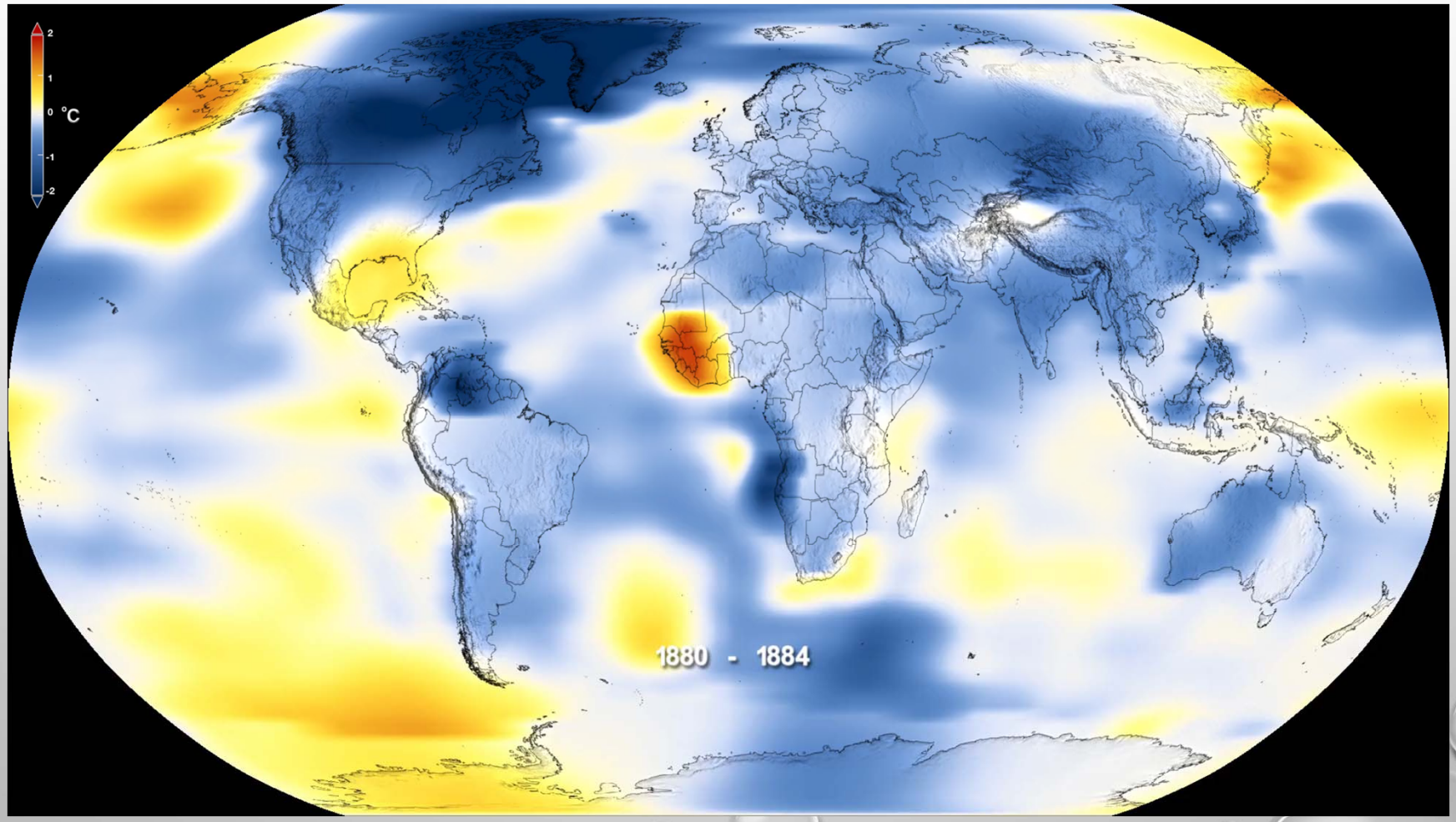
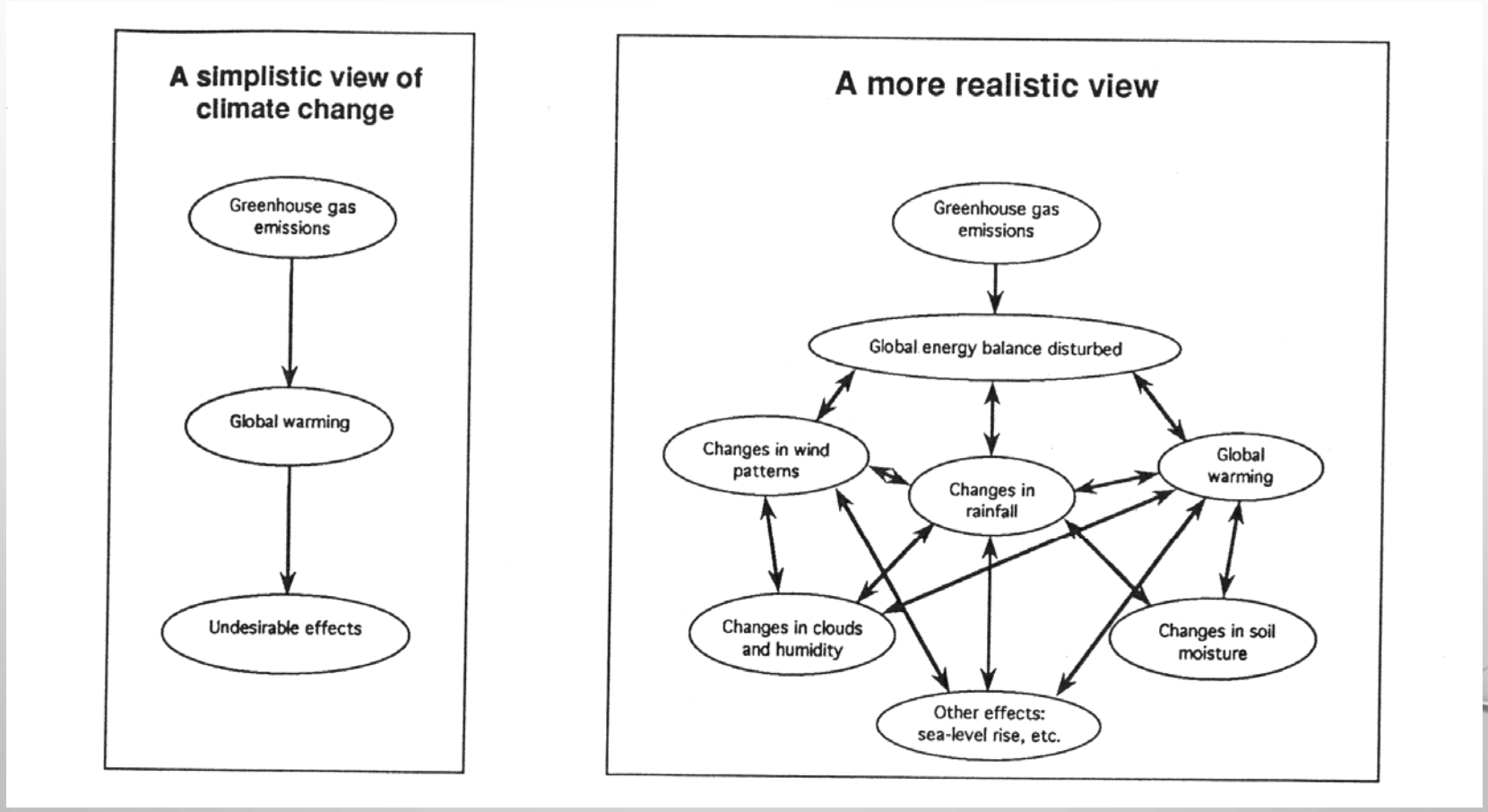
FIVE-YEAR AVERAGE GLOBAL TEMPERATURE ANOMALIES FROM 1880 TO 2018

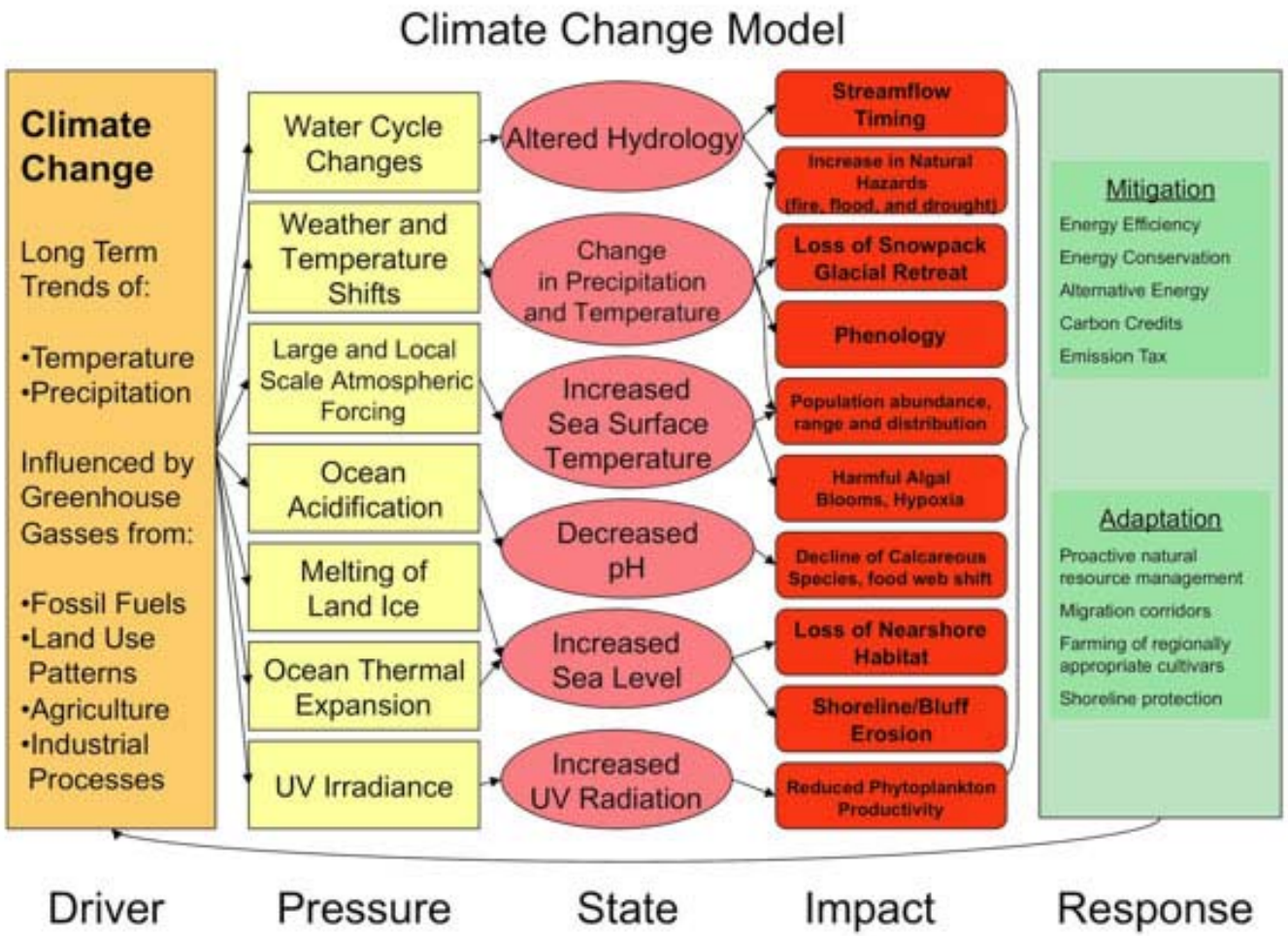


Climate change as a…system



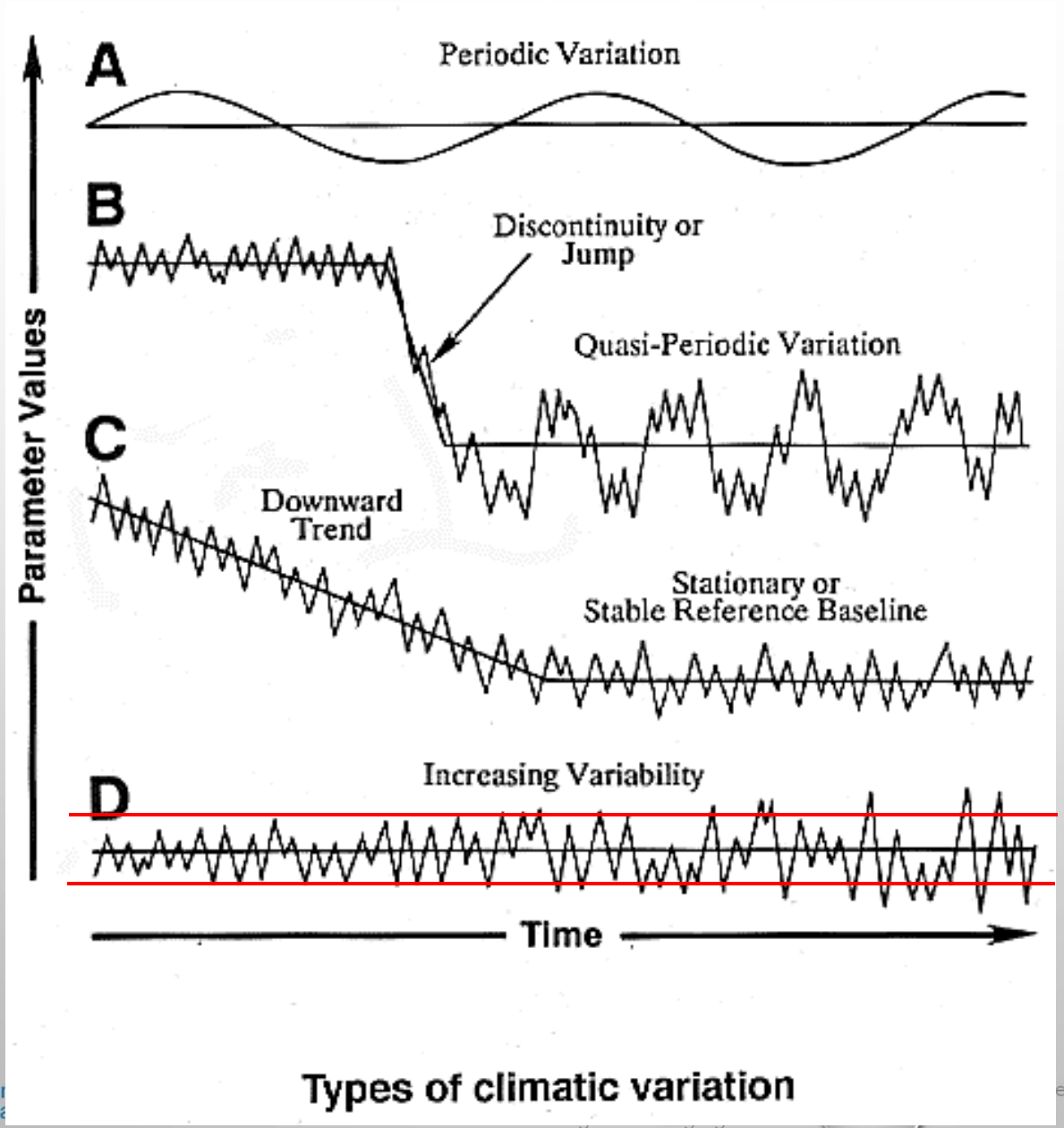
United Nations/UNEP

PROCESS, IMPACT, STRATEGIES



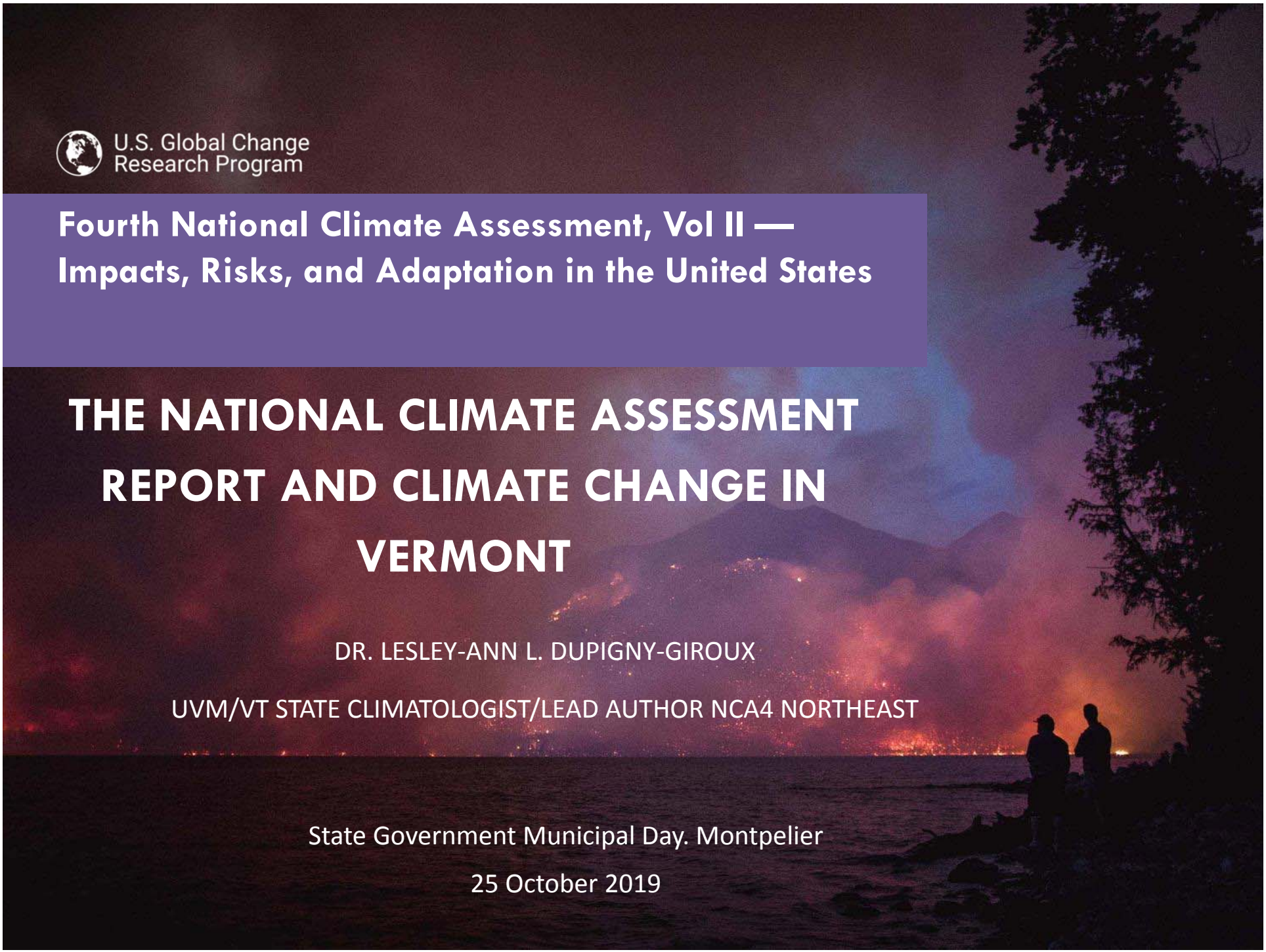
http://pugetsoundscienceupdate.com/pmwiki.php?n=Chapter3.Section2

Credit: David Robinson, NJSC



Types of climatic variation

Increased human vulnerability



U.S. Global Change Research Program

Fourth National Climate Assessment, Vol II — Impacts, Risks, and Adaptation in the United States

THE NATIONAL CLIMATE ASSESSMENT REPORT AND CLIMATE CHANGE IN VERMONT

DR. LESLEY-ANN L. DUPIGNY-GIROUX

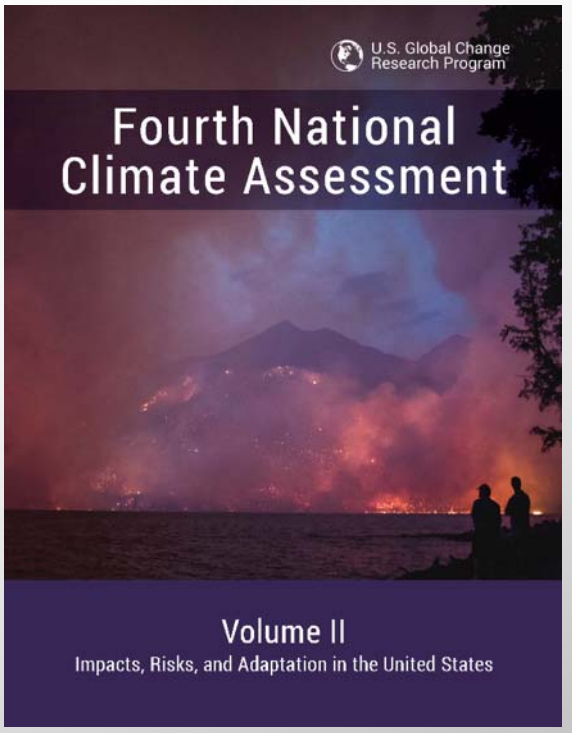
UVM/VT STATE CLIMATOLOGIST/LEAD AUTHOR NCA4 NORTHEAST

State Government Municipal Day. Montpelier

25 October 2019

NCA4 VOL II:
IMPACTS, RISKS, AND ADAPTATION IN THE U.S.

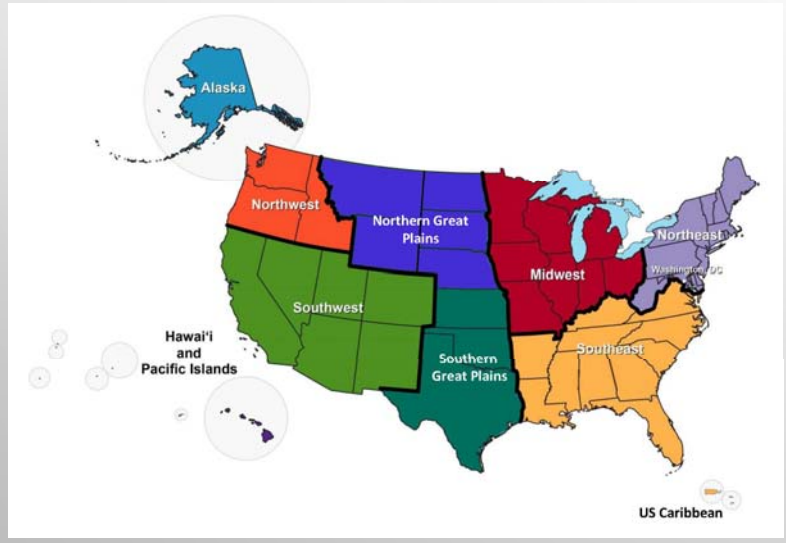
- POLICY RELEVANT, BUT NOT POLICY PRESCRIPTIVE
- PLACES A STRONG EMPHASIS ON REGIONAL INFORMATION
- ASSESSES A RANGE OF POTENTIAL IMPACTS, HELPING DECISION MAKERS BETTER IDENTIFY RISKS THAT COULD BE AVOIDED OR REDUCED
- USES CASE STUDIES TO PROVIDE ADDITIONAL CONTEXT AND OPPORTUNITIES TO SHOWCASE COMMUNITY SUCCESS STORIES



NCA4 Vol II is available at
nca2018.globalchange.gov

ADVANCES SINCE NCA3

- **EXPANDED REGIONAL FOCUS** IN RESPONSE TO GROWING DEMAND FOR LOCALIZED INFORMATION:
  - NEW CHAPTER DEDICATED TO THE U.S. CARIBBEAN, AND GREAT PLAINS DIVIDED INTO NORTHERN AND SOUTHERN REGIONS



Extreme weather events in Vermont can take the form of prolonged heavy snowstorms, flash floods, river floods (following snowmelt and heavy rains), severe thunderstorms, droughts, tornadoes, and temperature extremes. Some of the heaviest flooding in the state's history has been due to tropical cyclones or their remnants. In 2011, Tropical Storm Irene transitioned into an extratropical cyclone as it moved quickly northeastward along the Vermont/New Hampshire border. Roughly 3 to 7 inches of rain fell in less than 18 hours, causing the worst flooding in Vermont since the Great Flood of November 1927. Many rivers reached stages that were second to only the 1927 flood. The flooding resulted in an estimated $733 million in damage across the state.

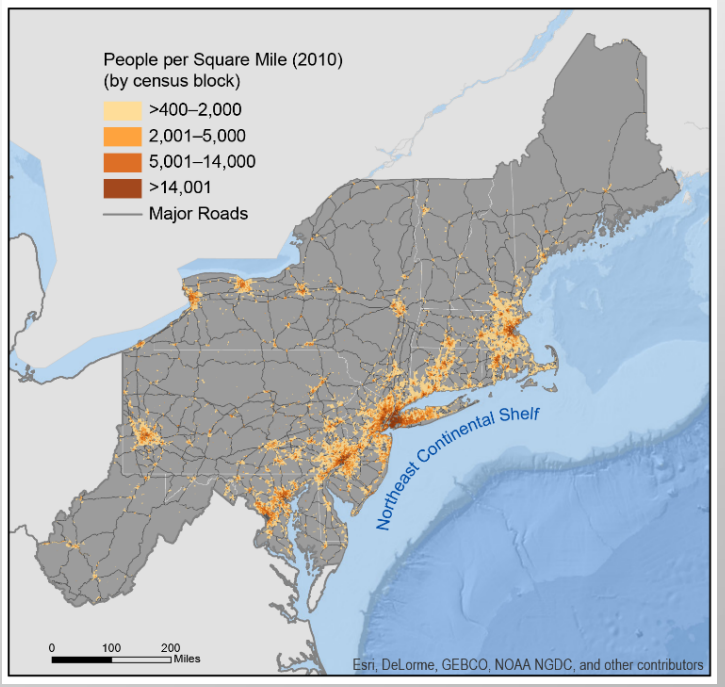
Severe winter storms are common in Vermont's cold winter climate and may include snowstorms, blizzards, and icing events. In addition to ice jams and melting snowpack as winter hazards, freezing rain and frozen ground conditions can also give rise to flooding. During the first week of January 1998, a prolonged storm brought 2 to 5 inches of rain to Vermont. Particularly across the Champlain Valley and parts of northern Vermont, temperatures were below freezing for much of the storm. This resulted in the "Great Ice Storm of '98" where heavy ice accumulations of 1 to 2 inches caused severe damage to trees and utility lines. Total damage from the ice storm across the whole of the northeastern United States was about $2 billion ($1.4 billion in 1998 dollars)

Under a higher emissions pathway, historically unprecedented warming is projected by the end of the 21st century (Figure 1). Even under a pathway of lower greenhouse gas emissions, average annual temperatures are projected to most likely exceed historical record levels by the middle of the 21st century. However, there is a large range of temperature increases under both pathways, and under the lower pathway, a few projections are only slightly warmer than historical records (Figure 1). Increases in the number of hot days and decreases in the number of very cold nights are projected to accompany the overall warming.

Average annual precipitation is projected to increase in Vermont over the 21st century, particularly during winter and spring (Figure 5). Corresponding increases in temperature will increase the proportion of precipitation falling as rain rather than snow. In addition, extreme precipitation is projected to increase, potentially increasing the frequency and intensity of floods.

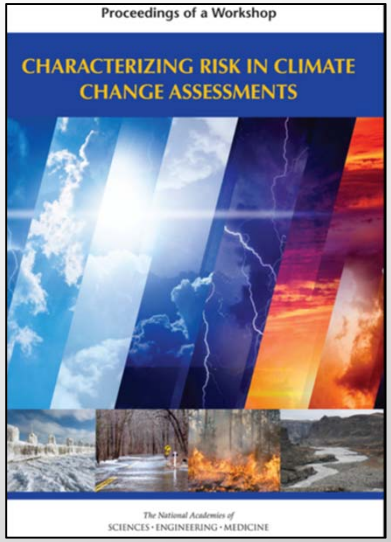
OTHER NEW ELEMENTS OF NCA4

- PRODUCTS DEVELOPED
  - ECONOMIC VALUATION STUDIES & WHERE POSSIBLE:
    - QUANTIFICATION OF CLIMATE CHANGE IMPACTS IN ECONOMIC TERMS UNDER DIFFERENT FUTURE GREENHOUSE GAS EMISSIONS SCENARIOS
    - DOES NOT YET CHARACTERIZE DIFFERENTIAL ECONOMIC IMPACTS FOR ALL 10 NCA REGIONS
    - PROVIDES AN INDICATION OF THE POTENTIAL FOR REDUCING RISKS THROUGH MITIGATION ACTIONS
  - CLIMATE CHANGE INDICATORS
  - LOCA DOWNSCALED PRODUCTS
- UNIQUE FEATURES EACH REGION
  - E.G. NORTHEAST
    - RURAL/URBAN
    - INLAND/COASTAL
    - CULTURAL HERITAGE
    - LENGTH OF SETTLEMENT
    - PHYSICAL GEOGRAPHY/TOPOGRAPHY



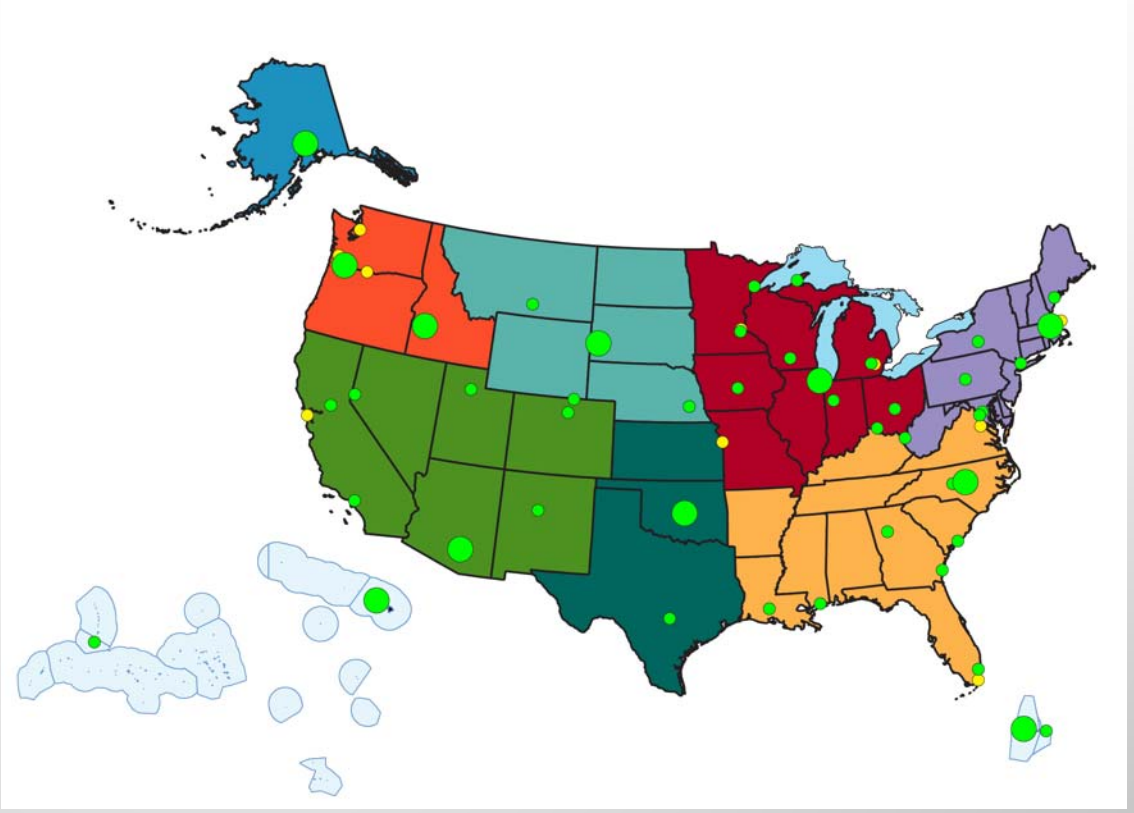
RISK FRAMING IN KEY MESSAGES

- A **"RISK-BASED FRAMING"** IS USED TO ENSURE NCA4 FOCUSES ON ISSUES OF HIGH IMPORTANCE TO DECISION-MAKING AND TO HELP WITH COMMUNICATING ASSESSMENT OUTCOMES
- IN RESPONSE TO AUDIENCE NEEDS AND WITH GUIDANCE FROM A WORKSHOP OF THE NATIONAL ACADEMIES, NCA4 KEY MESSAGES ADDRESSED:
  - ✓ WHAT DO STAKEHOLDERS VALUE/WHAT IS AT RISK IN A GIVEN SECTOR OR REGION?
  - ✓ WHAT OUTCOMES DO WE WISH TO AVOID WITH RESPECT TO THESE VALUED THINGS?
  - ✓ WHAT DO WE EXPECT TO HAPPEN IN THE ABSENCE OF ADAPTIVE ACTION AND/OR MITIGATION?
  - ✓ HOW BAD COULD THINGS PLAUSIBLY GET/ARE THERE IMPORTANT THRESHOLDS OR TIPPING POINTS IN THE UNIQUE CONTEXT OF A GIVEN REGION, SECTOR, ETC.?



PUBLIC PARTICIPATION

- PUBLIC FEEDBACK ON THE DRAFT PROSPECTUS
- PUBLIC CALL FOR AUTHOR NOMINATIONS
- PUBLIC CALL FOR TECHNICAL INPUTS
- A SERIES OF REGIONAL ENGAGEMENT WORKSHOPS (REWS) AND SECTOR-SPECIFIC WEBINARS
- PUBLIC CALL FOR REVIEW EDITORS
- A 90-DAY PUBLIC REVIEW & COMMENT PERIOD



Large green dots illustrate the hub locations for the 11 REWs in early 2017. Small green dots indicate satellite locations for those workshops. Small yellow dots show locations of some additional engagement activities, such as presentations or listening sessions at professional society meetings.

18 KEY MESSAGE #1

CHANGING SEASONS AFFECT RURAL ECOSYSTEMS, ENVIRONMENTS, AND ECONOMIES

THE SEASONALITY OF THE NORTHEAST IS CENTRAL TO THE REGION'S SENSE OF PLACE AND IS AN IMPORTANT DRIVER OF RURAL ECONOMIES. LESS DISTINCT SEASONS WITH MILDER WINTER AND EARLIER SPRING CONDITIONS ARE ALREADY ALTERING ECOSYSTEMS AND ENVIRONMENTS IN WAYS THAT ADVERSELY IMPACT TOURISM, FARMING, AND FORESTRY. THE REGION'S RURAL INDUSTRIES AND LIVELIHOODS ARE AT RISK FROM FURTHER CHANGES TO FORESTS, WILDLIFE, SNOWPACK, AND STREAMFLOW.

FIG. 18.1: POPULATION DENSITY

A SATELLITE MOSAIC OVERLAID WITH PRIMARY ROADS AND POPULATION DENSITY HIGHLIGHTS THE DIVERSE CHARACTERISTICS OF THE REGION IN TERMS OF SETTLEMENT PATTERNS, INTERCONNECTIONS AMONG POPULATION CENTERS OF VARYING SIZES, AND VARIABILITY IN RELIEF ACROSS THE OCEAN SHELF. *SOURCES: U.S. DEPARTMENT OF TRANSPORTATION, U.S. GEOLOGICAL SURVEY, AND ERT, INC.*

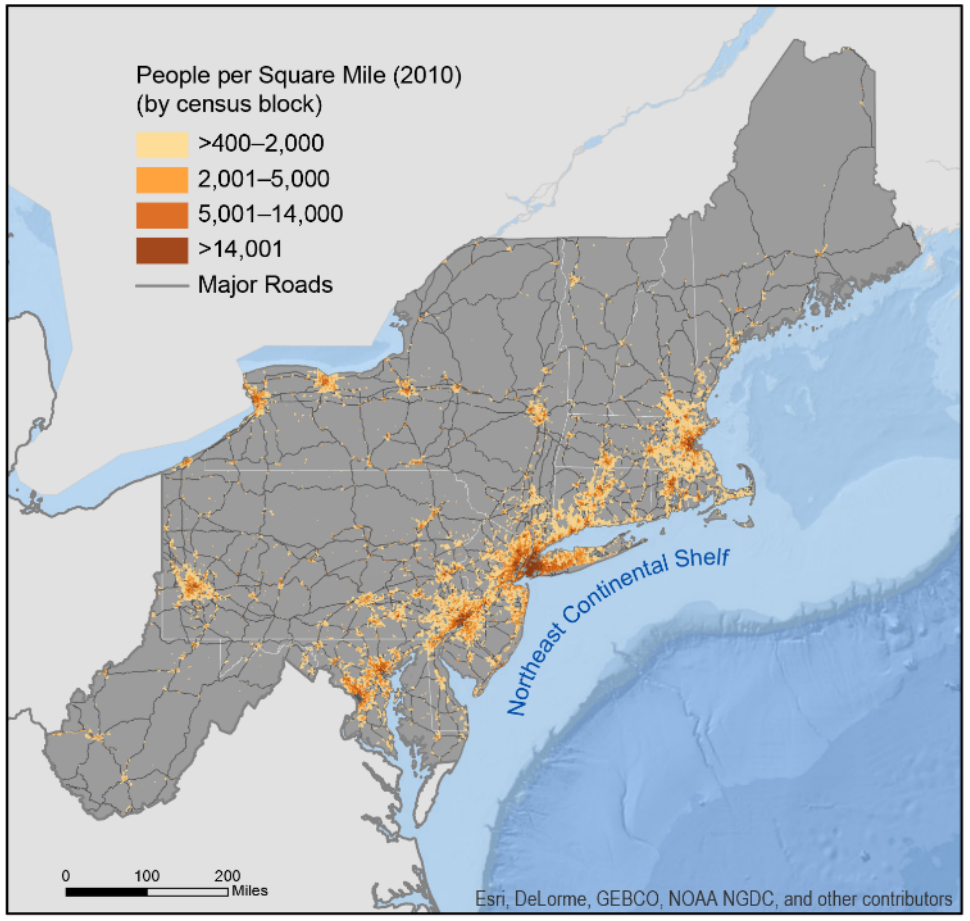
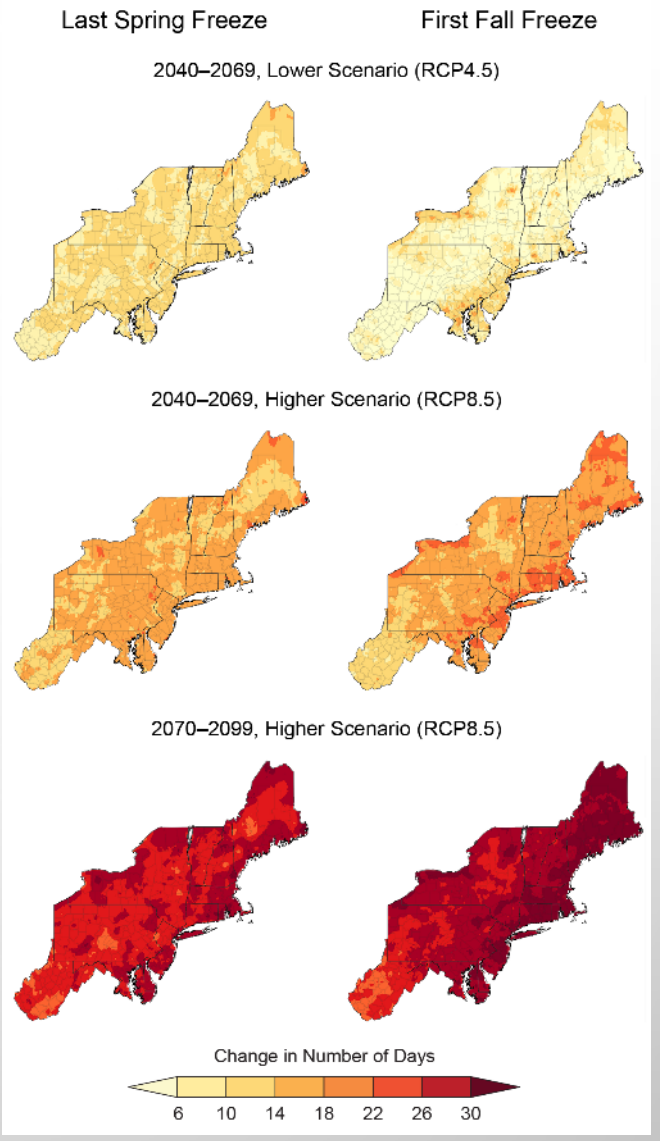


FIG. 18.3: LENGTHENING OF THE FREEZE-FREE PERIOD

THESE MAPS SHOW PROJECTED SHIFTS IN THE DATE OF THE LAST SPRING FREEZE (LEFT COLUMN) AND THE DATE OF THE FIRST FALL FREEZE (RIGHT COLUMN) FOR THE MIDDLE OF THE CENTURY (AS COMPARED TO 1979–2008) UNDER THE LOWER SCENARIO (RCP4.5; TOP ROW) AND THE HIGHER SCENARIO (RCP8.5; MIDDLE ROW). THE BOTTOM ROW SHOWS THE SHIFT IN THESE DATES FOR THE END OF THE CENTURY UNDER THE HIGHER SCENARIO. BY THE MIDDLE OF THE CENTURY, THE FREEZE-FREE PERIOD ACROSS MUCH OF THE NORTHEAST IS EXPECTED TO LENGTHEN BY AS MUCH AS TWO WEEKS UNDER THE LOWER SCENARIO AND BY TWO TO THREE WEEKS UNDER THE HIGHER SCENARIO. BY THE END OF THE CENTURY, THE FREEZE-FREE PERIOD IS EXPECTED TO INCREASE BY AT LEAST THREE WEEKS OVER MOST OF THE REGION. *SOURCE: ADAPTED FROM WOLFE ET AL. 2018.*[35]



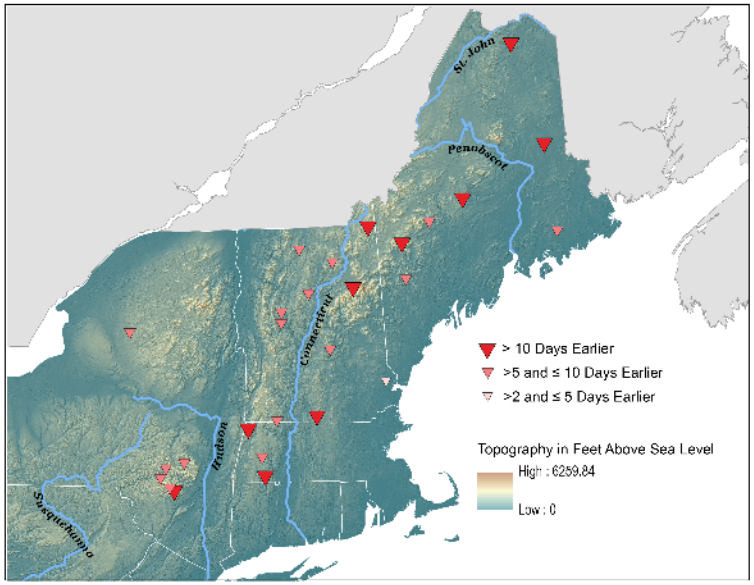


FIG. 18.2: HISTORICAL CHANGES IN THE TIMING OF SNOWMELT-RELATED STREAMFLOW

THIS MAP OF PART OF THE NORTHEAST REGION SHOWS CONSISTENTLY EARLIER SNOWMELT-RELATED STREAMFLOW TIMING FOR RIVERS FROM 1960 TO 2014. EACH SYMBOL REPRESENTS THE CHANGE FOR AN INDIVIDUAL RIVER OVER THE ENTIRE PERIOD. CHANGES IN THE TIMING OF SNOWMELT POTENTIALLY INTERFERE WITH THE REPRODUCTION OF MANY AQUATIC SPECIES[113] AND IMPACT WATER-SUPPLY RESERVOIR MANAGEMENT BECAUSE OF HIGHER WINTER FLOWS AND LOWER SPRING FLOWS.[114] THE TIMING OF SNOWMELT-RELATED STREAMFLOW IN THE NORTHEAST IS SENSITIVE TO SMALL CHANGES IN AIR TEMPERATURE. THE AVERAGE WINTER–SPRING AIR TEMPERATURE INCREASE OF 1.67°F IN THE NORTHEAST FROM 1940 TO 2014 IS THOUGHT TO BE THE CAUSE OF AVERAGE EARLIER STREAMFLOW TIMING OF 7.7 DAYS.[112] THE TIMING OF SNOWMELT-RELATED STREAMFLOW IS A VALUABLE LONG-TERM INDICATOR OF WINTER–SPRING CHANGES IN THE NORTHEAST. *SOURCE: ADAPTED FROM DUDLEY ET AL. 2017;[112] DIGITAL ELEVATION MODEL CGIAR–CSI (CGIAR CONSORTIUM FOR SPATIAL INFORMATION). REPRINTED WITH PERMISSION FROM ELSEVIER.*

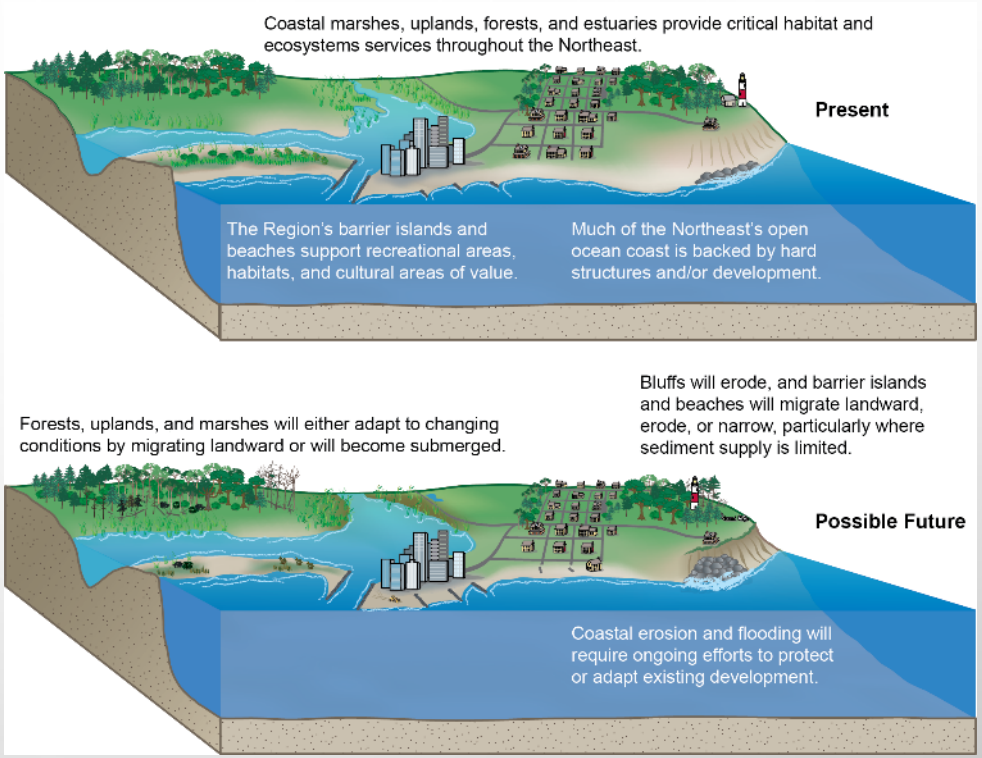
18 KEY MESSAGE #2

CHANGING COASTAL AND OCEAN HABITATS, ECOSYSTEM SERVICES, AND LIVELIHOODS

THE NORTHEAST'S COAST AND OCEAN SUPPORT COMMERCE, TOURISM, AND RECREATION THAT ARE IMPORTANT TO THE REGION'S ECONOMY AND WAY OF LIFE. WARMER OCEAN TEMPERATURES, SEA LEVEL RISE, AND OCEAN ACIDIFICATION THREATEN THESE SERVICES. THE ADAPTIVE CAPACITY OF MARINE ECOSYSTEMS AND COASTAL COMMUNITIES WILL INFLUENCE ECOLOGICAL AND SOCIOECONOMIC OUTCOMES AS CLIMATE RISKS INCREASE.

FIG 18.7: COASTAL IMPACTS OF CLIMATE CHANGE

(TOP) THE NORTHEASTERN COASTAL LANDSCAPE IS COMPOSED OF UPLANDS AND FORESTED AREAS, WETLANDS AND ESTUARINE SYSTEMS, MAINLAND AND BARRIER BEACHES, BLUFFS, HEADLANDS, AND ROCKY SHORES, AS WELL AS DEVELOPED AREAS, ALL OF WHICH PROVIDE A VARIETY OF IMPORTANT SERVICES TO PEOPLE AND SPECIES. (BOTTOM) FUTURE IMPACTS FROM INTENSE STORM ACTIVITY AND SEA LEVEL RISE WILL VARY ACROSS THE LANDSCAPE, REQUIRING A VARIETY OF ADAPTATION STRATEGIES IF PEOPLE, HABITATS, TRADITIONS, AND LIVELIHOODS ARE TO BE PROTECTED. *SOURCE: U.S. GEOLOGICAL SURVEY.*



18 KEY MESSAGE #3

MAINTAINING URBAN AREAS AND COMMUNITIES AND THEIR INTERCONNECTEDNESS

THE NORTHEAST'S URBAN CENTERS AND THEIR INTERCONNECTIONS ARE REGIONAL AND NATIONAL HUBS FOR CULTURAL AND ECONOMIC ACTIVITY. MAJOR NEGATIVE IMPACTS ON CRITICAL INFRASTRUCTURE, URBAN ECONOMIES, AND NATIONALLY SIGNIFICANT HISTORIC SITES ARE ALREADY OCCURRING AND WILL BECOME MORE COMMON WITH A CHANGING CLIMATE.

FIG 18.9: KING TIDE FLOODING IN ANNAPOLIS, MARYLAND

THE PHOTO SHOWS KING TIDE FLOODING ON DOCK STREET IN ANNAPOLIS, MARYLAND, ON DECEMBER 21, 2012. *PHOTO CREDIT: AMY MCGOVERN (CC BY 2.0).*

FIG 18.10: SUBWAY AIR VENT FLOOD PROTECTION

THE PHOTO SHOWS A SUBWAY AIR VENT WITH A MULTIUSE RAISED FLOOD PROTECTION GRATE THAT WAS INSTALLED AS PART OF THE POST–SUPERSTORM SANDY COASTAL RESILIENCE EFFORTS ON WEST BROADWAY IN LOWER MANHATTAN, NEW YORK CITY. *PHOTO CREDIT: WILLIAM SOLECKI.*

18 KEY MESSAGE #4

THREATS TO HUMAN HEALTH

CHANGING CLIMATE THREATENS THE HEALTH AND WELL-BEING OF PEOPLE IN THE NORTHEAST THROUGH MORE EXTREME WEATHER, WARMER TEMPERATURES, DEGRADATION OF AIR AND WATER QUALITY, AND SEA LEVEL RISE. THESE ENVIRONMENTAL CHANGES ARE EXPECTED TO LEAD TO HEALTH-RELATED IMPACTS AND COSTS, INCLUDING ADDITIONAL DEATHS, EMERGENCY ROOM VISITS AND HOSPITALIZATIONS, AND A LOWER QUALITY OF LIFE. HEALTH IMPACTS ARE EXPECTED TO VARY BY LOCATION, AGE, CURRENT HEALTH, AND OTHER CHARACTERISTICS OF INDIVIDUALS AND COMMUNITIES.

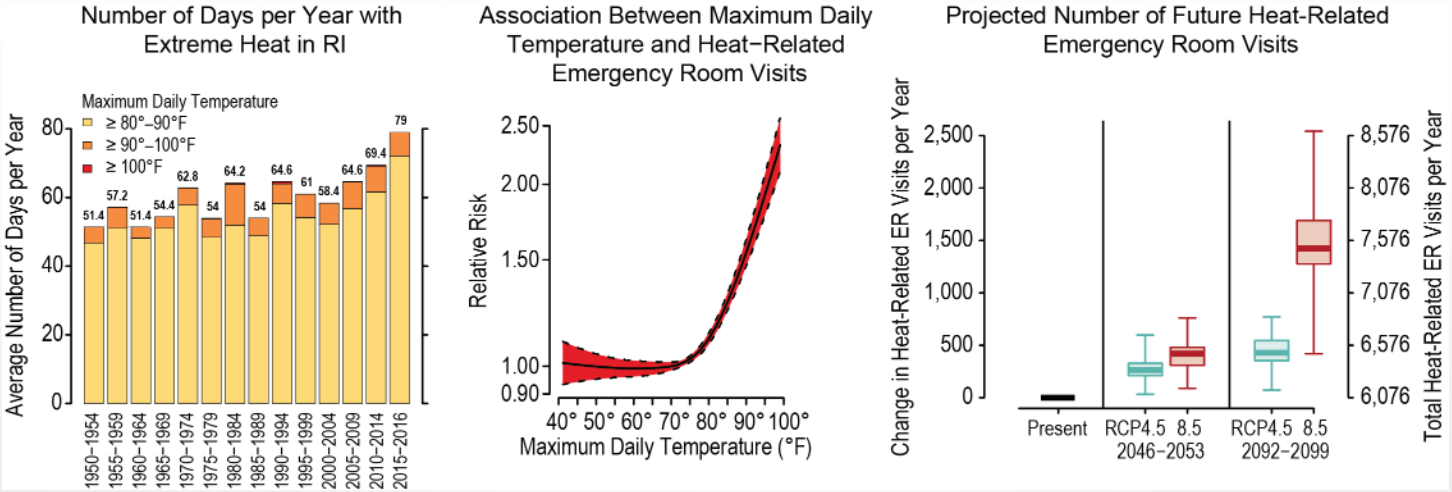


FIG. 18.11: OBSERVED AND PROJECTED IMPACTS OF EXCESS HEAT ON EMERGENCY ROOM VISITS IN RHODE ISLAND

THIS FIGURE SHOWS THE OBSERVED AND PROJECTED IMPACTS OF EXCESS HEAT ON EMERGENCY ROOM VISITS IN RHODE ISLAND. (LEFT) IN RHODE ISLAND, MAXIMUM DAILY TEMPERATURES IN THE SUMMER HAVE TRENDED UPWARDS OVER THE LAST 60 YEARS, SUCH THAT RESIDENTS EXPERIENCED ABOUT THREE MORE WEEKS OF HEALTH-THREATENING HOT WEATHER OVER 2015–2016 THAN IN THE 1950S. (MIDDLE) A RECENT STUDY LOOKING AT VISITS TO HOSPITAL EMERGENCY ROOMS (ERS) FOUND THAT THE INCIDENCE RATE OF HEAT-RELATED ER VISITS ROSE SHARPLY AS MAXIMUM DAILY TEMPERATURES CLIMBED ABOVE 80°F. (RIGHT) THE STUDY ESTIMATES THAT WITH CONTINUED CLIMATE CHANGE, RHODE ISLANDERS COULD EXPERIENCE AN ADDITIONAL 400 (6.8% MORE) HEAT-RELATED ER VISITS EACH YEAR BY 2050 AND UP TO AN ADDITIONAL 1,500 (24.4% MORE) SUCH VISITS EACH YEAR BY 2095 UNDER THE HIGHER SCENARIO (RCP8.5). ABOUT 1,000 FEWER ANNUAL HEAT-RELATED ER VISITS ARE PROJECTED FOR THE END OF THE CENTURY UNDER THE LOWER SCENARIO (RCP4.5) COMPARED TO THE HIGHER SCENARIO (RCP8.5), REFLECTING THE ESTIMATED HEALTH BENEFITS OF ADHERING TO A LOWER GREENHOUSE GAS EMISSIONS SCENARIO. *SOURCES: (LEFT) BROWN UNIVERSITY; (MIDDLE, RIGHT) ADAPTED FROM KINGSLEY ET AL. 2016.*[26] *REPRODUCED FROM ENVIRONMENTAL HEALTH PERSPECTIVES.*

18 KEY MESSAGE #5

ADAPTATION TO CLIMATE CHANGE IS UNDERWAY

COMMUNITIES IN THE NORTHEAST ARE PROACTIVELY PLANNING AND IMPLEMENTING ACTIONS TO REDUCE RISKS POSED BY CLIMATE CHANGE. USING DECISION SUPPORT TOOLS TO DEVELOP AND APPLY ADAPTATION STRATEGIES INFORMS BOTH THE VALUE OF ADOPTING SOLUTIONS AND THE REMAINING CHALLENGES. EXPERIENCE SINCE THE LAST ASSESSMENT PROVIDES A FOUNDATION TO ADVANCE FUTURE ADAPTATION EFFORTS.

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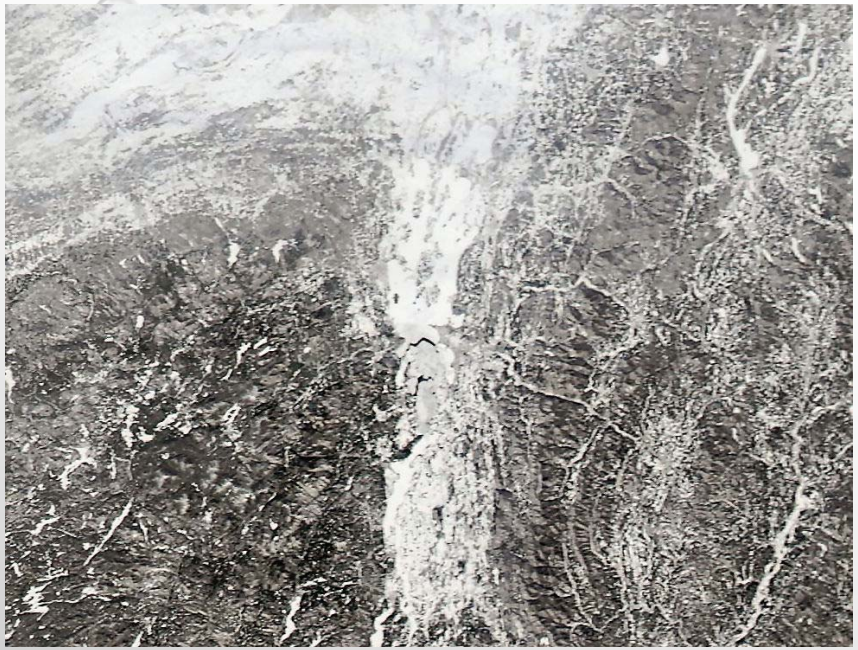
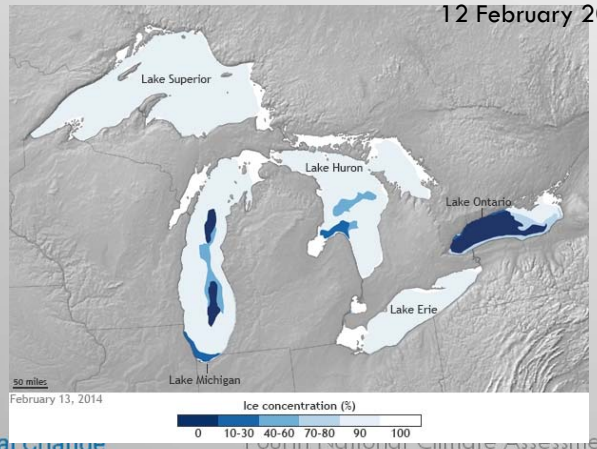
WHAT DOES CLIMATE CHANGE LOOK LIKE IN VERMONT?

LAKE CHAMPLAIN – AN INTEGRATOR OF CLIMATE

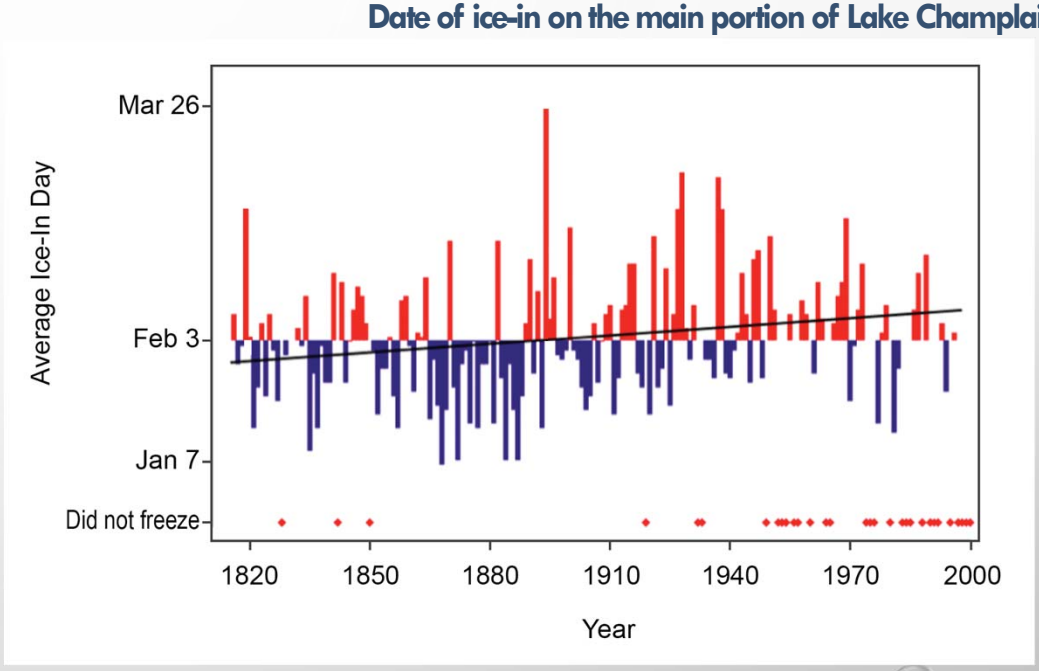


12 February 2014



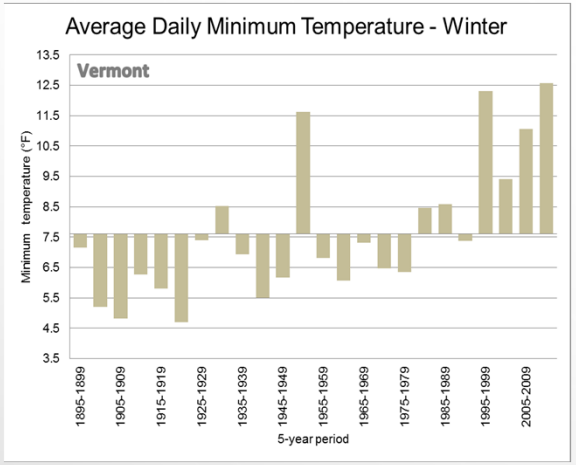
NOAA & National Weather Service

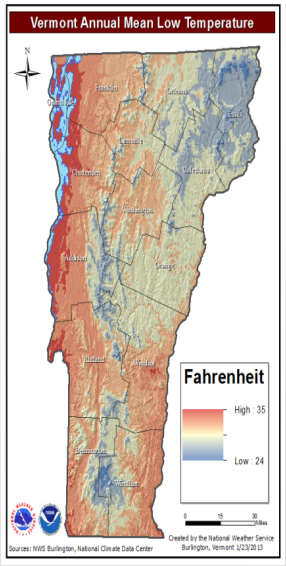
88% frozen (2014)
82% frozen (1996)

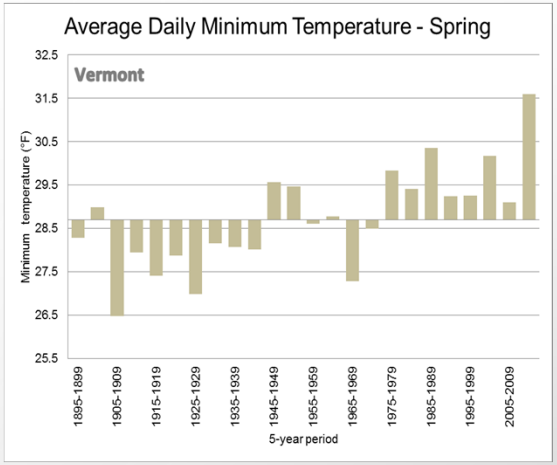


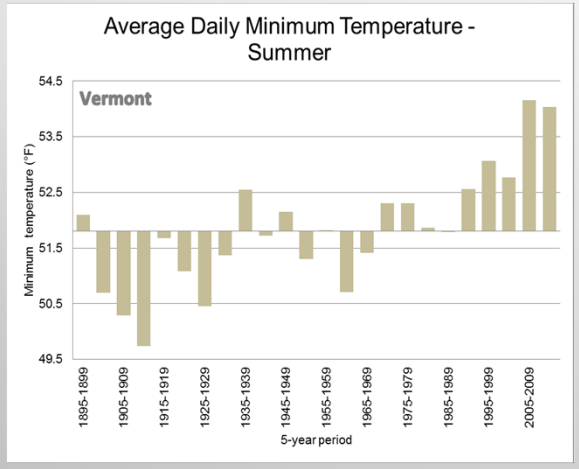
National Climate Assessment, 2013

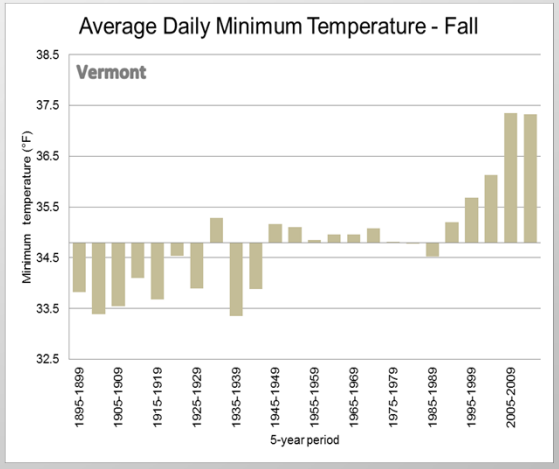
DAILY LOW TEMPERATURES ARE GETTING WARMER







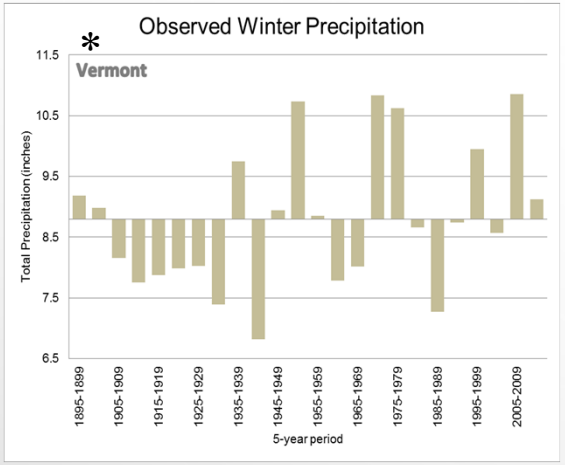


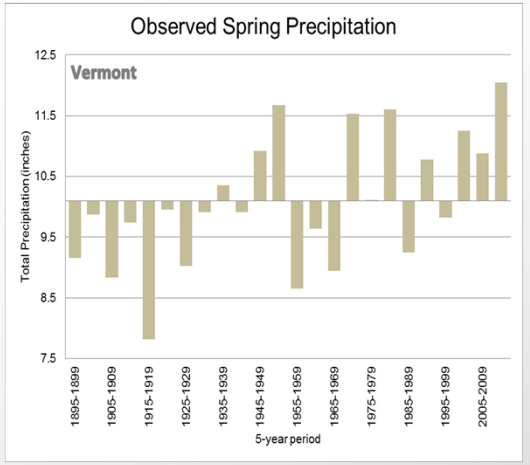


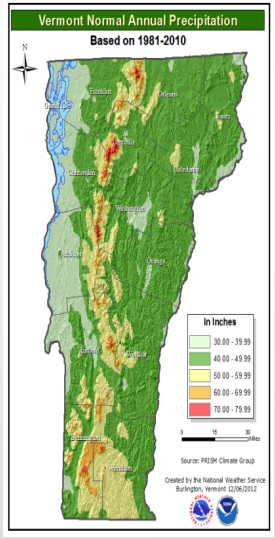
1895-2014, averaged over 5-year periods

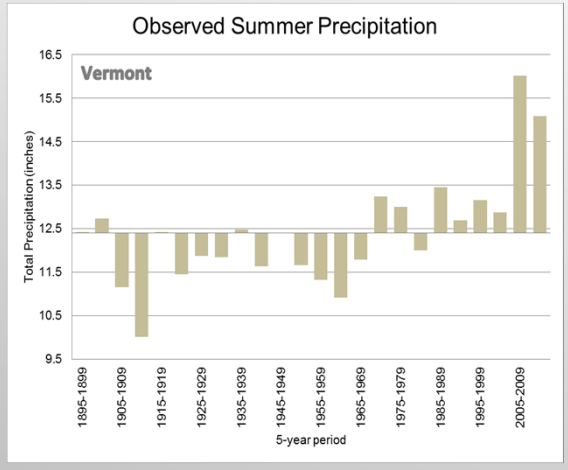
https://statesummaries.ncics.org/vt

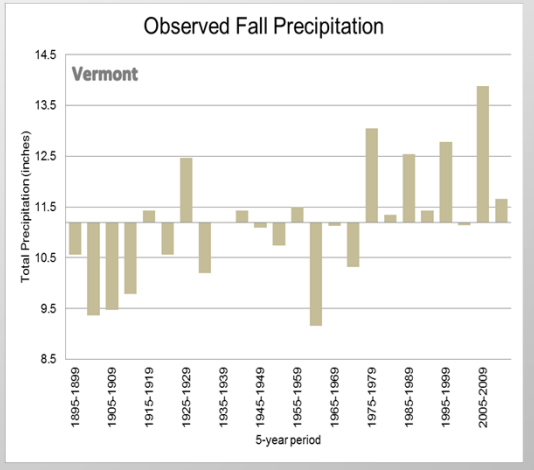
VARIATIONS IN THE AMOUNT OF PRECIPITATION











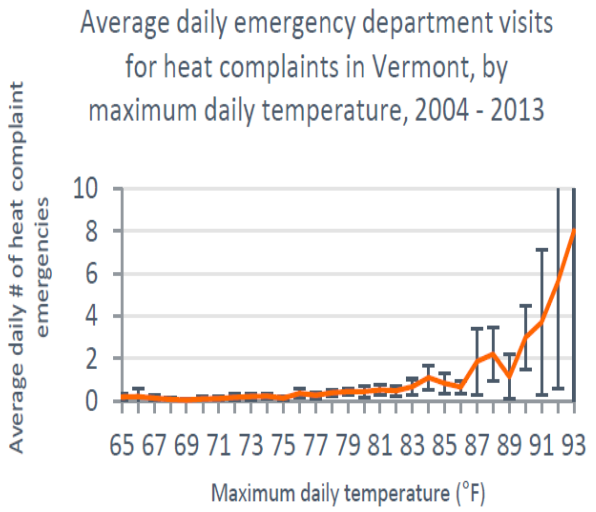
1895-2014, averaged over 5-year periods

https://statesummaries.ncics.org/vt

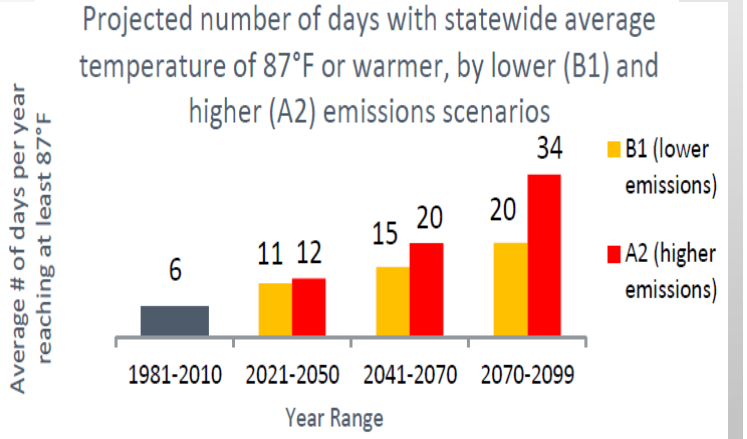
SECTORS THAT ARE SUSCEPTIBLE TO A CHANGING CLIMATE

HUMAN HEALTH

- HOT WEATHER (87°F)
- VULNERABLE POPULATIONS
- RISING LOW TEMPERATURES
- LYME DISEASE
- GROUND-LEVEL OZONE
- CLIMATE REFUGEES



Data sources: temperature data - PRISM Climate Group, in partnership with the Vermont State Climate Office; emergency department data - Early Aberration Reporting System (EARS).



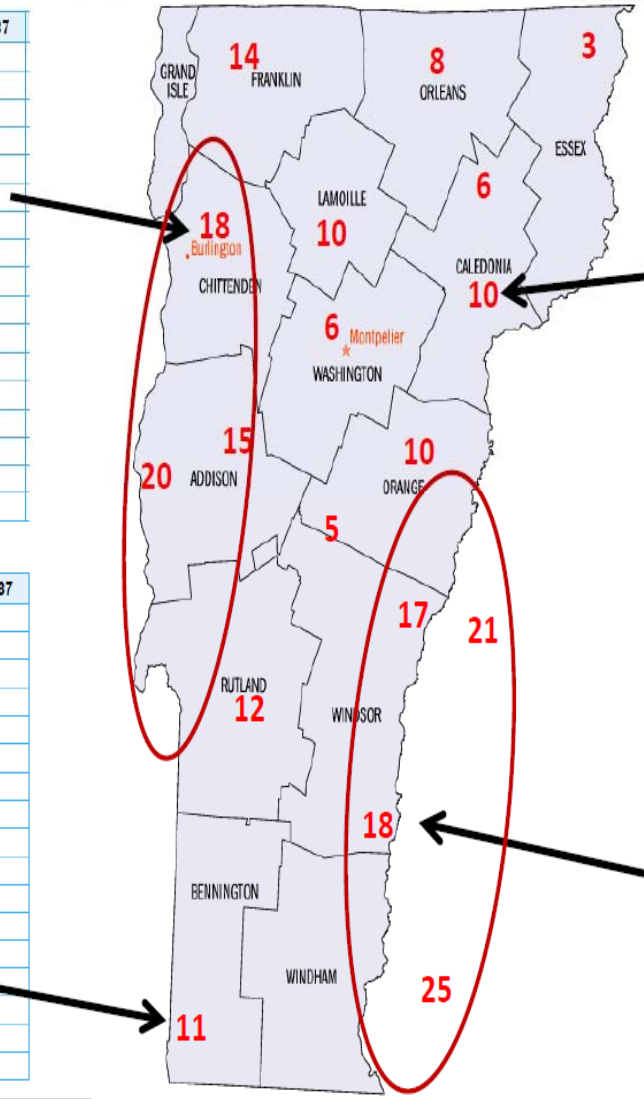
Projection Source: Vermont State Climate Office

VERMONT
DEPARTMENT OF HEALTH

Climatology of Mean # Days ≥ 87°

2000-2016

Year	Number of Days Max Temperature >= 87
2000	4
2001	24
2002	26
2003	18
2004	5
2005	24
2006	11
2007	21
2008	7
2009	9
2010	24
2011	15
2012	24
2013	19
2014	12
2015	23
2016	32



Year	Number of Days Max Temperature >= 87
2000	1
2001	27
2002	25
2003	6
2004	3
2005	13
2006	9
2007	14
2008	5
2009	6
2010	12
2011	9
2012	9
2013	11
2014	3
2015	8
2016	10

Year	Number of Days Max Temperature >= 87
2000	3
2001	9
2002	18
2003	3
2004	3
2005	18
2006	8
2007	13
2008	4
2009	6
2010	16
2011	9
2012	16
2013	16
2014	6
2015	16
2016	16

Year	Number of Days Max Temperature >= 87
2000	6
2001	26
2002	33
2003	13
2004	6
2005	27
2006	13
2007	17
2008	9
2009	8
2010	30
2011	18
2012	32
2013	18
2014	5
2015	22
2016	20

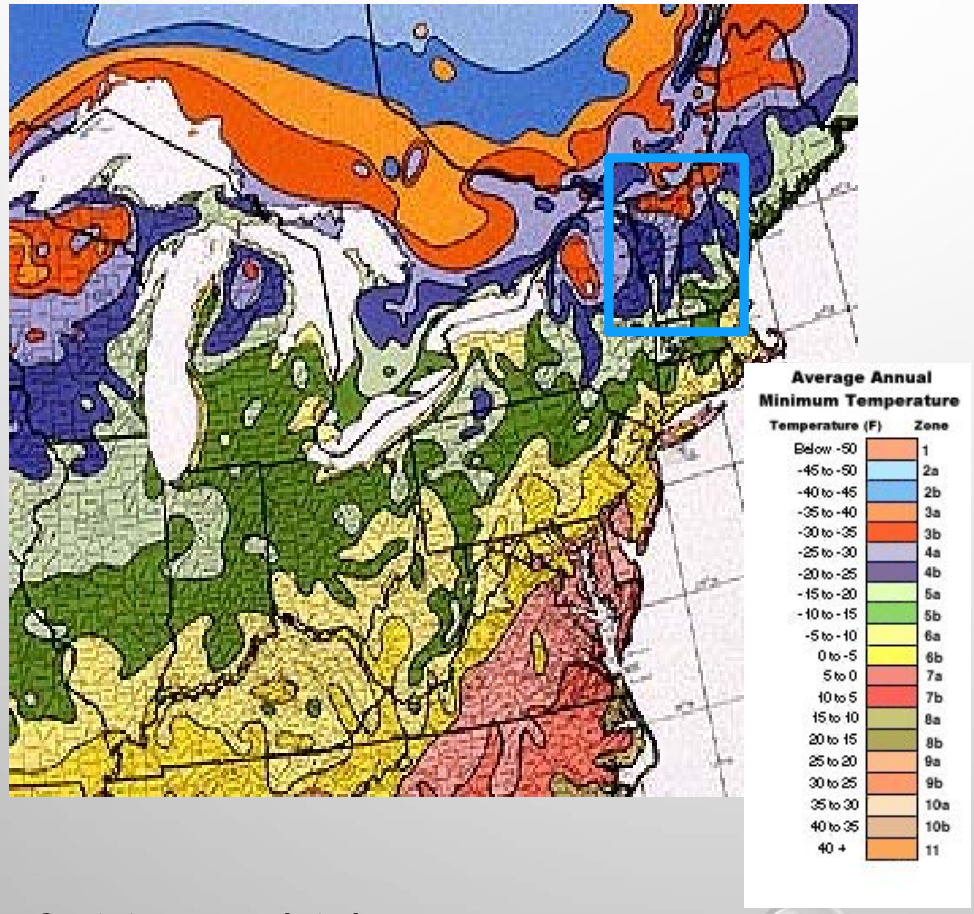
National Weather Service **Burlington** Follow Us: *www.weather.gov/btv*

Courtesy: NWS/Scott Whittier

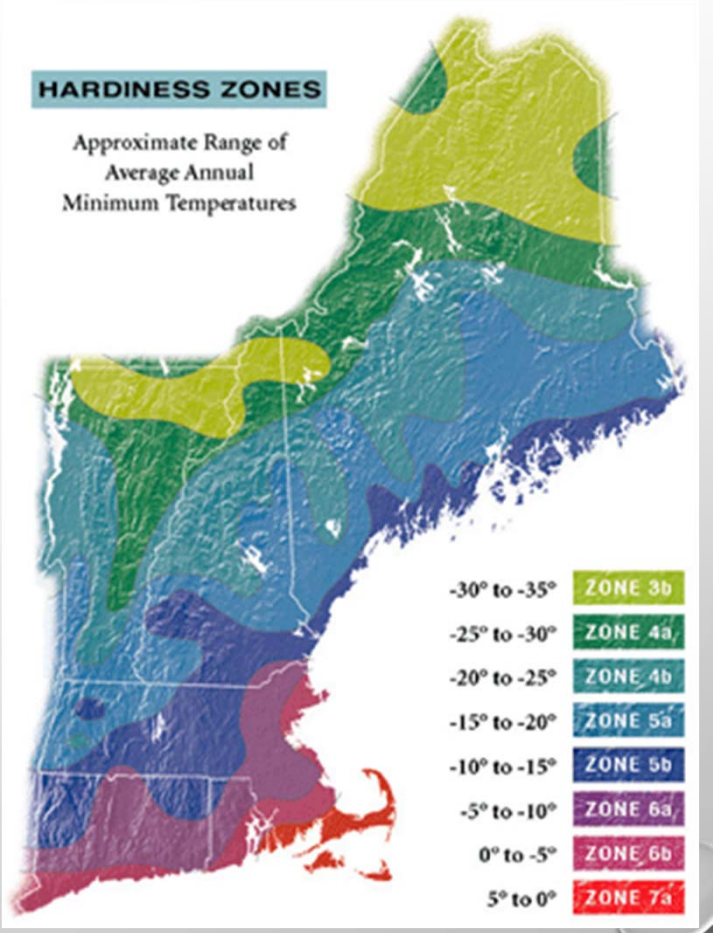
VEGETATION

http://usna.usda.gov/Hardzone/hzm-
http://www.arborday.org/treeinfo/z

PLANT HARDINESS MAPS



USDA National Arboretum



Arbor Day Foundation

AGRICULTURE

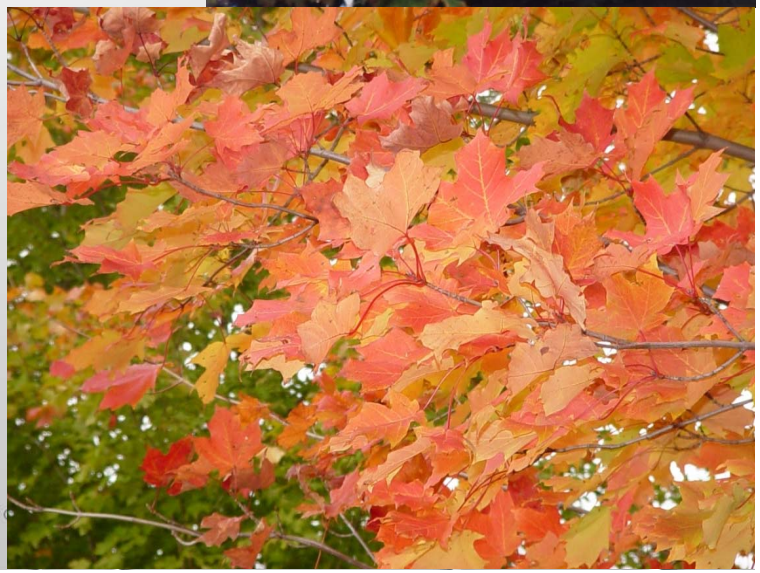
- SPRING
  - PLANTING DELAYS
  - FROSTS
- SUMMER
  - GROWTH & YIELDS AFFECTED BY PRECIPITATION EXTREMES
  - HEAT WAVES
- FALL
  - EARLY FROSTS
  - CHANGES IN PLANT SELECTION IN RESPONSE TO INCREASED PRECIPITATION
- WINTER
  - SWINGS
  - FREEZING OF SOILS – INFLUENCE ON COLD TOLERANCE (PAUL SCHABERG, USFS)

Field near Sam Mazza's stand – 5 August 2016

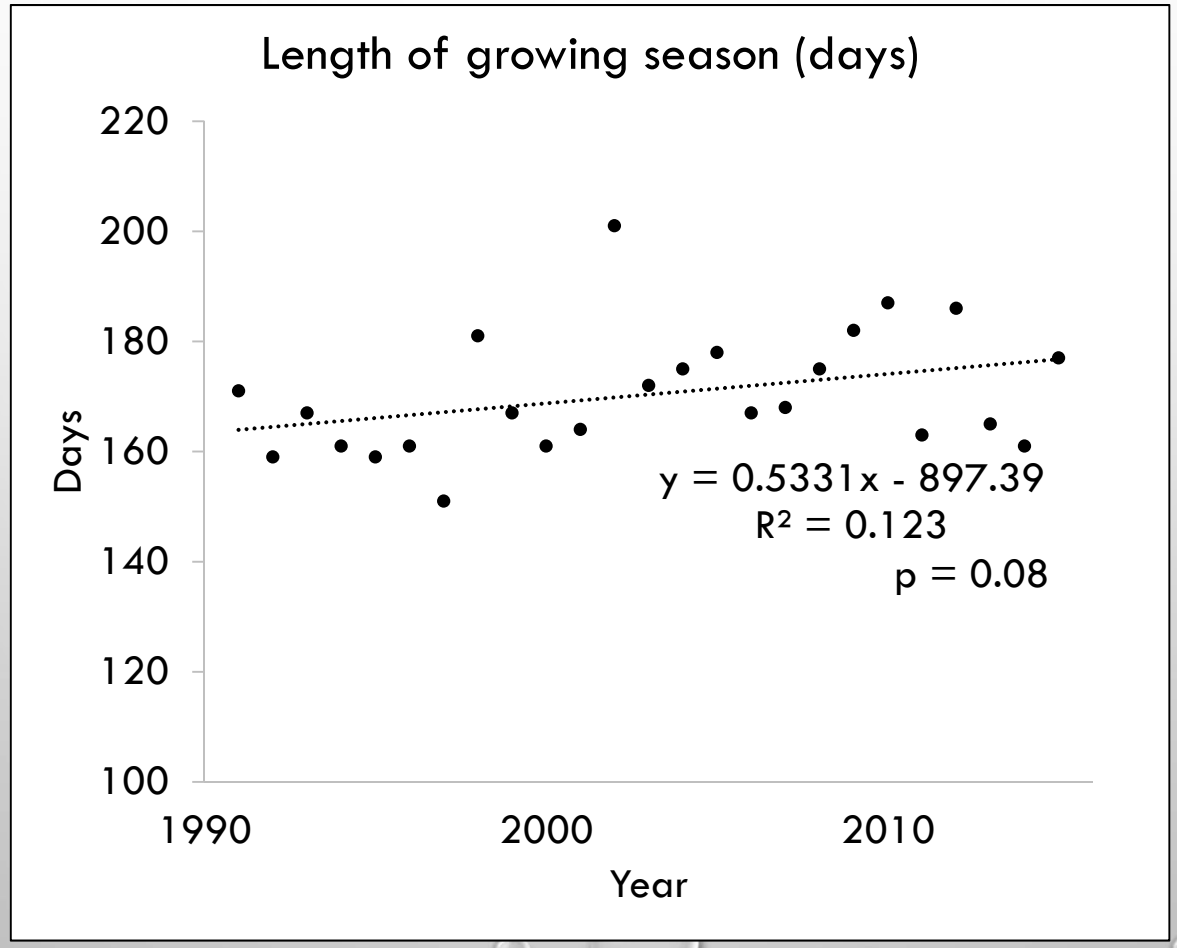
Photos: L-A. Dupigny-Giroux

FORESTRY AND TREE CROPS

- INVASIVE SPECIES – EMERALD ASH BORER
- WILDFIRE THREAT
- SPRING
  - FROSTS AND CHRISTMAS TREES
  - OVER-WINTER INJURY TO RED PINE
  - LENGTH AND QUALITY OF MAPLE SAP PRODUCTIONS
- SUMMER
  - DROUGHTS AND FALL FOLIAGE (EARLY)
  - OUTBREAKS AND DEFOLIATION (FTC)
- FALL
  - EARLY FROSTS
  - LATE FREEZES – LEAF DROP; EARLY SNOWFALL
  - DROUGHTS & FALL FOLIAGE (LATE)



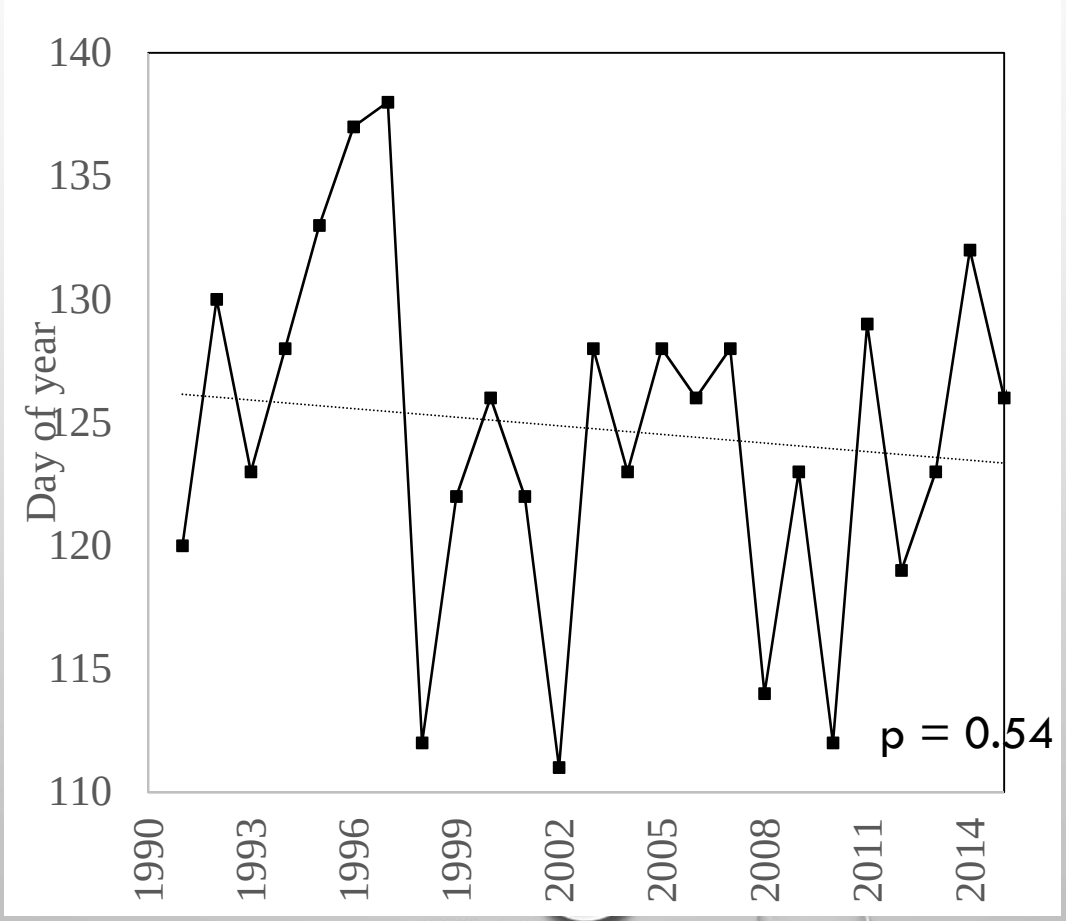
LENGTH OF GROWING SEASON – GRADUALLY EXTENDING (UNDERHILL SITE)



Josh Halman
VT Dept. of Forests, Parks and Recreation

EARLY SEASON PHENOLOGY: 1990 - 2016

Average Sugar Maple Budbreak – Underhill site



Josh Halman
VT Dept. of Forests, Parks and Recreation

GROUND-LEVEL OZONE

Ozone Injury to White Ash
Photo by Gretchen Smith

- REDUCES PLANT GROWTH & VIGOR
- REDUCES SEED PRODUCTION
- INCREASES SUSCEPTIBILITY TO INSECTS & DISEASE
- CUMULATIVE EFFECT OVER GROWING SEASON
- BLACK CHERRY, WHITE ASH, YELLOW POPLAR

RECREATION AND TOURISM

- LAKE AND RIVER-BASED ACTIVITIES
  - WATER TEMPERATURES
  - WATER LEVELS
- COLD-SEASON ACTIVITIES
  - SNOWFALL
  - DROUGHT
- LEAF PEEPING

Photos: L-A. Dupigny-Giroux

LOW LAKE LEVELS – ST. ALBANS BAY 8 JULY 2016

Photos: L-A. Dupigny-Giroux

FLOODING – BURLINGTON WATERFRONT

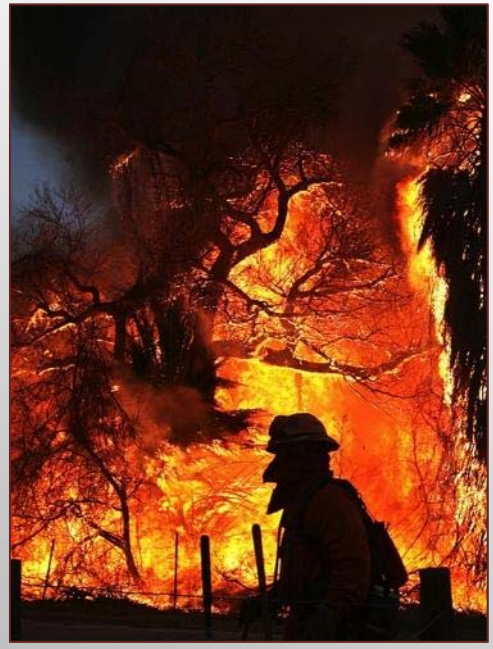
6 May 2019

Photos: L-A. Dupigny-Giroux

INFRASTRUCTURE

- ROADS AND HIGHWAYS
- RAIL (HEAT) AND AIRPORTS (BLIZZARDS)
- ELECTRICAL GRID
- WATER SUPPLIES
- CRITICAL INFRASTRUCTURE

PEOPLE & COMMUNITIES ARE EXPERIENCING MORE / MORE FREQUENT EXTREME EVENTS…



©AP Photo/The Press-Enterprise, Terry Pierson

Department of Defense, 2014

© Scott Olson/Getty Images

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© Dave Martin/AP/Corbis

…WITH COSTLY DAMAGES TO PROPERTY, STRUCTURES, AND INFRASTRUCTURE.

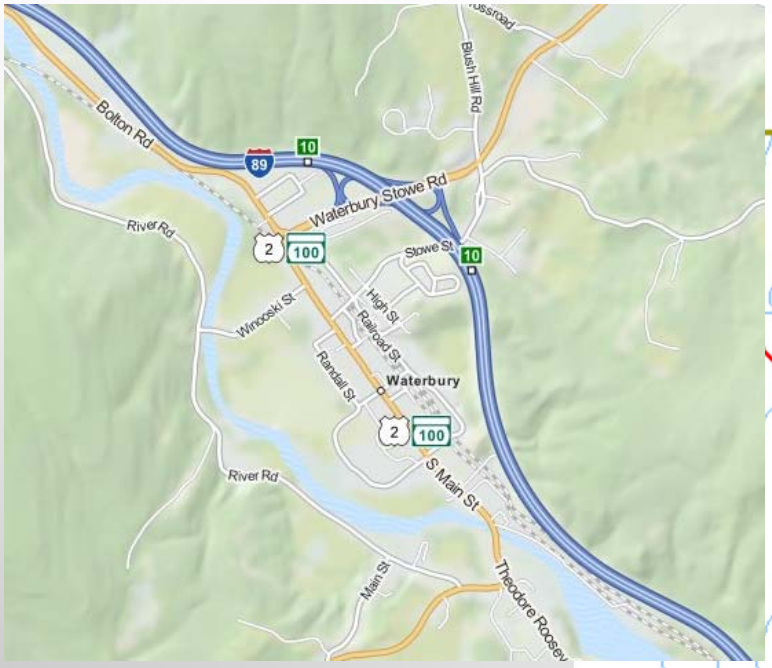
Credit: Virginia Pilot, Steve Earley

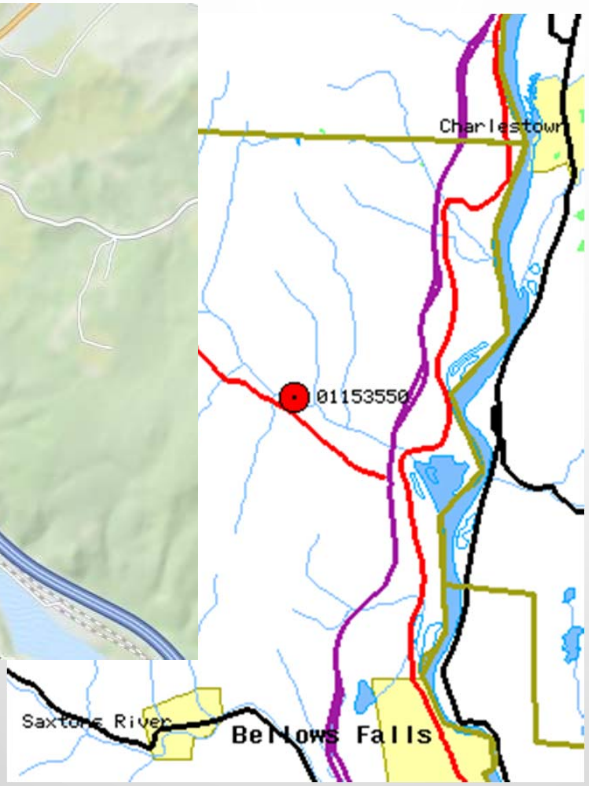
Source: U.S. Postal Service, 2014

Credit: William Vantuono, Railway Age Magazine, 2012

Credit: Vermont Agency of Transportation, 2013

JUXTAPOSITION OF RIVERS & ROADS TAKES A TOLL ON INFRASTRUCTURE

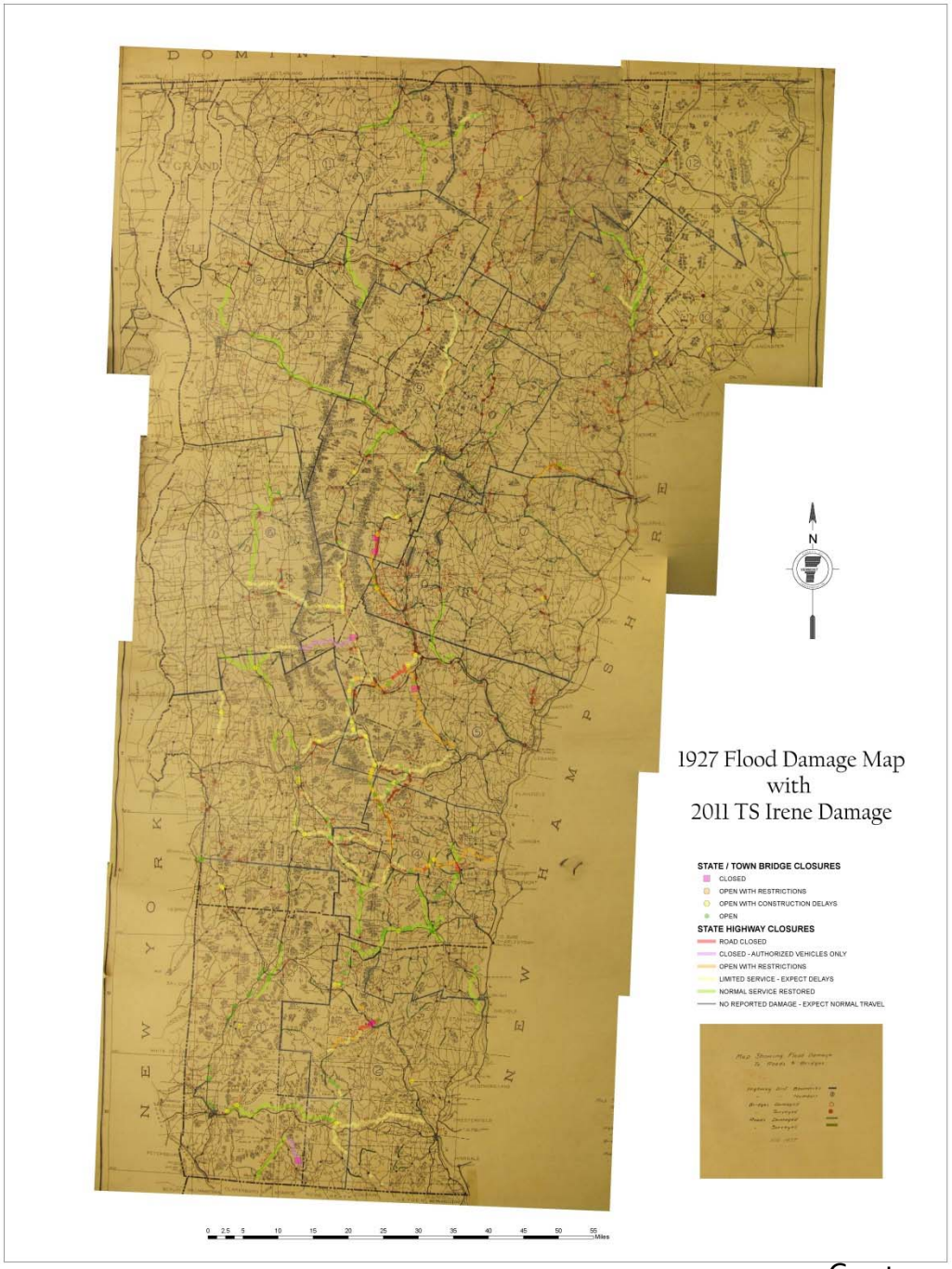




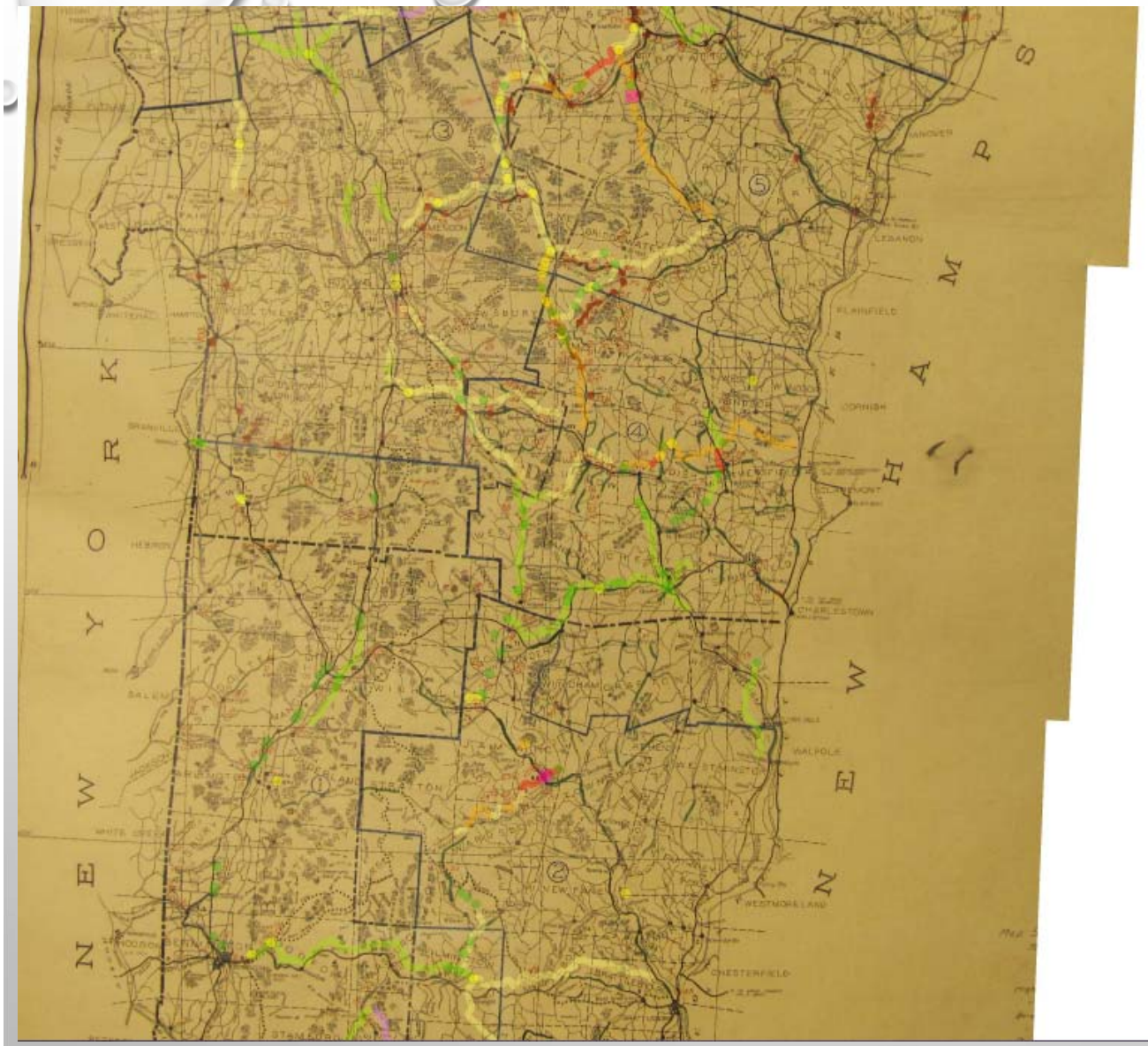
- REPEAT OCCURRENCES IN PREFERRED LOCATIONS
  - JAY PEAK, ROUTE 100

Montgomery flooding - July 199

Photo credit: NWS/BTV



Courtesy: Johnathan Croft, VTRans



1927 Flood Damage Map with 2011 TS Irene Damage

STATE / TOWN BRIDGE CLOSURES

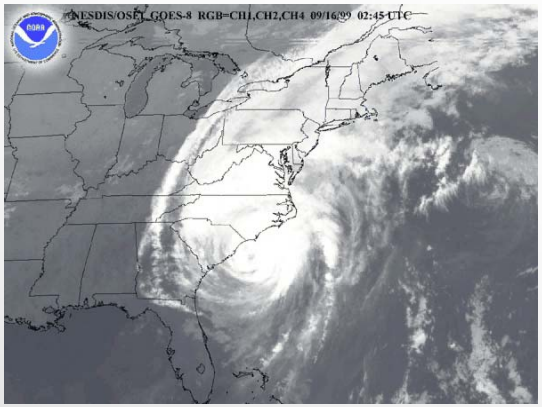
- CLOSED
- OPEN WITH RESTRICTIONS
- OPEN WITH CONSTRUCTION DELAYS
- OPEN

STATE HIGHWAY CLOSURES

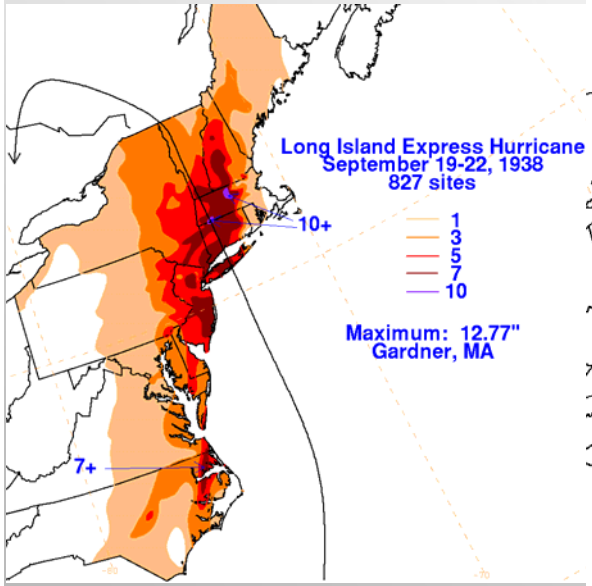
- ROAD CLOSED
- CLOSED - AUTHORIZED VEHICLES ONLY
- OPEN WITH RESTRICTIONS
- LIMITED SERVICE - EXPECT DELAYS
- NORMAL SERVICE RESTORED
- NO REPORTED DAMAGE - EXPECT NORMAL TRAVEL

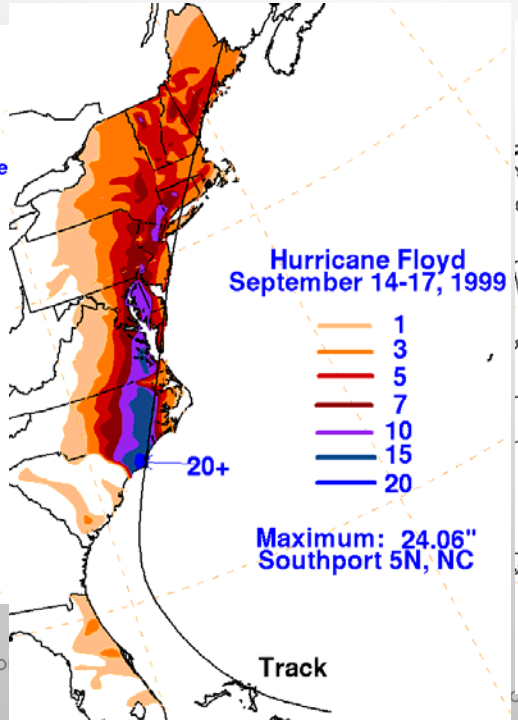
Courtesy: Johnathan Croft, VTRans

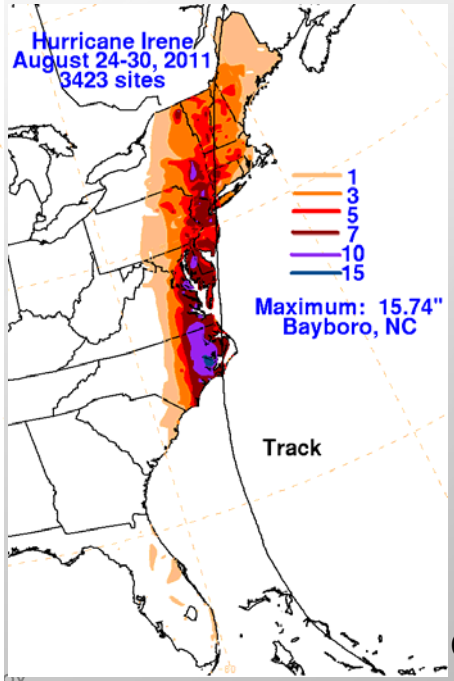
TROPICAL CYCLONES & REMNANTS



- NOVEMBER 1927
- AUGUST 1955 (CONNIE, DANNY)
- JUNE 1972 (AGNES)
- AUGUST 1998 (BONNIE)
- SEPTEMBER 1999 (DENNIS, FLOYD)
- AUGUST 2011 (IRENE)



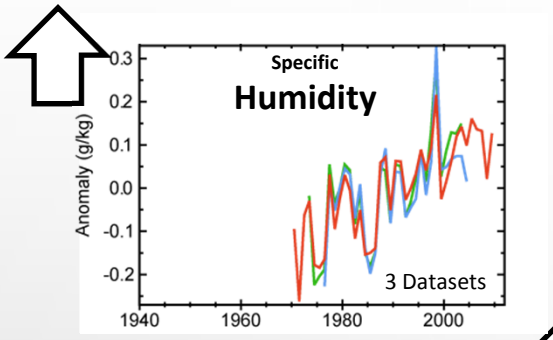


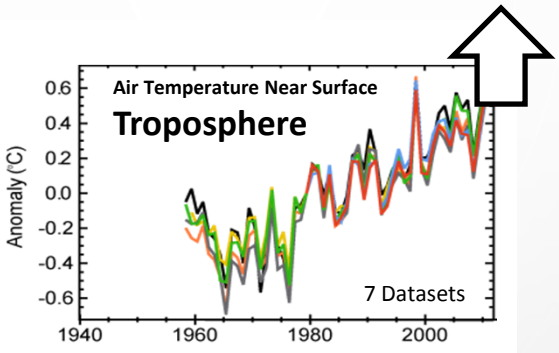


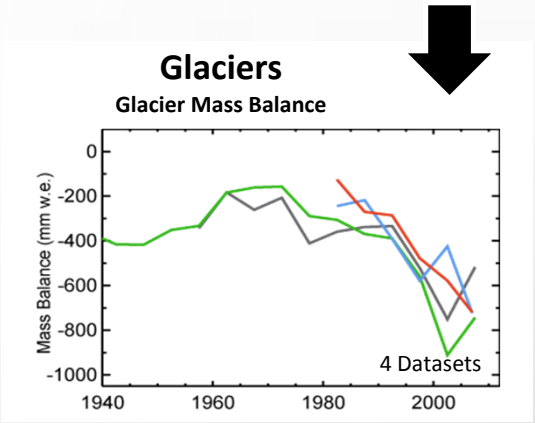
Courtesy: NOAA

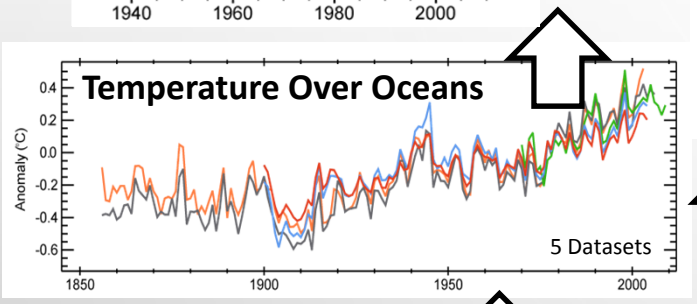
WHY THE CONCERN ABOUT HURRICANES?

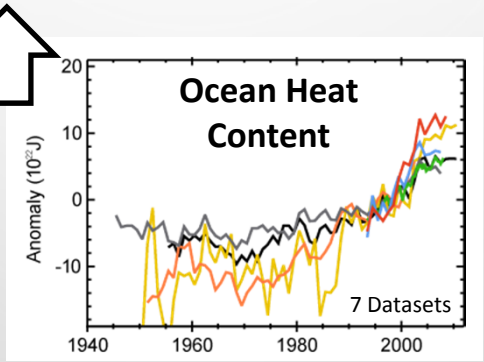
STATE OF THE CLIMATE INDICATORS

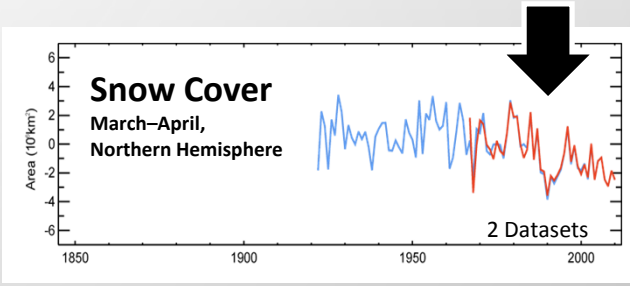


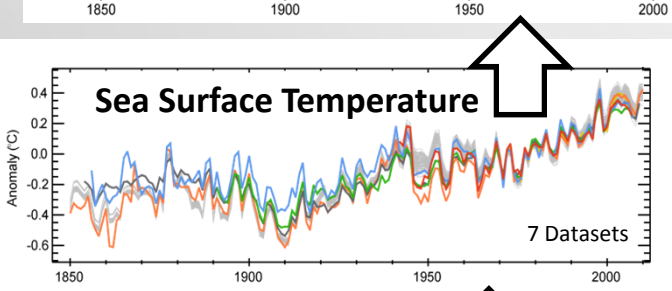


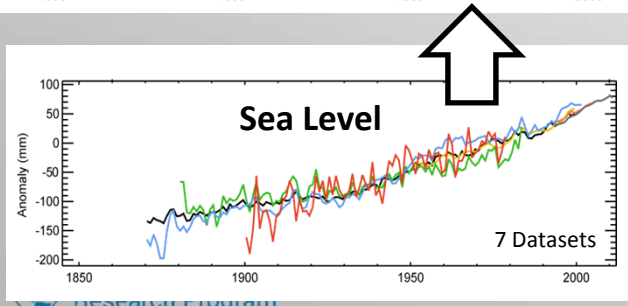


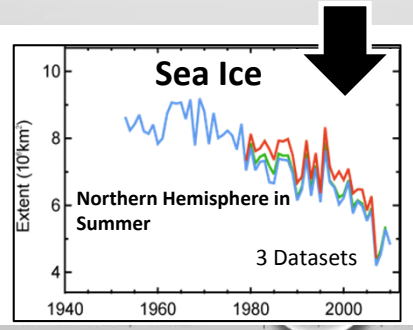


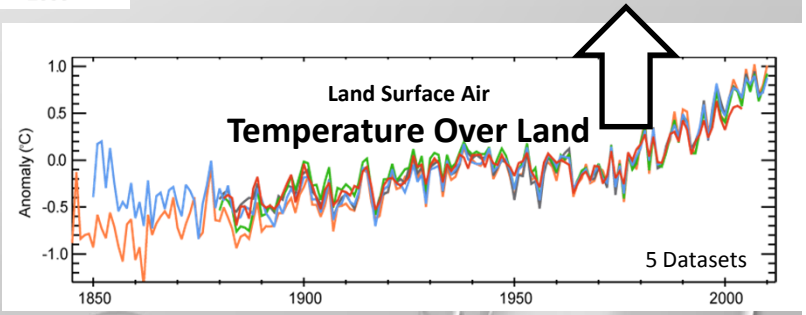












CNN U.S. » Hurricanes are slowing, which could be a big problem Live TV U.S. Edition +

Hurricanes are slowing, which could be a big problem

https://www.cnn.com/2018/06/06/us/hurricanes-slowing-wxc/index.html

By Brandon Miller, CNN

Updated 3:58 PM ET, Wed June 6, 2018

Source: CNN

In the Wake of Harvey 03:12

Story highlights

There has been a 10% decrease in tropical cyclone forward speed since 1949, a new study finds

(CNN) — Hurricanes and tropical storms, known as tropical cyclones, are moving slower around the planet, according to a new study from National Oceanic and Atmospheric Administration scientist James Kossin.

CNN US World Politics Business Opinion Health Entertainment Sty

TRENDING: Hurricane Dorian | California boat fire | West Texas shoo

Dorian is barely moving at 1 mph

The strongest storm ever to hit the Bahamas has killed at least five people. The hurricane is expected to be 'dangerously close' to Florida Tuesday.

Track the storm here | In the storm's path? Bookmark CNN's lite site

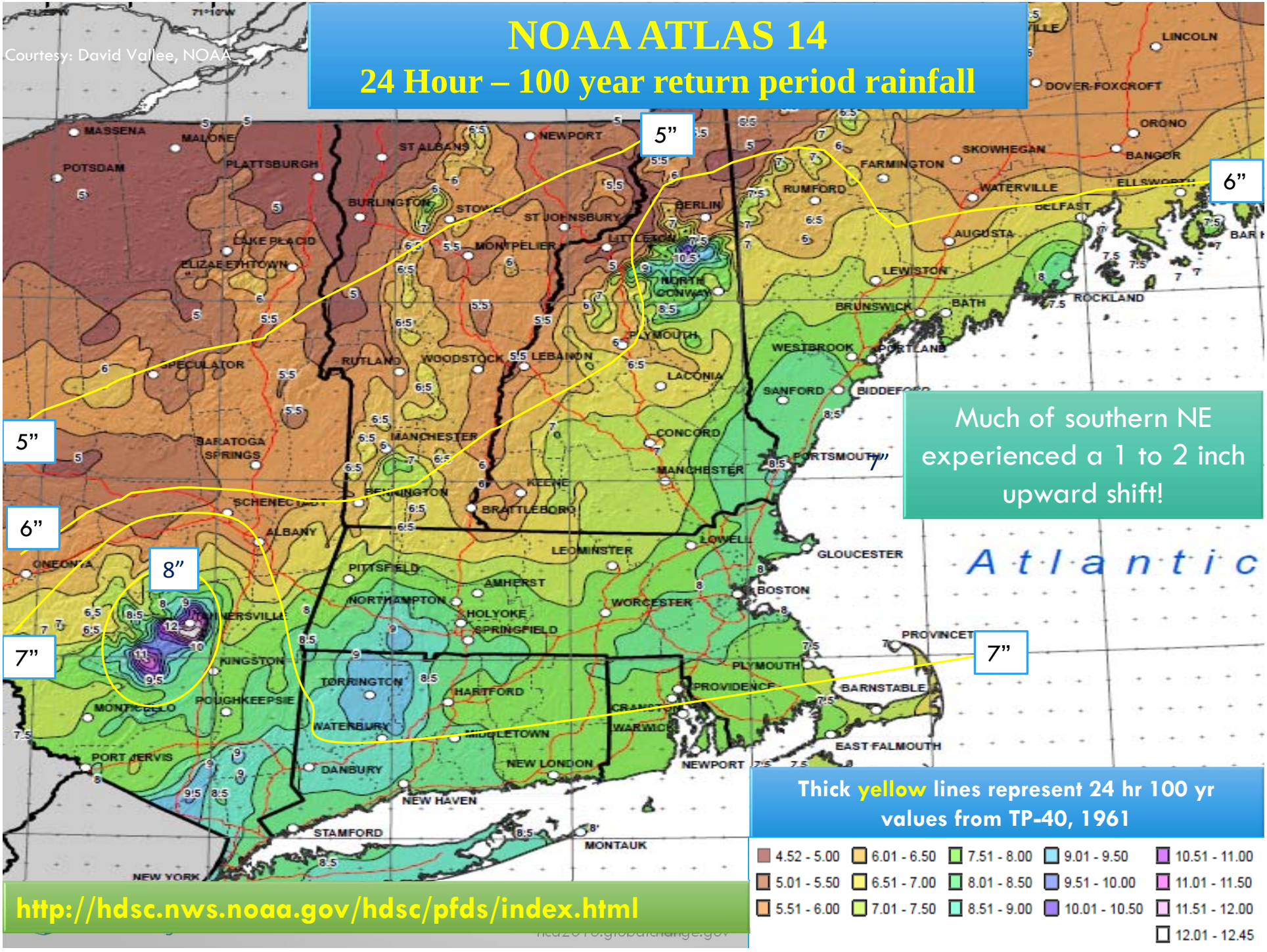
This is Hurricane Dorian's latest track

Hurricane Dorian obliterates houses in the Bahamas

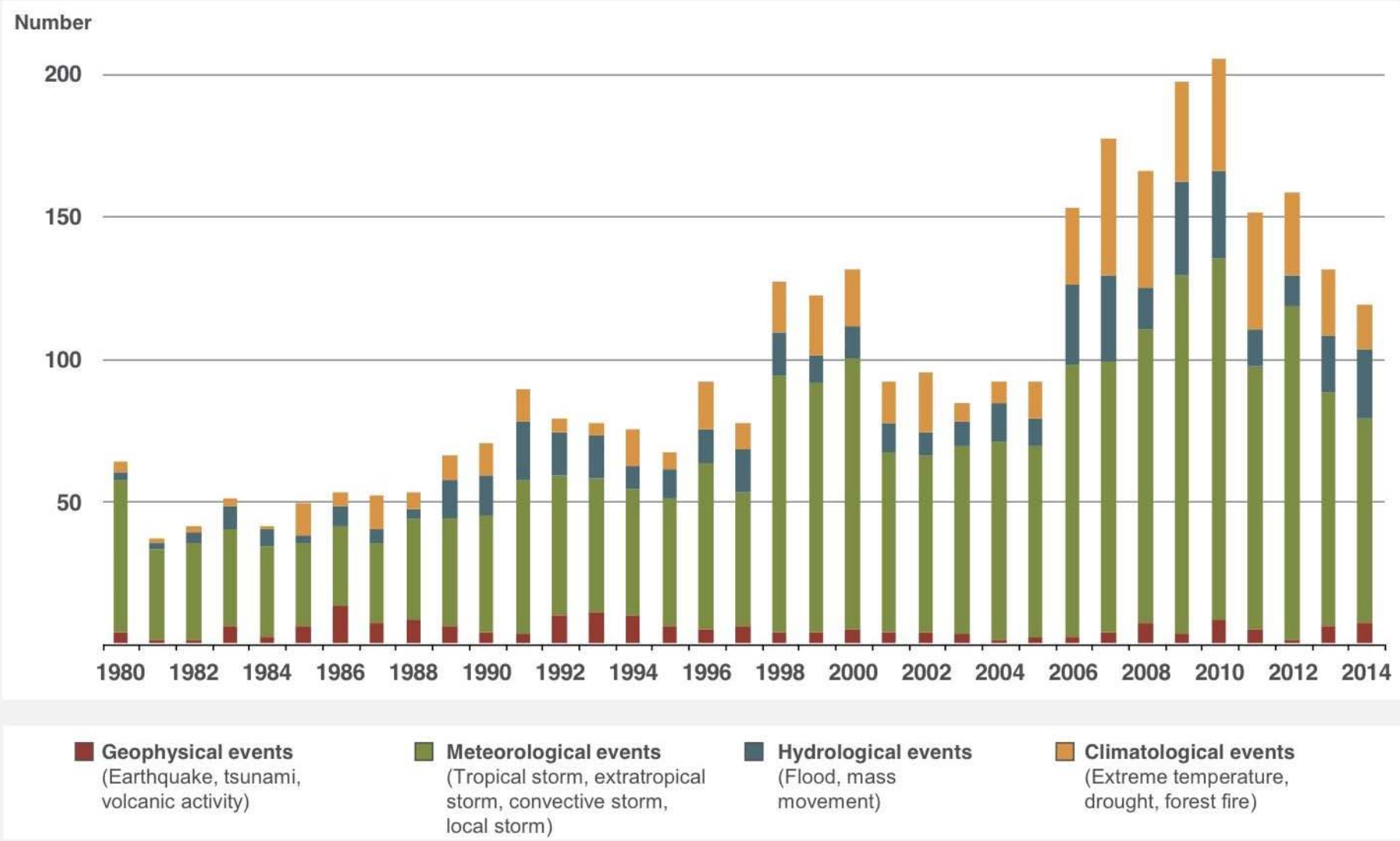
WATCH LIVE Conditions in Florida intensify as Dorian nears

See Air Force fly a reconnaissance plane through the eye

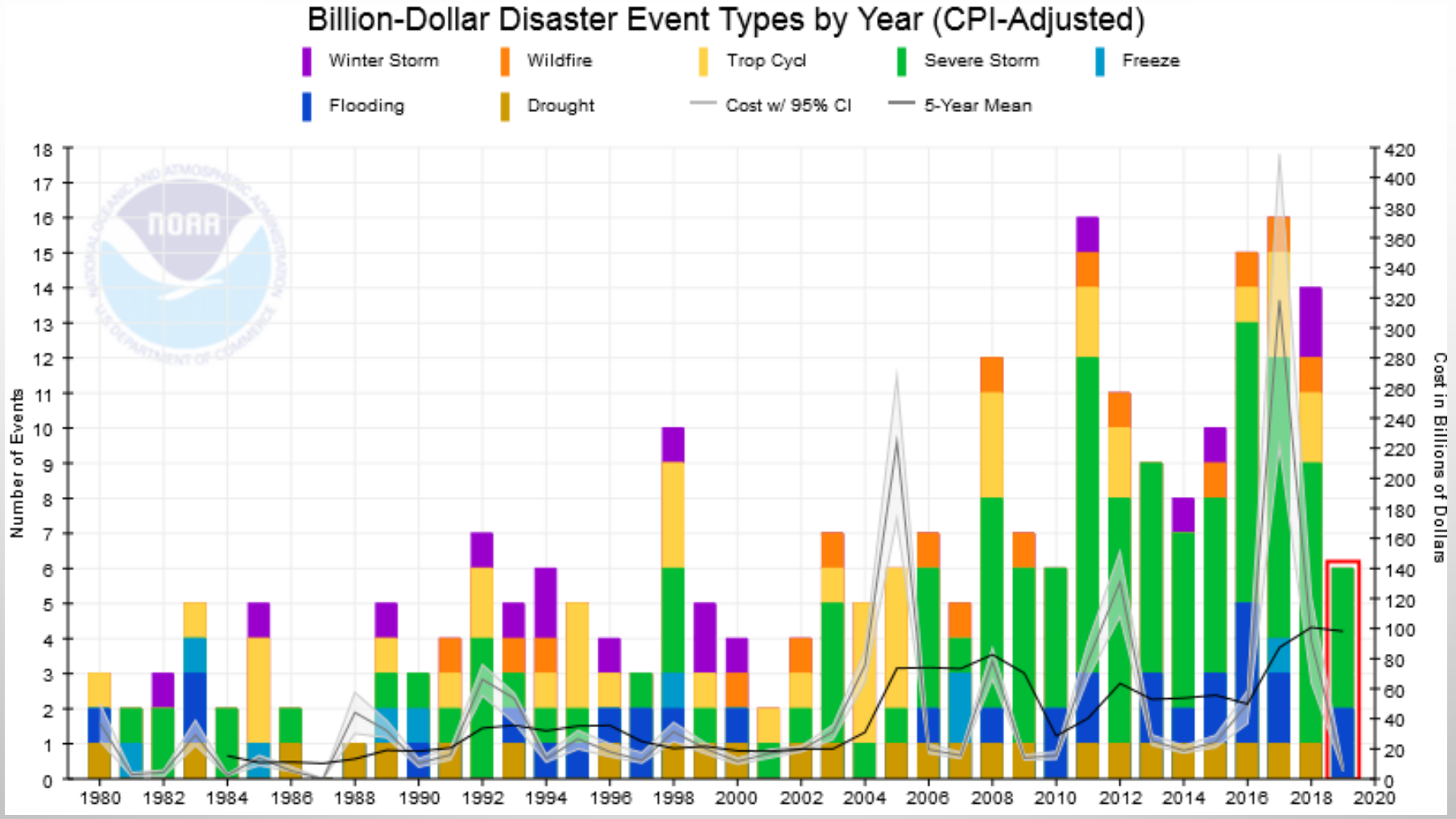
http://www.cnn.com/


NOAA ATLAS 14
24 Hour – 100 year return period rainfall
Courtesy: David Vallee, NOAA
5”
6”
5”
6”
8”
7”
7”
7”
Much of southern NE experienced a 1 to 2 inch upward shift!
Thick yellow lines represent 24 hr 100 yr values from TP-40, 1961
4.52 - 5.00
5.01 - 5.50
5.51 - 6.00
6.01 - 6.50
6.51 - 7.00
7.01 - 7.50
7.51 - 8.00
8.01 - 8.50
8.51 - 9.00
9.01 - 9.50
9.51 - 10.00
10.01 - 10.50
10.51 - 11.00
11.01 - 11.50
11.51 - 12.00
12.01 - 12.45
http://hdsc.nws.noaa.gov/hdsc/pfds/index.html

NATURAL CATASTROPHES ARE ON THE RISE…

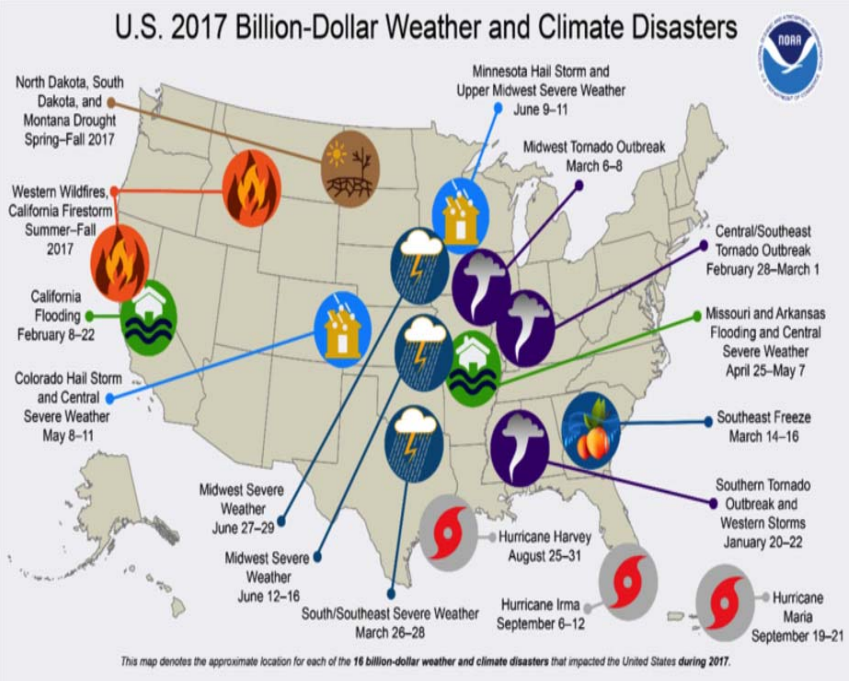


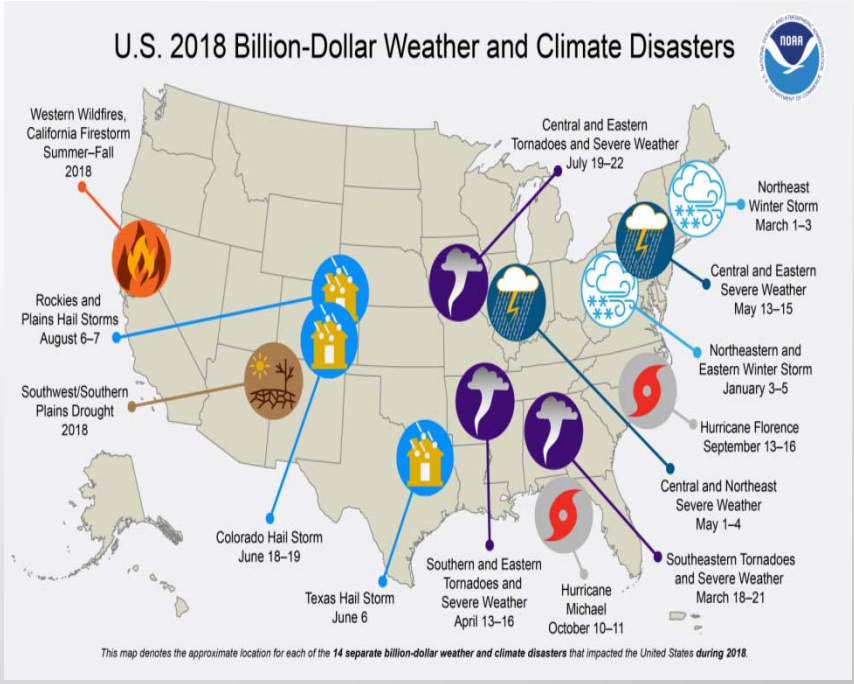
https://www.ncdc.noaa.gov/billions/time-series



"In 2018, there were 14 separate billion-dollar weather and climate disaster events across the United States, with a total cost of $91 billion. The total cost over the last 3 years (2016-2018) exceeds **$450 billion**- averaging **$150 billion/year**. The total cost over the last 5 years (2014-2018) is approximately **$500 billion** - averaging **$100 billion/year**, as indicated by the black line below." as of 9 July 2019

BILLION DOLLAR DISASTERS





SUMMARY REMARKS

- SYSTEMS APPROACH – LAND, OCEAN, ATMOSPHERE
- IMPORTANCE OF TOPOGRAPHY & GEOGRAPHY
- TIME & SPACE SCALES
- MULTI-HAZARD APPROACH
  - COASTAL/INLAND; TIMING
- MULTIPLE VULNERABILITIES
- ZONING, FLOODPLAIN USAGE, COMMUNITY RESILIENCE

THANK YOU!

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