RPI2.0

Risk Prediction Initiative

Annual Report 2014

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Bermuda Institute of Ocean Sciences

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Image source: NASA

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Hurricane Gonzalo bears down on Bermuda. Image courtesy of NASA.

RPI*2.0* – Connecting Science and the Risk Transfer Industry

The Risk Prediction Initiative has a long history of facilitating and funding academic research relevant to the re/insurance industry. With the increasing market penetration of Insurance Linked Securities (ILS) investors, our view (like that of the reinsurance industry) has expanded to include new ideas and initiatives. As we move into 2015, our vision of bringing more scientific analyses to risk transfer encompasses research that supports decision-making for special purpose vehicles; for example, regarding trigger catastrophe events for Cat Bonds and Industry Loss Warranties.

We translate scientific hazard research into usable, actionable results for our Member companies. Our experienced management team combines expertise in climate-related natural disasters with a background in risk management. We help scientists focus their interests on needs and timescales relevant to the industry, in addition to stimulating and supporting high-level research on natural hazards such as tropical cyclones, floods, and tornadoes.

We actively help scientists understand which questions the industry is asking, and sponsor research designed to answer those questions. Our support of industry-defined research projects brings the scientific and business communities into closer alignment, engaging scientists to educate those involved with re/insurance underwriting, risk aggregation assessment, and ILS investment.

Selected Research and Collaborative Initiatives


Source: Wikimedia, Ben Salter

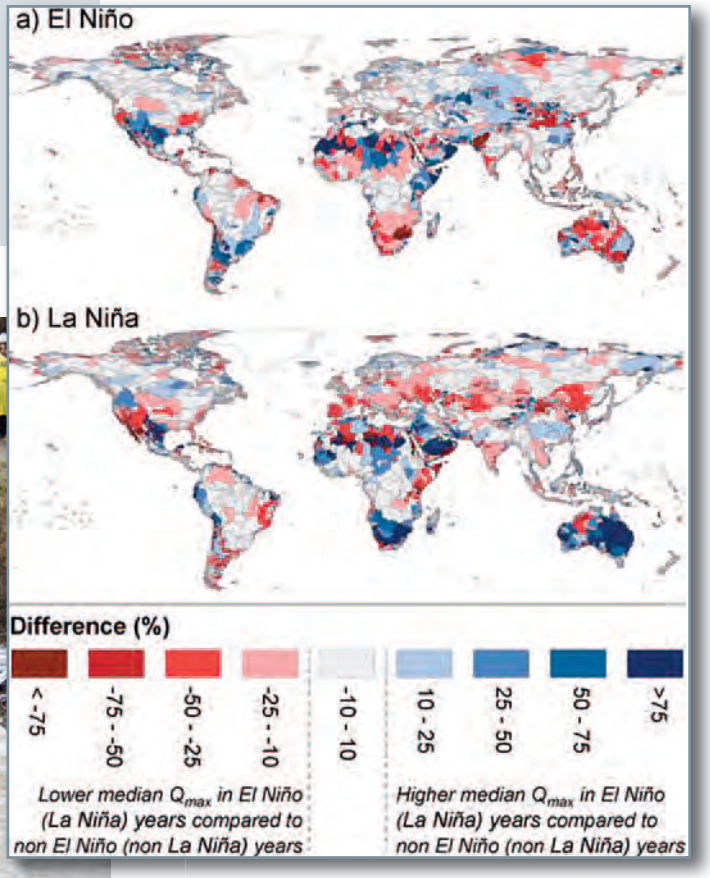
Simulated Footprint of a European Winter Wind Storm. Source: Massey & Allen, RPI*2.0* Project Report

Datasets and Models Delivered

The Oxford Probabilistic European Winter Windstorm Event Set – Smith School for Enterprise and the Environment, and the Environmental Change Institute, University of Oxford

This dataset represents the culmination of a study by the University of Oxford which applied its large volunteer distributed computing network to develop a new view of the current state of winter storm hazard in Europe. The dataset, which has been delivered to RPI*2.0* Members, may be used in internal and external modelling platforms for comparison with vendor model stochastic hazard events. The main deliverable of this project is a probabilistic event set, based on a large number of model runs from a regional climate model (RCM), which is driven at the boundaries by a global climate model (GCM). The events returned represent European winter storms in over 20,000 realizations of winter seasons in Europe for the period 1985-2010. The final dataset is comprised of wind footprints, mean sea level pressure, and geopotential height fields over Europe for each 6-hour time period. It also includes a 72-hour integrated footprint centered on the time of maximum winds in the domain for each event. Parameterized gust footprints are also provided. A calibration dataset is also provided for comparison with observed winds. Given the large volume of data derived from this project (approximately 61,000 events), datasets were provided to RPI*2.0* Members physically via external USB hard drives.

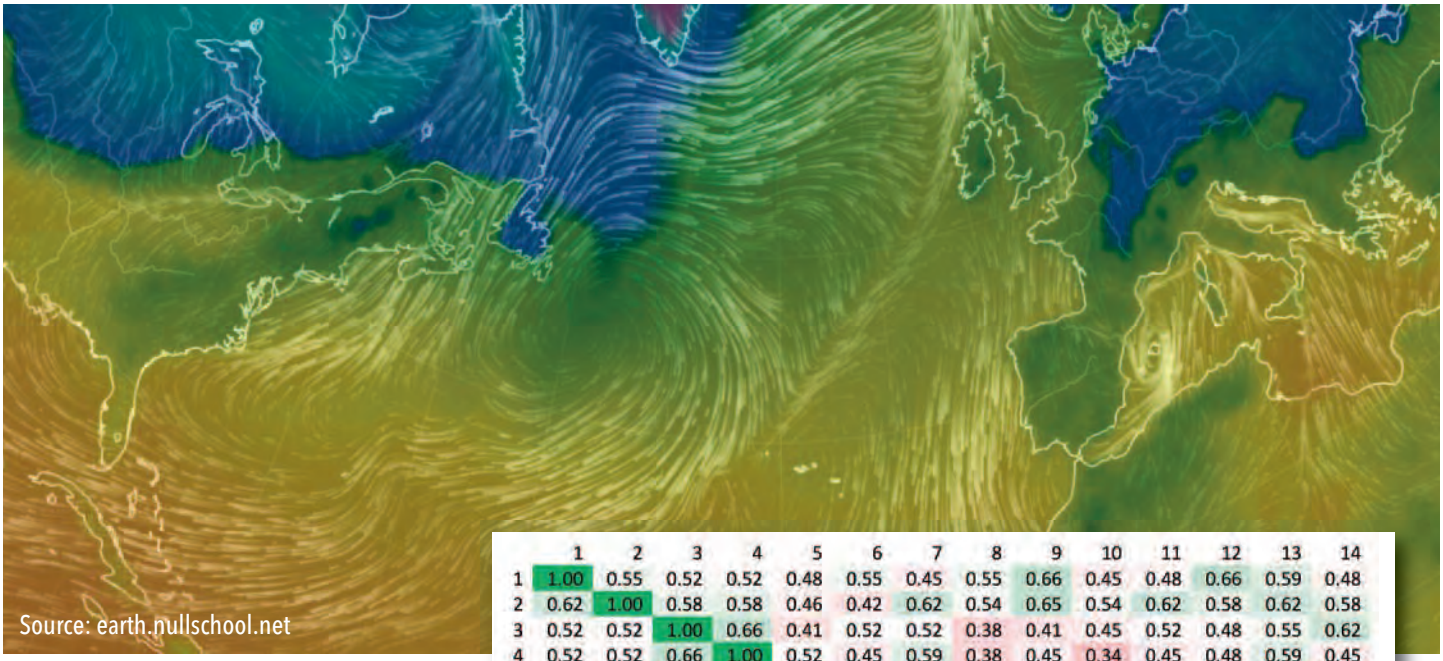
Anomaly (%) in peak annual discharge during El Niño years (above) and La Niña years (below). Source: Ward et al., 2014. Hydrology and Earth System Sciences Discussions




Source: NOAA

Mapping the Influence of Climate Variability on Global Scale Flood Risk - Institute for Environmental Studies, VU University Amsterdam

RPI*2.0* commissioned VU University Amsterdam to conduct a project to assess and map the influence of the El Niño Southern Oscillation (ENSO) on flood risk . The principal investigators developed a model framework to examine the variability of flood hazard and economic flood exposure (populations and gross domestic product) globally, by country and by river basin-scale. The framework was then used to calculate flood risk in an average annual climate, and conditioned on El Niño and La Niña years alone. The datasets provided are in GIS (e.g. shapefile) and spreadsheet formats, for simple assimilation into commonly-used platforms. These results were then used to calculate and map anomalies in flood risk during El Niño years (compared to all years) and La Niña years (compared to all years) at different scales, aggregated at country and large river basin levels. Return periods (5-1,000 years) of the differences between El Niño, La Niña, and average climatological flood risk characteristics were also provided to RPI*2.0* Member companies. Members have expressed great interest in this data, enabling them to gain insight into flood risk characteristics for all countries and major river basins in an easy-to use format.

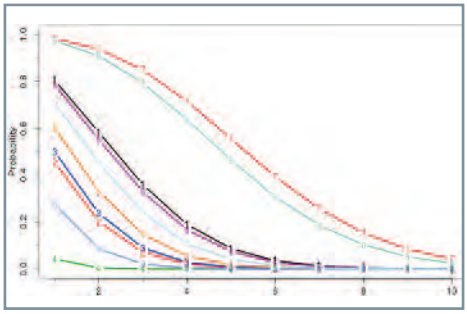


	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	1.00	0.55	0.52	0.52	0.48	0.55	0.45	0.55	0.66	0.45	0.48	0.66	0.59	0.48
2	0.62	1.00	0.58	0.58	0.46	0.42	0.62	0.54	0.65	0.54	0.62	0.58	0.62	0.58
3	0.52	0.52	1.00	0.66	0.41	0.52	0.52	0.38	0.41	0.45	0.52	0.48	0.55	0.62
4	0.52	0.52	0.66	1.00	0.52	0.45	0.59	0.38	0.45	0.34	0.45	0.48	0.59	0.45
5	0.56	0.48	0.48	0.60	1.00	0.52	0.64	0.56	0.52	0.24	0.32	0.64	0.40	0.44
6	0.50	0.34	0.47	0.41	0.41	1.00	0.50	0.50	0.56	0.47	0.47	0.56	0.44	0.44
7	0.46	0.57	0.54	0.61	0.57	0.57	1.00	0.50	0.39	0.36	0.43	0.50	0.50	0.54
8	0.59	0.52	0.41	0.41	0.52	0.59	0.52	1.00	0.44	0.33	0.37	0.52	0.41	0.48
9	0.70	0.63	0.44	0.48	0.48	0.67	0.41	0.44	1.00	0.52	0.56	0.67	0.41	0.48
10	0.62	0.67	0.62	0.48	0.29	0.71	0.48	0.43	0.67	1.00	0.95	0.38	0.62	0.62
11	0.61	0.70	0.65	0.57	0.35	0.65	0.52	0.43	0.65	0.87	1.00	0.39	0.65	0.57
12	0.68	0.54	0.50	0.50	0.57	0.64	0.50	0.50	0.64	0.29	0.32	1.00	0.50	0.50
13	0.63	0.59	0.59	0.63	0.37	0.52	0.52	0.41	0.41	0.48	0.56	0.52	1.00	0.56
14	0.47	0.50	0.60	0.43	0.37	0.47	0.50	0.43	0.43	0.43	0.43	0.47	0.50	1.00

Correlation Matrix of extreme precipitation in studied regions (by number).Given that region 8 is experiencing an above-average extreme year, how likely is it that region 4 will also be experiencing one? Source: LaRow & Stefanova, RPI*2.0* Project Report.

Relating Large-Scale Climate Drivers to Regional/Continental/Global Scale Frequency of Extremes – Florida State University

Large-scale climate oscillations are responsible for setting up favorable conditions for regional changes in the distribution of climate extremes. The scientific literature includes many studies of large-scale climate oscillations and their impact on regional weather patterns. Understanding the superposition of these oscillations (climate drivers) and their impacts on multiple regional climate extremes is generally lacking. This report examines the annual averages of these climate drivers with derived severe indices to explore predictive relationships that can be used by RPI*2.0* Members. Additionally, this work examines the average July-December climate drivers of the preceding year with the Northern Hemisphere's regional annual tropical cyclone landfall counts.



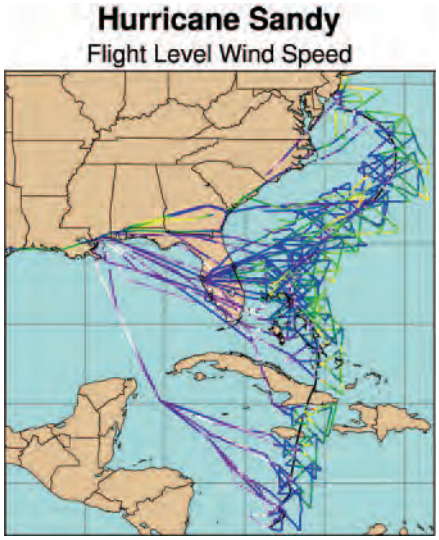
Sample output: Probability of tropical cyclone landfall counts in given regions

Strategically, the potential benefits of this project include an improvement in understanding accumulated risk due to regional aggregation of multiple perils, as well as the correlation of risk across different regions. Together, these provide a global perspective on climate hazard variability, which may be applied directly to a re/insurance view of risk via the deliverable of spatial maps and time series of aggregated extreme indices.

RPI*2.0* takes advantage of opportunities to bring together Member companies and visiting natural hazard scientists. In September 2014, NOAA Hurricane Hunter aircraft, crews, and scientists were based in Bermuda to fly missions into Hurricane Edouard. This was the first time unmanned aerial vehicles were deployed into a hurricane, launched from a research aircraft. Leveraging contacts within NOAA and the Bermuda Weather Service, RPI*2.0* was able to coordinate a tour of the aircraft for our Member companies. This gave them first-hand insight into data collection processes and platforms that contribute to the hurricane catalogues used in risk research.

Tropical Cyclone Size Parameters - National Center for Atmospheric Research/Research Applications Laboratory

The focus of this project is to derive a large wind dataset from existing flight reconnaissance and satellite-based information; the resulting data can then be used for further analyses by Member companies and other researchers. The HURDAT hurricane database has always been the main benchmark tool for calibrating event sets against, and making inferences about, the variability of tropical cyclone characteristics. However, it has often been difficult to analyze important aspects of landfalling tropical cyclones due to the relative dearth of consistent information about the wind footprint of each storm, and how it relates to intensity, rainfall, and other parameters of relevance to risk analysis. This project compiles a huge volume of available data derived from scatterometer (e.g. QuikSCAT) retrievals and aircraft measurements, with the goal of augmenting the existing HURDAT database.



Source: Jonathan Vigh, NCAR

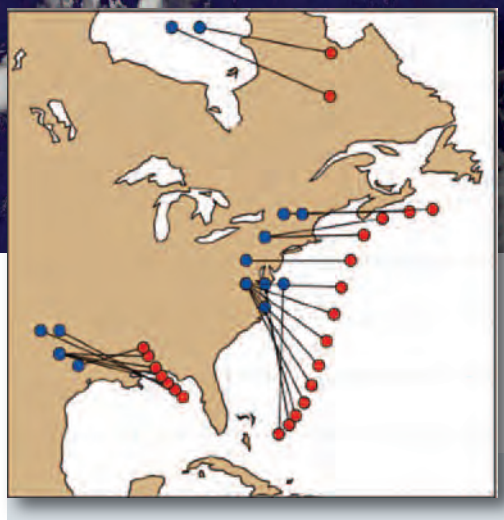
The additional information about wind footprint will be valuable to Members and researchers for making more robust conclusions, for example, about the correlations between a hurricane's intensity and its radius of maximum winds. Ongoing research into the improvement of tropical cyclone pressure-wind relationships will also certainly benefit from this work, enabling stronger conclusions about storms in relatively data-sparse regions, such as the central/western Pacific.

Image courtesy of NASA.

The Impact of Cyclone Interaction in Quantifying United States East Coast Tropical Cyclone Risk – Florida State University

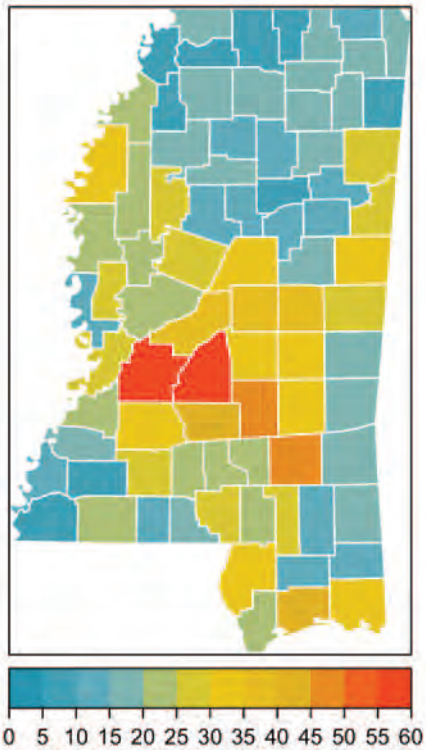
The intent of this project's proposed research was to determine how important interactions, such as were seen during the evolution of 2012 Hurricane Sandy, are in the potential for landfall. The outcomes revealed a significant impact of cyclone interactions on the landfall frequency of hurricanes. Given that events in stochastic sets utilized in catastrophe risk models tend to be independent of one another (i.e. each storm doesn't 'know about' the others), a question remains: do stochastic processes used to develop event sets adequately represent this phenomenon?

This project delivered an analysis and two catalogues of a) all tropical cyclones in the Atlantic hurricane record (HURDAT) that interacted with other tropical cyclones and, b) tropical cyclones that interacted with mid-latitude (extratropical) systems, such as was the case with Hurricane Sandy. Also delivered were vector maps of the average anomalous motions these systems undertake, which reveals the resulting displacement of the track of one storm within a threshold interaction distance from another.



Tropical Cyclone - Extratropical Cyclone (TC-XC) proximity within interacting range for one of the years in the dataset. Red and blue markers are used to denote tropical and extratropical cyclones, respectively. Source: Hart, RPI*2.0* Report, 2014

Photo courtesy of Oklahoma National Guard.



Number of Mississippi EF1+ Tornadoes 1954-2013, Courtesy: James Elsner

RPI*2.0* Supports Historic Conference

The Risk Prediction Initiative has a proud tradition of supporting conversations about emerging topics of interest to the industry. In light of recent concern about how climate change and variability may affect the frequency and intensity of severe convective storms, RPI*2.0* was pleased to be a sponsor of the 1st International Summit on Tornadoes and Climate Change. We supported the participation of renowned tornado scientist, Dr. Chuck Doswell, along with doctoral student Kelsey Mulder from the University of Manchester, who is undertaking work on climatology of severe convective storm outbreaks in the Europe.

This meeting, the first of its kind in recent years, had a number of talks focusing on a variety of research issues related to severe weather. Much discussion centered on data quality, and how errors, biases, and uncertainty can be accounted for to make robust conclusions about the climate variability of severe weather and its precursor ingredients.

Newly Funded RPI*2.0* Research

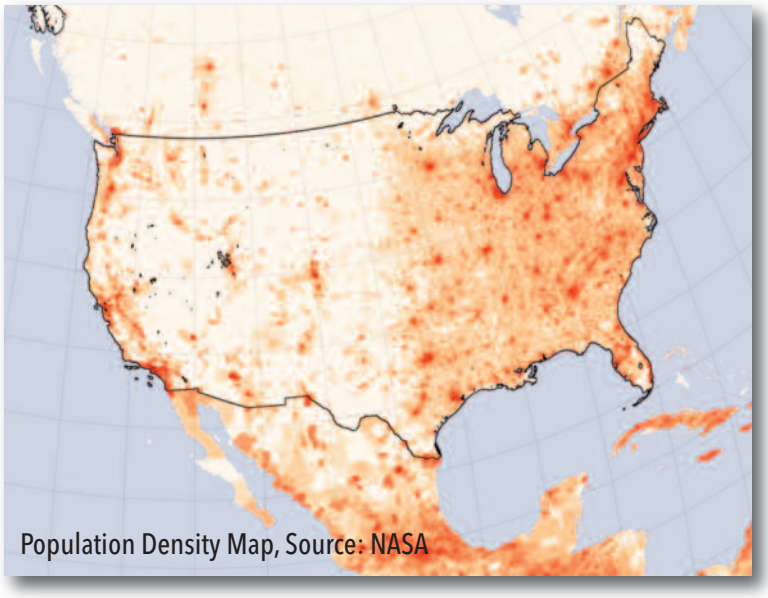
Synergistic research funding is selected by the group of RPI*2.0* Member companies in a democratic process which yields the best combination of projects for the group.

Cyclone Center: Toward a Global Reanalysis of the Tropical Cyclone Record

By Dr. Chris Hennon, UNC Asheville

RPI*2.0* Members voted to support the ongoing work of Cyclone Center, which has a goal of improving the tropical cyclone (TC) intensity record via a crowd-sourced approach. For TCs in the historical record with few or no wind speed data points over the ocean, Cyclone Center facilitates multiple intensity estimates by educating amateur analysts on how to classify TCs, and allowing them to submit their analysis.

This work innovatively addresses the perennial problem of inconsistencies and biases in the various intensity estimates in the 'best track' datasets. These datasets are often (especially in the Pacific) produced by agencies with overlapping geographical regions of interest and differing methodologies. The proposed research has the potential to yield datasets of intensity, including uncertainty estimates. The methodology mitigates concerns about untrained observers' contributions by both providing 'training' via their website guidelines, and a rigorous quality control process. It also complements the existing work on Atlantic TC size parameters, by providing Pacific TC intensity parameters.



Population Density Map, Source: NASA

A Granular National Assessment of Coastal Flood Exposure Growth

By Dr. Ben Strauss, Climate Central

The evolution of coastal exposure is often neglected in many storm surge risk assessments. This project aims to estimate the effect of growing coastal populations on the overall risk from seawater inundation, and derive return periods which incorporate historical and projected sea level rise (SLR). This builds on existing work at Climate Central to deliver applications that drive an understanding of coastal risk.

Much of our research is on the hazard component of risk, whereas this project examines an element of the vulnerability of exposed populations. This project centers on the assessment of how exposure growth and sea level rise impact overall risk, while holding storm characteristics 'constant' (i.e. basing them on the current/historical view). This is a novel approach to evaluating two phenomena that have a potentially profound impact on storm surge risk. The research team here has demonstrated an understanding of the need for a multi-faceted examination of risk which is timely and relevant.

Seasonal Extratropical Storm Clustering

By Dr. Gregor C. Leckebusch & Prof. Uwe Ulbrich, University of Birmingham & Freie Universität Berlin

This project is focused on the increased frequency of severe, damaging European wind storms in a single season and the mechanisms that trigger such years. Previous research of the PIs has shown the importance of the interplay between large-scale conditions and synoptic scale forcing for the seasonal clustering, or so called insurance clustering (IC). This project will quantify the IC effect from a meteorological and insured loss perspective, and provide a scientific analysis of the driving factors. It will also develop a statistical model which, combined with seasonal or decadal weather forecasts, can be used to quantify the likelihood of extreme seasons in the medium-term future.

In the recent past, the interannual variability of wind storm events in Europe has raised questions about different clustering mechanisms and stimulated a considerable debate of our scientific understanding of these effects. This project will not only present state-of-the-art underlying science, carried out by experts who have an impressive track record of industry-relevant research, it will also provide tools to improve our medium-term view on high frequency seasons. This two-year project, in conjunction with last year's RPI*2.0*-RMS workshop on European wind storm modeling, promises a significant improvement of our understanding of Europe's most important catastrophe risk.

Tropical Cyclone and Major Hurricane Return Periods from a Probabilistic Model of Hurricane Activity

By Dr. Amato T. Evan, Scripps Institution of Oceanography, University of California, San Diego

This project will create global maps of TC and major hurricane return periods, and maps of how those return periods vary with changes in regional climate indices (e.g., El Niño Southern Oscillation) and African dust outbreaks.

This research is attractive because a) there is a straightforward probabilistic approach which aligns with the statistical methods used for loss projection, and b) the maps which it provides can be quickly digested. This work would build upon previous RPI*2.0* work to deliver maps of historical risk, and build upon the concept to produce probabilistic projections associated with different conditions under historical, current and future views of risk.

Student Support

Through our relationship with the other programs at our host institution, the Bermuda Institute of Ocean Sciences, RPI*2.0* is able to mentor students during their undergraduate and graduate level work during summer internships. This year we facilitated the mentoring of Michael Johnston, a Bermudian meteorology undergraduate at Penn State. He examined the cold water wakes that are created by hurricanes over the Atlantic, and the interactions between the atmosphere and ocean during hurricane passages. The passage of a number of tropical cyclones near Bermuda in 2014 facilitated some interesting conclusions.

This approach, combined with the results of student work facilitated by our funded research projects, has led us to consider offering more formalized RPI*2.0* education programs in the future. If you have any interest in assisting with the development of this educational aspect of our program (e.g. internships or summer courses), please get in touch.

RPI*2.0* Events

In-House Meetings

One of the services each RPI*2.0* Member company enjoys as part of their Membership is access to our scientists on a one-to-one basis. We help to answer the most important questions about the science of extreme events posed by RPI*2.0* Members. After consulting our network partners, we present the results in a distilled form in Members' offices. On request of the Member, an appropriate scientist joins the RPI*2.0* team for the in-house event. Topics presented may include: a seasonal outlook, updates and headlines of RPI*2.0* funded research, dynamical model results and their current skill, as well as the latest insights into new developments in commercial risk modelling. Membership includes, as a minimum, one in-house event at the sponsoring company. The wide reach of our network of researchers has enabled us to provide in-house presentations in your offices, wherever they may be. We have delivered in-house meetings in Member's offices in London, New York, Bermuda, Zurich, and other jurisdictions. Additionally, videoconferencing has improved our ability to bring scientists and reinsurance personnel together regardless of their respective locations.

RPI*2.0* Personnel carried out a number of outreach efforts in 2014 surrounding the themes of climate change and natural hazards in Bermuda, including public lectures and briefings on Hurricanes Fay and Gonzalo. Photo by Bermuda Ocean Explorers

Hosted Workshops and Seminars

RPI*2.0* Research Update Workshop 2014

When: September 25, 2014

RPI*2.0* hosted its annual Research Update Workshop, at which world-renowned scientists presented their research on a variety of topics relevant to RPI*2.0* Members. This annual workshop offers our Member companies the opportunity to keep up to date with the progress of currently-funded research projects and also to liaise with scientists to ensure that their business needs remain a focal point of the research.

Many thanks to XL Re, who hosted the workshop in their Hamilton, Bermuda offices, at O'Hara House.

RPI*2.0*/BII Joint Catastrophe Risk Seminar

When: October 28, 2014

RPI*2.0* once again joined forces with the Bermuda Insurance Institute (BII) to deliver a highly-relevant program on the subjects of Flood Risk and Storm Seawater Inundation research.

Many thanks to the Bermuda Insurance Institute for administering this event, which was held at their offices in Hamilton, Bermuda.

RPI*2.0* Publications in 2014

Caron, L.-P., M. Boudreault and C.L. Bruyere (2014). **Changes in large-scale controls of Atlantic tropical cyclone activity with the phases of the Atlantic Multidecadal Oscillation**, *Climate Dynamics*, June 2014.

Caron, L.P., Hermanson, L. and Doblas-Reyes, F.J., **Multi-annual forecasts of Atlantic US tropical cyclone wind damage**, *Nature Geosciences* (submitted), November 2014.

Elsner, J. and Guishard, MP, **Meeting Summary: First International Summit on Tornadoes and Climate Change,** *Eos, Transactions, American Geophysical Union*, Volume 95, Issue 45, page 412, 11 November 2014.

Hodges, R.E., Jagger, T., Elsner, J. T**he sun-hurricane connection: Diagnosing the solar impacts on hurricane frequency over the North Atlantic basin using a space-time model**, *Natural Hazards*, March 2014.

Walsh, KJE., Camargo, S., Vecchi, GA, Daloz, AS, Elsner, J, Emanuel, K, Horn, M, Lim, YK, Roberts, M, Patricola, C, Scoccimarro E, Sobel, AH, Strazzo, S, Villarini, G, Wehner, M, Zhao, M, Kossin, JP, LaRow, T, Oouchi, K, Schubert, S, Wang, H, Bacmeister, J, Chang, P, Chauvin, F, Jablonowski, C, Kumar, A, MurakamiH, Ose, T, Reed, KA, Saravanan, R, Yamada, Y, Zarzycki, CM, Vidale, PL, Jonas, JA, Henderson, N, **Hurricanes and climate: the U.S. CLIVAR working group on hurricanes**, *Bulletin of the American Meteorological Society*, Sept 2014.

Ward, P.J., Jongman, B., Kummu, M., Dettinger, M.D., Sperna Weiland, F.C., Winsemius, H.C., **Strong influence of El Niño Southern Oscillation on flood risk around the globe**, *Proceedings of the National Academy of Sciences*, September 2014.

RPI*2.0* Reports to Members

Agard, V. and Emanuel, K.A., **Tornadoes, Hail Storms, and Climate**, Massachusetts Institute of Technology – RPI*2.0* Project Reports.

Caron, L.P., **Multi-annual Forecasts of Atlantic Tropical Cyclones in a Climate Service Context**, Institut Català de Ciències del Clima (IC3), Barcelona, Spain – RPI*2.0* Project Final Report

Elsner , J., **Sensitivity and Predictability of Hurricanes to Warming Seas, PART 1**, Florida State University – RPI*2.0* Project Report.

Guishard, M.P., **31st American Meteorological Society Conference on Hurricanes and Tropical Meteorology** - RPI*2.0* Report, April 2014.

Guishard, M.P., **A Review of China Flood and Inundation Risk Research & Data** - RPI*2.0* Report, November 2014.

Guishard, M.P., **1st International Summit on Tornadoes and Climate Change**, RPI*2.0* Report, July 2014.

LaRow, T, and Stafanova, L., **Relating Large-Scale Climate Drivers to Regional/Continental/Global Scale Frequency of Extremes** – RPI*2.0* Project Final Report, November 2014.

Hart, R.E., **The Impact of Cyclone Interaction in Quantifying United States East Coast Tropical Cyclone Risk**, Florida State University – RPI*2.0* Project Final Report.

Massey, N. and Allen, M., **Using Large Ensemble Volunteer Computing to Develop a Weather Event Dataset for the Historical Period, University of Oxford** – RPI*2.0* Project Final Report.

Ward, P.J., **Mapping the Influence of Climate Variability on Global Scale Flood Risk**, IVW, Institute for Environmental Studies, Amsterdam, Netherlands – RPI*2.0* Project Final Report.

General Information

RPI*2.0* Member Companies 2014

Key Personnel

Mark Guishard Ph.D. RPI*2.0* Program Manager
Bill Curry, Ph.D, BIOS President and Director
Charles King, **M.Aq.**, Research Specialist and Web Technician

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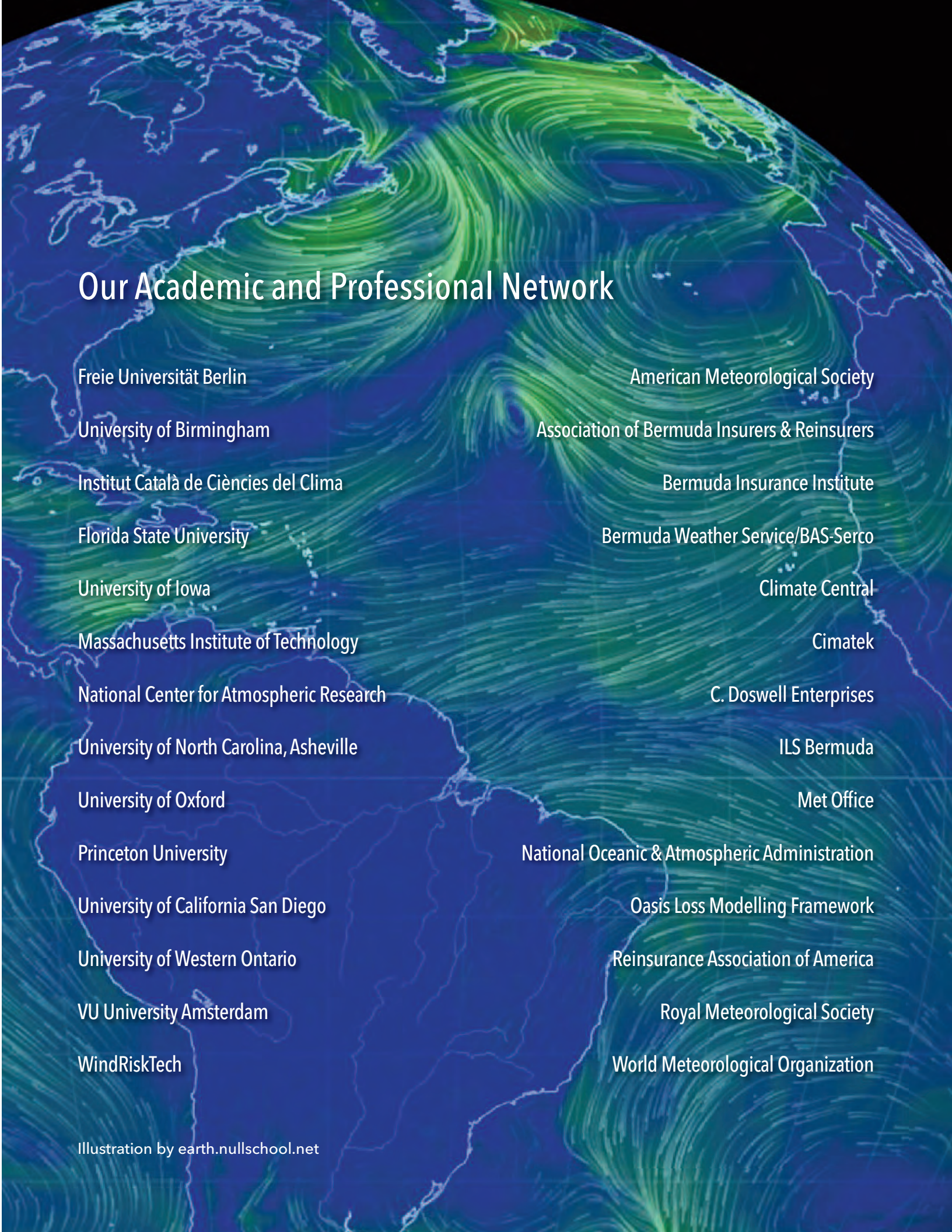
Membership Levels

- **RPI*2.0* Bronze Membership - $65K/year**
  The basic subscription includes Member-only access to current and past research projects and reports, one in-house presentation, data/modelling deliverables, and your corporate logo displayed prominently on the RPI2.0 website. These services are also included in Silver and Gold membership.

- **RPI*2.0* Silver Membership - $85K/year**
  The Silver Membership facilitates more access to the researchers, with a view to developing more targeted and specific research deliverables and reports. There are two additional in-house events, one of which includes attendance by an independent scientist.

- **RPI*2.0* Gold Membership – $125K/year**
  This membership level includes specific support for a graduate student at one of our world-renowned partner universities, or an internship in a relevant discipline. In addition, quarterly visits to your company will be made, two of which include attendance by an independent scientist.



Our Academic and Professional Network

Freie Universität Berlin

University of Birmingham

Institut Català de Ciències del Clima

Florida State University

University of Iowa

Massachusetts Institute of Technology

National Center for Atmospheric Research

University of North Carolina, Asheville

University of Oxford

Princeton University

University of California San Diego

University of Western Ontario

VU University Amsterdam

WindRiskTech

American Meteorological Society

Association of Bermuda Insurers & Reinsurers

Bermuda Insurance Institute

Bermuda Weather Service/BAS-Serco

Climate Central

Cimatek

C. Doswell Enterprises

ILS Bermuda

Met Office

National Oceanic & Atmospheric Administration

Oasis Loss Modelling Framework

Reinsurance Association of America

Royal Meteorological Society

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