INTRODUCTION

WHAT IS SLOW SLIP?
Slow slip events (SSEs) involve slip along a fault greater than the plate rate, but occur over days, weeks, or months (Figure 1).

WHAT ARE REPEATING EARTHQUAKES?
Repeating earthquakes have similar waveforms and locations. Used as a proxy for slow slip (Figure 2).

NEW ZEALAND TECTONIC SETTING
Located on the boundary of the Pacific and Australian tectonic plates (Figure 3). At the North Island, the Hikurangi Plateau, a large igneous province, subducts beneath the Australian plate at a rate of ~4.5 cm/year. The subduction interface is shallow (~<10 km) depth to the interface is ~<15 km at the coast.

SLOW SLIP IN NEW ZEALAND
Numerous patches of slow slip at the Hikurangi margin (Figure 4a). Northern margin:
• Shallow SSEs (~<15 km)
• Mostly offshore
• 18-24 month recurrence
• 1-3 week duration (Fig. 4b)

HIKURANGI-OCEAN BOTTOM INVESTIGATION OF TREND AND SLOW SLIP (HOBITSS)
Figure 5a. HOBITSS experimental array.
Figure 5b. Regional map of New Zealand.
HOBITSS Experiment (Figure 5):
• Deployed offshore Gisborne, New Zealand to record anticipated SSEs
• May 2014 - June 2015
• 24 absolute pressure gauges (APGs)
• 15 ocean-bottom seismometers (OBSs)
• RECORDED A 3-3.5 WEEK M6.8 SSE IN SEPTEMBER/OCTOBER 2014 (Figures 4a, 6, 7)

GOAL
Evaluate the spatiotemporal relationship between shallow slow slip and repeating earthquakes for the 2014 Gisborne SSE.

WHY?
• Repeating earthquakes have been used as a proxy for slow slip (Figure 8).
• However, not widely confirmed with geodesy.
• The HOBITSS network recorded the shallow offshore Gisborne 2014 SSE with seafloor instruments (APG & OBS).
• Great opportunity to test repeating earthquakes as “slip-meters” with geodetically confirmed slow slip!
• In addition, Gisborne SSEs are associated with increases in microseismicity (DeMets et al., 2009).
• Promising for finding repeating earthquakes.

MATCHED-FILTER REPEATING EARTHQUAKE DETECTION

1. EARTHQUAKE LOCATIONS
1. Located in Anipopo (dip-slip or dlhcs)2 using HOBITSS OBS stations and GEOMET land seismometers (where possible) 16
2. Relocated in NontiLaai or Bayes 17
3. Relocated again in GroCoast (Figure 9) - a relative relocation algorithm that uses waveform cross-correlations
North island, Figure 10

2. TEMPLATE SELECTION
• Events with final locations in general region of 2014 Gisborne SSE (~70°E, 100 km area, ~2-12 km depth) & within 5 km of the plate interface are selected as templates (Figure 10) – 169 total
• Most template M ≥ 2 (Figure 16) - challenging to determine focal mechanisms and verify plate interface location

3. TEMPLATE MATCHING
• Used open-source Python package, EQcorrscan (Chamberlain and Hopp, 2016):
  • Preprocessing: 3-10 Hz bandpass filter, 50 Hz downsample
  • Two template lengths:
    • 5 seconds around P-phase, 0.15 second pre-pick (Figure 11)
    • 2 second around S-Phase, 1 second pre-pick (Figure 12) - emergent P-phase

RESULTS

1. Repeating earthquakes are detected in the Gisborne SSE region (Figure 13)

2. Average cross-correlation coefficient > 0.55 at a minimum of 3 stations

3. REPEATING EARTHQUAKES
3 families (7 events) occur before SSE – all north of main slow slip (Fig. 15 & 16)
  • 2 families (4 events), 1 within peak slow slip (slow slip > 200 mm) & 21, colocated with seamount, occur during but toward end of the SSE (Fig. 15 & 16)
  • 26 families (73 events) occur after SSE (Fig. 15 & 16)

Key Results:
• Majority of repeating earthquakes located within main slow slip area (slow slip > 50 mm) occur toward the end or after the SSE
• Concentration of repeating earthquakes at the subducting earthquake

REFERENCES


DISTRIBUTION

• Repeating earthquakes located near the subducting seamount have short and irregular repeat intervals (Figure 17)

• Tremor also occurs after SSE & is colocated with the seamount (Figure 18)

CONCLUSIONS

1. Repeating earthquakes in the area of the 2014 Gisborne SSE occurred toward the end and after the duration of slow slip.
• Repeating earthquakes cannot be used as a proxy for slow slip rate for the 2014 Gisborne SSE.
• Repeating earthquakes may not be reliable indicators of slow slip in some environments.

2. The majority of repeating earthquake families in the main slow slip area (slow slip > 50 mm) are colocated with a subducting seamount.
• The repeating earthquakes associated with the seamount are likely related to a fracture network surrounding the seamount rather than the plate interface.
• Repeating earthquake activity at the seamount may be driven by the SSE.