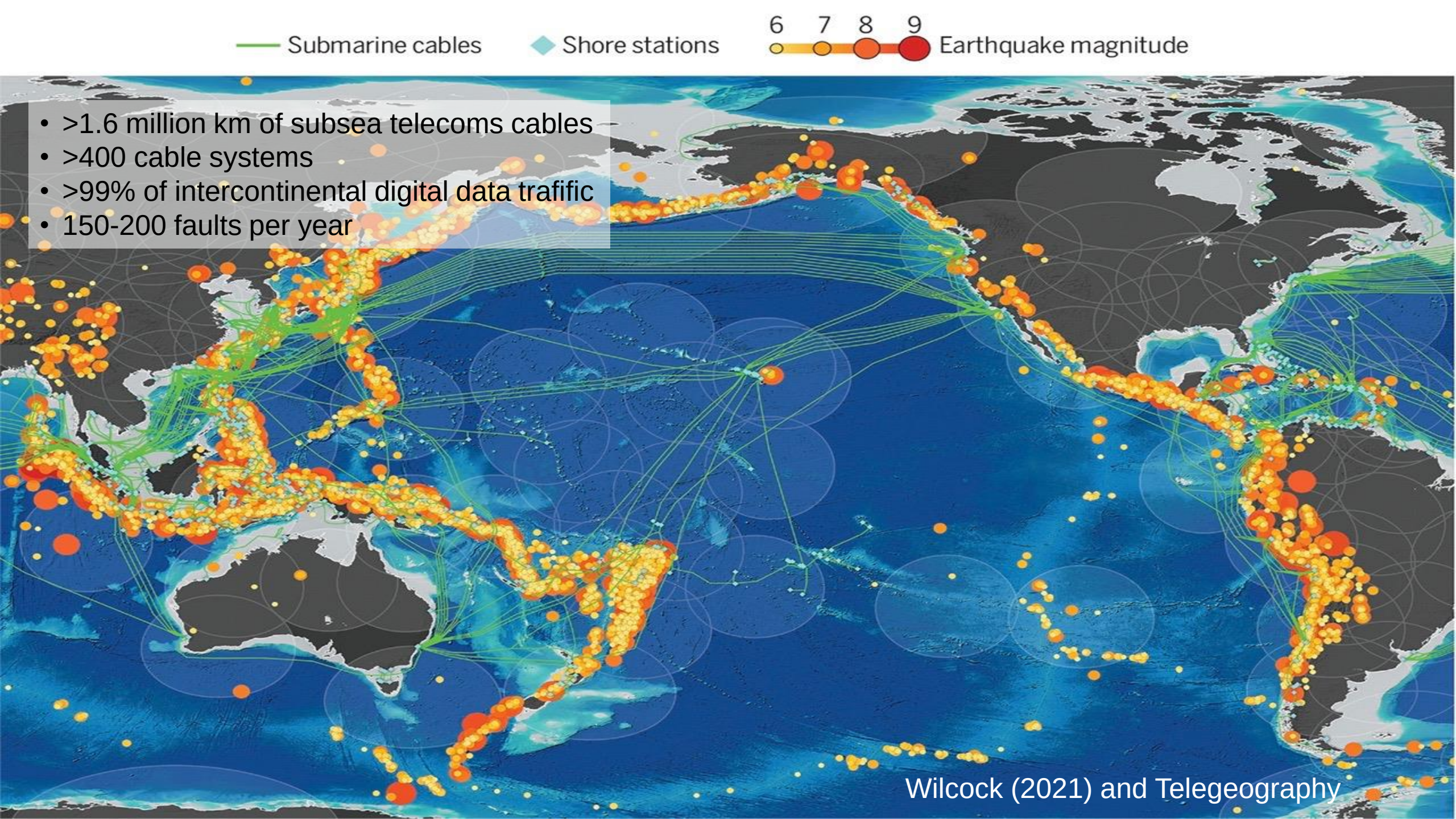
THE FASTEST UNDERWATER FLOWS ON EARTH

MICHAEL CLARE & ISOBEL YEO
SALLY WATSON, RICHARD WYSOCZANSKI, SARAH SEABROOK, KEVIN MACKAY, JAMES HUNT, EMILY LANE, PETER TALLING, EDWARD POPE, SHANE CRONIN, MARTA RIBÓ GENE, TAANIELA KULA, DAVID TAPPIN, STUART HENRYS, CORNEL DE RONDE, MORELIA URLAUB, STEFFAN KUTTEROLF, MIKE WILLIAMS


Submarine cables
Shore stations
6 7 8 9
Earthquake magnitude
• >1.6 million km of subsea telecoms cables
• >400 cable systems
• >99% of intercontinental digital data trafific
• 150-200 faults per year
Wilcock (2021) and Telegeography

The specific case of natural hazards

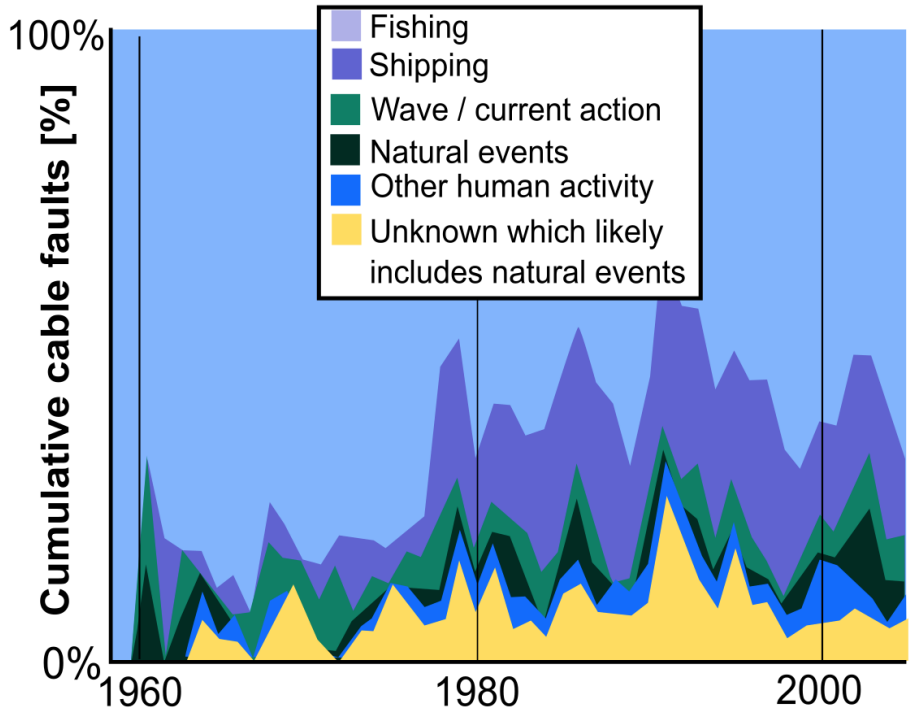
- Only account for 10-20% of subsea cable faults

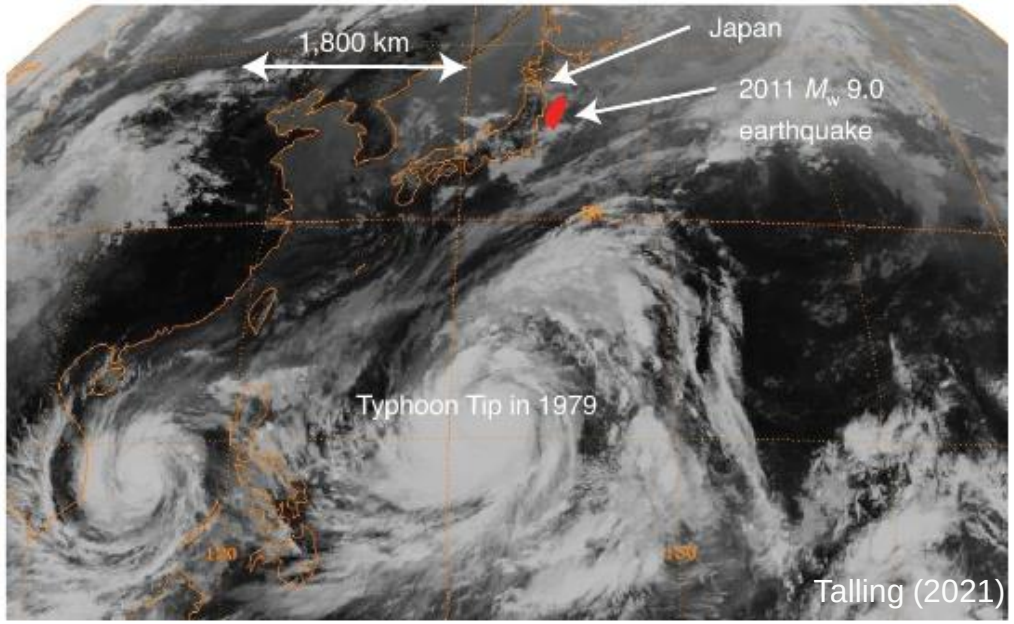
But….

- Affect cables in all water depths
  - >30% of faults in deep water

- Can affect multiple systems synchronously over large areas leading to $100Ms repair and bigger knock on effects

Clare et al. (2022) after Kordahi et al. (2019)





THE TIMES | Today's sections | Past six days | Explore | Times Radio | Log in

Undersea avalanche snaps internet cables as cascade from Congo spews into Atlantic

Jane Flanagan, Cape Town

Tuesday June 08 2021, 5.00pm,

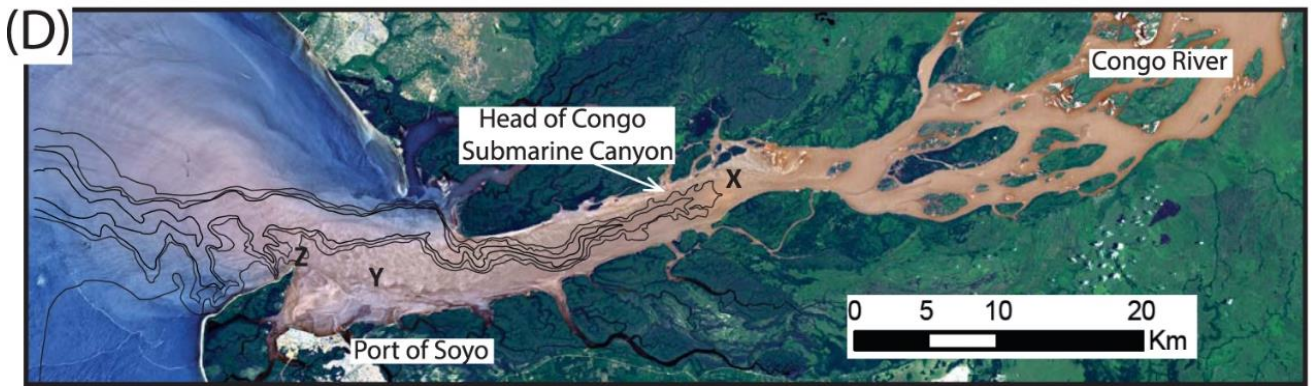
BUSINESS INSIDER SOUTH AFRICA

TECH

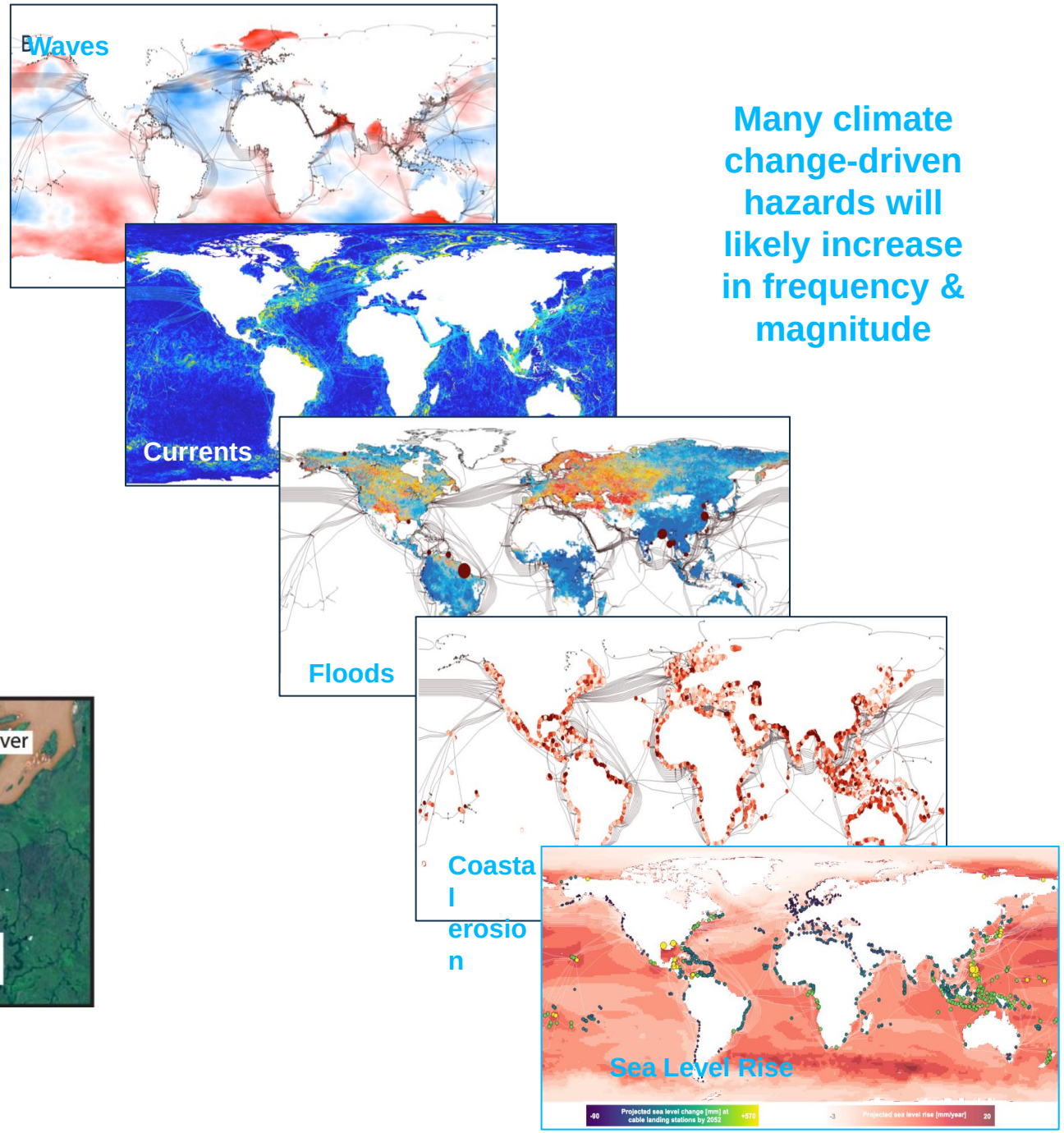
PICS: The burnt-out undersea cable that crippled SA's internet

Jay Caboz, Business Insider SA

07 Feb 2020



Flood triggered cable-damaging flows ran out >1200 km into the deep sea during first COVID-19 lockdown

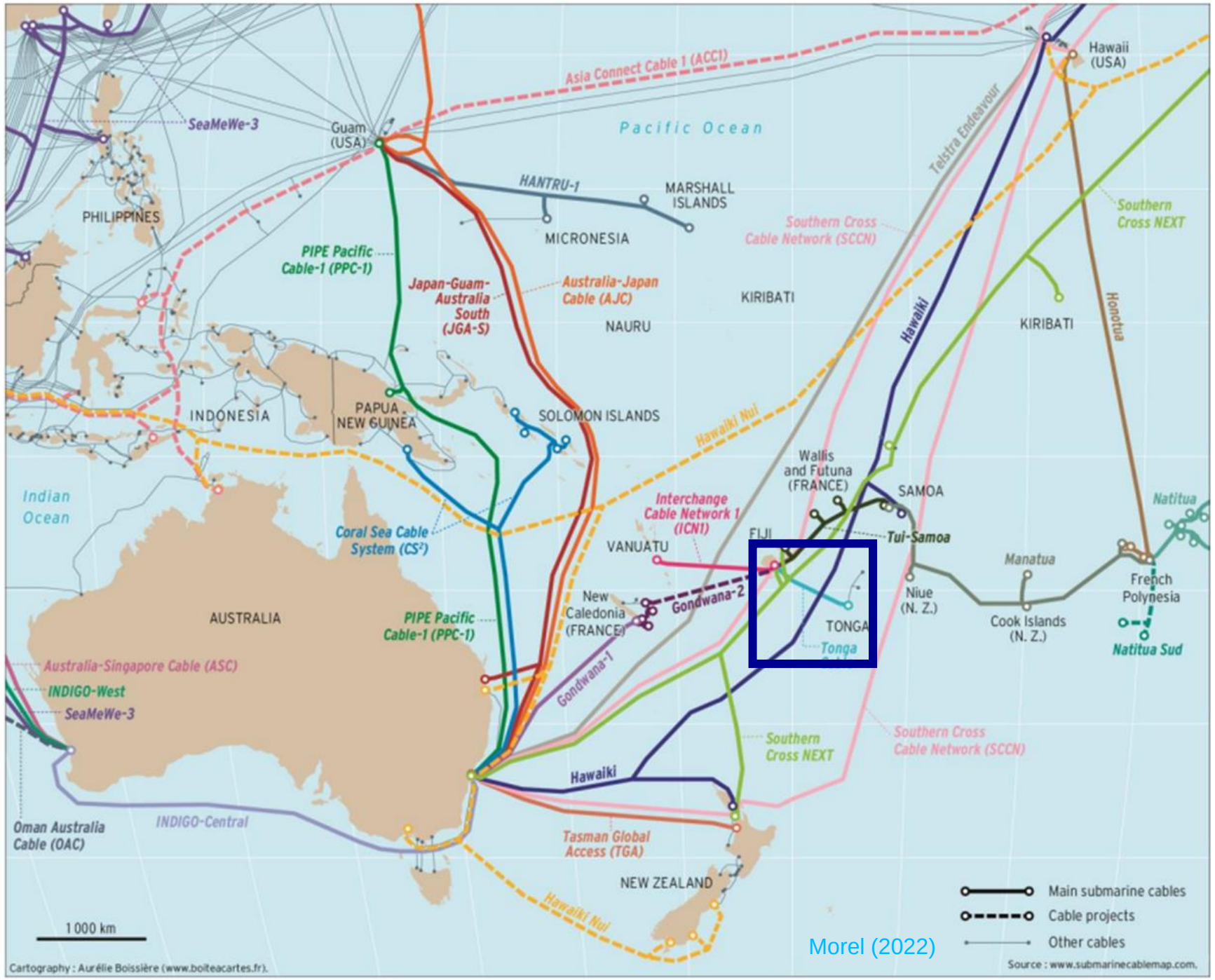


Many climate change-driven hazards will likely increase in frequency & magnitude

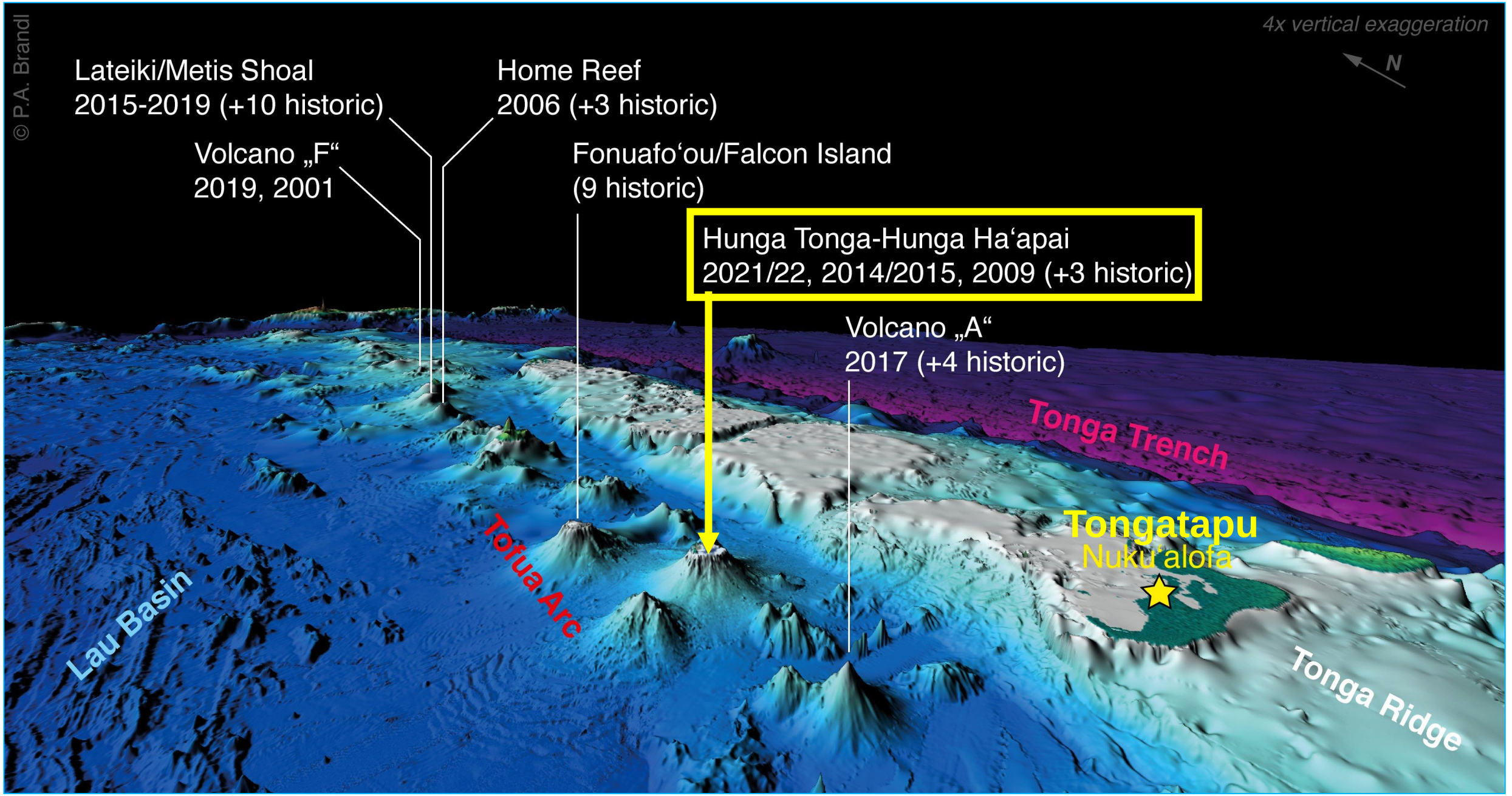
Clare et al. (2022)

- Most regions are resilient due to:
  - Redundancy in the network
  - Ready access to repair ships
  - Sufficient replacement stocks

The South Pacific is an exception

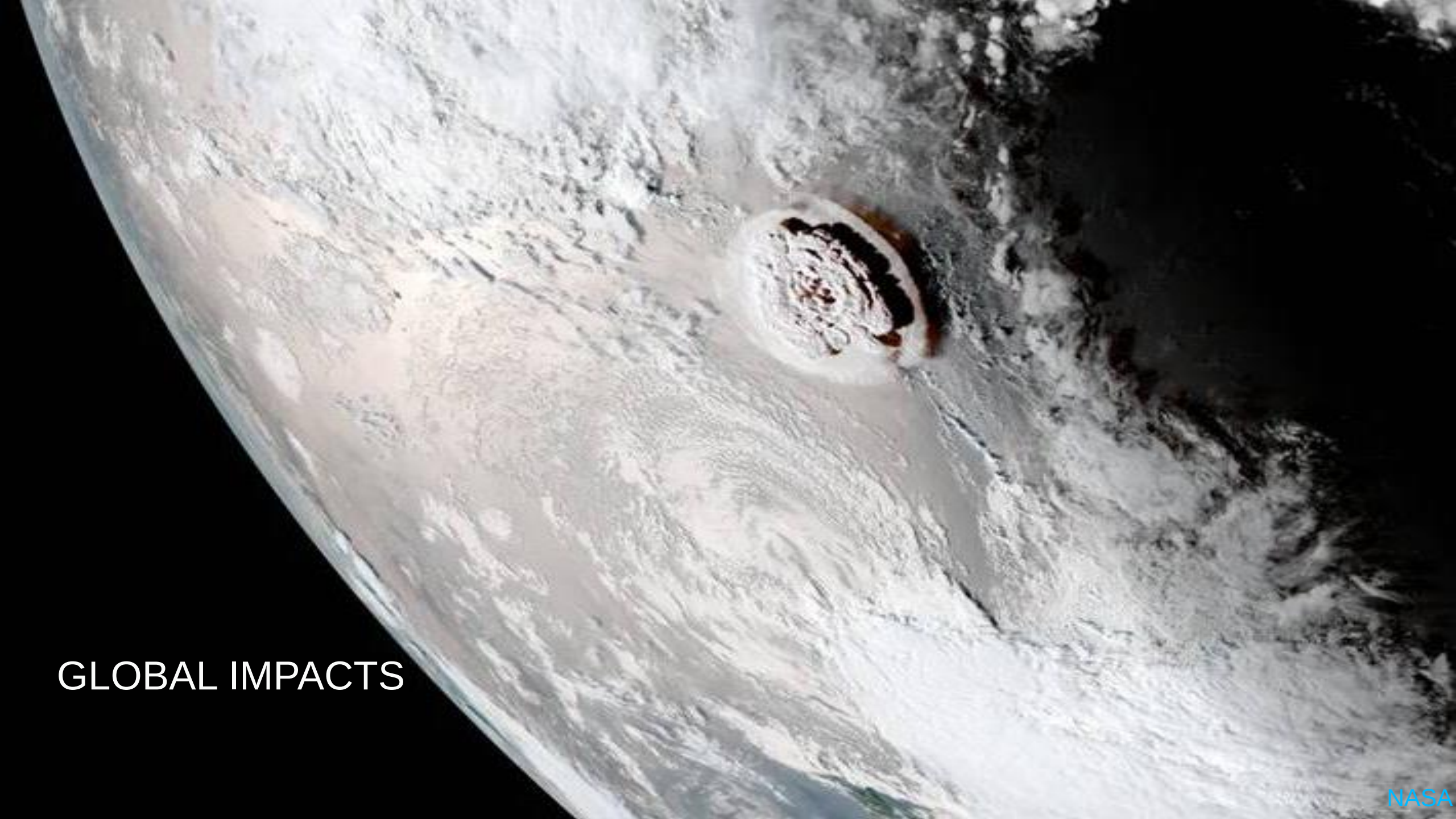


Morel (2022)


© P.A. Brandl
4x vertical exaggeration
N
Lateiki/Metis Shoal
2015-2019 (+10 historic)
Home Reef
2006 (+3 historic)
Volcano „F“
2019, 2001
Fonuafo‘ou/Falcon Island
(9 historic)
Hunga Tonga-Hunga Ha‘apai
2021/22, 2014/2015, 2009 (+3 historic)
Volcano „A“
2017 (+4 historic)
Tonga Trench
Tongatapu
Nuku‘alofa
Tofua Arc
Lau Basin
Tonga Ridge


Pununu Tukuafu - Tonga Geological Services


November 17 2021
A
Planet Earth
January 3 2022
B
Planet Earth
January 7 2022
C
Planet Earth
January 15 2022; 15:25 TOT
D
Planet Earth
TONGA GEOLOGICAL SERVICES
TONGA GEOLOGICAL SERVICES
TONGA GEOLOGICAL SERVICES

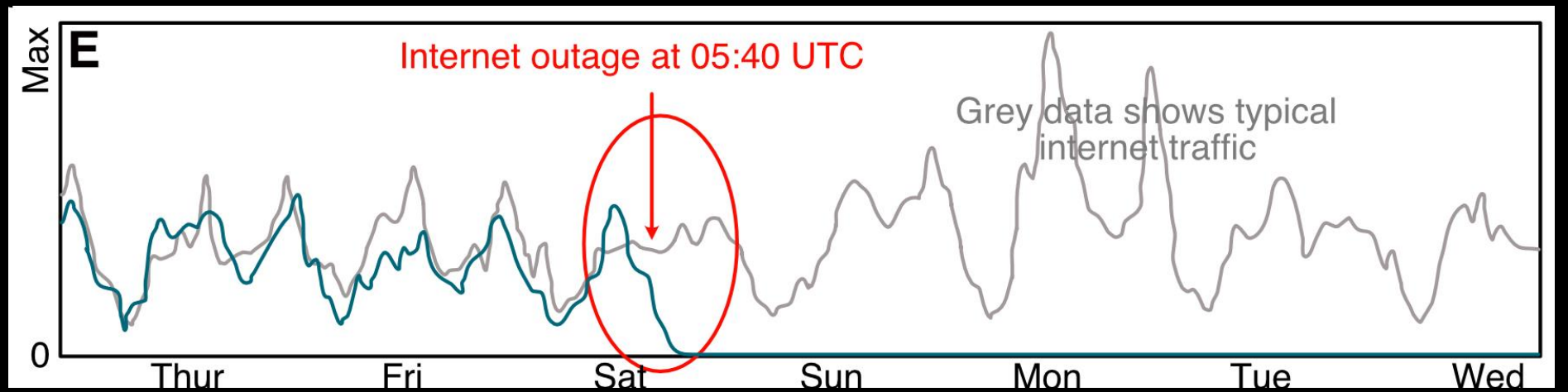


GLOBAL IMPACTS

NASA

Dr Faka’iloatonga Taumoefolau (15/01/22)

and then, in the middle of a crisis….



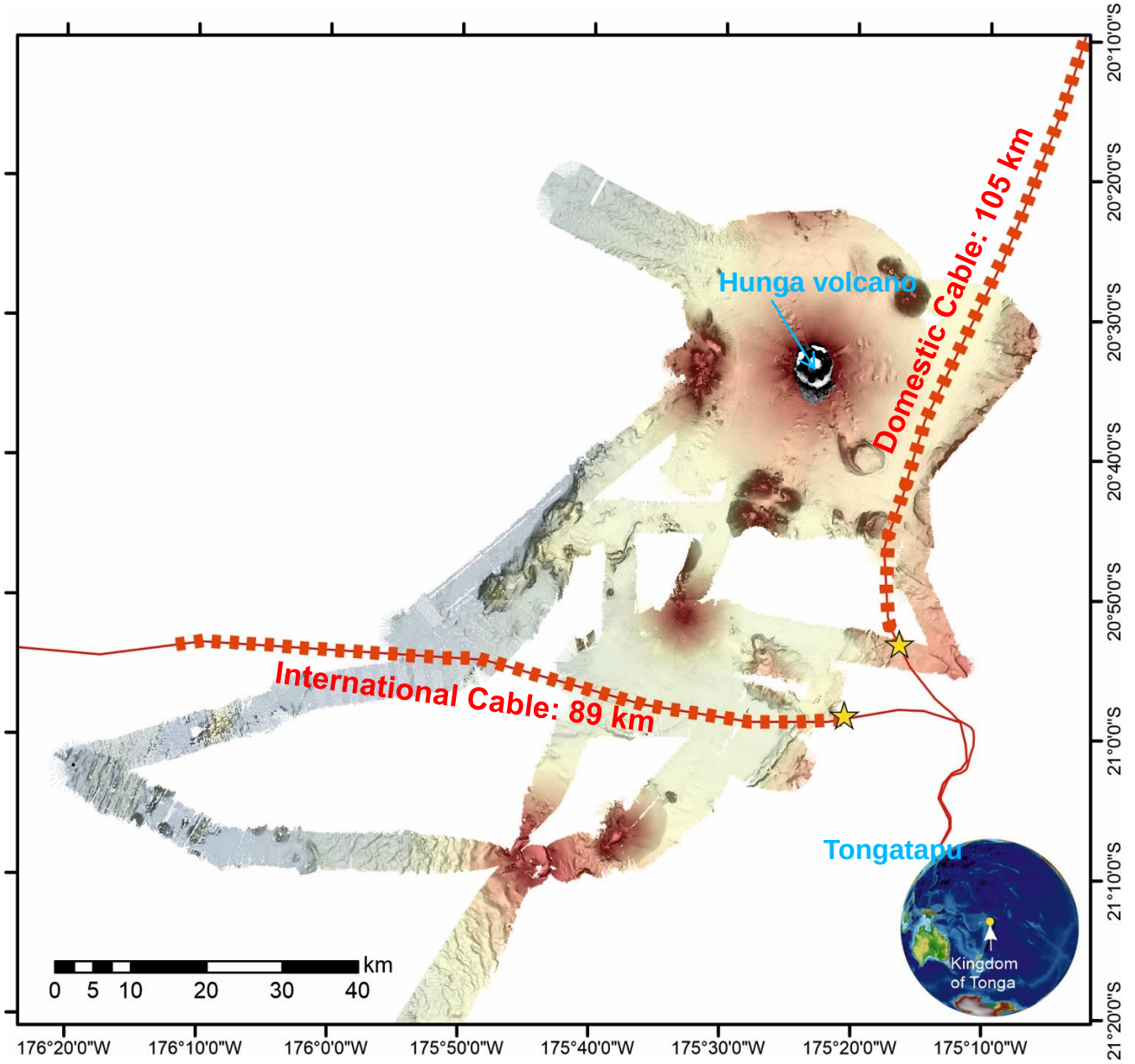
Broken Cable Shuts Down Tonga's Internet

NFK EDITORS - JANUARY 27, 2019

Nuku'alofa, Tonga —(Map)

EXTENSIVE SEAFLOOR CABLE DAMAGE

- Repair to international cable took 5 weeks
- Domestic cable repaired 1.5 years later…



Clare & Yeo et al. (Science, 2020)

EXTENSIVE SEAFLOOR CABLE DAMAGE

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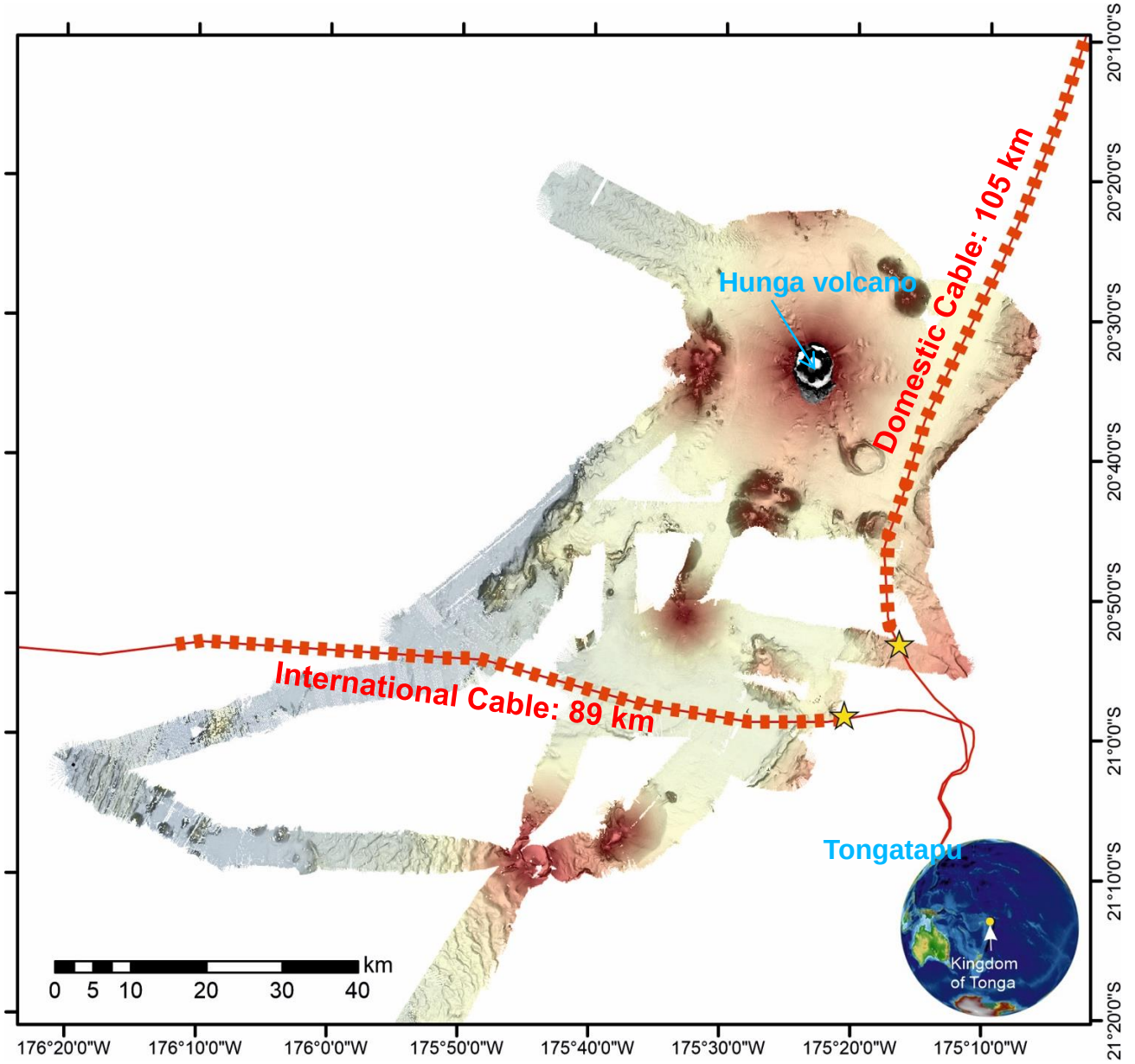
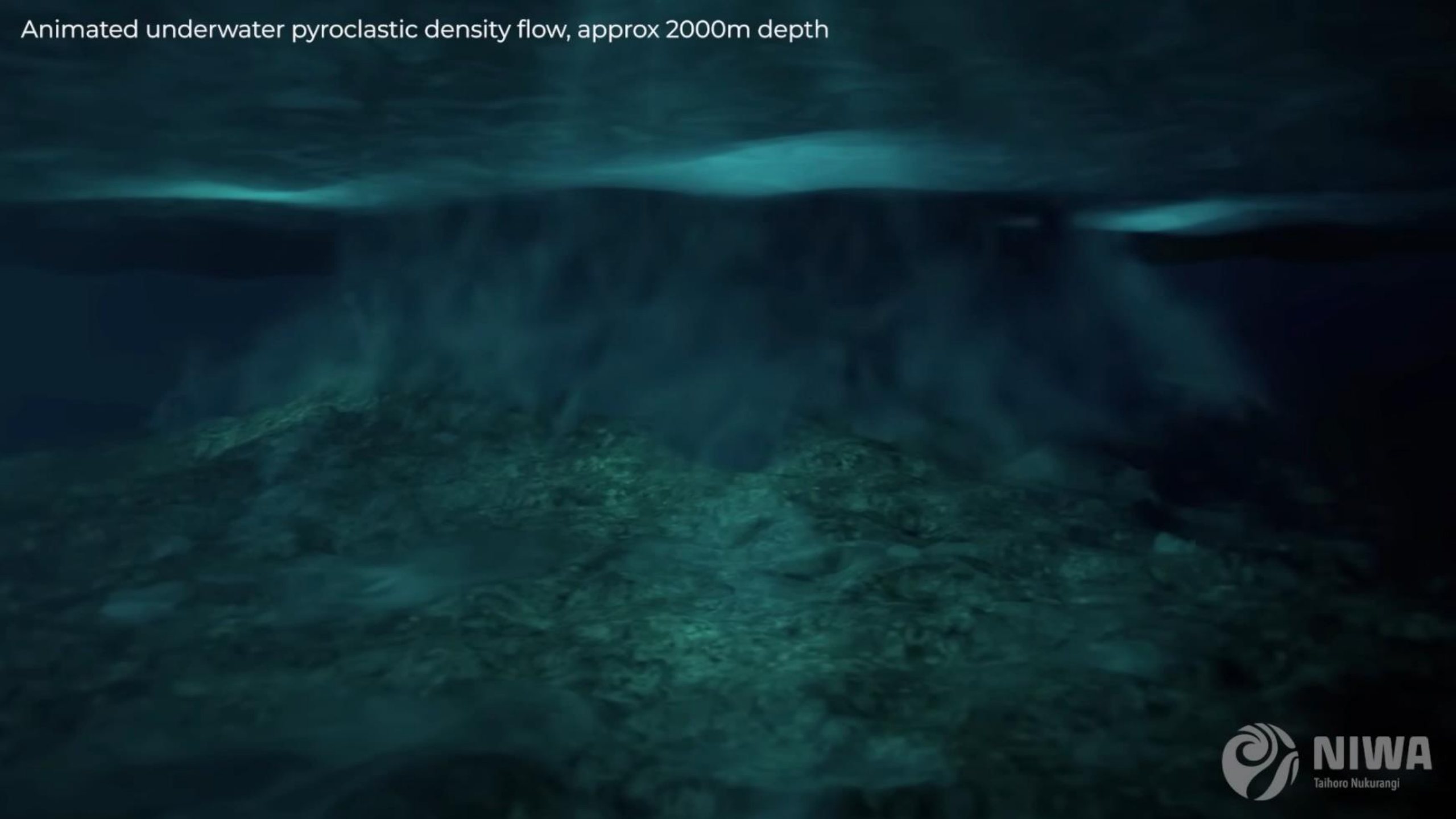


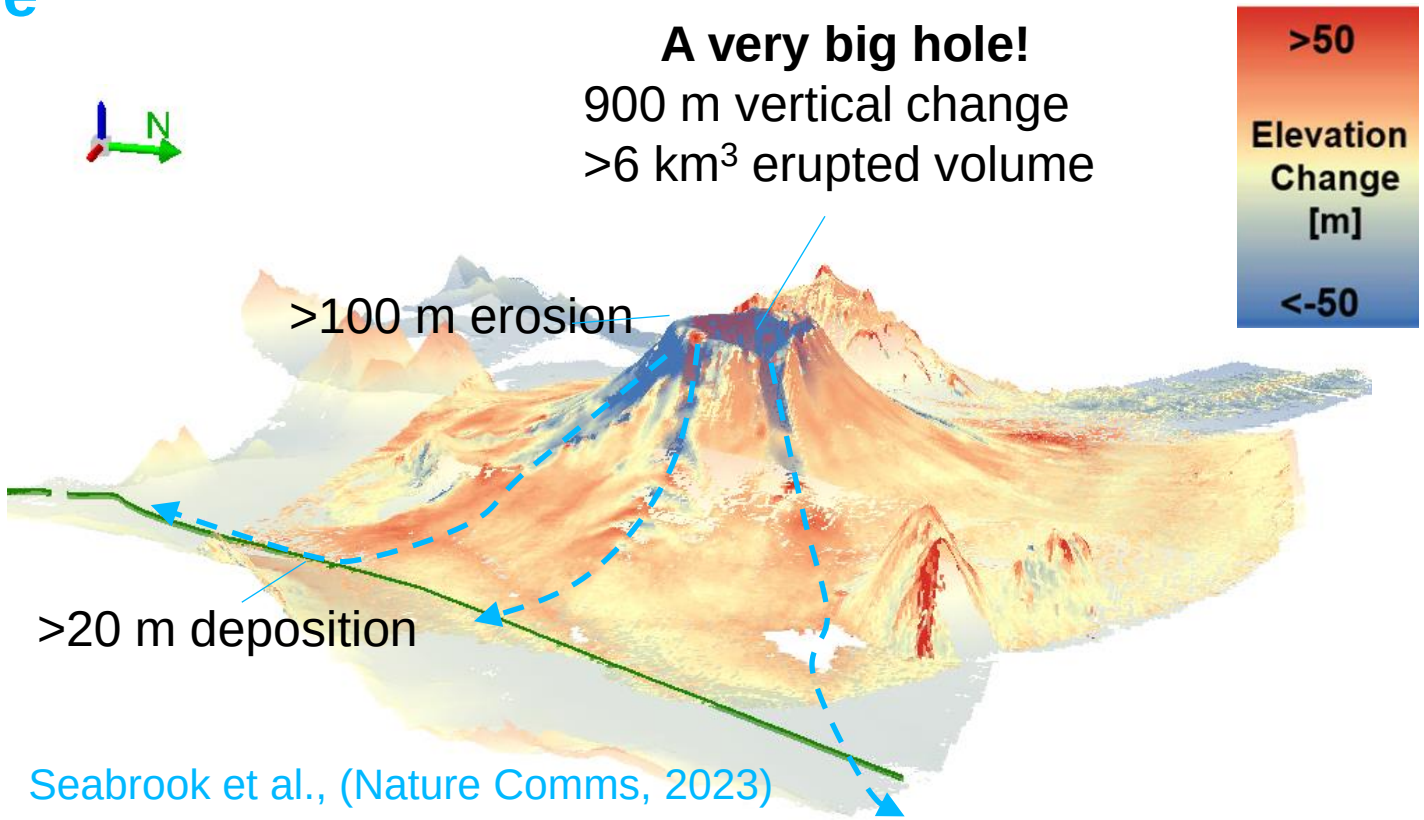
Clare & Yeo et al. (Science, 2020)


Animated underwater pyroclastic density flow, approx 2000m depth
NIWA
Taihoro Nukurangi

What caused the extensive damage?

- Identified from seafloor surveys performed within 3 months of the eruption
- Powerful and dense flows of volcanic material sampled >80 km away from the volcano

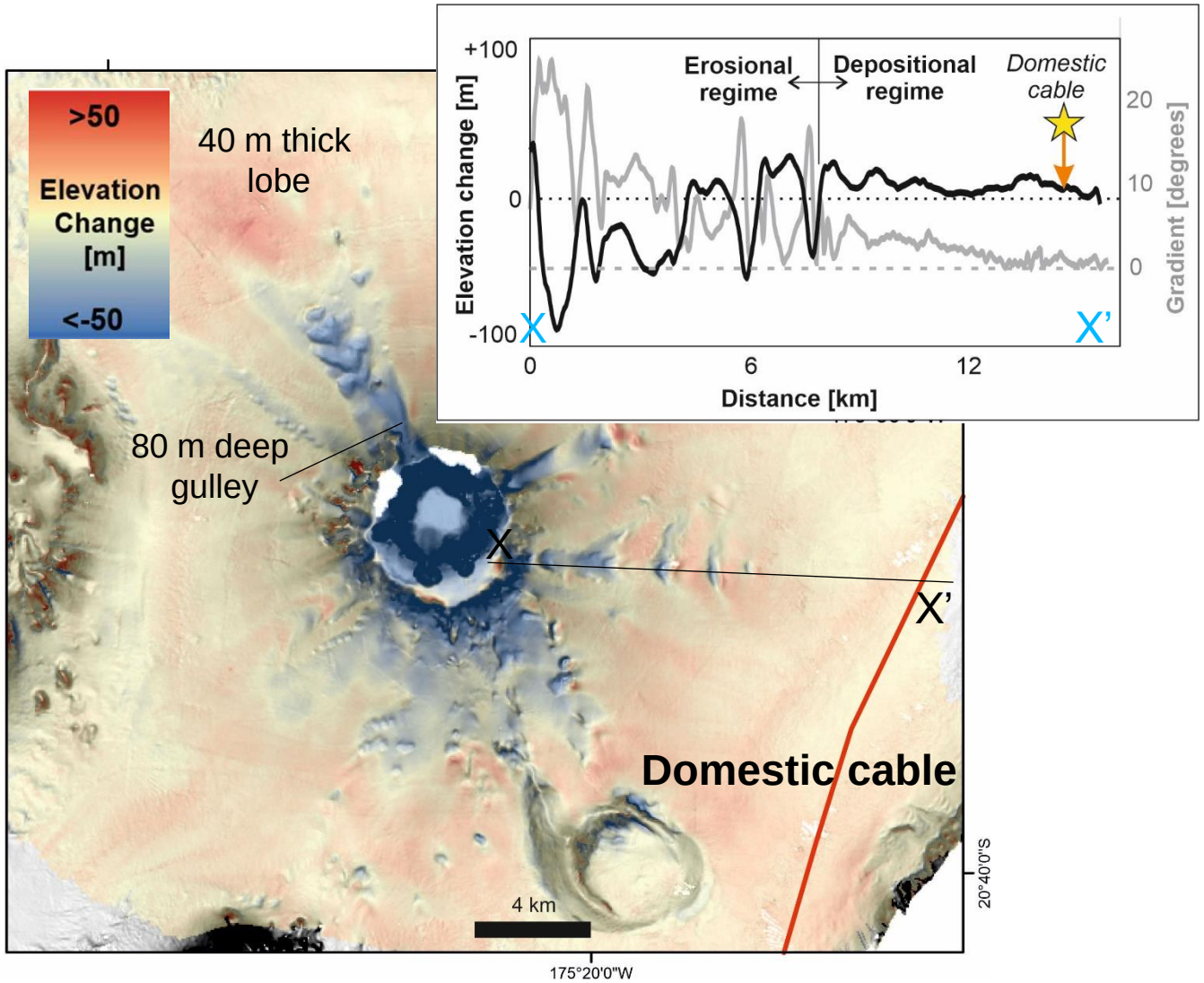
A very big hole!
900 m vertical change
>6 km^3 erupted volume

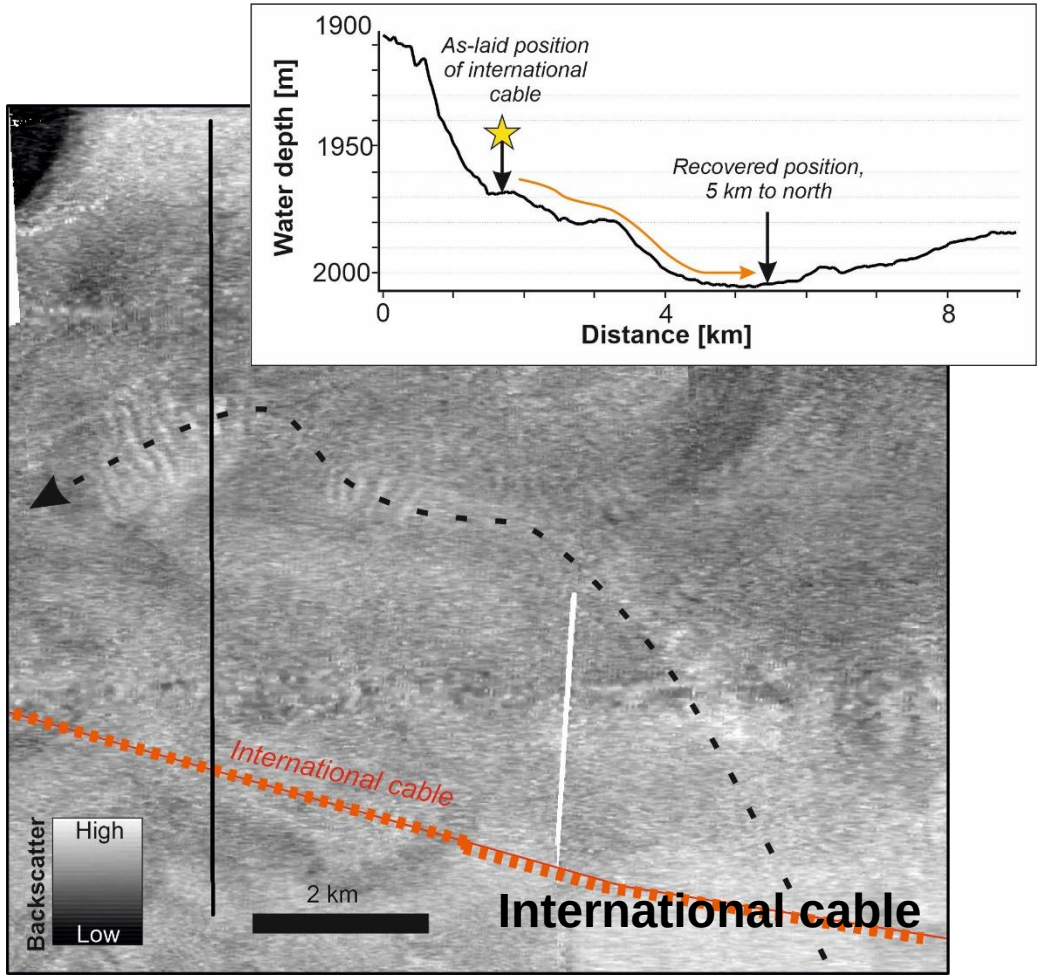


Seabrook et al., (Nature Comms, 2023)

NIWA
Taihoro Nukurangi

WIDE-REACHING FOOTPRINT OF DAMAGE

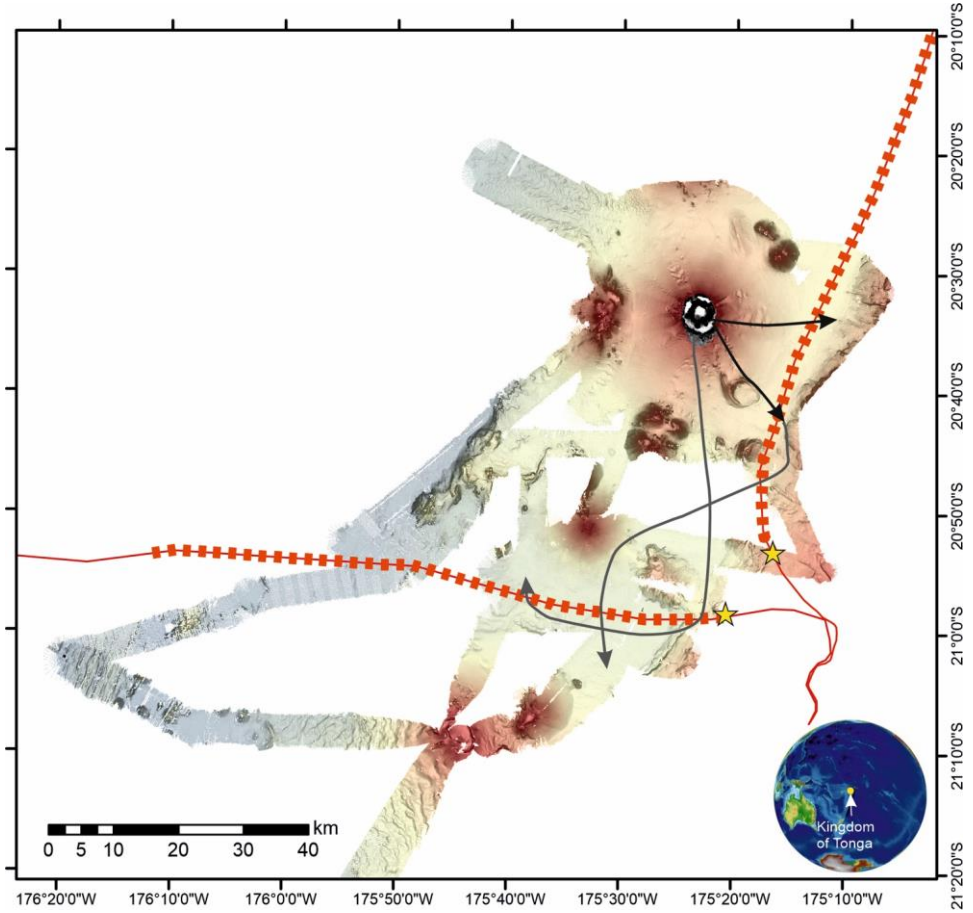


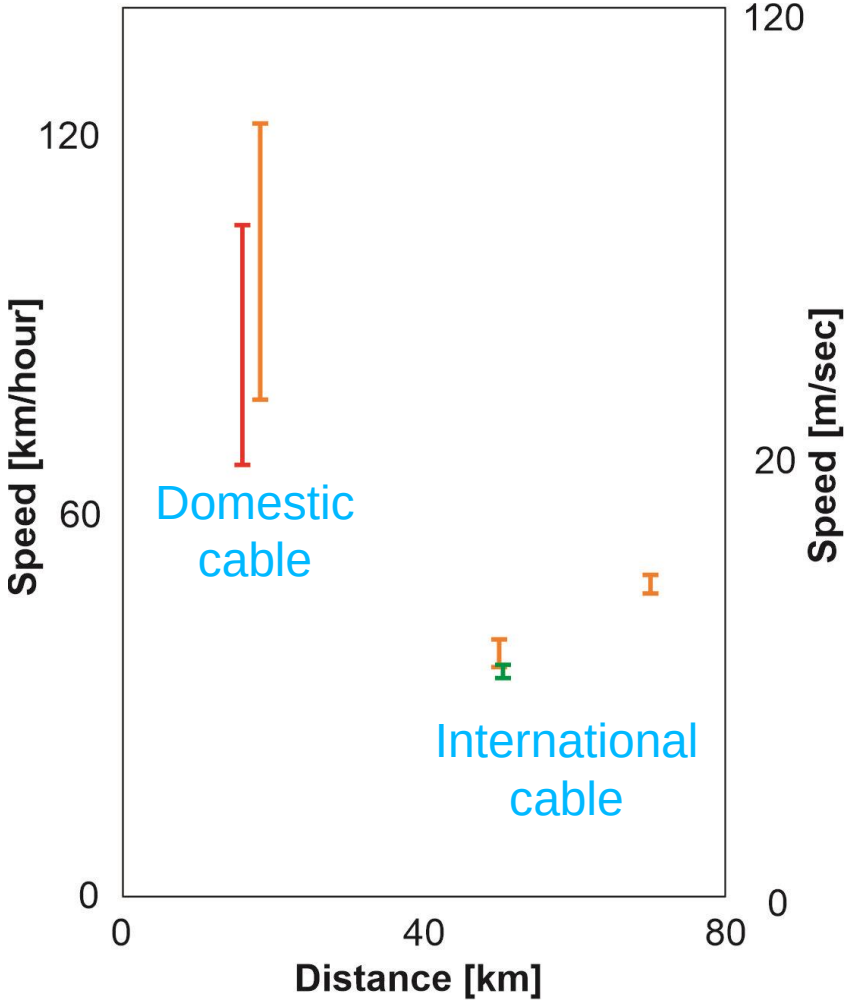


Clare & Yeo et al. (Science, 2020)

FIRST MEASUREMENTS OF SUBMARINE VOLCANICLASTIC DENSITY CURRENTS

National Oceanography Centre

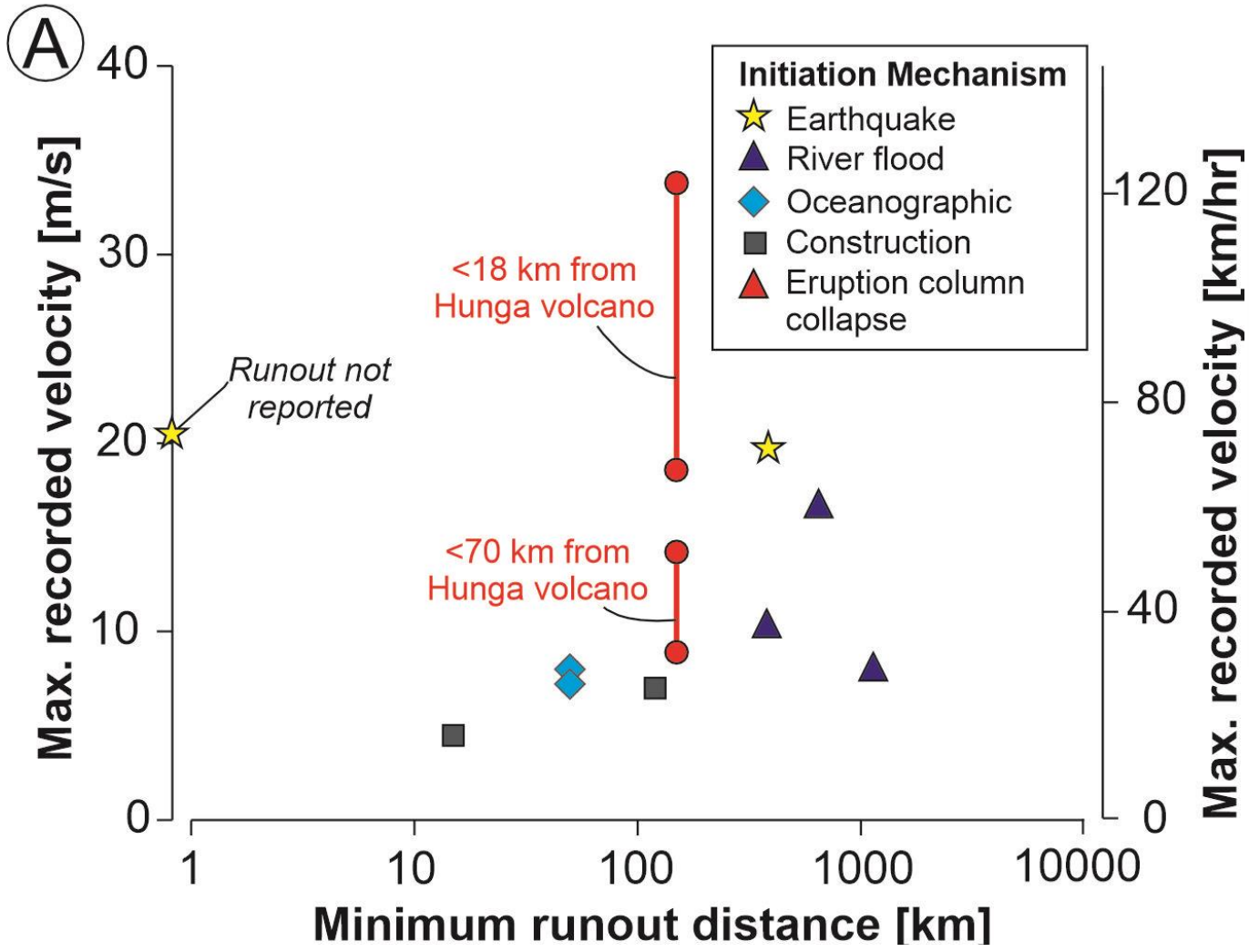


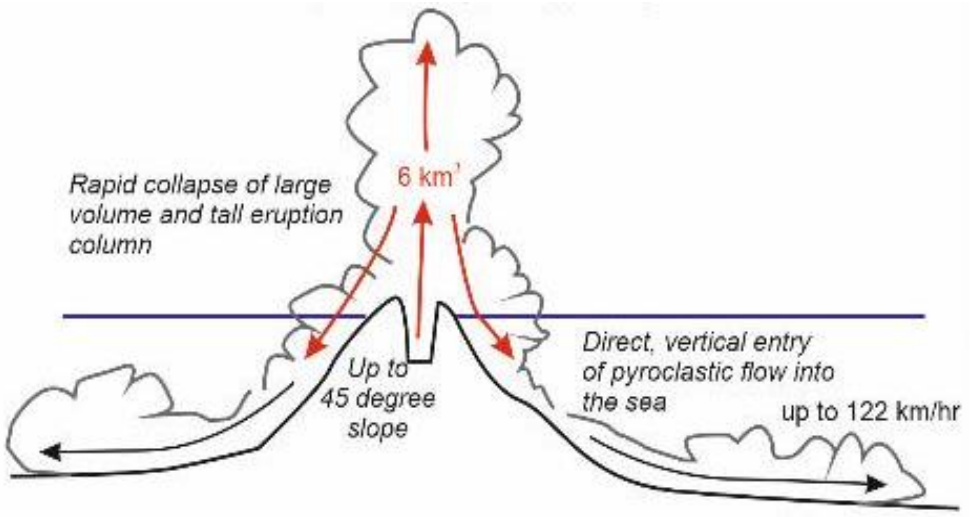


Clare & Yeo et al. (Science, 2020)

FASTEST FLOWS EVER MEASURED IN THE OCEAN

National Oceanography Centre

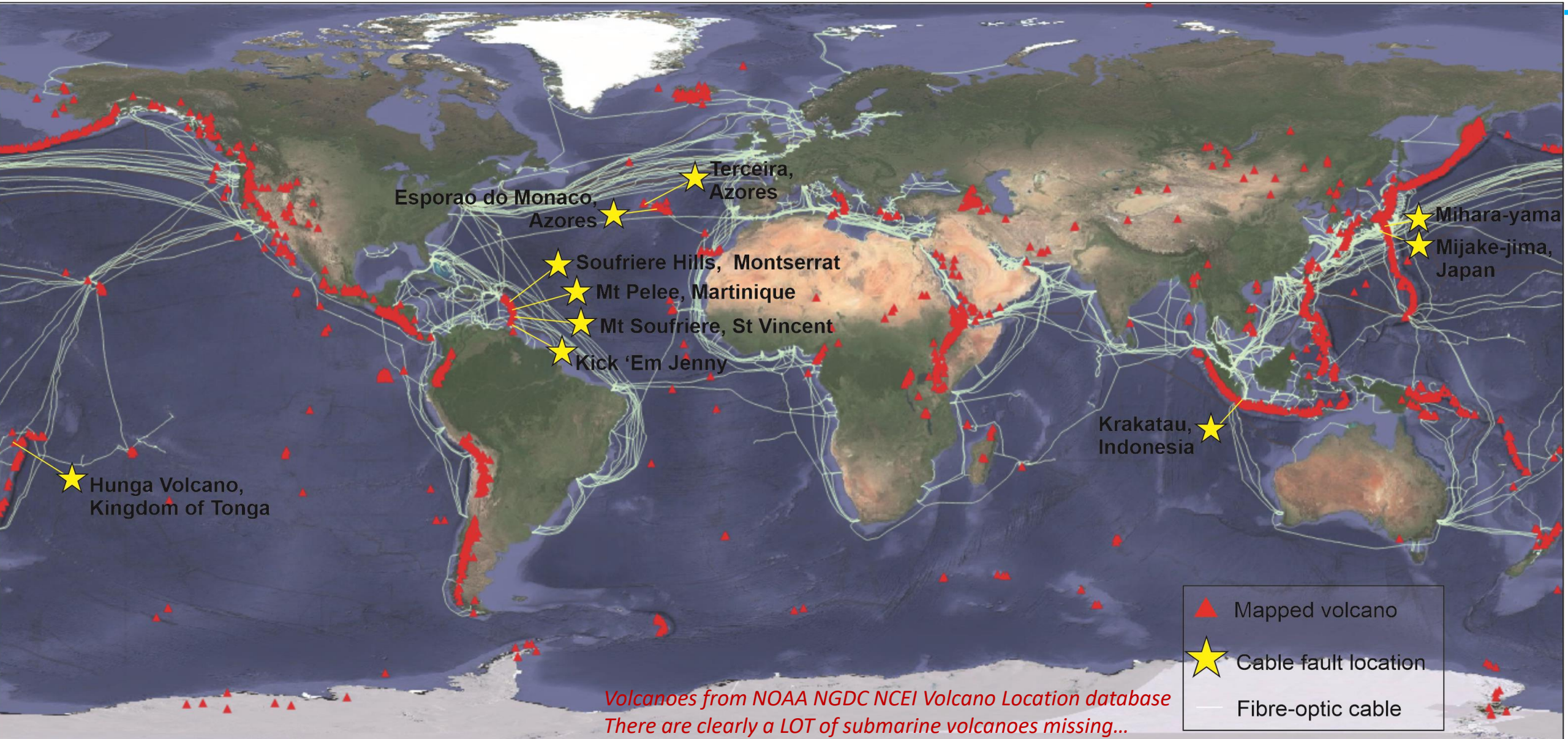




Clare & Yeo et al. (Science, 2020)

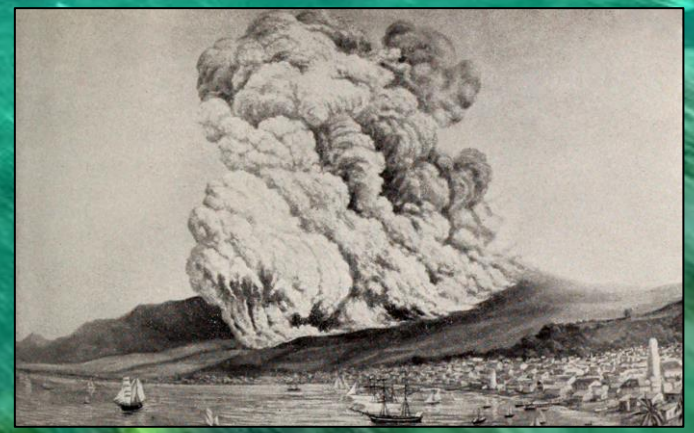
THE GLOBAL SUBSEA TELECOMS NETWORK

National Oceanography Centre

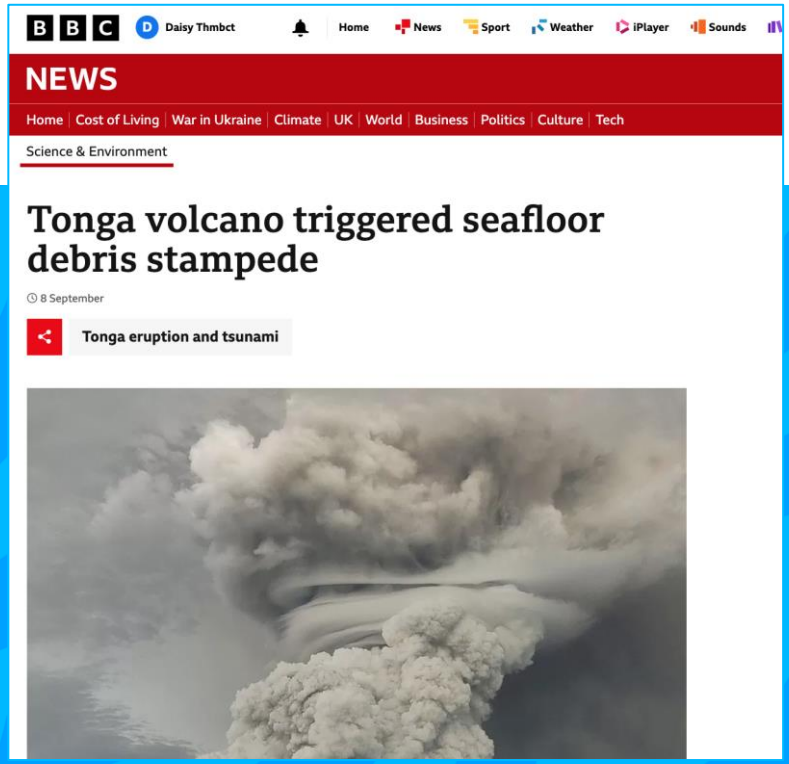


SO WHAT SHOULD WE DO?

- Better mapping incl. repeat surveys
- Regional monitoring incl. use of fibre-optic sensing along cables
- More and diverse routes and landing points
- Local stocks of cable
- Increased investment in back-up low level satellite communications



National Oceanography Centre



RESEARCH

VOLCANOLOGY

Fast and destructive density currents created by ocean-entering volcanic eruptions

Michael A. Clare[1]*†, Isobel A. Yeo[1]*†, Sally Watson[2], Richard Wysoczanski[2], Sarah Seabrook[2], Kevin Mackay[2], James E. Hunt[1], Emily Lane[2], Peter J. Talling[3], Edward Pope[3], Shane Cronin[4], Marta Ribó[5], Taaniela Kula[6], David Tappin[7], Stuart Henrys[8], Cornel de Ronde[8], Morelia Urlaub[9], Stefan Kutterolf[9], Samuiela Fonua[10], Semisi Panuve[10], Dean Veverka[11], Ronald Rapp[12], Valey Kamalov[13], Michael Williams[2]

Volcanic eruptions on land create hot and fast pyroclastic density currents, triggering tsunamis or surges that travel over water where they reach the ocean. However, no field study has documented what happens when large volumes of erupted volcanic material are instead delivered directly into the ocean. We show how the rapid emplacement of large volumes of erupted material onto steep submerged slopes triggered extremely fast (122 kilometers per hour) and long-runout (>100 kilometers) seafloor currents. These density currents were faster than those triggered by earthquakes, floods, or storms, and they broke seafloor cables, cutting off a nation from the rest of the world. The deep scours excavated by these currents are similar to those around many submerged volcanoes, providing evidence of large eruptions at other sites worldwide.

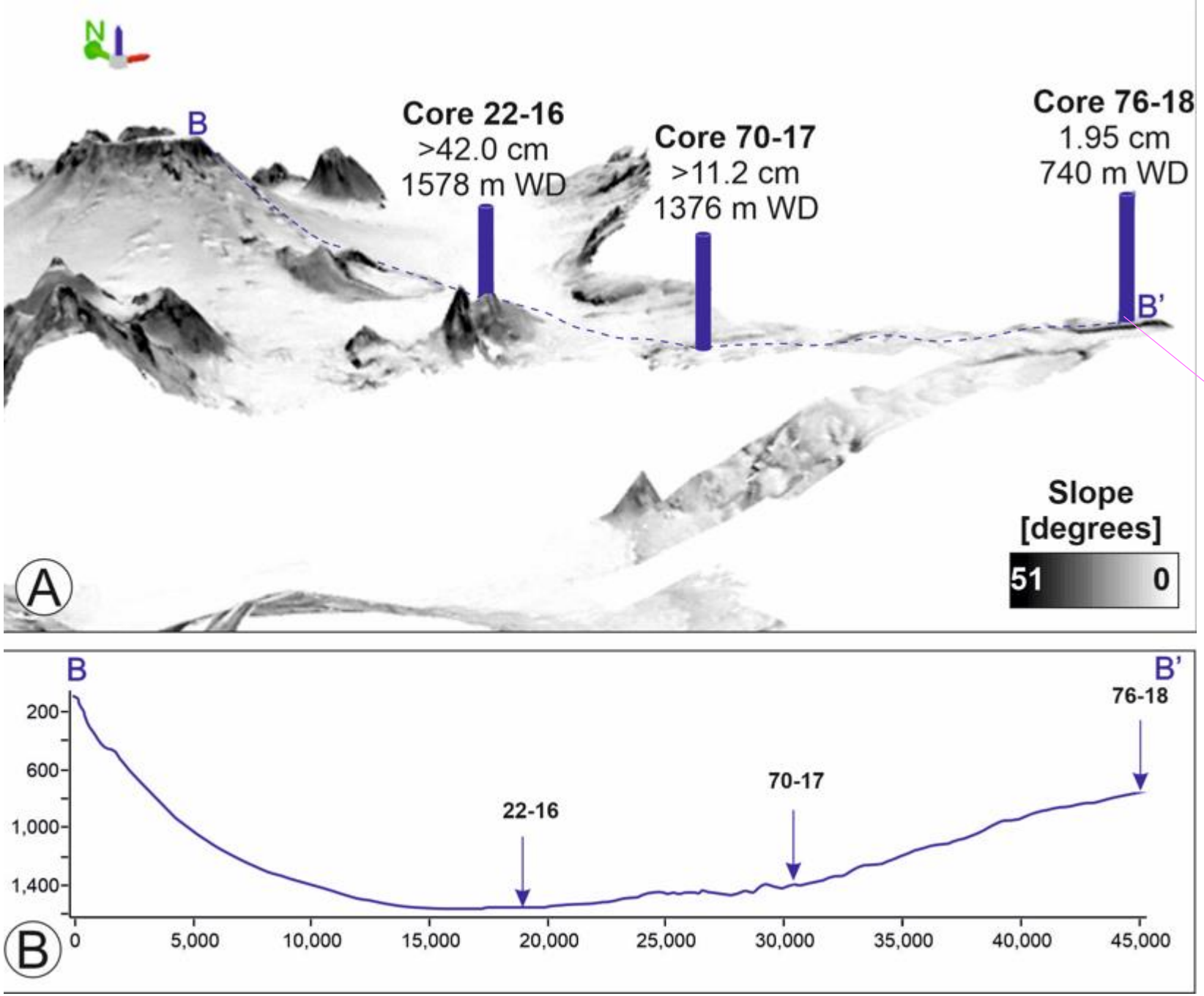
Explosive volcanism poses a wide range of hazards, with more than a third of volcanoes and devastating marine biological communities (*10–15*).

of ancient ocean-entering eruptions (*23*, scaled-down laboratory modeling (*25*), and ysis of geomorphic features around submerged volcanoes to infer the behavior of past eruptions (*26*, *27*). Fields of large sediment waves and scours, commonly observed radiating around submerged flanks of volcanoes, are thought to be diagnostic of catastrophic eruptions (*26–28*). However, this hypothesis remains untested because of a lack of repeat seafloor surveys before and after a large eruption. These uncertainties severely limit the understanding of the behavior and associated risks at submerged volcanoes.

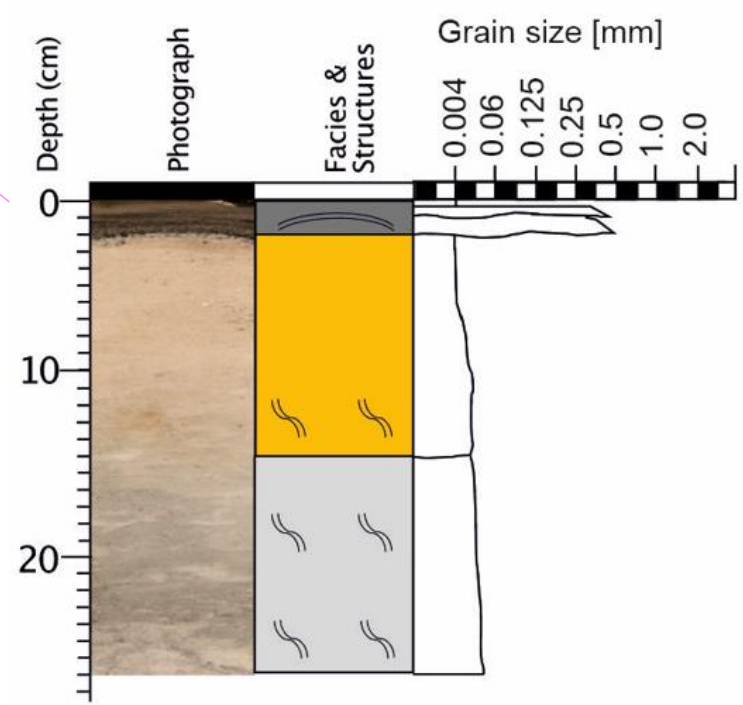
We present observations of voluminous volcaniclastic density currents that were triggered by the 15 January 2022 eruption of Hunga volcano in the Kingdom of Tonga. This eruption was the most explosive in more than a century and had worldwide impacts (*29–35*). The eruption plume entered the mesosphere (57 km high), tsunamis traveled across the Pacific Ocean and caused 19- to 20-m runups in Tonga, and a pressure wave encircled the globe multiple times (*29–31*, *33*, *34*). More than 1 hour

Clare, Yeo et al. Science (2023)

Branko Sugar (15/01/2022)



Flows ran more than 600 m up slope



Clare & Yeo et al. (Science, 2020)