

1. Background
2. Physical Hazards
3. Impacts and Risk



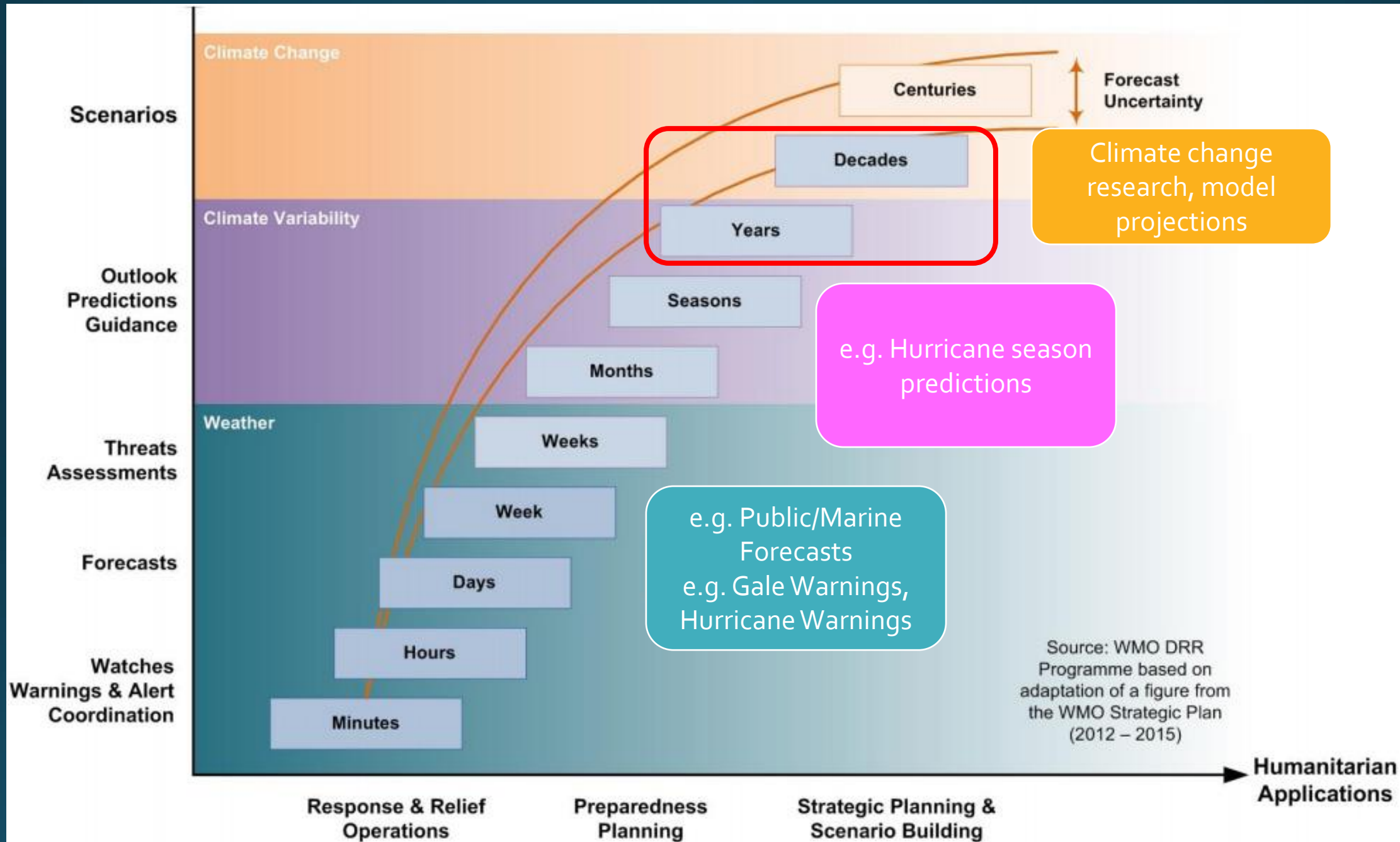
Climate Change and Bermuda

Dr. Mark Guishard

Some definitions

- **Weather:** *The state of the atmosphere at a given time, mainly with respect to its effects on life and human activities.*
 - Minutes to days

- **Climate:** *Slowly-varying aspects of the atmosphere-hydrosphere-land surface system*
 - Average of conditions
 - Years-Decades-Centuries... and longer

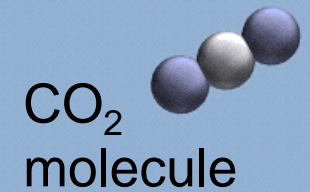


Some definitions

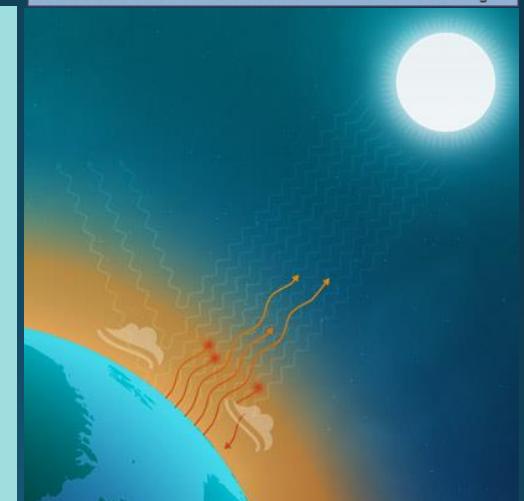
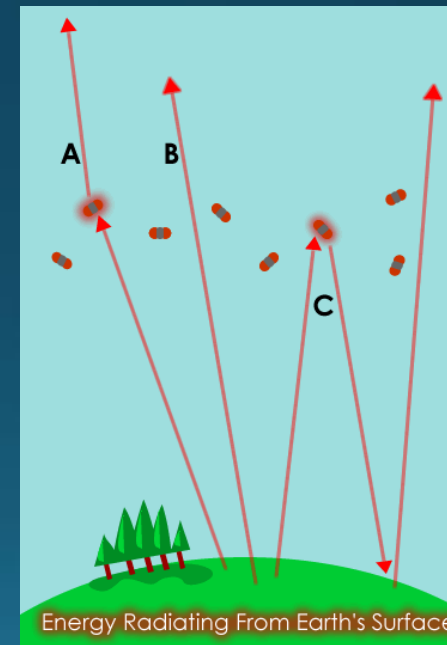
Greenhouse effect, global warming and climate change

- In the absence of an atmosphere, our average global temperature would be around -18°C or -0.4°F !
- Thankfully we have the Greenhouse Effect:
 - Sunlight penetrates the atmosphere, but some of the outgoing heat is trapped under a 'blanket' of greenhouse gases (GHGs), such as Carbon Dioxide (CO_2).
- Actual average global temperature is around 15°C or 59°F .

Carbon Dioxide & other 'greenhouse gases' absorb and then re-emit solar infrared radiation



The COMET Program

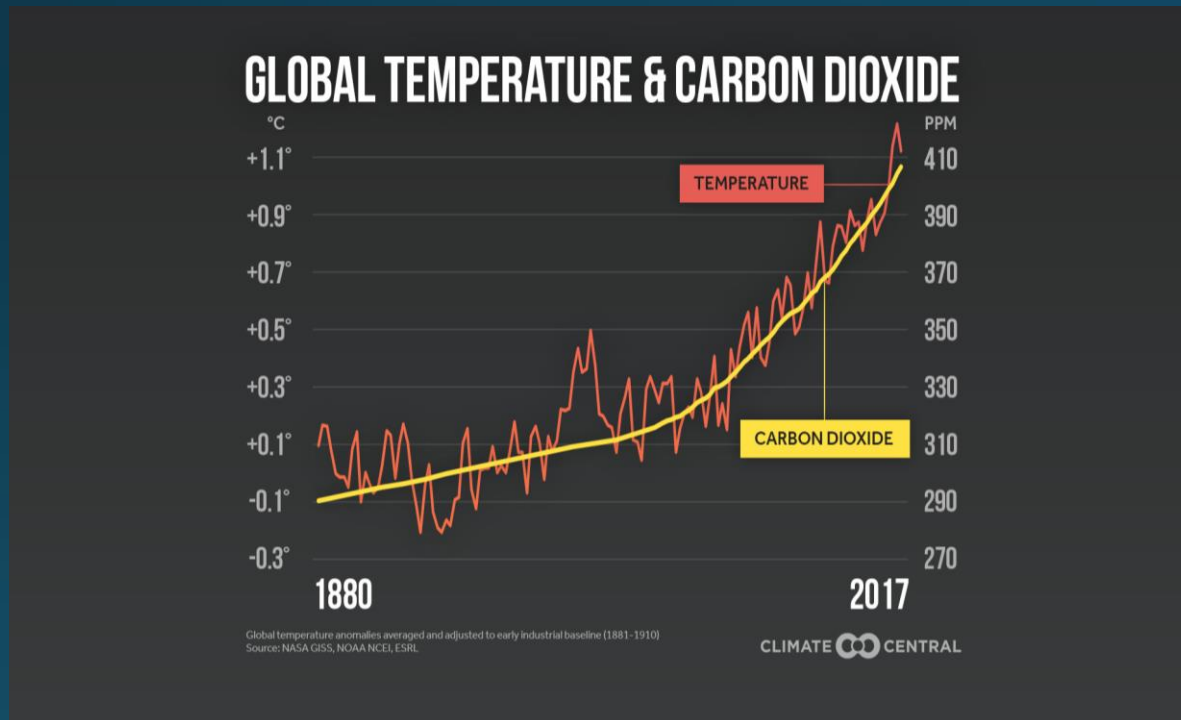


Proportion of solar radiation is trapped by GHGs

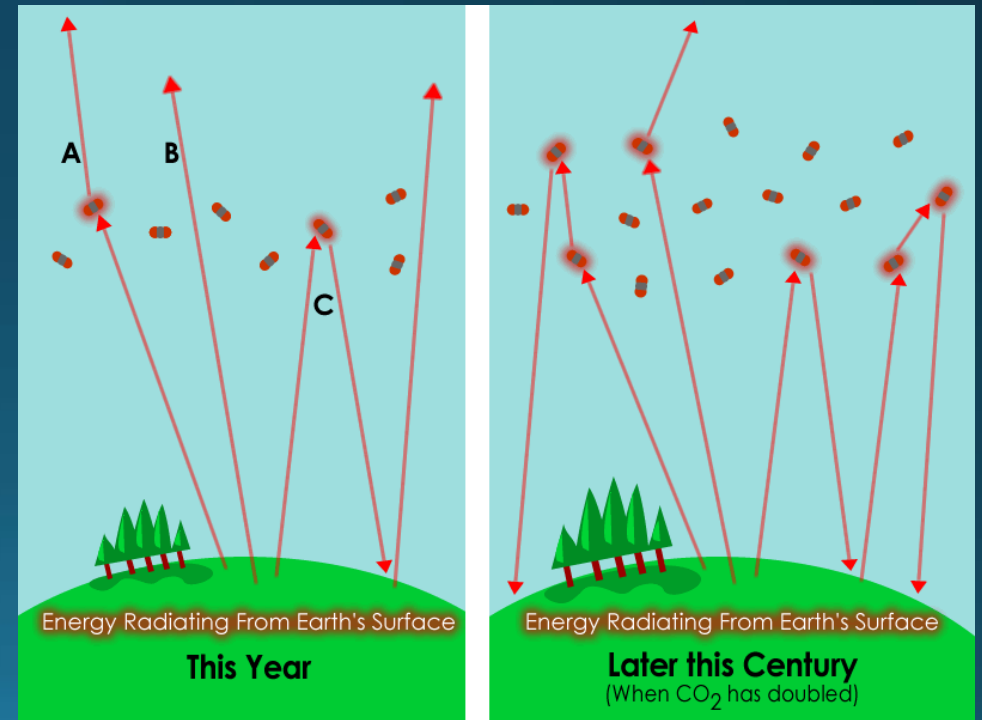
Some definitions

Greenhouse effect, global warming and climate change

- GHGs have been increasing in concentration since the Industrial Revolution
- This is due to burning of fossil fuels (coal, oil, natural gas)
- More GHG = More Greenhouse Effect = Hotter planet

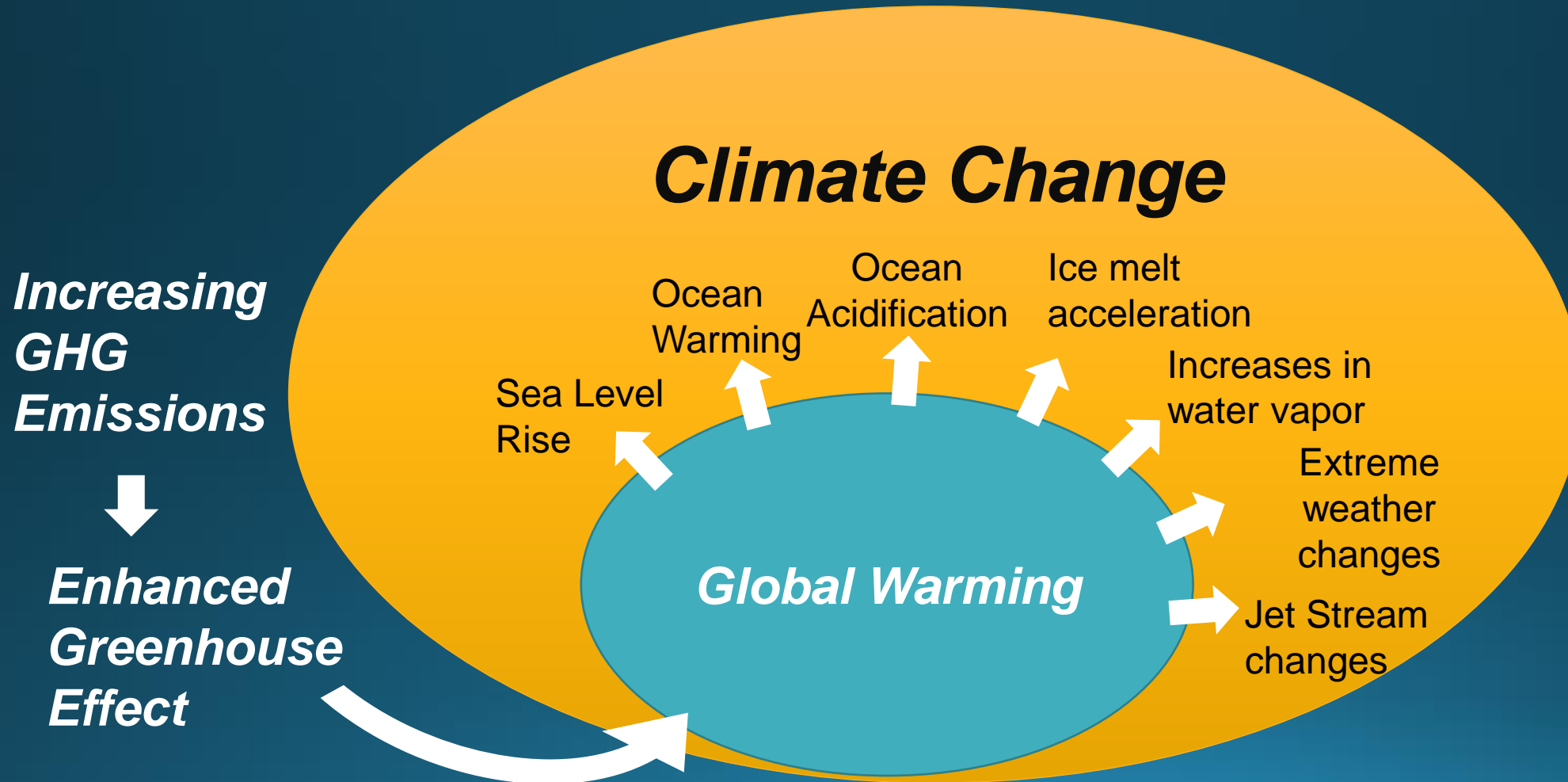


Graphics: Climate Central



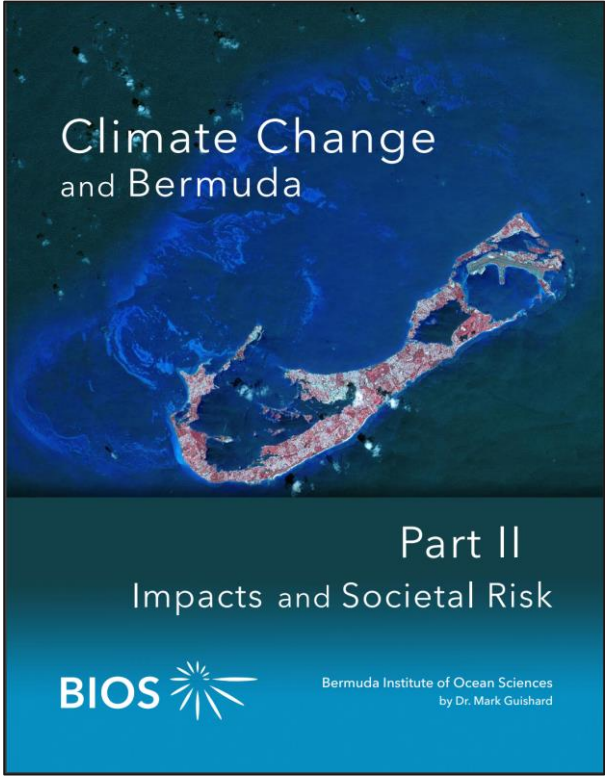
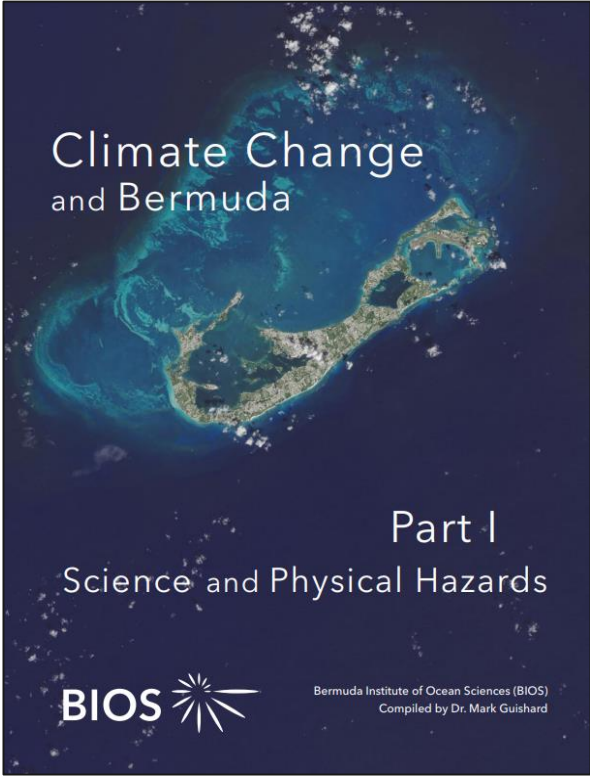
Graphics source: US National Center for Atmospheric Research

Global Warming, driven by an **Enhanced Greenhouse Effect** is a leading influence of **Climate Change**.



Climate Change and Bermuda

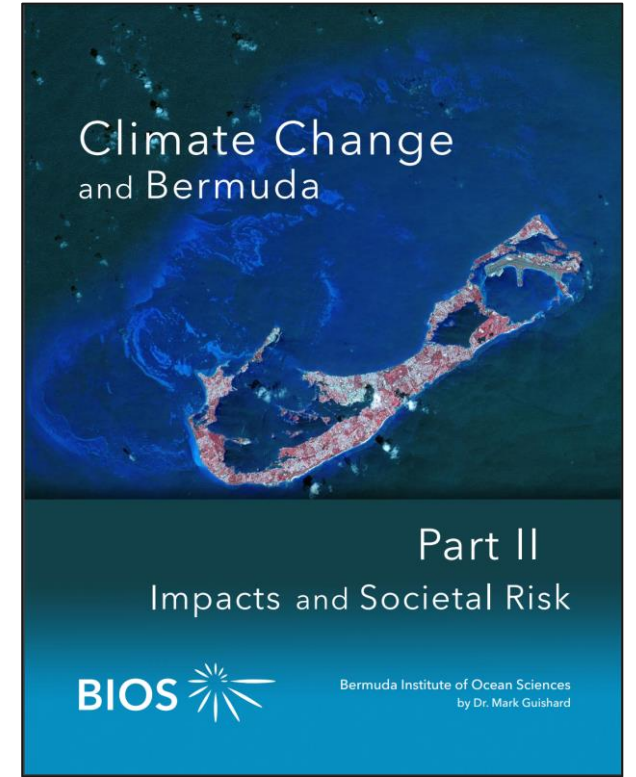
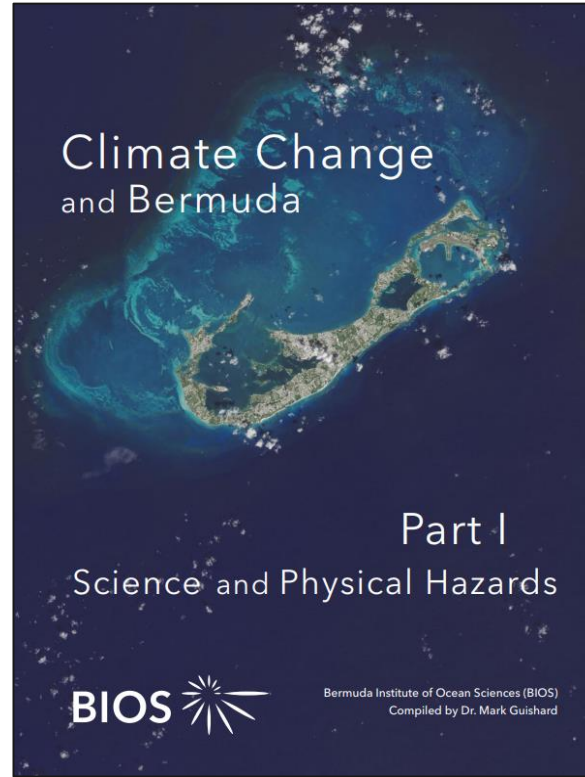
- Synthesis of a decade of science and research.
- Local and international student interns contributed to the work presented in the report.



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<https://bios.edu/research/projects/natural-hazards-and-risk-prediction/>



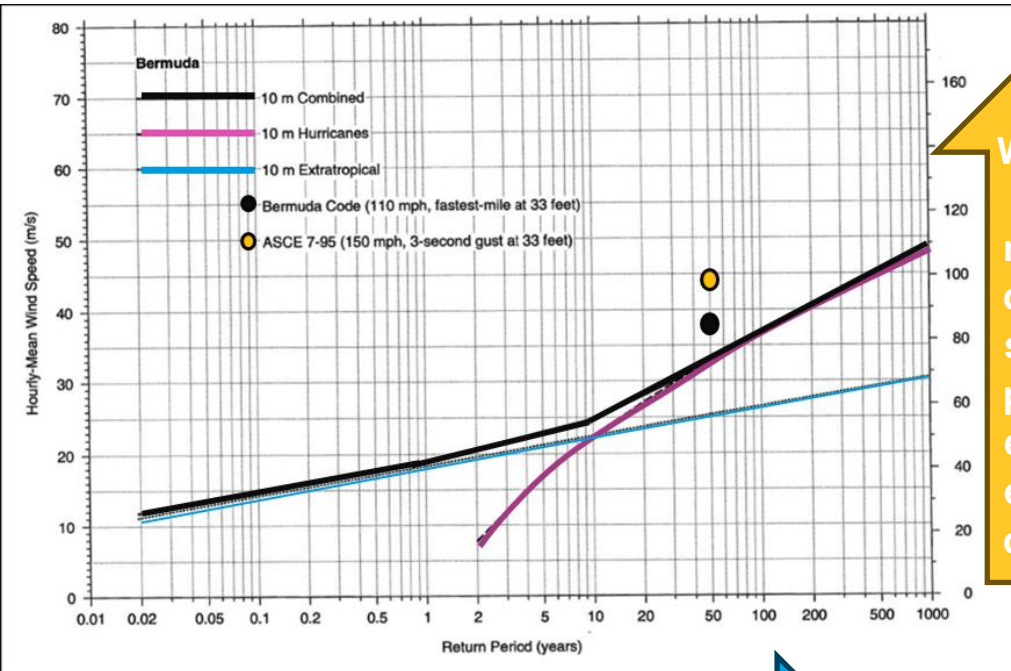
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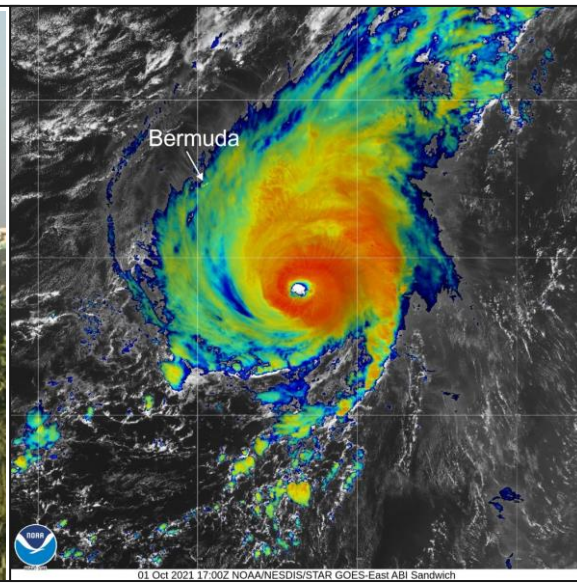
<https://bios.edu/research/projects/natural-hazards-and-risk-prediction/>

Storms and Floods – exposures & vulnerabilities

Strong Building Code



Wind speed (mph)



Bermuda's building code is engineered to withstand stronger storms than we currently experience.

Average return period

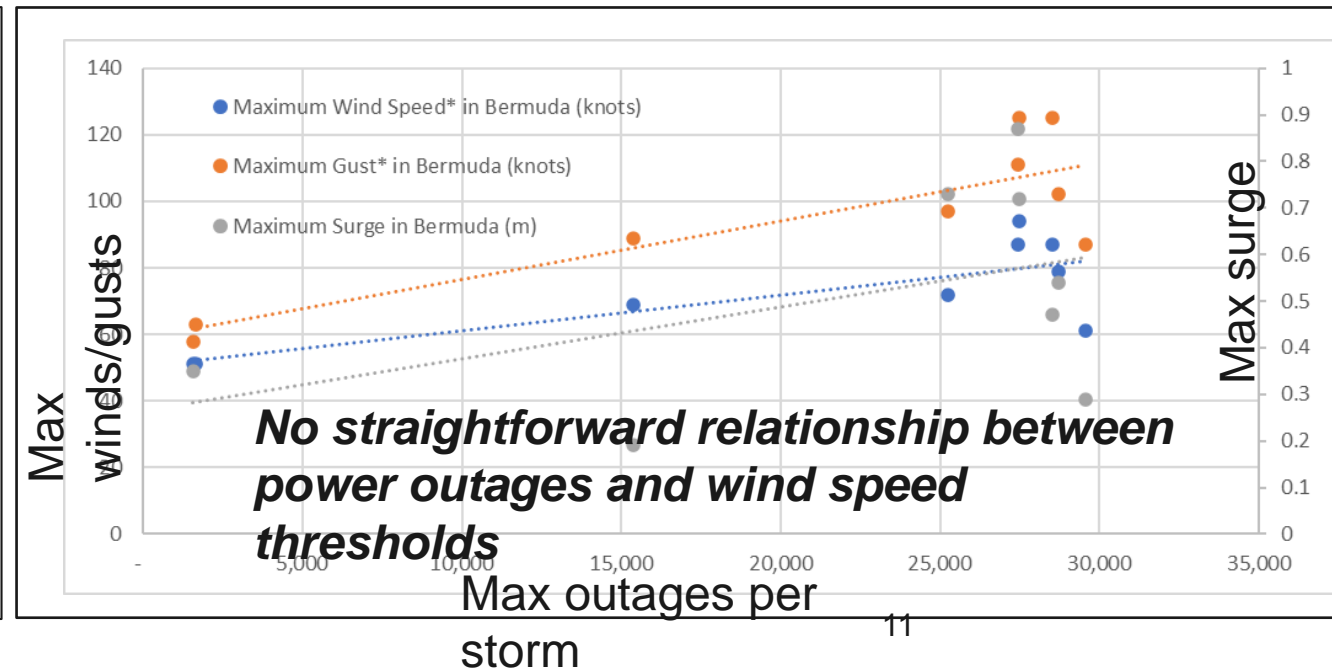
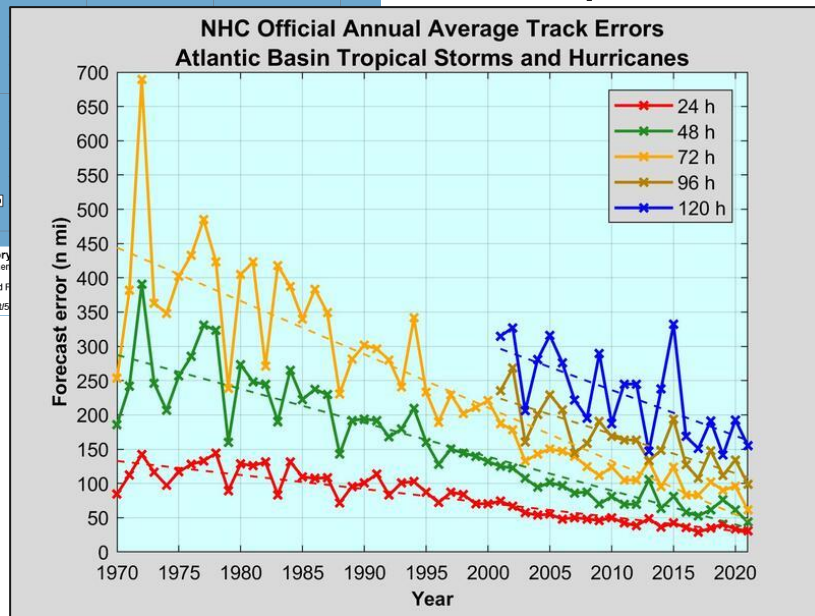
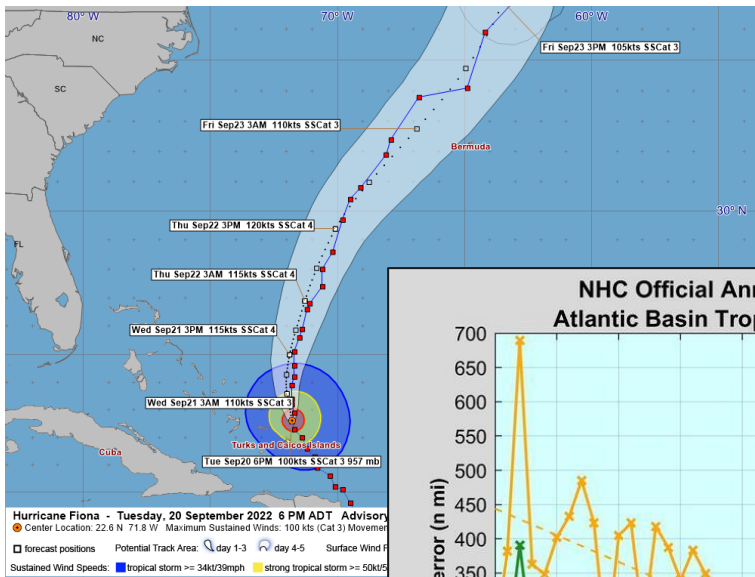
Ho and Mara, 2014



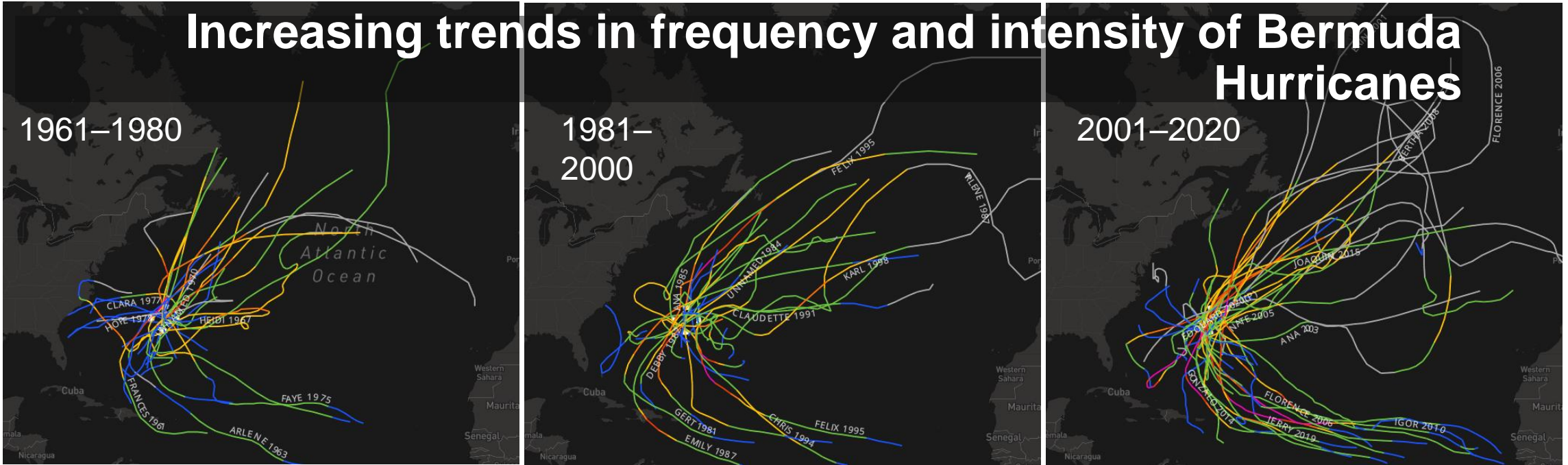
Storms and Floods – exposures & vulnerabilities

Disaster Risk Governance

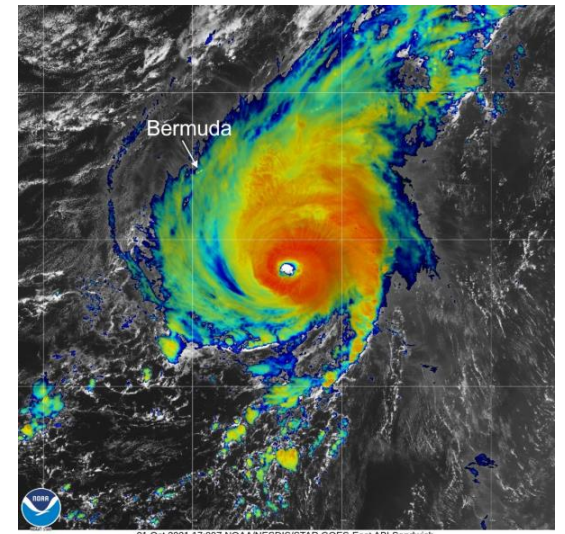
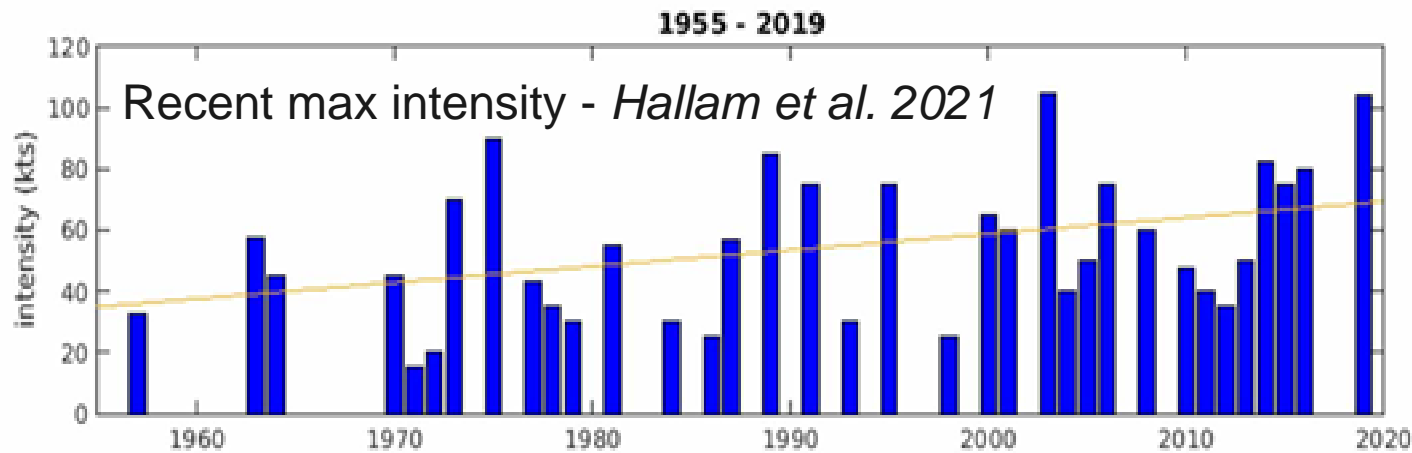
- Forecasting/warning has improved year on year
- Business interruption and economic impacts mitigated by frequent communications from EMO



Increasing trends in frequency and intensity of Bermuda Hurricanes



Above: Tropical cyclone tracks within 100 nm of Bermuda.

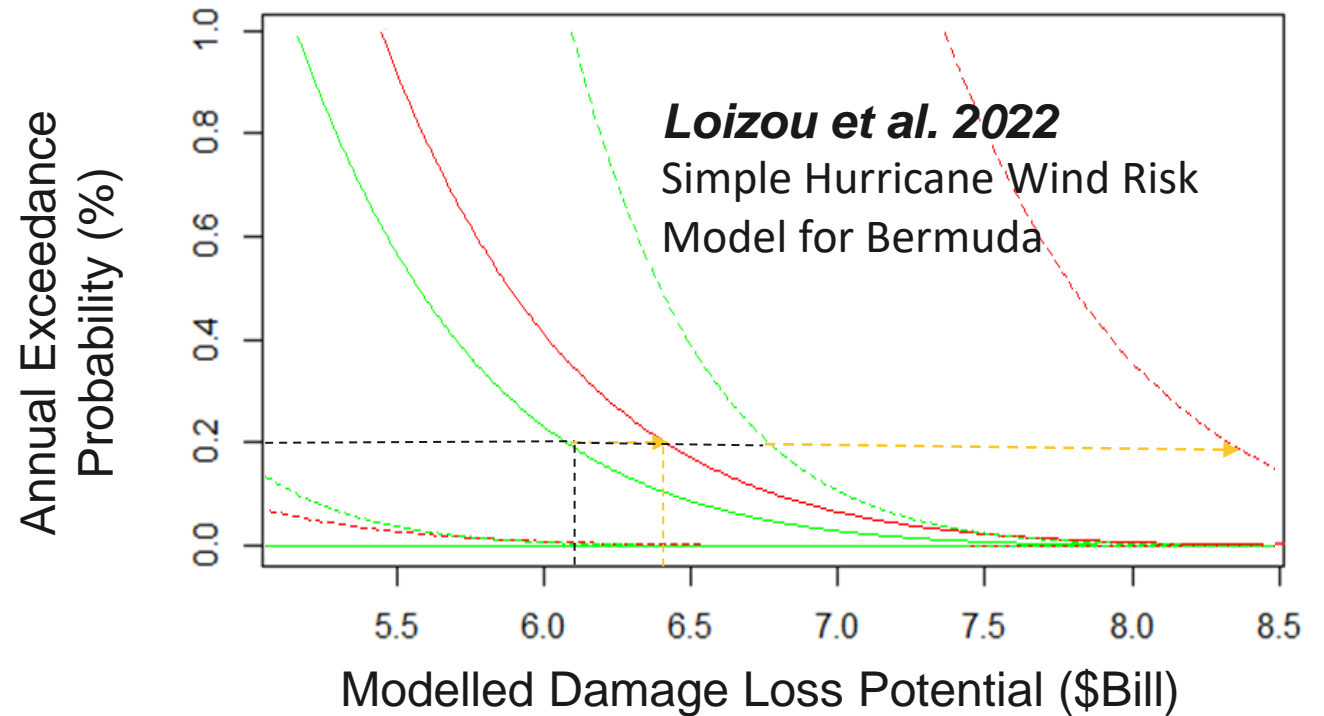


Storms and Floods – exposures & vulnerabilities

Wind Risk

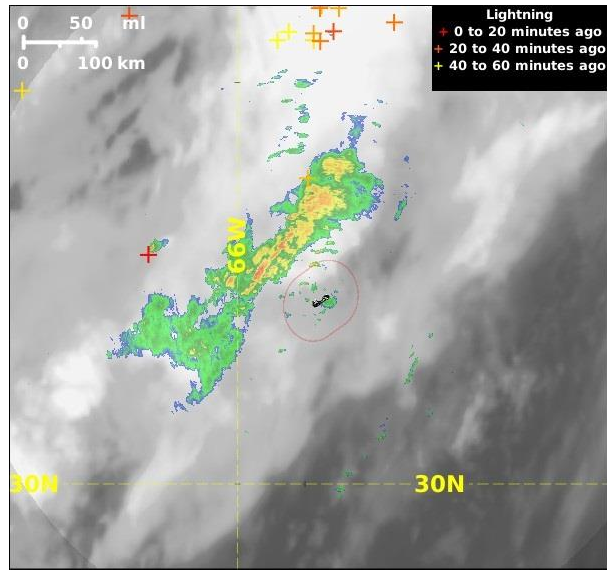
- Despite Bermuda's resilience...
- We see a 5-7% increase in potential average wind damage losses now (**early 21st century**) vs long term average risk (1877-2018)...**BUT**
- ...uncertainty is an order of magnitude greater, and also increases,
- due to hazard record deficiencies, small sample size, etc.

Sounds helpful – but wait! Huge uncertainty, that grows as well as the modelled risk.

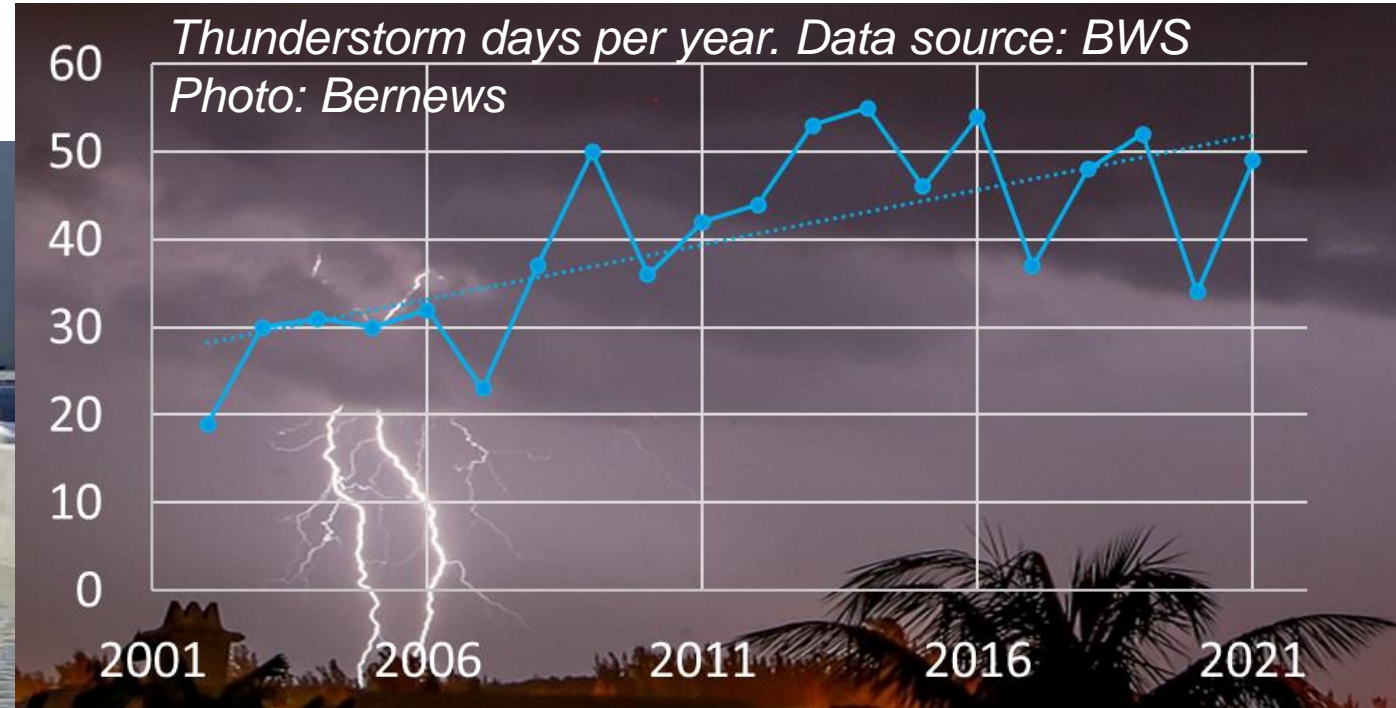


https://github.com/PinelopiLoizou/Risk_Model

Storms and Floods – exposures & vulnerabilities



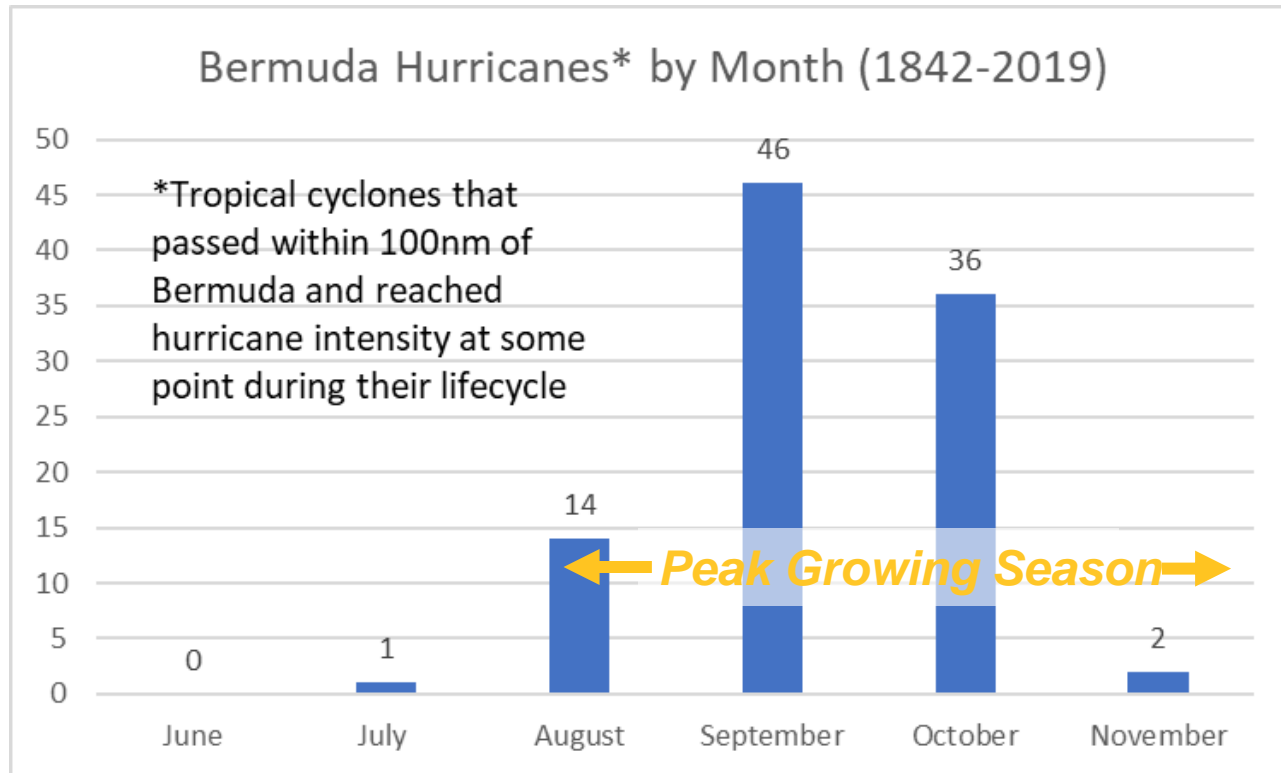
Quote from Bakery Lane business owner (Bernews, 2015): “Each business is losing between \$13,000 and \$40,000 per day on flooding days.”



Changes in rainfall → increases in road flooding potential
Current climate (based on 2005-2015 records): flooding threshold reached every 2 months on average. *Johnston et al. 2018*

Storms and Floods – exposures & vulnerabilities

Impacts to Agriculture



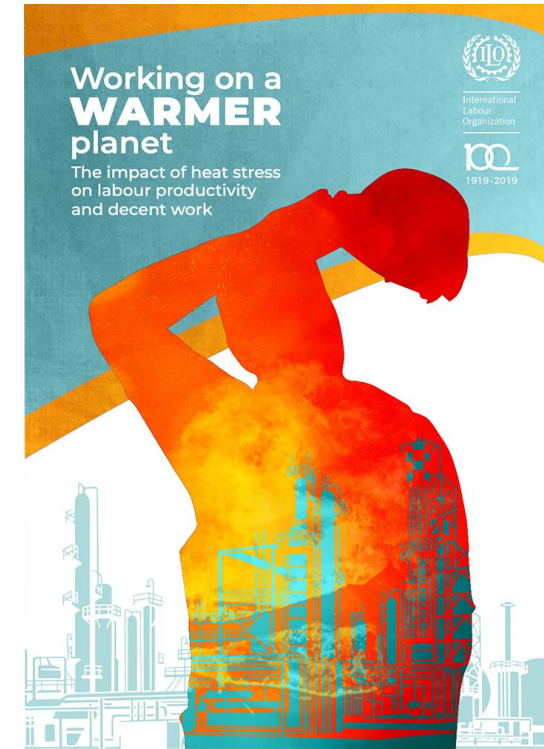
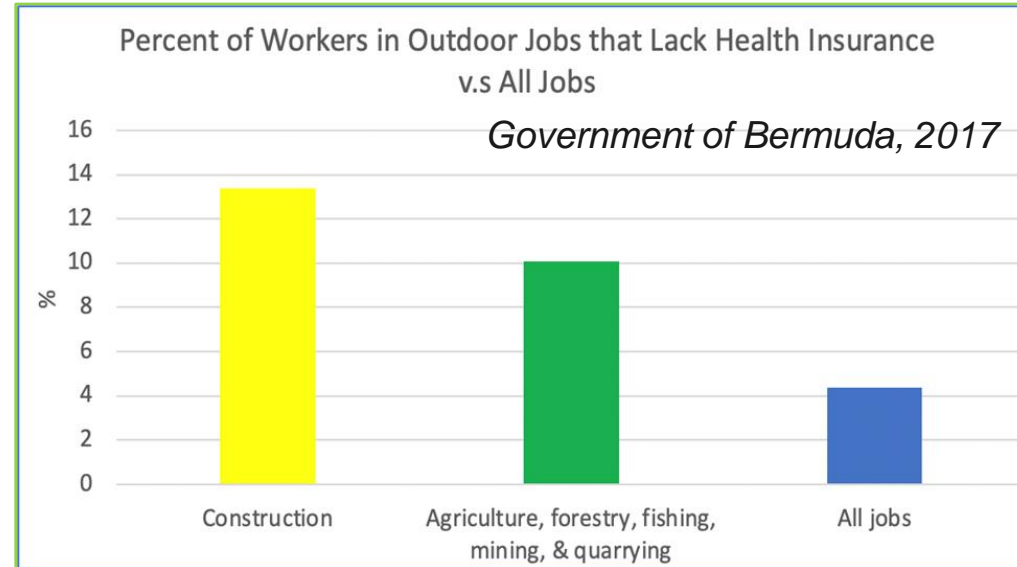
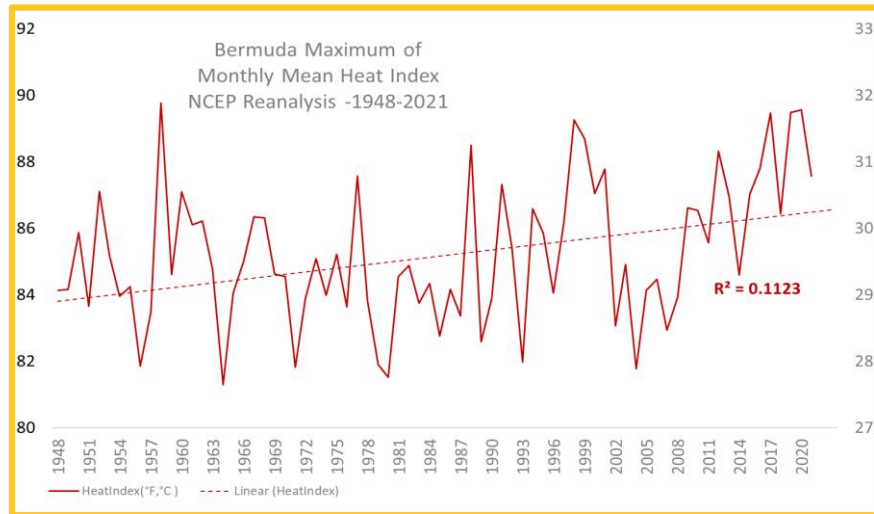
Later season hurricanes are more impactful to local crop production. Farmers take 100% of the economic loss on themselves, due to a lack of crop insurance options.



O'Farrell, 2022

Heat – exposures & vulnerabilities

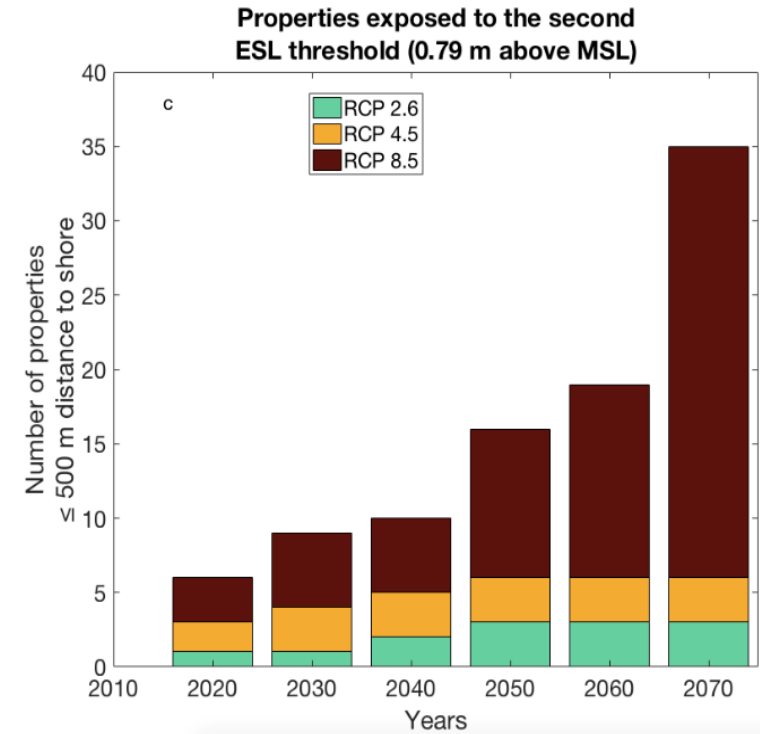
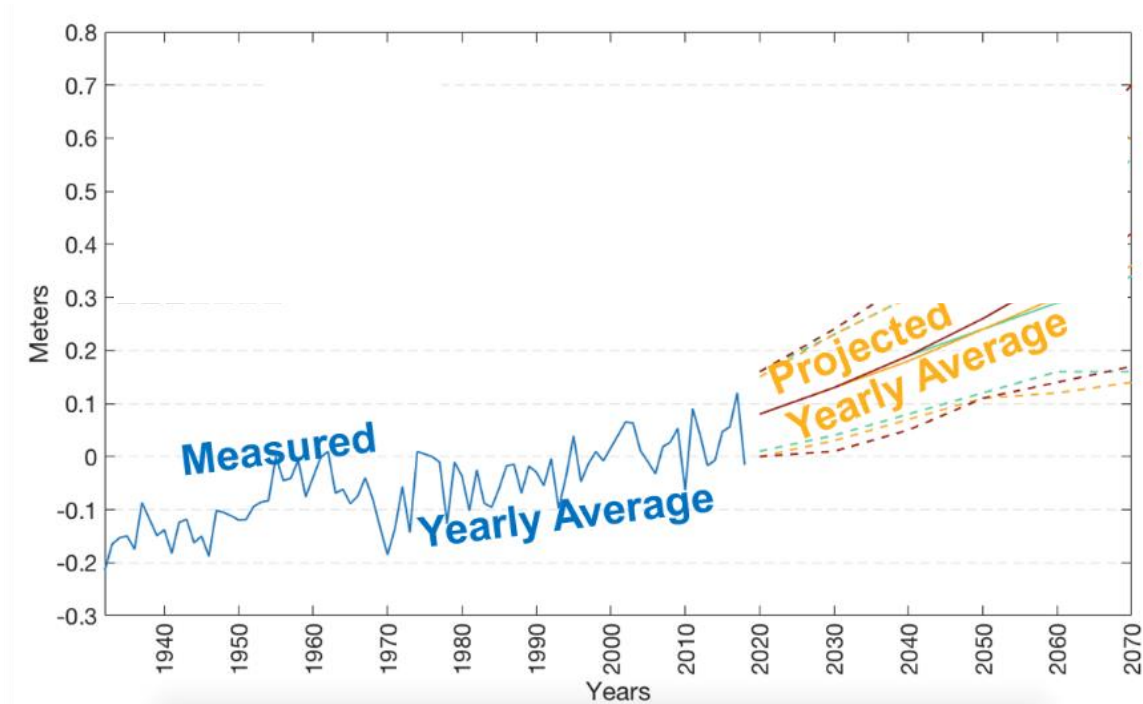
Effects of Heat Stress



- Increased **hazard** (heat)
- Higher **exposure** for outdoor workers
- Higher **vulnerability** in the form of lower pay, less health insurance.

➔ greater **risk** of heat-related conditions for outdoor workers.

The Impacts of Sea Level Rise



Boza, 2019

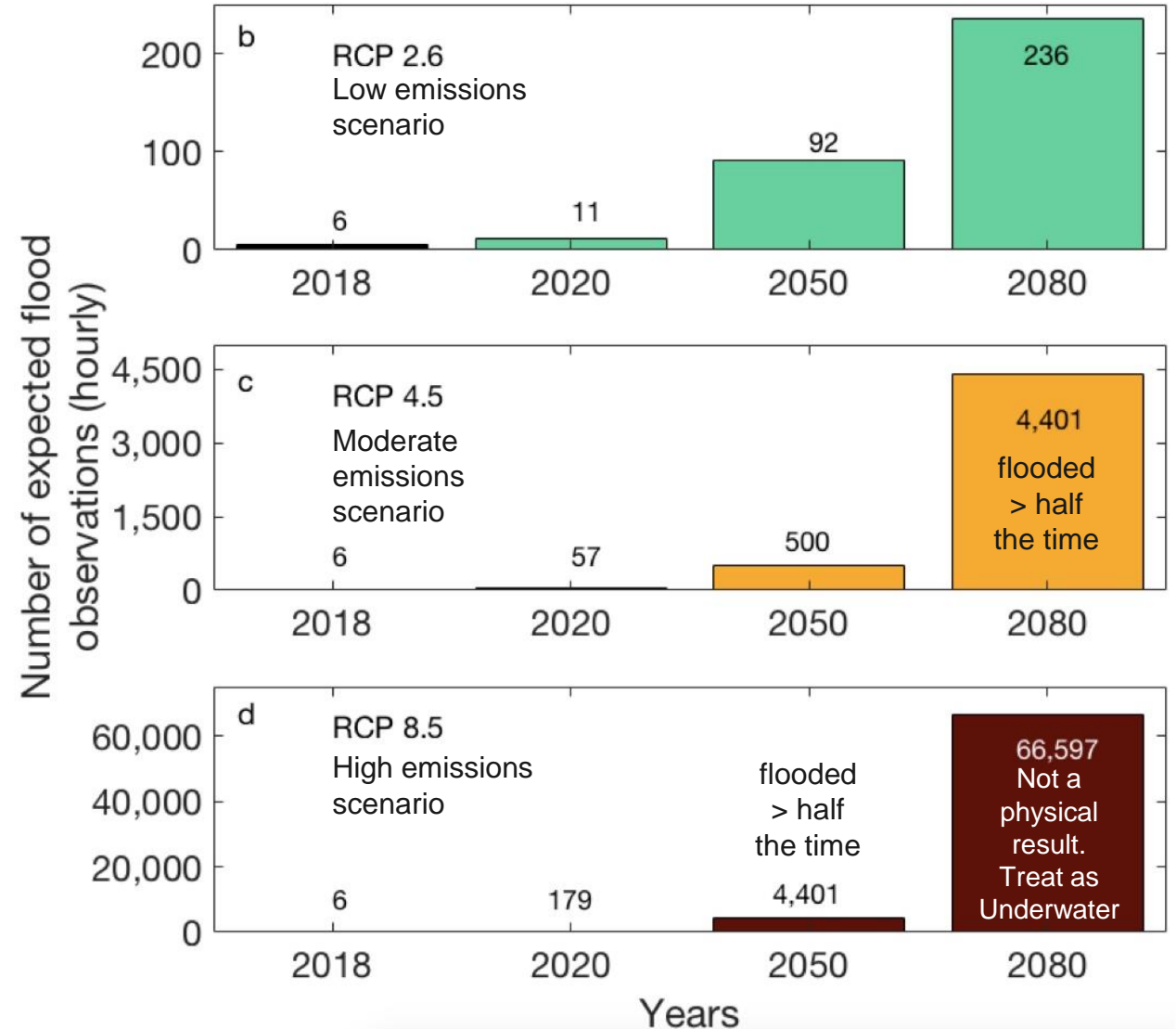


The Impacts of Sea Level Rise *Boza, 2019*

Coastal Property Exposure

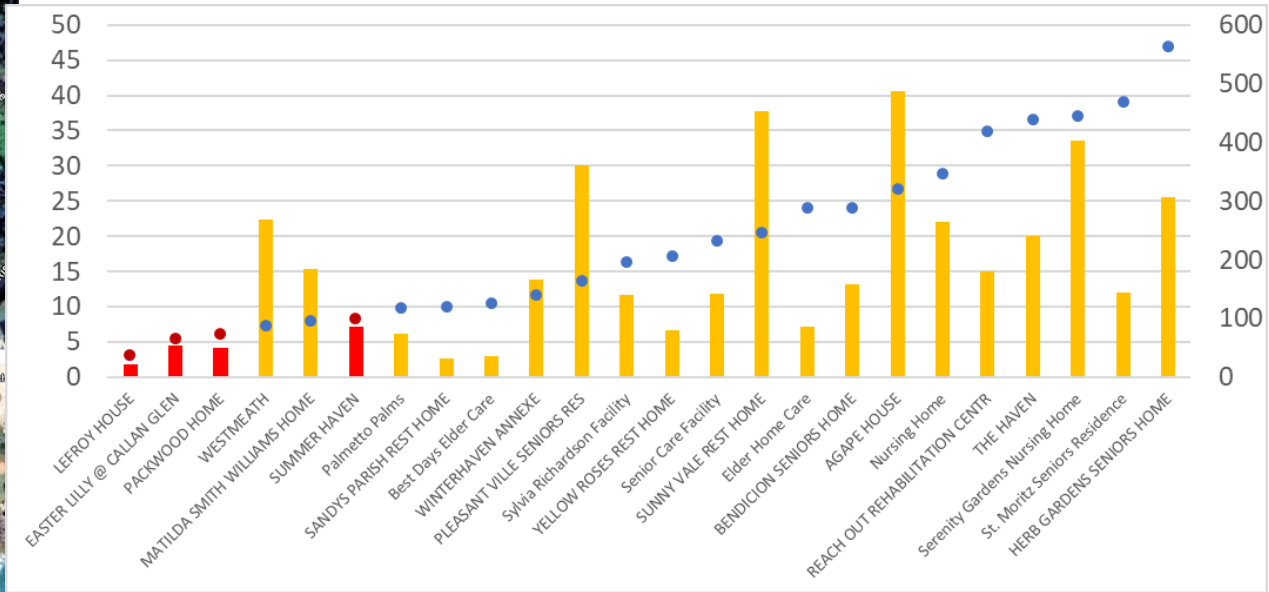
- Different Perspective: The number of hours of flooding for a property at 1 metre above (today's) Mean Sea Level

Boza, 2019



The Impacts of Sea Level Rise

Some assisted living facilities vulnerable to coastal hazards and sea level rise

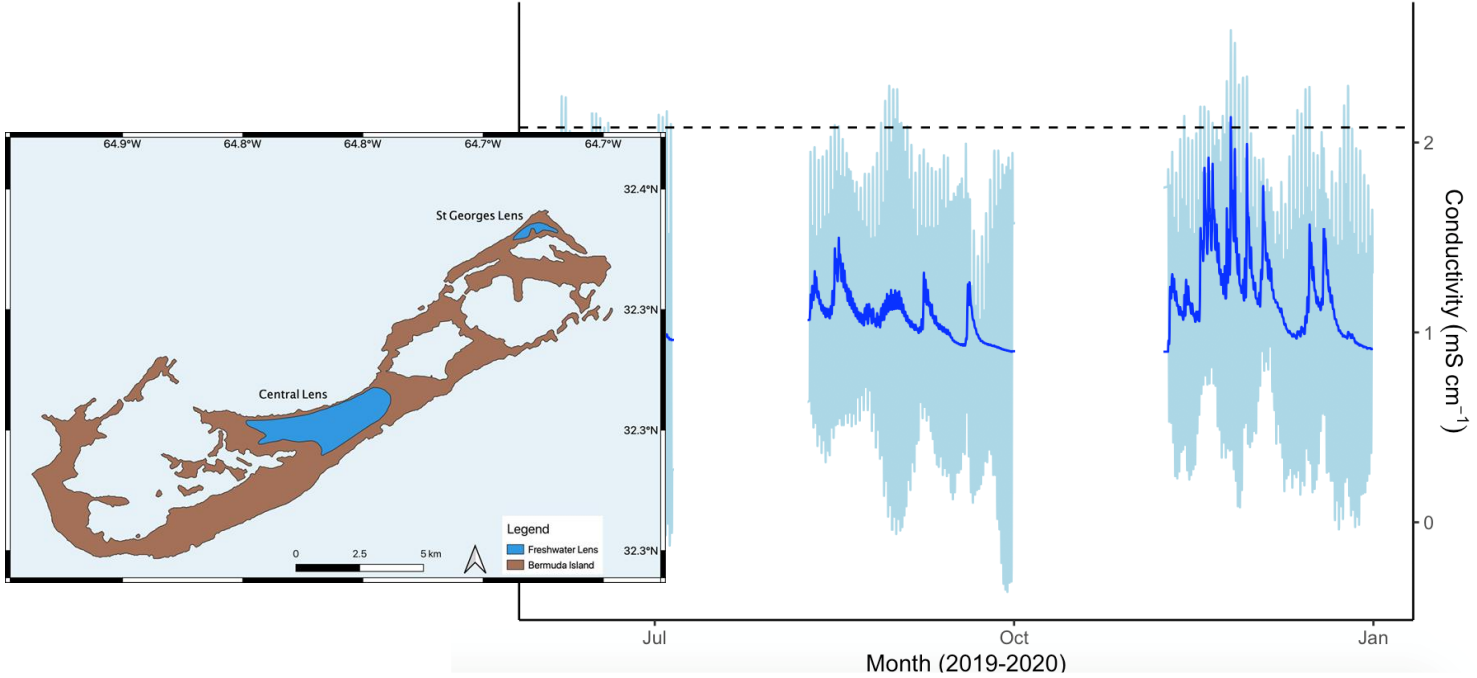
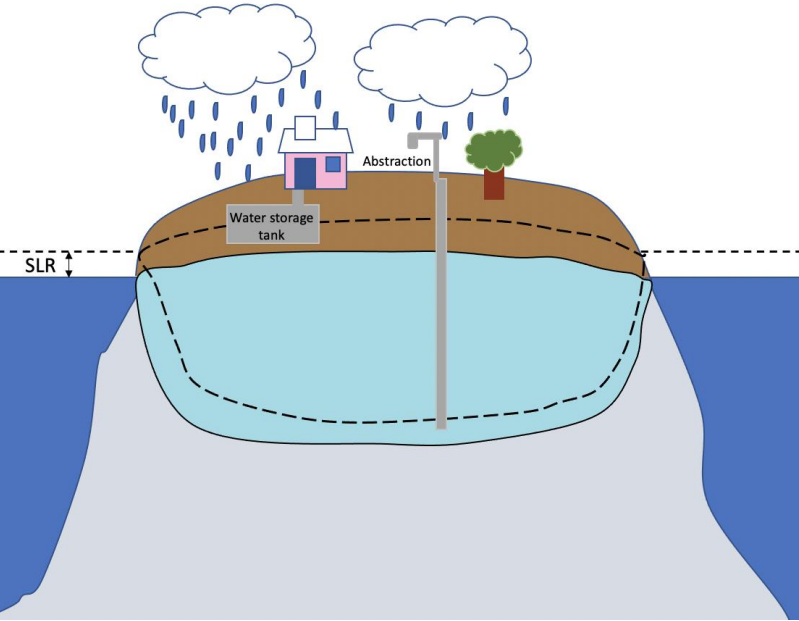


Elevations (dots, in metres) and distance from shore (bars, in metres) of all the assisting living facilities.

O'Farrell, 2022

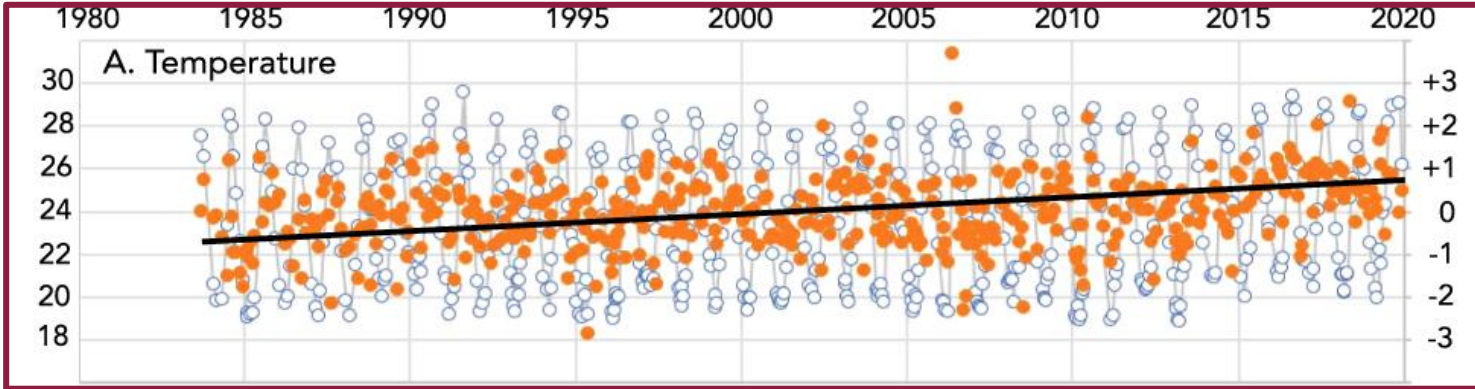
The Impacts of Sea Level Rise

Sea level rise leads to increased groundwater salinity

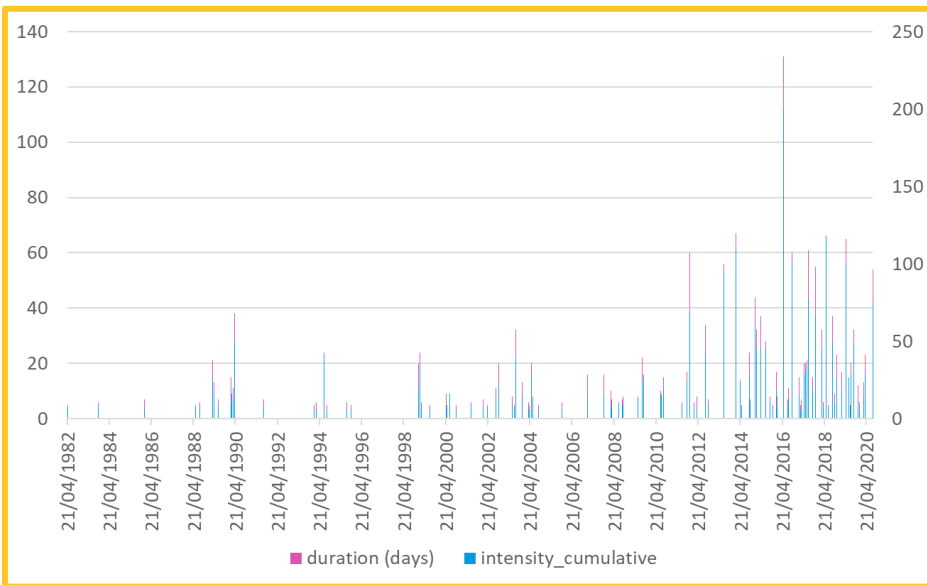


Alexander, 2022

Ocean Temperature

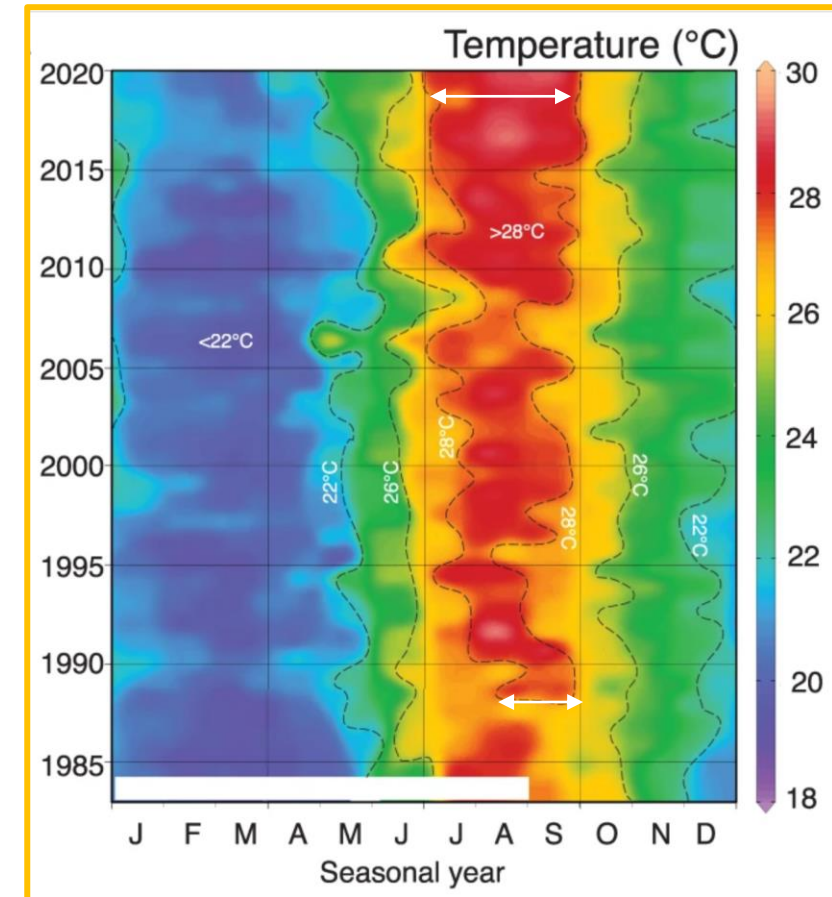


← BATS surface ocean temperature
Bates and Johnson, 2020



Marine Heatwaves
increased in frequency
← and intensity
Hobday et al., 2016

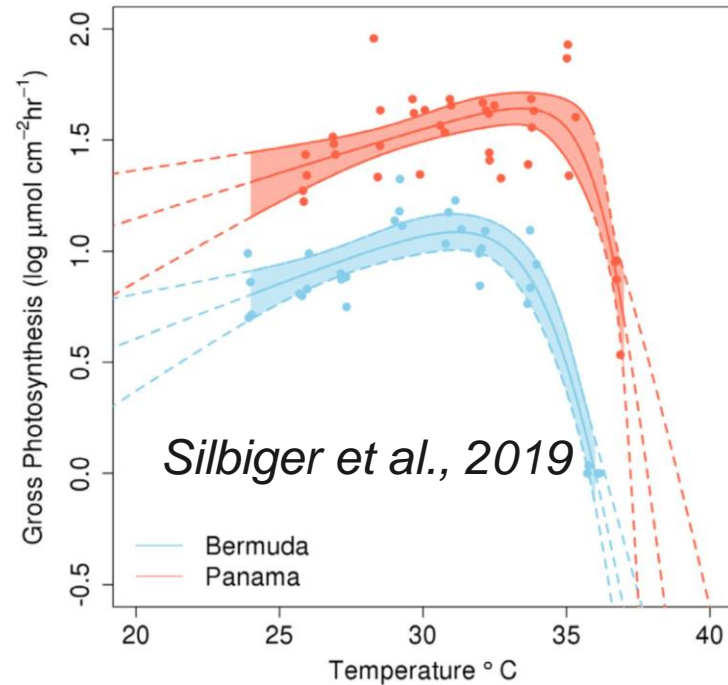
Duration of summer
temperatures increased →



The Marine Environment

Coral Reefs

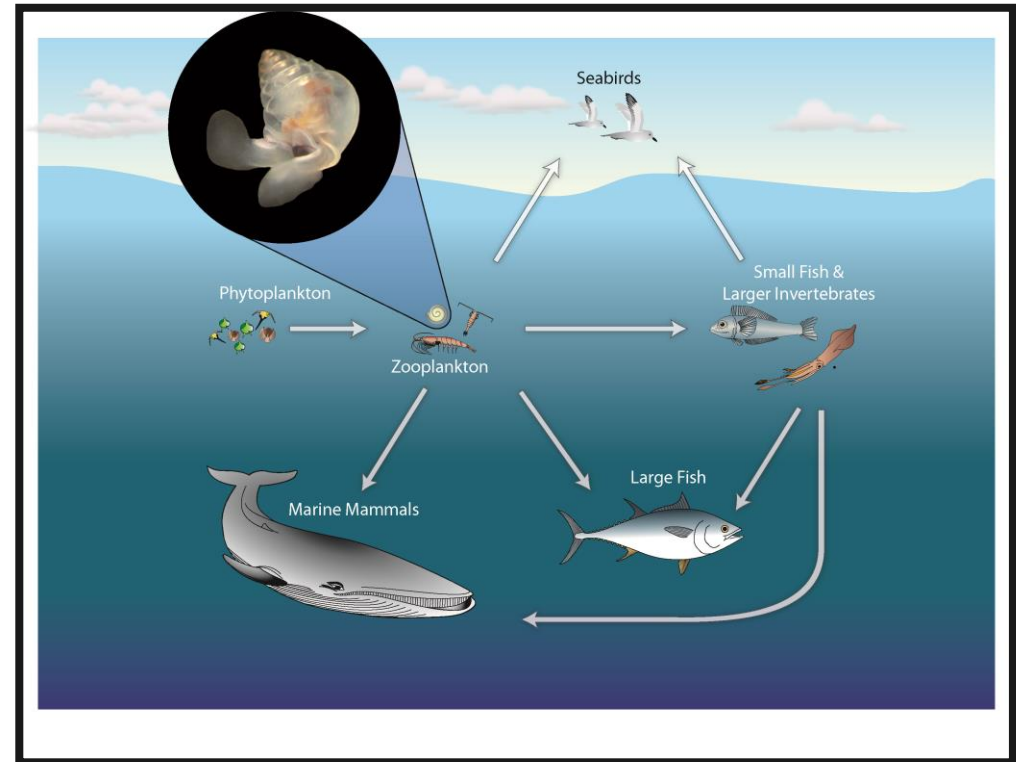
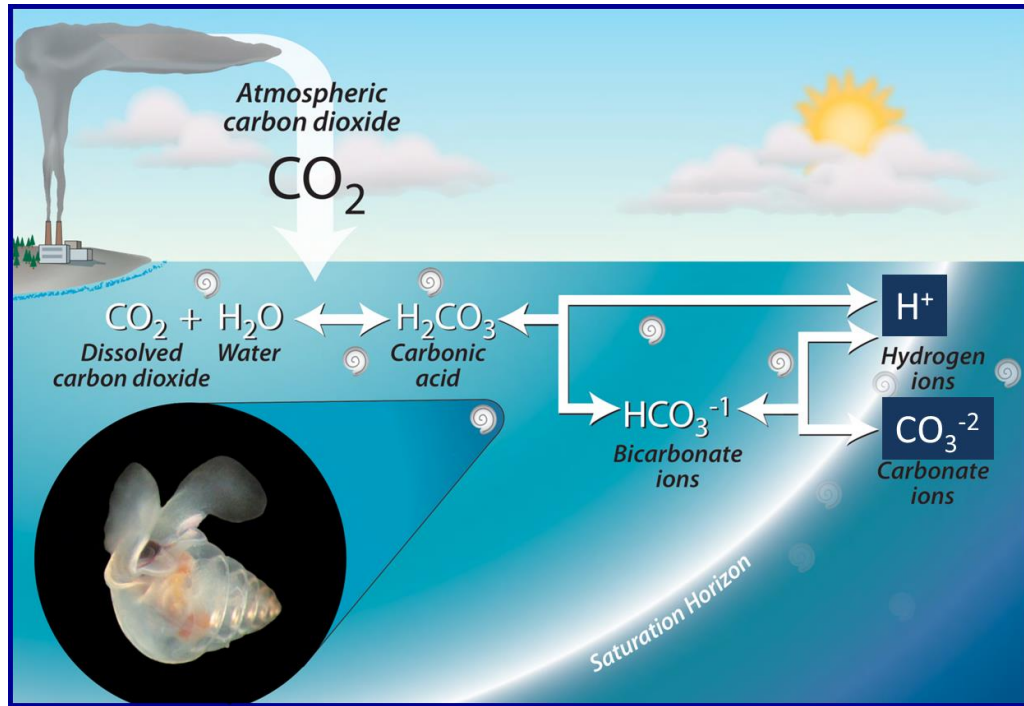
- Marine Heatwaves can lead to coral bleaching events



Fire coral bleaching, Bay, Somerset, 25 Sept. 2022.
Photo courtesy M. Henagulph.

The Marine Environment

Ocean Acidification affects Deep Sea Organisms → Food Web Disruption

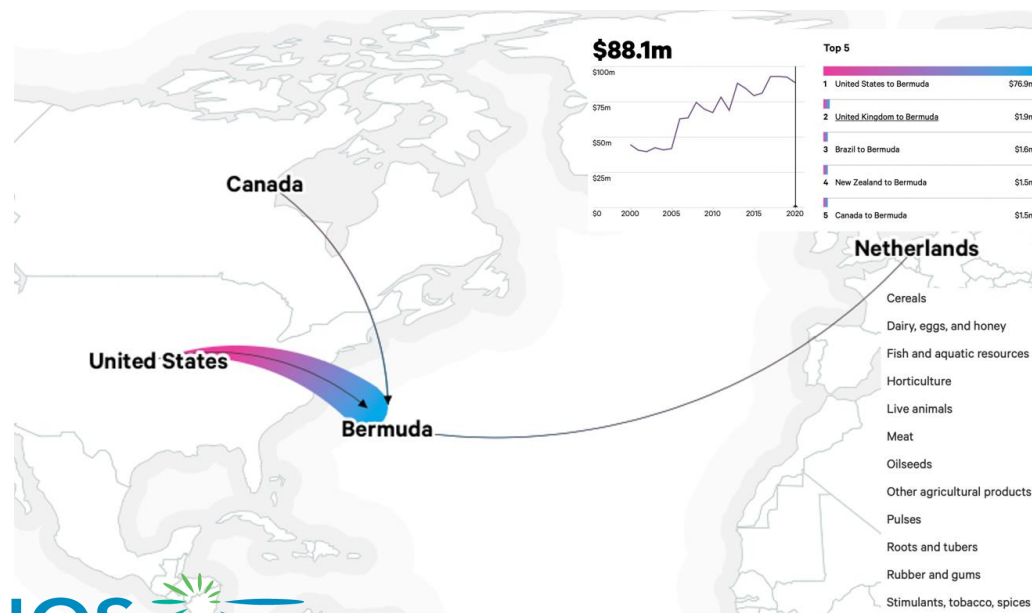


Courtesy of Dr. Amy Maas, BIOS

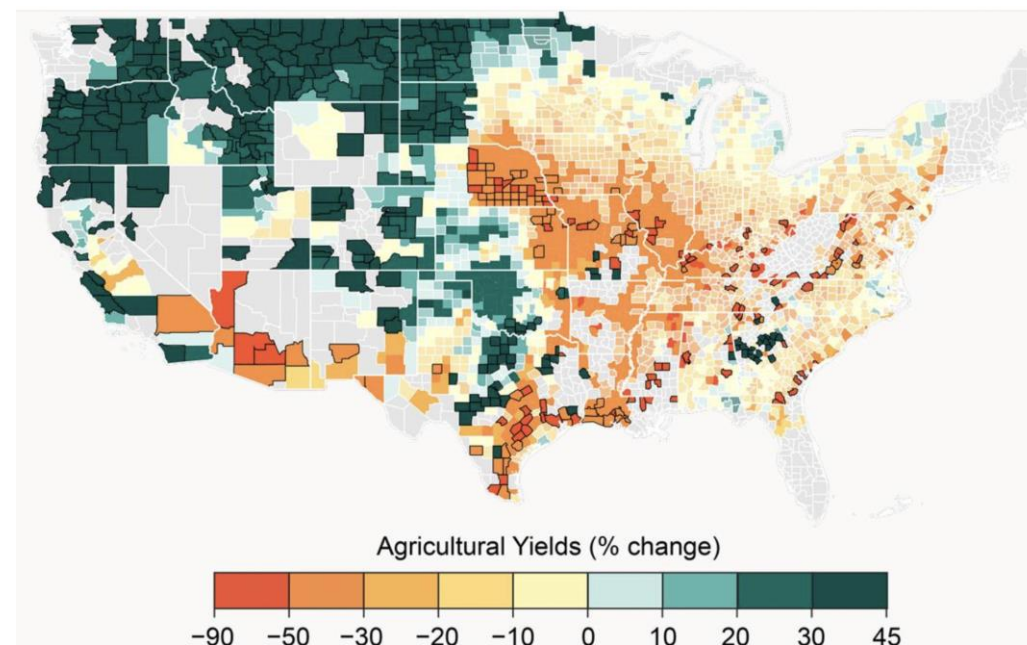
Risks to Supply Chain, Tourism and Travel

Food and Agricultural Supply Chain

Map of exporters of agricultural goods to Bermuda. In 2020 the island imported 88.1 million dollars' worth of food, an increase from 42.4 million in 2000. Source: resourcetrade.earth



O'Farrell, 2022 (unpub.)

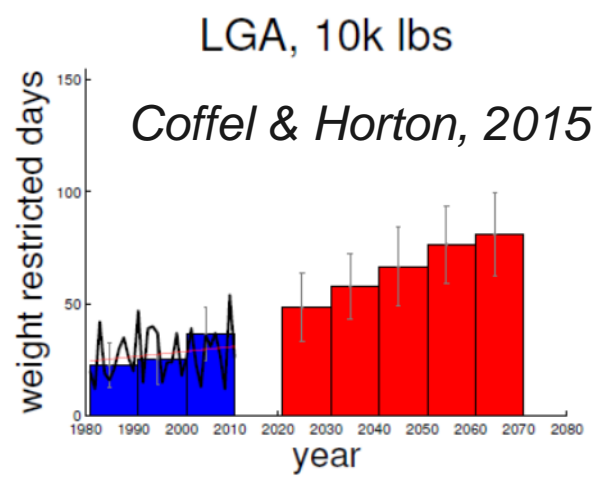
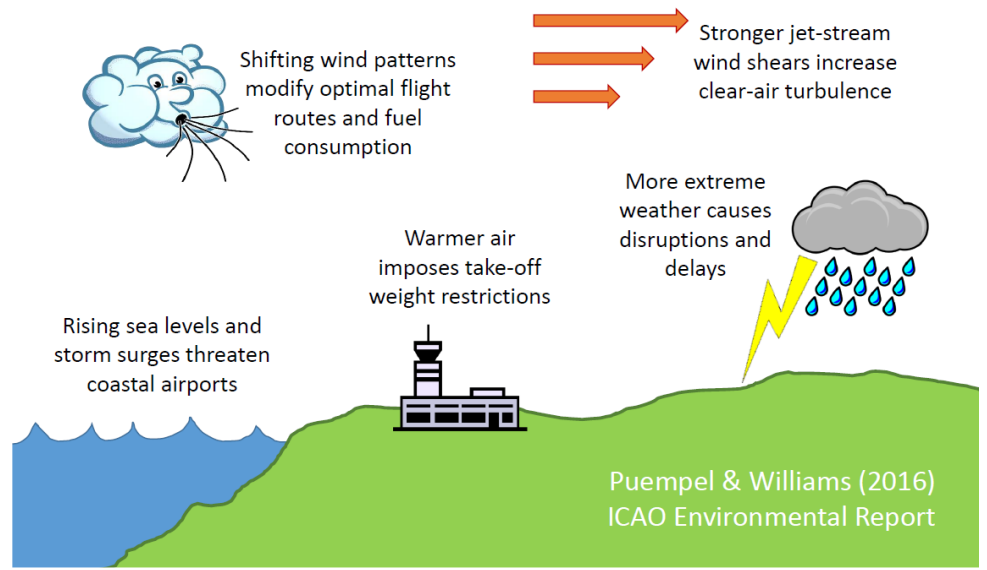


% change in corn, wheat, soy, cotton yields under the RCP 8.5 scenario in 2080-2099 (Hsiang et al., 2017).

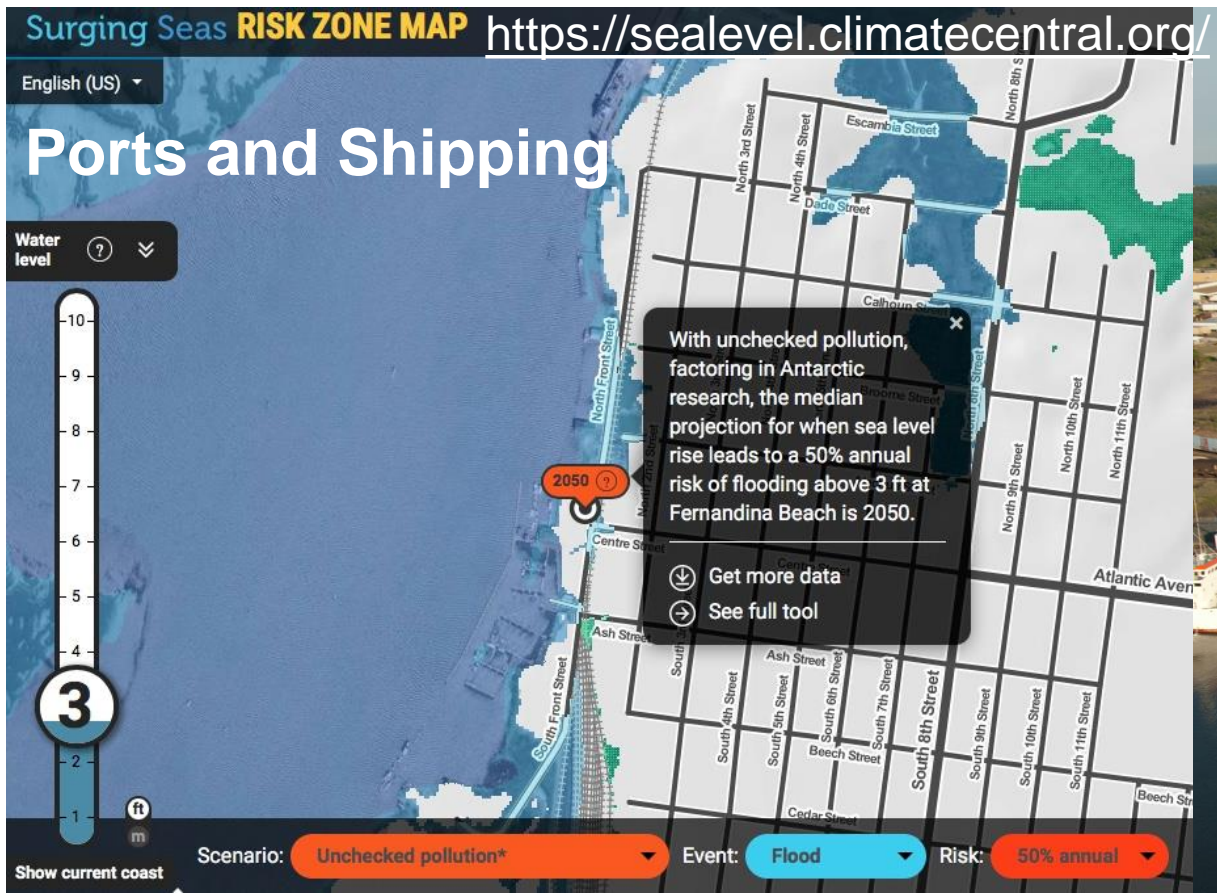
Risks to Supply Chain, Tourism and Travel

Aviation and Air Travel

Climate change impacts on aviation



Risks to Supply Chain, Tourism and Travel



Port of Fernandina FL

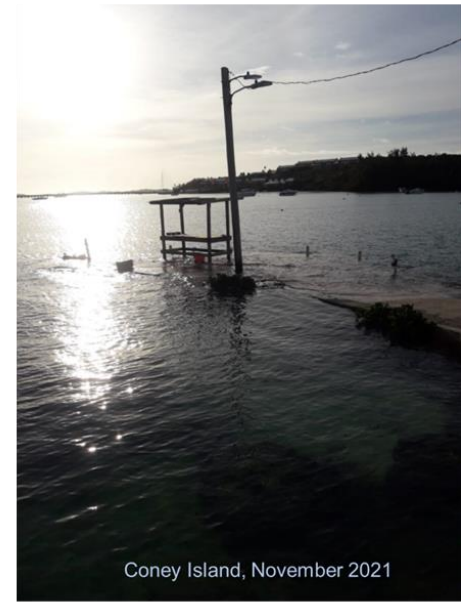
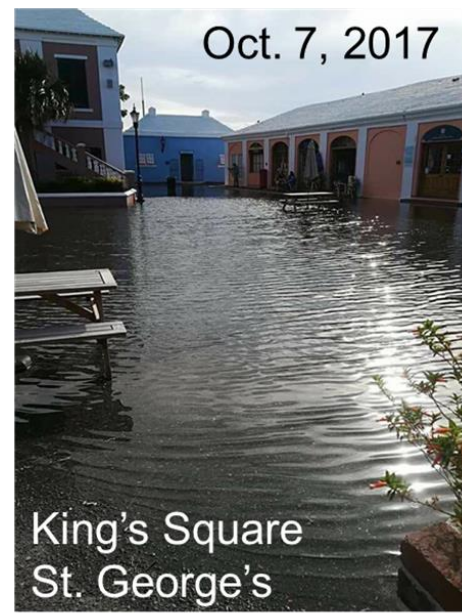


Somers Isles Shipping Ltd.

Risks to Supply Chain, Tourism and Travel

Coastal inundation risk of tourist attractions

- Beach erosion and inundation of popular tourist attractions will become more prevalent
- The normal high tide in ~20 years:

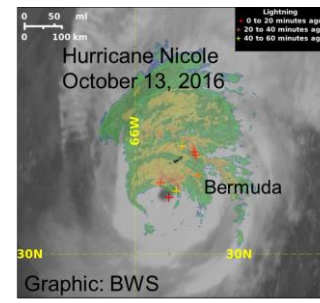


Opportunities?

- Showcase our resilience against storm activity.
- Climate risk finance activities (but must demonstrate and celebrate climate action locally).
- Ecotourism and regenerative tourism to highlight sustainability initiatives.



Summary of reports



Physical Hazards

- More frequent and stronger hurricanes (Cat 4s more likely) →
- Rain, thunderstorm days & heavy downpours increasing →
- Sea level rising (+ 1 foot in 20 years) →

Resulting Impacts and Risk

- Hurricane wind risk up this century 5-7% vs. long term averages, with increasing uncertainty
- Rainfall flooding event frequency currently ~ 2months. Expect this to increase over time.
- About \$3 mill more of ARV exposed coastal flooding events in the next 50 years. Properties at or below 1m above today's sea level particularly exposed – expect considerably more risk in next 2-3 decades.

Summary of reports

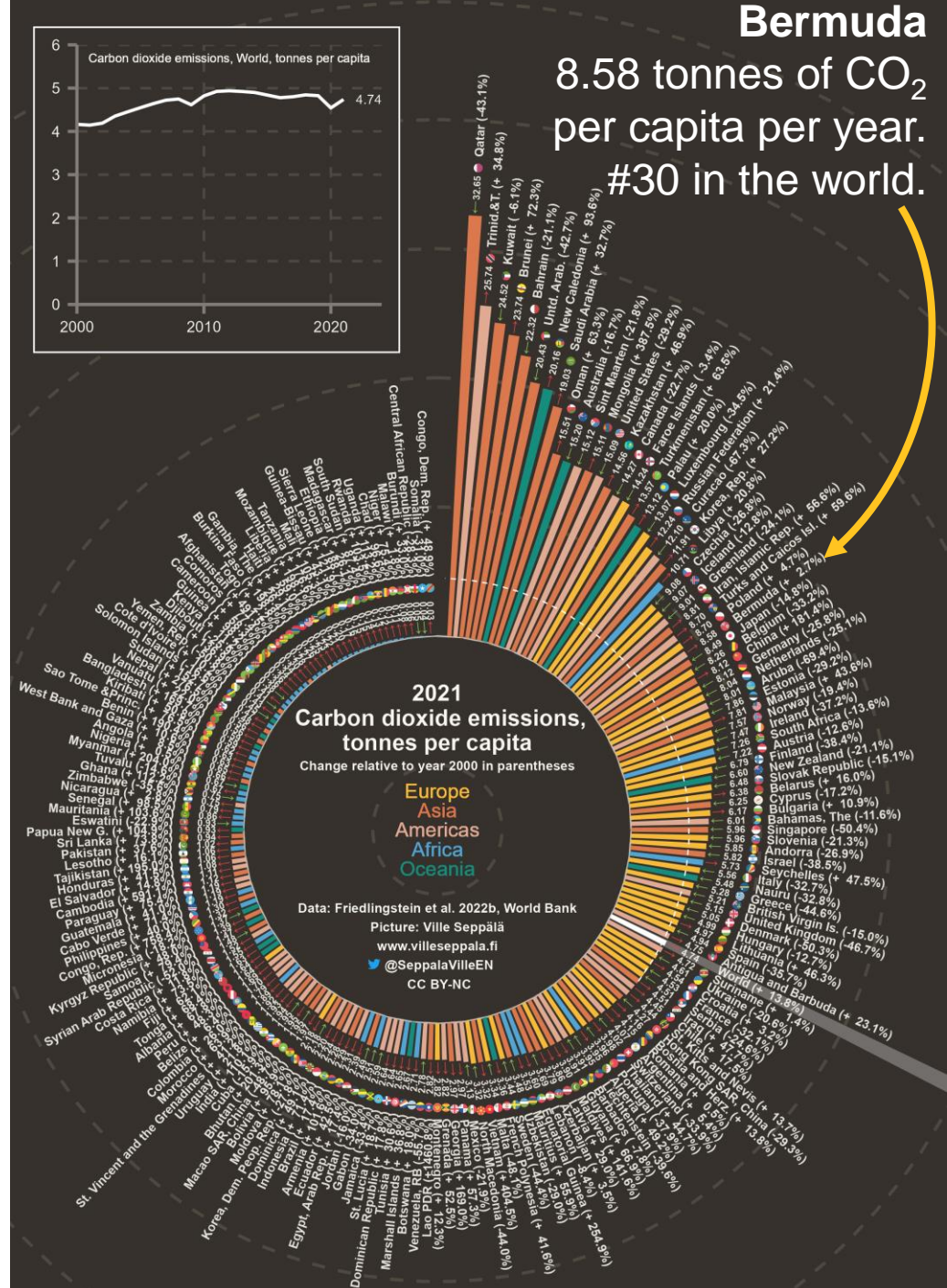
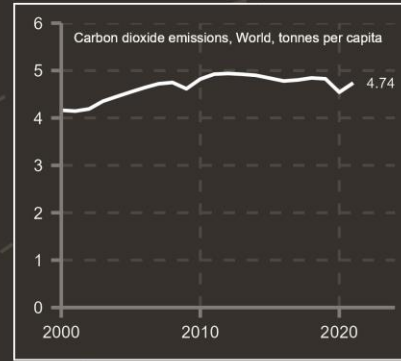
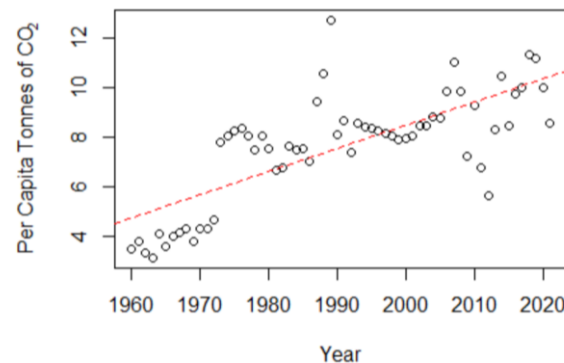
- Outdoor labour increasingly at risk from heat-related health problems.
- Agriculture is increasingly stressed by storm and rainfall variability, with limited mitigants (e.g. insurance)
- Marine heatwaves mean greater likelihood of bleaching events, perhaps mitigated by deeper (cooler) coral refuges.
- Impacts to aviation, shipping are not just local; supply chain and tourism risk assessments should include ports of departure.



Summary

Numerous economic and societal impacts

- Report scratches the surface, and all aspects bear further research.
- It stops short of recommending specific actions.
- It is more supportive of exploring adaptation responses.
- As for mitigation...



The Good News...

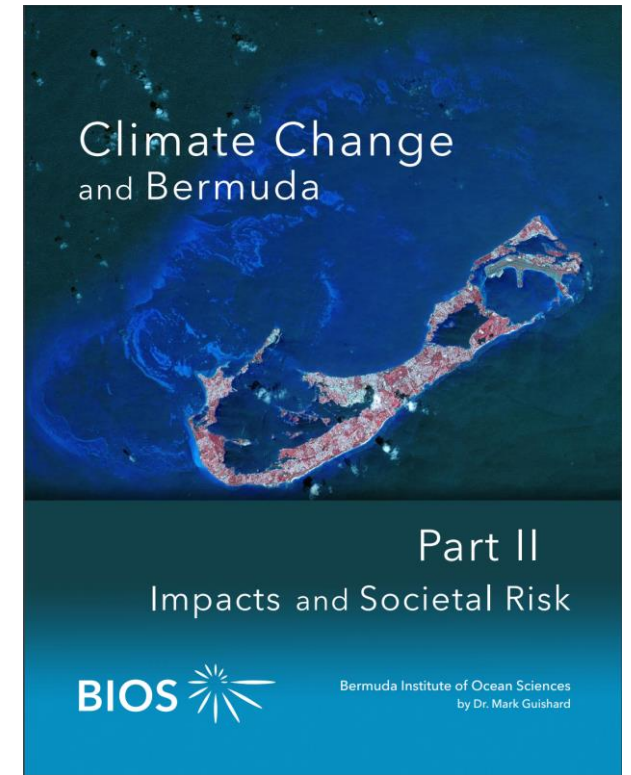
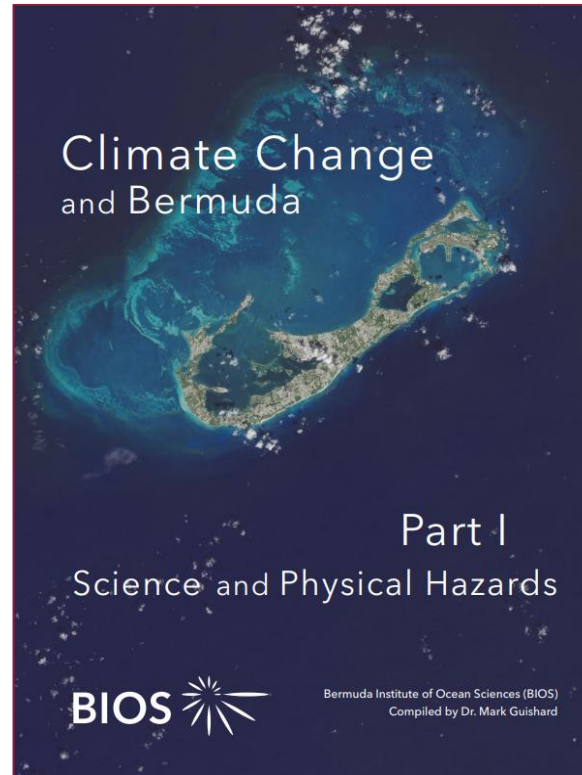
- Disaster governance and storm resilience is good (for today's climate).
- Corals may have deep water refugia.
- Recent storm and coastal flooding events give us an early heads-up of what's down the road
- Opportunities exist to lead by example to increase local resilience and security (food, water, energy, etc.)...
- ...and build the economy by supporting global efforts in climate risk finance





Climate Change and Bermuda

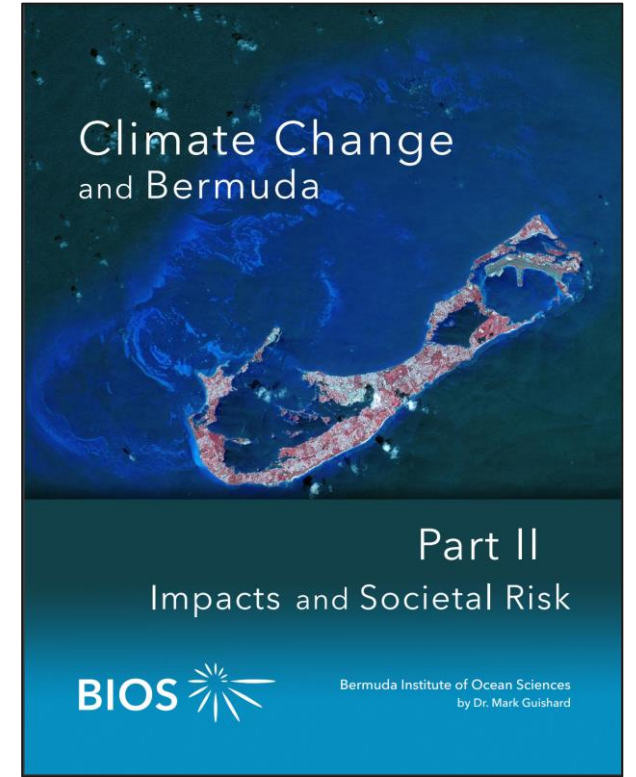
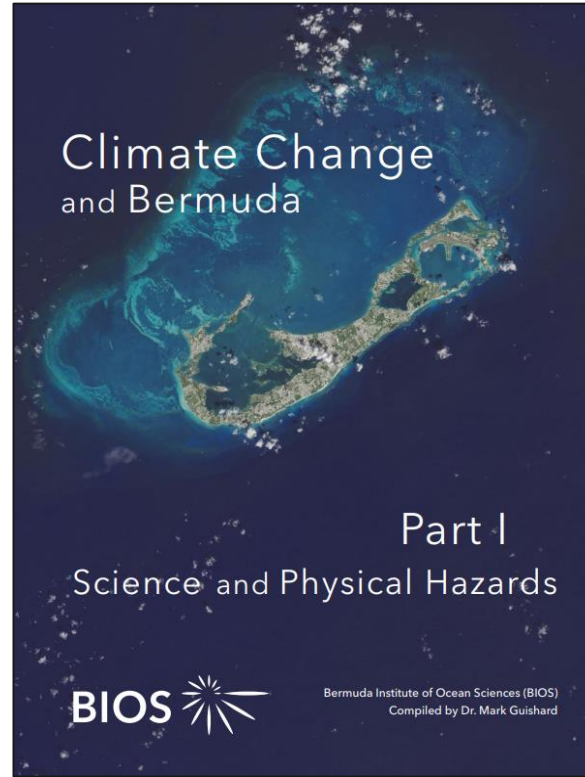
Dr. Mark Guishard



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Bermuda Red Cross, in partnership with QBE Foundation, is pleased to invite the general community to attend a presentation on **“Climate Change and Bermuda”**:

1. **Date** **Thursday, 6 July 2023**
 Time **5:30pm-7:00pm**
 St. Paul’s AME Church Hall (Central)

2. **Date** **Thursday, 13 July 2023**
 Time **5.30pm-7.00pm**
 Penno’s Wharf, St. George’s (East)

3. **Date** **Tuesday, 25 July 2023**
 Time **6.00pm – 7.30pm**
 St. James Church Hall (West)

Climate Change and Bermuda - References

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