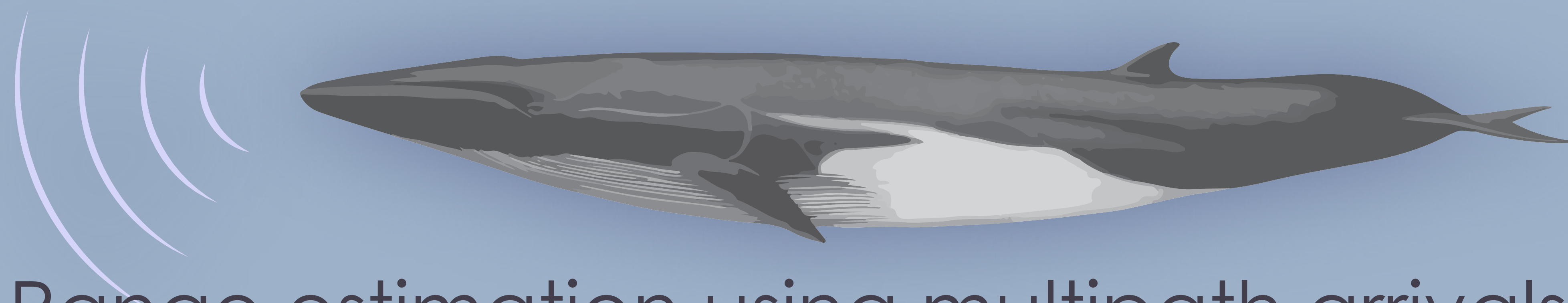


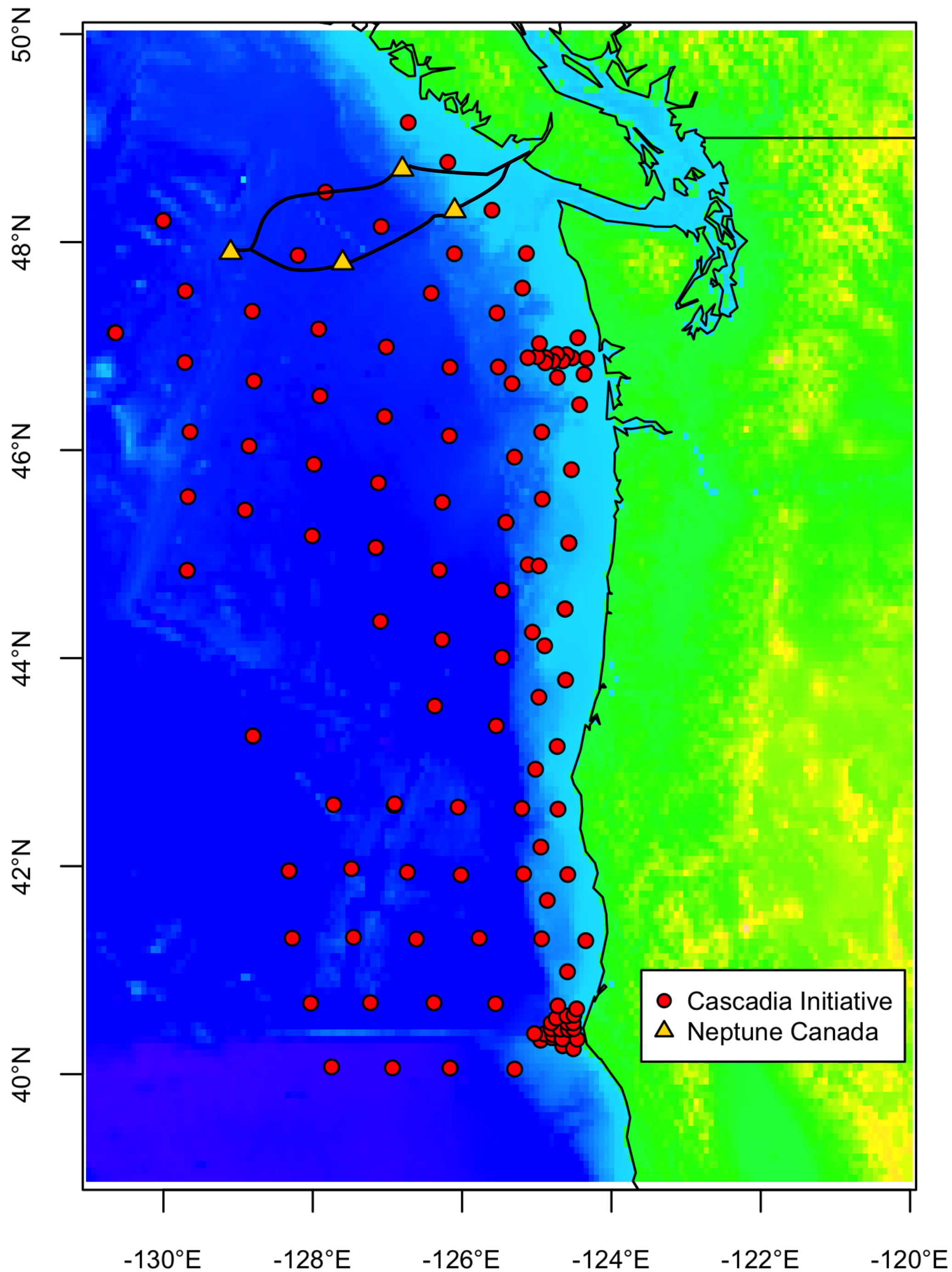
Range estimation using multipath arrivals from 20 Hz fin whale vocalizations recorded in the NE Pacific Ocean

Michelle Weirathmueller and William S.D. Wilcock
University of Washington

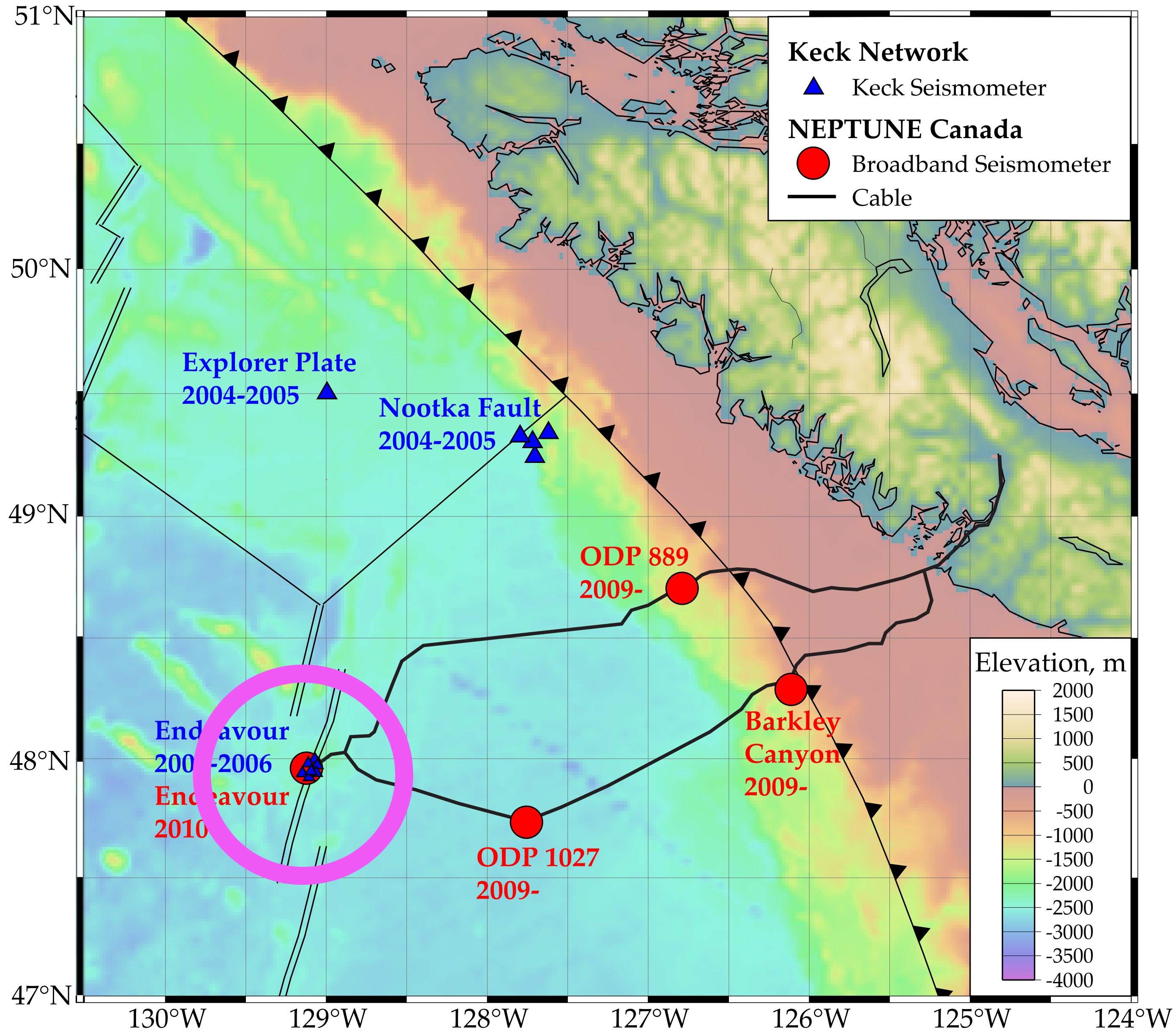
DCLDE 2015

Funded by:

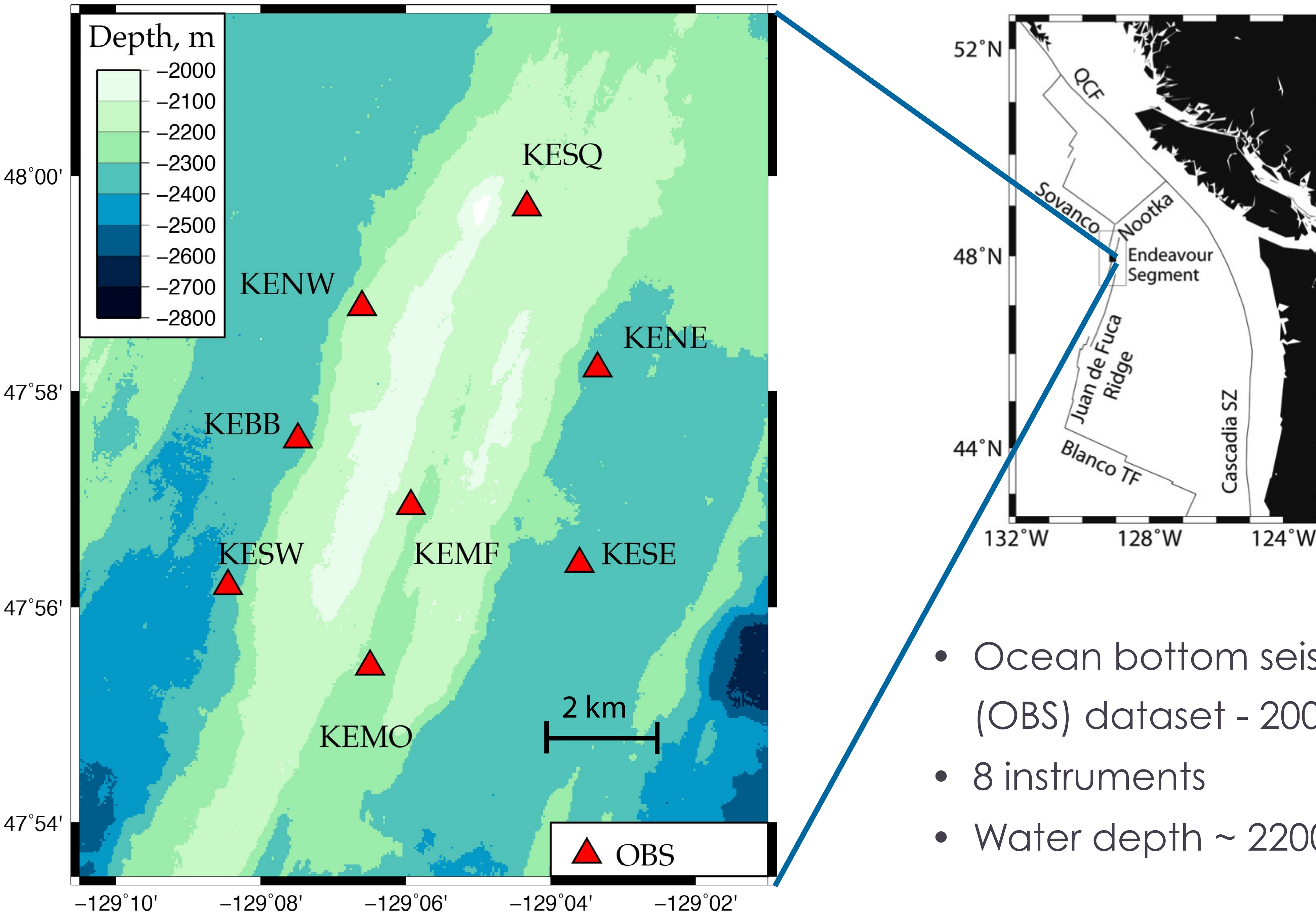
Cascadia Initiative experiment and Neptune Canada cabled observatory



Keck Endeavour Network



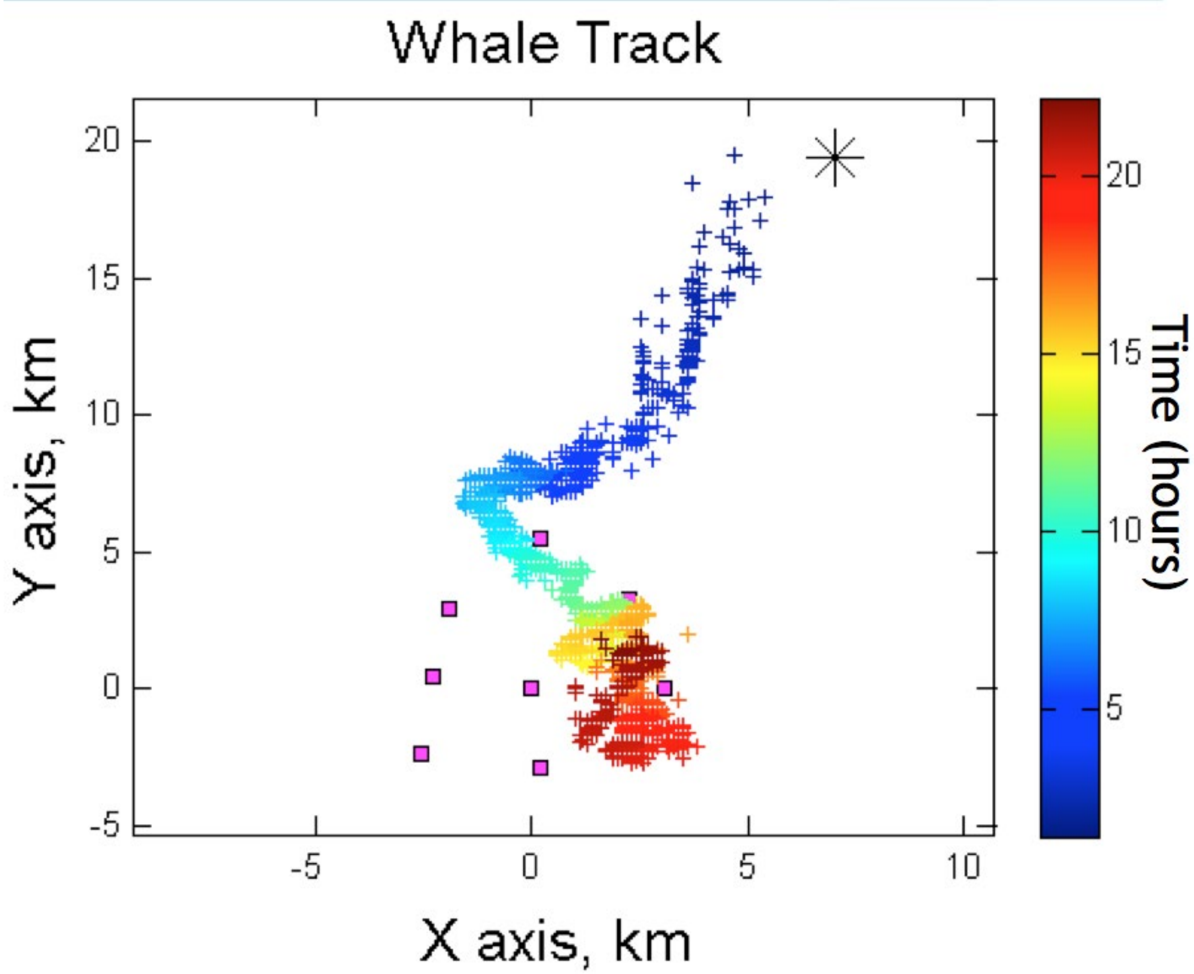
Keck Endeavour Network



- Ocean bottom seismometer (OBS) dataset - 2003-2006
- 8 instruments
- Water depth ~ 2200m

Keck experiment: Call tracking

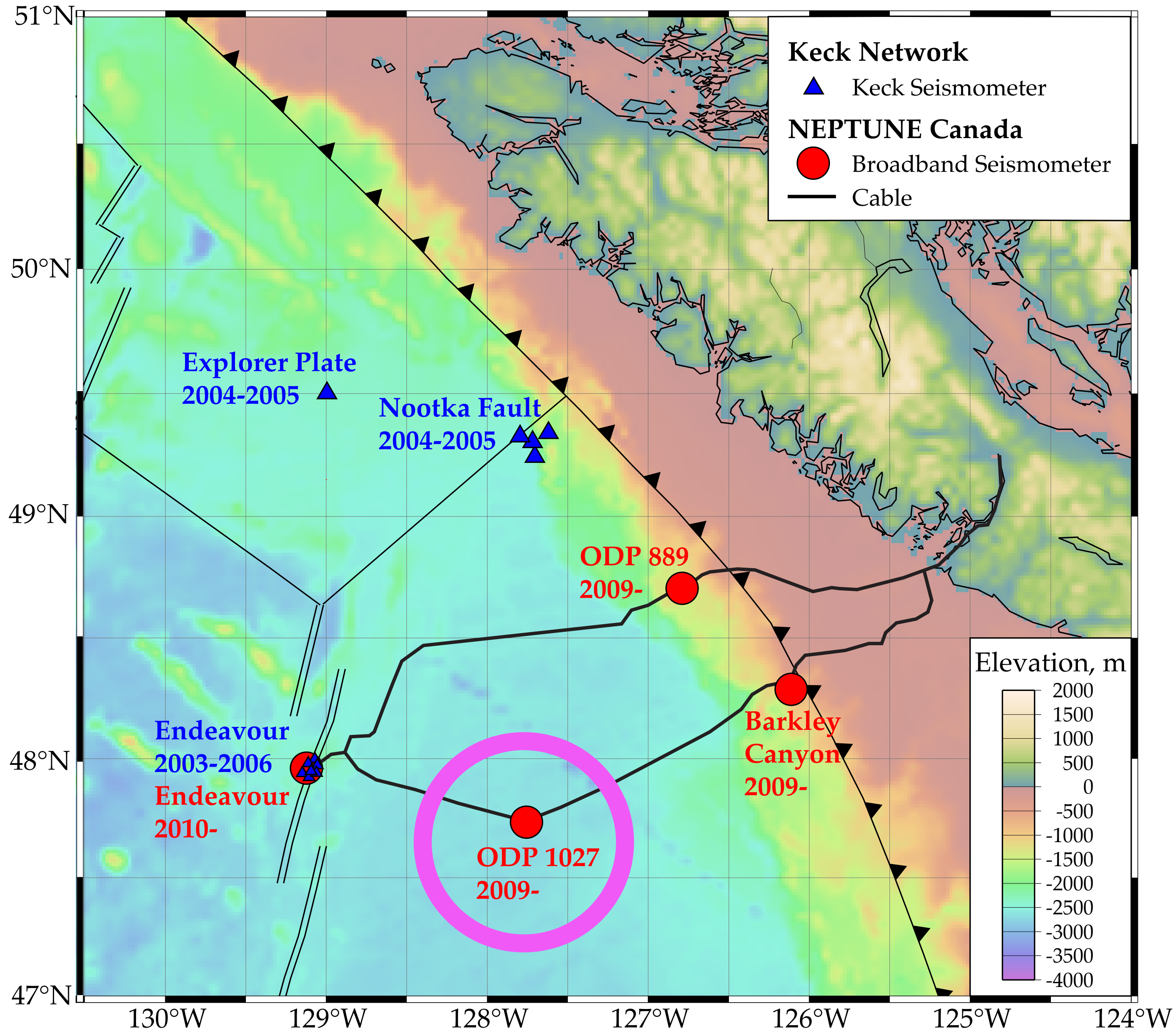
- Network used to find **154 whale tracks** during the first year of data collection



Wilcock, William SD. JASA 132 (2012): 2408.

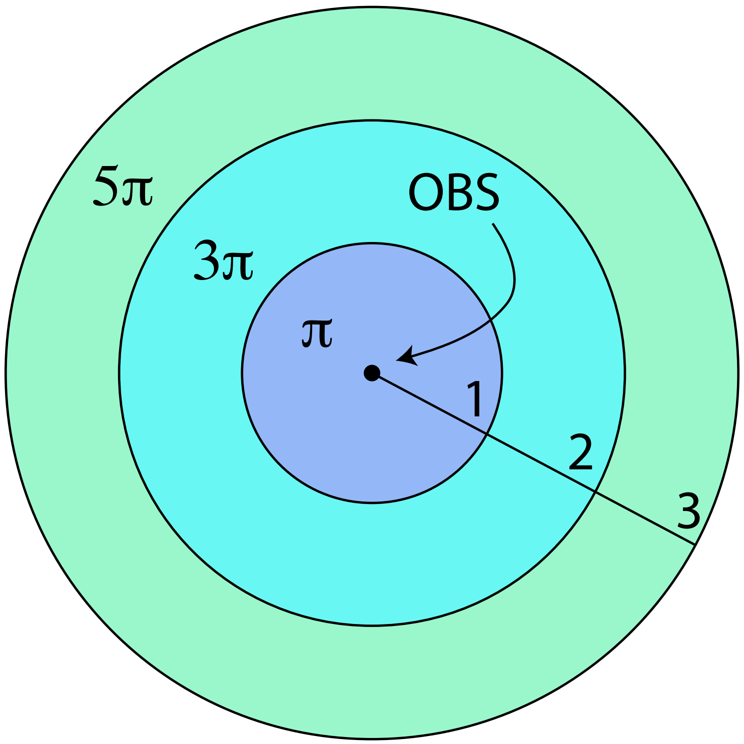
Soule, Dax C., and William SD Wilcock. JASA 133 (2013): 1751.

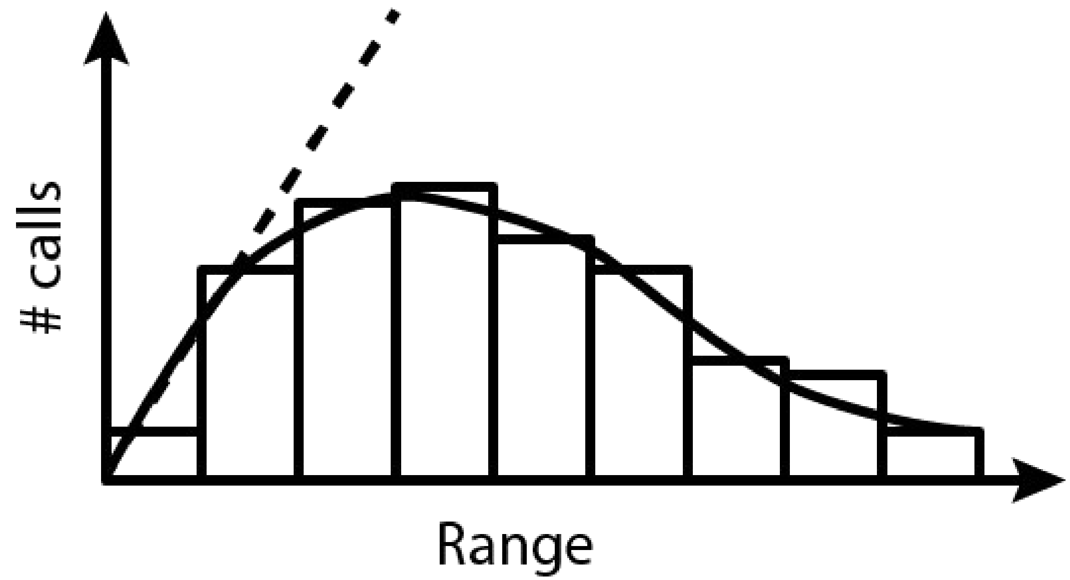
Neptune Canada Cascadia Basin



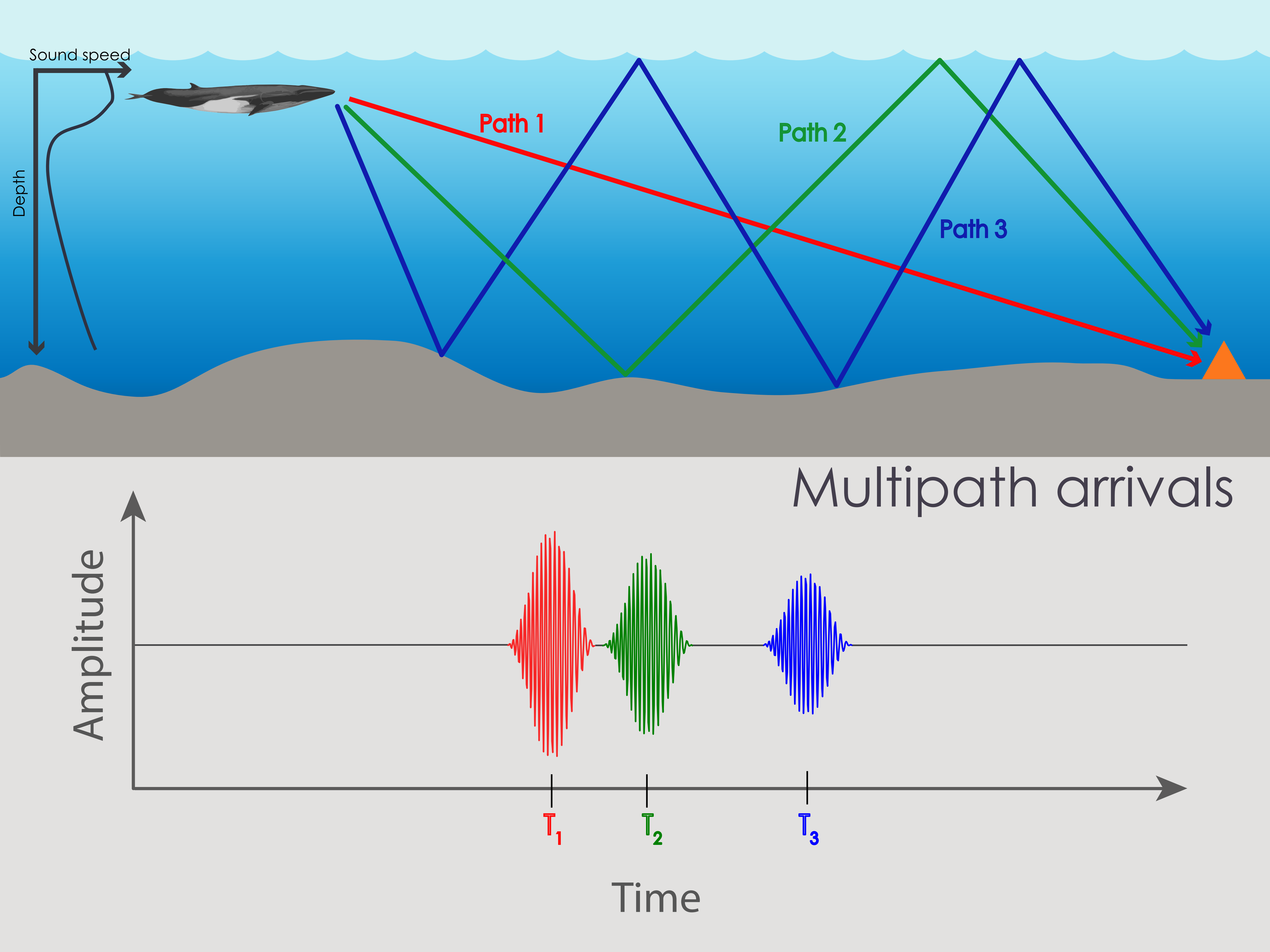
Point transect distance sampling

We want:
calls per unit area



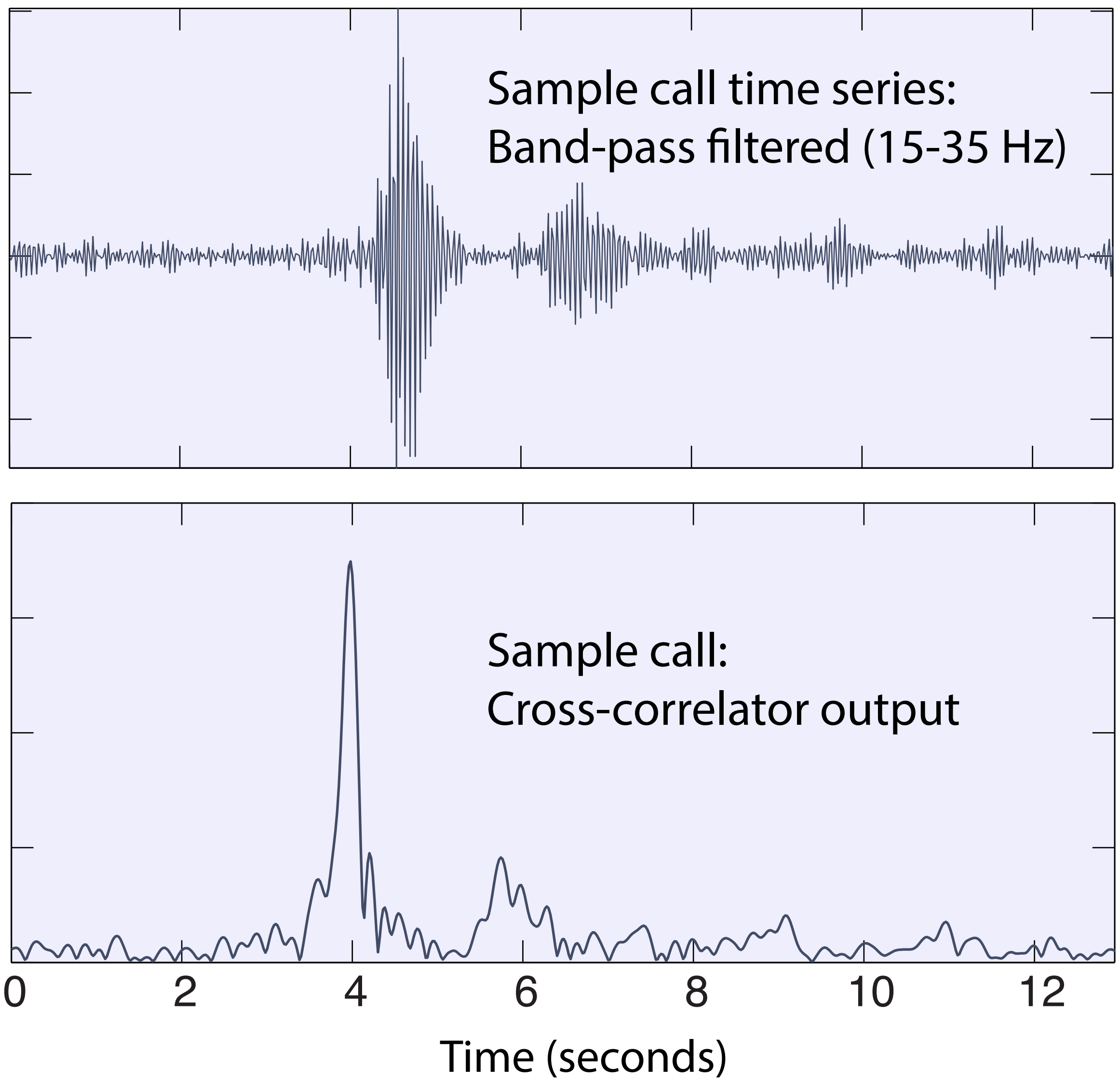


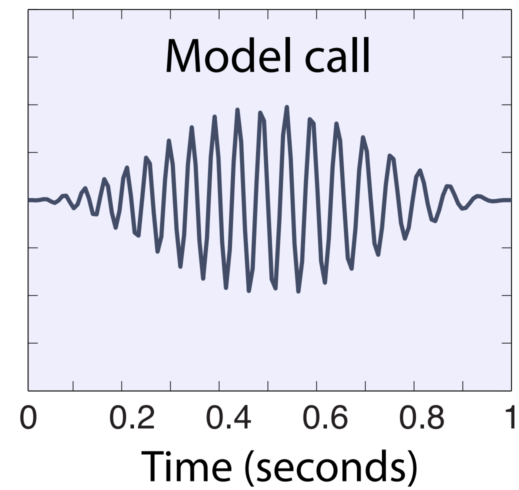
Estimate range from OBS to each detected call, fit model to range distribution to estimate call density



Sound speed
Depth
Path 1
Path 2
Path 3
Multipath arrivals
Amplitude
T_1
T_2
T_3
Time

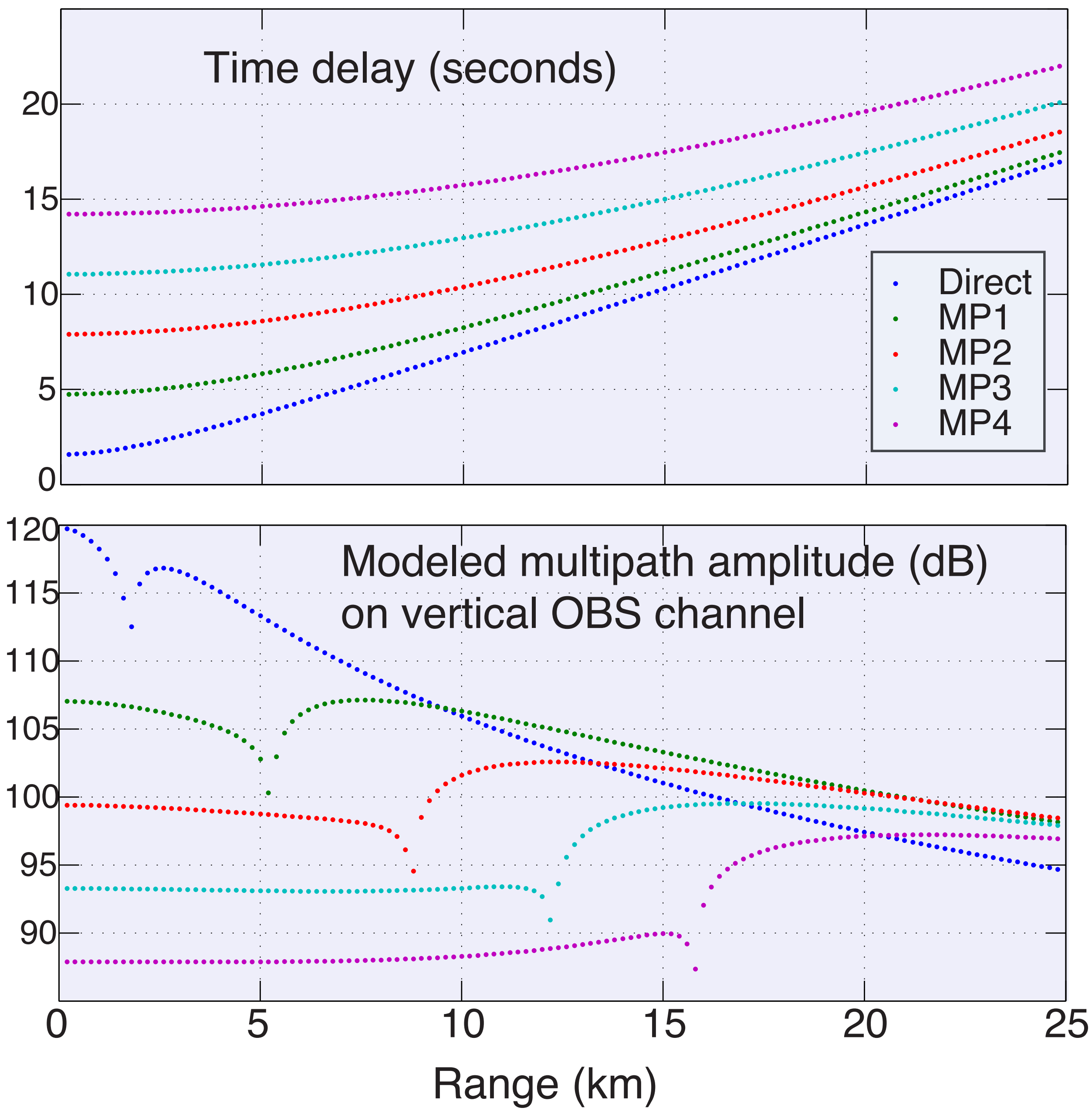
Store multipath structure near each pick





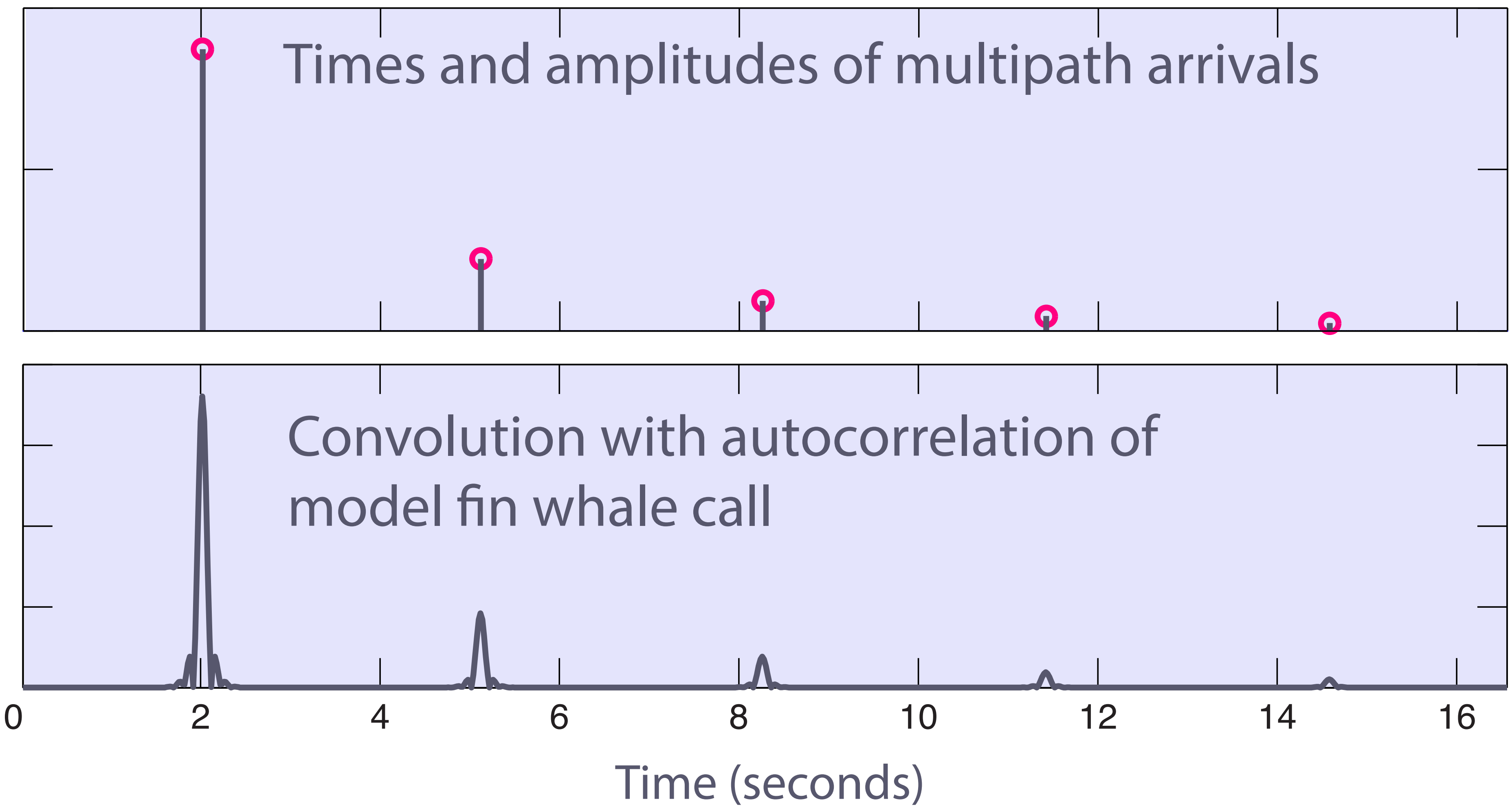
- Time series of received signal and model chirp basebanded at 20 Hz
- Cross-correlate basebanded signal and model chirp to find calls (including multipaths)

Modeling multipath timing and amplitude

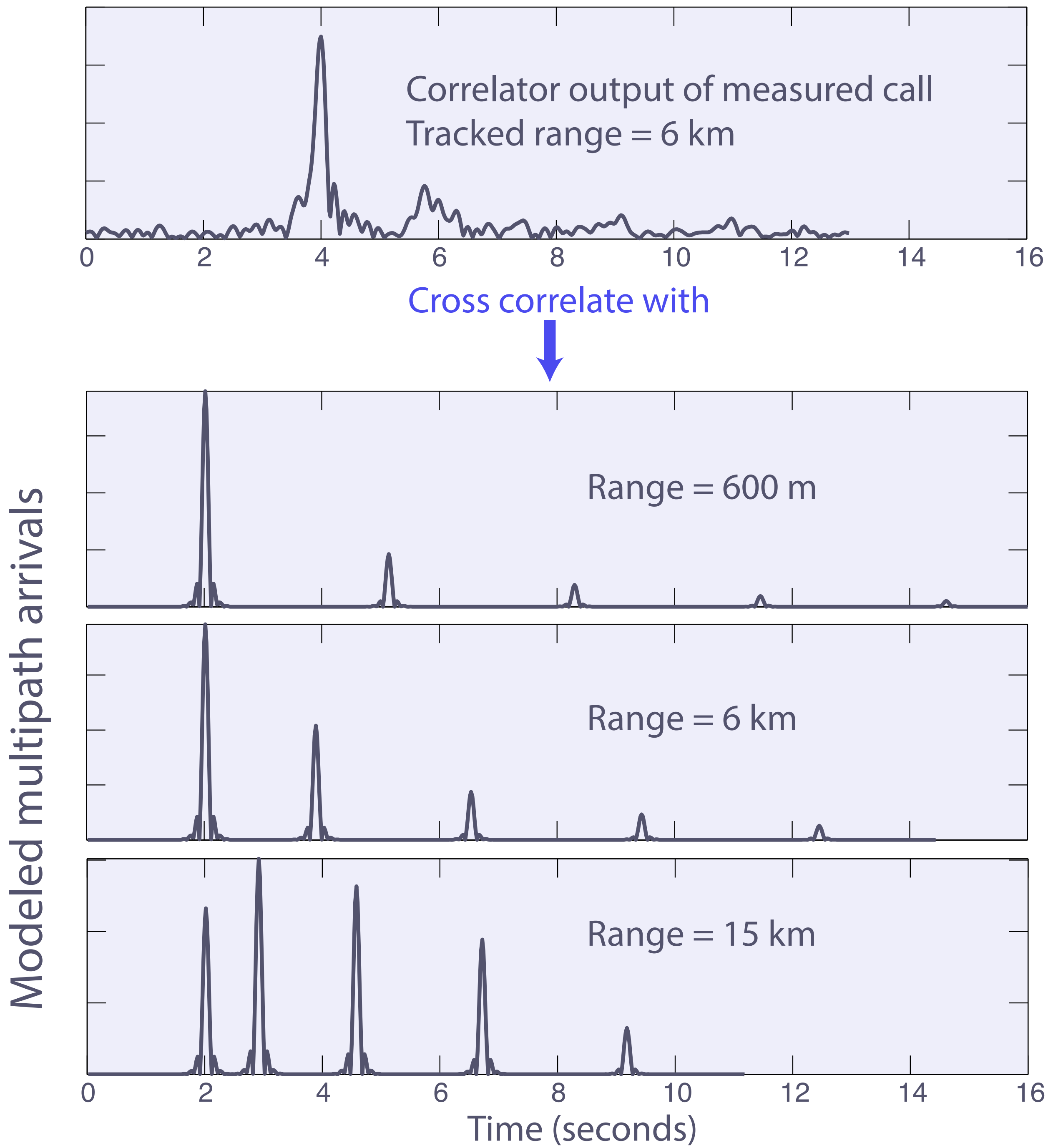


- **Rays traced** using Bellhop (HLS Research, Inc.) assuming:
  - depth varying sound speed profile
  - flat seafloor
- **Transmission loss** modeled assuming:
  - ray divergence
  - uniform bottom properties

Model representation of multipath structure

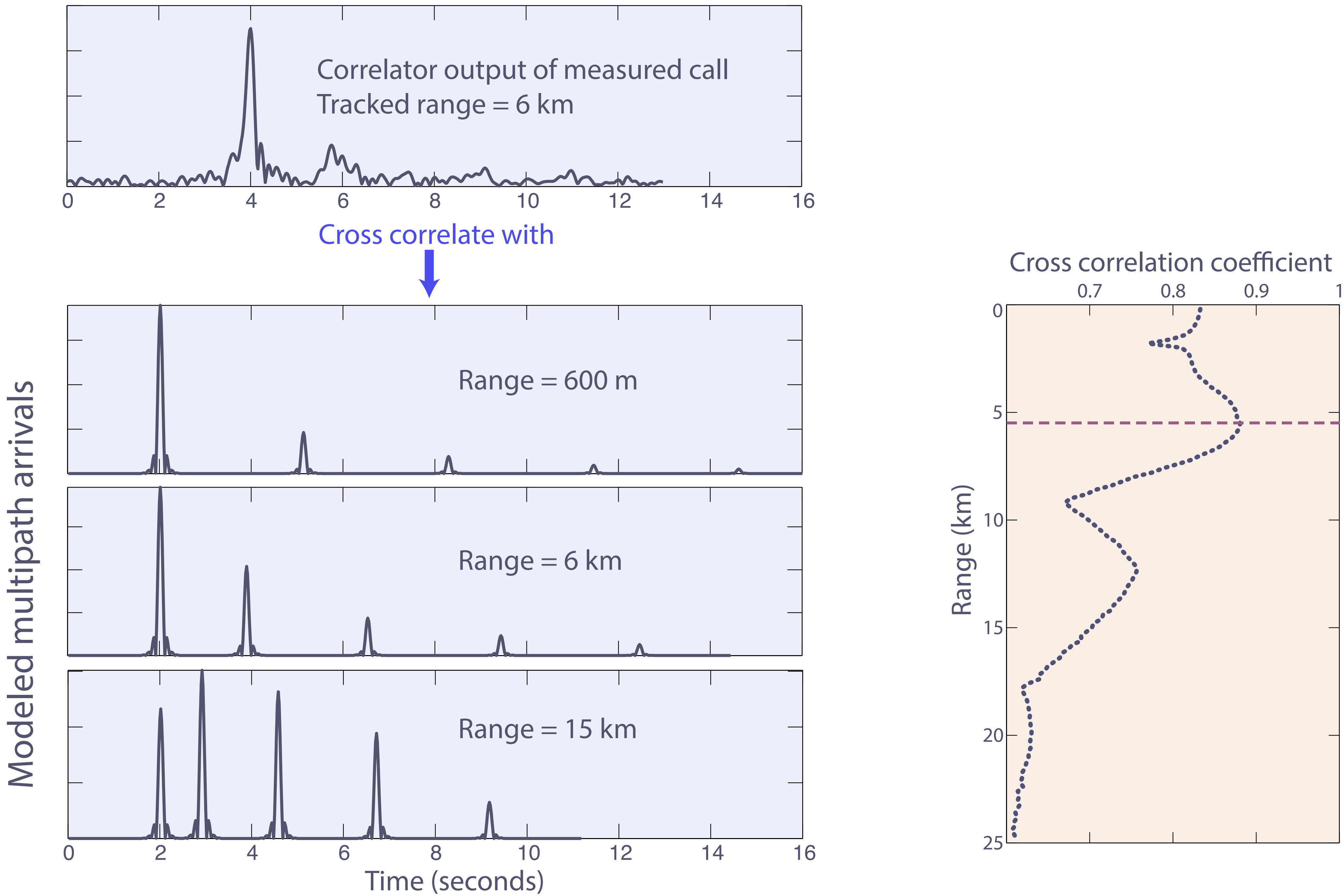


Range estimation using multipath spacing

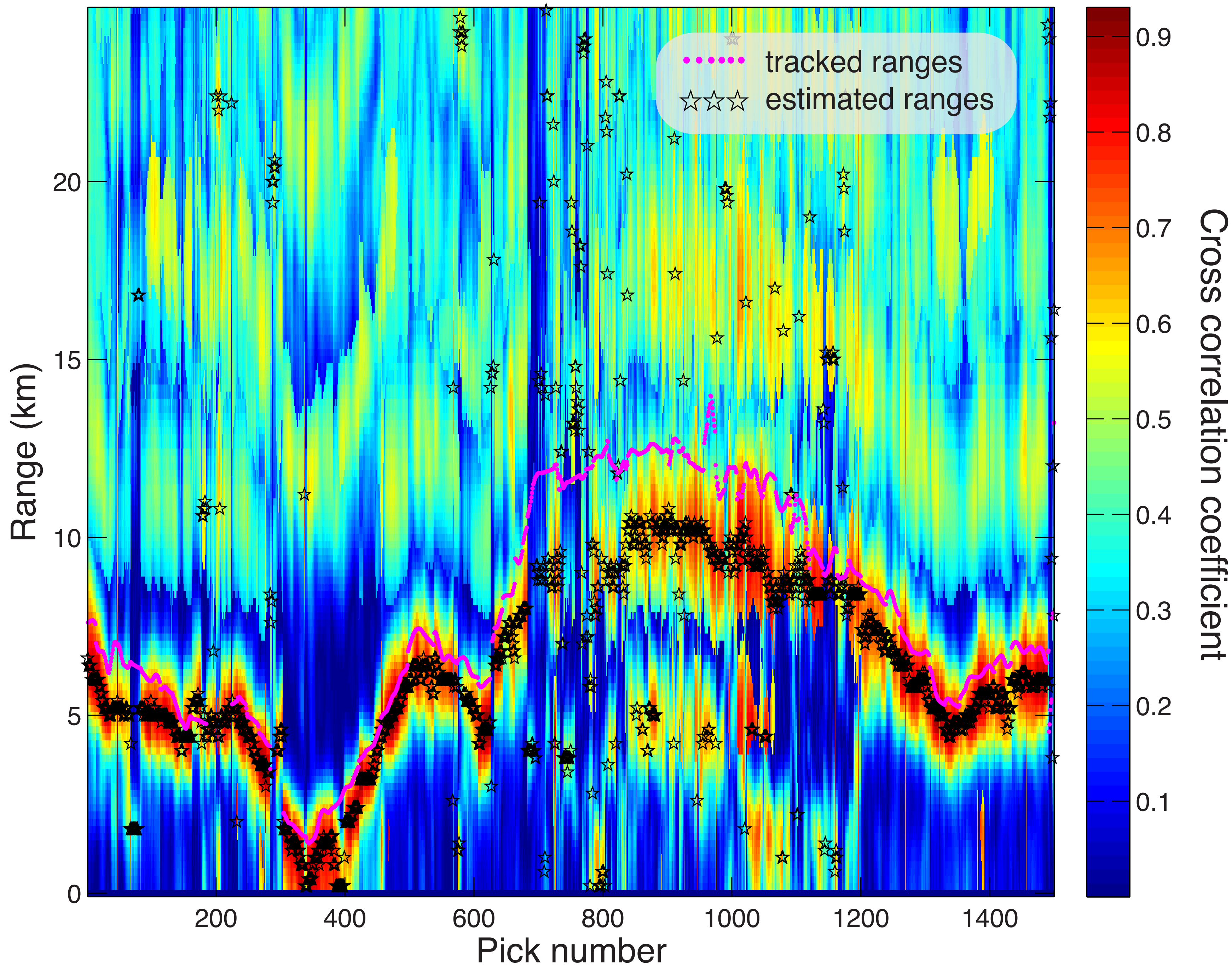


- Measured call is cross correlated with the multipath model at each range
- Maximum correlator output at each range is stored
- Best estimate of range corresponds to maximum correlator output of all possible ranges

Range estimation using multipath spacing



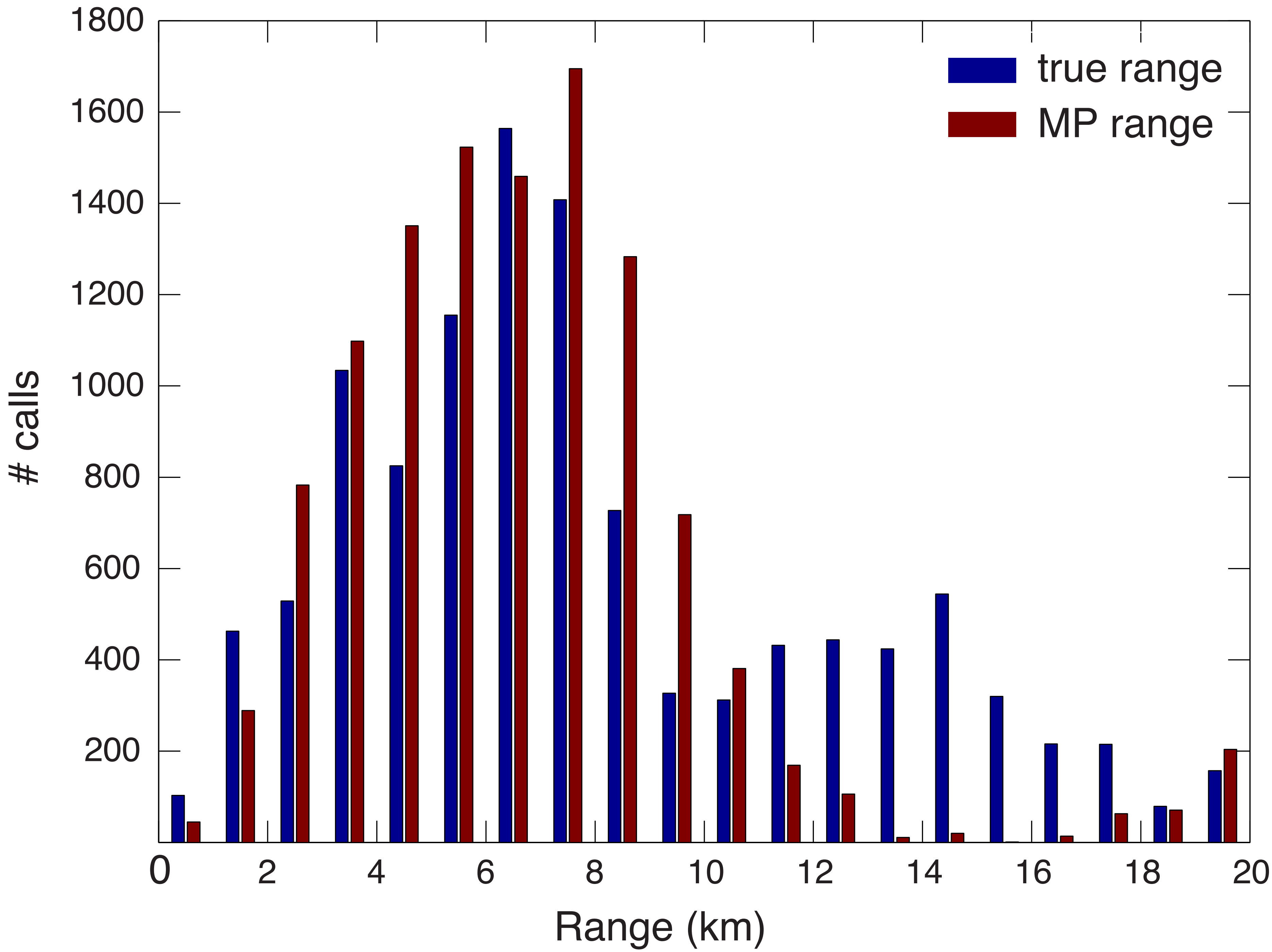
Results: Keck Endeavour Experiment



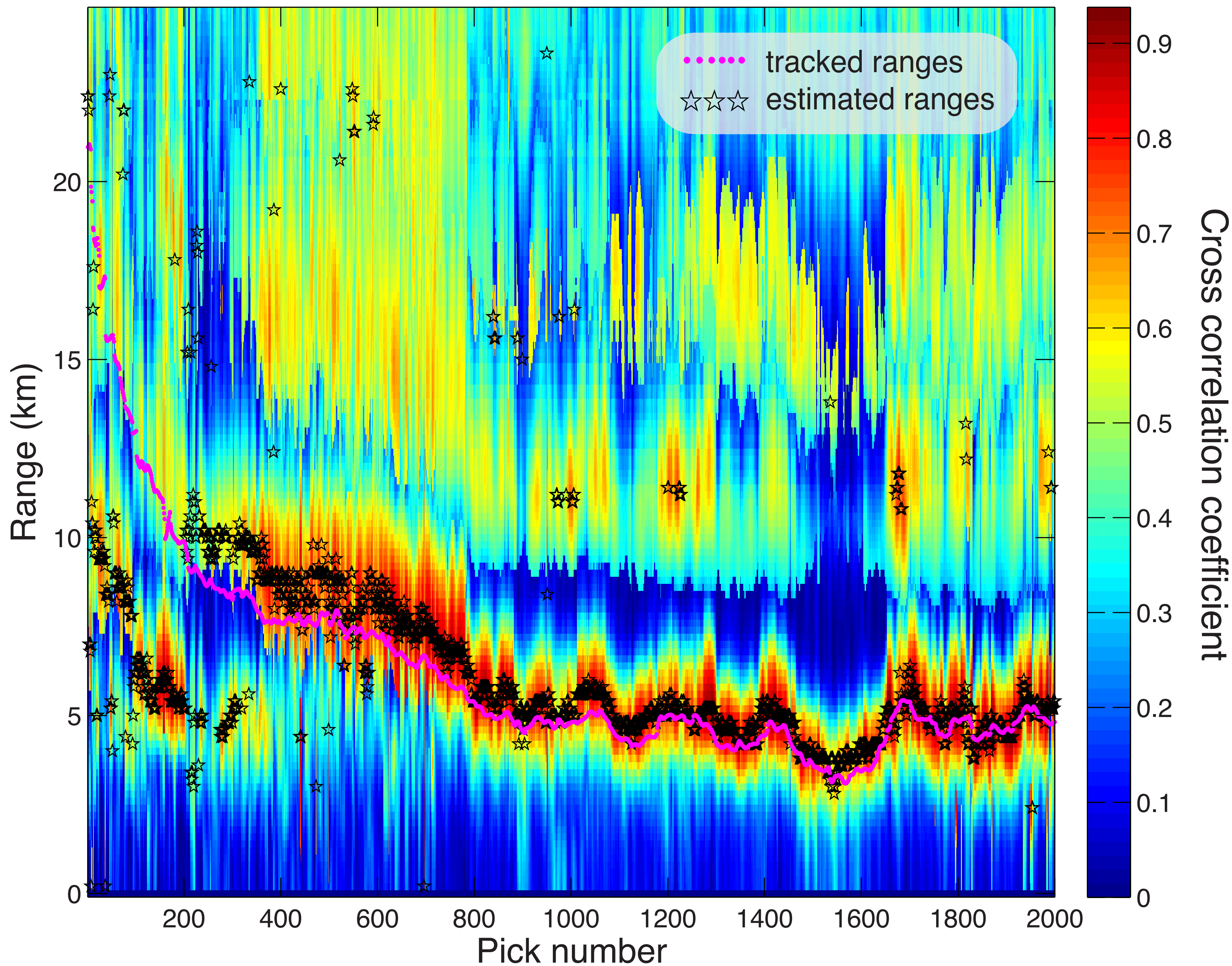
Most common sources of error

- Range ambiguities related to uncertainties in multipath alignment/identification
- Errors due to extra arrivals reflected off the base of the sediment layer

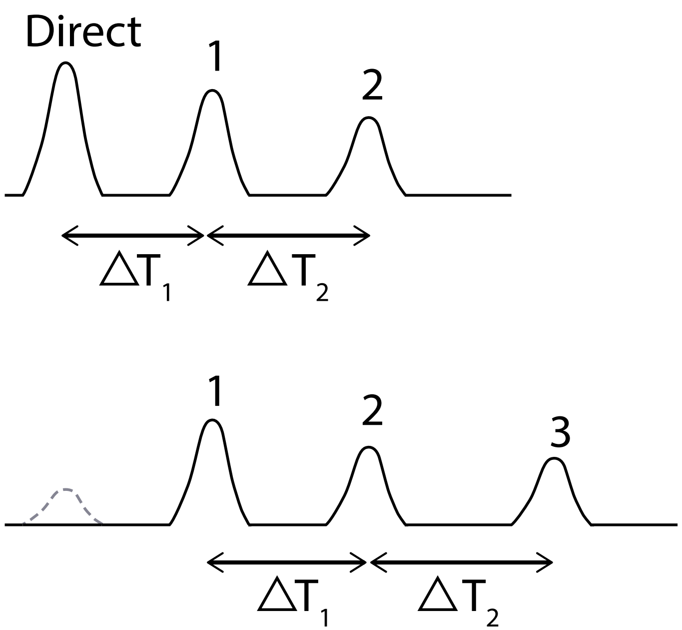
Range distribution: Keck Endeavour Experiment

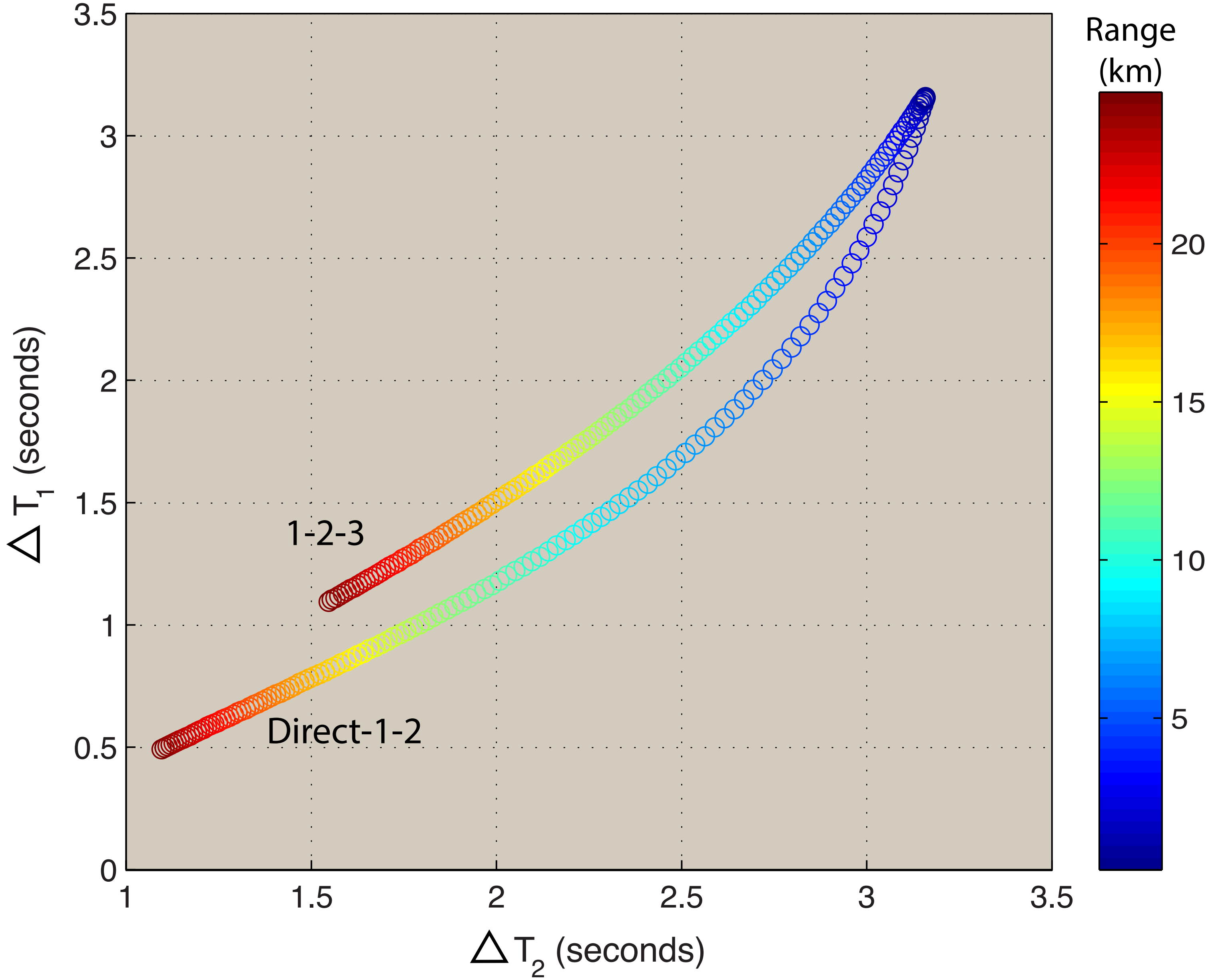


Results: Keck Endeavour Experiment

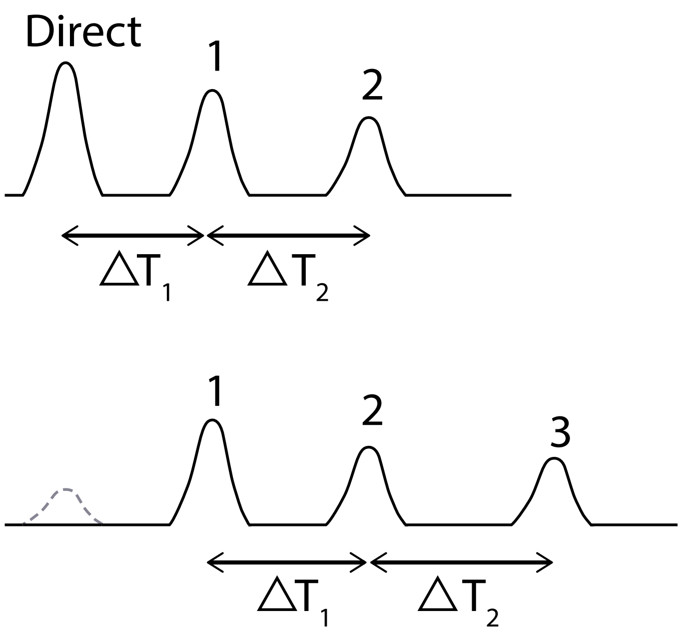


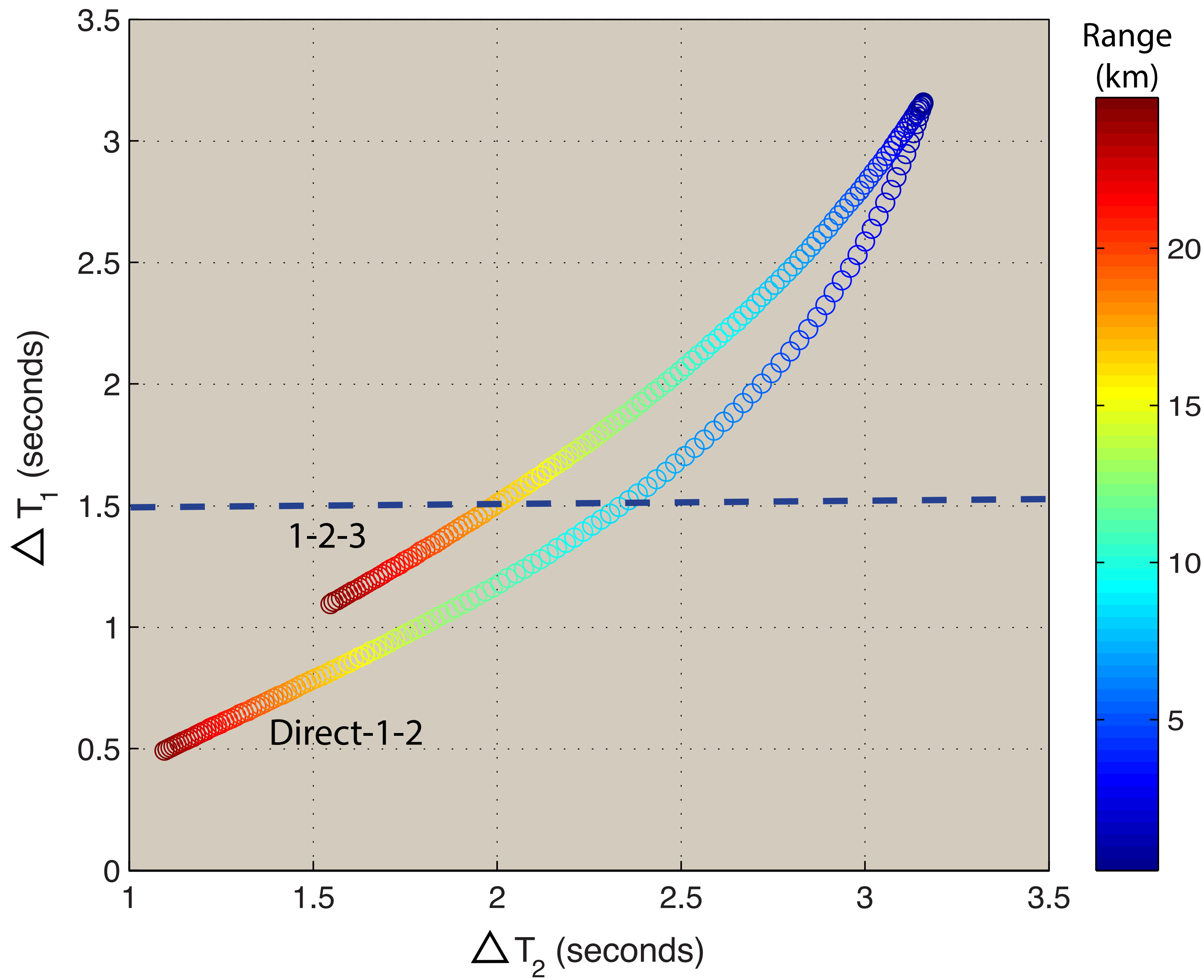
Sources of uncertainty : Modeled pick times



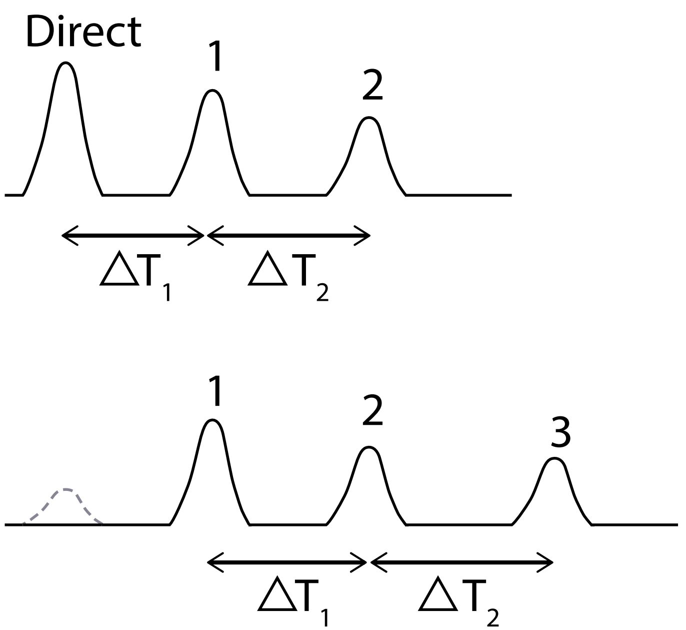


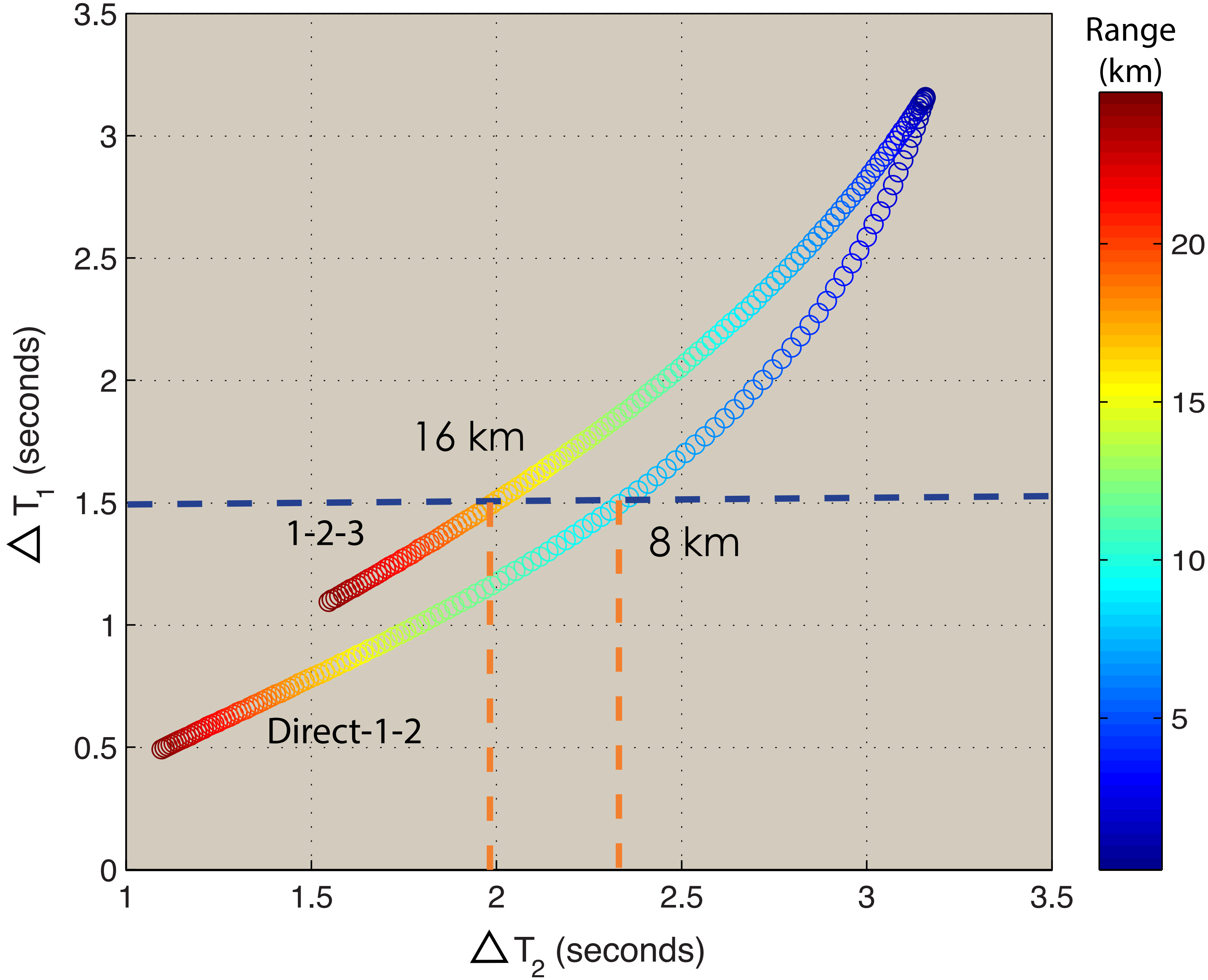
Sources of uncertainty : Modeled pick times



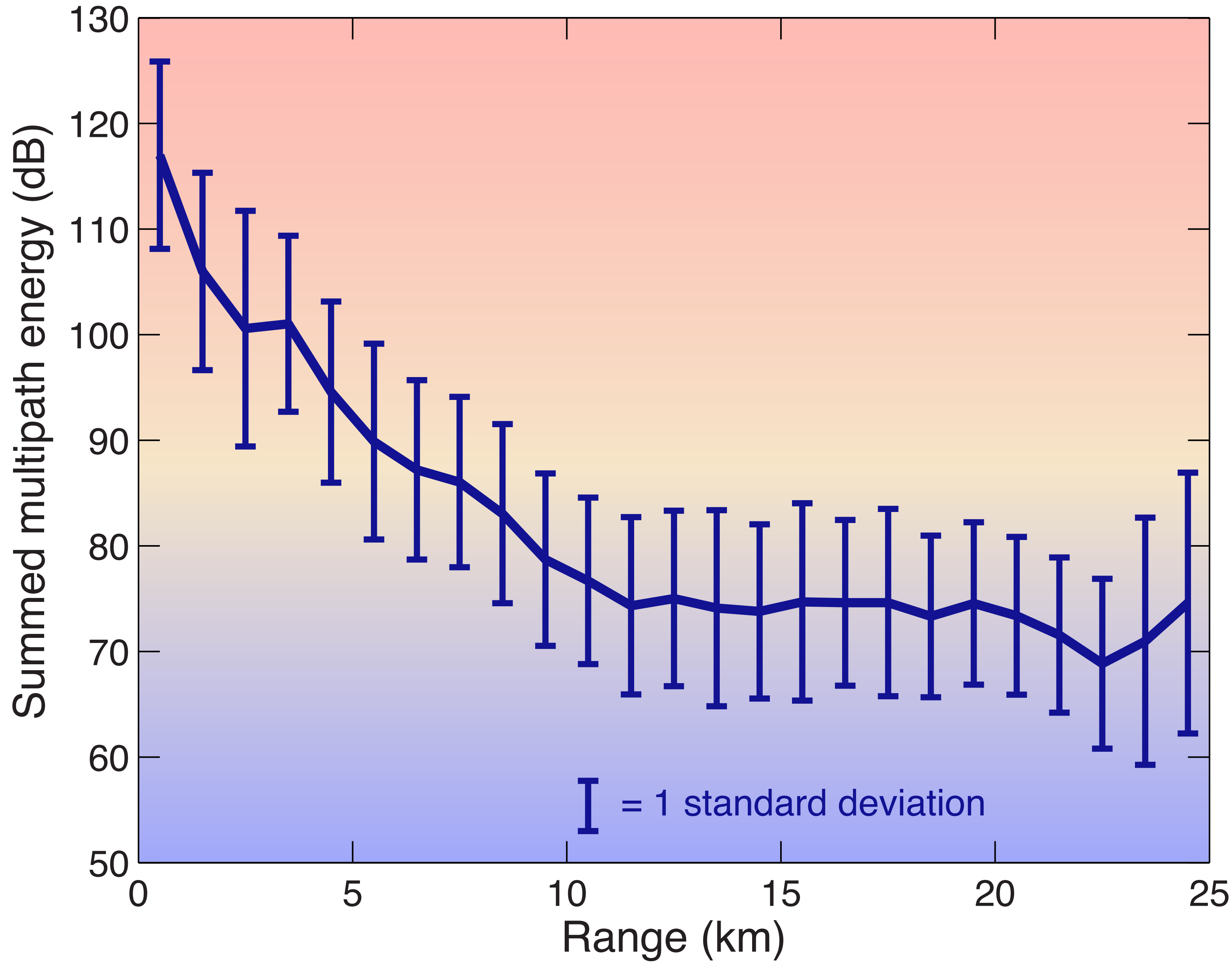


Sources of uncertainty : Modeled pick times

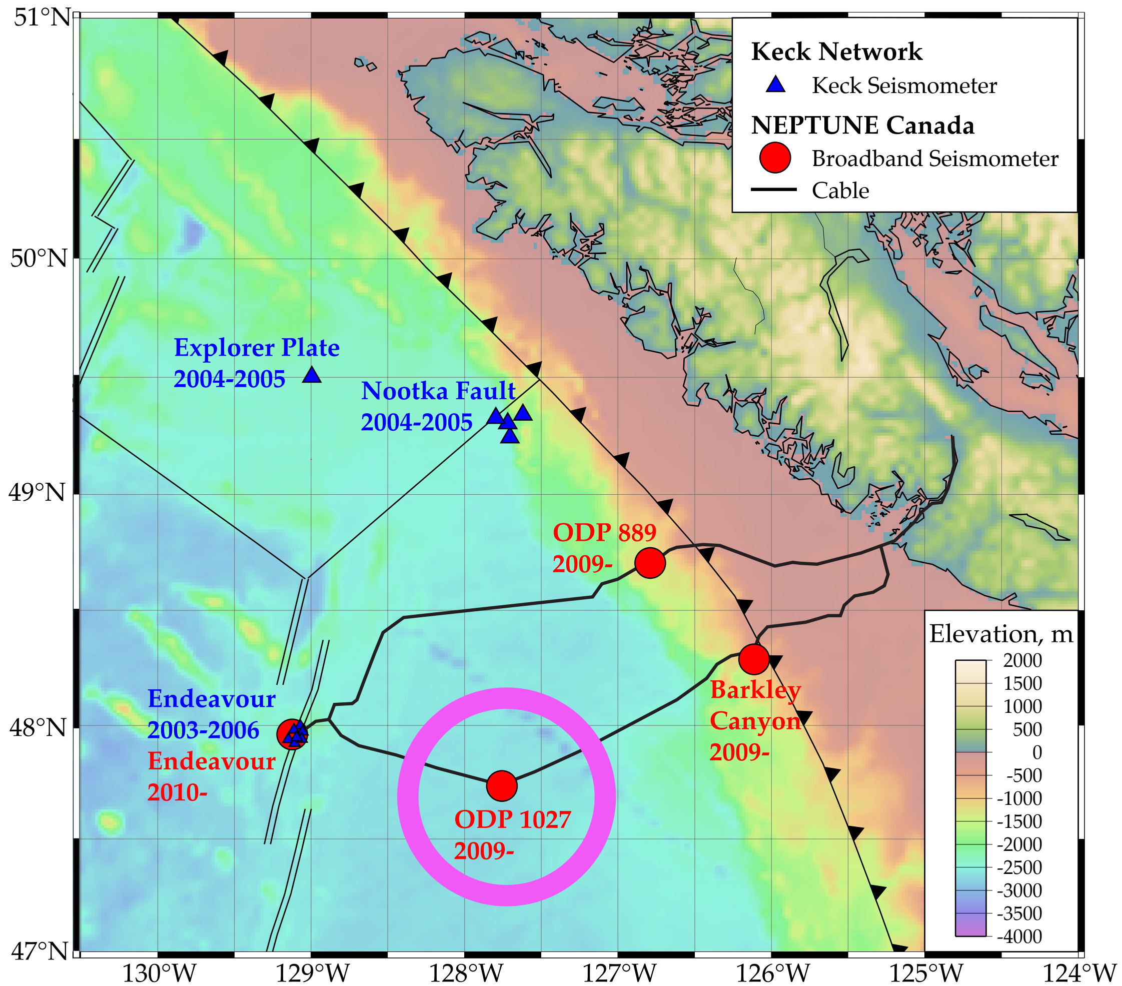




Measured pick amplitudes



Potential for improvement with flatter, sedimented sites



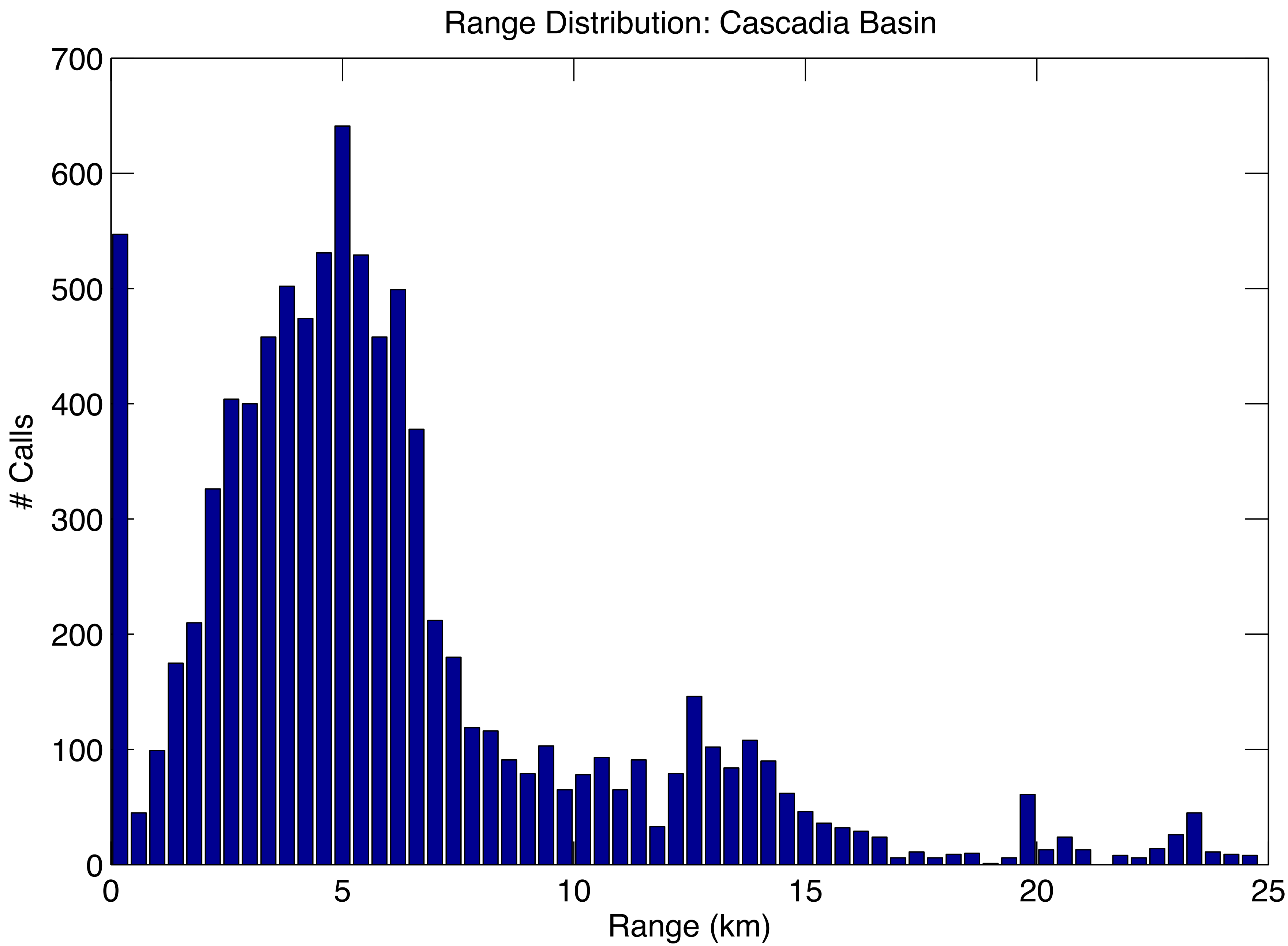
Pros:

- More accurate modeling of multipath spacing
- Amplitude more diagnostic of range

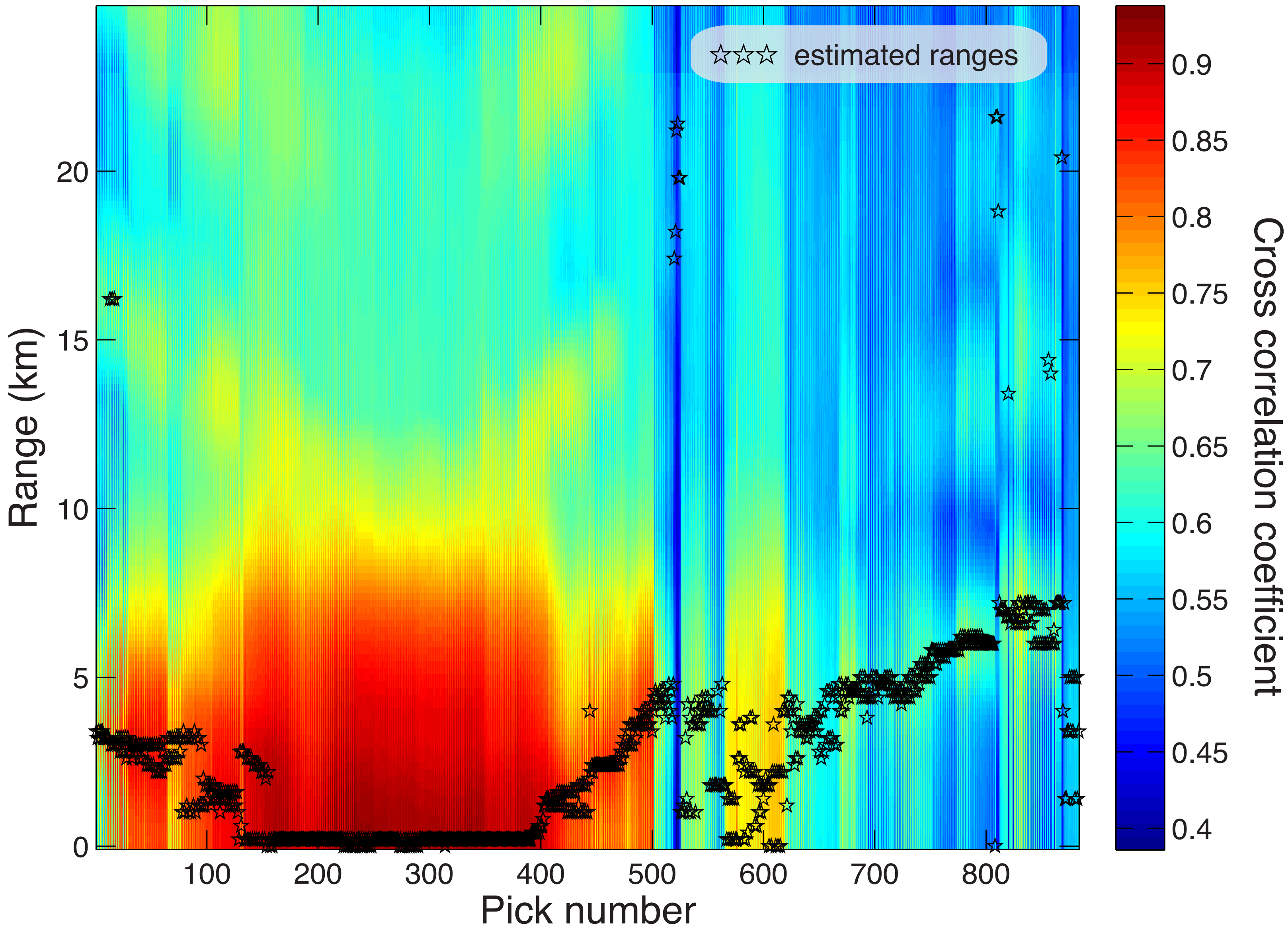
Cons:

- Less energy reflected with each seafloor bounce (multipath suppression)

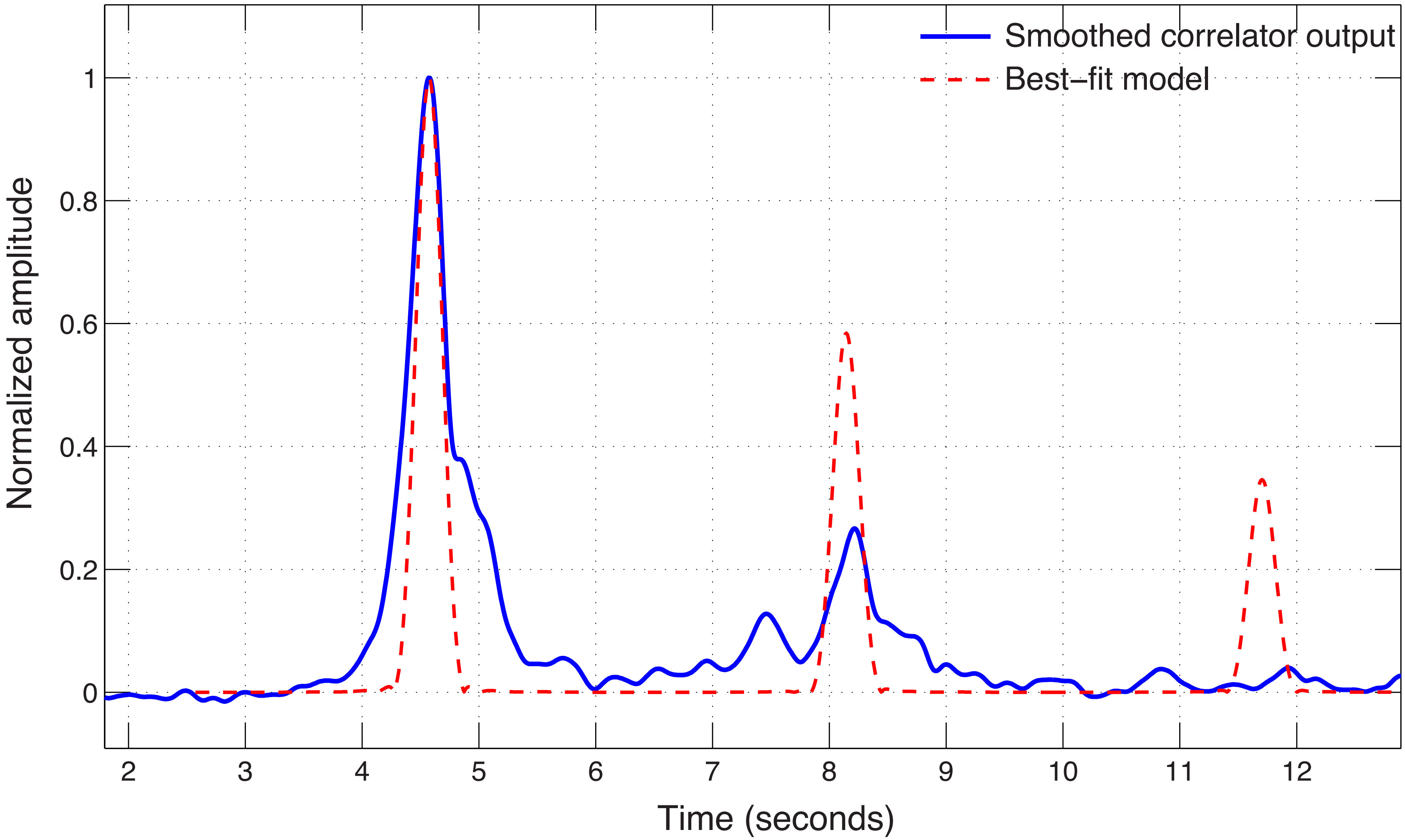
Range distribution: Cascadia Basin



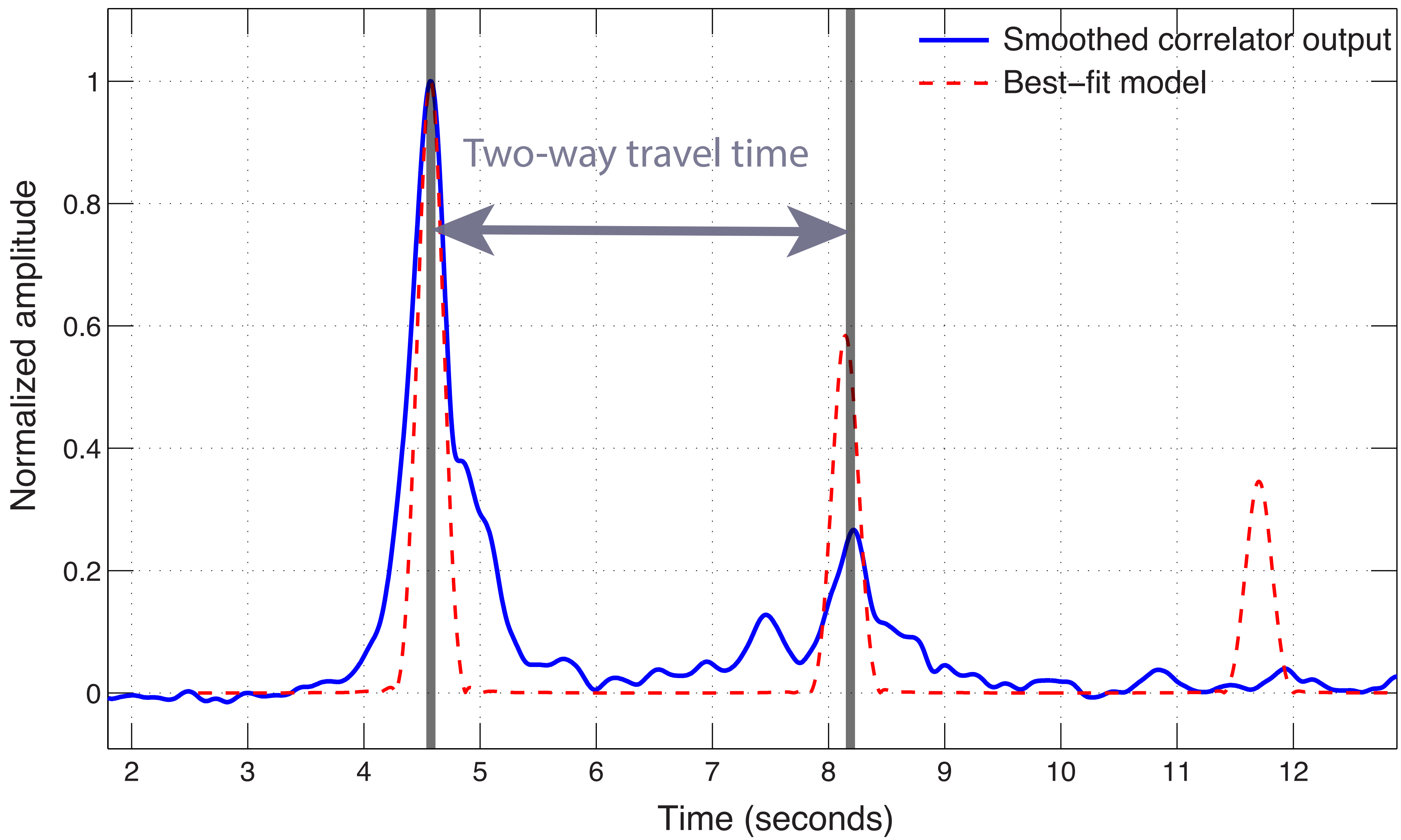
Cascadia Basin - Zero ranges



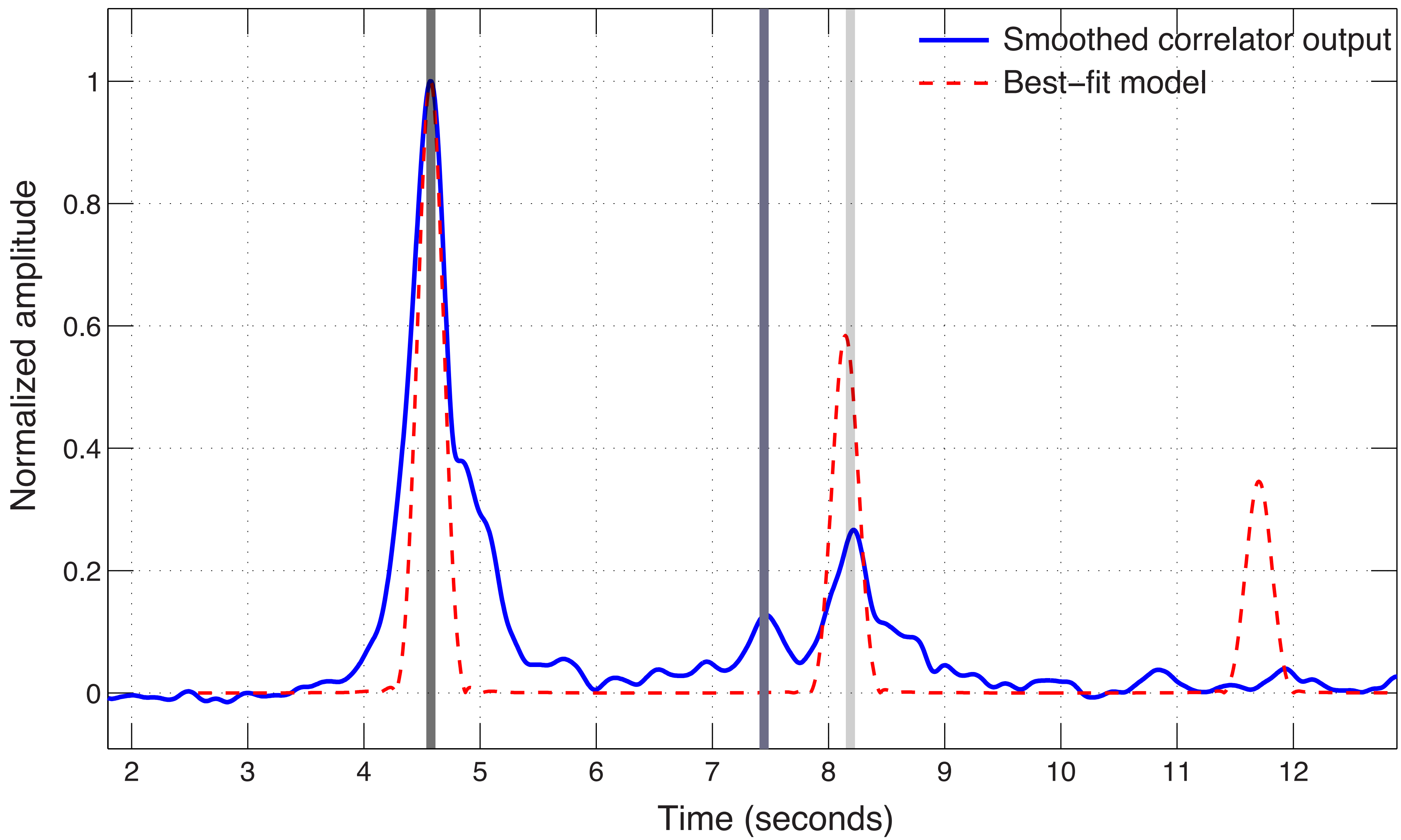
Cascadia Basin - Zero ranges



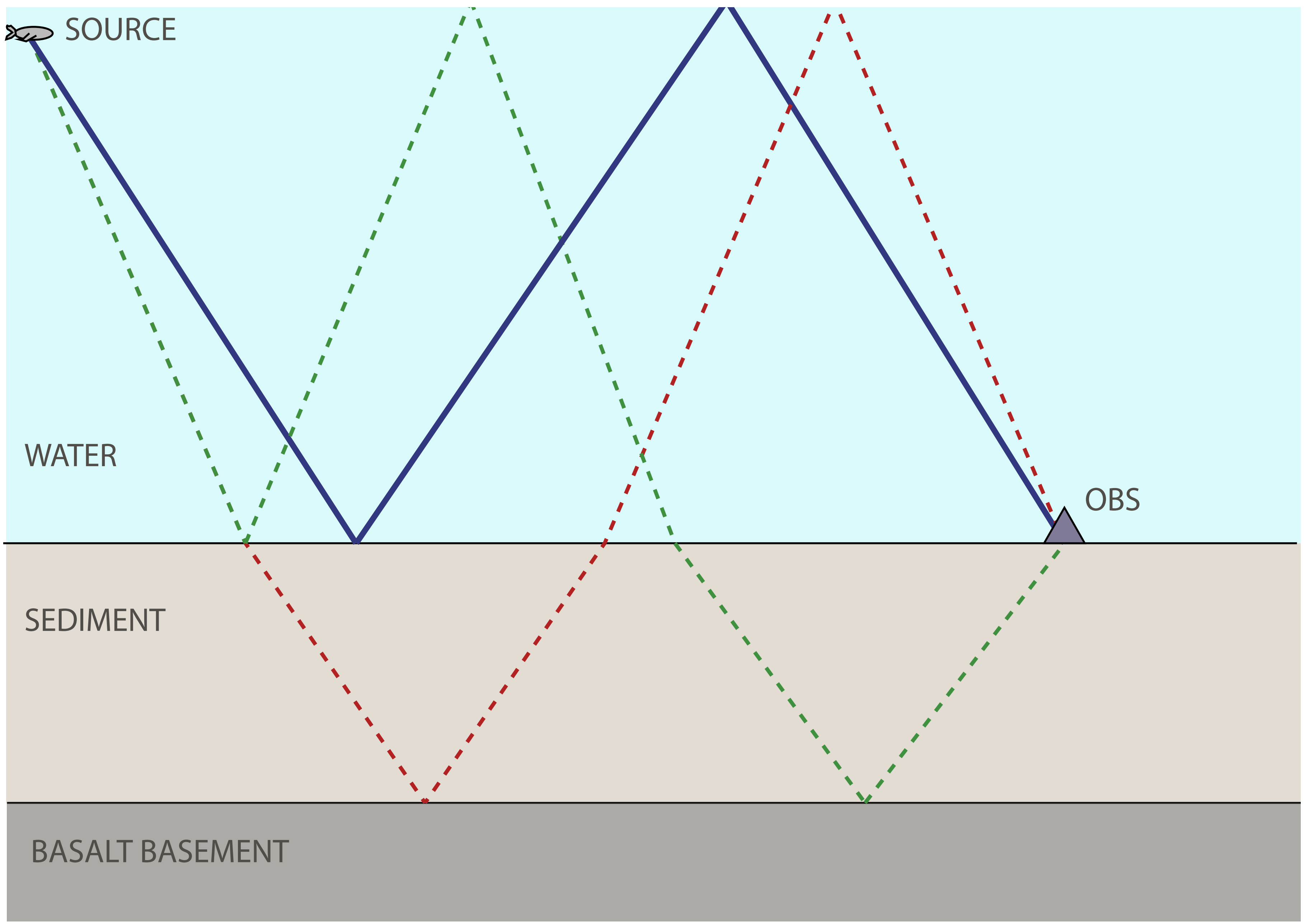
Cascadia Basin - Zero ranges



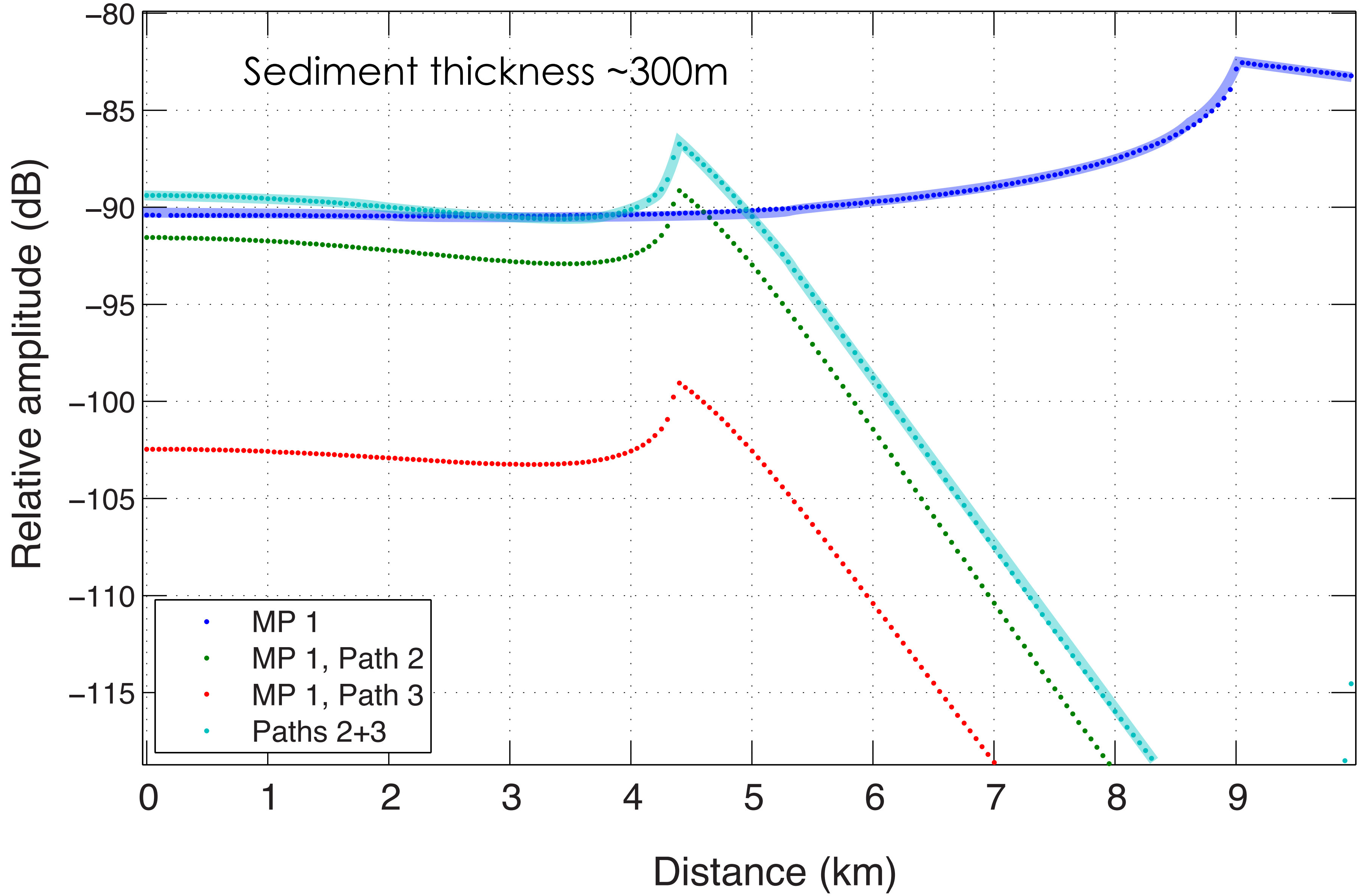
Cascadia Basin - Zero ranges



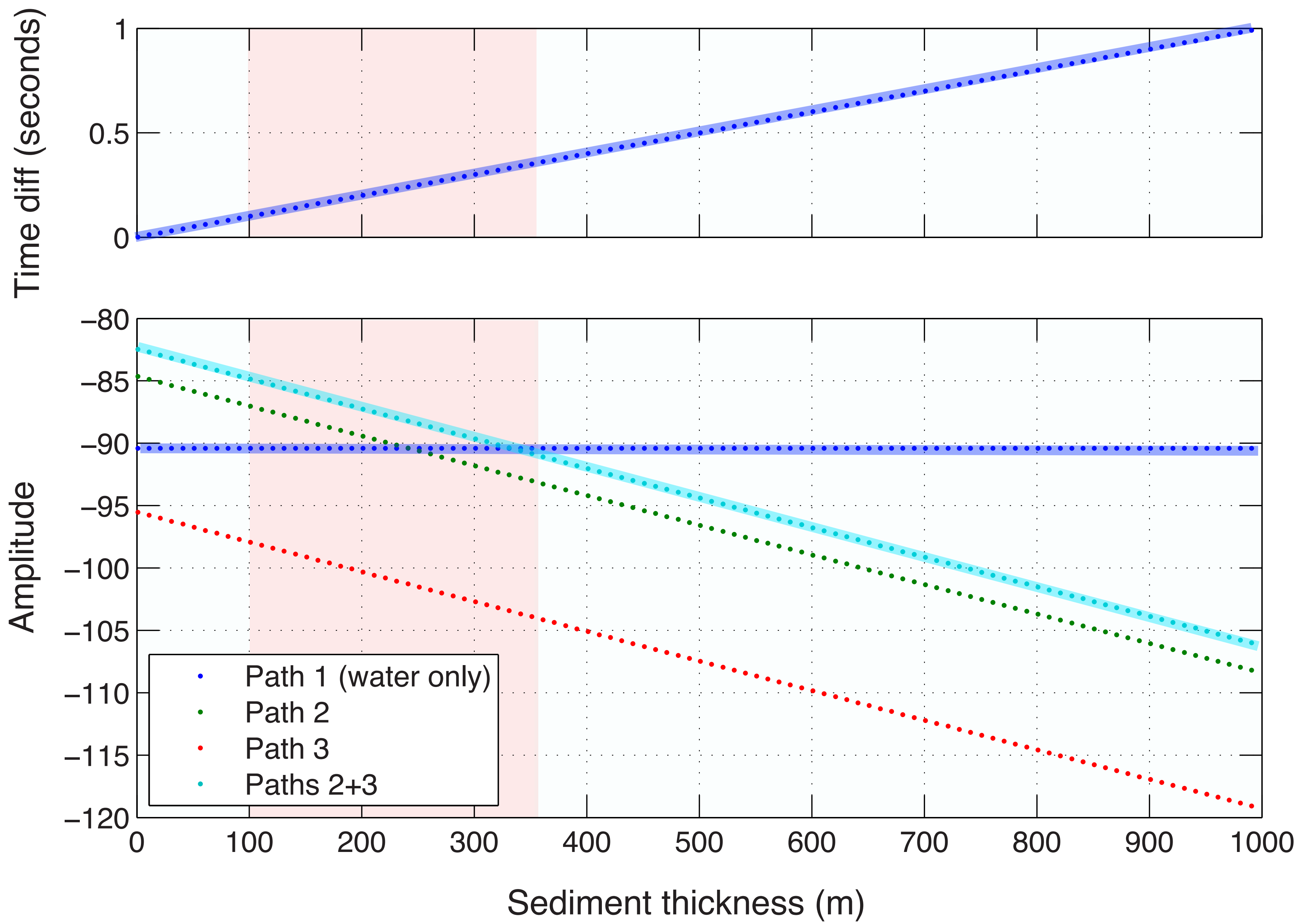
Cascadia Basin - Basement reflections



Cascadia Basin - Zero ranges



Cascadia Basin - Zero ranges



Summary

- The method is working well and is at a stage where we can compare with other methods

Remaining issues:

- Range ambiguities
    - We are exploring ways to constrain solutions in regions of complex bathymetry
    - In some cases more complex modeling schemes might be required to resolve ambiguities
    - Less of an issue in flatter bathymetry

- Zero ranges (Cascadia Basin)
    - Related to basement reflections
    - Resolved, solution being implemented

Funded by:

Cascadia Basin - Zero ranges