Municipal Planning for Drought and Flood Resilience

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MA Clean Energy Conference

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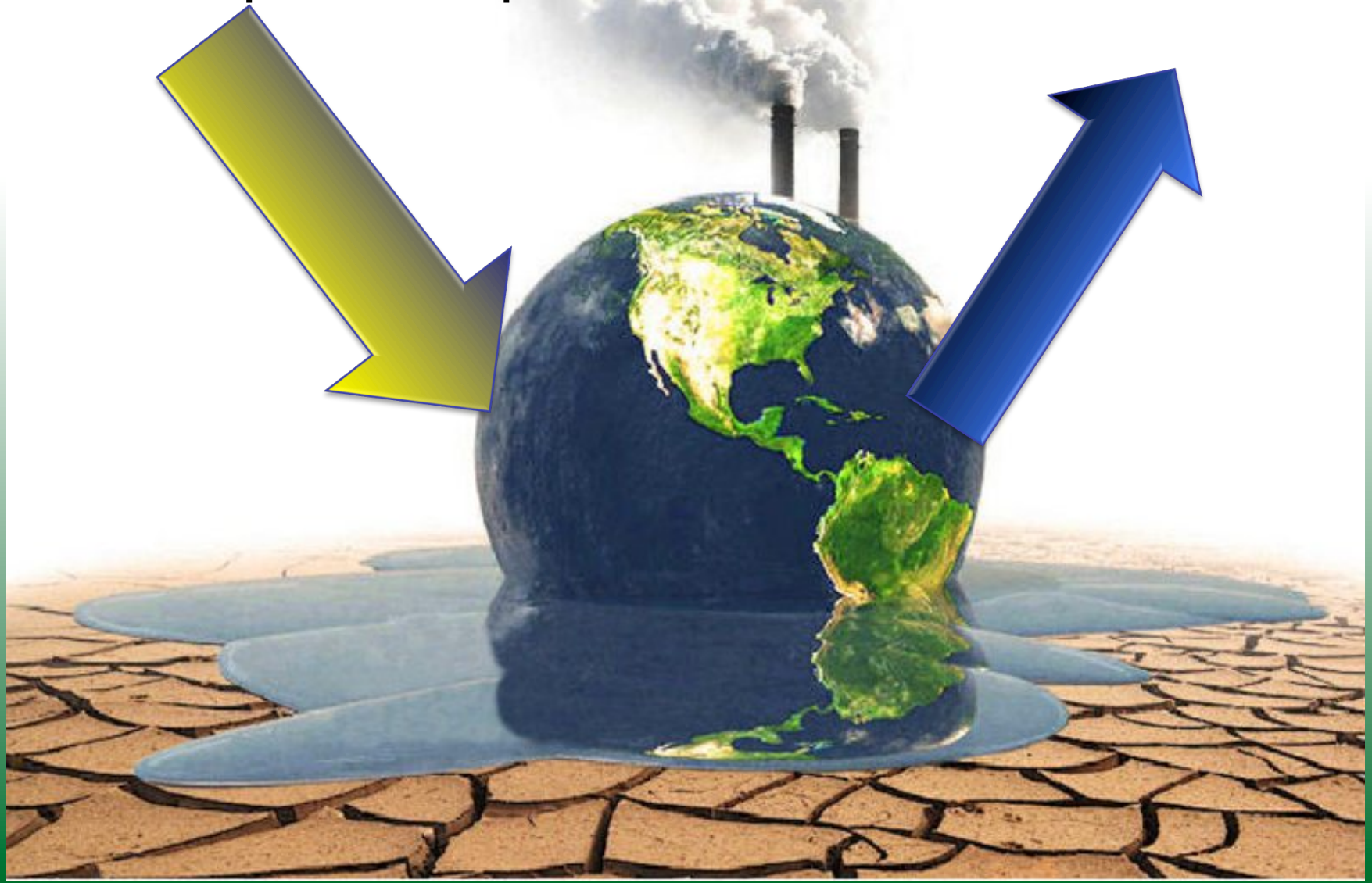
- Where do droughts and floods come from? Do they happen in New England?
- Let's talk about the drought
- Resilience to drought and floods
- What does it mean to be river-smart?
- (Some) Lessons from river floods
- Our vision for managing rivers and floods in MA

Energy balance of the earth

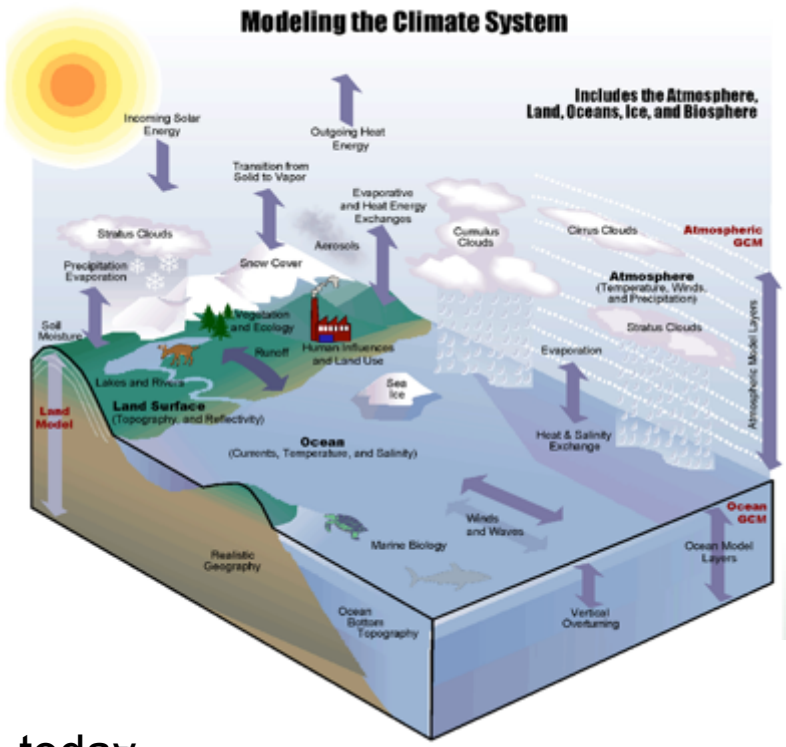
- Input – Output = Heat

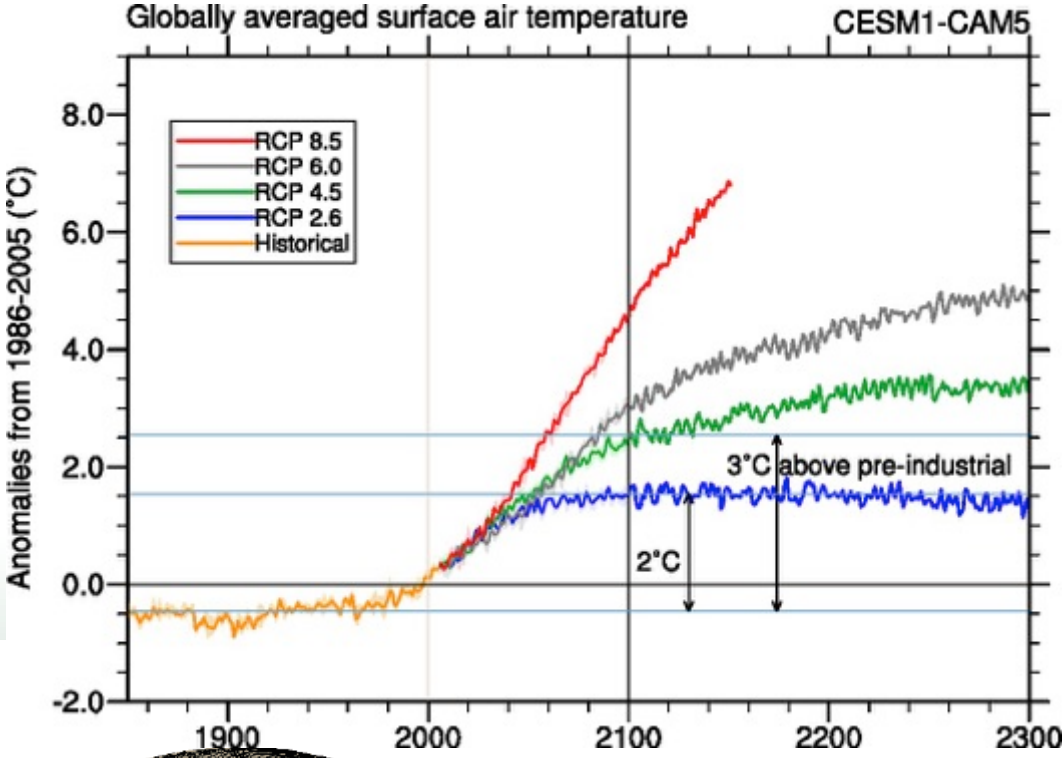


The State of Climate Science
(*this is not new…)*

Welcome to the **Anthropocene**

- Global temperatures are increasing
- Sea level is rising
- These affect the hydrologic cycle
- The cause is anthropogenic





today

drill site selection, science objectives

model boundary conditions

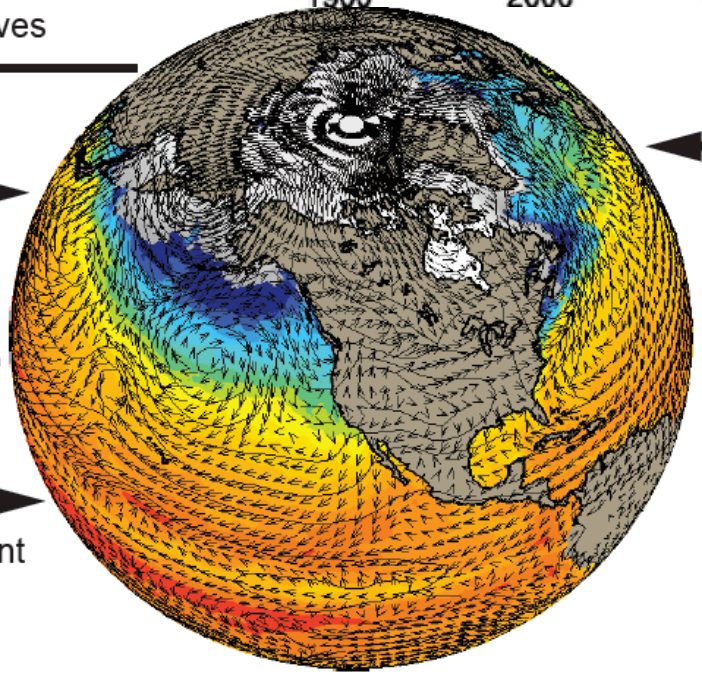
proxy data

comparison & testing

model output

model development & calibration

Back in time →

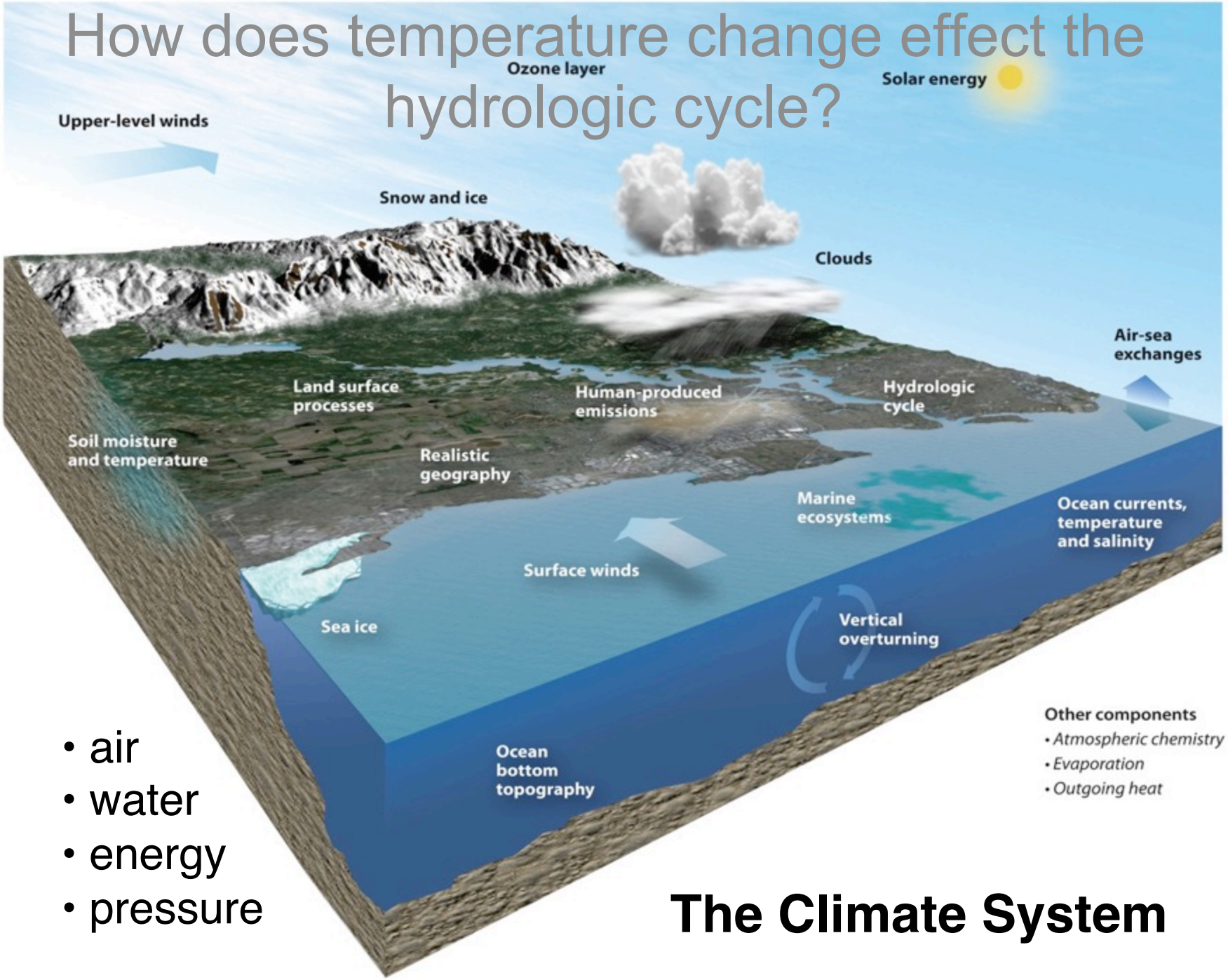


solar
volcanic
orbital
greenhouse gases
tectonics/gateways

Climate Observations and Future Predictions: ***It Matters.***

- Weather and Climate Variables
  - Temperature, Precipitation, Winds
- Extreme Phenomena
  - Monsoons, El Niño, (Extra)tropical Cyclones
- Impacts on the Physical Environment
  - **Floods**, **Droughts**, Sealevel rise, Coastal Erosion, Permafrost melting

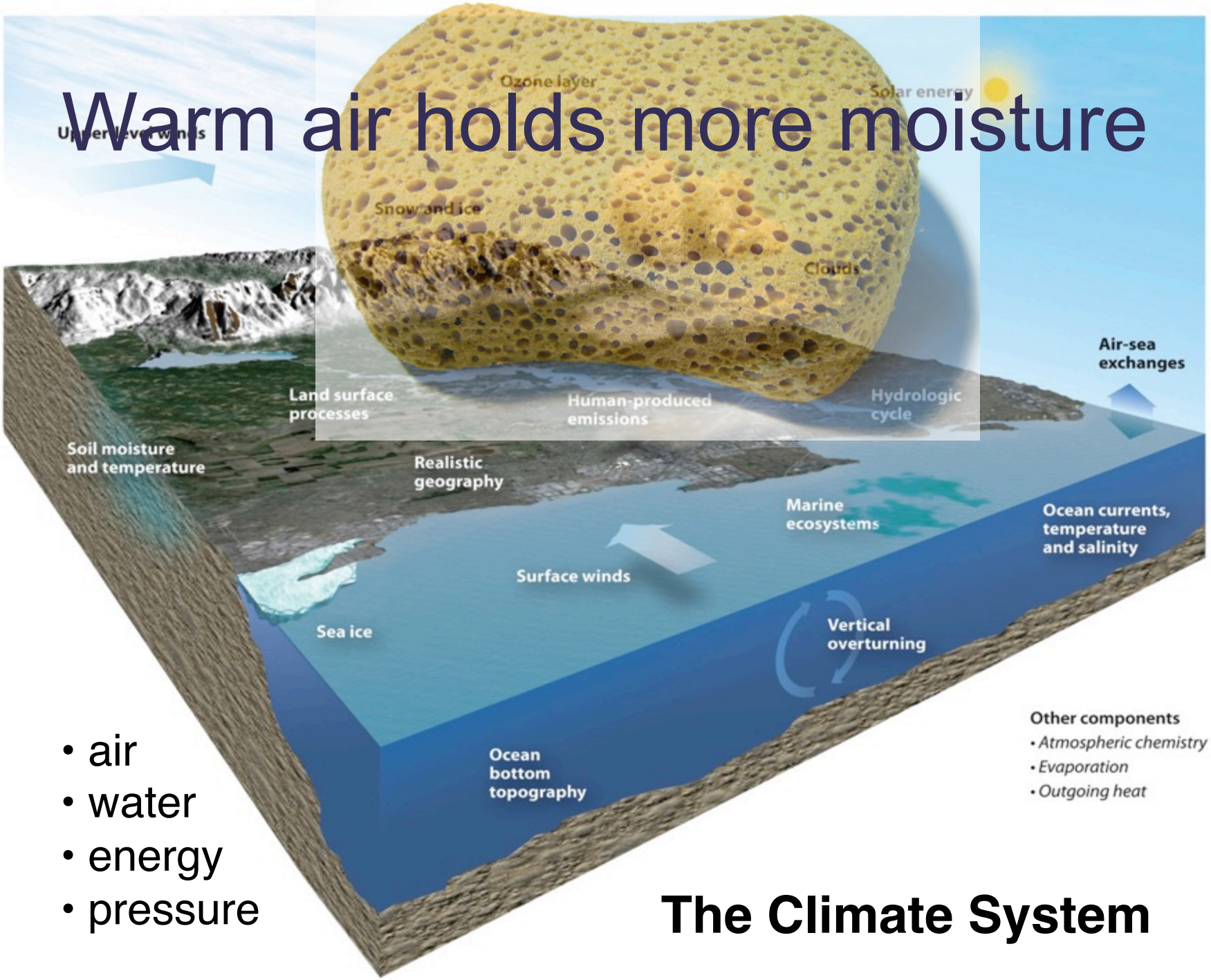
How does temperature change effect the hydrologic cycle?



- air
- water
- energy
- pressure

The Climate System

Warm air holds more moisture



- air
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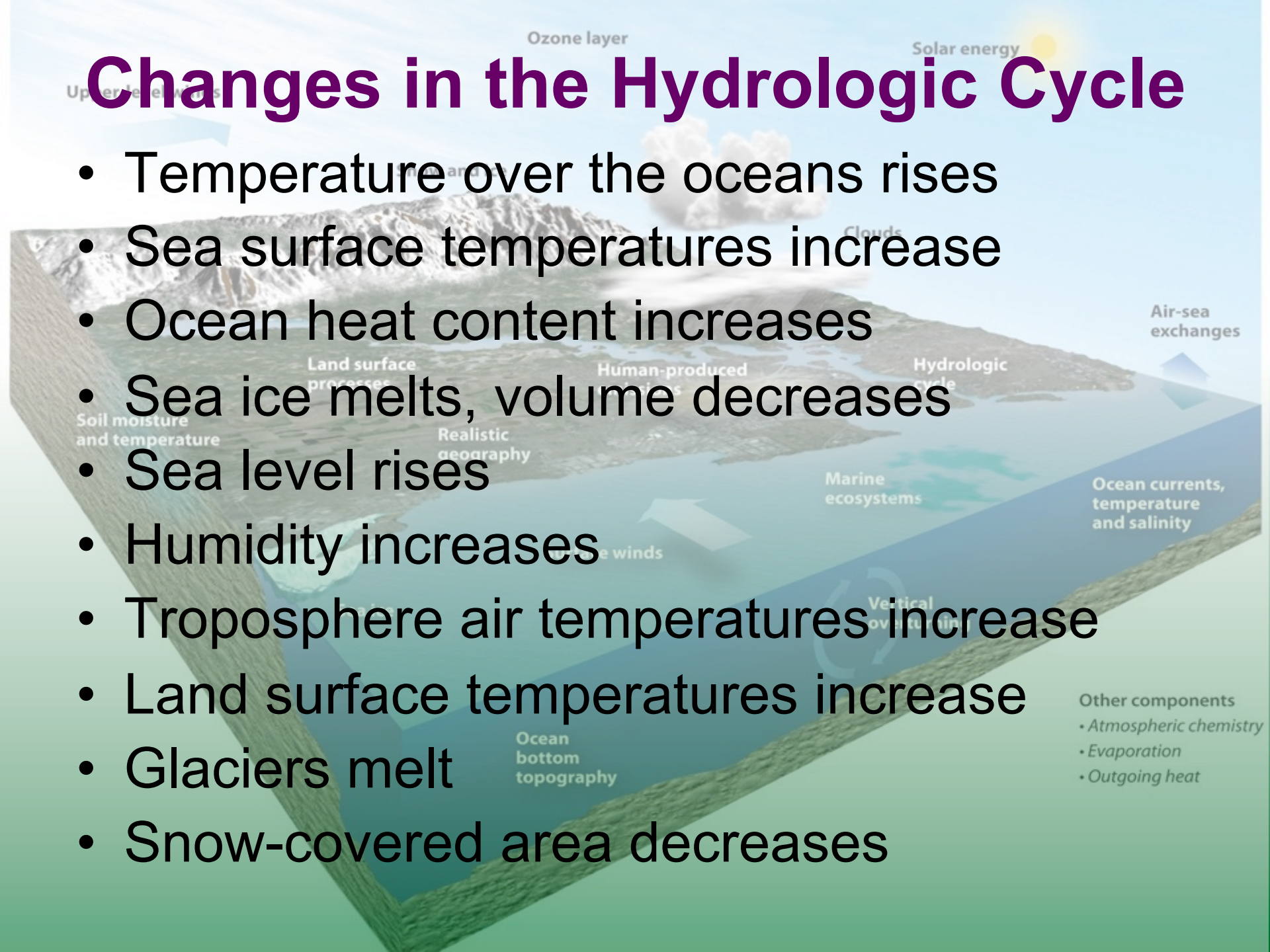
The Climate System

Changes in the Hydrologic Cycle

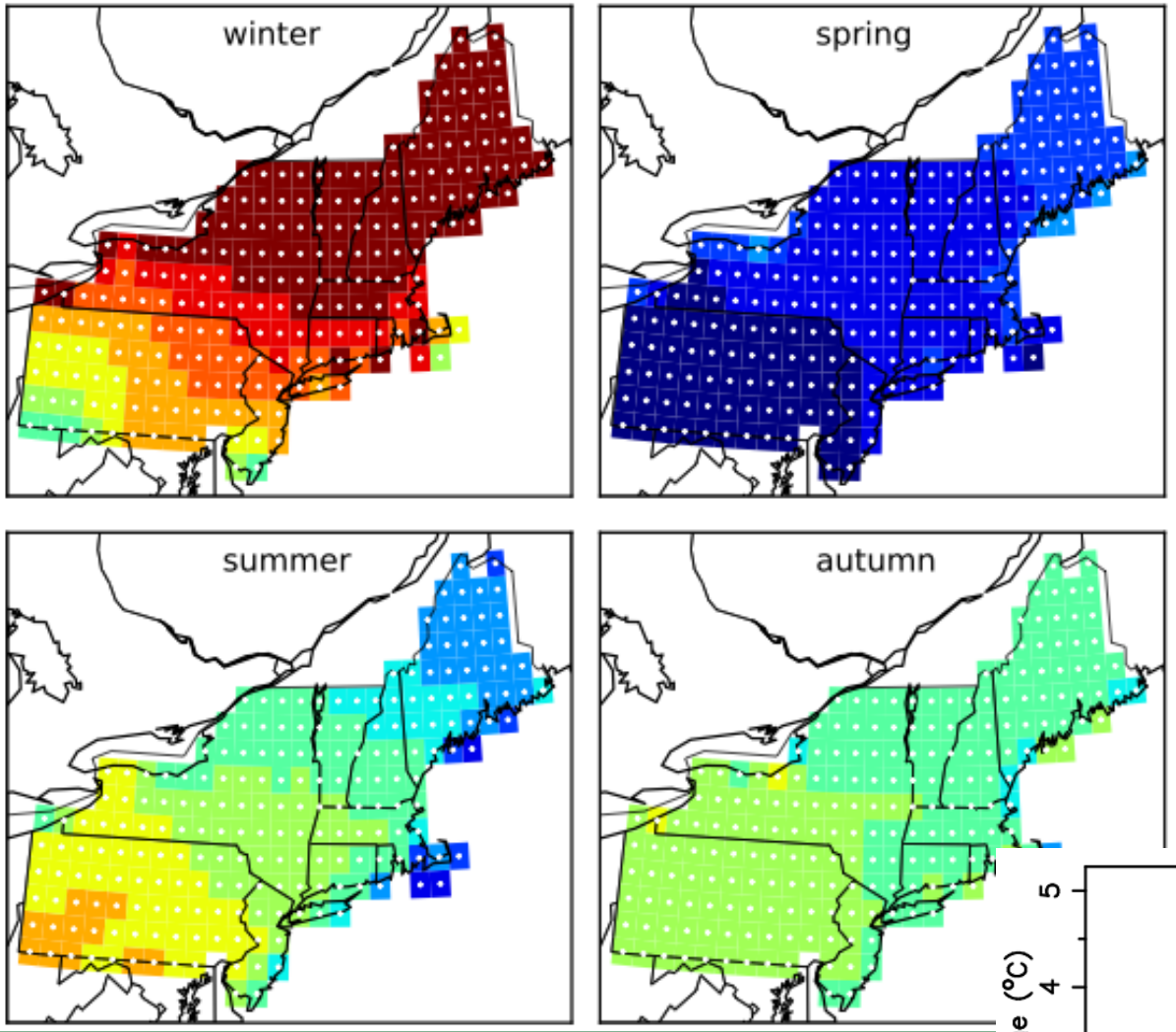
- Temperature over the oceans rises
- Sea surface temperatures increase
- Ocean heat content increases
- Sea ice melts, volume decreases
- Sea level rises
- Humidity increases
- Troposphere air temperatures increase
- Land surface temperatures increase
- Glaciers melt
- Snow-covered area decreases



Climate change predictions for the N.E. U.S. and the hydrologic cycle

- Less snow
- Reduced extent of snow
- Shorter winter
- Earlier breakup of winter ice on lakes and rivers
- Earlier spring snowmelt
- More winter rain (4”)
- Increased snow density
- More days T > 90°F
- Longer growing season
- Rising sea-surface temperatures and sea levels
- Earlier peak river flows

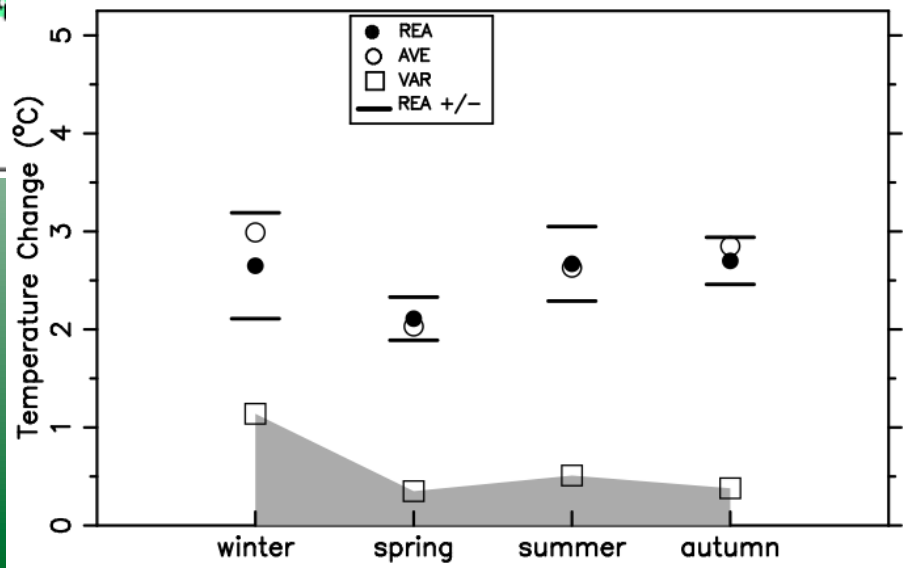
Summary from: *Frumhoff, et al,. 2007*. Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions. *NECIA, UCS*.



Temp.

(Rawlins et al., JGR 2012)

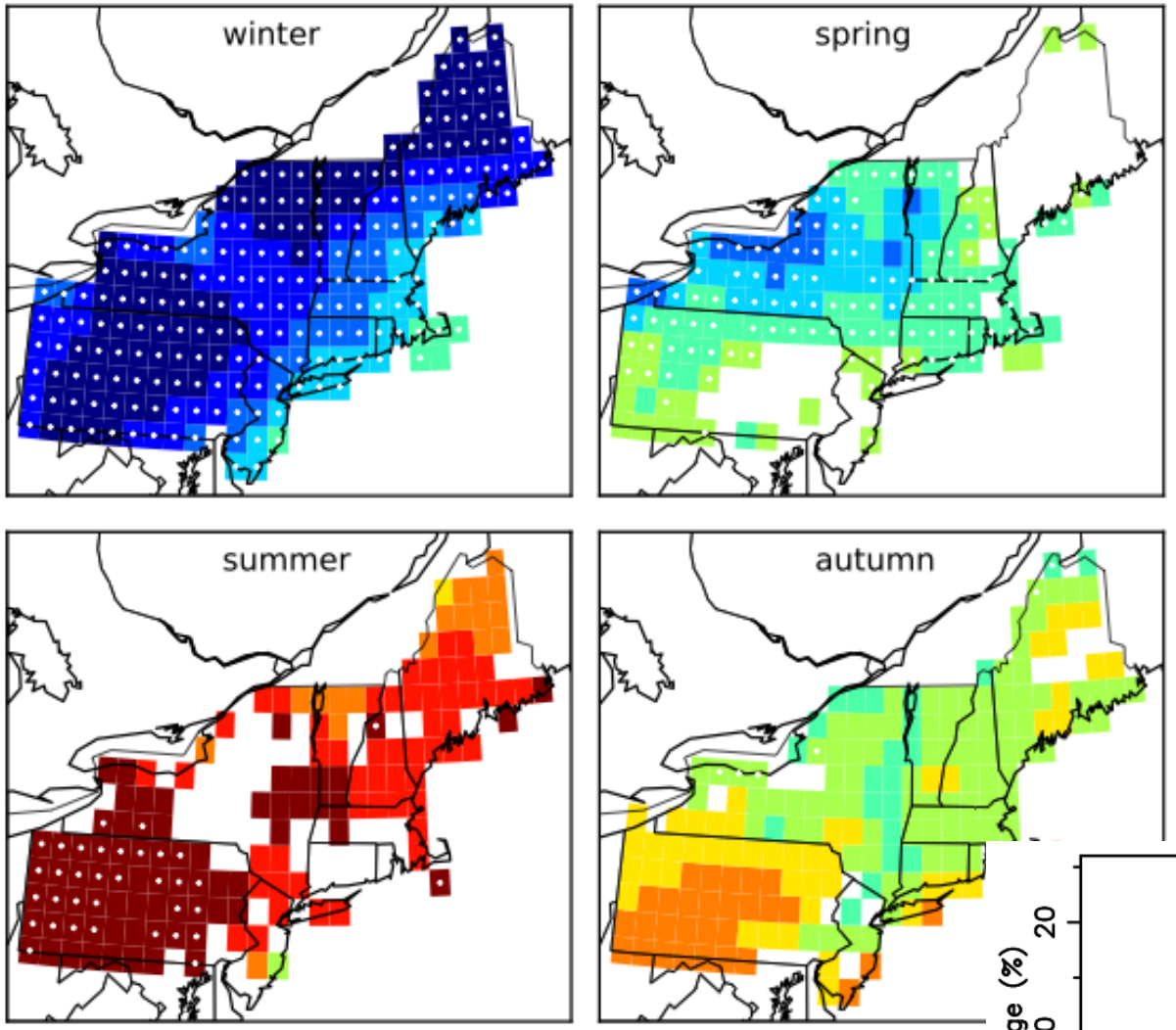
REA: ΔT (2041–2070 minus 1971– 2000),
AVE: averaged ΔT,
VAR: natural variability



Consequences of rain vs. snow:

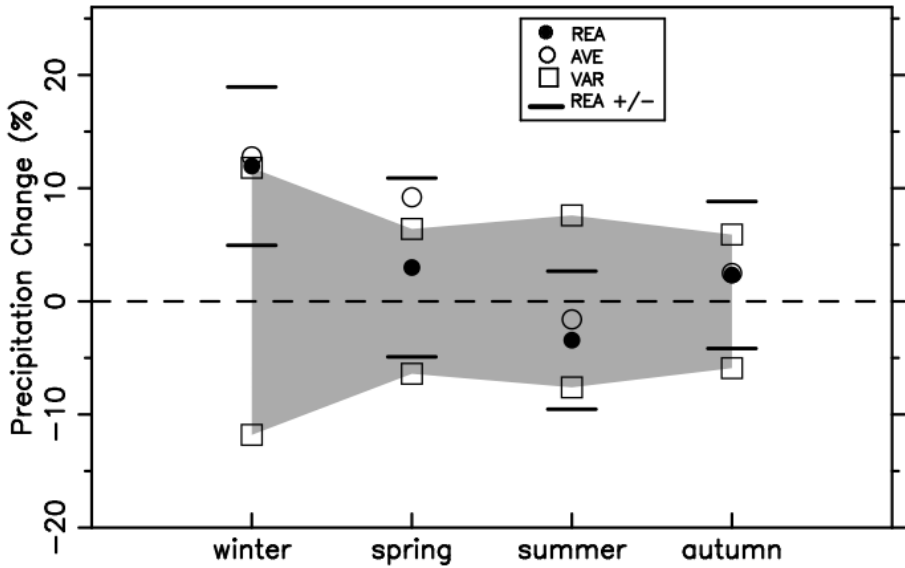
- Shorter duration winter
  - Effects on recreation and tourism
  - Less water “storage time” in snowpack
- Early, warmer spring
  - More mosquitoes (and associated illness)
  - Spring flooding
- Longer growing season
  - Forest changes
  - Some crops like it cold

Summary from: *Frumhoff, et al,. 2007.* Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions. *NECIA, UCS.*



Precip.

(Rawlins et al., JGR, 2012)



Consequences of changing precipitation:

- Increased intensity of precipitation
  - Landslides
  - Erosion
  - Flooding
- Increased frequency of extreme events
  - Design storms are inadequate predictions
  - Storm surge damage
- Increased likelihood of droughts
  - Water shortages for crops and municipal supply

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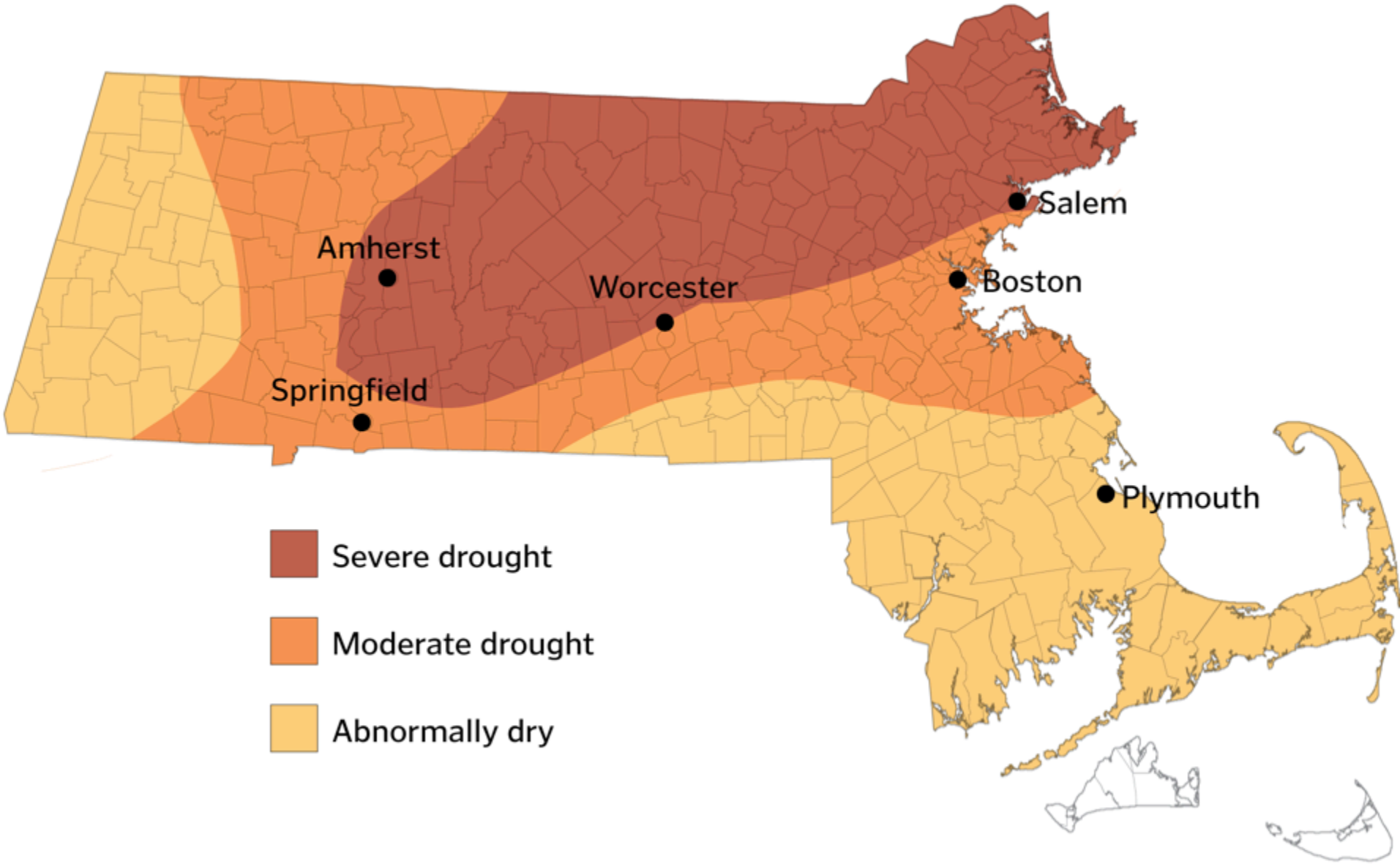
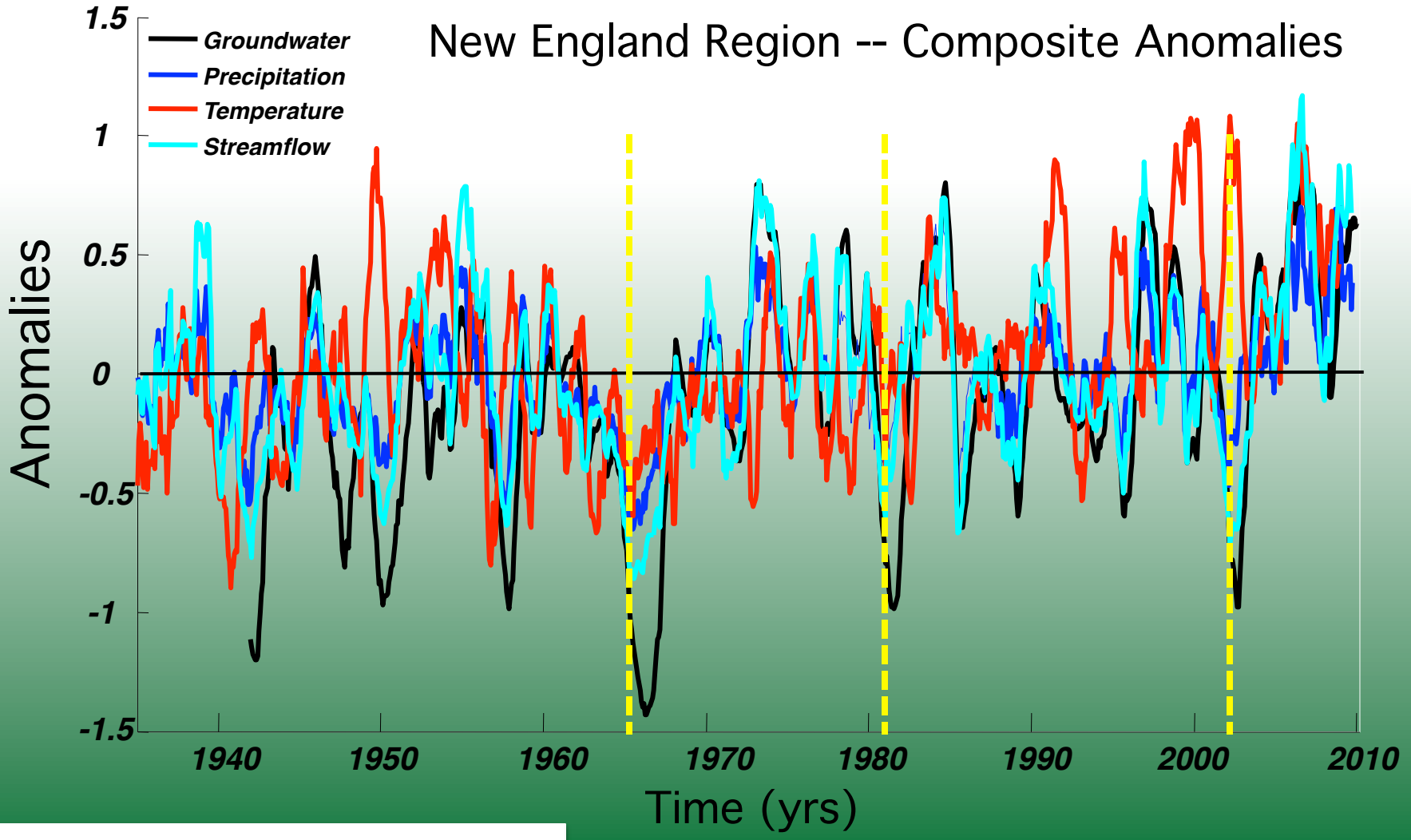
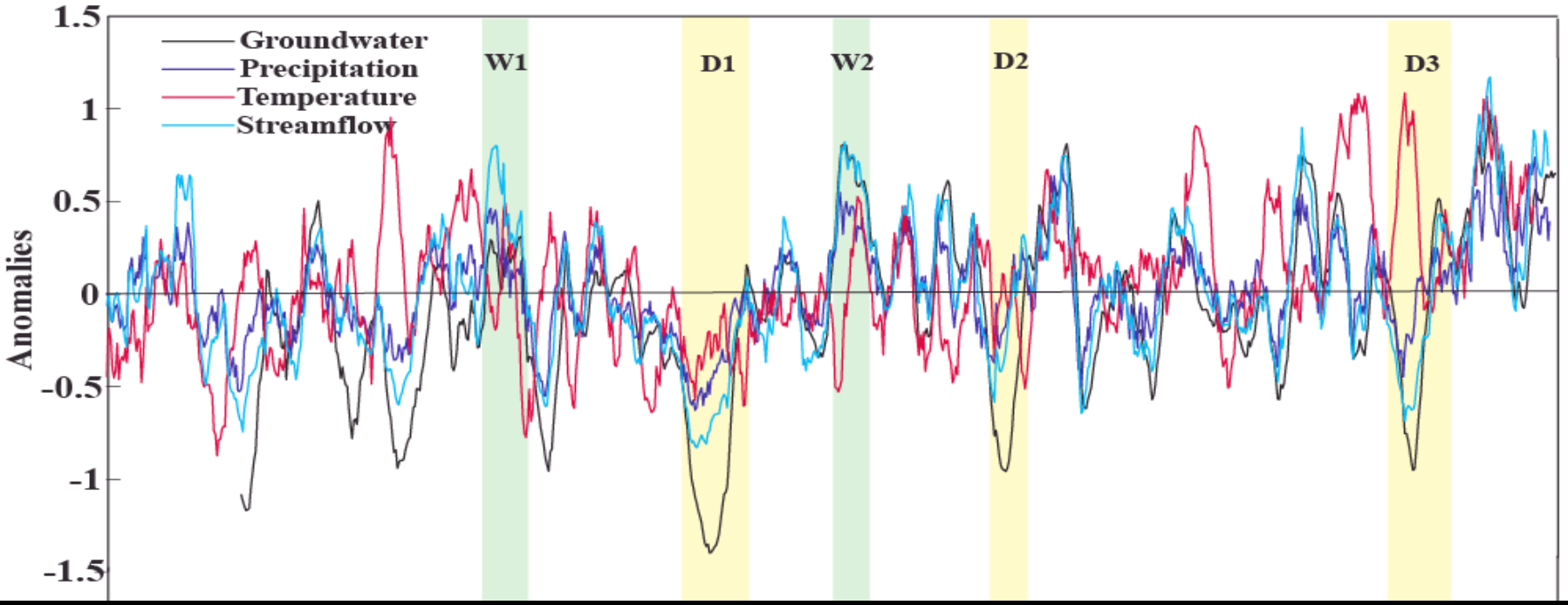
Let’s talk about the drought



Climate in the Water Cycle



Weider and Boutt, GRL, 2010



Historical Context of drought in New England:
D1 (1962-1967) – Quabbin was 20 feet lower than today
D2 (1980's) – UMass was closed to conserve Amherst water supply
D3 (2000's) – SWMI discussions began

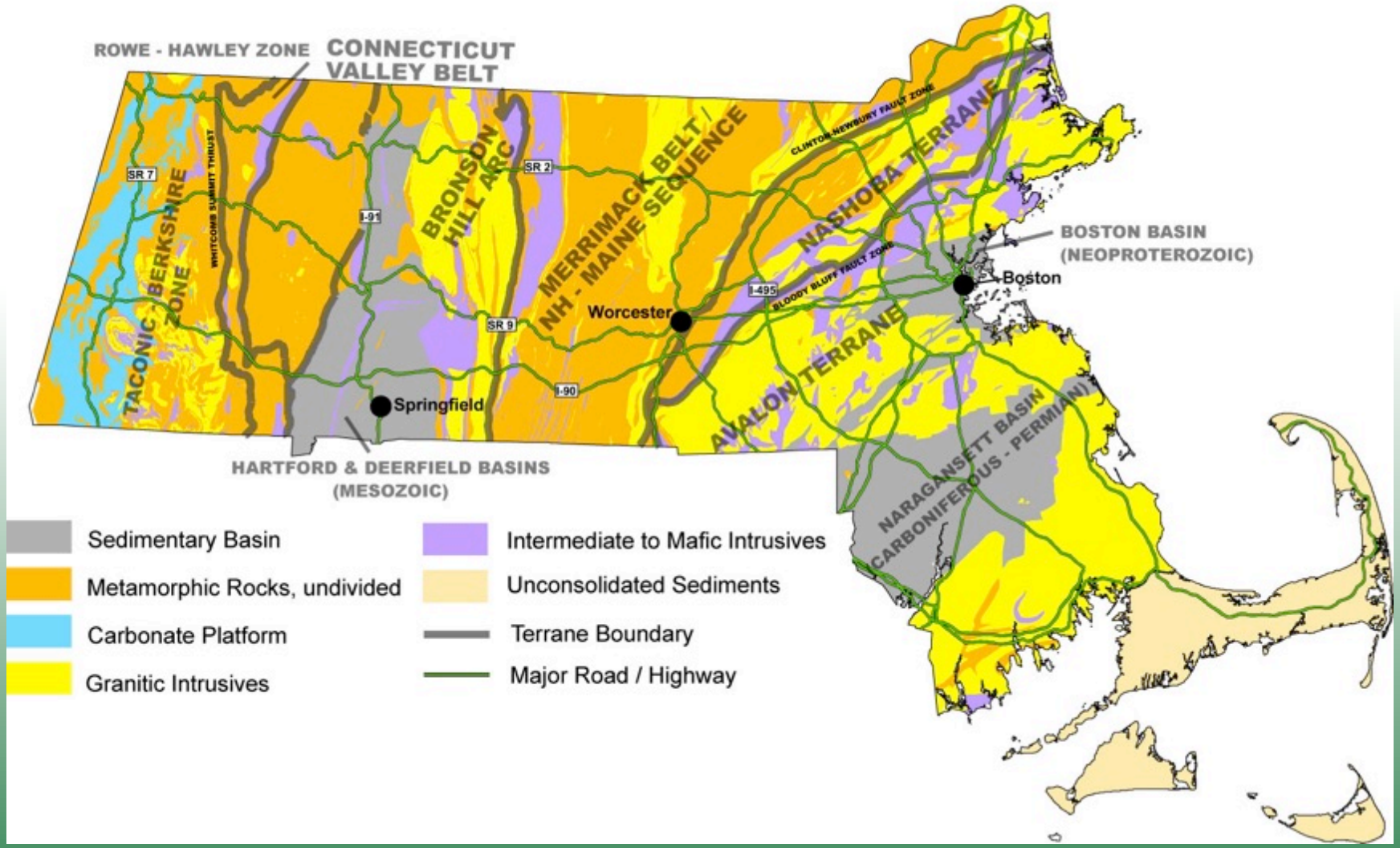
The current drought:
Not yet in the top 5
Since ~2013 (droughts are not 1 year events)
During the growing season! Impacts farmers, home owners, gardeners

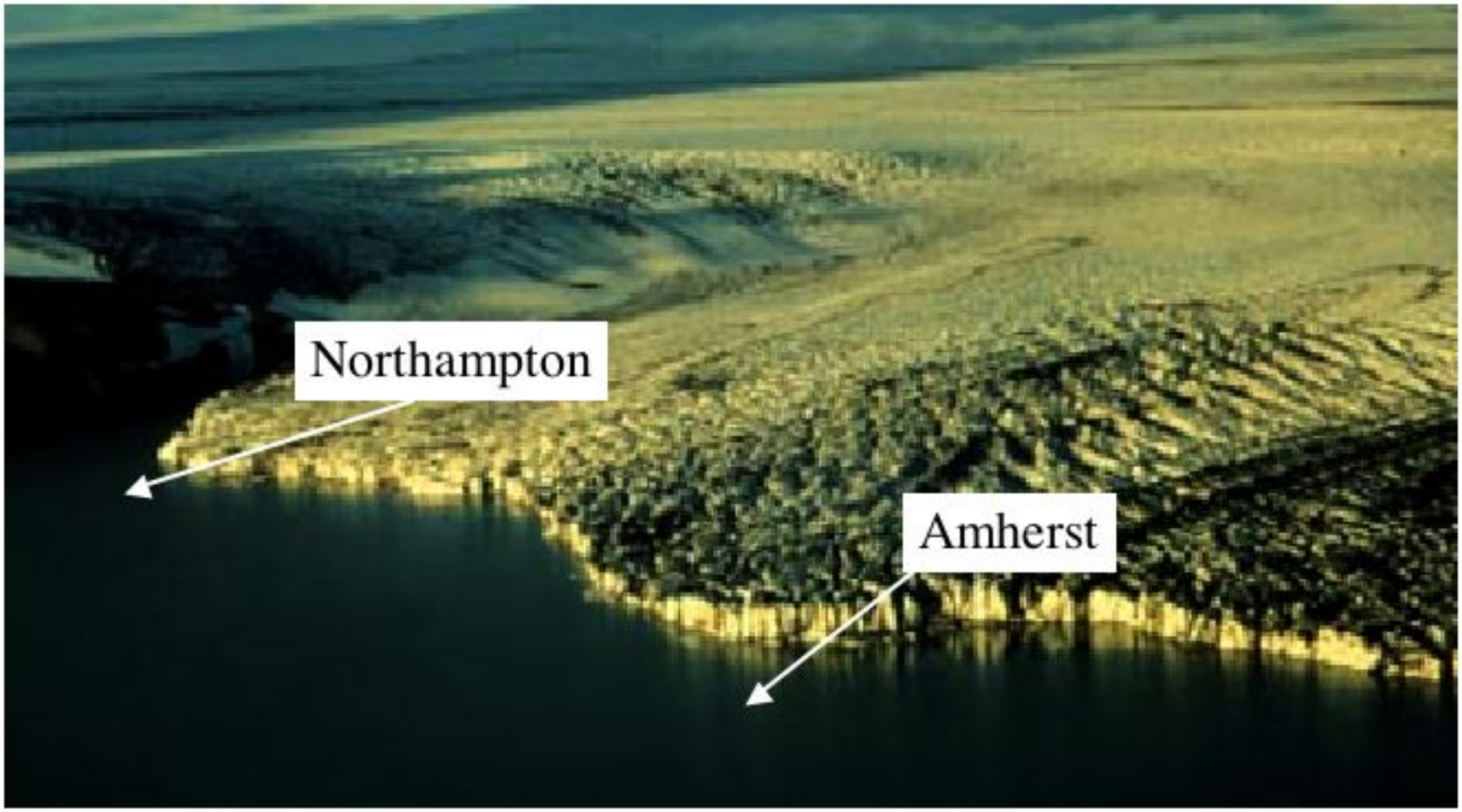
Rain → groundwater → streams can take 5-25 years to become baseflow

A Global Problem
(but solutions and consequences are local)

- Ultimately, emissions controls MUST be addressed on a global scale
- Local Adaptation and Mitigation are of critical importance to Resilience

First, some Geologic Context

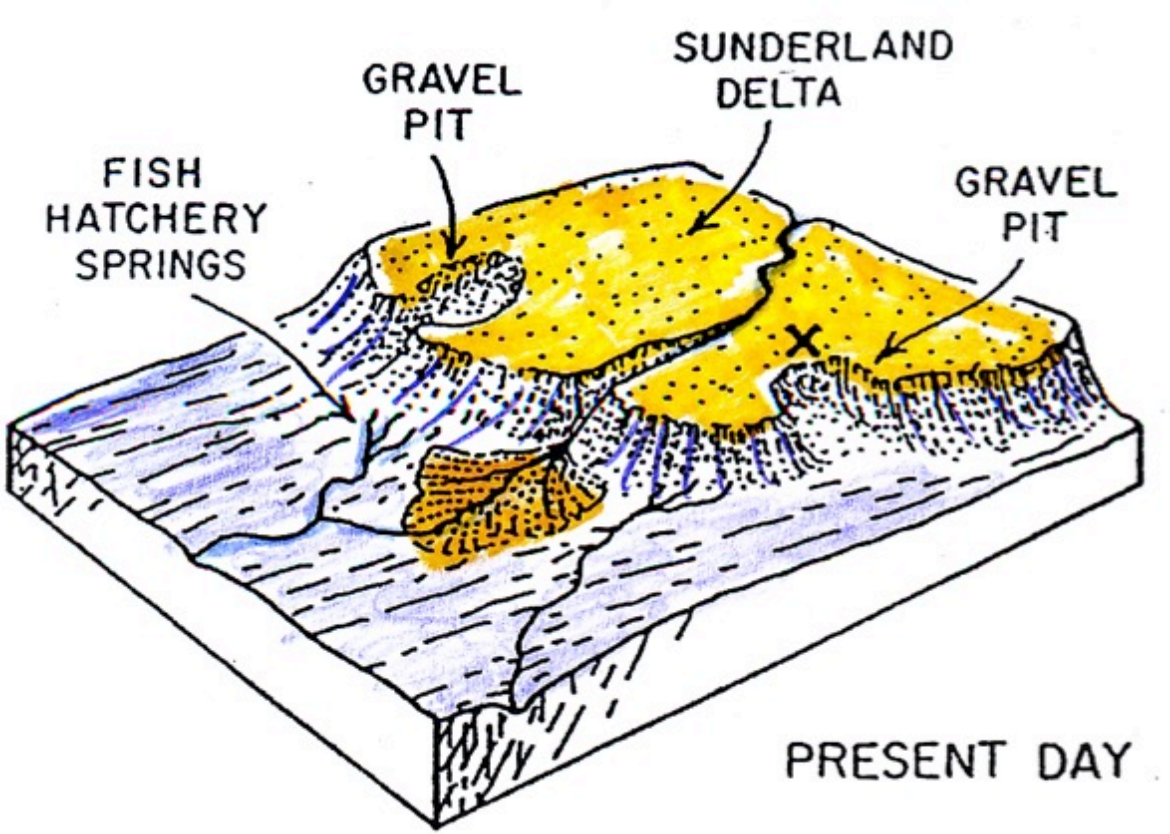




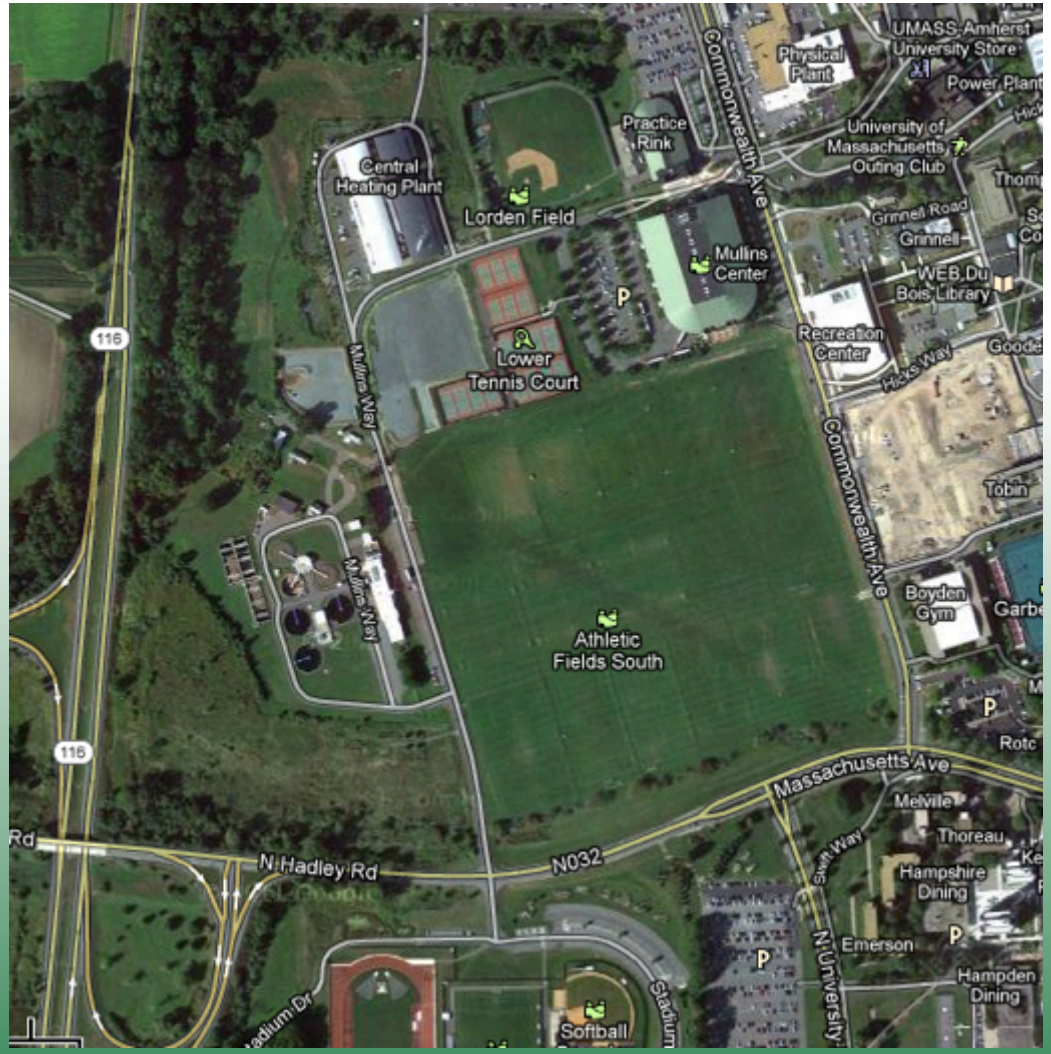
Central Massachusetts, 13-14 ka yrs BP


Glacial Lake Bascom
Glacial Lake Hitchcock
Swift River lakes
Glacial Lake Nashua
Glacial Lake Shawsheen-Merrimack
Glacial Lake Concord
Glacial Lake Sudbury
Glacial Lake Housatonic
Glacial Lake Winimussett
Glacial Lake Assabet
Glacial Lake Bouve
Glacial Lake Whipples
Glacial Lake Charles
Glacial Lake Great Falls
Westfield arm of Glacial Lake Hitchcock
Glacial Cape Cod Bay lake
Glacial Lake Neponset
Glacial Lake Taunton
Glacial Cape Cod Bay lake
Glacial Geology of Massachusetts
Stratified Deposits - Coarse Grained
Stratified Deposits - Fine Grained
Floodplain Alluvium
Till and/or Till with Shallow or Exposed Bedrock
Outline of Glacial Lake
Position of Glacier Margin


SCALE OF MILES
0 1 2 3 4 5 6 7
ICE FRONT
Hoosic
Bennington
North Petersburg
North Pownal
Pownal
Williamstown
North Adams
Berlin
Adams
1110 FT. OUTLET TO
KINDERHOOK CREEK
TACONIC RANGE
HOOSAC MOUNTAIN
BERKSHIRE


GRAVEL PIT
SUNDERLAND DELTA
FISH HATCHERY SPRINGS
GRAVEL PIT
X
PRESENT DAY

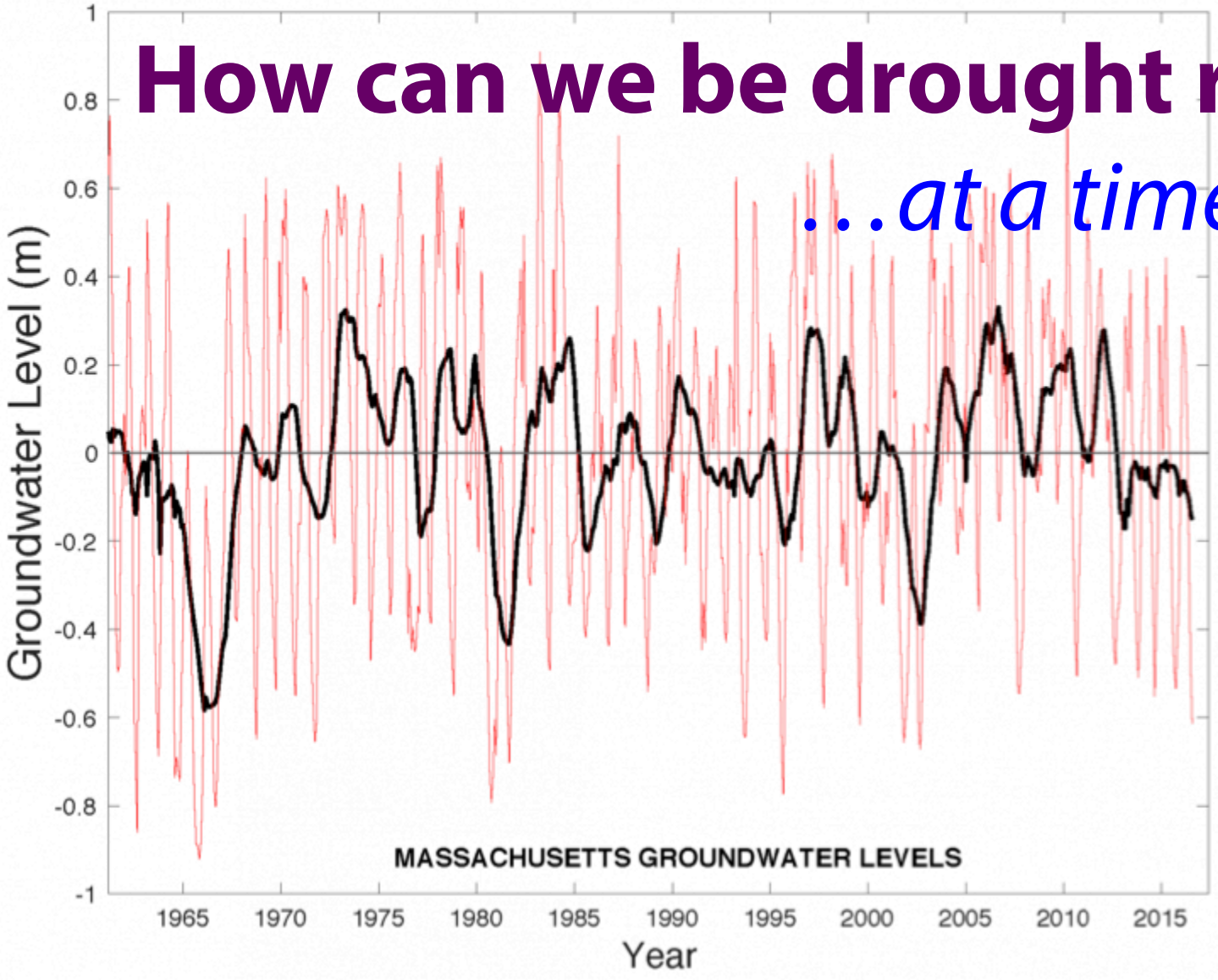
Glacial Lake Hitchcock Varve Record, 17.5-13.5 ka BP



Rittenour, Brigham-Grette and Mann, 2000, *Science*

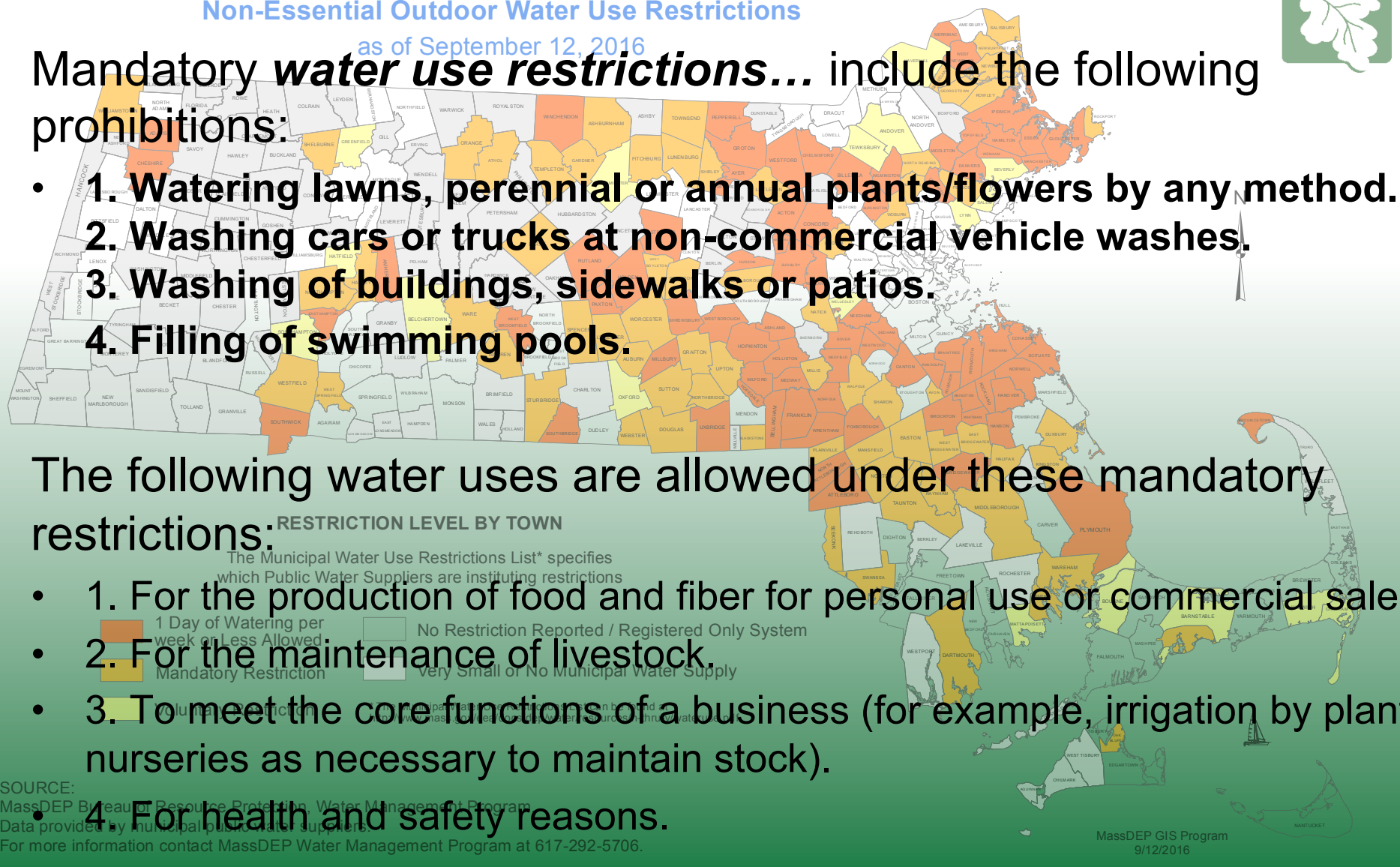
How can we be drought resilient?

…at a time like this?



1. It's not that bad (yet)

2. Follow recommended guidelines



Mandatory ***water use restrictions…*** include the following prohibitions:

- **1. Watering lawns, perennial or annual plants/flowers by any method.**
  2. Washing cars or trucks at non-commercial vehicle washes.
  3. Washing of buildings, sidewalks or patios.
  4. Filling of swimming pools.

The following water uses are allowed under these mandatory restrictions:

- 1. For the production of food and fiber for personal use or commercial sale.
- 2. For the maintenance of livestock.
- 3. To meet the core functions of a business (for example, irrigation by plant nurseries as necessary to maintain stock).
- 4. For health and safety reasons.

Try permaculture techniques

- Rain barrels
- Straw mulch
- Water reuse
- No-till
- Perennials
- Diversified crops

Consequences of changing precipitation:

- Increased intensity of precipitation
  - Landslides
  - Erosion
  - ***–Flooding***
- Increased frequency of extreme events
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- Increased likelihood of droughts
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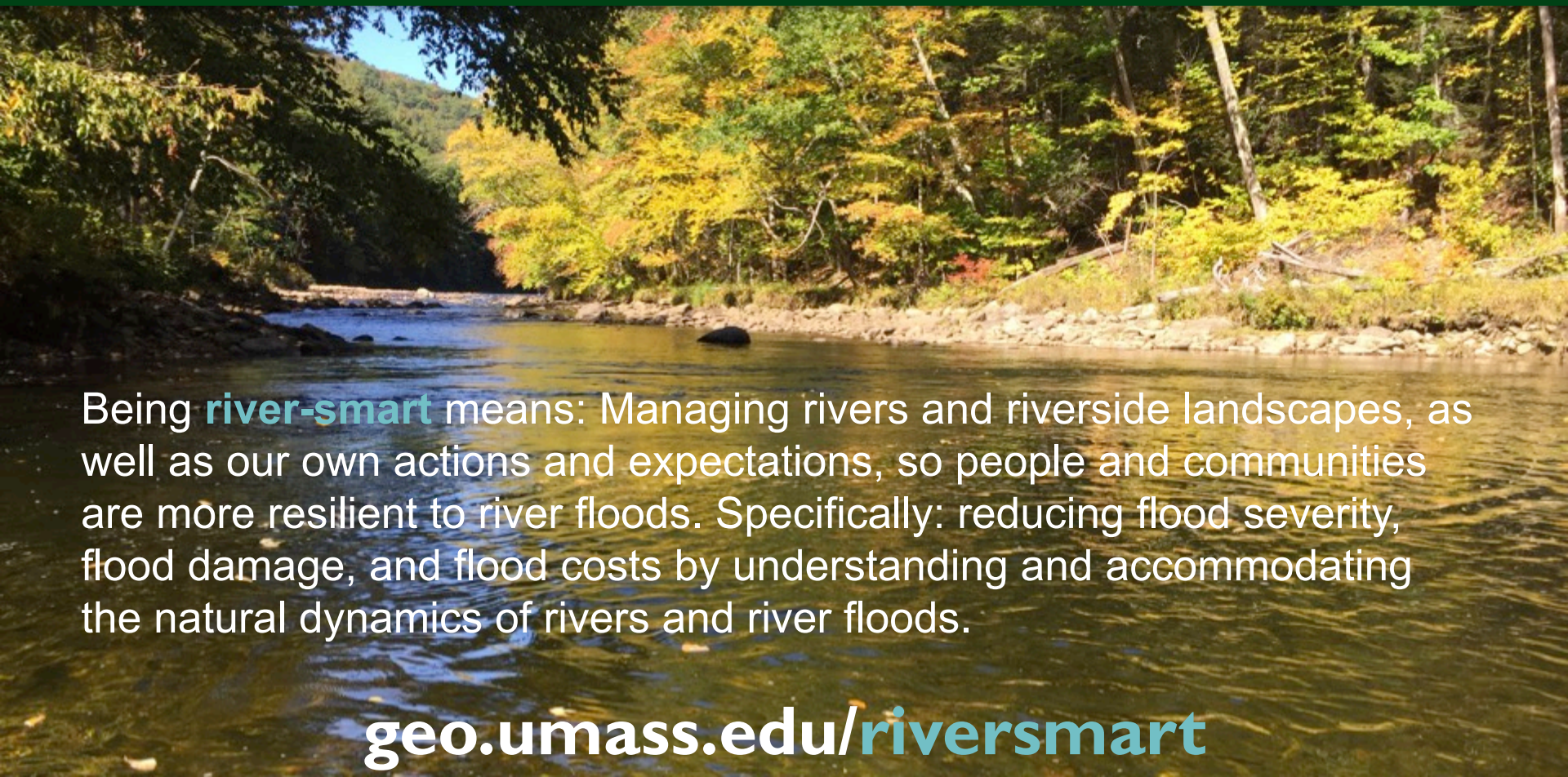
riversmart communities

supporting ecologically restorative flood prevention and remediation in New England



Being **river-smart** means: Managing rivers and riverside landscapes, as well as our own actions and expectations, so people and communities are more resilient to river floods. Specifically: reducing flood severity, flood damage, and flood costs by understanding and accommodating the natural dynamics of rivers and river floods.

geo.umass.edu/riversmart

riversmart communities

Recommendations from our report:

"Supporting New England Communities to Become River-smart: Policies and programs that can Help New England Towns Thrive Despite River Floods"

1. Develop and implement fluvial erosion hazard assessment mapping and user access systems across New England states.
2. Support upgrades of stream crossing infrastructure vulnerable to damage.
3. Support River-smart community planning and mitigation.
4. Prepare and disseminate outreach materials and training on river dynamics, lessons for river flood hazards and river-smart best management practices.
5. Support Regional Intermediaries to provide flood support services to municipalities and landowners.

extension.umass.edu/riversmart/policy-report