Re-Analysis of Truncated Periods and Amplitudes

Introduction

Errors in one of the ISC's data collection programs have resulted in truncated data values being published in the ISC Bulletin. Data from 1996 January through 1997 June were affected. In the Reviewed Event Bulletins from the prototype IDC (agency code EIDC), the leading (most significant) digits were truncated from

- slownesses greater than 99.9 seconds/degree
- amplitudes greater than 9.99 nanometers
- periods greater than 9.9 seconds

The ISC re-parsed all EIDC bulletins for this period and re-analysed magnitudes for all events in the ISC Bulletin that may have been affected by the truncation. As described in the 1999 Fourth Quarter Update the ISC plans to distribute a replacement for CD 7 (which included the truncated amplitudes from 1996) to all Bulletin subscribers and CD purchasers.

Summary of Affected Measurements

Our re-analysis included more than 444,000 EIDC amplitudes during 1996-JAN to 1997-JUN that were re-published in the ISC Bulletin. [As a result of receiving reports for some stations from both EIDC and a station operator, there is some uncertainty about the source of each amplitude. Thus, the numbers of amplitudes reported here are only approximate].

We are issuing revised Bulletin data with corrections for 11,400 previously truncated amplitudes and 10,300 previously truncated periods. A total of 13,600 measurements have been affected; in most instances both the amplitude and period were truncated.

Because both amplitude and period of teleseismic phases are almost always smaller than the truncation thresholds, only a very small fraction of those measurements were affected, regardless of whether they were direct phases or "depth phases" (Table 1). Even among regional phases, which often have larger amplitudes, less than 2% of amplitudes were truncated. Among surface waves, on the other hand, period was almost always truncated, and amplitude was usually truncated as well.

Table 1: Number of amplitudes from EIDC-reported stations that are includde in both the Bulletin as originally and in the revised Bulletin data now released. Classification into regional, surface wave, teleseismic and depth phases is based on the operator phase identification.

		With truncated...		
class	**total**	**ampl.**	**period**	**either**
regional	28639	518	0	518
surface	10376	8159	10323	10323
teleseismic	364918	2585	5	2590
depth phase	19931	159	0	159

In addition, the revised Bulletin data include approximately 500 EIDC amplitudes and periods that were previously excluded. These amplitudes had been excluded because they appeared to be anomalous as a result of truncation. Finally, approximately 200 amplitudes originally in the Bulletin have been excluded from the revised data. These had originally appeared consistent with other amplitudes only as a result of truncation.

Summary of Affected Magnitudes

We followed standard ISC procedures regarding anomalous amplitudes in both the original editing for the Bulletin and in the re-analysis. Under these procedures, special action is required when the range of single-station magnitudes for an event exceeds 2.2 magnitude units. When this range is exceeded, an editor subjectively identifies anomalous amplitudes for the event and excludes them from the Bulletin.

In the newly released Bulletin data, the ISC has computed 3567 surface wave magnitudes. Almost all of these, 3461, included at least one amplitude that was previously published with a truncated value. The newly released Bulletin data also have 27410 body wave magnitudes. But only a small proportion of these, 1019, include a a teleseismic or depth phase amplitude that was truncated in the original publication of the Bulletin.

Discussion of Surface Wave Magnitudes

Of the 3461 earthquakes with an ISC MS based at least partly on EIDC amplitudes, 1648 were originally published with no MS due to the lack of any associated amplitude data. Of the other 1813, over over half include contributions from fewer than four previously truncated amplitudes. Since the average number of amplitudes from non-EIDC for these events is 23, most changes in the network-average MS are expected to be small. Indeed, nearly three-quarters are changed by no more than 0.1 magnitude units (Table 2).

Table 2: Frequency of occurrence of changes in magnitude values. Negative change means smaller magnitude in the newly released data. Only magnitudes computed from at least one previously truncated amplitude are included. Many more magnitudes, computed only from amplitudes that were accurately reported in the original Bulletin data, are unchanged.

Mag Diff	MS	mb
-1.5	1	
-1.4	1	
-1.3	1	
-1.2	2	
-1.1	4	
-1.0	5	
-0.9	3	
-0.8	12	
-0.7	21	
-0.6	28	
-0.5	51	
-0.4	50	
-0.3	111	
-0.2	171	
-0.1	500	3
0.0	764	838
0.1	64	170
0.2	12	4
0.3	8	2
0.4	1	
0.5	1	
0.6		
0.7		
0.8	2	
0.9		1

Previously none of the truncated LR amplitudes were used by the ISC to compute MS, since the periods were truncated to less than 10 seconds. Thus, the number of contributing amplitudes has gone up for every MS (Table 3). Since the previously truncated amplitudes were unused, we have no expectation that increases in MS will be more common that decreases. In fact, somewhat surprisingly, the preponderance of significant changes in MS were decreases (Table 2).

Table 3: Frequency of occurrence of changes in number of contributing amplitudes. Negative change means fewer amplitudes in the newly released data. Only magnitudes computed from at least one previously truncated amplitude are included. Many more magnitudes, computed only from amplitudes that were accurately reported in the original Bulletin data, are unchanged.

sta diff	MS count	mb count
-2		1
-1		29
0		800
1	296	115
2	274	42
3	270	10
4	252	9
5	222	6
6	161	4
7	125	2
8	73	
9	64	
10	32	
11	14	
12	18	
13	6	
14	1	
15	2	
16	3	

Discussion of Body Wave Magnitudes

Of the 1019 earthquakes with an ISC mb based at least partly on previously truncated amplitudes, 1018 are adjustments of a previously published value. For a 800 of these, the number of contributing amplitudes has not changed at all. For almost all of the other 218, the number of contributing amplitudes has increased. This is the result from restoring previously truncated amplitudes so that they are now within the appropriate range to use with other amplitudes for the event. In just a few instances, the number of contributing teleseismic amplitudes has decreased. This occurs sometimes because a previously truncated amplitude is now anomalously large, and other times because the best-estimate of event magnitude changes sufficiently that a previously acceptable amplitude is now anomalous.

Unlike surface waves, teleseismic body waves have periods that are not affected by truncation, so truncated body wave amplitudes were used in computing mb values for the Bulletin. But only a small fraction of teleseismic amplitudes were truncated, so even mb values from one or two truncated amplitudes were usually based on mostly on accurate amplitudes. Recognising futhermore that severely truncated amplitudes would have been excluded as anomalous, only small changes of mb values are expected. In fact, only 7 mb values changed by more than 0.1 units. The predominance of increases over decreases in mb is entirely expected as a

result of restoring truncated amplitudes that were already being used. An mb could be decreased only as a result of excluding a large amplitude that has come to appear anomalous during re-analysis.

Discussion of Large Magnitude Changes

Of 82 MS values that changed by 0.5 or more magnitude units, 3 were previously computed from three LR amplitudes, and the other 79 from just one or two amplitudes. In these cases, changes of of better than 0.5 units are not surprising. For 9 earthquakes, the ISC's MS value has decreased by more than 1.0 units. In these cases the previously truncated data predominate the new best estimate of MS, and in some instances amplitude used originally is different enough from the newly used amplitudes to be excluded as anomalous. In the case of these very large differences, it may be less surprising that the new magnitudes are all smaller than the original amplitude. A "censoring" affect, which biases magnitudes high because small amplitude phases are simply not seen, would be more important for magnitudes computed from just one or two amplitudes.

The largest increase in any magnitude was an mb that changed from 5.4 to 6.3 for an earthquake in Indonesia. The ISC's mb estimate for this event is based exclusively on six EIDC amplitudes, of which three were truncated. The most severe affect from truncation was for Alice Springs, at D=23 degrees, where the station magnitude was changed from 4.4 to 7.1. The ASAR truncated amplitude was almost so small that it would have had to be exclued as anomalous. The restored ASAR amplitude, in contrast, is large compared with the others, none of which give a station magnitude larger than 6.4.

Summary

For the period 1996-January-01 to 1997-June-30:

- Amplitudes of regional and teleseismic body waves reported in the Bulletin for EIDC stations are very occasionally truncated.
- Amplitudes and periods of surface waves reported in the Bulletin for EIDC stations are often truncated.
- Body wave magnitudes reported in the Bulletin are almost always correct.
- Surface wave magnitudes reported in the Bulletin are based on accurate amplitudes, but miss out EIDC amplitudes. New values differ much only where MS was computed from an insufficient number of amplitudes.