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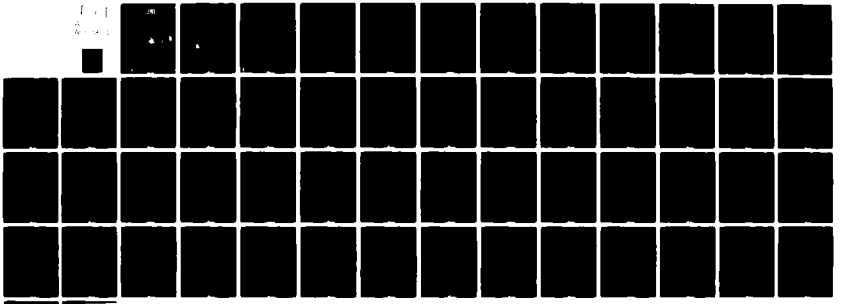

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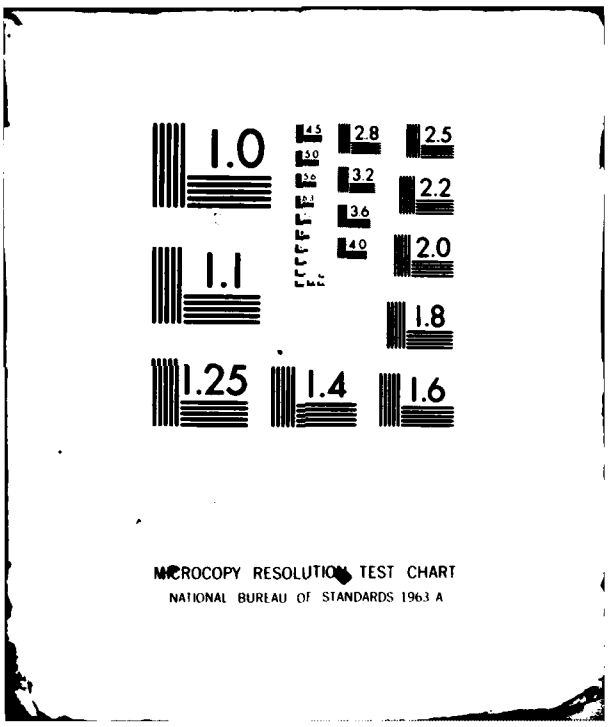
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# RECENT STANDARD OCEAN EVALUATION RESULTS



June 1980



Surveillance Environmental Acoustic Support Project

Ocean Program Management Office
Naval Ocean Research and Development Activity
NSTL Station, MS 39529

SEAS Report 80-037

# RECENT STANDARD OCEAN EVALUATION RESULTS



S. C. Daubin, Jr.

Pacific-Sierra Research Corporation

SEAS

Surveillance Environmental Acoustic Support Project

Naval Ocean Research and Development Activity
NSTL Station, MS 39529

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Evaluates recent changes in NAVOCEANO's Generalized Digital Environmental Model. GDEM is the prime candidate for Standard Ocean--a system for retrieving oceanographic and acoustic data in 1° × 1° oceanic squares, formatted for NORDA's numerical acoustic models and usable by nonspecialists. Eighteen recent GDEM (Mod 1) sound speed (SS) profiles for various locations and seasons in the North Pacific are compared with typical real SS profiles selected by NOSC as well as previously reported GDEM (Mod 0) results. Mod 1 is better able than Mod 0 to match the typical real profiles at most locations. Mod 1 values

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now lie within the envelope of observed data and show decreased deep seasonal shifts. Further, the mean typical-minus-GDEM SS differences and standard deviations improve in Mod 1. However, Mod 1 still has difficulty representing secondary sound channels accurately and, in areas of high variability or few observations, occasionally shows a decreased matching ability.

## PREFACE

This report, sponsored by the Surveillance Environmental Acoustic Support (SEAS) Project of the Naval Ocean Research and Development Activity (NORDA), presents recent sound speed profiles of the Generalized Digital Environmental Model (GDEM). GDEM is being developed by Dr. Thomas M. Davis of the Naval Oceanographic Office (NAVOCEANO--Code 022). It is currently being evaluated as a prime candidate ocean data retrieval system for the SEAS data bank by the Standard Ocean Evaluation Group.* Previous evaluation results based on a pre-June 1979 version of GDEM are presented in PSR Report 922, *Evaluation of Standard Ocean Candidates*, by J. G. Colborn, S. C. Daubin, Jr., E. Hashimoto, and F. J. Ryan (March 1980). The present report reflects the most recent changes to the model.

The Standard Ocean Evaluation Group has received additional GDEM plots for the North Pacific from Dr. Davis that are not presented here. Evaluation of that information will be published later this year, along with results for the Mediterranean.

The report draws on information provided by J. G. Colborn and E. Hashimoto. It is published by PSR under Office of Naval Research contract N00014-79-C-0310, and carries PSR report number 1015.

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*Members of the group include S. C. Daubin, Jr., Pacific-Sierra Research Corporation (PSR), Coordinator; J. G. Colborn (Naval Ocean Systems Center Code 7243); and E. Hashimoto (NORDA Code 320).

## CONTENTS

## INTRODUCTION

This report summarizes recent results of the Naval Oceanographic Office's (NAVOCEANO) Generalized Digital Environmental Model (GDEM). PSR Report 922, *Evaluation of Standard Ocean Candidates* (J. G. Colborn, S. C. Daubin, Jr., E. Hashimoto, and F. J. Ryan, March 1980), identified GDEM as a prime candidate for the ocean data retrieval system to be installed in the Surveillance Environmental Acoustic Support (SEAS) Project data bank. That evaluation, based on a pre-June 1979 version of GDEM (Mod Ø), compared 18 GDEM sound-speed profiles at 11 locations in the North Pacific (Fig. 1)* with typical real profiles† statistically selected by the Naval Ocean Systems Center (NOSC).**

Because the model occasionally tended toward mismatch, Dr. Thomas M. Davis of NAVOCEANO investigated and redesigned selected portions of it. The merging of the upper Butterworth filter model (0 to 400 m) and the middepth orthogonal model (200 to 2450 m) was found satisfactory; replacing the quadratic tail in the upper-layer temperature model (0 to 400 m) with an exponential function eliminated the shallow channel discrepancies in the sound speed model. In addition, geographically varying the merge depth, previously fixed at 400 m, over a range of depths between 200 and 400 m produced a smoother fit.

In the fall of 1979, NAVOCEANO recomputed the sound speed profiles for the original 11 locations using the updated version of GDEM (Mod 1). Figures 2 through 19 illustrate those profiles, along with the Mod Ø and typical profiles (Tables 1 through 18 give the numerical data). Additional plots for the North Pacific obtained recently will be published later this year, along with data for the Mediterranean.

The present evaluation compares GDEM and typical real profiles both graphically and statistically. The graphic comparison determines the model's ability to duplicate acoustically significant features of the typical profiles, including primary and secondary sound channels,

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*Figures and tables are grouped at the end of the report, p. 11ff.

†These typical profiles are representative of all observations made in a particular area during a single season and over a number of years.

**J. G. Colborn and J. D. Pugh, *A Procedure for Selection of Typical Sound Speed Profiles*, Naval Undersea Center, NUC TN 1006, May 1973.

surface layers, and overall shape, as well as whether the GDEM profiles lie within the envelope of all observed data at a given location, and whether there are any suspect deep, seasonal sound-speed variations. Mod Ø profiles fall outside the envelope at locations 4', 1-winter and summer, 2-winter, and 6-summer; none of the Mod 1 profiles were found outside that envelope. Large (≥1 m/sec), deep, seasonal variations not evident in the typical data are seen in the Mod Ø profiles at locations 1, 2, 5, and 6; the variations are less than 1 m/sec in Mod 1, except at location 5.

As a backup to the graphic inspection, sound speed differences have been checked statistically. The arithmetic mean $\overline{\Delta\ SS}$ and standard deviation S of the sound speed differences Δ SS (typical-minus-GDEM value) are calculated for each location (see Tables 1 through 18); S is calculated using an N - 1 weighting, such that

$$S = \left[ \frac{\sum_{i=1}^{N} \Delta\ SS_i^2 - \frac{\left( \sum_{i=1}^{N} \Delta\ SS_i \right)^2}{N}}{N - 1} \right]^{1/2} ,$$

where N is the number of depths at which sound speeds are compared. Because S is not corrected for the uneven depth distribution of the data points, emphasis is on the upper few hundred meters where the data are plentiful. A favorable GDEM-to-typical match is indicated by a low S coupled with a low absolute value of $\overline{\Delta\ SS}$. An analysis of the mean Δ SS value alone is inconclusive: both statistically significant reductions and increases in $\overline{\Delta\ SS}$ appear in Tables 1 through 18. A near-zero mean Δ SS does not by itself necessarily indicate a good match (for example, see the GDEM Mod Ø-to-typical comparison at location 1' [Fig. 2, Table 1]). The best comparison, both graphically and statistically, has a $\overline{\Delta\ SS}$ of 0.1 m/sec and an S of 0.3 m/sec (see GDEM Mod 1-to-typical comparison at location 2-winter [Fig. 10, Table 9]). Other $\overline{\Delta\ SS}$ diverge both positively and negatively from the 0.1 m/sec value; other S are all larger. In 10 of the 18 comparisons,

S for Mod 1 is lower than the Mod Ø value, indicating an improvement in the matching ability of the later model.

Selection of the typical profiles for locations 4, 5, and 6 was hampered by both insufficient observational data and high variability. The GDEM-to-typical comparisons at those locations are inconclusive. The greatest mismatch (for both Mod Ø and Mod 1) is that of Mod 1 at location 6-summer, where there are few observations--$\overline{\Delta SS}$ = -2.5 m/sec and S = 3.2 m/sec (Fig. 19, Table 18).

## EVALUATIONS

The following brief comparisons of the 18 sound-speed profiles generated by GDEM, Mods Ø and 1, discuss changes in the profile reflecting modifications to the model as well as the new model's ability to duplicate the typical real profiles. Locations 1' through 5' (Figs. 2 through 7, Tables 1 through 6) correspond to areas 1 through 5 in attachment 2 of Appendix C in PSR Report 922; locations 1 through 6 (Figs. 8 through 19, Tables 7 through 18) are as in Appendix C of that report.

The typical profiles at locations 1' through 5' are representative of large sound-speed provinces. The typical profiles for locations 1 through 6, on the other hand, are representative of smaller data samples from 1° × 1° squares centered about the stated locations. Despite similar positions, therefore, the typical profiles at locations 1' and 1-summer describe different sample and area sizes: 1' is selected from a 642-profile sample covering a large area, whereas 1-summer is selected from a 265-profile subset of 1' within a single 1° × 1° square. The two profiles differ slightly at all depths.

The typical profile for each location was selected from all real profiles observed there. Tables 1 through 18 list a number that includes only those reaching at least 200 m and having observations at each standard depth. For location 4, the depth qualification is 50 rather than 200 m. PSR Report 922 presents cumulative plots of all observed sound-speed profiles at locations 4' and 1 through 6.

Location 1'

The GDEM-to-typical comparison at location 1' (Fig. 2, Table 1) shows Mod 1 to have an improved matching ability. The Mod Ø version exhibits positive and negative differences greater than 1 m/sec from the typical profile between 100 and 1000 m; whereas, in Mod 1, the mean Δ SS changes from 0 to -0.6 m/sec, and S decreases from 1.8 to 0.7 m/sec. Surface layer thickness and sound-channel axis depth are very close to the typical values. GDEM duplicates the inflection in sound speed near 80 m.

Location 2'

The comparison of GDEM to the typical profile at location 2' remains favorable (Fig. 3, Table 2). Mean values of Δ SS change from -0.1 m/sec for Mod Ø (S = 1.2 m/sec) to -0.2 m/sec for Mod 1 (S = 1.4 m/sec). The model's sound-channel axis depth remains ~100 m below the typical value. The improved Mod 1 profile duplicates the surface layer in the typical profile; Mod Ø does not have this feature.

Location 2T'

Mod 1, like Mod Ø, favorably matches the typical profile over the entire depth range at location 2T' (Fig. 4, Table 3). Between 400 and 1200 m, the Mod 1 sound speeds are slightly greater than both the typical and the Mod Ø values ($\overline{\Delta\ SS}$ changes from -0.3 to -0.9 m/sec, S decreases from 1.2 to 0.8 m/sec). The Mod 1 sound-channel axis depth is ~150 m greater than the typical depth, while the surface layer is approximately 20 m shallower than the typical thickness.

The weak secondary sound channel of the typical profile near 100 m is represented by an inflection in both the Mod Ø and 1 profiles. The acoustic significance of this feature in the typical profile is uncertain; the sound speed difference between its axis and maximum is only 0.3 m/sec.

Location 3'

In some respects, GDEM's ability to match a typical profile containing a double sound channel improves at location 3' (Fig. 5, Table 4). In the Mod Ø version, the quadratic tail of the upper temperature

model causes the GDEM sound-speed profile to make a wide positive excursion from the typical profile in the 100 to 400 m depth range. The exponential tail of Mod 1 allows GDEM to fit the typical profile much closer overall--reflected in a decrease in S from 1.2 to 0.8 m/sec, and a change in $\overline{\Delta\ SS}$ from -0.6 to -0.1 m/sec.

The sharp sound-speed inversion near 150 m, which in the typical profile is represented by an increase of 2.6 m/sec in 50 m, shows as an increase of only 1.1 m/sec in 100 m with Mod 1. The inversion is ~150 m deep in the typical profile and 200 m in the Mod Ø and 1 profiles.

Location 4'

GDEM's ability to match the typical profile for location 4' shows an improvement similar to that for location 3' (Fig. 6, Table 5). The exponential tail of the Mod 1 temperature model significantly reduces the wide excursions in the Mod Ø profile. The new profile has a primary sound-channel axis at the same depth as in the typical profile (300 m), whereas the Mod Ø profile places it 200 m deeper--at 500 m. Surface sound speeds are more accurately represented by Mod 1. The mean value of the Mod 1 Δ SS remains -0.7 m/sec, as in Mod Ø. However, the standard deviation of Δ SS decreases from 2.0 to 1.0 m/sec.

As at location 3', the Mod 1 profile at location 4' only approximately reproduces the sharp curvature of the secondary sound channel at 100 m. In Mod 1, the curve is represented as a zone of constant sound speed, not an inversion as in the typical profile. Mod Ø produces a broad inversion at the same depth.

The secondary-sound-channel mismatch in GDEM Mod 1 appears to derive from a difference in the data input to the temperature model. Attachment 3 to Appendix C of PSR Report 922 shows that Mod 1 correctly models this sound speed feature when using NOSC temperature and salinity values as inputs. Other data produce a profile that does not contain the feature (as shown in Fig. 6 at depth ~100 m). The ~1.5 m/sec inflection in both the typical and the attachment 3 profiles is due primarily to the combined effect of increasing pressure and a nearly constant temperature between 80 and 150 m; and, secondarily, to a salinity increasing with depth. Since the effect of salinity on sound

speed is relatively small, and the pressure effect is the same in both cases, it seems likely that the mismatch is primarily due to an anomalous negative change in the GDEM temperature gradient.

Location 5'

The current comparison at location 5' yields only slight changes from the previous results, with the Mod 1 profile showing the same general shape as the typical (Fig. 7, Table 6). Below 400 m, the Mod 1 profile lies closer to the typical than does the Mod Ø; between 100 and 400 m, however, Mod 1 differs more from the typical than does Mod Ø. Mean Δ SS and standard deviations remain nearly the same: $\overline{\Delta SS}$ = -0.3 m/sec and S = 1.0 m/sec for Mod Ø, and $\overline{\Delta SS}$ = -0.5 m/sec and S = 1.0 m/sec for Mod 1.

Location 1

The Mod Ø profiles at location 1 show a seasonal shift in the sound speed extending to 2000 m (Figs. 8 and 9)--more serious in the upper part of the middepth sound-speed model. For example, at 600 m in Mod Ø, there is a 4.6 m/sec shift between summer and winter. The Mod 1 profiles show an improvement to 0.6 m/sec at the same depth for the same seasons. Further, the Mod 1 sound speeds for both seasons now lie within the observed data envelope (dotted lines labeled "maximum" and "minimum" in Fig. 8); the Mod Ø profiles exceed that envelope at some depths. Statistically, the Mod 1 sound speeds show an improvement over Mod Ø. The mean Δ SS for winter is reduced from -1.4 m/sec for Mod Ø to -0.8 m/sec for Mod 1 (S = 1.1 m/sec and 0.5 m/sec, respectively--see Table 7). For summer, $\overline{\Delta SS}$ changes from 0.1 to -0.6 m/sec, whereas S decreases from 1.9 to 1.5 m/sec (see Table 8).

The depth of the Mod 1 sound-channel axis in the winter comparison is closer to the typical value by ≈50 m than is the Mod Ø depth. In the summer, the depth difference is ≈50 m for Mod 1, whereas the Mod Ø difference is ≈0 m. Surface layer thicknesses are identical.

Location 2

Figures 10 and 11 illustrate the location 2 comparisons. The Mod 1 winter comparison shows significant improvement (Fig. 10), with

the profile lying entirely within the envelope of observed data, whereas it extends outside in Mod Ø. The closeness of the Mod 1 GDEM-to-typical match is reflected in the mean and standard deviation of Δ SS--0.1 and 0.3 m/sec, respectively (Table 9)--the smallest values in all 18 comparisons.

The profile mismatch between 30 and 500 m for summer (Fig. 11) is still evident in Mod 1, although the values are closer to the typical ones than in Mod Ø. The value of $\overline{\Delta\ SS}$ changes from -0.2 to 0.2 m/sec (S = 1.2 m/sec and 1.3 m/sec, respectively--Table 10). Neither version of GDEM matches the sharpness of the summer sound channel at 125 m, which is an individual characteristic of the selected typical profile.

For winter, sound-channel axis depth in Mod 1 is closer to the typical depth than in Mod Ø (depth difference ≈ 50 m); the difference is the same for the summer comparison (≈25 m). Surface layer depths are approximately the same in the two comparisons.

Location 3

Mod Ø and 1 profiles for the winter and summer seasons at location 3 show no significant differences (Figs. 12 and 13). Values of $\overline{\Delta\ SS}$ are between -0.3 and -0.5 m/sec; S is 1.4 m/sec in the winter and ~1.8 m/sec in the summer (Tables 11 and 12).

Location 4

The comparison at location 4 (Figs. 14 and 15) is hampered by data that are insufficient for winter and highly variable for summer; results are therefore inconclusive. The winter comparison shows that modifying GDEM shifts the model profile to the right of the typical profile ($\overline{\Delta\ SS}$ changes from 1.0 to -0.8 m/sec; S remains 0.7 m/sec--see Table 13). In the summer, the Mod 1 profile converges to the typical profile below 400 m. Between 100 and 300 m, the Mod 1 values show a larger divergence from the typical values than do those of Mod Ø. The mean values of Δ SS increase from 0.8 to 2.1 m/sec; the corresponding standard deviations decrease from 2.4 to 1.5 m/sec (Table 14). The sound-channel axis depth (summer only) is closer to the typical in Mod 1 than in Mod Ø (differences ≈ 25 m and 63 m, respectively).

Location 5

Because location 5 is also in an area of high variability, results of comparisons for that site should be viewed cautiously. Mod 1 shows a slight improvement for the winter (Fig. 16), relative to the typical profile; but degradation for the summer (Fig. 17). A slight seasonal shift in the deep sound speed of Mod 1 remains; it is not evident in the typical data (e.g., a shift of 1 m/sec between winter and summer at 1000 m). The Mod 1 sound speeds for winter are generally lower than the typical values from the surface to 2000 m ($\overline{\Delta\ SS}$ is 1.5 m/sec for Mod 1 versus 1.8 m/sec for Mod Ø--see Table 15). The Δ SS standard deviation reduces slightly, from 1.4 m/sec (Mod Ø) to 1.3 m/sec (Mod 1). The Mod 1 summer profile shows a greater difference from the typical profile than the Mod Ø profile ($\overline{\Delta\ SS}$ changes from -0.5 m/sec for Mod Ø to -1.0 m/sec for Mod 1, while S increases from 1.7 to 2.1 m/sec--see Table 16). The sound-channel axis depth in Mod 1 is identical to the typical value for winter, shifting upwards ~200 m in the summer comparison.

Location 6

Comparisons for location 6-winter are inclusive because of a lack of observational data. In the winter comparison (Fig. 18), there is still a mismatch in Mod 1 between 125 and 400 m, although that profile matches the typical winter profile below 400 m better than does the Mod Ø profile (S decreases from 2.1 to 1.7 m/sec, as shown in Table 17).

In the summer comparison, Mod 1 shows a slightly greater discrepancy from the typical between 50 and 500 m, but a greater similarity to the typical below 500 m (Fig. 19). Whereas the deep Mod Ø profile extends outside the observed data envelope, the Mod 1 profile lies within it. Values of $\overline{\Delta\ SS}$ are larger for Mod 1 than for Mod Ø (-2.5 m/sec versus -1.7 m/sec--see Table 18), and the Δ SS standard deviation is also slightly larger (3.2 m/sec versus 3.1 m/sec). The large, deep, seasonal variations in Mod Ø are reduced in Mod 1. The differences between the models and typical profile in the upper layer reflects the high oceanographic variability observed in this area.

FIGURES AND TABLES

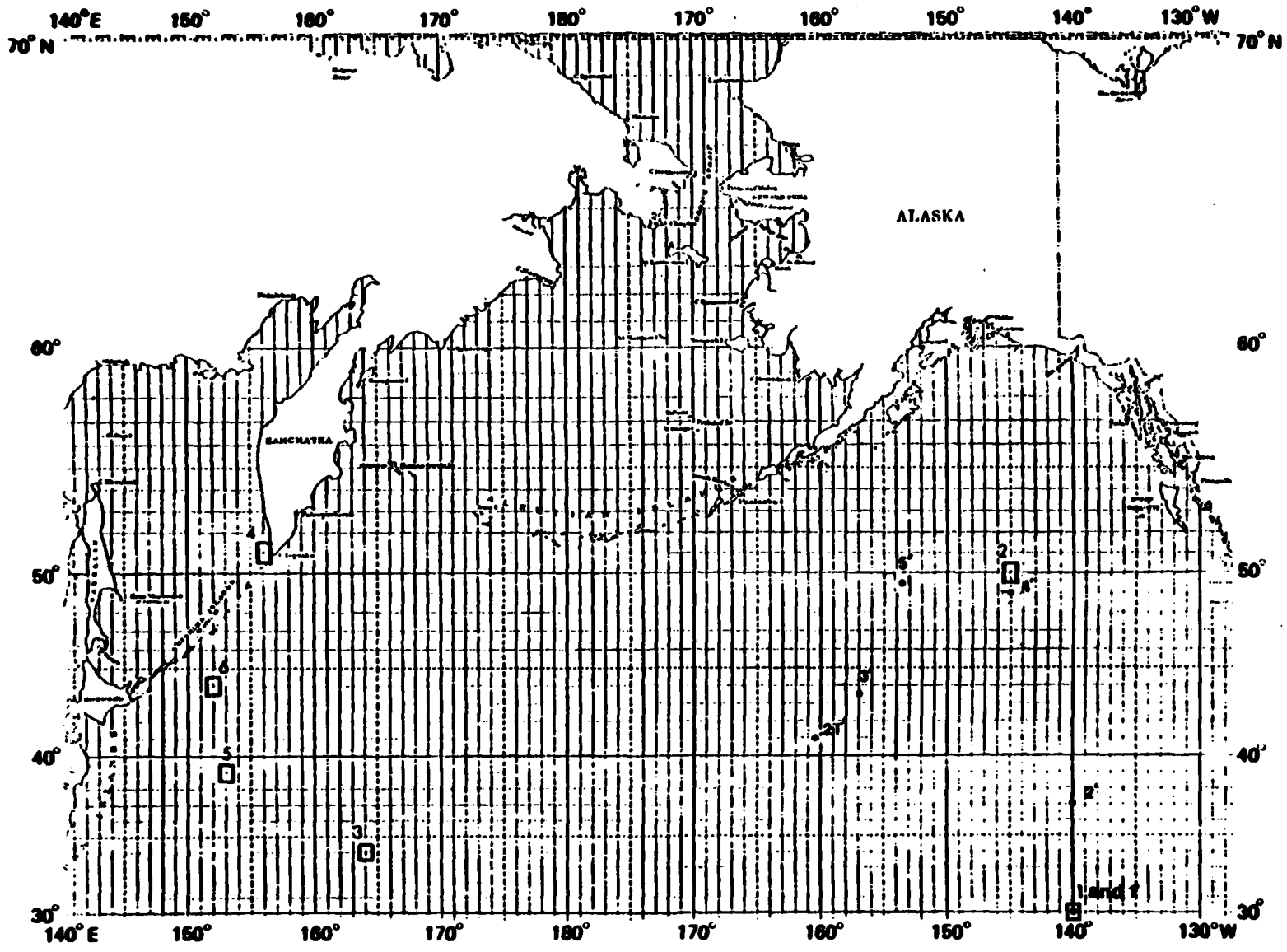


Fig. 1--Locations of GDEM-typical profile comparisons

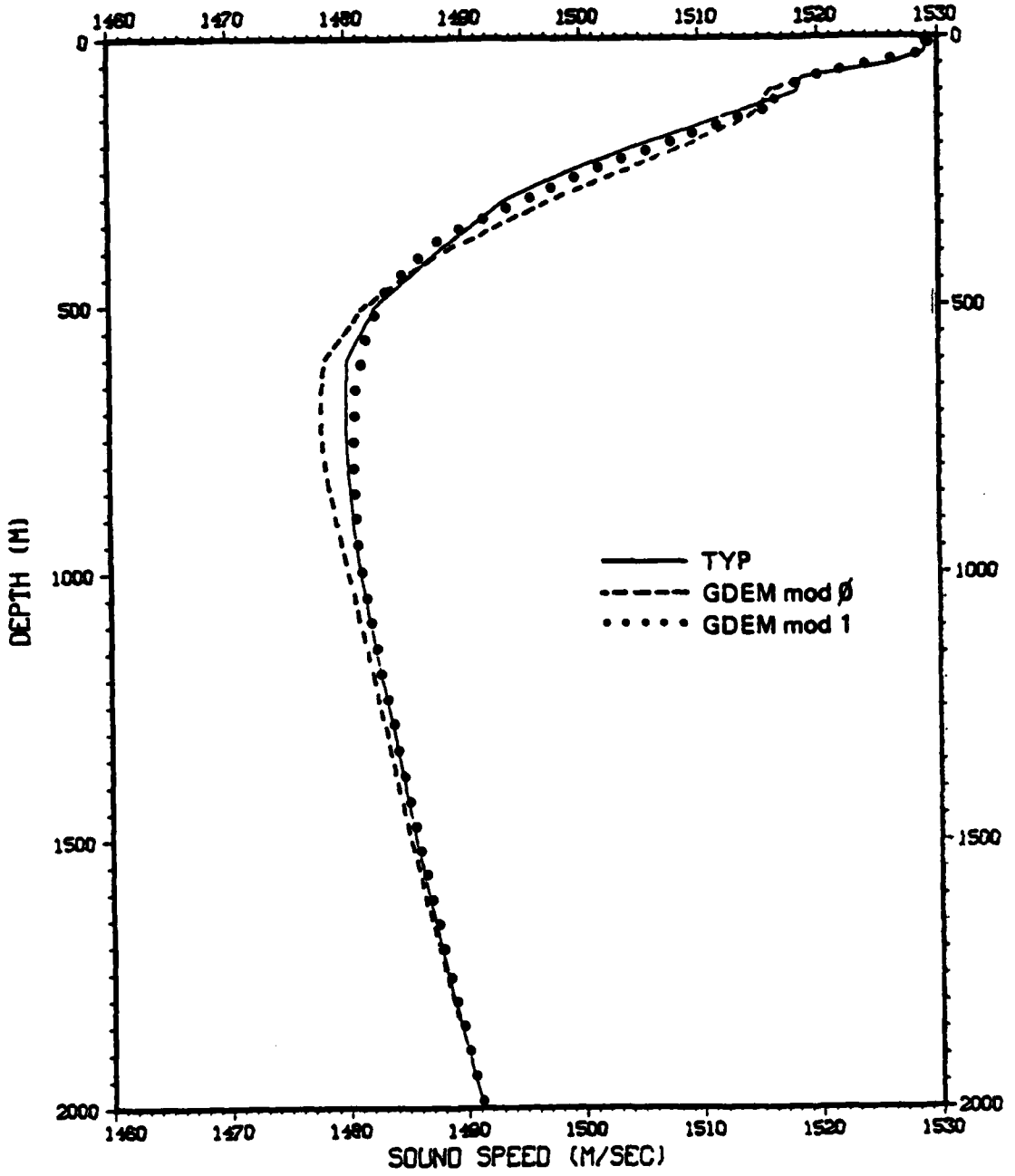


Fig. 2--GDEM-typical profile comparison, location 1' (30°N, 140°W), summer (July through September)

Table 1

DATA FOR GDEM-TYPICAL COMPARISON, LOCATION 1', SUMMER (JULY-SEPTEMBER)

| Depth (m) | Typical SS[a] (m/sec) | GDEM SS (m/sec) | | Δ SS (m/sec) | |
|---|---|---|---|---|---|
| | | Mod 1 | Mod Ø | Mod 1 | Mod Ø |
| 0 | 1528.7 | 1529.2 | 1528.8 | -.5 | -.1 |
| 10 | 1528.8 | 1529.3 | 1528.8 | -.5 | 0 |
| 20 | 1529.0 | 1529.3 | 1528.9 | -.3 | .1 |
| 30 | 1528.8 | 1529.9 | 1528.7 | -.1 | .1 |
| 50 | 1526.0 | 1525.3 | 1525.6 | -.7 | .4 |
| 75 | 1518.7 | 1519.3 | 1519.1 | -.6 | -.4 |
| 100 | 1518.3 | 1516.8 | 1515.9 | -1.5 | 2.4 |
| 125 | 1515.0 | 1515.8 | 1515.2 | -.8 | -.2 |
| 150 | 1511.7 | 1513.5 | 1514.2 | -1.8 | -2.5 |
| 200 | 1505.0 | 1507.6 | 1508.9 | -2.6 | -3.9 |
| 250 | 1498.8 | 1501.1 | 1503.4 | -2.3 | -4.6 |
| 300 | 1493.7 | 1495.2 | 1497.7 | -1.5 | -4.0 |
| 400 | 1487.7 | 1487.1 | 1488.0 | -.6 | -.3 |
| 500 | 1482.5 | 1482.9 | 1481.5 | -.4 | 1.0 |
| 600 | 1480.1 | 1481.1 | 1478.2 | -1.0 | 1.9 |
| 700 | 1480.0 | 1480.3 | 1477.8 | -.3 | 2.2 |
| 800 | 1480.2 | 1480.3 | 1478.2 | -.1 | 2.0 |
| 900 | 1480.6 | 1480.5 | 1479.1 | -.2 | 1.5 |
| 1000 | 1481.2 | 1481.5 | 1480.1 | -.3 | 1.1 |
| 1100 | 1482.1 | 1482.3 | 1481.2 | -.2 | .9 |
| 1200 | 1483.0 | 1483.1 | 1482.2 | -.1 | .8 |
| 1300 | 1484.0 | 1483.9 | 1483.2 | .1 | .8 |
| 1400 | 1484.9 | 1484.8 | 1484.2 | .1 | .7 |
| 1500 | 1485.8 | 1485.8 | 1485.2 | 0 | .6 |
| 1750 | 1488.3 | 1488.4 | 1488.0 | -.1 | .3 |
| 2000 | 1491.3 | 1491.4 | 1491.2 | -.1 | .1 |
| Mean Δ SS ..... | | | | -0.6 | 0.0 |
| S ..... | | | | 0.7 | 1.8 |

[a]Typical profile selected from 642 sound speed profiles.

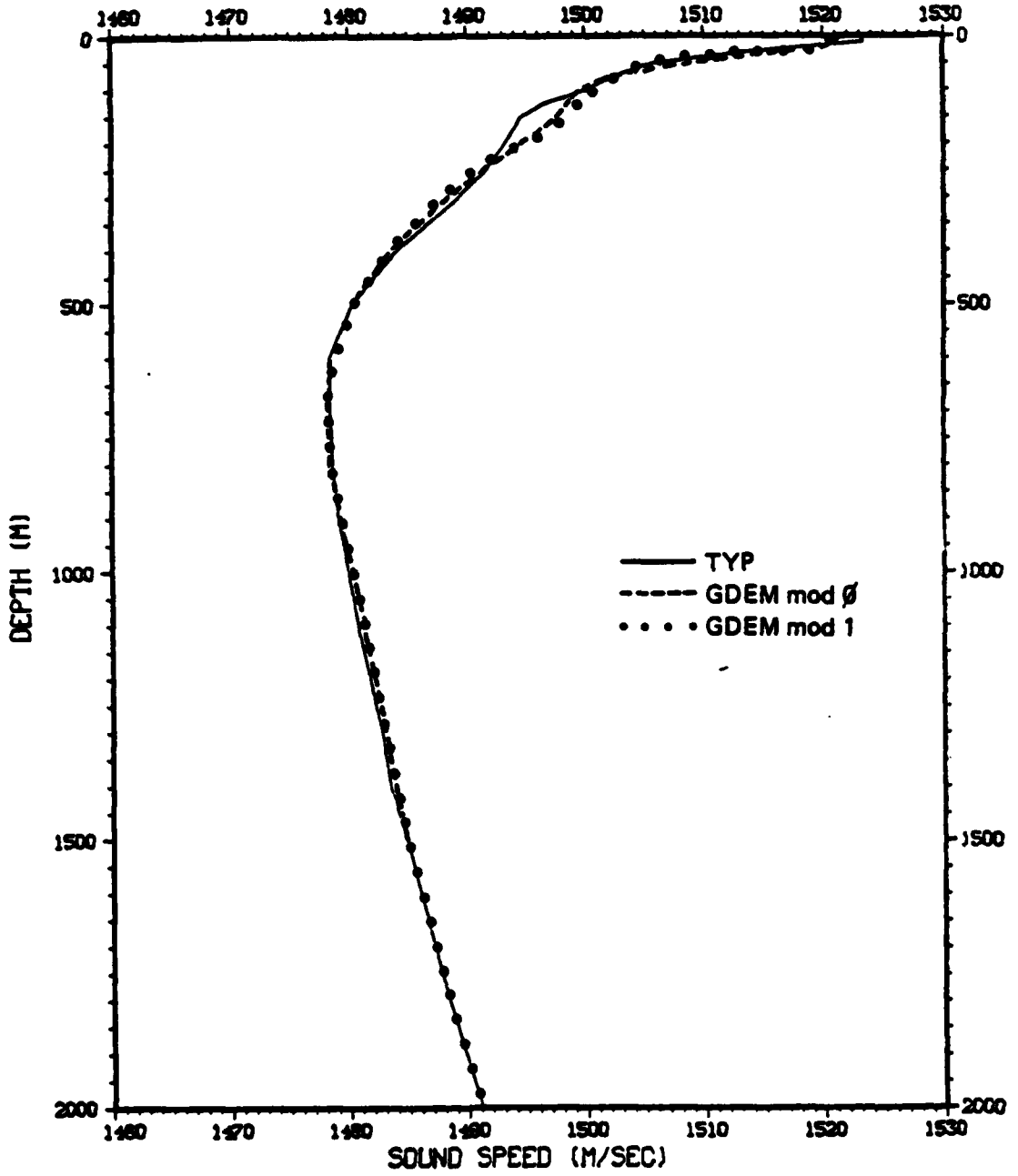


Fig. 3--GDEM-typical profile comparison, location 2' (37°N, 140°W), summer (July through September)

Table 2

DATA FOR GDEM-TYPICAL COMPARISON, LOCATION 2', SUMMER (JULY-SEPTEMBER)

| Depth (m) | Typical SS[a] (m/sec) | GDEM SS (m/sec) | | Δ SS (m/sec) | |
|---|---|---|---|---|---|
| | | Mod 1 | Mod Ø | Mod 1 | Mod Ø |
| 0 | 1523.3 | 1520.8 | 1521.1 | 2.5 | 2.2 |
| 10 | 1523.4 | 1520.9 | 1521.0 | 2.5 | 2.4 |
| 20 | 1517.7 | 1518.1 | 1518.8 | -.4 | -1.1 |
| 30 | 1512.7 | 1513.7 | 1515.2 | -1.0 | -2.5 |
| 50 | 1505.7 | 1506.1 | 1507.6 | -.4 | -1.9 |
| 75 | 1502.4 | 1502.5 | 1501.8 | -.1 | .6 |
| 100 | 1500.1 | 1501.1 | 1499.3 | -1.0 | .8 |
| 125 | 1496.5 | 1499.5 | 1498.3 | -4.0 | -1.8 |
| 150 | 1494.6 | 1497.7 | 1497.3 | -3.1 | -2.7 |
| 200 | 1493.2 | 1494.0 | 1494.2 | -.8 | -1.0 |
| 250 | 1491.6 | 1490.5 | 1491.2 | 1.1 | .4 |
| 300 | 1489.3 | 1487.4 | 1488.2 | 1.9 | 1.1 |
| 400 | 1484.0 | 1483.0 | 1483.3 | 1.0 | .7 |
| 500 | 1480.3 | 1480.5 | 1480.1 | -.2 | .2 |
| 600 | 1478.4 | 1479.2 | 1478.3 | -.8 | .1 |
| 700 | 1478.5 | 1478.7 | 1478.0 | -.2 | .5 |
| 800 | 1478.7 | 1478.9 | 1478.3 | -.2 | .4 |
| 900 | 1479.2 | 1479.6 | 1479.1 | -.4 | .1 |
| 1000 | 1480.0 | 1480.5 | 1480.1 | -.5 | -.1 |
| 1100 | 1480.8 | 1481.4 | 1481.1 | -.6 | -.3 |
| 1200 | 1481.8 | 1482.3 | 1482.1 | -.5 | -.3 |
| 1300 | 1482.8 | 1483.1 | 1483.0 | -.3 | -.2 |
| 1400 | 1483.5 | 1483.9 | 1483.8 | -.4 | -.3 |
| 1500 | 1484.9 | 1484.8 | 1484.7 | .1 | .2 |
| 1750 | 1487.8 | 1487.6 | 1487.6 | .2 | .2 |
| 2000 | 1491.1 | 1491.1 | 1491.1 | 0 | 0 |
| Mean Δ SS ..... | | | | -0.2 | -0.1 |
| S ..... | | | | 1.4 | 1.2 |

[a]Typical profile selected from 85 sound speed profiles.

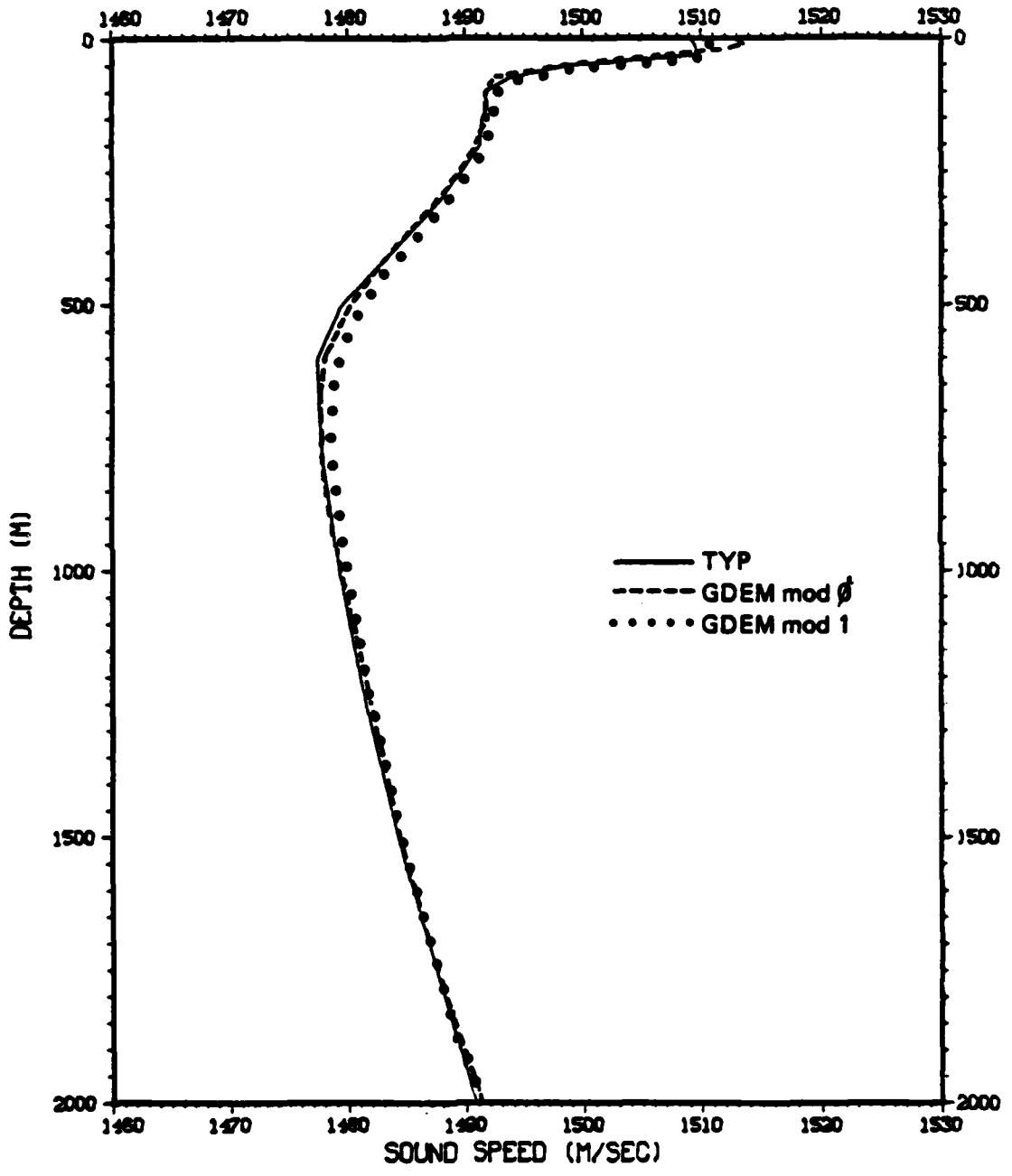


Fig. 4--GDEM-typical profile comparison, location 2T' (41°N, 160°30'W), summer (July through September)

Table 3

DATA FOR GDEM-TYPICAL COMPARISON, LOCATION 2T', SUMMER (JULY-SEPTEMBER)

| Depth (m) | Typical SS[a] (m/sec) | GDEM SS (m/sec) | | Δ SS (m/sec) | |
|---|---|---|---|---|---|
| | | Mod 1 | Mod Ø | Mod 1 | Mod Ø |
| 0 | 1509.3 | 1510.9 | 1512.3 | -1.6 | -3.0 |
| 10 | 1509.5 | 1510.9 | 1513.5 | -1.4 | -4.0 |
| 20 | 1509.6 | 1510.6 | 1512.0 | -1.0 | -2.4 |
| 30 | 1509.8 | 1508.0 | 1508.6 | 1.8 | 1.2 |
| 50 | 1498.7 | 1500.4 | 1498.9 | -1.7 | -.2 |
| 75 | 1493.7 | 1494.1 | 1492.4 | -.4 | 1.3 |
| 100 | 1491.7 | 1492.8 | 1491.6 | -1.1 | .1 |
| 125 | 1492.0 | 1492.7 | 1491.6 | -.7 | .4 |
| 150 | 1491.5 | 1492.4 | 1491.8 | -.9 | -.3 |
| 200 | 1591.3 | 1491.5 | 1490.8 | -.2 | .5 |
| 250 | 1489.7 | 1490.2 | 1489.4 | -.5 | .3 |
| 300 | 1488.0 | 1488.5 | 1487.6 | -.5 | .4 |
| 400 | 1483.8 | 1485.1 | 1483.6 | -1.3 | .2 |
| 500 | 1479.5 | 1481.9 | 1480.2 | -2.4 | -.7 |
| 600 | 1477.5 | 1479.8 | 1478.0 | -2.3 | -.5 |
| 700 | 1477.6 | 1479.1 | 1477.4 | -1.5 | .2 |
| 800 | 1478.0 | 1479.1 | 1477.7 | -1.1 | .3 |
| 900 | 1478.7 | 1479.6 | 1478.4 | -.9 | .3 |
| 1000 | 1479.3 | 1480.3 | 1479.3 | -1.0 | 0 |
| 1100 | 1480.2 | 1481.2 | 1480.3 | -1.0 | -.1 |
| 1200 | 1481.1 | 1482.1 | 1481.4 | -1.0 | -.3 |
| 1300 | 1482.1 | 1482.9 | 1482.3 | -.8 | -.2 |
| 1400 | 1483.2 | 1483.8 | 1483.3 | -.6 | -.1 |
| 1500 | 1484.3 | 1484.8 | 1484.3 | -.5 | 0 |
| 1750 | 1487.5 | 1487.7 | 1487.4 | -.2 | .1 |
| 2000 | 1490.9 | 1491.3 | 1491.1 | -.4 | -.2 |
| Mean Δ SS ..... | | | | -0.9 | -0.3 |
| S ..... | | | | 0.8 | 1.2 |

[a]Typical profile selected from 35 sound speed profiles.

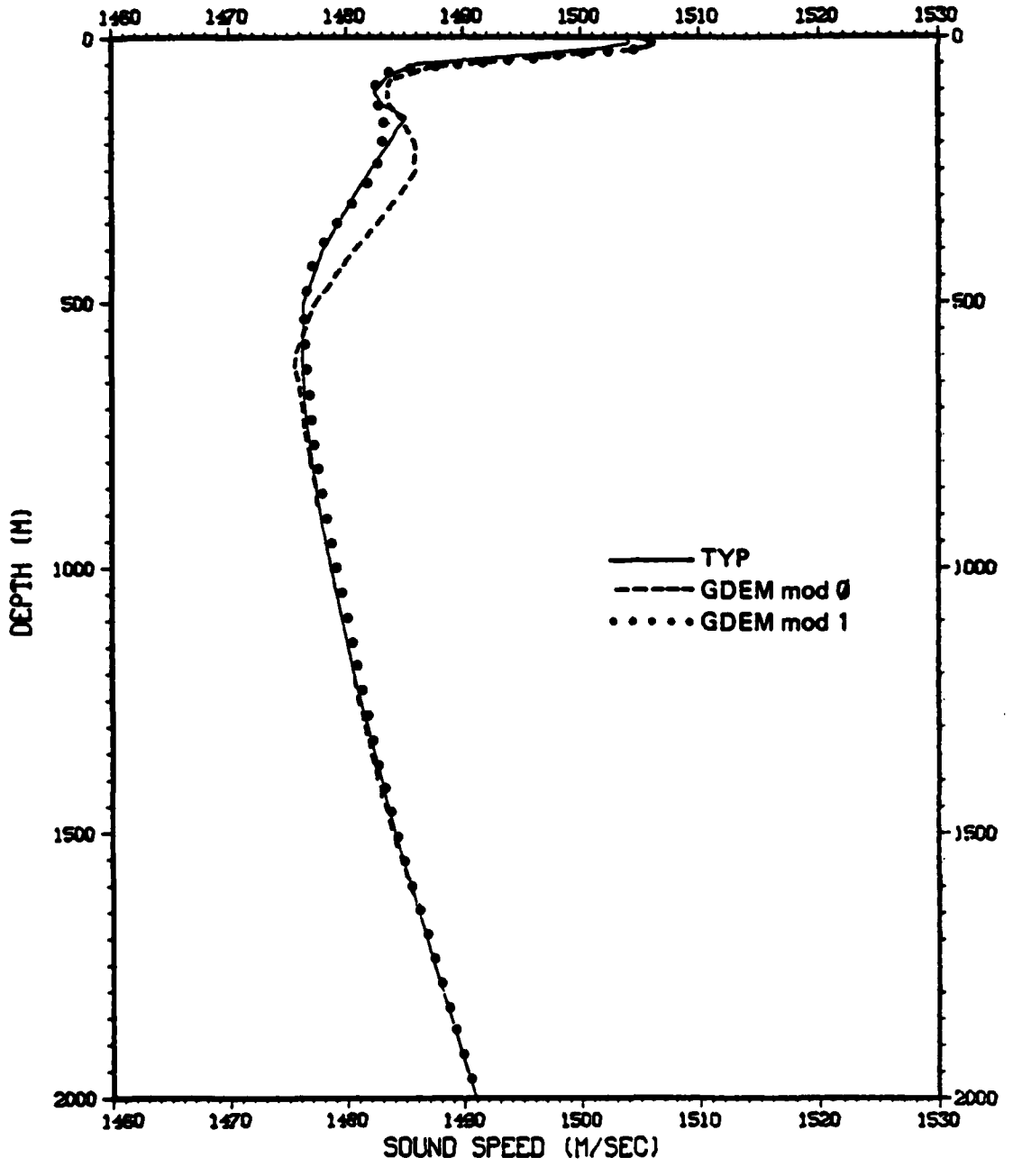


Fig. 5--GDEM-typical profile comparison, location 3' (43°30'N, 157°W), summer (July through September)

Table 4

DATA FOR GDEM-TYPICAL COMPARISON, LOCATION 3', SUMMER (JULY-SEPTEMBER)

| Depth (m) | Typical SS[a] (m/sec) | GDEM SS (m/sec) | | Δ SS (m/sec) | |
|---|---|---|---|---|---|
| | | Mod 1 | Mod Ø | Mod 1 | Mod Ø |
| 0 | 1504.0 | 1505.6 | 1504.7 | -1.6 | -.7 |
| 10 | 1504.2 | 1505.6 | 1506.3 | -1.4 | -2.1 |
| 20 | 1501.9 | 1503.4 | 1503.3 | -1.5 | -1.4 |
| 30 | 1497.2 | 1497.4 | 1497.8 | -.2 | -.6 |
| 50 | 1486.0 | 1486.8 | 1487.4 | -.8 | -1.4 |
| 75 | 1483.5 | 1482.8 | 1483.5 | .7 | 0 |
| 100 | 1482.5 | 1482.2 | 1483.2 | .3 | -.7 |
| 125 | 1483.0 | 1482.4 | 1483.5 | .6 | -.5 |
| 150 | 1485.1 | 1482.9 | 1484.5 | 2.2 | .6 |
| 200 | 1483.7 | 1483.3 | 1485.7 | .4 | -2.0 |
| 250 | 1482.1 | 1482.3 | 1485.6 | -.2 | -3.5 |
| 300 | 1480.7 | 1480.2 | 1484.1 | .5 | -3.4 |
| 400 | 1478.0 | 1477.3 | 1480.3 | .7 | -2.3 |
| 500 | 1476.4 | 1476.4 | 1477.0 | 0 | -.6 |
| 600 | 1476.3 | 1476.5 | 1475.4 | -.2 | .9 |
| 700 | 1476.5 | 1476.9 | 1476.0 | -.4 | .5 |
| 800 | 1477.1 | 1477.6 | 1476.7 | -.5 | .4 |
| 900 | 1477.8 | 1478.3 | 1477.6 | -.5 | .2 |
| 1000 | 1478.7 | 1479.1 | 1478.5 | -.4 | .2 |
| 1100 | 1479.7 | 1479.9 | 1479.5 | -.2 | .2 |
| 1200 | 1480.7 | 1480.8 | 1480.5 | -.1 | .2 |
| 1300 | 1481.8 | 1481.8 | 1481.5 | 0 | .3 |
| 1400 | 1483.0 | 1483.0 | 1482.6 | 0 | .4 |
| 1500 | 1484.2 | 1484.2 | 1483.9 | 0 | .3 |
| 1750 | 1487.5 | 1487.5 | 1487.3 | 0 | .2 |
| 2000 | 1491.0 | 1491.0 | 1490.9 | 0 | .1 |
| Mean Δ SS ..... | | | | -0.1 | -0.6 |
| S ..... | | | | 0.8 | 1.2 |

[a]Typical profile selected from 100 sound speed profiles.

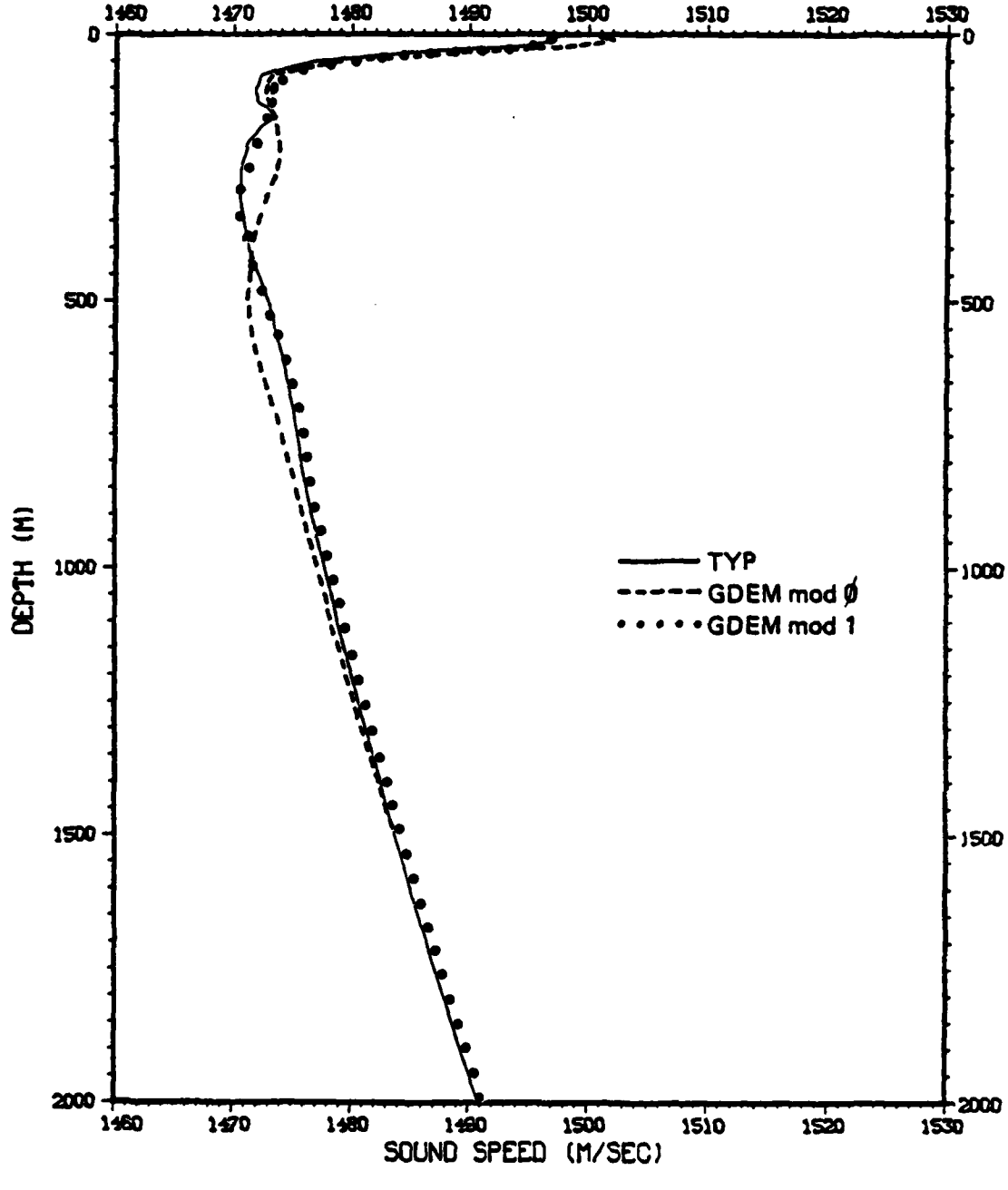


Fig. 6--GDEM-typical profile comparison, location 4' (49°N, 145°W), summer (July through September)

Table 5

DATA FOR GDEM-TYPICAL COMPARISON, LOCATION 4', SUMMER (JULY-SEPTEMBER)

| Depth (m) | Typical SS[a] (m/sec) | GDEM SS (m/sec) | | Δ SS (m/sec) | |
|---|---|---|---|---|---|
| | | Mod 1 | Mod Ø | Mod 1 | Mod Ø |
| 0 | 1497.2 | 1497.3 | 1500.1 | -.1 | -2.9 |
| 10 | 1497.1 | 1497.3 | 1502.1 | -.2 | -5.0 |
| 20 | 1495.2 | 1496.1 | 1498.6 | -.9 | -3.4 |
| 30 | 1486.8 | 1490.9 | 1491.9 | -4.1 | -5.1 |
| 50 | 1476.8 | 1480.0 | 1478.9 | -3.2 | -2.1 |
| 75 | 1472.4 | 1474.2 | 1473.2 | -1.8 | -.8 |
| 100 | 1471.9 | 1473.3 | 1472.6 | -1.4 | -.7 |
| 125 | 1472.0 | 1473.3 | 1472.8 | -1.3 | -.8 |
| 150 | 1473.4 | 1472.8 | 1473.3 | .6 | .1 |
| 200 | 1471.3 | 1471.7 | 1473.8 | -.4 | -2.5 |
| 250 | 1470.6 | 1470.7 | 1473.6 | -.1 | -3.0 |
| 300 | 1470.5 | 1470.4 | 1472.7 | .1 | -2.2 |
| 400 | 1471.3 | 1471.7 | 1471.4 | -.4 | -.1 |
| 500 | 1473.0 | 1472.8 | 1471.1 | .2 | 1.9 |
| 600 | 1474.1 | 1474.5 | 1471.8 | -.4 | 2.3 |
| 700 | 1475.1 | 1475.6 | 1473.3 | -.5 | 1.8 |
| 800 | 1475.8 | 1476.5 | 1474.6 | -.7 | 1.2 |
| 900 | 1476.7 | 1477.4 | 1475.8 | -.7 | .9 |
| 1000 | 1477.8 | 1478.3 | 1477.0 | -.5 | .8 |
| 1100 | 1478.9 | 1479.3 | 1478.2 | -.4 | .7 |
| 1200 | 1480.1 | 1480.4 | 1479.5 | -.3 | .6 |
| 1300 | 1481.3 | 1481.6 | 1480.8 | -.3 | .5 |
| 1400 | 1482.6 | 1482.8 | 1482.2 | -.2 | .4 |
| 1500 | 1483.8 | 1484.1 | 1483.6 | -.3 | .2 |
| 1750 | 1487.2 | 1487.5 | 1487.2 | -.3 | 0 |
| 2000 | 1490.9 | 1490.9 | 1490.8 | 0 | .1 |
| Mean Δ SS ..... | | | | -0.7 | -0.7 |
| S ..... | | | | 1.0 | 2.0 |

[a]Typical profile selected from 140 sound speed profiles.

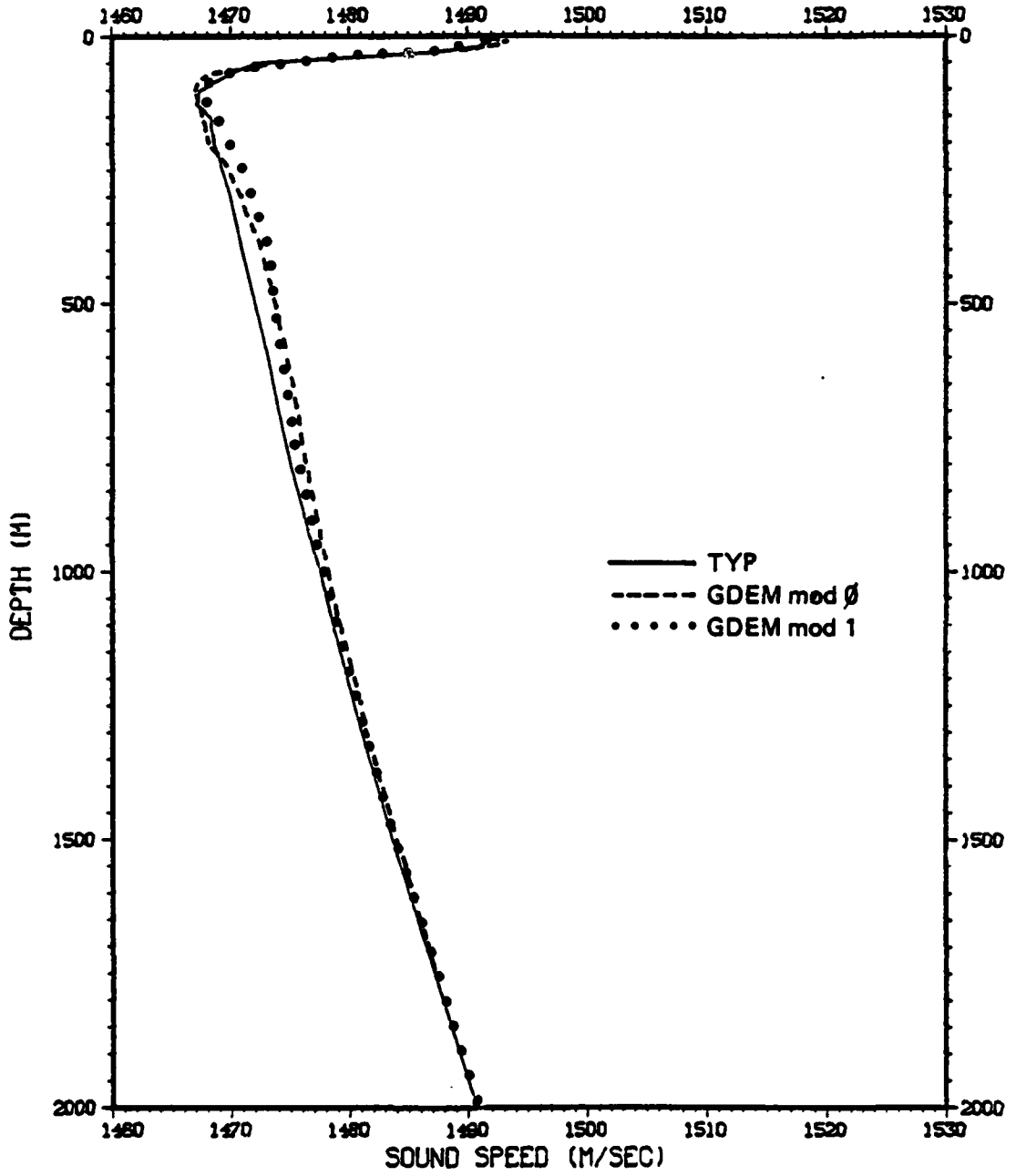


Fig. 7--GDEM-typical profile comparison, location 5' (49°30'N, 153°30'W) summer (July through September)

Table 6

DATA FOR GDEM-TYPICAL COMPARISON, LOCATION 5', SUMMER (JULY-SEPTEMBER)

| Depth (m) | Typical SS[a] (m/sec) | GDEM SS (m/sec) | | Δ SS (m/sec) | |
|---|---|---|---|---|---|
| | | Mod 1 | Mod Ø | Mod 1 | Mod Ø |
| 0 | 1491.8 | 1491.6 | 1491.4 | .2 | .4 |
| 10 | 1492.0 | 1491.6 | 1493.3 | .4 | -1.3 |
| 20 | 1490.8 | 1490.1 | 1490.4 | .7 | .4 |
| 30 | 1486.8 | 1484.4 | 1484.7 | 2.4 | 2.1 |
| 50 | 1472.0 | 1473.5 | 1473.0 | -1.5 | -1.0 |
| 75 | 1469.5 | 1468.6 | 1467.6 | .9 | 1.9 |
| 100 | 1467.5 | 1468.2 | 1467.0 | -.7 | .5 |
| 125 | 1467.1 | 1468.8 | 1467.3 | -1.7 | -.2 |
| 150 | 1468.3 | 1469.4 | 1467.7 | -1.1 | .6 |
| 200 | 1468.7 | 1470.5 | 1458.2 | -1.8 | .5 |
| 250 | 1469.3 | 1471.4 | 1469.8 | -2.1 | -.5 |
| 300 | 1470.0 | 1472.0 | 1470.8 | -2.0 | -.8 |
| 400 | 1471.0 | 1472.7 | 1472.5 | -1.7 | -1.5 |
| 500 | 1472.1 | 1473.3 | 1473.7 | -1.2 | -1.6 |
| 600 | 1473.2 | 1474.0 | 1474.7 | -.8 | -1.5 |
| 700 | 1474.1 | 1474.9 | 1475.5 | -.8 | -1.4 |
| 800 | 1475.1 | 1475.8 | 1476.3 | -.7 | -1.2 |
| 900 | 1476.3 | 1476.7 | 1477.2 | -.4 | -.9 |
| 1000 | 1477.6 | 1477.7 | 1478.1 | -.1 | -.5 |
| 1100 | 1478.7 | 1478.8 | 1479.1 | -.1 | -.4 |
| 1200 | 1479.9 | 1480.0 | 1480.3 | -.1 | -.4 |
| 1300 | 1481.1 | 1481.2 | 1481.4 | -.1 | -.3 |
| 1400 | 1482.4 | 1482.5 | 1482.7 | -.1 | -.3 |
| 1500 | 1483.7 | 1483.8 | 1484.0 | -.1 | -.3 |
| 1750 | 1487.2 | 1487.1 | 1487.3 | .1 | -.1 |
| 2000 | 1490.8 | 1490.7 | 1490.8 | .1 | 0 |
| Mean Δ SS ..... | | | | -0.5 | -0.3 |
| S ..... | | | | 1.0 | 1.0 |

[a]Typical profile selected from 116 sound speed profiles.

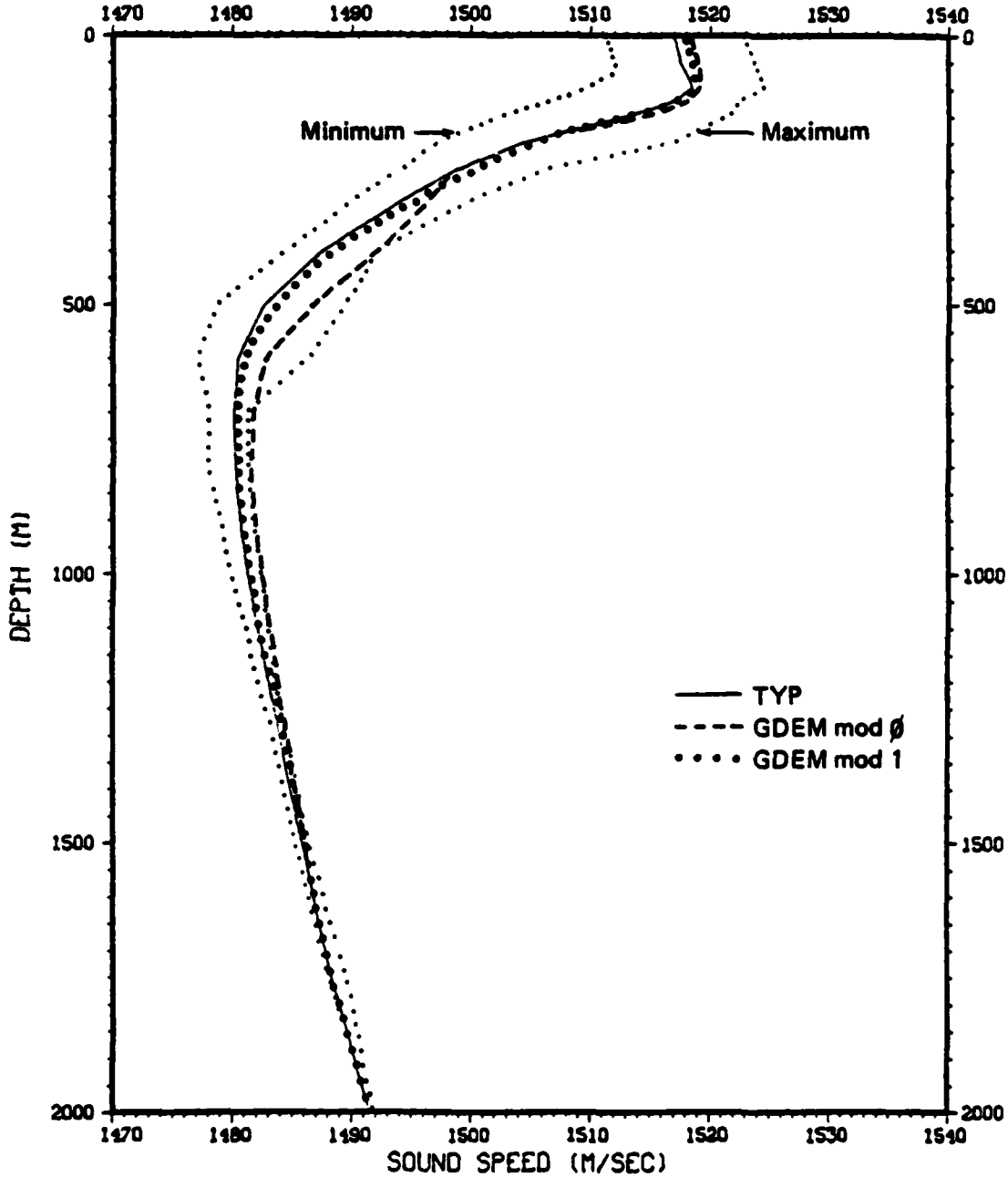


Fig. 8--GDEM-typical profile comparison, location 1 (30°N, 140°W), winter

Table 7

DATA FOR GDEM-TYPICAL COMPARISON, LOCATION 1, WINTER

| Depth (m) | Typical SS[a] (m/sec) | GDEM SS (m/sec) | | Δ SS (m/sec) | |
|---|---|---|---|---|---|
| | | Mod 1 | Mod Ø | Mod 1 | Mod Ø |
| 0 | 1516.9 | 1518.3 | 1518.6 | -1.4 | -1.7 |
| 10 | 1517.2 | 1518.4 | 1518.7 | -1.2 | -1.5 |
| 20 | 1517.3 | 1518.5 | 1518.8 | -1.2 | -1.5 |
| 30 | 1517.4 | 1518.6 | 1518.9 | -1.2 | -1.5 |
| 50 | 1517.6 | 1518.7 | 1519.1 | -1.1 | -1.5 |
| 75 | 1518.2 | 1518.9 | 1519.3 | -.7 | -1.1 |
| 100 | 1518.6 | 1518.8 | 1519.2 | -.2 | -.6 |
| 125 | 1516.4 | 1517.5 | 1518.1 | -1.1 | -1.7 |
| 150 | 1512.6 | 1514.0 | 1515.0 | -1.4 | -2.4 |
| 200 | 1504.0 | 1504.2 | 1504.6 | -.2 | -.6 |
| 250 | 1498.6 | 1500.0 | 1498.7 | -1.4 | -.1 |
| 300 | 1494.5 | 1495.8 | 1496.8 | -1.3 | -2.2 |
| 400 | 1487.4 | 1488.5 | 1492.3 | -1.1 | -4.9 |
| 500 | 1482.6 | 1484.1 | 1486.9 | -1.5 | -4.3 |
| 600 | 1480.5 | 1481.7 | 1482.9 | -1.2 | -2.4 |
| 700 | 1480.1 | 1480.8 | 1481.8 | -0.7 | -1.7 |
| 800 | 1480.3 | 1480.8 | 1481.6 | -0.5 | -1.3 |
| 900 | 1480.7 | 1481.2 | 1482.0 | -0.5 | -1.3 |
| 1000 | 1481.3 | 1482.0 | 1482.6 | -0.7 | -1.3 |
| 1100 | 1482.2 | 1482.8 | 1483.3 | -0.6 | -1.1 |
| 1200 | 1483.1 | 1483.6 | 1484.0 | -0.5 | -.9 |
| 1300 | 1484.0 | 1484.3 | 1484.7 | -0.3 | -.7 |
| 1400 | 1484.9 | 1485.1 | 1485.4 | -0.2 | -.5 |
| 1500 | 1485.9 | 1485.9 | 1486.2 | 0 | -.3 |
| 1750 | 1488.4 | 1488.4 | 1488.6 | 0 | -.2 |
| 2000 | 1491.6 | 1491.5 | 1491.6 | .1 | 0 |
| Mean Δ SS ..... | | | | -0.8 | -1.4 |
| S ..... | | | | 0.5 | 1.1 |

[a]Typical profile selected from 234 sound speed profiles.

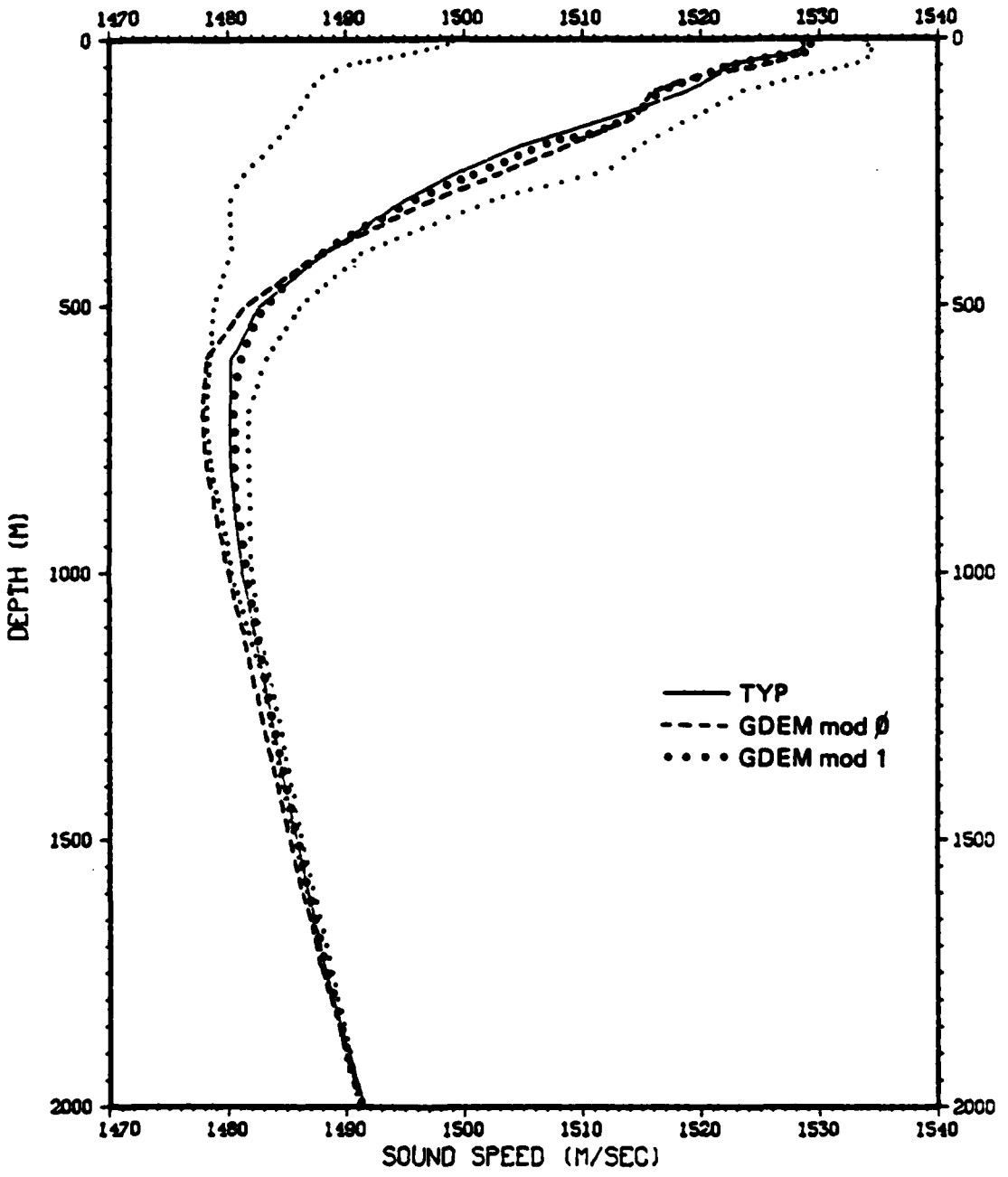


Fig. 9--GDEM-typical profile comparison, location 1 (30°N, 140°W), summer

Table 8

DATA FOR GDEM-TYPICAL COMPARISON, LOCATION 1, SUMMER

| Depth (m) | Typical SS[a] (m/sec) | GDEM SS (m/sec) | | Δ SS (m/sec) | |
|---|---|---|---|---|---|
| | | Mod 1 | Mod Ø | Mod 1 | Mod Ø |
| 0 | 1528.5 | 1529.2 | 1528.8 | -0.7 | -.3 |
| 10 | 1528.6 | 1529.3 | 1528.8 | -0.7 | -.2 |
| 20 | 1528.7 | 1429.3 | 1528.9 | -5.6 | -.2 |
| 30 | 1527.5 | 1428.9 | 1528.7 | -1.4 | -1.2 |
| 50 | 1522.4 | 1525.3 | 1525.6 | -2.9 | -3.2 |
| 75 | 1521.0 | 1519.3 | 1519.1 | 1.7 | 1.9 |
| 100 | 1518.5 | 1516.8 | 1515.9 | 1.7 | 2.6 |
| 125 | 1515.3 | 1515.8 | 1515.2 | -0.5 | .1 |
| 150 | 1511.9 | 1513.5 | 1514.2 | -1.6 | -2.3 |
| 200 | 1504.7 | 1507.6 | 1508.9 | -2.9 | -4.2 |
| 250 | 1499.4 | 1501.1 | 1503.4 | -1.7 | -4.0 |
| 300 | 1495.1 | 1495.2 | 1497.7 | -0.1 | -2.6 |
| 400 | 1488.3 | 1487.1 | 1488.0 | 1.2 | .3 |
| 500 | 1482.7 | 1482.9 | 1481.5 | -0.2 | 1.2 |
| 600 | 1480.3 | 1481.1 | 1478.2 | -0.8 | 2.1 |
| 700 | 1480.2 | 1480.3 | 1477.8 | -0.1 | 2.4 |
| 800 | 1480.3 | 1480.3 | 1478.2 | 0 | 2.1 |
| 900 | 1480.7 | 1480.8 | 1479.1 | -0.1 | 1.6 |
| 1000 | 1481.3 | 1481.5 | 1480.1 | -0.2 | 1.2 |
| 1100 | 1482.2 | 1482.3 | 1481.2 | -0.1 | 1.0 |
| 1200 | 1483.1 | 1483.1 | 1482.2 | 0 | .9 |
| 1300 | 1484.0 | 1483.9 | 1483.2 | 0.1 | .8 |
| 1400 | 1484.9 | 1484.8 | 1484.2 | 0.1 | .7 |
| 1500 | 1485.9 | 1485.8 | 1485.2 | 0.1 | .7 |
| 1750 | 1488.4 | 1488.4 | 1488.0 | 0 | .4 |
| 2000 | 1491.6 | 1491.4 | 1491.2 | 0.2 | .4 |
| Mean Δ SS ..... | | | | -0.6 | 0.1 |
| S ..... | | | | 1.5 | 1.9 |

[a]Typical profile selected from 265 sound speed profiles.

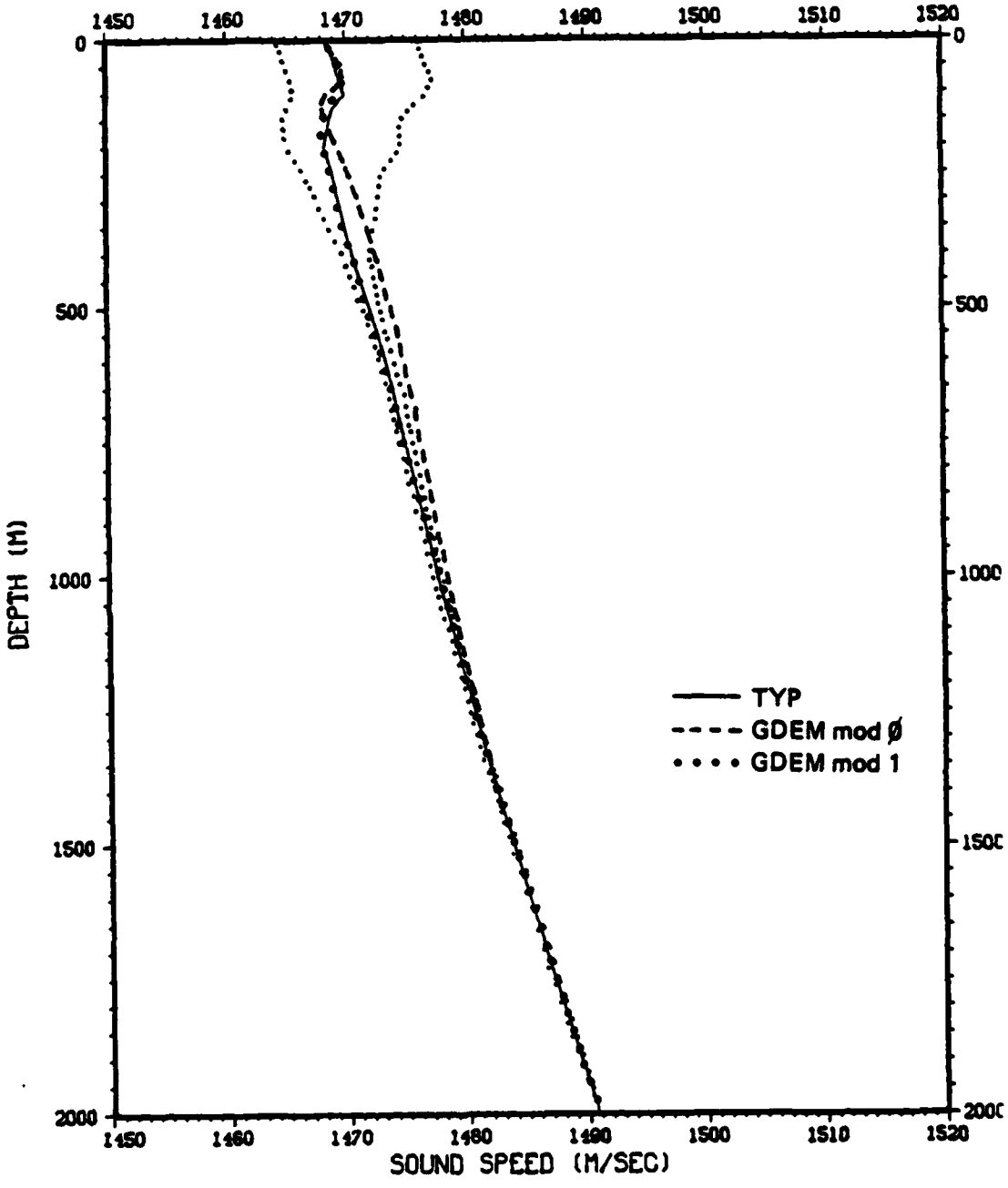


Fig. 10--GDEM-typical profile comparison, location 2 (50°N, 145°W), winter

Table 9

DATA FOR GDEM-TYPICAL COMPARISON, LOCATION 2, WINTER

| Depth (m) | Typical SS[a] (m/sec) | GDEM SS (m/sec) | | Δ SS (m/sec) | |
|---|---|---|---|---|---|
| | | Mod 1 | Mod Ø | Mod 1 | Mod Ø |
| 0 | 1468.4 | 1468.5 | 1468.6 | -0.1 | -.2 |
| 10 | 1468.6 | 1468.8 | 1468.9 | -0.2 | -.3 |
| 20 | 1468.8 | 1469.0 | 1469.1 | -0.2 | -.3 |
| 30 | 1469.0 | 1469.3 | 1469.4 | -0.3 | -.4 |
| 50 | 1469.3 | 1469.7 | 1470.0 | -0.4 | -.7 |
| 75 | 1469.6 | 1469.7 | 1470.0 | -0.1 | -.4 |
| 100 | 1470.0 | 1469.1 | 1468.4 | 0.9 | 1.6 |
| 125 | 1469.0 | 1468.3 | 1468.2 | 0.7 | .8 |
| 150 | 1468.7 | 1467.9 | 1468.7 | 0.8 | 0 |
| 200 | 1468.3 | 1468.2 | 1469.6 | 0.1 | -1.3 |
| 250 | 1469.0 | 1468.8 | 1470.5 | 0.2 | -1.5 |
| 300 | 1469.5 | 1469.2 | 1471.3 | 0.3 | -1.8 |
| 400 | 1470.6 | 1470.5 | 1472.7 | 0.1 | -2.1 |
| 500 | 1472.1 | 1472.0 | 1474.0 | 0.1 | -1.9 |
| 600 | 1473.4 | 1473.4 | 1475.0 | 0 | -1.6 |
| 700 | 1474.4 | 1474.5 | 1475.9 | -0.1 | -1.5 |
| 800 | 1475.5 | 1475.6 | 1476.8 | -0.1 | -1.3 |
| 900 | 1476.6 | 1476.6 | 1477.6 | 0 | -1.0 |
| 1000 | 1477.6 | 1477.6 | 1478.5 | 0 | -.9 |
| 1100 | 1478.8 | 1478.7 | 1479.4 | 0.1 | -.6 |
| 1200 | 1480.0 | 1479.9 | 1480.4 | 0.1 | -.4 |
| 1300 | 1481.2 | 1481.1 | 1481.5 | 0.1 | -.3 |
| 1400 | 1482.5 | 1482.4 | 1482.8 | 0.1 | -.3 |
| 1500 | 1483.8 | 1483.7 | 1484.0 | 0.1 | -.2 |
| 1750 | 1487.2 | 1487.9 | 1487.3 | -0.7 | -.1 |
| 2000 | 1490.8 | 1490.6 | 1490.8 | 0.2 | 0 |
| Mean Δ SS ..... | | | | 0.1 | -0.6 |
| S ..... | | | | 0.3 | 0.8 |

[a]Typical profile selected from 115 sound speed profiles.

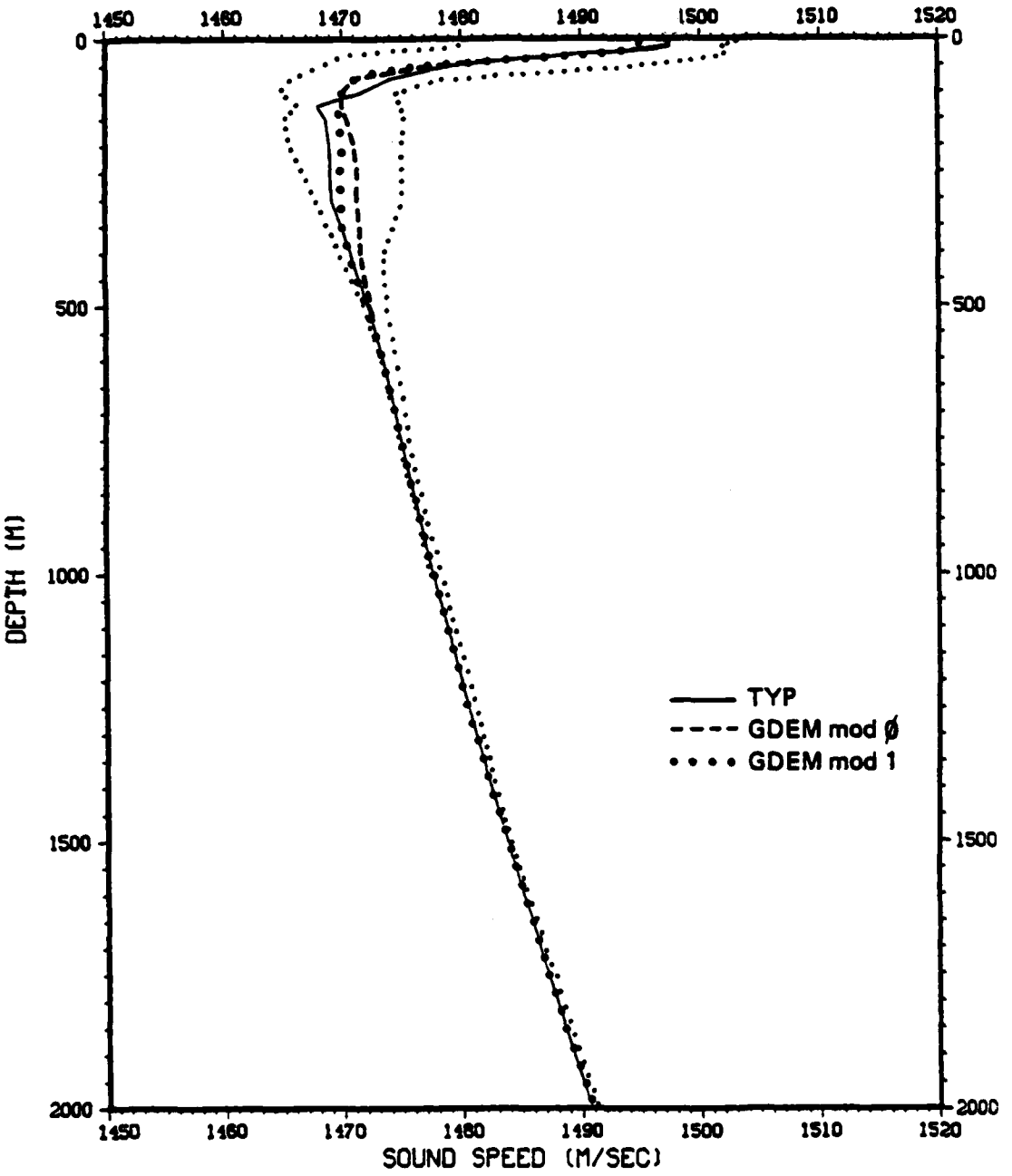


Fig. 11--GDEM-typical profile comparison, location 2 (50°N, 145°W), summer

Table 10

DATA FOR GDEM-TYPICAL COMPARISON, LOCATION 2, SUMMER

| Depth (m) | Typical SS[a] (m/sec) | GDEM SS (m/sec) | | Δ SS (m/sec) | |
|---|---|---|---|---|---|
| | | Mod 1 | Mod Ø | Mod 1 | Mod Ø |
| 0 | 1497.4 | 1494.8 | 1496.2 | 2.6 | 1.2 |
| 10 | 1496.7 | 1494.8 | 1497.8 | 1.9 | -1.1 |
| 20 | 1496.5 | 1493.8 | 1495.4 | 2.7 | 1.1 |
| 30 | 1489.1 | 1489.1 | 1490.4 | 0 | -1.3 |
| 50 | 1479.2 | 1478.2 | 1478.4 | 1.0 | .8 |
| 75 | 1474.0 | 1471.2 | 1471.1 | 2.8 | 2.9 |
| 100 | 1471.6 | 1469.8 | 1470.0 | 1.8 | 1.6 |
| 125 | 1468.0 | 1469.8 | 1470.1 | -1.8 | -2.1 |
| 150 | 1468.7 | 1470.2 | 1470.4 | -1.5 | -1.7 |
| 200 | 1469.0 | 1470.8 | 1471.0 | -1.8 | -2.0 |
| 250 | 1469.1 | 1470.5 | 1471.3 | -1.4 | -2.2 |
| 300 | 1469.2 | 1469.9 | 1471.3 | -0.7 | -2.1 |
| 400 | 1470.8 | 1470.2 | 1471.6 | 0.6 | -.8 |
| 500 | 1472.2 | 1471.9 | 1472.3 | 0.3 | -.1 |
| 600 | 1473.5 | 1473.7 | 1473.4 | -0.2 | .1 |
| 700 | 1474.5 | 1474.8 | 1474.5 | -0.3 | 0 |
| 800 | 1475.5 | 1475.8 | 1475.6 | -0.3 | -.1 |
| 900 | 1476.6 | 1476.8 | 1476.6 | -0.2 | 0 |
| 1000 | 1477.6 | 1477.8 | 1477.7 | -0.2 | -.1 |
| 1100 | 1478.8 | 1478.9 | 1478.8 | -0.1 | 0 |
| 1200 | 1480.0 | 1480.0 | 1479.9 | 0 | .1 |
| 1300 | 1481.2 | 1481.3 | 1481.2 | -0.1 | 0 |
| 1400 | 1482.5 | 1482.6 | 1482.5 | -0.1 | 0 |
| 1500 | 1483.8 | 1483.9 | 1483.8 | -0.1 | 0 |
| 1750 | 1487.2 | 1487.3 | 1487.3 | -0.1 | -.1 |
| 2000 | 1490.8 | 1490.8 | 1490.8 | 0 | 0 |
| Mean Δ SS ..... | | | | 0.2 | -0.2 |
| S ..... | | | | 1.3 | 1.2 |

[a]Typical profile selected from 124 sound speed profiles.

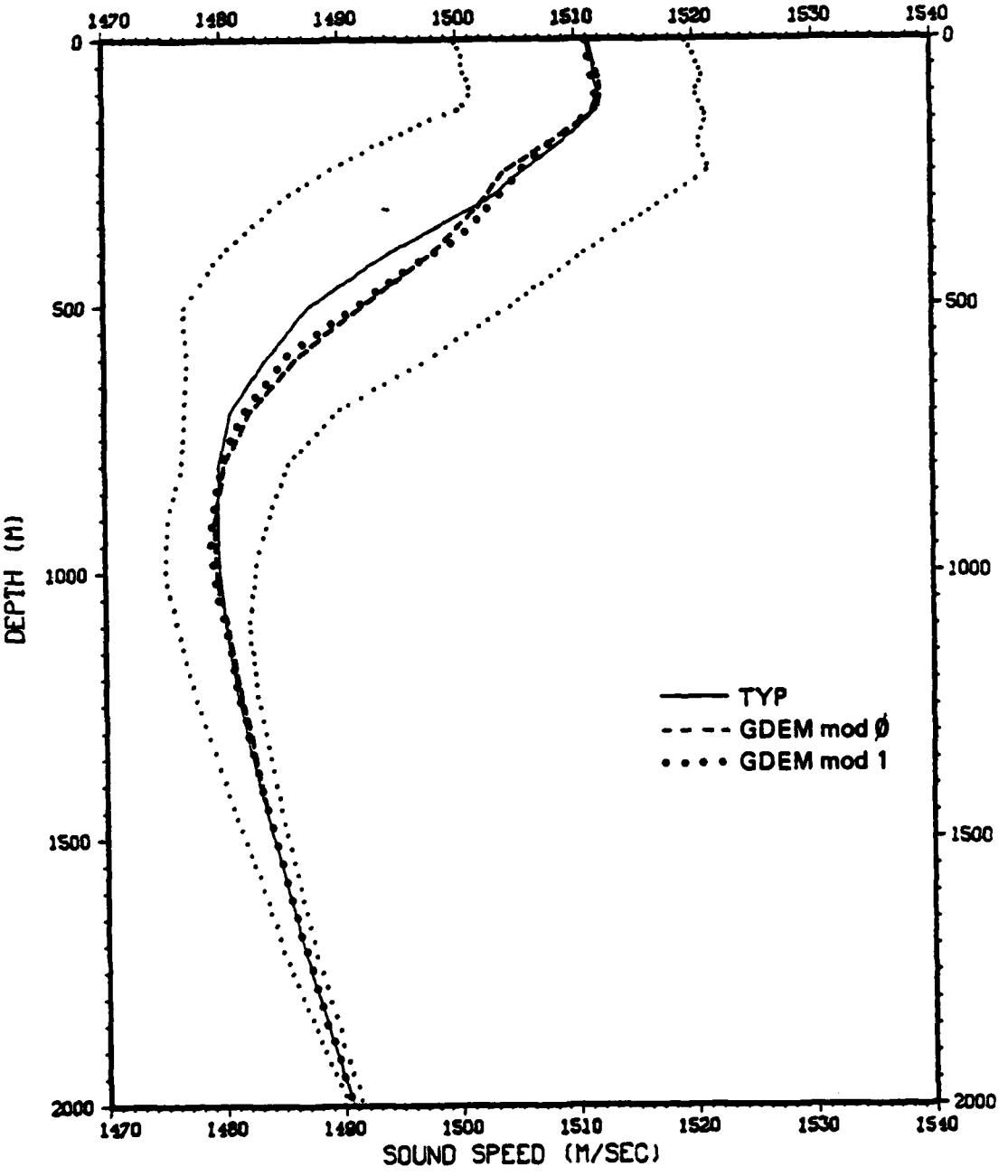


Fig. 12--GDEM-typical profile comparison, location 3 (34°N, 164°E), winter

Table 11

DATA FOR GDEM-TYPICAL COMPARISON, LOCATION 3, WINTER

| Depth (m) | Typical SS[a] (m/sec) | GDEM SS (m/sec) | | Δ SS (m/sec) | |
|---|---|---|---|---|---|
| | | Mod 1 | Mod Ø | Mod 1 | Mod Ø |
| 0 | 1511.3 | 1510.6 | 1510.8 | 0.7 | .5 |
| 10 | 1511.4 | 1510.9 | 1511.0 | 0.5 | .4 |
| 20 | 1511.5 | 1511.1 | 1511.1 | 0.4 | .4 |
| 30 | 1511.6 | 1511.3 | 1511.3 | 0.3 | .3 |
| 50 | 1511.7 | 1511.6 | 1511.6 | 0.1 | .1 |
| 75 | 1511.8 | 1511.9 | 1512.0 | -0.1 | -.2 |
| 100 | 1512.1 | 1512.0 | 1512.1 | 0.1 | 0 |
| 125 | 1511.6 | 1511.6 | 1511.9 | 0 | -.3 |
| 150 | 1511.1 | 1510.6 | 1510.9 | 0.5 | .2 |
| 200 | 1508.5 | 1507.4 | 1507.3 | 1.1 | 1.2 |
| 250 | 1505.5 | 1505.0 | 1503.8 | 0.5 | 1.7 |
| 300 | 1502.6 | 1503.6 | 1502.2 | -1.0 | .4 |
| 400 | 1494.2 | 1498.8 | 1497.9 | -4.6 | -3.7 |
| 500 | 1487.5 | 1492.1 | 1492.0 | -4.6 | -4.5 |
| 600 | 1583.6 | 1485.9 | 1486.2 | -2.3 | -2.6 |
| 700 | 1480.7 | 1482.0 | 1482.2 | -1.3 | -1.5 |
| 800 | 1479.7 | 1479.8 | 1480.0 | -0.1 | -.3 |
| 900 | 1479.6 | 1479.0 | 1479.2 | 0.6 | .4 |
| 1000 | 1479.8 | 1479.2 | 1479.4 | 0.6 | .4 |
| 1100 | 1480.3 | 1480.0 | 1480.2 | 0.3 | .1 |
| 1200 | 1481.0 | 1481.0 | 1481.1 | 0 | -.1 |
| 1300 | 1481.9 | 1482.0 | 1482.2 | -0.1 | -.3 |
| 1400 | 1483.0 | 1483.0 | 1483.1 | 0 | -.1 |
| 1500 | 1484.2 | 1484.0 | 1484.1 | 0.2 | .1 |
| 1750 | 1487.3 | 1486.9 | 1487.0 | 0.4 | .3 |
| 2000 | 1490.8 | 1490.8 | 1490.9 | 0 | -.1 |
| Mean Δ SS ..... | | | | -0.3 | -0.3 |
| S ..... | | | | 1.4 | 1.4 |

[a]Typical profile selected from 103 sound speed profiles.

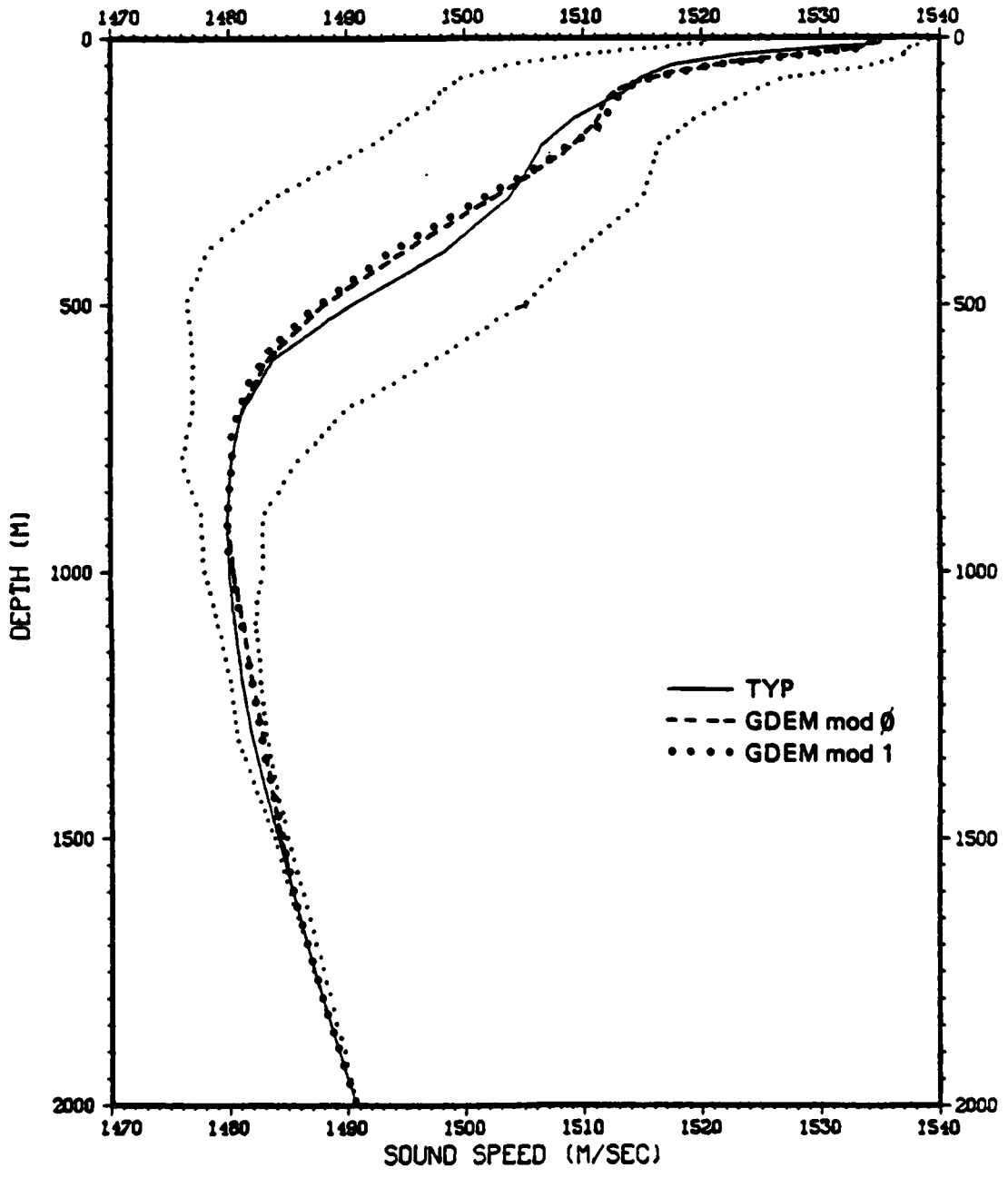


Fig. 13--GDEM-typical profile comparison, location 3 (34°N, 164°E), summer

Table 12

DATA FOR GDEM-TYPICAL COMPARISON, LOCATION 3, SUMMER

| Depth (m) | Typical SS[a] (m/sec) | GDEM SS (m/sec) | | Δ SS (m/sec) | |
|---|---|---|---|---|---|
| | | Mod 1 | Mod Ø | Mod 1 | Mod Ø |
| 0 | 1535.2 | 1534.6 | 1534.3 | 0.6 | .9 |
| 10 | 1535.0 | 1534.1 | 1534.0 | 0.9 | 1.0 |
| 20 | 1528.6 | 1531.3 | 1531.6 | -2.7 | -3.0 |
| 30 | 1523.2 | 1527.2 | 1528.0 | -4.0 | -4.8 |
| 50 | 1517.5 | 1519.9 | 1520.4 | -2.4 | -2.9 |
| 75 | 1514.8 | 1515.8 | 1514.9 | -1.0 | -.1 |
| 100 | 1513.5 | 1514.4 | 1512.6 | -0.9 | .9 |
| 125 | 1511.3 | 1513.1 | 1511.7 | -1.8 | -.4 |
| 150 | 1509.2 | 1511.7 | 1511.3 | -2.5 | -2.1 |
| 200 | 1506.5 | 1508.8 | 1509.0 | -2.3 | -2.5 |
| 250 | 1505.2 | 1505.4 | 1505.9 | -0.2 | -.7 |
| 300 | 1503.7 | 1501.4 | 1502.2 | 2.3 | 1.5 |
| 400 | 1498.2 | 1493.6 | 1494.6 | 4.6 | 3.6 |
| 500 | 1490.3 | 1587.1 | 1488.0 | 3.2 | 2.3 |
| 600 | 1483.8 | 1482.8 | 1483.3 | 1.0 | .5 |
| 700 | 1481.1 | 1481.0 | 1481.0 | 0.1 | .1 |
| 800 | 1480.2 | 1480.4 | 1480.1 | -0.2 | .1 |
| 900 | 1479.9 | 1480.5 | 1480.0 | -0.6 | -.1 |
| 1000 | 1480.1 | 1481.1 | 1480.5 | -1.0 | -.4 |
| 1100 | 1480.5 | 1481.7 | 1481.2 | -1.2 | -.7 |
| 1200 | 1481.1 | 1482.4 | 1482.0 | -1.3 | -.9 |
| 1300 | 1481.9 | 1483.1 | 1482.8 | -1.2 | -.9 |
| 1400 | 1483.0 | 1483.8 | 1483.6 | -0.8 | -.6 |
| 1500 | 1484.2 | 1484.6 | 1484.4 | -0.4 | -.2 |
| 1750 | 1487.3 | 1487.4 | 1487.2 | -0.1 | .1 |
| 2000 | 1490.8 | 1491.1 | 1491.0 | -0.3 | -.2 |
| Mean Δ SS ..... | | | | -0.5 | -0.4 |
| S ..... | | | | 1.9 | 1.7 |

[a]Typical profile selected from 198 sound speed profiles.

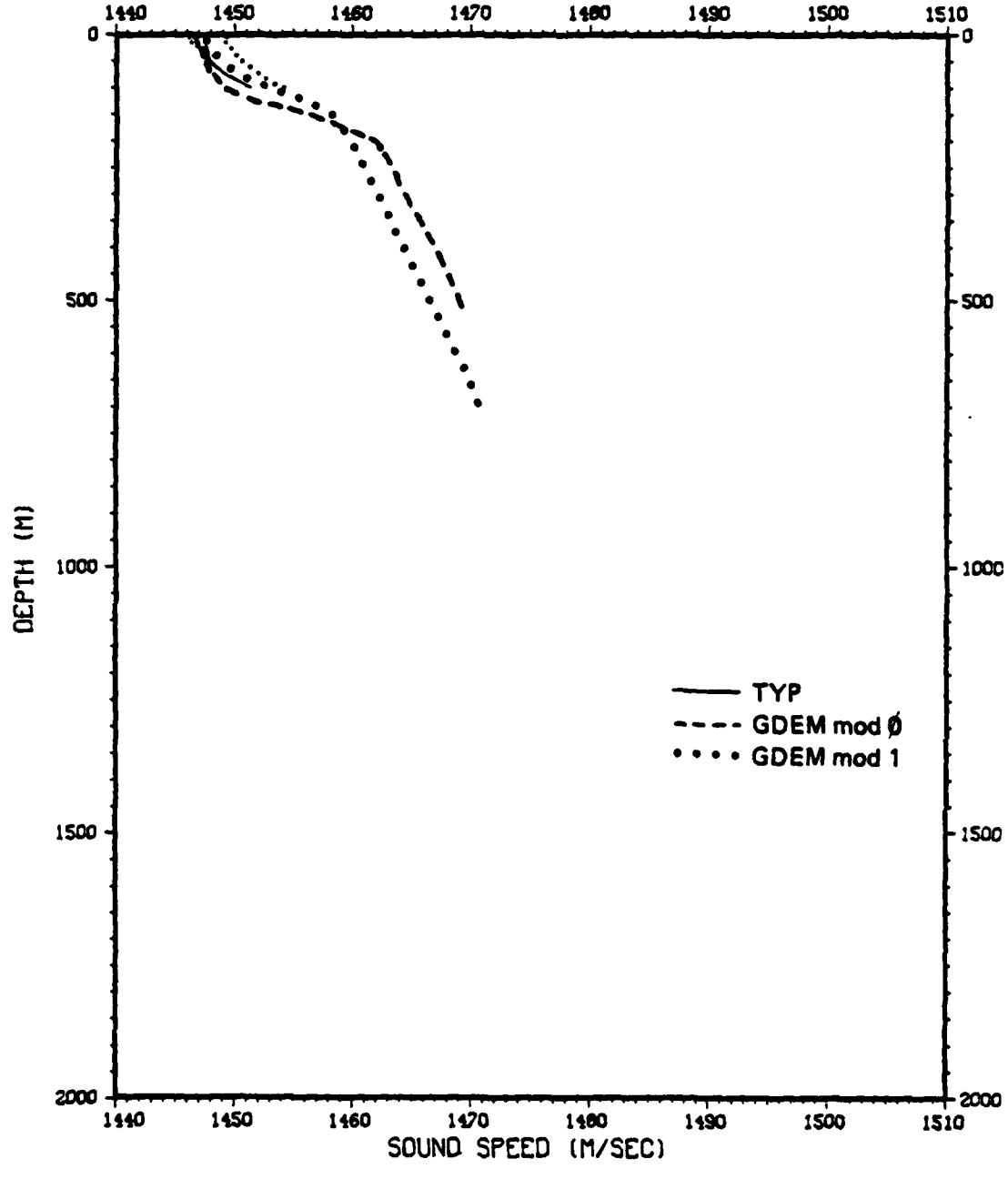


Fig. 14--GDEM-typical profile comparison, location 4 (51°N, 156°E), winter

Table 13

DATA FOR GDEM-TYPICAL COMPARISON, LOCATION 4, WINTER

| Depth (m) | Typical SS[a] (m/sec) | GDEM SS[b] (m/sec) | | Δ SS (m/sec) | |
|---|---|---|---|---|---|
| | | Mod 1 | Mod Ø | Mod 1 | Mod Ø |
| 0 | 1447.7 | 1447.5 | 1446.4 | 0.2 | 1.3 |
| 10 | 1447.5 | 1447.7 | 1446.6 | -0.2 | .9 |
| 20 | 1447.5 | 1448.0 | 1446.8 | -0.5 | .7 |
| 30 | 1447.6 | 1448.2 | 1447.1 | -0.6 | .5 |
| 50 | 1447.8 | 1449.0 | 1447.5 | -1.2 | .3 |
| 75 | 1449.1 | 1450.6 | 1448.1 | -1.5 | 1.0 |
| 100 | 1451.3 | 1452.9 | 1448.9 | -1.6 | 2.4 |
| 125 | -- | 1455.3 | -- | -- | -- |
| 150 | -- | 1457.3 | -- | -- | -- |
| 200 | -- | 1459.6 | -- | -- | -- |
| 250 | -- | 1460.7 | -- | -- | -- |
| 300 | -- | 1461.8 | -- | -- | -- |
| 400 | -- | 1464.0 | -- | -- | -- |
| 500 | -- | 1466.3 | -- | -- | -- |
| 600 | -- | 1468.5 | -- | -- | -- |
| 700 | -- | 1470.5 | -- | -- | -- |
| 800 | -- | 1472.3 | -- | -- | -- |
| Mean Δ SS ..... | | | | -0.8 | 1.0 |
| S ..... | | | | 0.7 | 0.7 |

[a]Typical profile selected from 4 sound speed profiles.

[b]The Mod 1 profile is located at 51°N, 155°E.

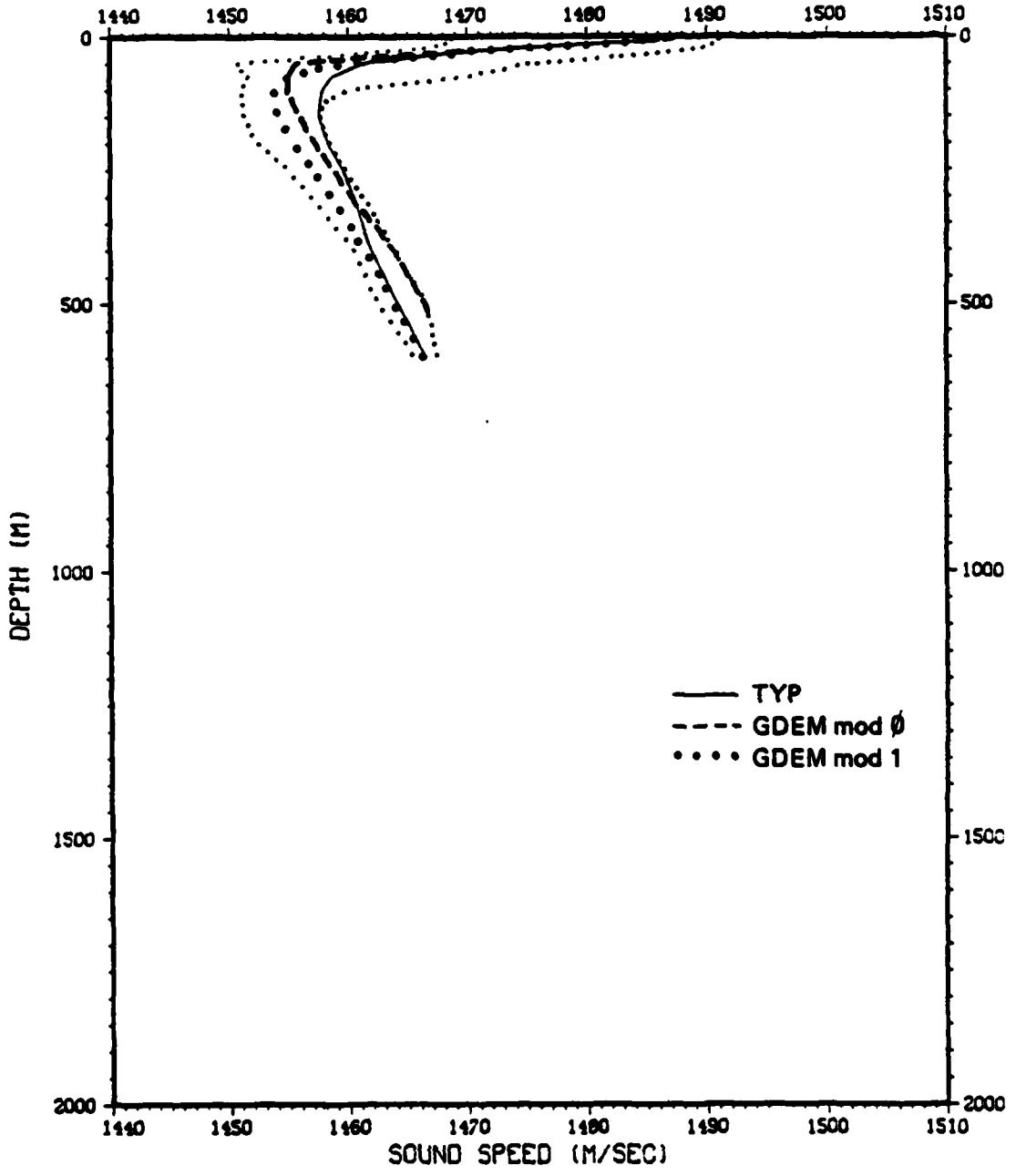


Fig. 15--GDEM-typical profile comparison, location 4 (51°N, 156°E), summer

Table 14

DATA FOR GDEM-TYPICAL COMPARISON, LOCATION 4, SUMMER

| Depth (m) | Typical SS[a] (m/sec) | GDEM SS[b] (m/sec) | | Δ SS (m/sec) | |
|---|---|---|---|---|---|
| | | Mod 1 | Mod Ø | Mod 1 | Mod Ø |
| 0 | 1487.0 | 1486.2 | 1488.4 | 0.8 | -1.4 |
| 10 | 1484.2 | 1480.7 | 1485.3 | 3.5 | -1.1 |
| 20 | 1475.0 | 1474.2 | 1477.1 | 0.8 | -2.1 |
| 30 | 1468.8 | 1469.7 | 1466.9 | -0.9 | 1.9 |
| 50 | 1461.1 | 1459.0 | 1455.4 | 2.1 | 5.7 |
| 75 | 1458.6 | 1455.4 | 1454.8 | 3.2 | 3.8 |
| 100 | 1457.8 | 1454.1 | 1454.8 | 3.7 | 3.0 |
| 125 | 1457.6 | 1453.7 | 1455.3 | 3.9 | 2.3 |
| 150 | 1457.5 | 1454.2 | 1455.9 | 3.3 | 1.6 |
| 200 | 1458.3 | 1455.6 | 1457.2 | 2.7 | 1.1 |
| 250 | 1459.6 | 1457.0 | 1458.7 | 2.6 | .9 |
| 300 | 1460.5 | 1458.5 | 1460.3 | 2.0 | .2 |
| 400 | 1461.9 | 1461.2 | 1463.8 | 0.7 | -1.9 |
| 500 | 1464.1 | 1463.8 | 1466.5 | 0.3 | -2.4 |
| Mean Δ SS ..... | | | | 2.1 | 0.8 |
| S ..... | | | | 1.5 | 2.4 |

[a]Typical profile selected from 69 sound speed profiles.

[b]The Mod 1 profile is located at 51°N, 155°E.

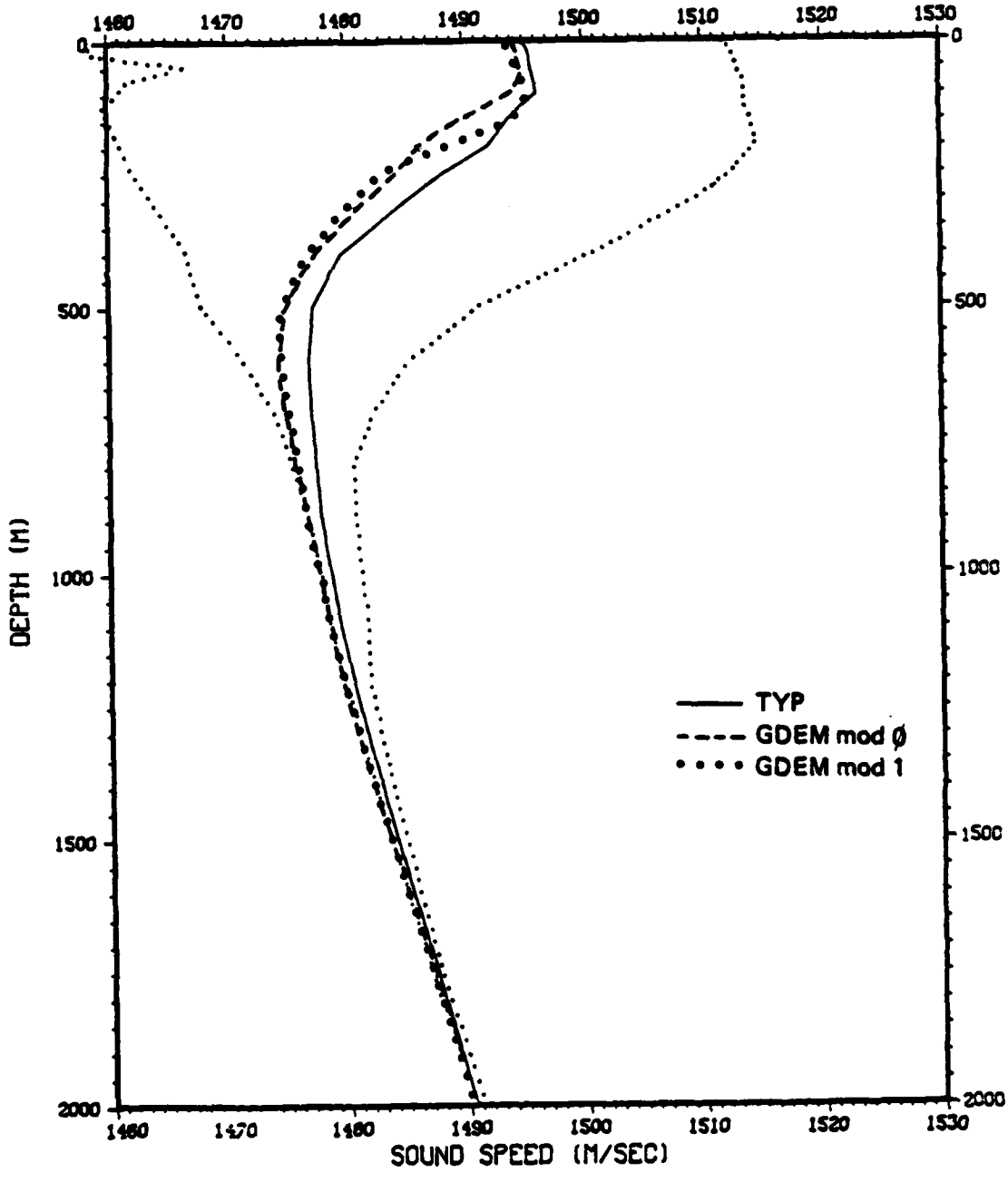


Fig. 16--GDEM-typical profile comparison, location 5 (39°N, 153°E), winter

Table 15

DATA FOR GDEM-TYPICAL COMPARISON, LOCATION 5, WINTER

| Depth (m) | Typical SS[a] (m/sec) | GDEM SS (m/sec) | | Δ SS (m/sec) | |
|---|---|---|---|---|---|
| | | Mod 1 | Mod Ø | Mod 1 | Mod Ø |
| 0 | 1494.6 | 1493.6 | 1494.0 | 1.0 | .6 |
| 10 | 1495.3 | 1493.8 | 1494.1 | 1.5 | 1.2 |
| 20 | 1495.5 | 1493.9 | 1494.3 | 1.6 | 1.2 |
| 30 | 1495.6 | 1494.1 | 1494.4 | 1.5 | 1.2 |
| 50 | 1495.7 | 1494.3 | 1494.7 | 1.4 | 1.0 |
| 75 | 1496.0 | 1494.7 | 1494.8 | 1.3 | 1.2 |
| 100 | 1496.2 | 1494.9 | 1494.1 | 1.3 | 2.1 |
| 125 | 1494.9 | 1494.8 | 1492.1 | 0.1 | 2.8 |
| 150 | 1493.8 | 1494.1 | 1489.5 | -0.3 | 4.3 |
| 200 | 1492.1 | 1489.6 | 1486.2 | 2.5 | 5.9 |
| 250 | 1488.3 | 1483.6 | 1484.4 | 4.7 | 3.9 |
| 300 | 1485.3 | 1480.4 | 1481.8 | 4.9 | 3.5 |
| 400 | 1479.7 | 1476.7 | 1477.4 | 3.0 | 2.3 |
| 500 | 1477.3 | 1474.7 | 1474.9 | 2.6 | 2.4 |
| 600 | 1476.9 | 1474.3 | 1474.2 | 2.6 | 2.7 |
| 700 | 1477.1 | 1475.1 | 1474.9 | 2.0 | 2.2 |
| 800 | 1477.5 | 1475.9 | 1475.8 | 1.6 | 1.7 |
| 900 | 1477.9 | 1476.8 | 1476.8 | 1.1 | 1.1 |
| 1000 | 1478.7 | 1477.7 | 1477.7 | 1.0 | 1.0 |
| 1100 | 1479.5 | 1478.7 | 1478.6 | 0.8 | .9 |
| 1200 | 1480.5 | 1479.7 | 1479.6 | 0.8 | .9 |
| 1300 | 1481.6 | 1480.8 | 1480.8 | 0.8 | .8 |
| 1400 | 1482.8 | 1482.1 | 1482.1 | 0.7 | .7 |
| 1500 | 1484.0 | 1483.5 | 1483.5 | 0.5 | .5 |
| 1750 | 1487.3 | 1487.1 | 1487.1 | 0.2 | .2 |
| 2000 | 1490.8 | 1490.6 | 1490.6 | 0.2 | .2 |
| Mean Δ SS ..... | | | | 1.5 | 1.8 |
| S ..... | | | | 1.3 | 1.4 |

[a]Typical profile selected from 108 sound speed profiles.

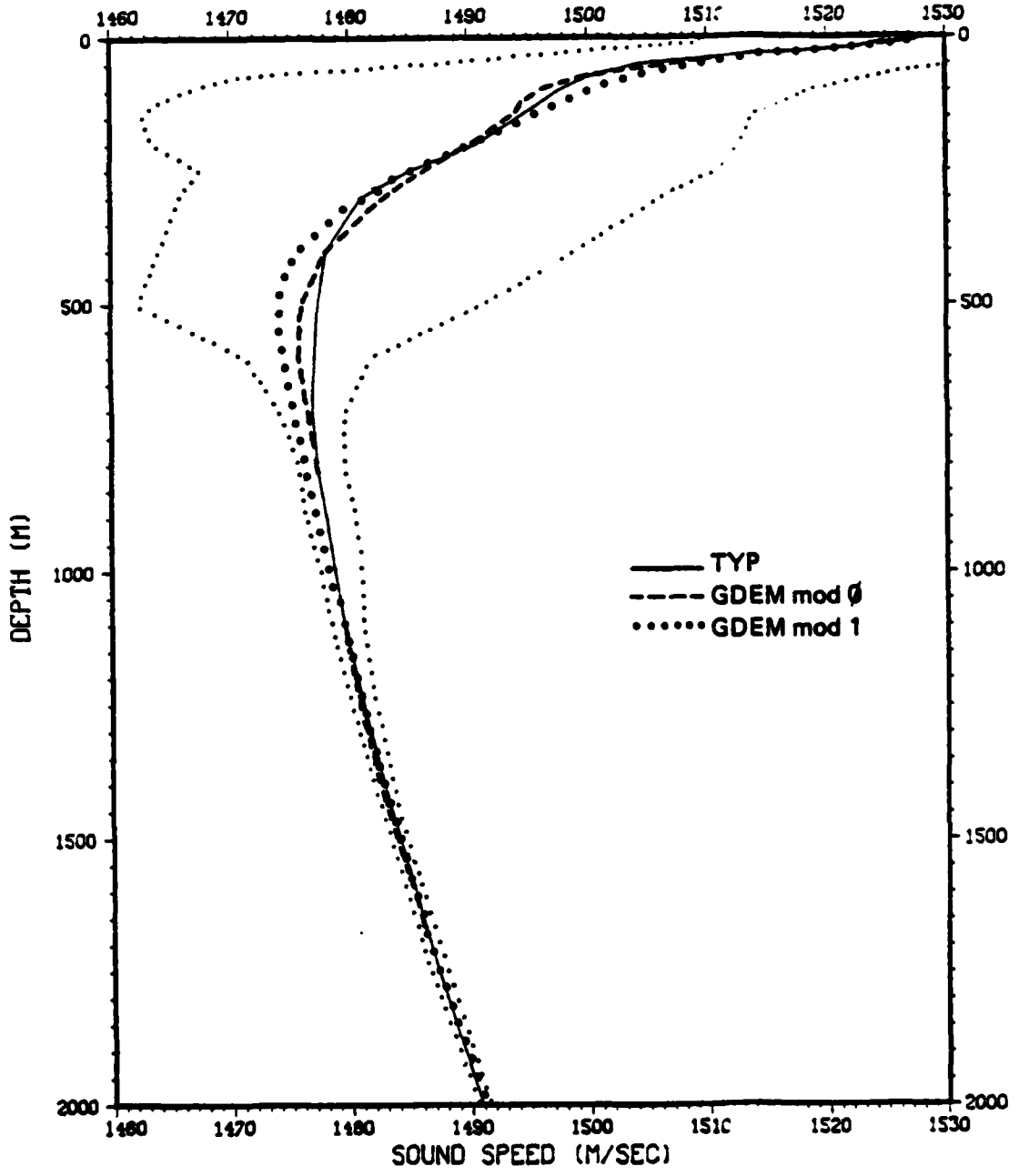


Fig. 17--GDEM-typical profile comparison, location 5 (39°N, 153°E), summer

Table 16

DATA FOR GDEM-TYPICAL COMPARISON, LOCATION 5, SUMMER

| Depth (m) | Typical SS[a] (m/sec) | GDEM SS (m/sec) | | Δ SS (m/sec) | |
|---|---|---|---|---|---|
| | | Mod 1 | Mod Ø | Mod 1 | Mod Ø |
| 0 | 1525.5 | 1528.5 | 1528.0 | -3.0 | -2.5 |
| 10 | 1524.6 | 1528.5 | 1527.8 | -3.9 | -3.2 |
| 20 | 1522.7 | 1526.2 | 1525.0 | -3.5 | -2.3 |
| 30 | 1516.7 | 1521.1 | 1520.3 | -4.4 | -3.6 |
| 50 | 1504.3 | 1510.2 | 1509.8 | -5.9 | -5.3 |
| 75 | 1500.0 | 1503.1 | 1500.6 | -3.1 | -.6 |
| 100 | 1497.6 | 1500.8 | 1496.4 | -3.2 | 1.2 |
| 125 | 1496.0 | 1498.5 | 1494.5 | -2.5 | 1.5 |
| 150 | 1494.3 | 1496.0 | 1493.8 | -1.7 | .5 |
| 200 | 1490.8 | 1490.6 | 1490.4 | 0.2 | .4 |
| 250 | 1485.1 | 1485.6 | 1486.6 | -0.5 | -1.5 |
| 300 | 1481.0 | 1481.5 | 1483.0 | -0.5 | -2.0 |
| 400 | 1478.0 | 1476.6 | 1478.1 | 1.4 | -.1 |
| 500 | 1477.3 | 1474.8 | 1476.0 | 2.5 | 1.3 |
| 600 | 1477.0 | 1474.9 | 1475.7 | 2.1 | 1.3 |
| 700 | 1476.8 | 1475.6 | 1476.4 | 1.2 | .4 |
| 800 | 1477.2 | 1476.6 | 1477.2 | 0.6 | 0 |
| 900 | 1478.0 | 1477.7 | 1478.0 | 0.3 | 0 |
| 1000 | 1478.7 | 1478.7 | 1478.7 | 0 | 0 |
| 1100 | 1479.5 | 1479.6 | 1479.5 | -0.1 | 0 |
| 1200 | 1480.5 | 1480.6 | 1480.3 | -0.1 | .2 |
| 1300 | 1481.6 | 1481.7 | 1481.3 | -0.1 | .3 |
| 1400 | 1482.8 | 1482.9 | 1482.5 | -0.1 | .3 |
| 1500 | 1484.0 | 1484.1 | 1483.8 | -0.1 | .2 |
| 1750 | 1487.3 | 1487.6 | 1487.3 | -0.3 | 0 |
| 2000 | 1490.8 | 1491.0 | 1490.7 | -0.2 | .1 |
| Mean Δ SS ..... | | | | -1.0 | -0.5 |
| S ..... | | | | 2.1 | 1.7 |

[a]Typical profile selected from 245 sound speed profiles.

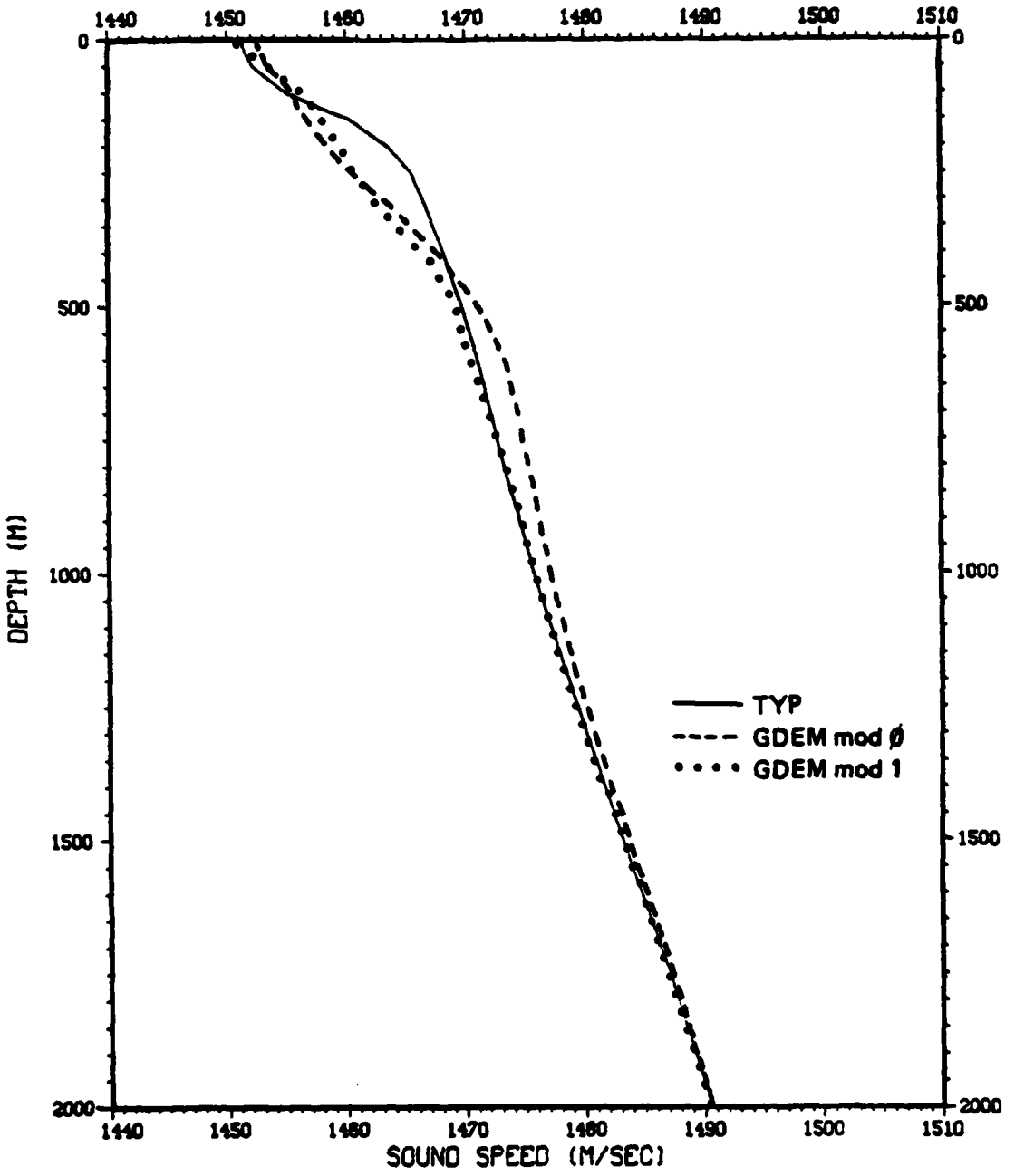


Fig. 18--GDEM-typical profile comparison, location 6 (44°N, 152°E), winter

Table 17

DATA FOR GDEM-TYPICAL COMPARISON, LOCATION 6, WINTER

| Depth (m) | Typical SS[a] (m/sec) | GDEM SS (m/sec) | | Δ SS (m/sec) | |
|---|---|---|---|---|---|
| | | Mod 1 | Mod Ø | Mod 1 | Mod Ø |
| 0 | 1451.3 | 1450.3 | 1452.4 | 1.0 | -1.1 |
| 10 | 1451.3 | 1450.8 | 1452.6 | 0.5 | -1.3 |
| 20 | 1451.5 | 1451.4 | 1452.9 | 0.1 | -1.4 |
| 30 | 1451.7 | 1452.1 | 1453.1 | -0.4 | -1.4 |
| 50 | 1452.2 | 1453.4 | 1453.5 | -1.2 | -1.3 |
| 75 | 1453.5 | 1454.8 | 1454.6 | -1.3 | -1.1 |
| 100 | 1455.0 | 1455.9 | 1455.6 | -0.9 | -.6 |
| 125 | 1457.6 | 1456.9 | 1456.1 | 0.7 | 1.5 |
| 150 | 1460.3 | 1457.7 | 1456.9 | 3.2 | 3.4 |
| 200 | 1463.5 | 1459.0 | 1458.6 | 4.5 | 4.9 |
| 250 | 1465.5 | 1460.4 | 1460.7 | 5.1 | 4.8 |
| 300 | 1466.5 | 1462.5 | 1463.3 | 4.0 | 3.2 |
| 400 | 1468.2 | 1466.3 | 1467.8 | 1.9 | .4 |
| 500 | 1469.7 | 1468.8 | 1471.2 | 0.9 | -1.5 |
| 600 | 1471.0 | 1470.7 | 1473.3 | 0.3 | -2.3 |
| 700 | 1472.1 | 1472.2 | 1474.4 | -0.1 | -2.3 |
| 800 | 1473.2 | 1473.5 | 1475.3 | -0.3 | -2.1 |
| 900 | 1474.5 | 1474.6 | 1476.2 | -0.1 | -1.7 |
| 1000 | 1475.7 | 1475.8 | 1477.1 | -0.1 | -1.4 |
| 1100 | 1477.1 | 1477.1 | 1478.2 | 0 | -1.1 |
| 1200 | 1478.6 | 1478.5 | 1479.4 | 0.1 | -.8 |
| 1300 | 1480.1 | 1480.0 | 1480.8 | 0.1 | -.7 |
| 1400 | 1481.6 | 1481.6 | 1482.2 | 0 | -.6 |
| 1500 | 1483.1 | 1483.2 | 1483.7 | -0.1 | -.6 |
| 1750 | 1487.0 | 1487.1 | 1487.4 | -0.1 | -.4 |
| 2000 | 1490.6 | 1490.7 | 1490.9 | -0.1 | -.3 |
| Mean Δ SS ..... | | | | 0.7 | -0.2 |
| S ..... | | | | 1.7 | 2.1 |

[a]This is the only sound speed profile for this location and season.

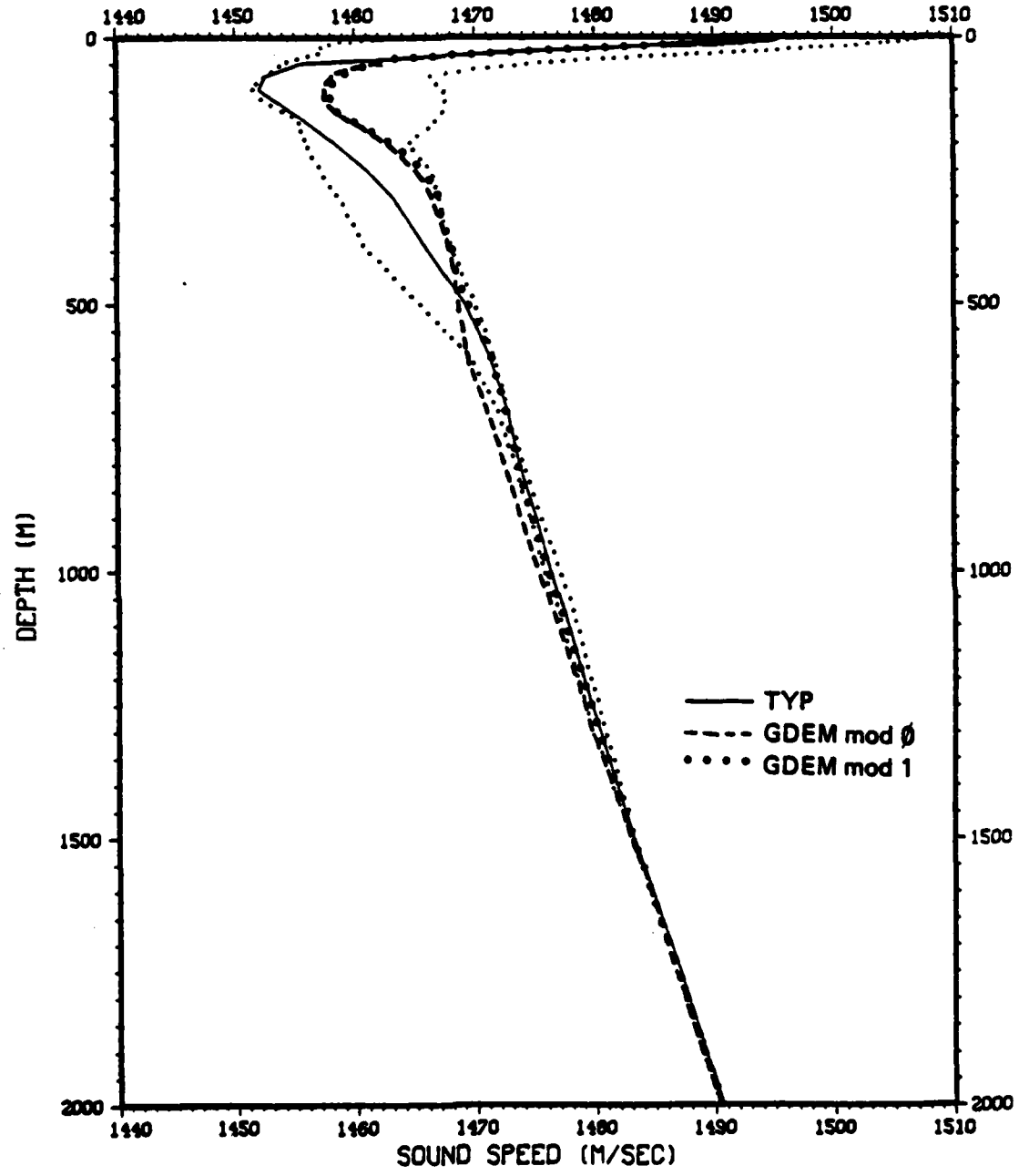


Fig. 19--GDEM-typical profile comparison, location 6 (44°N, 152°E), summer

Table 18

DATA FOR GDEM-TYPICAL COMPARISON, LOCATION 6, SUMMER

| Depth (m) | Typical SS[a] (m/sec) | GDEM SS (m/sec) | | Δ SS (m/sec) | |
|---|---|---|---|---|---|
| | | Mod 1 | Mod Ø | Mod 1 | Mod Ø |
| 0 | 1493.0 | 1494.2 | 1495.1 | -1.2 | -2.1 |
| 10 | 1489.1 | 1494.3 | 1495.8 | -5.2 | -6.7 |
| 20 | 1481.5 | 1488.7 | 1488.9 | -7.2 | -7.4 |
| 30 | 1472.3 | 1480.1 | 1478.2 | -7.8 | -5.9 |
| 50 | 1455.5 | 1465.5 | 1461.9 | -10.0 | -6.4 |
| 75 | 1452.5 | 1459.5 | 1457.8 | -7.0 | -5.3 |
| 100 | 1452.0 | 1458.0 | 1457.1 | -6.0 | -5.1 |
| 125 | 1453.7 | 1457.8 | 1457.2 | -4.1 | -3.5 |
| 150 | 1455.3 | 1458.5 | 1458.3 | -3.2 | -3.0 |
| 200 | 1458.3 | 1462.3 | 1462.1 | -4.0 | -3.8 |
| 250 | 1461.0 | 1465.6 | 1464.6 | -4.6 | -3.6 |
| 300 | 1463.1 | 1466.5 | 1466.1 | -3.4 | -3.0 |
| 400 | 1466.0 | 1467.8 | 1467.6 | -1.8 | -1.6 |
| 500 | 1469.1 | 1469.5 | 1468.1 | -0.4 | .8 |
| 600 | 1471.1 | 1471.1 | 1469.1 | 0 | 2.0 |
| 700 | 1472.6 | 1472.3 | 1470.7 | 0.3 | 1.9 |
| 800 | 1473.6 | 1473.4 | 1472.2 | 0.2 | 1.4 |
| 900 | 1475.0 | 1474.6 | 1473.6 | 0.4 | 1.4 |
| 1000 | 1476.2 | 1475.9 | 1475.1 | 0.3 | 1.1 |
| 1100 | 1477.6 | 1477.3 | 1476.6 | 0.3 | 1.0 |
| 1200 | 1478.9 | 1478.7 | 1478.1 | 0.2 | .8 |
| 1300 | 1480.3 | 1480.2 | 1479.6 | 0.1 | .7 |
| 1400 | 1481.7 | 1481.6 | 1481.2 | 0.1 | .5 |
| 1500 | 1483.1 | 1483.1 | 1482.8 | 0 | .3 |
| 1750 | 1487.0 | 1486.8 | 1486.5 | 0.2 | .5 |
| 2000 | 1490.6 | 1490.3 | 1490.2 | -0.1 | .4 |
| Mean Δ SS ..... | | | | -2.5 | -1.7 |
| S ..... | | | | 3.2 | 3.1 |

[a]Typical profile selected from 48 sound speed profiles.

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