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SURFACE WATER AND ATMOSPHERIC CARBON DIOXIDE AND NITROUS OXIDE OBSERVATIONS BY SHIPBOARD AUTOMATED GAS CHROMATOGRAPHY: RESULTS FROM EXPEDITIONS BETWEEN 1977 AND 1990

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ACKNOWLEDGMENTS

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ABSTRACT

R. F. WEISS, F. A. VAN WOY, AND P. K. SALAMEH. 1992. Surface water and atmospheric carbon dioxide and nitrous oxide observations by shipboard automated gas chromatography: Results from expeditions between 1977 and 1990. Scripps Institution of Oceanography Reference 92-11. ORNL/CDIAC-59, NDP-044. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, Tennessee. 144 pp.

This document presents the results of surface water and atmospheric carbon dioxide (CO_2) and nitrous oxide (N_2O) measurements carried out by shipboard gas chromatography over the period 1977–1990. These data include results from 11 different oceanic surveys for a total of 41 expedition legs. Collectively, they represent a globally distributed sampling that includes locations in the Atlantic, Pacific, Indian, and Southern Oceans, as well as the Mediterranean and Red Seas.

The measurements were made by an automated high-precision shipboard gas chromatographic system developed during the late 1970s and used extensively over the intervening years. This instrument measures CO_2 by flame ionization after quantitative reaction to methane in a stream of hydrogen. Nitrous oxide is measured by a separate electron capture detector. The chromatographic system measures 196 dry-gas samples a day, divided equally among the atmosphere, gas equilibrated with surface water, a low-range gas standard, and a high-range gas standard.

These data constitute one of the most extensive records available of CO_2 and, particularly, N_2O in marine air and surface seawater. The data will be valuable in modeling applications dealing with the ocean's role in the global cycles of carbon and nitrogen, in studies of ocean–atmosphere dynamics, and in studies evaluating other methodologies for determining pCO_2.

All data have been assessed for quality and consistency and have been edited to remove serious outliers and contaminated samples and to correct gross numerical errors.

These data are available free of charge as a numeric data package (NDP) from the Carbon Dioxide Information Analysis Center (CDIAC). The NDP consists of this document and a magnetic tape (or set of floppy diskettes) containing machine-readable files.[a] This document provides sample listings of the surface water and atmospheric CO_2 and N_2O data, offers retrieval program listings (in FORTRAN and SAS[b] languages), furnishes graphical and tabular information on each of the contributing oceanic expeditions, defines limitations and restrictions of the data, and reprints pertinent literature.

[a] Files are also available through Internet using the File Transfer Protocol (FTP) from CDIAC's anonymous FTP area.

[b] SAS is the registered trademark of SAS Institute, Inc., Cary, NC 27511-8000.

PART 1

INFORMATION ABOUT THE NUMERIC DATA PACKAGE

1. NAME OF THE NUMERIC DATA PACKAGE

Surface Water and Atmospheric Carbon Dioxide and Nitrous Oxide Observations by Shipboard Automated Gas Chromatography: Results from Expeditions between 1977 and 1990

2. CONTRIBUTORS

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3. KEYWORDS

Carbon dioxide (CO_2); gas chromatography; marine atmospheric concentrations; nitrous oxide (N_2O); oceanography; surface seawater dissolved gases.

4. SOURCE INFORMATION

The surface water and atmospheric carbon dioxide (CO_2) and nitrous oxide (N_2O) data reported here were obtained by direct shipboard gas chromatographic measurement. These data include results from 11 different oceanic surveys for a total of 41 expedition legs. The represented oceanic surveys include the following: (1) the Indomed expedition, 1977–1979 [Indomed legs 4 and 5 are also part of the Geochemical Ocean Sections (GEOSECS) Indian Ocean expedition]; (2) the North Pacific Experiment (NORPAX) Hawaii–Tahiti Shuttle Experiment, 1979–1980; (3) and (4) the Transient Tracers in the Ocean, North Atlantic and Tropical Atlantic Studies (TTO/NAS, TTO/TAS), 1981–1983; (5) the Hudson 82-001 expedition, 1982; (6) the Ajax expedition, 1983–1984; (7) and (8) the Trans-Pacific Sections expeditions along 24 degrees North and 47 degrees North (TPS24 and TPS47), 1985; (9) the fifth "Antarktis" expedition (Ant V) of the R/V Polarstern, as part of the Winter Weddell Sea Experiment, 1986; (10) the South Atlantic Ventilation Experiment (SAVE), 1987–1989 (SAVE legs 4–6 are also designated as legs 2–4 of R/V Melville's Hydros expedition); and (11) the 1990 expedition of the National Oceanic and Atmospheric Administration's Climate and Global Change series (CGC-90). Table 1 presents a track list showing the dates, ports of departure and arrival, regions surveyed, and cruise ship names for each of the 41 expedition legs that contributed data. In addition, a series of maps showing the tracks of the expeditions and the N_2O and CO_2 results for each expedition leg is presented in Figs. 1–83.

Table 1. Track list of expeditions that contributed measurements to the surface water and atmospheric CO_2 and N_2O data set

No.	Cruise	Date	Port	Date	Port	Region	Ship
	Indomed						
1	* Leg 2	7 Nov 77	Panama	1 Dec 77	Cadiz	Carib./Atl.	Melville
2	* Leg 3	4 Dec 77	Cadiz	12 Dec 77	Alexandria	Med.	Melville
3	* Leg 4	16 Dec 77	Alexandria	22 Jan 78	Mauritius	Red S./Ind.	Melville
4	* Leg 5	28 Jan 78	Mauritius	25 Feb 78	Fremantle	S. Ind.	Melville
5	Leg 11A	21 Sep 78	Bermuda	25 Sep 78	San Juan	Atl.	Melville
6	Leg 12	28 Sep 78	San Juan	1 Nov 78	Montevideo	Atl.	Melville
7	Leg 15	10 Feb 79	Punta Arenas	5 Mar 79	Panama	S. Pac.	Melville
8	Leg 15A	7 Mar 79	Panama	15 Mar 79	Manzanillo	Trop. Pac.	Melville
	NORPAX Shuttle						
9	Transit	6 Jul 79	Newport OR	14 Jul 79	Honolulu	N. Pac.	Wecoma
10	Leg 7	19 Aug 79	Papeete	11 Sep 79	Honolulu	Trop. Pac.	Wecoma
11	Leg 9	31 Oct 79	Papeete	24 Nov 79	Honolulu	Trop. Pac.	Wecoma
12	Leg 13	18 Mar 80	Papeete	10 Apr 80	Honolulu	Trop. Pac.	Wecoma
13	Leg 15	18 May 80	Papeete	15 Jun 80	Honolulu	Trop. Pac.	Wecoma
	TTO/NAS						
14	Leg 1	1 Apr 81	Woods Hole	13 Apr 81	Bahamas	N. Atl.	Knorr
15	Leg 2	15 Apr 81	Bahamas	12 May 81	Bermuda	N. Atl.	Knorr
16	Leg 3	16 May 81	Bermuda	14 Jun 81	Azores	N. Atl.	Knorr
17	Leg 4	19 Jun 81	Azores	15 Jul 81	Glasgow	N. Atl.	Knorr
18	Leg 5	21 Jul 81	Glasgow	16 Aug 81	Reykjavik	Gnlnd. Sea	Knorr
19	Leg 6	21 Aug 81	Reykjavik	17 Sep 81	St. John's	N. Atl.	Knorr
20	Leg 7	23 Sep 81	St. John's	19 Oct 81	Woods Hole	N. Atl.	Knorr
	Hudson 82-001						
21	Leg 1	14 Feb 82	Halifax	23 Mar 82	Tromso	Gnlnd. Sea	Hudson
22	Leg 2	25 Mar 82	Tromso	6 Apr 82	Reykjavik	Gnlnd. Sea	Hudson
	TTO/TAS						
23	Leg 1	1 Dec 82	San Juan	22 Dec 82	Belem	Trop. Atl.	Knorr
24	Leg 2	29 Dec 82	Belem	24 Jan 83	Dakar	Trop. Atl.	Knorr
25	Leg 3	30 Jan 83	Dakar	18 Feb 83	Recife	Trop. Atl.	Knorr
26	Ajax 1	7 Oct 83	Abidjan	6 Nov 83	Cape Town	S. Atl.	Knorr
27	Ajax 2	11 Jan 84	Cape Town	18 Feb 84	Punta Arenas	S. Atl.	Knorr
28	TPS24 1	29 Mar 85	San Diego	1 May 85	Midway	N. Pac.	Thompson
29	TPS24 2	2 May 85	Midway	4 Jun 85	Nagasaki	N. Pac.	Thompson
30	TPS47 1	4 Aug 85	Hakodate	7 Sep 85	Seattle	N. Pac.	Thompson
31	Ant V/2	27 Jun 86	Bahia Blanca	17 Sep 86	Cape Town	Wedd. Sea	Plrstern
32	Ant V/3	28 Sep 86	Cape Town	13 Dec 86	Cape Town	Wedd. Sea	Plrstern
	SAVE						
33	Transit	31 Oct 87	Woods Hole	19 Nov 87	Recife	Atl.	Knorr
34	Leg 1	23 Nov 87	Recife	13 Dec 87	Abidjan	Trop. Atl.	Knorr
35	Leg 2	18 Dec 87	Abidjan	21 Jan 88	Rio	S. Atl.	Knorr
36	Leg 3	28 Jan 88	Rio	7 Mar 88	Abidjan	S. Atl.	Knorr
37	Leg 4	8 Dec 88	Punta Arenas	15 Jan 89	Cape Town	S. Atl.	Melville
38	Leg 5	23 Jan 89	Cape Town	8 Mar 89	Montevideo	S. Atl.	Melville
39	Leg 6	13 Mar 89	Montevideo	19 Apr 89	Barbados	S. Atl.	Melville
	CGC-90						
40	Leg 1	22 Feb 90	Pago Pago	22 Mar 90	Wellington	S. Pac.	Baldrige
41	Leg 2	27 Mar 90	Wellington	16 Apr 90	Honolulu	S. Pac.	Baldrige

* CO_2 not measured on these legs.

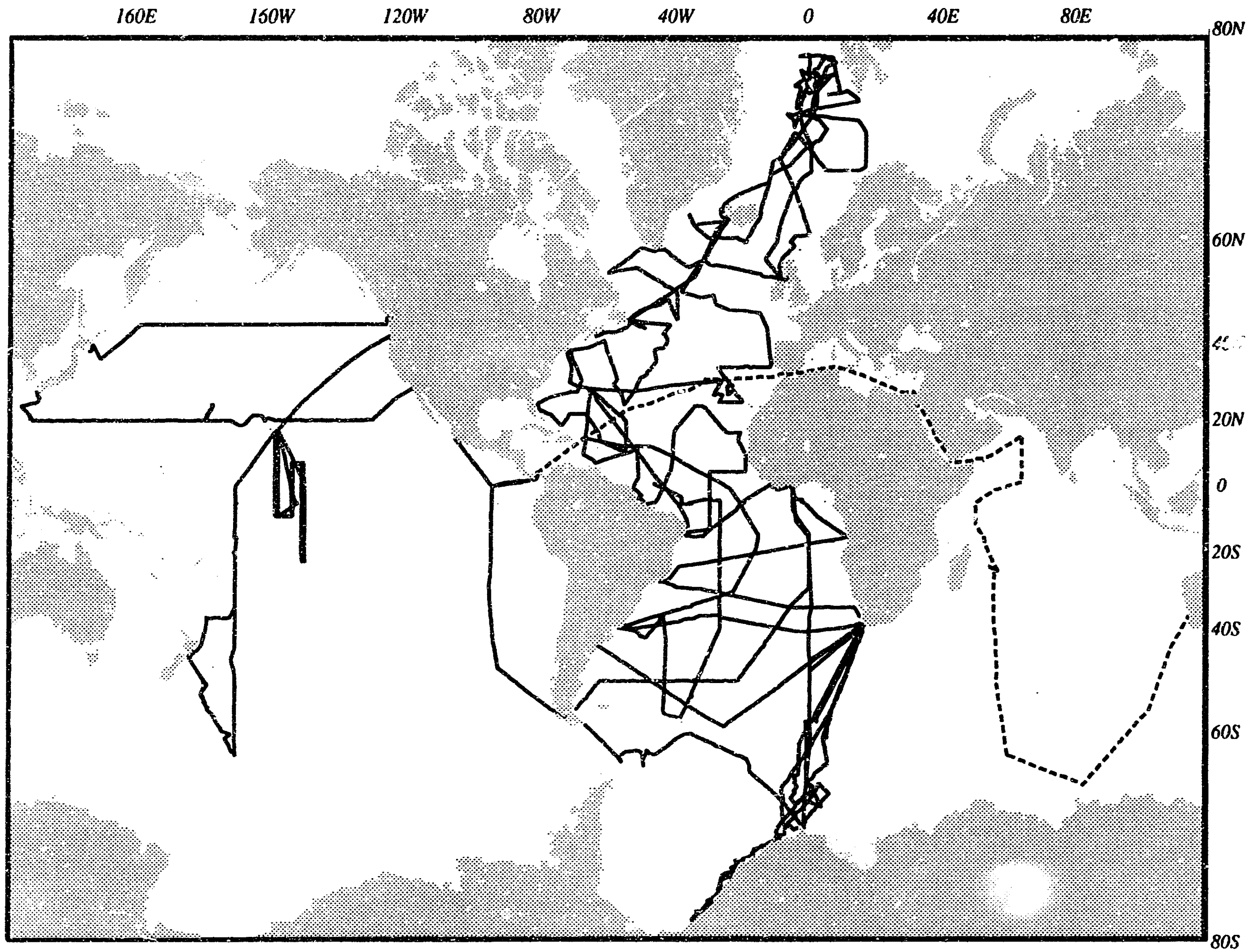


Figure 1. World map showing composite cruise track locations. Dashed lines denote expedition legs on which only N_2O was measured; on all other legs, both N_2O and CO_2 were measured.

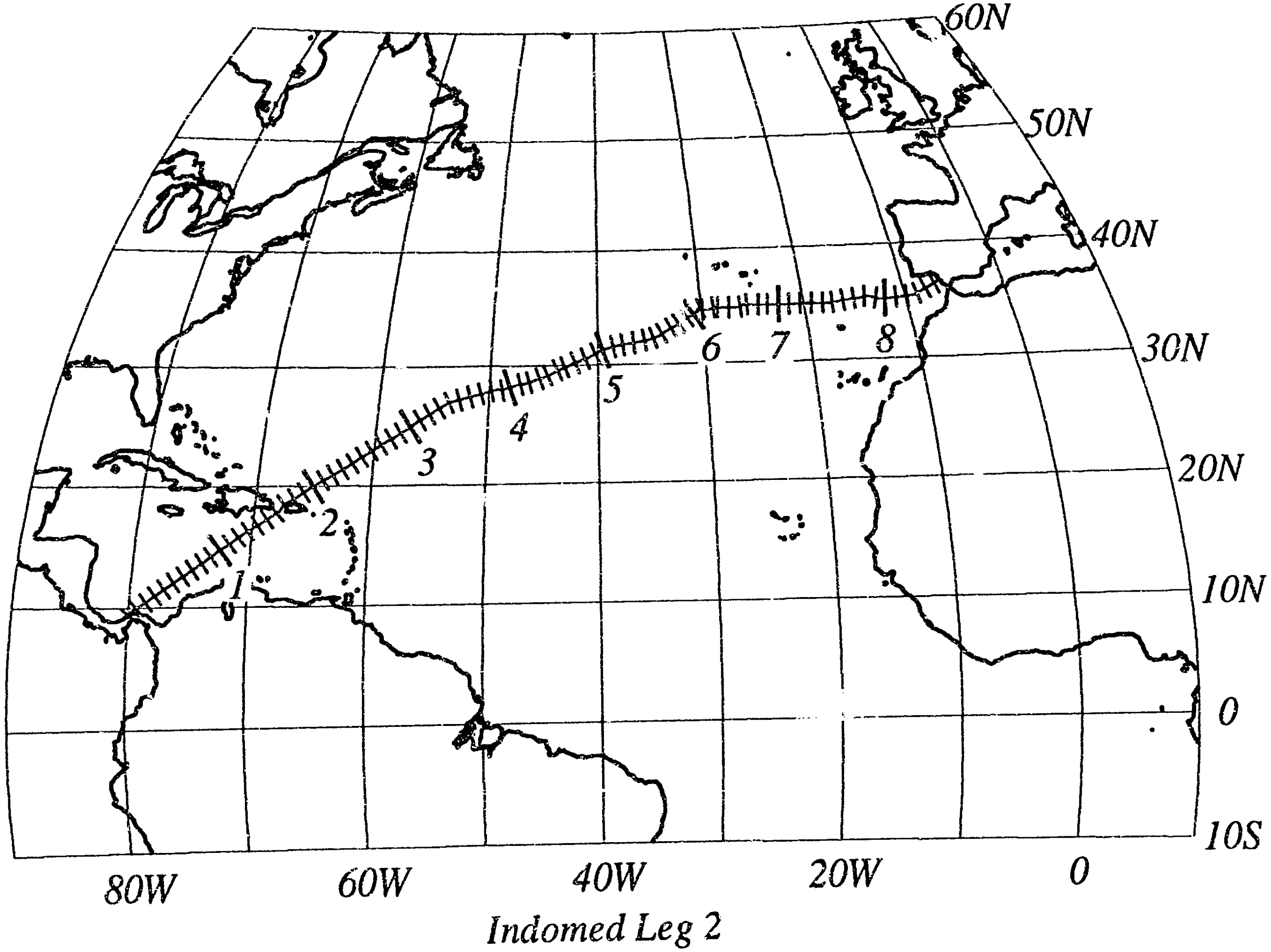


Figure 2. Cruise track plot, Indomed Leg 2. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

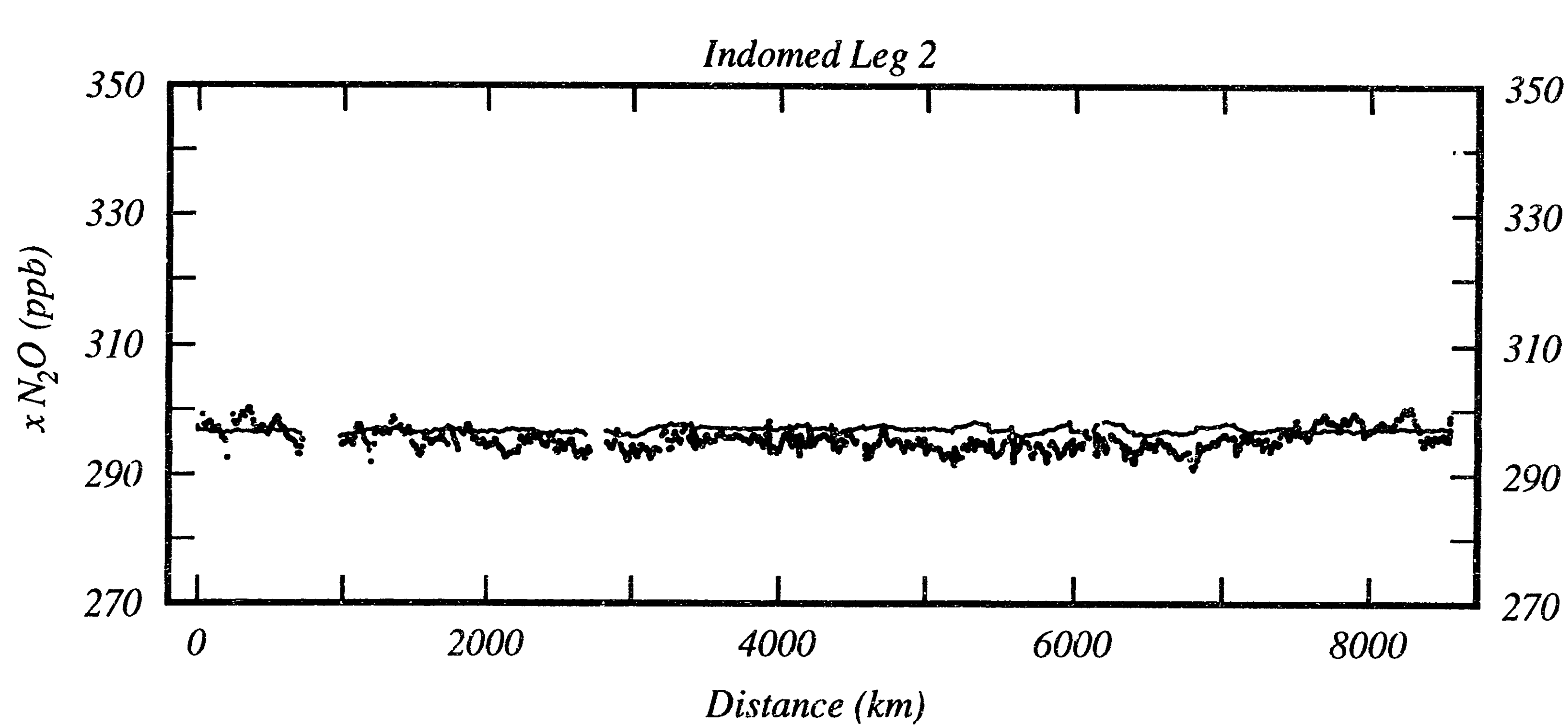


Figure 3. Data plot of xN_2O (dry gas mole fraction), Indomed Leg 2. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

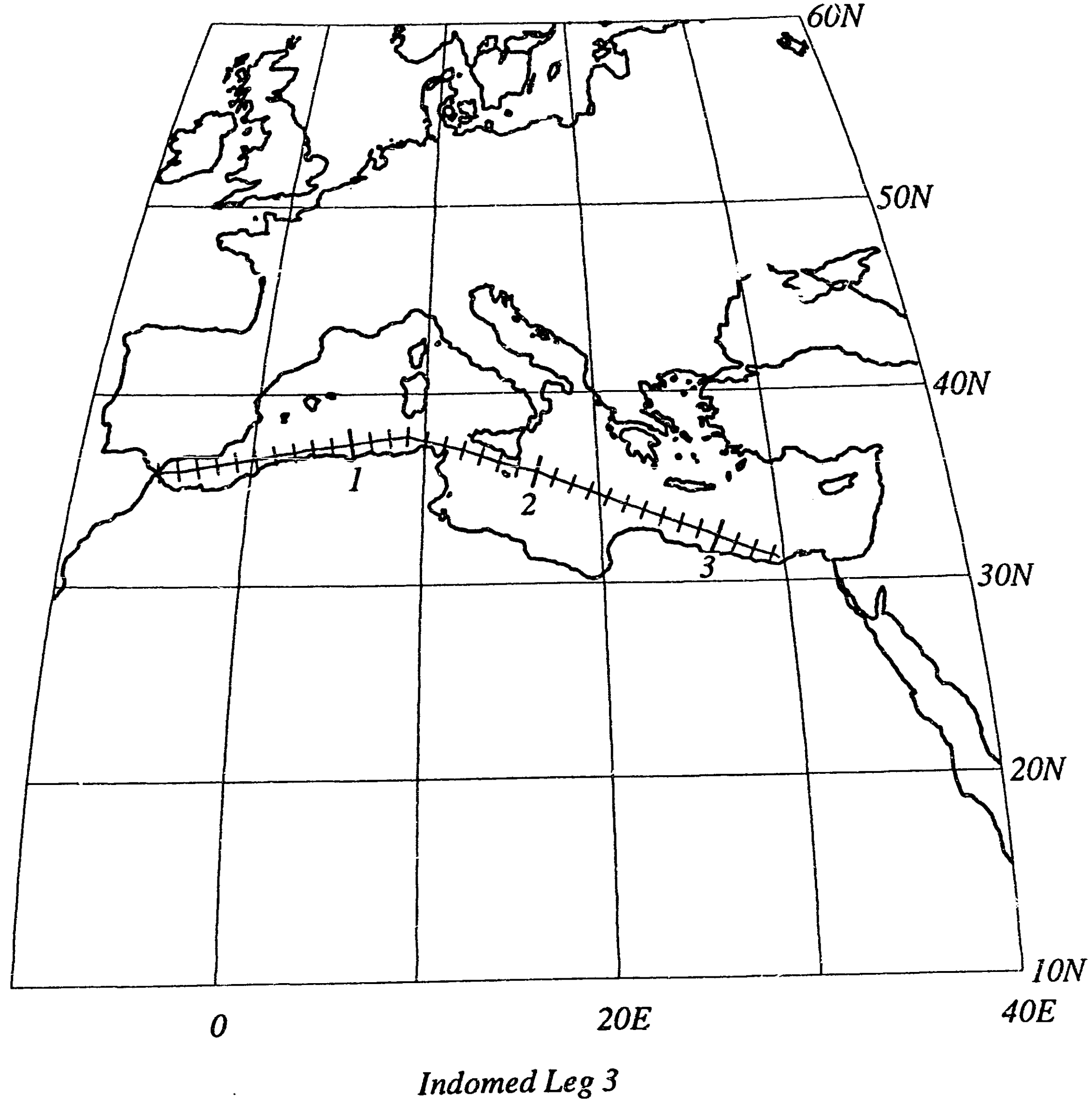


Figure 4. Cruise track plot, Indomed Leg 3. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

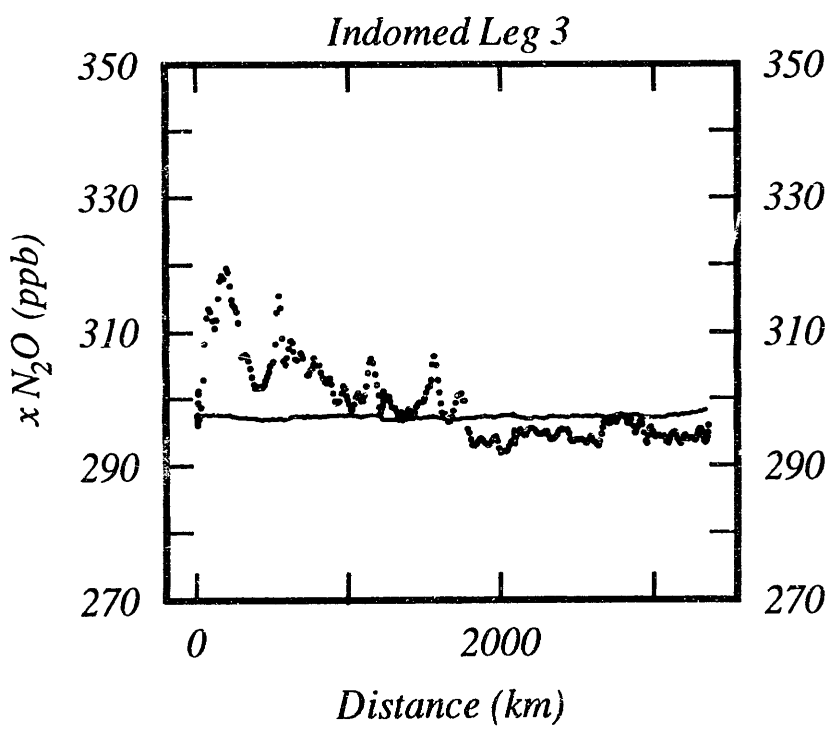


Figure 5. Data plot of xN_2O (dry gas mole fraction), Indomed Leg 3. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

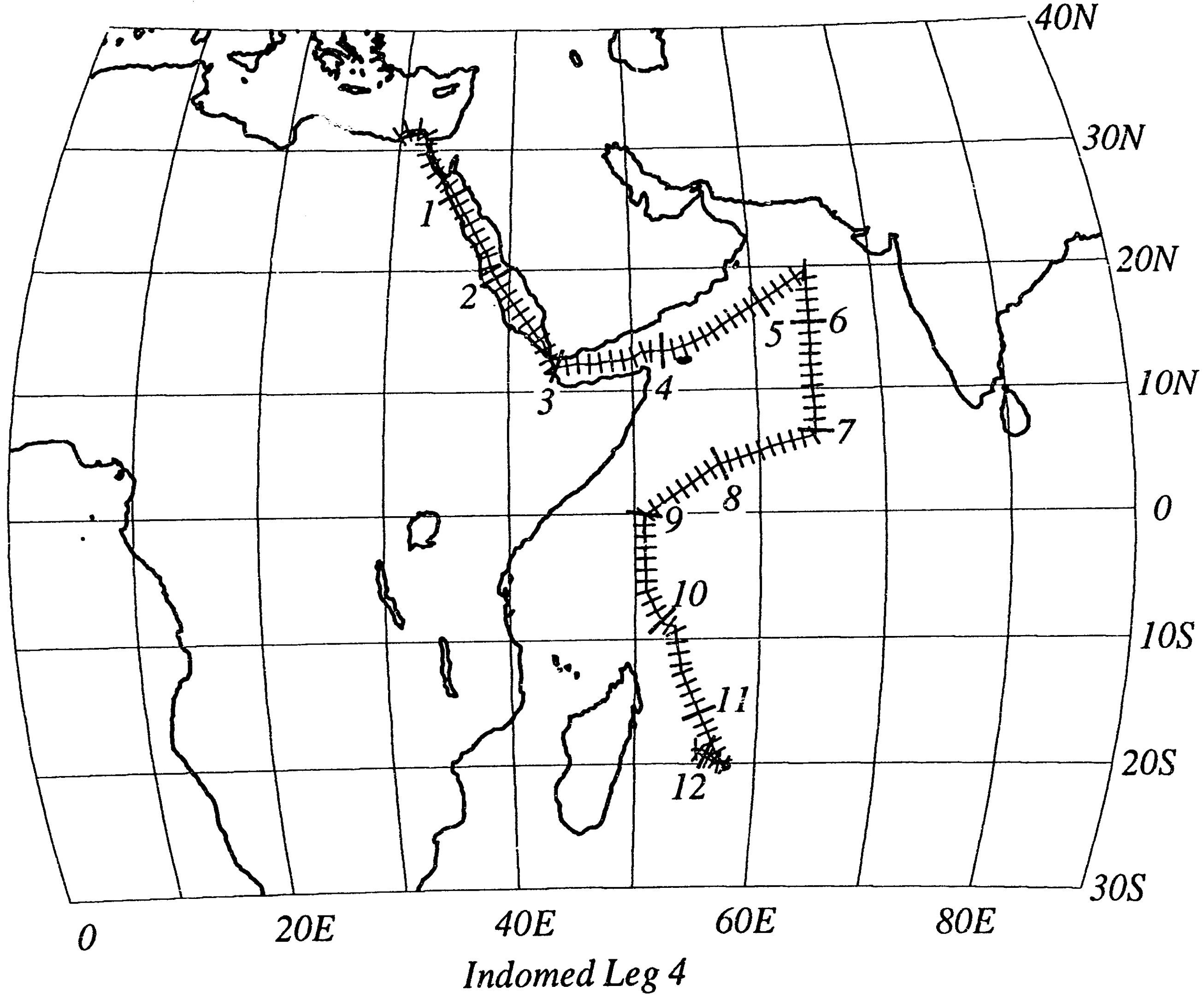


Figure 6. Cruise track plot, Indomed Leg 4. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

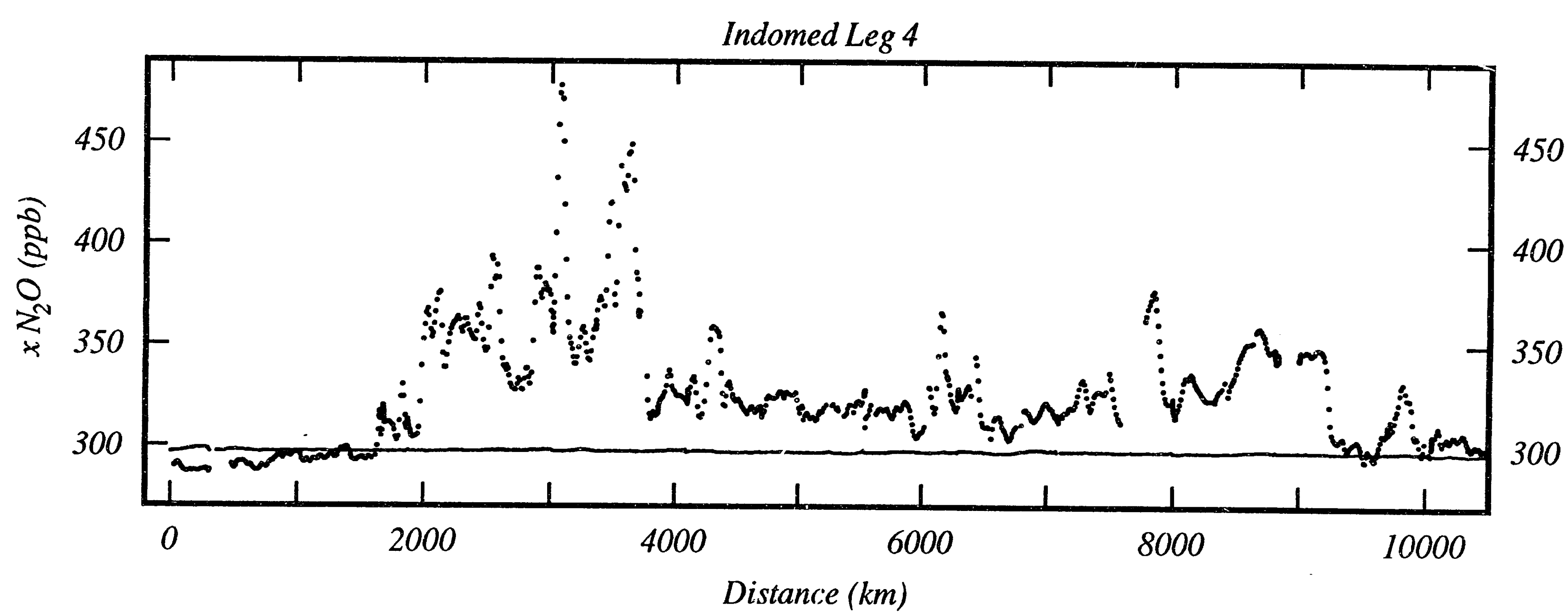


Figure 7. Data plot of xN_2O (dry gas mole fraction), Indomed Leg 4. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

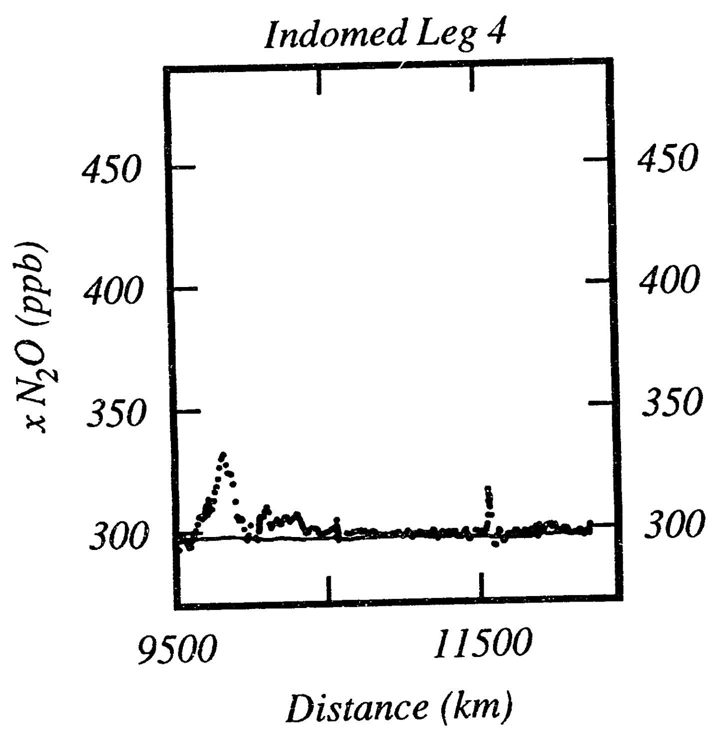


Figure 7. Continued

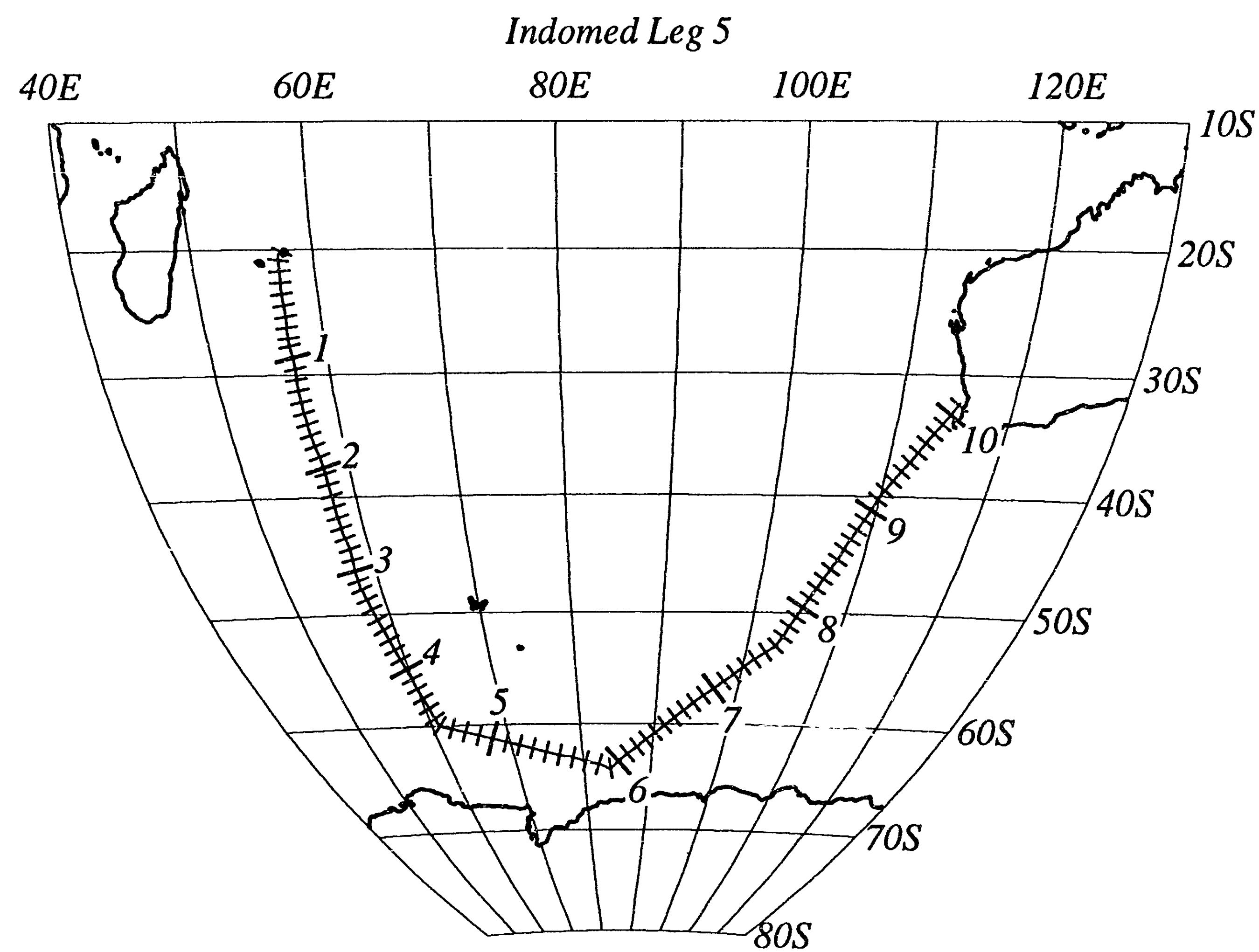


Figure 8. Cruise track plot, Indomed Leg 5. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

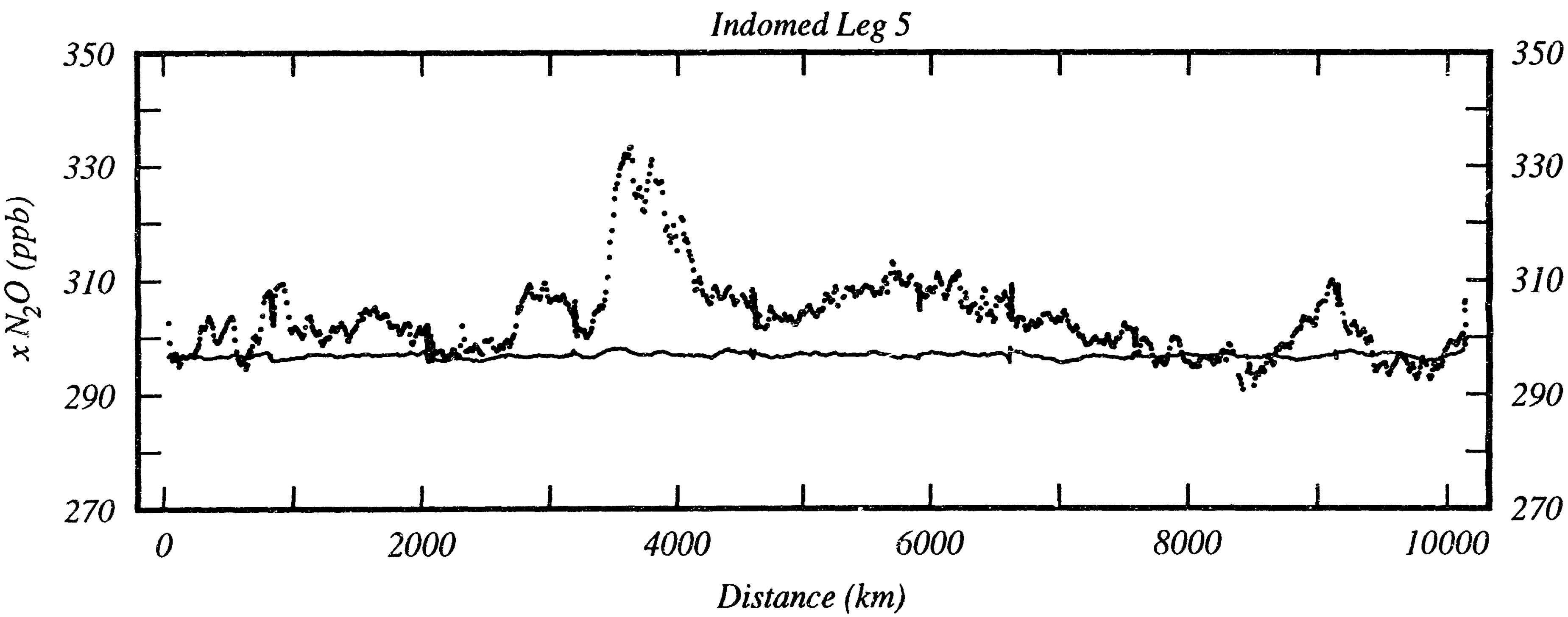


Figure 9. Data plot of xN_2O (dry gas mole fraction), Indomed Leg 5. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

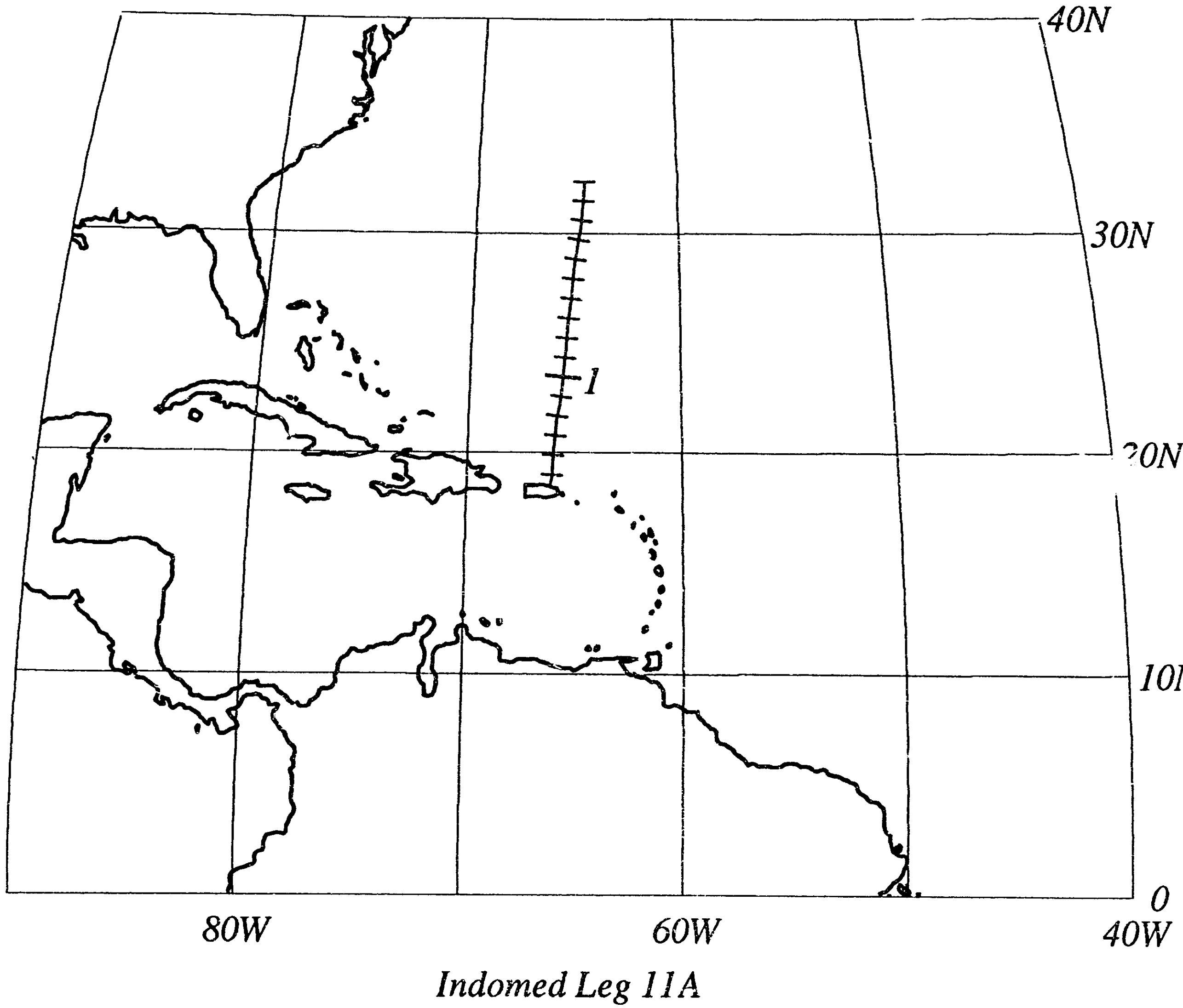


Figure 10. Cruise track plot, Indomed Leg 11A. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

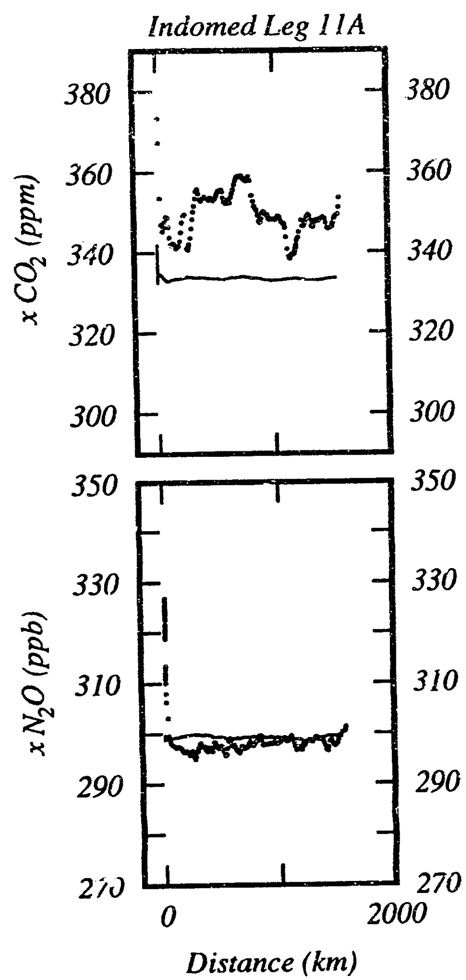


Figure 11. Data plot of xCO_2 and xN_2O (dry gas mole fractions), Indomed Leg 11A. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

Indomed Leg 12

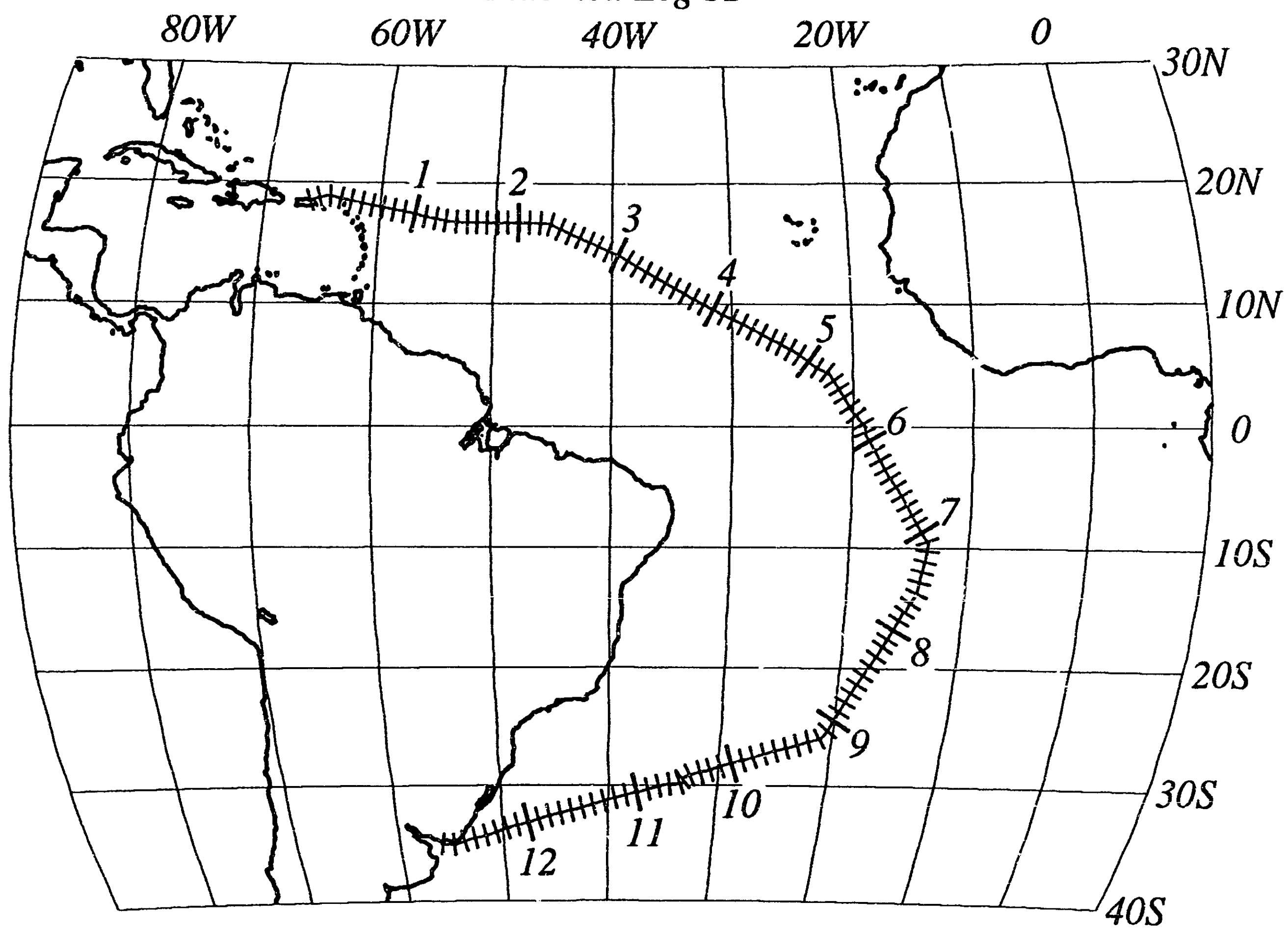


Figure 12. Cruise track plot, Indomed Leg 12. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

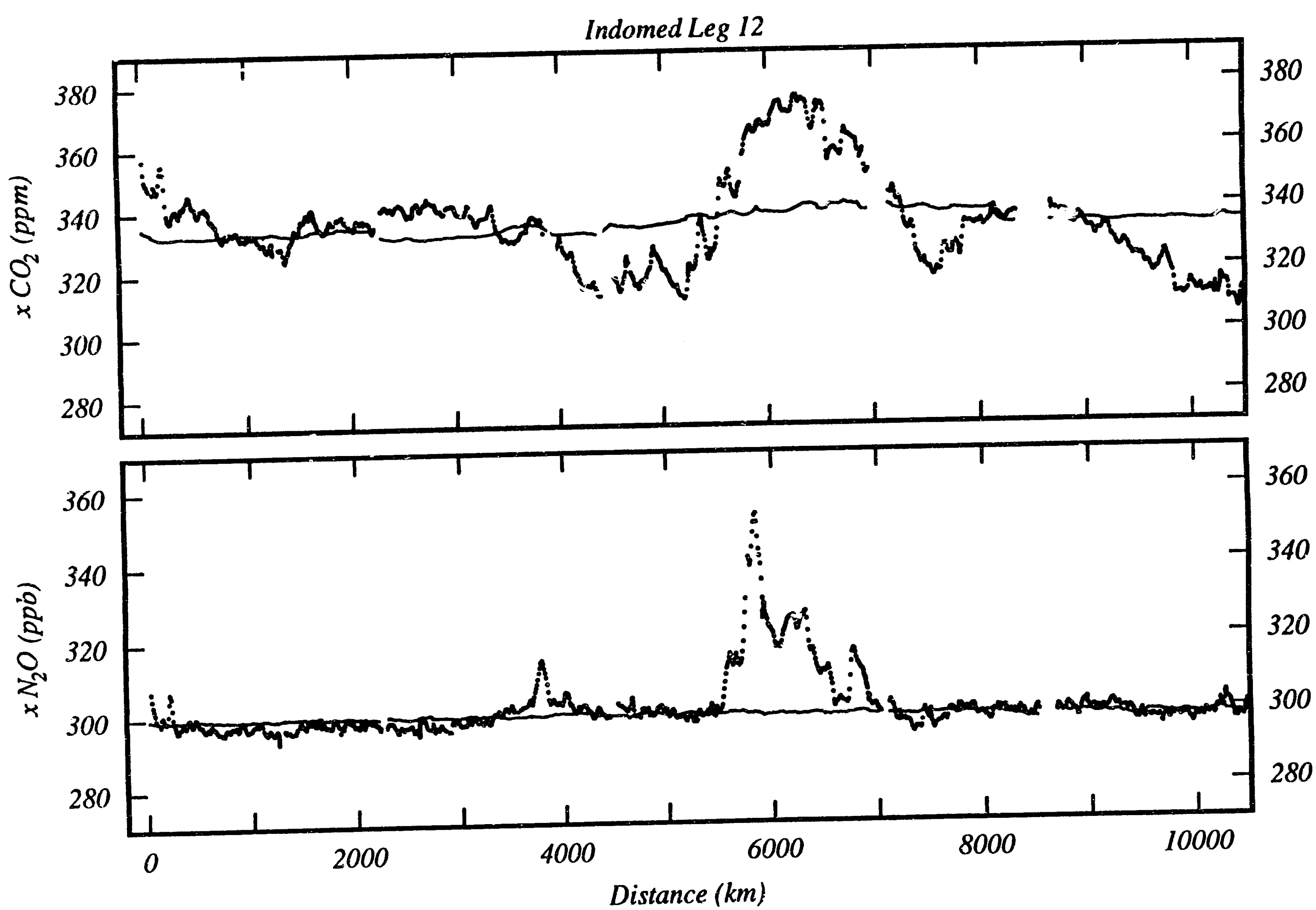


Figure 13. Data plot of xCO_2 and xN_2O (dry gas mole fractions), Indomed Leg 12. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

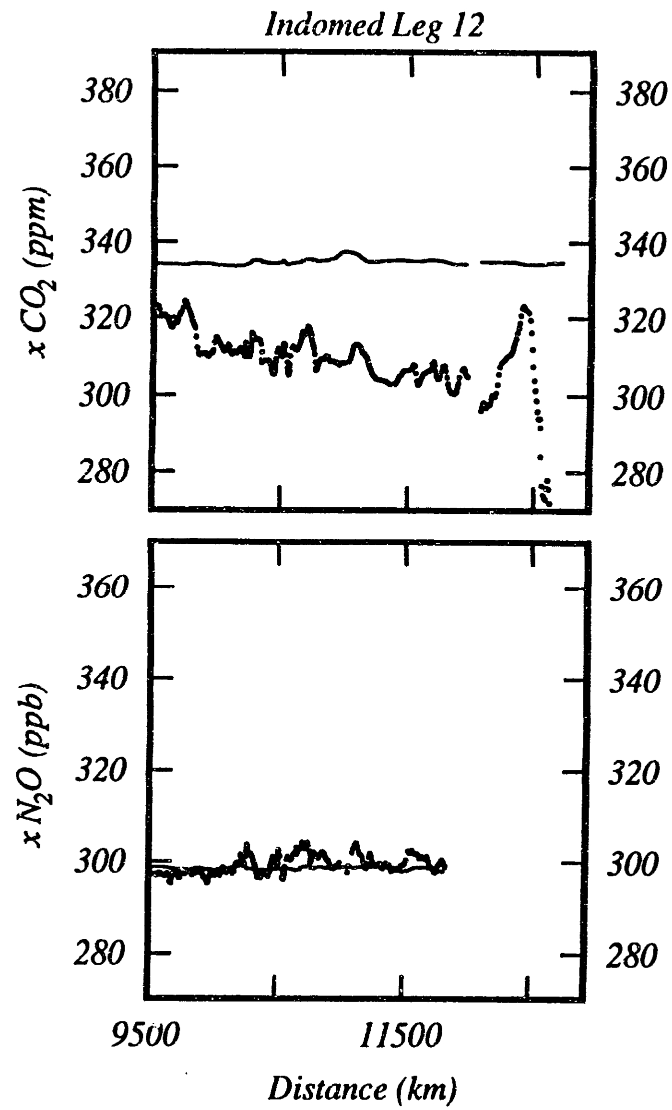


Figure 13. Continued

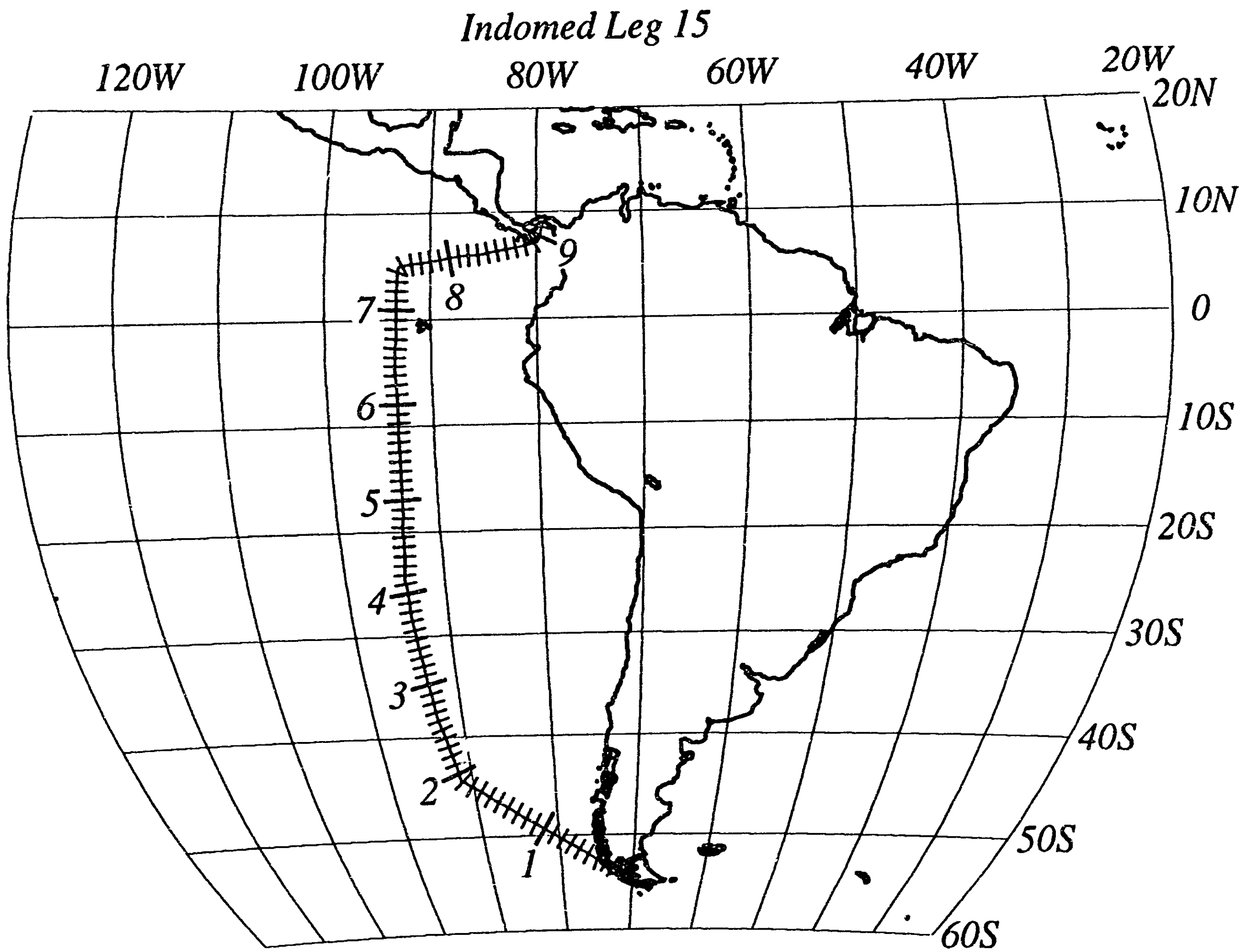


Figure 14. Cruise track plot, Indomed Leg 15. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

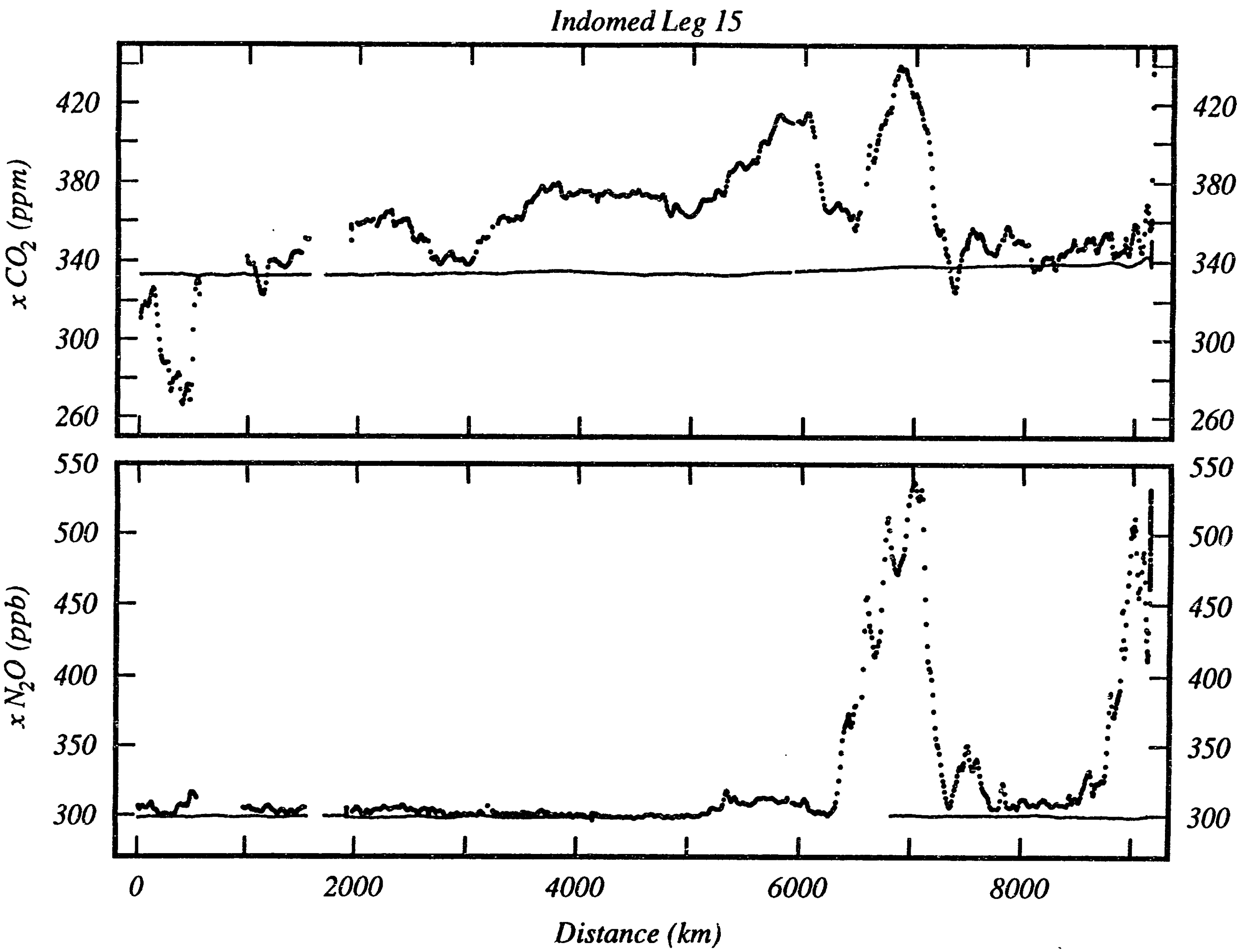


Figure 15. Data plot of xCO_2 and xN_2O (dry gas mole fractions), Indomed Leg 15. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

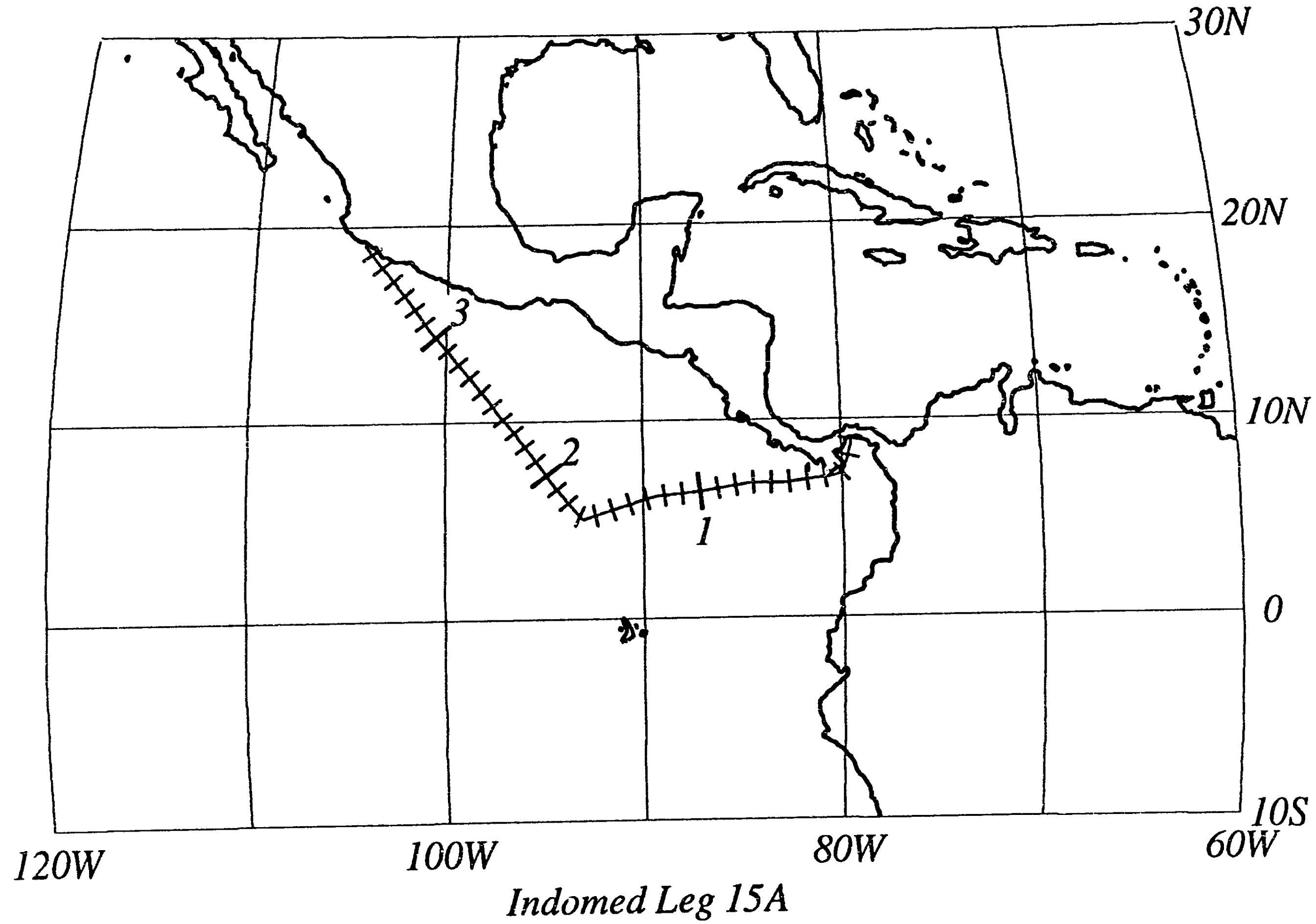


Figure 16. Cruise track plot, Indomed Leg 15A. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

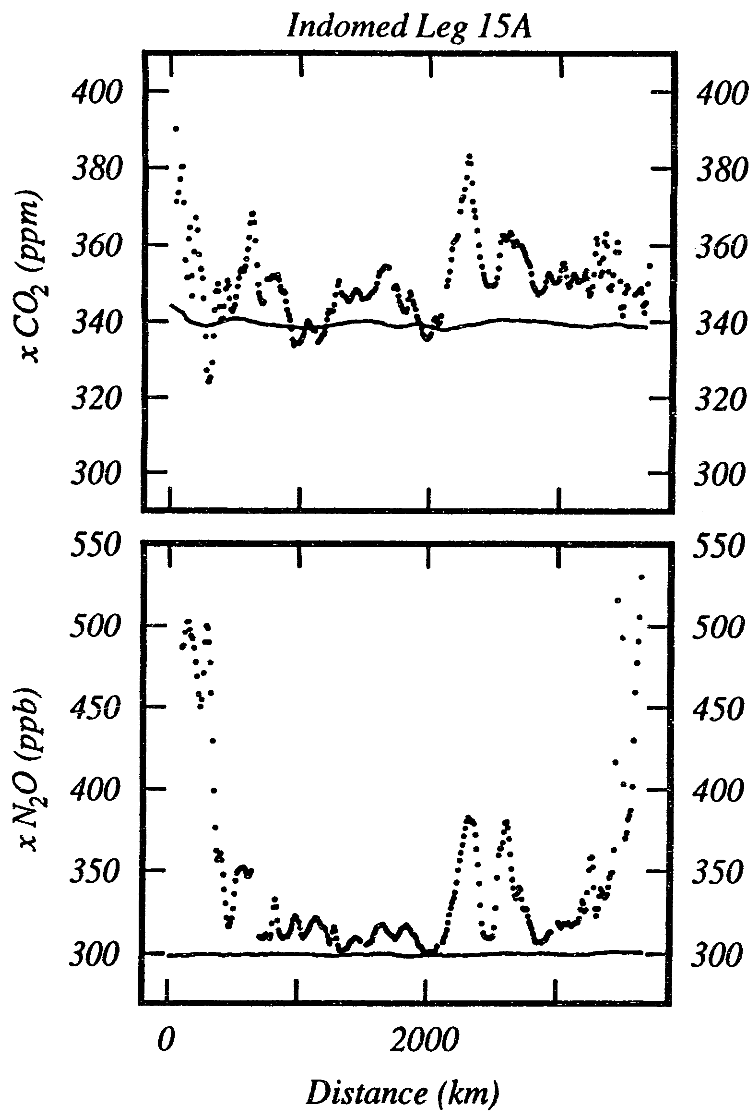


Figure 17. Data plot of xCO_2 and xN_2O (dry gas mole fractions), Indomed Leg 15A. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

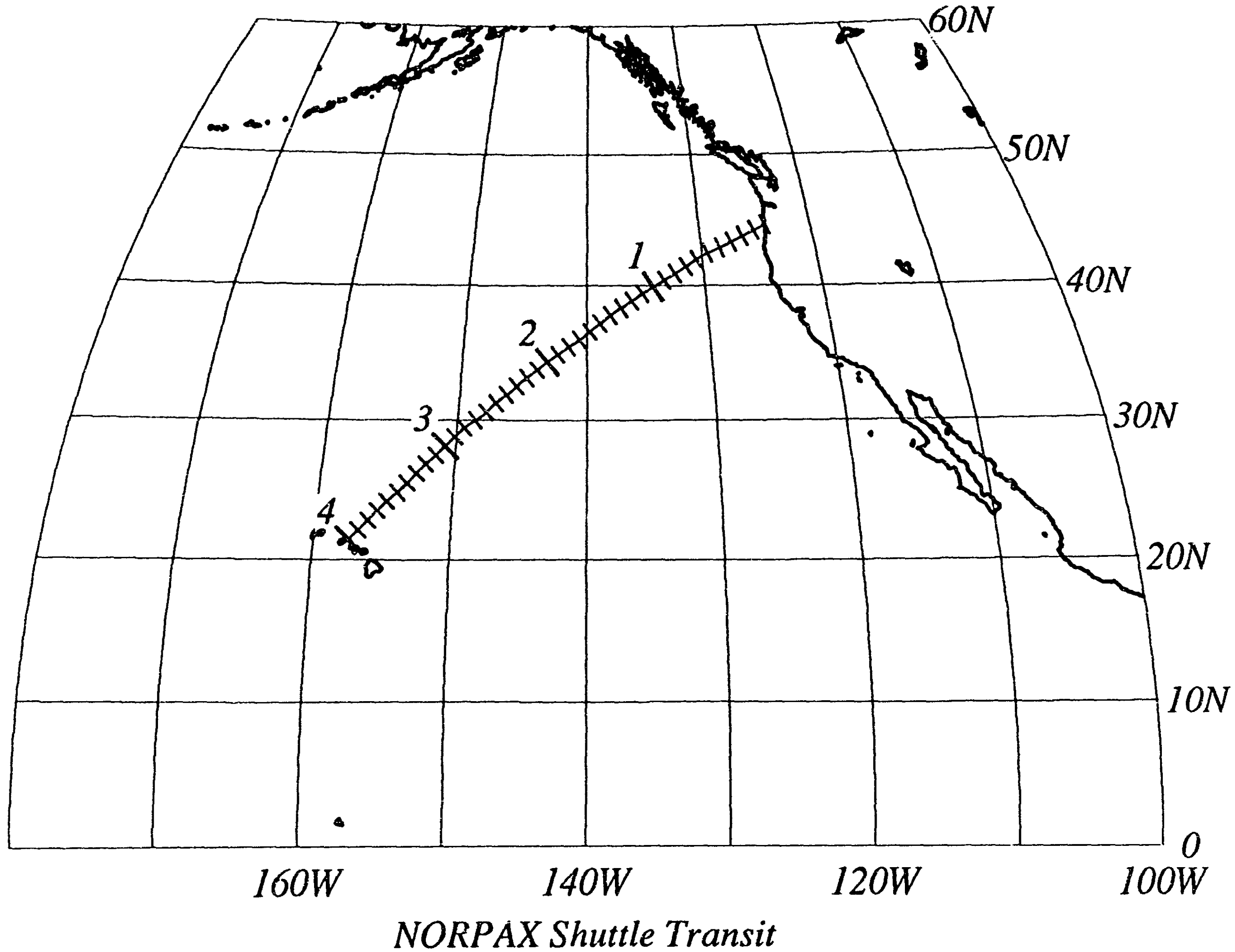


Figure 18. Cruise track plot, NORPAX Shuttle Transit. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

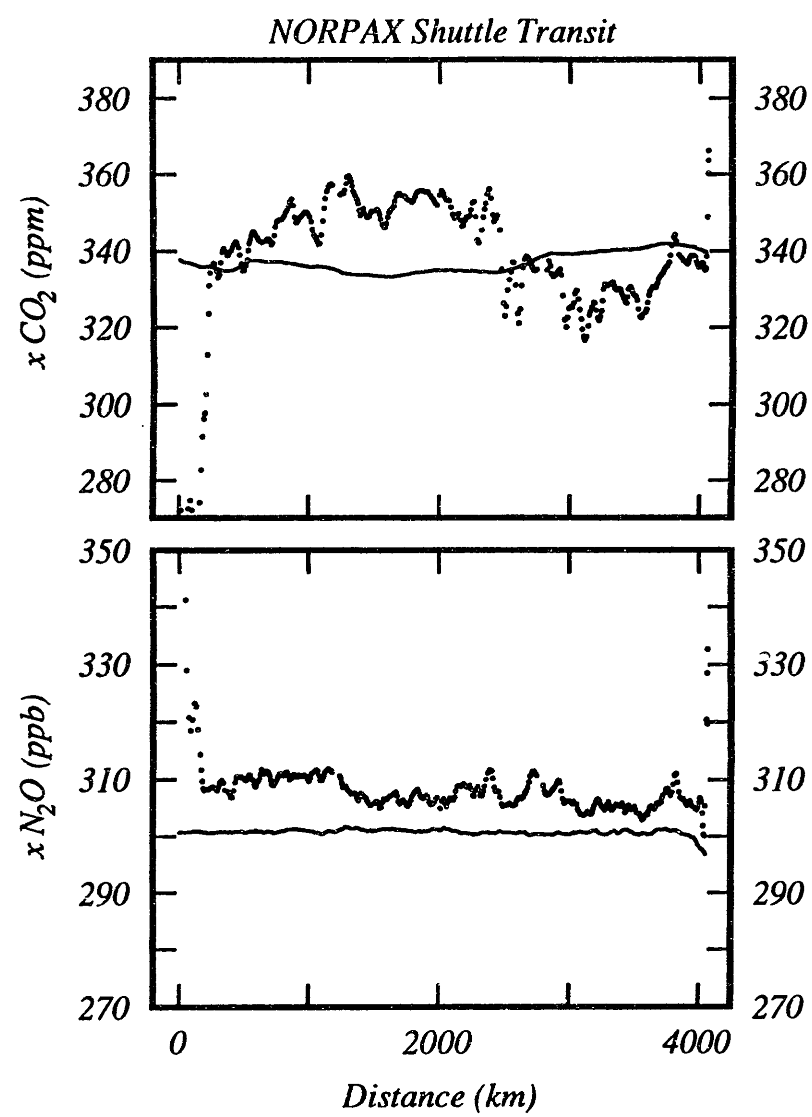


Figure 19. Data plot of xCO_2 and xN_2O (dry gas mole fractions), NORPAX Shuttle Transit. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

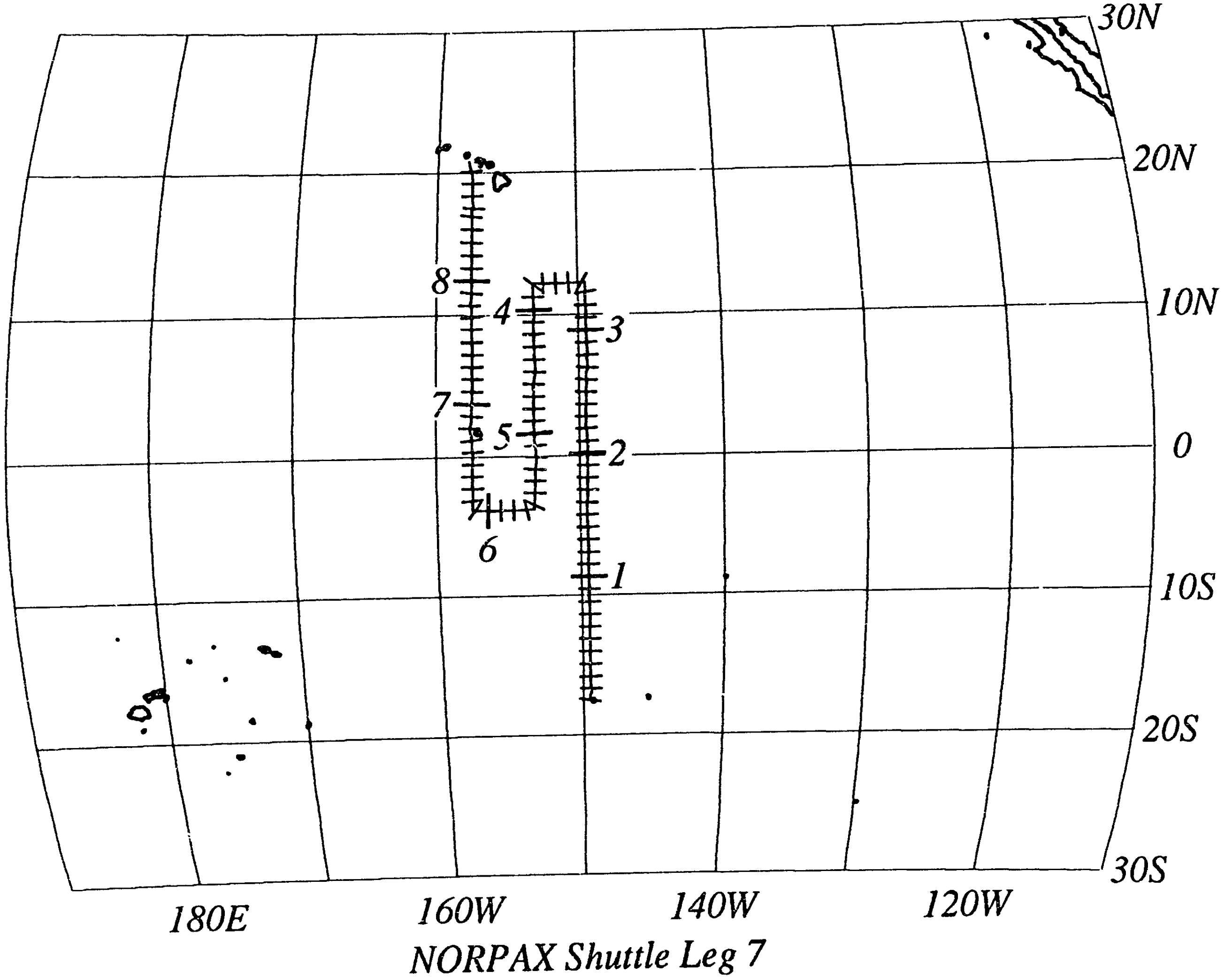


Figure 20. Cruise track plot, NORPAX Shuttle Leg 7. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

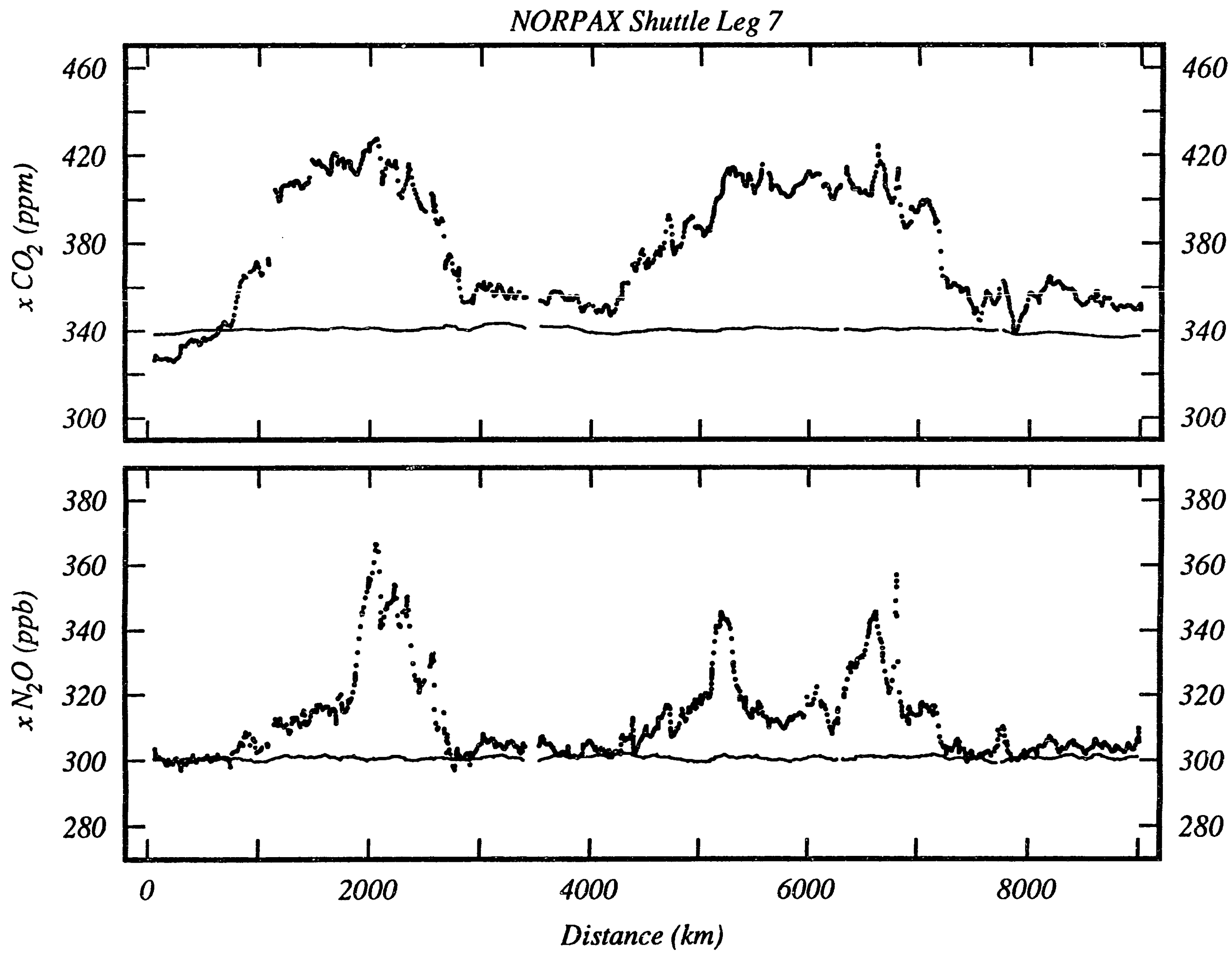
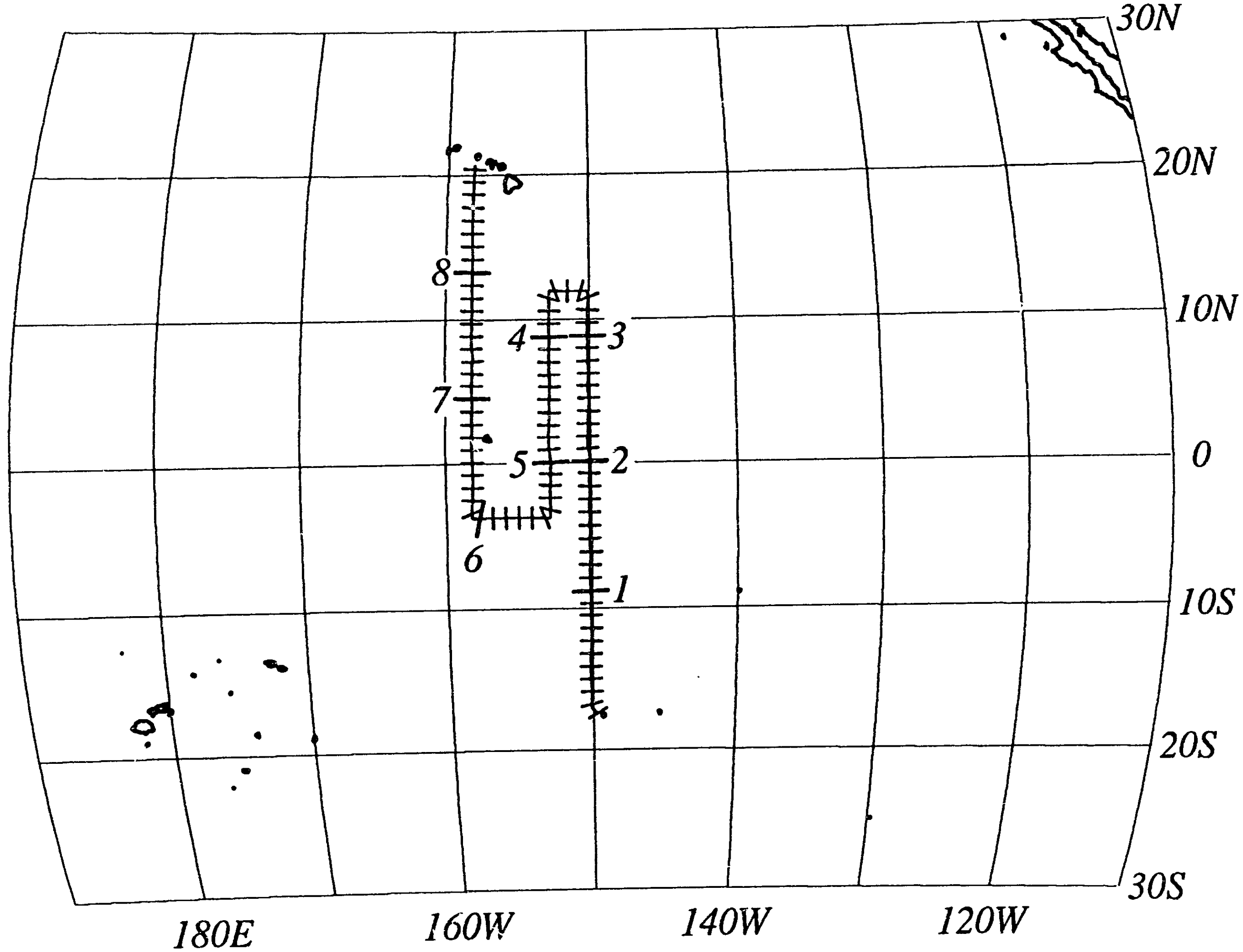


Figure 21. Data plot of xCO_2 and xN_2O (dry gas mole fractions), NORPAX Shuttle Leg 7. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.



NORPAX Shuttle Leg 9

Figure 22. Cruise track plot, NORPAX Shuttle Leg 9. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

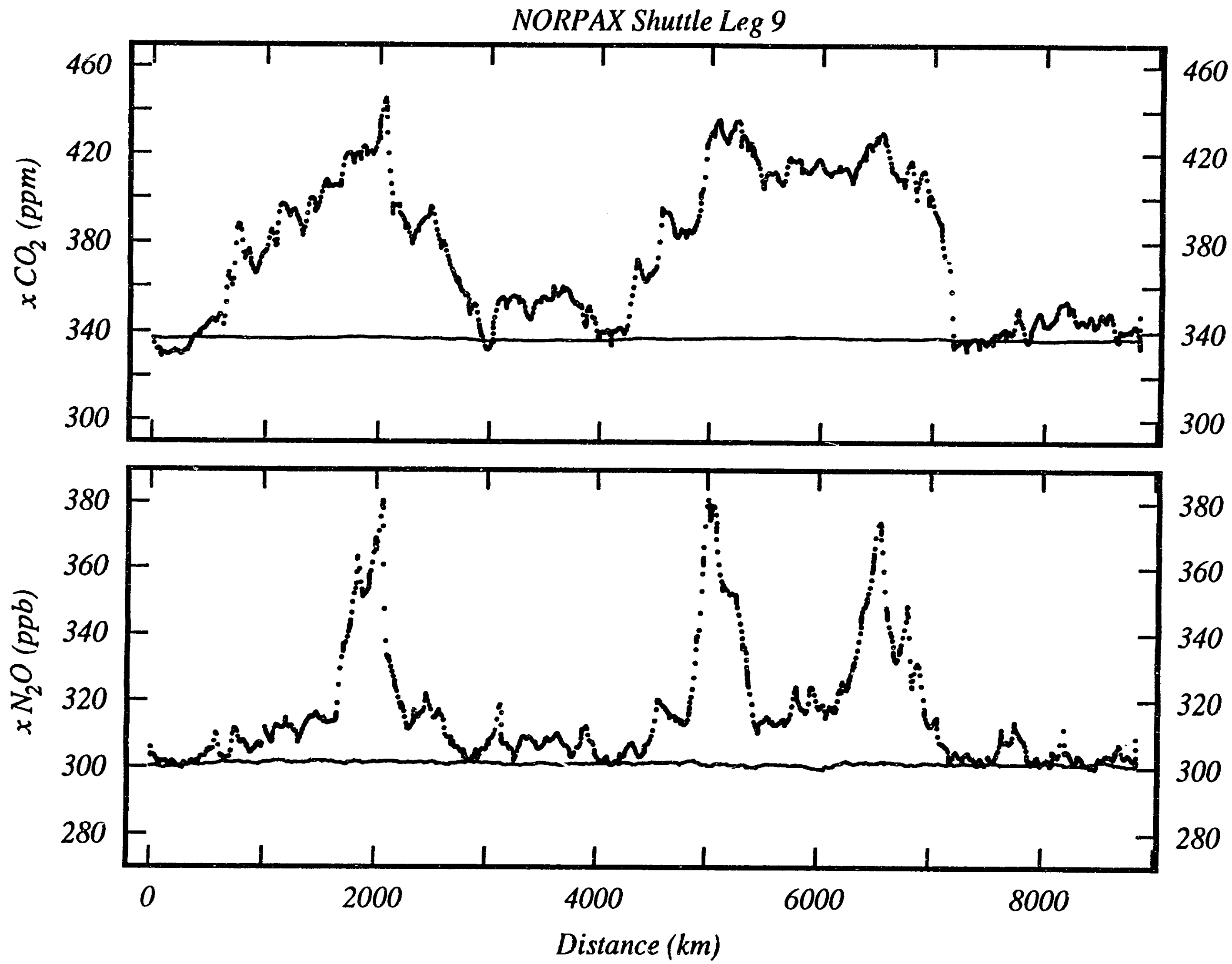


Figure 23. Data plot of xCO_2 and xN_2O (dry gas mole fractions), NORPAX Shuttle Leg 9. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

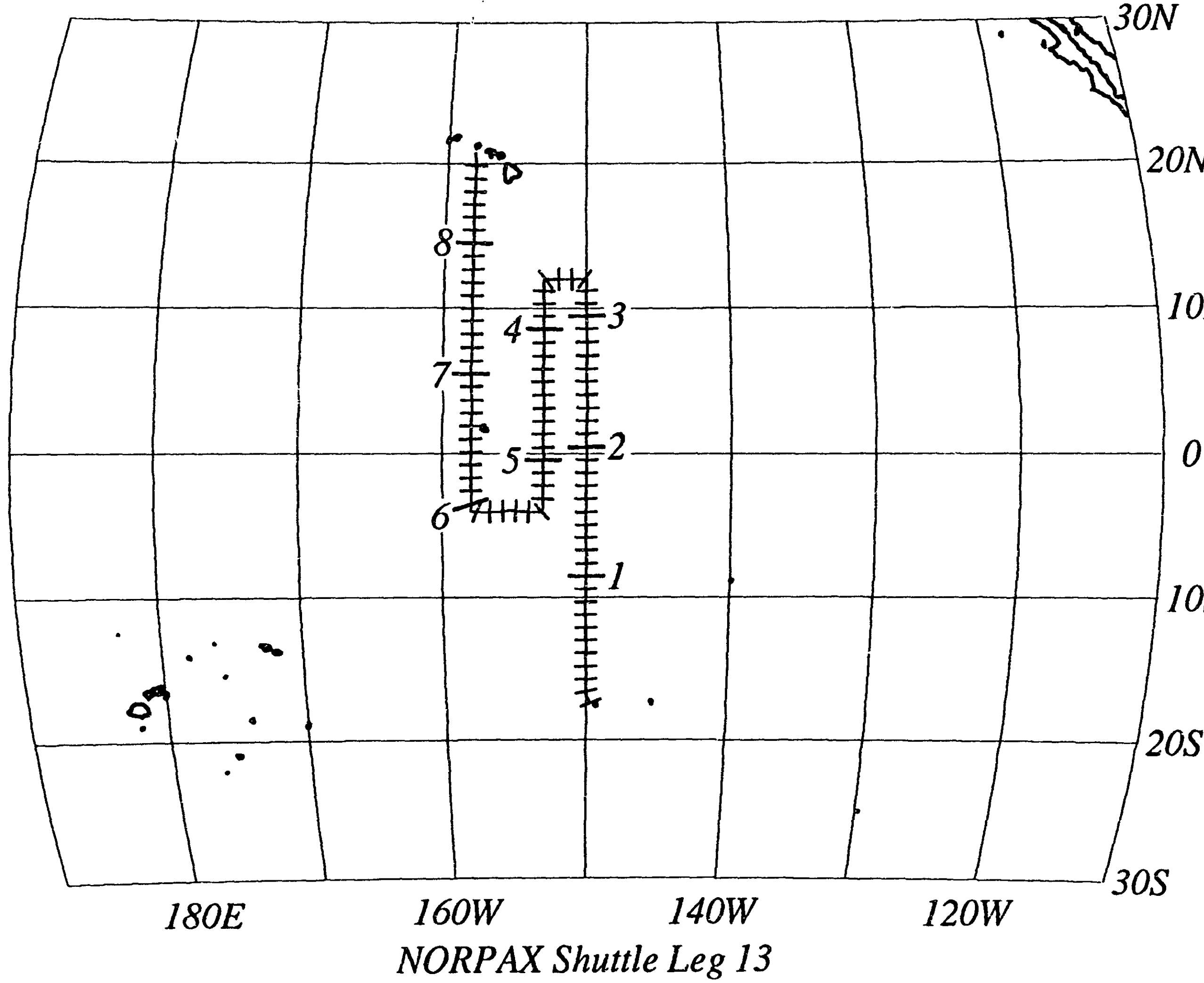


Figure 24. Cruise track plot, NORPAX Shuttle Leg 13. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

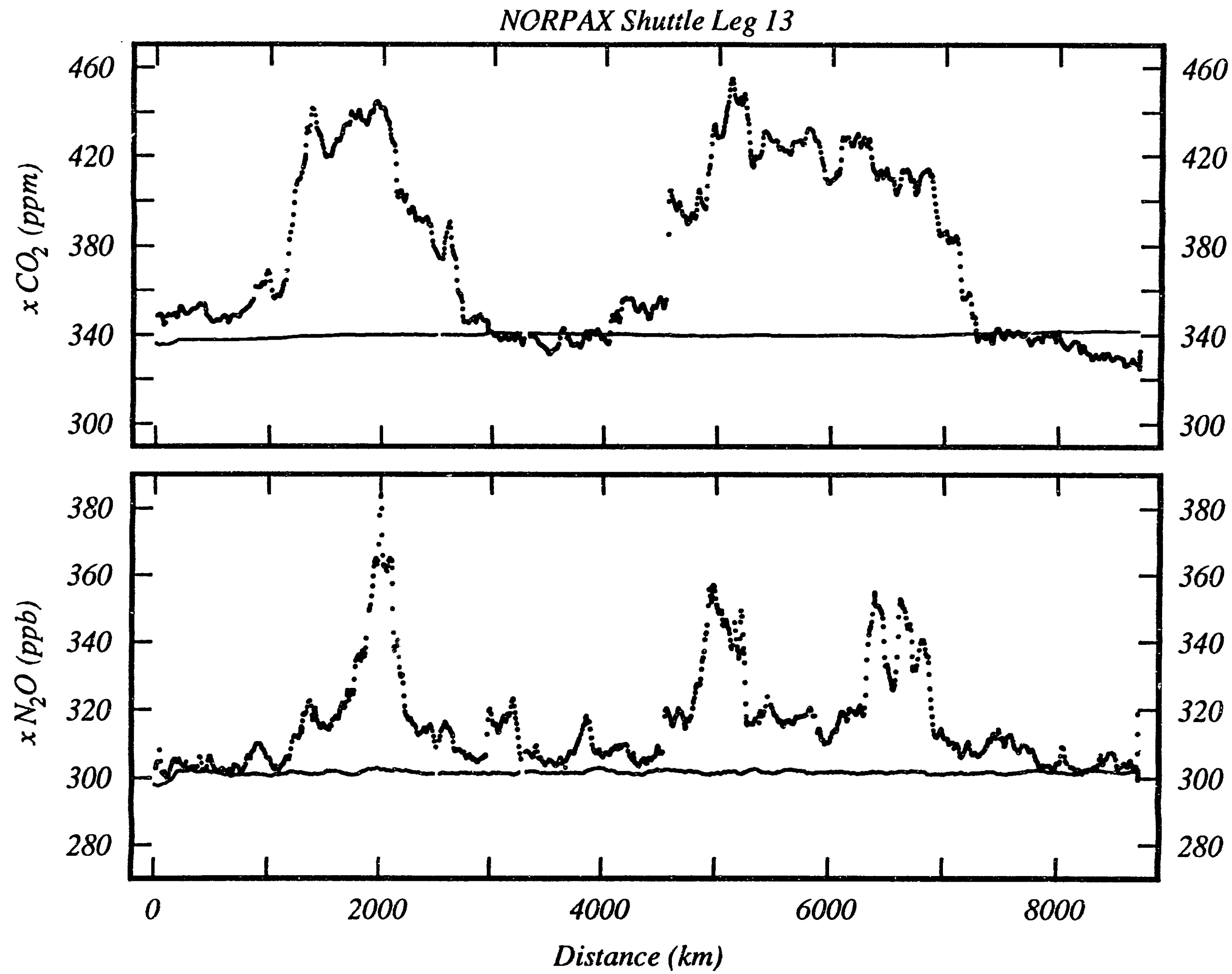


Figure 25. Data plot of xCO_2 and xN_2O (dry gas mole fractions), NORPAX Shuttle Leg 13. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

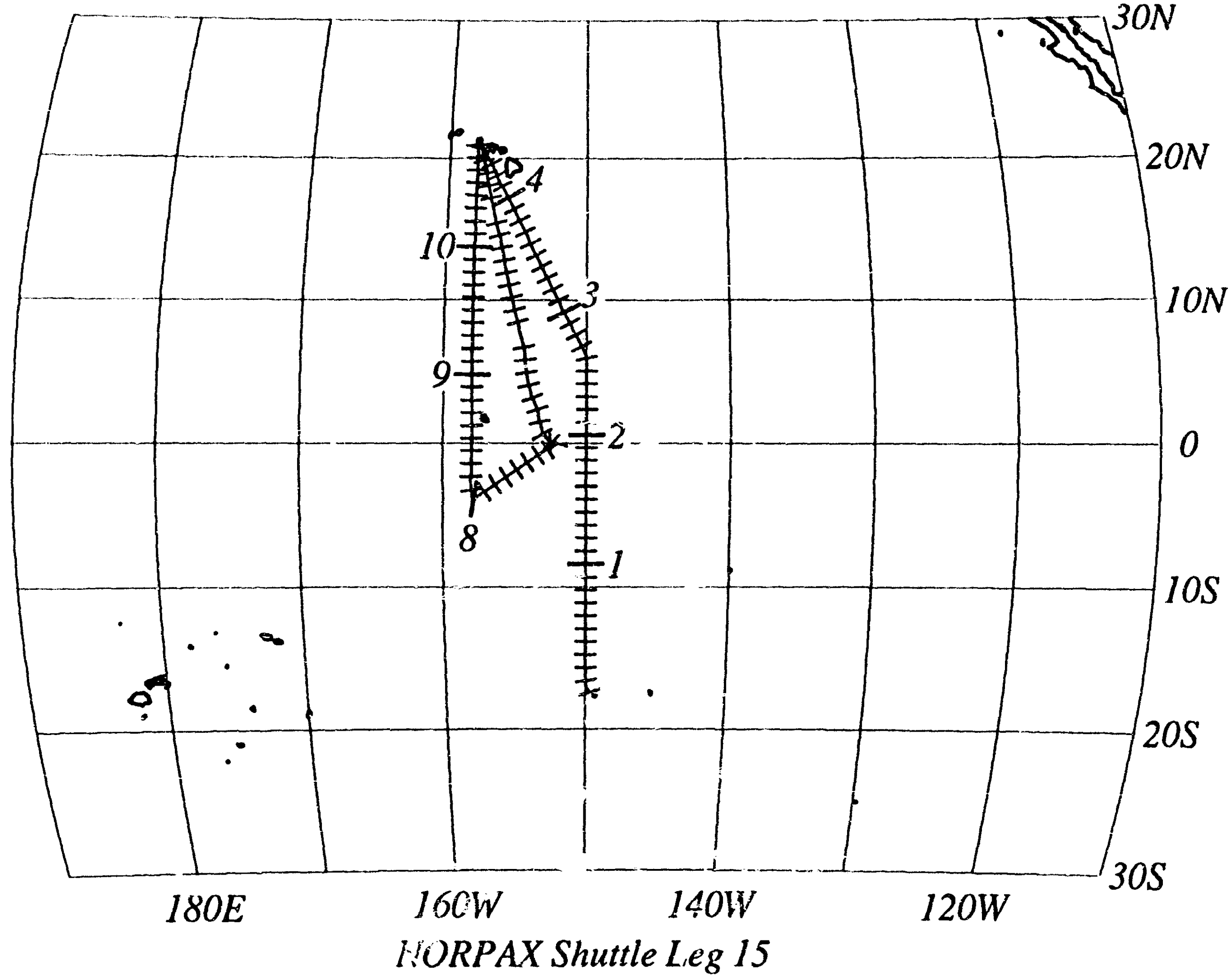


Figure 26. Cruise track plot, NORPAX Shuttle Leg 15. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

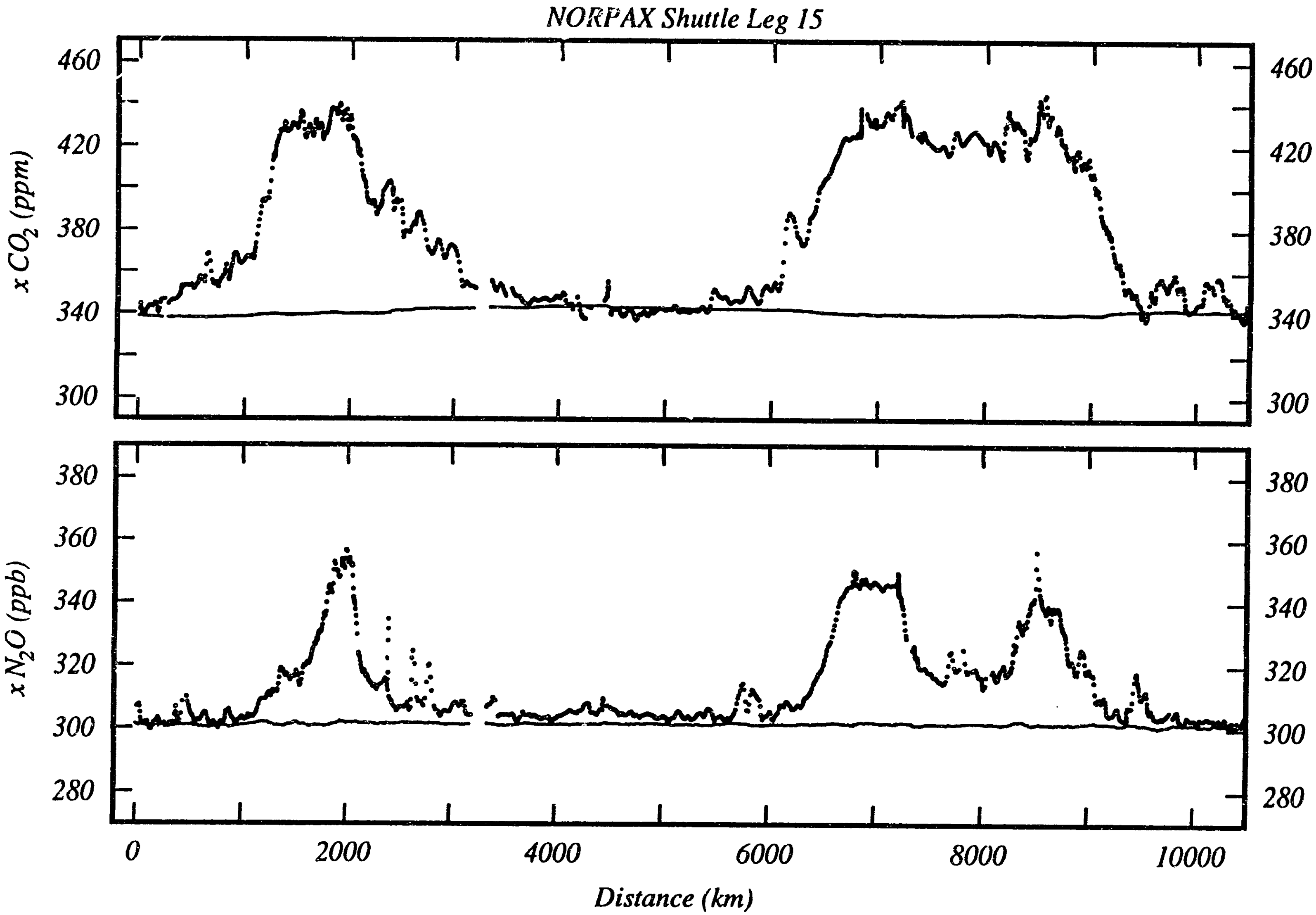


Figure 27. Data plot of xCO_2 and xN_2O (dry gas mole fractions), NORPAX Shuttle Leg 15. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

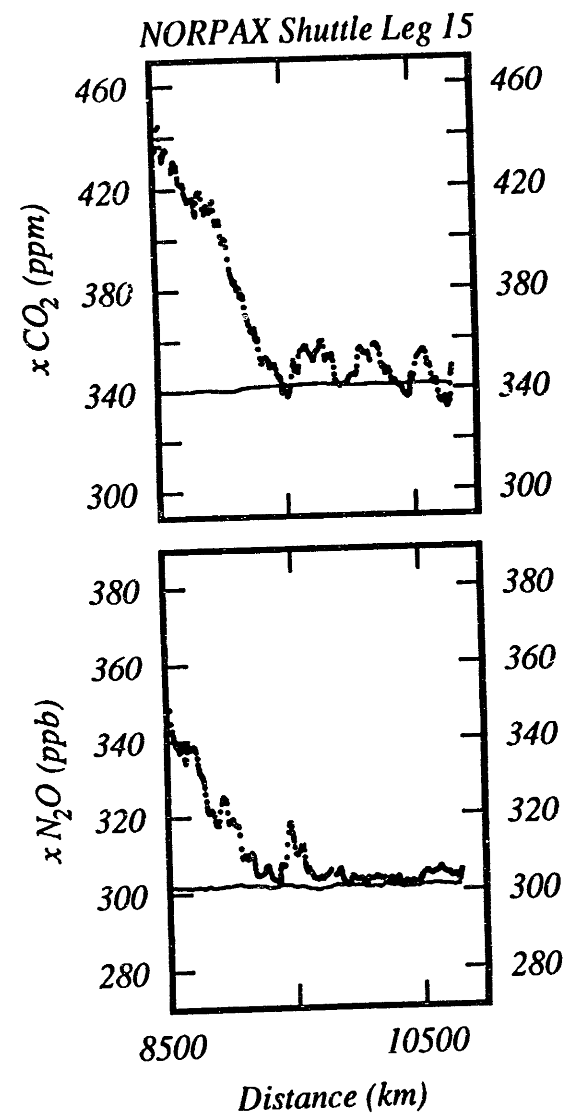


Figure 27. Continued

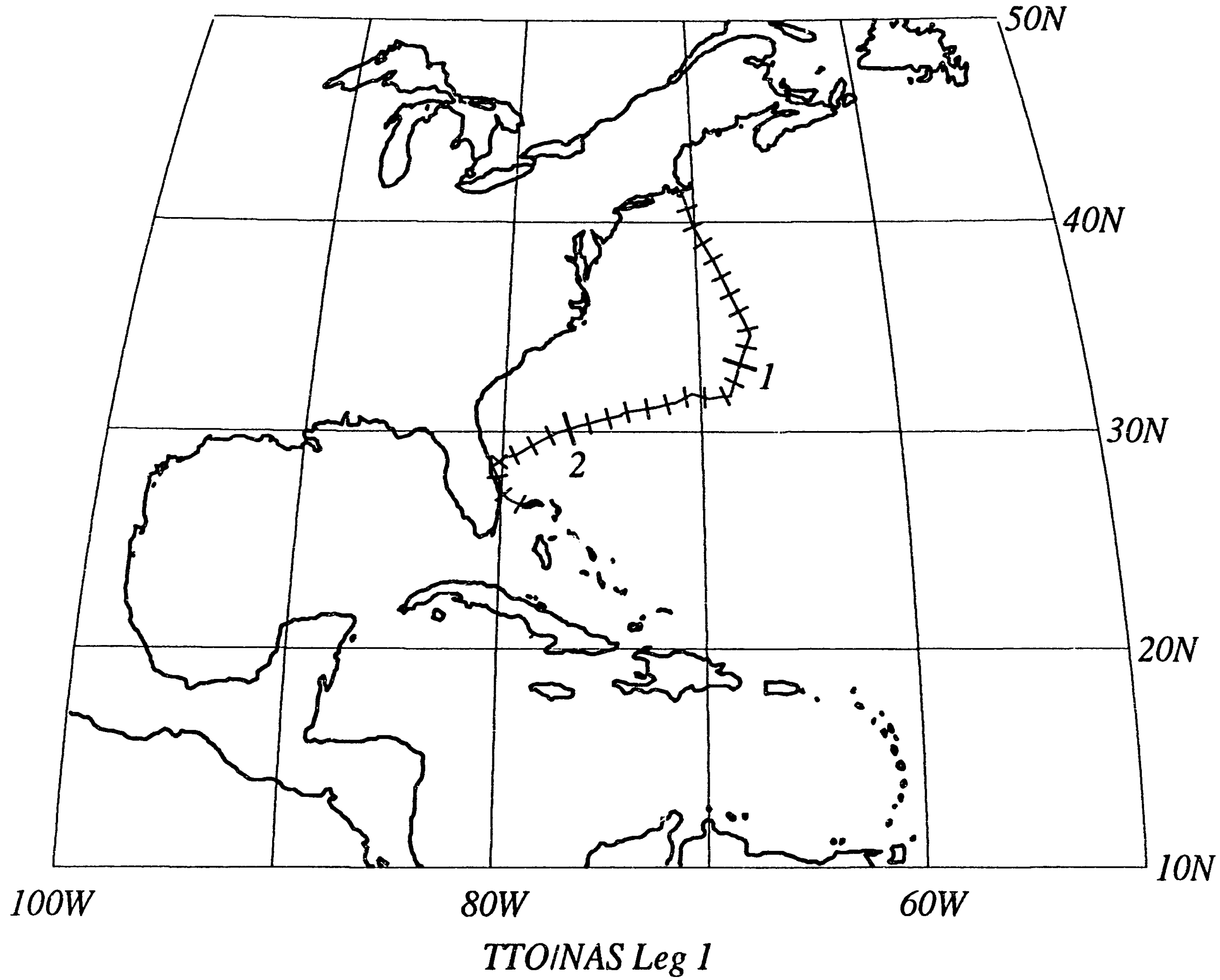


Figure 28. Cruise track plot, TTO/NAS Leg 1. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

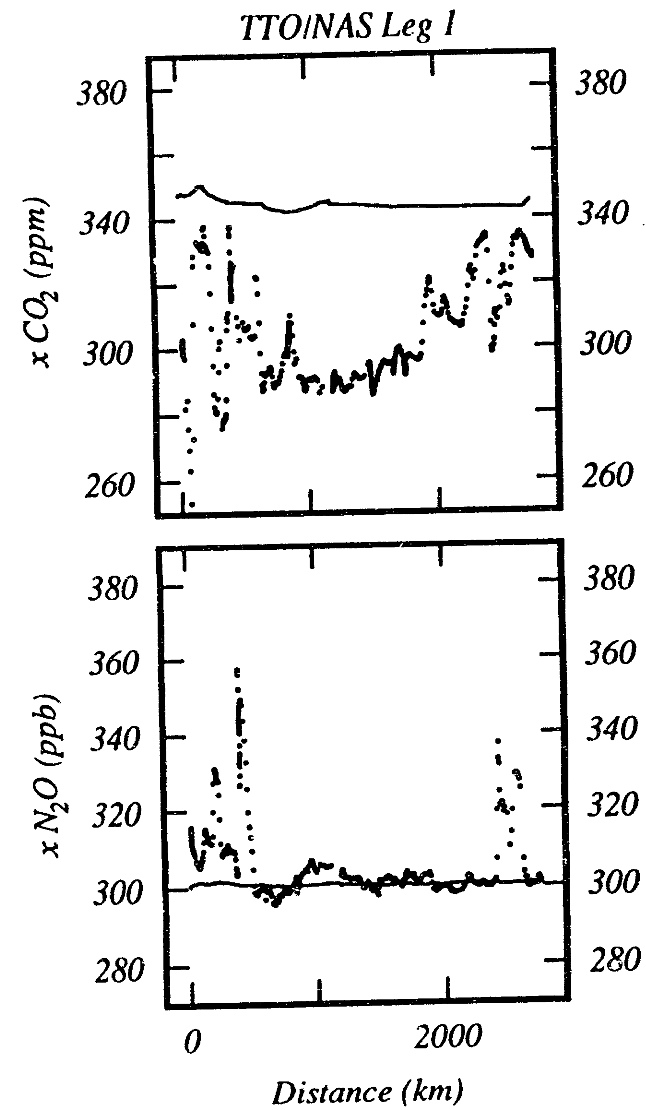


Figure 29. Data plot of xCO_2 and xN_2O (dry gas mole fractions), TTO/NAS Leg 1. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

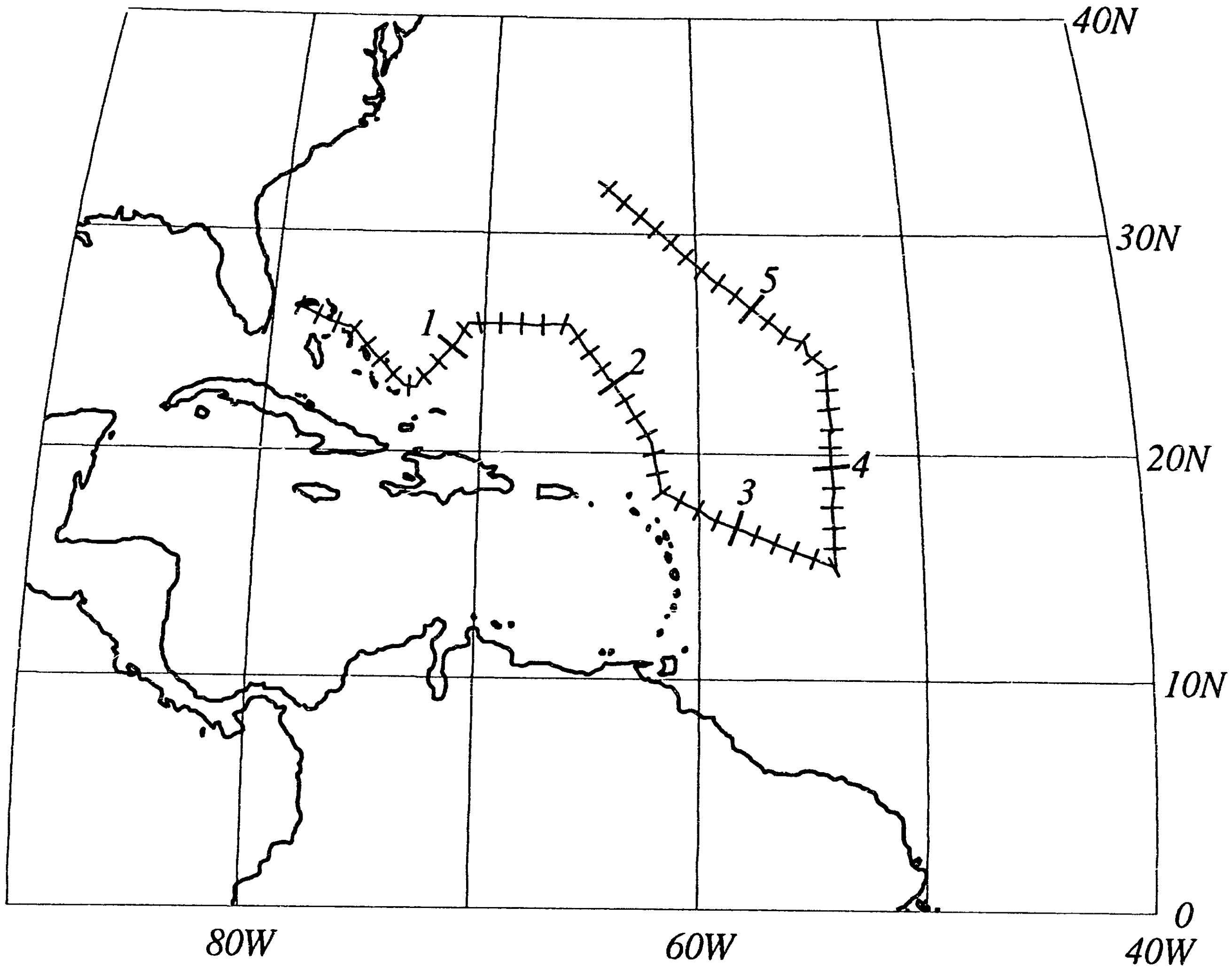


Figure 30. Cruise track plot, TTO/NAS Leg 2. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

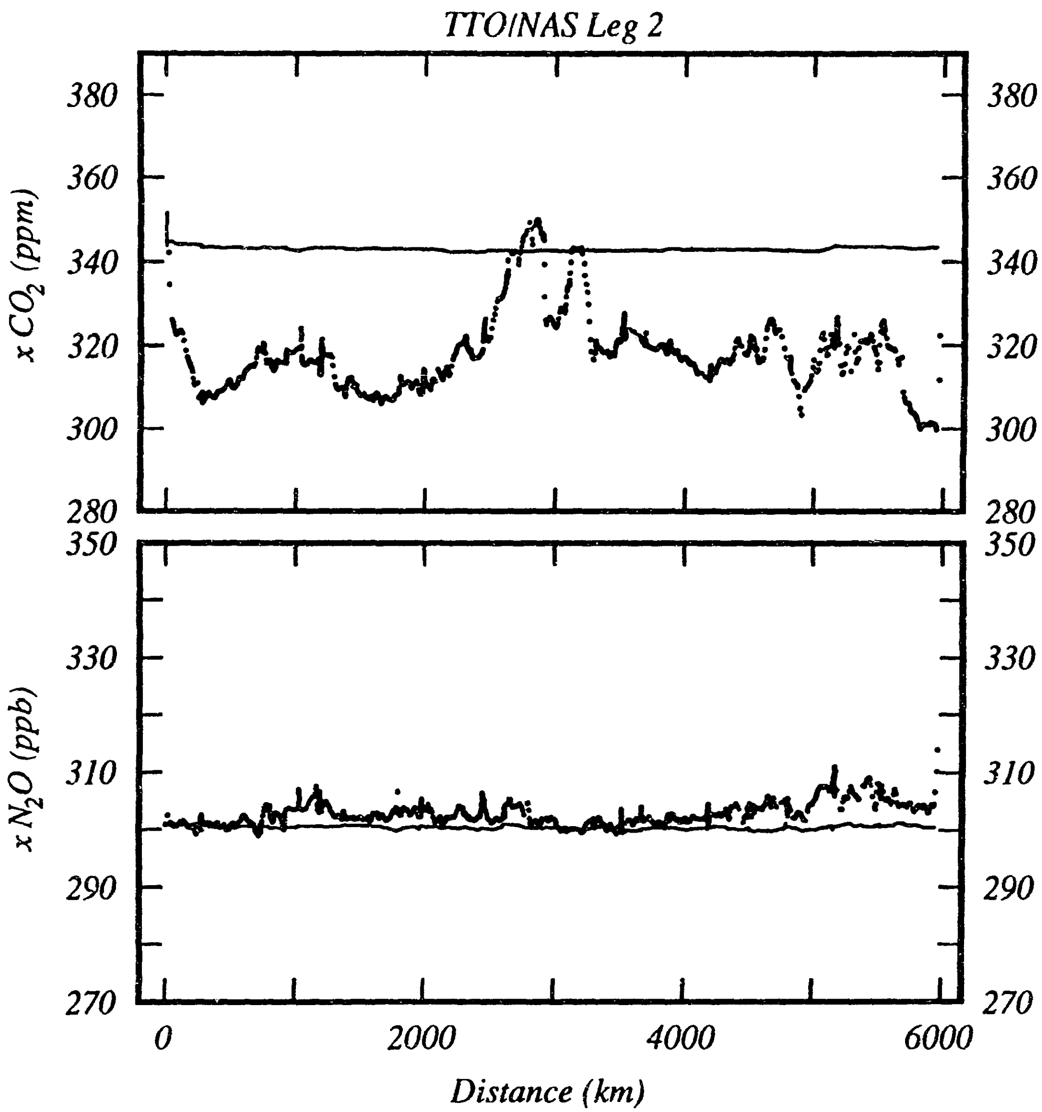


Figure 31. Data plot of xCO_2 and xN_2O (dry gas mole fractions), TTO/NAS Leg 2. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

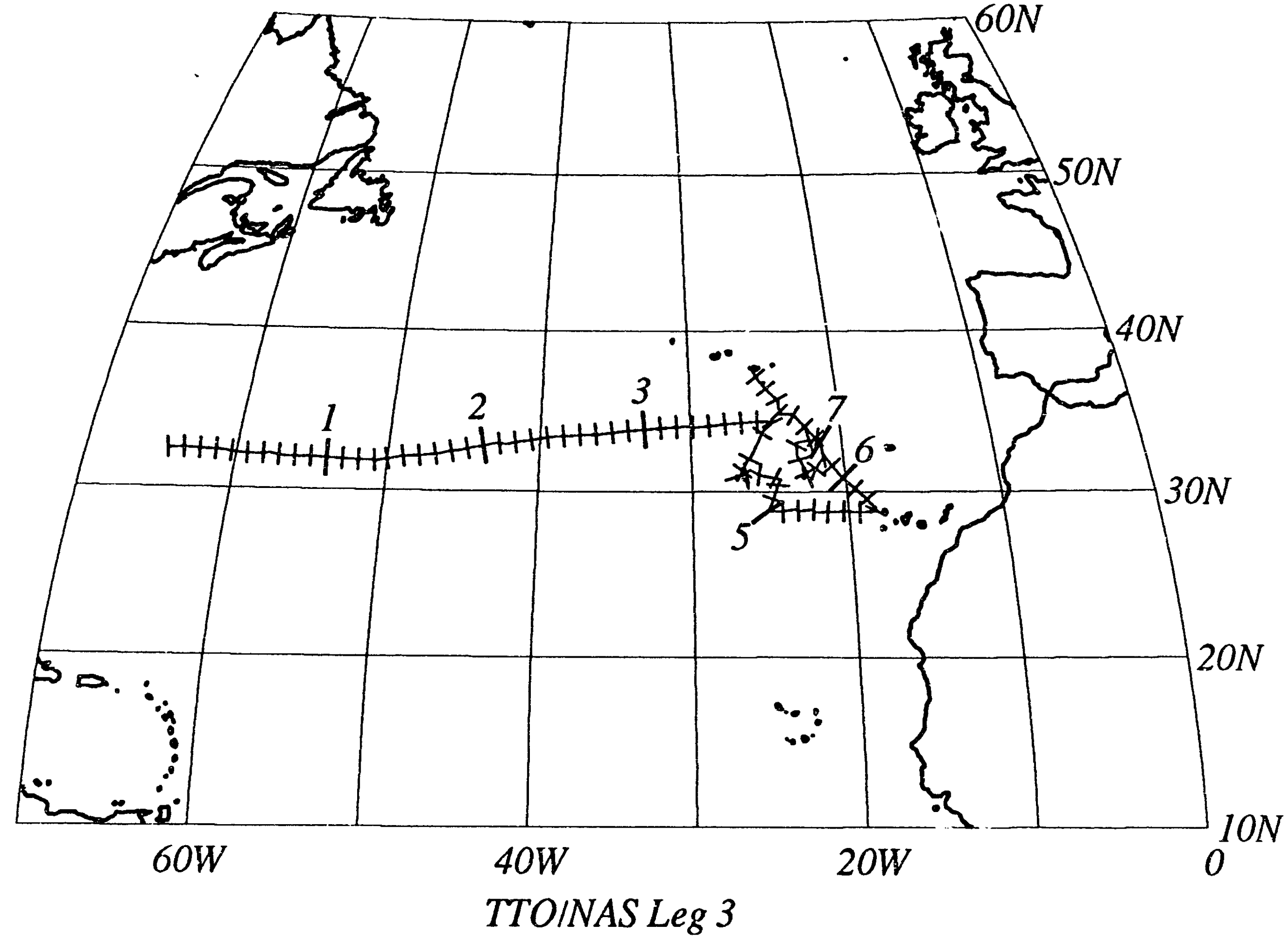


Figure 32. Cruise track plot, TTO/NAS Leg 3. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

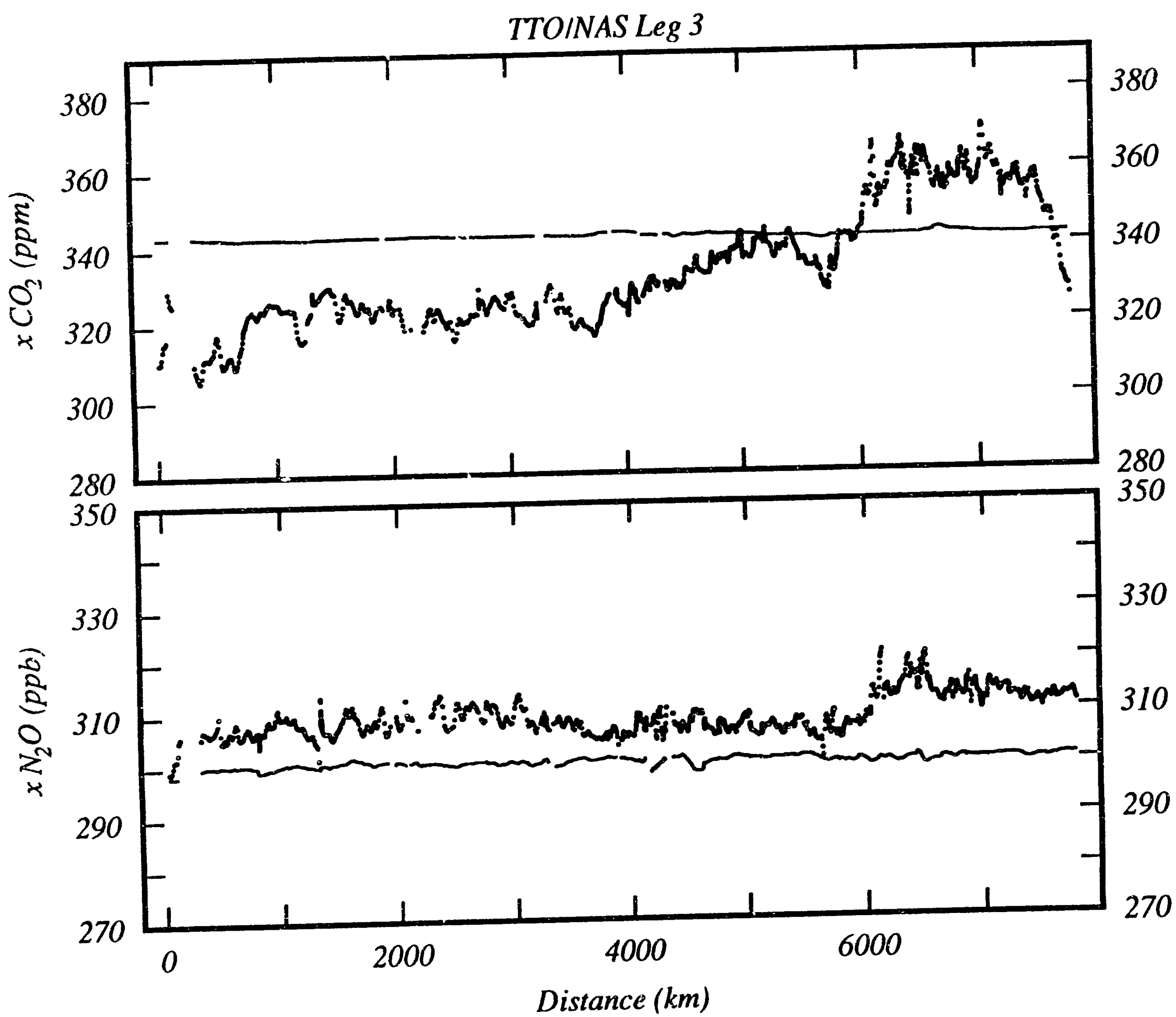


Figure 33. Data plot of xCO_2 and xN_2O (dry gas mole fractions), TTO/NAS Leg 3. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

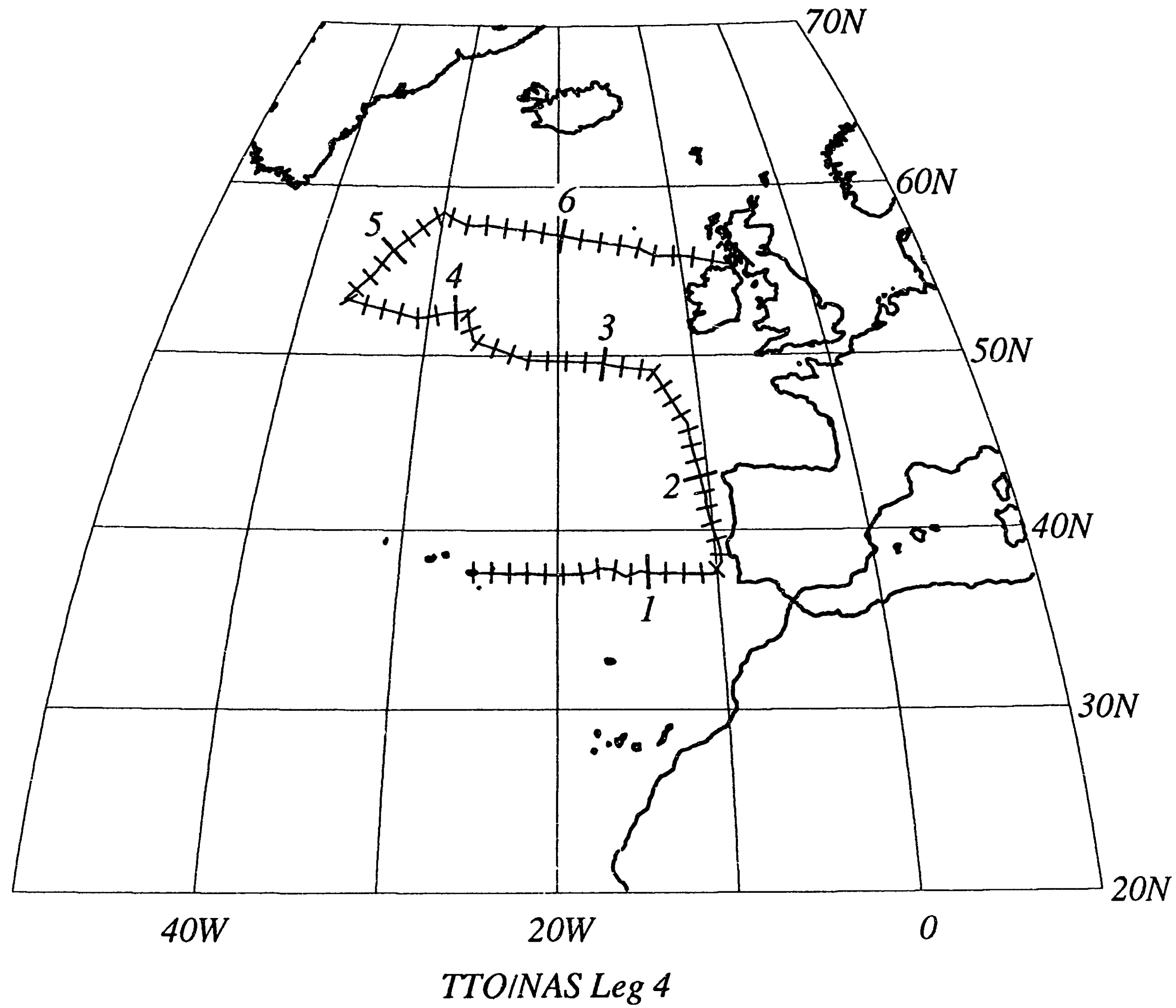


Figure 34. Cruise track plot, TTO/NAS Leg 4. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

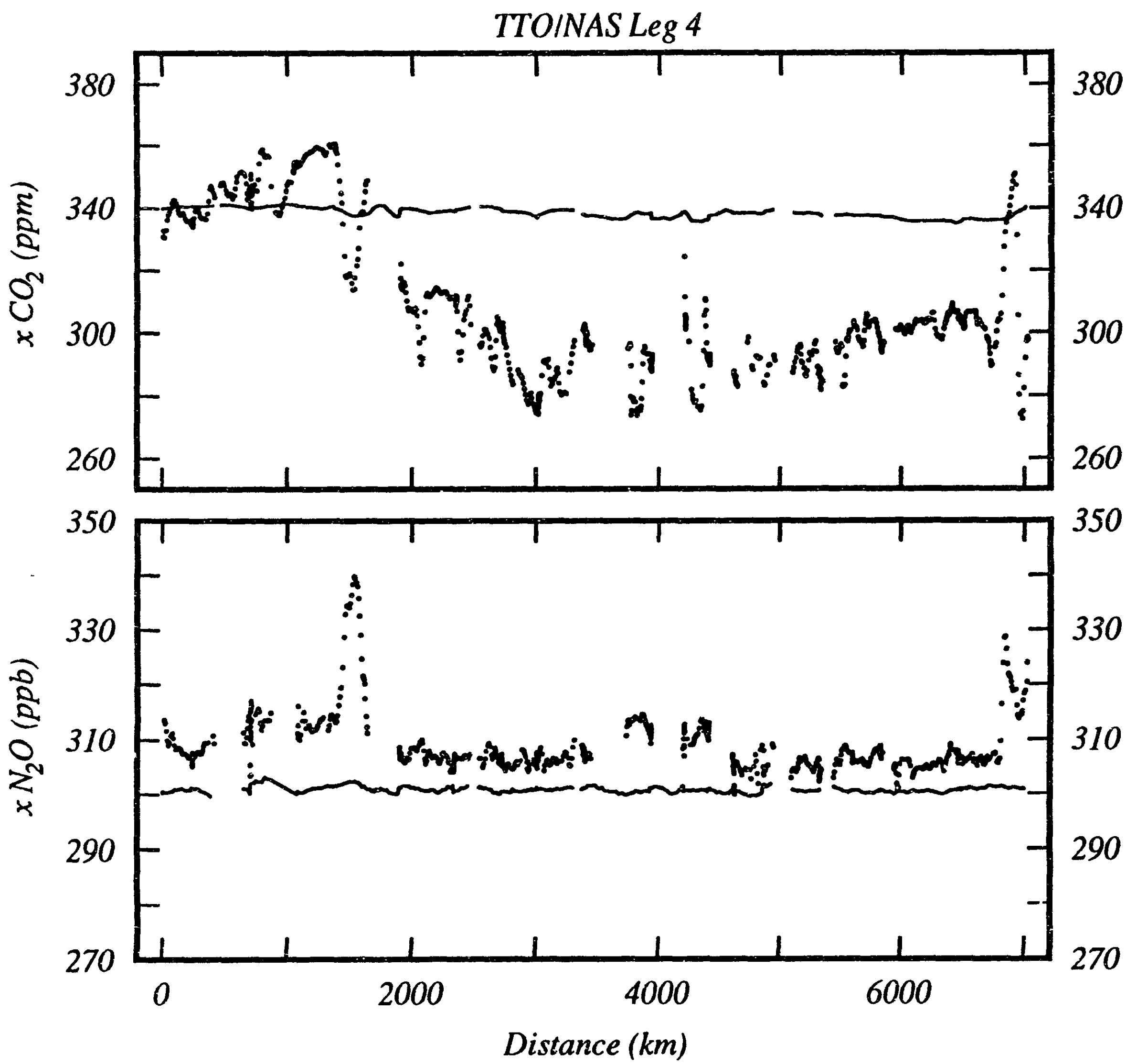


Figure 35. Data plot of xCO_2 and xN_2O (dry gas mole fractions), TTO/NAS Leg 4. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

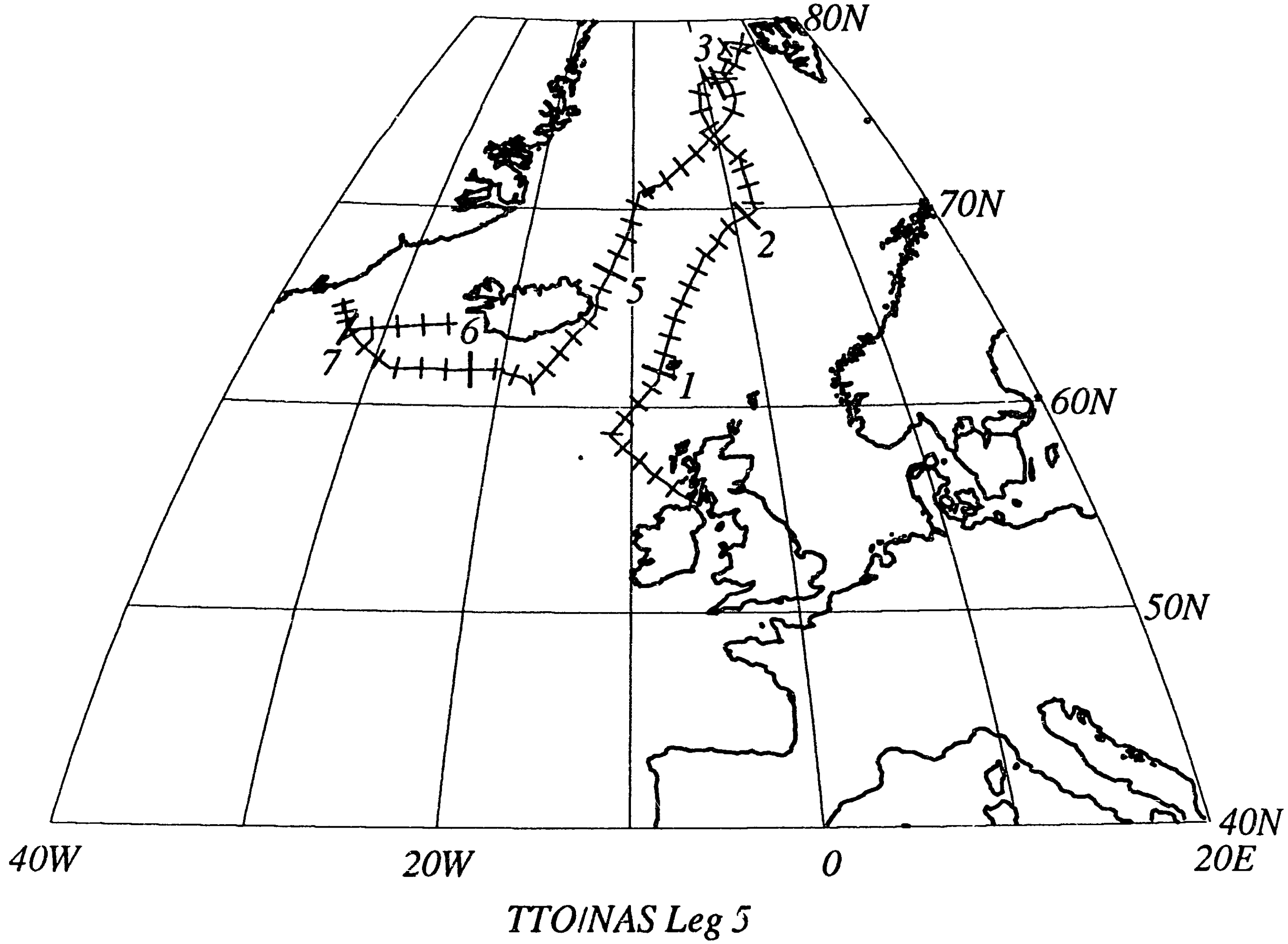


Figure 36. Cruise track plot, TTO/NAS Leg 5. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

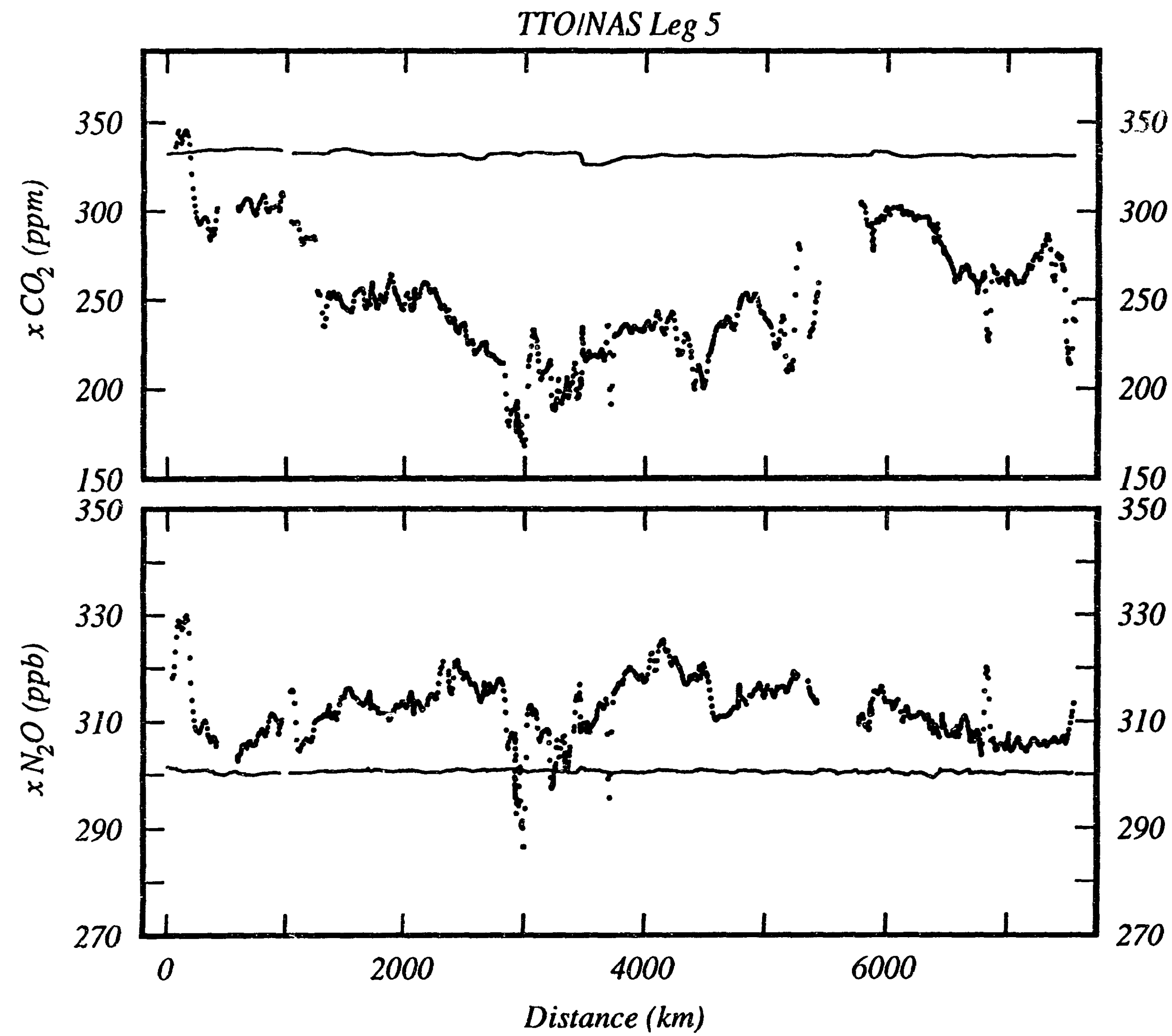


Figure 37. Data plot of xCO_2 and xN_2O (dry gas mole fractions), TTO/NAS Leg 5. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

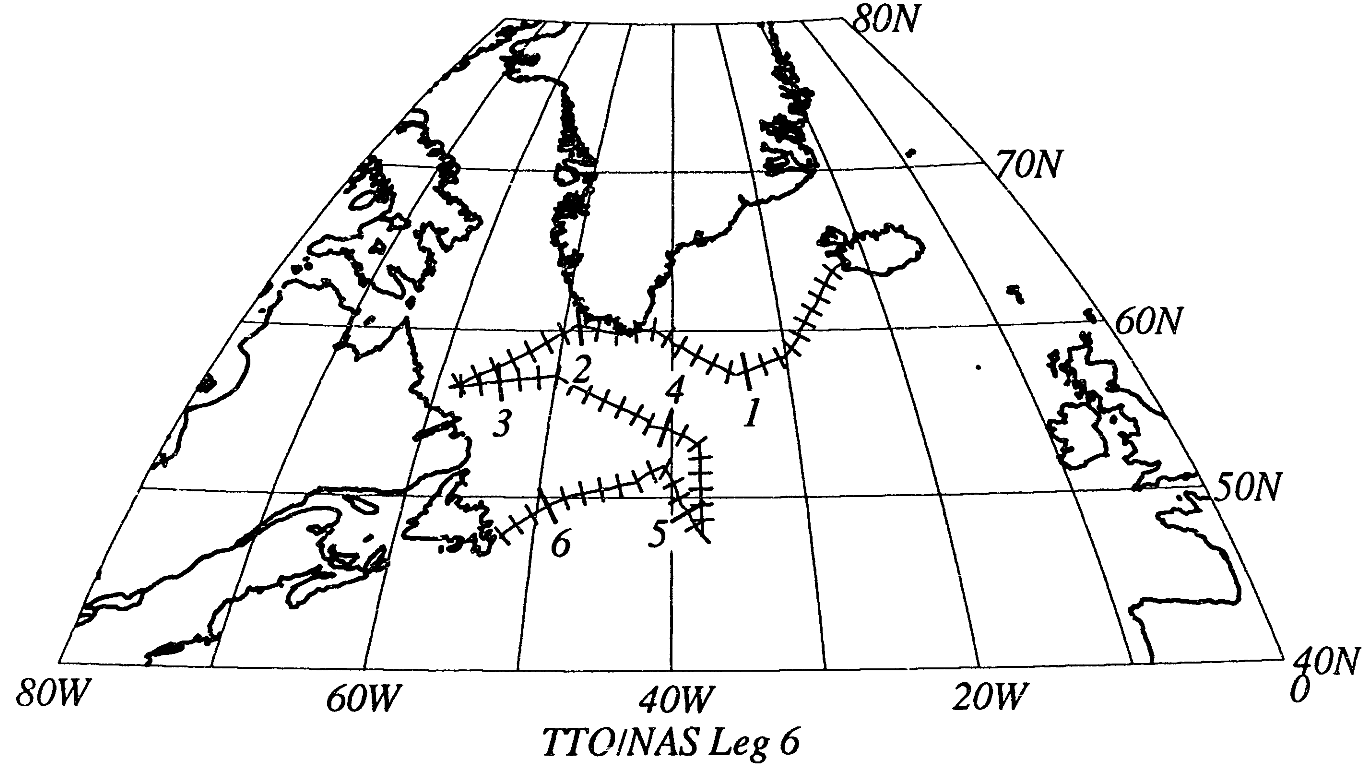


Figure 38. Cruise track plot, TTO/NAS Leg 6. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

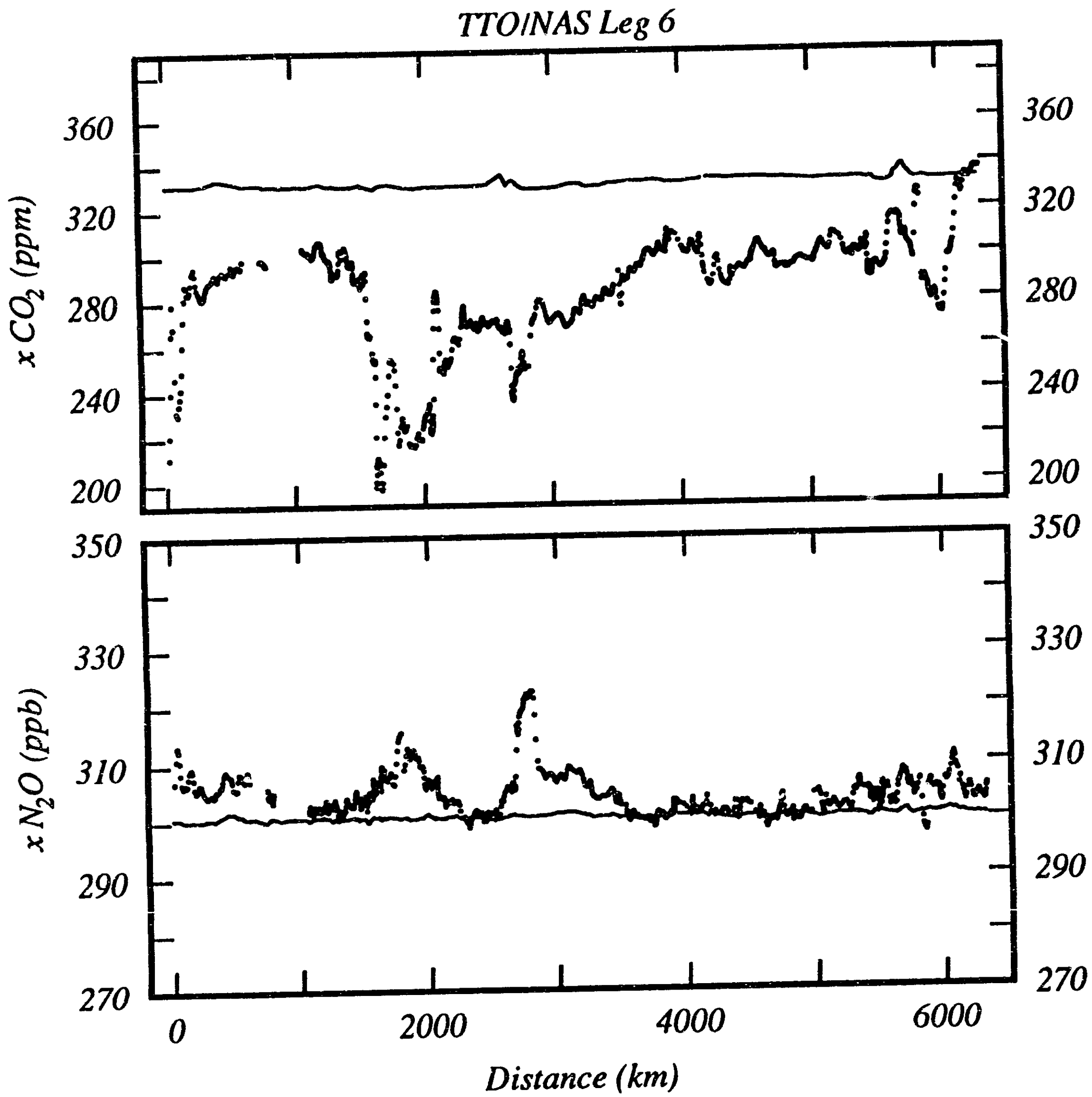


Figure 39. Data plot of xCO_2 and xN_2O (dry gas mole fractions), TTO/NAS Leg 6. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

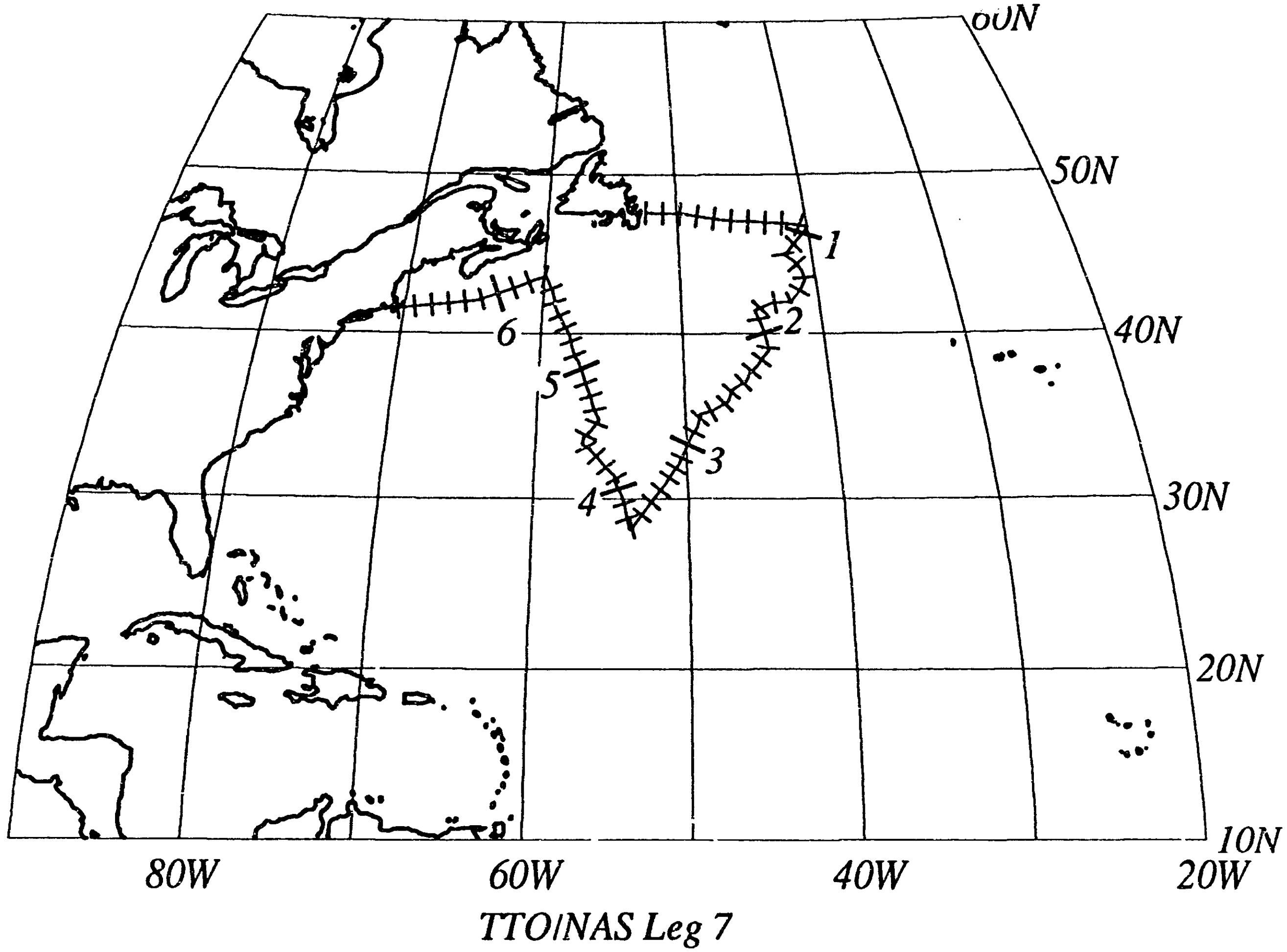


Figure 40. Cruise track plot, TTO/NAS Leg 7. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

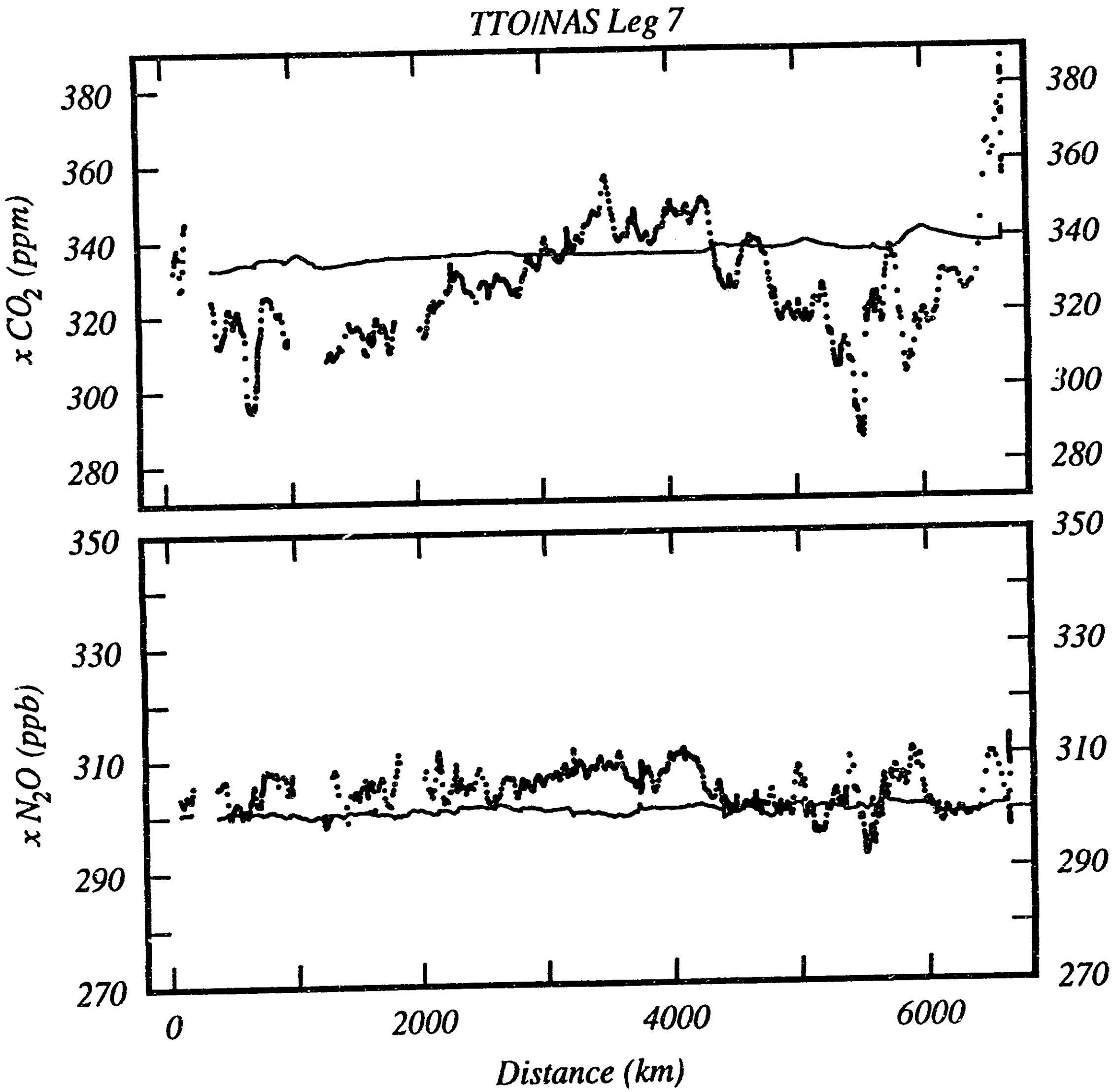


Figure 41. Data plot of xCO_2 and xN_2O (dry gas mole fractions), TTO/NAS Leg 7. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

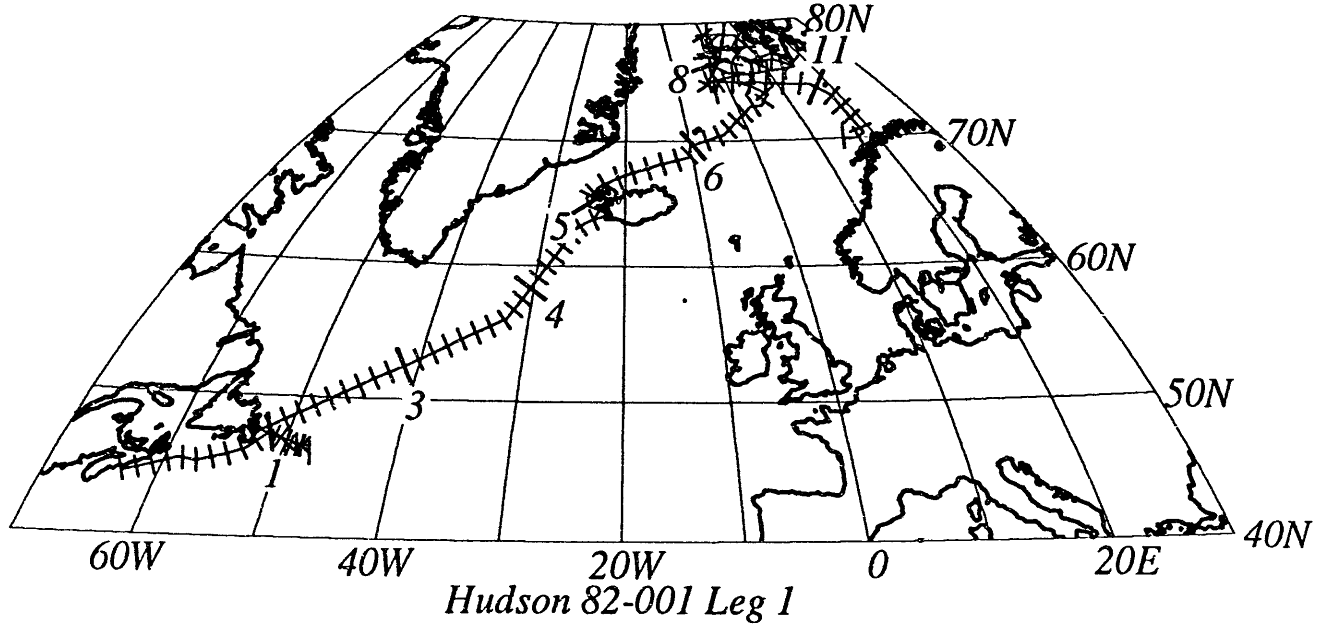


Figure 42. Cruise track plot, Hudson 82-001 Leg 1. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

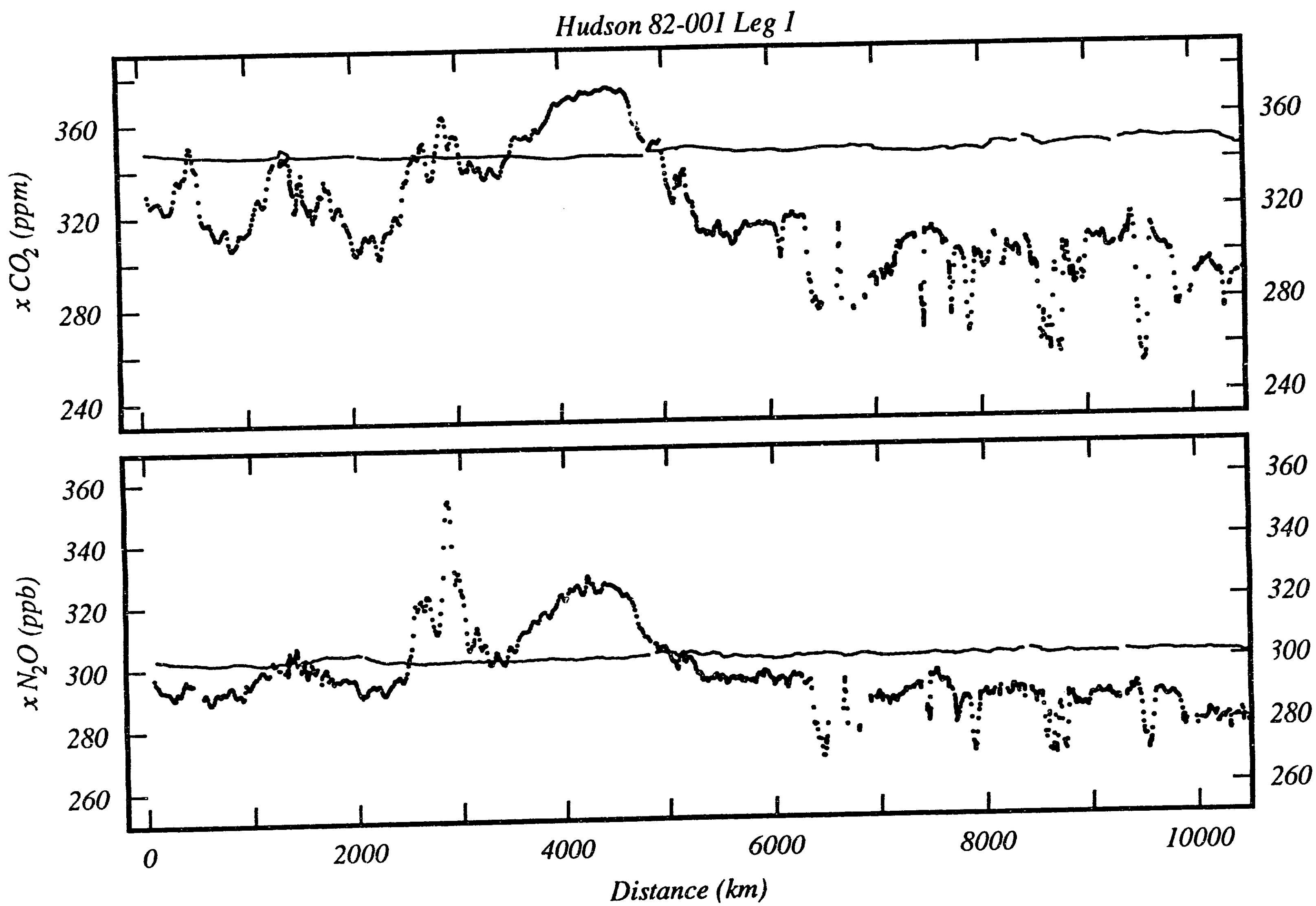


Figure 43. Data plot of xCO_2 and xN_2O (dry gas mole fractions), Hudson 82-001 Leg 1. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

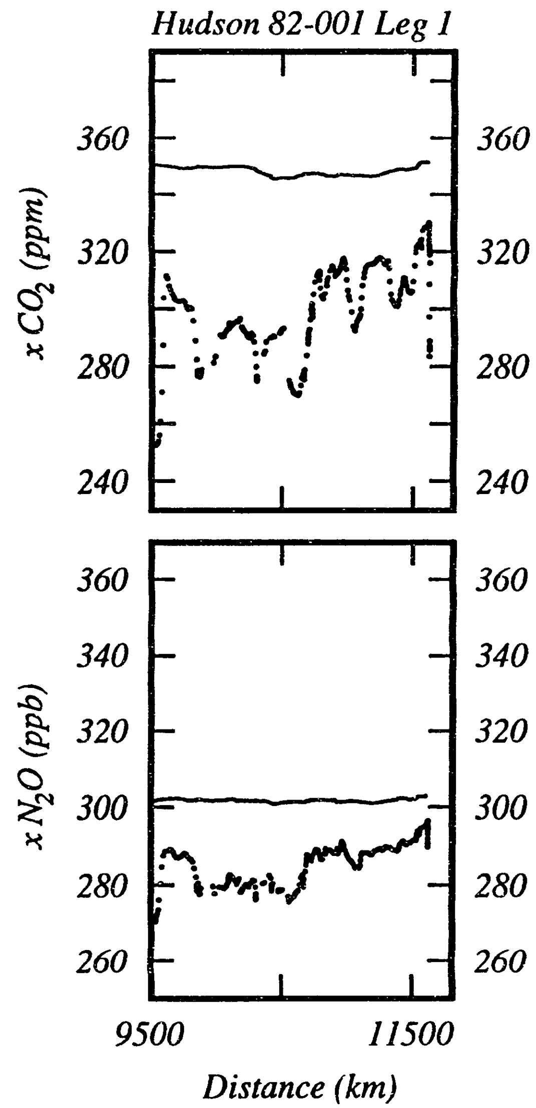


Figure 43. Continued

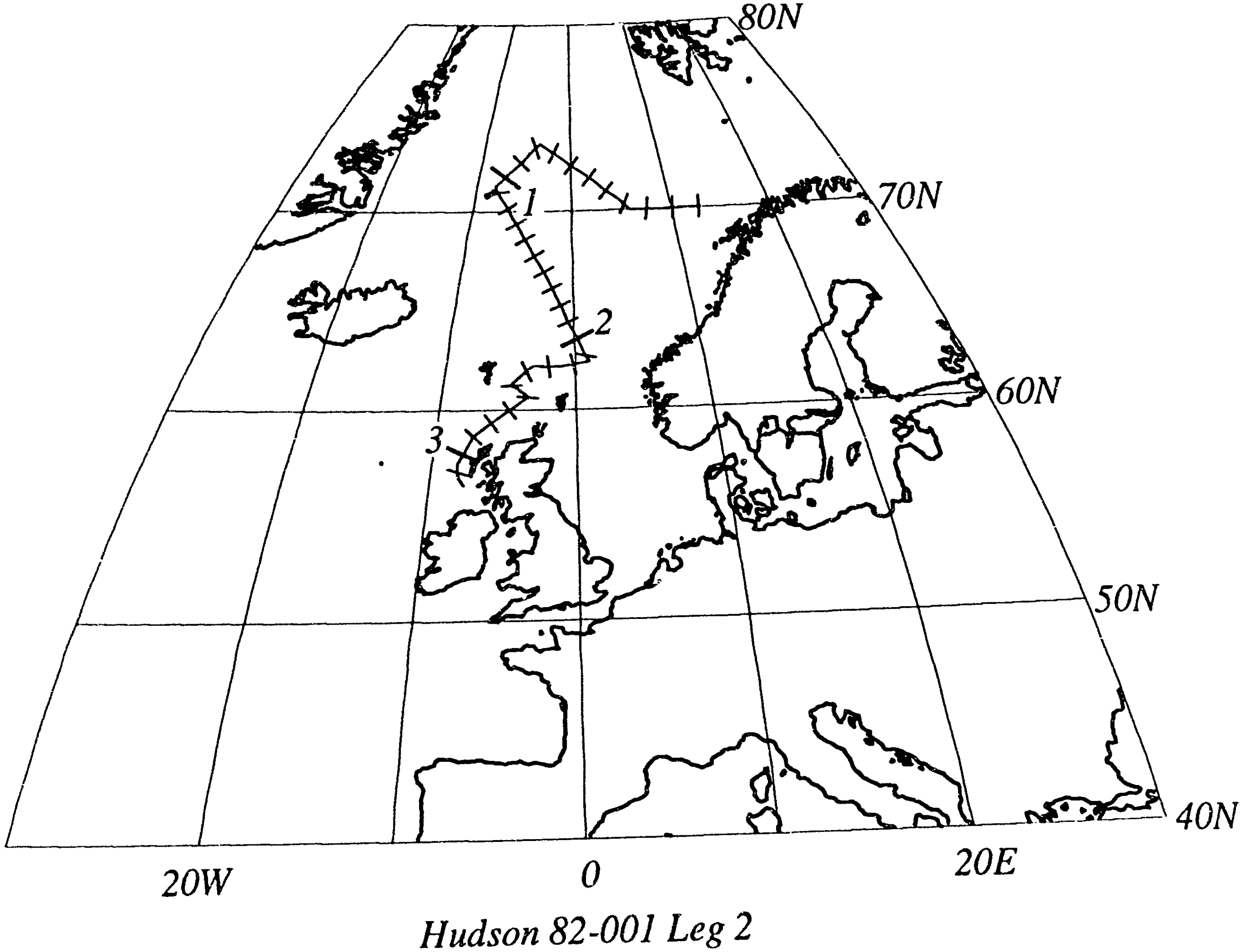


Figure 44. Cruise track plot, Hudson 82-001 Leg 2. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

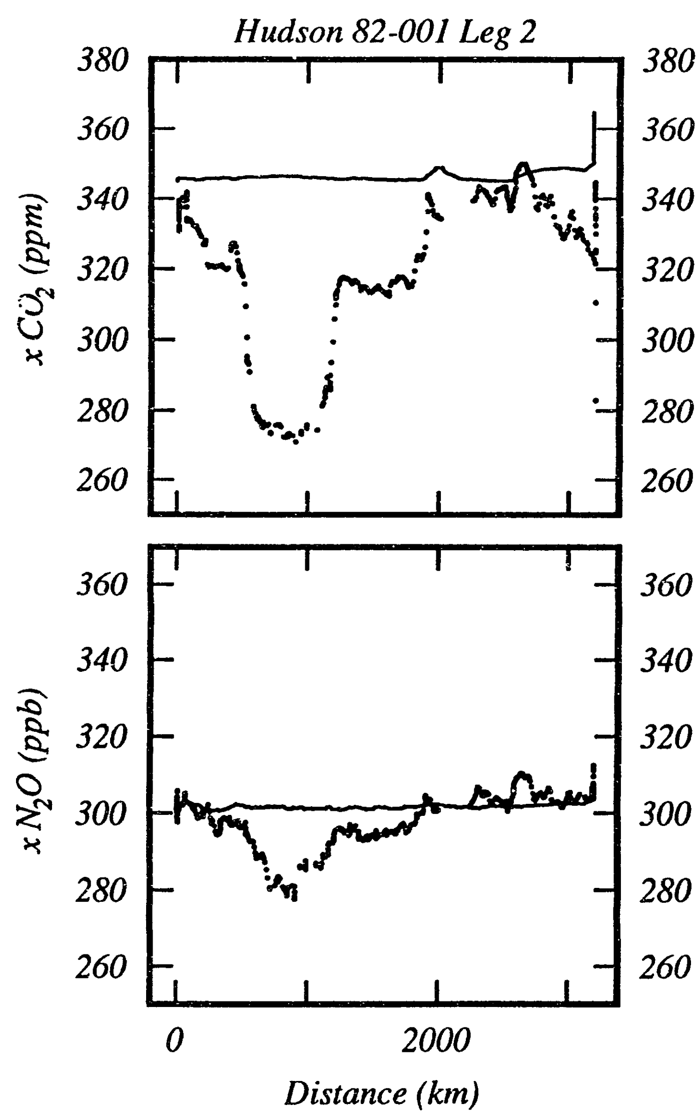


Figure 45. Data plot of xCO_2 and xN_2O (dry gas mole fractions), Hudson 82-001 Leg 2. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

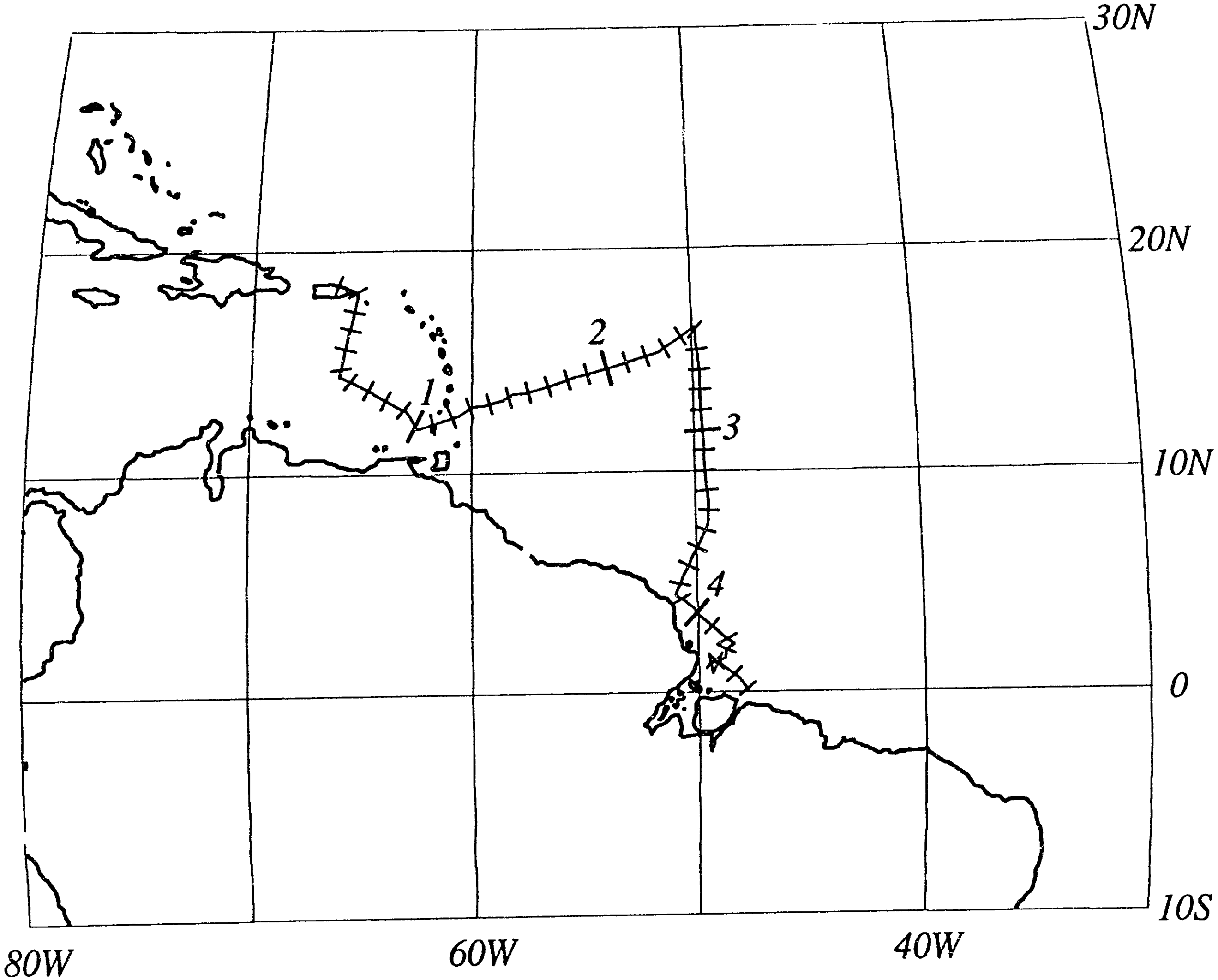


Figure 46. Cruise track plot, TTO/TAS Leg 1. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

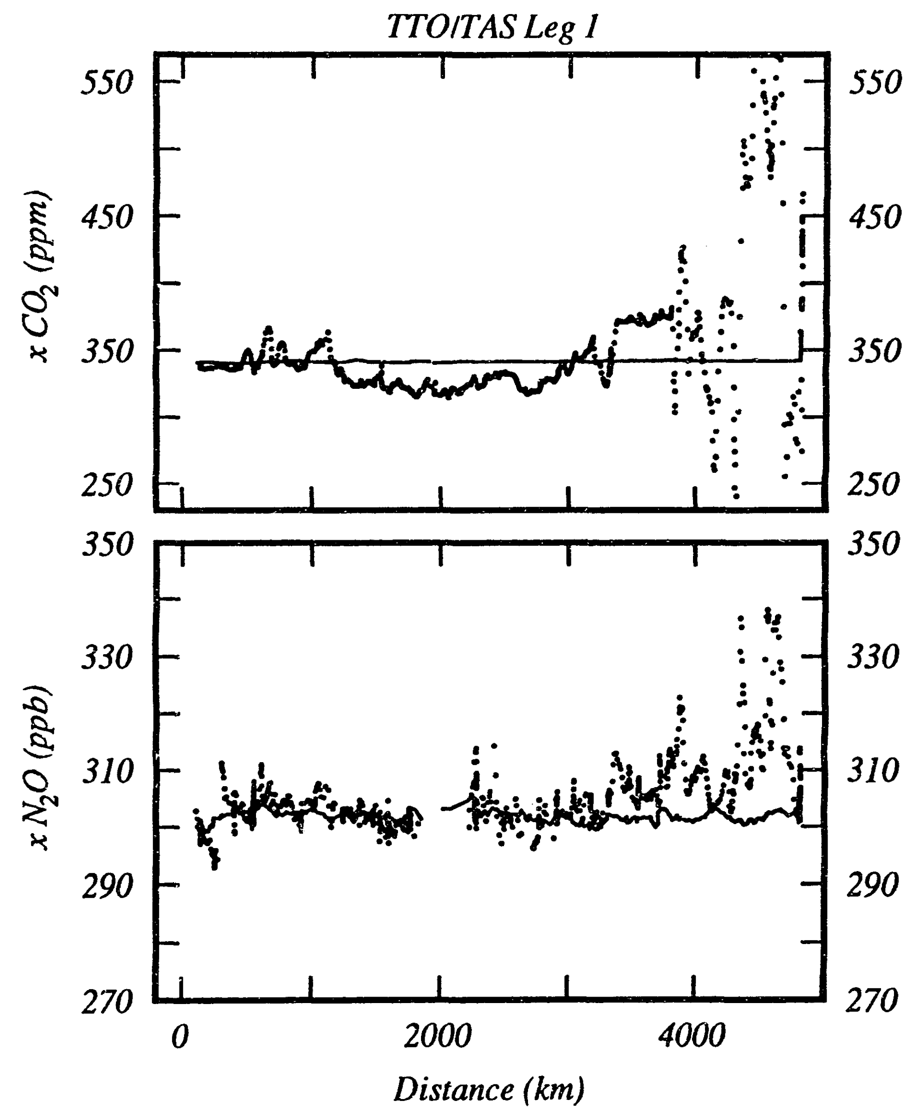


Figure 47. Data plot of xCO_2 and xN_2O (dry gas mole fractions), TTO/TAS Leg 1. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

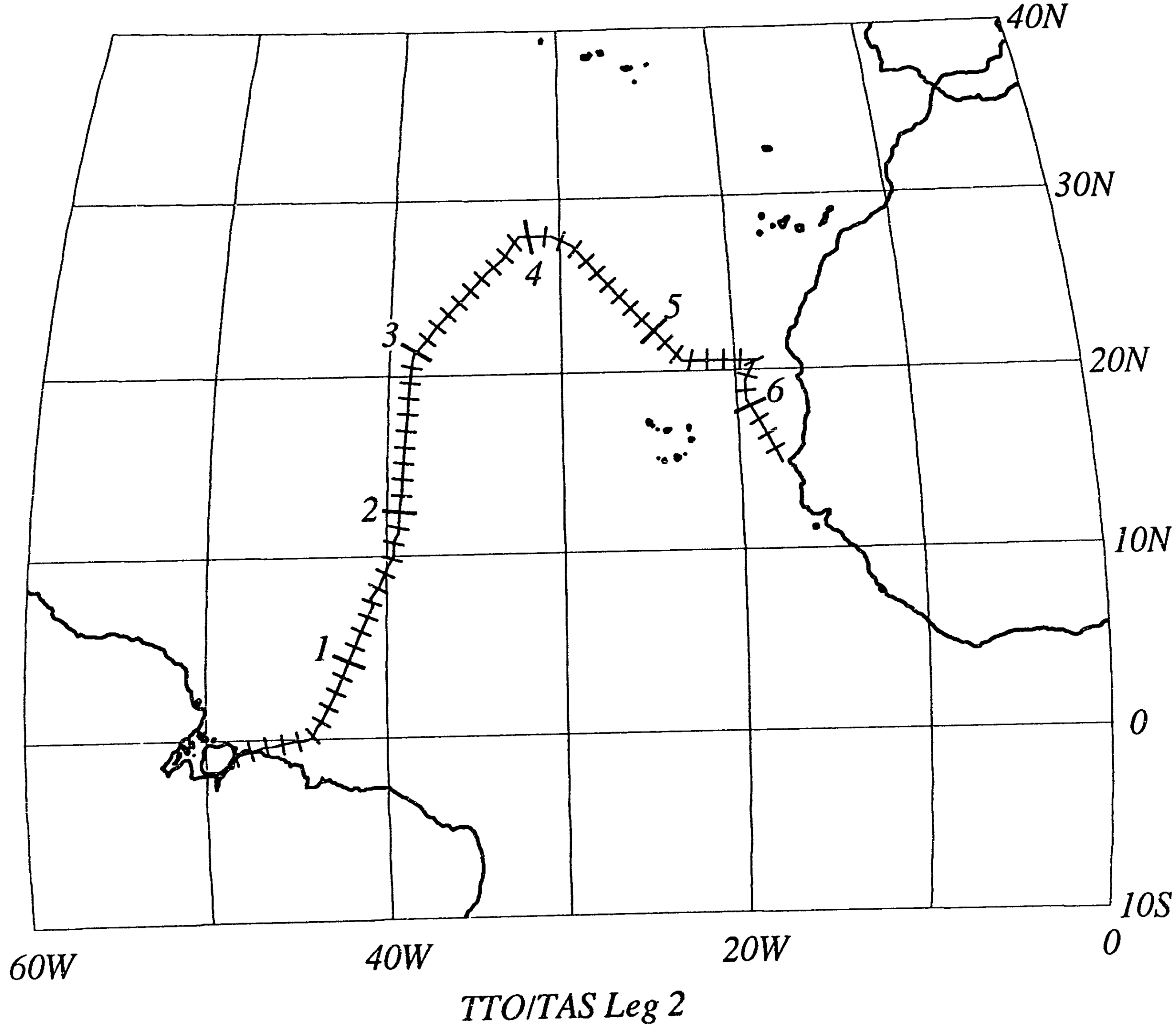


Figure 48. Cruise track plot, TTO/TAS Leg 2. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

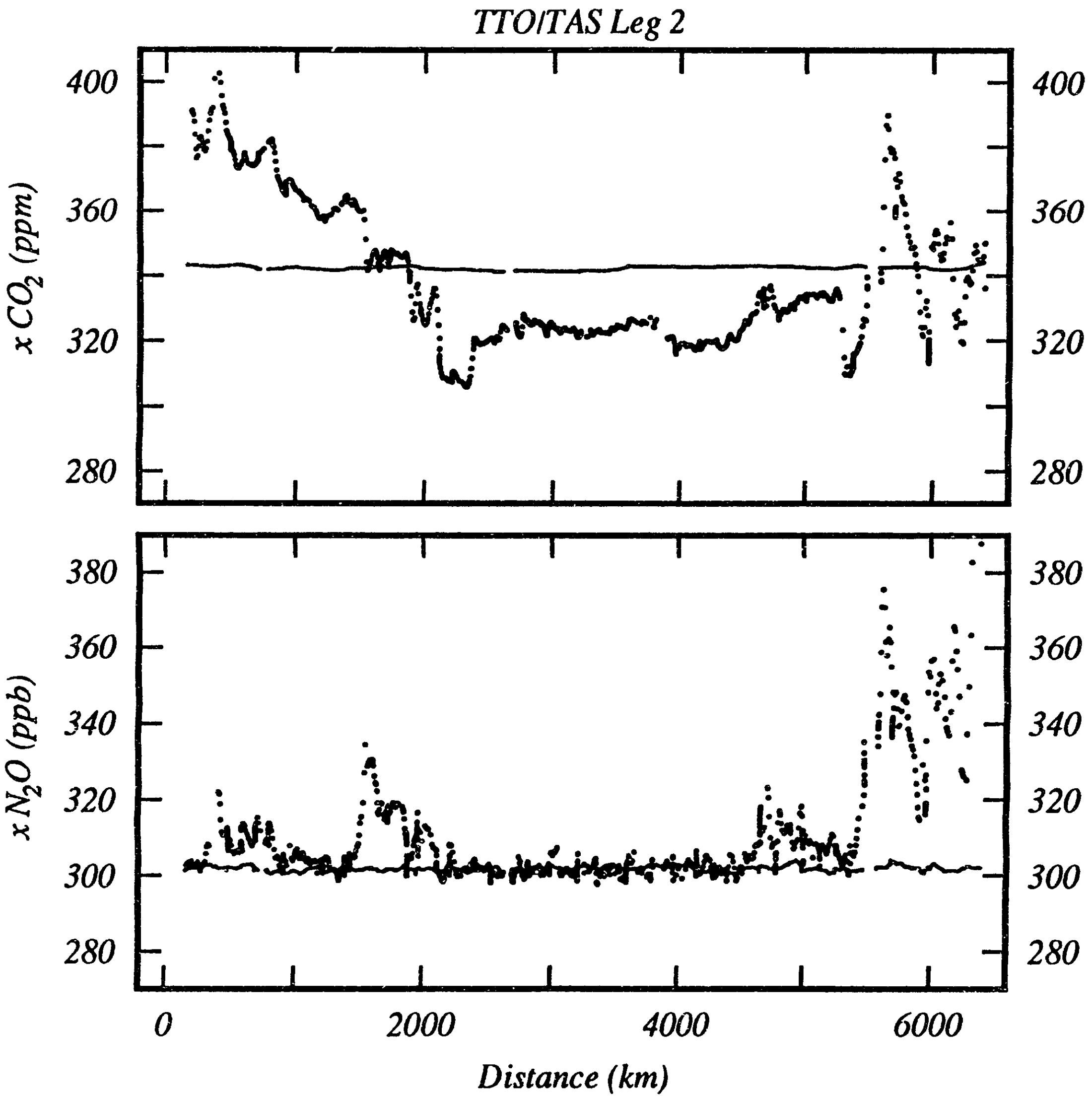


Figure 49. Data plot of xCO_2 and xN_2O (dry gas mole fractions), TTO/TAS Leg 2. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

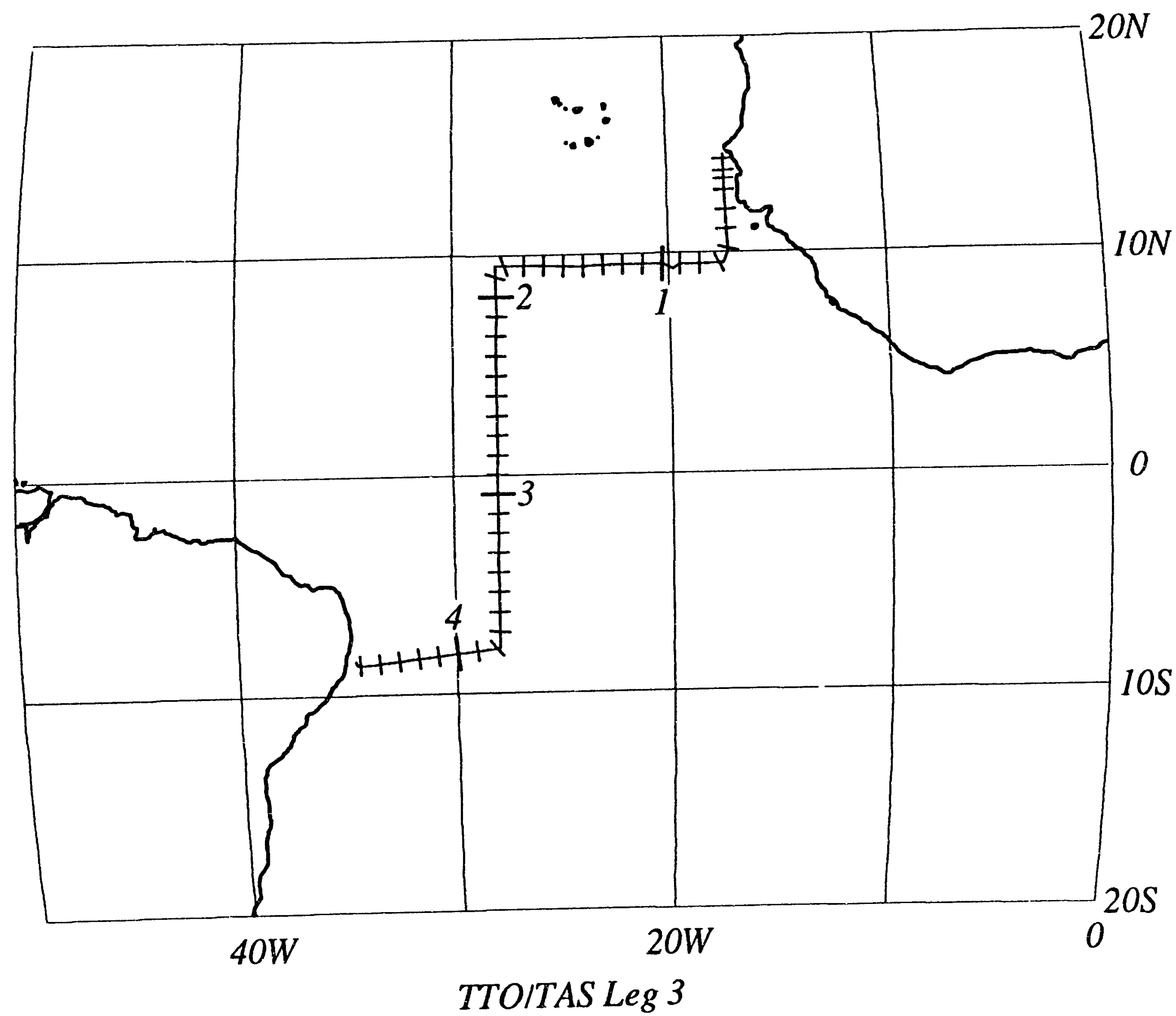


Figure 50. Cruise track plot, TTO/TAS Leg 3. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

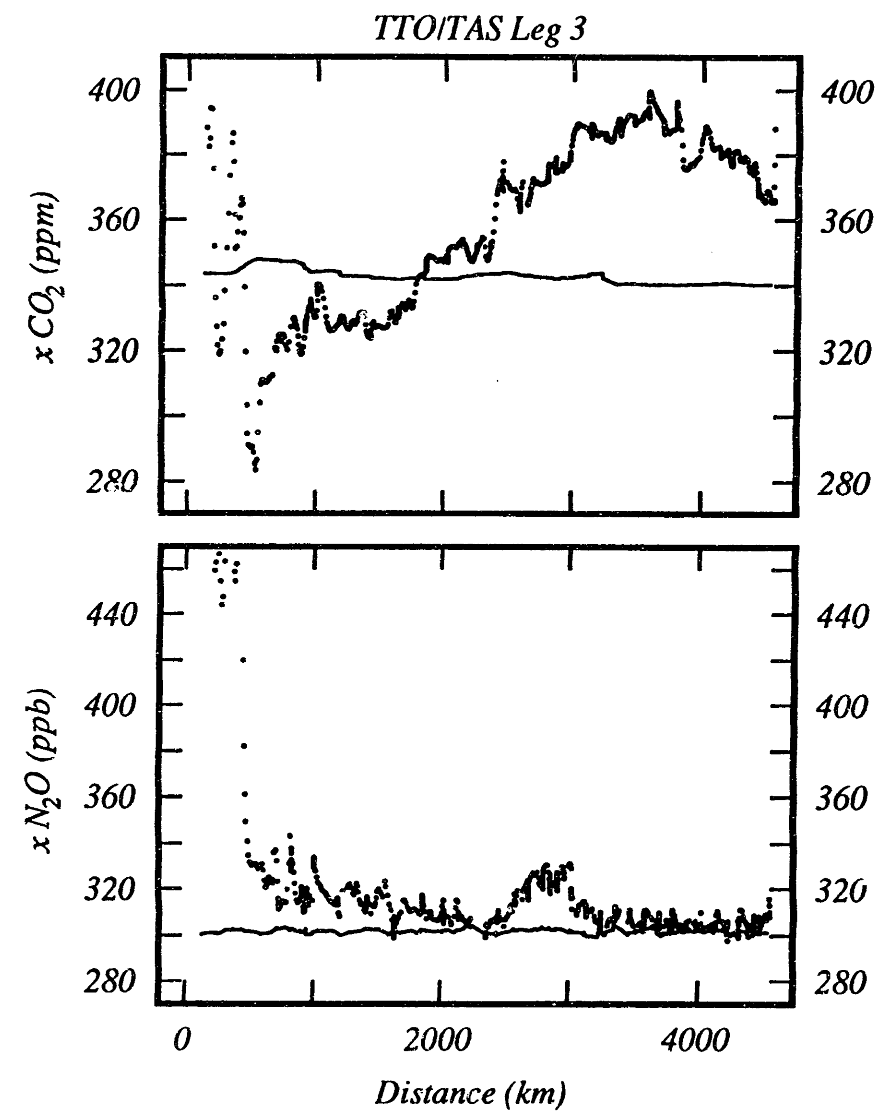


Figure 51. Data plot of xCO_2 and xN_2O (dry gas mole fractions), TTO/TAS Leg 3. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

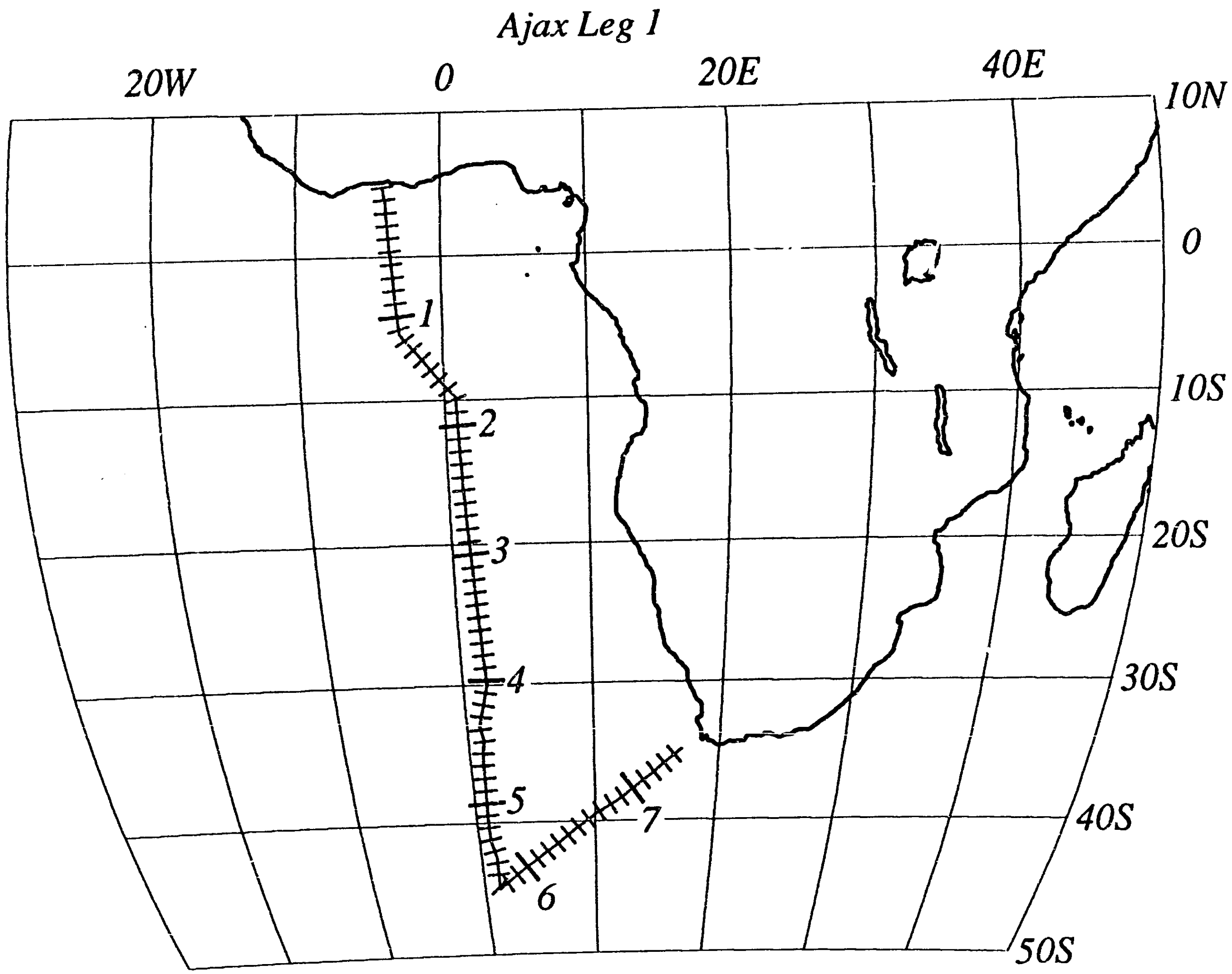


Figure 52. Cruise track plot, Ajax Leg 1. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

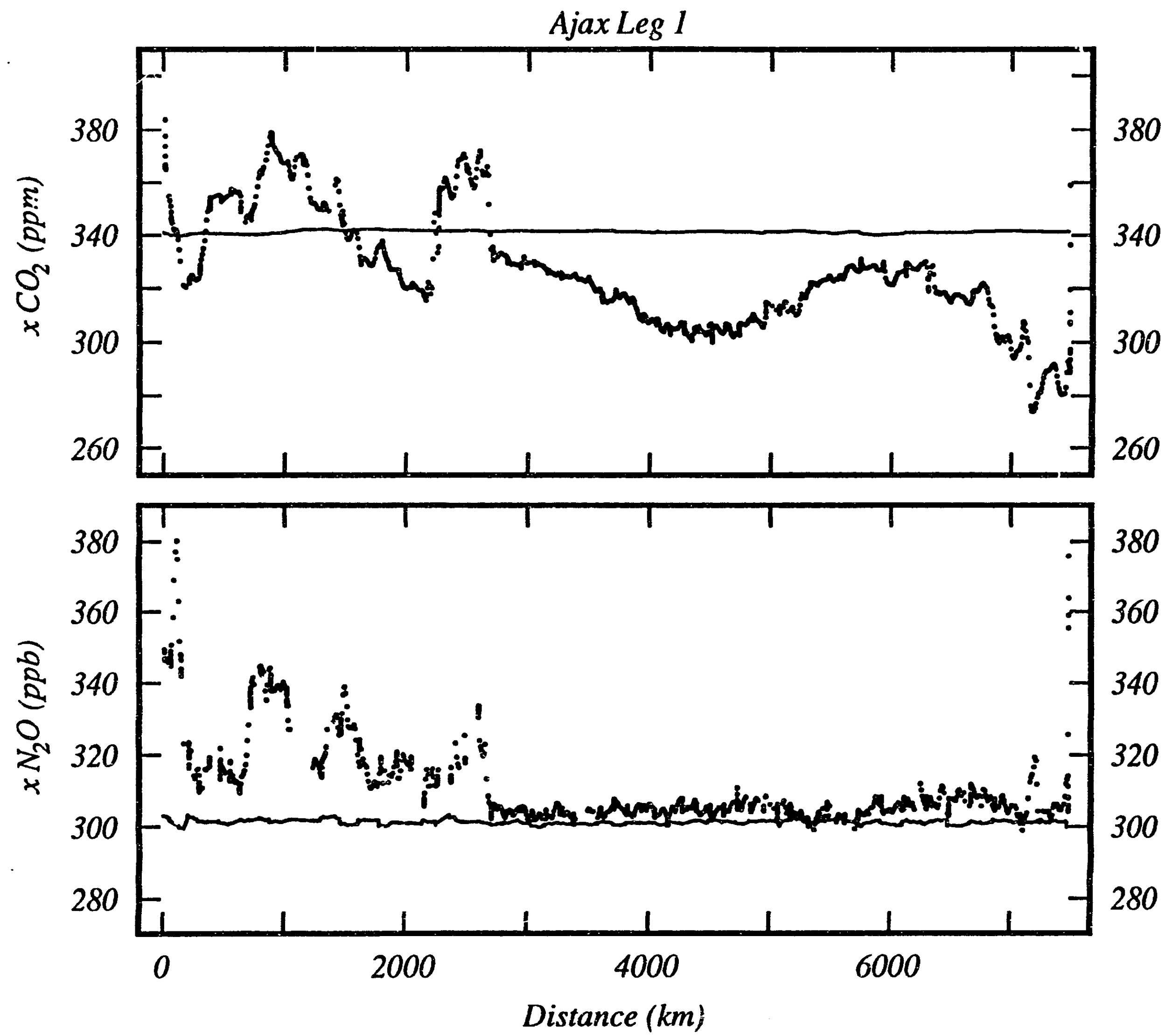


Figure 53. Data plot of xCO_2 and xN_2O (dry gas mole fractions), Ajax Leg 1. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

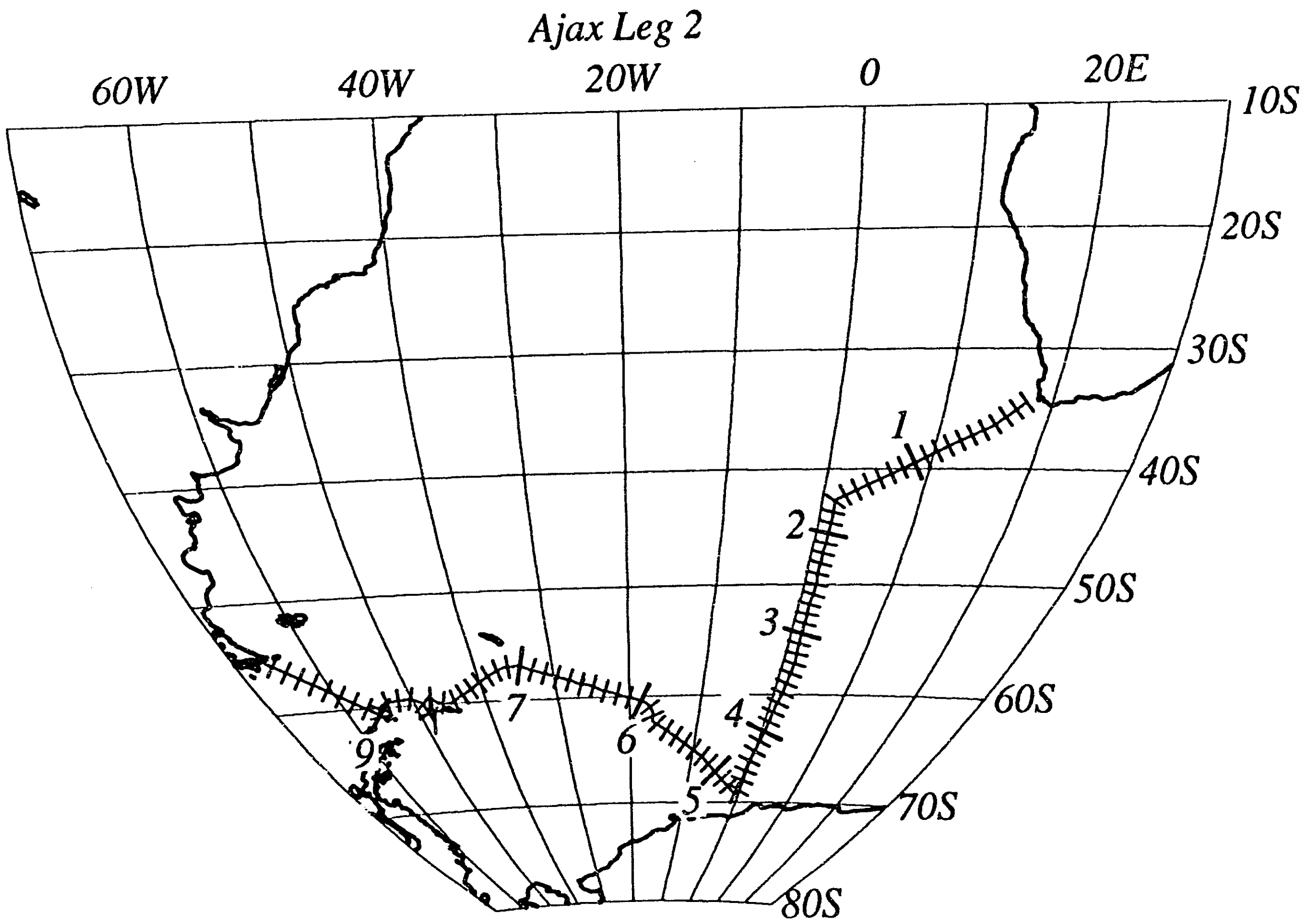


Figure 54. Cruise track plot, Ajax Leg 2. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

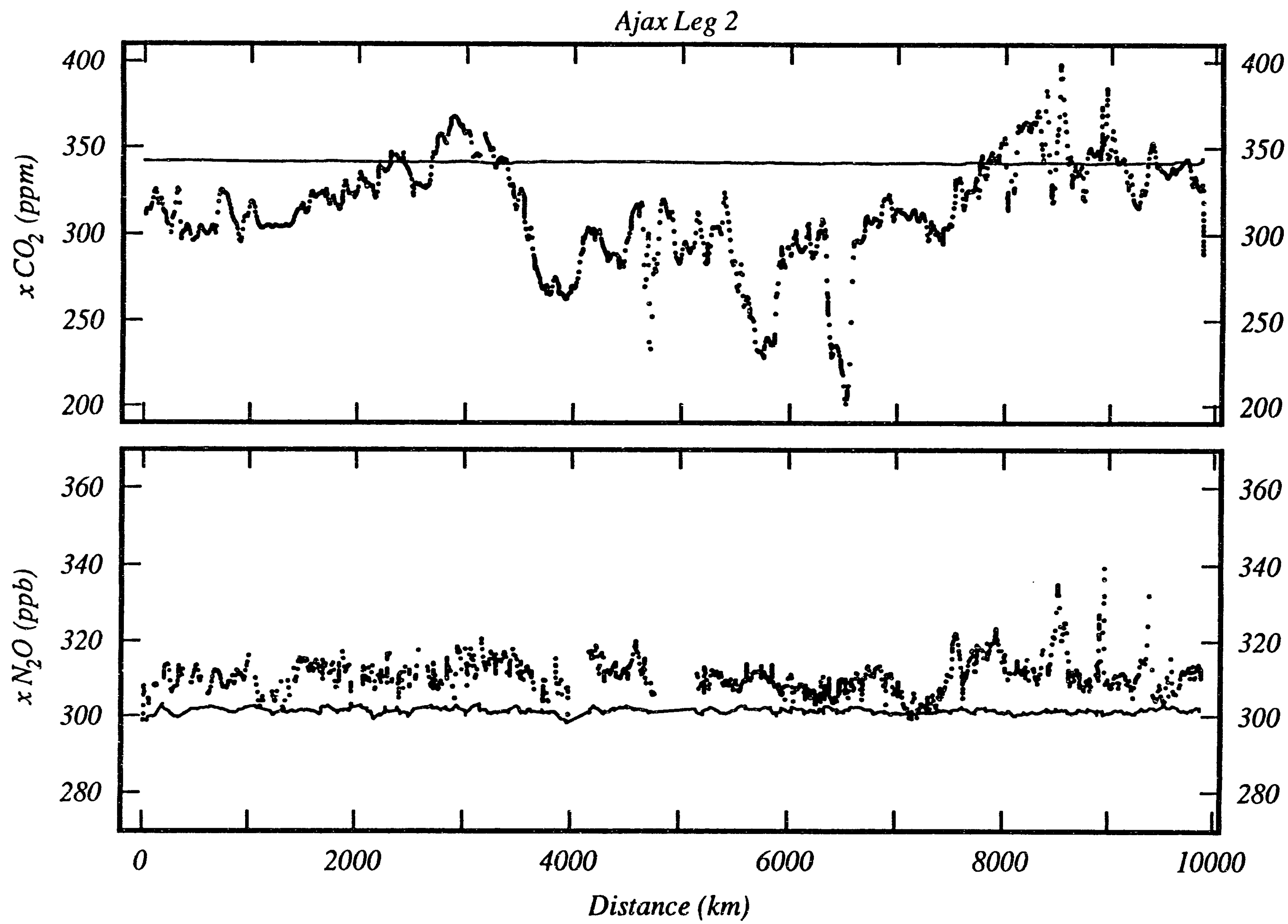


Figure 55. Data plot of xCO_2 and xN_2O (dry gas mole fractions), Ajax Leg 2. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

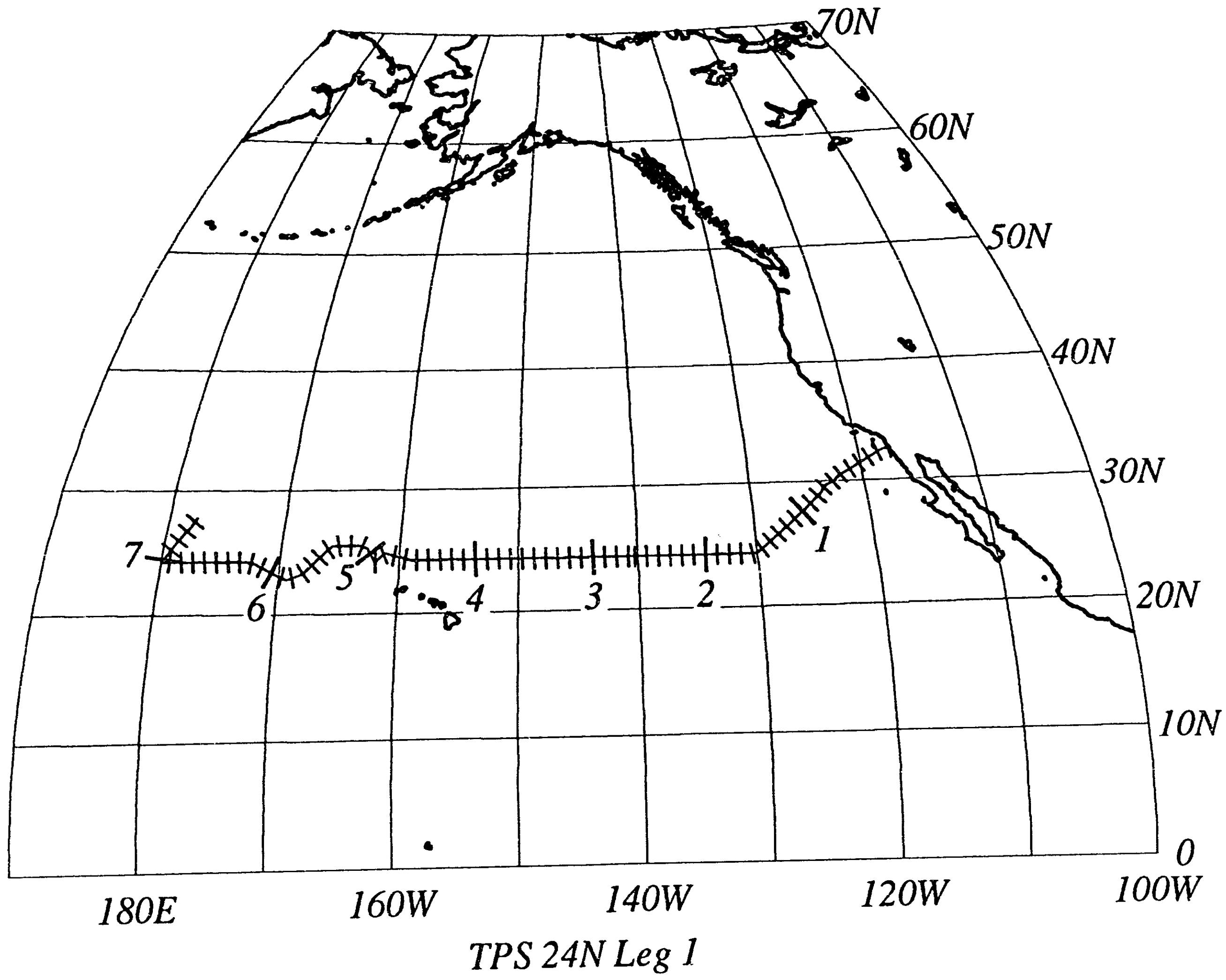


Figure 56. Cruise track plot, TPS24 Leg 1. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

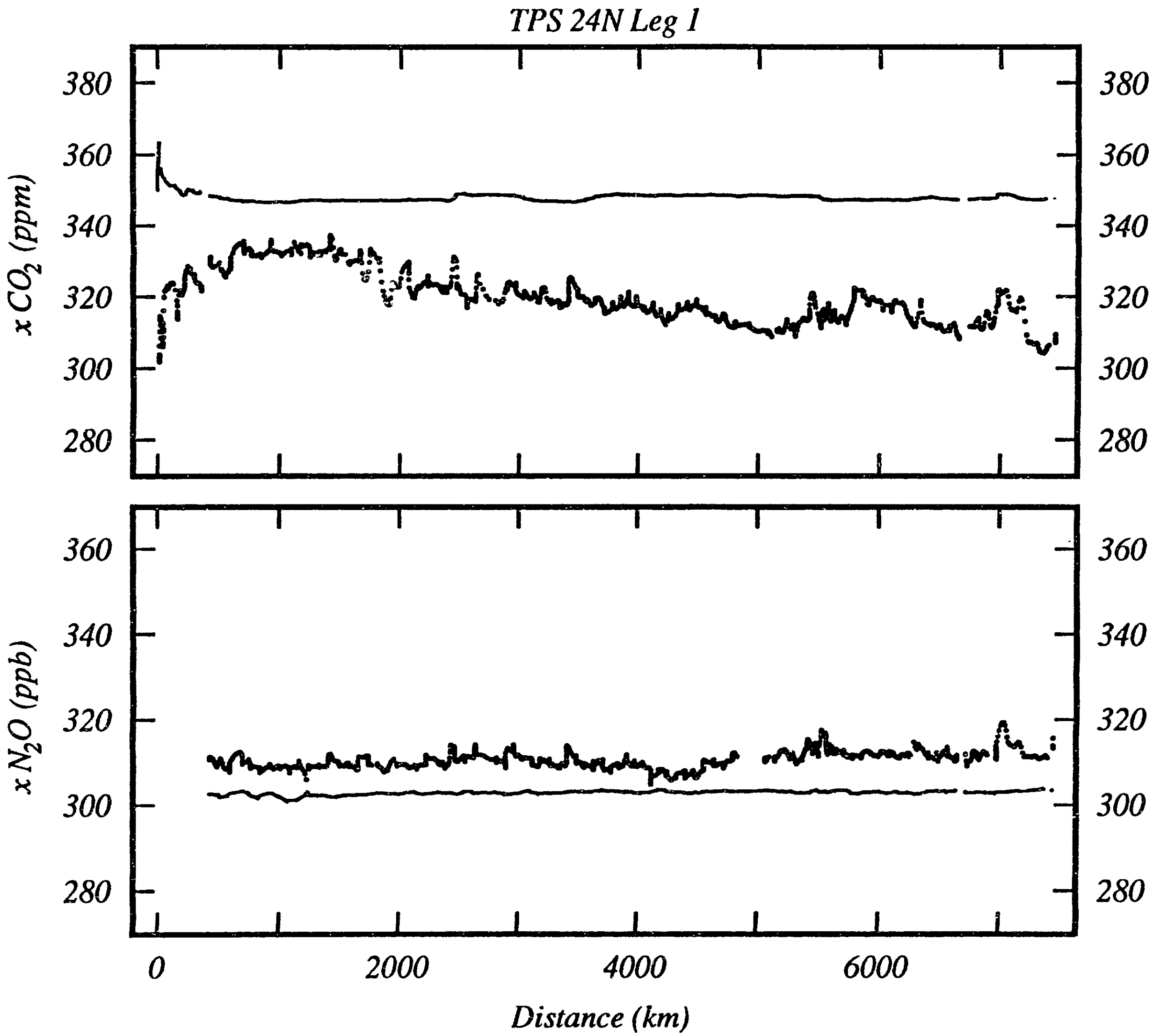


Figure 57. Data plot of xCO_2 and xN_2O (dry gas mole fractions), TPS24 Leg 1. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

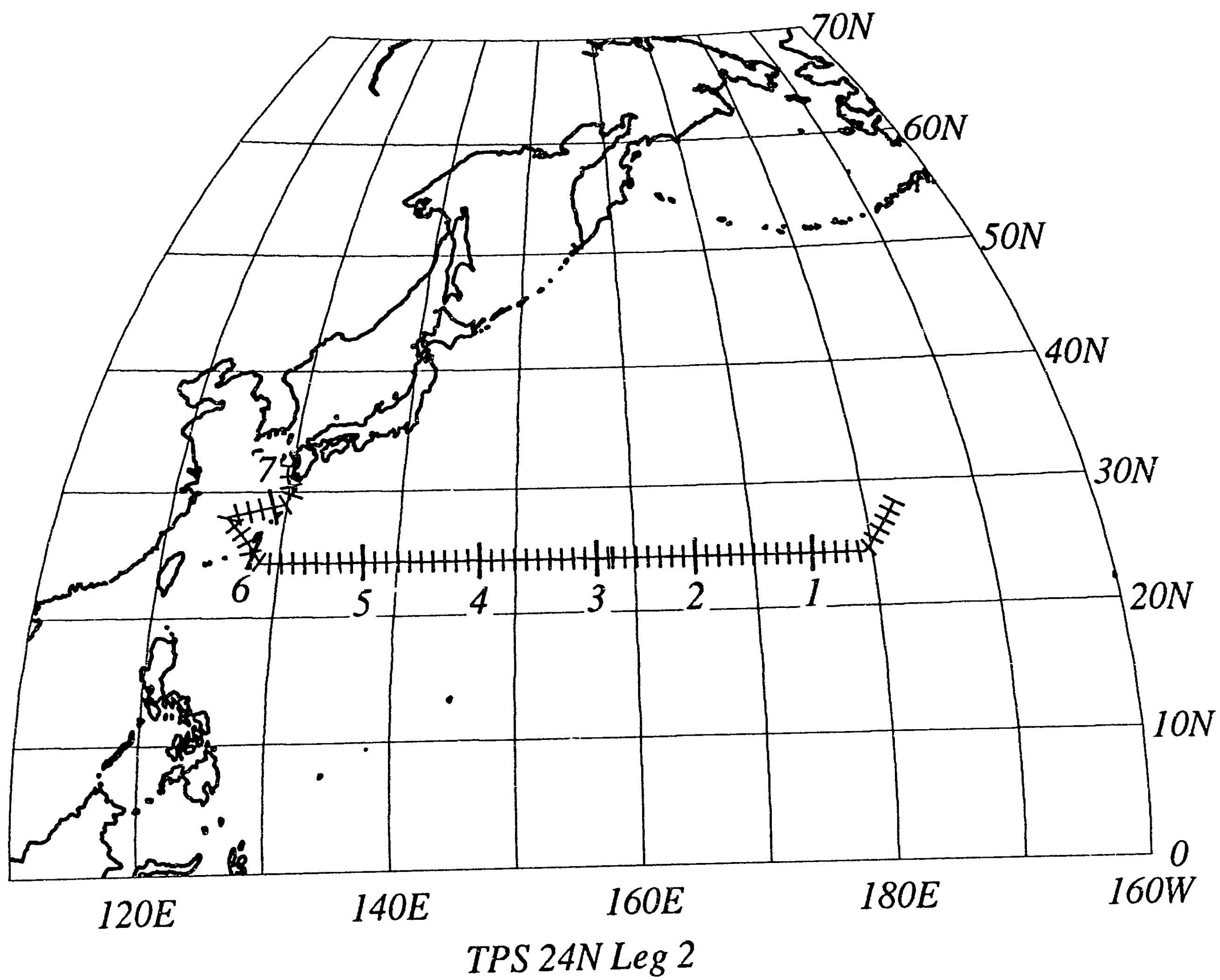


Figure 58. Cruise track plot, TPS24 Leg 2. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

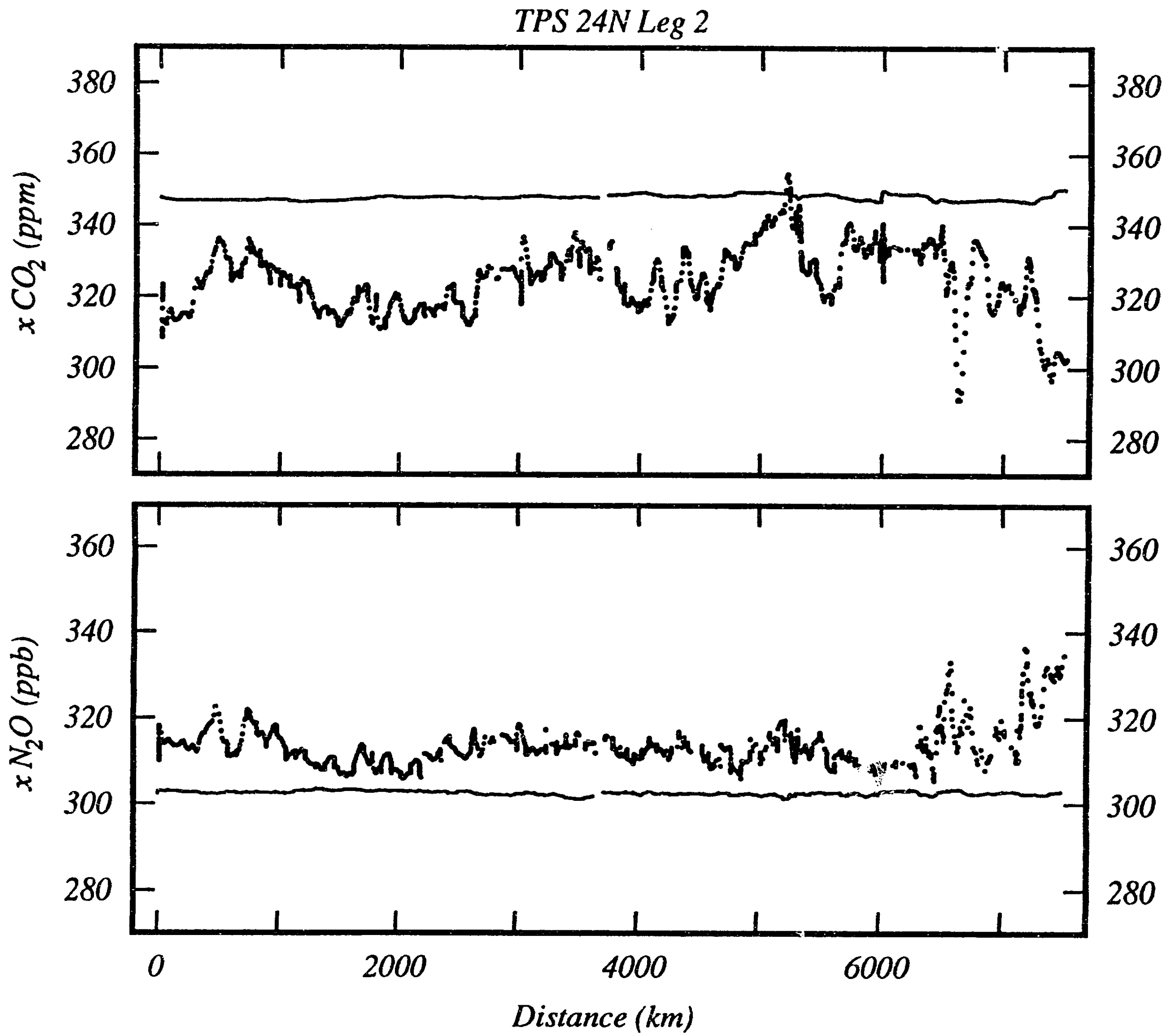


Figure 59. Data plot of xCO_2 and xN_2O (dry gas mole fractions), TPS24 Leg 2. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

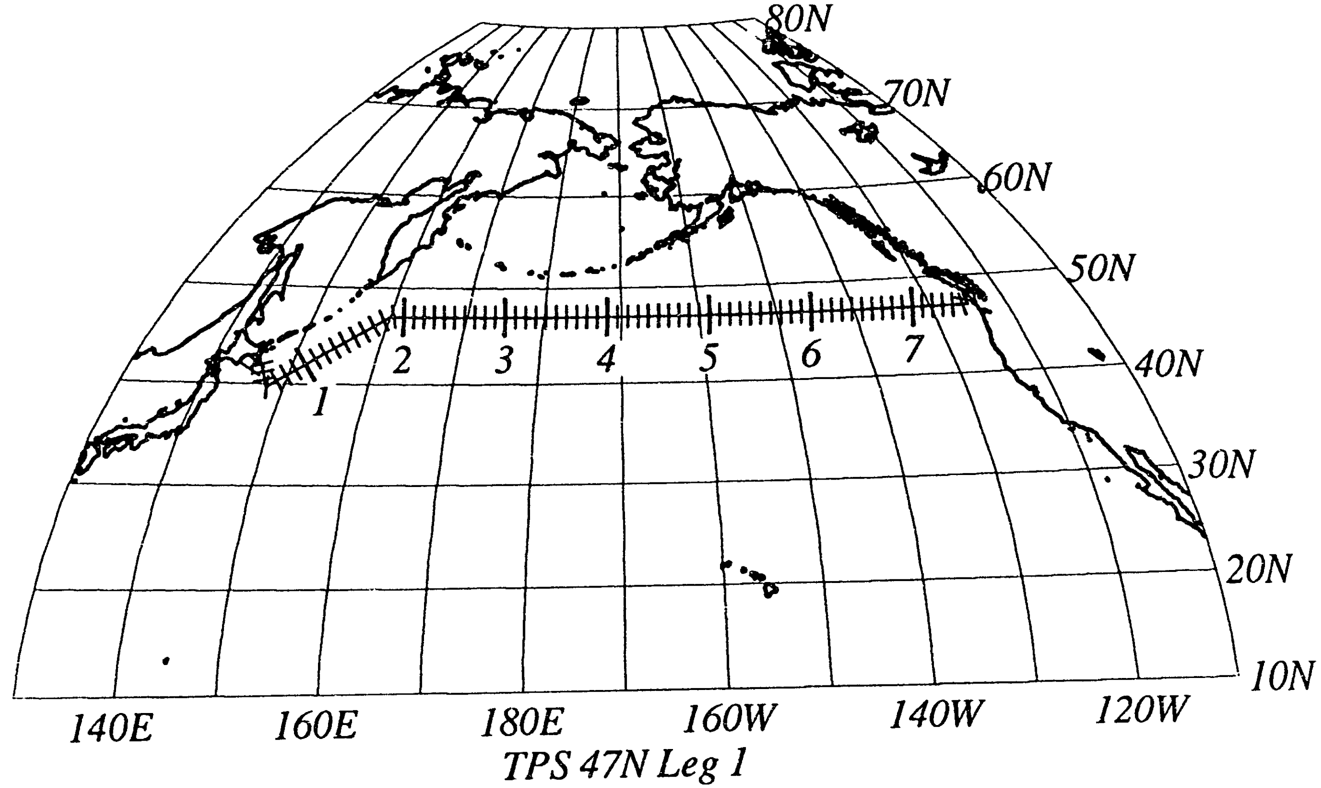


Figure 60. Cruise track plot, TPS47 Leg 1. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

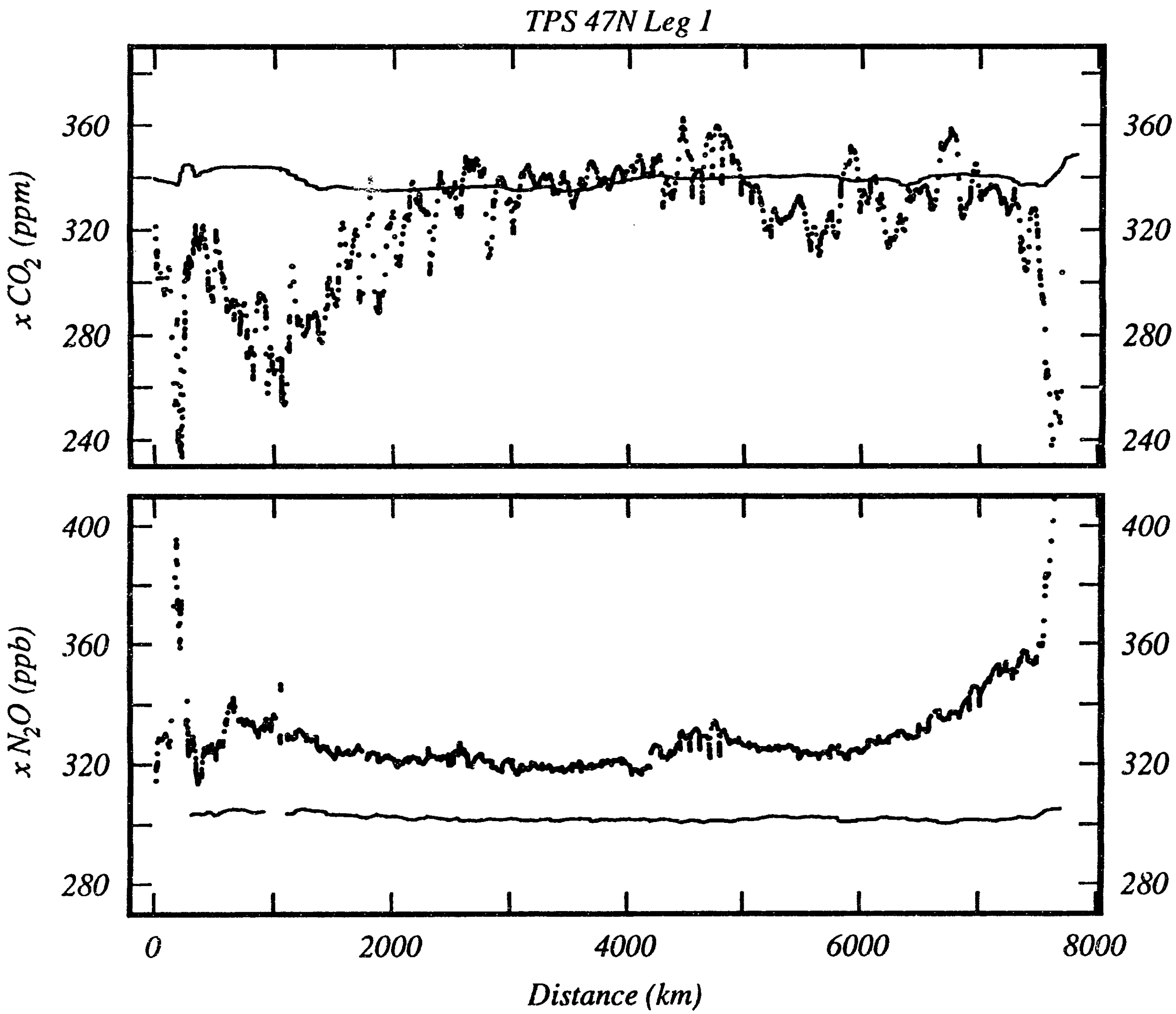


Figure 61. Data plot of xCO_2 and xN_2O (dry gas mole fractions), TPS47 Leg 1. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

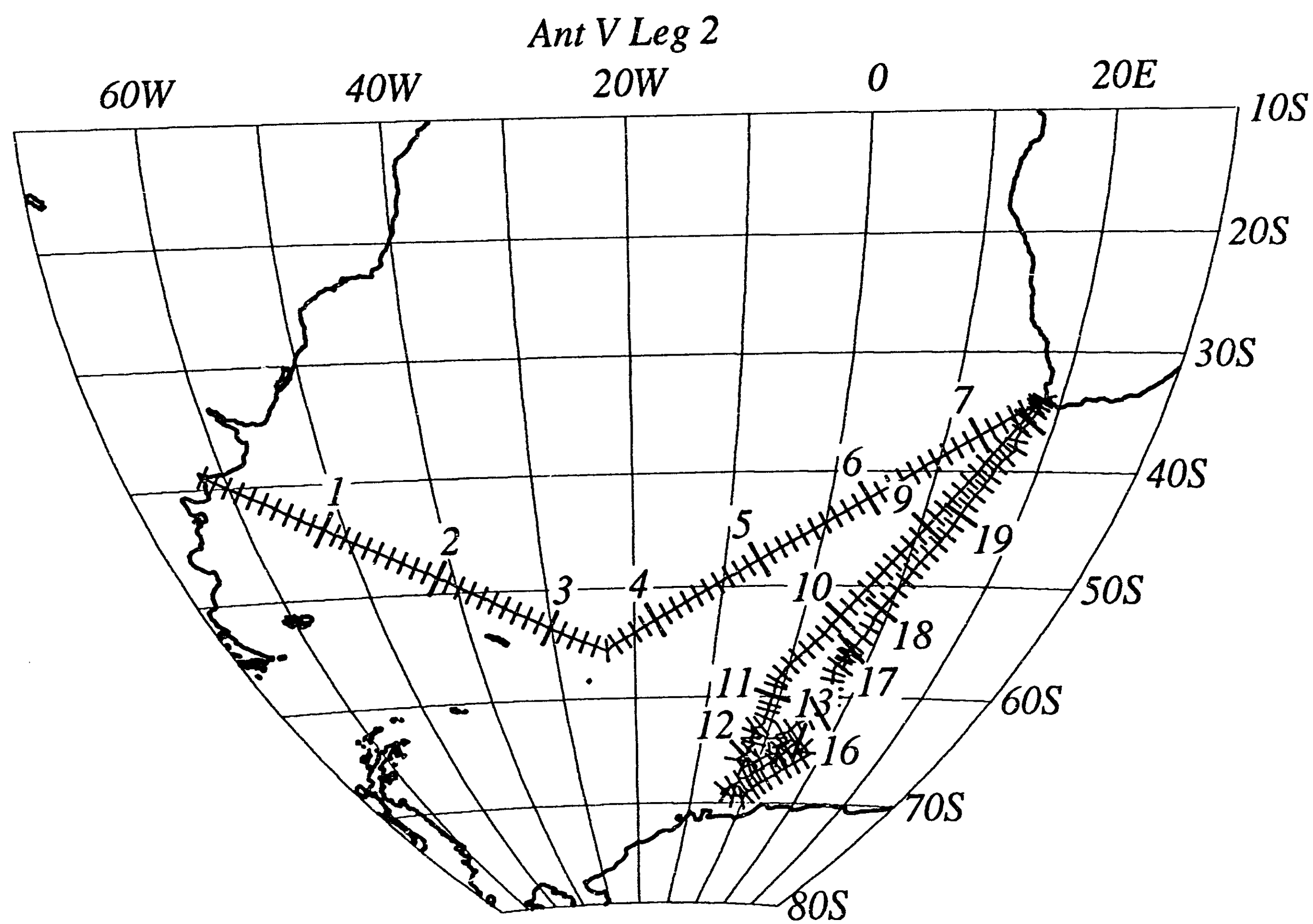


Figure 62. Cruise track plot, Ant V Leg 2. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

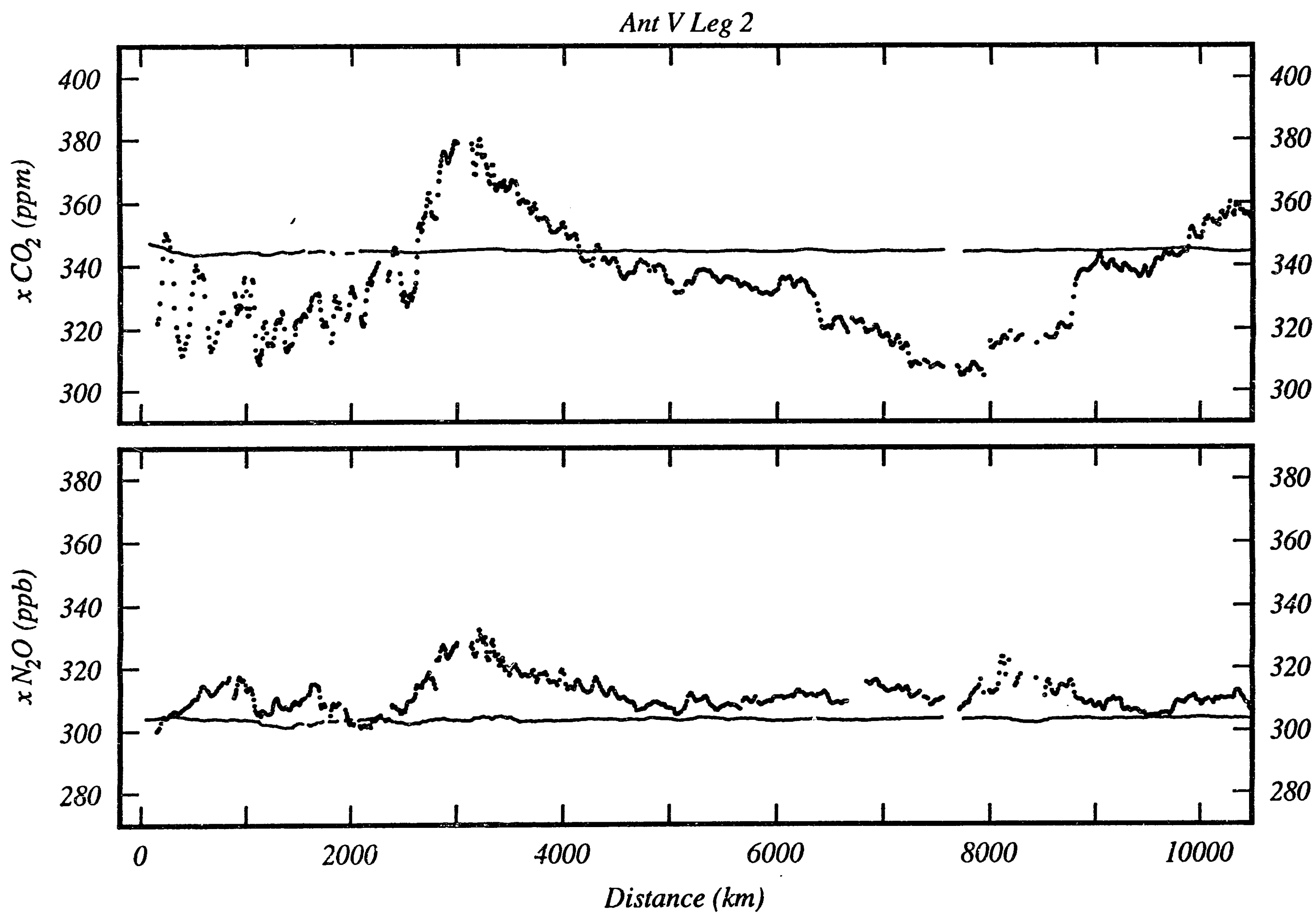


Figure 63. Data plot of xCO_2 and xN_2O (dry gas mole fractions), Ant V Leg 2. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

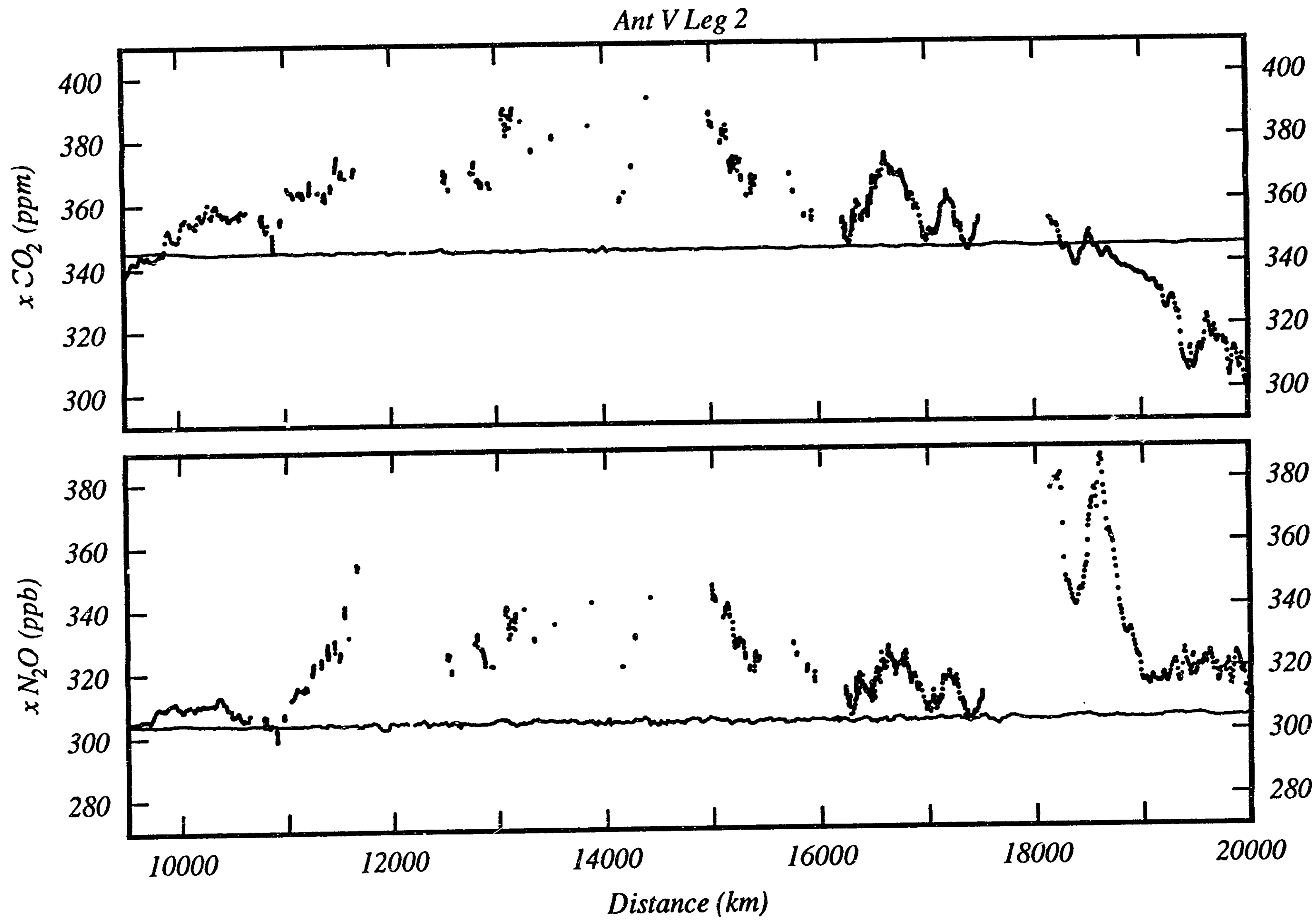


Figure 63. Continued

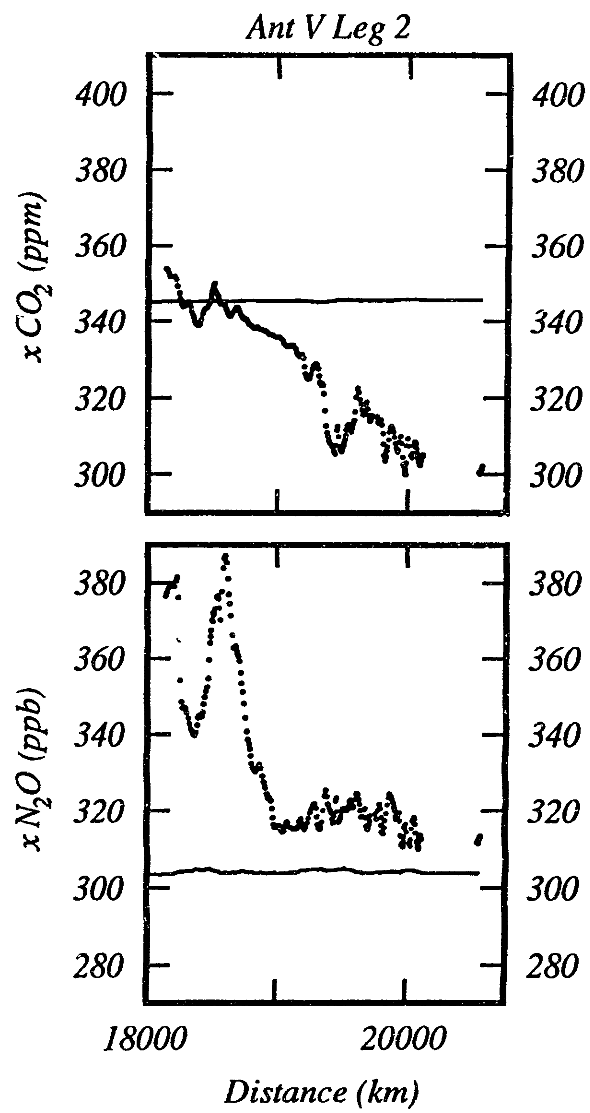


Figure 63. Continued

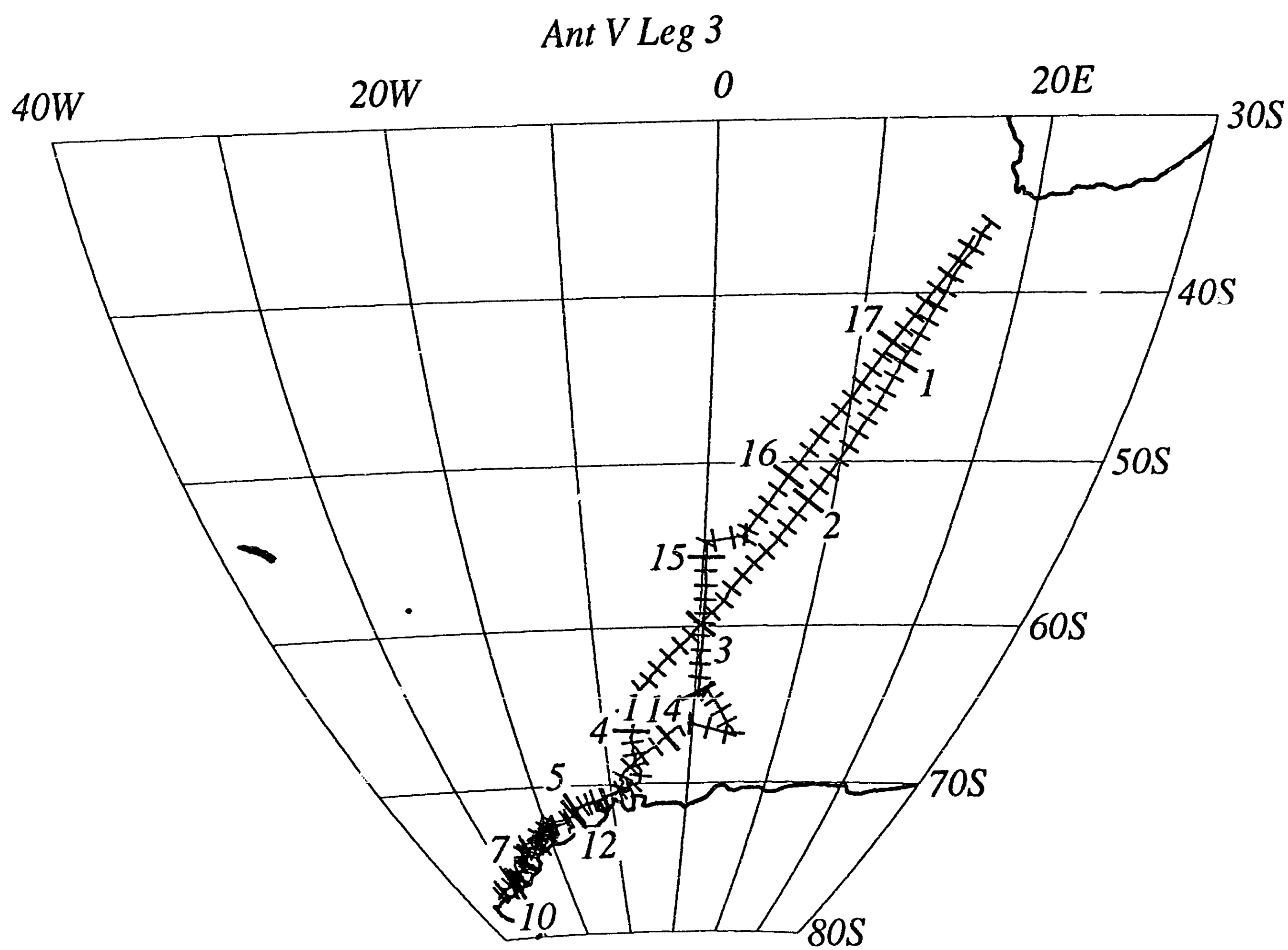


Figure 64. Cruise track plot, Ant V Leg 3. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

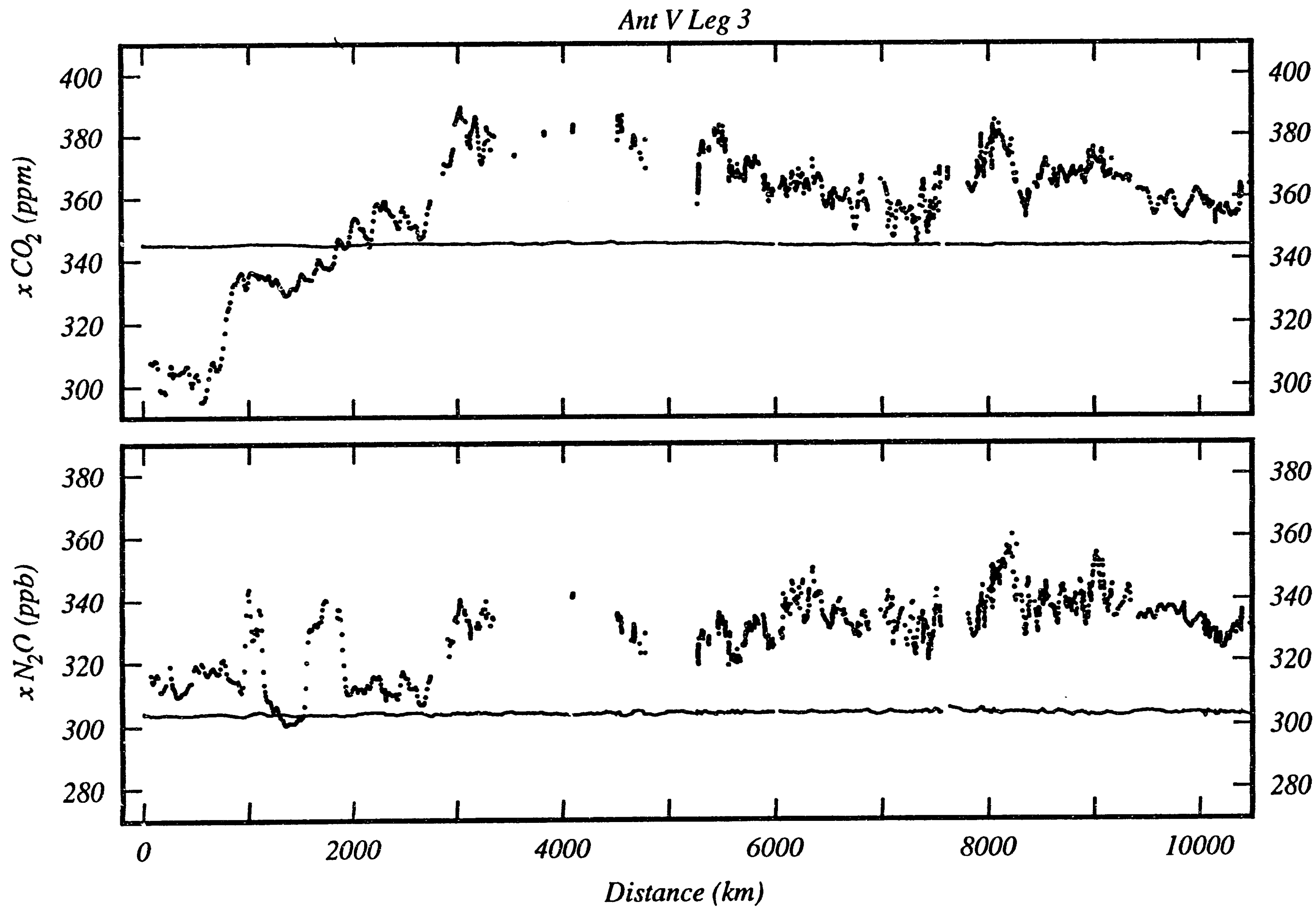


Figure 65. Data plot of xCO_2 and xN_2O (dry gas mole fractions), Ant V Leg 3. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

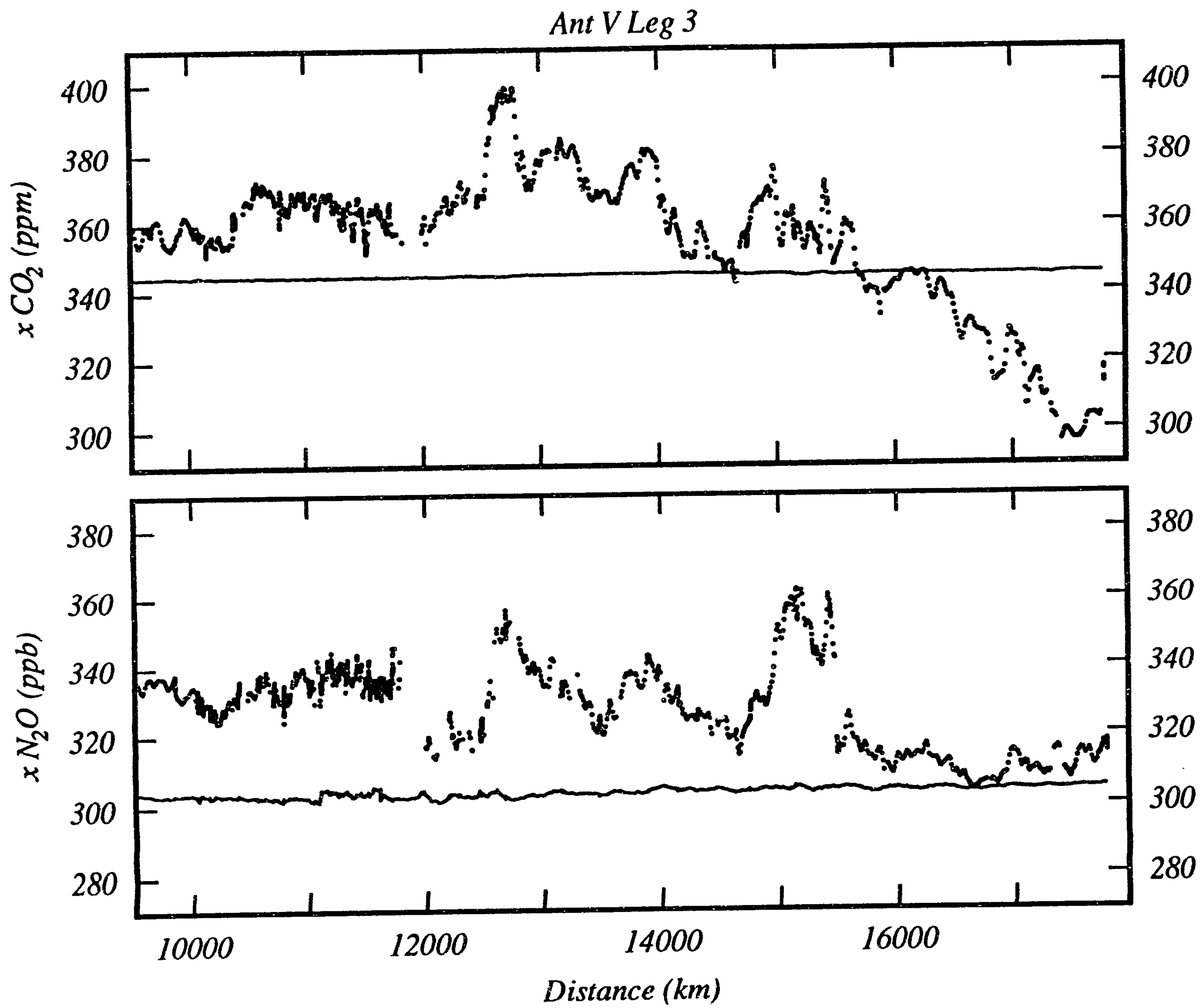


Figure 65. Continued

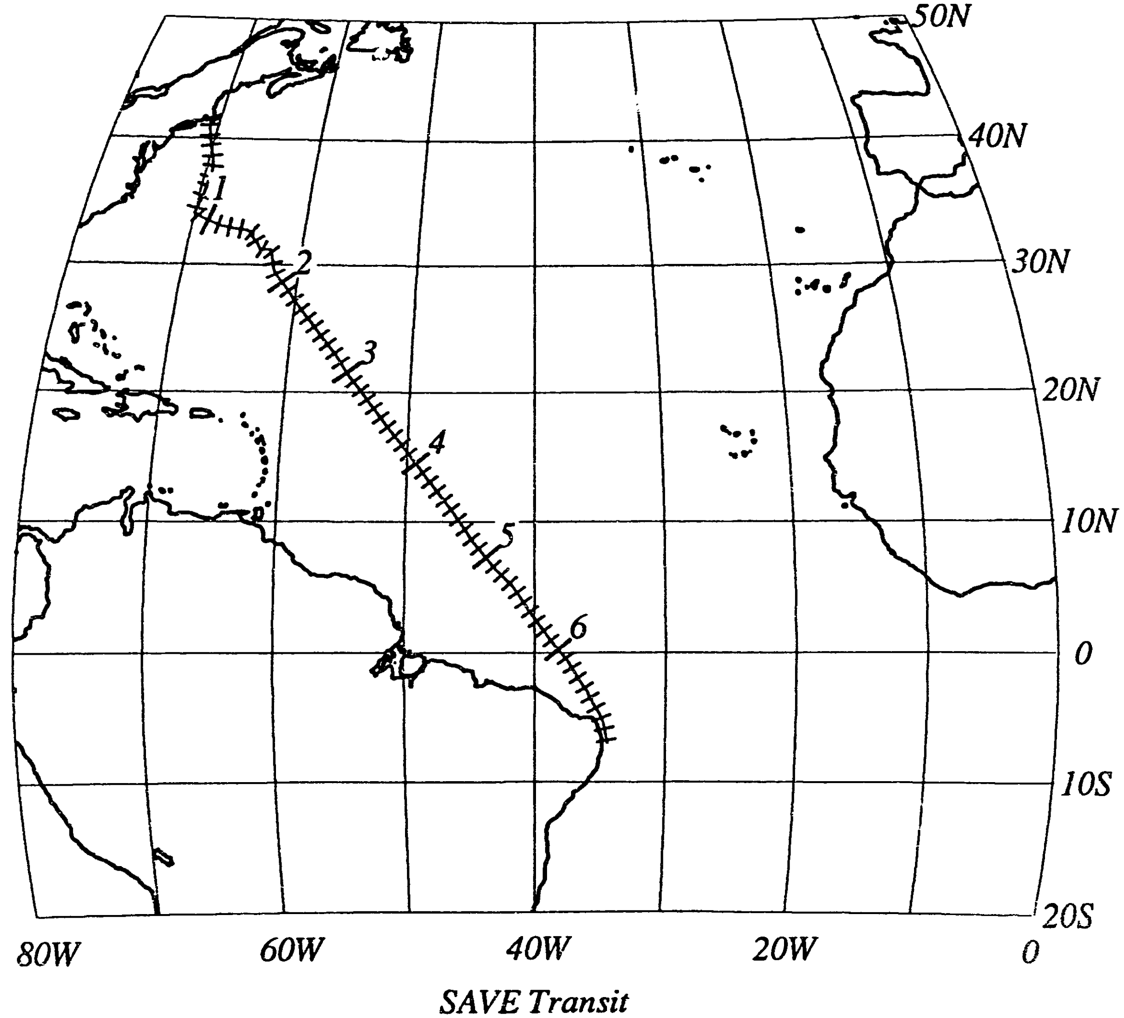


Figure 66. Cruise track plot, SAVE Transit. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

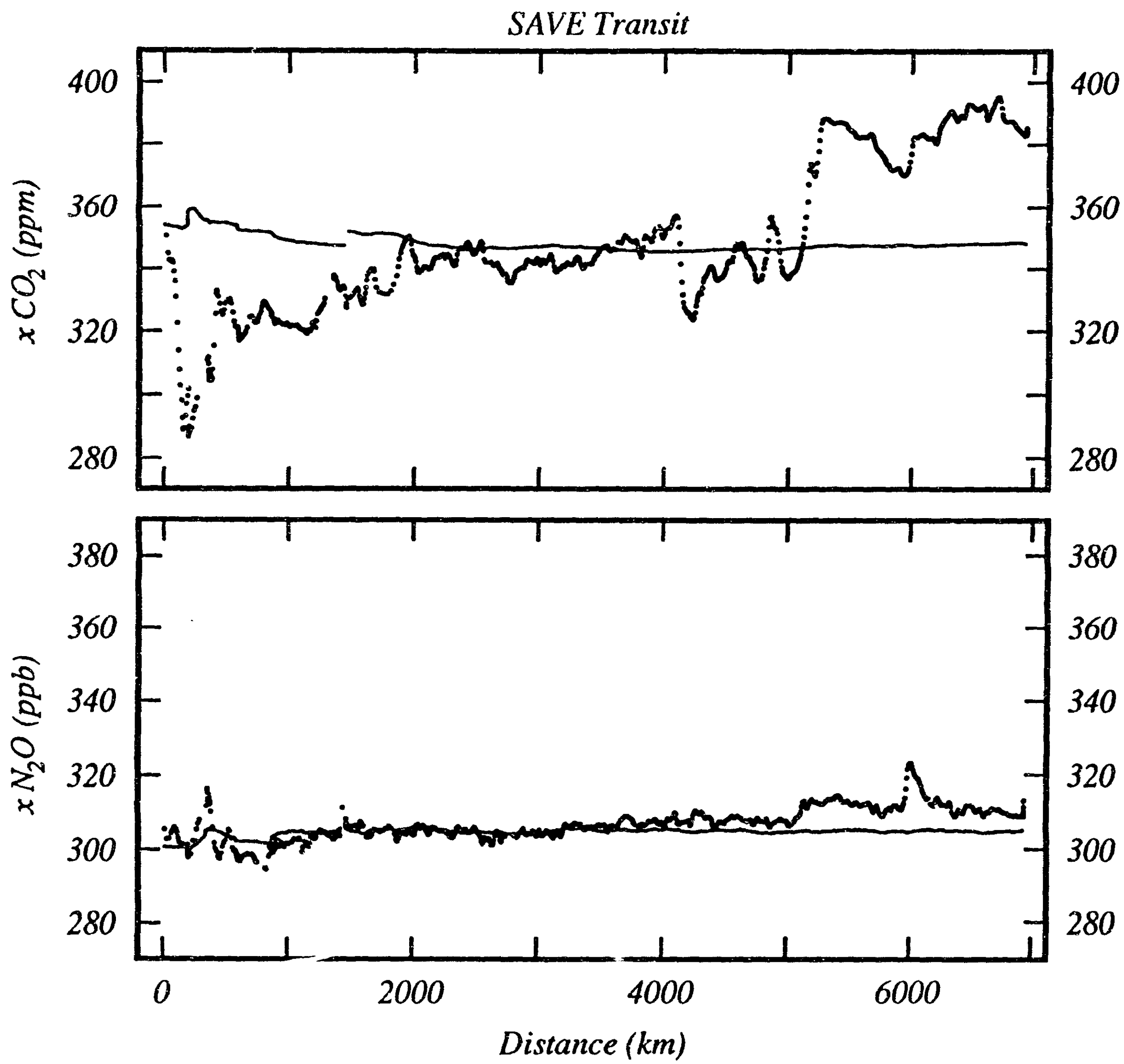


Figure 67. Data plot of xCO_2 and xN_2O (dry gas mole fractions), SAVE Transit. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

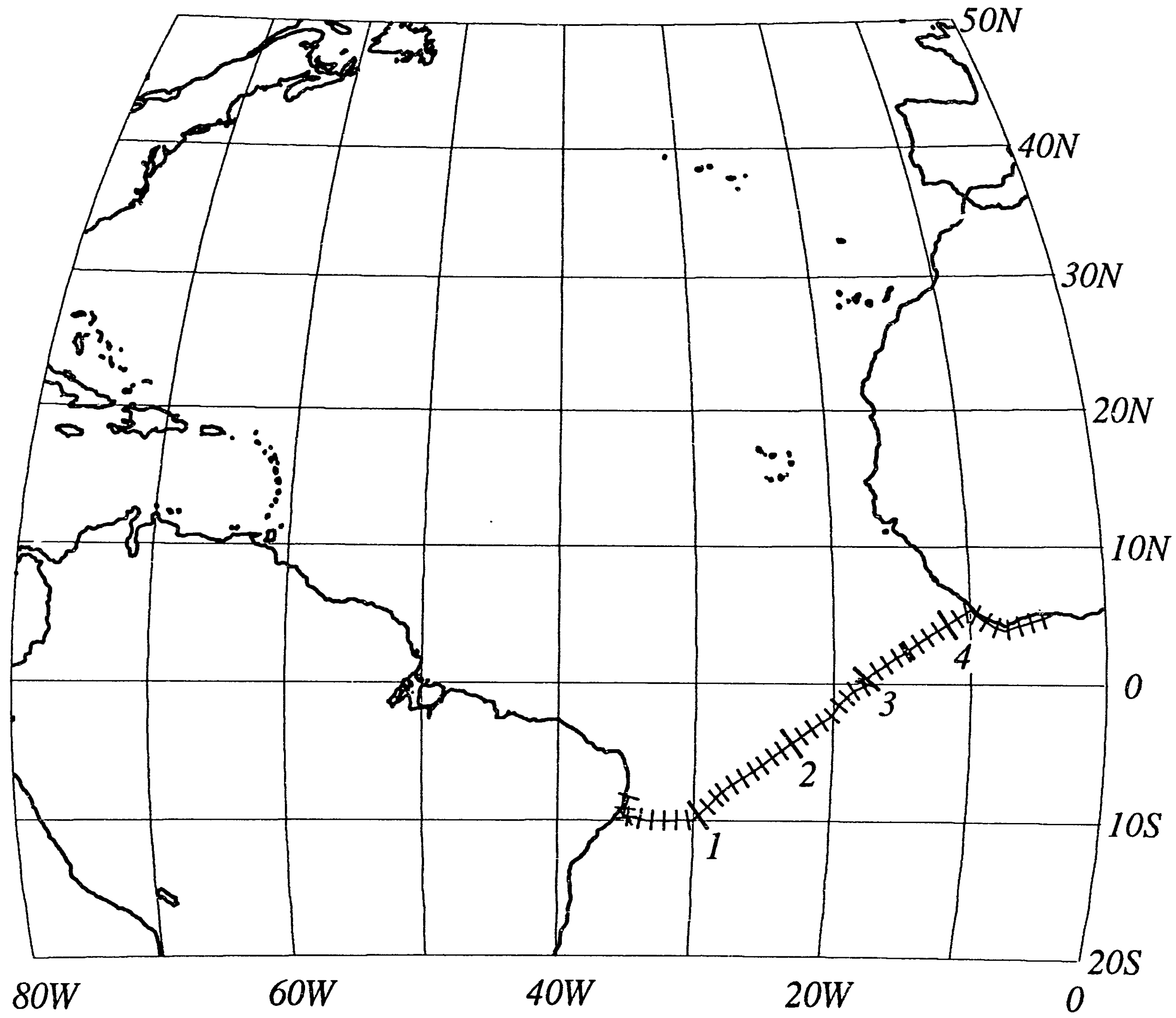


Figure 68. Cruise track plot, SAVE Leg 1. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

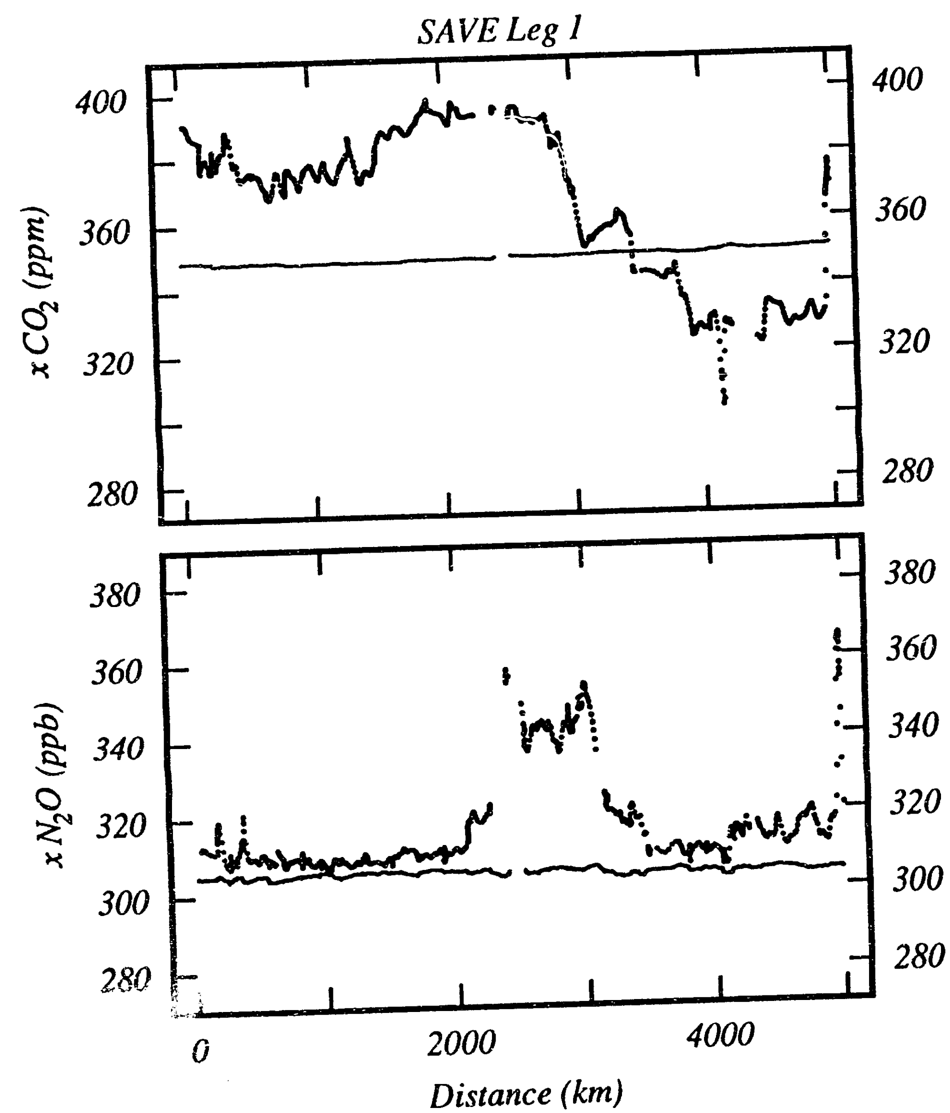


Figure 69. Data plot of xCO_2 and xN_2O (dry gas mole fractions), SAVE Leg 1. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

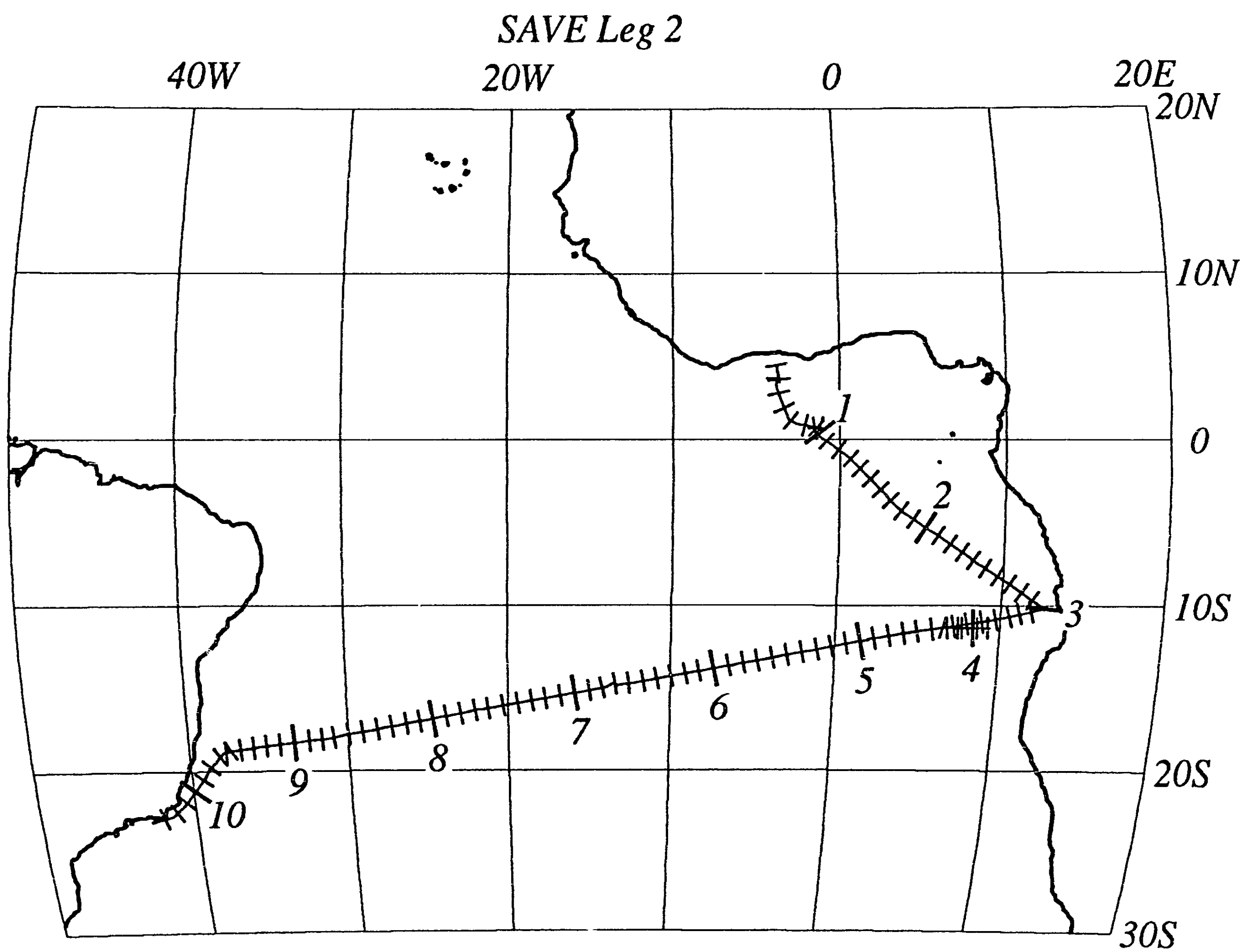


Figure 70. Cruise track plot, SAVE Leg 2. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

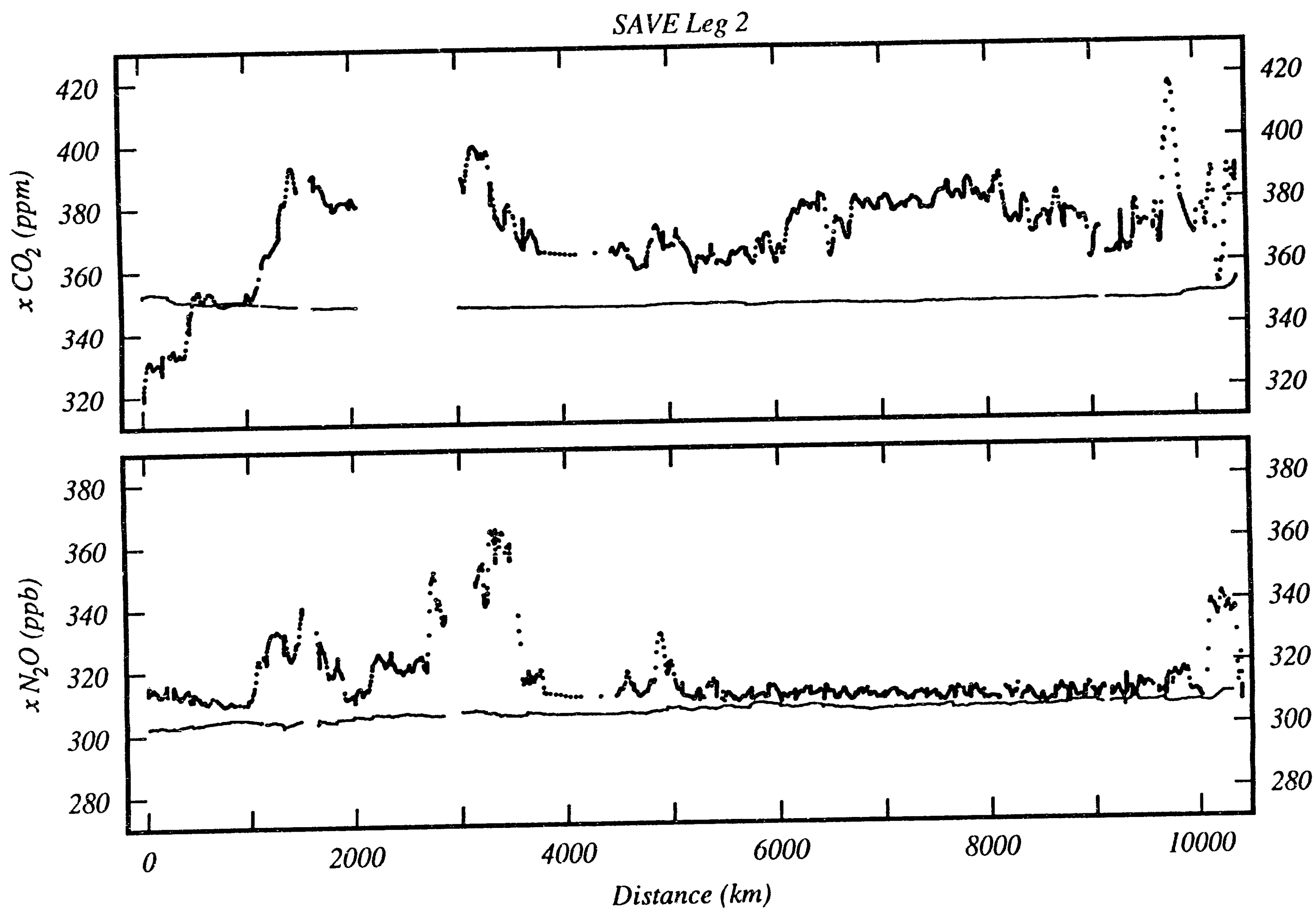


Figure 71. Data plot of xCO_2 and xN_2O (dry gas mole fractions), SAVE Leg 2. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

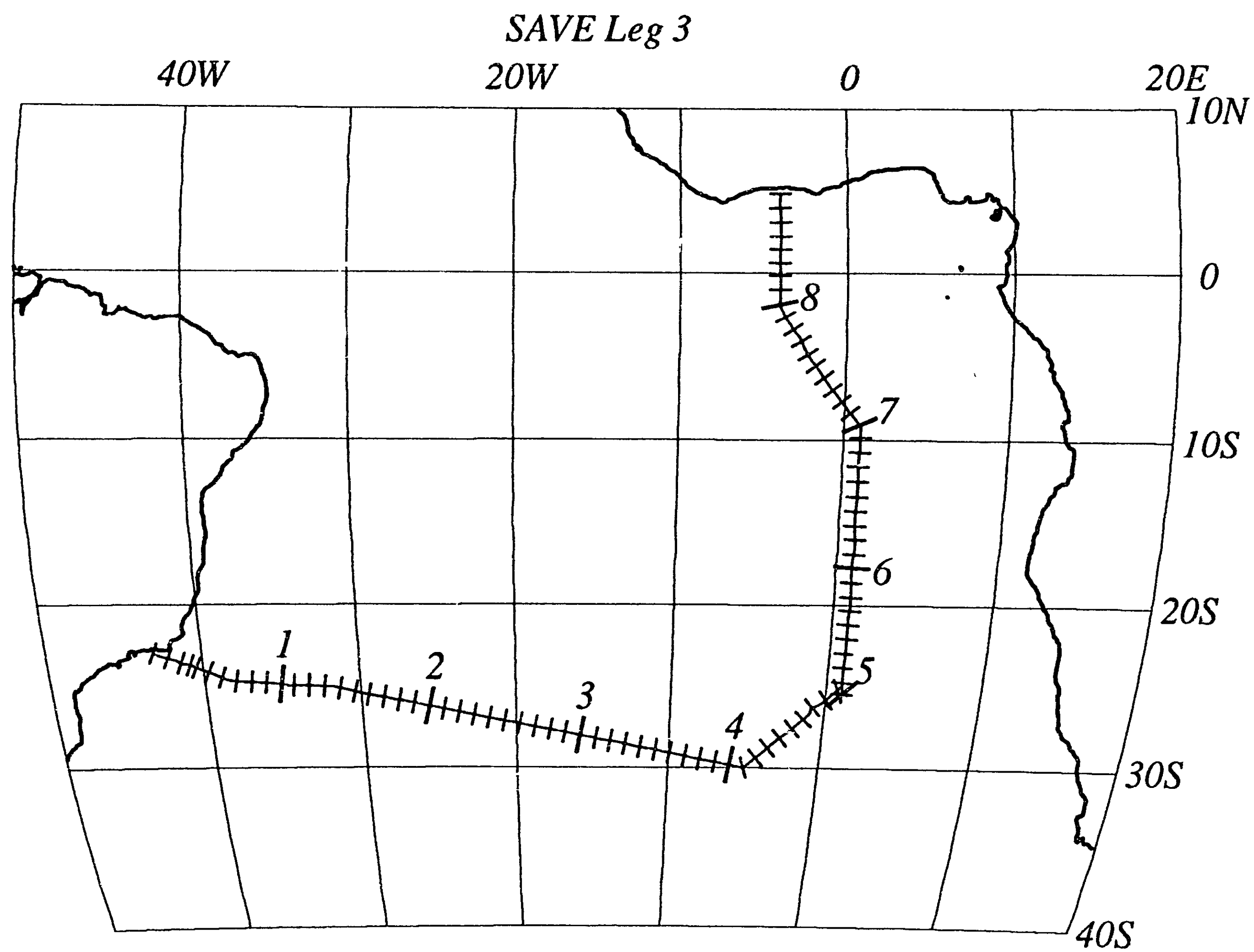


Figure 72. Cruise track plot, SAVE Leg 3. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

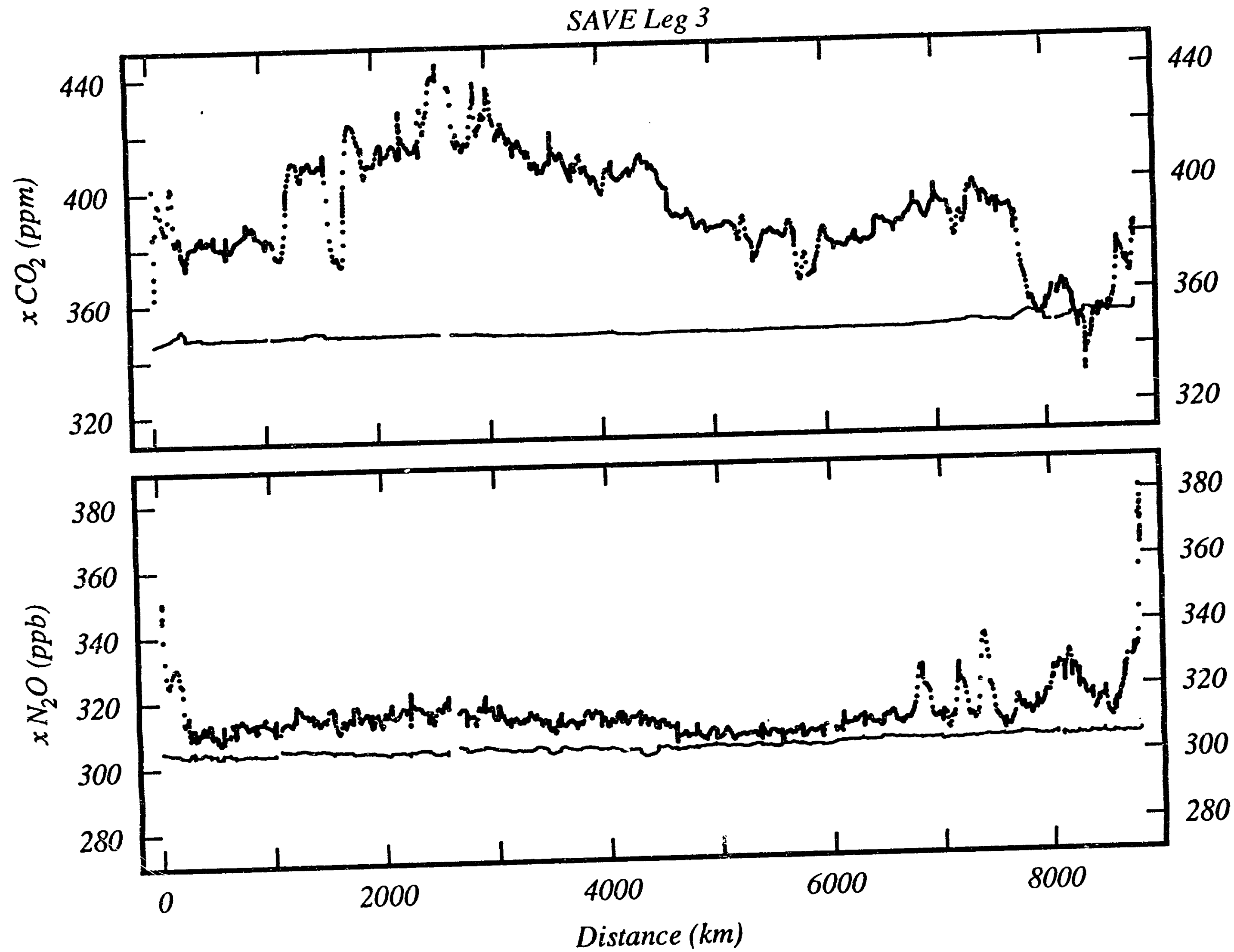


Figure 73. Data plot of xCO_2 and xN_2O (dry gas mole fractions), SAVE Leg 3. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

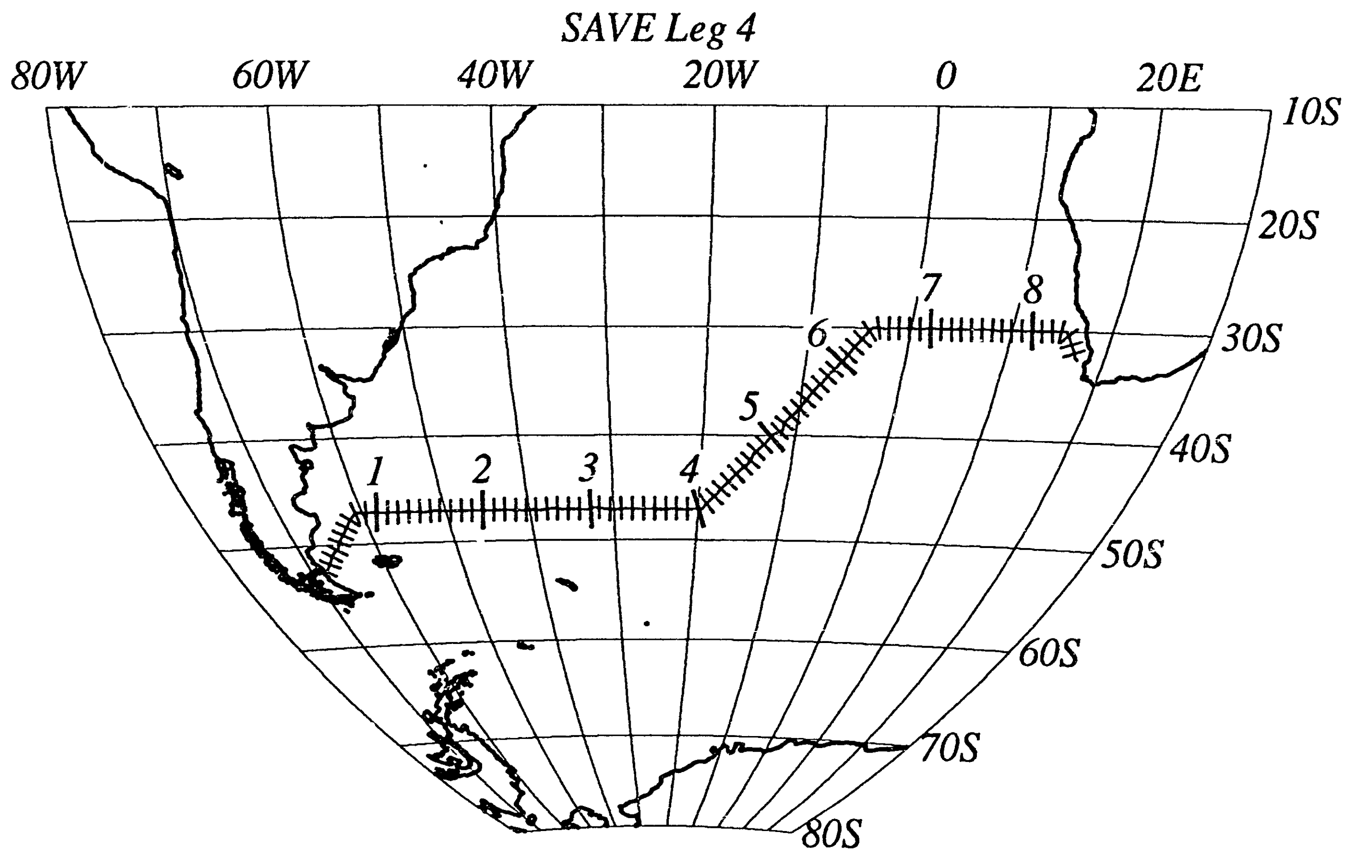


Figure 74. Cruise track plot, SAVE Leg 4. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

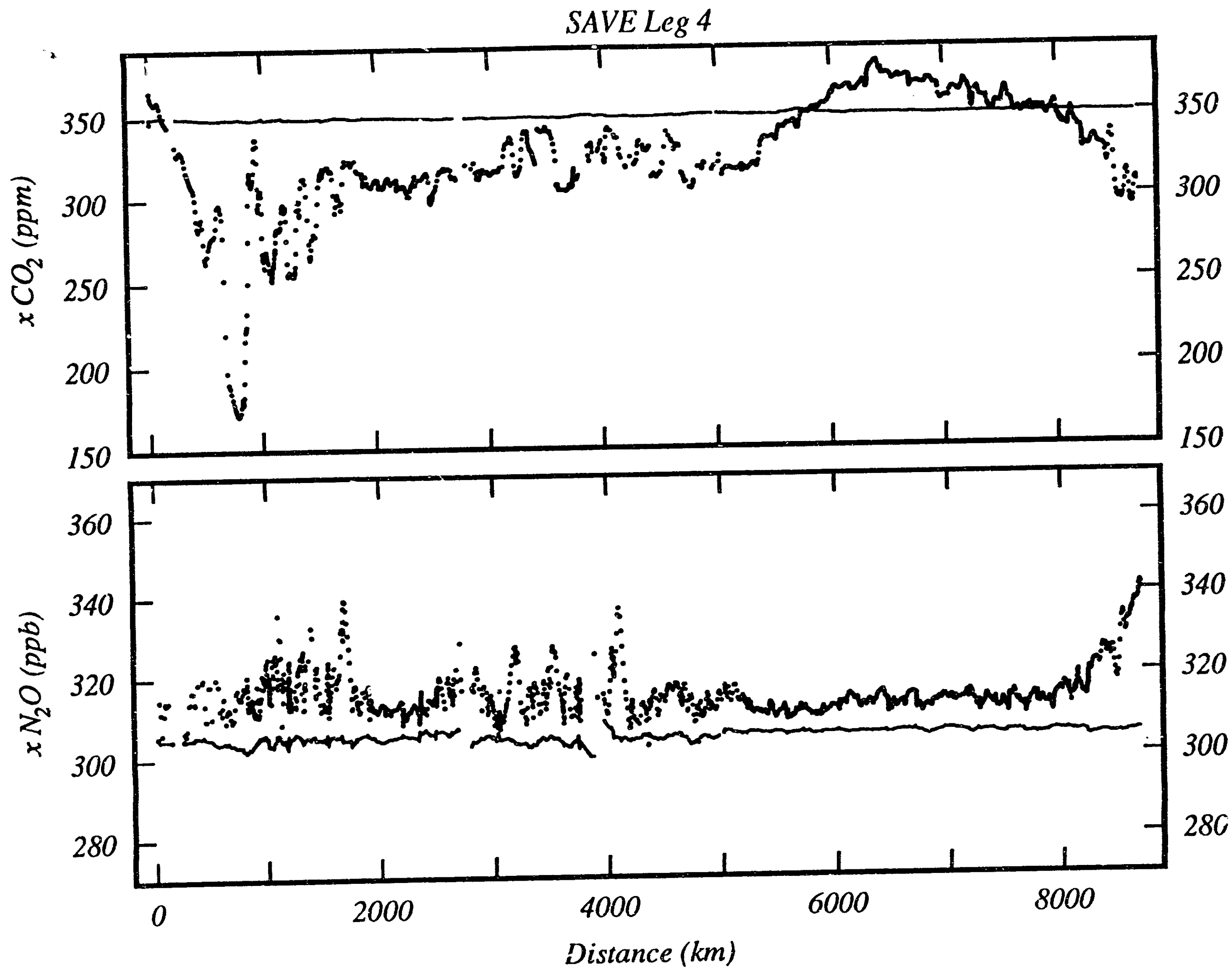


Figure 75. Data plot of xCO_2 and xN_2O (dry gas mole fractions), SAVE Leg 4. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

SAVE Leg 5

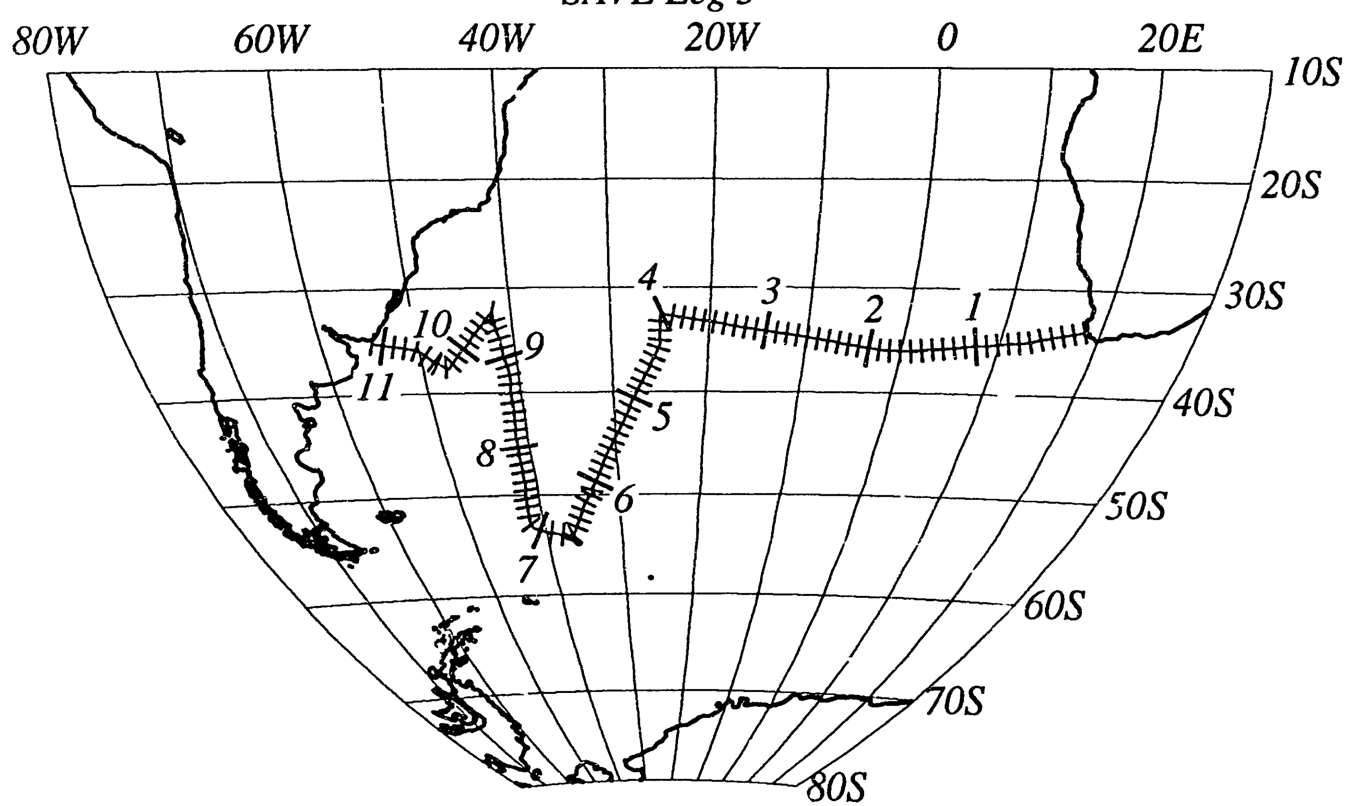


Figure 76. Cruise track plot, SAVE Leg 5. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

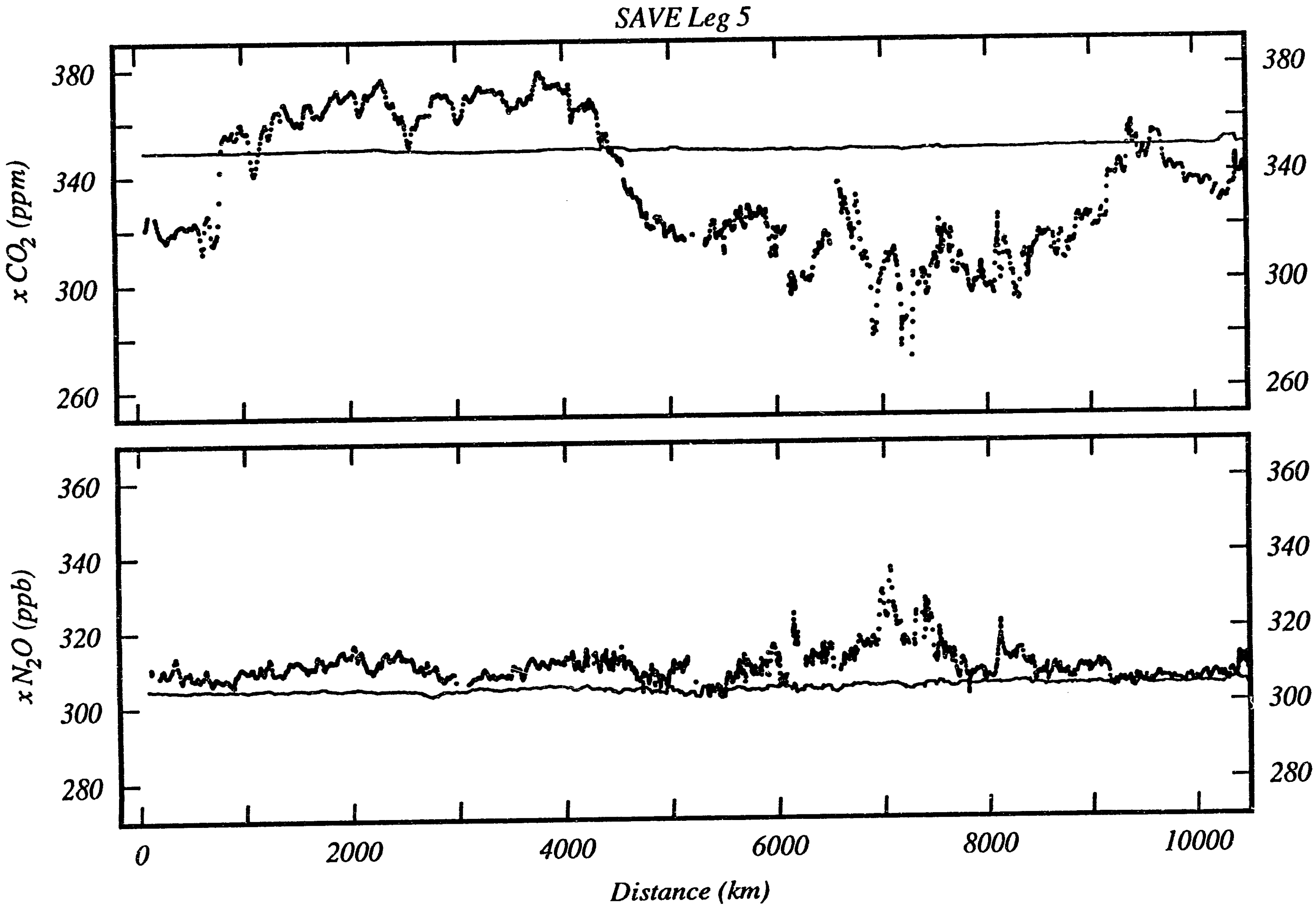


Figure 77. Data plot of xCO_2 and xN_2O (dry gas mole fractions), SAVE Leg 5. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

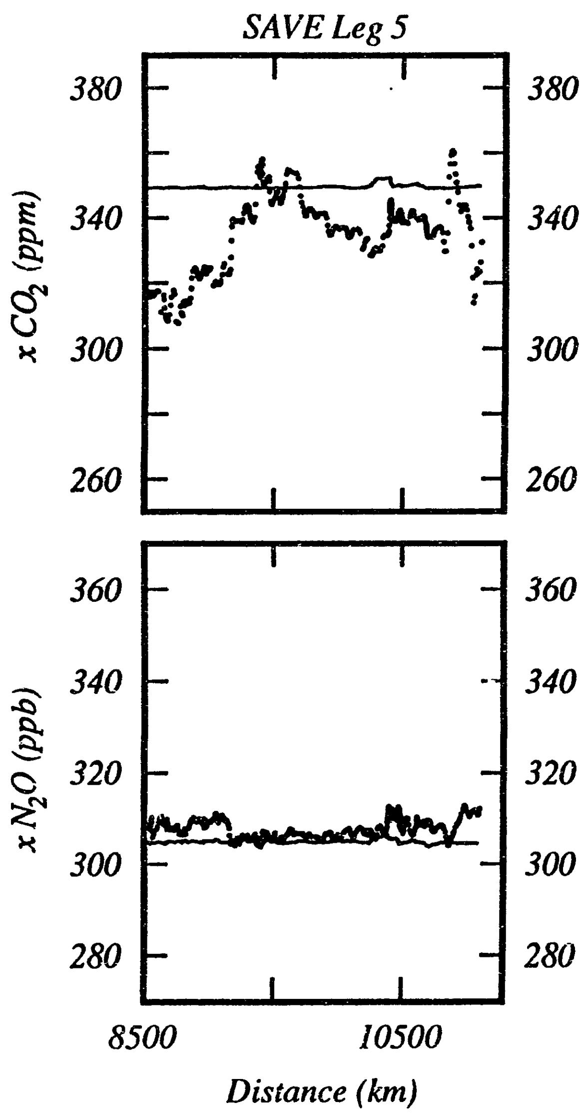


Figure 77. Continued

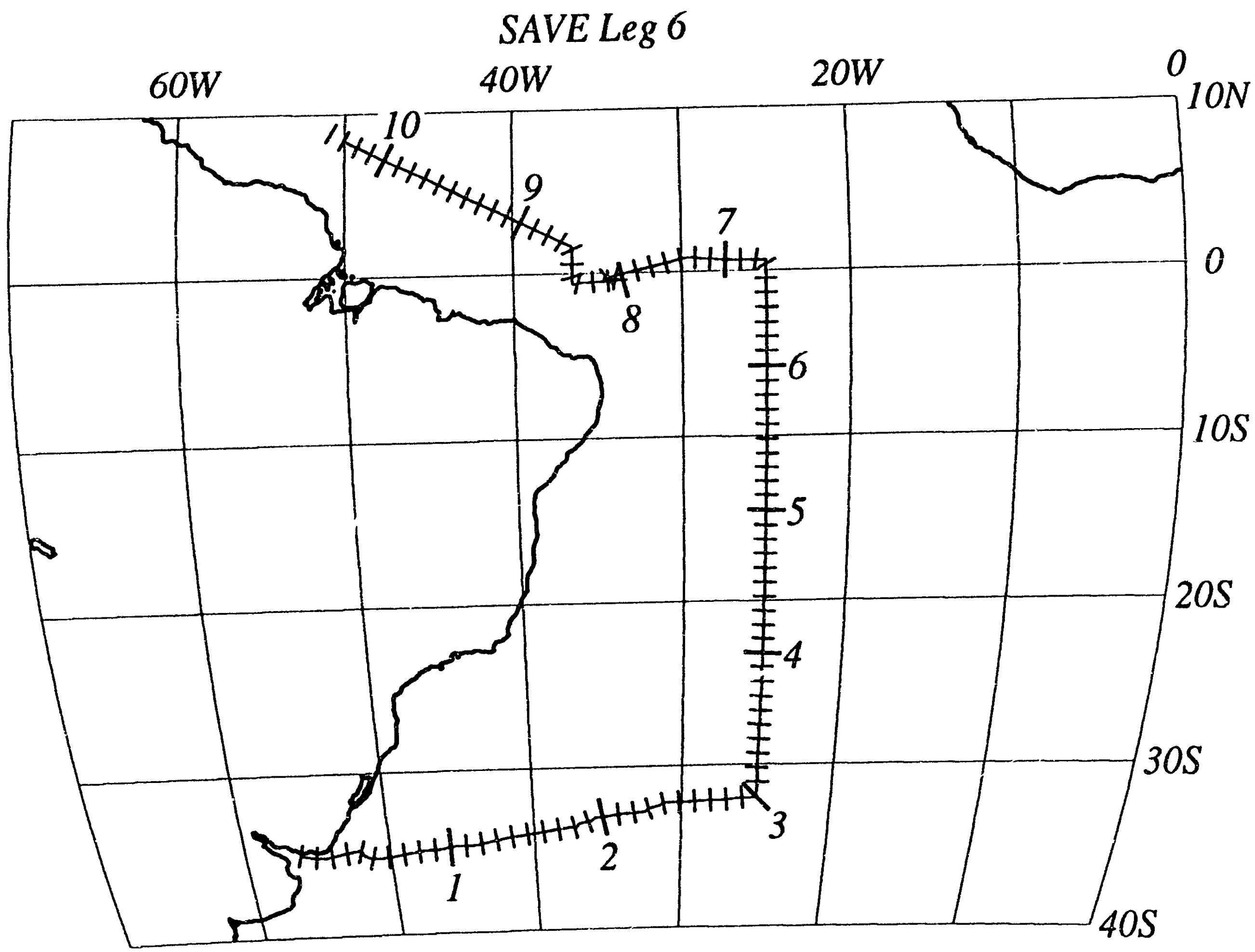


Figure 78. Cruise track plot, SAVE Leg 6. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

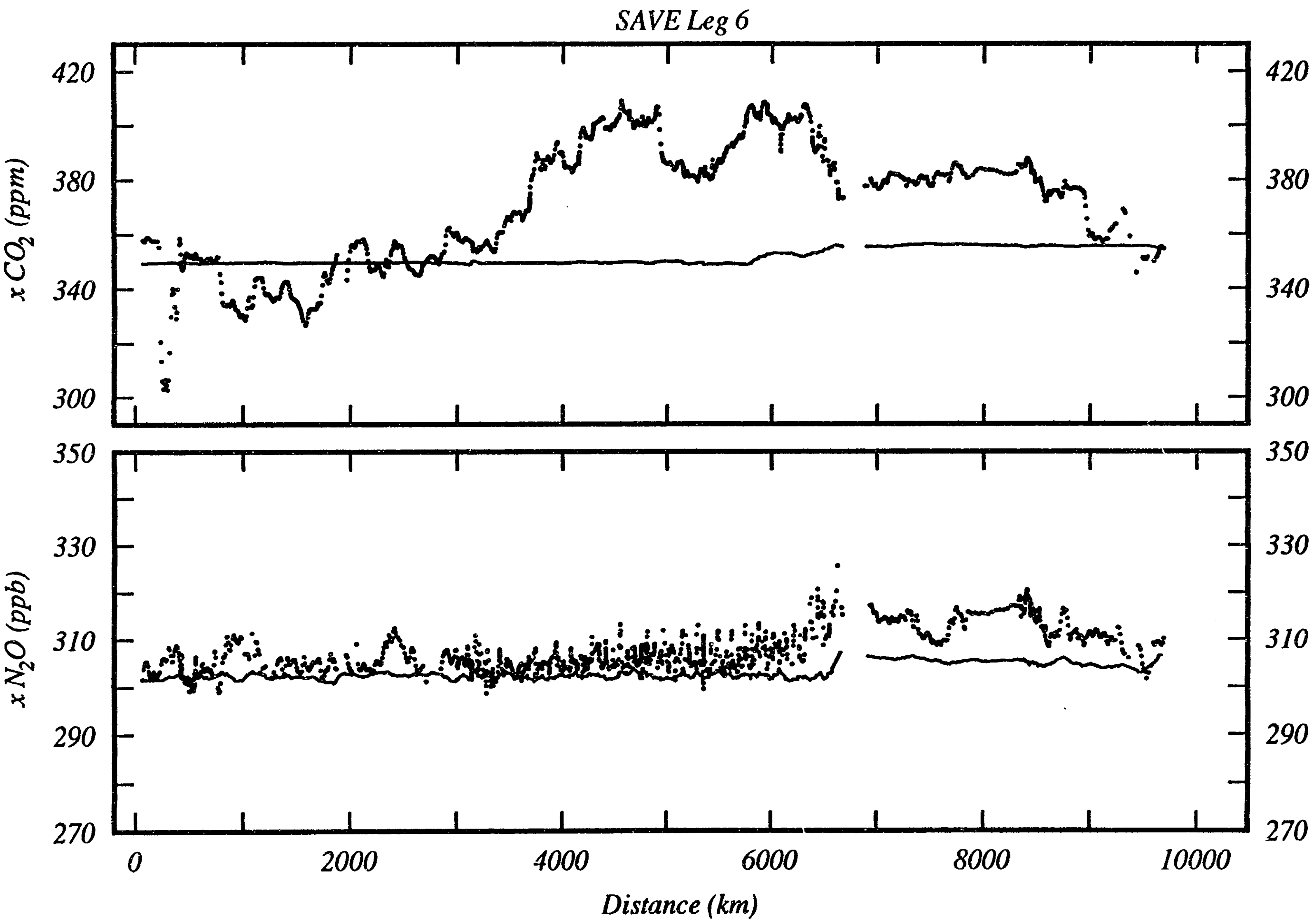


Figure 79. Data plot of xCO_2 and xN_2O (dry gas mole fractions), SAVE Leg 6. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

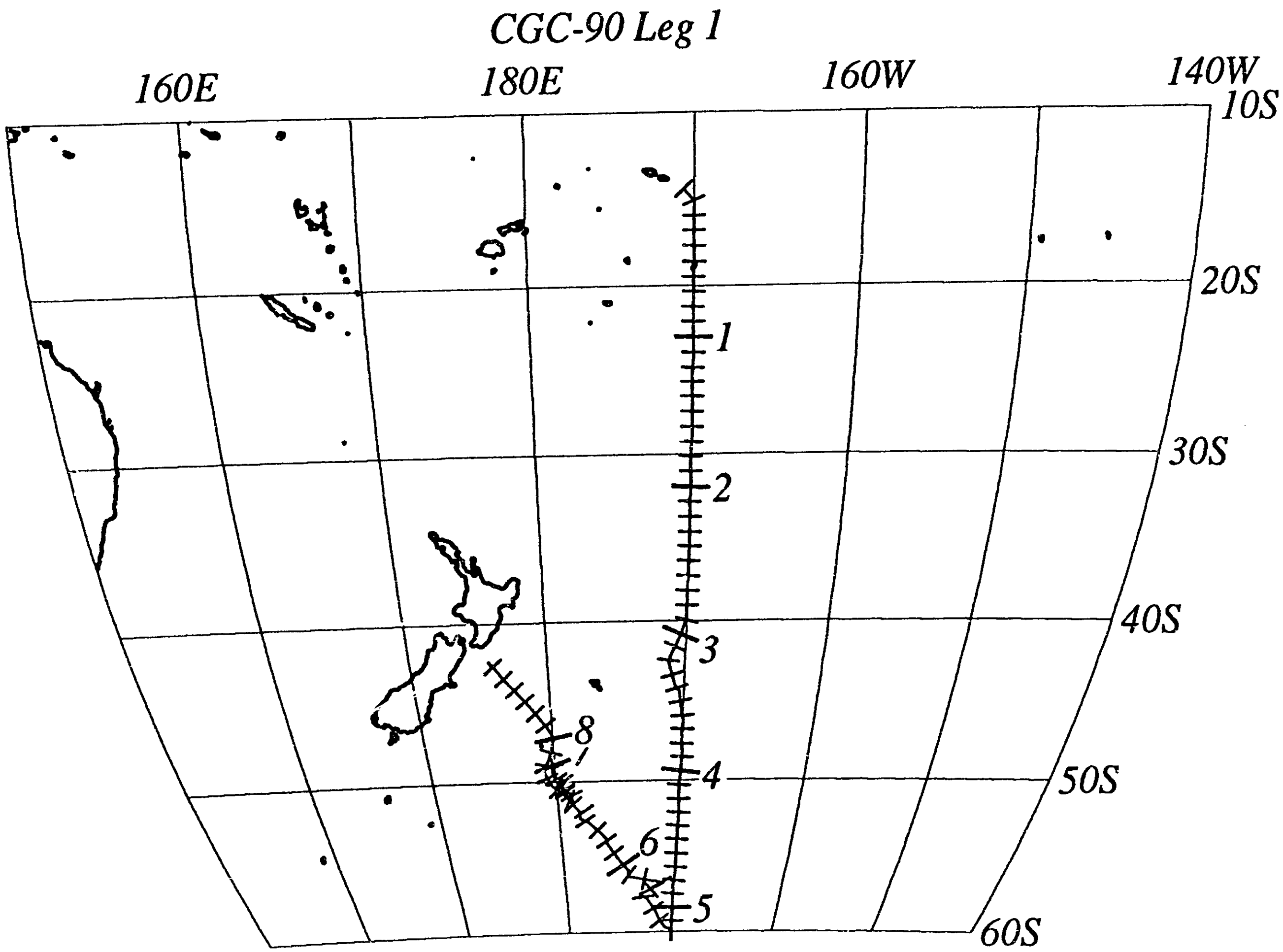


Figure 80. Cruise track plot, CGC-90 Leg 1. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

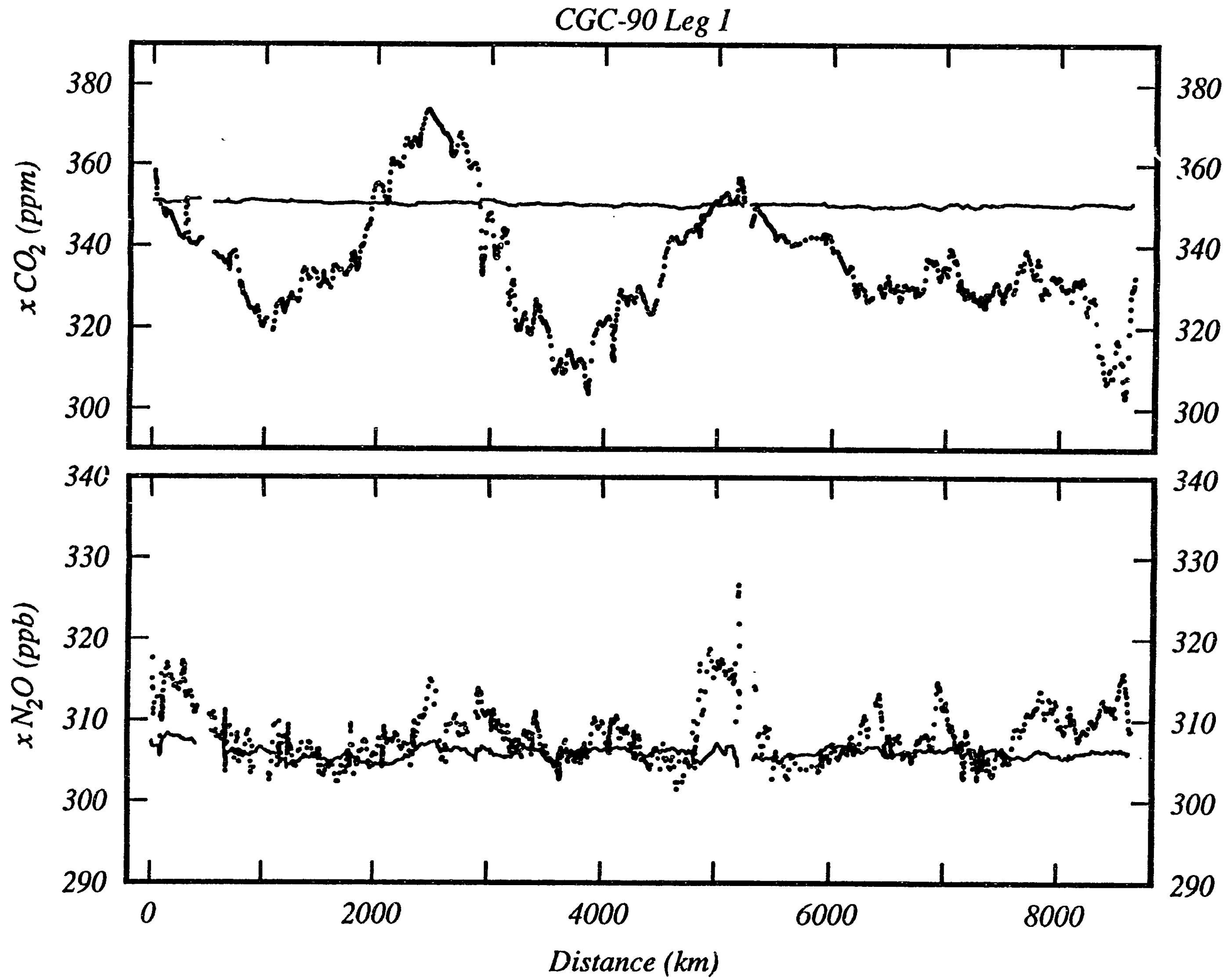


Figure 81. Data plot of xCO_2 and xN_2O (dry gas mole fractions), CGC-90 Leg 1. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

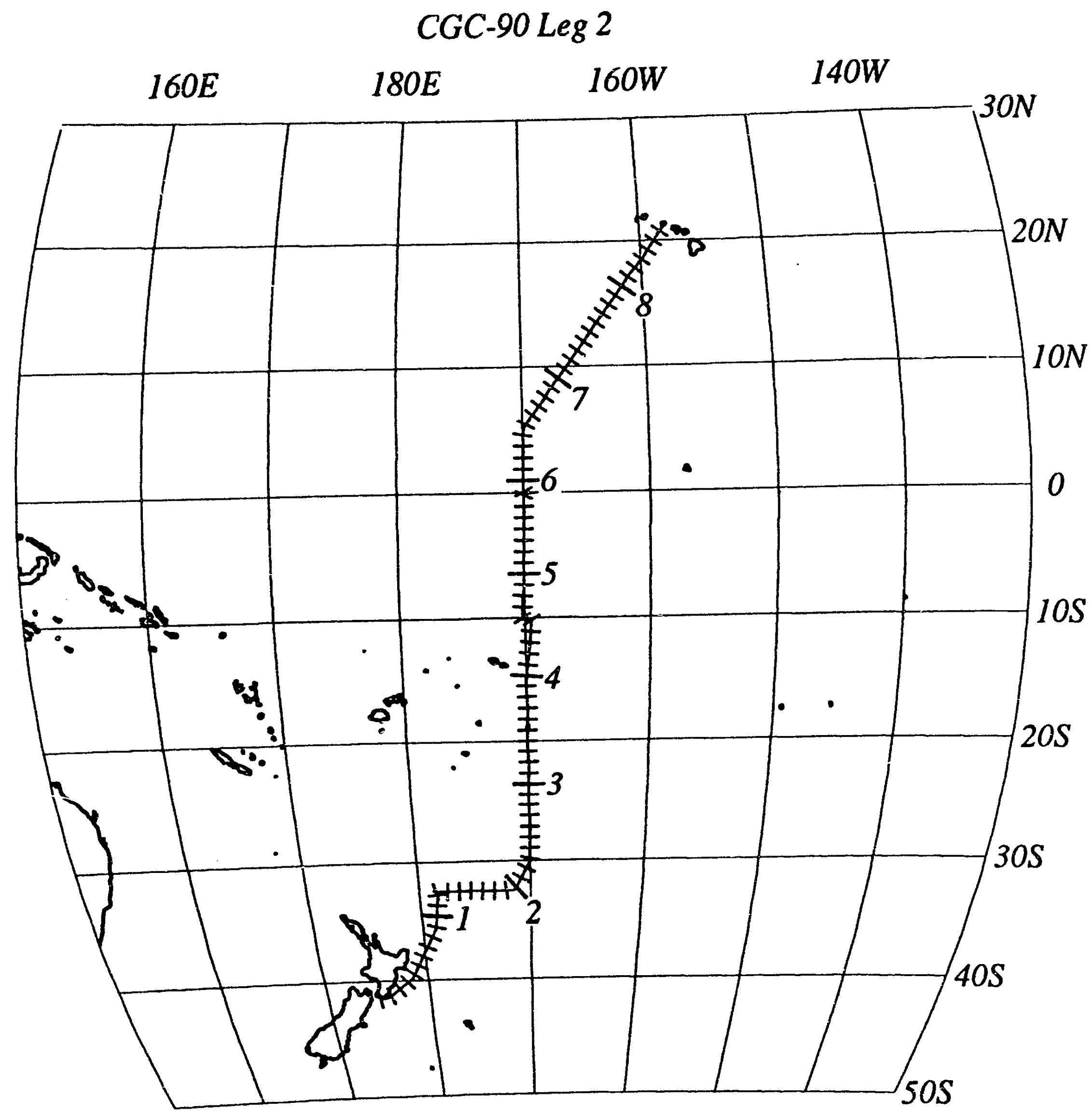


Figure 82. Cruise track plot, CGC-90 Leg 2. Track indicates cumulative distance in 1000 km intervals, with subdivisions of 100 km.

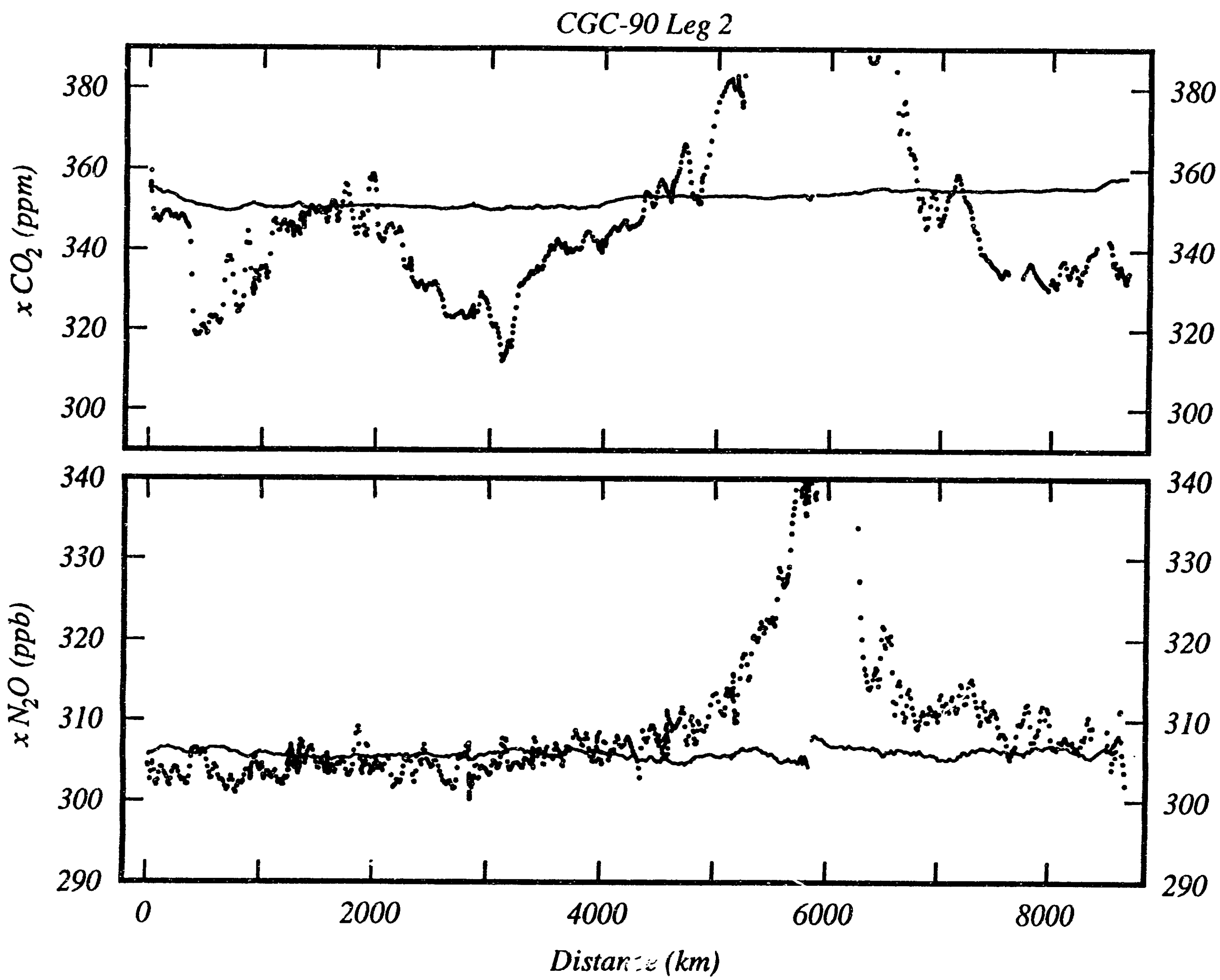


Figure 83. Data plot of xCO_2 and xN_2O (dry gas mole fractions), CGC-90 Leg 2. Atmospheric measurements are plotted as a line (20 point running mean). Measurements of gas equilibrated with seawater are plotted as individual points after smoothing with a 5-point Gaussian smoother.

5. METHODOLOGY

This document describes the results of surface water and atmospheric CO_2 and N_2O measurements carried out by shipboard gas chromatography over the period 1977–1990. The measurements were made by an automated high-precision shipboard gas chromatographic system developed during the late 1970s and used extensively over the intervening years. This instrument, which is described by Weiss (1981), measures CO_2 by flame ionization after quantitative reaction to methane in a stream of hydrogen using a reduced nickel catalyst preceded by a palladium catalyst to protect the nickel from oxygen and other atmospheric oxidants. Nitrous oxide is measured by a separate electron capture detector. (Methane is also measured by the flame ionization detector, although the system is not optimized for this gas. The methane results are not included in this data set because methane's equilibration time constant is long, and the results are therefore subject to contamination by biological activity in the ship's seawater pumping system.)

The chromatographic system measures 196 dry-gas samples a day, divided equally among the atmosphere, gas equilibrated with surface water, a low-range gas standard, and a high-range gas standard. Thus, the atmosphere and the ocean are each measured every half-hour, or 48 times a day. This corresponds to a spatial resolution of about 10 km when the ship is under way and gives several replicate measurements at each hydrographic station. The typical relative standard deviation of a single determination is about 0.04% for CO_2 and 0.3% for N_2O, but precision is occasionally affected adversely by shipboard operating conditions. The measurements are calibrated with dry-air secondary standards stored in Spectra-Seal aluminum cylinders. These standards are periodically calibrated for CO_2 against the Scripps Institution of Oceanography (SIO) manometric scale in the laboratory of C. D. Keeling and for N_2O against the calibration scale developed by Weiss *et al.* (1981). In addition to its accuracy, the chromatographic method for CO_2 offers the benefits over other commonly used techniques of being independent of oxygen concentration and using small amounts of sample and standard.

Surface seawater is pumped continuously from the bow of the ship (nominal depth approximately 3 m) at a rate of about 100 liters/min. This high pumping rate and the use of plastic polyvinylchloride (PVC) piping assure a minimal change in temperature and a minimal opportunity for chemical alteration of the water. The equilibrator is constructed of heavy acrylic plastic (for visibility and temperature insulation) and has an internal gas volume of about 20 liters. The equilibrator design consists of 2 concentric cylindrical stages, with a drain at the center to minimize volume changes as a result of ship motion. The water "rains" through the 2 stages of the equilibrator at a combined rate of about 20 liters/min, and a low 0.2-atm pressure head minimizes spraying, bubble entrapment, and other dynamic pressure effects. The 20-liter gas space is circulated by an air pump through a closed loop which provides the pressurized gas required by the chromatograph. Each half-hourly analysis removes about 75 ml of gas from this pumped loop. The first stage of the equilibrator is vented to the outside atmosphere so that the gas used for the analysis is replaced by clean marine air.

The temperature of the equilibrator is monitored and compared with the surface ocean temperatures measured at hydrographic stations to determine the thermal effect of the ship's pumping system as a function of intake temperature. The maximum amount of change, found for the coldest surface waters, is typically a warming of $<1°C$. As expected, this temperature difference decreases to zero when the water temperature reaches the mean inside temperature of the ship. The measured CO_2 values are corrected for this thermal effect (roughly 4% per degree) using an empirical equation (Weiss *et al.* 1982) which is dominated by the temperature dependence of the CO_2 solubility coefficient (Weiss 1974). The measured N_2O values are also corrected for the solubility effect (Weiss and Price 1980).

The response time of the equilibrator has been evaluated theoretically and experimentally. For unbuffered gases such as nitrous oxide, oxygen and nitrogen, the theoretical response time (assuming complete exchange between water and gas) is given as *FS/V*, where *F* is the flux of water through the system, *V* is the volume of the equilibrated gas phase, and *S* is the Ostwald solubility coefficient. For the equilibrator used in the measurements presented here, this gives a characteristic (1/*e*) response time of about 1 min for N_2O, about 0.5 hr for oxygen and about 1 hr for nitrogen. For CO_2 the response time would be similar to N_2O if there were no chemical buffering, but with chemical buffering (see gas exchange discussion in Broecker and Peng 1982) the response time is enhanced by an order of magnitude to about 0.1 min. Laboratory experiments by Weiss *et al.* (1982) and by scientists at the National Oceanic and Atmospheric Administration (NOAA), Pacific Marine Environmental Laboratory (PMEL) and Climate Monitoring and Diagnostics Laboratory (CMDL), who have adopted this equilibrator design, have confirmed that the actual equilibration times are close to these theoretical values.

These differences in exchange times are important in understanding the performance of an equilibrator that is vented to atmospheric pressure. Since the major components of equilibrated gas — nitrogen, oxygen, and argon — have equilibration times that are much longer than those of the measured species, N_2O and CO_2, the effect will be for the equilibrium partial pressures of these latter two gases to be present in a water-saturated gas phase at a total pressure equal to the barometric pressure. This is exactly the condition that is satisfied by the actual atmosphere when it is in equilibrium with the ocean, since the gas-phase boundary layer is always saturated with water vapor and at the total barometric pressure. Since the chromatographic system measures the dry-gas mole fractions of these constituents, xCO_2 and xN_2O, in both the atmosphere and the equilibrated gas, and the total pressure is the same in both cases, the differences in xCO_2 between these phases are a close measure of the differences in CO_2 partial pressure (pCO_2), as long as the total pressure is near 1 atm:

$$\text{delta}(pCO_2) = \text{delta}(xCO_2)(P - pH_2O),$$

where delta signifies the difference between sea and air, *P* is the barometric pressure, and pH_2O is the water vapor pressure. Because the temperature and the barometric pressure are routinely recorded, the system is effectively completely constrained, but even without these variables delta(xCO_2) is a very good approximation of delta(pCO_2). The argument is, of course, the same for the partial pressure of N_2O.

Another question which is more difficult to answer is whether the equilibrium reached by the equilibrator is the true thermodynamic equilibrium that we wish to measure. This type of question is always very difficult to answer, but there is indirect evidence that it is very close. The discrete equilibrator pCO_2 measurements carried out by T. Takahashi's group at Lamont-Doherty Geological Observatory during the SAVE expeditions have shown agreement with the equilibrator values presented here to within 1 or 2 ppm (T. Takahashi, personal communication), even though their measurements are made at a fixed temperature and must be corrected to the surface water temperature. Also, the measurements of pN_2O in the central gyres of the major oceans presented here are generally within 1% of atmospheric saturation. If this were not the correct equilibrium value, one could not explain the constancy of these values over many thousands of kilometers in many different central gyres. Through continued use of the same equilibrator design during the World Ocean

Circulation Experiment (WOCE), it is hoped to obtain further verification that the measurements are being made at true equilibrium through comparisons with the discrete pCO_2 and carbon system measurements being carried out by other laboratories.

Concentrations of CO_2 and N_2O are calculated by fitting detector peak area response to a quadratic polynomial forced through the origin (zeroth order term is zero). The calculation is performed with the assumption that the linearity of the detector varies slowly compared with changes in detector sensitivity. Accordingly, the second order term of the quadratic polynomial (linearity of the detector) is determined from a running mean of the high standard to low standard response ratio over a range of plus and minus 20 runs, and the first order term (sensitivity of the detector) is determined from the immediately bracketing high and low standard runs. Further details concerning the methods of sample measurement and analysis are provided in Weiss (1981), a copy of which is provided in the appendix of this document.

The magnetic tape (or floppy diskettes) that accompanies this document includes a descriptive information file (File 1 on the magnetic tape or NDP044.DES on the floppy diskettes), a file (File 2 on the magnetic tape or TRACK.LST on the floppy diskettes) containing a list of the expedition legs on which measurements were made, and a file (File 3 on the magnetic tape or DATA.LST on the floppy diskettes) containing a list of the corresponding data filenames. The tape or diskettes also contain two data files for each expedition leg: one file containing the atmospheric results and one containing the surface seawater results for xCO_2 and xN_2O [in parts per million (ppm) and parts per billion (ppb), respectively].

6. APPLICATIONS OF THE DATA

The data in this package constitute one of the most extensive records available of xCO_2 and, particularly, xN_2O in marine air and surface seawater. These data will be useful in modeling applications dealing with the ocean's role in the global biogeochemical cycles of carbon and nitrogen. The combination of atmospheric and surface seawater sampling represented in these data should also make them useful in studies of ocean--atmosphere dynamics. In addition, since determinations of pCO_2 in the past were usually derived indirectly, these shipboard gas chromatographic analyses are especially valuable in that they represent direct measurements of seawater CO_2 and will be useful in studies evaluating other methodologies for determining pCO_2.

7. LIMITATIONS AND RESTRICTIONS

The locations, surface water temperatures, and barometric pressures presented in the surface water and atmospheric CO_2 and N_2O data set are all interpolated from the discrete values recorded on the ship, and therefore must be taken only as approximations. As noted in the list of expeditions presented in Table 1, only N_2O was measured on the first four expedition legs. Barometric pressure also was not measured on these first four expedition legs, but this should not be a significant impediment to the use of the data for most applications, as was discussed in the methodology section (Section 5). The reader should note that measurements on NORPAX leg 7 and before were made using anhydrous calcium sulfate drying agent to dry the measured samples, which may bias the CO_2 results slightly due to acid-base reactions. This problem is discussed by Weiss (1981) and affects only these early legs. During the TPS-24 and TPS-47 expeditions, nitrogen carrier gas was used instead of argon-methane carrier gas for the N_2O determinations. Subsequent comparisons with flask atmospheric samples suggested that this may have produced a small bias of 1 or 2 ppb in the N_2O results from these legs, but no corrections have been applied.

The primary purpose of these data is to describe large-scale distributions of CO_2 and N_2O. The times of the measurements are accurate to within about 1 min, but the ancillary data such as position, sea surface temperature, and barometric pressure were interpolated from observations of extremely variable frequency and accuracy. The uncertainties resulting from these interpolations do not significantly increase the errors in the CO_2 and N_2O results. Ancillary data are reported for the sake of completeness but should not be used in their own right without a more thorough investigation of measurement and interpolation errors.

8. DATA CHECKS PERFORMED BY CDIAC

The Carbon Dioxide Information Analysis Center (CDIAC) endeavors to provide quality assurance (QA) of all data before their distribution. To ensure the highest possible quality in the data, CDIAC conducts extensive reviews for reasonableness, accuracy, completeness, and consistency of form. Although the reviews have common objectives, the specific form must be tailored to each data set; this tailoring process may involve considerable programming efforts. The entire QA process is an important part of CDIAC's effort to ensure accurate, usable CO_2-related data for researchers.

It is important to emphasize that the data were edited by the authors before submission to CDIAC to remove serious outliers and contaminated samples and to correct gross numerical errors. However, not all the data have yet been subjected to the level of scrutiny associated with careful interpretive work. Readers are therefore requested to draw to the attention of the authors any suspected inconsistencies in these data. Readers who have obtained this report directly from CDIAC will automatically receive notification of updates and corrections. *The authors also wish to encourage scientific collaborations with readers for the purpose of interpreting the results of these observations.*

The following summarizes the QA checks performed on the surface water and atmospheric CO_2 and N_2O data by CDIAC.

1. The format of all information, including header items, was checked to ensure consistency throughout each data file.

2. All numeric values were inspected for logical inconsistencies (*e.g.*, values of DATEDA <1 or >31; YEAR <1977 or >1990; TIME <0 or >2359; LAT <-90.0 or >90.0; LON <-180.0 or >180.0) and for the presence of outliers (*e.g.*, PRESS <900 or >1100; H2OTMP <-5 or >32).

The data distributed in this package are identical to the original data received by CDIAC. However, in order to enhance the ease of use of these data, the following alterations in format were made.

1. The data filenames were modified to conform to the two-level naming convention of DOS-based systems; for example, 05.INDOMED.LEG11A.WATER was changed to

INDOM11A.H2O. A complete listing of the filenames and the corresponding expedition legs is given in Section 11 of this document.

2. Within each data file, all header material was condensed into a single line. This involved removing blank lines and abbreviating the designations for sample type (*i.e.*, atmospheric data or surface seawater data). In addition, all descriptive column titles were removed.

3. Values of latitude and longitude were converted from degrees and minutes to decimal degrees, and signs were added to denote the hemisphere (Northern and Eastern Hemispheres were assigned "+" values; Southern and Western Hemispheres were assigned "-" values).

4. The designations for missing values, given as blanks in the original files, were changed to the following: -999.9 for missing values of barometric pressure; 99.99 for missing values of surface water temperature; and -99.9 for missing values of xN_2O and xCO_2.

9. REFERENCES

Broecker, W. S., and T.-H. Peng. 1982. *Tracers in the Sea.* Eldigio Press, Lamont-Doherty Geological Observatory of Columbia University, Palisades, New York.

Weiss, R. F. 1974. Carbon dioxide in water and seawater: The solubility of a non-ideal gas. *Marine Chemistry* 2:203-215.

Weiss, R. F., and B. A. Price. 1980. Nitrous oxide solubility in water and seawater. *Marine Chemistry* 8:347-359.

Weiss, R. F. 1981. Determinations of carbon dioxide and methane by dual catalyst flame ionization chromatography and nitrous oxide by electron capture chromatography. *Journal of Chromatographic Science* 19:611-616.

Weiss, R. F., C. D. Keeling, and H. Craig. 1981. The determination of tropospheric nitrous oxide. *Journal of Geophysical Research* 86:7197-7202.

Weiss, R. F., R. A. Jahnke, and C. D. Keeling. 1982. Seasonal effects of temperature and salinity on the partial pressure of carbon dioxide in seawater. *Nature* 300:511-513.

10. HOW TO OBTAIN THE DATA PACKAGE

This document describes a data set consisting of surface water and atmospheric CO_2 and N_2O measurements carried out by shipboard gas chromatography over the period 1977-1990. The data are available without charge upon request on nine-track magnetic tape, on floppy diskettes (IBM PC format, high- or low-density, 5.25- or 3.5-in. diskettes), or through File Transfer Protocol (FTP) from CDIAC. Requests for magnetic tapes should include any specific instructions for transmitting the data as required by the user to access the data. Requests not accompanied by specific instructions will be filled on nine-track, 6250 BPI, standard-labeled tapes with characters written in Extended Binary Codes Decimal Interchange Code (EBCDIC), and files will be formatted as given in Section 11. Requests should be addressed to the following:

Carbon Dioxide Information Analysis Center
Oak Ridge National Laboratory
Post Office Box 2008
Oak Ridge, Tennessee 37831-6335
U.S.A.

The tape and documentation can be ordered by telephone, fax, or through electronic mail.

Telephone: (615) 574-0390

Fax: (615) 574-2232

Electronic mail: BITNET: CDP@ORNLSTC
OMNET: CDIAC
INTERNET: CDP@ORNL.GOV

PART 2

INFORMATION ABOUT THE DATA FILES PROVIDED ON MAGNETIC TAPE OR FLOPPY DISKETTES

11. CONTENTS OF THE MAGNETIC TAPE OR FLOPPY DISKETTES

The following is a list of files distributed on magnetic tape or floppy diskettes by CDIAC along with this documentation.

File number, description, and name	Logical records	Record format[a]	Block size	Record length
1. General descriptive information file: NDP044.DES	324	FB	8000	80
2. Track list of expedition legs: TRACK.LST	66	FB	9000	90
3. List of data filenames: DATA.LST	84	FB	8000	80
4. FORTRAN-77 data retrieval code to read and print the surface water and atmospheric CO_2 and N_2O data (Files 5–86): NDP044.FOR	21	FB	8000	80
5. SAS[b] input/output routine to read and print the surface water and atmospheric CO_2 and N_2O data (Files 5–86): NDP044.SAS	26	FB	8000	80
6. Atmospheric CO_2 and N_2O data for Indomed Leg 2: INDOM2.AIR	1080	FB	8000	80
7. Surface seawater CO_2 and N_2O data for Indomed Leg 2: INDOM2.H2O	1068	FB	8000	80
8. Atmospheric CO_2 and N_2O data for Indomed Leg 3: INDOM3.AIR	349	FB	8000	80
9. Surface seawater CO_2 and N_2O data for Indomed Leg 3: INDOM3.H2O	357	FB	8000	80
10. Atmospheric CO_2 and N_2O data for Indomed Leg 4: INDOM4.AIR	1607	FB	8000	80

File number, description, and name	Logical records	Record format[a]	Block size	Record length
11. Surface seawater CO_2 and N_2O data for Indomed Leg 4: INDOM4.H2O	1529	FB	8000	80
12. Atmospheric CO_2 and N_2O data for Indomed Leg 5: INDOM5.AIR	1233	FB	8000	80
13. Surface seawater CO_2 and N_2O data for Indomed Leg 5: INDOM5.H2O	1223	FB	8000	80
14. Atmospheric CO_2 and N_2O data for Indomed Leg 11A: INDOM11A.AIR	204	FB	8000	80
15. Surface seawater CO_2 and N_2O data for Indomed Leg 11A: INDOM11A.H2O	207	FB	8000	80
16. Atmospheric CO_2 and N_2O data for Indomed Leg 12: INDOM12.AIR	1520	FB	8000	80
17. Surface seawater CO_2 and N_2O data for Indomed Leg 12: INDOM12.H2O	1521	FB	8000	80
18. Atmospheric CO_2 and N_2O data for Indomed Leg 15: INDOM15.AIR	989	FB	8000	80
19. Surface seawater CO_2 and N_2O data for Indomed Leg 15: INDOM15.H2O	934	FB	8000	80
20. Atmospheric CO_2 and N_2O data for Indomed Leg 15A: INDOM15A.AIR	353	FB	8000	80
21. Surface seawater CO_2 and N_2O data for Indomed Leg 15A: INDOM15A.H2O	353	FB	8000	80
22. Atmospheric CO_2 and N_2O data for NORPAX Transit: NORPAX0.AIR	375	FB	8000	80
23. Surface seawater CO_2 and N_2O data for NORPAX Transit: NORPAX0.H2O	375	FB	8000	80
24. Atmospheric CO_2 and N_2O data for NORPAX Leg 7: NORPAX7.AIR	1115	FB	8000	80

File number, description, and name	Logical records	Record format[a]	Block size	Record length
25. Surface seawater CO_2 and N_2O data for NORPAX Leg 7: NORPAX7.H2O	1107	FB	8000	80
26. Atmospheric CO_2 and N_2O data for NORPAX Leg 9: NORPAX9.AIR	1141	FB	8000	80
27. Surface seawater CO_2 and N_2O data for NORPAX Leg 9: NORPAX9.H2O	1143	FB	8000	80
28. Atmospheric CO_2 and N_2O data for NORPAX Leg 13: NORPAX13.AIR	1130	FB	8000	80
29. Surface seawater CO_2 and N_2O data for NORPAX Leg 13: NORPAX13.H2O	1128	FB	8000	80
30. Atmospheric CO_2 and N_2O data for NORPAX Leg 15: NORPAX15.AIR	1301	FB	8000	80
31. Surface seawater CO_2 and N_2O data for NORPAX Leg 15: NORPAX15.H2O	1300	FB	8000	80
32. Atmospheric CO_2 and N_2O data for TTO/NAS Leg 1: NAS1.AIR	568	FB	8000	80
33. Surface seawater CO_2 and N_2O data for TTO/NAS Leg 1: NAS1.H2O	542	FB	8000	80
34. Atmospheric CO_2 and N_2O data for TTO/NAS Leg 2: NAS2.AIR	1201	FB	8000	80
35. Surface seawater CO_2 and N_2O data for TTO/NAS Leg 2: NAS2.H2O	1115	FB	8000	80
36. Atmospheric CO_2 and N_2O data for TTO/NAS Leg 3: NAS3.AIR	1300	FB	8000	80
37. Surface seawater CO_2 and N_2O data for TTO/NAS Leg 3: NAS3.H2O	1274	FB	8000	80
38. Atmospheric CO_2 and N_2O data for TTO/NAS Leg 4: NAS4.AIR	1119	FB	8000	80

File number, description, and name	Logical records	Record format[a]	Block size	Record length
39. Surface seawater CO_2 and N_2O data for TTO/NAS Leg 4: NAS4.H2O	933	FB	8000	80
40. Atmospheric CO_2 and N_2O data for TTO/NAS Leg 5: NAS5.AIR	1206	FB	8000	80
41. Surface seawater CO_2 and N_2O data for TTO/NAS Leg 5: NAS5.H2O	1109	FB	8000	80
42. Atmospheric CO_2 and N_2O data for TTO/NAS Leg 6: NAS6.AIR	1255	FB	8000	80
43. Surface seawater CO_2 and N_2O data for TTO/NAS Leg 6: NAS6.H2O	1212	FB	8000	80
44. Atmospheric CO_2 and N_2O data for TTO/NAS Leg 7: NAS7.AIR	1144	FB	8000	80
45. Surface seawater CO_2 and N_2O data for TTO/NAS Leg 7: NAS7.H2O	1089	FB	8000	80
46. Atmospheric CO_2 and N_2O data for Hudson 82-001 Leg 1: HUD1.AIR	1578	FB	8000	80
47. Surface seawater CO_2 and N_2O data for Hudson 82-001 Leg 1: HUD1.H2O	1590	FB	8000	80
48. Atmospheric CO_2 and N_2O data for Hudson 82-001 Leg 2: HUD2.AIR	544	FB	8000	80
49. Surface seawater CO_2 and N_2O data for Hudson 82-001 Leg 2: HUD2.H2O	496	FB	8000	80
50. Atmospheric CO_2 and N_2O data for TTO/TAS Leg 1: TAS1.AIR	953	FB	8000	80
51. Surface seawater CO_2 and N_2O data for TTO/TAS Leg 1: TAS1.H2O	947	FB	8000	80
52. Atmospheric CO_2 and N_2O data for TTO/TAS Leg 2: TAS2.AIR	1165	FB	8000	80

File number, description, and name	Logical records	Record format[a]	Block size	Record length
53. Surface seawater CO_2 and N_2O data for TTO/TAS Leg 2: TAS2.H2O	1133	FB	8000	80
54. Atmospheric CO_2 and N_2O data for TTO/TAS Leg 3: TAS3.AIR	905	FB	8000	80
55. Surface seawater CO_2 and N_2O data for TTO/TAS Leg 3: TAS3.H2O	904	FB	8000	80
56. Atmospheric CO_2 and N_2O data for Ajax Leg 1: AJAX1.AIR	1408	FB	8000	80
57. Surface seawater CO_2 and N_2O data for Ajax Leg 1: AJAX1.H2O	1407	FB	8000	80
58. Atmospheric CO_2 and N_2O data for Ajax Leg 2: AJAX2.AIR	1785	FB	8000	80
59. Surface seawater CO_2 and N_2O data for Ajax Leg 2: AJAX2.H2O	1748	FB	8000	80
60. Atmospheric CO_2 and N_2O data for TPS24 Leg 1: TPS241.AIR	1392	FB	8000	80
61. Surface seawater CO_2 and N_2O data for TPS24 Leg 1: TPS241.H2O	1485	FB	8000	80
62. Atmospheric CO_2 and N_2O data for TPS24 Leg 2: TPS242.AIR	1499	FB	8000	80
63. Surface seawater CO_2 and N_2O data for TPS24 Leg 2: TPS242.H2O	1513	FB	8000	80
64. Atmospheric CO_2 and N_2O data for TPS47 Leg 1: TPS471.AIR	1554	FB	8000	80
65. Surface seawater CO_2 and N_2O data for TPS47 Leg 1: TPS471.H2O	1595	FB	8000	80
66. Atmospheric CO_2 and N_2O data for Ant V Leg 2: ANT52.AIR	3641	FB	8000	80

File number, description, and name	Logical records	Record format[a]	Block size	Record length
67. Surface seawater CO_2 and N_2O data for Ant V Leg 2: ANT52.H2O	1697	FB	8000	80
68. Atmospheric CO_2 and N_2O data for Ant V Leg 3: ANT53.AIR	3592	FB	8000	80
69. Surface seawater CO_2 and N_2O data for Ant V Leg 3: ANT53.H2O	2797	FB	8000	80
70. Atmospheric CO_2 and N_2O data for SAVE Transit: SAVE0.AIR	825	FB	8000	80
71. Surface seawater CO_2 and N_2O data for SAVE Transit: SAVE0.H2O	816	FB	8000	80
72. Atmospheric CO_2 and N_2O data for SAVE Leg 1: SAVE1.AIR	930	FB	8000	80
73. Surface seawater CO_2 and N_2O data for SAVE Leg 1: SAVE1.H2O	888	FB	8000	80
74. Atmospheric CO_2 and N_2O data for SAVE Leg 2: SAVE2.AIR	1624	FB	8000	80
75. Surface seawater CO_2 and N_2O data for SAVE Leg 2: SAVE2.H2O	1618	FB	8000	80
76. Atmospheric CO_2 and N_2O data for SAVE Leg 3: SAVE3.AIR	1790	FB	8000	80
77. Surface seawater CO_2 and N_2O data for SAVE Leg 3: SAVE3.H2O	1785	FB	8000	80
78. Atmospheric CO_2 and N_2O data for SAVE Leg 4: SAVE4.AIR	1713	FB	8000	80
79. Surface seawater CO_2 and N_2O data for SAVE Leg 4: SAVE4.H2O	1697	FB	8000	80
80. Atmospheric CO_2 and N_2O data for SAVE Leg 5: SAVE5.AIR	2044	FB	8000	80

File number, description, and name	Logical records	Record format[a]	Block size	Record length
81. Surface seawater CO_2 and N_2O data for SAVE Leg 5: SAVE5.H2O	1927	FB	8000	80
82. Atmospheric CO_2 and N_2O data for SAVE Leg 6: SAVE6.AIR	1471	FB	8000	80
83. Surface seawater CO_2 and N_2O data for SAVE Leg 6: SAVE6.H2O	1466	FB	8000	80
84. Atmospheric CO_2 and N_2O data for CGC-90 Leg 1: CGC901.AIR	1175	FB	8000	80
85. Surface seawater CO_2 and N_2O data for CGC-90 Leg 1: CGC901.H2O	1197	FB	8000	80
86. Atmospheric CO_2 and N_2O data for CGC-90 Leg 2: CGC902.AIR	996	FB	8000	80
87. Surface seawater CO_2 and N_2O data for CGC-90 Leg 2: CGC902.H2O	1003	FB	8000	80
Total records	102,523	(or ~7.1 mB)		

[a] FB = fixed block.
[b] SAS is the registered trademark of SAS Institute, Inc., Cary, NC 27511-8000.

12. DESCRIPTIVE FILE ON THE TAPE/DISKETTES

The following is a listing of File 1 on the magnetic tape (or NDP044.DES on the floppy diskettes) distributed by CDIAC. This file is intended to complement the documentation and provide details (*i.e.*, variable descriptions, formats, and units) about the data files on the magnetic tape or floppy diskettes.

TITLE OF THE DATA SET

Surface Water and Atmospheric Carbon Dioxide and Nitrous Oxide Observations by Shipboard Automated Gas Chromatography: Results from Expeditions between 1977 and 1990.

DATA CONTRIBUTORS

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La Jolla, California

SOURCE AND SCOPE OF THE DATA

Note: The material provided on the magnetic tape or floppy diskettes for this section is essentially identical to the contents of Sections 4 (Source Information) and 5 (Methodology) of Part I of this documentation.

DATA FORMAT

Eighty-seven files are provided on this magnetic tape or these floppy diskettes, including (1) this descriptive file — File 1 on the magnetic tape or NDP044.DES on the floppy diskettes; (2) a file containing a list of expedition legs on which measurements were made — File 2 on the magnetic tape or TRACK.LST on the floppy diskettes; (3) a file containing a list of the data filenames corresponding (by number) to the expedition legs listed in File 2 (or TRACK.LST) — File 3 on the magnetic tape or DATA.LST on the floppy diskettes; (4) a FORTRAN-77 retrieval program to read and print any of the data files — File 4 on the magnetic tape or NDP044.FOR on the floppy diskettes; (5) a SAS input/output routine to read and print any of the data files — File 5 on the magnetic tape or NDP044.SAS on the floppy diskettes; and (6)–(87) 82 files containing the surface water and atmospheric CO_2 and N_2O data — Files 6–87 on the magnetic tape or *.AIR and *.H2O on the floppy diskettes [with full filenames as listed in File 3 (or DATA.LST)].

Table 2 (located in the documentation that accompanies this tape/diskettes) presents a partial listing of one of the surface water and atmospheric CO_2 and N_2O data files. The data files are formatted in the following way:

```
      CHARACTER SAMPTYP, HEADER*77, DATEMO*3, LATHEM, LONHEM
      INTEGER DATEDA, DATEYR, TIME
      REAL LAT, LON, PRESS, H2OTMP, XN2O, XCO2
      READ (5,500) SAMPTYP, HEADER
   10 READ (5,600,END=800) DATEDA, DATEMO, DATEYR, TIME,
     1  LAT, LATHEM, LON, LONHEM, PRESS, H2OTMP, XN2O, XCO2
      GOTO 10
  500 FORMAT (A1,2X,A77)
  600 FORMAT (I2,1X,A3,1X,I2,3X,I4,3X,F7.3,1X,A1,3X,F8.3,
     1        1X,A1,3X,F6.1,3X,F5.2,3X,F5.1,3X,F5.1)
  800 STOP
```

where

SAMPTYP	is a one-character code describing the type of samples being presented in the data file: A = atmospheric samples, S = surface seawater (*i.e.*, gas equilibrated with surface seawater) samples;
HEADER	is a descriptive character string consisting of (1) the name of the expedition (*e.g.*, AJAX Leg 1) and (2) the name of the research vessel (*e.g.*, R/V Knorr);
DATEDA	is the numeric day of the month on which the sample was collected;
DATEMO	is the three-letter abbreviation (Jan, Feb, etc.) for the month in which the sample was collected;
DATEYR	is the final two digits of the year (since 1900) in which the sample was collected;
TIME	is the Greenwich Mean Time at which the sample was collected, expressed in 24-hour time from 0000 to 2359;
LAT	is the latitude (in decimal degrees) at which the sample was collected, with possible values from -90.000 to 90.000 (north latitudes are represented as positive);
LATHEM	is the latitudinal hemisphere in which the sample was taken: N = Northern Hemisphere, S = Southern Hemisphere;
LON	is the longitude (in decimal degrees) at which the sample was collected, with possible values from -180.000 to 180.000 (east longitudes are represented as positive);
LONHEM	is the longitudinal hemisphere in which the sample was taken: E = Eastern Hemisphere, W = Western Hemisphere;

PRESS | is the approximate sea level barometric pressure in mBar, interpolated from discrete values recorded on the ship at hydrographic stations;

H2OTMP | is the approximate surface water temperature in degrees Celsius, interpolated from discrete values recorded on the ship at hydrographic stations;

XN2O | is the dry gas mole fraction of nitrous oxide (N_2O) in the sample, measured in parts per billion (ppb);

XCO2 | is the dry gas mole fraction of carbon dioxide (CO_2) in the sample, measured in parts per million (ppm);

Stated in tabular form the contents include the following:

Variable[a]	Variable type	Variable width[b]	Line	Starting column	Ending column
SAMPTYP	Character	A1	1	1	1
HEADER	Character	A77	1	4	80
DATEDA	Numeric	I2	2...n	1	2
DATEMO	Character	A3	2...n	4	6
DATEYR	Numeric	I2	2...n	8	9
TIME	Numeric	I4	2...n	13	16
LAT	Numeric	F7.3	2...n	20	26
LATHEM	Character	A1	2...n	28	28
LON	Numeric	F8.3	2...n	32	39
LONHEM	Character	A1	2...n	41	41
PRESS	Numeric	F6.1	2...n	45	50
H2OTMP	Numeric	F5.2	2...n	54	58
XN2O	Numeric	F5.1	2...n	62	66
XCO2	Numeric	F5.1	2...n	70	74

[a] Missing values are represented as follows — PRESS: -999.9; H2OTMP: 99.99; XN2O: -99.9; XCO2: -99.9.

[b] Values for variable width are entered as FORTRAN 77 format codes.

Table 2. Partial listing of one of the surface water and atmospheric CO_2 and N_2O data files (File 23 on the magnetic tape or NORPAX0.H2O on the floppy diskettes)

S NORPAX	Transit	R/V Wecoma						
6 Jul 79	2015	44.633 N	-124.050 W	1019.2	15.77	442.7	270.8	
6 Jul 79	2045	44.605 N	-124.115 W	1019.6	15.48	445.8	273.5	
6 Jul 79	2115	44.570 N	-124.193 W	1019.7	15.45	439.8	277.5	
6 Jul 79	2145	44.537 N	-124.272 W	1019.6	15.60	350.6	244.5	
6 Jul 79	2215	44.502 N	-124.350 W	1019.6	15.21	359.9	235.7	
6 Jul 79	2245	44.467 N	-124.428 W	1019.6	14.82	343.9	248.2	
6 Jul 79	2315	44.420 N	-124.547 W	1019.4	15.13	321.7	274.7	
6 Jul 79	2345	44.362 N	-124.707 W	1019.2	15.58	321.0	269.7	
7 Jul 79	0015	44.303 N	-124.868 W	1018.9	16.03	314.3	279.9	
7 Jul 79	0045	44.245 N	-125.028 W	1018.7	16.15	320.2	274.4	
7 Jul 79	0115	44.187 N	-125.188 W	1018.4	16.21	325.2	263.3	
7 Jul 79	0145	44.128 N	-125.348 W	1018.1	16.06	327.6	264.0	
7 Jul 79	0215	44.070 N	-125.510 W	1017.8	15.91	316.5	265.4	
7 Jul 79	0245	44.012 N	-125.670 W	1017.4	15.88	313.0	274.4	
7 Jul 79	0315	43.963 N	-125.795 W	1017.2	15.97	312.0	278.9	
7 Jul 79	0345	43.923 N	-125.885 W	1016.8	16.06	309.8	297.8	
7 Jul 79	0415	43.885 N	-125.973 W	1016.6	16.14	307.0	298.9	
7 Jul 79	0445	43.845 N	-126.063 W	1016.3	16.21	308.7	296.1	
7 Jul 79	0515	43.805 N	-126.153 W	1016.1	16.19	307.9	295.2	
7 Jul 79	0545	43.765 N	-126.243 W	1015.8	16.07	308.9	316.0	
7 Jul 79	0615	43.727 N	-126.332 W	1015.5	16.02	307.8	325.0	
7 Jul 79	0645	43.687 N	-126.422 W	1015.1	16.02	308.4	333.8	
7 Jul 79	0715	43.640 N	-126.528 W	1014.7	16.02	308.3	334.9	
7 Jul 79	0745	43.588 N	-126.653 W	1014.3	16.02	309.1	336.2	
7 Jul 79	0815	43.537 N	-126.778 W	1013.8	16.03	308.4	337.3	
7 Jul 79	0845	43.485 N	-126.903 W	1013.3	16.09	308.8	338.1	
7 Jul 79	0915	43.433 N	-127.028 W	1012.9	16.18	309.0	336.1	
7 Jul 79	0945	43.382 N	-127.153 W	1012.4	16.27	307.0	330.1	
7 Jul 79	1015	43.330 N	-127.278 W	1012.1	16.31	307.9	332.0	
7 Jul 79	1045	43.278 N	-127.403 W	1012.0	16.28	311.6	338.1	
7 Jul 79	1115	43.227 N	-127.528 W	1011.9	16.25	308.7	340.8	
7 Jul 79	1145	43.175 N	-127.653 W	1011.8	16.27	310.9	341.8	
7 Jul 79	1215	43.127 N	-127.778 W	1011.7	16.32	307.1	340.3	
7 Jul 79	1245	43.082 N	-127.903 W	1011.6	16.37	-99.9	337.2	
7 Jul 79	1315	43.035 N	-128.028 W	1011.5	16.39	308.2	339.4	
7 Jul 79	1345	42.990 N	-128.153 W	1011.4	16.39	308.4	339.6	
7 Jul 79	1415	42.943 N	-128.278 W	1011.3	16.32	305.8	340.8	
7 Jul 79	1445	42.898 N	-128.403 W	1011.2	16.19	306.7	340.1	
7 Jul 79	1515	42.852 N	-128.528 W	1011.1	16.05	307.1	342.5	
7 Jul 79	1545	42.807 N	-128.653 W	1010.9	15.92	310.8	341.9	
7 Jul 79	1615	42.762 N	-128.777 W	1010.2	15.78	310.8	344.7	
7 Jul 79	1645	42.718 N	-128.898 W	1009.6	15.65	310.3	338.8	
7 Jul 79	1715	42.673 N	-129.018 W	1008.8	15.51	310.4	341.2	
7 Jul 79	1745	42.630 N	-129.140 W	1007.6	15.34	310.6	336.3	
7 Jul 79	1815	42.587 N	-129.260 W	1007.2	15.30	310.6	333.6	
7 Jul 79	1845	42.543 N	-129.382 W	1007.3	15.37	310.3	333.8	
7 Jul 79	1915	42.498 N	-129.502 W	1007.4	15.43	309.9	337.7	
7 Jul 79	1945	42.455 N	-129.623 W	1007.5	15.50	309.2	335.2	
7 Jul 79	2015	42.412 N	-129.727 W	1007.7	15.54	311.0	342.5	
7 Jul 79	2045	42.368 N	-129.815 W	1007.8	15.54	310.8	342.5	
7 Jul 79	2115	42.323 N	-129.902 W	1007.9	15.54	310.9	342.0	
7 Jul 79	2145	42.280 N	-129.990 W	1008.0	15.54	-99.9	344.6	
7 Jul 79	2215	42.237 N	-130.077 W	1008.1	15.54	309.8	345.8	
7 Jul 79	2245	42.193 N	-130.165 W	1008.2	15.55	310.9	345.0	
7 Jul 79	2315	42.148 N	-130.252 W	1008.1	15.57	309.0	344.3	
7 Jul 79	2345	42.105 N	-130.340 W	1008.0	15.58	307.6	343.8	
8 Jul 79	0015	42.057 N	-130.428 W	1008.0	15.59	309.7	343.5	
8 Jul 79	0045	42.005 N	-130.518 W	1008.2	15.60	310.2	343.5	
8 Jul 79	0115	41.953 N	-130.607 W	1008.2	15.61	309.5	341.8	

REFERENCES

Note: The material provided on the magnetic tape or floppy diskettes for this section is identical to the contents of Section 9 (References) of Part I of this documentation.

13. LISTING OF THE FORTRAN-77 DATA RETRIEVAL PROGRAM

The following is a listing of the FORTRAN-77 data retrieval program (File 4 on magnetic tape or NDP044.FOR on floppy diskette) provided by CDIAC to read and print the surface water and atmospheric CO_2 and N_2O data (Files 6–87 on magnetic tape or files *.AIR and *.H2O on floppy diskettes). The job control language (JCL) statements (preceded by // or /*) shown below are not provided in the file on the tape/diskette; requestors must add JCL statements themselves if required. The statements required will vary for each operating system. The JCL statements shown below are provided to illustrate the statements that an individual using an IBM mainframe (*e.g.*, IBM 3090) at ORNL would need to read these data from a nine-track, 6250 BPI, standard-labeled tape with characters written in EBCDIC.

```
//UIDCO2 JOB(12345),'USER ADDRESS'
//OUT OUTPUT DEFAULT=YES,JESDS=ALL,DEST=LOCAL
//EXEC FORTVCLG
//FORT.SYSIN DD *

C*******************************************************************
C A FORTRAN program to read and print the surface water and
C   atmospheric carbon dioxide and nitrous oxide data.
C*******************************************************************
      CHARACTER SAMPTYP, HEADER*77, DATEMO*3, LATHEM, LONHEM
      INTEGER DATEDA, DATEYR, TIME
      REAL LAT, LON, PRESS, H2OTMP, XN2O, XCO2
      READ (5,500) SAMPTYP, HEADER
      WRITE (6,500) SAMPTYP, HEADER
   10 READ (5,600,END=800) DATEDA, DATEMO, DATEYR, TIME, LAT,
     1  LATHEM, LON, LONHEM, PRESS, H2OTMP, XN2O, XCO2
      WRITE (6,650) DATEDA, DATEMO, DATEYR, TIME, LAT,
     1  LATHEM, LON, LONHEM, PRESS, H2OTMP, XN2O, XCO2
      GOTO 10
  500 FORMAT (A1,2X,A77)
  600 FORMAT (I2,1X,A3,1X,I2,3X,I4,3X,F7.3,1X,A1,3X,F8.3,1X,A1,
     1        3X,F6.1,3X,F5.2,3X,F5.1,3X,F5.1)
  650 FORMAT (I2,1X,A3,1X,I2,3X,I4.4,3X,F7.3,1X,A1,3X,F8.3,1X,
     1        A1,3X,F6.1,3X,F5.2,3X,F5.1,3X,F5.1,'      ')
  800 STOP
      END
/*
//GO.FT05F001 DD UNIT=TAPE62,VOL=SHR=TAPEVOL,DISP=(,PASS),
// LABEL=(4,SL,RETPD=0),
// DSN=TAB.NDP044.DATA
//GO.FT06F001 DD *
//
```

14. LISTING OF THE SAS INPUT/OUTPUT RETRIEVAL PROGRAM

The following is a listing of the SAS[a] data retrieval program (File 5 on magnetic tape or NDP044.SAS on floppy diskette) provided by CDIAC to read and print the surface water and atmospheric CO_2 and N_2O data (Files 6–87 on magnetic tape or files *.AIR and *.H2O on floppy diskettes). The JCL statements (preceded by // or /*) shown below are not provided in the file on the tape/diskette; requestors must add JCL statements themselves if required. The statements required will vary for each operating system. The JCL statements shown below are provided to illustrate the statements that an individual using an IBM mainframe (*e.g.*, IBM 3090) at ORNL would need to read these data from a nine-track, 6250 BPI, standard-labeled tape with characters written in EBCDIC.

```
//UIDCO2 JOB (12345),'USER ADDRESS'
//OUT OUTPUT DEFAULT=YES,JESDS=ALL,DEST=LOCAL
//STEP1 EXEC SAS,SASRGN=4096K,WORK=1600
//IN DD UNIT=TAPE62,VOL=SER=TAPEVOL,DISP=(,PASS),
// DSN=TAB.NDP044.DATA,LABEL=(4,SL,RETPD=0)
//FT06F001 DD SYSOUT=A
//SYSIN DD *

* A SAS program to read and print the surface water and
   atmospheric carbon dioxide and nitrous oxide data;
DATA WEISS(DROP=X);
  INFILE IN;
  INPUT X $ 2 @;
  IF X EQ ' ' THEN DO;
    INPUT SAMPTYP $ 1 @4 HEADER $CHAR77.;
    RECCODE=1;
    END;
  ELSE DO;
    INPUT DATEDA 1-2 DATEMO $ 4-6 DATEYR 8-9 TIME 13-16 LAT 20-26
      LATHEM $ 28 LON 32-39 LONHEM $ 41 PRESS 45-50 H2OTMP 54-58
      XN2O 62-66 XCO2 70-74;
    RECCODE=2;
    END;
DATA PRINT;
  SET WEISS;
  FILE PRINT;
  OPTIONS MISSING=' ';
  IF RECCODE=1 THEN
    PUT SAMPTYP 1 HEADER 4-80;
  ELSE IF RECCODE=2 THEN
    PUT DATEDA 1-2 DATEMO 4-6 DATEYR 8-9 @13 TIME z4. @20 LAT 7.3
    LATHEM 28 @32 LON 8.3 LONHEM 41 @45 PRESS 6.1 @54 H2OTMP 5.2
      @62 XN2O 5.1 @70 XCO2 5.1 @75 '      ';
RUN;
/*
//
```

[a] SAS is the registered trademark of SAS Institute, Inc., Cary, NC 27511-8000.

15. VERIFICATION OF DATA TRANSPORT

The surface water and atmospheric CO_2 and N_2O data can be read by using the FORTRAN or SAS input/output routines provided. Users should verify that the data file has been correctly transported to their systems by generating some or all of the statistics presented in Table 3. These statistics were generated in FORTRAN but can be duplicated in other languages or statistical packages. If the statistics generated by the user differ from those presented here, the data files may have been corrupted in transport.

These statistics are presented only as a tool to ensure proper reading of the data files. They are not to be construed as summarizing the surface water and atmospheric CO_2 and N_2O data.

Table 3. Characteristics of numeric variables in the collective surface water and atmospheric CO_2 and N_2O data files

Variable	Number of observations	Mean	Minimum value	Maximum value
DATEDA	101920	14.991	1.000	31.000
DATEYR	101920	83.469	77.000	90.000
TIME	101920	1176.071	0.000	2359.000
LAT	101920	-2.444	-77.177	79.005
LON	101920	-36.570	-179.998	179.998
PRESS	101920	843.456	-999.900	1035.400
H2OTMP	101920	18.075	-2.130	99.990
XN2O	101920	279.027	-99.900	725.600
XCO2	101920	291.289	-99.900	737.900

The following is a listing of the FORTRAN program used to generate the statistics described in Table 3:

```
      CHARACTER DATAFIL*12, VARNAME(9)*6
      INTEGER DATEDA, DATEYR, TIME, I, J, N
      REAL LAT, LON, PRESS, H2OTMP, XN2O, XCO2, DATA(9,5)
      VARNAME(1)='DATEDA'
      VARNAME(2)='DATEYR'
      VARNAME(3)='TIME  '
      VARNAME(4)='LAT   '
      VARNAME(5)='LON   '
      VARNAME(6)='PRESS '
      VARNAME(7)='H2OTMP'
      VARNAME(8)='XN2O  '
      VARNAME(9)='XCO2  '
      DO 10 I=1,9
        DO 5 J=1,5
          DATA(I,J)=0
 5      CONTINUE
 10   CONTINUE
      N=0
      OPEN (UNIT=2, FILE='DATA.LST', ACCESS='SEQUENTIAL',
     1  FORM='FORMATTED', STATUS='OLD')
      OPEN (UNIT=4, FILE='SUMSTATS.OUT', ACCESS='SEQUENTIAL',
     1  FORM='FORMATTED', STATUS='NEW')
 15   READ (2,100,END=45) DATAFIL
      OPEN (UNIT=3, FILE=DATAFIL, ACCESS='SEQUENTIAL',
     1  FORM='FORMATTED', STATUS='OLD')
      READ (3,200)
 20   READ (3,300,END=40) DATEDA, DATEYR, TIME, LAT, LON, PRESS
     1  H2OTMP, XN2O, XCO2
      DATA(1,1)=REAL(DATEDA)
      DATA(2,1)=REAL(DATEYR)
      DATA(3,1)=REAL(TIME)
      DATA(4,1)=LAT
      DATA(5,1)=LON
      DATA(6,1)=PRESS
      DATA(7,1)=H2OTMP
      DATA(8,1)=XN2O
      DATA(9,1)=XCO2
```

```
      IF(N.EQ.0) THEN
        DO 30 I=1,9
          DO 25 J=4,5
            DATA(I,J)=DATA(I,1)
25        CONTINUE
30      CONTINUE
      END IF
      DO 35 I=1,9
        DATA(I,2)=DATA(I,2)+DATA(I,1)
        IF(DATA(I,1).LT.DATA(I,4)) DATA(I,4)=DATA(I,1)
        IF(DATA(I,1).GT.DATA(I,5)) DATA(I,5)=DATA(I,1)
35    CONTINUE
      N=N+1
      GOTO 20
40    CLOSE (UNIT=3)
      GOTO 15
45    CLOSE (UNIT=2)
      DO 50 I=1,9
        DATA(I,3)=DATA(I,2)/REAL(N)
50    CONTINUE
      DO 55 I=1,9
        WRITE (4,400) VARNAME(I), N, DATA(I,3), DATA(I,4),
     1    DATA(I,5)
55    CONTINUE
      CLOSE (UNIT=4)
      STOP
100   FORMAT (4X,A12)
200   FORMAT (1X)
300   FORMAT (I2,5X,I2,3X,I4,3X,F7.3,5X,F8.3,5X,F6.1,3X,F5.2,
     1  3X,F5.1,3X,F5.1)
400   FORMAT (1X,A6,2X,I6,2X,F8.3,2X,F8.3,2X,F8.3)
      END
```

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