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Actuaries Climate Index

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23 September 2014

Outline

- Resource and Environment Board
- Actuaries Climate Index

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Resource and Environment Board

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Actuaries Climate Index

Progress

- CIA, SoA, CAS, AAA
- Phase I: research report
  https://www.soa.org/Research/Research-Projects/Risk-Management/research-2012-climate-change-reports.aspx
- Phase II: develop Actuaries Climate Index and Actuaries Climate Risk Index
- Expected release: 2015

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Aims

- Easy to understand
- Compelling in its illustration of climate change
- Serves and educates public
- Enhance profession

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What does it measure?

- Components: high and low temperature, precipitation, drought, high winds, sea level
- Public data sources
- Canada & USA
- Base period: 1961-1990, five year moving average

Combining components

- Components have different units and levels of noise
- Change (“anomaly”) relative to 1961-1990 base period
- Normalise anomaly wrt standard deviation over base period:

  Eg: $TX90' = \Delta TX90 / \sigma_{ref}(TX90)$
- The “Common Sense Climate Index”

The ACI defines “normal” climatic variations as falling within ±1σ of the seasonal mean reference period value

Temperature

- Data from the Global Historical Climatological Network (GHCN)
- GHCNDEX Indexes based on the data:
  - TX90: % of warm days exceeding 90%ile base period T
  - TN90: % of warm nights exceeding 90%ile base period T
  - TX10: % of cold days less than 10%ile base period T
  - TN10: % of cold nights exceeding 10%ile base period T

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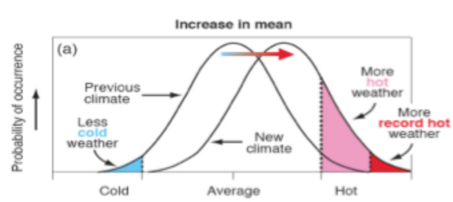
Temperature

- Change ("anomaly") relative to 1961-1990 base period
- Composite index to express changes in all extremes:

$$\Delta T_X = 0.5*(\Delta TX90 + \Delta TN90) - 0.5*(\Delta TX10 + \Delta TN10)$$



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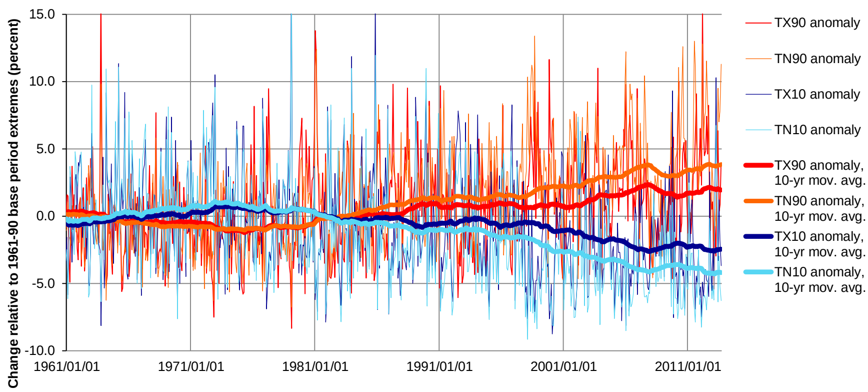
Changing Temperature Extremes since 1960



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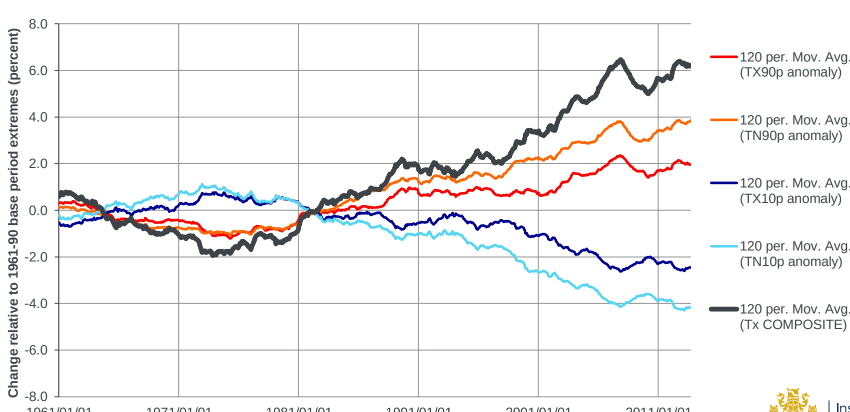
Composite Temperature Index, ΔT_X



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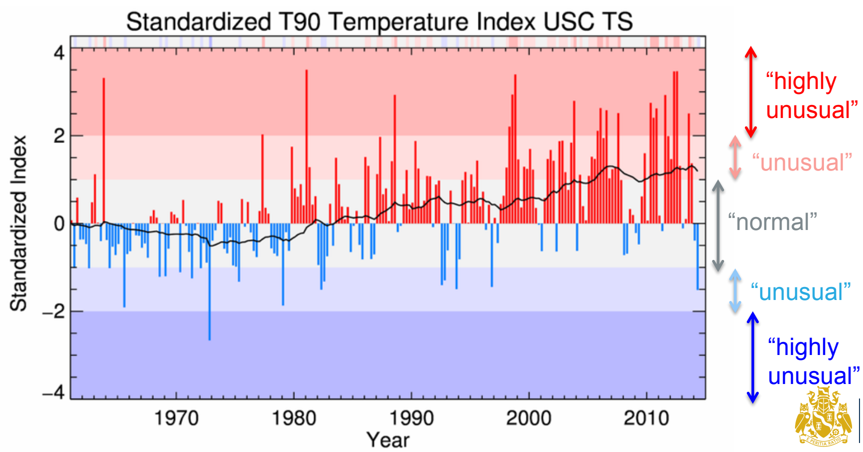
Index T90: Excess frequency of warm days and nights

$$T90' = \frac{\Delta TX90}{2\times\sigma_{ref}(TX90)} + \frac{\Delta TN90}{2\times\sigma_{ref}(TN90)}$$



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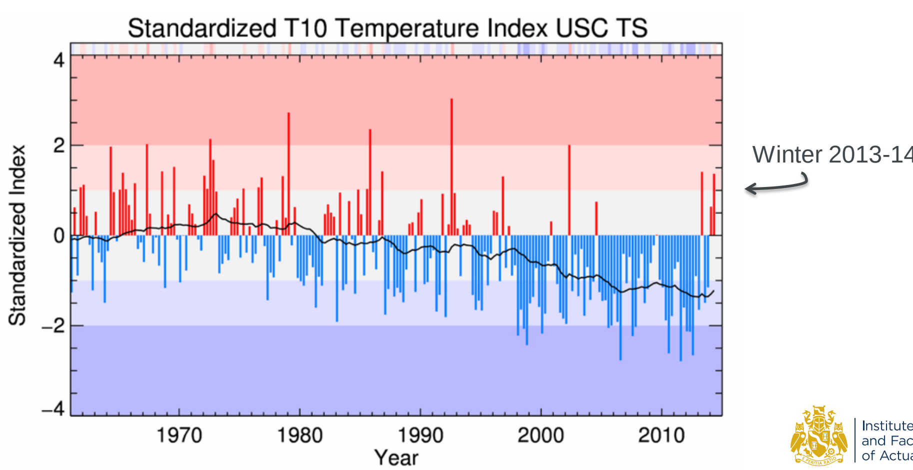
Index T10: Excess frequency of cool days and nights

$$T10' = \frac{\Delta TX10}{2\times\sigma_{ref}(TX10)} + \frac{\Delta TN10}{2\times\sigma_{ref}(TN10)}$$



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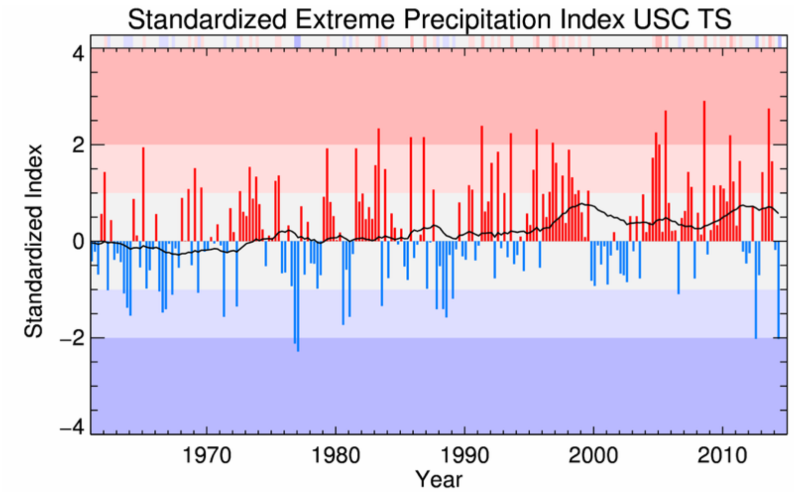
Extreme precipitation

GHCNDEX maximum 5-day precipitation amount in a month: P_X



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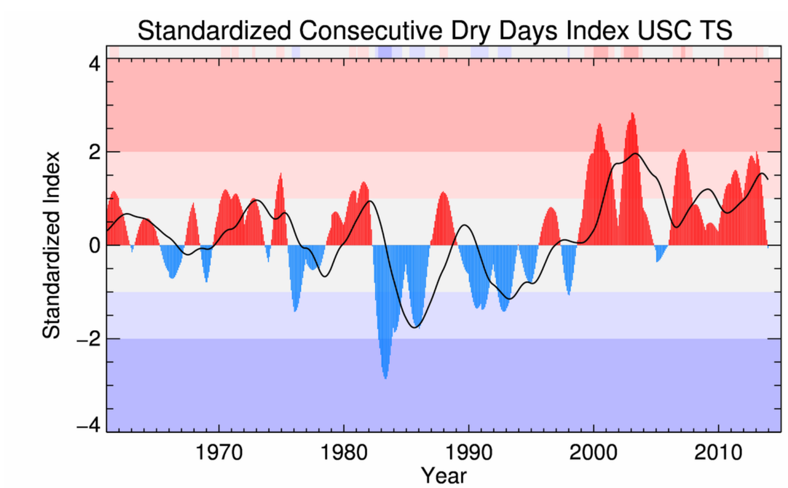
Drought

GHCNDEX consecutive dry days in a calendar year: D'_X



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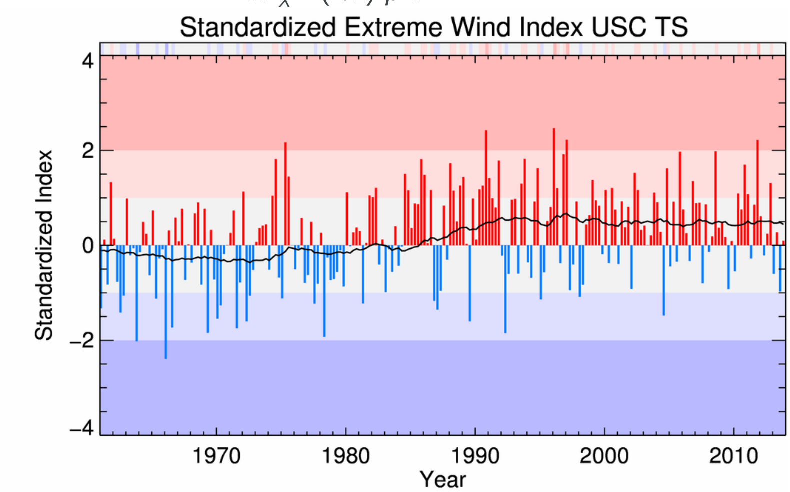
Wind

NCEP Reanalysis 90th percentile monthly wind power/destructiveness, derived from daily wind speed (*v*): $W'_X = (1/2)*\rho*v^3$



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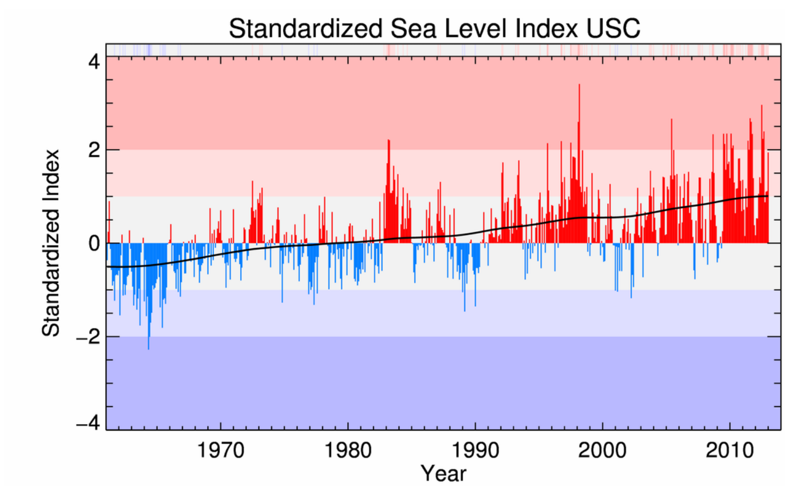
Sea level

Monthly tide gauge (sea level) measurements from 76 stations with 40-year minimum records over U.S. and Canada: S'



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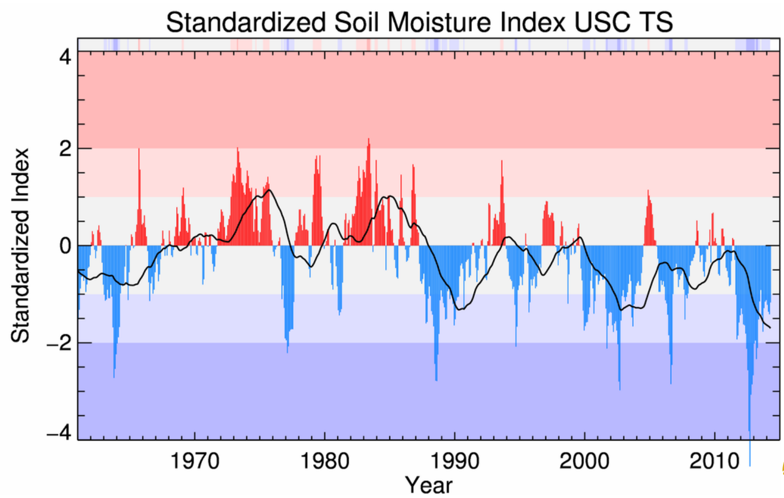
Soil moisture

Monthly soil moisture anomaly from NOAA Climate Prediction Center: M'



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Composite ACI: Putting it all together

$$ACI = \text{mean}(T90' - T10' + P'_X + D'_X + W'_X + S')$$

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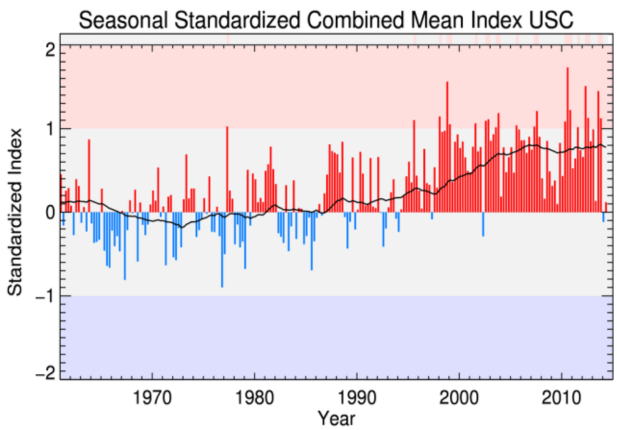
Composite seasonal ACI



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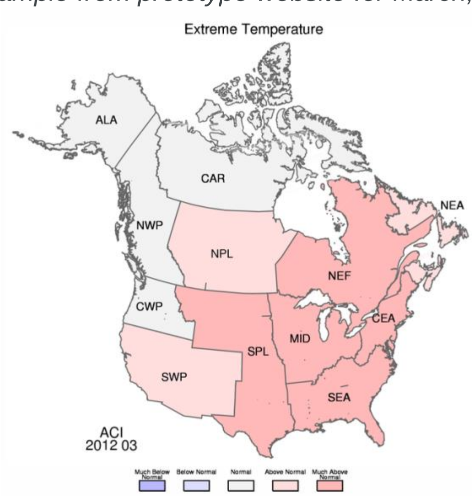
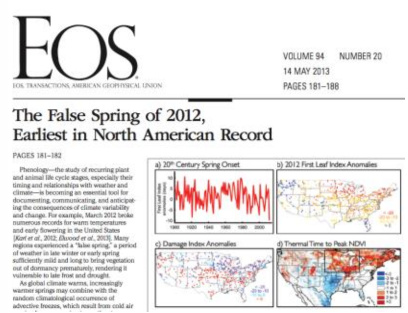
ACI: Validation and regional breakdown

Example from prototype website for March, 2012




EOS
EOS TRANSACTIONS, AMERICAN GEOPHYSICAL UNION

VOLUME 94 NUMBER 20
14 MAY 2013
PAGES 181–188

The False Spring of 2012, Earliest in North American Record

PAGES 181–182

Phenology—the study of recurring plant and animal life cycle stages, especially their timing and relationships with weather and climate—is becoming an essential tool for documenting, communicating, and anticipating the consequences of climate variability and change. For example, March 2012 broke numerous records for warm temperatures and early flowering in the United States [*Karl et al.*, 2012; *Elwood et al.*, 2013]. Many regions experienced a "false spring," a period of weather in late winter or early spring sufficiently mild and long to bring vegetation out of dormancy prematurely, rendering it vulnerable to late frost and drought.

As global climate warms, increasingly warmer springs may combine with the random climatological occurrence of advective freezes, which result from cold air

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ACI summary

- Supports scientific consensus on climate change:
- Monitoring tool
- Website
- Quarterly updates

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Actuaries Climate Risk Index (ACRI)

- Incorporating the effects of changes
- Goal is to provide an index that is especially useful to the insurance industry
- Relationships between climatic and socioeconomic factors

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ACRI framework

In the language of risk, ACI represents hazard (H). By adding population/ economic exposure (PE) and vulnerability (V) components, can transform the ACI into the ACRI:

$$K = C\, f(H)\, g(P)\, s(V),$$

$$K = C \times (PE)^{\alpha} \times V_1^{\alpha 1} \times\ V_2^{\alpha 2} \times\ V_3^{\alpha 3} \times \ldots$$

$$\ln(K) = \ln(C) + \alpha \ln(PE) + \alpha_1 \ln(V_1) + \alpha_2 \ln(V_2) + \ldots$$

K: risk index (ACRI),
H: hazard (ACI),
P: population/assets
PE: physical exposure, = *H x P*
V: vulnerability factors; e.g., GDP/capita, percentage cropland, etc.
C: proportionality constant
α_i: regression coefficients

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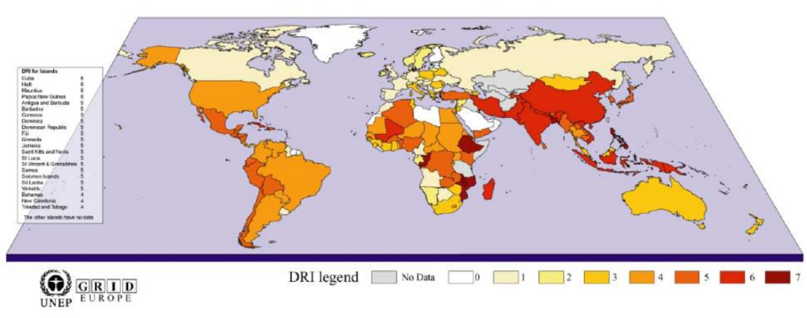
Disaster risk index

An example of this approach is the Disaster Risk Index of Peduzzi et al. (2009):

The Disaster Risk Index (DRI)



Peduzzi et al. (2009), Assessing global exposure and vulnerability towards natural hazards: the Disaster Risk Index. *Nat. Hazards and Earth Sys. Sci.,* 4, 1149.

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Discussion

- Do you envisage using the ACI in your work? How?
- How useful would it be to extend it to other territories? Is this something the IFoA should get involved in?
- How useful will the ACRI be?
- What would you like to see the R&E Board doing?

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