Seismic Anisotropy in Northwest Himalaya from core-mantle refracted shear (SKS) waves

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Supplementary Materials

A.Methodology:

A1. Defining the quality assessment term (Q):

X_1 = delay time from minimum energy method; X_2 = delay time from rotation correlation method

$X=X_1/X_2$;

Y_1 = fast axis from minimum energy method; Y_2 = fast axis from rotation correlation method

$Y=\text{modulo}(Y_1-Y_2,90)$, so $0<=Y<=89$
$Y=90-Y$; when $Y>45$
$Y=Y/45$; thus Y is scaled from 0 to 1.

$$M=\sqrt{X^2+(Y-1)^2}/\sqrt{(0.5)} \qquad N=\sqrt{(X-1)^2+Y^2}/\sqrt{(0.5)}$$

When $M<N$; $Q=-1X(1-M)$

When $M>N$;

$$Q=1X(1-N)$$

Thus Q ranges from -1 to 1; with -1 representing ideal null and 1 representing ideal non null cases.

A2. Converting the quality of non-null and null measurements to Q values

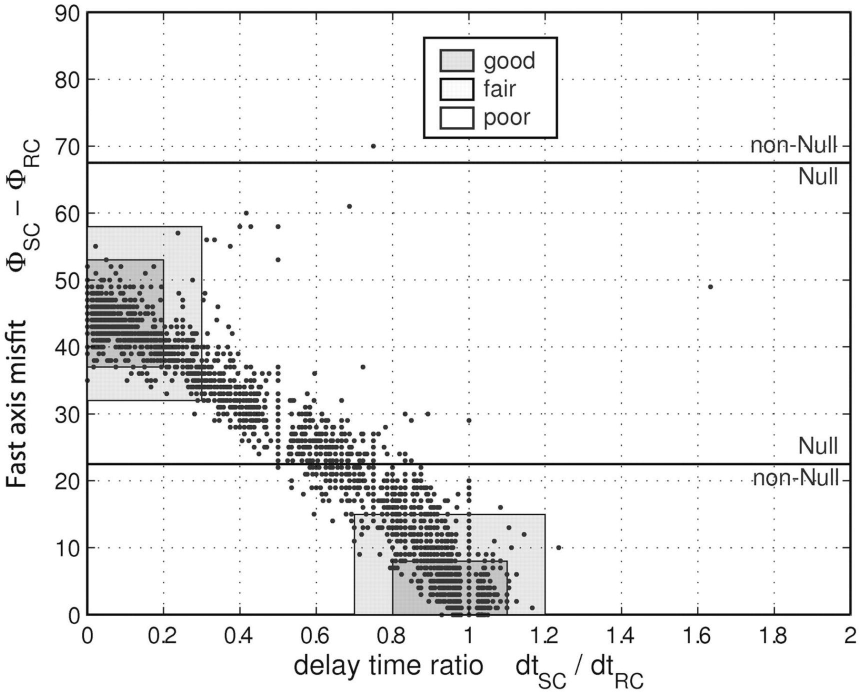


Fig. S1: Distribution of delay-time ratio and fast-axis estimates from the Rotation correlation and Minimum energy methods calculated for 3185 synthetic seismograms at five different SNR_R values between 3 and 30 and seven input delay times between 0 and 2 sec from all backazimuths. The Null criterion helps to identify Null measurements and at the same time gives a quality attribute.

Wuestefeld and Bokelmann, 2007

Following this graph, we have converted the fast axis misfit and delay time to Q values represented (using the equations mentioned) by the following table-

fast axis misfit $(Y_1 - Y_2)$	**delay time ratio(X)**	**Assesment**	**Q**
$Y_1 - Y_2 < 8$	$0.8 < X < 1.1$	Good Non-null	$Q > 0.7$
$Y_1 - Y_2 < 15$	$0.7 < X < 1.2$	Fair Non null	$0.4 < Q < 0.7$
$38 < Y_1 - Y_2 < 53$	$0 < X < 0.2$	Good null	$-1 <= Q < -0.7$
$32 < Y_1 - Y_2 < 58$	$0 < X < 0.3$	Fair null	$-0.7 <= Q < -0.4$

A3. Why is the Y value (difference of obtained phi values from both methods) scaled with the factor of 45?

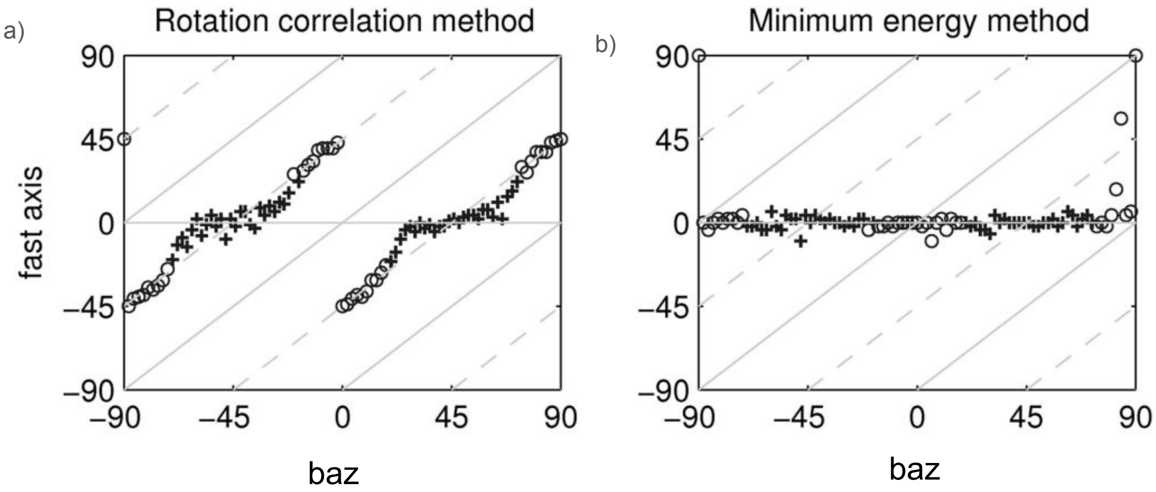
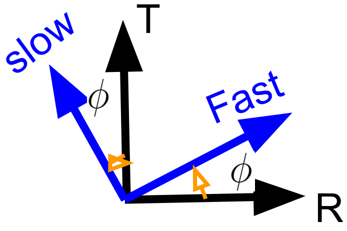


Fig. S2:Distribution of the fast axes obtained by a synthetic test (with input values of fast axis=0° , delay time=1.3s and SNR=15) through (a) rotation correlation and (b) minimum energy methods. Since the input fast axis is 0° thus backazimuth 0° (and ±90°) represent null directions. And near these null directions, there is a deviation of fast axes orientation of ±45°. Thus, the synthetic test shows that maximum difference between the fast axes obtained by these 2 methods are 45° and the minimum energy method appears stable across all back azimuth.

Wuestefeld and Bokelmann, 2007

A4. Why the rotation correlation method gives a fast axis that is off by ±45° at near null directions?



If the amplitude in Fast, slow, radial and transverse direction is denoted as F,S,R a.d T, respectively; and the angle between the fast axis and the radial direction is ϕ, then

$$F = R\cos(\theta) - T\sin(\theta); S = R\sin(\theta) + T\cos(\theta)$$

In near null condition there is negligible energy at the T component, thus both the F and S is identical with R with no time delay. F and S yield maximum cross correlation at θ=±45°, since in that case cos(θ)=sin(θ). And rotation correlation finds optimum splitting when the correlation between the horizontals are maximum.

B.Results

B1.Distribution of the splitting parameters for RAMN with respect to the backazimuth

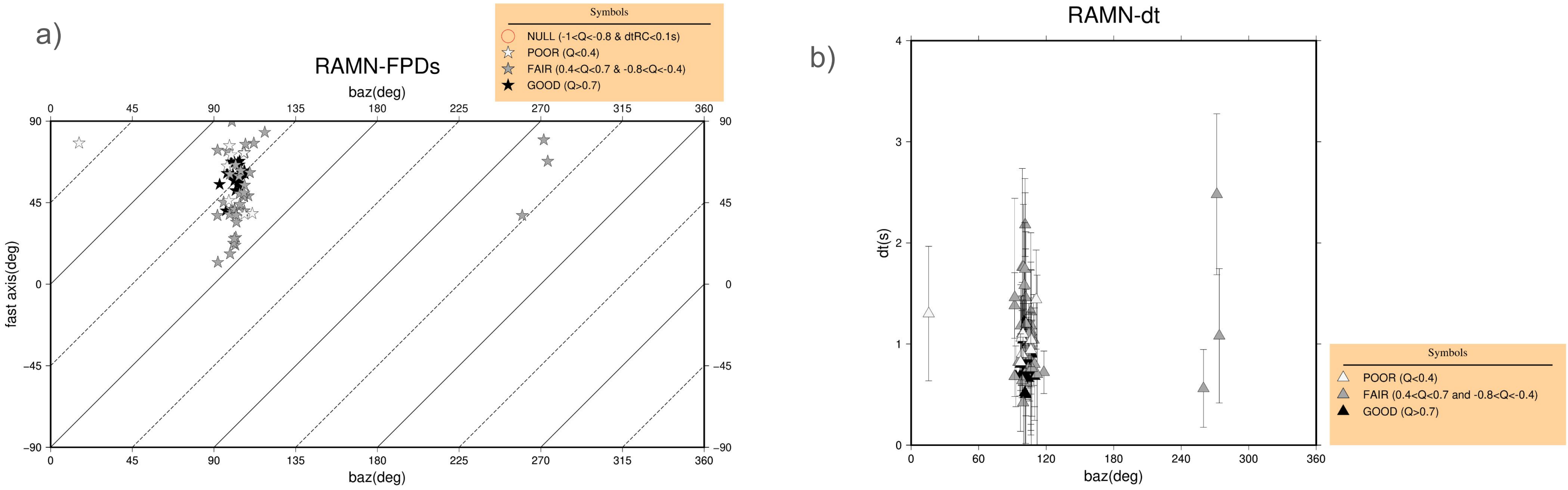


Fig. S3: (a)- Distribution of the fast axis orientation for all events recorded at the RAMN. The stars are color coded with the quality assessment term (Q). Black represents good, grey is fair and white is poor. The value of Q corresponding tho them being good, fair and poor are written at the top. Good means the splitting measurements obtained from the minimum energy and the rotation correlation method are similar while poor Q value represents their dissimilarity. (b) the non null delay times and their corresponding uncertainties are represented with the triangles and the error bars, respectively. The color code are the same as (a)

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