



XL Insurance
Reinsurance



Incorporating Exposure Information into Science: *The Risk of Synoptic-Scale Arctic Cyclones to Shipping*

Dr. Alec Vessey (AXA XL),

Dr. Kevin Hodges (UoR), Prof. Len Shaffrey (UoR), Dr. Jonathan Day (ECMWF)

AXA XL Science and Natural Perils Team

European Windstorm Conference

Bern, 5 -7 February 2025

Introduction to AXA XL

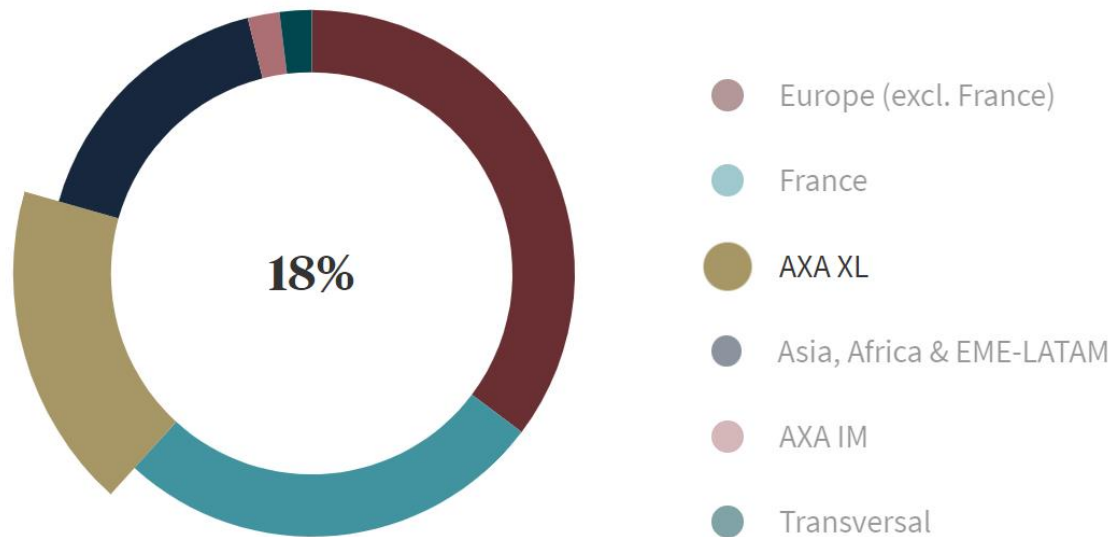
Introduction to AXA and AXA XL

AXA: One of largest worldwide multinational (re)insurance companies (regarding business & total assets - [SWFI, 2022](#))

AXA XL: Is a division of AXA Group, which specialises in Property, Casualty and Specialty risk

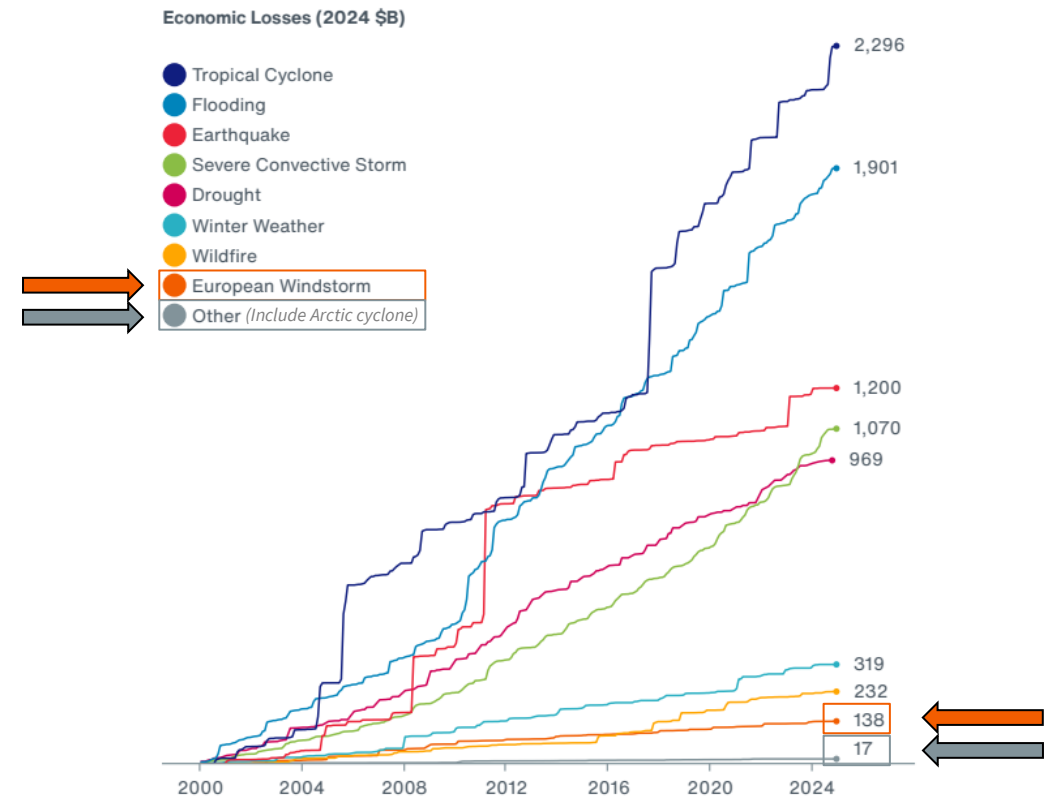
- Natural perils are a primary cause of damage

Revenues by geographic region



<https://www.axa.com/en/about-us/key-figures#tab=financial-data>

Cumulative Global Economic Losses by Peril



AON Cat Insight Reports (2024)

Insurance Industry Background

- **Primary Insurers** write insurance **contracts** and assess **claims**
 - Primary Insurers transfer risk to Reinsurers (*AXA XL does both insurance and reinsurance*)



AXA Insurance Reinsurance

- **(Re)Insurance Brokers** **provide services** and facilitate transactions between (re)insurers, and include:

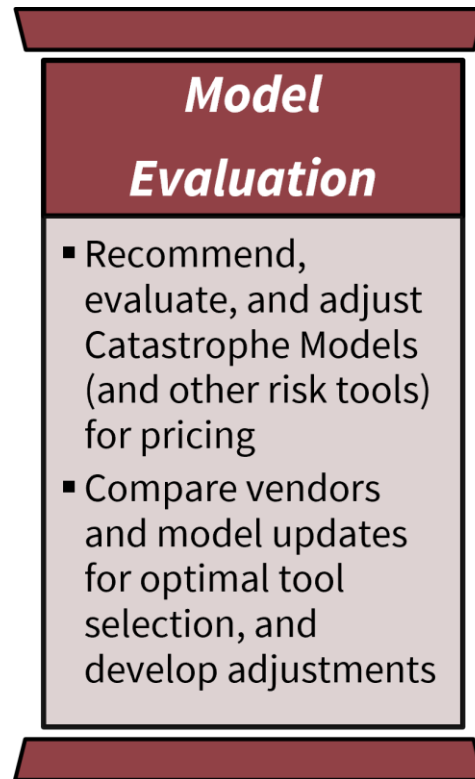
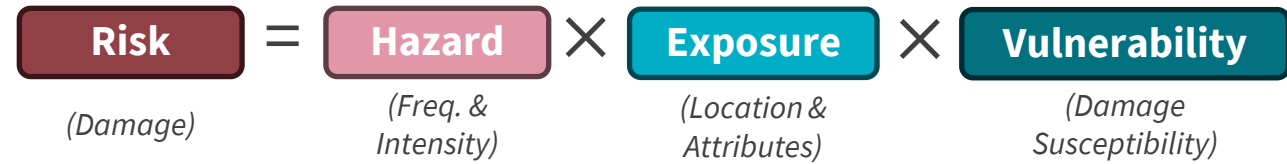


- **Model Vendors** **provide risk assessment tools** (e.g., Catastrophe Models, Risk Maps etc.), and include:



Role of AXA XL Science and Natural Perils Team

- **Aim:**
Apply the latest Science into the AXA XL business
- **Business Objectives (Pillars):**

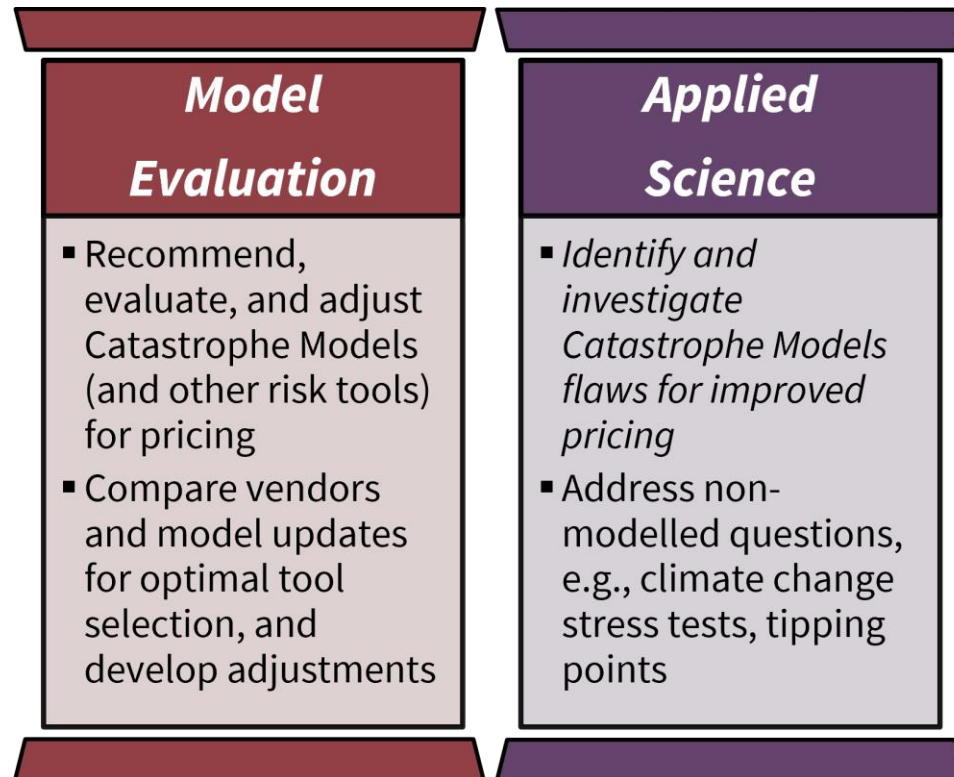


Role of the AXA XL Science and Natural Perils Team

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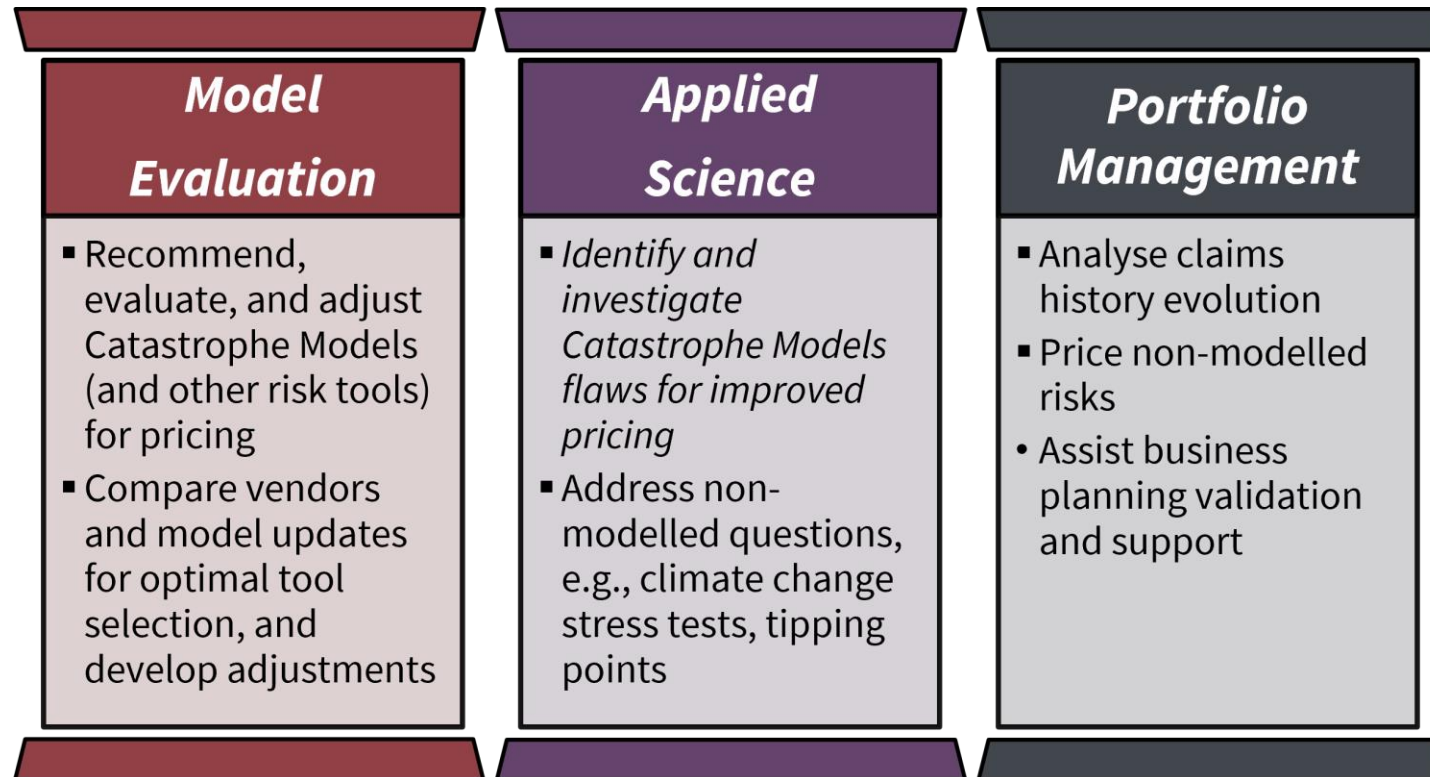


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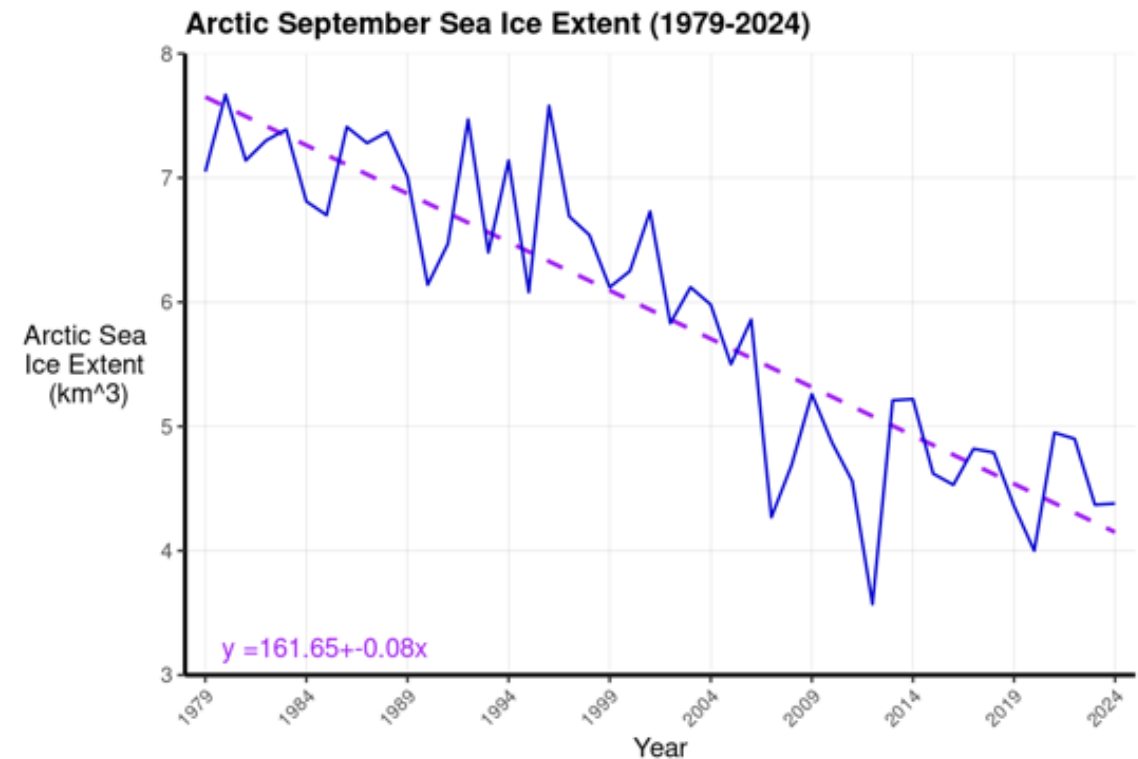
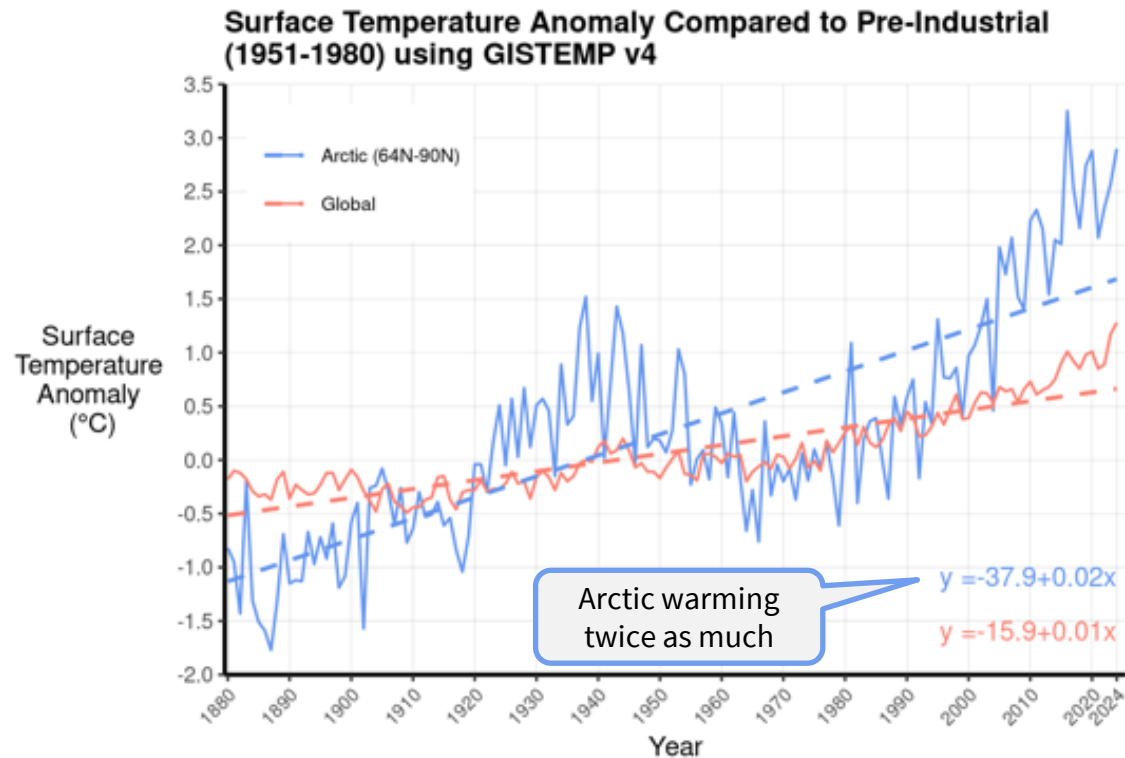
- **Business Objectives (Pillars):**



Arctic Cyclone Risk Motivation

Global Warming and Arctic Amplification

- Global warming has a **greater impact** on surface temperatures **in the Arctic** (*due to Arctic Amplification*)
 - Leading to great changes in the Arctic environment (e.g., decreasing sea ice extent)



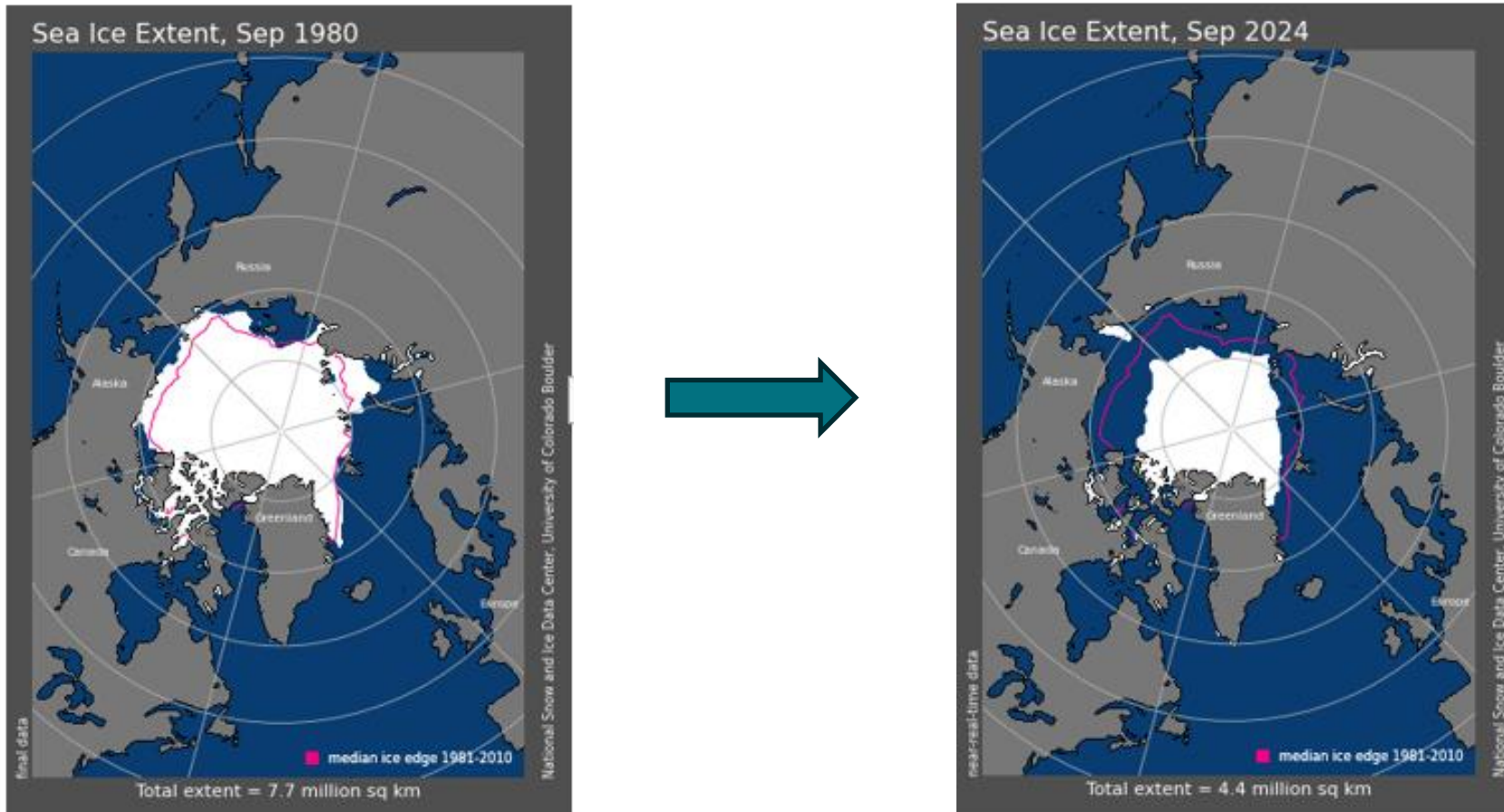
Consequences of Warming Arctic

- Has both **negative** and **positive** consequences for environment and society



Changing Arctic Sea Ice Extent

- Arctic Ocean is now **'open'** due to dramatic reductions in Arctic sea ice extent



Hazards include:

- **Cold temperatures**

- Risk to life
- Risk of equipment failure

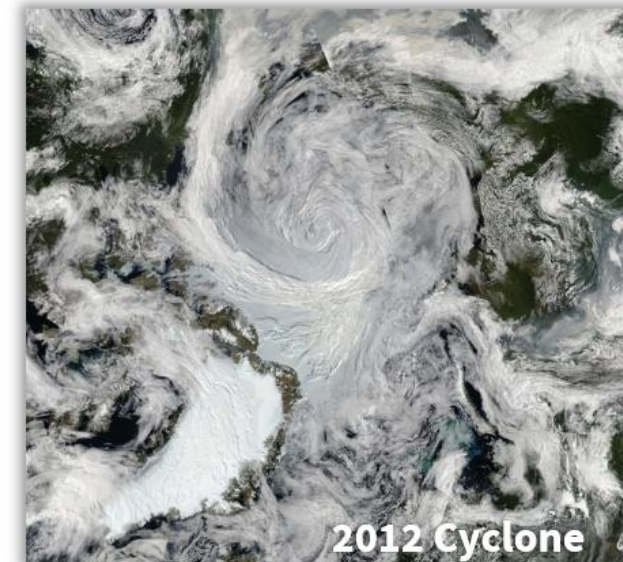


- **Sea Ice**

- Direct hit could damage ship
- Confines ships to travel near shallow coastlines

- **Cyclones**

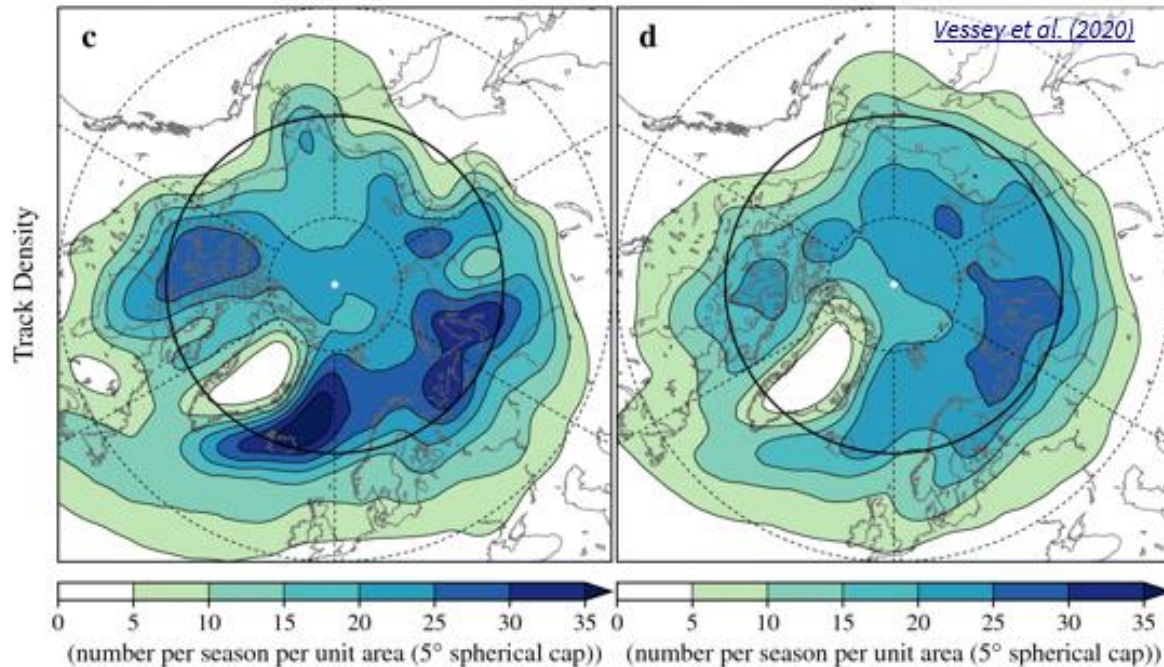
- Rough sea conditions (high wind and high ocean waves)
- Enhance break-up of sea ice that can drift and hit ships



Arctic Cyclone Spatial Density

- Arctic cyclone track density varies per season
 - Winter (DJF):** highest track density over **Norwegian and Barents Sea (Scandinavia)**
 - Summer (JJA):** highest track density over **Barents and Kara Seas (north Russia)**

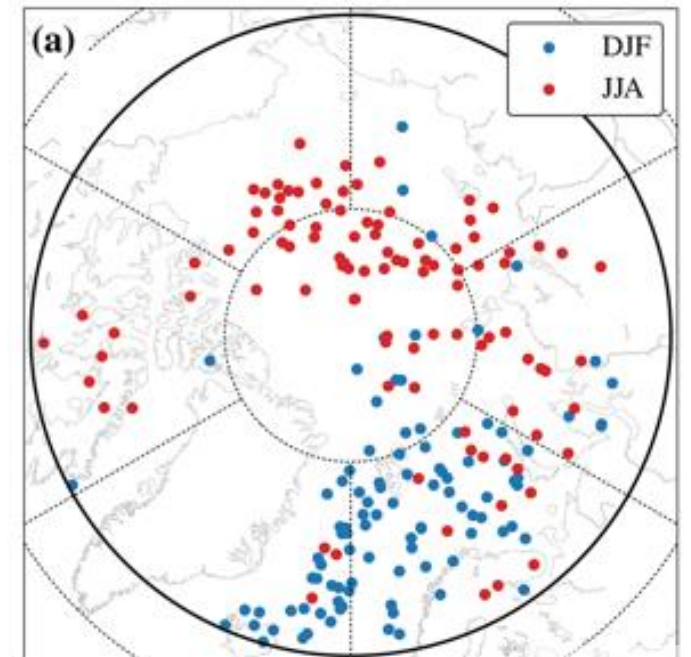
Track Density of **All** Arctic Cyclones



Winter (left) and summer (right) Arctic cyclones

[Vessey et al. \(2020\)](#)

100 Most Intense Arctic Cyclones



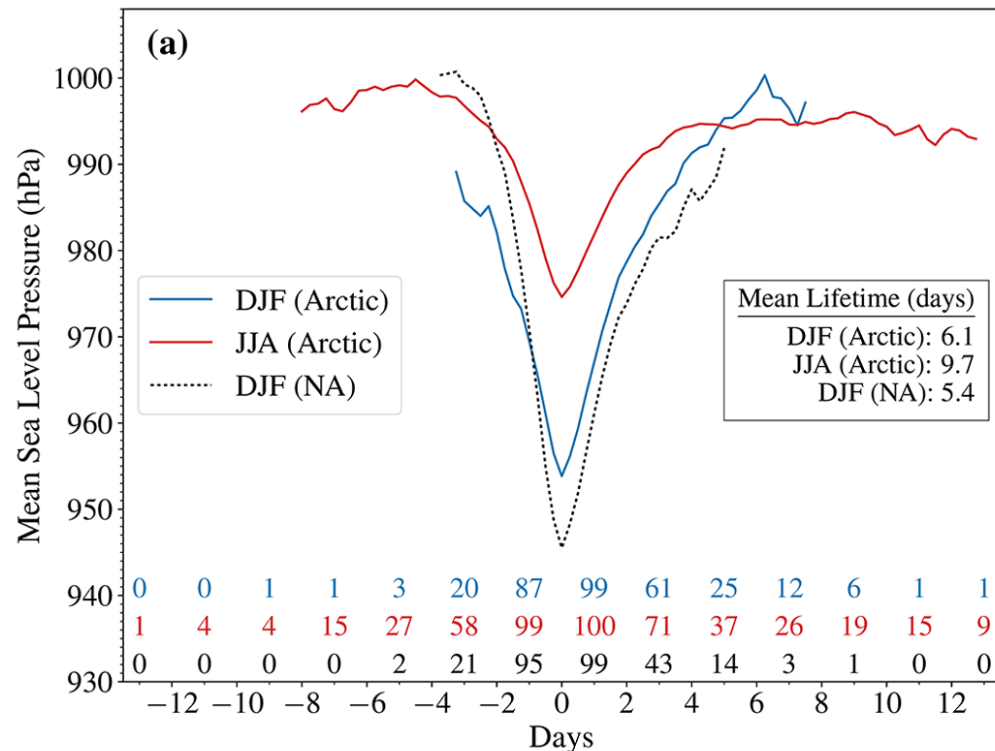
Location of max. 925 hPa wind

[Vessey et al. \(2022\)](#)

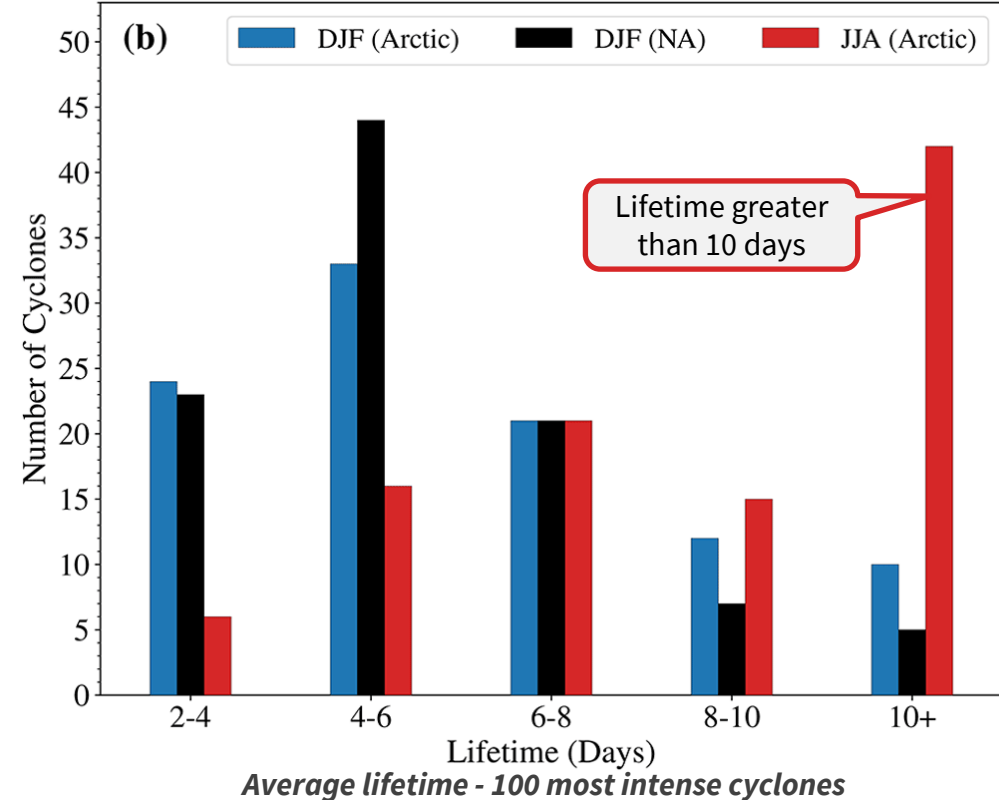
Arctic Cyclone Intensity and Lifetime

- Arctic cyclones are generally **weaker than North Atlantic (NA) ETCs**, more so in summer than in winter
- But, **summer Arctic** cyclones are much **longer-lived**

100 Most Intense Cyclones

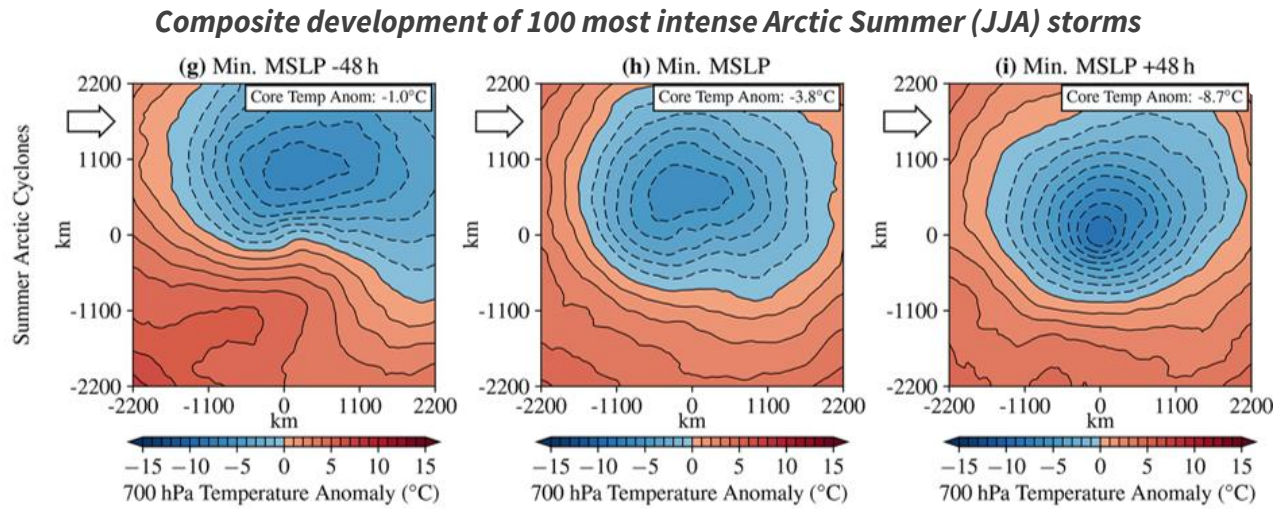
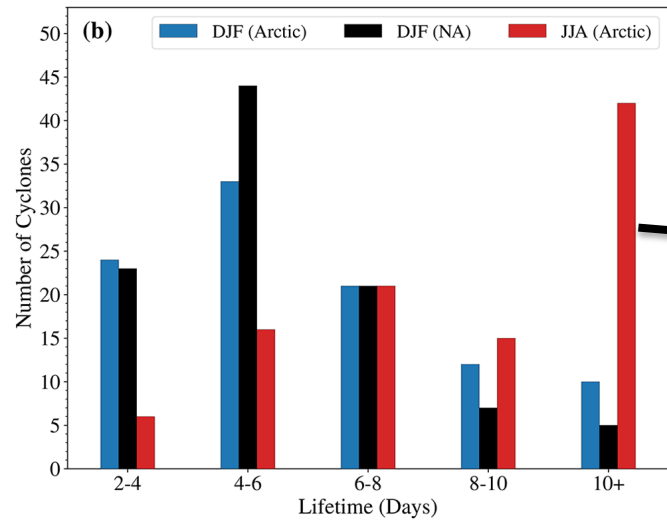


100 Most Intense Cyclones



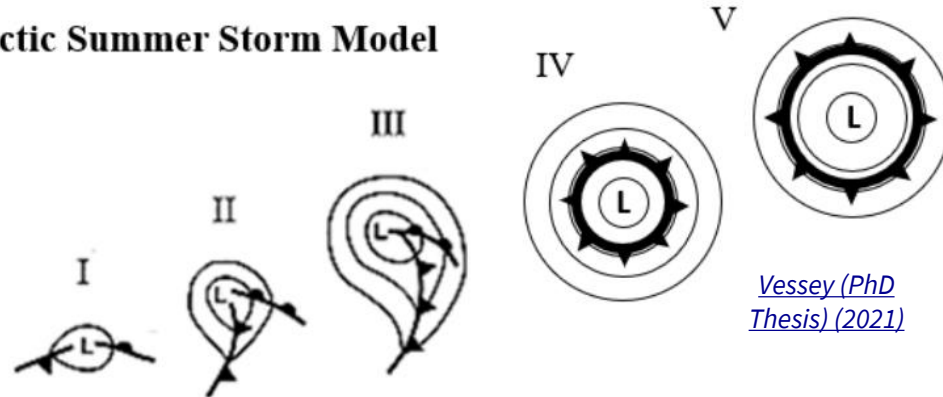
Arctic Cyclone Lifetime

- Intense summer Arctic cyclones have **different development cycle** to NA ETCs and winter Arctic cyclones
 - Unique structure found to be common in most Arctic summer cyclones in later publications (e.g., [Croard et al. 2023](#))



[Vessey et al. \(2022\)](#)

c) Arctic Summer Storm Model



[Vessey \(PhD Thesis\) \(2021\)](#)

■ Aims:

$$\text{Risk} = \text{Hazard} \times \text{Exposure} \times \text{Vulnerability}$$

- Examine Arctic shipping activity, incidents, and cyclone-induced damages, using public data

■ Research Questions:

1. Has Arctic sea ice reduction led to **a trend in ship numbers and incidents?**
2. Does Arctic **shipping distribution** change with **seasonal** sea ice extent variations?
3. How often do **cyclones cause shipping incidents/damage?**

■ My PhD was sponsored by AXA XL

- Will the Arctic pay-outs become more common in future?

■ Work published in [NHES - The risk of synoptic-scale Arctic cyclones to shipping](#)

Nat. Hazards Earth Syst. Sci., 24, 2115–2132, 2024
<https://doi.org/10.5194/nhess-24-2115-2024>
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Natural Hazards and Earth System Sciences 

The risk of synoptic-scale Arctic cyclones to shipping

Alexander Frank Vessey^{1,2}, Kevin I. Hodges^{2,3}, Len C. Shaffrey^{2,3}, and Jonathan J. Day⁴

¹AXA XL, 20 Gracechurch Street, London EC3V 0BG, United Kingdom

²Department of Meteorology, University of Reading, Earley Gate, Reading RG6 6BB, United Kingdom

³National Centre for Atmospheric Science, University of Reading, Earley Gate, Reading RG6 6BB, United Kingdom

⁴ECMWF, Shinfield Park, Reading RG2 9AX, United Kingdom

Correspondence: Alexander Frank Vessey (alexander.vessey@axaxl.com)

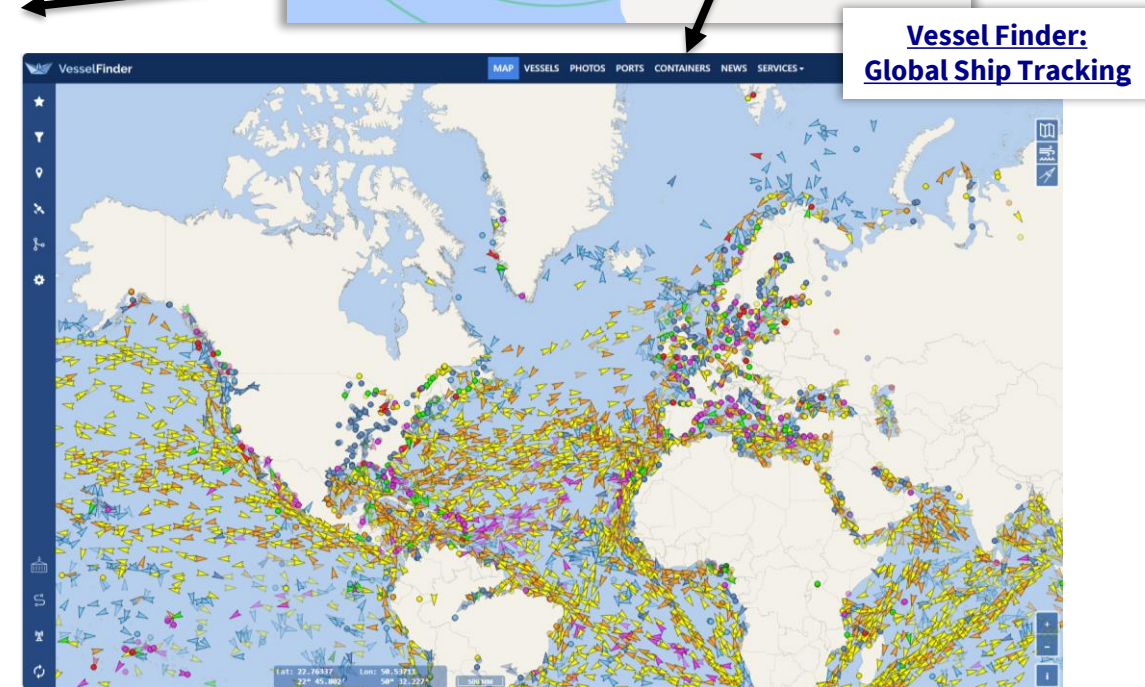
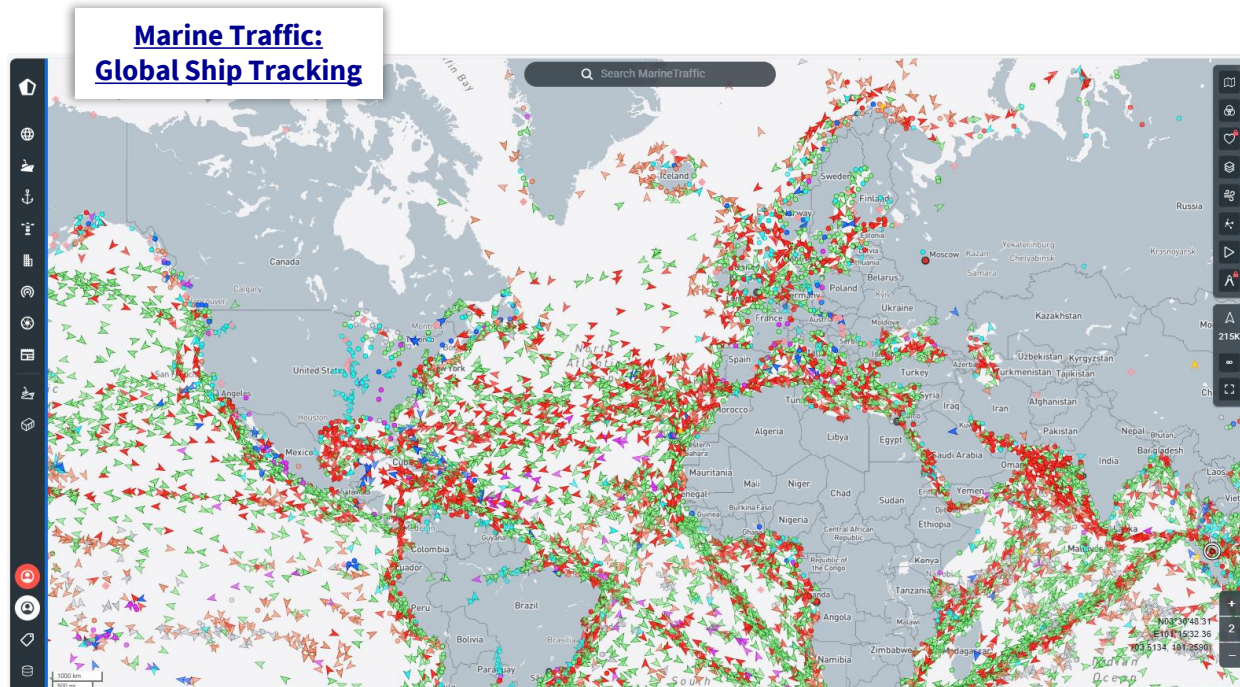
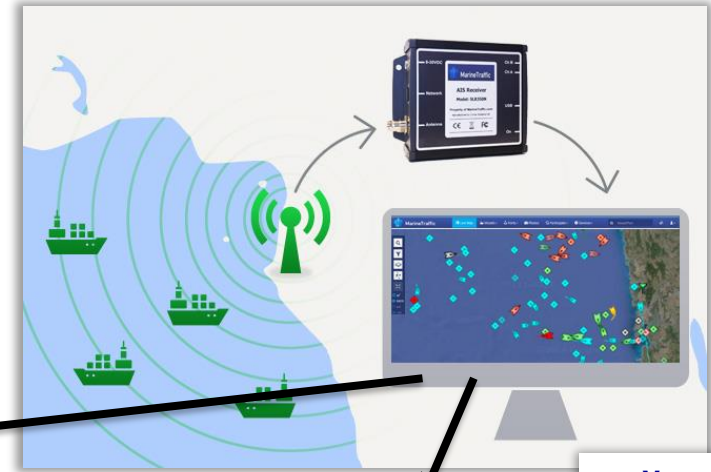
Received: 28 September 2023 – Discussion started: 9 November 2023

Revised: 3 April 2024 – Accepted: 10 April 2024 – Published: 27 June 2024

Methodology

Limitations to Quantifying Risk

- Ship tracks routinely collected through **Automated Information System (AIS)** transponders installed on ships for safety
- But such data is **often privatised** by various companies



■ Arctic Ship Tracks and Incidents:

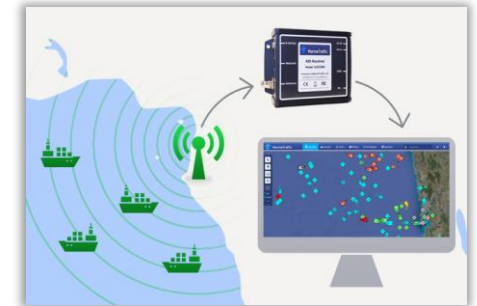
- [Berkman et al. \(2020\)](#) Arctic ship tracks derived from AIS transponders
 - Sept. 2009 to Dec. 2016
 - Filtered to 1-hourly to match ERA5
- [Arctic Council Compendium of Arctic Ship Accidents \(CASA\)](#) database of Arctic shipping incidents (2005-2017)

■ Cyclone Track:

- TRACK (*Hodges, 1994, 1995, 1999*) 850 hPa relative vorticity using 1-hourly [ERA5](#) (1979-2021)
- Add max. ERA5 'significant wave height including tide and surge' within 5° radius to track
- Filter to tracks travelling north of Arctic Circle (66.5° N) at any point

■ Cyclone and Ship Intersections

- Ship-cyclone intersect: if ship within 3° of cyclones' max. wave height (>2.5m)
- Incidents: if damage reported up to 48 hours after the passage of cyclone

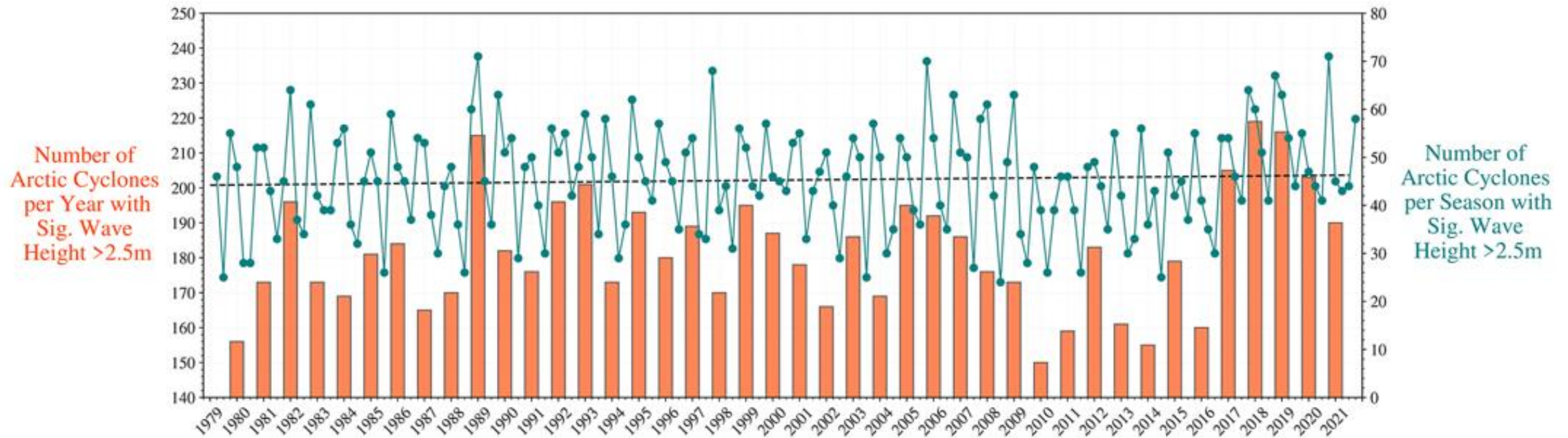


Results

Trends in Arctic Cyclones

- **No trends in Arctic cyclone number**
 - Interannual variability (highest: 1989, 2017-2020)
 - Seasonal variability (winter highest, lowest in summer)

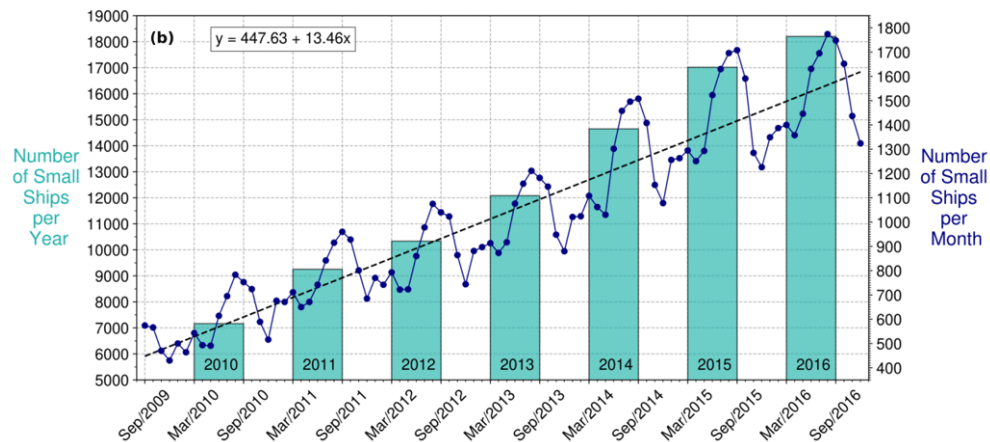
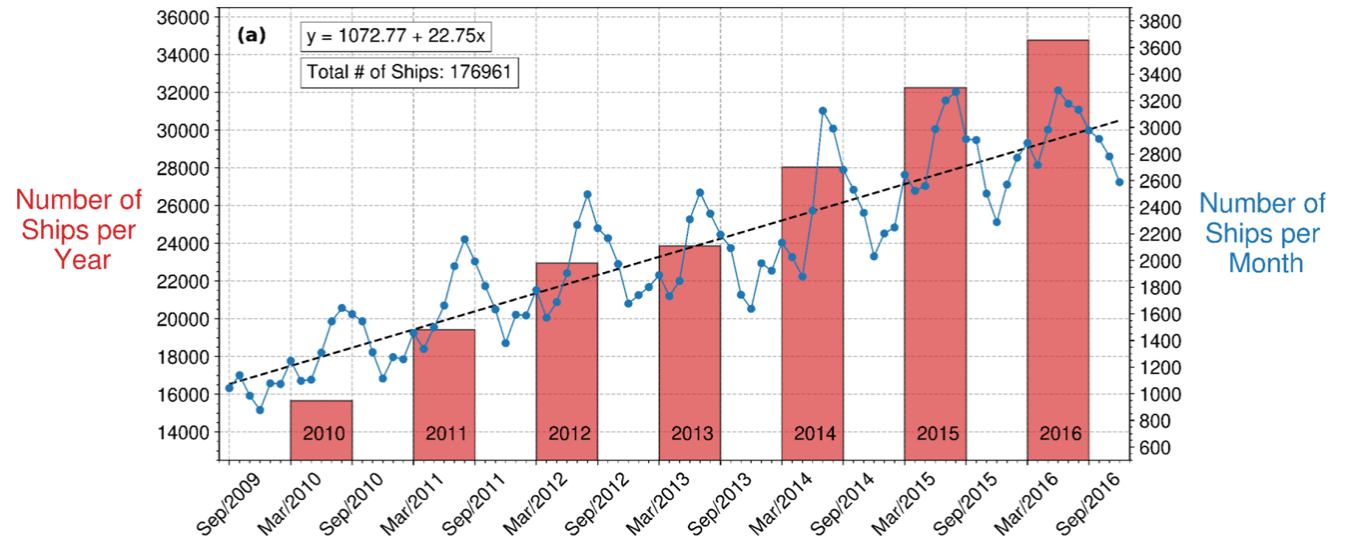
Annual and Seasonal Arctic Cyclone Count (significant wave height > 2.5 m)



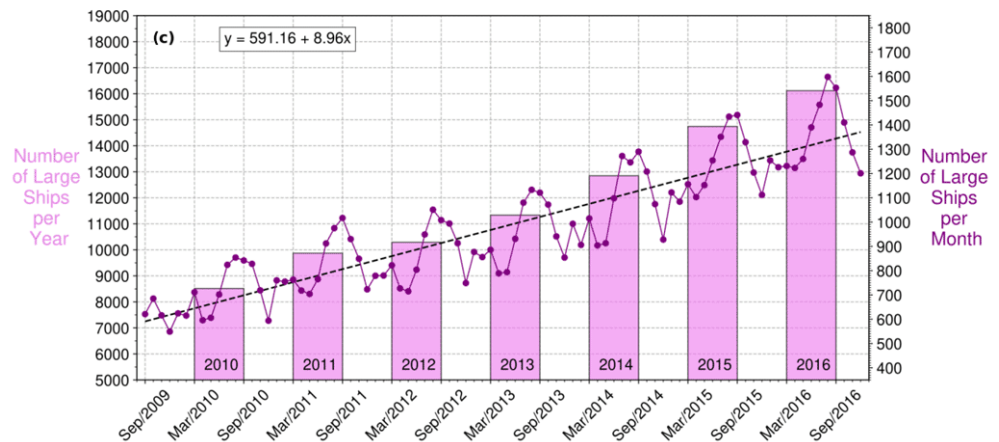
Trends in Arctic Shipping

- Number of ships using Arctic has **increased**
 - **2010:** ~15,800 ships
 - **2016:** ~34,700 ships **(+119%)**
- Considerable seasonal variability
 - **Highest** in **Sept.** when sea ice at min. extent
 - **Lowest** in **Mar.** when sea ice at max. extent
- **Greater** trend in number of **small ships**

Number of ships with unique identifier in Arctic per year



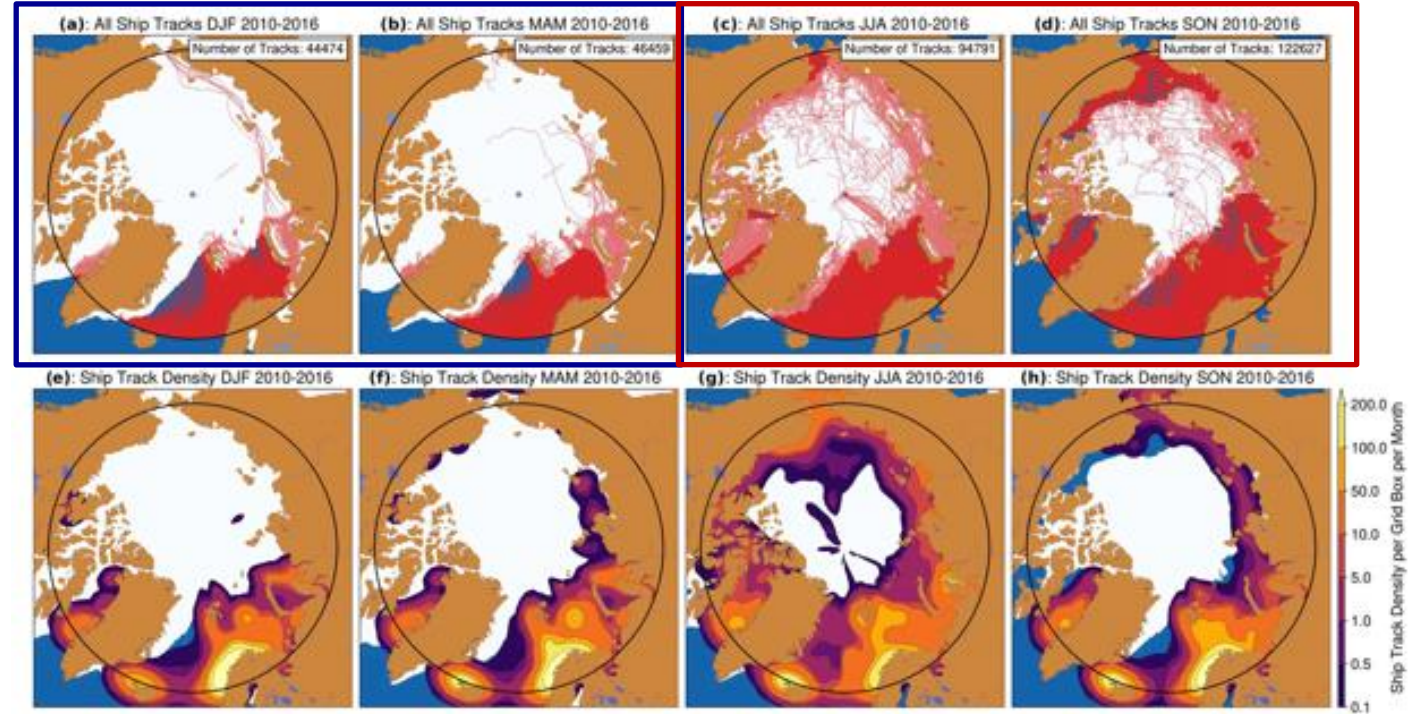
Small Ships



Large Ships

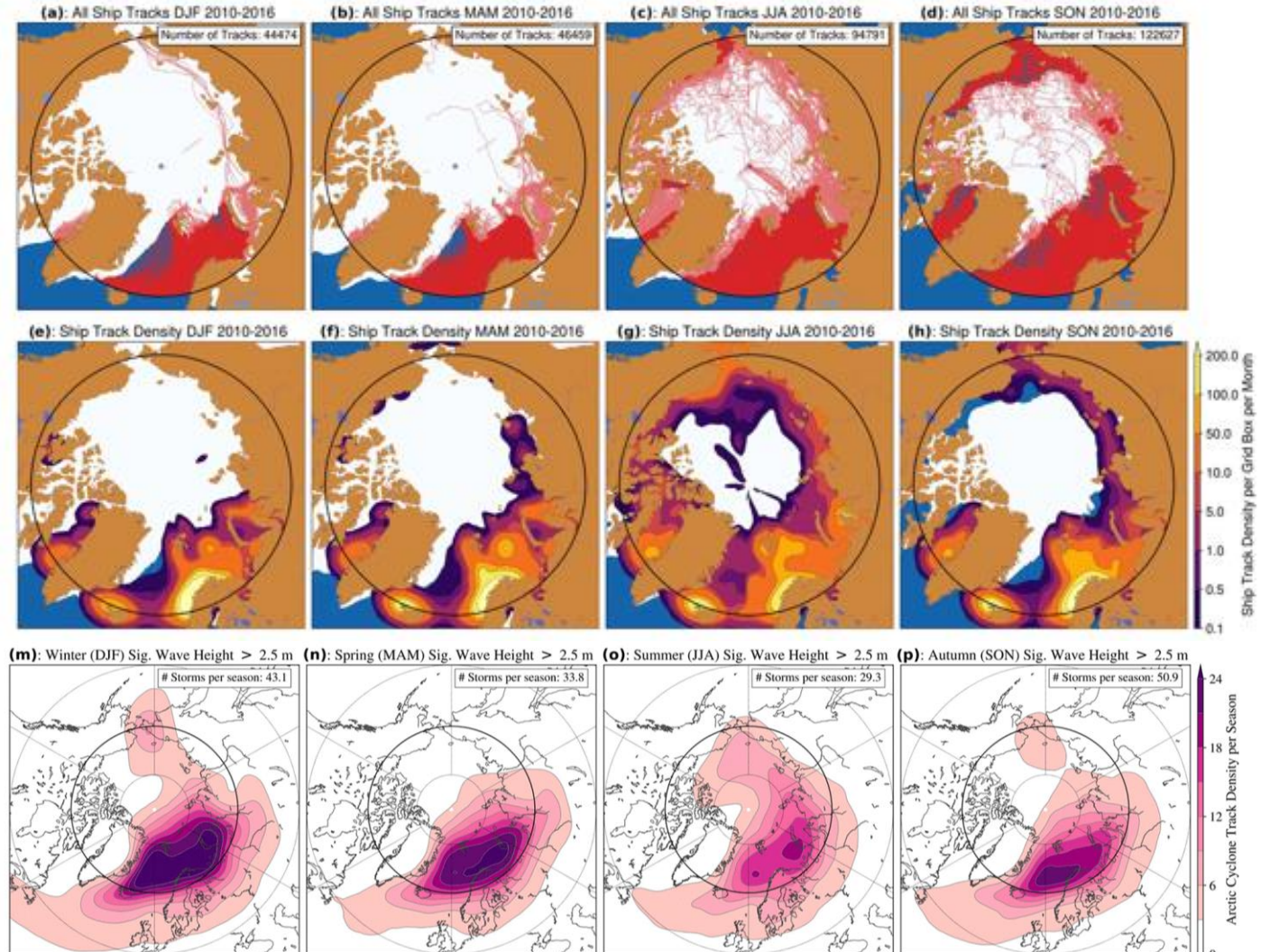
Spatial Variation in Hazard and Exposure

- Highest density of **ship tracks** in **Barents Sea** (Scandinavia) year-round
 - **Winter and Spring** shipping confined to ice-free Barents Sea
 - **Summer and Autumn** shipping includes some Northern Sea Route (Russia) and North-West Passage (Canada) transits



Spatial Variation in Hazard and Exposure

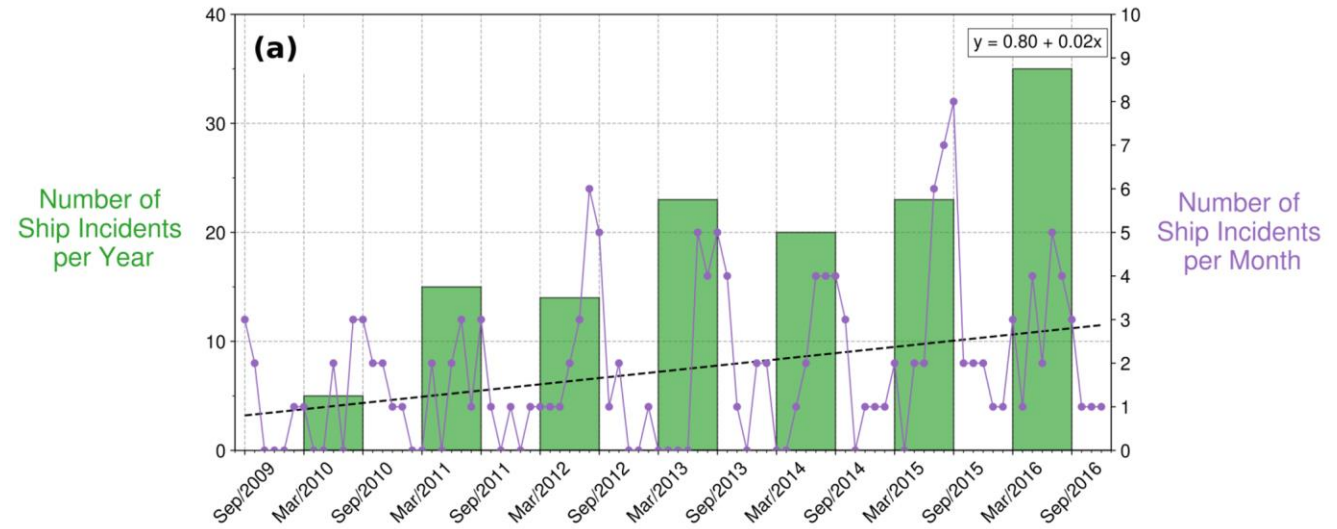
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 - Winter and spring shipping confined to ice-free Barents Sea
 - Summer and Autumn shipping includes some Northern Sea Route (Russia) and North-West Passage (Canada) transits
- Highest density of **intense cyclones** in **Barents Sea** (Scandinavia) every season
 - Highest in Autumn (50.9 cyclones per year)



Takeaway:
Where **exposure is highest** (Barents Sea), **density of intense cyclones is also highest**

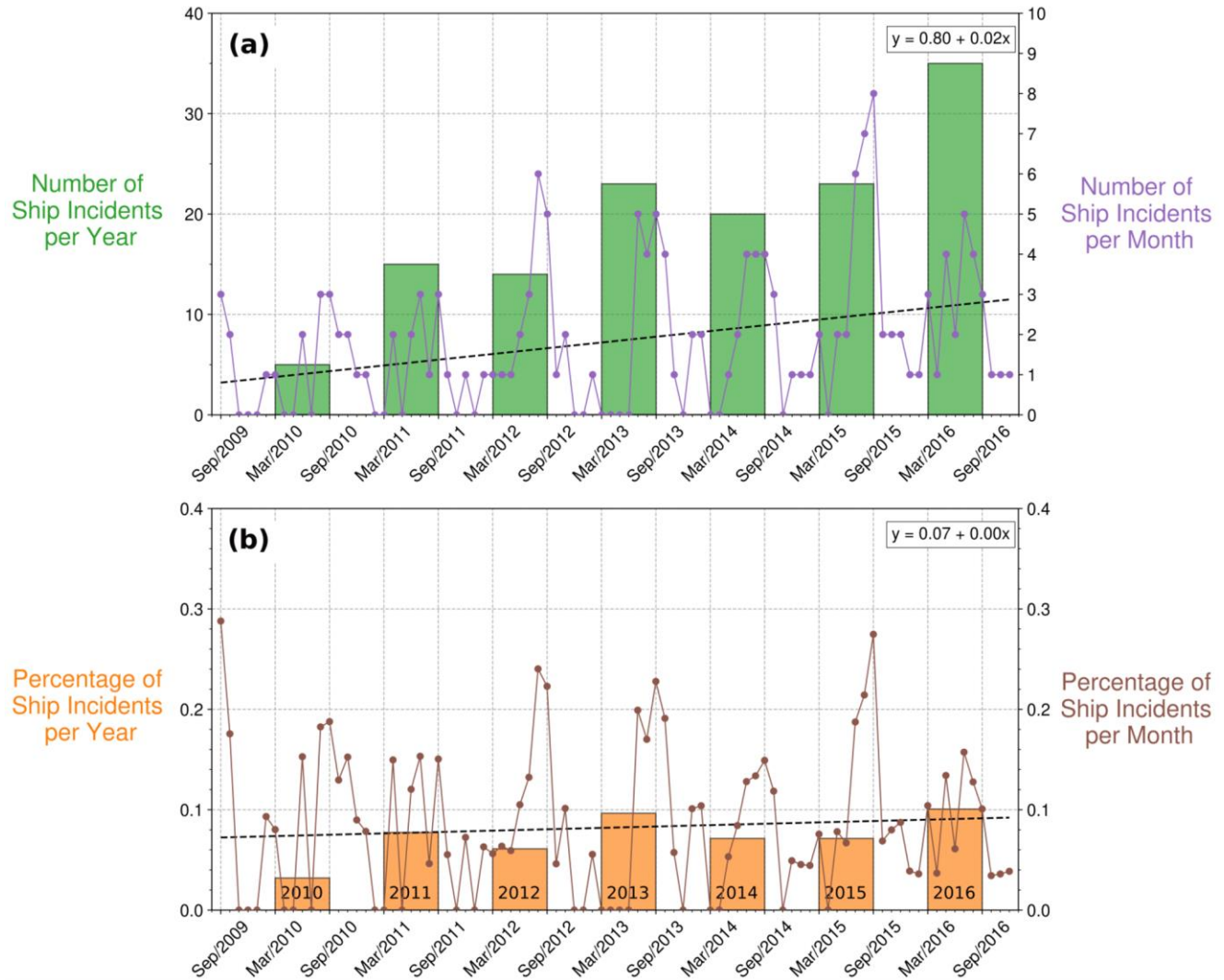
Trends in Arctic Shipping Incidents

- Number of Arctic shipping incidents **increased**
 - But generally low: **only 35 in 2016**



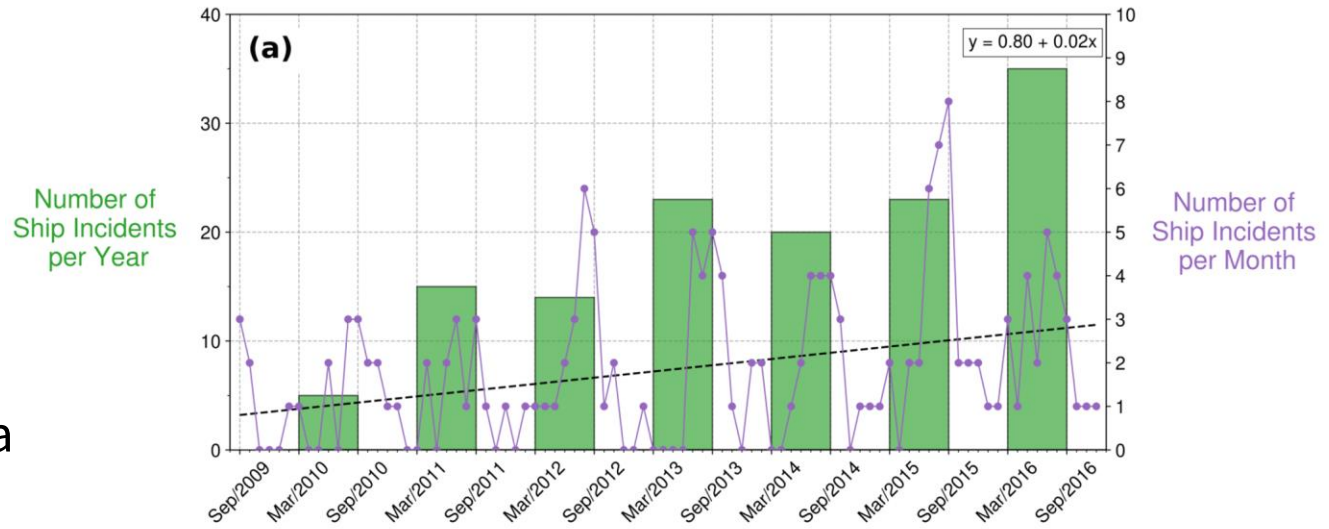
Trends in Arctic Shipping Incidents

- Number of Arctic shipping incidents **increased**
 - But generally low: **only 35 in 2016**
- As a % of total ship number, **~0.1%** of Arctic ships per year have an incident
 - 2016: 34,700 Arctic ships, but only 35 incidents

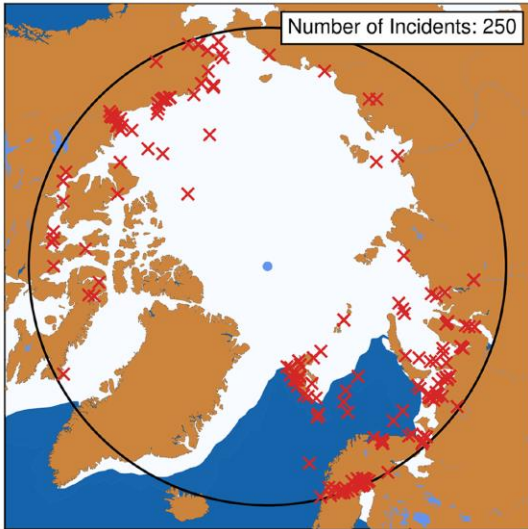


Trends in Arctic Shipping Incidents

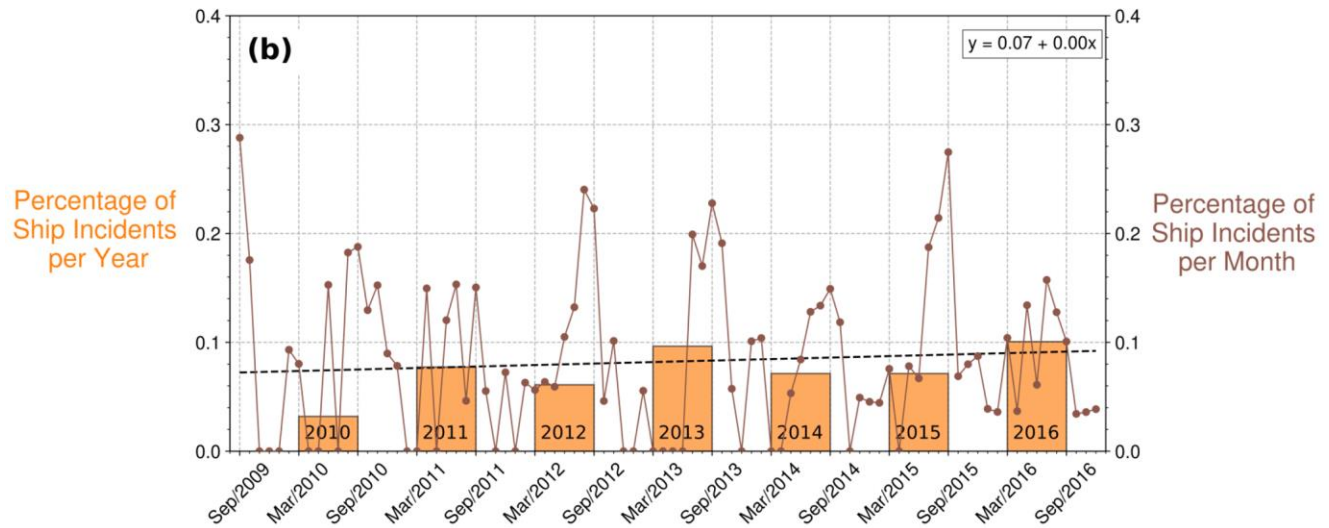
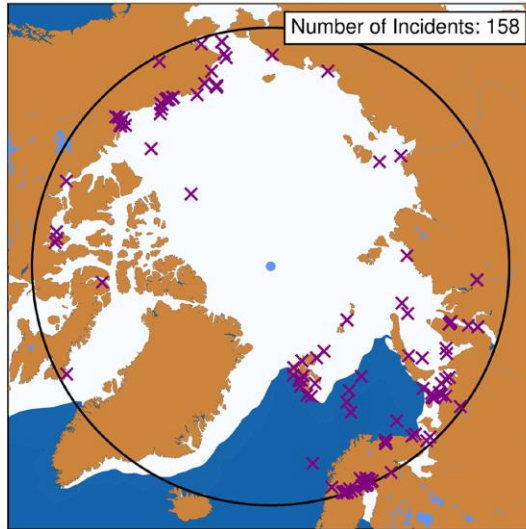
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 - But generally low: **only 35 in 2016**
- As a % of total ship number, **~0.1%** of Arctic ships per year have an incident
 - 2016: 34,700 Arctic ships, but only 35 incidents
- Incidents occur in Barents Sea, and north Alaska



(a) All Reported Shipping Incidents (2005-2017)



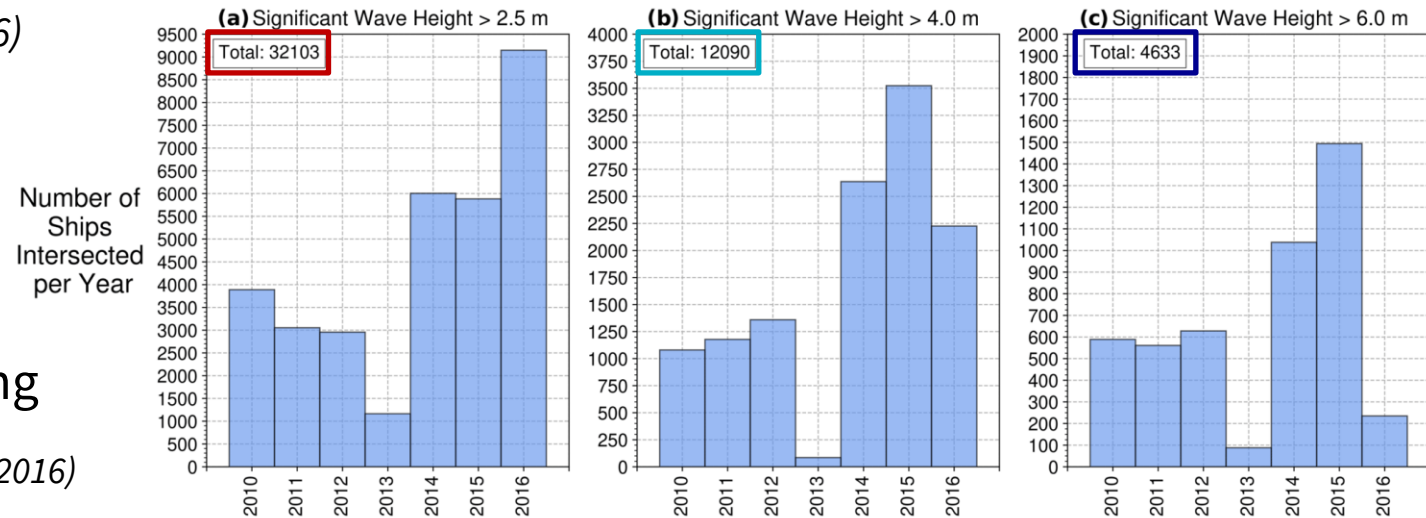
(b) All Reported Shipping Incidents (2010-2016)



Cyclones Intersecting Ships

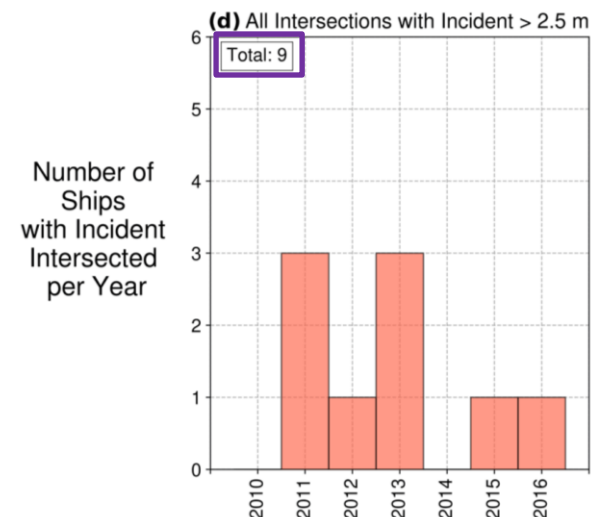
- Arctic cyclones frequently hit ships (2010-2016)
 - **32,103** unique ships hit (waves > 2.5 m)
 - **12,090** ships hit (waves > 4.0 m)
 - **4,633** ships hit (waves > 6.0 m)
- But only **9 incidents** were reported following the intersection of ships and a cyclone (2010-2016)

Number of unique ships impacted by cyclones with high waves



Takeaway:

Thousands of ships are **impacted** by intense Arctic cyclones, but **extremely few** lead to damages



Cyclones Intersecting Ships

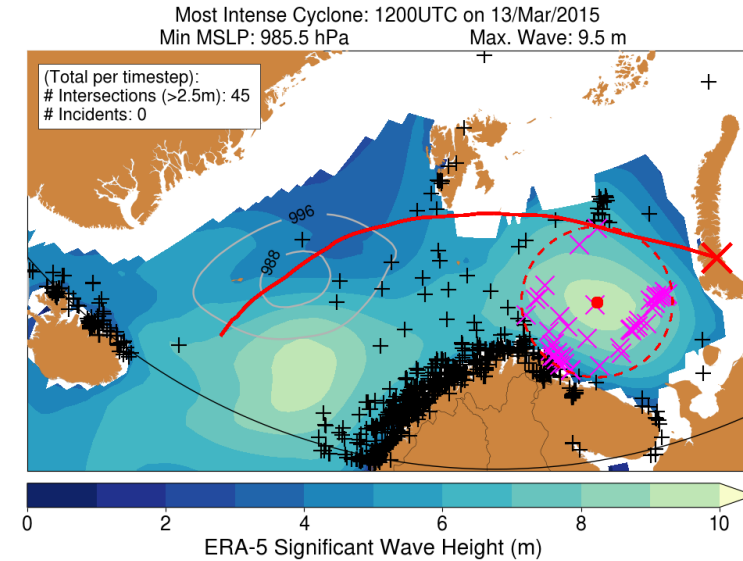
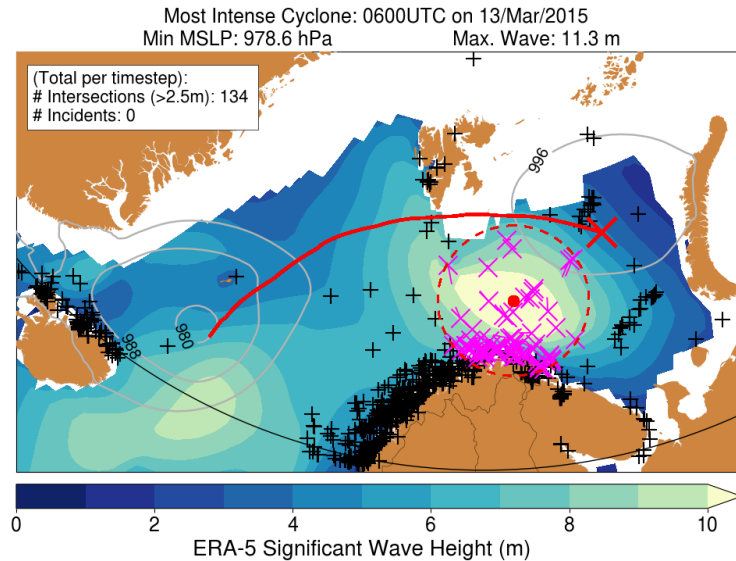
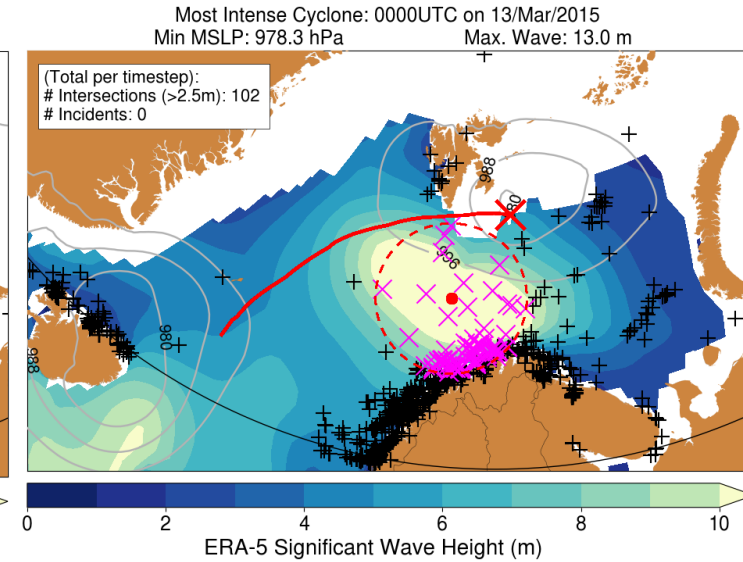
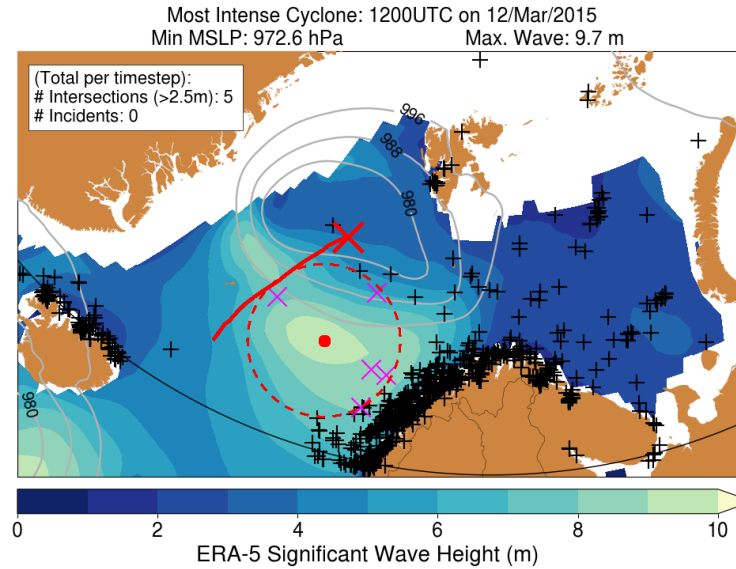
- Arctic cyclones frequently intersect ships but do not lead to reported damage

Ship-cyclone intersect:

if ship within 3° of cyclones max. wave height (>2.5m)

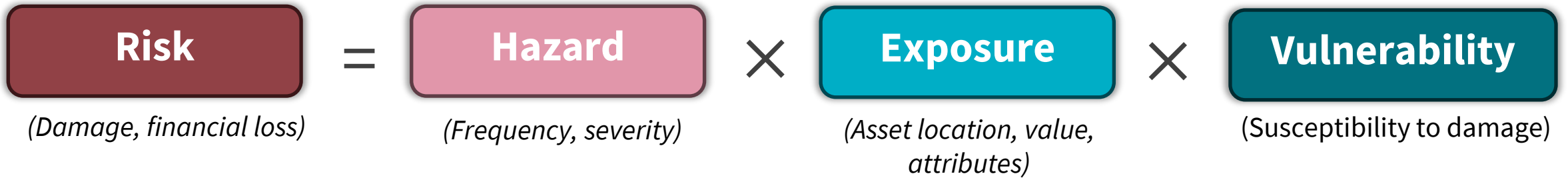
Note:

Hundreds of ships intersected by waves > 10m, but no reported damage



Conclusions

Conclusions



(Analysis indicates) **Arctic Cyclones:**

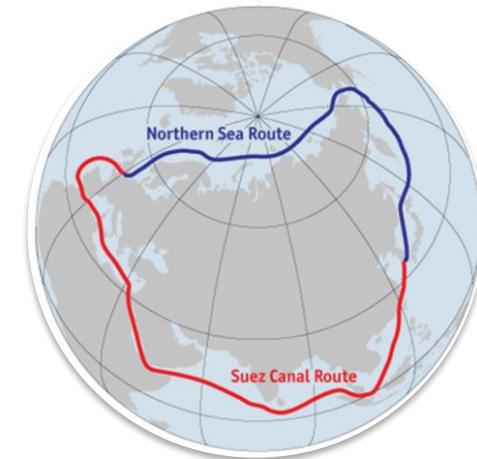
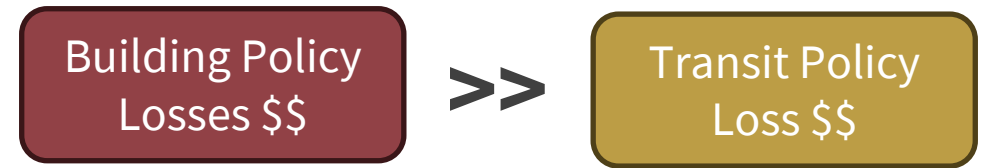


This study suggest:

Ship **vulnerability** to Arctic cyclones is **low**:
Ships are **built to withstand** rough sea conditions caused by Arctic cyclones
Or
Ships can **effectively navigate** Arctic cyclones given weather forecasts

Conversations with Marine Underwriters

- Two main marine insurance policy types:
 1. **Building Policies** - Insuring ports and warehouses
 2. **Transit Policies** - Insuring ship transits
- Mainly because **buildings are stationery** and **ships are mobile**
 - Also, ship vulnerability technology is more advanced than buildings
- Most Arctic cyclone losses (Scandinavia) covered by EUWS models
 - Unique vulnerability modifiers for marine buildings and their contents
- Limitations for future exposure growth:
 1. Infrastructure very limited in the Arctic
 2. Russia/Ukraine conflict – *sanctions limit exposure in Northern Sea Route*
 3. Shipping technology is advancing quickly
- Donald Trump – surge in Arctic oil exploration and exposure growth?



Conclusions

- Risk is changing globally
- AXA XL Science Team work to better understand global risks **through collaboration**
 - MSc / PhD Student Supervision
 - In-kind contributions to research projects
 - AXA XL Sponsored to research projects
- Contact: alexander.vessey@axaxl.com

**Thank you very much
for your attention**
Any Questions?



**Thank you
for your attention**