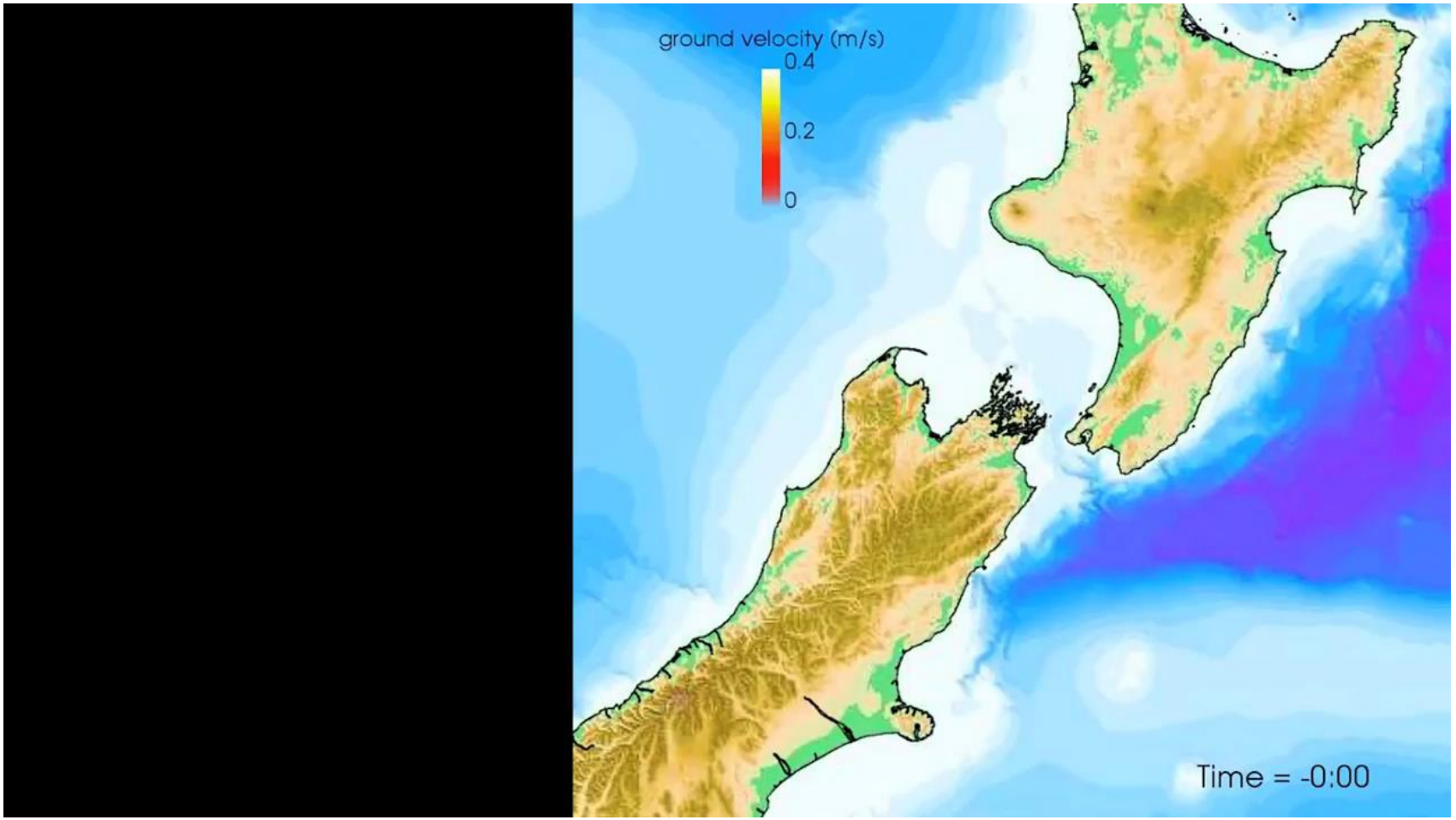
The 2016 M_W 7.8 Kaikōura earthquake: Coastal deformation

Kate Clark, on behalf of the GNS Earthquake Geology team & many collaborators.

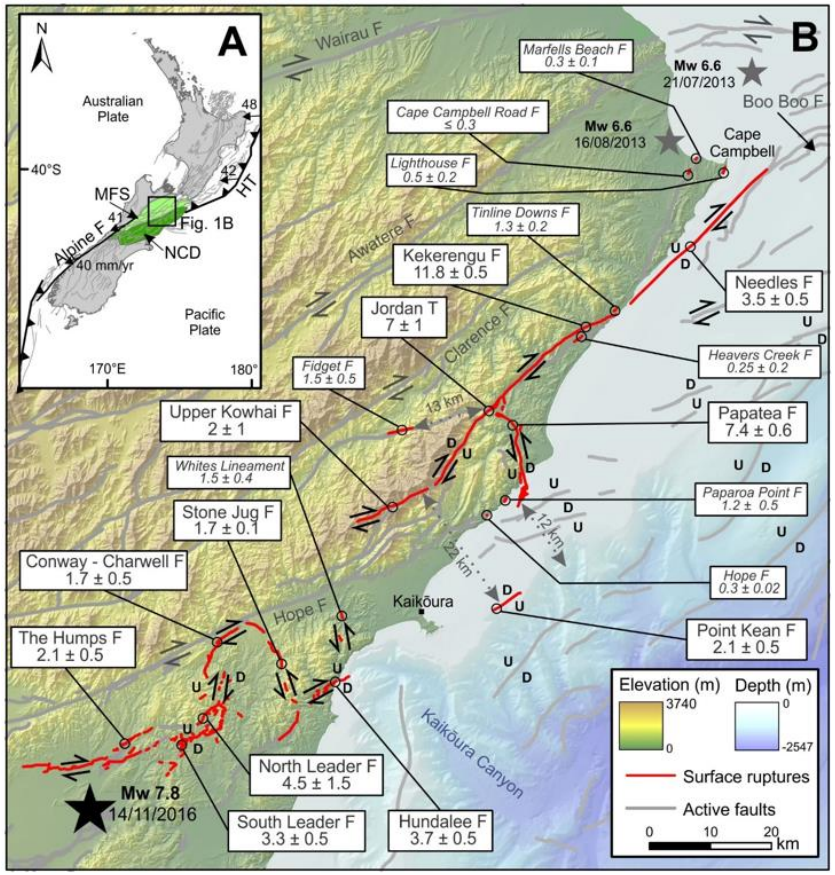
2016 M_W 7.8 Kaikōura earthquake rupture



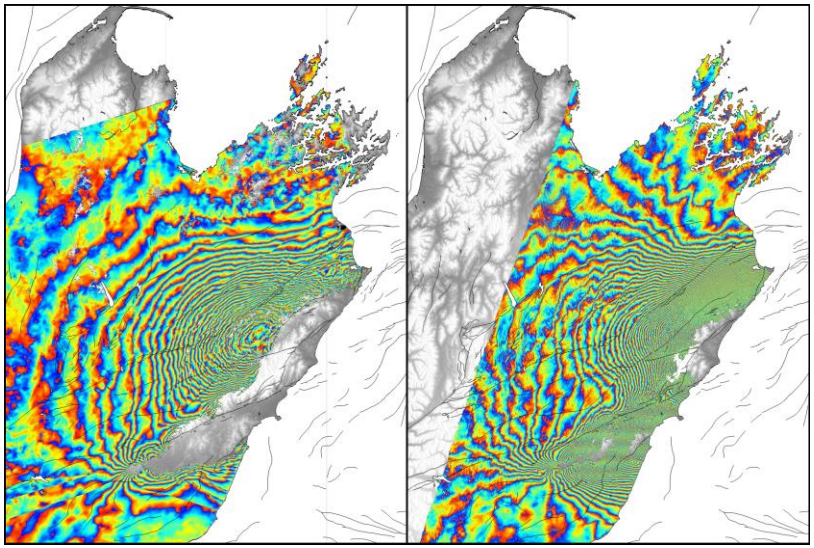
Yoshi Koneko & Xiaoming Wang

Complex surface deformation

- Surface rupture on multiple faults
- Widespread surface deformation measured by satellite & GPS techniques



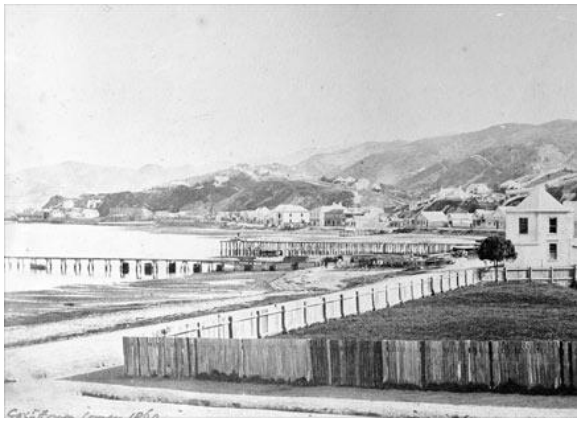
Litchfield et al. (2018)



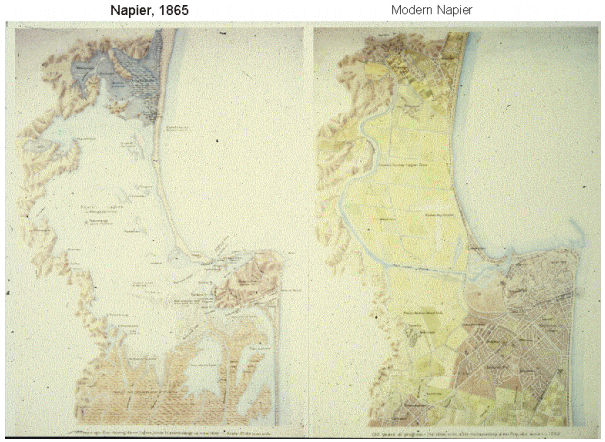
Satellite interferograms – Hamling et al 2017

Coastal deformation

- Coastal uplift & subsidence was one of the more immediately apparent impacts of the Kaikōura earthquake.
- The Kaikōura EQ follows a number of historic EQs in NZ that have caused widespread coastal deformation

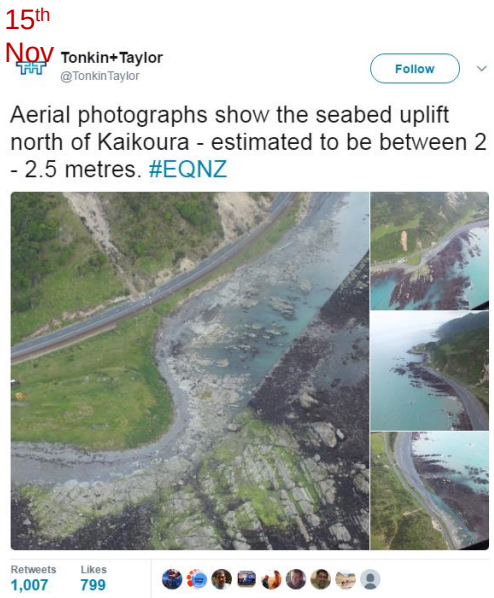


1855 M_w 8.2 Wairarapa EQ



1931 M_w 7.8 Napier EQ

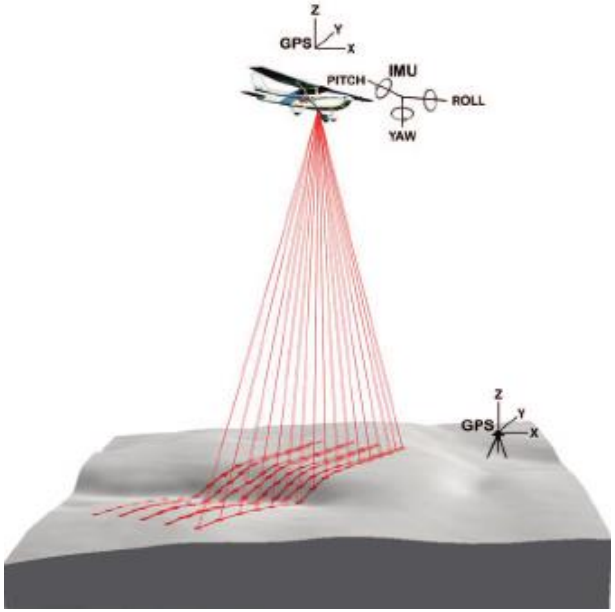
15th Nov



Stuff.co.nz - 18th Nov

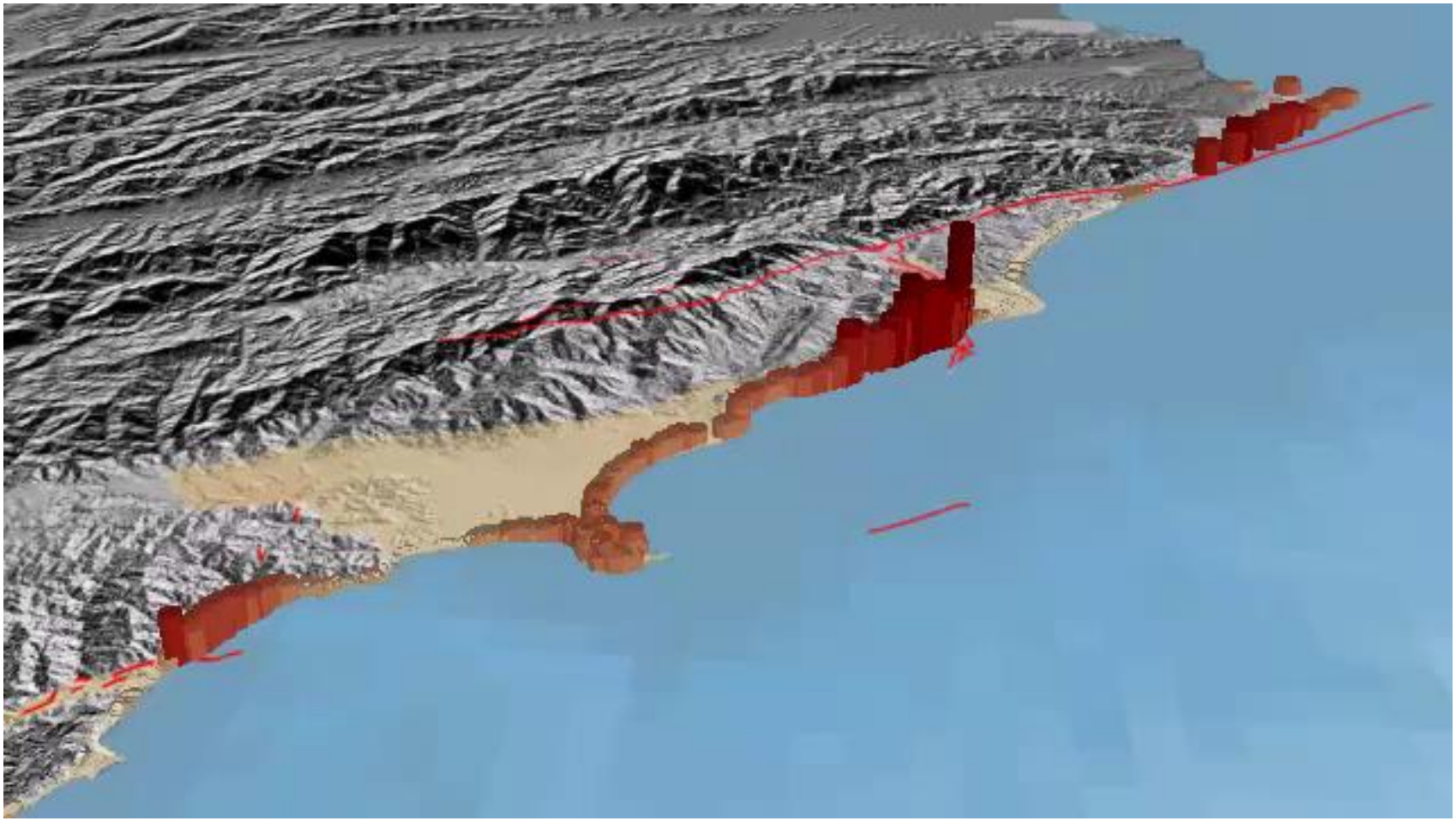
Measuring coastal deformation of the Kaikōura earthquake

- Measuring the amount of coastal deformation contributes to understanding the amount of slip on fault lines on & offshore.
- Geonet earthquake response involved geologists in the field within 2 – 3 days of the earthquake
- Coastal deformation studied in the field by a team of 7 geologists from GNS + 2 marine biologists from UC.
- LiDAR differencing (2016 – 2012)

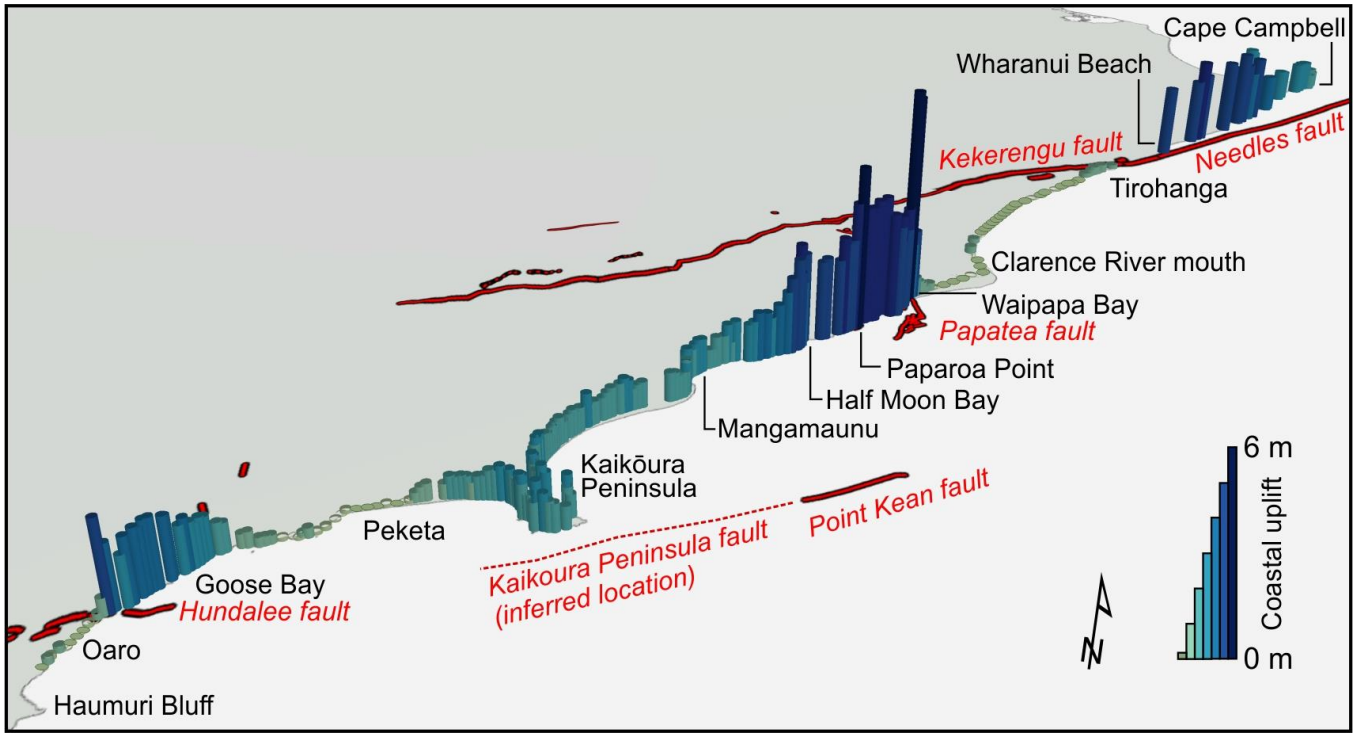


Reutebuch et al. 2005

Coastal deformation measurement compilation

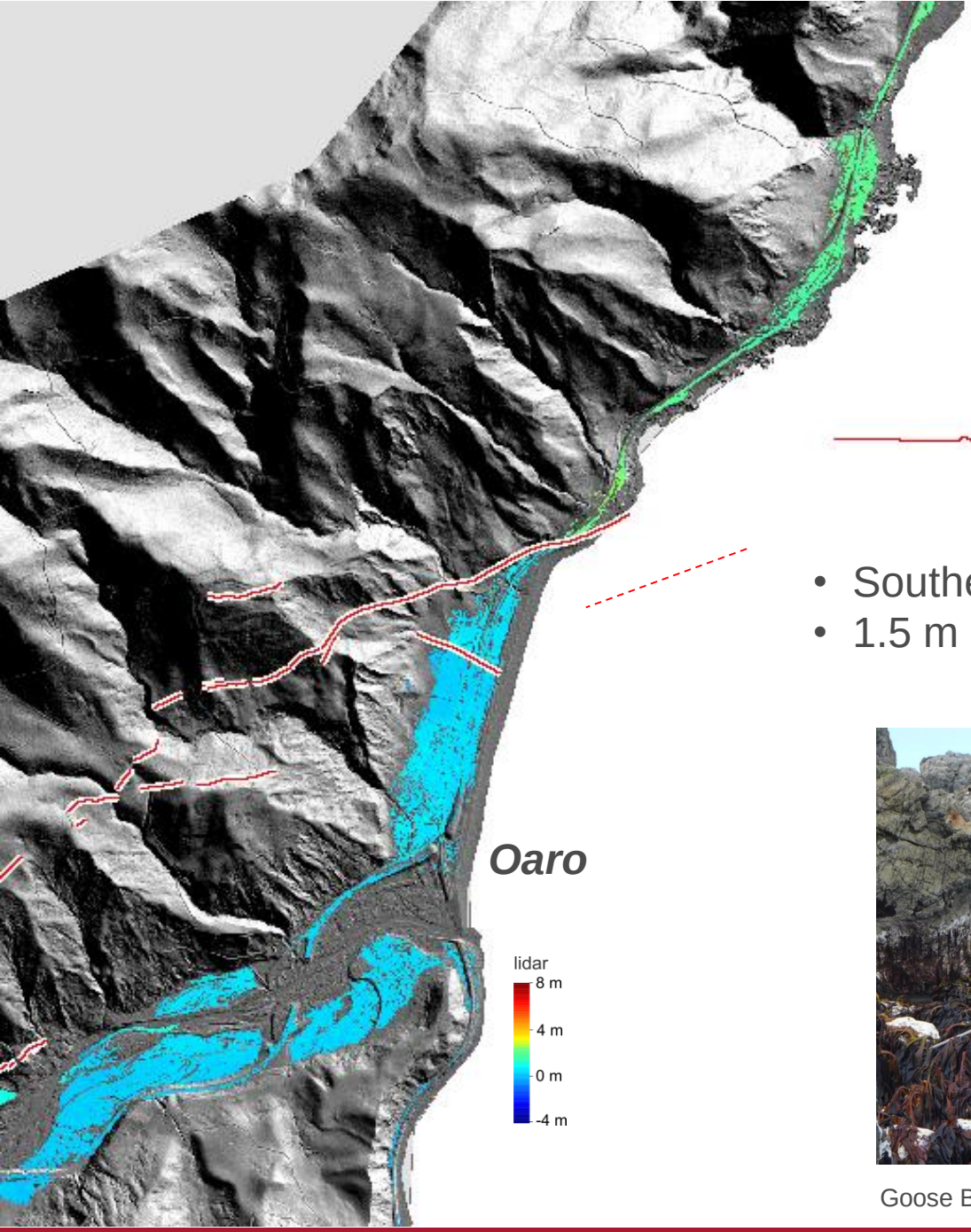


Coastal deformation measurement compilation



- Approximately 110 km of the coastline underwent deformation
- 80 km / **73% of coast uplifted** → 48 km / **44% went up by > 1 m.**
- 28 km / 25 % went down by <0.5 m.
- Only 3 km / 2 % did not move.
- Deformation characterised by high variability
  - Sharp changes around fault ruptures
  - 3 major & 5 minor fault ruptures across coast
  - Broad uplift around Kaikoura Peninsula & northwards related to an offshore fault

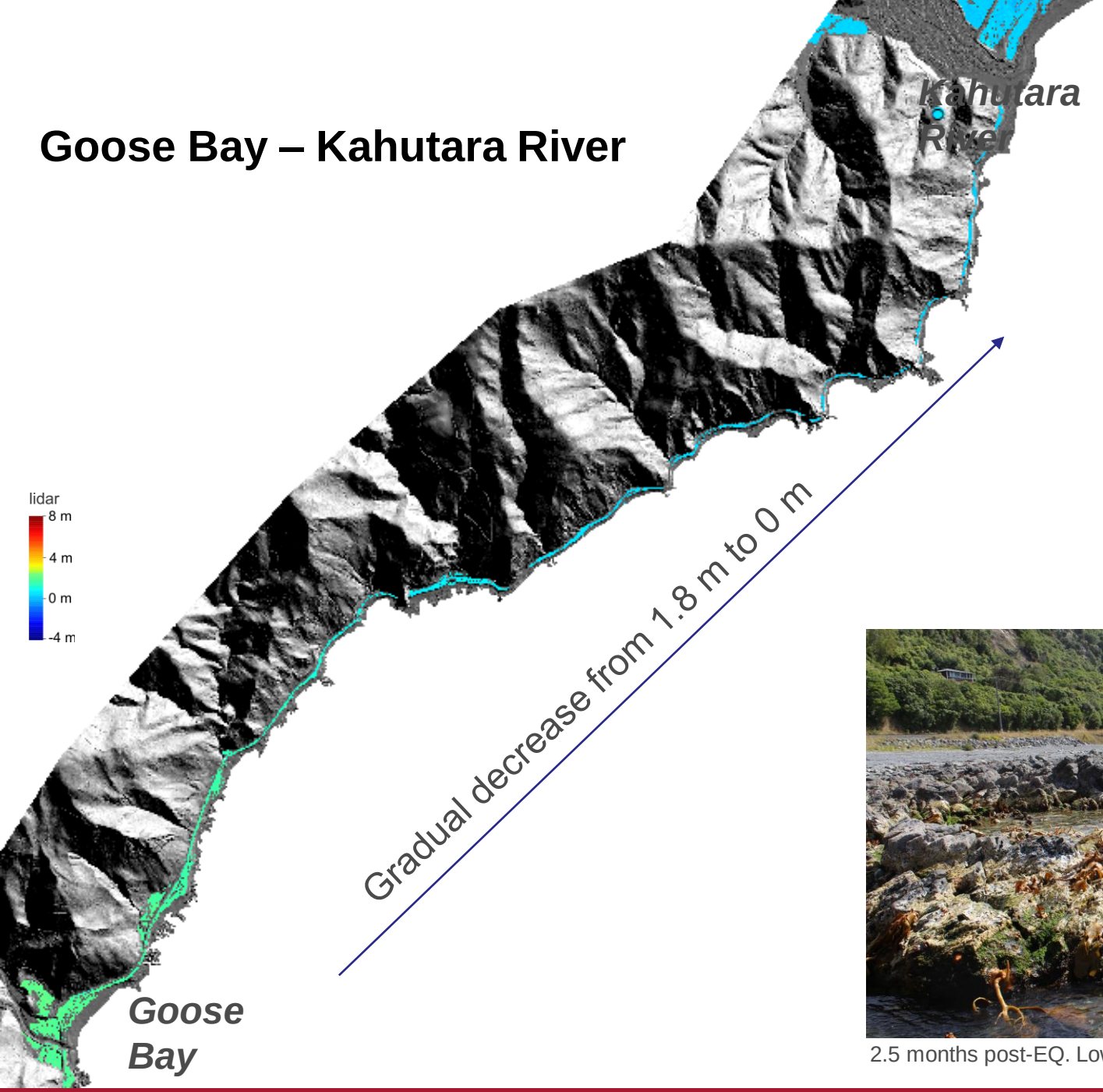
Hundalee Fault



- Southern limit of coastal uplift
- 1.5 m step across Hundalee Fault

Goose Bay, 1.5 +/- 0.27 m

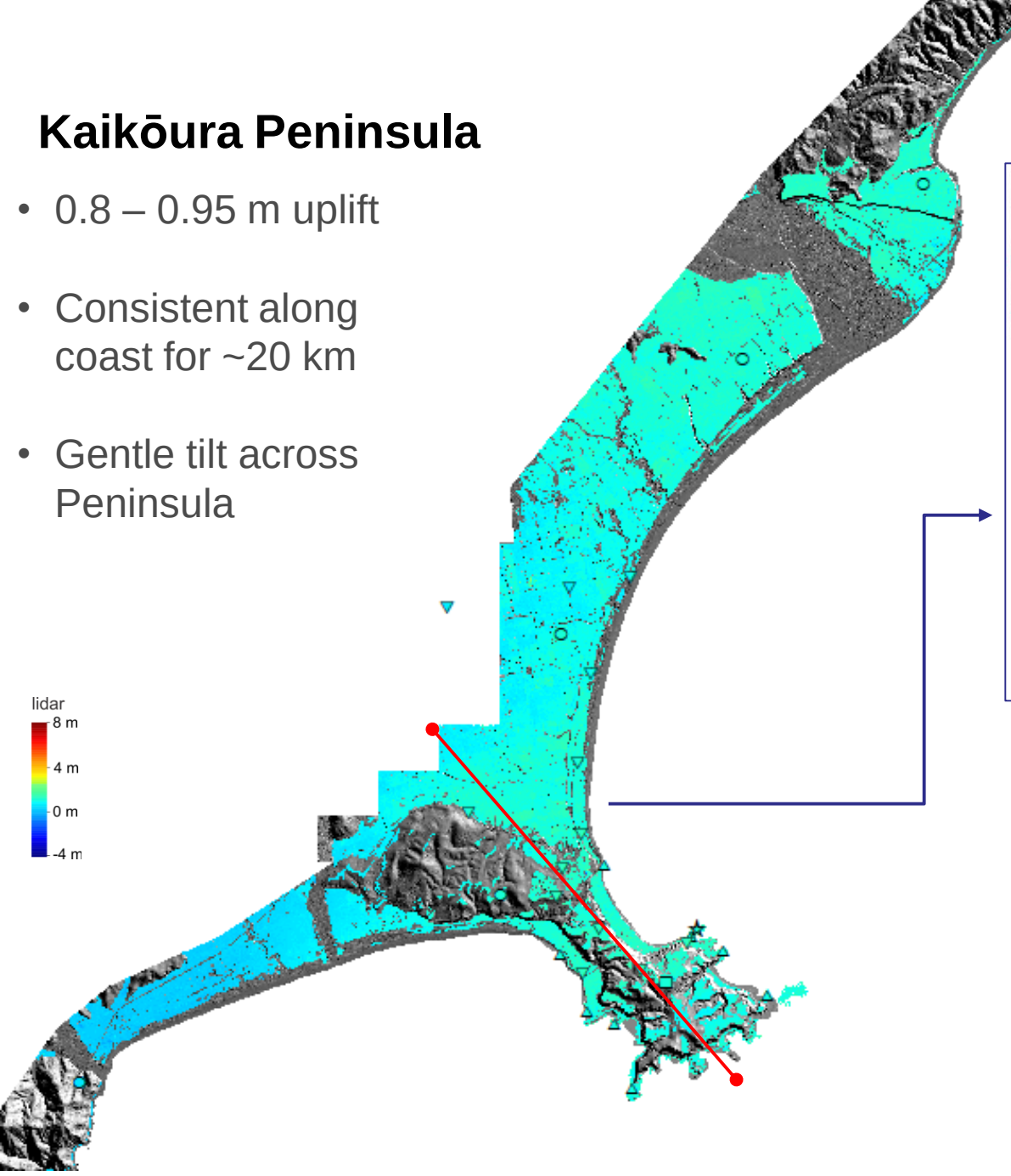
Goose Bay – Kahutara River

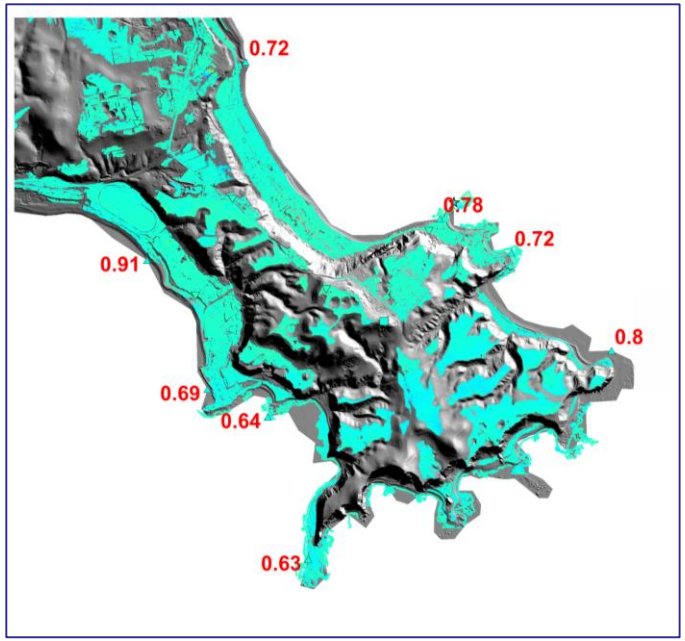


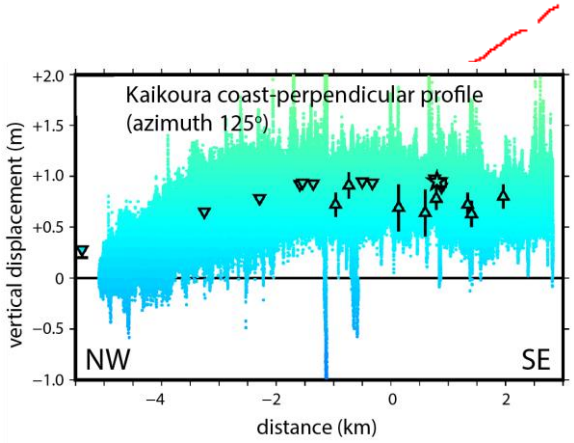
2.5 months post-EQ. Low uplift of 0.5 m near Rileys Lookout.

Kaikōura Peninsula

- 0.8 – 0.95 m uplift
- Consistent along coast for ~20 km
- Gentle tilt across Peninsula

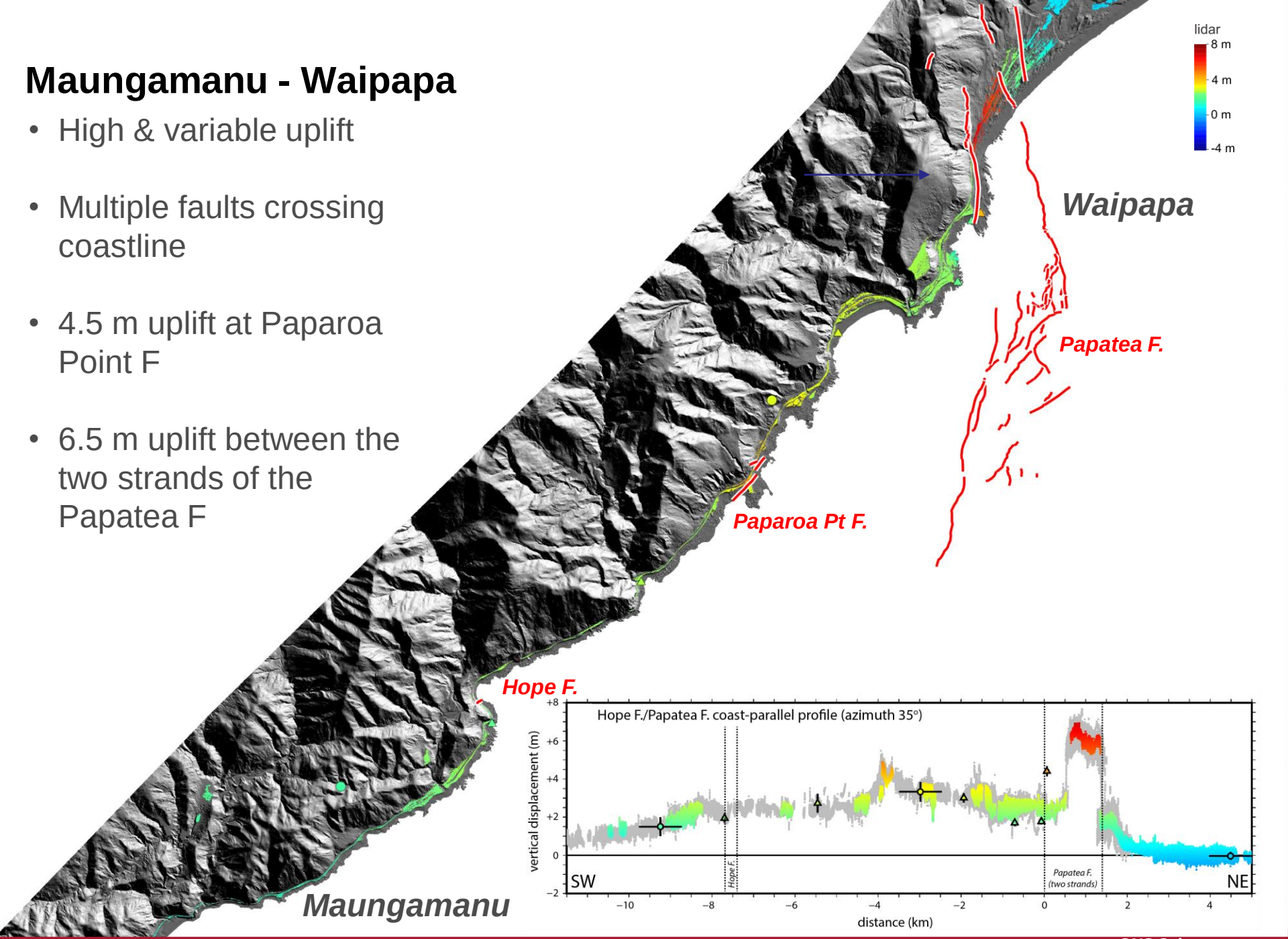




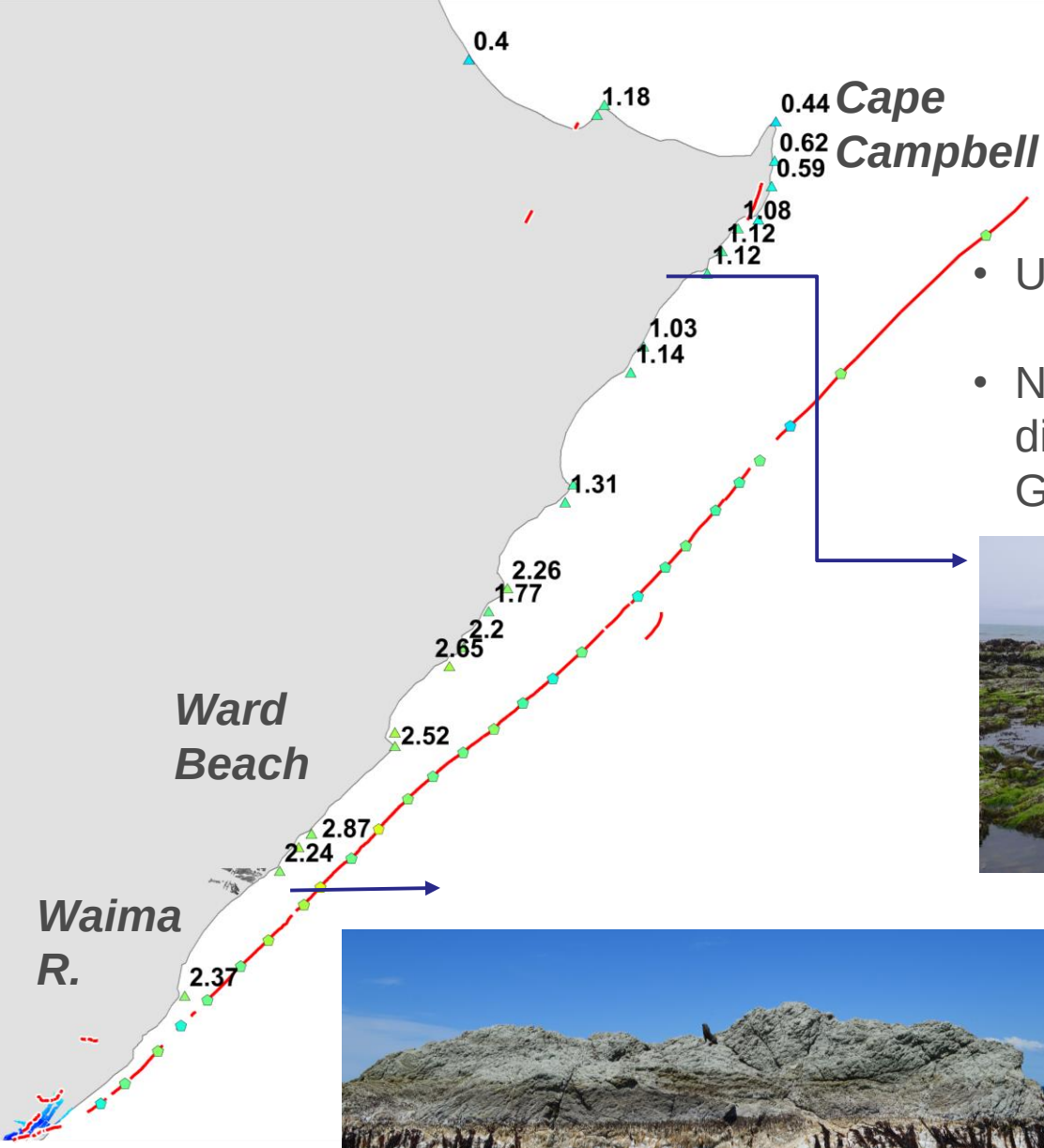


Maungamanu - Waipapa

- High & variable uplift
- Multiple faults crossing coastline
- 4.5 m uplift at Paparoa Point F
- 6.5 m uplift between the two strands of the Papatea F



Cape Campbell



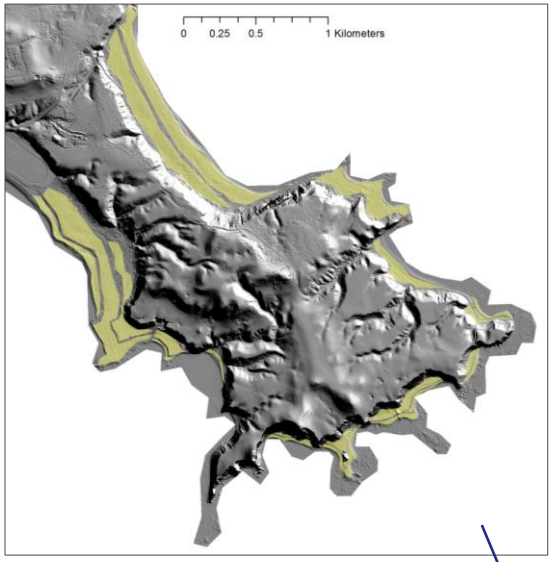
- Uplift decreases from SW to NE
- Needles Fault drives uplift, with some distributed deformation toward Lake Grassmere

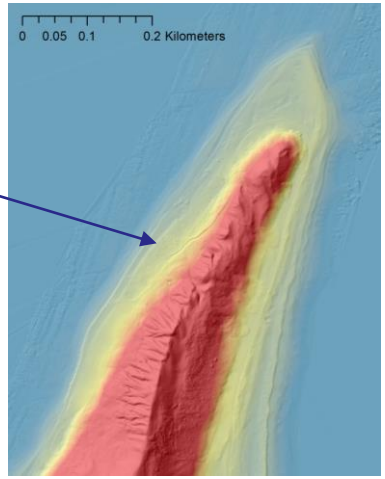
Cape Campbell, 0.45 m uplift, 10 days post-EQ at low tide.

North of Waima River, 2.8 m uplift, 12 days post-EQ.

Kaikōura coast marine terraces

- Kaikōura Peninsula: 3 uplift events in past 3000 years. Uplift amounts appear similar to 2016.
- We are now using terraces to understand timing and magnitude of past earthquakes but preliminary info indicates centennial - millennial-scale recurrence.





Tsunami impact - Kaikoura coast

- Tsunami inundation based on field evidence of debris and scouring, and eyewitness reports
- Up to 7 m tsunami runup at Goose Bay, up to 4.5 m at Needles Point
- Uplift + low tide = little tsunami impact

Needles Point: 4.5 m runup

Summary

The 2016 Kaikōura earthquake is one of the most complex earthquakes ever recorded.

The high variability in vertical deformation along 110 km of coastline reflects the rupture complexity.

2016 Kaikōura joins a number of historic NZ earthquakes which have produced widespread coastal deformation.

Evidence of past coseismic uplift shows the Kaikoura coast experiences earthquake-driven disruption on centennial to millennial timescales.

Waipapa, Papatea Fault popup block, 4 days post-EQ, 4.5 m uplift.