Defense Threat Reduction Agency
8725 John J. Kingman Road, MS 6201
Fort Belvoir, VA 22060-6201

DTRA-TR-03-21

TECHNICAL REPORT

Formation of Ground Truth Databases and Related Studies and Regional Seismic Monitoring Research

Approved for public release; distribution is unlimited.

June 2006

DSWA01-98-C-0156

Ivan Henson, et al.

Prepared by:
Multimax, Inc.
1441 McCormick
Largo, MD 20774

DARE Tracking
73759

DESTRUCTION NOTICE

FOR CLASSIFIED documents, follow the procedures in DoD 5550.22-M, National Industrial Security Program Operating Manual, Chapter 5, Section 7 (NISPOM) or DoD 5200.1-R, Information Security Program Regulation, Chapter 1X.

FOR UNCLASSIFIED limited documents, destroyed by any method that will prevent disclosure of contents or reconstruction of the document.

Retention of this document by DoD contractors is authorized in accordance with DoD 5220.22M, Industrial Security manual.

PLEASE NOTIFY THE DEFENSE THREAT REDUCTION AGENCY, ATTN: IMMI, 8725 JOHN J. KINGMAN ROAD, MS-6201, FT. BELVOIR, VA 22060-6201. IF YOUR ADDRESS IS INCORRECT, IF YOU WISH IT DELETED FROM THE DISTRIBUTION LIST, OR IF THE ADDRESSEE IS NO LONGER EMPLOYED BY YOUR ORGANIZATION.

DISTRIBUTION LIST UPDATE

This mailer is provided to enable DTRA to maintain current distribution lists for reports. (We would appreciate you providing the requested information.)

- ☐ Add the individual listed to your distribution list.
- ☐ Delete the cited organization/individual.
- ☐ Change of address.

Note:
Please return the mailing label from the document so that any additions, changes, corrections or deletions can be made easily. For distribution cancellation or more information call DTRA/BDLMI (703) 767-4725.

NAME: _____

ORGANIZATION: _____

OLD ADDRESS	NEW ADDRESS
_____	_____
_____	_____
_____	_____

TELEPHONE NUMBER: ( ) _____

DTRA PUBLICATION NUMBER/TITLE	CHANGES/DELETIONS/ADDITONS, etc. *(Attach Sheet if more Space is Required)*
_____	_____
_____	_____
_____	_____

DTRA or other GOVERNMENT CONTRACT NUMBER: _____

CERTIFICATION of NEED-TO-KNOW BY GOVERNMENT SPONSOR (if other than DTRA):

SPONSORING ORGANIZATION: _____

CONTRACTING OFFICER or REPRESENTATIVE: _____

SIGNATURE: _____

DEFENSE THREAT REDUCTION AGENCY
ATTN: BDLMI
8725 John J Kingman Road, MS 6201
Fort Belvoir, VA 22060-6201

DEFENSE THREAT REDUCTION AGENCY
ATTN: BDLMI
8725 John J Kingman Road, MS 6201
Fort Belvoir, VA 22060-6201

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. **PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.**

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
	Technical Report	9/21/98 to 12/31/00

4. TITLE AND SUBTITLE
Formation of Ground Truth Databases and Related Studies

And Regional Seismic Monitoring Research

5a. CONTRACT NUMBER
DSWA01-98-C-0156

5b. GRANT NUMBER
N/A

5c. PROGRAM ELEMENT NUMBER
4613

6. AUTHOR(S)
Ivan Henson, Indra Gupta and Robert Wagner

5d. PROJECT NUMBER
CD

5e. TASK NUMBER
99Q

5f. WORK UNIT NUMBER
66463

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Multimax, Incorporated
1441 McCormick Drive
Largo, MD 20774

8. PERFORMING ORGANIZATION REPORT NUMBER

MM-02-01-001

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Defense Threat Reduction Agency
8725 John J. Kingman Road
Mail Stop 6201
Fort Belvoir, VA 22060-6201

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S) DTRA-TR-03-21

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES
This research was sponsored by the Defense Threat Reduction Agency

14. ABSTRACT

The main objective of this project is the formation of databases providing ground truth for regional seismic monitoring research conforming to the latest Center for Monitoring Research (CMR) schema. Selected Calibration Event Bulletin (CEB) events from China, the former Soviet Union (FSU), and North America are reanalyzed using the seismic analysis software program *Geotool* starting with the Reviewed Event Bulletin (REB) solutions. In order to add a large number of arrivals from regional phases, new waveform are retrieved and analyzed from available IRIS and other stations. Two sets of location results per event are derived: the first by using only the revised International Data Center (IDC) arrivals, and the second by combining the mostly IRIS and revised IDC data. Analyses of datasets of 70, 80 and 163 CEB events in China, the FSU and North America, respectively, have been completed.

Other studies include an analysis of local seismic data from the aftershocks of a 100 ton chemical explosion at the Degelen, Kazakh Test Site on 22 August 1998 (Omega-1). Epicentral locations, based on P-wave arrivals from 14 well-recorded aftershocks, showed all epicenters to lie within 200 meters of ground zero. The result that aftershock locations determined within several days of the detonation time of an explosion can provide a fairly accurate location of ground zero is important for the on-site inspection part of CTBT monitoring. It will therefore be useful to carry out similar studies of aftershocks from other large explosions at this and other test sites.

15. SUBJECT TERMS
Ground truth, database, seismic monitoring, CTBT, aftershock activity, on-site inspection

16. SECURITY CLASSIFICATION OF: UNCLASSIFIED			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER *(include area code)*
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	112	

CONVERSION TABLE

Conversion Factors for U.S. Customary to metric (SI) units of measurement.

MULTIPLY →	BY →	TO GET
TO GET ←	BY ←	DIVIDE

angstrom	1.000 000 x E -10	meters (m)
atmosphere (normal)	1.013 25 x E +2	kilo pascal (kPa)
bar	1.000 000 x E +2	kilo pascal (kPa)
barn	1.000 000 x E -28	meter^2 (m^2)
British thermal unit (thermochemical)	1.054 350 x E +3	joule (J)
calorie (thermochemical)	4.184 000	joule (J)
cal (thermochemical/cm^2)	4.184 000 x E -2	mega joule/m^2 (MJ/m^2)
curie	3.700 000 x E +1	*giga bacquerel (GBq)
degree (angle)	1.745 329 x E -2	radian (rad)
degree Fahrenheit	$t_k = (t°f + 459.67)/1.8$	degree kelvin (K)
electron volt	1.602 19 x E -19	joule (J)
erg	1.000 000 x E -7	joule (J)
erg/second	1.000 000 x E -7	watt (W)
foot	3.048 000 x E -1	meter (m)
foot-pound-force	1.355 818	joule (J)
gallon (U.S. liquid)	3.785 412 x E -3	meter^3 (m^3)
inch	2.540 000 x E -2	meter (m)
jerk	1.000 000 x E +9	joule (J)
joule/kilogram (J/kg) radiation dose absorbed	1.000 000	Gray (Gy)
kilotons	4.183	terajoules
kip (1000 lbf)	4.448 222 x E +3	newton (N)
kip/inch^2 (ksi)	6.894 757 x E +3	kilo pascal (kPa)
ktap	1.000 000 x E +2	newton-second/m^2 ($N-s/m^2$)
micron	1.000 000 x E -6	meter (m)
mil	2.540 000 x E -5	meter (m)
mile (international)	1.609 344 x E +3	meter (m)
ounce	2.834 952 x E -2	kilogram (kg)
pound-force (lbs avoirdupois)	4.448 222	newton (N)
pound-force inch	1.129 848 x E -1	newton-meter (N-m)
pound-force/inch	1.751 268 x E +2	newton/meter (N/m)
pound-force/foot^2	4.788 026 x E -2	kilo pascal (kPa)
pound-force/inch^2 (psi)	6.894 757	kilo pascal (kPa)
pound-mass (lbm avoirdupois)	4.535 924 x E -1	kilogram (kg)
pound-mass-foot^2 (moment of inertia)	4.214 011 x E -2	kilogram-meter^2 ($kg-m^2$)
pound-mass/foot^3	1.601 846 x E +1	kilogram-meter^3 (kg/m^3)
rad (radiation dose absorbed)	1.000 000 x E -2	**Gray (Gy)
roentgen	2.579 760 x E -4	coulomb/kilogram (C/kg)
shake	1.000 000 x E -8	second (s)
slug	1.459 390 x E +1	kilogram (kg)
torr (mm Hg, 0^0 C)	1.333 22 x E -1	kilo pascal (kPa)

*The bacquerel (Bq) is the SI unit of radioactivity; 1 Bq = 1 event/s.
**The Gray (GY) is the SI unit of absorbed radiation.

TABLE OF CONTENTS

SUMMARY 1
INTRODUCTION 2
ANALYSIS METHODOLOGY 2
CHINA DATABASE 3
FORMER SOVIET UNION DATABASE 4
NORTH AMERICA DATABASE 6
MISCELLANEOUS RELATED STUDIES 7
CONCLUSIONS AND RECOMMENDATIONS 8
REFERENCES 9

FIGURES

1. Epicentral locations of CEB events....10
2. Location map of IDC and other stations....11
3. Seventy (70) CEB events in China....12
4. Pn phases with corresponding propagation paths available in the original REB dataset....13
5. Pn phases with corresponding propagation paths available in the revised IDC dataset....14
6. Pn phases with corresponding propagation paths available in the IRIS....15
7. Sn phases with corresponding propagation paths available in the original REB dataset....16
8. Sn phases with corresponding propagation paths available in the revised IDC dataset....17
9. Sn phases with corresponding propagation paths available in the IRIS....18
10. Lg phases with corresponding propagation paths available in the original REB dataset....19
11. Lg phases with corresponding propagation paths available in the revised IDC dataset....20
12. Lg phases with corresponding propagation paths available in the IRIS....21
13. Differences in the epicentral location....22
14. Differences in estimates of source depth....23
15. Differences in estimates of source depth between the ISC bulletin....24
16. Locations of 45 IDC and 22 IRIS recording stations....25
17. Locations of 586 recording stations used by the ISC....26
18. Comparison of epicentral location and depth for the event of 12 March 1996....27
19. REB epicentral locations of 80 events....28
20. Comparison of Pn phases and corresponding propagation paths....29
21. Comparison of Pn phases and corresponding propagation paths for the FSU....30
22. Comparison of Pn phases (IRIS and revised IDC dataset)....31
23. Comparison of Sn phases and corresponding propagation paths for the FSU....32
24. Comparison of Sn phases and corresponding propagation paths for the FSU in the IDC....33
25. Comparison of Sn phases and corresponding propagation paths for the FSU in the IRIS....34
26. Comparison of Lg phases and corresponding propagation paths for the FSU available....35
27. Comparison of Lg phases and corresponding propagation paths (IDC)....36
28. Comparison of Lg phases and corresponding propagation paths (IRIS)....37
29. Differences in epicentral location between the original REB....38
30. Differences in estimates of source depth between in the original REB....39
31. Differences in estimates of source depth between the ISC Bulletin and combined IRIS....40
32. Recording stations providing data for 100-ton chemical shots at Degelen, Kazakah....41
33. Close-in recording stations for (a) 22 August 1998 (Omega-1) and (b) 42
34. Epicentral locations with error ellipses....43
35. REB epicentral locations of 163 CEB events in North America and the 150 IDC....44
36. Pn phases with corresponding propagation paths available in the original REB....45
37. Pn phases with corresponding propagation paths available in the revised IDC datasets....46
38. Pn phases with corresponding propagation paths available in the IRIS....47
39. Sn phases with corresponding propagation paths available in the original REB dataset....48
40. Sn phases with corresponding propagation paths available in the revised IDC dataset....49
41. Sn phases with corresponding propagation paths available in the IRIS, USGS....50
42. Lg phases with corresponding propagation paths available in the original REB dataset....51
43. Lg phases with corresponding propagation paths available in the revised IDC dataset....52
44. Lg phases with corresponding propagation paths available in the IRIS, USGS....53

FIGURES

45. Differences in epicentral location between the original REB.....54
46. Differences in estimates of source depth between the original REB and the combined.....55
47. Differences in estimates of source depth between the ISC Bulletin and the combined.....56
48. Comparison of travel time residuals for Pn and Sn (China).....57
49. Comparison of travel time residuals for Pn and Sn (North America).....58

TABLES

1. List of 70 CEB Events in China: REB Locations.....59
2. List of 96 IRIS Stations Used for CEB Events in China.....61
3. List of 70 CEB Events in China: Revised IDC Locations.....64
4. List of 70 CEB Events in China: Revised IDC + IRIS Locations.....66
5. List of 80 CEB Events in Former Soviet Union: REB Locations.....68
6. List of 159 IRIS and Lamont Stations Used for CEB Events in Former Soviet Union.....71
7. List of 80 CEB Events in Former Soviet Union: Revised IDC Locations.....76
8. List of 80 CEB Events in Former Soviet Union: Revised IDC + IRIS Locations.....79
9. List of 163 CEB Events in North America: REB Locations.....82
10. List of 348 IRIS and USGS Stations Used for CEB Events in North America.....87
11. List of 163 CEB Events in North America: Revised IDC Locations.....96
12. List of 163 CEB Events in North America: Revised IDC + IRIS, USGS Locations.....101

FORMATION OF GROUND TRUTH DATABASES AND RELATED STUDIES FOR REGIONAL SEISMIC MONITORING RESEARCH

SUMMARY

The main objective of this project is the formation of databases providing ground truth for regional seismic monitoring research conforming to the latest Center for Monitoring Research (CMR) schema. The effort focuses on events in the CMR Calibration Event Bulletin (CEB) from China, the former Soviet Union (FSU), and North America. Selected CEB events are re-analyzed using the seismic analysis software program *geotool* starting with the Reviewed Event Bulletin (REB) solutions. Modifications to the original REB results include mostly arrival phase re-timings and adding missed phases, including depth phases. In order to add a large number of arrivals from regional phases, new waveform data are retrieved and analyzed from available IRIS and other stations, mostly within 25 degrees distance. A modified version of *LocSAT*, called *Locate*, is used to locate the CEB events. Two sets of location results per event are derived: the first by using only the revised International Data Center (IDC) arrivals, and the second by combining the mostly IRIS and revised IDC data. These ground truth data sets have been incorporated into the existing Reference Event Database (REDB), formerly CEB, archived at the CMR.

Analyses of datasets of 70, 80, and 163 CEB events in China, FSU, and North America, respectively, have been completed. Re-analysis of the China data included using waveforms from 150 IDC stations contributing over 4000 arrivals, supplemented by nearly 3800 waveforms from 96 IRIS stations providing nearly 2300 additional arrivals. The FSU data included not only waveforms from 130 IDC stations contributing over 4000 arrivals, but also nearly 4000 waveforms from about 160 IRIS stations providing over 2300 new arrivals. Similarly, the data from North America included waveforms from 150 IDC stations contributing over 10,900 arrivals, together with over 8900 waveforms from 348 IRIS and USGS stations providing over 4000 additional arrivals. An examination of the travel time residuals versus epicentral distance, based on the use of IASPEI91 travel time tables, for the China, FSU, and North American datasets indicated that the residuals for Pn, derived from the combined use of mostly IRIS and revised IDC data, are small. But for both Sn and Lg, the residuals are large and mostly negative (average values several seconds negative), suggesting that the IASPEI91 tables for these two phases are not strictly valid for the three regions. Furthermore, a comparison of the residuals indicates that both Pn and Sn arrive relatively later for events in China than those in FSU and North America.

Other studies included an analysis of local seismic data from the aftershocks of a 100-ton chemical explosion at the Degelen, Kazakh Test Site on 22 August 1998 (Omega-1). The epicentral locations of all well-recorded aftershocks were determined to be within 200 m of ground zero. The result that aftershock locations determined within several days of the detonation time of an explosion can provide a fairly accurate location of ground zero is important for the on-site inspection part of CTBT monitoring. It will therefore be useful to carry out similar studies of aftershocks from other large explosions at this site (*e.g.*, the 100-ton shot of 29 July 2000, Omega-3) and at other test sites.

INTRODUCTION

Monitoring the Comprehensive Test Ban Treaty (CTBT) requires the ability to detect, locate and identify seismic events effectively. Once a suspicious event has been detected, its location must be accurately determined as a precursor to event identification and potential on-site inspections. The Calibration Event Bulletin (CEB) database was initiated at the Center for Monitoring Research (CMR) in June 1996 in response to recommendations by the Group of Scientific Experts (Bondar, 1998a). Note that the term CEB is now replaced by Reference Event Database, REDB (Yang *et al.*, 2000a). The main purpose of the CEB database is to collect data routinely for the calibration of the International Monitoring System (IMS) network so that locations can be improved. The selection of CEB events is made from the Reviewed Event Bulletin (REB) events by meeting certain criteria, such as a body wave magnitude between 4 and 6. Soon after the calibration effort began at the PIDC it was recognized that not all calibration events can be accepted as ground truth (Bondar,1998b). A primary objective of this project is the formation of databases which provide improved ground truth for selected CEB events in China, the former Soviet Union, and North America. Several studies have demonstrated the usefulness of such databases for improved monitoring of the CTBT (*e.g.*, Grant *et al.*, 1997; Bondar *et al.*, 1998). Re-analysis of the IDC data combined with retrieval and analysis of selected IRIS data leads to improved location and depth estimates of CEB events.

ANALYSIS METHODOLOGY

Analysis procedures followed are basically the same as for the REB bulletin. However, no attempt was made to review hydro-acoustic data. Most revisions consist of minor re-timings with emphasis on defining phase types, and missed phases are added whenever possible. At far regional distances, most of the later crustal phase types Sn and Lg are often made non-defining due to large residuals that result from using IASPEI91 travel times. Occasionally, a CEB event undergoes significant changes when, for example, improper depth phases or multiple events occur. The most important contribution of the IRIS data is the addition of a large number of arrivals from regional phases. Waveform data are retrieved using AutoDRM and converted to CSS 3.0 format, then analyzed with program "geotool". The criterion for acquiring data from IRIS stations is primarily to collect data within 25° distance, then to reduce the largest azimuthal gap for distances beyond 25° (up to about 50° or 60°), and to obtain data near the PKP caustics.

A modified version of *LocSAT*, called *Locate*, which uses a graphical user interface (GUI) and allows interactive processing to generate location results, is used to locate the CEB events. *Locate* displays parameters from CSS 3.0 tables (*e.g.*, arrival, assoc, origin) in an editable GUI and updates them after each computed location. Time residuals that exceed standard IDC limitations are highlighted. Locate reads the same travel time tables and crustal models as currently used at the IDC for generating the REB. Relocations can be computed quickly for different combinations of defining arrivals to assess the effect of adding arrivals, such as those measured from IRIS data, to the original REB data set. Two sets of location results per event are derived: the first by using only the revised IDC

arrivals, and the second by using both the IRIS (and sometimes other) and revised IDC data. These ground truth data sets have been incorporated into the existing Reference Event Database (REDB) for use at the CMR. Analyses of datasets of 70 CEB events in China, 80 CEB events in the former Soviet Union, and 163 CEB events in North America have been completed. The REB epicentral locations of the three sets of CEB events are shown in Figure 1 whereas the IDC, IRIS, and other (United States Geological Survey, USGS and Lamont Doherty Earth Observatory, LDEO) stations which recorded all these events are shown in Figure 2.

CHINA DATABASE

Analysis and relocation of seventy (70) CEB events in China for the three-year period 1 January 1995 to 31 December 1998 (Table 1) have been completed by using waveform data from 150 IDC stations and 96 IRIS stations (Henson *et al.*, 1999). The 96 IRIS stations providing new waveform data that were retrieved and contributed arrivals are listed in Table 2. The REB epicentral locations of these 70 CEB events are shown in Figure 3 along with the locations of both IDC and IRIS stations that recorded these events. Note the large number of IRIS stations at regional distances for most of the 70 China events. For epicentral distances less than 17° (about 1900 km), the regional phases (Pn, Pg, Sn, and Lg) in the three datasets consisting of combined IRIS and revised IDC, only the revised IDC, and the original REB arrivals, total 1374, 230, and 140, respectively.

A comparison of the propagation paths available in the original REB, revised IDC, and the combined IRIS and revised IDC datasets for Pn, Sn, and Lg are shown in Figures 4 through 12. These figures, showing propagation paths connecting the event epicenters with recording stations available for Pn (Figures 4, 5, and 6), Sn (Figures 7, 8, and 9), and Lg (Figures 10, 11, and 12), clearly demonstrate the significant contribution of the IRIS data in providing additional regional phases Pn, Sn, and Lg.

Two sets of location results per event are derived: the first by using only the revised IDC arrivals (Table 3), and the second by using both the IRIS and revised IDC data (Table 4). For the entire China dataset of 70 events, a comparison of the REB locations with those derived by using the two methods mentioned above show no systematic trend and generally small differences (average less than 9 km in each case). Figure 13 shows differences in epicentral location between the original REB and those derived by the combined use of both IRIS and revised IDC data for all 70 China events. The arrows point from the REB location to the new location and the location differences range between 0.8 and 28.3 km with an average value of 8.5 km.

A similar comparison of source depths shows the REB estimates to be significantly larger than those derived by the combined use of both IRIS and revised IDC data, suggesting that the REB source depths may have been overestimated. These differences in source depth, shown in Figure 14, have an average value of about 17 km, indicating that for most events the new depths are significantly shallower than those in the original REB. Results from only 49 events are shown since, out of 70 China events, source

depths for both sets were non-zero for only 49 events. A comparison of the estimates of source depth between the ISC Bulletin and those derived by our combined use of both IRIS and revised IDC data for 42 common events with non-zero depths is shown in Figure 15. On the average, the ISC depths are only about 2.5 km deeper, indicating that the two estimates of source depth are not significantly different. It seems therefore that our estimates of source depths, based on the combined use of IRIS and revised IDC data, are in good agreement with those available from the ISC Bulletin. According to Storchak (1999), epicentral locations and depth estimates from the ISC, derived from a much larger dataset and covering a larger range of azimuths than those by the IDC, are probably more accurate than the IDC locations. It should however be noted that the ISC determinations are generally over two years behind real time and may therefore be of only limited use for monitoring the CTBT.

We next compare location and depth estimates for an event for which results from several independent sources of data are available. As an example, the recording stations that provided data used in determining the epicentral location and depth of the China seismic event of 12 March 1996, are shown in Figure 16. For this seismic event near the border of Mongolia and former Soviet Union, the original REB solution was based on the use of only 44 IDC stations, whereas the solution based on the combined use of IRIS and revised IDC data made use of 22 IRIS and 1 IDC additional stations. For the same event, the epicentral location determined by the International Seismological Centre (ISC) used data from a much larger number (586) of recording stations (Figure 17). A comparison of the epicentral location and depth for this seismic event, as obtained from seven different sources: (1) the original REB, (2) revised IDC, (3) combination of IRIS and revised IDC, (4) ISC, (5) National Earthquake Information Center, USGS, (6) BJI (State Seismological Bureau, Beijing, China), and (7) MOS (Institute of Physics of the Earth, Moscow, Russia), is shown in Figure 18. Location error ellipses from the first four sources are also shown. The solutions from BJI and MOS networks, based on the use of numerous stations at local and regional distances, are likely to be more accurate than that in the original REB. It is interesting to note that the epicentral location based on the combined use of IRIS and revised IDC (No. 3 in Figure 18) lies somewhere in the middle of the BJI and MOS determinations and the REB location. The derived source depth also lies between the BJI and MOS determinations. It seems therefore that the solution based on the use of both IRIS and revised IDC data provides improved estimates of both epicentral location and depth in comparison to the original REB solution.

FORMER SOVIET UNION DATABASE

Analysis, similar to that carried out for the China events, has been completed for 80 CEB events in the former Soviet Union (FSU) by using waveform data from both IDC and IRIS stations (Henson *et al.*, 2000). For the two 100-ton each Degelen calibration shots on 22 August 1998 and 25 September 1999, useful waveform data at local and regional distances were also available from several stations deployed by the Lamont-Doherty Earth Observatory (LDEO). These events, listed in Table 5, cover the period January 1995 through September 1999. Analysis and relocation involved using waveform data

from 130 IDC stations contributing over 4000 arrivals, and nearly 4000 waveforms from 159 IRIS and LDEO stations (listed in Table 6) providing over 2300 new arrivals. The REB epicentral locations of these 80 CEB events are shown in Figure 20 along with the locations of IDC, IRIS and LDEO stations that recorded these events. Note the large number of IRIS and LDEO stations at regional distances for most of the 80 FSU events.

Similar to the China data, a comparison of the propagation paths available in the original REB, revised IDC, and the combined IRIS and revised IDC datasets for Pn, Sn, and Lg are shown in Figures 20 through 28. These figures, showing propagation paths connecting the event epicenters with recording stations available for Pn (Figures 20, 21, and 22), Sn (Figures 23, 24, and 25), and Lg (Figures 26, 27, and 28) clearly demonstrate the significant contribution of the IRIS data in providing additional regional phases Pn, Sn, and Lg.

Two sets of location results per event are derived: the first by using only the revised IDC arrivals (Table 7), and the second by using the IRIS and revised IDC data (Table 8). For the entire FSU dataset of 80 events, a comparison of the REB locations with those derived by the combined use of both IRIS and revised IDC (Figure 29) shows no systematic trend and generally small differences. In Figure 29, the arrows point from the REB location to the new location and the location differences range between 1.2 and 45.0 km with an average value of 9.7 km. However, a similar comparison of source depths shows the REB estimates to be significantly larger than each of the other two estimates, suggesting that the REB source depths may have been overestimated. The differences in source depth between the original REB and those derived by the combined use of the IRIS and revised IDC data, shown in Figure 30, have an average value of about 10 km, indicating that for most events the new depths are significantly shallower than those in the original REB. Results from only 39 events are shown since, out of 80 FSU events, source depths for both sets of data were non-zero for only 39 events. A comparison of the estimates of source depth between the ISC Bulletin and those derived by our combined use of both IRIS + LDEO and revised IDC data for 50 FSU events with non-zero depths is shown in Figure 31. On the average, the ISC depths are about 5 km deeper, indicating that the two estimates of source depth are not much different.

As mentioned earlier, the 80 CEB events in FSU included the two 100-ton chemical shots at Degelen on 22 August 1998 (Omega-1) and 25 September 1999 (Omega-2) with precisely known zero locations, so that a comparison of epicentral locations from various sources of data can be made. We analyzed available data from not only the IDC and IRIS stations but also from several local stations operated by the LDEO (Figures 32 and 33). A comparison of the REB and two revised locations for the two GT0 events is shown in Figure 34. For both shots, epicentral locations based on the use of additional data from IRIS and LDEO are significantly better than the REB locations.

NORTH AMERICA DATABASE

We also analyzed 163 CEB events in North America from January 1995 through May 2000 listed in Table 9, which includes their REB locations and magnitude. Analysis and relocation involved using waveform data from 150 IDC stations contributing over 10,900 associated arrivals and over 8900 waveforms from 348 IRIS and USGS stations (Table 10) providing over 4000 additional arrivals. The REB epicentral locations of these 163 CEB events are shown in Figure 35 along with the locations of IDC, IRIS and USGS stations that recorded these events. A large number of IRIS and USGS stations lie at regional distances for most of the 163 events in North America.

A comparison of the propagation paths available in the original REB, revised IDC, and the combined IRIS + USGS + revised IDC datasets for Pn, Sn, and Lg are shown in Figures 36 through 44, similar to the China and FSU data. These figures, showing propagation paths connecting the event epicenters with recording stations available for Pn (Figures 36, 37, and 38, Sn (Figures 39, 40, and 41), and Lg (Figures 42, 43, and 44) again demonstrate the significant contribution of the IRIS and USGS data in providing additional regional phases Pn, Sn, and Lg.

Similar to the China and FSU data, two sets of location results per event are derived: the first by using only the revised IDC arrivals (Table 11) and the second by using the IRIS + USGS and revised IDC data (Table 12). For the entire North America dataset of 163 events, a comparison of the REB locations with those derived by the combined use of IRIS, USGS, and revised IDC (Figure 45) shows no systematic trend and generally small differences, except for a few events. In Figure 45, the arrows point from the REB location to the new location and the location differences range between 0.7 and 143.0 km with an average value of 11.7 km. However, a similar comparison of source depths shows the REB estimates to be significantly larger than each of the other two estimates, suggesting that the REB source depths may have been overestimated. The differences in source depth between the original REB and those derived by the combined use of the IRIS + USGS and revised IDC data, shown in Figure 46, have an average value of about 10 km, indicating that for most events the new depths are significantly shallower than those in the original REB. Results from only 102 events are shown since, out of 163 North American events, source depths for both sets of data were non-zero for only 102 events. A comparison of the estimates of source depth between the ISC Bulletin and those derived by our combined use of IRIS, USGS, and revised IDC data for 85 common events with non-zero depths is shown in Figure 47. On the average, the ISC depths are only about 1 km deeper, indicating that the two estimates of source depth are nearly the same.

The *Locate* software uses the IASPEI91 tables in order to obtain predicted travel times for a suite of seismic phases at various distance and depth ranges. Frequently, the arrival time residuals for various phases were observed to be too large to be selected as defining phases. In order to determine whether these residuals show any systematic trends, we examined the dependence of observed arrival time residuals with distance for P and the four regional phases, Pn, Pg, Sn, and Lg for the China, FSU, and North America data.

The residuals for all phases, based on the "revised IDC + IRIS" arrival times, show generally larger scatter (both positive and negative) with increasing distance. The residuals are small for P, Pn, and Pg, with average values less than 0.5 sec. But for both Sn and Lg, the residuals are large and mostly negative (average values several seconds negative), suggesting that the IASPEI91 travel-time tables for Sn and Lg are probably not applicable to any of the three regions. Figure 48 shows the results for Pn and Sn for epicentral distances up to 15 degrees. All data points are shown along with the moving medians (each with a window length of 2 degrees and shift of 0.5 degrees). For distances up to about 10 degrees, a comparison of the residuals for China and FSU shows significant differences. The residual medians for China and FSU differ by about 0.7 and 2.8 sec for Pn and Sn, respectively, indicating that both Pn and Sn arrive relatively later for events in China than those in FSU. A possible reason is generally deeper Moho for most seismic events in China as compared to those in the FSU, as indicated by the global crustal model of Mooney *et al.* (1998; see Plate 1d, p. 733). Pn and Sn residuals for events in North America, shown in Figure 49, indicate the moving median for Pn to be almost flat with an average value close to 0 and that for Sn appears to be similar to that for FSU in Figure 48.

MISCELLANEOUS RELATED STUDIES

We also carried out seismological investigations of topical interest assigned to us from time to time, such as the analysis of waveform data from Kazakhstan (Yang *et al.*, 2000b). The latter included the acquisition and analysis of local and regional waveform data for (i) four Balapan Depth of Burial (DOB) shots in 1997 recorded at stations operated by the Lawrence Livermore National Laboratory (LLNL) (Glenn and Myers, 1997), (ii) two Kazakh calibration shots in 1998 (a 100-ton shot at Degelen on 22 August 1998 (Omega-1) and a 25-ton shot at Balapan on 17 September 1998; Kim, 1998), and (iii) a 100-ton tunnel closing shot on 25 September 1999 at Degelen (Omega-2). The analysis included determining phase type and arrival times by using the seismic analysis program "geotool" and obtaining epicentral locations by using LocSAT. Note that the identification and determination of arrival times of various seismic phases from these large calibration shots at Kazakhstan have been used by Jih and Wagner (2000) to obtain local crustal velocity models for the region. A collection of waveform data from the IDC, IRIS, LLNL, and LDEO stations and location results were loaded into the REDB database.

Other related studies include a detailed examination of aftershock activity due to the 100-ton shot at the Degelen, Kazakh Test Site on 22 August 1998 (Omega-1); the results are described in Gupta *et al.* (2000), attached to this report as Appendix A. Note that analysis of aftershock data from a suspected nuclear event is one of the principal technologies employed for the on-site inspection part of CTBT monitoring.

CONCLUSIONS AND RECOMMENDATIONS

Location results for the 70 CEB events in China, 80 in FSU, and 163 in North America have been delivered to CMR as 560, 636, and 1304 CSS 3.0 database tables, respectively. Each event solution generated four CSS 3.0 files, including the origin, origerr, arrival, and assoc database tables. Two LocSAT solutions were produced per event, specifically for revised IDC data only, and the combination of revised IDC and IRIS data. All tables contain unique identifiers (e.g., orid and arid) which allow them to be installed in existing CMR databases. All IRIS, USGS, and LDEO waveform data which contributed to the CEB events in the three regions have been delivered to CMR (contact person: Dr. Xiaoping Yang) on three 8 mm Unix tar archive tapes in CSS 3.0 format, one for each of the three regions.

Careful analysis of IDC data, combined with waveform data from IRIS and other stations, improves the quality of REDB solutions used for calibrating the IMS network of stations. For each of the China, FSU, and North America datasets, the most important contribution of recording stations belonging to the IRIS and USGS is the addition of a large number of arrivals from regional phases, so that solutions based on the combined use of all available data provide improved estimates of both epicentral location and depth in comparison to the original REB solutions. Our work increased the number of associated arrivals in the REB by over 80% for both China and FSU, and 70% for North America. Our estimates of source depth were generally shallower than those in the REB, especially for events in western China, near Hindu Kush. A comparison with available ISC data generally indicated that our estimates of source depth were closer to the ISC than the original REB. According to Storchak (1999), epicentral locations and depth estimates from the ISC, derived from a much larger dataset and covering a larger range of azimuths than those by the IDC, are probably more accurate than the IDC determinations. It should however be noted that the ISC determinations are generally over two years behind real time and may therefore be of only limited use for monitoring the CTBT. Analysis of events in China, FSU and North America should be extended to include more recent CEB or REDB events. Similar acquisition of new data and analysis should also be undertaken for other regions of the world.

Analysis of aftershock data from a suspected nuclear event is one of the principal technologies employed for the on-site inspection part of CTBT monitoring. Our preliminary analysis of local seismic data from the aftershocks of the 100-ton chemical explosion at the Degelen, Kazakh Test Site on 22 August 1998 (Omega-1) showed all epicenters to lie within 200 m of ground zero. The results suggest that aftershock locations determined within several days of the detonation time of an explosion can provide a fairly accurate location of ground zero. It will be useful to confirm and advance these preliminary results by carrying out similar studies of aftershocks from other large explosions at this site (*e.g.*, the 100-ton shot of 29 July 2000, Omega-3) and at other test sites.

REFERENCES

Bondar, I. (1998a). PIDC Calibration Event Bulletin Technical Reference, CMR-98/16, Center for Monitoring Research, Arlington, Virginia.

Bondar, I. (1998b). PIDC Ground Truth Event Bulletin Technical Reference, CMR-98/21, Center for Monitoring Research, Arlington, Virginia.

Bondar, I., X. Yang, J. Wang, M. Bahavar, H. Israelsson, and K. McLaughlin (1998). Tuning and calibration activities at the PIDC, Proceedings of the 20th Annual Seismic Research Symposium on Monitoring a Comprehensive Test Ban Treaty (CTBT), U. S. Department of Energy, Washington, DC, 1-10.

Glenn, L. A. and S. C. Myers (1997), Depth of Burial Experiments at Balapan, Lawrence Livermore National Laboratory, UCRL-JC-128313.

Grant, L., R. Wagner, F. Ryall, and I. Henson (1997). Ground truth database for regional seismic discrimination research, Proceedings of the 19th Annual Seismic Research Symposium on Monitoring a Comprehensive Test Ban Treaty, U. S. Department of Energy, Washington, 867-876.

Gupta, I., R. Wagner, and I. Henson (2000). Study of aftershocks from the 100-ton Degelen shot of 22 August 1998, MM-02-00-002, Defense Threat Reduction Agency, Dulles, Virginia.

Henson, I., I. Gupta, and R. Wagner (1999). A ground truth database for regional seismic research, Proceedings of the 21st Seismic Research Symposium: Technologies for Monitoring the Comprehensive Nuclear-Test-Ban Treaty, Volume II, U. S. Department of Energy, Washington, 338-347.

Henson, I., I. Gupta, and R. Wagner (2000). Formation of ground truth databases and other studies for regional seismic research, Proceedings of the 22nd Annual DoD/DOE Seismic Research Symposium, Vol. III, U. S. Department of Defense/Energy, 337-346.

Jih, R. S. and R. A. Wagner (2000). Location calibration of Kazakhstan based on DTRA (U.S.)-NNC (Rok) joint experiments (1997-1999) in the former Semipalatinsk test site, Proceedings of the 22nd Annual DoD/DOE Seismic Research Symposium, Vol. I, U. S. Department of Defense/Energy, 55-66.

Kim, Won-Young (1998), Waveform Data Information Product: Calibration Explosions at Semipalatinsk Test Site, Kazakstan during August and September 1998, Lamont-Doherty Earth Observatory of Columbia University, Palisades, New York.

Mooney, W. D., G. Laske, and T. G. Masters (1998). CRUST 5.1: A global crustal model at 5° X 5°, J. Geophys. Res. 103, 727-747.

Storchak, D. A. (1999). Reasons for pIDC mislocations: a view from the ISC, oral presentation at the 1999 General Assembly of the IUGG, 30 July 1999 (EG12/LT4).

Yang, X., I. Bondar, and K. McLaughlin (2000a). PIDC Reference Event Database (REDB), CMR-00/17, Center for Monitoring Research, Arlington, Virginia.

Yang, X., I. Bondar, and C. Romney (2000b). PIDC Ground Truth Event (GT) Database (Revision 1), CMR-00/15, Center for Monitoring Research, Arlington, Virginia.

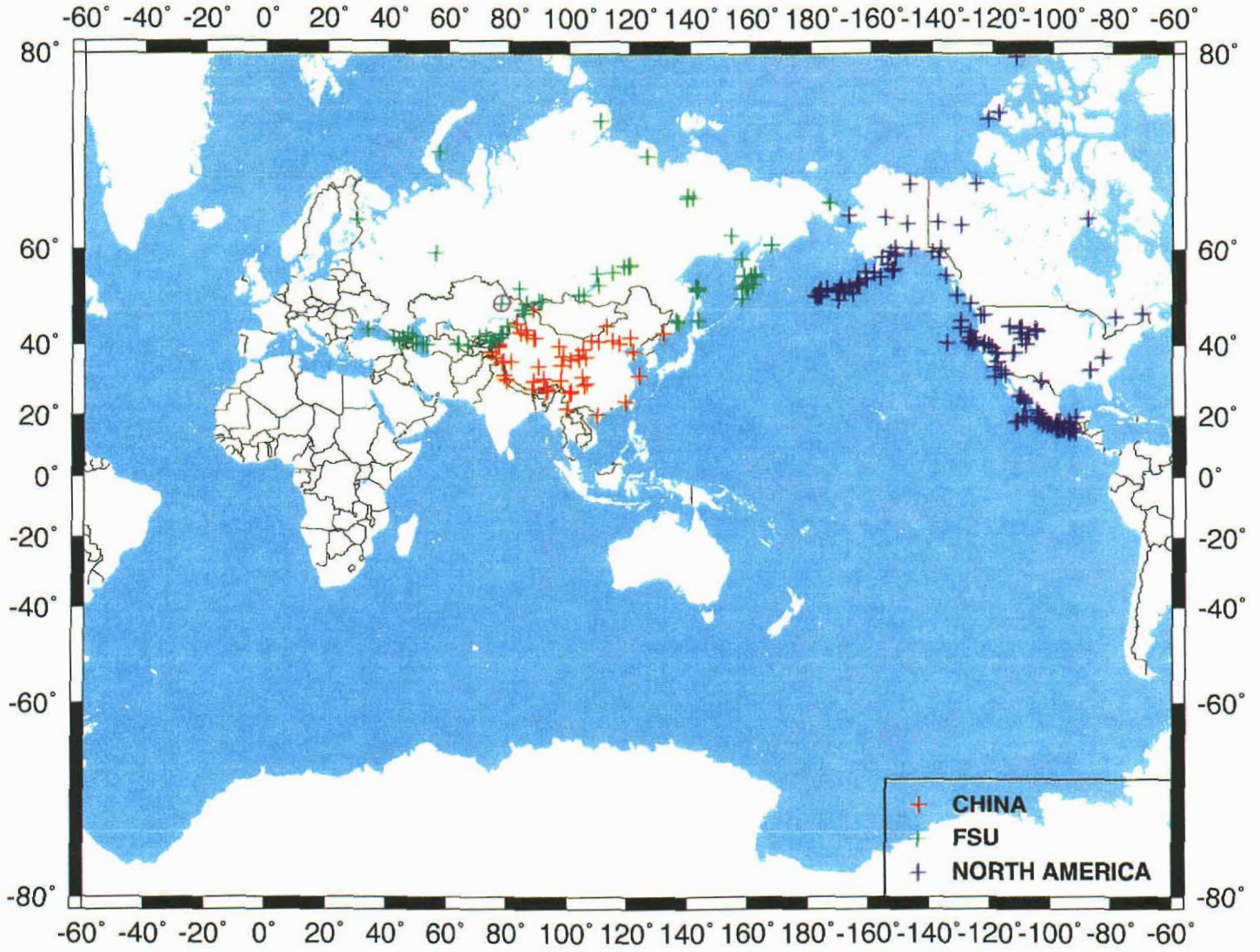

Figure 1. Epicentral (REB) locations of CEB events analyzed in this project, including 70 in China, 80 in the Former Soviet Union, and 163 in North America. The two Degelen calibration shots are circled.

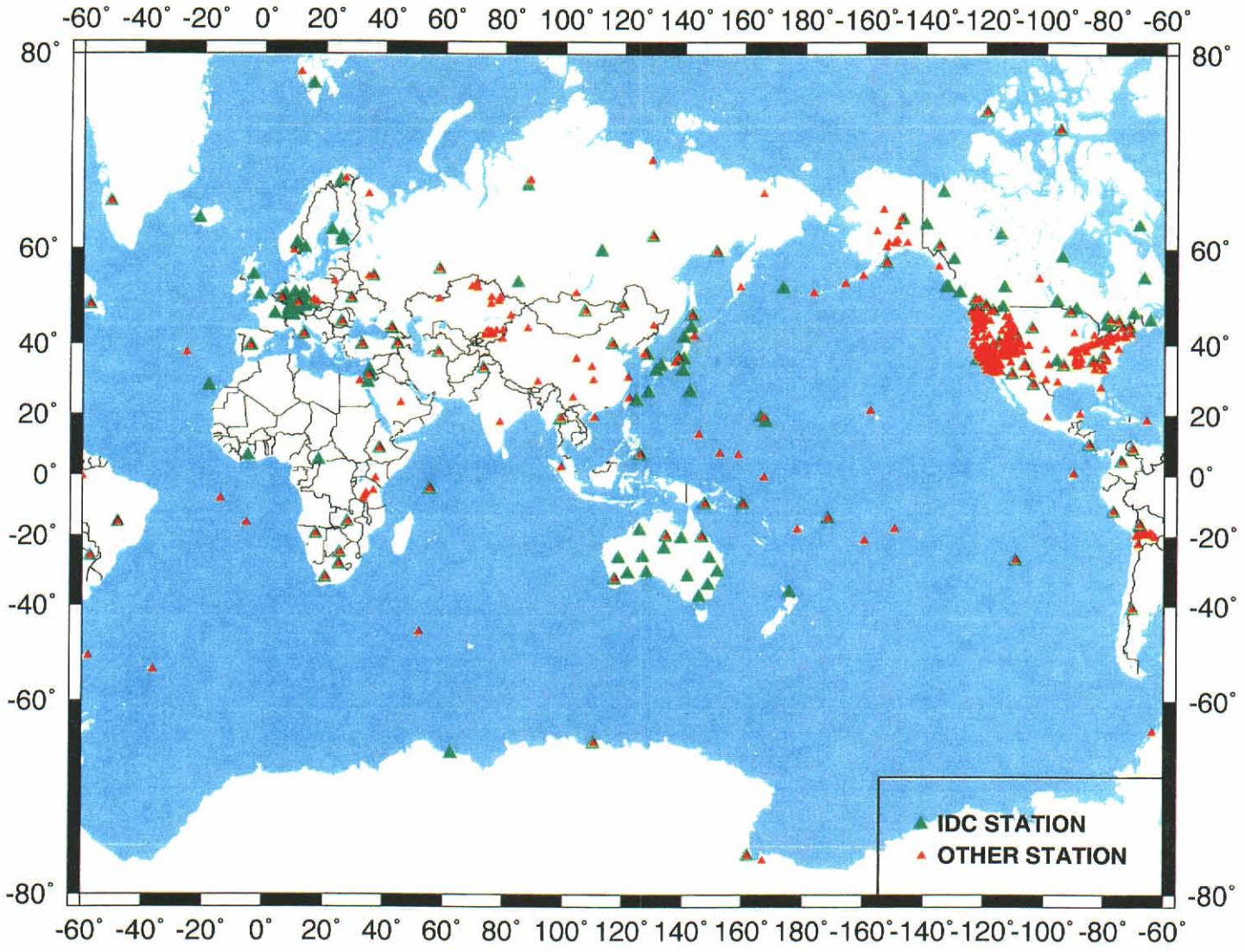

Figure 2. Location map of IDC and other (IRIS, USGS, LDEO) stations which recorded events in China, the Former Soviet Union and North America. IDC stations are plotted as larger green triangles and other stations as smaller red triangles.

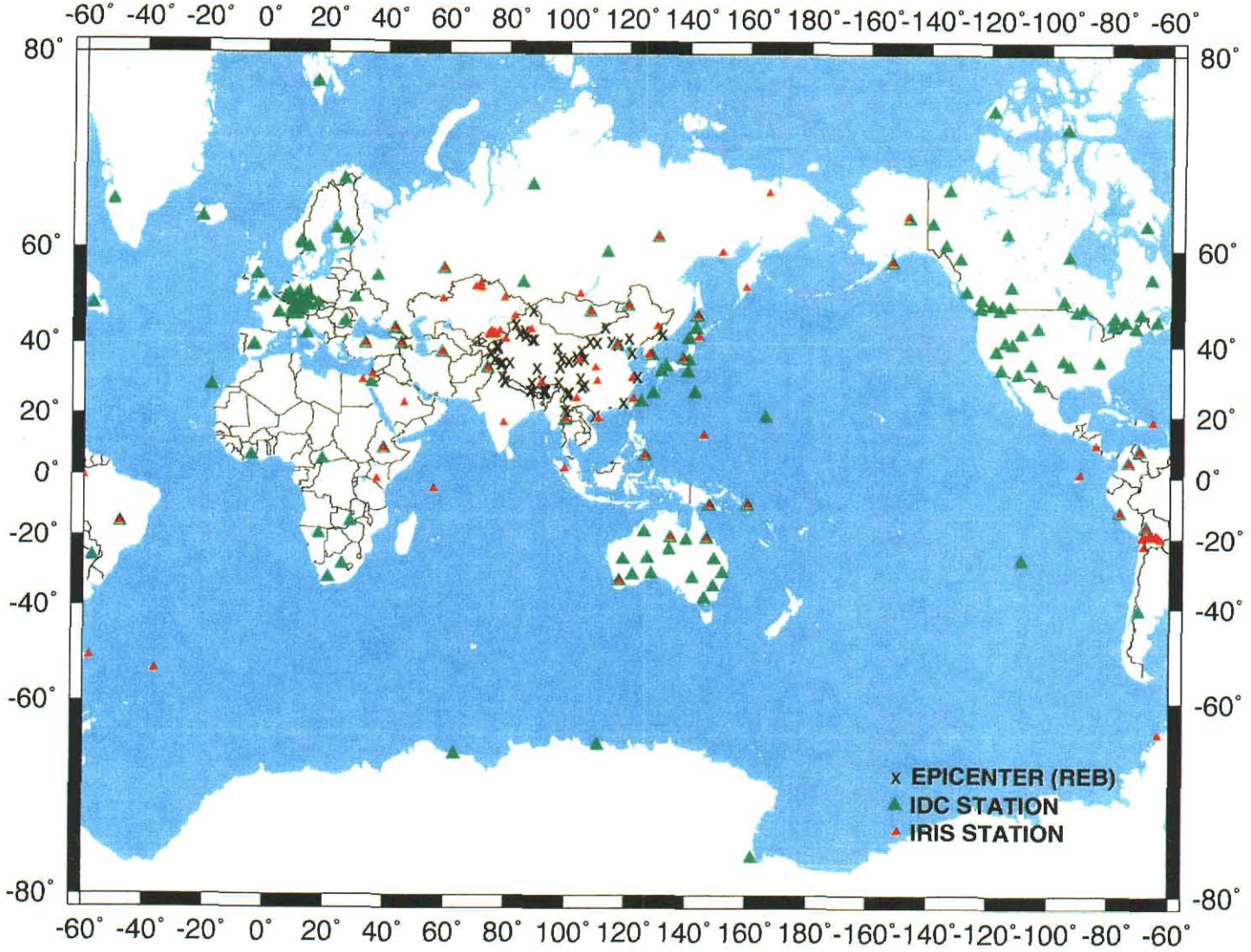

Figure 3. Seventy (70) CEB events in China with their REB epicentral locations, and the IDC and IRIS recording stations which provided waveform data analyzed in this project. Note the large number of IRIS stations at regional distances for most of the 70 Chinese events.

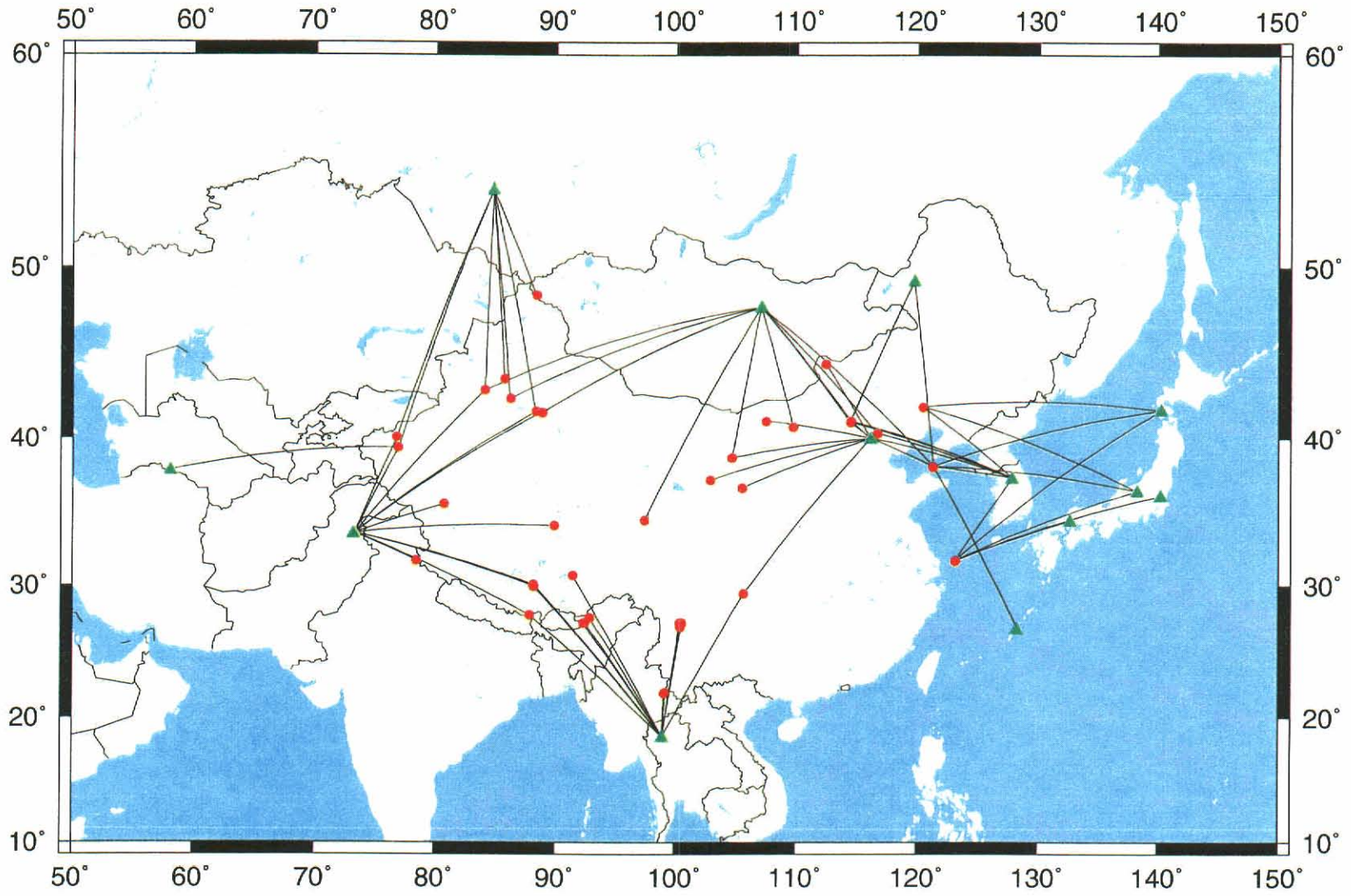

Figure 4. Pn phases with corresponding propagation paths available in the original REB dataset for China showing 42 events with 74 paths. The red circles and green triangles denote epicenters and recording stations, respectively.

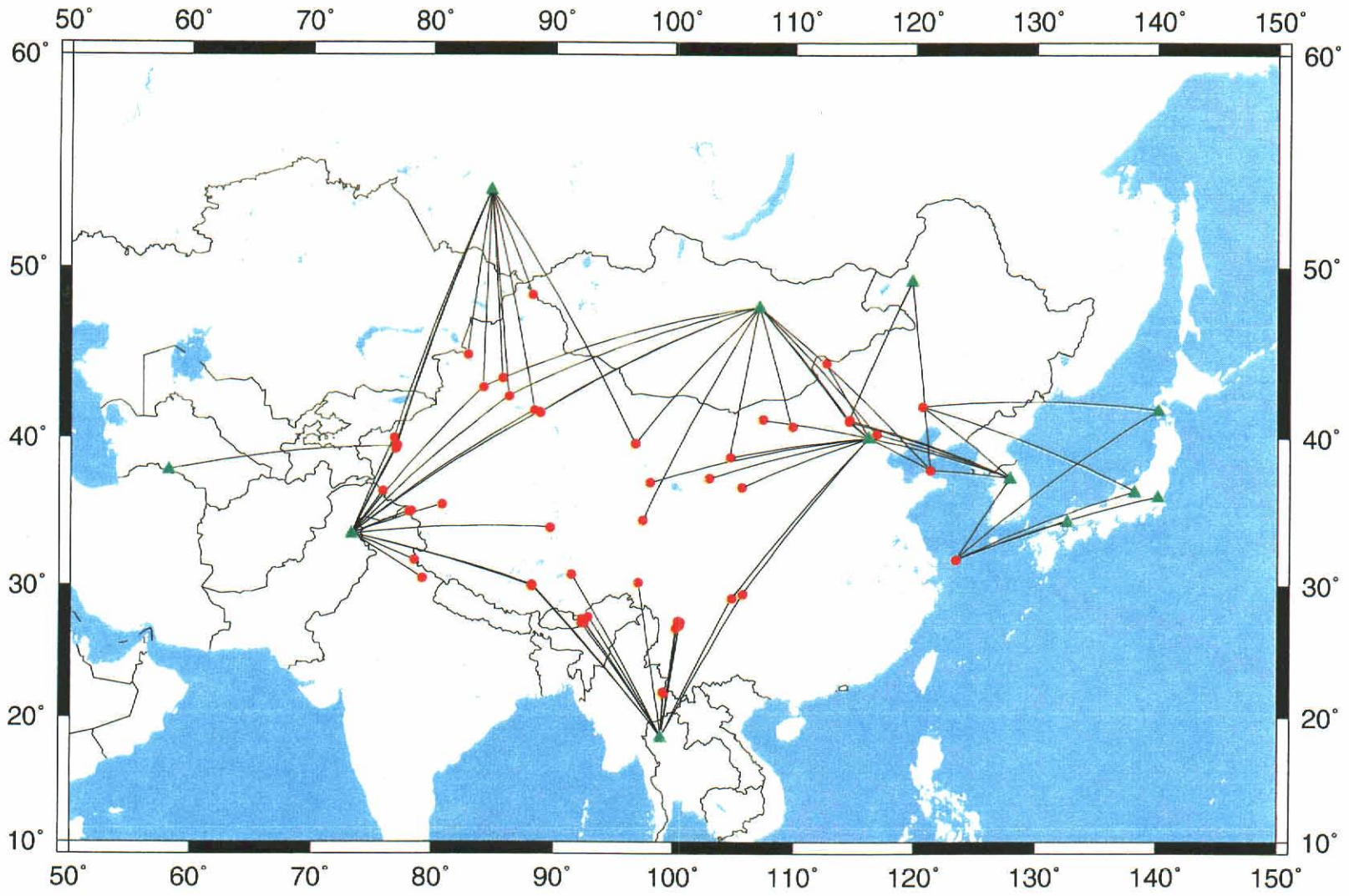

Figure 5. Pn phases with corresponding propagation paths available in the revised IDC dataset for China showing 58 events with 95 paths. The red circles and green triangles denote epicenters and recording stations, respectively.

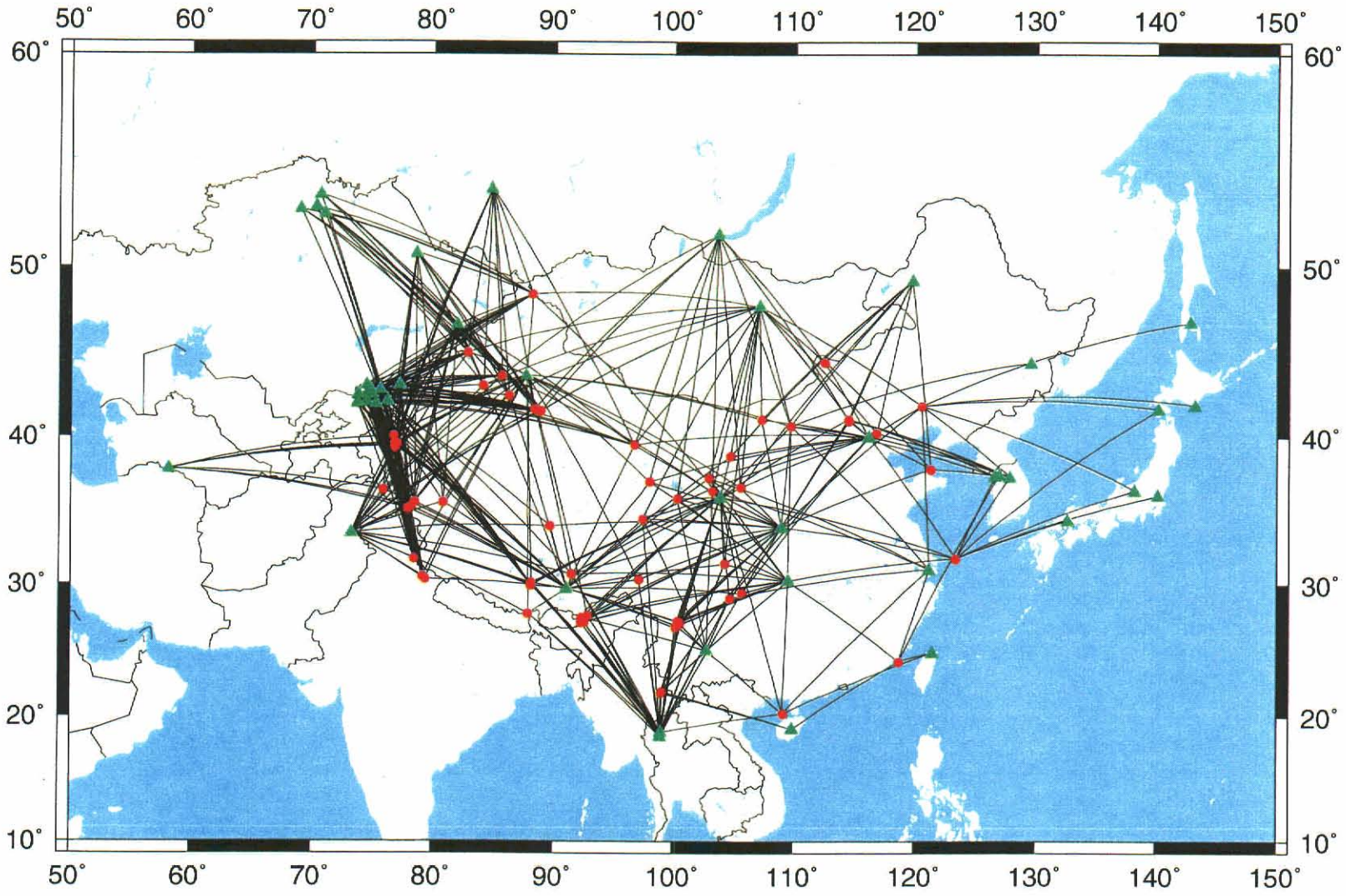

Figure 6. Pn phases with corresponding propagation paths available in the IRIS and revised IDC dataset for China showing 66 events with 592 paths. The red circles and green triangles denote epicenters and recording stations, respectively. Note that the IRIS data provide a large number of additional Pn arrivals.

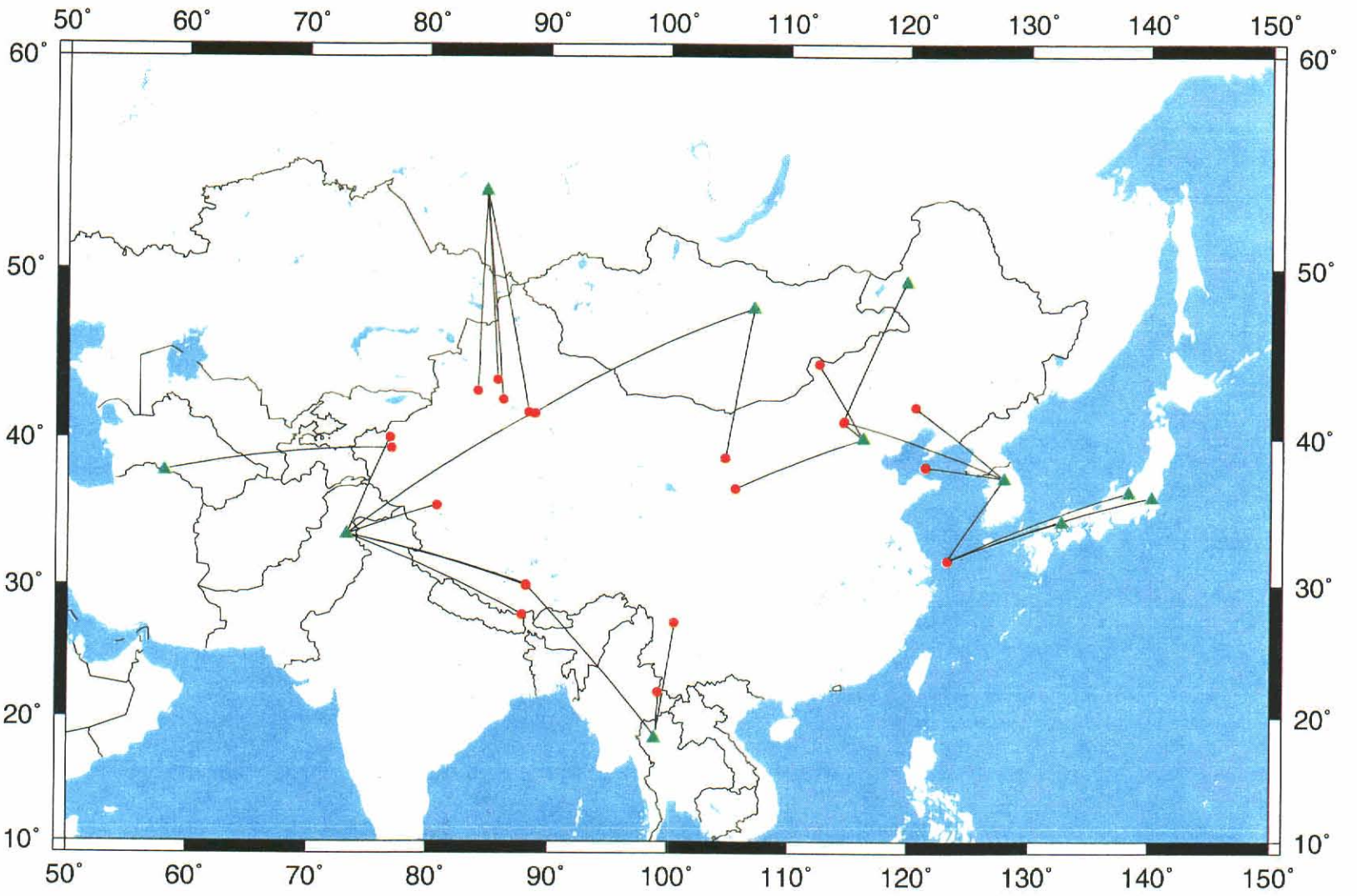

Figure 7. Sn phases with corresponding propagation paths available in the original REB dataset for China showing 23 events with 28 paths. The red circles and green triangles denote epicenters and recording stations, respectively.

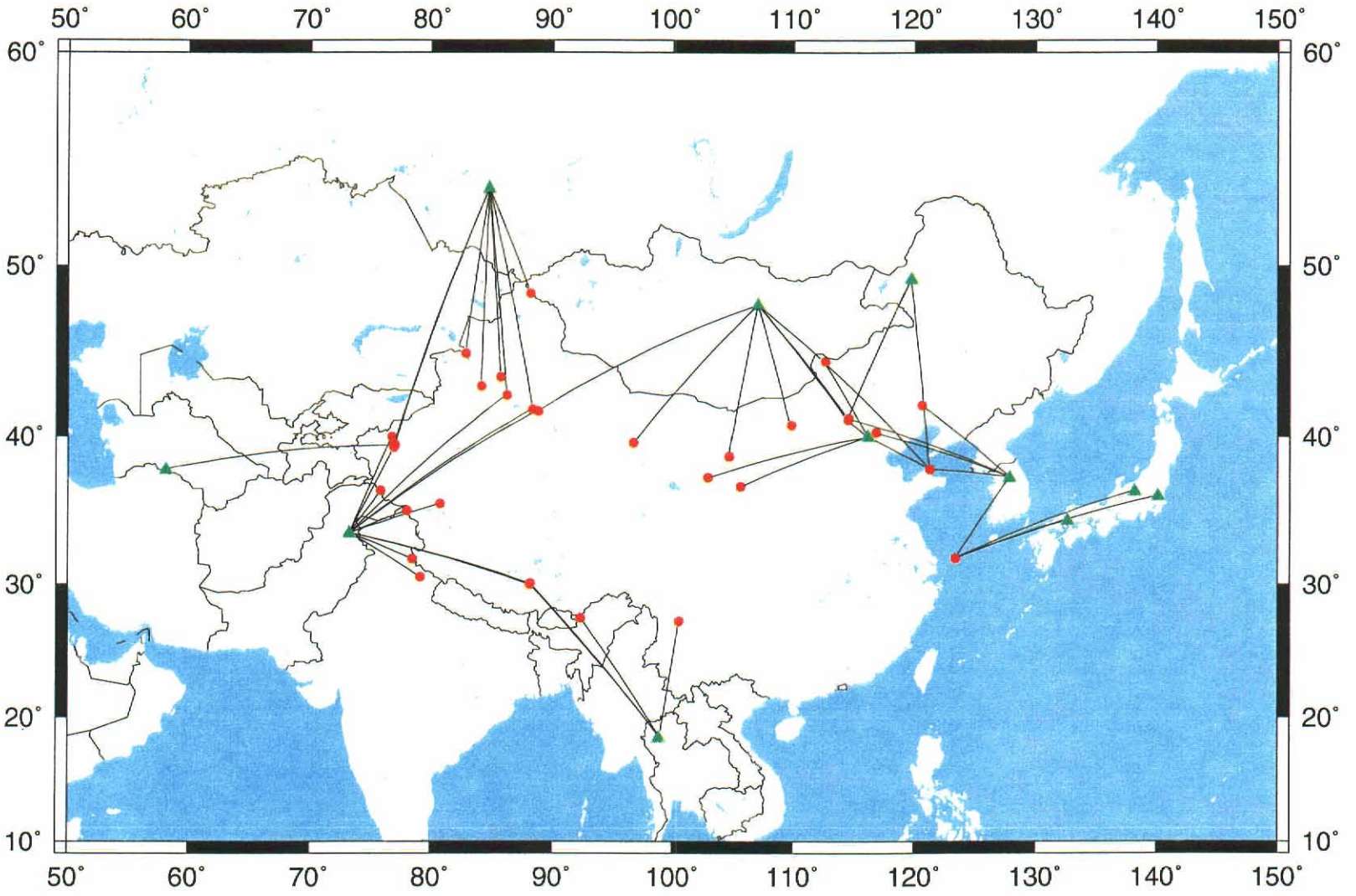

Figure 8. Sn phases with corresponding propagation paths available in the revised IDC dataset for China showing 35 events with 49 paths. The red circles and green triangles denote epicenters and recording stations, respectively.

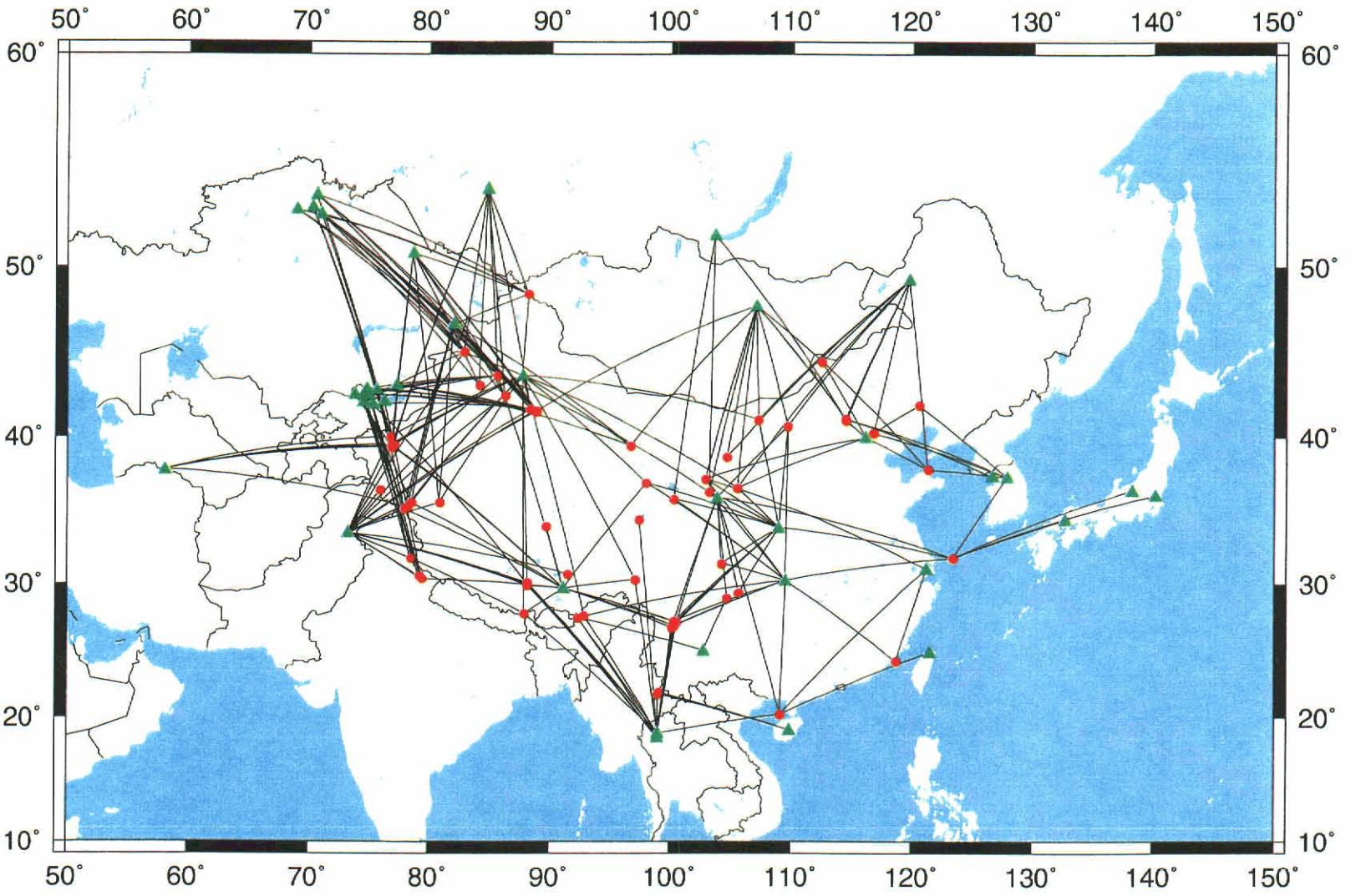

Figure 9. Sn phases with corresponding propagation paths available in the IRIS and revised IDC dataset for China showing 64 events with 243 paths. The red circles and green triangles denote epicenters and recording stations, respectively. Note that the IRIS data provide a large number of additional Sn arrivals.

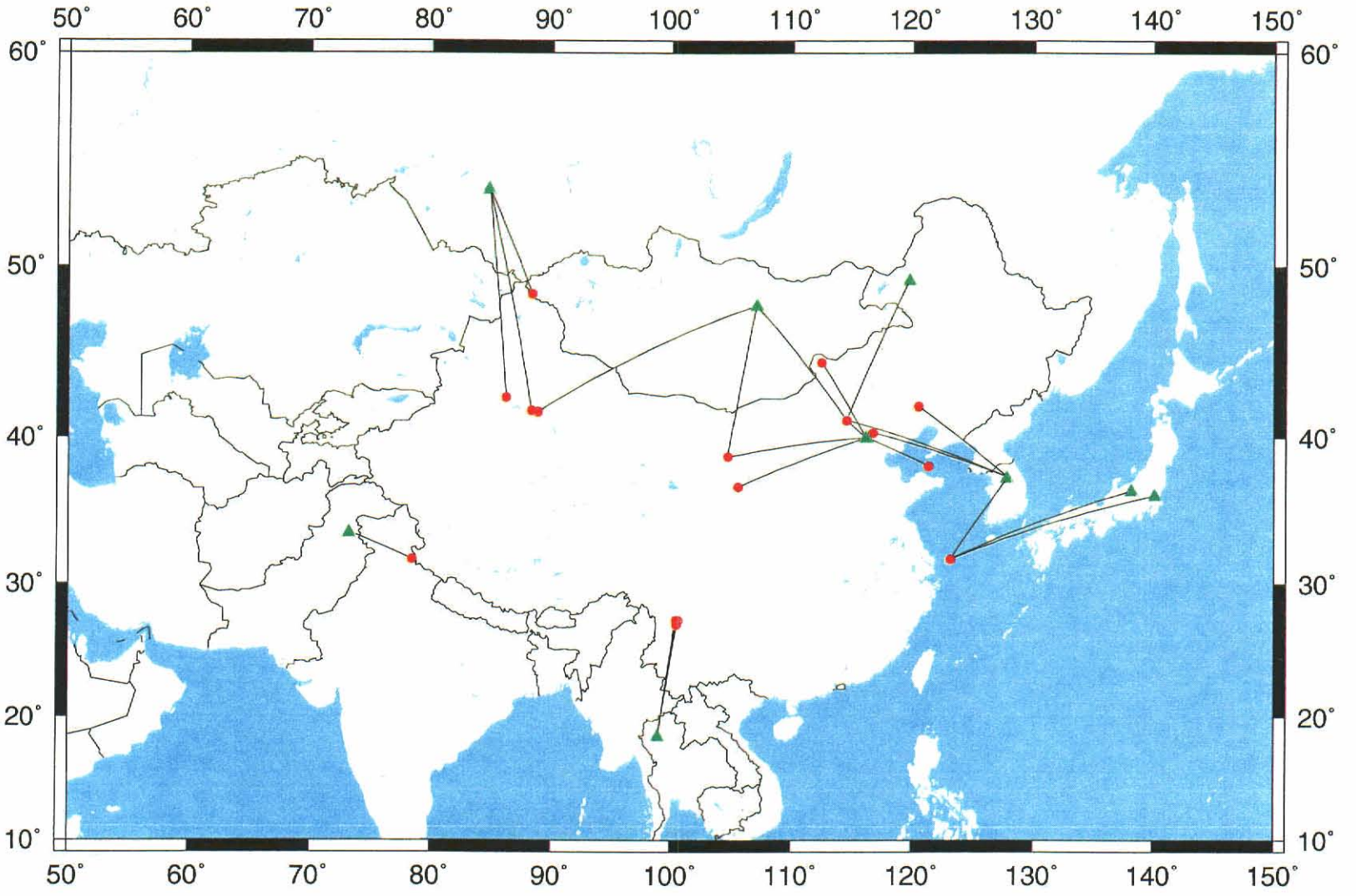

Figure 10. Lg phases with corresponding propagation paths available in the original REB dataset for China showing 18 events with 24 paths. The red circles and green triangles denote epicenters and recording stations, respectively.

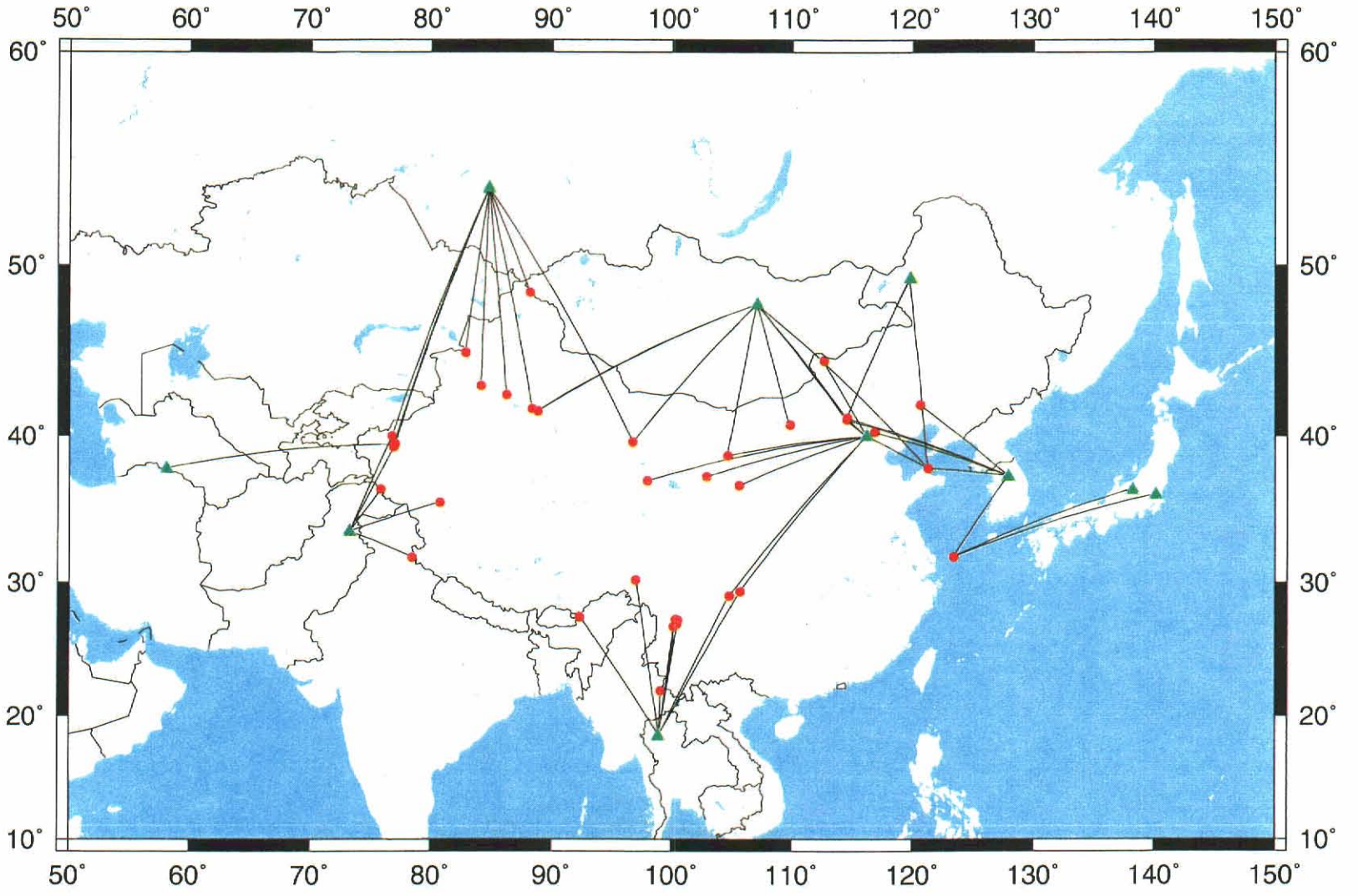

Figure 11. Lg phases with corresponding propagation paths available in the revised IDC dataset for China showing 41 events with 59 paths. The red circles and green triangles denote epicenters and recording stations, respectively.

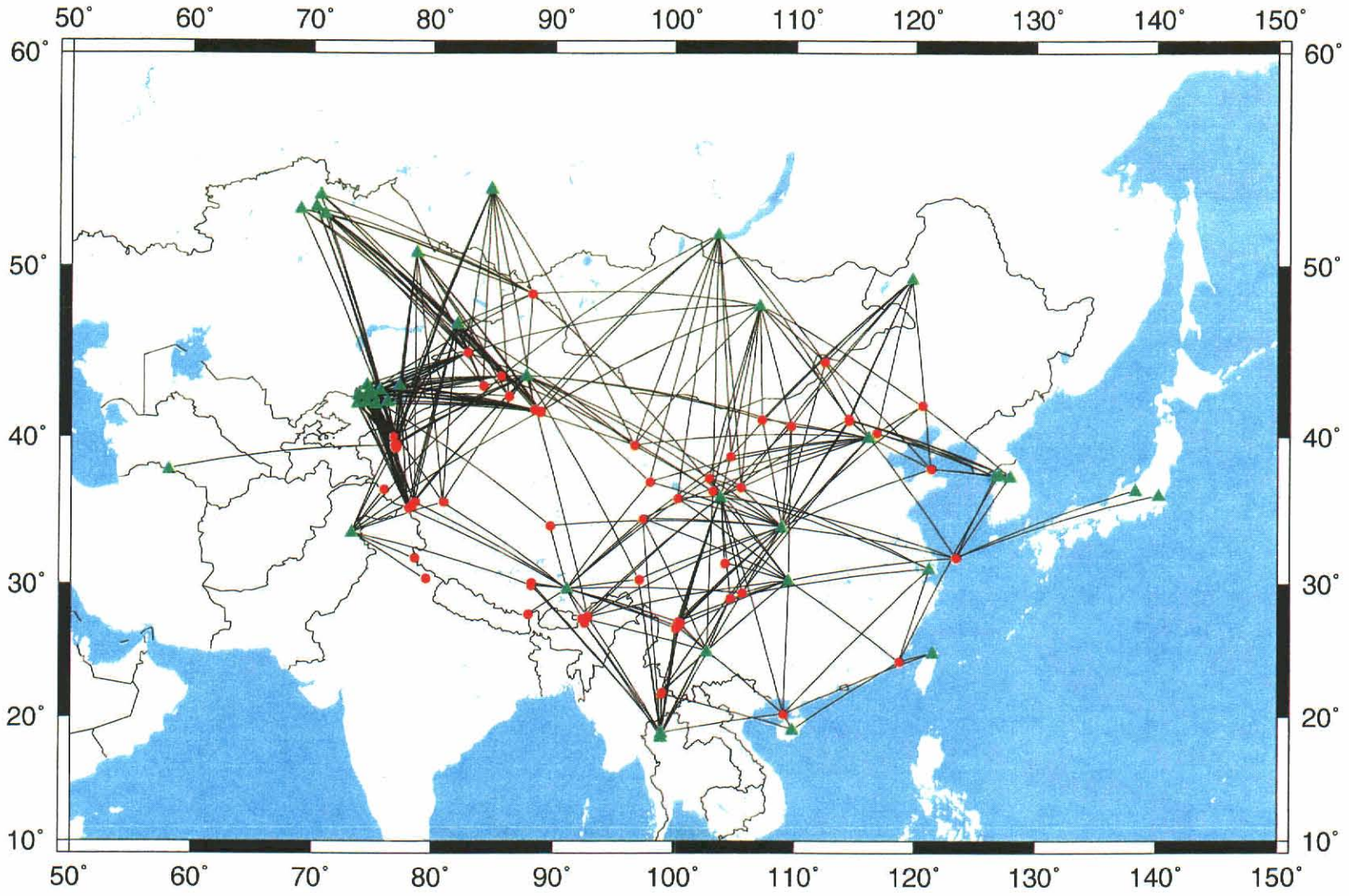

Figure 12. Lg phases with corresponding propagation paths available in the IRIS and revised IDC dataset for China showing 62 events with 410 paths. The red circles and green triangles denote epicenters and recording stations, respectively. Note that the IRIS data provide a large number of additional Lg arrivals.

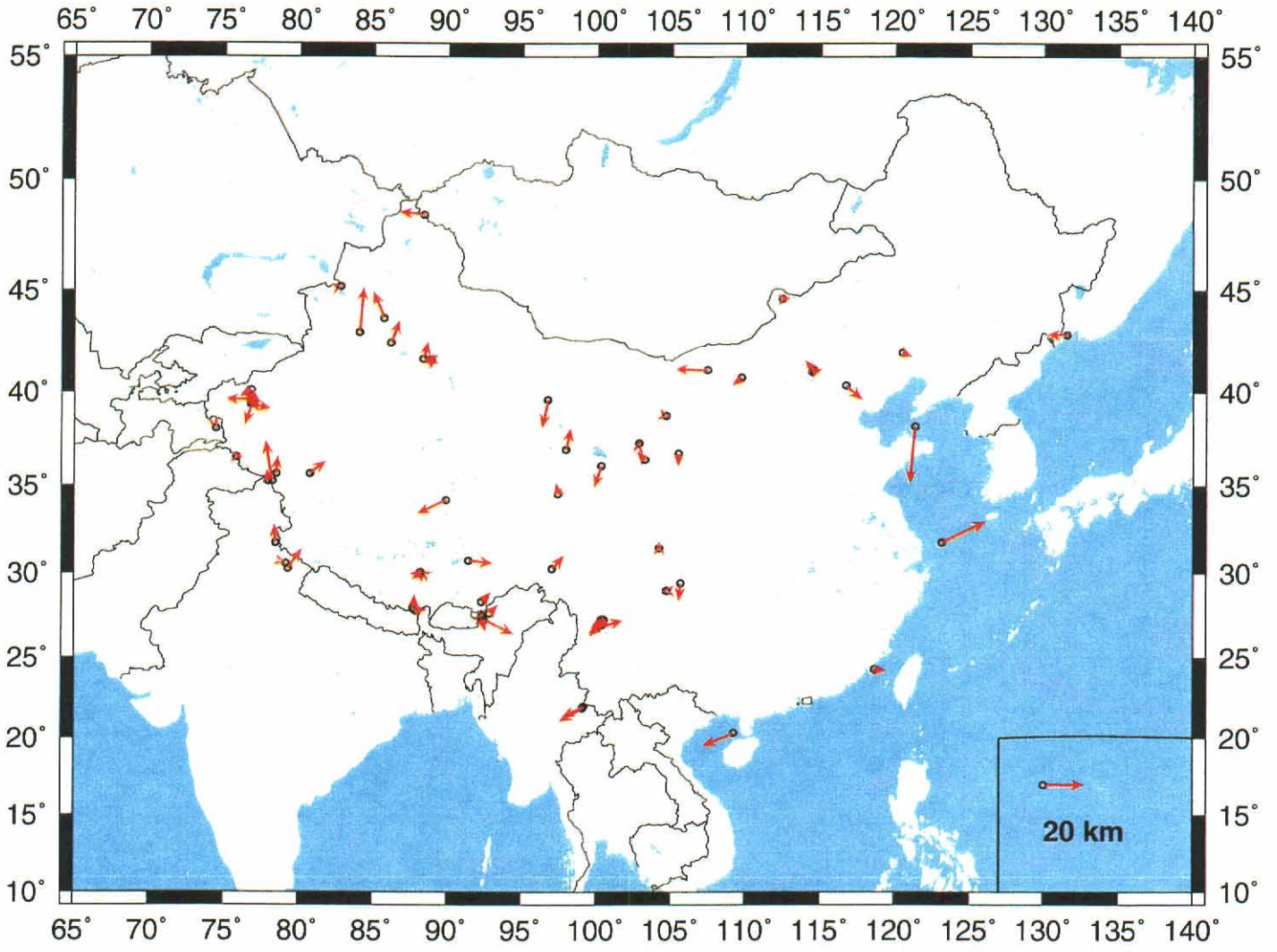

Figure 13. Differences in epicentral location between the original REB (denoted by black circles) and those derived by the combined use of both IRIS and revised IDC for all 70 Chinese events. Arrows point towards the new locations and the average difference between the two locations is 8.5 km.

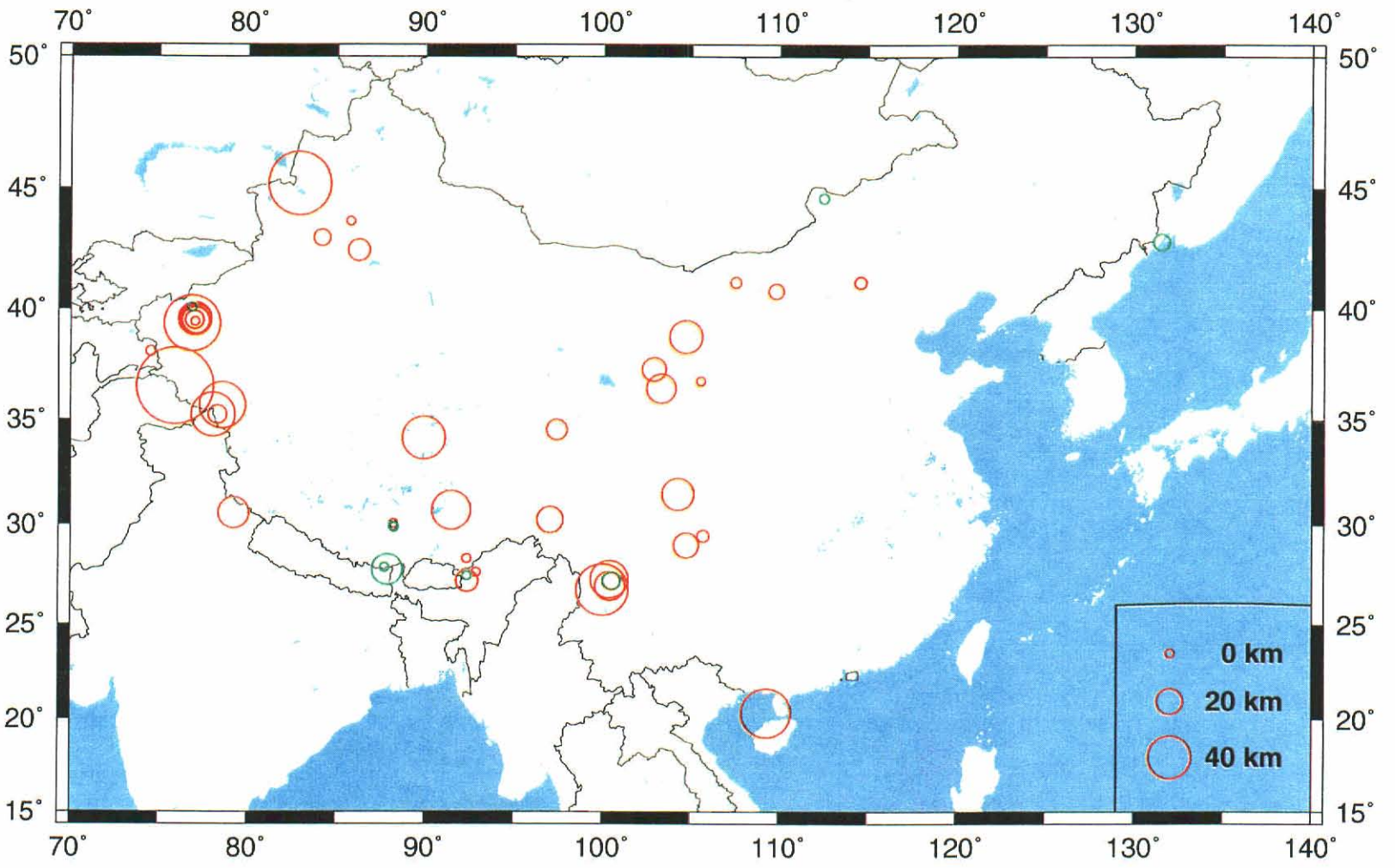

Figure 14. Differences in estimates of source depth between the original REB and the combined IRIS and revised IDC data for 49 Chinese events with non-zero depths (REB averages about 17 km deeper). The red circles denote new depths shallower than those in the REB and the green circles the opposite. For most events, the new depths are significantly shallower than those in the REB.

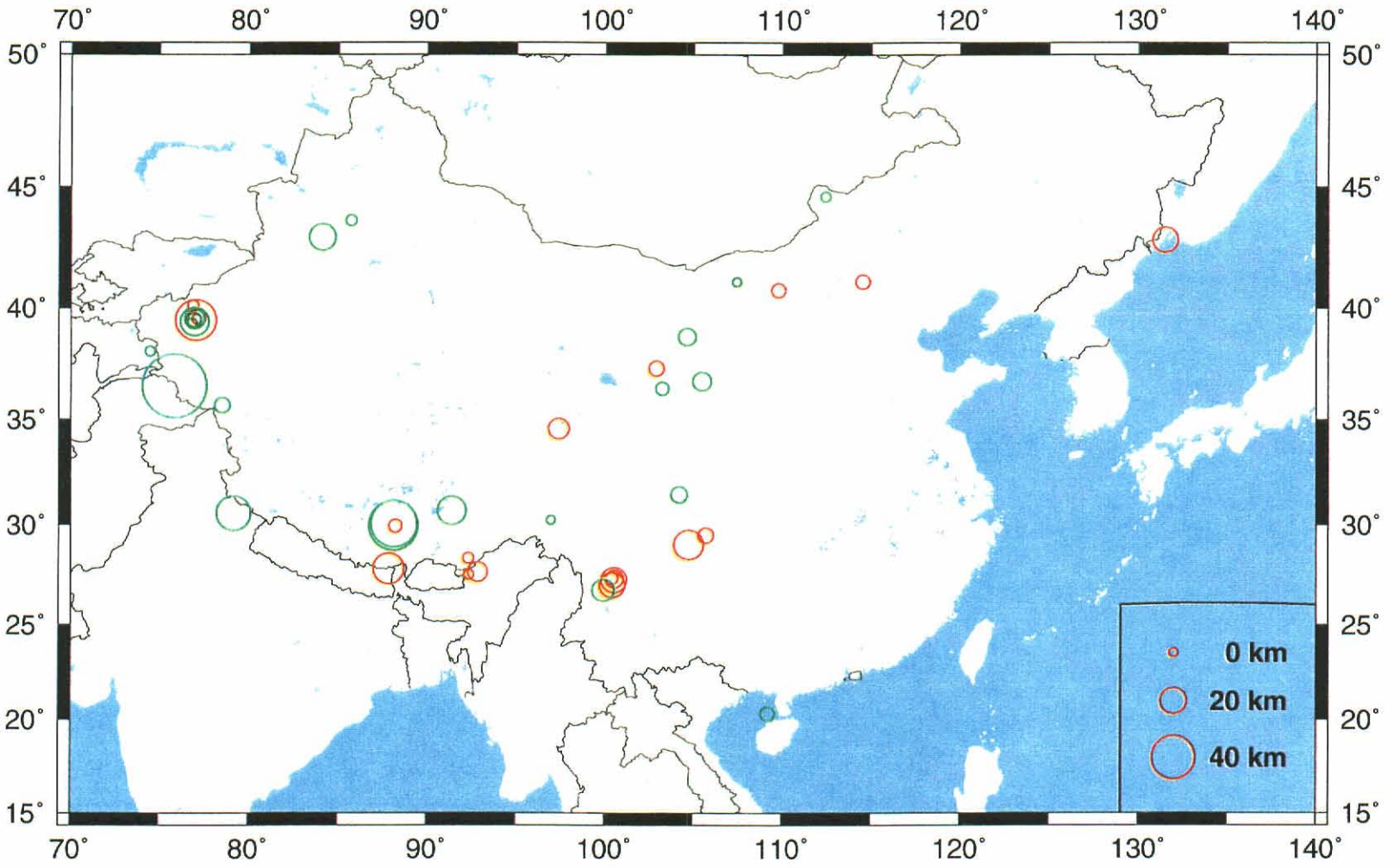

Figure 15. Differences in estimates of source depth between the ISC Bulletin and the combined IRIS and revised IDC data for 42 common events in China with non-zero depths (ISC depths average about 2.5 km deeper). The red circles denote ISC depths shallower than the new depths and the green circles the opposite. The two estimates of source depth are not significantly different.

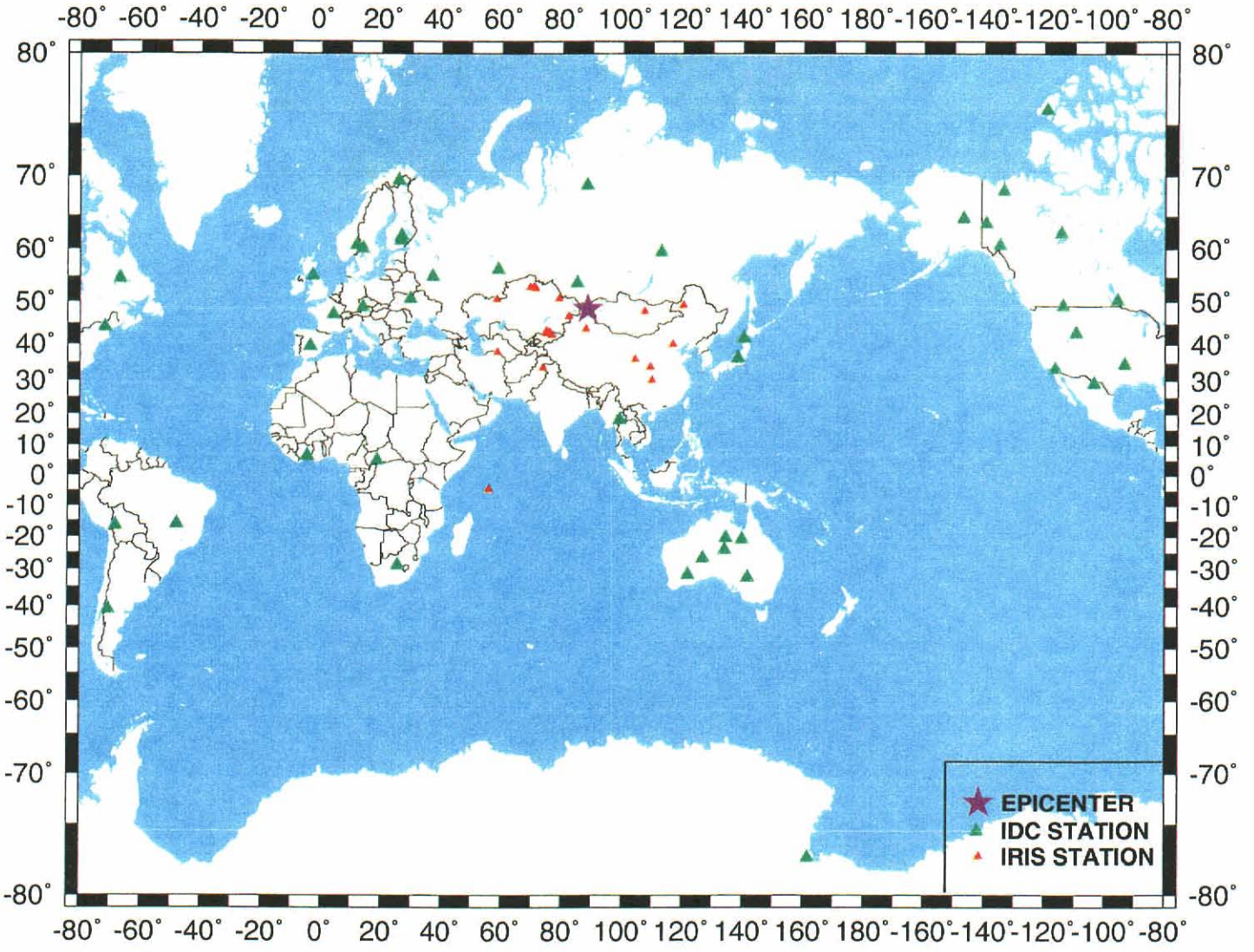

Figure 16. Locations of 45 IDC and 22 IRIS recording stations used in determining the epicentral location and depth of the seismic event of 12 March 1996 (18:43 hrs).

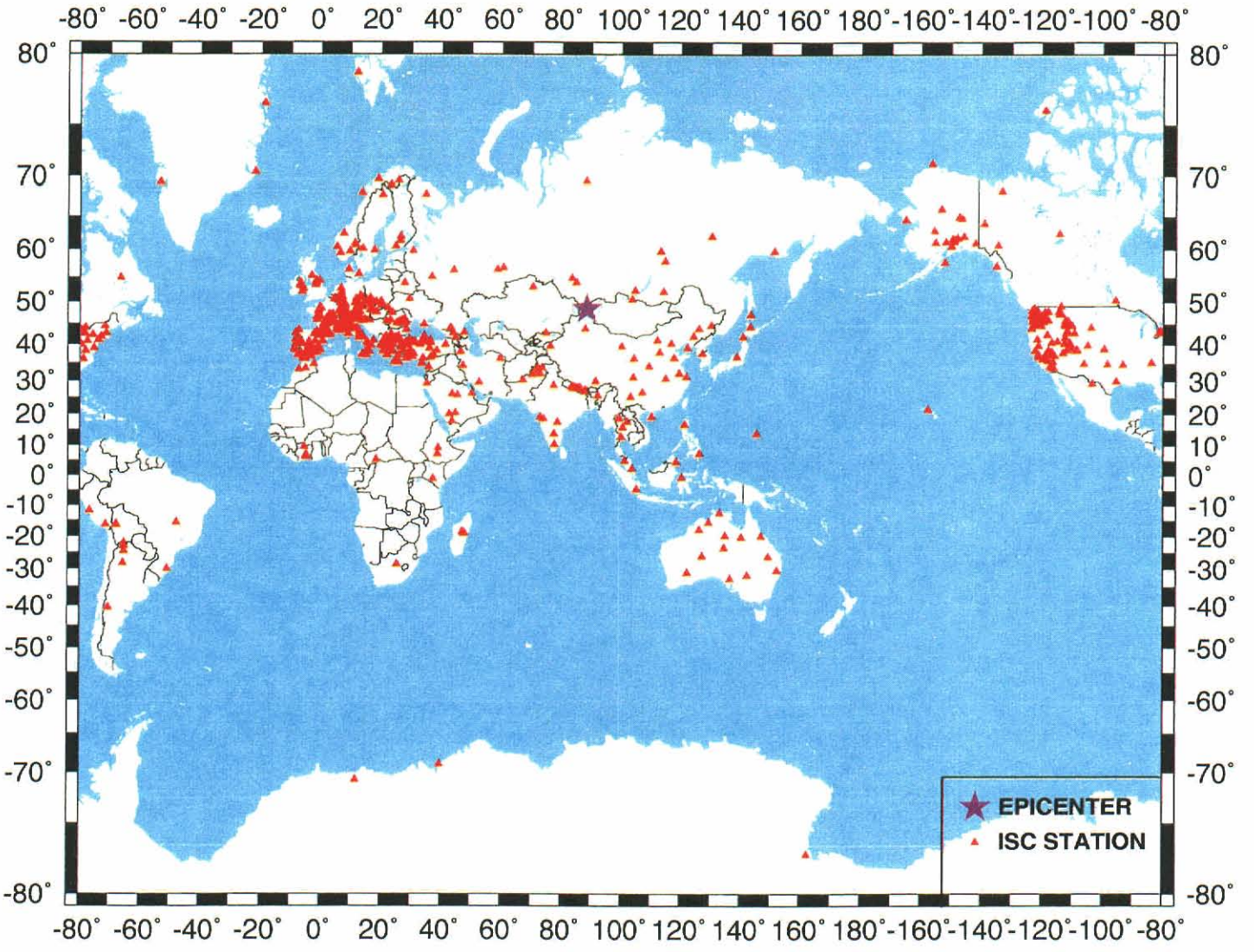

Figure 17. Locations of 586 recording stations used by the ISC in determining epicentral location and depth of the seismic event of 12 March 1996 (18:43 hrs). Note the significantly larger number of stations used by the ISC compared to those in our study (Figure 16).

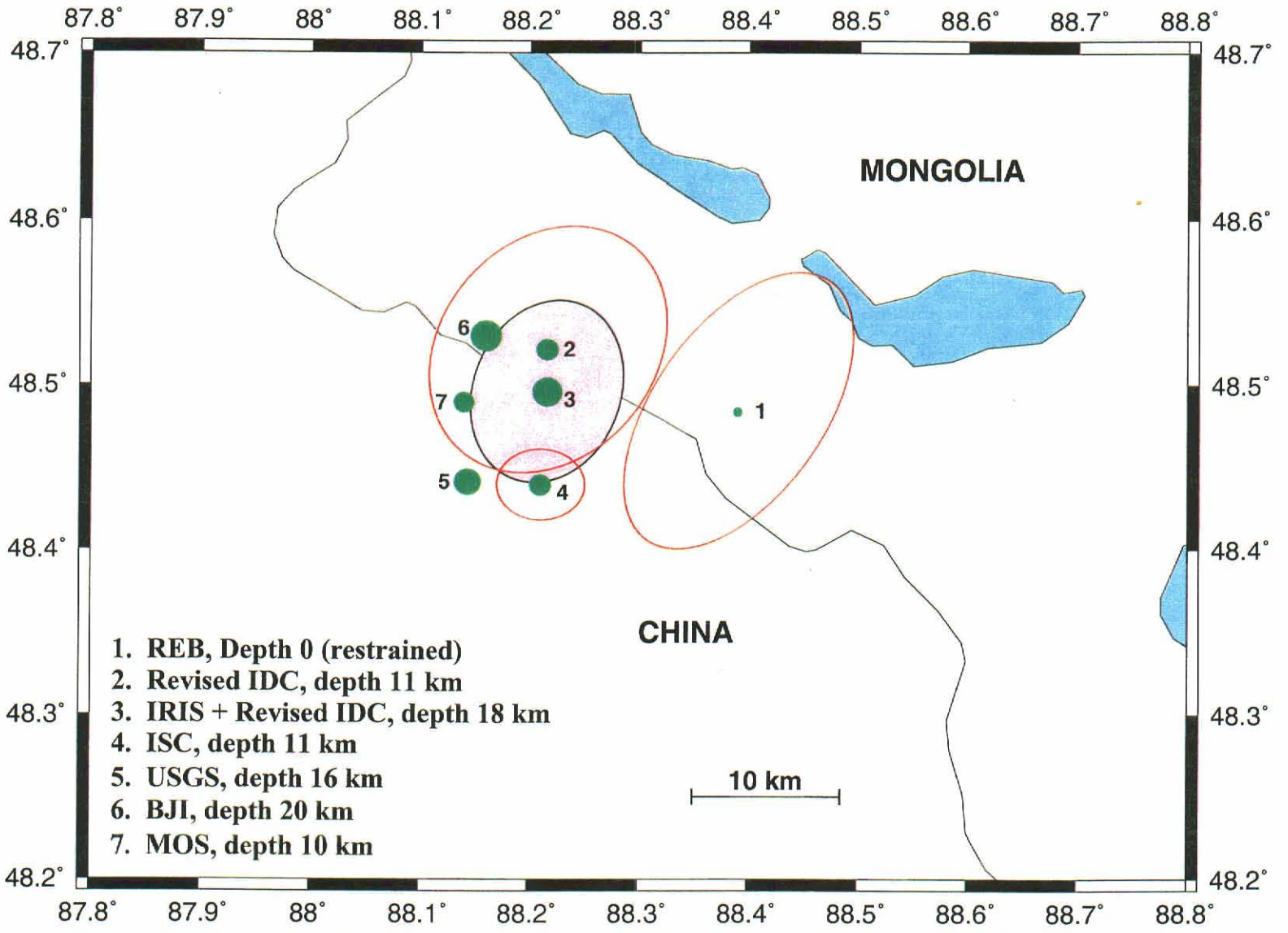

Figure 18. Comparison of epicentral location and depth for the event of 12 March 1996 (18:43 hrs) from seven sources of data. Size of green circle is proportional to source depth and location error ellipses from the first four sources are shown. Results based on the use of both IRIS and revised IDC data (No. 3) appear to improve the REB estimates of both epicentral location and depth (No. 1).

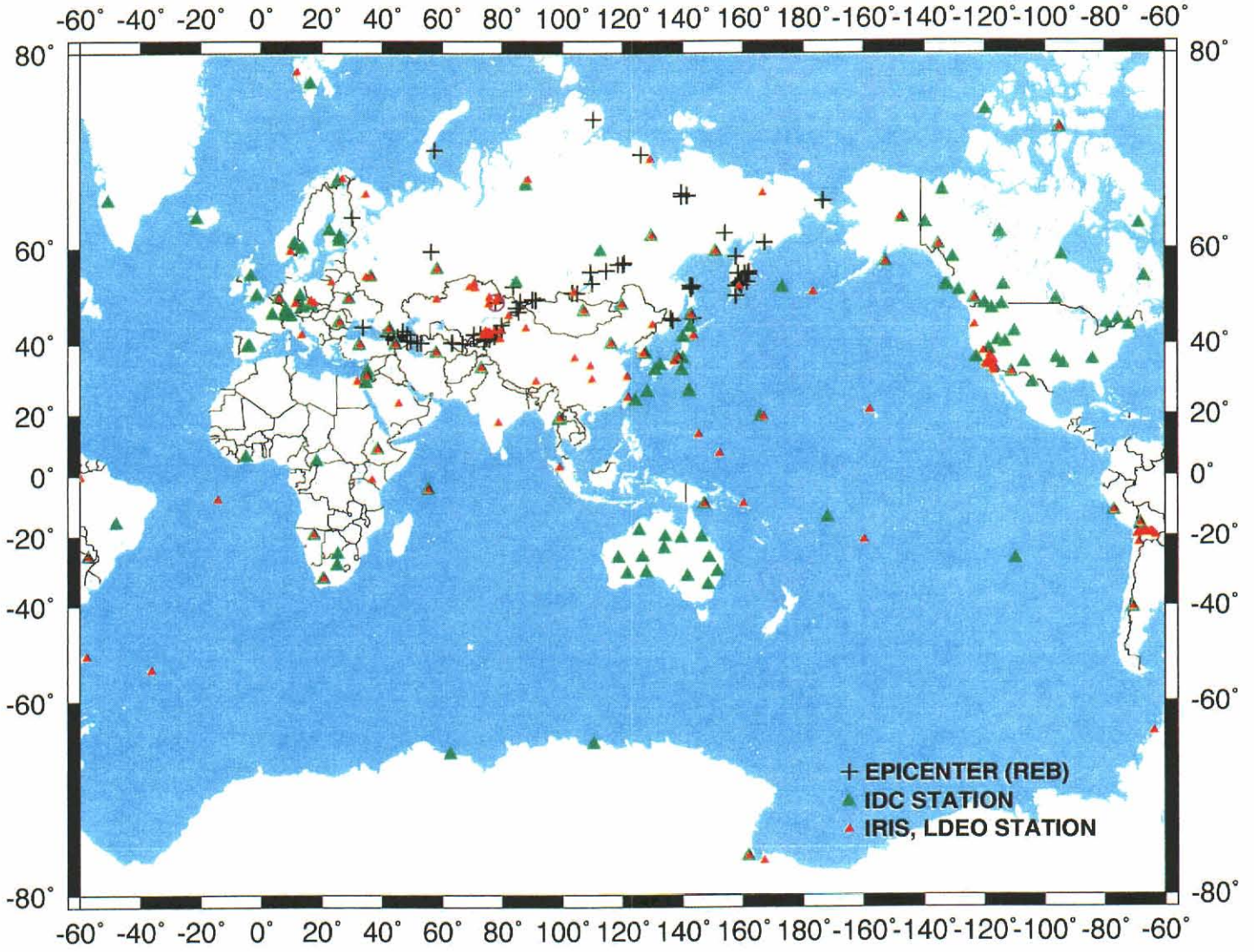

Figure 19. REB epicentral locations of 80 events in the former Soviet Union (FSU) recorded at 148 IDC and 159 IRIS and LDEO stations. For most FSU events, regional data are provided by a large number of IRIS and LDEO stations.

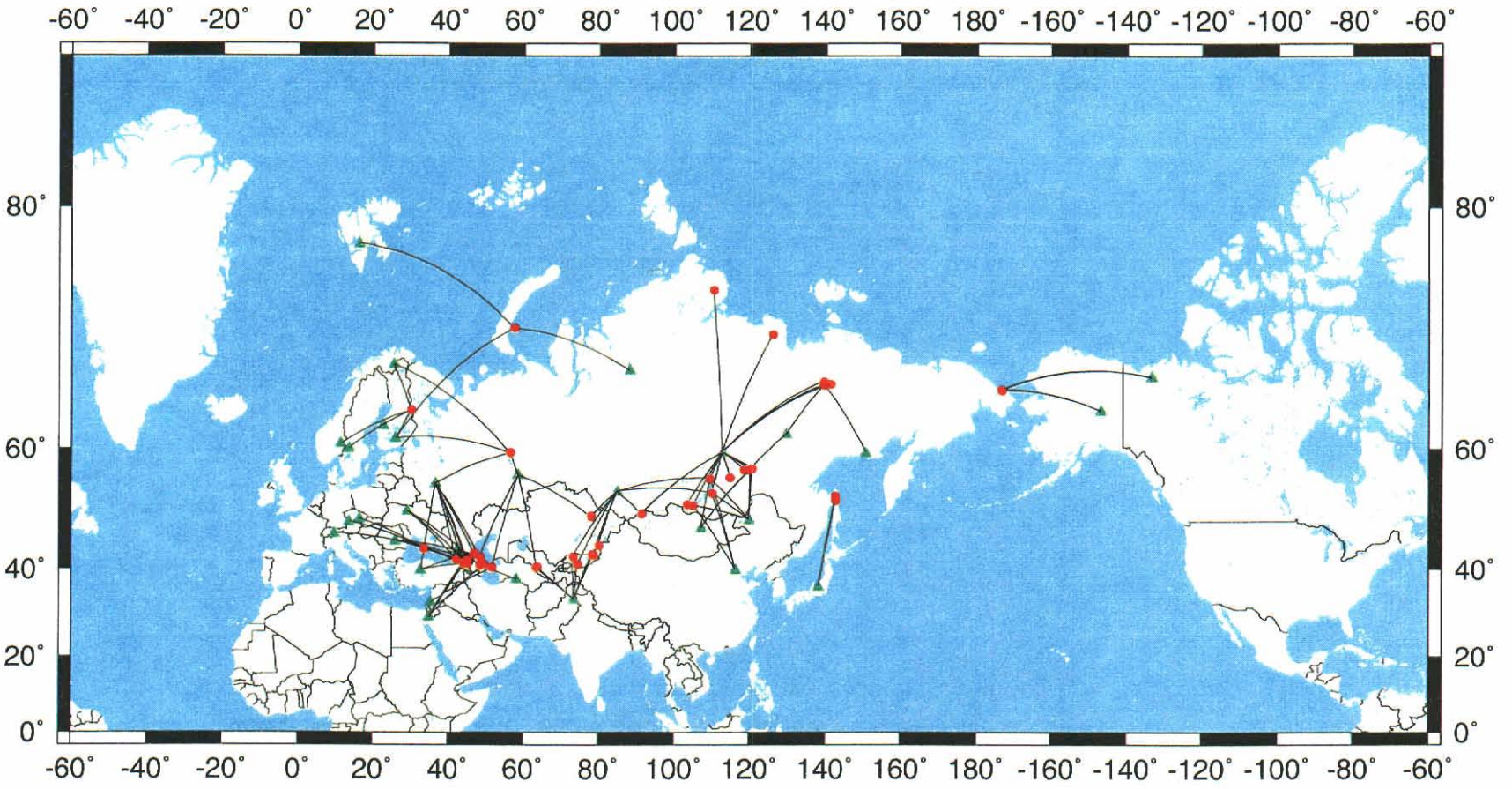

Figure 20. Comparison of Pn phases and corresponding propagation paths for the FSU available in the original REB dataset showing 45 events and 111 paths. The red circles and green triangles denote epicenters and recording stations, respectively.

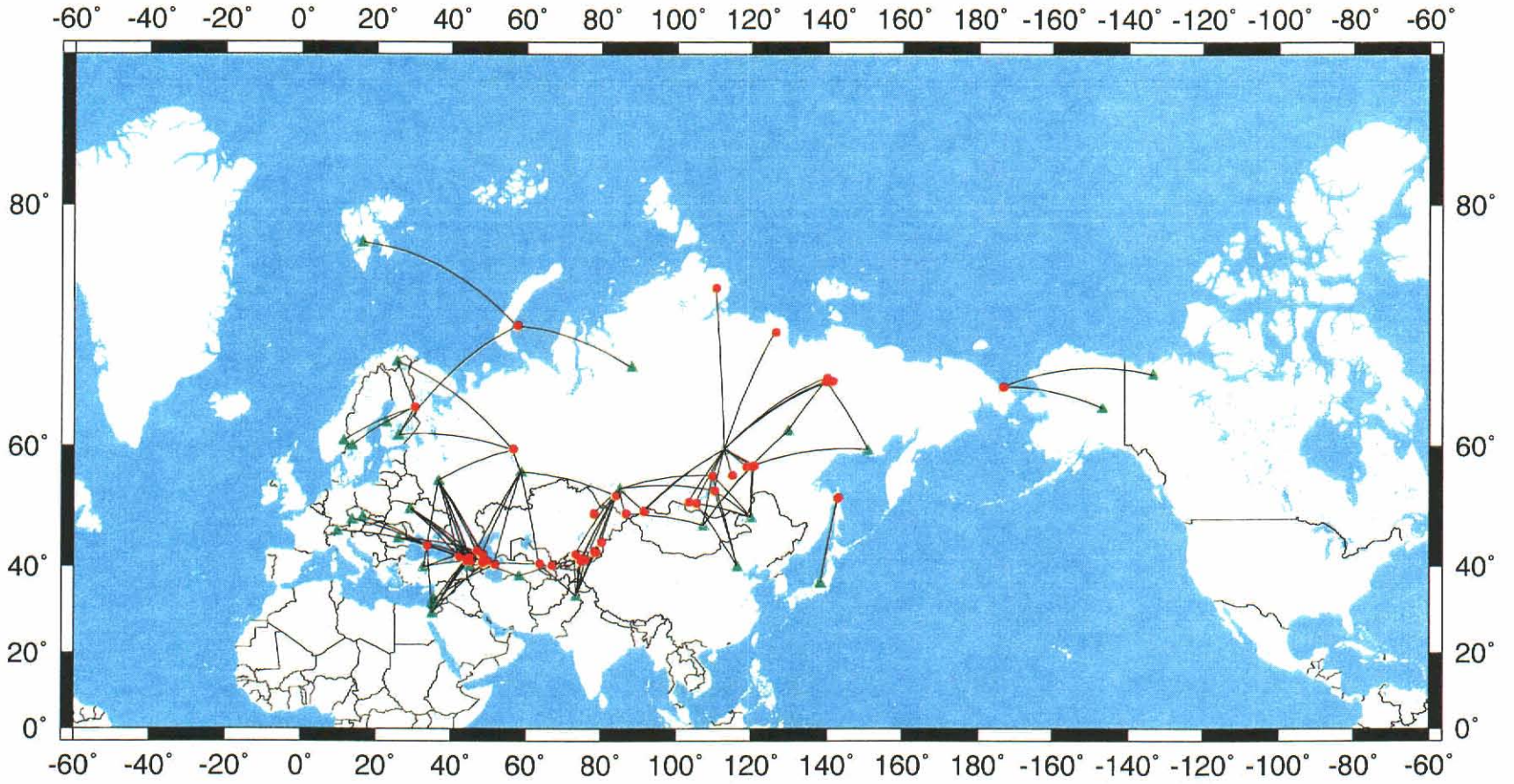

Figure 21. Comparison of Pn phases and corresponding propagation paths for the FSU available in the revised IDC dataset showing 50 events and 127 paths. The red circles and green triangles denote epicenters and recording stations, respectively.

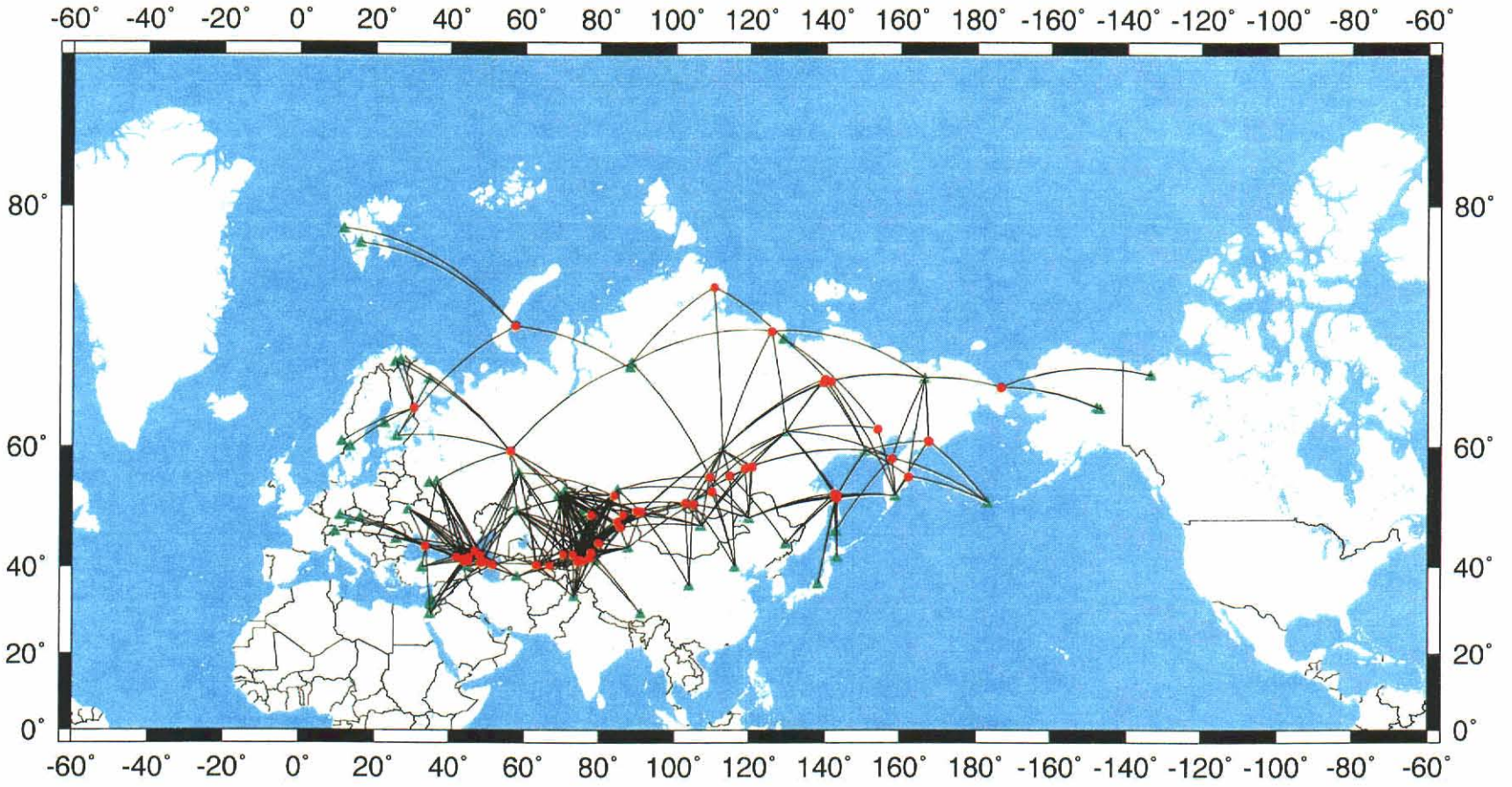

Figure 22. Comparison of Pn phases and corresponding propagation paths for the FSU available in the IRIS and revised IDC dataset showing 65 events and 479 paths. The red circles and green triangles denote epicenters and recording stations, respectively. The IRIS data provide a large number of additional Pn arrivals.

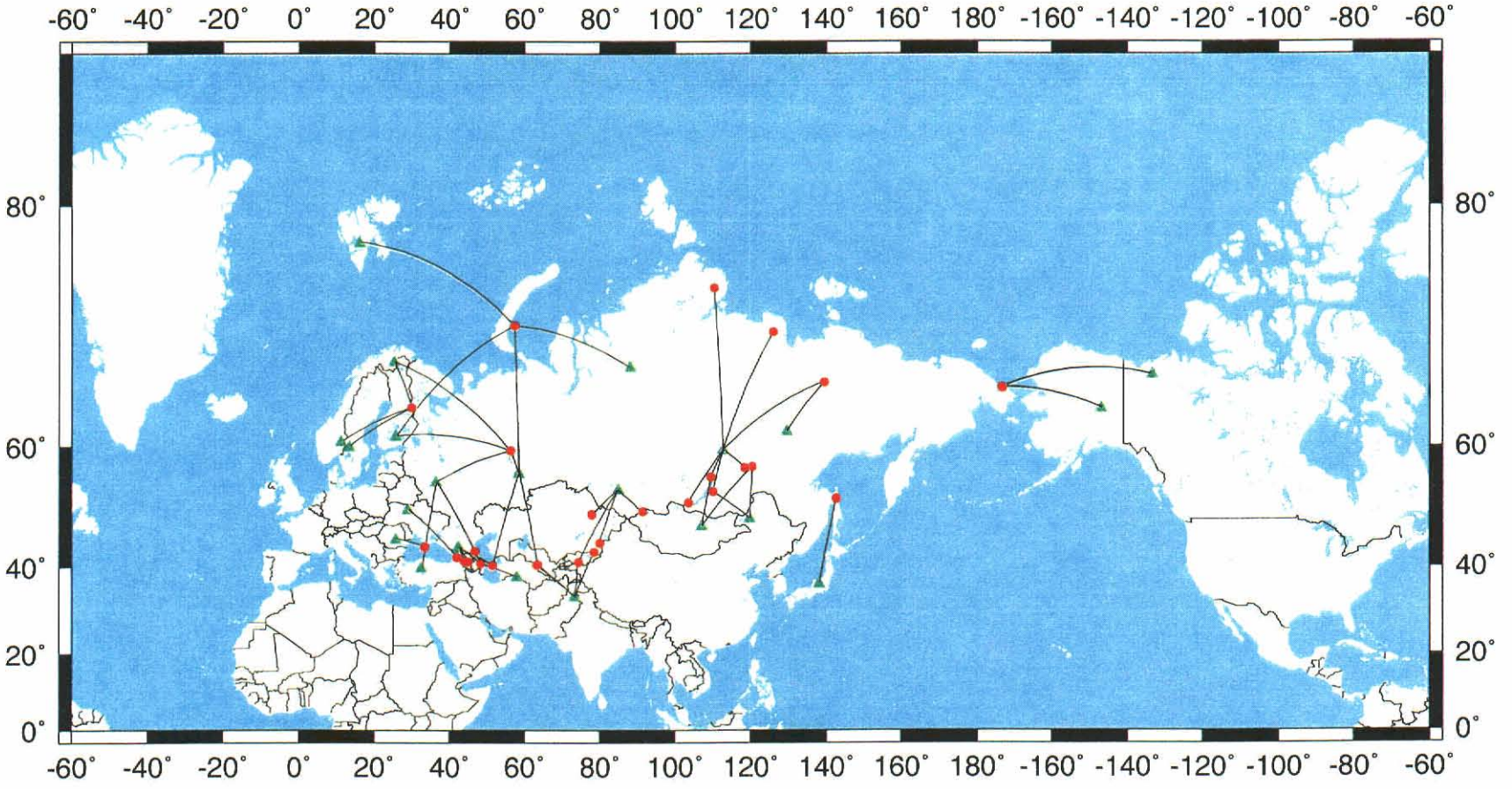

Figure 23. Comparison of Sn phases and corresponding propagation paths for the FSU available in the original REB dataset showing 30 events and 51 paths. The red circles and green triangles denote epicenters and recording stations, respectively.

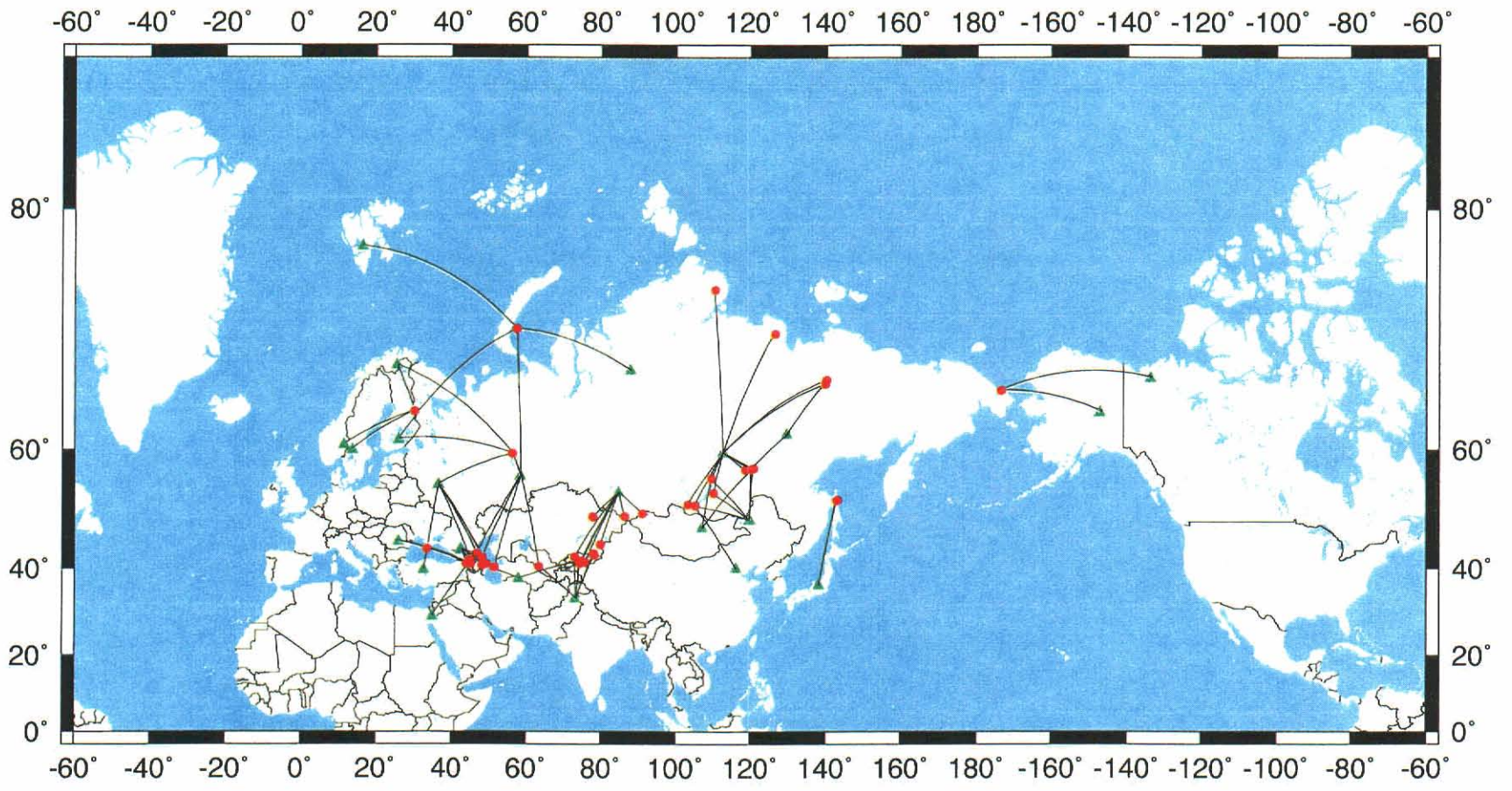

Figure 24. Comparison of Sn phases and corresponding propagation paths for the FSU available in the revised IDC dataset showing 42 events and 77 paths. The red circles and green triangles denote epicenters and recording stations, respectively.

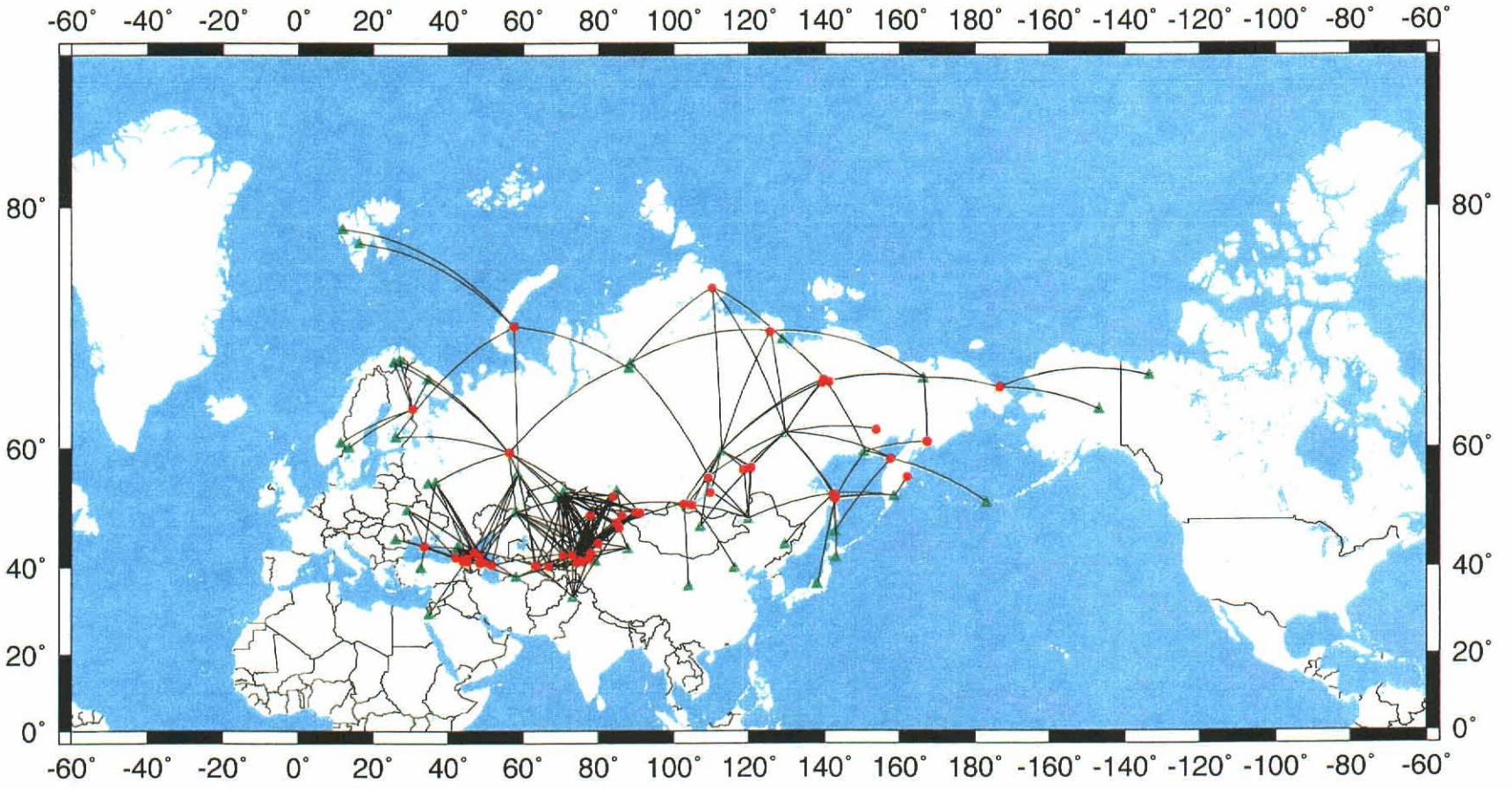

Figure 25. Comparison of Sn phases and corresponding propagation paths for the FSU available in the IRIS and revised IDC dataset showing 62 events and 272 paths. The red circles and green triangles denote epicenters and recording stations, respectively. The IRIS data provide a large number of additional Sn arrivals.

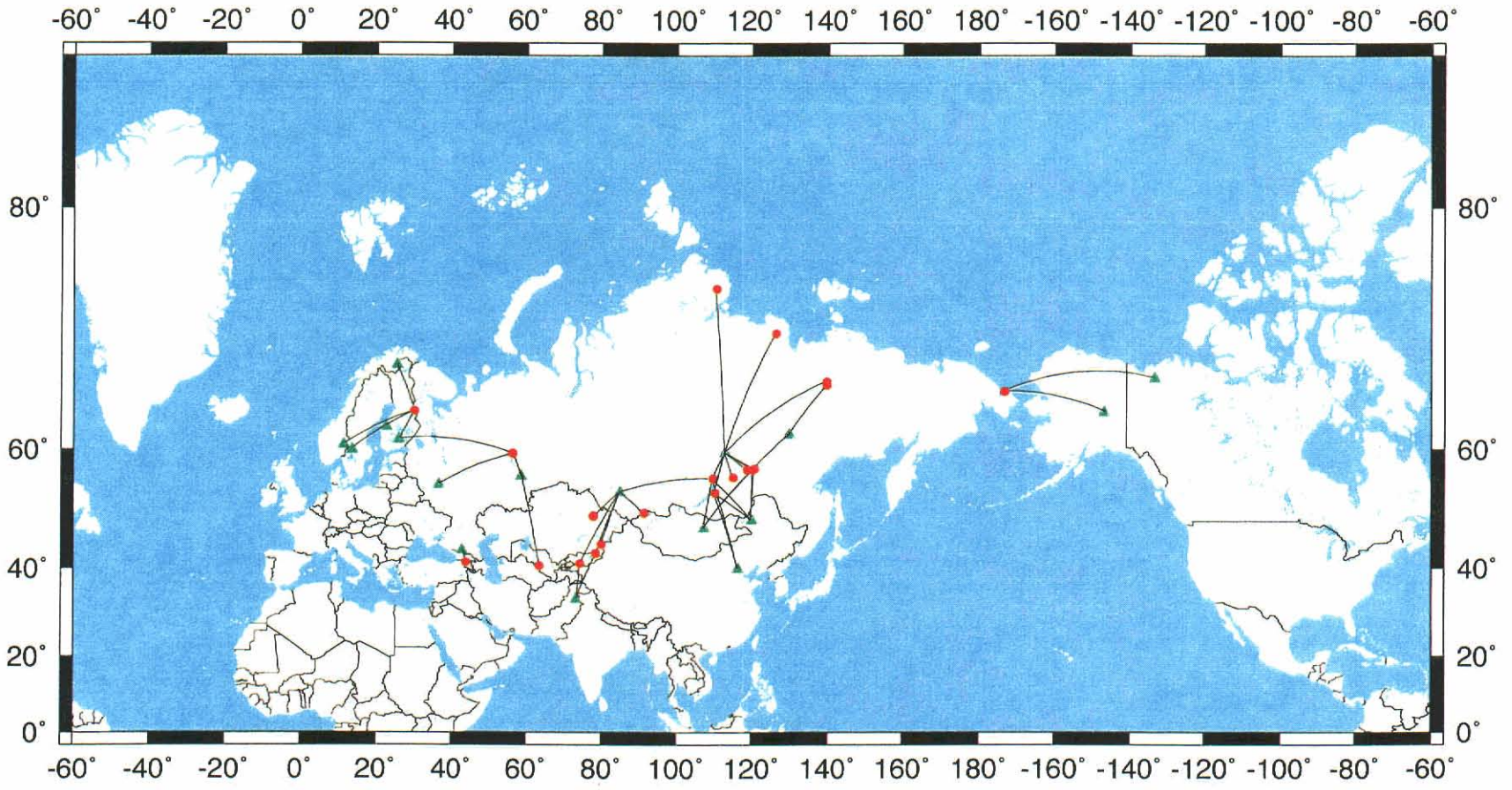

Figure 26. Comparison of Lg phases and corresponding propagation paths for the FSU available in the original REB dataset showing 21 events and 41 paths. The red circles and green triangles denote epicenters and recording stations, respectively.

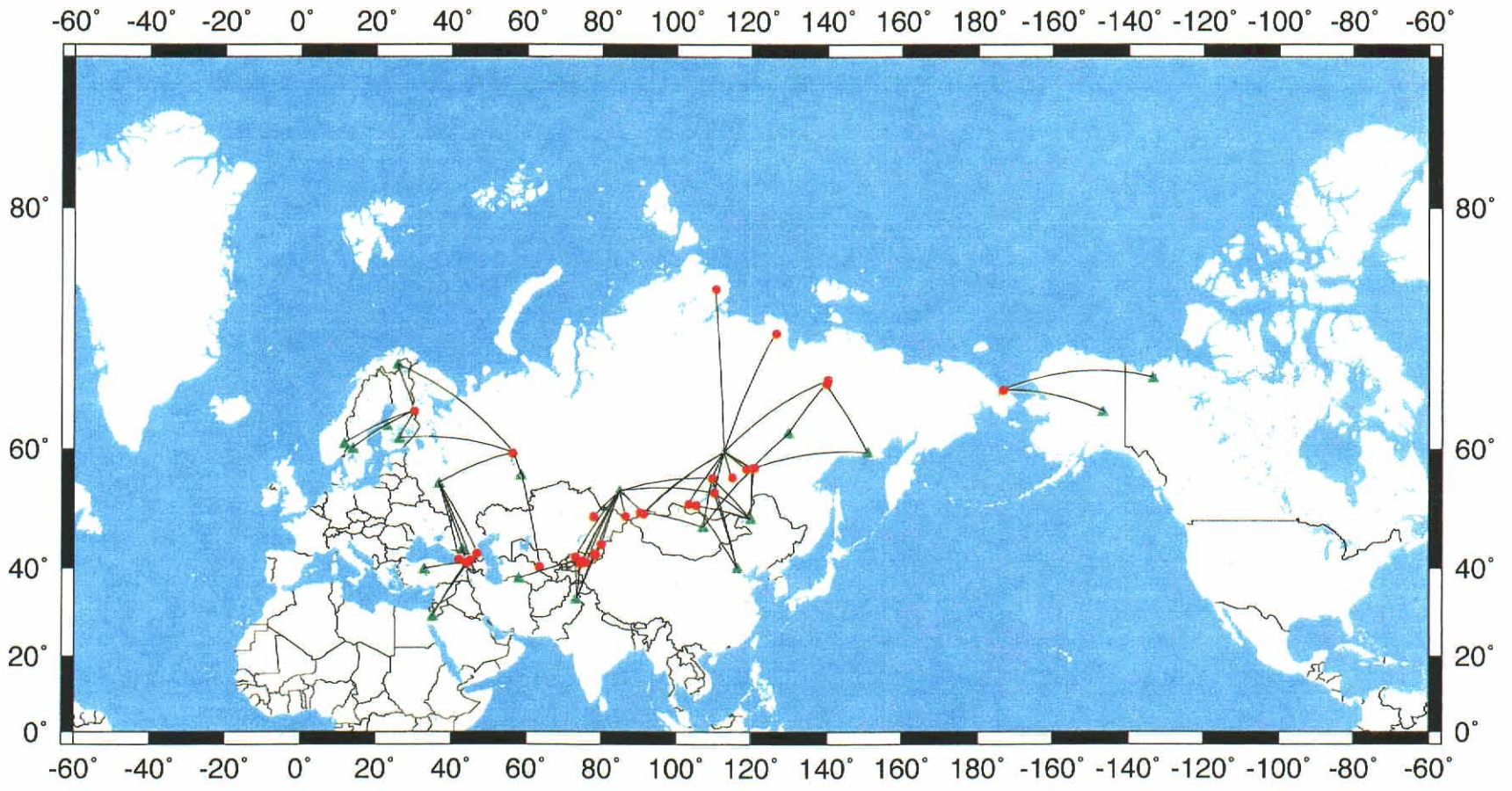

Figure 27. Comparison of Lg phases and corresponding propagation paths for the FSU available in the revised IDC dataset showing 37 events and 71 paths. The red circles and green triangles denote epicenters and recording stations, respectively.

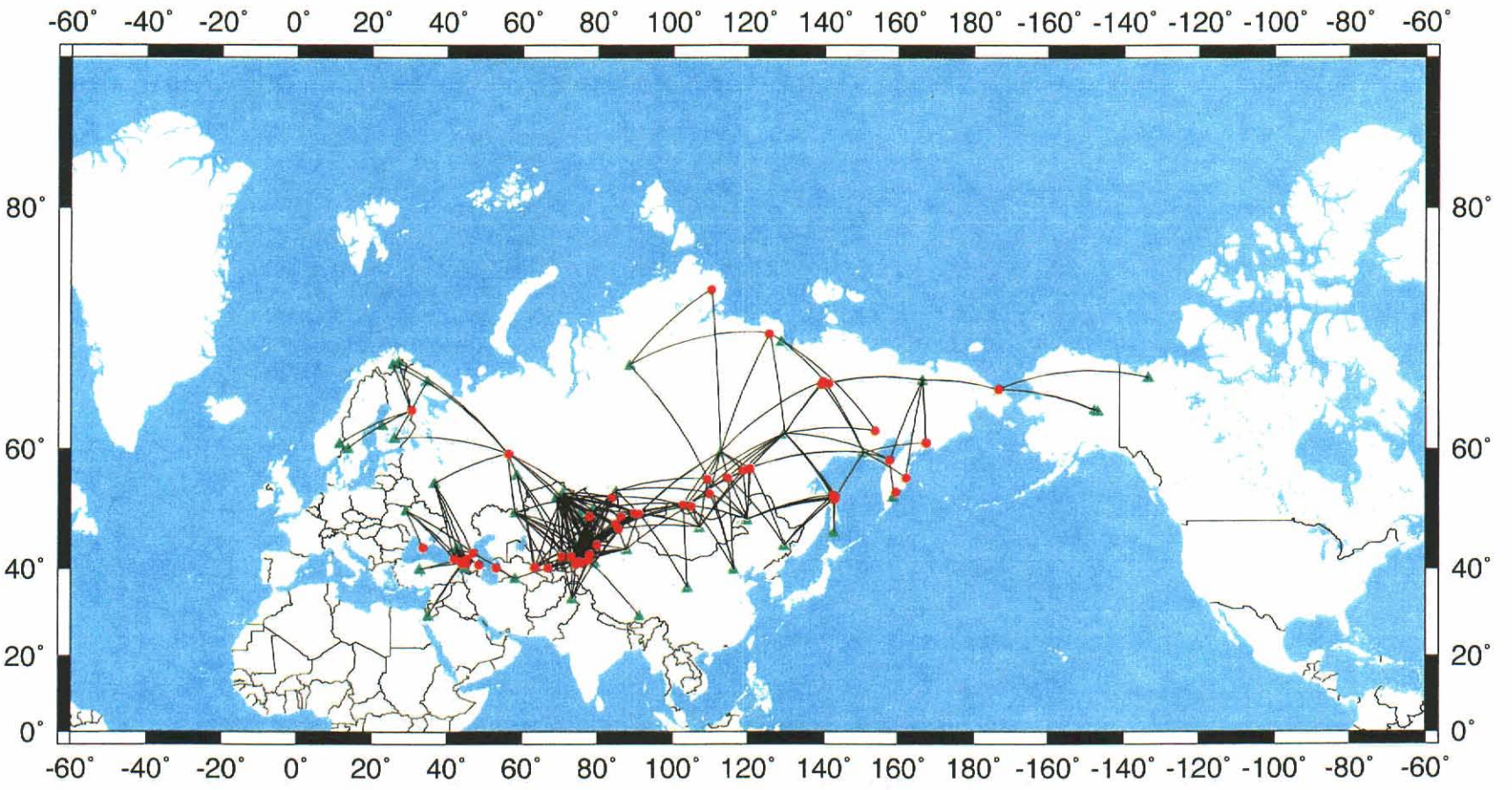

Figure 28. Comparison of Lg phases and corresponding propagation paths for the FSU available in the IRIS and revised IDC dataset showing 63 events and 438 paths. The red circles and green triangles denote epicenters and recording stations, respectively. The IRIS data provide a large number of additional Lg arrivals.

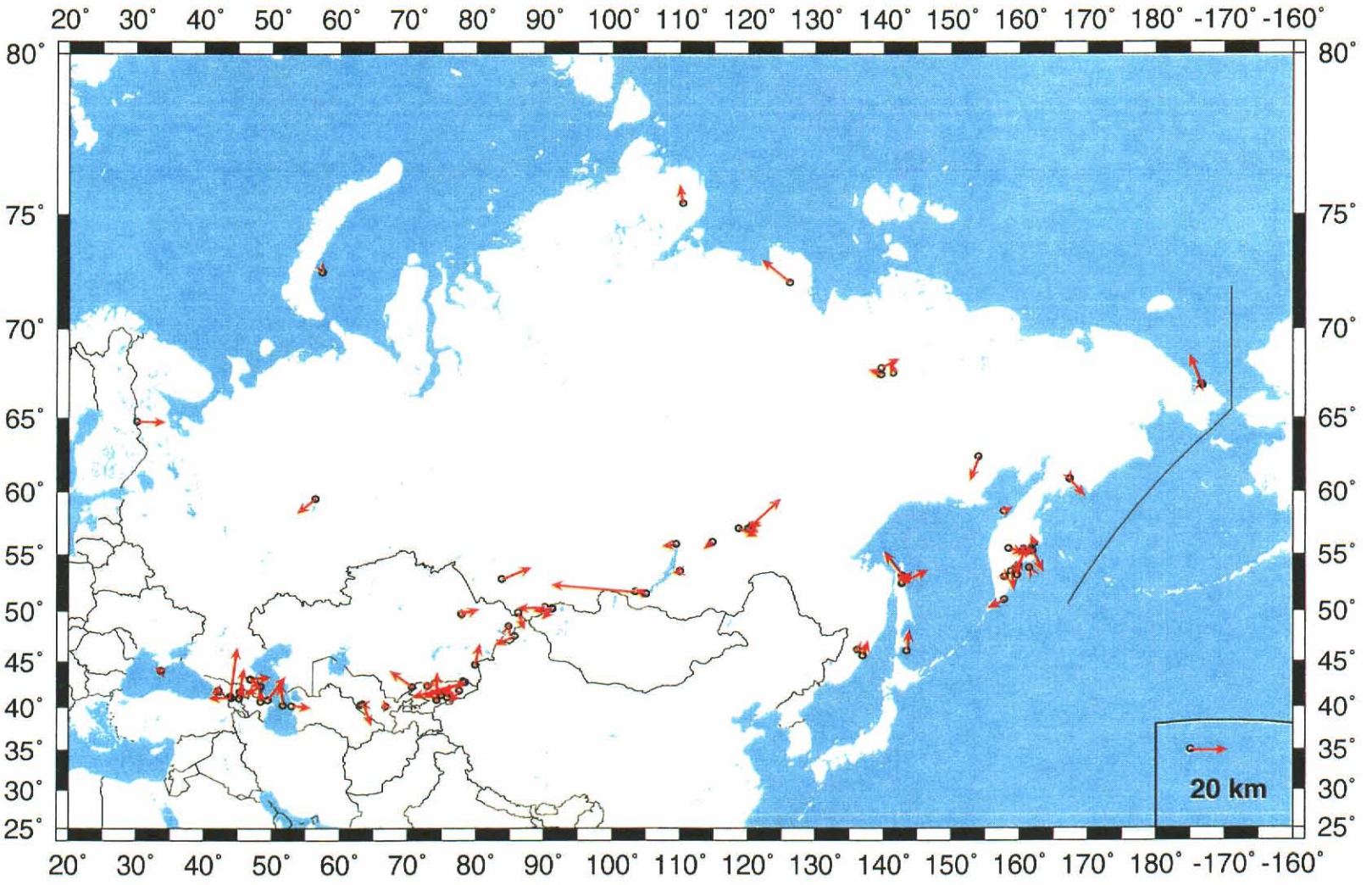

Figure 29. Differences in epicentral location between the original REB (denoted by black circles) and those derived by the combined use of both IRIS and revised IDC data for all 80 FSU events. Arrows point towards the new locations and the average difference between the two locations is 9.7 km.

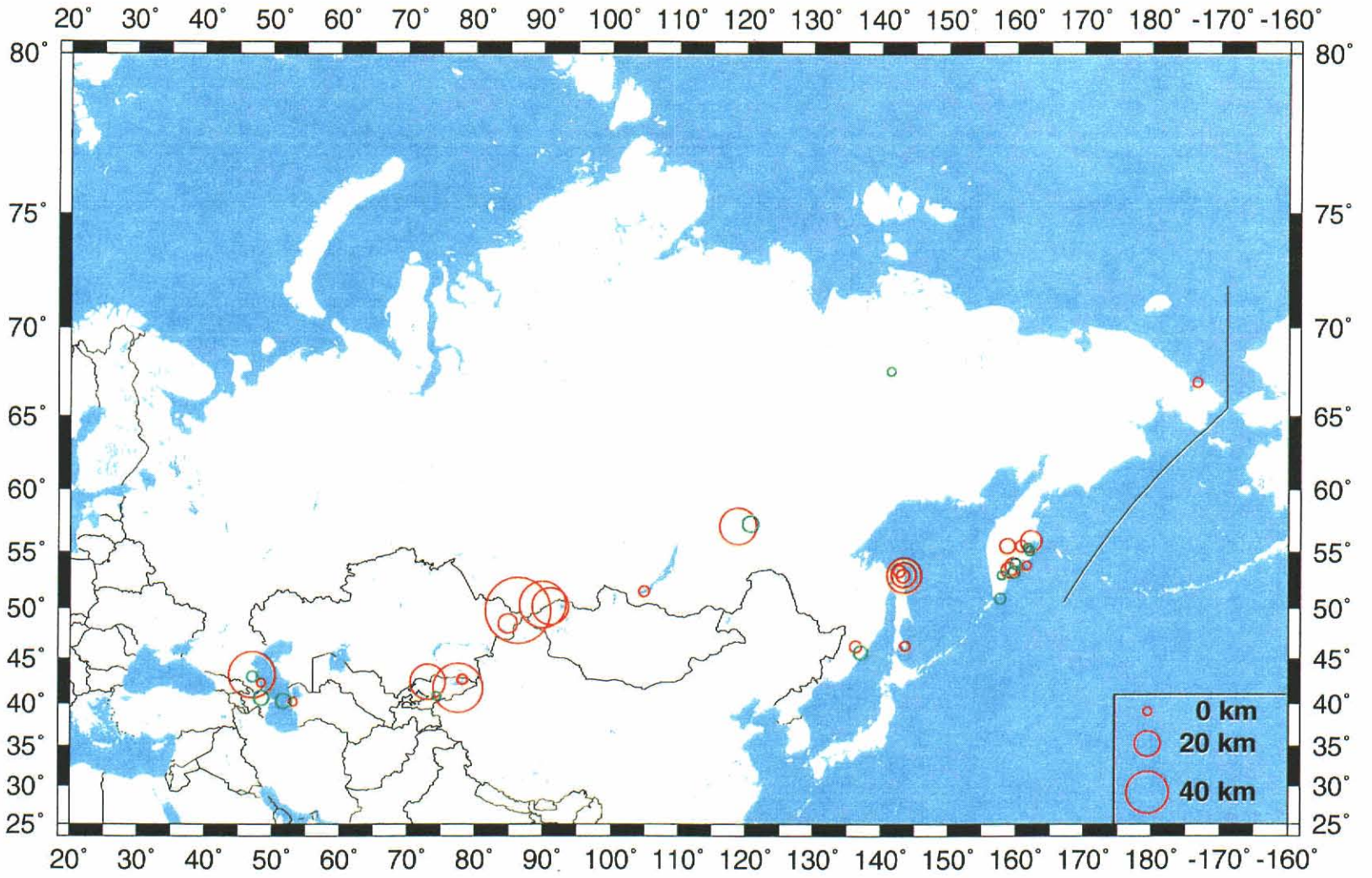

Figure 30. Differences in estimates of source depth between the original REB and the combined IRIS and revised IDC data for 39 FSU events with non-zero depths (REB averages about 10 km deeper). The red circles denote new depths shallower than those in the REB and the green circles the opposite. For most events, the new depths are significantly shallower than those in the REB.

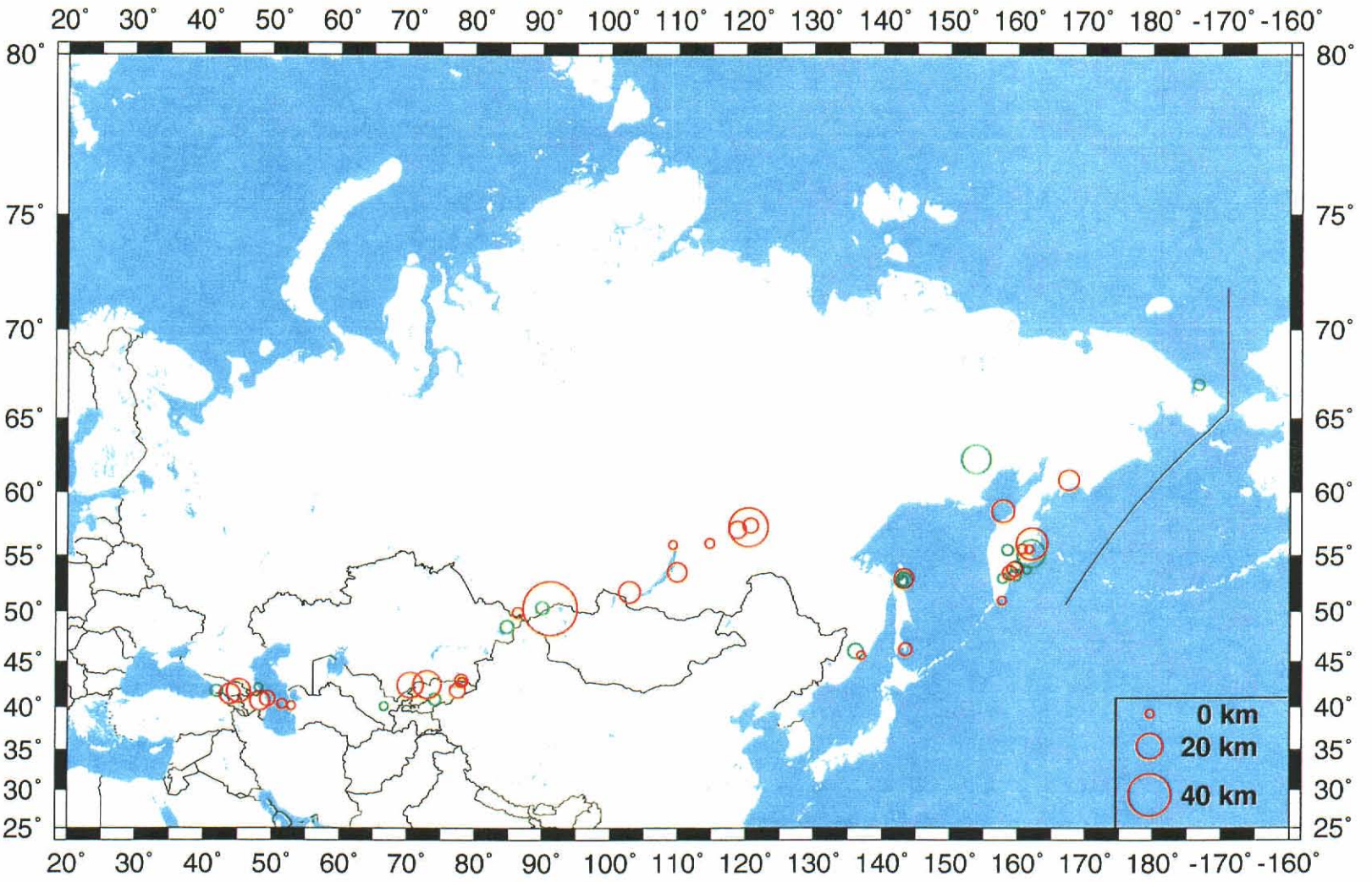

Figure 31. Differences in estimates of source depth between the ISC Bulletin and combined IRIS and revised IDC data for 50 FSU events with non-zero depths (ISC averages about 5 km deeper). The red circles denote new depths shallower than the those in the ISC Bulletin and the green circles the opposite.

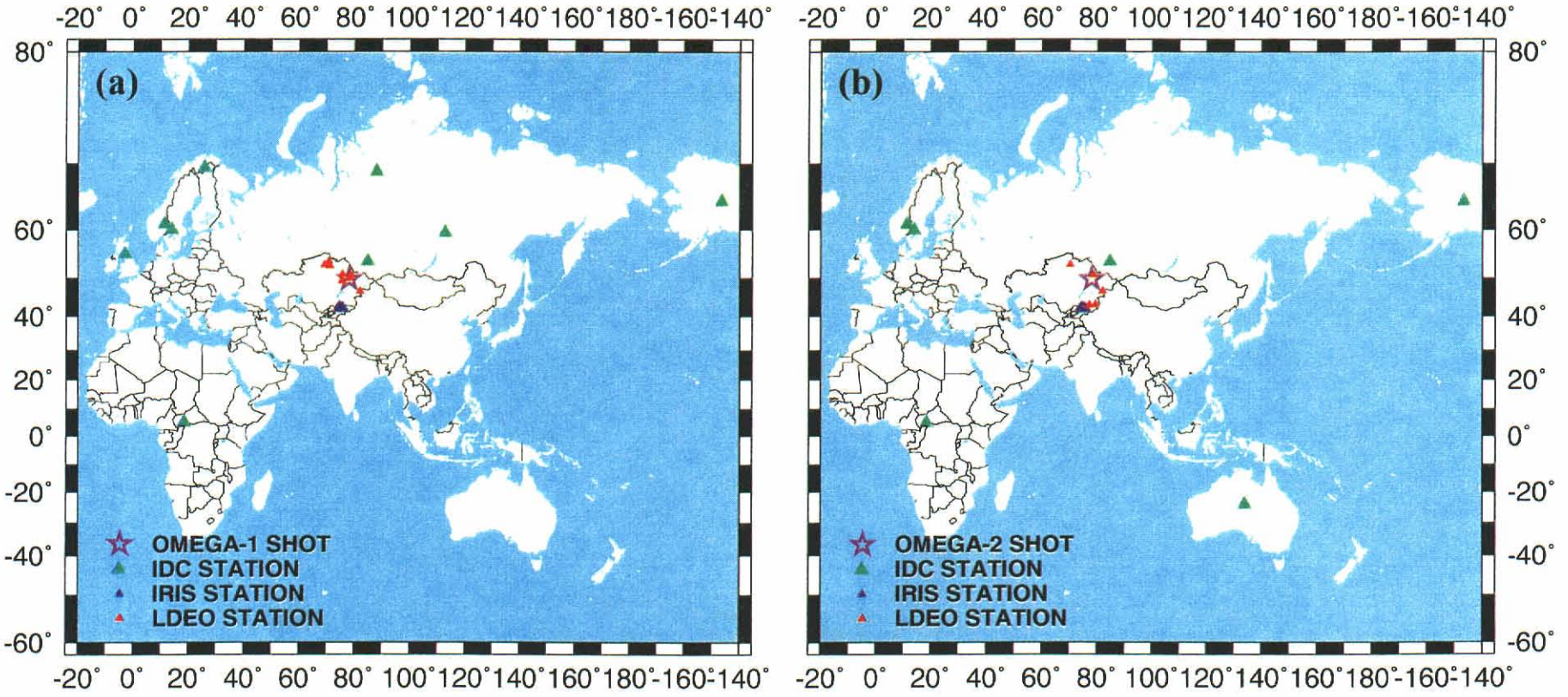

Figure 32. Recording stations providing data for 100-ton chemical shots at Degelen, Kazkah Test Site on (a) 22 August 1998 (Omega-1) and (b) 25 September 1999 (Omega-2).

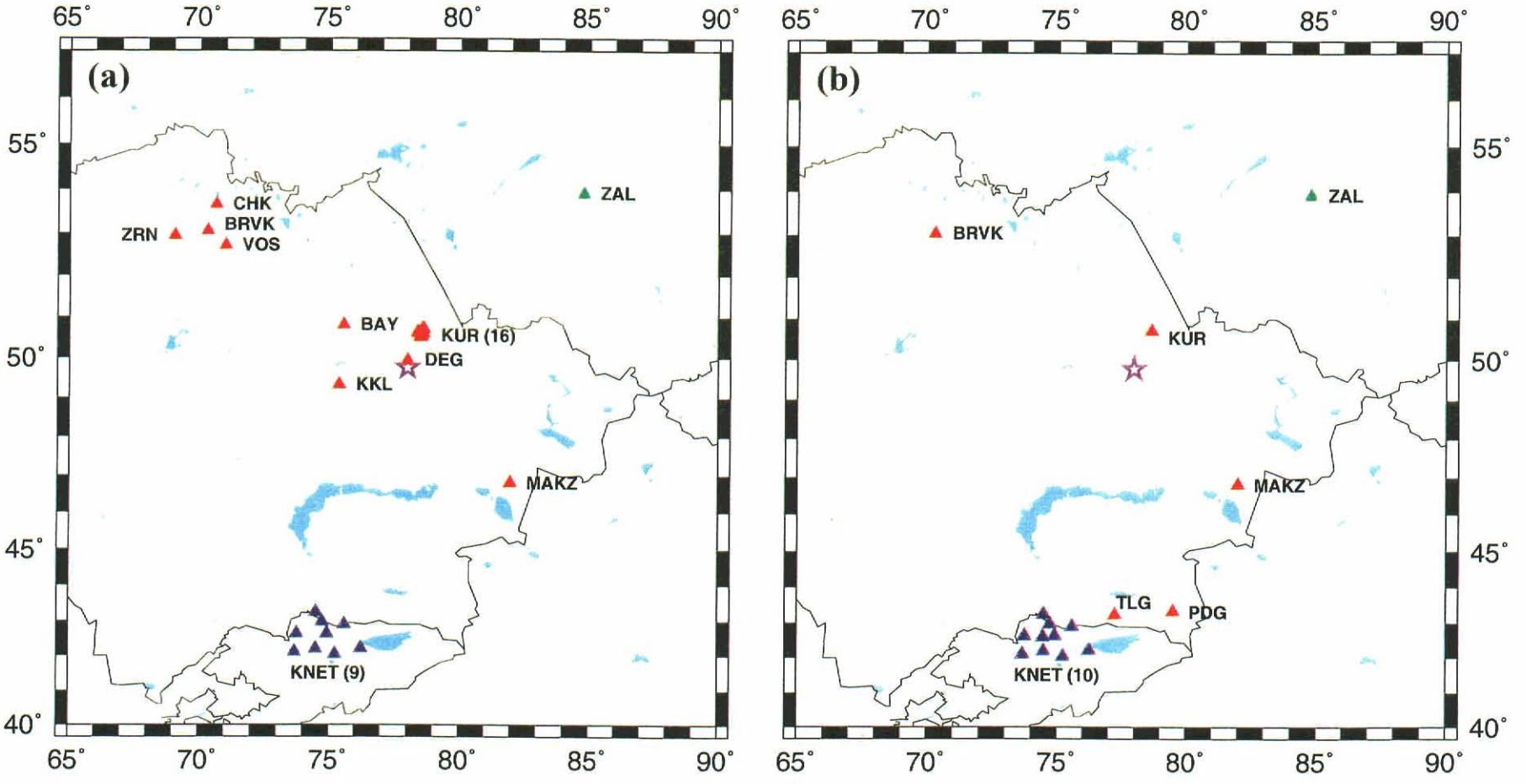

Figure 33. Close-in recording stations for (a) 22 August 1998 (Omega-1) and (b) 25 September 1999 (Omega-2). The representation of various colored symbols is the same as in Figure 32.

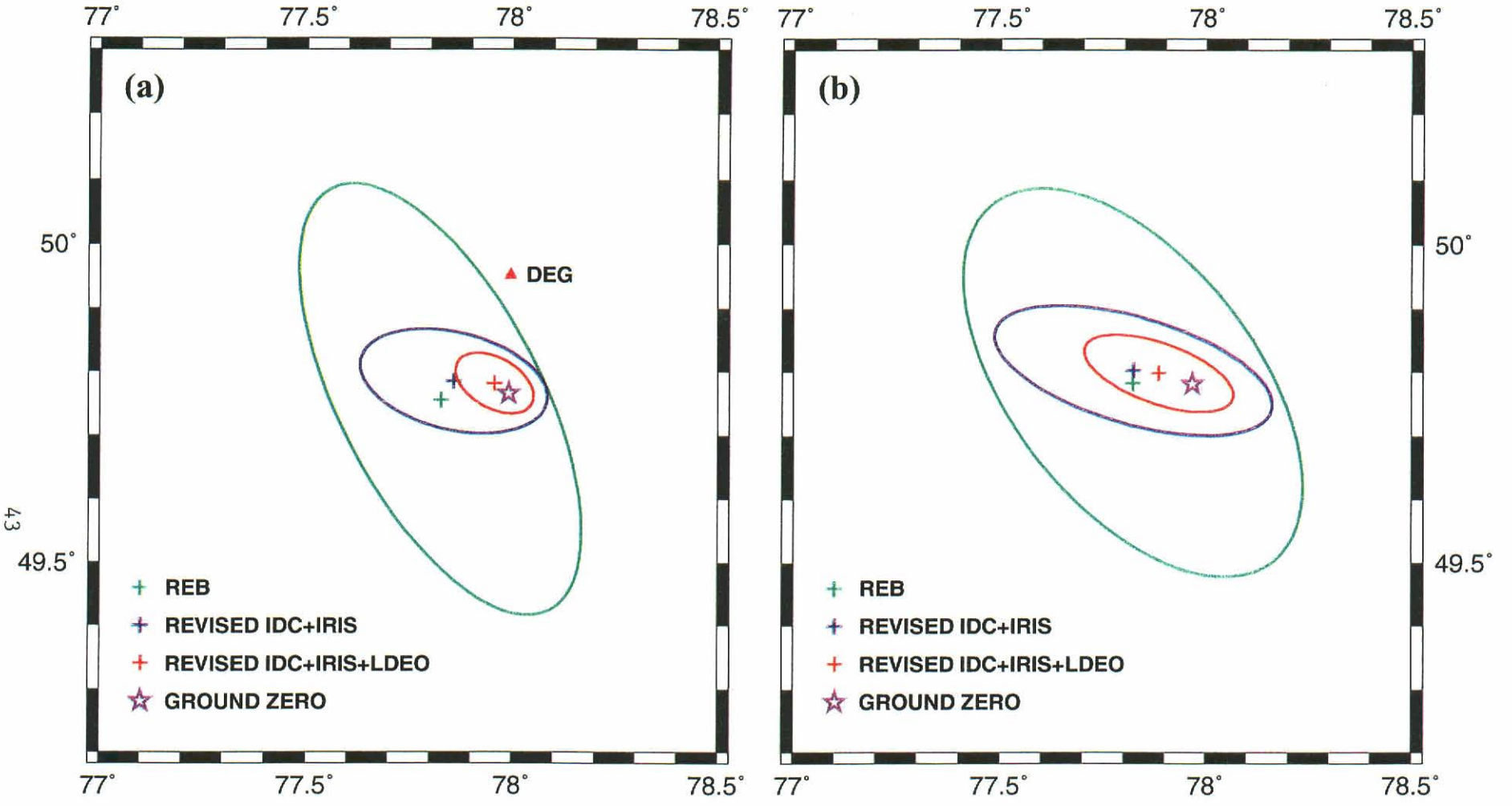

Figure 34. Epicentral locations with error ellipses for (a) 22 August 1998 (Omega-1) and (b) 25 September 1999 (Omega-2). For both shots, epicentral locations based on the use of additional data from IRIS and LDEO are significantly better than the original REB locations.

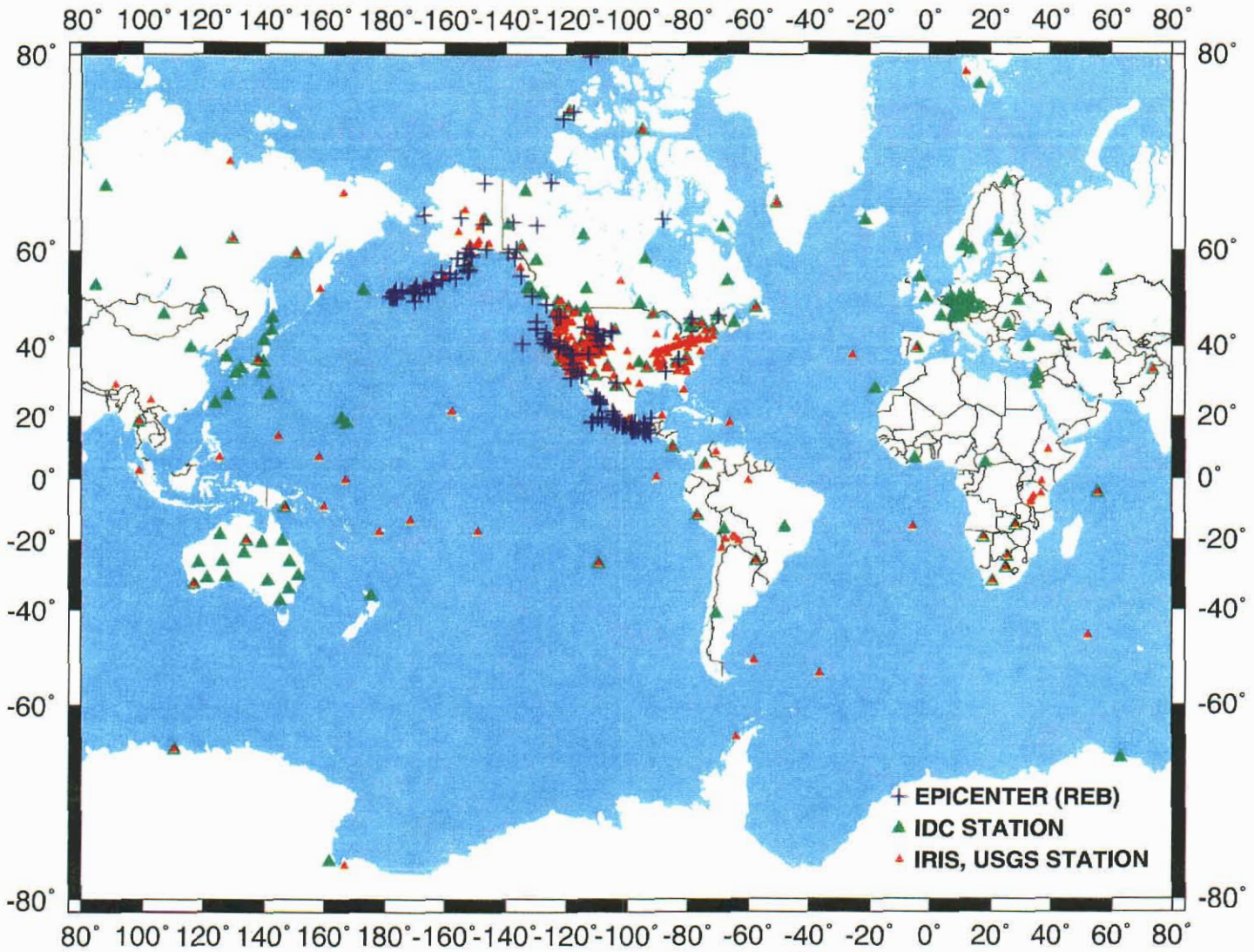

Figure 35. REB epicentral locations of 163 CEB events in North America and the 150 IDC and 348 IRIS and USGS recording stations which provided waveform data analyzed in this project. Note the large number of IRIS and USGS stations at regional distances for most of the North America events.

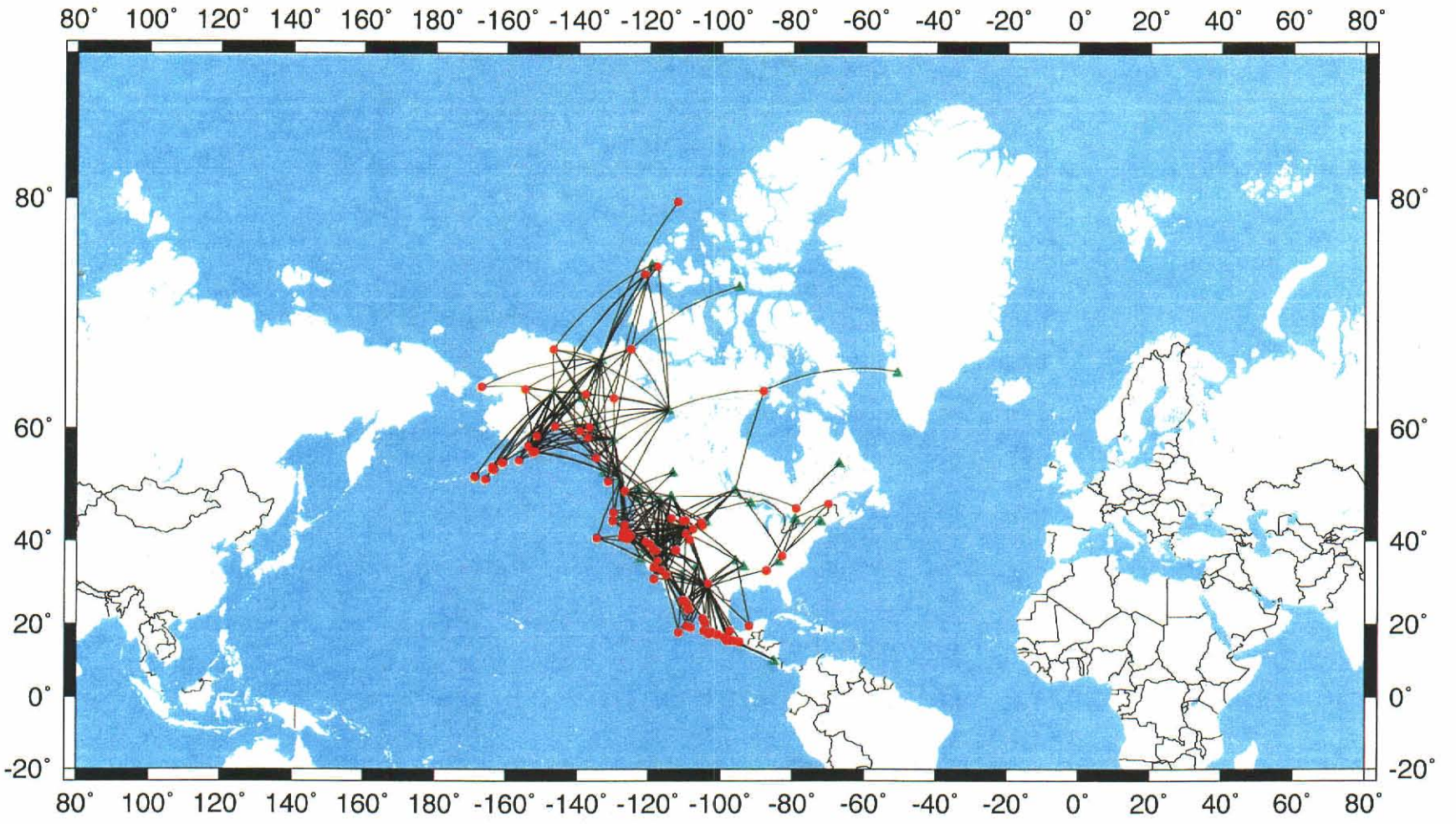

Figure 36. Pn phases with corresponding propagation paths available in the original REB dataset showing 102 events in North America with 356 paths. The red circles and green triangles denote epicenters and recording stations, respectively.

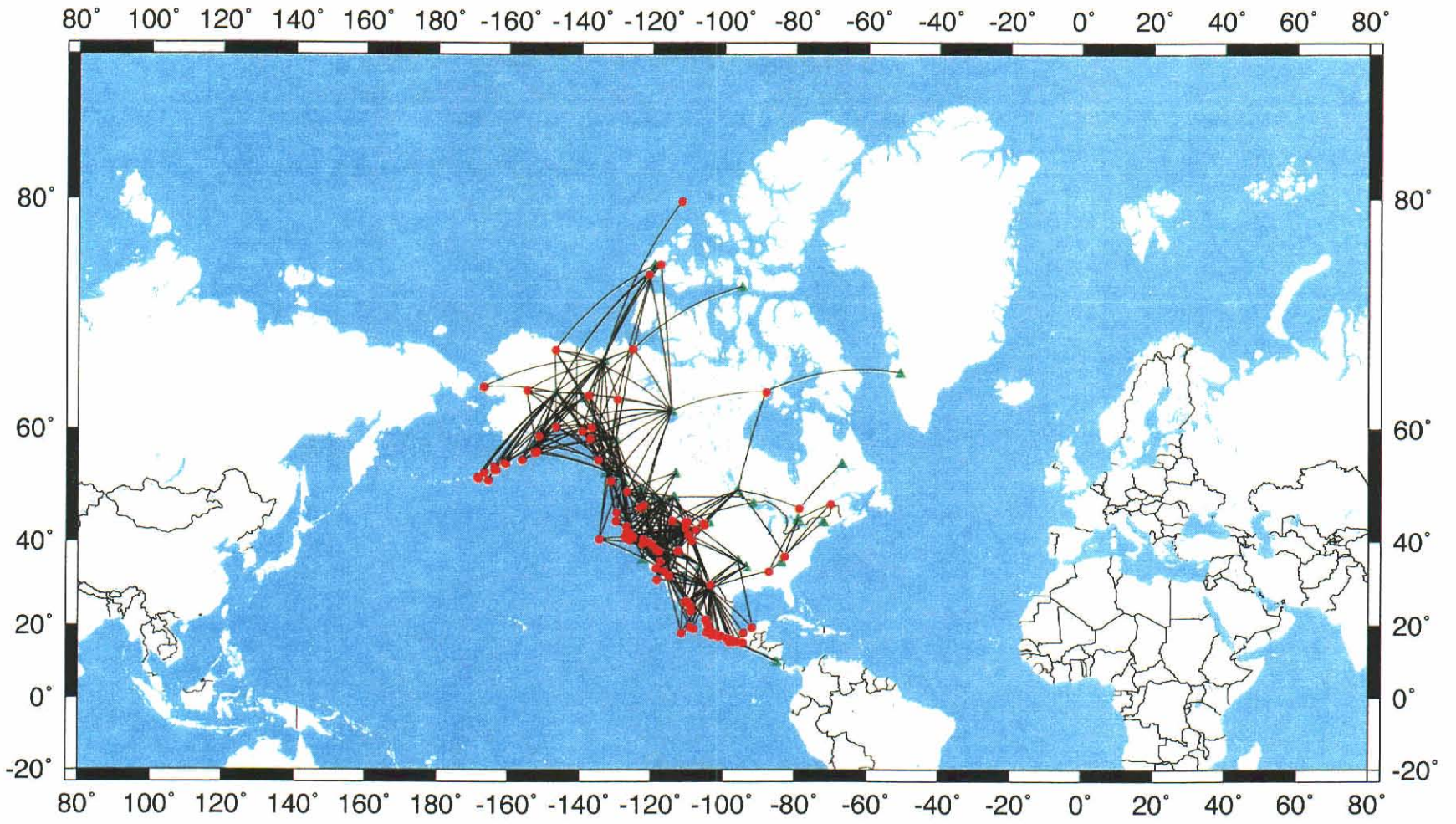

Figure 37. Pn phases with corresponding propagation paths available in the revised IDC dataset showing 113 events in North America with 420 paths. The red circles and green triangles denote epicenters and recording stations, respectively.

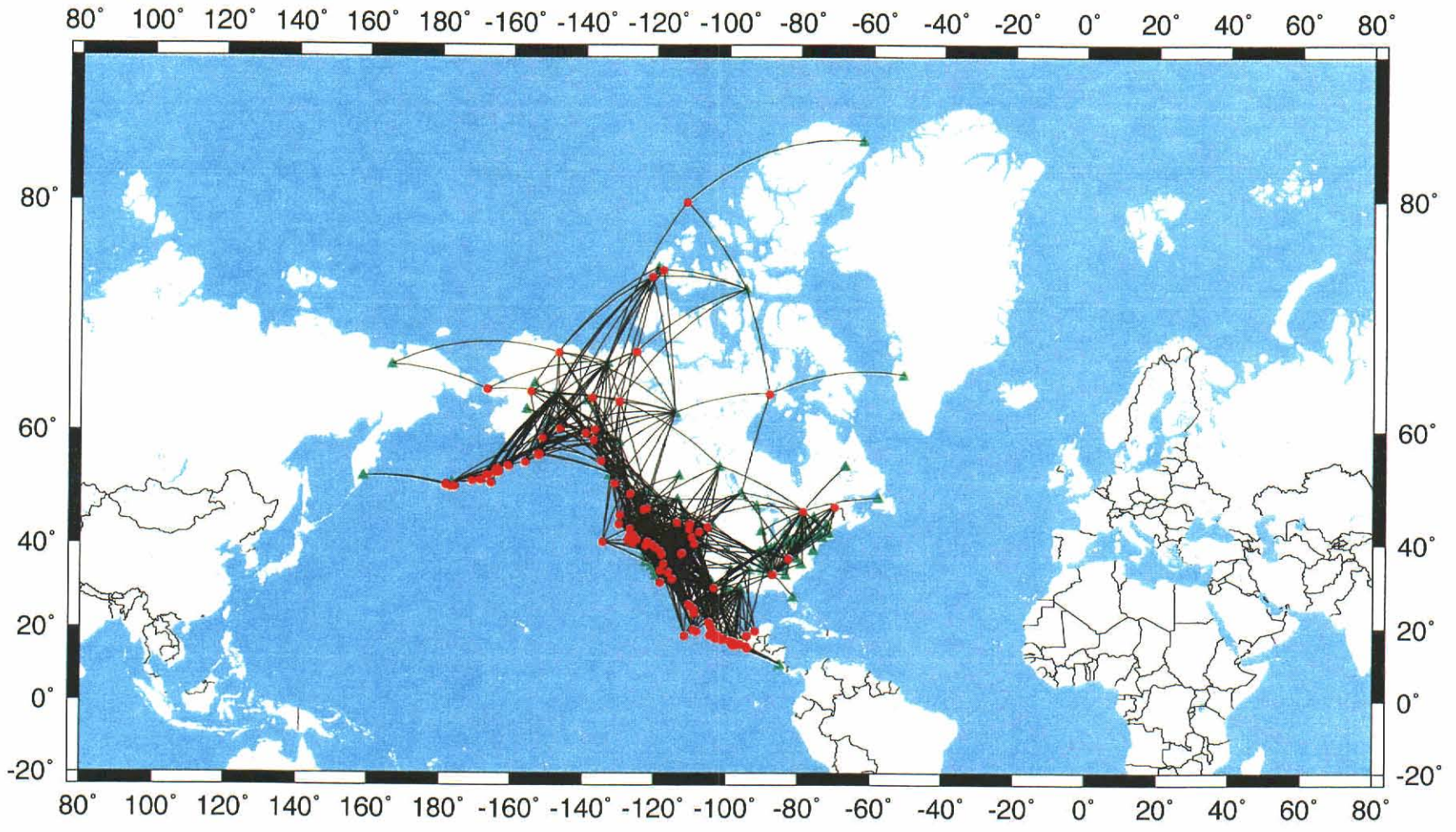

Figure 38. Pn phases with corresponding propagation paths available in the IRIS, USGS, and revised IDC dataset showing 124 events in North America with 1328 paths. The red circles and green triangles denote epicenters and recording stations, respectively. Note that the IRIS data provide a large number of additional Pn arrivals.

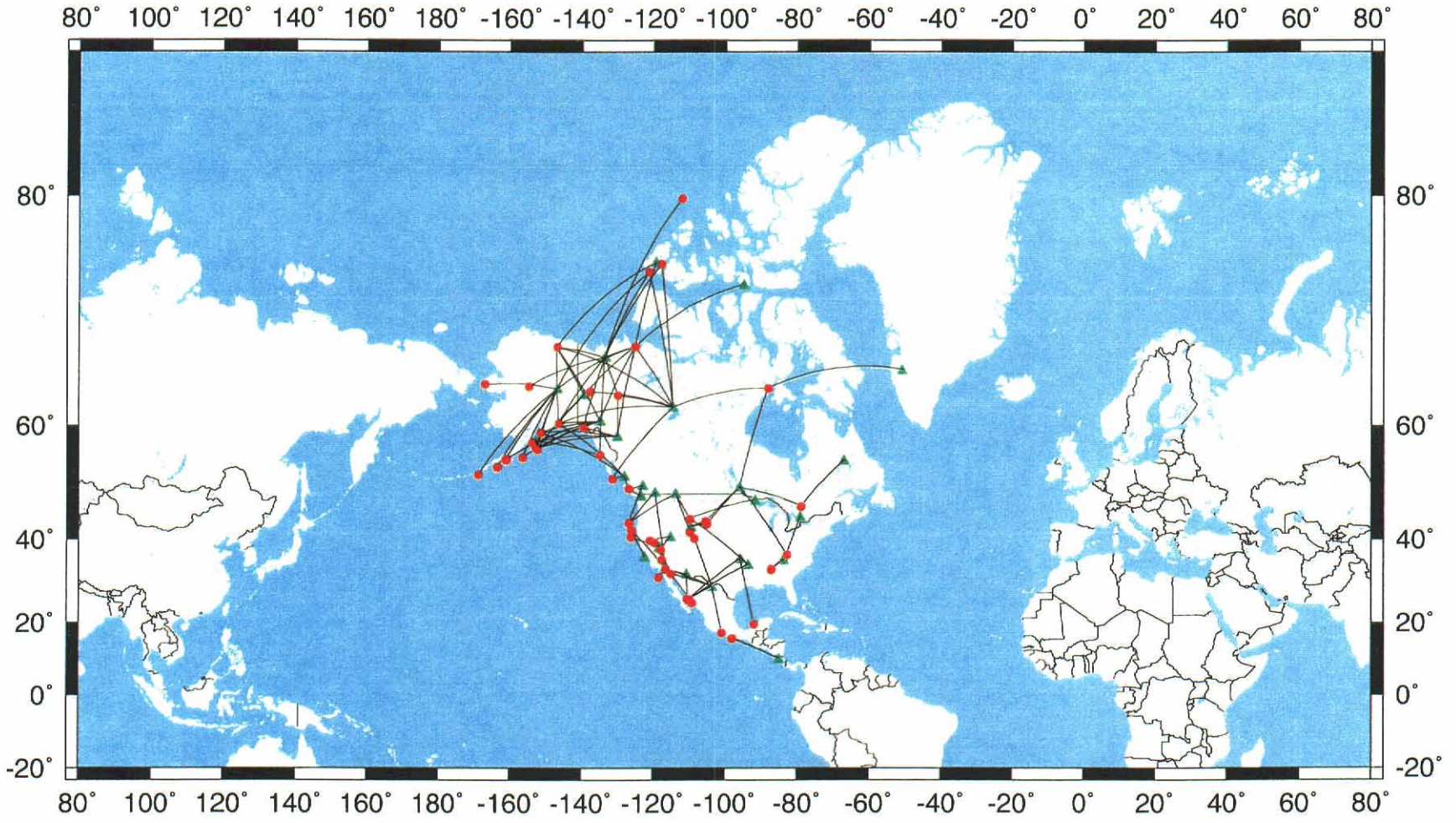

Figure 39. Sn phases with corresponding propagation paths available in the original REB dataset showing 55 events in North America with 105 paths. The red circles and green triangles denote epicenters and recording stations, respectively.

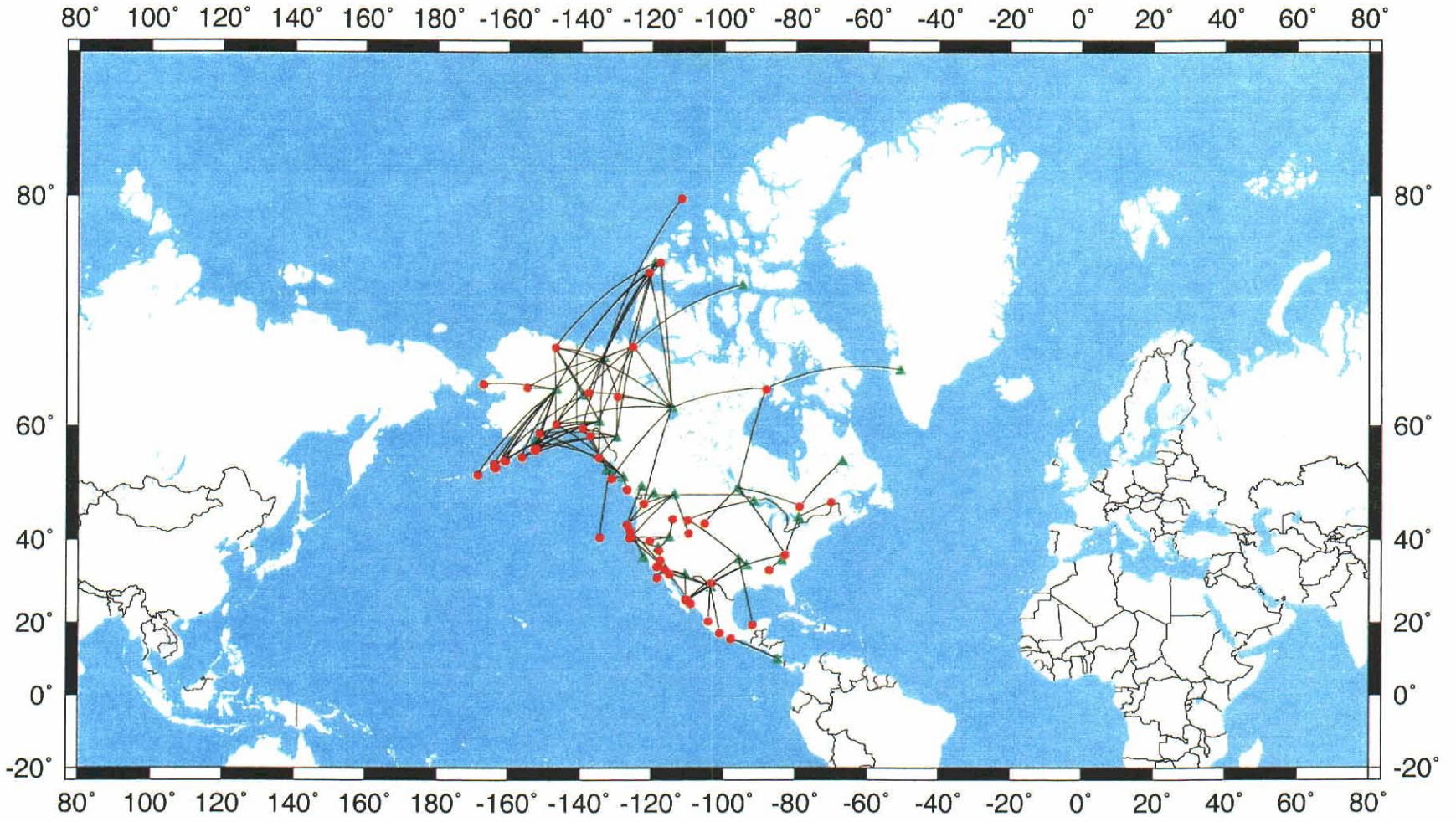

Figure 40. Sn phases with corresponding propagation paths available in the revised IDC dataset showing 60 events in North America with 117 paths. The red circles and green triangles denote epicenters and recording stations, respectively.

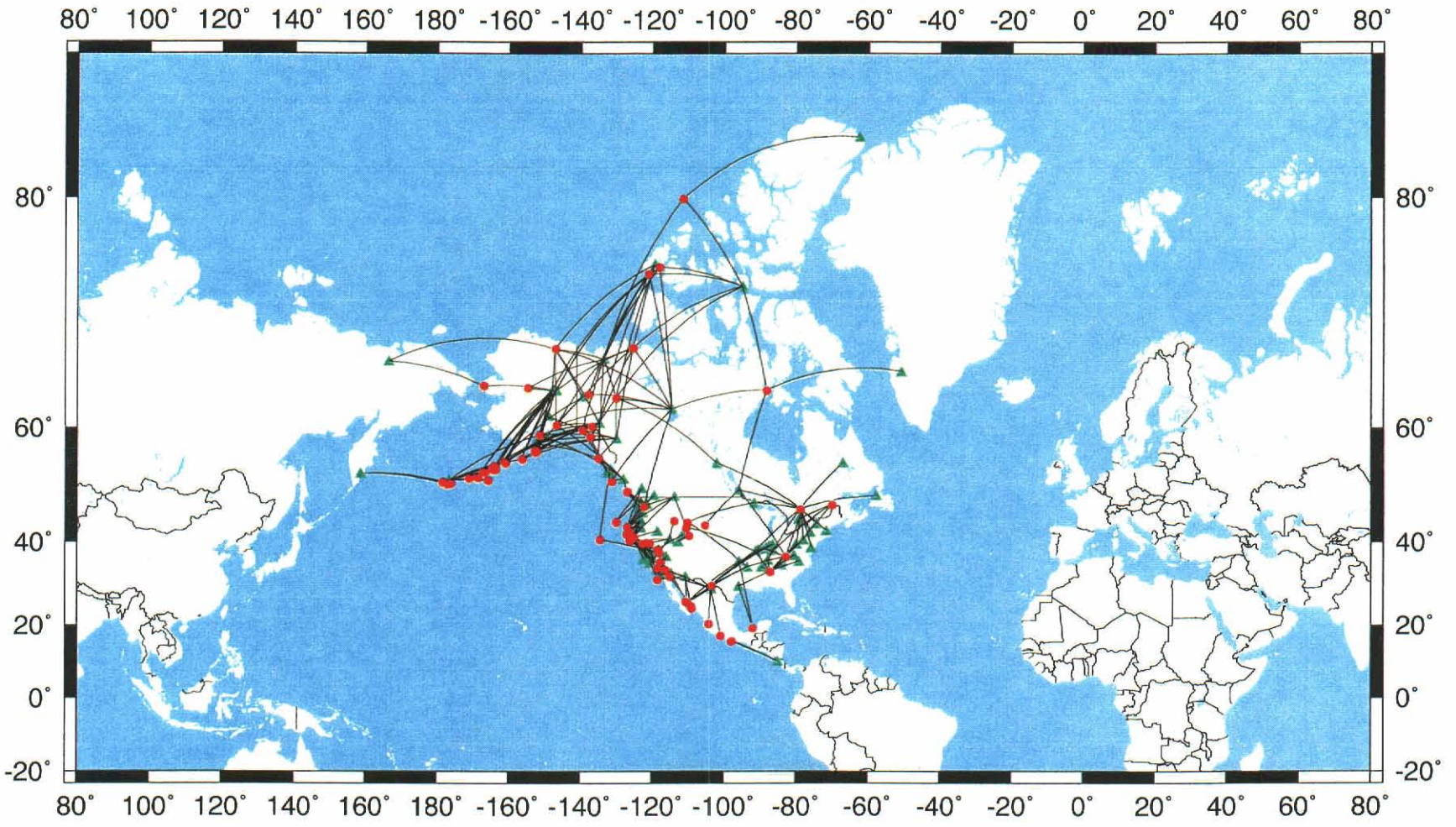

Figure 41. Sn phases with corresponding propagation paths available in the IRIS, USGS, and revised IDC dataset showing 80 events in North America with 249 paths. The red circles and green triangles denote epicenters and recording stations, respectively. Note that the IRIS data provide a large number of additional Sn arrivals.

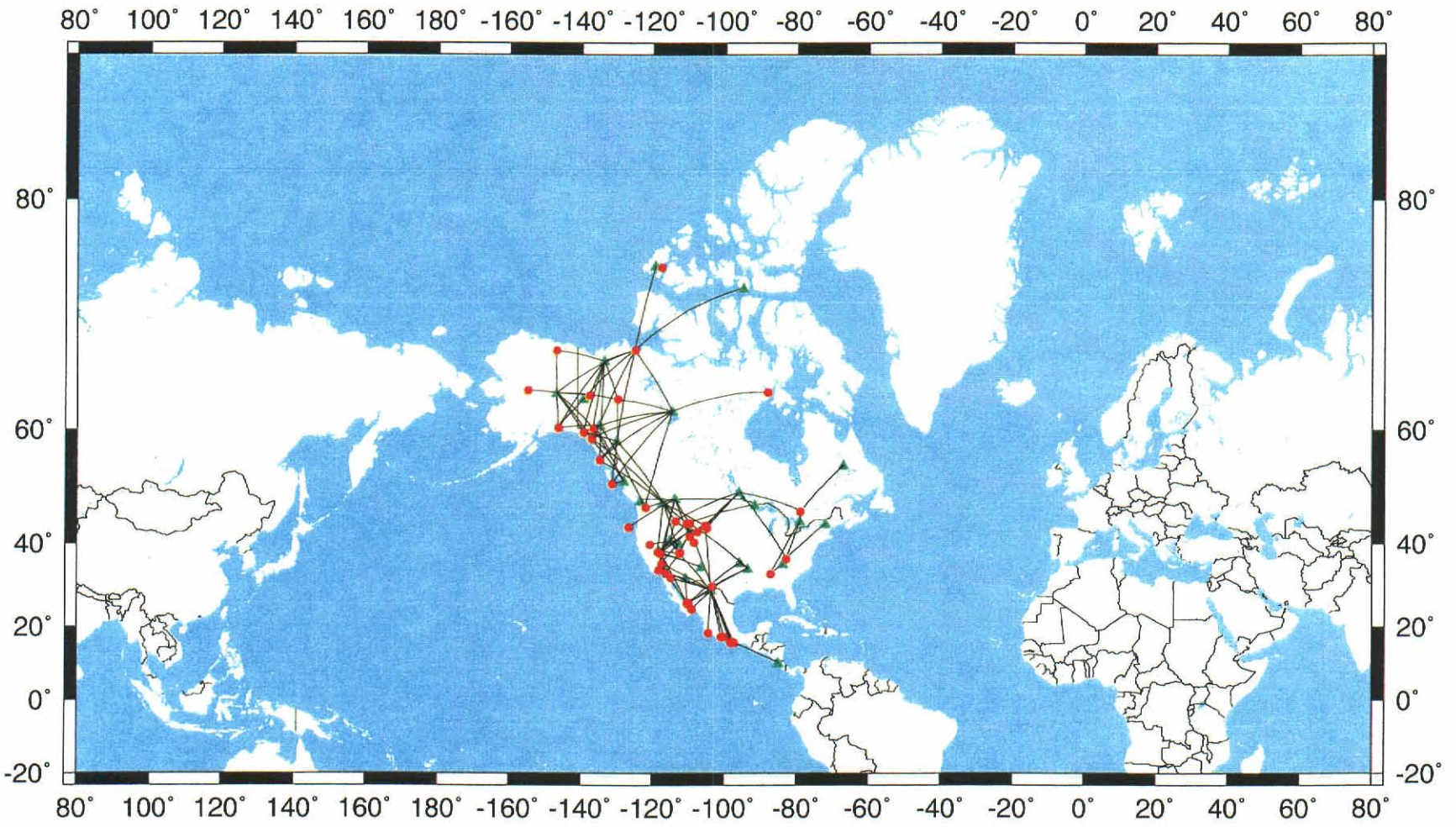

Figure 42. Lg phases with corresponding propagation paths available in the original REB dataset showing 53 events in North America with 134 paths. The red circles and green triangles denote epicenters and recording stations, respectively.

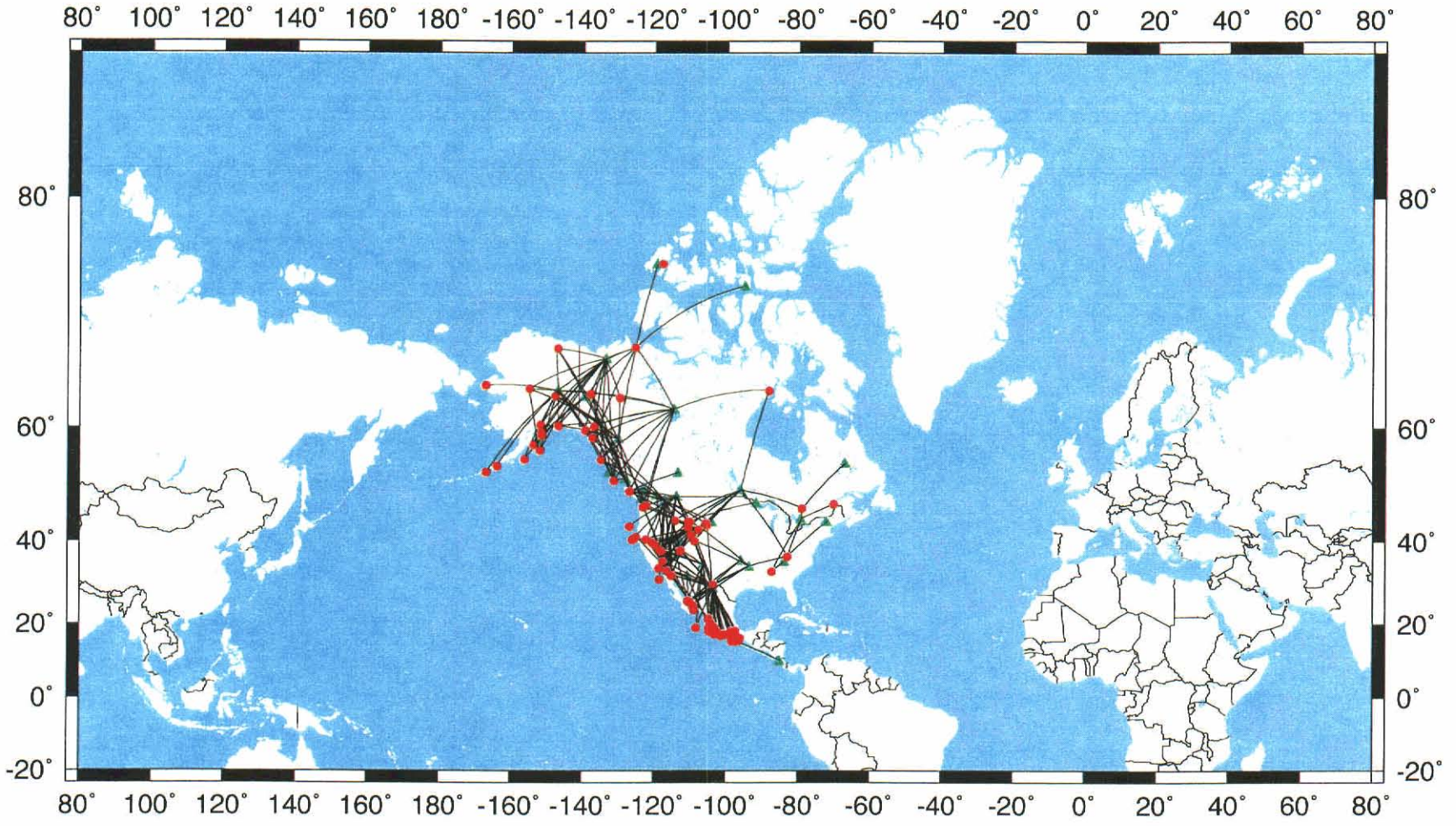

Figure 43. Lg phases with corresponding propagation paths available in the revised IDC dataset showing 98 events in North America with 281 paths. The red circles and green triangles denote epicenters and recording stations, respectively.

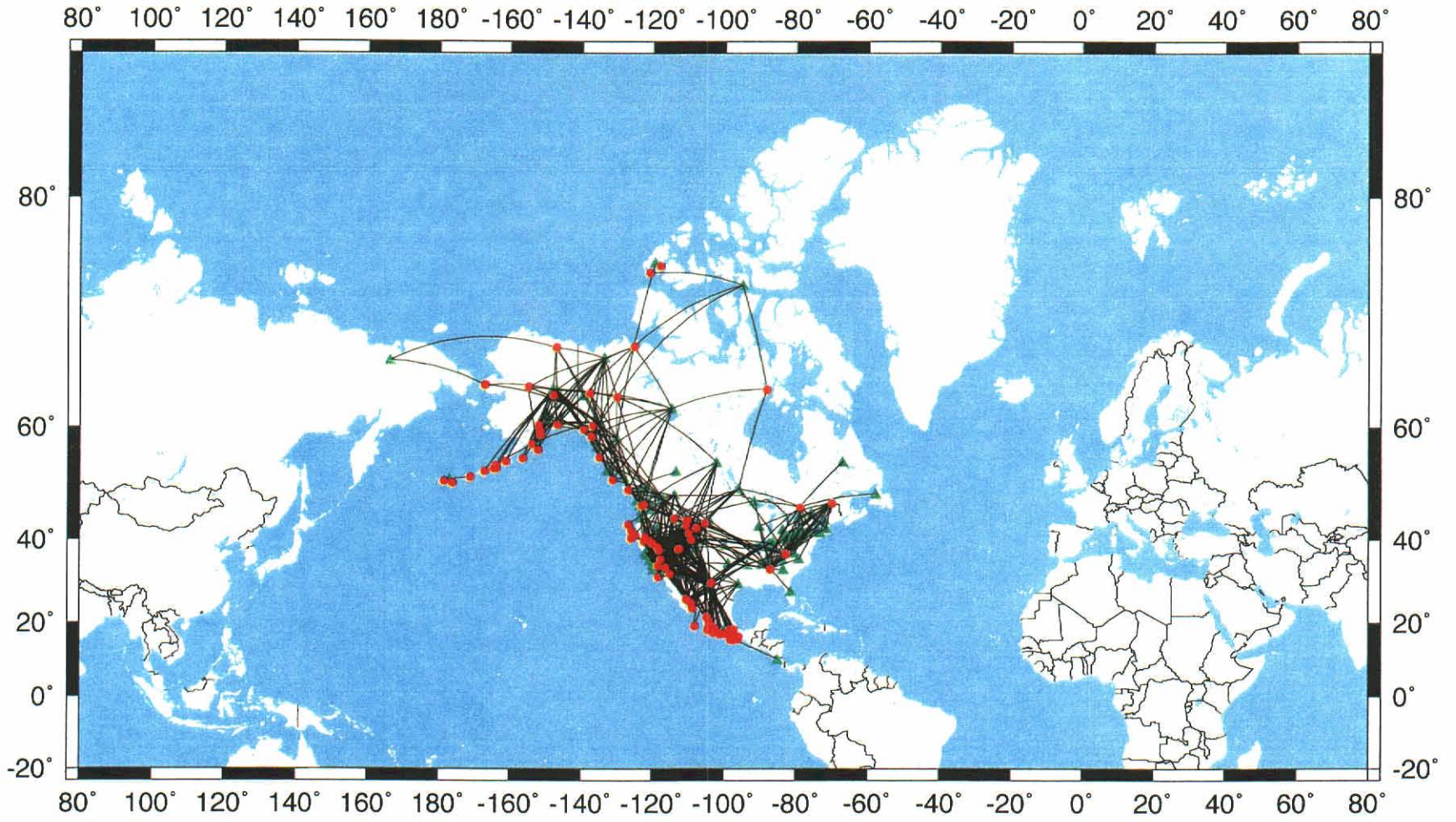

Figure 44. Lg phases with corresponding propagation paths available in the IRIS, USGS, and revised IDC dataset showing 109 events in North America with 846 paths. The red circles and green triangles denote epicenters and recording stations, respectively. Note that the IRIS data provide a large number of additional Lg arrivals.

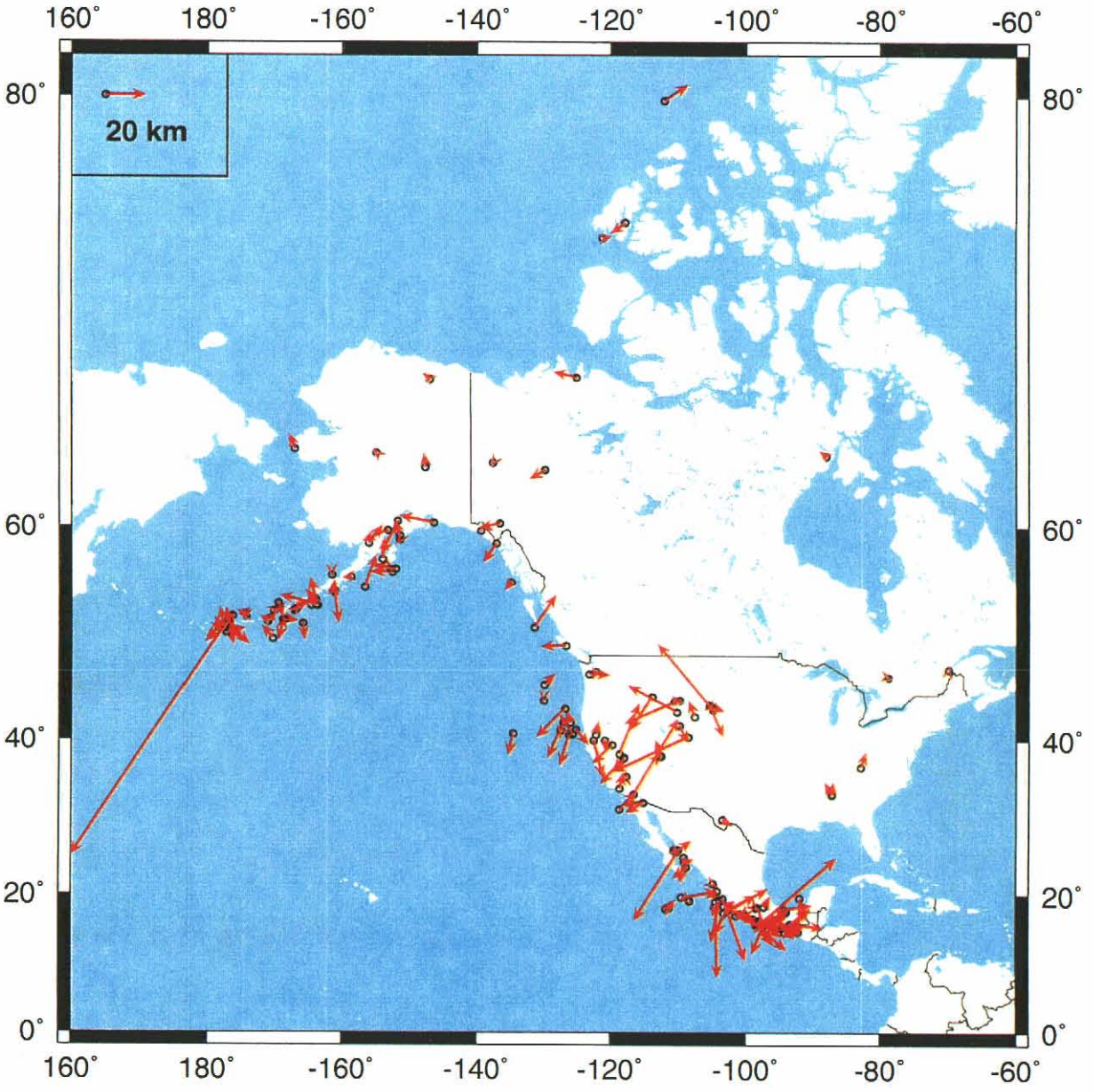

Figure 45. Differences in epicentral location between the original REB (denoted by black circles) and those derived by the combined use of both IRIS and revised IDC for all 163 North America events. Arrows point towards the new locations and the average difference between the two locations is 11.7 km.

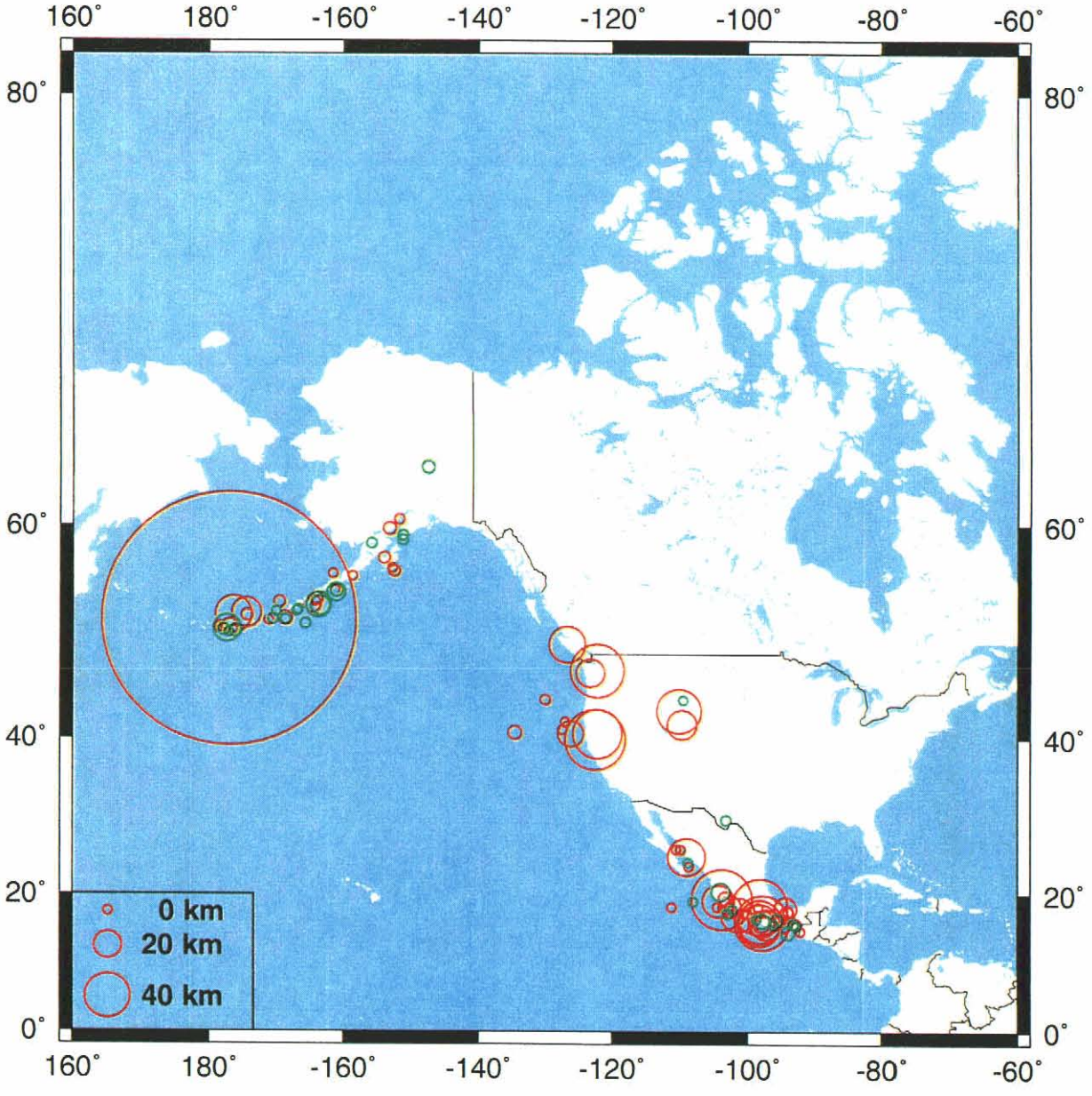

Figure 46. Differences in estimates of source depth between the original REB and the combined IRIS, USGS, and revised IDC data for 102 North America events with non-zero depths (REB averages about 10 km deeper). The red circles denote new depths shallower than those in the REB and the green circles the opposite.

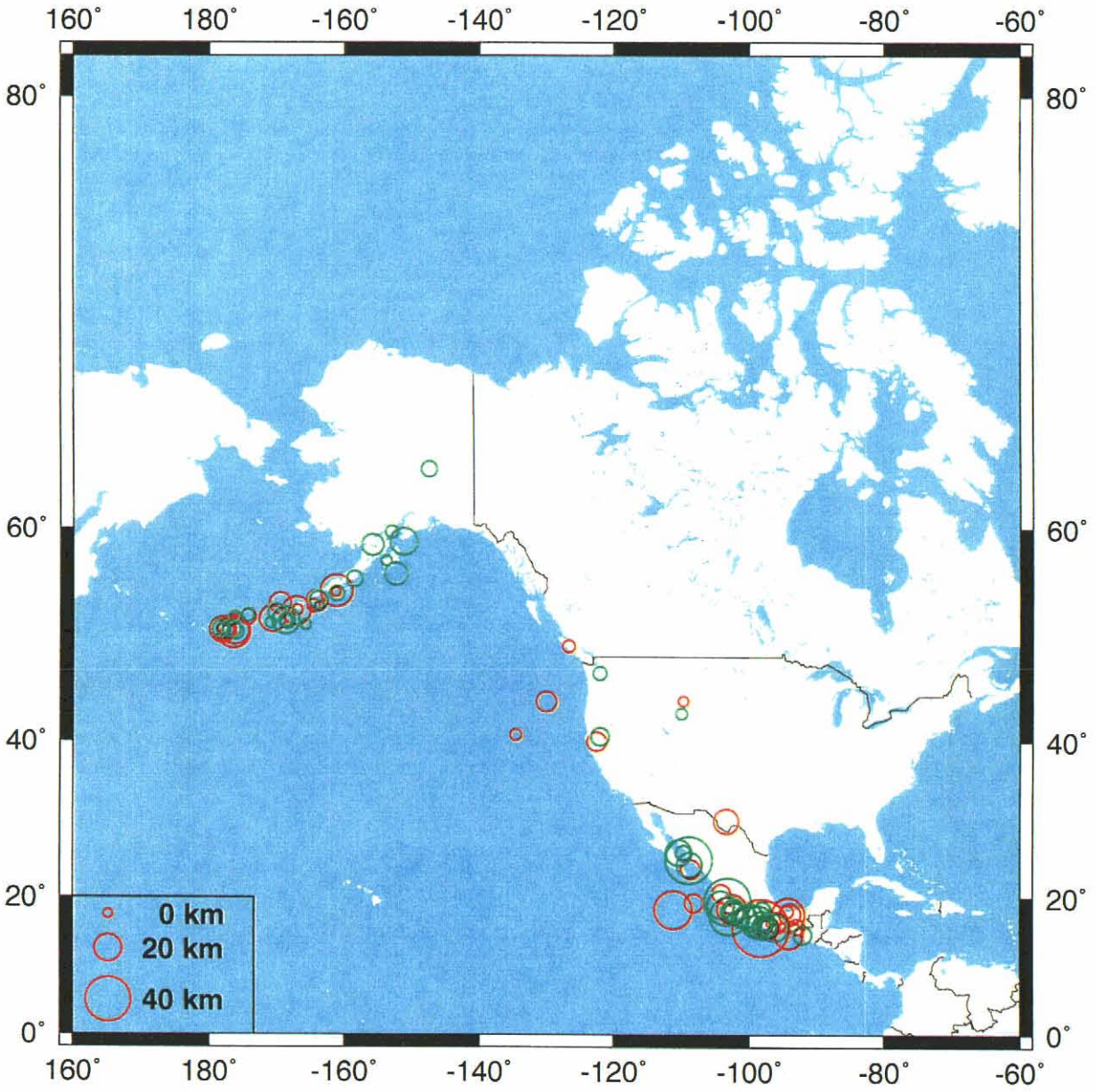

Figure 47. Differences in estimates of source depth between the ISC Bulletin and the combined IRIS, USGS and revised IDC data for 85 common events in North America with non-zero depths (average difference only about 1 km). The red circles denote ISC depths shallower than the new depths and the green circles the opposite. The two estimates of source depth are not significantly different.

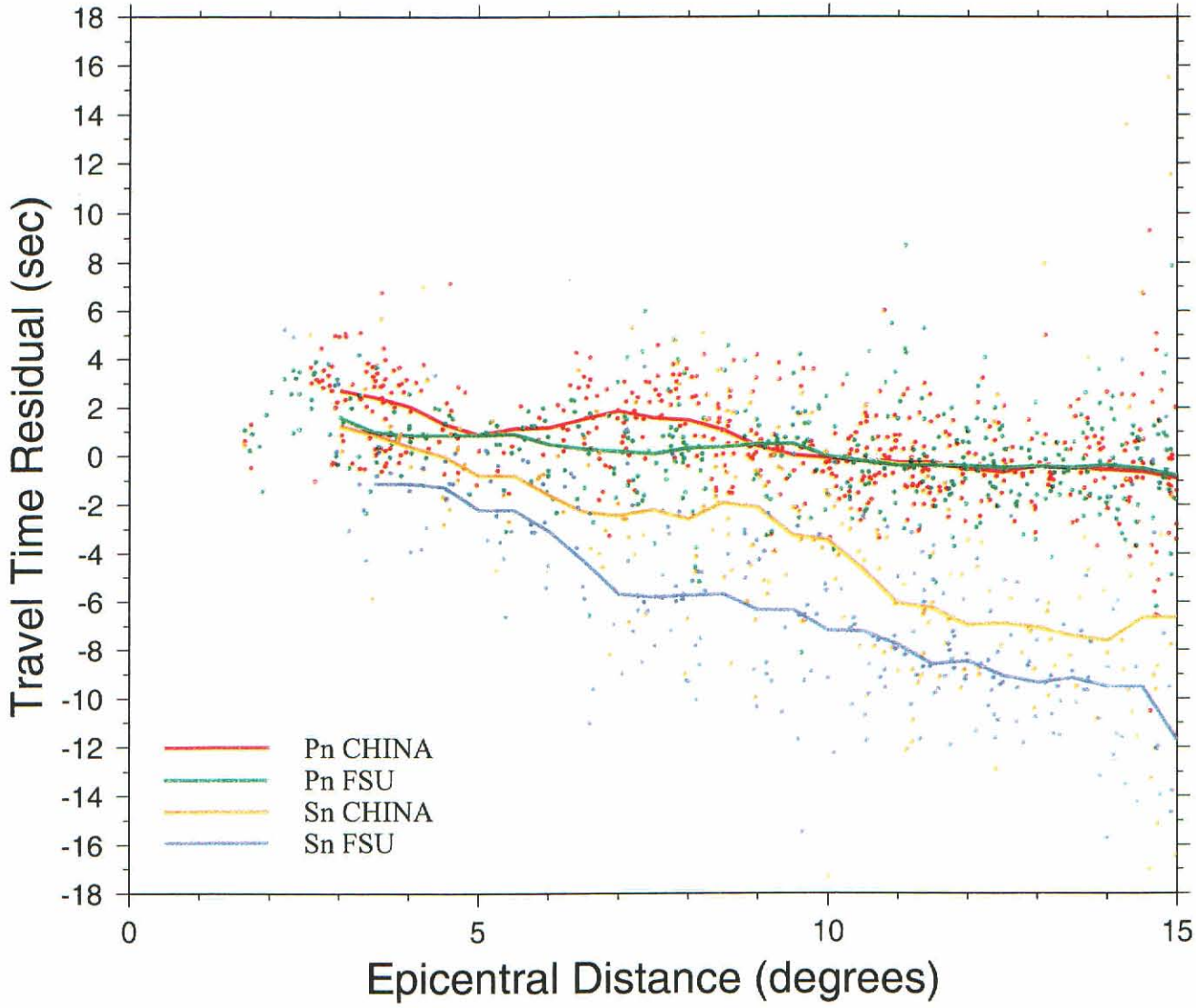

Figure 48. Comparison of travel time residuals for Pn and Sn in China and FSU for the IRIS and revised IDC dataset showing both data points and moving medians. For distances up to 10 degrees, the residuals indicate that both Pn and Sn arrive relatively later for events in China than those in FSU; a possible reason is a relatively deeper Moho under China.

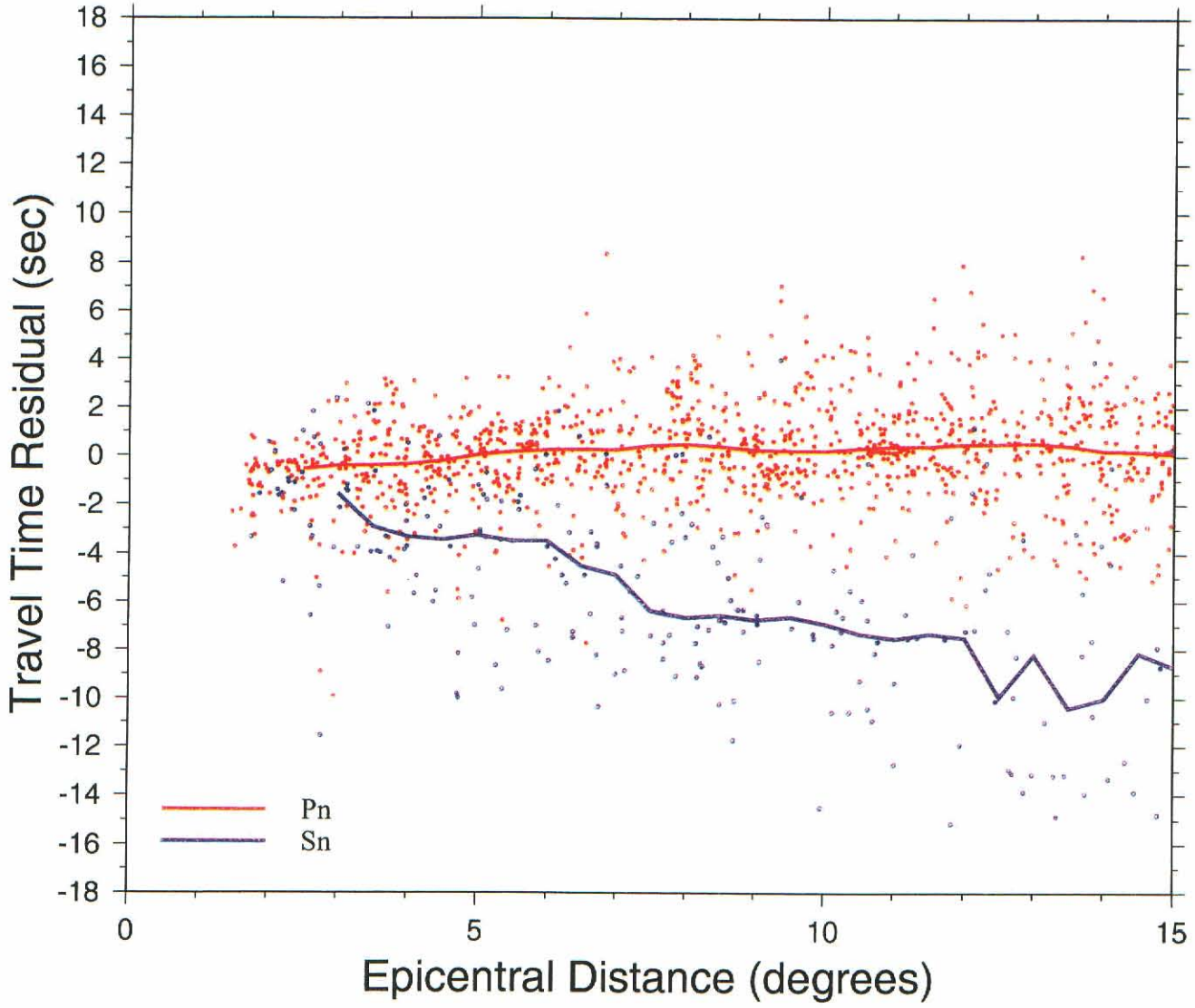

Figure 49. Comparison of travel time residuals for Pn and Sn in North America, similar to that in Figure 48. Note that the moving median for Pn is relatively flat and that for Sn shows residuals similar to that for FSU in Figure 48.

TABLE 1

LIST OF 70 CEB EVENTS IN CHINA: REB LOCATIONS

DATE	ORIGIN TIME	LAT	LON	DEPTH	ORID	EVID	MB
10 Jan 1995	10:09:54.343	20.3163	109.2339	56.6	276881	275620	4.64
17 Feb 1995	02:44:27.062	27.5411	92.3461	40.1	304019	303144	4.52
25 Feb 1995	03:15:06.113	24.3077	118.6216	0.0	307738	306918	4.61
15 May 1995	04:05:59.618	41.6305	88.8701	0.0	352042	350334	5.73
03 Jul 1995	00:59:49.507	27.2459	92.3268	32.8	379569	378978	4.14
09 Jul 1995	15:56:24.677	36.0902	100.3254	0.0	383246	382182	4.75
10 Jul 1995	22:43:15.756	22.0081	99.1679	0.0	383769	382548	4.64
11 Jul 1995	21:46:38.348	21.8935	99.0820	0.0	383777	383055	5.64
21 Jul 1995	22:44:08.337	36.4427	103.2556	29.2	387925	387492	5.12
17 Aug 1995	00:59:59.308	41.5965	88.8575	0.0	406350	403735	5.54
26 Nov 1995	20:21:27.041	31.7633	78.4404	0.0	475064	472903	4.11
18 Dec 1995	04:57:07.860	34.5557	97.4088	42.9	515202	514553	4.64
04 Jan 1996	03:49:31.615	38.7667	104.6518	51.6	530619	529667	4.21
09 Jan 1996	06:27:55.672	43.6830	85.7223	33.9	534001	534001	4.84
23 Jan 1996	17:34:37.152	30.2887	79.2882	0.0	554670	554351	4.11
26 Jan 1996	02:21:14.308	30.7380	91.4233	45.6	555727	555479	4.65
03 Feb 1996	11:14:26.427	27.3177	100.3635	48.7	566407	564713	5.62
03 Feb 1996	11:39:47.839	27.2905	100.5335	30.3	566291	564740	4.43
04 Feb 1996	16:58:13.512	26.9947	100.4081	55.7	567238	565729	4.99
28 Feb 1996	11:22:06.708	29.0126	104.7059	64.1	584507	583851	4.51
05 Mar 1996	14:47:57.068	35.6605	78.4904	65.8	592003	590641	4.66
12 Mar 1996	18:43:40.803	48.4846	88.3905	0.0	599755	598150	5.17
12 Mar 1996	21:20:16.855	29.9385	88.2089	11.2	599867	598221	4.49
20 Mar 1996	00:14:54.413	40.0909	76.8001	18.7	608174	606343	4.40
26 Mar 1996	08:30:26.752	30.5760	79.1289	43.4	616091	614428	4.19
26 Apr 1996	16:30:59.510	27.8532	87.8415	25.0	653200	651766	4.53
03 May 1996	03:32:50.377	40.7569	109.7361	38.1	663084	659804	4.80
04 May 1996	07:01:34.281	44.6276	112.4446	19.9	663872	661437	4.08
11 May 1996	03:58:47.095	29.9851	88.1732	0.0	672119	669306	4.65
01 Jun 1996	12:49:16.666	37.3145	102.8754	32.4	690994	690136	4.54
08 Jun 1996	02:55:59.433	41.6455	88.7641	0.0	699783	697194	5.69
09 Jun 1996	23:25:20.453	28.3734	92.2996	86.1	702741	699010	4.76

02 Jul 1996	07:05:11.167	26.7860	99.9863	63.8	733691	731903	4.55
17 Jul 1996	10:35:08.324	42.0031	120.4758	0.0	745228	743475	4.36
29 Jul 1996	01:48:59.142	41.6921	88.3534	0.0	754997	754119	4.71
24 Sep 1996	19:24:52.113	27.2462	100.4925	43.8	811635	809677	4.83
09 Nov 1996	13:56:04.647	31.7859	123.1471	0.0	857609	854412	4.88
19 Nov 1996	10:44:47.991	35.2246	78.2076	46.6	865344	863497	5.30
19 Nov 1996	16:19:15.272	35.2339	77.9424	69.4	864594	863865	4.43
20 Nov 1996	18:09:21.755	39.6109	96.7241	42.0	865702	864612	4.62
30 Nov 1996	14:06:02.266	45.1764	82.8139	71.5	875158	873076	4.28
15 Dec 1996	21:36:33.665	40.3444	116.6959	0.0	887733	885927	4.12
06 Jan 1997	14:03:53.772	36.9848	97.9573	68.9	907200	904503	4.35
21 Jan 1997	01:47:20.553	39.4882	76.8971	64.5	923649	922216	4.25
06 Feb 1997	03:00:10.374	38.1006	74.4536	162.9	949125	945169	4.37
01 Mar 1997	06:04:21.681	39.3493	76.7843	77.5	968525	965503	4.47
10 Mar 1997	17:55:11.617	27.3027	92.4513	0.0	977011	974175	4.24
06 Apr 1997	04:36:39.537	39.5106	77.0129	56.9	1001036	997993	5.04
06 Apr 1997	12:58:22.915	39.5486	76.9252	58.8	1001135	998281	4.55
11 Apr 1997	05:34:51.097	39.4737	76.9594	78.7	1006220	1003036	5.06
15 Apr 1997	18:19:15.502	39.5761	76.9969	59.5	1009914	1007469	4.96
15 May 1997	03:58:36.426	34.1790	89.8764	54.5	1039614	1036902	4.27
16 May 1997	11:18:11.771	30.2738	97.0137	53.8	1040345	1038332	4.67
17 May 1997	03:58:23.145	39.4137	76.9254	20.2	1042116	1038515	4.47
24 May 1997	17:09:02.751	31.4699	104.2194	53.7	1048355	1046245	4.09
27 May 1997	01:56:26.344	42.4992	86.1857	22.7	1049564	1047878	4.34
04 Jun 1997	12:16:30.396	43.0092	84.0967	34.6	1056617	1055510	4.04
14 Jun 1997	04:04:53.434	36.5478	75.8097	91.2	1064163	1062374	4.11
06 Jul 1997	01:51:48.906	42.8881	131.5257	547.5	1080308	1078056	4.15
13 Aug 1997	08:13:35.122	29.4538	105.6475	35.4	1107897	1106686	4.22
18 Sep 1997	06:31:58.502	38.1988	121.3178	0.0	1136116	1134766	4.17
15 Oct 1997	20:30:52.180	35.6548	80.7466	0.0	1162918	1162030	4.36
21 Oct 1997	06:32:36.538	41.1395	107.4419	23.9	1167759	1166500	4.53
10 Jan 1998	03:50:40.677	41.1369	114.5229	16.7	1259721	1255985	5.28
02 Jun 1998	01:32:06.737	41.0666	114.4642	0.0	1475213	1454842	4.24
20 Jul 1998	01:05:57.849	30.0922	88.1782	15.5	20023426	20019984	5.21
29 Jul 1998	01:15:22.134	36.7697	105.5139	16.9	20031652	20030795	4.32
30 Aug 1998	03:37:46.514	29.9994	88.1521	4.7	20074218	20070787	4.59
26 Sep 1998	18:27:05.152	27.6699	92.8437	18.5	20106764	20103435	5.18
01 Dec 1998	05:35:16.188	27.9555	87.6872	76.9	20246276	20238850	4.11

TABLE 2

LIST OF 96 IRIS STATIONS USED FOR CEB EVENTS IN CHINA

STATION	LAT	LON	ELEV(KM)	LOCATION
AAE	9.0292	38.7656	2.4420	Addis Ababa, Ethiopia
AAK	42.6390	74.4940	1.6450	Ala Archa, Kyrgyzstan
ABKT	37.9304	58.1189	0.6780	Alibek, Turkmenistan
AKT	50.4348	58.0167	0.3600	Aktyubinsk, Kazakhstan
AML	42.1311	73.6941	3.4000	Almayashu, Kyrgyzstan
ANTO	39.8689	32.7936	0.8830	Ankara, Turkey
ARU	56.4302	58.5625	0.2500	Arti, Russia
BATO	-19.6260	-65.4365	3.3530	Bolivia
BDFB	-15.6418	-48.0148	1.0950	Brasilia, Brazil
BGIO	31.7219	35.0877	0.7520	Bar Giyyora, Israel
BILL	68.0651	166.4524	0.2990	Bilibino, Russia
BJT	40.0183	116.1679	0.1370	Baijiatuan, Beijing, China
BOCO	4.5869	-74.0432	3.1370	Bogota, Colombia
BRVK	53.0581	70.2828	0.3300	Borovoye, Kazakhstan
CHK	53.6762	70.6152	0.2400	Chkalovo, Kazakhstan
CHM	42.9986	74.7513	0.6550	Chumysh, Kazakhstan
CHTO	18.7900	98.9769	0.3160	Chiang Mai, Thailand
COL	64.9000	-147.7933	0.3200	College Outpost, Alaska, USA
COLA	64.8738	-147.8511	0.0740	College Outpost, Alaska, USA
CRUZ	-19.1034	-66.2212	4.2670	Bolivia
CTAO	-20.0882	146.2545	0.3570	Charters Towers, Australia
DAV	7.0878	125.5747	0.0850	Davao, Philippines
DOOR	-19.3538	-67.2233	3.7490	Bolivia
EFI	-51.6753	-58.0637	0.1100	Mount Kent, East Falkland Island
EKS2	42.6615	73.7772	1.3600	Erkin-Sai, Kyrgyzstan
ENH	30.2718	109.4868	0.4870	Enshi, Hubei Province, China
ERM	42.0150	143.1572	0.0400	Erimo, Hokkaido Island, Japan
FURI	8.9030	38.6883	2.5400	Mt. Furi, Ethiopia
GNI	40.0530	44.7240	1.4580	Garni, Armenia
GUMO	13.5878	144.8662	0.0140	Guam, Marianas Islands
HIA	49.2667	119.7417	0.6100	Hailar, Neimenggu Province, China
HIZO	-19.6070	-68.3258	3.6880	Chile

HNR	-9.4322	159.9471	0.0720	Honiara, Solomon Islands
HOPE	-54.2836	-36.4879	0.0200	Hope Point, South Georgia Island
HYB	17.4170	78.5530	0.5100	Hyderabad, India
INCN	37.4833	126.6333	0.4190	Inchon, Republic of Korea
ITIT	-20.2551	-63.1582	0.8230	Bolivia
JTS	10.2908	-84.9525	0.3400	Juntas de Abangares, Costa Rica
KBK	42.6564	74.9478	1.7600	Karagaibulak, Kyrgyzstan
KDAK	57.7828	-152.5834	0.1520	Kodiak Island, Alaska, USA
KEG	29.9275	31.8292	0.4600	Kottamya, Egypt
KIV	43.9553	42.6863	1.0540	Kislovodsk, Russia
KMBO	-1.1268	37.2523	1.9400	Kilima Mbogo, Kenya
KMI	25.1233	102.7400	1.9400	Kunming, Yunnan Province, China
KUR	50.7149	78.6208	0.2400	Kurchatov, Kazakhstan
KURK	50.7154	78.6202	0.1840	Kurchatov, Kazakhstan
KZA	42.0778	75.2496	3.5200	Kuzart, Kyrgyzstan
LPAZ	-16.2879	-68.1307	4.6690	La Paz, Bolivia
LSA	29.7000	91.1500	3.7740	Tibet, China
LVC	-22.6128	-68.9113	2.1650	Limon Verde, Chile
LZH	36.0867	103.8444	1.5600	Lanzhou, Gansu Province, China
MA2	59.5756	150.7700	0.3390	Magadan, Russia
MAJO	36.5425	138.2072	0.4050	Matsushiro, Japan
MAK	46.8075	81.9774	0.6000	Makanchi, Kazakhstan
MAKZ	46.8080	81.9770	0.5900	Makanchi, Kazakhstan
MDJ	44.6164	129.5919	0.2500	Mudanjiang, Heilongjiang Province, China
MSEY	-4.6737	55.4792	0.4750	Mahe Island, Seychelles
NIL	33.6500	73.2517	0.5360	Nilore, Pakistan
NNA	-11.9875	-76.8422	0.5750	Nana, Peru
NWAO	-32.9266	117.2333	0.2650	Narrogin, Australia
PACH	-19.8689	-69.4195	1.6200	Chile
PAYG	0.6741	-90.2863	0.1950	Puerto Ayora, Galapagos Islands
PET	53.0235	158.6498	0.1500	Petropavlovsk, Russia
PICH	-19.8115	-63.7210	1.6760	Bolivia
PMG	-9.4092	147.1539	0.0670	Port Moresby, Papua New Guinea
PMSA	-64.7742	-64.0490	0.0100	Palmer Station, Antarctica
PSI	2.6938	98.9237	0.9870	Prapat, Sumatera, Indonesia
PTGA	-0.7308	-59.9666	0.1370	Pitinga, Amazonas, Brazil
QIZ	19.0294	109.8433	0.2300	Qiongzhong, Guangduong Province, China
RAYN	23.5225	45.5032	0.6310	Ar Rayn, Saudi Arabia
ROSL	-19.4857	-64.1779	2.0730	Bolivia
SALI	-19.6207	-67.7263	3.7790	Bolivia
SCHO	-19.1480	-64.6428	2.5910	Bolivia

SDV	8.8790	-70.6330	1.5500	Santo Domingo, Venezuela
SEO	37.5667	126.9667	0.0860	Seoul, South Korea
SJG	18.1117	-66.1500	0.4570	San Juan, Puerto Rico
SPA	-89.9990	115.0000	2.9270	South Pole, Antarctica
SSE	31.0956	121.1867	0.0150	Sheshan, Shanghai, China
TACA	-18.8276	-66.7337	3.8100	Bolivia
TATO	24.9754	121.4881	0.0530	Taipei, Taiwan
TKM2	42.9208	75.5966	2.0200	Tokmak, Kyrgyzstan (north-east of TKM)
TLG	43.2330	77.2250	1.1200	Talgar, Kazakhstan
TLY	51.6807	103.6438	0.5790	Talaya, Russia
UCH	42.2275	74.5134	3.8500	Uchtor, Kyrgyzstan
ULHL	42.2456	76.2417	2.0400	Ulahole, Kyrgyzstan
ULN	47.8652	107.0528	1.6150	Ulaanbaatar, Mongolia
USP	43.2669	74.4997	0.7400	Uspenovka, Kazakhstan
VOS	52.7232	70.9797	0.4500	Vostochnoye, Kazakhstan
WMQ	43.8211	87.6950	0.8970	Urumqi, Xinjiang Province, China
WRAB	-19.9336	134.3600	0.3660	Tennant Creek, NT, Australia
WUS	41.1990	79.2180	1.4570	Wushi, Xinjiang Uygur, China
XAN	34.0313	108.9237	0.6300	Xi'an, China
YAK	62.0308	129.6812	0.1050	Yakutsk, Russia
YSS	46.9583	142.7610	0.0980	Yuzhno Sakhalinsk, Russia
YUNZ	-19.1582	-65.0687	2.8960	Bolivia
ZRN	52.9510	69.0043	0.4200	Zerenda, Kazakhstan

TABLE 3

LIST OF 70 CEB EVENTS IN CHINA: REVISED IDC LOCATIONS

DATE	ORIGIN TIME	LAT	LON	DEPTH	ORID	EVID
10 Jan 1995	10:09:53.546	20.3567	109.2279	51.5	1293960	275620
17 Feb 1995	02:44:26.714	27.5239	92.3897	40.3	1293915	303144
25 Feb 1995	03:15:06.485	24.4513	118.6270	0.0	1293913	306918
15 May 1995	04:05:59.698	41.6483	88.8752	0.0	1293947	350334
03 Jul 1995	00:59:44.502	27.2444	92.3161	0.0	1293959	378978
09 Jul 1995	15:56:24.616	35.9842	100.2334	0.0	1293957	382182
10 Jul 1995	22:43:19.409	21.9659	99.0742	22.8	1293949	382548
11 Jul 1995	21:46:38.281	21.8757	99.1418	0.0	1293951	383055
21 Jul 1995	22:44:08.986	36.4490	103.2746	32.9	1293953	387492
17 Aug 1995	00:59:59.517	41.5832	88.8507	0.0	1294115	403735
26 Nov 1995	20:21:29.354	31.8547	78.4291	14.8	1293943	472903
18 Dec 1995	04:57:07.247	34.5760	97.3626	37.2	1293941	514553
04 Jan 1996	03:49:30.143	38.7437	104.6245	36.3	1293939	529667
09 Jan 1996	06:27:55.841	43.7310	85.7256	33.2	1293937	534001
23 Jan 1996	17:34:41.491	30.3488	79.3457	27.9	1293935	554351
26 Jan 1996	02:21:10.112	30.7967	91.4891	12.2	1293925	555479
03 Feb 1996	11:14:25.740	27.3340	100.3193	41.2	1293921	564713
03 Feb 1996	11:39:49.726	27.2405	100.5088	44.8	1293923	564740
04 Feb 1996	16:58:13.217	26.9934	100.4051	53.1	1293919	565729
28 Feb 1996	11:22:05.670	29.0345	104.7500	53.9	1294116	583851
05 Mar 1996	14:47:53.348	35.7213	78.5667	31.1	1293911	590641
12 Mar 1996	18:43:42.920	48.5220	88.2158	11.2	1293909	598150
12 Mar 1996	21:20:16.889	29.9774	88.1841	11.0	1293903	598221
20 Mar 1996	00:14:54.052	40.0554	76.7589	19.0	1293907	606343
26 Mar 1996	08:30:23.040	30.5543	79.1197	17.5	1293905	614428
26 Apr 1996	16:31:03.850	27.8777	87.9022	60.7	1293898	651766
03 May 1996	03:32:49.120	40.7119	109.7468	30.1	1294000	659804
04 May 1996	07:01:34.446	44.6358	112.5558	21.8	1294002	661437
11 May 1996	03:58:51.216	29.9817	88.1702	25.5	1293901	669306
01 Jun 1996	12:49:15.931	37.3556	102.8684	25.5	1293990	690136
08 Jun 1996	02:55:59.477	41.6523	88.7802	0.0	1293970	697194
09 Jun 1996	23:25:20.454	28.4242	92.3724	84.9	1293992	699010

02 Jul 1996	07:05:06.524	26.8434	100.1474	25.2	1293994	731903
17 Jul 1996	10:35:12.299	41.9893	120.6057	29.2	1293996	743475
29 Jul 1996	01:48:59.402	41.7579	88.3866	0.0	1293976	754119
24 Sep 1996	19:24:51.973	27.2576	100.4983	41.4	1294008	809677
09 Nov 1996	13:56:04.543	31.8625	123.3681	0.0	1293998	854412
19 Nov 1996	10:44:47.235	35.2183	78.1759	40.1	1293968	863497
19 Nov 1996	16:19:08.397	35.1871	77.9797	13.2	1293966	863865
20 Nov 1996	18:09:21.063	39.6226	96.7098	33.5	1294113	864612
30 Nov 1996	14:05:53.163	45.1110	82.8251	0.0	1293962	873076
15 Dec 1996	21:36:33.660	40.2816	116.7729	0.0	1293988	885927
06 Jan 1997	14:03:45.239	37.0840	97.9844	0.0	1294013	904503
21 Jan 1997	01:47:15.363	39.3541	76.9232	23.3	1294010	922216
06 Feb 1997	03:00:10.349	38.0871	74.4613	161.6	1293964	945169
01 Mar 1997	06:04:14.545	39.3177	76.8829	17.9	1294011	965503
10 Mar 1997	17:55:17.293	27.2712	92.5549	37.7	1294004	974175
06 Apr 1997	04:36:37.490	39.5416	77.0179	36.6	1293984	997993
06 Apr 1997	12:58:21.586	39.4841	76.9176	46.0	1293980	998281
11 Apr 1997	05:34:49.064	39.4533	76.8949	58.4	1293982	1003036
15 Apr 1997	18:19:14.967	39.5700	76.9917	52.9	1293894	1007469
15 May 1997	03:58:28.878	34.0953	89.7141	0.0	1294019	1036902
16 May 1997	11:18:08.815	30.2081	96.9675	29.1	1294025	1038332
17 May 1997	03:58:23.443	39.4760	76.8835	19.7	1294028	1038515
24 May 1997	17:09:01.599	31.5117	104.1922	43.0	1293974	1046245
27 May 1997	01:56:23.178	42.6243	86.2347	0.0	1294015	1047878
04 Jun 1997	12:16:29.999	43.1741	84.1036	26.4	1294006	1055510
14 Jun 1997	04:04:44.799	36.5402	75.8388	13.8	1293955	1062374
06 Jul 1997	01:51:50.226	42.8552	131.3535	560.6	1293899	1078056
13 Aug 1997	08:13:34.357	29.3456	105.6434	32.2	1293972	1106686
18 Sep 1997	06:31:57.009	37.9335	121.2560	0.0	1294017	1134766
15 Oct 1997	20:30:51.913	35.6447	80.7439	0.0	1293978	1162030
21 Oct 1997	06:32:36.102	41.1545	107.3035	20.5	1294023	1166500
10 Jan 1998	03:50:40.588	41.1667	114.5272	13.2	1293895	1255985
02 Jun 1998	01:32:09.135	41.0615	114.4872	16.0	1294021	1454842
20 Jul 1998	01:05:57.737	30.0767	88.1989	17.4	1293933	20019984
29 Jul 1998	01:15:21.985	36.7600	105.5356	16.9	1293931	20030795
30 Aug 1998	03:37:46.428	30.0321	88.1440	5.8	1293929	20070787
26 Sep 1998	18:27:05.020	27.6885	92.8784	18.0	1293927	20103435
01 Dec 1998	05:35:15.994	27.9604	87.6807	76.7	1294031	20238850

TABLE 4

LIST OF 70 CEB EVENTS IN CHINA: REVISED IDC + IRIS LOCATIONS

DATE	ORIGIN TIME	LAT	LON	DEPTH	ORID	EVID
10 Jan 1995	10:09:47.736	20.2613	109.0854	9.9	1293961	275620
17 Feb 1995	02:44:26.767	27.5531	92.3561	41.0	1293916	303144
25 Feb 1995	03:15:07.479	24.3029	118.6770	8.8	1293914	306918
15 May 1995	04:05:59.772	41.6527	88.9021	0.0	1293948	350334
03 Jul 1995	00:59:47.330	27.1989	92.3411	17.6	1294117	378978
09 Jul 1995	15:56:24.659	35.9944	100.2832	0.0	1293958	382182
10 Jul 1995	22:43:18.815	21.9607	99.0630	18.9	1293950	382548
11 Jul 1995	21:46:39.780	21.8334	98.9675	9.3	1293952	383055
21 Jul 1995	22:44:04.802	36.4810	103.2136	4.9	1293954	387492
17 Aug 1995	00:59:59.456	41.5838	88.8101	0.0	1293946	403735
26 Nov 1995	20:21:29.419	31.8429	78.4355	15.6	1293944	472903
18 Dec 1995	04:57:06.300	34.6050	97.3959	28.6	1293942	514553
04 Jan 1996	03:49:28.317	38.7611	104.6759	22.9	1293940	529667
09 Jan 1996	06:27:56.043	43.7990	85.6505	33.2	1293938	534001
23 Jan 1996	17:34:40.637	30.3741	79.3598	22.0	1293936	554351
26 Jan 1996	02:21:09.832	30.7247	91.5496	11.4	1293926	555479
03 Feb 1996	11:14:21.937	27.2849	100.3102	15.8	1293922	564713
03 Feb 1996	11:39:49.296	27.2190	100.4604	40.7	1294114	564740
04 Feb 1996	16:58:10.549	26.9557	100.3370	30.9	1293920	565729
28 Feb 1996	11:22:04.746	29.0108	104.6833	45.3	1293918	583851
05 Mar 1996	14:47:52.345	35.7385	78.5016	23.1	1293912	590641
12 Mar 1996	18:43:43.872	48.4962	88.2160	17.7	1293910	598150
12 Mar 1996	21:20:16.875	29.9416	88.1511	11.3	1293904	598221
20 Mar 1996	00:14:54.169	40.0621	76.7377	19.3	1293908	606343
26 Mar 1996	08:30:23.029	30.5743	79.1351	17.5	1293906	614428
26 Apr 1996	16:31:02.733	27.8561	87.9003	51.1	1293897	651766
03 May 1996	03:32:49.203	40.7235	109.6785	30.4	1294001	659804
04 May 1996	07:01:34.457	44.6315	112.4926	21.9	1294003	661437
11 May 1996	03:58:49.817	29.9625	88.1284	16.5	1293902	669306
01 Jun 1996	12:49:14.160	37.3307	102.8798	14.2	1293991	690136
08 Jun 1996	02:55:59.500	41.6640	88.7488	0.0	1293971	697194
09 Jun 1996	23:25:20.523	28.4140	92.3437	85.7	1293993	699010

02 Jul 1996	07:05:04.685	26.8259	100.1233	14.8	1293995	731903
17 Jul 1996	10:35:07.823	41.9852	120.5356	0.0	1293997	743475
29 Jul 1996	01:48:59.437	41.7681	88.3788	0.0	1293977	754119
24 Sep 1996	19:24:50.905	27.2287	100.5254	32.9	1294009	809677
09 Nov 1996	13:56:04.634	31.8800	123.3795	0.0	1293999	854412
19 Nov 1996	10:44:46.763	35.4038	78.1729	34.3	1293969	863497
19 Nov 1996	16:19:10.978	35.2821	77.9359	28.5	1293967	863865
20 Nov 1996	18:09:15.376	39.4867	96.6880	0.0	1293987	864612
30 Nov 1996	14:05:55.184	45.1801	82.8306	10.2	1293963	873076
15 Dec 1996	21:36:33.707	40.2828	116.7900	0.0	1294118	885927
06 Jan 1997	14:03:45.224	37.0825	97.9809	0.0	1294014	904503
21 Jan 1997	01:47:19.001	39.3850	76.8538	52.6	1294030	922216
06 Feb 1997	03:00:10.380	38.0939	74.4562	161.1	1293965	945169
01 Mar 1997	06:04:15.633	39.3282	76.9032	23.4	1294012	965503
10 Mar 1997	17:55:11.659	27.2376	92.5990	0.0	1294005	974175
06 Apr 1997	04:36:37.085	39.5614	77.0067	32.5	1293985	997993
06 Apr 1997	12:58:19.851	39.4975	76.9535	30.2	1293981	998281
11 Apr 1997	05:34:49.076	39.4868	76.9101	57.1	1293983	1003036
15 Apr 1997	18:19:13.194	39.5802	76.8332	34.3	1294027	1007469
15 May 1997	03:58:31.373	34.1148	89.7160	14.9	1294020	1036902
16 May 1997	11:18:09.523	30.3339	97.0733	32.8	1294026	1038332
17 May 1997	03:58:23.395	39.4648	76.8760	19.7	1294029	1038515
24 May 1997	17:08:59.590	31.5021	104.2185	27.2	1293975	1046245
27 May 1997	01:56:24.324	42.5968	86.2333	7.2	1294016	1047878
04 Jun 1997	12:16:30.047	43.2075	84.1195	25.7	1294007	1055510
14 Jun 1997	04:04:44.789	36.5473	75.8472	13.6	1293956	1062374
06 Jul 1997	01:51:49.943	42.8872	131.3969	557.0	1293900	1078056
13 Aug 1997	08:13:34.420	29.3792	105.6368	31.5	1293973	1106686
18 Sep 1997	06:31:57.124	37.9451	121.2897	0.0	1294018	1134766
15 Oct 1997	20:30:51.849	35.7097	80.8354	0.0	1293979	1162030
21 Oct 1997	06:32:35.986	41.1454	107.2457	20.8	1294024	1166500
10 Jan 1998	03:50:40.478	41.1792	114.4738	11.8	1293896	1255985
02 Jun 1998	01:32:08.179	41.0793	114.5227	8.0	1294022	1454842
20 Jul 1998	01:05:57.476	30.0976	88.1673	14.7	1293934	20019984
29 Jul 1998	01:15:21.884	36.7153	105.5121	16.3	1293932	20030795
30 Aug 1998	03:37:46.329	30.0177	88.1604	5.5	1293930	20070787
26 Sep 1998	18:27:05.040	27.7094	92.8834	17.9	1293928	20103435
01 Dec 1998	05:35:16.113	28.0185	87.6916	77.5	1294032	20238850

TABLE 5

LIST OF 80 CEB EVENTS IN FORMER SOVIET UNION: REB LOCATIONS

DATE	ORIGIN TIME	LAT	LON	DEPTH	ORID	EVID	MB
05 Jan 1995	12:46:01.252	59.5246	56.3086	0.0	273228	271133	4.35
24 Jan 1995	07:29:38.586	55.5360	160.5823	141.1	289209	287205	4.49
10 Mar 1995	05:22:23.694	46.1505	143.4114	348.3	313997	313040	5.08
17 Apr 1995	18:19:23.730	50.2410	91.2461	0.0	334466	333555	4.43
27 May 1995	13:03:52.010	52.6563	142.7172	0.0	360492	359385	5.76
27 May 1995	13:26:37.548	53.0676	143.1215	53.9	360531	359387	4.48
27 May 1995	13:27:12.387	52.9898	143.2876	71.6	360535	360535	4.62
27 May 1995	14:19:10.295	52.9567	143.1619	41.2	360999	359437	4.30
28 May 1995	20:48:05.434	52.5502	142.7070	27.4	364062	360191	4.57
28 May 1995	21:46:52.812	47.6529	85.6598	0.0	364061	360207	4.35
22 Jun 1995	01:01:25.892	50.3936	90.1571	58.2	375228	374823	5.16
29 Jun 1995	23:02:26.885	51.8064	103.3545	0.0	378038	377954	4.91
19 Aug 1995	20:28:06.251	42.3272	70.6472	0.0	407557	406154	4.57
28 Nov 1995	10:53:36.823	50.2900	91.1949	47.9	475990	474109	4.34
06 Dec 1995	02:57:28.448	57.1995	118.5397	46.2	506915	504499	4.14
02 Jan 1996	02:06:32.701	53.8676	159.4001	16.3	528776	527566	4.37
03 Jan 1996	03:57:27.614	53.6305	158.6968	136.1	529898	528721	4.77
08 Jan 1996	10:04:50.038	53.2482	142.6375	12.4	534966	533420	5.20
13 Jan 1996	05:26:33.768	51.0765	157.7140	50.2	539601	539204	4.72
15 Jan 1996	06:15:15.810	52.9576	83.7154	78.5	548149	542539	4.14
18 Jan 1996	09:33:56.509	41.8679	77.5102	63.2	551891	550436	4.78
12 Feb 1996	18:56:57.400	57.4744	120.5410	0.0	571628	571529	4.05
25 Mar 1996	00:44:05.385	55.5529	161.6771	64.1	615152	613141	4.17
07 Apr 1996	14:18:59.946	53.2753	159.5743	51.4	627721	626978	4.54
09 May 1996	10:58:44.691	40.6636	48.3520	35.8	669025	667555	4.00
14 May 1996	12:45:34.184	41.4369	74.9510	56.6	676318	673686	4.31
28 May 1996	04:50:08.688	41.9453	42.0877	0.0	687196	685661	4.46
13 Jun 1996	00:15:46.142	55.5716	158.3667	319.8	709468	703972	4.28
14 Jun 1996	22:45:42.269	42.4517	72.9032	35.9	709843	706593	4.73
07 Jul 1996	10:49:59.196	58.5505	157.6834	0.0	737428	735655	5.32
13 Jul 1996	19:12:21.840	56.0809	114.7569	0.0	742355	740819	4.30
11 Aug 1996	14:11:21.506	55.9456	162.0645	15.7	766724	765137	4.87

16 Aug 1996	09:15:31.708	64.8032	30.0865	0.0	772537	769149	4.04
14 Sep 1996	19:29:41.671	75.4406	110.3295	0.0	802492	800104	4.02
15 Sep 1996	00:21:22.399	72.1958	126.1565	0.0	802355	800274	4.22
18 Sep 1996	09:51:43.287	67.9540	139.6471	0.0	805712	802983	4.39
30 Sep 1996	05:49:51.903	54.1115	159.7722	103.8	819832	814886	4.90
03 Oct 1996	16:09:21.365	62.5246	153.9403	0.0	822922	819721	4.14
24 Oct 1996	19:31:52.272	66.9558	-173.2562	0.0	841522	838278	5.34
24 Oct 1996	21:57:38.982	67.0601	-173.3876	17.7	841513	839062	4.59
04 Dec 1996	02:49:42.408	40.2075	52.8965	51.0	876844	875528	4.25
16 Dec 1996	06:59:52.767	42.8416	78.4043	22.9	888450	886665	4.04
16 Dec 1996	07:00:14.799	42.8516	78.3332	22.2	888466	888466	4.25
28 Dec 1996	07:40:30.836	42.9514	78.0350	0.0	899209	896492	4.27
03 Jan 1997	21:51:28.490	60.9499	167.3014	0.0	905369	902063	5.23
03 Jan 1997	22:40:40.995	60.9684	167.2361	0.0	905338	902120	4.32
09 Jan 1997	13:43:32.112	40.8471	74.2443	21.0	915856	907037	5.15
28 Jan 1997	10:56:55.762	42.3592	48.3505	34.4	930619	928797	4.04
09 Feb 1997	18:57:42.014	55.3344	161.8240	58.6	950515	948607	5.21
09 Feb 1997	21:49:09.555	41.2770	43.8881	0.0	950983	948670	4.35
05 Mar 1997	09:35:15.283	41.1766	75.7609	68.9	974264	969719	4.37
05 Mar 1997	16:58:35.845	40.8747	49.3968	0.0	972715	969632	4.71
13 Apr 1997	18:04:12.535	55.9134	109.3410	0.0	1007258	1005378	4.46
07 May 1997	16:16:47.124	40.2864	51.6210	40.8	1031554	1029969	4.77
18 Jul 1997	07:33:53.848	41.0213	45.1694	0.0	1090002	1087914	4.13
16 Aug 1997	02:10:59.907	72.6484	57.3517	0.0	1112268	1108725	3.91
29 Aug 1997	02:16:30.615	40.1361	66.7378	0.0	1117736	1117024	4.41
18 Sep 1997	14:31:45.536	49.9246	86.2065	81.1	1136103	1135191	4.22
01 Oct 1997	06:05:50.152	46.2411	136.1448	417.9	1149730	1147641	4.55
20 Oct 1997	10:21:43.316	44.6737	79.8073	0.0	1167120	1166237	4.10
24 Oct 1997	11:50:13.365	57.3462	120.4268	0.0	1171818	1169423	4.21
24 Oct 1997	12:52:49.373	57.2192	120.0120	0.0	1172145	1169891	4.37
19 Nov 1997	22:39:54.421	40.4360	63.4057	0.0	1199186	1194451	4.11
27 Nov 1997	17:34:25.978	41.7470	45.2022	0.0	1207383	1205836	4.77
05 Dec 1997	12:22:38.310	53.8818	161.3688	44.0	1218284	1212052	4.41
15 Jan 1998	03:33:08.711	67.6021	139.6571	0.0	1261962	1261092	4.53
22 Jan 1998	16:05:53.839	48.5659	84.7883	32.7	1271968	1269029	4.44
25 Feb 1998	15:52:34.164	53.6122	109.9279	0.0	1300892	1299987	4.07
20 Aug 1998	09:36:35.743	45.6559	136.8865	346.0	20064872	20059482	4.63
22 Aug 1998	05:00:18.664	49.7566	77.8273	0.0	20067161	20062944	3.80 **
16 Sep 1998	22:48:15.945	40.3049	63.0788	0.0	20095967	20093659	4.07
18 Oct 1998	05:22:07.097	44.0394	33.6464	0.0	20133806	20130812	4.42
31 Oct 1998	14:03:34.998	53.1459	157.7465	159.6	20147736	20144609	4.56

07 Jan 1999	18:13:40.907	67.6797	141.3994	15.6	20284784	20283977	4.82
14 Jan 1999	22:45:15.052	41.1047	44.0036	0.0	20294097	20291674	4.42
20 Jan 1999	13:28:03.231	57.4058	120.5791	17.3	20298504	20296560	4.16
31 Jan 1999	05:07:11.739	43.1106	46.8532	8.6	20317443	20312703	5.11
10 Feb 1999	08:05:32.833	51.6133	104.9380	15.9	20331210	20328469	4.24
21 Feb 1999	18:14:39.893	43.2158	46.8683	65.8	20347857	20344268	4.55
25 Sep 1999	05:00:05.710	49.7841	77.8240	0.0	20581444	20579513	3.67 **

** Degelen calibration shot

TABLE 6

LIST OF 159 IRIS AND LAMONT STATIONS USED FOR CEB EVENTS IN FORMER SOVIET UNION

STATION	LAT	LON	ELEV(KM)	LOCATION
AAE	9.0292	38.7656	2.4420	Addis Ababa, Ethiopia
AAK	42.6390	74.4940	1.6450	Ala Archa, Kyrgyzstan
ABKT	37.9304	58.1189	0.6780	Alibek, Turkmenistan
ADK	51.8837	-176.6844	0.1160	Adak, Aleutian Islands, Alaska, USA
AKT	50.4348	58.0167	0.3600	Aktyubinsk, Kazakhstan
AML	42.1311	73.6941	3.4000	Almayashu, Kyrgyzstan
ANTO	39.8689	32.7936	0.8830	Ankara, Turkey
AQU	42.3540	13.4050	0.7100	L'Aquila, Italy
ARU	56.4302	58.5625	0.2500	Arti, Russia
ASCN	-7.9327	-14.3601	0.1730	Butt Crater, Ascension Island
BAR	32.6800	-116.6720	0.5480	Barrett Dam, California, USA
BATO	-19.6260	-65.4365	3.3530	Bolivia
BGIO	31.7219	35.0877	0.7520	Bar Giyyora, Israel
BILL	68.0651	166.4524	0.2990	Bilibino, Russia
BJT	40.0183	116.1679	0.1370	Baijiatuan, Beijing, China
BRVK	53.0581	70.2828	0.3150	Borovoye, Kazakhstan
BZN	33.4915	-116.6670	1.3010	Buzz Northern's Place, Terwilliger, Calif.
CALB	34.1430	-118.6269	0.0000	Calabasas, California, USA
CHK	53.6762	70.6152	0.2400	Chkalovo, Kazakhstan
CHM	42.9986	74.7513	0.6550	Chumysh, Kazakhstan
CHTO	18.7900	98.9769	0.3160	Chiang Mai, Thailand
CMB	38.0350	-120.3850	0.7190	Columbia College, California, USA
COL	64.9000	-147.7933	0.3200	College Outpost, Alaska, USA
COLA	64.8738	-147.8511	0.0740	College Outpost, Alaska, USA
COR	44.5857	-123.3032	0.1210	Corvallis, Oregon, USA
CPUP	-26.3306	-57.3292	0.0050	Villa Florida, Paraguay
CRUZ	-19.1034	-66.2212	4.2670	Bolivia
CRY	33.5654	-116.7373	1.1280	Cary Ranch, Anza, Calif.
DGR	33.6500	-117.0090	0.7000	Domenigoni Valley Reservoir, California, USA
DOOR	-19.3538	-67.2233	3.7490	Bolivia
DPC	50.3583	16.4111	0.7600	Dobruska, Czech Republic
EFI	-51.6753	-58.0637	0.1100	Mount Kent, East Falkland Island

EKS2	42.6615	73.7772	1.3600	Erkin-Sai, Kyrgyzstan
ENH	30.2718	109.4868	0.4870	Enshi, Hubei Province, China
ERM	42.0150	143.1572	0.0400	Erimo, Hokkaido Island, Japan
FRD	33.4947	-116.6022	1.1640	Ford Ranch, Terwillger, Calif.
FURI	8.9030	38.6883	2.5400	Mt. Furi, Ethiopia
GNI	40.0530	44.7240	1.4580	Garni, Armenia
GRFO	49.6919	11.2217	0.4250	Grafenberg, Germany
GSC	35.3017	-116.8046	0.9900	Goldston, California, USA
GUMO	13.5878	144.8662	0.0140	Guam, Marianas Islands
HGN	50.7640	5.9317	0.1350	Heimansgroeve, Nederland
HIA	49.2667	119.7417	0.6100	Hailar, Neimenggu Province, China
HIZO	-19.6070	-68.3258	3.6880	Chile
HNR	-9.4322	159.9471	0.0720	Honiara, Solomon Islands
HOPE	-54.2836	-36.4879	0.0200	Hope Point, South Georgia Island
HYB	17.4170	78.5530	0.5100	Hyderabad, India
INCN	37.4833	126.6333	0.4190	Inchon, Republic of Korea
INU	35.3500	137.0290	0.1320	Inuyama, Japan
ISA	35.6633	-118.4733	0.8350	Isabella, California, USA
ITIT	-20.2551	-63.1582	0.8230	Bolivia
KBK	42.6564	74.9478	1.7600	Karagaibulak, Kyrgyzstan
KBS	78.9175	11.9239	0.0460	Kingsbay, Svalbard, Norway
KDAK	57.7828	-152.5834	0.1520	Kodiak Island, Alaska, USA
KEG	29.9275	31.8292	0.4600	Kottamya, Egypt
KEV	69.7553	27.0067	0.0650	Kevo, Finland
KIEV	50.6944	29.2083	0.1230	Kiev, Ukraine
KIP	21.4233	-158.0149	0.0700	Kipapa, Oahu, Hawaii, USA
KIV	43.9553	42.6863	1.0540	Kislovodsk, Russia
KMBO	-1.1268	37.2523	1.9400	Kilima Mbogo, Kenya
KNW	33.7141	-116.7119	1.5070	Keenwild Fire Station, Mountain Center, Calif.
KONO	59.6491	9.5982	-0.1240	Kongsberg, Norway
KUR	50.7149	78.6208	0.2400	Kurchatov, Kazakhstan
KURK	50.7154	78.6202	0.1840	Kurchatov, Kazakhstan
KZA	42.0778	75.2496	3.5200	Kuzart, Kyrgyzstan
LIRI	-19.8515	-68.8493	4.1100	Chile
LPAZ	-16.2879	-68.1307	4.6690	La Paz, Bolivia
LSA	29.7000	91.1500	3.7740	Tibet, China
LVA2	33.3516	-116.5615	1.4350	Lost Valley Boy Scout Camp, California, USA
LVC	-22.6128	-68.9113	2.1650	Limon Verde, Chile
LVZ	67.8979	34.6514	0.6300	Lovozero, Russia
LZH	36.0867	103.8444	1.5600	Lanzhou, Gansu Province, China
MA2	59.5756	150.7700	0.3390	Magadan, Russia

MAJO	36.5425	138.2072	0.4050	Matsushiro, Japan
MAK	46.8075	81.9774	0.6000	Makanchi, Kazakhstan
MAKZ	46.8080	81.9770	0.5900	Makanchi, Kazakhstan
MDJ	44.6164	129.5919	0.2500	Mudanjiang, Heilongjiang Province, China
MHV	54.9595	34.7664	0.1500	Michnevo, Russia
MLR	45.4912	25.9456	1.3780	Muntele Rosu, Romania
MORC	49.7766	17.5428	0.7400	Moravsky Beroun, Czech Republic
MSEY	-4.6737	55.4792	0.4750	Mahe Island, Seychelles
MWC	34.2237	-118.0529	1.6960	Mount Wilson, California, USA
NIL	33.6500	73.2517	0.5360	Nilore, Pakistan
NNA	-11.9875	-76.8422	0.5750	Nana, Peru
NRIL	69.5049	88.4414	0.0920	Norilsk, Russia
OBN	55.1138	36.5687	0.1600	Obninsk, Russia
PACH	-19.8689	-69.4195	1.6200	Chile
PAS	34.1483	-118.1717	0.2950	Pasadena, California, USA
PET	53.0235	158.6498	0.1500	Petropavlovsk, Russia
PFO	33.6092	-116.4553	1.2800	Pinon Flat, California, USA
PICH	-19.8115	-63.7210	1.6760	Bolivia
PLCA	-40.7328	-70.5508	0.9500	Paso Flores, Argentina
PLM	33.3537	-116.8627	1.6600	Palomar, California, USA
PMB	50.5188	-123.0765	0.4000	Pemberton, British Columbia, Canada
PMG	-9.4092	147.1539	0.0670	Port Moresby, Papua New Guinea
PMSA	-64.7742	-64.0490	0.0100	Palmer Station, Antarctica
PSI	2.6938	98.9237	0.9870	Prapat, Sumatera, Indonesia
PTGA	-0.7308	-59.9666	0.1370	Pitinga, Amazonas, Brazil
RAR	-21.2125	-159.7733	-0.1720	Rarotonga, Cook Islands
RAYN	23.5225	45.5032	0.6310	Ar Rayn, Saudi Arabia
RDM	33.6300	-116.8478	1.3650	Red Mountain, Riverside Co., Calif.
RES	74.6870	-94.9000	0.0150	Resolute, Nunavut, Canada
ROSL	-19.4857	-64.1779	2.0730	Bolivia
SALI	-19.6207	-67.7263	3.7790	Bolivia
SBA	-77.8491	166.7573	0.0200	Scott Base, Antarctica
SBC	34.4417	-119.7133	0.0900	Santa Barbara, California, USA
SCHO	-19.1480	-64.6428	2.5910	Bolivia
SEO	37.5667	126.9667	0.0860	Seoul, South Korea
SND	33.5519	-116.6129	1.3580	Jim Saunders Place, Anza, California, USA
SPA	-89.9990	115.0000	2.9270	South Pole, Antarctica
SSE	31.0956	121.1867	0.0150	Sheshan, Shanghai, China
SUR	-32.3797	20.8117	1.7700	Sutherland, South Africa
SUW	54.0125	23.1808	0.1520	Suwalki, Poland
TACA	-18.8276	-66.7337	3.8100	Bolivia

TATO	24.9754	121.4881	0.0530	Taipei, Taiwan
TIN	37.0542	-118.2301	1.1640	Tinemaha, California, USA
TIXI	71.6490	128.8665	0.0500	Tiksi, Sakha, Russia
TKK	7.4472	151.8870	0.0010	Chuuk Micronesia
TKM2	42.9208	75.5966	2.0200	Tokmak, Kyrgyzstan (north-east of TKM)
TLG	43.2330	77.2250	1.1200	Talgar, Kazakhstan
TLY	51.6807	103.6438	0.5790	Talaya, Russia
TSUM	-19.2022	17.5838	1.2400	Tsumeb, Namibia
TUC	32.3096	-110.7845	0.8740	Tucson, Arizona, USA
UCH	42.2275	74.5134	3.8500	Uchtor, Kyrgyzstan
ULHL	42.2456	76.2417	2.0400	Ulahole, Kyrgyzstan
ULN	47.8652	107.0528	1.6150	Ulaanbaatar, Mongolia
USP	43.2669	74.4997	0.7400	Uspenovka, Kazakhstan
VNDA	-77.5172	161.8528	0.0510	Wright Valley (Bull Pass) Antarctica
VOS	52.7232	70.9797	0.4500	Vostochnoye, Kazakhstan
VTV	34.5670	-117.3330	0.8470	Victorville, California, USA
WAKE	19.2833	166.6536	-0.0807	Wake Island
WHY	60.6597	-134.8806	1.2920	Whitehorse, Yukon Territory, Canada
WMC	33.5736	-116.6747	1.2710	Walmic Ranch, Anza, California, USA
WMQ	43.8211	87.6950	0.8970	Urumqi, Xinjiang Province, China
WUS	41.1990	79.2180	1.4570	Wushi, Xinjiang Uygur, China
XAN	34.0313	108.9237	0.6300	Xi'an, China
YAK	62.0308	129.6812	0.1050	Yakutsk, Russia
YSS	46.9583	142.7610	0.0980	Yuzhno Sakhalinsk, Russia
YUNZ	-19.1582	-65.0687	2.8960	Bolivia
ZRN	52.9510	69.0043	0.4200	Zerenda, Kazakhstan
PDG	43.3275	79.4850	1.2770	Podgornoye, Kazakstan
BAY	50.8264	75.5537	0.4420	Bayanaul, Kazakstan
DEG	49.9520	77.9945	0.4030	Degelen, Kazakstan
KKL	49.3387	75.3823	0.9250	Karkalarinsk, Kazakstan
KUR01	50.7211	78.5625	0.2400	Cross-array, Kurchatov, Kazakhstan
KUR02	50.7017	78.5564	0.2400	Cross-array, Kurchatov, Kazakhstan
KUR03	50.6808	78.5475	0.2400	Cross-array, Kurchatov, Kazakhstan
KUR04	50.6622	78.5433	0.2400	Cross-array, Kurchatov, Kazakhstan
KUR05	50.6425	78.5367	0.2400	Cross-array, Kurchatov, Kazakhstan
KUR06	50.6056	78.5231	0.2400	Cross-array, Kurchatov, Kazakhstan
KUR08	50.5631	78.5106	0.2400	Cross-array, Kurchatov, Kazakhstan
KUR09	50.5428	78.5047	0.2400	Cross-array, Kurchatov, Kazakhstan
KUR10	50.5239	78.4978	0.2400	Cross-array, Kurchatov, Kazakhstan
KUR14	50.6147	78.5931	0.2400	Cross-array, Kurchatov, Kazakhstan
KUR15	50.6181	78.5617	0.2400	Cross-array, Kurchatov, Kazakhstan

KUR16	50.6272	78.4992	0.2400	Cross-array, Kurchatov, Kazakhstan
KUR17	50.6331	78.4681	0.2400	Cross-array, Kurchatov, Kazakhstan
KUR18	50.6347	78.4386	0.2400	Cross-array, Kurchatov, Kazakhstan
KUR20	50.6439	78.3747	0.2400	Cross-array, Kurchatov, Kazakhstan

TABLE 7

LIST OF 80 CEB EVENTS IN FORMER SOVIET UNION: REVISED IDC LOCATIONS

DATE	ORIGIN TIME	LAT	LON	DEPTH	ORID	EVID
05 Jan 1995	12:46:00.571	59.5447	56.3919	0.0	1294241	271133
24 Jan 1995	07:29:38.423	55.5509	160.5178	139.0	1294204	287205
10 Mar 1995	05:22:24.133	46.2246	143.4864	350.4	1294225	313040
17 Apr 1995	18:19:23.415	50.2019	91.2707	0.0	1294202	333555
27 May 1995	13:03:51.868	52.6232	142.8810	0.0	1294194	359385
27 May 1995	13:26:37.247	53.0701	143.1897	50.2	1294196	359387
27 May 1995	13:27:11.254	52.9821	143.2509	61.4	1294198	360535
27 May 1995	14:19:04.288	52.9500	143.1485	0.0	1294200	359437
28 May 1995	20:48:01.297	52.5844	142.7365	0.0	1294157	360191
28 May 1995	21:46:52.841	47.6078	85.5884	0.0	1294155	360207
22 Jun 1995	01:01:19.972	50.4486	90.1922	12.6	1294159	374823
29 Jun 1995	23:02:28.730	51.8574	103.0625	12.0	1294161	377954
19 Aug 1995	20:28:06.216	42.3243	70.6456	0.0	1294163	406154
28 Nov 1995	10:53:34.879	50.3302	91.1180	26.7	1294165	474109
06 Dec 1995	02:57:30.474	57.2052	118.5213	64.2	1294243	504499
02 Jan 1996	02:06:31.781	53.8556	159.3887	9.7	1294167	527566
03 Jan 1996	03:57:27.498	53.5822	158.7923	133.3	1294169	528721
08 Jan 1996	10:04:49.963	53.3251	142.5812	7.6	1294171	533420
13 Jan 1996	05:26:34.057	51.1293	157.5828	51.2	1294173	539204
15 Jan 1996	06:15:05.766	52.8743	83.7800	0.0	1294140	542539
18 Jan 1996	09:33:50.638	41.8239	77.4916	16.7	1294134	550436
12 Feb 1996	18:57:01.661	57.5263	120.6578	26.9	1294175	571529
25 Mar 1996	00:44:05.643	55.5277	161.6747	65.3	1294177	613141
07 Apr 1996	14:18:59.946	53.2753	159.5743	51.4	627721	626978 *
09 May 1996	10:58:46.020	40.7003	48.3252	47.1	1294180	667555
14 May 1996	12:45:31.660	41.5672	74.9119	30.9	1294182	673686
28 May 1996	04:50:09.648	41.9214	42.0816	0.0	1294184	685661
13 Jun 1996	00:15:45.405	55.5770	158.4482	312.2	1294033	703972
14 Jun 1996	22:45:36.837	42.3644	72.9063	0.0	1294041	706593
07 Jul 1996	10:50:01.278	58.5371	157.7042	12.4	1294035	735655
13 Jul 1996	19:12:25.656	55.9924	114.7142	25.5	1294037	740819
11 Aug 1996	14:11:19.708	56.0079	161.9729	3.4	1294186	765137

16 Aug 1996	09:15:32.317	64.7734	30.2157	0.0	1294245	769149
14 Sep 1996	19:29:42.032	75.4538	110.2498	0.0	1294191	800104
15 Sep 1996	00:21:22.928	72.2100	126.2449	0.0	1294189	800274
18 Sep 1996	09:51:43.964	68.0279	139.8815	0.0	1294056	802983
30 Sep 1996	05:49:52.463	54.1143	159.8206	106.4	1294058	814886
03 Oct 1996	16:09:24.927	62.3559	153.8447	25.2	1294064	819721
24 Oct 1996	19:31:54.429	67.0790	-173.2354	11.0	1294043	838278
24 Oct 1996	21:57:39.052	67.0399	-173.3689	17.2	1294051	839062
04 Dec 1996	02:49:42.522	40.1993	52.9233	50.9	1294055	875528
16 Dec 1996	06:59:52.687	42.8392	78.3907	22.7	1294047	886665
16 Dec 1996	07:00:14.051	42.6700	78.1792	19.9	1294066	888466
28 Dec 1996	07:40:35.539	42.9617	78.0708	28.9	1294049	896492
03 Jan 1997	21:51:29.926	60.8896	167.3139	9.2	1294062	902063
03 Jan 1997	22:40:41.039	60.9452	167.2607	0.0	1294078	902120
09 Jan 1997	13:43:32.715	41.0280	74.3232	19.9	1294072	907037
28 Jan 1997	10:56:55.876	42.3070	48.3289	34.4	1294045	928797
09 Feb 1997	18:57:42.140	55.3315	161.7909	56.4	1294074	948607
09 Feb 1997	21:49:12.680	41.3397	43.8699	19.8	1294080	948670
05 Mar 1997	09:35:13.486	41.2052	75.7691	49.3	1294070	969719
05 Mar 1997	16:58:42.869	40.9748	49.4829	50.5	1294076	969632
13 Apr 1997	18:04:14.325	55.9149	109.4129	10.1	1294082	1005378
07 May 1997	16:16:48.288	40.3168	51.5871	51.1	1294068	1029969
18 Jul 1997	07:33:54.163	40.9921	45.2370	0.0	1294096	1087914
16 Aug 1997	02:10:59.675	72.6439	57.3733	0.0	1294233	1108725
29 Aug 1997	02:16:30.787	40.1349	66.7211	0.0	1294097	1117024
18 Sep 1997	14:31:36.791	49.8441	86.2595	11.3	1294039	1135191
01 Oct 1997	06:05:49.515	46.2200	136.1059	415.0	1294088	1147641
20 Oct 1997	10:21:43.398	44.6931	79.8167	0.0	1294090	1166237
24 Oct 1997	11:50:13.296	57.3568	120.3966	0.0	1294084	1169423
24 Oct 1997	12:52:53.594	57.2636	120.0146	24.8	1294092	1169891
19 Nov 1997	22:39:54.323	40.4449	63.4325	0.0	1294109	1194451
27 Nov 1997	17:34:28.402	41.7902	45.1695	14.0	1294107	1205836
05 Dec 1997	12:22:38.347	53.8902	161.3478	43.3	1294086	1212052
15 Jan 1998	03:33:08.611	67.6193	139.5649	0.0	1294235	1261092
22 Jan 1998	16:05:53.452	48.5867	84.7989	28.1	1294105	1269029
25 Feb 1998	15:52:37.600	53.6445	109.9523	20.8	1294103	1299987
20 Aug 1998	09:36:36.538	45.7074	136.9201	354.6	1294099	20059482
22 Aug 1998	05:00:18.638	49.7772	77.8896	0.0	1294121	20062944 **
16 Sep 1998	22:48:20.141	40.4135	63.3568	34.3	1294101	20093659
18 Oct 1998	05:22:07.267	44.0493	33.6124	0.0	1294206	20130812
31 Oct 1998	14:03:34.877	53.1234	157.8266	159.8	1294239	20144609

07 Jan 1999	18:13:41.063	67.7176	141.3889	16.0	1294208	20283977
14 Jan 1999	22:45:14.775	41.1385	44.0153	0.0	1294212	20291674
20 Jan 1999	13:28:04.749	57.4013	120.5555	28.8	1294216	20296560
31 Jan 1999	05:07:12.015	43.0699	46.9365	11.9	1294227	20312703
10 Feb 1999	08:05:32.669	51.6321	104.9839	15.1	1294229	20328469
21 Feb 1999	18:14:35.268	43.0966	46.9587	28.2	1294231	20344268
25 Sep 1999	05:00:05.663	49.7954	77.8429	0.0	1294223	20579513 **

* same as REB; no IDC waveform data available

** Degelen calibration shot

TABLE 8

LIST OF 80 CEB EVENTS IN FORMER SOVIET UNION: REVISED IDC + IRIS LOCATIONS

DATE	ORIGIN TIME	LAT	LON	DEPTH	ORID	EVID
05 Jan 1995	12:46:02.155	59.4508	56.1303	6.7	20436938	271133
24 Jan 1995	07:29:38.352	55.5466	160.5387	137.3	1294205	287205
10 Mar 1995	05:22:23.577	46.2487	143.4226	346.0	1294226	313040
17 Apr 1995	18:19:23.346	50.1939	91.1672	0.0	1294203	333555
27 May 1995	13:03:52.305	52.7022	142.7835	0.0	1294195	359385
27 May 1995	13:26:35.500	53.0619	143.1738	34.0	1294197	359387
27 May 1995	13:27:09.110	52.9988	143.2189	41.0	1294199	360535
27 May 1995	14:19:09.679	52.9478	143.1013	35.4	1294201	359437
28 May 1995	20:48:01.386	52.6115	142.9068	0.0	1294158	360191
28 May 1995	21:46:53.179	47.6120	85.5136	0.0	1294156	360207
22 Jun 1995	01:01:20.173	50.3906	89.9473	14.1	1294160	374823
29 Jun 1995	23:02:27.852	51.8408	102.7043	7.5	1294162	377954
19 Aug 1995	20:28:07.616	42.4050	70.4976	4.9	1294164	406154
28 Nov 1995	10:53:33.282	50.2788	91.0530	15.0	1294166	474109
06 Dec 1995	02:57:24.257	57.1598	118.7087	13.5	1294244	504499
02 Jan 1996	02:06:31.223	53.8326	159.4223	6.1	1294168	527566
03 Jan 1996	03:57:26.822	53.5413	158.7108	128.6	1294170	528721
08 Jan 1996	10:04:50.000	53.3597	142.4914	7.6	1294172	533420
13 Jan 1996	05:26:33.936	51.0367	157.5858	52.8	1294174	539204
15 Jan 1996	06:15:06.137	53.0148	83.9526	0.0	1294141	542539
18 Jan 1996	09:33:50.537	41.8107	77.4436	15.5	1294135	550436
12 Feb 1996	18:57:01.180	57.4896	120.6185	24.8	1294176	571529
25 Mar 1996	00:44:05.584	55.5129	161.6304	64.8	1294178	613141
07 Apr 1996	14:19:00.847	53.4141	159.6303	55.9	1294179	626978 *
09 May 1996	10:58:45.715	40.7232	48.3446	43.3	1294181	667555
14 May 1996	12:45:26.506	41.4849	74.9131	0.0	1294183	673686
28 May 1996	04:50:12.425	41.9311	42.0424	16.8	1294185	685661
13 Jun 1996	00:15:45.350	55.5484	158.4978	312.1	1294034	703972
14 Jun 1996	22:45:37.690	42.4598	72.9521	3.6	1294042	706593
07 Jul 1996	10:50:00.731	58.5702	157.7551	8.5	1294036	735655
13 Jul 1996	19:12:25.766	56.0469	114.6787	24.6	1294038	740819
11 Aug 1996	14:11:19.215	55.9870	162.0272	0.7	1294187	765137

16 Aug 1996	09:15:31.277	64.8008	30.4157	0.0	1294246	769149
14 Sep 1996	19:29:42.559	75.5311	110.2702	0.0	1294193	800104
15 Sep 1996	00:21:23.531	72.3040	125.7150	0.0	1294190	800274
18 Sep 1996	09:51:44.256	67.9976	139.8726	0.0	1294057	802983
30 Sep 1996	05:49:52.520	54.1436	159.7892	106.6	1294059	814886
03 Oct 1996	16:09:26.516	62.4066	153.8447	35.0	1294065	819721
24 Oct 1996	19:31:52.685	67.1040	-173.4083	0.0	1294044	838278
24 Oct 1996	21:57:39.242	67.0827	-173.3703	15.7	1294052	839062
04 Dec 1996	02:49:42.303	40.1953	53.0170	49.8	1294054	875528
16 Dec 1996	06:59:52.799	42.7690	78.0575	20.9	1294048	886665
16 Dec 1996	07:00:14.771	42.7799	78.0664	19.3	1294067	888466
28 Dec 1996	07:40:31.981	42.9126	77.9826	8.2	1294050	896492
03 Jan 1997	21:51:29.654	60.8682	167.4485	7.6	1294063	902063
03 Jan 1997	22:40:41.062	60.9480	167.2589	0.0	1294079	902120
09 Jan 1997	13:43:32.361	40.9816	74.2443	21.1	1294073	907037
28 Jan 1997	10:56:56.127	42.3163	48.2451	33.5	1294046	928797
09 Feb 1997	18:57:42.472	55.2347	161.9109	60.6	1294075	948607
09 Feb 1997	21:49:13.986	41.5100	43.9284	20.1	1294081	948670
05 Mar 1997	09:35:06.599	41.2424	75.7708	0.0	1294071	969719
05 Mar 1997	16:58:42.647	40.9869	49.5070	47.9	1294077	969632
13 Apr 1997	18:04:14.261	55.9056	109.2190	9.6	1294083	1005378
07 May 1997	16:16:48.065	40.3939	51.6003	48.4	1294069	1029969
18 Jul 1997	07:33:54.524	41.0858	45.1982	0.0	1294095	1087914
16 Aug 1997	02:10:59.685	72.6387	57.3738	0.0	1294234	1108725
29 Aug 1997	02:16:34.304	40.1693	66.7168	21.2	1294098	1117024
18 Sep 1997	14:31:37.196	49.8439	86.2521	13.8	1294040	1135191
01 Oct 1997	06:05:49.445	46.2301	136.1208	413.6	1294089	1147641
20 Oct 1997	10:21:43.834	44.7792	79.8369	0.0	1294091	1166237
24 Oct 1997	11:50:13.723	57.3698	120.4240	0.0	1294085	1169423
24 Oct 1997	12:52:50.777	57.3616	120.3022	6.9	1294093	1169891
19 Nov 1997	22:39:53.570	40.3272	63.4553	0.0	1294110	1194451
27 Nov 1997	17:34:28.215	41.8623	45.2291	11.5	1294108	1205836
05 Dec 1997	12:22:38.363	53.8920	161.3602	43.5	1294087	1212052
15 Jan 1998	03:33:08.781	67.6233	139.4818	0.0	1294236	1261092
22 Jan 1998	16:05:52.180	48.5809	84.7966	19.6	1294106	1269029
25 Feb 1998	15:52:37.478	53.6067	109.8704	20.5	1294104	1299987
20 Aug 1998	09:36:36.456	45.7268	136.9166	352.9	1294100	20059482
22 Aug 1998	05:00:18.942	49.7823	77.9561	0.0	1294129	20062944 **
16 Sep 1998	22:48:15.536	40.3047	63.0650	0.0	1294102	20093659
18 Oct 1998	05:22:07.305	44.0515	33.6078	0.0	1294207	20130812
31 Oct 1998	14:03:34.874	53.1257	157.7810	160.0	1294240	20144609

07 Jan 1999	18:13:41.097	67.7282	141.3449	16.0	1294209	20283977
14 Jan 1999	22:45:14.864	41.1009	43.8557	0.0	1294213	20291674
20 Jan 1999	13:28:04.507	57.4110	120.5583	26.6	1294218	20296560
31 Jan 1999	05:07:12.213	43.1174	46.9883	12.1	1294228	20312703
10 Feb 1999	08:05:32.575	51.6373	104.8509	13.3	1294230	20328469
21 Feb 1999	18:14:34.533	43.1627	46.9420	21.8	1294232	20344268
25 Sep 1999	05:00:05.733	49.7988	77.8844	0.0	1294237	20579513 **

* no IDC waveform data available

** Degelen calibration shot (includes LDEO data)

TABLE 9

LIST OF 163 CEB EVENTS IN NORTH AMERICA: REB LOCATIONS

DATE	ORIGIN TIME	LAT	LON	DEPTH	ORID	EVID	MB
29 Jan 1995	03:11:28.852	47.3777	-122.2275	67.3	292161	291130	4.35
03 Feb 1995	15:26:16.014	41.6177	-109.7606	24.7	294959	294226	4.96
12 Feb 1995	20:13:38.502	59.7647	-153.2423	114.9	301618	300649	4.84
19 Feb 1995	04:03:22.481	40.6700	-125.6973	40.5	304850	304146	5.26
11 Mar 1995	08:15:53.744	36.8472	-82.8513	0.0	314985	313623	4.06
14 Mar 1995	17:33:50.380	54.7660	-161.2791	22.5	316563	315467	5.54
20 Mar 1995	12:46:19.132	40.3286	-108.5508	0.0	320118	318146	4.12
26 Mar 1995	05:57:14.086	54.8094	-161.3252	43.5	321757	321000	4.54
01 Apr 1995	07:12:30.357	53.6100	-164.5904	47.5	324598	324117	4.54
14 Apr 1995	00:32:57.945	30.2943	-103.4530	21.3	332045	331268	5.09
07 May 1995	11:03:30.450	33.5295	-116.6026	0.0	348468	347247	4.24
17 May 1995	02:29:24.220	39.9135	-122.6097	76.9	354044	351985	4.13
22 May 1995	20:08:31.615	58.7440	-156.0566	155.0	357861	356346	4.48
23 May 1995	15:48:07.624	51.1975	-177.2744	34.6	358512	356869	4.95
04 Jun 1995	01:07:39.746	54.1374	-164.1745	47.5	366580	365972	4.33
06 Jun 1995	04:04:54.941	60.3077	-146.4734	0.0	368994	366977	4.93
19 Jun 1995	14:45:36.890	59.0272	-151.4431	30.3	374192	373986	4.51
26 Jun 1995	08:40:26.623	34.2053	-118.6453	0.0	376495	376495	4.25
08 Jul 1995	17:15:26.038	53.6753	-163.9150	16.6	382877	381690	5.16
14 Jul 1995	19:06:28.297	53.2332	-166.9351	34.6	385007	384488	4.36
20 Jul 1995	08:53:04.579	52.8699	-174.3856	225.9	387610	386795	4.29
09 Aug 1995	11:29:58.659	42.5931	-107.6021	0.0	399601	399601	-1.00
17 Aug 1995	22:39:57.956	35.6913	-117.7077	0.0	406468	404828	4.71
18 Aug 1995	09:18:07.325	53.6301	-163.6349	26.1	406647	405318	4.51
19 Aug 1995	22:03:25.073	50.5964	-170.3882	0.0	407753	406213	4.49
28 Aug 1995	03:16:28.924	44.3774	-109.7928	15.7	412952	411834	4.13
28 Aug 1995	10:46:10.583	25.9676	-110.3178	0.0	413065	412033	5.14
28 Aug 1995	12:23:08.801	26.2401	-109.9823	20.6	413416	412064	4.26
31 Aug 1995	08:20:52.912	69.3164	-147.0594	0.0	414305	413474	4.76
18 Nov 1995	09:07:23.282	64.1211	-147.7105	102.5	465935	465813	4.30
31 Dec 1995	04:30:57.931	51.9958	-165.8386	29.6	526225	525209	4.03
04 Jan 1996	19:43:14.788	52.4456	-170.7298	57.0	531397	530178	4.43

08 Jan 1996	09:20:21.398	16.2039	-98.2190	51.9	534866	533390	4.41
07 Feb 1996	21:19:04.925	55.1935	-156.6125	0.0	568944	568417	4.89
20 Feb 1996	00:52:08.086	43.4537	-126.8010	0.0	578814	576944	4.46
22 Feb 1996	20:13:42.990	19.7071	-109.4627	0.0	580218	579218	4.55
25 Feb 1996	03:08:12.351	15.8363	-97.9959	0.0	582979	580915	5.01
25 Feb 1996	04:17:06.493	16.0759	-97.7340	0.0	582809	580978	4.81
25 Feb 1996	05:34:32.962	15.9773	-97.8144	59.4	582181	581074	4.22
25 Feb 1996	09:17:59.032	16.0244	-97.9014	20.8	582409	581316	4.88
25 Feb 1996	14:27:35.158	16.0387	-97.8166	65.9	582473	581571	4.49
25 Feb 1996	15:09:32.235	15.7550	-98.2957	132.7	582125	581626	4.28
03 Mar 1996	23:44:35.639	56.4417	-152.5767	21.5	590686	587402	4.88
13 Mar 1996	21:04:19.846	16.7402	-98.8371	24.7	600464	599040	4.64
14 Mar 1996	09:12:09.656	19.6661	-91.9395	0.0	601514	599600	4.27
18 Mar 1996	08:02:05.048	49.9386	-126.7696	43.8	605865	604564	4.28
19 Mar 1996	15:31:42.593	25.2244	-109.1223	37.9	608643	605911	4.51
19 Mar 1996	17:12:44.870	15.8601	-97.2328	44.1	608195	606016	4.96
20 Mar 1996	04:53:24.342	15.8074	-97.3128	11.4	608630	606526	4.86
27 Mar 1996	12:34:48.604	16.4419	-98.0038	16.9	618430	615815	5.08
28 Mar 1996	01:48:25.047	52.4114	-168.6609	40.8	618450	616486	4.69
28 Mar 1996	19:51:08.031	52.3952	-168.8359	28.1	619854	617367	5.18
28 Mar 1996	21:32:48.339	52.3623	-168.8618	13.6	619734	617475	4.91
01 Apr 1996	03:43:03.676	16.5507	-95.8758	54.1	621752	621062	4.56
20 Apr 1996	06:33:23.841	54.9113	-161.1698	29.6	645552	642949	4.51
21 Apr 1996	03:00:17.697	18.0751	-111.7514	0.0	646501	644009	4.24
23 Apr 1996	06:53:37.567	17.1868	-101.4351	47.7	650587	647379	4.79
09 May 1996	21:54:22.948	19.1542	-104.3491	81.9	669792	668161	4.41
16 May 1996	22:13:51.459	18.3077	-111.3446	43.1	677971	676670	4.10
03 Jun 1996	11:55:24.453	17.6588	-94.2169	166.2	694220	691725	4.56
07 Jun 1996	23:07:03.776	69.3806	-125.1371	0.0	698602	696672	4.11
08 Jun 1996	23:19:17.132	51.4474	-178.0580	40.5	700196	697652	5.41
10 Jun 1996	04:03:34.975	51.5348	-177.5710	22.5	705672	699173	5.55
10 Jun 1996	04:54:20.760	52.2709	-176.9723	303.5	703705	699233	4.13
10 Jun 1996	17:44:19.474	51.5739	-176.9163	47.3	705841	700421	4.92
11 Jun 1996	10:40:07.630	51.3517	-176.2432	21.1	704911	702009	5.21
11 Jun 1996	11:00:47.464	51.3322	-176.2265	23.4	705756	702034	4.88
11 Jun 1996	13:03:05.538	51.2648	-176.4315	38.3	709226	702145	4.89
25 Jun 1996	18:52:22.354	14.8743	-92.1411	70.1	720969	719054	4.02
10 Jul 1996	05:48:21.074	52.1817	-171.1066	37.7	738887	737937	4.93
15 Jul 1996	21:23:31.939	17.4309	-100.9147	0.0	743377	742188	5.24
19 Jul 1996	09:00:53.785	17.3836	-100.0593	43.0	748555	745363	4.44
21 Jul 1996	20:38:18.473	64.4252	-137.6903	0.0	751100	746895	4.67

24 Jul 1996	20:15:44.968	41.9148	-126.0112	0.0	751813	751389	4.87
03 Aug 1996	06:15:18.937	44.7912	-113.8496	0.0	759382	758063	4.08
08 Aug 1996	17:10:54.615	53.1691	-167.1606	47.5	763792	762673	5.41
20 Aug 1996	12:02:39.593	51.5530	-178.3570	37.8	773447	772239	4.72
31 Aug 1996	20:47:23.230	51.5657	-178.1639	50.9	784978	781848	5.03
02 Sep 1996	07:43:39.037	56.0257	-158.6299	56.8	785016	782861	4.09
03 Sep 1996	17:01:56.851	26.2177	-110.6010	17.7	787166	784475	4.54
13 Sep 1996	13:41:14.425	51.5348	-178.3832	37.8	802090	799045	4.79
28 Sep 1996	07:36:29.330	19.5223	-103.3653	106.2	817790	813315	4.39
26 Oct 1996	20:05:33.635	63.9703	-129.9045	0.0	842498	840276	4.16
20 Nov 1996	20:04:17.697	53.1021	-170.1523	106.7	866472	864695	4.56
08 Dec 1996	06:05:20.924	56.6991	-152.0193	0.0	880791	878849	4.73
31 Dec 1996	12:41:44.074	15.9203	-92.9564	101.5	901010	898793	5.17
11 Jan 1997	20:28:33.596	18.4022	-102.5834	86.2	916731	913142	5.46
16 Jan 1997	21:41:08.376	18.1528	-102.5713	28.3	921692	918465	4.74
27 Jan 1997	16:47:34.712	18.1132	-102.4265	21.9	930539	928395	4.62
05 Feb 1997	19:29:03.556	51.6733	-131.4566	0.0	949512	944856	4.38
10 Feb 1997	20:17:27.429	24.6444	-109.0645	19.9	951631	949792	4.58
23 Mar 1997	20:23:14.686	17.4516	-100.6249	39.4	987992	986423	4.31
03 Apr 1997	21:22:35.775	18.3444	-98.1862	108.2	996882	996277	4.65
22 May 1997	14:27:09.382	65.2941	-167.0578	0.0	1045574	1044338	4.03
02 Jun 1997	05:17:27.356	19.2436	-108.2912	20.2	1054968	1053533	4.08
16 Jun 1997	22:43:56.747	40.6893	-134.5962	29.3	1065139	1064472	4.41
20 Jun 1997	08:51:53.420	76.1133	-117.8057	0.0	1068820	1066899	3.88
19 Jul 1997	14:22:02.664	15.9121	-98.2791	0.0	1090129	1088829	4.74
19 Jul 1997	17:40:48.294	15.8092	-98.1702	0.0	1090817	1088941	4.33
21 Aug 1997	16:36:45.975	38.3161	-118.6474	0.0	1114598	1112418	4.11
06 Sep 1997	08:54:59.223	18.1449	-94.3588	53.0	1127103	1124285	4.27
07 Oct 1997	23:06:11.465	18.4959	-103.1898	67.5	1156837	1155290	4.05
11 Oct 1997	15:54:02.674	44.3156	-130.0283	25.5	1160653	1158296	4.32
18 Oct 1997	04:55:15.978	17.5186	-103.2216	26.4	1166191	1164282	4.20
26 Oct 1997	10:44:07.519	41.1437	-125.1722	0.0	1173012	1171043	4.63
28 Oct 1997	11:44:17.189	47.6350	-69.9544	0.0	1175219	1172650	4.20
02 Nov 1997	08:51:55.595	37.9078	-118.0514	0.0	1178981	1176750	4.46
02 Nov 1997	15:03:06.020	37.9593	-118.0419	0.0	1179054	1177004	3.98
05 Nov 1997	01:42:39.259	65.0515	-154.9703	0.0	1181336	1179417	4.38
05 Nov 1997	17:49:31.086	39.9189	-120.8929	0.0	1181993	1180025	4.08
06 Dec 1997	08:06:49.010	64.8726	-88.0497	0.0	1224325	1214683	5.15
12 Dec 1997	08:42:20.561	33.4598	-87.1506	0.0	1229152	1225605	4.19
02 Jan 1998	07:28:28.014	38.1251	-112.4626	0.0	1251720	1246891	4.08
03 Jan 1998	00:19:19.525	14.7216	-94.1037	18.3	1252381	1247582	4.41

03 Jan 1998	23:02:13.881	54.1651	-163.9794	18.6	1253270	1248387	5.00
26 Jan 1998	01:07:28.688	46.0033	-129.9249	0.0	1273539	1271837	4.02
03 Feb 1998	07:17:52.848	15.8724	-96.2893	22.4	1278961	1277838	4.56
03 Mar 1998	07:38:23.252	15.8807	-96.2297	28.4	1306074	1304463	4.39
05 Mar 1998	20:04:23.212	20.5918	-104.1599	41.0	1307545	1306726	4.27
25 Apr 1998	11:19:39.094	17.7317	-93.9478	64.0	1361078	1358896	4.50
20 Jun 1998	21:16:26.470	43.0961	-110.2200	43.5	19948922	19942919	3.92
09 Jul 1998	06:33:31.949	31.5660	-118.6403	38.7	20006333	20004787	4.16
12 Jul 1998	11:15:59.624	52.6221	-174.3459	167.3	20010502	20008000	4.32
17 Aug 1998	06:06:39.357	57.4813	-153.9836	38.1	20054837	20052833	4.30
24 Aug 1998	17:05:42.343	53.8035	-169.5328	197.6	20066941	20064688	4.25
28 Oct 1998	23:40:00.605	21.6607	-104.7984	0.0	20142464	20141789	4.30
30 Oct 1998	09:53:36.171	39.4273	-119.8117	35.2	20146680	20143557	4.24
05 Nov 1998	14:47:08.123	23.8974	-108.7610	22.7	20158129	20149360	4.50
26 Nov 1998	08:37:51.338	44.2815	-110.5807	0.0	20233745	20232505	4.04
26 Nov 1998	19:49:59.665	40.5811	-122.2165	66.3	20233636	20232617	4.28
30 Nov 1998	02:11:06.894	52.7107	-176.3574	220.9	20245910	20237075	4.34
16 Dec 1998	05:54:04.418	55.5713	-134.9584	0.0	20261369	20259940	4.33
01 Jan 1999	09:28:08.370	79.8784	-112.0873	0.0	20280212	20276869	4.71
18 Jan 1999	07:00:55.723	33.4916	-87.1853	0.0	20298127	20293941	4.33
29 Jan 1999	06:28:07.208	15.5078	-94.5384	37.9	20315565	20309799	4.12
31 Jan 1999	03:38:44.962	15.4534	-94.5483	38.6	20317519	20312624	4.13
23 Mar 1999	09:05:45.608	16.0001	-93.3248	83.2	20394278	20389674	4.19
18 Apr 1999	15:05:59.298	60.4396	-151.8340	68.9	20444487	20440874	4.67
05 May 1999	10:30:04.232	59.3629	-151.4984	64.6	20467602	20466067	4.93
06 May 1999	03:34:03.166	56.6460	-152.8189	24.4	20467926	20467134	4.39
19 May 1999	18:40:00.458	15.6895	-92.8379	102.6	20485908	20483482	4.15
27 May 1999	08:08:59.236	58.7516	-137.1243	0.0	20494155	20493049	5.04
01 Jun 1999	08:28:05.277	41.9474	-127.0332	19.3	20499341	20497495	4.06
01 Jun 1999	15:18:03.293	32.4606	-115.1902	0.0	20499566	20498002	4.52
10 Jun 1999	09:08:15.748	56.1975	-161.5470	177.3	20506854	20505770	4.41
15 Jun 1999	20:41:58.387	18.4072	-97.2680	0.0	20511232	20509878	5.99
03 Jul 1999	01:43:57.399	47.1465	-123.2960	61.7	20526849	20523419	4.91
08 Aug 1999	04:45:16.871	40.9976	-127.4601	30.4	20550709	20550101	4.17
11 Sep 1999	21:23:26.626	60.2501	-136.6404	0.0	20572130	20570821	4.23
22 Oct 1999	17:51:16.187	38.0773	-112.7537	0.0	20599042	20597117	4.05
06 Nov 1999	18:03:34.343	43.6733	-105.1608	0.0	20608373	20607067	4.13
10 Nov 1999	21:05:07.420	43.3874	-104.8771	0.0	20610742	20610318	4.17
11 Nov 1999	23:33:43.602	15.7783	-92.9018	99.5	20611763	20610824	4.06
07 Dec 1999	05:35:55.426	75.5682	-121.2143	0.0	20632492	20631268	4.64
08 Dec 1999	22:01:10.283	18.3839	-104.5044	14.4	20634058	20632980	4.46

14 Dec 1999	07:12:16.899	18.2819	-98.4349	55.8	20638922	20636762	4.40
29 Dec 1999	20:01:47.643	43.7928	-105.3533	0.0	20654692	20649997	4.05
01 Jan 2000	11:22:56.120	46.8342	-78.8227	0.0	20656512	20652935	4.53
08 Jan 2000	02:17:35.953	40.5577	-126.1892	29.4	20660678	20658668	4.41
18 Jan 2000	19:52:02.803	43.9141	-105.3644	0.0	20666500	20665232	4.26
07 Mar 2000	04:32:28.453	19.4258	-103.8331	89.1	20725099	20708173	4.19
02 May 2000	06:45:47.225	32.4261	-115.0917	0.0	20778478	20775666	4.08
02 May 2000	23:59:17.932	59.7009	-139.4469	0.0	20783686	20776600	5.00

TABLE 10

LIST OF 348 IRIS AND USGS STATIONS USED FOR CEB EVENTS IN NORTH AMERICA

STATION	LAT	LON	ELEV(KM)	LOCATION
AAE	9.0292	38.7656	2.4420	Addis Ababa, Ethiopia
AAM	42.3012	-83.6567	0.1720	Ann Arbor, Michigan, USA
ABL	34.8508	-119.2208	1.9810	Mount Abel, California, USA
ADK	51.8837	-176.6844	0.1160	Adak, Aleutian Islands, Alaska, USA
AFI	-13.9093	-171.7772	0.7080	Afiamalu, Samoa
AHID	42.7654	-111.1004	1.9600	Auburn Hatchery, Idaho, USA
ALE	82.4800	-62.4000	0.0000	Alert, Nunavut, Canada
AMBA	-8.1060	33.2588	1.4150	Tanzania
ANMO	34.9462	-106.4567	1.8400	Albuquerque, New Mexico, USA
ARUT	37.7880	-113.4403	1.6460	Antelope Range, Utah, USA
ASBS	33.6208	-116.4664	1.4000	California, USA
ASMM	38.8233	-120.6833	1.2140	Slate Mountain, California, USA
BAR	32.6800	-116.6720	0.5480	Barrett Dam, California, USA
BEKR	39.8667	-120.3586	1.7430	Beckwourth, California, USA
BHU	37.5925	-112.8570	3.2300	Blowhard Mountain, UT, USA
BILL	68.0651	166.4524	0.2990	Bilibino, Russia
BINY	42.1993	-75.9861	0.4980	Binghamton, New York, USA
BISC	46.0272	-78.2407	0.0000	Bisset Creek, Ontario, Canada
BLA	37.2113	-80.4210	0.6340	Blacksburg, Virginia, USA
BMN	40.4315	-117.2217	1.5000	Battle Mountain, Nevada, USA
BMW	46.4750	-123.2280	0.8700	Boistfort Mountain, Washington, USA
BNM	34.1502	-106.6278	2.1210	Barren Site, New Mexico, USA
BOCO	4.5869	-74.0432	3.1370	Bogota, Colombia
BOSA	-28.6137	25.2559	1.2800	Boshof, Free State, South Africa
BOZ	45.6470	-111.6296	1.5890	Bozeman, Montana, USA
BTU	37.7557	-111.8743	3.2350	Barney Top, UT, USA
BW06	42.7667	-109.5583	2.2240	Boulder Array Site 6 (Pinedale), Wyoming, USA
BZN	33.4915	-116.6670	1.3010	Buzz Northern's Place, Terwilliger, Calif.
CALA	40.1134	-108.5358	2.3450	Caldeira, Azores, Portugal
CALB	34.1430	-118.6269	0.0000	Calabasas, California, USA
CALI	40.3653	-108.5670	2.0850	Calico Draw, Colorado, USA
CASY	-66.2792	110.5364	0.1540	Casey, Antarctica

CBKS	38.8140	-99.7374	0.6770	Cedar Bluff, Kansas, USA
CCM	38.0557	-91.2446	0.2740	Cathedral Cave, Missouri, USA
CEH	35.8900	-79.0900	0.0000	Chapel Hill, North Carolina, USA
CHF	34.3334	-118.0259	1.5670	Chilao Flats, California, USA
CHMT	46.9143	-113.2519	2.0770	Chamberlain Mountain, Montana, USA
CHTO	18.7900	98.9769	0.3160	Chiang Mai, Thailand
CIA	33.4020	-118.4152	0.4280	Catalina Island Airport, California, USA
CIU	33.4458	-118.4830	0.2330	Catalina Island, California, USA
CMB	38.0350	-120.3850	0.7190	Columbia College, California, USA
CMK	46.9346	-121.2285	1.3800	Chipmunk Creek, Washington, USA
CMLA	37.7637	-25.5243	0.4290	Cha de Macela, Sao Miguel Island, Azores
COL	64.9000	-147.7933	0.3200	College Outpost, Alaska, USA
COLA	64.8738	-147.8511	0.0740	College Outpost, Alaska, USA
COR	44.5857	-123.3032	0.1210	Corvallis, Oregon, USA
CPUP	-26.3306	-57.3292	0.0050	Villa Florida, Paraguay
CRY	33.5654	-116.7373	1.1280	Cary Ranch, Anza, Calif.
CRZF	-46.4300	51.8610	0.1400	Port Alfred, Crozet, South Indian Ocean
CSD	40.4364	-108.2792	1.9310	Cedar Spring Draw, Colorado, USA
CTU	40.6925	-111.7503	1.7310	Camp Tracy, Utah, USA
CVR	37.4512	-121.7991	0.2650	Calaveras Reservoir, California, USA
CWC	36.4399	-118.0802	1.5530	Cottonwood Creek Canyon, California, USA
CYF	37.5542	-109.8658	2.0570	Cyclone Flat, Utah, USA
DAC	36.2770	-117.5936	1.8140	Darwin, California, USA
DAN	34.6371	-115.3805	0.3980	Danby, California, USA
DAU	40.4125	-111.2558	2.7710	Daniels Canyon, Utah, USA
DAV	7.0878	125.5747	0.0850	Davao, Mindanao, Phillipines
DBO	43.1192	-123.2427	0.9800	Dodson Butte, Oregon, USA
DGR	33.6500	-117.0090	0.7000	Domenigoni Valley Reservoir, California, USA
DIV	61.1295	-145.7716	0.9310	Divide, Alaska, USA
DJJ	34.1058	-118.4538	0.2450	Donna Jones Jenkins, California, USA
DOUG	40.5703	-108.6886	2.1530	Douglas Mountain, Colorado, USA
DPW	47.8706	-118.2028	0.8920	Davenport, Washington, USA
DRLN	49.2560	-57.5042	0.2380	Deer Lake, Newfoundland, Canada
DRY	40.6995	-108.5367	2.0590	Dry Mountain, Colorado, USA
DUG	40.1960	-112.8163	1.4770	Dugway, Utah, USA
DWPF	28.1102	-81.4327	0.0200	Disney Wilderness Preserve, Florida, USA
DWU	38.1053	-112.9975	2.2700	Dry Willow, Utah, USA
EFI	-51.6753	-58.0637	0.1100	Mount Kent, East Falkland Island
EKU	37.0747	-112.4968	1.8290	East Kanab, Utah, USA
ELK	40.7448	-115.2387	2.2100	Elko, Nevada, USA
ELKS	33.5813	-116.4496	1.1690	California, USA

ERW	48.4540	-122.6250	0.3890	Mount Erie, Washington, USA
EYMN	47.9462	-91.4950	0.4750	Ely, Minnesota, USA
FERN	37.1526	-121.8123	0.5180	Fern Peak, California, USA
FFC	54.7200	-101.9800	0.0000	Flin Flon, Manitoba, Canada
FRD	33.4947	-116.6022	1.1640	Ford Ranch, Terwillger, Calif.
FSU	39.7225	-113.3913	1.4870	Fish Springs, UT, USA
FWGP	40.9642	-108.7681	2.0770	Fonce wash-gravel pit, Colorado, USA
GAC	45.7033	-75.4783	0.0620	Glen Almond, Quebec, Canada
GAR	38.8808	-114.1020	1.9770	Garrison, Utah-Nevada border, USA
GDL2	32.2003	-104.3635	1.2130	Guadalupe Mountain, New Mexico, USA
GLA	33.0500	-114.8300	0.0000	Glamis, California, USA
GLAC	33.6014	-116.4781	1.1690	California, USA
GLD	39.7506	-105.2213	1.7620	Golden, Colorado, USA
GMW	47.5479	-122.7863	0.5060	Gold Mountain, Washington, USA
GNW	47.5644	-122.8253	0.1600	Green Mountain, Washington, USA
GOGA	33.4112	-83.4666	0.1500	Godfrey, Georgia, USA
GOU	61.1892	-149.8003	0.0710	Gould Hall, Alaska, USA
GPO	35.6494	-117.6619	0.7350	China Lake , California, USA
GRAN	41.1084	-108.6420	2.1640	Granary Draw, Colorado, USA
GSC	35.3017	-116.8046	0.9900	Goldstone, California, USA
GUMO	13.5878	144.8662	0.0140	Guam, Marianas Islands
GWDE	38.8256	-75.6171	0.0190	Greenwood, Delaware, USA
HAWA	46.3925	-119.5326	0.3640	Hanford, Washington, USA
HAYW	43.6396	-110.3325	2.8350	Haystack Fork, Wyoming, USA
HELL	41.0470	-108.5767	2.1530	Hells Canyon, Colorado, USA
HIAW	41.0148	-108.7345	2.1050	Hiawatha Road, Colorado, USA
HKT	29.9618	-95.8384	-0.4150	Hockley, Texas, USA
HLID	43.5625	-114.4138	1.7720	Hailey, Idaho, USA
HNR	-9.4322	159.9471	0.0720	Honiara, Solomon Islands
HOPE	-54.2836	-36.4879	0.0200	Hope Point, South Georgia
HRV	42.5060	-71.5580	0.1810	Harvard--Oak Ridge, Massachusetts, USA
HRY	46.7113	-111.8311	1.3410	Holter Research Foundation--York Bridge, Montana, USA
HSO	43.5258	-123.0899	1.0200	Harness Mountain, Oregon, USA
HVU	41.7797	-112.7750	1.6090	Hansel Valley, Utah, USA
HWUT	41.6069	-111.5652	1.8300	Hardware Ranch, Cache County, Utah, USA
ICAN	37.5049	-121.3278	0.3120	Ingram Canyon, California, USA
ICU	37.1497	-113.9235	1.4510	Indian Springs Canyon, Utah, USA
IMA	66.0685	-153.6786	1.3800	Indian Mountain, Alaska, USA
IMU	38.6332	-113.1583	1.8330	Iron Mountain, Utah, USA
ISA	35.6633	-118.4733	0.8350	Isabella, California, USA
ISCO	39.7997	-105.6134	2.7430	Idaho Springs, Colorado, USA

ITIT	-20.2551	-63.1582	0.8230	Bolivia
JCS	33.0859	-116.5959	1.2580	Julian Camp Stevens, California, USA
JCT	30.4794	-99.8022	0.5910	Junction, Texas, USA
JFWS	42.9143	-90.2481	0.3350	Jewell Farm, Wisconsin, USA
JNMT	40.4592	-108.0203	2.2310	Juniper Mountain, Colorado, USA
JSC	34.2789	-81.2580	0.1200	Jenkinsville, South Carolina, USA
JTS	10.2908	-84.9525	0.3400	Juntas de Abangares, Costa Rica
JWM	40.5717	-108.6039	2.0770	John Weller Mesa, Colorado, USA
KBRM	40.7298	-123.9556	0.8530	Barry Ridge, California, USA
KBS	78.9175	11.9239	0.0460	Kingsbay, Svalbard, Norway
KDAK	57.7828	-152.5834	0.1520	Kodiak Island, Alaska, USA
KDC	57.7500	-152.4900	0.0000	Kodiak, Alaska, USA
KIBA	-5.3223	36.5695	1.5000	Tanzania
KINN	41.1801	-108.5926	2.2920	Kinney Rim, Colorado, USA
KIP	21.4233	-158.0149	0.0700	Kipapa, Oahu, Hawaii, USA
KIPM	39.8087	-123.4804	1.3670	Iron Peak, California, USA
KMBO	-1.1268	37.2523	1.9400	Kilima Mbogo, Kenya
KMI	25.1233	102.7400	1.9400	Kunming, Yunnan Province, China
KNB	37.0200	-112.8200	0.0000	Kanab, Utah, USA
KNW	33.7141	-116.7119	1.5070	Keenwild Fire Station, Mountain Center
LANG	40.8731	-108.2906	2.2580	Lang Springs, Colorado, USA
LAZ	34.4020	-107.1393	1.8530	Ladron, New Mexico, USA
LBNH	44.2401	-71.9259	0.3670	Lisbon, New Hampshire, USA
LBTB	-25.0151	25.5966	1.1280	Lobatse, Botswana
LCCM	45.8377	-111.8781	1.6690	Lewis and Clark Caverns, Montana, USA
LDS	37.2425	-113.3514	1.1010	Leeds, Washington County, Utah, USA
LENM	34.1655	-106.9741	1.6980	Lemitar, New Mexico, USA
LGU	34.1082	-119.0659	0.3810	Laguna Peak, California, USA
LHS	34.4792	-80.8083	0.1200	Liberty Hill, South Carolina, USA
LIME	40.8714	-108.7859	2.3710	Limestone Gap, Colorado, USA
LKC	37.7380	-122.0638	0.3120	Lake Chabot, California, USA
LKWY	44.5652	-110.4000	2.4240	Lake (Yellowstone--Lake), Wyoming, USA
LLLB	50.6090	-121.8815	0.7000	Lillooet, B.C.
LMP	37.9783	-111.1960	1.9220	Lampstand, Utah, USA
LNOR	45.8711	-118.2850	0.7680	Lincton Mountain, Oregon, USA
LON	46.7500	-121.8099	0.0000	Longmire, Washington, USA
LOOK	40.8634	-108.4823	2.4150	Lookout Mountain, Colorado, USA
LPM	34.3117	-106.6318	1.7370	Los Pinos Mountain, New Mexico, USA
LRV	36.4248	-121.0183	0.5410	Little Rabbit Valley, California, USA
LSA	29.7000	91.1500	3.7740	Lhasa, Tibet, China
LSC	40.5328	-108.4414	1.8020	Little Snake Canyon, Colorado, USA

LSCT	41.6784	-73.2244	0.3180	Lakeside, Connecticut, USA
LSZ	-15.2766	28.1882	1.1850	Lusaka, Zambia
LTX	29.3339	-103.6669	1.0130	Lajitas, Texas, USA
LTY	47.2559	-120.6648	0.9700	Liberty, Washington, USA
LVA2	33.3516	-116.5615	1.4350	Lost Valley Boy Scout Camp, California, USA
LVC	-22.6128	-68.9113	2.1650	Limon Verde, Chile
MA2	59.5756	150.7700	0.3390	Magadan, Russia
MAJO	36.5425	138.2072	0.4050	Matsushiro, Japan
MAYB	40.4828	-108.1928	1.8880	East of Maybell, Colorado, USA
MBC	76.2420	-119.3600	0.0150	Mould Bay, Canada
MCK	63.7323	-148.9349	0.6100	McKinley, Alaska, USA
MCMT	44.8277	-112.8488	2.3230	McKenzie Canyon, Montana, USA
MCWV	39.6581	-79.8456	0.2800	Mont Chateau, West Virginia, USA
MIAR	34.5457	-93.5730	0.2070	Mount Ida, Arkansas, USA
MITU	-6.0192	34.0560	1.5660	Tanzania
MLAC	37.6310	-118.8340	2.1700	Mammoth Lakes, California, USA
MLC	38.9883	-116.7680	2.2920	Mill Canyon, Nevada, USA
MM02	42.1660	-73.7187	0.1340	Hudson, New York, USA
MM04	41.8530	-76.1980	0.4730	LeRaysville, Pennsylvania, USA
MM05	41.6530	-76.9220	0.7010	Gleason, Pennsylvania, USA
MM06	41.3915	-78.1262	0.6470	Emporium, Pennsylvania, USA
MM07	41.2571	-79.1350	0.5180	Sigel, Pennsylvania, USA
MM08	41.1095	-80.0682	0.3810	Slippery Rock , Pennsylvania, USA
MM09	40.7911	-81.2056	0.3570	East Canton, Ohio, USA
MM10	40.6147	-82.3031	0.3460	Bellville, Ohio, USA
MM11	40.2214	-83.1947	0.2830	Columbus, Ohio, USA
MM12	40.0439	-84.3725	0.3050	Laura, Ohio, USA
MM13	39.8317	-85.3114	0.3370	Spiceland, Indiana, USA
MM14	39.5494	-86.3948	0.2900	Brooklyn, Indiana, USA
MM15	39.2945	-87.3135	0.1906	Terra Haute, Indiana, USA
MM16	38.9219	-88.3046	0.1650	Lake Newton, Illinois, USA
MM17	38.6694	-89.3255	0.1438	Lake Carlyle, Illinois, USA
MM18	38.5287	-90.5686	0.1856	Tyson, Missouri, USA
MMU	38.1985	-111.2943	2.3870	Miners Mountain, Utah, USA
MNV	38.4328	-118.1531	1.5240	Mina, Nevada, USA
MOD	41.9033	-120.3058	0.3000	Modoc, California, USA
MPM	36.0580	-117.4890	0.1853	Manuel Prospect Mine, California, USA
MPU	40.0155	-111.6333	1.9090	Maple Canyon, Utah, USA
MSEY	-4.6737	55.4792	0.4750	Mahe Island, Seychelles
MSU	38.5133	-112.1741	2.1410	Marysvale, Utah, USA
MSVF	-17.7333	178.0500	0.7830	Monasavu, Fiji

MTPC	35.4848	-115.5533	1.5820	Mountain Pass, California, USA
MTUM	37.3533	-118.5634	1.8100	Tungsten Hills, California, USA
MVU	38.5037	-112.2123	2.2400	Marysvale, Utah, USA
MWC	34.2237	-118.0529	1.6960	Mount Wilson, California, USA
MYNC	35.0739	-84.1279	0.5500	Murphy, North Carolina, USA
NAU	-0.5063	166.9326	0.0010	Nauru
NCB	43.9708	-74.2235	0.5000	Newcomb, New York, USA
NDH	40.3706	-108.1364	1.9570	North Danford Hills, Colorado, USA
NEE	34.8230	-114.5960	0.1390	Needles, California, USA
NEW	48.2633	-117.1200	0.7600	Newport, Washington, USA
NIL	33.6500	73.2517	0.5360	Nilore, Pakistan
NMU	38.5165	-112.8500	1.8530	North Mineral Mountains, Utah, USA
NNA	-11.9875	-76.8422	0.5750	Nana, Peru
NOQ	40.6525	-112.1203	1.6220	North Oquirrh Mountains, Utah, USA
NSHM	38.5200	-122.6071	0.3280	Saint Helena Road, California, USA
NWAO	-32.9266	117.2333	0.2650	Narrogin, Australia
NWC	37.6332	-113.5566	1.7500	Newcastle, Utah, USA
OCWA	47.7489	-124.1781	0.6710	Octopus Mountain, Washington, USA
OFR	47.9333	-124.3947	0.1500	Olympics - Forest Resource Center, Washington, USA
OHCM	39.3357	-121.4840	0.0790	Honcut, California, USA
OSI	34.6145	-118.7235	0.7060	Osito Adit, California, USA
OWUT	38.7800	-111.4237	2.5680	Old Woman Plateau, Utah, USA
OXF	34.5120	-89.4090	0.1010	Oxford, Mississippi, USA
PAB	39.5458	-4.3483	0.9250	San Pablo de los Montes, Spain
PAHR	39.7065	-119.3841	1.5000	Pah Rah Range, Nevada, USA
PAS	34.1483	-118.1717	0.2950	Pasadena, California, USA
PAYG	0.6741	-90.2863	0.1950	Puerto Ayora, Galapagos Islands
PET	53.0235	158.6498	0.1500	Petropavlovsk, Russia
PFO	33.6092	-116.4553	1.2800	Pinon Flat, California, USA
PHL	35.4082	-120.5455	0.3510	Parkhill, California, USA
PHR	37.6483	-114.9890	1.5850	Pahroc, Nevada, USA
PIN	43.8111	-120.8719	1.8600	Pine Mt., Oregon, USA
PINR	40.3634	-108.3684	2.0970	Pinyon Ridge, Colorado, USA
PLAL	34.9824	-88.0755	0.1650	Pickwick Lake, Alabama, USA
PLM	33.3537	-116.8627	1.6600	Palomar, California, USA
PMB	50.5188	-123.0765	0.4000	Pemberton, British Columbia, Canada
PMG	-9.4092	147.1539	0.0670	Port Moresby, Papua New Guinea
PMR	61.5922	-149.1308	0.1000	Palmer, Alaska, USA
PMSA	-64.7742	-64.0490	0.0100	Palmer Station, Antarctica
PNI	7.0060	158.1518	0.0010	Pohnpei, Piemonte, Italy
PNT	49.3167	-119.6166	0.5500	Penticton, British Columbia, Canada

POW	40.9353	-108.4212	2.1690	Powder Wash, Colorado, USA
PPT	-17.5690	-149.5760	0.3400	Pamatai, Papeete, Tahiti (Pacific Ocean)
PSI	2.6938	98.9237	0.9870	Prapat, Sumatera, Indonesia
PTGA	-0.7308	-59.9666	0.2370	Pitinga, Amazonas, Brazil
PTI	42.8703	-112.3701	1.6700	Pocatello Creek, Idaho, USA
PTRM	35.6547	-120.2111	0.6430	Twissleman Ranch, California, USA
PV09	38.4987	-109.1334	2.6520	Paradox Valley (North La Sal), Utah, USA
PV10	38.3763	-109.0388	2.3160	Paradox Valley (South La Sal), Colorado, USA
PWLA	34.9800	-88.0637	0.2040	Pickwick Lake, Alabama, USA
QLMT	44.8317	-111.4274	2.0120	Earthquake Lake, Montana, USA
RAIO	46.0403	-122.8851	0.0110	Rainier, Oregon, USA
RC01	61.0894	-149.7366	0.3740	Rabbit Creek Array Site 1, Alaska, USA
RCC	40.5162	-110.5856	2.2800	Rock Corral Creek, Utah, USA
RDM	33.6300	-116.8478	1.3650	Red Mountain, Riverside Co., California, USA
REDW	43.3624	-110.8518	2.1920	Red Top Meadow, Wyoming, USA
RES	74.6870	-94.9000	0.0150	Resolute, Nunavut, Canada
RMW	47.4597	-121.8053	1.0240	Rattlesnake Mountain, Washington, USA
ROSL	-19.4857	-64.1779	2.0730	Bolivia
RPN	-27.1267	-109.3343	0.1100	Rapa Nui, Easter Island, Valparaiso, Chile
RPV	33.7438	-118.4035	0.1150	Rancho Palos Verde California, USA
RRE	41.1687	-108.7323	2.3530	Rifle Rim East, Colorado, USA
RRW	41.1389	-108.8589	2.3200	Rifle Rim West, Colorado, USA
RSO	60.4622	-152.7538	1.9210	Redoubt South, Alaska, USA
RSSD	44.1200	-104.0360	2.0600	Black Hills, South Dakota, USA
RUNG	-6.9372	33.5180	1.2300	Tanzania
RW3	38.2502	-107.6870	2.6030	Ridgway, Colorado, USA
RWW	46.9639	-123.5432	0.0100	Ranney Well, Washington, USA
SAC	37.5825	-122.4171	0.2070	San Andreas, California, USA
SALI	-19.6207	-67.7263	3.7790	Bolivia
SAVY	37.3889	-121.4956	0.6000	San Antonio Valley, California, USA
SBA	-77.8491	166.7573	0.0200	Scott Base, Antarctica
SBC	34.4417	-119.7133	0.0900	Santa Barbara, California, USA
SCCK	35.0228	-82.9915	0.7010	Coley Creek, South Carolina, USA
SCHO	-19.1480	-64.6428	2.5910	Bolivia
SCZ	36.5980	-121.4030	0.2610	Chualar Canyon, Santa Cruz, California, U.S.A.
SDD	33.5531	-117.6618	0.9140	Saddleback College, California, USA
SDN	55.3413	-160.4971	0.0230	Sand Point, Alaska, USA
SDV	8.8790	-70.6330	1.5500	Santo Domingo, Venezuela
SFJ	66.9967	-50.6156	0.3650	Sondre Stromfjord, Greenland
SFTN	35.3575	-90.0187	-0.0220	Shelby Forest, Tennessee, USA
SGS	33.1927	-80.5118	0.0240	Saint George, South Carolina, USA

SHEL	-15.9588	-5.7457	0.5370	Horse Pasture, St. Helena Island
SHUM	33.6327	-116.4445	1.1950	California, USA
SHW	46.1925	-122.2366	1.4230	Mount Saint Helens, Washington, USA
SIT	57.0570	-135.3244	0.0190	Sitka, Alaska, USA
SIUC	37.7149	-89.2176	0.1370	Southern Illinois University (Carbondale), USA
SJG	18.1117	-66.1500	0.4570	San Juan, Puerto Rico
SLA	35.8908	-117.2834	1.1900	Slate Mt., California, USA
SLM	38.6361	-90.2361	0.1610	Saint Louis, Missouri, USA
SMR	40.7217	-108.3028	1.9000	Seven Mile Ridge, Colorado, USA
SMTC	32.9490	-115.7200	-0.0500	Superstition Mountain, California, USA
SNCC	33.2480	-119.5240	0.2270	San Nicolas Island, California, USA
SND	33.5519	-116.6129	1.3580	Jim Saunders Place, Anza, California, USA
SOL	32.8410	-117.2480	0.2450	MPL Laboratory, Mt. Soledad, La Jolla, California, USA
SPA	-89.9990	115.0000	2.9270	South Pole, Antarctica
SPU	61.1817	-152.0543	0.8000	Mount Spurr, Alaska, USA
SRS	38.9127	-110.6016	2.0190	San Rafael Swell, Utah, USA
SRU	39.1108	-110.5238	1.8040	San Rafael, Utah, USA
SSOR	44.8560	-122.4605	1.2400	Sweet Springs, Oregon, USA
SSPA	40.6401	-77.8914	0.2520	Standing Stone, Pennsylvania, USA
SSW	46.9723	-123.4338	0.1200	Satsop, Washington, USA
STEW	44.0497	-110.6817	2.3160	Steamboat Mountain, Wyoming, USA
SUR	-32.3797	20.8117	1.7700	Sutherland, South Africa
SUTT	40.5787	-108.2859	1.8520	Suttles Basin, Colorado, USA
SVD	34.1045	-117.0970	0.6000	Seven Oaks Dam, California, USA
SWB	40.6542	-108.3806	1.8150	Sandy Wash Basin, Colorado, USA
TANK	40.4053	-108.7370	2.4410	Tanks Peak, Colorado, USA
TEIG	20.2264	-88.2766	0.0690	Tepich, Yucatan, Mexico
TIN	37.0542	-118.2301	1.1640	Tinemaha, California, USA
TIXI	71.6490	128.8665	0.0500	Tiksi, Sakha, Russia
TMI	43.3056	-111.9180	2.1790	Taylor Mountain, Idaho, USA
TOV	34.1560	-118.8190	0.0500	Thousand Oaks, California, USA
TPH	38.0750	-117.2225	1.8830	Tonopah, Nevada, USA
TPNV	36.9488	-116.2495	1.6000	Topopah Spring, Nevada, USA
TRO	33.5234	-116.4256	2.6280	Tromso, Norway
TRW	46.2922	-120.5419	0.7200	Toppenish Ridge, Washington, USA
TSUM	-19.2022	17.5838	1.2400	Tsumeb, Namibia
TTA	62.9301	-156.0116	0.9900	Tatalina, Alaska, USA
TTW	47.6946	-121.6889	0.5400	Tolt Res, Washington, USA
TUC	32.3096	-110.7845	0.8740	Tucson, Arizona, USA
TWIN	40.7556	-108.3845	1.8830	Twin Buttes, Colorado, USA
UNM	19.3300	-99.1900	0.0000	Universidad Nacional Autonoma de Mexico (UNAM)

UNV	53.8465	-166.5019	0.0670	Unalaska Valley, Alaska, USA
USC	34.0200	-118.2799	0.0000	University of Southern California, USA
VCS	34.4840	-118.1118	0.9620	Vincent SCE, California, USA
VGB	45.5157	-120.7774	0.7290	Gordon Butte, Oregon, USA
VIPM	44.5082	-120.6188	1.7300	Ingram Point, Oregon, USA
VMCK	41.0789	-108.7098	2.1360	Vermillion Creek, Colorado, USA
VMSC	40.9284	-108.6484	2.0060	Vermillion-Shell con, Colorado, USA
VTV	34.5670	-117.3330	0.8470	Victorville, California, USA
WADM	36.3661	-89.7959	0.0780	Wardell, Missouri, USA
WCI	38.2290	-86.2940	0.5060	Wyandotte Cave, Indiana, USA
WCN	39.3106	-119.7563	1.7090	Washoe City, Nevada, USA
WCP	40.5242	-114.1670	1.5730	Wildcat Peak, Nevada, USA
WCU	38.9647	-112.0900	2.7140	Willow Creek, Utah, USA
WHY	60.6597	-134.8806	1.2920	Whitehorse, Yukon Territory, Canada
WJPM	35.4108	-118.4806	1.1220	Johns Peak, California, USA
WMC	33.5736	-116.6746	1.2710	Walmic Ranch, Anza, California, USA
WMOK	34.7379	-98.7810	0.4860	Wichita Mountains, Oklahoma, USA
WMT	40.1111	-112.8380	1.5160	West Mountain, Utah, USA
WMUT	40.0767	-111.8333	1.9810	West Mountain, Utah, USA
WRAB	-19.9336	134.3600	0.3660	Tennant Creek, NT, Australia
WUAZ	35.5169	-111.3738	0.0000	Wupatki, Arizona, USA
WVOR	42.4339	-118.6367	1.3440	Wild Horse Valley, Oregon, USA
WVT	36.1300	-87.8300	0.1570	Waverly, Tennessee, USA
YAK	62.0308	129.6812	0.1050	Yakutsk, Russia
YBH	41.7318	-122.7105	0.9690	Yreka Blue Horn, California, USA
YSCF	40.4289	-108.4301	1.9660	Yampa-Snake Con, Colorado, USA
YSNY	42.4758	-78.5375	0.6280	Yorkshire, New York, USA
YUNZ	-19.1582	-65.0687	2.8960	Bolivia
ZENO	40.6028	-108.8245	2.3020	Zenobia Peak, Colorado, USA

TABLE 11

LIST OF 163 CEB EVENTS IN NORTH AMERICA: REVISED IDC LOCATIONS

DATE	ORIGIN TIME	LAT	LON	DEPTH	ORID	EVID
29 Jan 1995	03:11:22.434	47.3841	-122.3463	17.7	20437149	291130
03 Feb 1995	15:26:13.760	41.5352	-109.7877	13.8	20437152	294226
12 Feb 1995	20:13:37.557	59.6453	-153.3318	113.4	20437148	300649
19 Feb 1995	04:03:16.323	40.7164	-125.8081	0.0	20437145	304146
11 Mar 1995	08:15:53.901	36.8437	-82.9307	0.0	20437141	313623
14 Mar 1995	17:33:52.128	54.7869	-161.2716	35.0	20437144	315467
20 Mar 1995	12:46:17.856	40.2277	-108.7354	0.0	20437140	318146
26 Mar 1995	05:57:13.666	54.8642	-161.3542	40.5	20437136	321000
01 Apr 1995	07:12:29.475	53.6416	-164.6201	39.6	20437137	324117
14 Apr 1995	00:32:57.995	30.2727	-103.4484	22.7	20437133	331268
07 May 1995	11:03:30.489	33.5766	-116.4434	0.0	20437130	347247
17 May 1995	02:29:13.094	39.6844	-122.5056	0.0	20437132	351985
22 May 1995	20:08:31.688	58.7581	-156.0667	155.2	20437127	356346
23 May 1995	15:48:07.685	51.2115	-177.1838	35.8	20437126	356869
04 Jun 1995	01:07:39.106	54.0826	-164.2096	40.7	20437120	365972
06 Jun 1995	04:04:55.069	60.2863	-146.8341	0.0	20437121	366977
19 Jun 1995	14:45:37.111	58.9926	-151.5013	32.2	20437117	373986
26 Jun 1995	08:40:26.312	34.1376	-118.6814	0.0	20437116	376495
08 Jul 1995	17:15:29.298	53.7305	-164.0526	36.3	20437113	381690
14 Jul 1995	19:06:28.607	53.2787	-166.9039	36.1	20437112	384488
20 Jul 1995	08:53:04.751	52.8800	-174.4002	225.6	20437109	386795
09 Aug 1995	11:30:00.061	42.6752	-107.6335	0.0	20437123	399601
17 Aug 1995	22:39:58.222	35.6184	-117.7308	4.7	20437108	404828
18 Aug 1995	09:18:09.260	53.5934	-163.8101	38.7	20437104	405318
19 Aug 1995	22:03:24.914	50.5751	-170.3945	0.0	20437105	406213
28 Aug 1995	03:16:26.290	44.2363	-109.9817	0.0	20437101	411834
28 Aug 1995	10:46:10.874	26.0159	-110.2702	0.0	20437100	412033
28 Aug 1995	12:23:07.725	26.0333	-110.0055	19.1	20437096	412064
31 Aug 1995	08:20:53.008	69.3055	-147.2153	0.0	20437097	413474
18 Nov 1995	09:07:23.550	64.1382	-147.7292	102.6	20437093	465813
31 Dec 1995	04:30:58.101	51.9123	-165.8359	31.4	20437089	525209
04 Jan 1996	19:43:14.833	52.4657	-170.7289	56.2	20437092	530178

08 Jan 1996	09:20:16.290	16.1937	-98.2274	14.1	20816123	533390
07 Feb 1996	21:19:06.332	55.3106	-156.4989	4.3	20437088	568417
20 Feb 1996	00:52:07.730	43.3278	-126.9555	0.0	20437084	576944
22 Feb 1996	20:13:43.462	19.7847	-109.3001	0.0	20816126	579218
25 Feb 1996	03:08:12.568	15.8484	-97.9227	0.0	20816121	580915
25 Feb 1996	04:17:09.200	16.0765	-97.7337	16.3	20816136	580978
25 Feb 1996	05:34:30.148	15.9815	-97.7977	33.2	20816130	581074
25 Feb 1996	09:17:58.417	16.0114	-97.8687	15.2	20816132	581316
25 Feb 1996	14:27:29.432	16.1169	-97.6699	15.2	20816135	581571
25 Feb 1996	15:09:28.324	16.0853	-97.8019	81.5	20816127	581626
03 Mar 1996	23:44:35.779	56.4543	-152.6590	18.0	20437085	587402
13 Mar 1996	21:04:19.777	16.7385	-99.0088	26.0	20816105	599040
14 Mar 1996	09:12:09.012	19.5605	-91.8756	0.0	20816103	599600
18 Mar 1996	08:02:01.276	49.9511	-126.9659	13.4	20437081	604564
19 Mar 1996	15:31:36.676	25.1039	-109.1438	0.0	20437080	605911
19 Mar 1996	17:12:41.724	15.8396	-97.1792	18.5	20816102	606016
20 Mar 1996	04:53:22.151	15.6441	-97.3044	0.0	20816099	606526
27 Mar 1996	12:34:49.877	16.3908	-97.8620	24.3	20816098	615815
28 Mar 1996	01:48:24.508	52.2632	-168.7226	34.0	20437076	616486
28 Mar 1996	19:51:08.002	52.3860	-168.8548	26.1	20437073	617367
28 Mar 1996	21:32:48.884	52.3897	-168.7538	16.0	20437077	617475
01 Apr 1996	03:43:03.900	16.5221	-95.9765	59.3	20816095	621062
20 Apr 1996	06:33:23.630	54.7561	-161.1450	33.4	20437072	642949
21 Apr 1996	03:00:17.855	18.1251	-111.6981	0.0	20816093	644009
23 Apr 1996	06:53:34.712	17.1006	-101.2821	24.7	20816091	647379
09 May 1996	21:54:21.077	19.1576	-104.5832	64.3	20816088	668161
16 May 1996	22:13:52.529	18.3363	-111.2888	52.4	20816084	676670
03 Jun 1996	11:55:24.039	17.6577	-94.1745	161.3	20816086	691725
07 Jun 1996	23:07:09.924	69.4316	-125.3885	41.9	20816081	696672
08 Jun 1996	23:19:17.517	51.5177	-178.0646	41.6	20437068	697652
10 Jun 1996	04:03:36.815	51.6068	-177.5938	33.7	20437064	699173
10 Jun 1996	04:53:45.930	51.1743	-178.1330	35.5	20437069	699233
10 Jun 1996	17:44:18.389	51.5999	-176.8899	36.4	20437061	700421
11 Jun 1996	10:40:07.979	51.3588	-176.1849	21.7	20437065	702009
11 Jun 1996	11:00:46.750	51.3732	-176.1320	16.1	20437060	702034
11 Jun 1996	13:03:06.341	51.2477	-176.4358	44.1	20437057	702145
25 Jun 1996	18:52:22.099	14.8657	-92.2075	69.4	20816080	719054
10 Jul 1996	05:48:21.314	52.2159	-171.1795	37.2	20437053	737937
15 Jul 1996	21:23:32.547	17.3954	-101.0156	4.2	20816077	742188
19 Jul 1996	09:00:53.679	17.3748	-100.0488	41.9	20816076	745363
21 Jul 1996	20:38:19.346	64.4059	-137.7358	0.0	20816073	746895

24 Jul 1996	20:15:45.422	41.9611	-126.0338	0.0	20437052	751389
03 Aug 1996	06:15:17.476	44.5153	-114.1725	0.0	20437048	758063
08 Aug 1996	17:10:54.734	53.2067	-167.1255	46.5	20437049	762673
20 Aug 1996	12:02:40.108	51.6742	-178.4232	38.7	20437045	772239
31 Aug 1996	20:47:23.396	51.5479	-178.2367	50.9	20437044	781848
02 Sep 1996	07:43:38.937	56.0138	-158.6816	56.5	20437040	782861
03 Sep 1996	17:01:57.073	26.2706	-110.5970	17.8	20437041	784475
13 Sep 1996	13:41:14.508	51.5632	-178.4308	38.5	20437037	799045
28 Sep 1996	07:36:29.078	19.5077	-103.1395	102.5	20816072	813315
26 Oct 1996	20:05:37.838	63.9361	-129.6605	22.6	20816022	840276
20 Nov 1996	20:04:17.969	53.1239	-170.1283	106.5	20437033	864695
08 Dec 1996	06:05:21.768	56.7320	-152.0632	3.7	20437036	878849
31 Dec 1996	12:41:43.757	15.9245	-92.7782	97.4	20816019	898793
11 Jan 1997	20:28:31.395	18.3042	-102.5837	68.5	20816018	913142
16 Jan 1997	21:41:09.024	18.2310	-102.3574	28.7	20436945	918465
27 Jan 1997	16:47:34.715	18.0907	-102.4352	21.8	20436948	928395
05 Feb 1997	19:29:06.990	51.8423	-131.3144	12.9	20436951	944856
10 Feb 1997	20:17:27.493	24.6836	-109.0128	20.5	20436952	949792
23 Mar 1997	20:23:14.844	17.4232	-100.6450	38.9	20436955	986423
03 Apr 1997	21:22:29.827	18.2177	-98.1291	56.3	20437055	996277
22 May 1997	14:27:09.682	65.3687	-167.1941	0.0	20816069	1044338
02 Jun 1997	05:17:27.339	19.2731	-108.2196	21.0	20436956	1053533
16 Jun 1997	22:43:55.863	40.6081	-134.6101	25.0	20436959	1064472
20 Jun 1997	08:51:55.267	76.2775	-117.8511	0.0	20436960	1066899
19 Jul 1997	14:22:01.532	15.7396	-98.2631	0.0	20436963	1088829
19 Jul 1997	17:40:48.665	15.8523	-98.1185	0.0	20436964	1088941
21 Aug 1997	16:36:46.269	38.4039	-118.6709	0.0	20816068	1112418
06 Sep 1997	08:54:56.533	18.1334	-94.3251	33.0	20436967	1124285
07 Oct 1997	23:06:10.336	18.4449	-103.1733	60.8	20436968	1155290
11 Oct 1997	15:54:02.885	44.3219	-129.9290	23.5	20436970	1158296
18 Oct 1997	04:55:16.097	17.5585	-103.1691	26.9	20436973	1164282
26 Oct 1997	10:44:06.657	41.0565	-125.0861	0.0	20816065	1171043
28 Oct 1997	11:44:19.759	47.6569	-69.9991	14.7	20816061	1172650
02 Nov 1997	08:51:55.192	37.8854	-117.9826	0.0	20816064	1176750
02 Nov 1997	15:03:05.676	37.8974	-118.0696	0.0	20816060	1177004
05 Nov 1997	01:42:38.672	64.9791	-155.0833	0.0	20816057	1179417
05 Nov 1997	17:49:31.960	39.9323	-120.7421	11.0	20816053	1180025
06 Dec 1997	08:06:50.554	64.8662	-88.1963	10.2	20436974	1214683
12 Dec 1997	08:42:20.227	33.4022	-87.2452	0.0	20816056	1225605
02 Jan 1998	07:28:30.522	38.1742	-112.5134	15.3	20816052	1246891
03 Jan 1998	00:19:20.675	14.8169	-94.0098	23.9	20436977	1247582

03 Jan 1998	23:02:13.410	54.2600	-164.0549	15.4	20816049	1248387
26 Jan 1998	01:07:28.971	46.0783	-129.7856	0.0	20436978	1271837
03 Feb 1998	07:17:52.710	15.8907	-96.2279	22.9	20436981	1277838
03 Mar 1998	07:38:23.216	15.9216	-96.1843	27.8	20436982	1304463
05 Mar 1998	20:04:21.975	20.5840	-104.1706	33.4	20436985	1306726
25 Apr 1998	11:19:38.671	17.7577	-93.9253	62.8	20436986	1358896
20 Jun 1998	21:16:23.646	43.0571	-110.4553	27.9	20436989	19942919
09 Jul 1998	06:33:25.907	31.5533	-118.6088	0.0	20816045	20004787
12 Jul 1998	11:15:59.612	52.6519	-174.3731	167.6	20816048	20008000
17 Aug 1998	06:06:39.354	57.5762	-153.9441	35.0	20816044	20052833
24 Aug 1998	17:05:42.155	53.7926	-169.5354	196.9	20816039	20064688
28 Oct 1998	23:40:00.521	21.6489	-104.7941	0.0	20436990	20141789
30 Oct 1998	09:53:30.377	39.3997	-119.8922	0.0	20816042	20143557
05 Nov 1998	14:47:07.703	23.9148	-108.8080	23.0	20436993	20149360
26 Nov 1998	08:37:51.063	44.2971	-110.5383	0.0	20816034	20232505
26 Nov 1998	19:49:54.151	40.6055	-122.3190	21.0	20816038	20232617
30 Nov 1998	02:11:04.043	52.6637	-176.3460	195.9	20816035	20237075
16 Dec 1998	05:54:03.279	55.3775	-134.9636	0.0	20816031	20259940
01 Jan 1999	09:28:12.423	79.8868	-111.7586	23.7	20436994	20276869
18 Jan 1999	07:00:57.938	33.4668	-87.2908	15.2	20816027	20293941
29 Jan 1999	06:28:06.781	15.4896	-94.4803	36.6	20436997	20309799
31 Jan 1999	03:38:44.650	15.4621	-94.5062	37.9	20436998	20312624
23 Mar 1999	09:05:45.575	16.0049	-93.3199	84.5	20437001	20389674
18 Apr 1999	15:05:59.518	60.4175	-151.9391	71.3	20816030	20440874
05 May 1999	10:30:04.486	59.4135	-151.5425	66.7	20816026	20466067
06 May 1999	03:34:02.826	56.6289	-152.7964	23.9	20437166	20467134
19 May 1999	18:40:00.321	15.7073	-92.8076	102.1	20437002	20483482
27 May 1999	08:08:58.495	58.6410	-137.2198	0.0	20437167	20493049
01 Jun 1999	08:28:04.547	41.8538	-126.9824	19.7	20437005	20497495
01 Jun 1999	15:18:02.930	32.4276	-115.2671	0.0	20437032	20498002
10 Jun 1999	09:08:15.484	56.2020	-161.5706	176.2	20437161	20505770
15 Jun 1999	20:42:08.988	18.4904	-97.2415	81.1	20437007	20509878
03 Jul 1999	01:43:54.746	47.1380	-123.1974	40.0	20437164	20523419
08 Aug 1999	04:45:15.758	41.1180	-127.3925	21.8	20437010	20550101
11 Sep 1999	21:23:25.938	60.1921	-136.8303	0.0	20437160	20570821
22 Oct 1999	17:51:16.763	38.0869	-112.7377	6.1	20437157	20597117
06 Nov 1999	18:03:36.737	43.5924	-105.2240	15.6	20437156	20607067
10 Nov 1999	21:05:12.279	43.6435	-105.2311	19.3	20816023	20610318
11 Nov 1999	23:33:43.580	15.7883	-92.8854	99.6	20437011	20610824
07 Dec 1999	05:35:55.909	75.5885	-121.0323	0.0	20437014	20631268
08 Dec 1999	22:01:09.981	18.3664	-104.5065	13.9	20437015	20632980

14 Dec 1999	07:12:16.768	18.2941	-98.4312	54.5	20437018	20636762
29 Dec 1999	20:01:48.944	43.9261	-105.3808	0.0	20437019	20649997
01 Jan 2000	11:22:56.196	46.8818	-78.8415	0.0	20437153	20652935
08 Jan 2000	02:17:32.501	40.4551	-126.2200	10.0	20437022	20658668
18 Jan 2000	19:52:05.406	43.9567	-105.4957	12.4	20437023	20665232
07 Mar 2000	04:32:24.524	19.4119	-103.8611	55.2	20437026	20708173
02 May 2000	06:45:47.257	32.4296	-115.1247	0.0	20437027	20775666
02 May 2000	23:59:17.876	59.6916	-139.4537	0.0	20437030	20776600

TABLE 12

LIST OF 163 CEB EVENTS IN NORTH AMERICA: REVISED IDC + IRIS, USGS LOCATIONS

DATE	ORIGIN TIME	LAT	LON	DEPTH	ORID	EVID
29 Jan 1995	03:11:22.614	47.3406	-122.2510	17.7	20437150	291130
03 Feb 1995	15:26:11.897	41.5373	-109.7103	2.2	20437151	294226
12 Feb 1995	20:13:37.449	59.7130	-153.4709	110.2	20437147	300649
19 Feb 1995	04:03:16.451	40.7534	-125.7712	0.0	20437146	304146
11 Mar 1995	08:15:53.678	36.9163	-82.8197	0.0	20437142	313623
14 Mar 1995	17:33:52.149	54.8034	-161.2754	33.2	20437143	315467
20 Mar 1995	12:46:17.332	40.1696	-108.9917	0.0	20437139	318146
26 Mar 1995	05:57:13.776	54.8590	-161.3190	41.0	20437135	321000
01 Apr 1995	07:12:29.414	53.6603	-164.6033	37.9	20437138	324117
14 Apr 1995	00:32:58.007	30.2669	-103.4007	22.6	20437134	331268
07 May 1995	11:03:32.687	33.8722	-116.3600	0.0	20437129	347247
17 May 1995	02:29:16.634	39.7440	-122.5543	20.4	20437131	351985
22 May 1995	20:08:32.195	58.8248	-155.9394	157.5	20437128	356346
23 May 1995	15:48:07.831	51.2116	-177.1387	35.4	20437125	356869
04 Jun 1995	01:07:39.556	54.1766	-164.2417	40.2	20437119	365972
06 Jun 1995	04:04:55.412	60.3376	-146.7830	0.0	20437122	366977
19 Jun 1995	14:45:37.233	59.0037	-151.4776	32.0	20437118	373986
26 Jun 1995	08:40:28.551	34.2785	-118.6217	5.4	20437115	376495
08 Jul 1995	17:15:29.468	53.7301	-163.9439	34.6	20437114	381690
14 Jul 1995	19:06:28.745	53.2658	-166.8369	35.7	20437111	384488
20 Jul 1995	08:53:02.203	52.8799	-174.4484	203.0	20437110	386795
09 Aug 1995	11:29:59.362	42.6640	-107.6374	0.0	20437124	399601
17 Aug 1995	22:39:58.610	35.7092	-117.7061	1.8	20437107	404828
18 Aug 1995	09:18:09.545	53.6712	-163.9245	38.5	20437103	405318
19 Aug 1995	22:03:25.106	50.6507	-170.4654	0.0	20437106	406213
28 Aug 1995	03:16:29.341	44.2653	-110.1405	16.8	20437102	411834
28 Aug 1995	10:46:11.241	26.0231	-110.2397	0.0	20437099	412033
28 Aug 1995	12:23:06.891	25.9205	-110.2055	19.5	20437095	412064
31 Aug 1995	08:20:53.315	69.3399	-147.1529	0.0	20437098	413474
18 Nov 1995	09:07:24.183	64.1831	-147.7322	106.7	20437094	465813
31 Dec 1995	04:30:58.132	51.9162	-165.8243	31.3	20437090	525209
04 Jan 1996	19:43:15.150	52.4761	-170.6821	58.4	20437091	530178

08 Jan 1996	09:20:16.520	16.2252	-98.0894	14.4	20816124	533390
07 Feb 1996	21:19:06.057	55.3336	-156.5247	2.4	20437087	568417
20 Feb 1996	00:52:07.668	43.3217	-126.9801	0.0	20437083	576944
22 Feb 1996	20:13:44.975	19.7375	-109.2908	9.4	20816125	579218
25 Feb 1996	03:08:12.417	15.8463	-97.9738	0.0	20816122	580915
25 Feb 1996	04:17:09.214	16.0734	-97.7483	16.6	20816137	580978
25 Feb 1996	05:34:30.898	15.9747	-97.7653	39.1	20816129	581074
25 Feb 1996	09:17:58.097	16.0164	-97.7531	11.9	20816133	581316
25 Feb 1996	14:27:29.324	16.1005	-97.6802	15.4	20816134	581571
25 Feb 1996	15:09:29.748	16.0639	-97.9251	95.6	20816128	581626
03 Mar 1996	23:44:35.555	56.4403	-152.7477	17.9	20437086	587402
13 Mar 1996	21:04:19.976	16.7546	-98.8251	24.8	20816106	599040
14 Mar 1996	09:12:08.782	19.4940	-91.9482	0.0	20816104	599600
18 Mar 1996	08:02:01.327	49.9310	-126.9462	13.6	20437082	604564
19 Mar 1996	15:31:37.823	25.1111	-109.1426	6.3	20437079	605911
19 Mar 1996	17:12:41.948	15.8419	-97.1497	19.1	20816101	606016
20 Mar 1996	04:53:22.191	15.6788	-97.3694	0.3	20816100	606526
27 Mar 1996	12:34:49.573	16.3684	-97.8973	24.0	20816097	615815
28 Mar 1996	01:48:24.649	52.3101	-168.7043	34.8	20437075	616486
28 Mar 1996	19:51:08.208	52.4054	-168.8343	26.1	20437074	617367
28 Mar 1996	21:32:48.742	52.3506	-168.7543	15.9	20437078	617475
01 Apr 1996	03:43:03.992	16.5255	-95.8926	58.2	20816096	621062
20 Apr 1996	06:33:23.676	54.7590	-161.1327	33.4	20437071	642949
21 Apr 1996	03:00:17.815	18.1180	-111.7092	0.0	20816094	644009
23 Apr 1996	06:53:33.982	17.1179	-101.2334	19.8	20816092	647379
09 May 1996	21:54:18.012	18.8088	-104.3469	55.9	20816089	668161
16 May 1996	22:13:51.500	18.3196	-111.3204	42.0	20816083	676670
03 Jun 1996	11:55:23.972	17.6433	-94.2103	162.4	20816085	691725
07 Jun 1996	23:07:09.778	69.4048	-125.4443	41.6	20816082	696672
08 Jun 1996	23:19:17.776	51.4989	-178.1031	43.2	20437067	697652
10 Jun 1996	04:03:38.035	51.6245	-177.6034	43.3	20437063	699173
10 Jun 1996	04:53:46.006	51.1932	-178.0967	35.2	20437070	699233
10 Jun 1996	17:44:18.411	51.4965	-176.8812	37.8	20437062	700421
11 Jun 1996	10:40:08.591	51.3030	-176.1678	25.4	20437066	702009
11 Jun 1996	11:00:47.640	51.2638	-176.1109	22.8	20437059	702034
11 Jun 1996	13:03:05.929	51.3650	-176.4724	37.9	20437058	702145
25 Jun 1996	18:52:22.112	14.8600	-92.2203	69.7	20816079	719054
10 Jul 1996	05:48:21.344	52.2045	-171.1591	36.7	20437054	737937
15 Jul 1996	21:23:32.062	17.4313	-100.8744	0.3	20816078	742188
19 Jul 1996	09:00:53.596	17.3656	-100.0688	42.0	20816075	745363
21 Jul 1996	20:38:19.353	64.4049	-137.7210	0.0	20816074	746895

24 Jul 1996	20:15:45.464	41.9659	-126.0325	0.0	20437051	751389
03 Aug 1996	06:15:18.146	44.6384	-113.9841	0.0	20437047	758063
08 Aug 1996	17:10:54.894	53.1975	-167.1259	47.5	20437050	762673
20 Aug 1996	12:02:39.685	51.5658	-178.4146	36.5	20437046	772239
31 Aug 1996	20:47:23.262	51.5185	-178.2664	50.4	20437043	781848
02 Sep 1996	07:43:38.875	56.0199	-158.7049	56.0	20437039	782861
03 Sep 1996	17:01:56.942	26.1985	-110.5630	17.4	20437042	784475
13 Sep 1996	13:41:14.148	51.4675	-178.4781	35.2	20437038	799045
28 Sep 1996	07:36:27.434	19.2426	-103.2607	100.8	20816071	813315
26 Oct 1996	20:05:34.499	63.9282	-130.0746	0.0	20816021	840276
20 Nov 1996	20:04:18.069	53.1178	-170.1048	106.7	20437034	864695
08 Dec 1996	06:05:21.545	56.7115	-152.2003	5.1	20437035	878849
31 Dec 1996	12:41:43.832	15.9074	-92.8131	98.7	20816020	898793
11 Jan 1997	20:28:31.961	18.2761	-102.6501	72.4	20816017	913142
16 Jan 1997	21:41:09.178	18.2421	-102.3835	26.8	20436946	918465
27 Jan 1997	16:47:34.936	18.0621	-102.2996	22.3	20436949	928395
05 Feb 1997	19:29:06.619	51.8161	-131.2968	13.1	20436950	944856
10 Feb 1997	20:17:27.389	24.6600	-109.0182	20.2	20436953	949792
23 Mar 1997	20:23:14.911	17.4422	-100.6437	38.6	20436954	986423
03 Apr 1997	21:22:29.763	18.1848	-98.1354	56.1	20437056	996277
22 May 1997	14:27:09.708	65.3605	-167.1290	0.0	20816070	1044338
02 Jun 1997	05:17:27.073	19.2351	-108.2794	20.8	20436957	1053533
16 Jun 1997	22:43:55.636	40.5887	-134.6253	23.8	20436958	1064472
20 Jun 1997	08:51:54.658	76.0670	-118.0949	0.0	20436961	1066899
19 Jul 1997	14:22:01.684	15.8195	-98.2045	0.0	20436962	1088829
19 Jul 1997	17:40:47.791	15.6959	-98.0372	0.0	20436965	1088941
21 Aug 1997	16:36:47.700	38.5456	-118.5332	3.9	20816067	1112418
06 Sep 1997	08:54:57.254	18.1649	-94.2249	37.5	20436966	1124285
07 Oct 1997	23:06:10.545	18.5206	-103.1371	59.7	20436969	1155290
11 Oct 1997	15:54:02.701	44.3028	-130.0300	23.4	20436971	1158296
18 Oct 1997	04:55:16.367	17.6036	-103.0710	28.0	20436972	1164282
26 Oct 1997	10:44:06.772	41.0716	-125.0959	0.0	20816066	1171043
28 Oct 1997	11:44:17.357	47.6538	-69.9500	0.0	20816062	1172650
02 Nov 1997	08:51:55.111	37.8548	-118.1076	0.9	20816063	1176750
02 Nov 1997	15:03:04.926	37.8391	-118.1781	0.0	20816059	1177004
05 Nov 1997	01:42:39.092	65.0696	-155.0094	0.0	20816058	1179417
05 Nov 1997	17:49:30.054	39.8682	-120.8860	0.0	20816054	1180025
06 Dec 1997	08:06:50.719	64.8989	-88.1353	10.2	20436975	1214683
12 Dec 1997	08:42:20.631	33.5185	-87.1884	0.0	20816055	1225605
02 Jan 1998	07:28:29.154	38.1946	-112.4956	1.7	20816051	1246891
03 Jan 1998	00:19:20.767	14.8364	-93.9868	24.0	20436976	1247582

03 Jan 1998	23:02:13.399	54.2573	-164.0169	14.7	20816050	1248387
26 Jan 1998	01:07:28.762	46.0490	-129.8546	0.0	20436979	1271837
03 Feb 1998	07:17:52.515	15.9021	-96.3281	23.6	20436980	1277838
03 Mar 1998	07:38:23.179	15.9256	-96.1578	27.2	20436983	1304463
05 Mar 1998	20:04:24.099	20.5624	-104.2112	52.2	20436984	1306726
25 Apr 1998	11:19:38.445	17.6917	-94.0165	62.7	20436987	1358896
20 Jun 1998	21:16:20.296	43.2140	-110.5192	4.7	20436988	19942919
09 Jul 1998	06:33:26.184	31.6492	-118.5492	0.0	20816046	20004787
12 Jul 1998	11:15:59.171	52.6263	-174.4013	164.4	20816047	20008000
17 Aug 1998	06:06:39.261	57.5734	-153.9659	34.6	20816043	20052833
24 Aug 1998	17:05:41.786	53.7365	-169.4968	194.1	20816040	20064688
28 Oct 1998	23:40:00.611	21.6500	-104.7757	0.0	20436991	20141789
30 Oct 1998	09:53:30.012	39.3422	-119.9266	0.0	20816041	20143557
05 Nov 1998	14:47:07.581	23.8489	-108.8272	21.7	20436992	20149360
26 Nov 1998	08:37:50.963	44.2813	-110.5186	0.0	20816033	20232505
26 Nov 1998	19:49:54.219	40.6387	-122.1980	21.9	20816037	20232617
30 Nov 1998	02:11:03.277	52.6010	-176.3468	190.3	20816036	20237075
16 Dec 1998	05:54:04.136	55.5344	-135.0091	0.0	20816032	20259940
01 Jan 1999	09:28:12.447	79.9476	-111.4809	24.3	20436995	20276869
18 Jan 1999	07:00:57.294	33.5492	-87.1758	9.1	20816028	20293941
29 Jan 1999	06:28:06.755	15.4867	-94.4491	36.0	20436996	20309799
31 Jan 1999	03:38:44.519	15.4183	-94.4811	37.1	20436999	20312624
23 Mar 1999	09:05:45.760	16.0695	-93.2418	84.6	20437000	20389674
18 Apr 1999	15:05:58.649	60.2883	-151.9837	67.2	20816029	20440874
05 May 1999	10:30:04.546	59.4265	-151.5530	66.5	20816025	20466067
06 May 1999	03:34:02.876	56.6415	-152.8103	23.8	20437165	20467134
19 May 1999	18:40:00.277	15.6972	-92.8158	102.2	20437003	20483482
27 May 1999	08:08:58.592	58.6636	-137.2401	0.0	20437168	20493049
01 Jun 1999	08:28:04.183	41.7861	-127.1298	18.5	20437004	20497495
01 Jun 1999	15:18:02.925	32.4486	-115.2953	0.0	20437031	20498002
10 Jun 1999	09:08:15.581	56.1841	-161.5461	177.0	20437162	20505770
15 Jun 1999	20:42:08.511	18.4591	-97.2409	78.0	20437008	20509878
03 Jul 1999	01:43:54.880	47.1378	-123.1564	40.3	20437163	20523419
08 Aug 1999	04:45:16.604	41.0195	-127.4835	29.3	20437009	20550101
11 Sep 1999	21:23:26.057	60.2298	-136.8281	0.0	20437159	20570821
22 Oct 1999	17:51:16.484	38.0871	-112.7394	2.1	20437158	20597117
06 Nov 1999	18:03:34.069	43.6579	-105.2013	0.0	20437155	20607067
10 Nov 1999	21:05:09.145	43.6852	-105.2193	0.0	20816024	20610318
11 Nov 1999	23:33:43.461	15.7581	-92.9324	99.5	20437012	20610824
07 Dec 1999	05:35:55.900	75.5759	-121.0636	0.0	20437013	20631268
08 Dec 1999	22:01:09.857	18.3452	-104.5169	13.9	20437016	20632980

14 Dec 1999	07:12:16.755	18.2701	-98.4206	54.8	20437017	20636762
29 Dec 1999	20:01:47.570	43.7651	-105.2597	0.0	20437020	20649997
01 Jan 2000	11:22:56.156	46.8302	-78.7902	0.0	20816138	20652935
08 Jan 2000	02:17:32.443	40.4169	-126.2441	10.2	20437021	20658668
18 Jan 2000	19:52:02.346	43.7654	-105.2772	0.0	20437024	20665232
07 Mar 2000	04:32:21.774	19.2334	-103.8739	32.8	20437025	20708173
02 May 2000	06:45:46.792	32.3800	-115.1852	0.0	20437028	20775666
02 May 2000	23:59:17.924	59.6975	-139.4604	0.0	20437029	20776600

DEPARTMENT OF DEFENSE

DEFENSE TECHNICAL INFORMATION CENTER
8725 JOHN J. KINGMAN ROAD,
SUITE 0944
FT. BELVOIR, VA 22060-0944
2 CYS ATTN: DTIC/OCA

DEFENSE THREAT REDUCTION AGENCY
8725 JOHN J. KINGMAN ROAD MS 6201
FT. BELVOIR, VA 22060-6218
2 CYS ATTN: TDND/ D. BARBER

DEPARTMENT OF DEFENSE CONTRACTORS

ITT INDUSTRIES
ITT SYSTEMS CORPORATION
1680 TEXAS STREET, SE
KIRTLAND AFB, NM 87117-5669
2 CYS ATTN: DTRIAC
ATTN: DARE

MULTIMAX, INCORPORATED
1441 MCCORMACK DRIVE
LARGO, MD 20774
ATTN: I. GUPTA