The Actuaries Climate (and Climate Risk) Indices: Uses for Modeling

ACTUARIES CLIMATE INDEX
INDICE ACTUARIEL CLIMATIQUE

ACTUARIES CLIMATE RISK INDEX
INDICE ACTUARIEL
DES RISQUES CLIMATIQUES

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November 6, 2017

Goals of this presentation

- Goals and genesis of the ACI & ACRI
- ACI Overview:
  - Components
  - Regions
- Highlights of the ACI website
- ACRI Overview: Regression components & results
- Next steps
- Brainstorming possible uses
- Q&A

Goals of the Actuaries Climate Index (ACI) and the Actuaries Climate Risk Index (ACRI)

- Create indices that reflect an actuarial perspective, are objective, and are easy to understand without being overly simplistic
- Create one index that measures changes in climate extremes, and a second index that relates those climate extremes to economic and human losses
- Use the indices to inform policymakers, insurance professionals, and the general public on the incidence and impact of extreme events
- Promote the actuarial profession by contributing constructively to the climate change debate

Research Sponsors:

American Academy of Actuaries
Objective. Independent. Effective.™

Canadian Institute of Actuaries / Institut canadien des actuaires

CAS

Society of Actuaries

Overview and Genesis of the Actuaries Climate Index (ACI) and the Actuaries Climate Risk Index (ACRI)

- Many years in the making
- Sponsoring organizations determined the need for the actuarial profession in our region to communicate to the public the actuarial aspects of climate risk
- Multiple work groups on Development, Design, and Communications with representatives from each of the sponsoring organizations
- Work with outside vendors and peer reviewers on climate science, economic data, and design features

Overview of the Actuaries Climate Index (ACI)

- The Actuaries Climate Index (ACI) was launched November 2016. It is intended to provide a useful monitoring tool—an objective indicator of the frequency of extreme weather and the extent of sea level change.
  - Website provides graphics and data for download
  - The ACI is available for the United States and Canada and 12 sub-regions thereof.
  - Six component sub-indices for hot temperatures, cold temperatures, high precipitation, drought, high wind, and coastal sea level

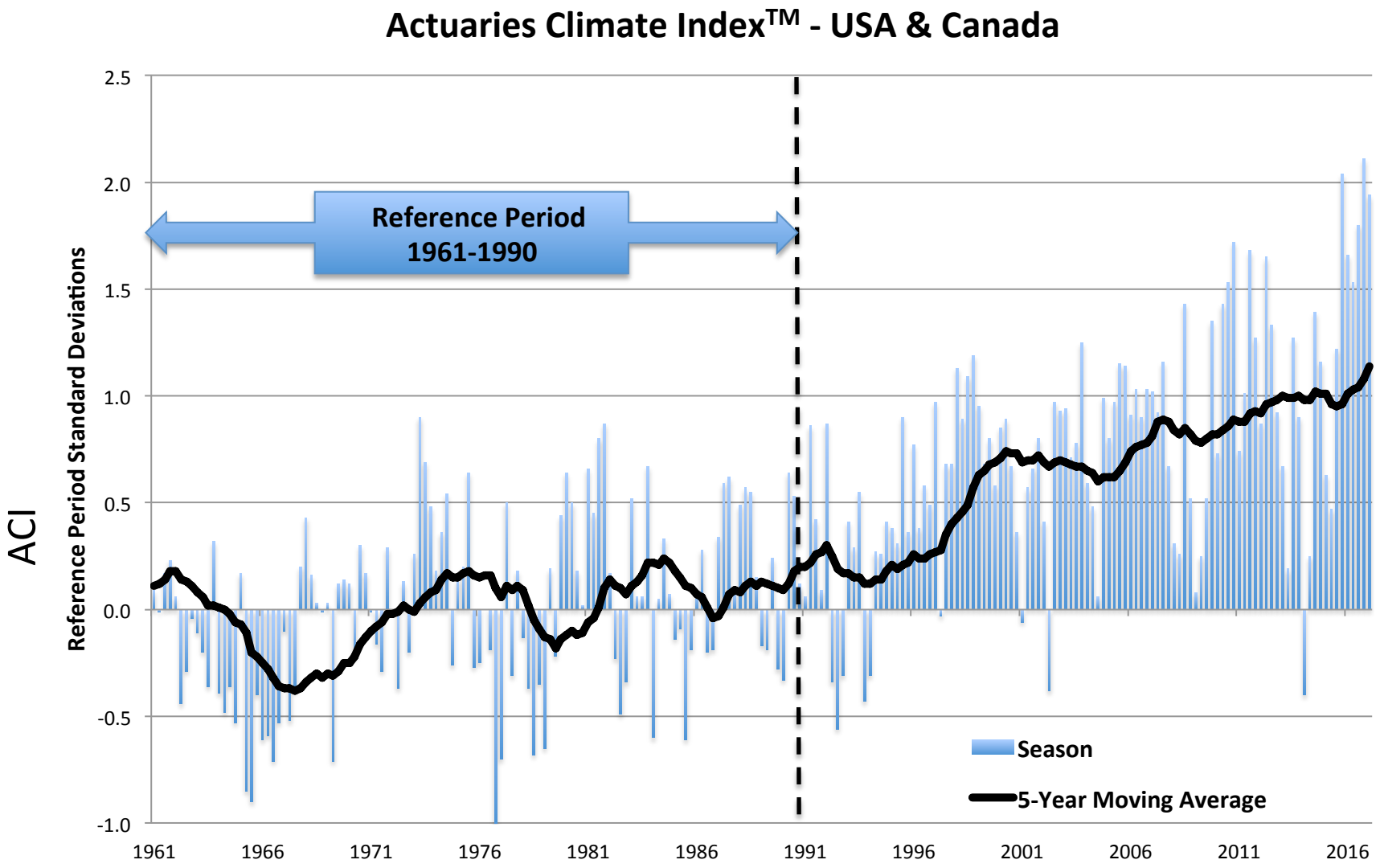
- It does not address debate over causes of climate change

- It does not provide projections of future effects of climate change

The Actuaries Climate Index (ACI) focuses on the frequency of severe weather

- Example: "How often is the temperature in a given month at or above the 90th percentile?"
- The 90th percentile is based on the 1961-1990 base reference period
- Average of six component sub-indices for hot temperatures, cold temperatures, high precipitation, drought, high wind, and coastal sea level
- $ACI = (\Delta T_H - \Delta T_C + \Delta P + \Delta D + \Delta W + \Delta S) / 6$
- ACI components are of the form:

$$(x - \mu_{ref}) / \sigma_{ref}$$


Actuaries Climate Index™ - USA & Canada
ACI
Reference Period Standard Deviations
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
1961
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Reference Period
1961-1990
Season
5-Year Moving Average

T90 and T10

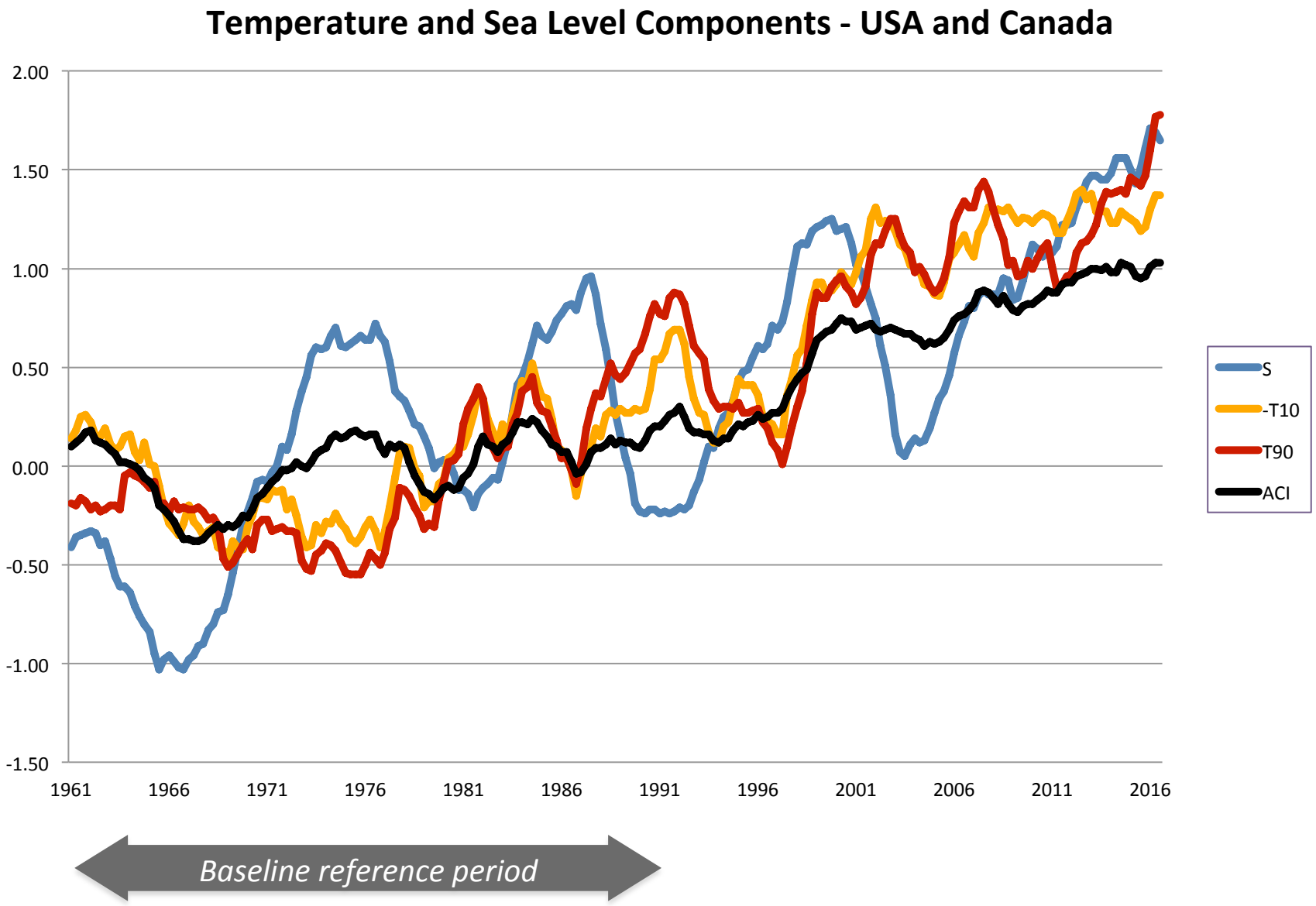
- T90: "How often is the temperature in a given month at or above the 90th percentile, based on the 1961-1990 base reference period?"
- T10: "How often is the temperature in a given month below the 10th percentile, based on the 1961-1990 base reference period?"
- T90 is calculated for both daily maximum temperatures (TX90) and the daily minimum temperatures (TN90); T90 is the average of TX90 and TN90
- Similar for T10, with T10 = (TX10 + TN10)/2
- TX90, TN90, TX10, TN10 come from GHCNDEX, which provides monthly data on a gridded dataset (2.5 degrees latitude and longitude)
- GHCNDEX is from the National Center for Atmospheric Research and the University Corporation of Atmospheric Research, headquartered at the University of Colorado

Precipitation and Drought

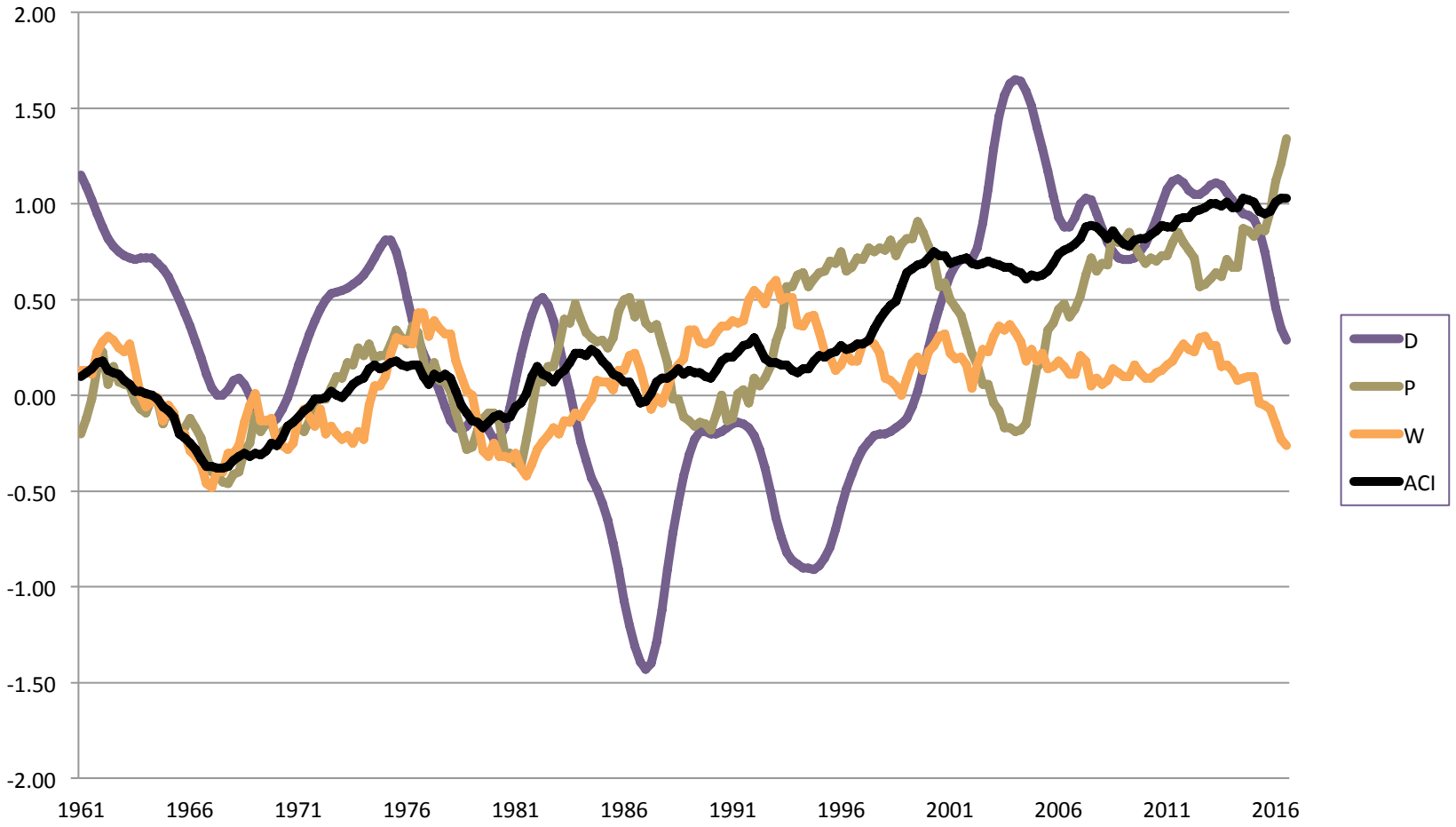
- Precipitation is measured as the maximum 5-day precipitation amount in a month
- It comes as a gridded dataset from GHCNDEX
- Drought is based on the maximum number of GHCNDEX Continuous Dry Days (a dry day is defined as less than 1 mm of precipitation)
- For each grid point, Continuous Dry Days is a single annual value
- We are looking to improve the frequency of this data measure

Wind Power and Sea Level

- Wind Power is calculated as the 90th percentile of the average Wind Speed from the National Centers for Environmental Protection (NCEP)
- Wind Power is equal to a constant x Wind Speed^3
- Wind Power is used, as damages have been found to be proportional to Wind Power
- Sea Level is our only component that is not based on a gridded dataset
- It comes from a worldwide database (Permanent Service for Mean Sea Level) from Liverpool, UK
- Based on mean monthly Sea Level at 76 coastal tidal stations; the stations within each region are averaged to produce a regional result


Temperature and Sea Level Components - USA and Canada
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
1961
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
S
-T10
T90
ACI
Baseline reference period

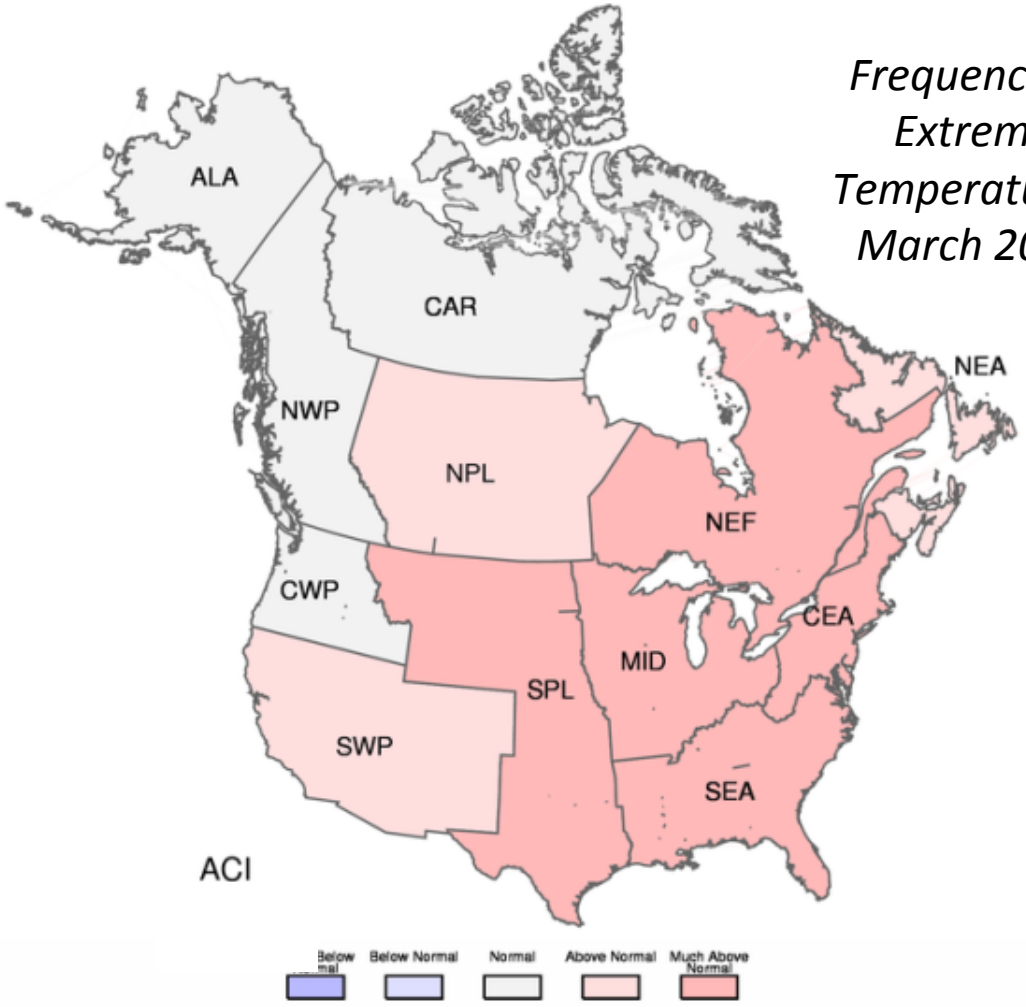
Wind Power, Precipitation, and Drought - USA and Canada



Baseline reference period

ACI data is constructed for geographic grids, then summarized to regions, countries, and in total

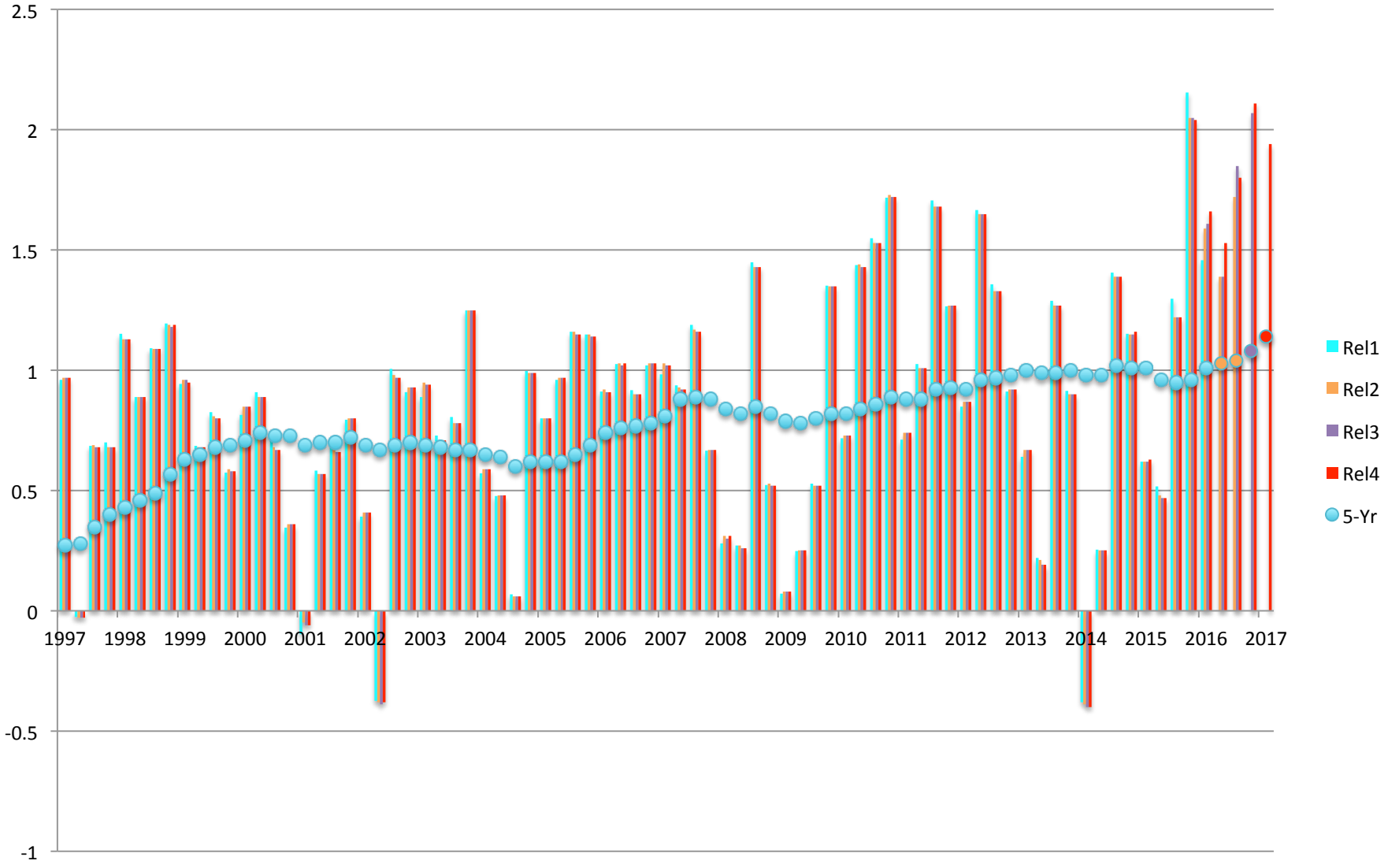
- ACI components are constructed in a uniform 2.5°grid across the USA and Canada
  - 275km by 275km at equator
- Grid components for each climate variable are summarized into indices for 12 natural regions, two countries and U.S. and Canada in total
- Summarized indices are unweighted averages of grid components
  - Each climate change component is equally important



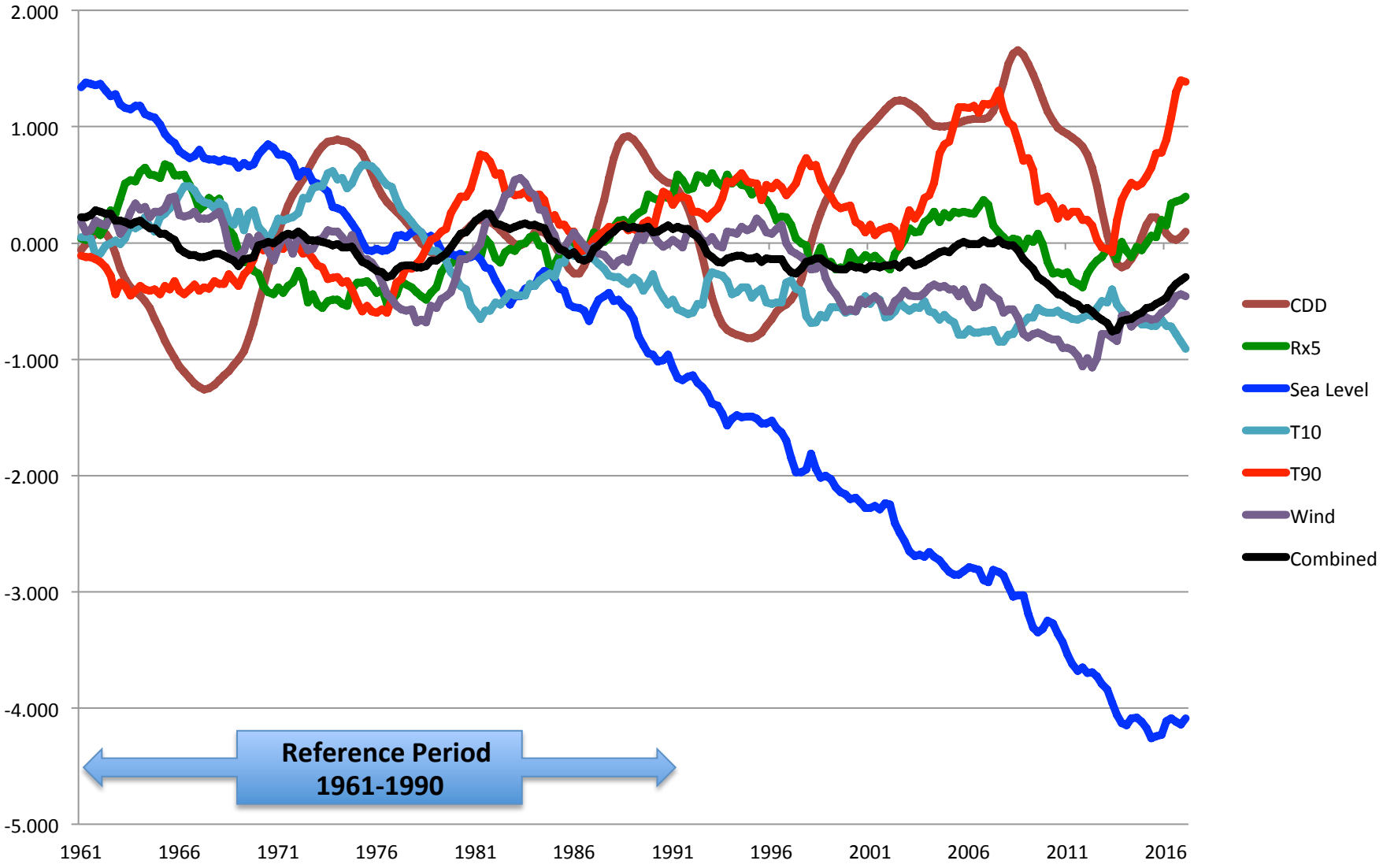
Frequency of Extreme Temperatures: March 2012

13

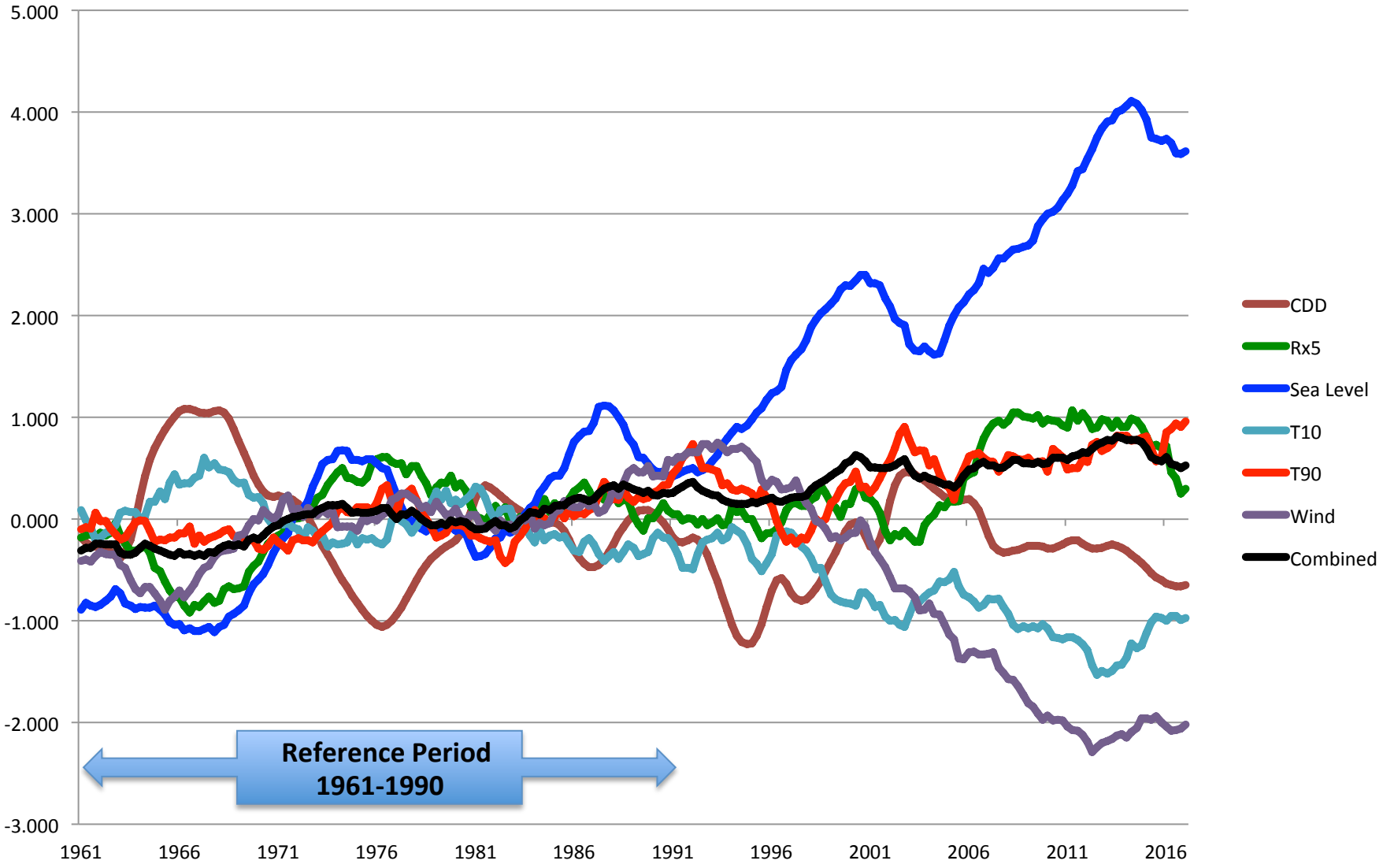
Comparison of ACI Results by Release

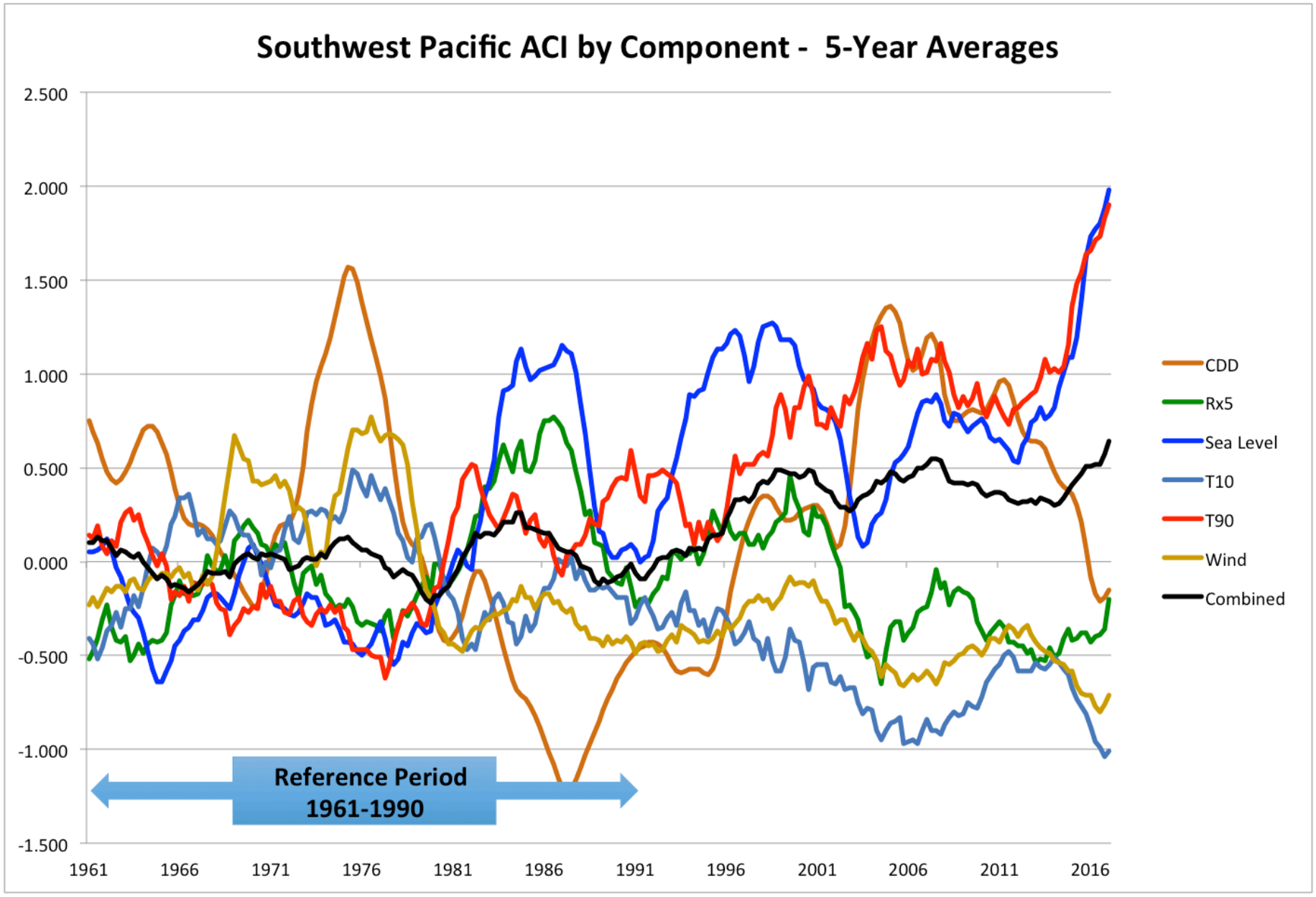


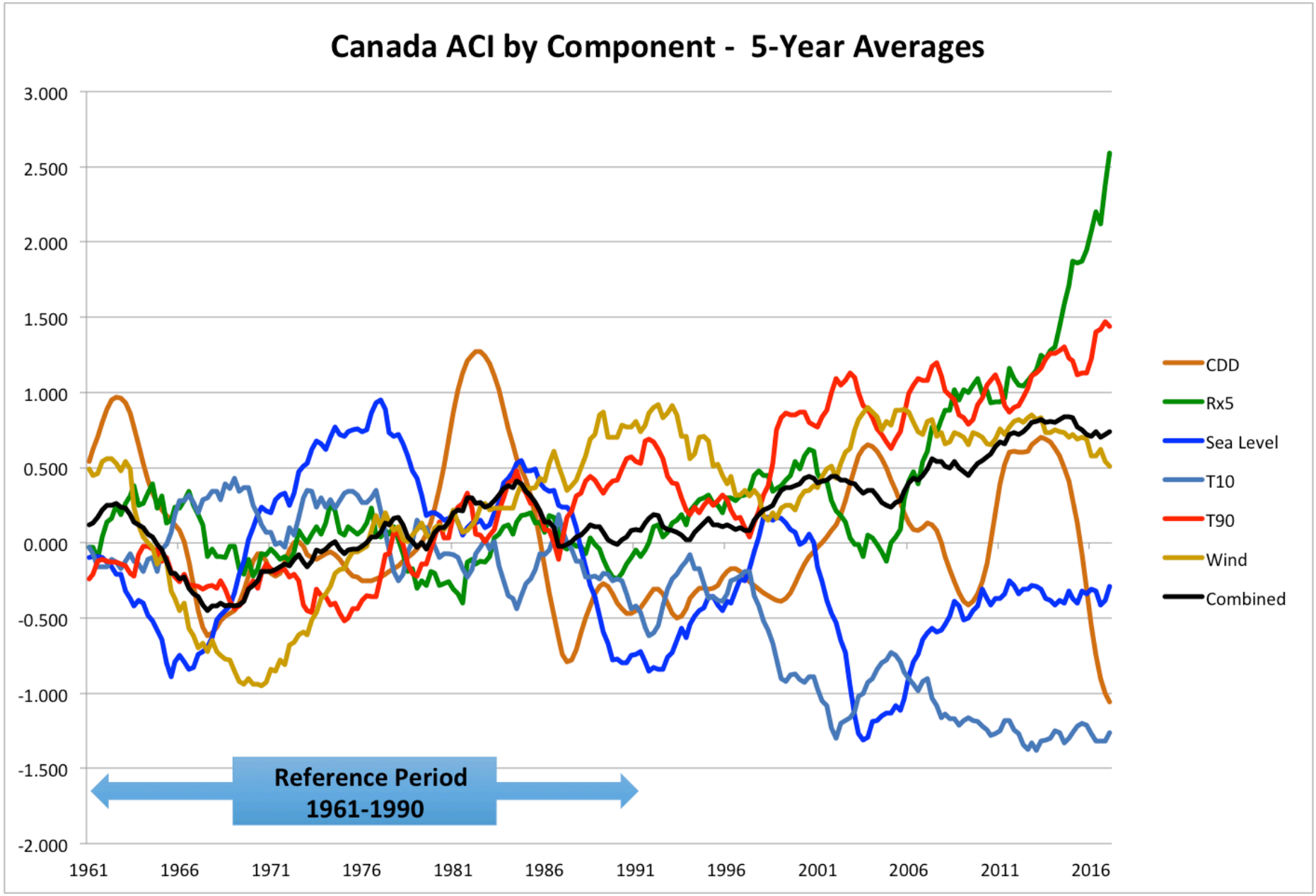
Alaska ACI by Component - 5-Year Averages



Central East Atlantic ACI by Component - 5-Year Averages




Southwest Pacific ACI by Component - 5-Year Averages
2.500
2.000
1.500
1.000
0.500
0.000
-0.500
-1.000
-1.500
1961
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Reference Period
1961-1990
CDD
Rx5
Sea Level
T10
T90
Wind
Combined


Canada ACI by Component - 5-Year Averages
3.000
2.500
2.000
1.500
1.000
0.500
0.000
-0.500
-1.000
-1.500
-2.000
1961
1966
1971
1976
1981
1986
1991
1996
2001
2006
2011
2016
Reference Period
1961-1990
CDD
Rx5
Sea Level
T10
T90
Wind
Combined

Highlights of the ACI Website

actuariesclimateindex.org

Data Disclosures

ACTUARIES CLIMATE INDEX
INDICE ACTUARIEL CLIMATIQUE

Website

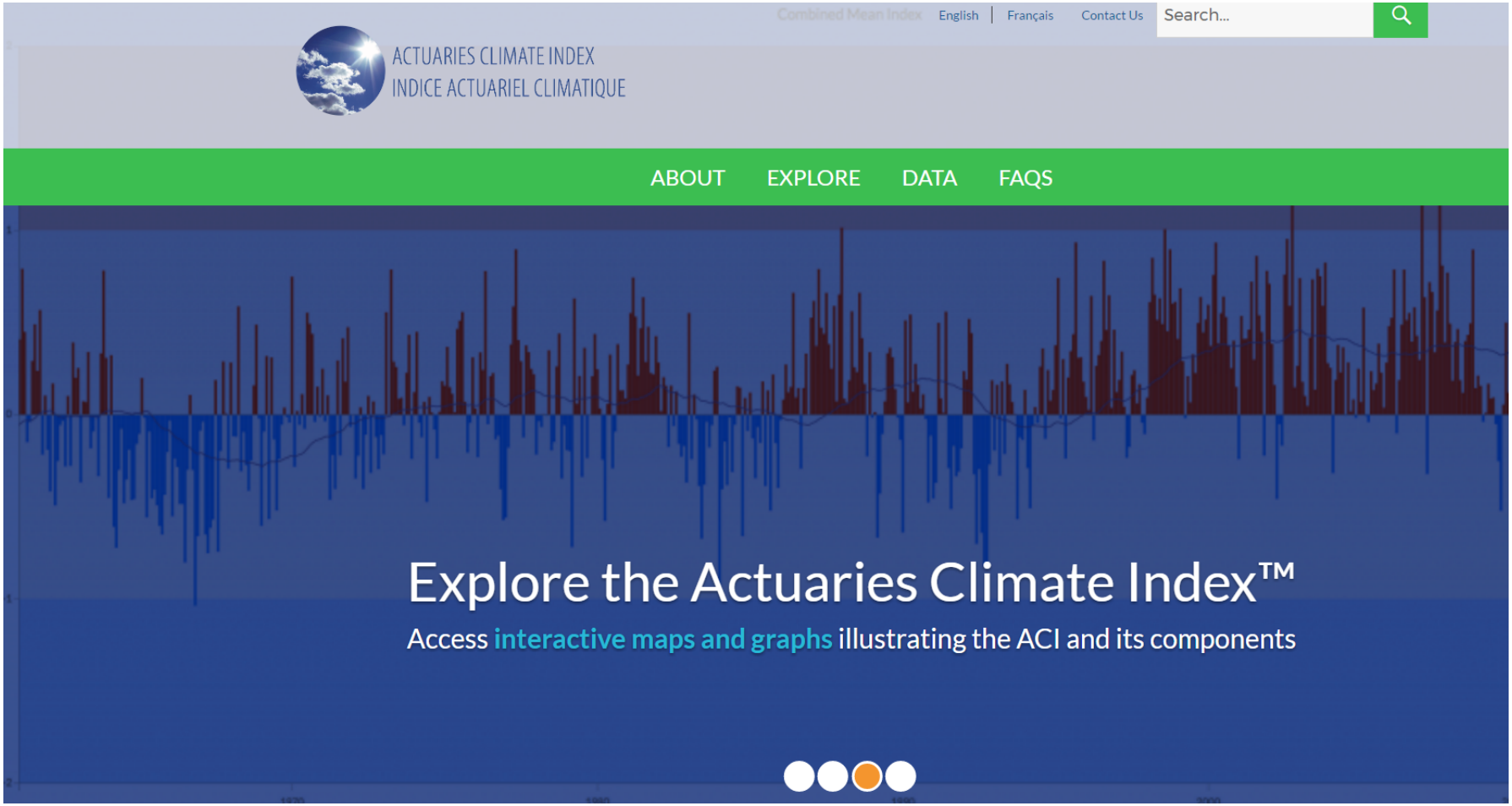
- ACI information publicly available on a dedicated website, as a resource for use in further research (ACRI will be added)
- Website includes commentary, documentation, charts of index components, maps showing variation by region, index data for download, and links to other information
- Commentary provided in English and French
- ACI and ACRI data will be updated quarterly on the website, based on data for each meteorological season (3 months ending February, May, August, and November)
- We send out a news release with each new update
- Third seasonal ACI update posted on October 5th
- Since launch, more than 22,000 visitor sessions from 134 countries have been tracked, and more than 1,600 data downloads have been made

Top 24 Countries visiting ACI Site (# of sessions)

- United States 11491
- Canada 3838
- Denmark 762
- United Kingdom 477
- Australia 246
- China 238
- India 224
- Hong Kong 163
- France 150
- Belgium 146
- Germany 124
- Indonesia 107
- South Korea 97
- Malaysia 93
- Mexico 89
- Japan 86
- Brazil 77
- Switzerland 66
- Taiwan 61
- Netherlands 57
- Pakistan 57
- South Africa 57
- Singapore 53
- Bermuda 51

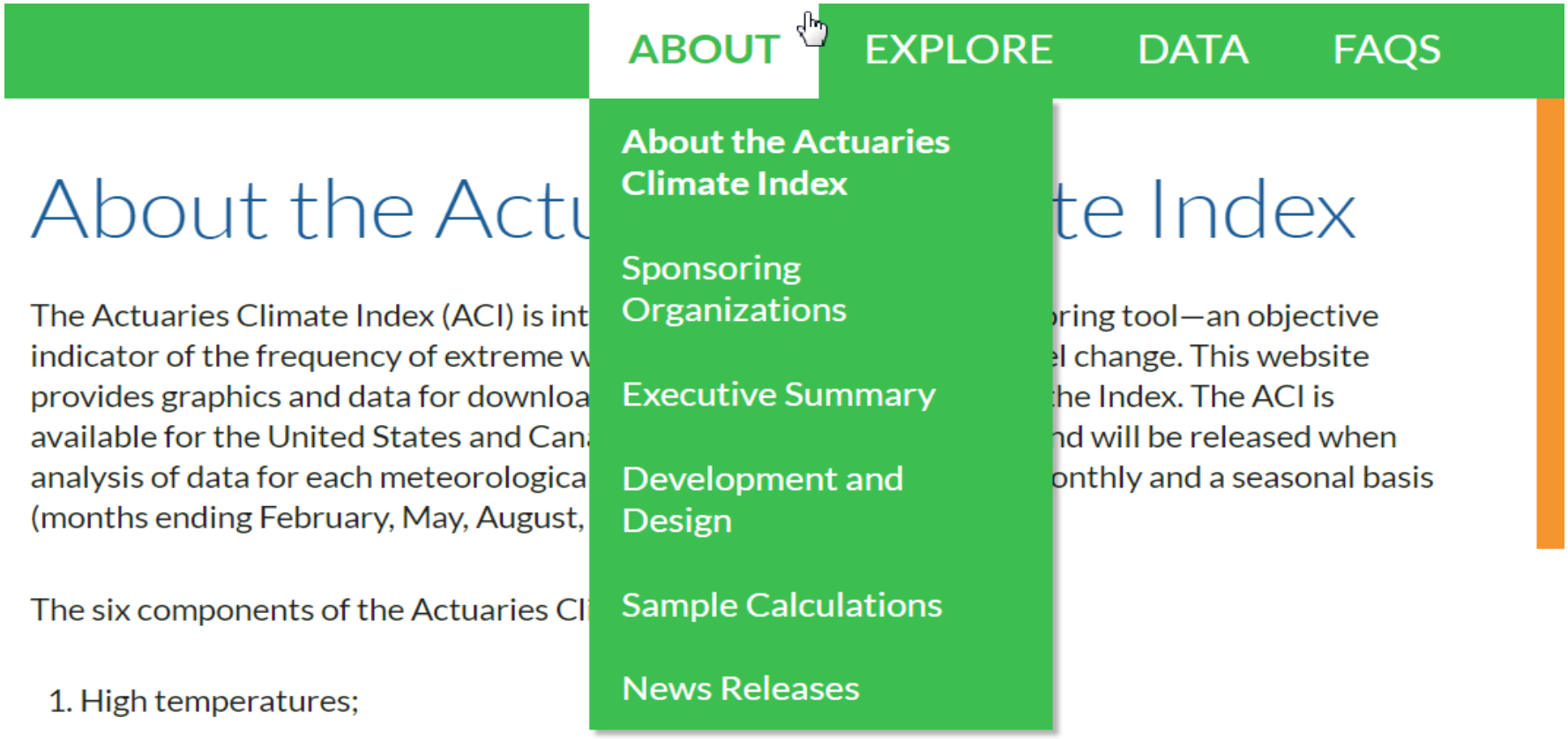
Website

www.actuariesclimateindex.org www.indiceactuarielclimatique.org

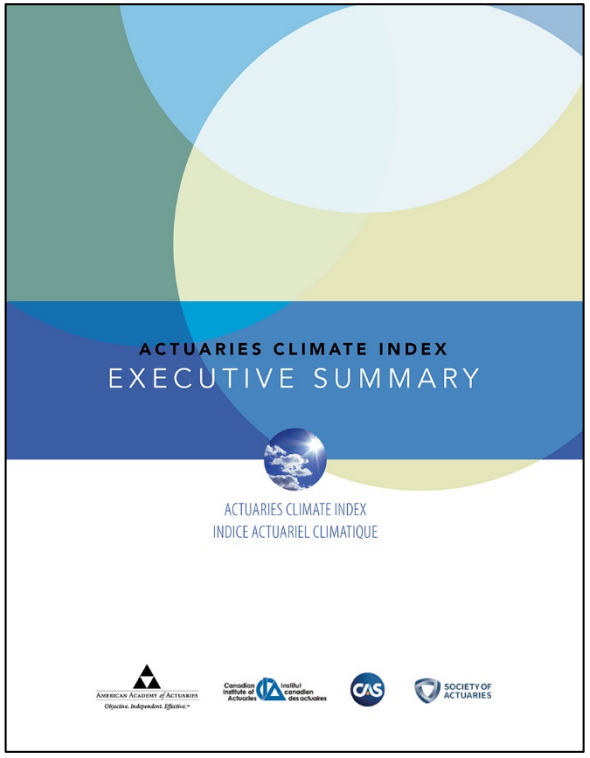


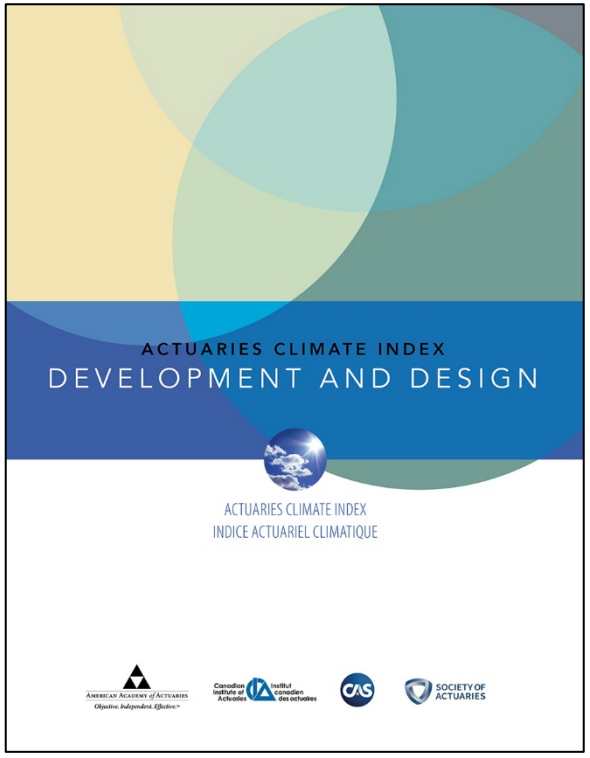
Website - About

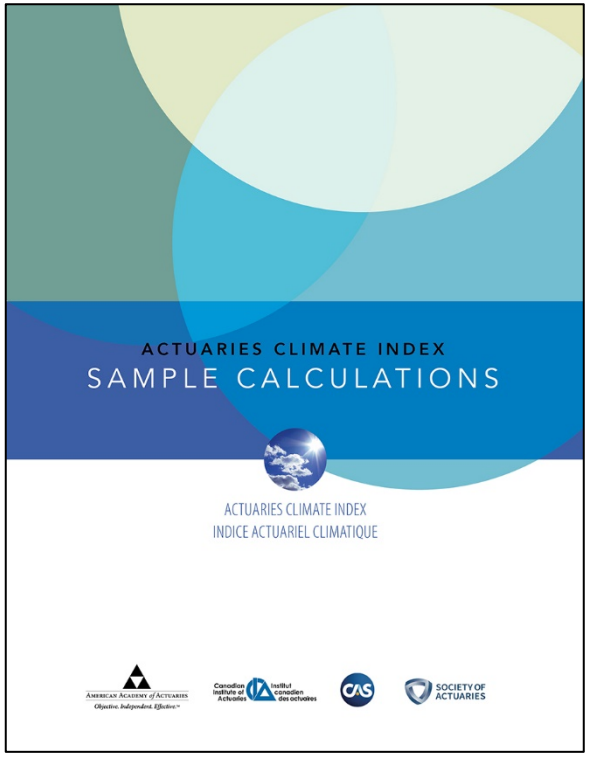
www.actuariesclimateindex.org



Three Foundational Documents on the ACI Website

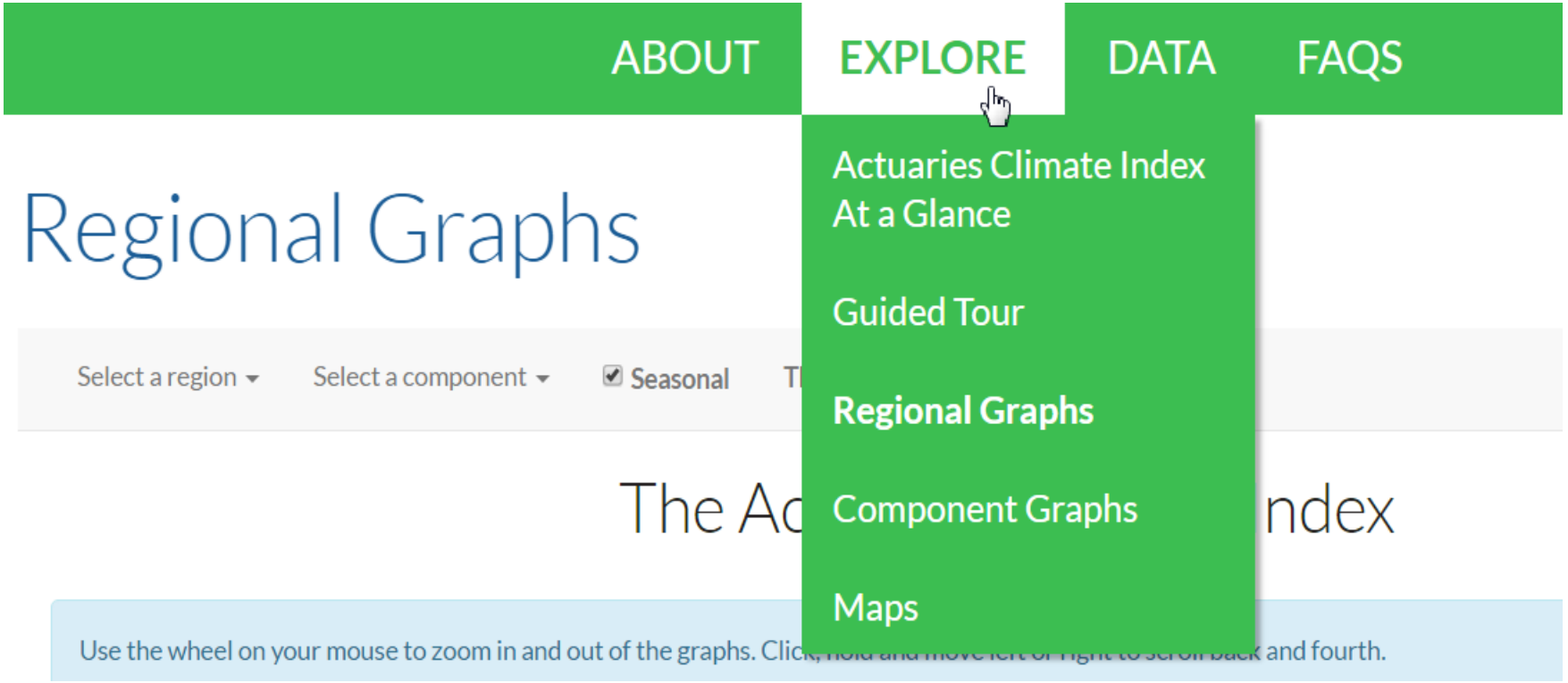






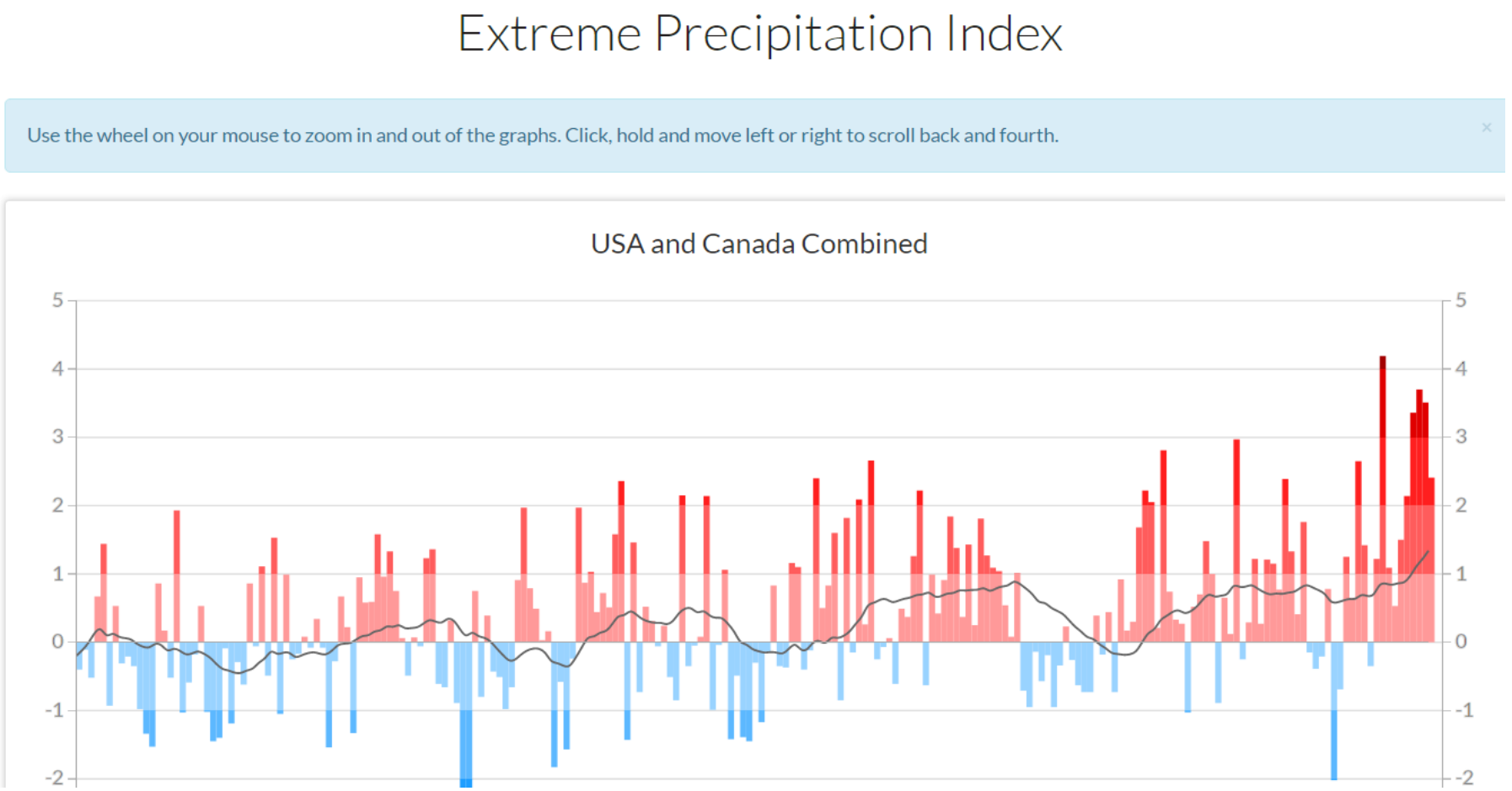
Website - Explore

www.actuariesclimateindex.org



Website – Explore – Component Graphs

www.actuariesclimateindex.org



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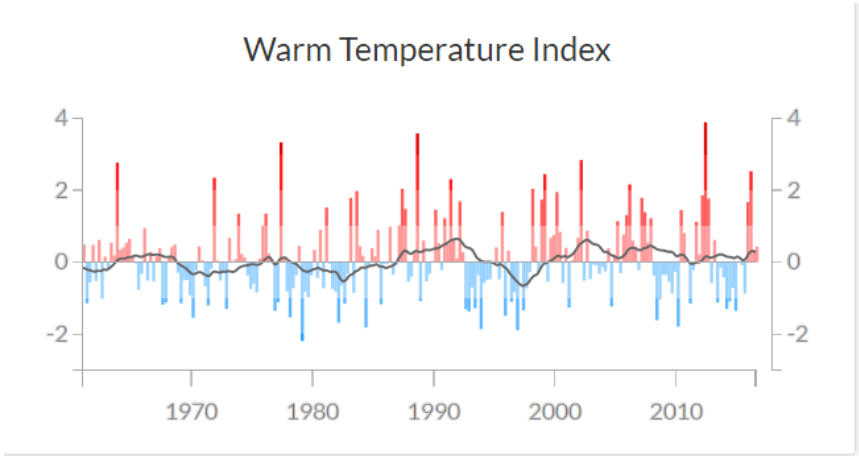
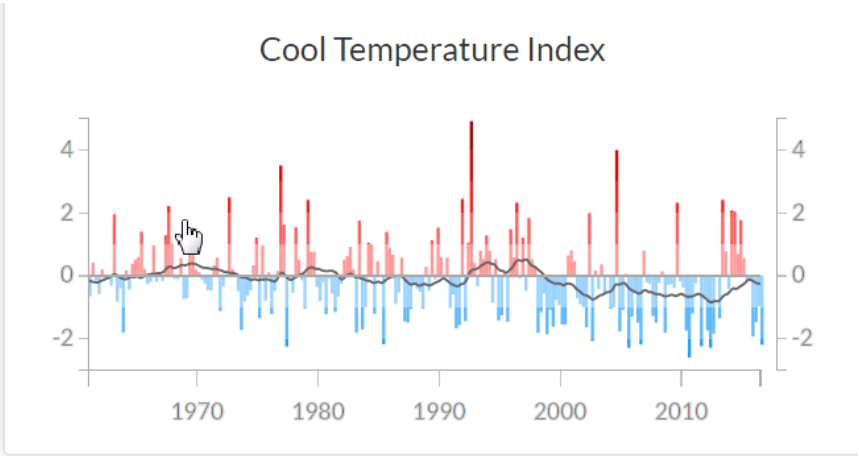
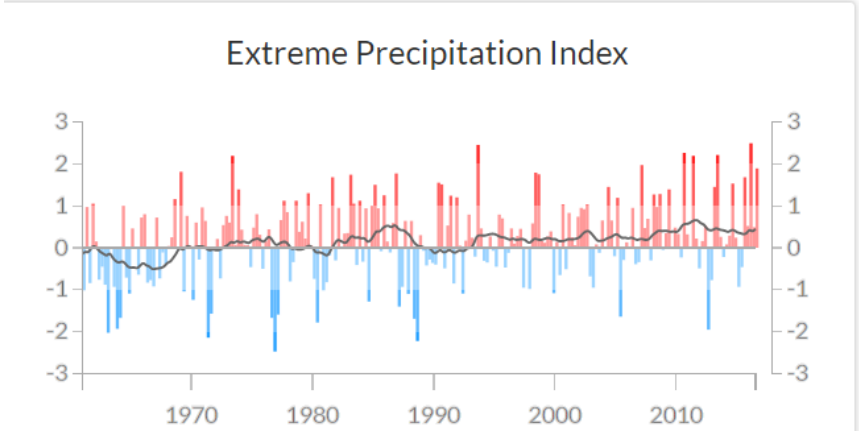
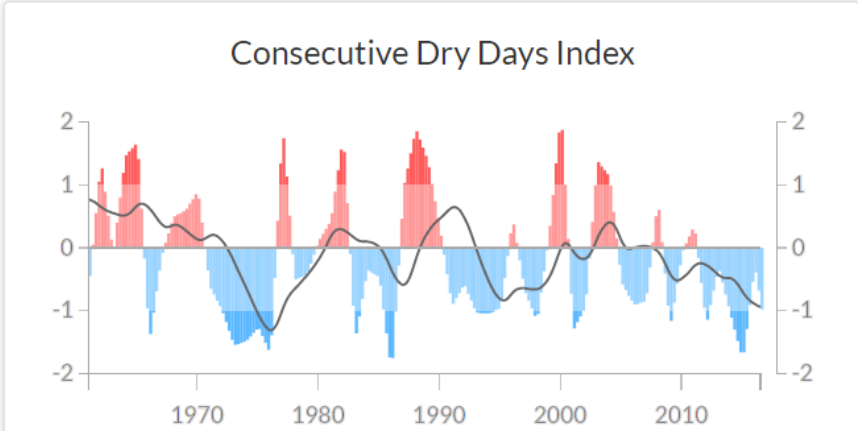


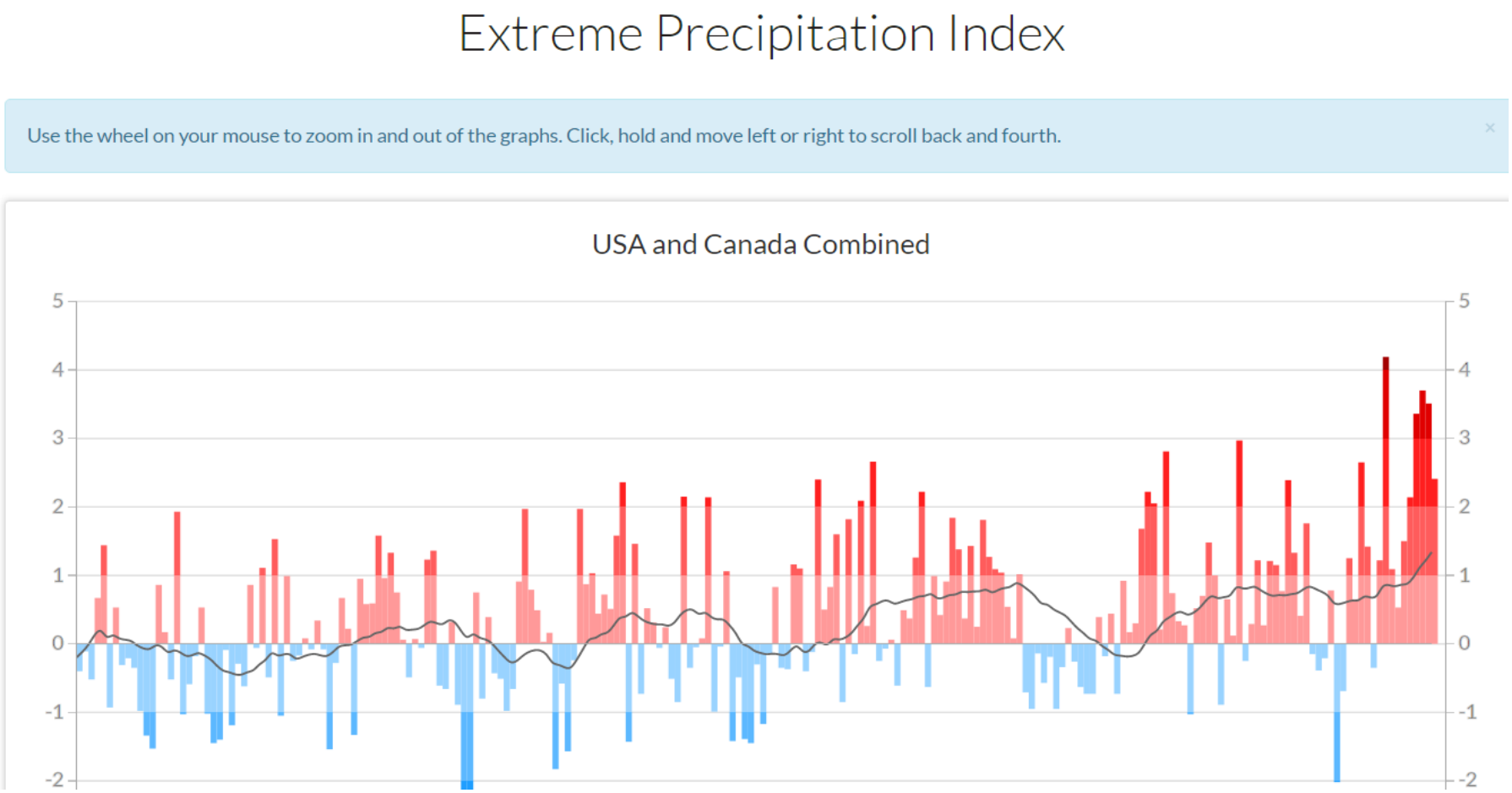






Website – Explore – Regional Graphs

www.actuariesclimateindex.org



Website – Explore – Regional Graphs

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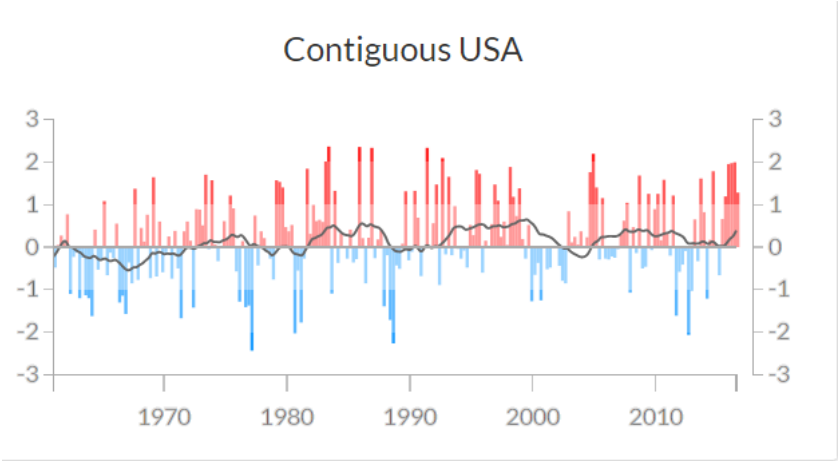
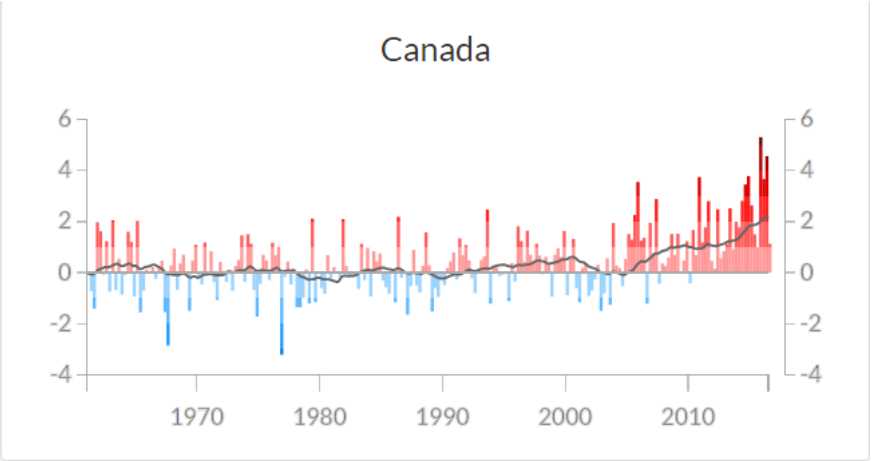
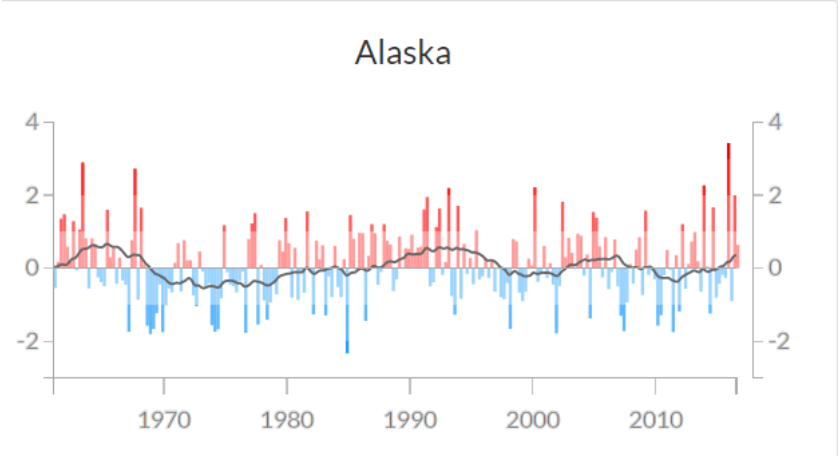
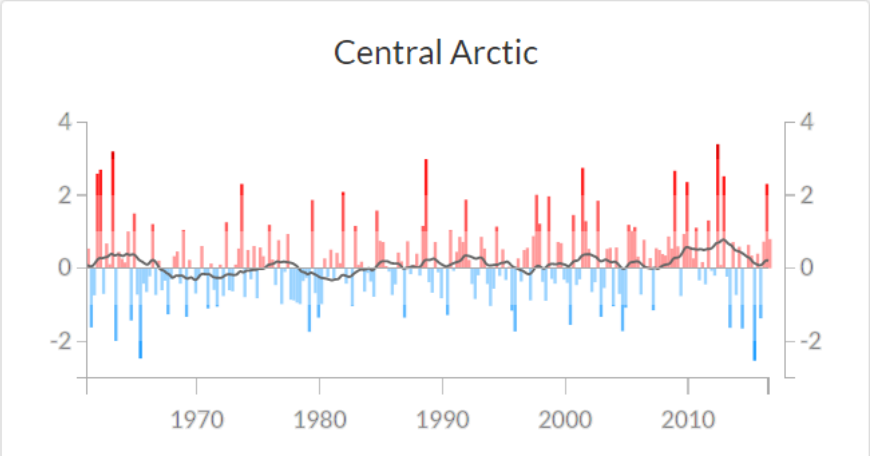


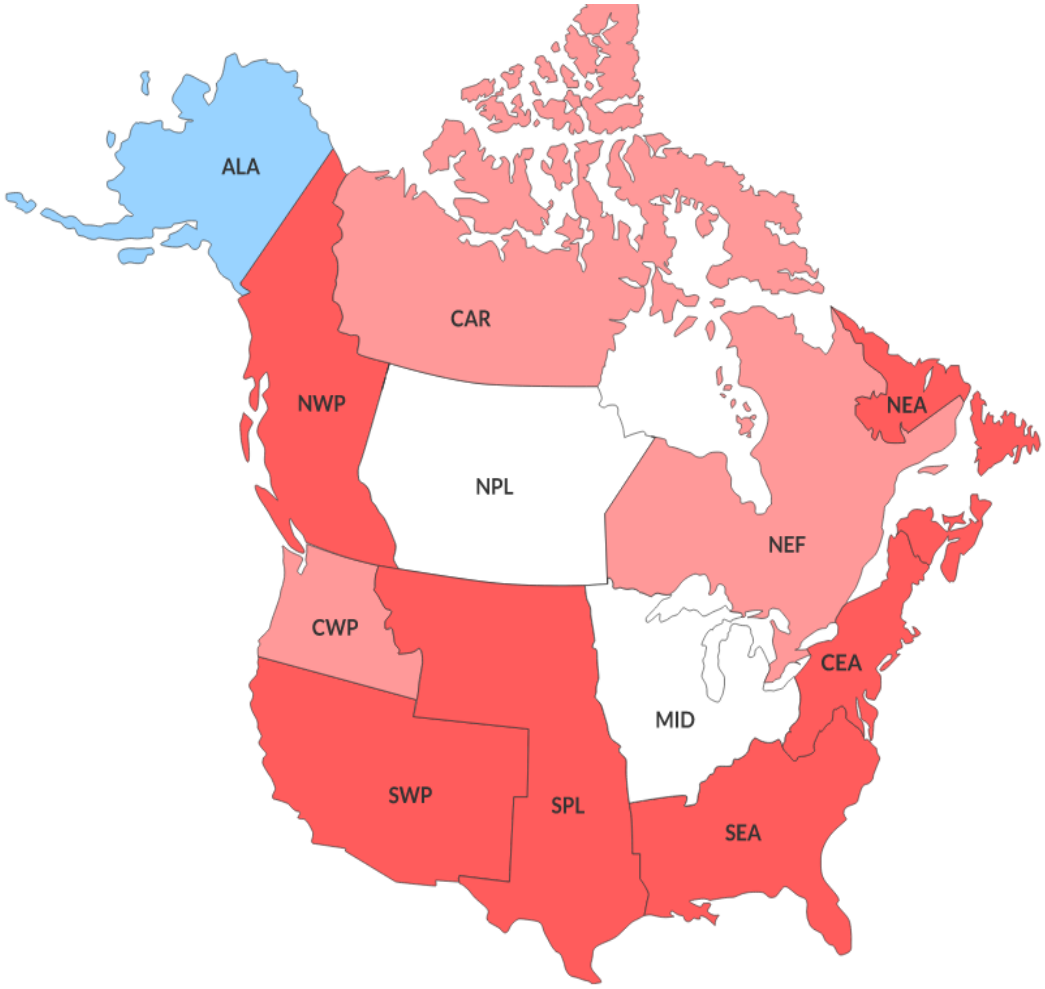


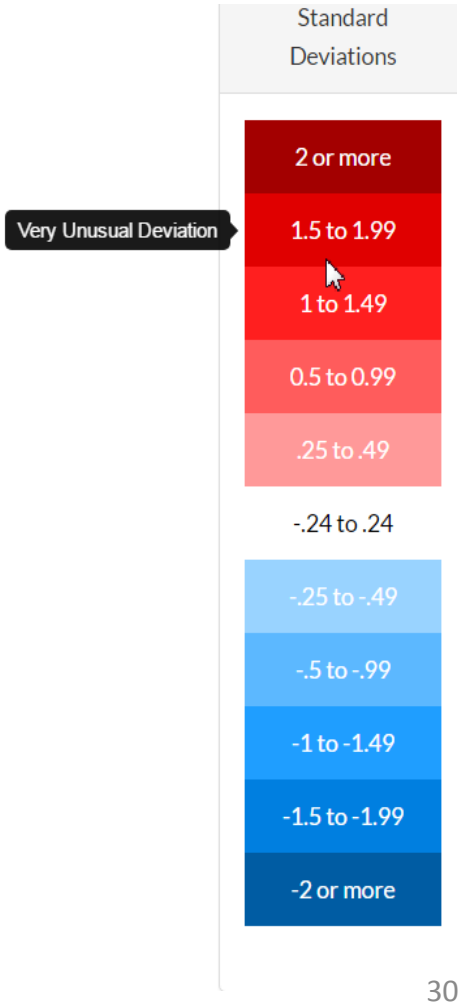




Website – Explore – Maps

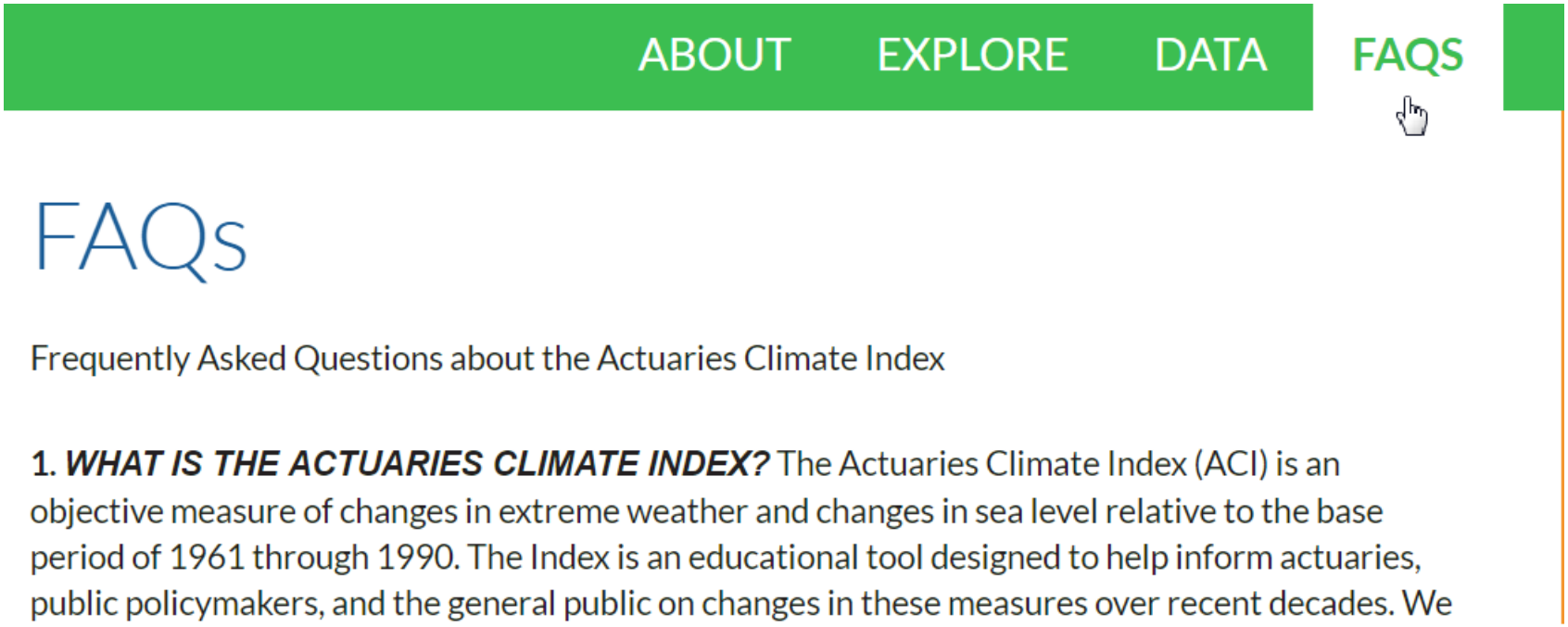
www.actuariesclimateindex.org





Website - FAQs

www.actuariesclimateindex.org



FAQs

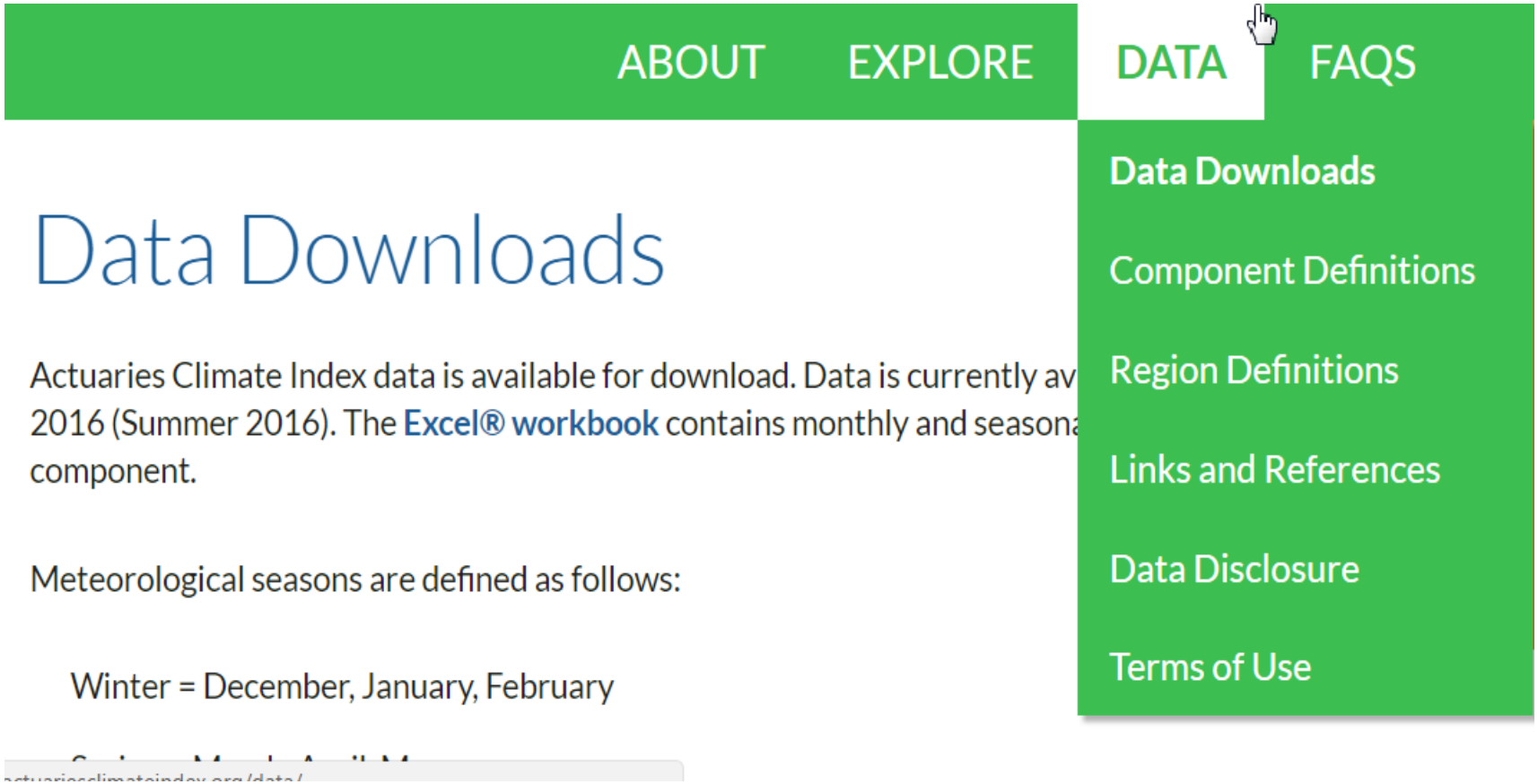
Frequently Asked Questions about the Actuaries Climate Index

1. ***WHAT IS THE ACTUARIES CLIMATE INDEX?*** The Actuaries Climate Index (ACI) is an objective measure of changes in extreme weather and changes in sea level relative to the base period of 1961 through 1990. The Index is an educational tool designed to help inform actuaries, public policymakers, and the general public on changes in these measures over recent decades. We intend to update the index quarterly, as data for each meteorological season is available. We also intend to publish a second index, the Actuaries Climate Risk Index (ACRI), based on the historical correlations of economic losses, deaths and injuries to the ACI data.

2. ***WHY ARE ACTUARIES WEIGHING IN ON CLIMATE CHANGE DISCUSSIONS?*** Actuaries are experienced in the assessment and mitigation of financial consequences of risks and in the

Website - Data

www.actuariesclimateindex.org



Website - Data

www.actuariesclimateindex.org

Data Disclosure

Data Disclosure for the Actuaries Climate Index™

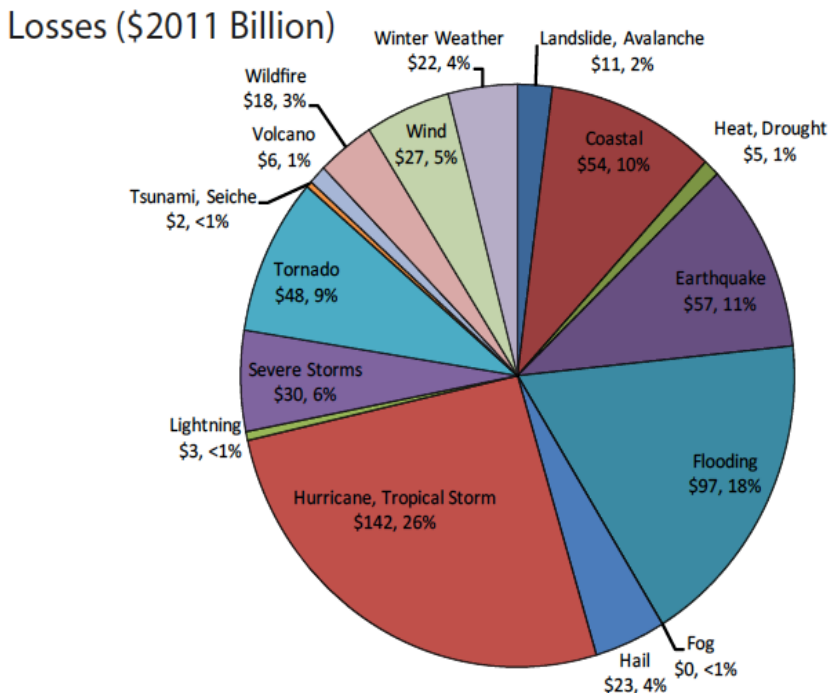
In performing the work for this project, the American Academy of Actuaries (Academy), Casualty Actuarial Society (CAS), Canadian Institute of Actuaries (CIA), and Society of Actuaries (SOA) relied upon data and information provided by Solterra Solutions and a number of publicly available data sources: the National Oceanic and Atmospheric Administration (NOAA), CLIMDEX*, and Permanent Service for Mean Sea Level. We reviewed the data and information provided for reasonableness but did not perform detailed audits. We have, therefore, relied upon each of these sources to provide accurate and complete data and information.

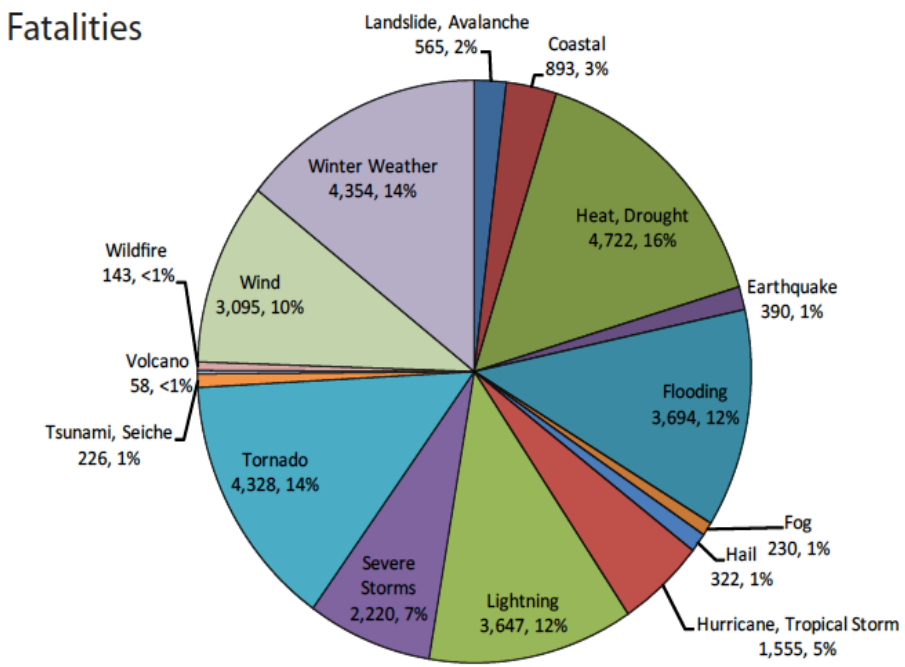
Actuaries Climate Risk Index

- Measure correlation of economic and human losses by peril to the relevant climate variable
  - Using SHELDUS (Spatial Hazard Events and Losses Database for the United States) data for economic losses, mortality and injuries in the U.S.
    - Wind losses in SHELDUS can be found in 5 categories: hurricanes & tropical storms, tornados, severe storms, winter storms, and wind; only the wind category was used.
  - Canadian Disaster Database, compiled by Public Safety Canada
- Goal is to produce an index especially useful to actuaries and insurance professionals

SHELDUS Data Summary 1960-2011

MONETARY & HUMAN LOSSES BY HAZARD TYPE





Source: http://hvri.geog.sc.edu/SHELDUS/docs/Summary_1960_2011.pdf

Actuaries Climate Risk Index - Methodology

- Regression analysis of damages and ACI components by region (statistically significant relationships found)
  - Mortality and injuries vs. heat (4/12)
  - Flood damages vs. maximum 5-day precipitation (8/12)
  - Drought damages vs. heat (3/12)
  - Wildfire damages vs. consecutive dry days (2/12)
  - Wind damages vs. wind power (7/12)
- Proxies or no index for regions with no finding of statistically significant relationships
- Create historical impacts index (HII)
  - Scale to an index ranging from 1-10
  - Includes variability component by factoring in a time series based on the standard deviations of the HII

ACRI – Regression results by region and peril

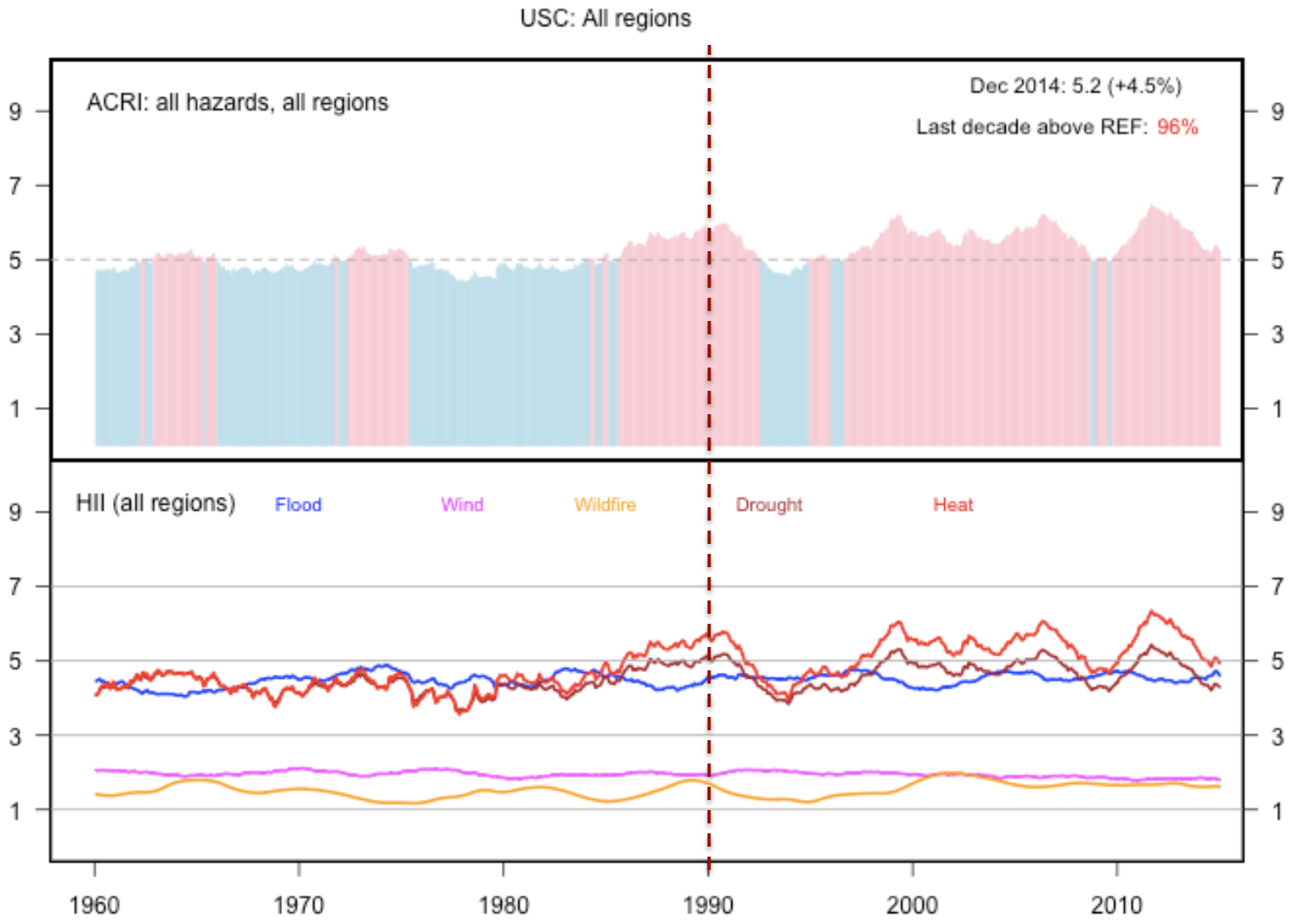
Region	Heat	Flood	Drought	Wildfire	Wind	Weight
US-CEA	✓	✓	✓	Mean	✓	18.6%
US-SEA	✓	✓	Mean	Mean	✓	21.3%
US-MID	Mean	✓	✓	Mean	✓	18.7%
US-SPL	✓	✓	✓	✓	✓	11.0%
US-SWP	✓	✓	Mean	✓	✓	16.6%
US-CWP	Mean	✓	Mean	Mean	✓	3.6%
US-ALA	No	CWP	No	Mean	CWP	0.2%
C-NEA	Mean	Mean	Mean	Mean	✓	0.7%
C-NEF	Mean	✓	Mean	Mean	NEA	6.2%
C-NPL	Mean	✓	Mean	SPL	NEA	1.8%
C-NWP	Mean	Mean	Mean	Mean	NEA	1.3%
C-CAR	No	No	No	No	No	n/a

✓= statistically significant; Mean = Mean of other region's parameters used; No = No index; Otherwise, region name of proxy region

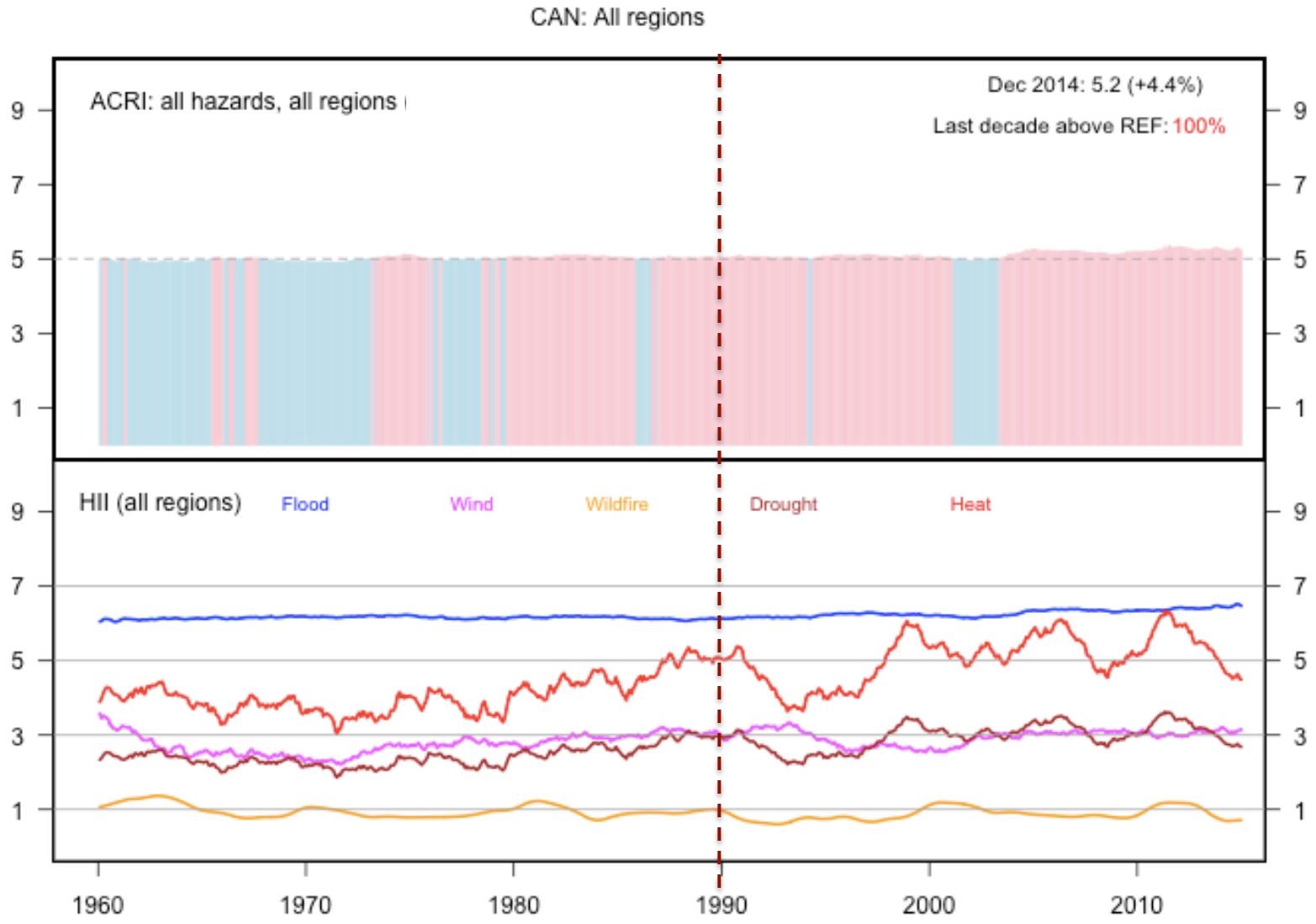
ACRI Results through 2014

- For the USA and Canada combined (and for USA, which is very similar since its population weight is 90% of the total), the ACRI has been above its average reference period value (which is set to 5) about 96% of the time since 2005, though it has been only slightly above 5 in the last year or so. Heat has been the primary driver of the index, although drought and flood have also been high at times.
- In Canada, the ACRI has been quite stable, though gradually increasing and dominated by the flood peril.
- By region in the USA, heat is usually the lead peril in determining the index but the sample graphs that follow show the varying impact of drought, flood and wildfire.
  - In the northeast USA (Central East Atlantic region), flood is the second leading peril
  - In the southwest USA (Southwest Pacific region), wildfire is the second leading peril
  - In the Midwest, drought is the leading peril

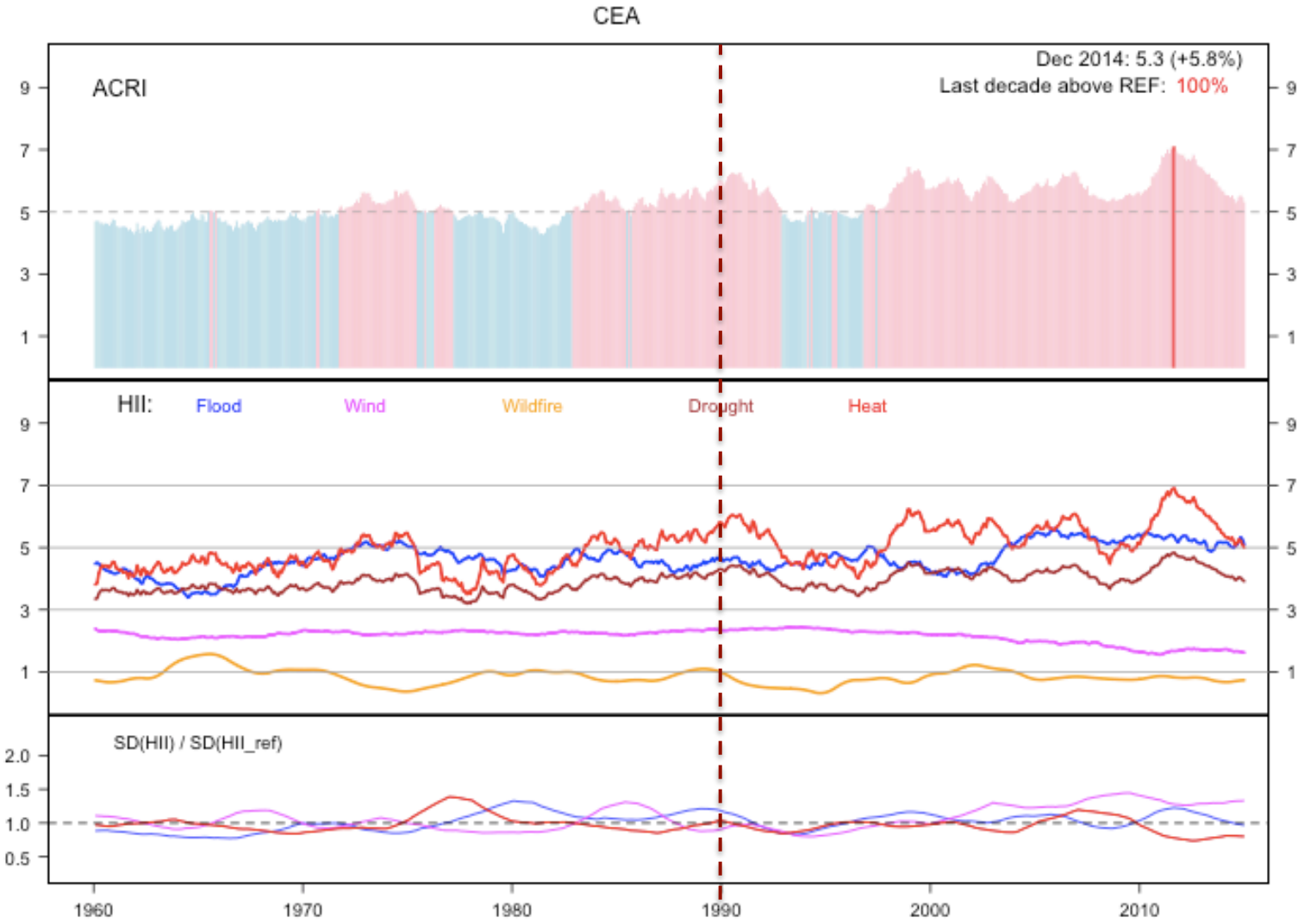
US and Canada Combined ACRI



Canada Combined ACRI

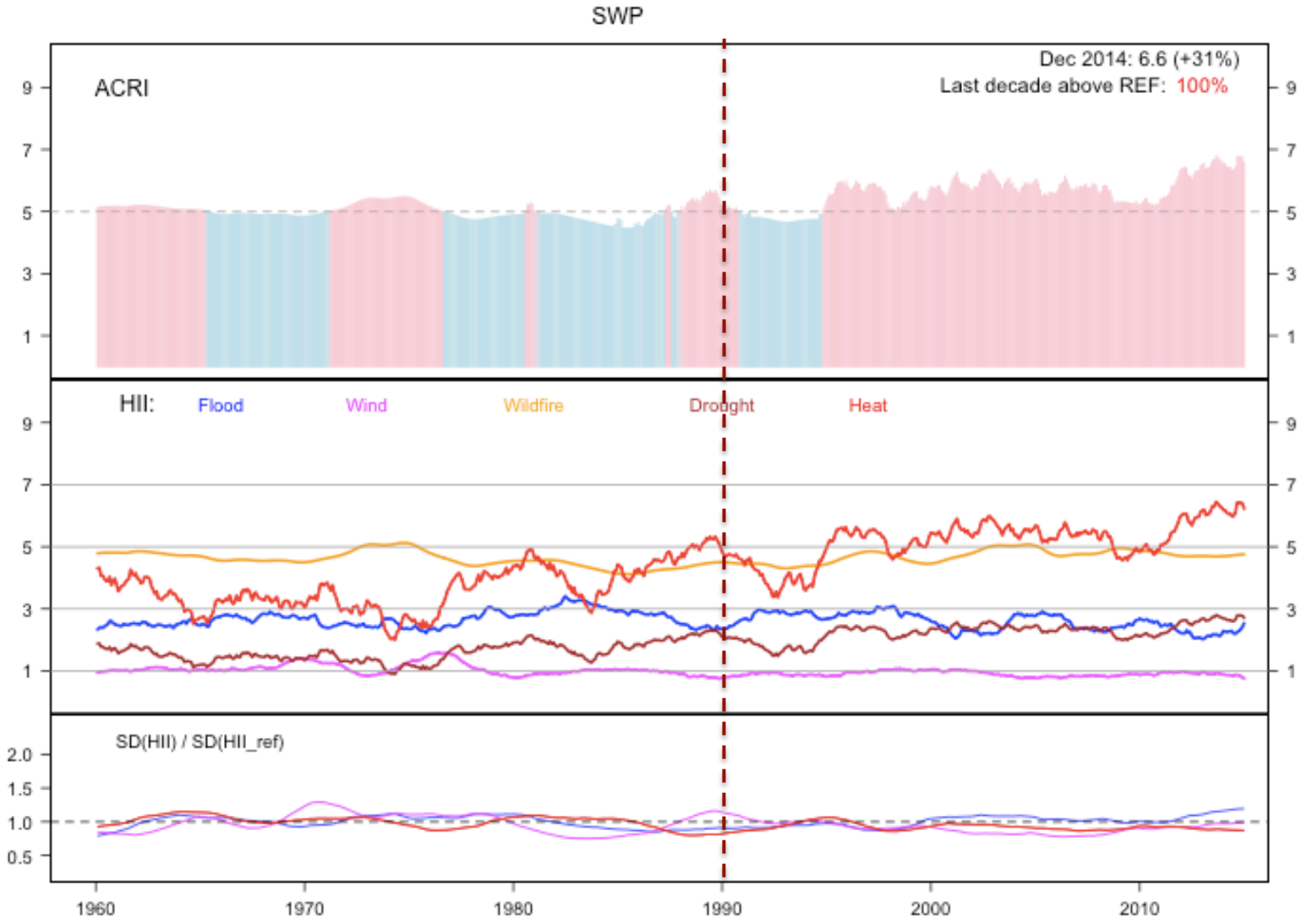


ACRI for the Northeastern U.S.

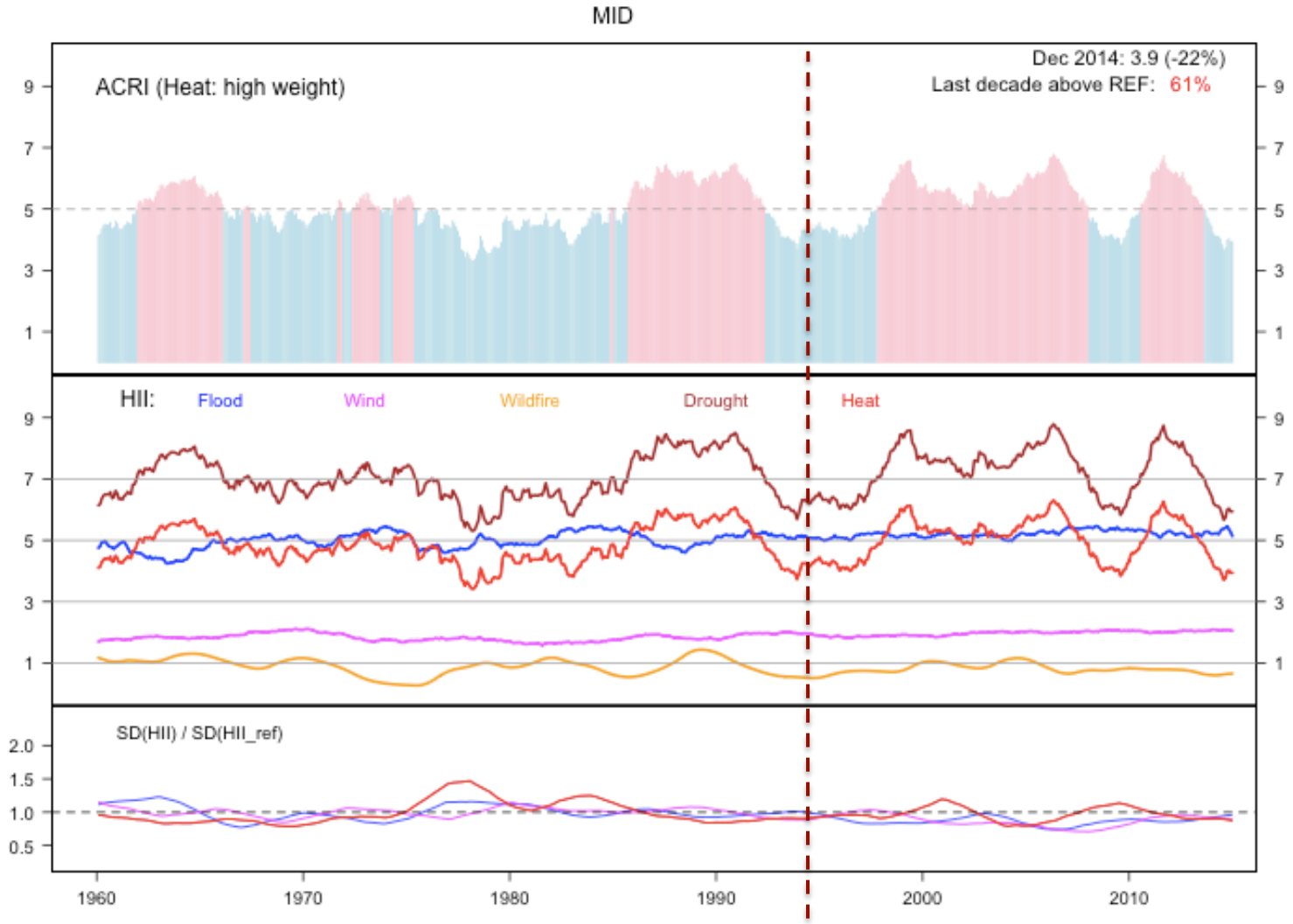


Note: The red line in the top graph indicates months when the ACRI is at least 7.

ACRI for the Southwestern U.S.



ACRI for the Midwest U.S.



Actuaries Climate Risk Index – Next Steps

- Peer review by the Research Committee of the Resource and Environment Board of the Institute and Faculty of Actuaries (IFoA)
- Incorporate any resulting changes in scripts
- Supplement the ACI website with ACRI content
- Expected launch in 2018

ACTUARIES CLIMATE RISK INDEX

INDICE ACTUARIEL
DES RISQUES CLIMATIQUES

Potential Uses of the ACI and ACRI

What uses do you see?

Actuaries Climate Index/Actuaries Climate Risk Index

Q&A