SnT 2019
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

Using Reflection Green's Functions Extracted From Ambient Seismic Noise and Signal for IMS Seismic Site Crustal Reflection Characterization

Robert C. Kemerait, Ph.D., Ileana M. Tibuleac, Ph.D., Mark T. Woods, Ph.D., and Mr. Daniel H. Stayt

Air Force Technical Applications Center, Patrick Air Force Base, FL 32935

T3.5-P6

RESEARCH OBJECTIVES

Develop a seismic interferometry method for constructing seismic velocity model

- Test Case: IMS array PDAR, Pinedale, Wyoming, USA.
- Develop & Test semi-automatic phase identification technique for extraction of two-way travel times from reflection Green's Functions (GF).

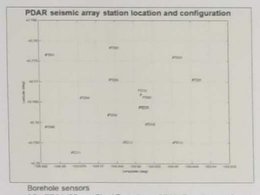
Estimate shallow and deep crustal reflection information directly beneath PDAR

Provide better understanding of the crustal structure for:

- Travel-times & epicenter locations
- Waveform simulation for event identification

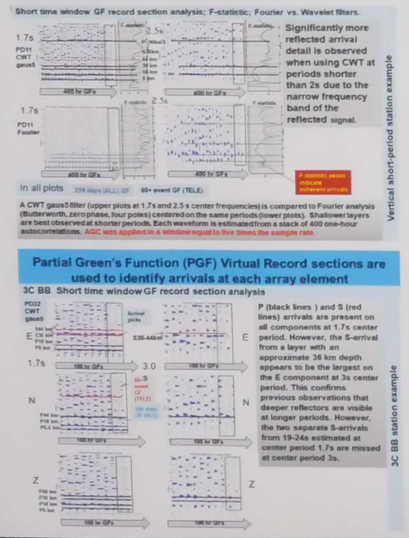
Data

- Three to six-months of continuous data in 2008 that were recorded at PDAR IMS seismic array were utilized. The array includes 13 short-period vertical component sensors (PD01-PD13), one short – period 3C sensor, PD31, and one broadband (BB) 3C sensor, PD32.
- Three months of continuous data (in 2008) recorded at the USArray Transportable Array (TA) stations located within 150 km of PDAR.
- More than 60 teleseismic earthquakes 5.5<M with variable depth and spatial location were used to extract Green's Functions (GF TELE) at each station.

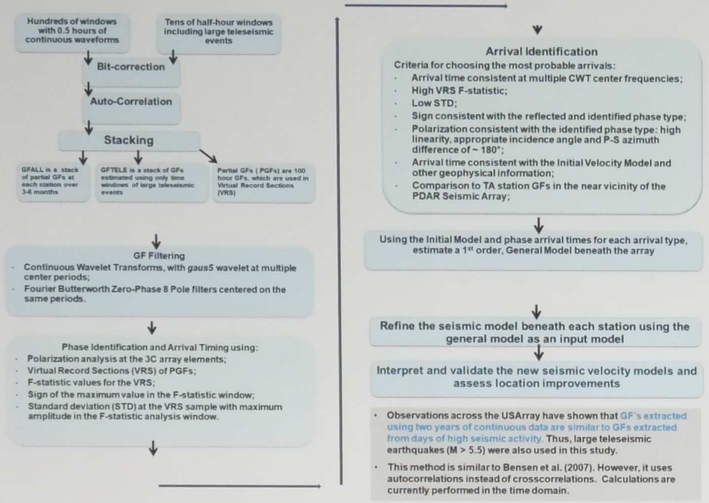


Borehole sensors
3C : PD31 (20sps, Short Period) and PD32 (Broadband, 40 sps) ;
Vertical Short-Period : PD01-PD13 (20 sps)

Green's Functions (GF)

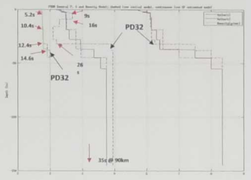


METHOD



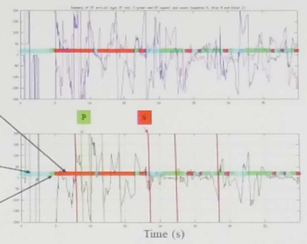
MODELS

PDAR VELOCITY MODEL: The initial model is shown as colored dashed lines. The General, GF-extracted Model (GM) is shown as continuous lines. PD32 – station seismic model is shown as black dashed lines. Two-way travel times are included.



The IRIS EARS receiver function study estimated a Moho depth of 43 km beneath the PDAR Seismic Array. The GM model resolution was higher than receiver function resolution. Note that significant seismic model differences may be observed at individual array elements, which are consistent with significant variations of subsurface structure.

PD32 Arrival score for the E (magenta) and N (blue) components, in the upper plot, and for the Z component in the lower plot. Red shows the center of the windows with waveforms vertically polarized, which are interpreted as P arrivals. Cyan shows waveforms with incidence angle between 40 and 70 deg from the vertical, and green shows S-polarized arrivals.



It is assumed that a deep crust reflection is observed at all center periods.

Note that upper crust reflectors (P/S) are identified at center periods 1s and 1.7s and are not visible on this plot

SUMMARY

Independent crustal reflector information can be obtained at each station from ambient seismic noise and signal using seismic interferometry.

We have developed a semi-automatic method for phase identification through using GF polarization parameters, F-statistic methods and other available geophysical information.

Wavelet transforms (CWT) are preferred to Fourier filters. It is recommended that Fourier-wavelet calibration is used to correct for the CWT non-causality at periods of interest.

At the current stage of the project, a General Model (1D for the whole array) is estimated beneath PDAR, which is more detailed than the Initial Model and models directly beneath each array element are extracted.

FUTURE INVESTIGATIONS

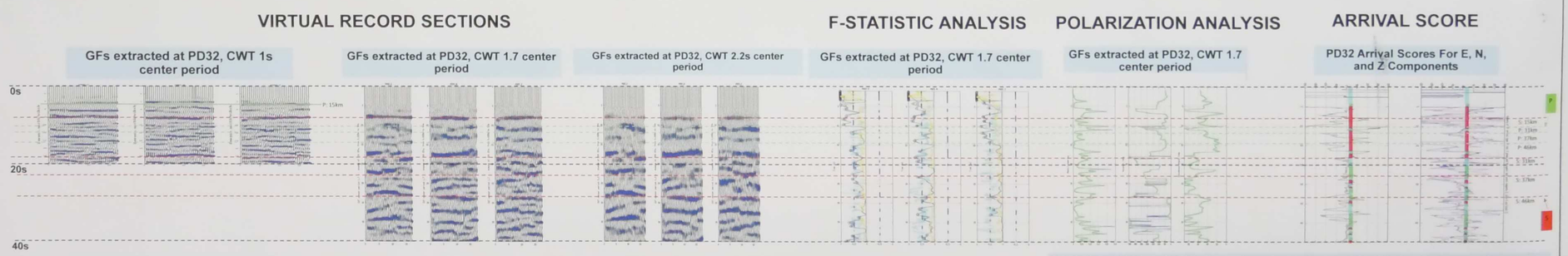
Continue the arrival interpretation and the model refinement beneath each station.

Use synthetic waveforms to evaluate and adjust the model.

Estimate reflective layer depth errors. Validate the model using seismic event analysis.

Arrival Identification at 3C Components

An example of polarization analysis when using CWT gaus5 centered on 1s, 1.7s and 2.2s at PD32: P (black), possible SV (green) and S (red) arrivals are identified using the incidence angles.

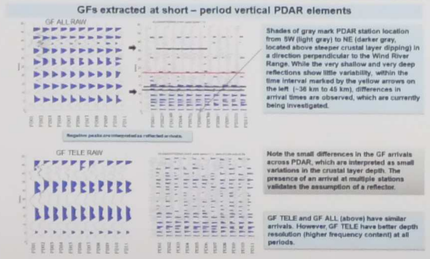


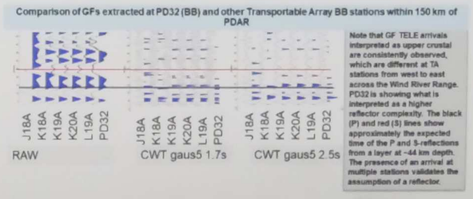
Note that shallower layers are best visible at shorter CWT center periods

Note that deeper layers are best visible at longer CWT center periods

At stations PD31 and PD32, for each center period, the identified arrivals are assigned a polarization according to their incidence angle from the vertical. P and S have different back azimuths in most of the cases. The PD32 polarization parameter variation in time is used to identify reflected phases at the short period elements.

Other geophysical information





Note that GF TELE arrivals interpreted as upper crustal are consistently observed, which are different at TA stations from west to east across the Wind River Range. PD32 is showing what is interpreted as a higher reflector complexity. The black (P) and red (S) lines show approximately the expected time of the P and S-reflections from a layer at ~44 km depth. The presence of an arrival at multiple stations validates the assumption of a reflector.

Disclaimer: The views expressed on this poster are those of the author and do not necessarily reflect the view of the CTBTO or the United States Government.