Ground-motion simulation validation for the 14 February 2016 Valentines Day earthquake

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Outline

- Motivation
- Ground-motion recordings
- Broadband simulations
- Validation of numerical modeling
- Introduction to site-specific method (work in progress)
- Key findings and future work

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- **Motivation**
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- Part of the Canterbury 2010-2011 earthquake sequence
- Initial/preliminary source model (Kaiser et. al., 2016)
- Liquefaction at some sites (Bucci et. al., 2017; Kaiser et. al., 2016)
- However, the ground-motions are poorly understood.....
- **Objectives:**
  - Analyze observed data (directivity, basin effects, liquefaction)
  - Additional earthquake for simulation validation exercise
  - Develope site specific HF computation method

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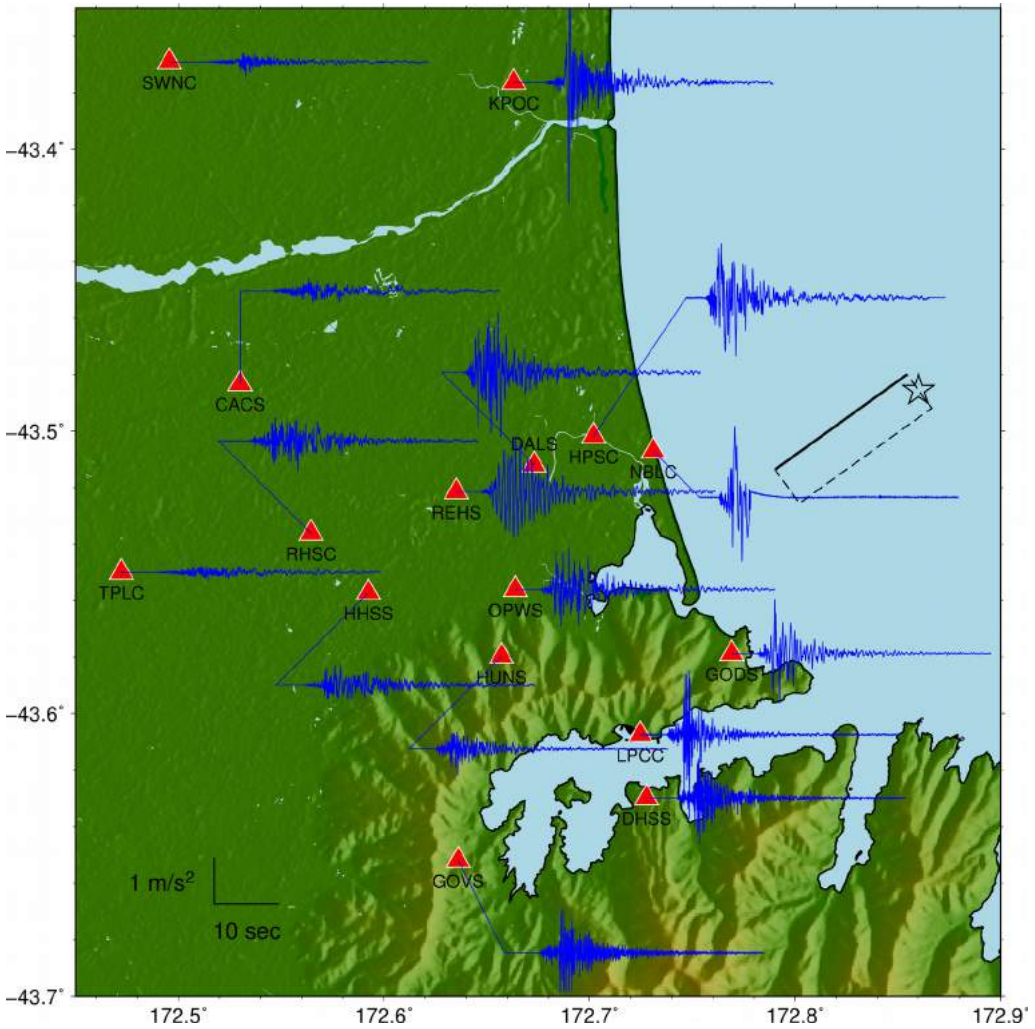
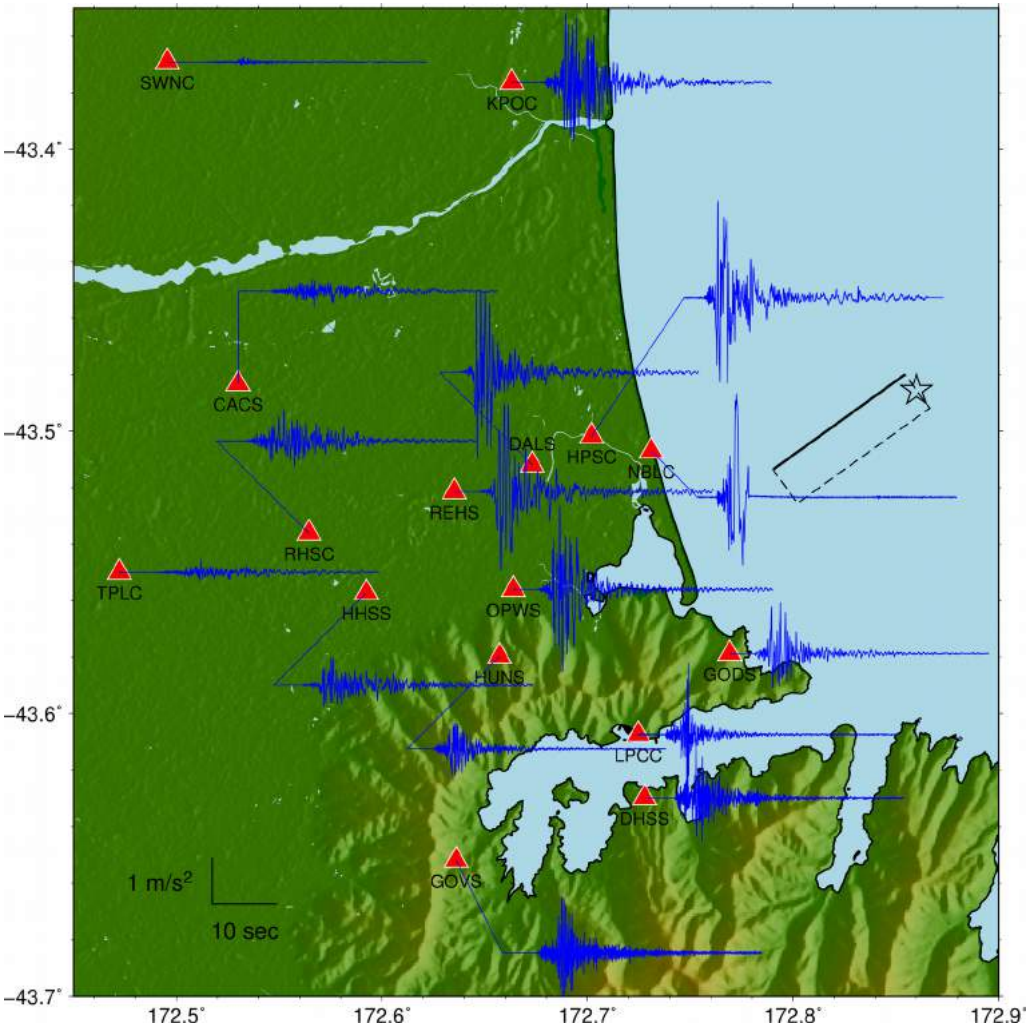
Fault parallel acceleration



Fault normal acceleration



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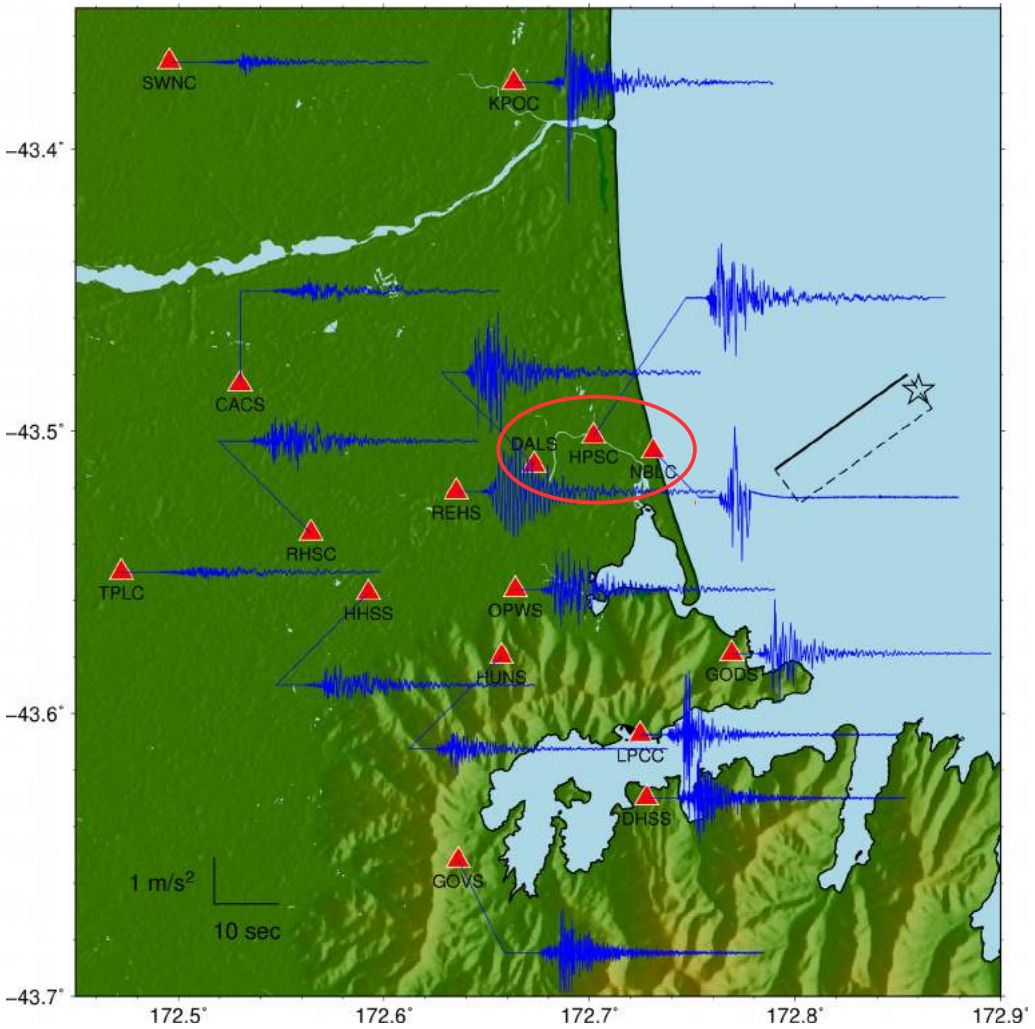

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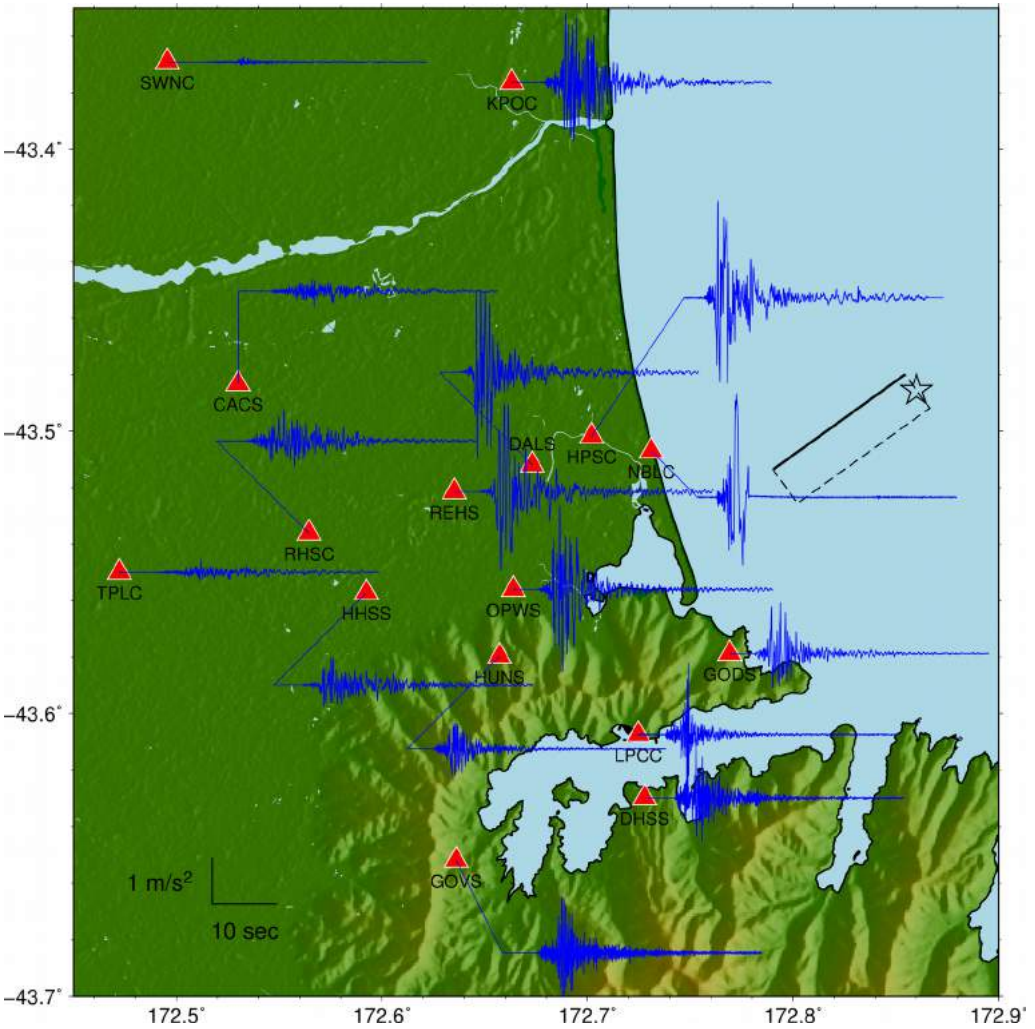
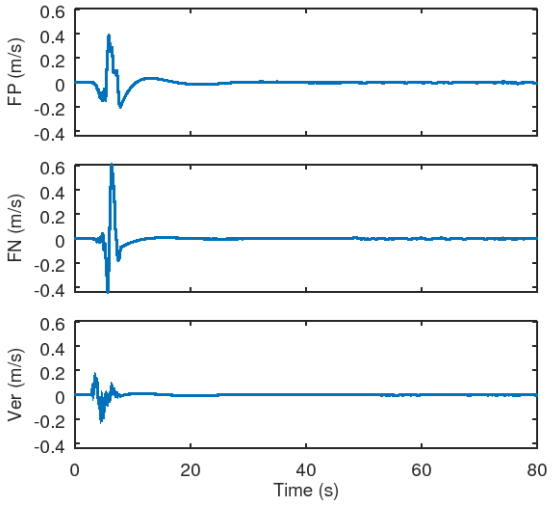
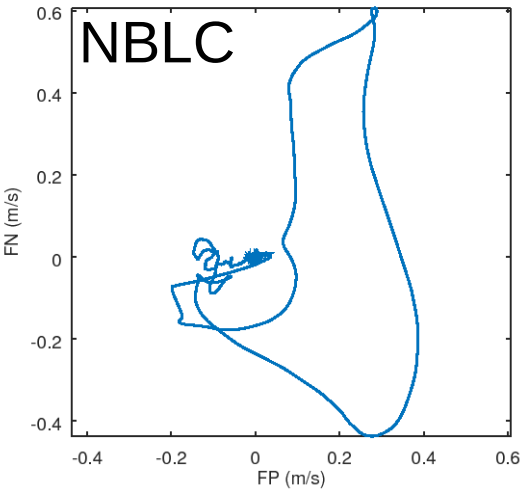
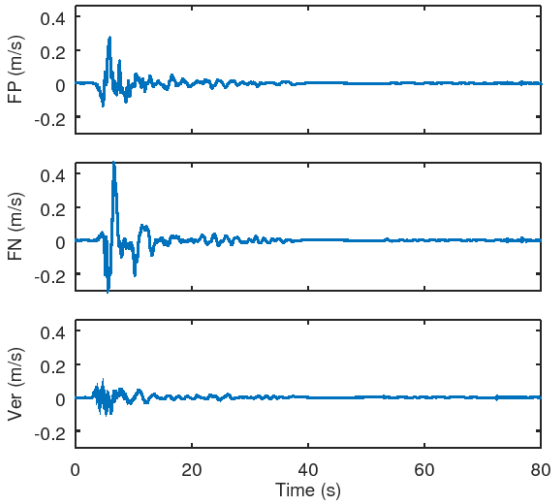
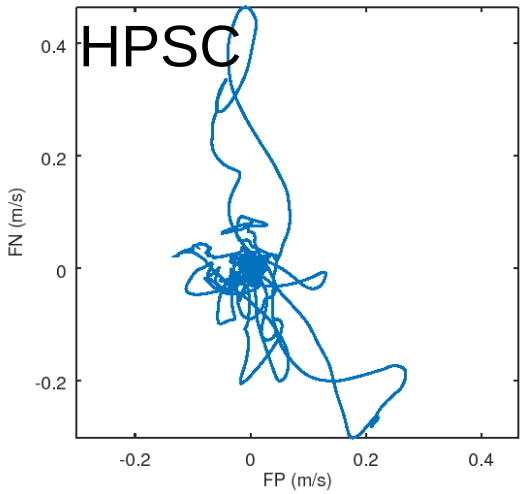
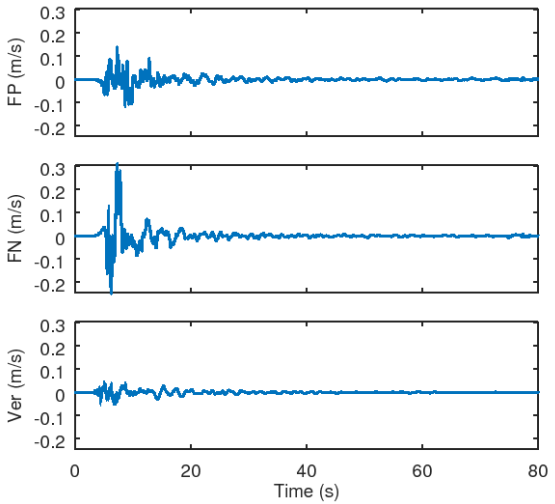


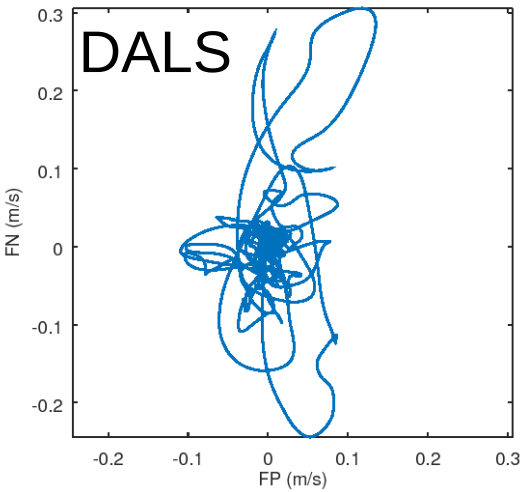








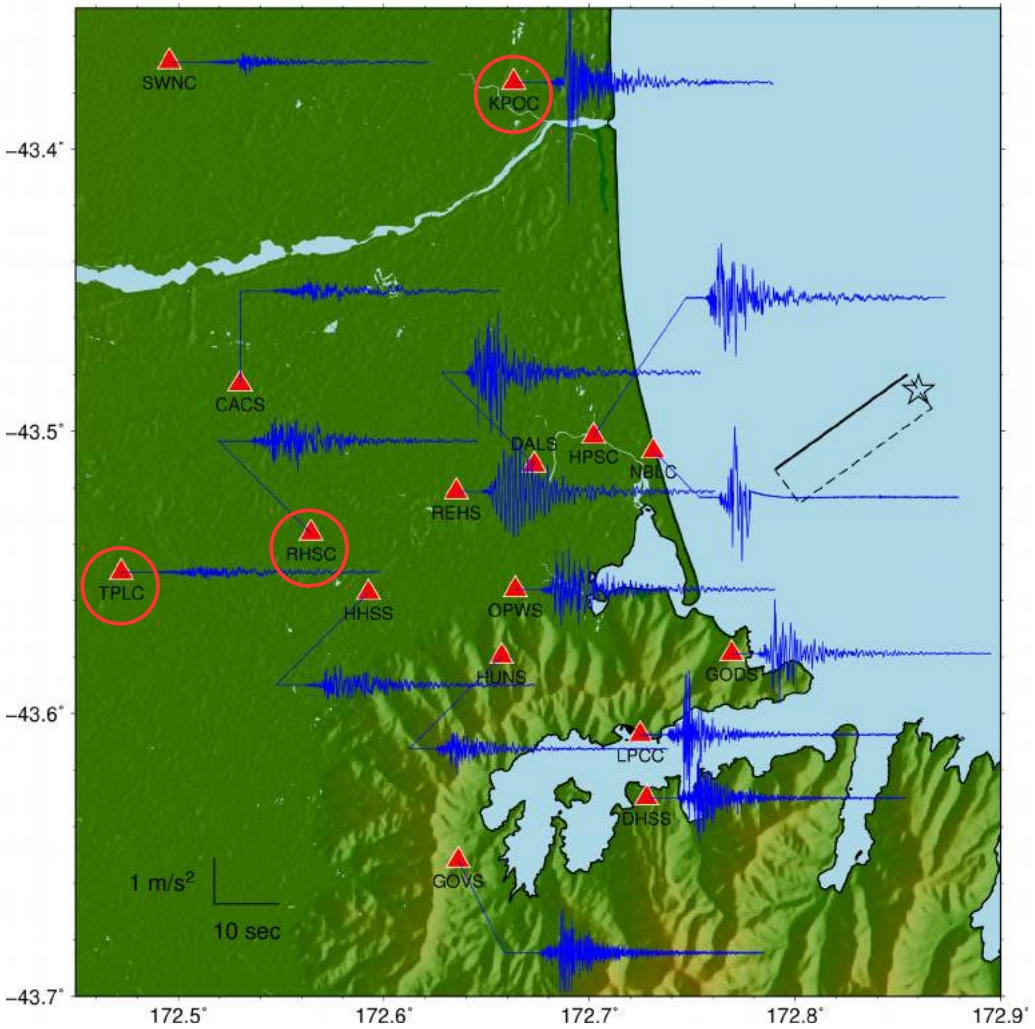




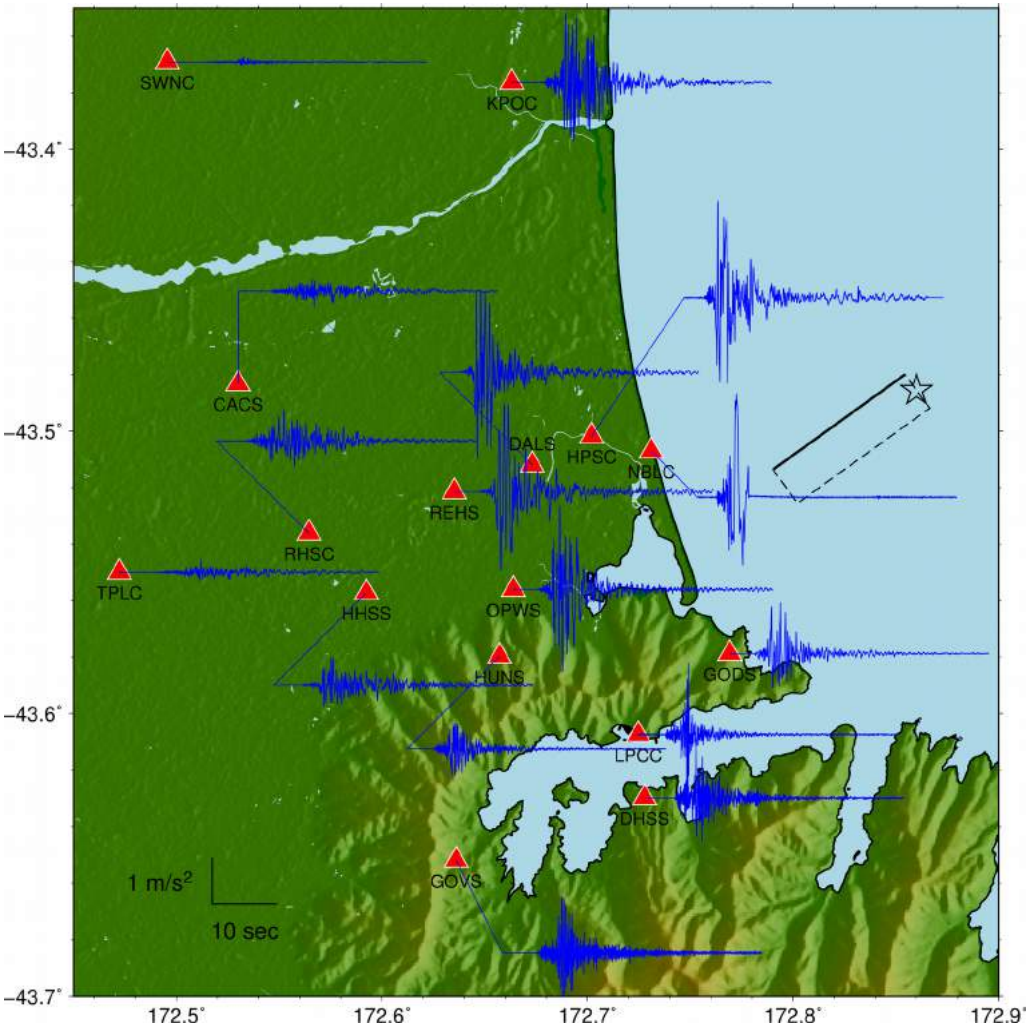
Velocity waveforms

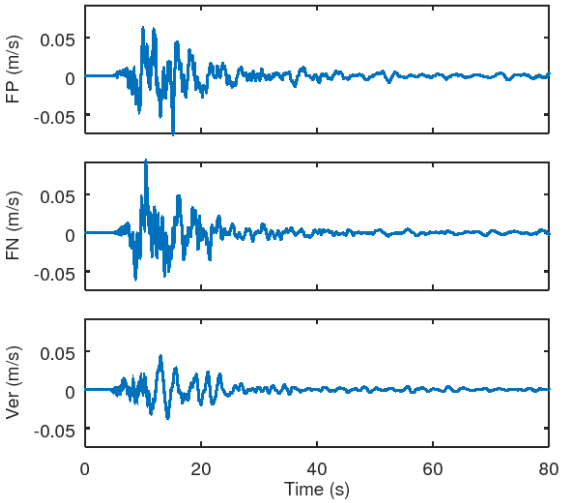
Directivity effects

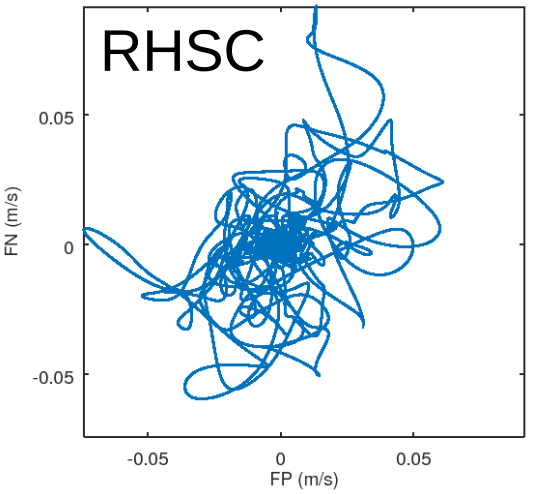
Fault parallel acceleration

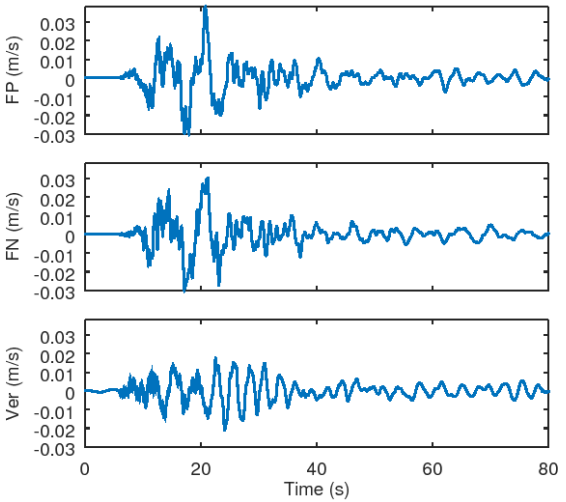


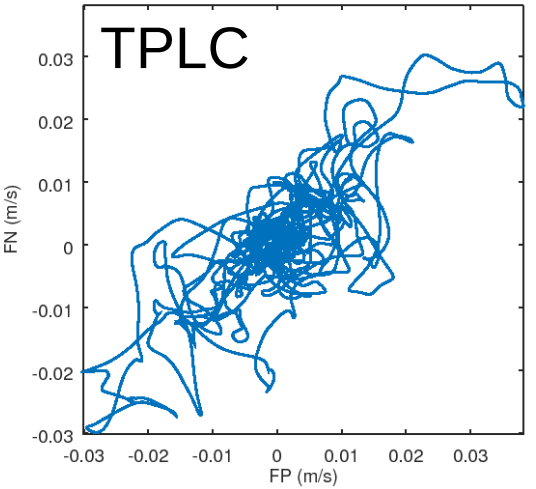
Fault normal acceleration

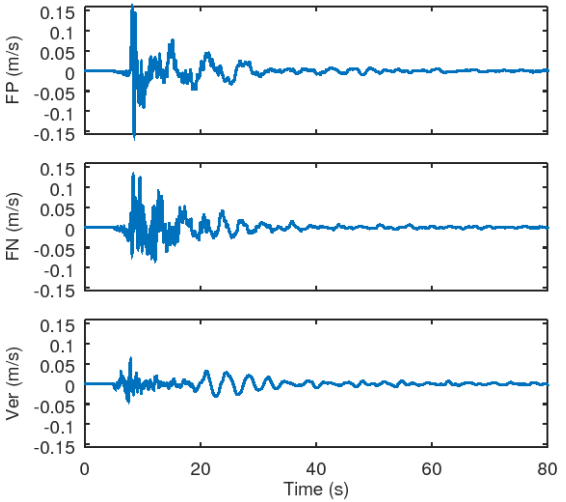


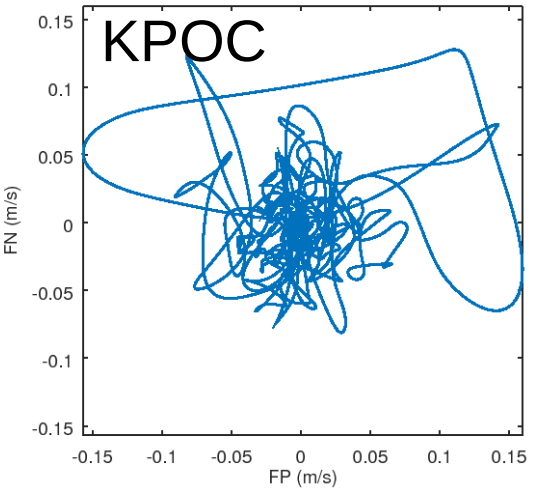










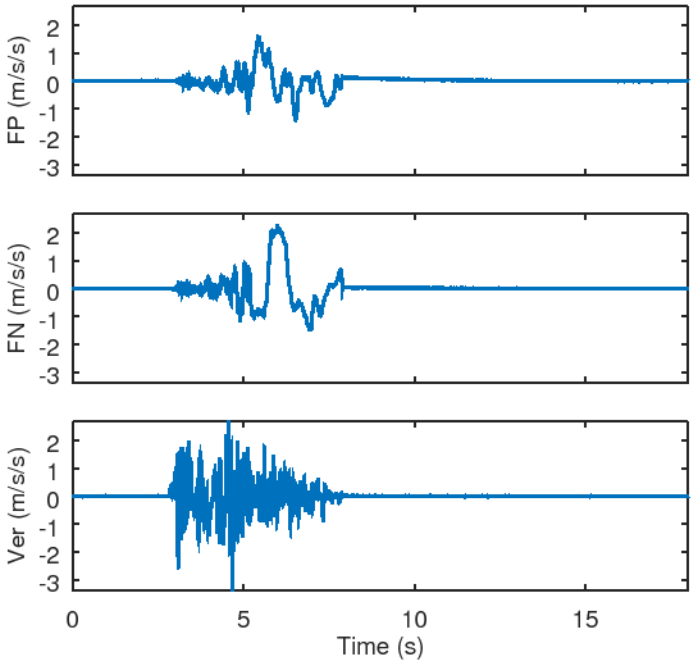


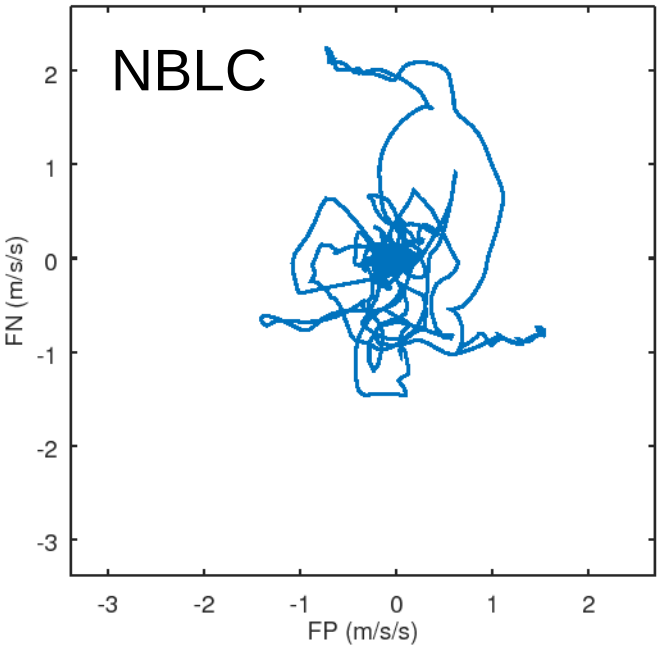
Velocity waveforms

Basin effects

Acceleration waveforms

Some hint of liquefaction (need to analyzed more)...





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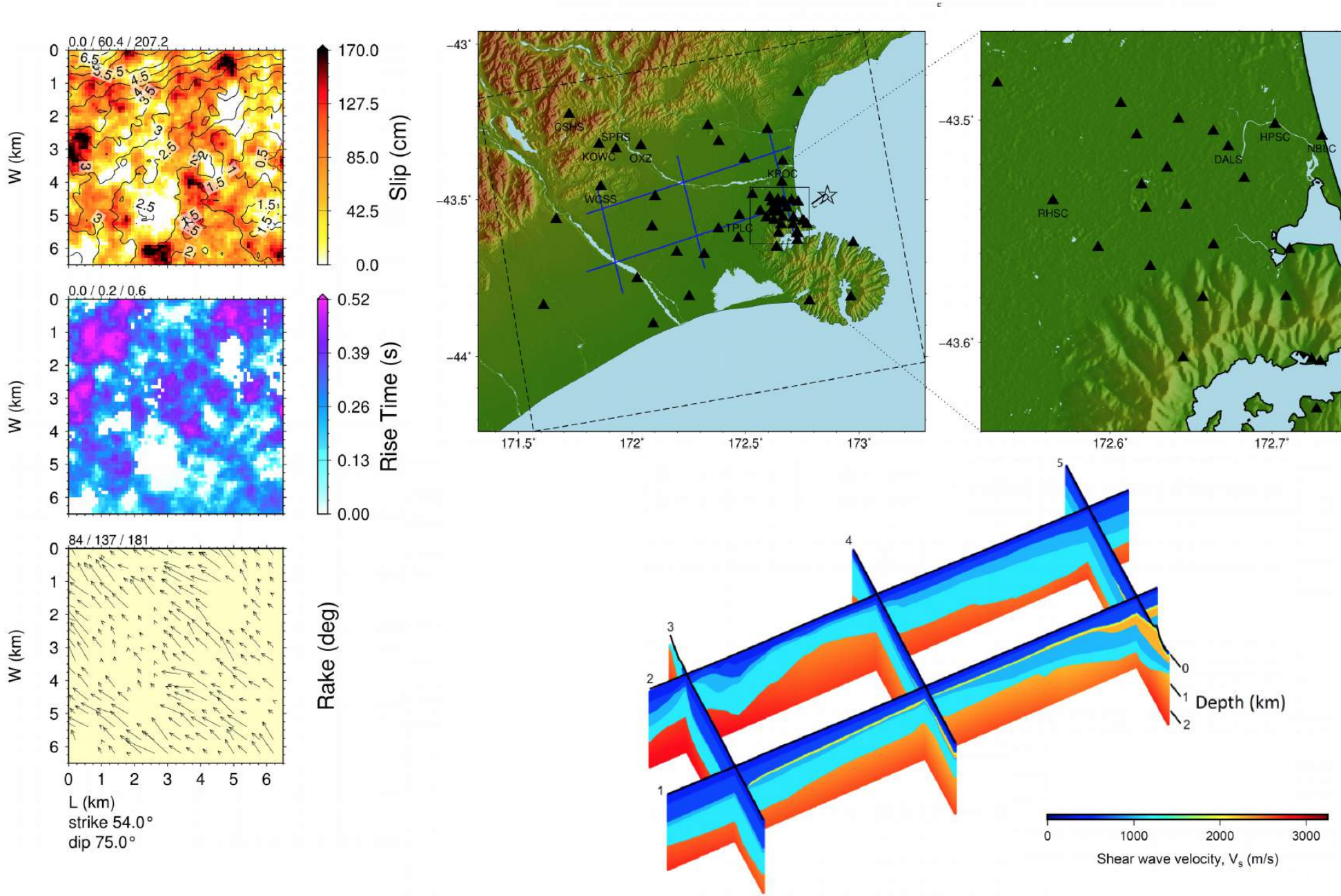
- Graves and Pitarka (2010, 2016)

  LF: solve equation of motion, finite difference method,
  3-D medium

  + (match filter at 1 Hz)

  HF: semi-empirical ray based approach,
  1-D generic (as base case),
  1-D site specific (work in progress)

- Site amplification correction only for HF (not for LF), Campbell and Bozorgnia (2014).


0.0 / 60.4 / 207.2
W (km)
Slip (cm)
170.0
127.5
85.0
42.5
0.0
0.0 / 0.2 / 0.6
Rise Time (s)
0.52
0.39
0.26
0.13
0.00
84 / 137 / 181
Rake (deg)
L (km)
strike 54.0°
dip 75.0°
OSHS
SPRS
KOWC
OXZ
WCSS
KPOC
TPLC
RHSC
DALS
HPSC
NBLC
Depth (km)
Shear wave velocity, Vs (m/s)

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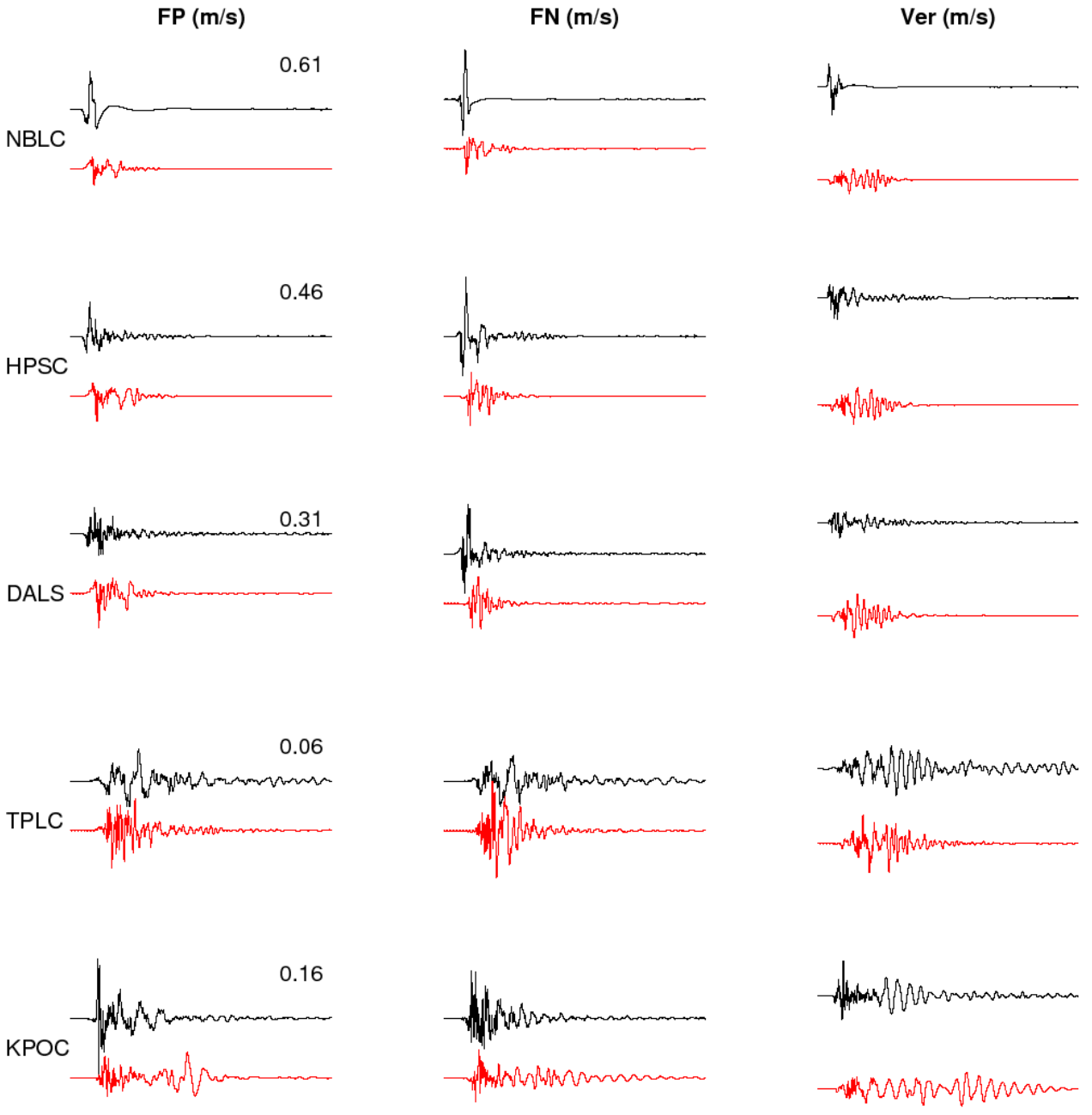
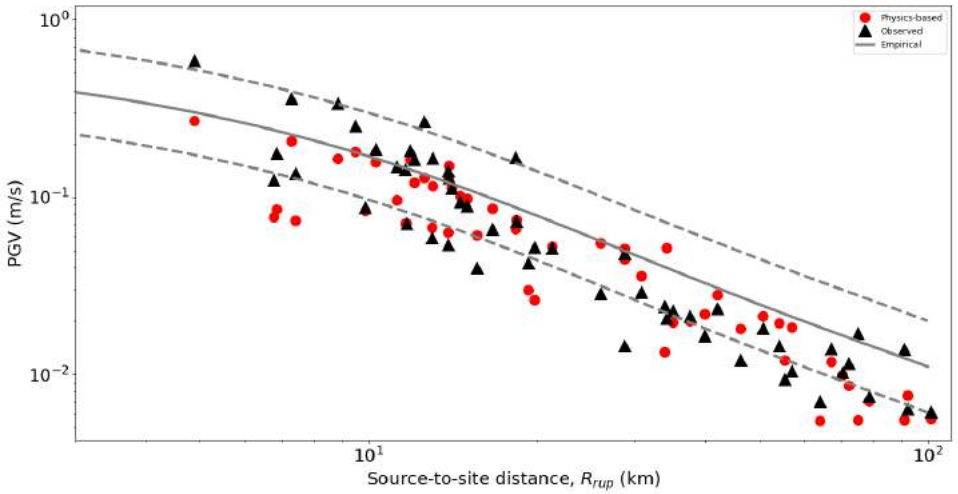
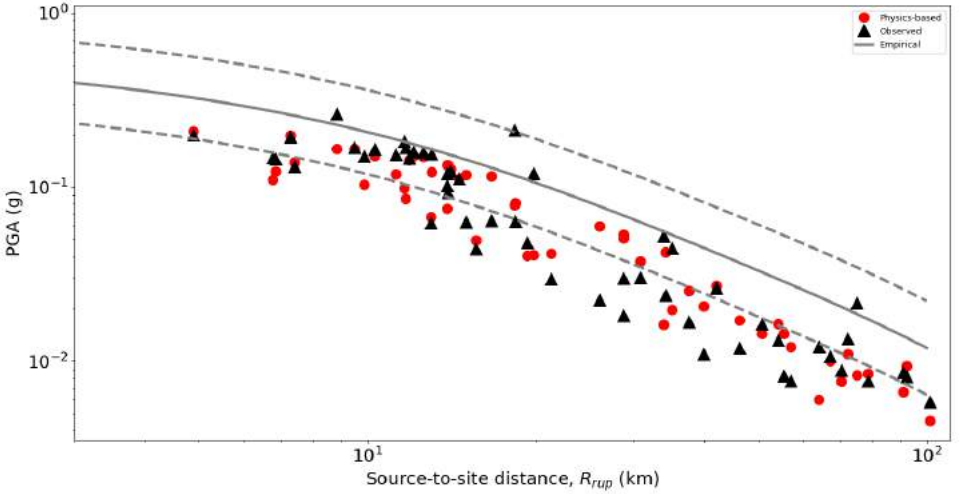
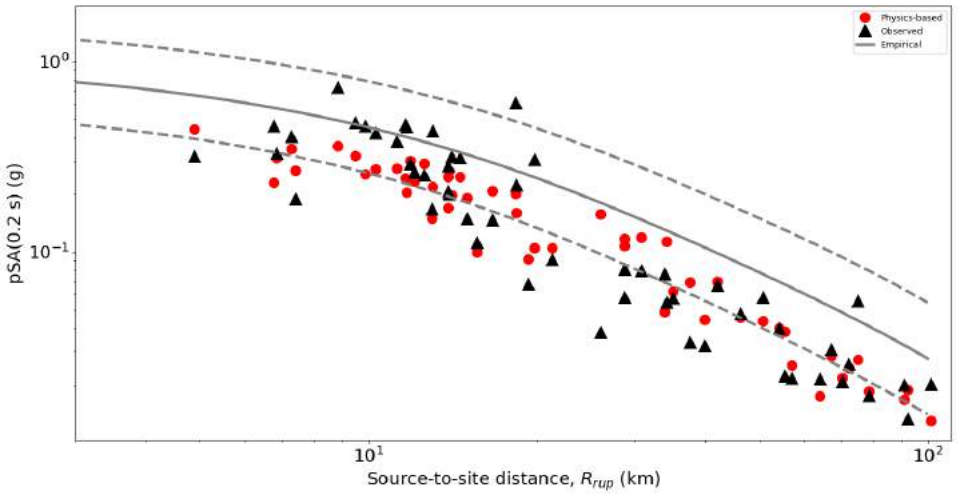
Directivity effects

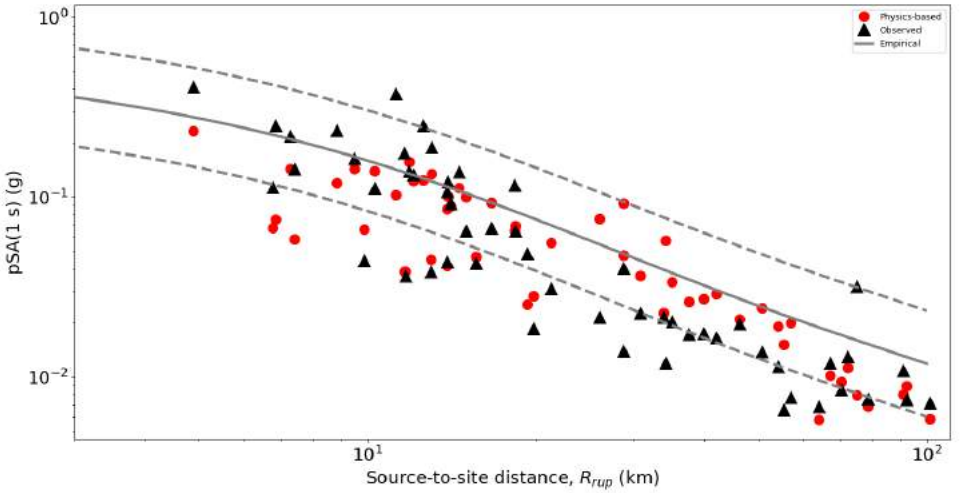
Basin effects

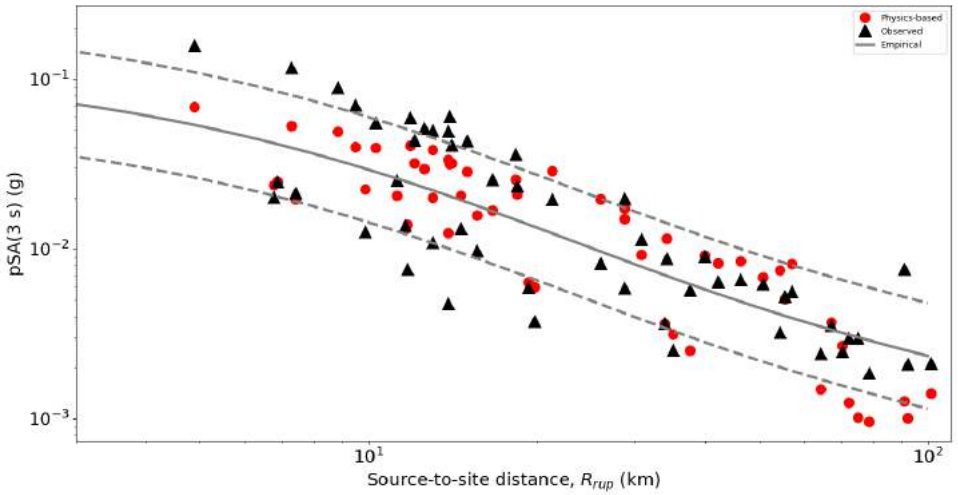


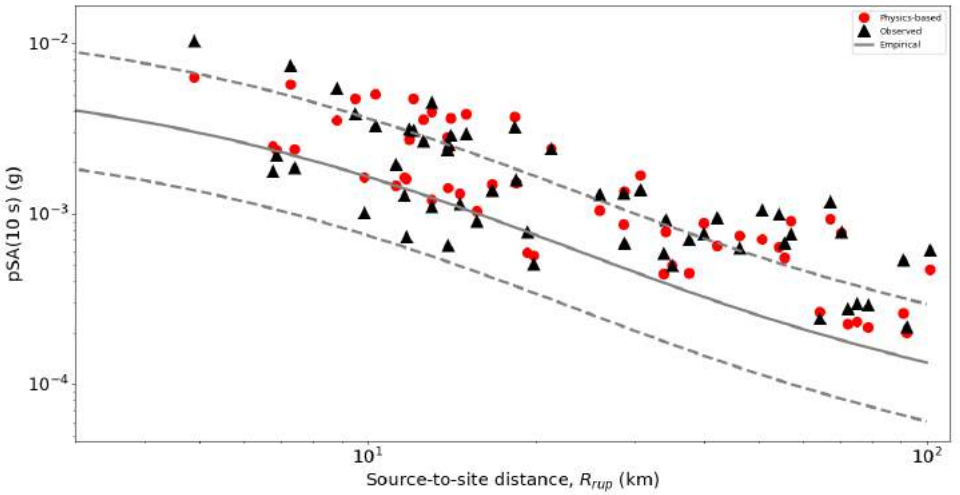

Physics-based
Observed
Empirical
PGV (m/s)
Source-to-site distance, R_{rup} (km)

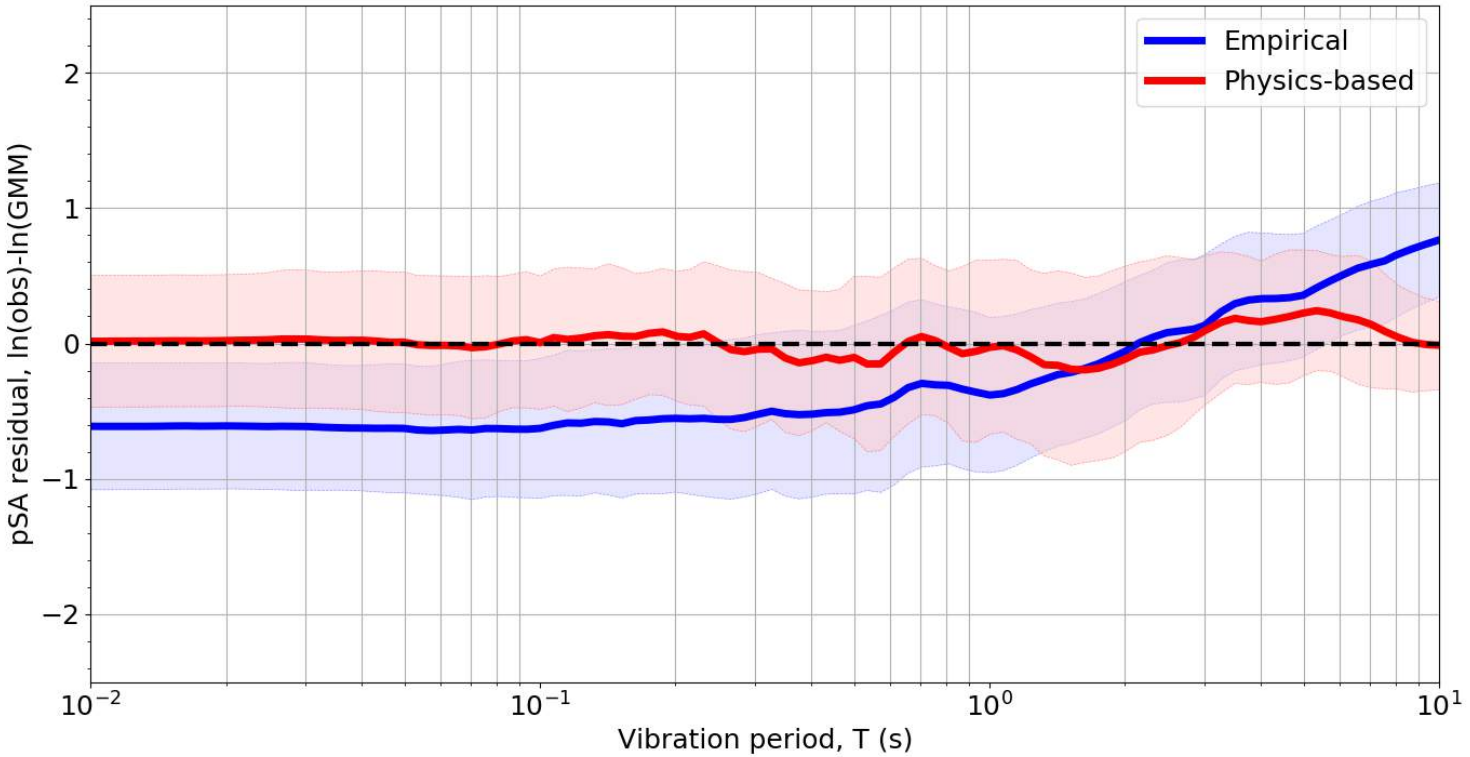

Physics-based
Observed
Empirical
PGA (g)
Source-to-site distance, R_{rup} (km)


Physics-based
Observed
Empirical
pSA(0.2 s) (g)
Source-to-site distance, R_{rup} (km)


Physics-based
Observed
Empirical
pSA(1 s) (g)
Source-to-site distance, R_{rup} (km)


Physics-based
Observed
Empirical
pSA(3 s) (g)
Source-to-site distance, R_{rup} (km)


Physics-based
Observed
Empirical
pSA(10 s) (g)
Source-to-site distance, R_{rup} (km)


Empirical
Physics-based
pSA residual, ln(obs)-ln(GMM)
2
1
0
−1
−2
10^{-2}
10^{-1}
10^{0}
10^{1}
Vibration period, T (s)

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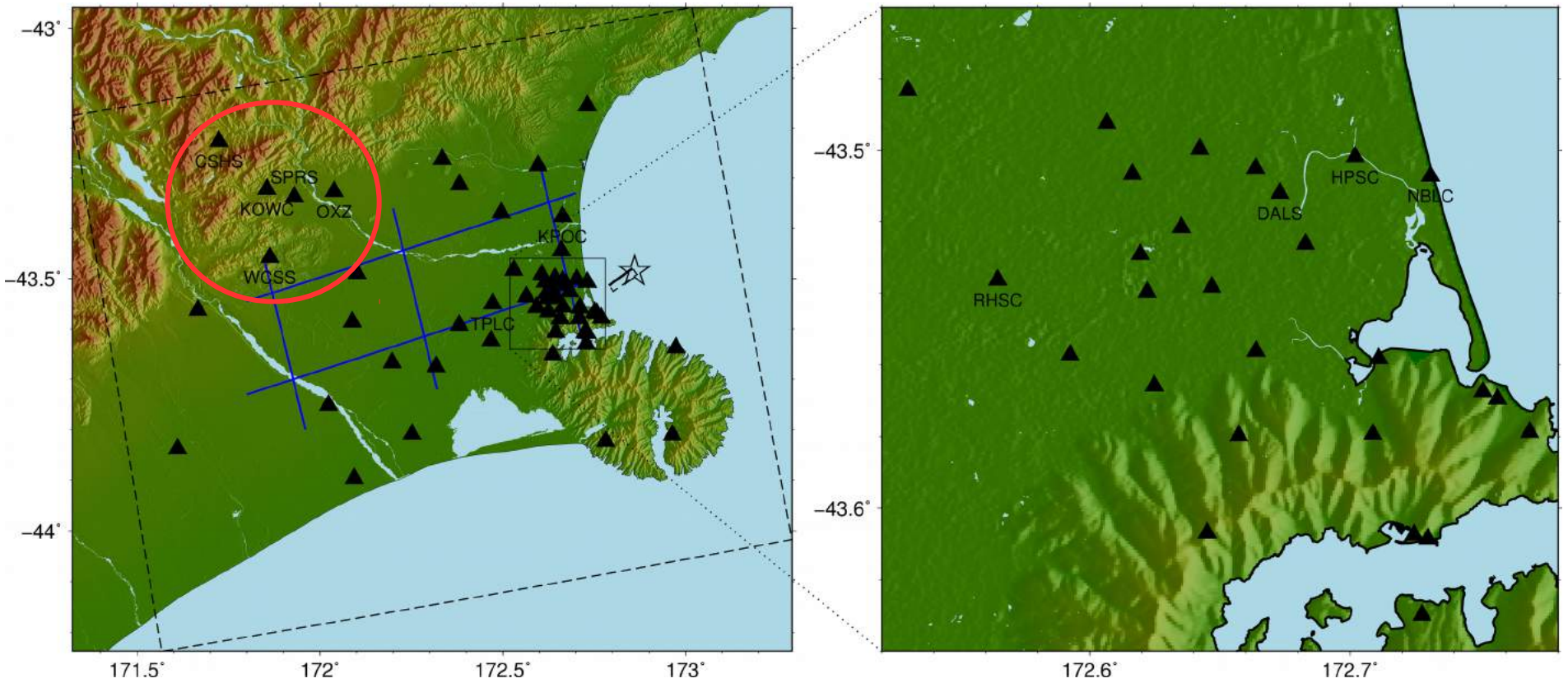
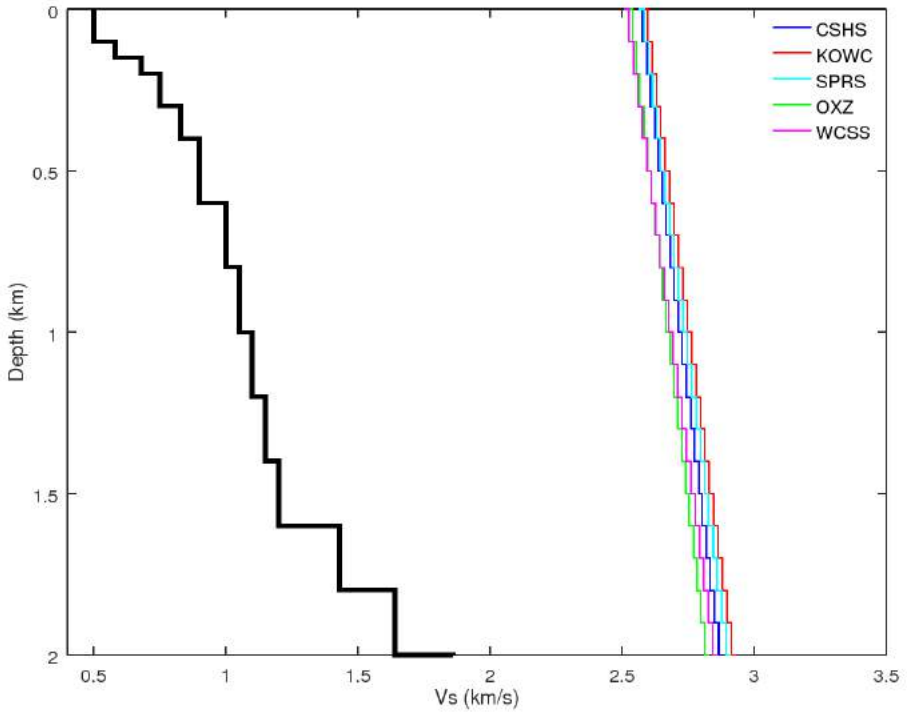
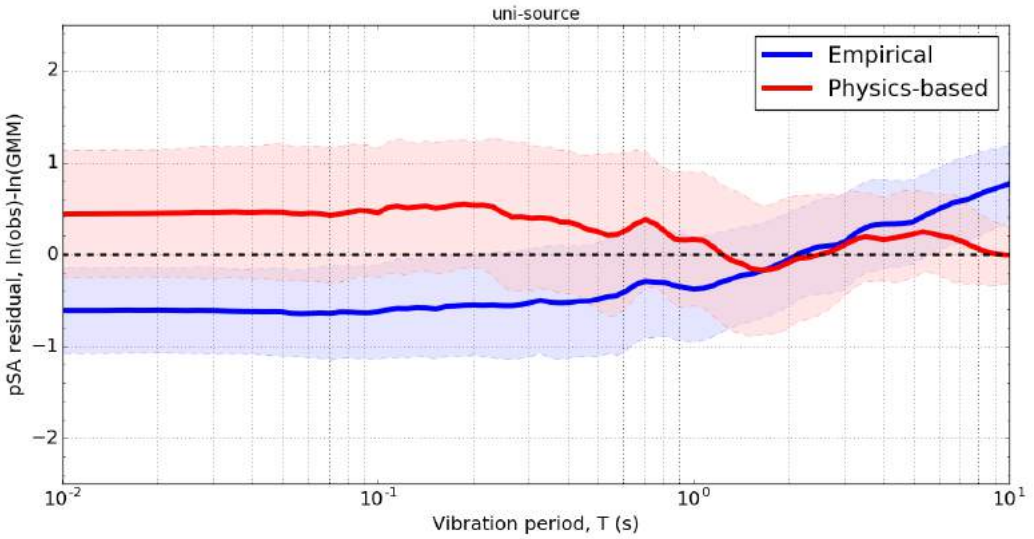
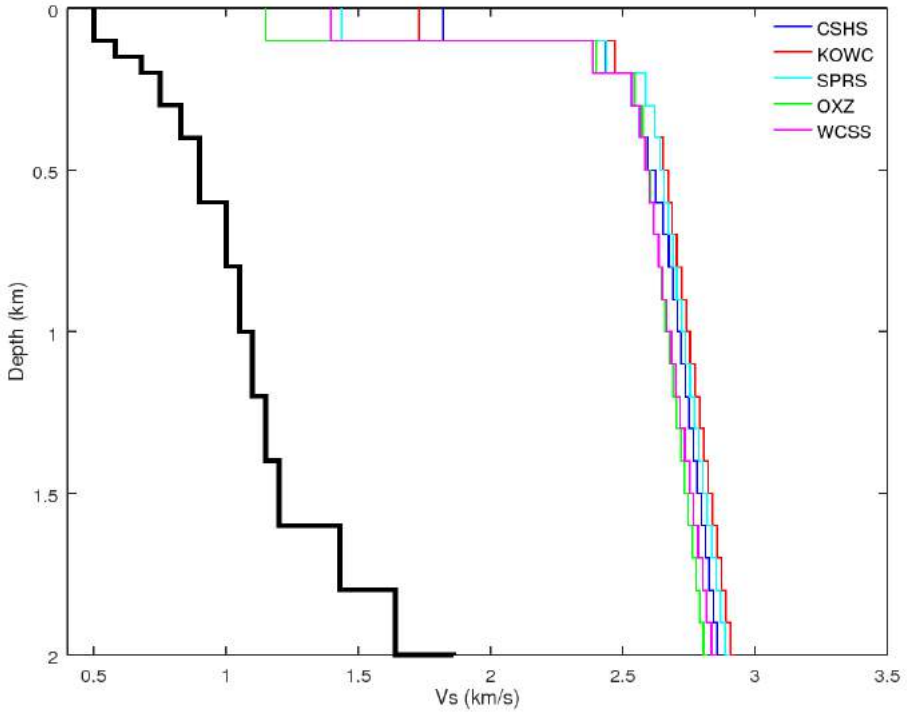
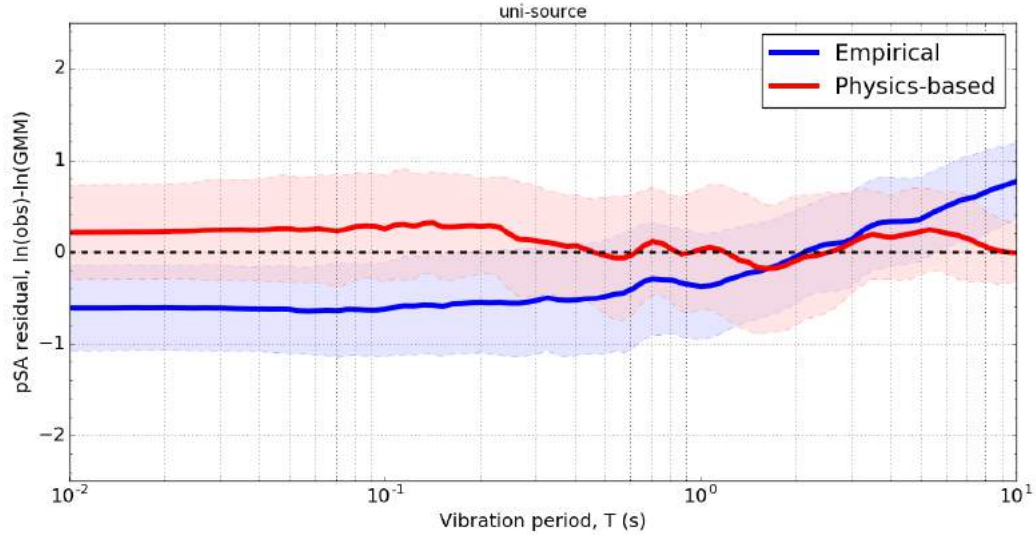

−43°
−43.5°
−44°
171.5°
172°
172.5°
173°
CSHS
SPRS
KOWC
OXZ
WCSS
KROC
TPLC
−43.5°
−43.6°
172.6°
172.7°
RHSC
DALS
HPSC
NBLC

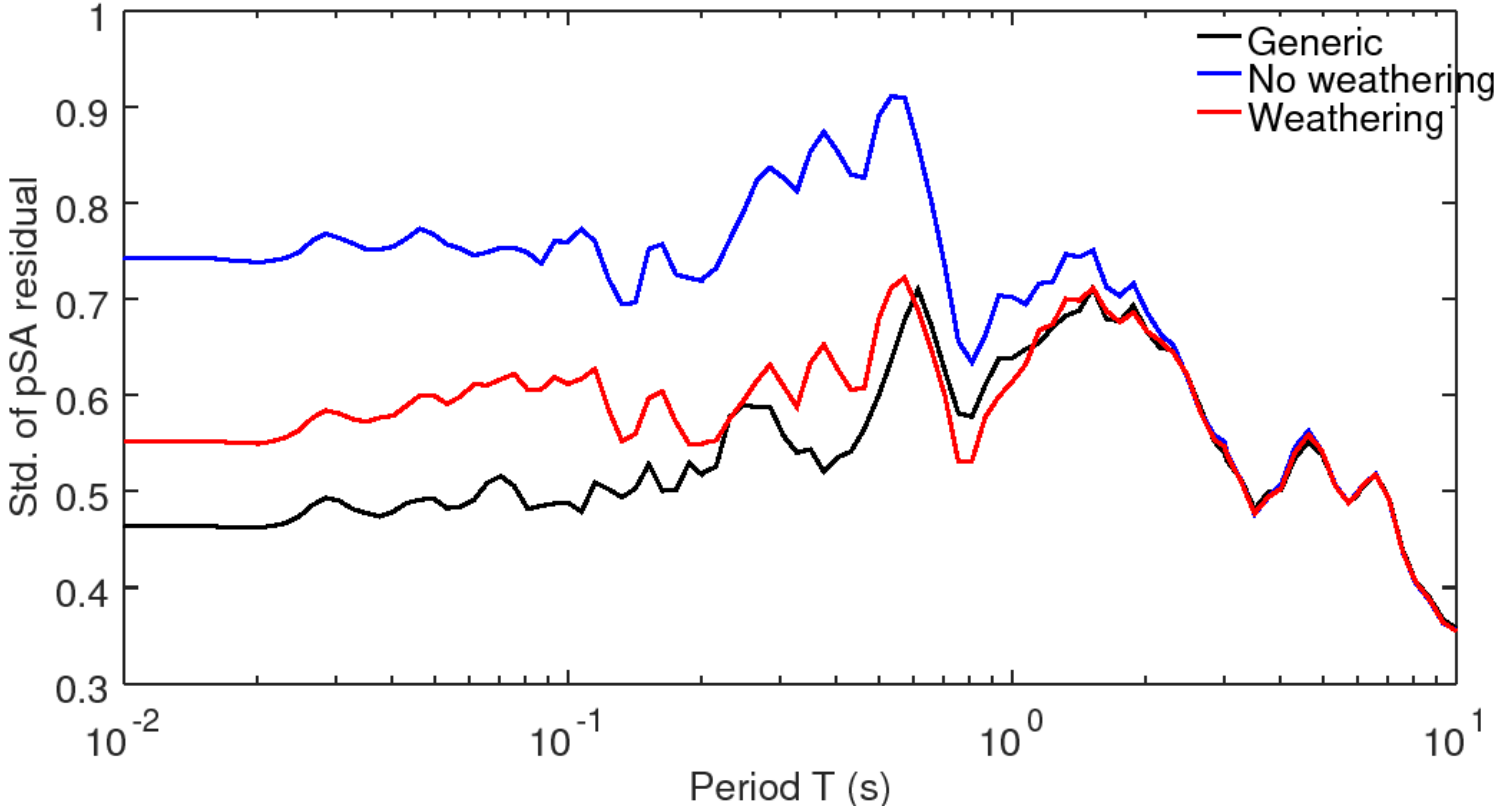






Weathering function by Ely et. al. (2010)




Generic
No weathering
Weathering
Std. of pSA residual
Period T (s)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
10^-2
10^-1
10^0
10^1

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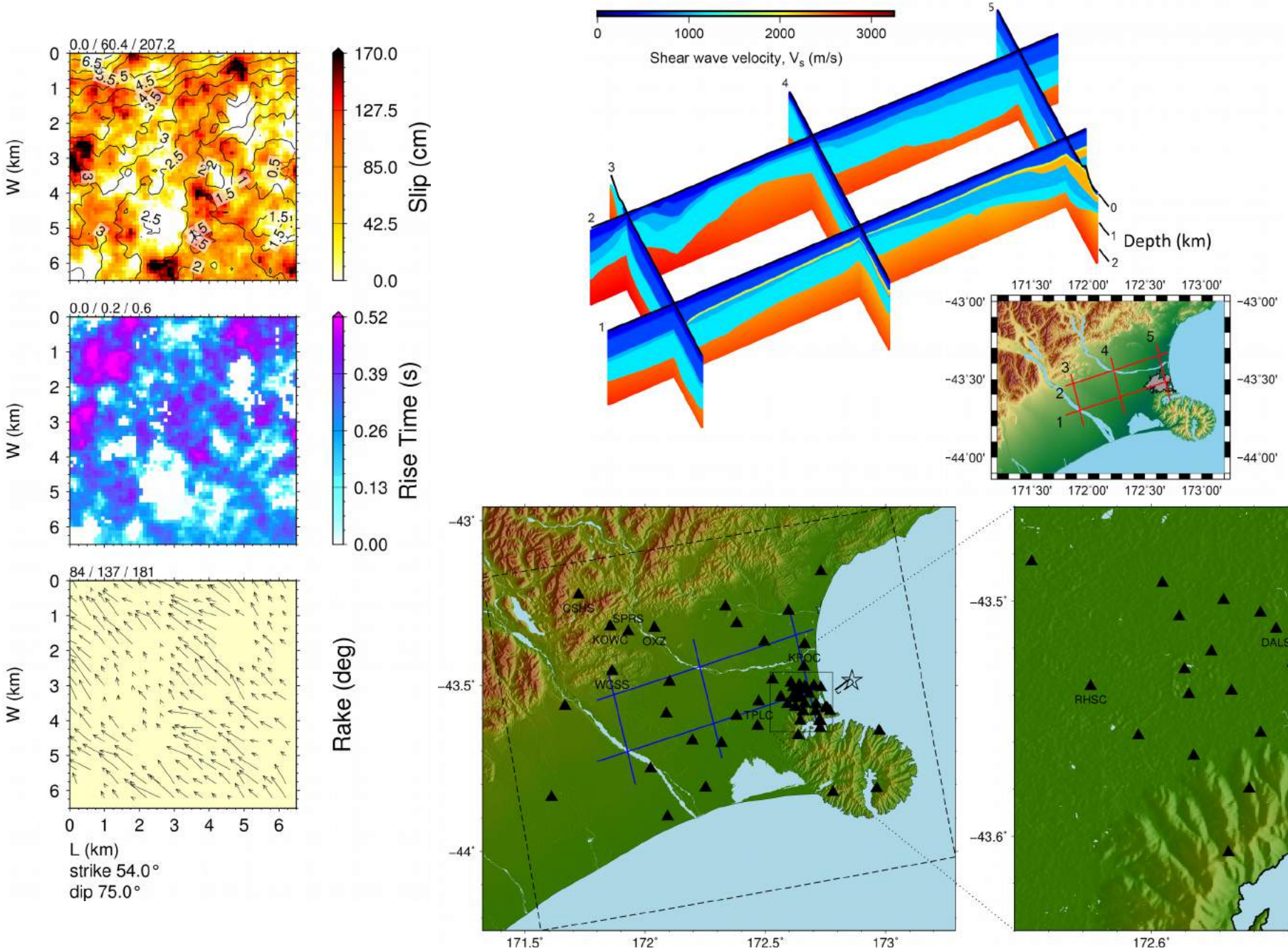
- Key findings:
  - Recorded ground-motions show: rupture directivity, basin effects, some hint of liquefaction.
  - Simulations are validated against observations and empirical GMM.
  - Site specific method seems working but further tests needed.

- Future work:
  - Implement weathering function for Port Hills region.
  - Apply site specific method to other earthquakes.
  - Multiple slip realizations.

Thanks ....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Rise Time (s)
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0.39
0.26
0.13
0.00
84 / 137 / 181
Rake (deg)
L (km)
strike 54.0°
dip 75.0°
Shear wave velocity, Vs (m/s)
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1000
2000
3000
Depth (km)
171°30'
172°00'
172°30'
173°00'
-43°00'
-43°30'
-44°00'
QSHS
SPRS
KOWC
OXZ
KHOC
WCSS
TPLC
HPSC
NBLC
DALS
RHSC
171.5°
172°
172.5°
173°
-43°
-43.5°
-44°
-43.6°
172.6°
172.7°