Cat Risk and Climate Change: Observations, Models, Theory

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Aims

- Highlight importance of observations, models and theory for climate change risk discussions

- Using an example of US Hurricane to demonstrate using observations, models and theory and their strengths/weaknesses

- And a couple of my favourite things:
  - Is no trend really no trend?
  - Small shifts in hazard and their importance to the tail

Simple Question

Should we set our risk based 100% on what has gone before?

Should X% of our risk-setting incorporate a tolerance to account for uncertainty around climate?

Sources of Climate Signals

- **“A Changing Climate”**
- **Guy Carpenter, 20 Oct 2019**
  - **Dr Jessica Turner**
  - **Matthew Eagle**

Although the climate-change debate is often polarized, it is both clear and indisputable that greenhouse gas emissions have increased and the planet as a whole has warmed considerably. There are some areas where theory, observations and climate model projections all align, resulting in stronger evidence of the consequences, although the impact on specific regions and perils is more mixed and, in some cases, less conclusive.

Climate Change: Three Pillars of Inquiry

- **Observations**
  - "Ground truth"
    - Hazard
    - Losses
- **Modelling**
  - Climate models
  - Regional climate models
  - Idealised modelling
- **Theory**
  - The science, the equations*

*you will not see any equations in this talk

Observations | Modelling | Theory

- **Observations**
  - "Ground truth"
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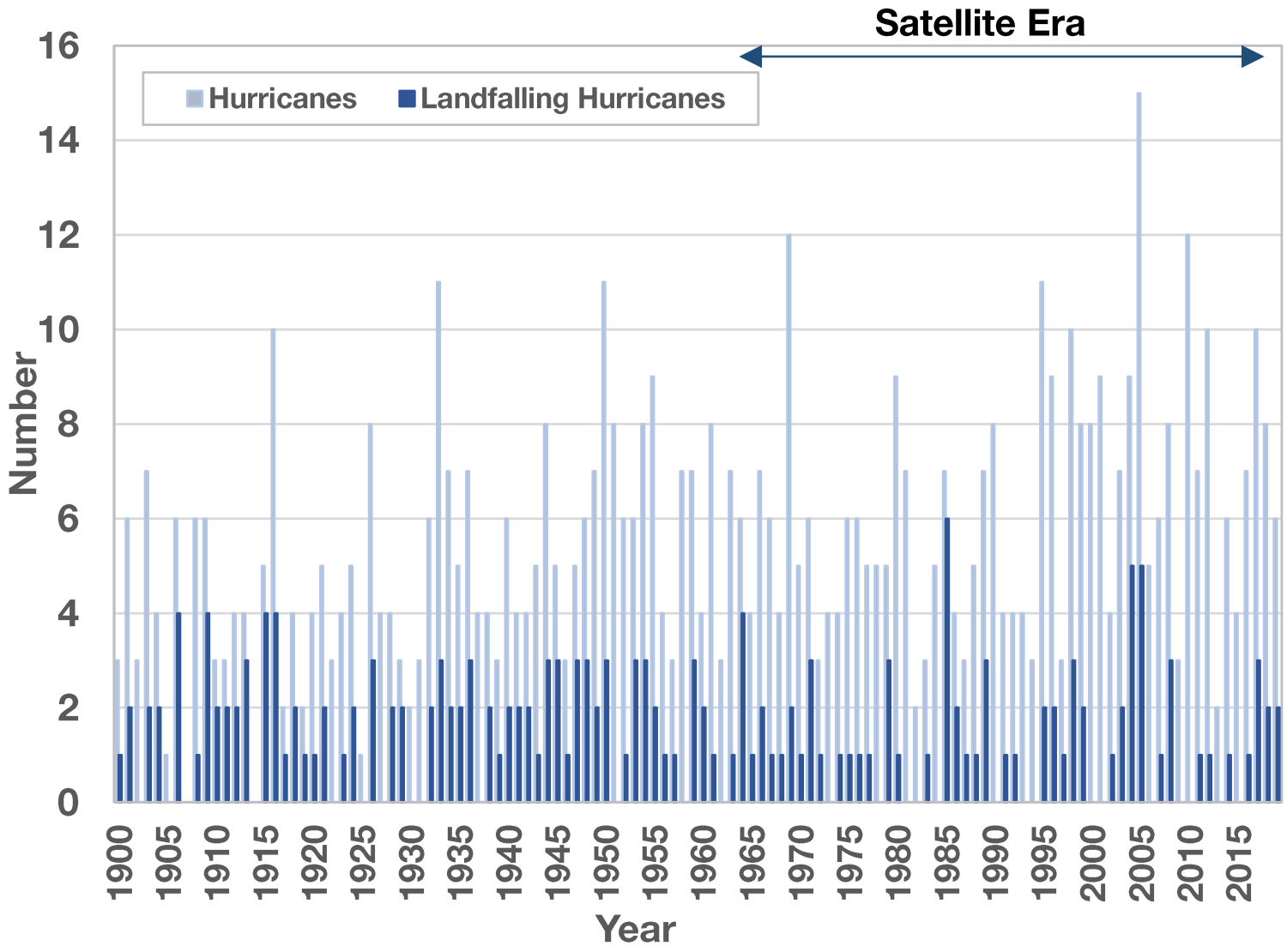
All three show no evidence of climate impact → OK to use historical data as a guide for present-day risk

One or more show evidence of climate impact → Start to think about stress-testing model output or building view of risk

Strengths and Weaknesses

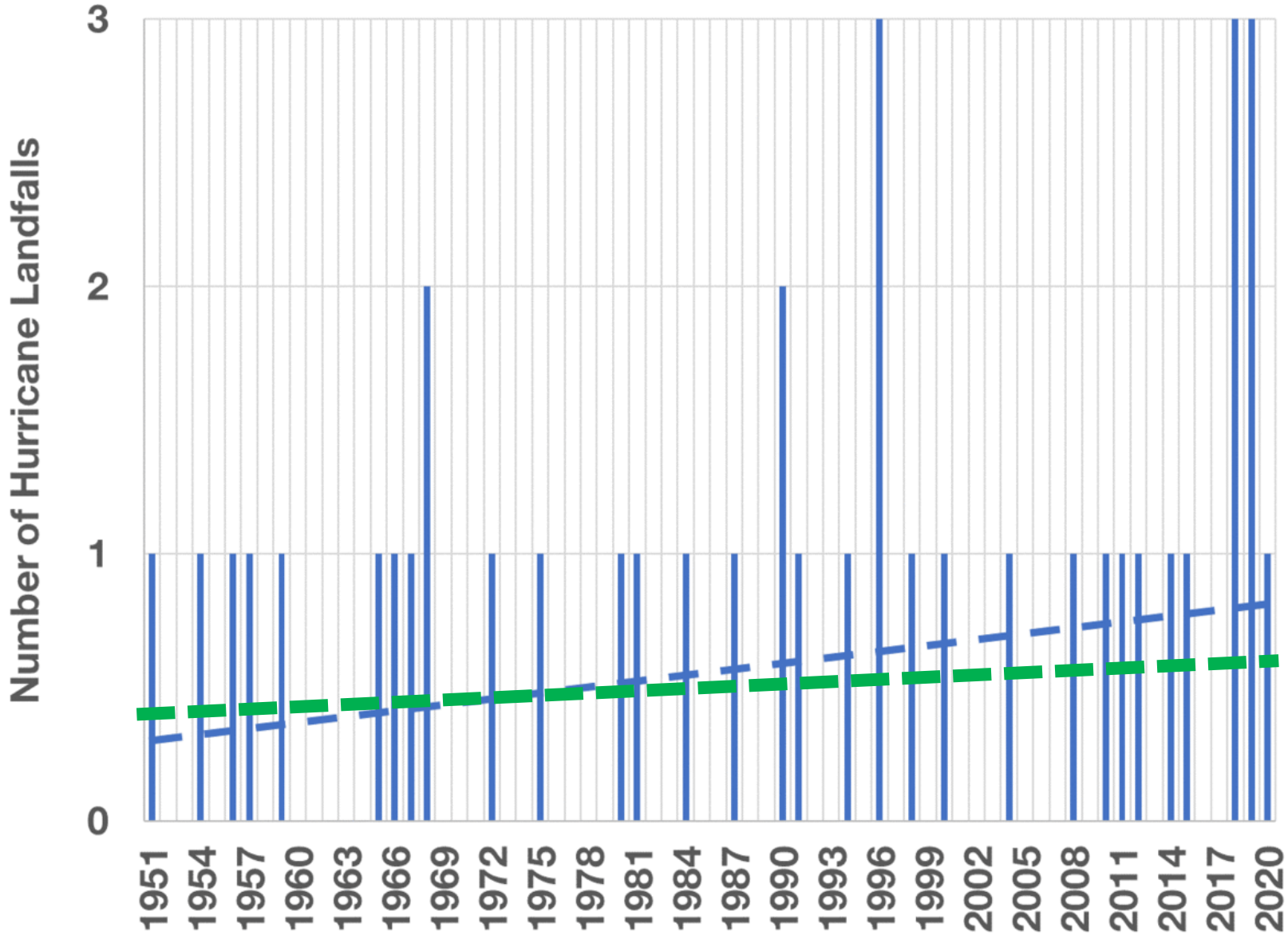
Observational Data

- It's the best "real" data that we have
  - "Ground truth"
- Some observational records last many decades
- Enough data for very short RP observations/trends
- Long return period observations an issue



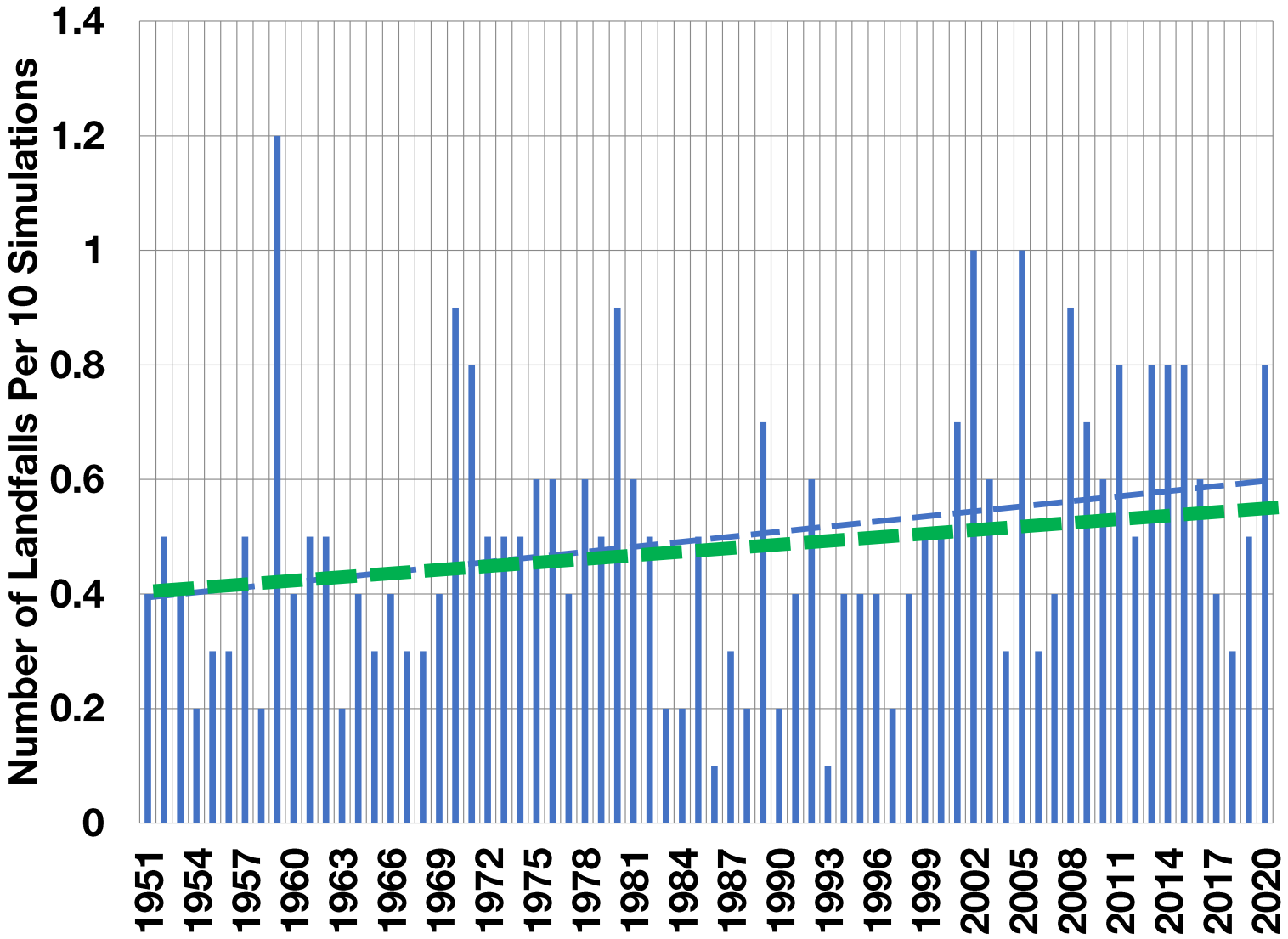
Trends and Historical Data: An Example

- US Cat 3-5 landfall: 0.4 per year
- Test: yearly chance of landfall change increases by 40%
  - (0.4 to 0.56)
- Even this can be difficult to spot
- We only have one shot to spot this using historical data



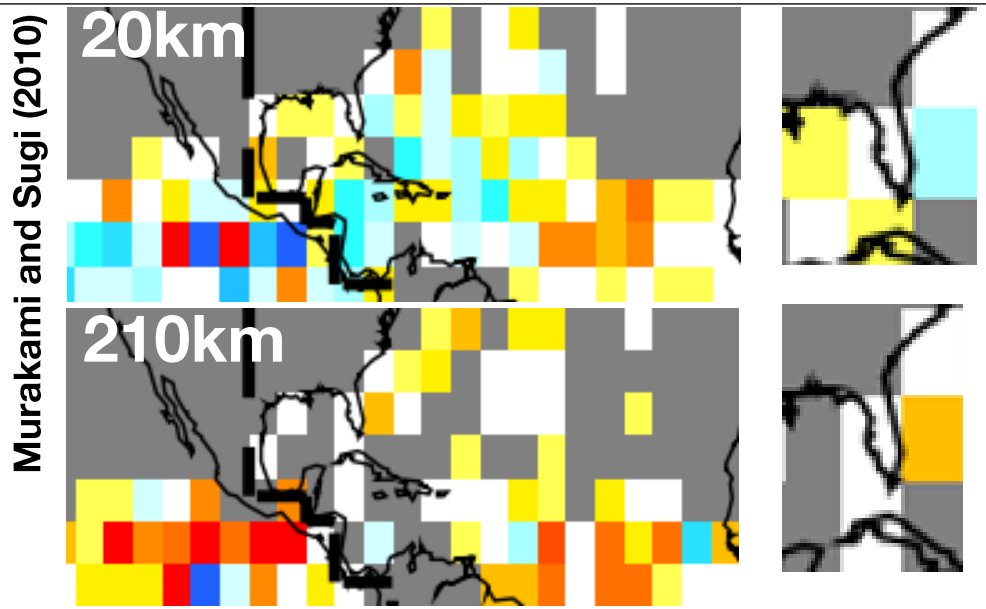
Modelling

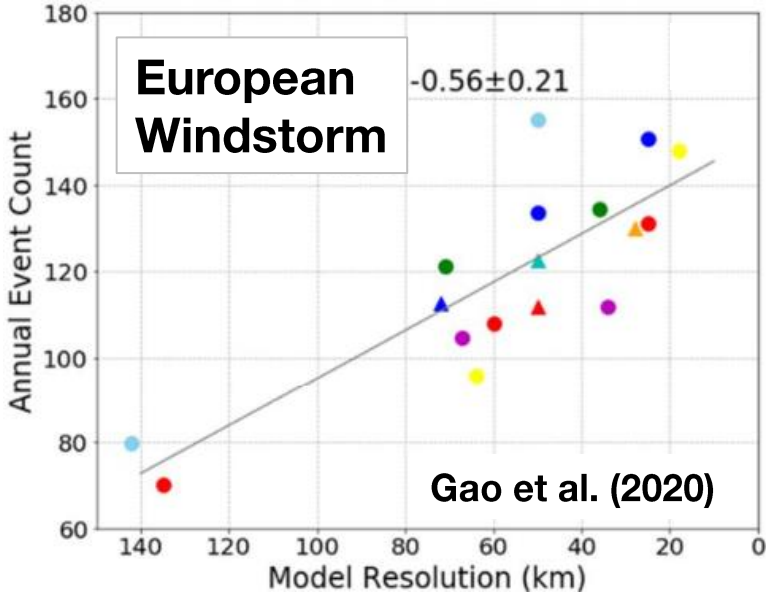
- "All models are wrong"
  - But some are useful
- Climate modelling can expand upon historical data
- Spot trends in data where historical data *might* not show anything
- Sum of 10 simulations from last slide
- Of course, models may have their own trends…



Modelling: A long way to go

- Cat hazard events often require high resolution
- Lots of years of data needed to understand trends & tail
- High resolution * Many years of simulation = $$$$ (and time!)
- Resolution changes = changes in results
- Science of climate change/cat risk is in its infancy: expect sharp changes in guidance from latest research!





Theory

- Important to understand what “science” feels might change
- E.g. warming air holds more water, can cause more rainfall

- Theory often simplifies things to help us understand them better
- Does theory capture the unknown unknowns or feedbacks in the climate system?

“As it becomes easier to undertake complex computer simulations of climate and weather….. it is tempting to use computers to simulate, rather than understand, nature. The author argues that simulation without understanding imperils scientific progress.”

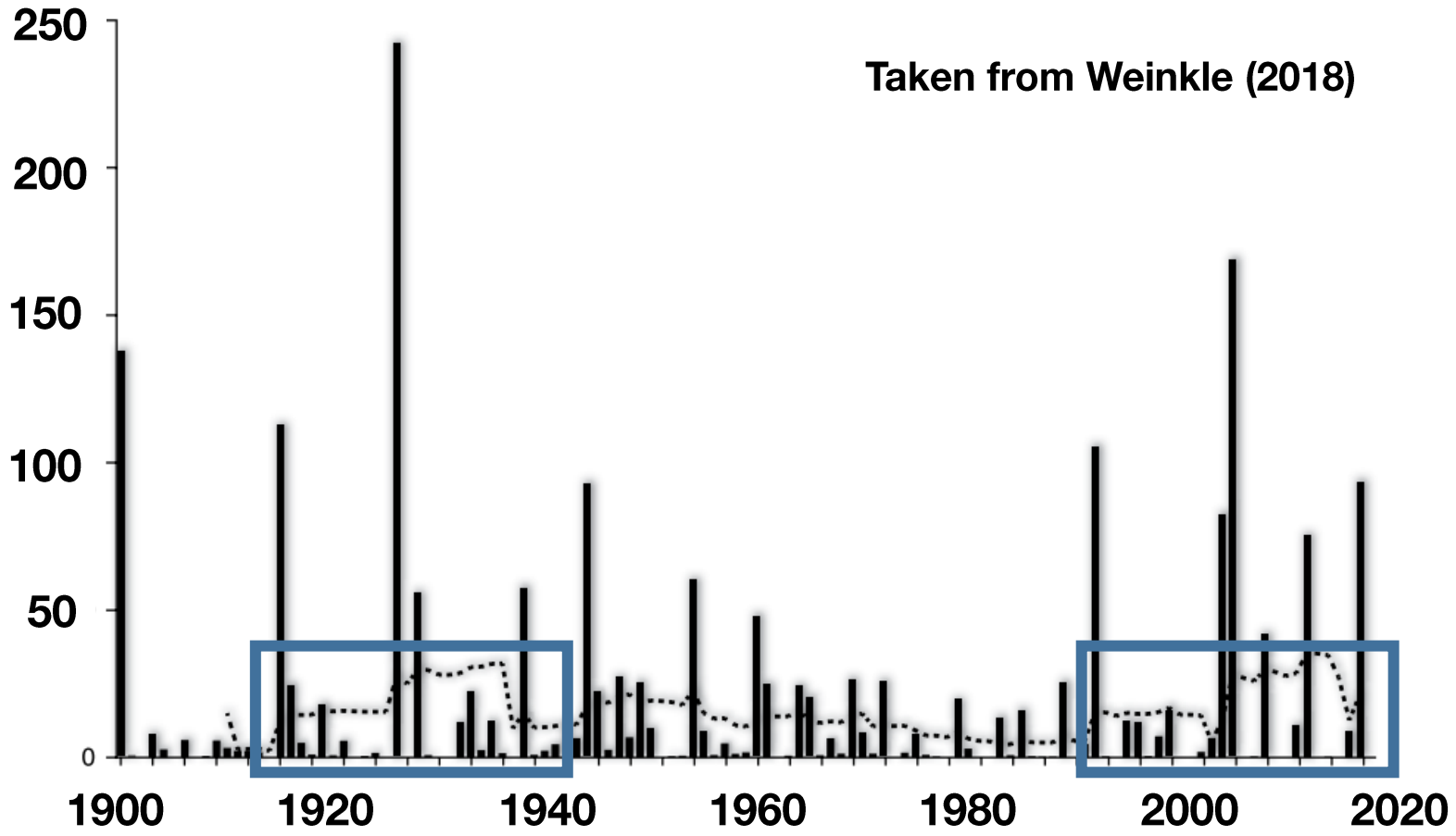
The Relevance of Theory for Contemporary Research in Atmospheres, Oceans, and Climate: Emanuel (2020)

US Hurricane (Wind)

Observations | Modelling | Theory

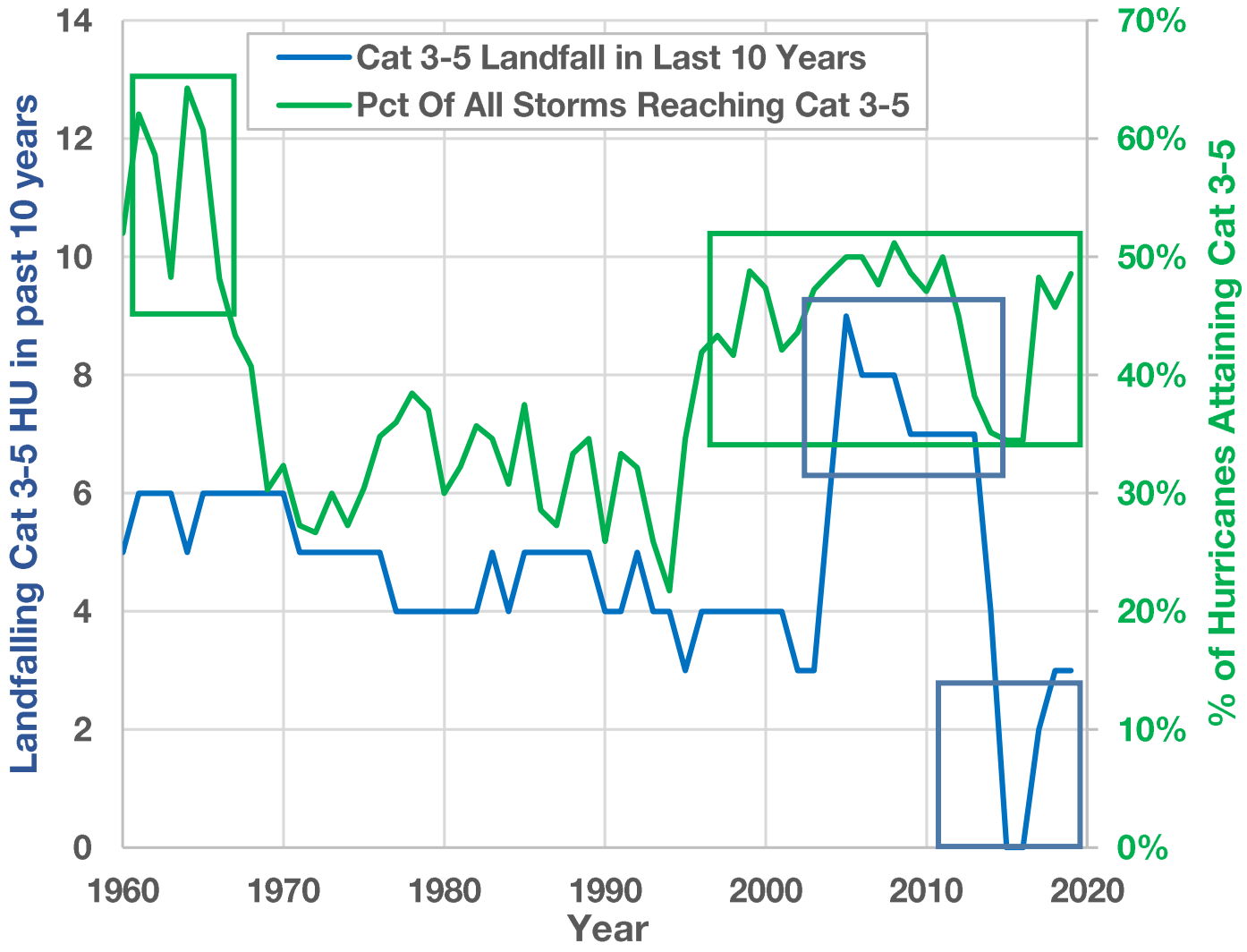
Observations: US As-If Losses from 1900-2018

- Weinkle (2018) looked at today's equivalent losses for hurricanes
  - No trend
- We could stop here and accept that risk isn't in flux
- But it's worth being inquisitive



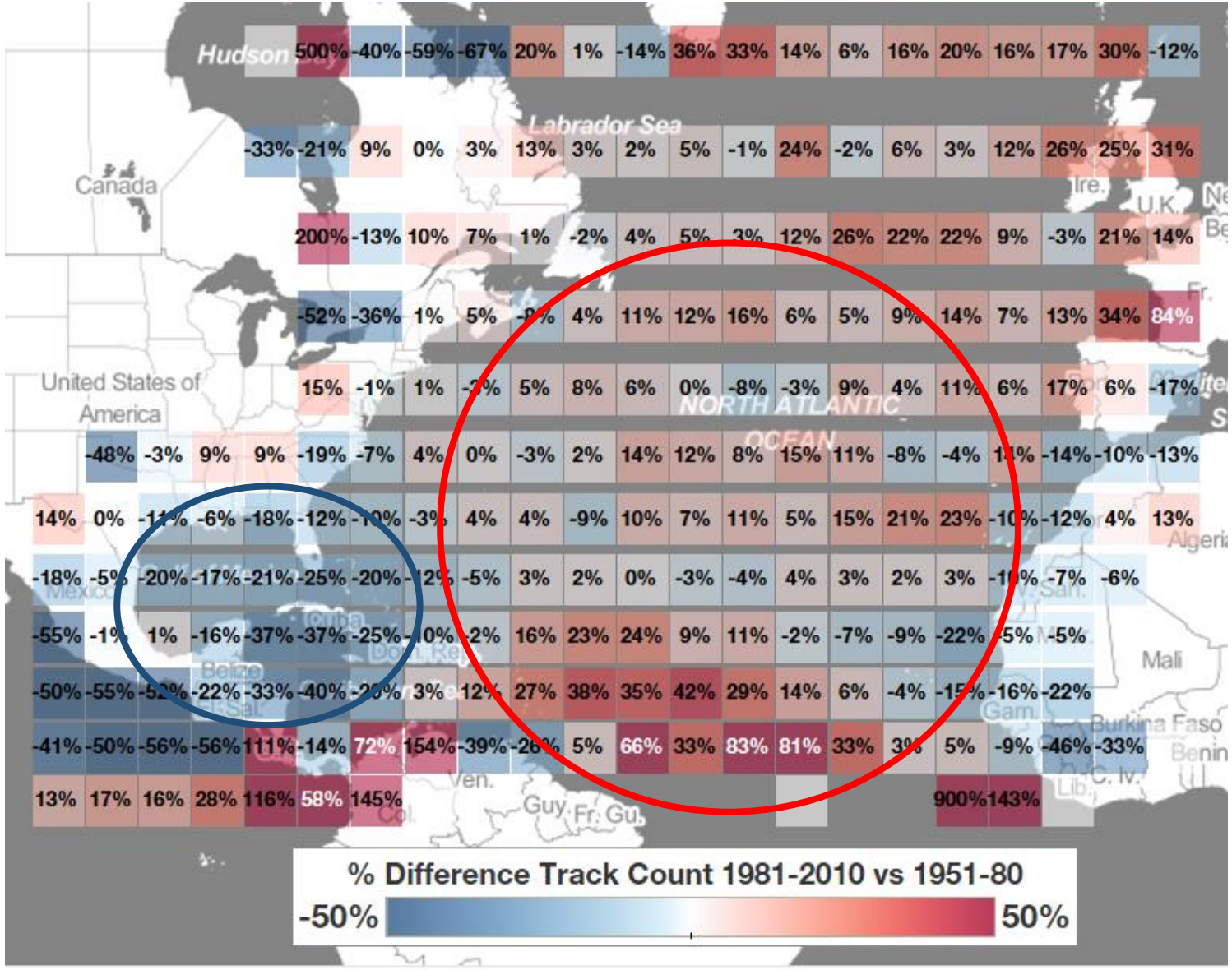
Observations:
Cat 3-5 Hurricane Activity: US and Atlantic Basin

- **Cat 3-5 storms make up vast proportion of EP curve > 20 years**
- **Academic interest in increase in % of storms (globally) reaching major status**
  - **Numbers were high in 1950s/1960s**
- **However 2006-2016 major HU drought**
  - **But also spike in 2004/5**
- **Battle going on:**
  - **Basin intensity**
  - **Landfall activity**



Modelling:
Simulating 1951-2011 Hurricane Seasons 100 Times

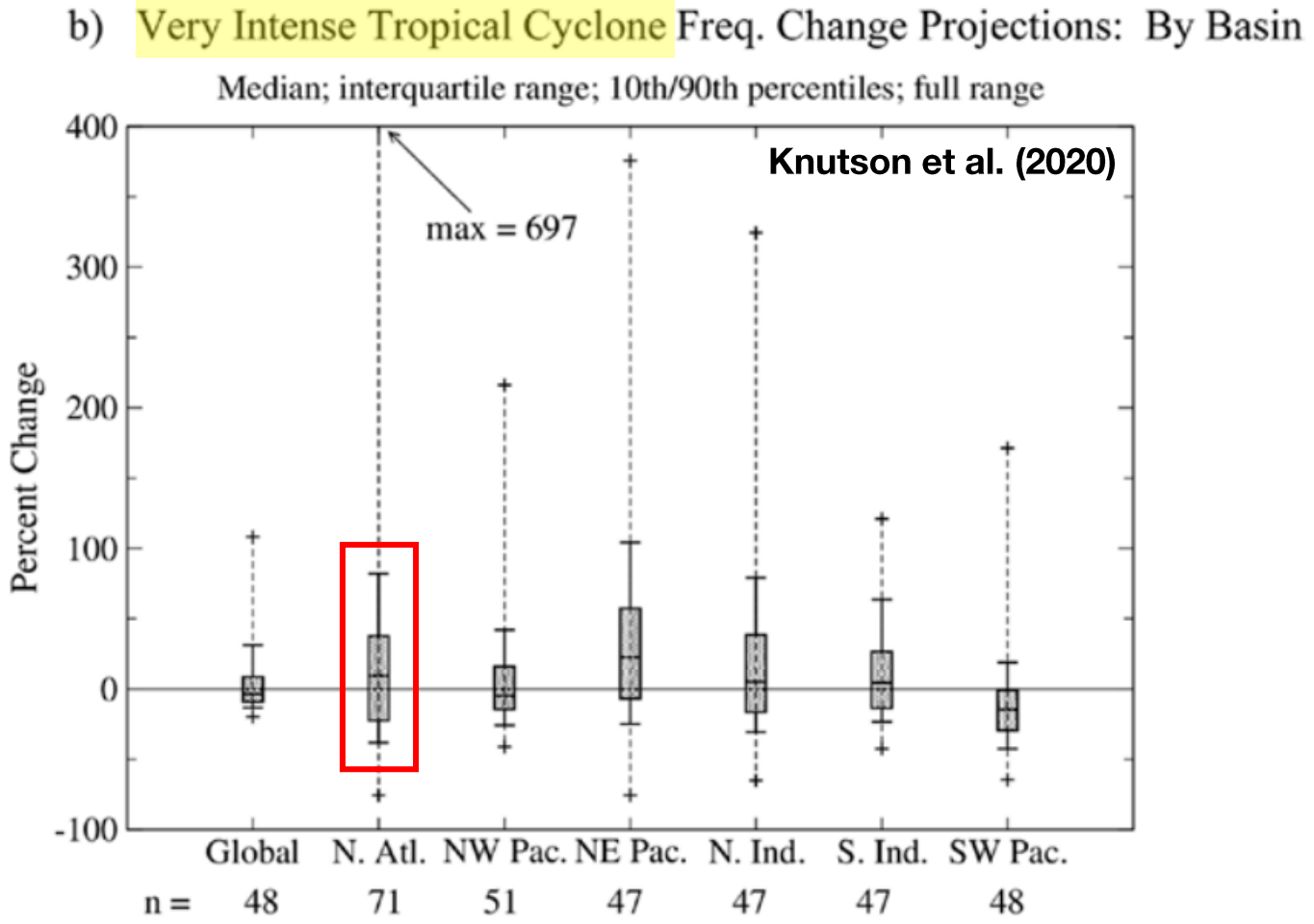
- 100 climate model "re-runs" of 1951-2011
- Forced by historical
  - greenhouse gases
  - sea temperatures
  - sea ice
- Points to lower landfalling activity
- More storms recurving or tracks shifting NE?



Modelling: Summary of Future HU Activity

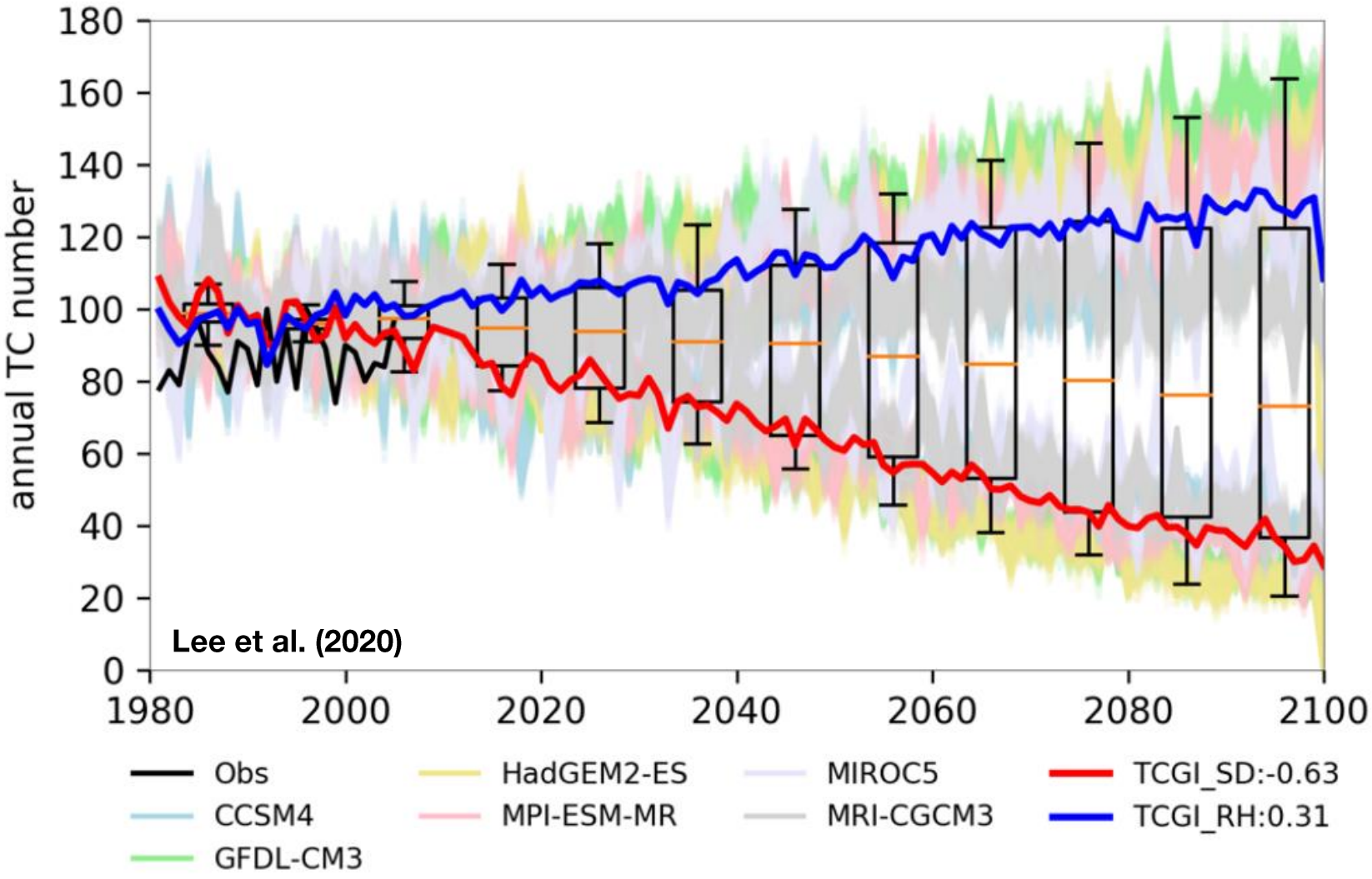
- **Knutson paper summarising modelling studies of future activity**
- **Paper suggests lower activity, changed tracks across Cat 1-5s in Atlantic**
- **Shown here: subtle bias however towards increased Cat 4/5 activity**
  - **But error bars are either side of zero !**

(Cat 4-5)



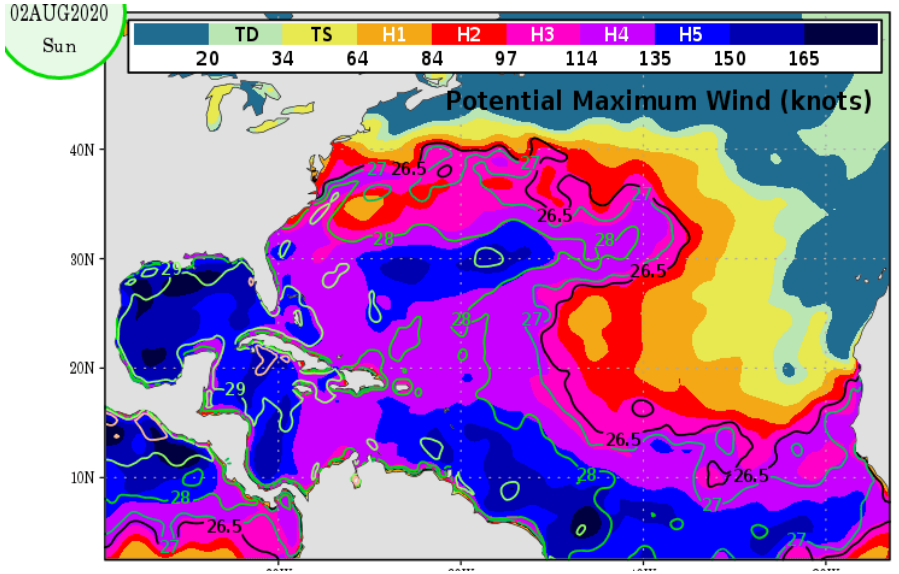
Modelling: A long way to go

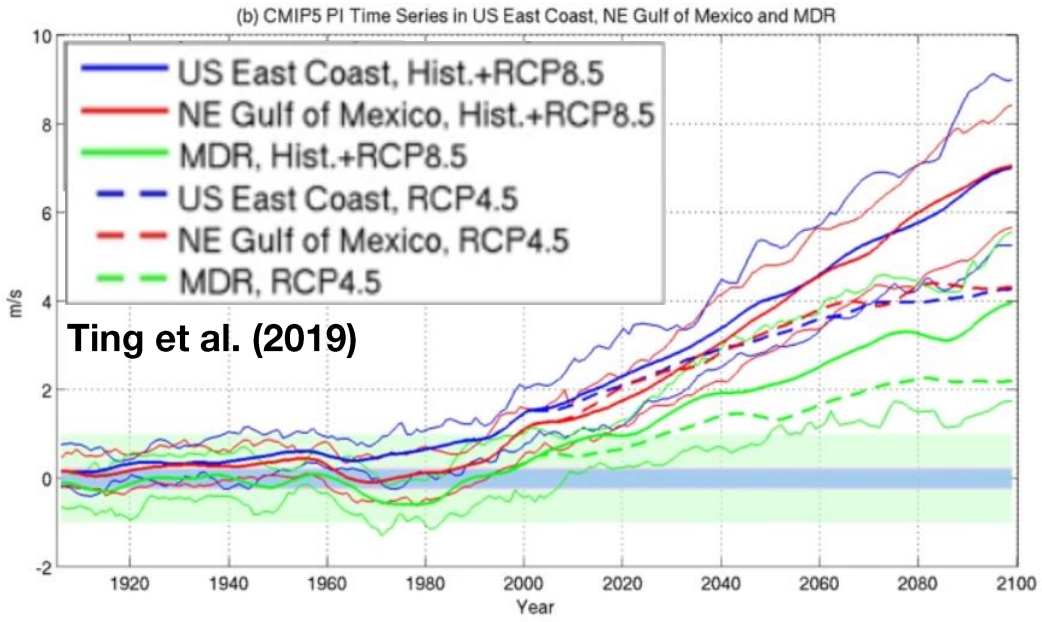
- Recent work by Columbia University
- How moisture is defined for hurricane genesis dramatically alters results
- Impacts future changes: up or down!



Theory: The Hurricane As A Heat Engine

- In its simplest form:
  - Warmer sea = more heat available for hurricanes
- Kerry Emanuel: theory of hurricane maximum potential intensity
- Change in future maximum potential intensity exists within Atlantic basin
- **Are increases in Cat 3-5s possible evidence this has happened already?**





Ting et al. (2019)

US Hurricane Wind Hazard Summary

US Hurricane Wind

- **Observations:** More Cat 4s/5s? Fewer landfalls? Shifting tracks?
- **Models:** Numbers Up? Numbers Down?
- **Theory:** Warmer seas, stronger hurricanes?

A lot of evidence to decipher: it's your choice as to how you interpret this data a form a "view of climate risk"

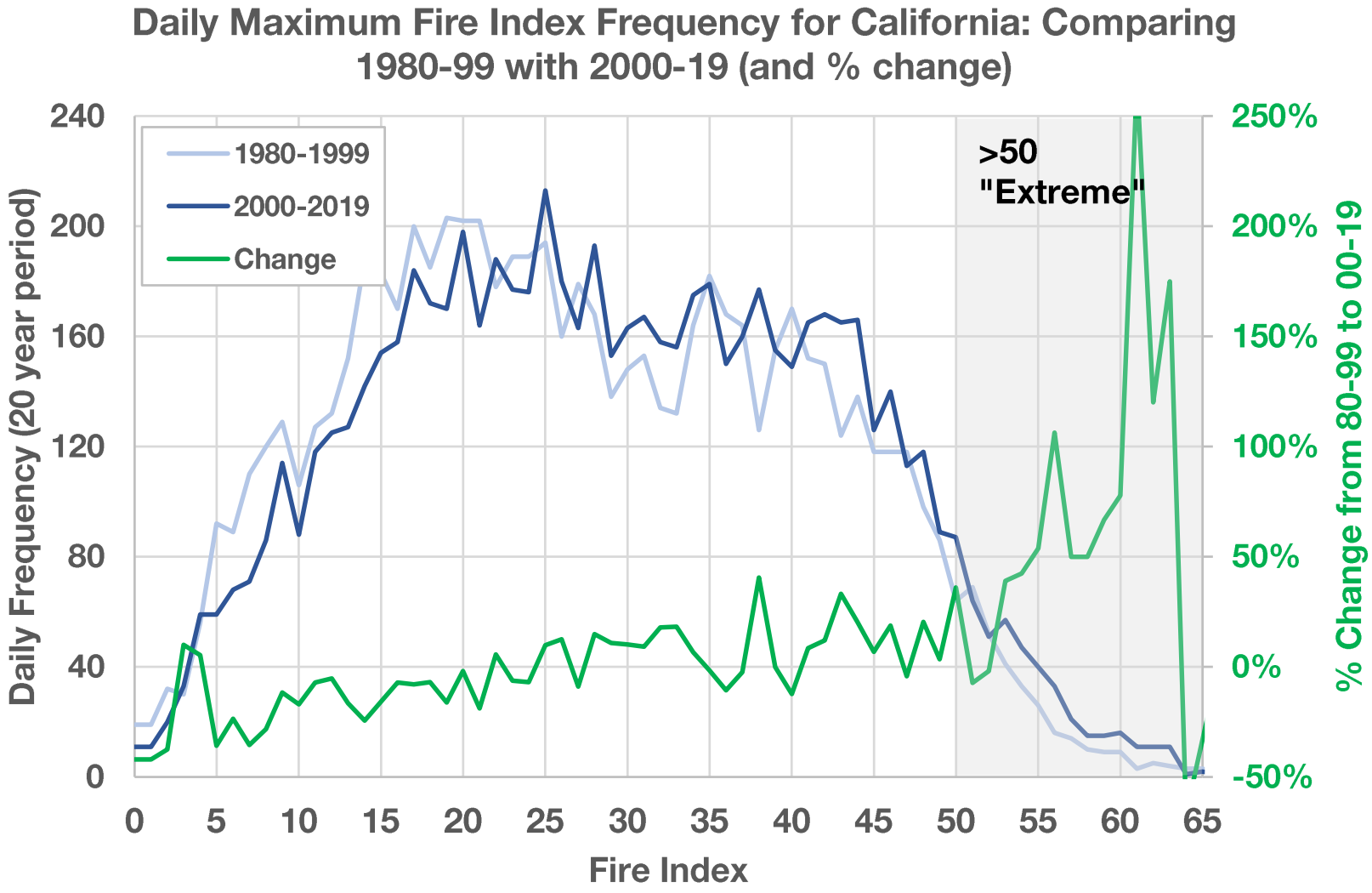
US Hurricane: Secondary Perils

	Rainfall	Surge
• Observations:	More Rainfall? Stalling storms?	Higher Surge?
• Models:	More Rainfall No stalling?	Higher/Wider Surge but uncertainty in storm numbers
• Theory:	Warmer atmosphere holds more water	Melting polar ice = higher sea levels

A lot of evidence to decipher: it's your choice as to how you interpret this data a form a "view of climate risk"

Don’t Overlook Subtle Shifts In Hazard

- 6% shift in mean “Fire Index” from 1980-99 to 2000-19
- Significant shifts in tail
- These are “now” changes
- Climate change often isn’t a “future time horizon” thing
- Must recognise human activity/exposure to wildfire changed hugely



Occasionally Controversial Closing Points

- Don’t overlook small changes in hazard
  - Could be tweaking the tail heavily; tiny changes may not mean no trend
- Even where main risk isn’t changing, remember secondary perils
- The science of climate change and tail risk is in its infancy
  - Guidance will change throughout all our careers
  - Climate change might become a new “view of risk” differentiator between risk-takers
- Be open-minded
  - The big picture message often loses a lot of detail
  - We’re risk takers: paramount to understand if/where climate risk is making numbers drop as well as rise
  - The “grey swan” of future shifts in vulnerability/building codes

Simple Question

Should we set our risk based 100% on what has gone before?

Should X% of our risk-setting incorporate a tolerance to account for uncertainty around climate?

Thank You

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