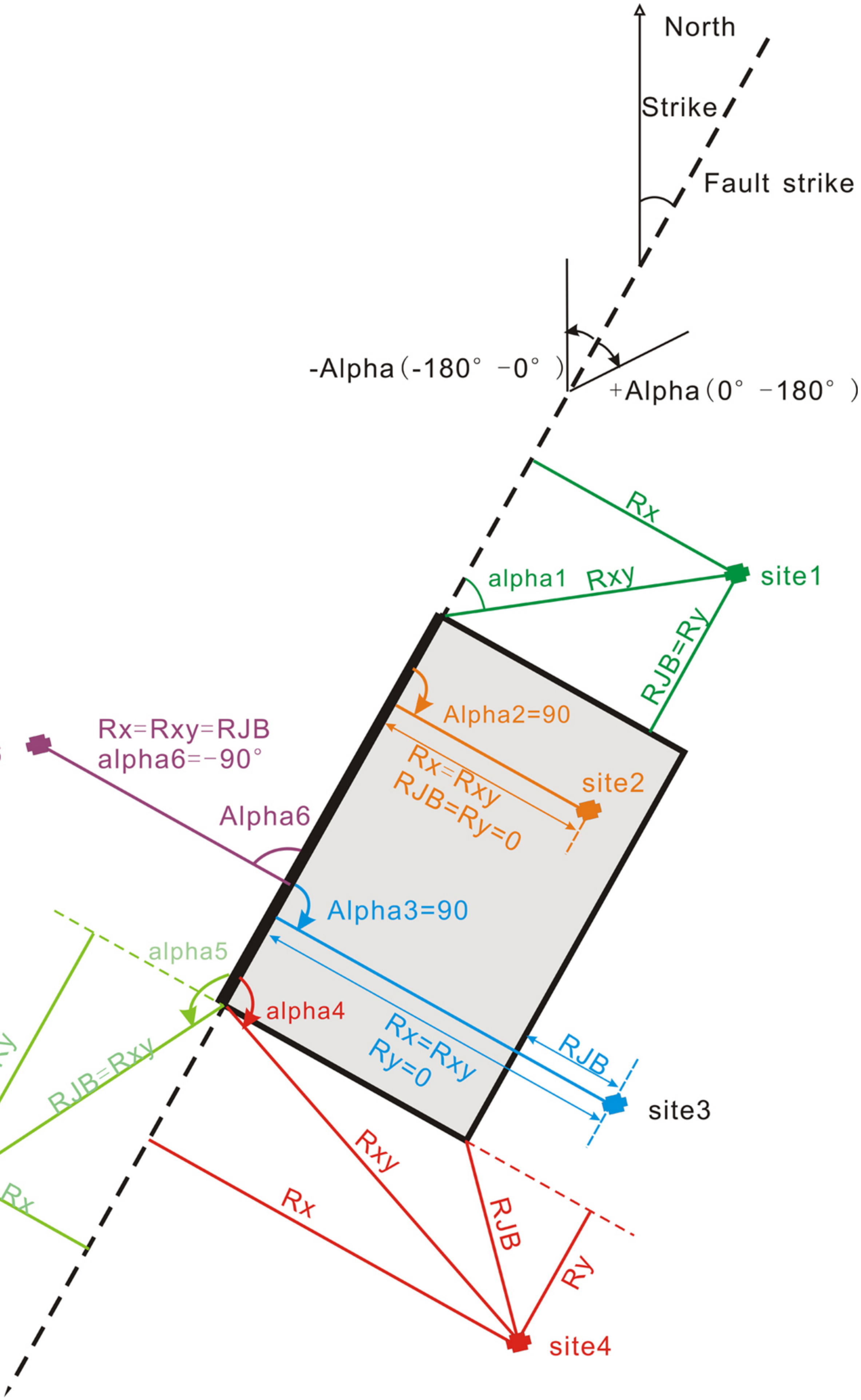
Physical equations for calculating fault-to-site distances used in NGA GMPEs based on earthquake source geometry

*xiaoliang zhang[1], yushan zhang[1]

1.China earthquake disaster prevention center

NGA GMPEs (NGA-West1, 2008 and NGA-West2, 2014) are beginning to be widely used in seismic hazard analyses. However, these new models are considerably more complicated than previous GMPEs, and they require several more input parameters. Users are faced with the challenge of estimating unknown input parameters when implementing NGA models.
In this paper, we are interested in fault-to-site distances parameter. Scherbaum *et al*. (2004) (termed “SSC04”) ever developed empirical expressions for converting source-to-site distance measures using simulated source geometries. The conversion equations are in the form of polynomial functions of M, R_{JB}, and style of faulting. Kaklamanos *et al*. (2011) (termed “KBB11”) derived physical equations relating the three distance measures (R_{JB}, R_{RUP}, and R_X) found in the NGA 2008 models using various geometric principles. KBB11 used the Joyner-Boore distance (R_{JB}) as the primary distance measure to compute other distances ($R_{RUP,}$ R_X) by characterizing the earthquake source by the geometric parameters down-dip rupture width *(W)*, depth-to-top of rupture (Z_{TOR}), fault dip (), and source-to-site azimuth (*alpha*). When R_X is also needed (as in the AS08 and CY08 models), KBB11 method is advantageous, because R_X cannot be estimated using the SSC04 relationships (because R_X had not yet been introduced as a distance measure in 2004). One other potential issue is that the SSC04 equations are technically only applicable for R_{JB}<100 km, whereas KBB2011 equations are physically derived and are applicable for any distance range at which the flat-earth assumption is valid (typically, several hundred kilometers).
KBB11 used the Joyner-Boore distance (R_{JB}) as the primary distance measure to compute other distances ($R_{RUP,}$ R_X). But in one situation R_{JB} is equal to zero, which means the site is located directly above the ruptured area; either R_X or R_{RUP} must be specified in order to calculate the third distance parameter using KBB11. In some other situations, when the fault trace and site location is known, we need to simulate the ground motion caused by different segment rupture of the whole entire fault. In these cases, the R_X and R_{XY} are easily measured by GIS tools but the R_{JB} is dependent on the down-dip rupture width *(W)*. In this paper we introduce a new distance measure R_{XY} (the closest distance from top of rupture) which is used to estimate source-to-site azimuth *alpha* (sin(*alpha)*= R_X/ R_{XY}) and R_Y (R_Y= R_{XY}·cos()). Based on KBB11 we derived distance equations using the R_X and R_{XY} to compute R_{JB}, R_{RUP}, R_X, and R_{Y0}.

Keywords: NGA GMPEs, source-to-site distances, RJB


North
Strike
Fault strike
-Alpha (-180° −0°)
+Alpha (0° −180°)
Rx
alpha1
Rxy
site1
RJB=Ry
Alpha2=90
Rx=Rxy
RJB=Ry=0
site2
site6
Rx=Rxy=RJB
alpha6=−90°
Alpha6
Alpha3=90
alpha5
alpha4
Rx=Rxy
Ry=0
RJB
site3
Ry
RJB=Rxy
site5
Rx
Rxy
Rx
RJB
Ry
site4

