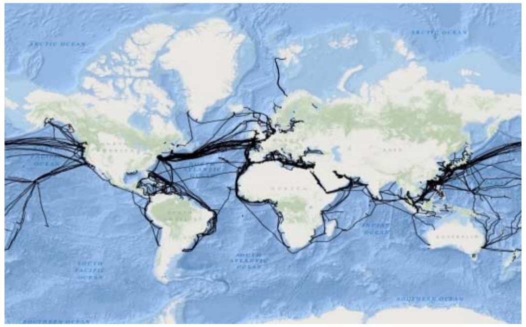
What threat do turbidity currents and submarine landslides pose to submarine telecommunications cable infrastructure?

Clare, M., Pope, E., Talling, P.J., Hunt, J.E., Carter, L. (m.clare@noc.ac.uk)

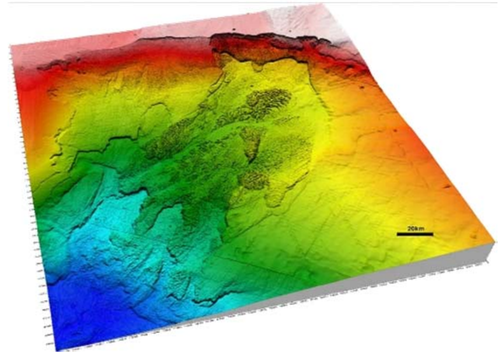
Click a text box for more information

Intro: Global Cable Network



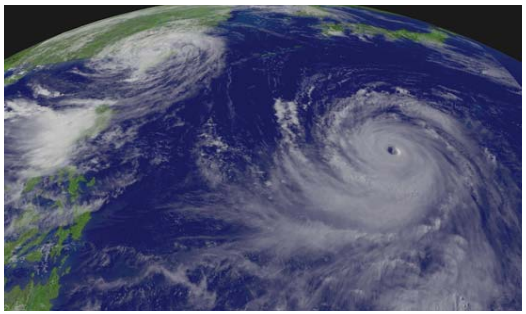
Cable Breaks by Marine Geohazards

Landslide and Turbidity Current Hazard

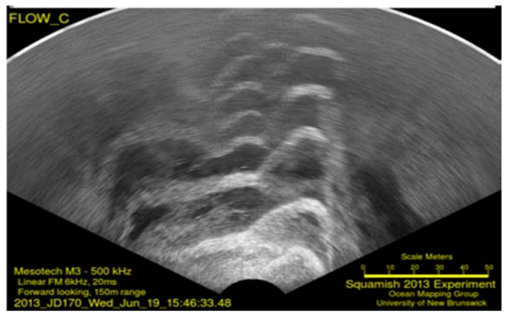


Earthquake Hazard

Tropical Cyclone Hazard



Conclusions & Monitoring of Marine Geohazards



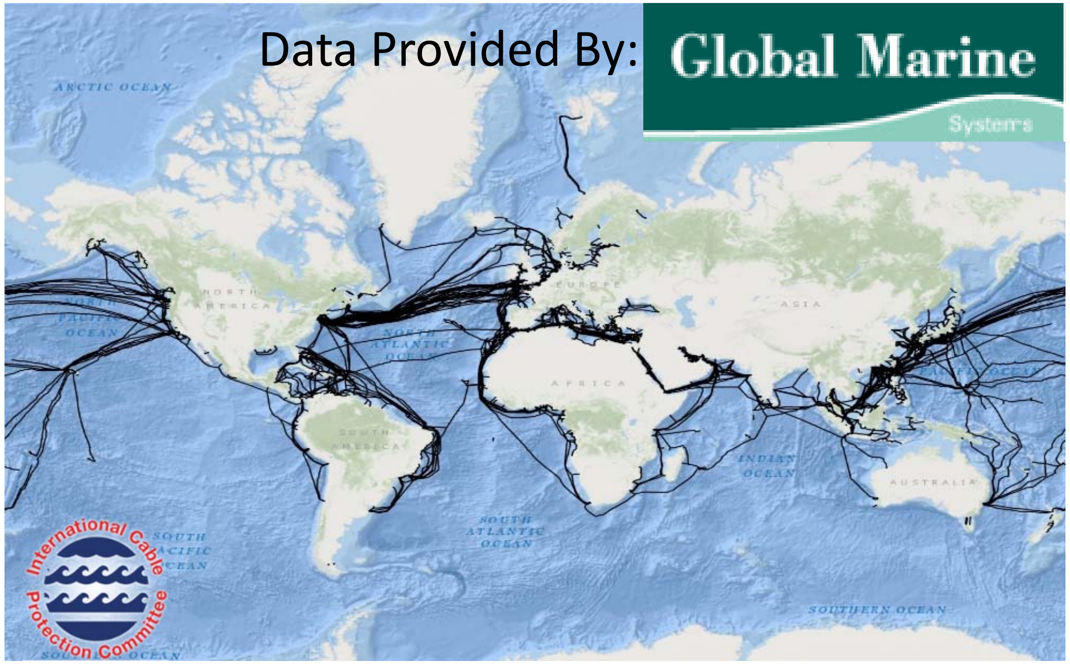
National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI
VICTORIA
UNIVERSITY OF WELLINGTON

Or click to begin in order…

A GLOBALLY IMPORTANT INFRASTRUCTURE NETWORK

- **Global economy relies on uninterrupted usage** of a network of telecommunication cables on the seafloor.
- These cables carry ~**99% of all digital data and voice communications** traffic **worldwide**.
- Over 9 million SWIFT banks transfers alone were made using these cables in 2004, (**$7.4 trillion/day** between 208 countries), growing to 15 million SWIFT transactions in 2014.
- Here, we present initial results from the first statistical analysis of a **global database of cable breaks and causes**.



Project funded by:

NATURAL ENVIRONMENT RESEARCH COUNCIL

Industry Partners:

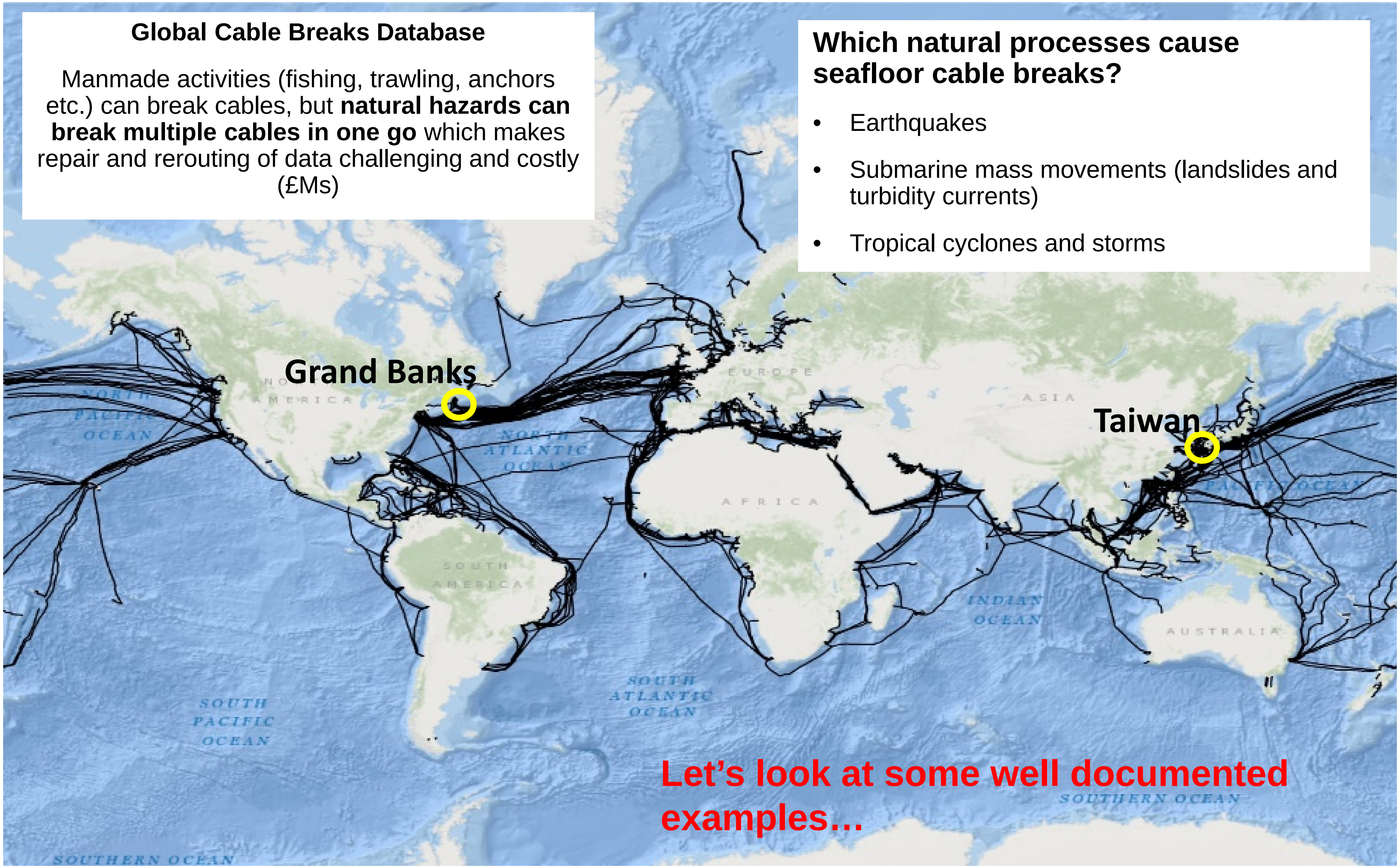
GCI
ConocoPhillips
ATKINS
HR Wallingford Working with water
Shell
Chevron
CATHIE ASSOCIATES
Scottish Water Always serving Scotland

Global Cable Breaks Database

Manmade activities (fishing, trawling, anchors etc.) can break cables, but **natural hazards can break multiple cables in one go** which makes repair and rerouting of data challenging and costly (£Ms)

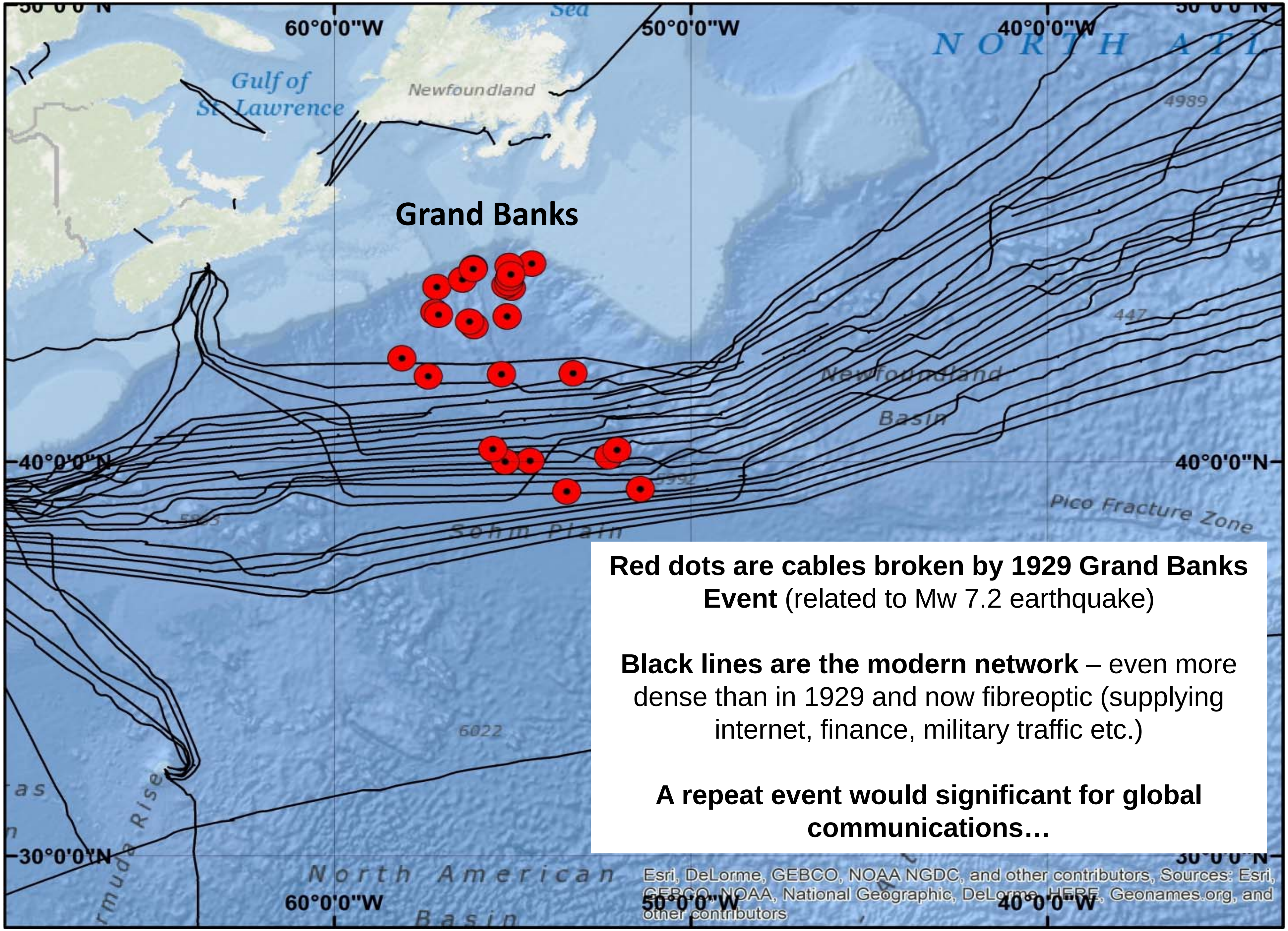
Which natural processes cause seafloor cable breaks?

- Earthquakes
- Submarine mass movements (landslides and turbidity currents)
- Tropical cyclones and storms



Let’s look at some well documented examples…

HOME
Global Cable Network
Marine Cable Breaks
Landslide & Turbidity Currents
Earthquake Hazard
Tropical Cyclone Hazard
Conclusions & Monitoring

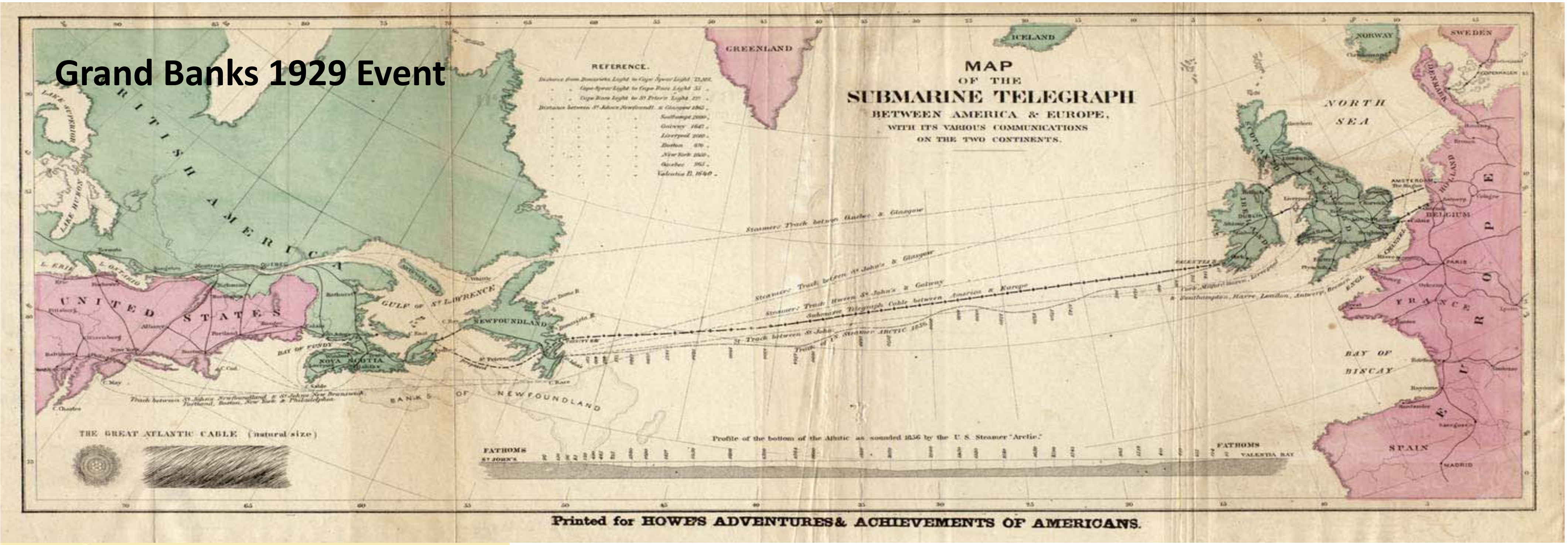


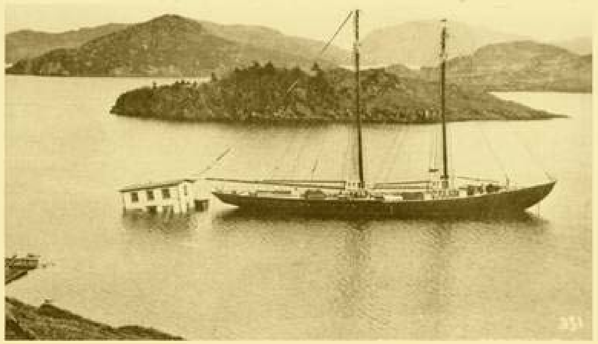
Red dots are cables broken by 1929 Grand Banks Event (related to Mw 7.2 earthquake)

Black lines are the modern network – even more dense than in 1929 and now fibreoptic (supplying internet, finance, military traffic etc.)

A repeat event would significant for global communications…

Grand Banks 1929 Event

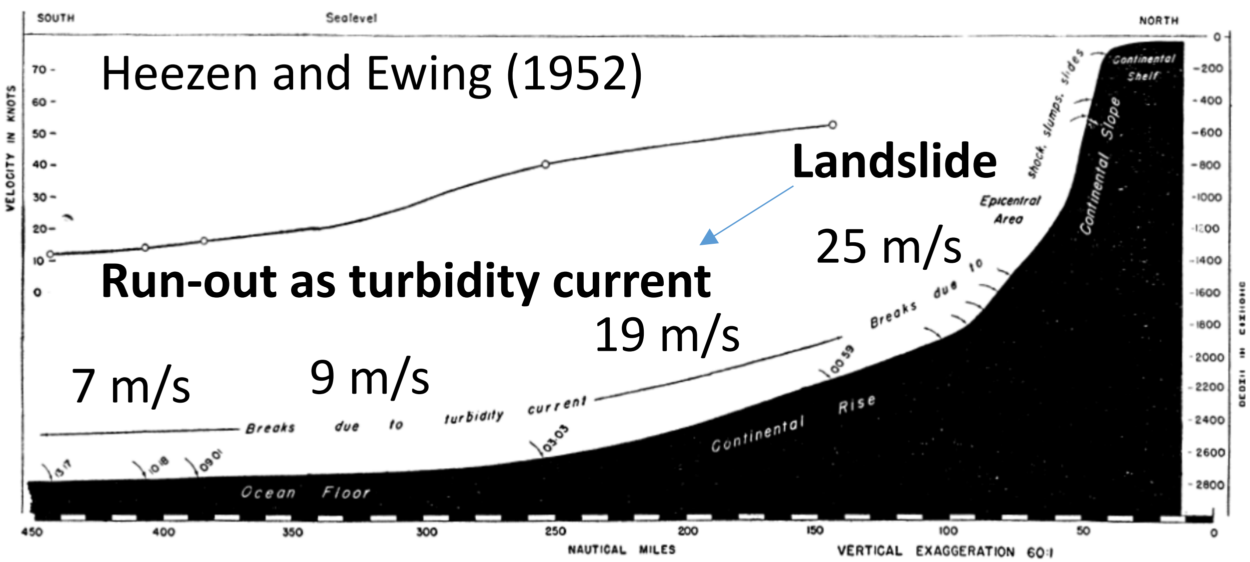




27* Dead in Newfoundland Tidal Wave

Wireless Report Brings News Of Great Disaster

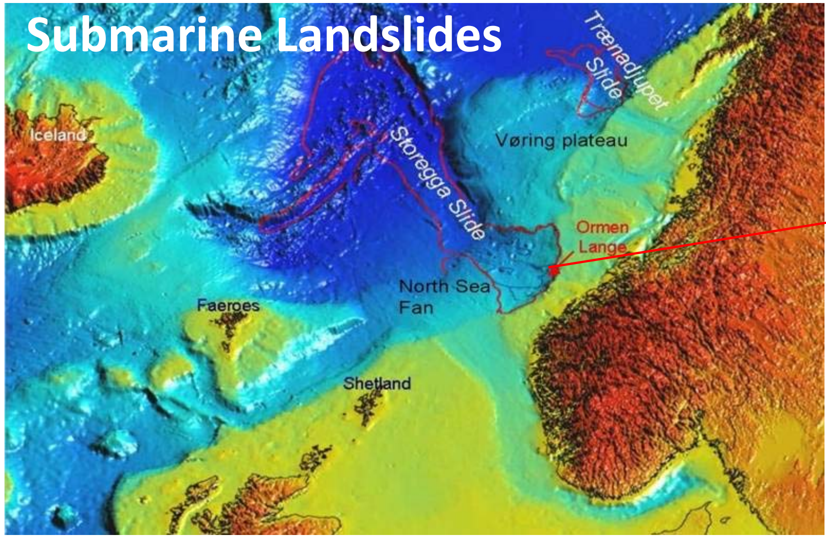
Women and Children Among Drowned—Building Swept Away—Communication Cut Off — Steamer Daisy Rendering Assistance



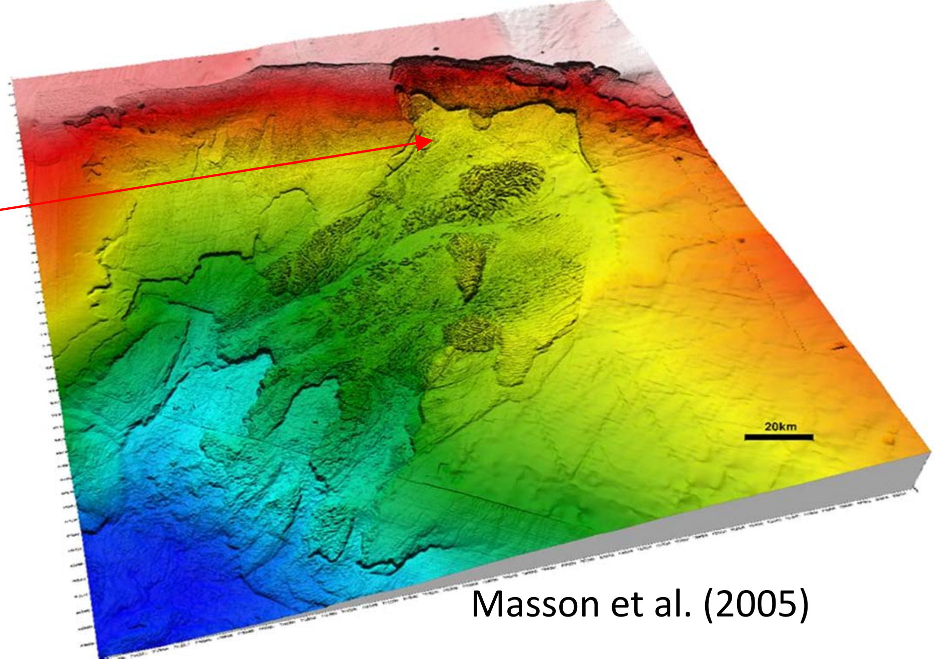
A sediment flow triggered by a Mw 7.2 earthquake in 1929, travelled up to 19m/s and broke 11 cables in the NE Atlantic, running out for ~800 km to the abyssal ocean

HOME | Global Cable Network | Marine Cable Breaks | Landslide & Turbidity Currents | Earthquake Hazard | Tropical Cyclone Hazard | Conclusions & Monitoring

Submarine Landslides

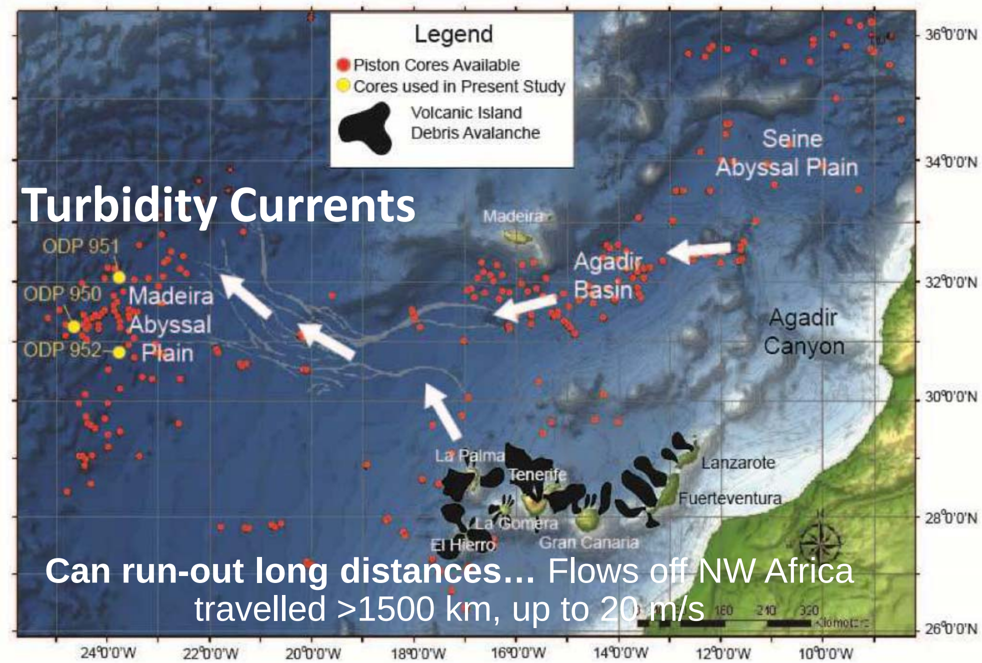


Can be very large… Storegga Landslide (8.2 ka), >3000 km3 of sediment, triggered a widespread tsunami



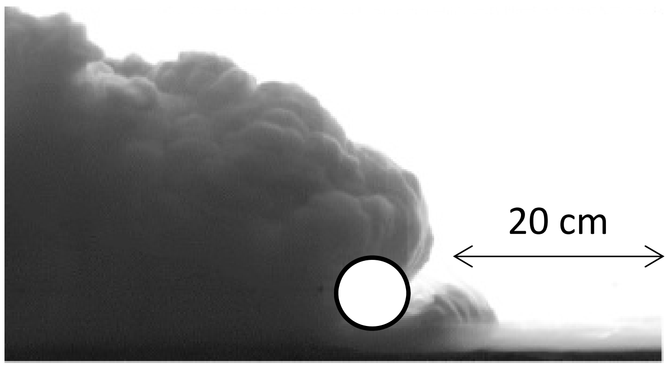
Masson et al. (2005)

Turbidity Currents



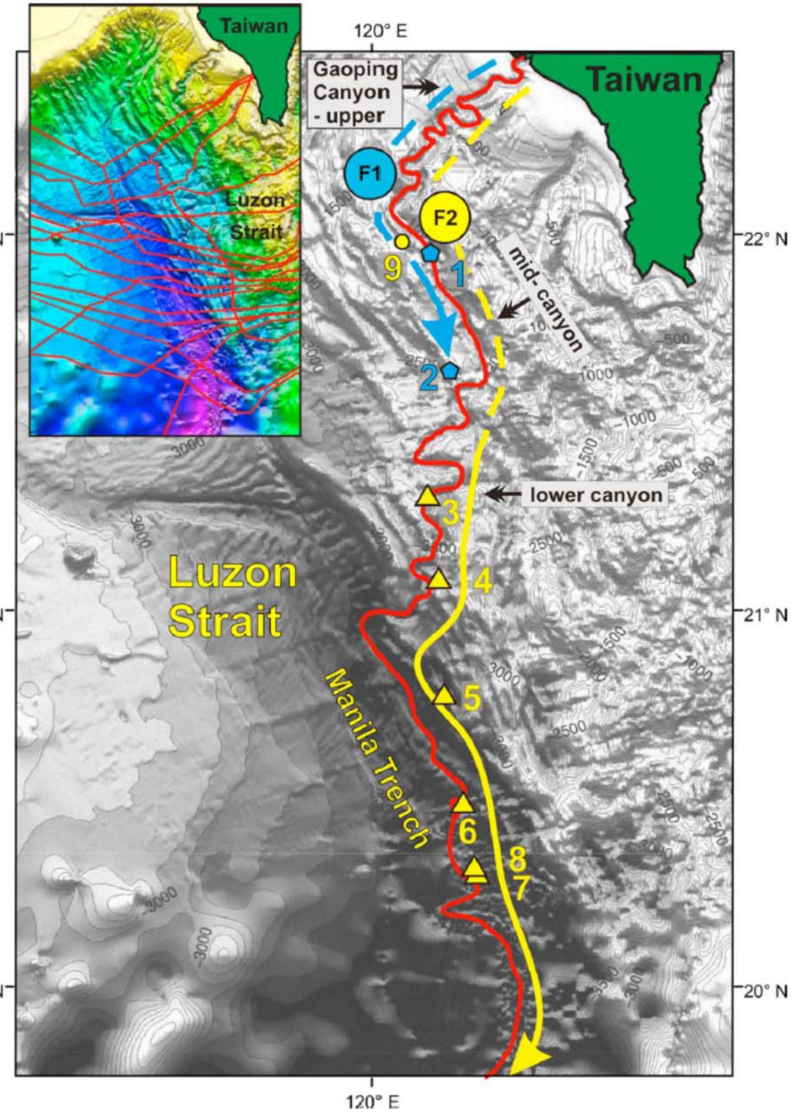
Can run-out long distances… Flows off NW Africa travelled >1500 km, up to 20 m/s

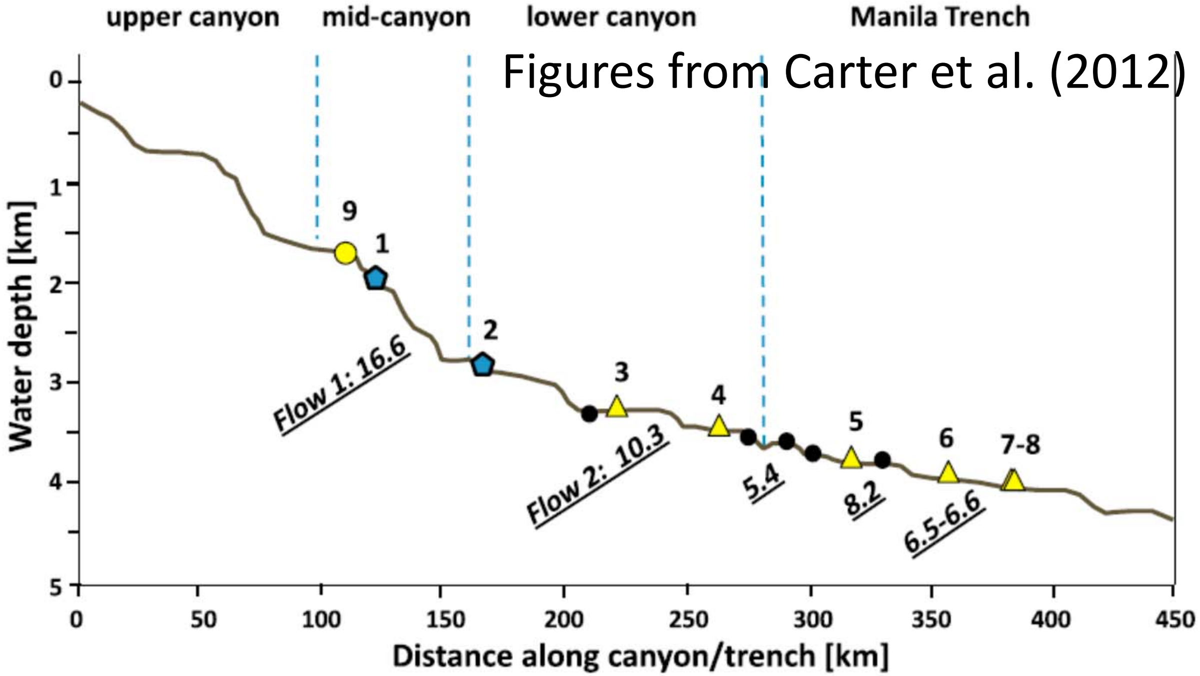
Talling et al. (2007, Nature)



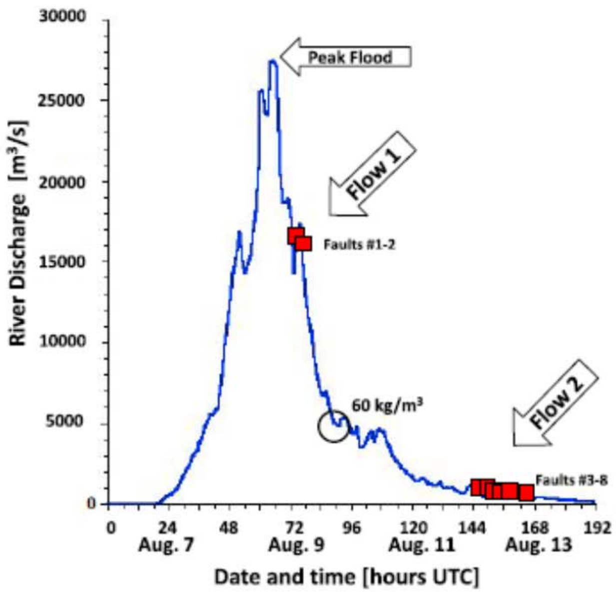
Clare et al. (2014)

But direct field measurements are very rare, most of what we know is based on deposits and scaled-down experiments





Figures from Carter et al. (2012)



Pingtung earthquake (2006) and Typhoon Morakot (2009) triggered a sediment flow (**up to 20 m/s**) that broke up to 22 cables offshore Taiwan over a distance of 450 km

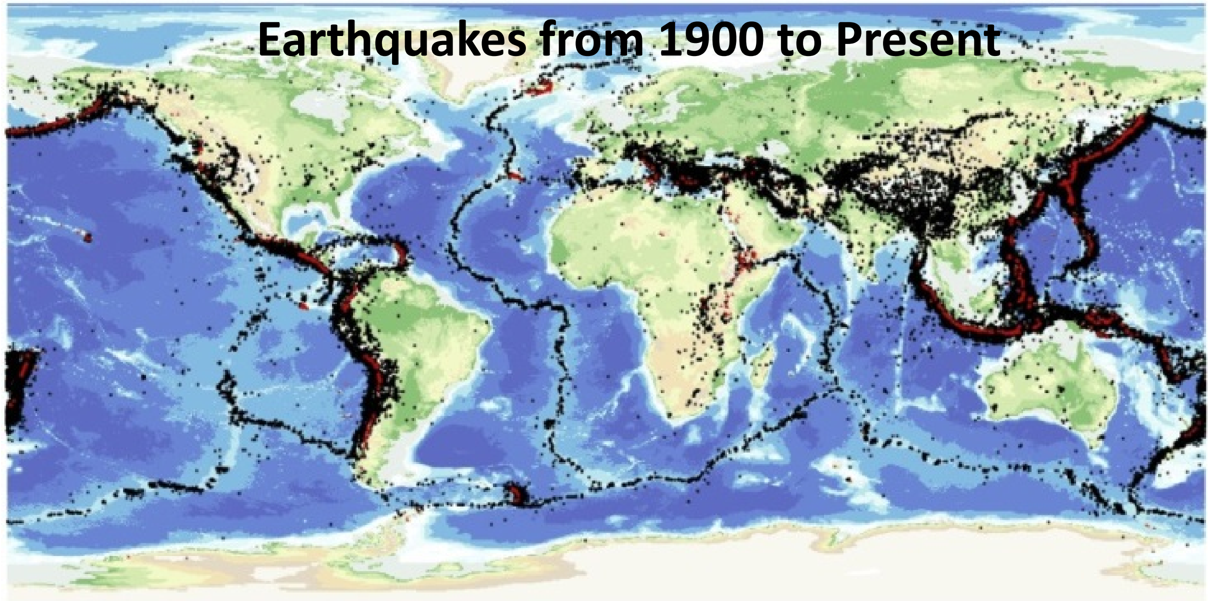
Which earthquakes trigger damaging submarine mass movements?

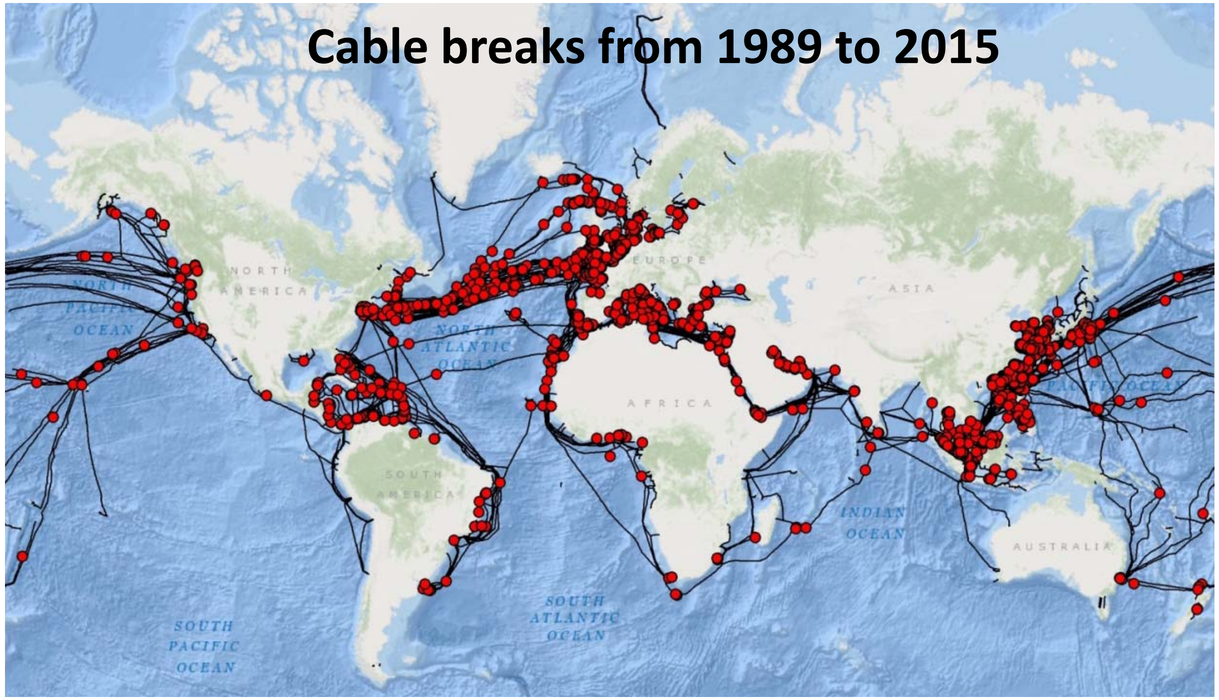
113 individual earthquake-related break events

13 earthquake swarm-related break events

71 break events in Taiwan alone!

Note: A break event may relate to multiple individual cable ruptures during one earthquake





Contents lists available at ScienceDirect

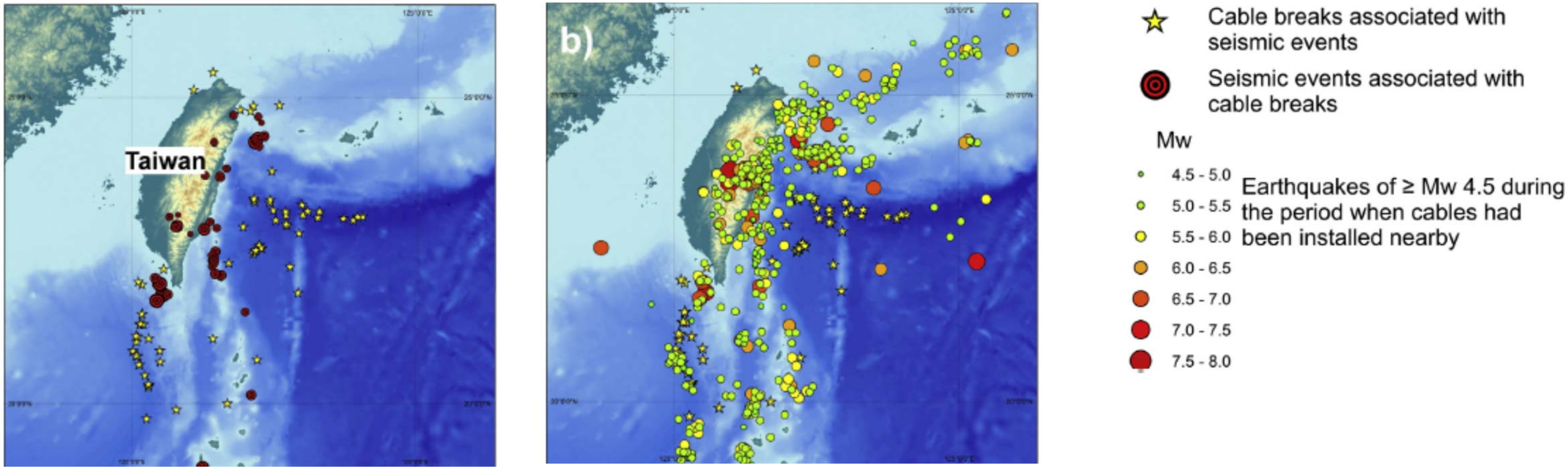
Marine Geology

journal homepage: www.elsevier.com/locate/margo

Which earthquakes trigger damaging submarine mass movements: Insights from a global record of submarine cable breaks?

Ed L. Pope [a,*], Peter J. Talling [a], Lionel Carter [b]

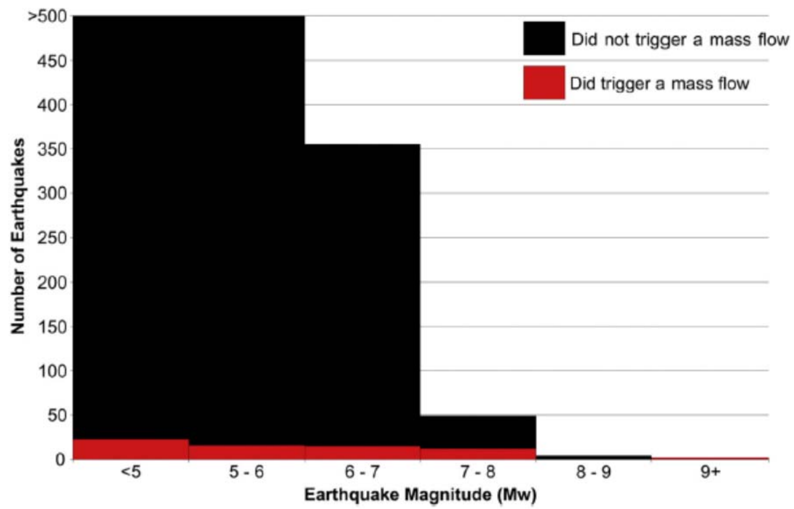
[a] National Oceanography Centre, Southampton, European Way, Southampton SO14 3ZH, UK
[b] Antarctic Research Centre, Victoria University of Wellington, Wellington, New Zealand

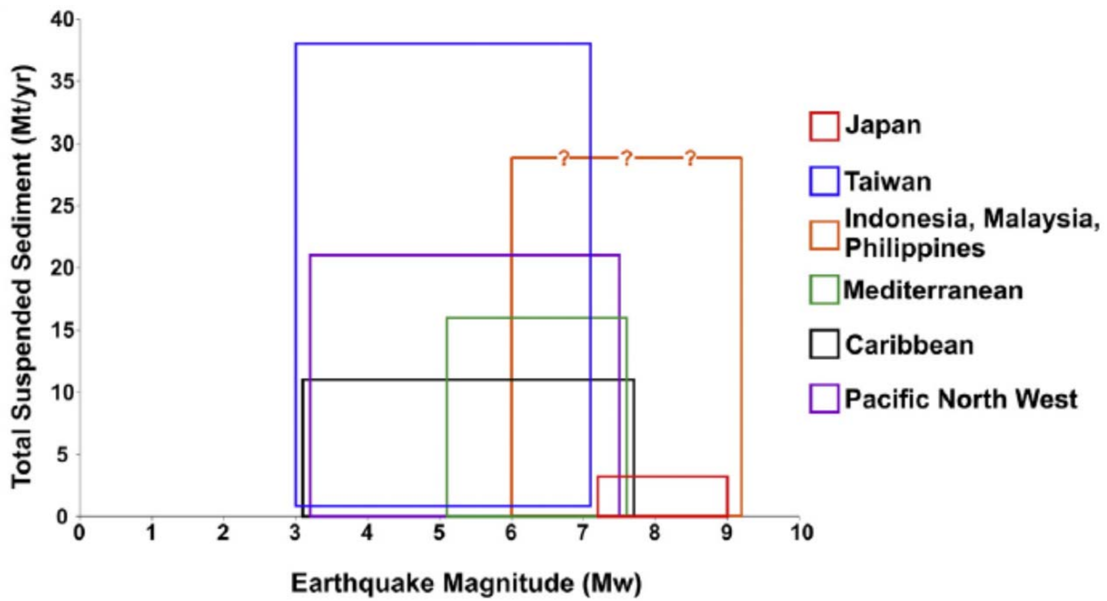


Analysis of global breaks database reveals:

1) **No obvious earthquake magnitude** which will trigger a submarine mass movement

2) Relationship between earthquake **magnitude**, peak ground **acceleration** and **triggering** of mass flow events **varies on a regional basis**
   e.g. In some areas <Mw 3.0-5.0 quakes can trigger mass flows, while in others mass flows can only be triggered by large events (>Mw 7.0)





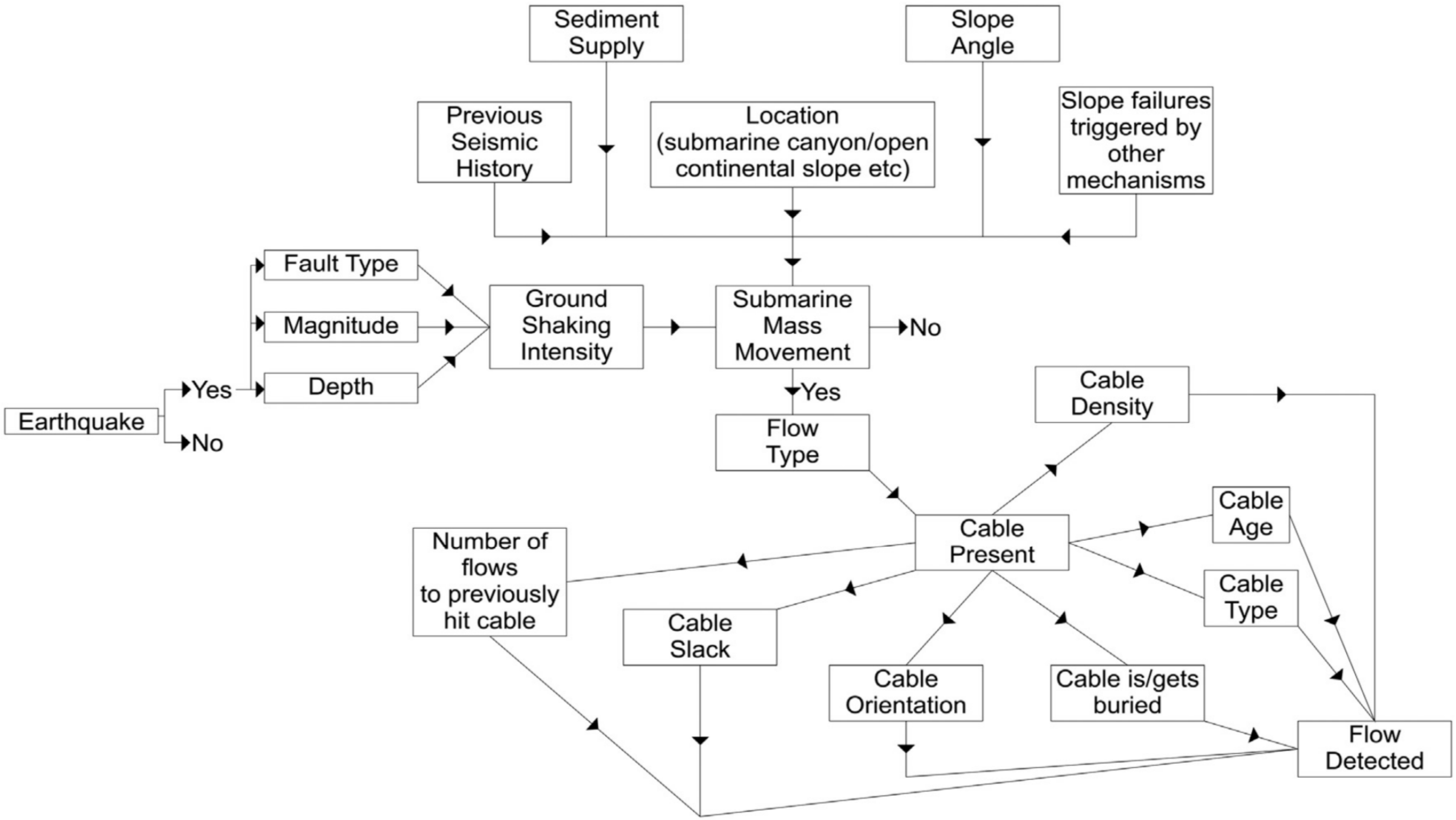
Conditions under which cable breaks were recorded

3) **Not all >Mw 7.0 earthquakes trigger cable-breaking flows** (see above), thus not all major earthquakes may produce powerful flows that cover large areas

- Only 15 of 56 earthquakes above MW 7.0 produced mass flows that broke cables

Sediment supply (left) is as important as earthquake magnitude as it effectively preconditions the system to failure

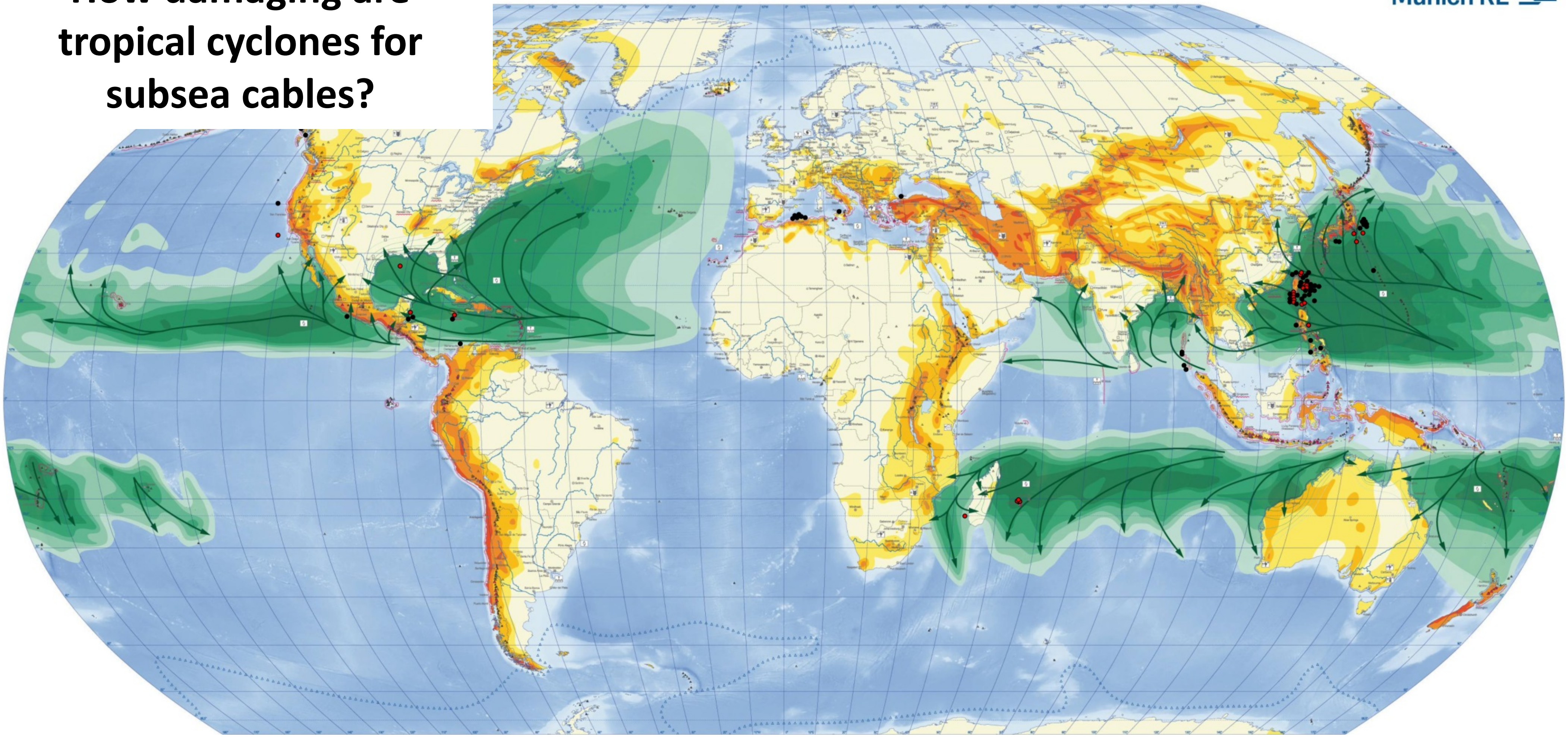
Earthquake triggered cables breaks – not a straightforward issue!



Pope et al. (2016)

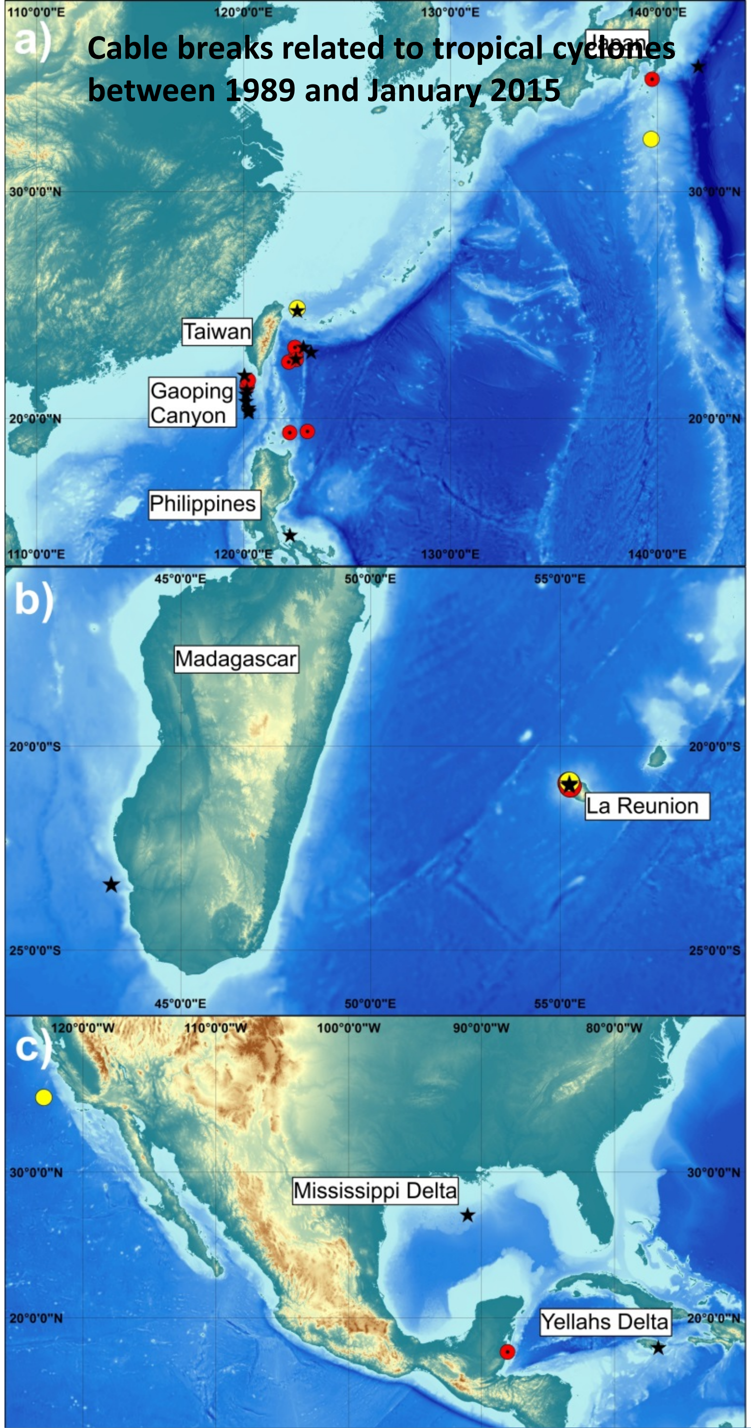
How damaging are tropical cyclones for subsea cables?

Munich RE



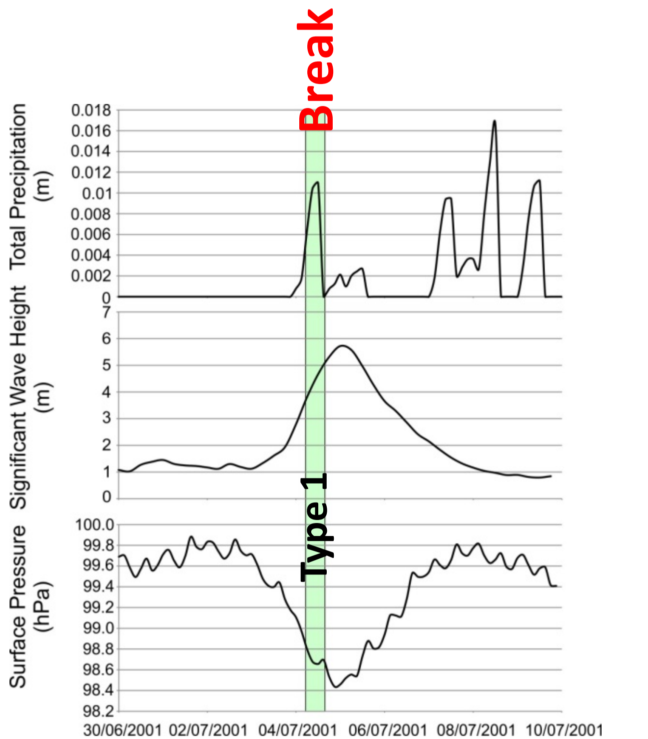
Areas which experience tropical cyclones are shown by green shading. The transition from light to dark green reflects low to high frequency of tropical cyclones. The direction of travel of these systems is shown by the green arrows. (Munich RE, 2011).

Cable breaks shown as filled circles

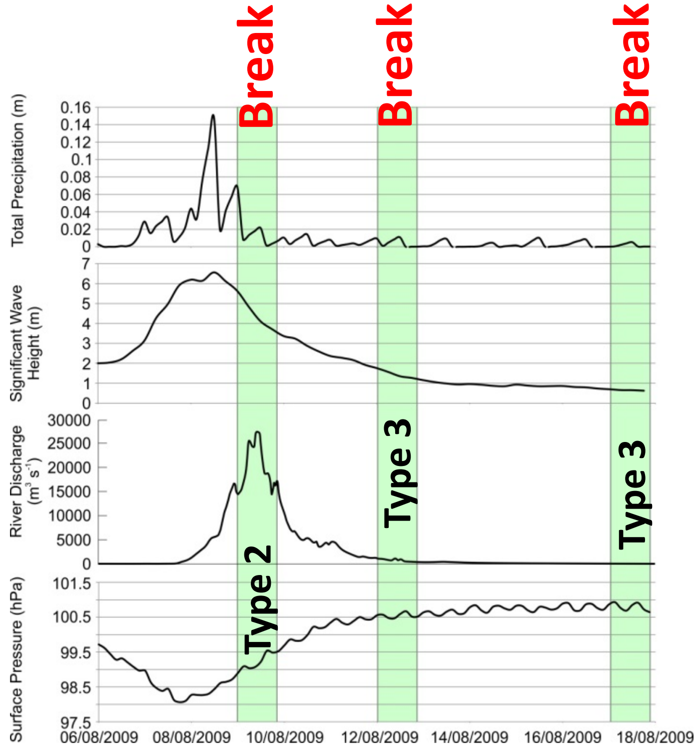


Three types of cyclone-related cable breaks:

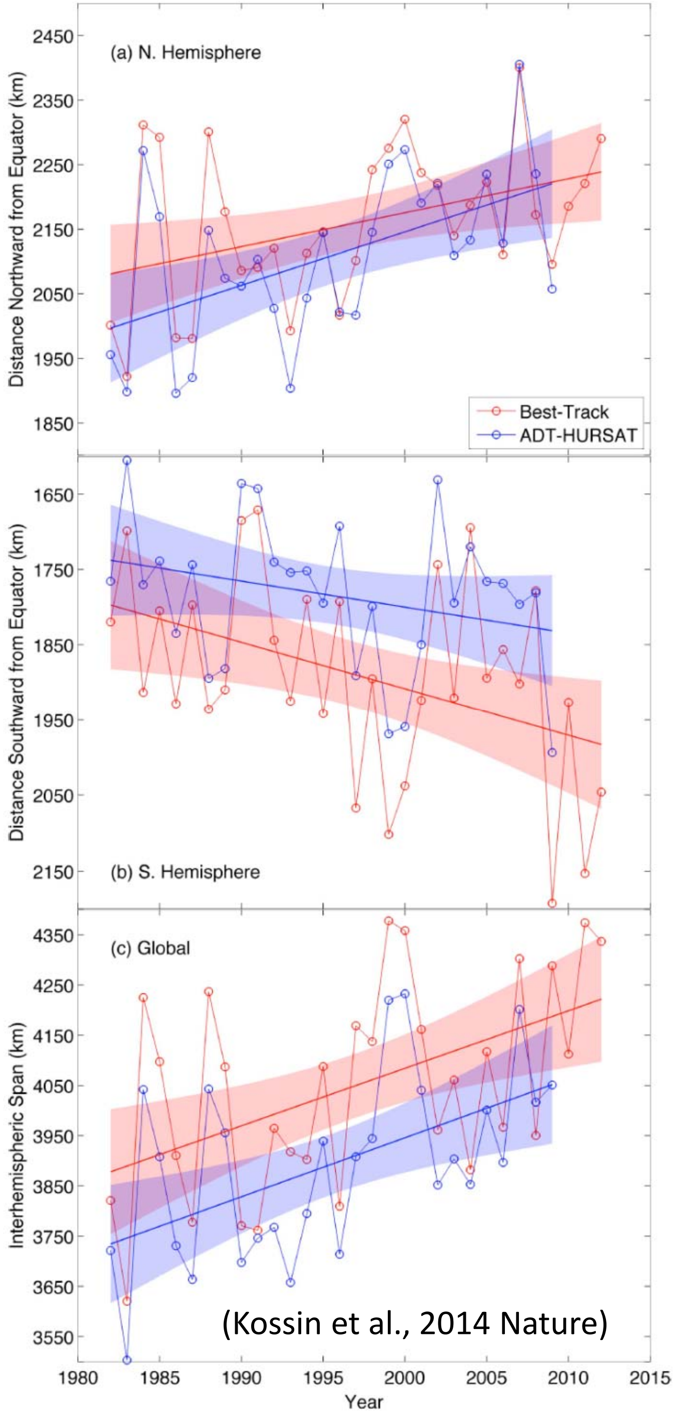
1. **Direct & Synchronous:** Cable breaks during the passage of the tropical cyclone (Yellow circles)
2. **Indirect & Near-Synchronous:** Cable breaks coincident with nearby river peak discharge (Red targets)
3. **Indirect & Delayed:** Cable breaks when peak discharge levels had returned to pre-tropical cyclone levels (Black stars)



2001 Severe Tropical Storm Utor



2009 Typhoon Morakot (Taiwan)



Will the frequency of cable breaks increase in future?

Based on available data and forecast models, it is **highly likely** in some areas, such as Taiwan…

- Over the past 3 decades, **tropical cyclone activity has migrated poleward** in the Northern and Southern Hemispheres at rates of 53 and 62km/decade respectively (left; Kossin et al., 2014).
- **Cyclone intensity is increasing** (Emanuel, 2005; Peduzzi et al., 2012).
- In Taiwan, only a modest increase typhoon numbers but a **marked rise in typhoon-related rainfall** between 1970-2010 (Tu and Chou, 2013).
- Thus, not only **typhoon intensification** but also **slower passage across Taiwan**. More **extreme rainfall** translates to increased debris flows thus **enhancing sediment availability** for erosion (Chen et al. 2012).
- Gaoping River between 1970 and 2012 shows **strong increase in mean daily sediment discharge** especially since 1990 (Lee et al., 2015) accompanied by a significant rise in **extreme sediment yields**, which is consistent with **typhoon intensification**.

As detailed in Gavey et al. (2016)

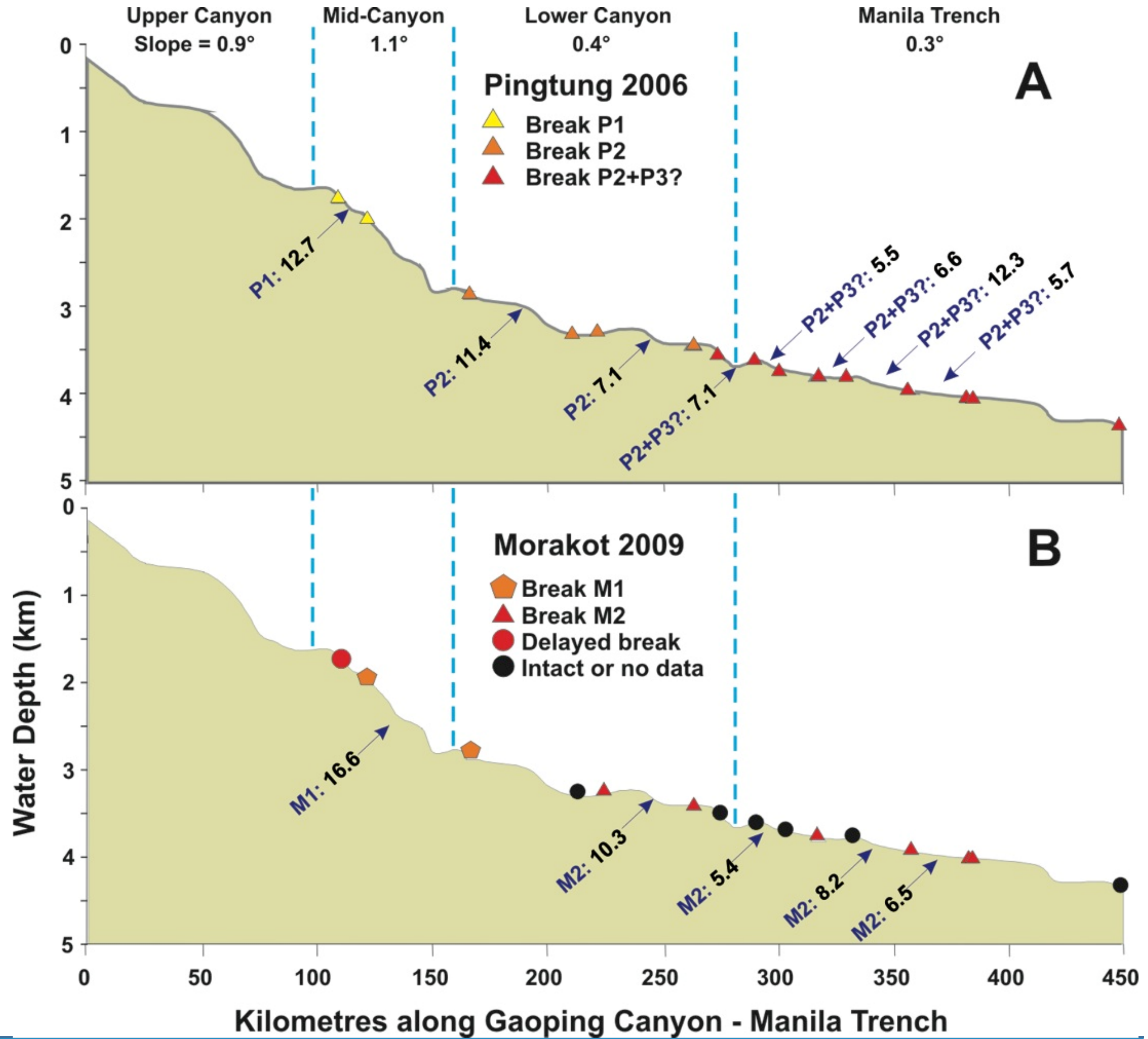
Why are some cables broken, but neighbouring cables remain intact?

It is apparent that fast (5-8 m/s) flows sometimes **fail to break** intervening cables.

There are several possible reasons for this :

1. an intact cable is **protected** by deposited sediment
2. its **orientation** across the canyon/channel presents a low drag profile to the flow, e.g. Zakeri (2012),
3. the **flow path** either through the thalweg or over the levee
4. the presence of sufficient **cable slack** to accommodate any down-slope movement

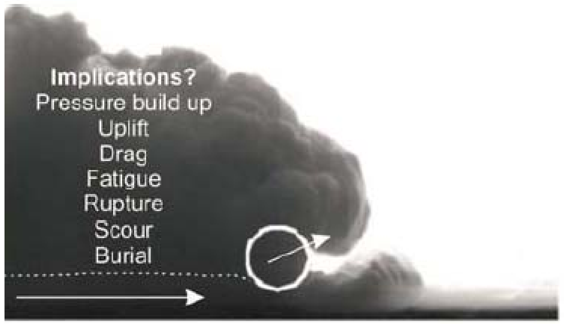
Gavey et al. (Marine Geology, In Press)



So, what threat do turbidity currents and submarine landslides pose to submarine telecommunications cable infrastructure?

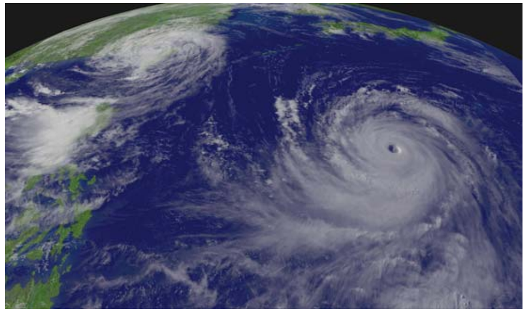
It depends….

Landslide and Turbidity Current Hazard



Earthquake Hazard

Tropical Cyclone Hazard



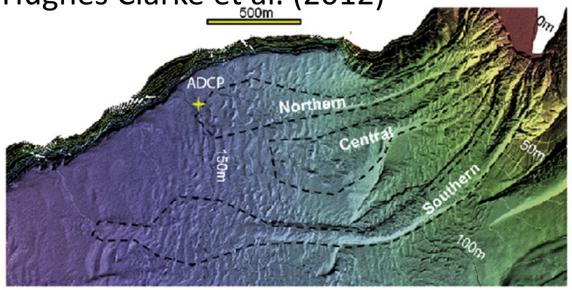
Key factors include:

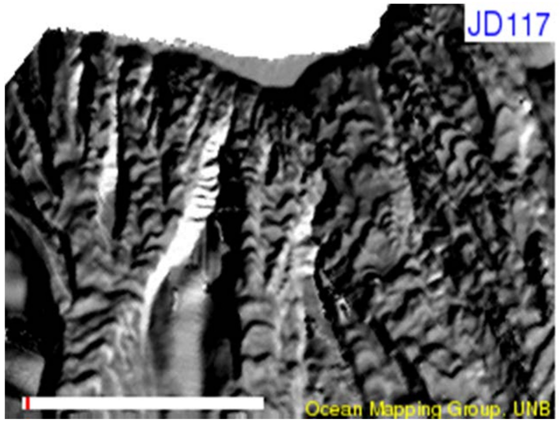
1. The number of cables which have been laid in a specific area (cable density)
2. Sea-floor topography
3. Seismicity of the area
4. Sediment supply
5. The frequency and duration of large tropical cyclones

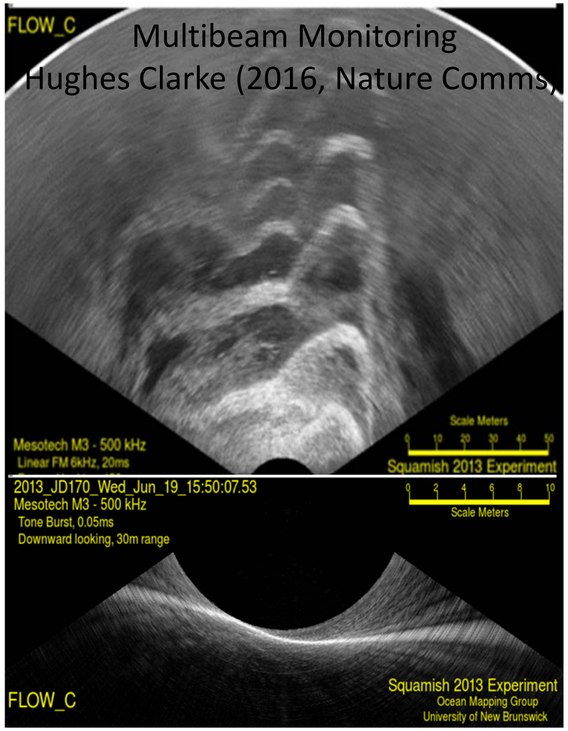
How can we better understand the risks posed to submarine cables?

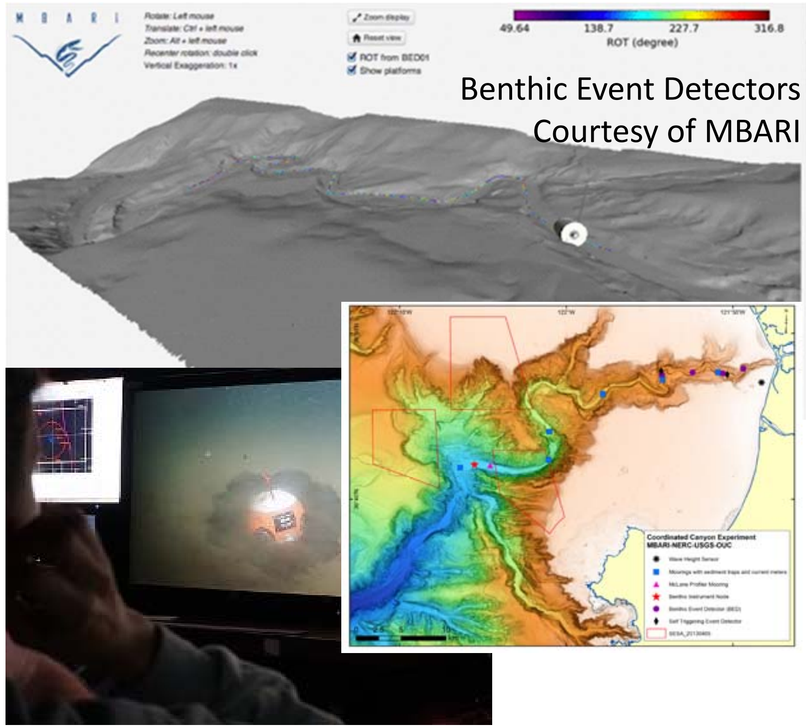
Through direct monitoring and measurements….

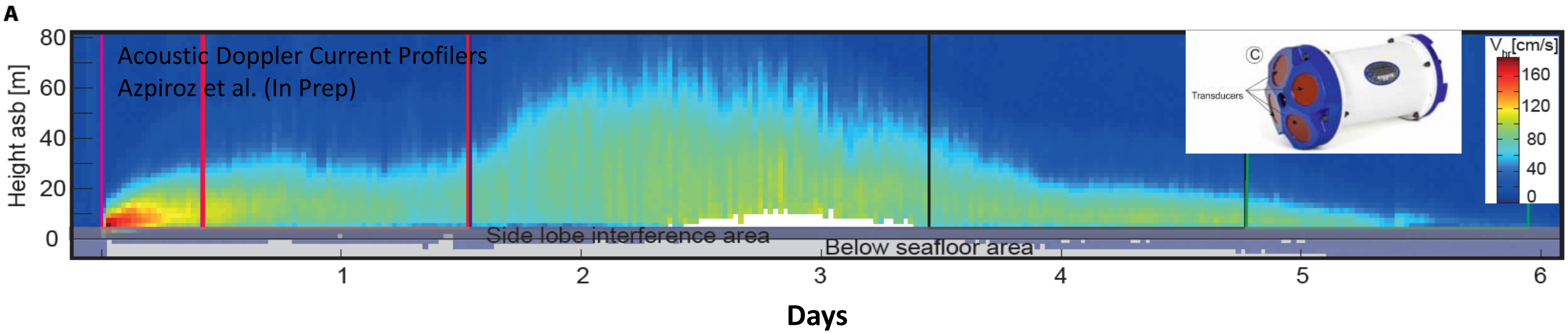
Repeat Mapping
Hughes Clarke et al. (2012)











HOME
Global Cable Network
Marine Cable Breaks
Landslide & Turbidity Currents
Earthquake Hazard
Tropical Cyclone Hazard
Conclusions & Monitoring
Replay