Actuaries Climate Index

Caterina Lindman

March 30, 2014

Climate Change Committee
Vijay Manghnani, Chair

Solterra Solutions

Climate Index Working Group
Caterina Lindman, Chair

Actuaries from the CIA, CAS, SOA and the American Academy of Actuaries

Cheri Widowski

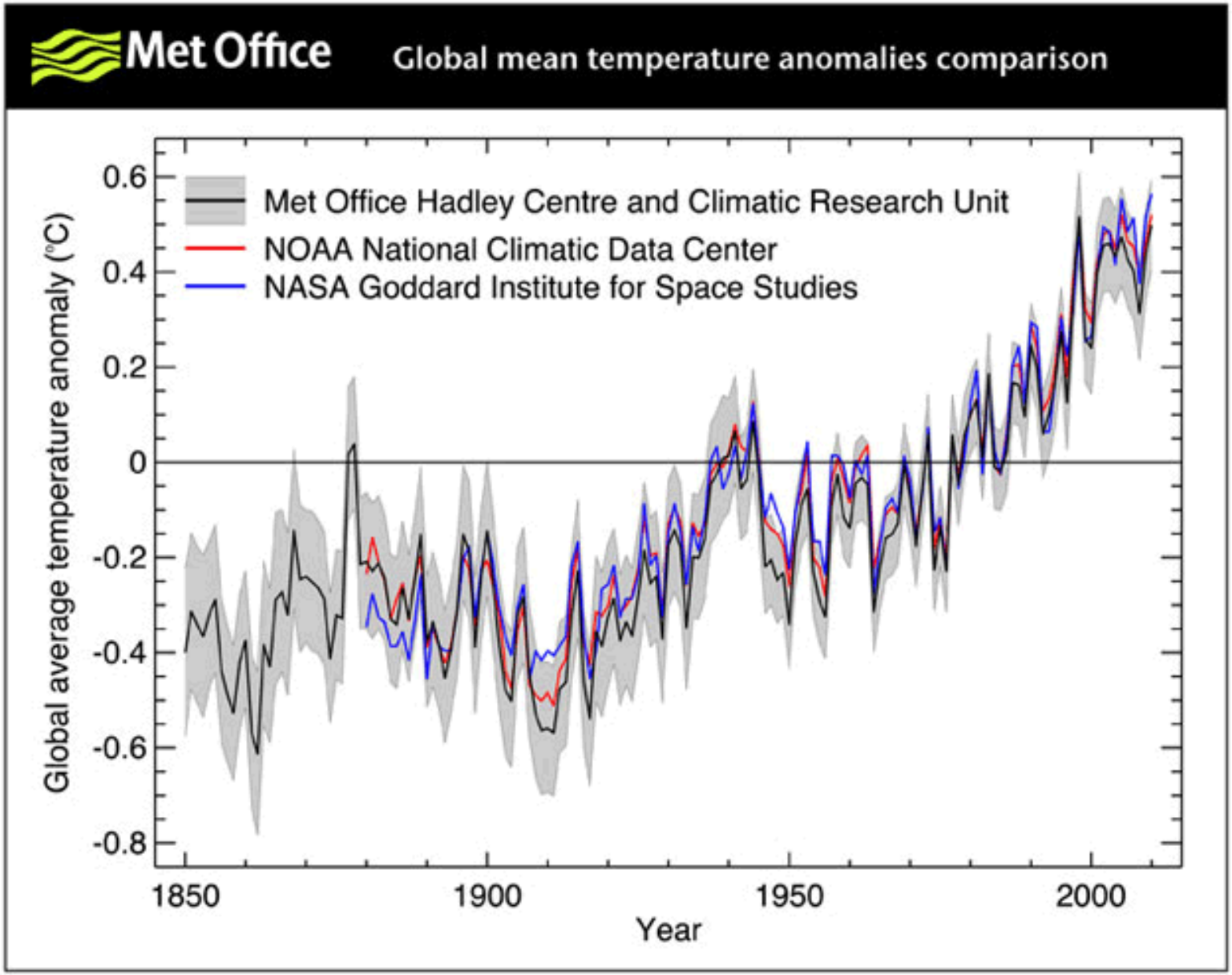
Lauren Pachman

Ronora Stryker

Les Dandridge

Actuaries Climate Index

- Resources: Solterra Solutions and CIWG
- Timing: August 2013 to 2014
- Goals:
  - Easy to understand, but not simplistic
  - Compelling
  - Serves and educates the public
  - Promotes our profession


Met Office
Global mean temperature anomalies comparison
Met Office Hadley Centre and Climatic Research Unit
NOAA National Climatic Data Center
NASA Goddard Institute for Space Studies
Global average temperature anomaly (°C)
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
1850
1900
1950
2000
Year

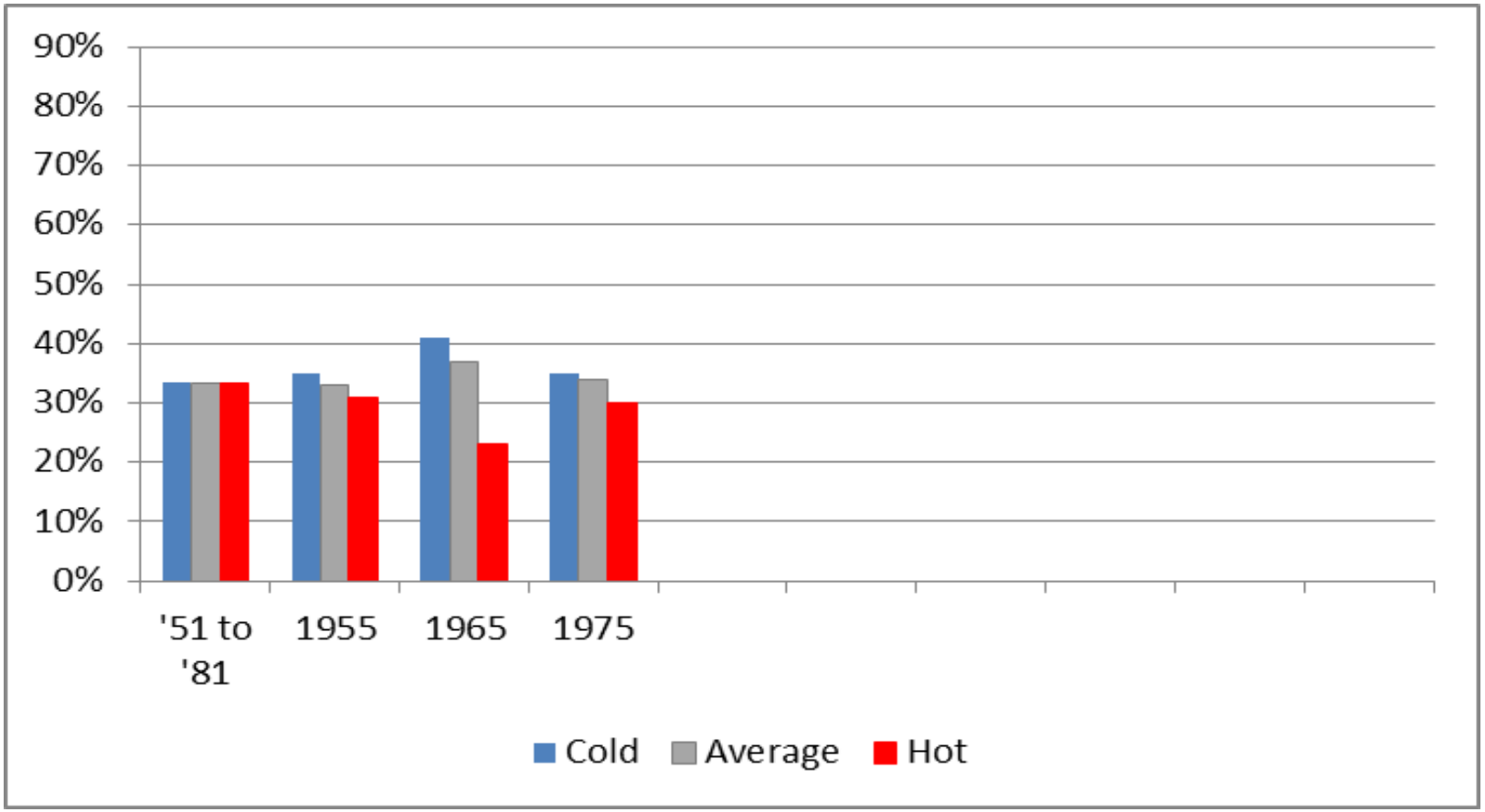
Temperatures

One way to illustrate temperatures is by using a die.

Source: Hansen, Sato and Ruedy, 2012, "The perception of climate"

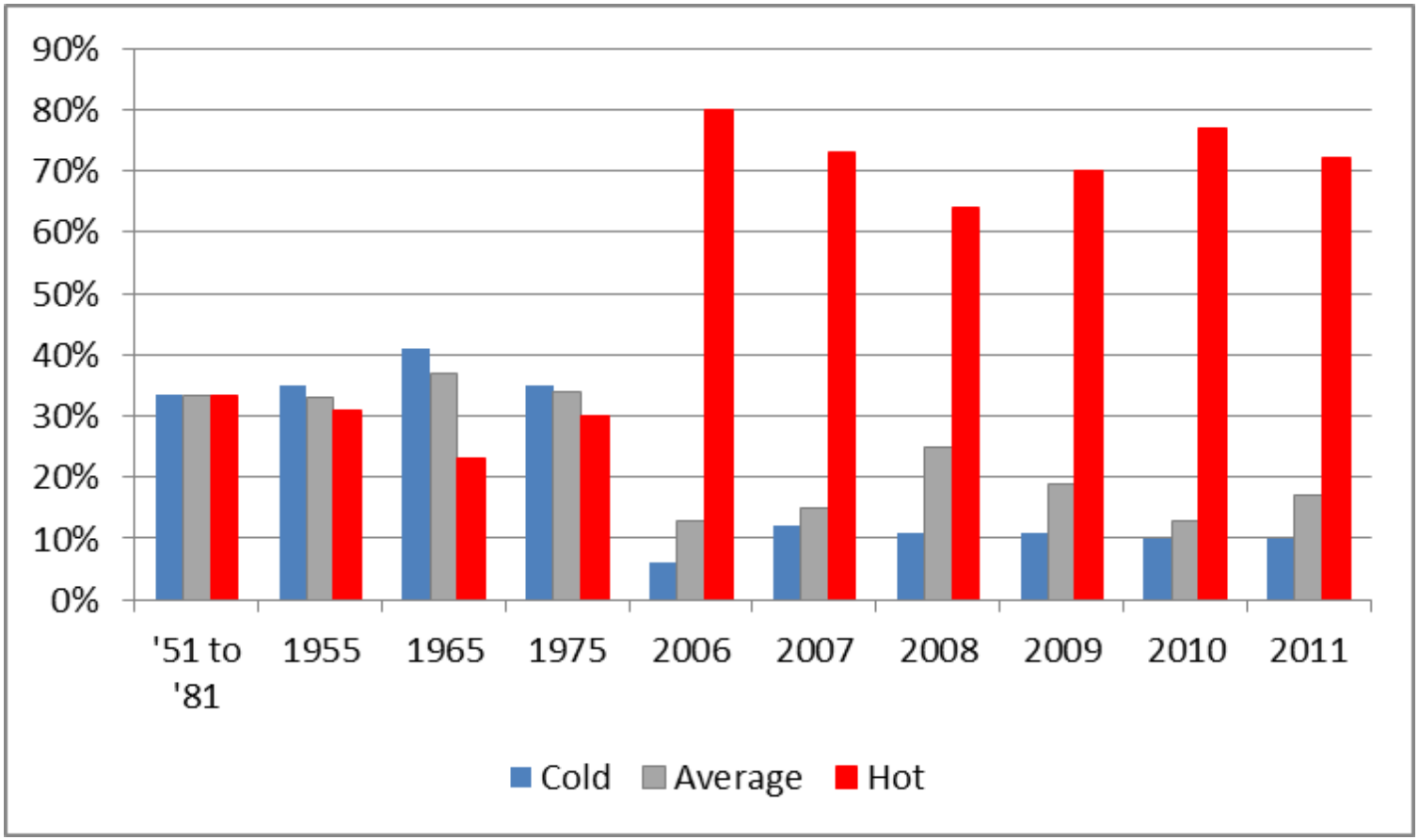
Summer Temperatures

Probability of Cold, Average and Hot Temperatures during the reference period (2/6 Cold, 2/6 Average, 2/6 Hot)



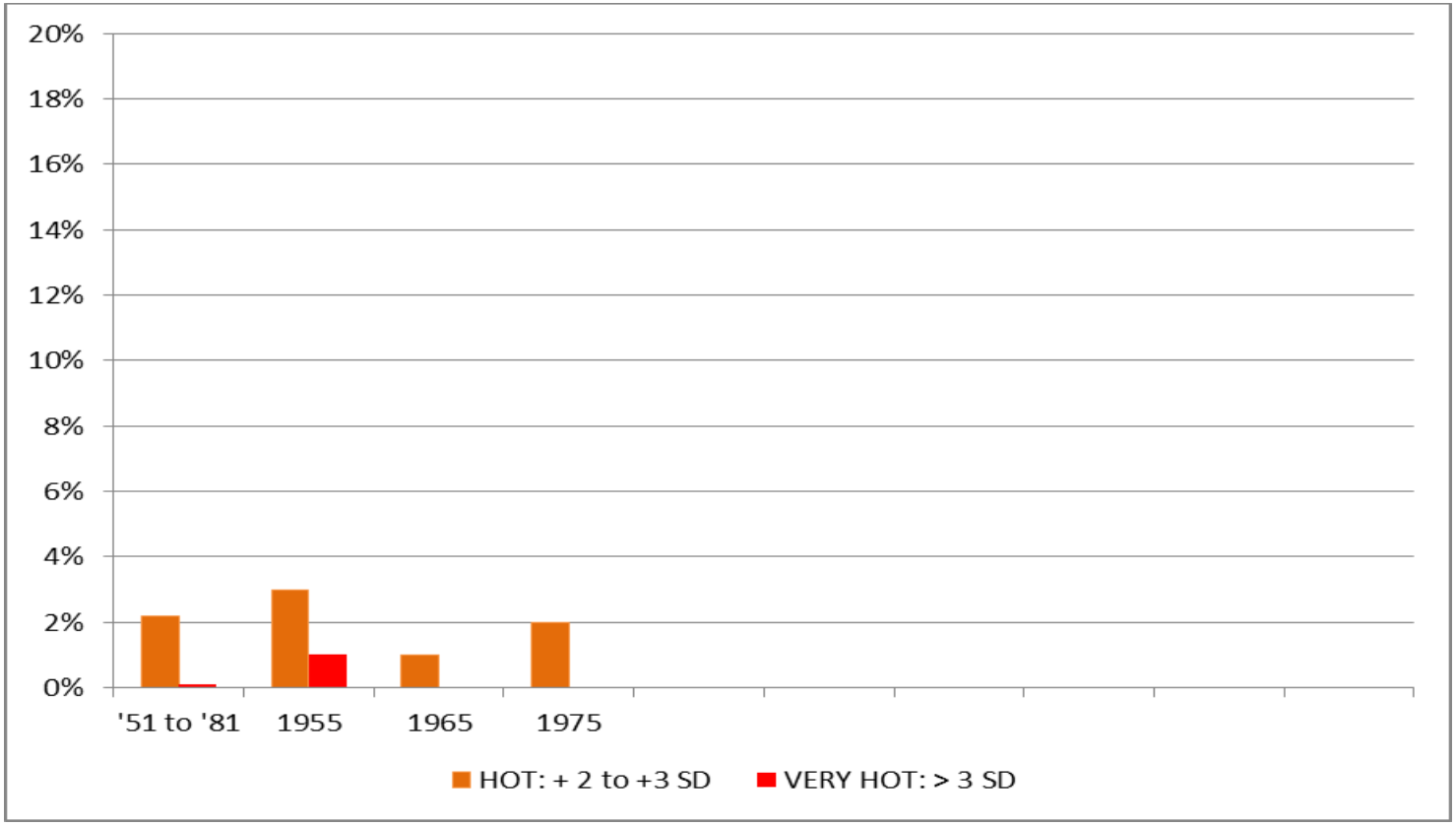
Summer Temperatures

Probability of Cold, Average and Hot Temperatures is changed (2/6 Cold, 2/6 Average, 2/6 Hot becomes 1/6 Cold, 1/6 Average, 4/6 Hot)



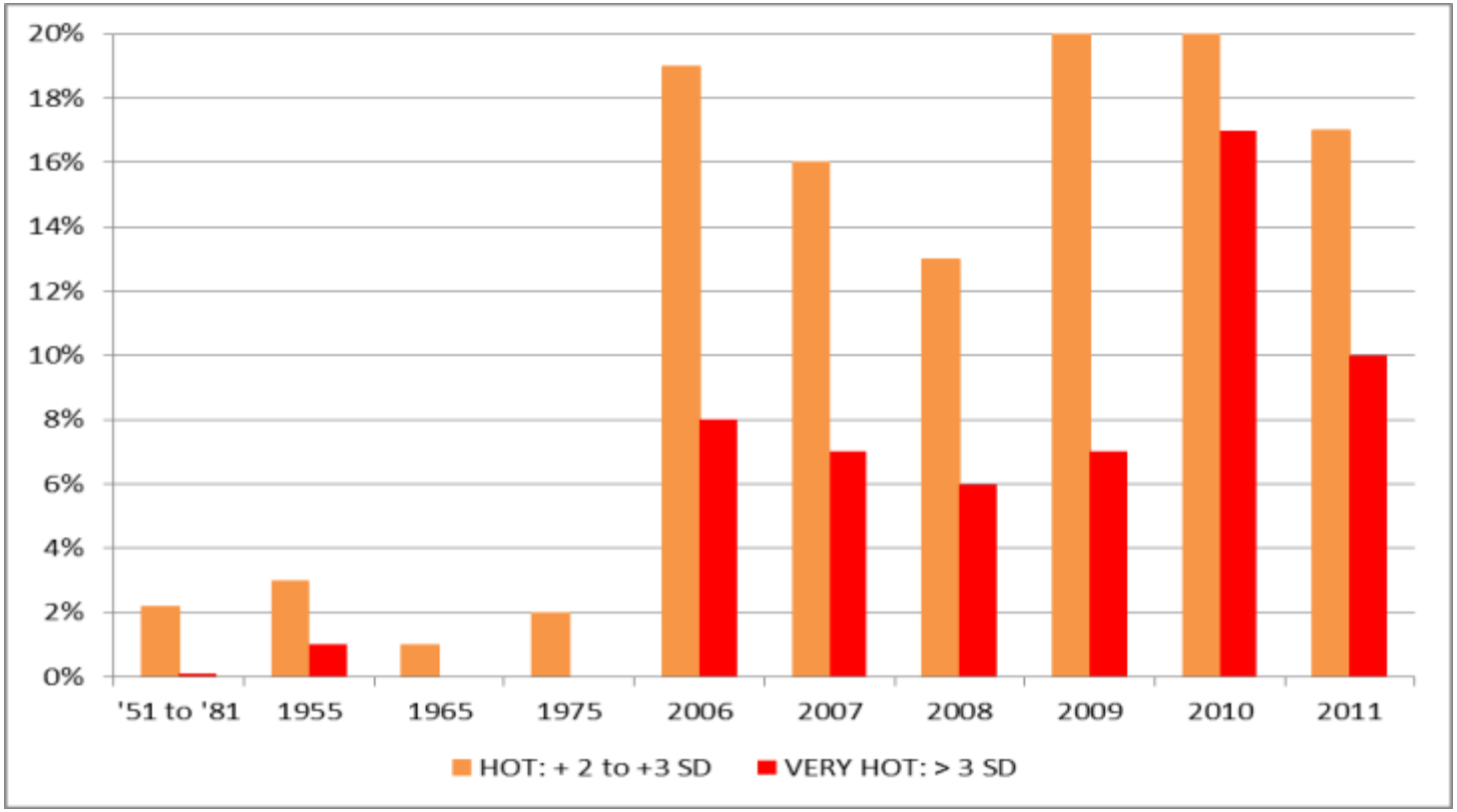
Summer Temperature Extremes

Frequency of Summer temperatures more than 2 or 3 Standard deviations above the norm in the base period:



Summer Temperature Extremes

Frequency of Summer temperatures more than 2 or 3 Standard deviations above the norm:

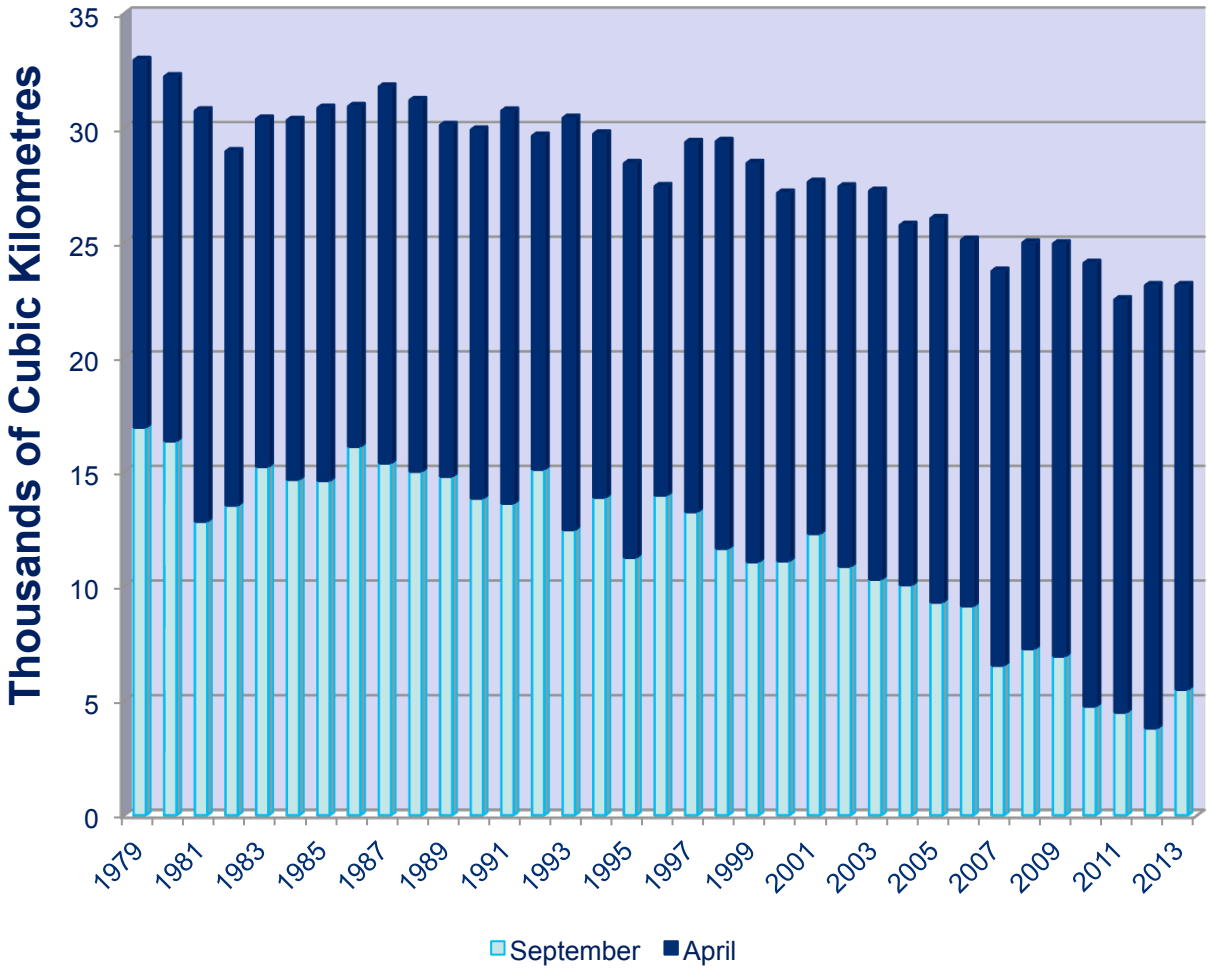


130 Years of Global Warming in 30 Seconds

http://videosift.com/video/NASA-130-Years-of-Global-Warming-in-30-seconds

Arctic Sea Ice Volume

Source: Pan-Arctic Ice Ocean Modeling and Assimilation System: PIOMAS



Polar Vortex –

A message from the U.S. Science Advisor

http://www.dailymotion.com/video/x19hmpi_global-climate-change-dr-holden-whitehouse-expert-explains-polar-vortex_news

ACI Basics

- Initial focus US and Canada
  - Hope to gradually add other parts of world where good data is available
  - Publish index and related information on web
- Focus on measuring frequency and intensity of extremes rather than averages
- 6 initial variables we are contemplating: temperature, precipitation, drought, soil moisture, wind, sea level
- all by 2.5°grid (275km x 275km at equator)

Temperature Data

- Global Historical Climatological Network (GHCN)
- Land-station based, gridded dataset, 1950-present
  GHCN Daily
- GHCNDEX indices* based on the above:
  - TX90 = 90%ile warm days
  - TN90 = 90%ile warm nights
  - TX10 = 10%ile cold days
  - TN10 = 10%ile cold nights

* Produced as part of the CLIMDEX project by the Climate Change Research Centre, at The University of New South Wales, Australia.

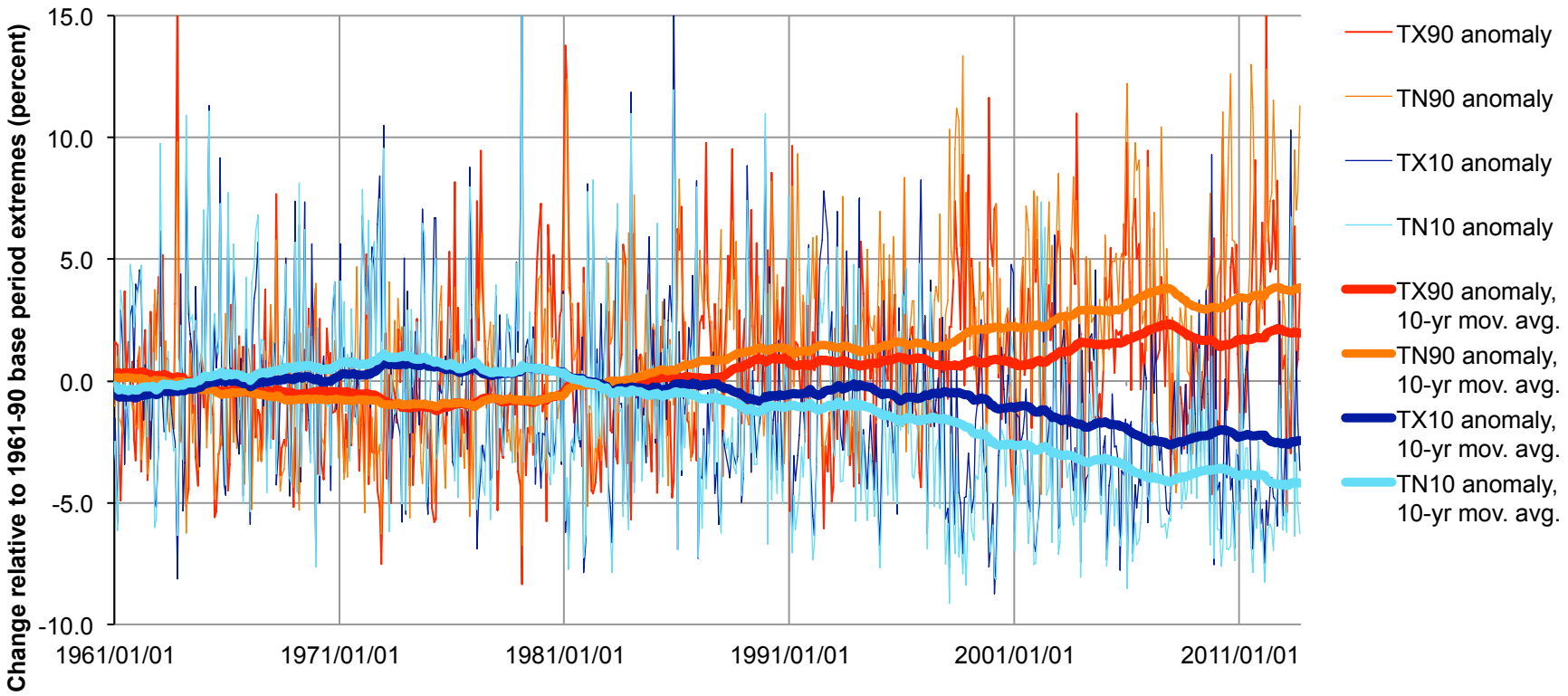
Percentiles are based on the number of days exceeding the 90^{th} percentile value (or lower than the 10^{th} percentile value) using the base 1961-1990

Extreme Temperature Index

- change relative to 1961-1990 base
- Composite index, Tx =

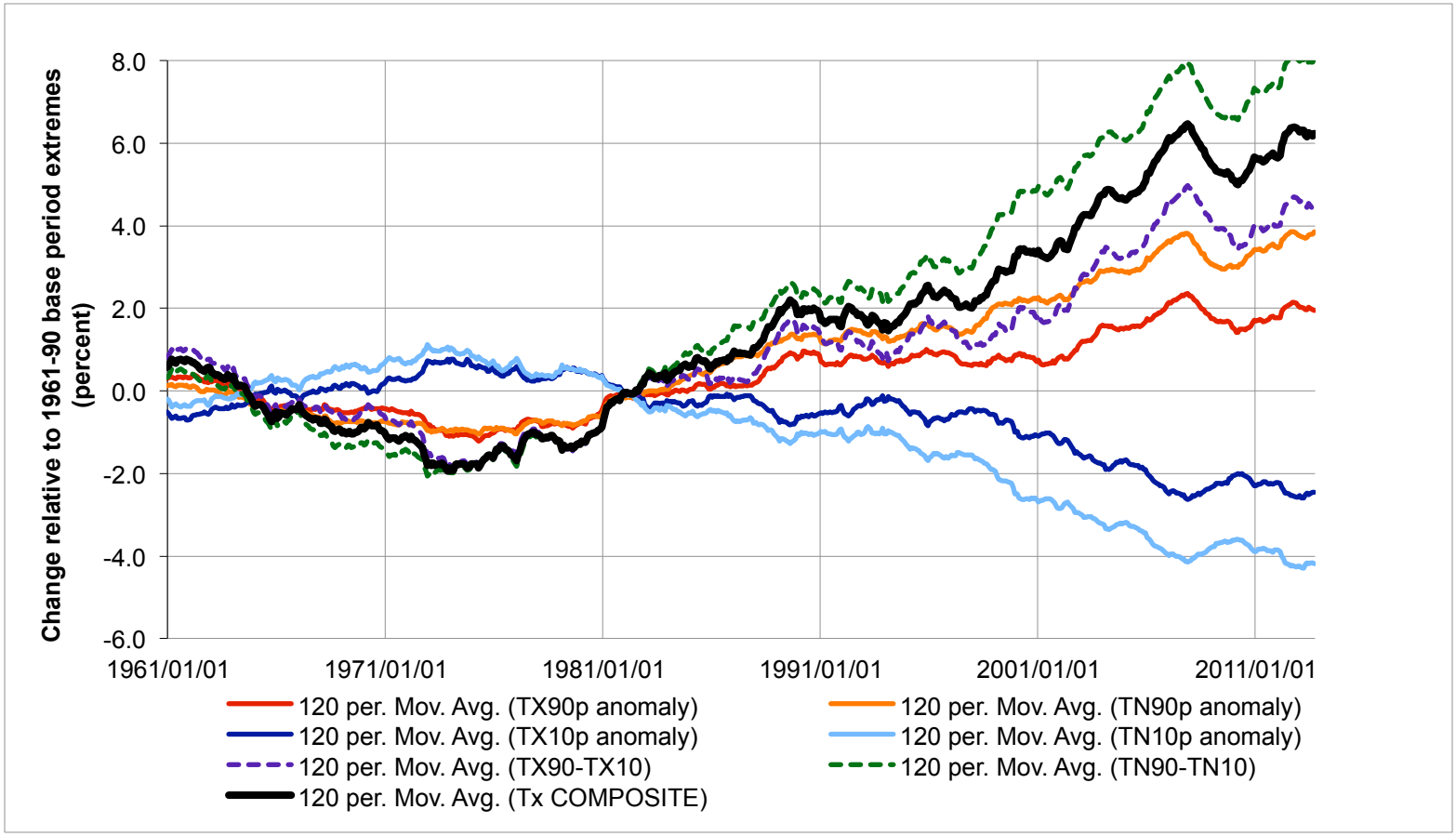
  0.5 x [(TX90 – TX10) + (TN90 - TN10)]
- The average of % anomalies relative to the base:
  - Warm days minus cold days; and
  - Warm nights minus cold nights
  - *Standardized anomaly:*
  - $Tx' = \Delta Tx / \sigma_{ref}(Tx)$

Day & Night Temp Extremes

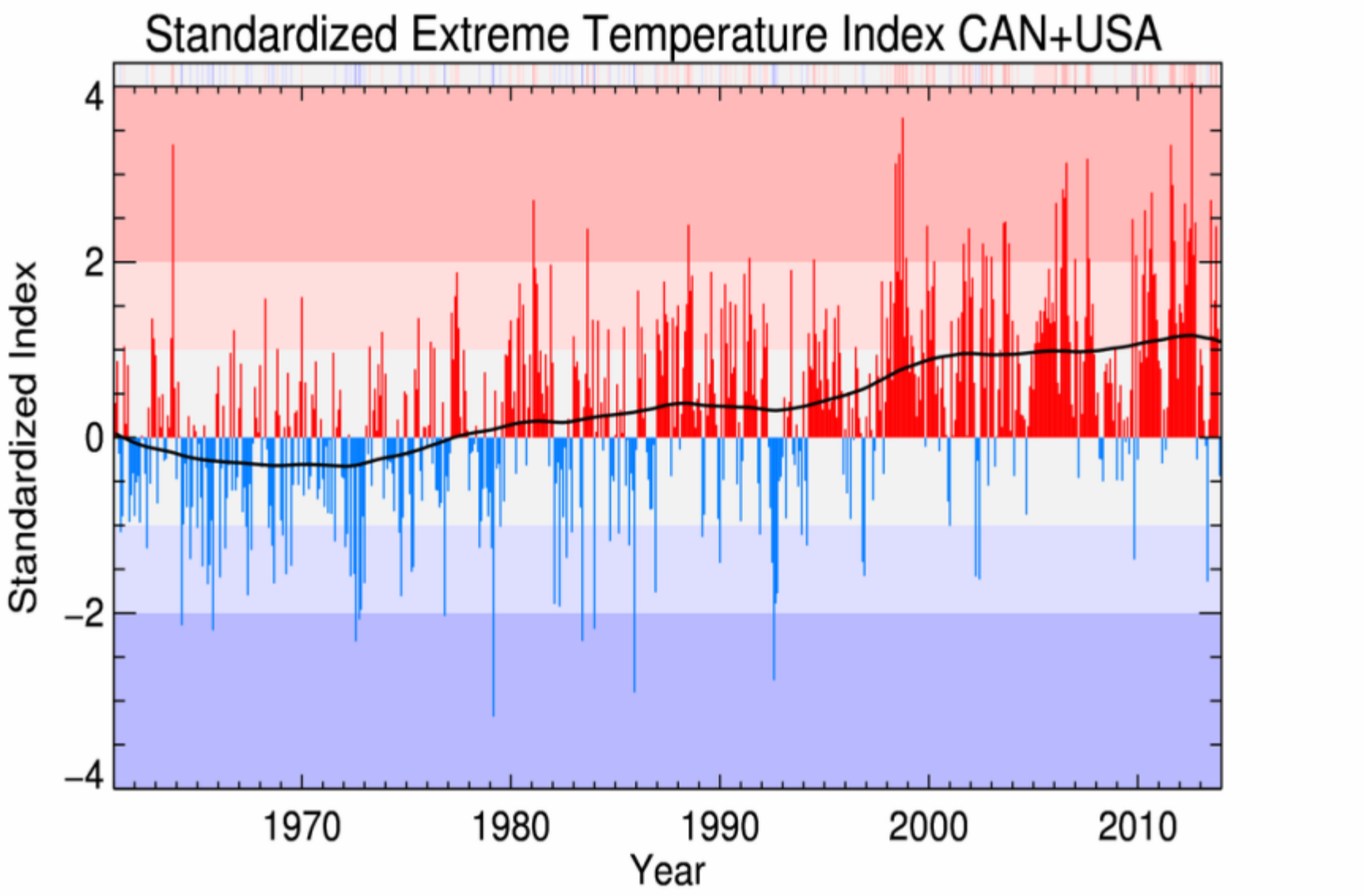


TX and TN for US and Canada

Day & Night Temp Extremes



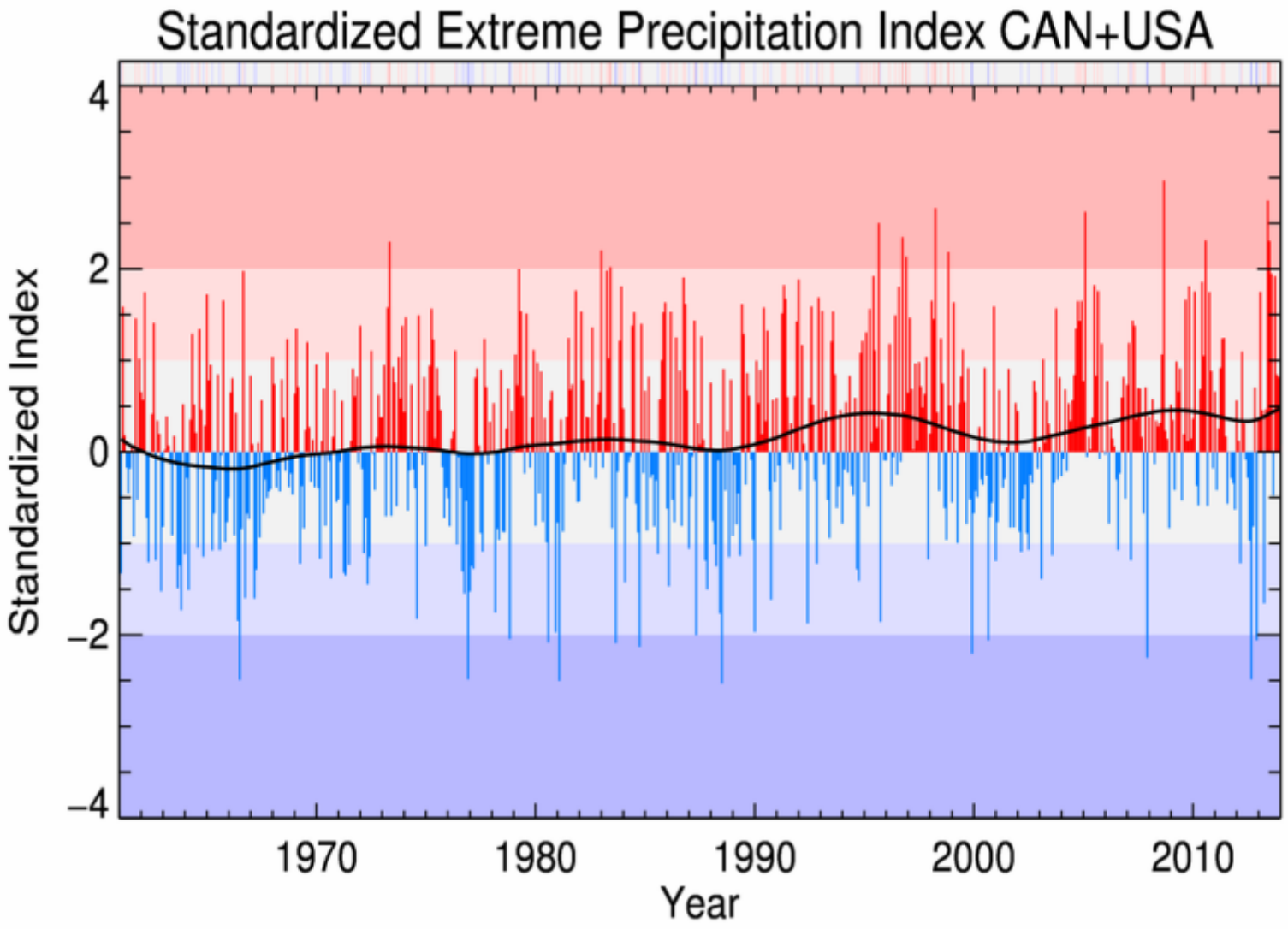
Tx and its components, US and Canada


Standardized Extreme Temperature Index CAN+USA
Standardized Index
4
2
0
−2
−4
1970
1980
1990
2000
2010
Year

Extreme Precipitation Index

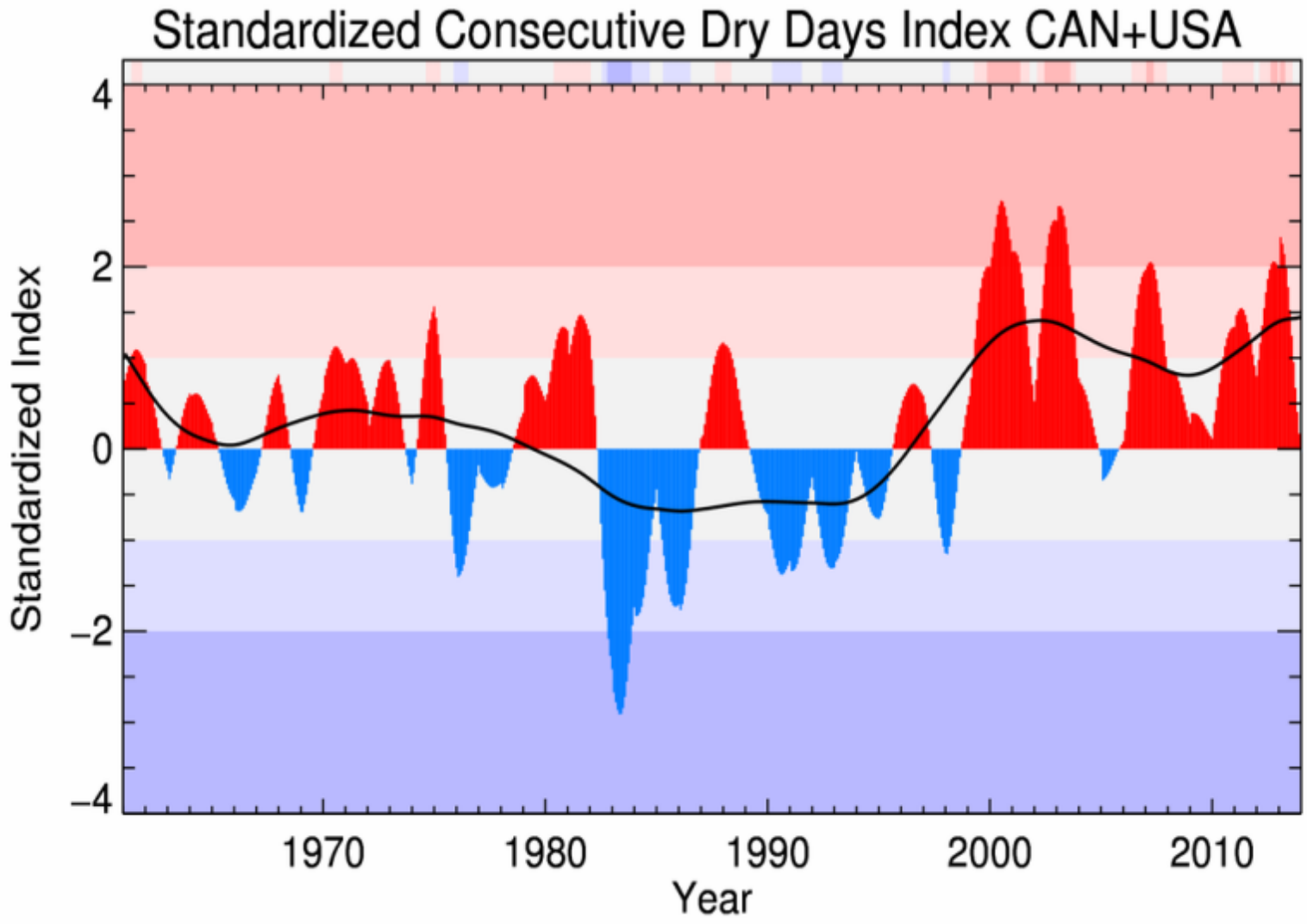
- GHCNDEX, using monthly maximum five-day precipitation data
- Precipitation index, Px =[(Rx5day – $Rx5day_{ref}$) / $Rx5day_{ref}$] x 100%

  Where the reference period is again 1961-90
- Standardized: $Px' = \Delta Px / \sigma_{ref}(Px)$


Standardized Extreme Precipitation Index CAN+USA
Standardized Index
4
2
0
−2
−4
1970
1980
1990
2000
2010
Year

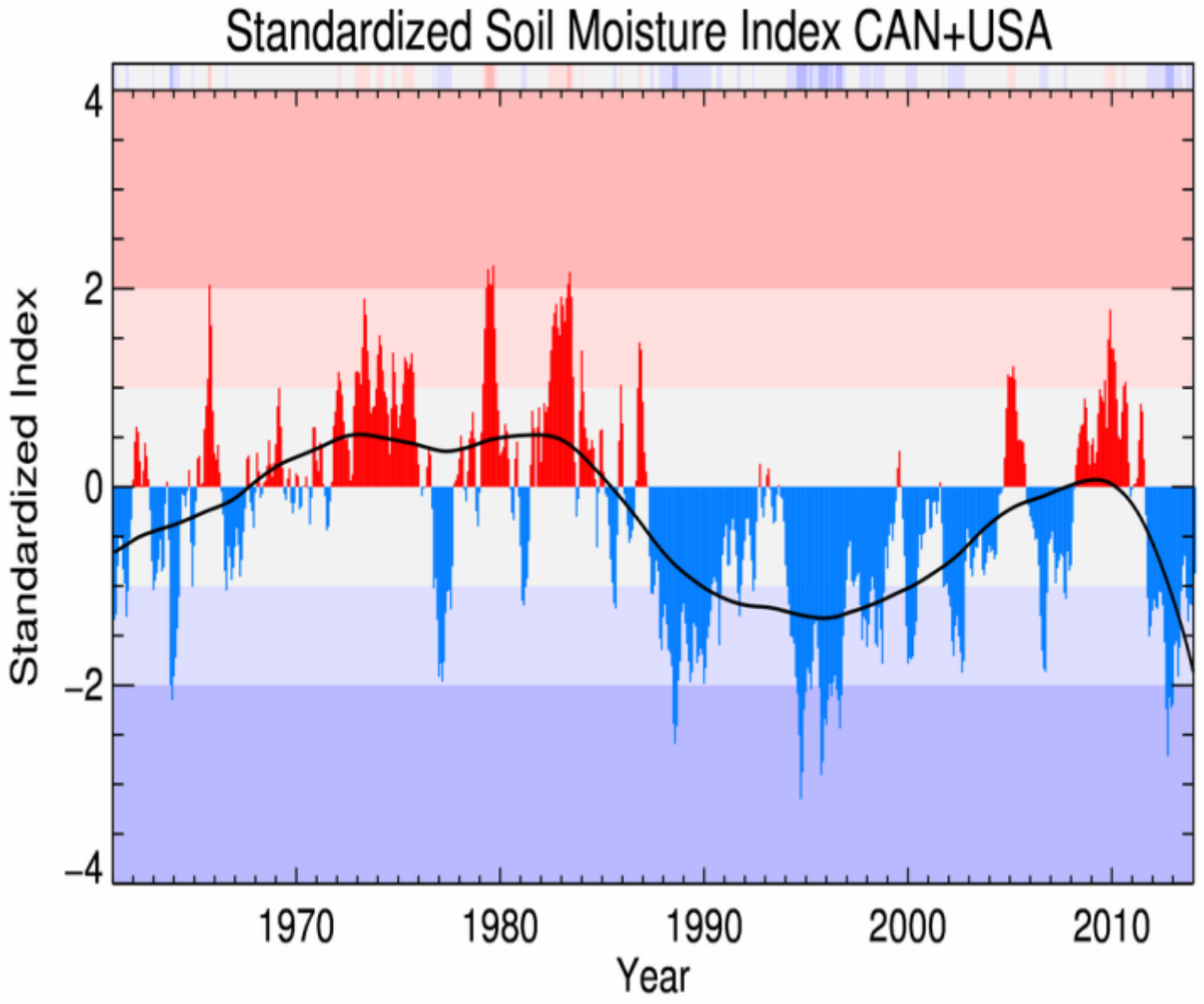
Drought Index

- GHCNDEX, consecutive dry days (CDD)
  - Max days/year with <1mm precipitation
- Drought index = 1 value of CDD/year
  - Linear interpolation to obtain monthly
  - % anomaly relative to 1961-1990
- Dx = 100% * $[(CDD - CDD_{ref})/CDD_{ref}]$
  - $Dx'\ std = \Delta Dx / \sigma_{ref}(Dx)$


Standardized Consecutive Dry Days Index CAN+USA
Standardized Index
4
2
0
−2
−4
1970
1980
1990
2000
2010
Year

Soil Moisture Index

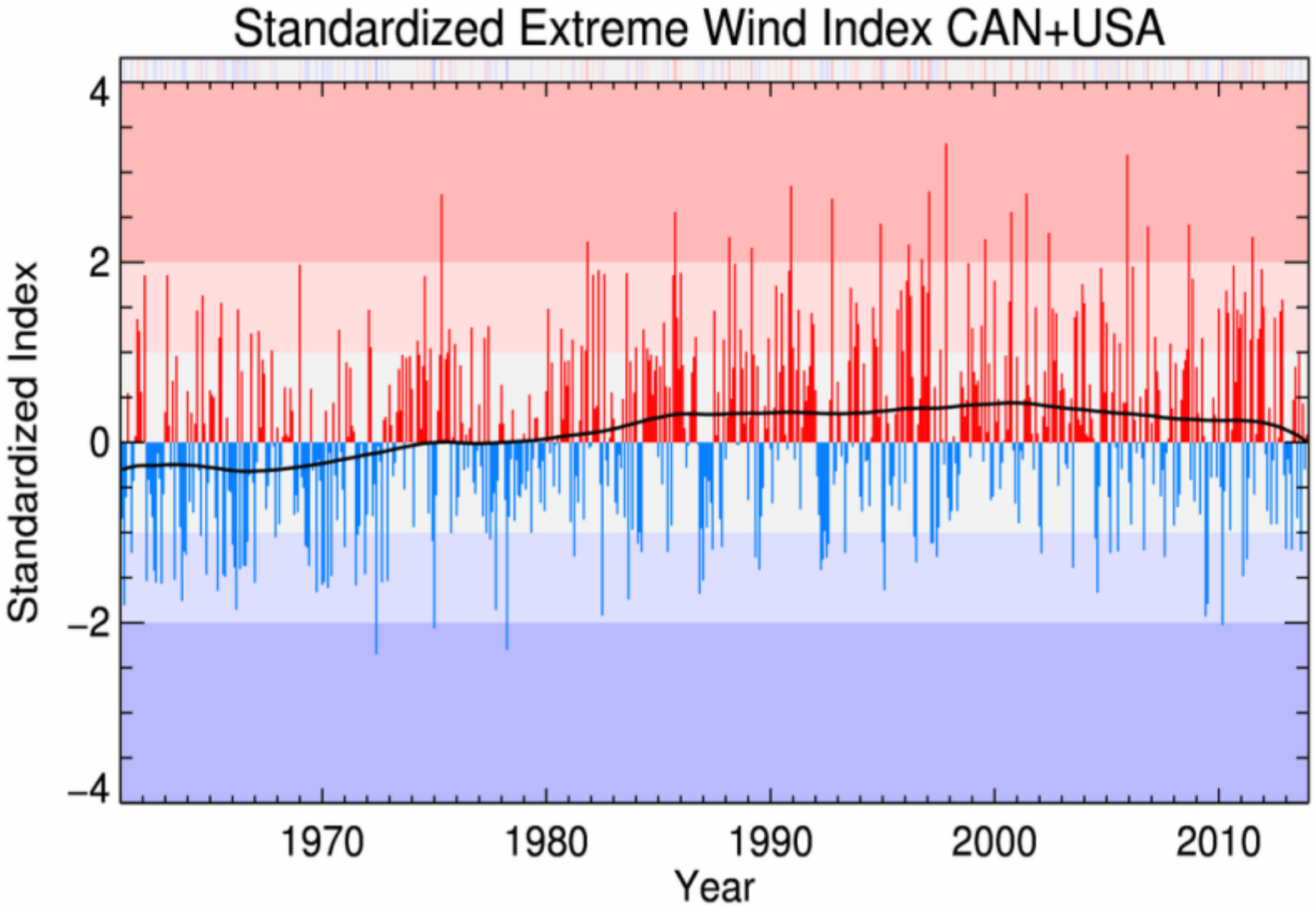
- Index derived by NOAA Earth System Research Laboratory from:
  - Monthly precipitation and temperature
  - Soil properties
  - Local evaporation rate
  - Water balance model
- $M = 100\% * [(SM90 - SM90_{ref})/SM90_{ref}]$
  - $M'\ std = \Delta M / \sigma_{ref}(M)$


Standardized Soil Moisture Index CAN+USA
Standardized Index
4
2
0
−2
−4
1970
1980
1990
2000
2010
Year

Wind Power Index

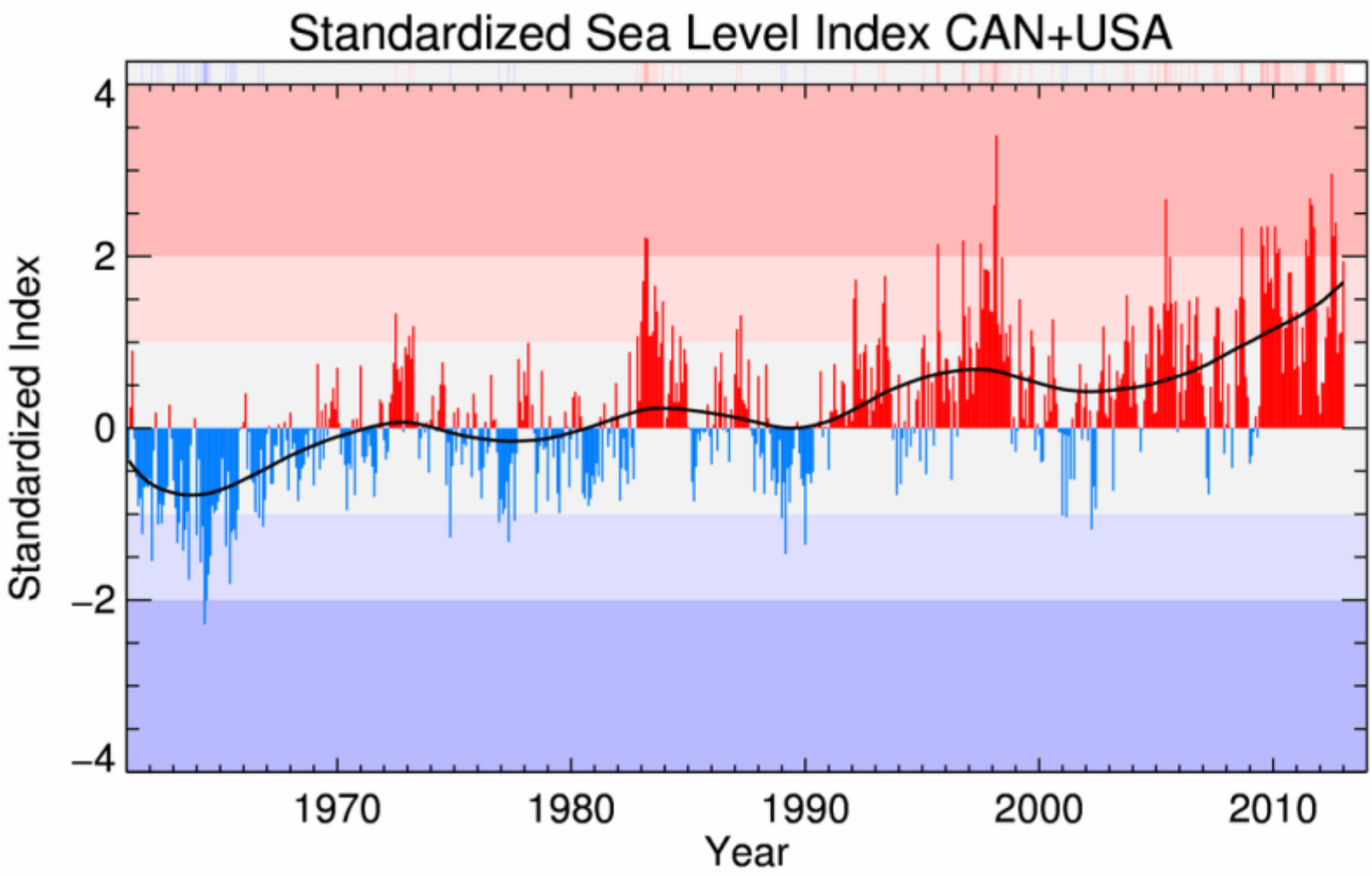
- Index derived from NOAA Earth System Research Laboratory data:
  - Daily mean wind speeds
  - $WP = (1/2)*\rho*w^3$

    Where ρ is air density, w is daily mean wind speed
- $Wx = 100\% * [(WP90 – WP90_{ref})/WP90_{ref}]$
  - Where WP90 is the 90^{th} percentile of daily wind power, calculated monthly
  - $W'\ std = \Delta Wx / \sigma_{ref}\,(Wx)$


Standardized Extreme Wind Index CAN+USA
Standardized Index
4
2
0
−2
−4
1970
1980
1990
2000
2010
Year

Sea Level Index (S)

- At tide gauge stations along US and Canada coast
  - Data provided by Permanent Service for Mean Sea Level (PSMSL), part of the UKs National Oceanography Center
    - Data will be matched to grids used for other variables
  - S' std = $\Delta Sx / \sigma_{ref}(Sx)$


Standardized Sea Level Index CAN+USA
Standardized Index
4
2
0
−2
−4
1970
1980
1990
2000
2010
Year

Composite ACI Index

Several options were considered:

1) *Unweighted sum of individual components*
   $ACIusum = Tx + Px + Dx + M + Wx + S$

2) *Unweighted average of individual components*
   $ACIuavg = (Tx + Px + Dx + M + Wx + S) / 6$

Composite ACI Index

3) Weighted average of individual components

$$ACIwavg = [Tx + Px - Dx + M + 2Wx + S] / 6$$

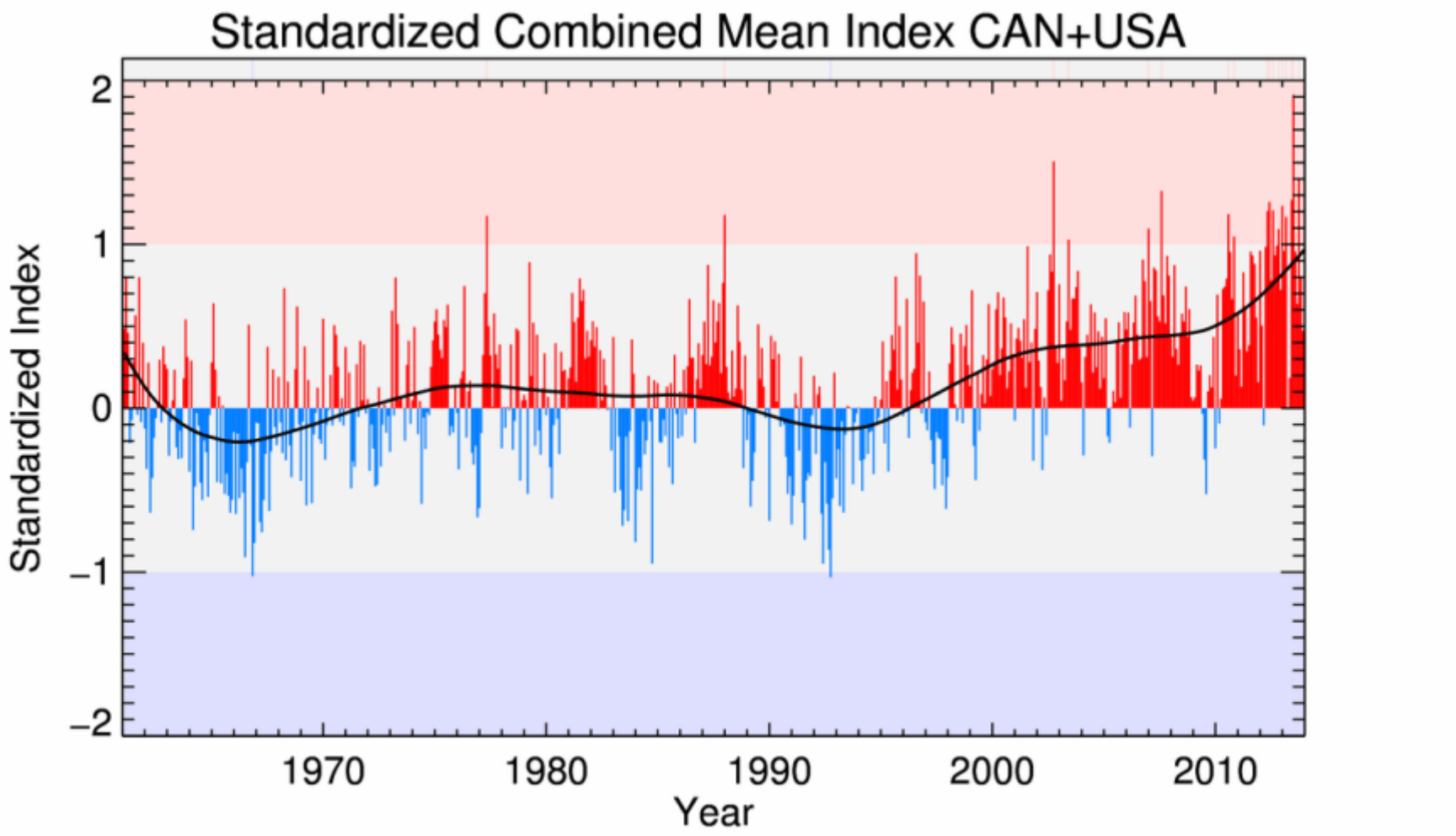
4) Unweighted average of standardized anomalies

$$ACI' = (Tx' + Px' + Dx' + M' + Wx' + S') / 6$$

Where the primes mean, for example:

$$Tx' = (Tx - Tx_{ref}) / SD (Tx_{ref})$$

Actuaries Climate Index



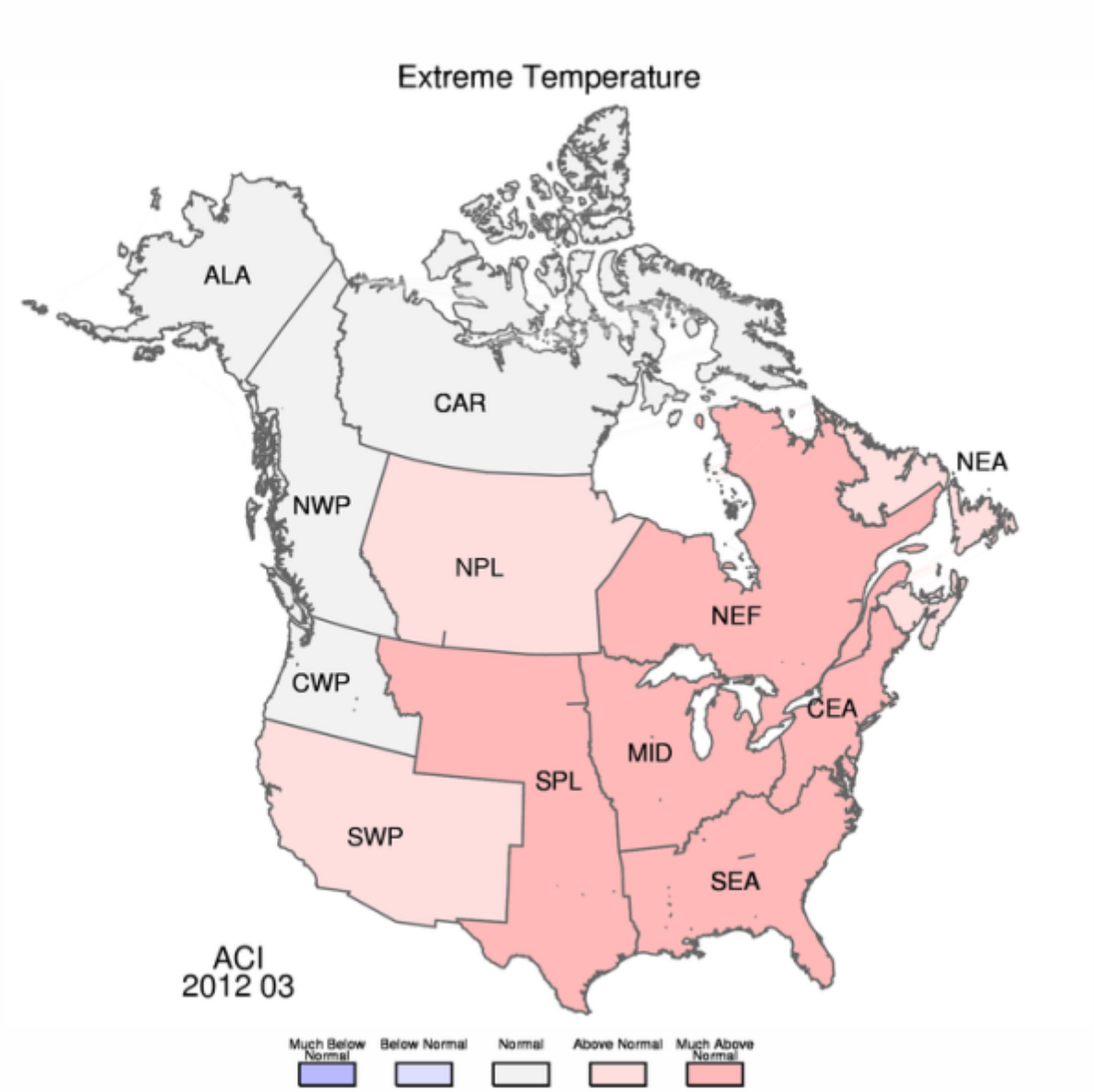
Possible Specialized Sub-Indices

- Warm and wet: mean(Tx' + Px' + M' + S')
- Warm and dry: mean(Tx' + Dx' – M')
- Wet: mean(Px' + M' + S')
- Drought: mean(Dx' – M')
- Storminess: mean(Px' + Wx')

ACI Communication

- Quarterly press releases
- Website
  - Charts of index components and composite indices
  - Maps of variation by 12 regions
  - Commentary in English and French
  - Links to related information

Website Prototype



Actuaries Climate Risk Index

- Combine components of ACI with exposure measures (population, property values) to produce ACRI
  - Same time period and grids as ACI
- Goal is to produce an index especially useful to the insurance industry

ACI/ACRI Timetable

- ACI rollout Summer/Fall 2014
- ACRI rollout late 2014

Resources for Further Learning

Yale Forum on Youtube: Short, Compelling Videos http://www.yaleclimatemediaforum.org/yale-climate-media-forum-on-youtube/

Books:

Hansen, James	Storms of my grandchildren
McKibbon, Bill	Eaarth
Monbiot, George	Heat
Nordhaus, William	The Climate Casino
Kolbert, Elizabeth	Field Notes from a Catastrophe
Weaver, Andrew	Generation Us

Movies: Chasing Ice; Greedy, Lying Bastards; Revolution; The Last Reef.

Reports: Climate Change and Resource Depletion, the Challenges for Actuaries. Resource and Environment Group, 2010 (UK Institute of Actuaries)

Websites: American Association for the Advancement of Science: www.whatweknow.aaas.org

Index Resources

Donat, M. G., et al. 2013, Global land-based datasets for monitoring climatic extremes. Bulletin of the American Meteorological Society, July, 997-1006, doi:10.1175/BAMS-D-12-00109.1.

Hansen J., et al. 1998, A Common Sense Climate Index: Is Climate Changing Noticeably? PNAS, 95, 4113-4120

Solterra Solutions, Determining the Impact of Climate Change on Insurance Risk and the Global Community, Phase I: Key Climate Indicators, November 2012. Available at: www.casact.org/research/ClimateChangeRpt_Final.pdf

Data sources:
GHCNDEX: www.climdex.org
GHCN-Daily: www.ncdc.noaa.gov/oa/climate/ghcn-daily/
Soil Moisture: www.esrl.noaa.gov/psd/data/gridded/data.cpcsoil.html
Sea Level: www.psmsl.org/data/obtaining/
Wind: www.esrl.noaa.gov/psd/data/gridded/datancep.reanalysis.html

Questions or Comments

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