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ON MEASURING MISORIENTATION OF SEISMIC SENSORS USING AMBIENT NOISE DATA

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The dependence of the results of many seismic studies (e.g. seismic anisotropy, extracting Love wave from ambient noise data, measuring wave amplitude and receiver functions) to the accuracy of seismic sensor's orientation are experienced many times. Therefore, the misorientation correction of seismic data in such studies must be taken into account seriously. Aligning the seismometer to the true geographical orientation is harder than it seems. Usually, a magnetic compass is used to estimate the geographic orientation in the sensor deployment stage. In this case, the accuracy of determining the true geographic orientation is affected by a variety of factors such as the presence of magnetic and mineral resources near the installation location and the lack of declination correction which is more important in high-latitude regions. In addition, although fiberoptic gyrocompass is very accurate to determine true geographic orientation, the cost and weight of such equipment prevents its usage widely (Wang *et al.*, 2016). Due to such reasons, seismograms analysis has been considered as a new tools to correct misorientation of the sensors in the recent years. There are two main methods for correcting misorientation of seismometers by seismograms analysis. The first one is based on the polarization analysis of long-period Rayleigh waves (25-50 s) or intermediate period P-waves (10-25 s) generated by telesismic earthquakes. The second method, which is used in this paper, is based on the analysis of empirical green functions through the cross correlation of ambient noise data. However, synthetic methods can be used for removing misorientation which is computationally expensive. In this paper, we estimated misorientation of the sensors for IIEES and IRSC seismic networks using the method developed by Zha et al. (2013) based on ambient noise analysis. First, we assumed that station A has a misorientation ψ (Figure 1).

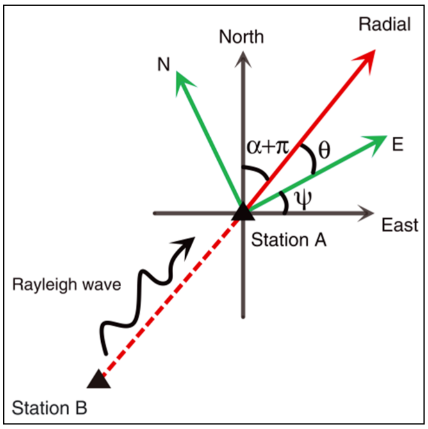

Figure 1. The coordinate systems used to calculate misorientation angle ψ for station A. α_{AB} is back azimuth from A to B. θ is correction angle to rotate E and N component to radial and transverse direction (Zha et al., 2013).

For this station, the stacked cross correlation functions (CCF) between the vertical components of all other stations (for example B) and the horizontal components of the station A are calculated and rotated by Equation 1 to construct the radial component (C_{RZ}):

$$\begin{pmatrix} C_{RZ} \\ C_{TZ} \end{pmatrix} = \begin{pmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{pmatrix} \begin{pmatrix} C_{EZ} \\ C_{NZ} \end{pmatrix}$$

where rotation angle θ is related to both back azimuth α_{AB} and misorientation ψ through the equation $\theta = \frac{\pi}{2} - (\alpha_{AB} + \pi) - \psi$ (Figure 1). Zha *et al.* (2013) showed that the sensor misorientations can be determined by maximizing the zero-lag cross correlation between the components C_{ZZ} and C_{RZ} of the CCFs by trying various misorientation angle ψ. So we have this angle between station A and every other stations. Finally, the average and standard deviation of the angle take into account for final misorientation angle and the uncertainty for station A. Figure 2 shows our results for 30 and 20 stations of IIESS and IRSC network, respectively with uncertainties less than 10 degrees.

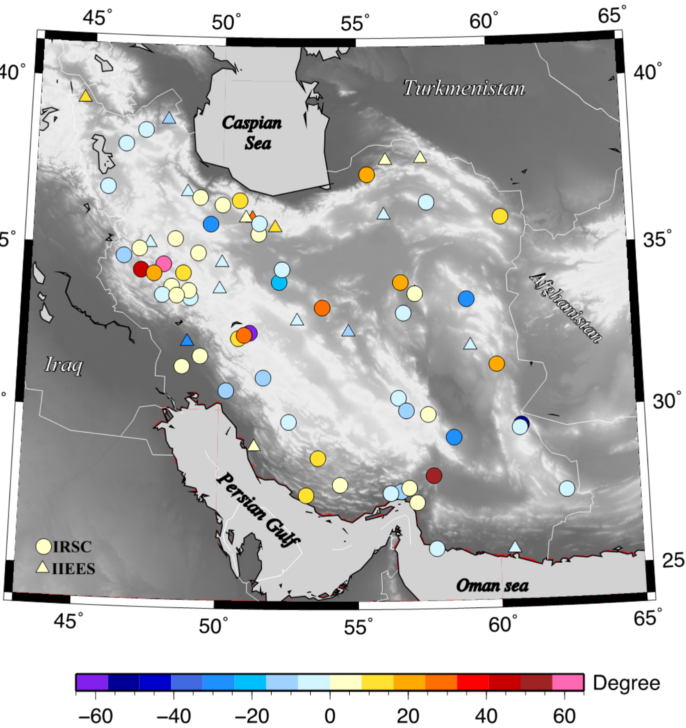

Figure 1. The misorientation angles for IIEES and IRSC stations. We only plotted the station with uncertainties less than 10 degree. The stations with higher misorientation angle have darker color.

REFERENCES

Wang, X., Chen, Q.F., Li, J., and Wei, S. (2016). Seismic Sensor Misorientation Measurement Using P-Wave Particle Motion: An Application to the NECsaids Array. *Seismological Research Letters, 87*, 901-911.

Zha, Y., Webb, S.C., and Menke, W. (2013). Determining the orientations of ocean bottom seismometers using ambient noise correlation. *Geophysical Research Letters, 40*, 3585-3590.