Tables of Seismological Co-latitude

By Eugene Herrin and James Taggart

Bullen (1937b, p. 160) suggests the use of a new latitude for the computation of distances involved in studies of seismic travel-times. He defines the "seismological latitude," θ, as:

$$\theta = 1.1\theta_1 - 0.1\theta_2$$

where θ_1 = geocentric latitude

and θ_2 = geographic latitude

Geocentric latitude is defined by the following equation:

$$\text{Tan } \theta_1 = 0.99327 \text{ Tan } \theta_2$$

The constant was computed from Jeffreys' (1952, p. 144) value of polar flattening.

The use of seismological latitude increases the accuracy of computations of great-circle distances and greatly simplifies the ellipticity correction for seismic travel-times. Bullen (1937b, p. 162) shows that the use of "seismological latitude" allows computations of travel-times with errors less than 0.1 second without recourse to the awkward triple-entry tables needed for complete ellipticity corrections (Bullen, 1937a).

The tables in this paper permit conversion of the geographic latitude to seismological co-latitude. The tables are entered by reading the geographic latitude to the nearest unit down the lefthand column and the nearest tenth across the page. Interpolations are possible to two or more orders of magnitude. The difference in values for an increment of 0.1 latitude are 0.099, 0.100, or 0.101 units so that interpolations may be made to sufficient accuracy by adopting a constant difference of 0.100 units. Thus reading the tables becomes very simple. For example, to find the seismological co-latitude corresponding to 65.°316 north latitude enter the northern hemisphere table (Table 1) at 65.°3 and read 25.862. The remaining digits beyond the tenth-place (0.016) are subtracted from this value to give 25.846. In the southern hemisphere table (Table 2) digits beyond the tenths-place are added to the values read. The seismological co-latitude obtained in this way is accurate $\pm$ 0.001 unit or approximately $\pm$ 100 meters and, therefore, is well within the limits of accuracy for seismological calculations.

TABLE 1

Northern Hemisphere

For Conversion of Geographic Latitude to Seismological Co-Latitude

Degrees	Tenths of Degrees									
	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900
0	90.000	89.901	.802	.702	.603	.504	.404	.305	.206	.107
1	89.007	88.908	.809	.710	.610	.511	.412	.313	.213	.114
2	88.015	87.916	.816	.717	.618	.519	.419	.320	.221	.121
3	87.022	86.923	.824	.724	.625	.526	.427	.327	.228	.129
4	86.030	85.930	.831	.732	.632	.533	.434	.335	.235	.136
5	85.037	84.938	.838	.739	.640	.540	.441	.342	.243	.143
6	84.044	83.945	.846	.746	.647	.548	.448	.349	.250	.151
7	83.051	82.952	.853	.753	.654	.555	.456	.356	.257	.158
8	82.058	81.959	.860	.761	.661	.562	.463	.363	.264	.165
9	81.066	80.966	.867	.768	.668	.569	.470	.370	.271	.172
10	80.072	79.973	.874	.775	.675	.576	.477	.377	.278	.179
11	79.079	78.980	.881	.781	.682	.583	.483	.384	.285	.186
12	78.086	77.987	.888	.788	.689	.590	.490	.391	.292	.192
13	77.093	76.994	.894	.795	.696	.596	.497	.398	.298	.199
14	.100	76.000	75.901	.801	.702	.603	.503	.404	.305	.205
15	75.106	75.007	74.907	.808	.709	.609	.510	.410	.311	.212
16	.112	74.013	73.914	.814	.715	.615	.516	.417	.317	.218
17	.119	73.019	72.920	.820	.721	.622	.522	.423	.323	.224
18	.125	72.025	71.926	.826	.727	.628	.528	.429	.329	.230
19	.131	71.031	70.932	.832	.733	.633	.534	.435	.335	.236
20	70.136	70.037	69.937	.838	.739	.639	.540	.440	.341	.241
21	.142	69,042	68.943	.844	.744	.645	.545	.446	.346	.247
22	.147	68.048	67.948	.849	.749	.650	.550	.451	.352	.252
23	.153	67.053	66.954	.854	.755	.655	.556	.456	.357	.257
24	.158	66.058	65.959	.859	.760	.660	.561	.461	.362	.262
25	65.162	65.063	64.963	.864	.764	.665	.565	.466	.366	.267
26	.167	64.068	63.968	.869	.769	.669	.570	.470	.371	.271
27	.172	63.072	62.972	.873	.773	.674	.574	.475	.375	.275
28	.176	62.076	61.977	.877	.778	.678	.578	.479	.379	.280
29	.180	61.080	60.981	.881	.781	.682	.582	.483	.383	.283
30	60.184	60.084	59.985	.885	.785	.686	.586	.486	.387	.287
31	.187	59.088	58.988	.888	.789	.689	.589	.490	.390	.290
32	.191	58.091	57.991	.892	.792	.692	.593	.493	.393	.294
33	.194	57.094	56.995	.895	.795	.695	.596	.496	.396	.297
34	.197	56.097	55.997	.898	.798	.698	.598	.499	.399	.299
35	55.200	.100	55.000	54.900	.801	.701	.601	.501	.401	.302
36	.202	.102	54.002	53.903	.803	.703	.603	.504	.404	.304
37	.204	.104	53.005	52.905	.805	.705	.605	.506	.406	.306
38	.206	.106	52.006	51.907	.807	.707	.607	.507	.407	.308
39	.208	.108	51.008	50.908	.808	.709	.609	.509	.409	.309
40	50.209	.109	50.009	49.910	.810	.710	.610	.510	.410	.310
41	.210	.110	49.011	48.911	.811	.711	.611	.511	.411	.311
42	.211	.111	48.011	47.912	.812	.712	.612	.512	.412	.312
43	.212	.112	47.012	46.912	.812	.712	.612	.512	.412	.312
44	.212	.112	46.012	45.912	.812	.713	.613	.513	.413	.313

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TABLE 1 (Continued)

Degrees	Tenths of Degrees								
	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900
	45.213	.113	45.013	44.913	.813	.713	.613	.513	.412	.312
45	.212	.112	44.012	43.912	.812	.712	.612	.512	.412	.312
46	.212	.112	43.012	42.912	.812	.712	.612	.512	.412	.312
47	.211	.111	42.011	41.911	.811	.711	.611	.511	.411	.311
48	.211	.110	41.010	40.910	.810	.710	.610	.510	.410	.310
49	40.209	.109	40.009	39.909	.809	.709	.609	.509	.408	.308
50	.208	.108	39.008	38.908	.807	.707	.607	.507	.407	.307
51	.206	.106	38.006	37.906	.806	.706	.605	.505	.405	.305
52	.205	.104	37.004	36.904	.804	.703	.603	.503	.403	.303
53	.202	.102	36.002	35.902	.801	.701	.601	.501	.400	.300
54	35.200	35.100	34.999	.899	.799	.699	.598	.498	.398	.298
55	.197	34.097	33.997	.897	.796	.696	.596	.495	.395	.295
56	.194	33.094	32.994	.894	.793	.693	.593	.492	.392	.292
57	.191	32.091	31.991	.890	.790	.690	.589	.489	.389	.288
58	.188	31.088	30.987	.887	.787	.686	.586	.486	.385	.285
59	30.184	30.084	29.984	.883	.783	.683	.582	.482	.381	.281
60	.181	29.080	28.980	.879	.779	.679	.578	.478	.377	.277
61	.177	28.076	27.976	.875	.775	.674	.574	.474	.373	.273
62	.172	27.072	26.971	.871	.771	.670	.570	.469	.369	.268
63	.168	26.067	25.967	.867	.766	.666	.565	.465	.364	.264
64	25.163	25.063	24.962	.862	.761	.661	.560	.460	.359	.259
65	.158	24.058	23.957	.857	.756	.656	.555	.455	.354	.254
66	.153	23.053	22.952	.852	.751	.651	.550	.450	.349	.249
67	.148	22.048	21.947	.846	.746	.645	.545	.444	.344	.243
68	.143	21.042	20.942	.841	.740	.640	.539	.439	.338	.238
69	20.137	20.036	19.936	.835	.735	.634	.534	.433	.332	.232
70	.131	19.031	18.930	.829	.729	.628	.528	.427	.327	.226
71	.125	18.025	17.924	.823	.723	.622	.522	.421	.320	.220
72	.119	17.019	16.918	.817	.717	.616	.515	.415	.314	.214
73	.113	16.012	15.912	.811	.710	.610	.509	.409	.308	.207
74	15.107	15.006	14.905	.805	.704	.603	.503	.402	.301	.201
75	14.100	13.999	.899	.798	.697	.597	.496	.395	.295	.194
76	13.093	12.993	.892	.791	.691	.590	.489	.389	.288	.187
77	12.087	11.986	.885	.785	.684	.583	.483	.382	.281	.181
78	11.080	10.979	.879	.778	.677	.576	.476	.375	.274	.174
79	10.073	9.972	.872	.771	.670	.569	.469	.368	.267	.167
80	9.066	8.965	.864	.764	.663	.562	.462	.361	.260	.160
81	8.059	7.958	.857	.757	.656	.555	.454	.354	.253	.152
82	7.052	6.951	.850	.749	.649	.548	.447	.347	.246	.145
83	6.044	5.944	.843	.742	.641	.541	.440	.339	.239	.138
84	5.037	4.936	.836	.735	.634	.533	.433	.332	.231	.130
85	4.030	3.929	.828	.727	.627	.526	.425	.325	.224	.123
86	3.022	2.922	.821	.720	.619	.519	.418	.317	.216	.116
87	2.015	1.914	.813	.713	.612	.511	.410	.310	.209	.108
88	1.007	0.907	.806	.705	.604	.504	.403	.302	.201	.101
89	0.000									
90										

References:K. E. Bullen (1937a) The ellipticity correction to travel-times of P and S earthquake waves. Mon. Not. Royal Astron. Soc., v. 4, no. 2, p. 143-57; (1937b) A suggested new "seismological latitude." *Ibid.*, v. 4, no. 2, p. 158-64. Harold Jeffreys (1952) *The Earth*. Camb. Univ. Press, p. 184.

TABLE 2

Southern Hemisphere

For Conversion of Geographic Latitude to Seismological Co-Latitude

Degrees	*Tenths of Degrees*									
	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900
0	90.000	.099	.199	.298	.397	.496	.596	.695	.794	.893
1	90.993	91.092	.191	.290	.390	.489	.588	.687	.787	.886
2	91.985	92.085	.184	.283	.382	.482	.581	.680	.779	.879
3	92.978	93.077	.176	.276	.375	.474	.574	.673	.772	.871
4	93.971	94.070	.169	.268	.368	.467	.566	.665	.765	.864
5	94.963	95.063	.162	.261	.360	.460	.559	.658	.757	.857
6	95.956	96.055	.155	.254	.353	.452	.552	.651	.750	.850
7	96.949	97.048	.147	.247	.346	.445	.545	.644	.743	.842
8	97.942	98.041	.140	.240	.339	.438	.537	.637	.736	.835
9	98.935	99.034	.133	.232	.332	.431	.530	.630	.729	.828
10	99.928	100.027	.126	.226	.325	.424	.523	.623	.722	.821
11	100.921	101.020	.119	.219	.318	.417	.517	.616	.715	.815
12	101.914	102.013	.113	.212	.311	.411	.510	.609	.709	.808
13	102.907	103.007	.106	.205	.305	.404	.503	.603	.702	.801
14	103.901	104.000	.099	.199	.298	.397	.497	.596	.695	.795
15	104.894	104.993	105.093	.192	.292	.391	.490	.590	.689	.788
16	.888	105.987	106.087	.186	.285	.385	.484	.583	.683	.782
17	.882	106.981	107.080	.180	.279	.379	.478	.577	.677	.776
18	.876	107.975	108.074	.174	.273	.373	.472	.571	.671	.770
19	.870	108.969	109.068	.168	.267	.367	.466	.566	.665	.764
20	109.864	109.963	110.063	.162	.262	.361	.460	.560	.659	.759
21	.858	110.958	111.057	.157	.256	.355	.455	.554	.654	.753
22	.853	111.952	112.052	.151	.251	.350	.450	.549	.649	.748
23	.848	112.947	113.047	.146	.246	.345	.444	.544	.643	.743
24	.842	113.942	114.042	.141	.241	.340	.440	.539	.639	.738
25	114.838	114.937	115.037	.136	.236	.335	.435	.534	.634	.733
26	.833	115.932	116.032	.132	.231	.331	.430	.530	.629	.729
27	.828	116.928	117.028	.127	.227	.326	.426	.525	.625	.725
28	.824	117.924	118.023	.123	.223	.322	.422	.521	.621	.721
29	.820	118.920	119.019	.119	.219	.318	.418	.517	.617	.717
30	119.816	119.916	120.016	.115	.215	.315	.414	.514	.613	.713
31	.813	120.912	121.012	.112	.211	.311	.411	.510	.610	.710
32	.809	121.909	122.009	.108	.208	.308	.407	.507	.607	.706
33	.806	122.906	123.006	.105	.205	.305	.404	.504	.604	.704
34	.803	123.903	124.003	.102	.202	.302	.402	.501	.601	.701
35	124.801	124.900	125.000	.100	.200	.299	.399	.499	.599	.698
36	.798	898	125.998	126.097	.197	.297	.397	.497	.596	.696
37	.796	.896	126.996	127.095	.195	.295	.395	.495	.594	.694
38	.794	.894	127.994	128.094	.193	.293	.393	.493	.593	.692
39	.792	.892	128.992	129.092	.192	.292	.391	.491	.591	.691
40	129.791	.891	129.991	130.091	.190	.290	.390	.490	.590	.690
41	.790	.890	130.990	131.089	.189	.289	.389	.489	.589	.689
42	.789	.889	131.989	132.089	.188	.288	.388	.488	.588	.688
43	.788	.888	132.988	133.088	.188	.288	.388	.488	.588	.688
44	.788	.888	133.988	134.088	.188	.288	.388	.488	.588	.688
45	134.788									

TABLE 2 (Continued)

Degrees	Tenths of Degrees								
	0.000	0.100	0.200	0.300	0.400	0.500	0.600	0.700	0.800	0.900
	134.788	.888	134.988	135.088	.188	.288	.388	.488	.588	.688
45	.788	.888	135.988	136.088	.188	.288	.388	.488	.588	.688
46	.788	.888	136.988	137.088	.188	.288	.388	.488	.588	.689
47	.789	.889	137.989	138.089	.189	.289	.389	.489	.589	.689
48	.790	.890	138.990	139.090	.190	.290	.390	.490	.590	.691
49	139.791	.891	139.991	140.091	.191	.291	.391	.492	.592	.692
50	.792	.892	140.992	141.092	.193	.293	.393	.493	.593	.694
51	.794	.894	141.994	142.094	.194	.295	.395	.495	.595	.695
52	.796	.896	142.996	143.096	.196	.297	.397	.497	.597	.698
53	.798	.898	143.998	144.098	.199	.299	.399	.499	.600	.700
54	144.800	144.900	145.001	.101	.201	.301	.402	.502	.602	.702
55	.803	145.903	146.003	.104	.204	.304	.404	.505	.605	.705
56	.806	146.906	147.006	.107	.207	.307	.407	.508	.608	.708
57	.809	147.909	148.009	.110	.210	.310	.411	.511	.611	.712
58	.812	148.912	149.013	.113	.214	.314	.414	.515	.615	.715
59	149.816	149.916	150.016	.117	.217	.318	.418	.518	.619	.719
60	.819	150.920	151.020	.121	.221	.321	.422	.522	.623	.723
61	.824	151.924	152.024	.125	.225	.326	.426	.526	.627	.727
62	.828	152.928	153.029	.129	.230	.330	.430	.531	.631	.732
63	.832	153.933	154.033	.134	.234	.335	.435	.535	.636	.736
64	154.837	154.937	155.038	.138	.239	.339	.440	.540	.641	.741
65	.842	155.942	156.043	.143	.244	.344	.445	.545	.646	.746
66	.847	156.947	157.048	.148	.249	.349	.450	.550	.651	.752
67	.852	157.953	158.053	.154	.254	.355	.455	.556	.656	.757
68	.858	158.958	159.059	.159	.260	.360	.461	.561	.662	.763
69	159.863	159.964	160.064	.165	.265	.366	.467	.567	.668	.768
70	.869	160.969	161.070	.171	.271	.372	.472	.573	.674	.774
71	.875	161.975	162.076	.177	.277	.378	.478	.579	.680	.780
72	.881	162.982	163.082	.183	.283	.384	.485	.585	.686	.786
73	.887	163.988	164.088	.189	.290	.390	.491	.592	.692	.793
74	164.894	164.994	165.095	.195	.296	.397	.497	.598	.699	.799
75	165.900	166.001	.101	.202	.303	.403	.504	.605	.705	.806
76	166.907	167.007	.108	.209	.309	.410	.511	.611	.712	.813
77	167.913	168.014	.115	.215	.316	.417	.517	.618	.719	.820
78	168.920	169.021	.122	.222	.323	.424	.524	.625	.726	.826
79	169.927	170.028	.129	.229	.330	.431	.531	.632	.733	.834
80	170.934	171.035	.136	.236	.337	.438	.538	.639	.740	.841
81	171.941	172.042	.143	.243	.344	.445	.546	.646	.747	.848
82	172.949	173.049	.150	.251	.351	.452	.553	.654	.754	.855
83	173.956	174.056	.157	.258	.359	.459	.560	.661	.762	.862
84	174.963	175.064	.165	.265	.366	.467	.567	.668	.769	.870
85	175.970	176.071	.172	.273	.373	.474	.575	.676	.776	.877
86	176.978	177.079	.179	.280	.381	.482	.582	.683	.784	.884
87	177.985	178.086	.187	.287	.388	.498	.590	.690	.791	.892
88	178.993	179.093	.194	.295	.396	.496	.597	.698	.799	.899
89	180.000									
90										