Supplementary Material

Goodness of fit

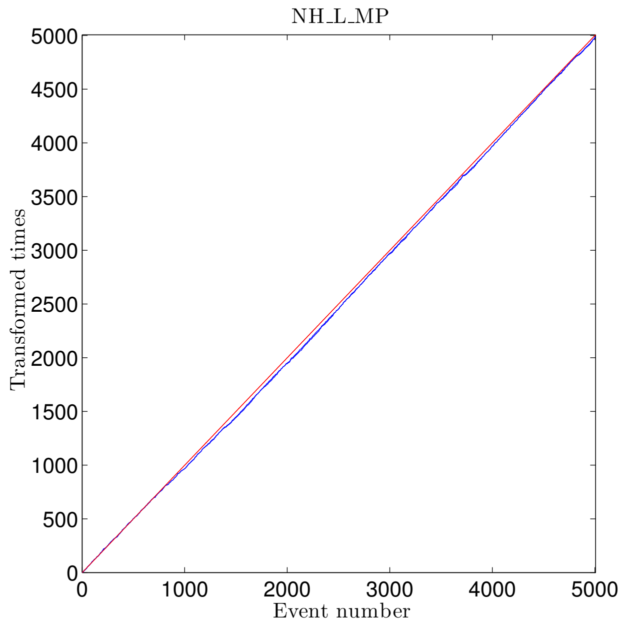
After estimating the unknown parameters and thereby the ETAS model, it is necessary to check the goodness of fit of the model to the observed earthquake data. For this purpose, the occurrence times of the earthquakes are transformed according to

$$\nu_i = \int_0^{t_i} \lambda(t)\, dt \tag{A5}$$

These transformed times ν_i are also known as residuals and such a sequence of transformed times is called the *Residual process* (Ogata, 1988). The above transformation would reduce a non-homogeneous Poisson process with correct rate $\lambda(t)$ that generated the observed data, to a unit rate homogeneous Poisson process. Hence, the obtained ETAS model is a good fit to the observed earthquake catalog only if the residual process derived from the estimated model is a homogeneous Poisson process with unit rate. For a unit rate homogeneous Poisson process, the plot of event number against the transformed times must be a straight line with slope one. It can be seen from the following figure (Fig. S1) that this verifies for the NS_L_MP and NS_Adapt models estimated for the considered GeoNet catalog.

References

Ogata Y (1988) Statistical models for earthquake occurrences and residual analysis for point processes. Journal of the American Statistical Association 83(401):9–27, DOI 10.1080/01621459.1988.10478560



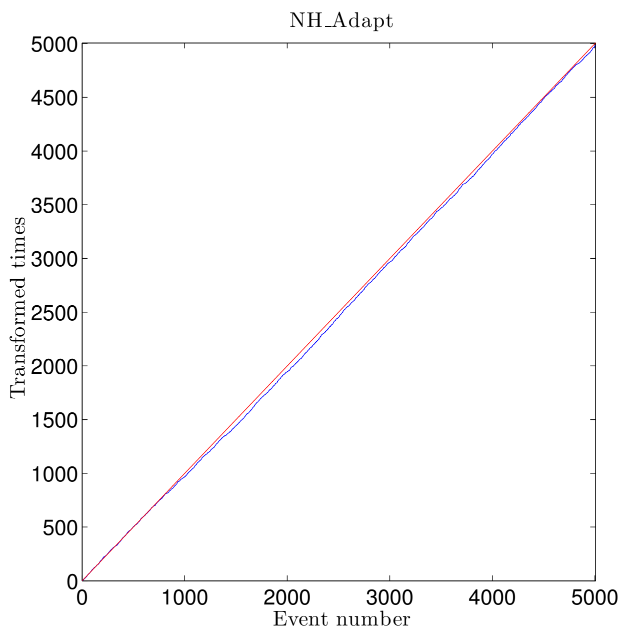


Figure S1: Plots of transformed times against the event number for the models NS_L_MP and NS_Adapt

Table S1: Estimates of the ETAS model aftershock parameters ($\hat{\Theta}$) for a Gaussian-type synthetic catalog obtained using the model NS_L_MP for different number of splines M.

M	K	α	c	p
50	0.0071	2.0106	0.0121	1.1539
100	0.0069	2.0139	0.0129	1.1737
150	0.0068	2.0197	0.0125	1.1677
200	0.0067	2.0234	0.0124	1.1679
250	0.0066	2.0290	0.0122	1.1650
300	0.0058	2.0497	0.0126	1.1908

Table S2: Estimates of the ETAS model aftershock parameters ($\hat{\Theta}$) for a Omori's law-type synthetic catalog obtained using the model NS_L_MP for different number of splines M.

M	K	α	c	p
50	0.0091	1.9389	0.0125	1.1685
100	0.0077	1.9846	0.0119	1.1582
150	0.0066	2.0290	0.0116	1.1486
200	0.0069	2.0124	0.0121	1.1648
250	0.0062	2.0411	0.0121	1.1625
300	0.0062	2.0491	0.0117	1.1483

Table S3: Estimates of the ETAS model aftershock parameters ($\hat{\Theta}$) for a Gaussian-type synthetic catalog obtained using the model NS_Adapt for different number of splines M and M_τ.

M	M_τ	K	α	c	p
50	10	0.0068	2.0183	0.0122	1.1624
50	20	0.0070	2.0185	0.0116	1.1435
50	30	0.0065	2.0287	0.0116	1.1565
50	40	0.0066	2.0272	0.0116	1.1540
100	10	0.0068	2.0212	0.0115	1.1462
100	20	0.0068	2.0220	0.0116	1.1508
100	30	0.0066	2.0257	0.0115	1.1528
100	40	0.0066	2.0277	0.0116	1.1564
100	50	0.0062	2.0356	0.0122	1.1752
100	60	0.0061	2.0314	0.0129	1.1901
150	10	0.0069	2.0196	0.0112	1.1410
150	20	0.0068	2.0216	0.0114	1.1472
150	30	0.0066	2.0336	0.0110	1.1419
150	40	0.0066	2.0271	0.0115	1.1512
150	50	0.0064	2.0322	0.0121	1.1695
150	60	0.0062	2.0363	0.0123	1.1766
200	10	0.0070	2.0177	0.0112	1.1407
200	20	0.0067	2.0231	0.0115	1.1505
200	30	0.0065	2.0360	0.0110	1.1437
200	40	0.0066	2.0276	0.0116	1.1570
200	50	0.0064	2.0316	0.0120	1.1660
200	60	0.0062	2.0433	0.0118	1.1666
250	10	0.0069	2.0193	0.0114	1.1452
250	20	0.0067	2.0235	0.0116	1.1516
250	30	0.0065	2.0368	0.0109	1.1406
250	40	0.0065	2.0306	0.0116	1.1561
250	50	0.0064	2.0322	0.0121	1.1690
250	60	0.0063	2.0361	0.0119	1.1677
300	10	0.0064	2.0259	0.0124	1.1756
300	20	0.0062	2.0310	0.0127	1.1863
300	30	0.0060	2.0436	0.0122	1.1807
300	40	0.0060	2.0387	0.0126	1.1887
300	50	0.0059	2.0425	0.0131	1.1991
300	60	0.0058	2.0437	0.0129	1.1966

Table S4: Estimates of the ETAS model aftershock parameters ($\hat{\Theta}$) for an Omori's law-type synthetic catalog obtained using the model NS_Adapt for different number of splines M and M_τ.

M	M_τ	K	α	c	p
50	10	0.0095	1.9359	0.0123	1.1576
50	20	0.0097	1.9374	0.0114	1.1358
50	30	0.0094	1.9379	0.0121	1.1533
50	40	0.0094	1.9378	0.0122	1.1564
100	10	0.0085	1.9772	0.0111	1.1284
100	20	0.0084	1.9791	0.0112	1.1316
100	30	0.0083	1.9804	0.0112	1.1332
100	40	0.0083	1.9797	0.0111	1.1323
100	50	0.0081	1.9783	0.0118	1.1514
100	60	0.0081	1.9811	0.0116	1.1453
150	10	0.0075	2.0281	0.0104	1.0971
150	20	0.0073	2.0291	0.0108	1.1096
150	30	0.0071	2.0277	0.0109	1.1178
150	40	0.0070	2.0282	0.0112	1.1288
150	50	0.0068	2.0301	0.0119	1.1437
150	60	0.0069	2.0292	0.0114	1.1336
200	10	0.0083	1.9832	0.0109	1.1253
200	20	0.0081	1.9851	0.0114	1.1389
200	30	0.0081	1.9859	0.0112	1.1336
200	40	0.0078	1.9847	0.0119	1.1553
200	50	0.0070	2.0073	0.0122	1.1658
200	60	0.0076	1.9884	0.0120	1.1602
250	10	0.0077	2.0169	0.0105	1.1052
250	20	0.0074	2.0173	0.0111	1.1228
250	30	0.0073	2.0186	0.0110	1.1221
250	40	0.0071	2.0181	0.0114	1.1366
250	50	0.0069	2.0222	0.0119	1.1465
250	60	0.0069	2.0239	0.0117	1.1431
300	10	0.0074	2.0353	0.0104	1.0944
300	20	0.0070	2.0359	0.0113	1.1197
300	30	0.0070	2.0372	0.0110	1.1134
300	40	0.0067	2.0345	0.0120	1.1432
300	50	0.0066	2.0380	0.0120	1.1432
300	60	0.0067	2.0377	0.0116	1.1336

Table S5: Estimates of the ETAS model aftershock parameters ($\hat{\Theta}$) for the earthquake occurrences in Gisborne region for the period 2012/01 - 2015/05 obtained using the model NS_Adapt for different number of splines M and M_τ.

M	M_τ	K	α	c	p
50	10	0.0173	1.5200	0.0103	1.0759
50	20	0.0164	1.5290	0.0106	1.0934
50	30	0.0157	1.5360	0.0110	1.1082
50	40	0.0146	1.5449	0.0120	1.1406
100	10	0.0167	1.5273	0.0103	1.0828
100	20	0.0159	1.5346	0.0104	1.0935
100	30	0.0145	1.5496	0.0110	1.1229
100	40	0.0145	1.5518	0.0110	1.1216
100	50	0.0142	1.5606	0.0109	1.1227
100	60	0.0136	1.5598	0.0113	1.1404
150	10	0.0156	1.5376	0.0107	1.1025
150	20	0.0145	1.5496	0.0108	1.1203
150	30	0.0133	1.5593	0.0116	1.1516
150	40	0.0131	1.5593	0.0115	1.1525
150	50	0.0131	1.5646	0.0114	1.1498
150	60	0.0117	1.5712	0.0130	1.2045
200	10	0.0154	1.5390	0.0107	1.1059
200	20	0.0144	1.5513	0.0108	1.1211
200	30	0.0128	1.5596	0.0119	1.1677
200	40	0.0129	1.5611	0.0116	1.1575
200	50	0.0125	1.5668	0.0118	1.1667
200	60	0.0123	1.5649	0.0121	1.1779
250	10	0.0154	1.5390	0.0107	1.1060
250	20	0.0144	1.5527	0.0108	1.1204
250	30	0.0130	1.5610	0.0118	1.1592
250	40	0.0095	1.5892	0.0157	1.2934
250	50	0.0123	1.5721	0.0118	1.1696
250	60	0.0119	1.5752	0.0123	1.1878
300	10	0.0149	1.5439	0.0108	1.1141
300	20	0.0140	1.5572	0.0109	1.1288
300	30	0.0128	1.5649	0.0118	1.1631
300	40	0.0122	1.5704	0.0121	1.1778
300	50	0.0122	1.5711	0.0119	1.1739
300	60	0.0120	1.5715	0.0123	1.1854