NOAA Data Report OAR AOML-40
University of Miami RSMAS Technical Report 2000-04

NORTH BRAZIL CURRENT RINGS EXPERIMENT: TIME SERIES DATA REPORT

Q. Yao
S. Garzoli
R. Zantopp
W. Johns

Atlantic Oceanographic and Meteorological Laboratory
Miami, Florida
December 2000

noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION / Oceanic and Atmospheric Research Laboratories

NOAA Data Report OAR AOML-40

NORTH BRAZIL CURRENT RINGS EXPERIMENT: TIME SERIES DATA REPORT

Q. Yao
The University of Miami, Cooperative Institute for Marine and Atmospheric Studies

S. Garzoli
Atlantic Oceanographic and Meteorological Laboratory

R. Zantopp
W. Johns
Rosenstiel School of Marine and Atmospheric Sciences, The University of Miami

Atlantic Oceanographic and Meteorological Laboratory
Miami, Florida
December 2000

UNITED STATES DEPARTMENT OF COMMERCE

Norman Y. Mineta
Secretary

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

D. JAMES BAKER
Under Secretary for Oceans and Atmosphere/Administrator

Oceanic and Atmospheric Research Laboratories

David L. Evans
Director

NOTICE

Mention of a commercial company or product does not constitute an endorsement by NOAA/OAR. Use of information from this publication concerning proprietary products or the tests of such products for publicity or advertising purposes is not authorized.

For sale by the National Technical Information Service,
5285 Port Royal Road, Springfield, VA 22161

Table of contents

Introduction and Objectives

This data report presents the data collected through moored instrumentation during the North Brazil Current Rings Experiment, a joint effort between the University of Miami's Rosenstiel School of Marine and Atmospheric Science, NOAA's Atlantic Oceanographic and Meteorological Laboratory, the Woods Hole Oceanographic Institution, and Columbia University's Lamont Doherty Earth Observatory. The program is funded by the National Science Foundation (NSF) and the National Oceanic and Atmospheric Administration (NOAA).

The main goal of this program is to study the contribution of the North Brazil Current (NBC) rings to inter-hemispheric exchange of heat and salt and to determine its role in climate.

The specific objectives of the program are:

1. To obtain a thorough description of the temporal evolution of the North Brazil Current retroflection and the shedding of rings from the retroflection.
2. To determine the physical structure of NBC rings after they separate from the retroflection and the volume of South Atlantic water they trap and transport, and
3. To determine the rates of translation, decay, and mixing with resident North Atlantic waters as the rings move northwestward toward the Caribbean Sea.

During the first two cruises (NBC1: November - December 1998, Fleurant *et al*, 2000a; NBC2: February - March 1999, Fleurant *ET al*, 2000b) the following instruments were deployed (Figure 1)

- one current meter mooring (CMM1),
- one CTD mooring (CMM2),
- an array of 14 inverted echo sounders (IES),
- one pressure gauge (PG)

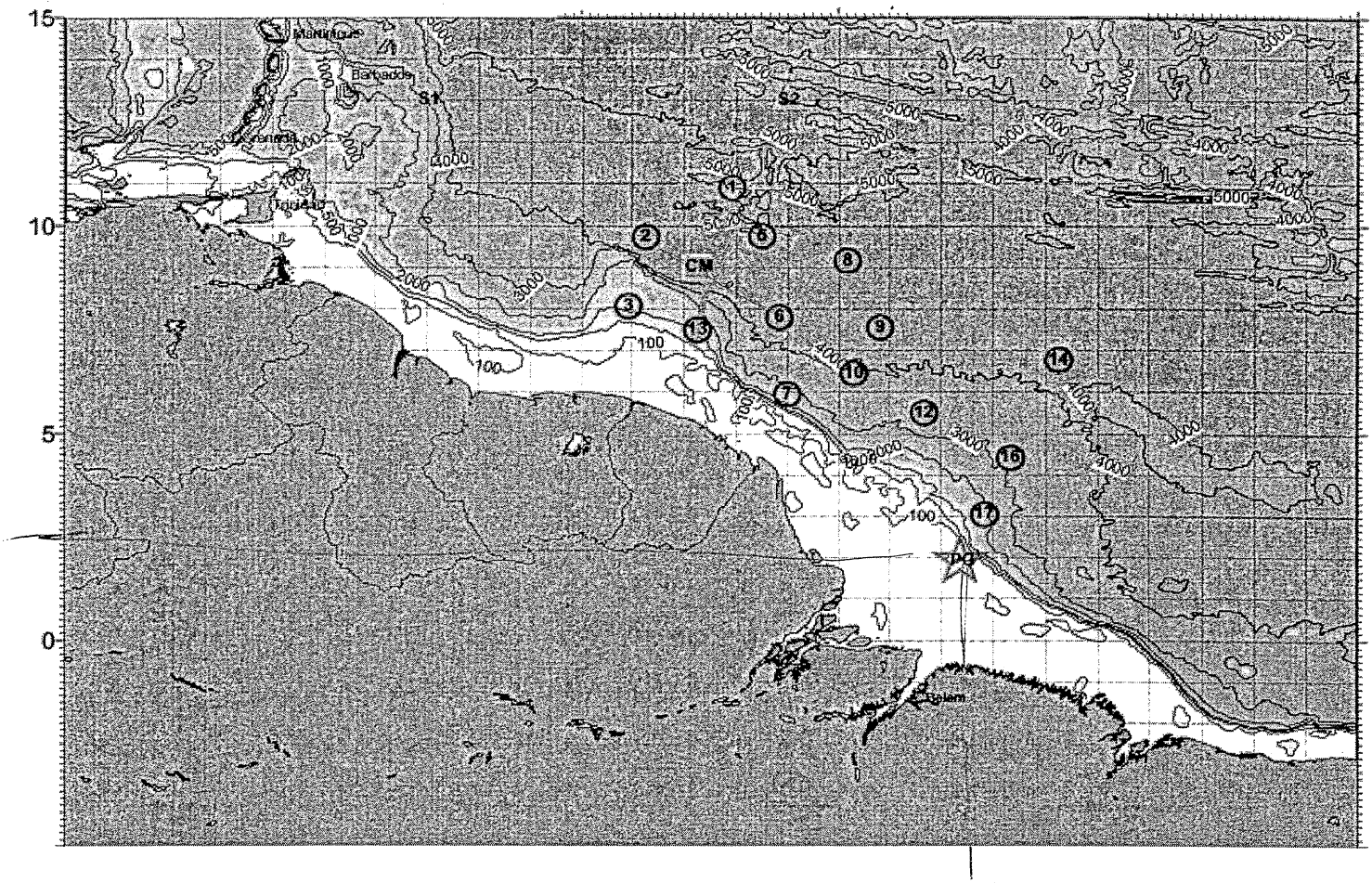


Figure 1: Location of the deployments, Table1.

All instruments were recovered during NBC4 cruise that took place from June 7 to June 3, 2000. This data report presents the time series of the data collected with these moorings.

Inverted Echo Sounders and Pressure gauges

Inverted Echo Sounders measures and records the time it takes for an acoustic signal to travel to the sea surface and back (travel time, TT):

$$TT = -2\int dz/c(T,S,P)$$

where c is the sound velocity as a function of temperature (T), salinity (S), and pressure (P), and z is a specific depth. TT is proportional to the inverse of the sound velocity, a quantity strongly

dependent on the temperature and salinity of the water column. Changes in the vertical structure of the water column, as those due to the motion of a front or the passage of rings, will be reflected in changes in travel time. Upward motion of the thermocline implies that the recorded signal will travel longer in colder water, and therefore the sound velocity will be lower and the travel time higher. If the thermocline deepens, then the sound velocity is higher and the travel time smaller. Time series of travel time can be directly related to time series of thermocline depth, integrated temperature, and dynamic height.

As part of the NBC experiment 14 IESs and one pressure gauge (PG) were deployed and recovered.

The locations of the moored instruments are given in Table 1. and shown in Figure 1. All dates are GMT.

The IES were of three different models: URI, Sea Data, and NOAA made. Two out of the 14 IES were also equipped with a pressure sensor and a bottom temperature sensor (sites 10 and 16). Data from the temperature sensor was used to calculate the pressure using the calibration formulas and constants provided by the manufacturer, Paroscientific, Inc.

The first part of this report (Appendix 1) presents:

- the time series of travel time obtained at the 14 sites described in Table 1 and the corresponding spectra.
- Time series of the pressure and bottom temperature records collected with the sensors deployed with the IES and from the pressure gauge deployed at site PG and the corresponding spectra.

Table 1.

Site	Instrument type	S/N	Latitude (°N)	Longitude (°W)	Depth (m)	Date of deployment	Date of recovered
PG	**SBE-26**	225	05°56.99	47° 38.322	68	5-Mar-99	9-Jun-00
1	**URI**	33	10° 54.612	52° 04.802	4137	12-Nov-98	19-Jun-00
2	**Sea Data**	56	09° 44.572	53° 46.802	4570	13-Nov-98	19-Jun-00
3	**TRIES**	8	8° 06.046	54° 02.461	1115	14-Nov-98	18-Jun-00
5	**URI**	37	09° 45.764	51° 29.081	4843	16-Nov-98	16-Jun-00
6	**Sea Data**	59	07° 47.947	51° 09.229	4395	17-Nov-98	14-Jun-00
7	**TRIES**	3	5° 56.99	51° 00.08	2700	24-Feb-99	13-Jun-00
8	**URI**	47	09° 09.014	49° 48.530	4653	17-Nov-98	16-Jun-00
9	**URI**	50	07° 35.589	49° 10.831	4288	18-Nov-98	12-Jun-00
10	**Sea Data**	58	06° 27.699	49° 42.522	3858	18-Nov-98	12-Jun-00
12	**Sea Data**	62	05° 29.900	48° 19.210	3442	21-Nov-98	11-Jun-00
13	**TRIES**	1	7° 47.05	52° 34.026	2012	25-Feb-99	14-Jun-00
14	**URI**	41	06° 46.009	45° 44.603	4200	22-Nov-98	10-Jun-00
16	**Sea Data**	50	04° 24.890	46° 39.185	3273	23-Nov-98	10-Jun-00
17	ElChipo	1	03° 04.703	47° 09.045	1802	23-Nov-98	09-Jun-00

Location of the moored PG and IES (Latitude and Longitude); depth of the deployments in meters (depth): data of deployment and date of recovery.

Current Meter Moorings

Two moorings were deployed as part of the experiment (Table 2.). CMM1 (UM ID: M347) has two types of current meters: an ADCP (Acoustic Doppler Current Profiler) at 240 m depth, providing time series of horizontal currents between 20 and 230 m, and 8 VACM (Vector Averaging Current Meter) at depths between 290 and 4300 m (see Table 3). The VACM provide time series of temperature and horizontal currents. One VACM at 1000 m failed and did not provide any data (open circle in Fig. 2). An additional Microcat provided temperature, salinity and pressure at 250 m, just below the ADCP.

CMM2 (UM ID: M348) is a CTD mooring with two types of instruments: 4 Seacats between 50 and 150 m, and 6 Microcats between 200 and 1000 m. Both instrument types provide time series of temperature, salinity and pressure. One Seacat at 100 failed and provided no data, and two Seacats, at 50 and 150 m, respectively., had battery failures and provided short records only.

The ADCP was manufactured by RD Instruments; Seacats and Microcats were manufactured by Seabird Electronics. The VACM were manufactured by EG&G Sea-Link.
A mooring diagram is shown in Fig. 2, with a relative distance between both moorings of 3 km. Note the change of vertical scale between the top (0-1000 m) and bottom part (1000-5000 m) in order to show instrumentation detail. Open symbols indicate instrument failures. Mooring configurations are shown in table 3.

Table 2

CMM	Latitude	Longitude	Deployment date	Recovery date	Bottom
1	08° 59.50' N	52° 44.00' W	13-Nov-98	17-Jun-00	4623m
2	09° 00.80' N	52° 45.36' W	15-Nov-98	17-Jun-00	4625m

Appendix 2. presents the data collected with the 2 moorings.

Figure 2. Schematic of the two moorings (CMM1 and CMM2).

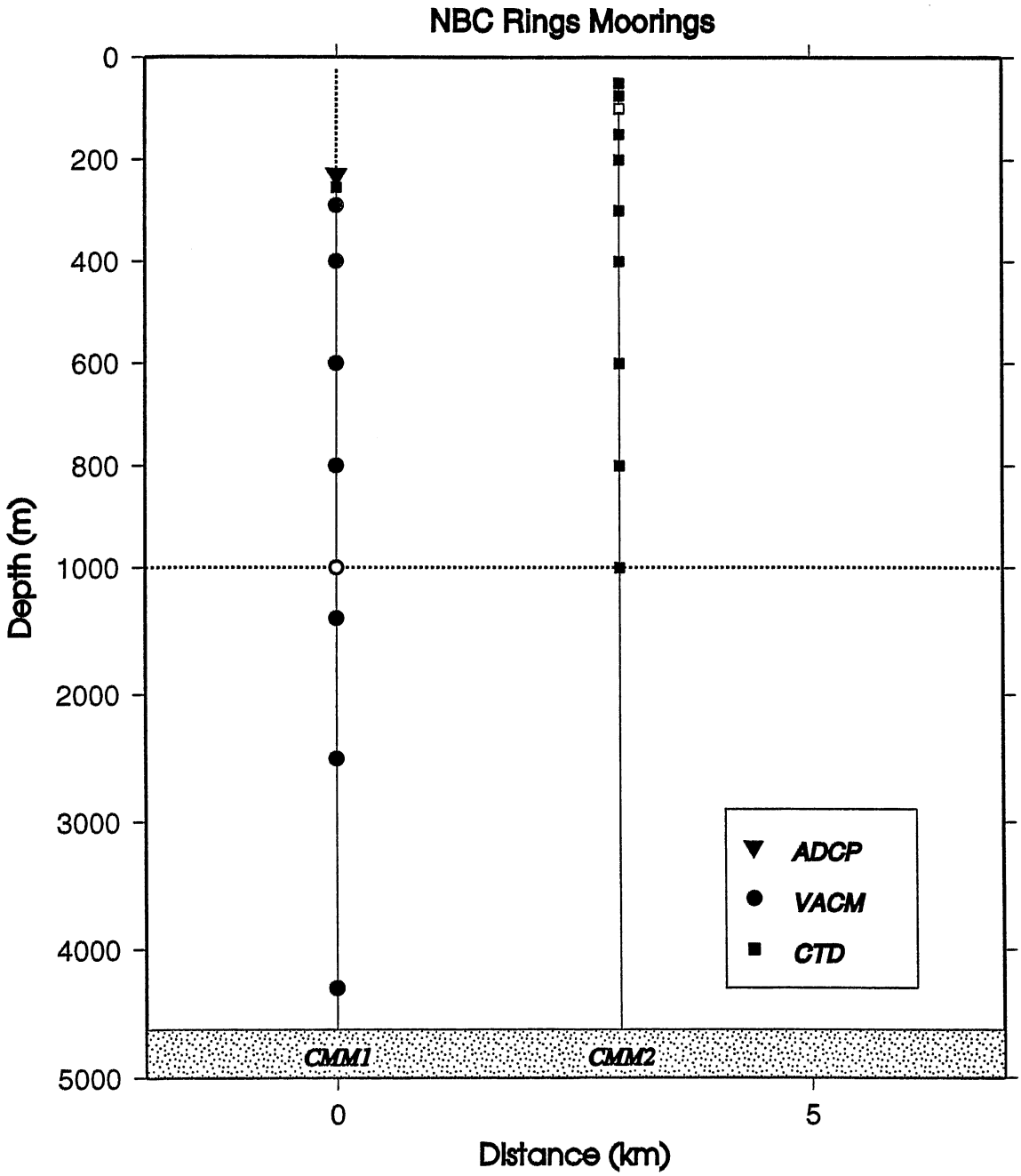


Table 3.

Mooring CMM1	Lat: 8°59.59'N Long: 52°44.28'W Bottom: 4623 m			
ID	**Depth**	**Inst. Type**	**s/n**	**Quality**
M34701	20 – 230	ADCP	230	ok
2	250	Microcat	486	ok
3	290	VACM	694	ok
4	400	VACM	710	ok
5	600	VACM	594	ok
6	800	VACM	332	ok
7	1000			failed, no data
8	1400	VACM	690	ok
9	2500	VACM	703	ok
10	4300	VACM	709	ok

Mooring CMM2	Lat: 9°00.30'N Long: 52°45.60'W Bottom: 4625 m			
ID	**Depth**	**Inst. Type**	**s/n**	**Quality**
M34801	50	Seacat	1658	short record
2	75	Seacat	1427	ok
3	100	Seacat		failed, no data
4	150	Seacat	1659	short record
5	200	Microcat	481	ok
6	300	Microcat	487	ok
7	400	Microcat	483	ok
8	600	Microcat	482	ok
9	800	Microcat	485	ok
10	1000	Microcat	484	ok

References

Fleurant *et al*; CTD/0_2, LADCP and XBT Measurements Collected Aboard the *R/V Seward Johnson*, November - December 1998; NBC1.

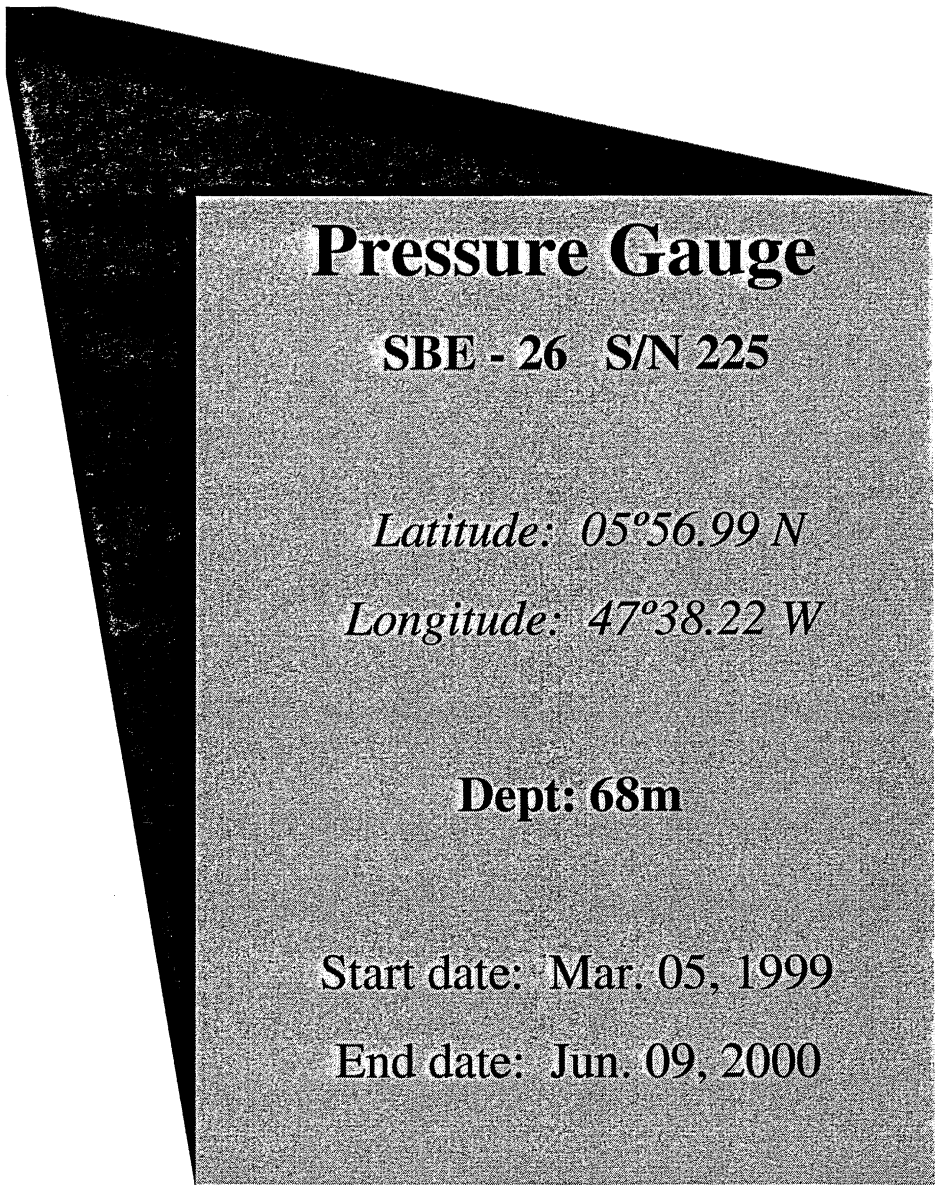
Fleurant *et al*; CTD/0_2, LADCP and XBT Measurements Collected Aboard the *R/V Seward Johnson*, February - March 1999; NBC2.

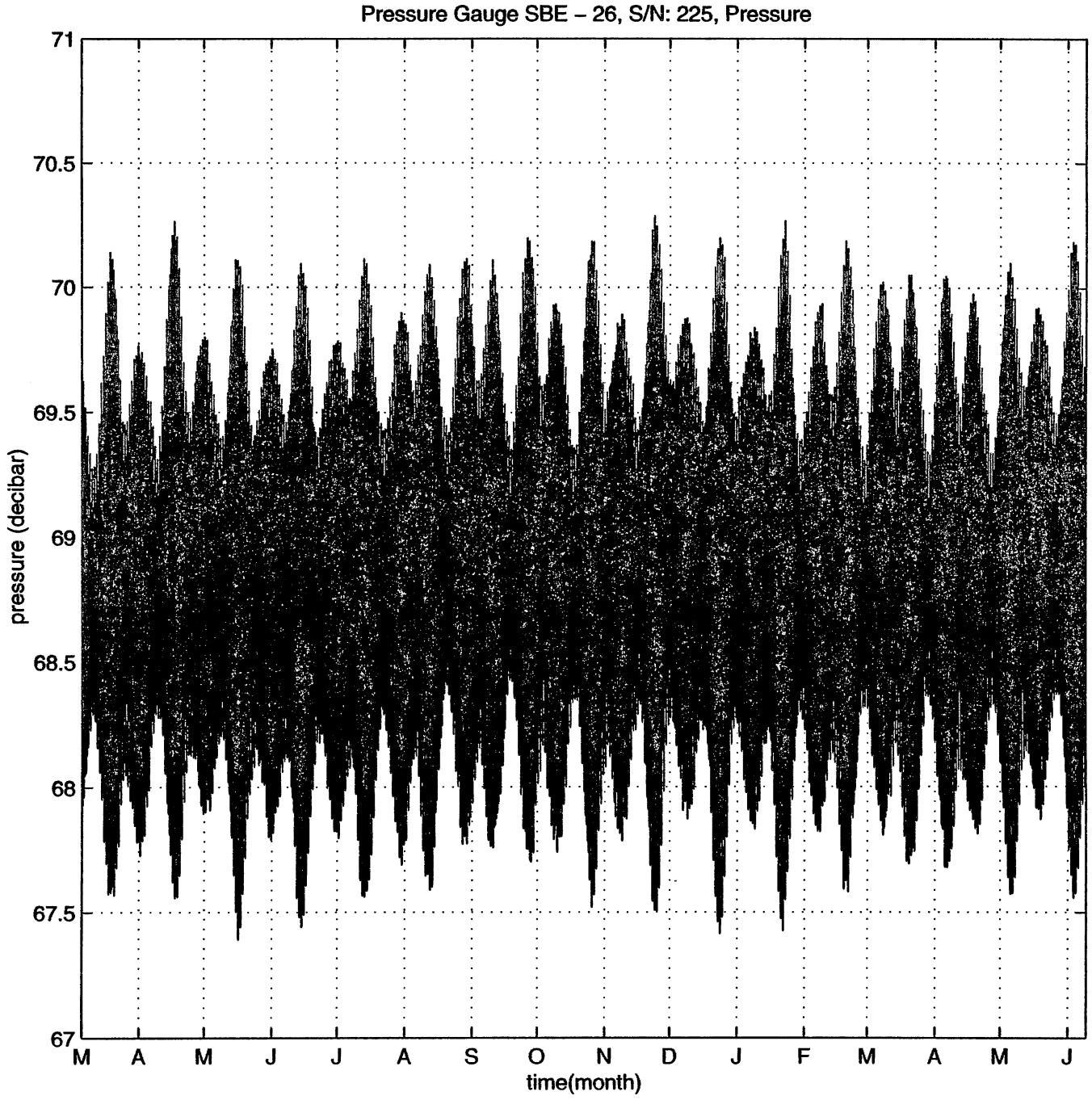
Fleurant *et al*; CTD/0_2, LADCP and XBT Measurements Collected Aboard the *R/V Seward Johnson,* February - March 1999, NBC3.

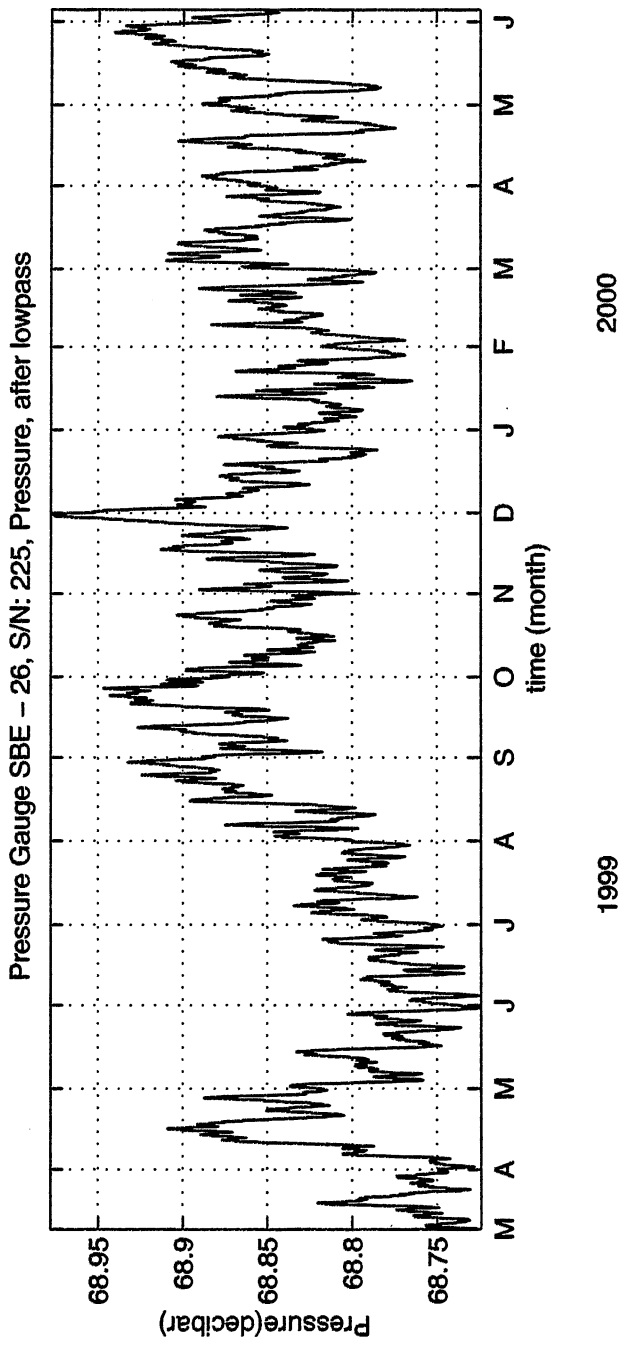
Acknowledgements

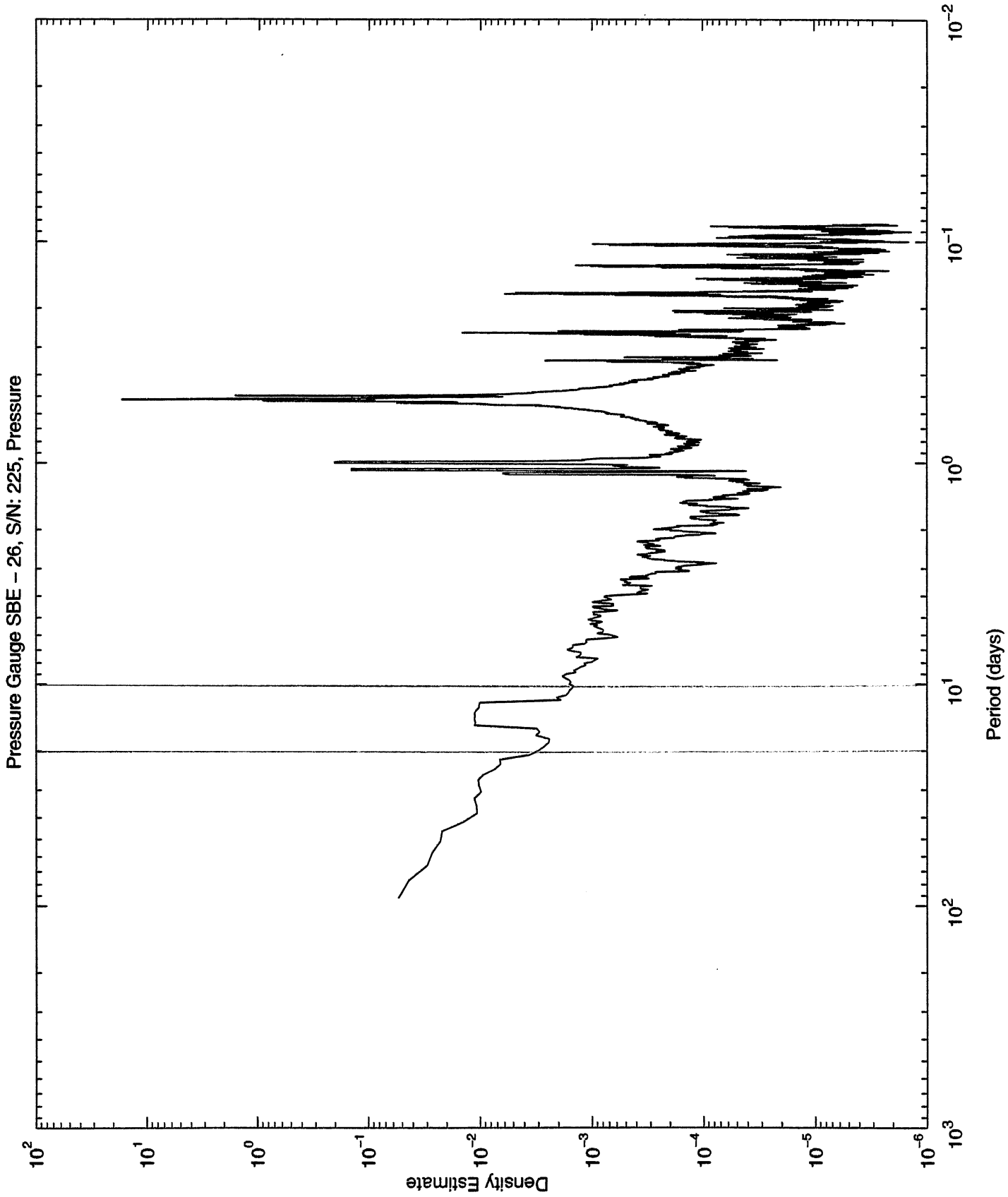
The support and assistance provided by the Captain and crew of the R/V Seward Johnson is gratefully acknowledged. David Bitterman (NOAA/AOML) was the engineer in charge of preparing a deploying the inverted echo sounders. Mark Graham and Robert Jones of the University of Miami Ocean Technology Group were responsible for designing and deploying the current meter and CTD moorings. Roberta Lusic prepared the document for publication. The U.S. National Science Foundation and the National Oceanic and Atmospheric Administration provided financial support for this research.

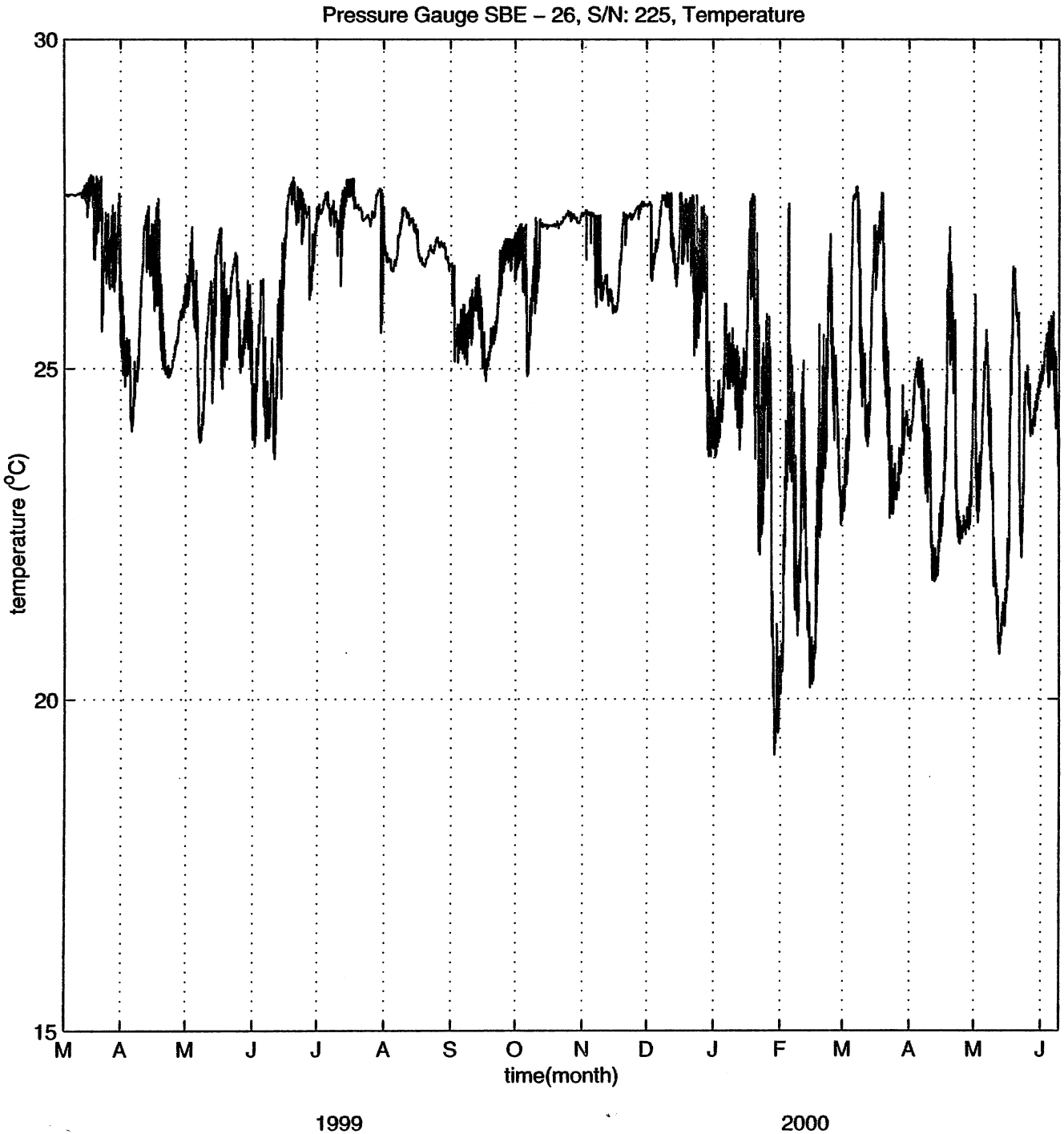
Appendix 1

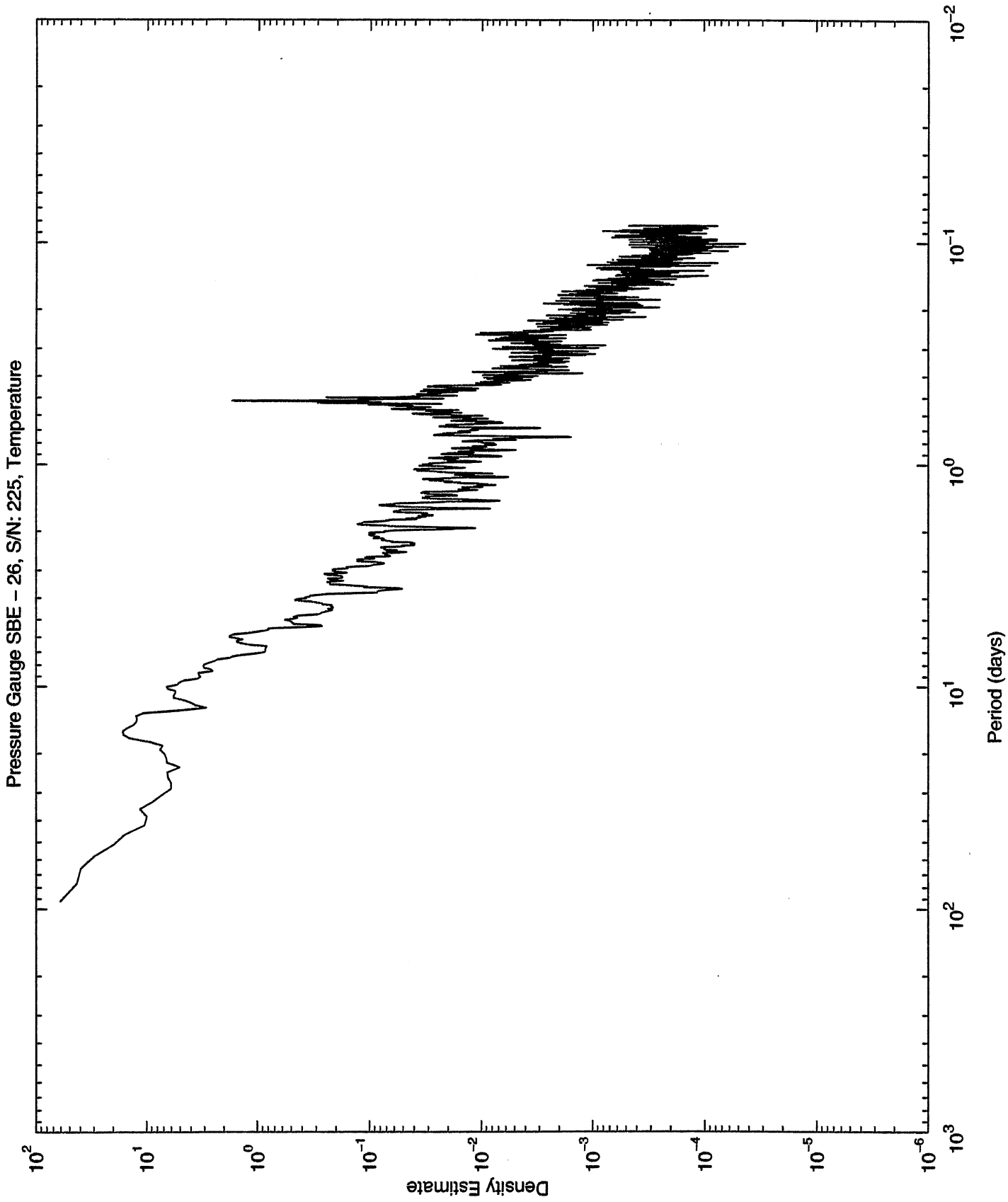

Pressure Gauge
SBE - 26 S/N 225
Latitude: 05°56.99 N
Longitude: 47°38.22 W
Dept: 68m
Start date: Mar. 05, 1999
End date: Jun. 09, 2000


Pressure Gauge SBE – 26, S/N: 225, Pressure
71
70.5
70
69.5
69
68.5
68
67.5
67
pressure (decibar)
M
A
M
J
J
A
S
O
N
D
J
F
M
A
M
J
time(month)
1999
2000


Pressure Gauge SBE – 26, S/N: 225, Pressure, after lowpass
Pressure(decibar)
68.95
68.9
68.85
68.8
68.75
M A M J J A S O N D J F M A M J
time (month)
1999
2000


Pressure Gauge SBE – 26, S/N: 225, Pressure
Density Estimate
Period (days)
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}


Pressure Gauge SBE – 26, S/N: 225, Temperature
30
25
20
15
temperature (°C)
M
A
M
J
J
A
S
O
N
D
J
F
M
A
M
J
time(month)
1999
2000


Pressure Gauge SBE – 26, S/N: 225, Temperature
Density Estimate
Period (days)
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}

IES SITE 1

URI S/N 33

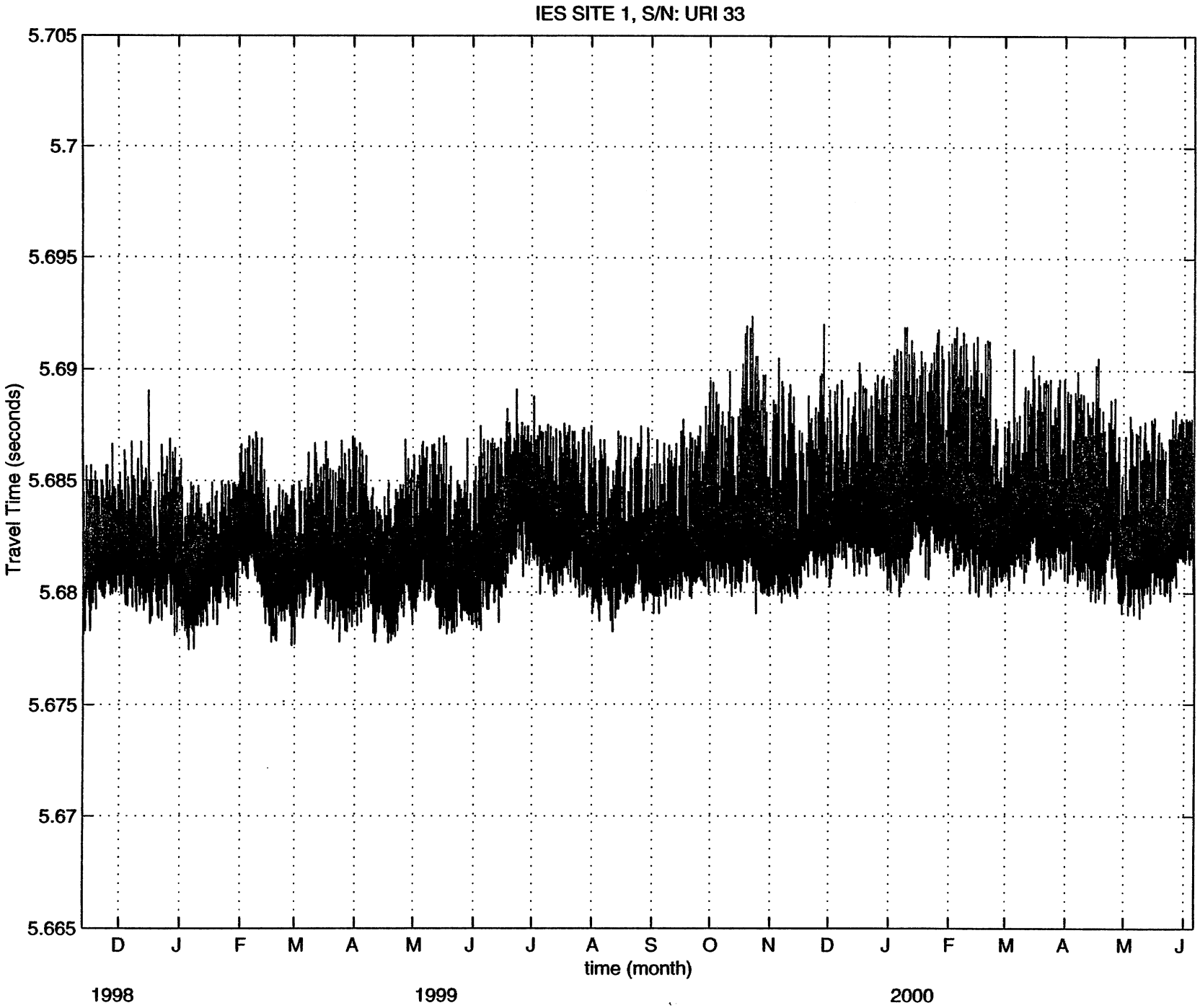
Latitude: *10º54.612 N*

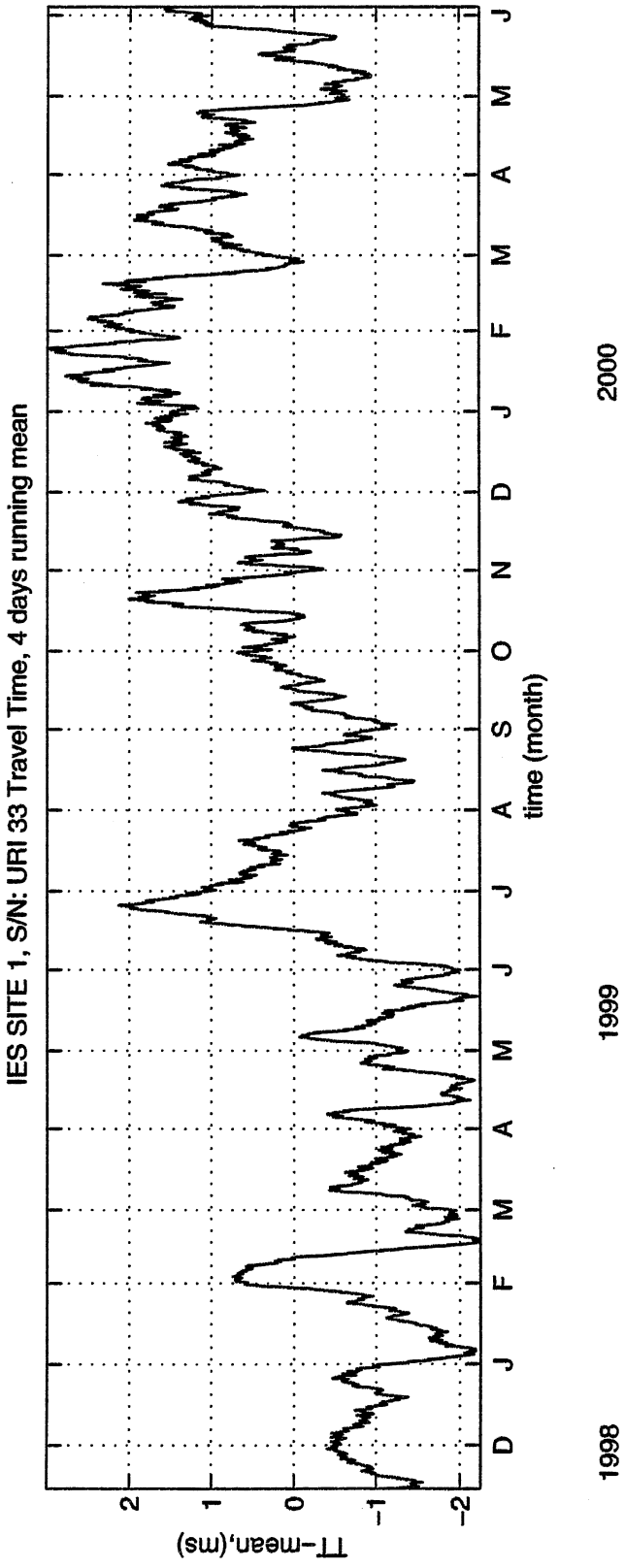
Longitude: *52º04.802 W*

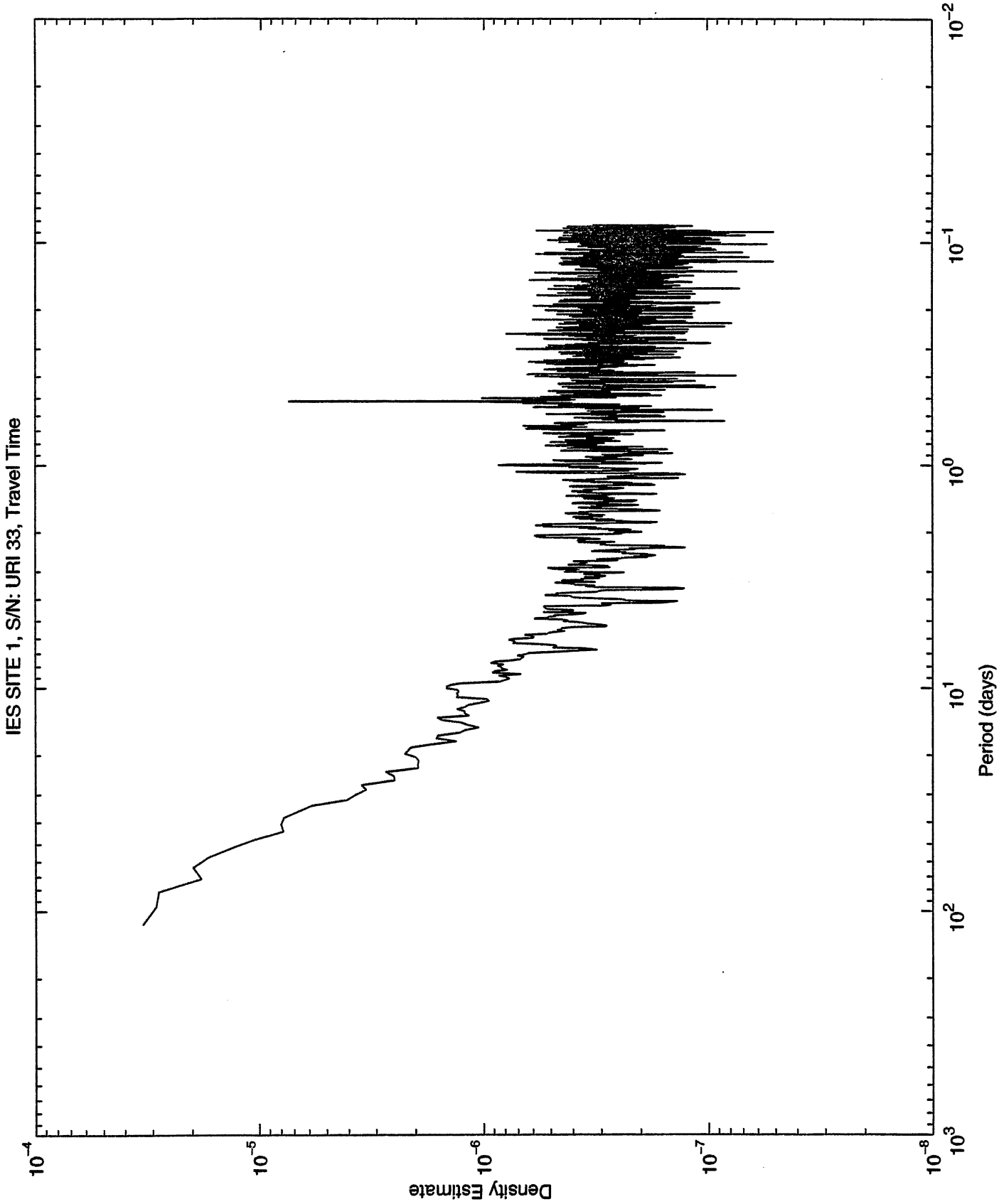
Dept: 4,137m

Start date: Nov. 12, 1998

End date: Jun. 06, 2000


IES SITE 1, S/N: URI 33
5.705
5.7
5.695
5.69
5.685
5.68
5.675
5.67
5.665
Travel Time (seconds)
D J F M A M J J A S O N D J F M A M J
time (month)
1998
1999
2000


IES SITE 1, S/N: URI 33 Travel Time, 4 days running mean
TT-mean,(ms)
2
1
0
-1
-2
D
J
F
M
A
M
J
J
A
S
O
N
D
J
F
M
A
M
J
time (month)
1998
1999
2000


IES SITE 1, S/N: URI 33, Travel Time
Density Estimate
Period (days)
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}

IES SITE 2

Sea Data S/N 56

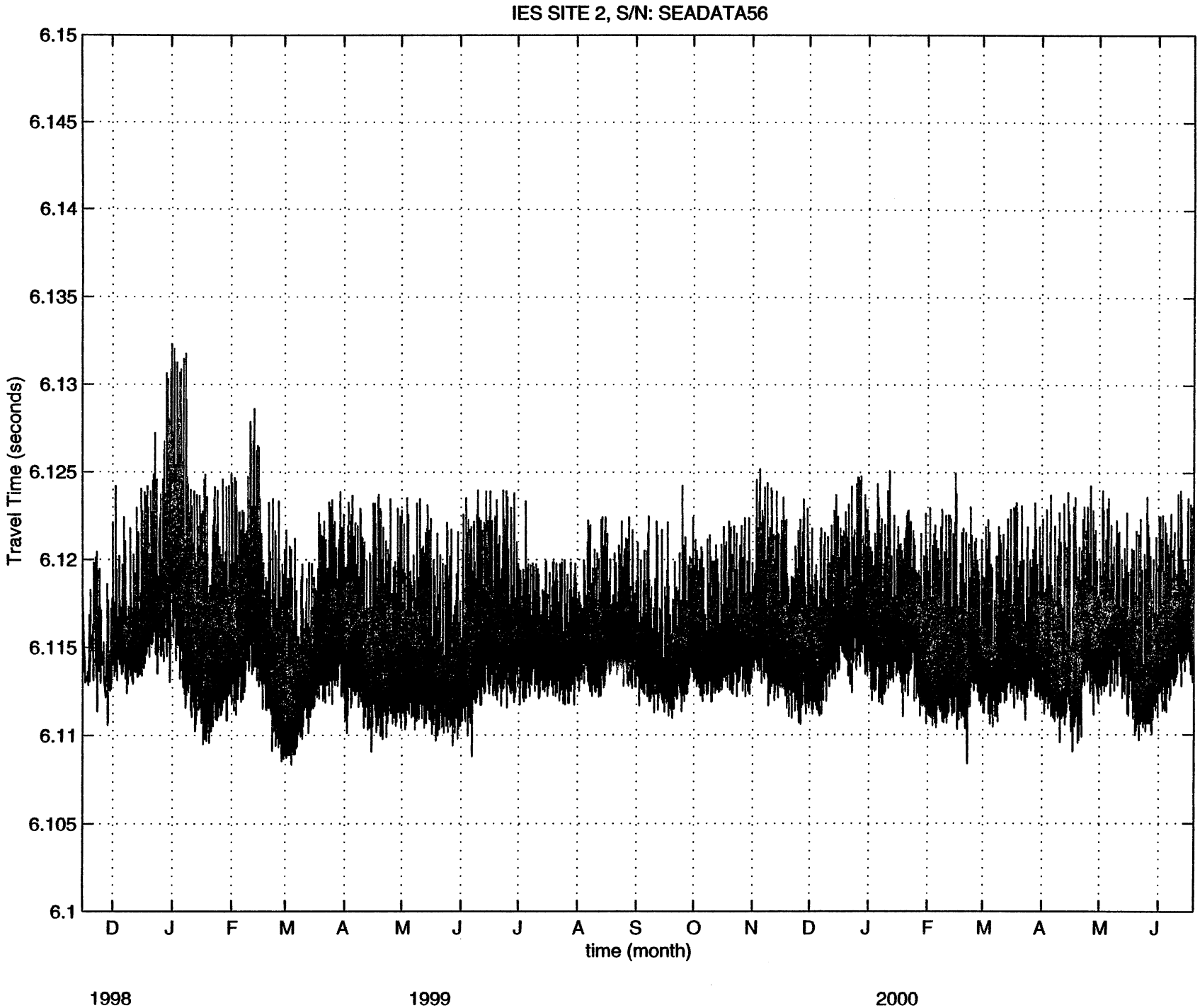
Latitude: *09º44.572 N*

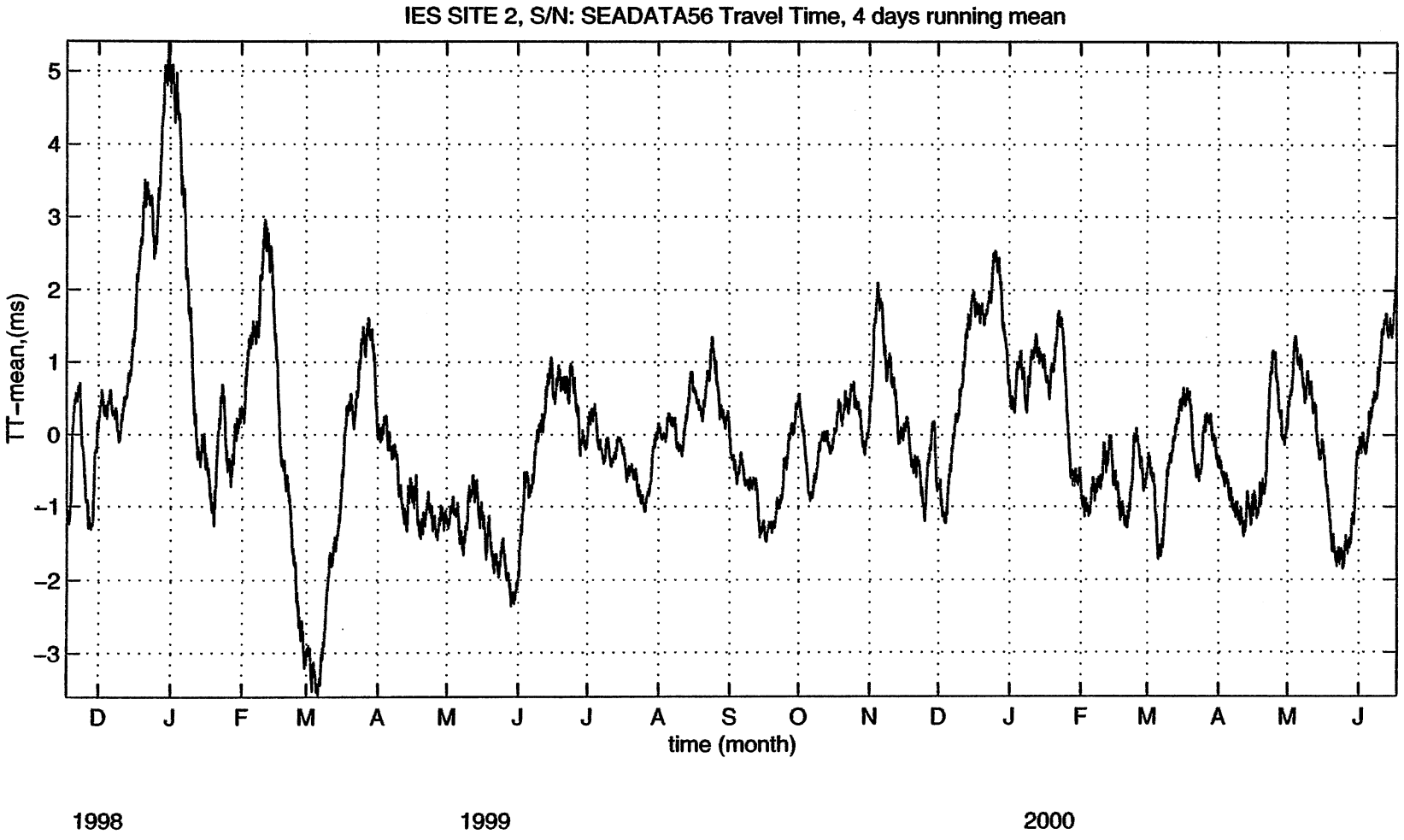
Longitude: *53º46.802 W*

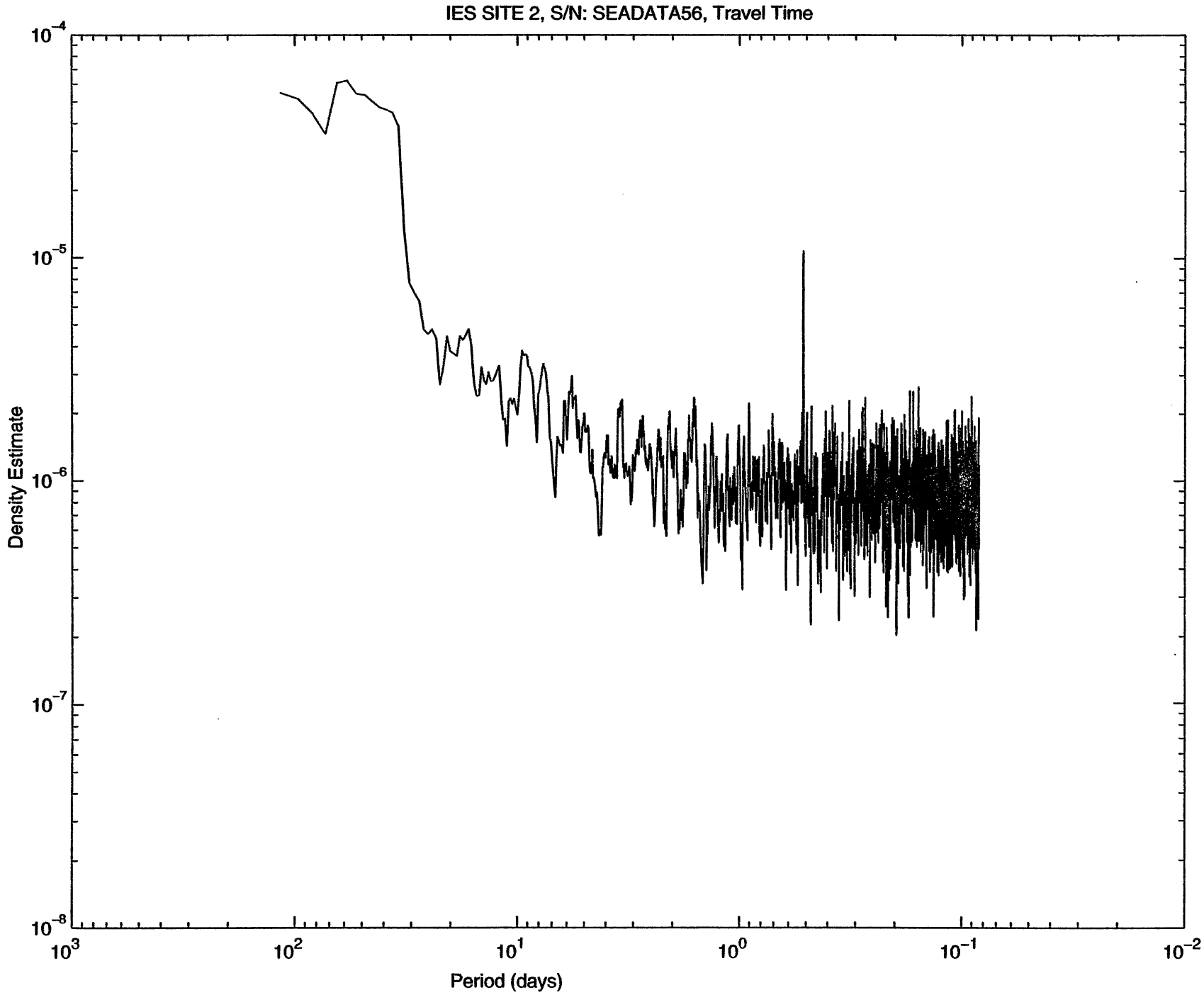
Dept: 4,570m

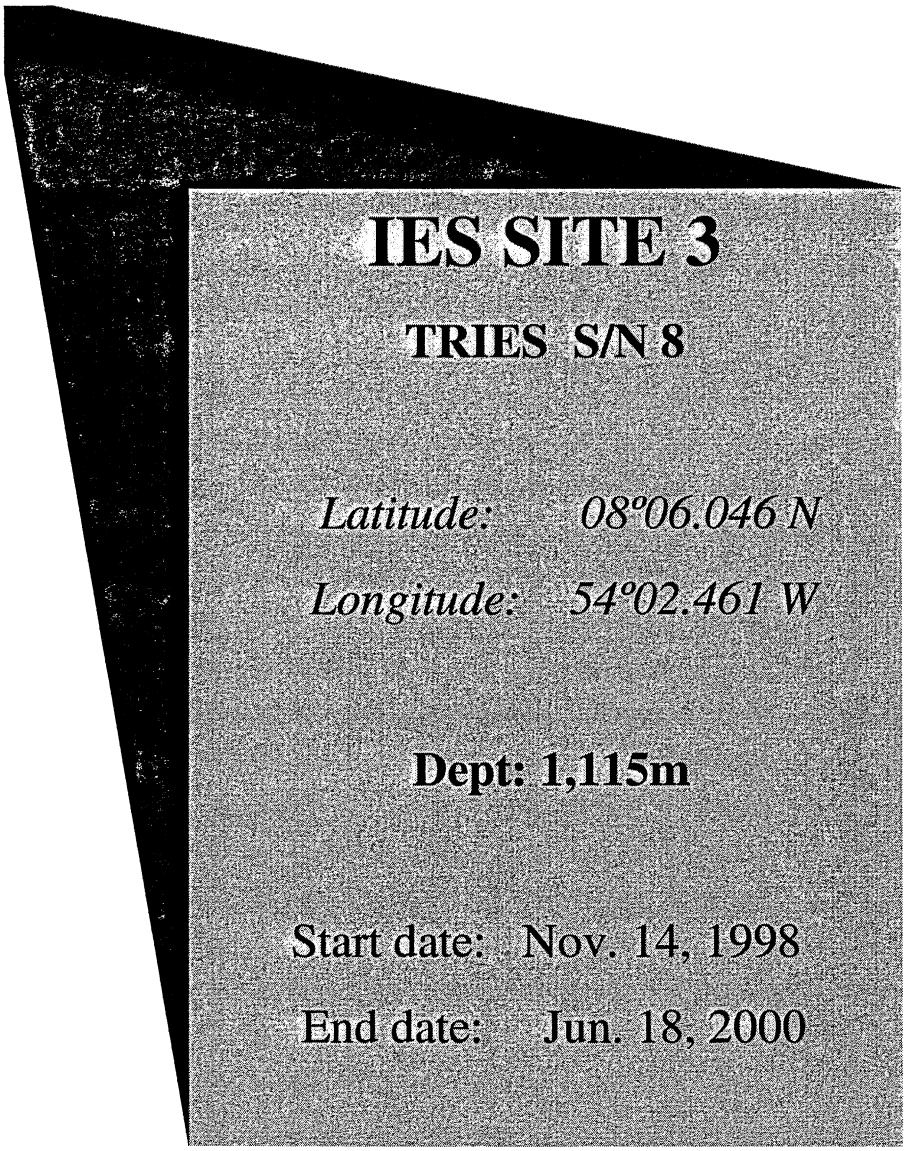
Start date: Nov. 15, 1998

End date: Jun. 19, 2000


IES SITE 2, S/N: SEADATA56
Travel Time (seconds)
6.15
6.145
6.14
6.135
6.13
6.125
6.12
6.115
6.11
6.105
6.1
D J F M A M J J A S O N D J F M A M J
time (month)
1998
1999
2000


IES SITE 2, S/N: SEADATA56 Travel Time, 4 days running mean
TT-mean,(ms)
5
4
3
2
1
0
-1
-2
-3
D
J
F
M
A
M
J
J
A
S
O
N
D
J
F
M
A
M
J
time (month)
1998
1999
2000


IES SITE 2, S/N: SEADATA56, Travel Time
Density Estimate
Period (days)
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}



IES SITE 3

TRIES S/N 8

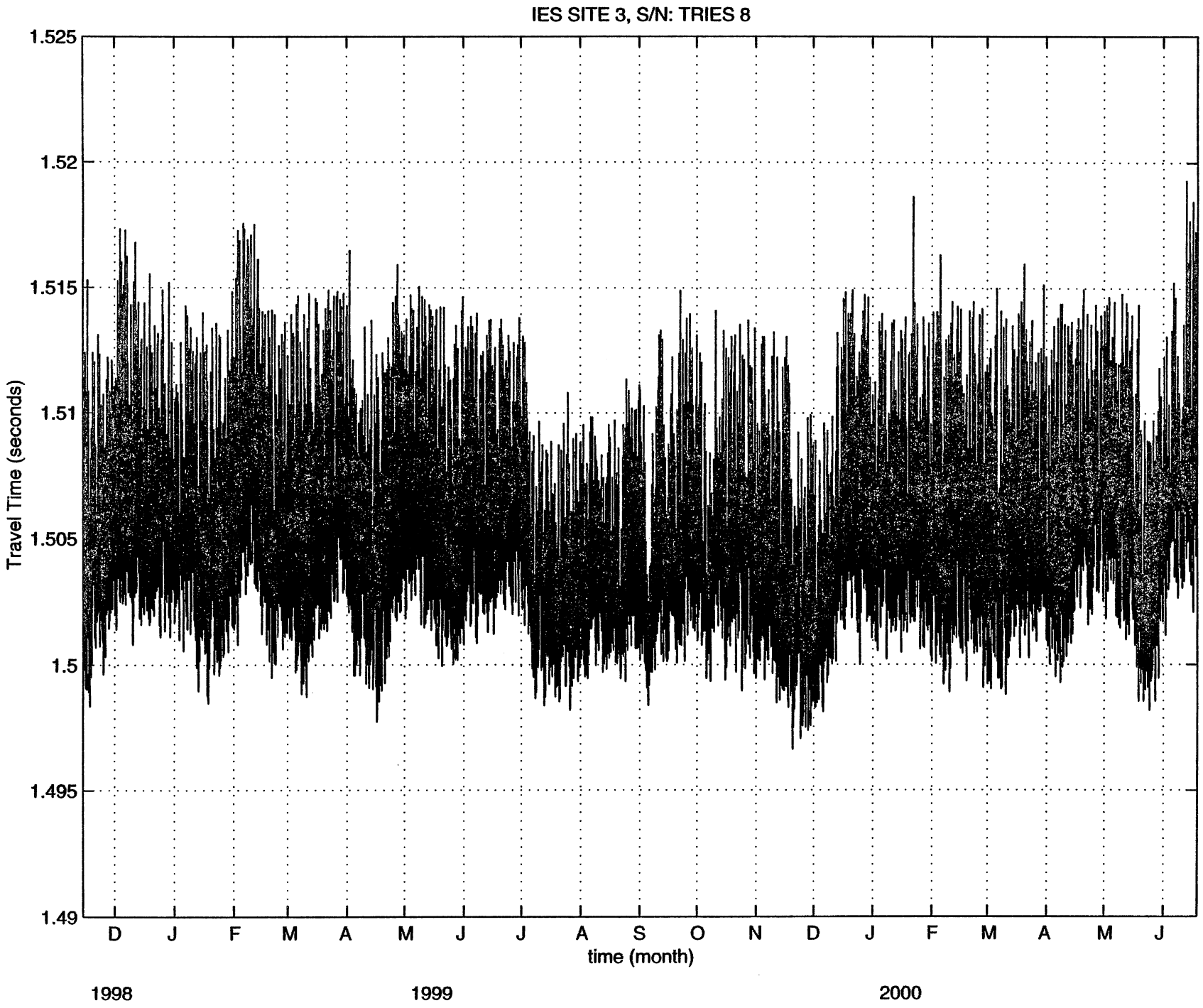
Latitude: 08º06.046 N

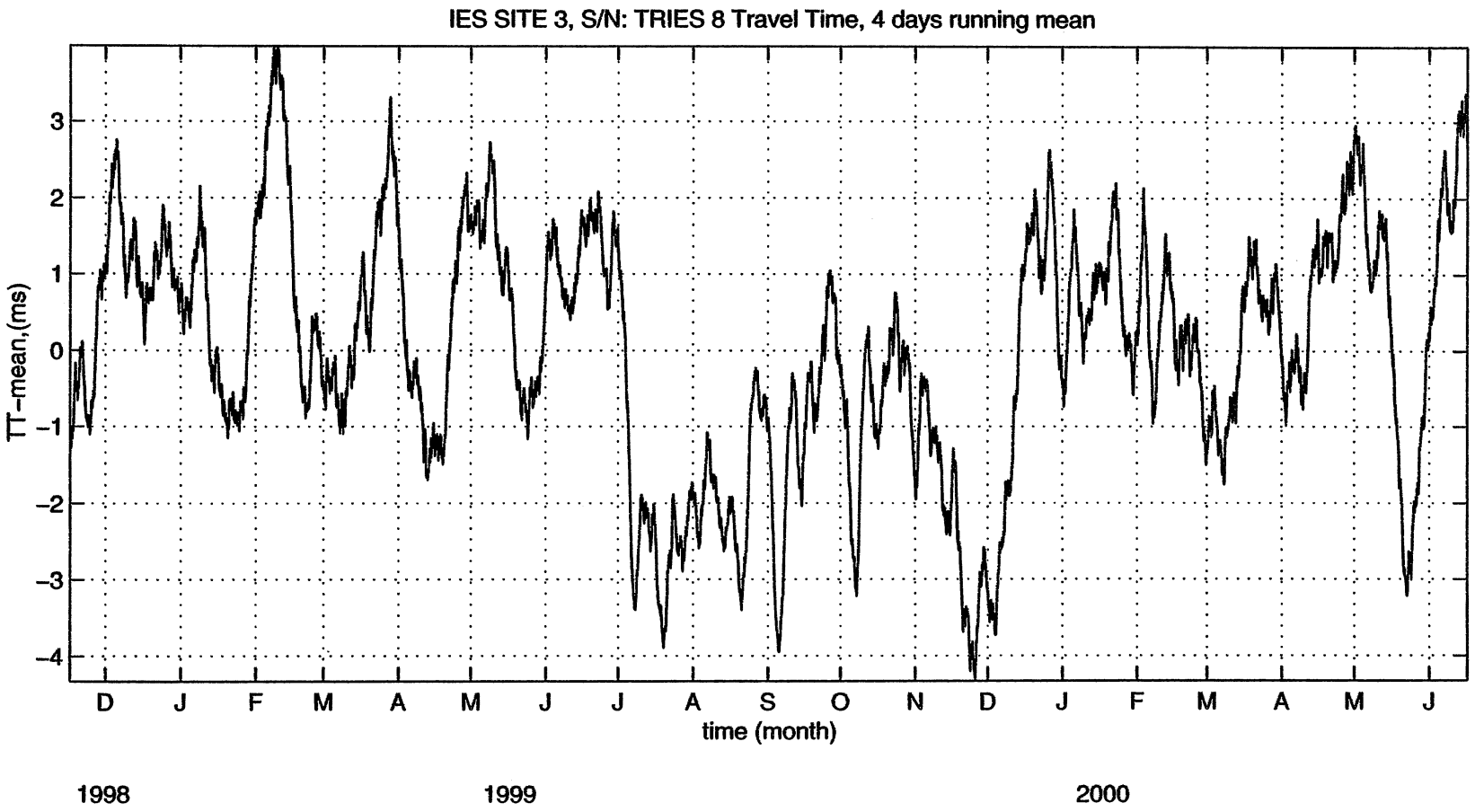
Longitude: 54º02.461 W

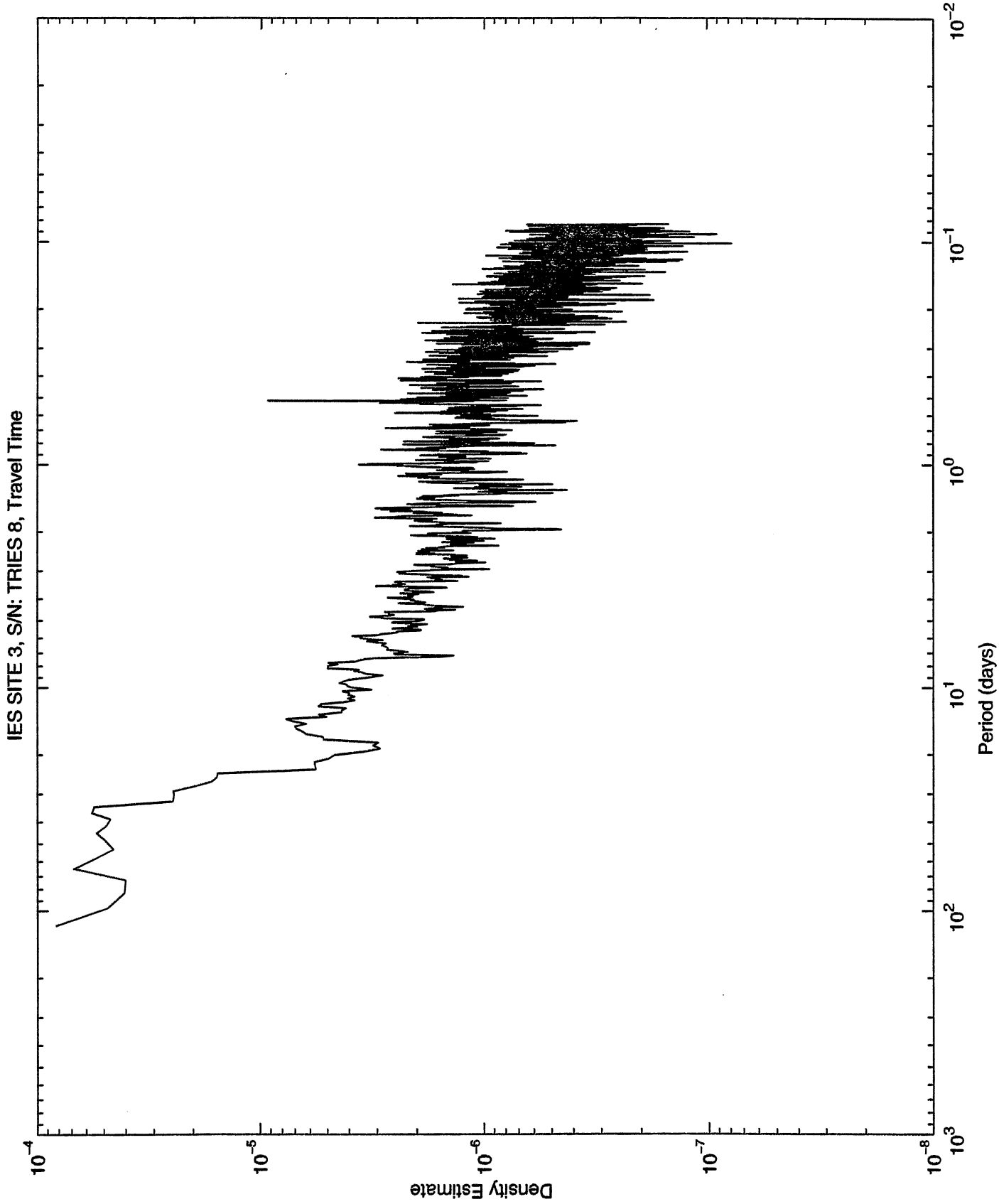
Dept: 1,115m

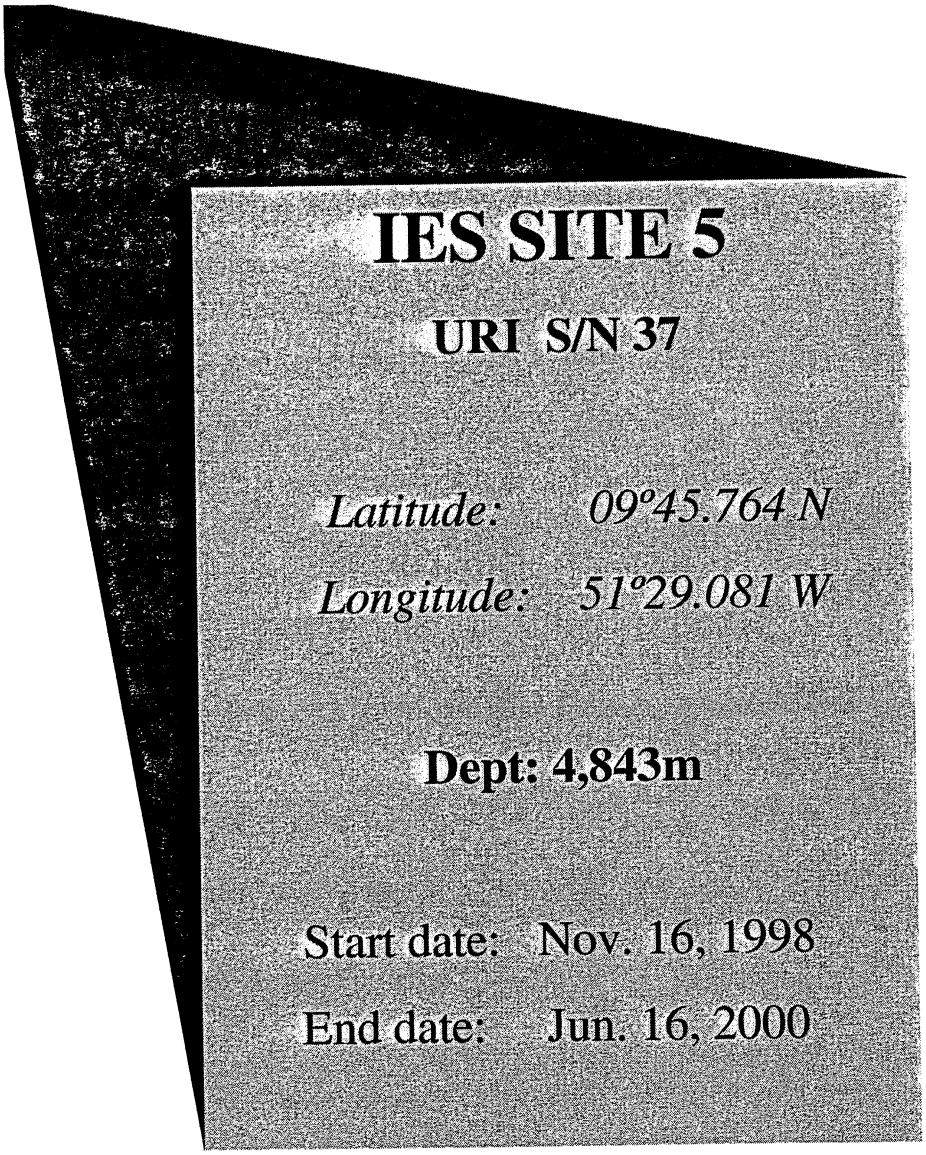
Start date: Nov. 14, 1998

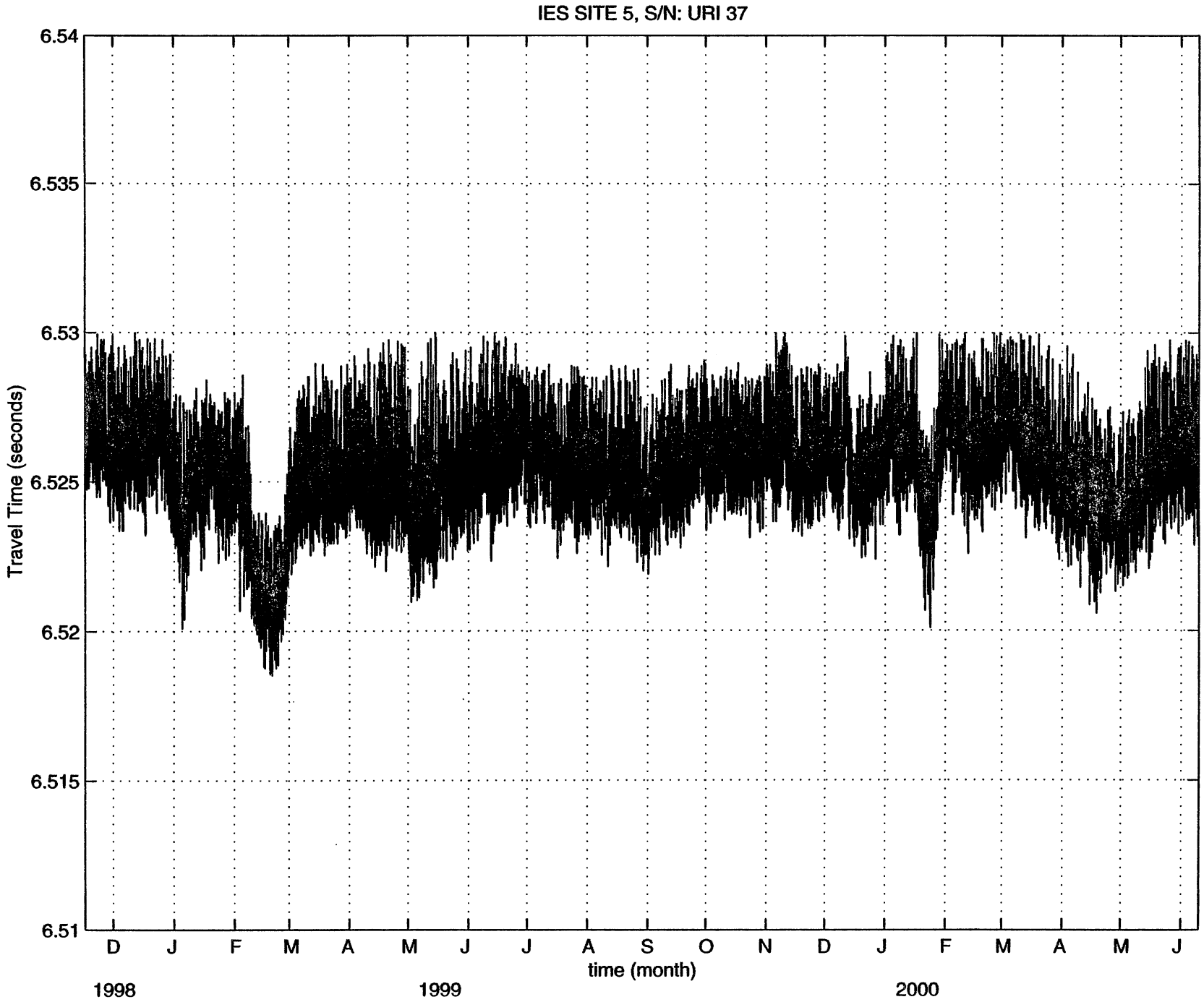
End date: Jun. 18, 2000

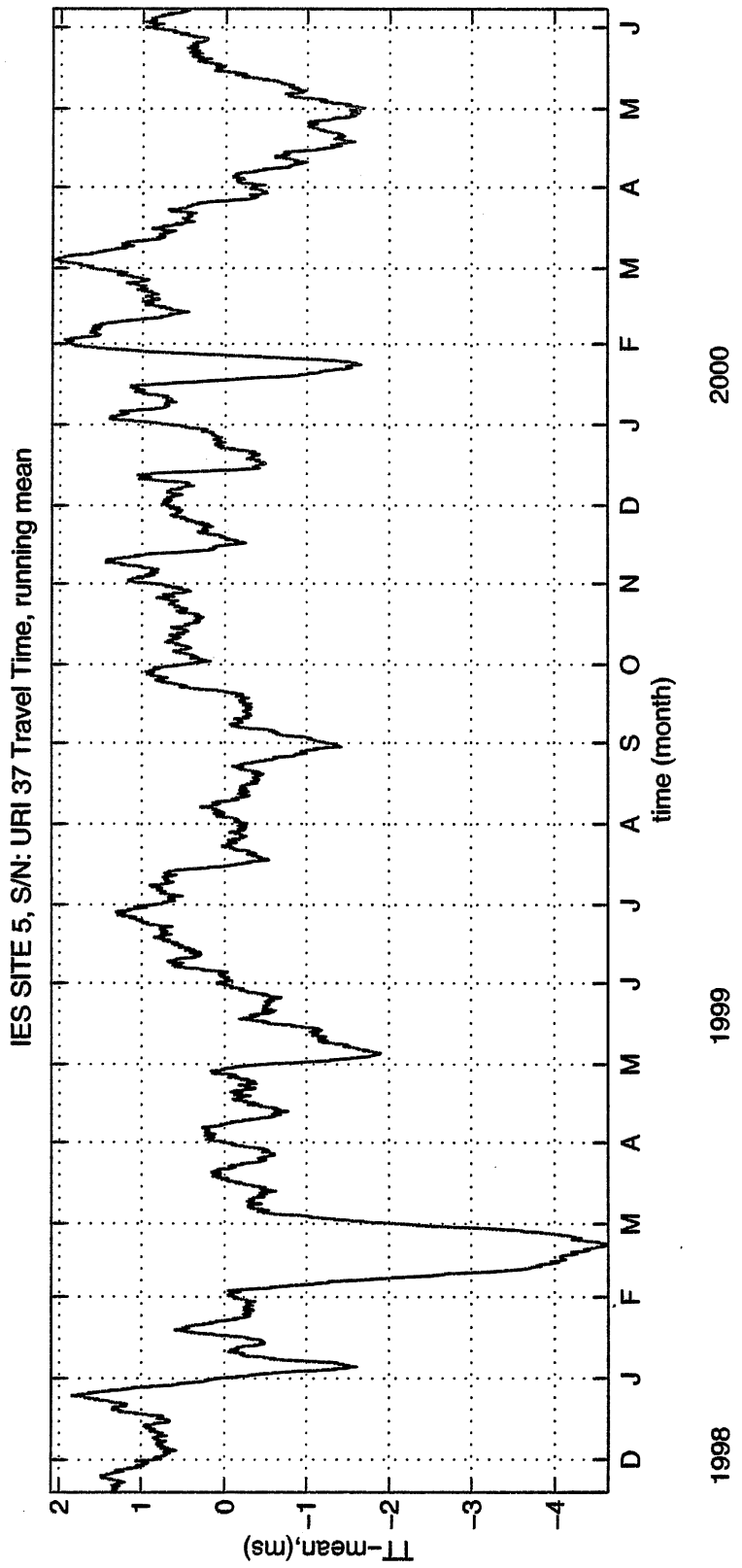

IES SITE 3, S/N: TRIES 8
1.525
1.52
1.515
1.51
1.505
1.5
1.495
1.49
Travel Time (seconds)
D
J
F
M
A
M
J
J
A
S
O
N
D
J
F
M
A
M
J
time (month)
1998
1999
2000

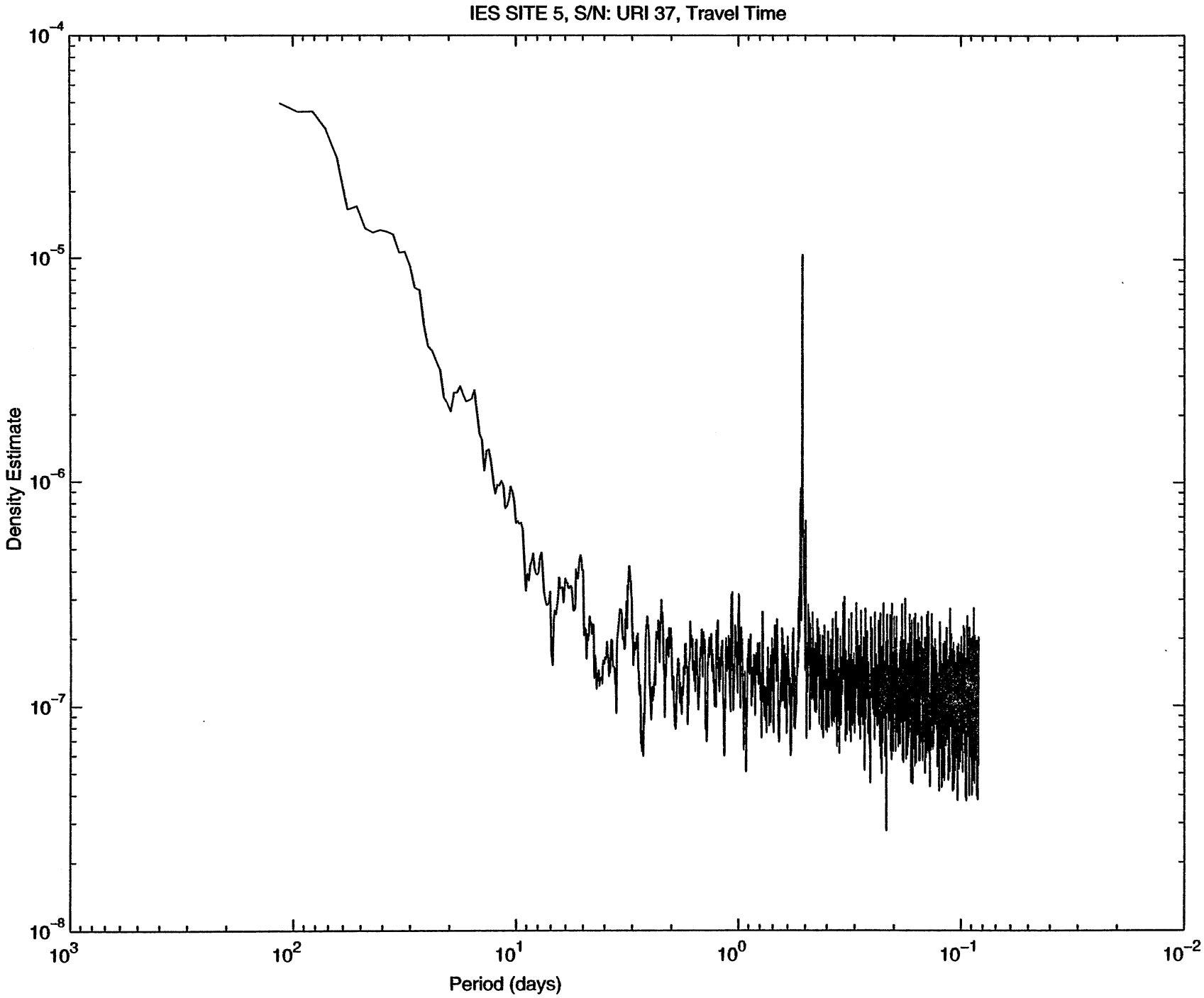

IES SITE 3, S/N: TRIES 8 Travel Time, 4 days running mean
TT-mean,(ms)
3
2
1
0
−1
−2
−3
−4
D
J
F
M
A
M
J
J
A
S
O
N
D
J
F
M
A
M
J
time (month)
1998
1999
2000

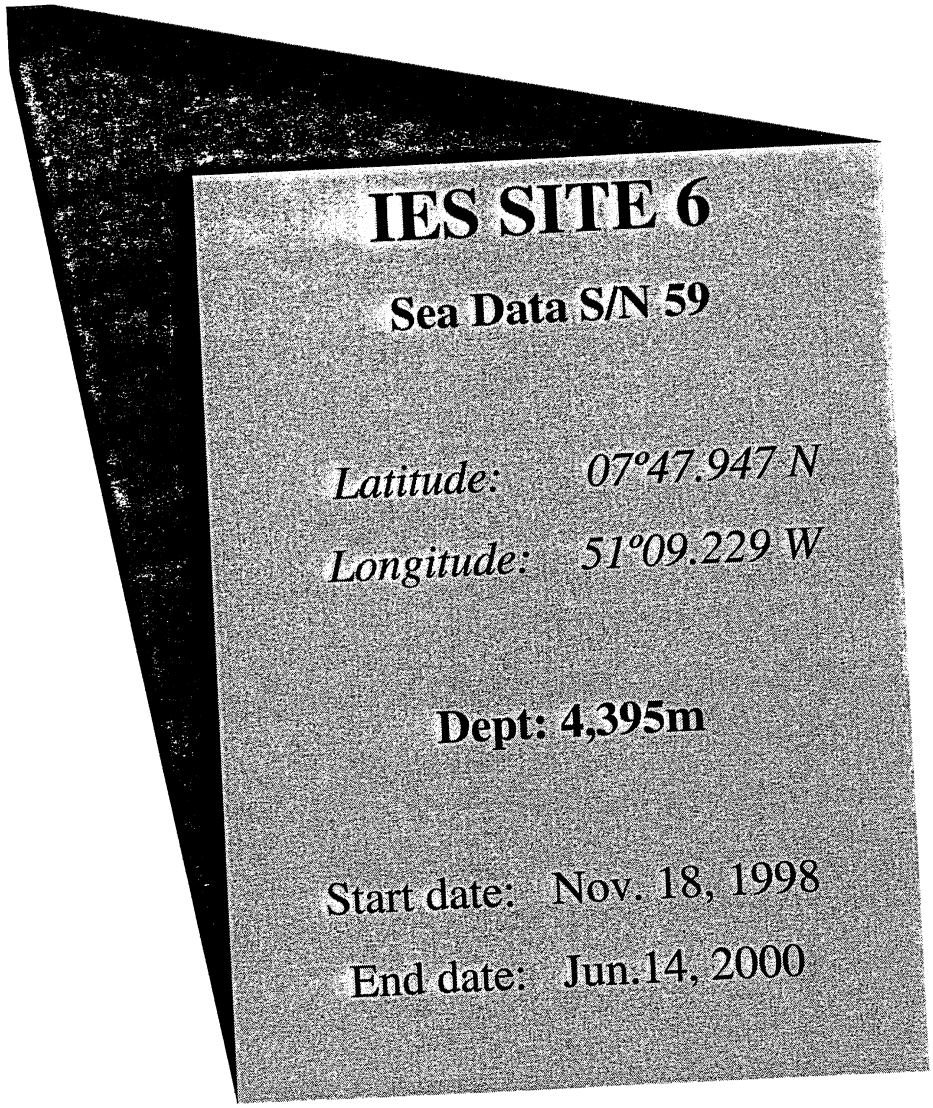

IES SITE 3, S/N: TRIES 8, Travel Time
Density Estimate
Period (days)
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}

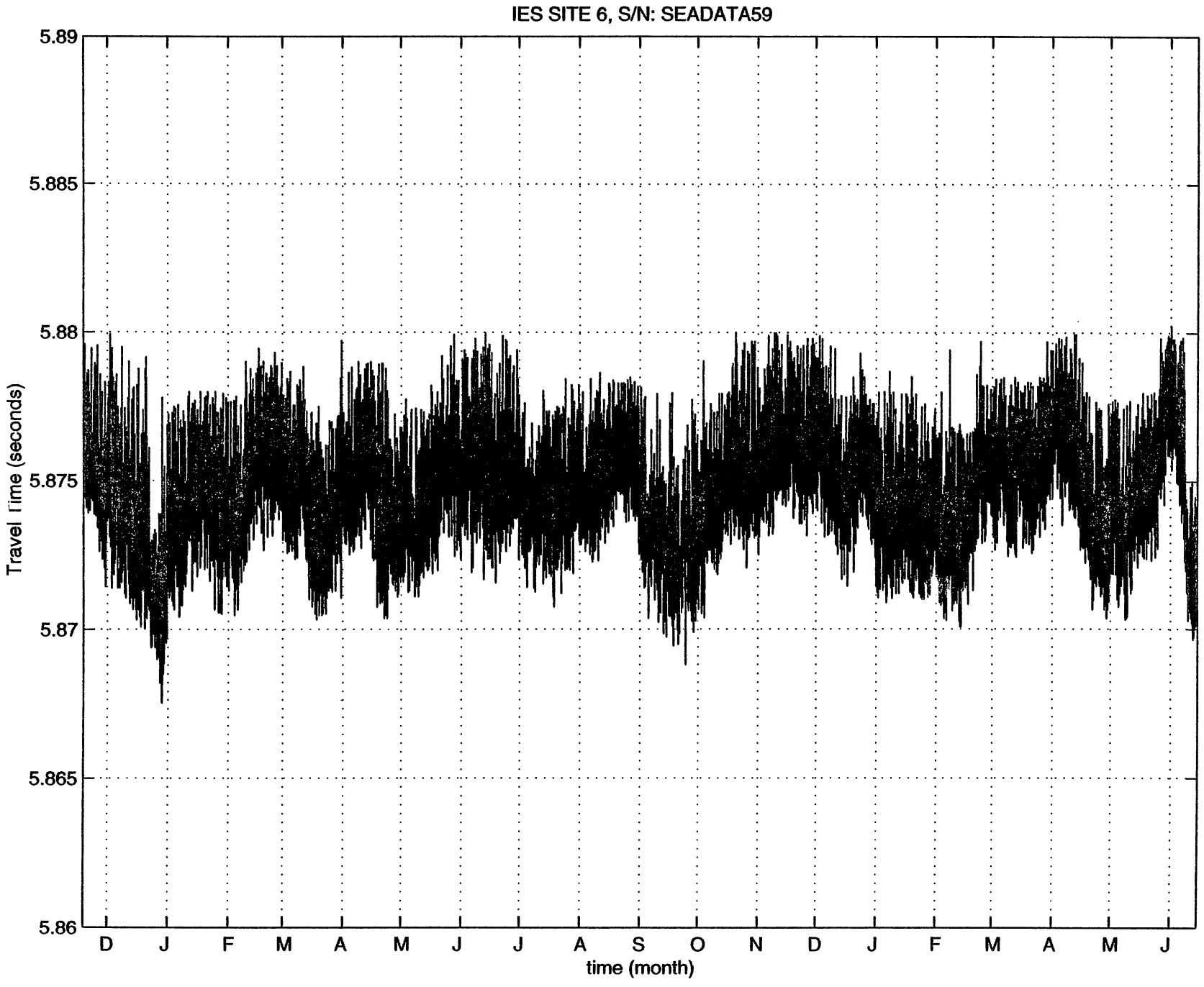

IES SITE 5
URI S/N 37
Latitude: 09°45.764 N
Longitude: 51°29.081 W
Dept: 4,843m
Start date: Nov. 16, 1998
End date: Jun. 16, 2000

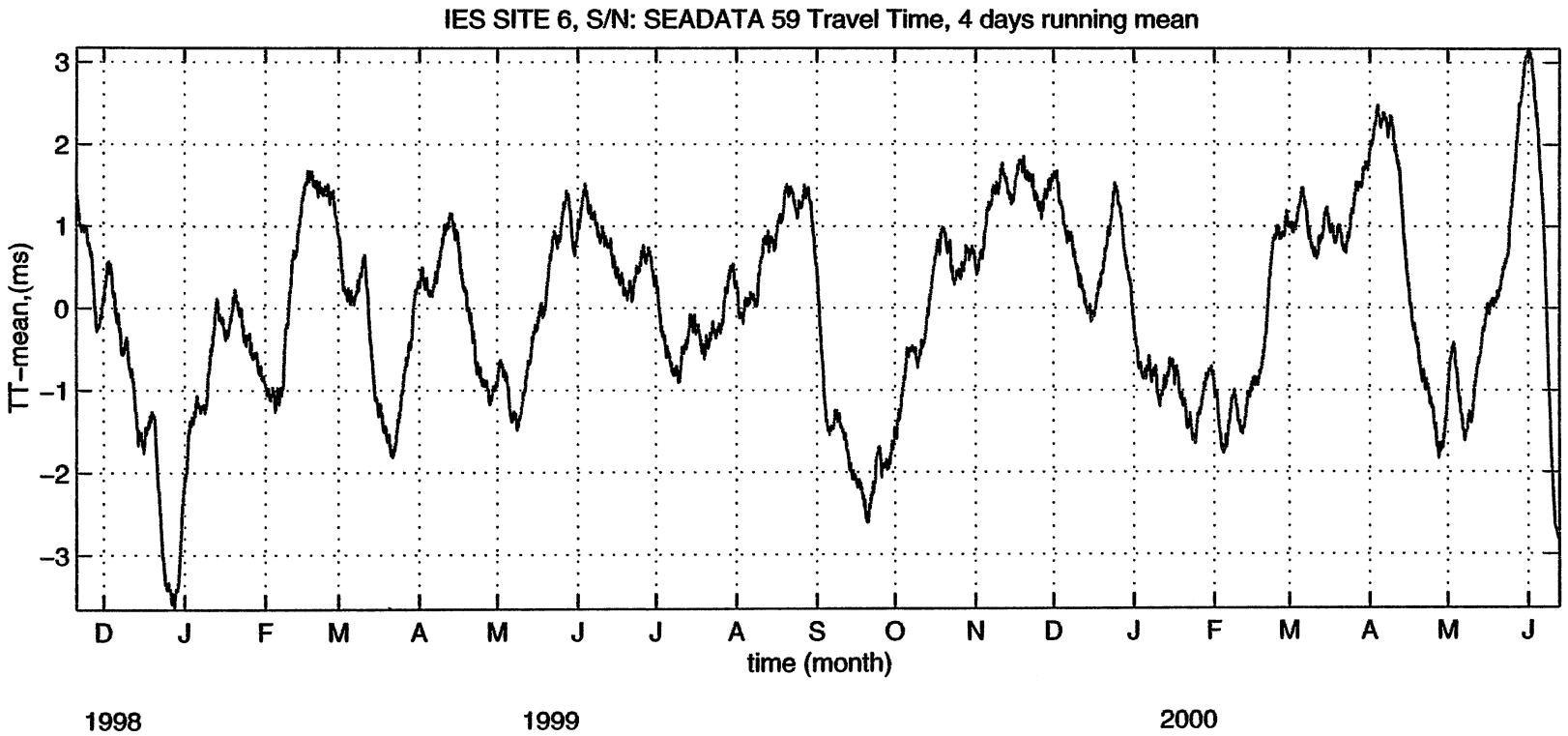

IES SITE 5, S/N: URI 37
6.54
6.535
6.53
6.525
6.52
6.515
6.51
Travel Time (seconds)
D
J
F
M
A
M
J
J
A
S
O
N
D
J
F
M
A
M
J
time (month)
1998
1999
2000

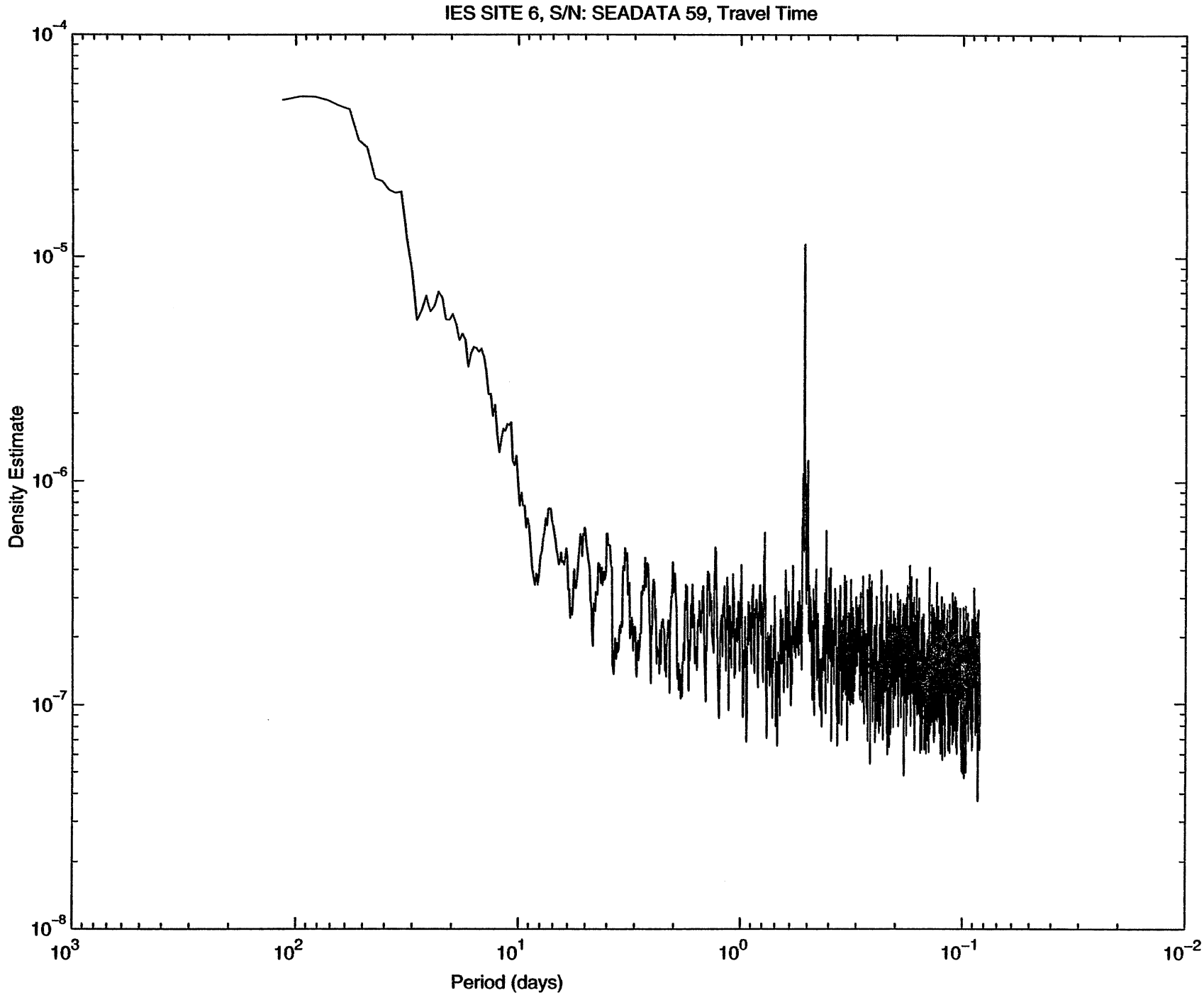

IES SITE 5, S/N: URI 37 Travel Time, running mean
TT-mean,(ms)
2
1
0
-1
-2
-3
-4
D
J
F
M
A
M
J
J
A
S
O
N
D
J
F
M
A
M
J
1998
1999
2000
time (month)


IES SITE 5, S/N: URI 37, Travel Time
Density Estimate
Period (days)
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}


IES SITE 6
Sea Data S/N 59
Latitude: 07°47.947 N
Longitude: 51°09.229 W
Dept: 4,395m
Start date: Nov. 18, 1998
End date: Jun.14, 2000


IES SITE 6, S/N: SEADATA59
5.89
5.885
5.88
5.875
5.87
5.865
5.86
Travel Time (seconds)
D
J
F
M
A
M
J
J
A
S
O
N
D
J
F
M
A
M
J
time (month)
1998
1999
2000


IES SITE 6, S/N: SEADATA 59 Travel Time, 4 days running mean
TT-mean,(ms)
3
2
1
0
−1
−2
−3
D
J
F
M
A
M
J
J
A
S
O
N
D
J
F
M
A
M
J
time (month)
1998
1999
2000


IES SITE 6, S/N: SEADATA 59, Travel Time
Density Estimate
Period (days)
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}

IES SITE 7

TRIES S/N 3

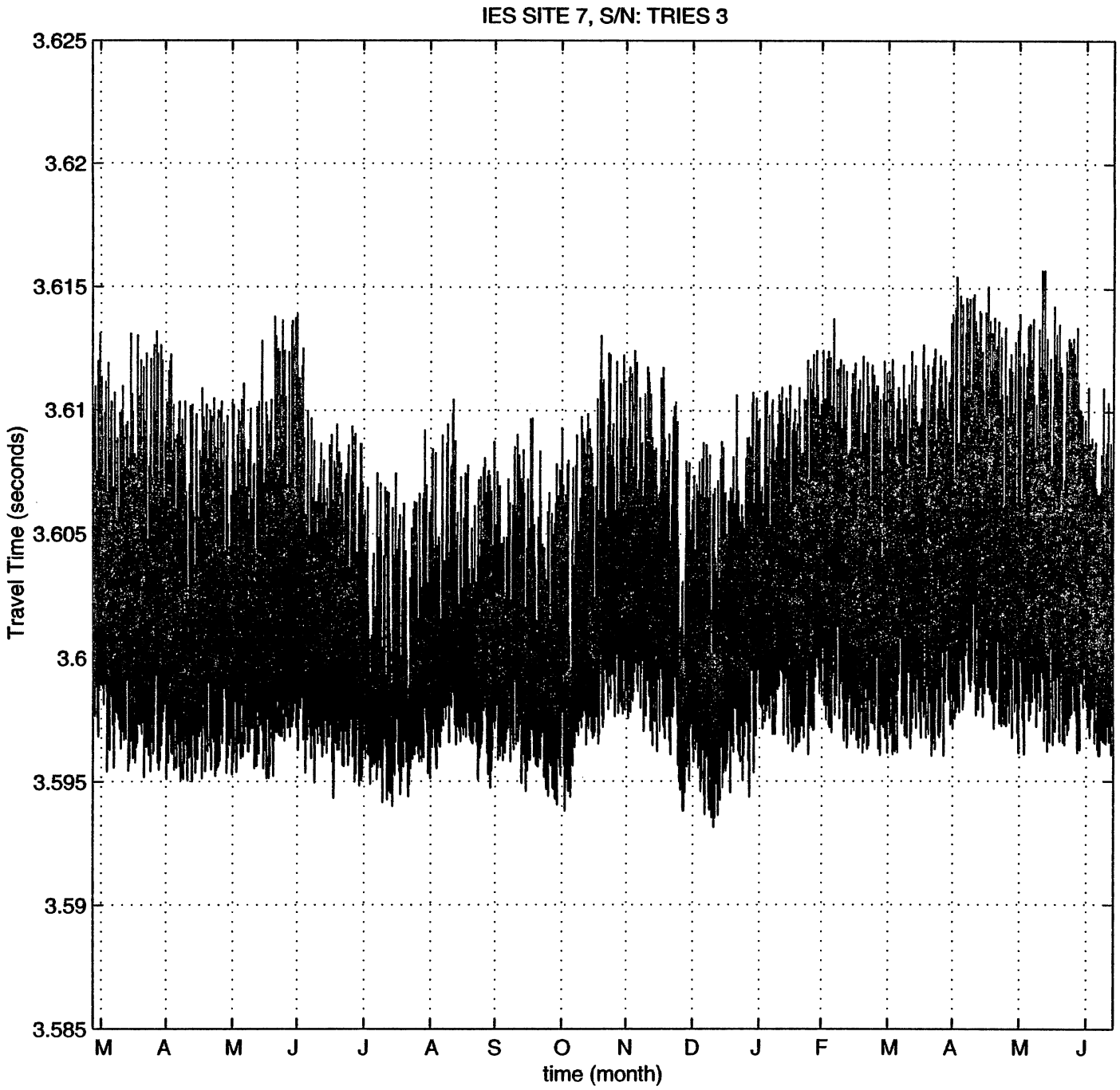
Latitude: *05°56.99 N*

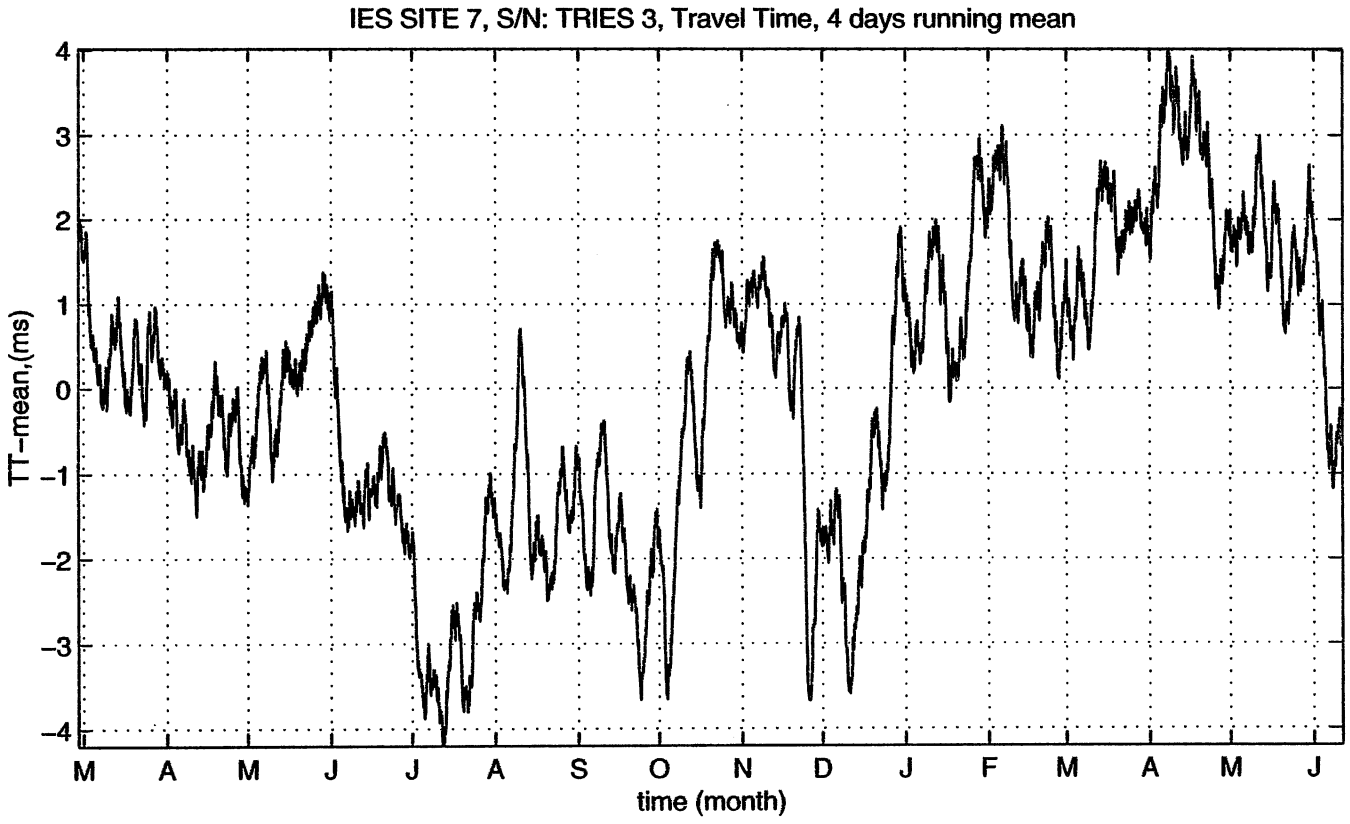
Longitude: *51°00.08 W*

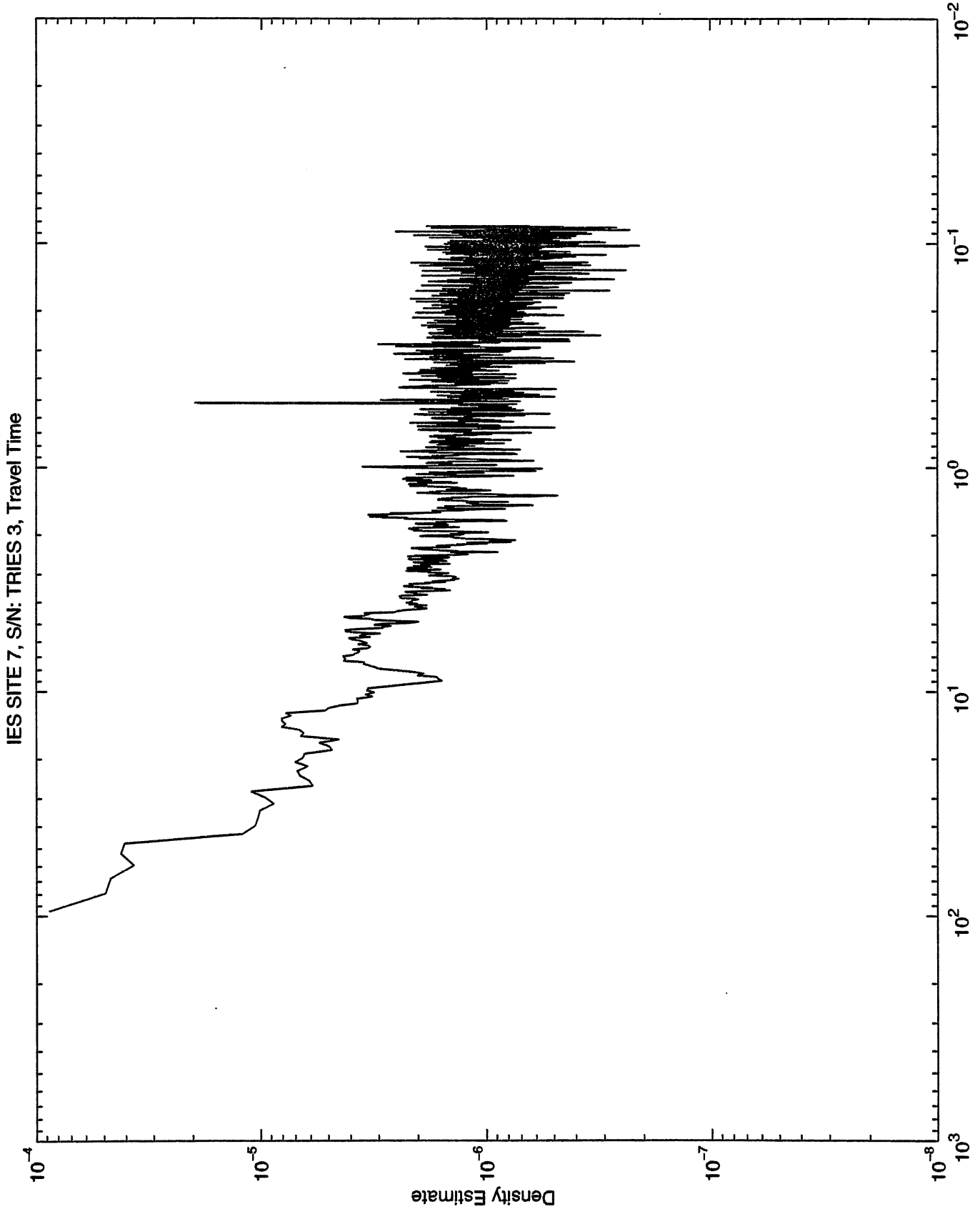
Dept: 2,700m

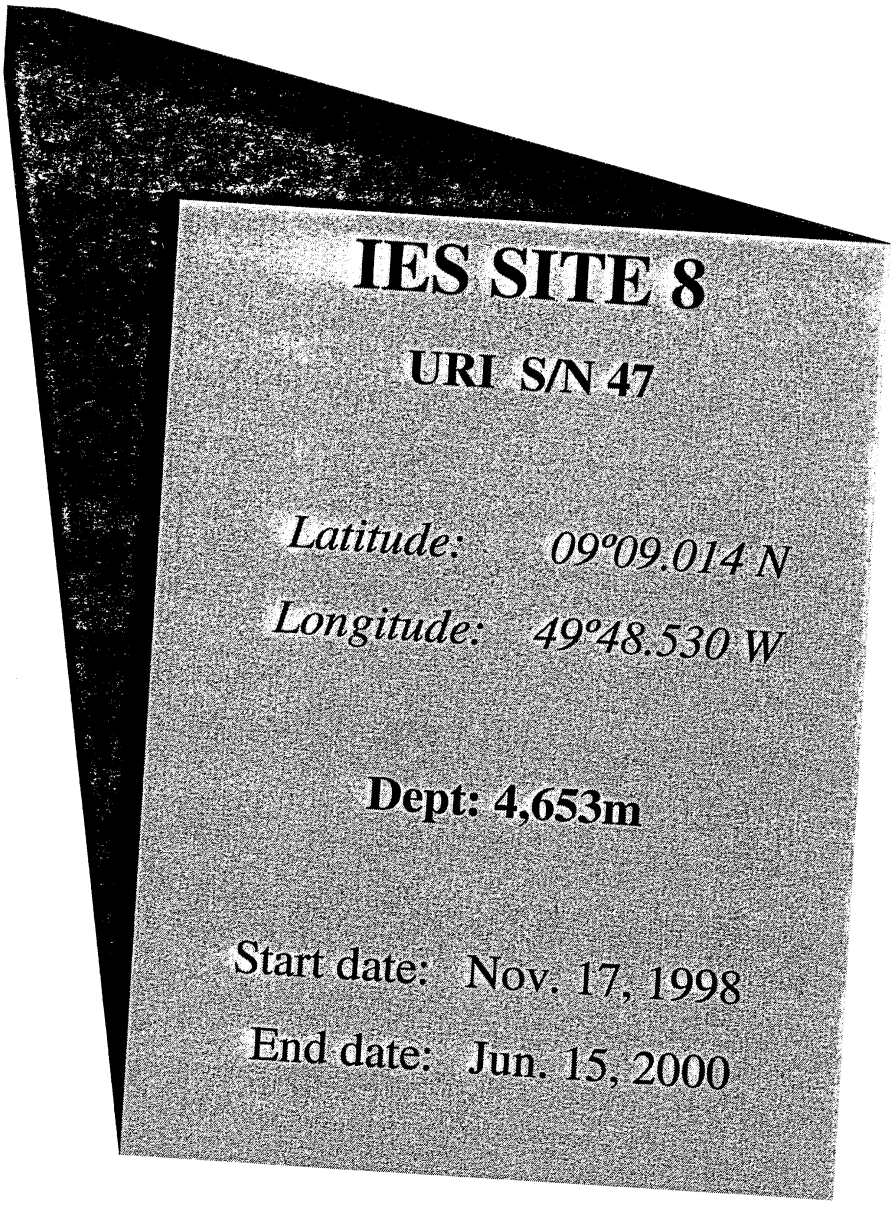
Start date: Feb. 24, 1999

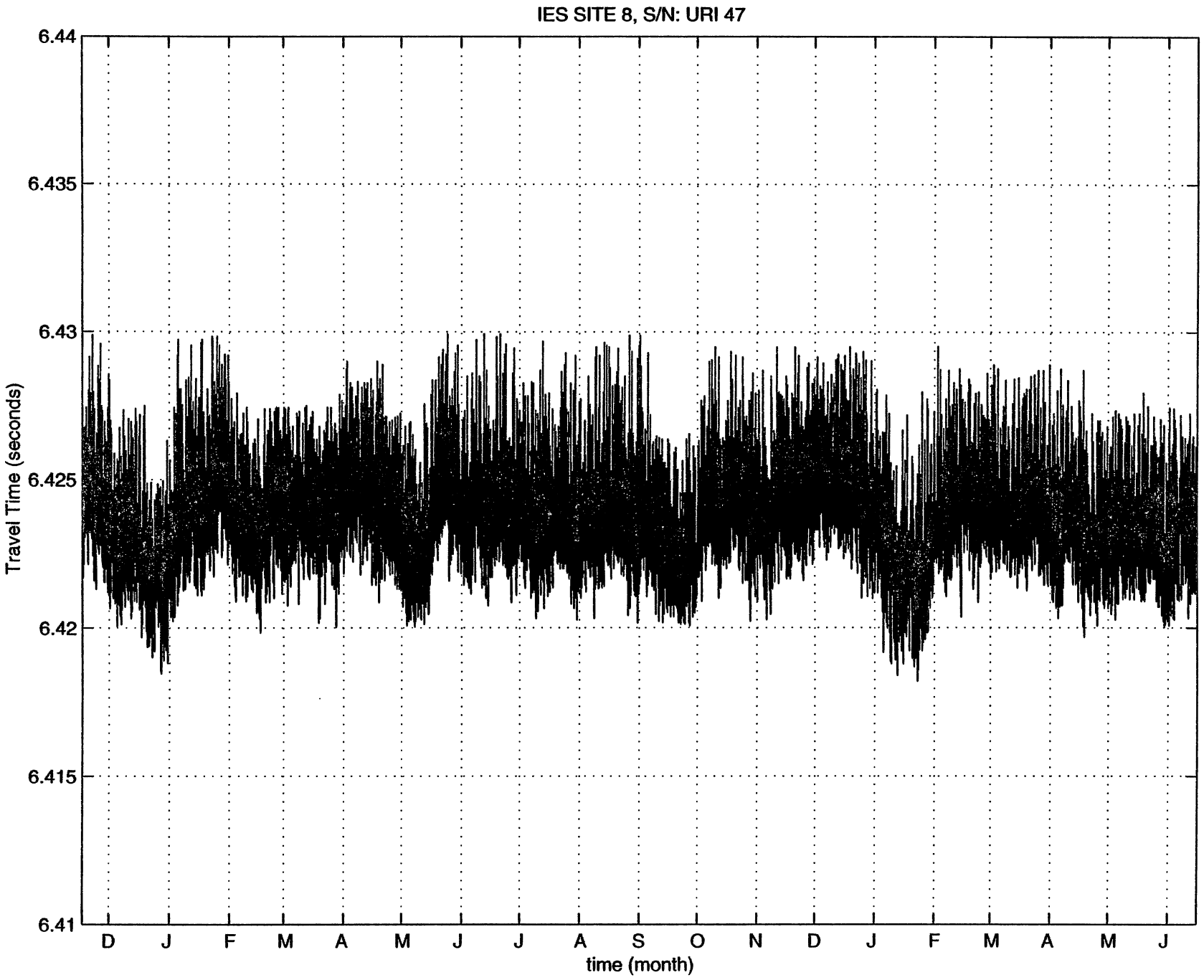
End date: Jun. 13, 2000

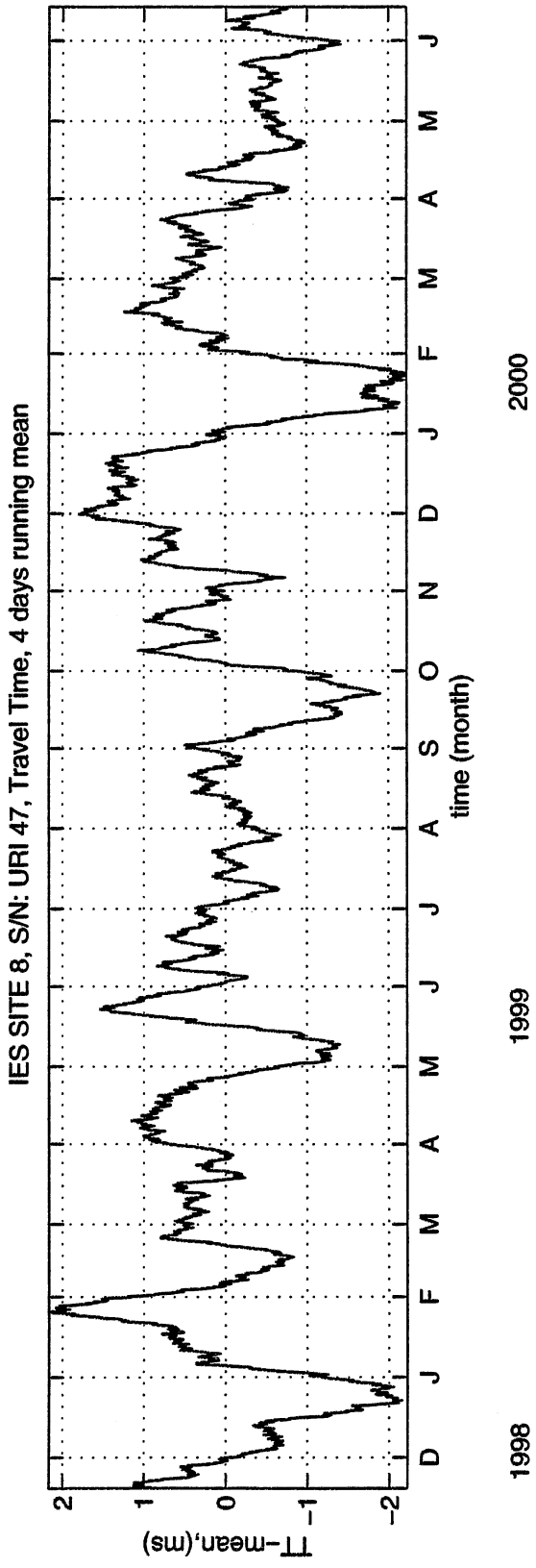

IES SITE 7, S/N: TRIES 3
3.625
3.62
3.615
3.61
3.605
3.6
3.595
3.59
3.585
Travel Time (seconds)
M
A
M
J
J
A
S
O
N
D
J
F
M
A
M
J
time (month)
1998
1999
2000

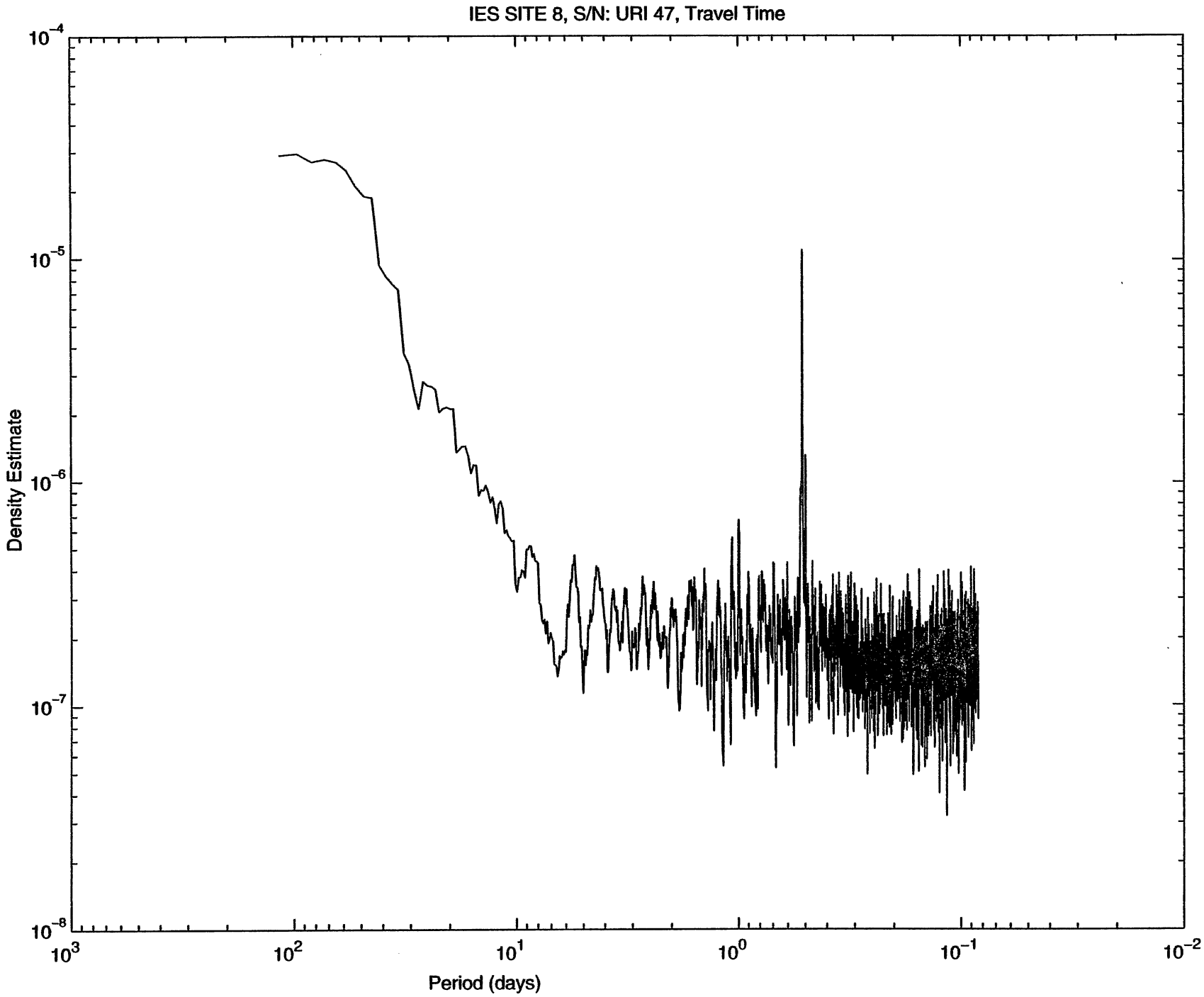

IES SITE 7, S/N: TRIES 3, Travel Time, 4 days running mean
TT-mean,(ms)
4
3
2
1
0
−1
−2
−3
−4
M
A
M
J
J
A
S
O
N
D
J
F
M
A
M
J
time (month)
1999
2000


IES SITE 7, S/N: TRIES 3, Travel Time
Density Estimate
Period (days)
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}


IES SITE 8
URI S/N 47
Latitude: 09°09.014 N
Longitude: 49°48.530 W
Dept: 4,653m
Start date: Nov. 17, 1998
End date: Jun. 15, 2000


IES SITE 8, S/N: URI 47
6.44
6.435
6.43
6.425
6.42
6.415
6.41
Travel Time (seconds)
D
J
F
M
A
M
J
J
A
S
O
N
D
J
F
M
A
M
J
time (month)
1998
1999
2000


IES SITE 8, S/N: URI 47, Travel Time, 4 days running mean
TT-mean,(ms)
2
1
0
−1
−2
D
J
F
M
A
M
J
J
A
S
O
N
D
J
F
M
A
M
J
1998
1999
2000
time (month)


IES SITE 8, S/N: URI 47, Travel Time
Density Estimate
Period (days)
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}

IES SITE 9

URI S/N 50

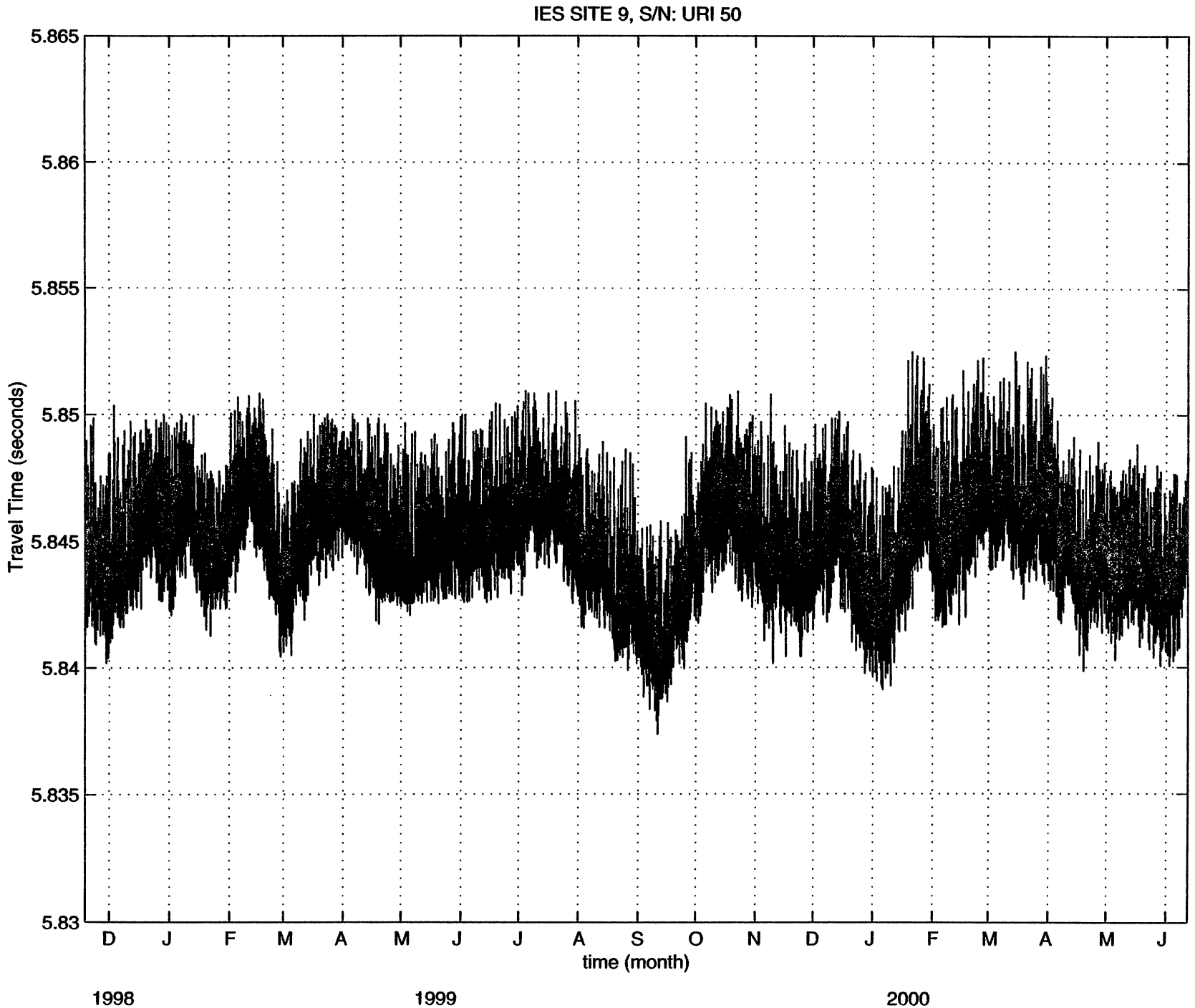
Latitude: 07°35.589 N

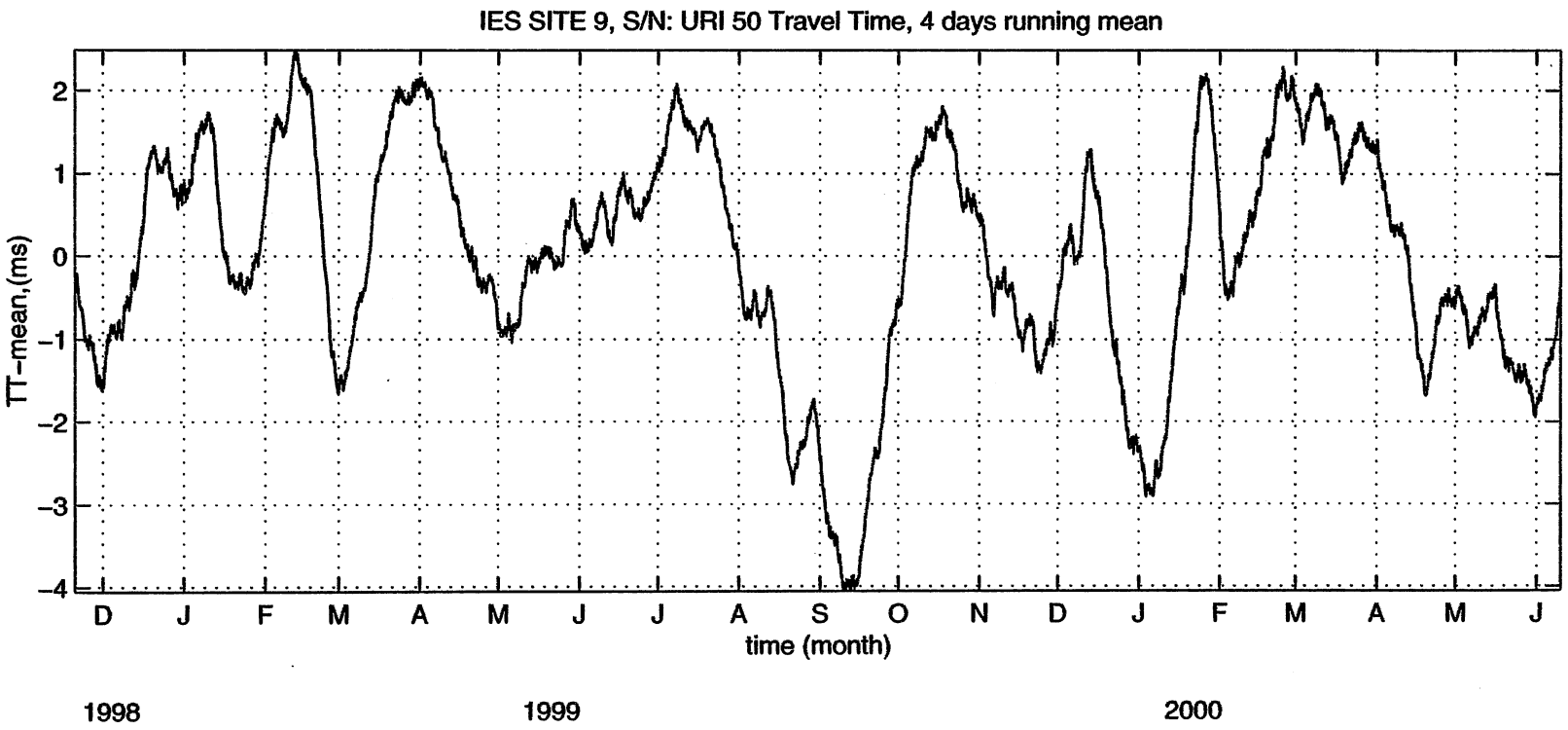
Longitude: 49°10.831 W

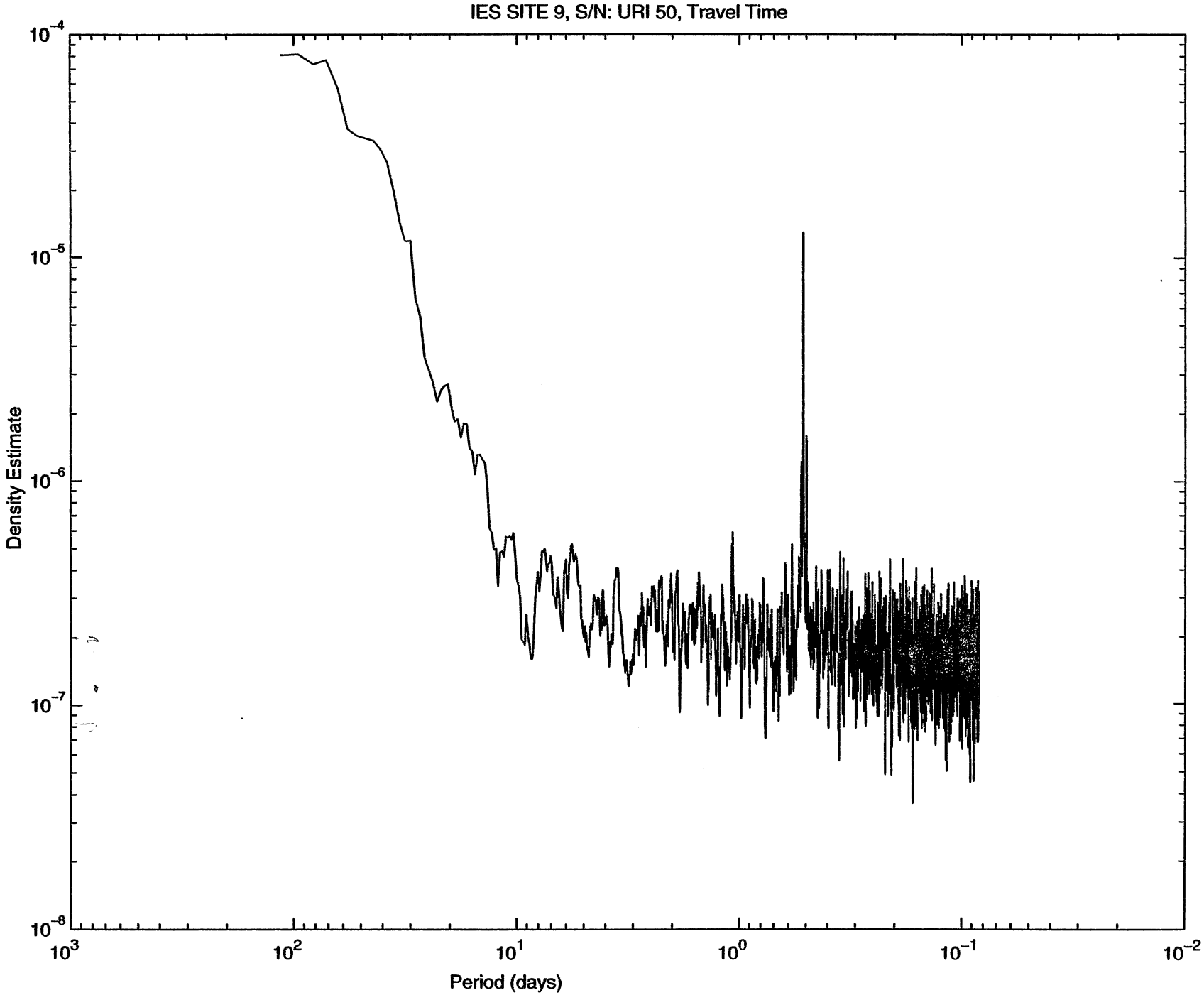
Dept: 4,288m

Start date: Nov. 18, 1998

End date: Jun. 12, 2000


IES SITE 9, S/N: URI 50
Travel Time (seconds)
5.865
5.86
5.855
5.85
5.845
5.84
5.835
5.83
D J F M A M J J A S O N D J F M A M J
time (month)
1998
1999
2000


IES SITE 9, S/N: URI 50 Travel Time, 4 days running mean
TT-mean,(ms)
2
1
0
−1
−2
−3
−4
D
J
F
M
A
M
J
J
A
S
O
N
D
J
F
M
A
M
J
time (month)
1998
1999
2000


IES SITE 9, S/N: URI 50, Travel Time
Density Estimate
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
Period (days)

IES SITE 10

Sea Data S/N 58

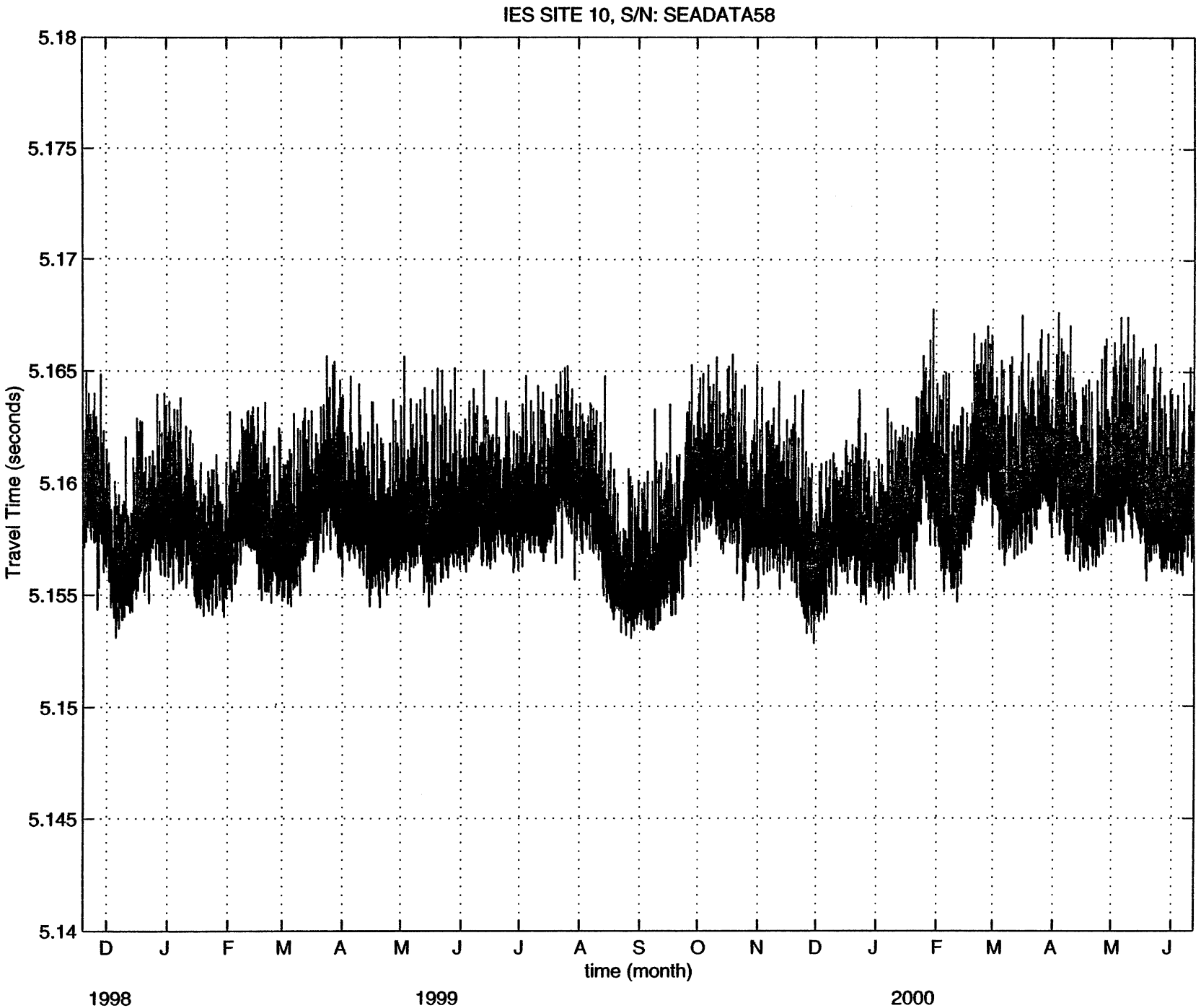
Latitude: *06°27.699 N*

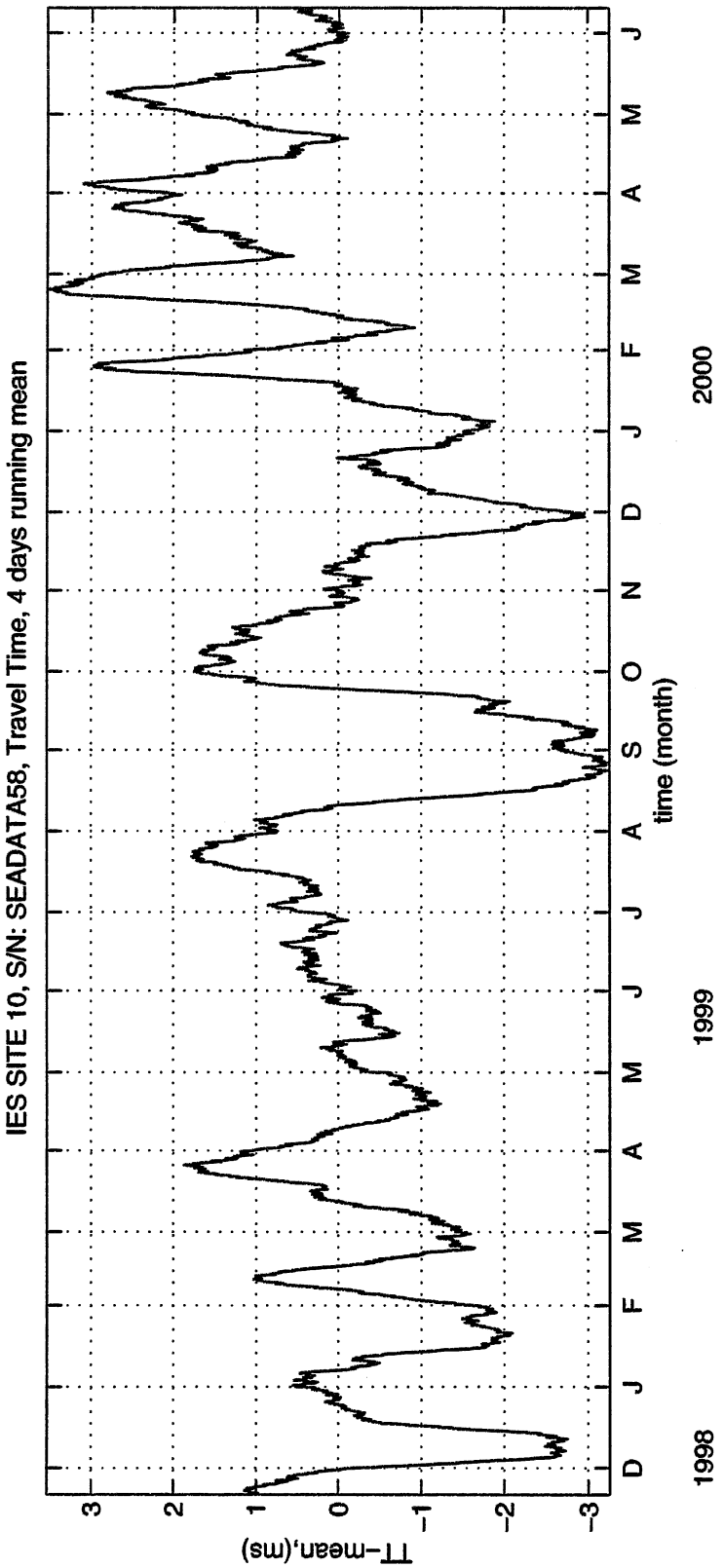
Longitude: *49°42.522 W*

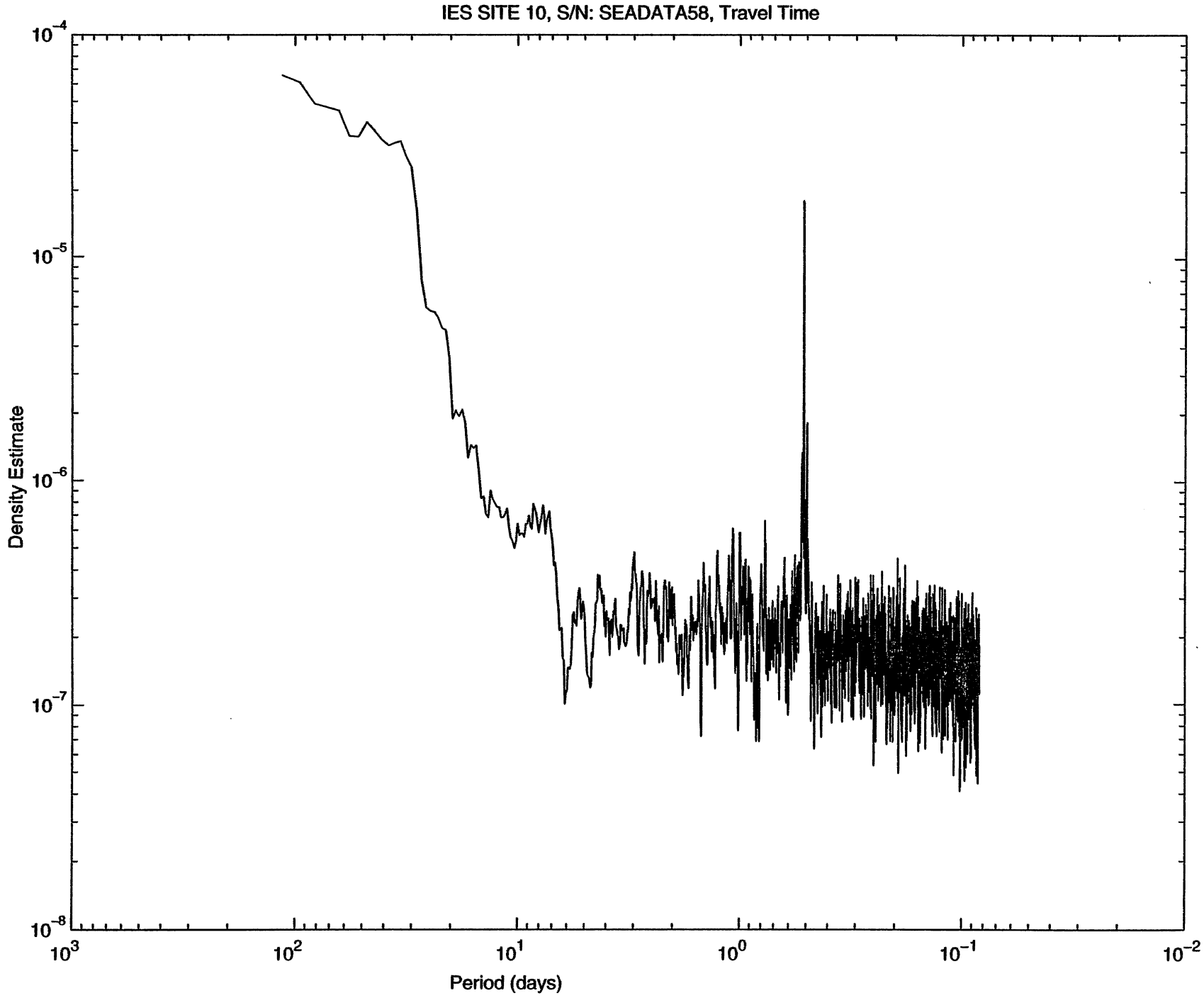
Dept: 3,858m

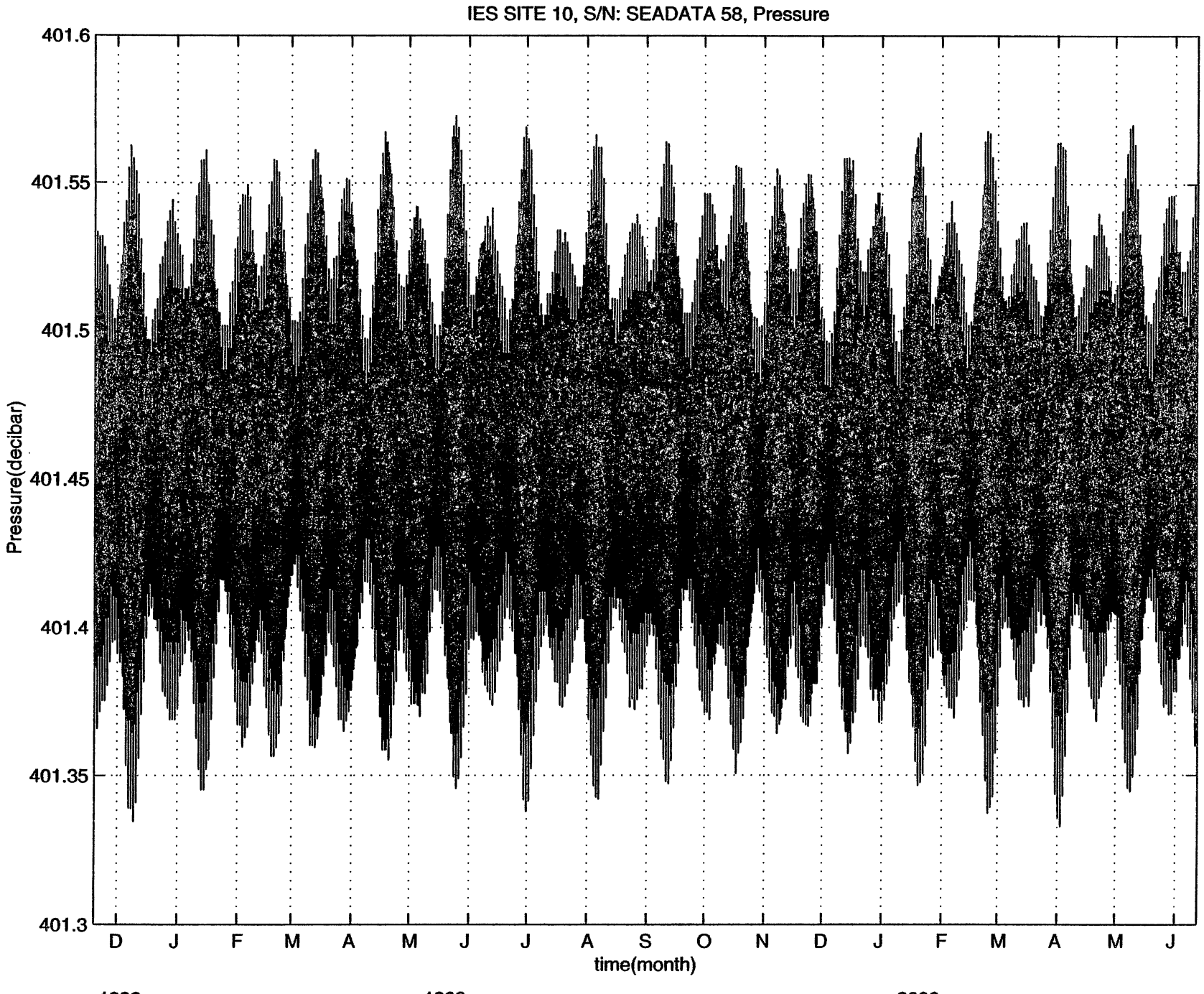
Start date: Nov. 18, 1998

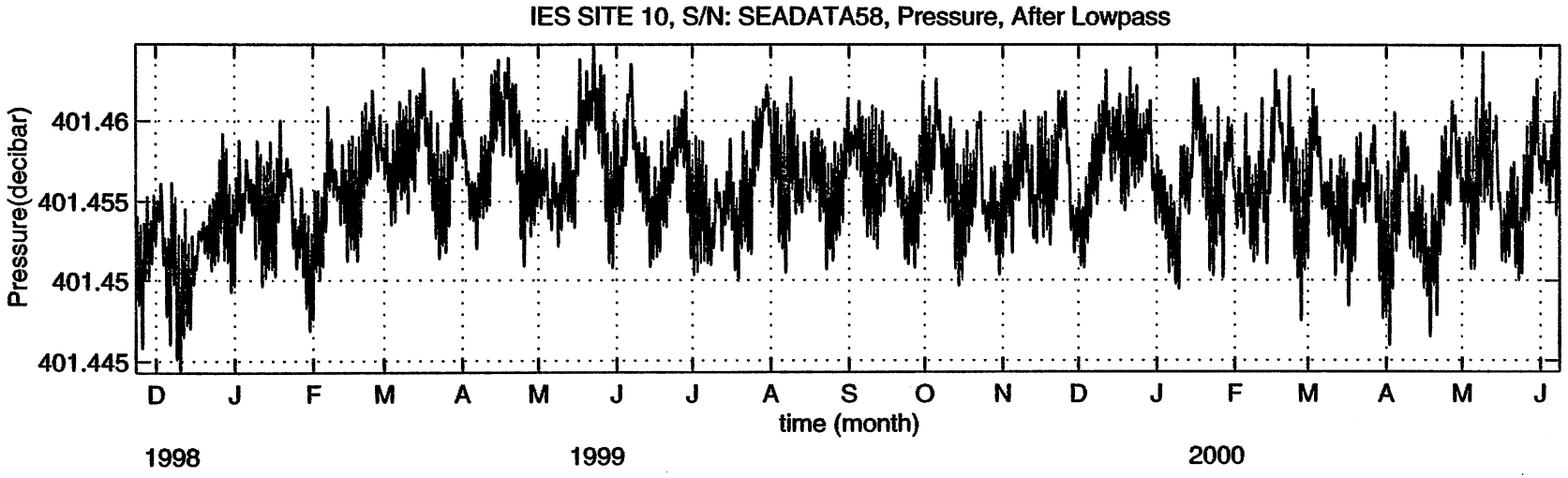
End date: Jun. 12, 2000

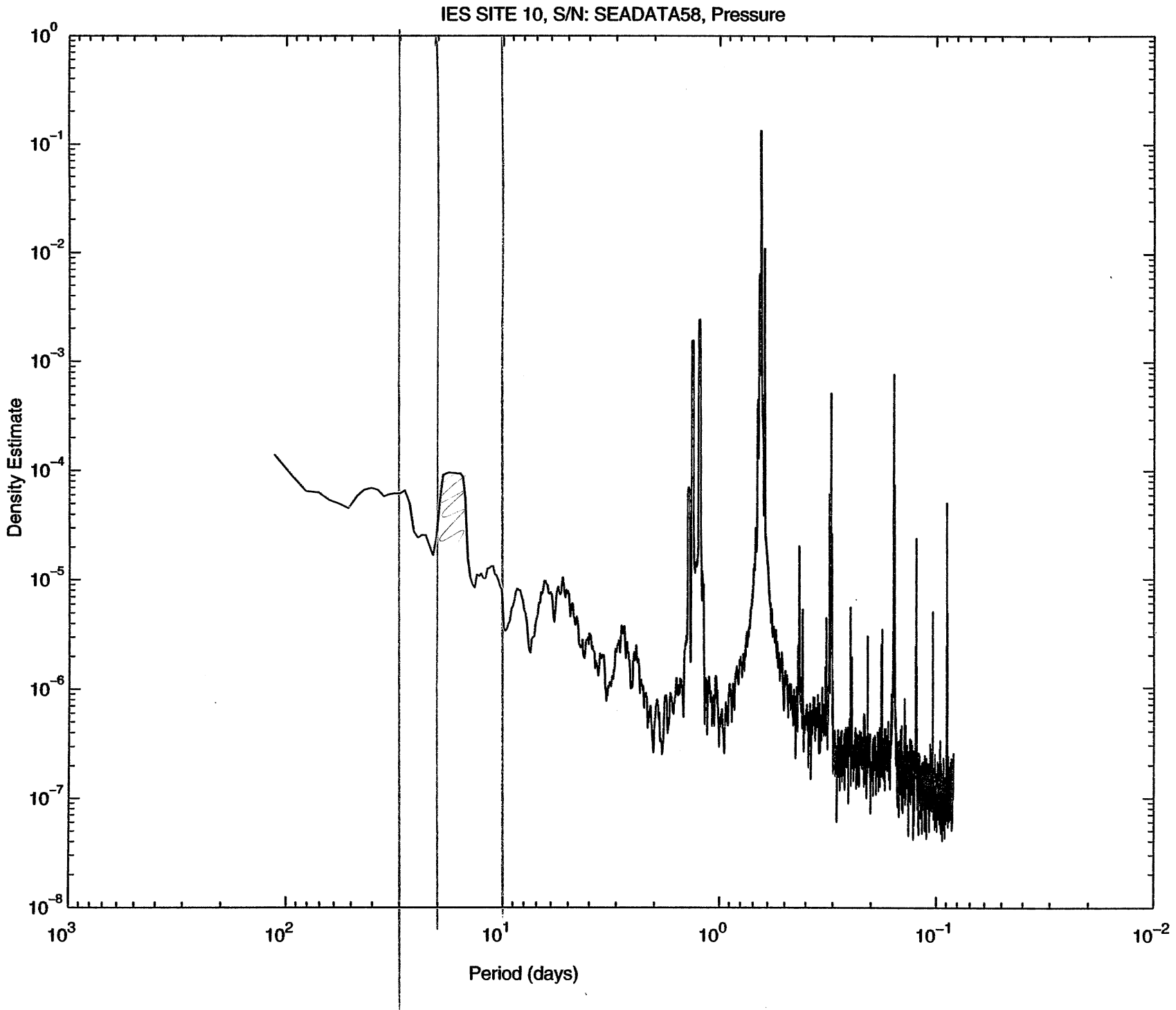

IES SITE 10, S/N: SEADATA58
5.18
5.175
5.17
5.165
5.16
5.155
5.15
5.145
5.14
Travel Time (seconds)
D J F M A M J J A S O N D J F M A M J
time (month)
1998
1999
2000

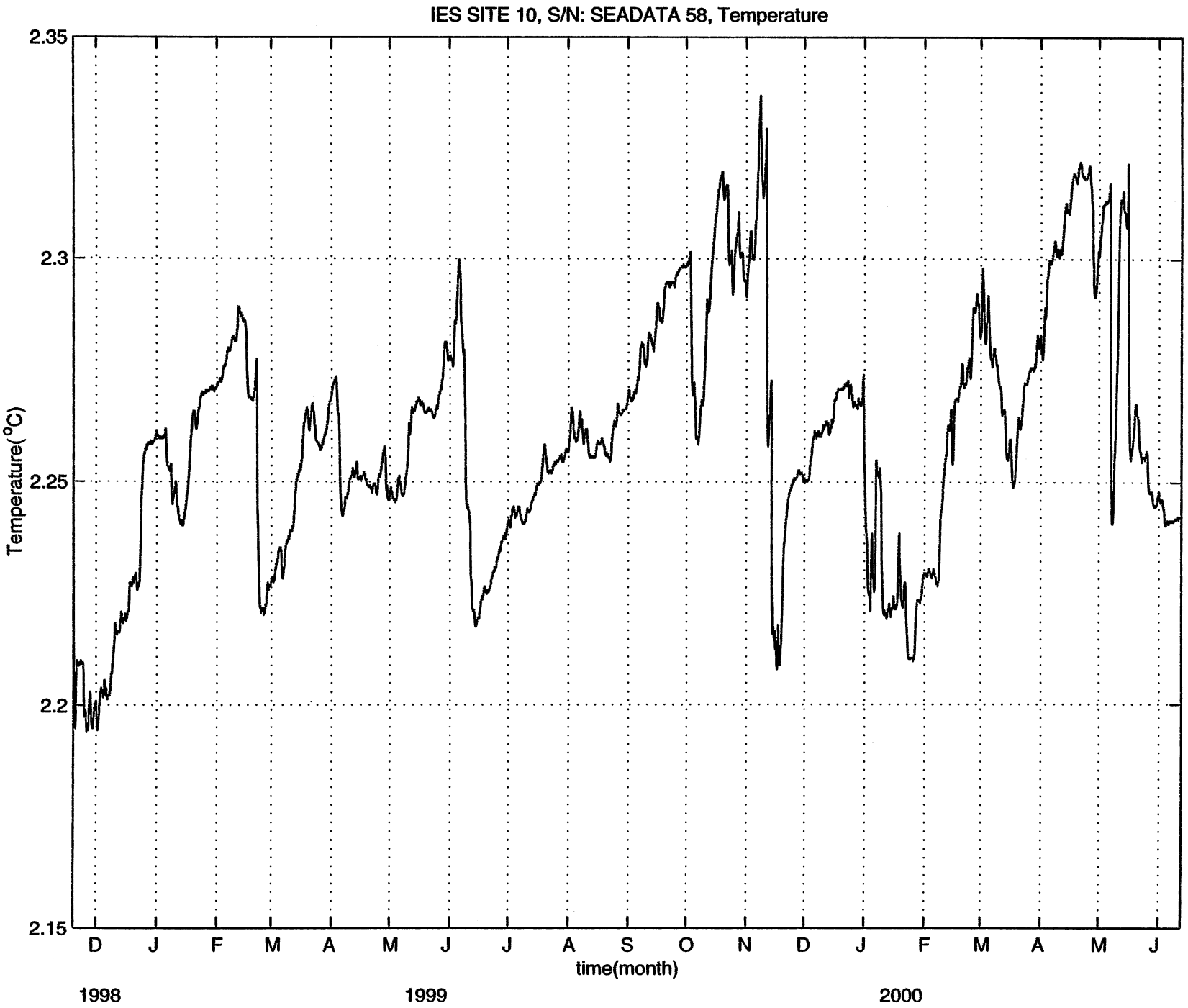

IES SITE 10, S/N: SEADATA58, Travel Time, 4 days running mean
TT-mean,(ms)
3
2
1
0
-1
-2
-3
D
J
F
M
A
M
J
J
A
S
O
N
D
J
F
M
A
M
J
1998
1999
2000
time (month)

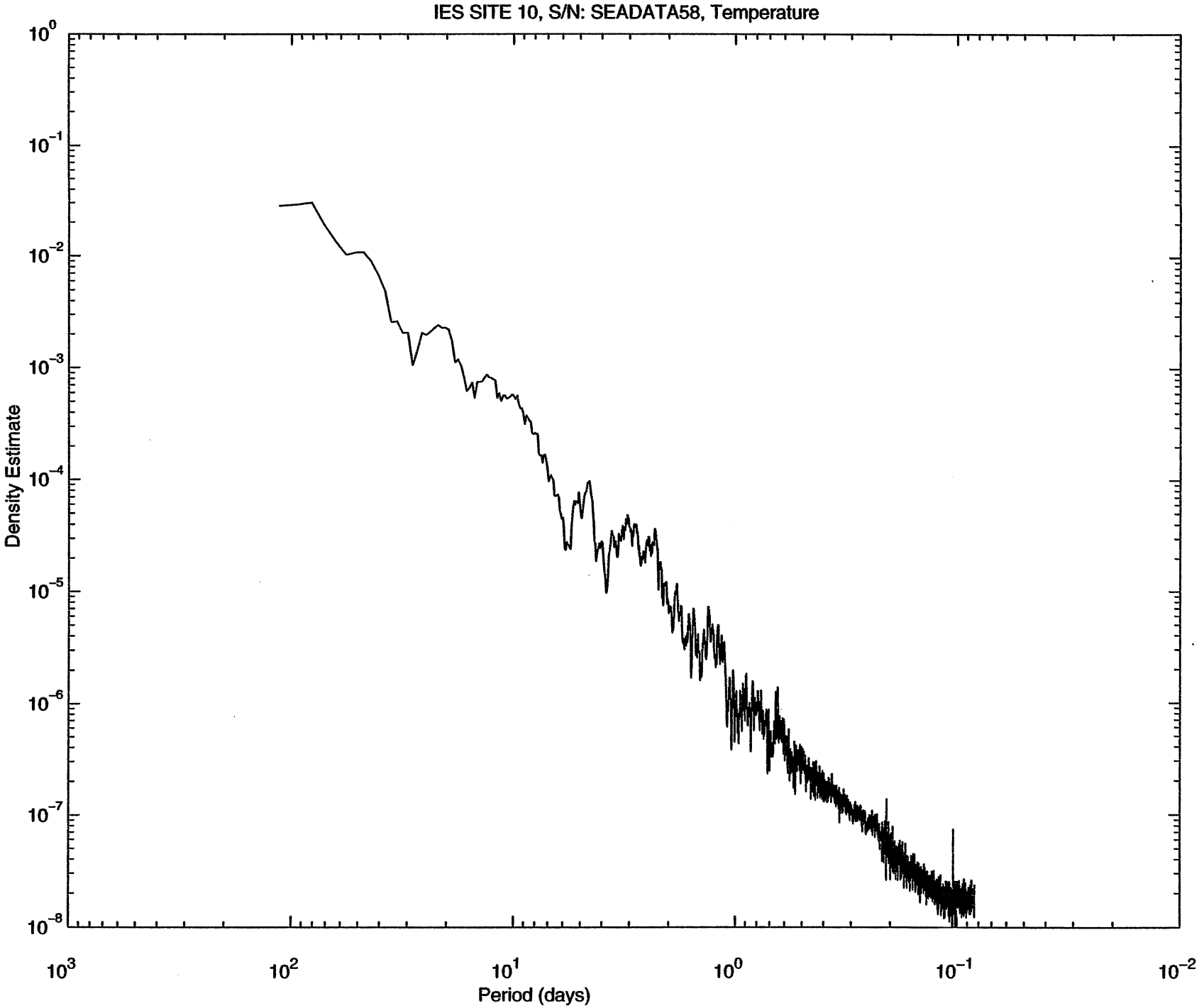

IES SITE 10, S/N: SEADATA58, Travel Time
Density Estimate
Period (days)
10^-4
10^-5
10^-6
10^-7
10^-8
10^3
10^2
10^1
10^0
10^-1
10^-2


IES SITE 10, S/N: SEADATA 58, Pressure
401.6
401.55
401.5
401.45
401.4
401.35
401.3
Pressure(decibar)
D J F M A M J J A S O N D J F M A M J
time(month)
1998
1999
2000


IES SITE 10, S/N: SEADATA58, Pressure, After Lowpass
Pressure(decibar)
401.46
401.455
401.45
401.445
D
J
F
M
A
M
J
J
A
S
O
N
D
J
F
M
A
M
J
time (month)
1998
1999
2000


IES SITE 10, S/N: SEADATA58, Pressure
Density Estimate
Period (days)
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}


IES SITE 10, S/N: SEADATA 58, Temperature
2.35
2.3
2.25
2.2
2.15
Temperature(°C)
D
J
F
M
A
M
J
J
A
S
O
N
D
J
F
M
A
M
J
time(month)
1998
1999
2000


IES SITE 10, S/N: SEADATA58, Temperature
Density Estimate
Period (days)
10^0
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
10^3
10^2
10^1
10^0
10^-1
10^-2

IES SITE 12

Sea Data S/N 62

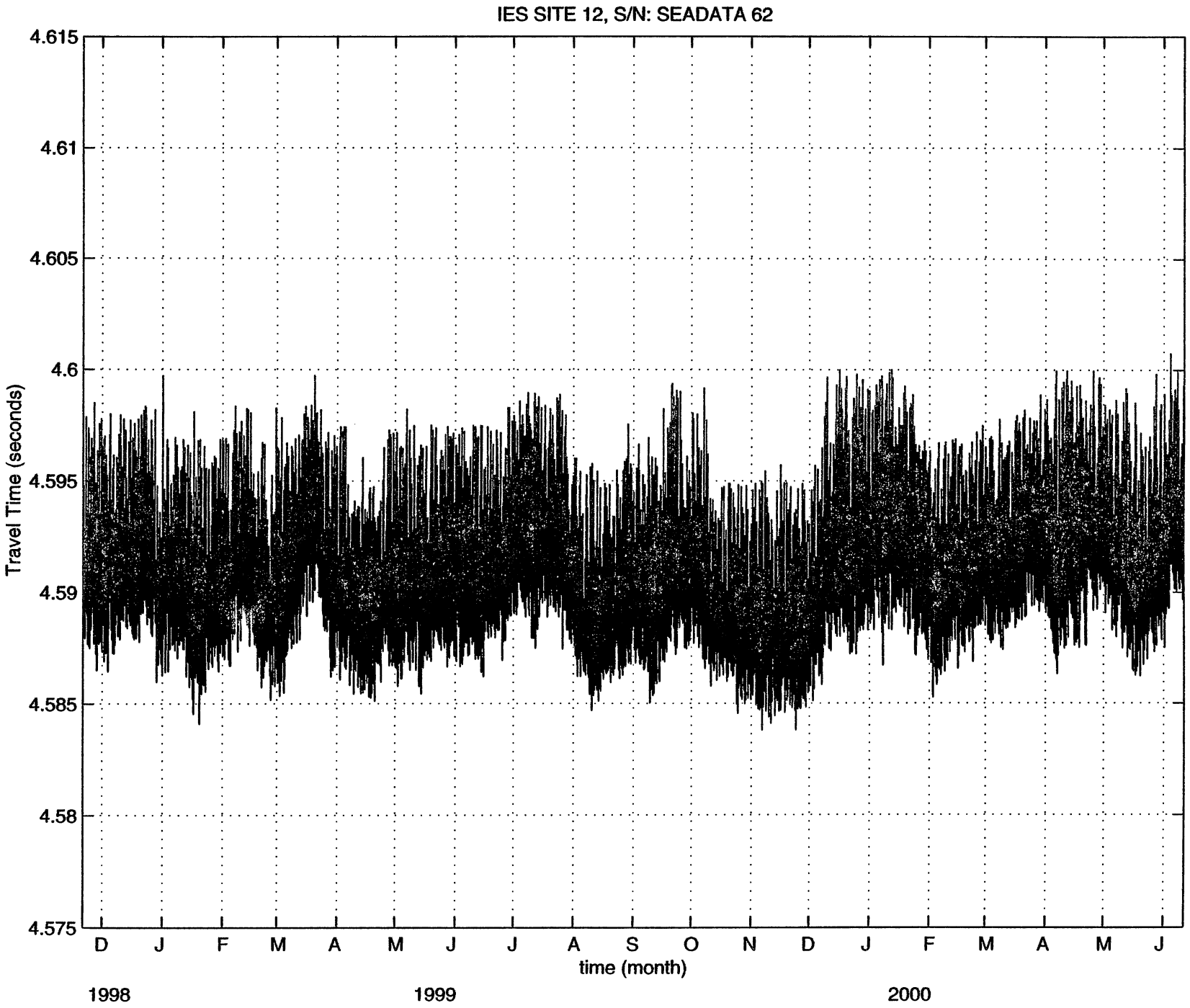
Latitude: 05º29.900 N

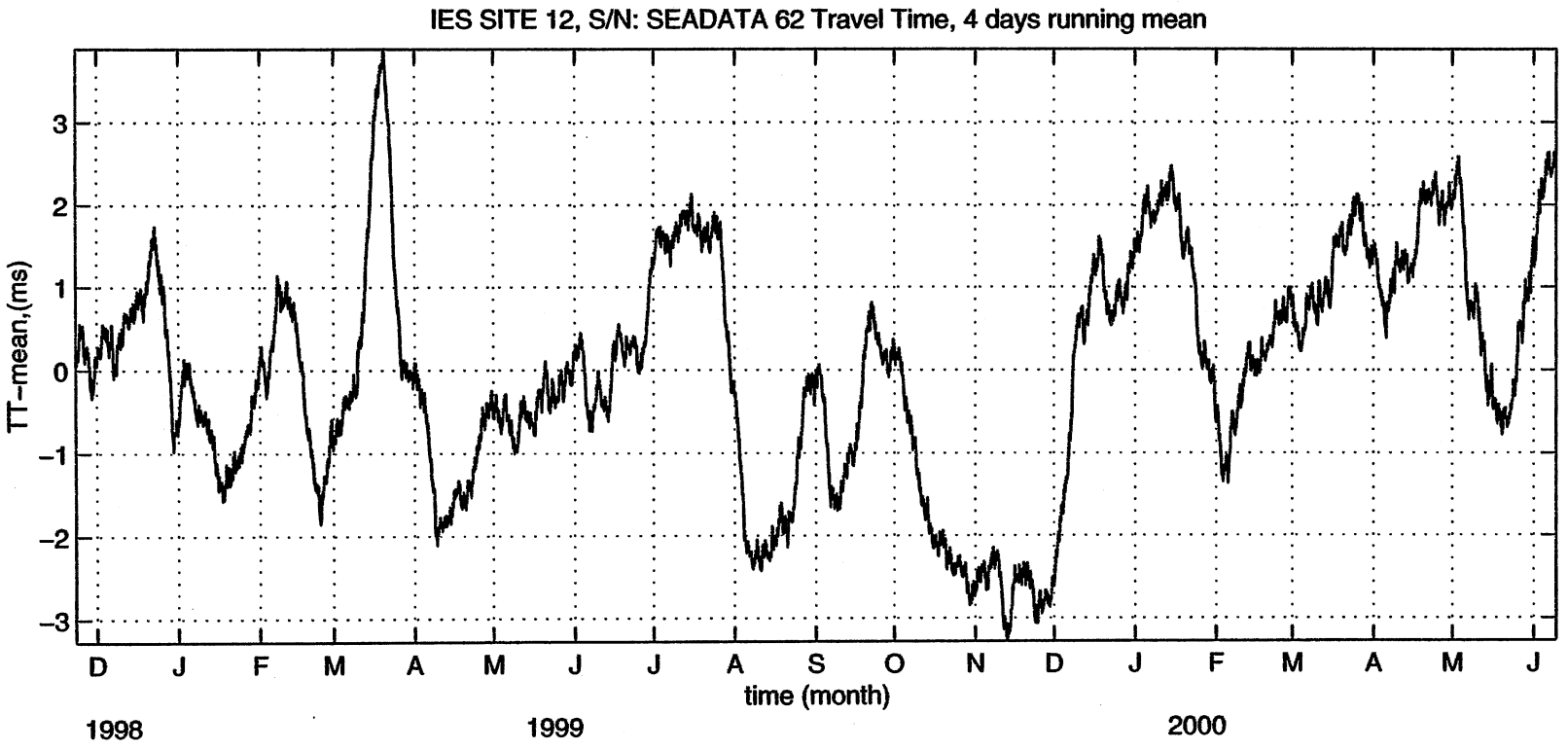
Longitude: 48º19.210 W

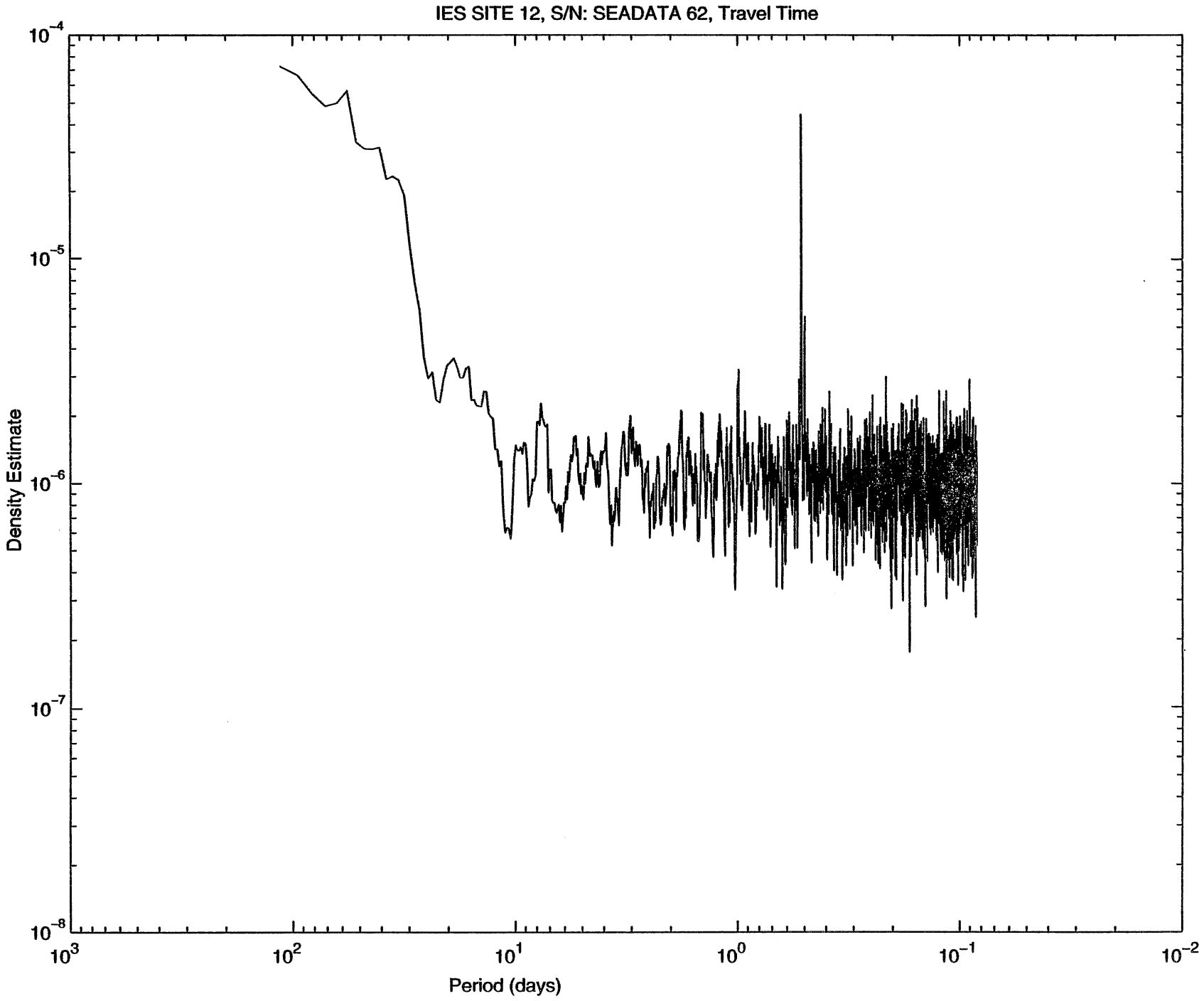
Dept: 3,442m

Start date: Nov. 21, 1998

End date: Jun. 11, 2000


IES SITE 12, S/N: SEADATA 62
Travel Time (seconds)
4.615
4.61
4.605
4.6
4.595
4.59
4.585
4.58
4.575
D J F M A M J J A S O N D J F M A M J
time (month)
1998
1999
2000


IES SITE 12, S/N: SEADATA 62 Travel Time, 4 days running mean
TT-mean,(ms)
3
2
1
0
−1
−2
−3
D
J
F
M
A
M
J
J
A
S
O
N
D
J
F
M
A
M
J
time (month)
1998
1999
2000


IES SITE 12, S/N: SEADATA 62, Travel Time
Density Estimate
Period (days)
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}

IES SITE 13

TRIES S/N 1

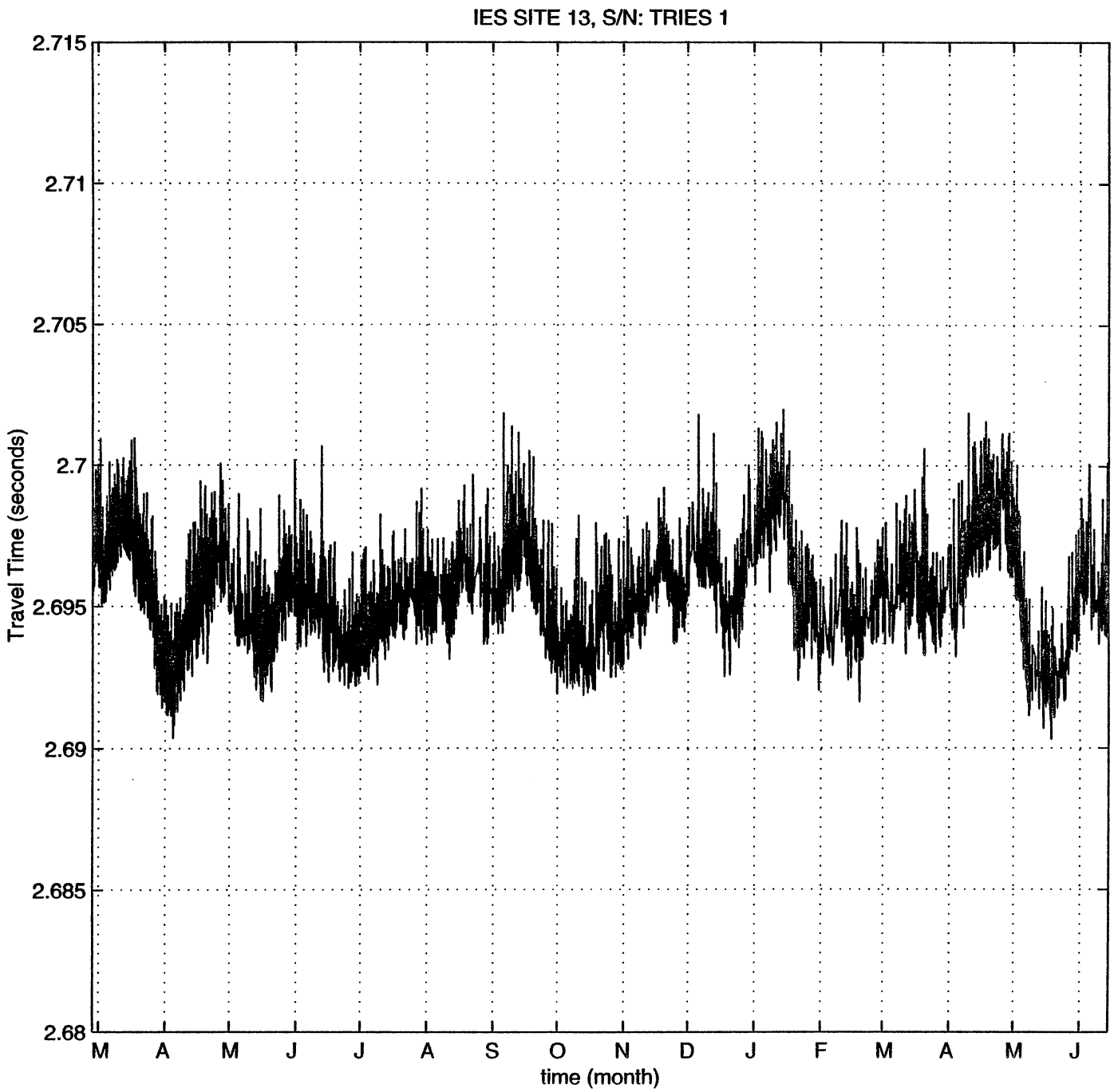
Latitude: 07°47.05 N

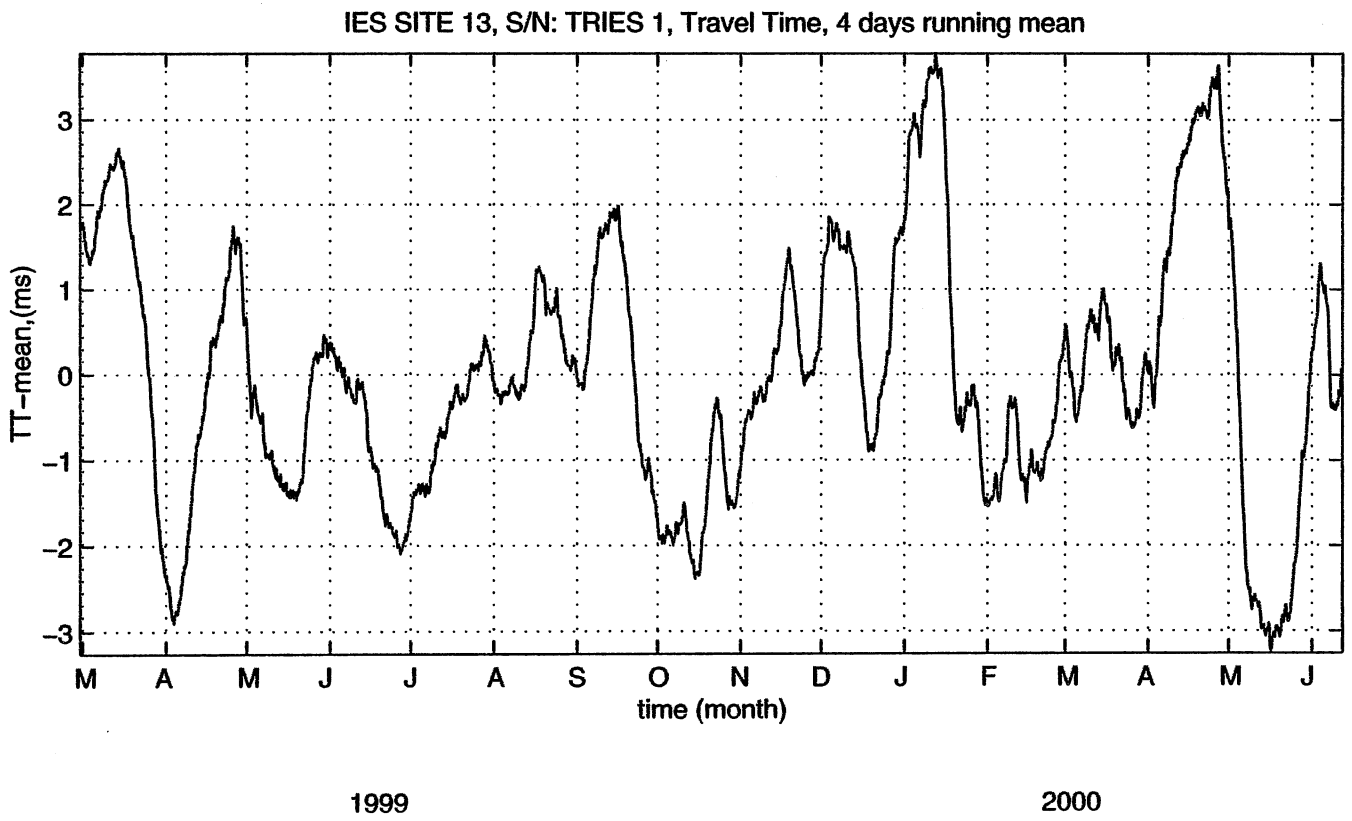
Longitude: 52°34.026 W

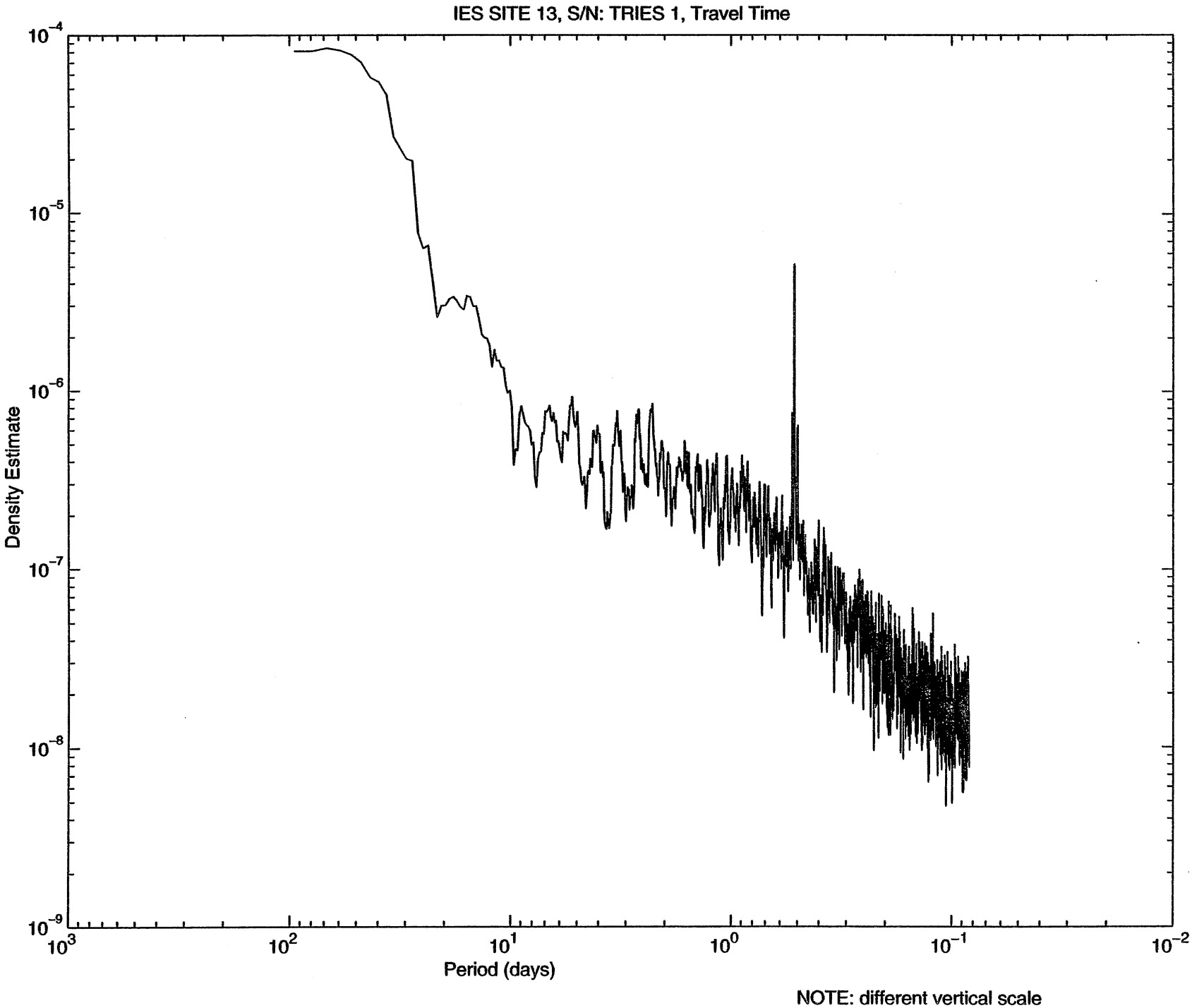
Depth: 2,012 m

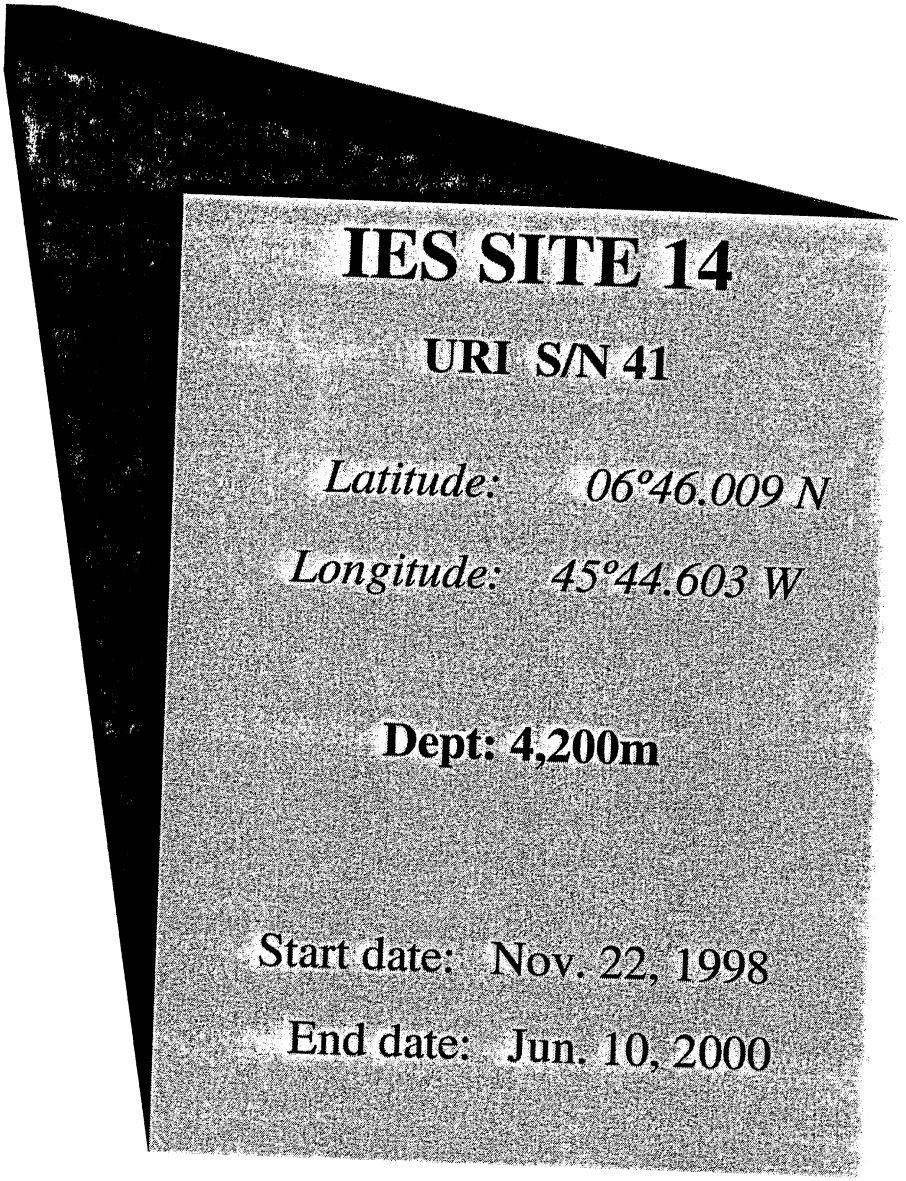
Start date: Feb. 26, 1999

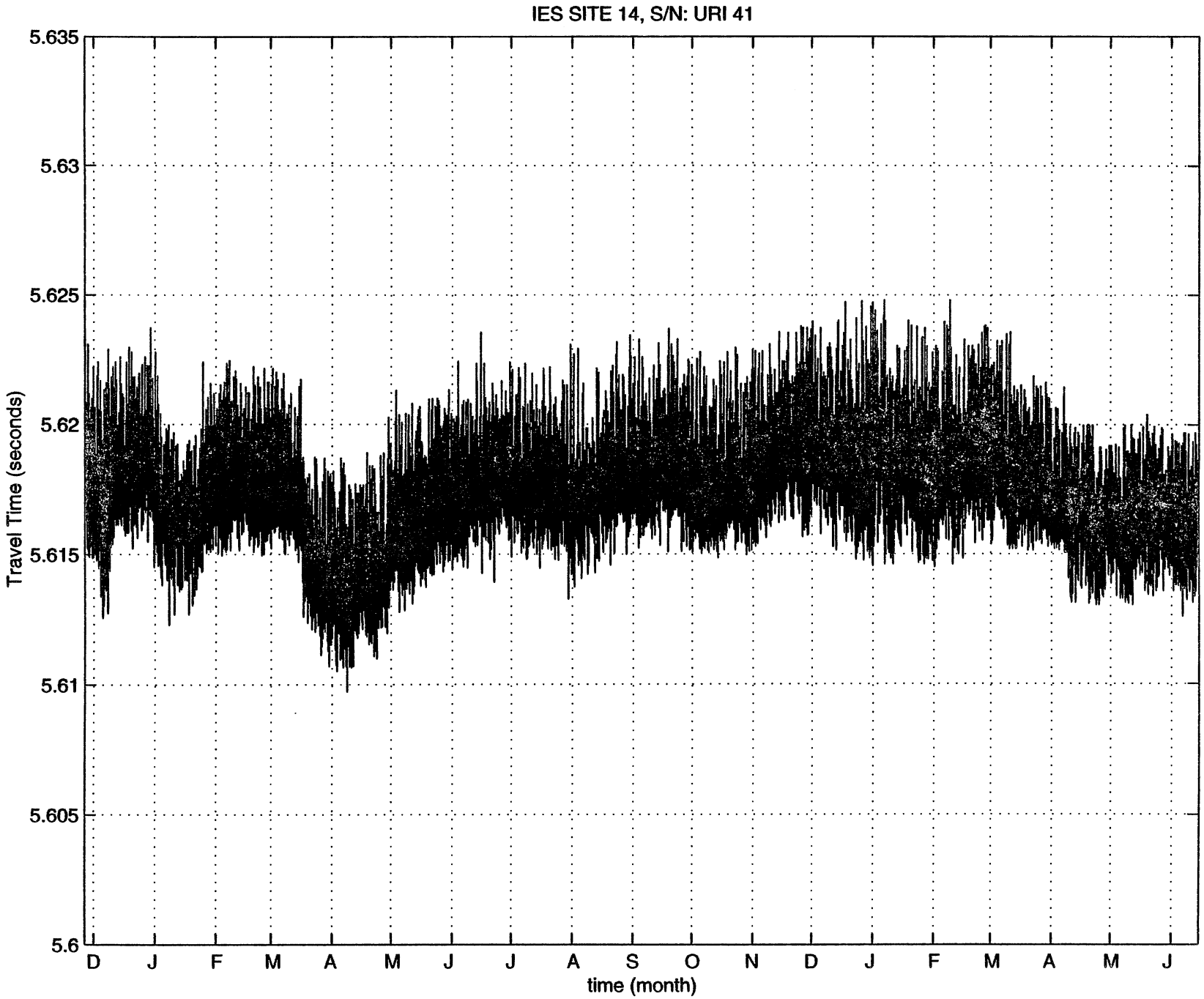
End date: Jun. 14, 2000

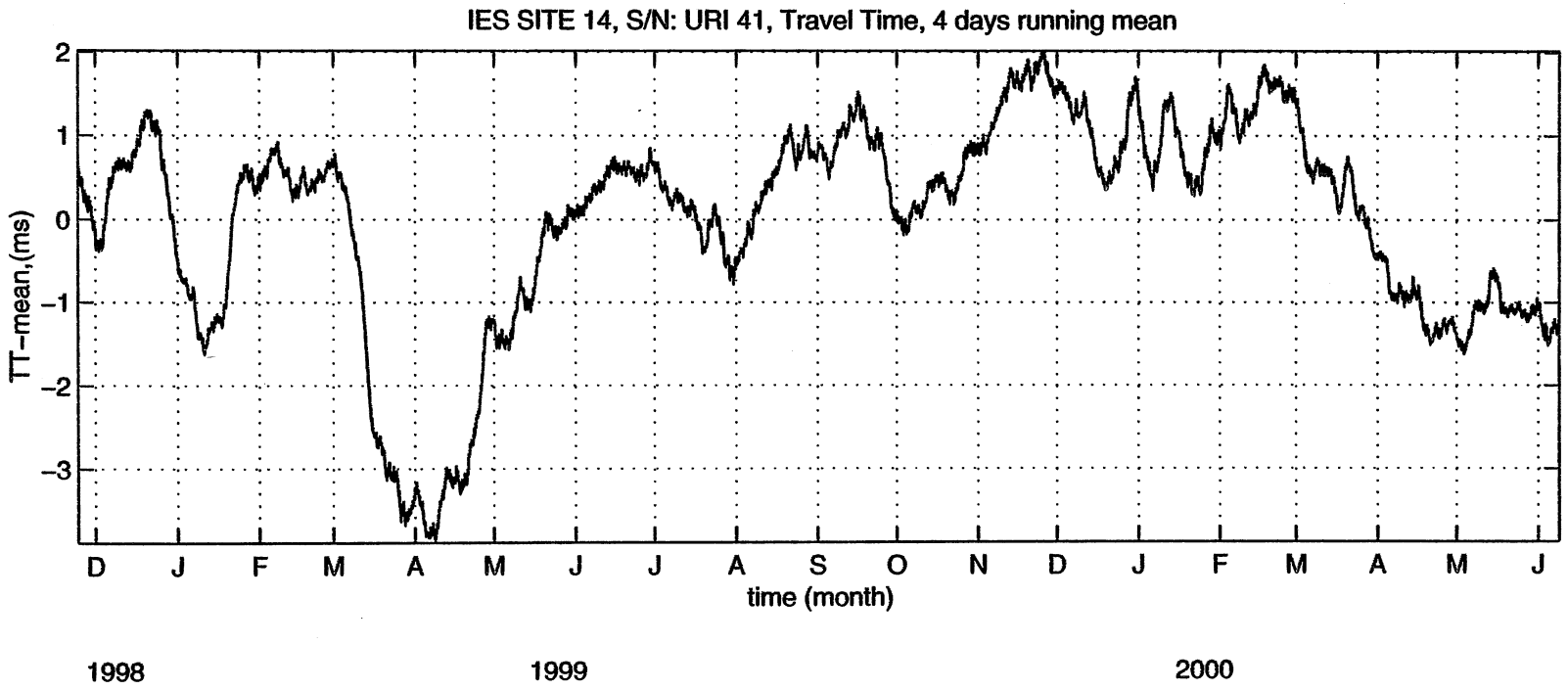

IES SITE 13, S/N: TRIES 1
Travel Time (seconds)
2.715
2.71
2.705
2.7
2.695
2.69
2.685
2.68
M
A
M
J
J
A
S
O
N
D
J
F
M
A
M
J
time (month)

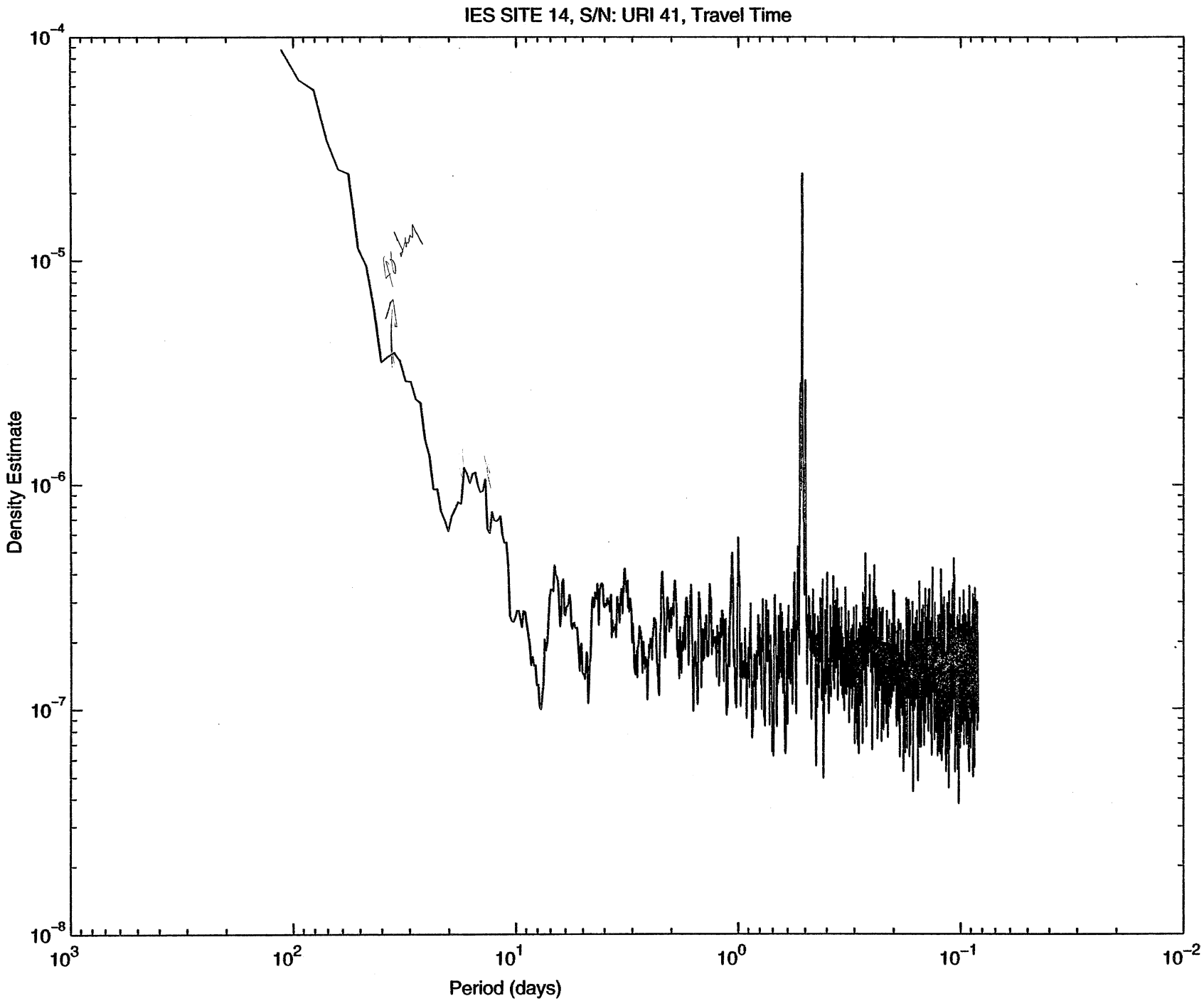

IES SITE 13, S/N: TRIES 1, Travel Time, 4 days running mean
TT−mean,(ms)
3
2
1
0
−1
−2
−3
M
A
M
J
J
A
S
O
N
D
J
F
M
A
M
J
time (month)
1999
2000


IES SITE 13, S/N: TRIES 1, Travel Time
Density Estimate
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
Period (days)
NOTE: different vertical scale


IES SITE 14
URI S/N 41
Latitude: 06°46.009 N
Longitude: 45°44.603 W
Dept: 4,200m
Start date: Nov. 22, 1998
End date: Jun. 10, 2000


IES SITE 14, S/N: URI 41
Travel Time (seconds)
5.635
5.63
5.625
5.62
5.615
5.61
5.605
5.6
D
J
F
M
A
M
J
J
A
S
O
N
D
J
F
M
A
M
J
time (month)


IES SITE 14, S/N: URI 41, Travel Time, 4 days running mean
TT−mean,(ms)
2
1
0
−1
−2
−3
D
J
F
M
A
M
J
J
A
S
O
N
D
J
F
M
A
M
J
time (month)
1998
1999
2000


IES SITE 14, S/N: URI 41, Travel Time
Density Estimate
Period (days)
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}

IES SITE 16

Sea Data S/N 50

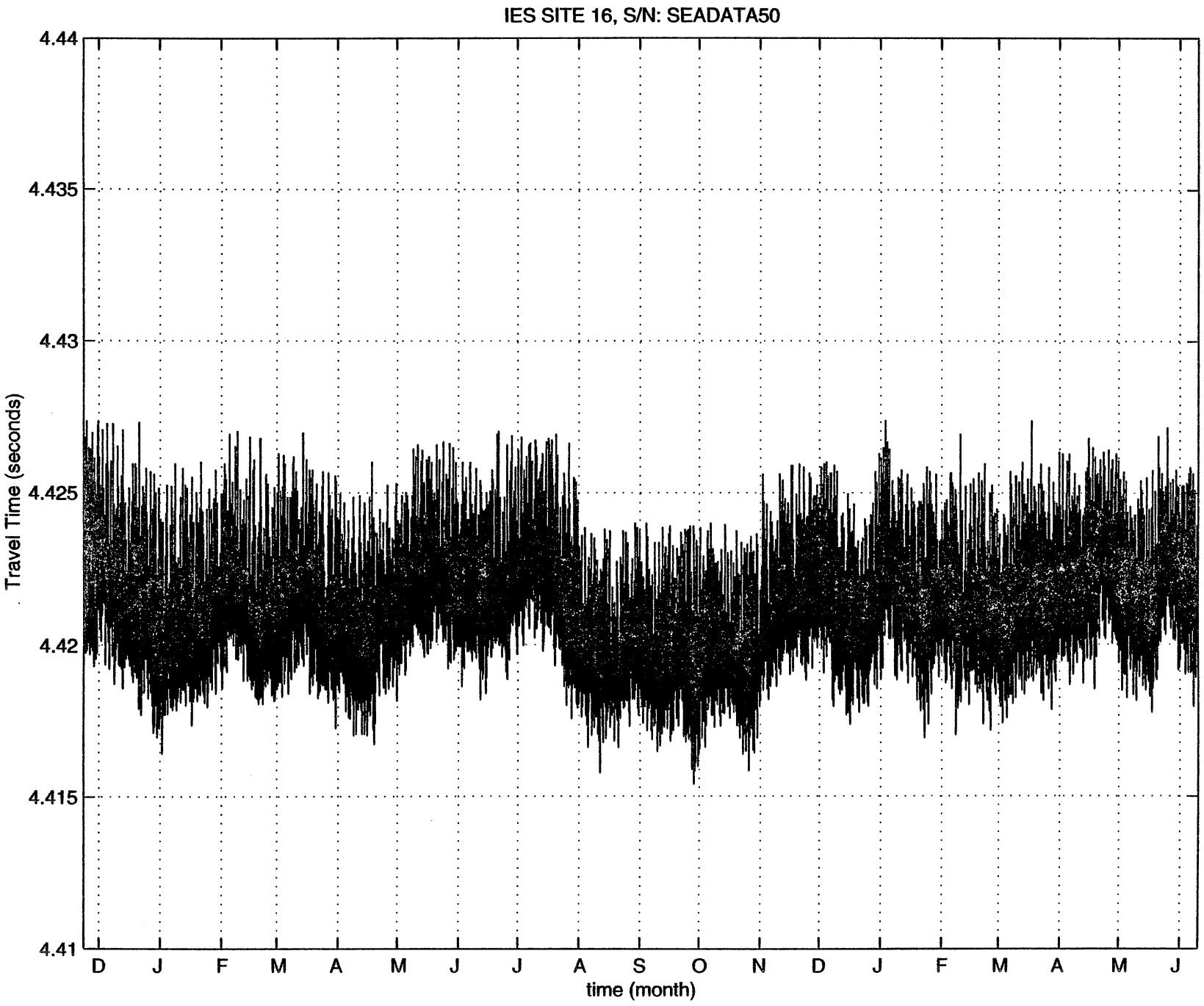
Latitude: 04°24.890 N

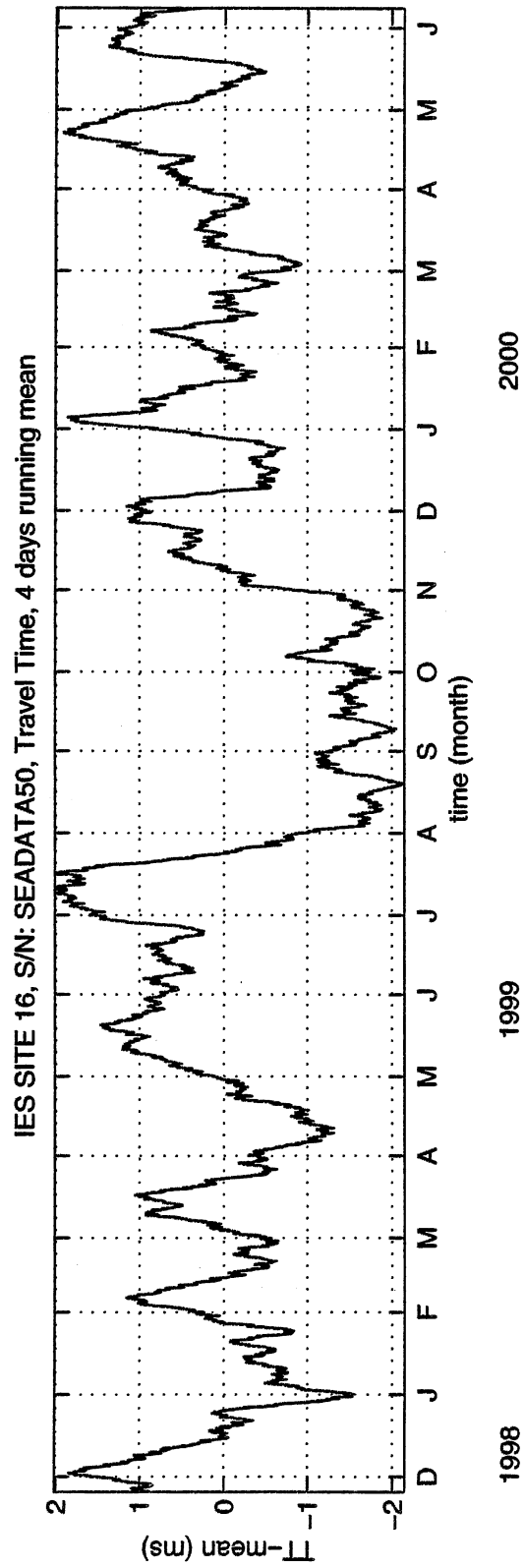
Longitude: 46°391.185 W

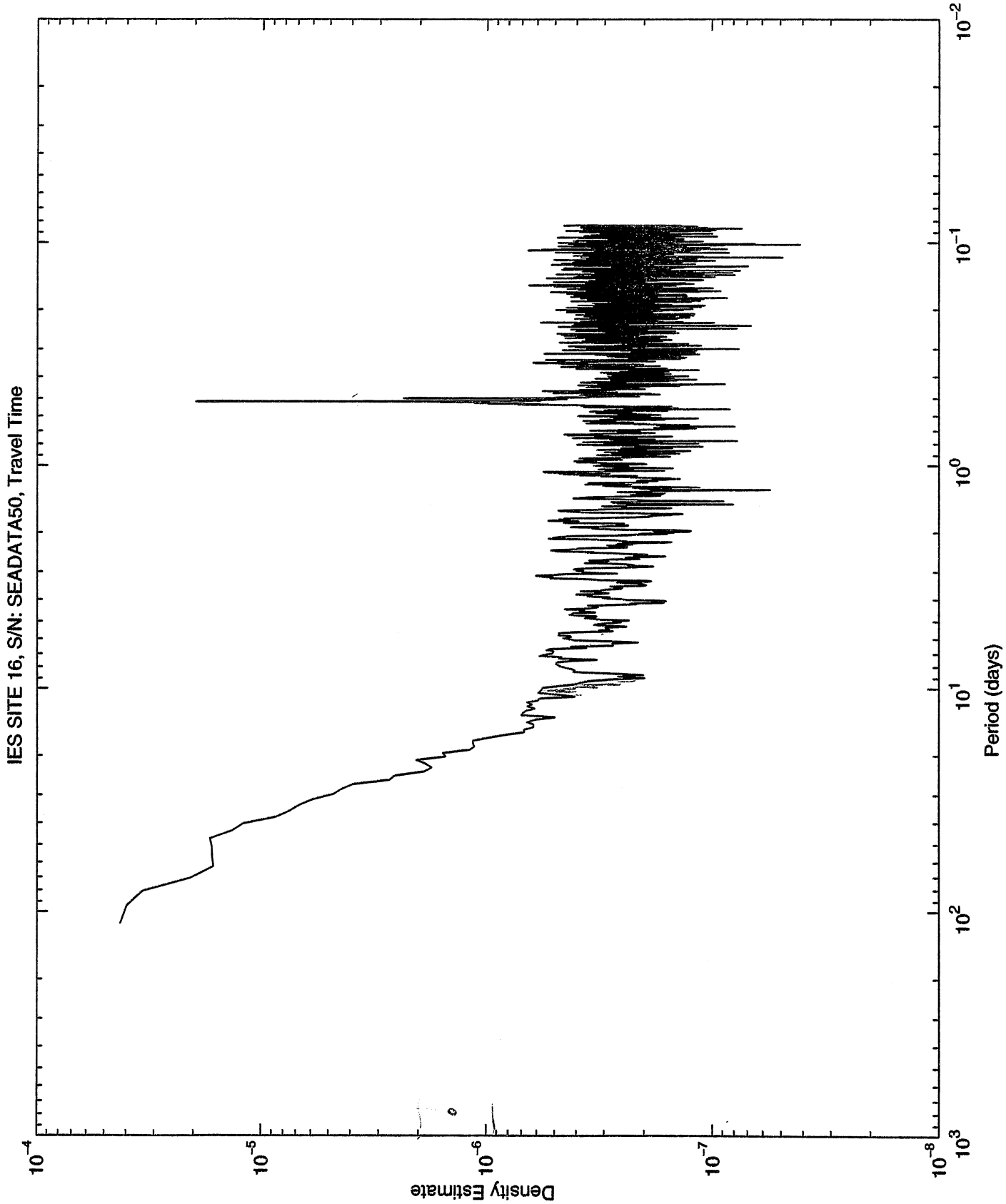
Dept: 3,273m

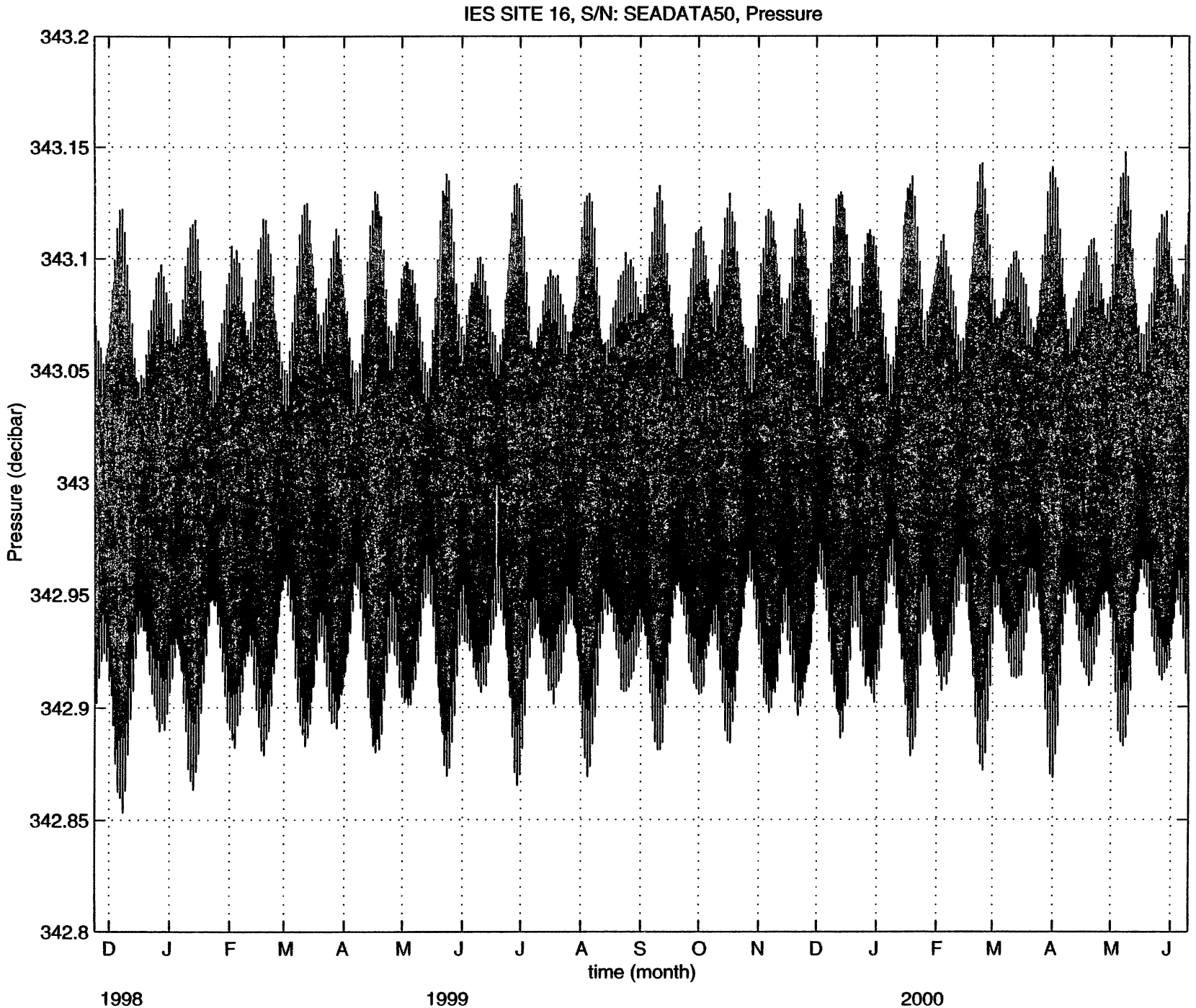
Start date: Nov. 23, 1998

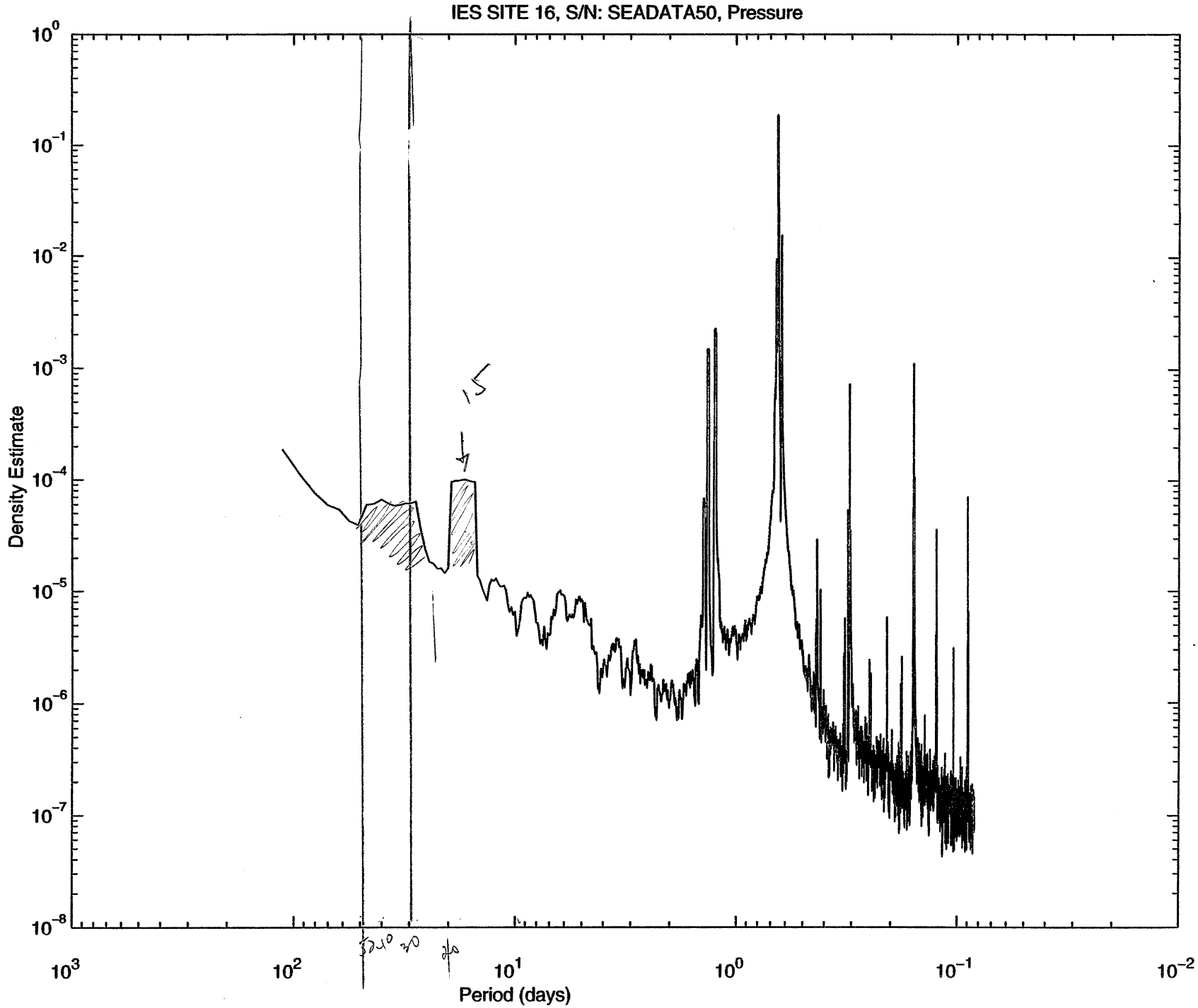
End date: Jun. 10, 2000

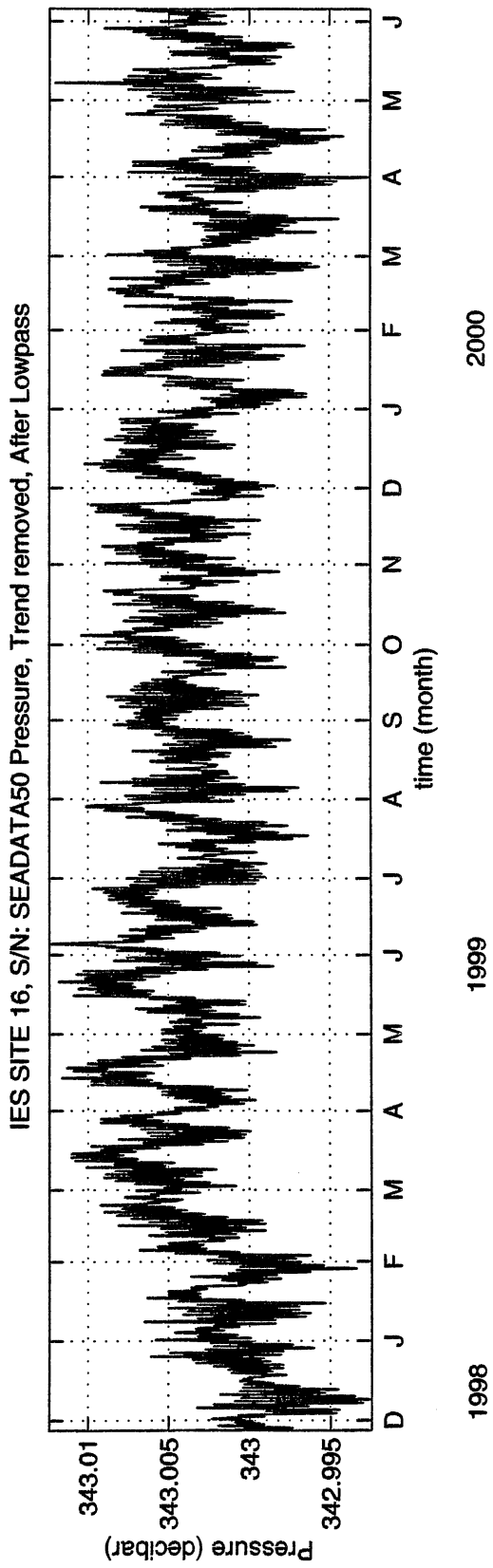

IES SITE 16, S/N: SEADATA50
4.44
4.435
4.43
4.425
4.42
4.415
4.41
Travel Time (seconds)
D J F M A M J J A S O N D J F M A M J
time (month)
1998
1999
2000

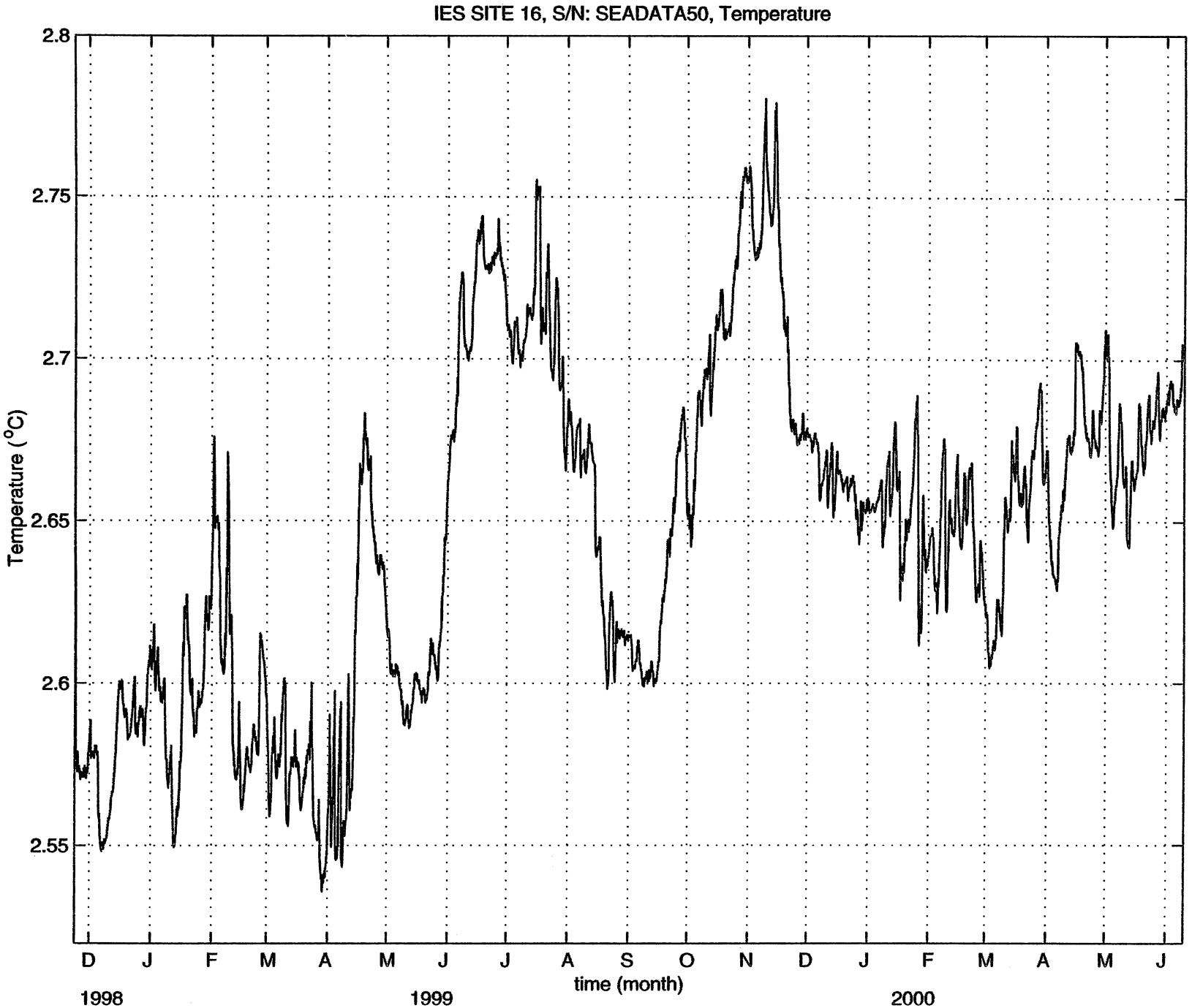

IES SITE 16, S/N: SEADATA50, Travel Time, 4 days running mean
TT-mean (ms)
2
1
0
−1
−2
D J F M A M J J A S O N D J F M A M J
1998
1999
2000
time (month)

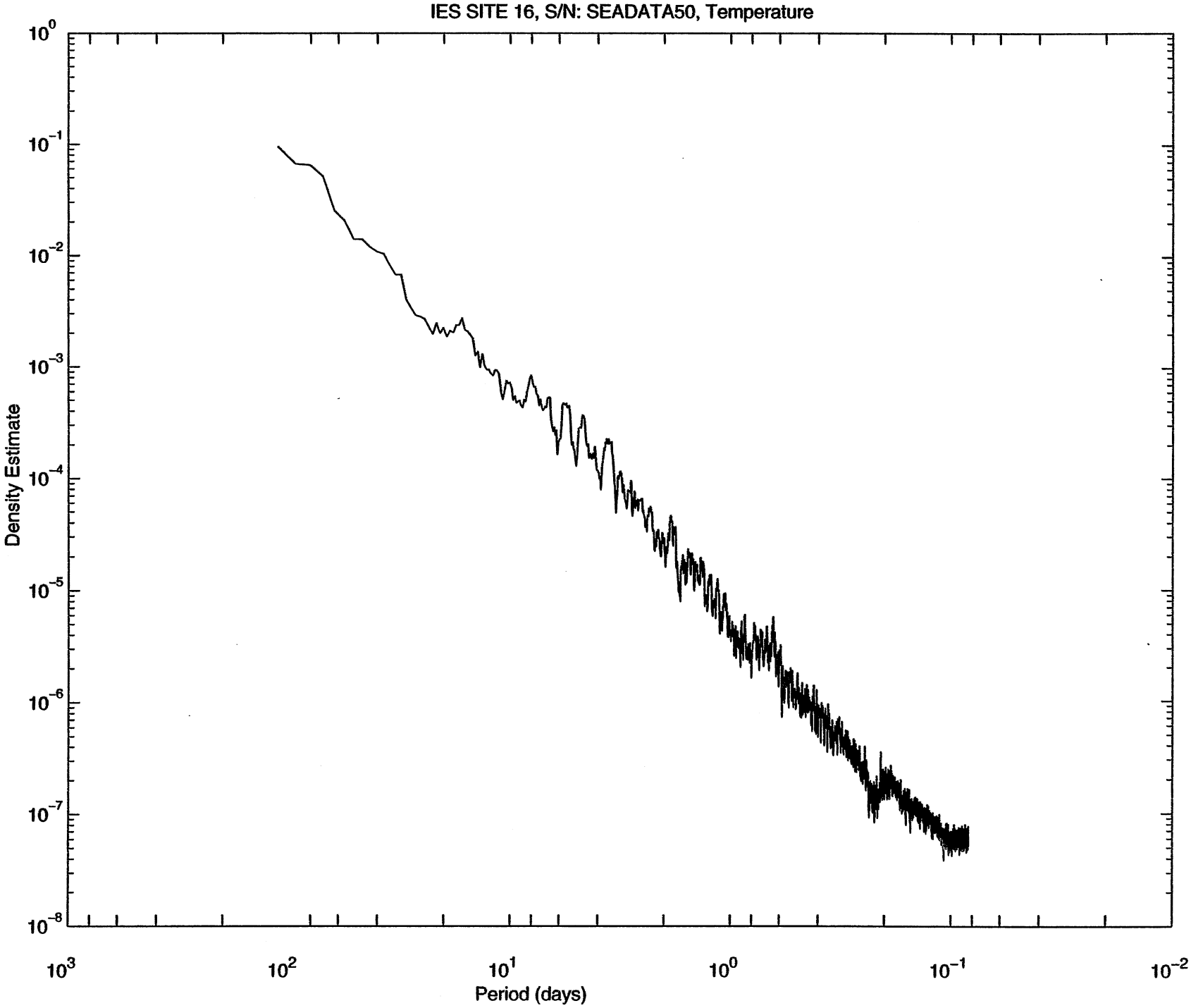

IES SITE 16, S/N: SEADATA50, Travel Time
Density Estimate
Period (days)
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}


IES SITE 16, S/N: SEADATA50, Pressure
343.2
343.15
343.1
343.05
343
342.95
342.9
342.85
342.8
Pressure (decibar)
D J F M A M J J A S O N D J F M A M J
time (month)
1998
1999
2000


IES SITE 16, S/N: SEADATA50, Pressure
Density Estimate
Period (days)
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}


IES SITE 16, S/N: SEADATA50 Pressure, Trend removed, After Lowpass
Pressure (decibar)
343.01
343.005
343
342.995
D J F M A M J J A S O N D J F M A M J
1998
1999
2000
time (month)


IES SITE 16, S/N: SEADATA50, Temperature
Temperature (°C)
2.8
2.75
2.7
2.65
2.6
2.55
D J F M A M J J A S O N D J F M A M J
1998
1999
2000
time (month)


IES SITE 16, S/N: SEADATA50, Temperature
Density Estimate
Period (days)
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}

IES SITE 17

ElChipo S/N 1

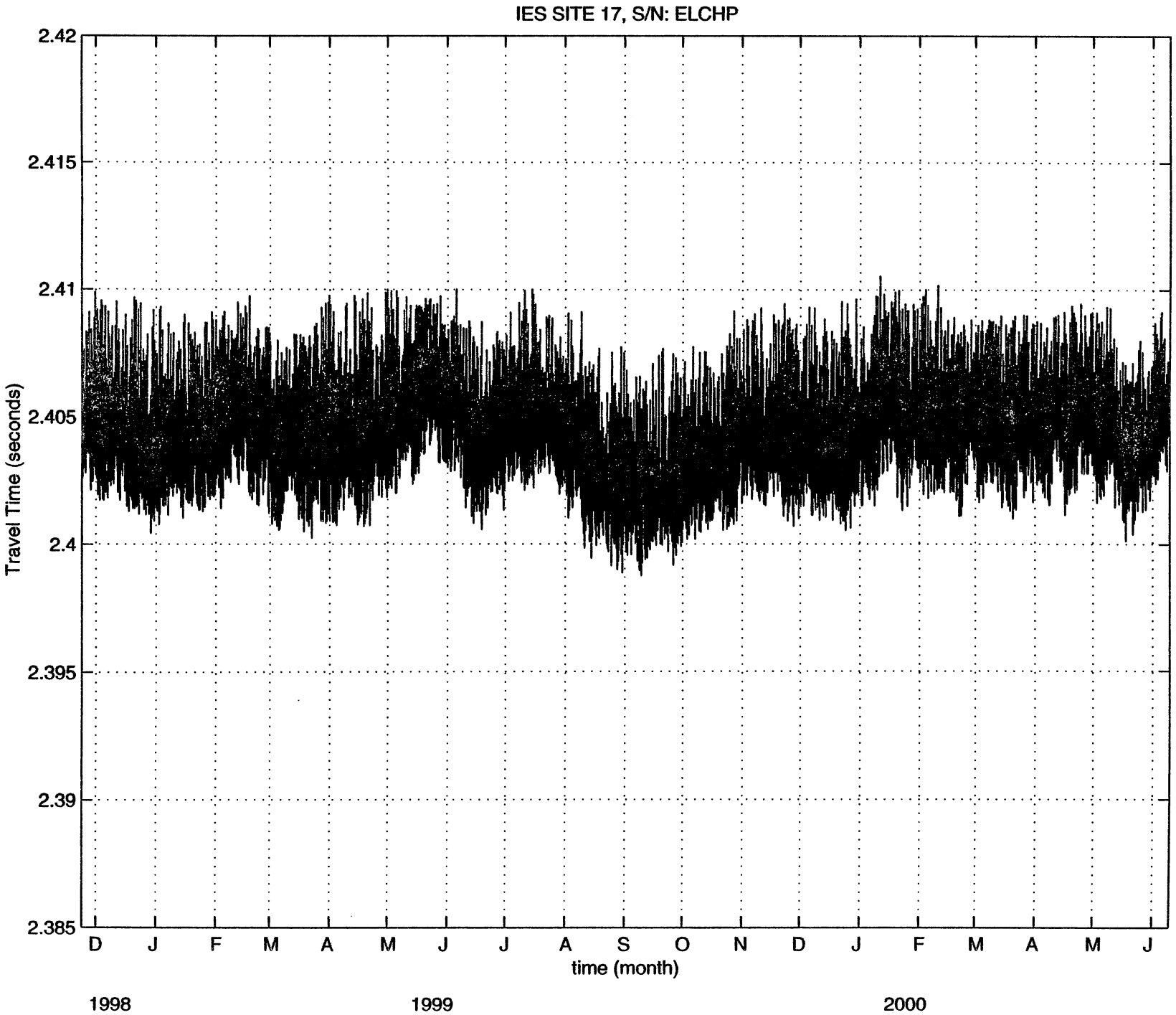
Latitude: *03º04.703 N*

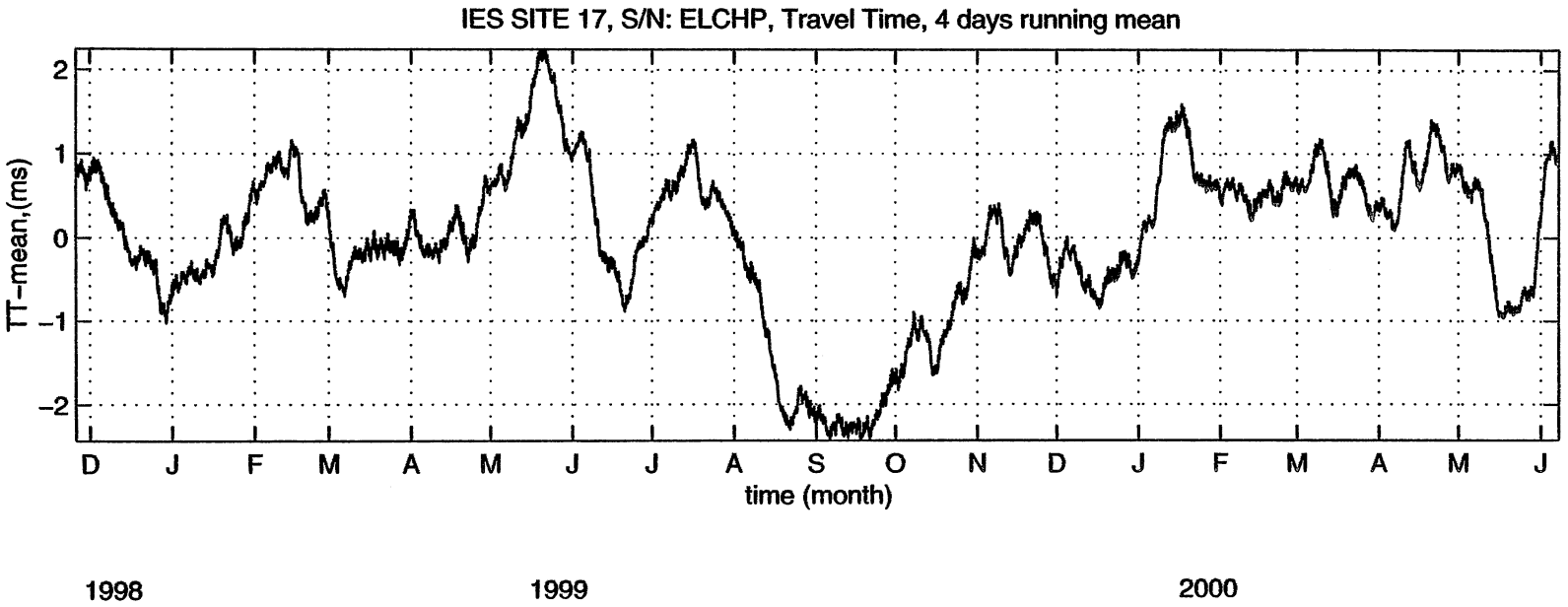
Longitude: *47º09.045 W*

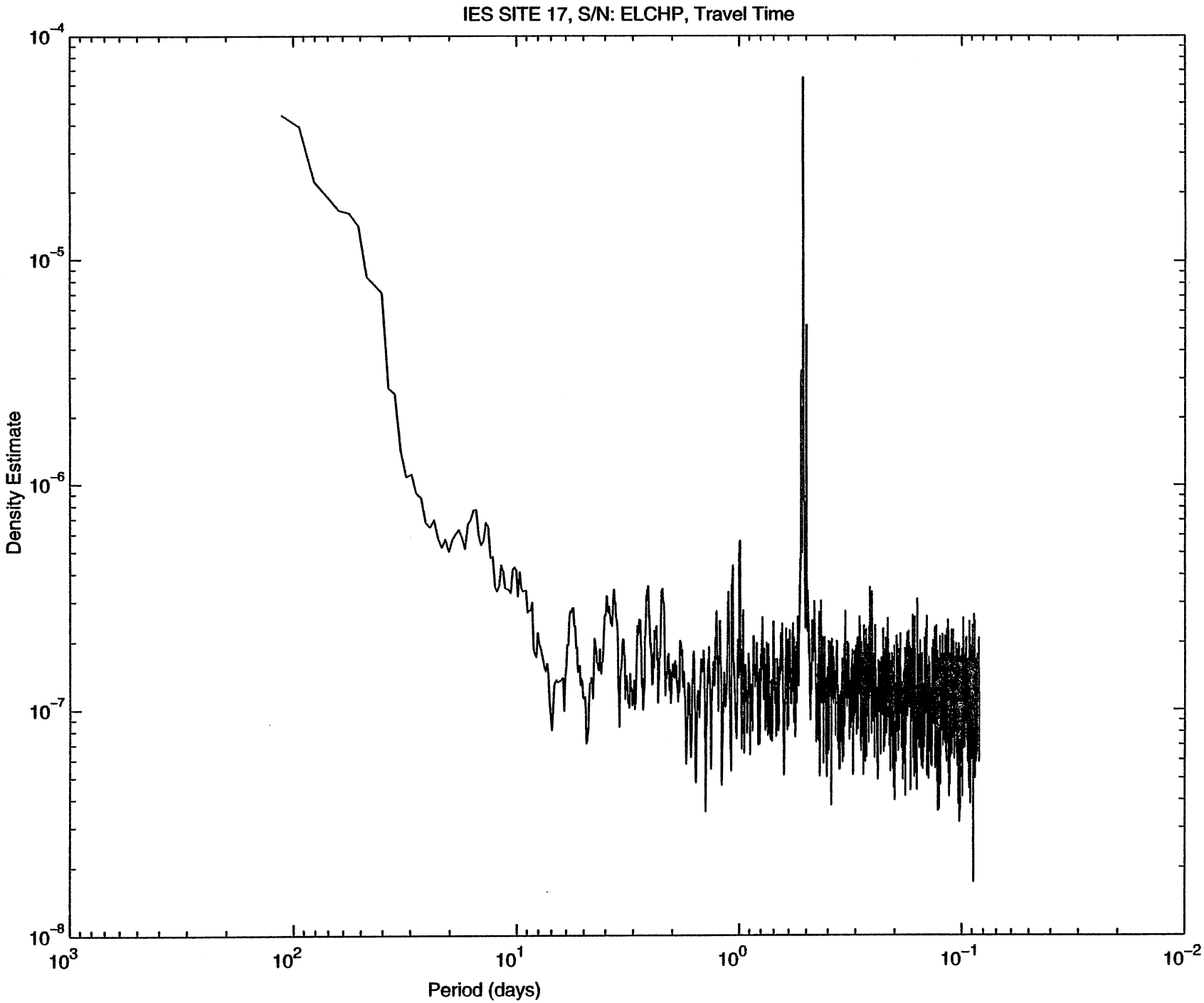
Dept: 1,802m

Start date: Nov. 23, 1998

End date: Jun. 09, 2000


IES SITE 17, S/N: ELCHP
2.42
2.415
2.41
2.405
2.4
2.395
2.39
2.385
Travel Time (seconds)
D J F M A M J J A S O N D J F M A M J
time (month)
1998
1999
2000


IES SITE 17, S/N: ELCHP, Travel Time, 4 days running mean
TT-mean,(ms)
2
1
0
−1
−2
D
J
F
M
A
M
J
J
A
S
O
N
D
J
F
M
A
M
J
time (month)
1998
1999
2000


IES SITE 17, S/N: ELCHP, Travel Time
Density Estimate
Period (days)
10^-4
10^-5
10^-6
10^-7
10^-8
10^3
10^2
10^1
10^0
10^-1
10^-2

Appendix 2

CMM 1

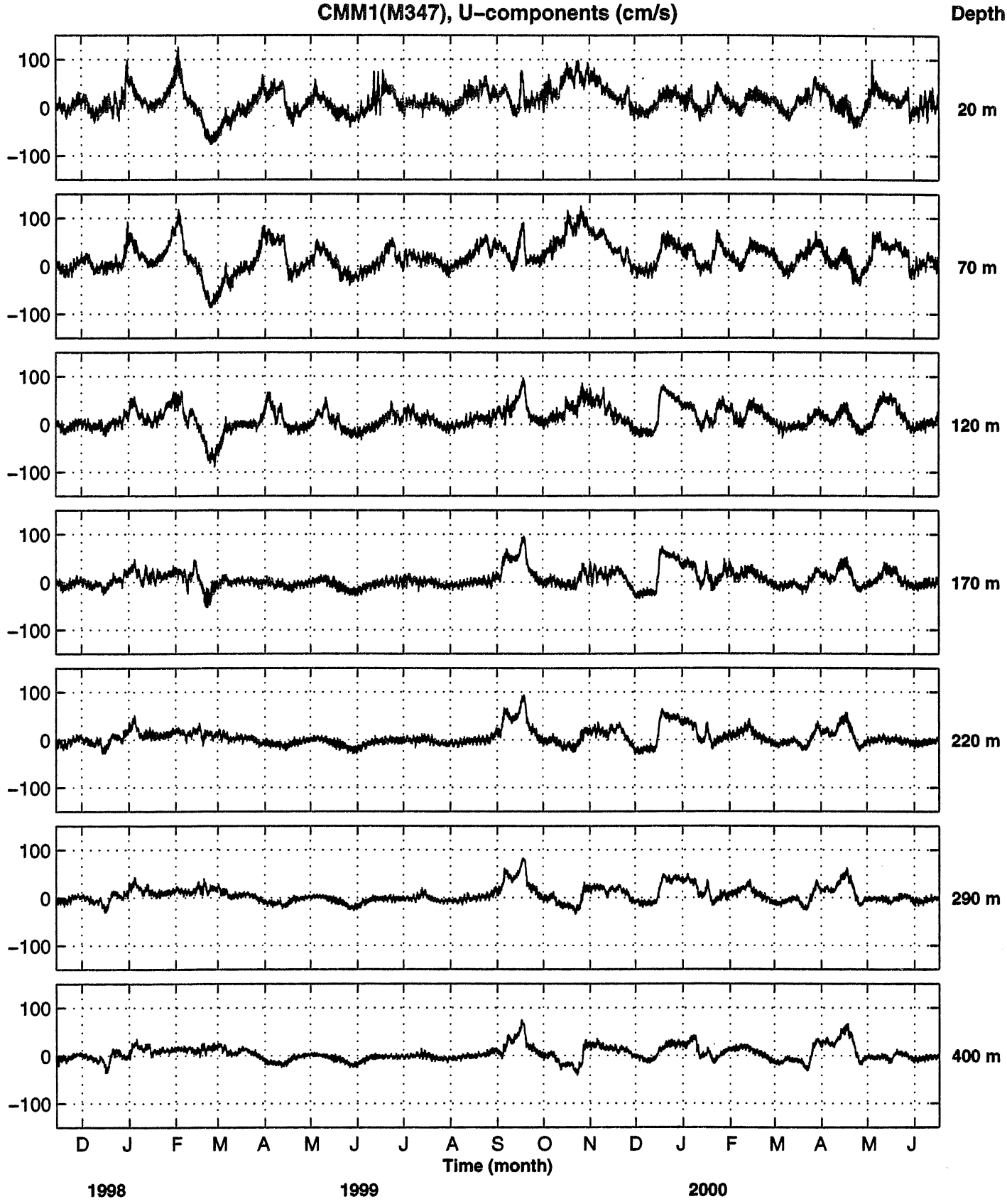
M347

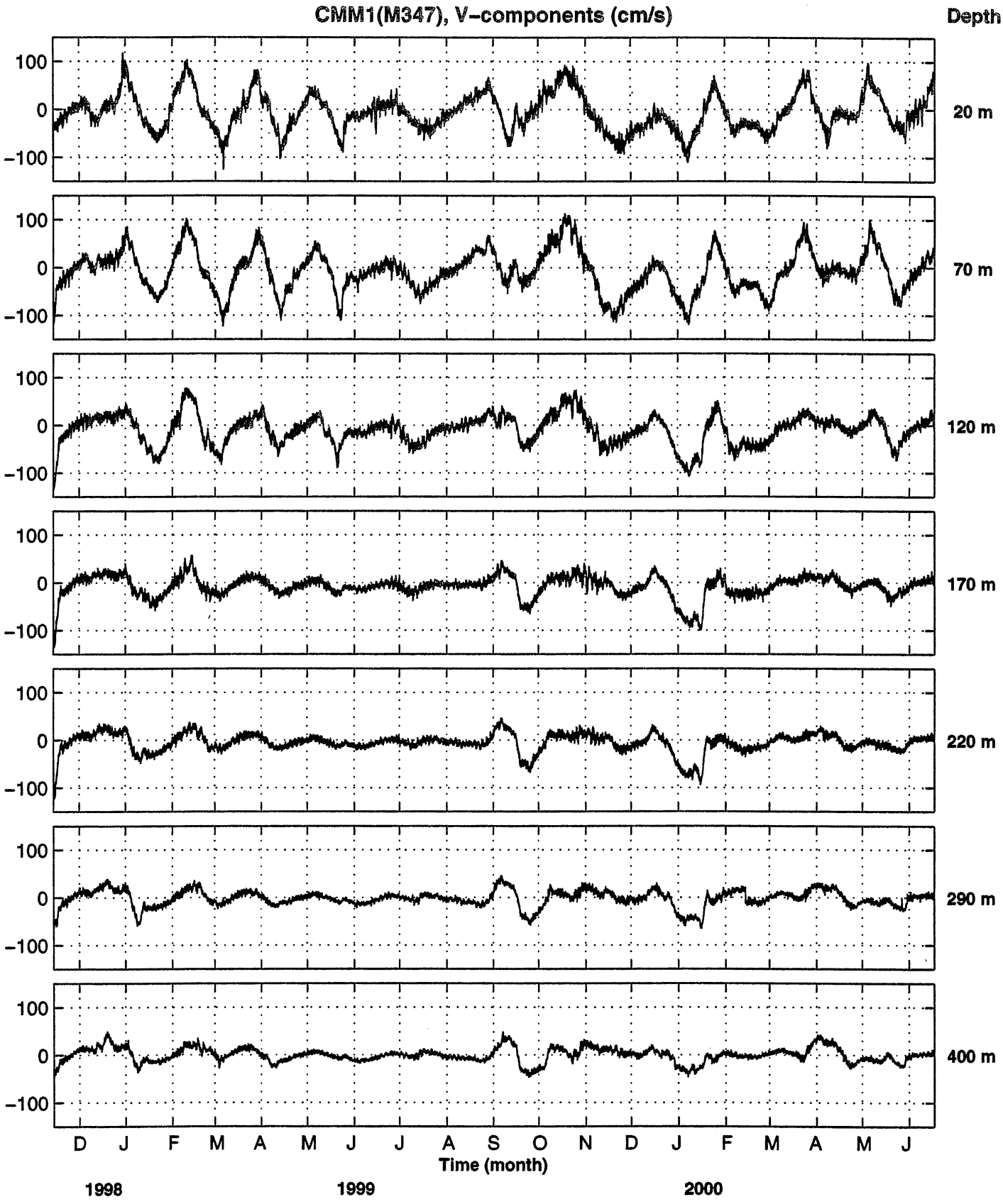
Latitude: *08°59.50 N*

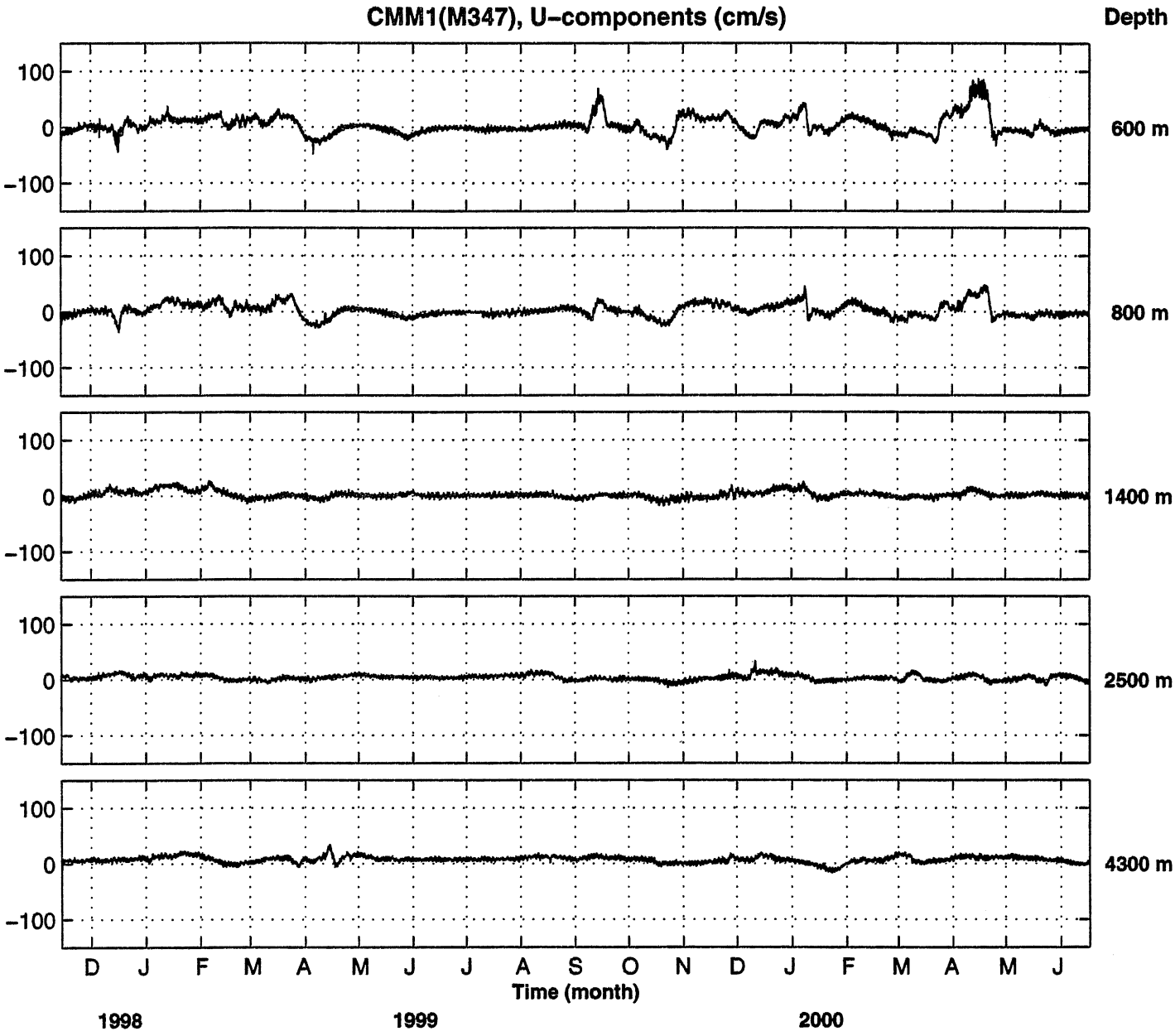
Longitude: *52°44.00 W*

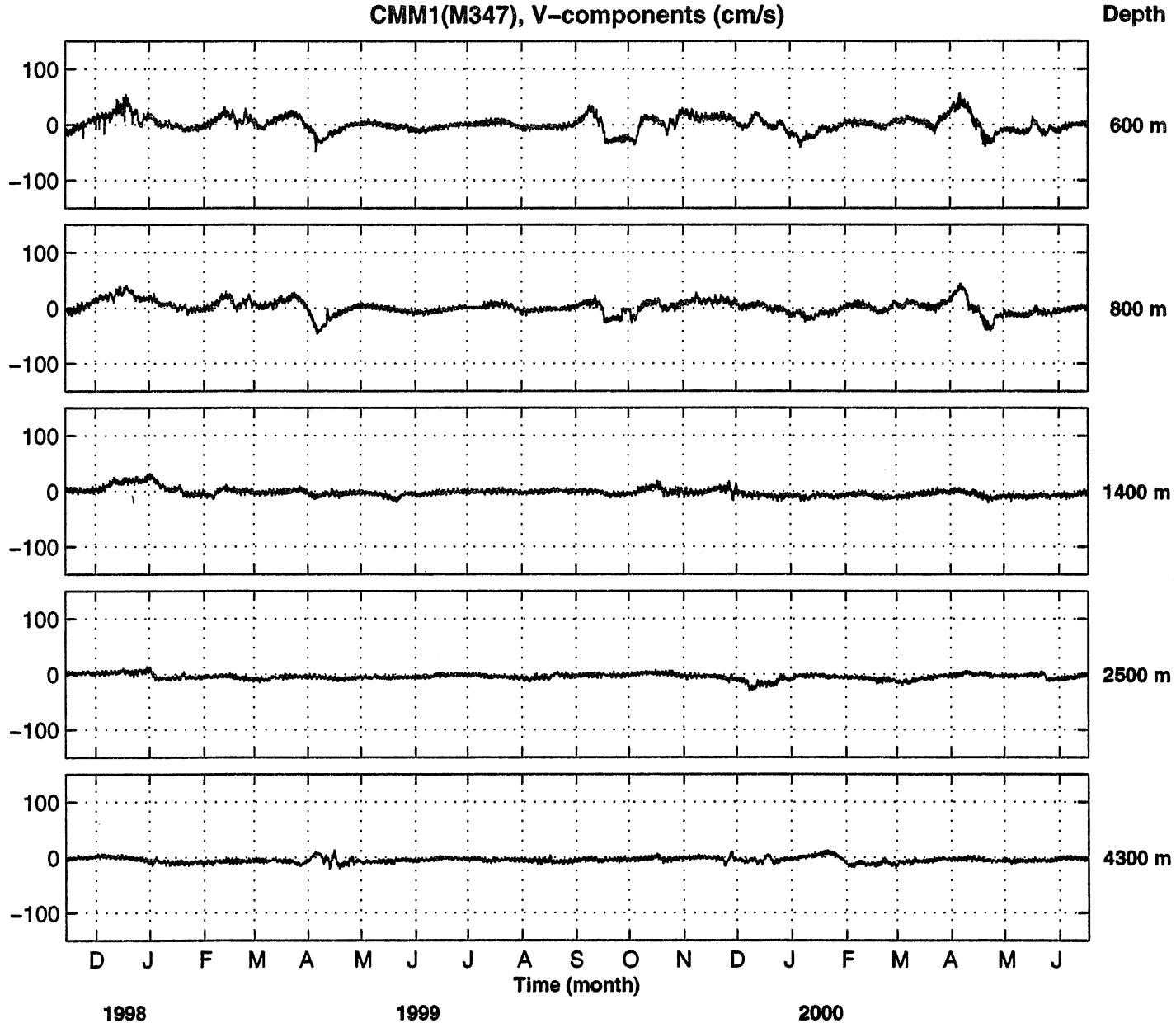
Start date: Nov. 13, 1998

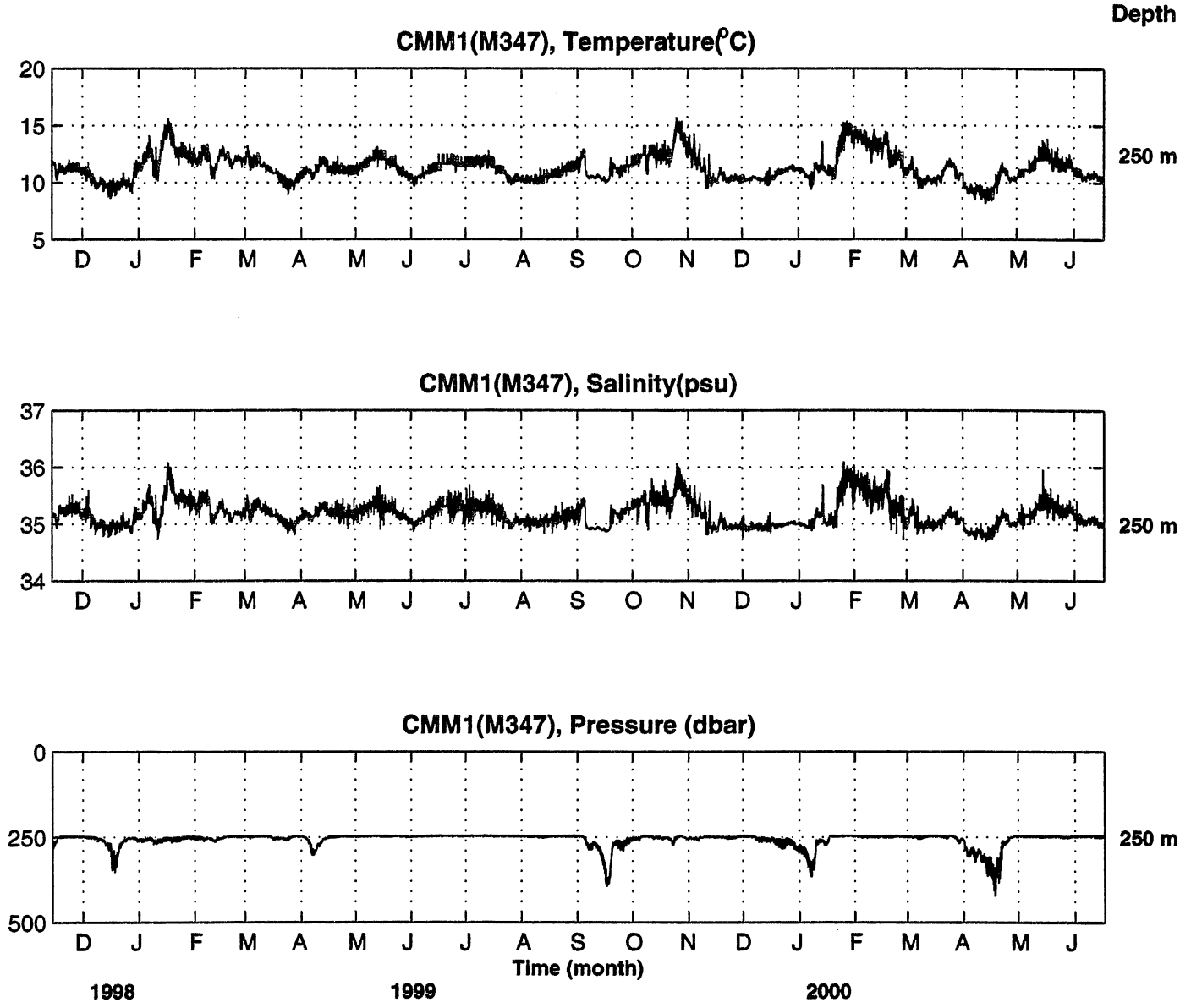
End date: Jun. 17, 2000

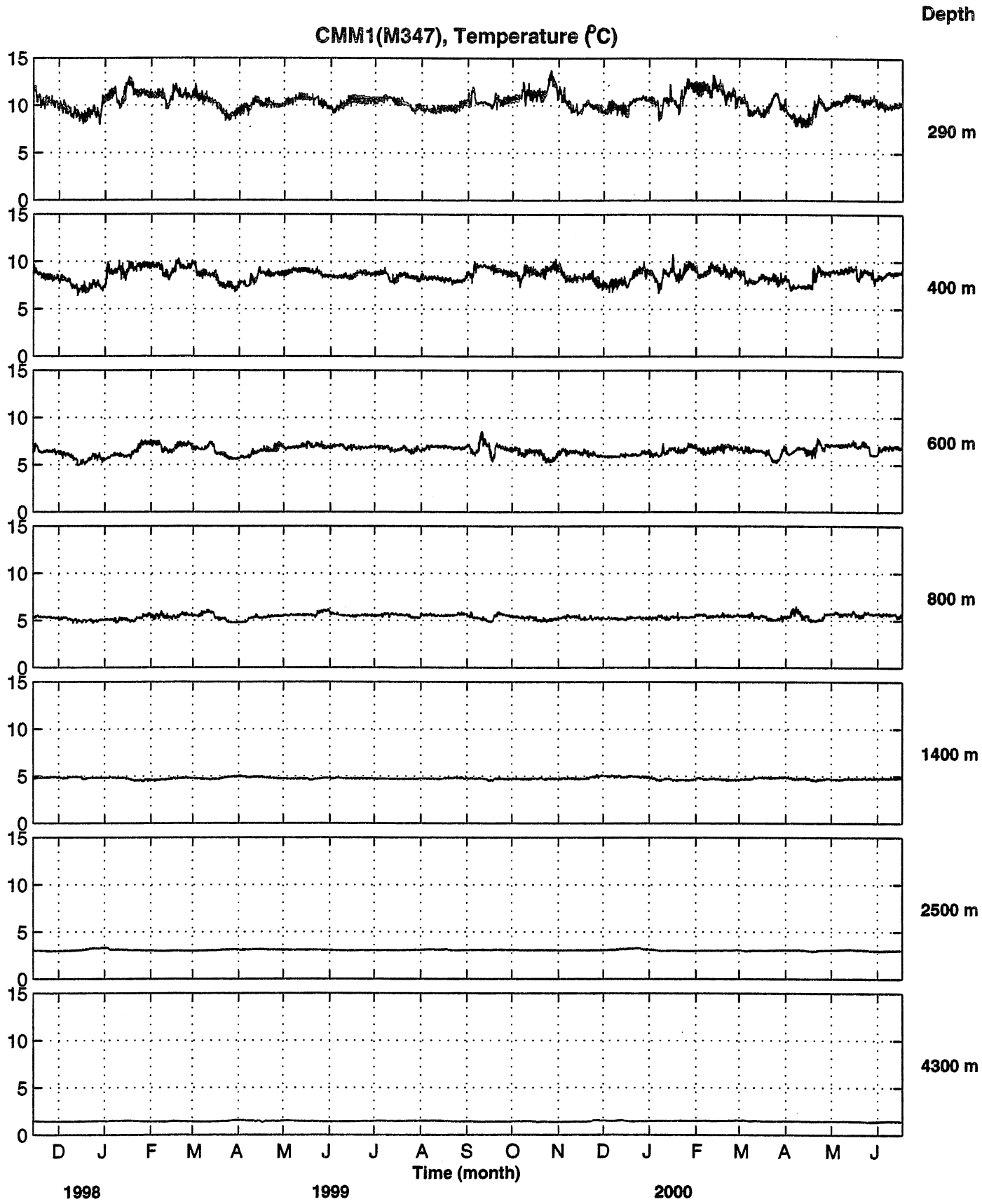

CMM1(M347), U-components (cm/s)
Depth
100
0
−100
20 m
70 m
120 m
170 m
220 m
290 m
400 m
D J F M A M J J A S O N D J F M A M J
Time (month)
1998
1999
2000


CMM1(M347), V-components (cm/s)
Depth
100
0
−100
20 m
70 m
120 m
170 m
220 m
290 m
400 m
D J F M A M J J A S O N D J F M A M J
Time (month)
1998
1999
2000


CMM1(M347), U-components (cm/s)
Depth
100
0
-100
600 m
800 m
1400 m
2500 m
4300 m
D J F M A M J J A S O N D J F M A M J
Time (month)
1998
1999
2000


CMM1(M347), V-components (cm/s)
Depth
100
0
−100
600 m
800 m
1400 m
2500 m
4300 m
D J F M A M J J A S O N D J F M A M J
Time (month)
1998
1999
2000


Depth
CMM1(M347), Temperature(°C)
20
15
10
5
250 m
D J F M A M J J A S O N D J F M A M J
CMM1(M347), Salinity(psu)
37
36
35
34
250 m
D J F M A M J J A S O N D J F M A M J
CMM1(M347), Pressure (dbar)
0
250
500
250 m
D J F M A M J J A S O N D J F M A M J
Time (month)
1998
1999
2000


CMM1(M347), Temperature (°C)
Depth
290 m
400 m
600 m
800 m
1400 m
2500 m
4300 m
15
10
5
0
D J F M A M J J A S O N D J F M A M J
Time (month)
1998
1999
2000

CMM 2

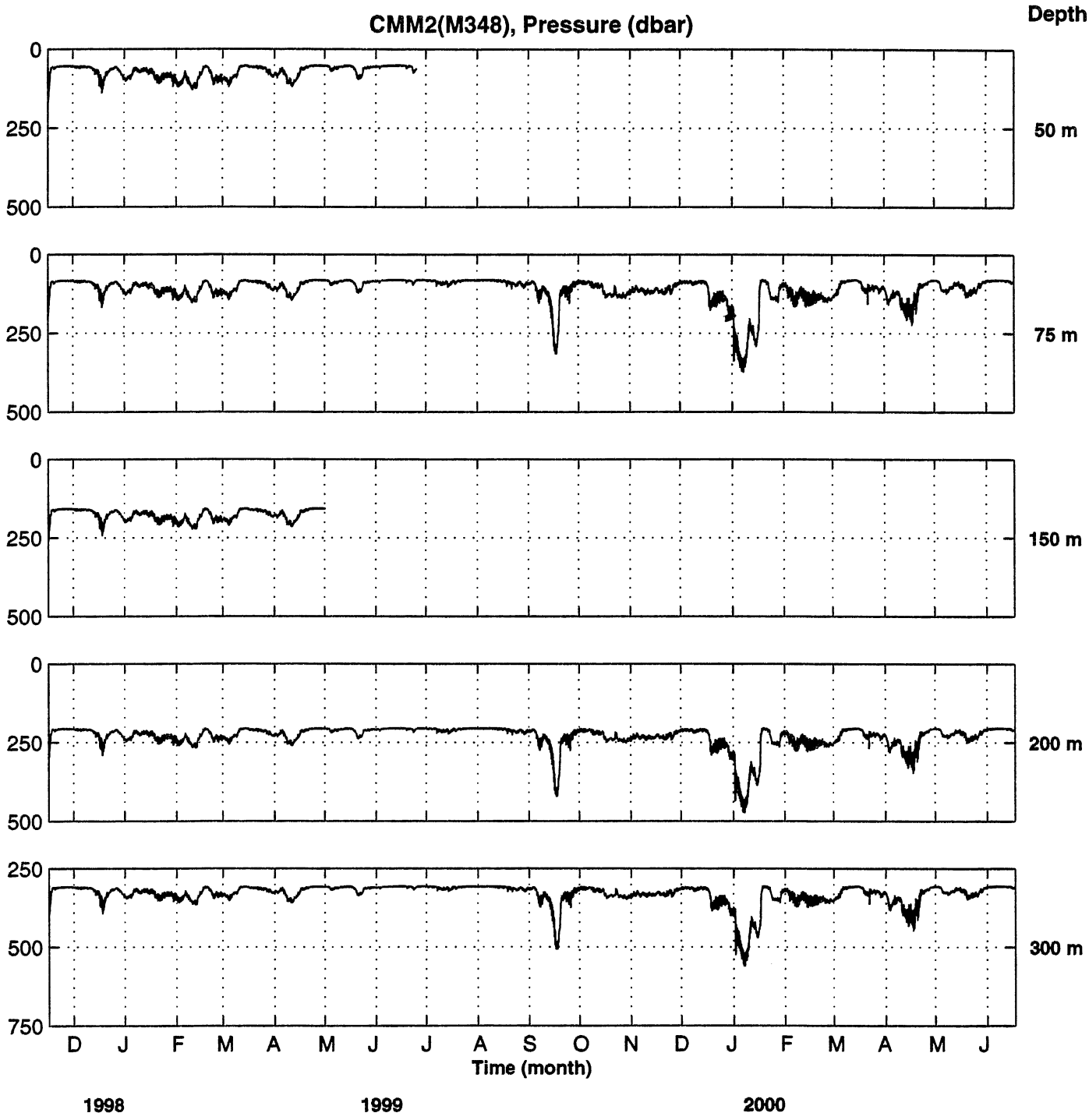
M348

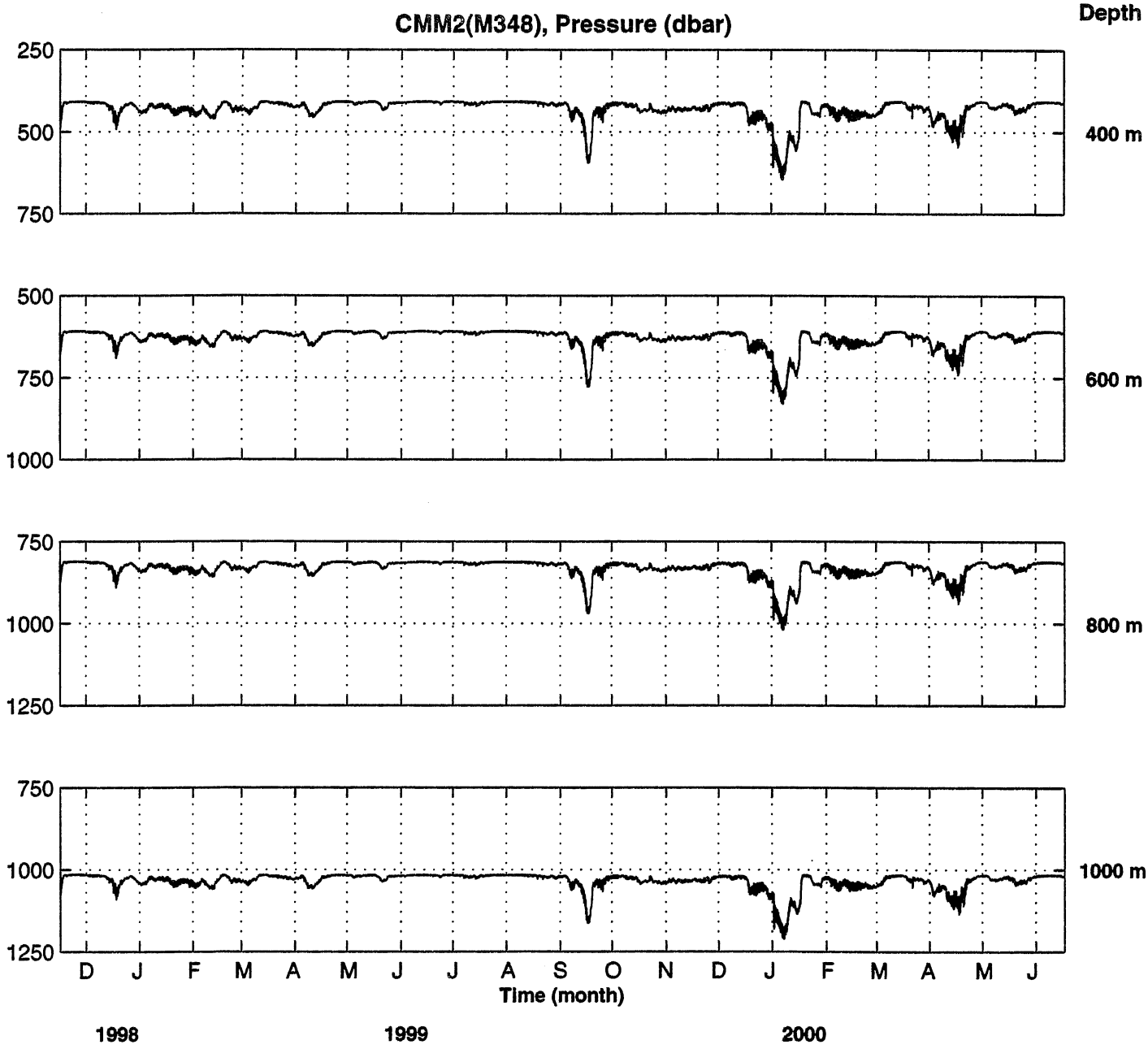
Latitude: *09°00.80 N*

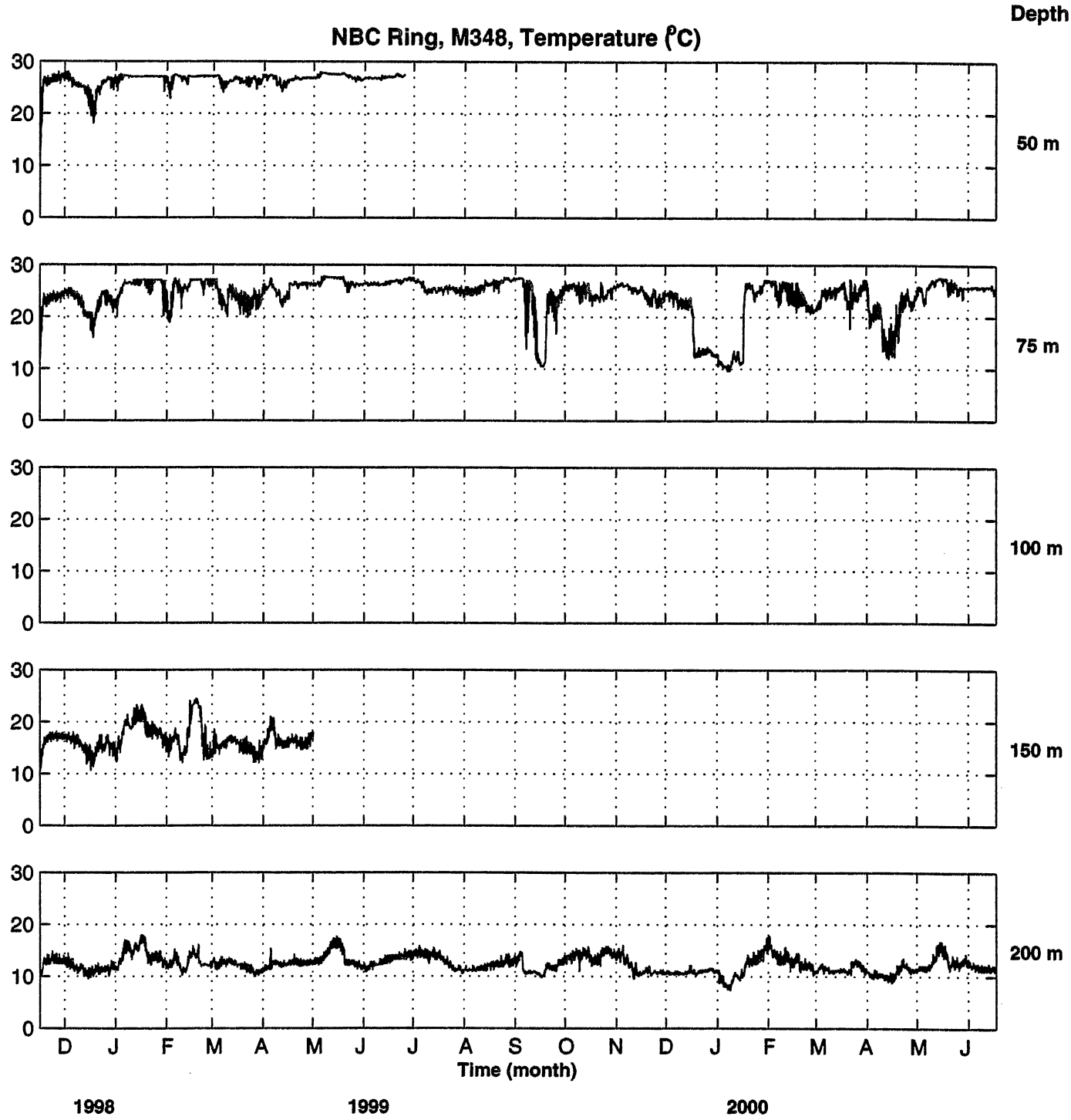
Longitude: *52°43.36 W*

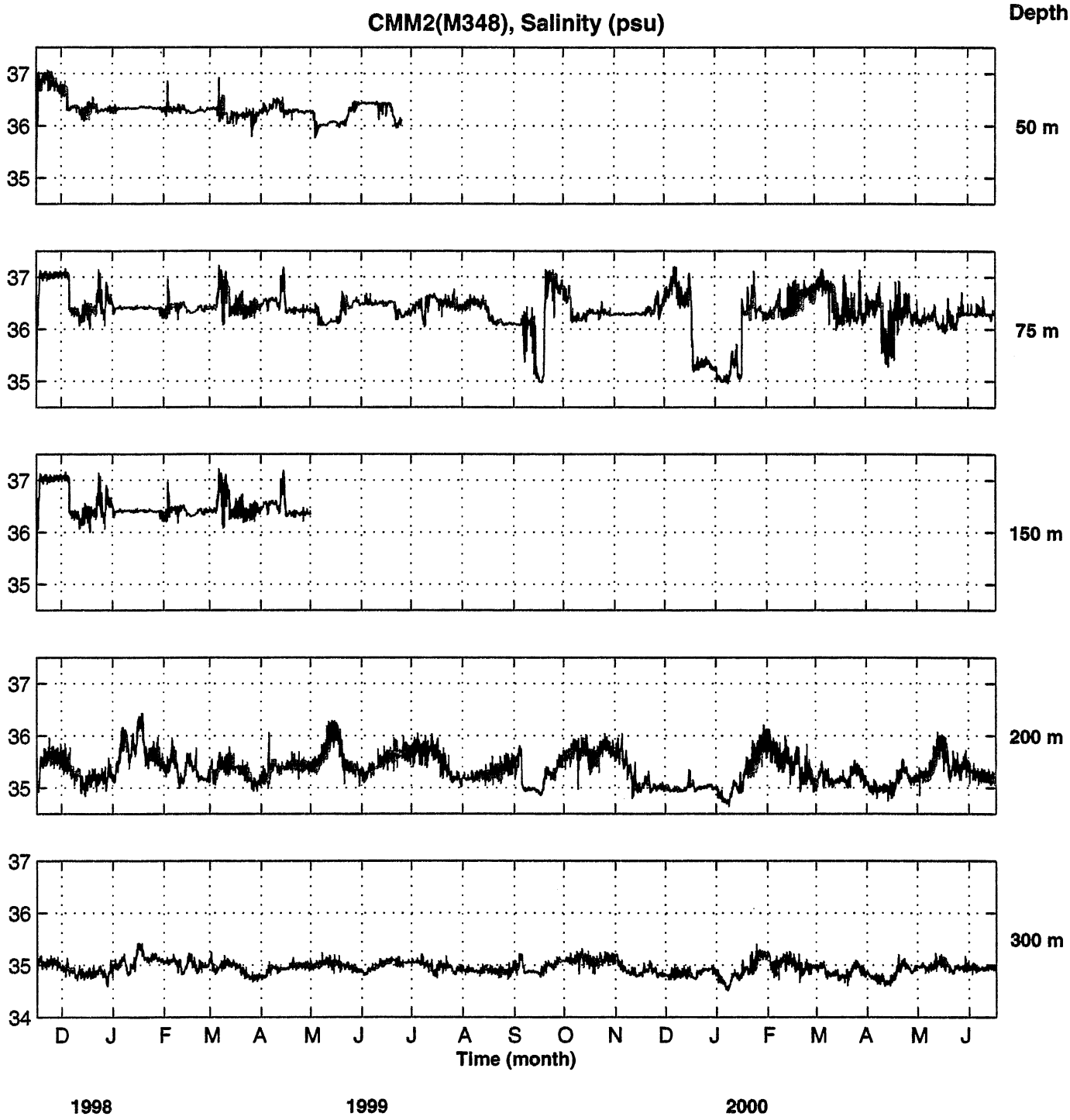
Start date: Nov. 15, 1998

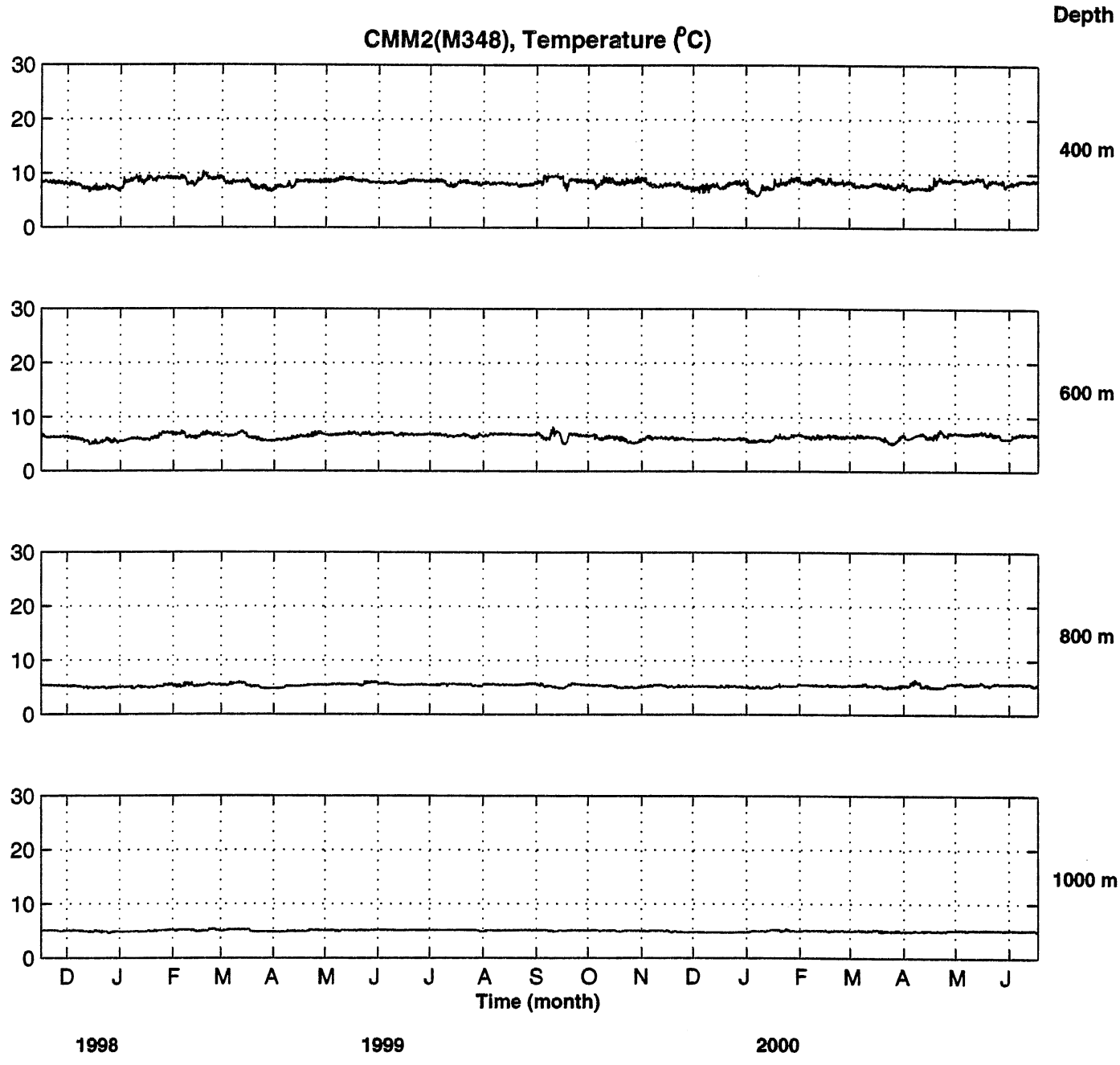
End date: Jun. 17, 2000

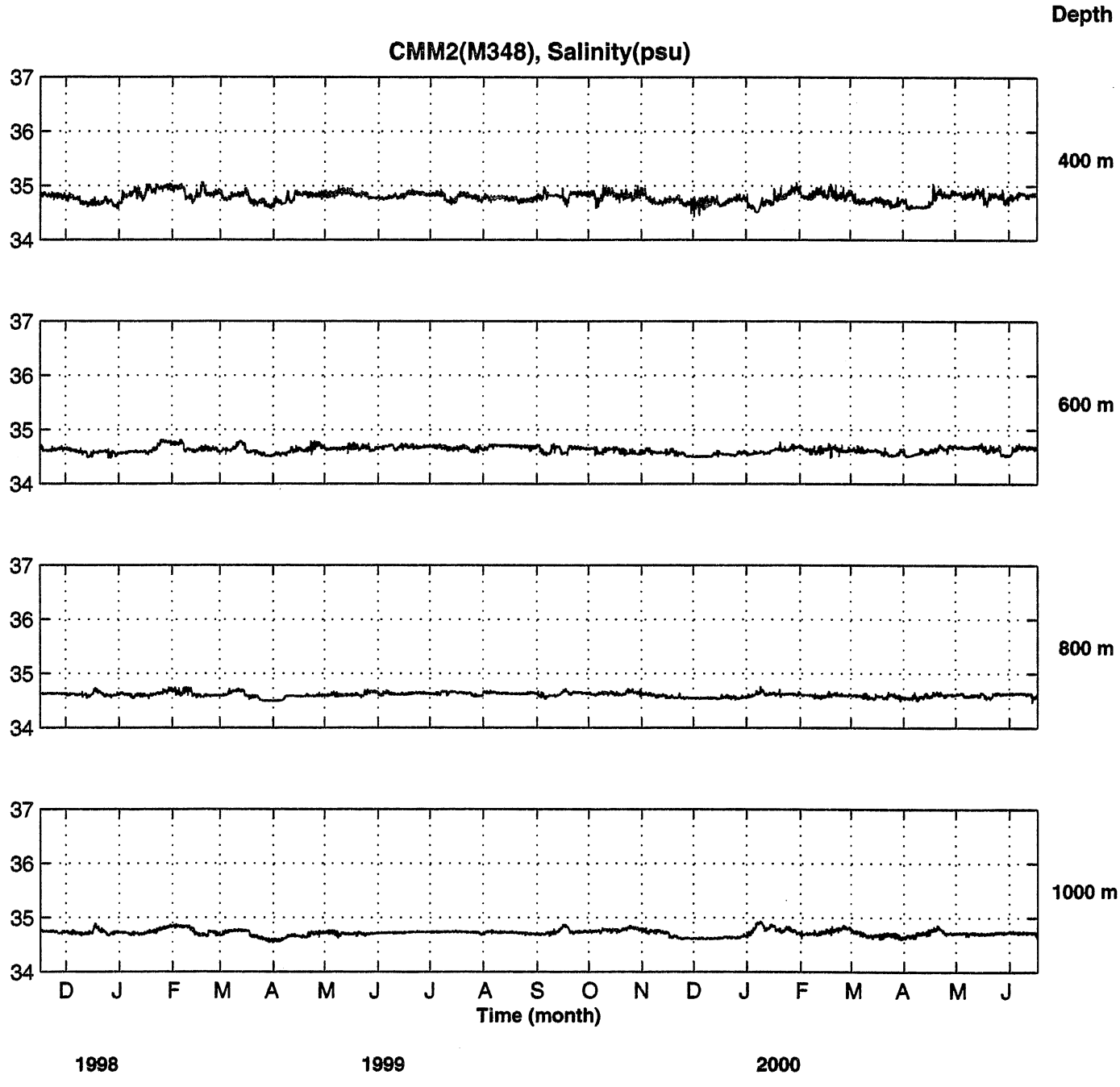

CMM2(M348), Pressure (dbar)
Depth
0
250
500
50 m
0
250
500
75 m
0
250
500
150 m
0
250
500
200 m
250
500
750
300 m
D J F M A M J J A S O N D J F M A M J
Time (month)
1998
1999
2000


CMM2(M348), Pressure (dbar)
Depth
250
500
750
400 m
500
750
1000
600 m
750
1000
1250
800 m
750
1000
1250
1000 m
D J F M A M J J A S O N D J F M A M J
Time (month)
1998
1999
2000


NBC Ring, M348, Temperature (°C)
Depth
50 m
75 m
100 m
150 m
200 m
30
20
10
0
D J F M A M J J A S O N D J F M A M J
Time (month)
1998
1999
2000


CMM2(M348), Salinity (psu)
Depth
37
36
35
50 m
37
36
35
75 m
37
36
35
150 m
37
36
35
200 m
37
36
35
34
300 m
D J F M A M J J A S O N D J F M A M J
Time (month)
1998
1999
2000


CMM2(M348), Temperature (°C)
Depth
400 m
600 m
800 m
1000 m
30
20
10
0
D J F M A M J J A S O N D J F M A M J
Time (month)
1998
1999
2000


Depth
CMM2(M348), Salinity(psu)
37
36
35
34
400 m
600 m
800 m
1000 m
D J F M A M J J A S O N D J F M A M J
Time (month)
1998
1999
2000