# Complexity in Climate Change

OASIS Conference 3-4th May, 2023

Panel Discussion

PartnerRe

# Complexity in Climate Change Panel Discussion

PartnerRe

Moderated by **Paul Della-Marta**, Head of Catastrophe Research, Partner Re

- **Steve Jewson**, Independent Climate Science Researcher
- **Kelsey Mulder**, Catastrophe Research Manager, Liberty Specialty Markets
- **Lauren Mudd**, Senior Engineer, Applied Research Associates
- **Cat Pigott**, Head of Science & Natural Perils, AXA XL

# Complexity in Climate Change Panel Discussion

How to implement **expected (and past)** climate change in cat models?

To estimate:

- Future
- Current

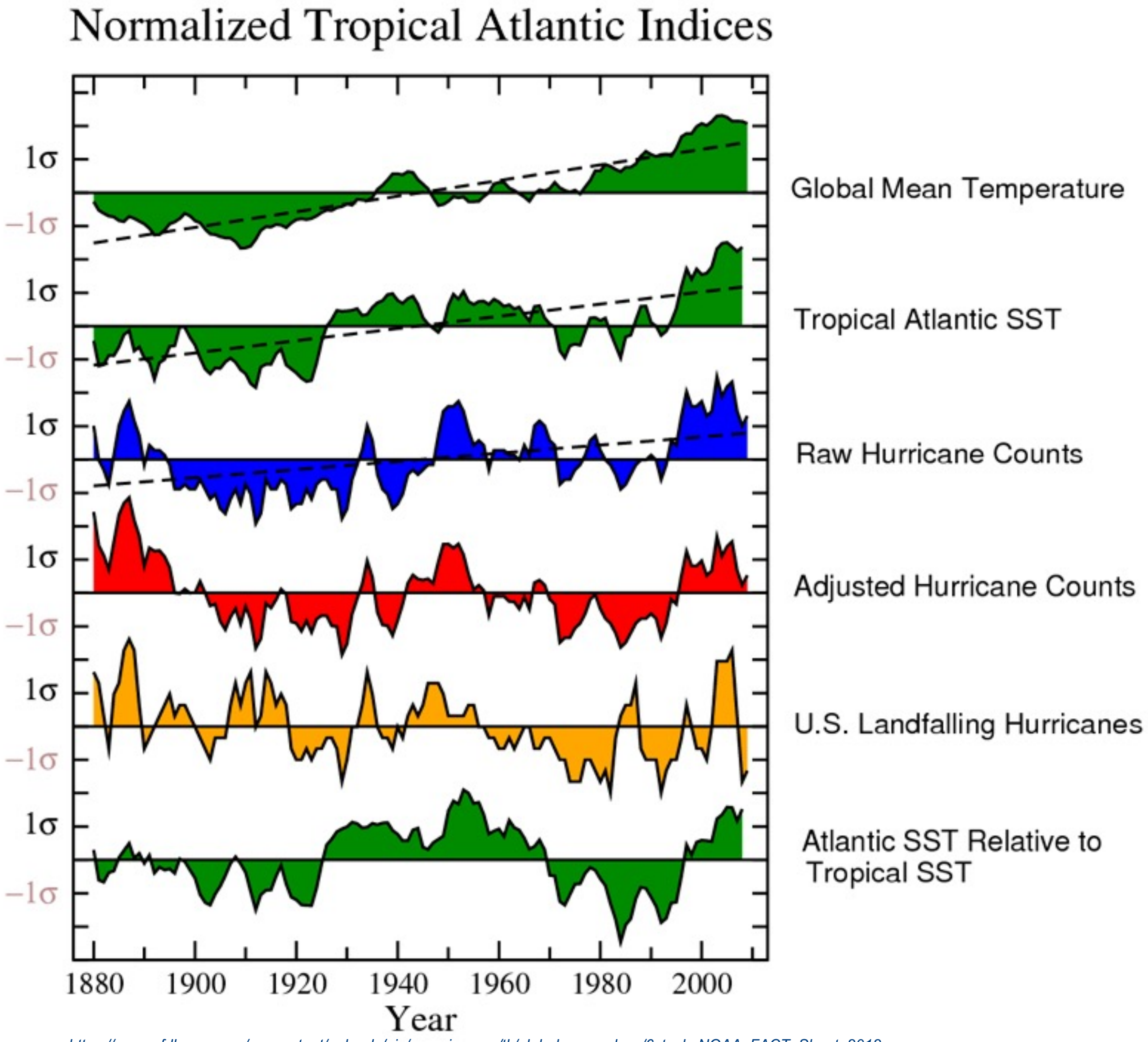
Risk-of-loss

# General Approaches to Capture Climate Effects on Hurricanes

**1: Identify and extrapolate statistical or temporal trends** between environmental parameters and hurricane behavior

- Simplicity is both an advantage and disadvantage
- *"... failure to account for radiative properties of the atmosphere can distort the response of tropical cyclone activity to changing distributions of sea surface temperature."*

*Emanuel, K. (2010). Tropical cyclone activity downscaled from NOAA-CIRES reanalysis, 1908–1958. Journal of Advances in Modeling Earth Systems, 2(1).*

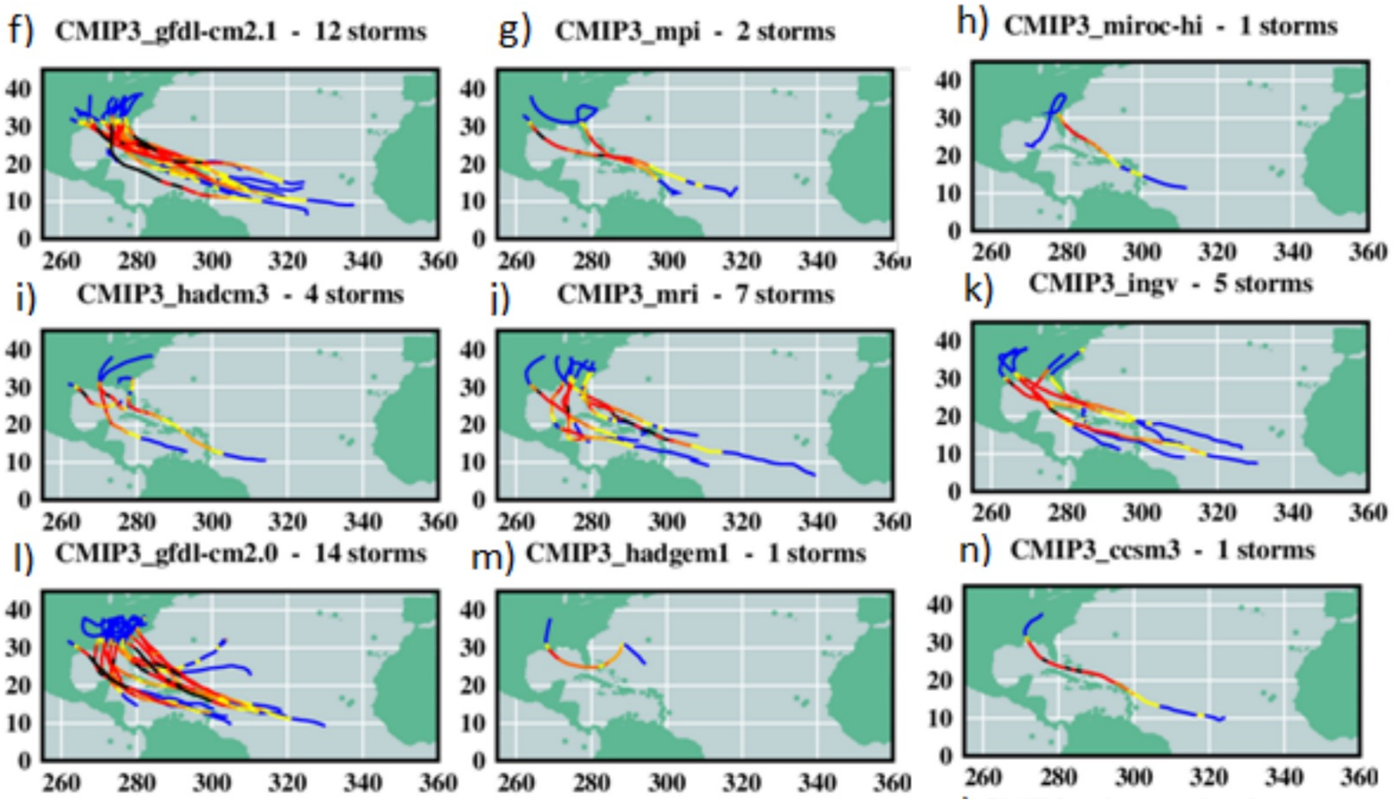



*https://www.gfdl.noaa.gov/wp-content/uploads/pix/user_images/tk/global_warm_hurr/6stack_NOAA_FACT_Sheet_2012_crop.png*

# General Approaches to Capture Climate Effects on Hurricanes

## 2: Downscale hurricane tracks from global circulation models

- Able to capture complex environmental interactions
- High level of uncertainty in downscaled tracks
  - + scenario uncertainty
  - + GCM uncertainty
- Computationally expensive
- Often can not accurately represent the historical record on a geographical level useful for planning, design, or risk analysis

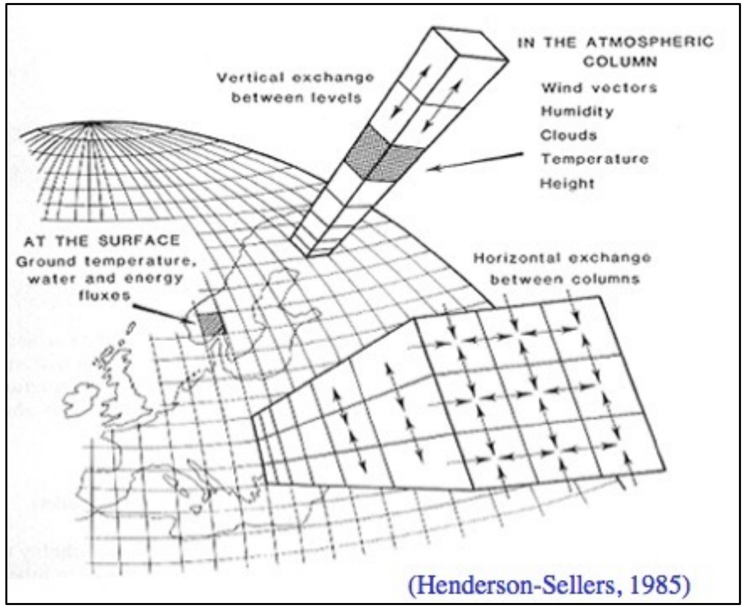



*Knutson, T. R., Sirutis, J. J., Bender, M. A., & Tuleya, R. E. (2021). Dynamical Downscaling Projections of Late 21st Century US Landfalling Hurricane Activity. Climatic Change.*

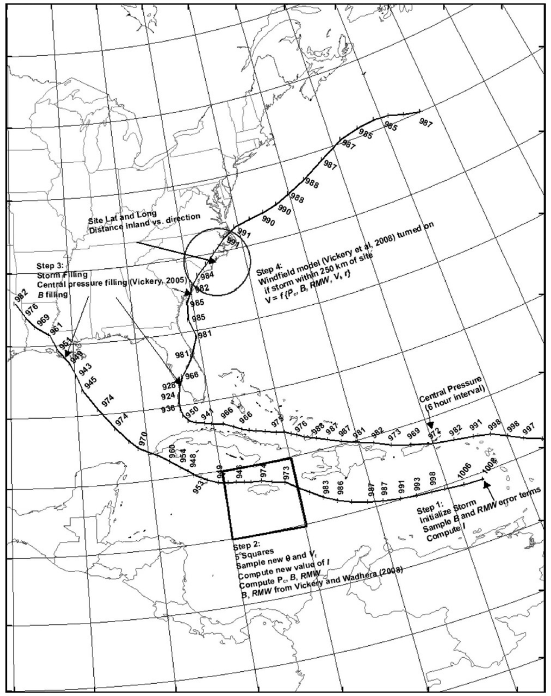
# General Approaches to Capture Climate Effects on Hurricanes

## 3: Couple GCM environmental data outputs with hurricane track and wind field models

- Downscaling environmental parameters is more accurate and efficient than downscaling tracks
- Able to capture interactions of changes in multiple environmental parameters and effect on hurricane hazard
- Requires statistical/physical dependencies in the track model on key environmental parameters



(Henderson-Sellers, 1985)



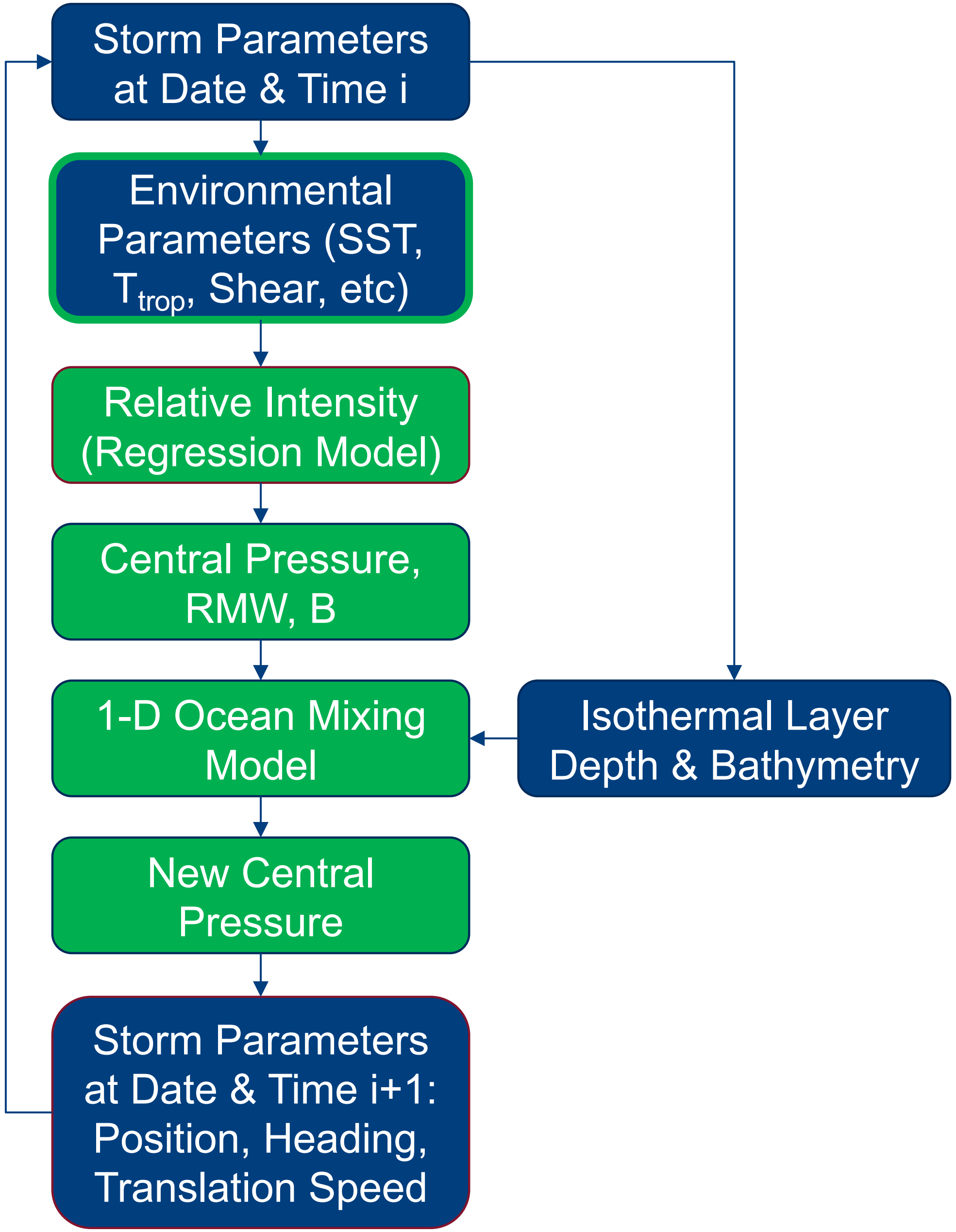
# Track Modeling + Climate Data

- ARA approach uses statistical/physical track model with climate dependencies in the intensity, size, and shape components of the model (Vickery et al., 2009b)

- The relative intensity components is a statistical model with physical climate dependencies based upon historical hurricane behavior

- Central pressure is modeled using the relative intensity concept and a 1-D ocean mixing model and is dependent upon thermodynamic and atmospheric environmental variables

- Regionally dependent statistical models of RMW and B were developed as a function of central pressure and sea surface temperature (SST)

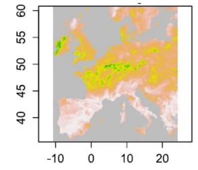


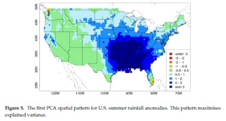
**Steve Jewson**
**CEO**
**Lambda Climate Research Ltd**

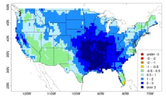
**Oasis Conference**

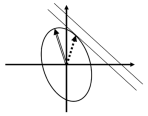
**May 4th 2023**

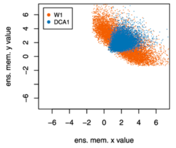
# Lambda Climate Research

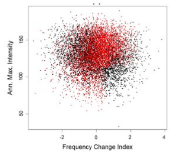


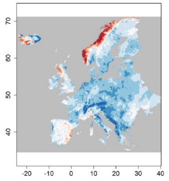


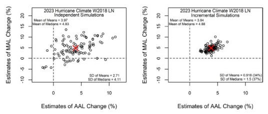


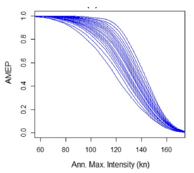












Peer-reviewed, published research into cat risk, climate and statistics

### Climate Modelling

Better methods for extracting climate model output

### Flood modelling

Free dataset on flood damage under climate change in Europe

### Statistical Modelling

New solutions for objective priors and frequentist prediction

### Hurricanes and TCs

Insights into climate change frequencies, intensities, correlations, distributions, landfall, damage, seasonal forecasts

### Decision making

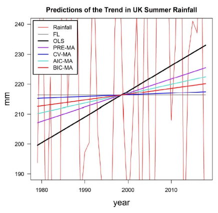
New algorithms for decision making under uncertainty

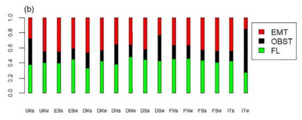
### Cat Model Simulation

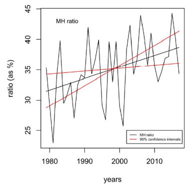
New algorithms for making adjustments and incorporating uncertainty

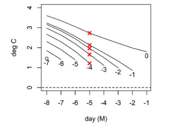
### Trend Estimation

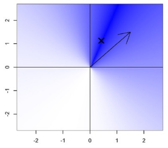
New algorithms for modelling trends in noisy data

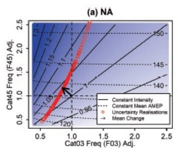


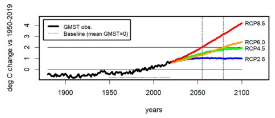


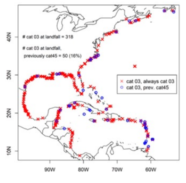


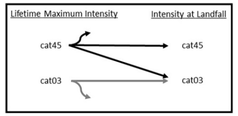


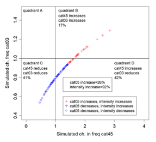


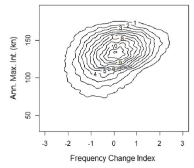


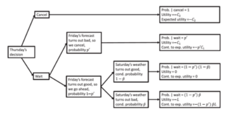






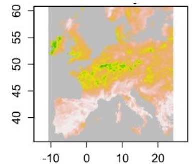
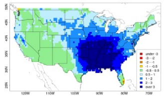
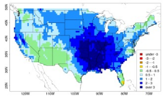
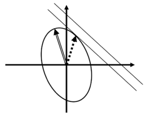
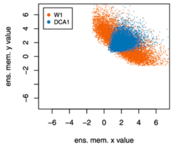
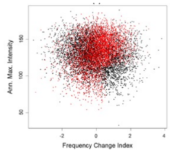
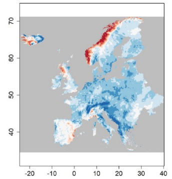







stephen.jewson@gmail.com // publications at www.stephenjewson.com // research updates on Linkedin.

# LCR Consortium Benefits

Lambda Climate Research is funded by a consortium of insurance companies

Early Access to research

Blogs

Discussions

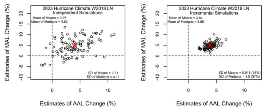
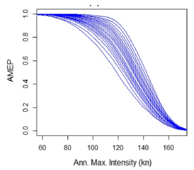
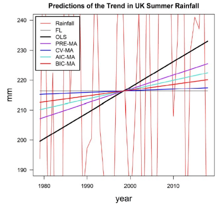
Software

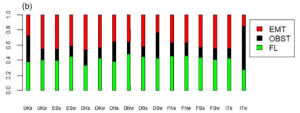
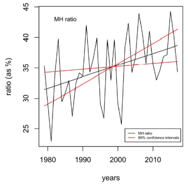
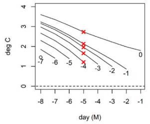
For adjusting cat model output for climate change, seasonal forecasts

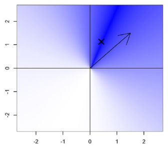
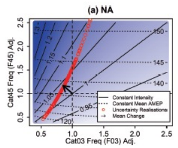
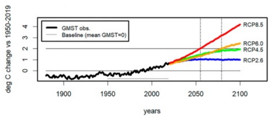
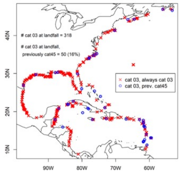
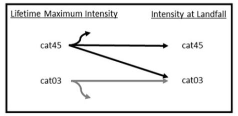
Review

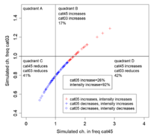
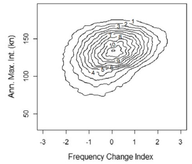
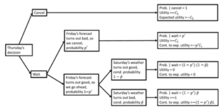
Data-Sets

Algorithms

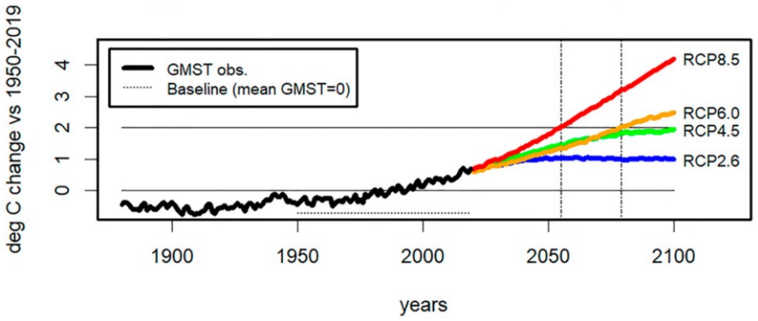






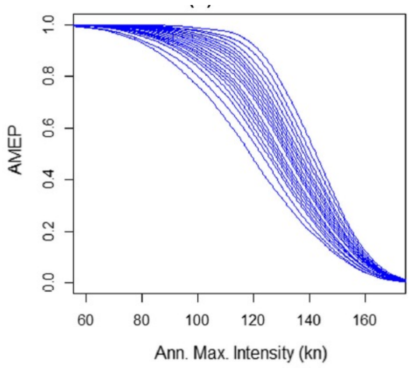




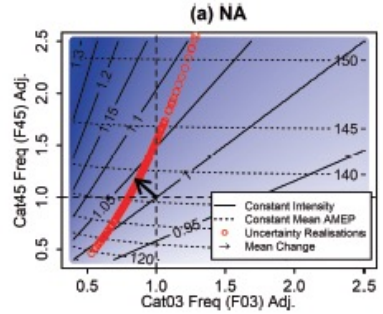
stephen.jewson@gmail.com // publications at www.stephenjewson.com // research updates on Linkedin.

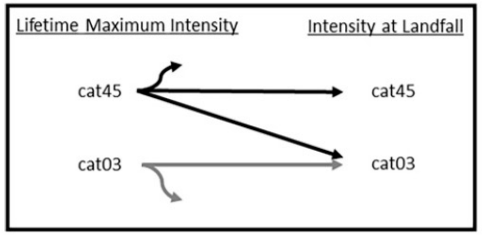
# 7 Things to Know About Hurricanes and Climate Change

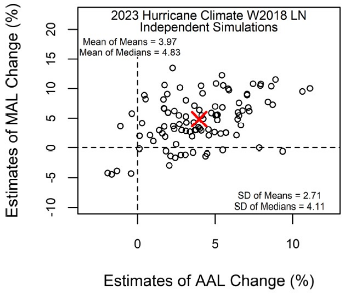
1. Make sure you understand your risk model baseline
2. Frequency and intensity changes are the same thing. Don't double count.
3. Climate change is uncertain. You should be applying changes as distributions.
4. To apply changes as distributions you probably need a new simulation algorithm.
5. To get accurate estimates of changes you probably need another new simulation algorithm.
6. Cat3 is likely not changing the same as cat0. Cat 5 is likely not changing the same as cat4.
7. Don't confuse basin and landfall intensity.
    1. Most climate models show that hurricane frequency is decreasing
    2. But the same models show that *landfall* hurricane frequency is *increasing*
    3. "few but more intense" should actually be "more and more intense"

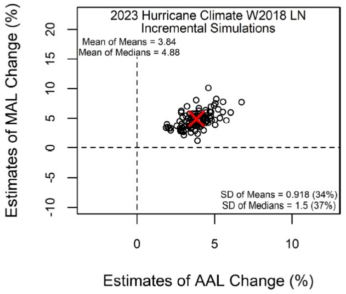


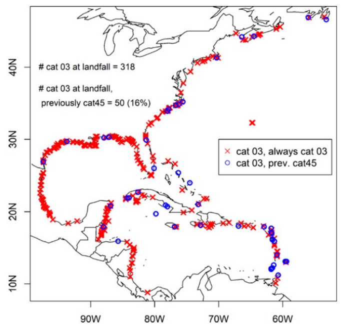



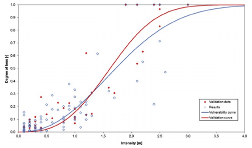




stephen.jewson@gmail.com // publications at www.stephenjewson.com // research updates on Linkedin.

# Oasis Conference 2023

**Cat Pigott, FIA**
**Head of Science & Natural Perils**
**AXA XL Risk Management**

# Risk vs Climate Change



**Risk = ƒ( Hazard, Exposure, Vulnerability )**

| | | |
|---|---|---|
| Hazard | Frequency & severity of a perilous event which can adversely impact exposure | • Natural Variability<br>• **Climate Change** |
| Exposure | Asset(s) exposed to a hazard in a given space and time | • Population Growth<br>• Urbanization<br>• Urban Sprawl |
| Vulnerability | Susceptibility or damageability of an exposed asset to a given intensity of the hazard | • Building Regulation<br>• Socio-Economic Development |

**Projection into the Future**

~+4% p.a.

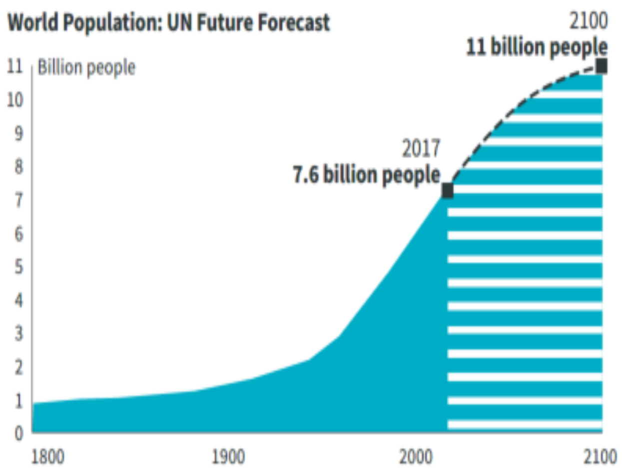
Prediction?

**Short-term projection - Exposure may be most important player, while Vulnerability is most difficult to predict. Climate Change is only one component of the problem**

# Exposure Changes

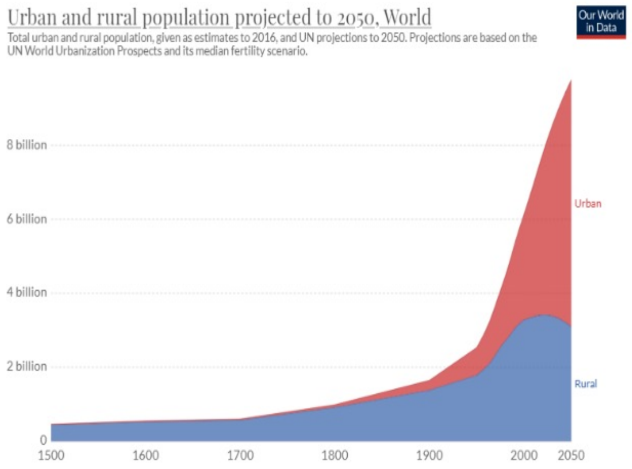
## Population growth

- Increases as economic development has progressed
- More people, with more assets are at risk from perils
- Population growth forecast.



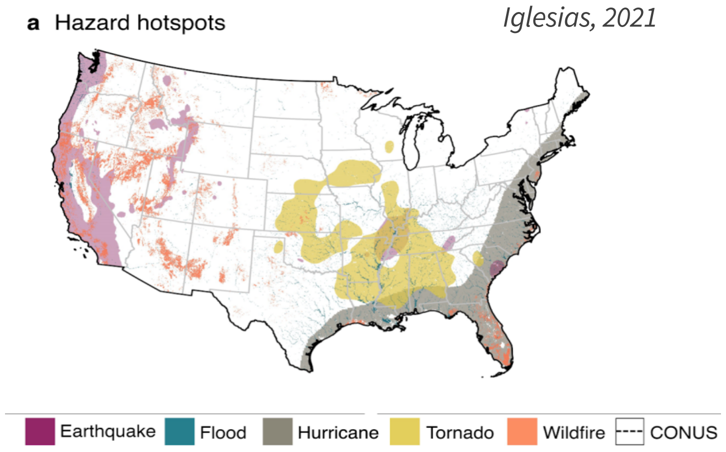

## Increased urbanization

- Economic development results in a move from rural to urban areas
- Urban areas tend to be close to rivers or the coast
- Continued urbanization forecast.




## Growing urban sprawl

- Number of people moving to urban areas will grow, but also expect urban areas to increase in size
- Demand for development has potential to put properties in high-risk areas (wildfires, risking sea-levels etc).




**Growth in exposure driven by number of factors including population growth and urban sprawl.**

# Quantifying Climate Change Risk

- Peril-region materiality
- Timescale
- Science! (IPCC Interactive Atlas a great starting point)
- Model Adjustments

IPCC WGI Interactive Atlas: Regional synthesis

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SELECT VISUALIZATION

MAP | REGIONS | COMBINATIONS

**AFRICA**
- North Africa
- Sahara (SAH)
- Western Africa (WAF)
- Central Africa (CAF)
- North Eastern Africa (NEAF)
- South Eastern Africa (SEAF)
- West Southern Africa (WSAF)
- East Southern Africa (ESAF)
- Madagascar (MDG)

**ASIA**
- Arabian Peninsula (ARP)
- West Central Asia (WCA)
- West Siberia (WSB)
- East Siberia (ESB)
- Russian Far East (RFE)
- East Asia (EAS)
- East Central Asia (ECA)
- Tibetan Plateau (TIB)
- South Asia (SAS)
- **South East Asia (SEA)**

**AUSTRALASIA**
- Northern Australia (NAU)
- Central Australia (CAU)
- Eastern Australia (EAU)
- Southern Australia (SAU)
- New Zealand (NZ)

**CENTER & SOUTH AMERICA**
- Southern Central America (SCA)
- North-Western South America (NWS)
- Northern South America (NSA)
- South American Monsoon (SAM)
- North-Eastern South America (NES)

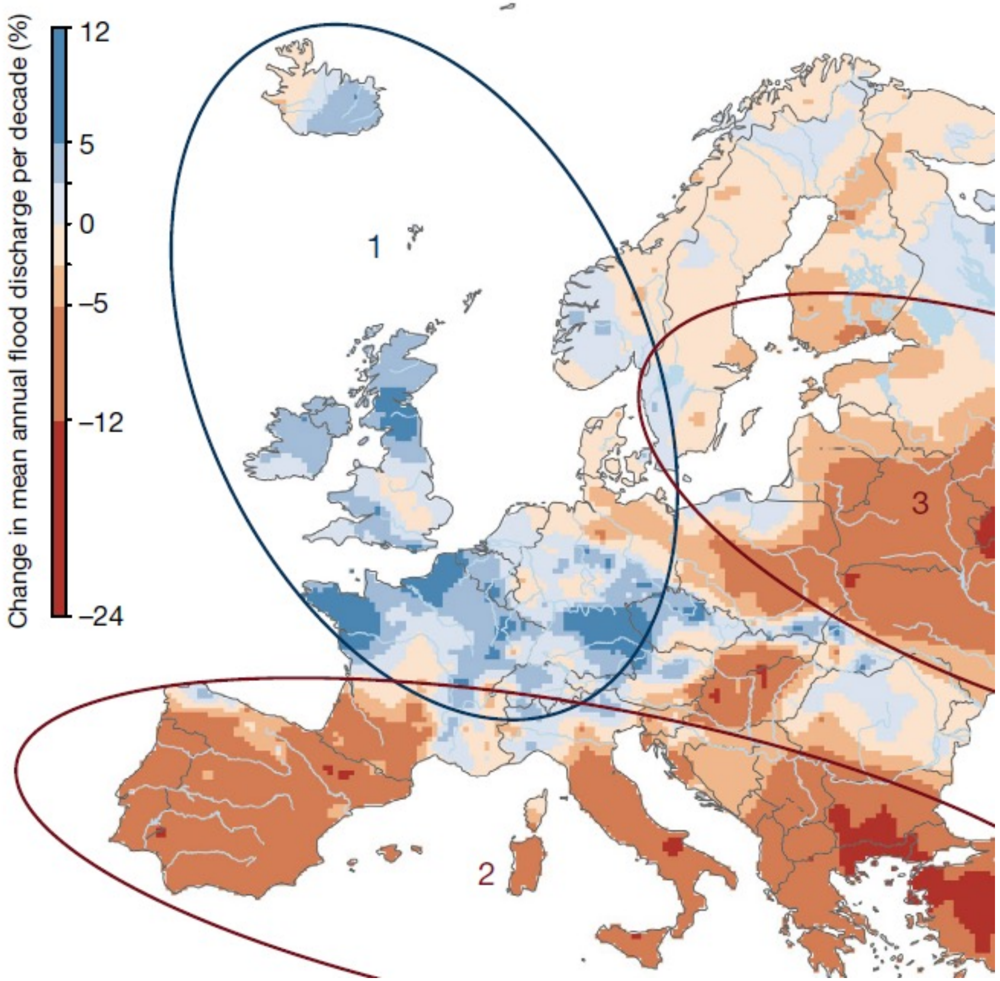
| CID | FUTURE CHANGES | TREND / ATTRIBUTION |
|---|---|---|
| **HEAT AND COLD** | | |
| Mean surface temperature | High confidence of increase | Upward trend without attribution |
| Extreme heat | High confidence of increase | Upward trend with high confidence of attribution |
| Cold spell | High confidence of decrease | Downward trend with high confidence of attribution |
| **WET AND DRY** | | |
| Mean precipitation | Medium confidence of increase | — |
| River flood | Medium confidence of increase | — |
| Heavy precipitation and pluvial flood | High confidence of increase | Upward trend without attribution |
| Landslide | Medium confidence of increase | — |
| **WIND** | | |
| Tropical cyclone | Medium confidence of increase | Upward trend without attribution |
| **COASTAL** | | |
| Relative sea level | High confidence of increase | Upward trend without attribution |
| Coastal flood | High confidence of increase | — |
| Coastal erosion | High confidence of increase | — |
| Marine heatwave | High confidence of increase | Upward trend without attribution |
| Ocean acidity | High confidence of increase | — |
| **OTHERS** | | |
| Atmospheric $CO_2$ at surface | High confidence of increase | Upward trend without attribution |

# Quantifying Climate Change Risk

- Peril-region materiality
- Timescale
- Science! (IPCC Interactive Atlas a great starting point)
- Model Adjustments

# Example Model Adjustment: Flood

- Water (or lack thereof) perils show the most confidence in climate change to date
- Test observed changes against baseline model assumptions – make adjustment on frequency/severity based on sensitivity testing
- Consider model uncertainty when considering model adjustments





Bloschl et al. 2019