Source and mechanisms by which water is transported to streams and groundwater in New England

Dr. David Boutt

University of Massachusetts-
Amherst, Geosciences Department

November 12, 2020 Mass. Water Resources Commission

Plan for Today

- Overview of UMass-Amherst Hydrology Research Program
- Quick Look at 2020 Drought Impacts
- Scientific perspective on NE Hydrological changes
- Needed Research Investments

GEOPHYSICAL RESEARCH LETTERS, VOL. 37, L24405, doi:10.1029/2010GL045561, 2010

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Kaitlyn Weider[1] a

Received 27 September

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David F. Boutt

Department of Geoscienc
Massachusetts-Amherst, A
USA

School of Earth & Sustainability
UNIVERSITY OF MASSACHUSETTS AMHERST

EPA

USGS
science for a changing world

100 ADVANCING EARTH AND SPACE SCIENCE

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Massachusetts Geological

Symposium on Groundwater Research for Drinking Water Professionals

FINAL Agenda, revised 1/09/2019

This symposium is a collaboration between the UMass School of Earth and Sustainability, the US EPA Region 1, and the USGS New England Water Science Center. The symposium will bring together groundwater-focused professionals working in drinking water supply and water management, including regulators, utilities, and consultants, in order to raise awareness and exchange ideas and information related to water quality, climate-driven changes, and assessment tools for use in New England aquifers.

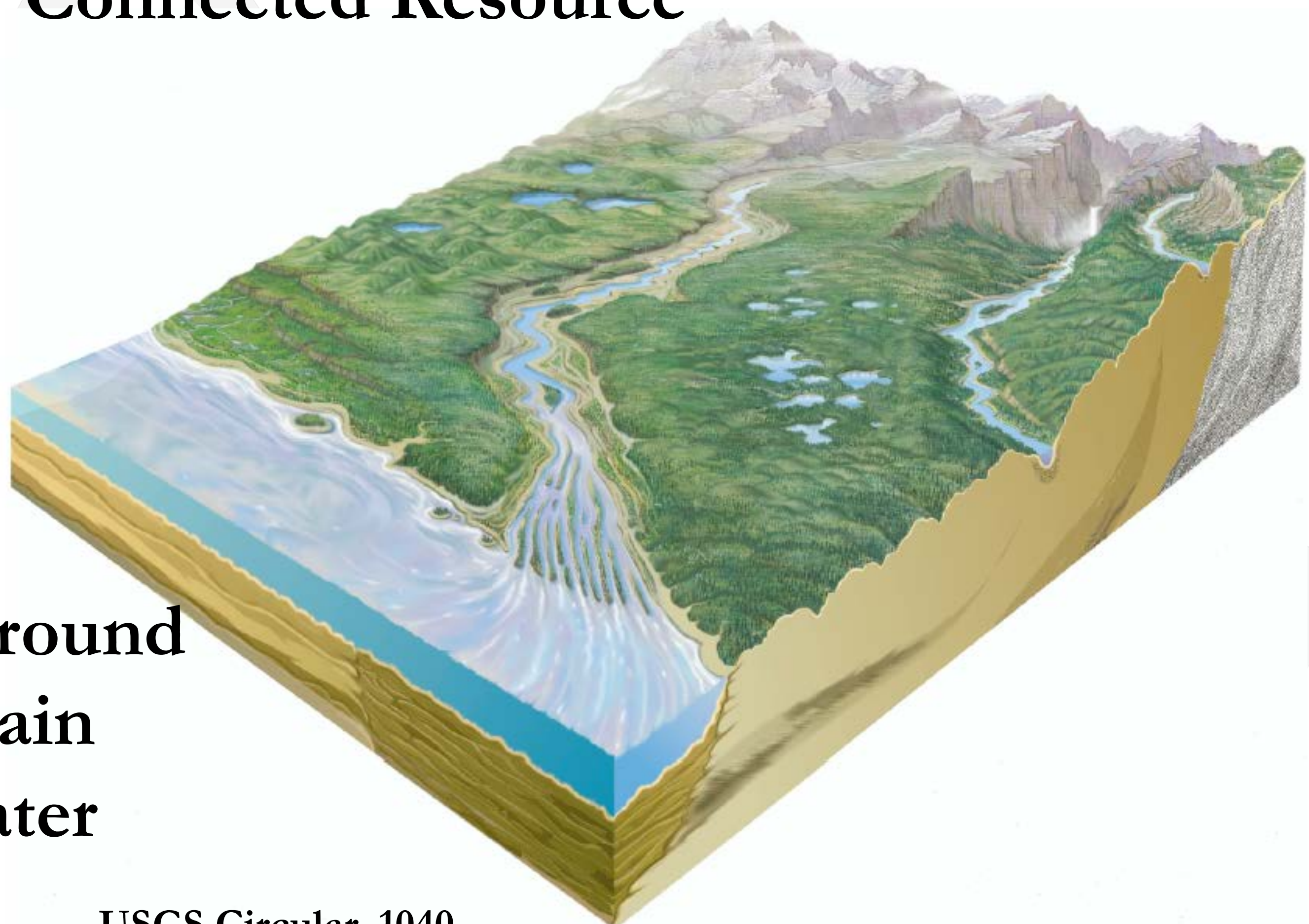
Date: January 14, 2020 (Snow date: January 16)

Location: UMass Amherst Life Sciences Laboratories S330-340

Time	Section/Talk	Speaker
9:00 – 9:30	**Introduction**	
	Welcome, introductions, logistics, goals	Marcel Belaval
	Groundwater as drinking water in New England: overview of aquifers, trends, emerging concerns, etc	Dave Boutt
9:30 – 10:50	**Climate-driven changes in the regional groundwater system** Climate change is driving changing precipitation patterns in New England with direct impacts on groundwater. This section will explore how climate-driven changes in the groundwater system are impacting drinking water supplies	

HYDROGEOLOGY

Groundwater and Surface water: A Connected Resource

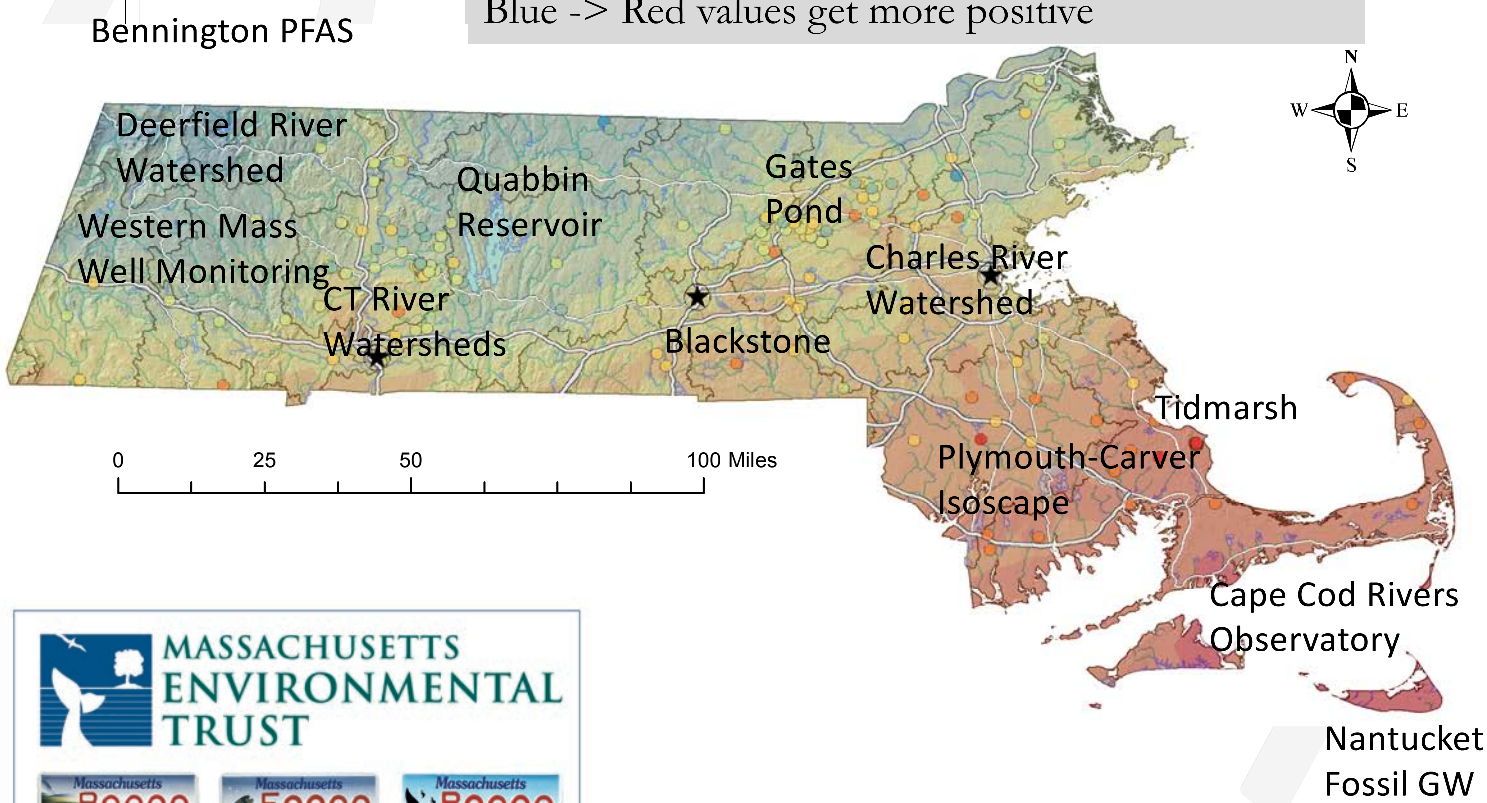


Soil and ground water sustain surface water

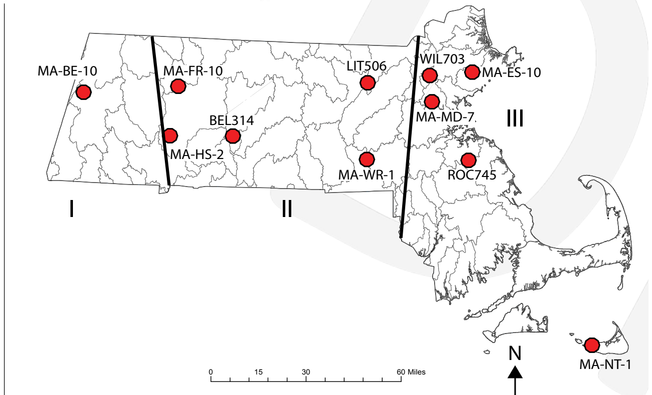
USGS Circular, 1040

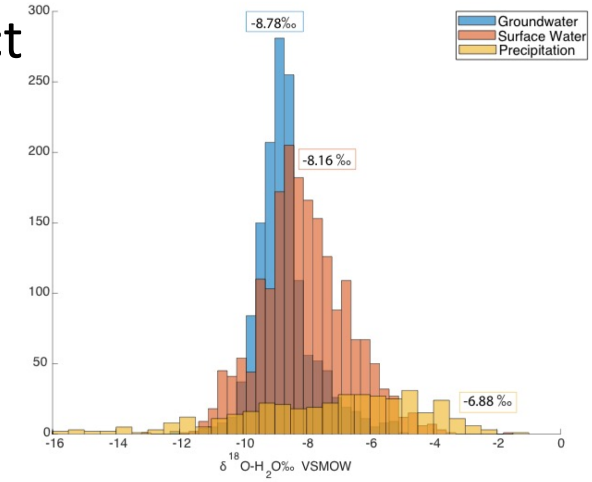
Massachusetts Isotope Monitoring Project

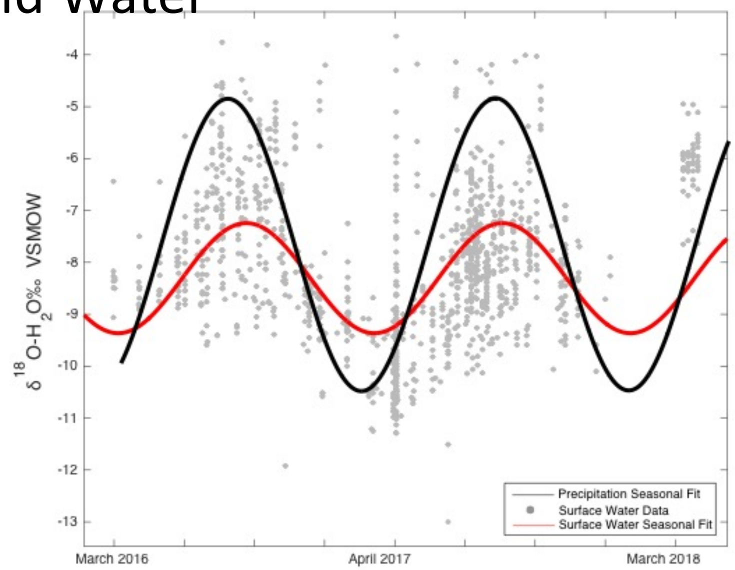
Map Displays $\delta^{18}O\text{-}H_2O$ ‰ of Groundwater
Blue -> Red values get more positive

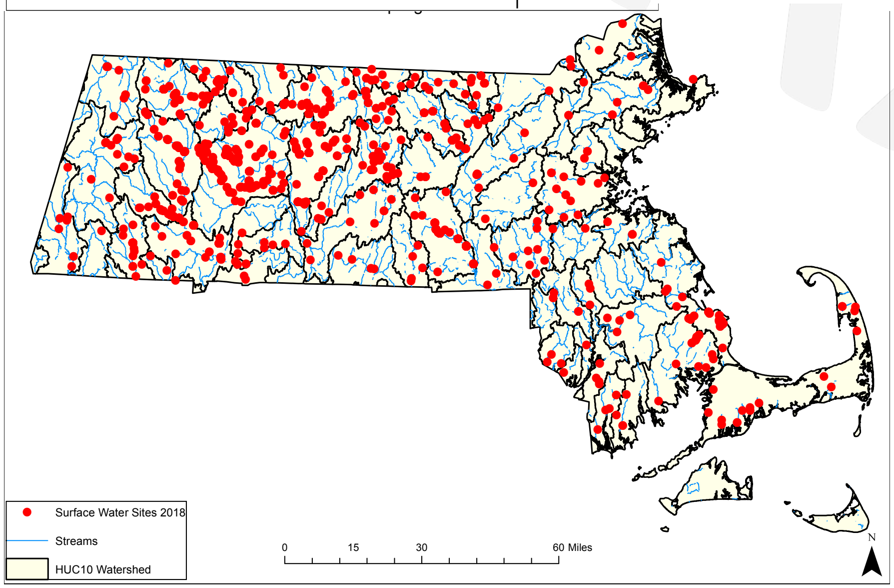


UMass Massachusetts Surface and Ground Water Isoscape Project









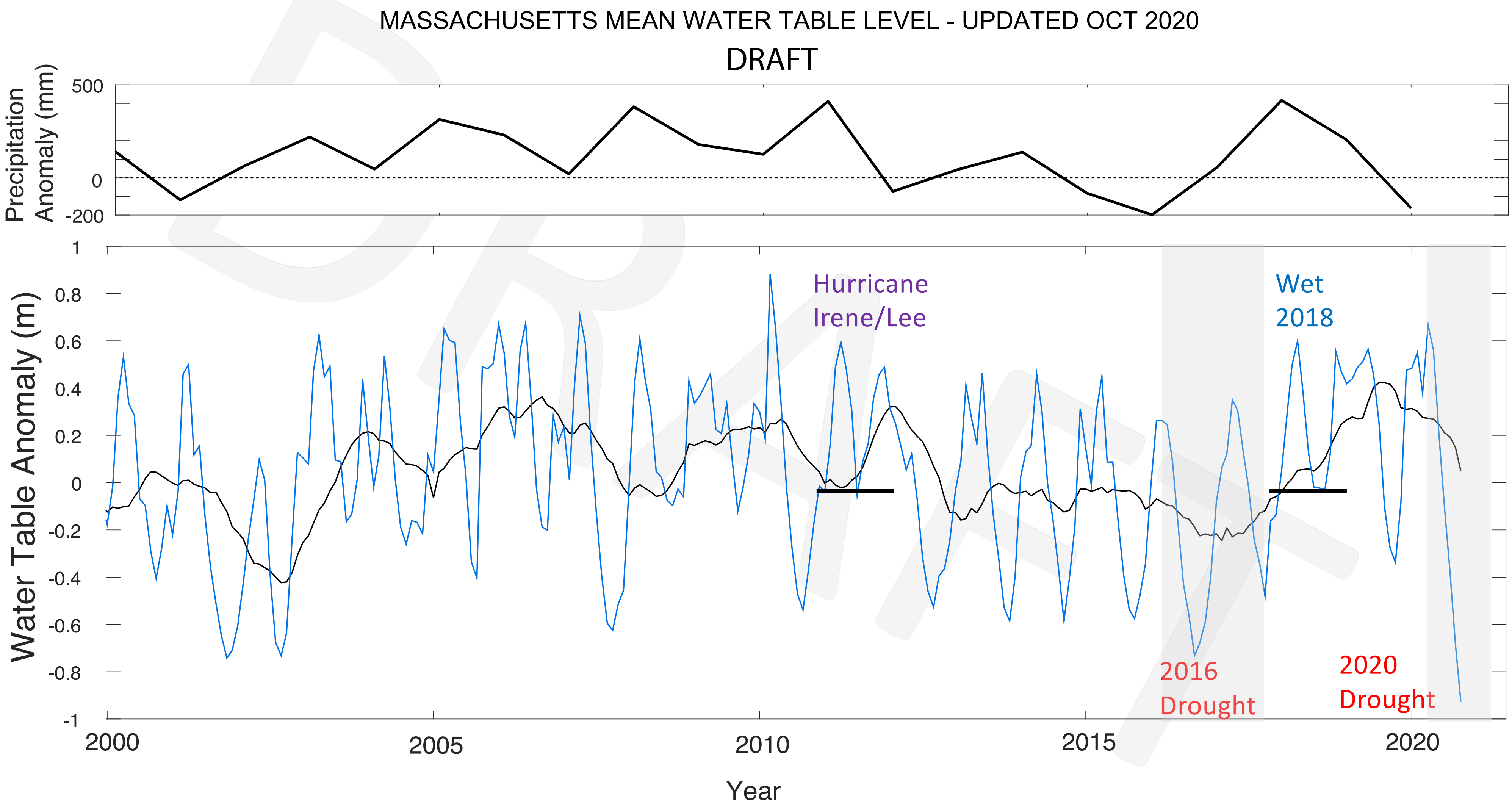
Statewide –

60% of stream water older than 2-3 months

98% of ground water older than 2-3 months

Groundwater and stream water dominated by cold-season precipitation

Strong west –east distinction in isotopic composition


MASSACHUSETTS MEAN WATER TABLE LEVEL - UPDATED OCT 2020
DRAFT
Precipitation Anomaly (mm)
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Hurricane Irene/Lee
Wet 2018
2016 Drought
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Common Misunderstood facts of New England Hydrology and Hydroclimate

1. Summer in New England is not ‘drier’ than winter
2. Vegetation plays important (huge!) role in the water balance
3. High summertime temperatures are not major contributing factors to drought – longer growing season is key
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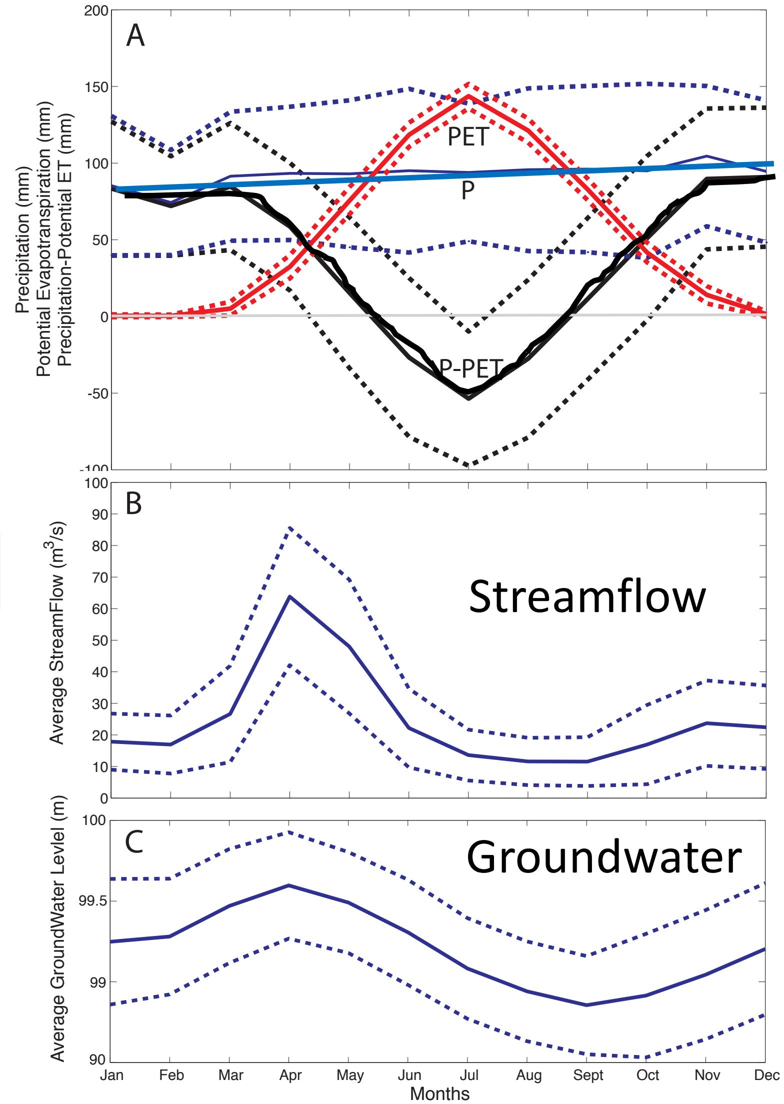
Seasonality of Long-term average of monthly Precipitation is essentially constant



Boutt, HP, 2017

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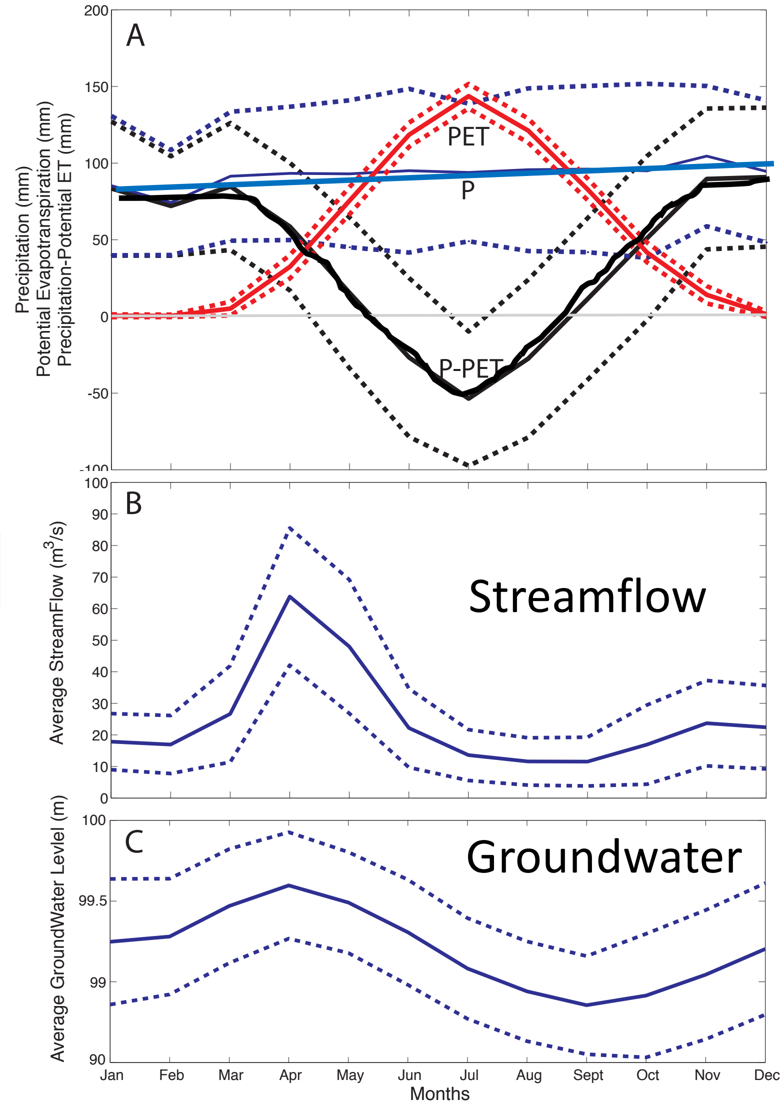
2. Vegetation plays a huge role in the water balance

Annual stream flow and ground water trends are controlled by P-PET and snow melt



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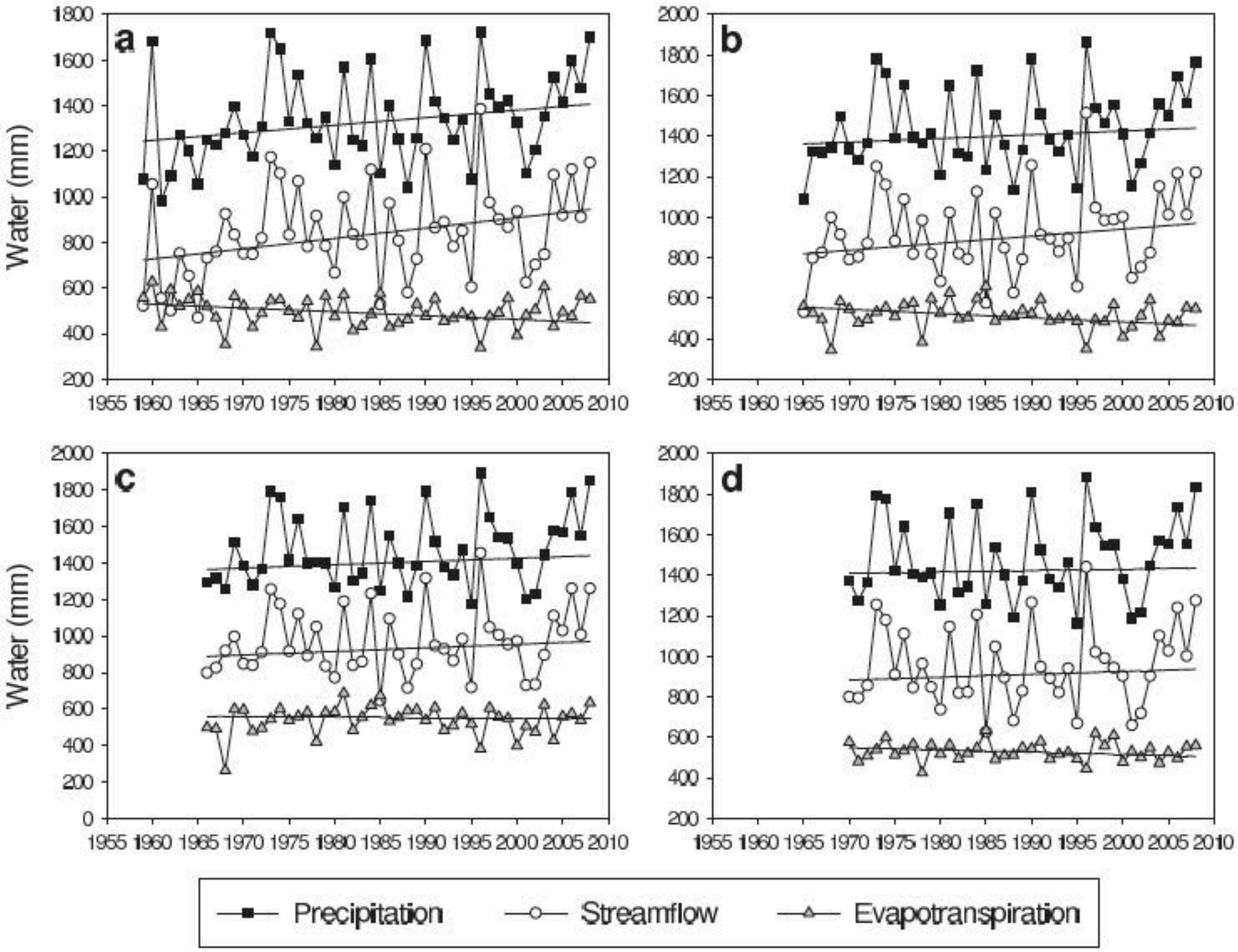
3. High summertime temperatures are not major contributing factors to drought

- Plants use less water (less transpiration) during precipitation deficits
- A 2-3 C increase in temperature only raises PET by 2-5%
- Historical analysis of droughts shows no correlation with temperature
- Weather conditions that lead to drought – high pressure systems – often are accompanied by clear skies and warm weather
- Limited open water body evaporation compared to forest landscapes

Streamflow responses to past and projected future changes in climate at the Hubbard Brook Experimental Forest, New Hampshire, United States

John L. Campbell,[1] Charles T. Driscoll,[2] Afshin Pourmokhtarian,[2] and Katharine Hayhoe[3]



Small year to year variability in ET – larger trends – here downwards due to forest age/sucession

Streamflow responses t
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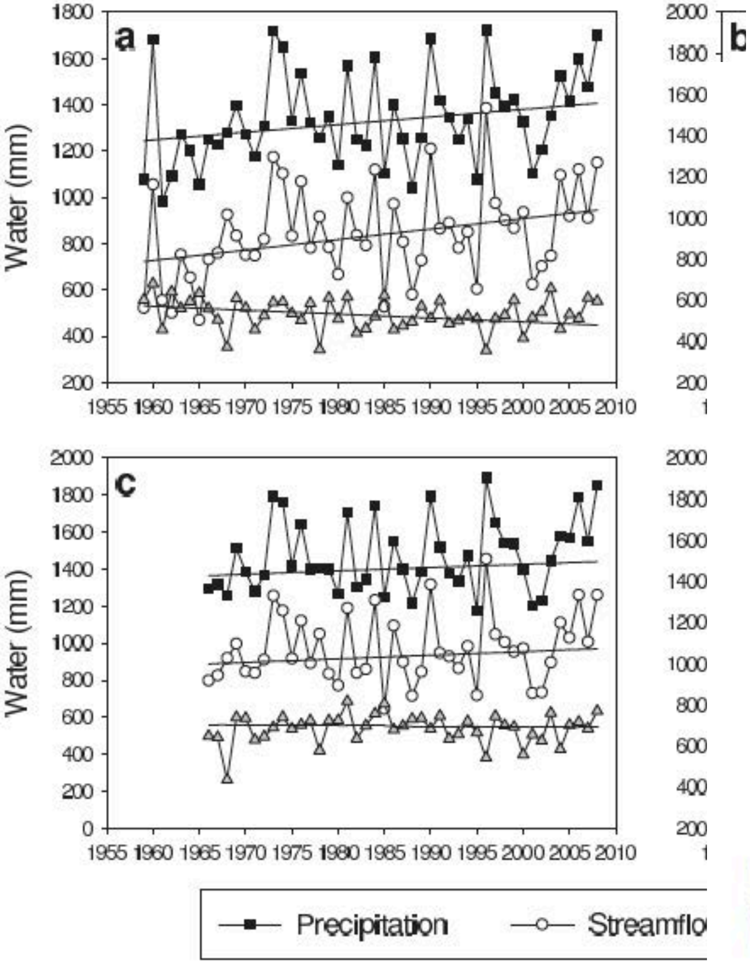
John L. Campbell,[1] Charles T. I



EVALUATING BIOLOGICAL AND PHYSICAL DRIVERS OF EVAPOTRANSPIRATION TRENDS AT NORTHEASTERN US WATERSHEDS

John L. Campbell, Matthew A. Vadeboncoeur, Heidi Asbjornsen, Mark B. Green, Mary Beth Adams, and Elizabeth W. Boyer[1]

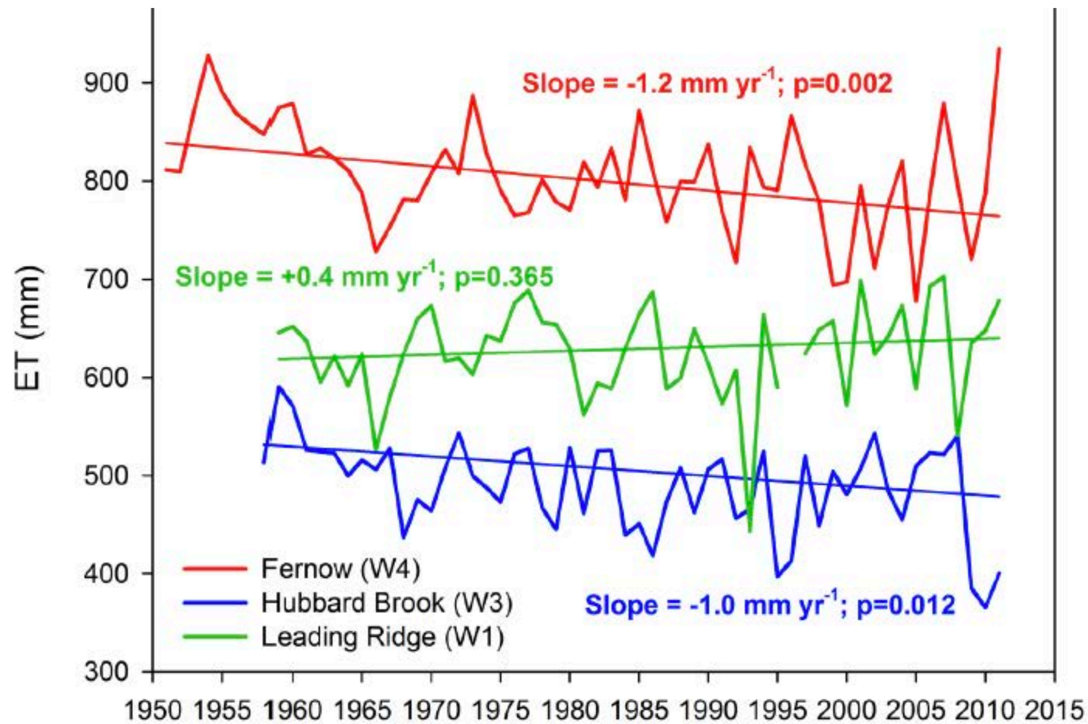
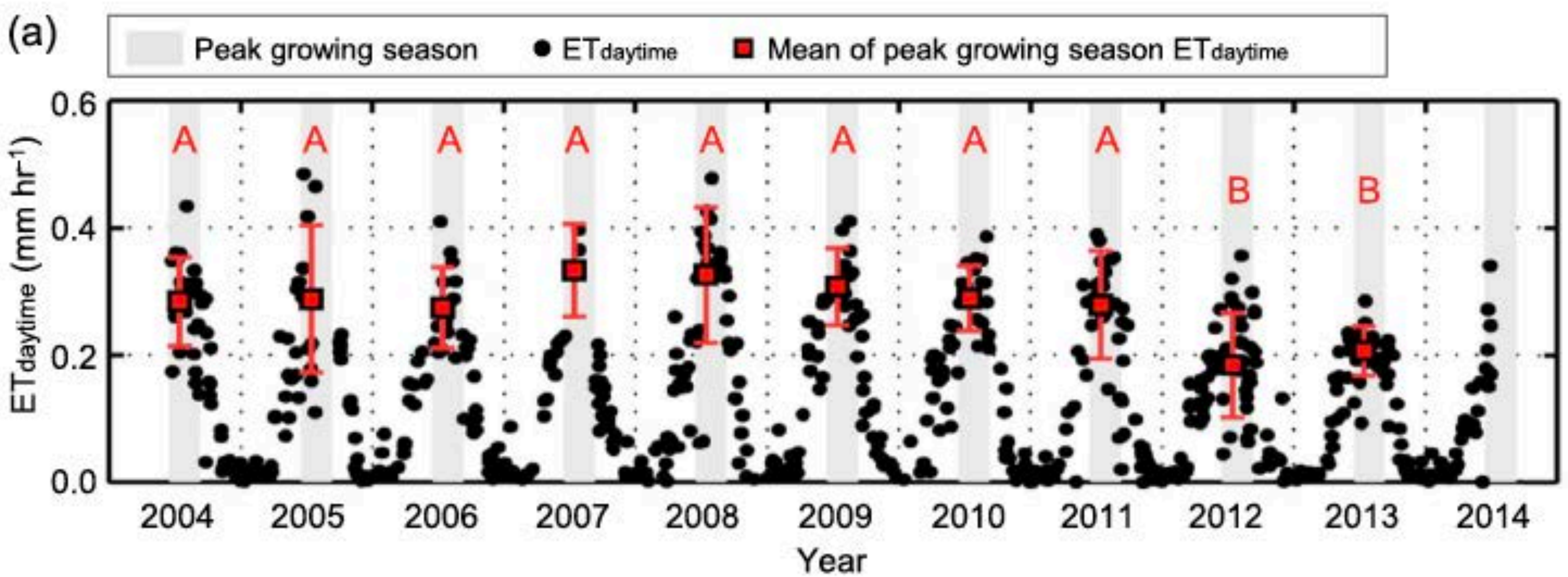


Figure 1—Long-term trends in evapotranspiration (ET) calculated using the water balance approach for gaged watersheds at the Fernow Experimental Forest, West Virginia; Hubbard Brook Experimental Forest, New Hampshire; and Leading Ridge, Pennsylvania.



Geophysical Research Letters

RESEARCH LETTER

10.1002/2016GL072327

Increased water yield due to the hemlock woolly adelgid infestation in New England

Jihyun Kim[1,2], Taehee Hwang[1], Crystal L. Schaaf[3], David A. Orwig[4], Emery Boose[4], and J. William Munger[5]

[1]Department of Geography, Indiana University Bloomington, Bloomington, Indiana, USA, [2]Department of Earth and Environment, Boston University, Boston, Massachusetts, USA, [3]School for the Environment, University of Massachusetts Boston, Boston, Massachusetts, USA, [4]Harvard Forest, Harvard University, Petersham, Massachusetts, USA, [5]School of Engineering and Applied Sciences and Department of Earth and Planetary Sciences, Harvard University, Cambridge, Massachusetts, USA

Key Points:

- In New England, eastern hemlocks have experienced significant foliar loss due to hemlock woolly adelgid (HWA) infestation
- Evapotranspiration flux over a hemlock-dominated forest has significantly decreased
- Water yield has increased due to the infestation, more in the catchment

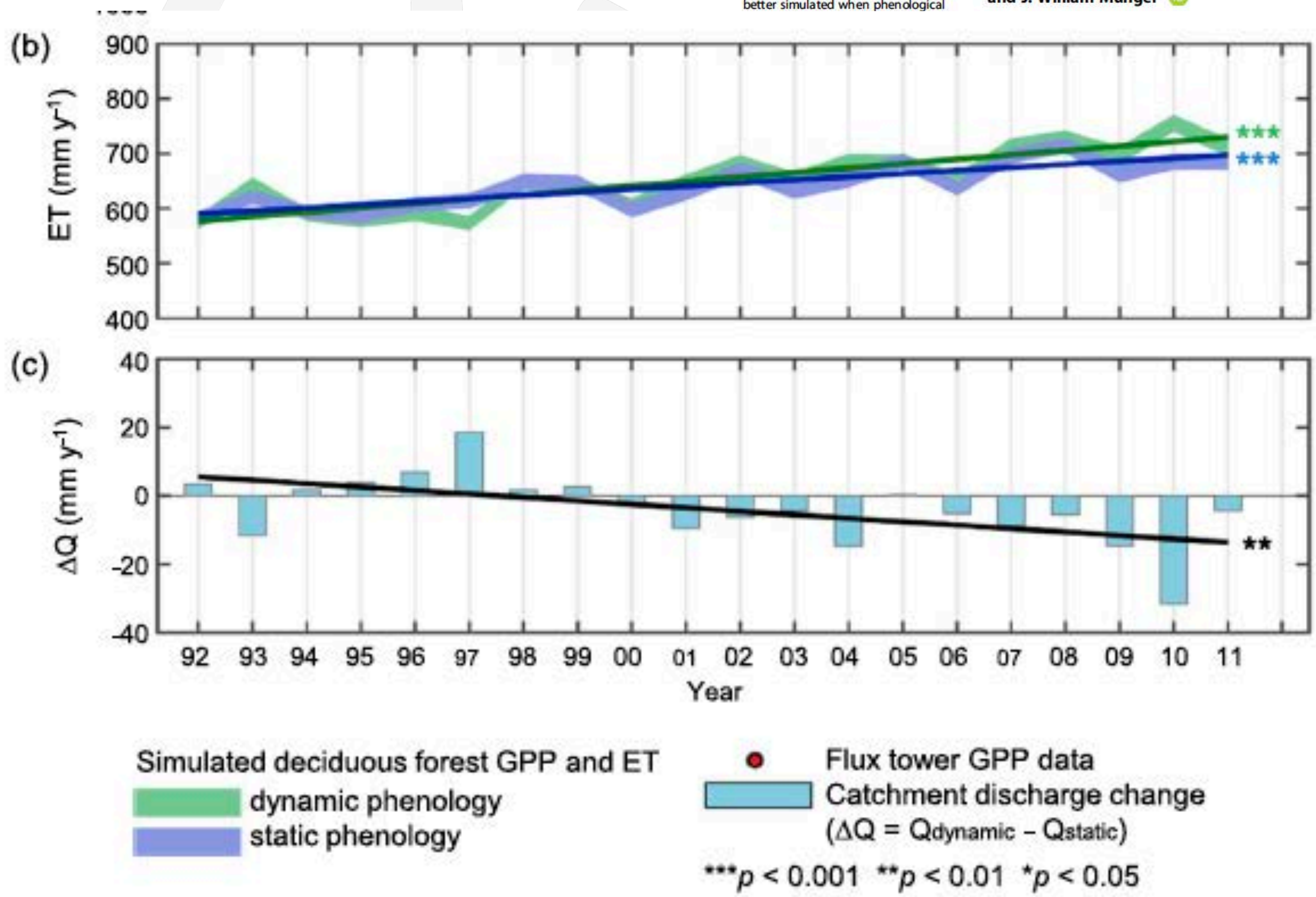
Journal of Geophysical Research: Biogeosciences

RESEARCH ARTICLE
10.1029/2018JG004438

Warming-Induced Earlier Greenup Leads to Reduced Stream Discharge in a Temperate Mixed Forest Catchment

Ji Hyun Kim[1,2,3], Taehee Hwang[1], Yun Yang[4], Crystal L. Schaaf[5], Emery Boose[6], and J. William Munger[7]

Key Points:
- Both carbon and water fluxes were better simulated when phenological



Water Resources Research

RESEARCH ARTICLE

10.1002/2017WR020376

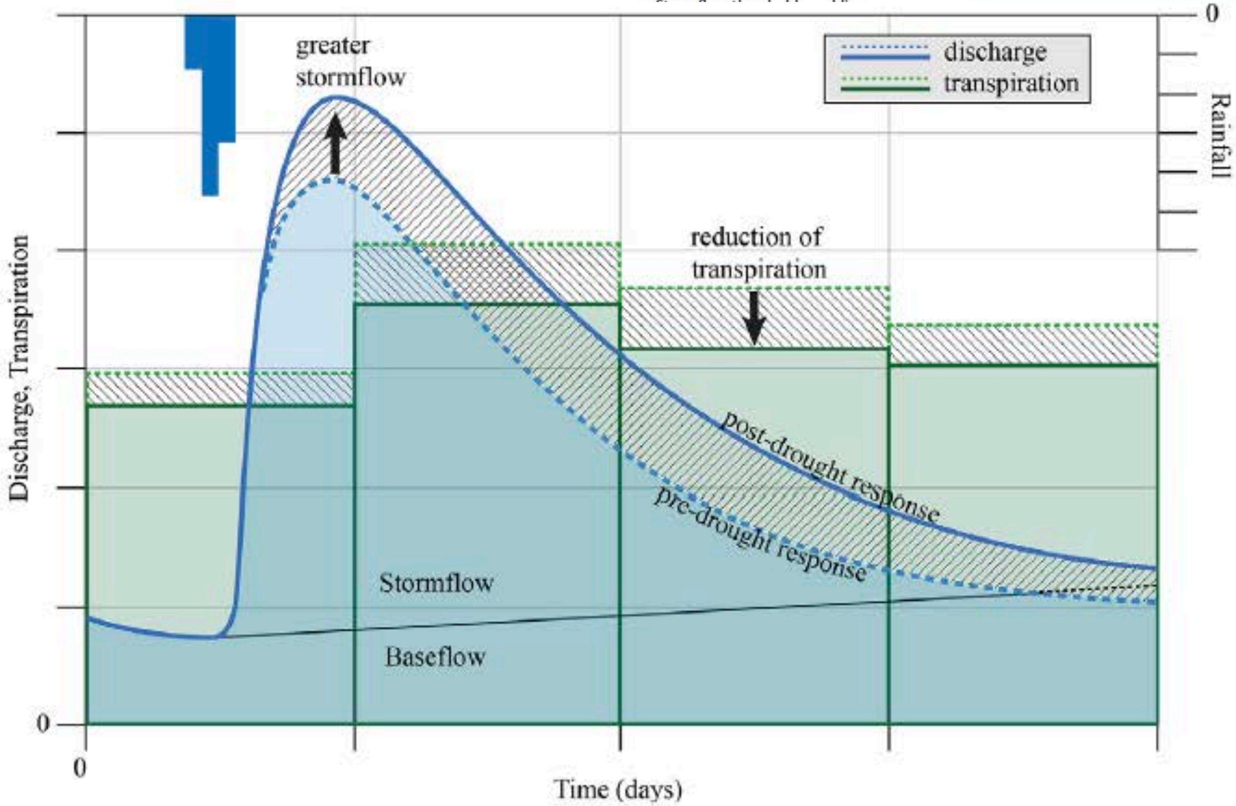
Nonstationarity in threshold response of stormflow in southern Appalachian headwater catchments

Charles I. Scaife[1,2] and Lawrence E. Band[1,2]

[1]Department of Geography, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina, USA, [2]Institute for the Environment, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina, USA

Key Points:

- Stormflow thresholds as functions of combined precipitation and antecedent soil moisture exhibit seasonal and interannual nonstationarity



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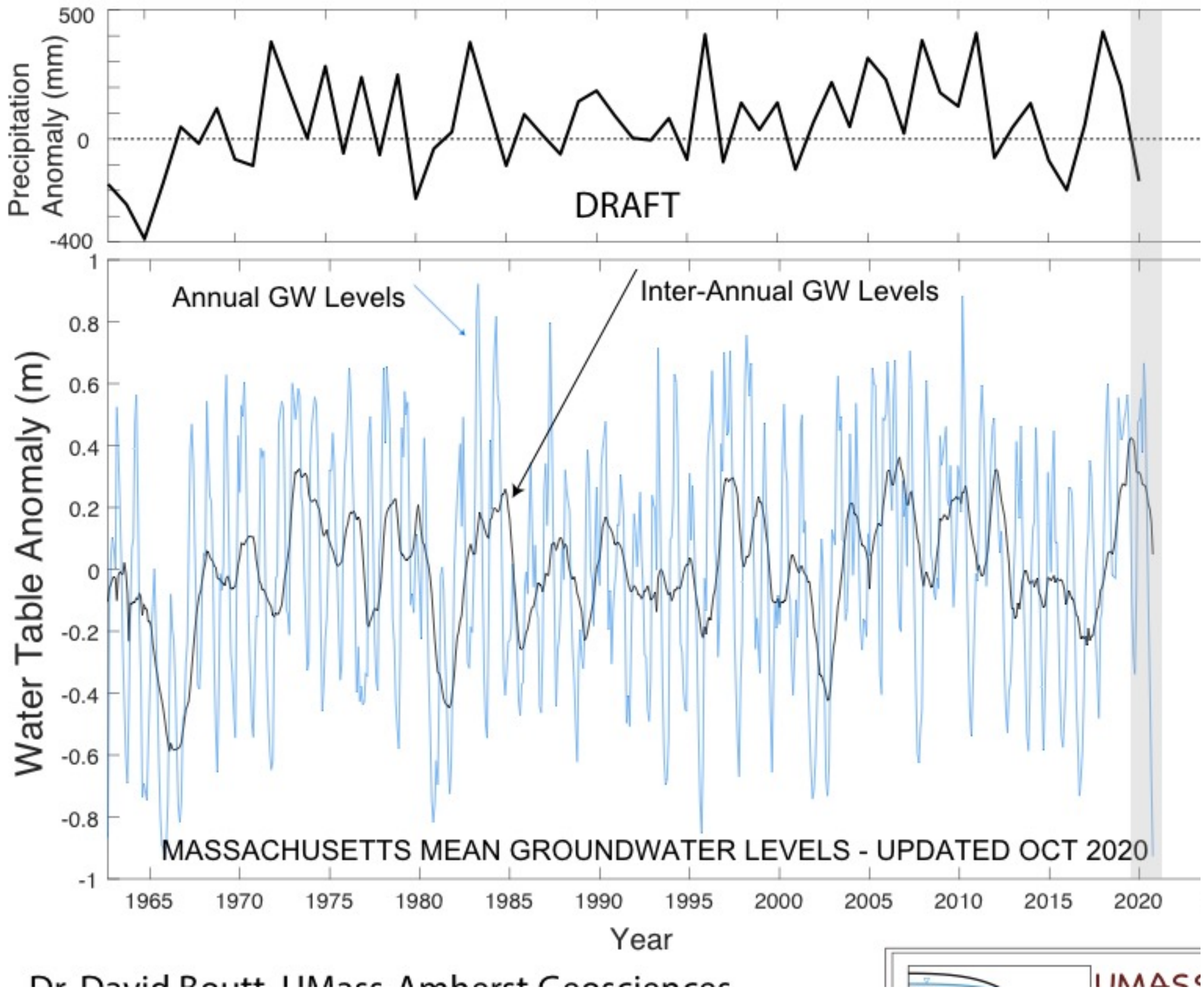
4. Water Budget does not close on annual basis

Precipitation deficits from years prior impacts the water level recovery in later years



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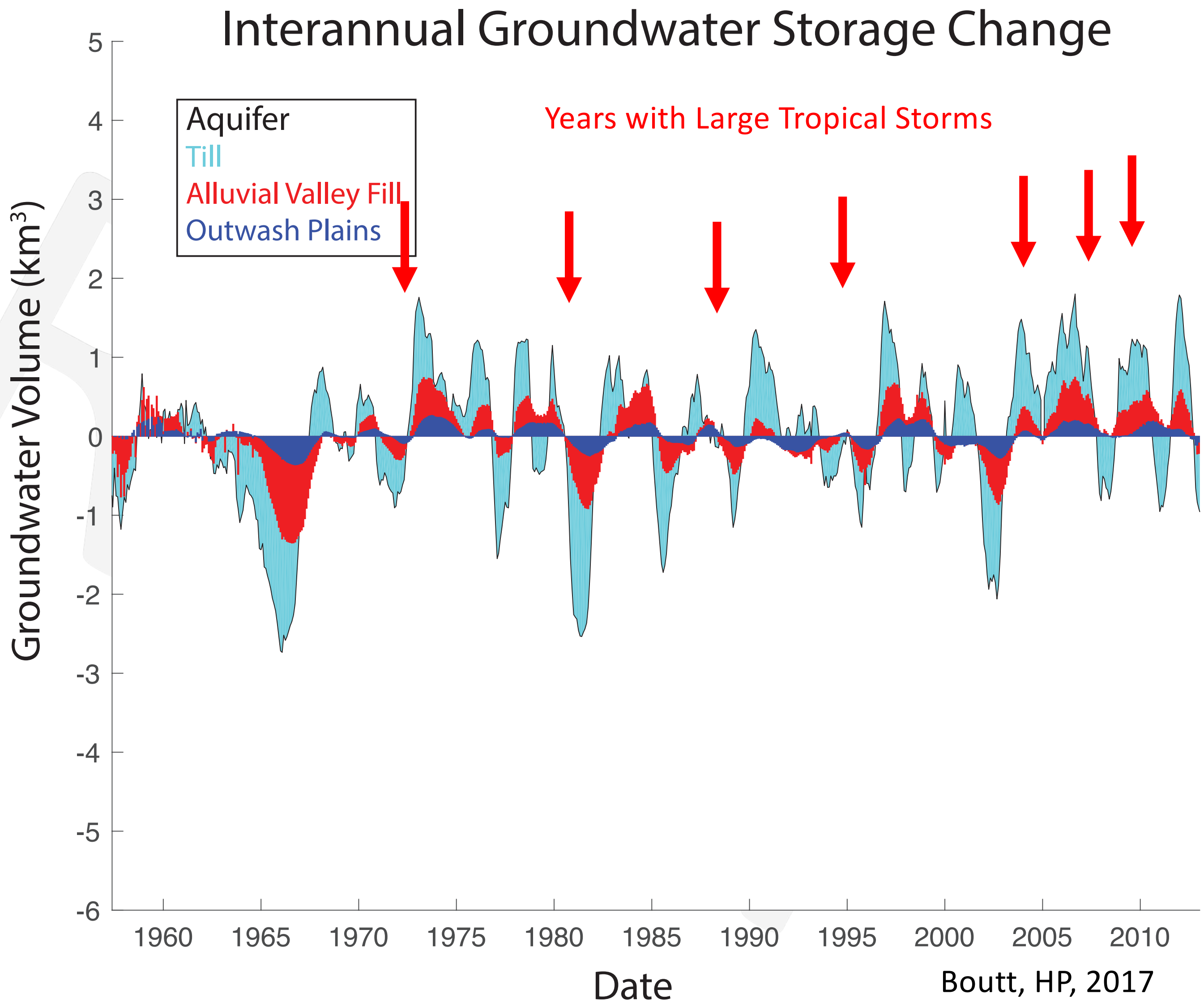
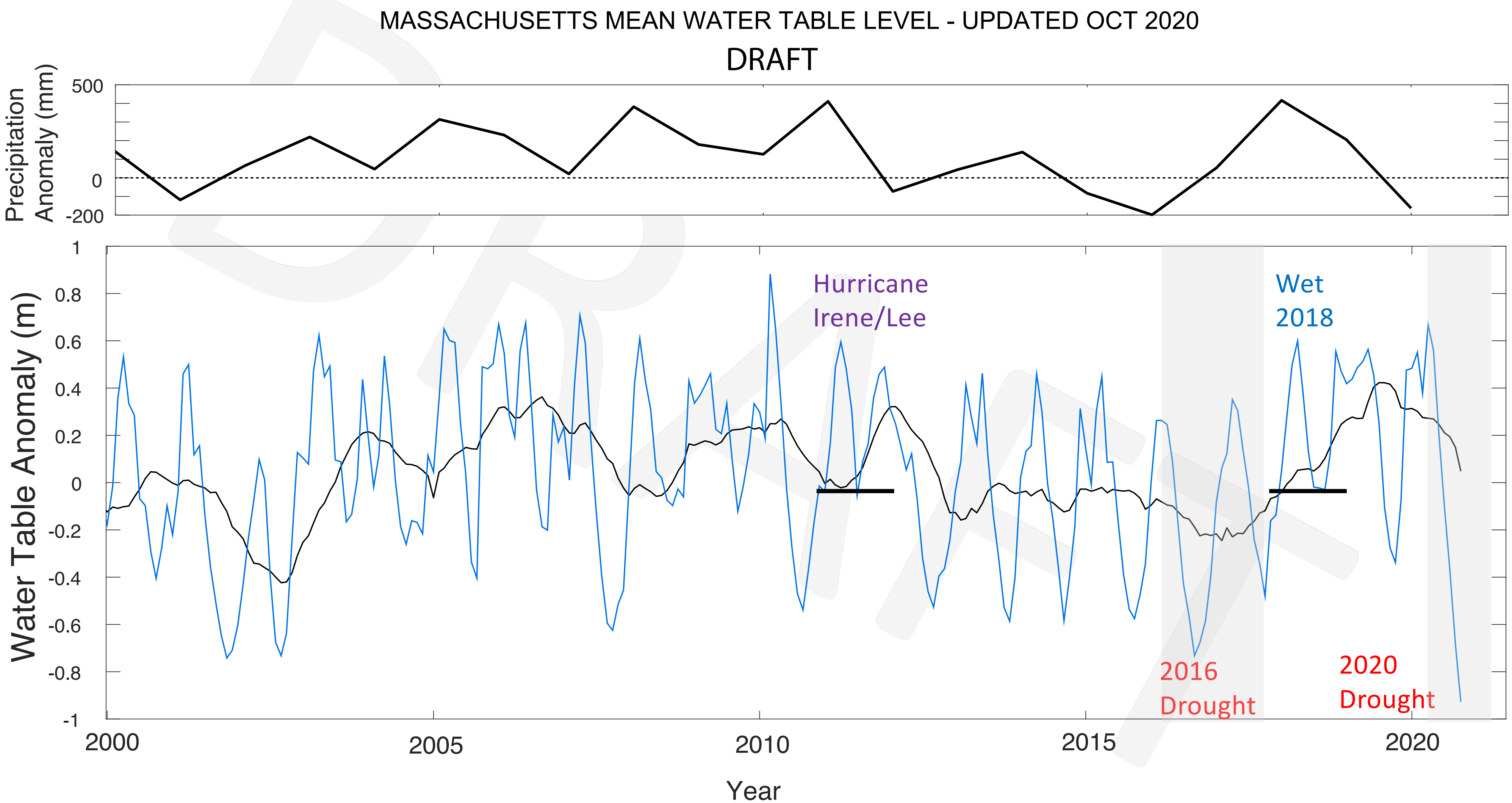
5. Tropical Cyclones are an important component of the water budget





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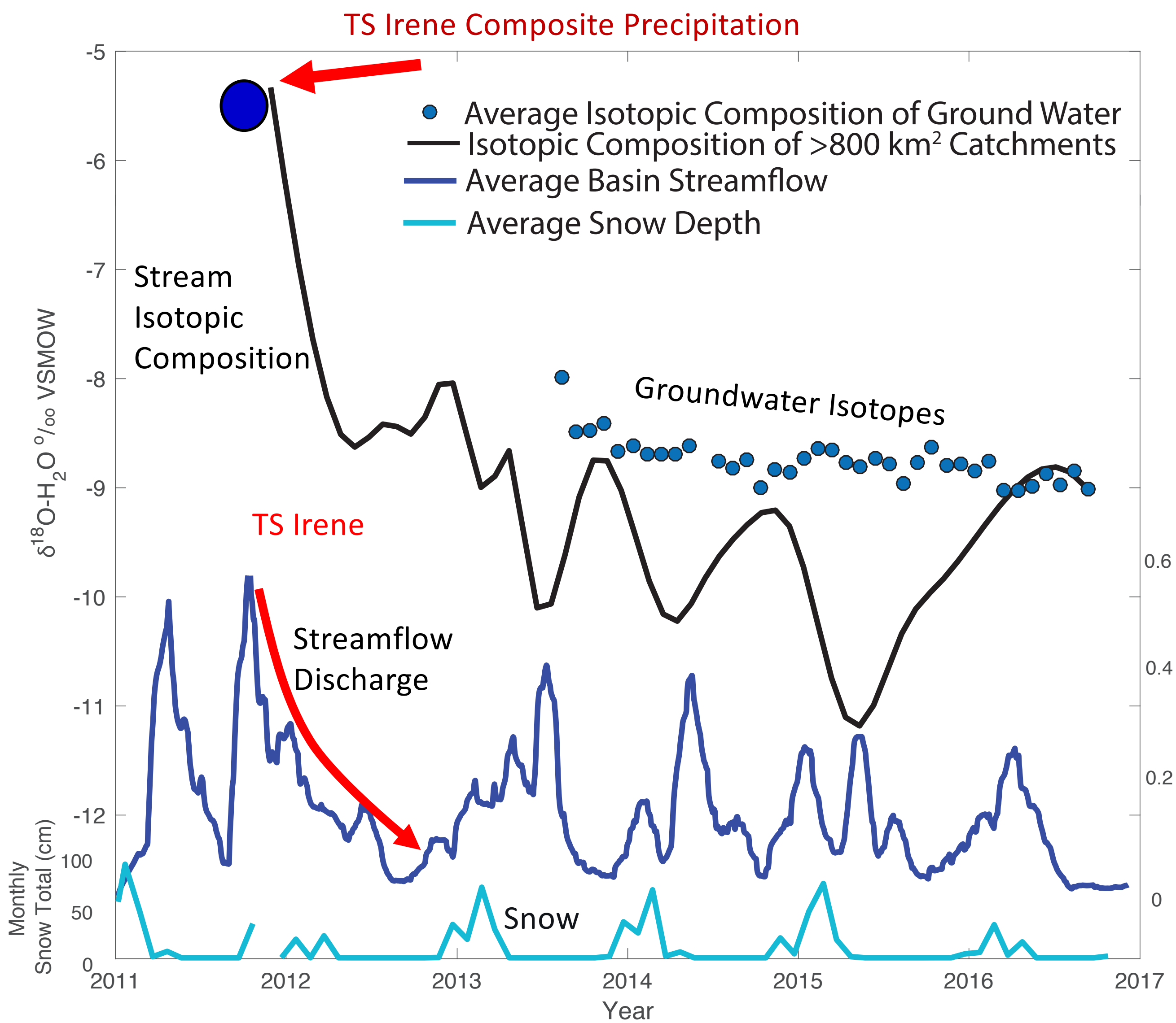

Boutt et al., 2019 GRL

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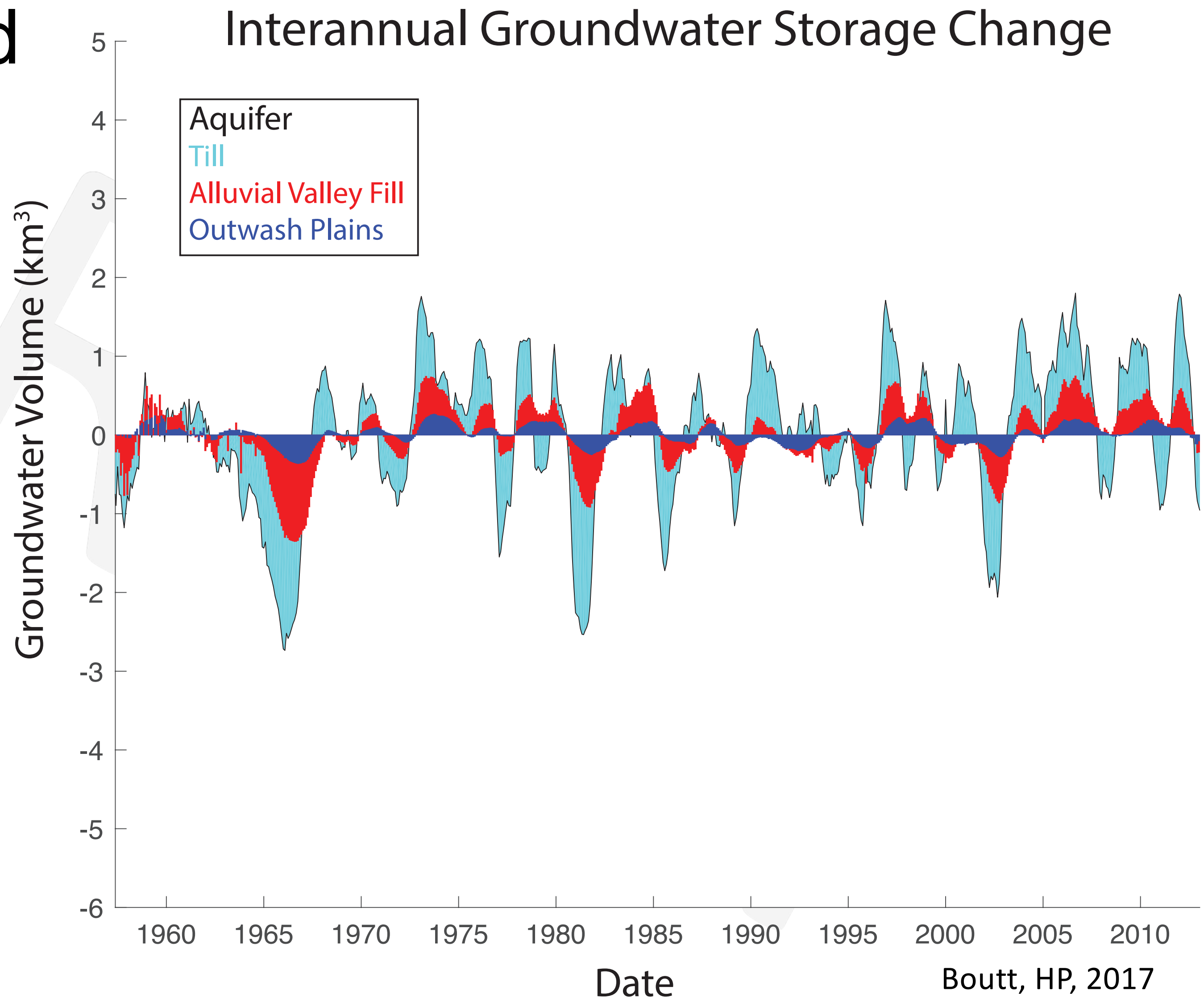

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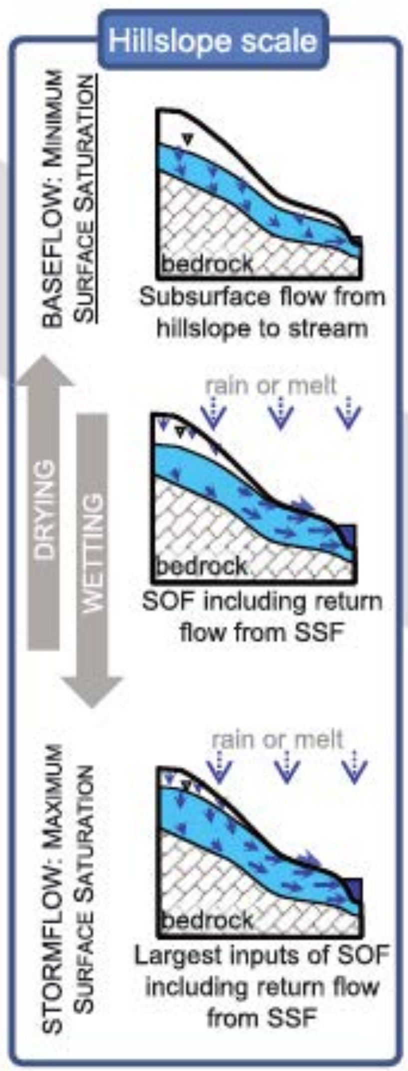
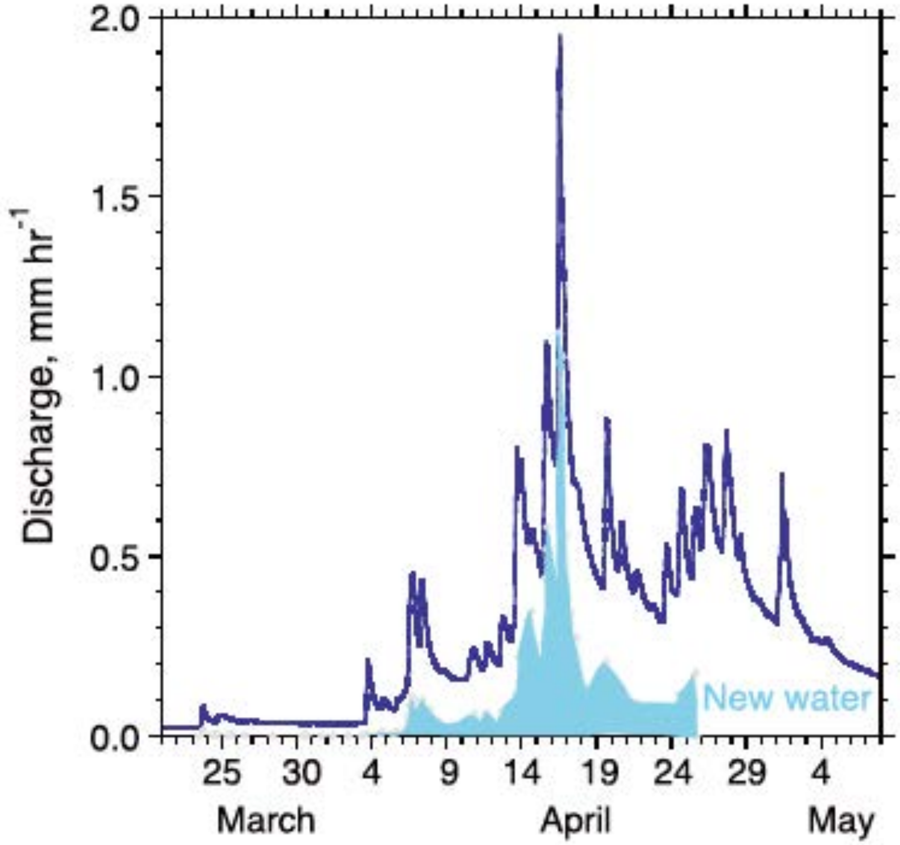
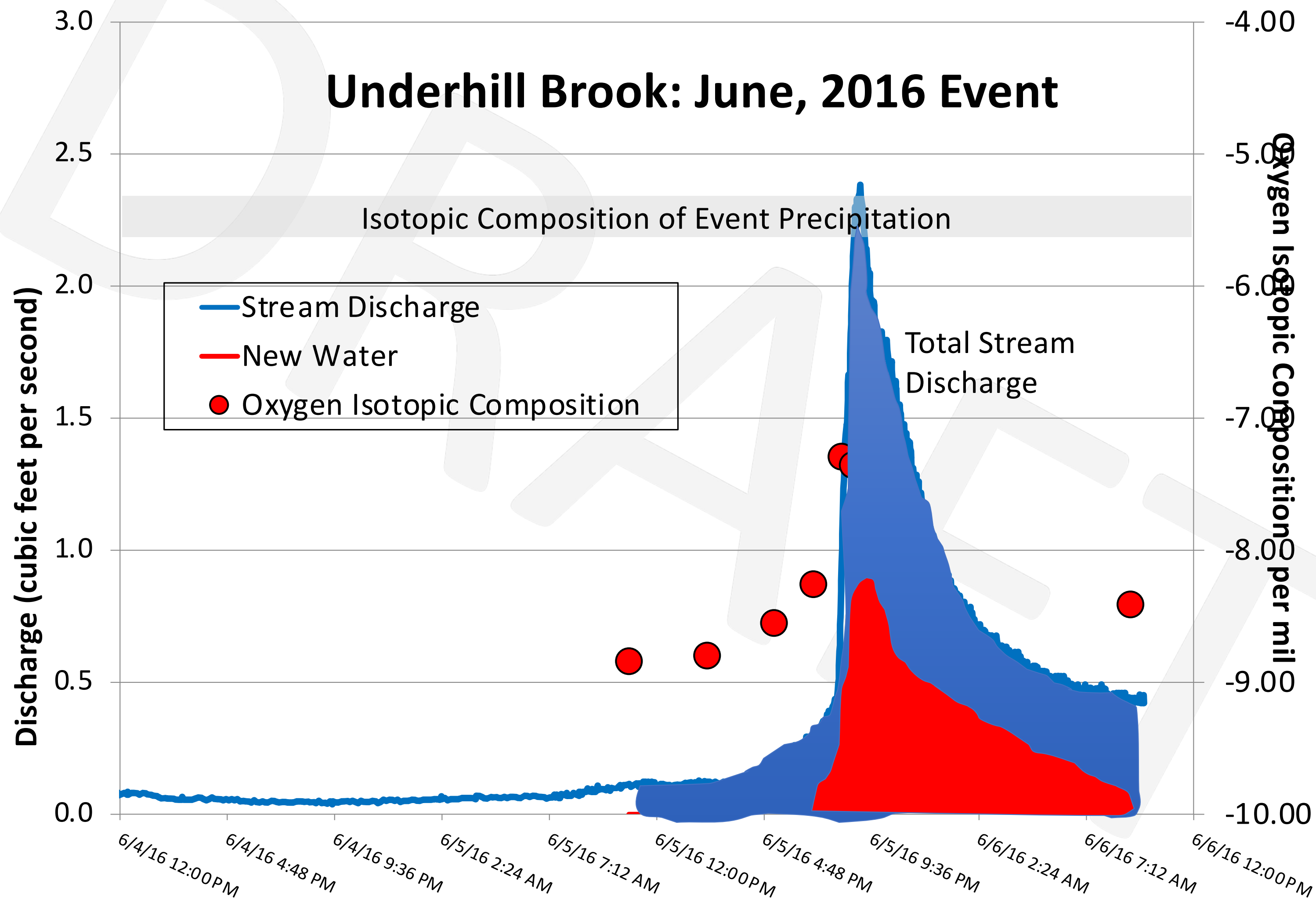




Water’s Way at Sleepers River watershed – revisiting flow generation in a post-glacial landscape, Vermont USA

James B. Shanley,[1*] Stephen D. Sebestyen,[2] Jeffrey J. McDonnell,[3,4] Brian L. McGlynn[5] and Thomas Dunne[6]



Underhill Brook: June, 2016 Event
Isotopic Composition of Event Precipitation
Stream Discharge
New Water
Oxygen Isotopic Composition
Total Stream Discharge
Discharge (cubic feet per second)
Oxygen Isotopic Composition per mil
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-4.00
-5.00
-6.00
-7.00
-8.00
-9.00
-10.00
6/4/16 12:00 PM
6/4/16 4:48 PM
6/4/16 9:36 PM
6/5/16 2:24 AM
6/5/16 7:12 AM
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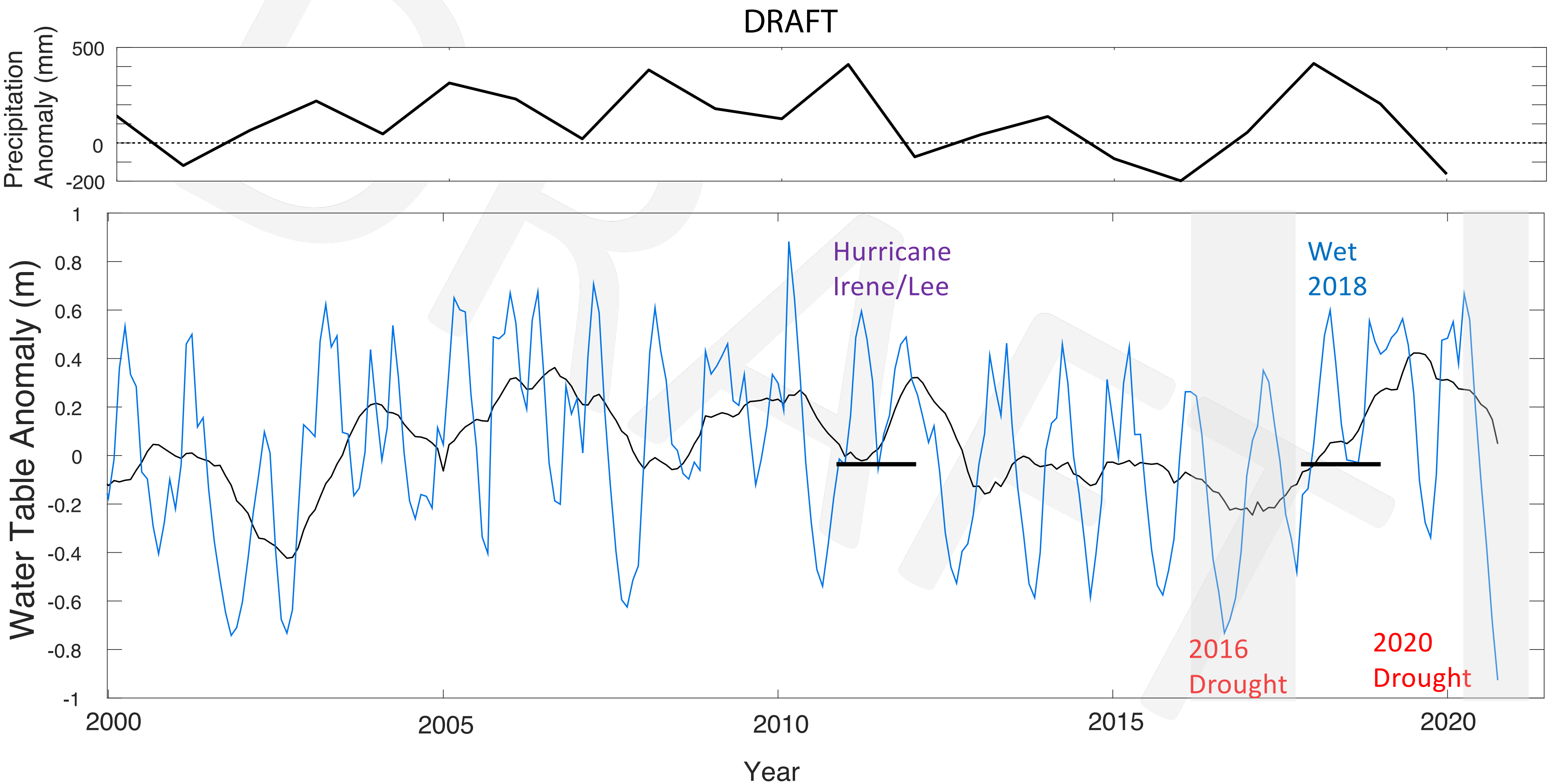

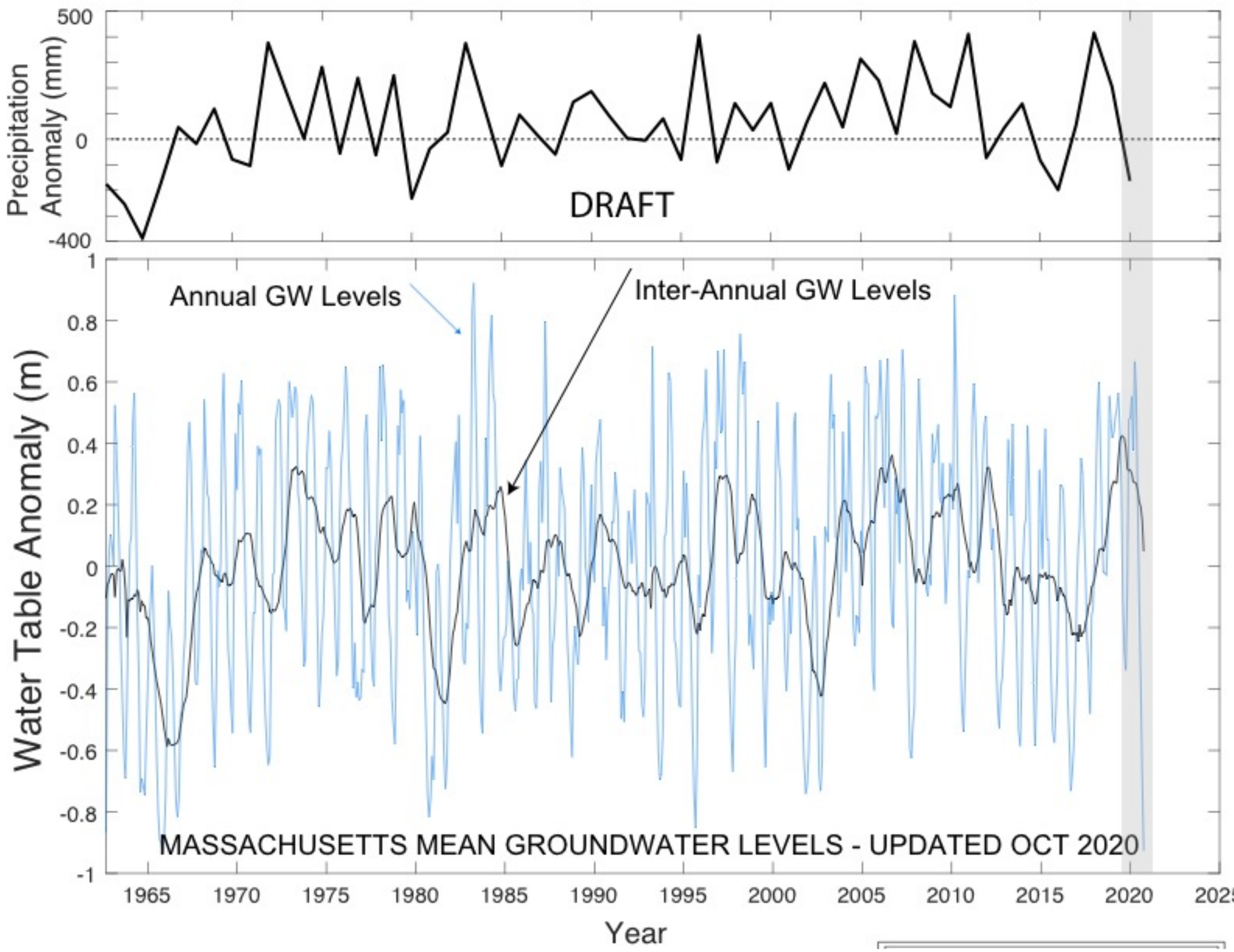

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You can’t manage what you don’t understand

Outstanding Questions that Need Investment

- Why are single (multiple?) annual precipitation deficits leading to more severe reductions in water availability compared to historical multi-year droughts (e.g. 1960s)?
- What are the impacts of more frequent droughts on year-to-year water budgets?
- What is the role of increasing length of growing season on water availability and drought impacts?
- How is water management and urbanization impacting hydrologic response to drought in New England?

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UMass Groundwater Symposium, January 2020

- Link to Recorded Symposium Presentations
- https://echo360.org/media/1559c8e5-0545-4650-8a4e-0ec6d1c28e66/public
- Link to Google Drive Repository of Presentation PDFs
- https://drive.google.com/drive/folders/1pr1hMvU_nGi-dqlMapJG4_lqk2aiillv