

1           **Rheologic**  
2           **con-**  
3           **straints**  
4           **on**  
5           **the**  
6           **up-**  
7           **per**  
8           **man-**  
9           **tle**  
10          **from**  
11          **five**  
12          **years**  
13          **of**  
14          **post-**  
15          **seis-**  
16          **mic**  
17          **de-**  
18          **for-**  
19          **ma-**  
20          **tion**  
21          **fol-**  
22          **low-**  
23          **ing**  
24          **the**  
25          **El**  
26          **Mayor-**  
27          **Cucapah**  
28          **earth-**  
29          **quake**

30           [fn]Department  
31          of  
32          Earth  
33          and  
34          En-  
35          vi-  
36          ron-  
37          men-  
38          tal

52       **Abstract**  
53       Five  
54       years  
55       of  
56       post-  
57       seis-  
58       mic  
59       de-  
60       for-  
61       ma-  
62       tion  
63       fol-  
64       low-  
65       ing  
66       the  
67       Mw7.2  
68       El  
69       Mayor-  
70       Cucapah  
71       earth-  
72       quake  
73       re-  
74       veals  
75       tran-  
76       sient  
77       de-  
78       for-  
79       ma-  
80       tion  
81       that  
82       de-  
83       cays  
84       back

85 to  
86 its  
87 pre-  
88 earthquake  
89 trend  
90 af-  
91 ter  
92 about  
93 3  
94 years  
95 at  
96 epi-  
97 cen-  
98 tral  
99 dis-  
100 tances  
101 greater  
102 than  
103 ~  
104 200  
105 km.  
106 In  
107 the  
108 near-  
109 field,  
110 we  
111 ob-  
112 serve  
113 rapid  
114 tran-  
115 sience  
116 that  
117 de-

118 cays  
119 to  
120 a  
121 sus-  
122 tained  
123 rate  
124 which  
125 ex-  
126 ceeds  
127 its  
128 pre-  
129 earthquake  
130 trend.  
131 We  
132 at-  
133 tempt  
134 to  
135 de-  
136 ter-  
137 mine  
138 the  
139 mech-  
140 a-  
141 nisms  
142 driv-  
143 ing  
144 this  
145 ob-  
146 served  
147 de-  
148 for-  
149 ma-  
150 tion,

151 where  
152 we  
153 con-  
154 sider  
155 af-  
156 ter-  
157 slip  
158 at  
159 seis-  
160 mo-  
161 genic  
162 depths  
163 and  
164 vis-  
165 coelas-  
166 tic  
167 re-  
168 lax-  
169 ation  
170 in  
171 the  
172 lower  
173 crust  
174 and  
175 up-  
176 per  
177 man-  
178 tle  
179 as  
180 can-  
181 di-  
182 date  
183 mech-

184 a-  
185 nisms.  
186 We  
187 find  
188 that  
189 early,  
190 rapid,  
191 near-  
192 field  
193 de-  
194 for-  
195 ma-  
196 tion  
197 can  
198 be  
199 ex-  
200 plained  
201 with  
202 af-  
203 ter-  
204 slip  
205 on  
206 the  
207 por-  
208 tion  
209 of  
210 the  
211 fault  
212 that  
213 rup-  
214 tured  
215 co-  
216 seis-

217 mi-  
218 cally,  
219 while  
220 the  
221 later,  
222 sus-  
223 tained,  
224 near-  
225 field  
226 de-  
227 for-  
228 ma-  
229 tion  
230 can  
231 be  
232 ex-  
233 plained  
234 with  
235 ei-  
236 ther  
237 con-  
238 tin-  
239 ued  
240 af-  
241 ter-  
242 slip  
243 in  
244 an  
245 ef-  
246 fec-  
247 tively  
248 elas-  
249 tic

250 lower  
251 crust,  
252 or  
253 lower  
254 crustal  
255 vis-  
256 coelas-  
257 tic  
258 re-  
259 lax-  
260 ation  
261 with  
262 a  
263 steady-  
264 state  
265 vis-  
266 COS-  
267 ity  
268 of  
269 ~  
270  $10^{19}$   
271 Pa  
272 S.  
273 The  
274 trend  
275 in  
276 far-  
277 field  
278 de-  
279 for-  
280 ma-  
281 tion  
282 is

283 best  
284 ex-  
285 plained  
286 with  
287 a  
288 tran-  
289 sient  
290 vis-  
291 cos-  
292 ity  
293 of  
294 ~  
295  $10^{18}$   
296 Pa  
297 S  
298 in  
299 the  
300 up-  
301 per  
302 man-  
303 tle.  
304 We  
305 ar-  
306 gue  
307 that  
308 a  
309 tran-  
310 sient  
311 rhe-  
312 ol-  
313 ogy  
314 in  
315 the

316 man-  
317 tle  
318 is  
319 prefer-  
320 able  
321 over  
322 a  
323 Maxwell  
324 rhe-  
325 ol-  
326 ogy  
327 be-  
328 cause  
329 it  
330 bet-  
331 ter  
332 pre-  
333 dicts  
334 the  
335 de-  
336 cay  
337 of  
338 the  
339 post-  
340 seis-  
341 mic  
342 de-  
343 for-  
344 ma-  
345 tion,  
346 and  
347 also  
348 be-

349 cause  
350 it  
351 does  
352 not  
353 con-  
354 flict  
355 with  
356 the  
357 gen-  
358 er-  
359 ally  
360 higher,  
361 steady-  
362 state  
363 vis-  
364 cosi-  
365 ties  
366 in-  
367 ferred  
368 from  
369 stud-  
370 ies  
371 of  
372 geo-  
373 phys-  
374 i-  
375 cal  
376 pro-  
377 cesses  
378 OC-  
379 cur-  
380 ring  
381 over

382 longer  
383 time-  
384 scales.

385

386 **1 Introduction**

387 Ground  
388 de-  
389 for-  
390 ma-  
391 tion  
392 in  
393 the  
394 years  
395 fol-  
396 low-  
397 ing  
398 a  
399 large  
400 ( $\gtrsim$ Mw7)  
401 earth-  
402 quake  
403 pro-  
404 vides  
405 in-  
406 sight  
407 into  
408 the  
409 me-  
410 chan-  
411 i-  
412 cal

413 be-  
414 haviour  
415 of  
416 the  
417 crust  
418 and  
419 up-  
420 per  
421 man-  
422 tle.  
423 It  
424 has  
425 long  
426 been  
427 rec-  
428 og-  
429 nized  
430 that  
431 in-  
432 ter-  
433 pre-  
434 ta-  
435 tions  
436 of  
437 post-  
438 seis-  
439 mic  
440 de-  
441 for-  
442 ma-  
443 tion  
444 can  
445 be

446 am-  
447 bigu-  
448 ous  
449 be-  
450 cause  
451 mul-  
452 ti-  
453 ple  
454 post-  
455 seis-  
456 mic  
457 de-  
458 for-  
459 ma-  
460 tion  
461 mech-  
462 a-  
463 nisms  
464 can  
465 have  
466 qual-  
467 i-  
468 ta-  
469 tively  
470 sim-  
471 i-  
472 lar  
473 sur-  
474 face  
475 ex-  
476 pres-  
477 sions  
478 ?,

479 e.g.] Savage1990.

480 Thanks

481 to

482 the

483 dense

484 geode-

485 tic

486 net-

487 work

488 de-

489 ployed

490 through-

491 out

492 the

493 2000s

494 as

495 part

496 of

497 the

498 Plate

499 Bound-

500 ary

501 Ob-

502 ser-

503 va-

504 tory,

505 the

506 April

507 4,

508 2010,

509 Mw7.2

510 El

511 Mayor-

512 Cucaphah  
513 earth-  
514 quake  
515 in  
516 Baja  
517 Cal-  
518 i-  
519 for-  
520 nia  
521 pro-  
522 duced  
523 ob-  
524 serv-  
525 able  
526 post-  
527 seis-  
528 mic  
529 de-  
530 for-  
531 ma-  
532 tion  
533 at  
534 more  
535 GPS  
536 sta-  
537 tions  
538 than  
539 any  
540 other  
541 earth-  
542 quake  
543 in  
544 Cal-

545 i-  
546 for-  
547 nia  
548 to  
549 date.  
550 With  
551 such  
552 a  
553 large  
554 col-  
555 lec-  
556 tion  
557 of  
558 data,  
559 we  
560 at-  
561 tempt  
562 to  
563 dis-  
564 cern  
565 the  
566 mech-  
567 a-  
568 nisms  
569 driv-  
570 ing  
571 post-  
572 seis-  
573 mic  
574 de-  
575 for-  
576 ma-  
577 tion

578 fol-  
579 low-  
580 ing  
581 the  
582 El  
583 Mayor-  
584 Cucapah  
585 earth-  
586 quake,  
587 where  
588 we  
589 con-  
590 sider  
591 both  
592 af-  
593 ter-  
594 slip  
595 and  
596 vis-  
597 coelas-  
598 tic  
599 re-  
600 lax-  
601 ation  
602 in  
603 the  
604 lower  
605 crust  
606 and  
607 up-  
608 per  
609 man-  
610 tle

611       as  
612       can-  
613       di-  
614       date  
615       mech-  
616       a-  
617       nisms.

618              Previous  
619       stud-  
620       ies  
621       which  
622       have  
623       mod-  
624       elled  
625       post-  
626       seis-  
627       mic  
628       de-  
629       for-  
630       ma-  
631       tion  
632       fol-  
633       low-  
634       ing  
635       the  
636       El  
637       Mayor-  
638       Cucapah  
639       earth-  
640       quake  
641       in-  
642       clude  
643       ?,

644 ]Pol-  
645 litz2012,  
646 ?,  
647 ]Gonzalez-  
648 ortega2014,  
649 ?,  
650 ]Spin-  
651 ler2015,  
652 and  
653 ?,  
654 ]Rollins2015.  
655 Of  
656 these  
657 stud-  
658 ies,  
659 ?,  
660 ]Gonzalez-  
661 ortega2014  
662 and  
663 ?,  
664 ]Rollins2015  
665 have  
666 at-  
667 tempted  
668 to  
669 de-  
670 scribe  
671 the  
672 post-  
673 seis-  
674 mic  
675 de-  
676 for-

677 ma-  
678 tion  
679 with  
680 af-  
681 ter-  
682 slip  
683 in  
684 an  
685 elas-  
686 tic  
687 half-  
688 space.  
689 ?,  
690 ]Gonzalez-  
691 ortega2014  
692 de-  
693 scribed  
694 five  
695 months  
696 of  
697 post-  
698 seis-  
699 mic  
700 de-  
701 for-  
702 ma-  
703 tion,  
704 ob-  
705 served  
706 by  
707 near-  
708 field  
709 ( $\lesssim$

710        50  
711        km  
712        from  
713        the  
714        rup-  
715        ture)  
716        cam-  
717        paign  
718        GPS  
719        and  
720        In-  
721        SAR,  
722        with  
723        af-  
724        ter-  
725        slip  
726        and  
727        con-  
728        trac-  
729        tion  
730        on  
731        the  
732        co-  
733        seis-  
734        mi-  
735        cally  
736        rup-  
737        tured  
738        fault.  
739        ?,  
740        ]Gonzalez-  
741        ortega2014  
742        noted

743 that  
744 their  
745 pre-  
746 fered  
747 model  
748 un-  
749 der-  
750 es-  
751 ti-  
752 mated  
753 the  
754 GPS  
755 dis-  
756 place-  
757 ments  
758 for  
759 sta-  
760 tions  
761  $\gtrsim$   
762 25  
763 km  
764 from  
765 the  
766 rup-  
767 ture  
768 and  
769 sug-  
770 gested  
771 that  
772 it  
773 could  
774 be  
775 the

776 re-  
777 sult  
778 of  
779 un-  
780 mod-  
781 elled  
782 vis-  
783 coelas-  
784 tic  
785 re-  
786 lax-  
787 ation.  
788 Us-  
789 ing  
790 con-  
791 tin-  
792 u-  
793 ous  
794 GPS  
795 sta-  
796 tions,  
797 which  
798 are  
799 mostly  
800 north  
801 of  
802 rup-  
803 ture  
804 zone,  
805 ?,  
806 ]Rollins2015  
807 found  
808 that

809 three  
810 years  
811 of  
812 post-  
813 seis-  
814 mic  
815 de-  
816 for-  
817 ma-  
818 tion  
819 can  
820 be  
821 ad-  
822 e-  
823 quately  
824 ex-  
825 plained  
826 by  
827 af-  
828 ter-  
829 slip,  
830 al-  
831 beit  
832 with  
833 an  
834 im-  
835 plau-  
836 si-  
837 bly  
838 large  
839 amount  
840 of  
841 slip

842 in-  
843 ferred  
844 on  
845 the  
846 least  
847 con-  
848 strained,  
849 southern-  
850 most  
851 fault  
852 seg-  
853 ment.  
854 Here,  
855 we  
856 sug-  
857 gest  
858 the  
859 af-  
860 ter-  
861 slip  
862 in-  
863 ferred  
864 by  
865 ?,  
866 ]Rollins2015  
867 may  
868 have  
869 been  
870 act-  
871 ing  
872 as  
873 a  
874 proxy

875 for  
876 dis-  
877 tributed  
878 re-  
879 lax-  
880 ation  
881 in  
882 the  
883 up-  
884 per  
885 man-  
886 tle.

887 ?,  
888 ]Pol-  
889 litz2012,  
890 ?,  
891 ]Rollins2015  
892 and  
893 ?,  
894 ]Spin-  
895 ler2015  
896 have  
897 ex-  
898 plored  
899 vis-  
900 coelas-  
901 tic  
902 re-  
903 lax-  
904 ation  
905 in  
906 the  
907 lower

908 crust  
909 and  
910 up-  
911 per  
912 man-  
913 tle  
914 as  
915 a  
916 po-  
917 ten-  
918 tial  
919 post-  
920 seis-  
921 mic  
922 de-  
923 for-  
924 ma-  
925 tion  
926 mech-  
927 a-  
928 nism.  
929 The  
930 rhe-  
931 ol-  
932 ogy  
933 of  
934 the  
935 crust  
936 and  
937 man-  
938 tle  
939 is  
940 largely

941 un-  
942 known  
943 and  
944 SO  
945 mod-  
946 elling  
947 post-  
948 seis-  
949 mic  
950 de-  
951 for-  
952 ma-  
953 tion  
954 with  
955 vis-  
956 coelas-  
957 tic  
958 re-  
959 lax-  
960 ation  
961 re-  
962 quires  
963 one  
964 to  
965 as-  
966 sume  
967 a  
968 rhe-  
969 o-  
970 logic  
971 model  
972 and  
973 then

974 find  
975 the  
976 best  
977 fit-  
978 ting  
979 rhe-  
980 O-  
981 logic  
982 pa-  
983 ram-  
984 e-  
985 ters.  
986 The  
987 in-  
988 fer-  
989 ence  
990 of  
991 these  
992 rhe-  
993 O-  
994 logic  
995 pa-  
996 ram-  
997 e-  
998 ters  
999 is  
1000 a  
1001 com-  
1002 pu-  
1003 ta-  
1004 tion-  
1005 ally  
1006 ex-

1007 pen-  
1008 sive  
1009 non-  
1010 linear  
1011 in-  
1012 verse  
1013 prob-  
1014 lem  
1015 which  
1016 is  
1017 typ-  
1018 i-  
1019 cally  
1020 ap-  
1021 proached  
1022 with  
1023 a  
1024 for-  
1025 ward  
1026 mod-  
1027 elling  
1028 grid  
1029 search  
1030 method.  
1031 Con-  
1032 se-  
1033 quently,  
1034 a  
1035 sim-  
1036 pli-  
1037 fied  
1038 struc-  
1039 ture

1040 for  
1041 the  
1042 litho-  
1043 sphere  
1044 must  
1045 be  
1046 made  
1047 to  
1048 min-  
1049 i-  
1050 mize  
1051 the  
1052 num-  
1053 ber  
1054 of  
1055 rhe-  
1056 O-  
1057 logic  
1058 pa-  
1059 ram-  
1060 e-  
1061 ters  
1062 that  
1063 need  
1064 to  
1065 be  
1066 es-  
1067 ti-  
1068 mated.  
1069 For  
1070 ex-  
1071 am-  
1072 ple,

1073 it  
1074 is  
1075 com-  
1076 monly  
1077 as-  
1078 sumed  
1079 that  
1080 the  
1081 litho-  
1082 sphere  
1083 con-  
1084 sists  
1085 of  
1086 only  
1087 three  
1088 ho-  
1089 mo-  
1090 ge-  
1091 neous,  
1092 Maxwell  
1093 vis-  
1094 coelas-  
1095 tic  
1096 lay-  
1097 ers,  
1098 which  
1099 may  
1100 be  
1101 an  
1102 in-  
1103 ad-  
1104 e-  
1105 quate

1106 rep-

1107 re-

1108 sen-

1109 ta-

1110 tion

1111 of

1112 the

1113 litho-

1114 sphere

1115 ?,

1116 ]Riva2009,Hines2013.

1117 To

1118 fur-

1119 ther

1120 re-

1121 duce

1122 the

1123 model

1124 space

1125 di-

1126 men-

1127 sions

1128 be-

1129 ing

1130 search,

1131 it

1132 is

1133 also

1134 nec-

1135 es-

1136 sary

1137 to

1138 make

1139 sim-  
1140 pli-  
1141 fy-  
1142 ing  
1143 as-  
1144 sump-  
1145 tions  
1146 about  
1147 the  
1148 na-  
1149 ture  
1150 of  
1151 af-  
1152 ter-  
1153 slip.  
1154 For  
1155 ex-  
1156 am-  
1157 ple,  
1158 one  
1159 can  
1160 as-  
1161 sume  
1162 a  
1163 fric-  
1164 tional  
1165 model  
1166 for  
1167 af-  
1168 ter-  
1169 slip  
1170 and  
1171 parametrize

1172 af-

1173 ter-

1174 slip

1175 in

1176 terms

1177 of

1178 the

1179 un-

1180 known

1181 rhe-

1182 O-

1183 logic

1184 prop-

1185 er-

1186 ties

1187 of

1188 the

1189 fault

1190 ?,  
e.g.] Johnson2009,Johnson2004.

1192 One

1193 can

1194 also

1195 as-

1196 sume

1197 that

1198 af-

1199 ter-

1200 slip

1201 does

1202 not

1203 per-

1204 sist

1205 for  
1206 more  
1207 than  
1208 a  
1209 few  
1210 months  
1211 and  
1212 then  
1213 model  
1214 the  
1215 later  
1216 post-  
1217 seis-  
1218 mic  
1219 de-  
1220 for-  
1221 ma-  
1222 tion  
1223 as-  
1224 sum-  
1225 ing  
1226 it  
1227 to  
1228 be  
1229 the  
1230 re-  
1231 sult  
1232 of  
1233 only  
1234 vis-  
1235 coelas-  
1236 tic  
1237 re-

1238 lax-  
1239 ation  
1240 ?,  
1241 e.g.] Pollitz2012, Spinler2015.  
1242 How-  
1243 ever,  
1244 post-  
1245 seis-  
1246 mic  
1247 af-  
1248 ter-  
1249 slip  
1250 in  
1251 sim-  
1252 i-  
1253 lar  
1254 tec-  
1255 tonic  
1256 set-  
1257 tings  
1258 has  
1259 been  
1260 ob-  
1261 served  
1262 to  
1263 per-  
1264 sist  
1265 for  
1266 decades  
1267 fol-  
1268 low-  
1269 ing  
1270 earth-

1271 quakes  
1272 ?,  
1273 ]Cakir2012,Cetin2014.  
1274 Ne-  
1275 glect-  
1276 ing  
1277 to  
1278 al-  
1279 low  
1280 for  
1281 sus-  
1282 tained  
1283 af-  
1284 ter-  
1285 slip  
1286 as  
1287 a  
1288 post-  
1289 seis-  
1290 mic  
1291 mech-  
1292 a-  
1293 nism  
1294 could  
1295 then  
1296 lead  
1297 to  
1298 a  
1299 bi-  
1300 ased  
1301 in-  
1302 fer-  
1303 ence

1304 of  
1305 litho-  
1306 spheric  
1307 vis-  
1308 COS-  
1309 ity.  
1310 In-  
1311 deed,  
1312 the  
1313 pre-  
1314 ferred  
1315 vis-  
1316 coelas-  
1317 tic  
1318 model  
1319 from  
1320 ?,  
1321 ]Pol-  
1322 litz2012  
1323 sig-  
1324 nif-  
1325 i-  
1326 cantly  
1327 un-  
1328 der-  
1329 es-  
1330 ti-  
1331 mates  
1332 near-  
1333 field  
1334 de-  
1335 for-  
1336 ma-

1337 tion,  
1338 which  
1339 could  
1340 be  
1341 in-  
1342 dica-  
1343 tive  
1344 of  
1345 un-  
1346 mod-  
1347 elled  
1348 con-  
1349 tin-  
1350 ued  
1351 af-  
1352 ter-  
1353 slip.

1354 In  
1355 this  
1356 study,  
1357 we  
1358 as-  
1359 sume  
1360 that  
1361 both  
1362 af-  
1363 ter-  
1364 slip  
1365 and  
1366 vis-  
1367 coelas-  
1368 tic  
1369 re-

1370 lax-  
1371 ation  
1372 can  
1373 con-  
1374 tribute  
1375 to  
1376 post-  
1377 seis-  
1378 mic  
1379 de-  
1380 for-  
1381 ma-  
1382 tion.  
1383 Mod-  
1384 elling  
1385 both  
1386 of  
1387 these  
1388 mech-  
1389 a-  
1390 nisms  
1391 cre-  
1392 ates  
1393 a  
1394 high  
1395 di-  
1396 men-  
1397 sional  
1398 model  
1399 space  
1400 that  
1401 must  
1402 be

1403        searched  
1404        with  
1405        non-  
1406        linear  
1407        op-  
1408        ti-  
1409        miza-  
1410        tion  
1411        meth-  
1412        ods.  
1413        We  
1414        first  
1415        de-  
1416        velop  
1417        an  
1418        ini-  
1419        tial  
1420        post-  
1421        seis-  
1422        mic  
1423        model  
1424        us-  
1425        ing  
1426        the  
1427        method  
1428        de-  
1429        scribed  
1430        in  
1431        ?,  
1432        ]Hines2016.  
1433        This  
1434        method  
1435        si-

1436 mul-  
1437 ta-  
1438 ne-  
1439 ously  
1440 es-  
1441 ti-  
1442 mate  
1443 the  
1444 af-  
1445 ter-  
1446 slip  
1447 and  
1448 ef-  
1449 fec-  
1450 tive  
1451 litho-  
1452 spheric  
1453 vis-  
1454 COS-  
1455 ity  
1456 struc-  
1457 ture  
1458 nec-  
1459 es-  
1460 sary  
1461 to  
1462 de-  
1463 scribe  
1464 the  
1465 first  
1466 0.8  
1467 years  
1468 of

1469 post-  
1470 seis-  
1471 mic  
1472 de-  
1473 for-  
1474 ma-  
1475 tion  
1476 fol-  
1477 low-  
1478 ing  
1479 the  
1480 El  
1481 Mayor-  
1482 Cucapah  
1483 earth-  
1484 quake.  
1485 We  
1486 then  
1487 use  
1488 the  
1489 in-  
1490 ferred  
1491 ef-  
1492 fec-  
1493 tive  
1494 vis-  
1495 COS-  
1496 ity  
1497 struc-  
1498 ture  
1499 to  
1500 cre-  
1501 ate

1502 a  
1503 suite  
1504 of  
1505 post-  
1506 seis-  
1507 mic  
1508 mod-  
1509 els  
1510 which  
1511 are  
1512 tested  
1513 against  
1514 the  
1515 avail-  
1516 able  
1517 5  
1518 years  
1519 of  
1520 post-  
1521 seis-  
1522 mic  
1523 data.  
1524 Of  
1525 the  
1526 suite  
1527 of  
1528 mod-  
1529 els  
1530 tested,  
1531 we  
1532 find  
1533 that  
1534 post-

1535 seis-  
1536 mic  
1537 de-  
1538 for-  
1539 ma-  
1540 tion  
1541 fol-  
1542 low-  
1543 ing  
1544 the  
1545 El  
1546 Mayor-  
1547 Cucapah  
1548 earth-  
1549 quake  
1550 can  
1551 be  
1552 ex-  
1553 plained  
1554 with  
1555 af-  
1556 ter-  
1557 slip  
1558 be-  
1559 neath  
1560 the  
1561 Sierra  
1562 Cu-  
1563 ca-  
1564 pah,  
1565 a  
1566 Zener  
1567 rhe-

1568 ol-  
1569 ogy  
1570 up-  
1571 per  
1572 man-  
1573 tle  
1574 with  
1575 a  
1576 tran-  
1577 sient  
1578 vis-  
1579 COS-  
1580 ity  
1581 that  
1582 de-  
1583 cays  
1584 from  
1585 5×  
1586  $10^{18}$   
1587 Pa  
1588 S  
1589 to  
1590 1×  
1591  $10^{18}$   
1592 Pa  
1593 S  
1594 at  
1595 120  
1596 km  
1597 depth,  
1598 and  
1599 a  
1600 rel-

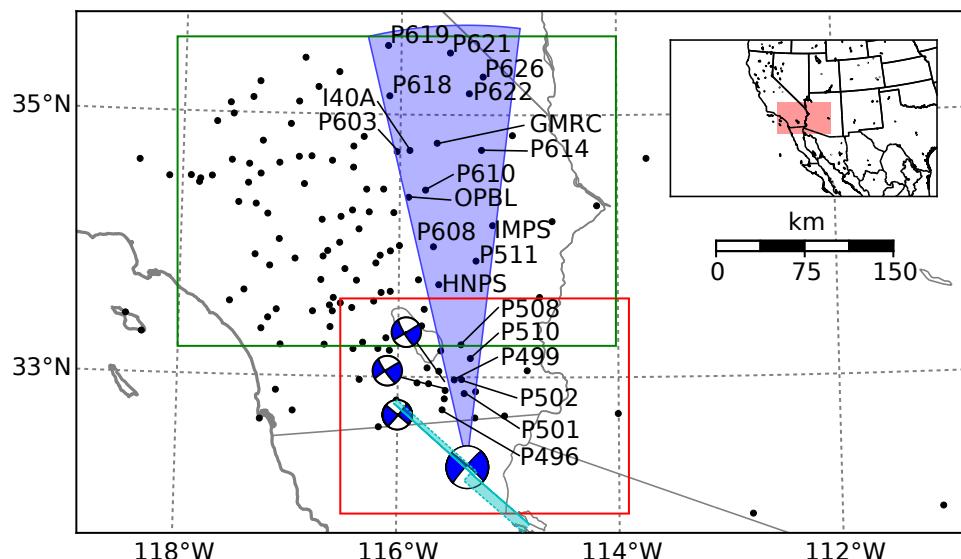
1601 a-  
1602 tively  
1603 stronger  
1604 lower  
1605 crust.

1763

## 2 Data Pro- cess- ing

We

use  
con-  
tin-  
u-  
ous  
GPS  
po-  
si-  
tion  
time  
se-  
ries  
pro-  
vided  
by  
Uni-  
ver-  
sity  
Navs-  
tar  
Con-  
sor-

**Figure 1.**

Map  
of  
the  
re-  
gion  
con-  
sid-  
ered  
in  
this  
study.

The  
large  
fo-  
cal  
mech-  
a-  
nism  
is  
for  
the  
El  
Mayor-  
Cucapah  
earth-  
quake  
and  
the  
three  
small  
fo-  
cal  
mech-  
-50-  
nisms

tium  
(UN-  
AVCO)  
for  
sta-  
tions  
within  
a  
400  
km  
ra-  
dius  
about  
the  
El  
Mayor-  
Cucapah  
epi-  
cen-  
tre.  
We  
col-  
lec-  
tively  
de-  
scribe  
the  
co-  
seis-  
mic  
and  
post-  
seis-

mic  
dis-  
place-  
ments  
re-  
sult-  
ing  
from  
the  
El  
Mayor-  
Cucapah  
earth-  
quake  
as  
 $u_{\text{post}}(t)$ .

We  
con-  
sider  
the  
GPS  
po-  
si-  
tion  
time  
se-  
ries,

$u_{\text{obs}}(t)$ ,  
to  
be  
the  
su-  
per-

po-  
si-  
tion  
of  
 $u_{\text{post}}(t)$ ,  
sec-  
u-  
lar  
tec-  
tonic  
de-  
for-  
ma-  
tion,  
an-  
nual  
and  
semi-  
annual  
os-  
cil-  
la-  
tions,  
and  
co-  
seis-  
mic  
off-  
sets  
from  
sig-  
nif-  
i-

cant  
earth-  
quakes  
over  
the  
time  
span  
of  
this  
study.

The  
June  
14,  
2010,  
Mw5.8

Ocotillo  
earth-  
quake  
and  
the  
Braw-

ley  
swarm,  
which  
in-  
cluded  
an  
Mw5.5

and  
an  
Mw5.3  
event  
on

Au-

gust

26,

2012,

(Fig-

ure

??)

are

the

only

earth-

quakes

that

pro-

duced

no-

tice-

able

dis-

place-

ments

in

any

of

the

time

se-

ries.

We

treat

the

dis-

place-

ments

re-

sult-

ing

from

the

Braw-

ley

swarm

as

a

sin-

gle

event

be-

cause

the

time

se-

ries

are

pro-

vided

by

UN-

AVCO

as

daily

so-

lu-

tions.

Al-

though

the  
Ocotillo  
earth-  
quake  
had  
its  
own  
se-  
ries  
of  
af-  
ter-  
shocks  
?,  
]Hauks-  
son2011,  
nei-  
ther  
the  
Ocotillo  
earth-  
quake  
nor  
the  
Braw-  
ley  
swarm  
pro-  
duced  
de-  
tectable  
post-  
seis-

mic  
de-  
for-  
ma-  
tion  
and  
we  
model  
dis-  
place-  
ments  
re-  
sult-  
ing  
from  
these  
events  
with  
a  
Heav-  
i-  
side  
func-  
tion,  
 $H(t)$ .  
We  
then  
model  
 $u_{\text{obs}}(t)$   
as

$$u_{\text{obs}}(t) = u_{\text{pred}}(t) + \epsilon \quad (1)$$

where

$$\begin{aligned}
 u_{\text{pred}}(t) = & u_{\text{post}}(t)H(t - t_{\text{emc}}) + c_0 + c_1 t + \\
 & c_2 \sin(2\pi t) + c_3 \cos(2\pi t) + c_4 \sin(4\pi t) + c_5 \cos(4\pi t) + \\
 & c_6 H(t - t_{\text{oc}}) + c_7 H(t - t_{\text{bs}}).
 \end{aligned} \tag{2}$$

1768 In  
 1769 the  
 1770 above  
 1771 equa-  
 1772 tions,  
 1773  $t_{\text{emc}}$ ,  
 1774  $t_{\text{oc}}$   
 1775 and  
 1776  $t_{\text{bs}}$   
 1777 are  
 1778 the  
 1779 times  
 1780 of  
 1781 the  
 1782 El  
 1783 Mayor-  
 1784 Cucapah  
 1785 earth-  
 1786 quake,  
 1787 Ocotillo  
 1788 earth-  
 1789 quake,  
 1790 and  
 1791 the  
 1792 Braw-  
 1793 ley  
 1794 swarm,  
 1795 re-

1796 spec-  
1797 tively,  
1798  $c_0$   
1799 through  
1800  $c_7$   
1801 are  
1802 un-  
1803 known  
1804 CO-  
1805 ef-  
1806 fi-  
1807 cients,  
1808 and  
1809  $\epsilon$   
1810 is  
1811 the  
1812 ob-  
1813 ser-  
1814 va-  
1815 tion  
1816 noise.  
1817 We  
1818 only  
1819 es-  
1820 ti-  
1821 mate  
1822 jumps  
1823 as-  
1824 SO-  
1825 ci-  
1826 ated  
1827 with  
1828 the

1829 Ocotillo  
1830 earth-  
1831 quake  
1832 and  
1833 Braw-  
1834 ley  
1835 swarm  
1836 for  
1837 sta-  
1838 tions  
1839 within  
1840 40  
1841 km  
1842 of  
1843 their  
1844 epi-  
1845 cen-  
1846 tres.

## 1847 Stations

1848 which  
1849 recorded  
1850 dis-  
1851 place-  
1852 ments  
1853 that  
1854 clearly  
1855 can-  
1856 not  
1857 be  
1858 de-  
1859 scribed  
1860 by  
1861 the

1862 afore-  
1863 men-  
1864 tioned  
1865 pro-  
1866 cesses  
1867 are  
1868 not  
1869 in-  
1870 cluded  
1871 in  
1872 our  
1873 anal-  
1874 y-  
1875 sis.  
1876 This  
1877 in-  
1878 cludes  
1879 sta-  
1880 tions  
1881 in  
1882 the  
1883 Los  
1884 An-  
1885 ge-  
1886 les  
1887 basin,  
1888 where  
1889 an-  
1890 thro-  
1891 pogenic  
1892 de-  
1893 for-  
1894 ma-

1895 tion  
1896 can  
1897 be  
1898 larger  
1899 than  
1900 the  
1901 post-  
1902 seis-  
1903 mic  
1904 sig-  
1905 nal  
1906 that  
1907 we  
1908 are  
1909 try-  
1910 ing  
1911 to  
1912 es-  
1913 ti-  
1914 mate  
1915 ?,  
1916 ]Baw-  
1917 den2001, Argus2005  
1918 .  
1919 In  
1920 or-  
1921 der  
1922 to  
1923 en-  
1924 sure  
1925 an  
1926 ac-  
1927 cu-

1928 rate  
1929 es-  
1930 ti-  
1931 ma-  
1932 tion  
1933 of  
1934 the  
1935 sec-  
1936 ul-  
1937 lar  
1938 de-  
1939 for-  
1940 ma-  
1941 tion,  
1942 we  
1943 only  
1944 use  
1945 sta-  
1946 tions  
1947 that  
1948 were  
1949 in-  
1950 stalled  
1951 at  
1952 least  
1953 six  
1954 months  
1955 prior  
1956 to  
1957 El  
1958 Mayor-  
1959 Cucapah  
1960 earth-

1961 quake.  
1962 Sev-  
1963 eral  
1964 GPS  
1965 sta-  
1966 tions  
1967 were  
1968 in-  
1969 stalled  
1970 af-  
1971 ter  
1972 the  
1973 El  
1974 Mayor-  
1975 Cucapah  
1976 earth-  
1977 quake  
1978 to  
1979 im-  
1980 prove  
1981 the  
1982 spa-  
1983 tial  
1984 res-  
1985 O-  
1986 lu-  
1987 tion  
1988 of  
1989 post-  
1990 seis-  
1991 mic  
1992 de-  
1993 for-

1994 ma-  
1995 tion  
1996 ?,  
1997 ]Spin-  
1998 ler2015  
1999 and  
2000 it  
2001 is  
2002 pos-  
2003 si-  
2004 ble  
2005 to  
2006 sub-  
2007 tract  
2008 sec-  
2009 u-  
2010 lar  
2011 ve-  
2012 loc-  
2013 i-  
2014 ties  
2015 de-  
2016 rived  
2017 from  
2018 elas-  
2019 tic  
2020 block  
2021 mod-  
2022 els  
2023 ?,  
2024 e.g.]Meade2005  
2025 from  
2026 ve-

2027 loc-  
2028 i-  
2029 ties  
2030 recorded  
2031 at  
2032 the  
2033 newly  
2034 in-  
2035 stalled  
2036 sta-  
2037 tions  
2038 to  
2039 get  
2040 an  
2041 es-  
2042 ti-  
2043 mate  
2044 of  
2045 post-  
2046 seis-  
2047 mic  
2048 ve-  
2049 loc-  
2050 i-  
2051 ties.  
2052 How-  
2053 ever,  
2054 we  
2055 use  
2056 co-  
2057 seis-  
2058 mic  
2059 and

2060 post-  
2061 seis-  
2062 mic  
2063 dis-  
2064 place-  
2065 ments,  
2066 rather  
2067 than  
2068 ve-  
2069 loc-  
2070 i-  
2071 ties,  
2072 in  
2073 our  
2074 in-  
2075 verse  
2076 method  
2077 de-  
2078 scribed  
2079 in  
2080 Sec-  
2081 tion  
2082 ??.  
2083 We  
2084 use  
2085 dis-  
2086 place-  
2087 ments  
2088 be-  
2089 cause  
2090 es-  
2091 ti-  
2092 mat-

2093 ing  
2094 ve-  
2095 loc-  
2096 i-  
2097 ties  
2098 from  
2099 an  
2100 al-  
2101 ready  
2102 noisy  
2103 dis-  
2104 place-  
2105 ment  
2106 time  
2107 se-  
2108 ries  
2109 can  
2110 in-  
2111 tro-  
2112 duce  
2113 sig-  
2114 nif-  
2115 i-  
2116 cant  
2117 aleatoric  
2118 and  
2119 epis-  
2120 temic  
2121 un-  
2122 cer-  
2123 tain-  
2124 ties  
2125 de-

2126 pend-  
2127 ing  
2128 on  
2129 ex-  
2130 actly  
2131 how  
2132 the  
2133 es-  
2134 ti-  
2135 ma-  
2136 tion  
2137 is  
2138 done.  
2139 This  
2140 mod-  
2141 elling  
2142 choice  
2143 pre-  
2144 vents  
2145 us  
2146 from  
2147 us-  
2148 ing  
2149 the  
2150 newly  
2151 in-  
2152 stalled  
2153 sta-  
2154 tions  
2155 in  
2156 Baja  
2157 Cal-  
2158 i-

2159 for-  
2160 nia  
2161 for  
2162 our  
2163 anal-  
2164 y-  
2165 sis.

2166 The

2167 Oc-  
2168 to-  
2169 ber  
2170 16,  
2171 1999,

2172 Mw7.1

2173 Hec-  
2174 tor  
2175 Mine  
2176 earth-  
2177 quake,  
2178 which

2179 OC-

2180 curred

2181 about

2182 270

2183 km

2184 north

2185 of

2186 the

2187 El

2188 Mayor-

2189 Cucapah

2190 epi-

2191 cen-

2192      tre,  
2193      pro-  
2194      duced  
2195      tran-  
2196      sient  
2197      post-  
2198      seis-  
2199      mic  
2200      de-  
2201      for-  
2202      ma-  
2203      tion  
2204      which  
2205      we  
2206      do  
2207      not  
2208      wish  
2209      to  
2210      model,  
2211      ei-  
2212      ther  
2213      me-  
2214      chan-  
2215      i-  
2216      cally  
2217      or  
2218      through  
2219      em-  
2220      pir-  
2221      i-  
2222      cal  
2223      line  
2224      fit-

2225 ting.  
2226 We  
2227 thus  
2228 re-  
2229 strict  
2230 our  
2231 anal-  
2232 y-  
2233 sis  
2234 to  
2235 de-  
2236 for-  
2237 ma-  
2238 tion  
2239 ob-  
2240 served  
2241 six  
2242 years  
2243 af-  
2244 ter  
2245 the  
2246 Hec-  
2247 tor  
2248 Mine  
2249 earth-  
2250 quake,  
2251 which  
2252 is  
2253 when  
2254 post-  
2255 seis-  
2256 mic  
2257 ve-

2258 loc-  
2259 i-  
2260 ties  
2261 at  
2262 sites  
2263 prox-  
2264 i-  
2265 mal  
2266 to  
2267 the  
2268 Hec-  
2269 tor  
2270 Mine  
2271 epi-  
2272 cen-  
2273 tre  
2274 are  
2275 ap-  
2276 prox-  
2277 i-  
2278 mately  
2279 CON-  
2280 stant  
2281 ?,  
2282 ]Sav-  
2283 age2009.  
2284 When  
2285 ap-  
2286 prais-  
2287 ing  
2288 our  
2289 model  
2290 fit

2291 in  
2292 Sec-  
2293 tion  
2294 ??,  
2295 we  
2296 see  
2297 some  
2298 sys-  
2299 tem-  
2300 atic  
2301 resid-  
2302 u-  
2303 als  
2304 in  
2305 the  
2306 vicin-  
2307 ity  
2308 of  
2309 the  
2310 Hec-  
2311 tor  
2312 Mine  
2313 epi-  
2314 cen-  
2315 tre,  
2316 which  
2317 may  
2318 be  
2319 the  
2320 re-  
2321 sult  
2322 of  
2323 er-

2324 rors  
2325 in  
2326 the  
2327 as-  
2328 sump-  
2329 tion  
2330 that  
2331 the  
2332 trend  
2333 in  
2334 Hec-  
2335 tor  
2336 Mine  
2337 post-  
2338 seis-  
2339 mic  
2340 de-  
2341 for-  
2342 ma-  
2343 tion  
2344 is  
2345 lin-  
2346 ear  
2347 af-  
2348 ter  
2349 six  
2350 years.

Studies

of  
post-  
seis-  
mic  
de-

for-  
ma-  
tion  
typ-  
i-  
cally  
as-  
sume  
a  
para-  
met-  
ric  
form  
for  
 $u_{\text{post}}(t)$ ,  
such  
as  
one  
with  
a  
log-  
a-  
rith-  
mic  
or  
ex-  
po-  
nen-  
tial  
time  
de-  
pen-  
dence

?,  
e.g.]Savage2005a.

How-

ever,

by

as-

sum-

ing

a

log-

a-

rith-

mic

or

ex-

po-

nen-

tial

form

of

$u_{\text{post}}(t)$

we

run

the

risk

of

over

fit-

ting

the

GPS

time

se-

ries  
and  
in-  
fer-  
ring  
a  
non-  
existent  
post-  
seis-  
mic  
sig-  
nal.  
  
We  
there-  
fore  
do  
not  
as-  
sume  
any  
para-  
met-  
ric  
form  
for  
 $u_{\text{post}}(t)$   
and  
rather  
treat  
it  
as  
in-

te-  
grated  
Brow-  
n-  
ian  
mo-  
tion,  
so  
that

$$\dot{u}_{\text{post}}(t) = \sigma^2 \int_0^t w(s) ds,$$

(3)

where  
 $w(t)$   
is  
white  
noise  
and  
the  
vari-  
ance  
of

$\dot{u}_{\text{post}}(t)$   
in-  
creases  
lin-  
early  
with  
time  
by  
a  
fac-  
tor  
of

$\sigma^2$ .

We

use

a

Kalman

fil-

ter-

ing

ap-

proach

to

es-

ti-

mate

$u_{\text{post}}(t)$

and

the

un-

known

pa-

ram-

e-

ters

in

eq.

(??).

In

the

con-

text

of

Kalman

fil-

ter-  
ing,  
our  
time  
vary-  
ing  
state  
vec-  
tor  
is

$$\mathbf{X}(t) = [u_{\text{post}}(t), \dot{u}_{\text{post}}(t), c_0, \dots, c_7]$$

(4)

2351 and  
2352 eq.  
2353 (??)  
2354 is  
2355 the  
2356 ob-  
2357 ser-  
2358 va-  
2359 tion  
2360 func-  
2361 tion  
2362 which  
2363 maps  
2364 the  
2365 state  
2366 vec-  
2367 tor  
2368 to  
2369 the  
2370 GPS  
2371 ob-

2372 ser-  
2373 va-  
2374 tions.  
2375 We  
2376 ini-  
2377 ti-  
2378 ate  
2379 the  
2380 Kalman  
2381 fil-  
2382 ter  
2383 by  
2384 as-  
2385 sum-  
2386 ing  
2387 a  
2388 prior  
2389 es-  
2390 ti-  
2391 mate  
2392 of  
2393  $\mathbf{X}(t)$   
2394 at  
2395 the  
2396 first  
2397 time  
2398 epoch,  
2399 de-  
2400 noted  
2401  $\mathbf{X}_{1|0}$ ,  
2402 which  
2403 has  
2404 a

2405 suf-  
2406 fi-  
2407 ciently  
2408 large  
2409 CO-  
2410 vari-  
2411 ance,  
2412 de-  
2413 noted  
2414  $\Sigma_{1|0}$ ,  
2415 to  
2416 ef-  
2417 fec-  
2418 tively  
2419 make  
2420 our  
2421 prior  
2422 un-  
2423 in-  
2424 formed.  
2425 For  
2426 each  
2427 time  
2428 epoch,  
2429  $t_i$ ,  
2430 Bayesian  
2431 lin-  
2432 ear  
2433 re-  
2434 gres-  
2435 sion  
2436 is  
2437 used

2438 to  
2439 in-  
2440 cor-  
2441 po-  
2442 rate  
2443 GPS  
2444 de-  
2445 rived  
2446 es-  
2447 ti-  
2448 mates  
2449 of  
2450 dis-  
2451 place-  
2452 ment  
2453 with  
2454 our  
2455 prior  
2456 es-  
2457 ti-  
2458 mate  
2459 of  
2460 the  
2461 state,  
2462  $\mathbf{X}_{i|i-1}$ ,  
2463 to  
2464 form  
2465 a  
2466 pos-  
2467 te-  
2468 rior  
2469 es-  
2470 ti-

2471 mate  
2472 of  
2473 the  
2474 state,  
2475  $\mathbf{X}_{i|i}$ ,  
2476 which  
2477 has  
2478 co-  
2479 vari-  
2480 ance  
2481  $\Sigma_{i|i}$ .

We

then

use

the

pos-

te-

rior

es-

ti-

mate

of

the

state

at

time

$t_i$

to

form

a

prior

es-

ti-

mate  
 of  
 the  
 state  
 at  
 time  
 $t_{i+1}$   
 through  
 the  
 tran-  
 si-  
 tion  
 func-  
 tion

$$\mathbf{X}_{i+1|i} = \mathbf{F}_{i+1} \mathbf{X}_{i|i} + \delta_{i+1}$$

(5)

where

$$(6) \quad \mathbf{F}_{i+1} = \begin{bmatrix} 1 & (t_{i+1} - t_i) & \mathbf{0} \\ 0 & 1 & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{I} \end{bmatrix}$$

and

 $\delta_{i+1}$ 

is

the

pro-

cess

noise,

which

has

zero

mean

and

co-

vari-  
ance  
de-  
scribed  
by

$$\mathbf{Q}_{i+1} = \sigma^2 \begin{bmatrix} \frac{(t_{i+1}-t_i)^3}{3} & \frac{(t_{i+1}-t_i)^2}{2} & \mathbf{0} \\ \frac{(t_{i+1}-t_i)^2}{2} & (t_{i+1} - t_i) & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} \end{bmatrix}. \quad (7)$$

The

co-  
vari-  
ance  
of  
the  
new  
prior  
state,  
 $\mathbf{X}_{i+1|i}$ ,  
is  
then  
de-  
scribed  
by

$$\Sigma_{i+1|i} = \mathbf{F}_{i+1} \Sigma_{i|i} \mathbf{F}_{i+1}^T + \mathbf{Q}_{i+1}.$$

(8)

2482            This  
2483        pro-  
2484        cess  
2485        is  
2486        re-  
2487        peated  
2488        for

2489 each  
2490 of  
2491 the  
2492  $N$   
2493 time  
2494 epochs  
2495 at  
2496 which  
2497 point  
2498 we  
2499 use  
2500 Rauch-  
2501 Tung-  
2502 Striebel  
2503 smooth-  
2504 ing  
2505 ?,  
2506 ]Rauch1965  
2507 to  
2508 find  
2509  $\mathbf{X}_{i|N}$ ,  
2510 which  
2511 is  
2512 an  
2513 es-  
2514 ti-  
2515 mate  
2516 of  
2517 the  
2518 state  
2519 at  
2520 time  
2521  $t_i$

2522 that  
2523 in-  
2524 cor-  
2525 po-  
2526 rates  
2527 GPS  
2528 ob-  
2529 ser-  
2530 va-  
2531 tion  
2532 for  
2533 all  
2534  $N$   
2535 time  
2536 epochs.  
2537 Our  
2538 fi-  
2539 nal  
2540 es-  
2541 ti-  
2542 mates  
2543 of  
2544  $u_{\text{post}}(t)$   
2545 are  
2546 used  
2547 in  
2548 sub-  
2549 se-  
2550 quent  
2551 anal-  
2552 y-  
2553 sis,  
2554 while

2555 the  
2556 re-  
2557 main-  
2558 ing  
2559 com-  
2560 po-  
2561 nents  
2562 of  
2563 the  
2564 state  
2565 vec-  
2566 tor  
2567 are  
2568 con-  
2569 sid-  
2570 ered  
2571 nui-  
2572 sance  
2573 pa-  
2574 ram-  
2575 e-  
2576 ters.  
2577 In  
2578 the  
2579 in-  
2580 ter-  
2581 ests  
2582 of  
2583 com-  
2584 pu-  
2585 ta-  
2586 tional  
2587 tractabil-

2588       ity,  
2589       we  
2590       down  
2591       sam-  
2592       ple  
2593       our  
2594       smoothed  
2595       time  
2596       se-  
2597       ries  
2598       from  
2599       daily  
2600       SO-  
2601       lu-  
2602       tions  
2603       down  
2604       to  
2605       weekly  
2606       SO-  
2607       lu-  
2608       tions.

2609           The  
2610       smooth-  
2611       ness  
2612       of  
2613        $u_{\text{post}}(t)$   
2614       is  
2615       con-  
2616       trolled  
2617       by  
2618       the  
2619       cho-  
2620       sen

2621 value  
2622 of  
2623  $\sigma^2$ ,  
2624 which  
2625 de-  
2626 scribes  
2627 how  
2628 rapidly  
2629 we  
2630 ex-  
2631 pect  
2632 post-  
2633 seis-  
2634 mic  
2635 dis-  
2636 place-  
2637 ments  
2638 to  
2639 vary  
2640 over  
2641 time.  
2642 Set-  
2643 ting  
2644  $\sigma^2$   
2645 equal  
2646 to  
2647 zero  
2648 will  
2649 ef-  
2650 fec-  
2651 tively  
2652 re-  
2653 sult

2654 in  
2655 mod-  
2656 elling  
2657  $u_{\text{post}}(t)$   
2658 as  
2659 a  
2660 straight  
2661 line  
2662 which  
2663 is  
2664 in-  
2665 suf-  
2666 fi-  
2667 cient  
2668 to  
2669 de-  
2670 scribe  
2671 the  
2672 ex-  
2673 pected  
2674 tran-  
2675 sient  
2676 be-  
2677 haviour  
2678 in  
2679 post-  
2680 seis-  
2681 mic  
2682 de-  
2683 for-  
2684 ma-  
2685 tion.  
2686 The

2687 other  
2688 end  
2689 mem-  
2690 ber,  
2691 where  
2692  $\sigma^2$   
2693 is  
2694 in-  
2695 finitely  
2696 large,  
2697 will  
2698 re-  
2699 sult  
2700 in  
2701  $u_{\text{pred}}(t)$   
2702 over  
2703 fit-  
2704 ting  
2705 the  
2706 data.  
2707 While  
2708 one  
2709 can  
2710 use  
2711 a  
2712 max-  
2713 i-  
2714 mum  
2715 like-  
2716 li-  
2717 hood  
2718 based  
2719 ap-

2720 proach  
2721 for  
2722 pick-  
2723 ing  
2724  $\sigma^2$   
2725 ?,  
2726 e.g.] Segall 1997,  
2727 we  
2728 rather  
2729 take  
2730 a  
2731 sub-  
2732 jec-  
2733 tive  
2734 ap-  
2735 proach  
2736 and  
2737 choose  
2738 a  
2739 value  
2740 for  
2741  $\sigma^2$   
2742 that  
2743 is  
2744 just  
2745 large  
2746 enough  
2747 to  
2748 faith-  
2749 fully  
2750 de-  
2751 scribe  
2752 the

2753 ob-  
2754 served  
2755 de-  
2756 for-  
2757 ma-  
2758 tion  
2759 at  
2760 the  
2761 most  
2762 near-  
2763 field  
2764 sta-  
2765 tion  
2766 in  
2767 our  
2768 study,  
2769 P496,  
2770 which  
2771 ex-  
2772 hibits  
2773 the  
2774 most  
2775 pro-  
2776 nounced  
2777 rapid  
2778 changes  
2779 in  
2780 ve-  
2781 loc-  
2782 ity.  
2783 This  
2784 en-  
2785 sures

2786 that  
2787  $\sigma^2$   
2788 will  
2789 be  
2790 suf-  
2791 fi-  
2792 ciently  
2793 large  
2794 SO  
2795 that  
2796 our  
2797 es-  
2798 ti-  
2799 mate  
2800 of  
2801  $u_{\text{post}}(t)$   
2802 does  
2803 not  
2804 smooth  
2805 out  
2806 po-  
2807 ten-  
2808 tially  
2809 valu-  
2810 able  
2811 post-  
2812 seis-  
2813 mic  
2814 sig-  
2815 nal  
2816 at  
2817 the  
2818 re-

2819 main-  
2820 ing  
2821 sta-  
2822 tions.  
2823 We  
2824 find  
2825 that  
2826 us-  
2827 ing  
2828  $\sigma^2 =$   
2829  $0.05\text{m}^2/\text{yr}^3$   
2830 ad-  
2831 e-  
2832 quately  
2833 de-  
2834 scribe  
2835 all  
2836 but  
2837 the  
2838 first  
2839 week  
2840 of  
2841 post-  
2842 seis-  
2843 mic  
2844 de-  
2845 for-  
2846 ma-  
2847 tion  
2848 at  
2849 sta-  
2850 tion  
2851 P496,

2852 which  
2853 gets  
2854 in-  
2855 cor-  
2856 po-  
2857 rated  
2858 into  
2859 our  
2860 es-  
2861 ti-  
2862 mate  
2863 of  
2864 co-  
2865 seis-  
2866 mic  
2867 dis-  
2868 place-  
2869 ments  
2870 (Fig-  
2871 ure  
2872 ??).  
2873 By  
2874 down  
2875 sam-  
2876 pling,  
2877 we  
2878 im-  
2879 plic-  
2880 itly  
2881 as-  
2882 sume  
2883 that  
2884 the

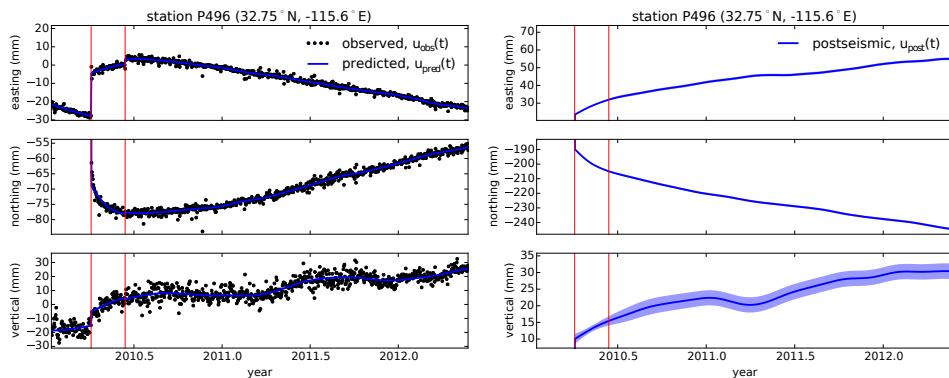
2885 first  
2886 week  
2887 of  
2888 de-  
2889 for-  
2890 ma-  
2891 tion  
2892 is  
2893 over-  
2894 whelm-  
2895 ingly  
2896 the  
2897 re-  
2898 sult  
2899 of  
2900 af-  
2901 ter-  
2902 slip  
2903 and  
2904 this  
2905 af-  
2906 ter-  
2907 slip  
2908 is  
2909 lumped  
2910 into  
2911 our  
2912 es-  
2913 ti-  
2914 mates  
2915 of  
2916 co-  
2917 seis-

2918 mic  
2919 slip.  
2920 ?,  
2921 ]Freed2007a  
2922 noted  
2923 that  
2924 post-  
2925 seis-  
2926 mic  
2927 de-  
2928 for-  
2929 ma-  
2930 tion  
2931 can  
2932 be  
2933 ob-  
2934 served  
2935 at  
2936 dis-  
2937 tances  
2938 greater  
2939 than  
2940 200  
2941 km  
2942 from  
2943 the  
2944 Hec-  
2945 tor  
2946 Mine  
2947 earth-  
2948 quake  
2949 and,  
2950 af-

2951 ter  
2952 fil-  
2953 ter-  
2954 ing  
2955 the  
2956 time  
2957 se-  
2958 ries  
2959 for  
2960 sta-  
2961 tions  
2962 up  
2963 to  
2964 400  
2965 km  
2966 from  
2967 the  
2968 El  
2969 Mayor-  
2970 Cucapah  
2971 epi-  
2972 cen-  
2973 tre,  
2974 we  
2975 also  
2976 clearly  
2977 see  
2978 far  
2979 reach-  
2980 ing  
2981 post-  
2982 seis-  
2983 mic

2984 tran-  
2985 sient  
2986 de-  
2987 for-  
2988 ma-  
2989 tion  
2990 (Fig-  
2991 ure  
2992 ??).

3095 It  
3096 is  
3097 im-  
3098 por-  
3099 tant  
3100 to  
3101 note  
3102 that  
3103 the  
3104 shown  
3105 un-  
3106 cer-  
3107 tain-  
3108 ties  
3109 in  
3110  $u_{\text{post}}(t)$   
3111 do  
3112 not  
3113 ac-  
3114 count  
3115 for  
3116 the  
3117 non-  
3118 negligible

**Figure 2.**

Left

pan-

els

show

GPS

time

se-

ries

from

UN-

AVCO

(black)

and

the

pre-

dicted

dis-

place-

ment

(blue)

from

eq.

(??)

for

a

near-

field

sta-

tion.

Red

lines

in-

di-

cate

the

times

of

the

El

2993

2994

2995 pan-

2996 els

2997 show

2998 GPS

2999 time

3000 se-

3001 ries

3002 from

3003 UN-

3004 AVCO

3005 (black)

3006 and

3007 the

3008 pre-

3009 dicted

3010 dis-

3011 place-

3012 ment

3013 (blue)

3014 from

3015 eq.

3016 (??)

3017 for

3018 a

3019 near-

3020 field

3021 sta-

3022 tion.

3023 Red

3024 lines

3025 in-

3026 di-

3027 cate

3028 the

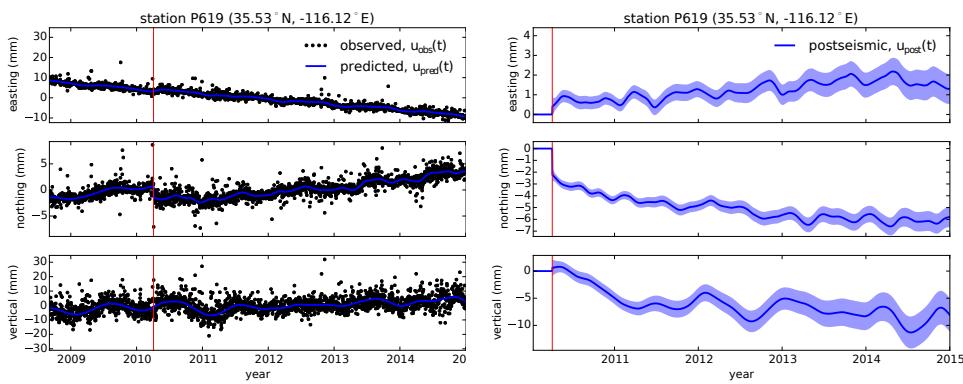
3029 times

3030 of

3031 the

3032 El

-105



3082 **Figure 3.**  
3083 same  
3084 as  
3085 Fig-  
3086 ure  
3087 ??  
3088 but  
3089 for  
3090 a  
3091 far-  
3092 field  
3093 sta-  
3094 tion.

3119 epis-  
3120 temic  
3121 un-  
3122 cer-  
3123 tainty  
3124 in  
3125 eq.  
3126 (??).  
3127 For  
3128 ex-  
3129 am-  
3130 ple,  
3131 we  
3132 as-  
3133 sume  
3134 a  
3135 con-  
3136 stant  
3137 rate  
3138 of  
3139 sec-  
3140 ul-  
3141 lar  
3142 de-  
3143 for-  
3144 ma-  
3145 tion,  
3146 which  
3147 ap-  
3148 pears  
3149 to  
3150 be  
3151 an

3152 ap-  
3153 pro-  
3154 pri-  
3155 ate  
3156 ap-  
3157 prox-  
3158 i-  
3159 ma-  
3160 tion  
3161 for  
3162 all  
3163 but  
3164 per-  
3165 haps  
3166 the  
3167 sta-  
3168 tions  
3169 clos-  
3170 est  
3171 to  
3172 the  
3173 Hec-  
3174 tor  
3175 Mine  
3176 epi-  
3177 cen-  
3178 tre,  
3179 as  
3180 noted  
3181 above.  
3182 Also,  
3183 our  
3184 model

3185 for  
3186 sea-  
3187 sonal  
3188 de-  
3189 for-  
3190 ma-  
3191 tion  
3192 in  
3193 eq.  
3194 (??)  
3195 as-  
3196 sumes  
3197 a  
3198 CON-  
3199 stant  
3200 am-  
3201 pli-  
3202 tude  
3203 over  
3204 time,  
3205 which  
3206 means  
3207 that  
3208 any  
3209 yearly  
3210 vari-  
3211 abil-  
3212 ity  
3213 in  
3214 the  
3215 cli-  
3216 matic  
3217 CON-

3218 di-  
3219 tions  
3220 could  
3221 in-  
3222 tro-  
3223 duce  
3224 sys-  
3225 tem-  
3226 atic  
3227 resid-  
3228 u-  
3229 als  
3230 ?,  
3231 ]Davis2012.  
3232 In-  
3233 deed,  
3234 it  
3235 would  
3236 be  
3237 more  
3238 ap-  
3239 pro-  
3240 pri-  
3241 ate  
3242 to  
3243 con-  
3244 sider  
3245 the  
3246 sea-  
3247 sonal  
3248 am-  
3249 pli-  
3250 tudes

3251         $c_2$ —  
3252         $c_5$   
3253        in  
3254        eq.  
3255        (?)  
3256        as  
3257        stochas-  
3258        tic  
3259        vari-  
3260        ables  
3261        ?,  
3262        ]Mur-  
3263        ray2005.  
3264        By  
3265        us-  
3266        ing  
3267        con-  
3268        stant  
3269        sea-  
3270        sonal  
3271        am-  
3272        pli-  
3273        tudes  
3274        our  
3275        es-  
3276        ti-  
3277        mate  
3278        of  
3279         $u_{\text{post}}(t)$   
3280        seems  
3281        to  
3282        de-  
3283        scribe

3284 some  
3285 of  
3286 the  
3287 un-  
3288 mod-  
3289 elled  
3290 an-  
3291 nual  
3292 and  
3293 semi-  
3294 annual  
3295 OS-  
3296 cil-  
3297 la-  
3298 tions  
3299 (e.g.  
3300 Fig-  
3301 ure  
3302 ??).

3303 We  
3304 show  
3305 in  
3306 Fig-  
3307 ures  
3308 ??  
3309 and  
3310 ??  
3311 the  
3312 near  
3313 and  
3314 far-  
3315 field  
3316 post-

3317 seis-  
3318 mic  
3319 dis-  
3320 place-  
3321 ments  
3322 ac-  
3323 cu-  
3324 mu-  
3325 lated  
3326 over  
3327 the  
3328 in-  
3329 ter-  
3330 vals  
3331 0-  
3332 0.8  
3333 years,  
3334 0.8-  
3335 3.0  
3336 years,  
3337 and  
3338 3.0-  
3339 5.0  
3340 years,  
3341 as  
3342 well  
3343 as  
3344 the  
3345 co-  
3346 seis-  
3347 mic  
3348 dis-  
3349 place-

3350 ments.  
3351 In  
3352 the  
3353 far-  
3354 field  
3355 to  
3356 the  
3357 north,  
3358 we  
3359 can  
3360 see  
3361 south  
3362 trend-  
3363 ing  
3364 dis-  
3365 place-  
3366 ments  
3367 for  
3368 the  
3369 first  
3370 3  
3371 years  
3372 fol-  
3373 low-  
3374 ing  
3375 the  
3376 earth-  
3377 quake  
3378 at  
3379 sta-  
3380 tions  
3381 as  
3382 far

3383 as  
3384 ~400  
3385 km  
3386 from  
3387 of  
3388 the  
3389 El  
3390 Mayor  
3391 Cu-  
3392 ca-  
3393 pah  
3394 epi-  
3395 cen-  
3396 tre.  
3397 These  
3398 dis-  
3399 place-  
3400 ments  
3401 are  
3402 most  
3403 pro-  
3404 nounced  
3405 along  
3406 the  
3407 di-  
3408 rec-  
3409 tion  
3410 of  
3411 the  
3412 El  
3413 Mayor-  
3414 Cucapah  
3415 P

3416 axis.  
3417 A  
3418 sim-  
3419 i-  
3420 lar  
3421 east-  
3422 ward  
3423 trend  
3424 can  
3425 be  
3426 seen  
3427 in  
3428 the  
3429 few  
3430 far-  
3431 field  
3432 sta-  
3433 tions  
3434 along  
3435 the  
3436 T  
3437 axis  
3438 in  
3439 Ari-  
3440 zona.  
3441 Af-  
3442 ter  
3443 3  
3444 years,  
3445 the  
3446 trend  
3447 in  
3448 far-

3449 field  
3450 post-  
3451 seis-  
3452 mic  
3453 de-  
3454 for-  
3455 ma-  
3456 tion  
3457 is  
3458 barely  
3459 per-  
3460 cep-  
3461 ti-  
3462 ble.  
3463 The  
3464 ver-  
3465 ti-  
3466 cal  
3467 de-  
3468 for-  
3469 ma-  
3470 tion  
3471 in  
3472 the  
3473 far-  
3474 field  
3475 is  
3476 dif-  
3477 fi-  
3478 cult  
3479 to  
3480 at-  
3481 tribute

3482 to  
3483 post-  
3484 seis-  
3485 mic  
3486 pro-  
3487 cesses.  
3488 Most  
3489 far-  
3490 field  
3491 sta-  
3492 tions  
3493 dis-  
3494 play  
3495 an  
3496 ini-  
3497 tial  
3498 sub-  
3499 si-  
3500 dence  
3501 for  
3502 the  
3503 first  
3504 year  
3505 af-  
3506 ter  
3507 the  
3508 El  
3509 Mayor-  
3510 Cucapah  
3511 earth-  
3512 quake  
3513 fol-  
3514 lowed

3515 by  
3516 con-  
3517 tin-  
3518 ued  
3519 up-  
3520 lift.  
3521 This  
3522 trend  
3523 in  
3524 ver-  
3525 ti-  
3526 cal  
3527 de-  
3528 for-  
3529 ma-  
3530 tion  
3531 can  
3532 be  
3533 ob-  
3534 served  
3535 in  
3536 all  
3537 three  
3538 of  
3539 the  
3540 quad-  
3541 rants  
3542 where  
3543 post-  
3544 seis-  
3545 mic  
3546 data  
3547 is

3548 avail-  
3549 able,  
3550 which  
3551 means  
3552 that  
3553 the  
3554 ver-  
3555 ti-  
3556 cal  
3557 de-  
3558 for-  
3559 ma-  
3560 tion  
3561 does  
3562 not  
3563 ex-  
3564 hibit  
3565 an  
3566 anti-  
3567 symmetric  
3568 quad-  
3569 rant  
3570 pat-  
3571 tern,  
3572 as  
3573 would  
3574 be  
3575 ex-  
3576 pected  
3577 for  
3578 post-  
3579 seis-  
3580 mic

3581 pro-

3582 cesses.

3583 Al-

3584 though

3585 we

3586 use

3587 ver-

3588 ti-

3589 cal

3590 de-

3591 for-

3592 ma-

3593 tion

3594 in

3595 our

3596 anal-

3597 y-

3598 sis

3599 in

3600 Sec-

3601 tion

3602 ??,

3603 we

3604 do

3605 not

3606 put

3607 an

3608 em-

3609 pha-

3610 sis

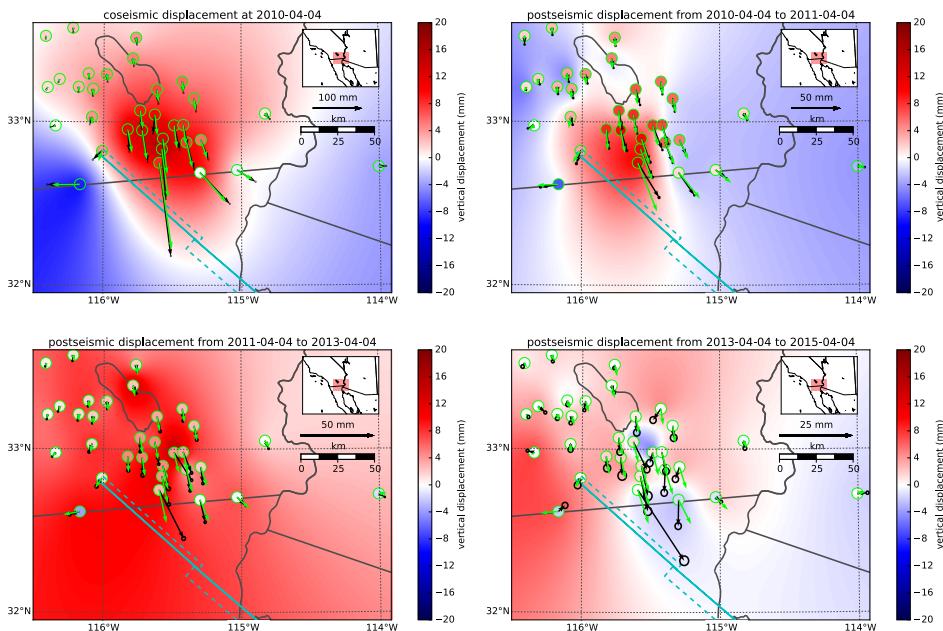
3611 on

3612 try-

3613 ing

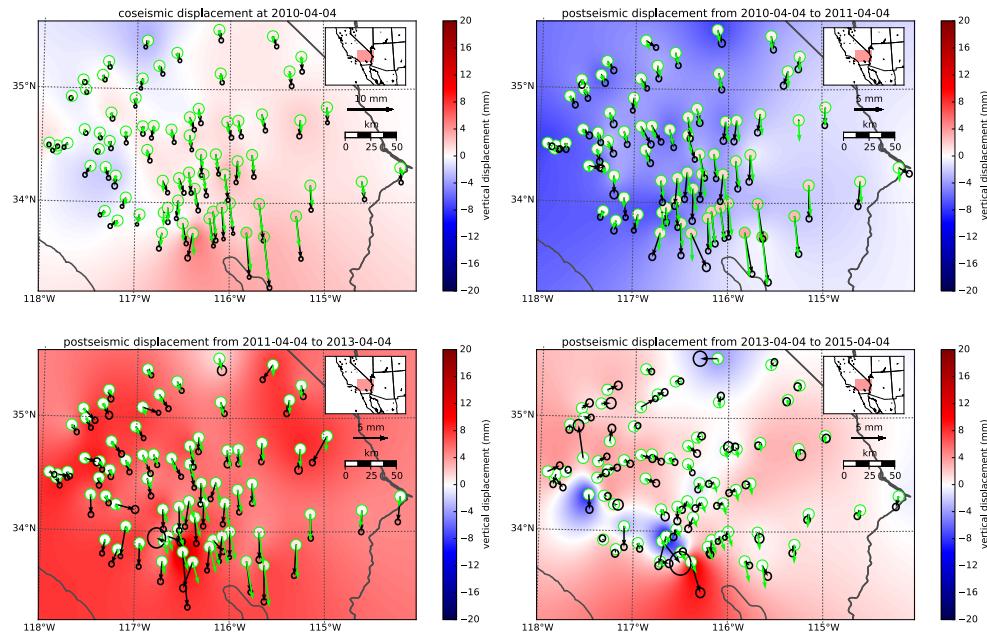
3614 to  
3615 de-  
3616 scribe  
3617 the  
3618 ver-  
3619 ti-  
3620 cal  
3621 de-  
3622 for-  
3623 ma-  
3624 tion  
3625 as  
3626 it  
3627 likely  
3628 does  
3629 not  
3630 have  
3631 post-  
3632 seis-  
3633 mic  
3634 ori-  
3635 gins.

3739 The  
3740 near-  
3741 field  
3742 post-  
3743 seis-  
3744 mic  
3745 de-  
3746 for-  
3747 ma-  
3748 tion  
3749 is

**Figure 4.**

Near-field

3636  
3637 CO-  
3638 seis-  
3639 mic  
3640 and  
3641 post-  
3642 seis-  
3643 mic  
3644 dis-  
3645 place-  
3646 ments  
3647 (black)  
3648 as  
3649 well  
3650 as  
3651 pre-  
3652 dicted  
3653 dis-  
3654 place-  
3655 ments  
3656 for  
3657 our  
3658 pre-  
3659 ferred  
3660 model  
3661 from  
3662 Sec-  
3663 tion  
3664 ??  
3665 (green).  
3666 -123-  
3667 Ob-  
3668 served

**Figure 5.**

3727 Same  
 3728 as  
 3729 Fig-  
 3730 ure  
 3731 ??  
 3732 but  
 3733 for  
 3734 far-  
 3735 field  
 3736 sta-  
 3737 tions.

3750 no-  
3751 tably  
3752 sus-  
3753 tained  
3754 when  
3755 com-  
3756 pared  
3757 to  
3758 the  
3759 far-  
3760 field  
3761 de-  
3762 for-  
3763 ma-  
3764 tion.  
3765 Namely,  
3766 the  
3767 sta-  
3768 tion  
3769 in  
3770 this  
3771 study  
3772 which  
3773 is  
3774 clos-  
3775 est  
3776 to  
3777 the  
3778 El  
3779 Mayor-  
3780 Cucapah  
3781 epi-  
3782 cen-

3783      tre,  
3784      P496,  
3785      has  
3786      been  
3787      mov-  
3788      ing  
3789      at  
3790      a  
3791      steady  
3792      rate  
3793      of  
3794      ~  
3795      1.5  
3796      cm/yr  
3797      to  
3798      the  
3799      south  
3800      since  
3801      ~  
3802      1  
3803      year  
3804      af-  
3805      ter  
3806      the  
3807      El  
3808      Mayor-  
3809      Cucapah  
3810      earth-  
3811      quake.  
3812      Ver-  
3813      ti-  
3814      cal  
3815      post-

3816 seis-  
3817 mic  
3818 de-  
3819 for-  
3820 ma-  
3821 tion  
3822 in  
3823 the  
3824 near-  
3825 field  
3826 does  
3827 dis-  
3828 play  
3829 a  
3830 quad-  
3831 rant  
3832 pat-  
3833 tern  
3834 which  
3835 is  
3836 con-  
3837 sis-  
3838 tent  
3839 with  
3840 the  
3841 CO-  
3842 seis-  
3843 mic  
3844 ver-  
3845 ti-  
3846 cal  
3847 de-  
3848 for-

3849 ma-  
3850 tion,  
3851 sug-  
3852 gest-  
3853 ing  
3854 that  
3855 it  
3856 is  
3857 re-  
3858 sult-  
3859 ing  
3860 from  
3861 tec-  
3862 tonic  
3863 pro-  
3864 cesses.  
3865 How-  
3866 ever,  
3867 the  
3868 ver-  
3869 ti-  
3870 cal  
3871 post-  
3872 seis-  
3873 mic  
3874 sig-  
3875 nal  
3876 is  
3877 only  
3878 ap-  
3879 par-  
3880 ent  
3881 for

3882 the  
3883 first  
3884 year  
3885 af-  
3886 ter  
3887 the  
3888 earth-  
3889 quake  
3890 (Fig-  
3891 ure  
3892 ??).  
3893 As  
3894 with  
3895 the  
3896 far-  
3897 field  
3898 de-  
3899 for-  
3900 ma-  
3901 tion,  
3902 there  
3903 is  
3904 a  
3905 gen-  
3906 eral  
3907 trend  
3908 of  
3909 up-  
3910 lift  
3911 in  
3912 the  
3913 near-  
3914 field

3915 af-  
3916 ter  
3917 ~  
3918 1  
3919 year,  
3920 which  
3921 we  
3922 do  
3923 not  
3924 con-  
3925 sider  
3926 to  
3927 be  
3928 re-  
3929 lated  
3930 to  
3931 post-  
3932 seis-  
3933 mic  
3934 pro-  
3935 cesses.  
3936

3937 **3 Postseismic**  
3938 **Mod-**  
3939 **el-**  
3940 **ing**

4000 In  
4001 this  
4002 pa-  
4003 per,  
4004 we  
4005 seek  
4006 to

depth (km)	$\lambda$ (GPa)	$\mu$ (GPa)	$\eta_{\text{eff}}$ ( $10^{18}$ Pa s)	$\mu_k/\mu$
0-5	24.0	24.3	-	-
5-15	35.2	35.4	-	-
15-30	41.8	41.9	44.3	0.0
30-60	61.0	60.8	5.91	0.375
60-90	61.0	60.8	1.99	0.375
90-120	61.0	60.8	1.31	0.375
120-150	61.0	60.8	1.10	0.375
150- $\infty$	61.0	60.8	1.07	0.375

**Table 1.**

As-

sumed

and

es-

ti-

mated

ma-

te-

rial

prop-

er-

ties.

 $\lambda$ 

and

 $\mu$ 

are

as-

sumed

known

*a**pri-**ori,* $\eta_{\text{eff}}$ 

is

es-

ti-

mated

in

Sec-

tion

??

and

 $\frac{\mu_k}{\mu}$ 

are

the

op-

ti-

mal

shear

mod-

uli

-131-

ra-

tios

4007 find  
4008 the  
4009 mech-  
4010 a-  
4011 nisms  
4012 driv-  
4013 ing  
4014 5  
4015 years  
4016 of  
4017 post-  
4018 seis-  
4019 mic  
4020 de-  
4021 for-  
4022 ma-  
4023 tion  
4024 fol-  
4025 low-  
4026 ing  
4027 the  
4028 El  
4029 Mayor-  
4030 Cucapah  
4031 earth-  
4032 quake.  
4033 We  
4034 con-  
4035 sider  
4036 af-  
4037 ter-  
4038 slip  
4039 and

4040 vis-  
4041 coelas-  
4042 tic  
4043 re-  
4044 lax-  
4045 ation  
4046 in  
4047 the  
4048 litho-  
4049 sphere  
4050 and  
4051 as-  
4052 theno-  
4053 sphere  
4054 as  
4055 can-  
4056 di-  
4057 date  
4058 mech-  
4059 a-  
4060 nisms.  
4061 Poroe-  
4062 las-  
4063 tic  
4064 re-  
4065 bound  
4066 has  
4067 also  
4068 been  
4069 used  
4070 to  
4071 model  
4072 post-

4073 seis-  
4074 mic  
4075 de-  
4076 for-  
4077 ma-  
4078 tion  
4079 ?,  
4080 e.g.]Jonsson2003;  
4081 how-  
4082 ever,  
4083 ?,  
4084 ]Gonzalez-  
4085 ortega2014  
4086 sug-  
4087 gest  
4088 that  
4089 any  
4090 CON-  
4091 tri-  
4092 bu-  
4093 tion  
4094 to  
4095 post-  
4096 seis-  
4097 mic  
4098 de-  
4099 for-  
4100 ma-  
4101 tion  
4102 from  
4103 poroe-  
4104 las-  
4105 tic

4106 re-  
4107 bound  
4108 would  
4109 be  
4110 neg-  
4111 li-  
4112 gi-  
4113 ble.  
4114 Fur-  
4115 ther-  
4116 more,  
4117 we  
4118 CON-  
4119 sider  
4120 sta-  
4121 tions  
4122 which  
4123 are  
4124 suf-  
4125 fi-  
4126 ciently  
4127 far  
4128 away  
4129 from  
4130 the  
4131 main  
4132 rup-  
4133 ture  
4134 that  
4135 poroe-  
4136 las-  
4137 tic  
4138 re-

4139 bound  
4140 should  
4141 be  
4142 in-  
4143 signif-  
4144 i-  
4145 cant.

4146 We

4147 es-  
4148 ti-  
4149 mate  
4150 co-  
4151 seis-  
4152 mic  
4153 and  
4154 time-  
4155 dependent  
4156 post-  
4157 seis-  
4158 mic  
4159 fault  
4160 slip,  
4161 both  
4162 of  
4163 which  
4164 are  
4165 as-  
4166 sumed  
4167 to  
4168 oc-  
4169 cur  
4170 on  
4171 a

4172 fault  
4173 ge-  
4174 om-  
4175 e-  
4176 try  
4177 mod-  
4178 i-  
4179 fied  
4180 from  
4181 ?,  
4182 ]Wei2011.  
4183 Field  
4184 stud-  
4185 ies  
4186 ?,  
4187 ]Fletcher2014  
4188 and  
4189 LI-  
4190 DAR  
4191 ob-  
4192 ser-  
4193 va-  
4194 tions  
4195 ?,  
4196 ]Os-  
4197 kin2012  
4198 have  
4199 re-  
4200 vealed  
4201 a  
4202 sig-  
4203 nif-  
4204 i-

4205 cantly  
4206 more  
4207 com-  
4208 pli-  
4209 cated  
4210 fault  
4211 ge-  
4212 om-  
4213 e-  
4214 try  
4215 than  
4216 what  
4217 was  
4218 in-  
4219 ferred  
4220 by  
4221 ?,  
4222 ]Wei2011,  
4223 es-  
4224 pe-  
4225 cially  
4226 within  
4227 the  
4228 Sierra  
4229 Cu-  
4230 ca-  
4231 pah.  
4232 How-  
4233 ever,  
4234 we  
4235 find  
4236 that  
4237 a

4238 rel-  
4239 a-  
4240 tively  
4241 sim-  
4242 ple  
4243 CO-  
4244 seis-  
4245 mic  
4246 fault  
4247 ge-  
4248 om-  
4249 e-  
4250 try  
4251 based  
4252 on  
4253 ?,  
4254 ]Wei2011  
4255 is  
4256 ad-  
4257 e-  
4258 quate  
4259 be-  
4260 cause  
4261 most  
4262 of  
4263 the  
4264 sta-  
4265 tions  
4266 used  
4267 in  
4268 this  
4269 study  
4270 are

4271 suf-  
4272 fi-  
4273 ciently  
4274 far  
4275 from  
4276 the  
4277 El  
4278 Mayor-  
4279 Cucapah  
4280 rup-  
4281 ture  
4282 zone  
4283 that  
4284 they  
4285 are  
4286 in-  
4287 sen-  
4288 si-  
4289 tive  
4290 to  
4291 the  
4292 de-  
4293 tails  
4294 in  
4295 the  
4296 fault  
4297 ge-  
4298 om-  
4299 e-  
4300 try  
4301 found  
4302 by  
4303 ?,

4304 ]Fletcher2014

4305 and

4306 ?,

4307 ]Os-

4308 kin2012.

4309 The

4310 fault

4311 ge-

4312 om-

4313 e-

4314 try

4315 used

4316 in

4317 this

4318 study

4319 (Fig-

4320 ure

4321 ??)

4322 con-

4323 sists

4324 of

4325 the

4326 two

4327 main

4328 fault

4329 seg-

4330 ments

4331 in-

4332 fered

4333 by

4334 ?,

4335 ]Wei2011,

4336 where

4337 the  
4338 north-  
4339 ern  
4340 seg-  
4341 ment  
4342 runs  
4343 through  
4344 the  
4345 Sierra  
4346 Cu-  
4347 ca-  
4348 pah  
4349 up  
4350 to  
4351 the  
4352 US-  
4353 Mexico  
4354 bor-  
4355 der  
4356 and  
4357 the  
4358 south-  
4359 ern  
4360 seg-  
4361 ment  
4362 is  
4363 the  
4364 In-  
4365 di-  
4366 viso  
4367 fault  
4368 which  
4369 ex-

4370 tends  
4371 down  
4372 to  
4373 the  
4374 Gulf  
4375 of  
4376 Cal-  
4377 i-  
4378 for-  
4379 nia.  
4380 Both  
4381 seg-  
4382 ments  
4383 ex-  
4384 tend  
4385 from  
4386 the  
4387 sur-  
4388 face  
4389 to  
4390 15  
4391 km  
4392 depth.  
4393 We  
4394 ex-  
4395 tend  
4396 the  
4397 north-  
4398 ern  
4399 seg-  
4400 ment  
4401 by  
4402 40

4403 km  
4404 to  
4405 the  
4406 north-  
4407 west,  
4408 mo-  
4409 ti-  
4410 vated  
4411 by  
4412 the  
4413 clus-  
4414 ter-  
4415 ing  
4416 of  
4417 af-  
4418 ter-  
4419 shocks  
4420 on  
4421 the  
4422 north-  
4423 ern  
4424 tip  
4425 of  
4426 the  
4427 co-  
4428 seis-  
4429 mic  
4430 rup-  
4431 ture  
4432 zone  
4433 ?,  
4434 ]Hauks-  
4435 son2011,Kroll2013.

4436 This  
4437 ex-  
4438 tended  
4439 fault  
4440 seg-  
4441 ment  
4442 was  
4443 also  
4444 found  
4445 to  
4446 be  
4447 nec-  
4448 es-  
4449 sary  
4450 by  
4451 ?,  
4452 ]Rollins2015  
4453 and  
4454 ?,  
4455 ]Pol-  
4456 litz2012  
4457 in  
4458 or-  
4459 der  
4460 to  
4461 de-  
4462 scribe  
4463 the  
4464 post-  
4465 seis-  
4466 mic  
4467 de-  
4468 for-

4469 ma-

4470 tion.

4471

4472 **3.1 elastic**

4473 **in-**

4474 **ver-**

4475 **sion**

We

con-

sider

a

va-

ri-

ety

of

rhe-

o-

logic

mod-

els

for

the

lower

crust

and

up-

per

man-

tle.

The

sim-

plest

rhe-  
o-  
logic  
model  
is  
to  
con-  
sider  
them  
to  
be  
ef-  
fec-  
tively  
elas-  
tic  
and  
isotropic.

In  
such  
case,  
the  
rhe-  
o-  
logic  
pa-  
ram-  
e-  
ters  
con-  
sist  
of  
the

Lamé

pa-

ram-

e-

ters,

$\lambda$

and

$\mu$ ,

which

are

rea-

son-

ably

well

known

and

we

use

the

val-

ues

listed

in

Ta-

ble

??

through-

out

this

pa-

per.

The

only

un-  
known  
is  
the  
dis-  
tri-  
bu-  
tion  
of  
fault  
slip,  
which  
can  
be  
eas-  
ily  
es-  
ti-  
mated  
from  
post-  
seis-  
mic  
de-  
for-  
ma-  
tion  
through  
lin-  
ear  
least  
squares.  
Us-

ing  
a  
sub-  
set  
of  
the  
GPS  
sta-  
tions  
con-  
sid-  
ered  
in  
this  
study,  
?,  
]Rollins2015  
found  
that  
post-  
seis-  
mic  
de-  
for-  
ma-  
tion  
fol-  
low-  
ing  
the  
El  
Mayor-  
Cucapah

earth-  
quake  
can  
be  
ex-  
plained  
with  
af-  
ter-  
slip  
on  
the  
co-  
seis-  
mic  
fault  
plane  
and  
they  
did  
not  
re-  
quire  
any  
vis-  
coelas-  
tic  
re-  
lax-  
ation  
to  
de-  
scribe

the  
ob-  
ser-  
va-  
tions.

We  
also  
per-  
form  
an  
elas-

tic  
slip  
in-  
ver-  
sion  
but

we  
use  
GPS  
sta-  
tions  
within

a  
larger

ra-  
dius  
about

the  
El

Mayor-  
Cucapah  
epi-

cen-  
tre  
(400  
km  
in-  
stead  
of  
 $\sim$ 200  
km).  
Our  
for-  
ward  
prob-  
lem  
de-  
scrib-  
ing  
pre-  
dicted  
post-  
seis-  
mic  
de-  
for-  
ma-  
tion,  
 $u_{\text{pred}}$ ,  
in  
terms  
of  
time  
de-  
pen-

dent

fault

slip,

$s$ ,

is

$$u_{\text{pred}}(x, t) = \int_F s(\xi, t) g(x, \xi) d\xi \quad (9)$$

where

$g(x, \xi)$

is

elas-

tic

Green's

func-

tion

de-

scrib-

ing

dis-

place-

ment

at

sur-

face

po-

si-

tion

$x$

re-

sult-

ing

from

a

unit

of

slip

at

$\xi$

on

the

fault,

which

is

de-

noted

by

*F.*

We

es-

ti-

mate

co-

seis-

mic

slip

and

the

rate

of

af-

ter-

slip

at

the

dis-

crete

time  
in-  
ter-  
vals,  
0.0-  
0.125,  
0.125-  
0.25,  
0.5-  
1.0,  
1.0-  
2.0,  
2.0-  
3.0,  
3.0-  
4.0,  
and  
4.0-  
5.0  
years  
af-  
ter  
the  
earth-  
quake.  
Each  
fault  
seg-  
ment  
is  
dis-  
cretized  
into

roughly

4

km

by

4

km

patches

and

we

es-

ti-

mate

a

strike-

slip

and

thrust

com-

po-

nent

of

slip

for

each

patch.

We

im-

pose

that

the

di-

rec-

tion

of  
slip  
and  
slip  
rate  
are  
within  
 $45^\circ$   
of  
right-  
lateral.

We  
also  
add  
ze-  
roth  
or-  
der  
Tikhonov

reg-  
u-  
lar-  
iza-  
tion  
so  
that  
our  
so-  
lu-  
tion  
for  
*s*  
sat-

is-

fies

$$(10) \quad \min_s \left( \left\| \frac{u_{\text{pred}}(s) - u_{\text{post}}}{\sigma_{\text{obs}}} \right\|_2^2 + \lambda_s \|s\|_2^2 \right).$$

4476 The

4477 penalty

4478 pa-

4479 ram-

4480 e-

4481 ters,

4482  $\lambda_s$ ,

4483 is

4484 cho-

4485 sen

4486 with

4487 a

4488 trade-

4489 off

4490 curve.

4491 We

4492 use

4493 Pylith

4494 ?,

4495 ]Aa-

4496 gaard2009

4497 to

4498 com-

4499 pute

4500 the

4501 Green's

4502 func-

4503 tions

4504 for

4505        this  
4506        in-  
4507        ver-  
4508        sion  
4509        and  
4510        for  
4511        the  
4512        re-  
4513        main-  
4514        ing  
4515        in-  
4516        ver-  
4517        sions  
4518        in  
4519        this  
4520        pa-  
4521        per.

4522              Our

4523        CO-  
4524        seis-  
4525        mic  
4526        slip  
4527        and  
4528        af-  
4529        ter-  
4530        slip  
4531        SO-  
4532        lu-  
4533        tions  
4534        are  
4535        shown  
4536        in  
4537        Fig-

4538      ure  
4539      ??.  
4540      As  
4541      with  
4542      ?,  
4543      ]Rollins2015,  
4544      we  
4545      find  
4546      that  
4547      a  
4548      large  
4549      amount  
4550      of  
4551      af-  
4552      ter-  
4553      slip  
4554      on  
4555      the  
4556      south-  
4557      ern  
4558      fault  
4559      seg-  
4560      ment  
4561      is  
4562      re-  
4563      quired  
4564      to  
4565      ex-  
4566      plain  
4567      the  
4568      ob-  
4569      ser-  
4570      va-

4571 tions.  
4572 The  
4573 po-  
4574 tency  
4575 of  
4576 our  
4577 in-  
4578 fered  
4579 CO-  
4580 seis-  
4581 mic  
4582 slip  
4583 is  
4584 3.2×  
4585  $10^9$  m<sup>3</sup>,  
4586 equiv-  
4587 a-  
4588 lent  
4589 to  
4590 a  
4591 Mw7.28  
4592 earth-  
4593 quake  
4594 when  
4595 as-  
4596 sum-  
4597 ing  
4598 a  
4599 shear  
4600 mod-  
4601 ul-  
4602 lus  
4603 of

4604 32  
4605 GPa.  
4606 The  
4607 po-  
4608 tency  
4609 of  
4610 our  
4611 in-  
4612 ferred  
4613 cu-  
4614 mu-  
4615 la-  
4616 tive  
4617 5  
4618 years  
4619 of  
4620 af-  
4621 ter-  
4622 slip  
4623 is  
4624  $6.1 \times$   
4625  $10^9 \text{ m}^3$ ,  
4626 equiv-  
4627 a-  
4628 lent  
4629 to  
4630 a  
4631 Mw7.46  
4632 earth-  
4633 quake,  
4634 which  
4635 is  
4636 un-

4637 re-  
4638 al-  
4639 is-  
4640 ti-  
4641 cally  
4642 large  
4643 if  
4644 we  
4645 CON-  
4646 sider  
4647 af-  
4648 ter-  
4649 slip  
4650 to  
4651 be  
4652 driven  
4653 by  
4654 CO-  
4655 seis-  
4656 mi-  
4657 cally  
4658 in-  
4659 duced  
4660 stresses.  
4661 Our  
4662 elas-  
4663 tic  
4664 slip  
4665 model  
4666 ac-  
4667 cu-  
4668 rately  
4669 de-

4670 scribes  
4671 near-  
4672 field  
4673 post-  
4674 seis-  
4675 mic  
4676 de-  
4677 for-  
4678 ma-  
4679 tion,  
4680 while  
4681 it  
4682 sys-  
4683 tem-  
4684 at-  
4685 i-  
4686 cally  
4687 un-  
4688 der-  
4689 es-  
4690 ti-  
4691 mates  
4692 post-  
4693 seis-  
4694 mic  
4695 de-  
4696 for-  
4697 ma-  
4698 tion  
4699 for  
4700 sta-  
4701 tions  
4702 fur-

4703 ther  
4704 than  
4705 ~  
4706 150  
4707 km  
4708 from  
4709 the  
4710 El  
4711 Mayor-  
4712 Cucapah  
4713 epi-  
4714 cen-  
4715 tre  
4716 (Fig-  
4717 ure  
4718 ??).  
4719 When  
4720 the  
4721 fault  
4722 seg-  
4723 ments  
4724 used  
4725 in  
4726 the  
4727 in-  
4728 ver-  
4729 sion  
4730 are  
4731 ex-  
4732 tended  
4733 down  
4734 to  
4735 30

4736 km  
4737 depth,  
4738 rather  
4739 than  
4740 15  
4741 km,  
4742 the  
4743 sys-  
4744 tem-  
4745 atic  
4746 far-  
4747 field  
4748 resid-  
4749 u-  
4750 als  
4751 are  
4752 smaller  
4753 but  
4754 re-  
4755 main  
4756 ap-  
4757 par-  
4758 ent.  
4759 Be-  
4760 cause  
4761 an  
4762 elas-  
4763 tic  
4764 model  
4765 for  
4766 the  
4767 litho-  
4768 sphere

4769 re-  
4770 quires  
4771 an  
4772 un-  
4773 re-  
4774 al-  
4775 is-  
4776 tic  
4777 amount  
4778 of  
4779 af-  
4780 ter-  
4781 slip  
4782 and  
4783 is  
4784 un-  
4785 able  
4786 to  
4787 pre-  
4788 dict  
4789 far-  
4790 field  
4791 de-  
4792 for-  
4793 ma-  
4794 tion,  
4795 we  
4796 move  
4797 on  
4798 to  
4799 CON-  
4800 sider  
4801 vis-

4802 coelas-  
4803 tic  
4804 mod-  
4805 els  
4806 in  
4807 the  
4808 next  
4809 sec-  
4810 tion.

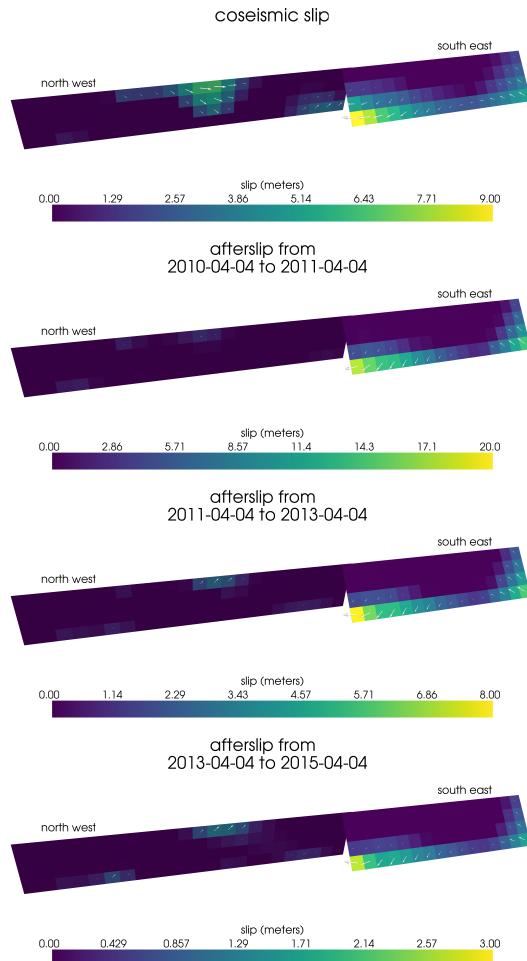
4968

4969 **3.2 constraints**

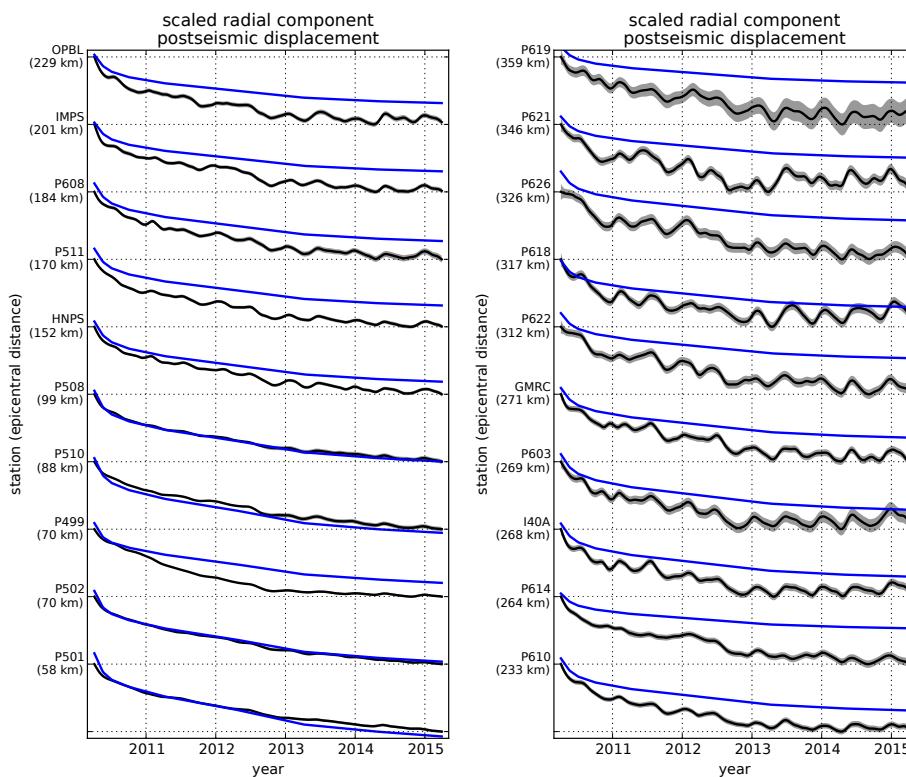
4970 **on**  
4971 **ef-**  
4972 **fec-**  
4973 **tive**  
4974 **vis-**  
4975 **cos-**  
4976 **ity**

For

any  
lin-  
ear  
vis-  
coelas-  
tic  
rhe-  
ol-  
ogy  
of  
the  
crust  
and



4811 **Figure 6.**  
4812 Co-  
4813 seis-  
4814 mic  
4815 slip  
4816 and  
4817 cu-  
4818 mu-  
4819 la-  
4820 tive  
4821 af-  
4822 ter-  
4823 slip  
4824 over  
4825 the  
4826 in-  
4827 di-  
4828 cated  
4829 in-  
4830 ter-  
4831 vals  
4832 for  
4833 -170e  
4834 elas-

**Figure 7.**

Scaled

record

sec-

tion

for

the

ra-

dial

com-

po-

nent

of

ob-

served

post-

seis-

mic

dis-

place-

ments,

 $u_{\text{obs}}$ 

(black)

and

dis-

place-

ments

pre-

man-  
tle,  
post-  
seis-  
mic  
dis-  
place-  
ments  
re-  
sult-  
ing  
from  
time  
de-  
pen-  
dent  
fault  
slip  
can  
be  
de-  
scribed  
as

$$u_{\text{pred}}(x, t) = \int_F s(\xi, t)g(x, \xi)d\xi + \int_0^t \int_F s(\xi, \tau)f(t-\tau, x, \xi)d\xi d\tau \quad (11)$$

4977 where  
 4978  $f(t, x, \xi)$   
 4979 de-  
 4980 scribes  
 4981 the  
 4982 time-  
 4983 dependent  
 4984 ve-

4985 loc-  
4986 ity  
4987 at  
4988  $x$   
4989 re-  
4990 sult-  
4991 ing  
4992 from  
4993 vis-  
4994 coelas-  
4995 tic  
4996 re-  
4997 lax-  
4998 ation  
4999 of  
5000 stresses  
5001 in-  
5002 duced  
5003 by  
5004 slip  
5005 at  
5006  $\xi.$   
5007  $f$   
5008 is  
5009 a  
5010 func-  
5011 tion  
5012 of  
5013  $\lambda,$   
5014  $\mu,$   
5015 and  
5016 any  
5017 ad-

5018 di-  
5019 tional  
5020 rhe-  
5021 O-  
5022 logic  
5023 pa-  
5024 ram-  
5025 e-  
5026 ters  
5027 con-  
5028 trol-  
5029 ling  
5030 the  
5031 vis-  
5032 coelas-  
5033 tic  
5034 re-  
5035 sponse,  
5036 which  
5037 are  
5038 gen-  
5039 er-  
5040 ally  
5041 not  
5042 well  
5043 known.  
5044 Schematic  
5045 rep-  
5046 re-  
5047 sen-  
5048 ta-  
5049 tions  
5050 of

5051 the  
5052 vis-  
5053 coelas-  
5054 tic  
5055 rhe-  
5056 o-  
5057 logic  
5058 mod-  
5059 els  
5060 con-  
5061 sid-  
5062 ered  
5063 in  
5064 this  
5065 study  
5066 are  
5067 shown  
5068 in  
5069 Fig-  
5070 ure  
5071 ??.  
5072 We  
5073 con-  
5074 sider  
5075 Maxwell  
5076 vis-  
5077 coelas-  
5078 tic-  
5079 ity,  
5080 where  
5081 the  
5082 steady-  
5083 state

5084 vis-  
5085 COS-  
5086 ity,  
5087  $\eta_M$ ,  
5088 is  
5089 un-  
5090 known,  
5091 Zener  
5092 vis-  
5093 coelas-  
5094 ticty,  
5095 where  
5096 the  
5097 tran-  
5098 sient  
5099 vis-  
5100 COS-  
5101 ity,  
5102  $\eta_K$ ,  
5103 and  
5104 tran-  
5105 sient  
5106 shear  
5107 mod-  
5108 u-  
5109 lus,  
5110  $\mu_K$ ,  
5111 are  
5112 un-  
5113 known,  
5114 and  
5115 Burg-  
5116 ers

5117 vis-  
5118 coelas-  
5119 tic-  
5120 ity,  
5121 where  
5122  $\eta_M$ ,  
5123  $\eta_K$ ,  
5124 and  
5125  $\mu_K$ ,  
5126 are  
5127 all  
5128 un-  
5129 known.  
5130 We  
5131 fur-  
5132 ther  
5133 dis-  
5134 cuSS  
5135 these  
5136 rhe-  
5137 O-  
5138 logic  
5139 mod-  
5140 els  
5141 and  
5142 their  
5143 use  
5144 in  
5145 geo-  
5146 phys-  
5147 i-  
5148 cal  
5149 stud-

5150       ies

5151       in

5152       Sec-

5153       tion

5154       **??.**

In

or-

der

to

greatly

sim-

plify

the

in-

verse

prob-

lem,

we

use

the

method

de-

scribed

in

?,

]Hines2016

to

con-

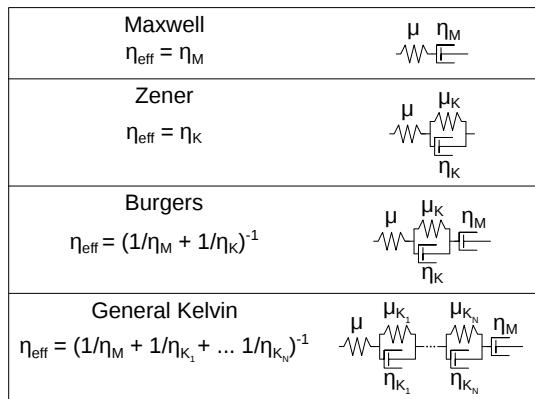
strain

an

ini-

tial

ef-

**Figure 8.**

Schematic

il-

lus-

tra-

tion

of

rhe-

o-

logic

mod-

els

con-

sid-

ered

in

this

pa-

per

as

well

as

their

ini-

tial

ef-

fec-

tion

vis-

cosi-

ties,

 $\eta_{\text{eff}} =$  $\frac{\sigma}{\epsilon} |_{t=0}.$

fec-  
tive  
litho-  
spheric  
vis-  
cos-  
ity  
struc-  
ture  
from  
the  
early  
post-  
seis-  
mic  
de-  
for-  
ma-  
tion.  
The  
method  
re-  
lies  
upon  
the  
fact  
that  
im-  
me-  
di-  
ately  
af-  
ter

an  
earth-  
quake,  
stresses  
through-  
out  
the  
crust  
and  
man-  
tle  
are  
only  
con-  
trolled  
by  
the  
rel-  
a-  
tively  
well  
known  
in-  
stan-  
ta-  
neous  
elas-  
tic  
prop-  
er-  
ties  
and  
each

par-

cel

will

have

a

strain

rate,

$\dot{\epsilon}$ ,

that

is

pro-

por-

tional

to

stress,

$\sigma$ ,

and

in-

versely

pro-

por-

tional

to

the

par-

cel's

ef-

fec-

tive

vis-

cos-

ity,

$\eta_{\text{eff}} =$

$\frac{\sigma}{\epsilon}|_{t=0}$ .

Through

lin-

ear

su-

per-

po-

si-

tion,

we

can

de-

duce

that

the

ini-

tial

rate

of

sur-

face

de-

for-

ma-

tion

re-

sult-

ing

from

vis-

coelas-

tic

re-

lax-  
ation  
is  
a  
sum-  
ma-  
tion  
of  
the  
sur-  
face  
de-  
for-  
ma-  
tion  
re-  
sult-  
ing  
from  
each  
par-  
cel,  
scaled  
by  
the  
re-  
cip-  
ro-  
cal  
of  
the  
par-  
cel's

ef-  
fec-  
tive  
vis-  
cos-  
ity.

That

is  
to  
say

$$f(0, x, \xi) = \int_L \frac{h(x, \xi, \zeta)}{\eta_{\text{eff}}(\zeta)} d\zeta,$$

(12)

where

$h(x, \xi, \zeta)$

de-  
scribes  
the  
ini-  
tial  
rate  
of  
de-  
for-  
ma-  
tion  
re-  
sult-  
ing  
from  
vis-  
coelas-  
tic  
re-

lax-

ation

at

$\zeta$

in-

duced

by

slip

at

$\xi$

and

$L$

de-

notes

the

crust

and

man-

tle.

We

can

com-

bine

eq.

(??)

with

eq.

(??)

to

get

a

first

or-

der

ap-

prox-

i-

ma-

tion

for

early

post-

seis-

mic

de-

for-

ma-

tion,

$$u_{\text{pred}}(x, t) \approx \int_F s(\xi, t) g(x, \xi) d\xi + \int_0^t \int_F \int_L \frac{s(\tau, \xi)}{\eta_{\text{eff}}(\zeta)} h(x, \xi, \zeta) d\zeta d\xi d\tau, \quad (13)$$

5188 which

5189 is

5190 valid

5191 for

5192 as

5193 long

5194 as

5195 the

5196 rate

5197 of

5198 de-

5199 for-

5200 ma-

5201 tion

5202 re-

5203 sult-

5204        ing  
5205        from  
5206        vis-  
5207        coelas-  
5208        tic  
5209        re-  
5210        lax-  
5211        ation  
5212        is  
5213        ap-  
5214        prox-  
5215        i-  
5216        mately  
5217        CON-  
5218        stant.  
5219        Al-  
5220        though  
5221        eq.  
5222        (??)  
5223        may  
5224        only  
5225        be  
5226        valid  
5227        for  
5228        a  
5229        short  
5230        por-  
5231        tion  
5232        of  
5233        the  
5234        post-  
5235        seis-  
5236        mic

5237 pe-  
5238 riod,  
5239 its  
5240 util-  
5241 ity  
5242 be-  
5243 comes  
5244 ap-  
5245 par-  
5246 ent  
5247 when  
5248 not-  
5249 ing  
5250 that  
5251 *g*  
5252 and  
5253 *h*  
5254 are  
5255 only  
5256 func-  
5257 tions  
5258 of  
5259 the  
5260 fault  
5261 ge-  
5262 om-  
5263 e-  
5264 try  
5265 and  
5266 in-  
5267 stan-  
5268 ta-  
5269 neous

5270       elas-  
5271       tic  
5272       prop-  
5273       er-  
5274       ties,  
5275        $\lambda$   
5276       and  
5277        $\mu$ ,  
5278       and  
5279       so  
5280        $g$   
5281       and  
5282        $h$   
5283       can  
5284       be  
5285       com-  
5286       puted  
5287       nu-  
5288       mer-  
5289       i-  
5290       cally  
5291       as  
5292       a  
5293       pre-  
5294       pro-  
5295       cess-  
5296       ing  
5297       step  
5298       and  
5299       the  
5300       for-  
5301       ward  
5302       prob-

5303      lem  
5304      in  
5305      eq.  
5306      (??)  
5307      can  
5308      be  
5309      rapidly  
5310      eval-  
5311      u-  
5312      ated  
5313      for  
5314      any  
5315      re-  
5316      al-  
5317      iza-  
5318      tion  
5319      of  
5320      *s*  
5321      and  
5322       $\eta_{\text{eff}}$ .  
5323      This  
5324      is  
5325      in  
5326      con-  
5327      trast  
5328      to  
5329      eval-  
5330      u-  
5331      at-  
5332      ing  
5333      the  
5334      full  
5335      for-

5336 ward  
5337 prob-  
5338 lem,  
5339 eq.  
5340 (??),  
5341 nu-  
5342 mer-  
5343 i-  
5344 cally  
5345 for  
5346 each  
5347 re-  
5348 al-  
5349 iza-  
5350 tion  
5351 of  
5352 s  
5353 and  
5354 un-  
5355 known  
5356 rhe-  
5357 O-  
5358 logic  
5359 prop-  
5360 er-  
5361 ties.  
5362 Fig-  
5363 ure  
5364 ??  
5365 shows  
5366 how  
5367 es-  
5368 ti-

5369        mates  
5370        of  
5371         $\eta_{\text{eff}}$   
5372        can  
5373        then  
5374        be  
5375        used  
5376        as  
5377        a  
5378        con-  
5379        straint  
5380        on  
5381        the  
5382        un-  
5383        known  
5384        pa-  
5385        ram-  
5386        e-  
5387        ters  
5388        for  
5389        var-  
5390        i-  
5391        ous  
5392        lin-  
5393        ear  
5394        vis-  
5395        coelas-  
5396        tic  
5397        rhe-  
5398        olo-  
5399        gies.

5400            We  
5401        per-

5402 form  
5403 an  
5404 ini-  
5405 tial  
5406 in-  
5407 ver-  
5408 sion  
5409 of  
5410 post-  
5411 seis-  
5412 mic  
5413 dis-  
5414 place-  
5415 ments  
5416 us-  
5417 ing  
5418 the  
5419 ap-  
5420 prox-  
5421 i-  
5422 ma-  
5423 tion  
5424 in  
5425 eq.  
5426 (??).  
5427 We  
5428 es-  
5429 ti-  
5430 mate  
5431 co-  
5432 seis-  
5433 mic  
5434 slip

5435 and  
5436 af-  
5437 ter-  
5438 slip  
5439 with  
5440 the  
5441 same  
5442 spa-  
5443 tial  
5444 and  
5445 tem-  
5446 po-  
5447 ral  
5448 dis-  
5449 cretiza-  
5450 tion  
5451 as  
5452 in  
5453 Sec-  
5454 tion  
5455 ??.  
5456 Si-  
5457 mul-  
5458 ta-  
5459 ne-  
5460 ously,  
5461 we  
5462 es-  
5463 ti-  
5464 mate  
5465  $\eta_{\text{eff}}$   
5466 within  
5467 six

5468 ver-  
5469 ti-  
5470 cally  
5471 strat-  
5472 i-  
5473 fied  
5474 lay-  
5475 ers  
5476 which  
5477 have  
5478 depths  
5479 rang-  
5480 ing  
5481 from  
5482 15-  
5483 30  
5484 km,  
5485 30-  
5486 60  
5487 km,  
5488 60-  
5489 90  
5490 km,  
5491 90-  
5492 120  
5493 km,  
5494 120-  
5495 150  
5496 km,  
5497 as  
5498 well  
5499 as  
5500 from

5501 150  
5502 km  
5503 to  
5504 the  
5505 bot-  
5506 tom  
5507 of  
5508 our  
5509 nu-  
5510 mer-  
5511 i-  
5512 cal  
5513 model  
5514 do-  
5515 main  
5516 at  
5517 800  
5518 km.  
5519 We  
5520 again  
5521 re-  
5522 strict  
5523 fault  
5524 slip  
5525 to  
5526 OC-  
5527 cur  
5528 be-  
5529 tween  
5530 0  
5531 and  
5532 15  
5533 km

5534 depth  
5535 and  
5536 we  
5537 made  
5538 this  
5539 choice  
5540 to  
5541 help  
5542 elim-  
5543 i-  
5544 nate  
5545 in-  
5546 evitable  
5547 non  
5548 unique-  
5549 ness.  
5550 It  
5551 has  
5552 long  
5553 been  
5554 rec-  
5555 og-  
5556 nized  
5557 that  
5558 fault  
5559 slip  
5560 at  
5561 suf-  
5562 fi-  
5563 ciently  
5564 great  
5565 depths  
5566 can

5567 pro-  
5568 duce  
5569 sur-  
5570 face  
5571 de-  
5572 for-  
5573 ma-  
5574 tion  
5575 that  
5576 is  
5577 in-  
5578 dis-  
5579 tin-  
5580 guish-  
5581 able  
5582 from  
5583 vis-  
5584 coelas-  
5585 tic  
5586 re-  
5587 lax-  
5588 ation,  
5589 at  
5590 least  
5591 in  
5592 two-  
5593 dimensional  
5594 earth-  
5595 quake  
5596 mod-  
5597 els  
5598 ?,  
5599 ]Sav-

5600 age1990.  
5601 Since  
5602 we  
5603 are  
5604 try-  
5605 ing  
5606 to  
5607 si-  
5608 mul-  
5609 ta-  
5610 ne-  
5611 ously  
5612 model  
5613 these  
5614 two  
5615 pro-  
5616 cesses,  
5617 it  
5618 is  
5619 nec-  
5620 es-  
5621 sary  
5622 to  
5623 put  
5624 sen-  
5625 si-  
5626 ble  
5627 con-  
5628 straints  
5629 on  
5630 the  
5631 depth  
5632 of

5633 fault  
5634 slip.  
5635 Ad-  
5636 di-  
5637 tion-  
5638 ally,  
5639 we  
5640 note  
5641 that  
5642 when  
5643 si-  
5644 mul-  
5645 ta-  
5646 ne-  
5647 ously  
5648 es-  
5649 ti-  
5650 mat-  
5651 ing  
5652 af-  
5653 ter-  
5654 slip  
5655 in  
5656 the  
5657 lower  
5658 crust  
5659 and  
5660 a  
5661 lower  
5662 crustal  
5663 vis-  
5664 COS-  
5665 ity,

5666 the  
5667 in-  
5668 verse  
5669 prob-  
5670 lem  
5671 be-  
5672 comes  
5673 par-  
5674 tic-  
5675 u-  
5676 larly  
5677 ill-  
5678 posed.  
5679 This  
5680 ill-  
5681 posedness  
5682 is  
5683 il-  
5684 lus-  
5685 trated  
5686 in  
5687 Fig-  
5688 ure  
5689 (??),  
5690 which  
5691 shows  
5692 the  
5693 dis-  
5694 place-  
5695 ments  
5696 re-  
5697 sult-  
5698 ing

5699 from  
5700 a  
5701 me-  
5702 ter  
5703 of  
5704 slip  
5705 on  
5706 a  
5707 fault  
5708 ex-  
5709 tend-  
5710 ing  
5711 from  
5712 15  
5713 to  
5714 30  
5715 km  
5716 depth  
5717 and  
5718 the  
5719 ini-  
5720 tial  
5721 ve-  
5722 loc-  
5723 ity  
5724 re-  
5725 sult-  
5726 ing  
5727 from  
5728 vis-  
5729 coelas-  
5730 tic  
5731 re-

5732 lax-  
5733 ation  
5734 in  
5735 the  
5736 lower  
5737 crust,  
5738 which  
5739 is  
5740 given  
5741 a  
5742 vis-  
5743 cos-  
5744 ity  
5745 of  
5746  $10^{18}$   
5747 Pa  
5748 S.  
5749 The  
5750 hor-  
5751 i-  
5752 zon-  
5753 tal  
5754 dis-  
5755 place-  
5756 ments  
5757 from  
5758 fault  
5759 slip  
5760 are  
5761 in  
5762 the  
5763 op-  
5764 po-

5765 site  
5766 di-  
5767 rec-  
5768 tion  
5769 as  
5770 the  
5771 dis-  
5772 place-  
5773 ments  
5774 re-  
5775 sult-  
5776 ing  
5777 from  
5778 sub-  
5779 se-  
5780 quent  
5781 vis-  
5782 coelas-  
5783 tic  
5784 re-  
5785 lax-  
5786 ation.  
5787 This  
5788 means  
5789 that  
5790 sur-  
5791 face  
5792 dis-  
5793 place-  
5794 ments  
5795 re-  
5796 sult-  
5797 ing

5798 from  
5799 af-  
5800 ter-  
5801 slip  
5802 at  
5803 lower  
5804 crustal  
5805 depths  
5806 can  
5807 be  
5808 can-  
5809 celled  
5810 out,  
5811 at  
5812 least  
5813 par-  
5814 tially,  
5815 by  
5816 a  
5817 low  
5818 vis-  
5819 COS-  
5820 ity  
5821 lower  
5822 crust.  
5823 We  
5824 elim-  
5825 i-  
5826 nate  
5827 this  
5828 null  
5829 space  
5830 by

5831 al-  
5832 low-  
5833 ing  
5834 only  
5835 one  
5836 mech-  
5837 a-  
5838 nism  
5839 in  
5840 the  
5841 lower  
5842 crust,  
5843 which  
5844 we  
5845 choose  
5846 to  
5847 be  
5848 vis-  
5849 coelas-  
5850 tic  
5851 re-  
5852 lax-  
5853 ation.  
5854 This  
5855 is  
5856 not  
5857 to  
5858 say  
5859 that  
5860 we  
5861 do  
5862 not  
5863 be-

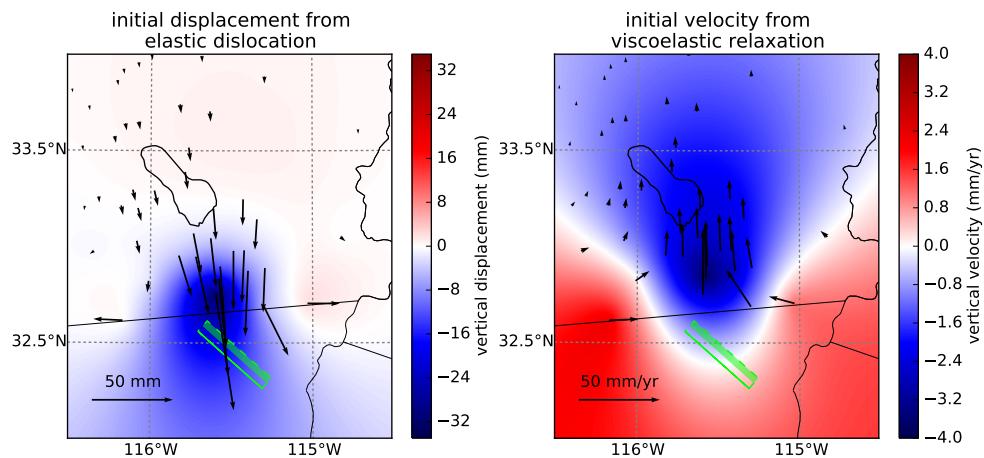
5864 lieve  
5865 deep  
5866 af-  
5867 ter-  
5868 slip  
5869 to  
5870 be  
5871 a  
5872 pos-  
5873 si-  
5874 bil-  
5875 ity,  
5876 rather  
5877 we  
5878 re-  
5879 strict  
5880 slip  
5881 to  
5882 seis-  
5883 mo-  
5884 genic  
5885 depths  
5886 as  
5887 a  
5888 mod-  
5889 elling  
5890 ne-  
5891 ces-  
5892 sity.  
5893 Al-  
5894 though,  
5895 it  
5896 has

5897 been  
5898 noted  
5899 that  
5900 the  
5901 pat-  
5902 tern  
5903 of  
5904 ver-  
5905 ti-  
5906 cal  
5907 post-  
5908 seis-  
5909 mic  
5910 de-  
5911 for-  
5912 ma-  
5913 tion  
5914 fol-  
5915 low-  
5916 ing  
5917 the  
5918 El  
5919 Mayor-  
5920 Cucpah  
5921 earth-  
5922 quake  
5923 in-  
5924 di-  
5925 cates  
5926 that  
5927 a  
5928 sig-  
5929 nif-

5930 i-  
5931 cant  
5932 amount  
5933 of  
5934 af-  
5935 ter-  
5936 slip  
5937 must  
5938 be  
5939 shal-  
5940 low  
5941 ?,  
5942 ]Rollins2015.

6081 Further

6082 de-  
6083 tails  
6084 on  
6085 how  
6086 *s*  
6087 and  
6088  $\eta_{\text{eff}}$   
6089 are  
6090 es-  
6091 ti-  
6092 mated  
6093 from  
6094 post-  
6095 seis-  
6096 mic  
6097 de-  
6098 for-  
6099 ma-  
6100 tion

**Figure 9.**

Dis-  
place-  
ments  
re-  
sult-  
ing  
from  
fault  
slip  
at  
lower  
crustal  
depths  
(left),  
and  
ini-  
tial  
ve-  
loc-  
ity  
re-  
sult-  
ing  
from  
sub-  
se-  
quent  
re-  
lax-  
ation  
of  
a  
vis-  
coelas-  
tic  
lower  
crust

5943

5944

5945 place-  
5946 ments5947 re-  
5948 sult-  
5949 ing5950 from  
5951 fault5952 slip  
5953 at5954 lower  
5955 crustal5956 depths  
5957 (left),5958 and  
5959 ini-5960 tial  
5961 ve-5962 loc-  
5963 ity5964 re-  
5965 sult-  
5966 ing5967 from  
5968 sub-5969 se-  
5970 quent5971 re-  
5972 lax-  
5973 ation5974 of  
5975 a5976 vis-  
5977 coelas-5978 tic  
5979 lower

5980 crust

6101 can  
6102 be  
6103 found  
6104 in  
6105 ?,  
6106 ]Hines2016.  
6107 A  
6108 non-  
6109 linear  
6110 Kalman  
6111 fil-  
6112 ter  
6113 based  
6114 in-  
6115 verse  
6116 method  
6117 can  
6118 also  
6119 be  
6120 used  
6121 to  
6122 es-  
6123 ti-  
6124 mate  
6125 *s*  
6126 and  
6127  $\eta_{\text{eff}}$   
6128 in  
6129 a  
6130 man-  
6131 ner  
6132 akin  
6133 to

6134 ?,  
6135 ]Segall1997  
6136 or  
6137 ?,  
6138 ]McGuire2003,  
6139 in  
6140 which  
6141 we  
6142 would  
6143 not  
6144 have  
6145 to  
6146 ex-  
6147 plic-  
6148 itly  
6149 im-  
6150 pose  
6151 a  
6152 time  
6153 de-  
6154 pen-  
6155 dent  
6156 parametriza-  
6157 tion  
6158 of  
6159 *s.*  
6160 We  
6161 have  
6162 thor-  
6163 oughly  
6164 ex-  
6165 plored  
6166 Kalman

6167 fil-  
6168 ter  
6169 based  
6170 ap-  
6171 proaches,  
6172 but  
6173 we  
6174 ul-  
6175 ti-  
6176 mately  
6177 pre-  
6178 fer  
6179 the  
6180 method  
6181 de-  
6182 scribed  
6183 in  
6184 ?,  
6185 ]Hines2016  
6186 be-  
6187 cause  
6188 of  
6189 its  
6190 rel-  
6191 a-  
6192 tive  
6193 sim-  
6194 plic-  
6195 ity.  
6196 More-  
6197 over,  
6198 we  
6199 be-

6200 lieve  
6201 the  
6202 piece-  
6203 wise  
6204 con-  
6205 tin-  
6206 u-  
6207 ous  
6208 rep-  
6209 re-  
6210 sen-  
6211 ta-  
6212 tion  
6213 of  
6214 slip  
6215 with  
6216 re-  
6217 spect  
6218 to  
6219 time  
6220 to  
6221 be  
6222 suf-  
6223 fi-  
6224 ciently  
6225 gen-  
6226 eral  
6227 for  
6228 the  
6229 re-  
6230 solv-  
6231 ing  
6232 power

6233 of  
6234 these  
6235 GPS  
6236 data.

6237 The  
6238 first  
6239 step  
6240 in  
6241 our  
6242 in-  
6243 verse  
6244 method  
6245 is  
6246 to  
6247 de-  
6248 ter-  
6249 mine  
6250 at  
6251 which  
6252 point  
6253 the  
6254 early  
6255 post-  
6256 seis-  
6257 mic  
6258 ap-  
6259 prox-  
6260 i-  
6261 ma-  
6262 tion  
6263 breaks  
6264 down,  
6265 which

6266 we  
6267 will  
6268 de-  
6269 note  
6270 as  
6271  $t_{bd}$ .  
6272 As  
6273 noted,  
6274 it  
6275 is  
6276 valid  
6277 for  
6278 ap-  
6279 prox-  
6280 i-  
6281 mately  
6282 as  
6283 long  
6284 as  
6285 the  
6286 rate  
6287 of  
6288 de-  
6289 for-  
6290 ma-  
6291 tion  
6292 re-  
6293 sult-  
6294 ing  
6295 from  
6296 vis-  
6297 coelas-  
6298 tic

6299 re-  
6300 lax-  
6301 ation  
6302 is  
6303 ap-  
6304 prox-  
6305 i-  
6306 mately  
6307 CON-  
6308 stant.  
6309 We  
6310 can  
6311 al-  
6312 most  
6313 cer-  
6314 tainly  
6315 as-  
6316 sume  
6317 that  
6318 de-  
6319 for-  
6320 ma-  
6321 tion  
6322 at  
6323 the  
6324 most  
6325 far-  
6326 field  
6327 sta-  
6328 tions,  
6329 which  
6330 are  
6331 ~

6332 400  
6333 km  
6334 away  
6335 from  
6336 the  
6337 El  
6338 Mayor-  
6339 Cucapah  
6340 epi-  
6341 cen-  
6342 tre,  
6343 is  
6344 the  
6345 re-  
6346 sult  
6347 of  
6348 vis-  
6349 coelas-  
6350 tic  
6351 re-  
6352 lax-  
6353 ation.  
6354 The  
6355 ap-  
6356 prox-  
6357 i-  
6358 ma-  
6359 tion  
6360 should  
6361 then  
6362 be  
6363 valid  
6364 for

6365 as  
6366 long  
6367 as  
6368 a  
6369 lin-  
6370 ear  
6371 trend  
6372 ad-  
6373 e-  
6374 quately  
6375 ap-  
6376 prox-  
6377 i-  
6378 mates  
6379 the  
6380 far-  
6381 field  
6382 de-  
6383 for-  
6384 ma-  
6385 tion.  
6386 Us-  
6387 ing  
6388 this  
6389 logic,  
6390 it  
6391 would  
6392 ap-  
6393 pear  
6394 that  
6395  $t_{bd} \approx$   
6396 1  
6397 year

6398 af-  
6399 ter  
6400 the  
6401 El  
6402 Mayor-  
6403 Cucapah  
6404 earth-  
6405 quake.  
6406 An-  
6407 other  
6408 way  
6409 to  
6410 de-  
6411 ter-  
6412 mine  
6413  $t_{bd}$   
6414 is  
6415 to  
6416 find  
6417 the  
6418 best  
6419 fit-  
6420 ting  
6421 pre-  
6422 dic-  
6423 tion  
6424 of  
6425 eq.  
6426 (??)  
6427 to  
6428 ob-  
6429 served  
6430 de-

6431 for-  
6432 ma-  
6433 tion  
6434 us-  
6435 ing  
6436 in-  
6437 creas-  
6438 ing  
6439 du-  
6440 ra-  
6441 tions  
6442 of  
6443 the  
6444 post-  
6445 seis-  
6446 mic  
6447 time  
6448 se-  
6449 ries.  
6450  $t_{bd}$   
6451 should  
6452 be  
6453 the  
6454 point  
6455 when  
6456 eq.  
6457 (??)  
6458 is  
6459 no  
6460 longer  
6461 ca-  
6462 pa-  
6463 ble

6464 of  
6465 de-  
6466 scrib-  
6467 ing  
6468 the  
6469 ob-  
6470 served  
6471 de-  
6472 for-  
6473 ma-  
6474 tion  
6475 with-  
6476 out  
6477 in-  
6478 cur-  
6479 ring  
6480 sys-  
6481 tem-  
6482 atic  
6483 mis-  
6484 fits.  
6485 This  
6486 is  
6487 il-  
6488 lus-  
6489 trated  
6490 in  
6491 Fig-  
6492 ure  
6493 ??,  
6494 which  
6495 show  
6496 the

6497 scaled  
6498 ra-  
6499 dial  
6500 com-  
6501 po-  
6502 nents  
6503 of  
6504 dis-  
6505 place-  
6506 ment  
6507 for  
6508 sta-  
6509 tions  
6510 along  
6511 the  
6512 El  
6513 Mayor-  
6514 Cucapah  
6515 P  
6516 axis.  
6517 When  
6518 us-  
6519 ing  
6520 eq.  
6521 (??)  
6522 to  
6523 fit  
6524 the  
6525 en-  
6526 tire  
6527 5  
6528 years  
6529 of

6530 post-  
6531 seis-  
6532 mic  
6533 dis-  
6534 place-  
6535 ment  
6536 we  
6537 see  
6538 that  
6539 the  
6540 near-  
6541 field  
6542 dis-  
6543 place-  
6544 ments,  
6545 e.g.  
6546 sta-  
6547 tion  
6548 P501,  
6549 are  
6550 ac-  
6551 cul-  
6552 rately  
6553 pre-  
6554 dicted  
6555 but  
6556 when  
6557 look-  
6558 ing  
6559 at  
6560 dis-  
6561 place-  
6562 ment

6563 in  
6564 the  
6565 far-  
6566 field,  
6567 e.g.  
6568 sta-  
6569 tion  
6570 P621,  
6571 we  
6572 see  
6573 that  
6574 eq.  
6575 (??)  
6576 over-  
6577 es-  
6578 ti-  
6579 mates  
6580 the  
6581 rate  
6582 of  
6583 de-  
6584 for-  
6585 ma-  
6586 tion  
6587 in  
6588 the  
6589 later  
6590 post-  
6591 seis-  
6592 mic  
6593 pe-  
6594 riod  
6595 and

6596 un-  
6597 der-  
6598 es-  
6599 ti-  
6600 mates  
6601 the  
6602 rate  
6603 of  
6604 de-  
6605 for-  
6606 ma-  
6607 tion  
6608 in  
6609 the  
6610 early  
6611 pe-  
6612 riod.  
6613 Due  
6614 to  
6615 the  
6616 low  
6617 signal-  
6618 to-  
6619 noise  
6620 ra-  
6621 tios  
6622 for  
6623 far-  
6624 field  
6625 sta-  
6626 tions,  
6627 it  
6628 is

6629 dif-  
6630 fi-  
6631 cult  
6632 to  
6633 de-  
6634 ter-  
6635 mine  
6636 at  
6637 what  
6638 point  
6639 eq.  
6640 (??)  
6641 is  
6642 no  
6643 longer  
6644 able  
6645 to  
6646 pre-  
6647 dict  
6648 the  
6649 ob-  
6650 served  
6651 dis-  
6652 place-  
6653 ments  
6654 with-  
6655 out  
6656 in-  
6657 cur-  
6658 ring  
6659 any  
6660 sig-  
6661 nif-

6662 i-  
6663 cant  
6664 sys-  
6665 tem-  
6666 atic  
6667 mis-  
6668 fit;  
6669 how-  
6670 ever,  
6671 we  
6672 set-  
6673 tle  
6674 on  
6675  $t_{bd} =$   
6676 0.8  
6677 years  
6678 af-  
6679 ter  
6680 the  
6681 earth-  
6682 quake,  
6683 while  
6684 ac-  
6685 knowl-  
6686 edg-  
6687 ing  
6688 that  
6689 the  
6690 choice  
6691 is  
6692 sub-  
6693 jec-  
6694 tive.

6695 As  
6696 noted  
6697 in  
6698 ?,  
6699 ]Hines2016,  
6700 over-  
6701 es-  
6702 ti-  
6703 mat-  
6704 ing  
6705  $t_{bd}$   
6706 will  
6707 re-  
6708 sult  
6709 in  
6710 a  
6711 bias  
6712 to-  
6713 wards  
6714 over-  
6715 es-  
6716 ti-  
6717 mat-  
6718 ing  
6719  $\eta_{eff}$ ,  
6720 while  
6721 pick-  
6722 ing  
6723 a  
6724  $t_{bd}$   
6725 which  
6726 is  
6727 too

6728 low  
6729 will  
6730 not  
6731 nec-  
6732 es-  
6733 sar-  
6734 ily  
6735 re-  
6736 sult  
6737 in  
6738 a  
6739 bi-  
6740 ased  
6741 es-  
6742 ti-  
6743 mate  
6744 of  
6745  $\eta_{\text{eff}}$ ,  
6746 al-  
6747 though  
6748 the  
6749 un-  
6750 cer-  
6751 tain-  
6752 ties  
6753 would  
6754 be  
6755 larger.  
6756 We  
6757 can  
6758 then  
6759 con-  
6760 sider

6761 in-  
6762 fer-  
6763 ences  
6764 of  
6765  $\eta_{\text{eff}}$   
6766 to  
6767 be  
6768 an  
6769 up-  
6770 per  
6771 bound  
6772 on  
6773 the  
6774 vis-  
6775 COS-  
6776 ity  
6777 needed  
6778 to  
6779 de-  
6780 scribe  
6781 the  
6782 far-  
6783 field  
6784 rate  
6785 of  
6786 de-  
6787 for-  
6788 ma-  
6789 tion  
6790 dur-  
6791 ing  
6792 the  
6793 first

6794 0.8

6795 years

6796 of

6797 post-

6798 seis-

6799 mic

6800 de-

6801 for-

6802 ma-

6803 tion.

We

es-

ti-

mate

co-

seis-

mic

slip,

af-

ter-

slip,

and

ef-

fec-

tive

vis-

cos-

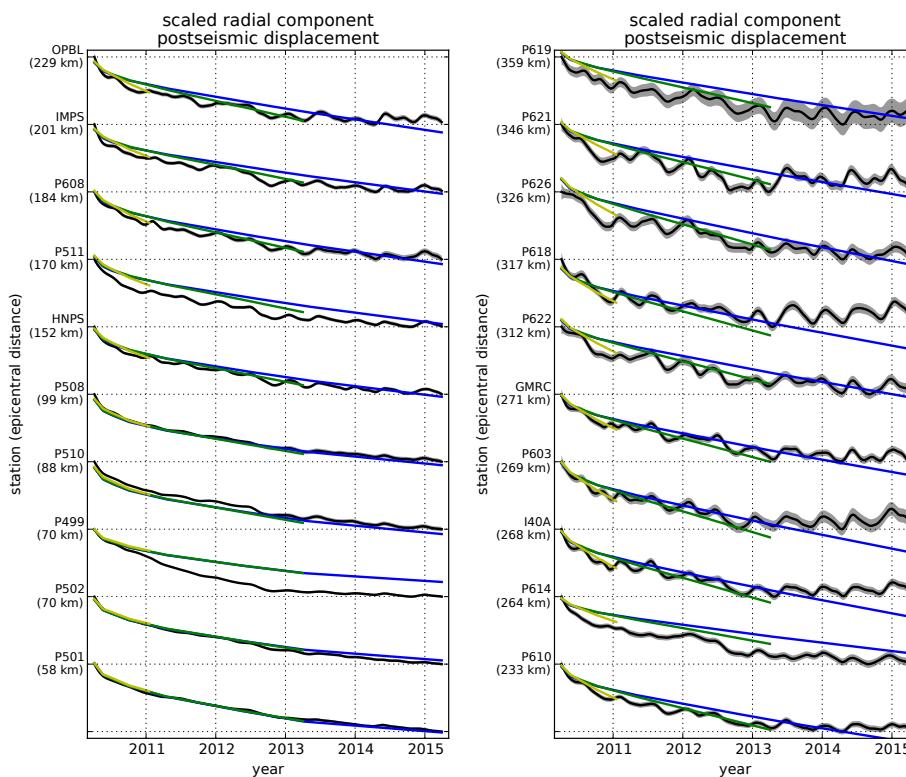
ity

by

solv-

ing

$$\min_{s, \eta_{\text{eff}}} \left( \left\| \frac{u_{\text{pred}}(s, \eta_{\text{eff}}) - u_{\text{obs}}}{\sigma_{\text{obs}}} \right\|_2^2 + \lambda_s \|s\|_2^2 + \lambda_\eta \|\nabla \eta_{\text{eff}}^{-1}\|_2^2 \right) \quad (14)$$

**Figure 10.**

II-  
lus-  
tra-  
tion  
of  
how  
 $t_{bd}$   
is  
cho-  
sen.  
Ob-  
served  
post-  
seis-  
mic  
dis-  
place-  
ments  
are  
shown  
in  
black.  
Blue,  
green  
and  
yellow

6859 where  
6860  $u_{\text{obs}}$   
6861 con-  
6862 sists  
6863 of  
6864 the  
6865 first  
6866 0.8  
6867 years  
6868 of  
6869 post-  
6870 seis-  
6871 mic  
6872 de-  
6873 for-  
6874 ma-  
6875 tion  
6876 and  
6877  $u_{\text{pred}}$   
6878 are  
6879 the  
6880 pre-  
6881 dicted  
6882 dis-  
6883 place-  
6884 ments  
6885 from  
6886 eq.  
6887 (??).  
6888 Due  
6889 to  
6890 in-  
6891 her-

6892 ent  
6893 non  
6894 unique-  
6895 ness,  
6896 we  
6897 have  
6898 added  
6899 ze-  
6900 roth  
6901 or-  
6902 der  
6903 Tikhonov  
6904 reg-  
6905 u-  
6906 lar-  
6907 iza-  
6908 tion  
6909 to  
6910 es-  
6911 ti-  
6912 mates  
6913 of  
6914 *s*,  
6915 and  
6916 sec-  
6917 ond  
6918 or-  
6919 der  
6920 Tikhonov  
6921 reg-  
6922 ul-  
6923 lar-  
6924 iza-

6925      tion  
6926      to  
6927      es-  
6928      ti-  
6929      mates  
6930      of  
6931      ef-  
6932      fec-  
6933      tive  
6934      flu-  
6935      id-  
6936      ity,  
6937       $\eta_{\text{eff}}^{-1}$ .  
6938      The  
6939      de-  
6940      gree  
6941      to  
6942      which  
6943      we  
6944      im-  
6945      pose  
6946      the  
6947      reg-  
6948      ul-  
6949      lar-  
6950      iza-  
6951      tion  
6952      on  
6953      slip  
6954      and  
6955      flu-  
6956      id-  
6957      ity

6958 is  
6959 con-  
6960 trolled  
6961 by  
6962 the  
6963 penalty  
6964 pa-  
6965 ram-  
6966 e-  
6967 ters  
6968  $\lambda_s$   
6969 and  
6970  $\lambda_\eta$ .  
6971 The  
6972 penalty  
6973 pa-  
6974 ram-  
6975 e-  
6976 ters  
6977 are  
6978 cho-  
6979 sen  
6980 with  
6981 two  
6982 trade-  
6983 off  
6984 curves.  
6985 We  
6986 first  
6987 choose  
6988  $\lambda_s$   
6989 while  
6990 fix-

6991 ing  
6992  $\lambda_\eta$   
6993 at  
6994 0  
6995 and  
6996 then  
6997 we  
6998 de-  
6999 ter-  
7000 mine  
7001  $\lambda_\eta$   
7002 with  
7003  $\lambda_s$   
7004 fixed  
7005 at  
7006 its  
7007 cho-  
7008 sen  
7009 value.  
7010 Our  
7011 goal  
7012 here  
7013 is  
7014 to  
7015 get  
7016 a  
7017 prior  
7018 con-  
7019 straint  
7020 on  
7021  $\eta_{\text{eff}}$   
7022 to  
7023 min-

7024 i-  
7025 mize  
7026 the  
7027 amount  
7028 of  
7029 search-  
7030 ing  
7031 we  
7032 have  
7033 to  
7034 do  
7035 when  
7036 de-  
7037 scrib-  
7038 ing  
7039 the  
7040 post-  
7041 seis-  
7042 mic  
7043 de-  
7044 for-  
7045 ma-  
7046 tion  
7047 over  
7048 the  
7049 full  
7050 5  
7051 years,  
7052 which  
7053 we  
7054 do  
7055 in  
7056 Sec-

7057      tion  
7058      ??.  
7059      Es-  
7060      ti-  
7061      mates  
7062      of  
7063      s  
7064      made  
7065      here  
7066      will  
7067      not  
7068      be  
7069      used  
7070      in  
7071      Sec-  
7072      tion  
7073      ??,  
7074      and  
7075      so  
7076      the  
7077      mo-  
7078      ti-  
7079      va-  
7080      tion  
7081      be-  
7082      hind  
7083      even  
7084      adding  
7085      reg-  
7086      u-  
7087      lar-  
7088      iza-  
7089      tion

7090 to  
7091 s  
7092 is  
7093 to  
7094 en-  
7095 sure  
7096 that  
7097 the  
7098 slip  
7099 driv-  
7100 ing  
7101 vis-  
7102 coelas-  
7103 tic  
7104 re-  
7105 lax-  
7106 ation  
7107 in  
7108 eq.  
7109 (??)  
7110 is  
7111 sen-  
7112 si-  
7113 ble.

7114 Our  
7115 in-  
7116 ferred  
7117 es-  
7118 ti-  
7119 mates  
7120 of  
7121 ef-  
7122 fec-

7123 tive  
7124 vis-  
7125 cosi-  
7126 ties,  
7127 and  
7128 cor-  
7129 re-  
7130 spond-  
7131 ing  
7132 flu-  
7133 idi-  
7134 ties,  
7135 are  
7136 shown  
7137 in  
7138 Fig-  
7139 ure  
7140 ??  
7141 with  
7142 their  
7143 95%  
7144 con-  
7145 fi-  
7146 dence  
7147 in-  
7148 ter-  
7149 vals  
7150 in-  
7151 di-  
7152 cated,  
7153 which  
7154 were  
7155 es-

7156 ti-  
7157 mated  
7158 through  
7159 boot-  
7160 strap-  
7161 ping.  
7162 Al-  
7163 though  
7164 flu-  
7165 id-  
7166 ity  
7167 is  
7168 rarely  
7169 used  
7170 in  
7171 geo-  
7172 phys-  
7173 i-  
7174 cal  
7175 lit-  
7176 er-  
7177 a-  
7178 ture,  
7179 eq.  
7180 (??)  
7181 is  
7182 lin-  
7183 ear  
7184 with  
7185 re-  
7186 spect  
7187 to  
7188 flu-

7189 id-  
7190 ity  
7191 and  
7192 so  
7193 the  
7194 flu-  
7195 id-  
7196 ity  
7197 in-  
7198 di-  
7199 cates  
7200 the  
7201 am-  
7202 pli-  
7203 tude  
7204 of  
7205 the  
7206 vis-  
7207 coelas-  
7208 tic  
7209 sig-  
7210 nal  
7211 com-  
7212 ing  
7213 from  
7214 each  
7215 layer.  
7216 We  
7217 note  
7218 that  
7219 the  
7220 mag-  
7221 ni-

7222 tude  
7223 of  
7224 the  
7225 un-  
7226 cer-  
7227 tain-  
7228 ties  
7229 on  
7230 vis-  
7231 cos-  
7232 ity  
7233 tend  
7234 to  
7235 de-  
7236 crease  
7237 as  
7238 we  
7239 in-  
7240 crease  
7241  $\lambda_\eta$ .  
7242 Our  
7243 choice  
7244 of  
7245  $\lambda_\eta$   
7246 was  
7247 based  
7248 on  
7249 a  
7250 stan-  
7251 dard  
7252 tech-  
7253 nique  
7254 used

7255 in  
7256 geo-  
7257 phys-  
7258 i-  
7259 cal  
7260 in-  
7261 verse  
7262 prob-  
7263 lems  
7264 which  
7265 has  
7266 no  
7267 sta-  
7268 tis-  
7269 ti-  
7270 cal  
7271 back-  
7272 ing.  
7273 It  
7274 is  
7275 there-  
7276 fore  
7277 dif-  
7278 fi-  
7279 cult  
7280 to  
7281 in-  
7282 ter-  
7283 pret  
7284 the  
7285 mag-  
7286 ni-  
7287 tude

7288 of  
7289 un-  
7290 cer-  
7291 tain-  
7292 ties  
7293 on  
7294 vis-  
7295 cosi-  
7296 ties  
7297 shown  
7298 in  
7299 Fig-  
7300 ure  
7301 ??;  
7302 al-  
7303 though,  
7304 we  
7305 do  
7306 be-  
7307 lieve  
7308 that  
7309 the  
7310 rel-  
7311 a-  
7312 tive  
7313 un-  
7314 cer-  
7315 tainty  
7316 be-  
7317 tween  
7318 lay-  
7319 ers  
7320 is

7321 ac-  
7322 cu-  
7323 rately  
7324 de-  
7325 picted.  
7326 A  
7327 ro-  
7328 bust  
7329 fea-  
7330 ture  
7331 that  
7332 we  
7333 see  
7334 is  
7335 that  
7336 the  
7337 largest  
7338 jump  
7339 in  
7340 flu-  
7341 id-  
7342 ity  
7343 is  
7344 at  
7345 60  
7346 km  
7347 depth,  
7348 which  
7349 is  
7350 con-  
7351 sis-  
7352 tent  
7353 with

7354 the  
7355 range  
7356 of  
7357 lithosphere-  
7358 asthenosphere  
7359 bound-  
7360 ary  
7361 depths  
7362 in-  
7363 fered  
7364 by  
7365 ?,  
7366 ]Le-  
7367 kic2011.  
7368 This  
7369 tran-  
7370 si-  
7371 tional  
7372 depth  
7373 is  
7374 also  
7375 con-  
7376 sis-  
7377 tent  
7378 with  
7379 the  
7380 the  
7381 vis-  
7382 cos-  
7383 ity  
7384 struc-  
7385 ture  
7386 re-

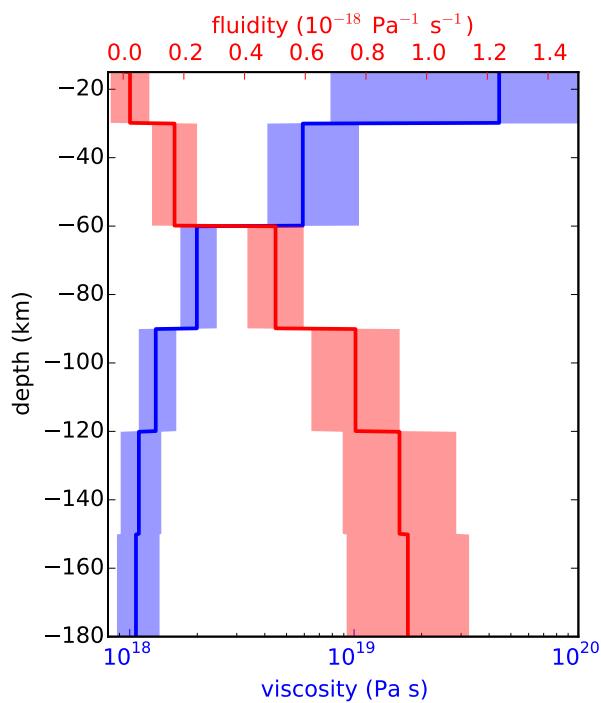
7387 quired  
7388 to  
7389 ex-  
7390 plain  
7391 far  
7392 field  
7393 post-  
7394 seis-  
7395 mic  
7396 de-  
7397 for-  
7398 ma-  
7399 tion  
7400 fol-  
7401 low-  
7402 ing  
7403 the  
7404 Hec-  
7405 tor  
7406 Mine  
7407 earth-  
7408 quake  
7409 ?,  
7410 ]Freed2007a.  
7411 We  
7412 find  
7413 that  
7414 the  
7415 vis-  
7416 COS-  
7417 ity  
7418 be-  
7419 low

7420 60  
7421 km  
7422 depth  
7423 needs  
7424 to  
7425 be  
7426 ~  
7427 1×  
7428 10<sup>18</sup>  
7429 Pa  
7430 s  
7431 to  
7432 de-  
7433 scribe  
7434 the  
7435 early  
7436 rate  
7437 of  
7438 post-  
7439 seis-  
7440 mic  
7441 de-  
7442 for-  
7443 ma-  
7444 tion  
7445 at  
7446 far-  
7447 field  
7448 sta-  
7449 tions  
7450 while  
7451 the  
7452 lower

7453 crust  
7454 and  
7455 up-  
7456 per-  
7457 most  
7458 man-  
7459 tle  
7460 need  
7461 to  
7462 be  
7463 rel-  
7464 a-  
7465 tively  
7466 stronger.  
7467 The  
7468 vis-  
7469 COS-  
7470 ity  
7471 of  
7472 the  
7473 lower  
7474 crust  
7475 is  
7476 the  
7477 least  
7478 well  
7479 con-  
7480 strained  
7481 as  
7482 there  
7483 is  
7484 no  
7485 ev-

7486 i-  
7487 dence  
7488 of  
7489 re-  
7490 lax-  
7491 ation  
7492 in  
7493 that  
7494 layer,  
7495 mean-  
7496 ing  
7497 that  
7498 it  
7499 is  
7500 ef-  
7501 fec-  
7502 tively  
7503 elas-  
7504 tic  
7505 over  
7506 the  
7507 first  
7508 0.8  
7509 years  
7510 af-  
7511 ter  
7512 the  
7513 earth-  
7514 quake.

7566 Our  
7567 ini-  
7568 tial  
7569 es-

**Figure 11.**

7515 Ef-  
 7516 fec-  
 7517 tive  
 7518 vis-  
 7519 cos-  
 7520 ity  
 7521 and  
 7522 as-  
 7523 so-  
 7524 ci-  
 7525 ated  
 7526 flu-  
 7527 di-  
 7528 ties  
 7529 in-  
 7530 fered  
 7531 by  
 7532 fit-  
 7533 ting  
 7534 eq.  
 7535 (??)  
 7536 to  
 7537 the  
 7538 first  
 7539 0.8  
 7540 years  
 7541 -255-  
 7542 post-

7570 ti-  
7571 mate  
7572 for  
7573 co-  
7574 seis-  
7575 mic  
7576 slip  
7577 and  
7578 cu-  
7579 mu-  
7580 la-  
7581 tive  
7582 af-  
7583 ter-  
7584 slip  
7585 over  
7586 the  
7587 first  
7588 0.8  
7589 years  
7590 af-  
7591 ter  
7592 the  
7593 El  
7594 Mayor-  
7595 Cucapah  
7596 earth-  
7597 quake  
7598 are  
7599 shown  
7600 in  
7601 Fig-  
7602 ure

7603 ??.  
7604 Sim-  
7605 i-  
7606 lar  
7607 to  
7608 our  
7609 elas-  
7610 tic  
7611 slip  
7612 model  
7613 from  
7614 Sec-  
7615 tion  
7616 ??,  
7617 co-  
7618 seis-  
7619 mic  
7620 slip  
7621 is  
7622 in-  
7623 ferred  
7624 to  
7625 be  
7626 in  
7627 the  
7628 Sierra  
7629 Cu-  
7630 ca-  
7631 pah  
7632 and  
7633 it  
7634 is  
7635 right

7636 lat-  
7637 eral  
7638 with  
7639 a  
7640 sig-  
7641 nif-  
7642 i-  
7643 cant  
7644 nor-  
7645 mal  
7646 com-  
7647 po-  
7648 nent.  
7649 This  
7650 is  
7651 con-  
7652 sis-  
7653 tent  
7654 with  
7655 field  
7656 stud-  
7657 ies  
7658 ?,  
7659 ]Fletcher2014,  
7660 as  
7661 well  
7662 as  
7663 the  
7664 co-  
7665 seis-  
7666 mic  
7667 slip  
7668 from

7669 ?,  
7670 ]Wei2011.  
7671 The  
7672 po-  
7673 tency  
7674 of  
7675 in-  
7676 fered  
7677 co-  
7678 seis-  
7679 mic  
7680 slip  
7681 is  
7682 3.3×  
7683 10<sup>9</sup> m<sup>3</sup>,  
7684 which  
7685 is  
7686 also  
7687 about  
7688 the  
7689 same  
7690 as  
7691 that  
7692 in-  
7693 fered  
7694 from  
7695 Sec-  
7696 tion  
7697 ??.  
7698 The  
7699 present  
7700 in-  
7701 fer-

7702 ence  
7703 of  
7704 af-  
7705 ter-  
7706 slip  
7707 on  
7708 the  
7709 In-  
7710 di-  
7711 viso  
7712 fault  
7713 is  
7714 sig-  
7715 nif-  
7716 i-  
7717 cantly  
7718 less  
7719 than  
7720 what  
7721 was  
7722 found  
7723 in  
7724 the  
7725 Sec-  
7726 tion  
7727 ??  
7728 where  
7729 we  
7730 did  
7731 not  
7732 ac-  
7733 count  
7734 for

7735 vis-  
7736 coelas-  
7737 tic-  
7738 ity.  
7739 When  
7740 fault  
7741 slip  
7742 is  
7743 si-  
7744 mul-  
7745 ta-  
7746 ne-  
7747 ously  
7748 es-  
7749 ti-  
7750 mated  
7751 with  
7752 a  
7753 litho-  
7754 spheric  
7755 and  
7756 as-  
7757 theno-  
7758 spheric  
7759 vis-  
7760 cos-  
7761 ity,  
7762 the  
7763 po-  
7764 tency  
7765 of  
7766 in-  
7767 ferred

7768 af-  
7769 ter-  
7770 slip  
7771 over  
7772 the  
7773 first  
7774 0.8  
7775 years  
7776 af-  
7777 ter  
7778 the  
7779 earth-  
7780 quake  
7781 is  
7782  $0.85\times$   
7783  $10^9 \text{ m}^3$ ,  
7784 com-  
7785 pared  
7786 to  
7787  $3.46\times$   
7788  $10^9 \text{ m}^3$   
7789 when  
7790 we  
7791 as-  
7792 sume  
7793 the  
7794 litho-  
7795 sphere  
7796 and  
7797 as-  
7798 theno-  
7799 sphere  
7800 are

7801 elas-  
7802 tic.  
7803 The  
7804 sig-  
7805 nif-  
7806 i-  
7807 cant  
7808 amount  
7809 of  
7810 af-  
7811 ter-  
7812 slip  
7813 in-  
7814 ferred  
7815 on  
7816 the  
7817 In-  
7818 di-  
7819 viso  
7820 fault  
7821 seems  
7822 to  
7823 be  
7824 com-  
7825 pen-  
7826 sat-  
7827 ing  
7828 for  
7829 un-  
7830 mod-  
7831 elled  
7832 vis-  
7833 coelas-

7834 tic  
7835 re-  
7836 lax-  
7837 ation  
7838 at  
7839 depths  
7840 greater  
7841 than  
7842 60  
7843 km.  
7844 The  
7845 fact  
7846 that  
7847 there  
7848 is  
7849 still  
7850 an  
7851 ap-  
7852 pre-  
7853 cia-  
7854 ble  
7855 amount  
7856 of  
7857 af-  
7858 ter-  
7859 slip  
7860 in-  
7861 ferred  
7862 on  
7863 the  
7864 In-  
7865 di-  
7866 viso

7867 fault  
7868 even  
7869 when  
7870 al-  
7871 low-  
7872 ing  
7873 for  
7874 vis-  
7875 coelas-  
7876 tic  
7877 re-  
7878 lax-  
7879 ation  
7880 in  
7881 the  
7882 lower  
7883 crust  
7884 and  
7885 up-  
7886 per  
7887 man-  
7888 tle  
7889 raises  
7890 the  
7891 ques-  
7892 tion  
7893 of  
7894 whether  
7895 it  
7896 is  
7897 com-  
7898 pen-  
7899 sat-

7900 ing  
7901 for  
7902 vis-  
7903 coelas-  
7904 tic  
7905 re-  
7906 lax-  
7907 ation  
7908 that  
7909 is  
7910 more  
7911 lo-  
7912 cal-  
7913 ized  
7914 than  
7915 what  
7916 we  
7917 al-  
7918 low  
7919 for  
7920 since  
7921 we  
7922 only  
7923 es-  
7924 ti-  
7925 mate  
7926 depth  
7927 de-  
7928 pen-  
7929 dent  
7930 vari-  
7931 a-  
7932 tions

7933 in

7934 vis-

7935 COS-

7936 ity.

7965

7966 **3.3 Full**

7967 **In-**

7968 **ver-**

7969 **sion**

In

the

pre-

vi-

ous

sec-

tion,

we

used

the

in-

verse

method

from

?,

]Hines2016

to

con-

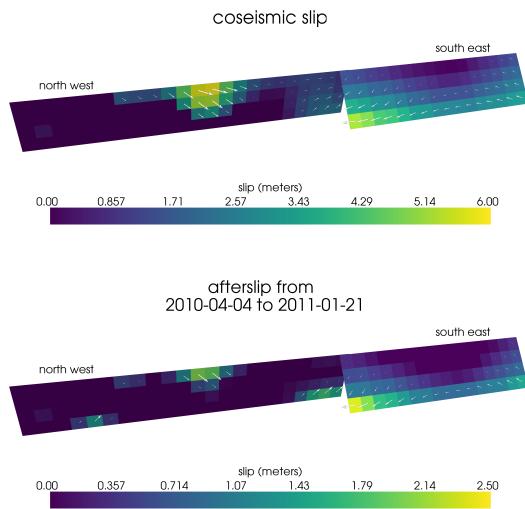
strain

the

ef-

fec-

tive

**Figure 12.**

7937 Co-  
 7938 seis-  
 7939 mic  
 7940 slip  
 7941 and  
 7942 af-  
 7943 ter-  
 7944 slip  
 7945 in-  
 7946 fered  
 7947 by  
 7948 fit-  
 7949 ting  
 7950 eq.  
 7951 (??)  
 7952 to  
 7953 the  
 7954 first  
 7955 0.8  
 7956 years  
 7957 of  
 7958 post-  
 7959 seis-  
 7960 mic  
 7961 dis-  
 7962 place-  
 7963 ments.

vis-  
cos-  
ity  
struc-  
ture  
re-  
quired  
to  
ex-  
plain  
the  
first  
0.8  
years  
of  
post-  
seis-  
mic  
de-  
for-  
ma-  
tion.  
In  
this  
sec-  
tion,  
we  
use  
the  
ef-  
fec-  
tive  
vis-

cosi-

ties

in-

ferred

above

as

a

prior

con-

straint

when

search-

ing

for

mod-

els

which

are

ca-

pa-

ble

of

de-

scrib-

ing

the

avail-

able

5

years

of

post-

seis-

mic

data,

where

our

for-

ward

prob-

lem

is

now

eq.

(??)

rather

than

the

ap-

prox-

i-

ma-

tion

given

by

eq.

(??).

We

per-

form

a

se-

ries

of

co-

seis-

mic

slip

and

af-

ter-

slip

in-

ver-

sion

as-

sum-

ing

a

va-

ri-

ety

of

rhe-

olo-

gies

for

the

lower

crust

and

up-

per

man-

tle

which

are

con-

sis-

tent

with

our

find-

ings

from

Sec-

tion

**??.**

We

ap-

praise

each

model

us-

ing

the

mean

chi

squared

value,

$$\bar{\chi}^2 = \frac{1}{N} \left\| \frac{u_{\text{pred}} - u_{\text{obs}}}{\sigma_{\text{obs}}} \right\|_2^2, \quad (15)$$

where

N

is

the

num-

ber

of

ob-

ser-

7979 va-

7980 tions.

7981 We

7982 first

7983 as-

7984 sume

7985 that

7986 the

7987 crust

7988 and

7989 man-

7990 tle

7991 can

7992 be

7993 de-

7994 scribed

7995 with

7996 a

7997 Maxwell

7998 rhe-

7999 ol-

8000 ogy,

8001 and

8002 we

8003 set

8004  $\eta_M$

8005 equal

8006 to

8007 our

8008 in-

8009 fer-

8010 ence

8011 of

8012         $\eta_{\text{eff}}$ .  
8013        We  
8014        com-  
8015        pute  
8016         $f$   
8017        and  
8018         $g$   
8019        from  
8020        eq.  
8021        (??)  
8022        us-  
8023        ing  
8024        the  
8025        fi-  
8026        nite  
8027        el-  
8028        e-  
8029        ment  
8030        soft-  
8031        ware,  
8032        Pylith  
8033        ?,  
8034        ]Aa-  
8035        gaard2009,  
8036        and  
8037        as-  
8038        sume  
8039        the  
8040        same  
8041        spa-  
8042        tial  
8043        and  
8044        tem-

8045 po-  
8046 ral  
8047 dis-  
8048 cretiza-  
8049 tion  
8050 of  
8051 s  
8052 as  
8053 in  
8054 Sec-  
8055 tions  
8056 ??  
8057 and  
8058 ??.  
8059 We  
8060 es-  
8061 ti-  
8062 mate  
8063 s  
8064 us-  
8065 ing  
8066 lin-  
8067 ear  
8068 least  
8069 squares  
8070 and  
8071 we  
8072 find  
8073  $\bar{\chi}^2 =$   
8074 37.4.  
8075 For  
8076 com-  
8077 par-

8078 i-  
8079 son,  
8080  $\bar{\chi}^2 =$   
8081 35.3  
8082 for  
8083 the  
8084 elas-  
8085 tic  
8086 model  
8087 from  
8088 Sec-  
8089 tion  
8090 ??.  
8091 The  
8092 Maxwell  
8093 vis-  
8094 coelas-  
8095 tic  
8096 model  
8097 has  
8098 a  
8099 larger  
8100 mis-  
8101 fit  
8102 be-  
8103 cause  
8104 it  
8105 tends  
8106 to  
8107 over-  
8108 es-  
8109 ti-  
8110 mate

8111 the  
8112 rate  
8113 of  
8114 de-  
8115 for-  
8116 ma-  
8117 tion  
8118 af-  
8119 ter  
8120 about  
8121 3  
8122 years  
8123 ??.  
8124 Since  
8125 our  
8126 ini-  
8127 tial  
8128 es-  
8129 ti-  
8130 mates  
8131 of  
8132  $\eta_{\text{eff}}$   
8133 may  
8134 be  
8135 bi-  
8136 ased  
8137 to-  
8138 wards  
8139 over-  
8140 es-  
8141 ti-  
8142 mat-  
8143 ing

8144 vis-  
8145 cosi-  
8146 ties,  
8147 we  
8148 have  
8149 also  
8150 per-  
8151 formed  
8152 the  
8153 slip  
8154 in-  
8155 ver-  
8156 sion  
8157 where  
8158 we  
8159 use  
8160 uni-  
8161 formly  
8162 lower  
8163 vis-  
8164 cosi-  
8165 ties  
8166 in  
8167 the  
8168 crust  
8169 and  
8170 man-  
8171 tle.  
8172 How-  
8173 ever,  
8174 de-  
8175 creas-  
8176 ing

8177 the  
8178 vis-  
8179 COS-  
8180 ity  
8181 only  
8182 in-  
8183 creases  
8184 the  
8185 mis-  
8186 fit.  
8187 Al-  
8188 though,  
8189 the  
8190 vis-  
8191 cosi-  
8192 ties  
8193 used  
8194 here  
8195 are  
8196 con-  
8197 sis-  
8198 tent  
8199 with  
8200 the  
8201 suc-  
8202 cess-  
8203 ful  
8204 Maxwell  
8205 vis-  
8206 coelas-  
8207 tic  
8208 mod-  
8209 els

8210 found  
8211 by  
8212 ?,  
8213 ]Rollins2015  
8214 and  
8215 ?,  
8216 ]Spin-  
8217 ler2015,  
8218 which  
8219 had  
8220 man-  
8221 tle  
8222 vis-  
8223 cosi-  
8224 ties  
8225 on  
8226 the  
8227 or-  
8228 der  
8229 of  
8230  $10^{18}$   
8231 Pa  
8232 s,  
8233 we  
8234 find  
8235 that  
8236 such  
8237 a  
8238 model  
8239 is  
8240 in-  
8241 ca-  
8242 pable

8243 of  
8244 de-  
8245 scrib-  
8246 ing  
8247 the  
8248 en-  
8249 tire  
8250 post-  
8251 seis-  
8252 mic  
8253 time  
8254 se-  
8255 ries.  
8256 ?,  
8257 ]Pol-  
8258 litz2001  
8259 sim-  
8260 i-  
8261 larly  
8262 rec-  
8263 og-  
8264 nized  
8265 this  
8266 de-  
8267 fi-  
8268 ciency  
8269 in  
8270 a  
8271 Maxwell  
8272 rhe-  
8273 ol-  
8274 ogy,  
8275 which

8276 then  
8277 mo-  
8278 ti-  
8279 vated  
8280 their  
8281 ex-  
8282 plo-  
8283 ration  
8284 of  
8285 a  
8286 Burg-  
8287 ers  
8288 rhe-  
8289 ol-  
8290 ogy  
8291 up-  
8292 per  
8293 man-  
8294 tle  
8295 ?,  
8296 ]Pol-  
8297 litz2003.

8298 Rather  
8299 than  
8300 ex-  
8301 plor-  
8302 ing  
8303 a  
8304 Burg-  
8305 ers  
8306 rhe-  
8307 ol-  
8308 ogy

8309 man-  
8310 tle,  
8311 which  
8312 in-  
8313 tro-  
8314 duces  
8315 two  
8316 new  
8317 pa-  
8318 ram-  
8319 e-  
8320 ters  
8321 that  
8322 need  
8323 to  
8324 be  
8325 es-  
8326 ti-  
8327 mated,  
8328  $\eta_K$   
8329 and  
8330  $\mu_K$ ,  
8331 we  
8332 first  
8333 con-  
8334 sider  
8335 a  
8336 Zener  
8337 rhe-  
8338 ol-  
8339 ogy  
8340 for  
8341 the

8342 man-  
8343 tle,  
8344 which  
8345 only  
8346 in-  
8347 tro-  
8348 duces  
8349 the  
8350 un-  
8351 known  
8352 pa-  
8353 ram-  
8354 e-  
8355 ter  
8356  $\mu_K$ .  
8357 We  
8358 as-  
8359 sume  
8360 that  
8361 the  
8362 lower  
8363 crust  
8364 still  
8365 has  
8366 a  
8367 Maxwell  
8368 rhe-  
8369 ol-  
8370 ogy.  
8371 The  
8372 steady-  
8373 state  
8374 vis-

8375 COS-  
8376 ity,  
8377  $\eta_M$ ,  
8378 in  
8379 the  
8380 crust  
8381 and  
8382 the  
8383 tran-  
8384 sient  
8385 vis-  
8386 COS-  
8387 ity,  
8388  $\eta_K$ ,  
8389 in  
8390 the  
8391 man-  
8392 tle  
8393 are  
8394 set  
8395 equal  
8396 to  
8397 the  
8398 in-  
8399 ferred  
8400 ef-  
8401 fec-  
8402 tive  
8403 vis-  
8404 cosi-  
8405 ties.  
8406 We  
8407 then

8408 es-  
8409 ti-  
8410 mate  
8411 the  
8412 ra-  
8413 tio  
8414 of  
8415 shear  
8416 mod-  
8417 uli,  
8418  $\frac{\mu_K}{\mu}$ .  
8419 We  
8420 com-  
8421 pute  
8422 nine  
8423 dif-  
8424 fer-  
8425 ent  
8426 sets  
8427 of  
8428 Green's  
8429 func-  
8430 tions,  
8431  $f$   
8432 and  
8433  $g$ ,  
8434 us-  
8435 ing  
8436 Pylith,  
8437 where  
8438 we  
8439 as-  
8440 sume

8441        val-  
8442        ues  
8443        of  
8444         $\frac{\mu_K}{\mu}$   
8445        rang-  
8446        ing  
8447        from  
8448        0  
8449        to  
8450        1.  
8451        The  
8452        for-  
8453        mer  
8454        be-  
8455        ing  
8456        a  
8457        de-  
8458        gen-  
8459        er-  
8460        ate  
8461        case  
8462        where  
8463        the  
8464        Zener  
8465        model  
8466        re-  
8467        duces  
8468        to  
8469        the  
8470        above  
8471        Maxwell  
8472        model.  
8473        We

8474 es-  
8475 ti-  
8476 mate  
8477 CO-  
8478 seis-  
8479 mic  
8480 slip  
8481 and  
8482 af-  
8483 ter-  
8484 slip  
8485 for  
8486 each  
8487 re-  
8488 al-  
8489 iza-  
8490 tion  
8491 of  
8492  $\frac{\mu_K}{\mu}$ .  
8493 The  
8494 shear  
8495 mod-  
8496 uli  
8497 ra-  
8498 tio  
8499 that  
8500 yields  
8501 to  
8502 best  
8503 pre-  
8504 dic-  
8505 tion  
8506 to

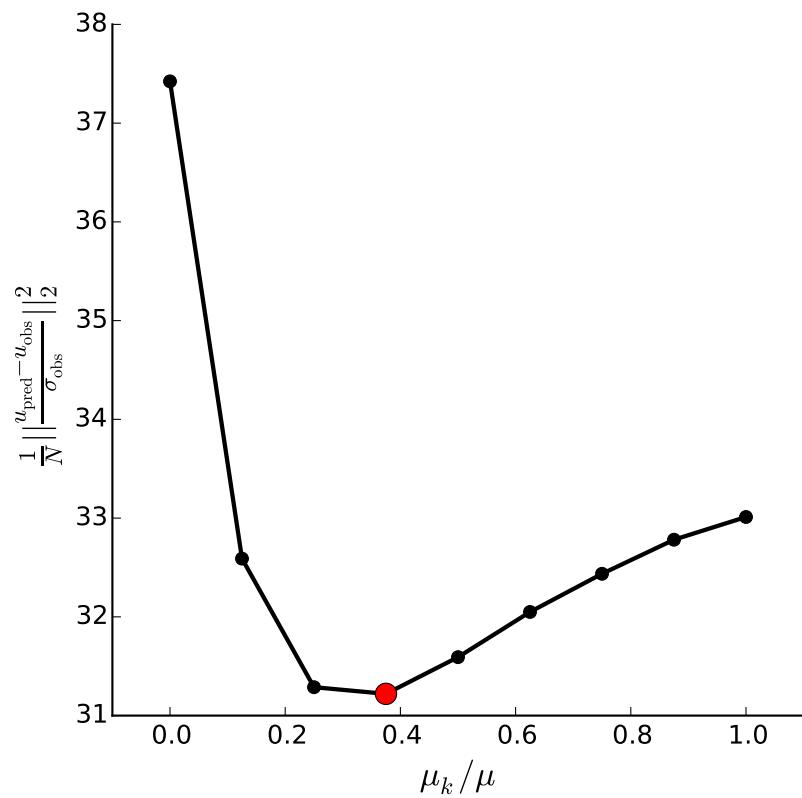
8507 the  
8508 ob-  
8509 served  
8510 post-  
8511 seis-  
8512 mic  
8513 dis-  
8514 place-  
8515 ments  
8516 is  
8517 found  
8518 to  
8519 be  
8520 0.375  
8521 with  
8522 a  
8523 mis-  
8524 fit  
8525 of  
8526  $\bar{\chi}^2 =$   
8527 31.2  
8528 (Fig-  
8529 ure  
8530 ??).  
8531 The  
8532 im-  
8533 prove-  
8534 ment  
8535 in  
8536 the  
8537 Zener  
8538 model  
8539 over

8540 the  
8541 Maxwell  
8542 model  
8543 can  
8544 be  
8545 clearly  
8546 seen  
8547 in  
8548 the  
8549 fit  
8550 to  
8551 the  
8552 far-  
8553 field  
8554 data  
8555 (Fig-  
8556 ure  
8557 ??).  
8558 The  
8559 Zener  
8560 model  
8561 does  
8562 a  
8563 sig-  
8564 nif-  
8565 i-  
8566 cantly  
8567 bet-  
8568 ter  
8569 job  
8570 at  
8571 ex-  
8572 plain-

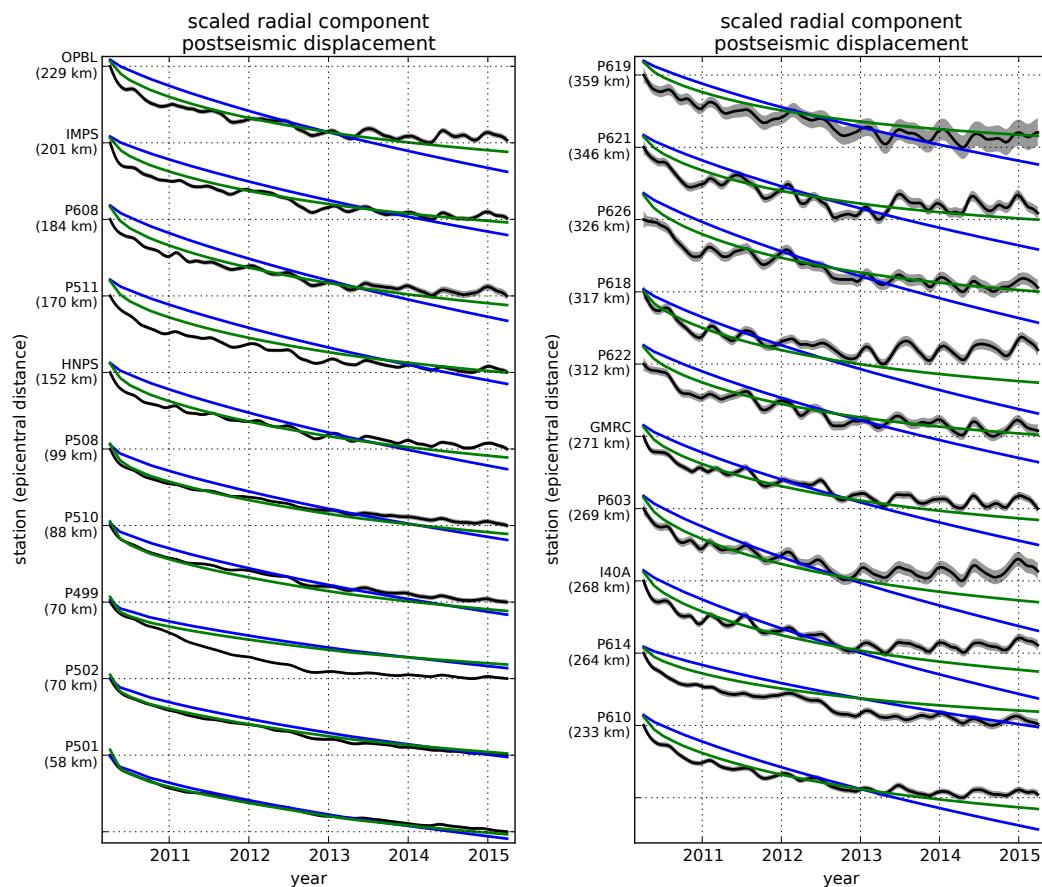
8573        ing  
8574        the  
8575        tran-  
8576        sient  
8577        rate  
8578        of  
8579        far-  
8580        field  
8581        de-  
8582        for-  
8583        ma-  
8584        tion  
8585        through-  
8586        out  
8587        the  
8588        5  
8589        years.

8681              Because

8682        we  
8683        are  
8684        able  
8685        to  
8686        ad-  
8687        e-  
8688        quately  
8689        de-  
8690        scribe  
8691        the  
8692        avail-  
8693        able  
8694        5  
8695        years  
8696        of

**Figure 13.**

Mis-fit as a function of the transient shear modulus in a Zener rheology model. The minimum of the mis-fit function is marked by a red dot.

**Figure 14.**

8615 Ob-  
 8616 served  
 8617 post-  
 8618 seis-  
 8619 mic  
 8620 dis-  
 8621 place-  
 8622 ments  
 8623 (black)  
 8624 and  
 8625 pre-  
 8626 dicted  
 8627 post-  
 8628 seis-  
 8629 mic  
 8630 dis-  
 8631 place-  
 8632 ments  
 8633 for  
 8634 the  
 8635 best  
 8636 -294-  
 8637 ting  
 8638 slip

8697 post-  
8698 seis-  
8699 mic  
8700 de-  
8701 for-  
8702 ma-  
8703 tion  
8704 with  
8705 a  
8706 Zener  
8707 model,  
8708 we  
8709 do  
8710 not  
8711 find  
8712 it  
8713 nec-  
8714 es-  
8715 sary  
8716 to  
8717 ex-  
8718 plore  
8719 the  
8720 pa-  
8721 ram-  
8722 e-  
8723 ter  
8724 space  
8725 for  
8726 a  
8727 more  
8728 com-  
8729 pli-

8730 cated  
8731 Burg-  
8732 ers  
8733 rhe-  
8734 ol-  
8735 ogy.  
8736 How-  
8737 ever,  
8738 since  
8739 the  
8740 Zener  
8741 model  
8742 is  
8743 a  
8744 Burg-  
8745 ers  
8746 model  
8747 with  
8748 an  
8749 in-  
8750 fi-  
8751 nite  
8752 steady-  
8753 state  
8754 vis-  
8755 COS-  
8756 ity,  
8757 we  
8758 can  
8759 con-  
8760 clude  
8761 that  
8762 any

8763 Burg-  
8764 ers  
8765 rhe-  
8766 ol-  
8767 ogy  
8768 that  
8769 has  
8770 a  
8771 tran-  
8772 sient  
8773 vis-  
8774 cos-  
8775 ity  
8776 con-  
8777 sis-  
8778 tent  
8779 with  
8780 that  
8781 found  
8782 in  
8783 Sec-  
8784 tion  
8785 ??  
8786 and  
8787 a  
8788 steady-  
8789 Ostate  
8790 vis-  
8791 cos-  
8792 ity  
8793 of  
8794  $\gtrsim$   
8795  $10^{20}$

8796 Pa  
8797 s,  
8798 which  
8799 is  
8800 ef-  
8801 fec-  
8802 tively  
8803 in-  
8804 fi-  
8805 nite  
8806 on  
8807 the  
8808 time  
8809 scale  
8810 of  
8811 5  
8812 years,  
8813 would  
8814 also  
8815 be  
8816 able  
8817 to  
8818 sat-  
8819 is-  
8820 fac-  
8821 to-  
8822 rily  
8823 de-  
8824 scribe  
8825 the  
8826 ob-  
8827 serv-  
8828 able

8829 post-  
8830 seis-  
8831 mic  
8832 de-  
8833 for-  
8834 ma-  
8835 tion.

8836 The

8837 reg-  
8838 u-  
8839 lar-  
8840 ized  
8841 in-  
8842 fer-  
8843 ence  
8844 of  
8845 co-  
8846 seis-  
8847 mic  
8848 slip  
8849 and  
8850 af-  
8851 ter-  
8852 slip  
8853 for  
8854 our  
8855 pre-  
8856 ferred  
8857 Zener  
8858 model  
8859 is  
8860 shown  
8861 in

8862      Fig-  
8863      ure  
8864      ??  
8865      and  
8866      the  
8867      pre-  
8868      dicted  
8869      post-  
8870      seis-  
8871      mic  
8872      dis-  
8873      place-  
8874      ments  
8875      are  
8876      shown  
8877      Fig-  
8878      ures  
8879      ??,  
8880      ??  
8881      and  
8882      ??.  
8883      Over-  
8884      all,  
8885      the  
8886      trends  
8887      in  
8888      the  
8889      near-  
8890      field  
8891      and  
8892      far-  
8893      field  
8894      tran-

8895 sient  
8896 de-  
8897 for-  
8898 ma-  
8899 tion  
8900 are  
8901 ac-  
8902 cu-  
8903 rately  
8904 de-  
8905 scribed  
8906 by  
8907 our  
8908 pre-  
8909 ferred  
8910 model.  
8911 In  
8912 par-  
8913 tic-  
8914 u-  
8915 lar,  
8916 the  
8917 trends  
8918 in  
8919 far-  
8920 field  
8921 de-  
8922 for-  
8923 ma-  
8924 tion  
8925 are  
8926 much  
8927 bet-

8928 ter  
8929 de-  
8930 scribed  
8931 by  
8932 our  
8933 pre-  
8934 ferred  
8935 Zener  
8936 model  
8937 than  
8938 ei-  
8939 ther  
8940 an  
8941 elas-  
8942 tic  
8943 model  
8944 or  
8945 a  
8946 model  
8947 with  
8948 a  
8949 Maxwell  
8950 vis-  
8951 coelas-  
8952 tic  
8953 man-  
8954 tle  
8955 (Fig-  
8956 ure  
8957 ??).  
8958 There  
8959 are  
8960 a

8961 few  
8962 ar-  
8963 eas  
8964 where  
8965 we  
8966 have  
8967 no-  
8968 table  
8969 mis-  
8970 fit.  
8971 Most  
8972 of  
8973 our  
8974 mis-  
8975 fit  
8976 is  
8977 for  
8978 the  
8979 near-  
8980 field  
8981 sta-  
8982 tions  
8983 in  
8984 the  
8985 Im-  
8986 pe-  
8987 rial  
8988 Val-  
8989 ley,  
8990 and  
8991 we  
8992 at-  
8993 tribute

8994 this  
8995 mis-  
8996 fit  
8997 to  
8998 our  
8999 rel-  
9000 a-  
9001 tively  
9002 sim-  
9003 ple  
9004 fault  
9005 ge-  
9006 om-  
9007 e-  
9008 try,  
9009 which  
9010 does  
9011 not  
9012 ac-  
9013 count  
9014 for  
9015 po-  
9016 ten-  
9017 tial  
9018 fault  
9019 slip  
9020 in  
9021 the  
9022 Im-  
9023 pe-  
9024 rial  
9025 Val-  
9026 ley

9027 trig-  
9028 gered  
9029 by  
9030 the  
9031 El  
9032 Mayor-  
9033 Cucapah  
9034 earth-  
9035 quake  
9036 ?,  
9037 ]Wei2011a,Wei2015.  
9038 In  
9039 par-  
9040 tic-  
9041 u-  
9042 lar,  
9043 we  
9044 are  
9045 un-  
9046 able  
9047 to  
9048 model  
9049 the  
9050 sus-  
9051 tained  
9052 rapid  
9053 rate  
9054 of  
9055 de-  
9056 for-  
9057 ma-  
9058 tion  
9059 at

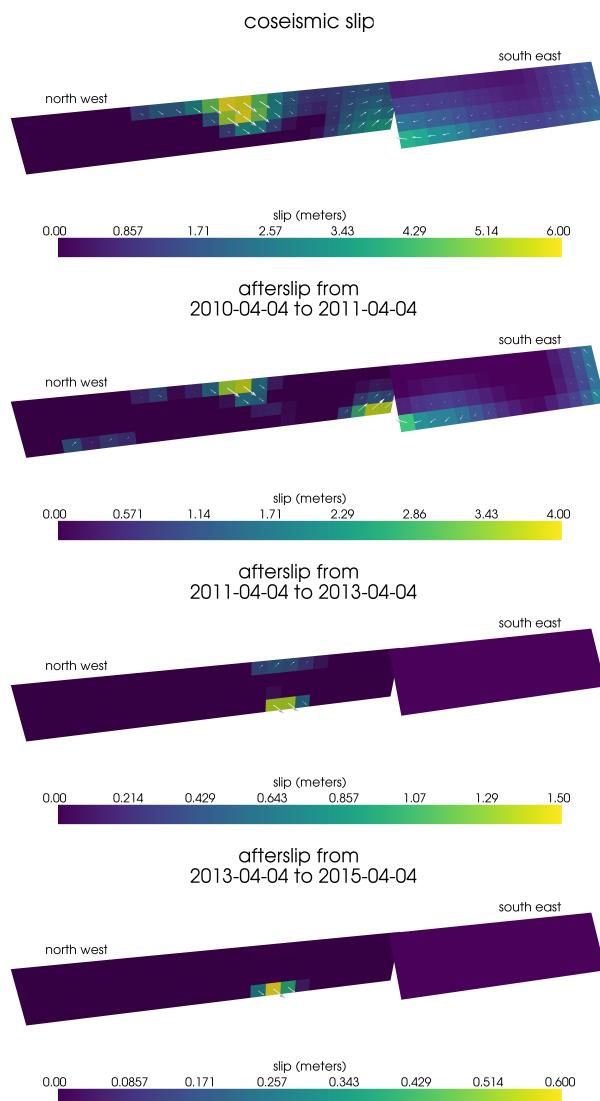
9060 sta-  
9061 tion  
9062 P496,  
9063 which  
9064 sug-  
9065 gests  
9066 that  
9067 this  
9068 sta-  
9069 tion  
9070 could  
9071 be  
9072 in-  
9073 flu-  
9074 enced  
9075 by  
9076 a  
9077 more  
9078 lo-  
9079 cal-  
9080 ized  
9081 de-  
9082 for-  
9083 ma-  
9084 tion  
9085 mech-  
9086 a-  
9087 nism  
9088 than  
9089 is  
9090 CON-  
9091 sid-  
9092 ered

9093 in  
9094 this  
9095 study.  
9096 Ad-  
9097 di-  
9098 tion-  
9099 ally,  
9100 we  
9101 see  
9102 sys-  
9103 tem-  
9104 atic  
9105 mis-  
9106 fit  
9107 in  
9108 the  
9109 later  
9110 post-  
9111 seis-  
9112 mic  
9113 pe-  
9114 riod  
9115 west  
9116 of  
9117 the  
9118 lo-  
9119 ca-  
9120 tion  
9121 of  
9122 the  
9123 Lan-  
9124 ders  
9125 and

9126 Hec-  
9127 tor  
9128 Mine  
9129 earth-  
9130 quakes,  
9131 which  
9132 may  
9133 be  
9134 the  
9135 re-  
9136 sult  
9137 of  
9138 un-  
9139 mod-  
9140 elled  
9141 post-  
9142 seis-  
9143 mic  
9144 de-  
9145 for-  
9146 ma-  
9147 tion  
9148 re-  
9149 sult-  
9150 ing  
9151 from  
9152 those  
9153 earth-  
9154 quakes.  
9155 Lastly,  
9156 there  
9157 are  
9158 clear

9159 dis-  
9160 crep-  
9161 an-  
9162 cies  
9163 be-  
9164 tween  
9165 the  
9166 ob-  
9167 served  
9168 and  
9169 pre-  
9170 dicted  
9171 ver-  
9172 ti-  
9173 cal  
9174 de-  
9175 for-  
9176 ma-  
9177 tion  
9178 fol-  
9179 low-  
9180 ing  
9181 the  
9182 first  
9183 year  
9184 af-  
9185 ter  
9186 the  
9187 El  
9188 Mayor  
9189 Cu-  
9190 ca-  
9191 pah

9192        earth-  
9193        quake.  
9194        We  
9195        ob-  
9196        serve  
9197        a  
9198        broad  
9199        up-  
9200        lift  
9201        through-  
9202        out  
9203        South-  
9204        ern  
9205        Cal-  
9206        i-  
9207        for-  
9208        nia,  
9209        which  
9210        is  
9211        in-  
9212        con-  
9213        sis-  
9214        tent  
9215        with  
9216        any  
9217        post-  
9218        seis-  
9219        mic  
9220        model.  
  
9292            The  
9293        in-  
9294        ferred  
9295        CO-

**Figure 15.**

9221 In-  
 9222 ferred  
 9223 co-  
 9224 seis-  
 9225 mic  
 9226 slip  
 9227 and  
 9228 af-  
 9229 ter-  
 9230 slip  
 9231 when  
 9232 as-  
 9233 sum-  
 9234 ing  
 9235 a  
 9236 Maxwell  
 9237 rhe-  
 9238 -3 10-  
 9239 ogy  
 .

9296 seis-  
9297 mic  
9298 po-  
9299 tency  
9300 is  
9301 3.0×  
9302 10<sup>9</sup> m<sup>3</sup>,  
9303 equiv-  
9304 a-  
9305 lent  
9306 to  
9307 a  
9308 Mw7.26  
9309 earth-  
9310 quake,  
9311 and  
9312 the  
9313 po-  
9314 tency  
9315 of  
9316 5  
9317 years  
9318 of  
9319 af-  
9320 ter-  
9321 slip  
9322 is  
9323 1.1×  
9324 10<sup>9</sup> m<sup>3</sup>.  
9325 Most  
9326 of  
9327 the  
9328 af-

9329 ter-  
9330 slip  
9331 in  
9332 our  
9333 pre-  
9334 ferred  
9335 model  
9336 OC-  
9337 curs  
9338 within  
9339 the  
9340 first  
9341 year  
9342 af-  
9343 ter  
9344 the  
9345 earth-  
9346 quake  
9347 with  
9348 a  
9349 sig-  
9350 nif-  
9351 i-  
9352 cant  
9353 amount  
9354 in-  
9355 ferred  
9356 to  
9357 be  
9358 shal-  
9359 low  
9360 and  
9361 in

9362 the  
9363 Sierra  
9364 Cu-  
9365 ca-  
9366 pah.  
9367 The  
9368 af-  
9369 ter-  
9370 slip  
9371 within  
9372 the  
9373 first  
9374 year  
9375 is  
9376 ac-  
9377 count-  
9378 ing  
9379 for  
9380 the  
9381 most  
9382 rapid  
9383 near-  
9384 field  
9385 tran-  
9386 sient  
9387 de-  
9388 for-  
9389 ma-  
9390 tion.  
9391 Af-  
9392 ter  
9393 1  
9394 year,

9395 af-  
9396 ter-  
9397 slip  
9398 is  
9399 in-  
9400 ferred  
9401 to  
9402 be  
9403 deeper  
9404 and  
9405 un-  
9406 der  
9407 the  
9408 Sierra  
9409 Cu-  
9410 ca-  
9411 pah,  
9412 which  
9413 is  
9414 de-  
9415 scrib-  
9416 ing  
9417 much  
9418 of  
9419 the  
9420 sus-  
9421 tained  
9422 near-  
9423 field  
9424 post-  
9425 seis-  
9426 mic  
9427 de-

9428 for-  
9429 ma-  
9430 tion.  
9431 We  
9432 em-  
9433 pha-  
9434 size,  
9435 that  
9436 the  
9437 GPS  
9438 sta-  
9439 tion  
9440 clos-  
9441 est  
9442 to  
9443 our  
9444 in-  
9445 ferred  
9446 af-  
9447 ter-  
9448 slip,  
9449 P496,  
9450 is  
9451 still  
9452 about  
9453 30  
9454 km  
9455 away,  
9456 which  
9457 is  
9458 too  
9459 far  
9460 away

9461 for  
9462 us  
9463 to  
9464 CON-  
9465 clu-  
9466 sively  
9467 ar-  
9468 gue  
9469 for  
9470 sus-  
9471 tained  
9472 brit-  
9473 tle  
9474 de-  
9475 for-  
9476 ma-  
9477 tion  
9478 rather  
9479 shal-  
9480 low  
9481 duc-  
9482 tile  
9483 de-  
9484 for-  
9485 ma-  
9486 tion.  
9487 The  
9488 deep  
9489 af-  
9490 ter-  
9491 slip  
9492 in-  
9493 ferred

9494 af-  
9495 ter  
9496 1  
9497 year  
9498 could  
9499 po-  
9500 ten-  
9501 tially  
9502 be  
9503 de-  
9504 scrib-  
9505 ing  
9506 de-  
9507 for-  
9508 ma-  
9509 tion  
9510 re-  
9511 sult-  
9512 ing  
9513 from  
9514 lower  
9515 crustal  
9516 flow.  
9517 To  
9518 test  
9519 this,  
9520 we  
9521 have  
9522 mod-  
9523 i-  
9524 fied  
9525 our  
9526 pre-

9527      ferred  
9528      model  
9529      by  
9530      de-  
9531      creas-  
9532      ing  
9533      the  
9534      lower  
9535      crustal  
9536      vis-  
9537      COS-  
9538      ity  
9539      from  
9540       $5.91 \times$   
9541       $10^{19}$   
9542      Pa  
9543      S  
9544      to  
9545       $1 \times$   
9546       $10^{19}$   
9547      Pa  
9548      S,  
9549      which  
9550      is  
9551      still  
9552      CON-  
9553      sis-  
9554      tent  
9555      with  
9556      our  
9557      vis-  
9558      COS-  
9559      ity

9560 in-  
9561 fer-  
9562 ence  
9563 from  
9564 Sec-  
9565 tion  
9566 ??.  
9567 Af-  
9568 ter  
9569 per-  
9570 form-  
9571 ing  
9572 an-  
9573 other  
9574 slip  
9575 in-  
9576 ver-  
9577 sion,  
9578 we  
9579 find  
9580 that  
9581 a  
9582 model  
9583 with  
9584 a  
9585 weaker  
9586 lower  
9587 crust  
9588 ad-  
9589 e-  
9590 quately  
9591 de-  
9592 scribes

9593 the  
9594 post-  
9595 seis-  
9596 mic  
9597 dis-  
9598 place-  
9599 ments  
9600 with-  
9601 out  
9602 any  
9603 af-  
9604 ter-  
9605 slip  
9606 af-  
9607 ter  
9608 1  
9609 year,  
9610 while  
9611 still  
9612 re-  
9613 quir-  
9614 ing  
9615 about  
9616 the  
9617 same  
9618 amount  
9619 of  
9620 af-  
9621 ter-  
9622 slip  
9623 over  
9624 the  
9625 first

9626 year.  
9627 We  
9628 do  
9629 be-  
9630 lieve  
9631 that  
9632 the  
9633 early  
9634 shal-  
9635 low  
9636 af-  
9637 ter-  
9638 slip  
9639 is  
9640 a  
9641 ro-  
9642 bust  
9643 fea-  
9644 ture  
9645 in  
9646 our  
9647 pre-  
9648 ferred  
9649 model,  
9650 while  
9651 we  
9652 are  
9653 not  
9654 con-  
9655 fi-  
9656 dent  
9657 in  
9658 our

9659 in-  
9660 fer-  
9661 ence  
9662 of  
9663 later  
9664 deep  
9665 af-  
9666 ter-  
9667 slip.

9668

9669 **4 Discussion**

9670 It  
9671 has  
9672 long  
9673 been  
9674 rec-  
9675 og-  
9676 nized  
9677 that  
9678 deep  
9679 af-  
9680 ter-  
9681 slip  
9682 and  
9683 vis-  
9684 coelas-  
9685 tic  
9686 re-  
9687 lax-  
9688 ation  
9689 fol-  
9690 low-

9691 ing  
9692 an  
9693 up-  
9694 per  
9695 crustal  
9696 earth-  
9697 quake  
9698 can  
9699 re-  
9700 sult  
9701 in  
9702 sim-  
9703 i-  
9704 lar  
9705 hor-  
9706 i-  
9707 zon-  
9708 tal  
9709 ground  
9710 de-  
9711 for-  
9712 ma-  
9713 tion  
9714 at  
9715 the  
9716 sur-  
9717 face  
9718 ?,  
9719 e.g.] Savage 1990,  
9720 Pol-  
9721 litz 2001, Hearn 2003, Feigl 2006.  
9722 The  
9723 sim-

9724 i-  
9725 lar-  
9726 ity  
9727 of  
9728 the  
9729 hor-  
9730 i-  
9731 zon-  
9732 tal  
9733 post-  
9734 seis-  
9735 mic  
9736 de-  
9737 for-  
9738 ma-  
9739 tion  
9740 re-  
9741 sults  
9742 in  
9743 a  
9744 non-  
9745 uniqueness  
9746 in  
9747 in-  
9748 fer-  
9749 ences  
9750 of  
9751 af-  
9752 ter-  
9753 slip  
9754 or  
9755 vis-  
9756 coelas-

9757 tic  
9758 re-  
9759 lax-  
9760 ation.  
9761 In  
9762 con-  
9763 trast,  
9764 the  
9765 spa-  
9766 tial  
9767 pat-  
9768 tern  
9769 of  
9770 ver-  
9771 ti-  
9772 cal  
9773 post-  
9774 seis-  
9775 mic  
9776 de-  
9777 for-  
9778 ma-  
9779 tion  
9780 has  
9781 been  
9782 pro-  
9783 posed  
9784 to  
9785 be  
9786 a  
9787 dis-  
9788 crim-  
9789 i-

9790 nant  
9791 be-  
9792 tween  
9793 deep  
9794 af-  
9795 ter-  
9796 slip  
9797 and  
9798 vis-  
9799 coelas-  
9800 tic  
9801 re-  
9802 lax-  
9803 ation  
9804 ?,  
9805 e.g.] Pollitz2001,  
9806 Hearn2003.  
9807 It  
9808 is,  
9809 how-  
9810 ever,  
9811 im-  
9812 por-  
9813 tant  
9814 to  
9815 note  
9816 that  
9817 pat-  
9818 terns  
9819 of  
9820 ver-  
9821 ti-  
9822 cal

9823 de-  
9824 for-  
9825 ma-  
9826 tion  
9827 are  
9828 very  
9829 sen-  
9830 si-  
9831 tive  
9832 to  
9833 the  
9834 depth-  
9835 dependence  
9836 of  
9837 vis-  
9838 COS-  
9839 ity  
9840 be-  
9841 low  
9842 the  
9843 up-  
9844 per  
9845 crust  
9846 ?,  
9847 ]Yang1981,  
9848 Het-  
9849 land2014.  
9850 The  
9851 sim-  
9852 i-  
9853 lar-  
9854 ity  
9855 be-

9856 tween  
9857 de-  
9858 for-  
9859 ma-  
9860 tion  
9861 re-  
9862 sult-  
9863 ing  
9864 from  
9865 deep  
9866 af-  
9867 ter-  
9868 slip  
9869 and  
9870 vis-  
9871 coelas-  
9872 tic  
9873 re-  
9874 lax-  
9875 ation  
9876 of  
9877 CO-  
9878 seis-  
9879 mic  
9880 stresses  
9881 is  
9882 dif-  
9883 fer-  
9884 ent  
9885 from  
9886 the  
9887 ill-  
9888 posedness

9889 de-  
9890 scribed  
9891 in  
9892 Sec-  
9893 tion  
9894 ??.  
9895 In  
9896 our  
9897 method,  
9898 any  
9899 in-  
9900 ferred  
9901 af-  
9902 ter-  
9903 slip  
9904 will  
9905 also  
9906 me-  
9907 chan-  
9908 i-  
9909 cally  
9910 drive  
9911 ad-  
9912 di-  
9913 tional  
9914 vis-  
9915 coelas-  
9916 tic  
9917 re-  
9918 lax-  
9919 ation.  
9920 The  
9921 hor-

9922 i-  
9923 ZON-  
9924 tal  
9925 de-  
9926 for-  
9927 ma-  
9928 tion  
9929 re-  
9930 sult-  
9931 ing  
9932 from  
9933 deep  
9934 af-  
9935 ter-  
9936 slip  
9937 will  
9938 gen-  
9939 er-  
9940 ally  
9941 be  
9942 in  
9943 the  
9944 op-  
9945 po-  
9946 site  
9947 di-  
9948 rec-  
9949 tion  
9950 as  
9951 hor-  
9952 i-  
9953 ZON-  
9954 tal

9955 de-  
9956 for-  
9957 ma-  
9958 tion  
9959 re-  
9960 sult-  
9961 ing  
9962 from  
9963 vis-  
9964 coelas-  
9965 tic  
9966 re-  
9967 lax-  
9968 ation  
9969 of  
9970 sub-  
9971 se-  
9972 quent  
9973 stresses  
9974 in  
9975 the  
9976 lower  
9977 crust  
9978 (Fig-  
9979 ure  
9980 ??).  
9981 As  
9982 a  
9983 re-  
9984 sult,  
9985 there  
9986 is  
9987 a

9988 trade-  
9989 off  
9990 be-  
9991 tween  
9992 in-  
9993 fer-  
9994 ences  
9995 of  
9996 deep  
9997 af-  
9998 ter-  
9999 slip  
10000 and  
10001 lower  
10002 crustal  
10003 vis-  
10004 COS-  
10005 ity.  
10006 In  
10007 our  
10008 syn-  
10009 thetic  
10010 tests  
10011 in  
10012 ?,  
10013 ]Hines2016,  
10014 we  
10015 have  
10016 found  
10017 that  
10018 in-  
10019 vert-  
10020 ing

10021 sur-  
10022 face  
10023 de-  
10024 for-  
10025 ma-  
10026 tion  
10027 for  
10028 af-  
10029 ter-  
10030 slip  
10031 and  
10032 vis-  
10033 COS-  
10034 ity  
10035 within  
10036 the  
10037 same  
10038 depth  
10039 in-  
10040 ter-  
10041 val  
10042 tends  
10043 to  
10044 re-  
10045 sult  
10046 in  
10047 over-  
10048 es-  
10049 ti-  
10050 mated  
10051 af-  
10052 ter-  
10053 slip

10054 and  
10055 an  
10056 un-  
10057 der-  
10058 es-  
10059 ti-  
10060 mated  
10061 vis-  
10062 cos-  
10063 ity  
10064 at  
10065 that  
10066 depth.

10067 Most

10068 post-  
10069 seis-  
10070 mic  
10071 stud-  
10072 ies  
10073 as-  
10074 sume  
10075 Maxwell  
10076 vis-  
10077 coelas-  
10078 tic-  
10079 ity  
10080 in  
10081 the  
10082 lower  
10083 crust  
10084 and  
10085 up-  
10086 per

10087 man-

10088 tle

10089 ?,

10090 e.g.]Nur1974,Pollitz2000,Hetland2003,Freed2006a,Johnson2009,Hearn2009,

10091 which

10092 is

10093 the

10094 sim-

10095 plest

10096 vis-

10097 coelas-

10098 tic

10099 rhe-

10100 O-

10101 logic

10102 model.

10103 In

10104 South-

10105 ern

10106 Cal-

10107 i-

10108 for-

10109 nia,

10110 post-

10111 seis-

10112 mic

10113 stud-

10114 ies

10115 fol-

10116 low-

10117 ing

10118 the

10119 Lan-

10120 ders  
10121 ?,  
10122 ]Pol-  
10123 litz2000,  
10124 Hec-  
10125 tor  
10126 Mine  
10127 ?,  
10128 ]Pol-  
10129 litz2001,  
10130 and  
10131 El  
10132 Mayor-  
10133 Cucapah  
10134 earth-  
10135 quake  
10136 ?,  
10137 ]Spin-  
10138 ler2015,Rollins2015,  
10139 have  
10140 as-  
10141 sumed  
10142 Maxwell  
10143 vis-  
10144 coelas-  
10145 tic-  
10146 ity  
10147 in  
10148 the  
10149 litho-  
10150 sphere  
10151 and  
10152 as-

10153      theno-  
10154      sphere  
10155      and  
10156      have  
10157      in-  
10158      ferred  
10159      up-  
10160      per  
10161      man-  
10162      tle  
10163      vis-  
10164      cosi-  
10165      ties  
10166      on  
10167      the  
10168      or-  
10169      der  
10170      of  
10171       $10^{17}$   
10172      to  
10173       $10^{18}$   
10174      Pa  
10175      S  
10176      and  
10177      lower  
10178      crust  
10179      vis-  
10180      cosi-  
10181      ties  
10182      of  
10183       $\gtrsim$   
10184       $10^{19}$   
10185      Pa

10186 S.  
10187 These  
10188 post-  
10189 seis-  
10190 mic  
10191 stud-  
10192 ies  
10193 are  
10194 cor-  
10195 rob-  
10196 O-  
10197 rated  
10198 by  
10199 ?,  
10200 ]Kauf-  
10201 mann2000  
10202 who  
10203 found  
10204 that  
10205 a  
10206 lower  
10207 crust  
10208 and  
10209 up-  
10210 per  
10211 man-  
10212 tle  
10213 with  
10214 vis-  
10215 cosi-  
10216 ties  
10217 on  
10218 the

10219 or-  
10220 der  
10221 of  
10222  $10^{20}$   
10223 and  
10224  $10^{18}$   
10225 Pa  
10226 s,  
10227 re-  
10228 spec-  
10229 tively,  
10230 are  
10231 nec-  
10232 es-  
10233 sary  
10234 to  
10235 de-  
10236 scribe  
10237 sub-  
10238 si-  
10239 dence  
10240 re-  
10241 sult-  
10242 ing  
10243 from  
10244 Lake  
10245 Mead,  
10246 which  
10247 is  
10248 a  
10249 pro-  
10250 cess  
10251 with

10252 sim-  
10253 i-  
10254 lar  
10255 spa-  
10256 tial  
10257 and  
10258 tem-  
10259 po-  
10260 ral  
10261 scales  
10262 as  
10263 post-  
10264 seis-  
10265 mic  
10266 de-  
10267 for-  
10268 ma-  
10269 tion.  
10270 While  
10271 these  
10272 stud-  
10273 ies  
10274 found  
10275 vis-  
10276 cosi-  
10277 ties  
10278 that  
10279 are  
10280 con-  
10281 sis-  
10282 tent  
10283 with  
10284 our

10285 ef-  
10286 fec-  
10287 tive  
10288 vis-  
10289 cosi-  
10290 ties  
10291 from  
10292 Sec-  
10293 tion  
10294 ??,  
10295 they  
10296 are  
10297 in-  
10298 CON-  
10299 sis-  
10300 tent  
10301 with  
10302 vis-  
10303 COS-  
10304 ity  
10305 es-  
10306 ti-  
10307 mates  
10308 made  
10309 from  
10310 geo-  
10311 phys-  
10312 i-  
10313 cal  
10314 pro-  
10315 cesses  
10316 that  
10317 OC-

10318 cur  
10319 over  
10320 longer  
10321 time  
10322 scales.  
10323 For  
10324 ex-  
10325 am-  
10326 ple,  
10327 ?,  
10328 ]Lund-  
10329 gren2009  
10330 found  
10331 that  
10332 lower  
10333 crust  
10334 and  
10335 up-  
10336 per  
10337 man-  
10338 tle  
10339 vis-  
10340 cosi-  
10341 ties  
10342 on  
10343 the  
10344 or-  
10345 der  
10346 of  
10347  $10^{21}$   
10348 and  
10349  $10^{19}$   
10350 Pa

10351 S,  
10352 re-  
10353 spec-  
10354 tively,  
10355 are  
10356 needed  
10357 to  
10358 de-  
10359 scribe  
10360 in-  
10361 ter-  
10362 seis-  
10363 mic  
10364 de-  
10365 for-  
10366 ma-  
10367 tion  
10368 along  
10369 the  
10370 South-  
10371 ern  
10372 San  
10373 An-  
10374 dreas  
10375 and  
10376 San  
10377 Jac-  
10378 into  
10379 fault.  
10380 An  
10381 even  
10382 higher  
10383 man-

10384 tle  
10385 vis-  
10386 COS-  
10387 ity  
10388 on  
10389 the  
10390 or-  
10391 der  
10392 of  
10393  $10^{20}$   
10394 Pa  
10395 S  
10396 is  
10397 re-  
10398 quired  
10399 to  
10400 de-  
10401 scribe  
10402 de-  
10403 flec-  
10404 tion  
10405 re-  
10406 sult-  
10407 ing  
10408 from  
10409 Lake  
10410 Bon-  
10411 neville,  
10412 which  
10413 OC-  
10414 curs  
10415 on  
10416 the

10417 time  
10418 scales  
10419 of  
10420  $10^4$   
10421 years  
10422 ?,  
10423 ]Crit-  
10424 ten-  
10425 den1967,Bills1987.  
  
10426 An  
10427 ad-  
10428 di-  
10429 tional  
10430 de-  
10431 fi-  
10432 ciency  
10433 with  
10434 the  
10435 Maxwell  
10436 rhe-  
10437 ol-  
10438 ogy  
10439 is  
10440 that  
10441 it  
10442 pre-  
10443 dicts  
10444 a  
10445 steady  
10446 de-  
10447 cay  
10448 over  
10449 time

10450 in  
10451 the  
10452 rate  
10453 of  
10454 post-  
10455 seis-  
10456 mic  
10457 de-  
10458 for-  
10459 ma-  
10460 tion,  
10461 which  
10462 fails  
10463 to  
10464 de-  
10465 scribe  
10466 the  
10467 com-  
10468 monly  
10469 ob-  
10470 served  
10471 rapid  
10472 early  
10473 tran-  
10474 sience  
10475 fol-  
10476 lowed  
10477 by  
10478 a  
10479 rel-  
10480 a-  
10481 tively  
10482 steady

10483 rate  
10484 of  
10485 post-  
10486 seis-  
10487 mic  
10488 de-  
10489 for-  
10490 ma-  
10491 tion.  
10492 One  
10493 could  
10494 ex-  
10495 plain  
10496 the  
10497 early  
10498 tran-  
10499 sient  
10500 post-  
10501 seis-  
10502 mic  
10503 de-  
10504 for-  
10505 ma-  
10506 tion  
10507 with  
10508 fault  
10509 creep  
10510 and  
10511 the  
10512 later  
10513 phase  
10514 with  
10515 re-

10516 lax-  
10517 ation  
10518 in  
10519 a  
10520 Maxwell  
10521 vis-  
10522 coelas-  
10523 tic  
10524 lower  
10525 crust  
10526 and  
10527 up-  
10528 per  
10529 man-  
10530 tle  
10531 ?,  
10532 e.g.] Hearn 2009, Johnson 2009.  
10533 How-  
10534 ever,  
10535 post-  
10536 seis-  
10537 mic  
10538 de-  
10539 for-  
10540 ma-  
10541 tion  
10542 at  
10543 dis-  
10544 tances  
10545 greater  
10546 than  
10547 ~  
10548 200

10549 km  
10550 from  
10551 the  
10552 El  
10553 Mayor-  
10554 Cucapah  
10555 epi-  
10556 cen-  
10557 tre  
10558 can  
10559 only  
10560 be  
10561 at-  
10562 tributed  
10563 to  
10564 vis-  
10565 coelas-  
10566 tic  
10567 re-  
10568 lax-  
10569 ation  
10570 ?,  
10571 ]Freed2007a  
10572 and  
10573 we  
10574 have  
10575 demon-  
10576 strated  
10577 that  
10578 the  
10579 far-  
10580 field  
10581 de-

10582 for-  
10583 ma-  
10584 tion  
10585 can-  
10586 not  
10587 be  
10588 ex-  
10589 plained  
10590 with  
10591 a  
10592 Maxwell  
10593 rhe-  
10594 ol-  
10595 ogy  
10596 (Fig-  
10597 ure  
10598 ??).

10599 We  
10600 found  
10601 that  
10602 a  
10603 Zener  
10604 rhe-  
10605 ol-  
10606 ogy  
10607 in  
10608 the  
10609 up-  
10610 per  
10611 man-  
10612 tle  
10613 with  
10614 a

10615 tran-  
10616 sient  
10617 vis-  
10618 COS-  
10619 ity  
10620 of  
10621 ~  
10622  $10^{18}$   
10623 Pa  
10624 S  
10625 does  
10626 a  
10627 no-  
10628 tice-  
10629 ably  
10630 bet-  
10631 ter  
10632 job  
10633 at  
10634 pre-  
10635 dict-  
10636 ing  
10637 far-  
10638 field  
10639 post-  
10640 seis-  
10641 mic  
10642 de-  
10643 for-  
10644 ma-  
10645 tion.  
10646 A  
10647 gen-

10648 er-  
10649 al-  
10650 iza-  
10651 tion  
10652 of  
10653 the  
10654 Zener  
10655 vis-  
10656 coelas-  
10657 tic  
10658 model,  
10659 schemat-  
10660 i-  
10661 cally  
10662 rep-  
10663 re-  
10664 sented  
10665 as  
10666 sev-  
10667 eral  
10668 Kelvin  
10669 el-  
10670 e-  
10671 ments  
10672 con-  
10673 nected  
10674 in  
10675 se-  
10676 ries,  
10677 is  
10678 com-  
10679 monly  
10680 used

10681 to  
10682 de-  
10683 scribe  
10684 seis-  
10685 mic  
10686 at-  
10687 ten-  
10688 u-  
10689 a-  
10690 tion  
10691 ?,  
10692 ]Liu1976.  
10693 The  
10694 high-  
10695 est  
10696 vis-  
10697 COS-  
10698 ity  
10699 needed  
10700 to  
10701 de-  
10702 scribe  
10703 seis-  
10704 mic  
10705 at-  
10706 ten-  
10707 u-  
10708 a-  
10709 tion  
10710 is  
10711 on  
10712 the  
10713 or-

10714 der  
10715 of  
10716  $10^{16}$   
10717 Pa  
10718 S  
10719 ?,  
10720 ]Yuen1982  
10721 which  
10722 has  
10723 a  
10724 char-  
10725 ac-  
10726 ter-  
10727 is-  
10728 tic  
10729 re-  
10730 lax-  
10731 ation  
10732 time  
10733 on  
10734 the  
10735 or-  
10736 der  
10737 of  
10738 days.  
10739 Even  
10740 though  
10741 our  
10742 in-  
10743 ferred  
10744 tran-  
10745 sient  
10746 vis-

10747 COS-  
10748 ity  
10749 is  
10750 or-  
10751 ders  
10752 of  
10753 mag-  
10754 ni-  
10755 tude  
10756 larger  
10757 than  
10758 that  
10759 re-  
10760 quired  
10761 for  
10762 seis-  
10763 mic  
10764 at-  
10765 ten-  
10766 u-  
10767 a-  
10768 tion  
10769 mod-  
10770 els,  
10771 the  
10772 two  
10773 mod-  
10774 els  
10775 are  
10776 not  
10777 in-  
10778 com-  
10779 pat-

10780 i-  
10781 ble.  
10782 Rather,  
10783 the  
10784 de-  
10785 layed  
10786 elas-  
10787 tic-  
10788 ity  
10789 in  
10790 seis-  
10791 mic  
10792 at-  
10793 ten-  
10794 u-  
10795 a-  
10796 tion  
10797 mod-  
10798 els  
10799 OC-  
10800 curs  
10801 on  
10802 such  
10803 short  
10804 time  
10805 scales  
10806 that  
10807 it  
10808 can  
10809 be  
10810 CON-  
10811 sid-  
10812 ered

10813 part  
10814 of  
10815 the  
10816 in-  
10817 stan-  
10818 ta-  
10819 neous  
10820 elas-  
10821 tic  
10822 phase  
10823 of  
10824 de-  
10825 for-  
10826 ma-  
10827 tion  
10828 as-  
10829 SO-  
10830 ci-  
10831 ated  
10832 with  
10833 the  
10834 pre-  
10835 ferred  
10836 Zener  
10837 model  
10838 in  
10839 this  
10840 study.  
  
10841 Of  
10842 course,  
10843 it  
10844 has  
10845 long

10846 been  
10847 rec-  
10848 og-  
10849 nized  
10850 that  
10851 a  
10852 Zener  
10853 rhe-  
10854 ol-  
10855 ogy  
10856 pro-  
10857 vides  
10858 an  
10859 in-  
10860 com-  
10861 plete  
10862 de-  
10863 scrip-  
10864 tions  
10865 of  
10866 the  
10867 as-  
10868 theno-  
10869 sphere,  
10870 as  
10871 it  
10872 does  
10873 not  
10874 have  
10875 the  
10876 fluid-  
10877 like  
10878 be-

10879 behaviour  
10880 re-  
10881 quired  
10882 to  
10883 ex-  
10884 plain  
10885 iso-  
10886 static  
10887 re-  
10888 bound  
10889 or  
10890 con-  
10891 vec-  
10892 tion  
10893 in  
10894 the  
10895 man-  
10896 tle  
10897 ?,  
10898 ]OCon-  
10899 nell1971.  
10900 ?,  
10901 ]Yuen1982  
10902 pro-  
10903 posed  
10904 a  
10905 Burg-  
10906 ers  
10907 rhe-  
10908 ol-  
10909 ogy  
10910 with  
10911 a

10912 low  
10913 tran-  
10914 sient  
10915 vis-  
10916 COS-  
10917 ity  
10918 ( $\eta_K \approx$   
10919  $10^{16}$   
10920 Pa  
10921 s)  
10922 and  
10923 high  
10924 steady-  
10925 state  
10926 vis-  
10927 COS-  
10928 ity  
10929 ( $\eta_M \approx$   
10930  $10^{21}$   
10931 Pa  
10932 s)  
10933 to  
10934 de-  
10935 scribe  
10936 both  
10937 seis-  
10938 mic  
10939 at-  
10940 ten-  
10941 u-  
10942 a-  
10943 tion  
10944 and

10945 long  
10946 term  
10947 ge-  
10948 O-  
10949 logic  
10950 pro-  
10951 cesses.  
10952 The  
10953 jus-  
10954 ti-  
10955 fi-  
10956 ca-  
10957 tion  
10958 of  
10959 a  
10960 Burger's  
10961 rhe-  
10962 ol-  
10963 ogy  
10964 man-  
10965 tle  
10966 is  
10967 fur-  
10968 ther  
10969 sup-  
10970 ported  
10971 by  
10972 lab-  
10973 O-  
10974 ra-  
10975 tory  
10976 ex-  
10977 per-

10978 i-  
10979 ments  
10980 on  
10981 olivine  
10982 ?,  
10983 ]Chopra1997.  
10984 ?,  
10985 ]Pol-  
10986 litz2003  
10987 sought  
10988 to  
10989 de-  
10990 scribe  
10991 post-  
10992 seis-  
10993 mic  
10994 de-  
10995 for-  
10996 ma-  
10997 tion  
10998 fol-  
10999 low-  
11000 ing  
11001 Hec-  
11002 tor  
11003 Mine  
11004 with  
11005 a  
11006 Burg-  
11007 ers  
11008 rhe-  
11009 ol-  
11010 ogy

11011 man-  
11012 tle  
11013 and  
11014 they  
11015 found  
11016 a  
11017 best  
11018 fit-  
11019 ting  
11020 tran-  
11021 sient  
11022 vis-  
11023 COS-  
11024 ity  
11025 of  
11026  $1.6 \times$   
11027  $10^{17}$   
11028 Pa  
11029 S  
11030 and  
11031 steady-  
11032 state  
11033 vis-  
11034 COS-  
11035 ity  
11036 of  
11037  $4.6 \times$   
11038  $10^{18}$   
11039 Pa  
11040 S.  
11041 While  
11042 the  
11043 Burg-

11044 ers  
11045 rhe-  
11046 ol-  
11047 ogy  
11048 was  
11049 in-  
11050 tro-  
11051 duced  
11052 as  
11053 a  
11054 means  
11055 of  
11056 bridg-  
11057 ing  
11058 the  
11059 gap  
11060 be-  
11061 tween  
11062 re-  
11063 lax-  
11064 ation  
11065 ob-  
11066 served  
11067 in  
11068 long  
11069 and  
11070 short  
11071 term  
11072 geo-  
11073 phys-  
11074 i-  
11075 cal  
11076 pro-

11077 cesses,  
11078 the  
11079 in-  
11080 ferred  
11081 steady  
11082 state  
11083 vis-  
11084 COS-  
11085 ity  
11086 from  
11087 ?,  
11088 ]Pol-  
11089 litz2003  
11090 is  
11091 still  
11092 in-  
11093 CON-  
11094 sis-  
11095 tent  
11096 with  
11097 the  
11098 Maxwell  
11099 vis-  
11100 cosi-  
11101 ties  
11102 in-  
11103 ferred  
11104 from  
11105 earth-  
11106 quake  
11107 cy-  
11108 cle  
11109 and

11110 lake  
11111 load-  
11112 ing  
11113 stud-  
11114 ies.  
11115 The  
11116 tran-  
11117 sient  
11118 vis-  
11119 cos-  
11120 ity  
11121 in-  
11122 ferred  
11123 by  
11124 ?,  
11125 ]Pol-  
11126 litz2003  
11127 is  
11128 CON-  
11129 strained  
11130 by  
11131 the  
11132 ear-  
11133 li-  
11134 est  
11135 phase  
11136 of  
11137 post-  
11138 seis-  
11139 mic  
11140 de-  
11141 for-  
11142 ma-

11143 tion  
11144 fol-  
11145 low-  
11146 ing  
11147 the  
11148 Hec-  
11149 tor  
11150 Mine  
11151 earth-  
11152 quake.  
11153 While  
11154 ?,  
11155 ]Pol-  
11156 litz2003  
11157 ruled  
11158 out  
11159 deep  
11160 af-  
11161 ter-  
11162 slip  
11163 as  
11164 an  
11165 al-  
11166 ter-  
11167 na-  
11168 tive  
11169 mech-  
11170 a-  
11171 nism  
11172 based  
11173 on  
11174 in-  
11175 CON-

11176 sis-  
11177 tent  
11178 ver-  
11179 ti-  
11180 cal  
11181 de-  
11182 for-  
11183 ma-  
11184 tion,  
11185 it  
11186 is  
11187 still  
11188 pos-  
11189 si-  
11190 ble  
11191 to  
11192 SUC-  
11193 CESS-  
11194 fully  
11195 de-  
11196 scribe  
11197 all  
11198 com-  
11199 po-  
11200 nents  
11201 of  
11202 early  
11203 post-  
11204 seis-  
11205 mic  
11206 de-  
11207 for-  
11208 ma-

11209 tion  
11210 fol-  
11211 low-  
11212 ing  
11213 the  
11214 Hec-  
11215 tor  
11216 Mine  
11217 earth-  
11218 quake  
11219 with  
11220 af-  
11221 ter-  
11222 slip  
11223 at  
11224 seis-  
11225 mo-  
11226 genic  
11227 depths  
11228 ?,  
11229 ]Ja-  
11230 cobs2002.  
11231 It  
11232 is  
11233 then  
11234 pos-  
11235 si-  
11236 ble  
11237 that  
11238 the  
11239 pre-  
11240 fered  
11241 rhe-

11242 O-  
11243 logic  
11244 model  
11245 from  
11246 ?,  
11247 ]Pol-  
11248 litz2003  
11249 was  
11250 bi-  
11251 ased  
11252 to-  
11253 wards  
11254 in-  
11255 fer-  
11256 ring  
11257 a  
11258 par-  
11259 tic-  
11260 u-  
11261 larly  
11262 low  
11263 tran-  
11264 sient  
11265 vis-  
11266 COS-  
11267 ity  
11268 by  
11269 ne-  
11270 glect-  
11271 ing  
11272 to  
11273 ac-  
11274 count

11275 for  
11276 af-  
11277 ter-  
11278 slip.  
11279 This  
11280 is  
11281 in  
11282 con-  
11283 trast  
11284 to  
11285 the  
11286 present  
11287 study,  
11288 where  
11289 we  
11290 have  
11291 in-  
11292 ferred  
11293 a  
11294 litho-  
11295 spheric  
11296 vis-  
11297 COS-  
11298 ity  
11299 struc-  
11300 ture  
11301 si-  
11302 mul-  
11303 ta-  
11304 ne-  
11305 ously  
11306 with  
11307 af-

11308 ter-  
11309 slip.  
11310 We  
11311 also  
11312 ar-  
11313 gue  
11314 that  
11315 a  
11316 tran-  
11317 sient  
11318 rhe-  
11319 ol-  
11320 ogy  
11321 is  
11322 nec-  
11323 es-  
11324 sary  
11325 to  
11326 ex-  
11327 plain  
11328 post-  
11329 seis-  
11330 mic  
11331 de-  
11332 for-  
11333 ma-  
11334 tion;  
11335 how-  
11336 ever,  
11337 our  
11338 pre-  
11339 ferred  
11340 tran-

11341 sient  
11342 vis-  
11343 COS-  
11344 ity  
11345 of  
11346 ~  
11347 10<sup>18</sup>  
11348 Pa  
11349 S  
11350 in  
11351 the  
11352 man-  
11353 tle  
11354 is  
11355 an  
11356 or-  
11357 der  
11358 of  
11359 mag-  
11360 ni-  
11361 tude  
11362 larger  
11363 than  
11364 the  
11365 tran-  
11366 sient  
11367 vis-  
11368 COS-  
11369 ity  
11370 found  
11371 by  
11372 ?,  
11373 ]Pol-

11374 litz2003.  
11375 Since  
11376 a  
11377 Zener  
11378 model  
11379 is  
11380 able  
11381 to  
11382 de-  
11383 scribe  
11384 the  
11385 avail-  
11386 able  
11387 post-  
11388 seis-  
11389 mic  
11390 de-  
11391 for-  
11392 ma-  
11393 tion  
11394 fol-  
11395 low-  
11396 ing  
11397 the  
11398 El  
11399 Mayor-  
11400 Cucapah  
11401 earth-  
11402 quake,  
11403 any  
11404 Burg-  
11405 ers  
11406 rhe-

11407 ol-  
11408 ogy  
11409 with  
11410 a  
11411 steady-  
11412 state  
11413 vis-  
11414 COS-  
11415 ity  
11416 that  
11417 is  
11418  $\gtrsim$   
11419  $10^{20}$   
11420 Pa  
11421 S,  
11422 ef-  
11423 fec-  
11424 tively  
11425 in-  
11426 fi-  
11427 nite  
11428 over  
11429 5  
11430 years,  
11431 would  
11432 also  
11433 be  
11434 able  
11435 to  
11436 de-  
11437 scribe  
11438 the  
11439 post-

11440 seis-  
11441 mic  
11442 de-  
11443 for-  
11444 ma-  
11445 tion.  
11446 Such  
11447 a  
11448 Burg-  
11449 ers  
11450 model  
11451 might  
11452 then  
11453 be  
11454 CON-  
11455 sis-  
11456 tent  
11457 with  
11458 the  
11459 steady  
11460 state  
11461 vis-  
11462 cosi-  
11463 ties  
11464 nec-  
11465 es-  
11466 sary  
11467 for  
11468 lake  
11469 load-  
11470 ing,  
11471 in-  
11472 ter-

11473 seis-  
11474 mic  
11475 de-  
11476 for-  
11477 ma-  
11478 tion,  
11479 and  
11480 man-  
11481 tle  
11482 dy-  
11483 nam-  
11484 ics.

11485

11486 **5 Conclusion**

11487 We  
11488 have  
11489 ex-  
11490 tracted  
11491 a  
11492 fil-  
11493 tered  
11494 and  
11495 smoothed  
11496 es-  
11497 ti-  
11498 mate  
11499 of  
11500 post-  
11501 seis-  
11502 mic  
11503 de-  
11504 for-

11505 ma-  
11506 tion  
11507 fol-  
11508 low-  
11509 ing  
11510 the  
11511 El  
11512 Mayor-  
11513 Cucapah  
11514 earth-  
11515 quake  
11516 from  
11517 GPS  
11518 dis-  
11519 place-  
11520 ments  
11521 time  
11522 se-  
11523 ries.  
11524 We  
11525 have  
11526 treated  
11527 post-  
11528 seis-  
11529 mic  
11530 de-  
11531 for-  
11532 ma-  
11533 tion  
11534 as  
11535 a  
11536 stochas-  
11537 tic

11538 pro-

11539 cess

11540 where

11541 we

11542 did

11543 not

11544 pre-

11545 sume

11546 any

11547 char-

11548 ac-

11549 ter-

11550 is-

11551 tic

11552 shape

11553 of

11554 the

11555 post-

11556 seis-

11557 mic

11558 time

11559 se-

11560 ries.

11561 We

11562 can

11563 ob-

11564 serve

11565 tran-

11566 sient

11567 post-

11568 seis-

11569 mic

11570 de-

11571 for-  
11572 ma-  
11573 tion  
11574 at  
11575 dis-  
11576 tances  
11577 of  
11578 ~  
11579 400  
11580 km  
11581 from  
11582 the  
11583 El  
11584 Mayor-  
11585 Cucapah  
11586 epi-  
11587 cen-  
11588 ter  
11589 which  
11590 is  
11591 largely  
11592 un-  
11593 de-  
11594 tectable  
11595 af-  
11596 ter  
11597 about  
11598 3  
11599 years.  
11600 Near-  
11601 field  
11602 de-  
11603 for-

11604 ma-  
11605 tion  
11606 ex-  
11607 hibits  
11608 tran-  
11609 sience  
11610 that  
11611 de-  
11612 cays  
11613 to  
11614 a  
11615 sus-  
11616 tained,  
11617 el-  
11618 e-  
11619 vated  
11620 rate  
11621 af-  
11622 ter  
11623 about  
11624 1  
11625 to  
11626 2  
11627 year.  
11628 We  
11629 found  
11630 that  
11631 the  
11632 near-  
11633 field  
11634 tran-  
11635 sient  
11636 de-

11637 for-  
11638 ma-  
11639 tion  
11640 can  
11641 be  
11642 ex-  
11643 plained  
11644 with  
11645 shal-  
11646 low  
11647 af-  
11648 ter-  
11649 slip  
11650 and  
11651 the  
11652 sus-  
11653 tained  
11654 rate  
11655 of  
11656 near  
11657 field  
11658 de-  
11659 for-  
11660 ma-  
11661 tion  
11662 can  
11663 ei-  
11664 ther  
11665 be  
11666 ex-  
11667 plained  
11668 with  
11669 CON-

11670 tin-  
11671 ued  
11672 af-  
11673 ter-  
11674 slip  
11675 or  
11676 re-  
11677 lax-  
11678 ation  
11679 in  
11680 a  
11681 lower  
11682 crustal  
11683 with  
11684 a  
11685 vis-  
11686 COS-  
11687 ity  
11688 of  
11689 ~  
11690  $10^{19}$   
11691 Pa  
11692 S.  
11693 Far-  
11694 field  
11695 tran-  
11696 sient  
11697 de-  
11698 for-  
11699 ma-  
11700 tion  
11701 can  
11702 be

11703 more  
11704 defini-  
11705 tively  
11706 as-  
11707 cribed  
11708 to  
11709 vis-  
11710 coelas-  
11711 tic  
11712 re-  
11713 lax-  
11714 ation  
11715 at  
11716 depths  
11717 greater  
11718 than  
11719 ~  
11720 60  
11721 km.  
11722 Be-  
11723 neath  
11724 that  
11725 depth,  
11726 a  
11727 tran-  
11728 sient  
11729 vis-  
11730 COS-  
11731 ity  
11732 of  
11733 ~  
11734  $10^{18}$   
11735 Pa

11736 S  
11737 is  
11738 re-  
11739 quired  
11740 to  
11741 de-  
11742 scribe  
11743 the  
11744 rate  
11745 of  
11746 far-  
11747 field  
11748 de-  
11749 for-  
11750 ma-  
11751 tion  
11752 through-  
11753 out  
11754 the  
11755 5  
11756 years  
11757 CON-  
11758 sid-  
11759 ered  
11760 in  
11761 this  
11762 study.  
11763 By  
11764 de-  
11765 scrib-  
11766 ing  
11767 the  
11768 avail-

11769 able  
11770 post-  
11771 seis-  
11772 mic  
11773 de-  
11774 for-  
11775 ma-  
11776 tion  
11777 with  
11778 a  
11779 tran-  
11780 sient  
11781 rhe-  
11782 ol-  
11783 ogy  
11784 in  
11785 the  
11786 man-  
11787 tle,  
11788 our  
11789 pre-  
11790 ferred  
11791 model  
11792 does  
11793 not  
11794 CON-  
11795 flict  
11796 with  
11797 the  
11798 gen-  
11799 er-  
11800 ally  
11801 higher

11802 steady-  
11803 state  
11804 vis-  
11805 cosi-  
11806 ties  
11807 in-  
11808 ferred  
11809 from  
11810 geo-  
11811 phys-  
11812 i-  
11813 cal  
11814 pro-  
11815 cesses  
11816 OC-  
11817 curr-  
11818 ring  
11819 over  
11820 longer  
11821 time  
11822 scales.  
11823

11824 **Acknowledgements**

11825 We  
11826 are  
11827 grate-  
11828 ful  
11829 to  
11830 Andy  
11831 Freed  
11832 for  
11833 an

11834 il-  
11835 lu-  
11836 mi-  
11837 nat-  
11838 ing  
11839 dis-  
11840 cus-  
11841 sion  
11842 on  
11843 the  
11844 ma-  
11845 te-  
11846 rial  
11847 in  
11848 this  
11849 manuscript.  
11850 This  
11851 ma-  
11852 te-  
11853 rial  
11854 is  
11855 based  
11856 on  
11857 Earth-  
11858 Scope  
11859 Plate  
11860 Bound-  
11861 ary  
11862 Ob-  
11863 ser-  
11864 va-  
11865 tory  
11866 data

11867 ser-  
11868 vices  
11869 pro-  
11870 vided  
11871 by  
11872 UN-  
11873 AVCO  
11874 through  
11875 the  
11876 GAGE  
11877 Fa-  
11878 cil-  
11879 ity  
11880 with  
11881 sup-  
11882 port  
11883 from  
11884 the  
11885 Na-  
11886 tional  
11887 Sci-  
11888 ence  
11889 Foun-  
11890 da-  
11891 tion  
11892 (NSF)  
11893 and  
11894 Na-  
11895 tional  
11896 Aero-  
11897 nau-  
11898 tics  
11899 and

11900 Space  
11901 Ad-  
11902 min-  
11903 is-  
11904 tra-  
11905 tion  
11906 (NASA)  
11907 un-  
11908 der  
11909 NSF  
11910 Co-  
11911 op-  
11912 er-  
11913 a-  
11914 tive  
11915 Agree-  
11916 ment  
11917 No.  
11918 EAR-  
11919 1261833.

11920 This  
11921 ma-  
11922 te-  
11923 rial  
11924 is  
11925 based  
11926 upon  
11927 work  
11928 sup-  
11929 ported  
11930 by  
11931 the  
11932 Na-

11933 tional  
11934 Sci-  
11935 ence  
11936 Foun-  
11937 da-  
11938 tion  
11939 un-  
11940 der  
11941 Grant  
11942 Num-  
11943 bers  
11944 EAR  
11945 1045372  
11946 and  
11947 EAR  
11948 1245263.