Can't Stand the Heat: Climate Change, Measuring Physical Risk and Financial Disclosures

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Casualty Loss Reserve Seminar | St. Louis | September 20, 2022

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CAN'T STAND THE HEAT
Measuring Climate Change Risk with The Actuaries Climate Risk Index

Steve Kolk, ACAS, MAAA
Chair of the CAS Climate Change Task Force

CLRS Casualty Loss Reserve Seminar
September 19-21, 2022
St. Louis, MO

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Agenda

Past, Present & Future Climate Change Measures of the A.C.R.I.

- PAST: Overview of ACI 1.1
- PAST: Overview of ACRI 1.0
- PRESENT: After-Action Report
- FUTURE: The ACI 2.0 and ACRI 2.0 Horizon

- APPENDICES:
  1. Know Thy Data – ACI 1.1 vs. ACI 1.0
  2. Details of the ACI component computation
  3. Preview of research underway for ACRI 2.0

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PAST: A.C.I. OVERVIEW
Actuaries Climate Index

Why? What? How? Where?

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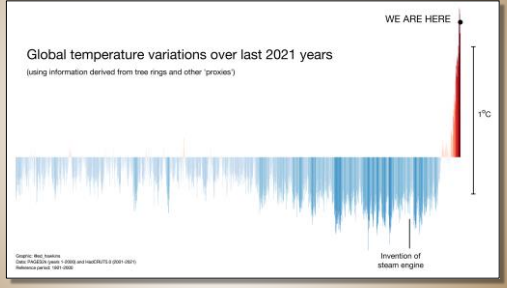
WHY? Global temperature year 0 to 2021 visualized



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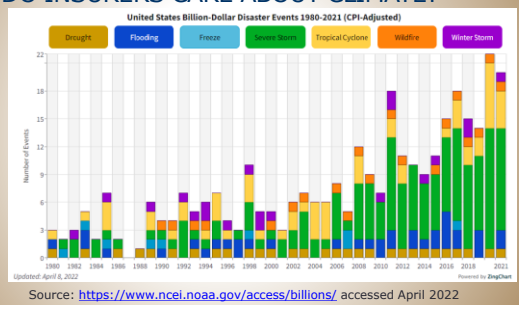
WHY DO INSURERS CARE ABOUT CLIMATE?



Source: https://www.ncei.noaa.gov/access/billions/ accessed April 2022

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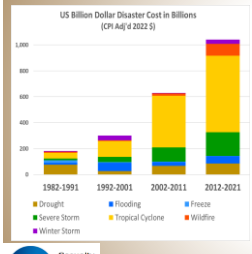
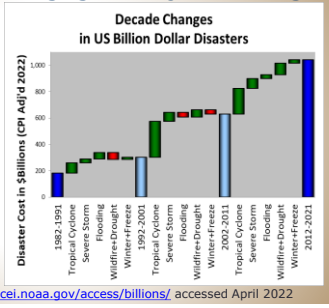
WHY INSURERS CARE: DISASTER MONEY TALKS….





Source: https://www.ncei.noaa.gov/access/billions/ accessed April 2022

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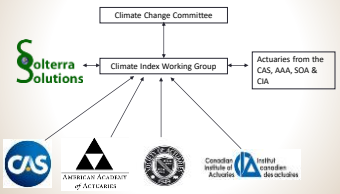
Actuaries Climate Index – Goals

- Create an objective index that measures changes in climate over recent decades
- Educate the insurance industry and the general public on the impact of climate change
- Easy to understand, but not simplistic
- Promote our profession

Structure of Climate Index Development Teams



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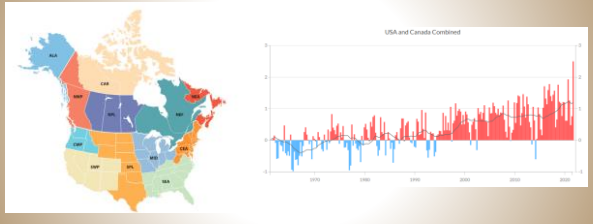
Current ACI – USA and Canada



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ACI Team chose six Climate Change measures indicative of extreme risk

Selected A.C.I. Climate Change Indicators

Greenhouse Gases	Weather and Climate	Oceans
• Greenhouse Gases Summary • U.S. Greenhouse Gas Emissions • Global Greenhouse Gas Emissions • Atmospheric Concentrations of Greenhouse Gases • Climate Forcing	• Weather and Climate Summary • U.S. and Global Temperature • Hurh and Low Temperatures • U.S. and Global Precipitation • Heavy Precipitation • Tropical Cyclone Activity • River Flooding* • Drought	• Oceans Summary • Ocean Heat • Sea Surface Temperature • Sea Level • Coastal Flooding* • Ocean Acidity
	• WIND	

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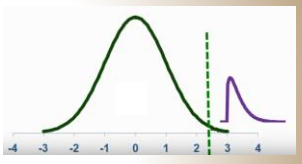
THE ACTUARIES CLIMATE INDEX FOCUSES ON "FREQUENCY OF SEVERITY"

WHAT IS THAT?

- Extreme Temperatures:
  - VERY HOT or
  - VERY COLD
- Extreme Precipitation:
  - VERY WET or
  - VERY DRY
- EXTREME WIND
  - (Wind Power)^3
- RISING SEAS



THE A.C.I MEASURES EXTREMES a.k.a.

"CHILD DISTRIBUTIONS"

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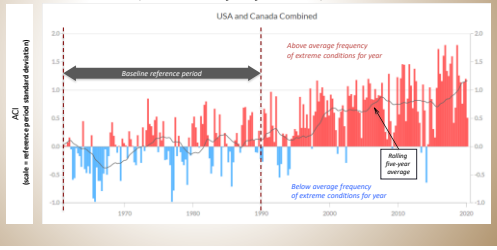
The Actuaries Climate Index (ACI) measures the increasing frequency of extreme weather

(More frequent heat, rain/drought, and less frequent cold)

(Combined mean index for all of US and Canada)



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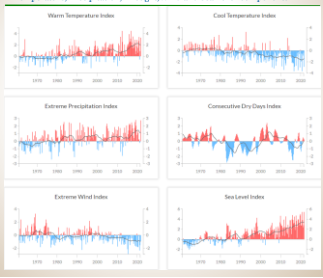
Continental USA - ACI Components – **Seasonal**

Temperature, Precipitation, Drought,Wind and Sea Level Components



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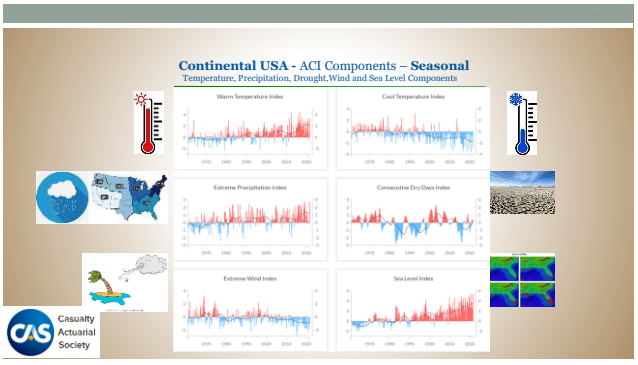

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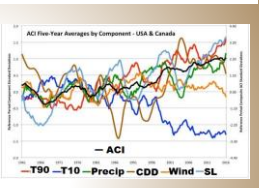
ACI – additional details

- Granularity of data – each variable is available for each 2.5° grid (275km x 275km at equator) in North America
  - While indices can be computed at this granularity, they'd be volatile
- And the six component indices measure different statistics:
  - Hot and Cold Temperatures in **% of extreme days in a month**
  - Rainfall in **inches**
  - Drought in **days**
  - Wind Power in **(Wind Speed)³**
  - Sea Level in **millimeters**
- To combine these varied measures together, values are converted to **standardized anomalies**:

$$X' = (X - X_{ref}) / \sigma_{ref}(X) = \Delta X / \sigma_{ref}(X)$$



ACI = Unweighted average of standardized anomalies

$$ACI = (T90' - T10' + P' + D' + W' + S') / 6$$

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PAST: A.C.R.I. OVERVIEW
Actuaries Climate RISK Index

What? How?

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WHAT DATA WAS USED FOR ACRI 1.0?

ACRI 1.0 Cost Analyses

Property Damage	Injuries	Fatalities
USA Sheldus Data	US Sheldus Data	US Sheldus Data
County Monthly Data Aggregated Countrywide	Not Reviewed	Not Reviewed
CANADA	Canadian Disaster Data	
Not Reviewed	Not Reviewed	Not Reviewed

The pinch of time-pressure for ground-breaking ACRI estimates resulted in analysis of just countrywide USA "Cat" property costs

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The ACRI

Preliminary Findings

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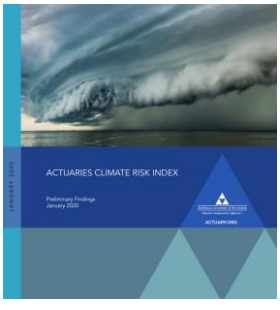
January 2020



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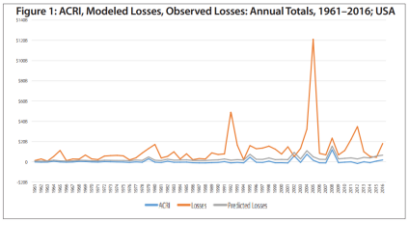
ACRI - Preliminary US Results

Graphical Findings



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ACRI 1.0 – Loss Data Model

$$Loss = I * Exposure^{e} * Precip.^{p} * (Low\ Temp.)^{l} * (High\ Temp.)^{h} * Wind^{w}$$

for a particular region in a particular month
where

Loss: Property losses in dollars

I: Intercept

Exposure: Estimated property value at risk

Precipitation (Rx5day): maximum 5-day precipitation in the month

Low Temp. (T10): the change in frequency of colder temp. below 10th percentile, relative to the reference period of 1961 to 1990

High Temp. (T90): *the change in frequency of warmer temp. above 90th percentile, relative to the reference period of 1961 to 1990*

Wind (WP90): Wind Power above the 90th percentile, determined after daily average wind speed measurements is converted to wind power, which is proportional to the cube of the wind speed.

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ACRI Preliminary Results – Statistical Findings

Table 2: Summary of Parameter Estimates Significant at the 90% Confidence Level
(based on estimates for 84 region-months)

	Statistically Significant	Average Value for Region-Months With Statistically Significant Values	Average Value for All
Exposure	70%	1.84	1.29
Rx5Day	54%	4.13	2.21
T10	12%	1.12	0.13
T90	19%	1.11	0.21
Wind	15%	2.80	0.43

It is worth noting that with an r-squared of 0.62, there is still significant unexplained variation. It is also worth noting that the included variables might also be capturing effects of excluded variables that are correlated with included variables.

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Statistical Findings – Overall US *versus* Regions

Ln(Loss) = ln(I) + e*ln(Exposure) + p*ln(Precipitation) + l*ln(Low Temperatures) + h*ln(High Temperatures) + w*ln(Wind).

Table 5: R-Squared by Region, Ln(Loss) and Loss in $

Region	ALA	CEA	CWP	MID	SEA	SPL	SWP	Mean	USA
R-Squared, Ln(Loss)	0.22	0.36	0.26	0.50	0.39	0.47	0.32	0.36	0.62
R-Squared, Loss in $	0.00	0.02	0.00	0.07	0.02	0.07	0.14	0.05	0.03

Table 7: R-Squared by Region: With and Without ACI Components

Region	ALA	CEA	CWP	MID	SEA	SPL	SWP	Mean	USA
R-Squared, With ACI	0.22	0.36	0.26	0.50	0.39	0.47	0.32	0.36	0.62
R-Squared, Without ACI	0.16	0.10	0.11	0.26	0.09	0.29	0.12	0.16	0.54
Predictive Bit of ACI	0.06	0.26	0.15	0.24	0.30	0.18	0.20	0.20	0.08

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PRESENT:
AN AFTER-ACTION REPORT

How are the ACI and the ACRI being improved?

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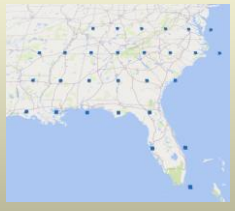
ACI 1.1 PROBLEM: VERY COARSE DATA



- ACI 1.0 grid points have 2.5° x 2.5° grid USA weather data
- Before looking, we thought there were six (6) Florida grid points
- PROBLEM: Three (3) Florida grid points miss land.
- 3 other Atlantic ocean grid points miss land.
- SOLUTION: Use finer 1° x 1° gridded data with many more points and/or use weather station data directly.

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SOLUTION: MORE GRANULAR WEATHER DATA

ACI 1.1 PROBLEM…

ACI 2.0 SOLUTION
1° GRIDS (ACTUALLY FINER)

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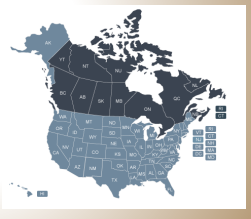
FINER GEOGRAPHIC RESOLUTION

12 Regions, US & Canada

Downscale from regions to State and Provinces



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DATA & ANALYTICS COMING INTO FOCUS
Transforming ACI 1.1 to 2.0 and ACRI 1.0 into 2.0

HOW WILL THE DATA BE IMPROVED?

- BETTER INPUT: More granular source data
- DIFFERENT INPUT: Replace/Drop/Add new index components
- BETTER OUTPUT: Compute ACI for smaller areas

HOW WILL THIS IMPROVE ANALYTICS?

- Better Quantification of Climate Trends from Clearer Signals
- More Certain Shape of Risk Distributions & Their Pace of Change

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FUTURE: STEPS BEING TAKEN TOWARD ACI 2.0 & ACRI 2.0

What are the current data sources?
What data & analytic gaps need to be filled?
What improvements are underway?

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ACI 2.0 Index Team progress

ACI 1.0 Climate Measure	Under consideration	ACI 2.0 DECISION
Temp: **T90**		Use ERA5
Temp: **T10**		ERA5
Precip: **Rx5Day**		ERA5, with shorter 2- or 3-day periods
Drought: **C.D.D.**	ERA5 Soil moisture	
Wind: **Power^3**	- T.B.D. -	
Sea Level: **76 gauges**	OCEAN5 grid pts,	
	And other measures likely to predict climate cost changes	

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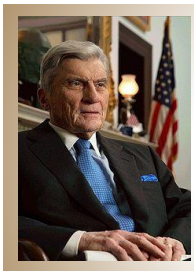

"Climate change is a 'threat multiplier' making worse the problems that already exist."

- Senator John Warner, in testimony before the Senate Foreign Relations Committee as quoted by John Kerry, Secretary of State at Old Dominion University.

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This overview describes the disaster costs in the United States that will be explored.

GOAL: find how best to estimate climate-attribution for fast-growing disaster costs.

ACRI 2.0 Analysis will ask WHAT? WHERE? WHEN? HOW? about Climate-driven costs

To See...	Pilot Studies are looking at
WHAT?	US Billion-Dollar Disaster Costs (in 2022 $) for seven types of disasters
WHERE?	The SouthEast Atlantic (SEA) region, the most disaster-prone ACI region in the US
WHEN?	Forty-two years of data, 1980-2021, aggregated by year, month, and week.
HOW?	Correlate trends in means & variations of disasters with ACI components and major explanatory variables.

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Can't Stand the Heat: Climate-Related Financial Disclosures (CRFD)

Steve Jackson, Ph.D.
Assistant Director for Research (Public Policy)
American Academy of Actuaries

Casualty Loss Reserve Seminar | St. Louis | September 20, 2022

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Plan for this section

Overview of Current Status of Climate-Related Financial Disclosures: International, U.S. and Canada

Academy Research: Past, Present, and Future

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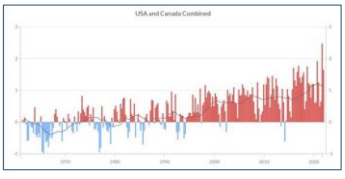
Prelude: Climate Generating More Extremes

Actuaries Climate Index



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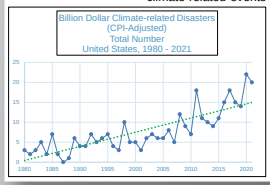
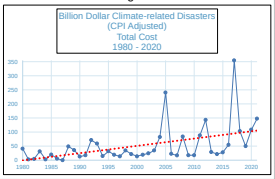
Prelude: Climate Risk Increasing

Both the number and the costs associated with large, climate-related events in the U.S. are increasing.





Source: Billion Dollar Weather and Climate Disasters, NCEI, NOAA
(Academy calculations; data downloaded on 5/6/22)

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Prelude: In the Face of Increasing Climate Risk

Companies are taking action to identify risks and opportunities
- Climate Related Financial Disclosures (CRFD) as a risk management tool

Regulators are requiring or considering requiring more extensive disclosures
- CRFD as both a risk management tool and a financial reporting requirement

Regulators are requiring or considering guidance for company actions to reduce risks

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Polling Question 1

How involved are you, if at all, in the preparation of climate disclosures for your company?

- My company does not produce climate disclosures
- My company produces climate disclosures but I am not involved
- I am somewhat involved
- I am very involved

Source: Billion Dollar Weather and Climate Disasters, NCEI, NOAA
(Academy calculations; data downloaded on 5/6/22)

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Overview of CRFD: International

- 2015: Task Force on Climate-related Financial Disclosures (TCFD) created by Financial Stability Board
- 2017: Release recommendations for CRFD
- 2018–2021: Annual Status Reports on Implementation and Assessment

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Overview of CRFD: International

- 2021: International Sustainability Standards Board (ISSB) created by the International Financial Reporting Standards (IFRS) Foundation

"The intention is for the ISSB to deliver a comprehensive global baseline of sustainability-related disclosure standards that provide investors and other capital market participants with information about companies' sustainability-related risks and opportunities to help them make informed decisions."

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Overview of CRFD: International

International Association of Insurance Supervisors (IAIS)

- 2020–2024: Climate risk as key theme of Strategic Plan
- 2021: "Application Paper on the Supervision of Climate-related Risks in the Insurance Sector"
- 2021: Climate Risk Steering Group launched
  - Climate risk scenario analysis
  - Gap analysis of IAIS supervisory material

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Overview of CRFD: U.S. Federal

- January 27, 2021: Presidential Executive Order: "It is the policy of my Administration to organize and deploy the full capacity of its agencies to combat the climate crisis to implement a Government-wide approach. …. The head of each agency shall submit a draft [climate] action plan to the [National Climate] Task Force … within 120 days of the date of this order."
- August 31, 2021: FIO publishes "Request for Information on the Insurance Sector and Climate-related Financial Requests."
- March 21, 2022: SEC proposes rules to expand and standardize climate disclosures by publicly owned companies.

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Overview of CRFD: U.S. States

- 2010-2022, Climate Risk Disclosure Survey: 9 Y/N questions, 8 prompts for narrative responses; adopted by 6 states, mandatory for companies with more than $100M in premiums (~70% of market)
- 2022 (April) Revision: NAIC adopts Task Force on Climate-related Financial Disclosures (TCFD) guidance [with 20 Y/N questions considered]

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American Academy of Actuaries: Climate Risk Financial Disclosure (CRFD) Analysis

While Academy research has looked primarily at disclosures in the U.S., the results are likely to apply wherever narrative responses (such as the TCFD) are relied upon. We will discuss briefly some research on Canadian disclosures revealing similar patterns to those we have found.
Three phases of research:

- Phases 1 and 2 largely reported in NAIC presentations in December 2020, January 2021, and January 2022
- Phase 3: in progress

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CRFD: Academy Research

Phase 1: Examine NAIC Surveys
Findings:

- Y/N responses indicate improvement, but problematic
- >500,000 words filed each year
- Only 20%-30% of companies providing robust responses

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Yes/No Response Changes; Relationship to Narrative Response

No → Yes					Yes → No			
	Text Response					Text Response		
Median # Words	Identical	Changed	Total		Median # Words	Identical	Changed	Total
45 → 107	57	144	201	**2018 → 2019**	74 → 76	33	25	58
45 → 122	56	254	310	**2015 → 2018**	57 → 60	54	102	156
49 → 88	60	250	310	**2012 → 2015**	70 → 53	58	113	171

From 2018-2019, 35% of changed Yes/No responses were accompanied by the exact same text.
From 2015-2018, 24% of changed Yes/No responses were accompanied by the exact same text.
From 2012-2015, 25% of changed Yes/No responses were accompanied by the exact same text.

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2019 Responses to NAIC Climate Disclosures Survey by Line of Business and Size

Number of Distinct Companies Responding

	Health	Life	Property & Casualty
Smallest 25% of Companies	10	29	42
Middle 50% of Companies	28	64	123
Largest 25% of Companies	12	35	94

Median Length of Report (# of Words)

	Health	Life	Property & Casualty
Smallest 25% of Companies	519	414	530
Middle 50% of Companies	450	555	720
Largest 25% of Companies	1,975	1,100	1,265

Size of company measured by net premiums written (NPWs); based on all active companies in a particular line of business as of 12/31/19.

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9 Categories Identified in Cluster Analysis of NAIC Survey Responses for 2019: Most Companies Low on Robustness

	Number of Companies	Number of Terms	Terms
Low Robustness (359)			
1	350	3	climate, change, risk
2	9	4	+ events
Medium Robustness (44)			
3	37	5	+ 2 of management, business, events, significant risk, impact
4	7	6	+ insurance, loss, catastrophic losses
High Robustness (37)			
5	20	8	+ 5 of management, business, policy, impact, events, loss, weather-related,
6	4	9	+ management, investment, business, insurance, policy, impact
7	5	10	+ management, investment, business, insurance, impact, events, loss
8	4	11	+ climate change, management, investment, business, insurance, policy, impact, events
9	4	14	+ management, investment, business, insurance, policy, impact, events, loss, climate risk, potential impact, insurance industry

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CRFD: Academy Research

Phase 2: Examine TCFD-aligned responses

Findings

- TCFD responses better on some issues, not as good as NAIC survey on others
- Only companies providing relatively robust NAIC responses, responding with TCFD responses so far.
- TCFD responses are longer than NAIC survey responses. Problem of lack of quantifiable responses at least as serious.

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Qualitative Comparison of TCFD and NAIC filings, 2019

- The information provided in the TCFD and NAIC responses overlapped substantially;
- TCFD responses contained much more information on issues of governance;
- TCFD responses contained much more information on quantitative metrics and model results;
- TCFD responses contained much more information on opportunities created by climate change;
- NAIC responses contained much more information on operational risk;
- NAIC responses contained somewhat more information on underwriting risk; and
- NAIC responses contained much more information on engagement with policyholders and key stakeholders.

Source: American Academy of Actuaries assessments based on NAIC Disclosure Survey and TCFD responses as made available on the NAIC Climate Disclosure Survey website maintained by the California Department of Insurance.

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Quantitative Comparison of TCFD and NAIC filings, 2020

	NAIC for All Reports, for 2018	NAIC 2018 for Reports of Companies which Filed TCFD for 2020	TCFD Reports Filed for 2020
Mean Words	1,188	4,251	7,756
Median Words	701	3,001	5,040
StdDev	1,733	3,755	6,676
Min	8	64	1,817
Max	16,145	16,086	26,506	
StdDev/Mean	1.46	0.88	0.86
COUNT	455	24	24

Source: American Academy of Actuaries calculations based on NAIC Disclosure Survey and TCFD responses as made available on the NAIC Climate Disclosure Survey website maintained by the California Department of Insurance.

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CRFD: Academy Research

Phase 3: Examine quantifiable responses to TCFD-aligned surveys

Plan

- CDP: TCFD-aligned, closed ended questions. Examine responses from U.S. insurance companies to ask:
  Which questions are most valuable in discerning progress and challenges?
  What questions are missing?
- ClimateWise: TCFD-aligned, narrative responses with evidence, scored by independent consultant
  Same questions as CDP
- Machine learning to score narrative responses (building on work done in phase 1 of our research), two possibilities:

UNSUPERVISED
Examine results of structured topic modeling
SUPERVISED
Use rubrics – e.g., developed in NYDFS – to "grade" company responses

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NYDFS Analysis Framework

Q5: Climate risks on investment portfolio?	
Yet to Start	No consideration of climate risks in investments and no explanation provided as to why the investment portfolio is not exposed to climate risks.
Early Stage	Recognizes climate risks in investments but does not have a separate process for considering them or provides little information on process, data and model, and asset classes.
Making Progress	Considers climate risks in investments and provides some information on the process, data and models, and asset classes.
Good Progress	Provides details on how climate risks are considered in the investment process and for different asset classes, and describes the data and models used.

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Overview of CRFD: Canada

May 2022

- Mandatory TCFD disclosures by banks and insurers by 2024
- Consultation begun on guidelines for all industries on climate risk management

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Summary of Canadian Research (2017)

Chartered Professional Accountants of Canada examined the Climate Disclosures of all public companies in Canada, in 2017:

- "The majority (79%) of companies are making climate-related disclosures, but the nature and extent varies."
- "Climate-related disclosures did not provide sufficient context for users to understand the significance of existing and potential business, risk-management and financial implications relative to past performance, company targets or industry peers."
- "Disclosures were not comparable across or within industries."

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Swiss Re

Can't Stand the Heat: A Company Perspective

Peter Ott, MAAA, FCAS
Senior Treaty Underwriter
Swiss Re

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Table of Contents

Measuring Physical Risk
- What is being reflected in our model view of risk?

ESG Considerations and Disclosures
- What do we report on and how do we measure progress?

Measuring Physical Risk

Polling Question 2

- Who has observed increased trends in their loss data associated with weather related perils?
- Who actively makes adjustments to vendor models to account for an internal view of climate change?

Reflecting Climate Risk Requires Constant Updating

- Monitoring trends
- Review the latest research
- Frequently updating models and tools

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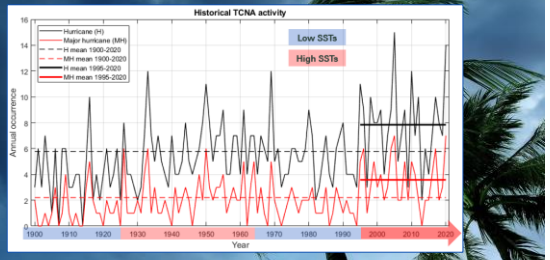
Tropical Cyclone



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Tropical Cyclone

- Long-term catalogues and time periods are not sufficient to reflect the recent activity
  - Swiss Re internal model is specifically tuned to reflect a shorter time horizon
  - Latest research suggests the multi-decadal oscillation can be accounted for by other factors (Mann, 2021)
- Recent events (ex: Harvey) have shown there are events not captured in the traditional catalogues
  - Torrential Rain is an explicit component of the peril
  - Research also connects climate change with this sub-peril

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All Other Perils (Severe Convective Storm, Wildfire)

- SCS
  - At this time, we don't see conclusive evidence to suggest an effect due to climate change
  - Extremely difficult to untangle exposure changes and reporting data quality; we continue to actively monitor
- Wildfire
  - Activity in California in recent years suggest a marked increase in wildfire activity
    - Swiss Re view has a shorter return period assumption compared to standard vendor models

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ESG Considerations and Disclosures

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Defining: How do we use sustainability, ESG and the SDGs?

Sustainability

We aim to meet the **needs of the present without compromising the ability of future generations to meet theirs.**

We do so by taking a **strategic and forward-looking view,** and by considering our **economic,** environmental and social impacts.

Environmental, social & governance criteria (ESG)

We consider ESG criteria in our business processes (e.g. investing, underwriting, sourcing) to make them more sustainable and responsible, and as part of our risk considerations.

Sustainable Development Goals (SDGs)

We use the 17 UN Sustainable Development Goals to **understand our positive and negative business impacts**, and to identify **areas** for **business opportunities**.

Consider ESG criteria → For better decision making

Unlock the SDGs → To create positive business impact

Sustainability: Creating long-term value

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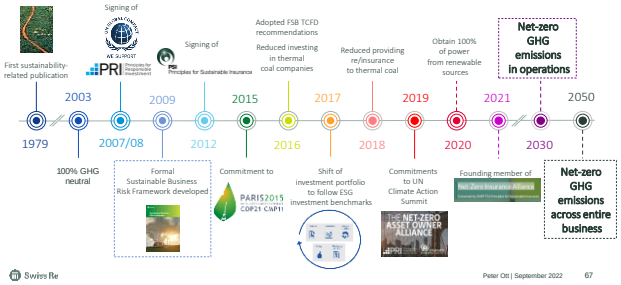
Swiss Re has a long tradition of sustainability



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What are the links between insurance and the SDGs?

- Companies play a key role in delivering solutions to the world's problems. They increasingly need to quantify their contribution to the UN's Sustainability Development Goals (SDGs), driven by growing regulations, stakeholder expectations, and performance drivers.
- Many re/insurance products and services already support the SDGs but industry lacks a comprehensive, standardised
  - systematic mapping of those;
  - clear narratives;
  - methods to measure impact
- Swiss Re is leading the "iSDG" initiative with UNEP PSI, an industry R&D effort to develop insurance-relevant SDG indicators and a quantification methodology for our industry to track our progress towards the global UN goals.
- Swiss Re is working with companies and industry associations across the globe to ensure we can all collectively build a common framework.

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Swiss Re Annual Disclosures

- Annual report is available to the public
  - Sustainability data - Annual report 2021 (swissre.com)
- Outlines our interval view of climate risks as well and the associated impact on expected peak peril losses
- Provides annual metrics and targets related to climate change and other ESG targets
  - Ex: GHG emissions, equity portfolio
- There is a need for consistency across the industry on well defined targets and metrics

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Swiss Re

Thank you!

Contact us

Peter Ott, FCAS, MAAA
Senior Treaty Underwriter
peter_ott@swissre.com

Follow us

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Legal notice

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QUESTIONS?

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APPENDIX 1: KNOW THY DATA
Read ACI Data Disclosures

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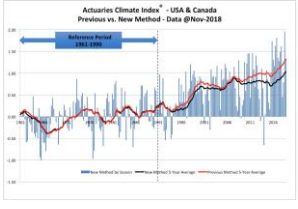
Data Disclosure: ACI 1.1 versus ACI 1.0



- PROBLEM: During routine quarterly ACI updates, careful data review revealed a problem.
- CAUSE: Data holes grew, primarily in Canada where station reporting decreased causing an upward bias in the ACI.
- CORRECTION: The ACI 1.0 formula was modified to remove this bias and results were restated as shown here.

See https://actuariesclimateindex.org/data/data-disclosure/ for details of this and future data releases

APPENDIX 2:

Details of the COMPUTATION OF THE ACTUARIES CLIMATE INDEX v1.1

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ACI Climate Regions

Region Name	Region
Central Arctic	CAR
Northeast Atlantic	NEA
Northeast Forest	NEF
Northern Plains	NPL
Northwest Pacific	NWP
Alaska	ALA
Central East Atlantic	CEA
Central West Pacific	CWP
Midwest	MID
Southeast Atlantic	SEA
Southern Plains	SPL
Southwest Pacific	SWP

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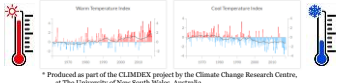
Extreme Temperature: VERY HOT or VERY COLD

- Global Historical Climatological Network (GHCN) – global, land station-based, gridded dataset, daily from 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
- The average of % anomalies relative to the 1961-1990 reference period for T90 and T10:
  - Standardized anomaly (T10' similar): $T90' = \Delta T90 / \sigma_{ref}(T90)$



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

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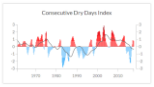
Extreme Precipitation Indices: VERY WET or VERY DRY

- GHCNDEX monthly maximum five-day precipitation data
  - Heavy precipitation index, $P' = \Delta Rx5day \; / \; \sigma_{ref}(Rx5day)$
- GHCNDEX, consecutive dry days (CDD) = Max days per year with <1mm precipitation
  - Drought index = 1 value of CDD/year
  - Linear interpolation to obtain monthly
  - $D' = \Delta CDD \; / \; \sigma_{ref}(CDD)$





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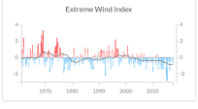
Wind Power Index: EXTREME WINDS

- 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
- $W' = \Delta WP90 \; / \; \sigma_{ref}(WP90)$
  - Where WP90 is the monthly frequency of the 90th percentile or higher of daily wind power

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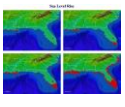
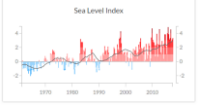
Sea Level Index

- At tide gauge stations along US and Canada coast
  - Data provided by Permanent Service for Mean Sea Level (PSMSL), part of the UK's National Oceanography Center
  - Data matched to grids used for other variables
    - Index reflects portion of each region represented by coastal grids
  - Land movements removed from tide gauge measurements to produce index reflecting sea movements only
- $S' = \Delta S \; / \; \sigma_{ref}(S)$

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APPENDIX 3

ILLUSTRATION OF STANDARD ANOMALY COMPUTATION FOR THE T90 INDEX

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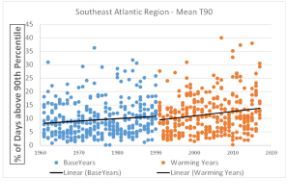
T90 = % of days in a month where max temperature falls above the 90th percentile of a 30-year reference period running from 1961 to 1990



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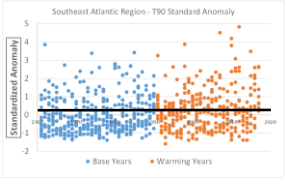
Standardized T90 Anomaly,
BASE YEARS = 30-year period from 1961 to 1990

Same data as prior slide, but
standardized using the reference period's mean and standard deviation



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APPENDIX 4

T90 STANDARD ANOMALY
IS NOT NORMALY DISTRIBUTED,

THE SKEWED
EXTREME VALUE DISTRIBUTION
FITS BETTER

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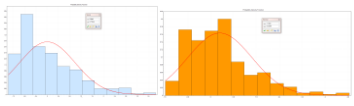
Distribution of T90 Standard Anomalies
Southeast Atlantic (SEA) Region

REFERENCE YEARS WARM YEARS



The smooth fitted curve, a standard Normal distribution, is a poor fit to the T90 Anomaly distribution

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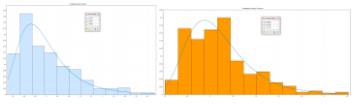
Distribution of T90 Standard Anomalies
Southeast Atlantic (SEA) Region

REFERENCE YEARS WARM YEARS



The skewed Generalized Extreme Value curve, fits T90 Anomalies better

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APPENDIX 5:

Peek at Research Underway
Actuaries Climate Risk Index v2.0

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DRAFT GOALS FOR A.C.R.I. 2.0

- The ACRI will inform policymakers, regulators and actuaries in regard to potential changes that may be present in underlying data for losses associated with certain types of extreme events.
  - For policymakers, this may help in pointing to geographic locations and types of climate events which might require more attention.
  - For actuaries, this may help in selecting assumptions related to future frequency and severity for pricing, budgeting/planning and enterprise risk management/capital allocation.
  - For regulators, this may help in assessing the assumptions relied upon by insurance companies for pricing.

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ACRI 2.0 Cost Analysis
Pilot Study Data Explorations

Building upon what was learned during ACRI 1.0 single-region pilot studies are getting underway as sketched in this table…

Where?

SouthEast Atlantic region of the USA

Northern Plains Region of Canada

Property Damage	Injuries	Fatalities
USA: BDD and Sheldus	**USA:** Sheldus Data	**USA:** BDD and Sheldus
Cost Data Aggregated by Region		Fatality Data Aggregated by Region
CANADA: IBC Data		
Cost Data Aggregated by Region	Data Not Available	Data Not Available

Pilot studies only explore the biggest US and Canada Region's Loss and Fatality data.

Both sources have more granular data. Thus, eventually, finer ACRI work by State/Province can be done in US/Canada, respectively.
And SHELDUS may make County analyses & Injury analyses possible, too.

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WHAT COST-DATA IS BEING EXPLORED?

CLIMATE-DRIVEN COST DATE BEING EXPLORED

Spatial Hazard Events and Losses Database for the United States

2021 U.S. billion-dollar weather and climate disasters in historical context

Climate.gov

https://www.ncei.noaa.gov/access/monitoring/billions/

Canadian Disaster History from the Insurance Bureau of Canada