CLIMATE CHANGE

LOCAL CHANGES AND IMPACTS

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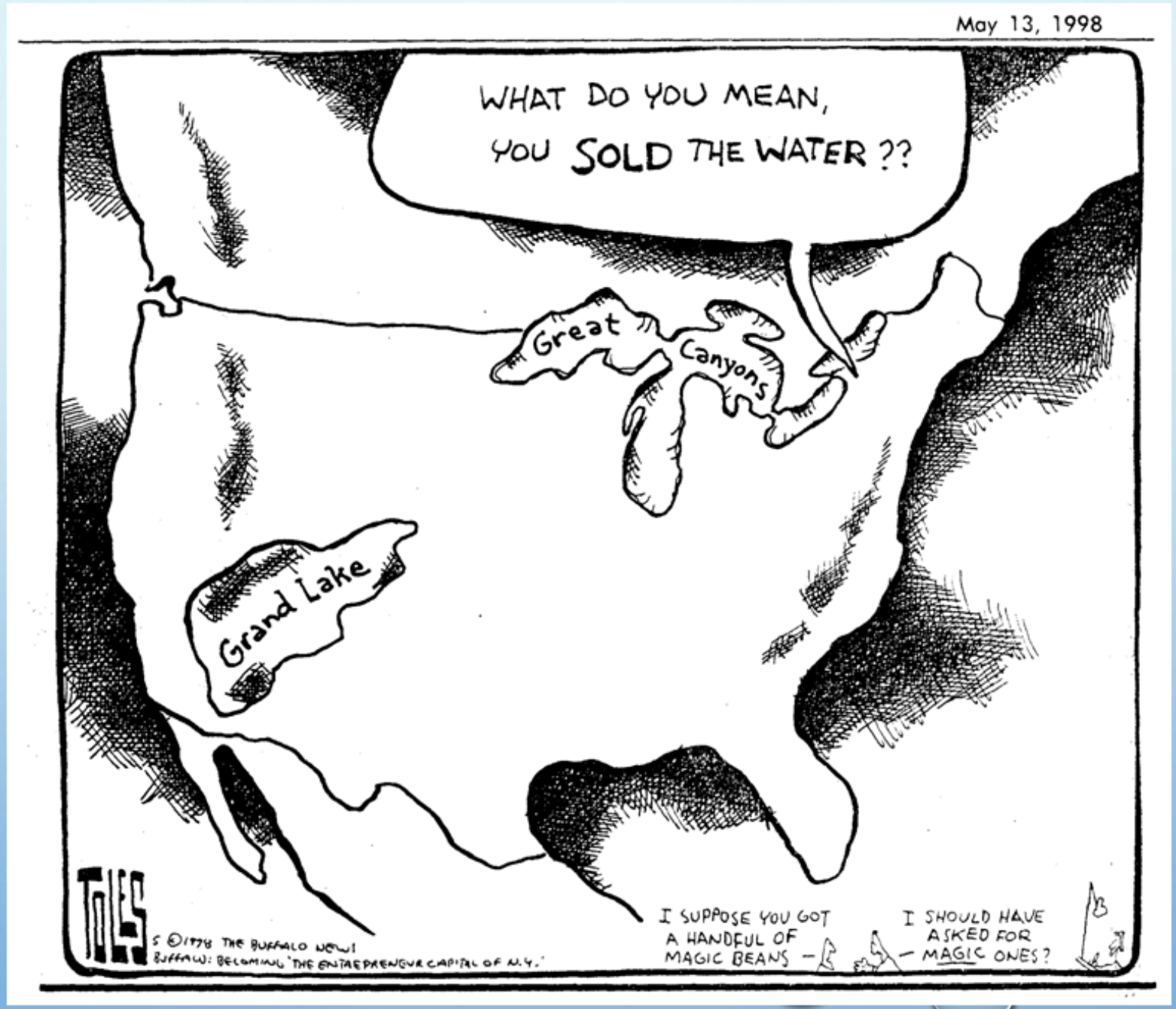
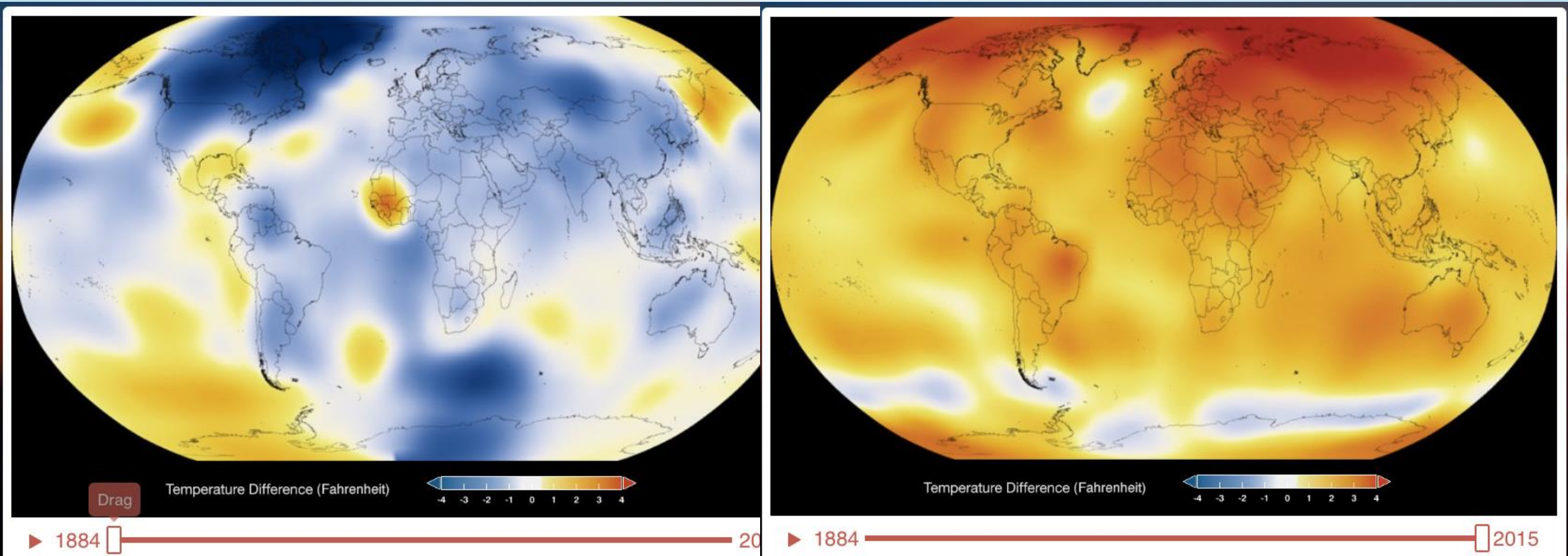
LIAA WORKSHOP

HANCOCK, 2016-06-13

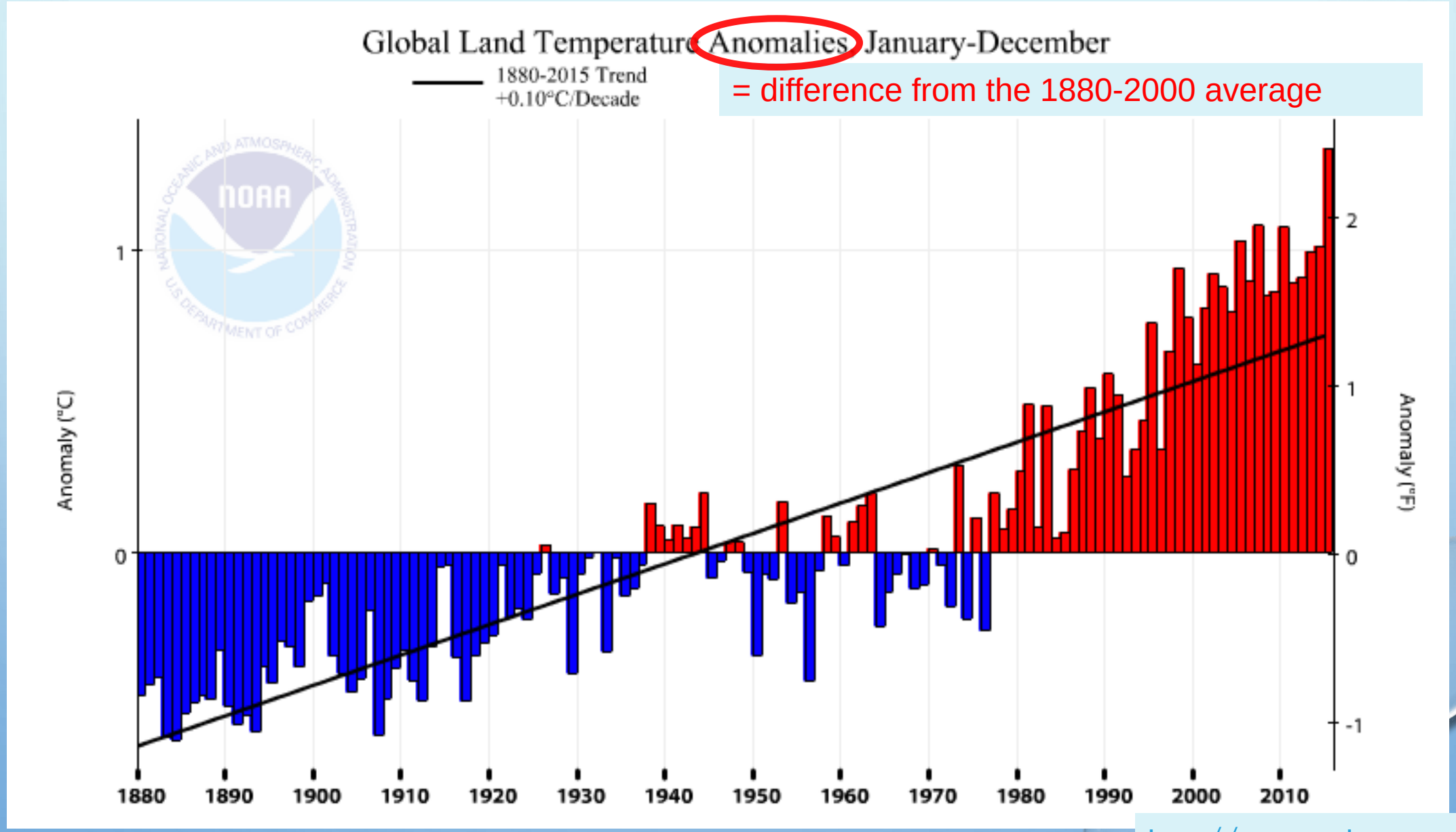

May 13, 1998
WHAT DO YOU MEAN, YOU SOLD THE WATER ??
Great Canyons
Grand Lake
TOLES
© 1998 THE BUFFALO NEWS
BUFFALO: BECOMING "THE ENTREPRENEUR CAPITAL OF N.Y."
I SUPPOSE YOU GOT A HANDFUL OF MAGIC BEANS —
I SHOULD HAVE ASKED FOR — MAGIC ONES?

GLOBAL TEMPERATURE CHANGE SINCE 1885

- NASA MOVIE HTTP://CLIMATE.NASA.GOV/INTERACTIVES/CLIMATE-TIME-MACHINE - /

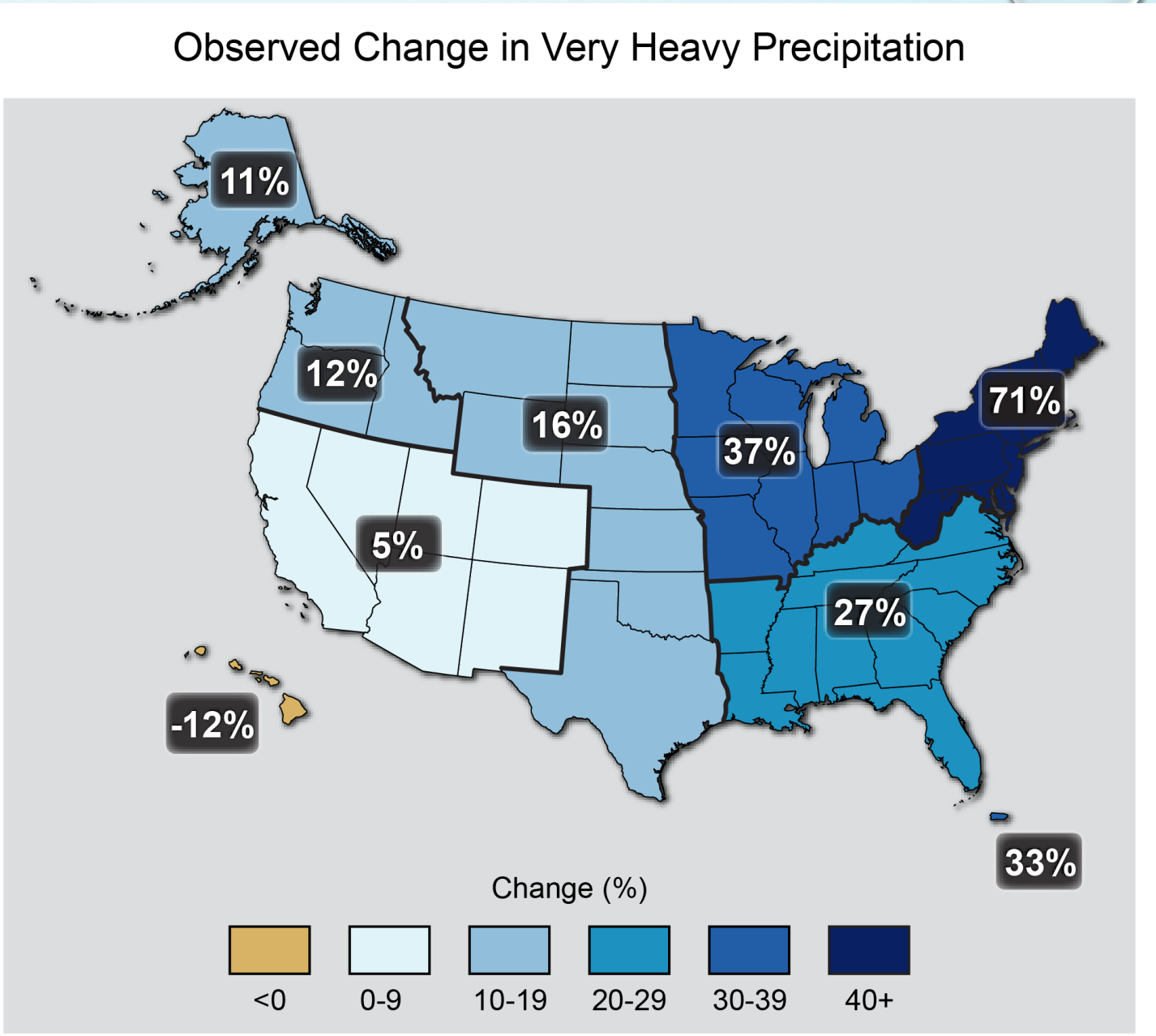


Warming climate



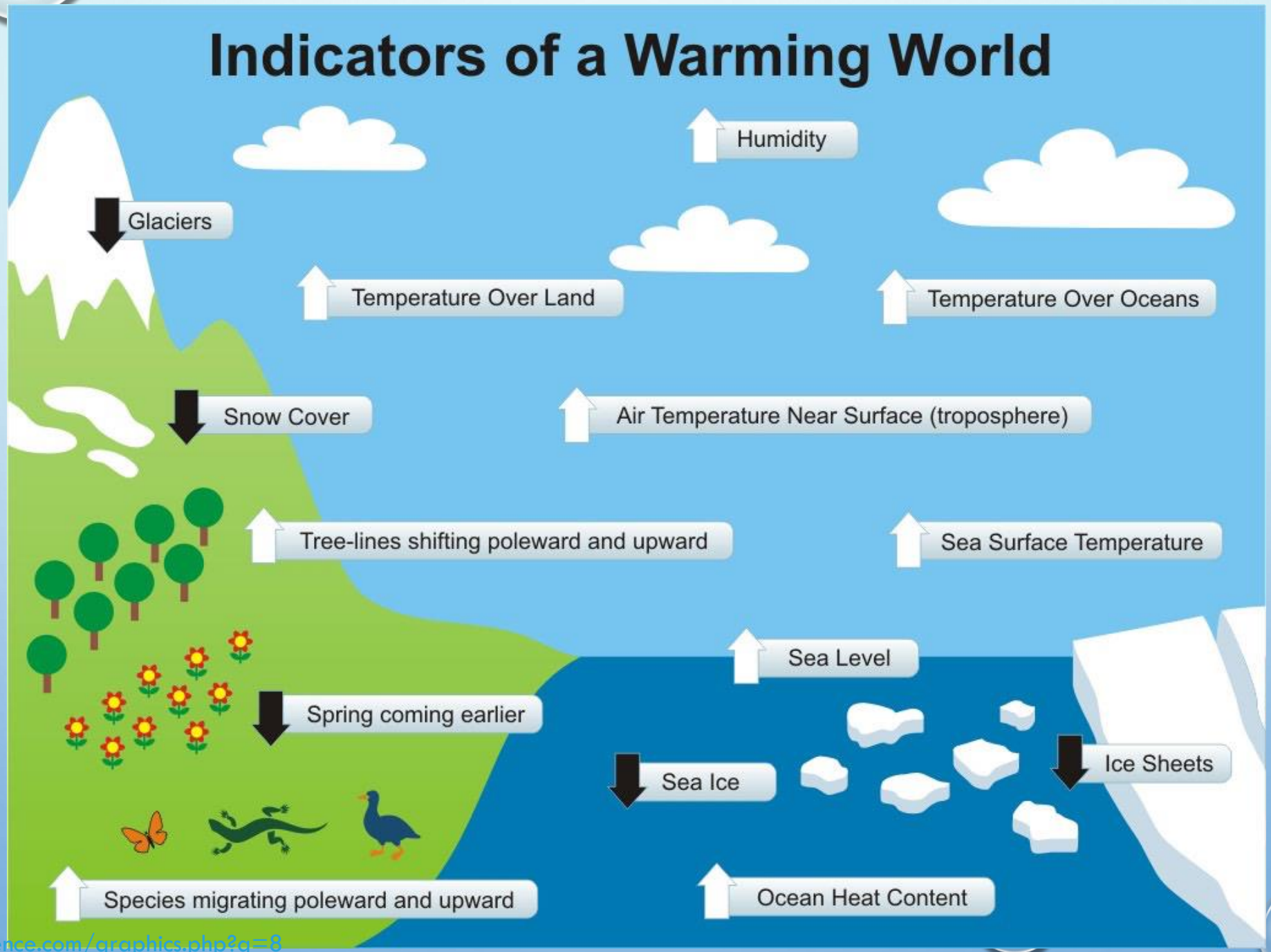
http://www.ncdc.noaa.gov/cag/

The map shows percent increases in the amount of precipitation falling in very heavy events (defined as the heaviest 1% of all daily events) from 1958 to 2012 for each region of the continental United States. These trends are larger than natural variations for the Northeast, Midwest, Puerto Rico, Southeast, Great Plains, and Alaska. (Figure source: updated from Karl et al. 2009

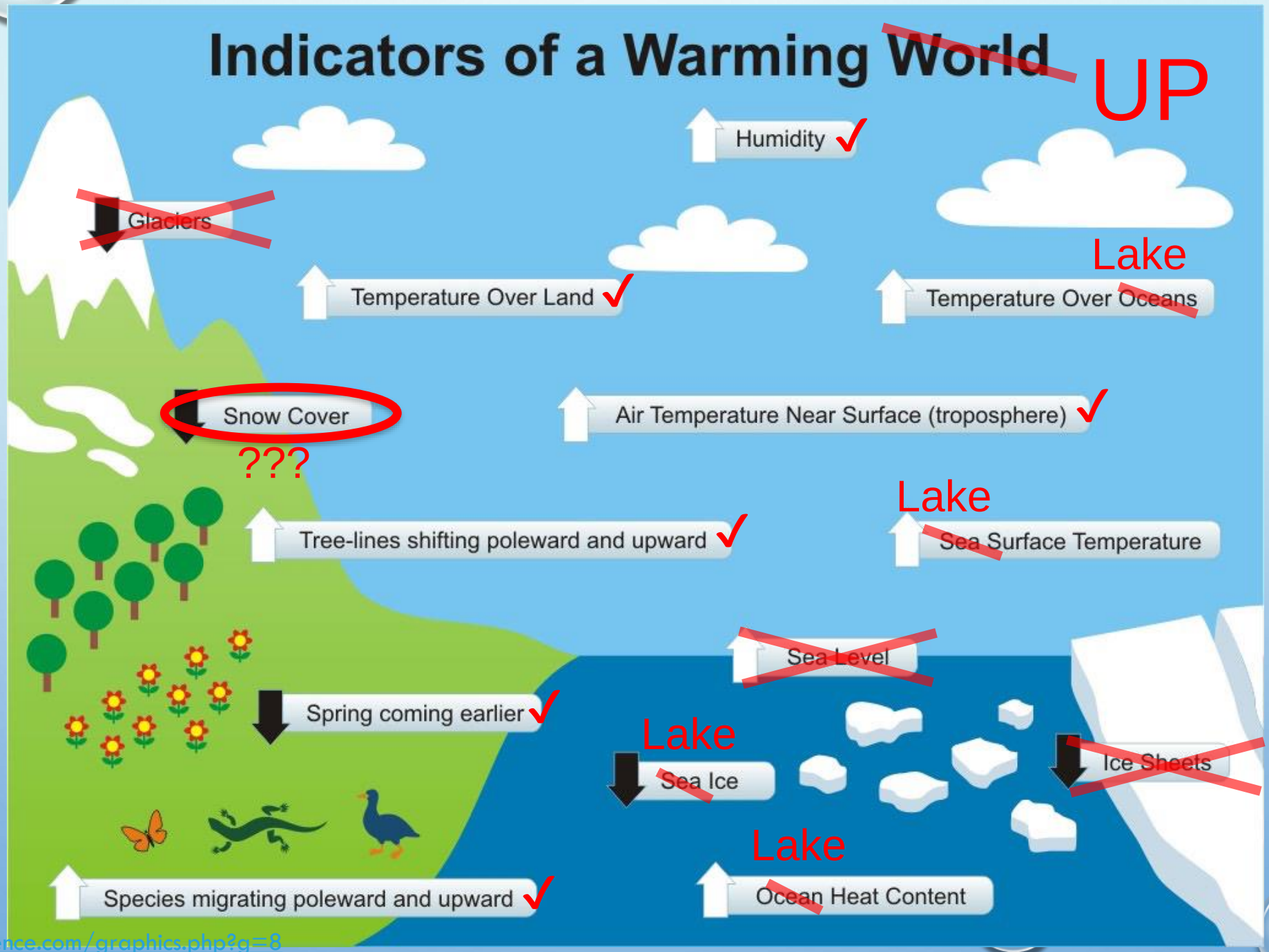


http://nca2014.globalchange.gov/highlights/overview/overview/graphics/observed-change-very-heavy-precipitation

Climate Change Impacts in the United States: The Third National Climate Assessment



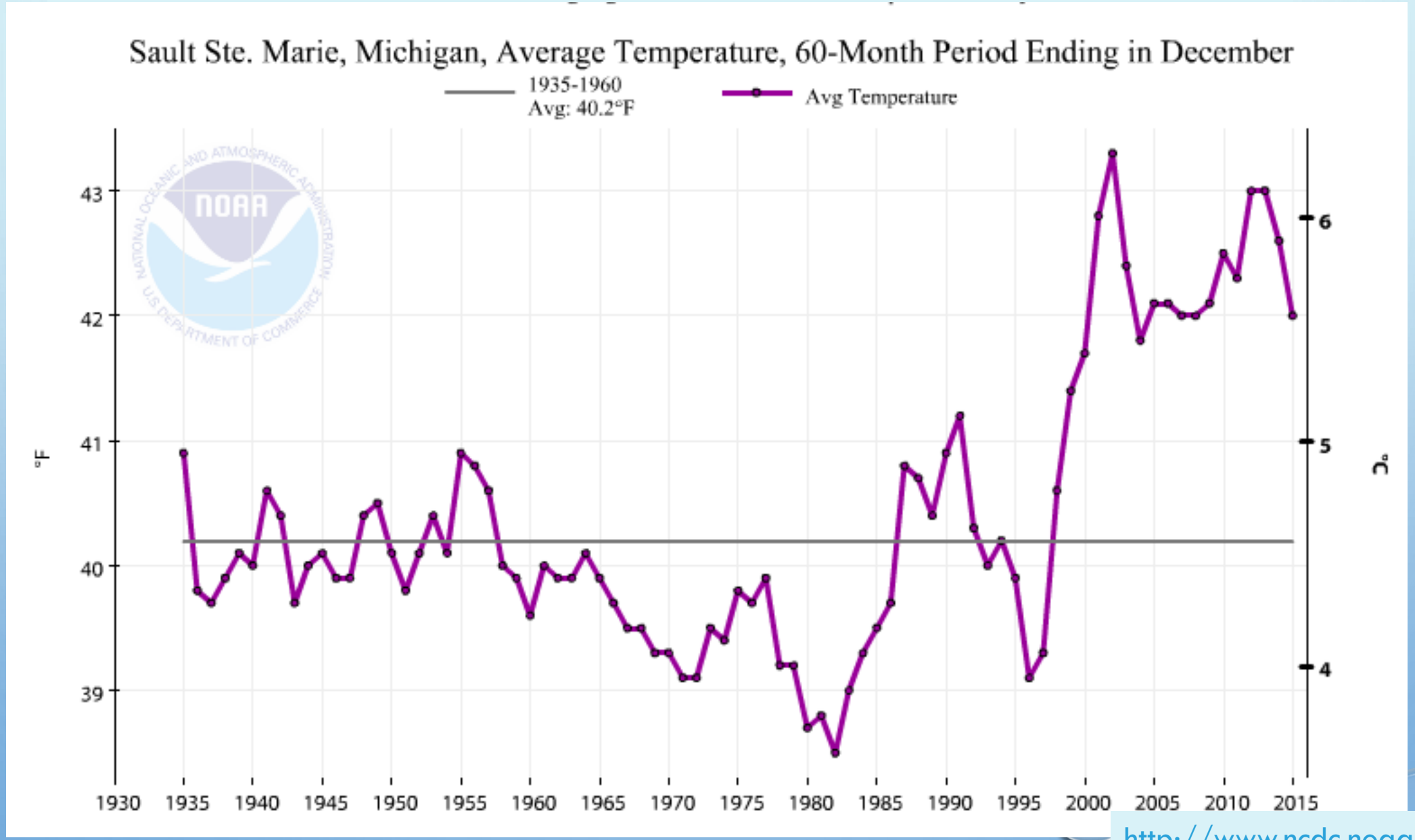
http://www.skepticalscience.com/graphics.php?g=8



http://www.skepticalscience.com/graphics.php?g=8

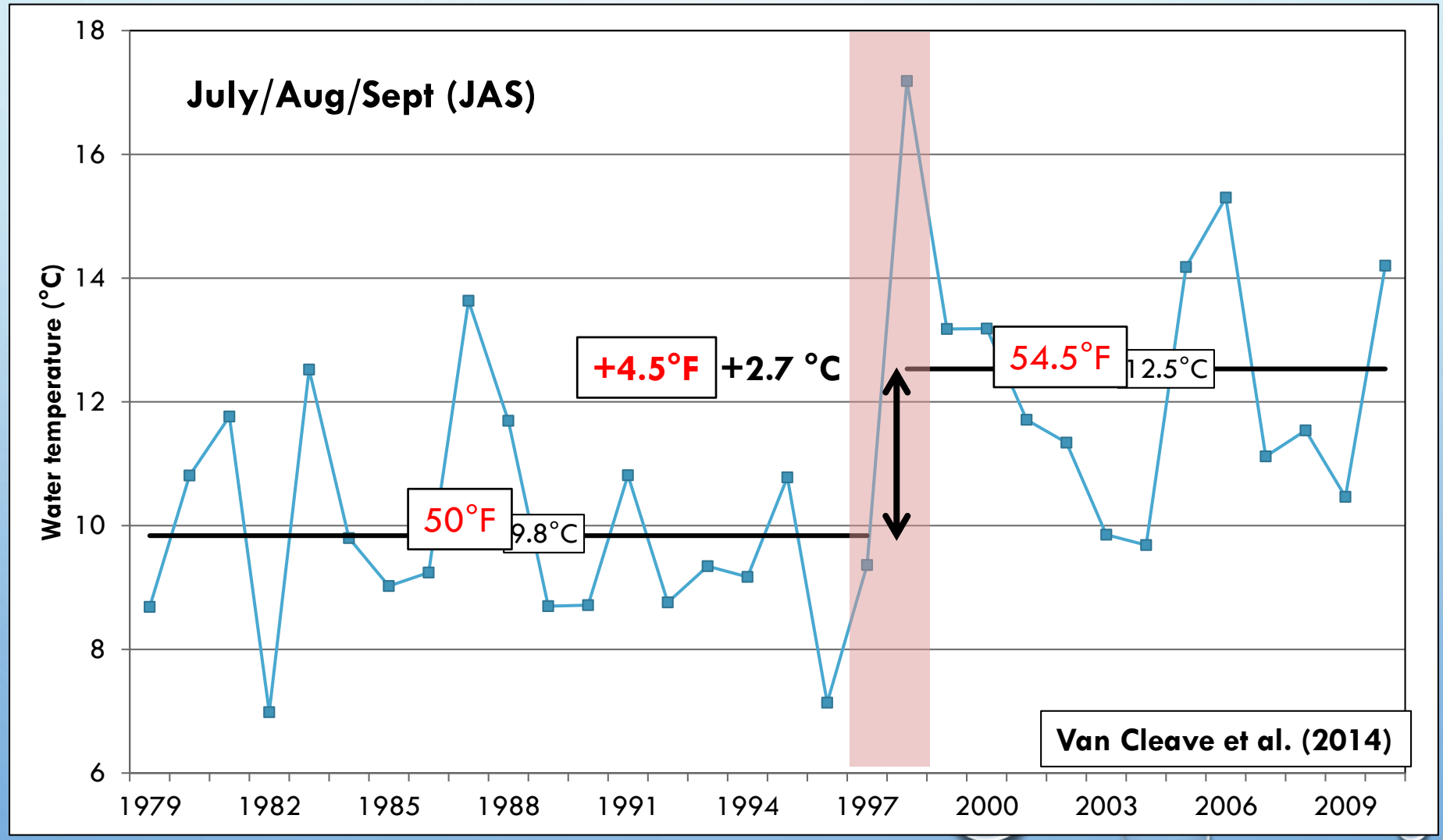
REGIONAL CHANGES

Warming Upper Peninsula



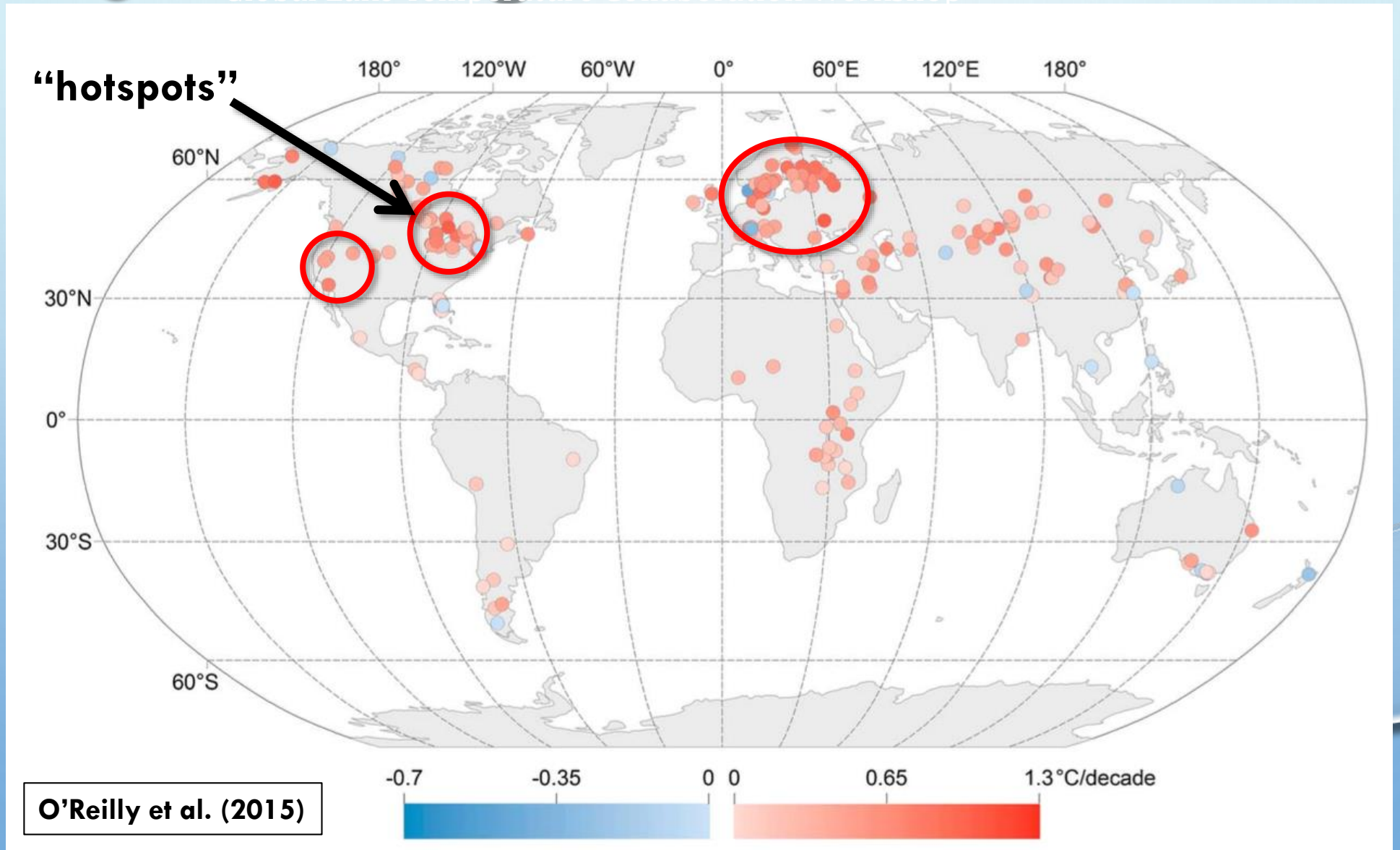
http://www.ncdc.noaa.gov/cag/

Warming Lake Superior



John Lenters

Warming lakes
(summer trends; 1985-2009)



O'Reilly et al. (2015)

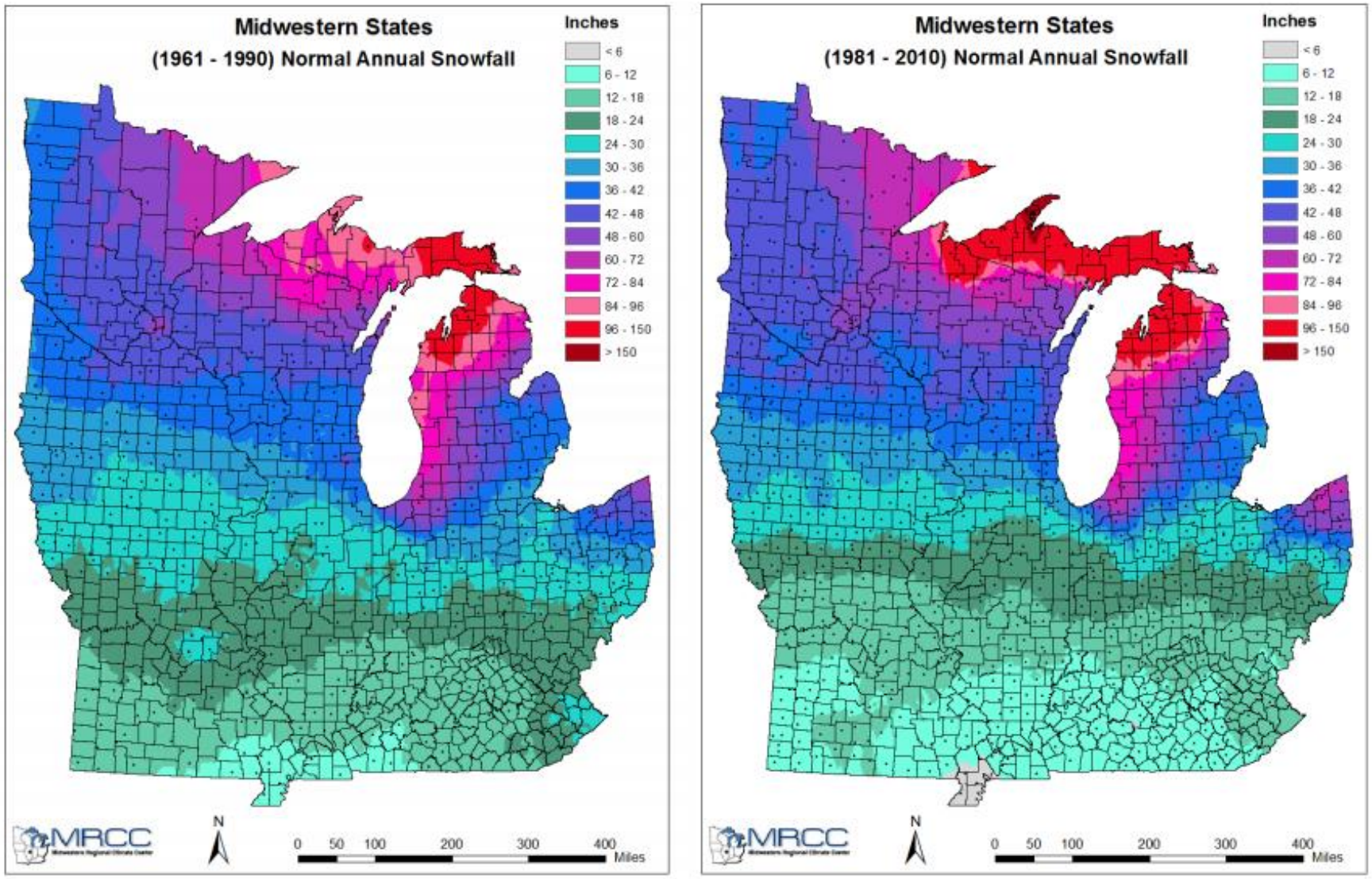
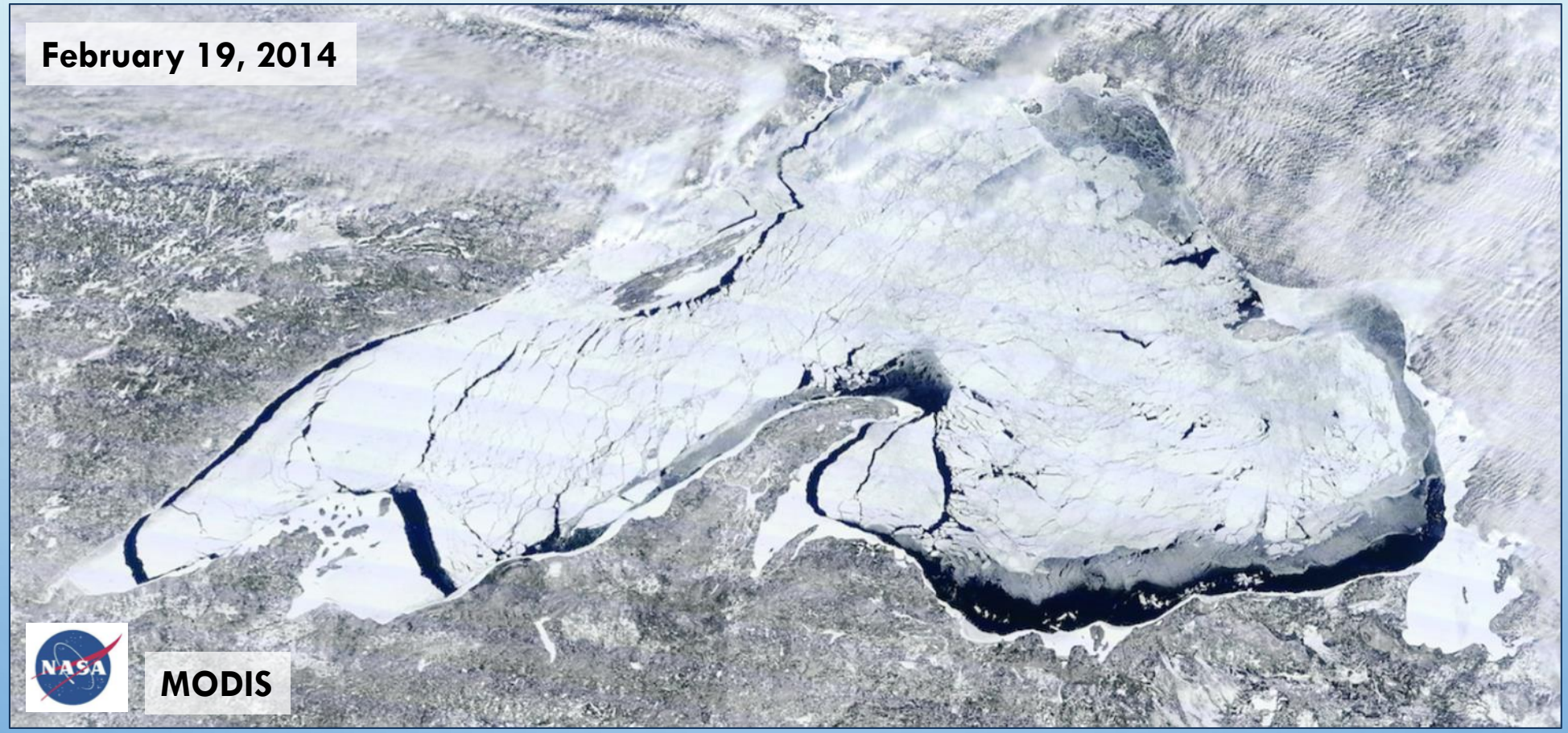


***Figure 8**. Mean seasonal snowfall (inches) across the Midwest for a) 1961-1990 (left) and b) 1981-2010 (right) periods. Figures courtesy of Midwest Regional Climate Center.* (Andresen et al., 2012)

http://glisa.msu.edu/docs/NCA/MTIT_Historical.pdf

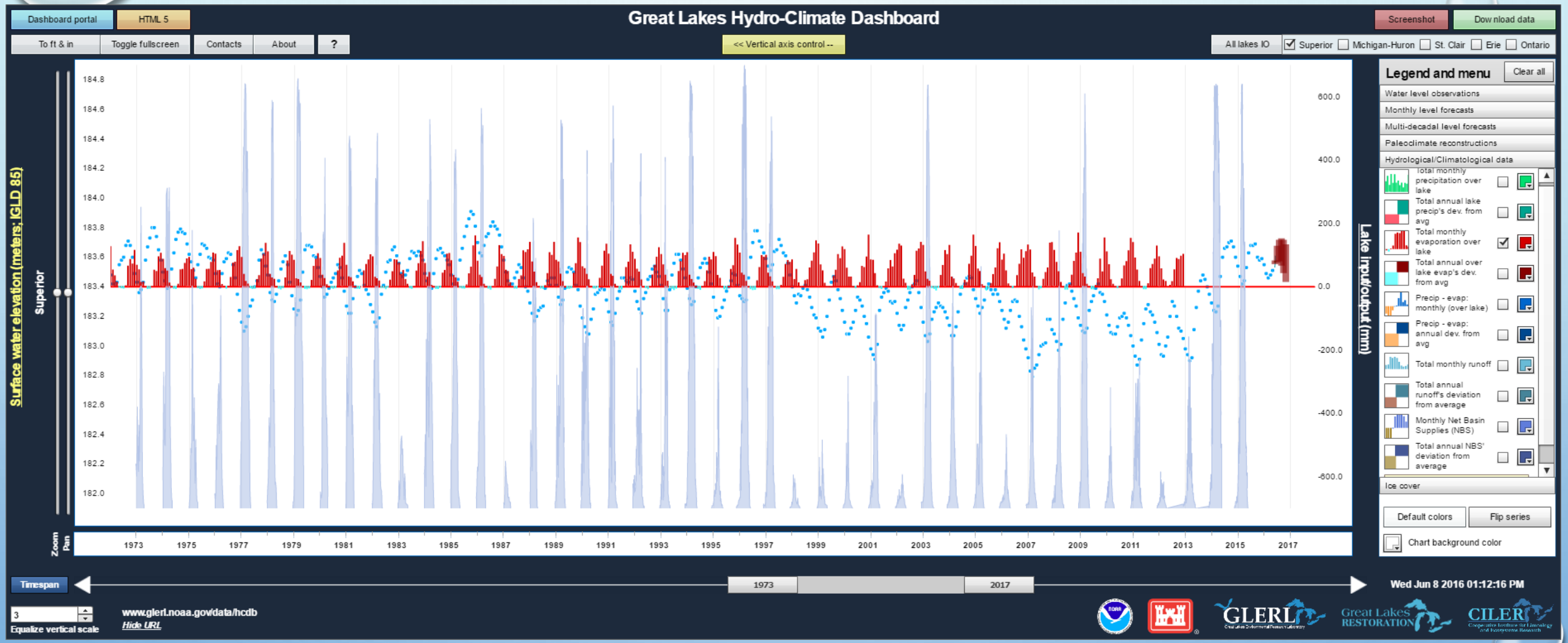
Lake Superior: Highly variable ice cover



John Lenters; NASA image

Lake Superior: Highly variable ice cover

John Lenters; NASA image



http://www.glerl.noaa.gov/data/dashboard/GLWLD.html

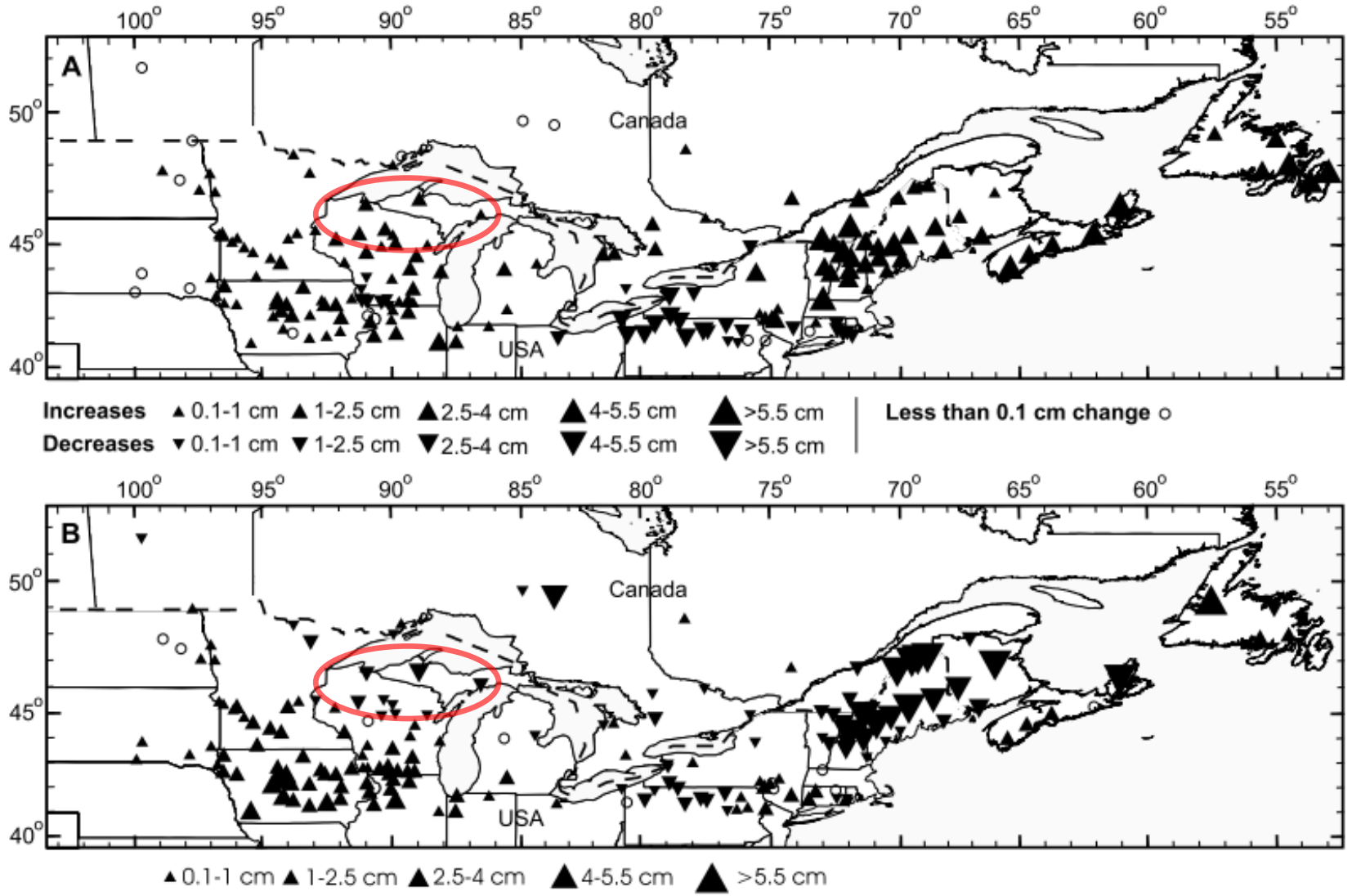
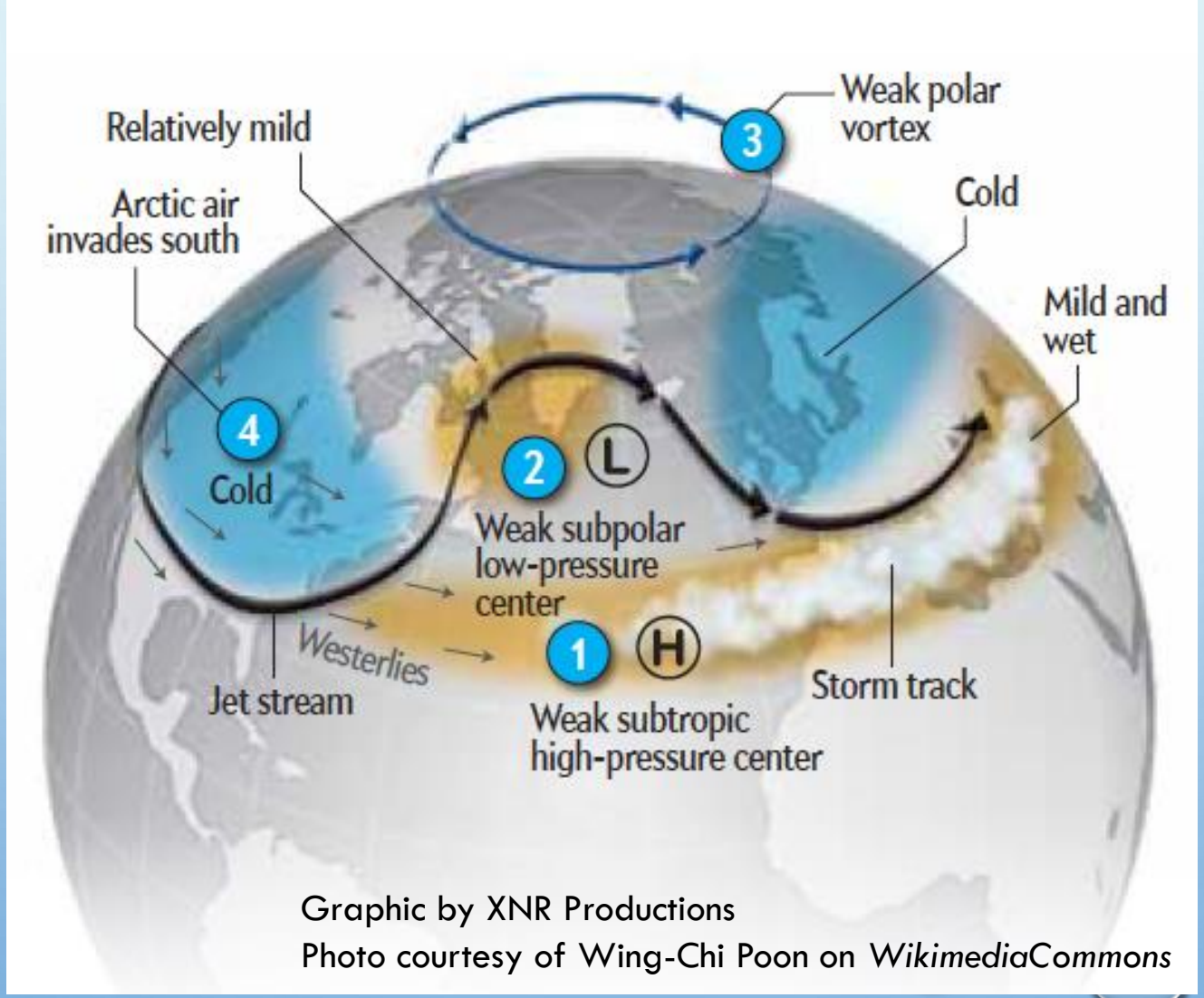


Figure 3. Magnitude and direction of changes in (a) March runoff and (b) May runoff, 1953–2002. (Hodgkins and Dudley, 2006)

PROJECTED CHANGES

Northern Weather: Highly Variable Jet Stream



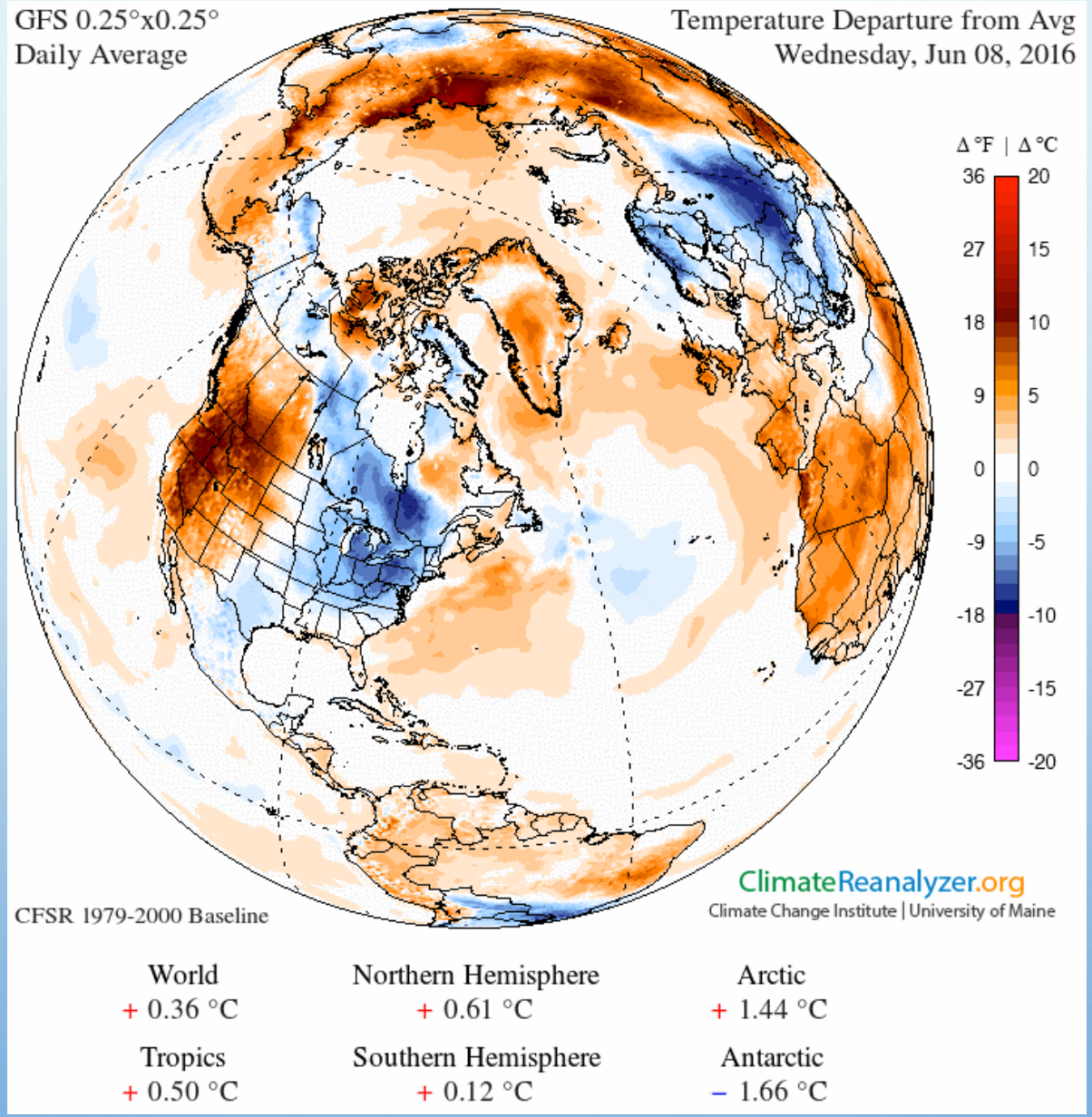
Graphic by XNR Productions
Photo courtesy of Wing-Chi Poon on *WikimediaCommons*

Weather: More Extreme Temperatures

Hot more often

and

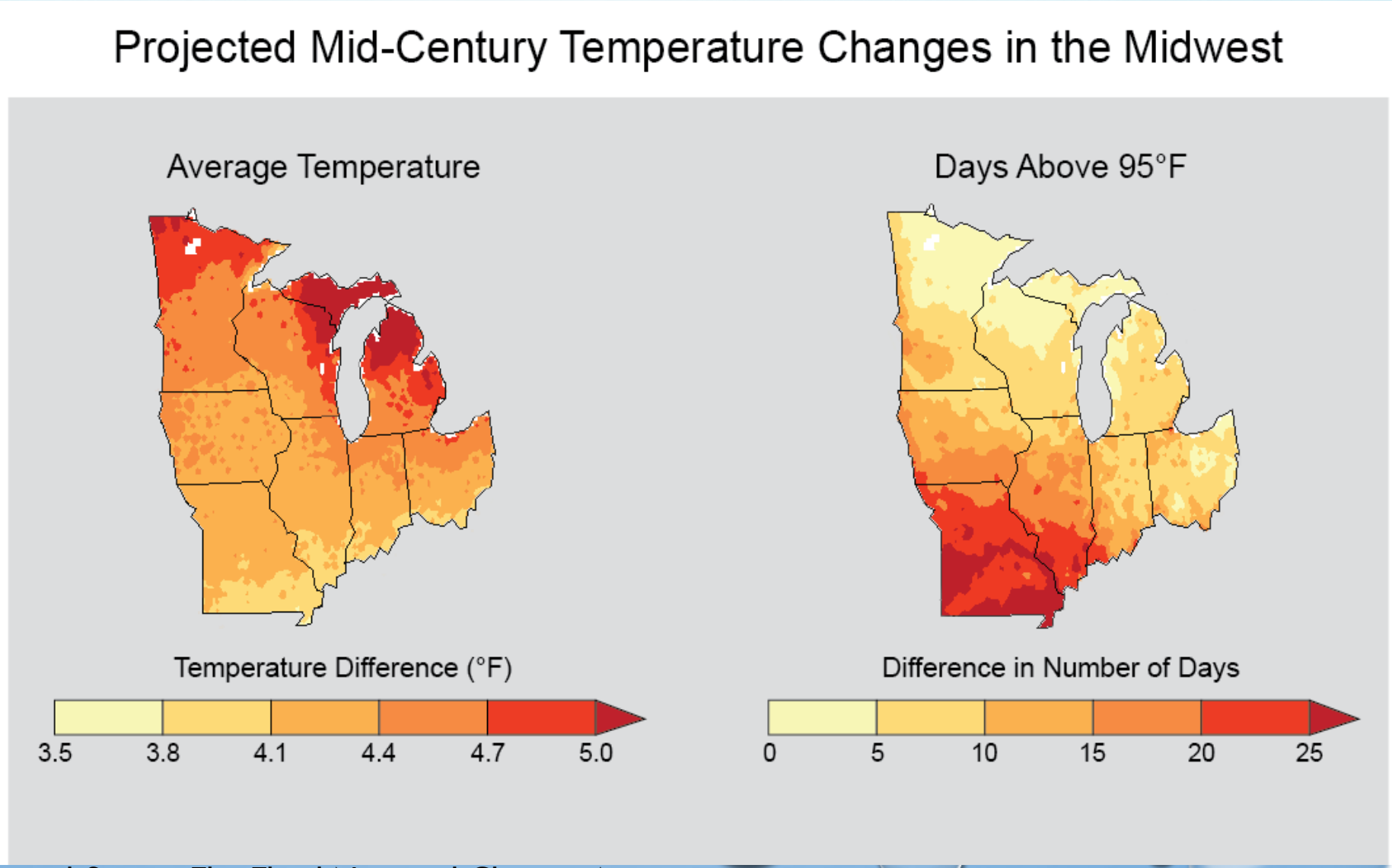
Often more hot.



PROJECTED CHANGES

Projected increase in annual average temperatures by mid-century (2041-2070) as compared to the 1971-2000 period tell only part of the climate change story. Maps also show annual projected increases in the number of the hottest days (days over 95°F), longer frost-free seasons, and an increase in cooling degree days, defined as the number of degrees that a day's average temperature is above 65°F, which generally leads to an increase in energy use for air conditioning. Projections are from global climate models that assume emissions of heat-trapping gases continue to rise (A2 scenario). (Figure source: NOAA NCDC / CICS-NC).

http://nca2014.globalchange.gov/highlights/regions/midwest/graphics/projected-climate-change



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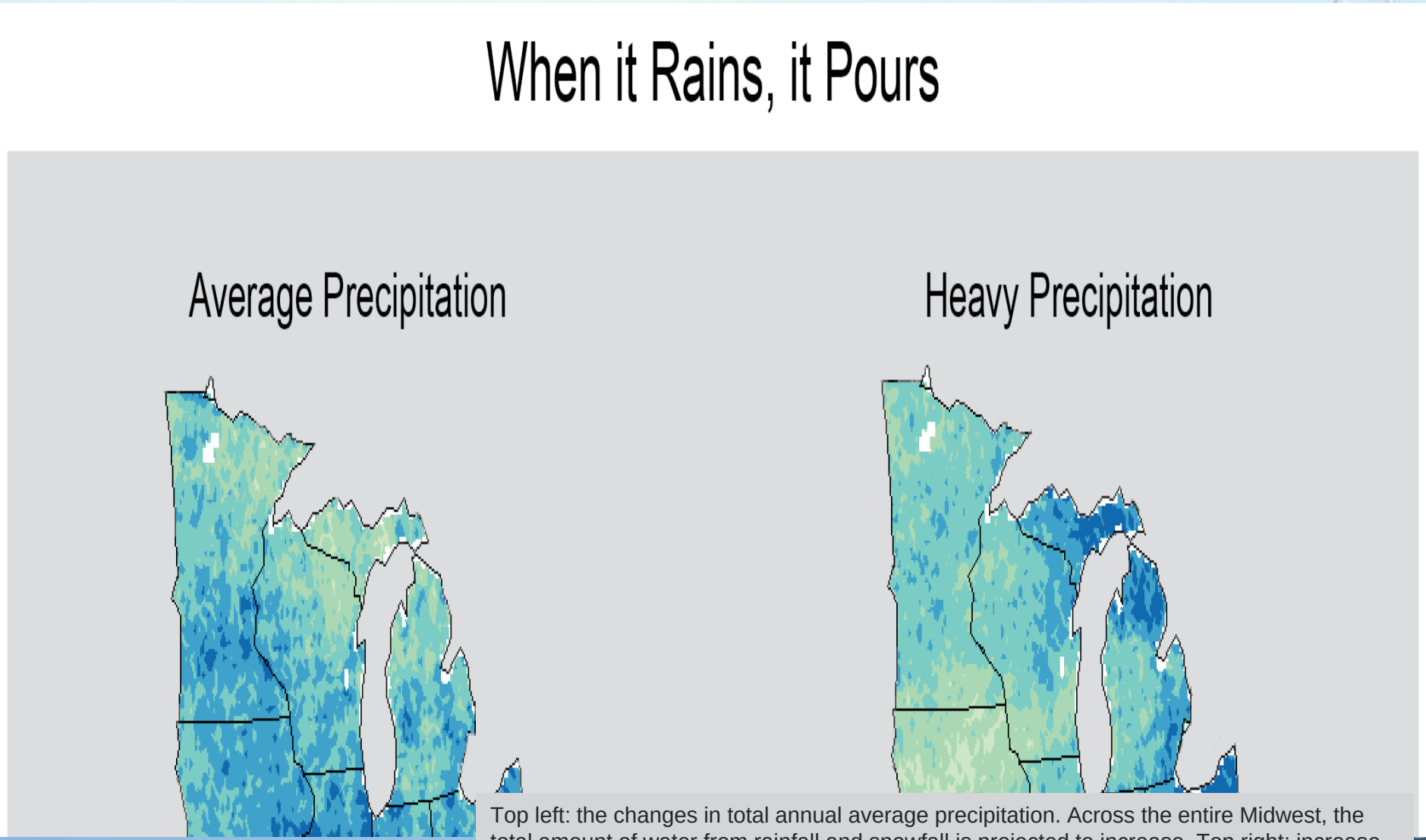
PROJECTED CHANGES

Projected changes for the middle of the current century (2041-2070) relative to the end of the last century (1971-2000) across the Midwest under continued emissions (A2 scenario).



Top left: the changes in total annual average precipitation. Across the entire Midwest, the total amount of water from rainfall and snowfall is projected to increase. Top right: increase in the number of days with very heavy precipitation (top 2% of all rainfalls each year). (Figure source: NOAA NCDC / CICS-NC)

http://nca2014.globalchange.gov/report/regions/midwest/graphics/when-it-rains-it-pours

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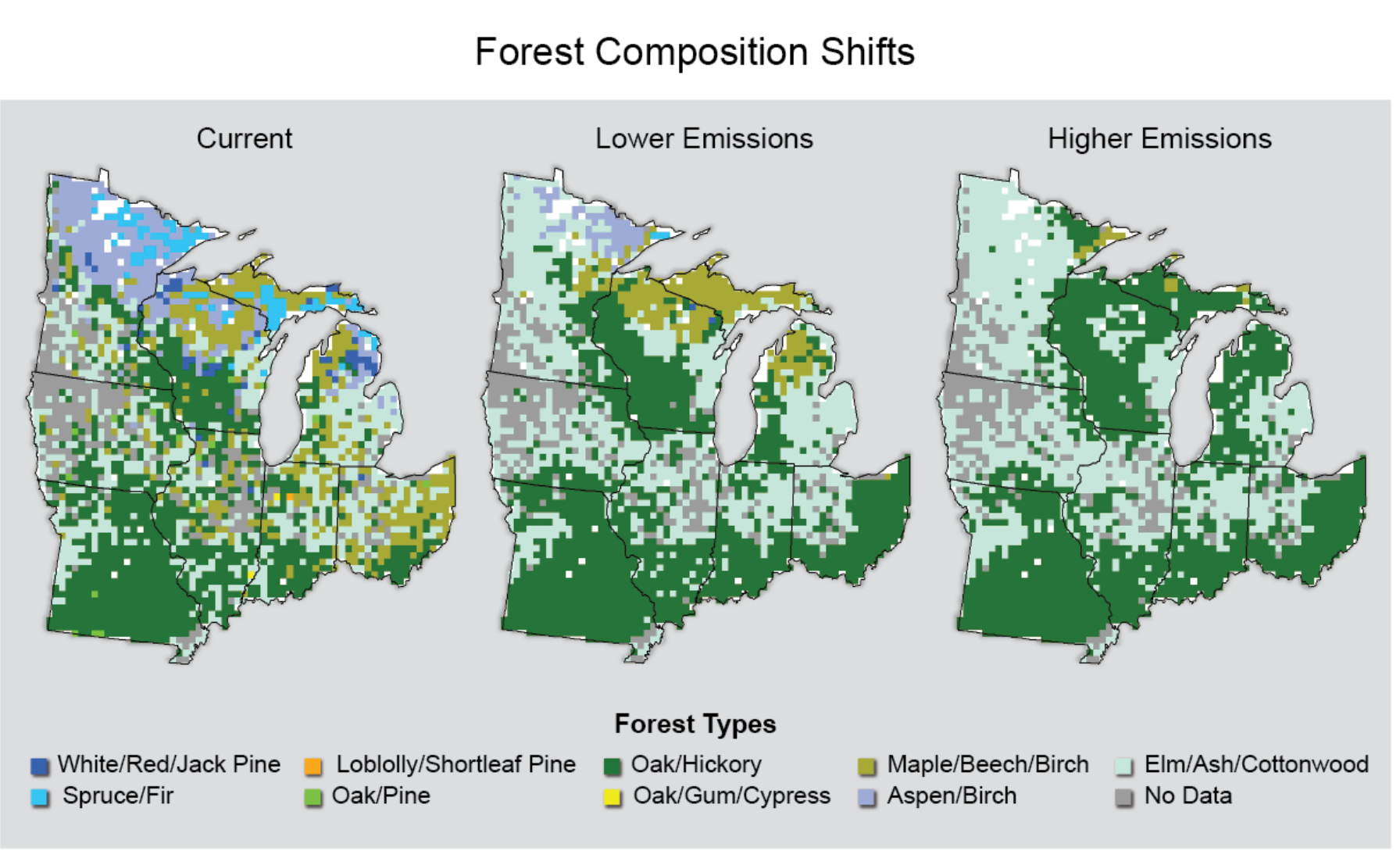
PROJECTED CHANGES

Forests and ecosystems are affected by temperature and rainfall.



http://data.globalchange.gov/report/nca3/chapter/midwest/figure/forest-composition-shifts

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REGIONAL IMPACTS, VULNERABILITIES, AND OPPORTUNITIES

LOCAL IMPACTS, VULNERABILITIES; OPPORTUNITIES?

ALREADY OBSERVED

- MORE AND LONGER HEAT WAVES
- SPECIES MIGRATING NORTHWARD
- WARMER LAKE TEMPERATURES
- CHANGES IN SEASONALITY
  - EARLIER SNOWMELT, SPRING RUNOFF, LONGER GROWING SEASON
- MORE HEAVY RAINFALL EVENTS
  - LOCAL FLOODING, EROSION, WATER QUALITY IMPACTS

LOCAL IMPACTS, VULNERABILITIES; OPPORTUNITIES?

LIKELY FUTURE

- MORE WET SNOWFALL, ICE STORMS
- LESS LAKE ICE

POSSIBLE FUTURE

- MORE VARIABILITY IN LAKE SUPERIOR WATER LEVELS (AND WAVE HEIGHTS)
  - COASTAL EROSION
- MORE VARIABILITY IN TEMPERATURES
  - MORE FREEZE-THAW EVENTS
  - MORE SNOW RELATIVE TO REST OF MIDWEST
- LESS EXTREME HEAT RELATIVE TO REST OF MIDWEST
- ??

REFERENCES

- ANDRESEN, J., S. HILBERG, K. KUNKEL, 2012: HISTORICAL CLIMATE AND CLIMATE TRENDS IN THE MIDWESTERN USA. IN: U.S. NATIONAL CLIMATE ASSESSMENT MIDWEST TECHNICAL INPUT REPORT. J. WINKLER, J. ANDRESEN, J. HATFIELD, D. BIDWELL, AND D. BROWN, COORDINATORS. AVAILABLE FROM THE GREAT LAKES INTEGRATED SCIENCES AND ASSESSMENTS (GLISA) CENTER, HTTP://GLISA.MSU.EDU/DOCS/NCA/MTIT_HISTORICAL.PDF.
- FISCHETTI, M., 2016: WHAT IS THIS POLAR VORTEX THAT IS FREEZING THE U.S.?, *SCIENTIFIC AMERICAN*, HTTP://BLOGS.SCIENTIFICAMERICAN.COM/OBSERVATIONS/WHAT-IS-THIS-POLAR-VORTEX-THAT-IS-FREEZING-THE-U-S/.
- GRONEWOLD, A.D., A.H. CLITES, J.P. SMITH, T.S. HUNTER, 2013: A DYNAMIC GRAPHICAL INTERFACE FOR VISUALIZING PROJECTED, MEASURED, AND RECONSTRUCTED SURFACE WATER ELEVATIONS ON THE EARTH'S LARGEST LAKES, *ENVIRONMENTAL MODELLING & SOFTWARE*, 49, 34–39, HTTP://DX.DOI.ORG/10.1016/J.ENVSOFT.2013.07.003.
- HODGKINS, G.A., R.W. DUDLEY, 2006: CHANGES IN THE TIMING OF WINTER–SPRING STREAMFLOWS IN EASTERN NORTH AMERICA, 1913–2002, *GEOPHYS. RES. LETT.*, 33, L06402, DOI:10.1029/2005GL025593.
- HUNTER, T.S., A.H. CLITES, A.D. GRONEWOLD, AND K.B. CAMPBELL, 2015: DEVELOPMENT AND APPLICATION OF A NORTH AMERICAN GREAT LAKES HYDROMETEOROLOGICAL DATABASE - PART I: PRECIPITATION, EVAPORATION, RUNOFF, AND AIR TEMPERATURE. JOURNAL OF GREAT LAKES RESEARCH 41(1): 65-77, DOI:10.1016/J.JGLR.2014.4.12.006. HTTP://WWW.GLERL.NOAA.GOV/PUBS/FULLTEXT/2015/20150006.PDF
- VAN CLEAVE, KATHERINE, ET AL. "A REGIME SHIFT IN LAKE SUPERIOR ICE COVER, EVAPORATION, AND WATER TEMPERATURE FOLLOWING THE WARM EL NIÑ WINTER OF 1997–1998." *LIMNOLOGY AND OCEANOGRAPHY 59.6 (2014): 1889-1898. DOI:* 10.4319/LO.2014.59.6.1889
- O'REILLY, C. M., S. SHARMA, D. K. GRAY, S. E. HAMPTON, J. S. READ, R. J. ROWLEY, P. SCHNEIDER, J. D. LENTERS, P. B. MCINTYRE, B. M. KRAEMER, ET AL. (2015), RAPID AND HIGHLY VARIABLE WARMING OF LAKE SURFACE WATERS AROUND THE GLOBE, GEOPHYS. RES. LETT., 42, 10,773–10,781, DOI:10.1002/2015GL066235.
- SKEPTICAL SCIENCE: HTTP://WWW.SKEPTICALSCIENCE.COM/GRAPHICS.PHP?G=8
- NOAA CLIMATE DATA: HTTP://WWW.NCDC.NOAA.GOV/CAG/
- GREAT LAKES DASHBOARD: HTTP://WWW.GLERL.NOAA.GOV/DATA/DASHBOARD/GLWLD.HTM
- CLIMATE CHANGE IMPACTS IN THE UNITED STATES: THE THIRD NATIONAL CLIMATE ASSESSMENT, CHAP 18, MIDWEST HTTP://NCA2014.GLOBALCHANGE.GOV/REPORT/REGIONS/MIDWEST DOI: 10.7930/J0J1012N **CONVENING LEAD AUTHORS SARA C. PRYOR, *DONALD SCAVIA***