Success Stories on User Engagement

Global Science & Technology, Inc.

Case Study 4: The Reinsurance Industry

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i. Success stories on user engagement

This report examines user engagement with NOAA's National Centers for Environmental Information's (NCEI) climate and weather data. It demonstrates the value that the free and publicly available provision of NCEI's climate and weather data has provided to the reinsurance sector. The extensive research and interviews that inform this case study, supplemented by desk-based research, detail how the reinsurance industry is using NCEI's climate and weather data, for what purpose, and ultimately what benefit the use of these data have provided to the sector. As documented in this report NCEI's climate and weather data are of fundamental importance to the reinsurance sector, a sector which in turn provides an invaluable service to the federal government and the American and international public; that is, providing economic insulation from the impacts of major catastrophes.

Acronyms and Abbreviations

CAT model: catastrophe model

CWC: Center for Weather and Climate (center within NCEI)

HURDAT: HURricane DATabase

HURSAT: Hurricane Satellite Data

IBTrACS: International Best Track Archive for Climate Stewardship (IBTrACS)

MRMS: Multiple Radar Multiple Sensor

ND: No Date

NEXRAD: Next Generation Radar

NCEI: NOAA's National Centers for Environmental Information (formerly, NCDC)

NCDC: National Climatic Data Center (now, CWC)

NHC: National Hurricane Center (NOAA agency)

NOAA: National Oceanic and Atmospheric Administration

NOAA SIS: NOAA Satellite Information System

NSSL: National Severe Storms Laboratory

NWS: National Weather Service

Re: Reinsurance

RMS: Risk Management Solutions

SWDI: Severe Weather Data Inventory

WMO: World Meteorological Organization

1. Report overview

This case study is based on interviews with various entities within the reinsurance sector including; reinsurance companies and their meteorological service providers, reinsurance brokers, professional reinsurance associations and catastrophe modelling firms. While the sector could have been broadened to include; insurance commissioners, investors and financial departments, the objective was to interview entities with a robust understanding of the applications of climate and weather data to the sector.

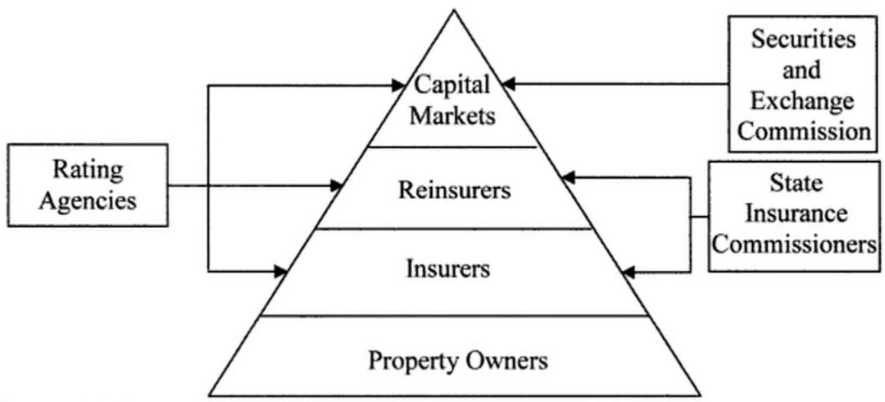

Figure 2: Reinsurance among the key private stakeholders of risk management
Source: Grossi and Kunreuther 2005; ERG 2014

The data products detailed is this report include those of relevance and value to the sector, as expressed by the interviewees. These include; International Best Track Archive for Climate Stewardship (IBTrACS), Severe Weather Data Inventory (SWDI), Global Historical Climatology Network Daily (GHCN), the Billion Dollar Disasters Report and Storm Reports (NOAA NCEI, 2010). A list of persons interviewed and their affiliations is provided in Appendix 1, on page 25.

This report focuses almost entirely on reinsurance, although some applications of primary insurance are discussed.

2. Introduction

The economic consequences associated with the frequency and intensity of extreme weather events pose enormous challenges to the world's largest economic sectors, insurance and reinsurance (NOAA, 2010). Weather-related disasters can amount to billions of dollars in damage. From 1980 to present (September, 2016), the U.S. sustained 200 weather and climate related disasters with overall damages and costs reaching or exceeding $1 billion per disaster, and total combined costs exceeding $1.1 trillion (NOAA NCEI, 2016 a). The rise in the value of insurance portfolios, particularly in vulnerable coastal areas creates greater exposure which will increase the economic losses associated with extreme events. This underscores the need for robust climate and weather data to inform future decision making for a number of sectors; emergency management planners, financial markets and insurance and reinsurance (NOAA NCEI, 2010).

Insurance and reinsurance companies offer financial protection against the probability of losses, although the scales in which they operate differ. Primary insurance is purchased by an individual or company to protect against multiple losses including life, health, property, and liability while reinsurance is essentially insurance for insurance companies. Primary insurance does not perform well under large catastrophes when there are tens of thousands of claims at once. Reinsurance allows the primary insurance company to cede some of its losses to the reinsurance company in exchange for a premium paid to the reinsurers. In the event of a catastrophe, the primary insurance company remains solvent and the reinsurance company takes up some of those costs, and spread the risk globally. Reinsurance provides economic insulation against the largest and most complex risks from terrorist attacks to natural disasters such as hurricanes. **The power of insurance, with reinsurance backing [it up], is the ability to channel billions of dollars to a region that has been impacted by a catastrophe, and help communities get back on their feet again**. Reinsurance provides this service quickly and efficiently and has been doing so successfully for well over a hundred years (Bove, pers. comm., Nov 1, 2016).

"Having NCEI data from NCEI and other NOAA agencies in near real-time is critical for the insurance and reinsurance sector to get a quicker response and expedite the claims process. This can help people get back on their feet in a more reasonable amount of time, plus help to determine the size and scope of the disaster for any additional federal response that may be required."

– Steve Bowen, Director and Meteorologist, Aon Benfield.

Reinsurance companies, and their service providers, depend on access to meteorological and climatological information to model extreme weather event probabilities and accurately price risk. NOAA's NCEI is a provider of this indispensable information, helping the sector effectively assess trends, and prepare for the future. NCEI's data is used by the reinsurance sector in multiple ways. Hurricane track data from **satellites** or storm data from **radar stations** can be used to generate and validate catastrophe (CAT models), which are computer generated simulations of specific risks associated with natural or man-made disasters. Daily temperature and precipitation data from NCEI's global network of **station data** can be used to evaluate the likelihood of drought or winter storms (NOAA, 2010). Insurance companies use weather and climate data to verify insurance claims and justify payouts. For example, following a hail claim, NCEI **radar data and Storm Reports** can be used retrospectively to analyze whether hail occurred at a given location, and if so, it's size (A Smith, pers. comm., Sept 30, 2016).

Reinsurance contracts are based on what is considered to be 'official data'. As a NOAA data center, NCEI is a provider of authoritative and official data. It is therefore used extensively across the reinsurance sector and may be used in a court of law. As a necessary, impartial, and reliable source of information to the reinsurance sector, NCEI has earned the reputation as 'the honest broker' to the reinsurance sector (Bowen, pers. comm., Nov 15, 2016).

Figure 1: Hurricane Andrew (1992) damage
Source: National Hurricane Center

3. Reinsurance and climate and weather data needs

The reinsurance sector utilizes NCEI's climate and weather data in two primary ways; as input into catastrophe (CAT) models and for validating these models (section 3.1 & 3.2). The insurance sector uses NCEI's data to review insurance claims and justify payouts (section 3.3).

3.1. Input to catastrophe models:

A catastrophe model is a computer-generated model that estimates sustained economic losses from catastrophic events. CAT model development is highly complex, and its use of data is highly sophisticated, drawing from meteorology, actuarial science, engineering and seismology. CAT models have been developed for a range of geographic locations and a spectrum of natural perils including hurricanes[1], severe convective storms including hail and tornados, wildfires, floods and earthquakes, and man-made events such as terrorism and cyber-attacks. Models operate both probabilistically; estimating the range of potential disasters and their associated losses, and deterministically; estimating the losses from a single historical event, or hypothetical event. These models provide a way to quantify and price risk for insurance and reinsurance contracts, and to manage risk at the portfolio level. Further, they allow reinsurers to answer key business questions related to the level of risk they can insure, the number of contracts they can undertake, and how they can diversify their portfolios (RMS, 2016).

CAT models are developed by third party vendors, reinsurance brokers, reinsurance companies and their support providers (consultants, private firms). Often times reinsurance companies will license models from third party vendors for primary use, and concurrently develop in-house models to evaluate third party models, or to cover perils that are not covered by vendor models. Due to the complexity and the diverse expertise required for CAT model development, reinsurance companies often lack the skills and resources required to develop in-house models that cover their entire risk portfolio (ERG, 2016).
There are three primary third party CAT vendors in the market; **RMS**, **AIR**, and **CoreLogic**. These vendors, agnostic towards any individual company's reinsurance portfolio, develop risk profiles for each peril and/or extreme weather event which have been described as the 'currency' or the 'bench mark'. It is important to note that the assumptions that go into CAT model development are vastly different, and therefore no two models will generate the same result. Peril inputs are indeed complex and can generate a myriad of possible outcomes (ERG, 2014). Reinsurance companies and brokers will utilize a

[1] Hurricanes, cyclones, tropical cyclones, and typhoon refer to the same phenomena. These terms are used throughout this report interchangeably.

blend of the CAT vendor products, and/or additionally develop their own internal models, that cater to their client portfolio and view of risk. CAT models do not determine a reinsurance company's rates, but are an important input into the overall process of price setting (AIR Worldwide, 2012).

CAT model development is intellectual property and therefore the combination of data and methodologies that inform model development are highly proprietary. Their specific contents, described as 'black box' are largely unknown even to those reinsurance firms who license their products. Disclosure generally only occurs when required by regulation (ERG, 2014; Porter and Scawthorn, 2007).

Catastrophe model development

There are four primary modules that govern a CAT model development; event, hazard, exposure and vulnerability, and financial (ERG, 2014). The first two modules; event and hazard, rely on meteorological inputs when modeling weather-related perils. While applicable to various perils, the following framework for CAT model development has been described in relation to hurricanes.

Event → **Hazard** → **Exposure and vulnerability** → **Financial**

The **Event module** involves the construction of a stochastic event set; a database of possible catastrophic events, including parameters such as severity, frequency and location (Bosari, 2012). For example, this module uses historical data to understand hurricane characteristics in a given basin (i.e. Gulf-Atlantic), and then generating a series of synthetic cyclones, or *stochastic tracks*. As there is only about 150 years of historic hurricane information available, this component essentially strives to recreate, or extend historical events (Young, pers. comm., Nov 21, 2016). Catalogues comprised of tens of thousands of computer-simulated hurricanes are generated, representing the broad spectrum of possible events (AIR Worldwide, 2012). These data are then used to establish the frequency of landfall rates (Nielsen, 2015).

Various data sources inform the development of stochastic track development including paleoclimatology and other pre-historical analysis, information on cyclone frequency and intensity from industry claims data and historic reports, and official meteorological center data. The U.S. National Hurricane Center's HURicane DATabse (HURDAT) is the best source of track and intensity data for the Gulf and Atlantic basin rates (Nielsen, 2015). NCEI's International Best Track Archive for Climate

Stewardship (IBTrACS) which contains HURDAT, an amalgamation of worldwide best track data, can be utilized in this module.

The **hazard module** then calculates the *intensity* at each location within the affected area, for each simulated event. Intensity for a hurricane is measured in terms of the wind field or the storm surge height (AIR Worldwide, 2012). For the wind field, storm track data are used to simulate the wind field, which is then adjusted to the local terrain for physical properties and geographical characteristics. The final output provides wind speed for each grid point (more granular than zip-code level) within a simulated cyclone. The **hazard module** relies on historic wind damage reports, wind field models/physical simulations and surface roughness and topography (Nielsen, 2015).

The **exposure and vulnerability module** calculates physical damage for each impacted exposure. The damage calculation will depend on the physical properties (i.e. the infrastructure’s structural integrity) and geographical characteristics of each location. For example, a region which has a high likelihood of hurricane occurrence and has buildings that cannot withstand high wind speeds, will have a high vulnerability, and therefore a high damage total (Bosari, 2012).

The **financial module** translates the physical damage to property into estimates of monetary loss. This is then translated into insured losses by applying policy conditions to total damage estimates. A probability is assigned to each level of loss. This probability distribution of losses shows the probability that any given level of loss will be exceeded in a given time period (AIR Worldwide, 2012).

3.2. Catastrophe model validation

Reinsurance companies that license products from CAT modeling vendors (including **RMS**, **AIR** and **Core Logic**) can use NCEI’s climate and weather data to validate these models for meteorological perils, to gauge how well they are performing and evaluating risk.

In-house models refer to those models developed within a reinsurance firm, broker or its service provider, and not one of the major CAT modeling vendors such as **RMS**, **AIR** or **CoreLogic**. In-house vendors will periodically update their models, usually following an extreme event. This can result in drastic changes to the output for certain risk. For example, following a major hurricane, observations of actual losses will be compared against model predictions, and the model will subsequently be adjusted to reflect what happened (WGA, ND).

3.2. Justification of insurance claims and payouts

NCEI's Next Generation Radar Data (NEXRAD) proves a valuable tool for *primary* insurance companies to verify claims and detect incidents of hail fraud. Following the 2008 U.S. market crash, hail claims were dramatically increasing in Texas. Following minor hail events, public adjusters would go door to door advising homeowners to repair their roofs, and submit a claim to their insurance company, even in events where no damage occurred. In exchange, the public adjusters would contract the roofing repair company and earn a percentage of the repair cost (Badger, 2014). NEXRAD data is capable of verifying whether hail events occurred, the size of the hail, and the location in which the event took place. This data can help insurance companies verify whether the hail event that took place was actually capable of producing the damages claimed (A Smith, pers. comm, Sept 30, 2016).

4. NCEI datasets and information used by the reinsurance industry:

4.1. IBTrACS: International Best Track Archive for Climate Stewardship

Peril: Tropical Cyclones

The International Best Track Archive for Climate Stewardship (IBTrACS) is an initiative led by NCEI to create a global repository of tropical cyclone best track data. IBTrACS is a repository of best track data from 10 international Tropical Cyclone Forecast Centers, consisting of all official Tropical Cyclone Warning Centers (TCWC)[2] or Regional Specialized Meteorological Centers (RSMC)[3], and the World Meteorological (WMO) Specialized Meteorological Centers[4], responsible for developing and archiving best track cyclone data, worldwide. IBTrACS was produced to address the lack of publically available datasets for global tropical cyclone data. The dataset contains information regarding the location, storm nature, maximum sustained winds and minimal central pressure of the storm. IBTrACS spans the record of 1848 to present. This data source provides a one-stop-shop for track data, saving the end-user visits to multiple agency websites (NOAA NCEI, 2016b).

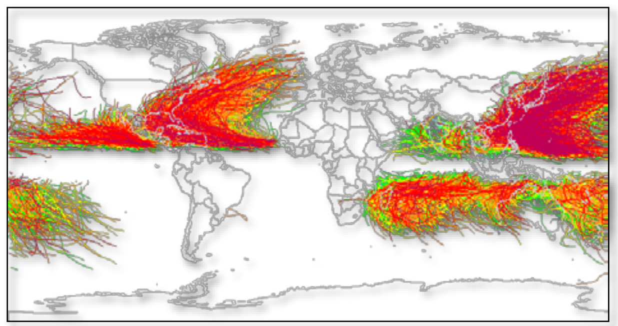

Figure 3: IBTrACS visualization
Source: NCEI

Applications

Aon Benfield is the world's largest reinsurance broker and full-service capital advisor. The role of the reinsurance broker is to negotiate the terms of the reinsurance contract between the primary insurance company and the reinsurance company. **Aon Benfield's** clients include the world's largest insurance and reinsurance companies, as well as corporations and government bodies (Aon Benfield, 2016). **Aon Benfield's** Impact Forecasting Division develops their own suite of catastrophe (CAT) models that cover the major perils globally, including tropical cyclone, severe convective storms, flooding, and wildfire. These in-house models can be customized based on their client's requirements and exposures, for example by using their client's own data to more accurately generate results for a specific line of

[2] TCWC Perth, TCWC Darwin, TCWC Brisbane, TCWC Wellington
[3] RSMC Miami, RSMC Honolulu, RSMC Tokyo, RSMC New Delhi, RSMC La Reunion, RSMC Nadi,
[4] CMA-Shanghai Typhoon Institute, Joint Typhoon Warning Center, Hong Kong Observatory, NCDC DSI-9635, NCDC DSI-9636, UCAR ds824.1

business (Aon Benfield, 2016). **Aon Benfield** additionally licenses third party vendor models to compare and contrast outputs from different models. For the tropical cyclone peril, the Impact Forecasting Division relies heavily on NCEI's IBTrACS data and uses this data source in a several ways. First, IBTrACS data is applied to the development of a stochastic event module of their tropical cyclone CAT models for the Gulf-Atlantic and Western Pacific basins. This data informs the development of stochastic tracks and includes data pertaining to expected maximum wind speeds and storm surge heights. IBTrACS data is available in six-hour intervals, unless there are active hurricane watches or warnings in effect, in which case the data is available in three-hour increments. In order to better serve their temporal needs, **Aon Benfield** undergoes an interpolation process to resolve the tracks into three-hour increments. Second, IBTrACS is used to actively monitor events in near real time, so **Aon Benfield** can advise its insurance and reinsurance clients on potential impacts, and the client can plan for proper allocation of resources. Third, Impact Forecasting uses IBTrACS to validate third party vendor models, and finally, to recalibrate their in-house models post event. The in-house models are recalibrated by comparing the projected model output against IBTrACS observed data. When discrepancies appear, the in-house models are recalibrated to better represent the actual event. This provides **Aon Benfield** with a more thorough understanding of model performance and requirements for improvements to more effectively replicate actual events.

IBTrACS serves as a one-stop-shop for worldwide track needs and avoids multiple data access pulls from individual Tropical Cyclone Centers. Further, the data are available in multiple formats, offering **Aon Benfield** the ability to easily and reliably manage their interpolation processes. However, if NCEI offered a higher temporal resolution of IBTrACS data, available at three-hour increments, this would save **Aon Benfield** the additional steps of interpolation and promote expedience. Additionally, providing the Radius of Maximum Wind (RMax) would prove extremely beneficial to both Impact Forecasting, and for CAT modeling in general (Bowen, pers. comm., Nov 15, 2016).

Guy Carpenter, a reinsurance broker and risk transfer specialist firm, utilizes IBTrACS data to evaluate third party vendor models, prior to endorsing them for their client's usage. Using IBTrACS for worldwide basins, or HURDAT 2 data for Gulf-Atlantic basins, the third-party models undergo a vetting process to assess their ability to accurately map the frequency and severity of tropical cyclone events. **Guy Carpenter** does not develop their own in-house tropical cyclone models as there are a number of reliable tropical cyclone CAT models available in the market.

When comparing the HURDAT 2 (Gulf-Atlantic best track data) with the Gulf-Atlantic region of IBTrACS data, **Guy Carpenter** occasionally encounters discrepancies. While **Guy Carpenter** knows how to correct for such discrepancies internally, they recommend that IBTrACS undergo a more consistent method in the reanalysis effort, so that these products remain identical (Anonymous, pers. comm., Dec 2, 2016).

Munich Re America refers to IBTrACS as a reference source. For example, if they need information on a historical storm to understand its characteristics, or to answer a specific question for the underwriting department, they turn to IBTrACS. While **Munich Re America** does develop a range of CAT models, these are exclusively developed in the European Offices (Bove, pers. comm. Nov 1, 2016).

IBTrACS and India

AgRisk is a modelling and analytics firm that specializes in agricultural risk. AgRisk builds probabilistic loss models for agricultural insurance and reinsurance for Asia; China and India, and regions of Africa. These models allow the client; reinsurers or risk transfer specialist, to incorporate details regarding their exposure, and receive analytics pertaining to the risk posed to their portfolio. In cyclonic-prone regions such as the Indian Ocean, AgRisk relies on IBTrACS to understand the risk that a cyclone could pose to India's agricultural regions. IBTrACS provides a historical record of regions that have been impacted by tropical cyclones, including the frequency and intensity of these events. This data is overlaid with crop-vulnerability data, to provide an appraisal of risk. This information is used to inform the cyclone impact model, a component of the Indian Agricultural Insurance Model. Further, as torrential rainfall is commonly associated with cyclones, IBTrACS can provide information pertaining to flood risks that may occur during a cyclone. While best track data for the Indian Ocean could be sourced directly from the Indian Meteorological Department, AgRisk chooses to obtain track data from IBTrACS as they prefer the format (Osbourne, pers. comm., Nov 15, 2016).

Other hurricane data

NCEI's Hurricane Satellite data, or HURSAT, is useful as a visualization tool to provide context to **Aon Benfield**'s clients. This dataset is helpful in showing the scope and magnitude of hurricane events. It also provides the Impact Forecasting division with important information pertaining to wind speed and storm surge (Bowen, pers. comm., Nov 15, 2016).

4.2. NOAA's Severe Weather Data Inventory (SWDI)

Peril: Severe Convective Storms (i.e. tornados, hail events, severe wind events, and thunderstorms).

The Severe Weather Data Inventory (SWDI) is a centralized database of severe weather records for the United States. The records in the inventory are pulled from three sources in the NCEI archive: storm attributes derived from radar data (NEXRAD), preliminary storm reports from the National Weather Service (NWS), and lightening data derived from Vaisala's National Lightening Detection Network. NEXRAD data collected from radar stations across the U.S., provides information regarding the formation and lifecycle of severe convective storms including: thunderstorms, mesocyclones (vortices of air within a storm), tornados, and hail. Algorithms are built on top of the data to track storm 'signatures' which detect where these events occurred and their severity (Del Greco, ND). These data are then made available through the SWDI, a one-stop shop for the user to find storm records for a particular geographic region and time period, and download search results in a variety of formats. The SWDI includes a format that can be integrated in Google Earth (NOAA SIS, ND).

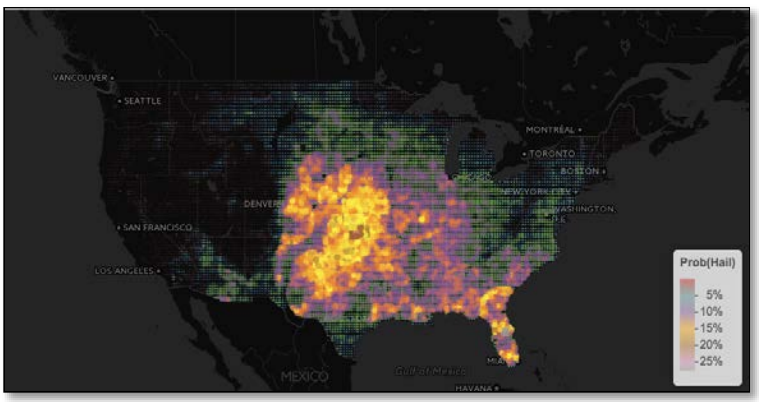

Figure 4: Daily hail risk probability by ~17 miles from 2005 to 2015
Source: Commerce Data Service

Applications

NCEI's SWDI database has applications for both severe convective storm (SCS) CAT model development, and validation. Much like its use of IBTrACS data, **Aon Benfield's** Impact Forecasting division utilizes SWDI in their severe convective storm model development, to recalibrate their own models post event, and to evaluate vendor model performance. For example, **Aon Benfield** uses hail swath data from the SWDI and overlays it with exposure from their client's portfolios, to evaluate how well their in-house SCS model performs (Bowen, pers. comm., Nov 15, 2016). **CoreLogic** and **RMS**, two major third party vendors, also use SWDI in their SCS models (Young, pers. comm., Nov 21, 2016) (D Smith & Haseemkunju, pers. comm., Oct 6, 2016).

Guy Carpenter makes extensive use of the SWDI to evaluate third-party vendor model performance and to monitor events in near real time. The SWDI can detect storm cells capable of producing severe weather events which may lead to severe weather events. Further it can detect severe weather conditions in remote areas where there may not have been anyone present to report a storm. This is particularly valuable in areas where there is exposure of buildings and assets. As **Guy Carpenter** is continually trying to improve understanding of weather perils, the **SWDI** serves as a valuable resource that helps improve understanding of storm formation (Anonymous, pers. comm., Dec 2, 2016).

Weather Predict, the private meteorological consulting provider to **Ren Re**, a leading global provider of catastrophe insurance in Bermuda, has used NEXRAD data to help make its clients aware of potential losses prior to losses reported by the primary insurance company. This data can also be used to reconcile disputes between the insurance and reinsurance company. For example, if an insurance company is making a claim that the reinsurer feels is questionable, the reinsurance company could perform a retrospective analysis to verify whether the actual event took place (Hamilton & Bachiochi, pers. comm., Oct 3, 2016).

The shortcoming of the track and swath characteristics from **SWDI** is that the data only reliably shows the start and end points of tornado events suggesting that tornados travel in straight lines. Scientifically it is recognized that this is not realistic. The data performs most reliably for hail events (Bowen, pers. comm., Nov 15, 2016).

NCEI retrospective analysis of the Multiple Radar Multiple Sensor (MRMS)[5] dataset for the periods of 2001-2012, would ameliorate some of the shortcomings of the SWDI. MRMS offers significant improvements in spatial and temporal resolution, over previous radar-derived products, with 1-km spatial resolution, and 5-minute temporal resolution. Furthermore, it would offer a more accurate and complete portrayal of storms, including their inception, evolution and precipitation characteristics (NSSL MRMS Decision brief). Due to unresolved licensing issues, this product it not yet available for public distribution from NCEI. The MRMS has great potential value to the reinsurance sector for analyzing severe convective storms as it would help obtain more precise hail swaths or point by point locations of tornado tracks (A Smith, pers. comm. Sept 30, 2016). Several interviewees expressed great interest in having this product made available.

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[5] The MRMS system was designed at NOAA's National Severe Storm Laboratory in 2016 and made available to the public through the NWS. NCEI has completed a retrospective analysis of NSSL's MRMS product for the time period of 2001-2012.

4.3. Global Historical Climatology Network-Daily (GHCN-D)

Peril: Droughts, Heatwaves, and Winter Storms

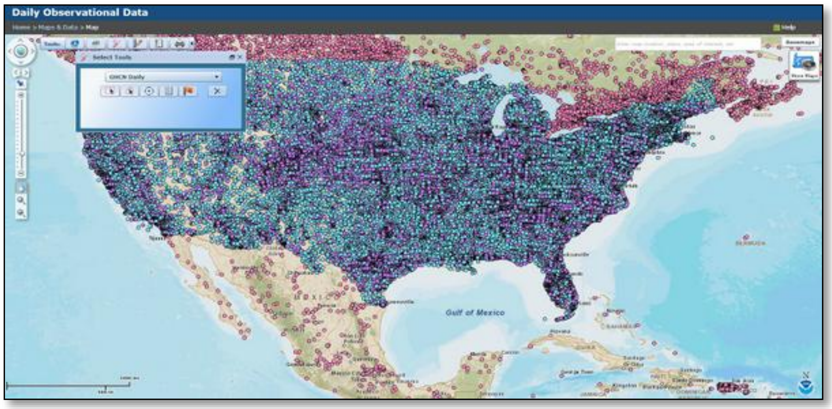

Figure 5: GHCN-D Station Data
Source: NOAA climate.gov

GHCN-D is a global, land-based (*in-situ*) database that collects observations from a number of different observing networks. The database was developed for a wide variety of potential applications that require data at a daily time scale (Menne, et al 2012). Sectors that rely on **GHCN-D** data in their operations include agriculture, construction, insurance and reinsurance, electric and gas utilities, energy management companies, and retail, among others (Adams, 2014). **GHCN-D** contains records from over 80,000 stations in over 180 countries and territories, and is the most comprehensive daily global dataset available. Variables commonly include maximum and minimum temperature, total daily precipitation, snowfall, and snow-depth. Data for the U.S. is reported once daily (usually in the mornings) from stations across the country (Menne, et al, 2012). Station data is critical as it provides the truest source ground based weather conditions.

Applications

The reinsurance brokerage firm **Guy Carpenter** relies on data from NCEI's GHCN-Daily database, to understand the implications of weather events such as extreme snowpack. In the winter months of 2015, Massachusetts experienced a record cold winter, and Boston experienced record-breaking snowfall. **Guy Carpenter** meteorologists made use of snow depth, snow fall, and temperature records from GHCN-D for the Boston area to better understand the frequency and severity of the snow pack formation. The implications of snow pack formation can be serious – if snow pack on residential buildings or businesses is unable to melt, it may result in ice damming and roof collapse, which can in turn lead to flooding.

Similarly, during the winter of 2014-2015, the central Great Lakes region experienced an extremely cold winter. Power and gas lines froze at Chicago's O'Hare airport, which impacted a number of clients that **Guy Carpenter** services. Precipitation and station data from GHCN-D was very important to actively monitor the event and understand the range of possible impacts and disruptions (Anonymous, pers. comm., Dec 2, 2016).

AgRisk is primarily interested in the perils that directly affect global agriculture including: drought, heat waves, and floods. As a first course of action, **AgRisk** sources data from local meteorological agencies, however depends on NCEI when it cannot obtain a sufficient period of record, quality, or format from the local agency. For example, when a record of station data from the Indian Meteorological Department ended, **AgRisk** retrieved **GHCN-D** to provide a longer period of record. **GHCN-D** was used to assess the merits of other data sources and thread together gaps in regional and local networks. **AgRisk** appreciates the on-going maintenance of this data source as it serves as an important back-up (Osbourne, pers. comm., Nov 15, 2016).

Daily weather data from **GHCN-D** is a critical input into **Aon Benfield's** crop models. **Aon Benfield** develops tools for its agricultural based clients, which help evaluate the profitability of a harvest, quantify commodity yields, and accurately assess potential losses. Daily weather data is a critical input for these tools (Bowen, pers. comm., Nov 15, 2016).

CAT modelling vendor **CoreLogic** relies on daily temperature data from **GHCN-D** including temperature, rainfall, and maximum sustained gust wind speed to inform its severe convection storm hail models (D Smith & Haseemkunju, pers. comm., Oct 6, 2016).

Aon Benfield relied on temperature and precipitation data from **GHCN-D**, along with drought monitoring products from **climate.gov** to monitor and analyze and the spread of recent wildfires in Western North Carolina and Eastern Tennessee which led to the devastating Gatlinburg fires. In addition to claiming 14 lives, the wildfires cost in excess of $500 million. **Aon Benfield** closely monitored the event given client exposure locations in the expansive fire perimeter (Bowen, pers comm., Nov 15, 2016).

4.4. Storm Events Database

NCEI archives storm data provided by the National Weather Service (NWS), into the **Storm Events Database**. The database contains archived records from 1950 to present which are updated monthly, occasionally with a window of delay. The database provides access to U.S. historical information pertaining to occurrences of tornados, hurricanes, high winds, hail, thunderstorms, lightening, flood, drought conditions, temperature extremes, snow storms, and other weather-related phenomena and contains information on injuries, deaths, property damage, and disruption to commerce. Users can search for storm information by state, county or other selection criteria.

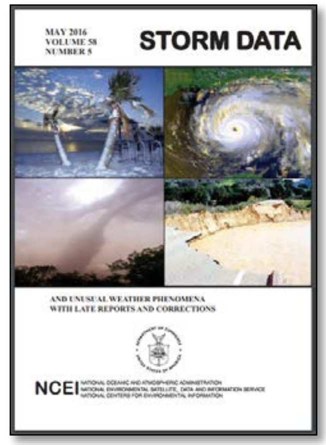

Figure 6: Storm Data Publication
Source: NCEI

The Storm Events Database is used to create the official NOAA **Storm Data Publication**, a monthly issue containing information on storm occurrences and unusual weather phenomena organized by state. Reports contain information pertaining to storm path, injuries, deaths, and property damage (NOAA NCEI, ND).

Applications

The Storm Events Database and monthly reports are used industry-wide to gain an understanding of historic events. When reinsurers need to get more detailed information about a historic storm, they can access the archived reports and locate the analysis. These reports are very useful in providing an overview of the storm event and understanding the impact that it had. They can be used in the development of the stochastic event module (synthetic event generation) of CAT models, or alternatively be used to validate the models. A challenge with storm reports is that they are subjective and do not always characterize events accurately, for example the size of the hail (Bowen, pers comm., Nov 15, 2016).

4.5. Billion Dollar Disasters Report

NCEI's **U.S. Billion Dollar Disasters** report is a quarterly publication that began in 1980, that highlights aggregate losses for major weather and climate events that have occurred in the U.S. The report quantifies losses for numerous weather and climate events that meet or exceed $1 billion each in economic losses. These events include tropical cyclones, severe convective storms (tornados, hail, straight-line wind damage), floods, droughts, heatwaves, wildfires, crop freeze events, and winter storms. The loss estimates reflect the direct impacts of the weather and climate events, and the total insured and uninsured losses including: physical damage to buildings, material assets within a building, business down time, vehicles, public and private infrastructure, and agricultural assets (e.g. livestock, forestry and crops) (Smith and Katz, 2013).

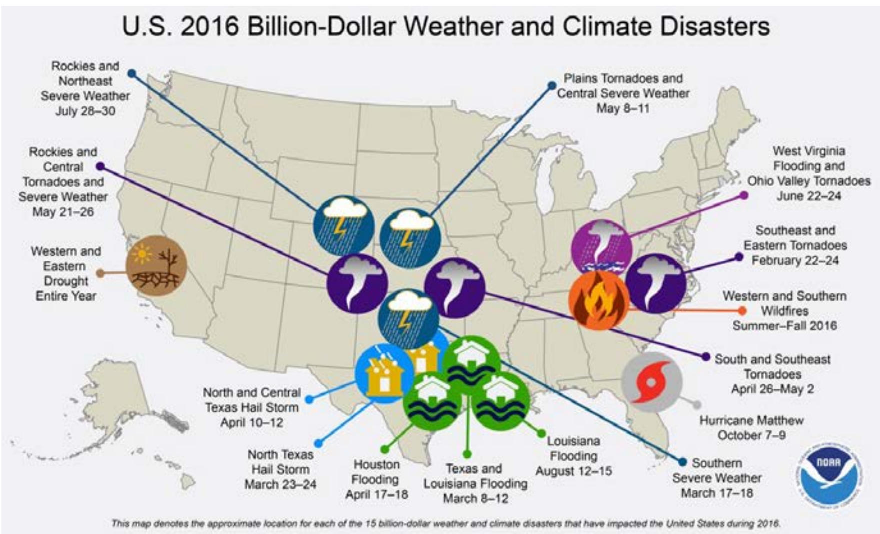

Figure 7: Billion Dollar Disasters (2016)
Source: NCEI

Applications

The **Billion-Dollar Disasters** report is a valuable reference source that is used industry wide. The report has been referenced by **Munich Re**, **Swiss Re**, **Aon Benfield**, **RMS**, **AIR**, **CoreLogic**, **Weather Predict**, and more. It provides a benchmark for known historical events and can be used to understand how past events would impact losses under present day exposure. **Munich Re America** contributes to the development of the **Billion-Dollar Events Database** by providing data on loss estimation to NCEI from its internal Natural Catastrophe Database (Bove, pers. comm., Nov 1, 2016). **Weather Predict** refers to the report alongside Property Claim Service Reports, to get a better understanding of total losses (Hamilton & Bachiochi, pers. comm, Oct 3, 2016). The losses from the **Billion-Dollar Disasters** report tend to be conservative, as they do not take into account non-market losses such as natural capital, health care related losses, or values associated with loss of life. Consequently, the report can be enhanced with additional data sources (A Smith, pers. comm., Sept 30, 2016).

5. Benefits of NCEI data

There are many benefits stemming from the use of specific products from NCEI, as well as the overall provision of NCEI's data to the reinsurance sector. The following points encapsulate the overall benefits of NCEI's data:

- Conflict resolution: NCEI datasets are helpful in settling disputes between insurers and reinsurers as it bears the 'official' seal of data
- Convenience: NCEI provides a clearinghouse of datasets that can be accessed in one central location
- Free: available at no cost
- Point of contact: ability to connect with NCEI staff with regards to a specific question/inquiry
- Neutral and scientifically defensible
- Processed and quality controlled data

6. General improvements

Interviewees provided feedback on how they would like to see NCEI's provision of data improved to better serve the reinsurance sector's needs. Recommendations pertaining to specific data products are listed in their respective sections. General recommendations include:

- Organization of datasets by peril (i.e. tropical cyclone, severe convective storms). There may be some redundancy in this approach, however it would make the data and information easier to find for a non-expert user
- Improved website interface: improve consistency, formatting, and make the datasets easier to locate
- Include more metadata and methodology documentation
- Better describe or quantify uncertainty metrics
- Provide alternate formats as a matter of convenience where possible, i.e. NetCDR, ESRI
- Resolve licensing issues to make MSMR data available
- Continue transitioning NCEI's data to the cloud

6. Conclusion

The financial services industry, including insurance and reinsurance, is the biggest sector in the U.S. economy accounting for 7.2 percent of the Gross Domestic Product, or $1.293 trillion (2015). This sector is of critical importance to the U.S. economy as it generates substantial economic activity and provides jobs both directly and indirectly (Select USA, 2015). Furthermore, the insurance and reinsurance industry provides a critical service to areas impacted by catastrophic events as it channels funding to communities in need allowing them to re-build quicker, and get back to their daily lives, faster (Mark Bove, pers. comm. Nov 1, 2016).

NCEI's data plays a critical role in providing the data and information that the reinsurance industry requires to develop tools and understand the potential frequency and magnitude of natural catastrophes. Without this understanding of natural catastrophes, the industry would not be able to price risk as accurately, and would be unable to operate their businesses efficiently. Access to NCEI's data holdings is invaluable to the reinsurance industry. It's foundational for the development of CAT models for weather-related perils, validating and recalibrating third party and in-house CAT models, and resolving disputes that may arise between insurance and reinsurance companies. While difficult to quantify its direct value to the sector, **NCEI's data is the backbone for many transactions in the reinsurance industry and without it billions of dollars of economic activity would be lost** (Mark Bove, pers. comm. Nov 1, 2016). As detailed in this report, the reinsurance sector is a substantial user of NCEI's hurricane track data (IBTrACS), severe weather data (SWDI), station data for temperature and precipitation (GHCN-D) the Billion Dollar Disasters Report and Storm Events Database.

This report offered insights from 14 industry representatives working within CAT modeling firms, brokerage firms, reinsurance companies, reinsurance associations, as well as three representatives from NOAA and NCEI. Beyond those interviewed for this study, there are likely many more reinsurance industry users worldwide that derive value from NCEI's suite of free and publically available products. The maintenance of existing products, and provision of new data products is of critical importance to the sector, and this study has likely underestimated its value. NCEI's data plays an important role in supporting the viability of reinsurance as an economic sector worldwide.

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Appendix 1: Firms and personnel Interviewed

Interviews conducted by phone or in-person unless otherwise specified

Reinsurance firms:

- Munich Re America
  - Mark Bove, *Senior Meteorologist*, November 1, 2016
  - Carl Hedde, *Head of Risk Accumulation*, November 16, 2016
- Arch Re: Manual Lonfat, *Chief Risk Officer*, October 10, 2016

Reinsurance meteorological support providers:

- Weather Predict:
  - Dave Hamilton: *Senior Scientist/Meteorologist,* October 3, 2016
  - Dave Bachiochi, *Senior Scientist/Meteorologist*, October 3, 2016

CAT modeling firms:

- CoreLogic:
  - David Smith, Senior Director Model Development, October 6, 2016
  - Vysyamparambil Haseemkunju, Model Development, October 6, 2016
- RMS: Michael Young, Senior Director Model Product Management, November 21, 2016
- AgRisk: Tom Osborne, *Principal Modeler*, November 15, 2016

Reinsurance Brokerage Firms:

- Aon Benfield: Steve Bowen, *Meteorologist and Director*, November 15, 2016
- Guy Carpenter: Anonymous, *Confidential*, December 2, 2016

Associations and not-for profit:

- Oasis Loss Modeling Framework: Dickie Whitaker, *Chief Executive Officer*, October 11, 2016
- Reinsurance Association of America: Frank Nutter, *President*, (email correspondence only)
- Risk Prediction Initiative: Mark Guishard, *Science Program Manager*, October 31, 2016

NOAA:

- NOAA NOC: Michael Weiss, *Director*, October 4, 2016
- NOAA NOC: Toni LaVoi, *Chief of Integrated Information Services Division*, October 4, 2016
- NOAA, NCEI, Adam Smith, *Applied Climatologist*, September 30, 2016