Status of directivity study

NGA USGS REVIEW WORKSHIP

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Testing these nonpolarized predictors for various subsets of the data:

$$0 \quad (\textit{no directivity})$$

$$\ln(\tilde{c}')$$

$$\ln(\tilde{c}'\overline{D}), \quad \textit{where } \overline{D} = D \Big/ \sqrt{L^2 + W^2}$$

$$\ln(\tilde{c}'\overline{D}\left|\vec{R}\right|), \quad \textit{where } \left|\vec{R}\right| = \sqrt{R_{fn}^2 + R_{fp}^2}$$

$$X\cos(\theta)$$

$$Y\cos(\phi)$$

Goal is to develop a directivity correction that can be added to a developer's prediction

I fit a directivity predictor P_{rq} for record r and quake q to developer's intraevent residuals Y_{rq} to determine a coefficient s:

$$Y_{rq} = k_q + s\, P_{rq}$$

k_q are dummy "directivity event terms" for each quake

s is the desired slope of the relation

Then if G_{rq} is the observed ground motion and F_{rq} is the developer's prediction, we have

$$G_{rq} = F_{rq} + K + s\, P_{rq} + e_{rq}$$ (erq = error)

The K that minimizes the s.d of e_{rq} is

$$K = \text{mean}(G_{rq} - F_{rq} - s\, P_{rq})$$

We have

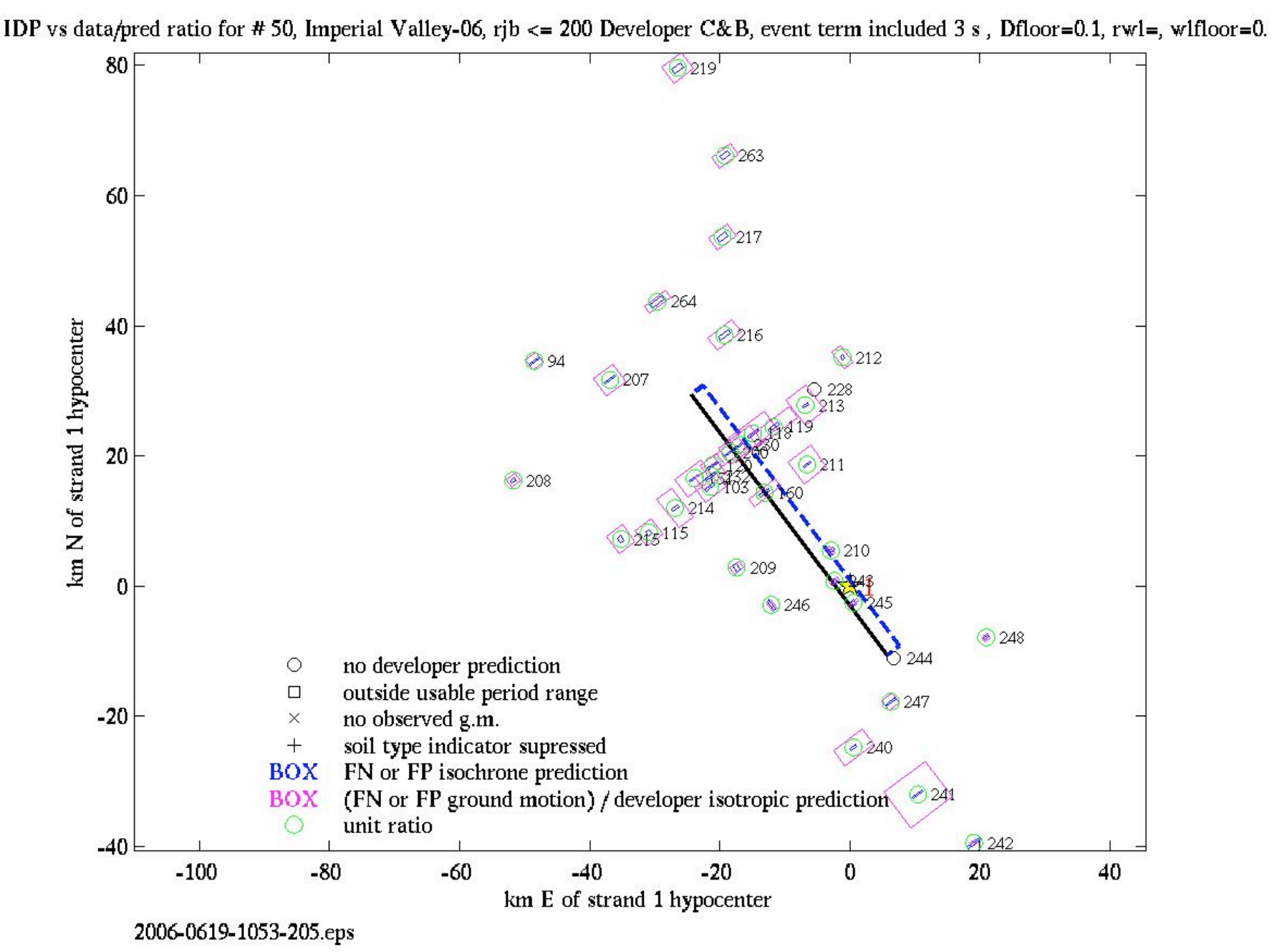
$G_{rq} = F_{rq} + K + s\,P_{rq} + e_{rq}$ (e_{rq} = error)

$e_{rq} = (G_{rq} - F_{rq}) - K - s\,P_{rq}$ = residual from directivity prediction

σ_e = standard deviation of e_{rq} for a particular directivity prediction

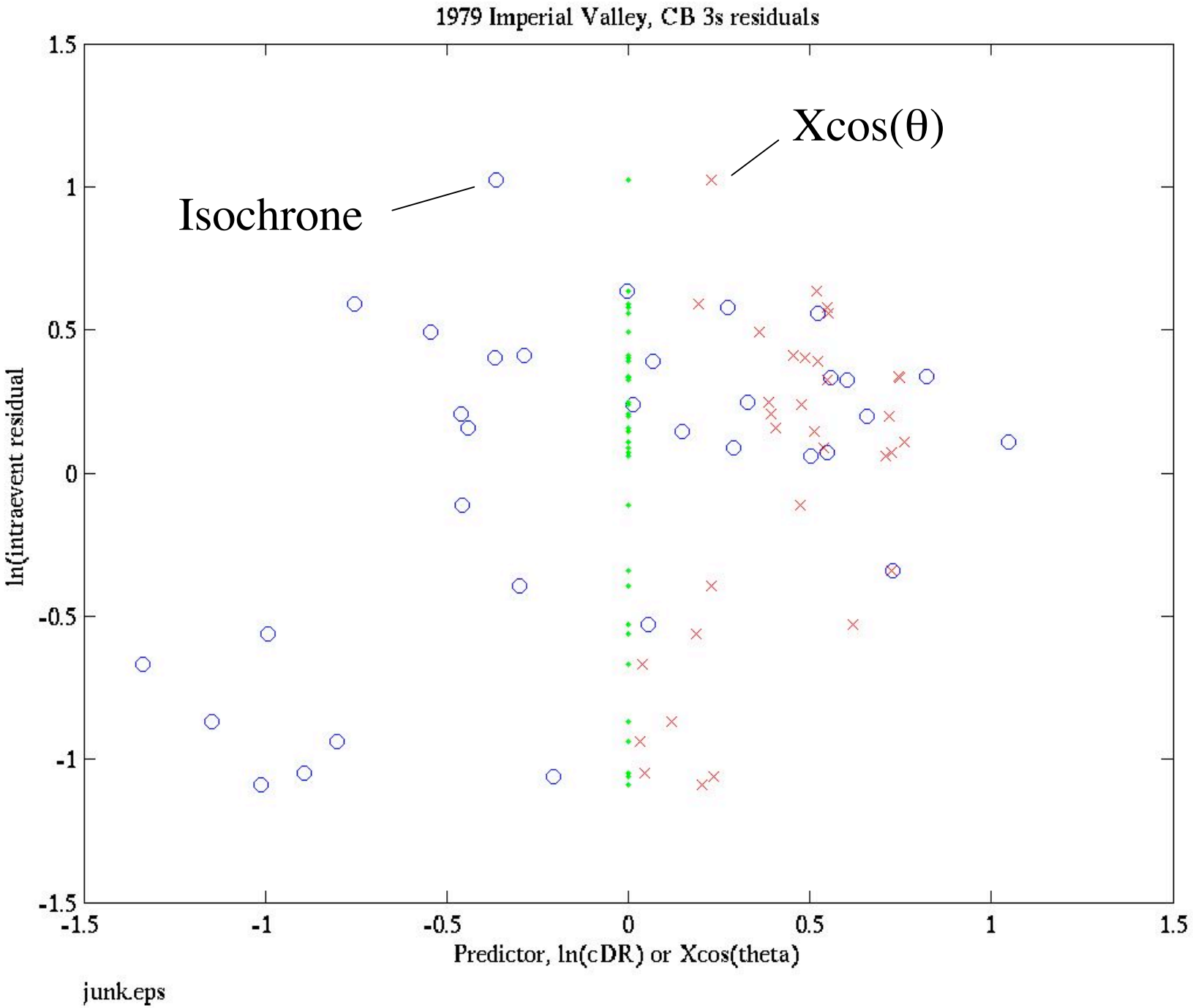
σ_o = standard deviation of e_{rq} for the null directivity prediction

I display $\sigma_e/\sigma_o - 1$


IDP vs data/pred ratio for # 50, Imperial Valley-06, rjb <= 200 Developer C&B, event term included 3 s , Dfloor=0.1, rwl=, wlfloor=0.
km N of strand 1 hypocenter
km E of strand 1 hypocenter
80
60
40
20
0
-20
-40
-100
-80
-60
-40
-20
0
20
40
219
263
217
264
216
212
94
207
228
213
119
118
120
211
208
103
160
214
115
210
209
246
245
248
244
247
240
241
242
no developer prediction
outside usable period range
no observed g.m.
soil type indicator supressed
BOX FN or FP isochrone prediction
BOX (FN or FP ground motion) / developer isotropic prediction
unit ratio
2006-0619-1053-205.eps

1979 Imperial Valley only, 0-60 km Rjb

BA		CB		CY		
1s	3s	1s	3s	1s	3s	
0	0	0	0	0	0	0
-0.0146	-0.0418	-0.0019	-0.0028	-0.0137	-0.0006	$\ln(\tilde{c}')$
-0.0007	-0.0718	-0.0002	-0.1131	-0.0025	-0.0740	$\ln(\tilde{c}'\overline{D})$
-0.0028	-0.0627	-0.0007	-0.1205	-0.0000	-0.0911	$\ln(\tilde{c}'\overline{D}\left\vert\vec{R}\right\vert)$
-0.0153	-0.0346	-0.0009	-0.1372	-0.0000	-0.1213	$X\cos(\theta)$
-0.0689	-0.0496	-0.0002	-0.0016	-0.0216	-0.0292	$Y\cos(\phi)$


1979 Imperial Valley, CB 3s residuals
Xcos(θ)
Isochrone
ln(intraevent residual
Predictor, ln(cDR) or Xcos(theta)
1.5
1
0.5
0
-0.5
-1
-1.5
junk.eps

Trying to reproduce Somerville et al results, using their earthquake list and rupture distance interval:

```
 6 % imperial 1940
12 % kern county
25 % parkfield 1966
30 % san fernando
41 % gazli
45 % santa barbara
46 % tabas
50 % imperial 1979
76 % coalinga
90 % morg hill
97 % nahanni
101 % north palm springs
113 % whittier
116 % sup hills 2
118 % loma prieta
125 % landers
127 % northridge
129 % kobe
```

all SS Somerville et al events, dip>70.5, 0-50 km Rrup

BA		CB		CY		
1s	3s	1s	3s	1s	3s	
0	0	0	0	0	0	0
-0.0099	0.0104	0.0052	0.0098	-0.0026	-0.0059	$\ln(\tilde{c}')$
-0.0103	0.0130	-0.0028	0.0159	-0.0007	0.0245	$\ln(\tilde{c}'\overline{D})$
-0.0069	0.0186	-0.0035	0.0201	-0.0024	0.0289	$\ln(\tilde{c}'\overline{D}\left\vert\vec{R}\right\vert)$
-0.0002	0.0272	-0.0001	0.0275	-0.0007	0.0348	$X\cos(\theta)$
-0.0429	-0.0252	-0.0003	0.0003	-0.0033	-0.0141	$Y\cos(\phi)$

Xcos(theta) does not fit Somerville earthquakes and NGA residuals!

Why doesn't Xcos(theta) work for Somerville's data set?

?? They fit interevent residuals with respect to Abrahamson and Silva (1997) predictions

I have not yet verified that I can get the same result if I use A&S97 predictions

First test, SS and DS events with good azimuthal coverage,
0 <= Rjb <= 200 km, developers BA, CB, CY, 1s, 3s

```
 30 % san fernando
48 % coyote lake
50 % imperial vy
68 % irp1
69 % irp2
73 % westmorland
90 % morg hill
101 % north palm springs
102 % chalfant 1
103 % chalfant 2
113 % wne
116 % sup hills 2
118 % loma prieta
125 % landers
127 % northridge
129 % kobe
136 % kocaeli
137 % chichi
138 % Duzce
144 % manjil
145 % Sierra madre
152 % little skull mtn
158 % hector
169 % Denali
```

all good events, SS and DS, 0-200 km Rjb

BA		CB		CY		
1s	3s	1s	3s	1s	3s	
0	0	0	0	0	0	0
0.0004	-0.0003	-0.0001	0.0025	-0.0026	-0.0013	$\ln(\tilde{c}')$
0.0079	0.0126	0.0045	0.0207	-0.0013	-0.0066	$\ln(\tilde{c}'\overline{D})$
0.0067	0.0112	0.0044	0.0209	-0.0005	-0.0081	$\ln(\tilde{c}'\overline{D}\lvert\vec{R}\rvert)$
-0.0019	-0.0023	-0.0056	-0.0022	0.0003	0.0097	$X\cos(\theta)$
-0.0005	0.0004	0.0012	0.0017	0.0028	0.0001	$Y\cos(\phi)$

No directivity model does well with NGA residuals for earthquakes having good azimuthal distribution.

all events dip<70.5 (DS), 0-200 km Rjb

BA		CB		CY		
1s	3s	1s	3s	1s	3s	
0	0	0	0	0	0	0
0.0024	-0.0110	0.0039	-0.0173	-0.0017	-0.0038	$\ln(\tilde{c}')$
0.0011	0.0077	0.0013	0.0132	0.0001	0.0213	$\ln(\tilde{c}'\overline{D})$
-0.0008	0.0075	-0.0004	0.0128	-0.0017	0.0223	$\ln(\tilde{c}'\overline{D}\lvert\vec{R}\rvert)$
0.0016	0.0038	-0.0021	0.0111	-0.0014	0.0249	$X\cos(\theta)$
0.0132	0.0233	0.0029	0.0130	0.0013	-0.0142	$Y\cos(\phi)$

all events dip>70.5 (SS) , 0-50 km Rjb

BA		CB		CY		
1s	3s	1s	3s	1s	3s	
0	0	0	0	0	0	0
-0.0033	0.0070	0.0007	0.0091	-0.0031	-0.0050	$\ln(\tilde{c}')$
-0.0097	-0.0004	-0.0054	0.0096	-0.0030	0.0214	$\ln(\tilde{c}'\overline{D})$
-0.0049	0.0070	-0.0048	0.0139	-0.0044	0.0251	$\ln(\tilde{c}'\overline{D}\left\vert\vec{R}\right\vert)$
-0.0007	0.0171	-0.0035	0.0213	-0.0035	0.0311	$X\cos(\theta)$
-0.0226	-0.0352	-0.0018	0.0000	0.0044	-0.0129	$Y\cos(\phi)$

Why does no directivity parameter work with NGA residuals I have chosen?

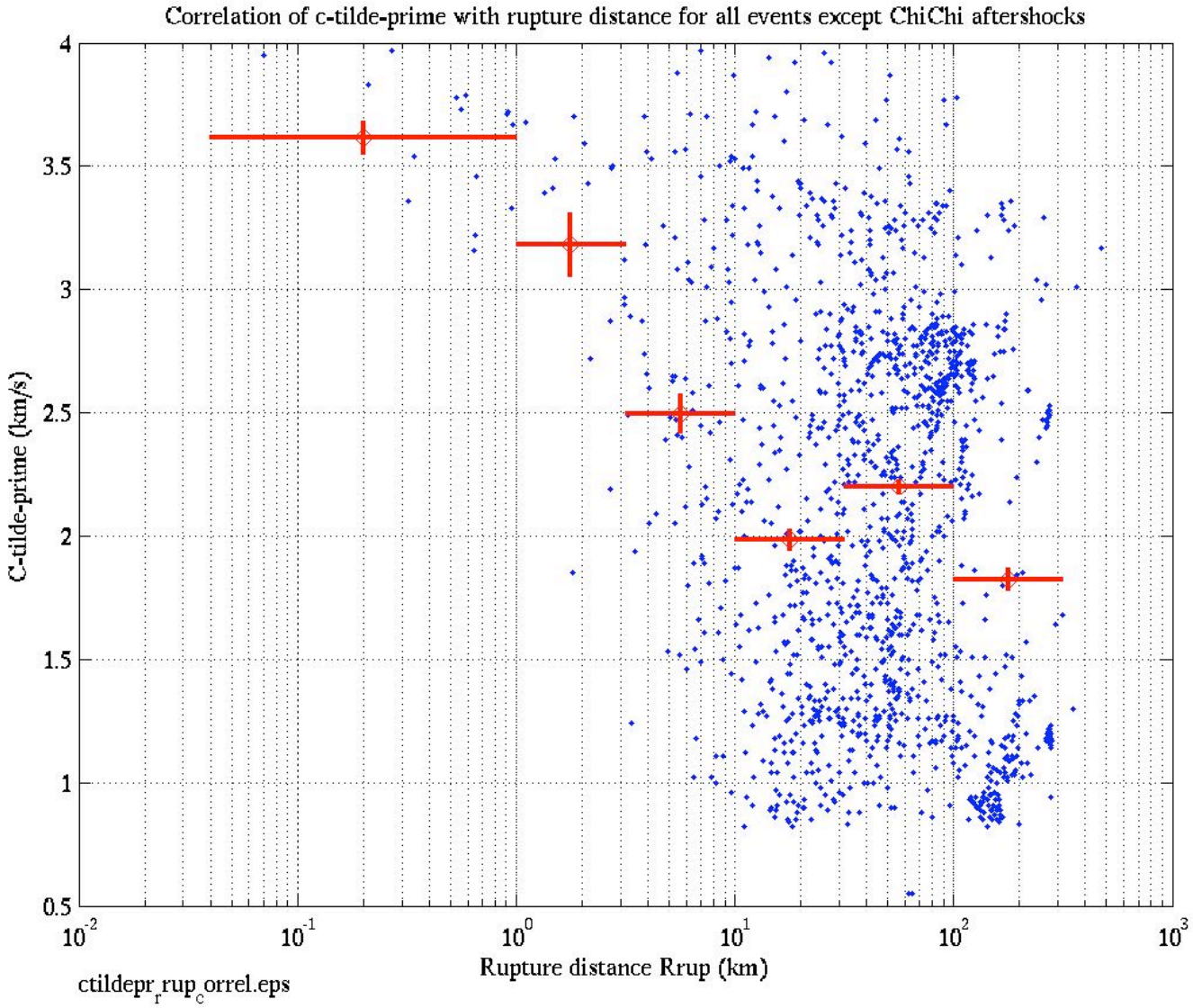
?? Maybe directivity only seen at large magnitude events ??

(I have not tried just large events. Easy to do.)

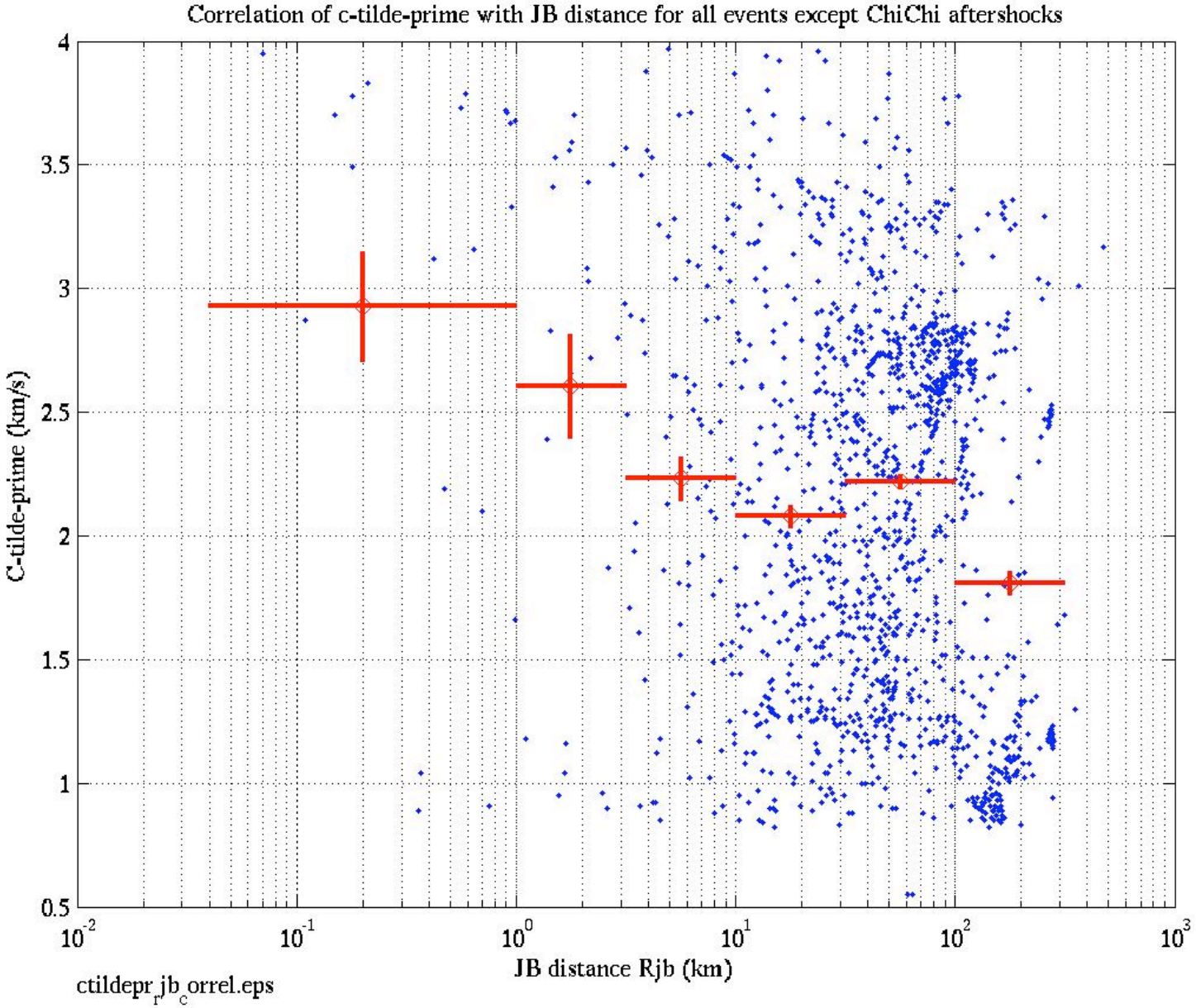
?? NGA developers' relations already fit a lot of the directivity that is near the fault??

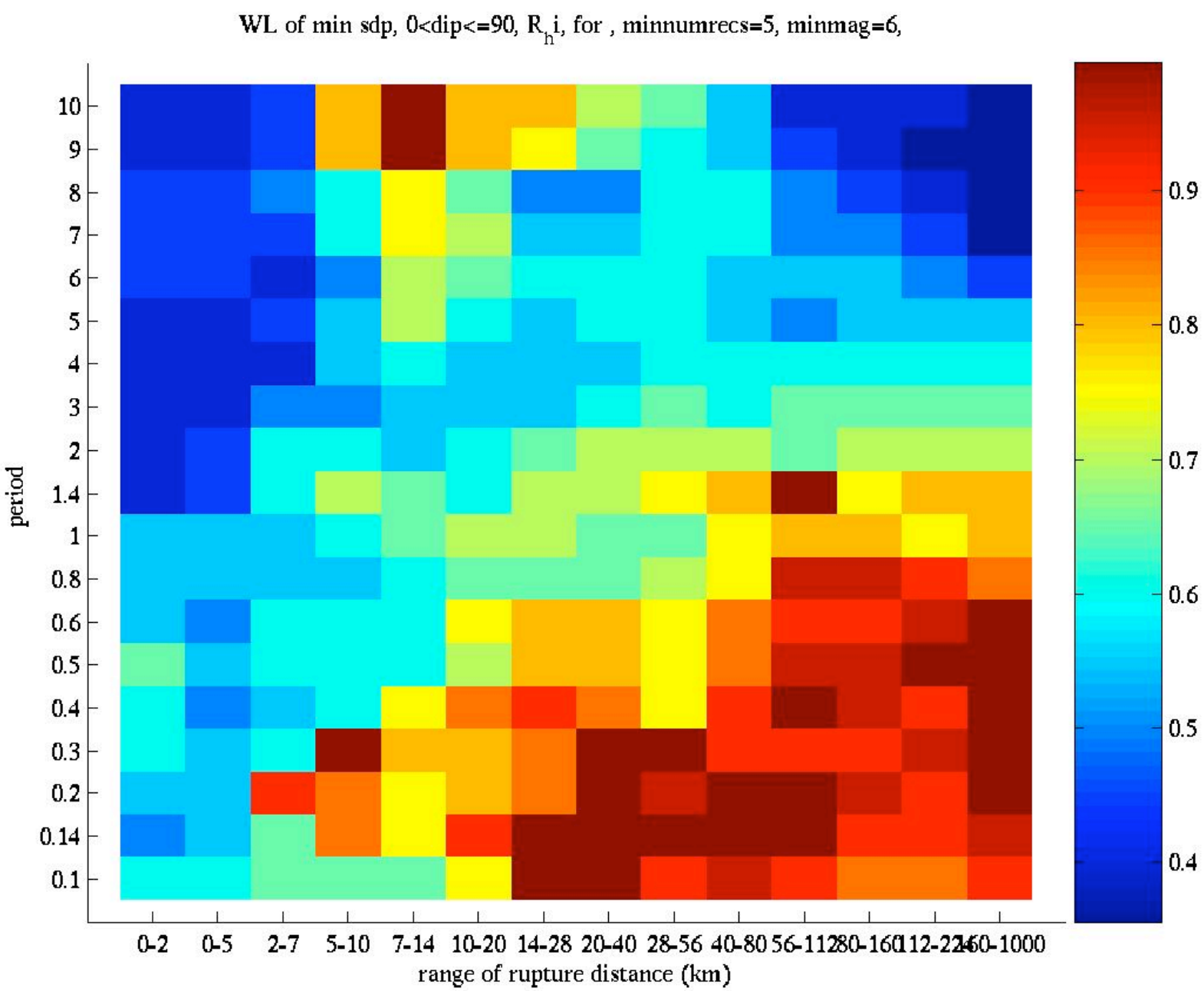
?? Result depends excessively on choice of small number of earthquakes ??

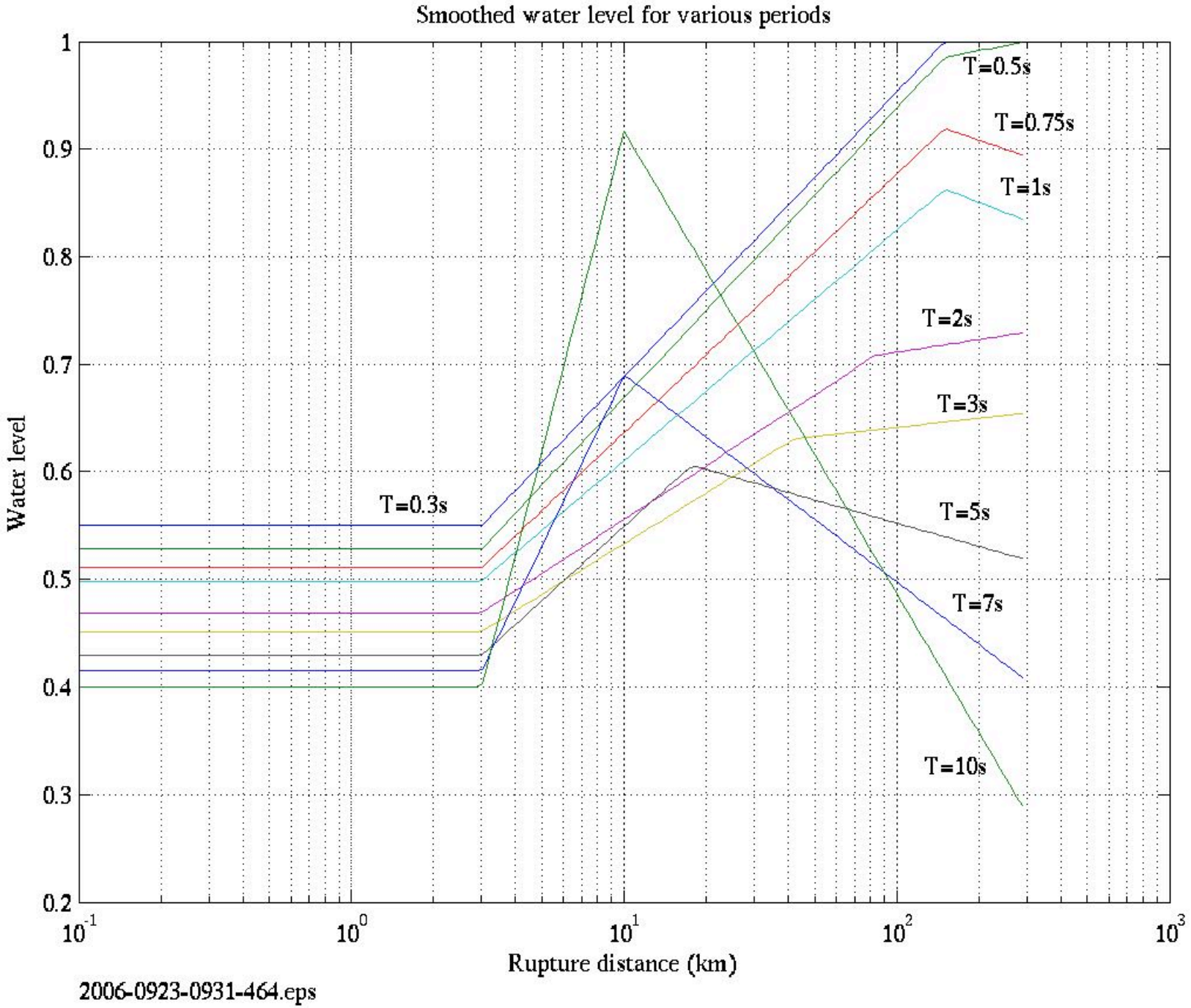
Correlation of c~' with Rrup



Correlation of c~' with Rjb




WL of min sdp, 0<dip<=90, R_h i, for , minnumrecs=5, minmag=6,
period
10
9
8
7
6
5
4
3
2
1.4
1
0.8
0.6
0.5
0.4
0.3
0.2
0.14
0.1
0.9
0.8
0.7
0.6
0.5
0.4
0-2
0-5
2-7
5-10
7-14
10-20
14-28
20-40
28-56
40-80
56-112
80-160
112-22
160-1000
range of rupture distance (km)
2006-0905-1513-265.eps



2006-0923-0931-464.eps

Surprising correlation of intraevent residual (CB here) with magnitude of the radiation pattern!