NIWA-Nippon Foundation Tonga Eruption Seabed Mapping Project

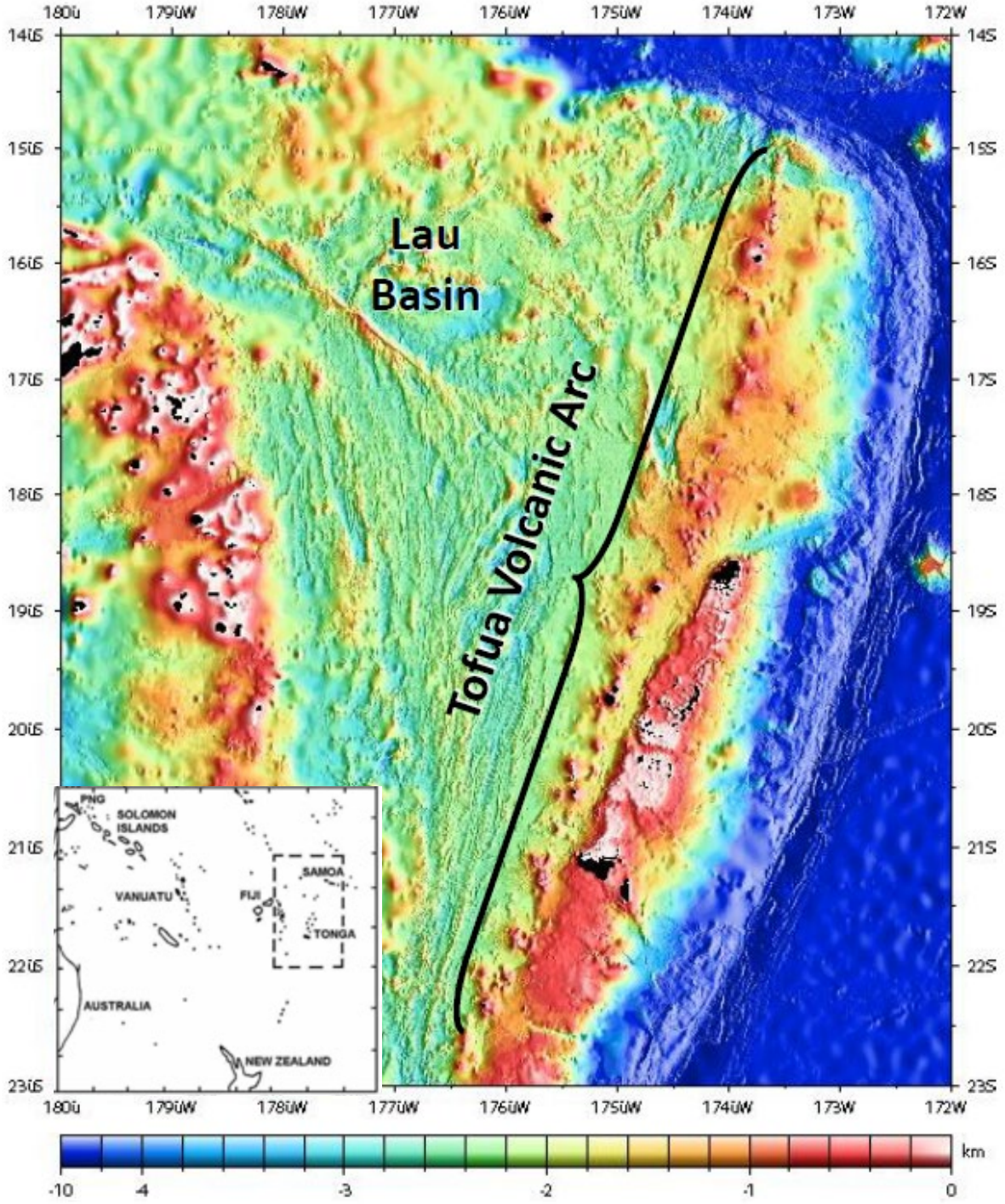
NIWA
Taihoro Nukurangi

THE NIPPON FOUNDATION

THE NIPPON FOUNDATION-GEBCO SEABED 2030

Post-eruption seafloor mapping around Hunga Tonga-Hunga Ha'apai volcano, Tonga

FEMME 2023, Edinburgh



Geological Context: Tofua Volcanic Arc

- Typical oceanic arc system
- Comprised of submarine and subaerial centres
- Predominately submarine centres
- Frequent periods of activity occur
- Ephemeral islands often formed during activity that only weeks or months

Hunga Tonga-Hunga Ha’apai

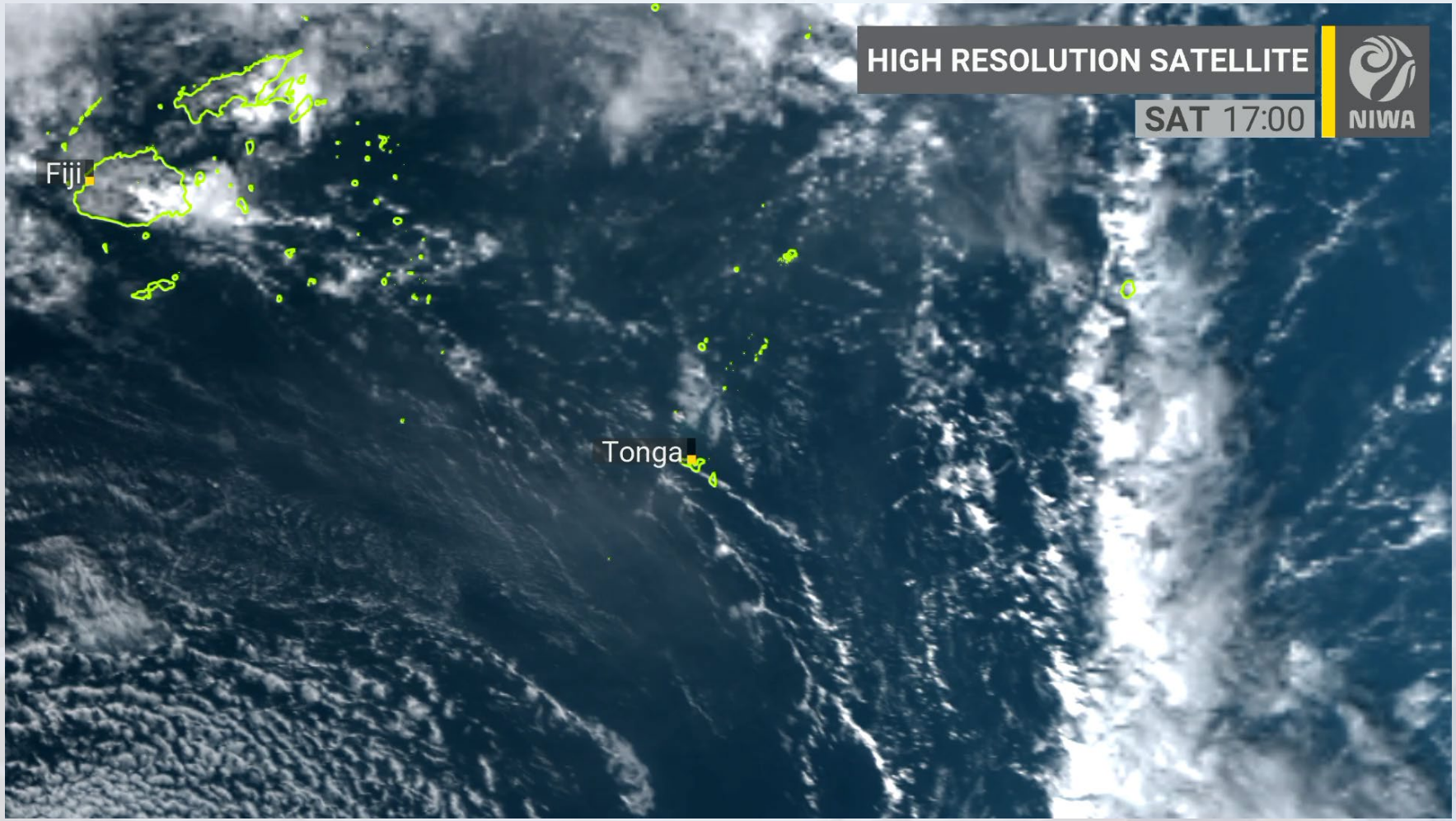
Hunga Tonga-Hunga Ha’apai


Newshub

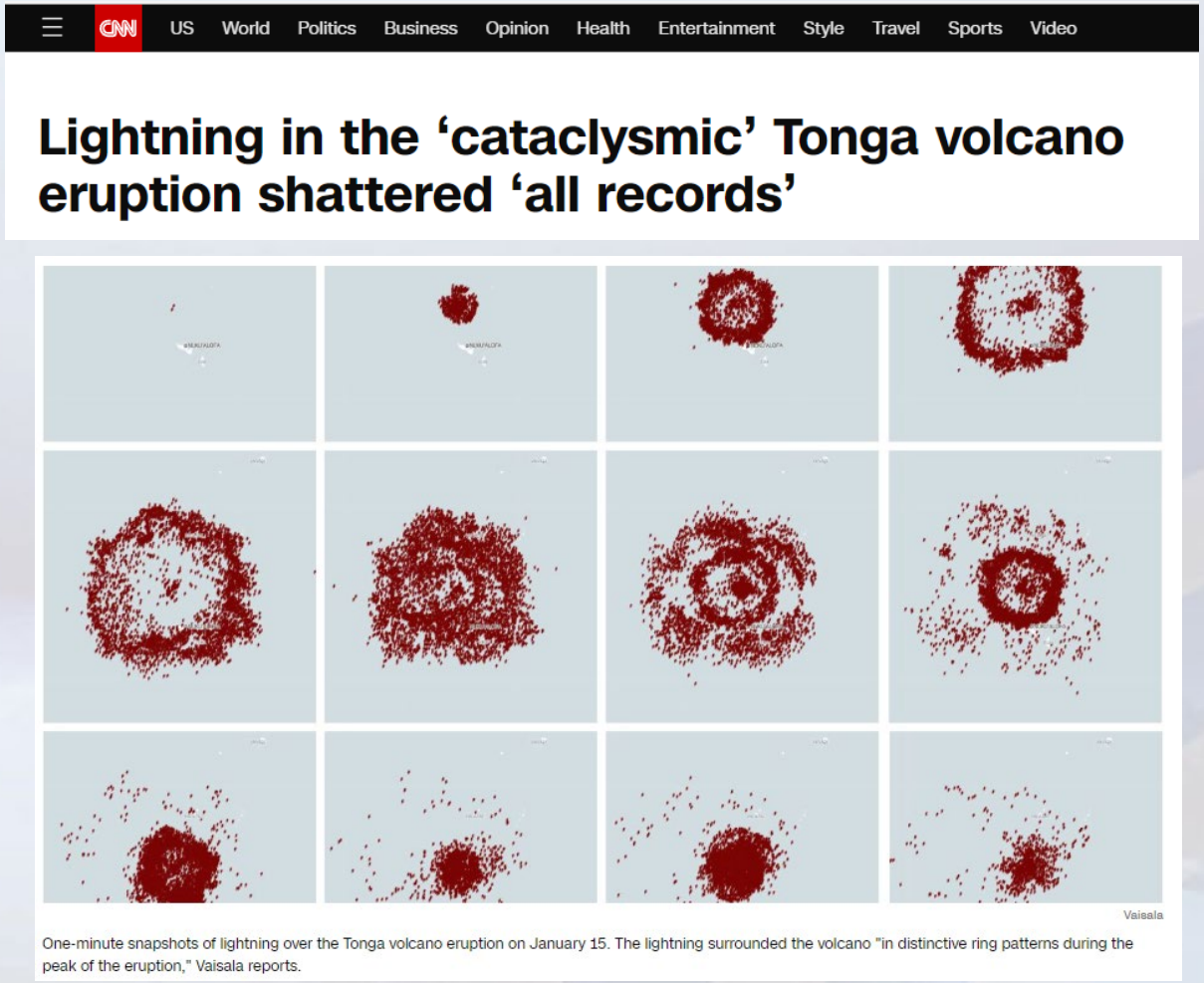
15 January 2022 VEI-5 Tonga Eruption

- 3 deaths in Tonga
- 80 per cent of Tonga population impacted by eruption and tsunami
- Underwater communications cables cut
- Crops, livestock, freshwater, fisheries badly affected
- ~US$90.4M in damages –approx. 18.5% of Tonga's Gross Domestic Product (GDP)

15 January 2022 VEI-5 Tonga Eruption

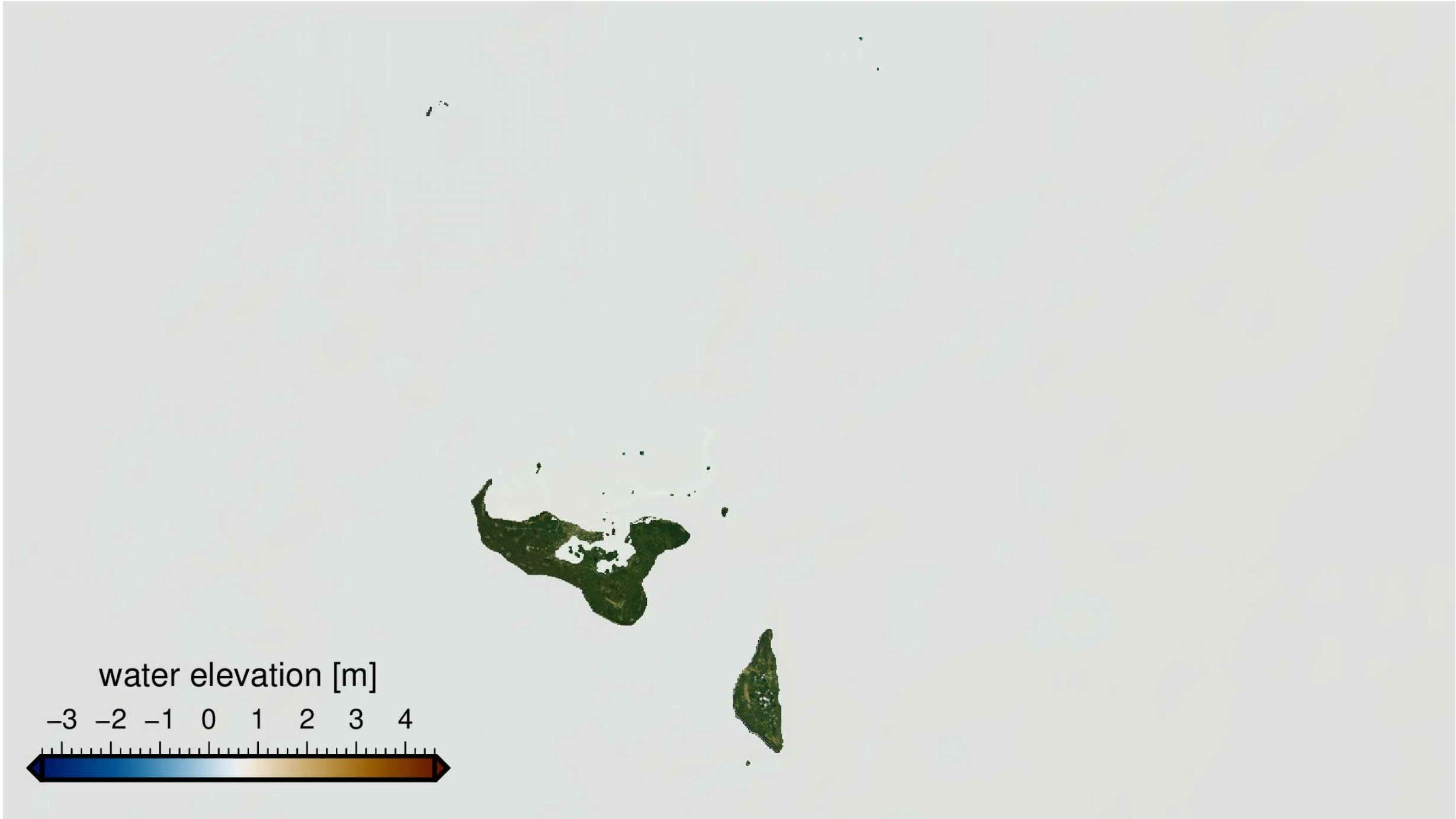


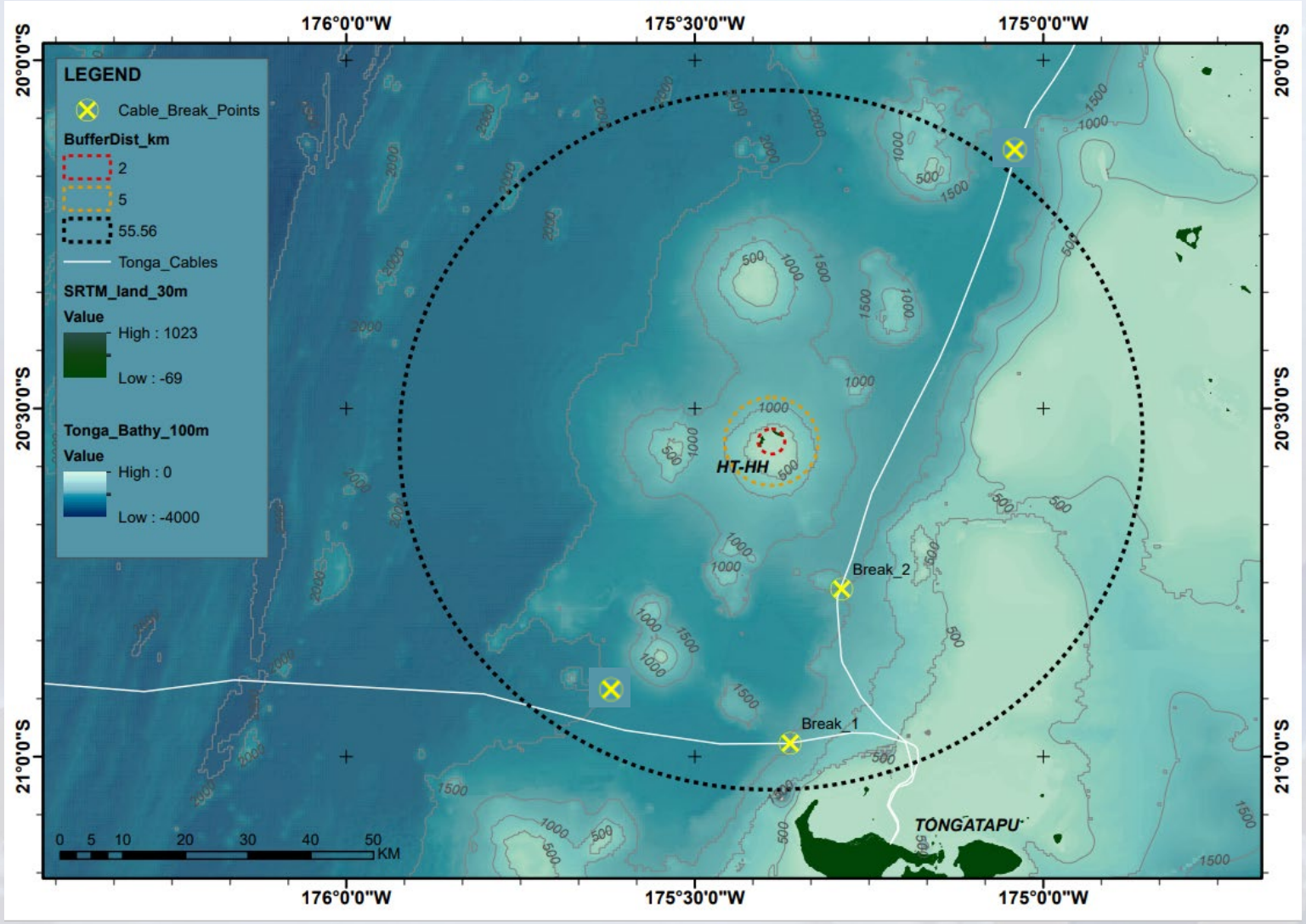
15 January 2022 VEI-5 Tonga Eruption



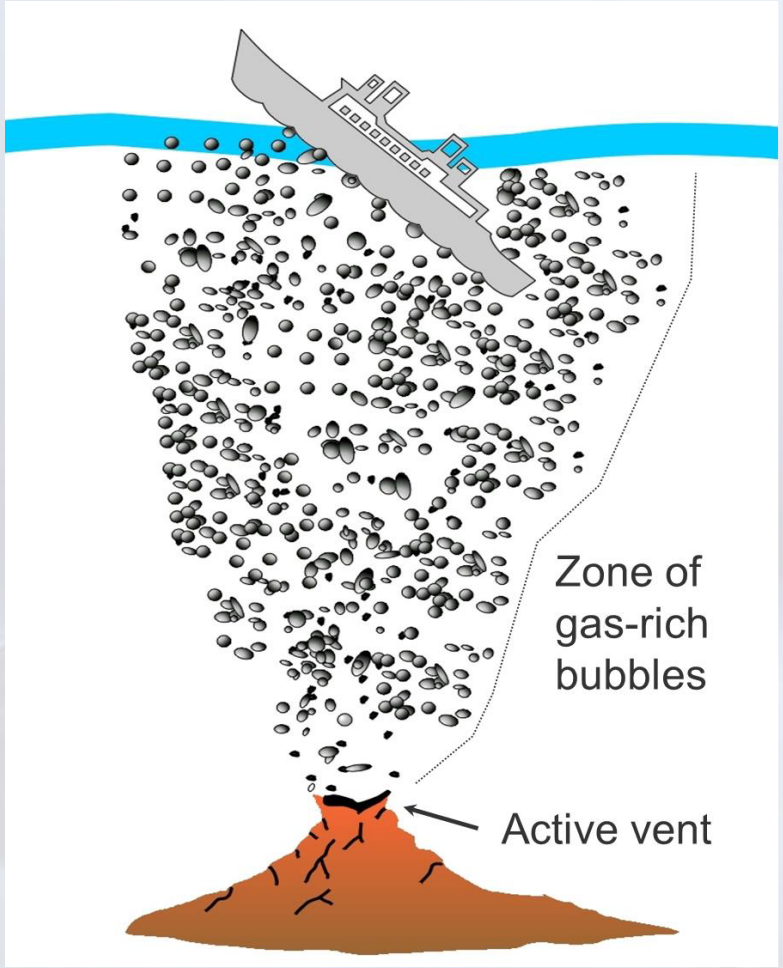
Officer Esafe Vuki - Tongan Maritime Force

Tsunami waves caused by the eruption


water elevation [m]
−3 −2 −1 0 1 2 3 4

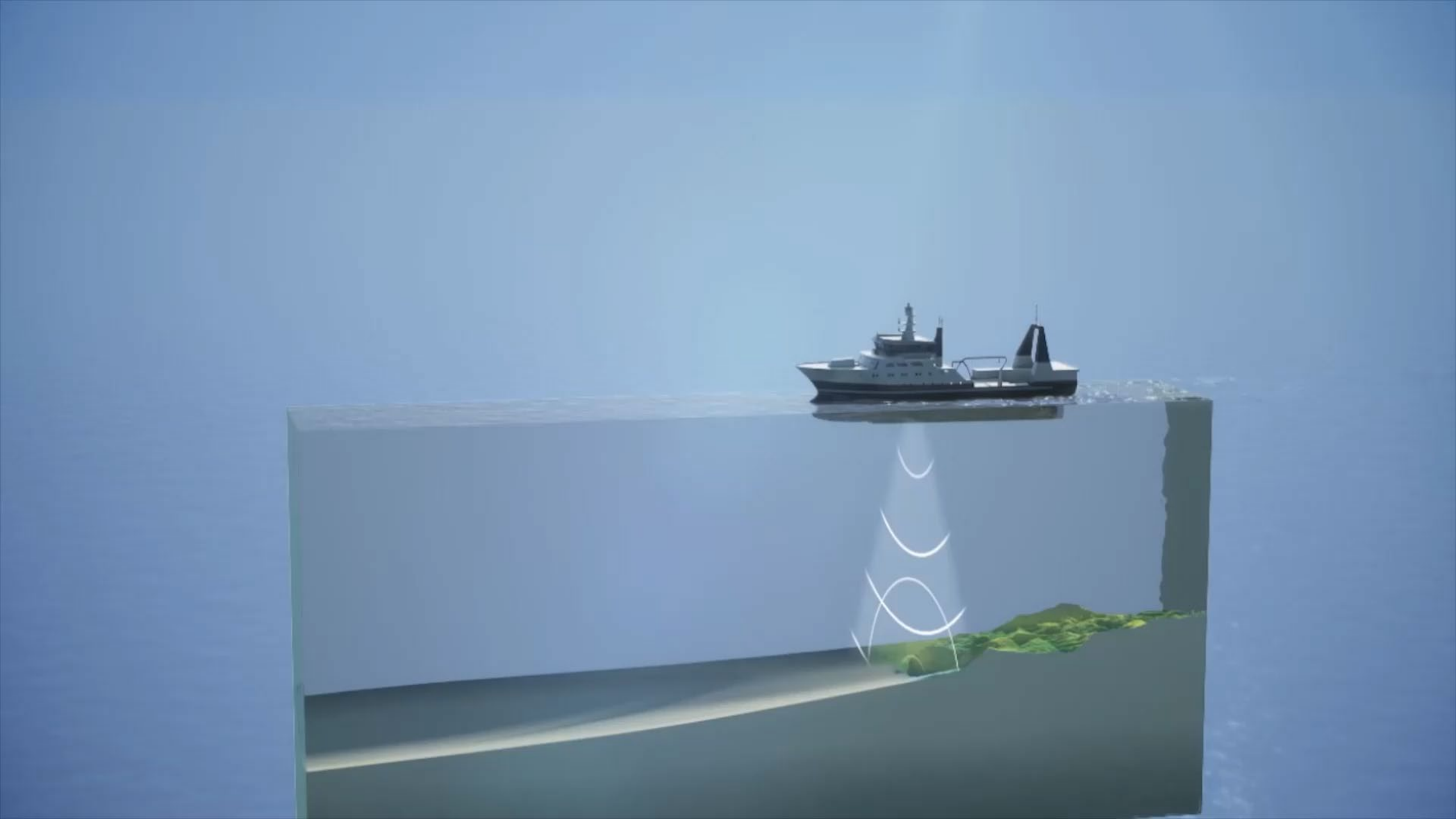

LEGEND
Cable_Break_Points
BufferDist_km
2
5
55.56
Tonga_Cables
SRTM_land_30m
Value
High : 1023
Low : -69
Tonga_Bathy_100m
Value
High : 0
Low : -4000
176°0'0"W
175°30'0"W
175°0'0"W
20°0'0"S
20°30'0"S
21°0'0"S
HT-HH
Break_2
Break_1
TONGATAPU
0 5 10 20 30 40 50
KM

Submarine volcanic activity creates a significant hazard to maritime transport.



Effect of Lowered Water Density

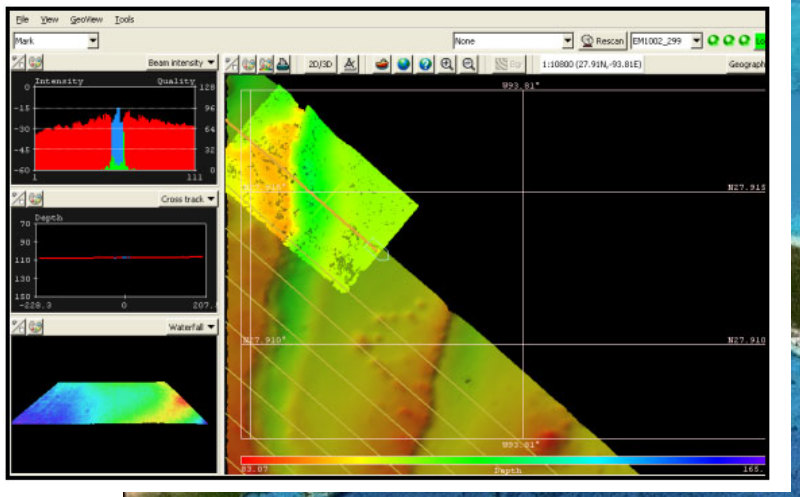
- Area of lowered water density above the active vent that is saturated in gas-rich bubbles
- Vessel enters area of lower water density and looses buoyancy
- Depending on the magnitude of buoyancy loss, vessel may sink

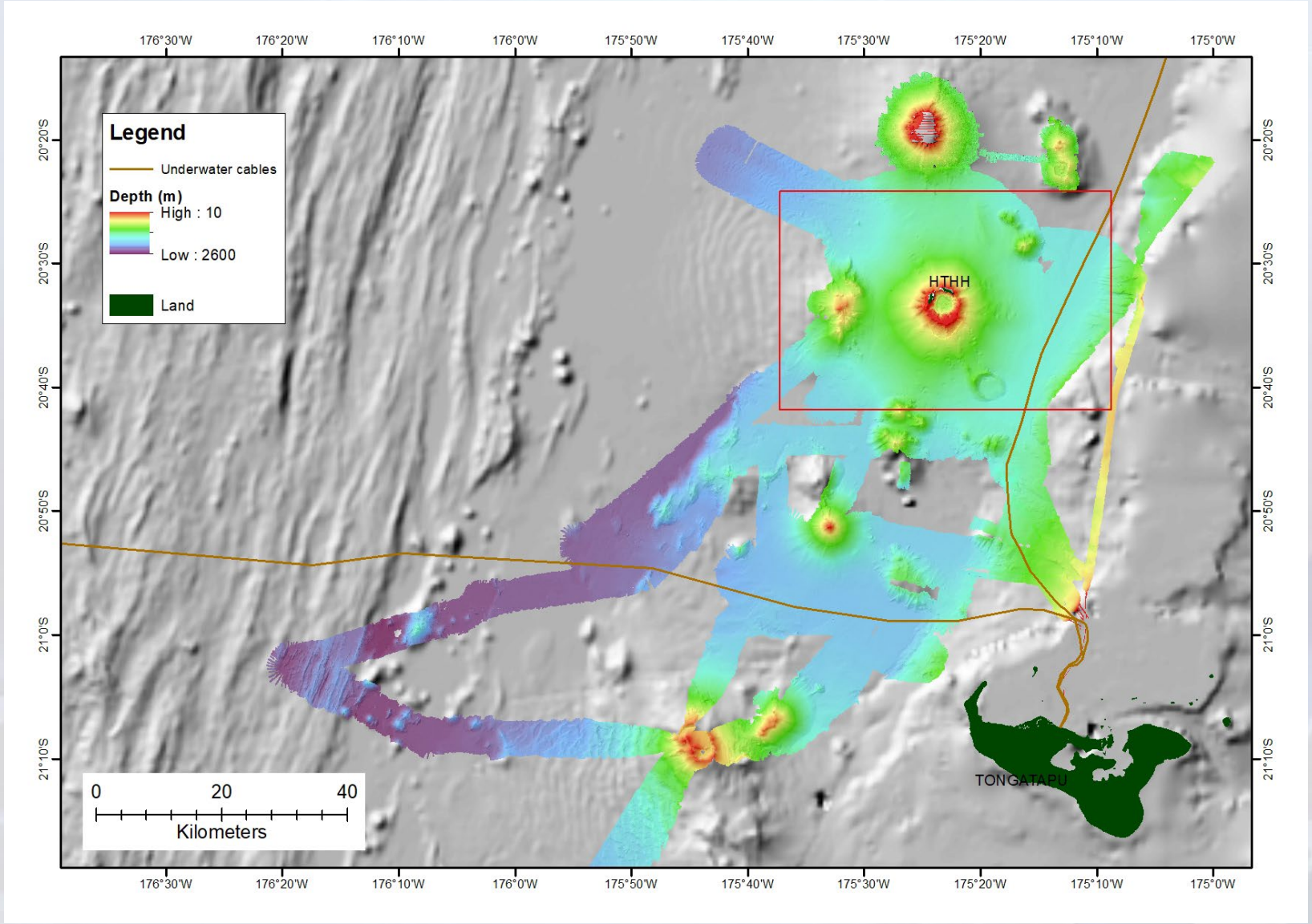


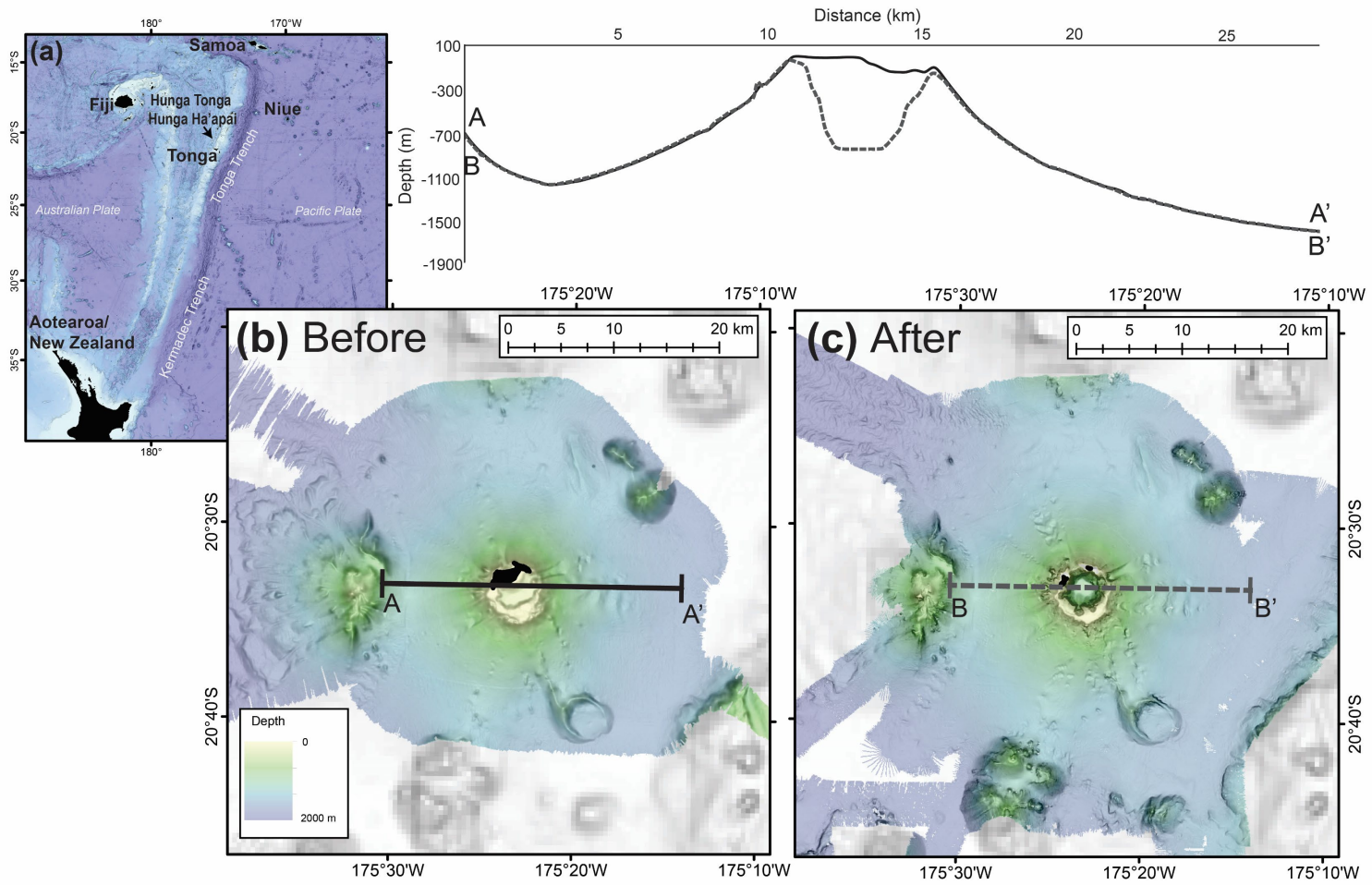
TESMaP – Part 2 Uncrewed Surface Vessel

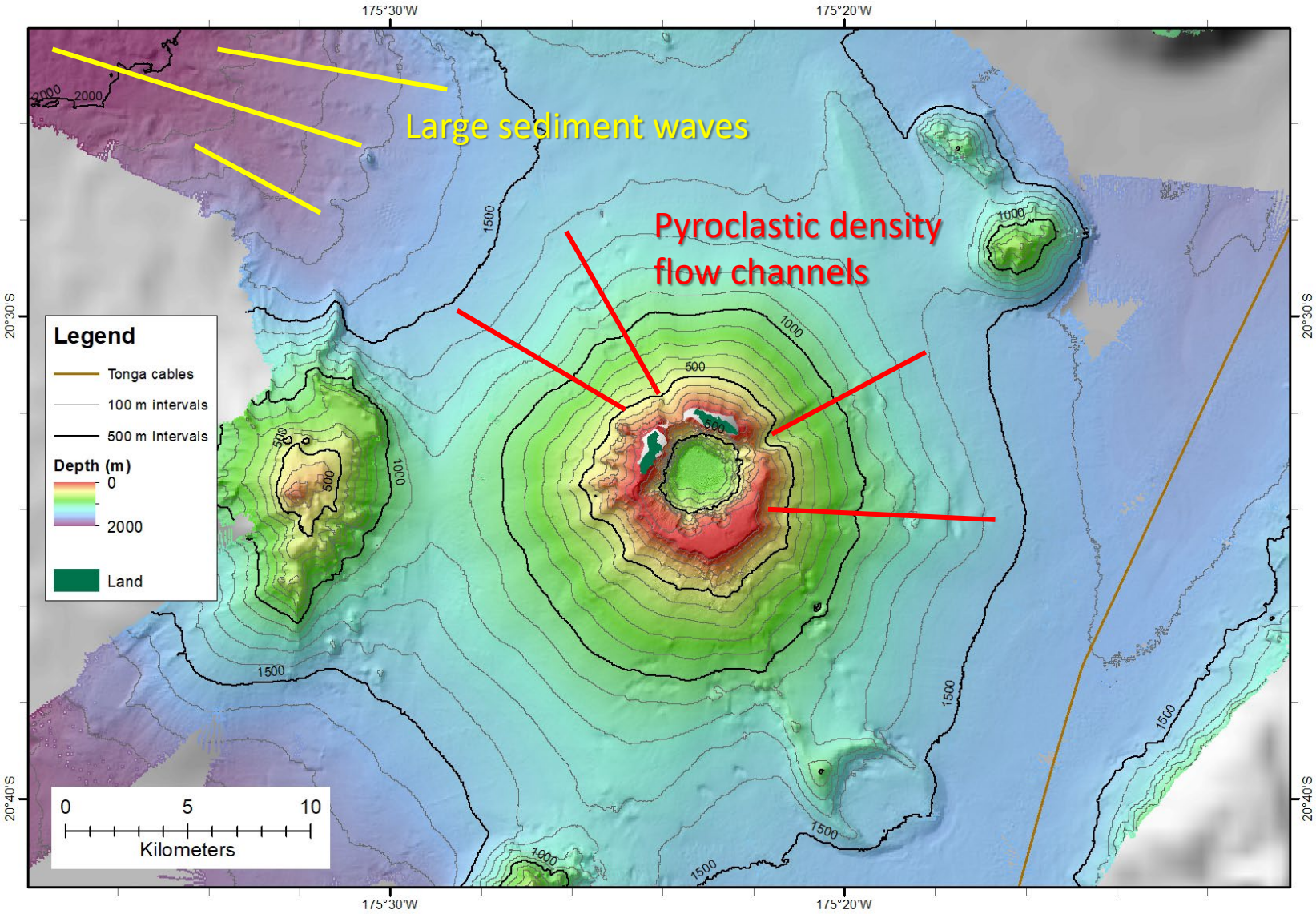
USV Maxlimer

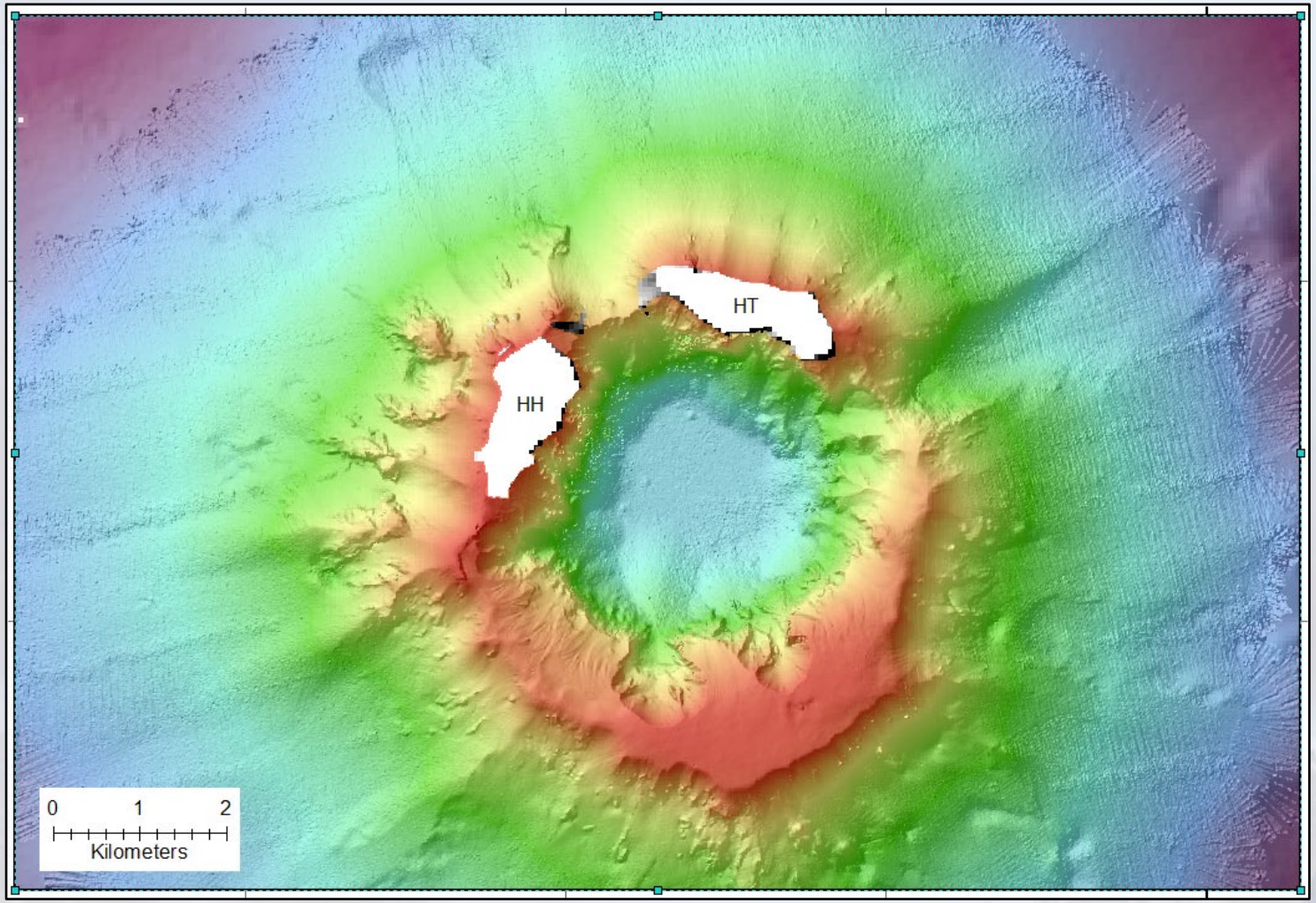
Controlled in Essex, UK

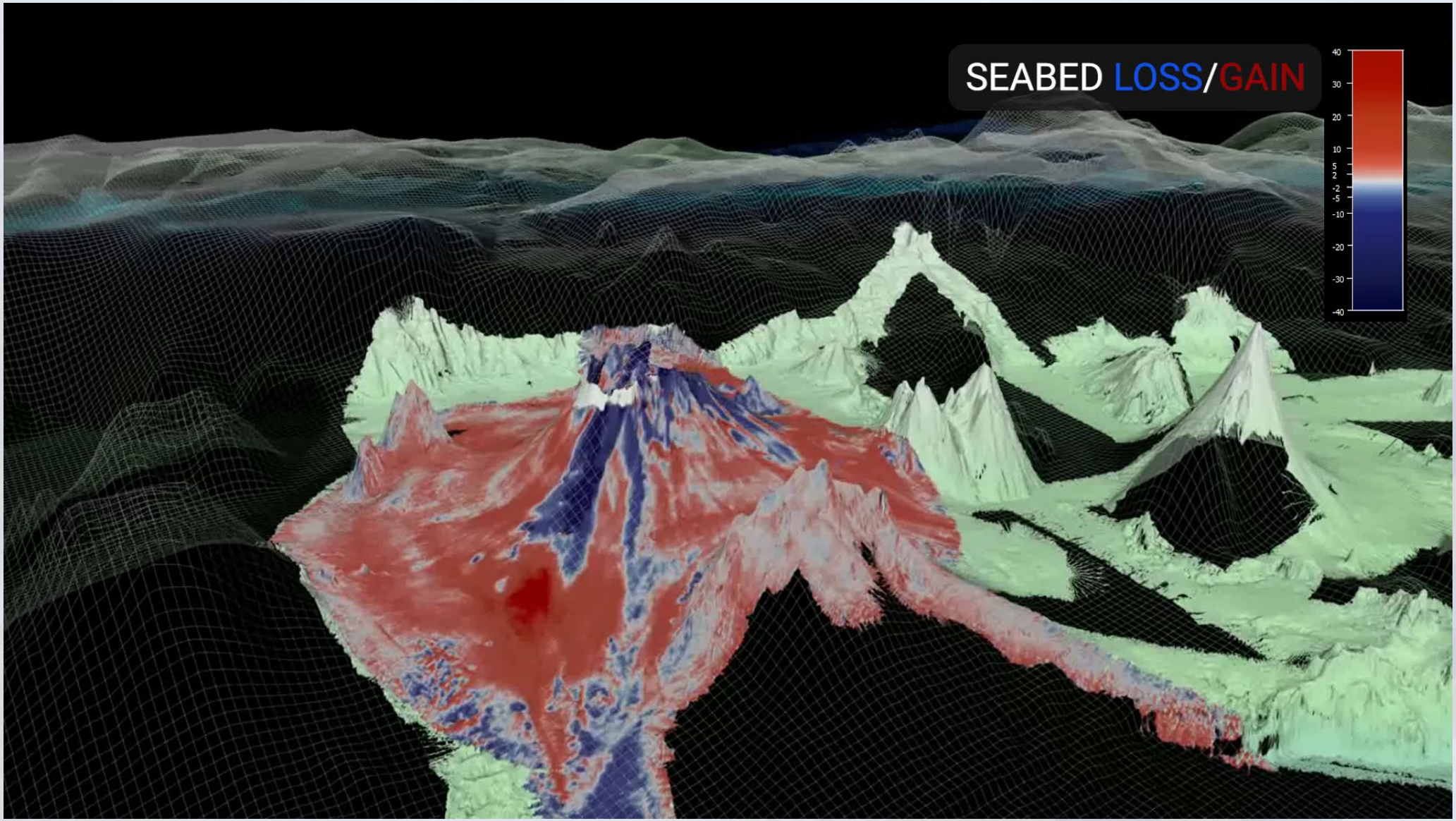

File View GeoView Tools
Mark
None
Rescan
EM1002_299
Beam intensity
Intensity
Quality
2D/3D
1:10800 (27.91N,-93.81E)
Geograph
W93.91°
N27.915
Cross track
Depth
Waterfall
N27.910°
N27.910
W93.901°
93.97
Depth
165

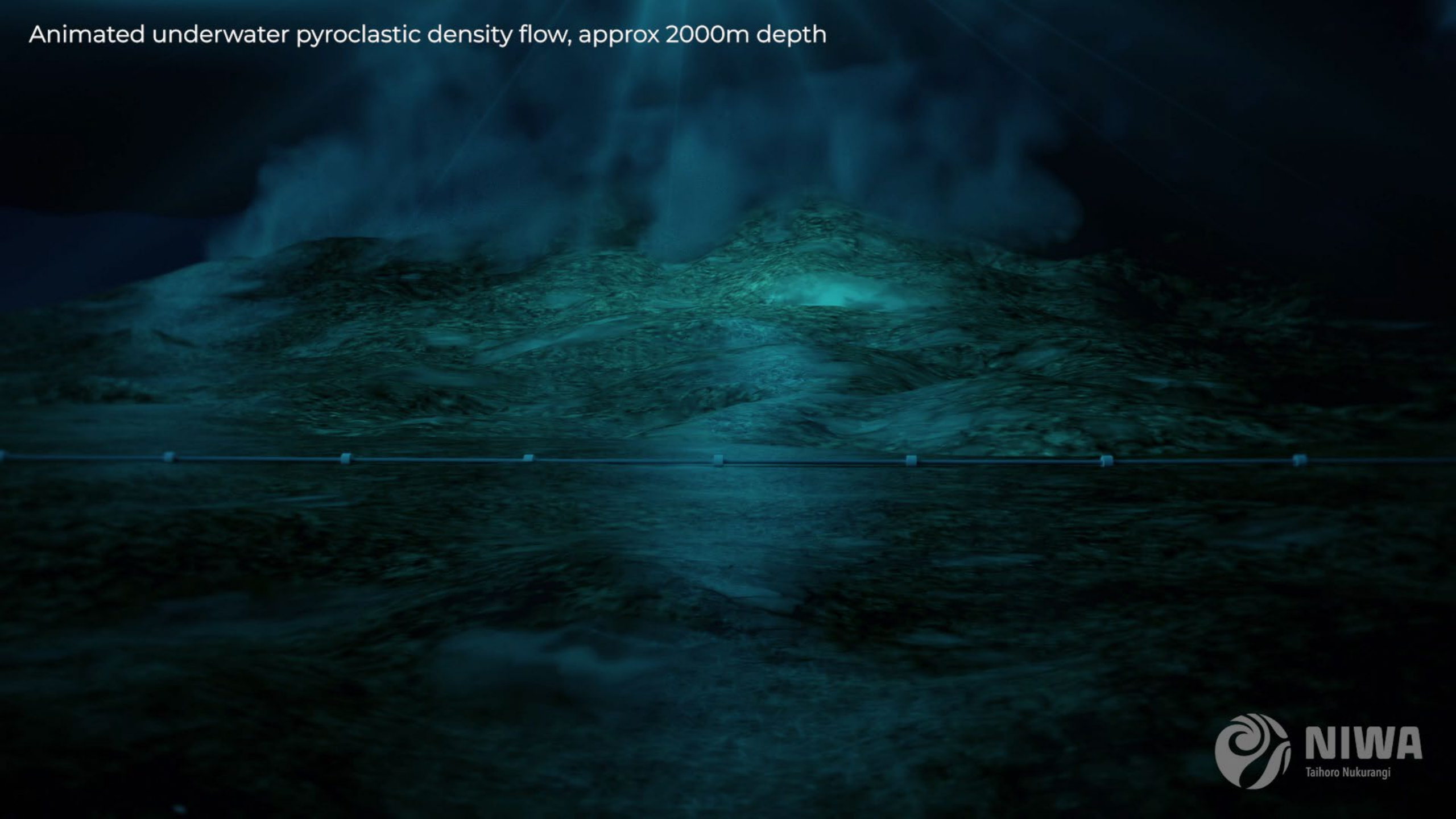

Legend
Underwater cables
Depth (m)
High : 10
Low : 2600
Land
HTHH
TONGATAPU
0
20
40
Kilometers
176°30'W
176°20'W
176°10'W
176°0'W
175°50'W
175°40'W
175°30'W
175°20'W
175°10'W
175°0'W
20°20'S
20°30'S
20°40'S
20°50'S
21°0'S
21°10'S

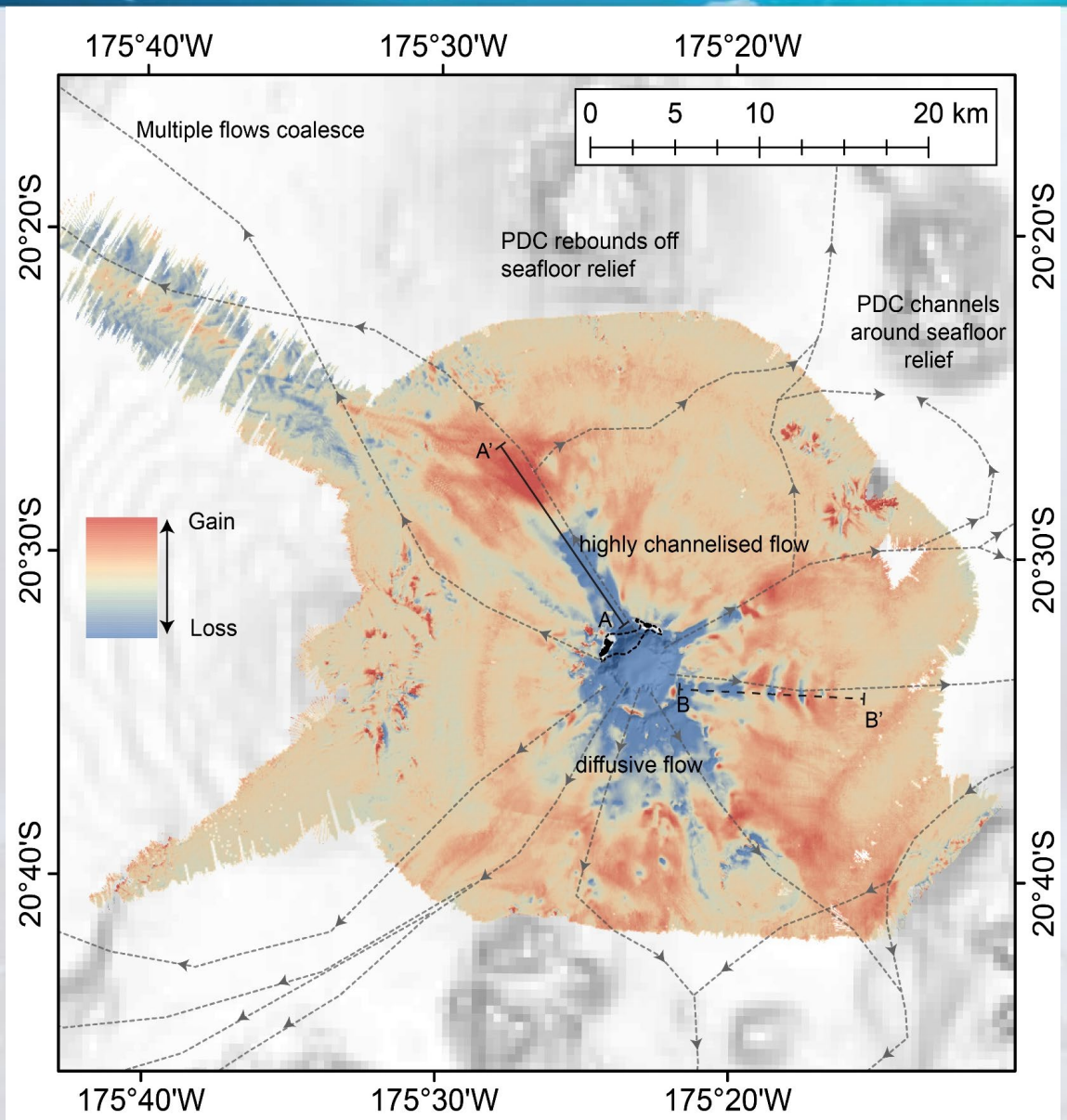

(a)
Samoa
Fiji
Hunga Tonga
Hunga Ha'apai
Niue
Tonga
Tonga Trench
Australian Plate
Pacific Plate
Kermadec Trench
Aotearoa/
New Zealand
180°
170°W
15°S
20°S
25°S
30°S
35°S
Distance (km)
5
10
15
20
25
100
-300
-700
-1100
-1500
-1900
Depth (m)
A
B
A'
B'
(b) Before
(c) After
0 5 10 20 km
Depth
0
2000 m
175°20'W
175°10'W
175°30'W
20°30'S
20°40'S


175°30'W
175°20'W
20°30'S
20°40'S
Large sediment waves
Pyroclastic density flow channels
Legend
Tonga cables
100 m intervals
500 m intervals
Depth (m)
0
2000
Land
0
5
10
Kilometers
2000
1500
1000
500


HT
HH
0
1
2
Kilometers

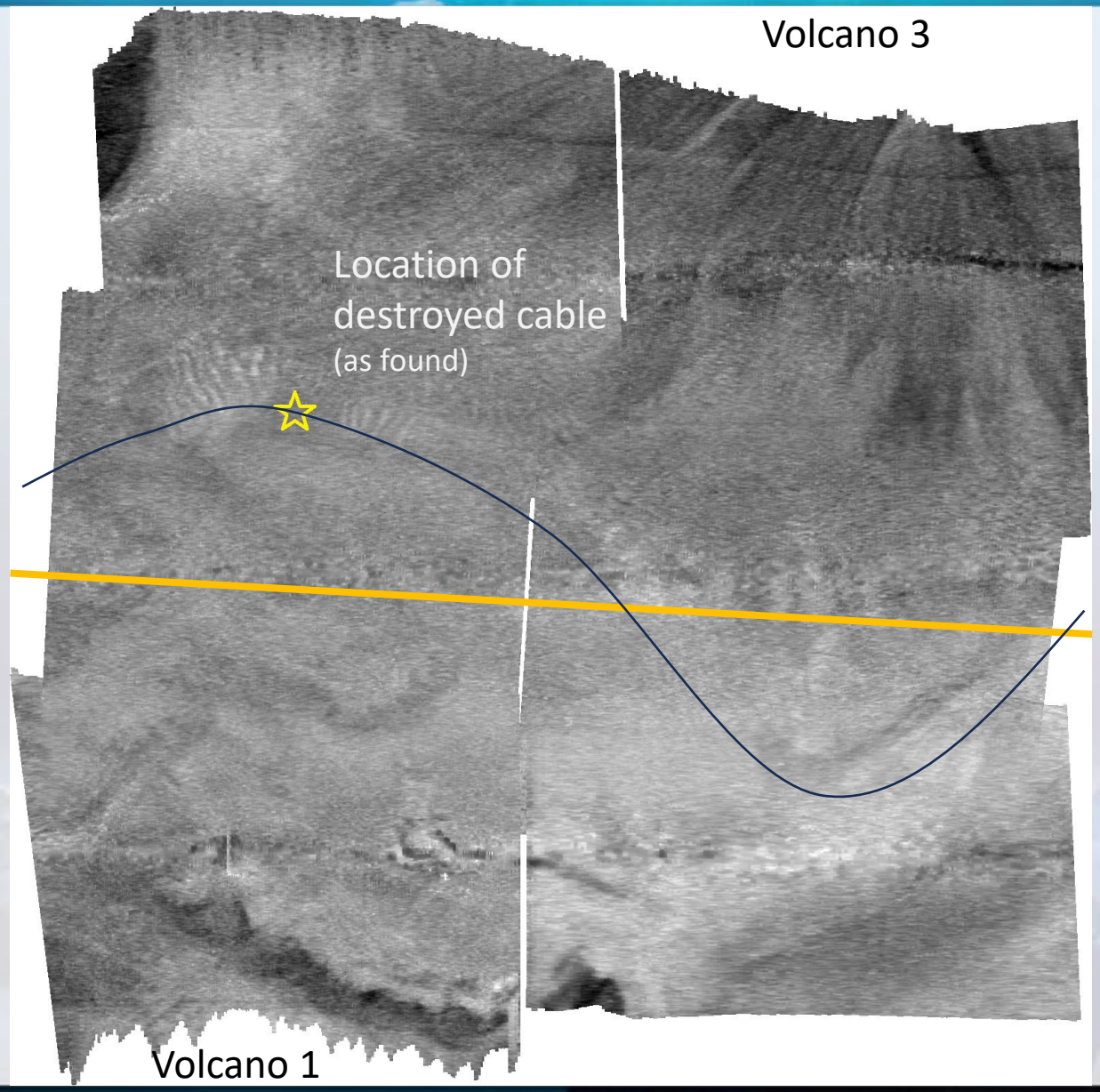

SEABED LOSS/GAIN
40
30
20
10
5
2
-2
-5
-10
-20
-30
-40


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



Seafloor Volume calculations:

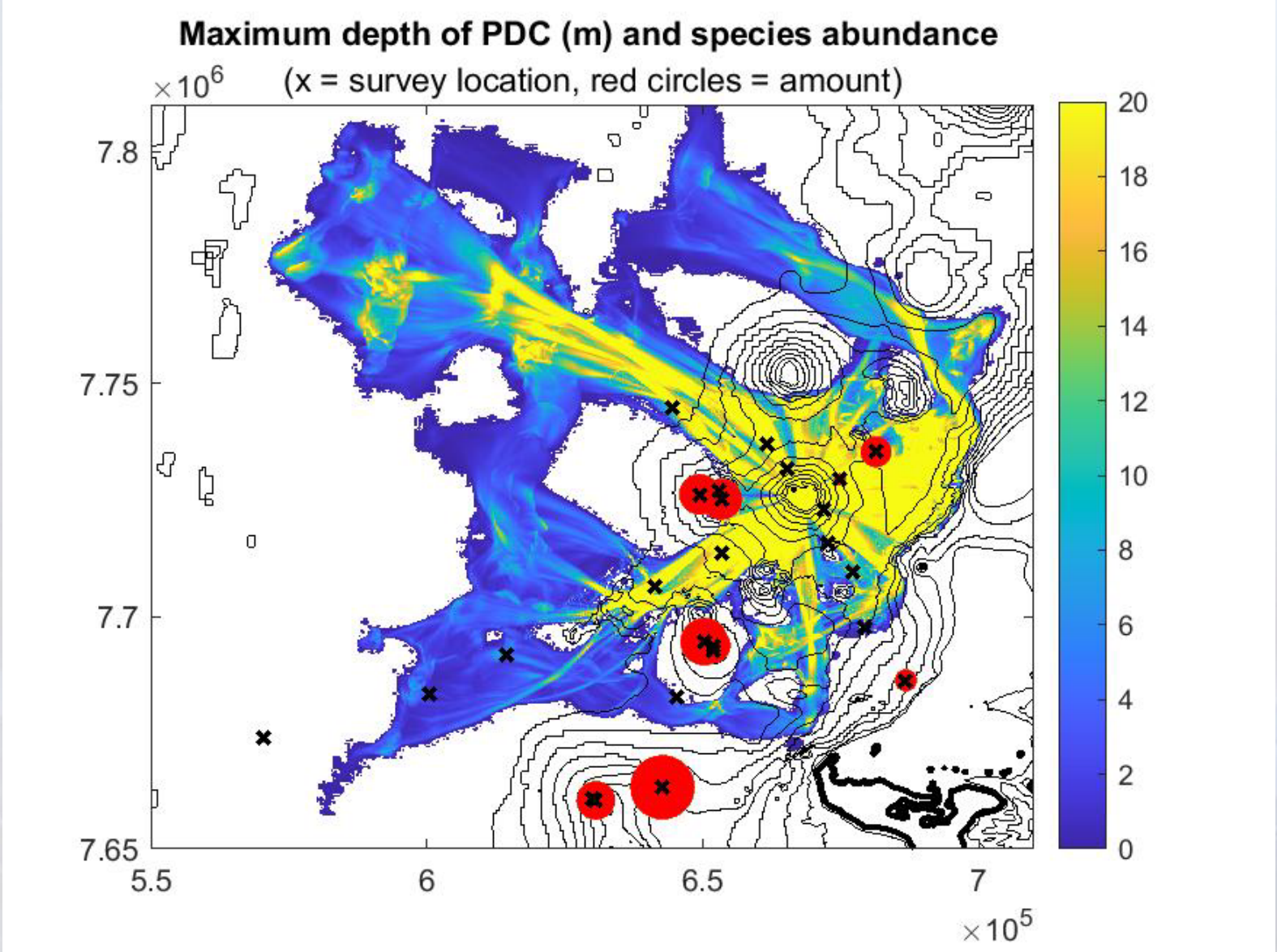
- **9.5 km³ lost (blue)**
- **6.7 km³ added (red)**

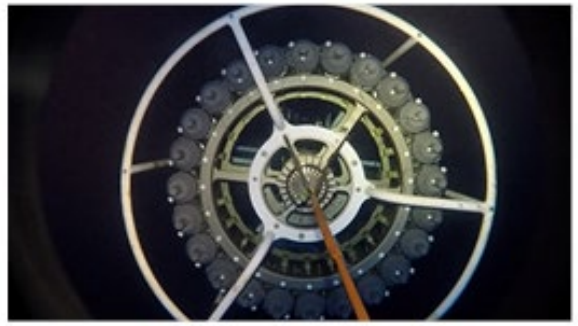


Fiji

Tonga

International
submarine cable
(in original position)


Maximum depth of PDC (m) and species abundance
(x = survey location, red circles = amount)
×10^6
7.8
7.75
7.7
7.65
5.5
6
6.5
7
×10^5
20
18
16
14
12
10
8
6
4
2
0

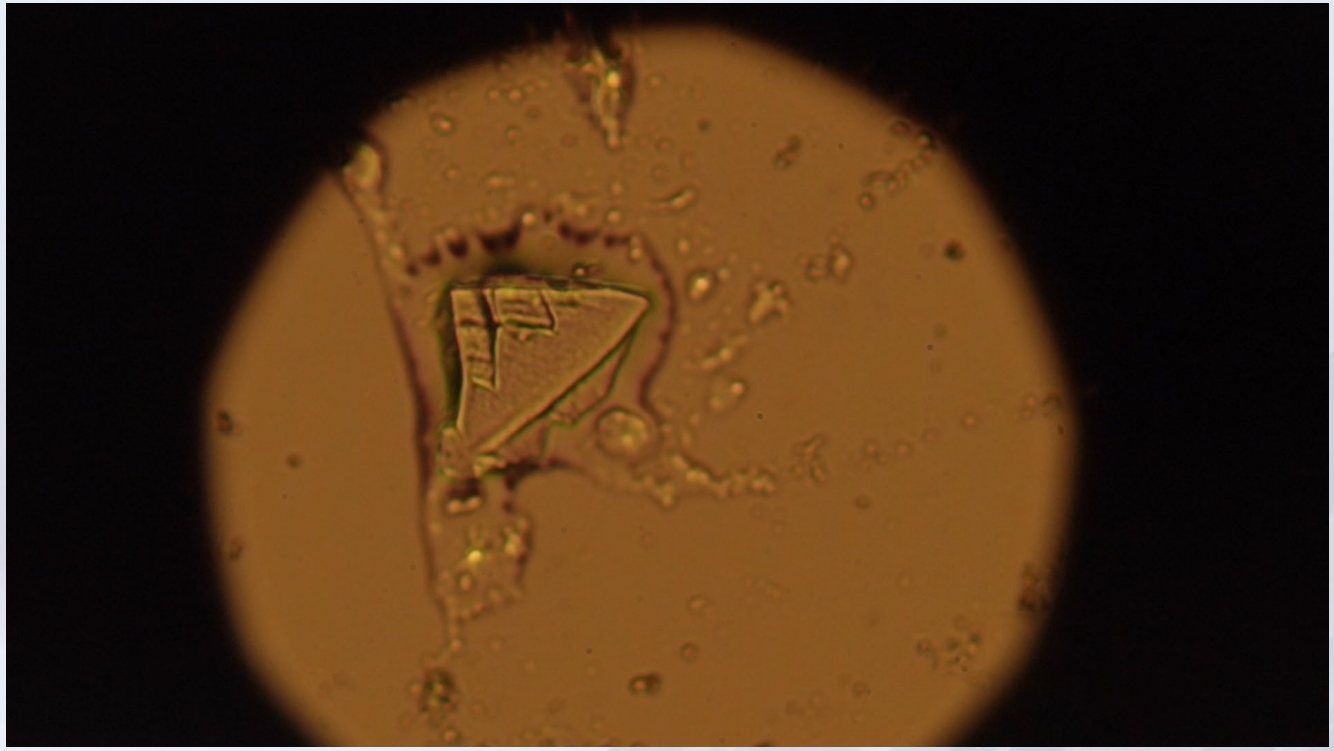


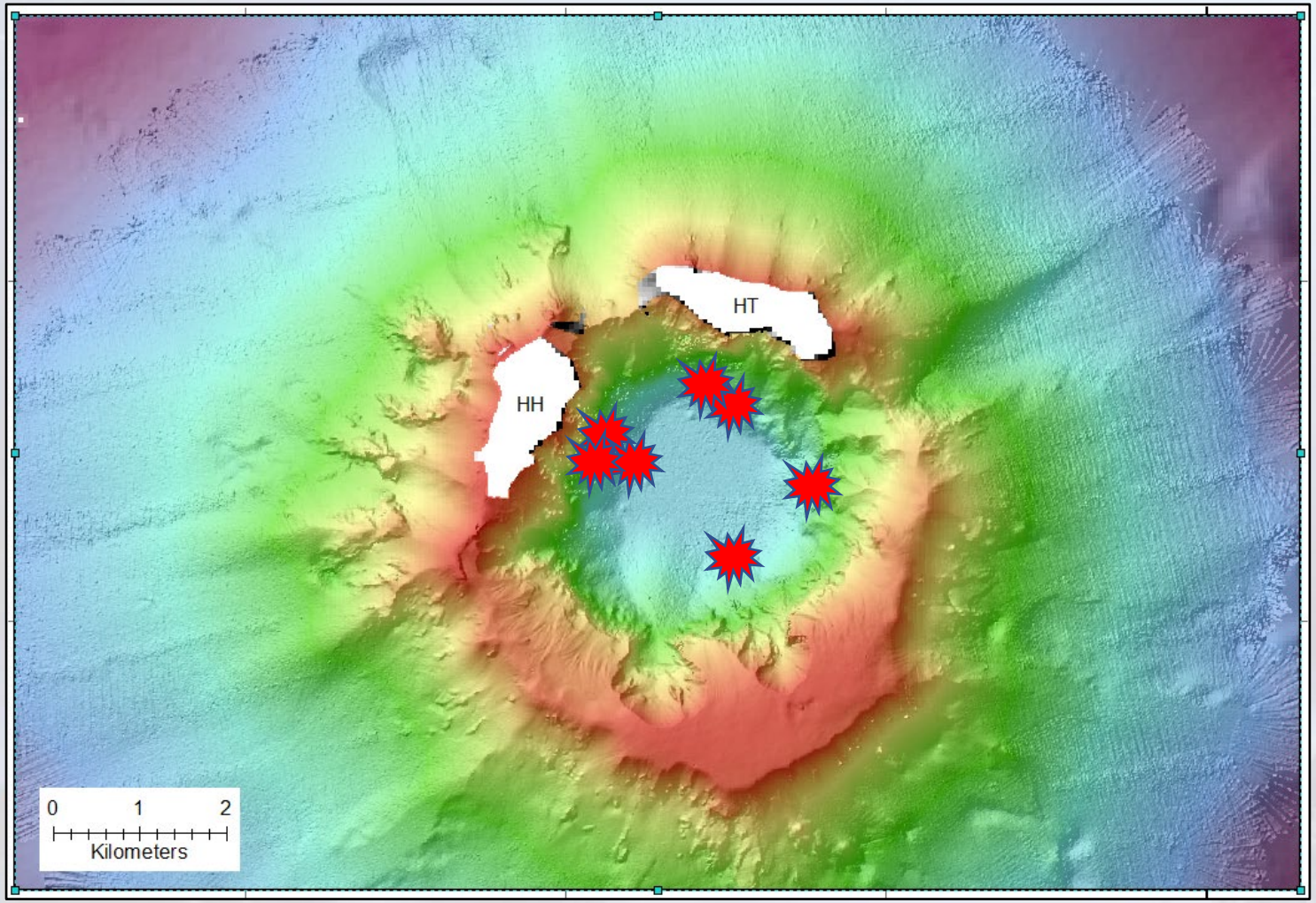
Above

In layer

Below

Ash layer rich in volcanic glass and other particles

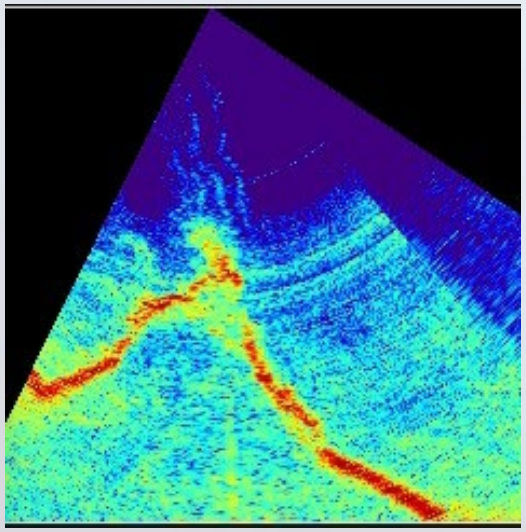


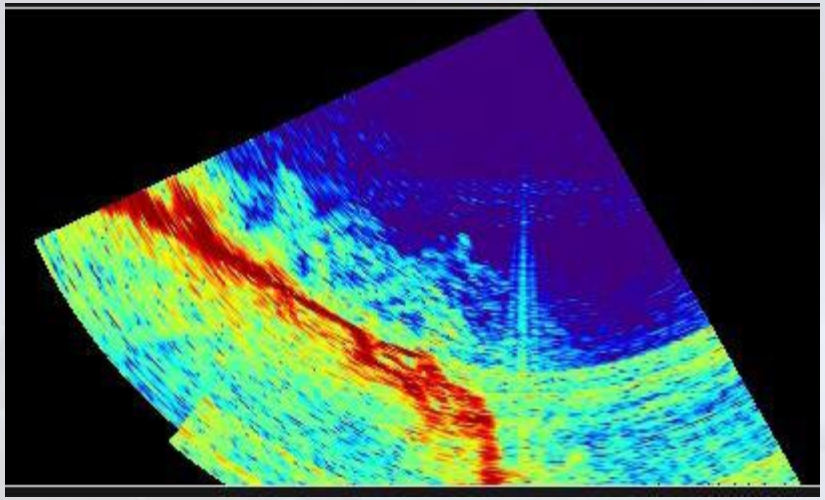


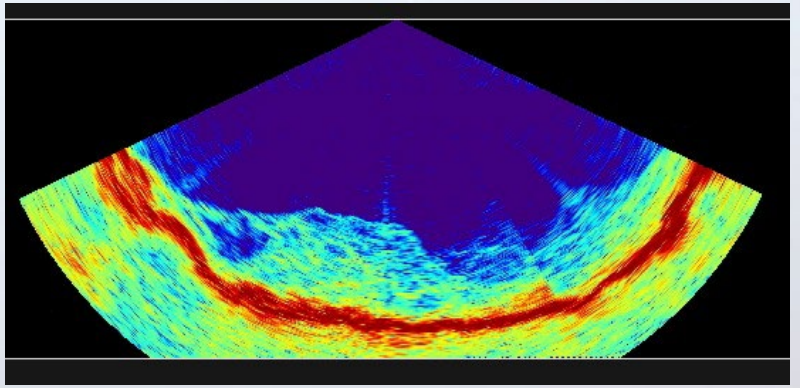
Extensive volcanic activity and hydrothermal venting

- ongoing activity within the caldera during July/August 2022
- occurred on the caldera walls adjacent to each island and in the east/southeastern part of the caldera

Extensive volcanic activity and hydrothermal venting







- Acoustic plumes rising from the seafloor from depths up to ~650 m
- Presence of reduced chemical species common to both submarine volcanic and hydrothermal plumes (e.g., Fe2+, H2S and H2) (*de Ronde and Walker pers. comm*.)

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Thank you

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