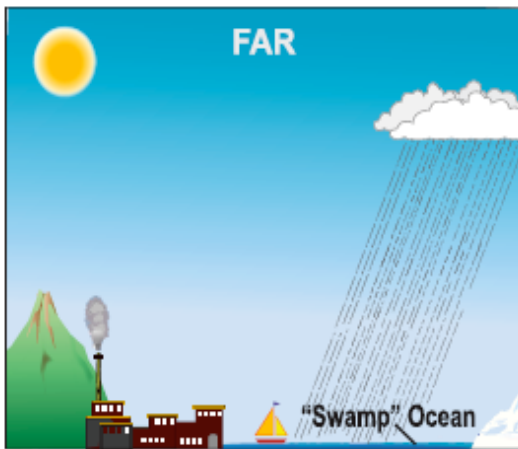
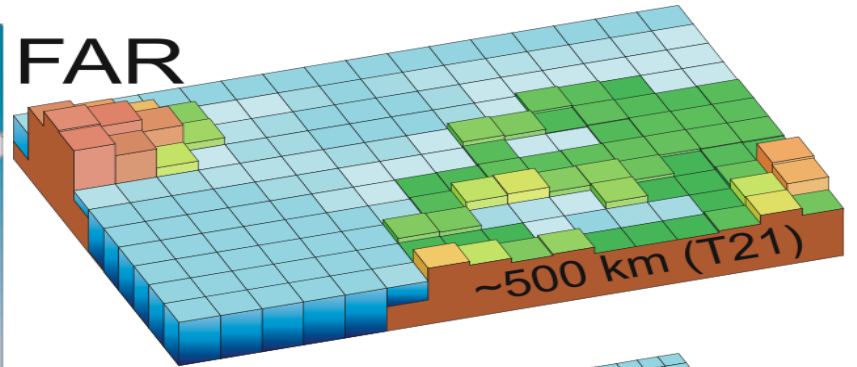
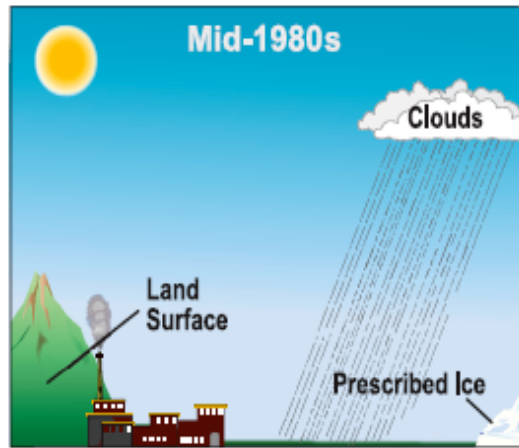
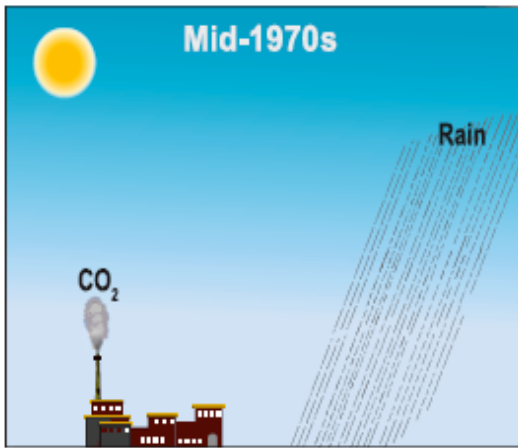
Future
Partners

Users, Superusers, Governments, People

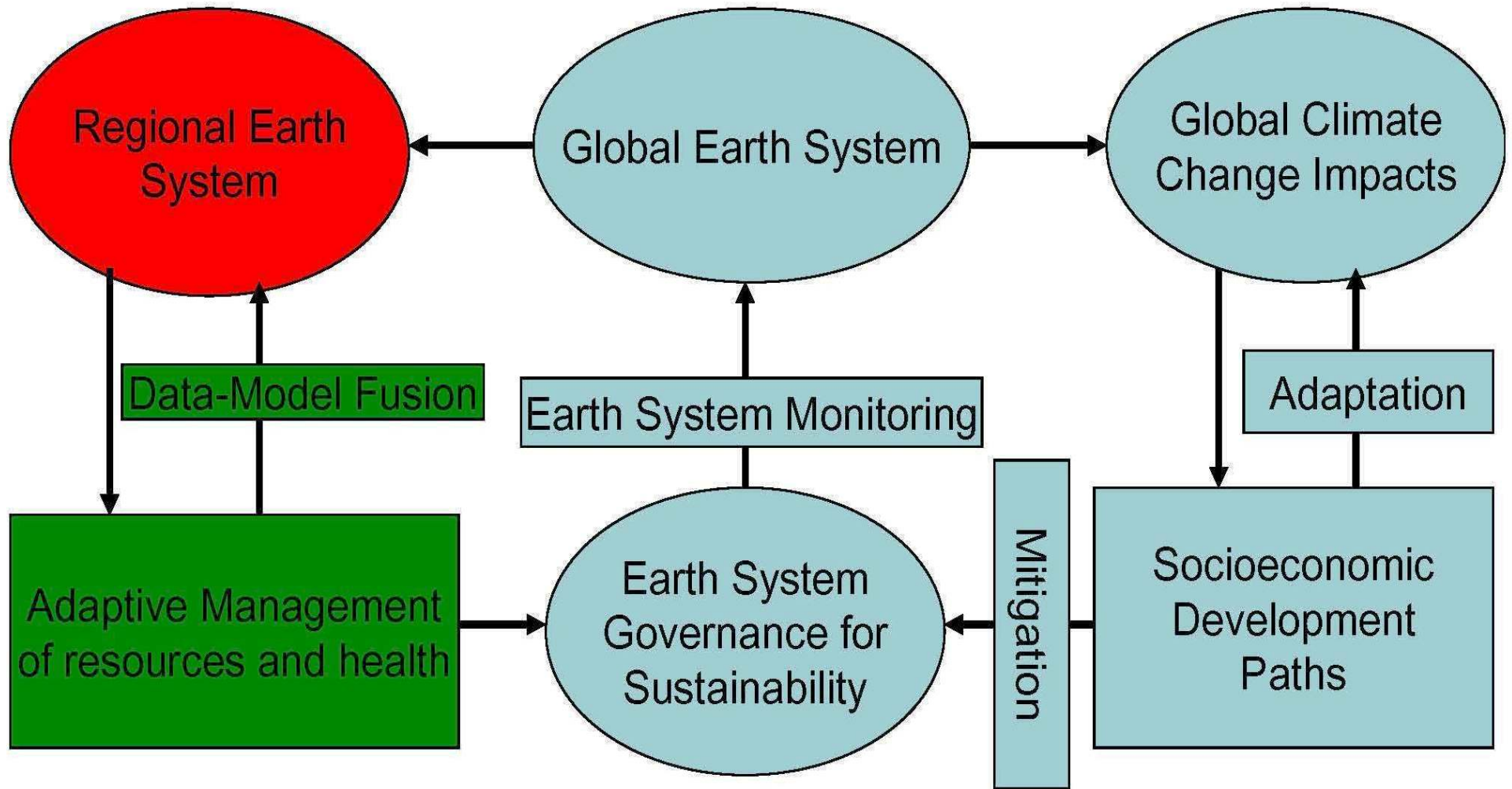


Forecast tools for decision-makers within critical time horizons

- Goals specified ***by customers*** in both private and public sectors and designed for decision support
- Intended to fill critical unmet national objectives – a national network that integrates the strengths of government, industry and academe



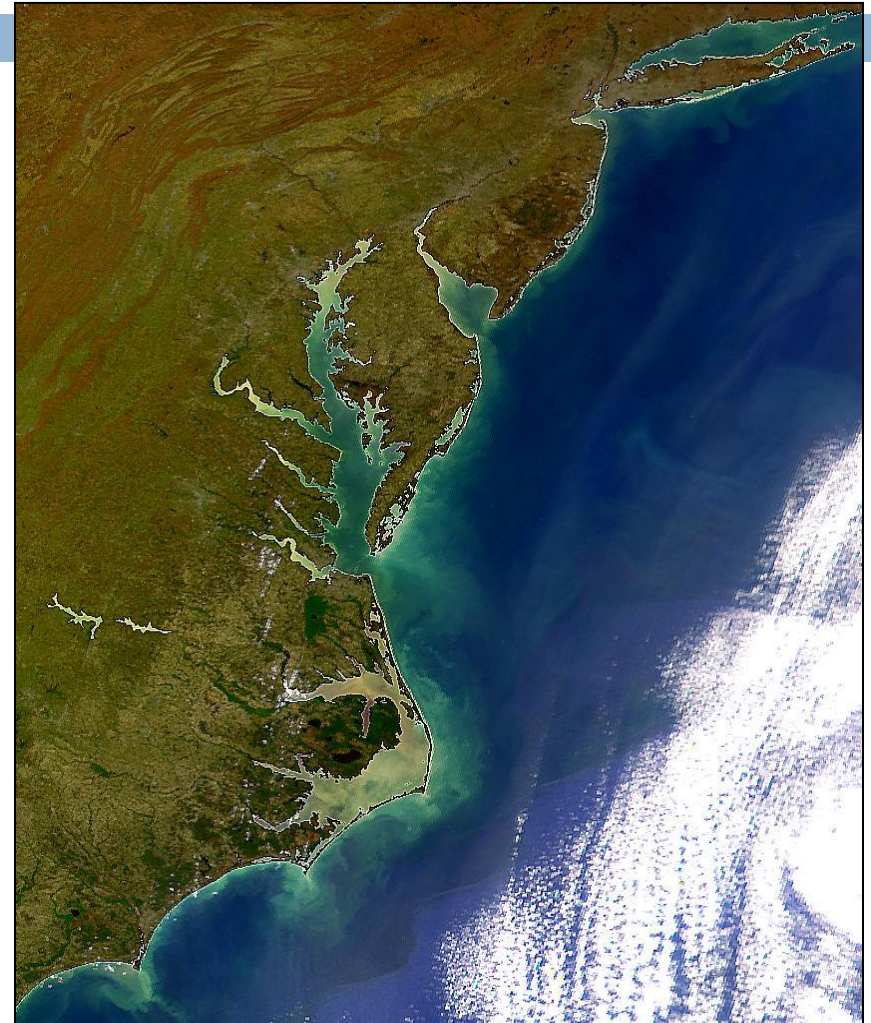
Global ESMs for global issues (IPCC negotiations) but regional ESMs for adaptive management, learning-by-doing, and participatory decision-making for sustainability



Regional Specificities: LEK

□ Know the USER

- ▣ Near-Real Time Applications: Nowcasting and forecasting of the Bay circulation, ecosystem, pathogens, harmful algal blooms, waves and inundation.
- ▣ Climate Projections: Estimating effect of climate change, between now and 2050, on the health of the Bay and its watershed.
- ▣ Provide a decision making tool for users

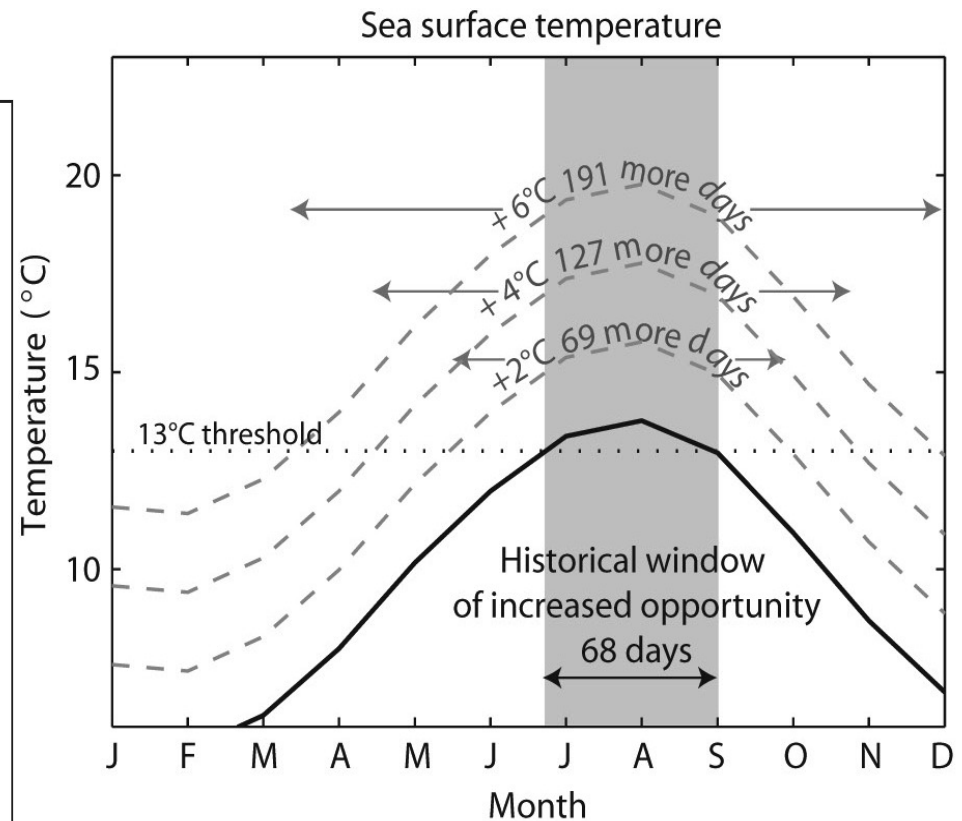
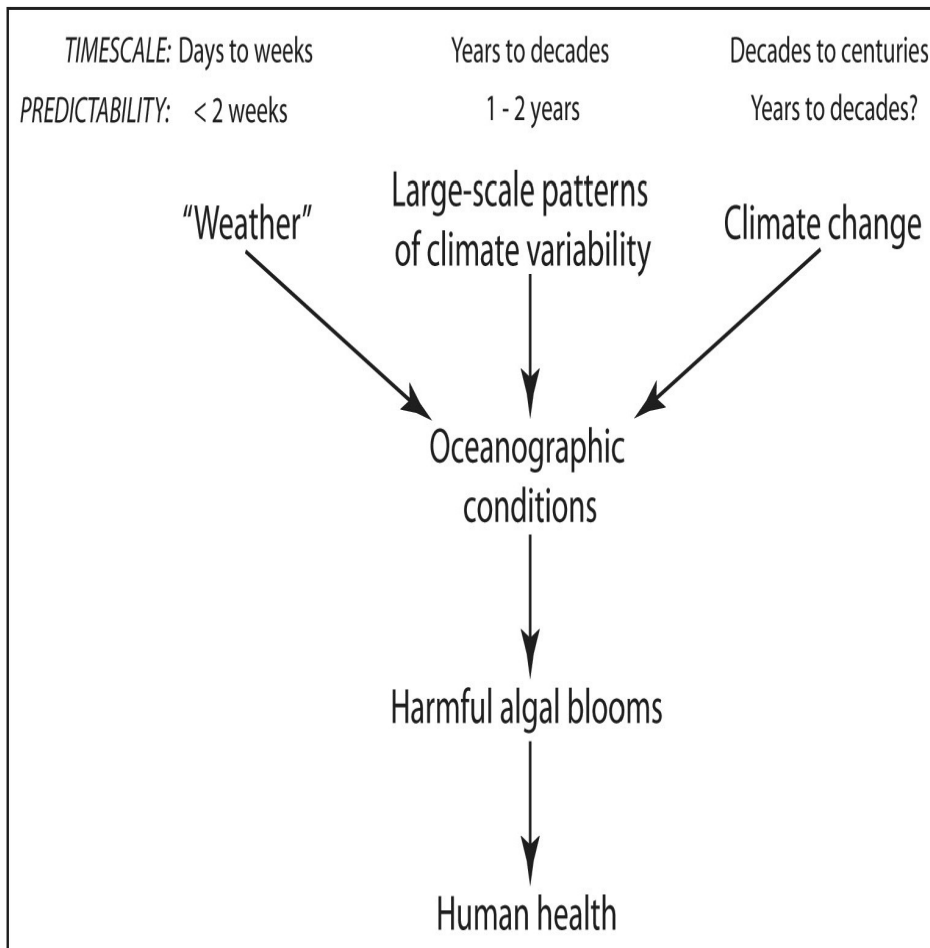


SeaWiFS true-color image of Mid-Atlantic Region from April 12, 1998.

Working with the users

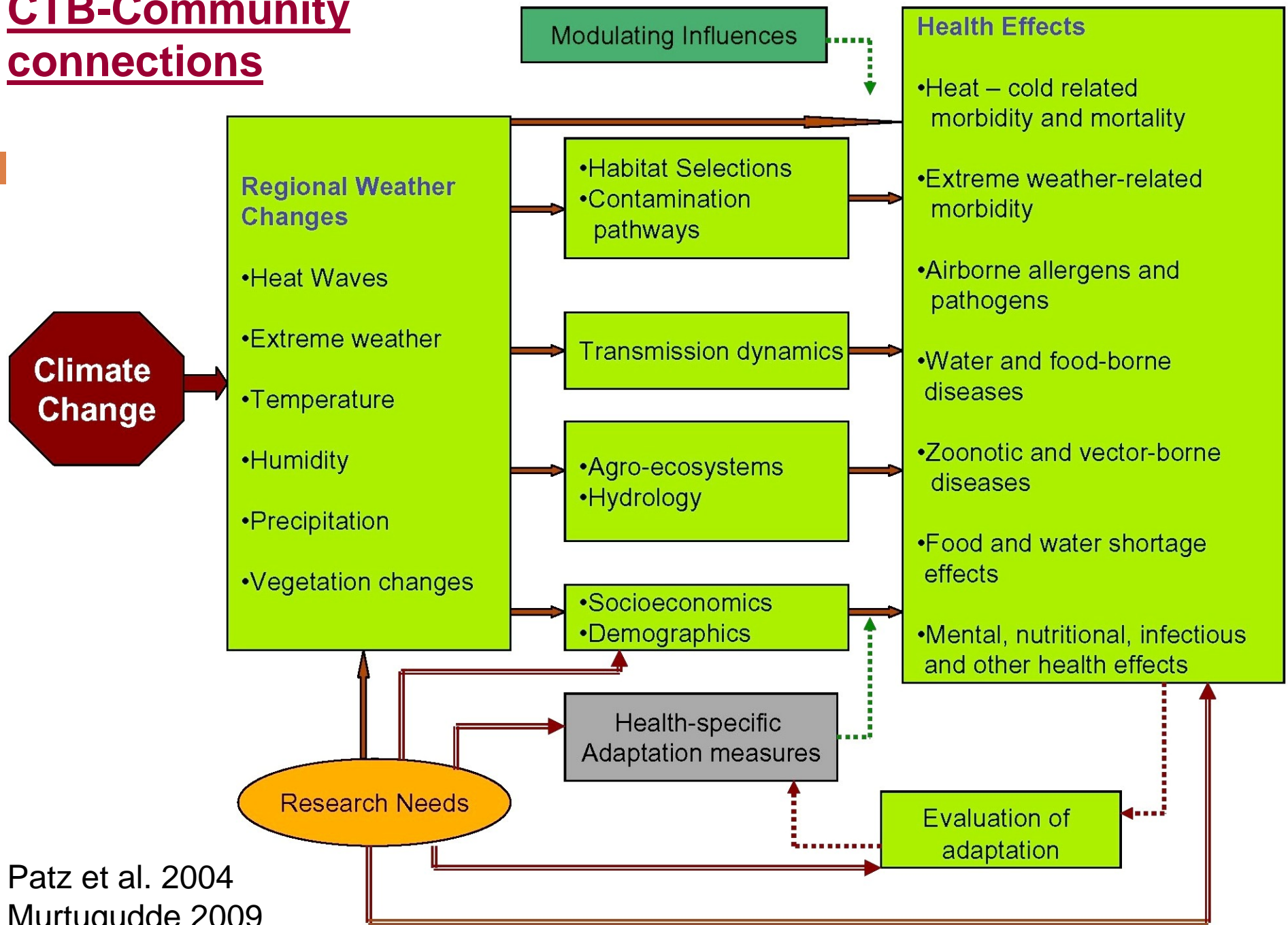
- **“Pilot Applications of the Chesapeake Bay Forecast System: Forecasting Future Drinking Water in an Urbanizing Warmer World”**
 - Opportunity to forecast how changes in climate can influence the transport of nutrients, metals and Pathogens, and serve as a resource for water quality managers and decision makers
- **A habitat suitability forecasting model for Chesapeake Bay’s striped bass population**
 - Produce and validate a forecast model of striped bass recruitment using output from the CBFS
- **Pilot User Collaboration for Harmful Algae Forecasts in MD Chesapeake Bay**
 - Model skill for HABs, and to refine the habitat suitability model.
- **Chesapeake Community Modeling Program proposal for CBFS applications**
 - Work in coordination with various Chesapeake Bay watershed groups and River Keepers.
- **Proposal to be a Pilot Application of the Chesapeake Bay Forecast System**
 - Integrate climate data focused on climate change and variability at seasonal-to-decades scale generated by the Chesapeake Bay Forecast System using the IPCC land use scenarios created by various groups.

Old Paradigm: CTB can start the two-way communication with **regional** modelers to **change** to the new paradigm



Moore et al. 2008

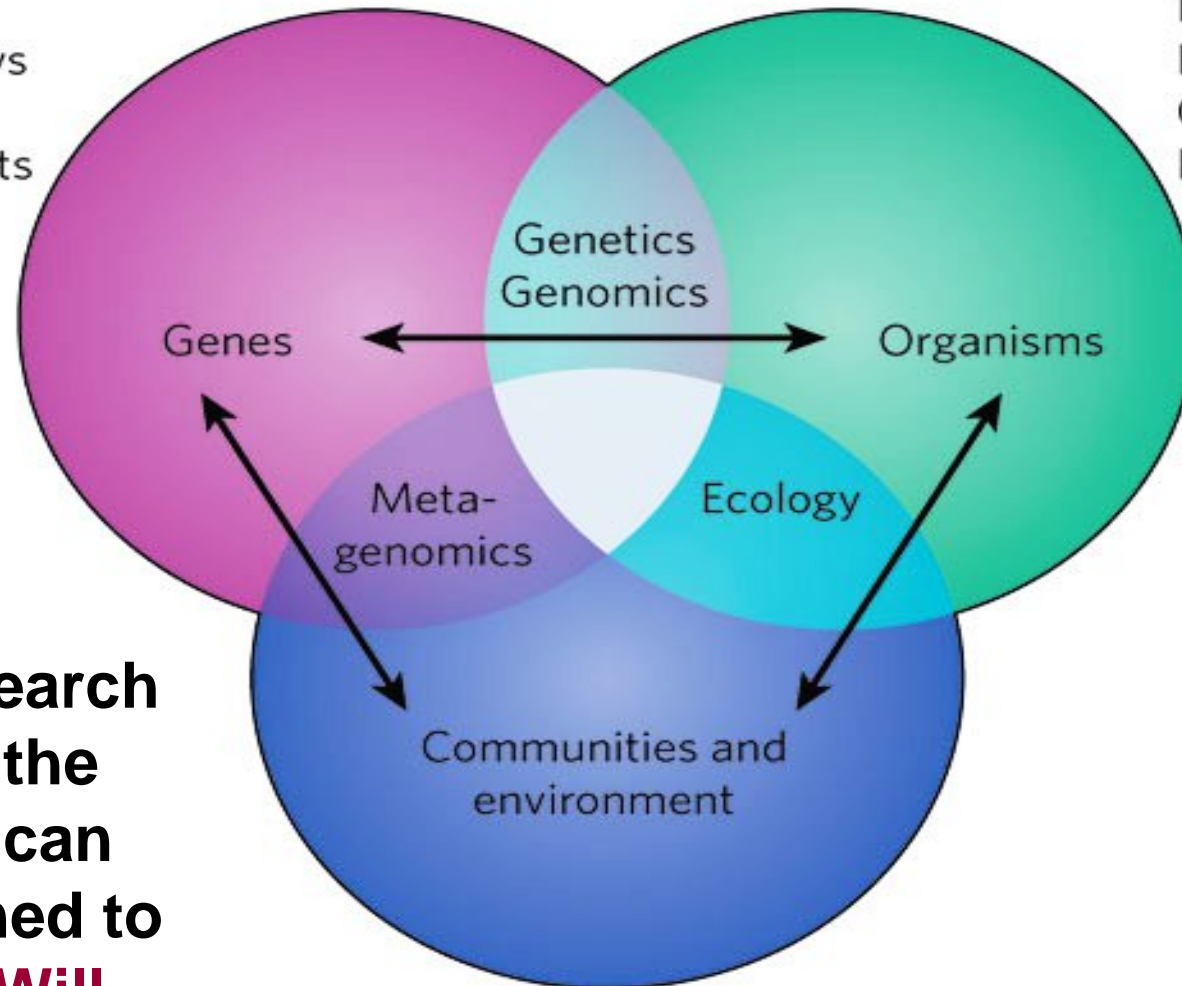
CTB-Community connections



Patz et al. 2004
Murtugudde 2009

Genotype
Allelic diversity
Metabolic pathways
Functional guilds
Regulatory elements

Phenotype
Physiology
Genetics
Regulation

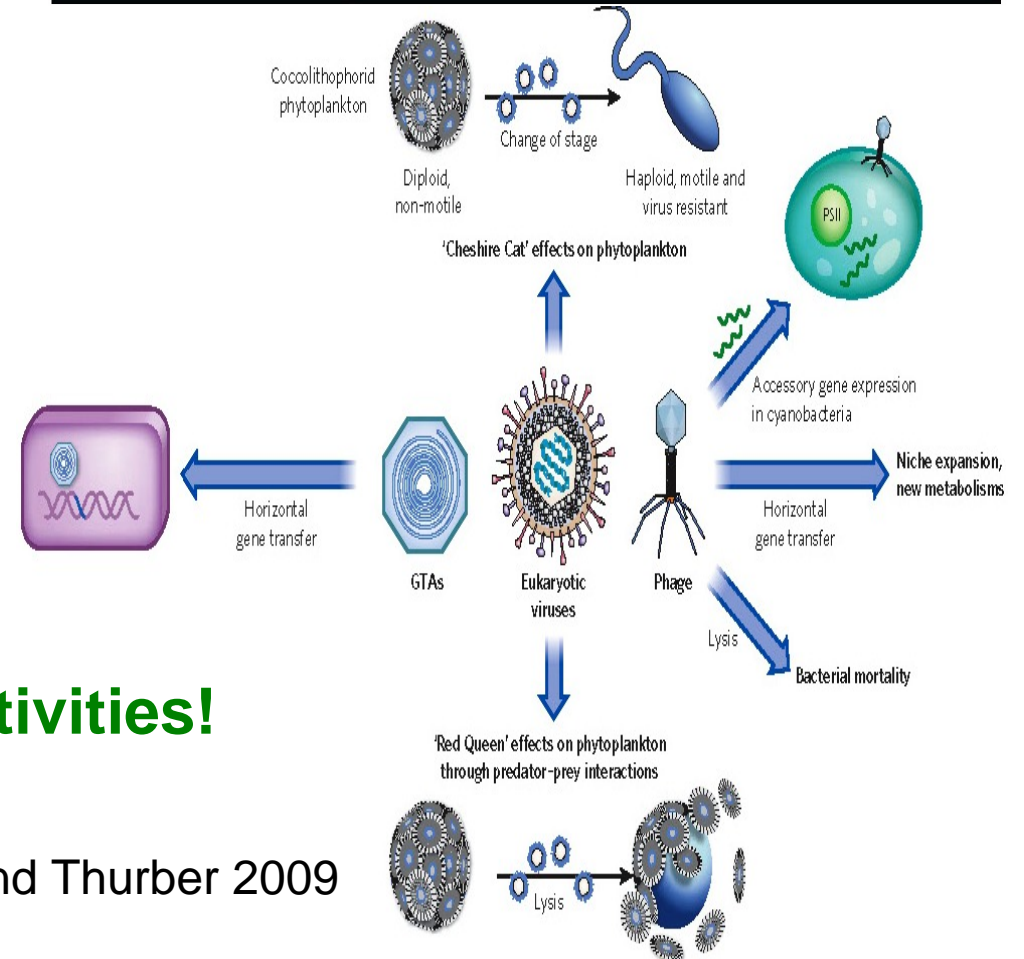
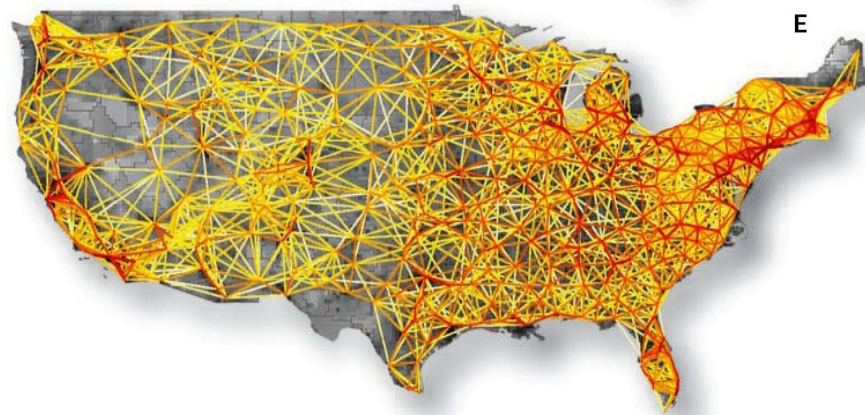


An ideal research Problem for the campus but can be transitioned to operations: Will CTB only do physical climate in the coming years?

Environmental variability
Community composition
Population genetics
Functional redundancy
Biogeochemistry
Community dynamics
Ecosystem response

Bowler et al. 2009, Nature

Computational social science: How things spread

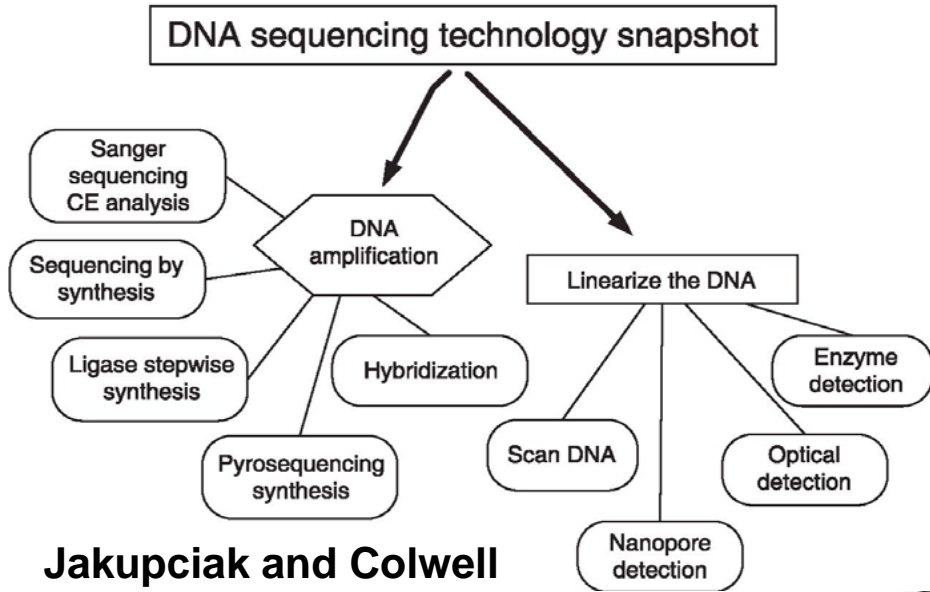


CTB: Environmental connectivities!

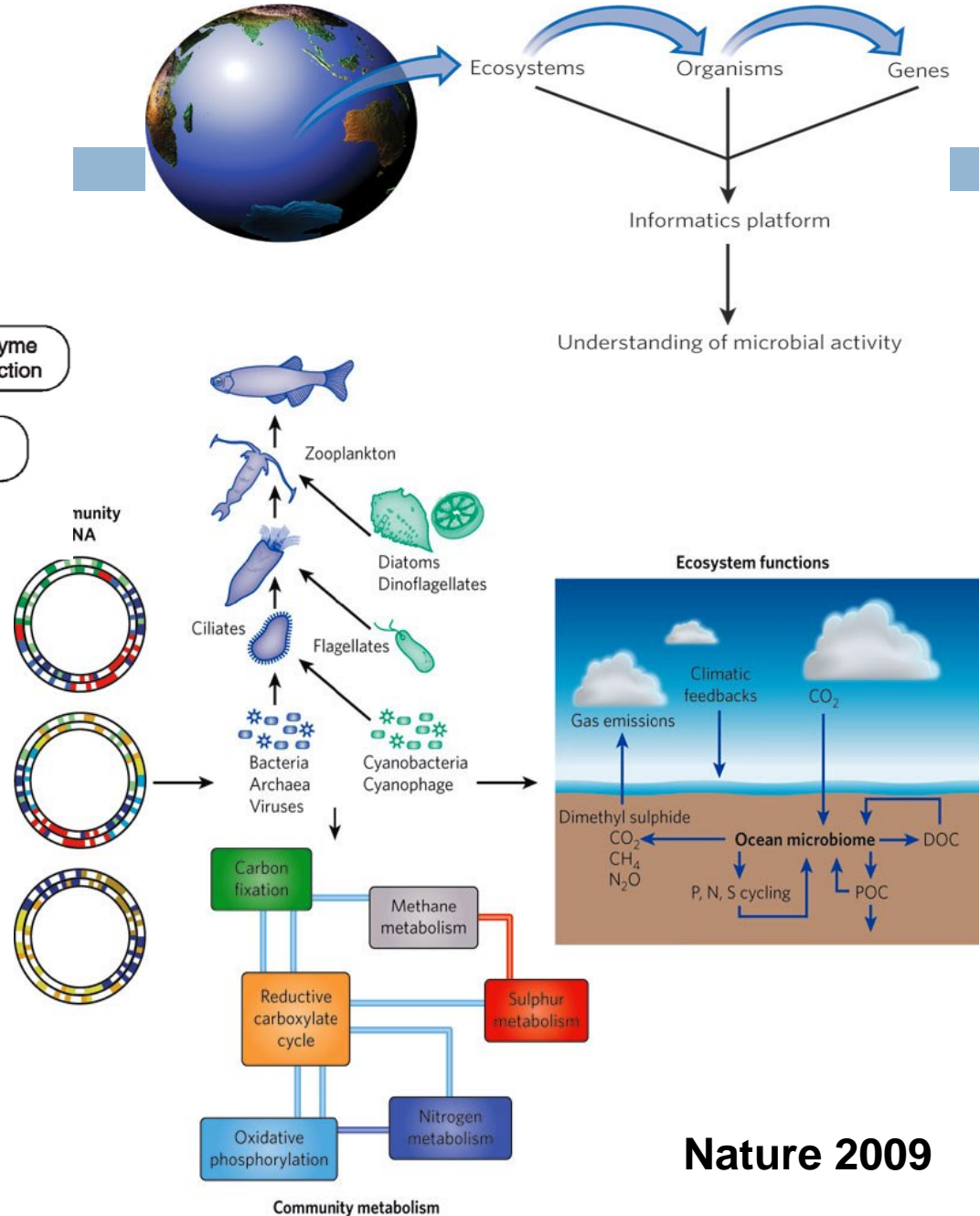
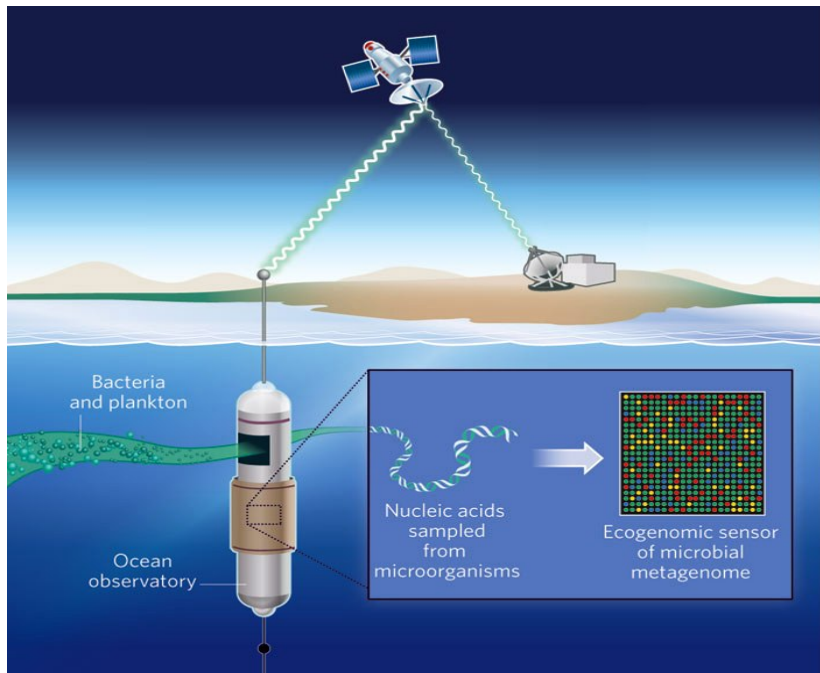
Vespignani et al. 2009

Rohwer and Thurber 2009

CTB: Drive Observational needs and innovation

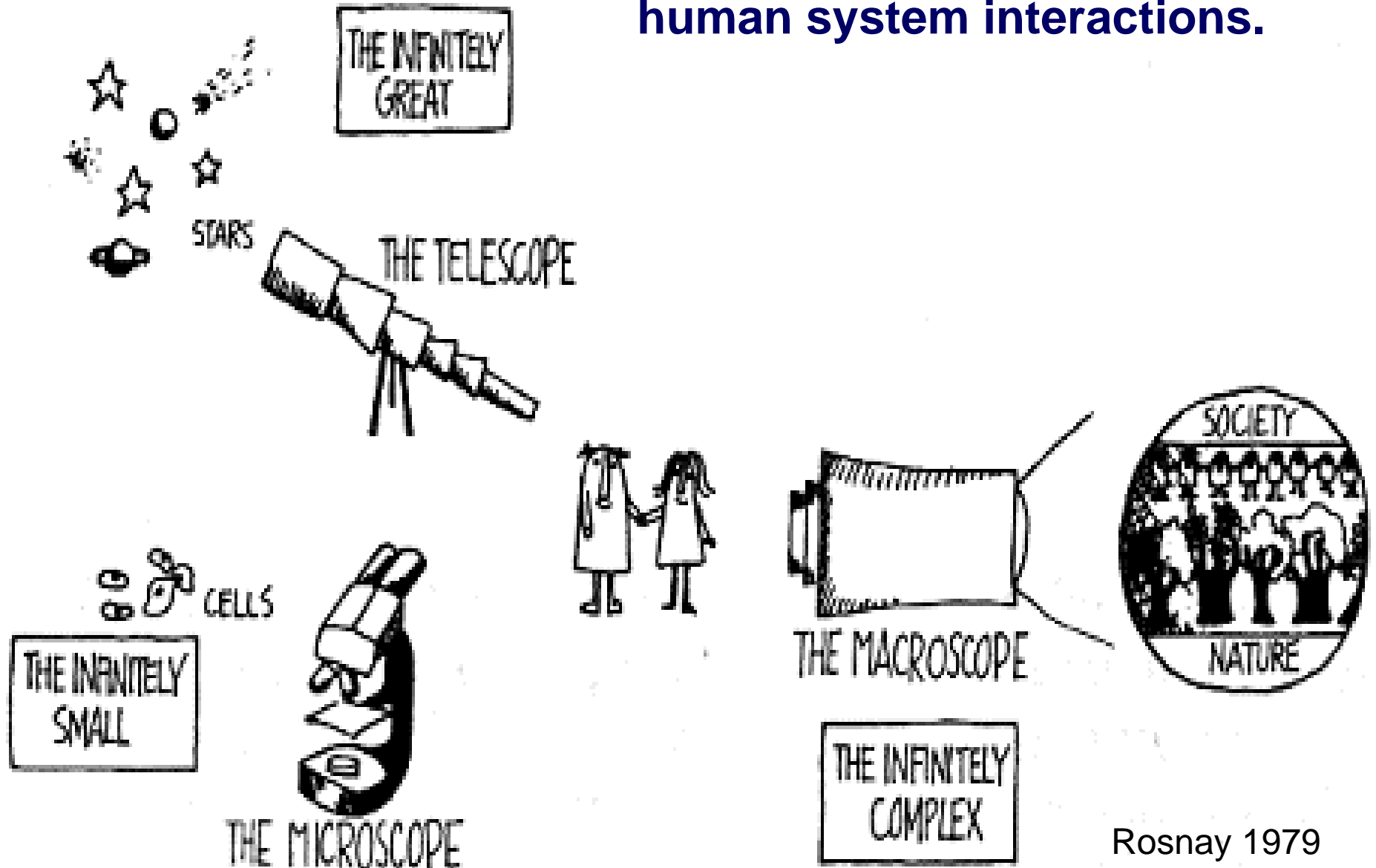


Jakupciak and Colwell 2009

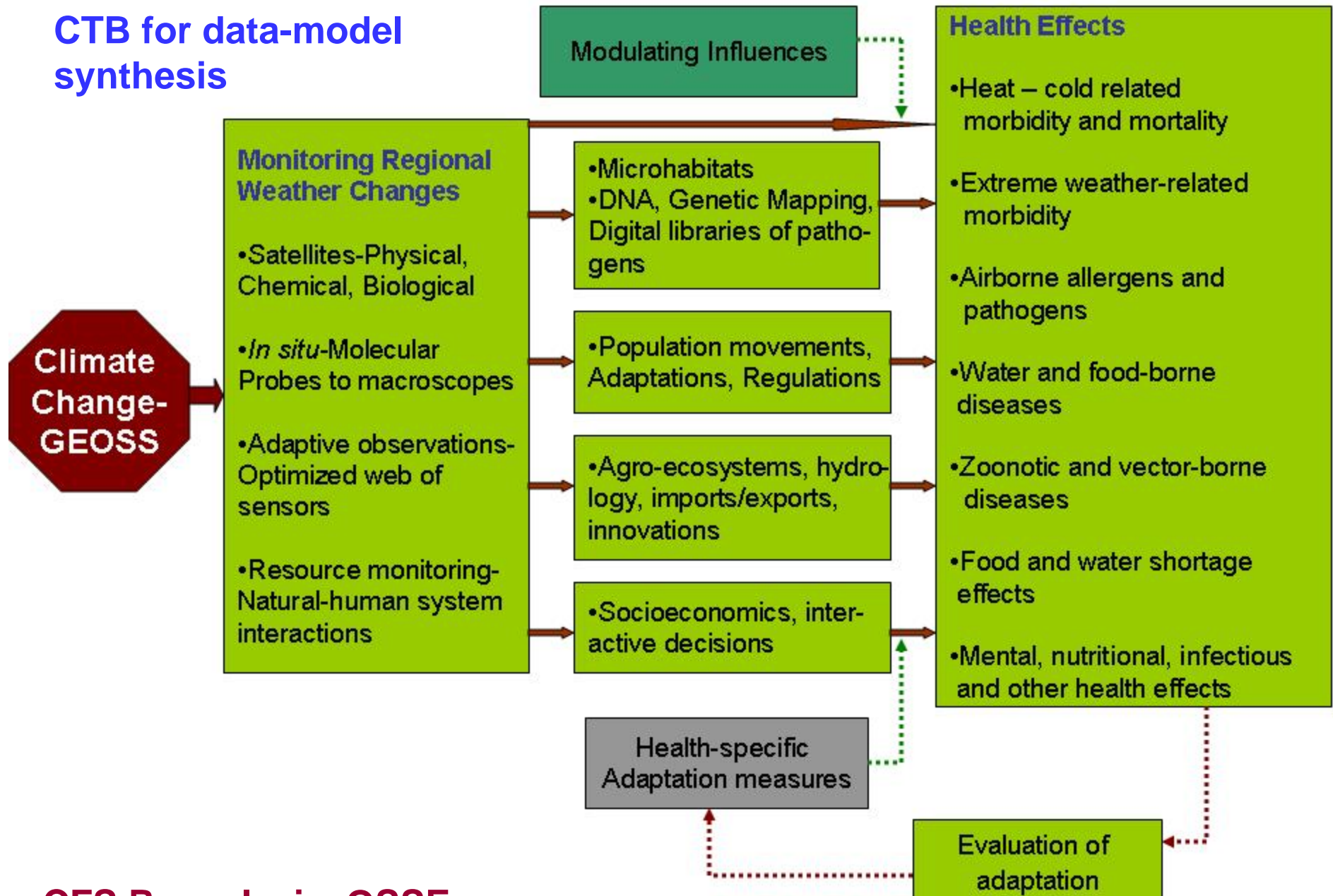


Nature 2009

Eventually CTB will work towards including natural-human system interactions.

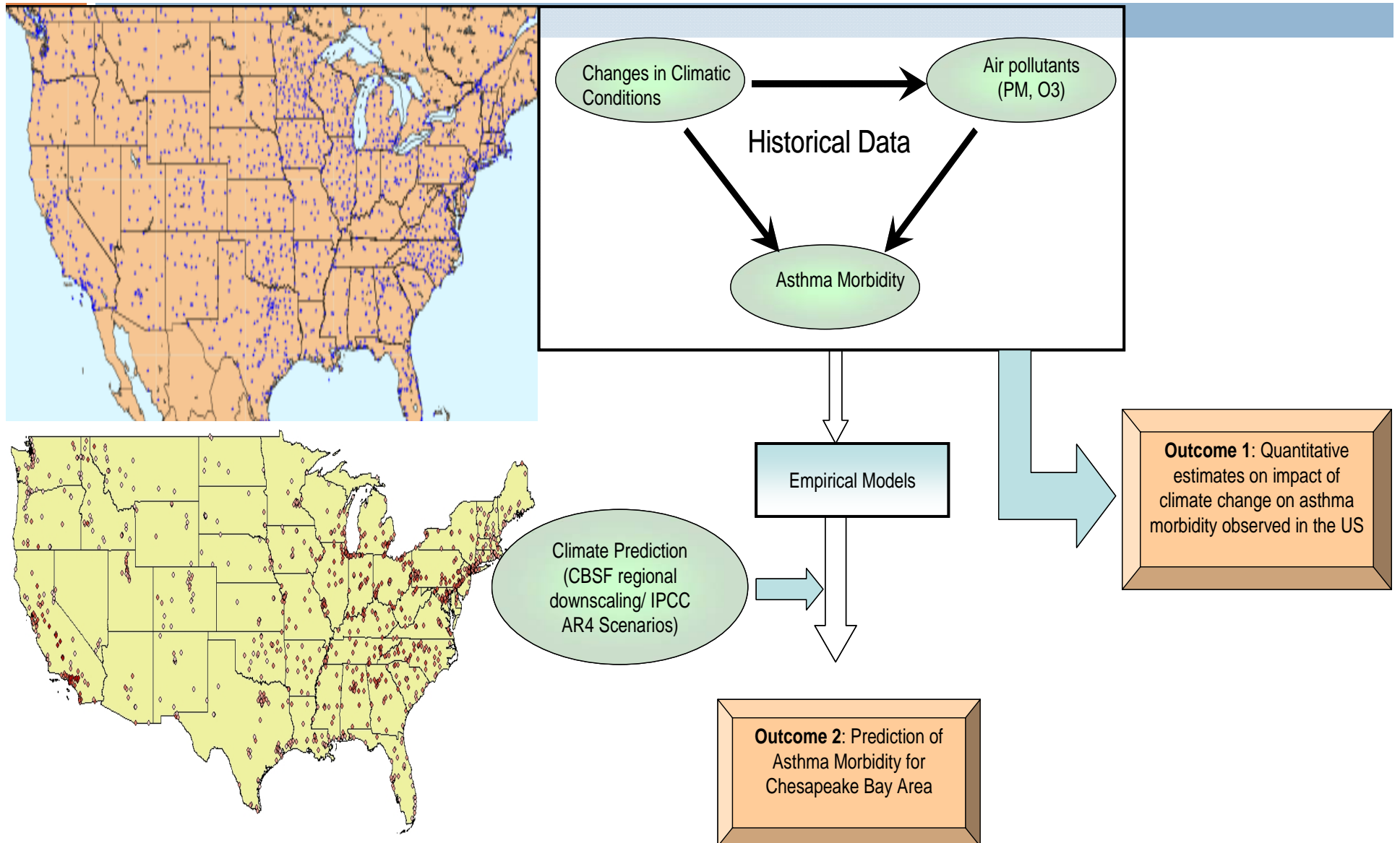


CTB for data-model synthesis



**CFS Reanalysis, OSSEs.
Learning by doing.**

Meteorological and air-quality data: CTB-Climate Services-Optimized data gathering with web of sensors



LEK: Regional CTBs'

Waterweed/Stargrass Bay Grass



Zooplankton



Eastern Oyster



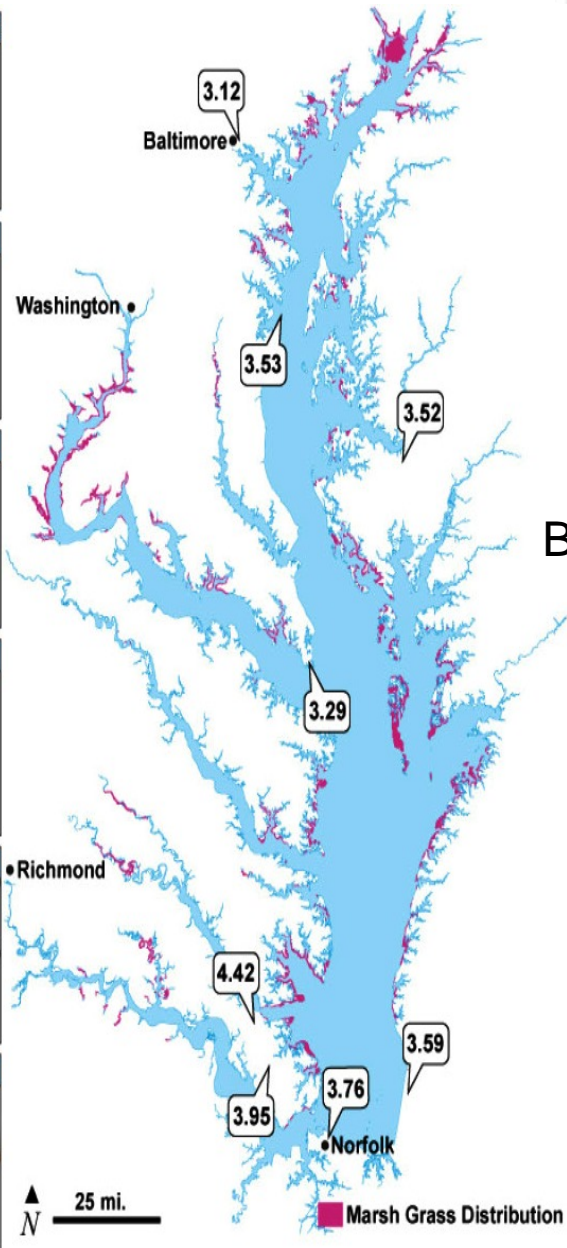
Maryland Blue Crab



American Shad



Great Egret



Historical Trends in Forest Cover for the Chesapeake Bay Watershed

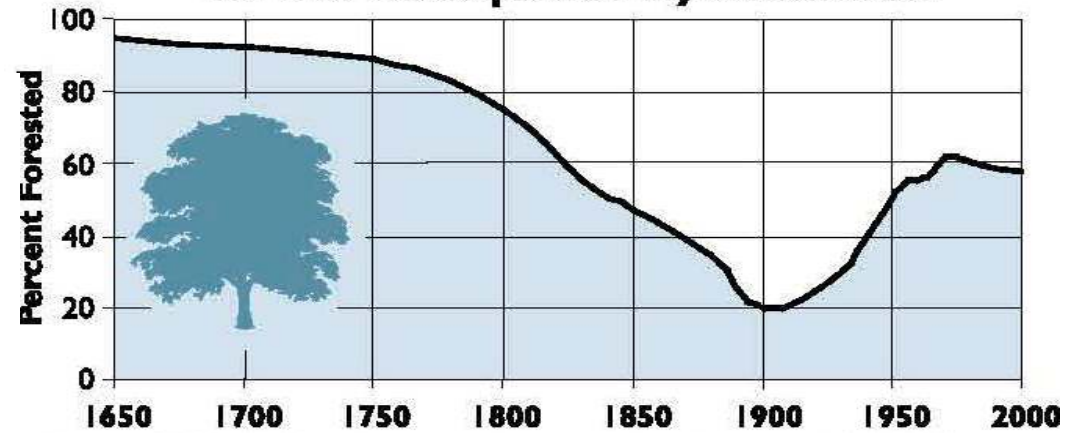


Figure 6-1. After bottoming out in the early 1900s, forest cover regained acreage throughout much of the last century. Recent decades show a slight decline.

Boesch and Greer 2003

Population Growth in the Chesapeake Bay Watershed

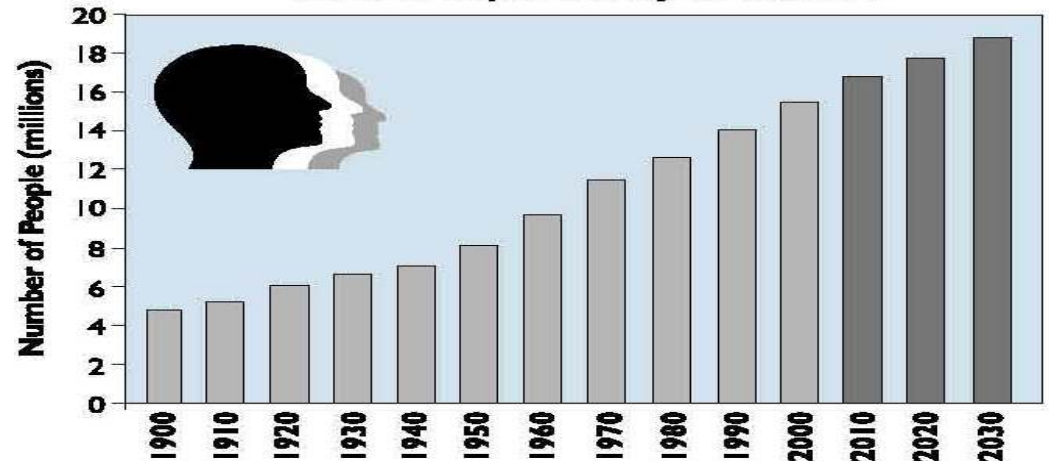


Figure 2-1. Since the beginning of the last century, population levels have shown a steady increase in the Bay watershed. Experts predict that numbers will continue to rise through the next three decades.

'Fisherman's Disease' afflicts association head

June 27, 2008 [Regional CTBs: Regional Specificities, Predictability](#)

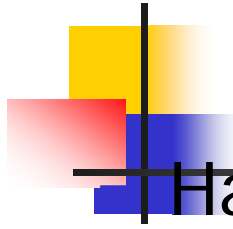
Ken Smith, a leader in the fight to clean up the Chesapeake Bay and its watershed, has been hospitalized with a serious vibrio infection commonly known as "fisherman's disease" and believed to be directly related to contaminated marine life and polluted water.

Smith, president of the Virginia Waterman's Association, was admitted on June 14 to Rappahannock General Hospital in Kilmarnock, suffering from a high fever and a badly swollen right arm.

"This reaffirms our belief, as watermen, that the continuing degradation of the Bay and its tributaries has reached the point that it is imperative that dramatic measures must be taken to improve the estuary's water quality," Smith said June 25 from his hospital bed.

Smith said he believes he contracted the vibrio disease on Tuesday when he scratched his arm while emptying a crab pot in Totuskey Creek off the Rappahannock River. He washed the wound, he said, but it became infected soon after.

LEK: Adding Value

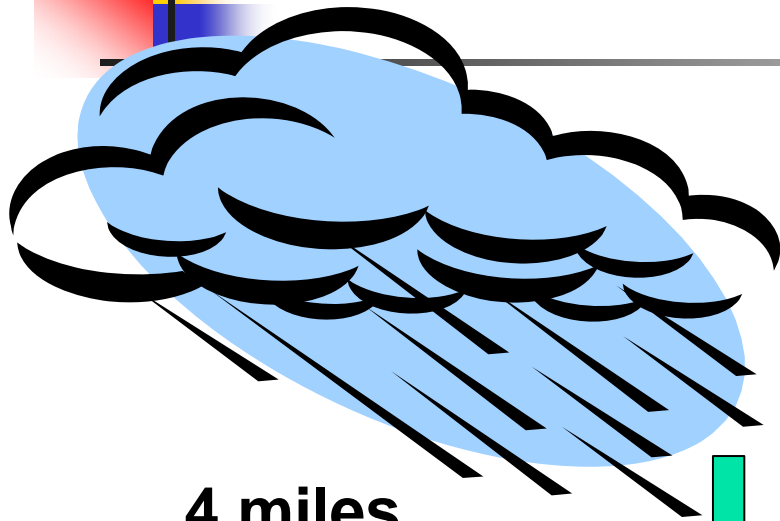


Harmful algal blooms

- Sea Nettles
- Human Pathogens
- Anoxia
- Insect Infestation
- Personalized-Preemptive-Predictive Health Information
- Sea level rise, inundation, storm-surge
- Future scenarios for Policy, Agriculture, Population, Health of the Bay



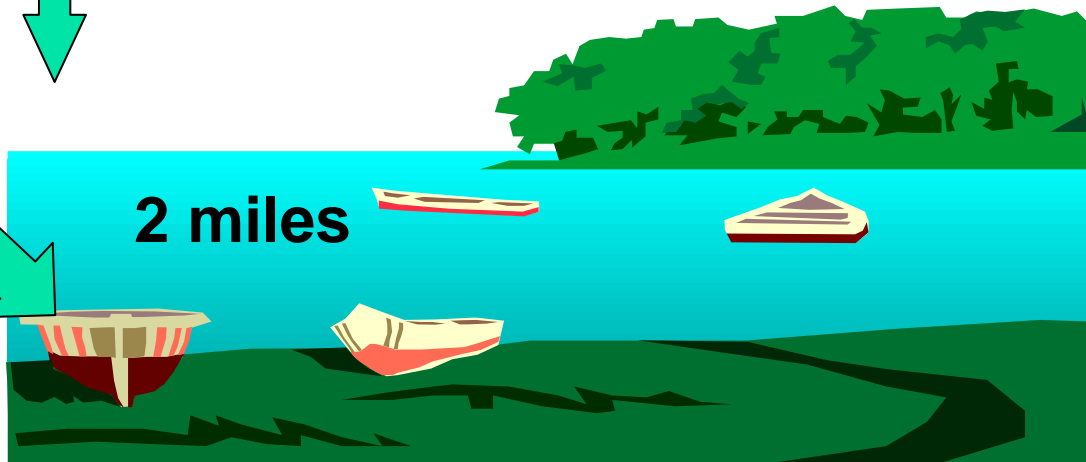
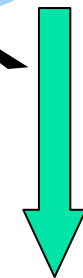
Dynamic Downscaling: Scales that matter – Regional CTBs, multi-models



4 miles



1/3 miles

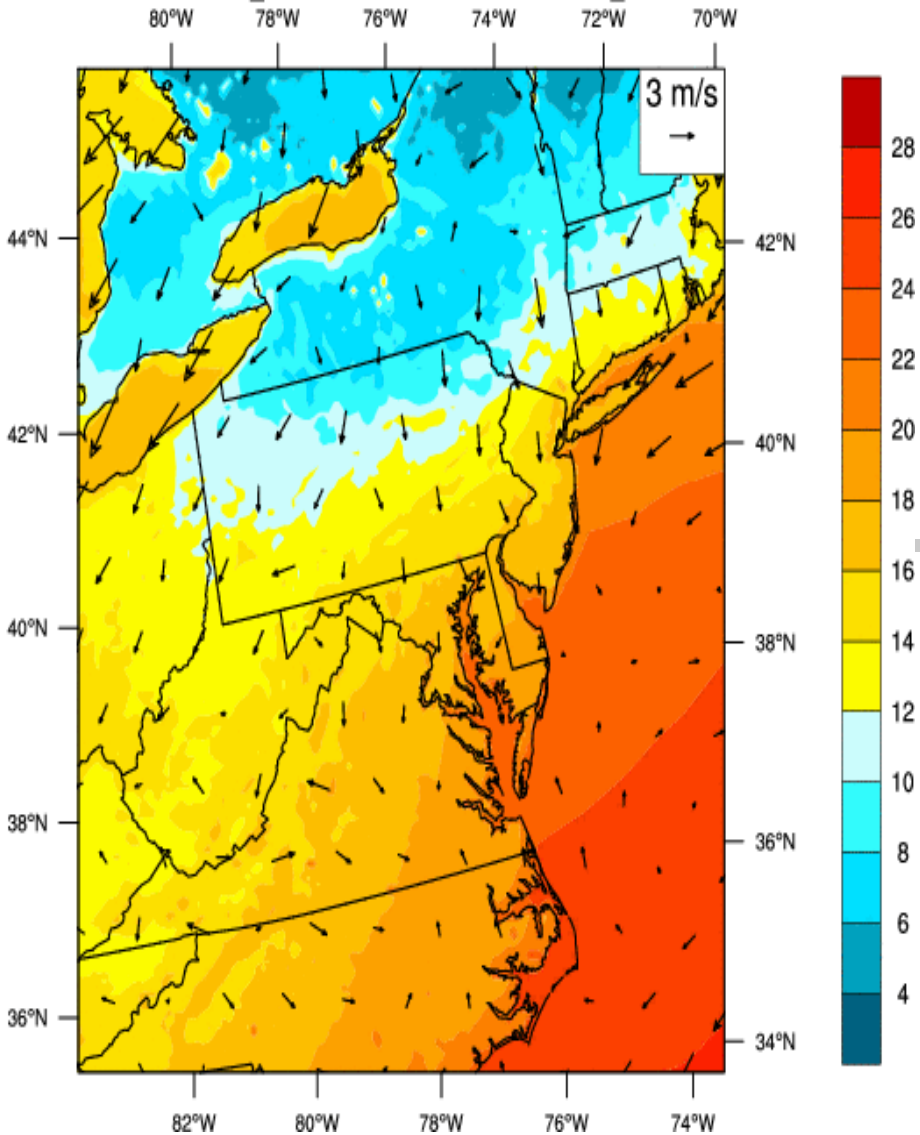


2 miles

- Climate information at meter-scale
- What are the rivers and streams carrying?
- Water quality, ecosystems, crabs, clams, sea grasses, oxygen.
- Agriculture, livestock, poultry, eutrophication

2-m Air Temperature (°C) / 10-m Winds (m/s)

Initial 2009-09-16_00:00:00 UTC / Valid 2009-09-16_06:00:00 UTC

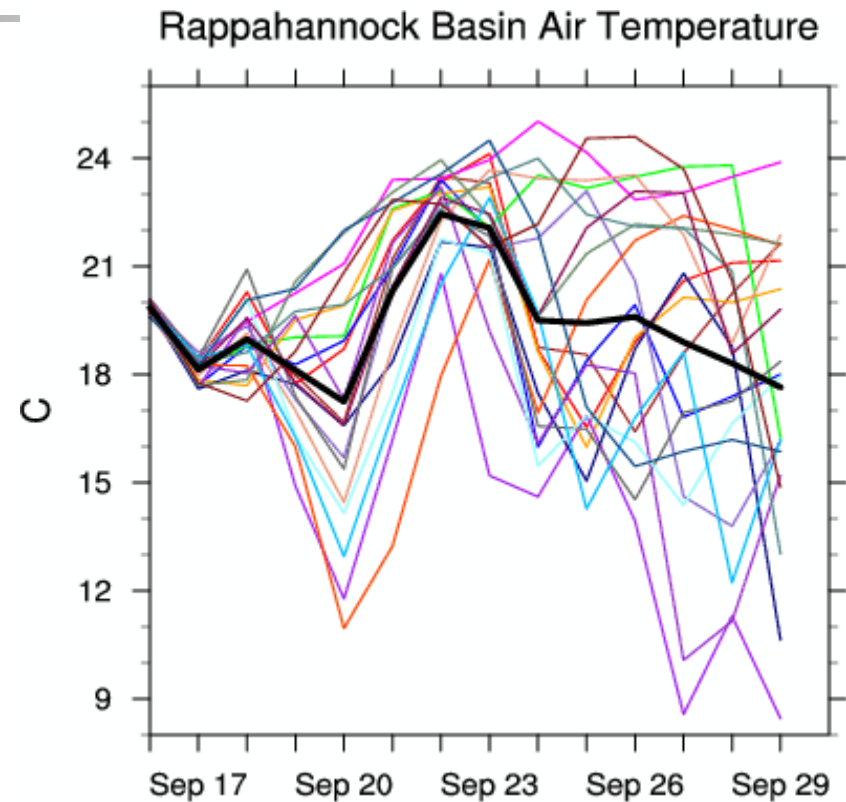
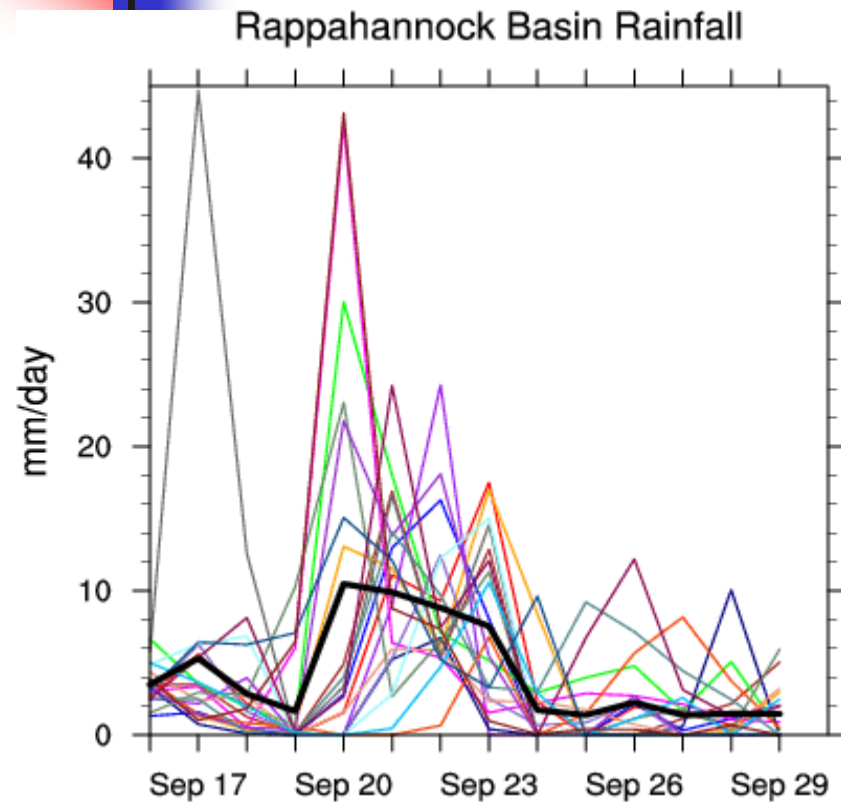


High resolution winds, temperatures, humidities, radiation, etc. have users from the aviation, public health, solar and wind-energy, recreational boating, etc. Designer forecasts for day 8 and beyond are possible.

How to depict uncertainties and skill for users from a wide variety of needs and tolerance levels?

20-member ensemble mean forecast of temperatures and winds.

Monitoring waterbodies and forecasting not only sediment and nutrient loadings but pathogen loading will be crucial. **DOABLE and In Great Demand. Regional CTBs can bring regional users/super-users.**

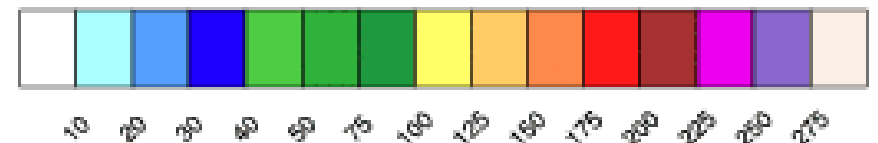
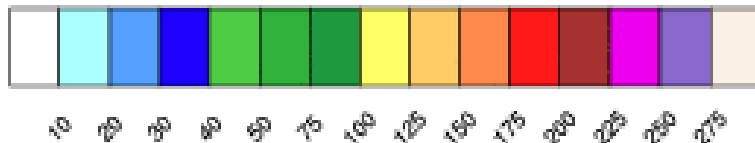
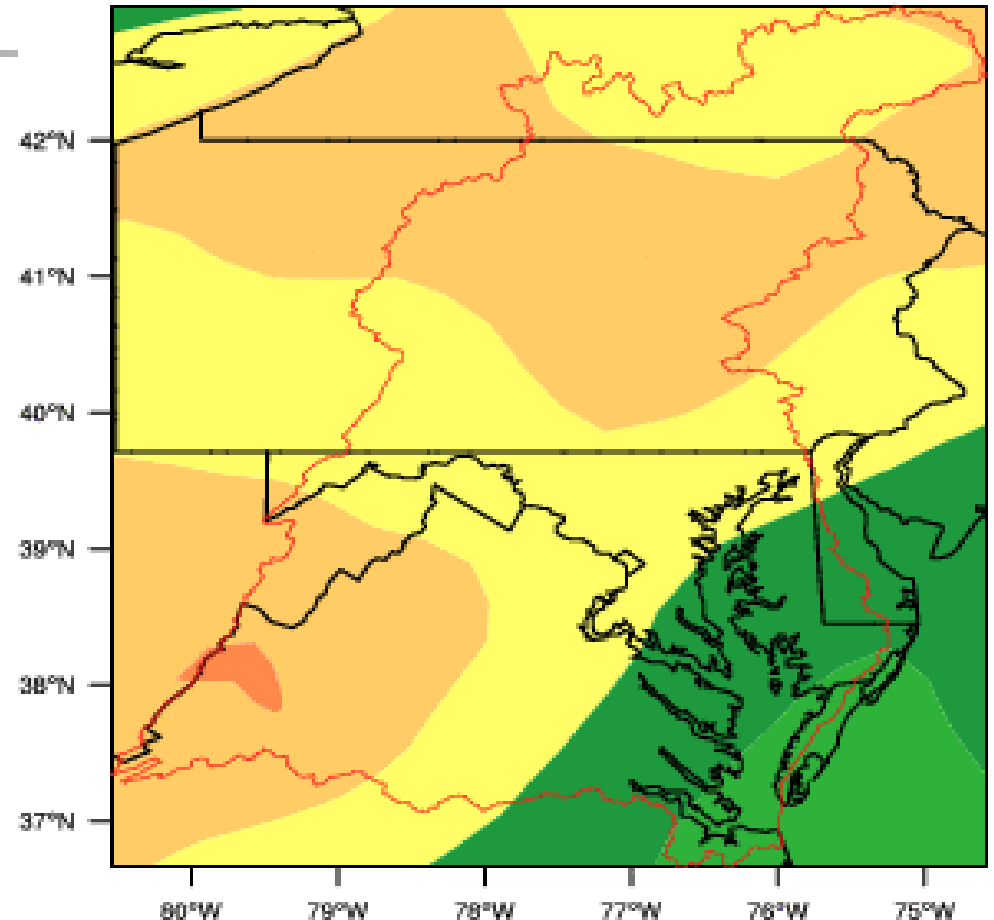
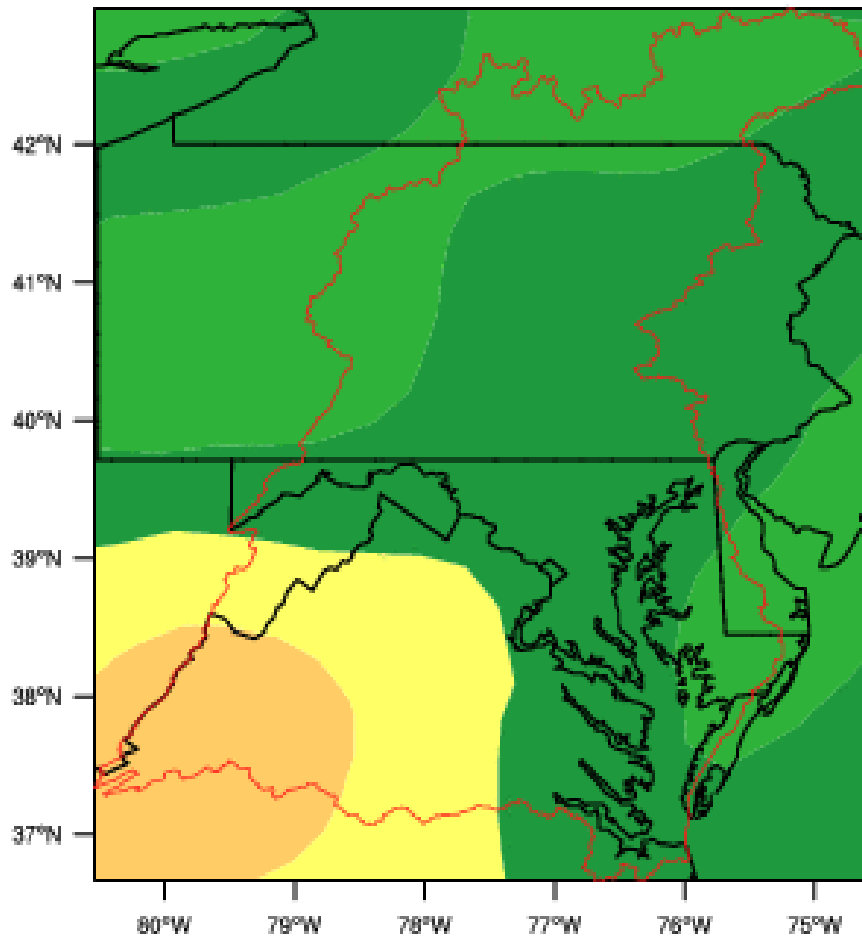


20-member ensemble forecast of daily rainfall and temperature in the Rappahannock Basin. Heavy black line shows the ensemble mean.

Projected 2047 daily precipitation anomalies superimposed (left) on 1995 observed daily precipitation (mm) (right): Smart growth, RGGIs, Adaptation.

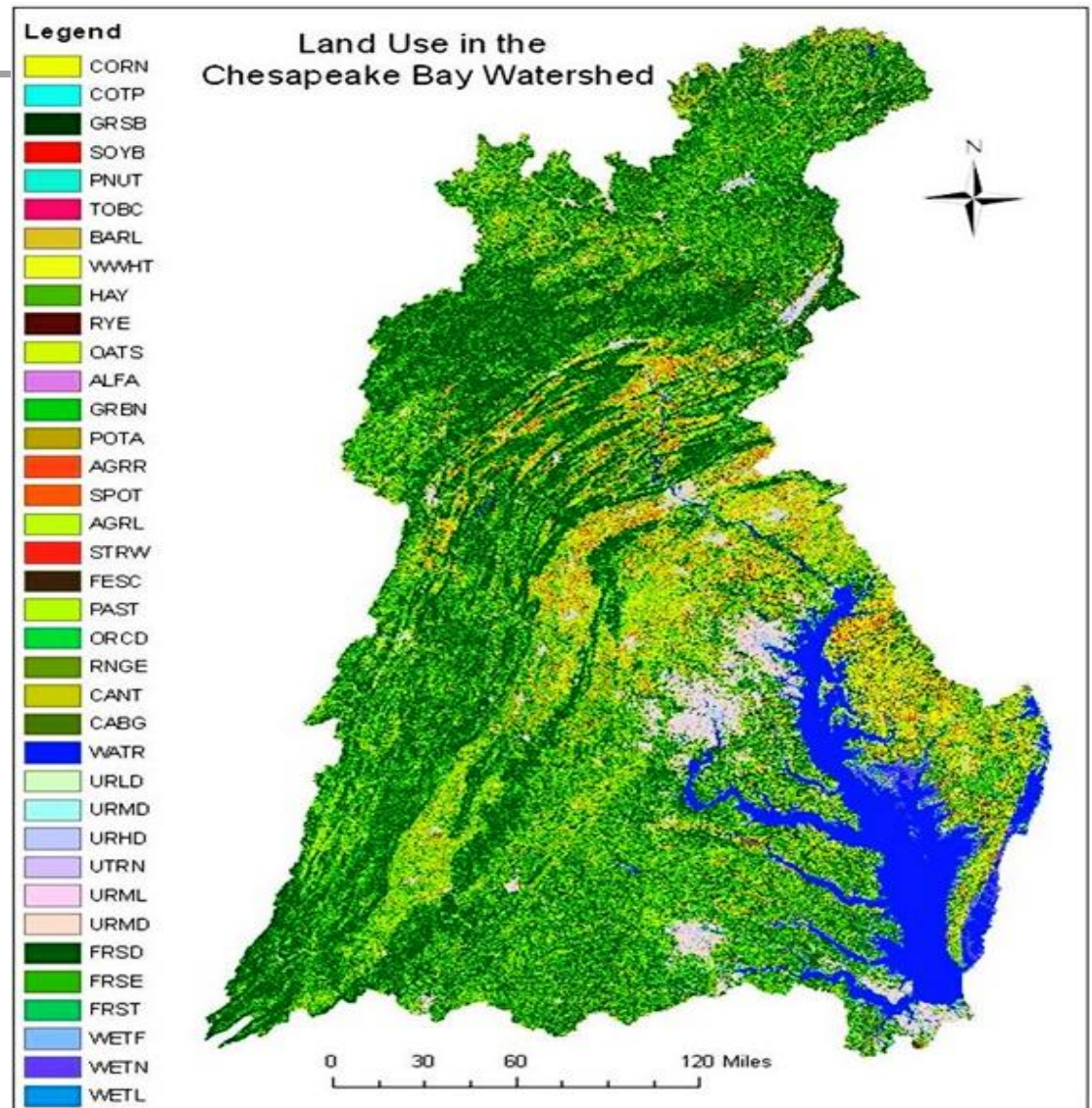
JAN 1995

JAN 2047

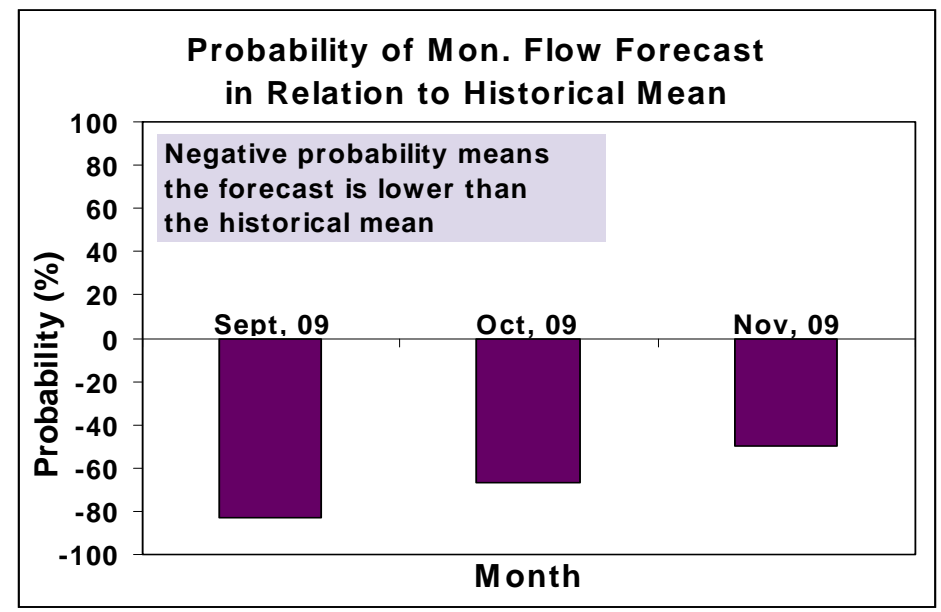
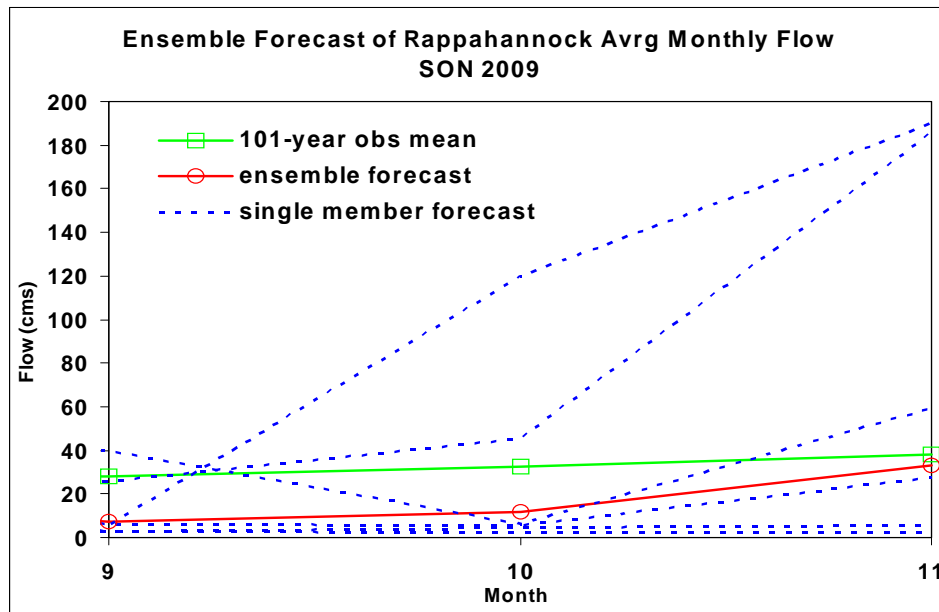
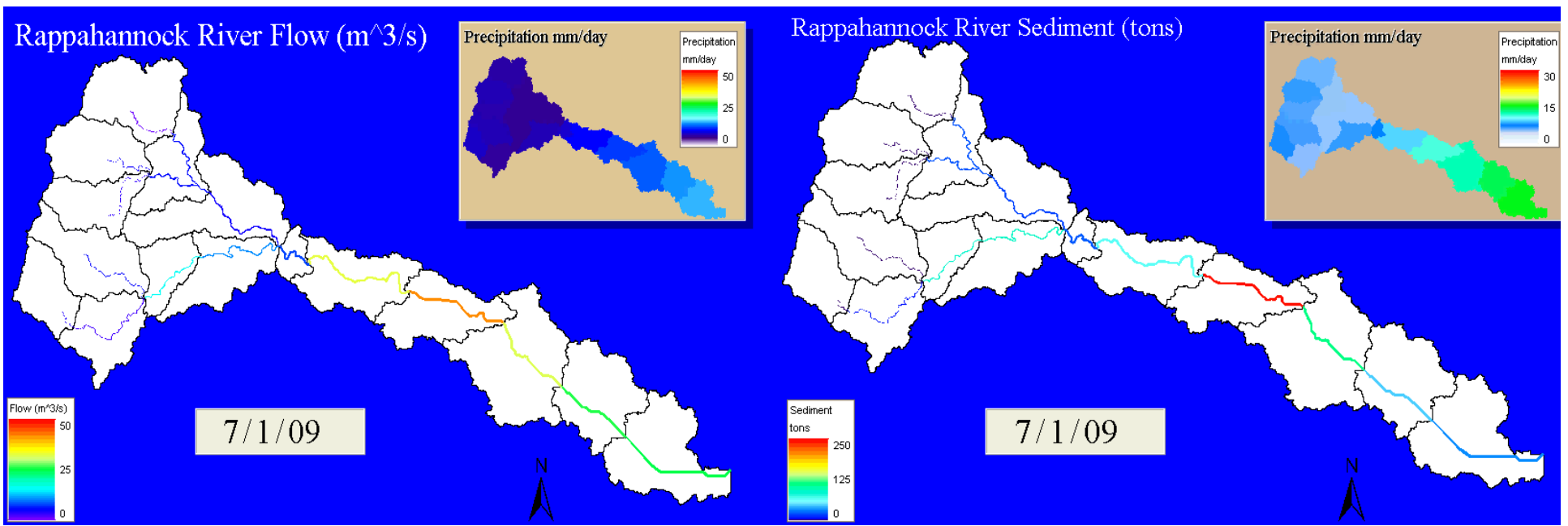


Regional CTBs: Adaptive, sustainable, participatory decision-making, learning by doing, what-if scenarios.

- On a 30 m square!
- Soil look up tables, manure/fertilizer applications, water withdrawals, crop types, wetlands, riparian buffers, forests, Best Management Practices
- Data from EPA, USGS, DNR, MDE, USDA
- Can provide details needed for effective policy and management

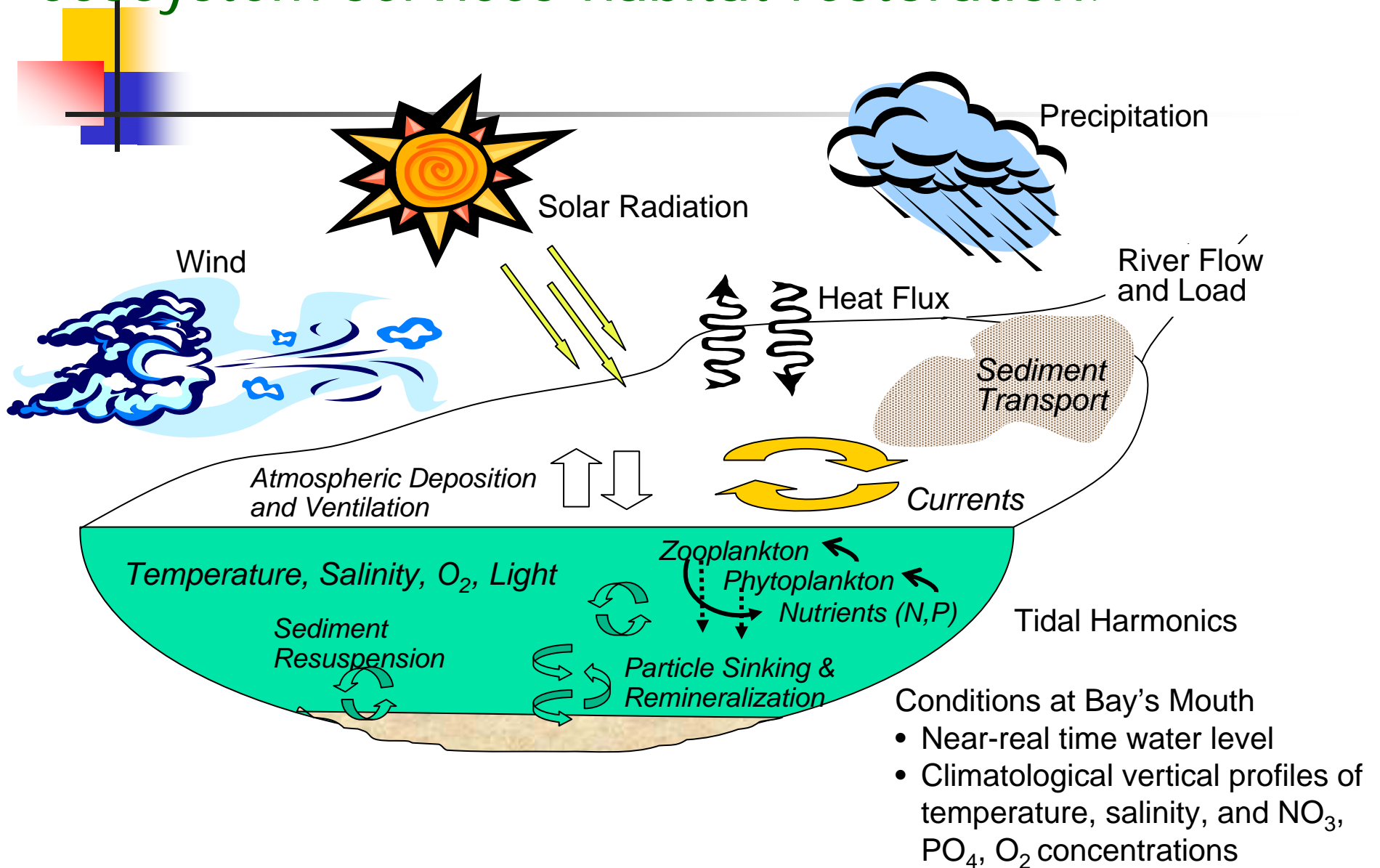


Most useful, data-intensive, laborious but most relevant

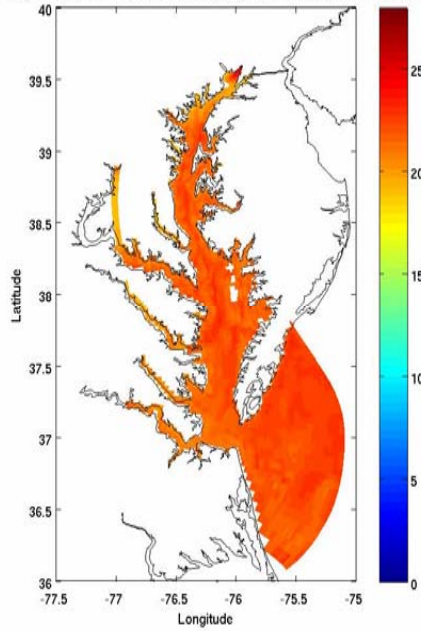


Below normal stream flow for the coming months: Impact on the Bay?

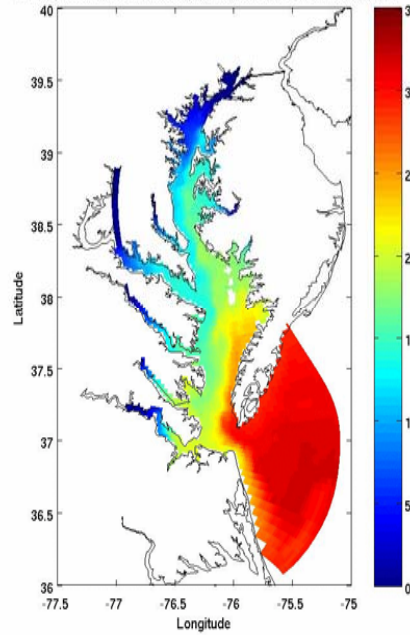
Coastal CTBs: Two-way Nesting? Land-Ocean-ecosystem services-habitat restoration.



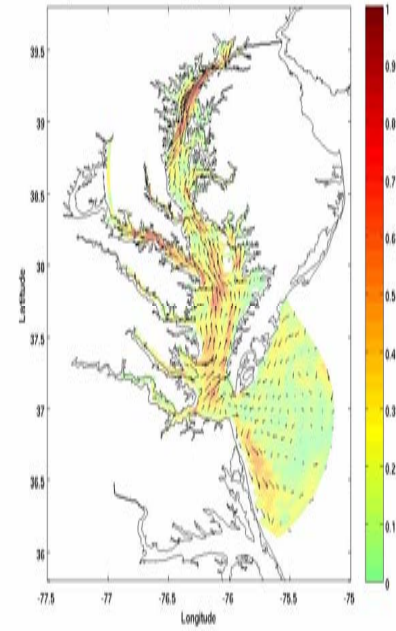
16-Day Fcst of Sfc Temperature (deg C) at 2009-09-14 00:00:00



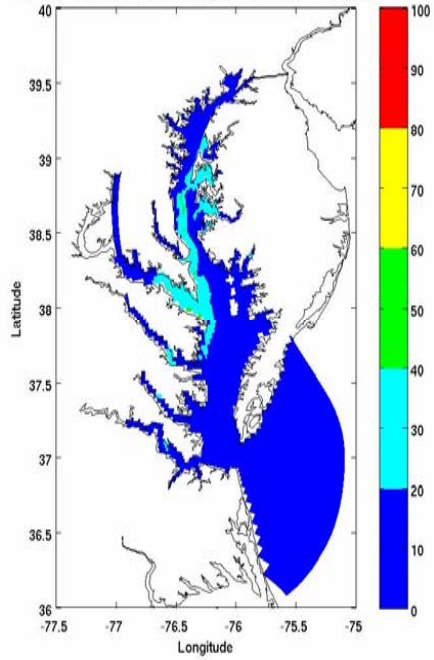
16-Day Fcst of Sfc Salinity (psu) at 2009-09-14 00:00:00



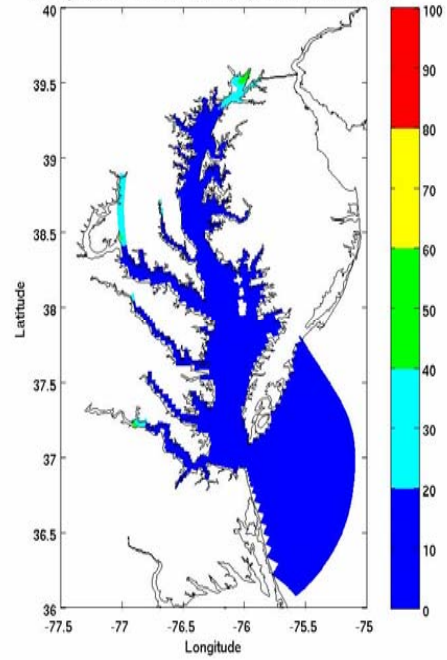
16-Day Fcst of Sfc Velocity (m/s) at 2009-09-14 00:00:00



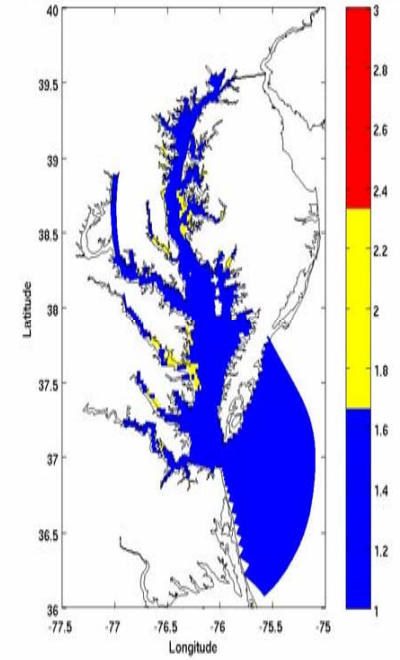
16-Day Fcst of Sea Nettles (%) at 2009-09-14 00:00:00



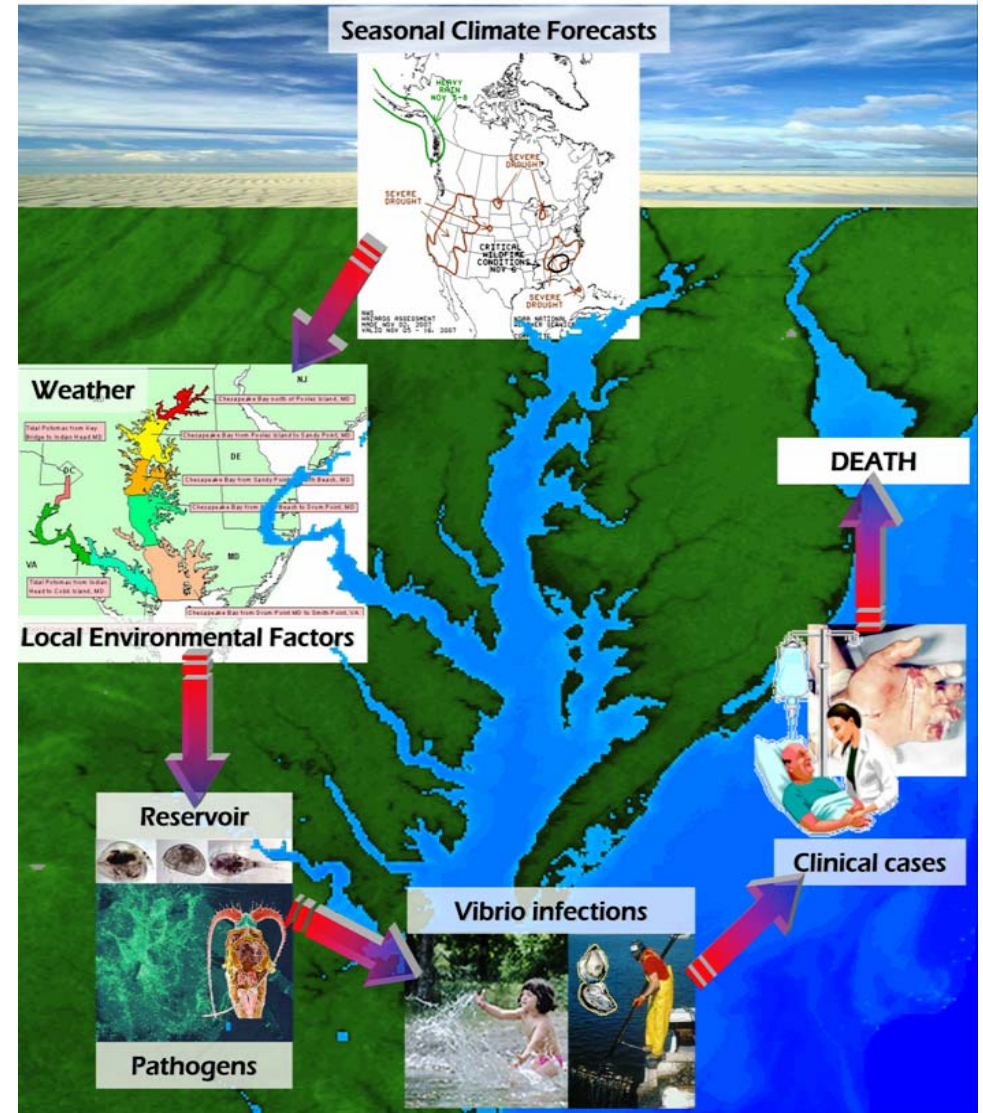
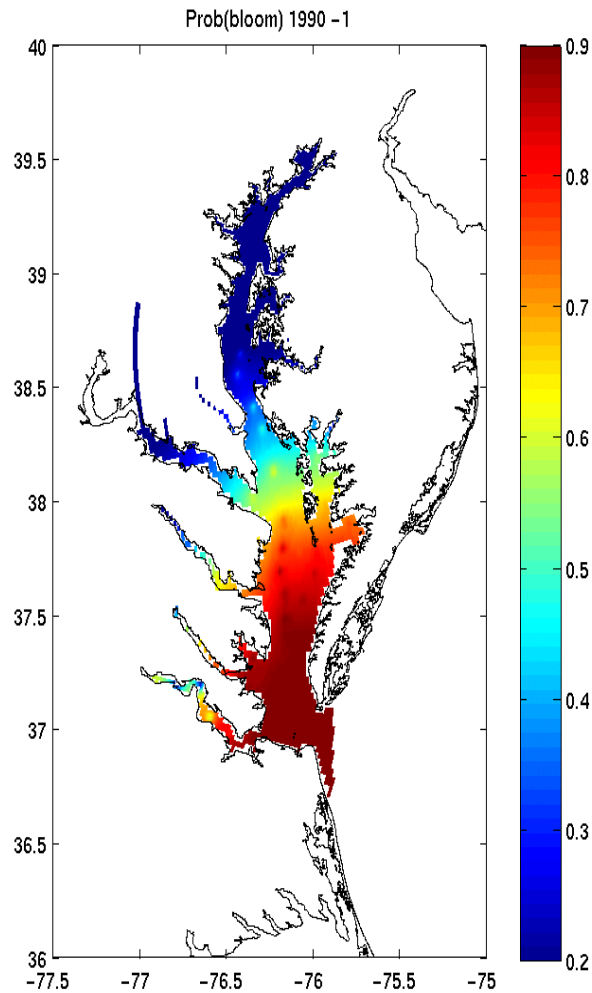
16-Day Fcst of Vibrio Cholera at 2009-09-14 00:00:00



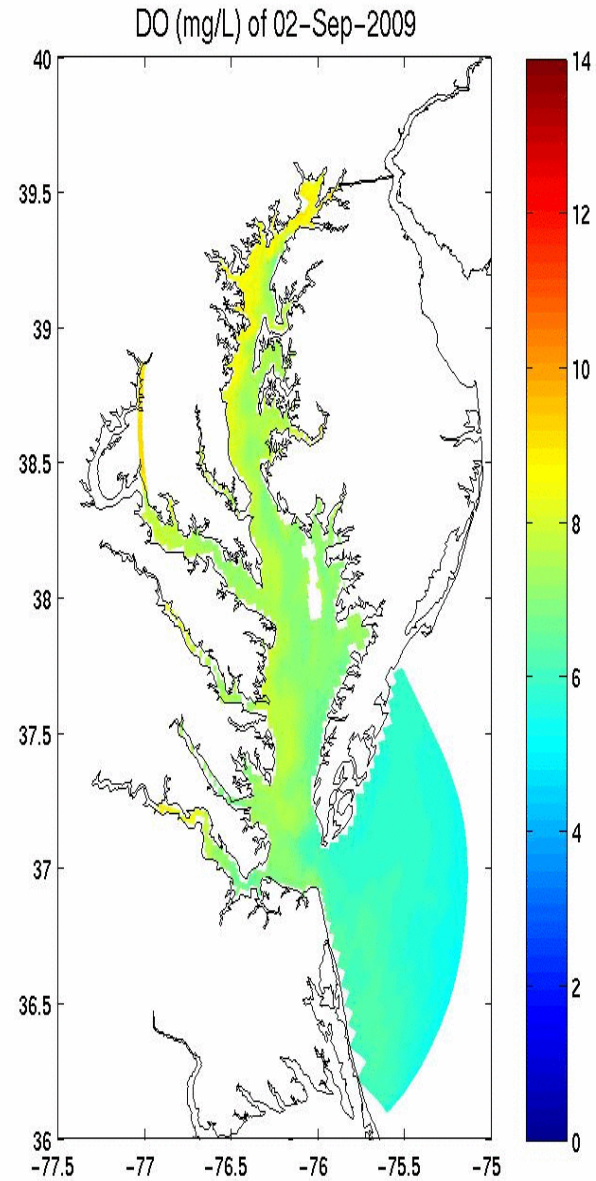
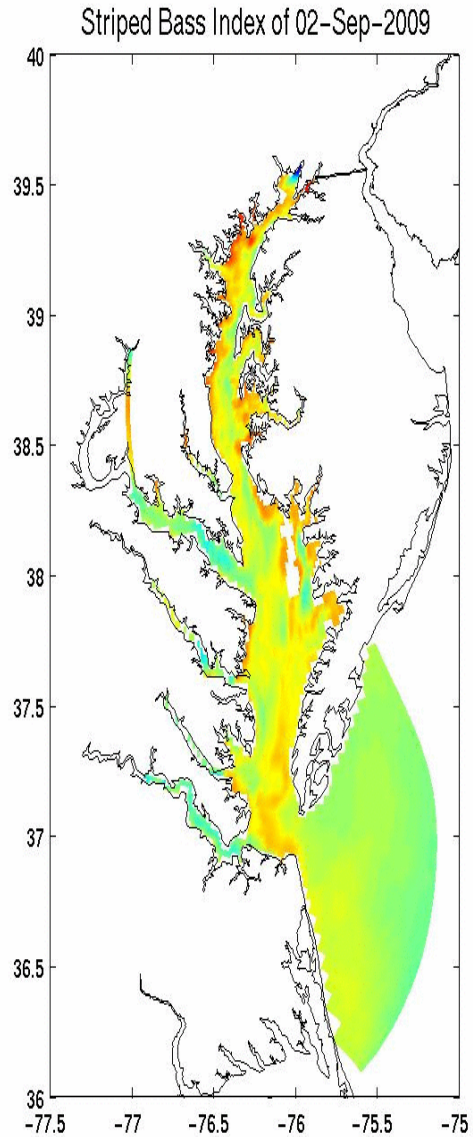
16-Day Fcst of Karlodinium Veneficum at 2009-09-14 00:00:00



An End-to-End Early Warning System: Can we provide reliable early warning? Multi-user interfaces, natural-human system interactions, socio-economic CTBs?

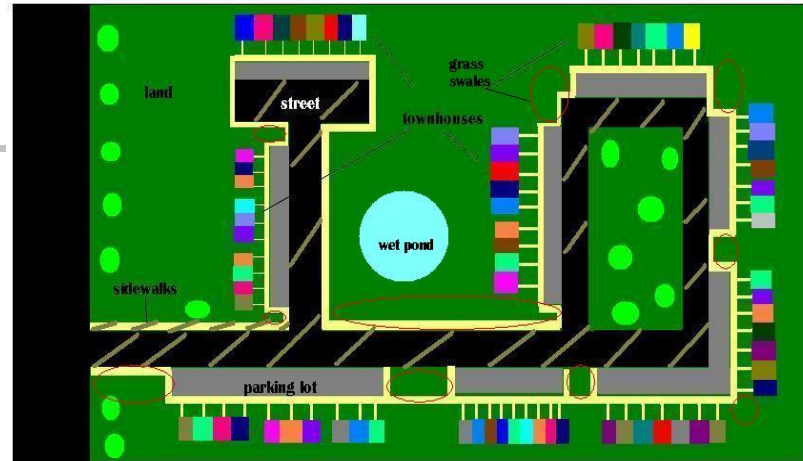


Predictability of biogeochemistry and ecosystems: **R20 – Ecosystem CTBs?**



How to consider sustainable-green methods and adaptation in CTB?

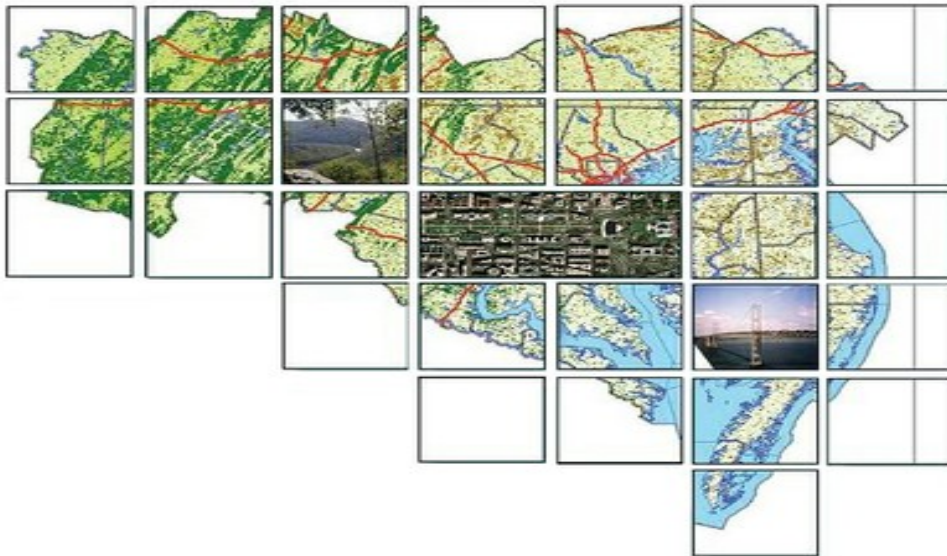
- Dryponds (detention) and Wetponds (retention)
- Grass Swales
- Permeable Pavers
- Storm Gardens



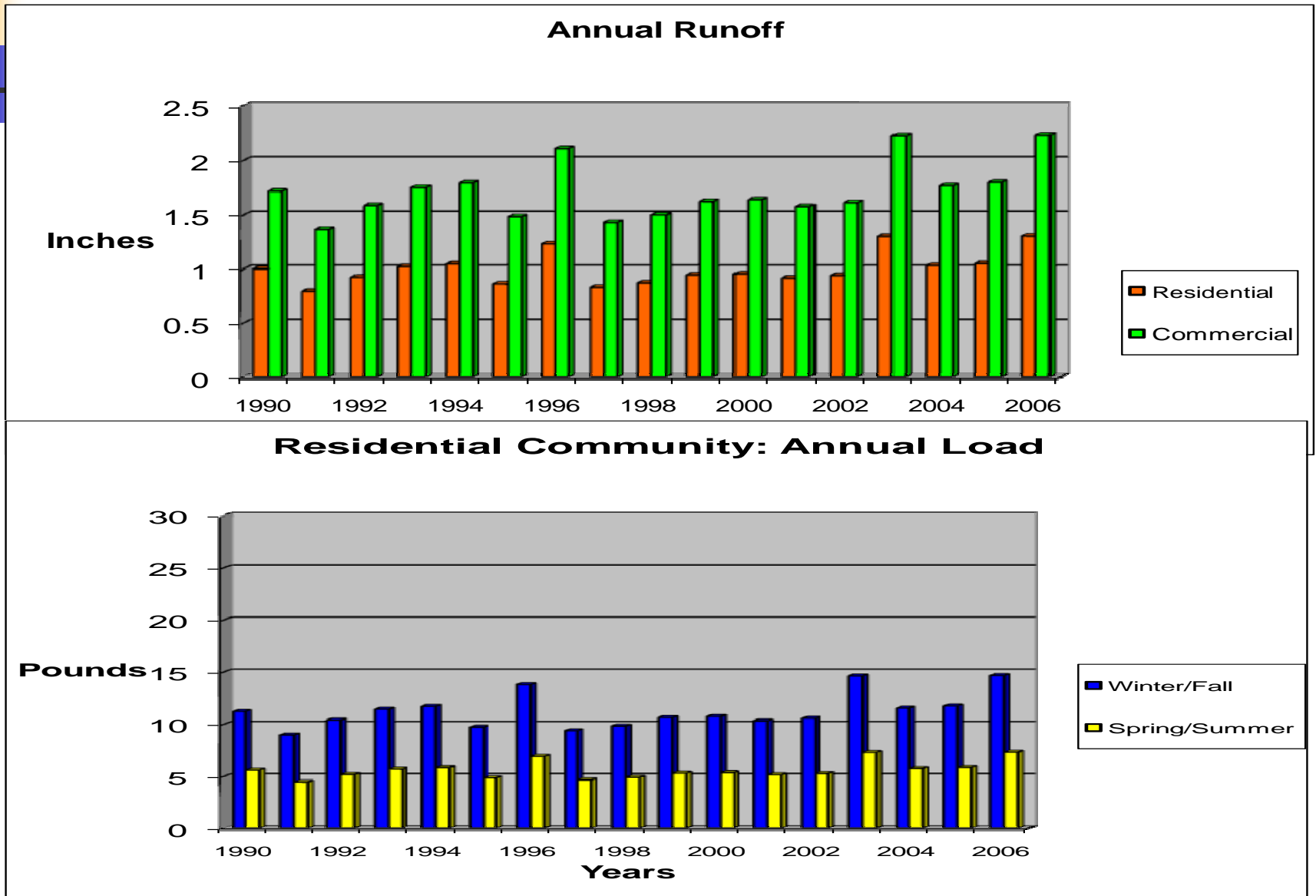
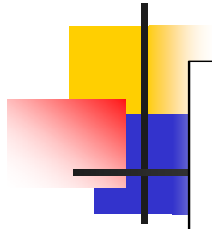
Counties at High Risk of Weather-Related Problems That Could Be Made Worse by Global Warming

Hazard	Counties at Risk
Drought	Frederick, Montgomery, Howard, Carroll, Baltimore City and County, Harford, Cecil
Extreme Heat	Baltimore City
Flash/River Flooding	Frederick, Allegany
Thunderstorm	Frederick, Montgomery, Anne Arundel
Tornado	Frederick, Anne Arundel
Winter Weather	Garrett
Tidal/Coastal Flooding	Dorchester, Worcester
Tropic Cyclone	Somerset, Worcester

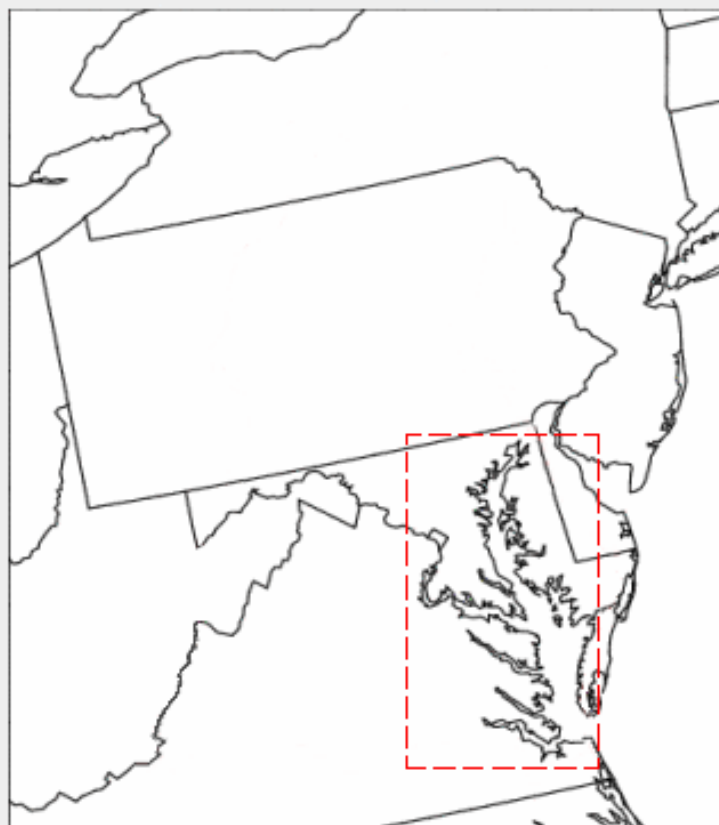
Maryland Scenario Project



CTB interactions with policy makers



Chesapeake Bay Forecast Tool



Set the region

Time Scale

months

years

Compute

Output Variables

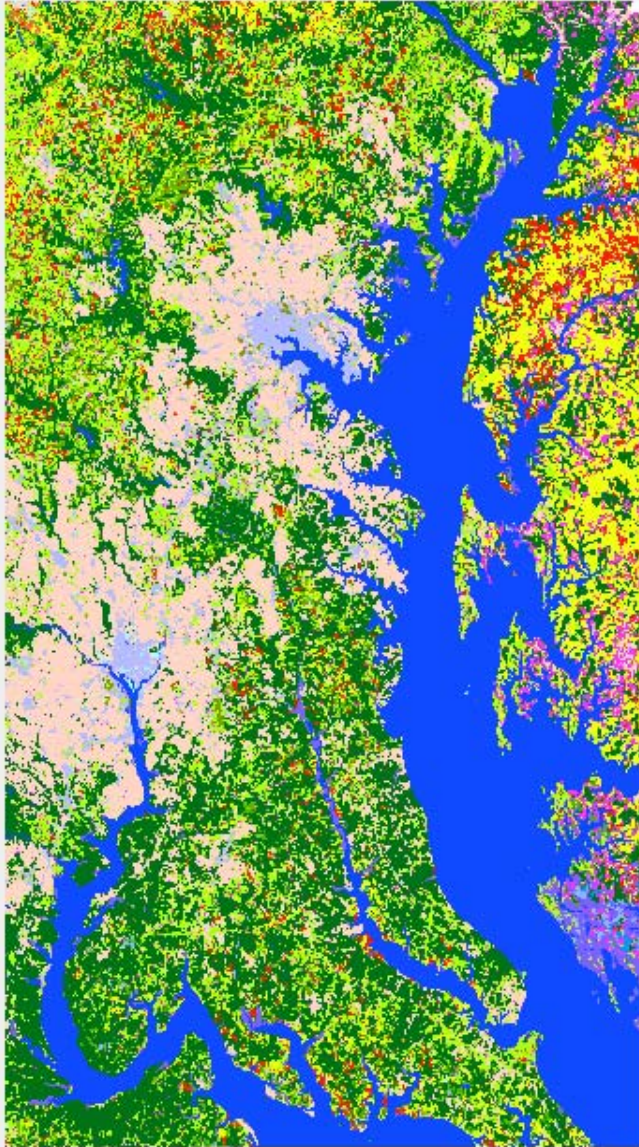
<input type="checkbox"/> Sealevel	<input checked="" type="checkbox"/> Phosphorus
<input type="checkbox"/> Storm surge	<input checked="" type="checkbox"/> Oxygen
<input type="checkbox"/> Land coverage	<input checked="" type="checkbox"/> Nitrogen
<input type="checkbox"/> Fish / Crabs	<input type="checkbox"/> Temperature
<input type="checkbox"/> Air quality	<input type="checkbox"/> Salinity
<input type="checkbox"/> Winds	<input checked="" type="checkbox"/> Algae bloom
<input type="checkbox"/> Precipitation	<input checked="" type="checkbox"/> Sea nettles

Input Variables

<input type="radio"/> Population density	<input checked="" type="radio"/> Land use
<input type="radio"/> CO2 pollution	<input type="radio"/> Stream runoff
<input type="radio"/> Hi/low prognosis	<input type="radio"/> Agricultural mix

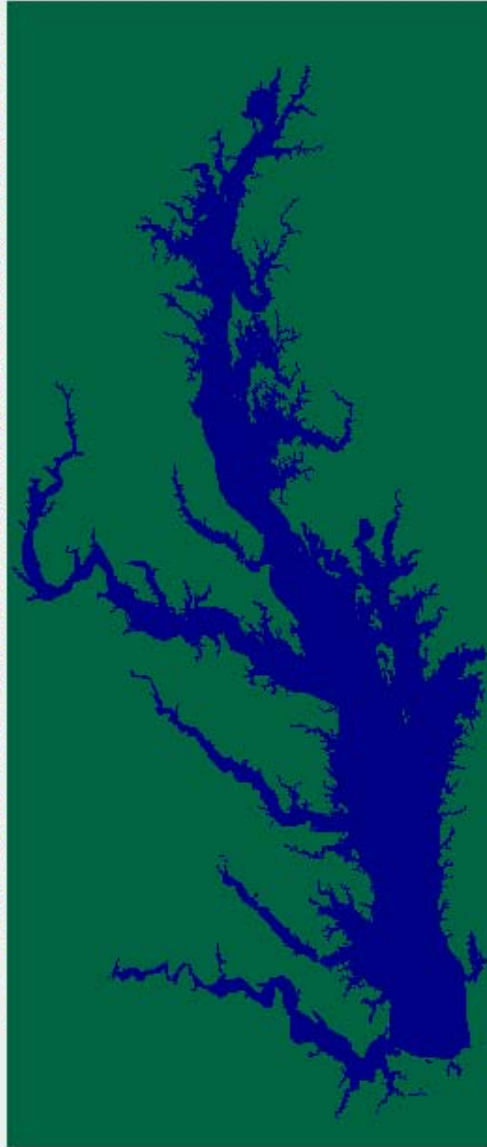
Decision-making under CTB

- CORN
- COTP
- GRSG
- SOYB
- PNUF
- TOBC
- BARL
- WWHT
- HAY
- RYE
- OATS
- ALFA
- GRBN
- POTA
- AGRR
- SPOT
- AGRL
- STRW
- FESC
- PAST
- CFRM
- ORCD
- RNGE
- CANT
- CABG
- WATR
- URLD
- URHD
- UTRN
- URML
- URMD
- FRSD
- FRSE
- FRST
- WETF
- WETN
- WETL



Show full map Restore original map

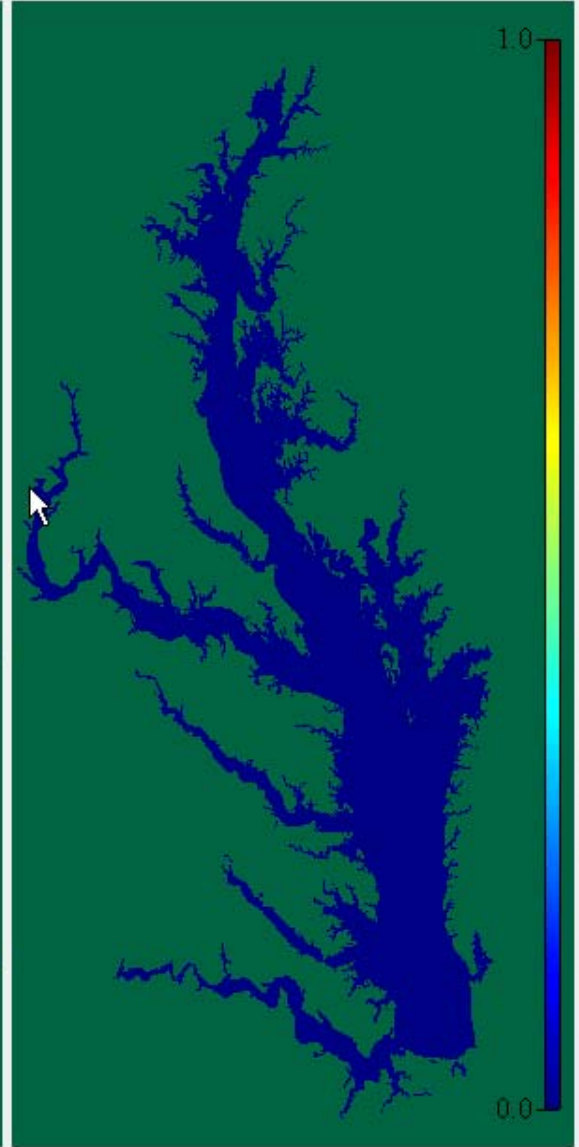
Eliminate selected land use



Store current results here

Reference map not available

Show corresponding land use map

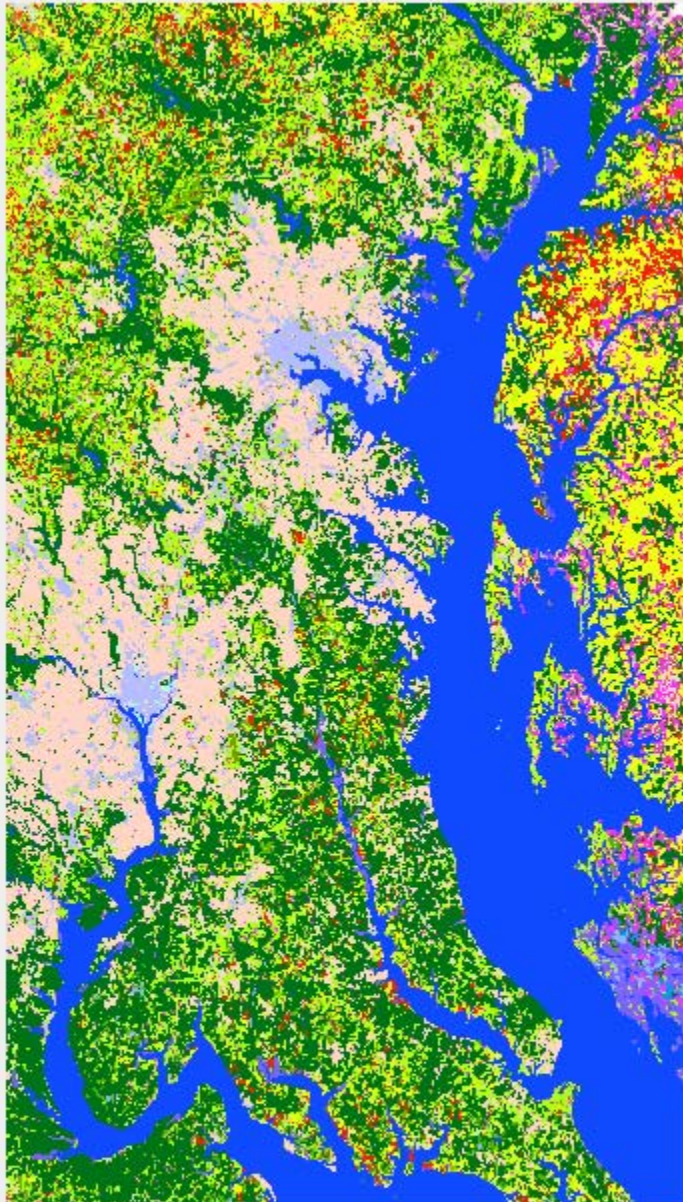


Climate data: August 2008

N P O Nettle HAB

Update result window

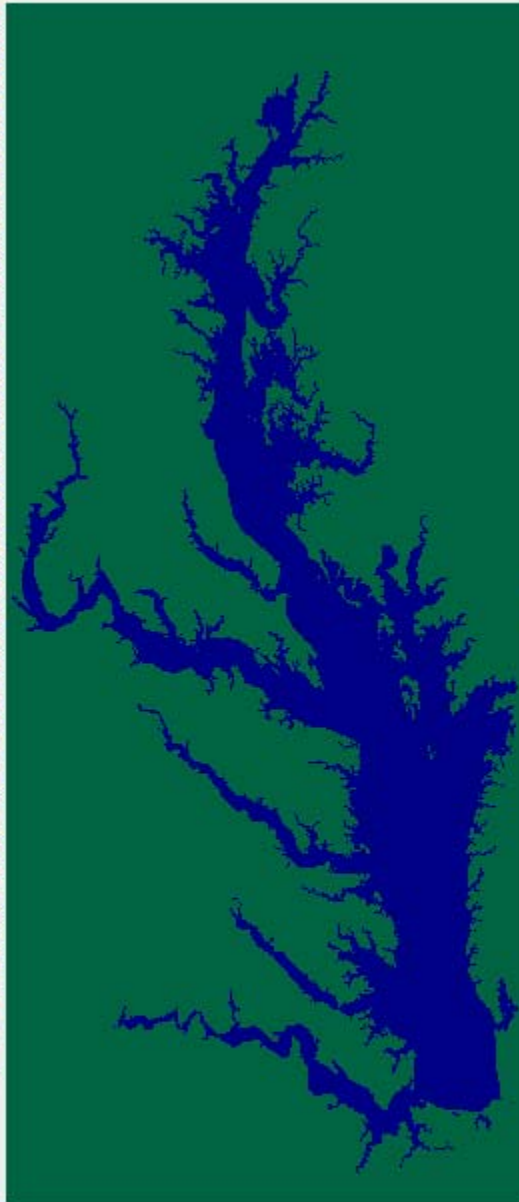
- CORN
- COTP
- GRSG
- SOYB
- PNUT
- TOBC
- BARL
- WWHT
- HAY
- RYE
- OATS
- ALFA
- GRBN
- POTA
- AGRR
- SPOT
- AGRL
- STRW
- FESC
- PAST
- CFRM
- ORCD
- RNGE
- CANT
- CABG
- WATR
- URLD
- URHD
- UTRN
- URML
- URMD
- FRSD
- FRSE
- FRST
- WETF
- WETN
- WETL



Show full map

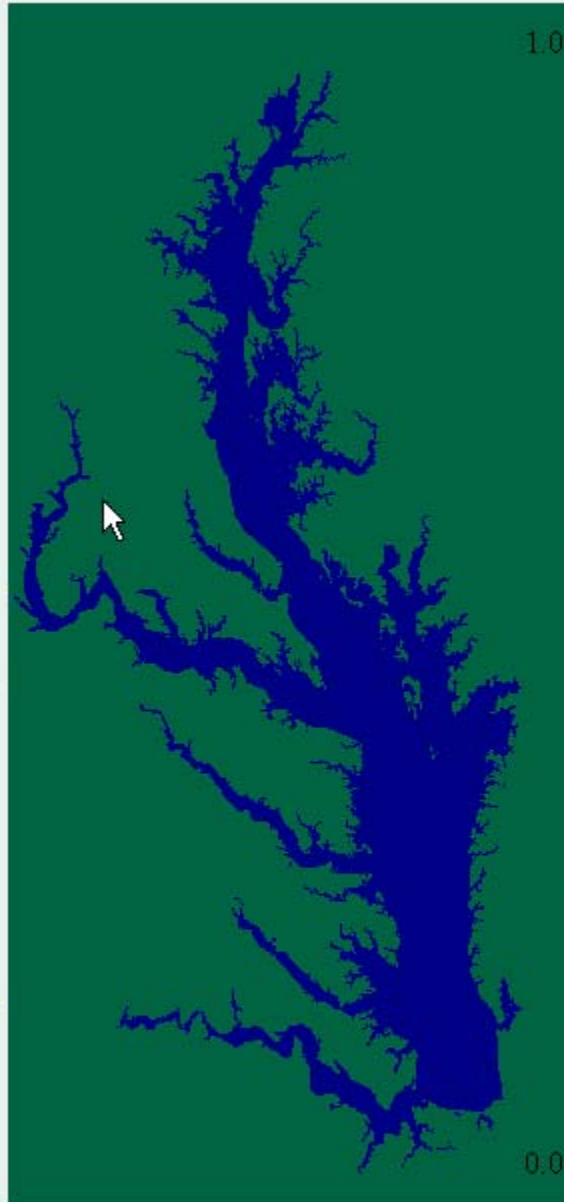
Restore original map

Eliminate selected land use



Store current results here

Show corresponding land use map



Climate data: July 2008

N P DO Nettle HAB

Update results

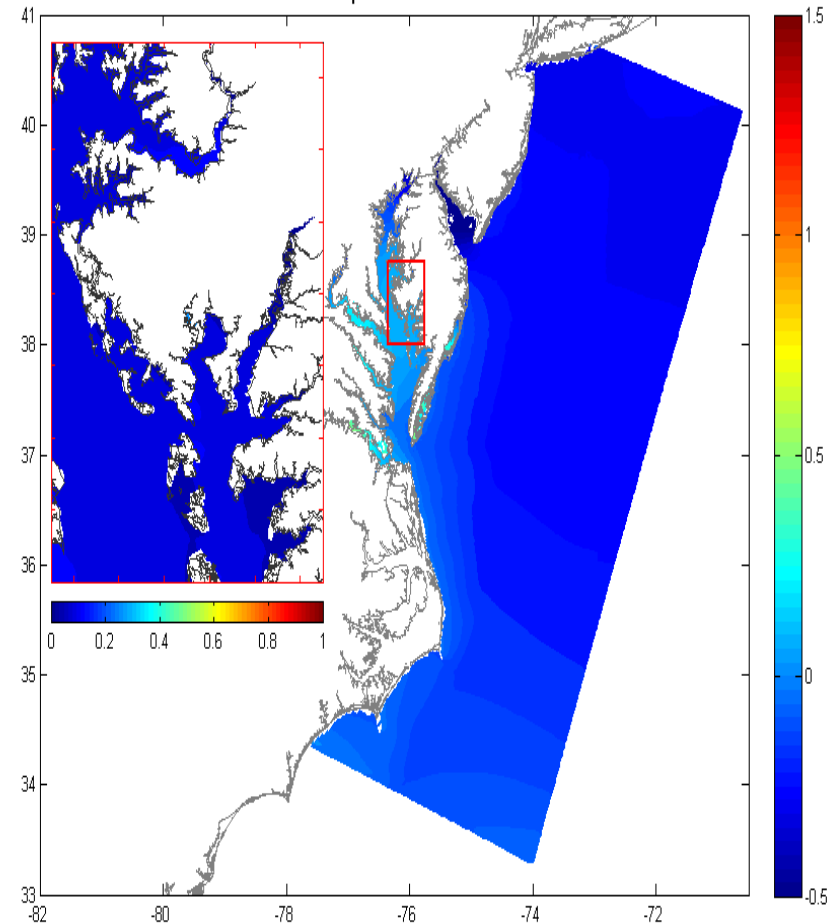
Show advanced

Emergencies under CTB

- Accessible streets, Hospital evacuations, resource allocations
- User Interfaces and rapid responses to special requests



18-Sep-2003 00:30:00



Sustainability: Goal and Strategy-Tactics

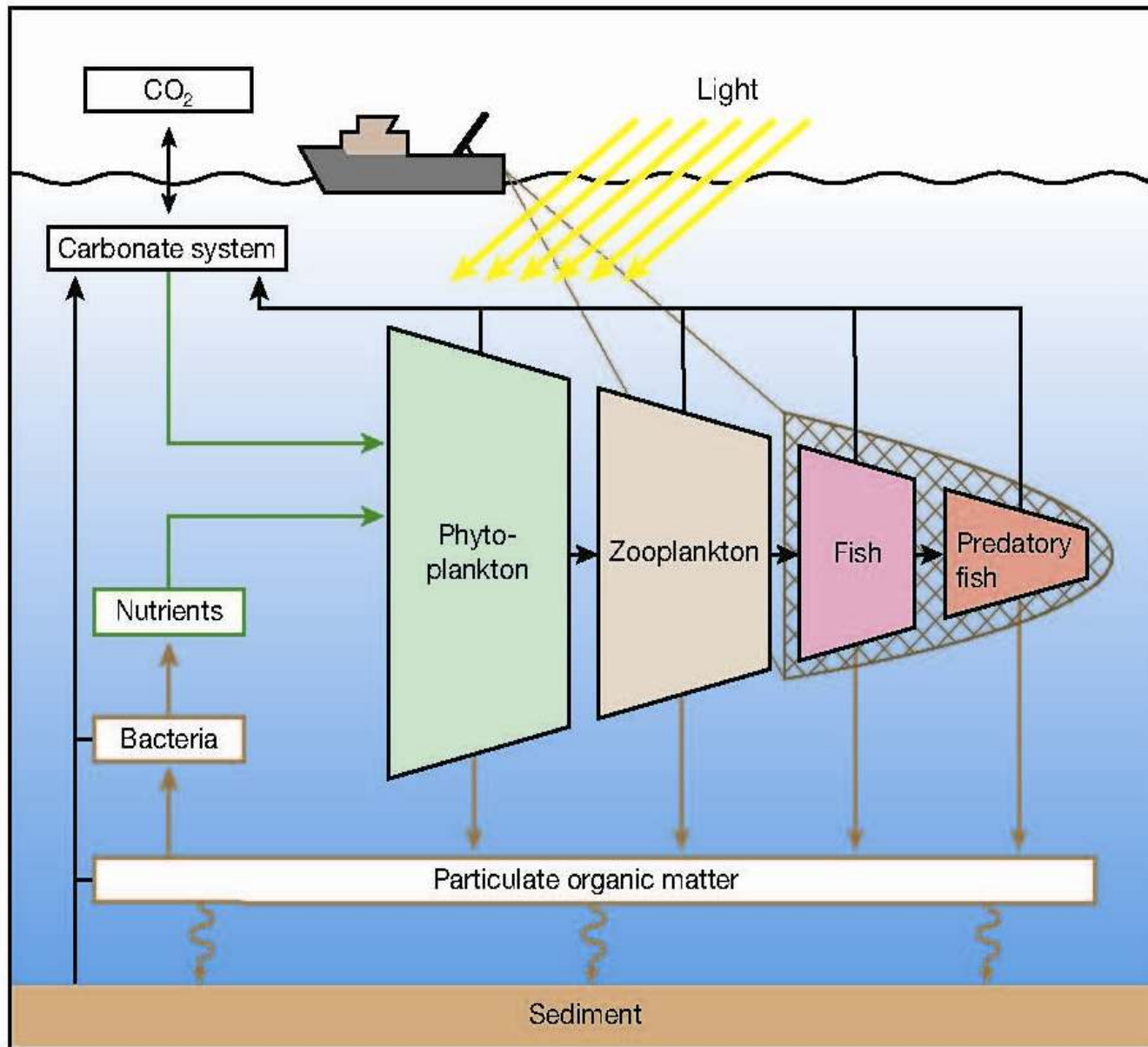


Figure 2.2-1

Schematic structure of a pelagic marine ecosystem. Green arrows: input to primary production; black arrows: interaction with the carbonate system; brown arrows: decomposition of biomass. In the interest of clarity, marine mammals and seabirds are not shown. Source: WBGU

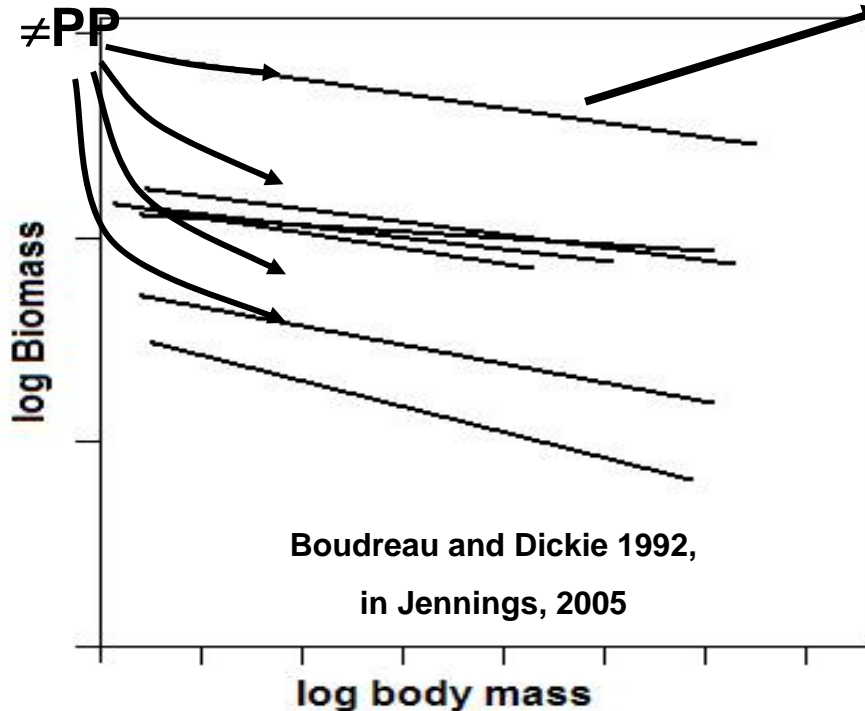


Physics to fish to fishermen: Interacting Physical, ecosystem, Socio-economic CTBs



Thermodynamics of ecosystems

- organism size largely determines its function in the ecosystem
- there is an obvious size-abundance relationship



Similar slopes suggest invariant processes leading to constant energy transfer through size spectrum

Turnover of population can be approximated by age at maturity

Time-trophic continuum: constrained by temperature & biodiversity

- size is linked to time and temperature
- metabolism (individual) and turn-over (population) are linked to size, time, and temperature.

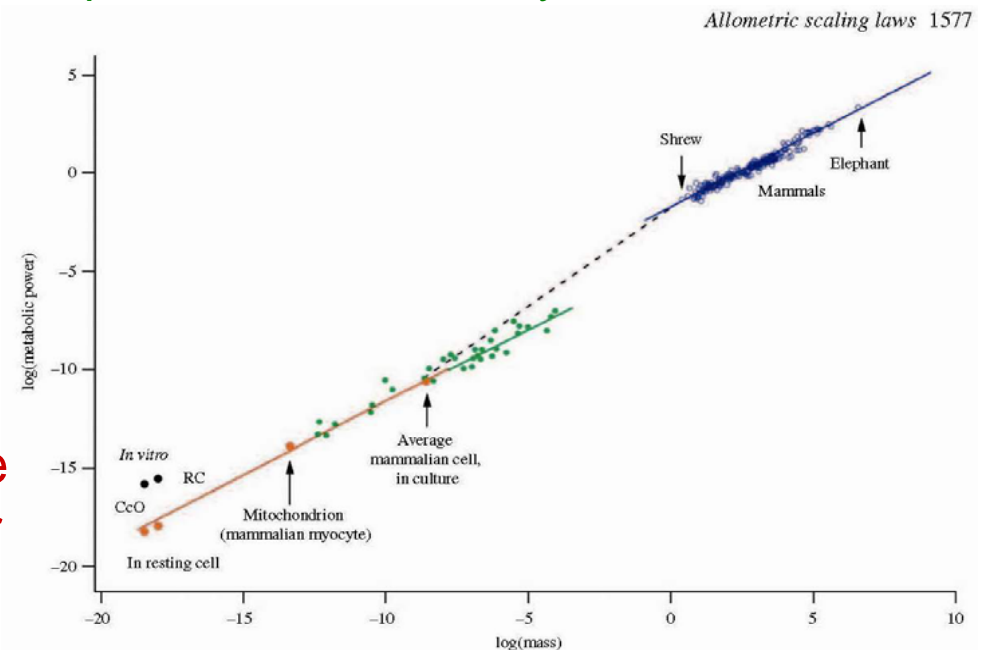
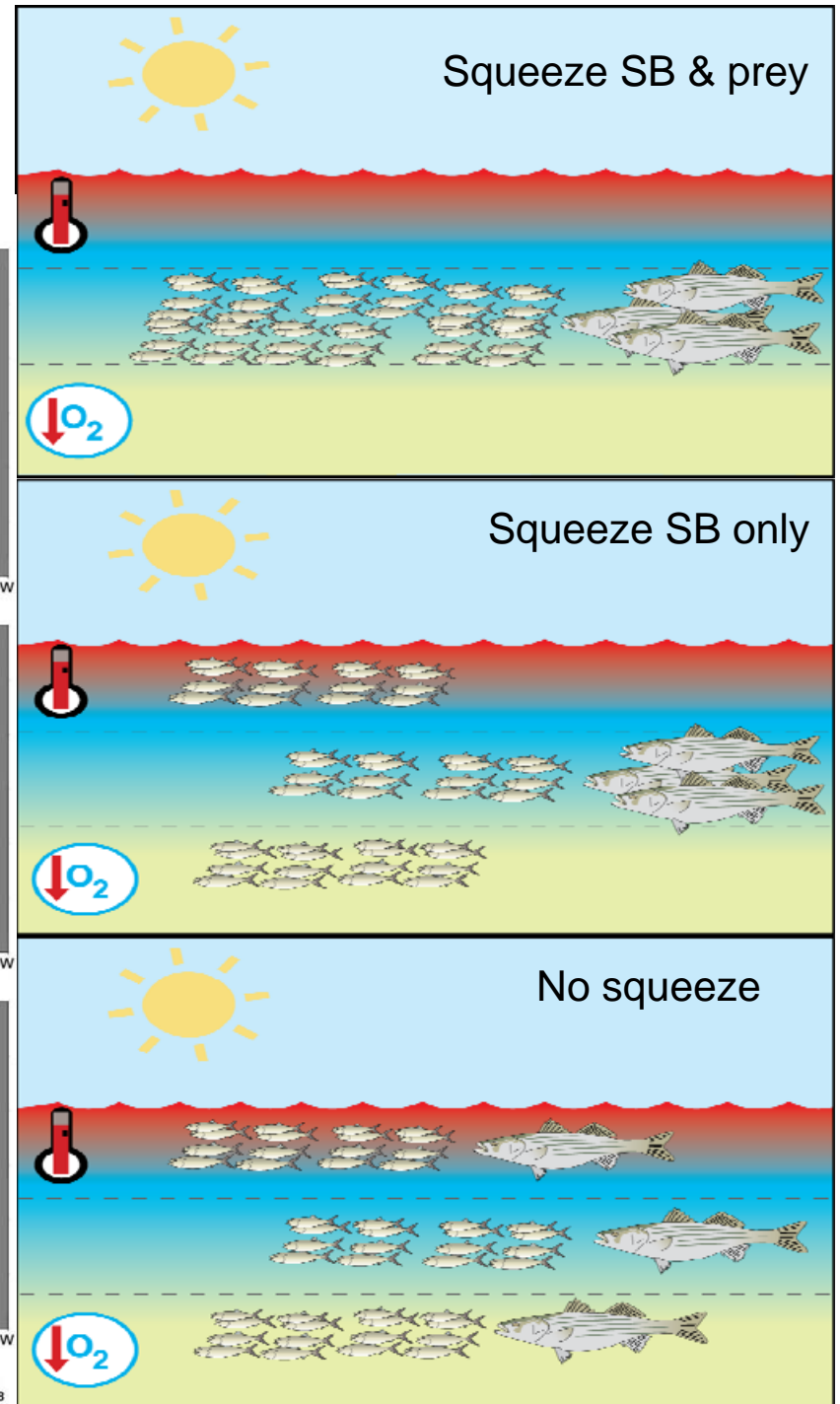
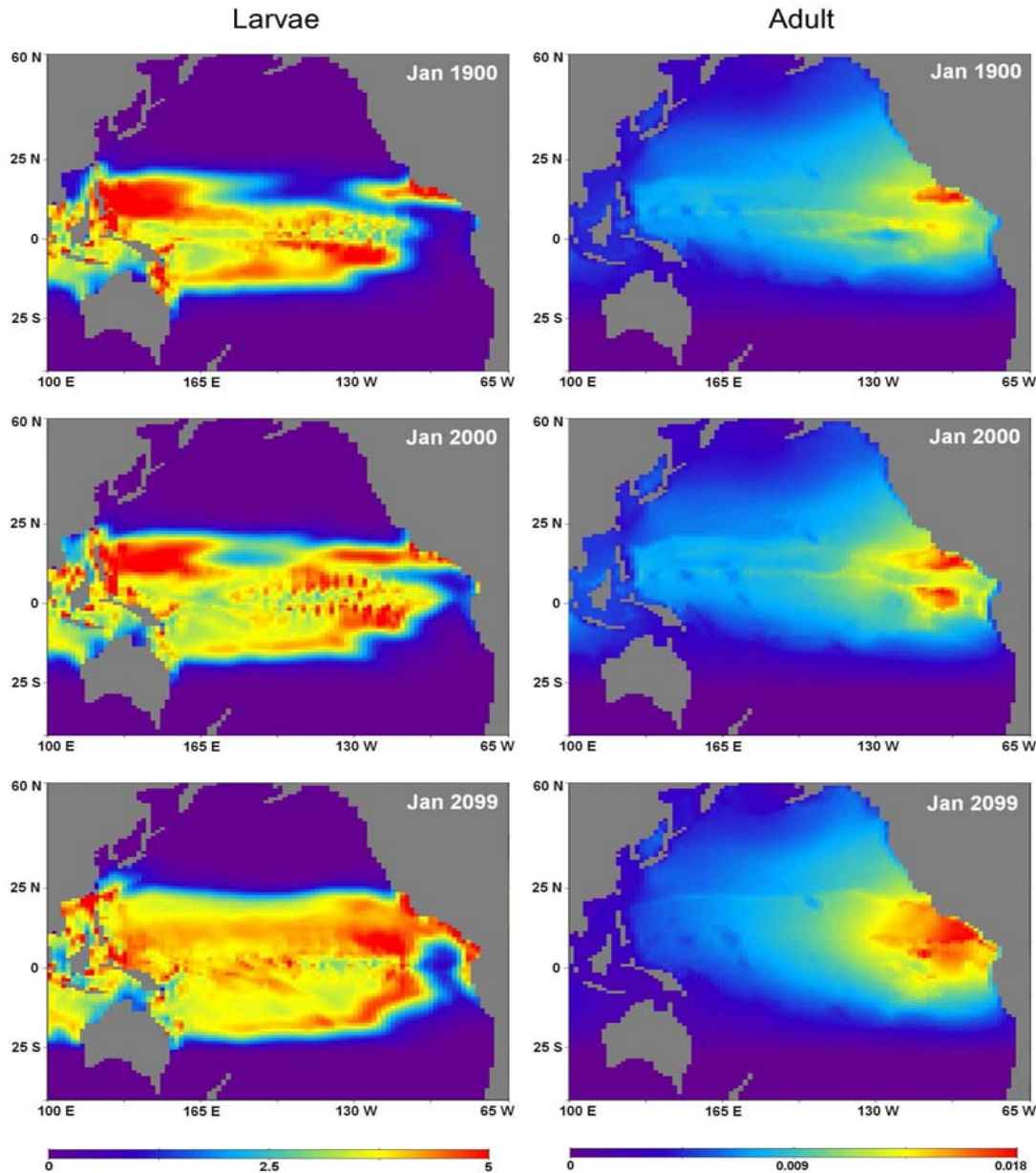


Fig. 2. Extension of Kleiber's 3/4-power law for the metabolic rate of mammals to over 27 orders of magnitude from individuals (blue circles) to uncoupled mammalian cells, mitochondria and terminal oxidase molecules, CcO of the respiratory complex, RC (red circles). Also shown are data for unicellular organisms (green circles). In the region below the smallest mammal (the shrew), scaling is predicted to extrapolate linearly to an isolated cell *in vitro*, as shown by the dotted line. The 3/4-power re-emerges at the cellular and intracellular levels. Figure taken from West et al. (2002b) with permission.

Global and regional governance issues





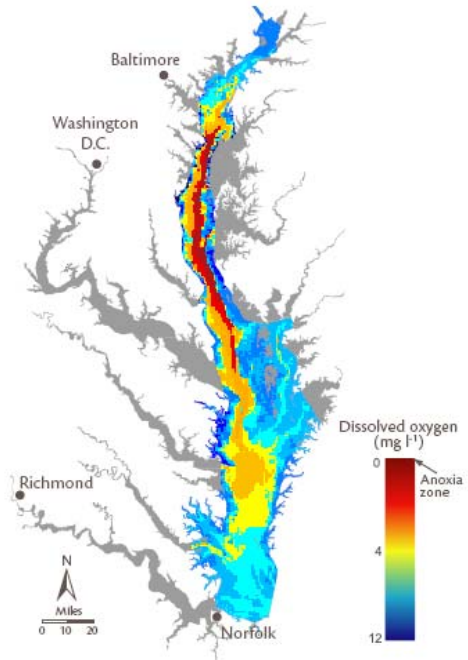
Observational CTB: Drive data needs

Dataflow 5.5

Water Quality Mapping program uses a technology known as DATAFLOW to rapidly collect spatially intensive water quality data.



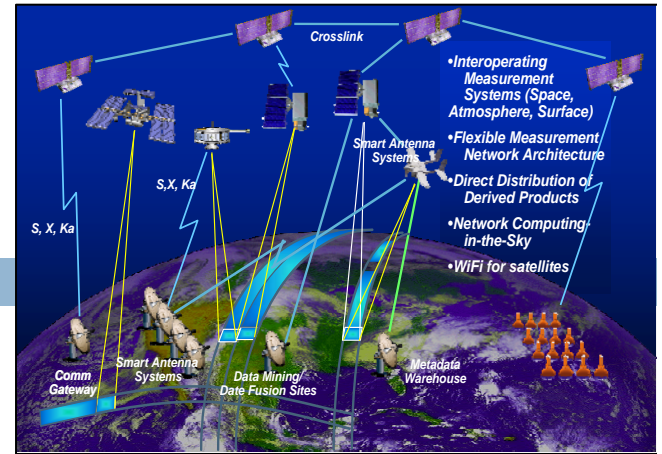
Dissolved Oxygen Sensor



Chesapeake Bay Dead Zone
2007 Forecast Map

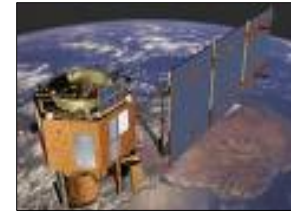


Crabs and flounder crowd into shallow water to escape low dissolved oxygen



Sensor Web

MODIS



EO-1



Mote Exemplars



Continuous Monitoring Station

MDDNR Continuous Monitoring Program - 54 continuous monitoring stations. Roughly a third of the sites will be equipped with cellular telemetry equipment powered by solar panels. The remaining sites will be posted on a bi-weekly basis.

Noblis

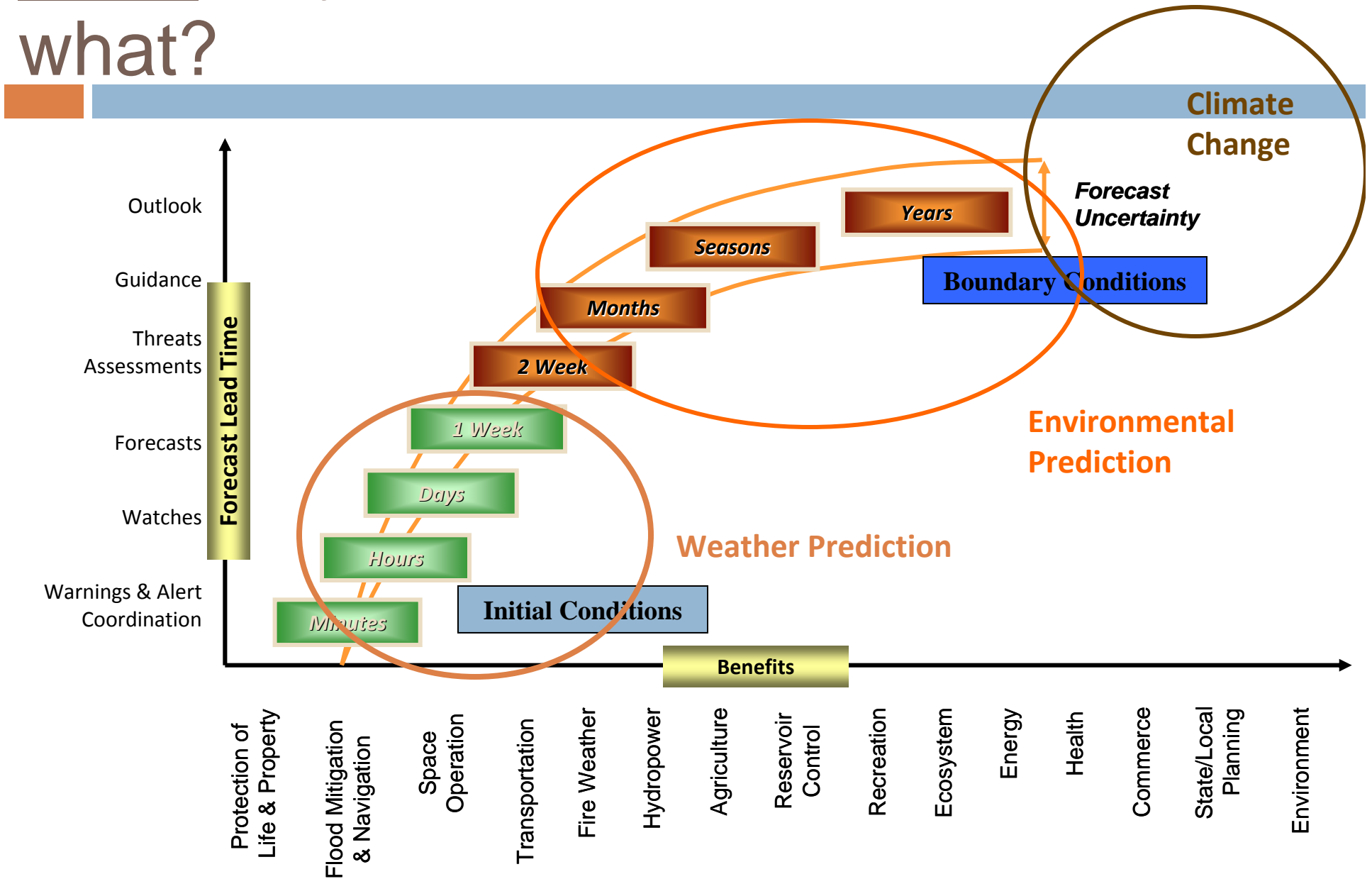


OASIS II ASV



Ikhana UAS

CTB: Days to decades-Who does what?



Major need for co-ordinate land use for the health of the Bay

The large-scale environmental and natural resource programs in the PNW region have several key features: (1) common land use and conservation objectives, (2) overlapping administrative programs of multiple agencies and organizations involving multiple species, and (3) similar database and analysis tool requirements. These three commonalities among natural resource programs motivate the need for similar watershed databases (e.g., stream networks, vegetation, roads, and so forth) and analysis tools that utilize those databases (e.g., fish habitat quality, erosion potential, fish migration blockages, and so forth).

Are there groups that are particularly difficult to engage?

a) State legislators; b) Hispanics and other minorities; c) retirees, newly relocated from outside of Florida

Absentee homeowners; average citizens

African-Americans

Agricultural community

Agricultural community, local officials

Agriculture and development communities

Agriculture industry; township governments

All involved with planning

Although insurance agents are not our target audience, their lack of knowledge has a negative statewide effect

Army Corps of Engineers, Soil and Water Conservation Districts, consulting engineers, planners, landscape designers

ATV users

Building industry

Business community

CalTrans, Corps of Engineers; agricultural groups at state, local, and federal level

CCA

Charter boat guides

Citizens

Citizens that are not angry or concerned about a topic

Coastal property owners

Coastal stakeholders

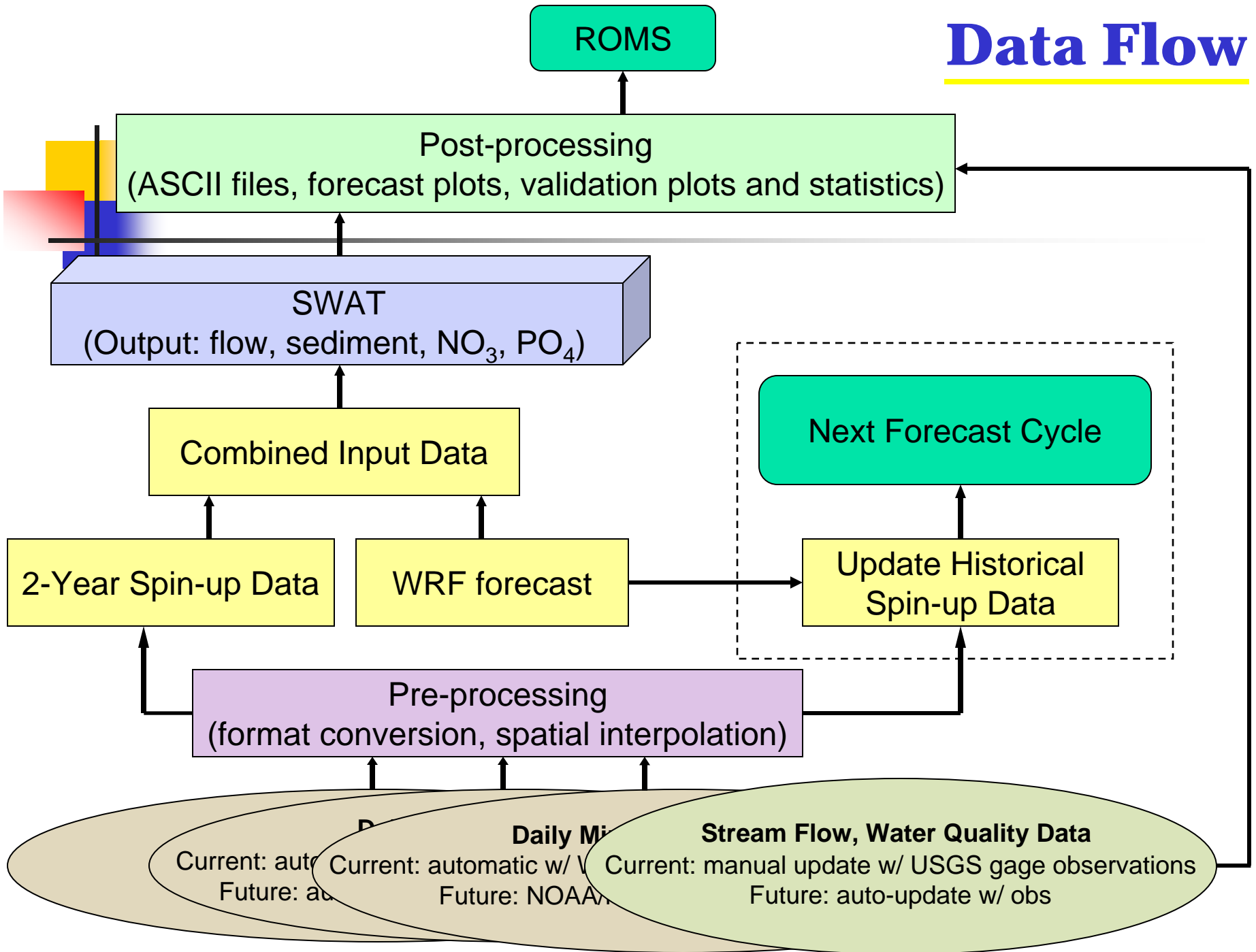
Coastal tourism industry members and managers

Commercial and recreational fishermen, NOAA higher level staff, Natural Sea Grant Office

Commercial fisherman and citizens sometimes believe our bureau is regulatory when it is not

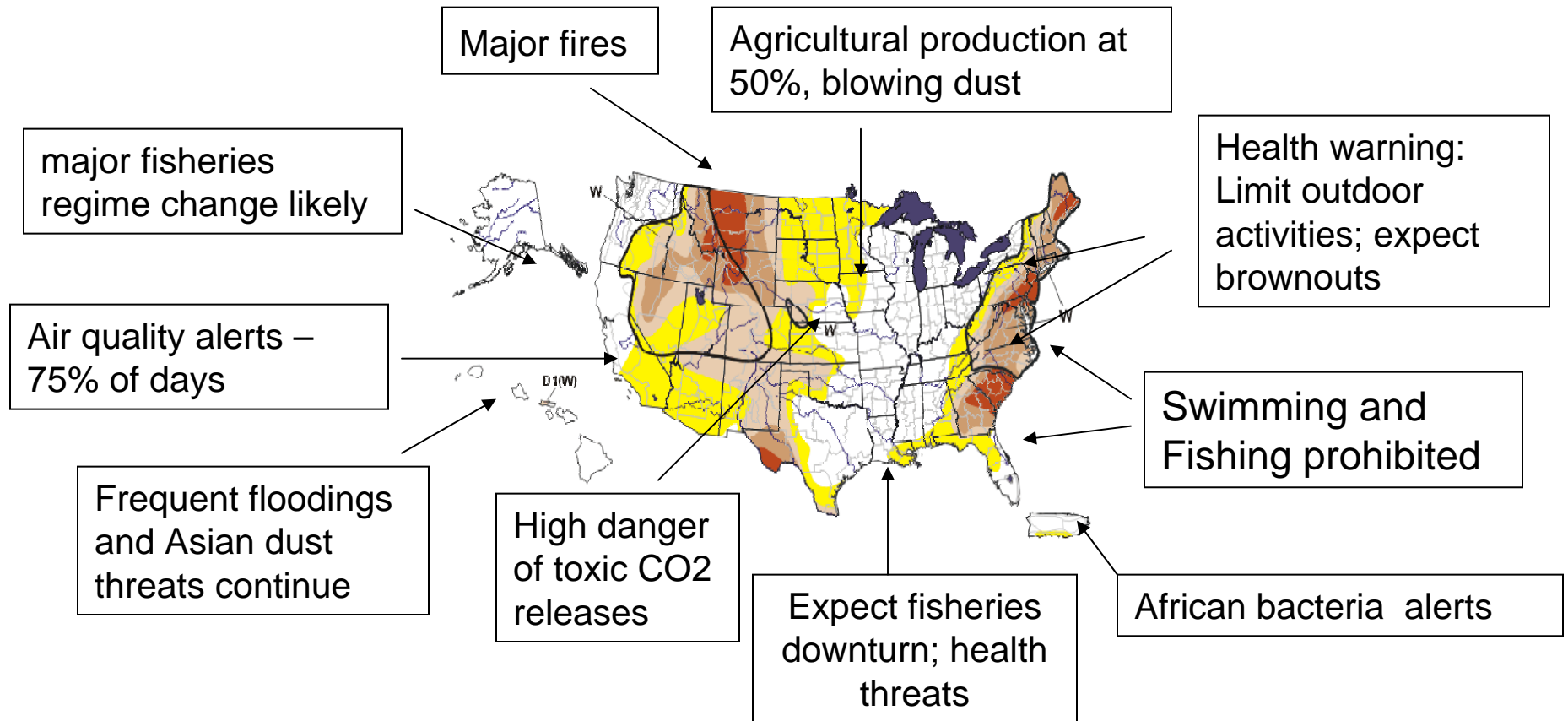
Commercial fishermen

Data Flow



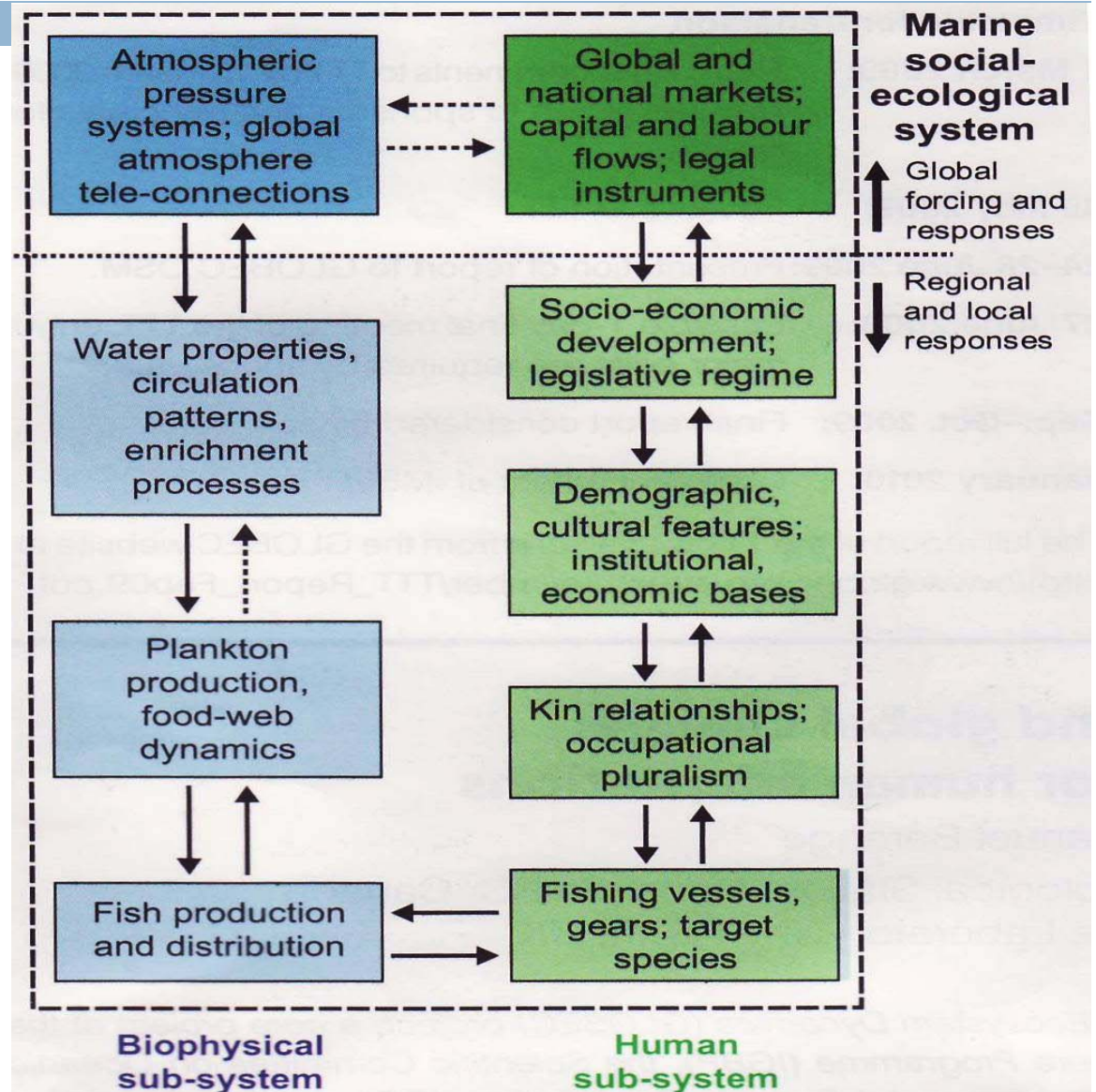
What are the prospects for the future? Capacity Building

New environmental forecast products will be feasible



Possible Threats-Summer 2020: hot, dry and unhealthy

Sustainability, Ecosystem-based management, Integrated assessment, adaptive management with participatory decision-making, and such require a reliable and scientific tool.



Perry et al. 2009