Seismic response of Cook Inlet sedimentary basin, southern Alaska

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One Year Later: Symposium on the 2018 M7.1 Anchorage Earthquake
Wednesday, September 25, 2019
Scientific Goal
Characterize basin ground motion response

Outline
1. Ambient (seismic) noise
2. Earthquake Spectral Ratios (SR)
3. Noise Vs SR

Background
28 SALMON stations (2015-2017) from Tape et al., 2017

Station Classification
18 Basin interior (15 ZE, 3 AK)
- Inside basin contours from Shellenbaum et al., 2010

12 Basin margin
- Outside contour
- < 20 km from basin

18 Non-Basin
- ≥ 20 km from basin

12 Unused
- Incomplete year of data
- JOES influenced by Beluga basin
- Anomalous high frequency
Study Region

Seismic Stations (n = 48/60)

Earthquakes (n = 34)
- \(3.0 \leq M \leq 7.0\)

- SALMON (ZE)
- TA, AK

Earthquakes!
Note: The basin is much deeper than the height of the mountains on either side.
x in decibel (dB) to amplification (A) conversion

\[ x = 10 \log P = 10 \log(A^2) \]

<table>
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<th>x, dB</th>
<th>P = P_1(f)/P_2(f)</th>
<th>A = A_1(f)/A_2(f)</th>
<th>ln A</th>
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Example: An amplification factor of 3 corresponds to \( \sim 10 \) dB power.
Noise amplification is influenced by basin depth

Horizontal (H)

0.1-0.5 Hz

Basin interior

Basin margin

Non-Basin

0.5-4.0 Hz

Vertical (Z)

Z: 0.1–0.5 Hz amp rel. to SSN (corr 0.92) [9–15 dB]

Z: 0.5–4.0 Hz amp rel. to SSN (corr 0.85) [15–50 dB]
Earthquake Spectral Ratios

(a) 
2016/02/03 M 4.5 D 189 km, Z

(b) 
2016/02/03 M 4.5 depth 189 km, Z

(c) 
2016/02/03 M 4.5 D 189 km, Z: NSKI/SLK
LF: [-, – dB]; HF: [12.2, 35.2 dB]
[0.972, 15.024] Hz; [0.520, 25.000] Hz

Basin station
Bedrock station

Accel. PSD, dB
Frequency, Hz

SNR PSD, dB
Frequency, Hz

NSKI
SLK

LF
HF
earthquake
noise

AK.SLK
Earthquake SRs are consistent with noise at < 0.5 Hz

Magnitude

Missing EQ. 2015/05/18 M4.3

NSKI/SLK median

Missing EQ. 2015/06/24 M5.8
Earthquake spectral ratios vs Basin Depth
Earthquake spectral ratios vs Basin Depth

< 50 km closer to EQs
Earthquake spectral ratios vs Basin Depth

< 50 km closer to EQs

> 50 km further to EQs
Earthquake spectral ratios vs Basin Depth

Z: LF 0.1-0.5 Hz spectral ratios

< 50 km closer to EQs

> 50 km further to EQs

Z: HF 0.5-4.0 Hz spectral ratios

Accel. PSD, dB vs Basin Depth, m

< 50 km closer to EQs

> 50 km further to EQs
Noise stack differences vs EQ Spectral Ratio
EQ Spectral Ratios vs Noise differences

Z: LF 0.1-0.5 Hz (corr 0.93)

Z: HF 0.5-4.0 Hz (corr 0.75)
Summary

• All earthquake waves are expected to be amplified by Cook Inlet basin.

• This study documents the amplification of the seismic wavefield in Cook Inlet basin, using an deployment of 28 stations from 2015–2017.

• Ambient noise (Z) is amplified by 9–15 dB (A = 2.8–5.6) at 0.1–0.5 Hz and 15–50 dB (A = 5.6–316) at 0.5–4.0 Hz.

• Earthquake exhibit basin amplification of 6–14 dB (A = 2.0–5.0) for 0.1–0.5 Hz

• Remaining work is needed to understand the mechanisms for amplification of the high-frequency wavefield.
Thank you!
Questions?
Basin interior
- P19K, O20K
Basin margin
Bedrock AK.SSN
Noise amplification is influenced by basin depth

SHOW HORIZONTAL FIRST
Ambient noise changes according to influence from the basin

Basin

Basin Marginal

Non-Basin