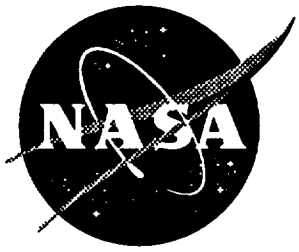
NASA Technical Memorandum 109177



Compendium Of NASA Data Base For The Global Tropospheric Experiment's Pacific Exploratory Mission West-A (PEM West-A)

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Hampton, Virginia 23681-0001

COMPENDIUM OF NASA DATA BASE FOR THE GLOBAL TROPOSPHERIC EXPERIMENT'S PACIFIC EXPLORATORY MISSION WEST-A (PEM WEST-A)

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SUMMARY

The report provides a compendium of NASA aircraft data that are available from NASA's Global Tropospheric Experiment's (GTE) Pacific Exploratory Mission West-A (PEM West-A) conducted in September and October 1991. The NASA PEM West experiments (PEM West-A and -B) are a major component of the East Asia/North Pacific Regional Study (APARE), a project within the International Global Atmospheric Chemistry (IGAC) Program. PEM West flight experiments focused on the Pacific rim region and were primarily based at Japan, Hong Kong, and Guam. The broad objectives of the experiments were to study chemical processes and long-range transport associated with Asian continental outflow over the northwest Pacific Ocean and to document the magnitude of the human impact on the oceanic/marine atmosphere oven this region with an emphasis on ozone and sulfur chemistry (gas). PEM West-B, conducted in the same region during February and March 1994, studied late-winter to early-spring meteorology during which continental outflow was enhanced in comparison to outflow during the early-fall PEM West-A time frame. Results from PEM West-B will become publicly available in the summer of 1995. PEM West-A data are public domain.

The format of this compendium utilizes data plots--time series and altitude profiles--of selective data acquired aboard the NASA/Ames DC-8 aircraft during PEM West-A. The purpose of this document is to provide a representation of aircraft data that are available in archived format via NASA Langley's Distributed Active Archive Center (DAAC). The data format is not

intended to support original research/analyses, but to assist the reader in identifying data that are of interest. This compendium is for only the NASA aircraft data. The DAAC archived data bases include numerous supporting data including meteorological observations/products, photochemical modeling products, results from surface studies, satellite observations, and sondes releases.

INTRODUCTION

The goal of the NASA Tropospheric Chemistry Program is to develop an understanding of the chemical cycles that control the composition of the troposphere and to assess the susceptibility of the global atmosphere to chemical change. A major component of the NASA program is the Global Tropospheric Experiment (GTE), which consists of a series of field experiments designed to (1) evaluate the capability of instrument techniques to measure, under field conditions, the minute concentrations of key chemical species in the troposphere; and (2) systematically address tropospheric chemistry issues relevant to global change, through airborne sampling expeditions, coupled with modeling and laboratory studies. GTE is primarily an aircraft-based program supplemented by ground-based measurements. Satellite data also play important roles. Space Shuttle observations of tropospheric carbon monoxide distributions have been used to plan and direct the course of expeditions, for example, over tropical rain forests and for continental outflow into the tropical Atlantic Ocean. Landsat land-surface images have facilitated the extrapolation of regional Arctic-tundra measurements into global-scale conclusions. Total Ozone Measurements from Satellites (TOMS) have helped place GTE observed ozone distributions/budgets into a global perspective (temporal and spatial) and to guide intensive aircraft studies over the tropical Atlantic Ocean. Weather data returned by environmental satellites have guided flight planning for research flights. The Distributed Active Archive Center (DAAC) data include many of the satellite, surface, and meteorological products used to support GTE missions or analyses.

The GTE airborne expeditions have focused on studies of the remote global atmosphere in order to provide well-documented baseline measurements of the unperturbed environment and to fully understand the chemical cycles underlying the natural environment. Table 1 and Figure 1 summarize GTE missions conducted through 1994. The GTE expeditions have been conducted in a diverse range of environments and with different scientific goals. The Chemical Instrument Test and Evaluation (CITE) series was designed to study

our ability to measure key tropospheric gaseous species by exposing selected instrumentation to a wide range of measurement conditions. The Atmospheric Boundary Layer Experiments (ABLE) were designed to study the emission, chemical processes, and dynamics of the boundary layer, and have been conducted over ecosystems known to have significant influence on the global troposphere. The importance of long-range transport of natural and anthropogenic emissions on the global troposphere has been investigated in the Pacific Exploratory Missions (PEM) and the Transport and Atmospheric Chemistry Experiment in the Atlantic (TRACE-A).

The GTE, managed through the Tropospheric Chemistry Program in the Mission to Planet Earth Office, NASA Headquarters, was initiated in the early 1980s. Implementation of the GTE Project is via a Project Office at the NASA Langley Research Center, Atmospheric Sciences Division.

SYMBOLS AND UNITS

ABLE	Atmospheric Boundary Layer Experiment
APARE	East Asia/North Pacific Regional Study
CITE	Chemical Instrument Test and Evaluation
CO	carbon monoxide
CO_2	carbon dioxide
C_2Cl_4	tetrachloroethylene
CH_3CCl_3	methyl chloroform
CH_3OOH	methyl peroxide
CH_3COOH	acetic acid
CH_4	methane
DAAC	Distributed Active Archive Center
deg.	degree
DMS	dimethyl sulfide
dp	dew point temperature, degree Centigrade

Ga.Inst. of Tech.	Georgia Institute of Technology, Atlanta, Georgia
GTE	Global Tropospheric Experiment
H_2O_2	hydrogen peroxide
HCOOH	formic acid
HNO_3	nitric acid
IGAC	International Global Atmospheric Chemistry Program
LaRC	Langley Research Center
N_2O	nitrous oxide
NASA	National Aeronautics and Space Administration
NIES	National Institute for Environmental Studies, Japan
NOAA	National Oceanic and Atmospheric Administration
NO	nitric oxide
NO_x	nitrogen oxides (nitric oxide + nitrogen dioxide)
NO_y	total odd nitrogen
NCAR	National Center for Atmospheric Research
O_3	ozone
PAN	peroxyacetyl nitrate
PEM	Pacific Exploratory Mission
ppbv	parts-per-billion, by volume
ppmv	parts-per-million, by volume
PPN	peroxypropionly nitrate
pptv	parts-per-trillion, by volume
Rel. Humidity	relative humidity, percent
SO_2	sulfur dioxide
T	air temperature, degree Centigrade
Theta	potential temperature, degree Kelvin
TOMS	Total Ozone Measurements from Satellites
TRACE-A	Transport and Atmospheric Chemistry Experiment in the Atlantic

Univ.of CA, Irvine	University of California at Irvine, California
Univ.of NH	University of New Hampshire, Durham, New Hampshire
Univ. of RI	University of Rhode Island, Narragansett, Rhode Island
Univ.	University

PROGRAM AND DATA DESCRIPTIONS

The National Aeronautics and Space Administration's Pacific Exploratory Mission West (PEM West) is a major component of the East Asia/North Pacific Regional study (APARE), a project within the International Global Atmospheric Chemistry (IGAC) program. The broad objectives of the PEM West/APARE initiative is to study chemical processes and long-range transport over the northwest Pacific Ocean, and to estimate the magnitude of the human impact (specifically Asian continental outflow) on the marine/oceanic atmosphere of the region. Specific objectives of PEM West are (1) to investigate the atmospheric chemistry of ozone (O_3) and its precursors over the northwest Pacific including examination of their natural budgets as well as the impact of anthropogenic sources; and (2) to investigate the atmospheric sulfur cycle over the northwest Pacific with emphasis on the relative importance and influence of continental versus marine sulfur sources.

The Pacific Ocean is, perhaps, the only major region in the Northern Hemisphere that is "relatively" free from direct anthropogenic influences. In the remote regions of the northern Pacific and in most of the southern Pacific, it should be possible to study the biogeochemical cycles of carbon, nitrogen, ozone, sulfur, and aerosols in an environment which, from a global perspective, is least perturbed by anthropogenic activities. On the other hand, there is little doubt that long-range transport of air pollutants from Asia and, to a lesser extent, Europe and North America is beginning to have significant impact on the atmosphere over a large part of the Pacific. The results from the PEM West studies provide an extensive set of baseline data

from which the anthropogenic impact of this region can be reliably assessed for decades to come.

The overall experiment design for the PEM-West/APARE program encompassed two field studies positioned in time such that contrasting meteorological regimes in the northwestern Pacific could be studied. The first phase of the Pacific Exploratory Mission West, PEM West-A, was conducted over the Pacific Ocean off the coast of Asia during September and October, 1991. Significant characteristics of the lower troposphere airflow during this time of year includes periods during which the predominance of flow is from the mid-Pacific (marine) regions and periods in which the marine flow is modified/mixed with Asian continental outflow. Phase B of PEM West was conducted during February and March 1994, a period characterized by maximum outflow from the Asian continent.

The centerpiece of PEM West-A was a series of 18 research flights with the instrumented NASA Ames DC-8. The aircraft operated from three staging areas: Yokota Air Force Base, Japan; Kai Tak International Airport, Hong Kong; and Anderson Air Force Base, Guam. Table 2 summarizes the flights, and Figure 2 shows the flight regions. Flights 6-9, 12-13, and 15-17 were site-intensive flights based from Japan, Hong Kong, and Guam, respectively. Survey/ferry flights included (a) flights 4-5 from Ames to Japan (via Anchorage, Alaska); (b) flights 10-11 from Japan to Hong Kong (via Okinawa); (c) flight 14 from Hong Kong to Guam; and (d) flights 18-21 from Guam to Ames (via Wake Island and Hawaii). Flight 20 was a Hawaiian Island flight designed in conjunction with surface sampling conducted by NOAA/NCAR at the Mauna Loa Observatory. While the prime objective of the survey/ferry flights was to move the aircraft to a new base of operation, the flight plans were designed to provide as much information on the atmospheric processes and vertical structure of the atmosphere as possible. The intensive flights were designed to take advantage of the geographical location of the site and prevailing meteorological conditions in addressing science objectives. As a result of the location of the three intensive sites (staging areas), flights covered a

latitude range of about 30° N to the Equator and sampled air with continental lifetimes of <1 day (i.e., passed over the Asian continent within 1 day of sampling) to air which had been over the Pacific Ocean for >10 days.

Special PEM West-A sampling events or targets of opportunity included (1) two "fly-bys" of Taiwan [flights 12 and 13, with flight 12 including a ground station flyby], (2) the first known airborne study of trace gases in a typhoon [flight 9--typhoon Mireille and flight 14--typhoon Orchid], and (3) the already noted Mauna Loa Observatory experiment of flight 20. Typhoon Mireille, a category 4 typhoon, struck the western side of Japan on September 27, 1991. As Mireille approached the coast of Japan, the DC-8 conducted flight 9 to study the roles of typhoons in the transport of trace gases, measuring both the inflow to the typhoon at low altitudes and the outflow within the eye at high altitudes. Sampling of typhoon Orchid, which occurred as a secondary objective of flight 14, was confined to sampling the high-altitude outflow in much lesser detail than for Mireille.

The core set of measurements aboard the aircraft focused on ozone and sulfur chemistry issues (gaseous). The aircraft data included a suite of chemical measurements which included ozone, nitric oxide, nitrogen dioxide, total odd or "reactive" nitrogen gaseous species, sulfur trace gases (sulfur dioxide, dimethyl sulfide, carbon disulfide, and carbonyl sulfide), peroxyacetyl nitrate or PAN, peroxypropionly nitrate, methane, carbon monoxide, carbon dioxide, nonmethane hydrocarbons, fluorocarbons, acetic acid, formic acid, nitric acid, hydrogen and methyl peroxides, and aerosol number/size distribution. Table 3 identifies investigators responsible for the measurements, and Figure 3 shows a schematic of the aircraft instrument plan.

The aircraft platform as used in PEM West-A had a cruise speed at altitude of about 12 km/min and a maximum flight duration and ceiling of about 8-9 hours and 13 km, respectively. Survey flights were generally long-duration flights at high altitude (10 to 13 km) with (generally) at least one descent (spiral or ramp in addition to takeoff and landing) to about 150 to

300 m above sea level. Intensive flights combined numerous ramps, profiles, and level-flight legs to meet planned objectives. Generally, altitude profiles (spirals or ramps) were flown with ascent/descent rates of 150 to 300 m/min.

The PEM West-A DAAC data archive includes (1) data taken aboard the NASA Ames DC-8 aircraft; (2) data measured at surface sites throughout the Pacific rim basin; (3) sondes released from multiple locations in support of the aircraft flights; (4) photochemical modeling products used in analyses of results; and (5) numerous meteorological, land-use, and satellite data products used in flight (field) planning and post-mission analyses.

The data plots for the PEM West-A missions are given in Appendix A. For each flight, five pages of time series plots are provided: page 1 -- a pictorial diagram of the flight region and time series plots of altitude, temperature (T), dew point temperature (dp), relative humidity, and potential temperature (theta); page 2 -- ozone (O_3), carbon monoxide (CO), carbon dioxide (CO_2,) methane, nitrous oxide (N_2O), and benzene; page 3 -- nitric oxide (NO), nitrogen oxides (NO_x), total odd or "reactive" nitrogen gas species (NO_y), peroxyacetly nitrate (PAN), and nitric acid; page 4 -- acetylene, ethane, propane, tetrachloroethylene (C_2Cl_4), and methyl chloroform (CH_3CCl_3); and page 5 -- sulfur dioxide (SO_2), dimethyl sulfide (DMS), ethylene, hydrogen peroxide (H_2O_2), and methyl peroxide (CH_3OOH). The species were selected to provide the reader with information on both the source characteristics and photochemical history of the air. Figure numbers correspond to flight numbers; e.g., Figure A4.2 represents page 2 of the plots for flight #4. Selected profile plots follow the time series plots as, e.g., Figure A4.6 is the first page of profile plots for flight 4. Profile plot sets include temperature, dew point temperature, ozone, carbon monoxide, and methane data plotted to the same altitude scale. One to three sets of profile plots are provided (format of two sets per page) for each flight. Table 4 summarizes the profiles selected. There are no figures with the prefix of A1, A2, or A3. Flights 1 to 3 were instrument checkout flights

based at Ames and data were not archived. Data plots are in standardized format as discussed in Appendix A. The DAAC archive includes measurements aboard the DC-8 aircraft during PEM West-A which are not plotted in Appendix A.

CONCLUDING REMARKS

This compendium of data from NASA's Global Tropospheric Experiment's Pacific Exploratory Mission West-A provides only a representation of aircraft data that are available in archived format from NASA Langley's Distributed Active Archive Center (DAAC). The presented data are not intended to support original research/analyses, but serve as an overview of the PEM West-A data and provide some assistance to the reader in identifying data that are of interest and which may be obtained from Langley's DAAC archive. This compendium covers only selected NASA DC-8 aircraft data. The archived data bases include other data measured on board the aircraft as well as numerous supporting data including meteorological observations/products, photochemical modeling products, surface station observations, satellite observations, and sondes releases. GTE-sponsored analyses/results from the PEM West-A expeditions have been accepted for a Special Issue of the Journal of Geophysical Research - Atmospheres scheduled for publication in 1995.

Questions or information regarding the Langley DAAC archive should be directed to Langley DAAC User and Data Services, Mail Stop 157B, NASA Langley Research Center, Hampton, Virginia 23681-0001. A brief description of the DAAC, log on procedures, and data bases is given as Appendix B.

TABLE 1. GTE Field Expeditions

Expedition	Date	General Geographic Region	Time of Year
ABLE-1	1984	Barbados, French Guyana	June
ABLE-2A	1985	Amazon Basin	August
ABLE-2B	1987	Amazon Basin	May
ABLE-3A	1988	Alaska--Barrow, Bethel, Cold Bay	July/August
ABLE-3B	1990	Canada--Hudson Bay, Schefferville	July/August
CITE-1	1983	Hawaii	November
CITE-1	1984	Eastern North Pacific--off the California coast	April
CITE-2	1986	Western USA	August
CITE-3	1989	Western North Atlantic--Virginia coast	August
		and Western South Atlantic--Brazil coast	September
PEM West-A	1991	Western Pacific Rim	October
PEM West-B	1994	Western Pacific Rim	Feb./March
TRACE-A	1992	Brazil, South Atlantic, southwest Africa	September

TABLE 2. Summary of the Flights Conducted during the 1991 PEM West-A Expedition (All times are GMT)

Mission Number	Flight Date	Departure		Arrival		Purpose
		Time	Location	Time	Location	
4	Sept. 16	1704	NASA Ames	2251	Anchorage, Alaska	survey & ferry
5	Sept. 17-18*	1857	Anchorage, Alaska	0328	Yokota, Japan	survey & ferry
6	Sept. 22	0224	Yokota, Japan	0947	Yokota, Japan	background marine air
7	Sept. 24	0213	Yokota, Japan	0915	Yokota, Japan	continental outflow
8	Sept. 25-26	1657	Yokota, Japan	0017	Yokota, Japan	diurnal photochemistry
9	Sept. 27	0105	Yokota, Japan	0739	Yokota, Japan	typhoon Mireille
10	Oct. 1	0244	Yokota, Japan	0935	Okinawa	survey & ferry
11	Oct. 2	0002	Okinawa	0223	Hong Kong	survey & ferry
12	Oct. 4	0152	Hong Kong	1015	Hong Kong	continental outflow & Taiwan flyby
13	Oct. 6	0119	Hong Kong	0815	Hong Kong	continental outflow
14	Oct. 8	0148	Hong Kong	1002	Guam	survey & ferry, typhoon Orchid
15	Oct. 11-12	2351	Guam	0729	Guam	marine, southeast of Guam
16	Oct. 13	0040	Guam	0814	Guam	marine, southwest of Guam
17	Oct. 14-15	1810	Guam	0209	Guam	diurnal photochemistry, west of Guam
18	Oct. 17-18	2344	Guam	0337	Wake Island	survey & ferry
19	Oct. 18-19*	2202	Wake Island	0339	Hawaii	survey & ferry
20	Oct. 20	1348	Hawaii	1947	Hawaii	intercomparison with Mauna Loa Observatory ground measurements
21	Oct. 21-22	1933	Hawaii	0113	NASA Ames	survey & ferry

* Crossed International date line

TABLE 3. Principal Investigators and Institutions Participating in Pacific Exploratory Mission West-A

Investigator	Institution	Investigation/Measurement
Bruce Anderson	NASA Langley Research Center	carbon dioxide
Alan Bandy	Drexel University	trace sulfur gases
John Barrick	NASA Langley Research Center	airborne meteorological/position data
John Bradshaw	Georgia Institute of Technology	nitric oxide, nitrogen dioxide, total oxides of nitrogen
Edward Browell	NASA Langley Research Center	ozone & aerosol profiles (remote sensor)
Gerald Gregory	NASA Langley Research Center	ozone, aerosols (in situ)
Brian Heikes	University of Rhode Island	H_2O_2, CH_3OOH
Kenneth Kelly	NOAA Boulder Laboratory	water vapor
Yutaka Kondo	Nagoya University, Japan	nitric oxide, total oxides of nitrogen
Sherry Rowland	University of California, Irvine	nonmethane hydrocarbons
Glen Sachse	NASA/Langley Research Center	carbon monoxide, methane, nitrous oxide
Fumio Sakamaka	National Institute for Environmental Health, Japan	nonmethane hydrocarbons
Hanwant Singh	NASA Ames Research Center	PAN, PPN, C_2Cl_4
Robert Talbot	University of New Hampshire	HNO_3, HCOOH, CH_3COOH, aerosol composition (elemental)

TABLE 4. PEM West-A Profiles

Flight	Date	Time	Latitude, °N	Longitude, °E
4	September 16	1715	38.4	-122.6
4	September 16	1930	50.0	-137.4
4	September 16	2130	55.7	-153.4
5	September 16	1900	60.8	-150.9
5	September 16	2215	52.5	176.2
5	September 17	0300	36.6	140.7
6	September 22	0415	29.1	148.5
6	September 22	0830	29.6	147.6
7	September 24	0300	35.1	144.7
7	September 24	0815	36.8	144.8
8	September 25	1930	30.1	147.1
8	September 25	2200	27.9	147.0
9	September 27	0400	29.0	134.3
9	September 27	0730	35.3	138.6
10	October 1	0300	34.7	139.6
10	October 1	0700	19.3	126.0
10	October 1	0915	25.4	126.9
11	October 2	0015	25.3	127.0
11	October 2	0215	21.7	114.8
12	October 4	0900	21.9	120.4
13	October 6	0445	29.3	126.2
13	October 6	0645	23.4	119.1

Times are GMT

TABLE 4. Profiles continued.

Flight	Date	Time	Latitude, °N	Longitude, °E
14	October 8	0200	21.6	115.0
14	October 8	0700	17.0	128.0
14	October 8	0945	14.2	144.1
15	October 12	0315	0.4	161.7
15	October 12	0715	13.2	145.5
16	October 13	0400	4.1	124.9
16	October 13	0800	13.5	144.9
17	October 14	2015	15.0	142.0
17	October 14	2300	14.9	139.5
17	October 15	0200	14.1	144.1
18	October 18	0115	12.9	155.8
18	October 18	0230	13.1	162.9
18	October 18	0330	18.8	166.2
19	October 19	0100	15.8	-175.3
19	October 19	0315	20.9	-159.1
20	October 20	1545	18.6	-155.4
21	October 21	1930	21.3	-157.6

Times are GMT

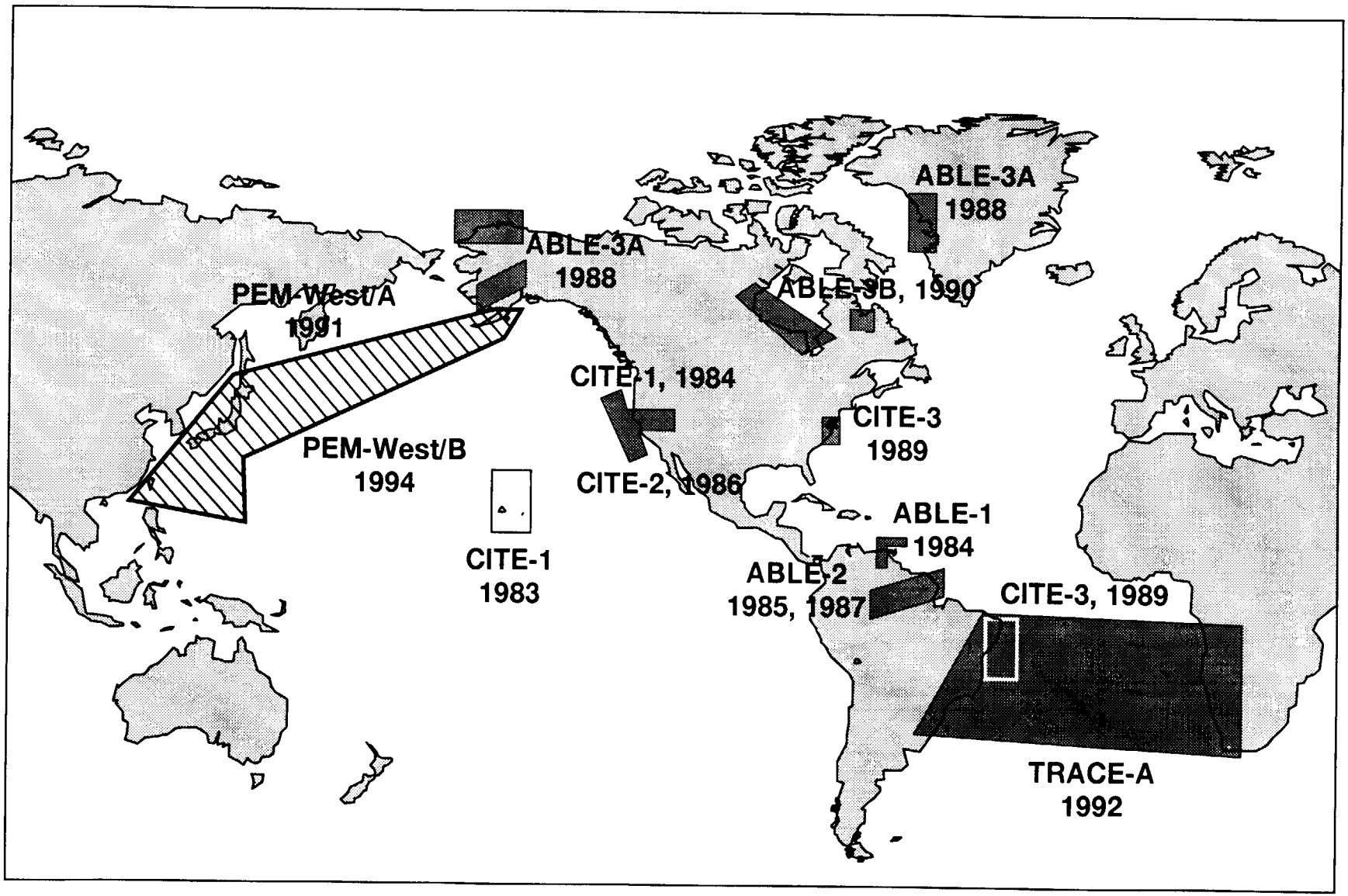


Figure 1. GTE mission sites.

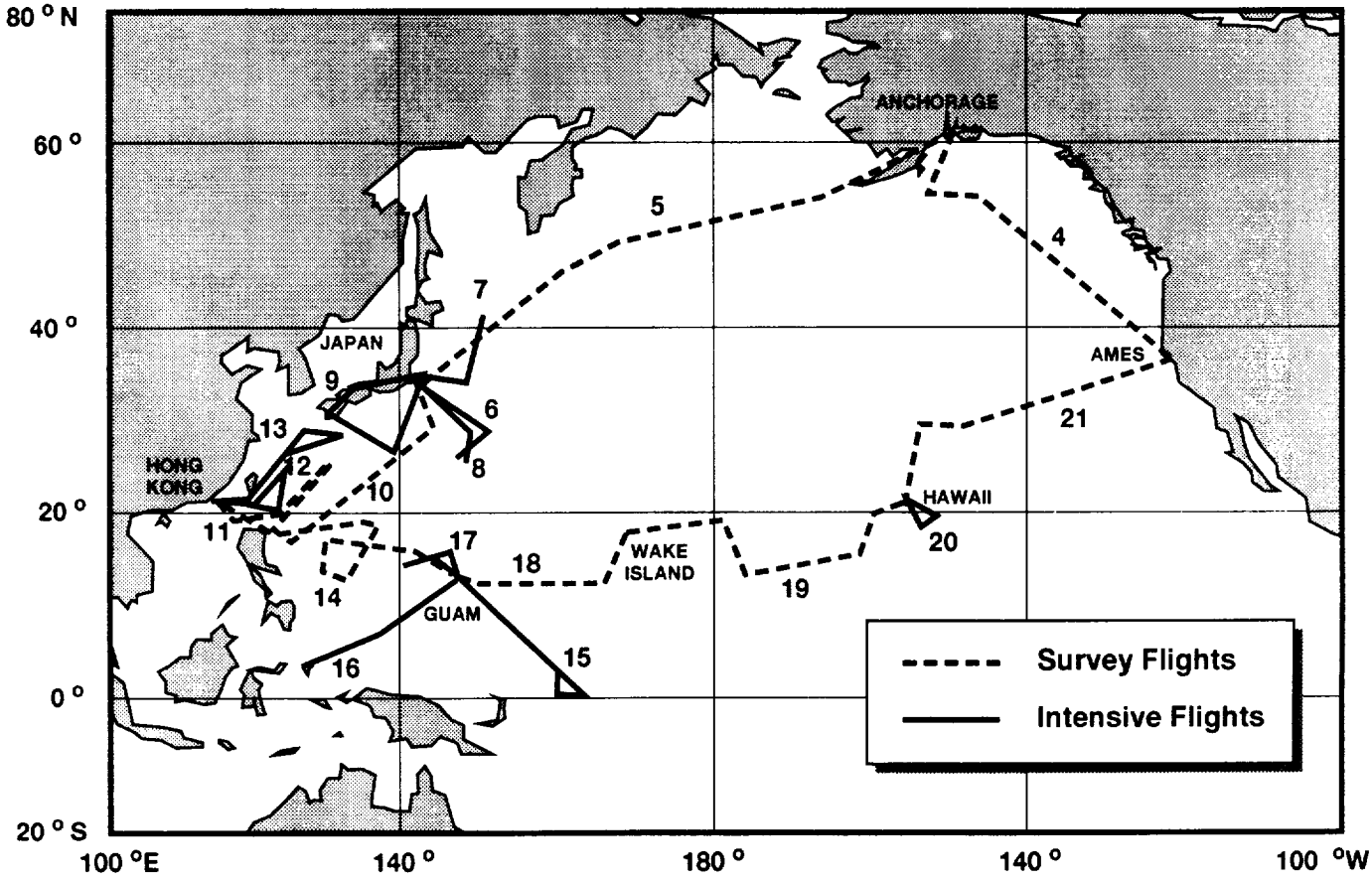


Figure 2. Flight tracks for the DC-8 aircraft during the PEM West-A mission.

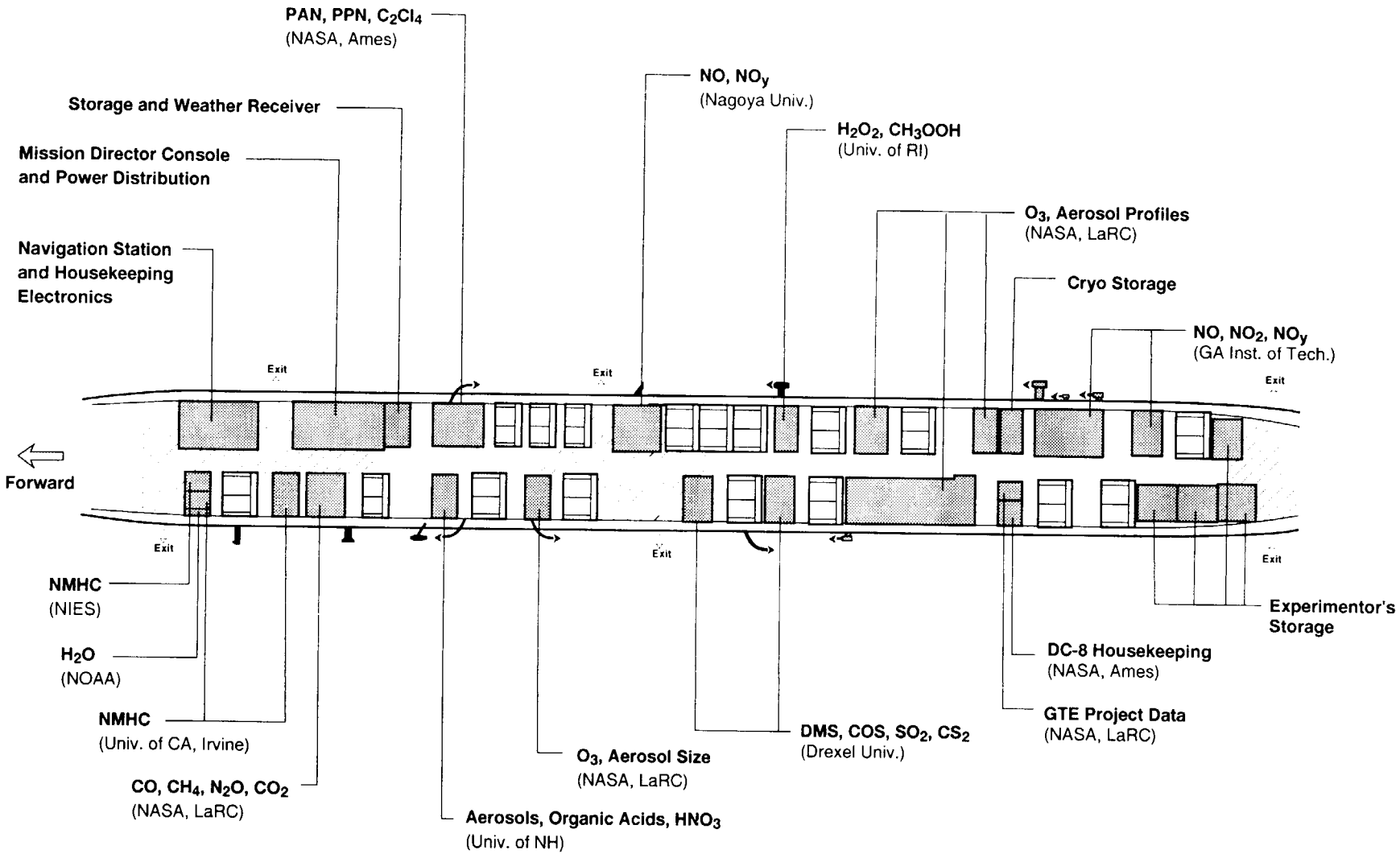


Figure 3. Instrumentation location on the NASA DC-8 aircraft during PEM West-A mission.

APPENDIX A: PEM WEST-A DATA PLOTS

Plots are presented in a standardized format, and the data (unedited) are from the Langley DAAC archive. Relative humidity and potential temperature are calculated from measurements made on the aircraft. In some cases (mostly for moist, boundary layer conditions) relative humidity may exceed 100% (not plotted) as dew point temperature exceeded air temperature by a few degrees (assumed to be the result of instrument measurement/calibration uncertainty). For time series plots, abscissa time scales for a given flight are identical, and ordinate scales (for a given parameter) are identical among all flights. Ordinate scales were selected to best represent all the data for a specie measured during the expedition; thus, some data may be off-scale. As a result of the software used for the plots and the data archive use of codes (in place of valid data) for data taken (1) during instrument calibration, (2) when measurements were at "detection limit," and/or (3) when measurements were invalid, it is sometimes difficult to distinguish from the plots if data are off-scale or coded as invalid. For example, a symbol without an attached line may either mean that adjacent data are off-scale or have been coded as invalid. Inspection of the other plotted data often provides information which resolves the uncertainty. For profile plots, altitude scales are identical for all plots and the specie scales are those selected for the time series plots. In order to maintain the standardized format, plots for flights in which a specie data were not reported are plotted with the axes and a "NO DATA" entry.

Given below are the beginning page numbers for each flight's sequence of plots:

PEM (A) PACIFIC MISSION: FLIGHT 4

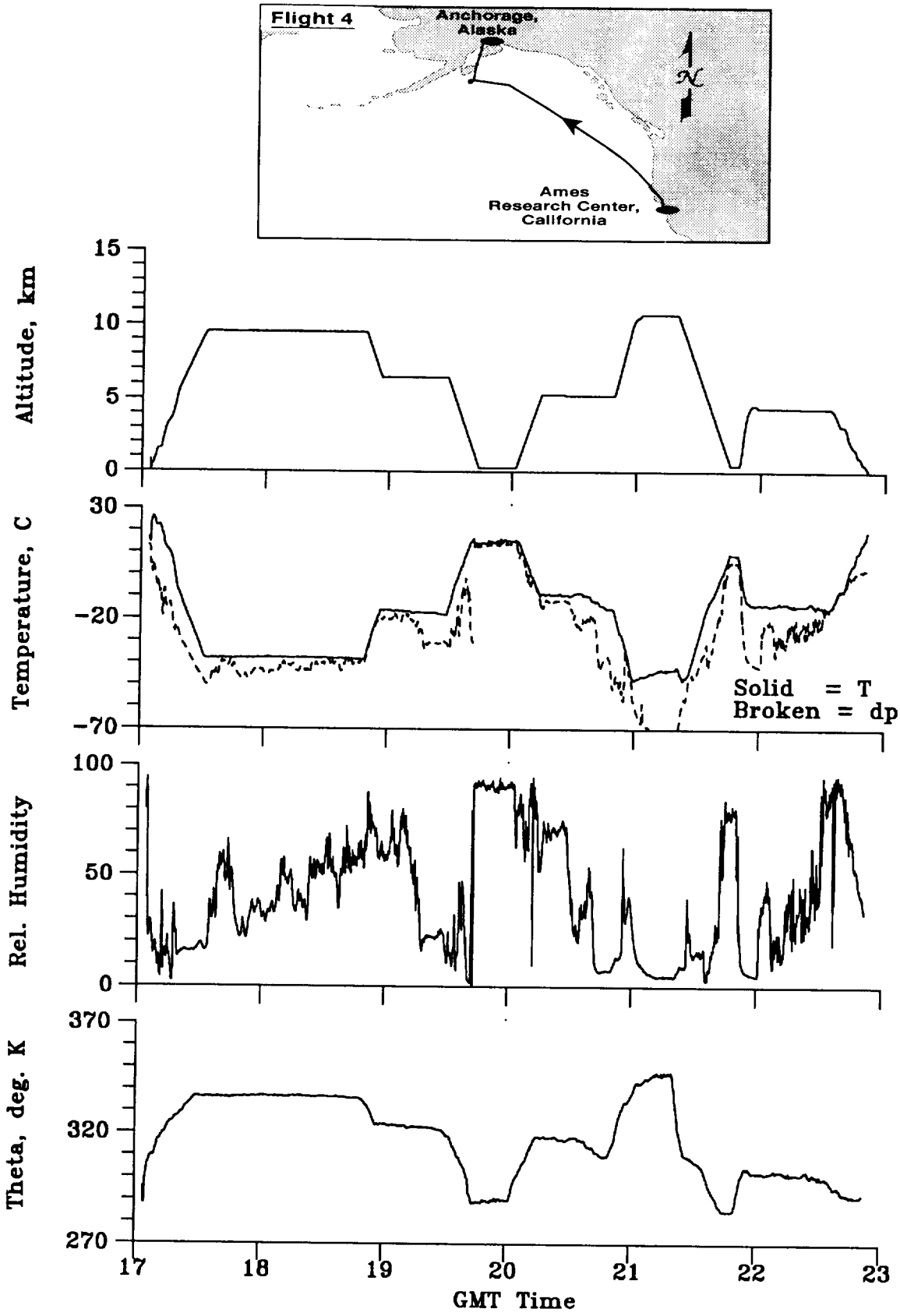


Figure A4.1

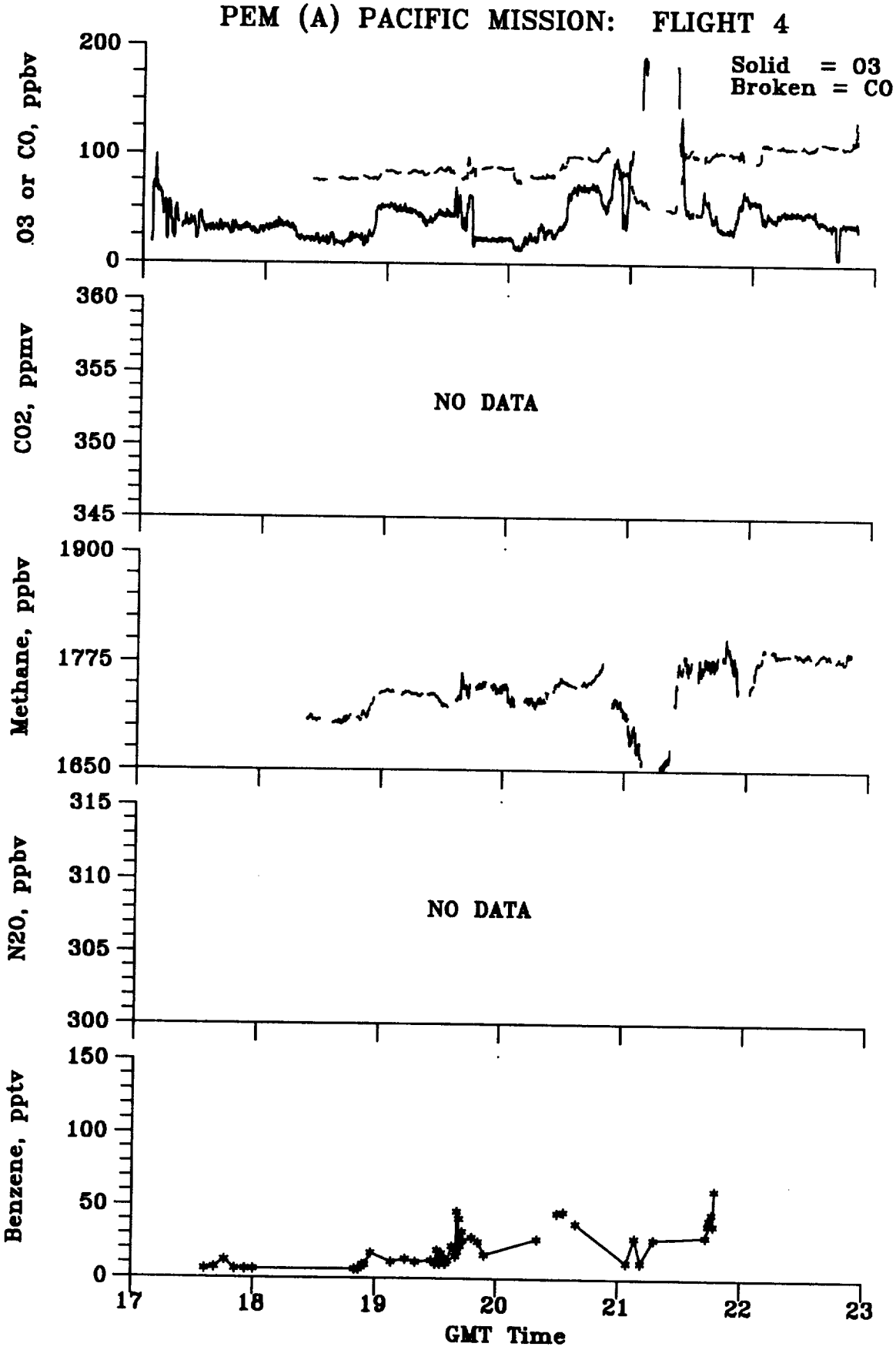

PEM (A) PACIFIC MISSION: FLIGHT 4
Solid = 03
Broken = CO
O3 or CO, ppbv
200
100
0
CO2, ppmv
360
355
350
345
NO DATA
Methane, ppbv
1900
1775
1650
N2O, ppbv
315
310
305
300
NO DATA
Benzene, pptv
150
100
50
0
17
18
19
20
21
22
23
GMT Time

Figure A4.2

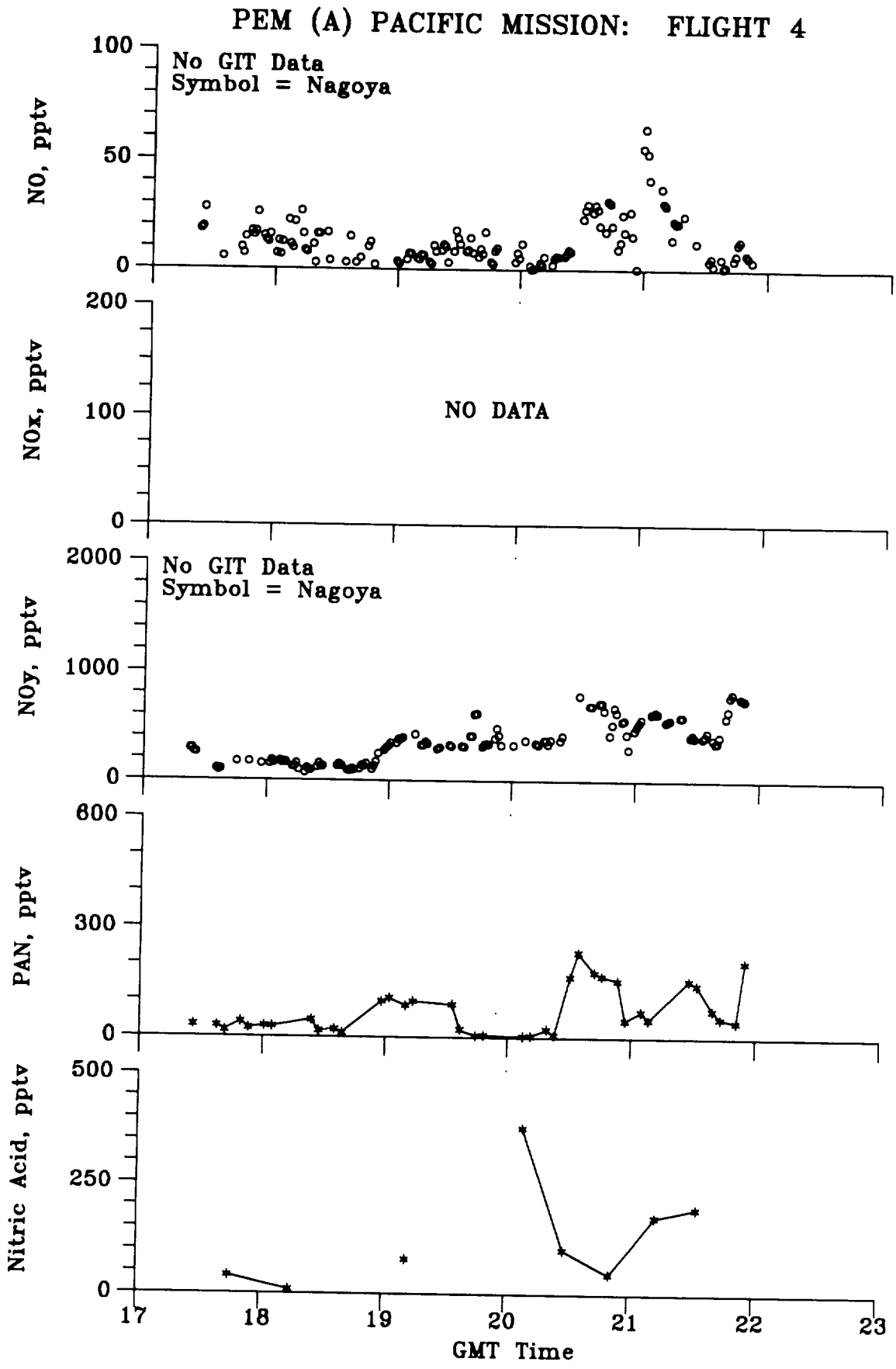

PEM (A) PACIFIC MISSION: FLIGHT 4
No GIT Data
Symbol = Nagoya
NO, pptv
100
50
0
NOx, pptv
200
100
0
NO DATA
No GIT Data
Symbol = Nagoya
NOy, pptv
2000
1000
0
PAN, pptv
600
300
0
Nitric Acid, pptv
500
250
0
17
18
19
20
21
22
23
GMT Time

Figure A4.3

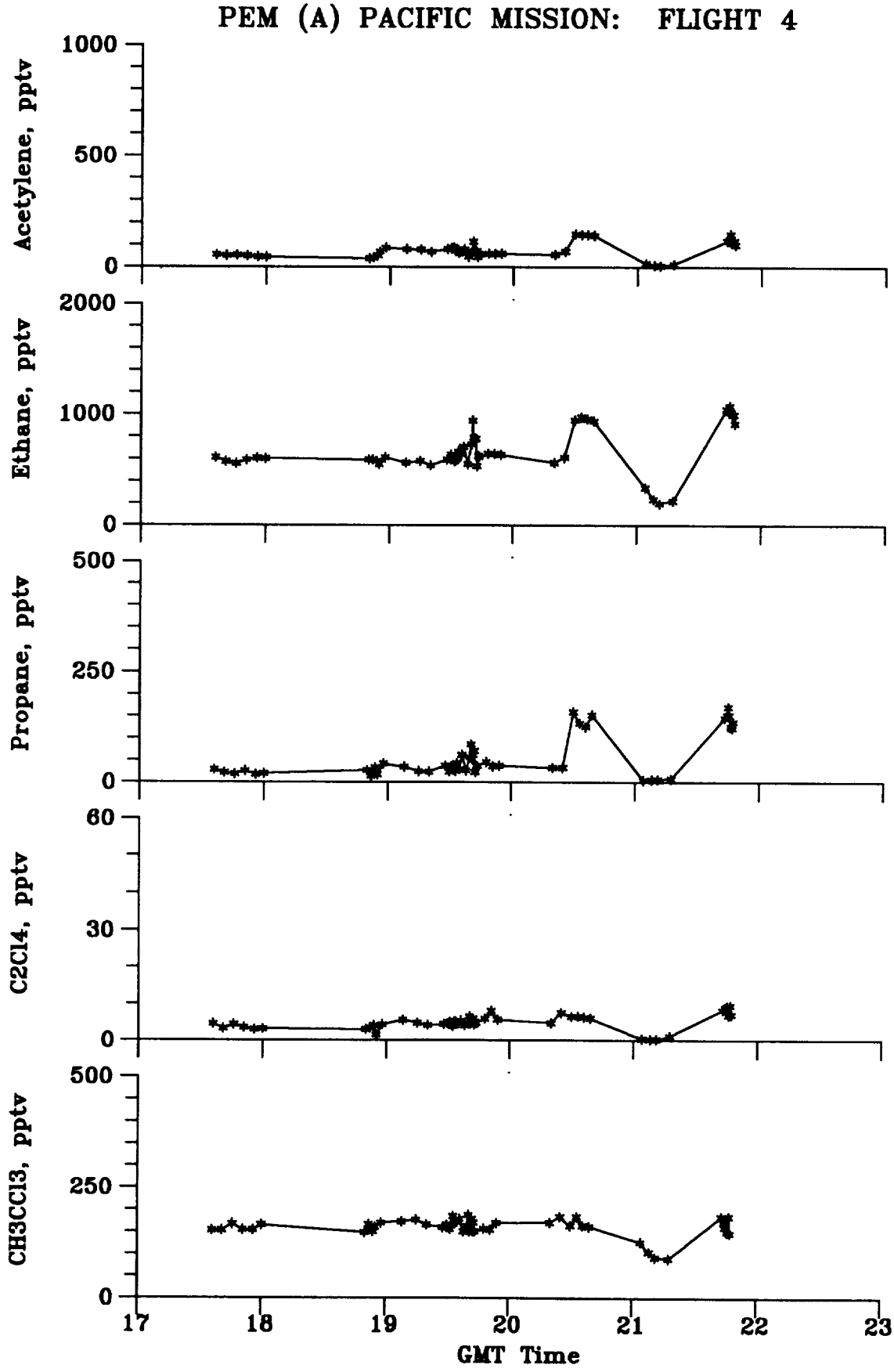

PEM (A) PACIFIC MISSION: FLIGHT 4
Acetylene, pptv
1000
500
0
Ethane, pptv
2000
1000
0
Propane, pptv
500
250
0
C2Cl4, pptv
60
30
0
CH3CCl3, pptv
500
250
0
17
18
19
20
21
22
23
GMT Time

Figure A4.4

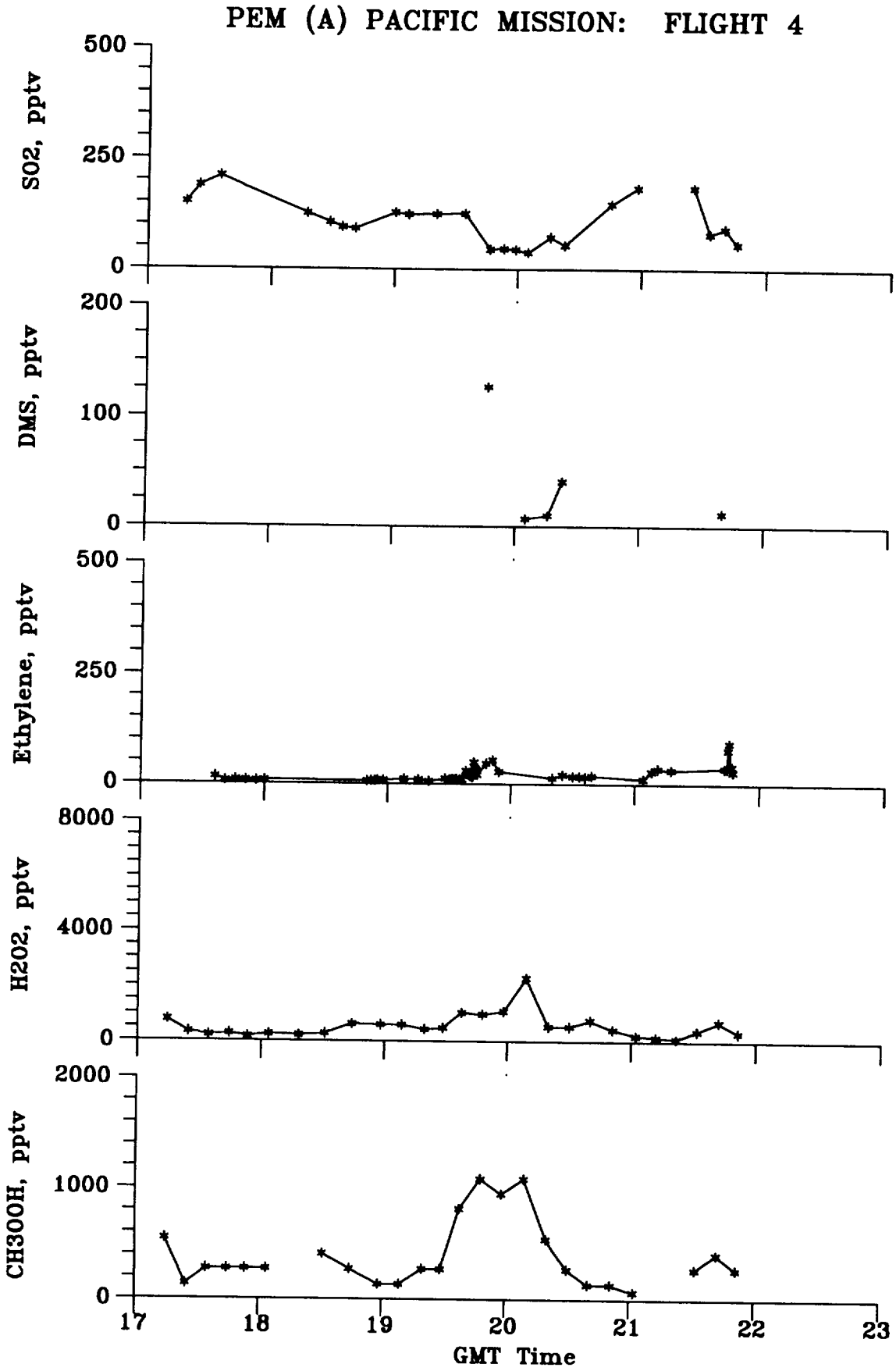
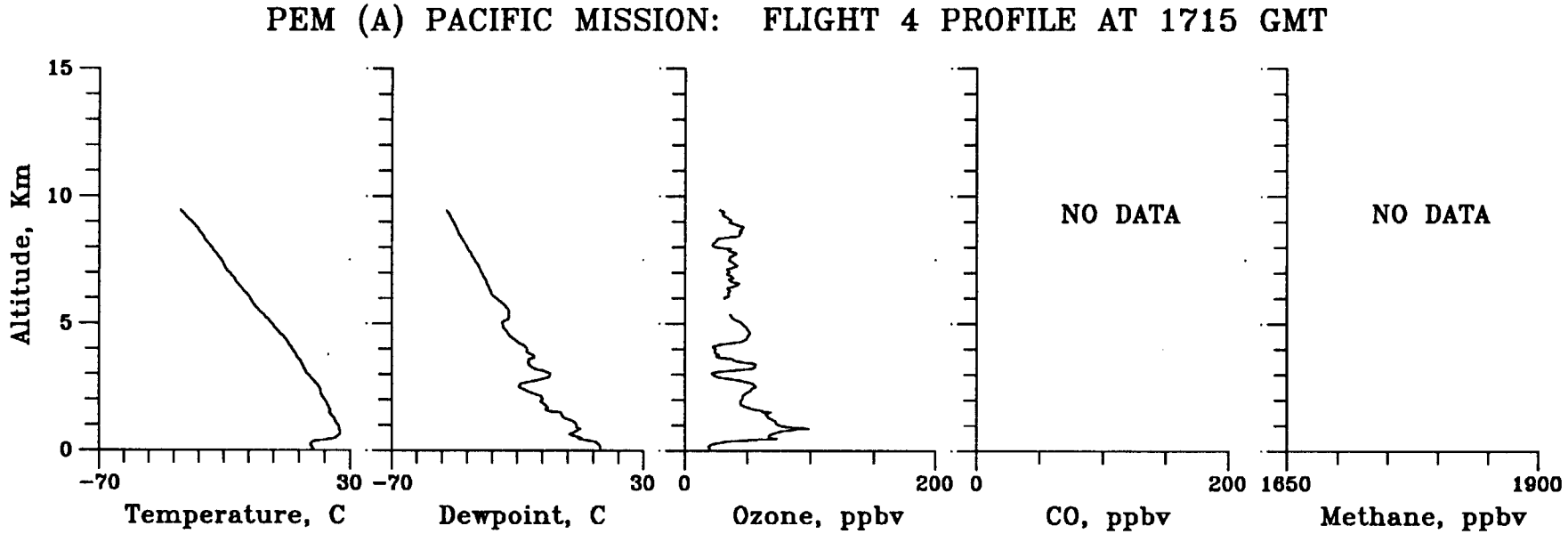
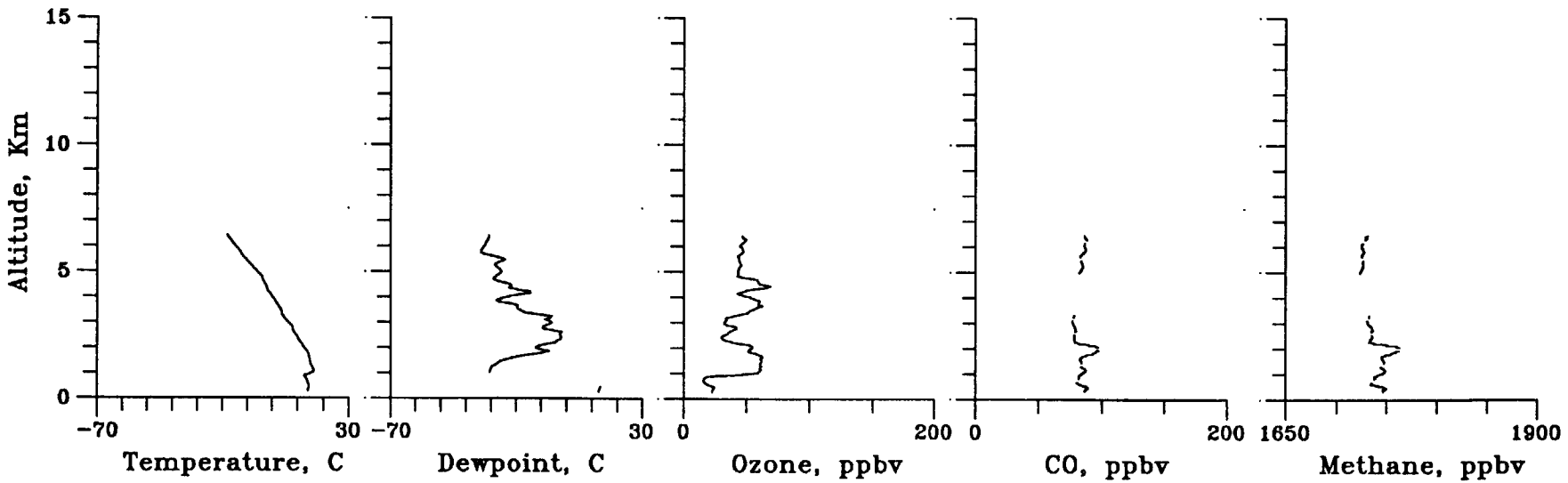

PEM (A) PACIFIC MISSION: FLIGHT 4
SO2, pptv
500
250
0
DMS, pptv
200
100
0
Ethylene, pptv
500
250
0
H2O2, pptv
8000
4000
0
CH3OOH, pptv
2000
1000
0
17
18
19
20
21
22
23
GMT Time

Figure A4.5

Figure A4.6


PEM (A) PACIFIC MISSION: FLIGHT 4 PROFILE AT 1715 GMT
Altitude, Km
15
10
5
0
NO DATA
NO DATA
-70
30
Temperature, C
-70
30
Dewpoint, C
0
200
Ozone, ppbv
0
200
CO, ppbv
1650
1900
Methane, ppbv


PEM (A) PACIFIC MISSION: FLIGHT 4 PROFILE AT 1930 GMT
Altitude, Km
15
10
5
0
-70
30
Temperature, C
-70
30
Dewpoint, C
0
200
Ozone, ppbv
0
200
CO, ppbv
1650
1900
Methane, ppbv

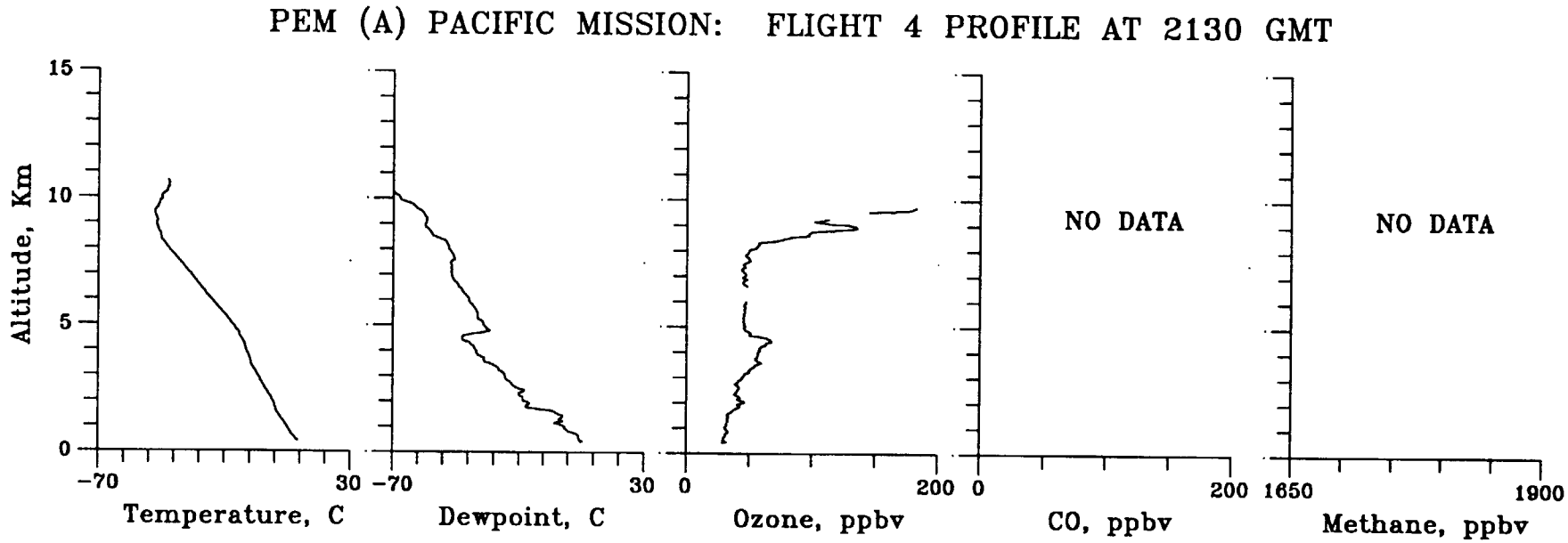

PEM (A) PACIFIC MISSION: FLIGHT 4 PROFILE AT 2130 GMT
Altitude, Km
15
10
5
0
-70
30
Temperature, C
-70
30
Dewpoint, C
0
200
Ozone, ppbv
NO DATA
0
200
CO, ppbv
NO DATA
1650
1900
Methane, ppbv

Figure A4.7

PEM (A) PACIFIC MISSION: FLIGHT 5

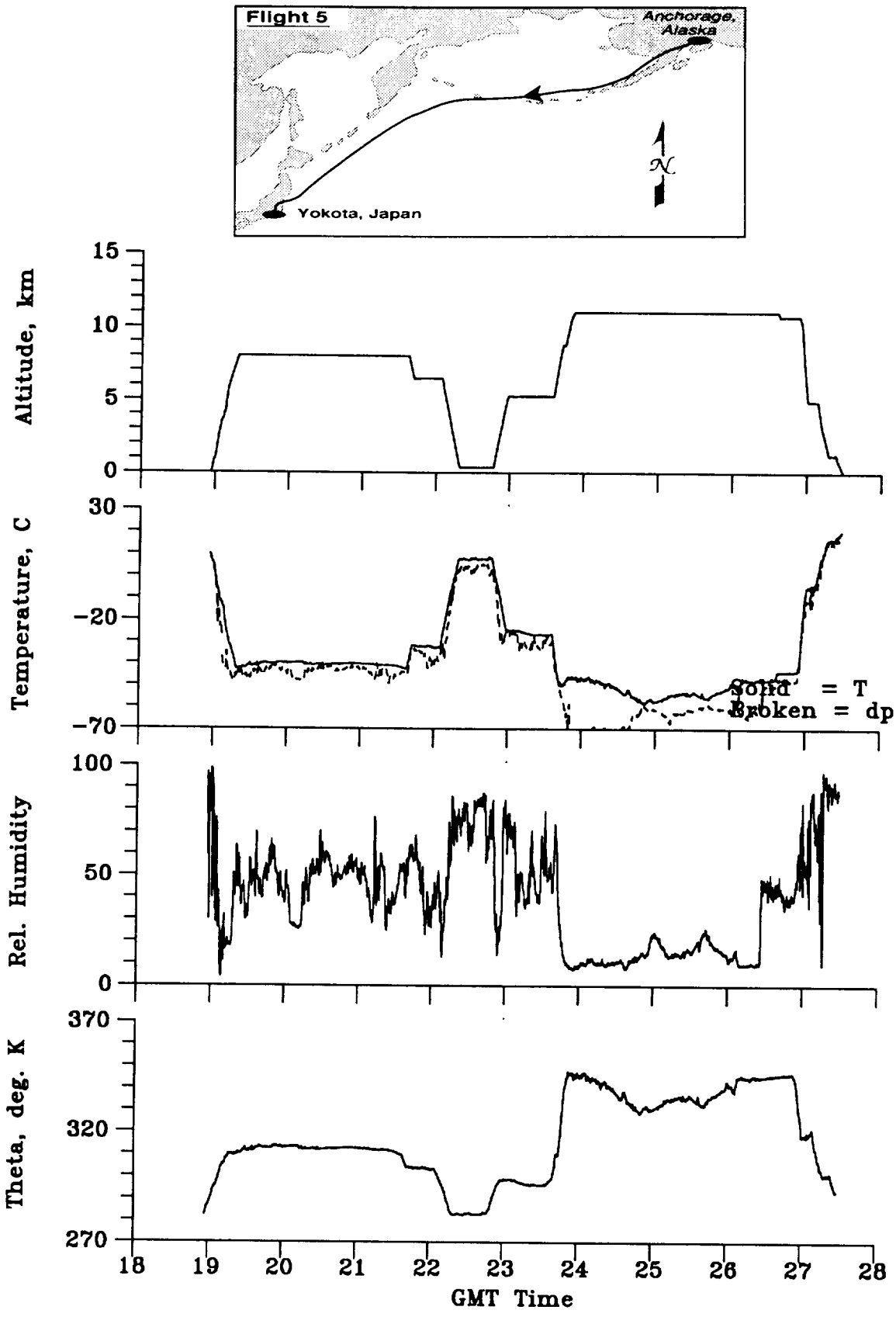


Figure A5.1

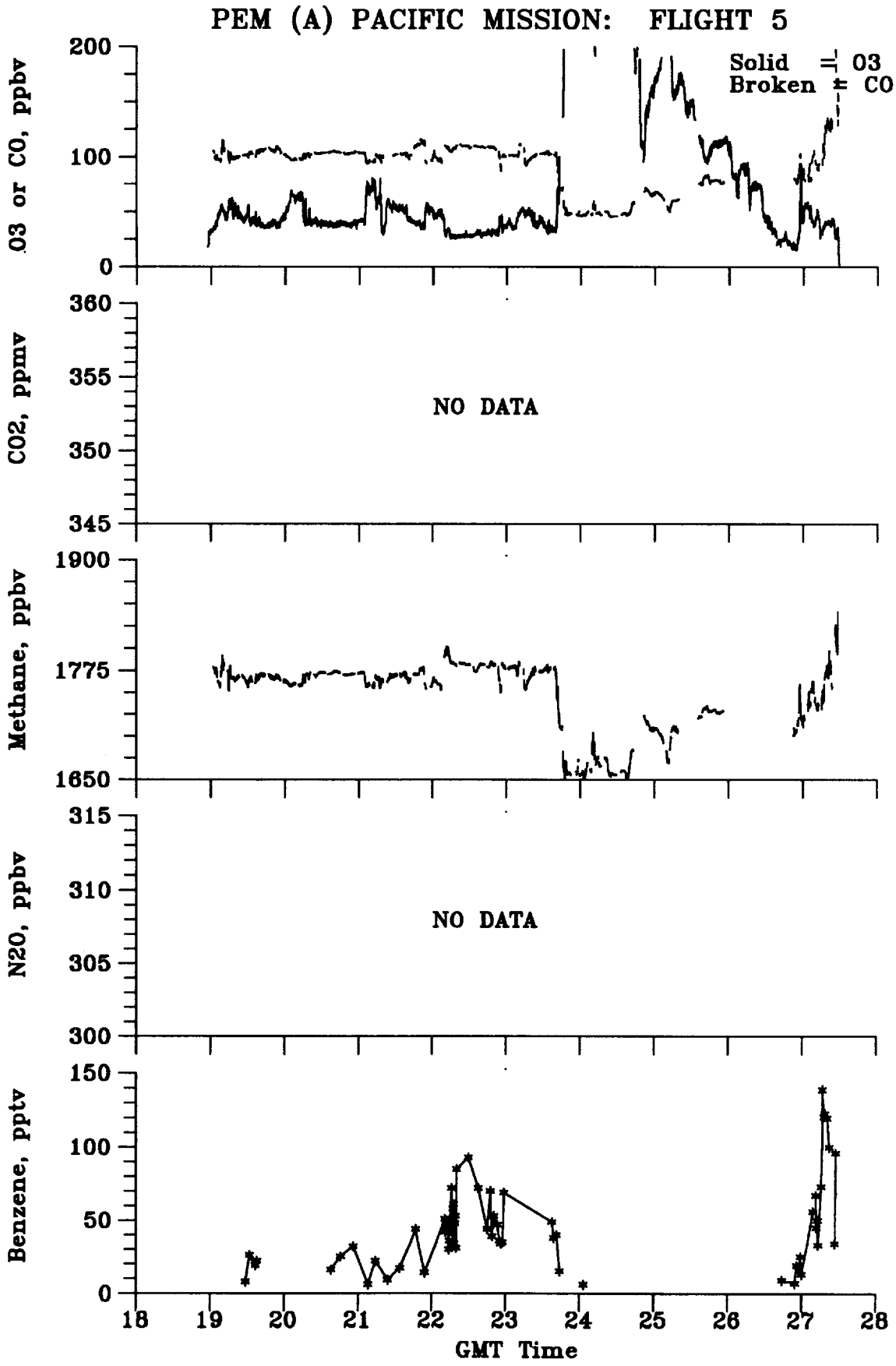

PEM (A) PACIFIC MISSION: FLIGHT 5
Solid = O3
Broken = CO
O3 or CO, ppbv
200
100
0
CO2, ppmv
360
355
350
345
NO DATA
Methane, ppbv
1900
1775
1650
N2O, ppbv
315
310
305
300
NO DATA
Benzene, pptv
150
100
50
0
18
19
20
21
22
23
24
25
26
27
28
GMT Time

Figure A5.2

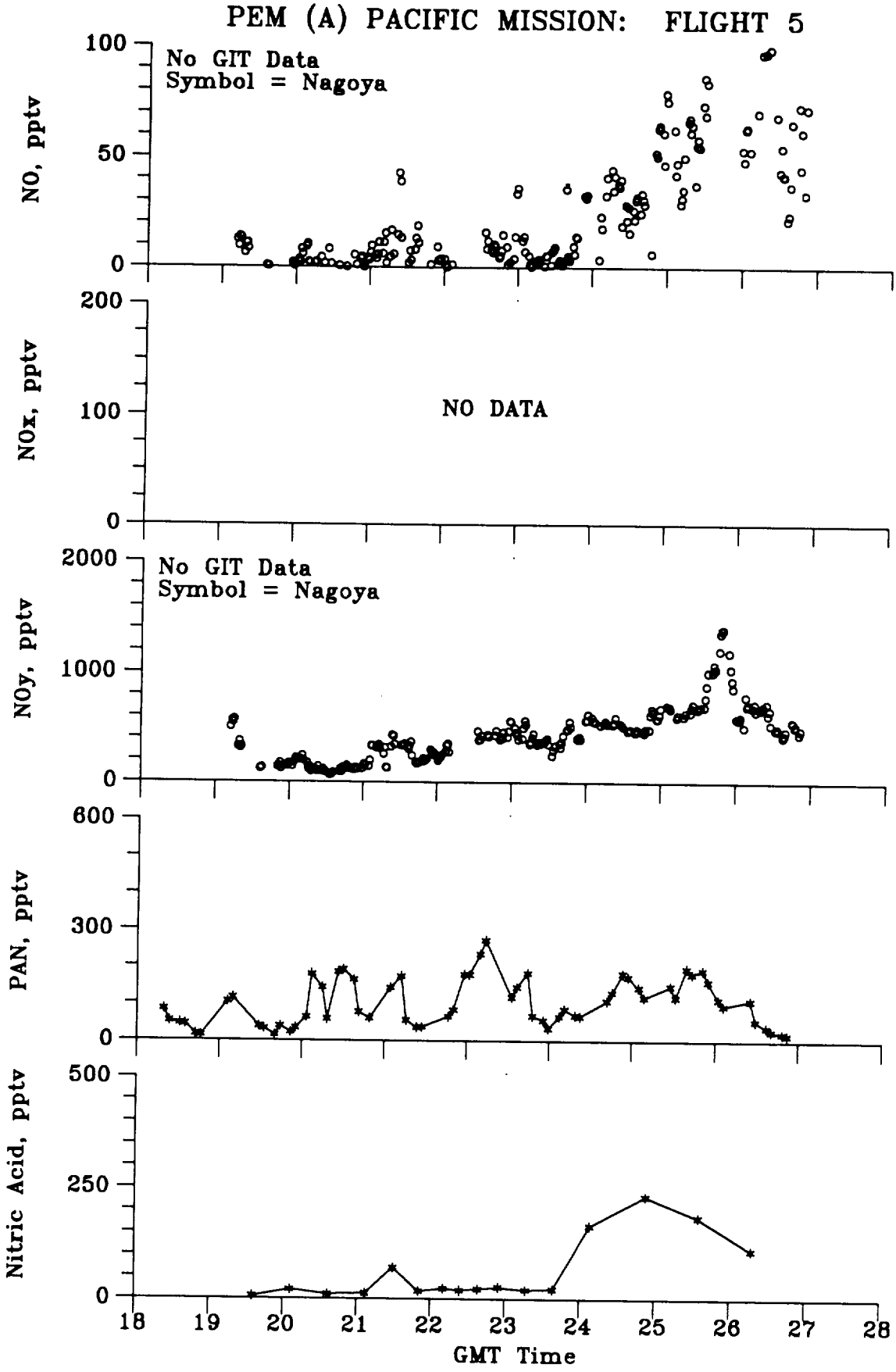

PEM (A) PACIFIC MISSION: FLIGHT 5
No GIT Data
Symbol = Nagoya
NO, pptv
100
50
0
NOx, pptv
200
100
0
NO DATA
No GIT Data
Symbol = Nagoya
NOy, pptv
2000
1000
0
PAN, pptv
600
300
0
Nitric Acid, pptv
500
250
0
18
19
20
21
22
23
24
25
26
27
28
GMT Time

Figure A5.3

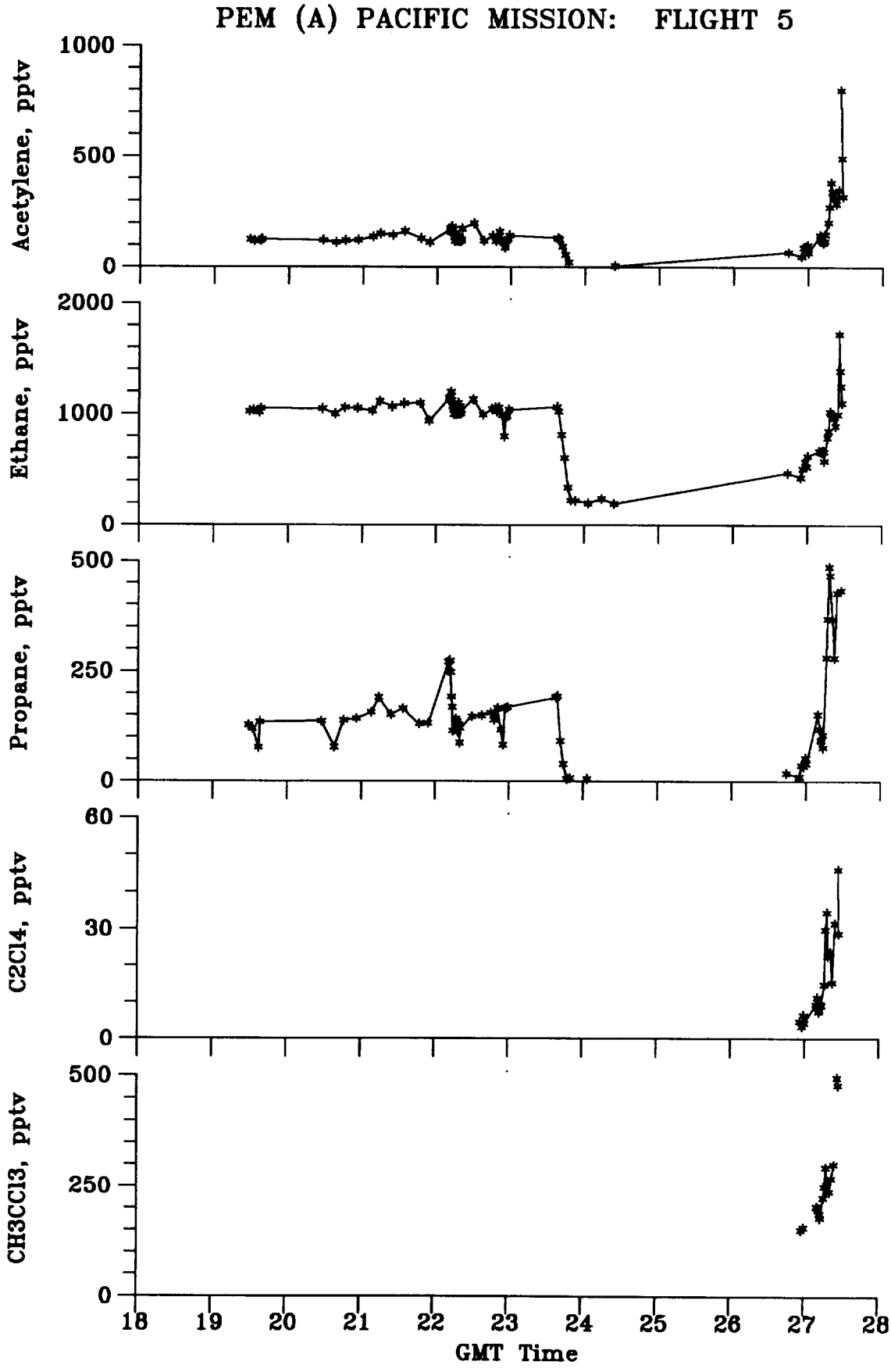

PEM (A) PACIFIC MISSION: FLIGHT 5
Acetylene, pptv
1000
500
0
Ethane, pptv
2000
1000
0
Propane, pptv
500
250
0
C2Cl4, pptv
60
30
0
CH3CCl3, pptv
500
250
0
18
19
20
21
22
23
24
25
26
27
28
GMT Time

Figure A5.4

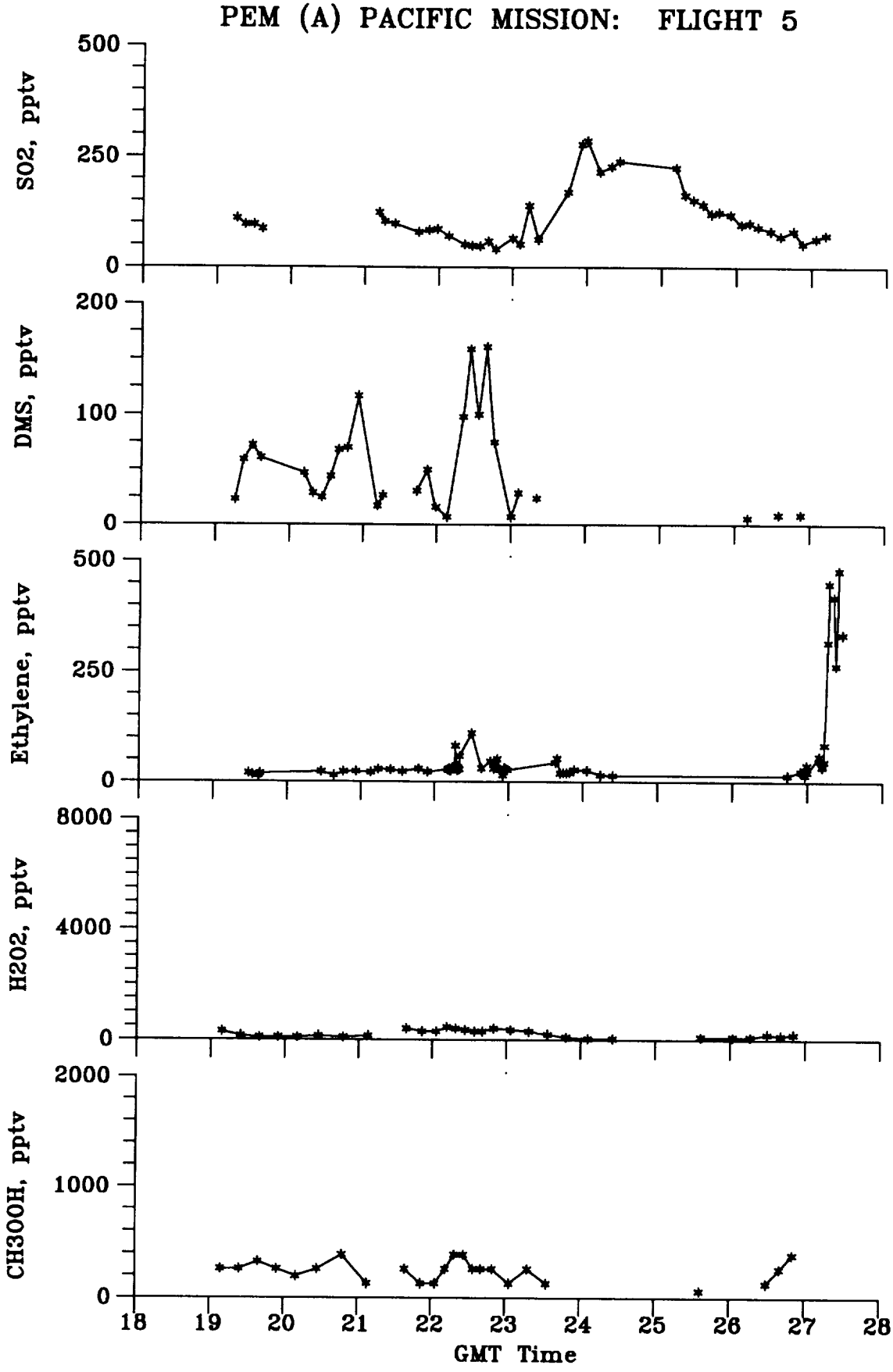

PEM (A) PACIFIC MISSION: FLIGHT 5
SO2, pptv
500
250
0
DMS, pptv
200
100
0
Ethylene, pptv
500
250
0
H2O2, pptv
8000
4000
0
CH3OOH, pptv
2000
1000
0
18
19
20
21
22
23
24
25
26
27
28
GMT Time

Figure A5.5

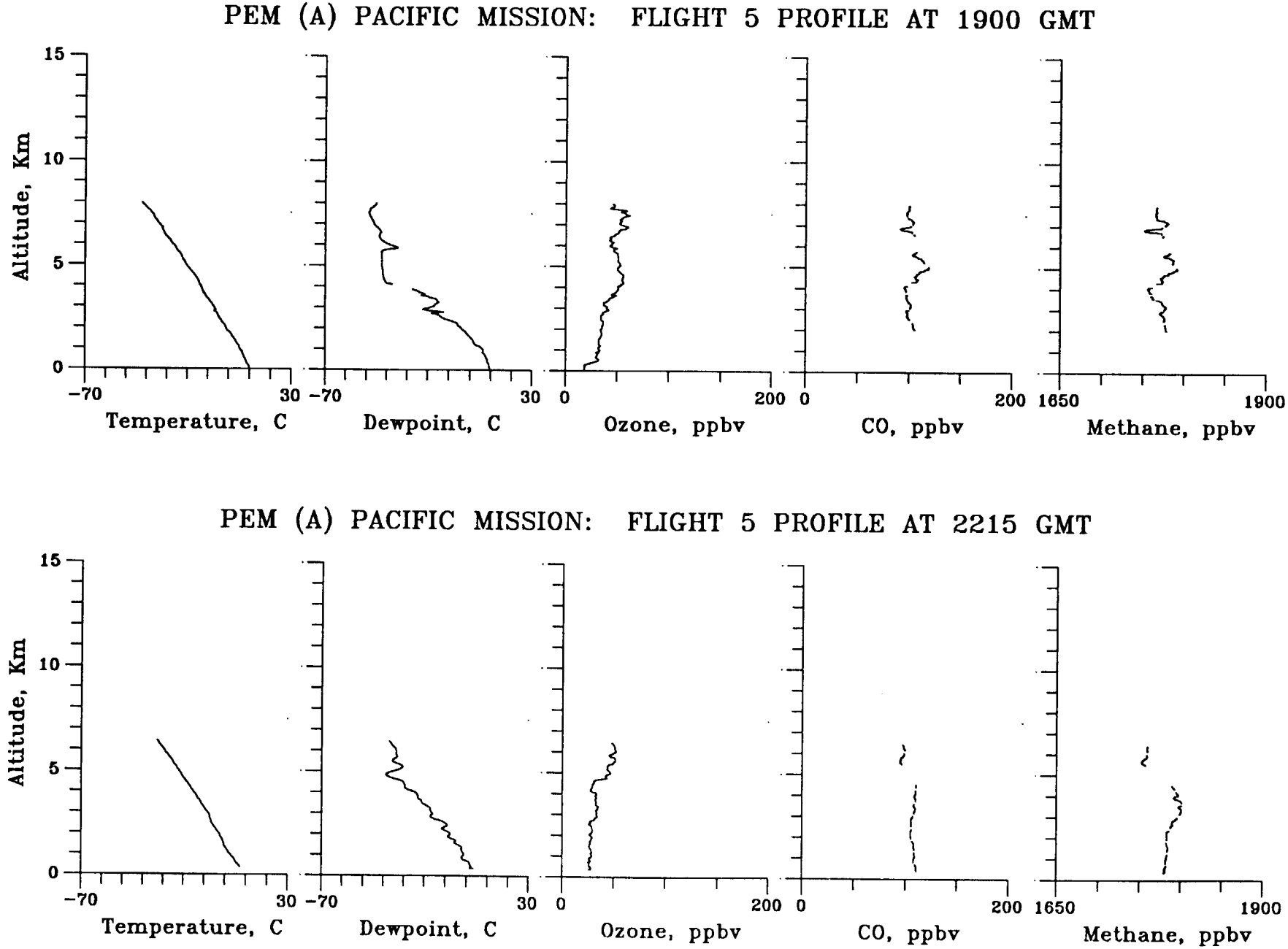

PEM (A) PACIFIC MISSION: FLIGHT 5 PROFILE AT 1900 GMT
Altitude, Km
15
10
5
0
-70
30
Temperature, C
Dewpoint, C
0
200
Ozone, ppbv
CO, ppbv
1650
1900
Methane, ppbv
PEM (A) PACIFIC MISSION: FLIGHT 5 PROFILE AT 2215 GMT

Figure A5.6

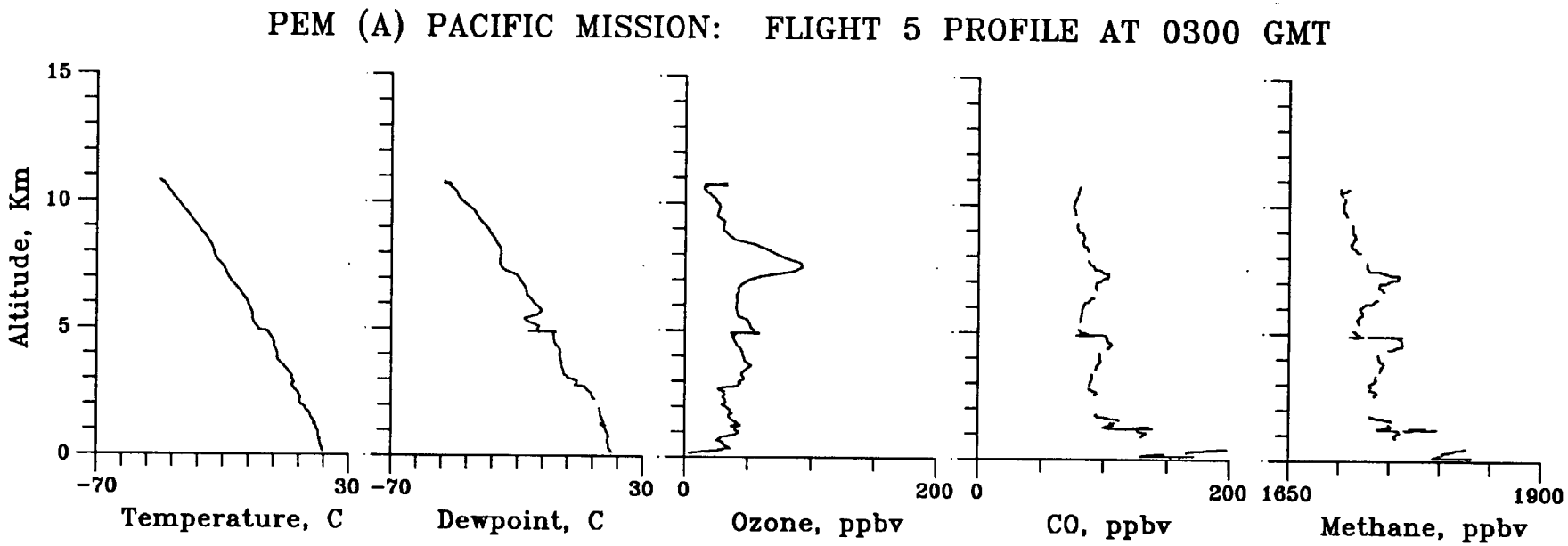

PEM (A) PACIFIC MISSION: FLIGHT 5 PROFILE AT 0300 GMT
Altitude, Km
15
10
5
0
-70
30
Temperature, C
-70
30
Dewpoint, C
0
200
Ozone, ppbv
0
200
CO, ppbv
1650
1900
Methane, ppbv

Figure A5.7

PEM (A) PACIFIC MISSION: FLIGHT 6

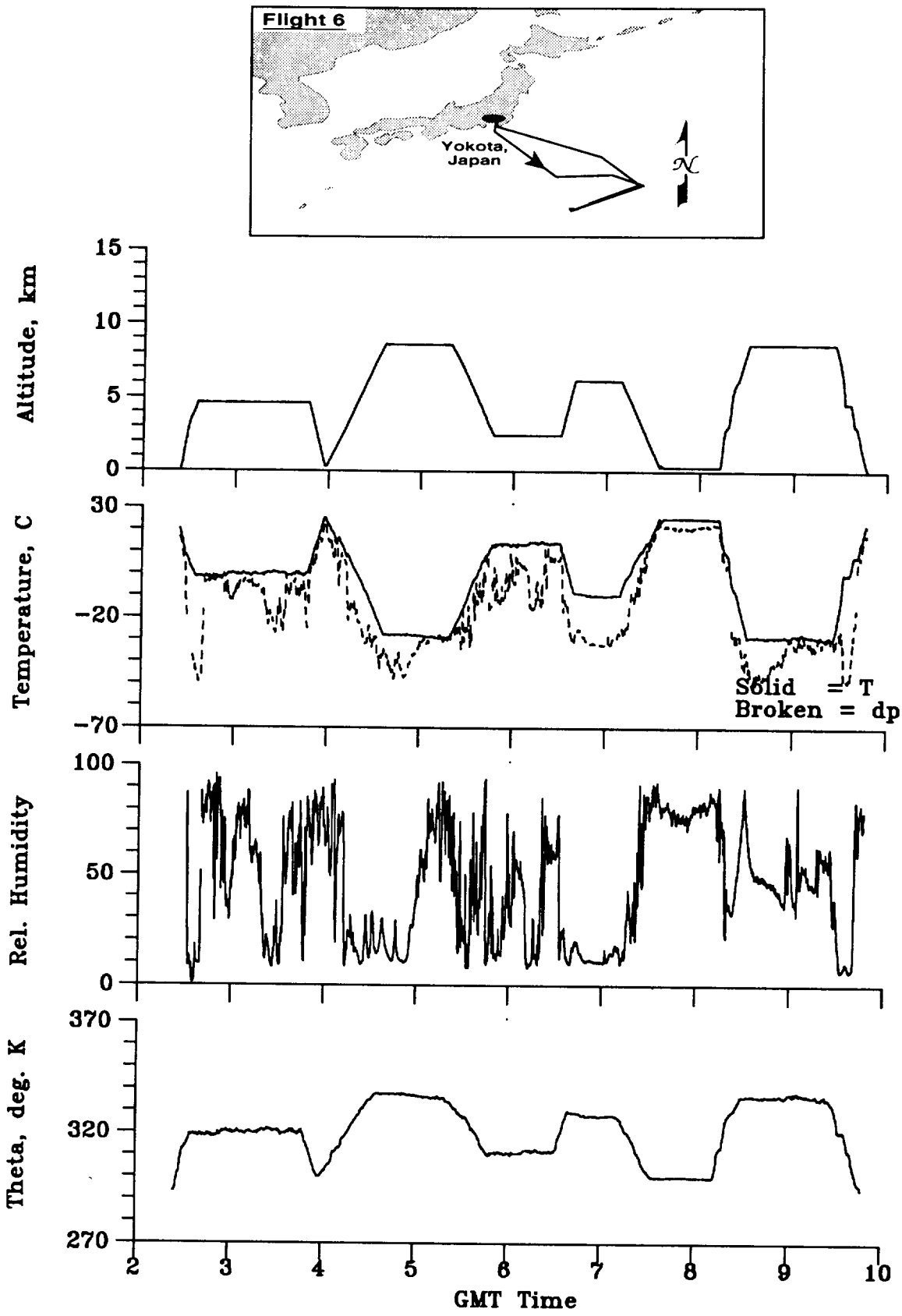


Figure A6.1

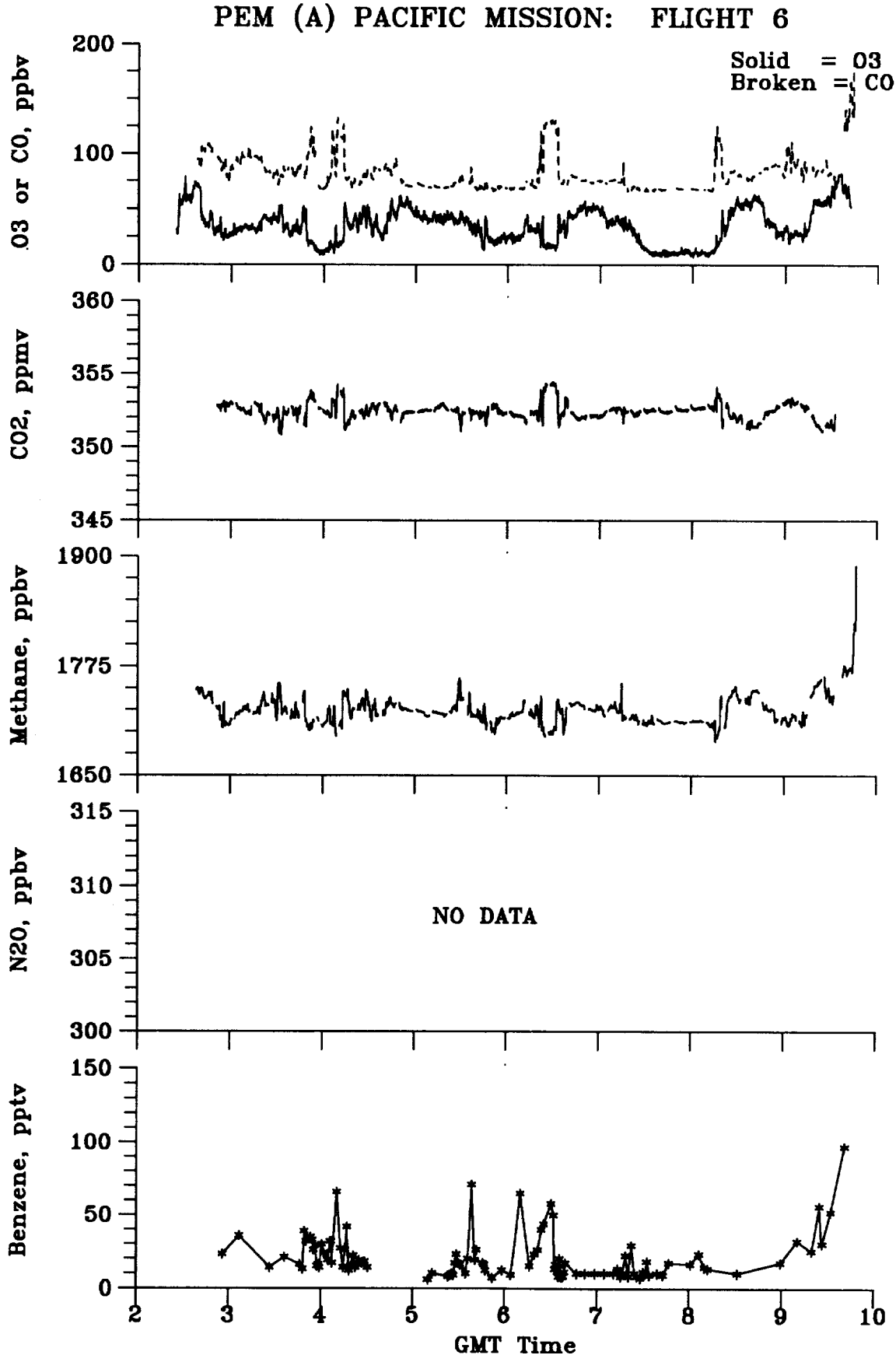

PEM (A) PACIFIC MISSION: FLIGHT 6
Solid = O3
Broken = CO
O3 or CO, ppbv
200
100
0
CO2, ppmv
360
355
350
345
Methane, ppbv
1900
1775
1650
N2O, ppbv
315
310
305
300
NO DATA
Benzene, pptv
150
100
50
0
2
3
4
5
6
7
8
9
10
GMT Time

Figure A6.2

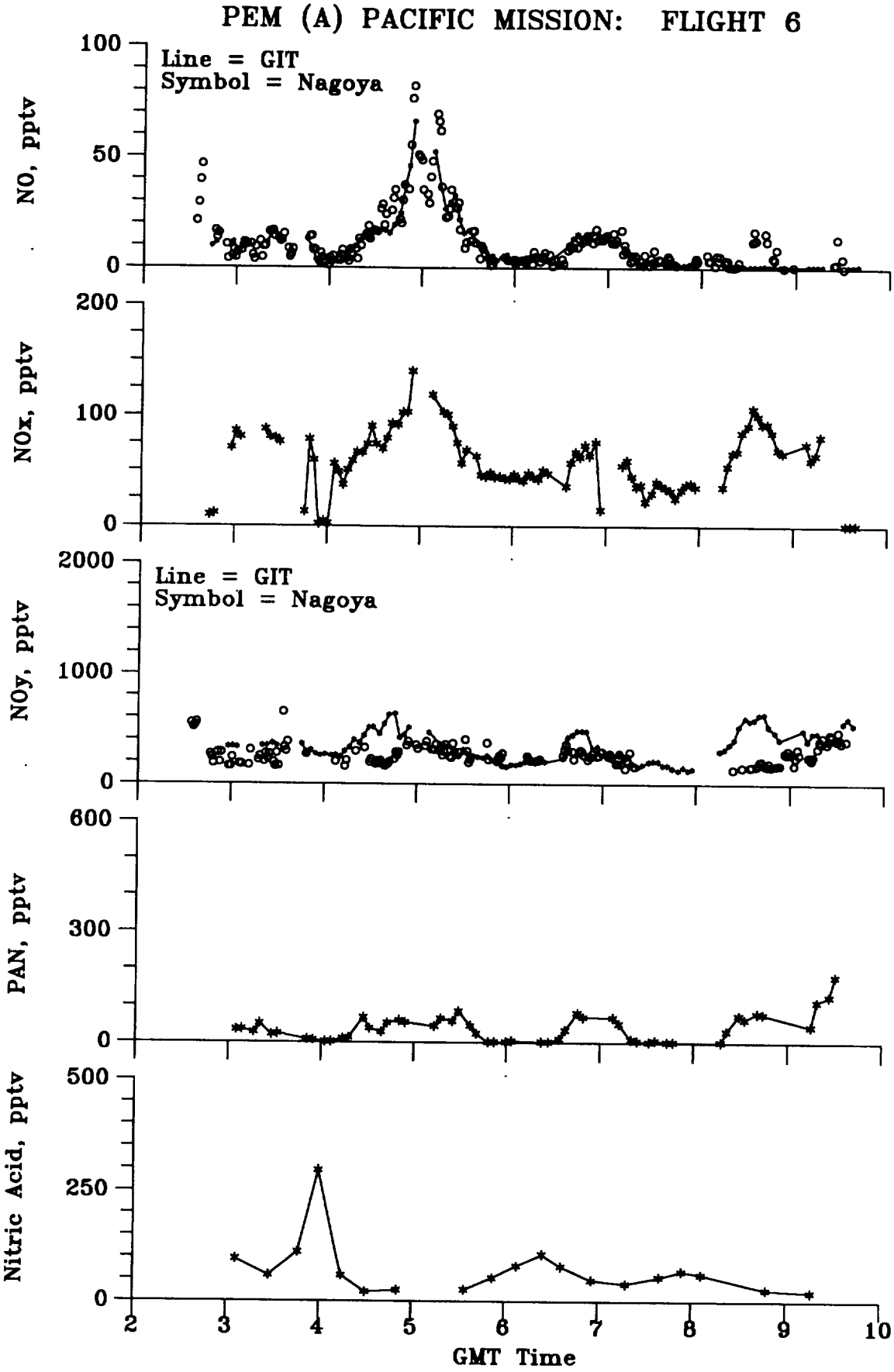

PEM (A) PACIFIC MISSION: FLIGHT 6
Line = GIT
Symbol = Nagoya
NO, pptv
100
50
0
NOx, pptv
200
100
0
Line = GIT
Symbol = Nagoya
NOy, pptv
2000
1000
0
PAN, pptv
600
300
0
Nitric Acid, pptv
500
250
0
2
3
4
5
6
7
8
9
10
GMT Time

Figure A6.3

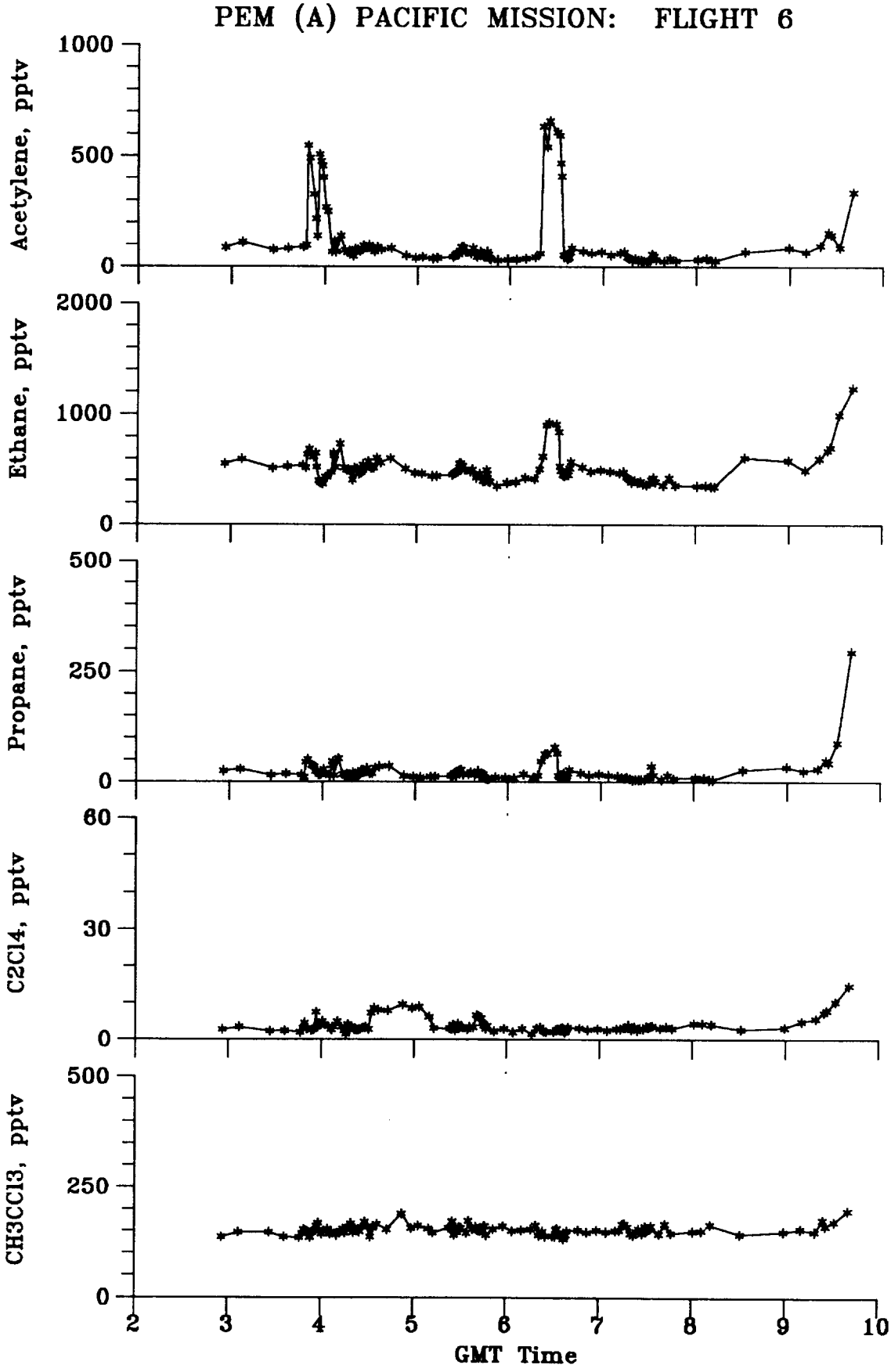

PEM (A) PACIFIC MISSION: FLIGHT 6
Acetylene, pptv
1000
500
0
Ethane, pptv
2000
1000
0
Propane, pptv
500
250
0
C2Cl4, pptv
60
30
0
CH3CCl3, pptv
500
250
0
2
3
4
5
6
7
8
9
10
GMT Time

Figure A6.4

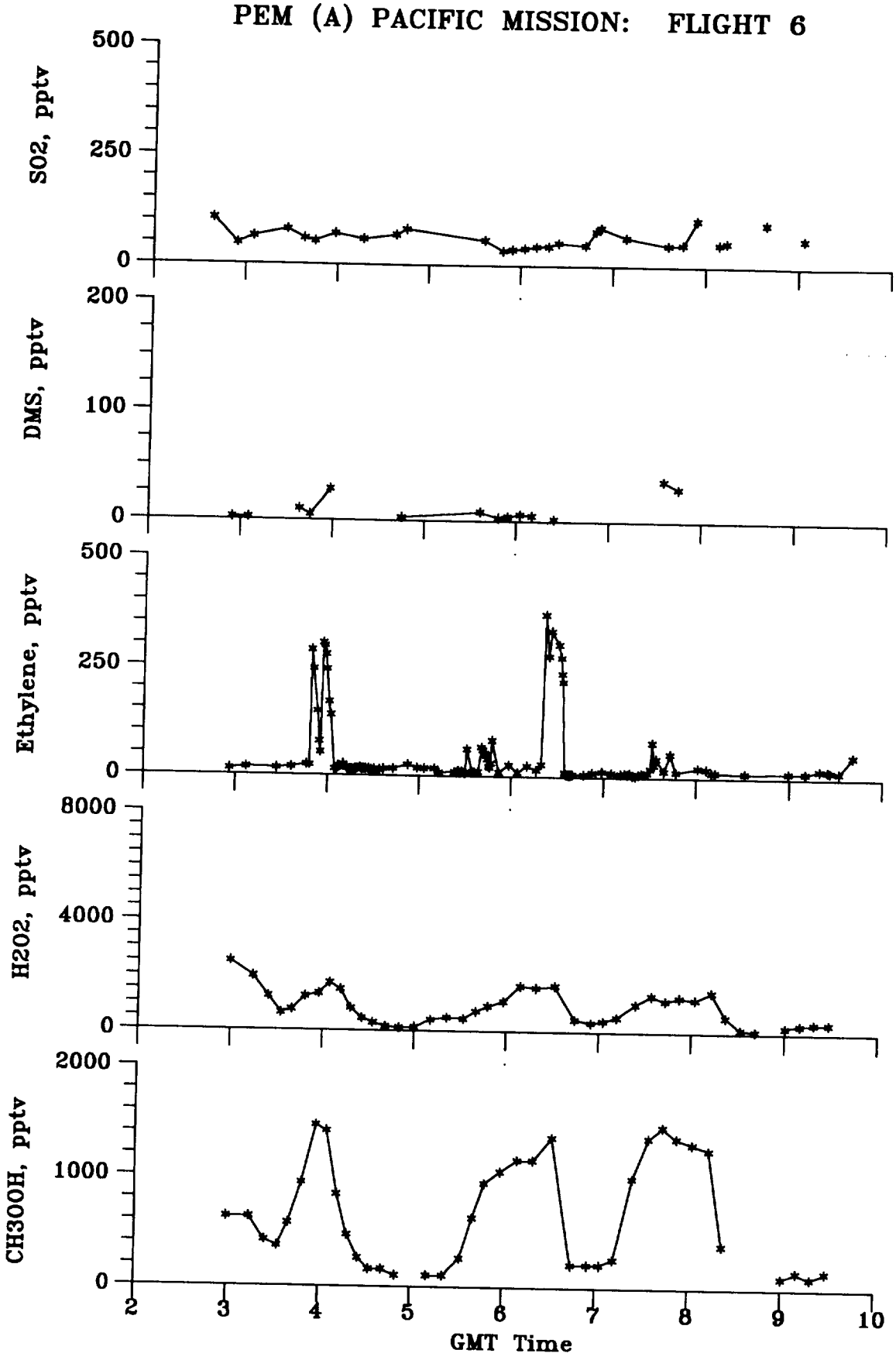

PEM (A) PACIFIC MISSION: FLIGHT 6
SO2, pptv
500
250
0
DMS, pptv
200
100
0
Ethylene, pptv
500
250
0
H2O2, pptv
8000
4000
0
CH3OOH, pptv
2000
1000
0
2
3
4
5
6
7
8
9
10
GMT Time

Figure A6.5

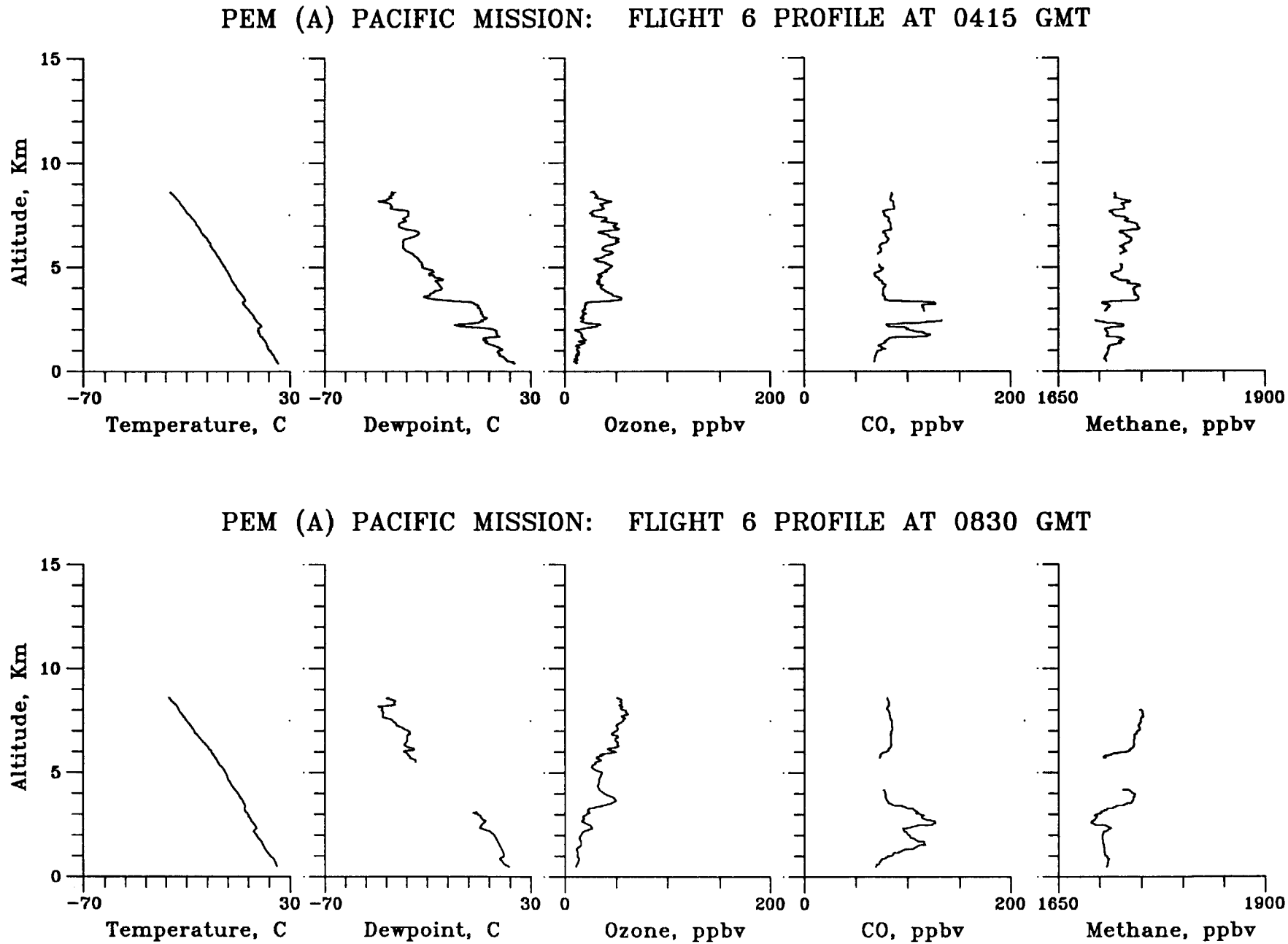

PEM (A) PACIFIC MISSION: FLIGHT 6 PROFILE AT 0415 GMT
Altitude, Km
15
10
5
0
-70
30
Temperature, C
Dewpoint, C
0
200
Ozone, ppbv
CO, ppbv
1650
1900
Methane, ppbv
PEM (A) PACIFIC MISSION: FLIGHT 6 PROFILE AT 0830 GMT
Altitude, Km
Temperature, C
Dewpoint, C
Ozone, ppbv
CO, ppbv
Methane, ppbv

Figure A6.6

PEM (A) PACIFIC MISSION: FLIGHT 7

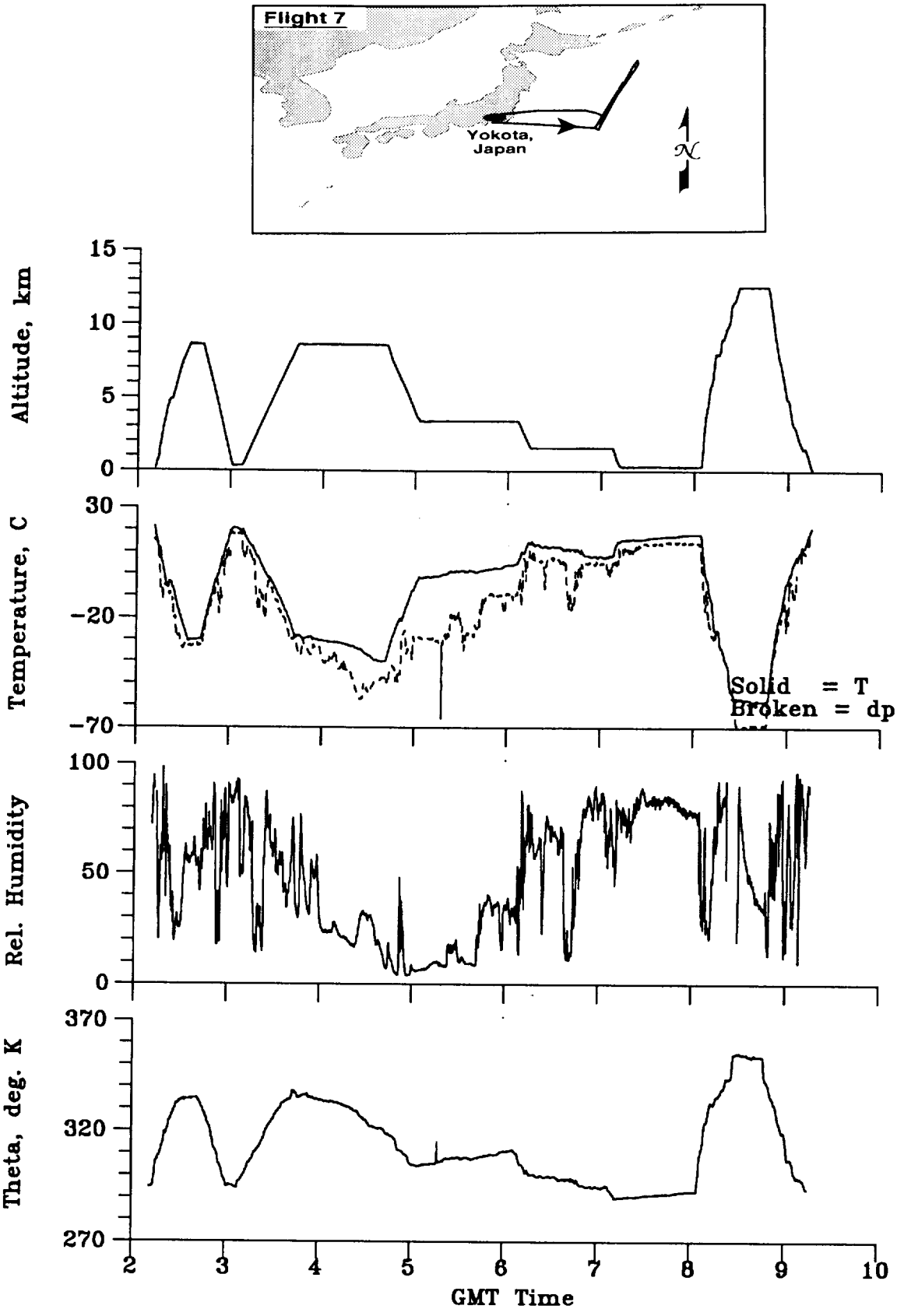


Figure A7.1

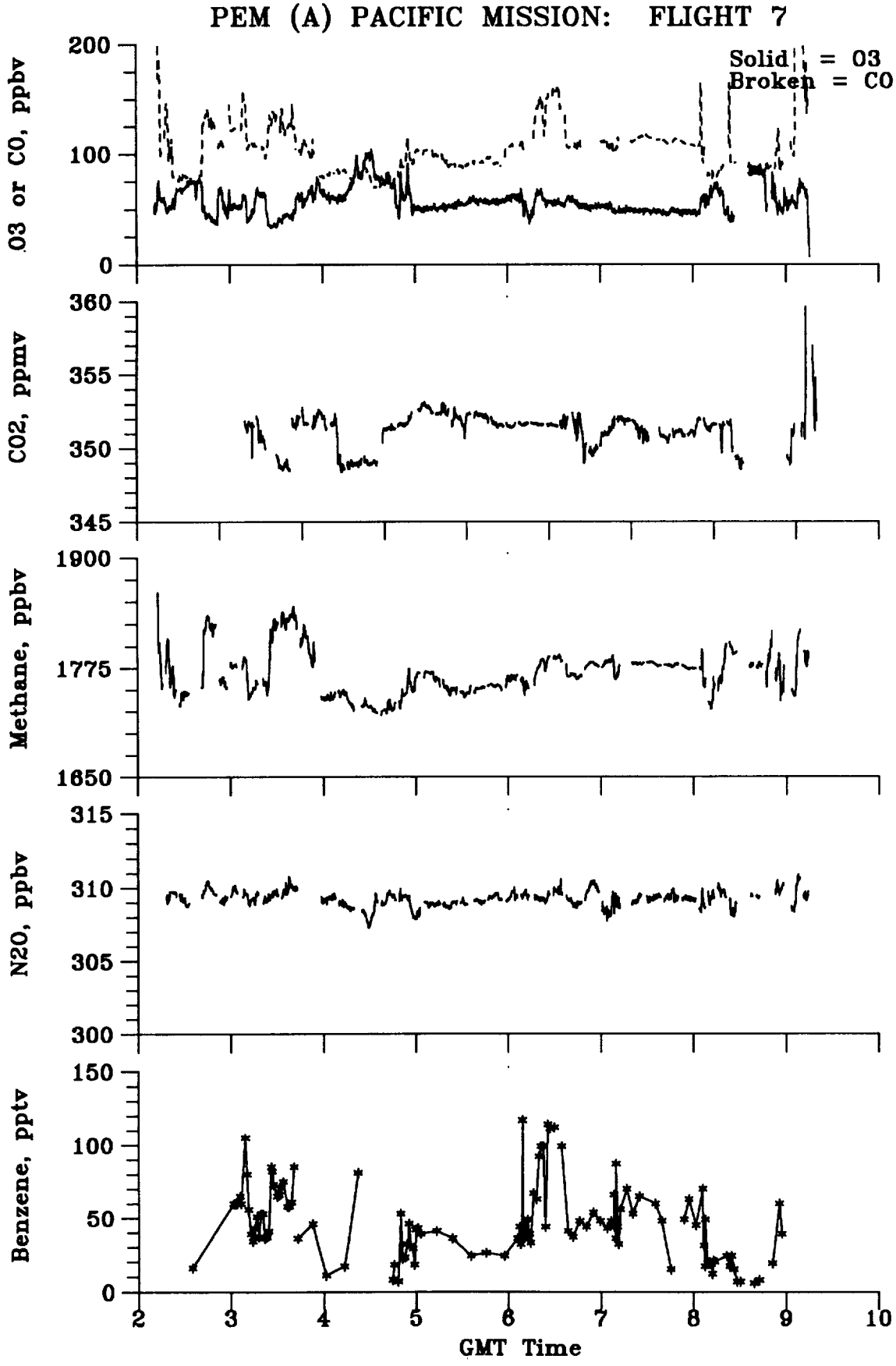

PEM (A) PACIFIC MISSION: FLIGHT 7
Solid = O3
Broken = CO
O3 or CO, ppbv
200
100
0
CO2, ppmv
360
355
350
345
Methane, ppbv
1900
1775
1650
N2O, ppbv
315
310
305
300
Benzene, pptv
150
100
50
0
2
3
4
5
6
7
8
9
10
GMT Time

Figure A7.2

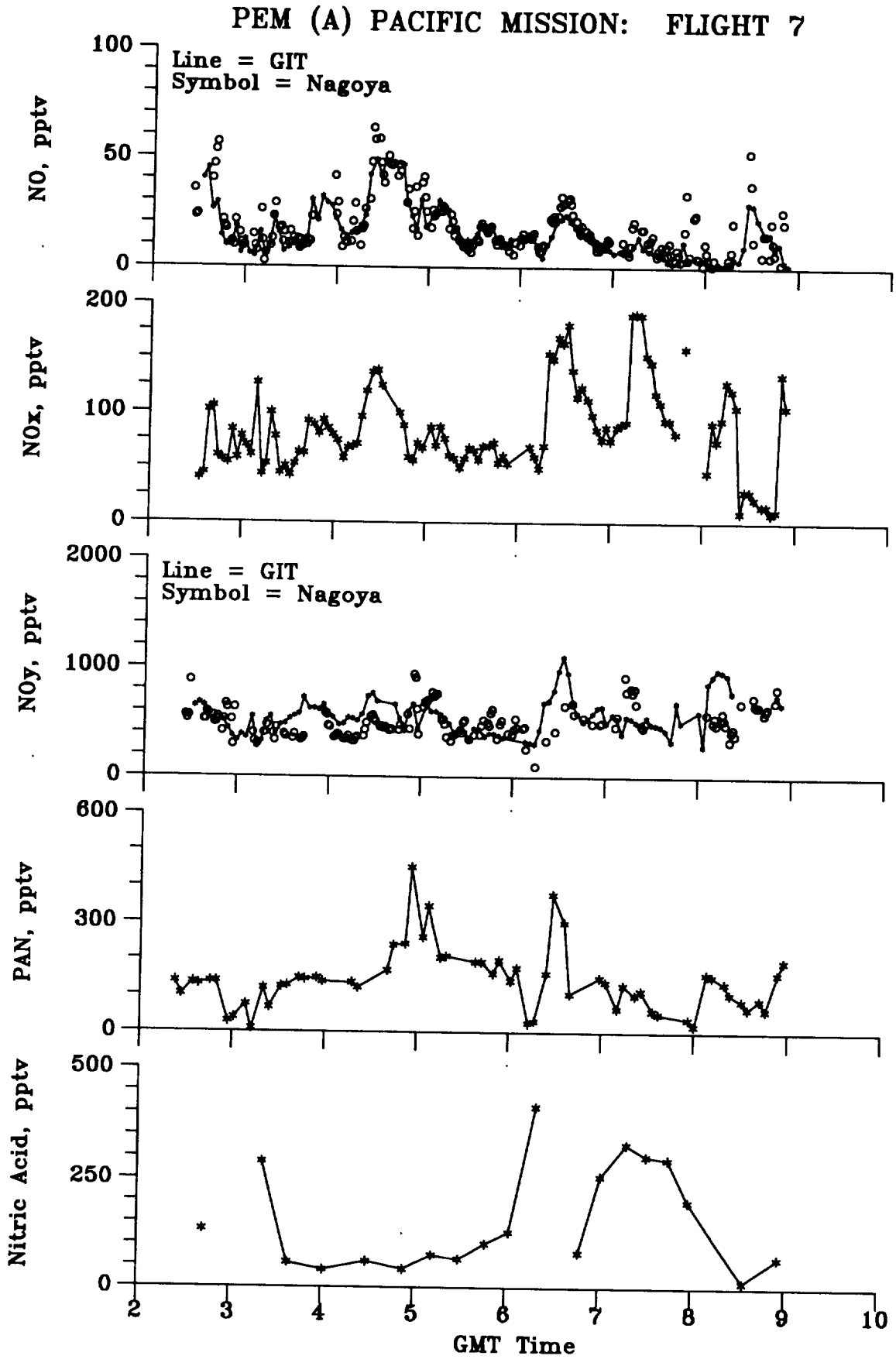

PEM (A) PACIFIC MISSION: FLIGHT 7
Line = GIT
Symbol = Nagoya
NO, pptv
100
50
0
NOx, pptv
200
100
0
Line = GIT
Symbol = Nagoya
NOy, pptv
2000
1000
0
PAN, pptv
600
300
0
Nitric Acid, pptv
500
250
0
2
3
4
5
6
7
8
9
10
GMT Time

Figure A7.3

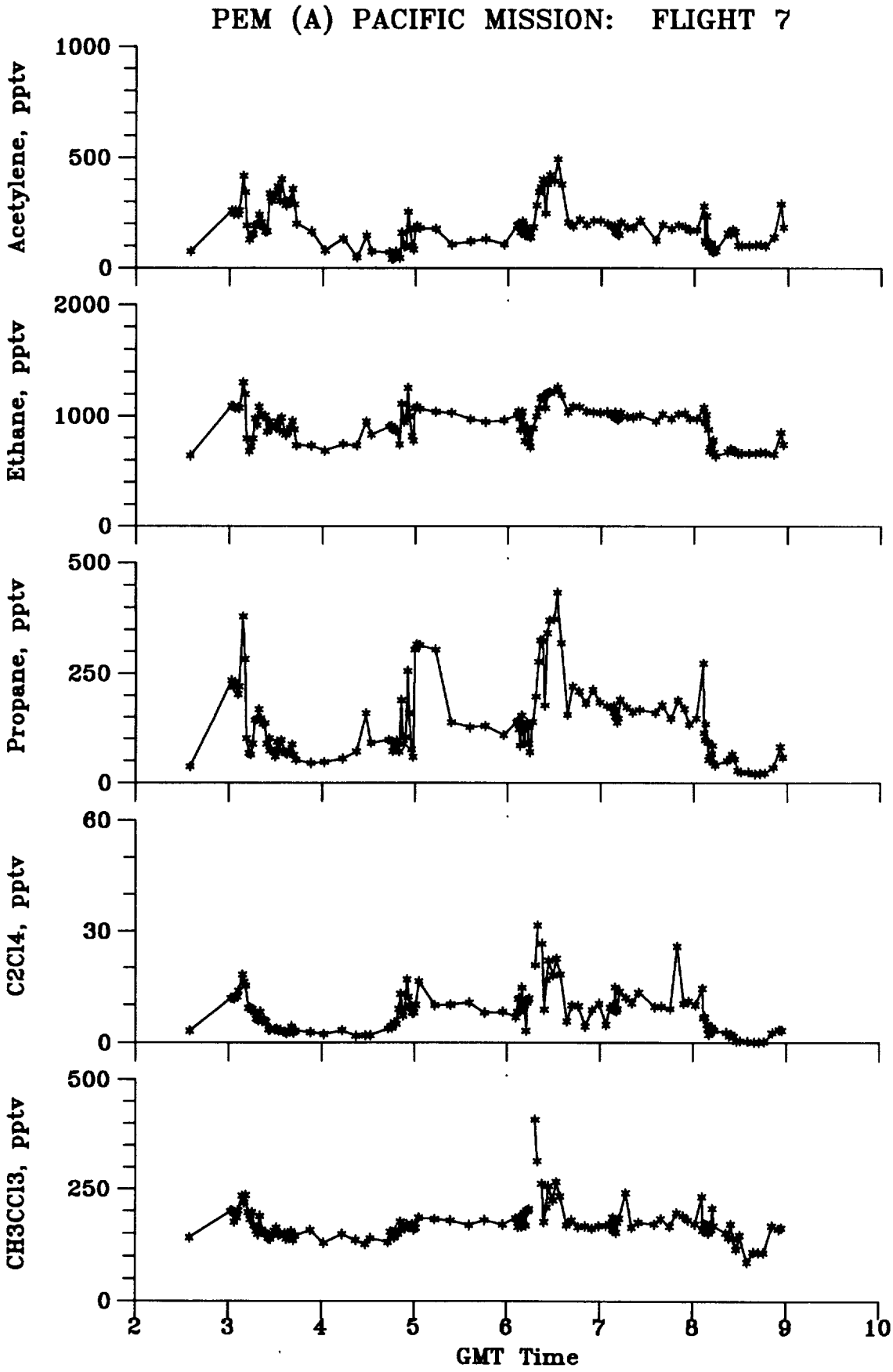

PEM (A) PACIFIC MISSION: FLIGHT 7
Acetylene, pptv
1000
500
0
Ethane, pptv
2000
1000
0
Propane, pptv
500
250
0
C2Cl4, pptv
60
30
0
CH3CCl3, pptv
500
250
0
2
3
4
5
6
7
8
9
10
GMT Time

Figure A7.4

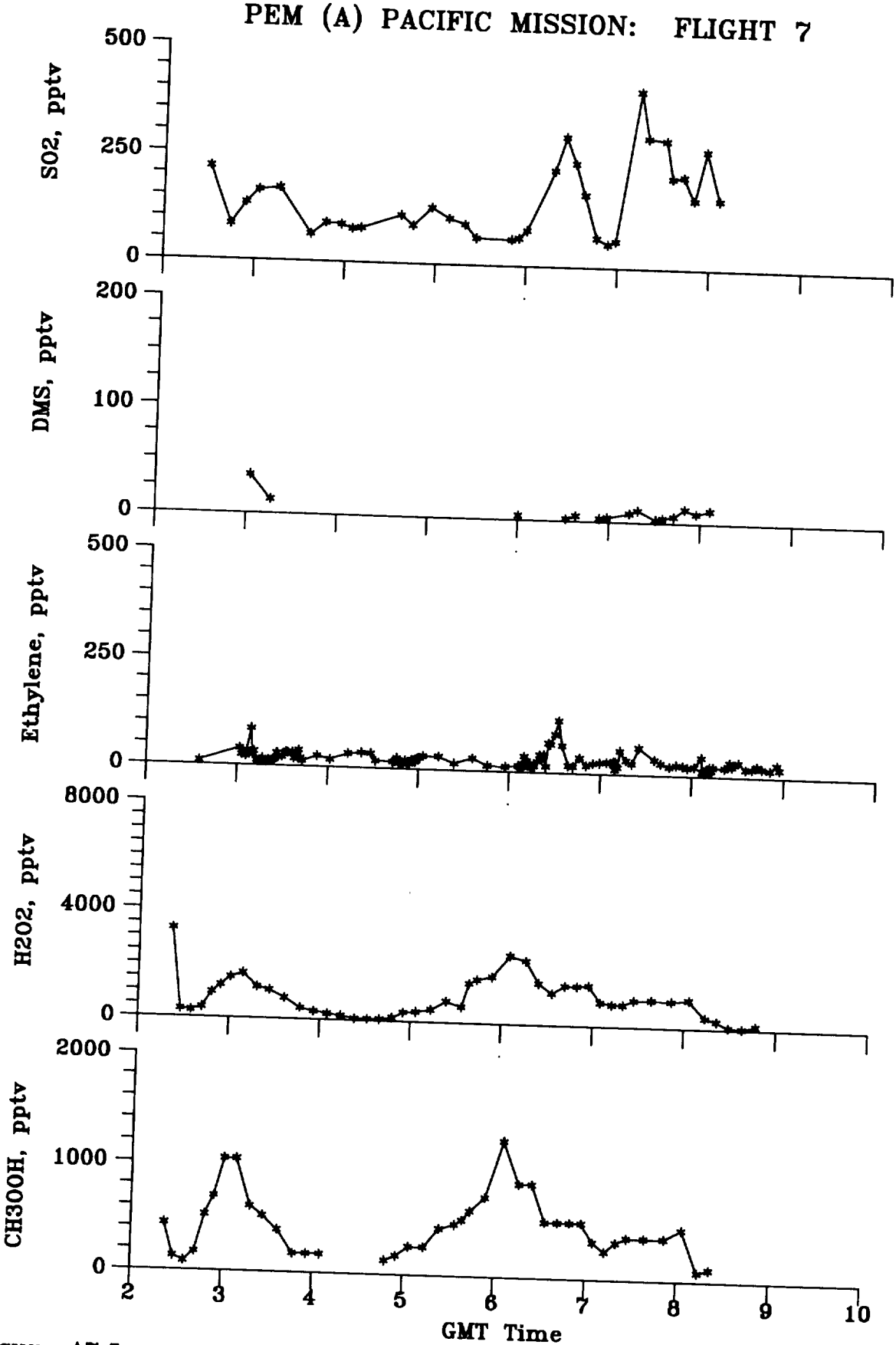
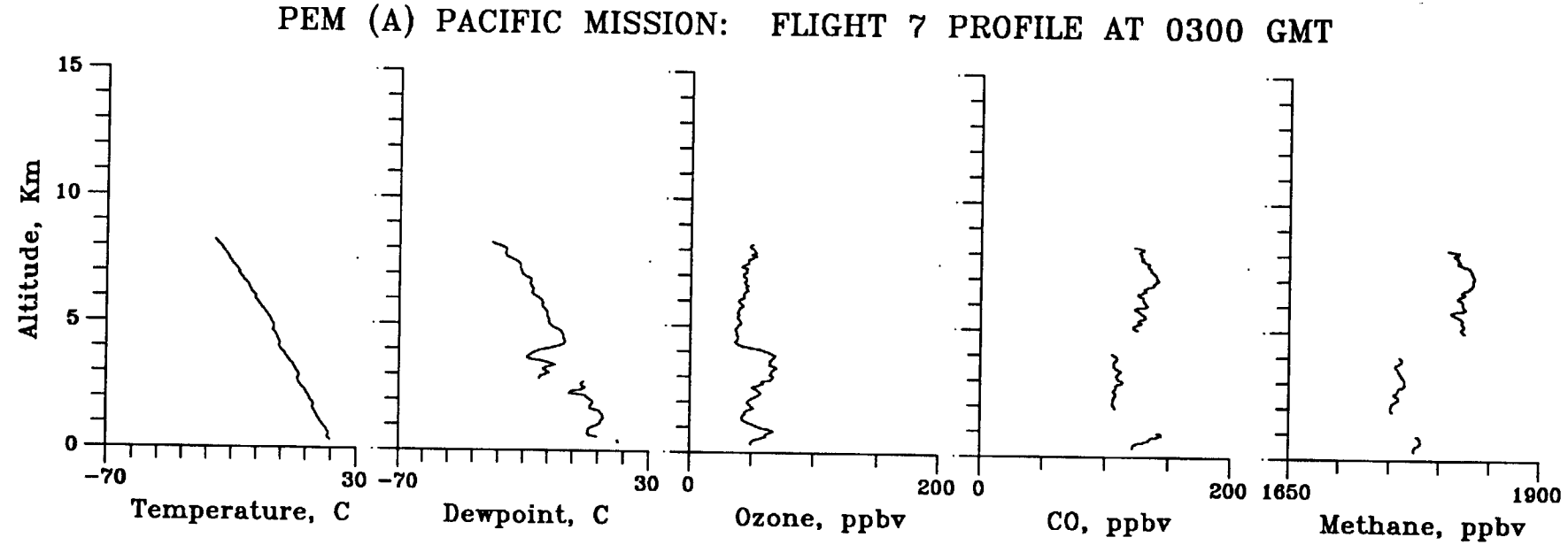
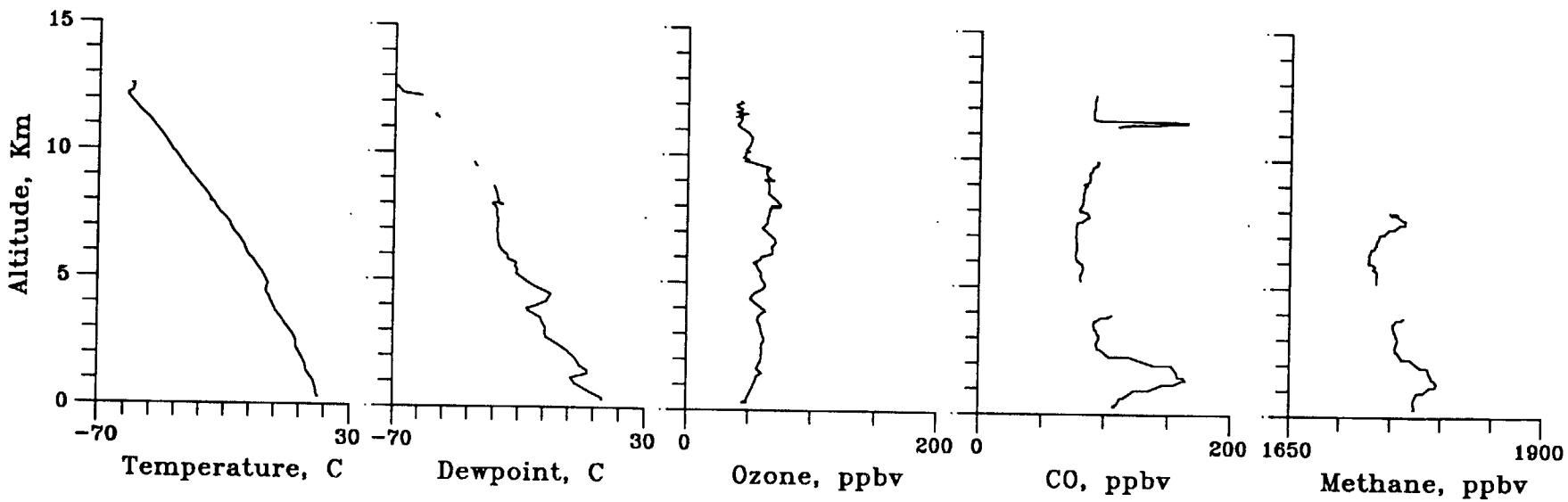

PEM (A) PACIFIC MISSION: FLIGHT 7
SO2, pptv
500
250
0
DMS, pptv
200
100
0
Ethylene, pptv
500
250
0
H2O2, pptv
8000
4000
0
CH3OOH, pptv
2000
1000
0
2
3
4
5
6
7
8
9
10
GMT Time

Figure A7.5

Figure A7.6


PEM (A) PACIFIC MISSION: FLIGHT 7 PROFILE AT 0300 GMT
Altitude, Km
15
10
5
0
-70
30
Temperature, C
Dewpoint, C
0
200
Ozone, ppbv
CO, ppbv
1650
1900
Methane, ppbv


PEM (A) PACIFIC MISSION: FLIGHT 7 PROFILE AT 0815 GMT
Altitude, Km
15
10
5
0
-70
30
Temperature, C
Dewpoint, C
0
200
Ozone, ppbv
CO, ppbv
1650
1900
Methane, ppbv

PEM (A) PACIFIC MISSION: FLIGHT 8

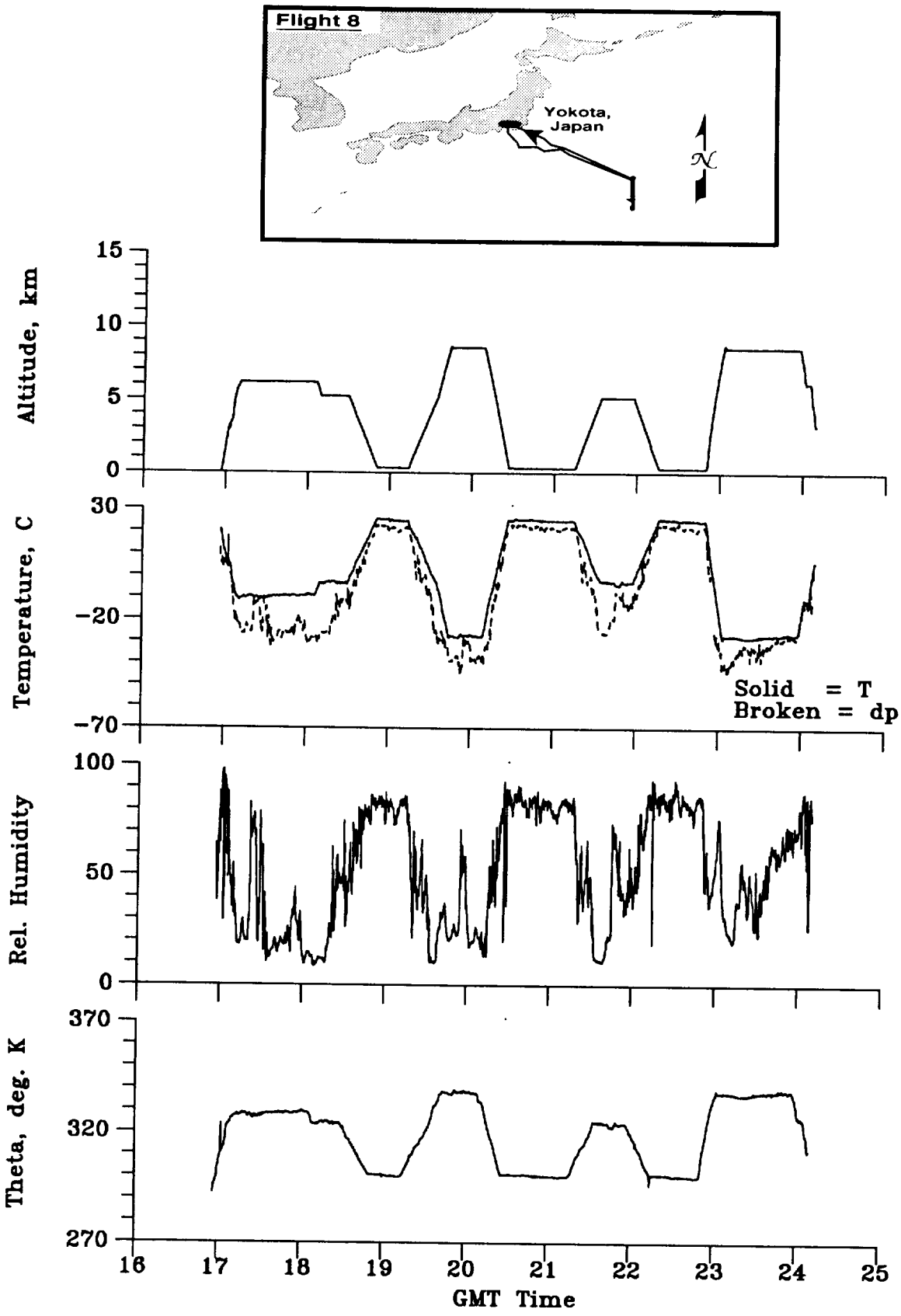


Figure A8.1

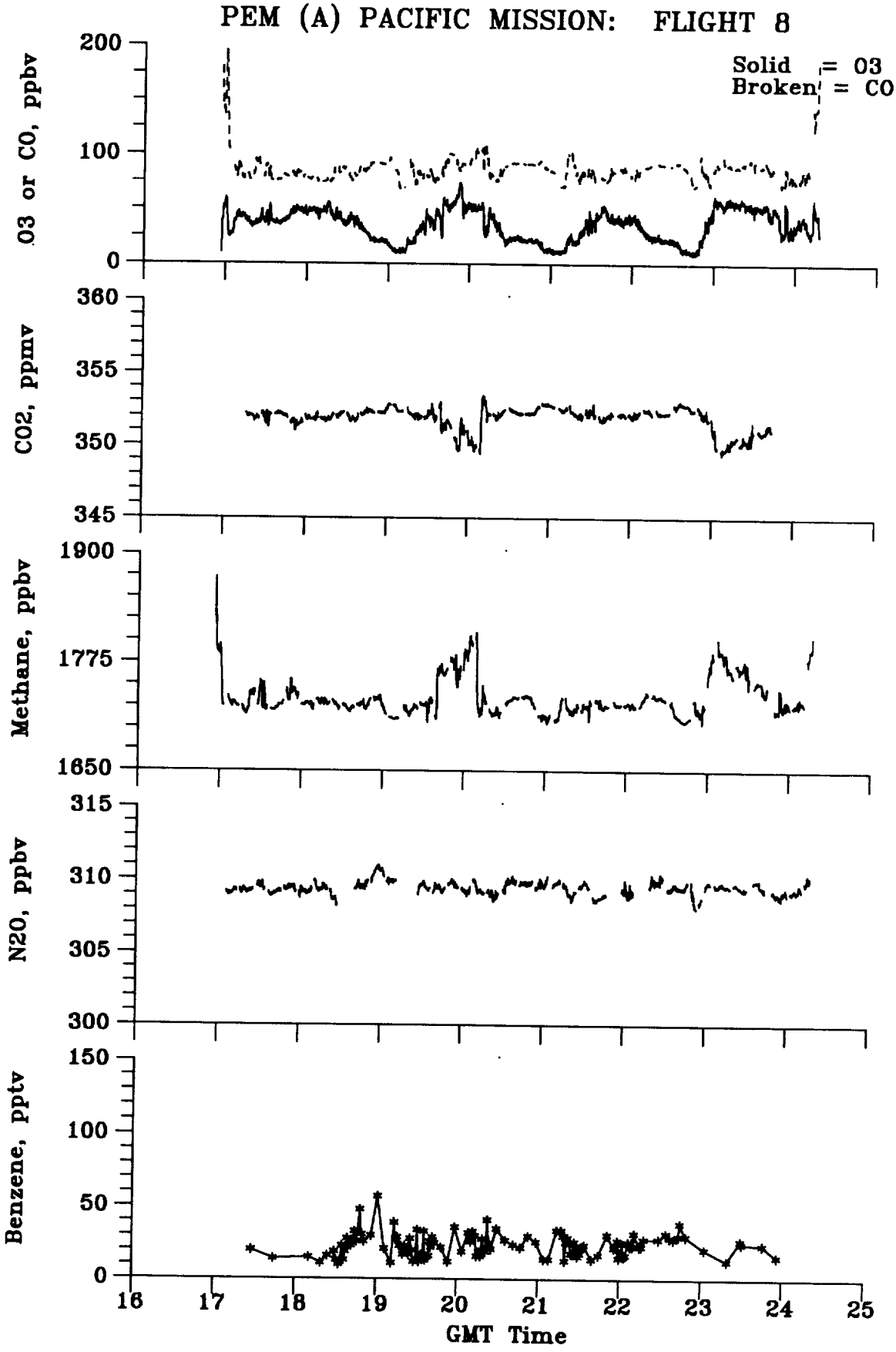

PEM (A) PACIFIC MISSION: FLIGHT 8
Solid = O3
Broken = CO
O3 or CO, ppbv
200
100
0
CO2, ppmv
360
355
350
345
Methane, ppbv
1900
1775
1650
N2O, ppbv
315
310
305
300
Benzene, pptv
150
100
50
0
16
17
18
19
20
21
22
23
24
25
GMT Time

Figure A8.2

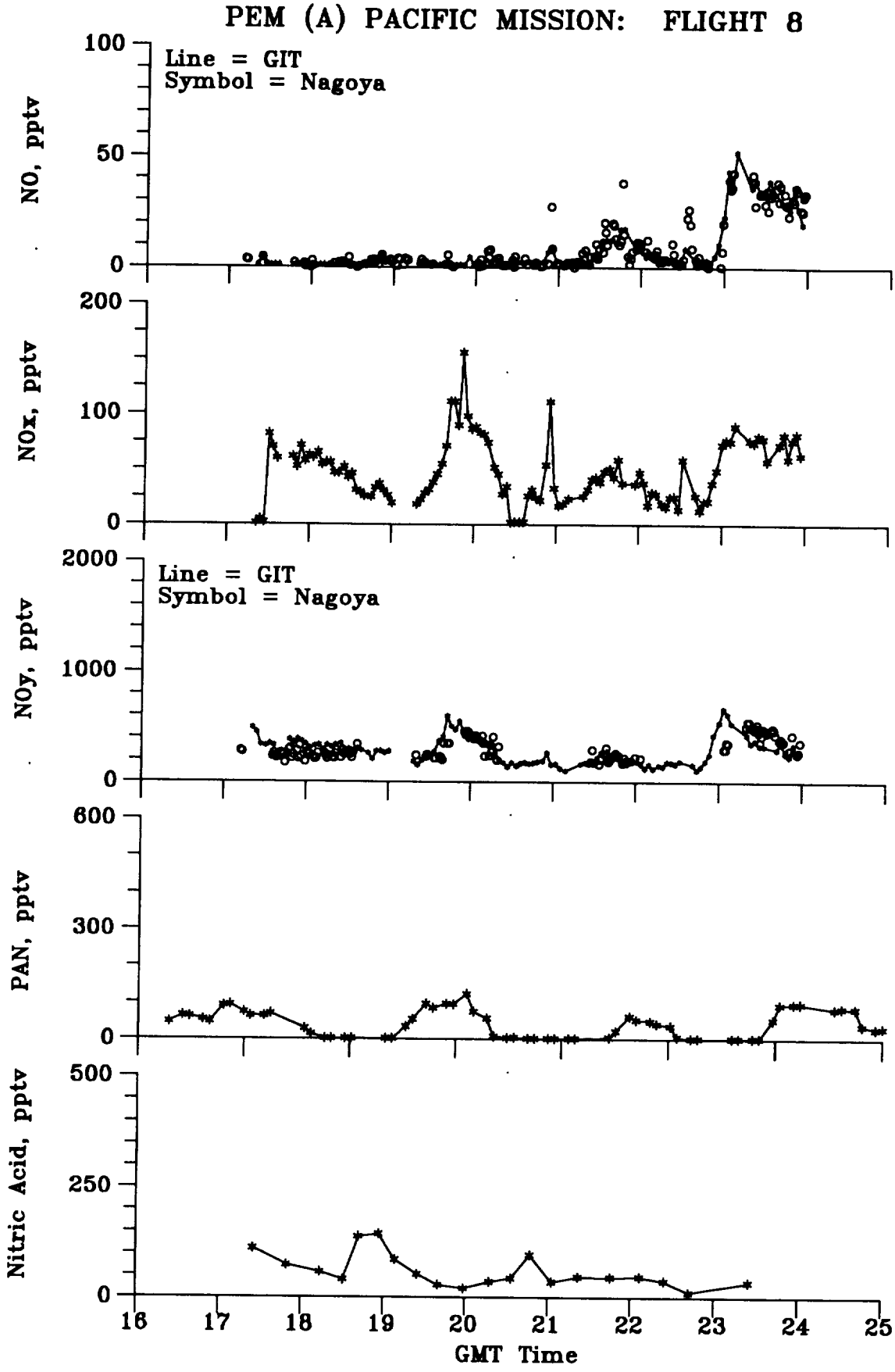

PEM (A) PACIFIC MISSION: FLIGHT 8
Line = GIT
Symbol = Nagoya
NO, pptv
100
50
0
NOx, pptv
200
100
0
Line = GIT
Symbol = Nagoya
NOy, pptv
2000
1000
0
PAN, pptv
600
300
0
Nitric Acid, pptv
500
250
0
16
17
18
19
20
21
22
23
24
25
GMT Time

Figure A8.3

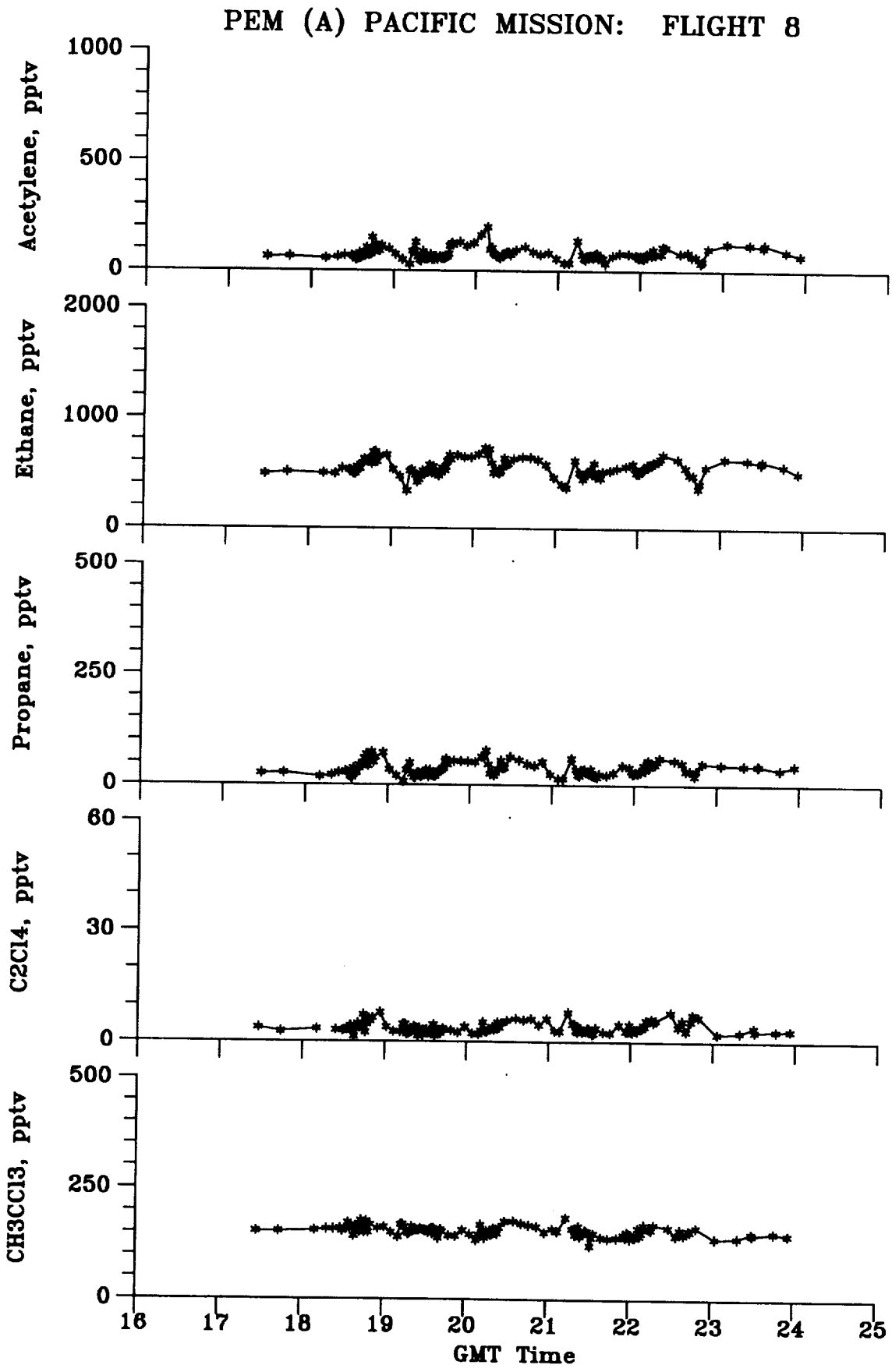

PEM (A) PACIFIC MISSION: FLIGHT 8
Acetylene, pptv
1000
500
0
Ethane, pptv
2000
1000
0
Propane, pptv
500
250
0
C2Cl4, pptv
60
30
0
CH3CCl3, pptv
500
250
0
16
17
18
19
20
21
22
23
24
25
GMT Time

Figure A8.4

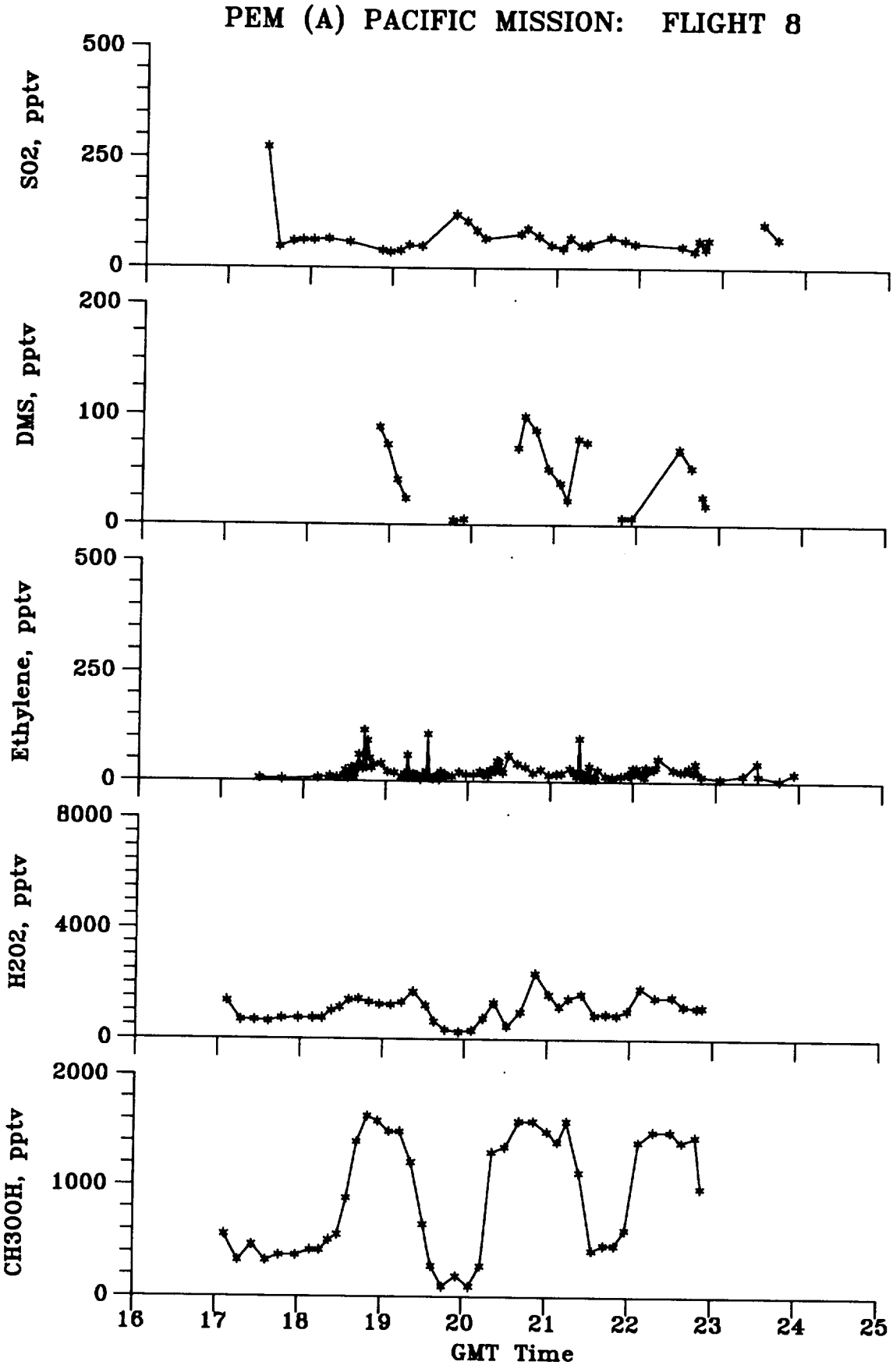
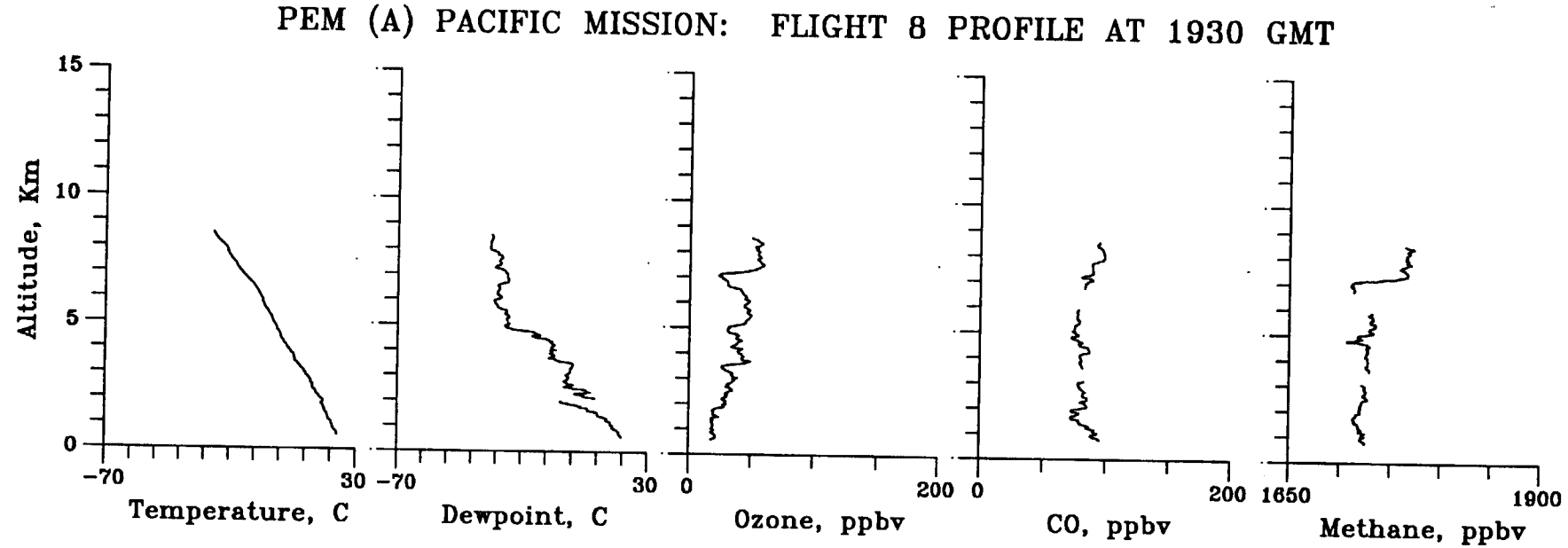
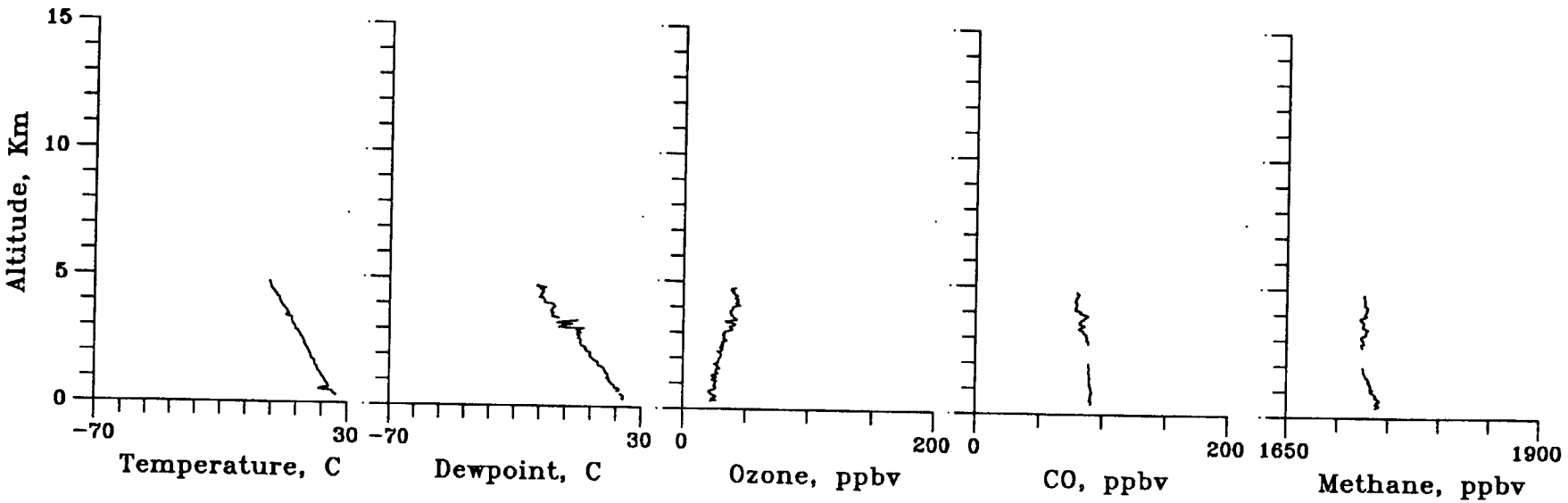

PEM (A) PACIFIC MISSION: FLIGHT 8
SO2, pptv
500
250
0
DMS, pptv
200
100
0
Ethylene, pptv
500
250
0
H2O2, pptv
8000
4000
0
CH3OOH, pptv
2000
1000
0
16
17
18
19
20
21
22
23
24
25
GMT Time

Figure A8.5

Figure A8.6


PEM (A) PACIFIC MISSION: FLIGHT 8 PROFILE AT 1930 GMT
Altitude, Km
15
10
5
0
-70
30
Temperature, C
Dewpoint, C
0
200
Ozone, ppbv
CO, ppbv
1650
1900
Methane, ppbv


PEM (A) PACIFIC MISSION: FLIGHT 8 PROFILE AT 2200 GMT
Altitude, Km
15
10
5
0
-70
30
Temperature, C
Dewpoint, C
0
200
Ozone, ppbv
CO, ppbv
1650
1900
Methane, ppbv

PEM (A) PACIFIC MISSION: FLIGHT 9

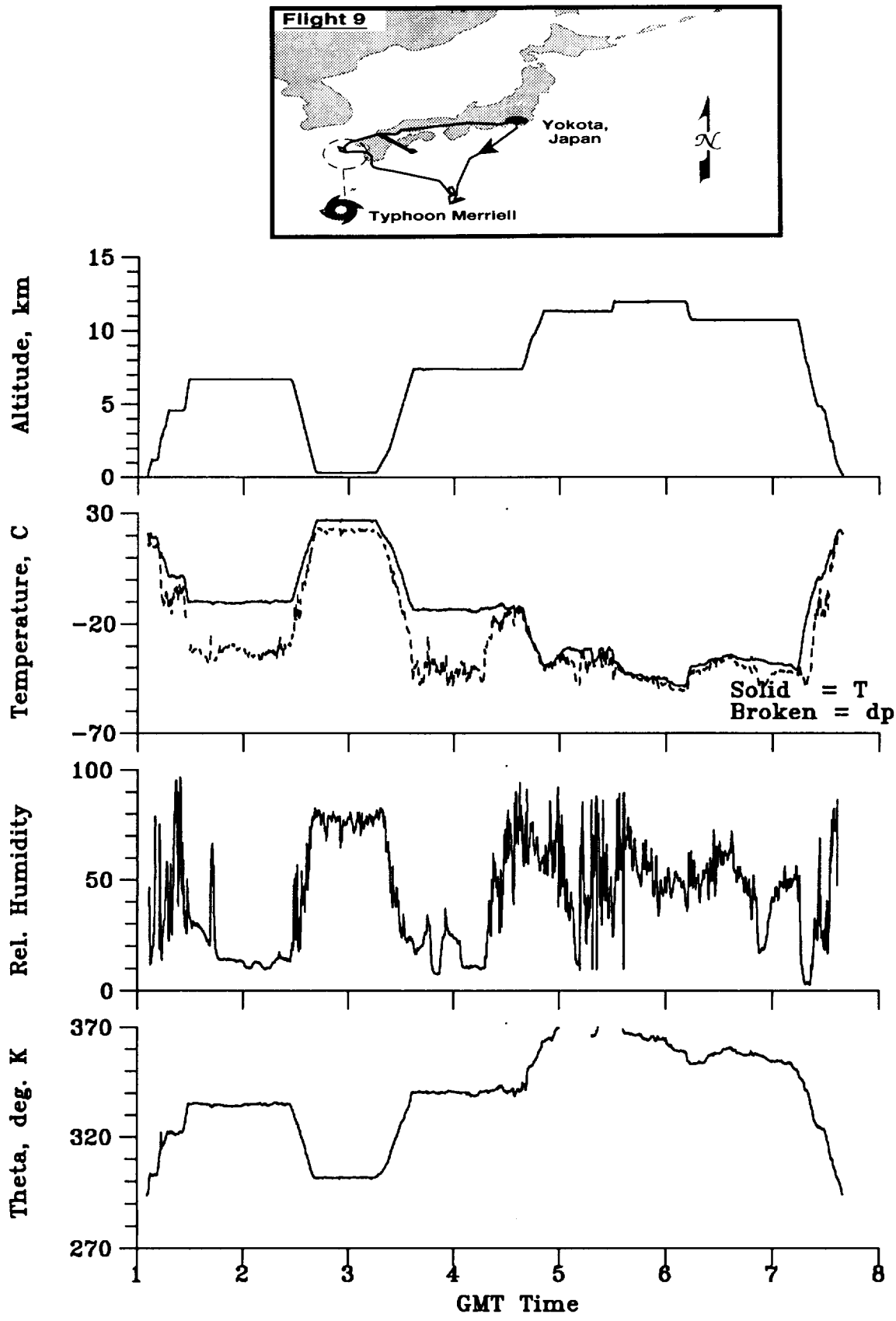


Figure A9.1

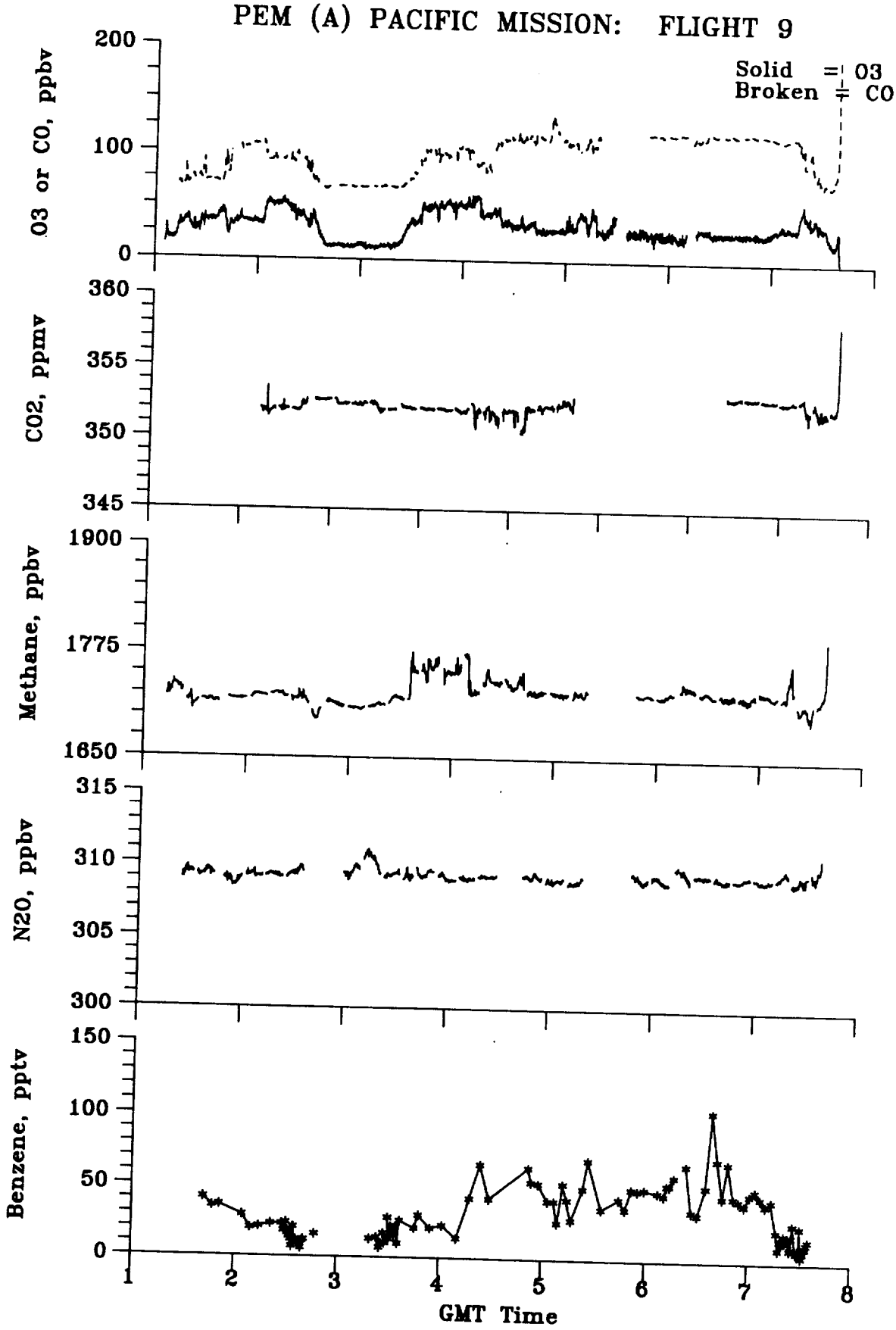

PEM (A) PACIFIC MISSION: FLIGHT 9
Solid = O3
Broken = CO
O3 or CO, ppbv
200
100
0
CO2, ppmv
360
355
350
345
Methane, ppbv
1900
1775
1650
N2O, ppbv
315
310
305
300
Benzene, pptv
150
100
50
0
1
2
3
4
5
6
7
8
GMT Time

Figure A9.2

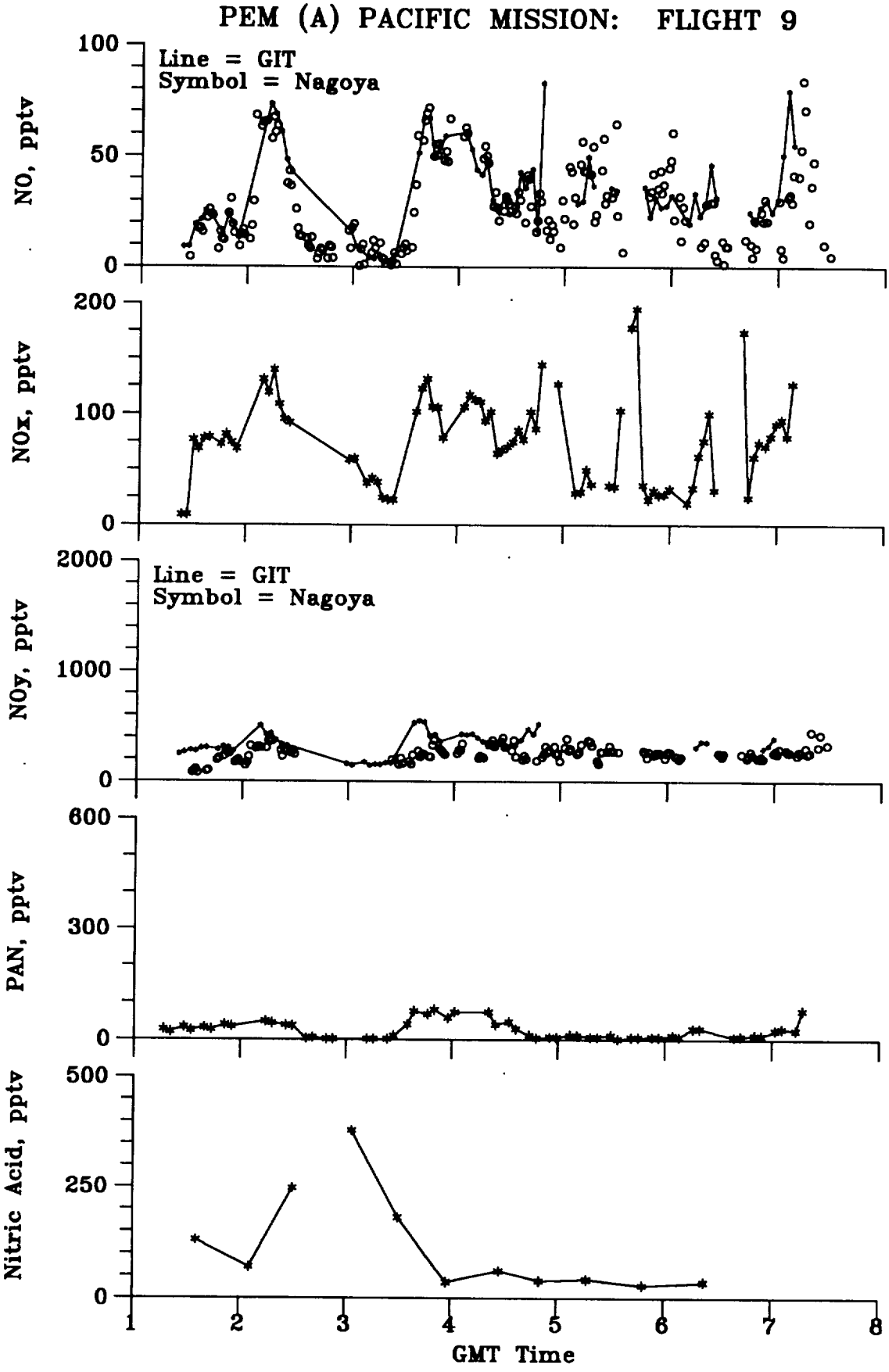

PEM (A) PACIFIC MISSION: FLIGHT 9
Line = GIT
Symbol = Nagoya
NO, pptv
100
50
0
NOx, pptv
200
100
0
Line = GIT
Symbol = Nagoya
NOy, pptv
2000
1000
0
PAN, pptv
600
300
0
Nitric Acid, pptv
500
250
0
1
2
3
4
5
6
7
8
GMT Time

Figure A9.3

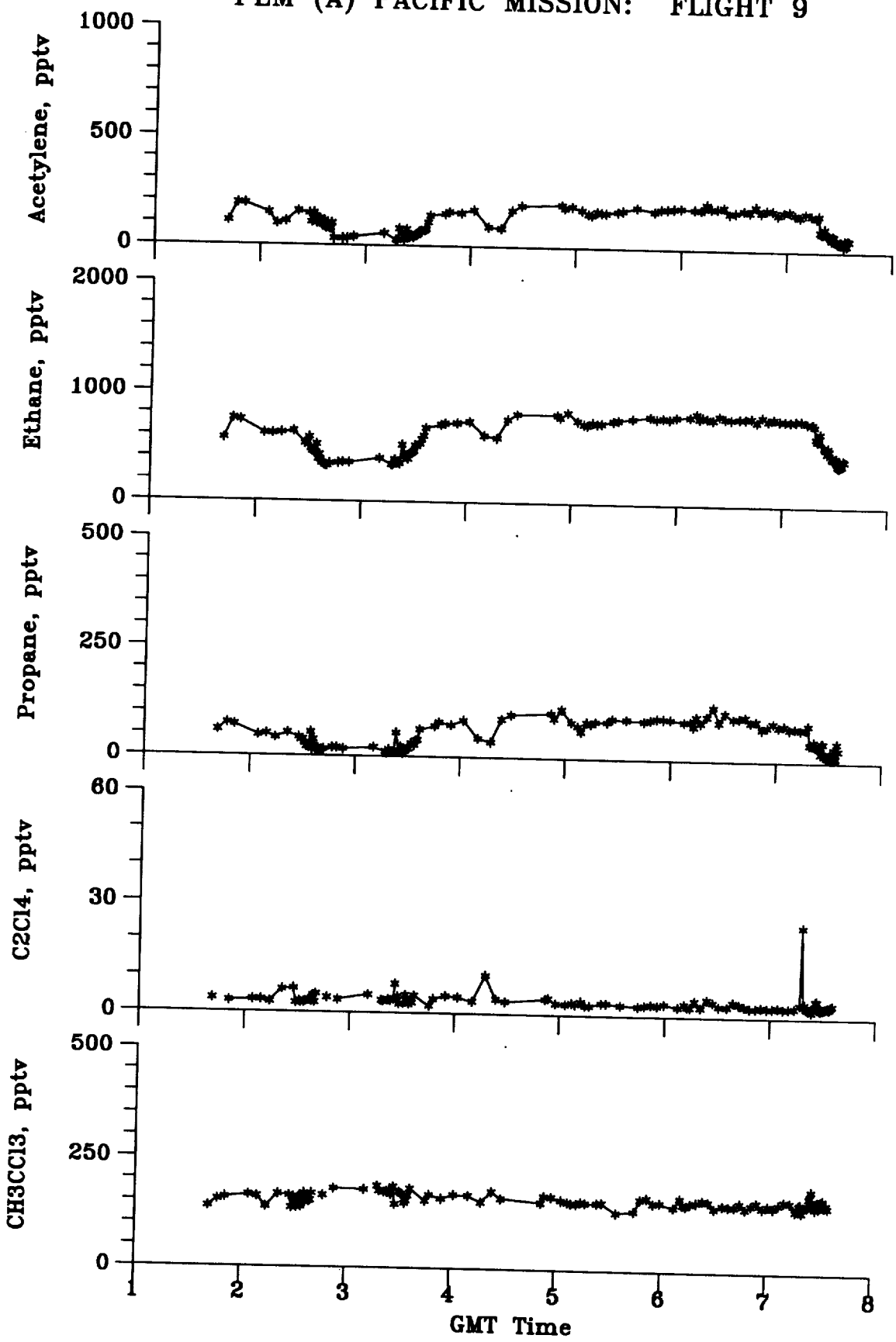

PEM (A) PACIFIC MISSION: FLIGHT 9
Acetylene, pptv
1000
500
0
Ethane, pptv
2000
1000
0
Propane, pptv
500
250
0
C2Cl4, pptv
60
30
0
CH3CCl3, pptv
500
250
0
1
2
3
4
5
6
7
8
GMT Time

Figure A9.4

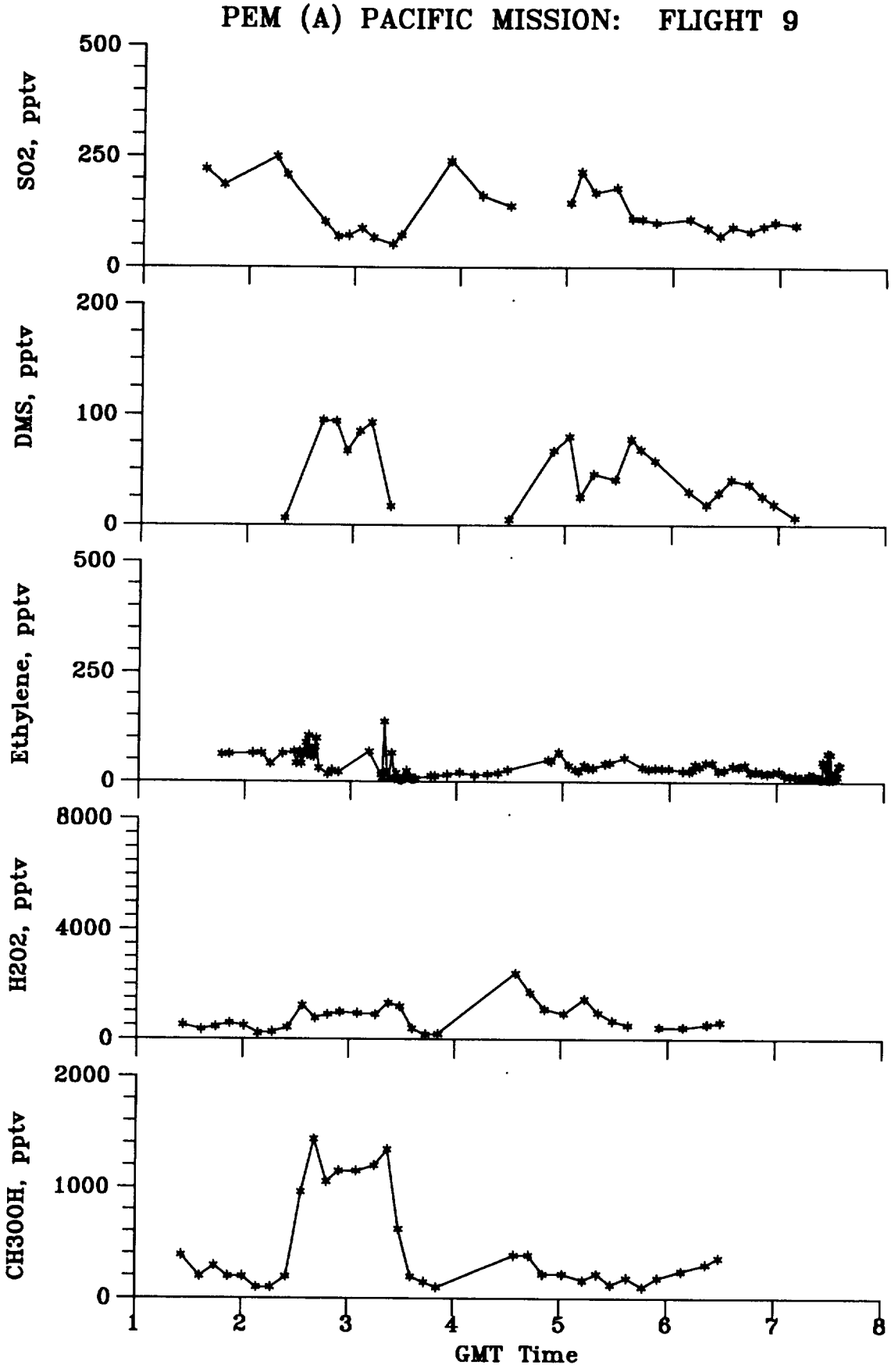

PEM (A) PACIFIC MISSION: FLIGHT 9
SO2, pptv
500
250
0
DMS, pptv
200
100
0
Ethylene, pptv
500
250
0
H2O2, pptv
8000
4000
0
CH3OOH, pptv
2000
1000
0
1
2
3
4
5
6
7
8
GMT Time

Figure A9.5

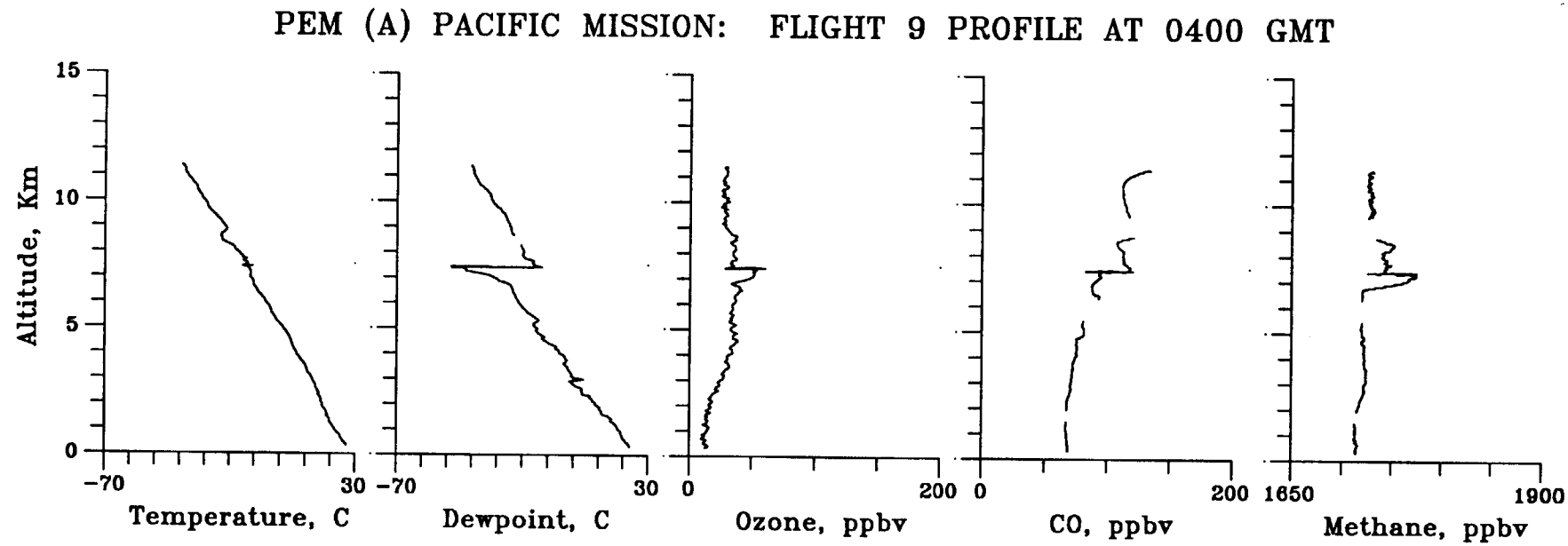
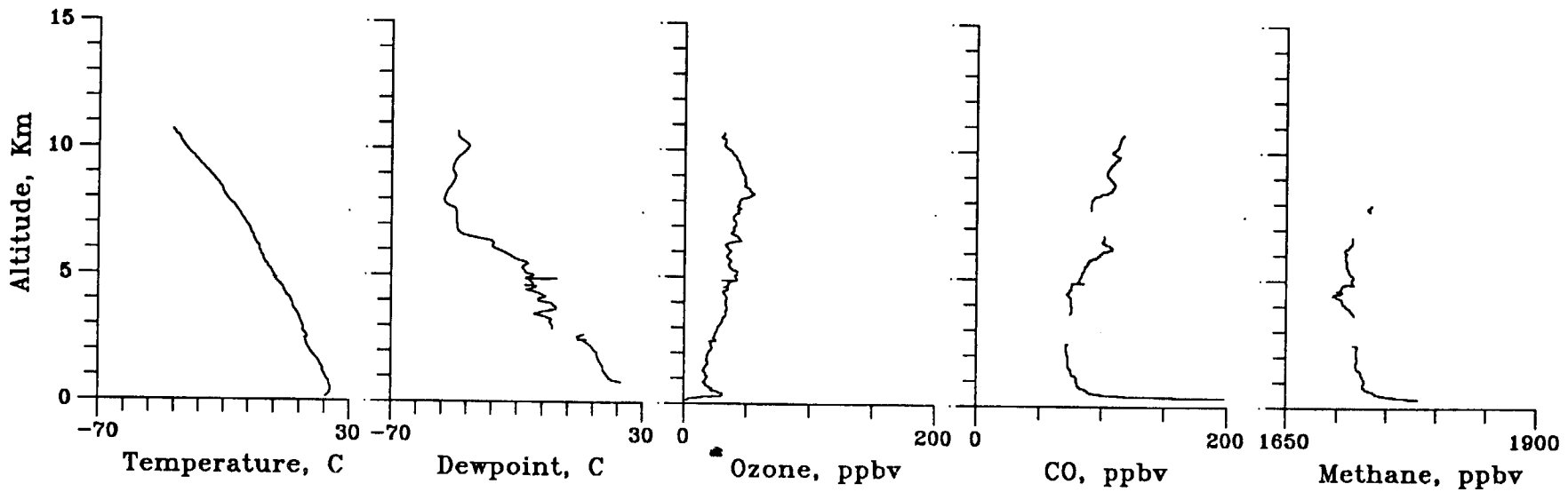

PEM (A) PACIFIC MISSION: FLIGHT 9 PROFILE AT 0400 GMT
Altitude, Km
15
10
5
0
-70
30
Temperature, C
Dewpoint, C
0
200
Ozone, ppbv
CO, ppbv
1650
1900
Methane, ppbv

Figure A9.6


PEM (A) PACIFIC MISSION: FLIGHT 9 PROFILE AT 0730 GMT
Altitude, Km
15
10
5
0
-70
30
Temperature, C
Dewpoint, C
0
200
Ozone, ppbv
CO, ppbv
1650
1900
Methane, ppbv

PEM (A) PACIFIC MISSION: FLIGHT 10

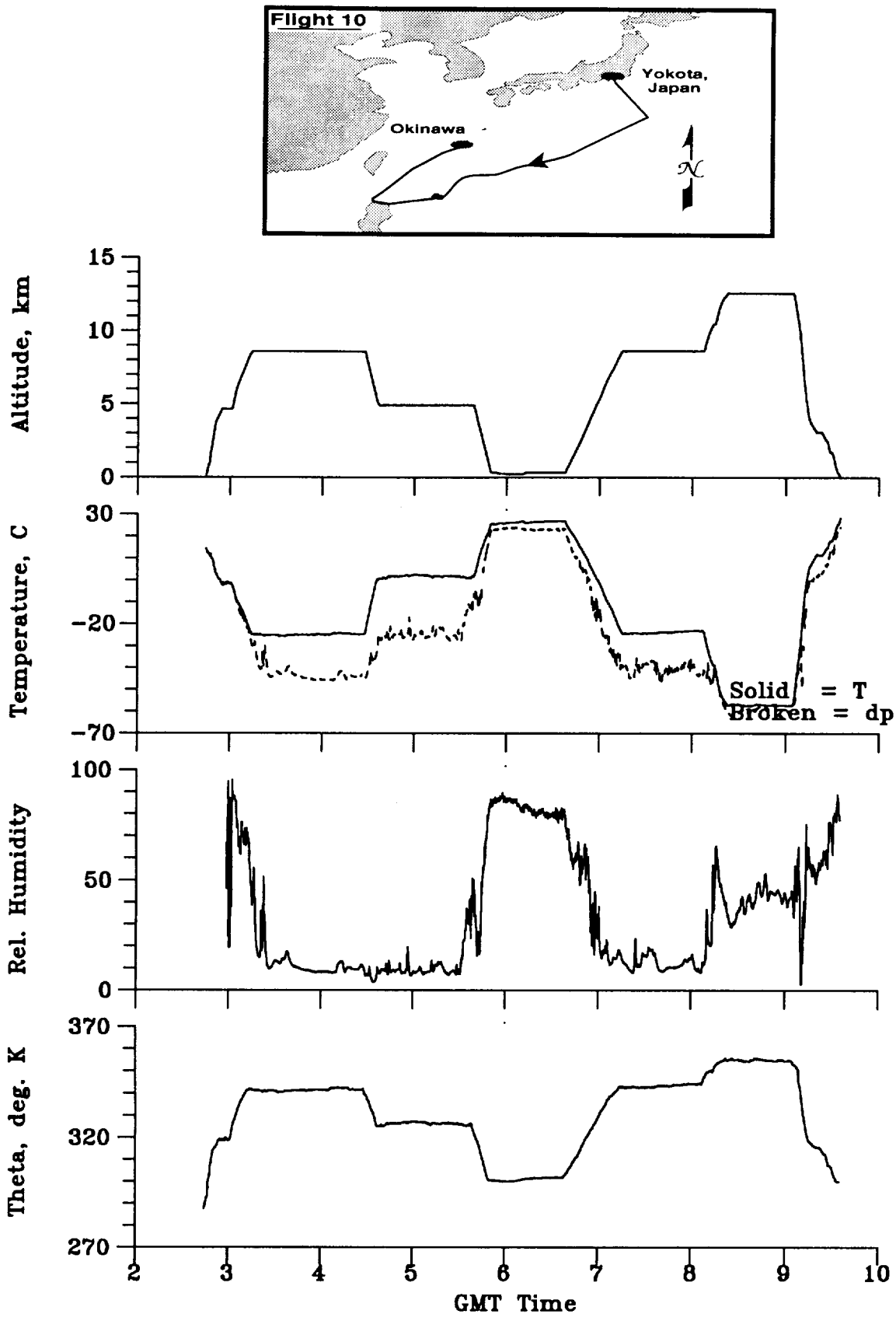


Figure A10.1

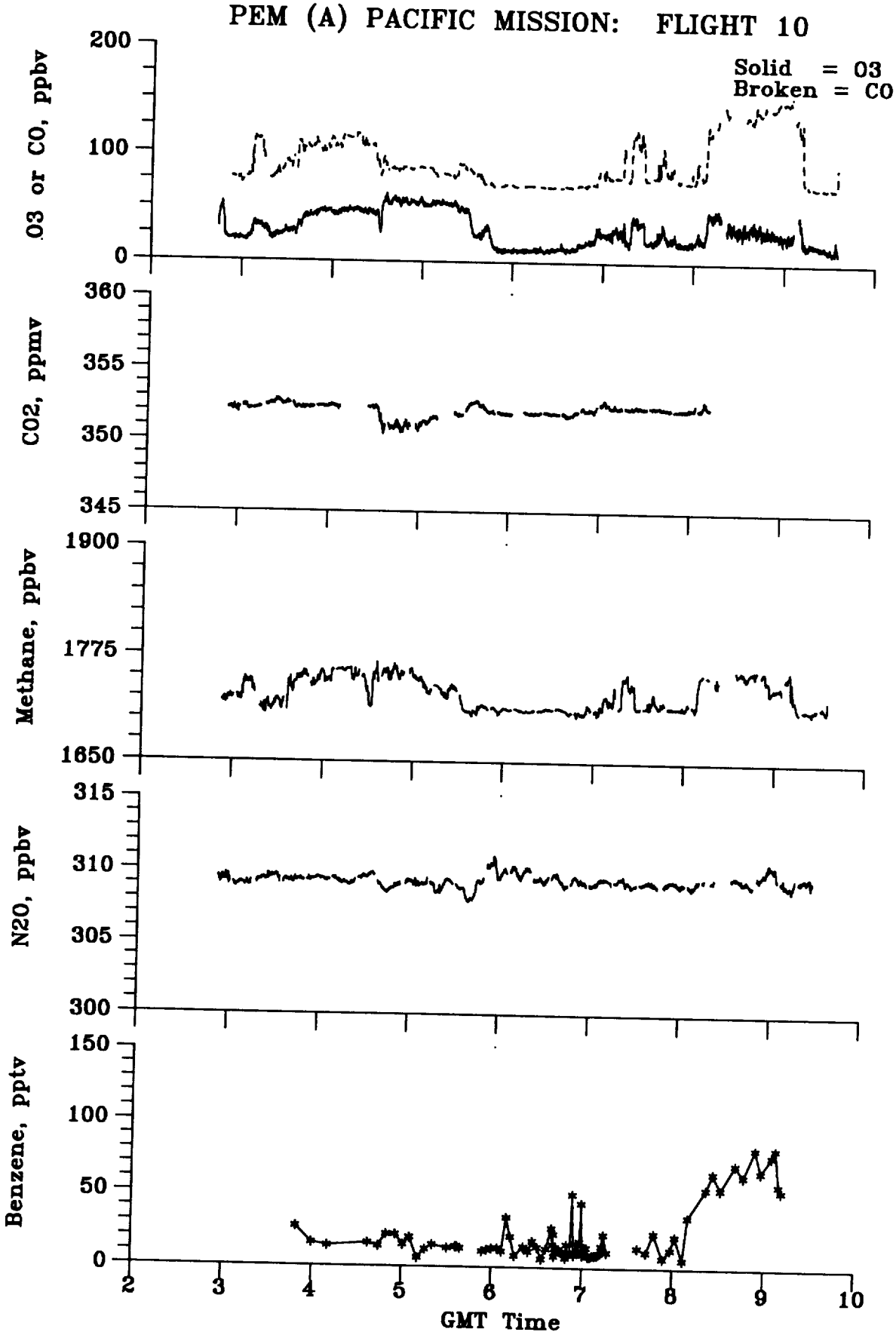

PEM (A) PACIFIC MISSION: FLIGHT 10
Solid = 03
Broken = CO
03 or CO, ppbv
200
100
0
CO2, ppmv
360
355
350
345
Methane, ppbv
1900
1775
1650
N2O, ppbv
315
310
305
300
Benzene, pptv
150
100
50
0
2
3
4
5
6
7
8
9
10
GMT Time

Figure A10.2

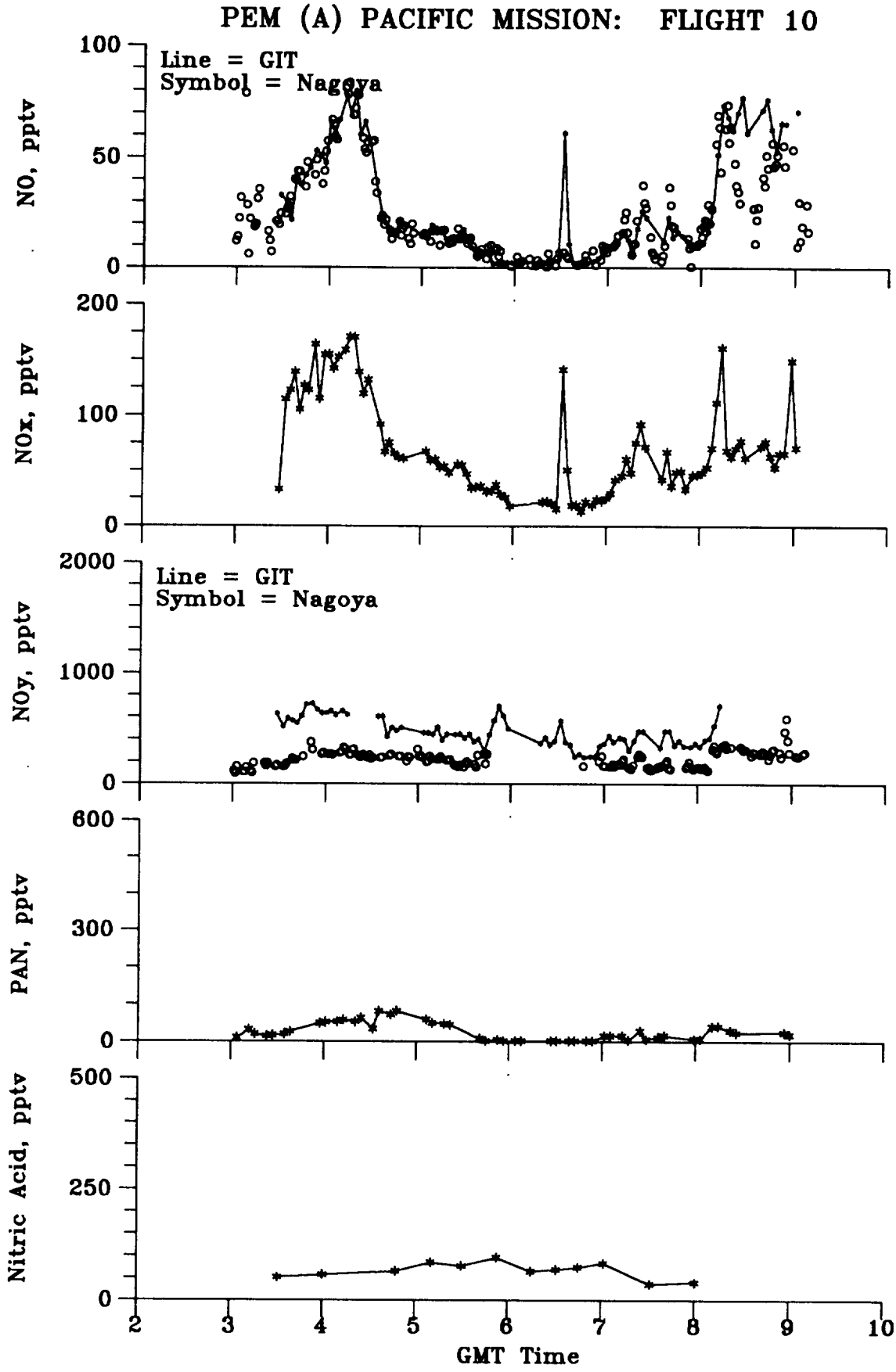

PEM (A) PACIFIC MISSION: FLIGHT 10
Line = GIT
Symbol = Nagoya
NO, pptv
100
50
0
NOx, pptv
200
100
0
Line = GIT
Symbol = Nagoya
NOy, pptv
2000
1000
0
PAN, pptv
600
300
0
Nitric Acid, pptv
500
250
0
2
3
4
5
6
7
8
9
10
GMT Time

Figure A10.3

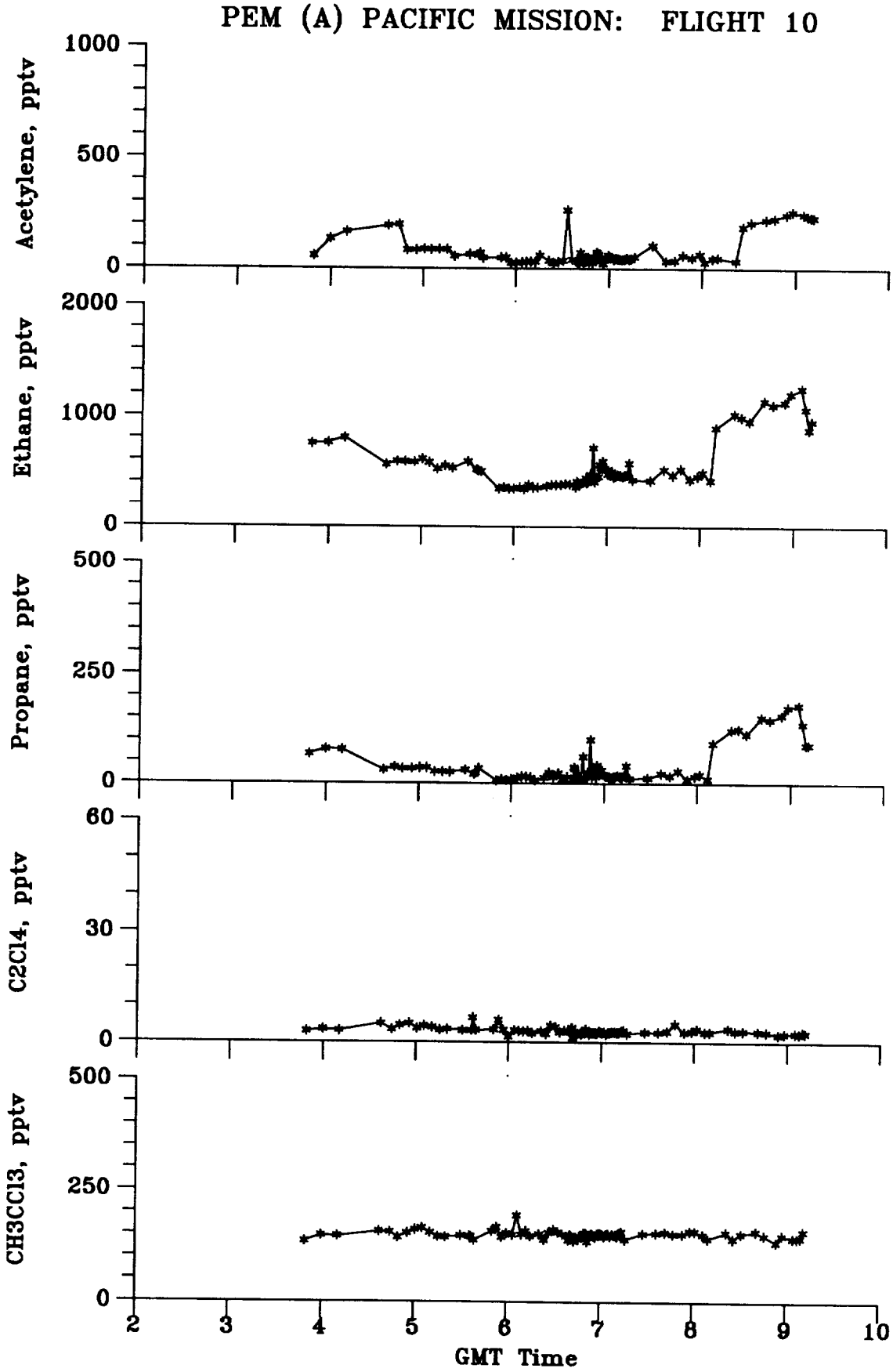

PEM (A) PACIFIC MISSION: FLIGHT 10
Acetylene, pptv
1000
500
0
Ethane, pptv
2000
1000
0
Propane, pptv
500
250
0
C2Cl4, pptv
60
30
0
CH3CCl3, pptv
500
250
0
2
3
4
5
6
7
8
9
10
GMT Time

Figure A10.4

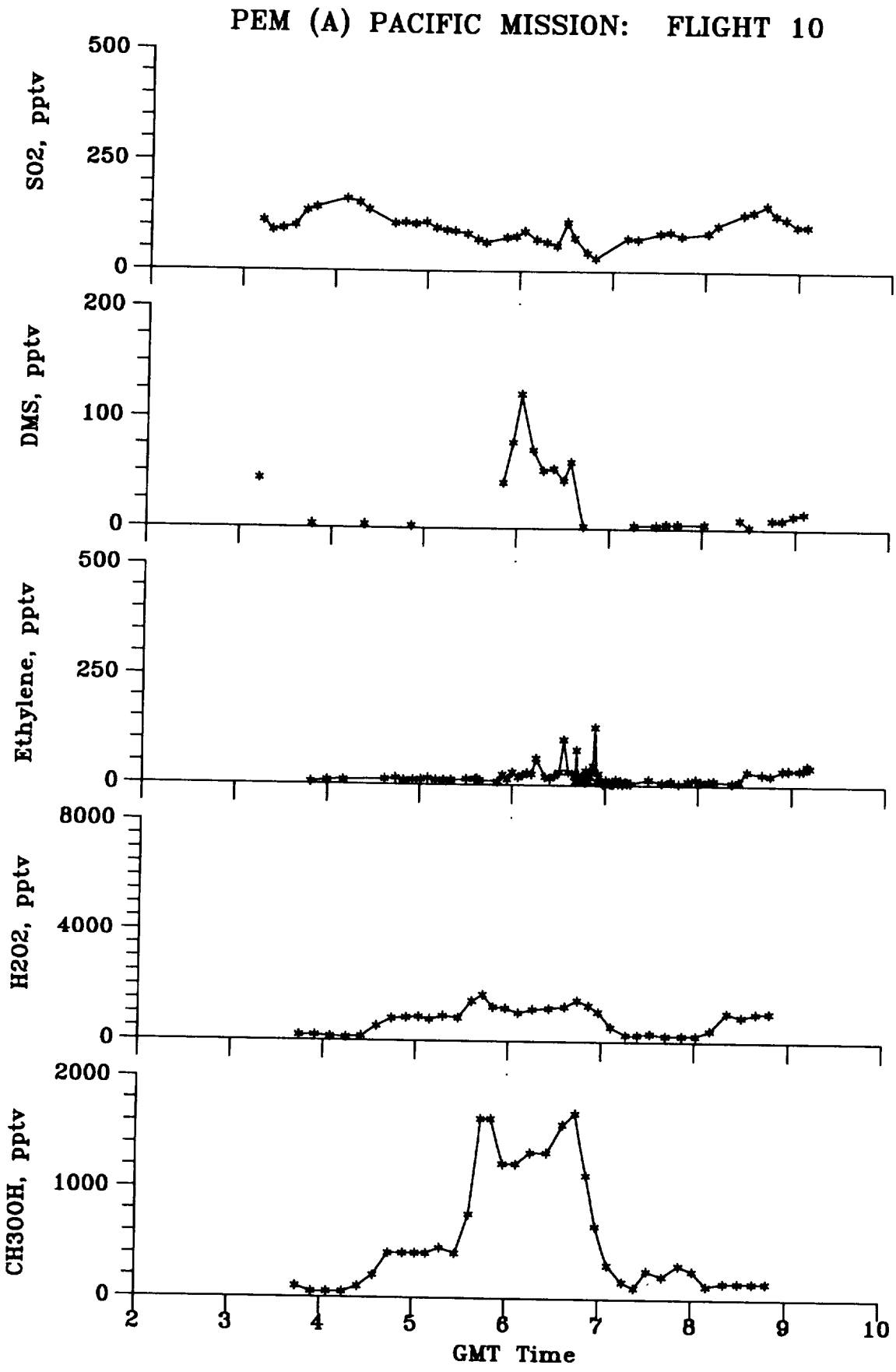
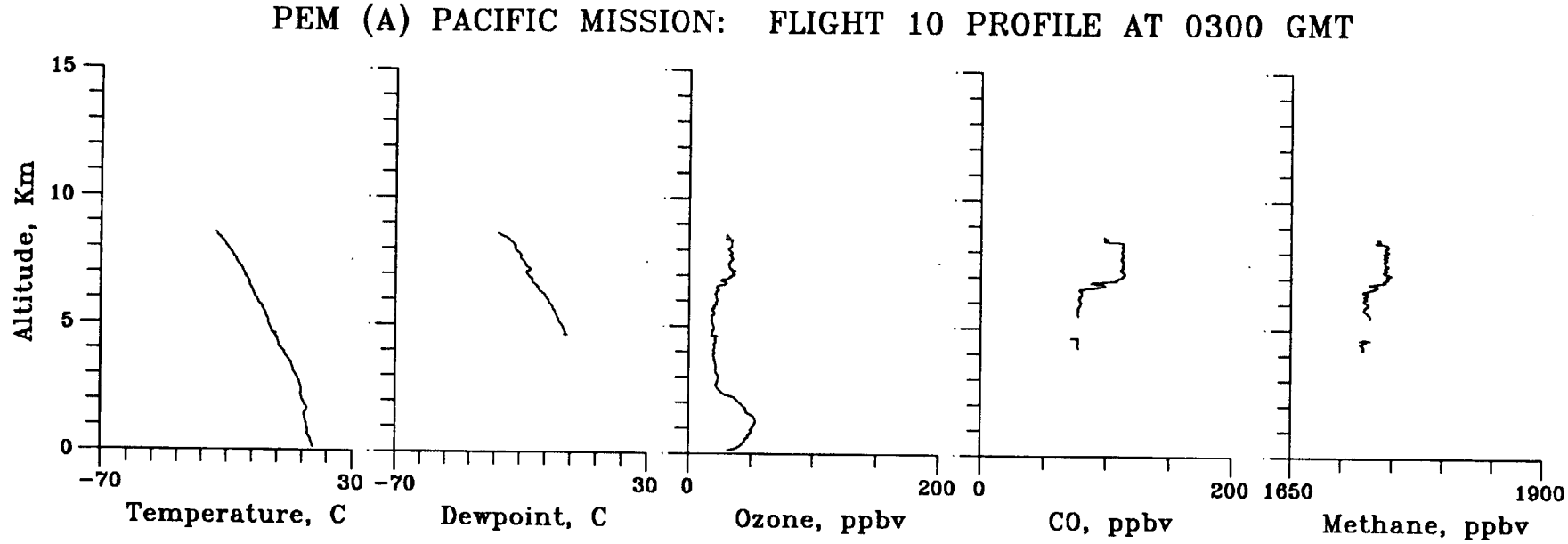
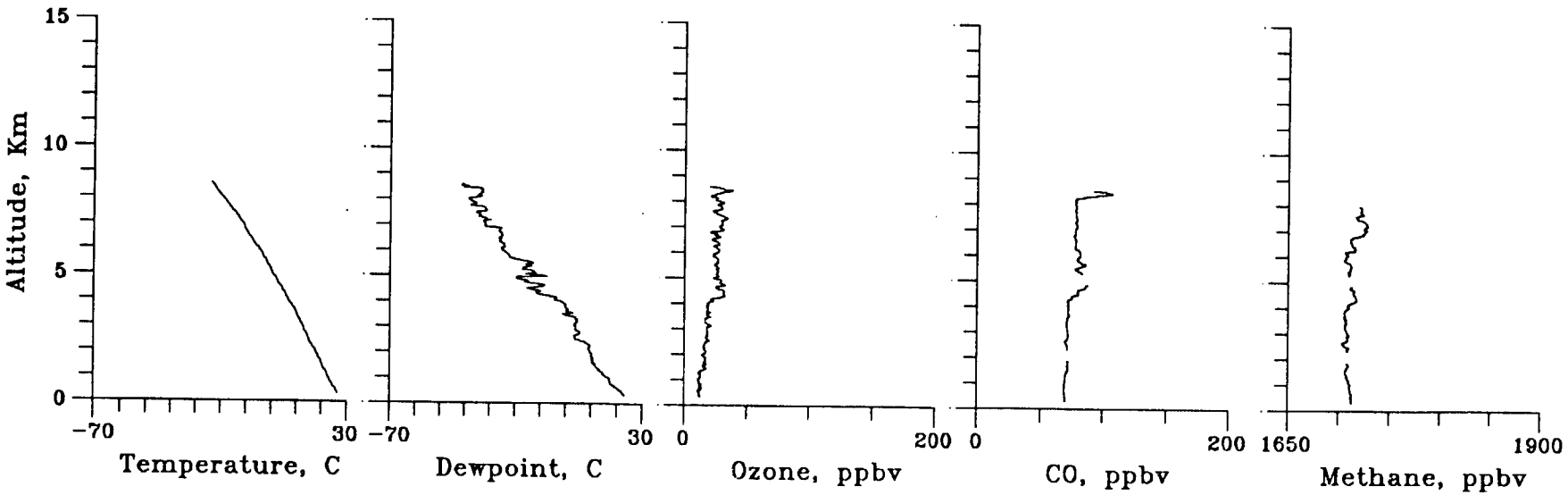

PEM (A) PACIFIC MISSION: FLIGHT 10
SO2, pptv
500
250
0
DMS, pptv
200
100
0
Ethylene, pptv
500
250
0
H2O2, pptv
8000
4000
0
CH3OOH, pptv
2000
1000
0
2
3
4
5
6
7
8
9
10
GMT Time

Figure A10.5

Figure A10.6


PEM (A) PACIFIC MISSION: FLIGHT 10 PROFILE AT 0300 GMT
Altitude, Km
15
10
5
0
-70
30
Temperature, C
Dewpoint, C
0
200
Ozone, ppbv
CO, ppbv
1650
1900
Methane, ppbv


PEM (A) PACIFIC MISSION: FLIGHT 10 PROFILE AT 0700 GMT
Altitude, Km
15
10
5
0
-70
30
Temperature, C
Dewpoint, C
0
200
Ozone, ppbv
CO, ppbv
1650
1900
Methane, ppbv

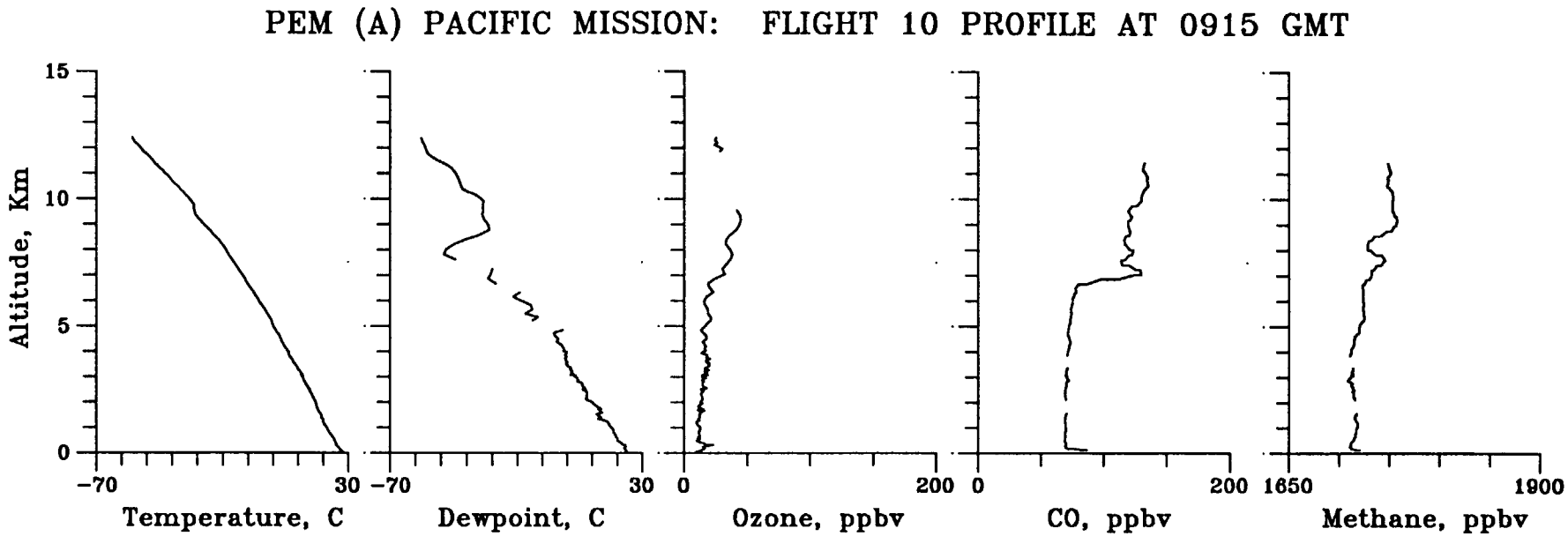

PEM (A) PACIFIC MISSION: FLIGHT 10 PROFILE AT 0915 GMT
Altitude, Km
15
10
5
0
−70
30
Temperature, C
Dewpoint, C
0
200
Ozone, ppbv
CO, ppbv
1650
1900
Methane, ppbv

Figure A10.7

PEM (A) PACIFIC MISSION: FLIGHT 11

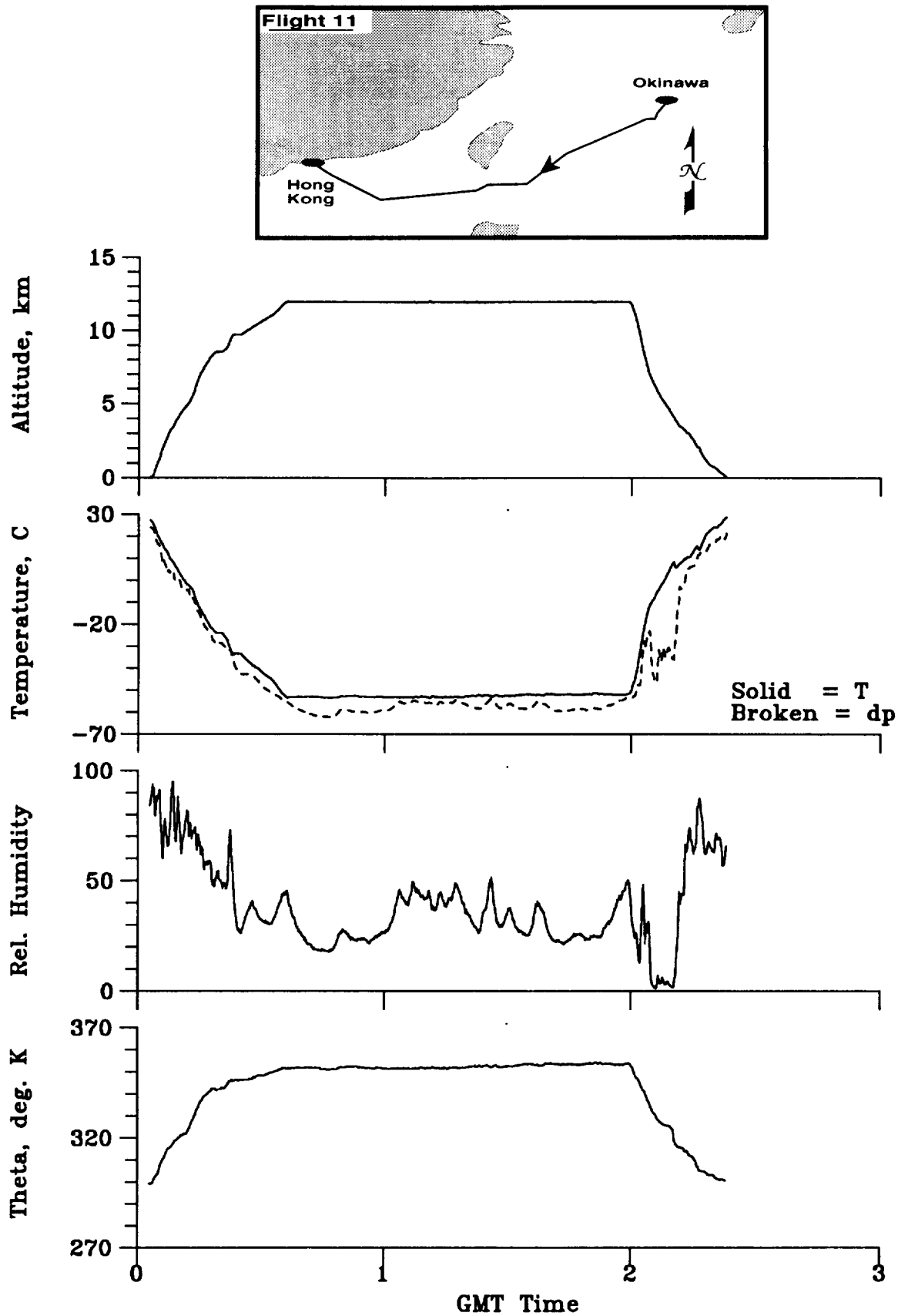


Figure A11.1

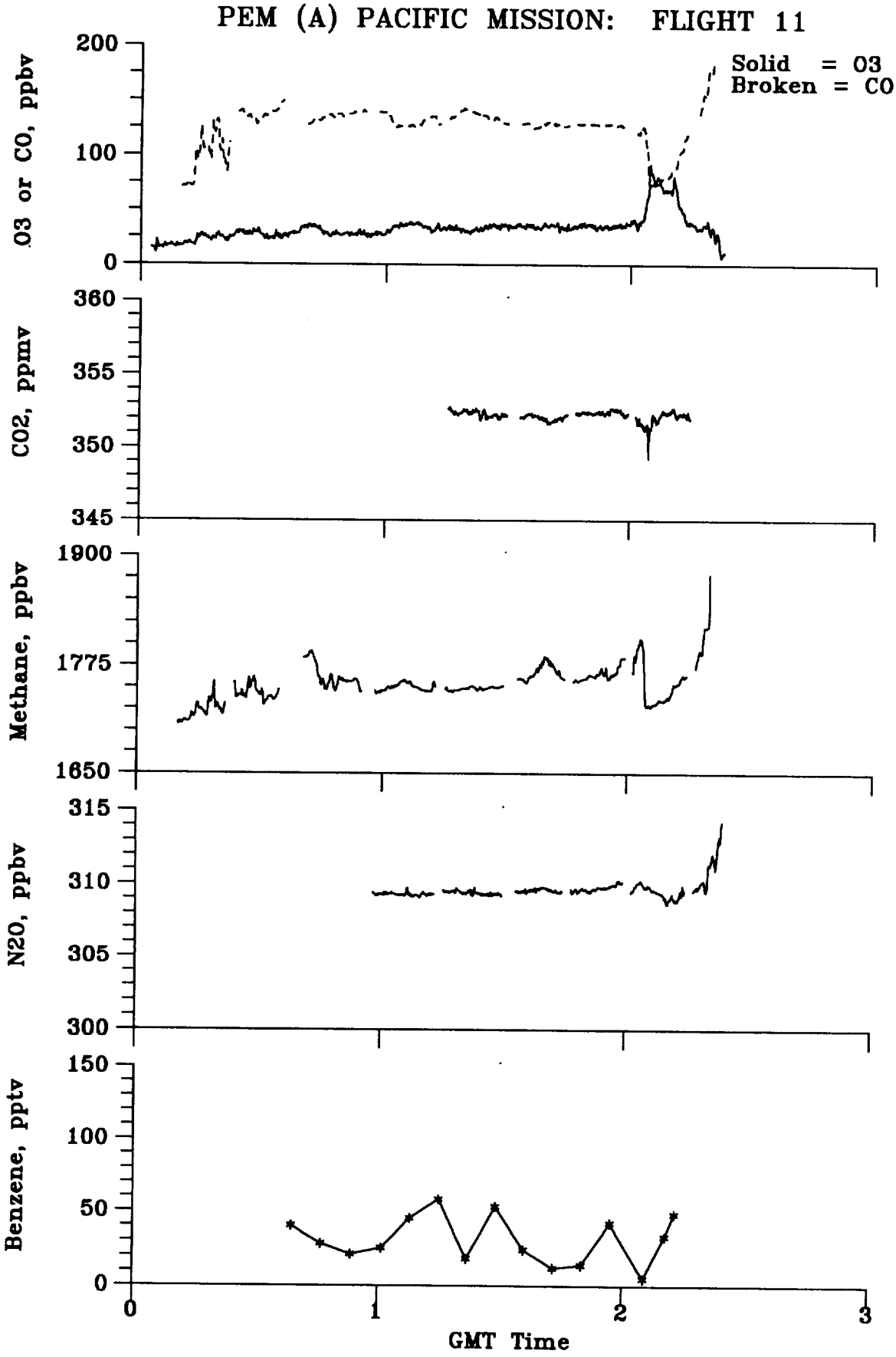

PEM (A) PACIFIC MISSION: FLIGHT 11
Solid = O3
Broken = CO
O3 or CO, ppbv
200
100
0
CO2, ppmv
360
355
350
345
Methane, ppbv
1900
1775
1650
N2O, ppbv
315
310
305
300
Benzene, pptv
150
100
50
0
0
1
2
3
GMT Time

Figure A11.2

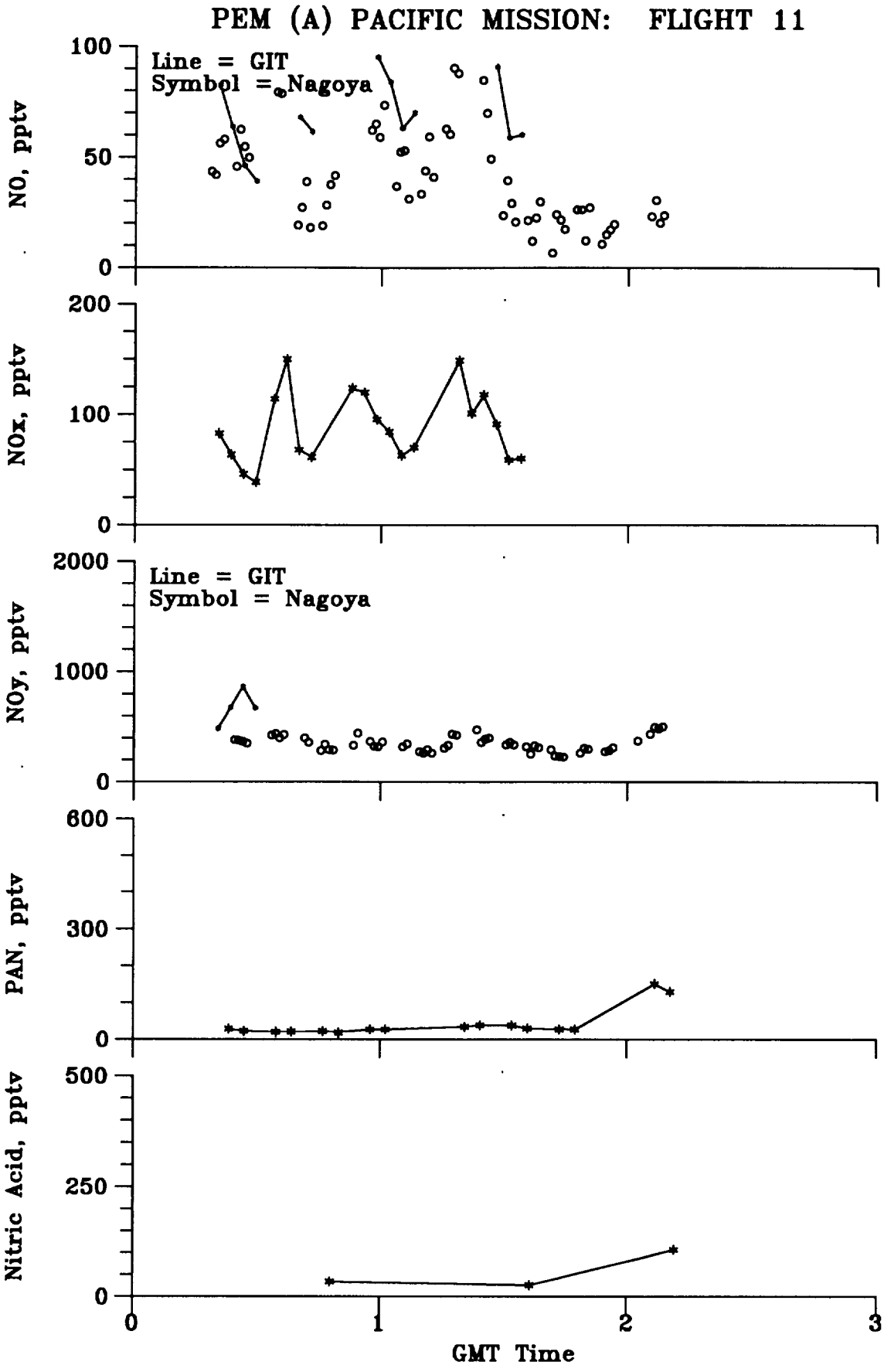

PEM (A) PACIFIC MISSION: FLIGHT 11
Line = GIT
Symbol = Nagoya
NO, pptv
100
50
0
NOx, pptv
200
100
0
Line = GIT
Symbol = Nagoya
NOy, pptv
2000
1000
0
PAN, pptv
600
300
0
Nitric Acid, pptv
500
250
0
0
1
2
3
GMT Time

Figure A11.3

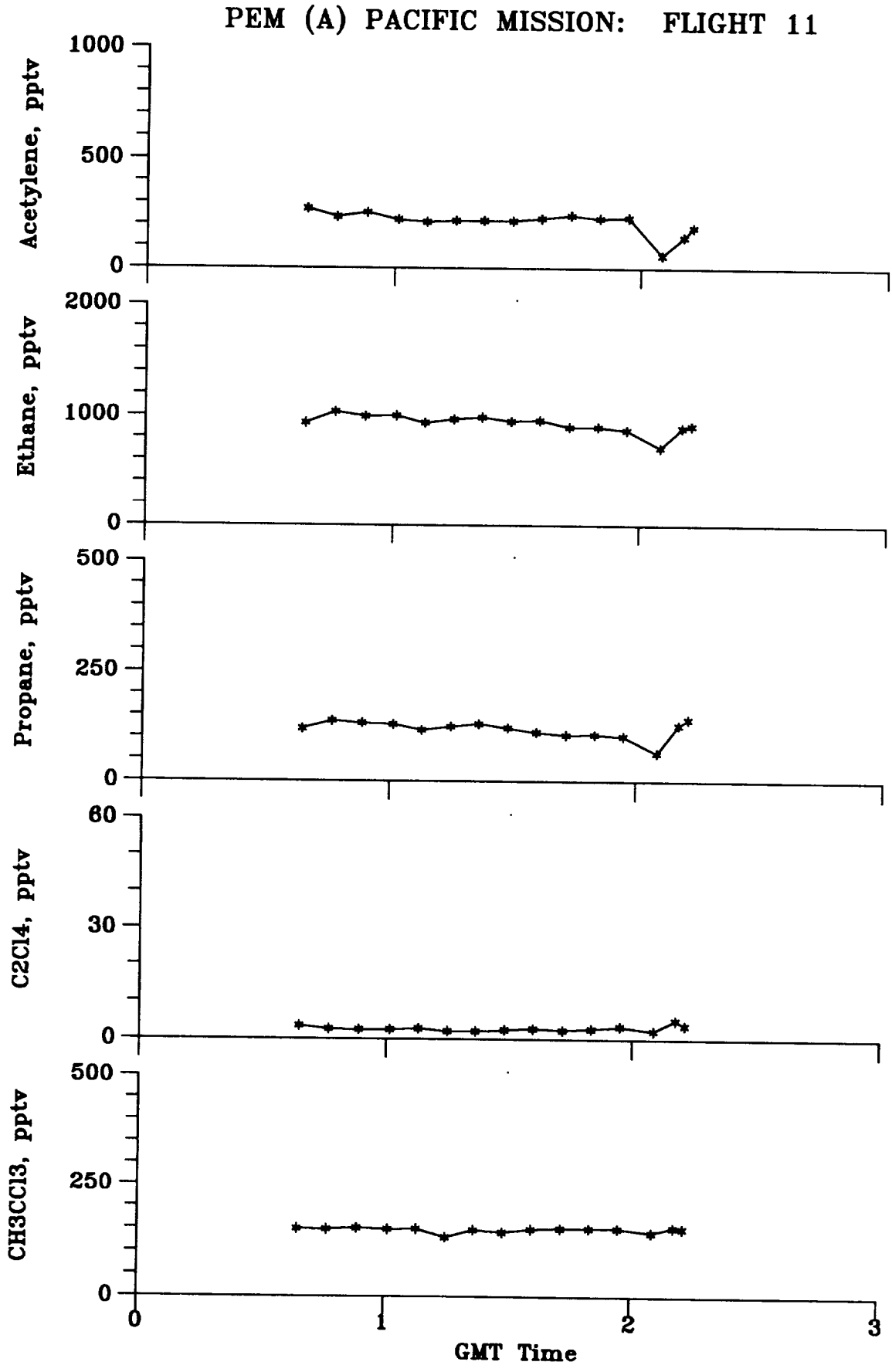

PEM (A) PACIFIC MISSION: FLIGHT 11
Acetylene, pptv
1000
500
0
Ethane, pptv
2000
1000
0
Propane, pptv
500
250
0
C2Cl4, pptv
60
30
0
CH3CCl3, pptv
500
250
0
0
1
2
3
GMT Time

Figure A11.4

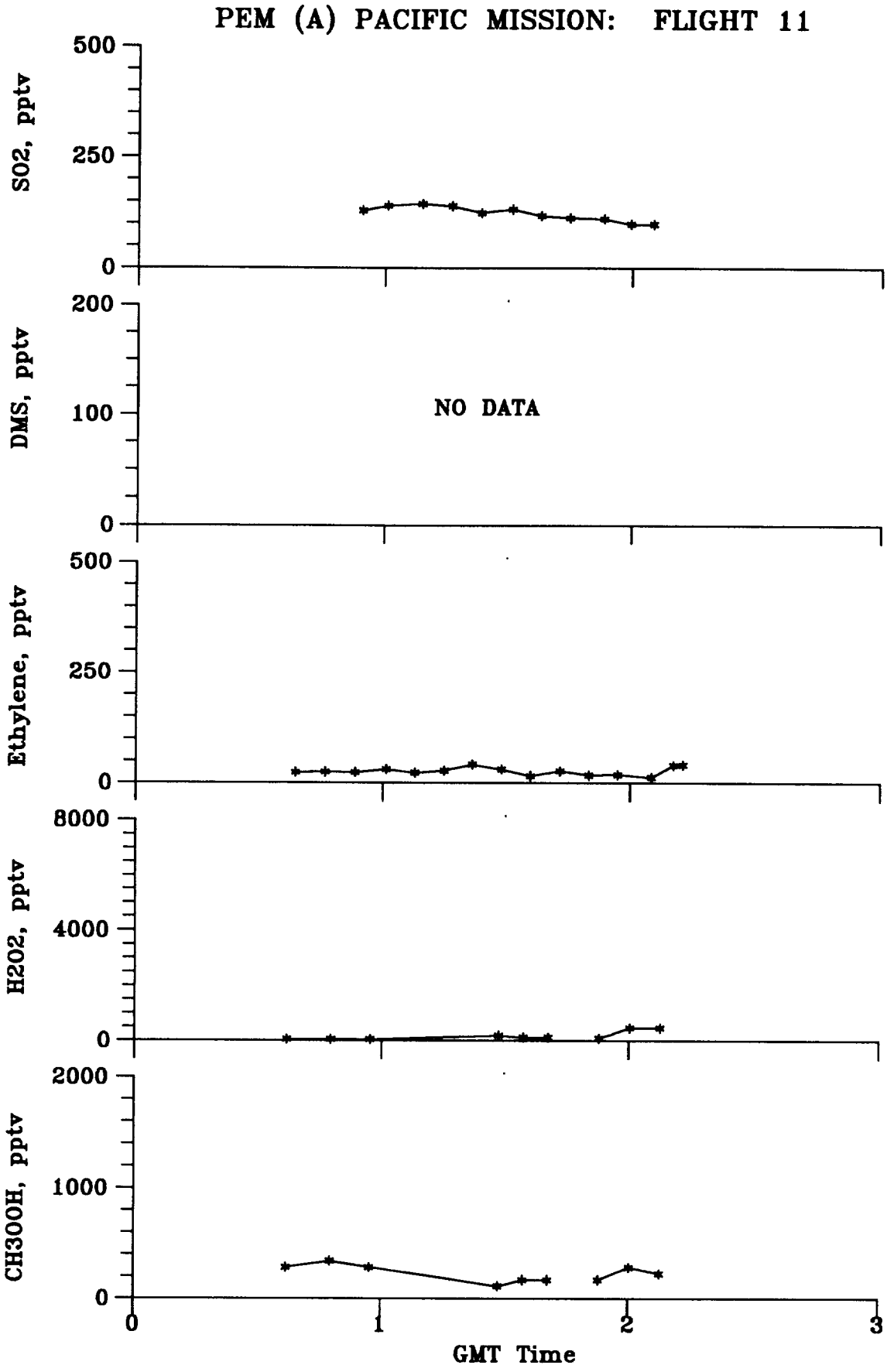

PEM (A) PACIFIC MISSION: FLIGHT 11
SO2, pptv
500
250
0
DMS, pptv
200
100
0
NO DATA
Ethylene, pptv
500
250
0
H2O2, pptv
8000
4000
0
CH3OOH, pptv
2000
1000
0
0
1
2
3
GMT Time

Figure A11.5

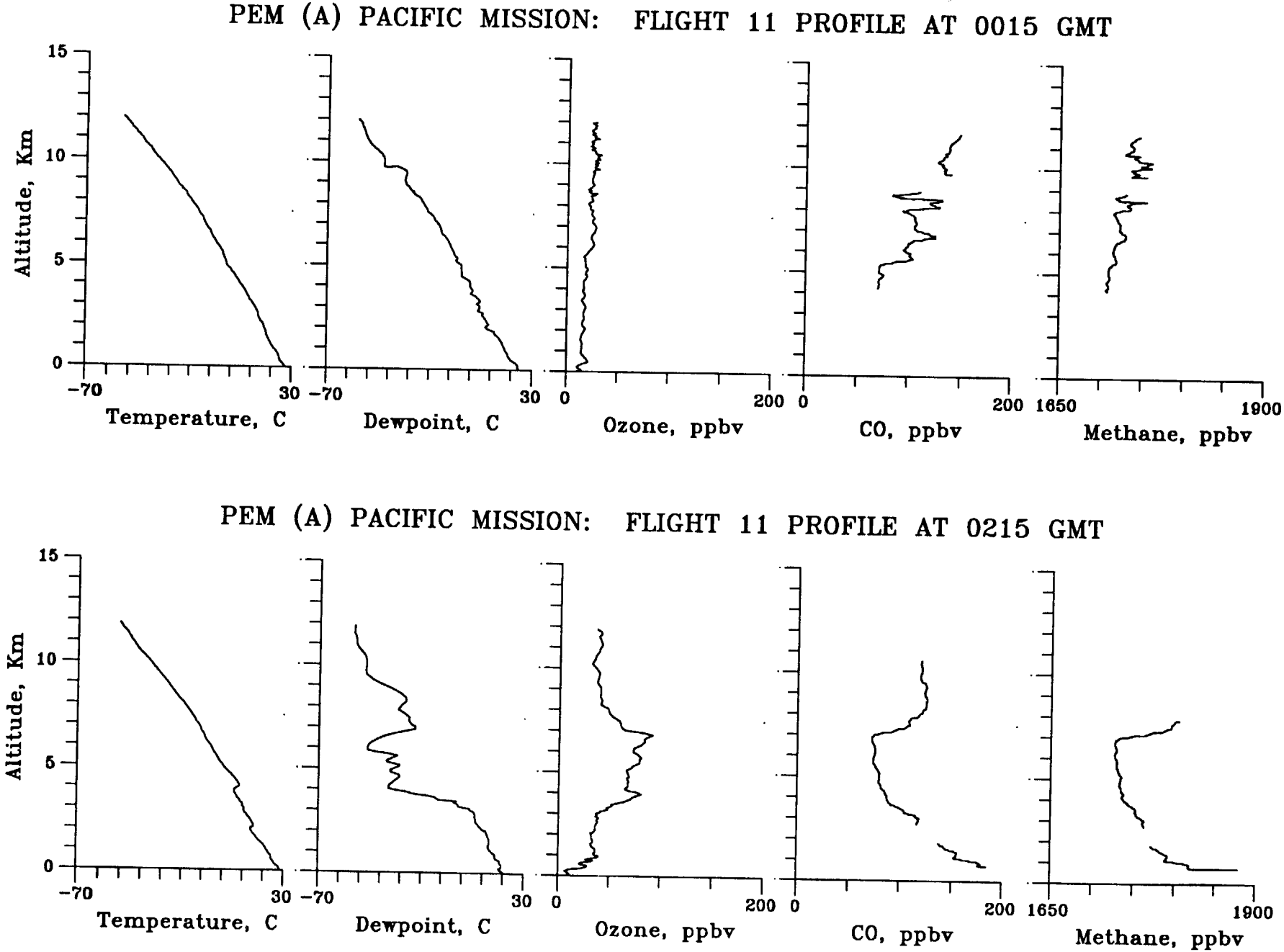

PEM (A) PACIFIC MISSION: FLIGHT 11 PROFILE AT 0015 GMT
Altitude, Km
15
10
5
0
-70
30
Temperature, C
Dewpoint, C
0
200
Ozone, ppbv
CO, ppbv
1650
1900
Methane, ppbv
PEM (A) PACIFIC MISSION: FLIGHT 11 PROFILE AT 0215 GMT
Altitude, Km
Temperature, C
Dewpoint, C
Ozone, ppbv
CO, ppbv
Methane, ppbv

Figure A11.6

PEM (A) PACIFIC MISSION: FLIGHT 12

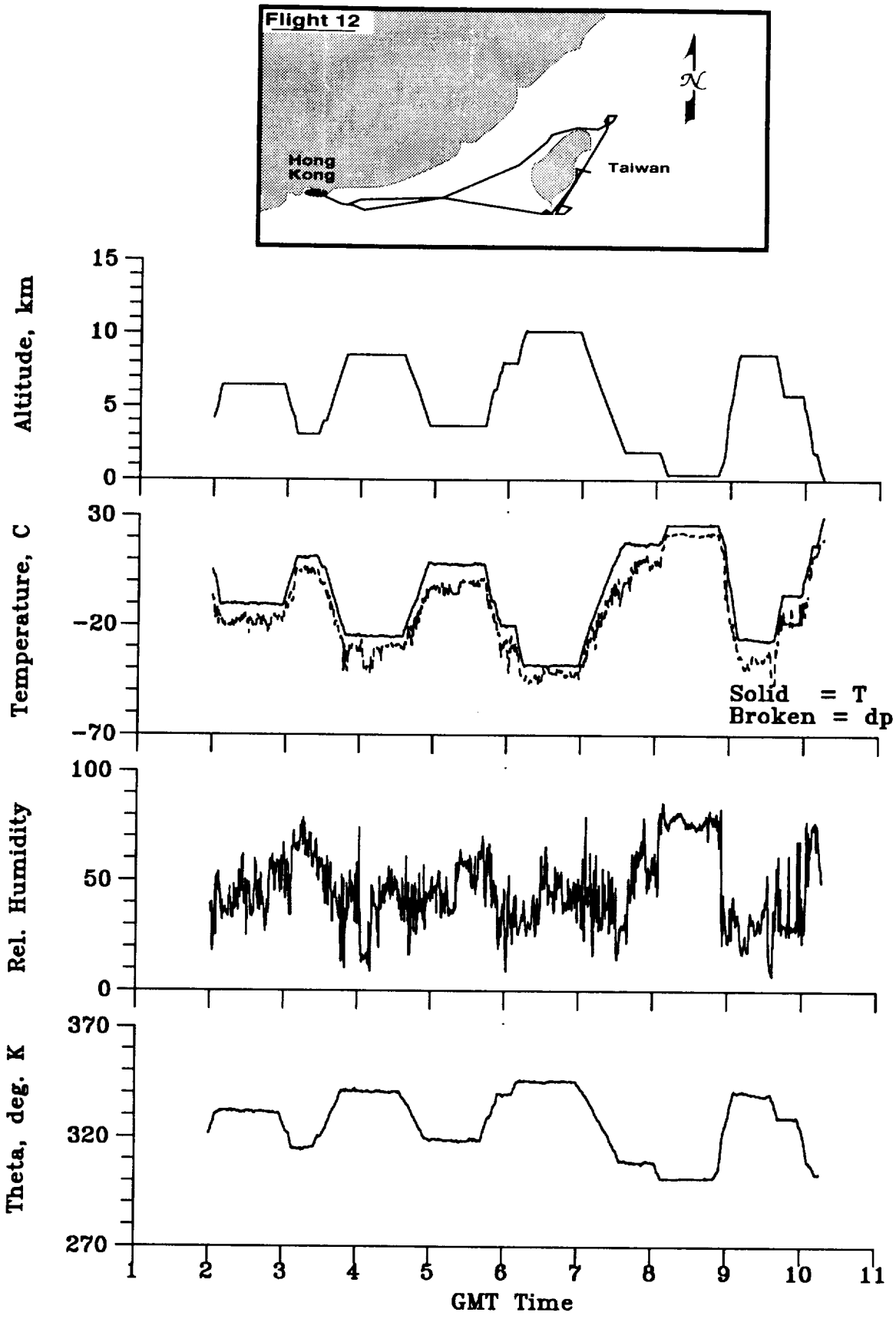


Figure A12.1

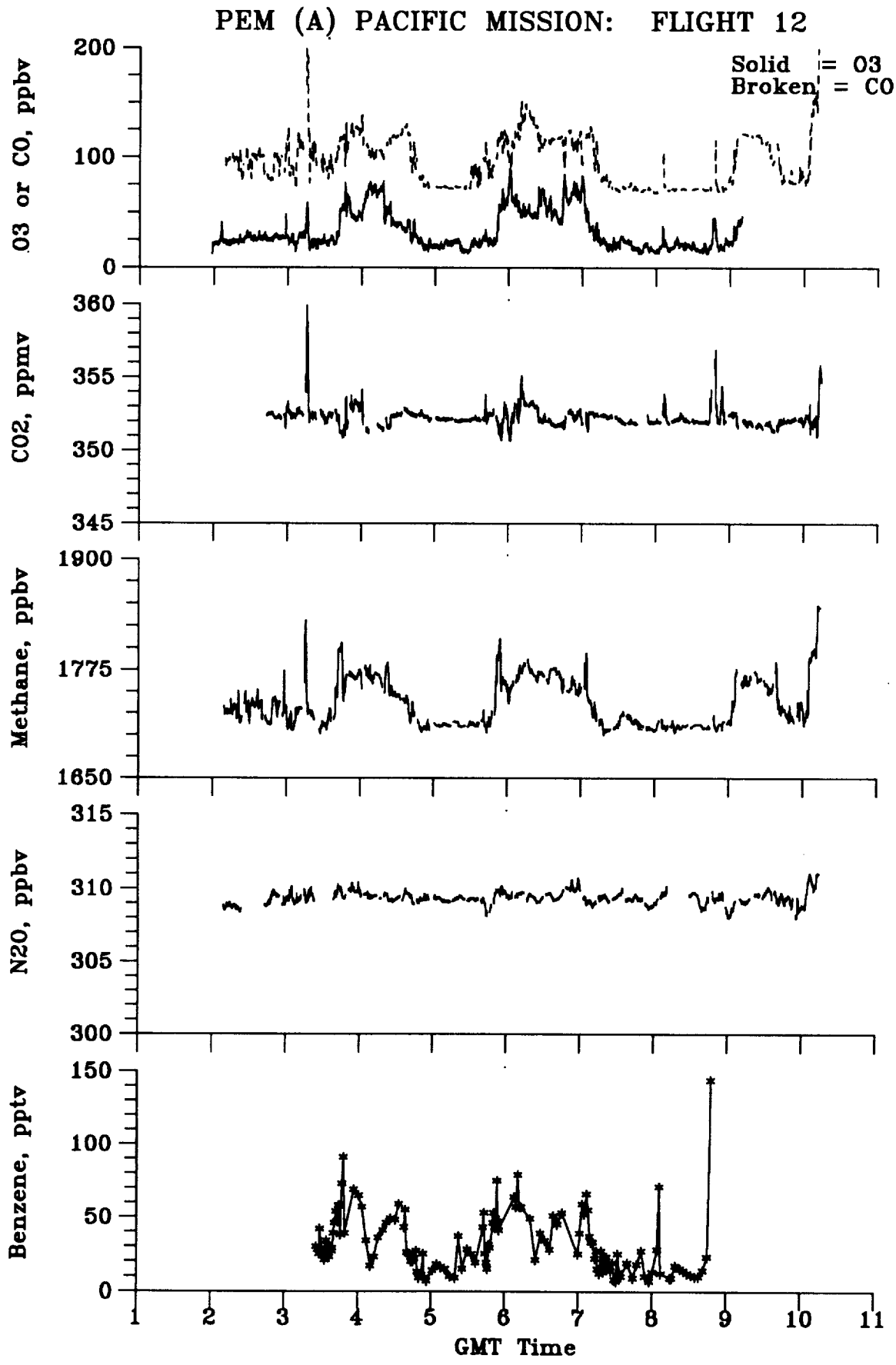

PEM (A) PACIFIC MISSION: FLIGHT 12
Solid = O3
Broken = CO
O3 or CO, ppbv
200
100
0
CO2, ppmv
360
355
350
345
Methane, ppbv
1900
1775
1650
N2O, ppbv
315
310
305
300
Benzene, pptv
150
100
50
0
1
2
3
4
5
6
7
8
9
10
11
GMT Time

Figure A12.2

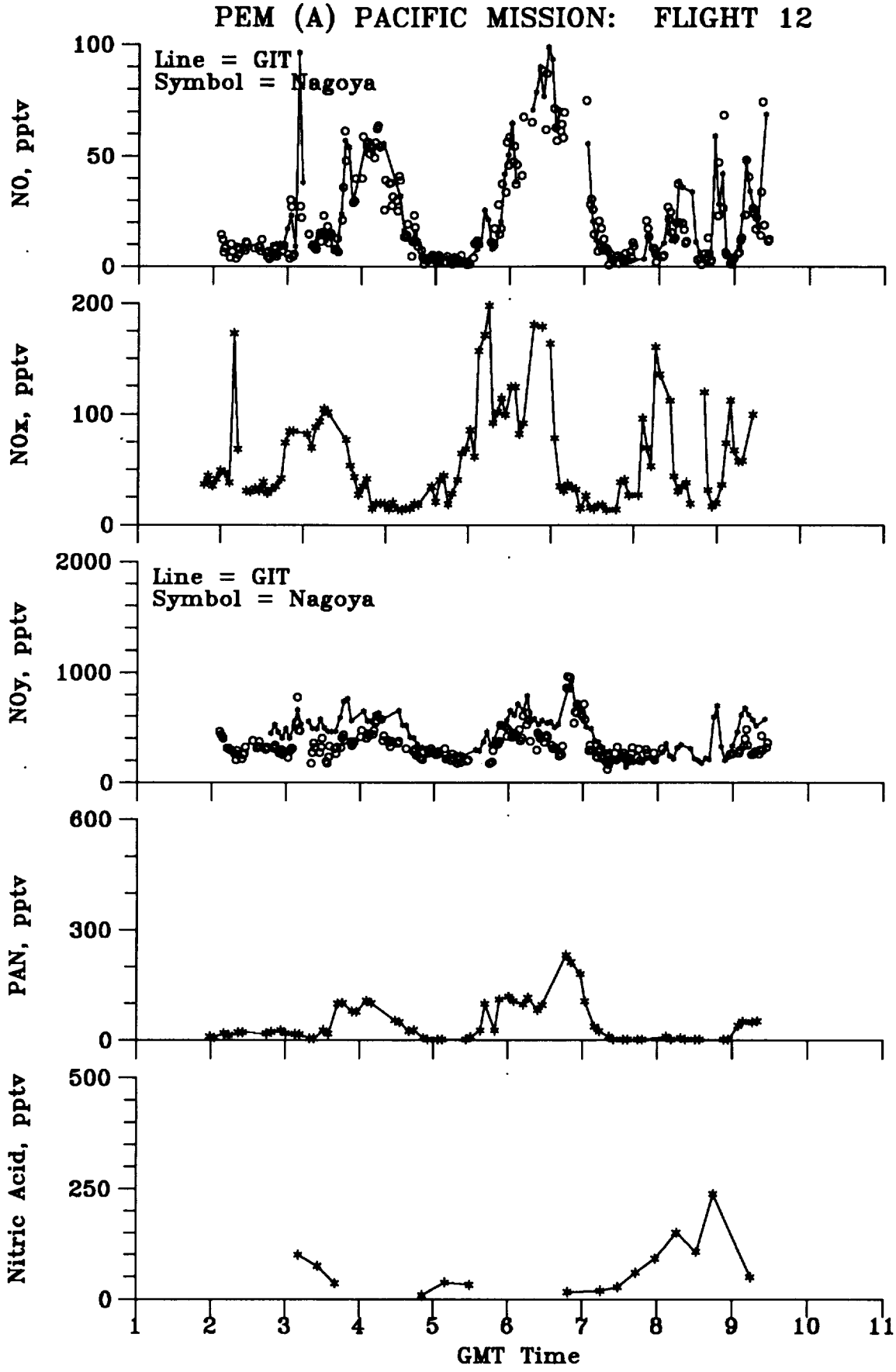

PEM (A) PACIFIC MISSION: FLIGHT 12
Line = GIT
Symbol = Nagoya
NO, pptv
100
50
0
NOx, pptv
200
100
0
Line = GIT
Symbol = Nagoya
NOy, pptv
2000
1000
0
PAN, pptv
600
300
0
Nitric Acid, pptv
500
250
0
1
2
3
4
5
6
7
8
9
10
11
GMT Time

Figure A12.3

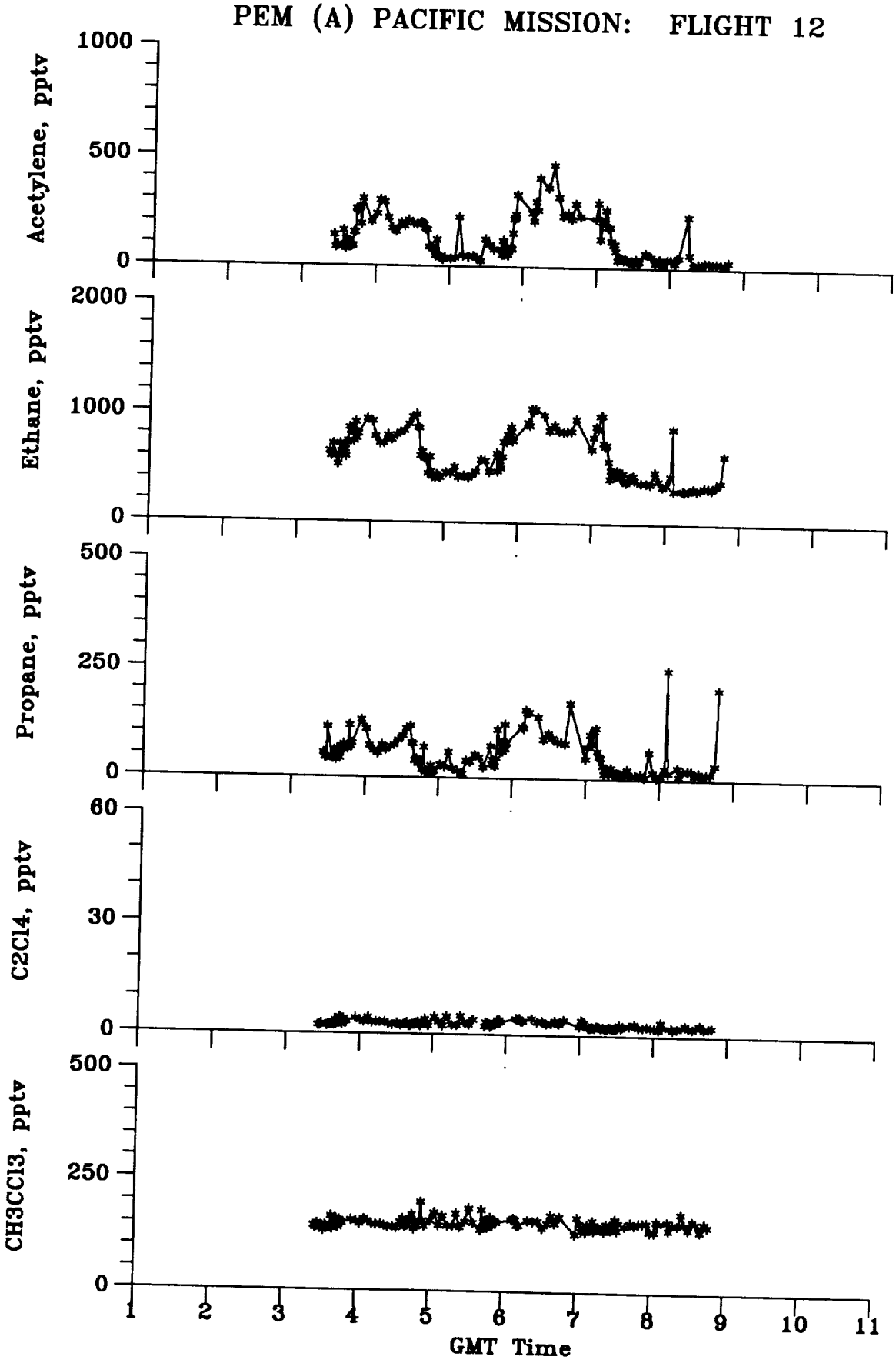

PEM (A) PACIFIC MISSION: FLIGHT 12
Acetylene, pptv
1000
500
0
Ethane, pptv
2000
1000
0
Propane, pptv
500
250
0
C2Cl4, pptv
60
30
0
CH3CCl3, pptv
500
250
0
1
2
3
4
5
6
7
8
9
10
11
GMT Time

Figure A12.4

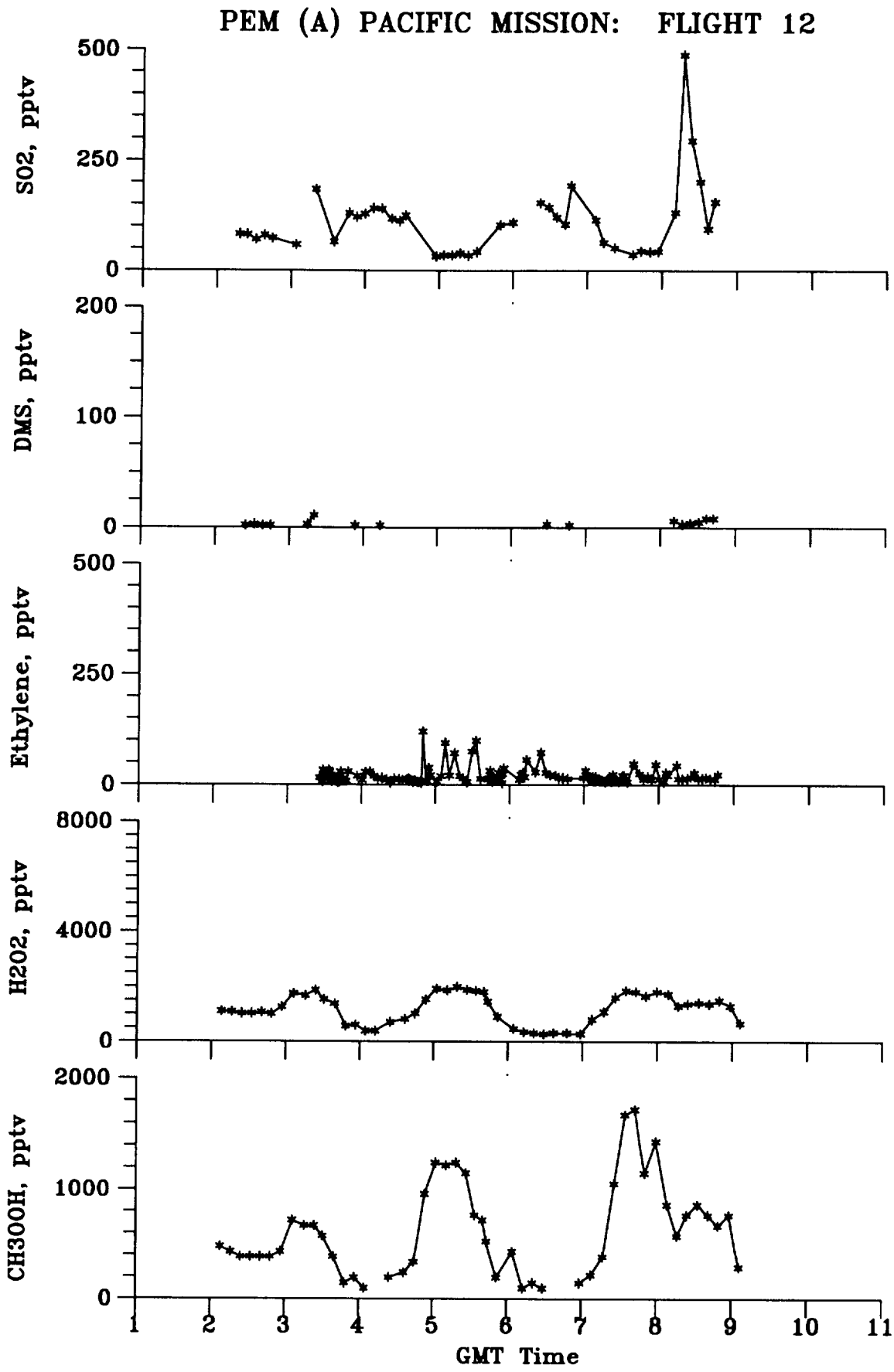

PEM (A) PACIFIC MISSION: FLIGHT 12
SO2, pptv
500
250
0
DMS, pptv
200
100
0
Ethylene, pptv
500
250
0
H2O2, pptv
8000
4000
0
CH3OOH, pptv
2000
1000
0
1
2
3
4
5
6
7
8
9
10
11
GMT Time

Figure A12.5

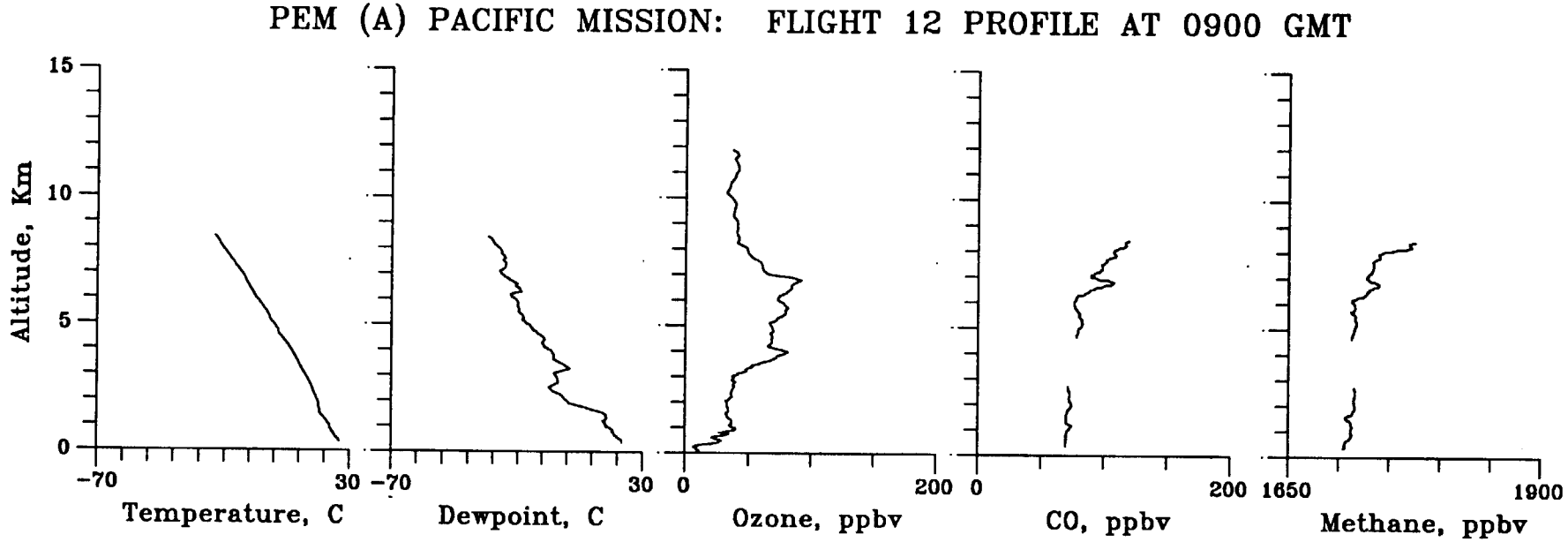

PEM (A) PACIFIC MISSION: FLIGHT 12 PROFILE AT 0900 GMT
Altitude, Km
15
10
5
0
-70
30
Temperature, C
-70
30
Dewpoint, C
0
200
Ozone, ppbv
0
200
CO, ppbv
1650
1900
Methane, ppbv

Figure A12.6

PEM (A) PACIFIC MISSION: FLIGHT 13

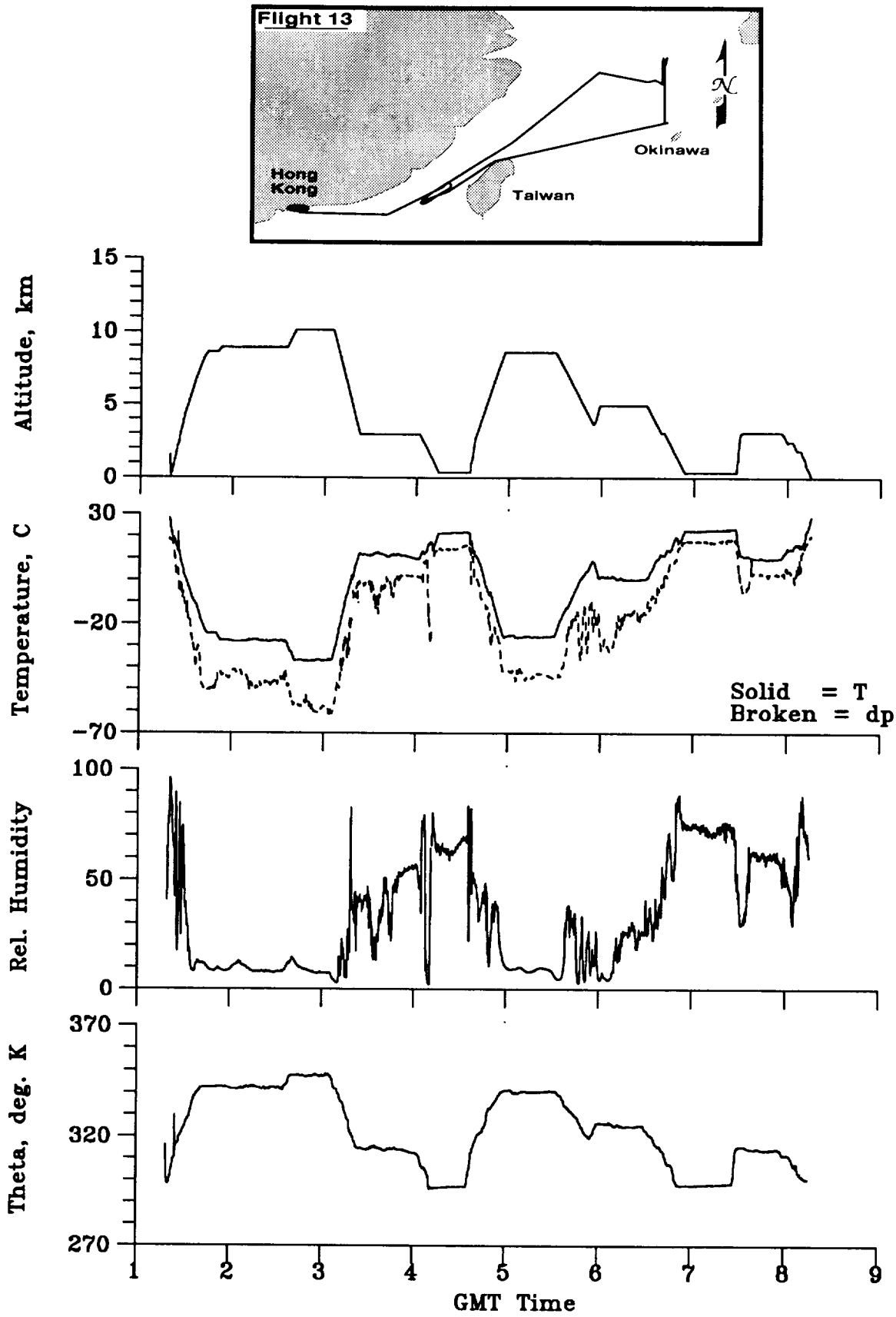


Figure A13.1

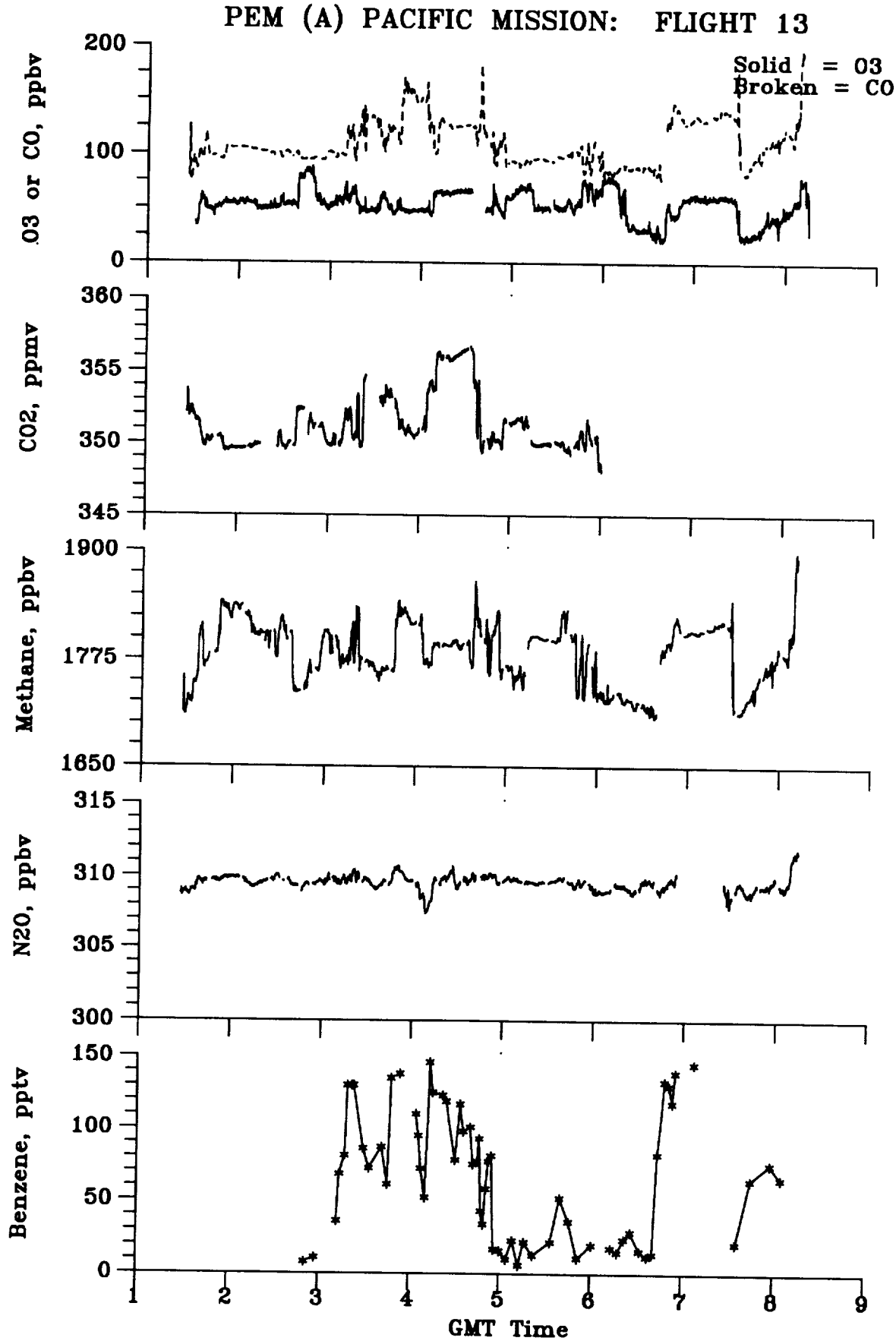

PEM (A) PACIFIC MISSION: FLIGHT 13
Solid = O3
Broken = CO
O3 or CO, ppbv
200
100
0
CO2, ppmv
360
355
350
345
Methane, ppbv
1900
1775
1650
N2O, ppbv
315
310
305
300
Benzene, pptv
150
100
50
0
1
2
3
4
5
6
7
8
9
GMT Time

Figure A13.2

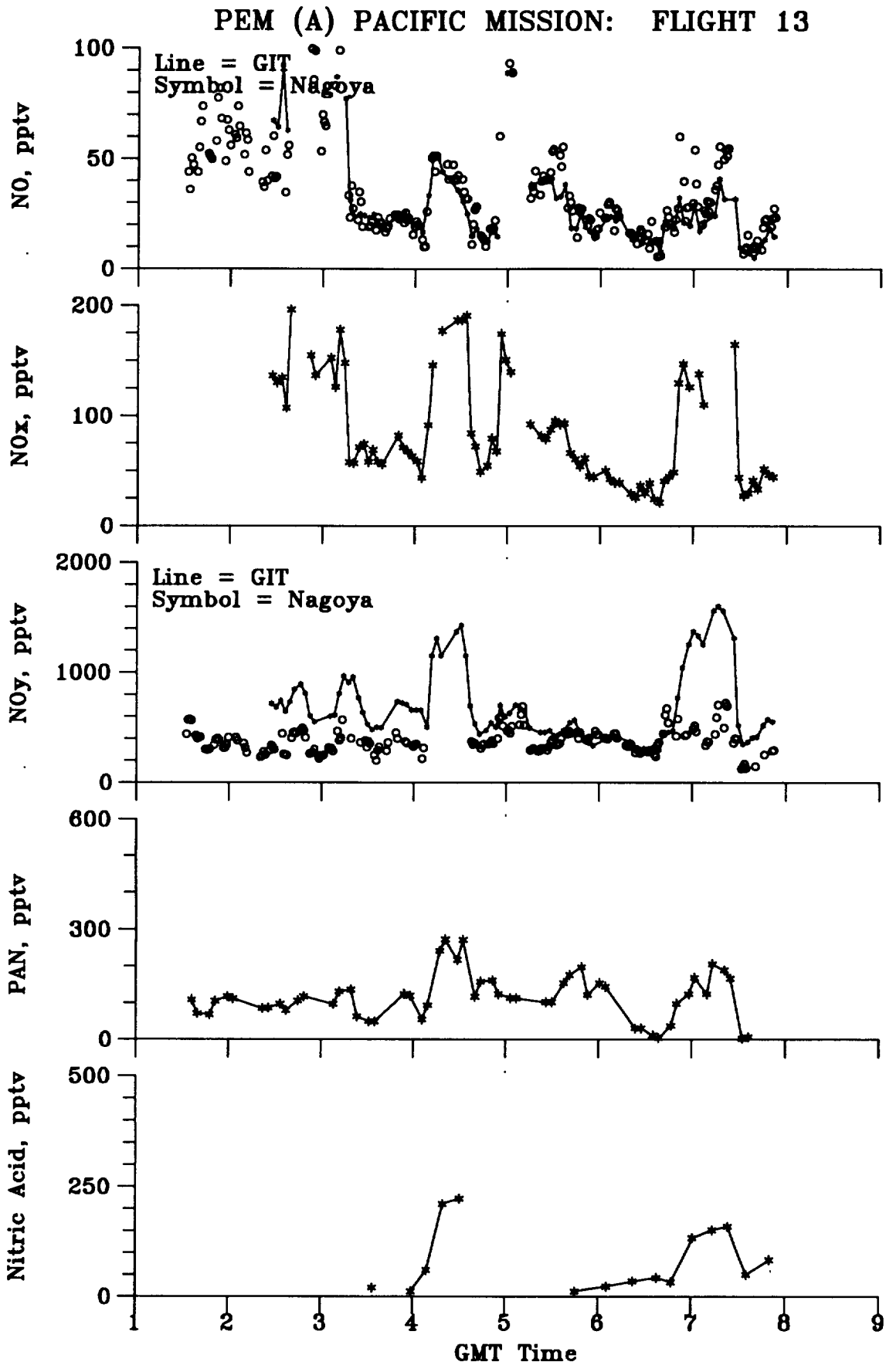

PEM (A) PACIFIC MISSION: FLIGHT 13
Line = GIT
Symbol = Nagoya
NO, pptv
100
50
0
NOx, pptv
200
100
0
Line = GIT
Symbol = Nagoya
NOy, pptv
2000
1000
0
PAN, pptv
600
300
0
Nitric Acid, pptv
500
250
0
1
2
3
4
5
6
7
8
9
GMT Time

Figure A13.3

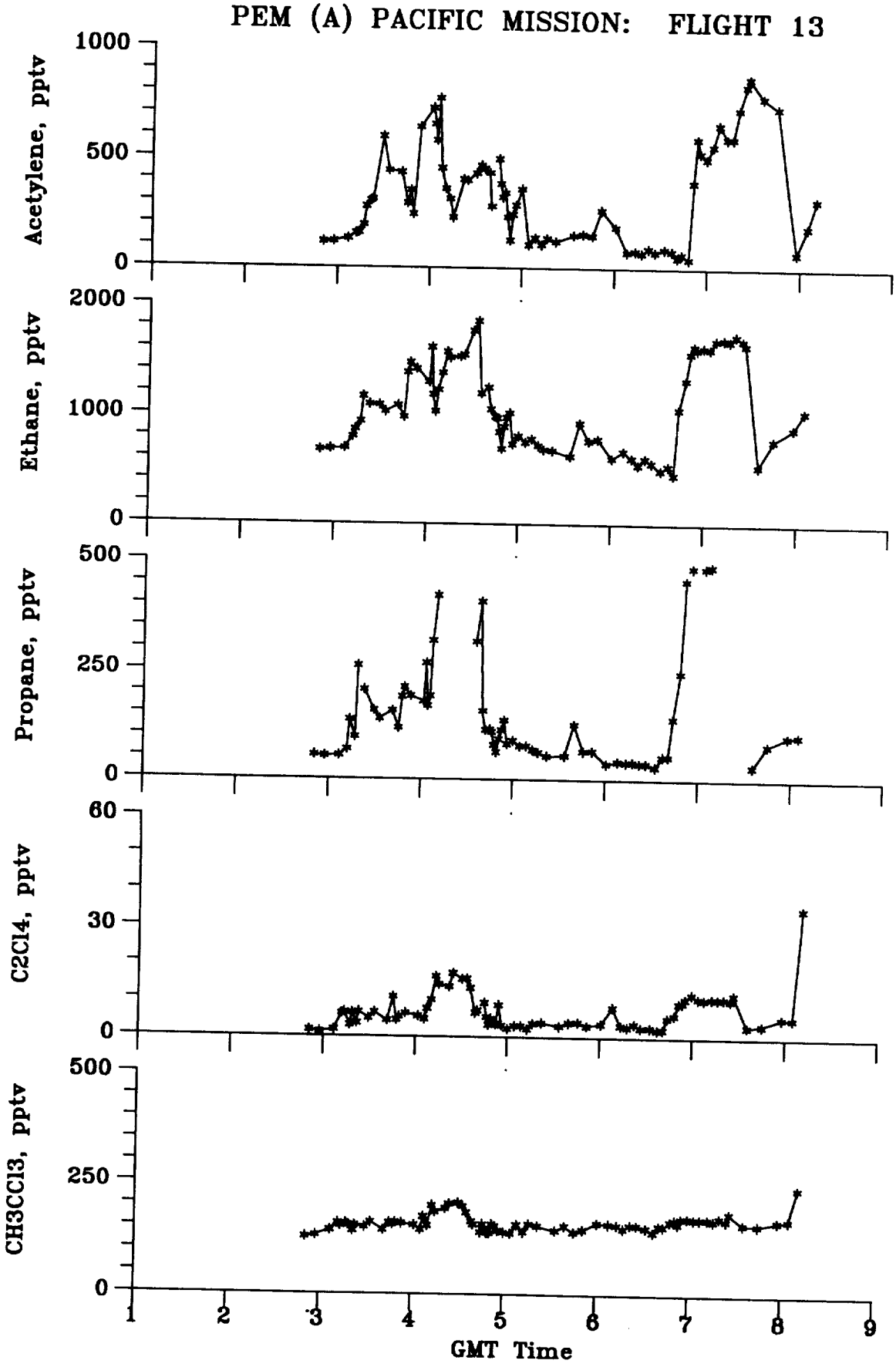

PEM (A) PACIFIC MISSION: FLIGHT 13
Acetylene, pptv
1000
500
0
Ethane, pptv
2000
1000
0
Propane, pptv
500
250
0
C2Cl4, pptv
60
30
0
CH3CCl3, pptv
500
250
0
1
2
3
4
5
6
7
8
9
GMT Time

Figure A13.4

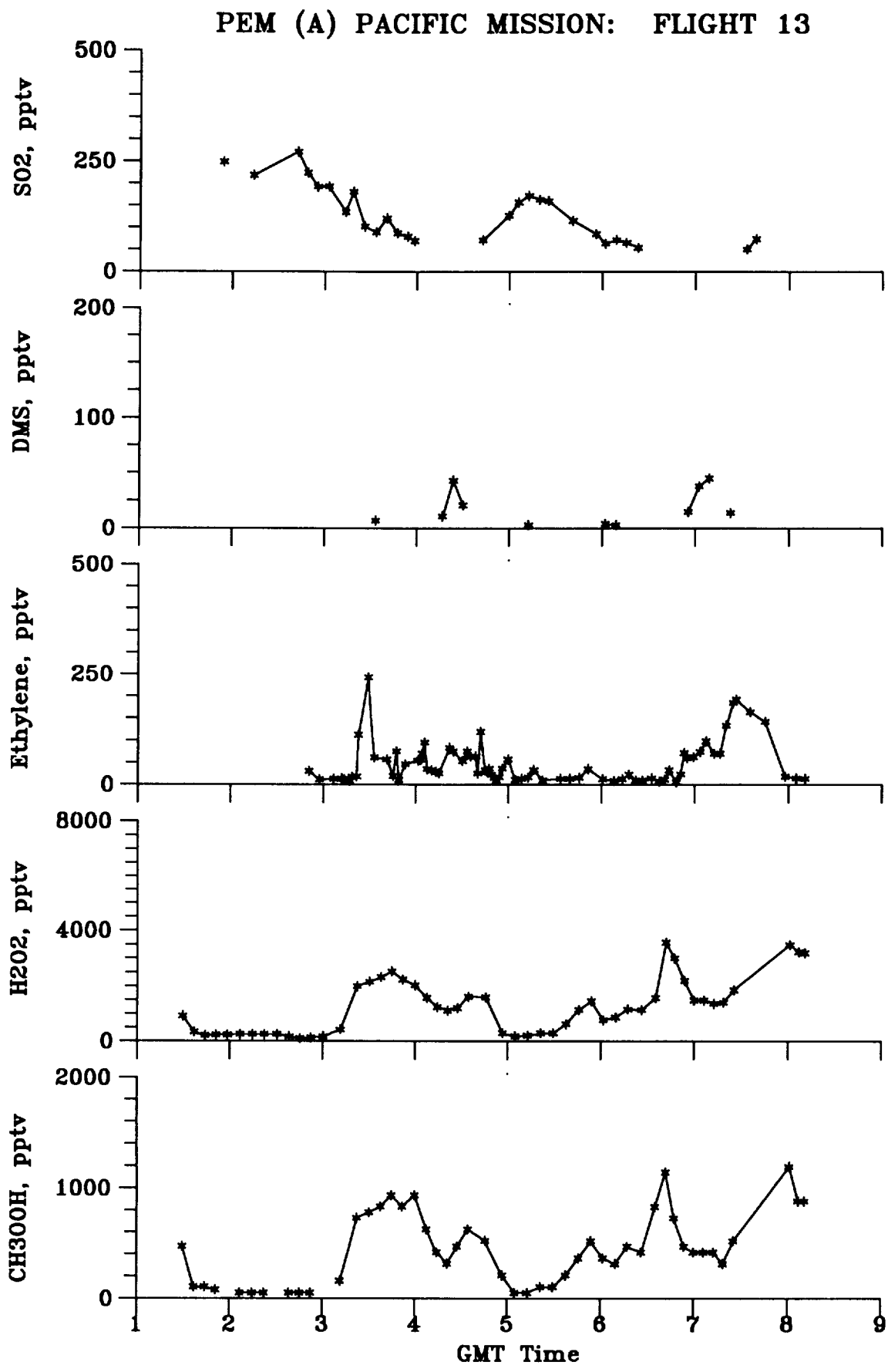

PEM (A) PACIFIC MISSION: FLIGHT 13
SO2, pptv
500
250
0
DMS, pptv
200
100
0
Ethylene, pptv
500
250
0
H2O2, pptv
8000
4000
0
CH3OOH, pptv
2000
1000
0
1
2
3
4
5
6
7
8
9
GMT Time

Figure A13.5

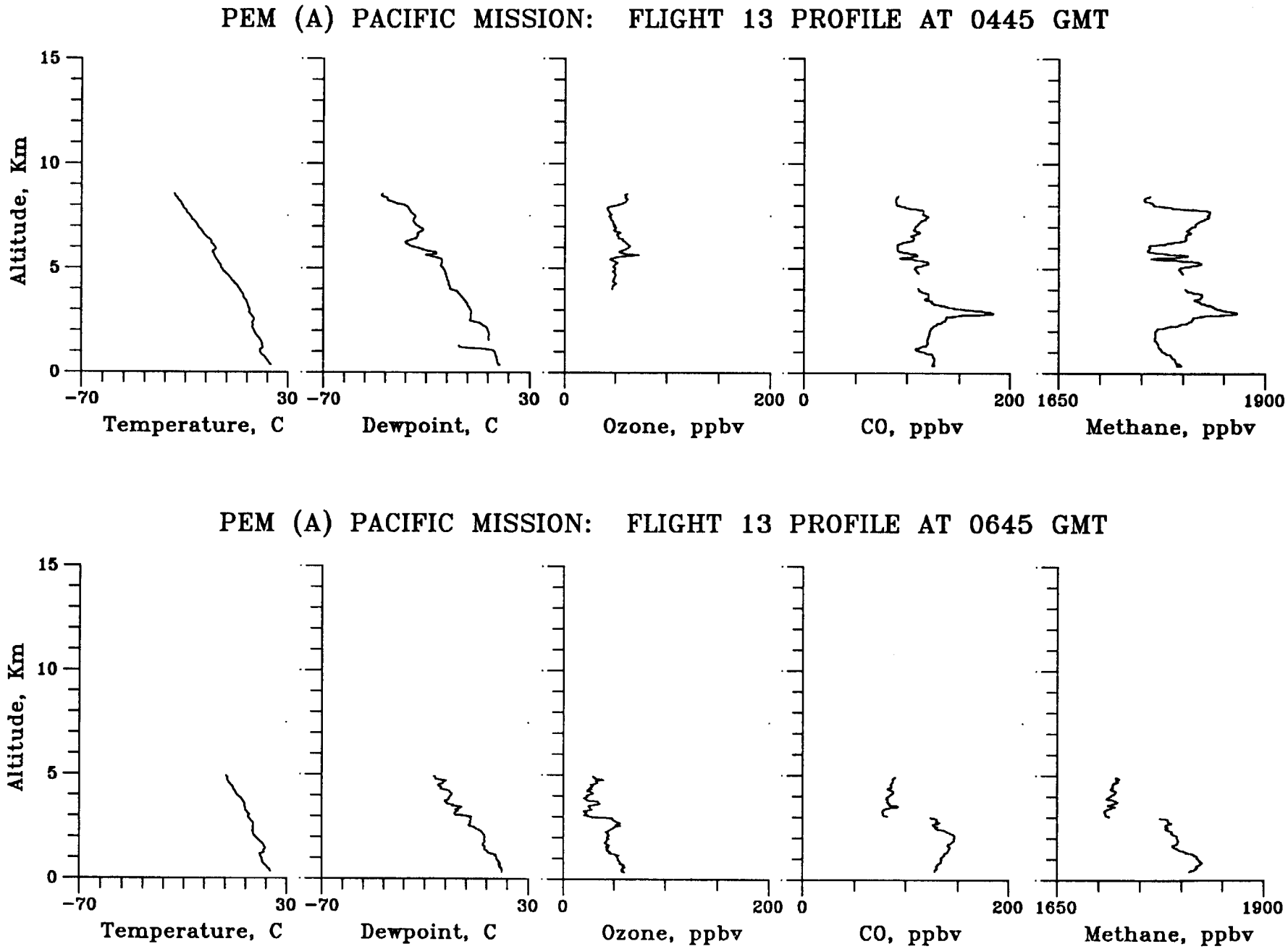

PEM (A) PACIFIC MISSION: FLIGHT 13 PROFILE AT 0445 GMT
Altitude, Km
15
10
5
0
-70
30
Temperature, C
Dewpoint, C
0
200
Ozone, ppbv
CO, ppbv
1650
1900
Methane, ppbv
PEM (A) PACIFIC MISSION: FLIGHT 13 PROFILE AT 0645 GMT

Figure A13.6

PEM (A) PACIFIC MISSION: FLIGHT 14

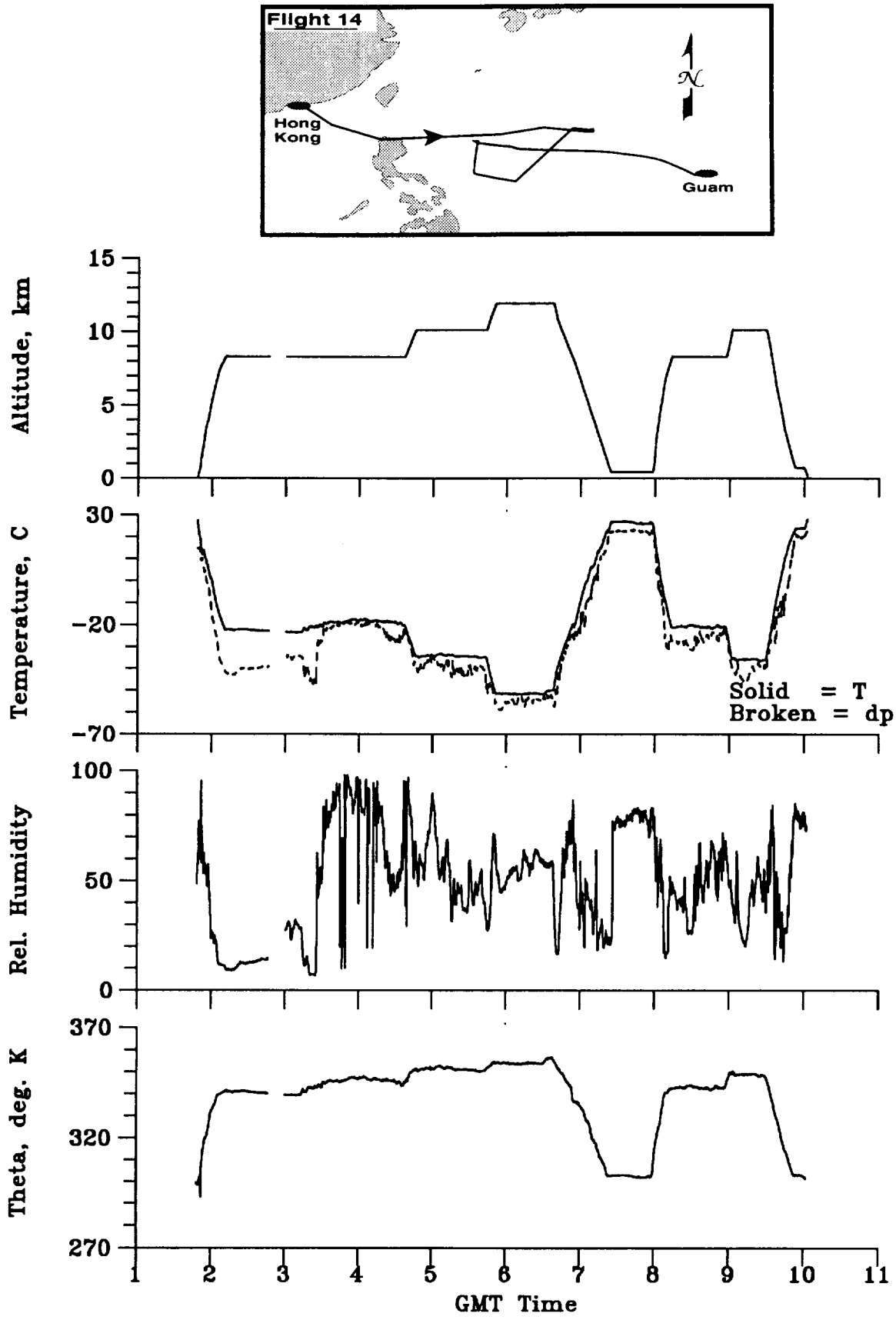


Figure A14.1

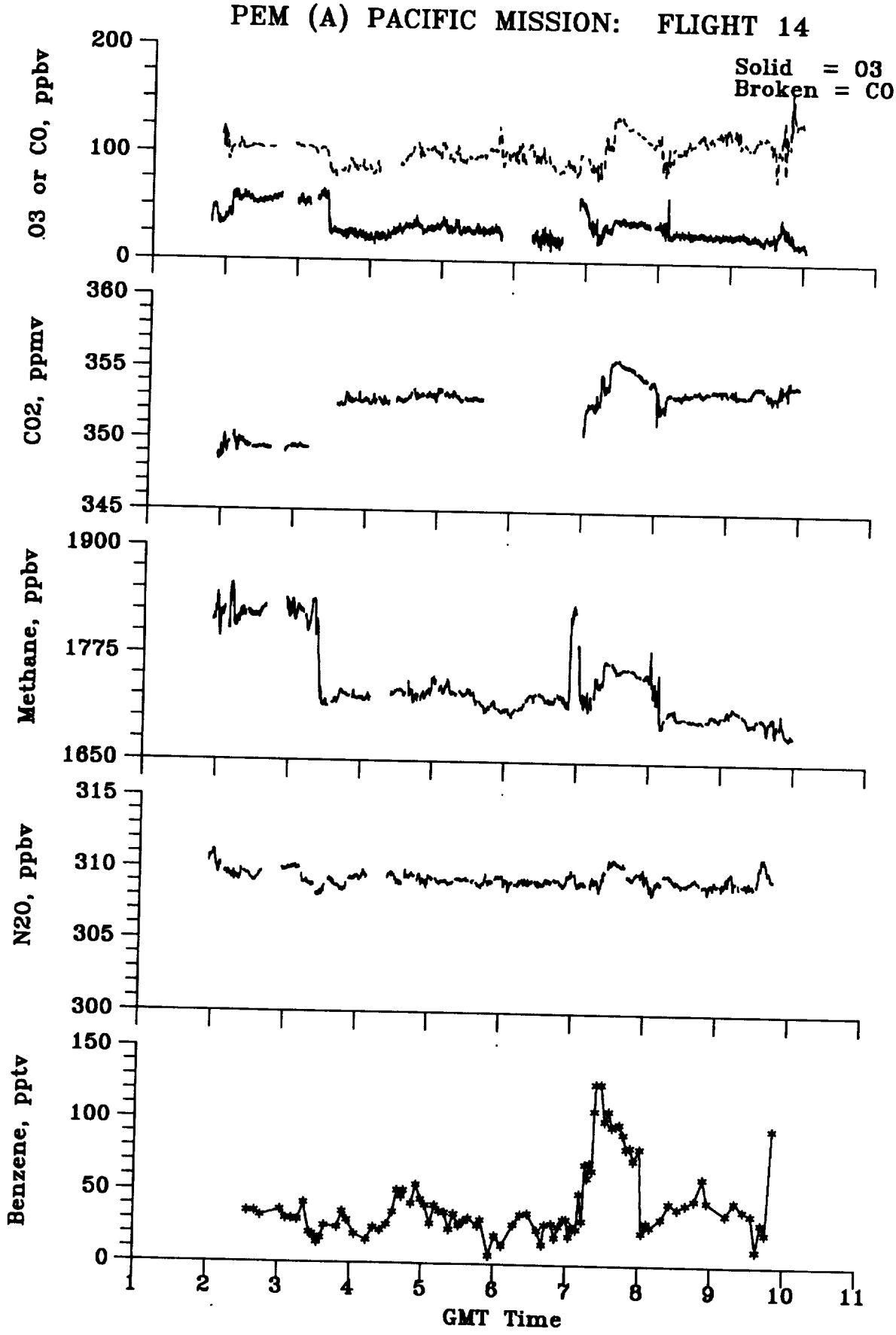

PEM (A) PACIFIC MISSION: FLIGHT 14
Solid = 03
Broken = CO
03 or CO, ppbv
200
100
0
CO2, ppmv
360
355
350
345
Methane, ppbv
1900
1775
1650
N2O, ppbv
315
310
305
300
Benzene, pptv
150
100
50
0
1
2
3
4
5
6
7
8
9
10
11
GMT Time

Figure A14.2

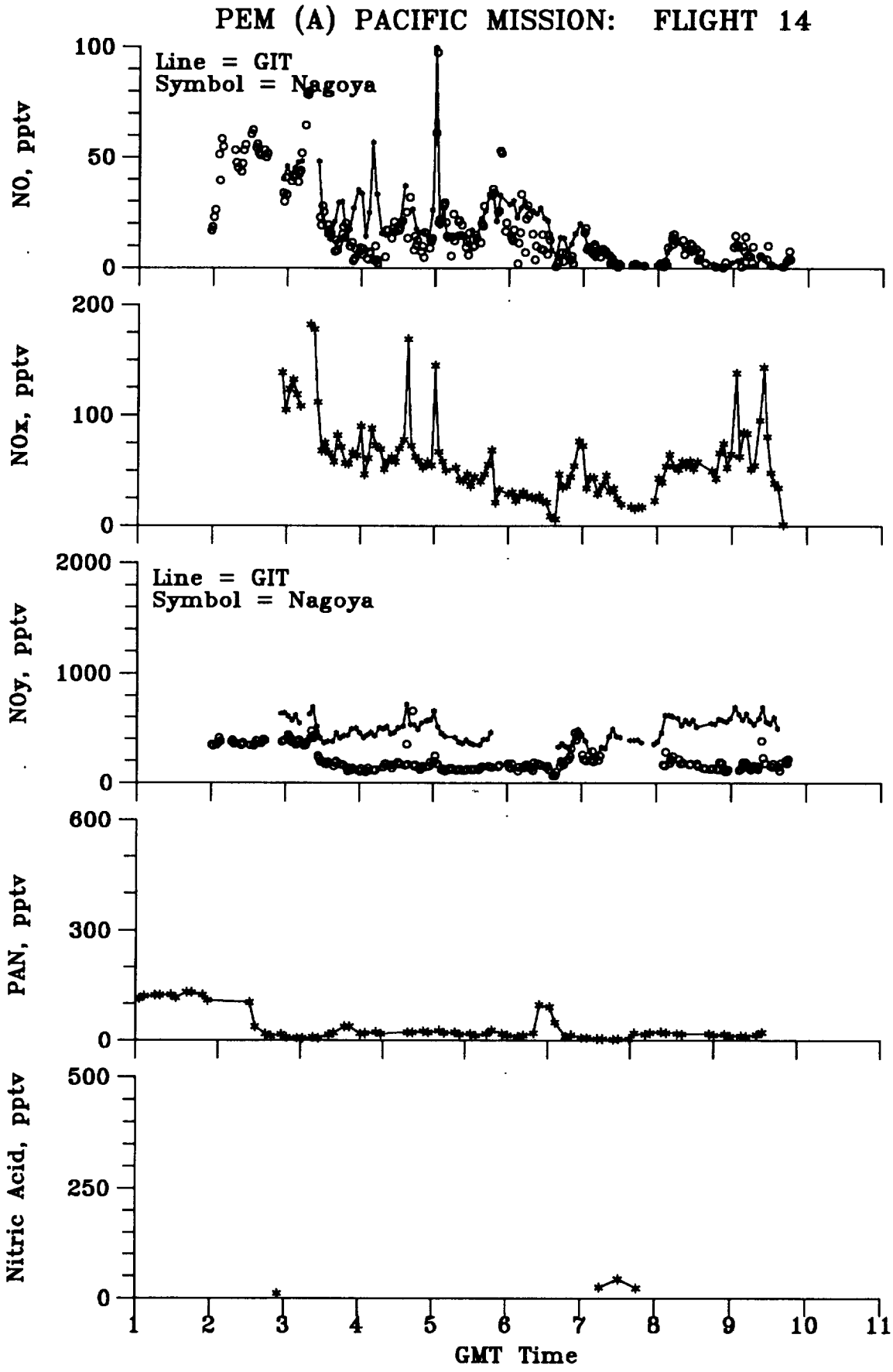

PEM (A) PACIFIC MISSION: FLIGHT 14
Line = GIT
Symbol = Nagoya
NO, pptv
100
50
0
NOx, pptv
200
100
0
Line = GIT
Symbol = Nagoya
NOy, pptv
2000
1000
0
PAN, pptv
600
300
0
Nitric Acid, pptv
500
250
0
1
2
3
4
5
6
7
8
9
10
11
GMT Time

Figure A14.3

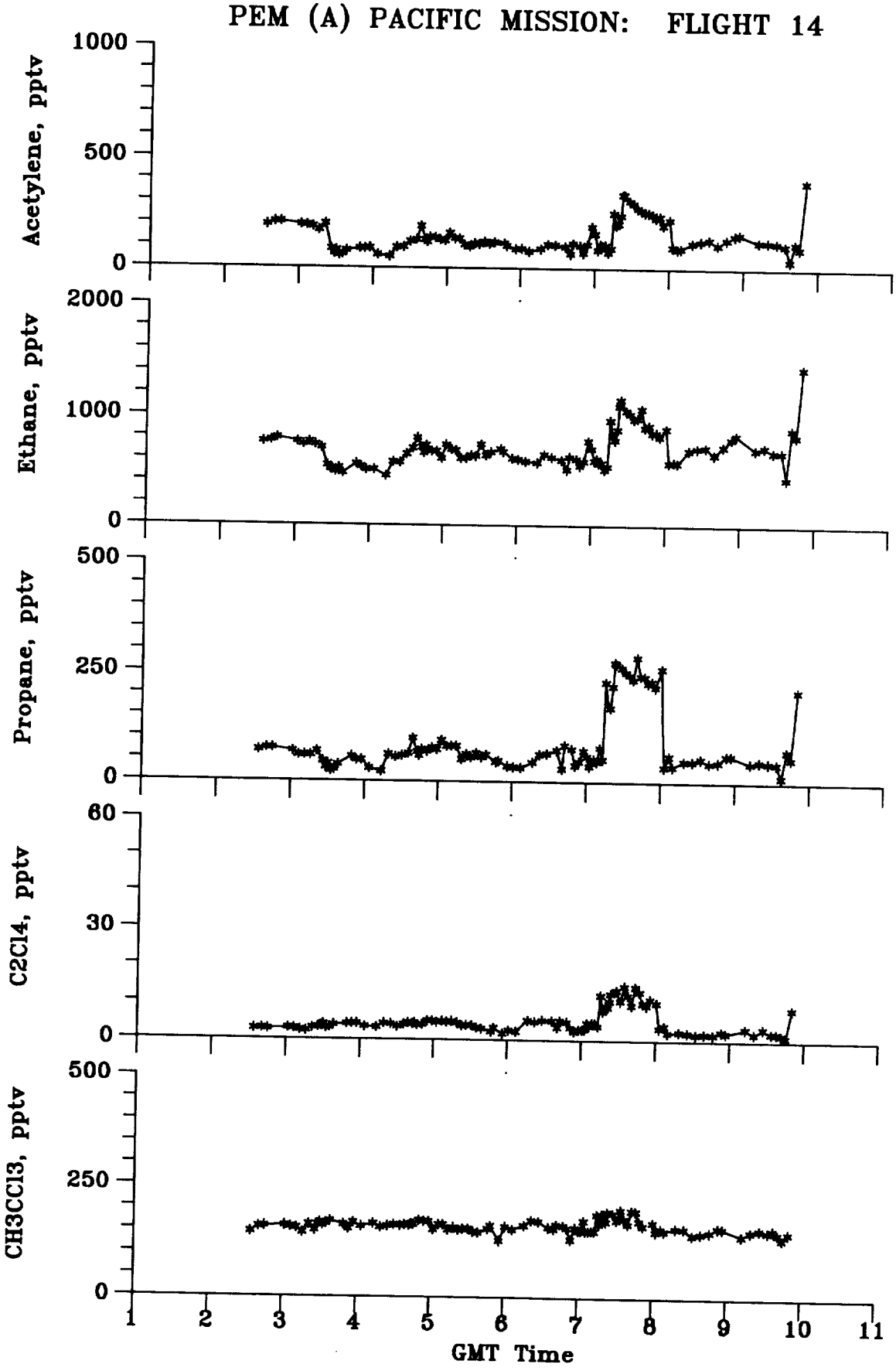

PEM (A) PACIFIC MISSION: FLIGHT 14
Acetylene, pptv
1000
500
0
Ethane, pptv
2000
1000
0
Propane, pptv
500
250
0
C2Cl4, pptv
60
30
0
CH3CCl3, pptv
500
250
0
1
2
3
4
5
6
7
8
9
10
11
GMT Time

Figure A14.4

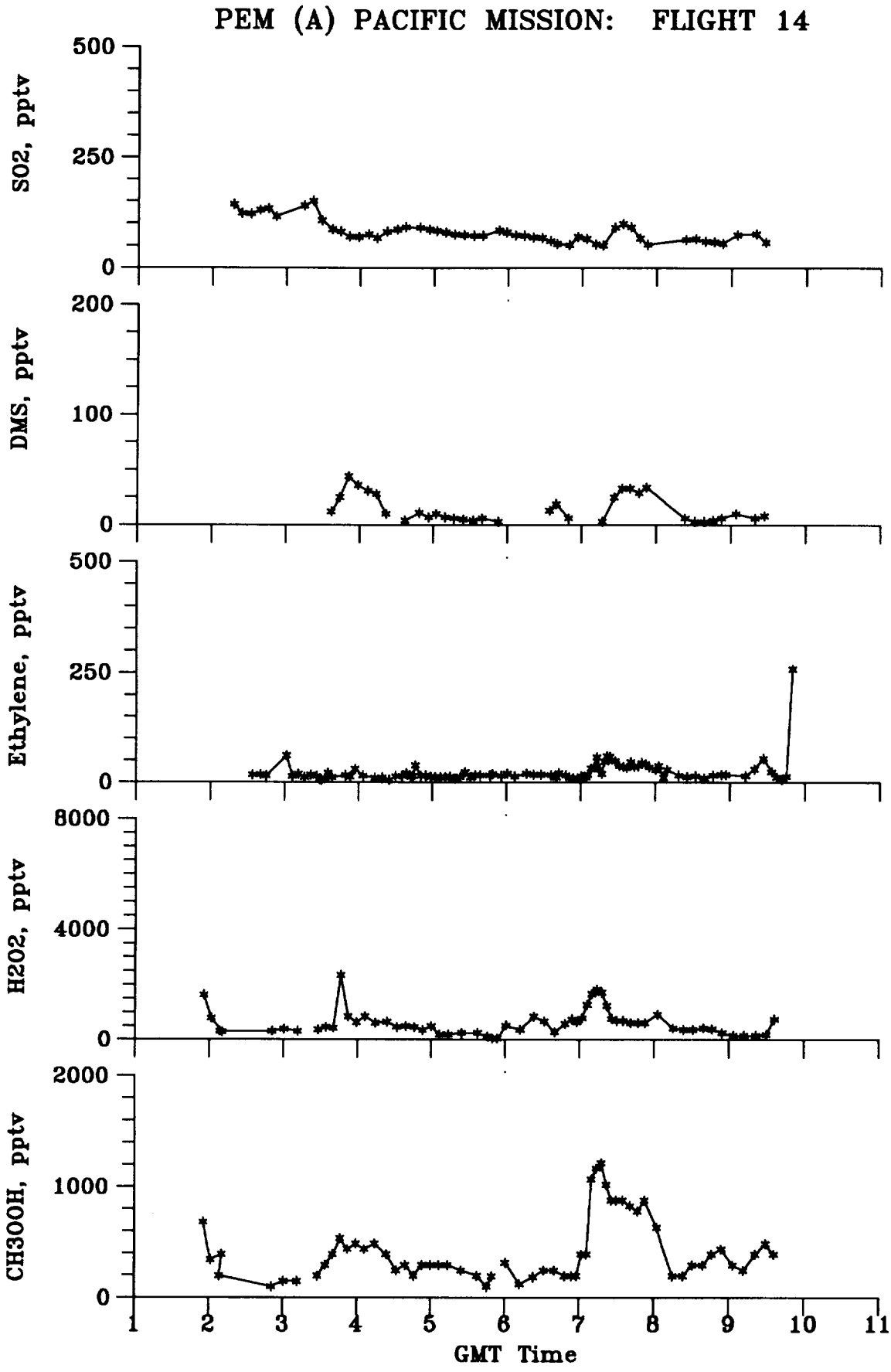
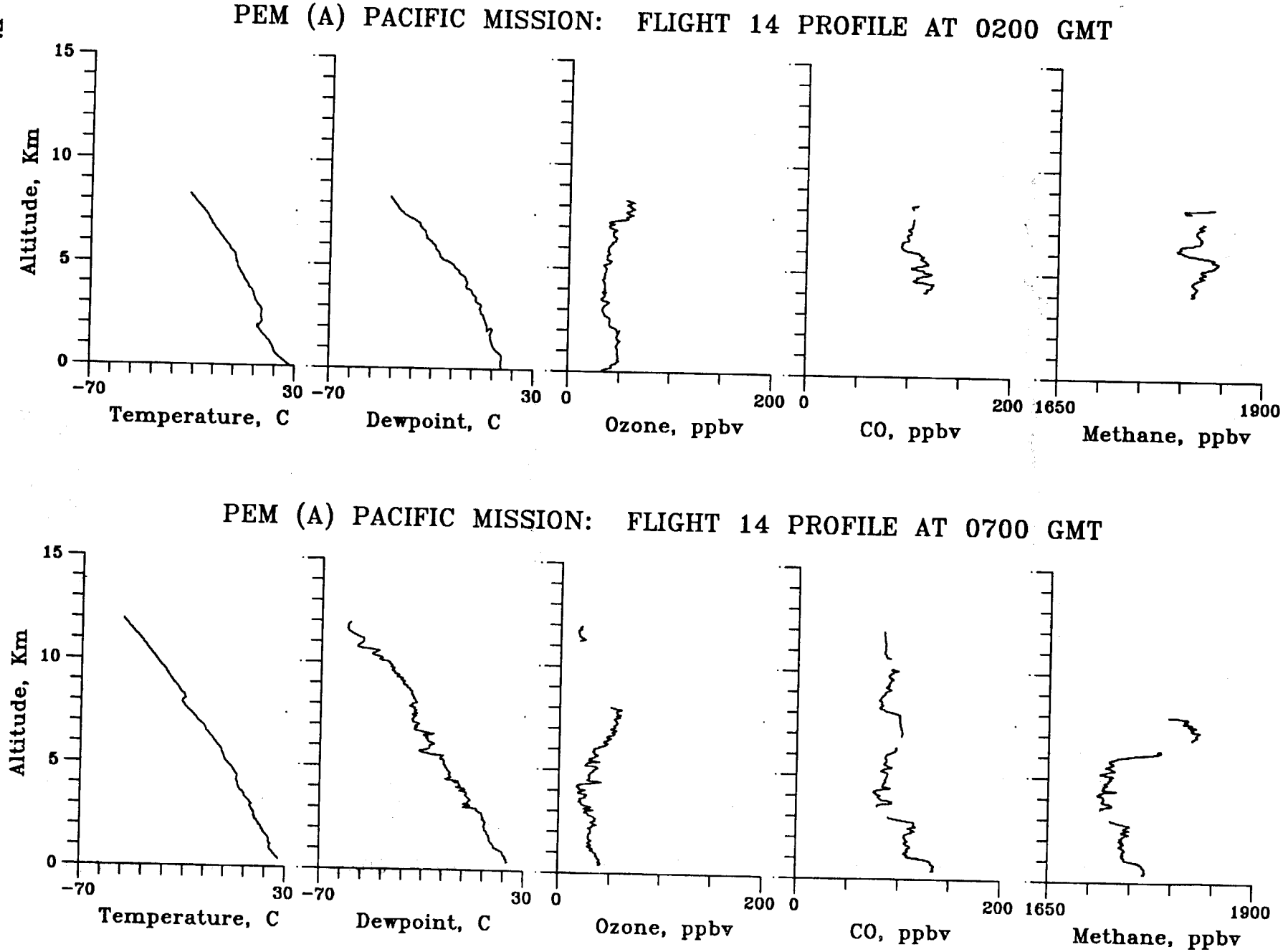

PEM (A) PACIFIC MISSION: FLIGHT 14
SO2, pptv
500
250
0
DMS, pptv
200
100
0
Ethylene, pptv
500
250
0
H2O2, pptv
8000
4000
0
CH3OOH, pptv
2000
1000
0
1
2
3
4
5
6
7
8
9
10
11
GMT Time

Figure A14.5

Figure A14.6


PEM (A) PACIFIC MISSION: FLIGHT 14 PROFILE AT 0200 GMT
Altitude, Km
15
10
5
0
-70
30
Temperature, C
Dewpoint, C
0
200
Ozone, ppbv
CO, ppbv
1650
1900
Methane, ppbv
PEM (A) PACIFIC MISSION: FLIGHT 14 PROFILE AT 0700 GMT

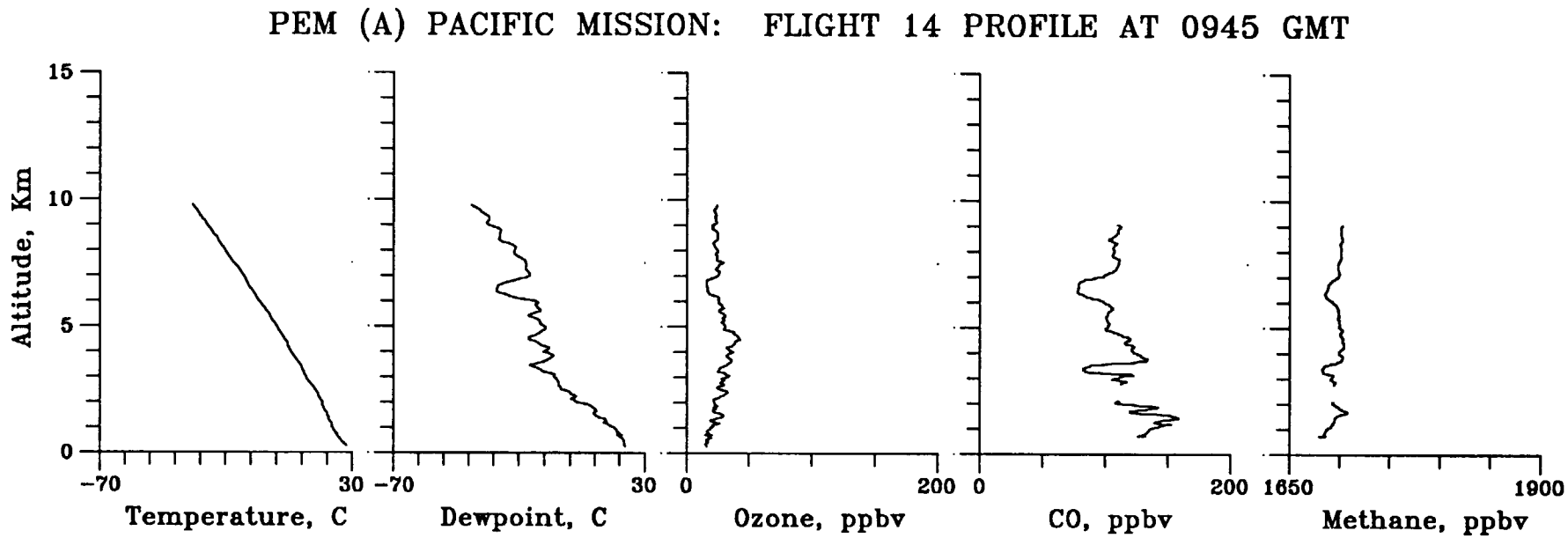

PEM (A) PACIFIC MISSION: FLIGHT 14 PROFILE AT 0945 GMT
Altitude, Km
15
10
5
0
-70
30
Temperature, C
-70
30
Dewpoint, C
0
200
Ozone, ppbv
0
200
CO, ppbv
1650
1900
Methane, ppbv

Figure A14.7

PEM (A) PACIFIC MISSION: FLIGHT 15

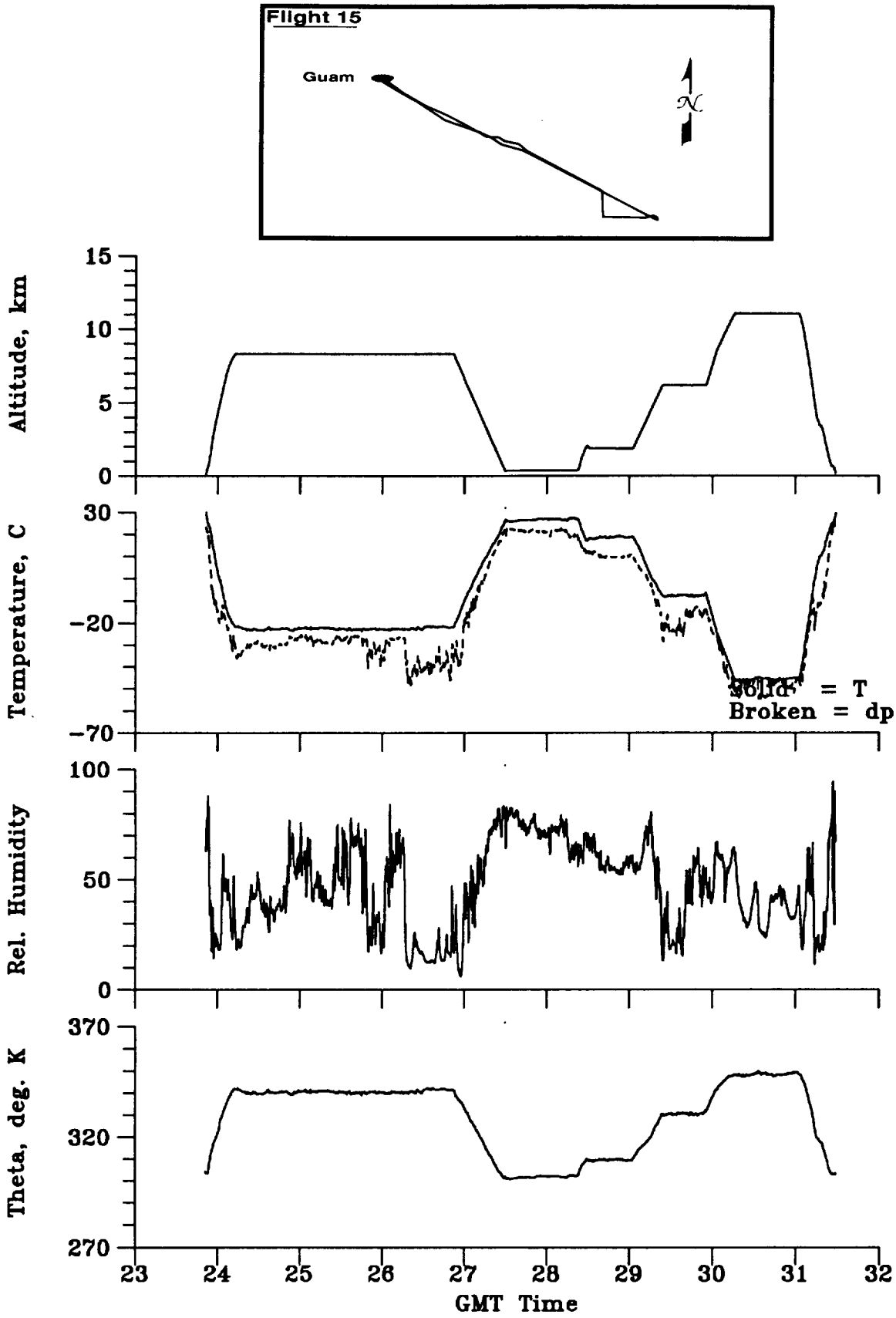


Figure A15.1

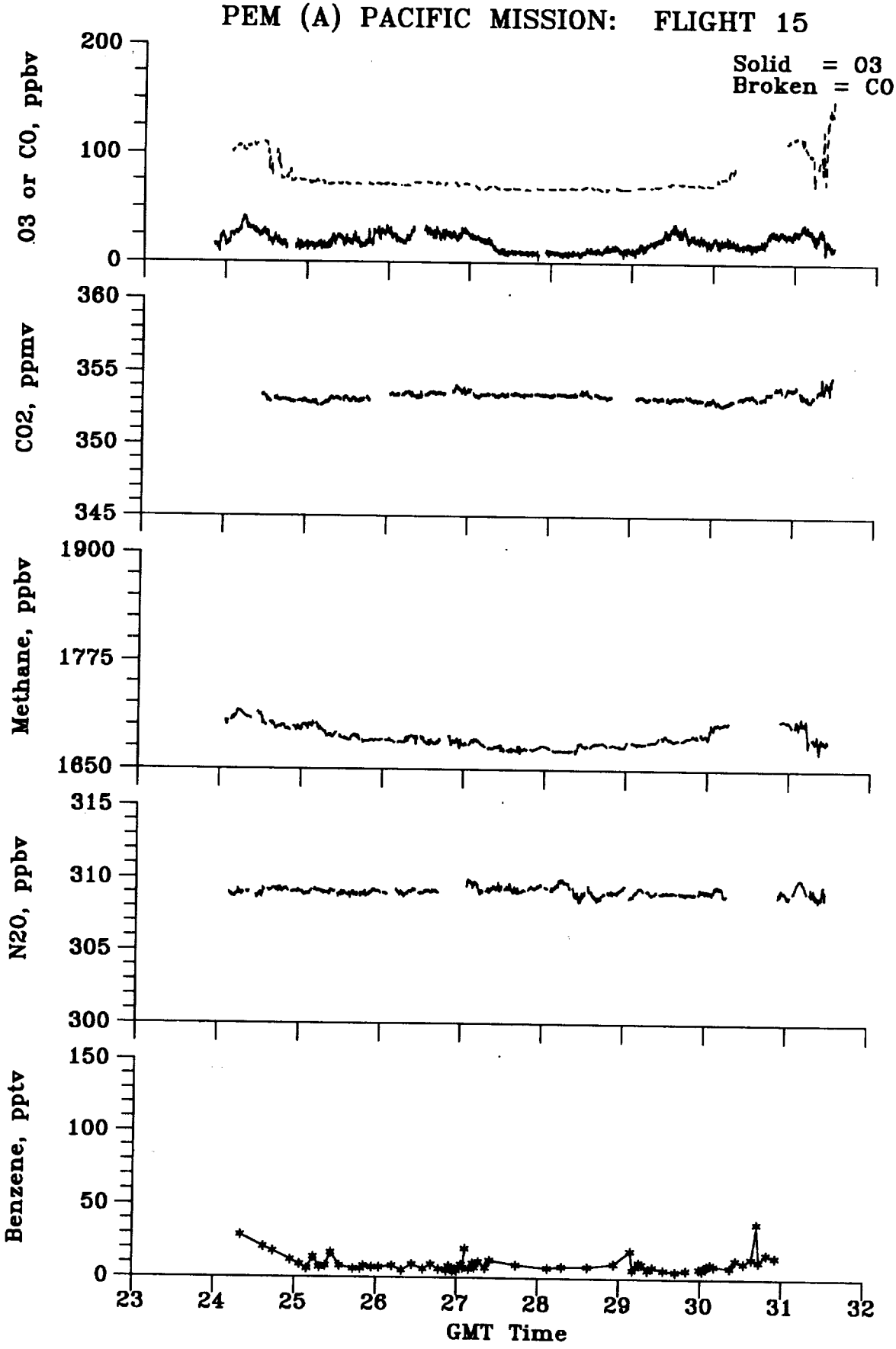

PEM (A) PACIFIC MISSION: FLIGHT 15
Solid = 03
Broken = CO
03 or CO, ppbv
200
100
0
CO2, ppmv
360
355
350
345
Methane, ppbv
1900
1775
1650
N2O, ppbv
315
310
305
300
Benzene, pptv
150
100
50
0
23
24
25
26
27
28
29
30
31
32
GMT Time

Figure A15.2

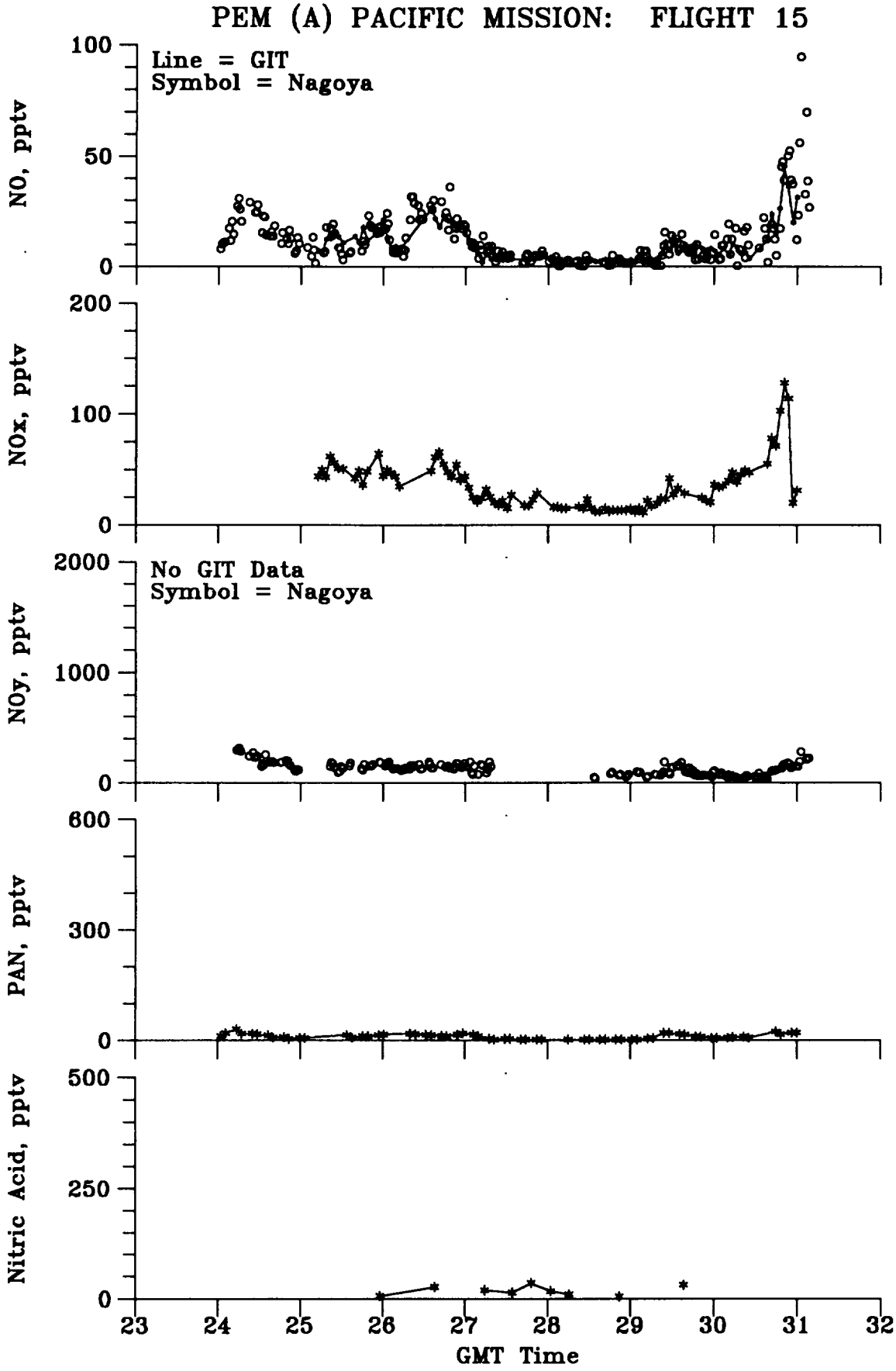

PEM (A) PACIFIC MISSION: FLIGHT 15
Line = GIT
Symbol = Nagoya
NO, pptv
100
50
0
NOx, pptv
200
100
0
No GIT Data
Symbol = Nagoya
NOy, pptv
2000
1000
0
PAN, pptv
600
300
0
Nitric Acid, pptv
500
250
0
23
24
25
26
27
28
29
30
31
32
GMT Time

Figure A15.3

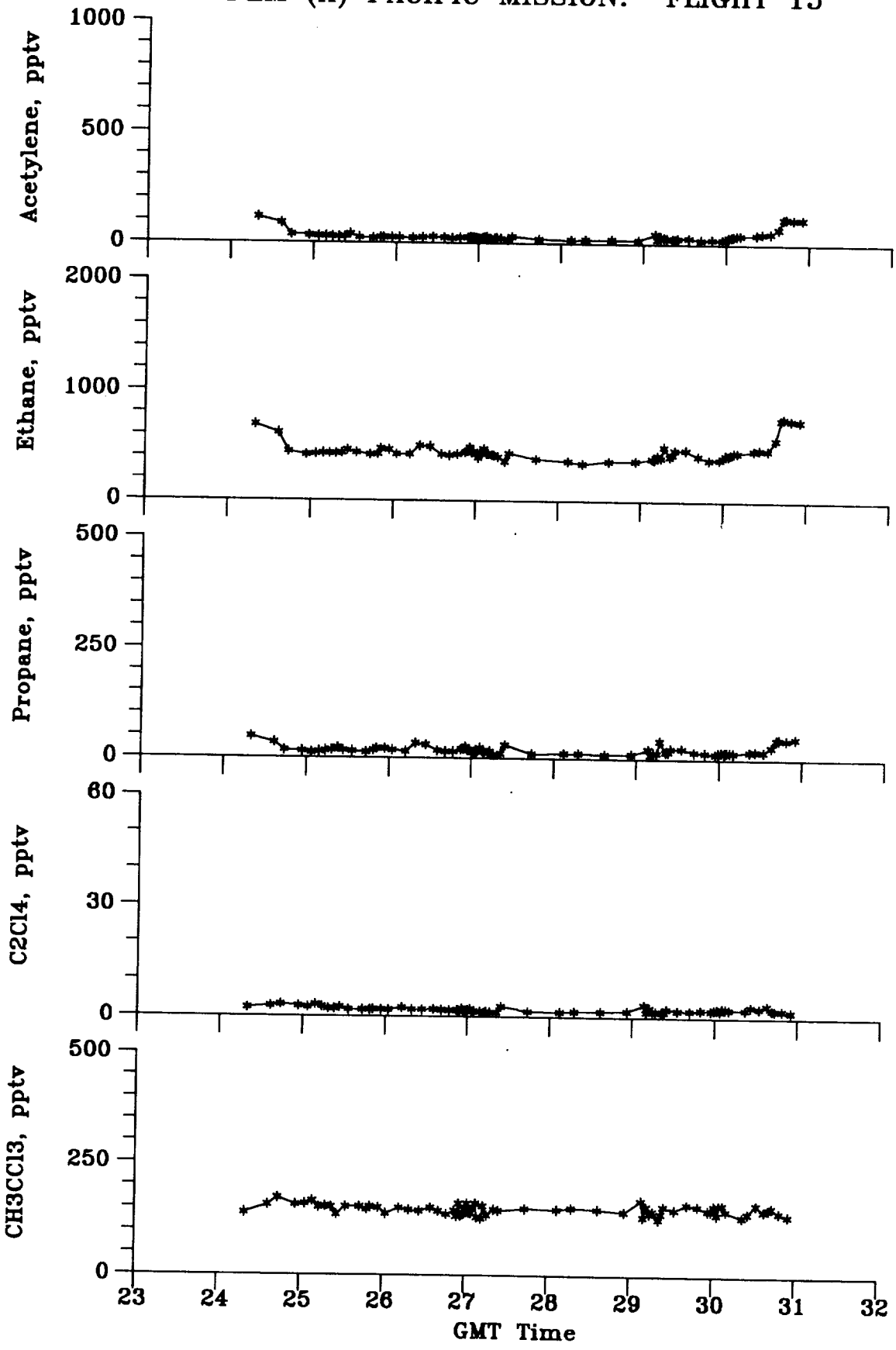

PEM (A) PACIFIC MISSION: FLIGHT 15
Acetylene, pptv
1000
500
0
Ethane, pptv
2000
1000
0
Propane, pptv
500
250
0
C2Cl4, pptv
60
30
0
CH3CCl3, pptv
500
250
0
23
24
25
26
27
28
29
30
31
32
GMT Time

Figure A15.4

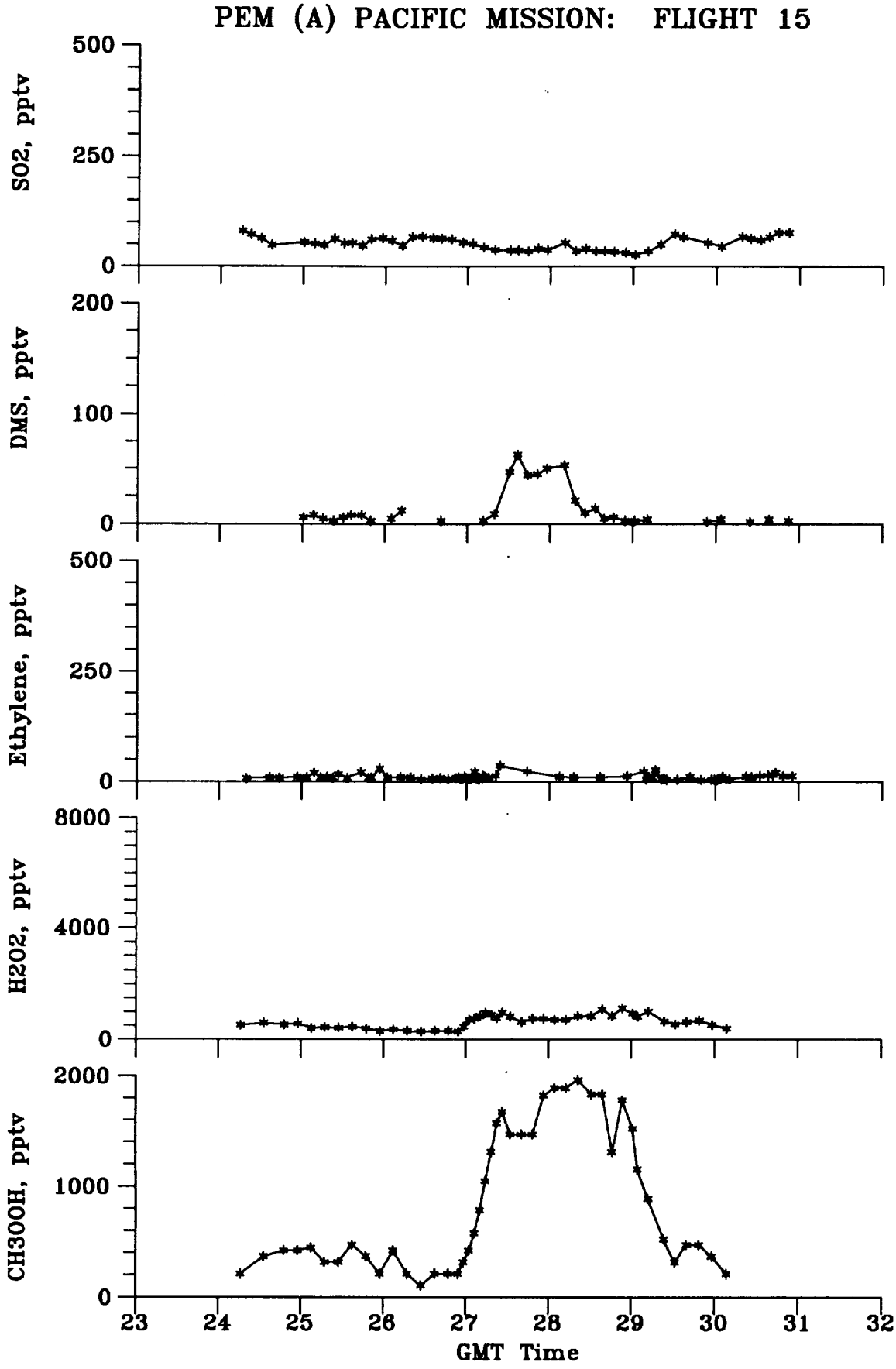
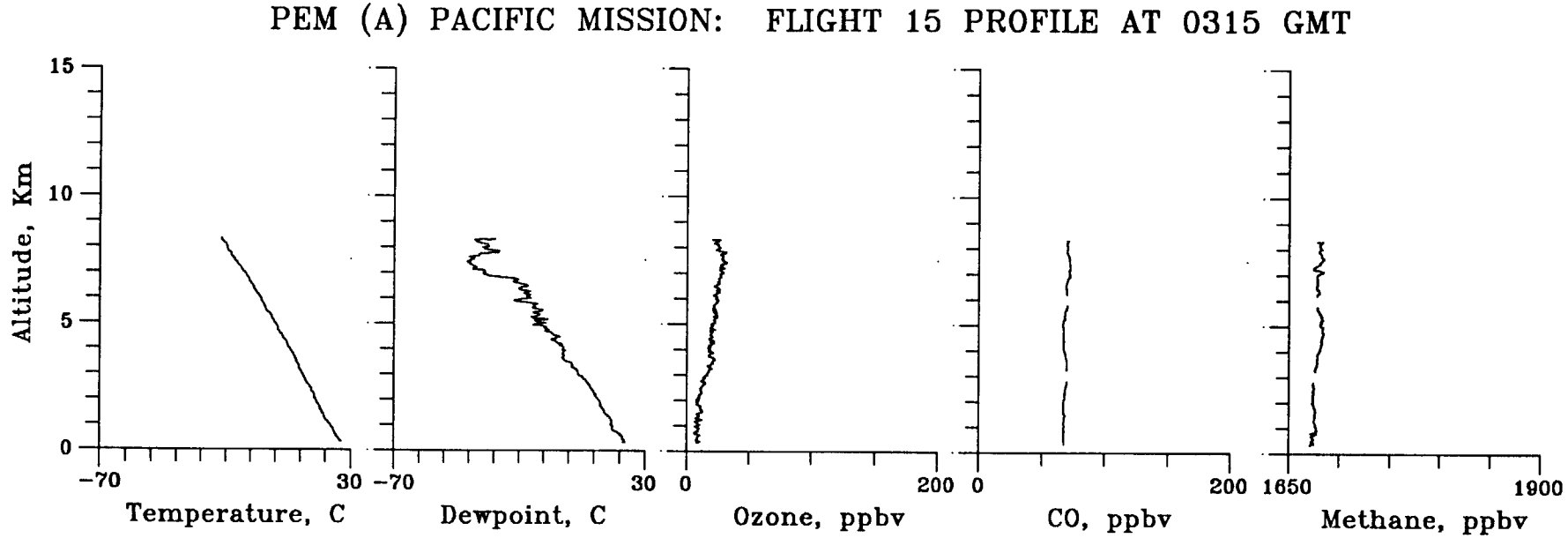
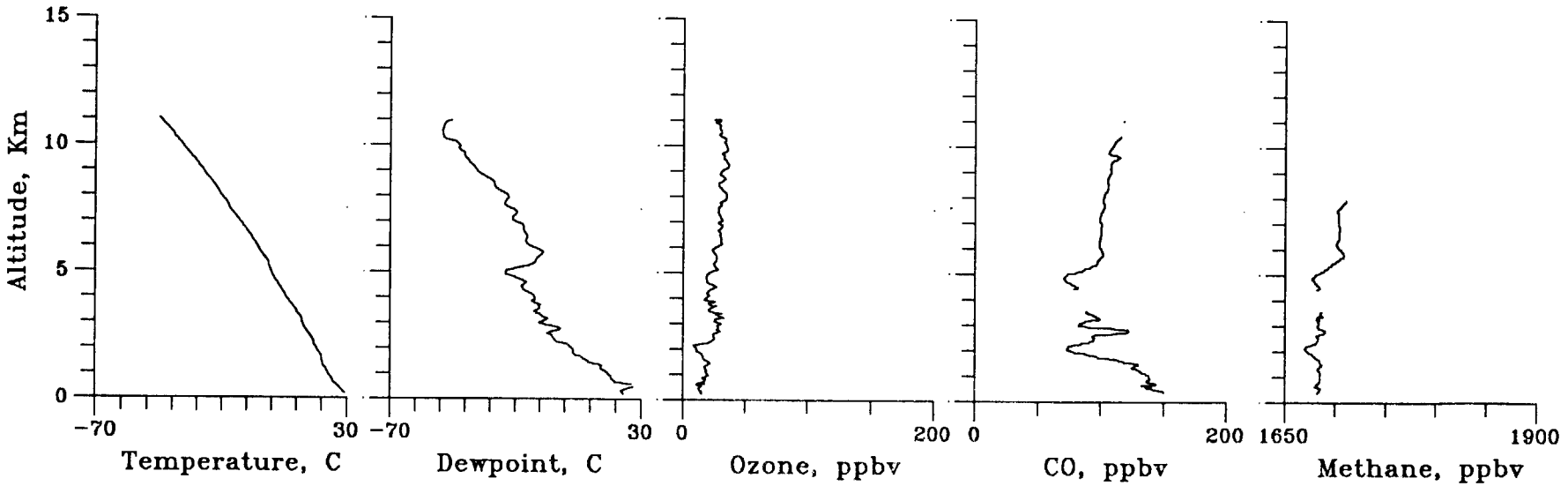

PEM (A) PACIFIC MISSION: FLIGHT 15
SO2, pptv
500
250
0
DMS, pptv
200
100
0
Ethylene, pptv
500
250
0
H2O2, pptv
8000
4000
0
CH3OOH, pptv
2000
1000
0
23
24
25
26
27
28
29
30
31
32
GMT Time

Figure A15.5

Figure A15.6


PEM (A) PACIFIC MISSION: FLIGHT 15 PROFILE AT 0315 GMT
Altitude, Km
15
10
5
0
-70
30
Temperature, C
Dewpoint, C
0
200
Ozone, ppbv
CO, ppbv
1650
1900
Methane, ppbv


PEM (A) PACIFIC MISSION: FLIGHT 15 PROFILE AT 0715 GMT
Altitude, Km
15
10
5
0
-70
30
Temperature, C
Dewpoint, C
0
200
Ozone, ppbv
CO, ppbv
1650
1900
Methane, ppbv

PEM (A) PACIFIC MISSION: FLIGHT 16

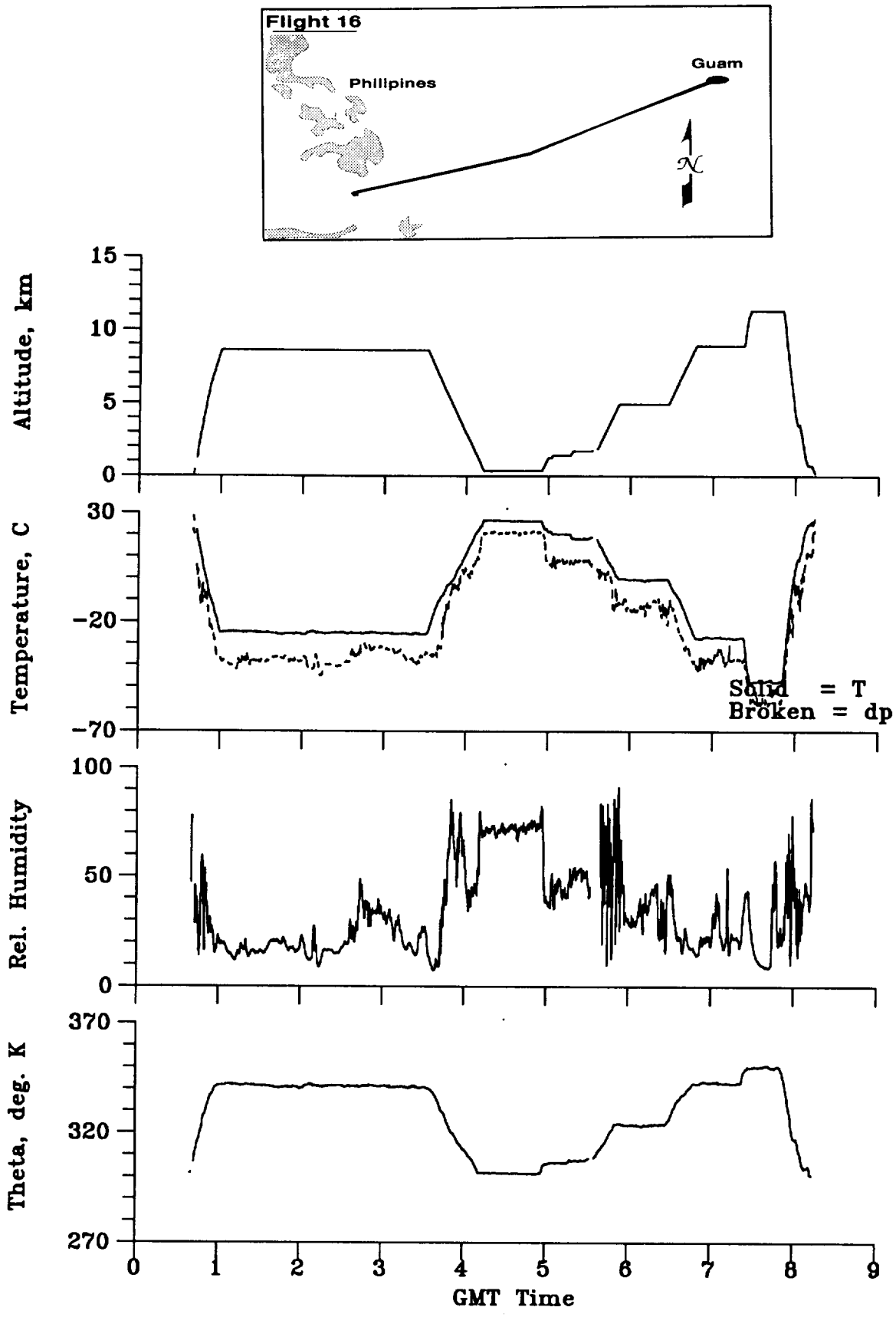


Figure A16.1

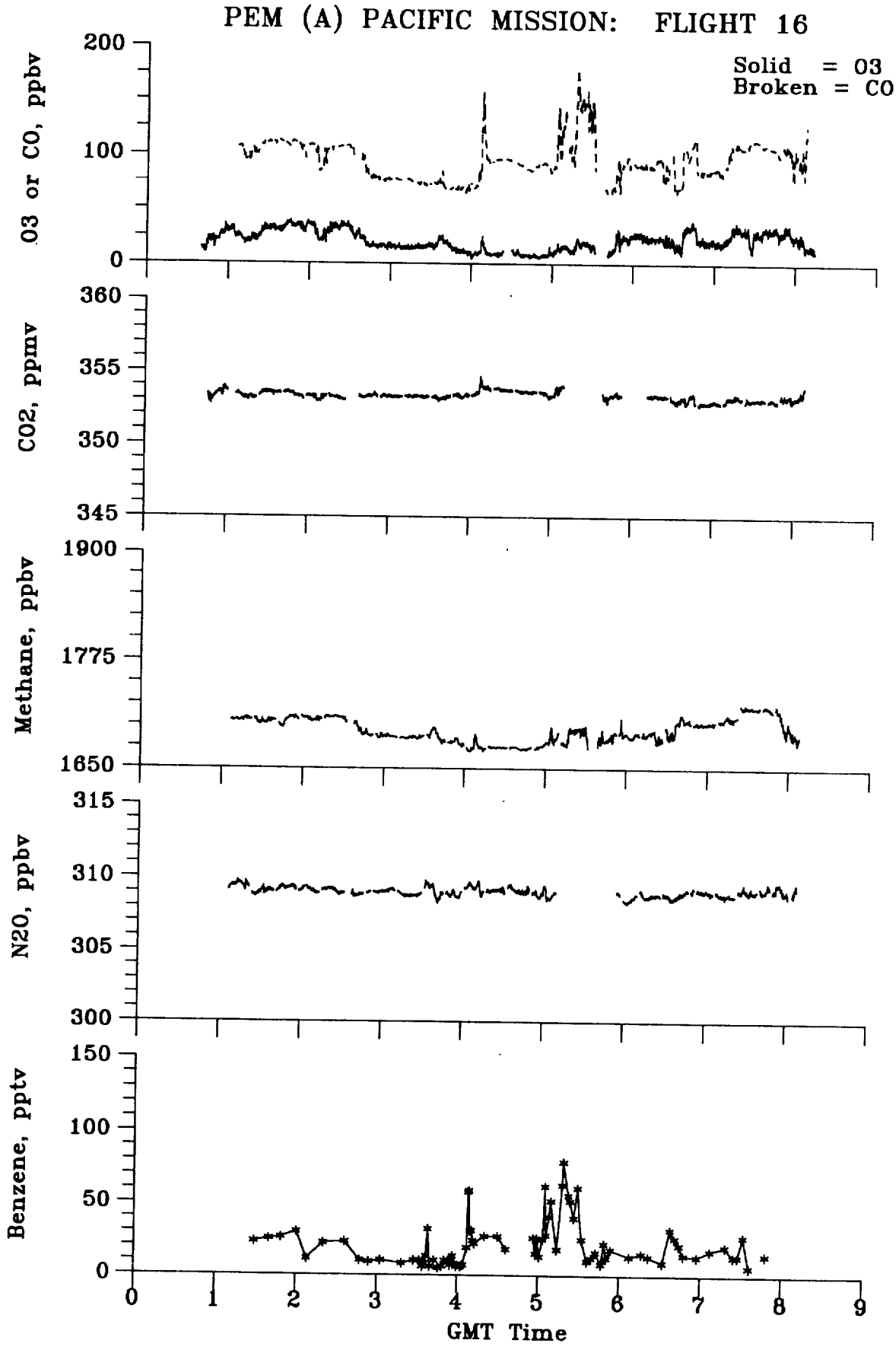

PEM (A) PACIFIC MISSION: FLIGHT 16
Solid = 03
Broken = CO
03 or CO, ppbv
200
100
0
CO2, ppmv
360
355
350
345
Methane, ppbv
1900
1775
1650
N20, ppbv
315
310
305
300
Benzene, pptv
150
100
50
0
0
1
2
3
4
5
6
7
8
9
GMT Time

Figure A16.2

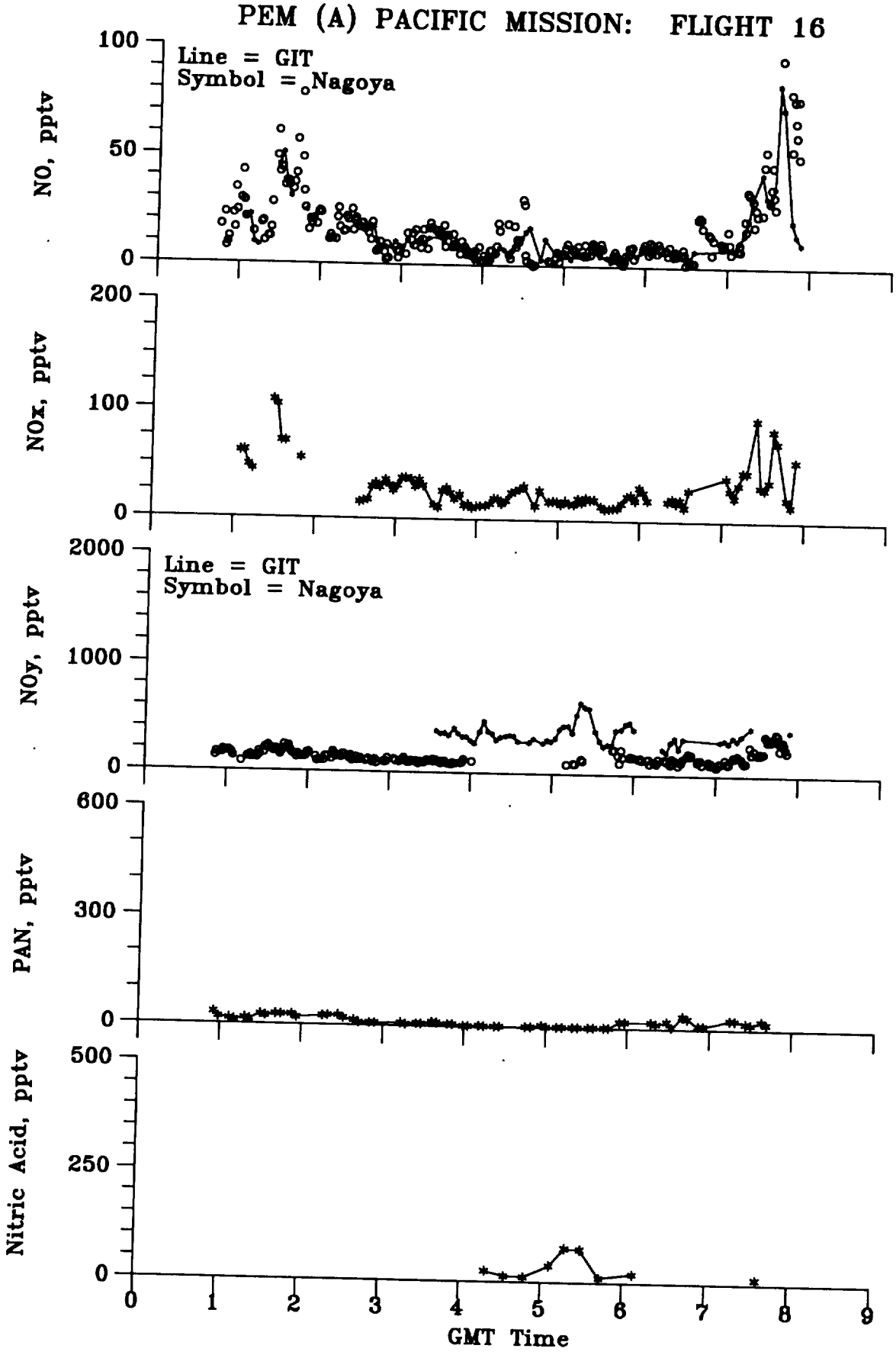

PEM (A) PACIFIC MISSION: FLIGHT 16
Line = GIT
Symbol = Nagoya
NO, pptv
100
50
0
NOx, pptv
200
100
0
Line = GIT
Symbol = Nagoya
NOy, pptv
2000
1000
0
PAN, pptv
600
300
0
Nitric Acid, pptv
500
250
0
0
1
2
3
4
5
6
7
8
9
GMT Time

Figure A16.3

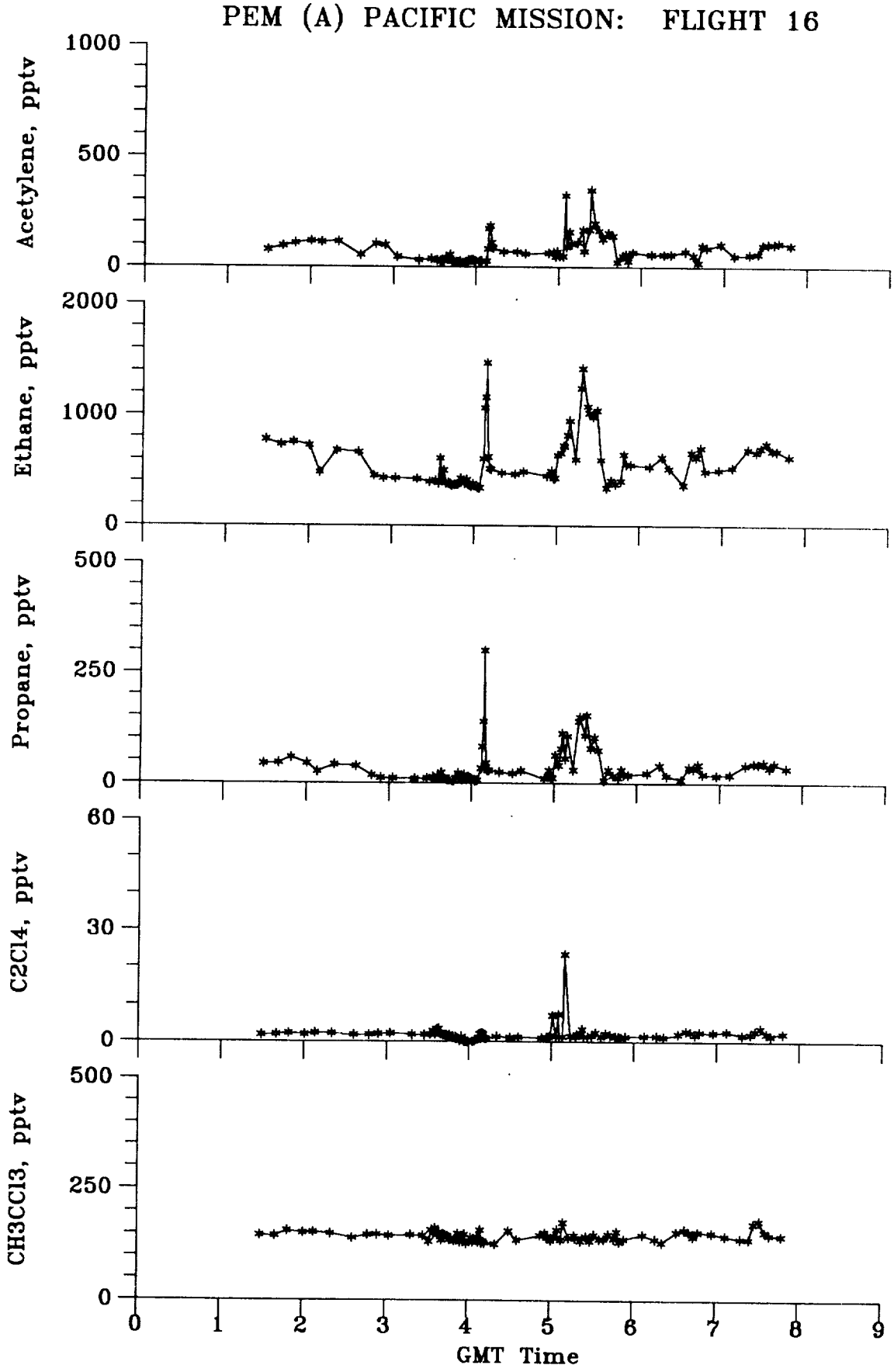

PEM (A) PACIFIC MISSION: FLIGHT 16
Acetylene, pptv
1000
500
0
Ethane, pptv
2000
1000
0
Propane, pptv
500
250
0
C2Cl4, pptv
60
30
0
CH3CCl3, pptv
500
250
0
0
1
2
3
4
5
6
7
8
9
GMT Time

Figure A16.4

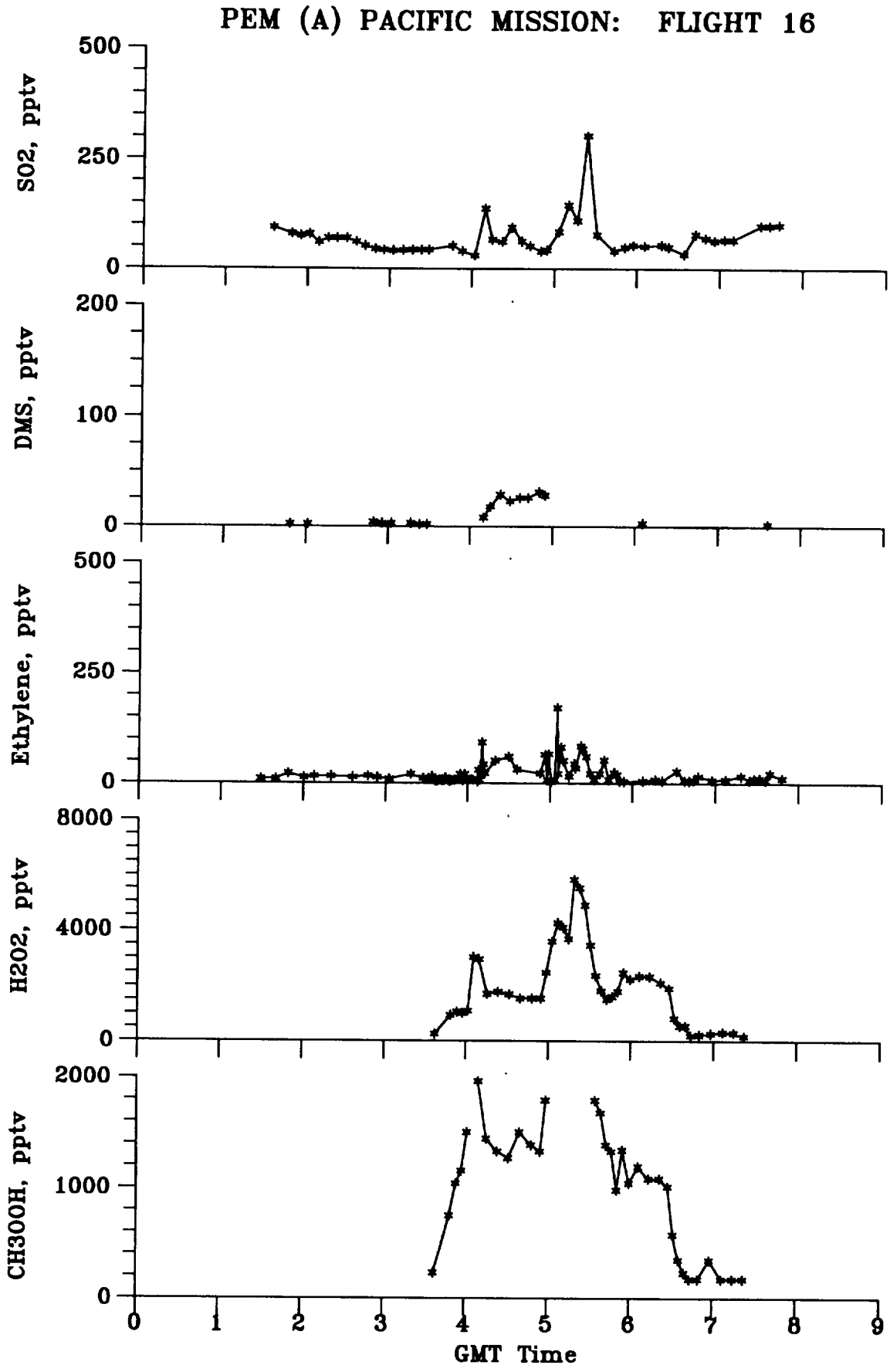

PEM (A) PACIFIC MISSION: FLIGHT 16
SO2, pptv
500
250
0
DMS, pptv
200
100
0
Ethylene, pptv
500
250
0
H2O2, pptv
8000
4000
0
CH3OOH, pptv
2000
1000
0
0
1
2
3
4
5
6
7
8
9
GMT Time

Figure A16.5

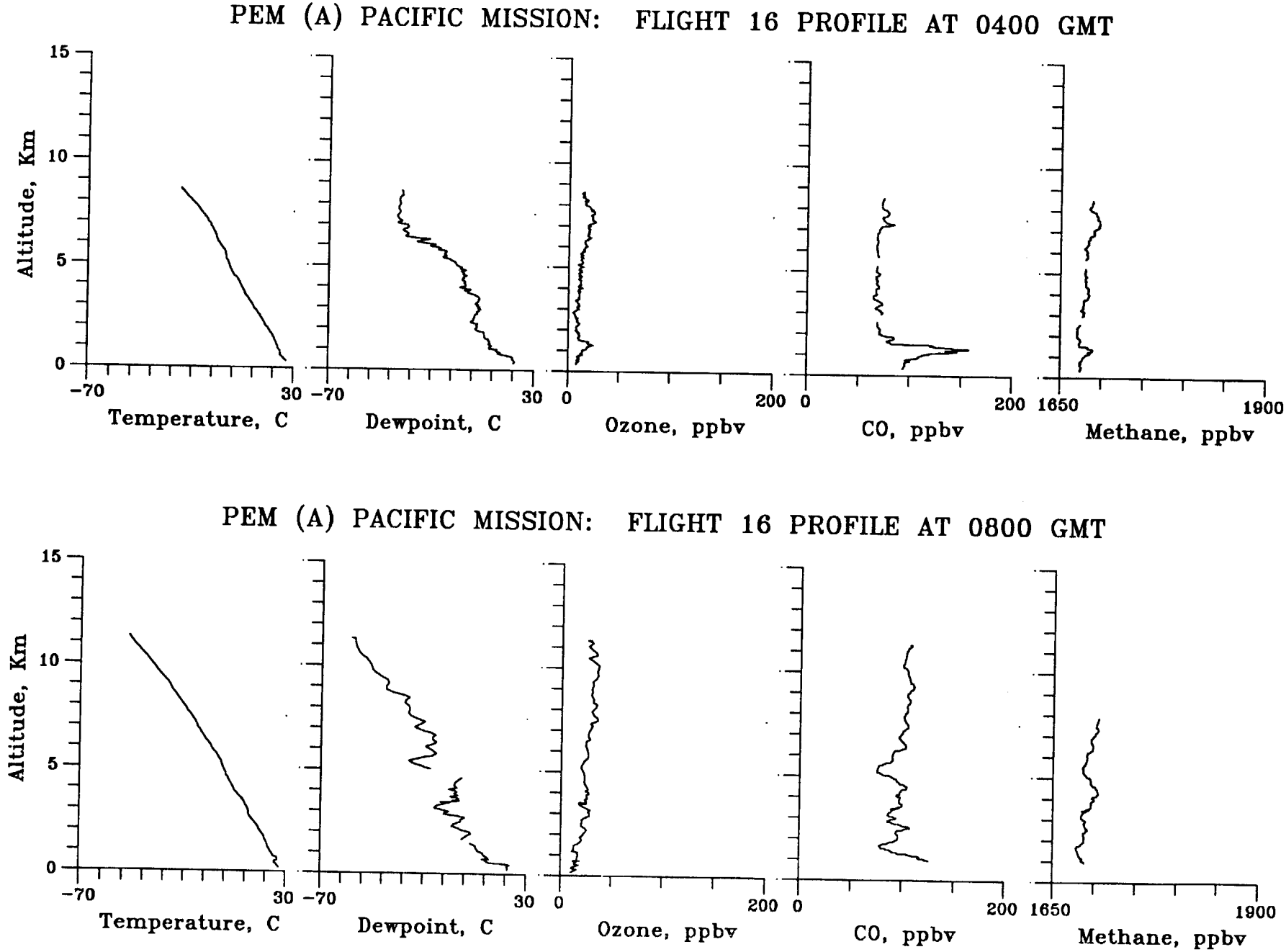

PEM (A) PACIFIC MISSION: FLIGHT 16 PROFILE AT 0400 GMT
Altitude, Km
15
10
5
0
-70
30
Temperature, C
Dewpoint, C
0
200
Ozone, ppbv
CO, ppbv
1650
1900
Methane, ppbv
PEM (A) PACIFIC MISSION: FLIGHT 16 PROFILE AT 0800 GMT

Figure A16.6

PEM (A) PACIFIC MISSION: FLIGHT 17

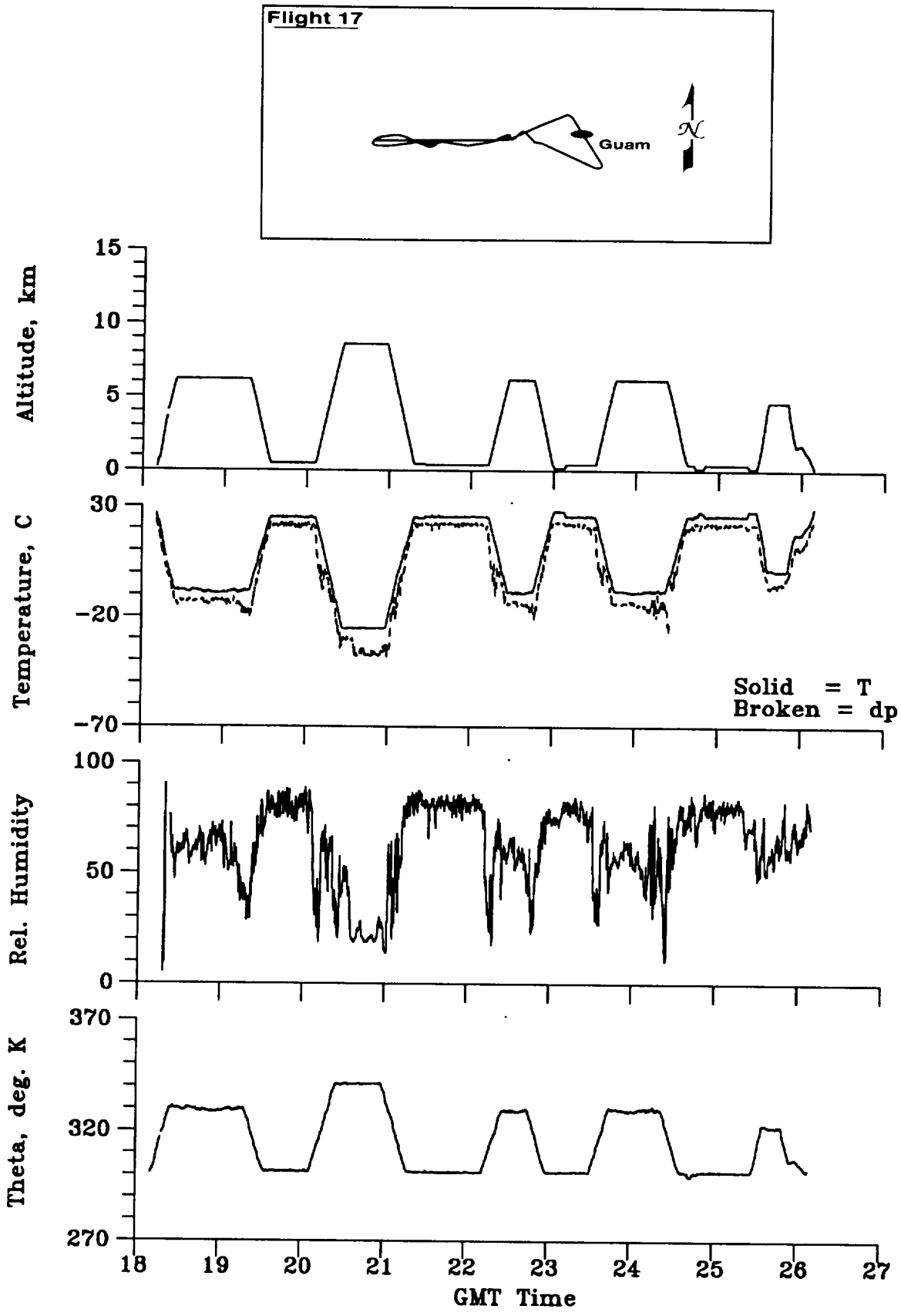


Figure A17.1

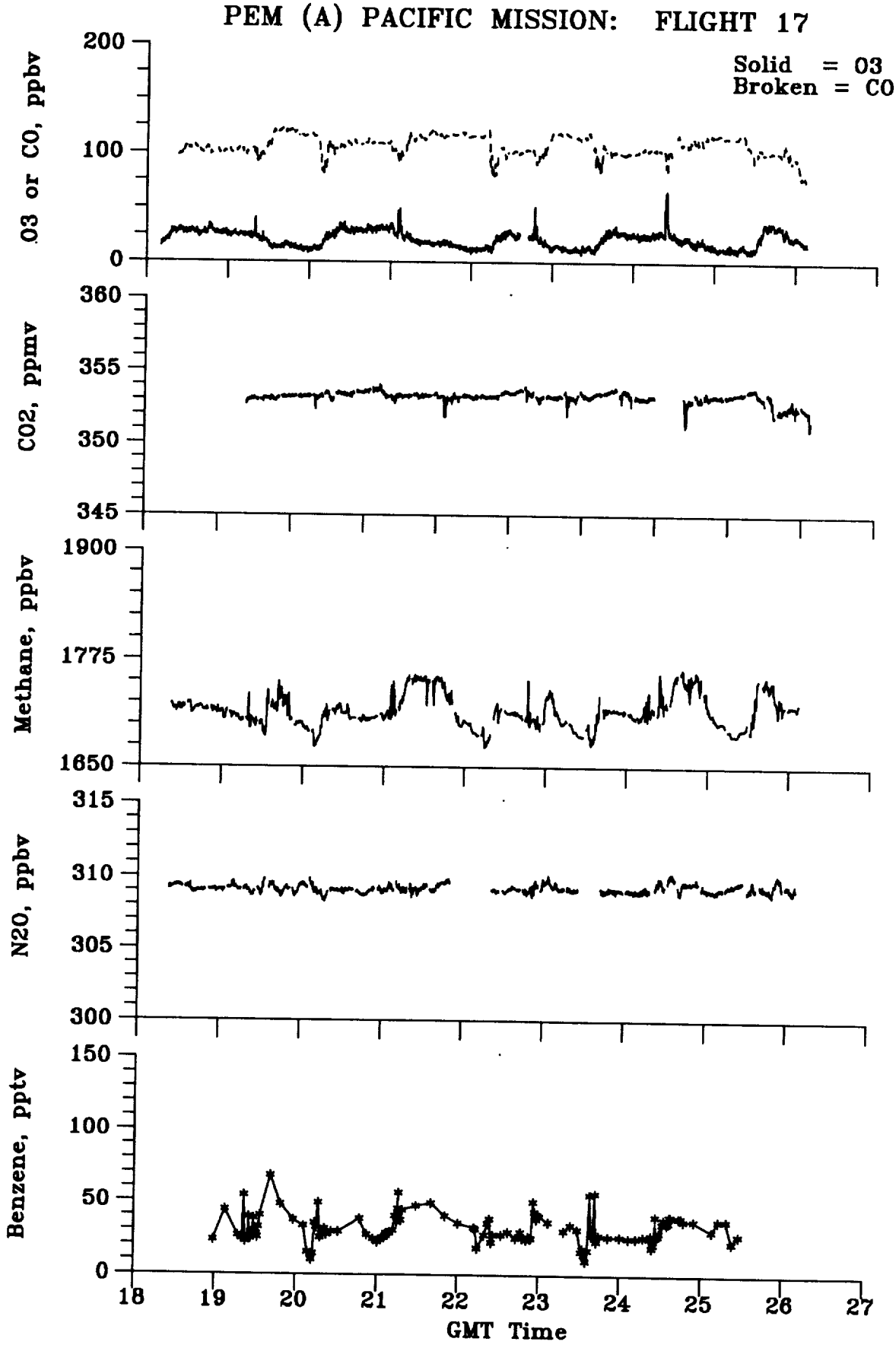

PEM (A) PACIFIC MISSION: FLIGHT 17
Solid = 03
Broken = CO
03 or CO, ppbv
200
100
0
CO2, ppmv
360
355
350
345
Methane, ppbv
1900
1775
1650
N2O, ppbv
315
310
305
300
Benzene, pptv
150
100
50
0
18
19
20
21
22
23
24
25
26
27
GMT Time

Figure A17.2

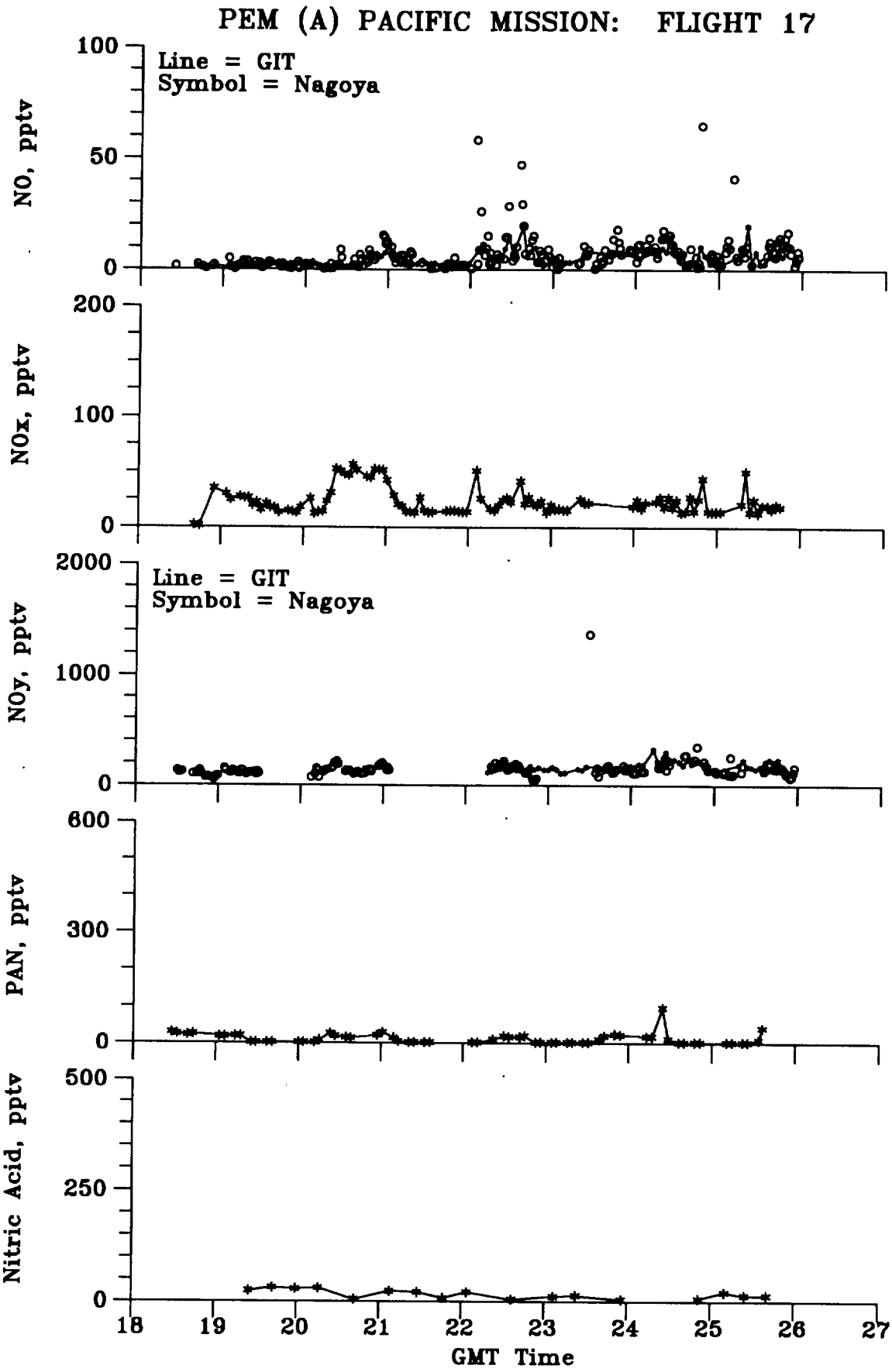

PEM (A) PACIFIC MISSION: FLIGHT 17
Line = GIT
Symbol = Nagoya
NO, pptv
100
50
0
NOx, pptv
200
100
0
Line = GIT
Symbol = Nagoya
NOy, pptv
2000
1000
0
PAN, pptv
600
300
0
Nitric Acid, pptv
500
250
0
18
19
20
21
22
23
24
25
26
27
GMT Time

Figure A17.3

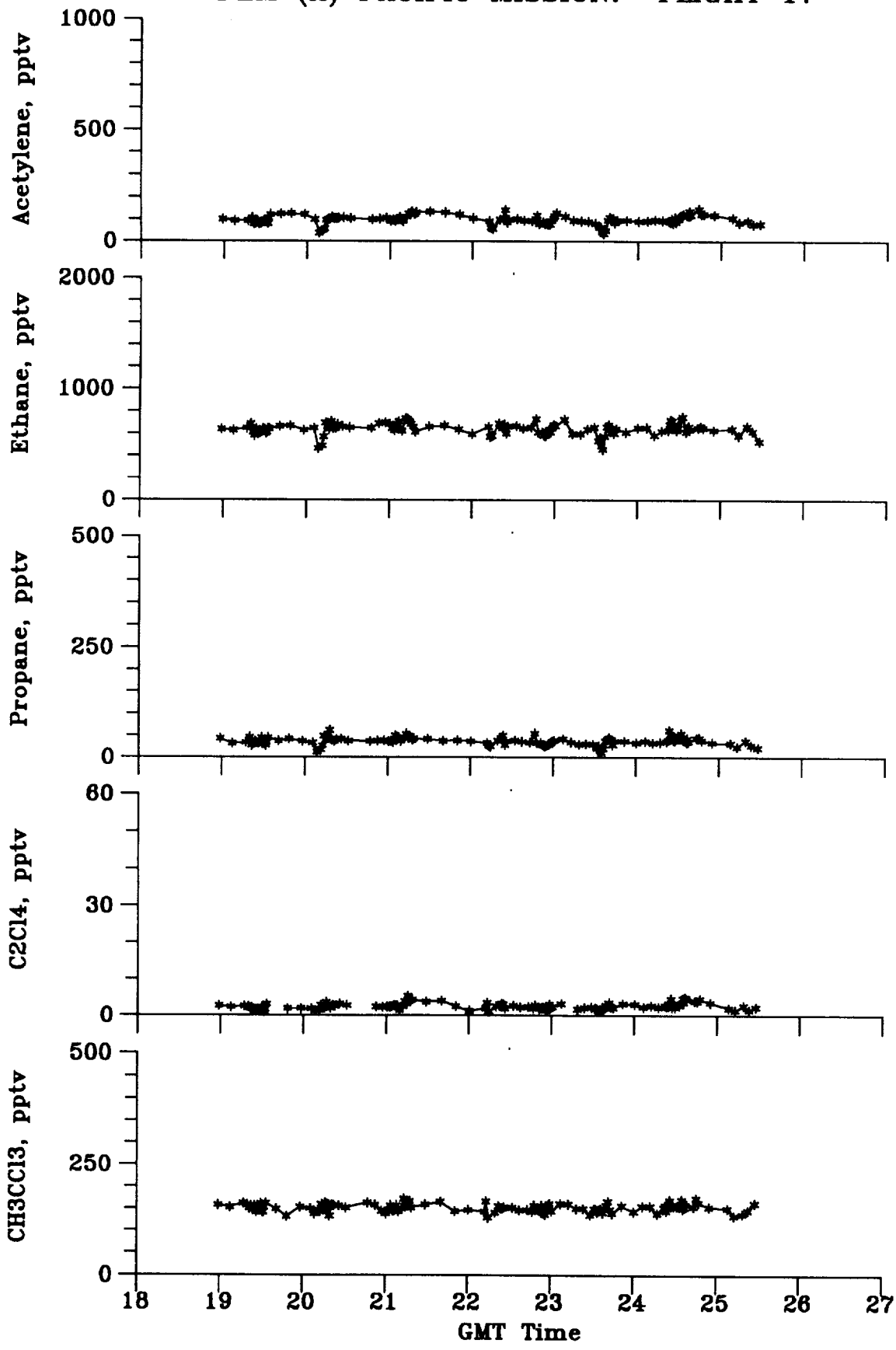

PEM (A) PACIFIC MISSION: FLIGHT 17
Acetylene, pptv
1000
500
0
Ethane, pptv
2000
1000
0
Propane, pptv
500
250
0
C2Cl4, pptv
60
30
0
CH3CCl3, pptv
500
250
0
18
19
20
21
22
23
24
25
26
27
GMT Time

Figure A17.4

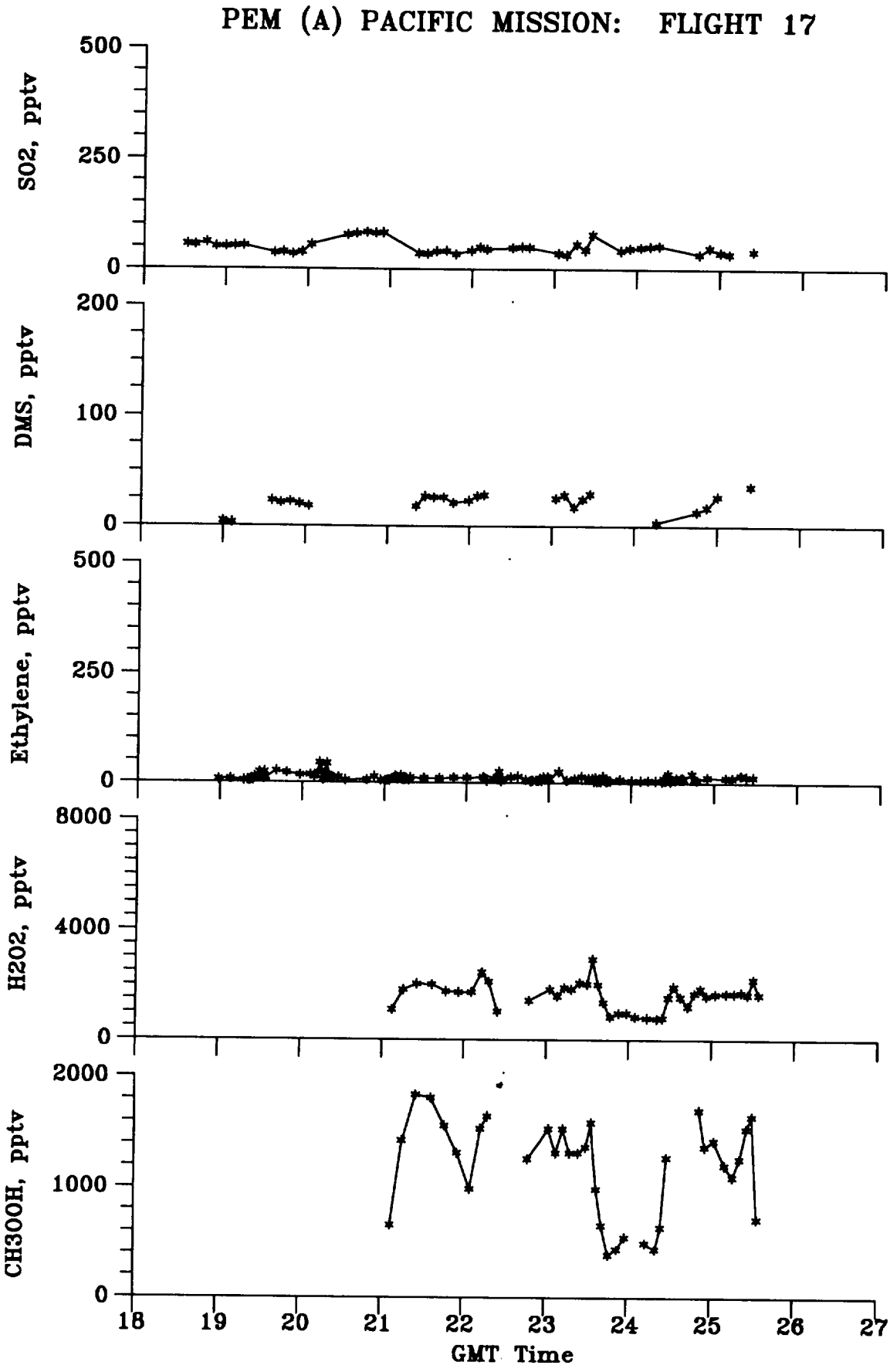

PEM (A) PACIFIC MISSION: FLIGHT 17
SO2, pptv
500
250
0
DMS, pptv
200
100
0
Ethylene, pptv
500
250
0
H2O2, pptv
8000
4000
0
CH3OOH, pptv
2000
1000
0
18
19
20
21
22
23
24
25
26
27
GMT Time

Figure A17.5

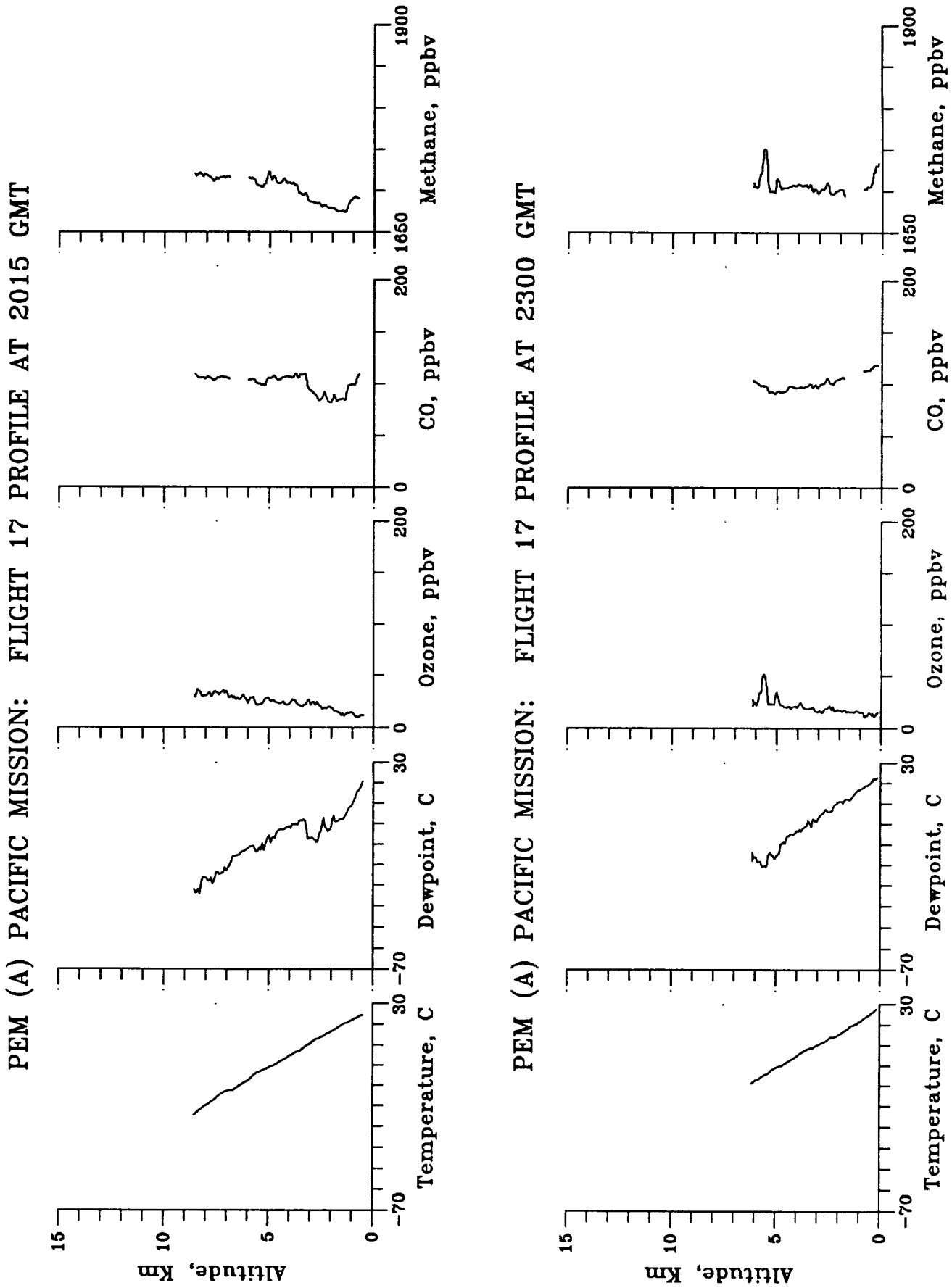

PEM (A) PACIFIC MISSION: FLIGHT 17 PROFILE AT 2015 GMT
PEM (A) PACIFIC MISSION: FLIGHT 17 PROFILE AT 2300 GMT
Altitude, Km
Temperature, C
Dewpoint, C
Ozone, ppbv
CO, ppbv
Methane, ppbv

Figure A17.6

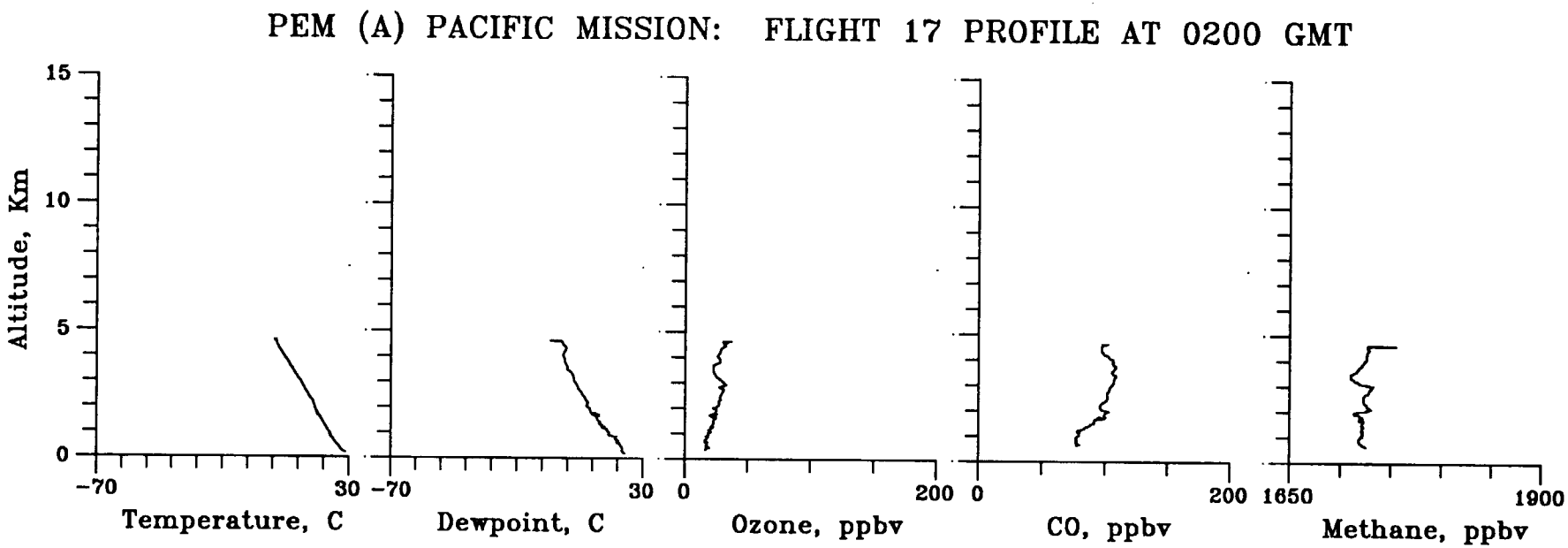

PEM (A) PACIFIC MISSION: FLIGHT 17 PROFILE AT 0200 GMT
Altitude, Km
15
10
5
0
-70
30
Temperature, C
-70
30
Dewpoint, C
0
200
Ozone, ppbv
0
200
CO, ppbv
1650
1900
Methane, ppbv

Figure A17.7

PEM (A) PACIFIC MISSION: FLIGHT 18

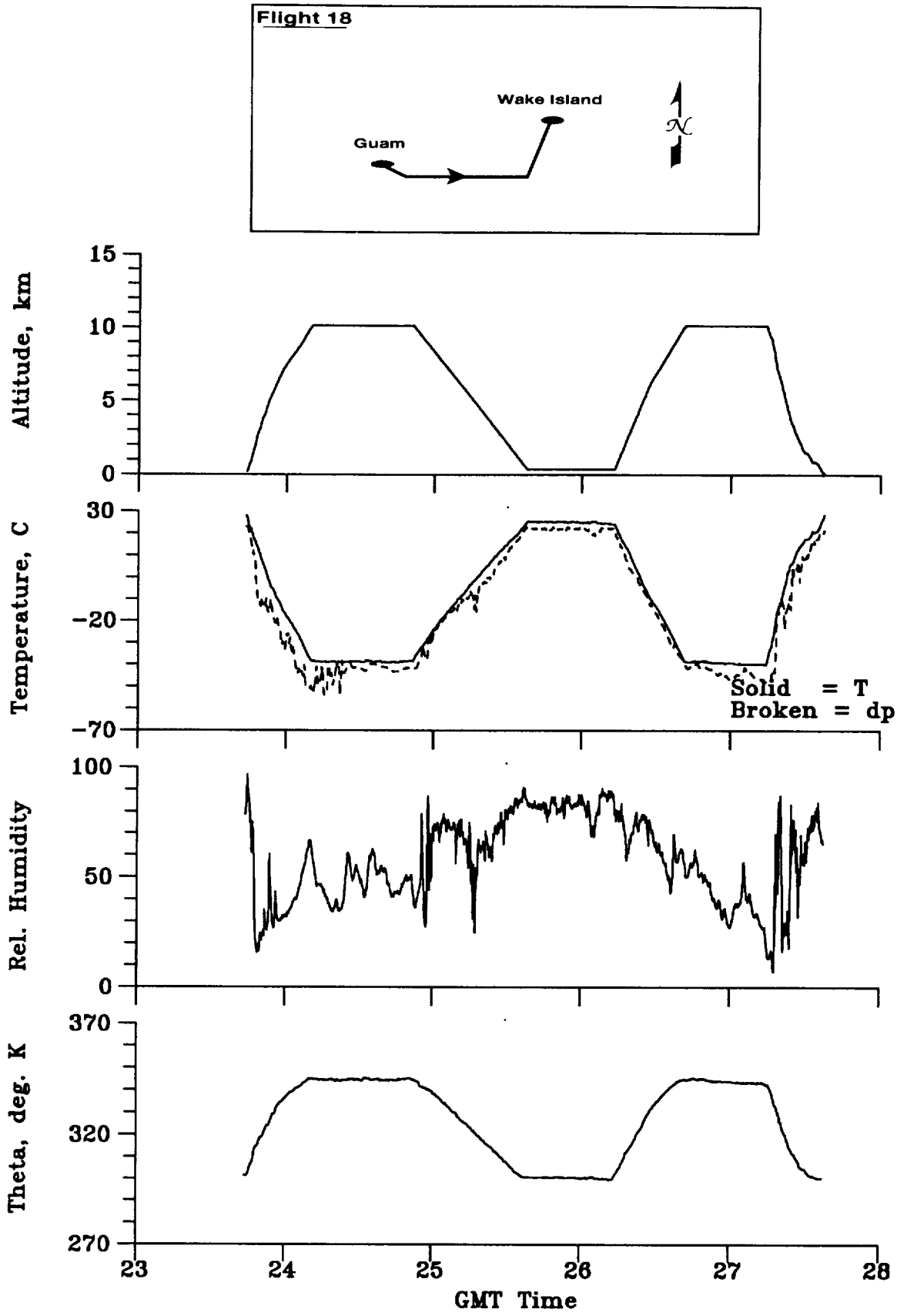


Figure A18.1

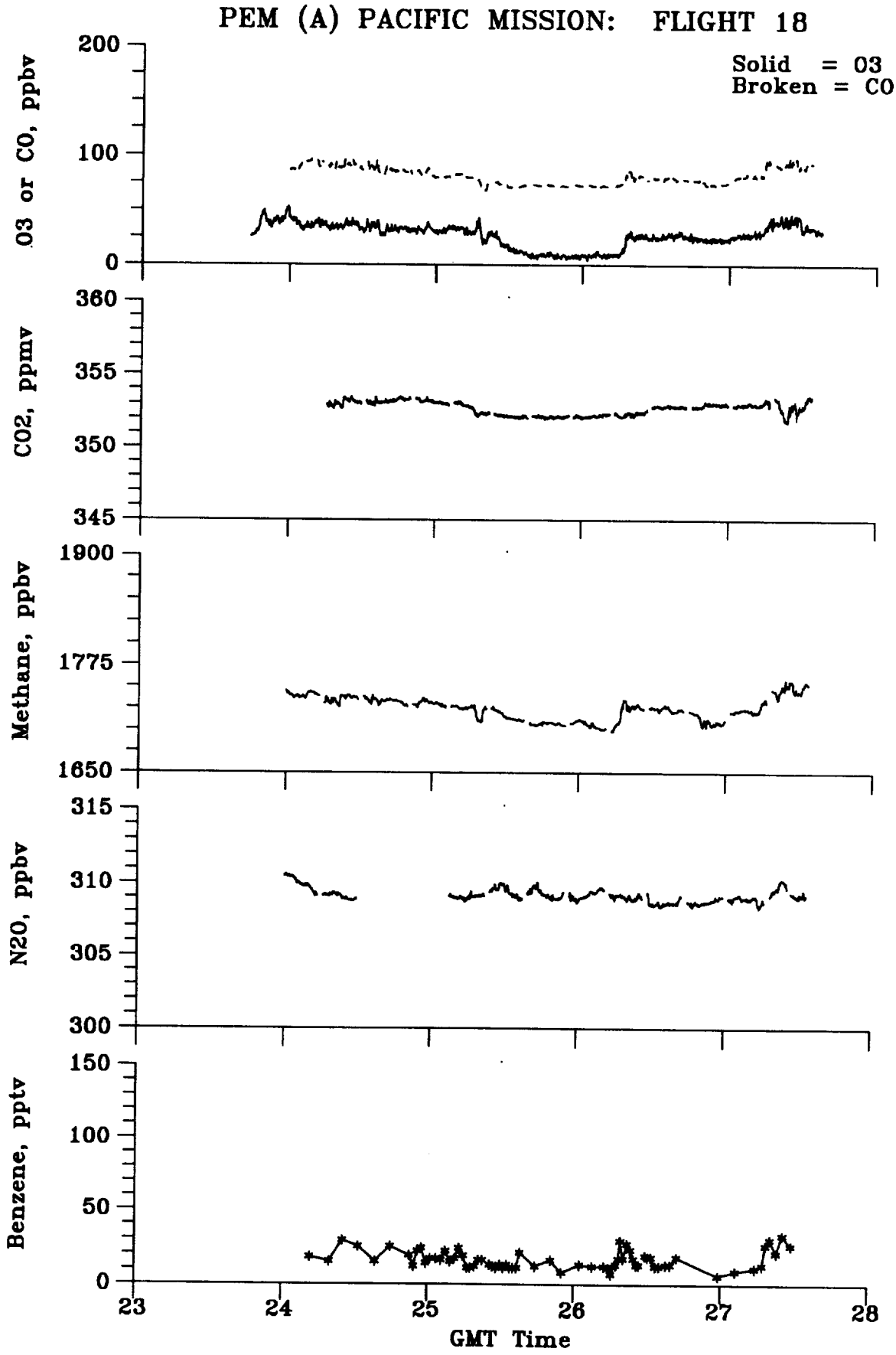

PEM (A) PACIFIC MISSION: FLIGHT 18
Solid = 03
Broken = CO
03 or CO, ppbv
200
100
0
CO2, ppmv
360
355
350
345
Methane, ppbv
1900
1775
1650
N2O, ppbv
315
310
305
300
Benzene, pptv
150
100
50
0
23
24
25
26
27
28
GMT Time

Figure A18.2

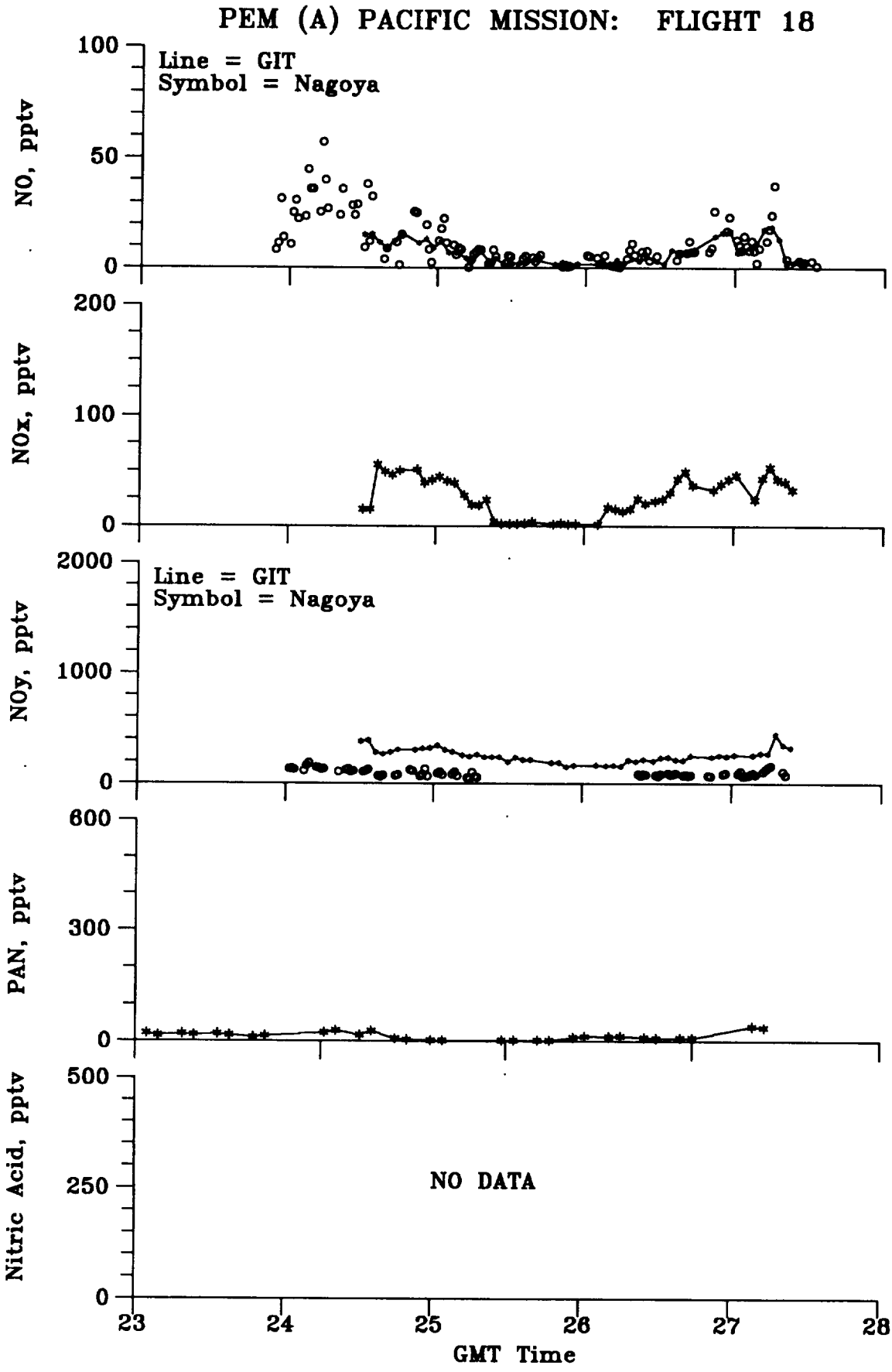

PEM (A) PACIFIC MISSION: FLIGHT 18
Line = GIT
Symbol = Nagoya
NO, pptv
100
50
0
NOx, pptv
200
100
0
Line = GIT
Symbol = Nagoya
NOy, pptv
2000
1000
0
PAN, pptv
600
300
0
Nitric Acid, pptv
500
250
0
NO DATA
23
24
25
26
27
28
GMT Time

Figure A18.3

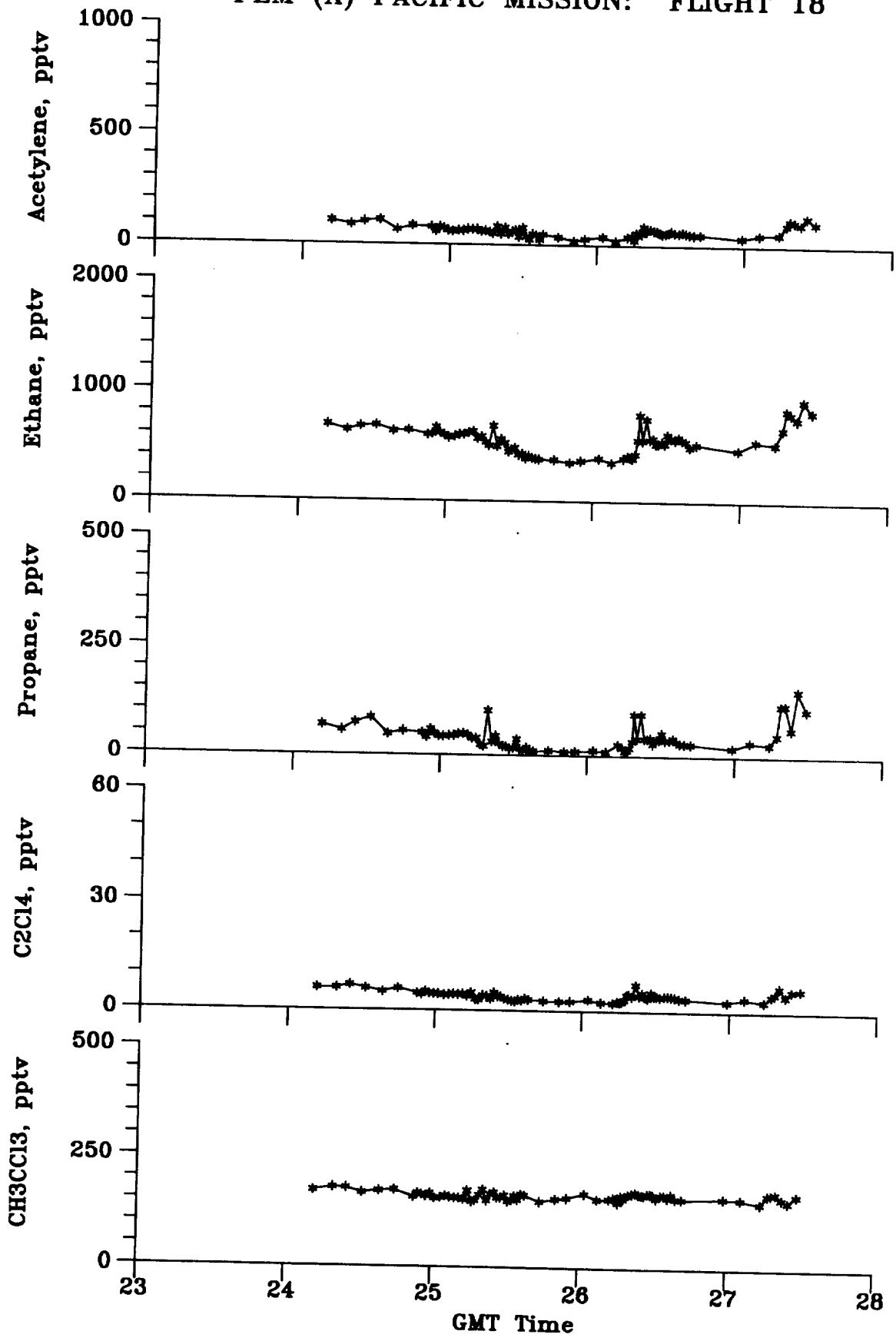

PEM (A) PACIFIC MISSION: FLIGHT 18
Acetylene, pptv
1000
500
0
Ethane, pptv
2000
1000
0
Propane, pptv
500
250
0
C2Cl4, pptv
60
30
0
CH3CCl3, pptv
500
250
0
23
24
25
26
27
28
GMT Time

Figure A18.4

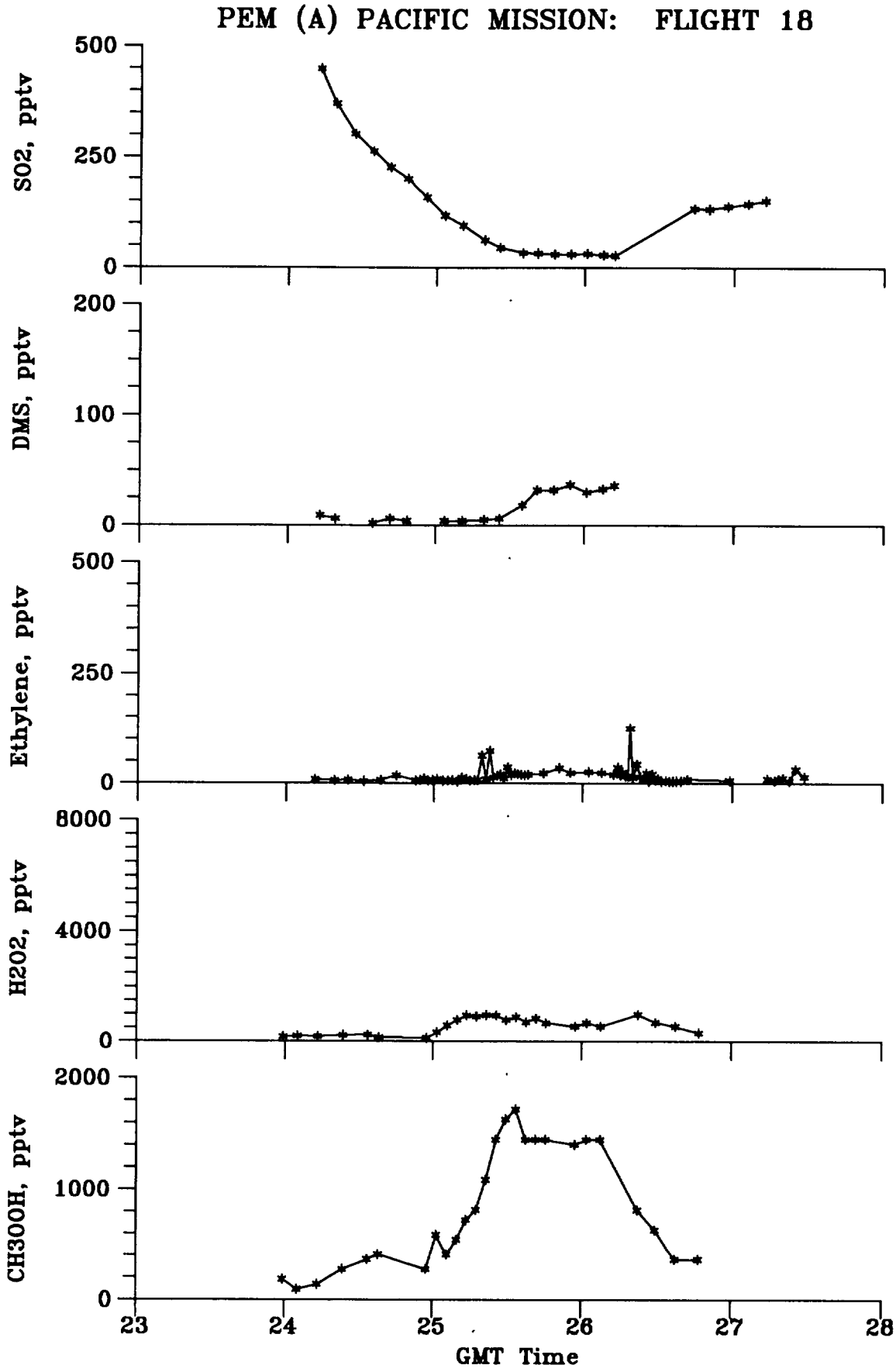
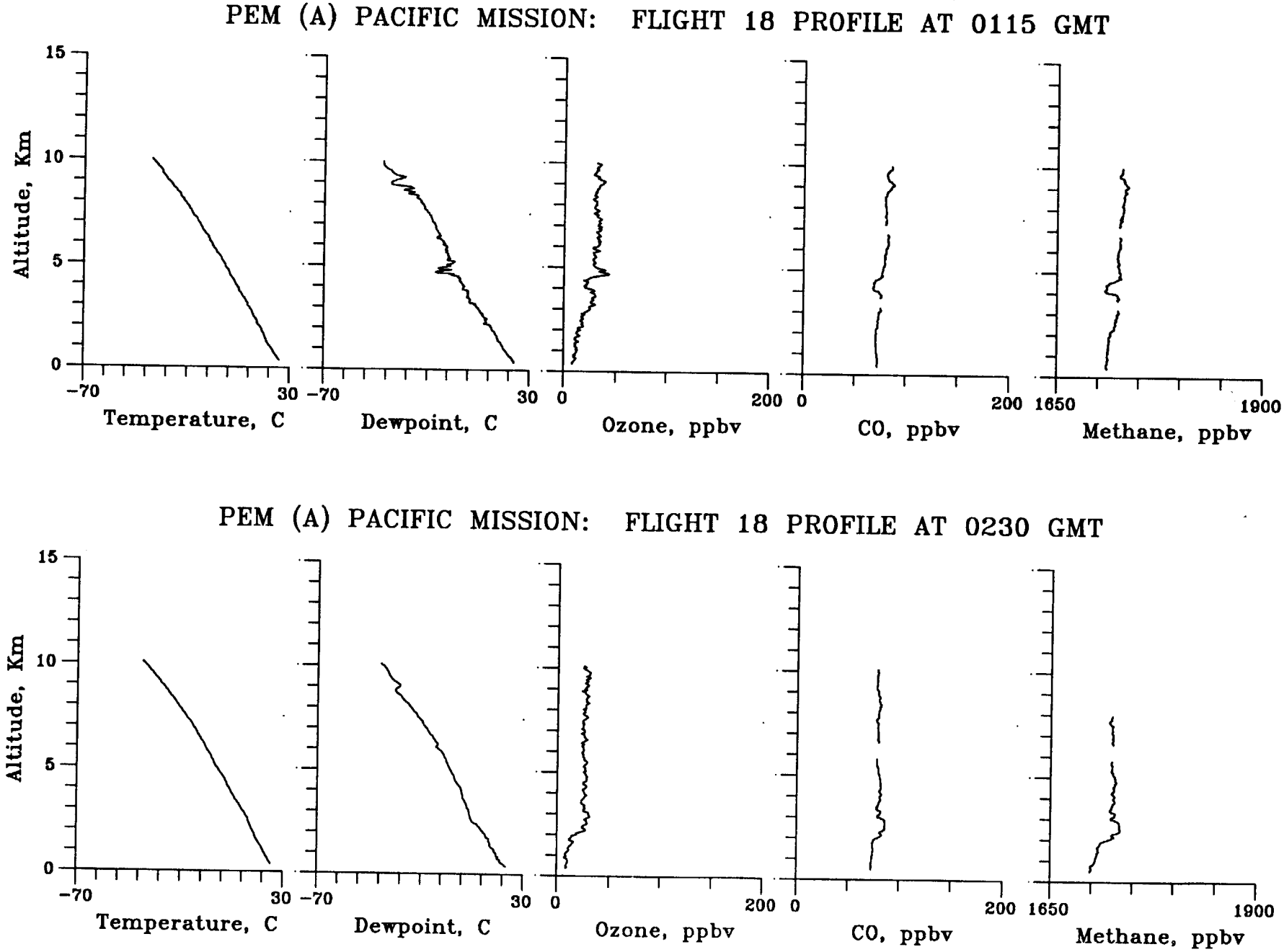

PEM (A) PACIFIC MISSION: FLIGHT 18
SO2, pptv
500
250
0
DMS, pptv
200
100
0
Ethylene, pptv
500
250
0
H2O2, pptv
8000
4000
0
CH3OOH, pptv
2000
1000
0
23
24
25
26
27
28
GMT Time

Figure A18.5

Figure A18.6


PEM (A) PACIFIC MISSION: FLIGHT 18 PROFILE AT 0115 GMT
Altitude, Km
15
10
5
0
−70
30
Temperature, C
Dewpoint, C
0
200
Ozone, ppbv
CO, ppbv
1650
1900
Methane, ppbv
PEM (A) PACIFIC MISSION: FLIGHT 18 PROFILE AT 0230 GMT

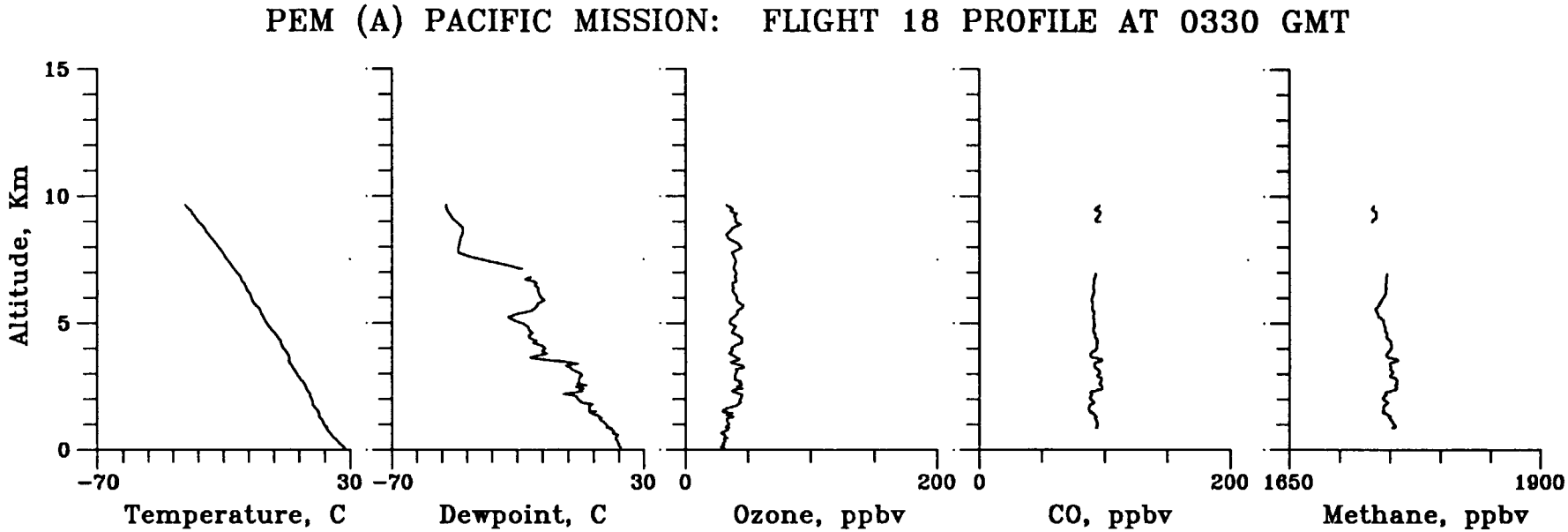

PEM (A) PACIFIC MISSION: FLIGHT 18 PROFILE AT 0330 GMT
Altitude, Km
15
10
5
0
-70
30
Temperature, C
-70
30
Dewpoint, C
0
200
Ozone, ppbv
0
200
CO, ppbv
1650
1900
Methane, ppbv

Figure A18.7

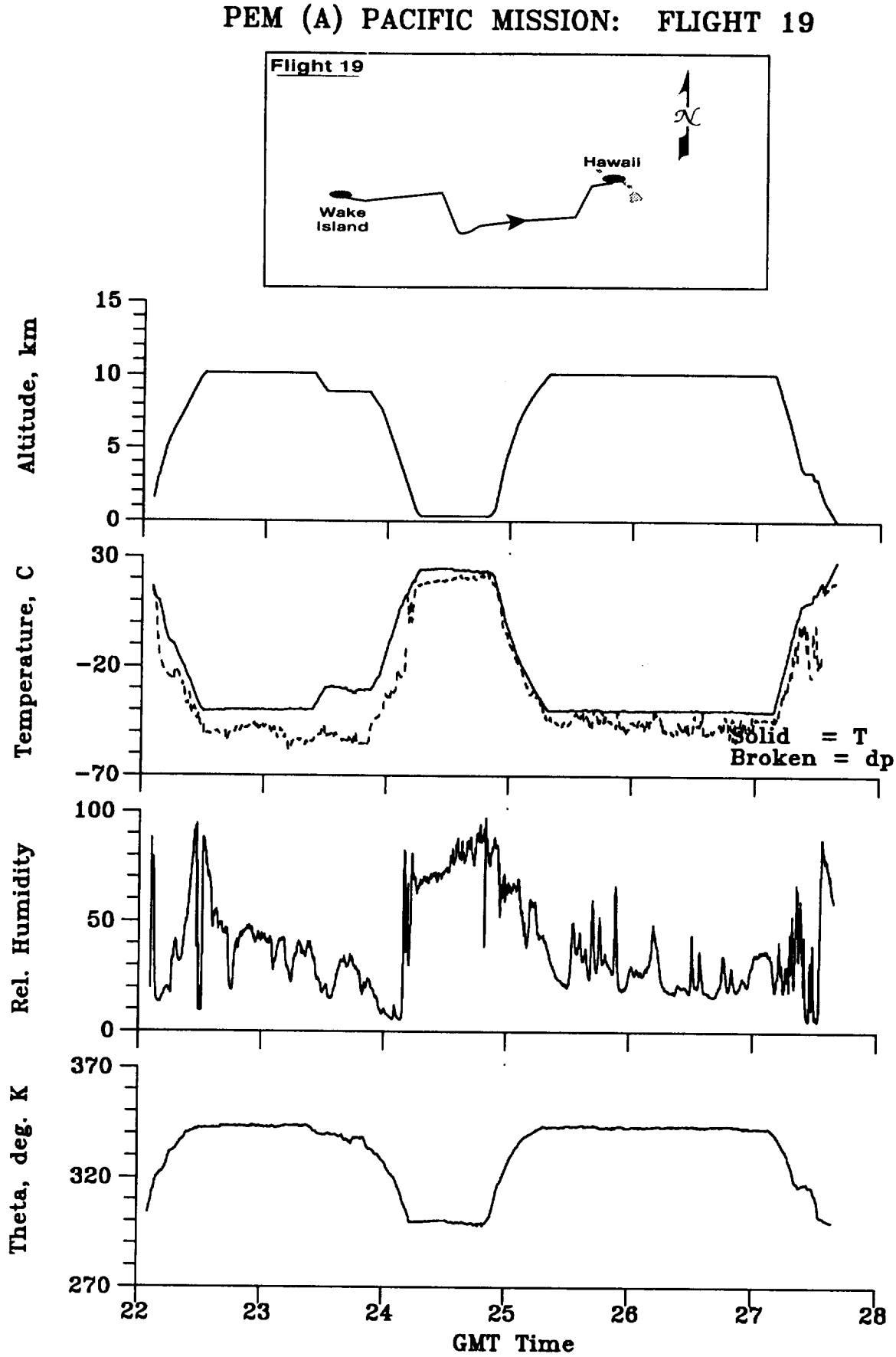


Figure A19.1

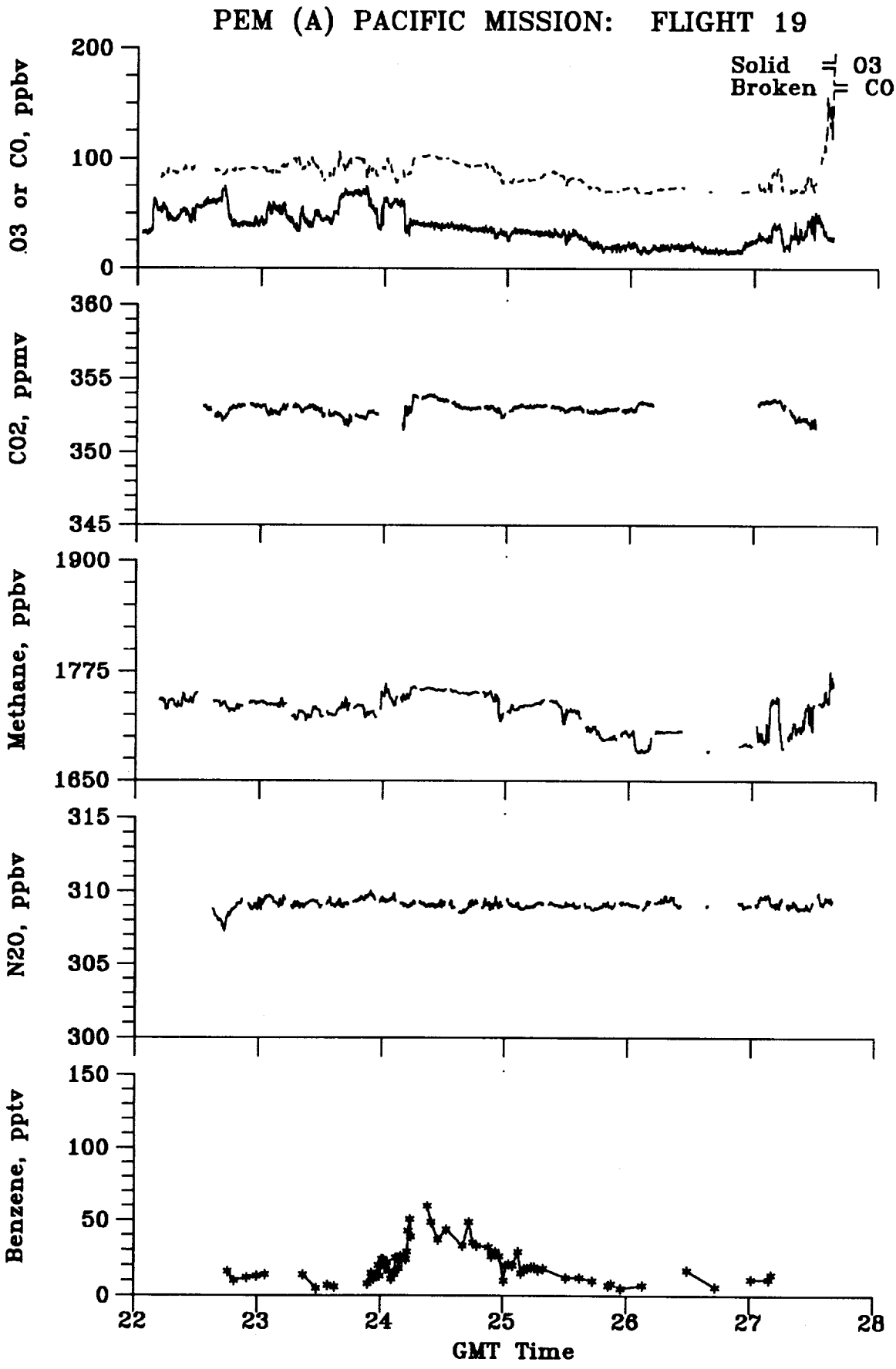

PEM (A) PACIFIC MISSION: FLIGHT 19
Solid 03
Broken CO
03 or CO, ppbv
200
100
0
CO2, ppmv
360
355
350
345
Methane, ppbv
1900
1775
1650
N2O, ppbv
315
310
305
300
Benzene, pptv
150
100
50
0
22
23
24
25
26
27
28
GMT Time

Figure A19.2

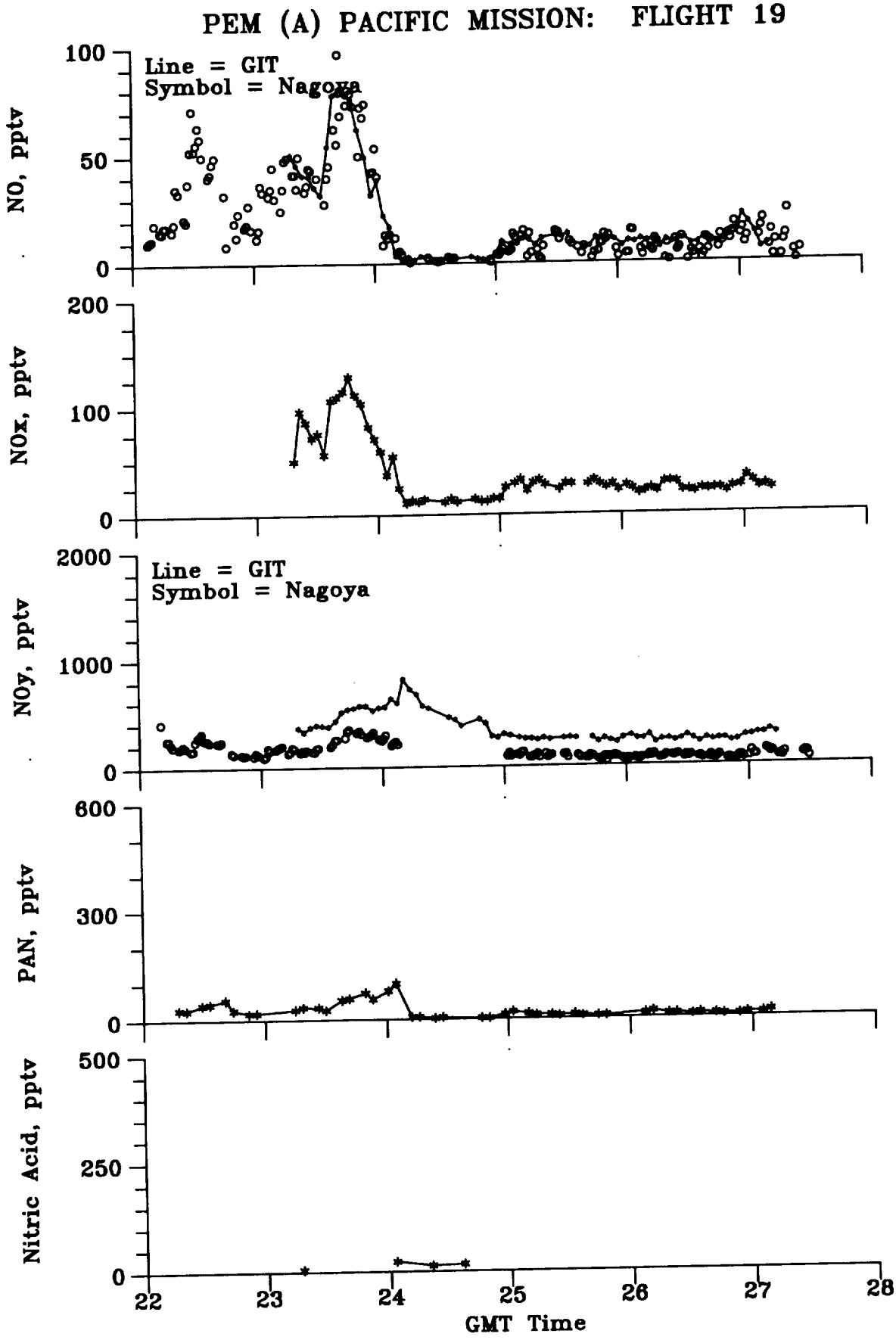

PEM (A) PACIFIC MISSION: FLIGHT 19
Line = GIT
Symbol = Nagoya
NO, pptv
100
50
0
NOx, pptv
200
100
0
Line = GIT
Symbol = Nagoya
NOy, pptv
2000
1000
0
PAN, pptv
600
300
0
Nitric Acid, pptv
500
250
0
22
23
24
25
26
27
28
GMT Time

Figure A19.3

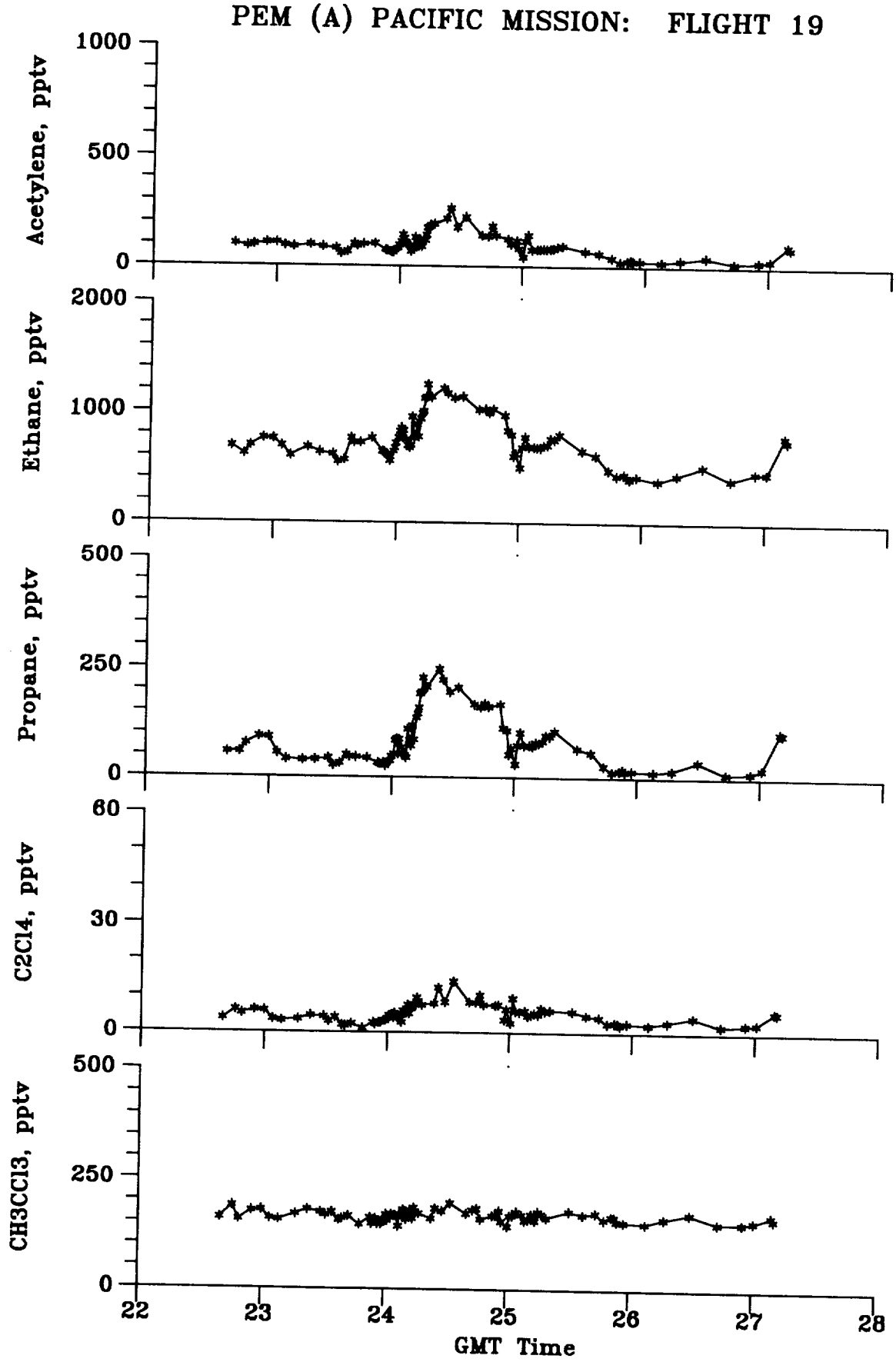

PEM (A) PACIFIC MISSION: FLIGHT 19
Acetylene, pptv
1000
500
0
Ethane, pptv
2000
1000
0
Propane, pptv
500
250
0
C2Cl4, pptv
60
30
0
CH3CCl3, pptv
500
250
0
22
23
24
25
26
27
28
GMT Time

Figure A19.4

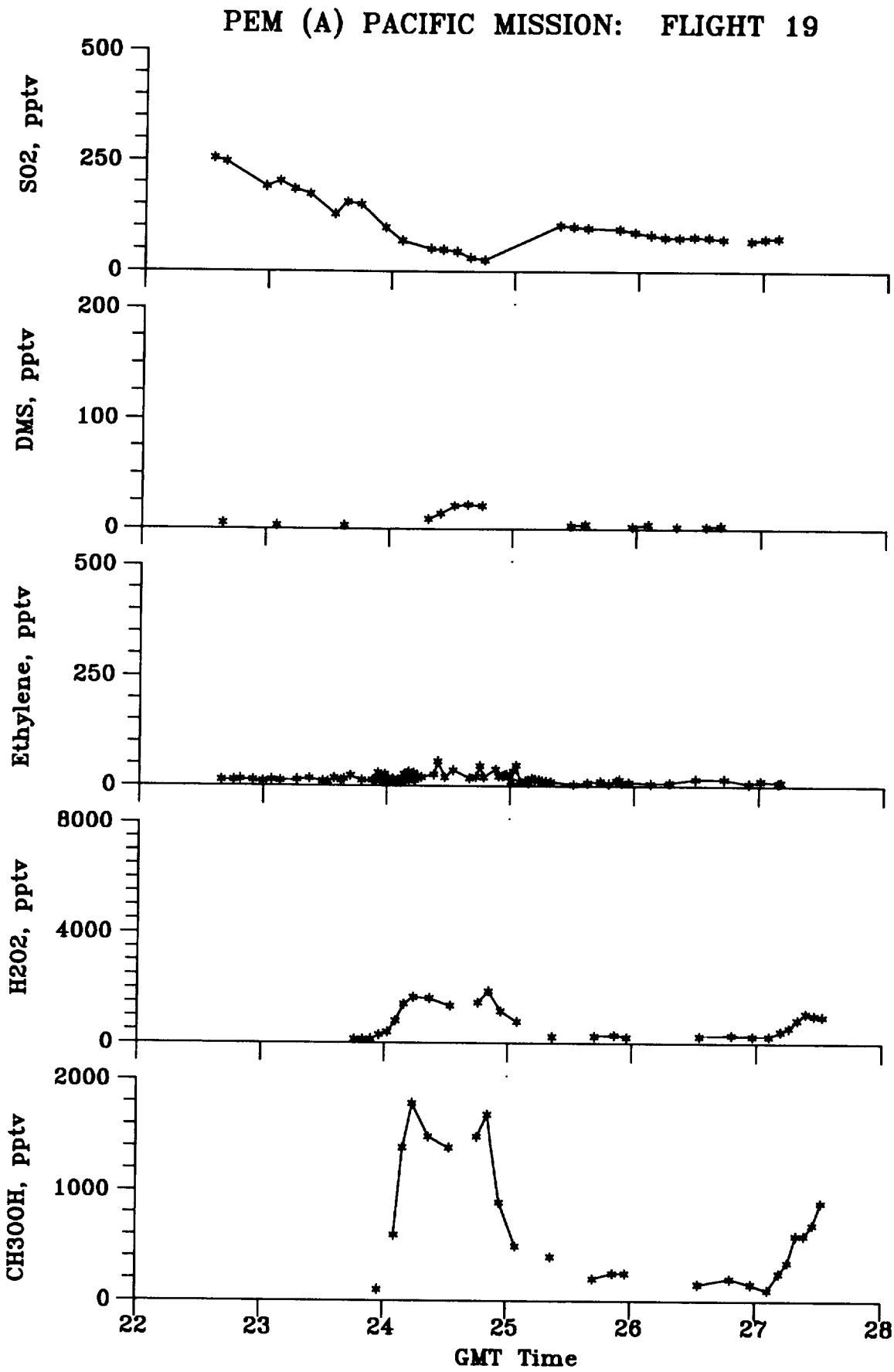
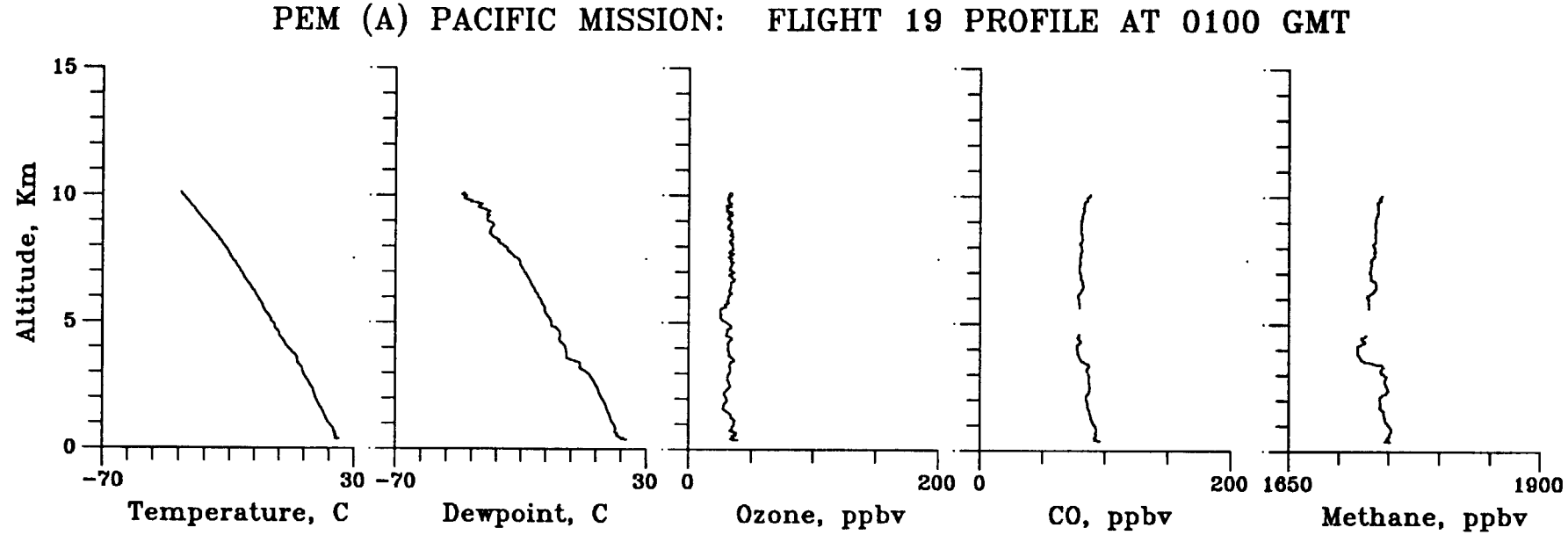
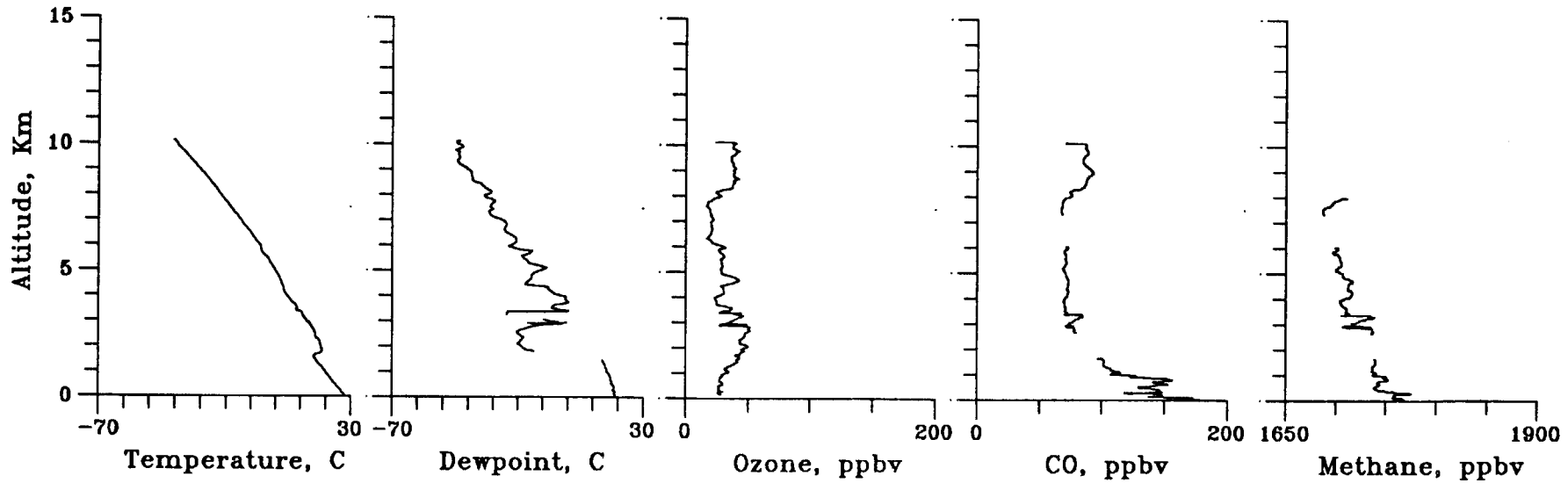

PEM (A) PACIFIC MISSION: FLIGHT 19
SO2, pptv
500
250
0
DMS, pptv
200
100
0
Ethylene, pptv
500
250
0
H2O2, pptv
8000
4000
0
CH3OOH, pptv
2000
1000
0
22
23
24
25
26
27
28
GMT Time

Figure A19.5

Figure A19.6


PEM (A) PACIFIC MISSION: FLIGHT 19 PROFILE AT 0100 GMT
Altitude, Km
15
10
5
0
-70
30
Temperature, C
Dewpoint, C
0
200
Ozone, ppbv
CO, ppbv
1650
1900
Methane, ppbv


PEM (A) PACIFIC MISSION: FLIGHT 19 PROFILE AT 0315 GMT
Altitude, Km
15
10
5
0
-70
30
Temperature, C
Dewpoint, C
0
200
Ozone, ppbv
CO, ppbv
1650
1900
Methane, ppbv

PEM (A) PACIFIC MISSION: FLIGHT 20

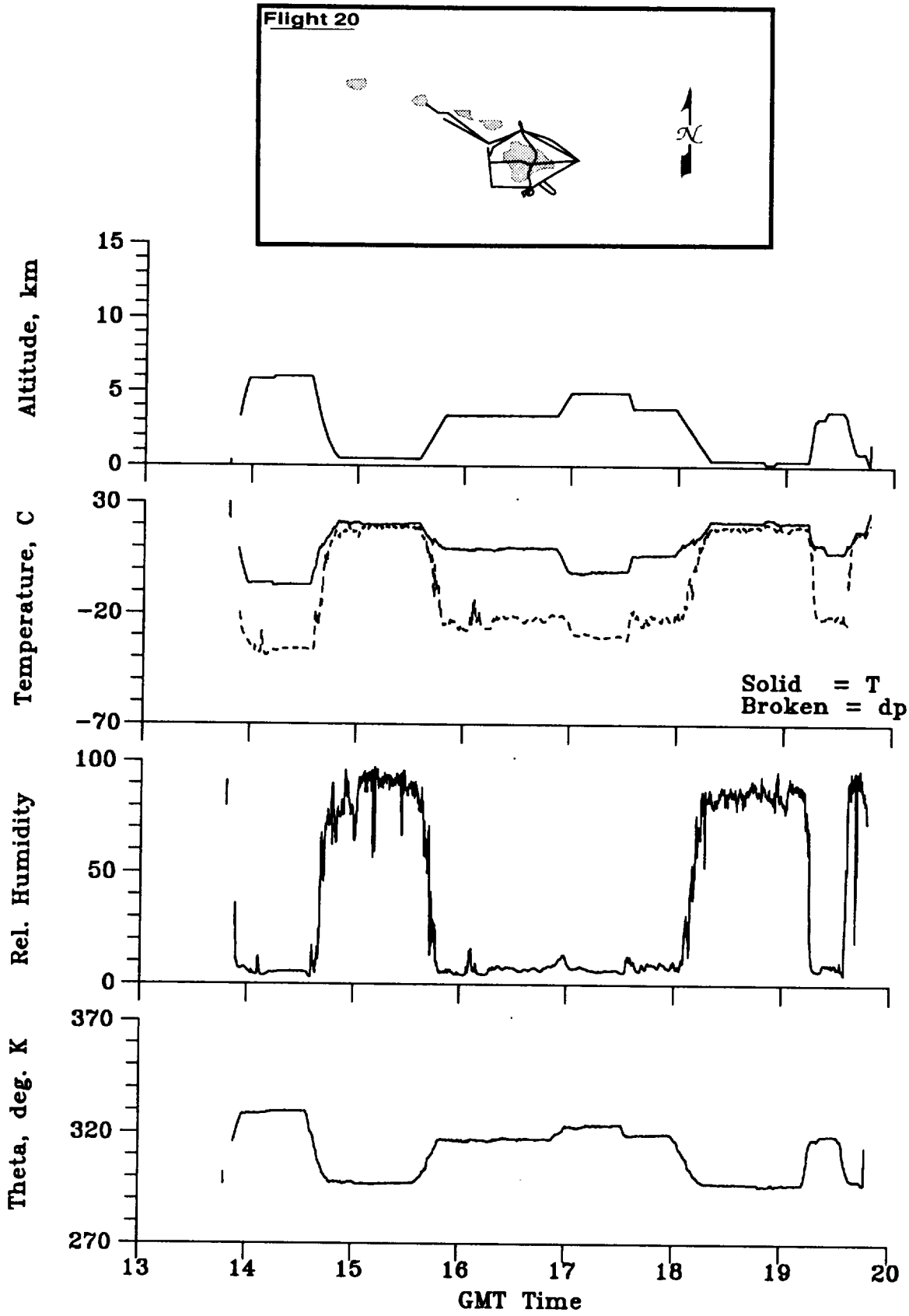


Figure A20.1

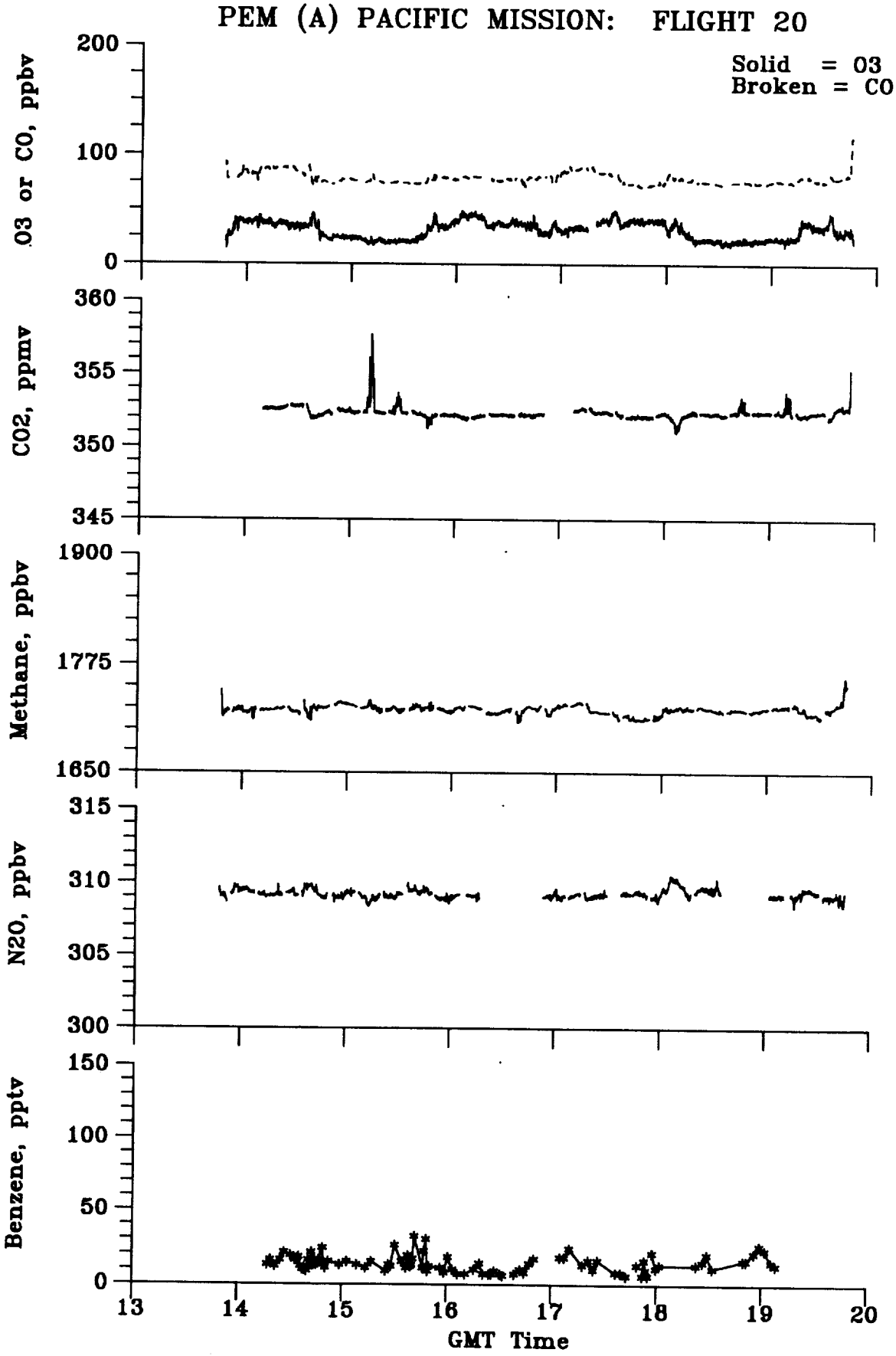

PEM (A) PACIFIC MISSION: FLIGHT 20
Solid = 03
Broken = CO
03 or CO, ppbv
200
100
0
CO2, ppmv
360
355
350
345
Methane, ppbv
1900
1775
1650
N2O, ppbv
315
310
305
300
Benzene, pptv
150
100
50
0
13
14
15
16
17
18
19
20
GMT Time

Figure A20.2

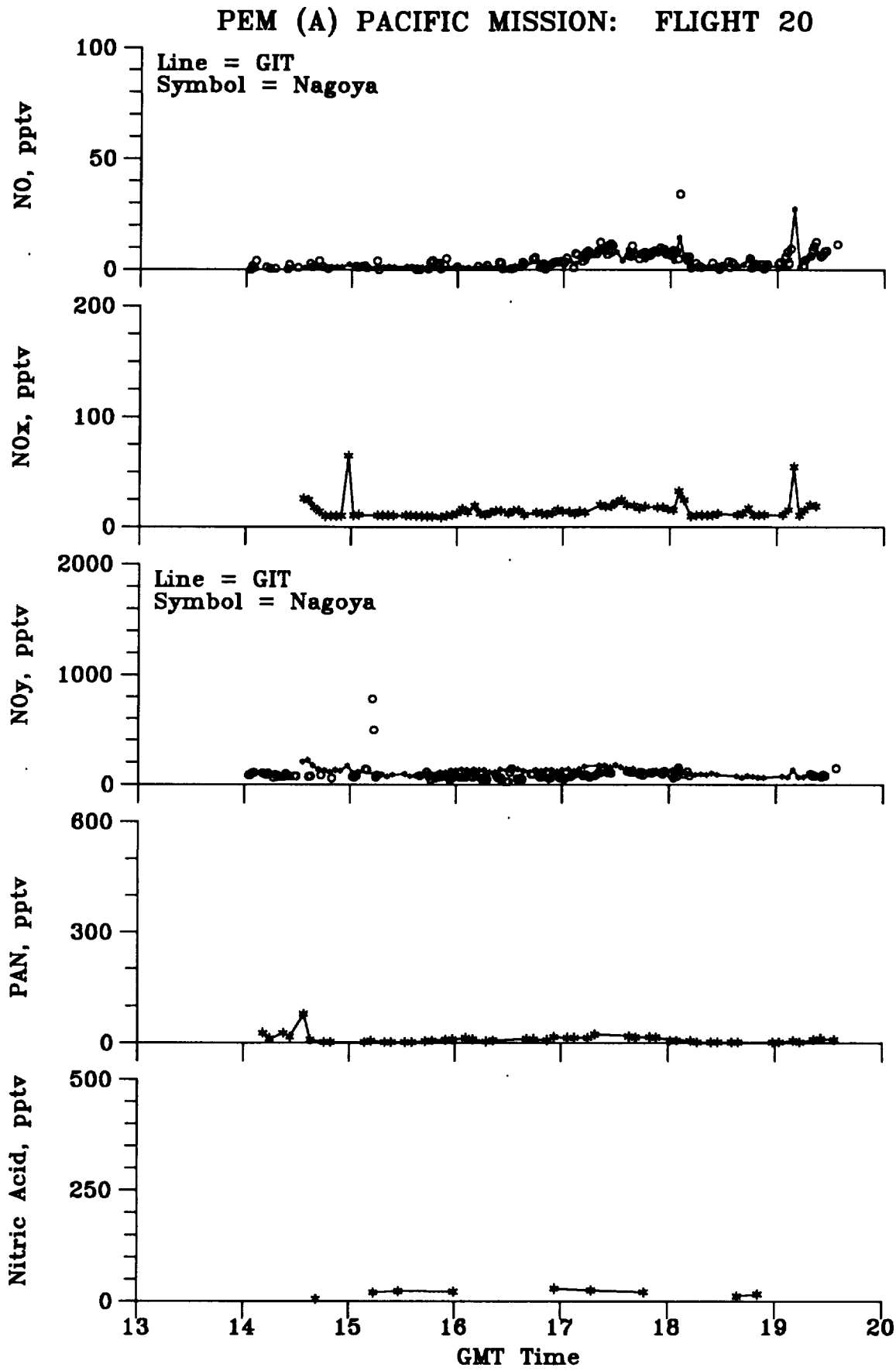

PEM (A) PACIFIC MISSION: FLIGHT 20
Line = GIT
Symbol = Nagoya
NO, pptv
100
50
0
NOx, pptv
200
100
0
Line = GIT
Symbol = Nagoya
NOy, pptv
2000
1000
0
PAN, pptv
600
300
0
Nitric Acid, pptv
500
250
0
13
14
15
16
17
18
19
20
GMT Time

Figure A20.3

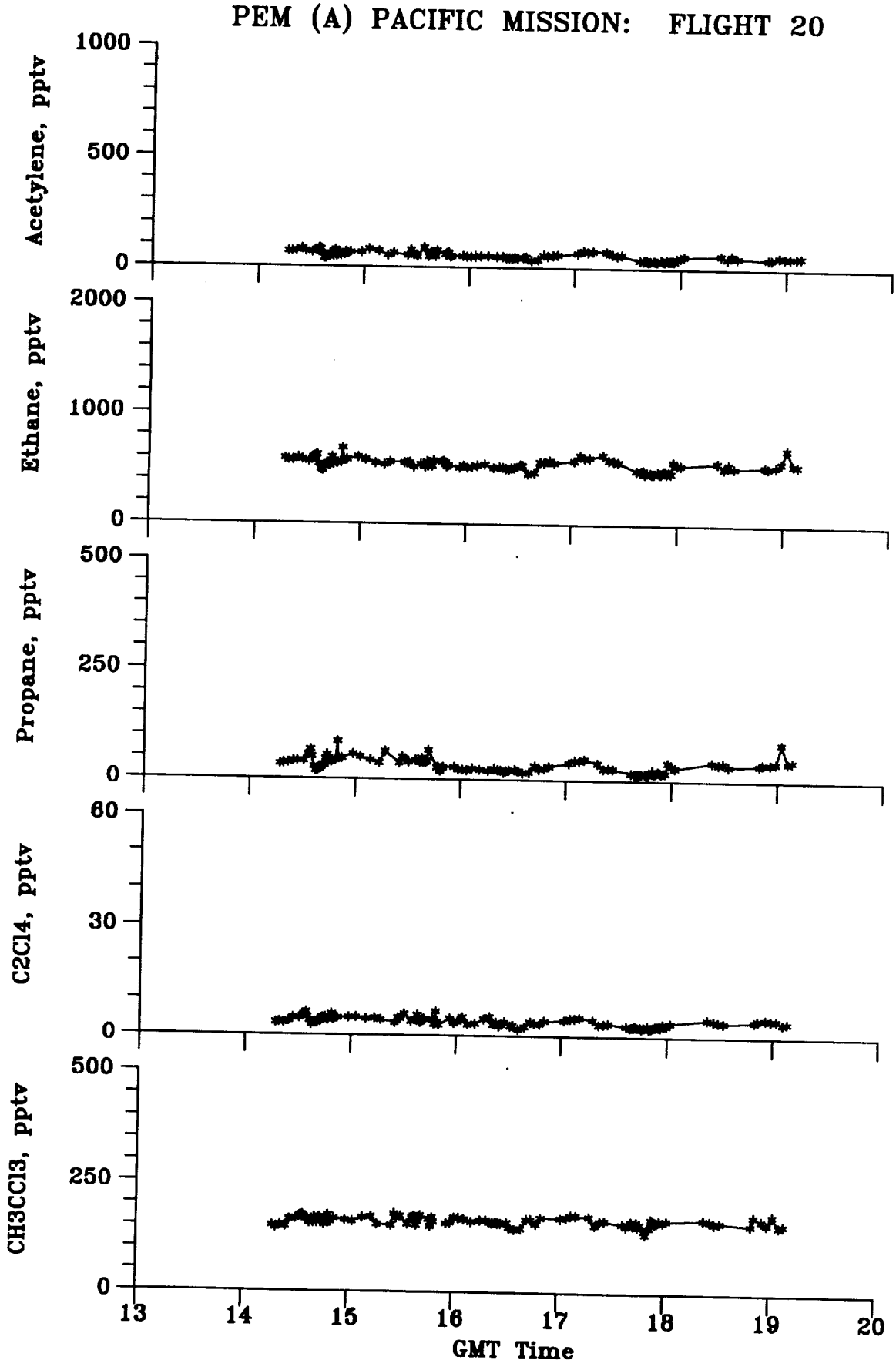

PEM (A) PACIFIC MISSION: FLIGHT 20
Acetylene, pptv
1000
500
0
Ethane, pptv
2000
1000
0
Propane, pptv
500
250
0
C2Cl4, pptv
60
30
0
CH3CCl3, pptv
500
250
0
13
14
15
16
17
18
19
20
GMT Time

Figure A20.4

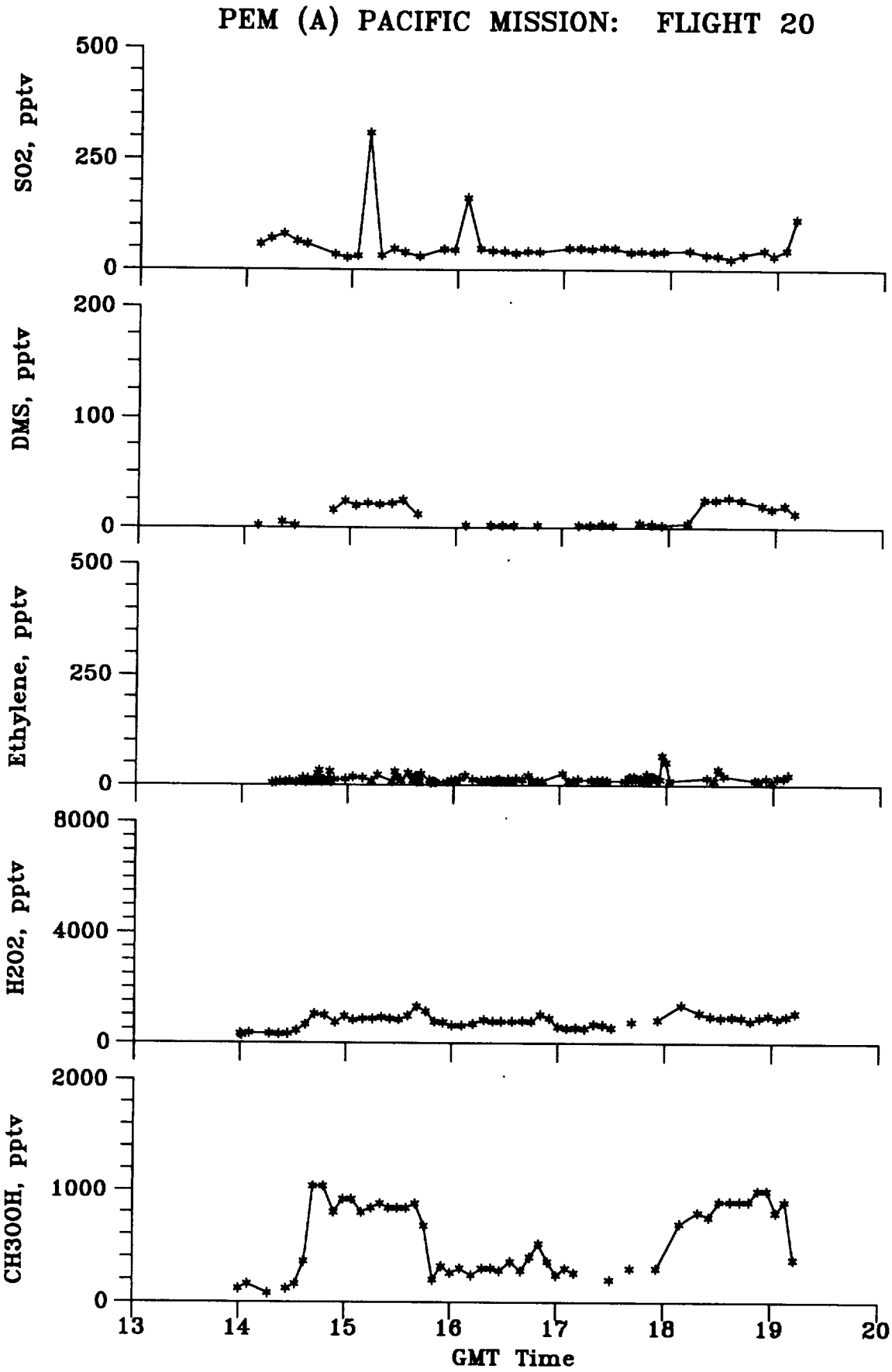

PEM (A) PACIFIC MISSION: FLIGHT 20
SO2, pptv
500
250
0
DMS, pptv
200
100
0
Ethylene, pptv
500
250
0
H2O2, pptv
8000
4000
0
CH3OOH, pptv
2000
1000
0
13
14
15
16
17
18
19
20
GMT Time

Figure A20.5

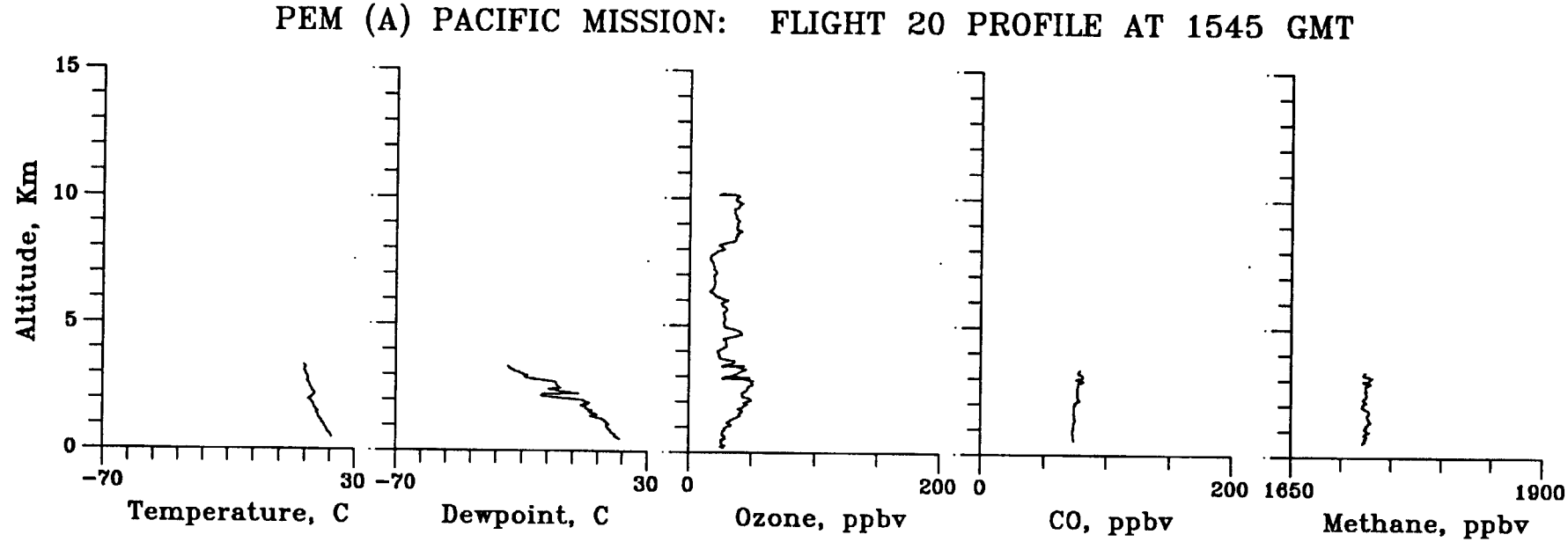

PEM (A) PACIFIC MISSION: FLIGHT 20 PROFILE AT 1545 GMT
Altitude, Km
15
10
5
0
-70
30
Temperature, C
-70
30
Dewpoint, C
0
200
Ozone, ppbv
0
200
CO, ppbv
1650
1900
Methane, ppbv

Figure A20.8

PEM (A) PACIFIC MISSION: FLIGHT 21

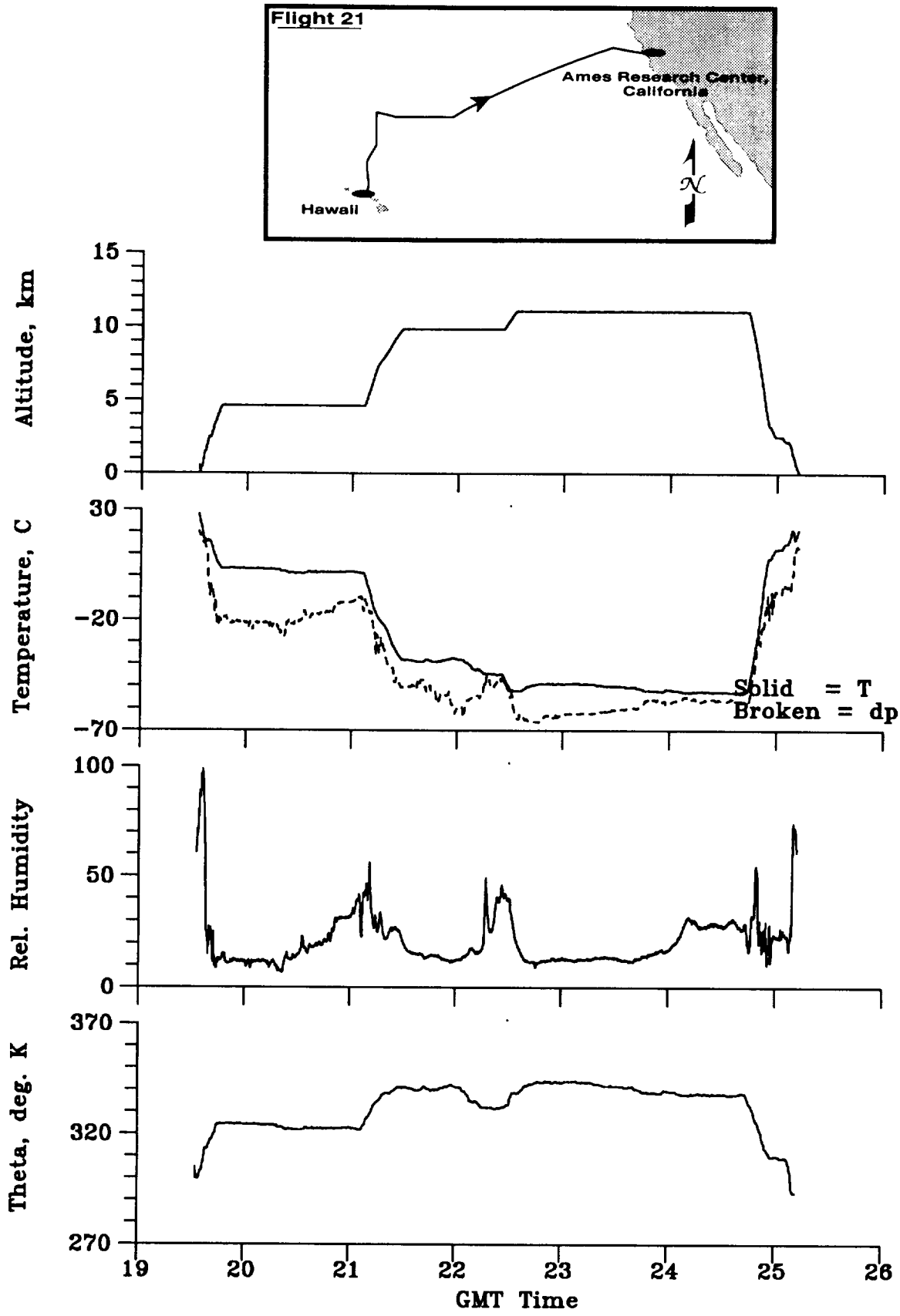


Figure A21.1

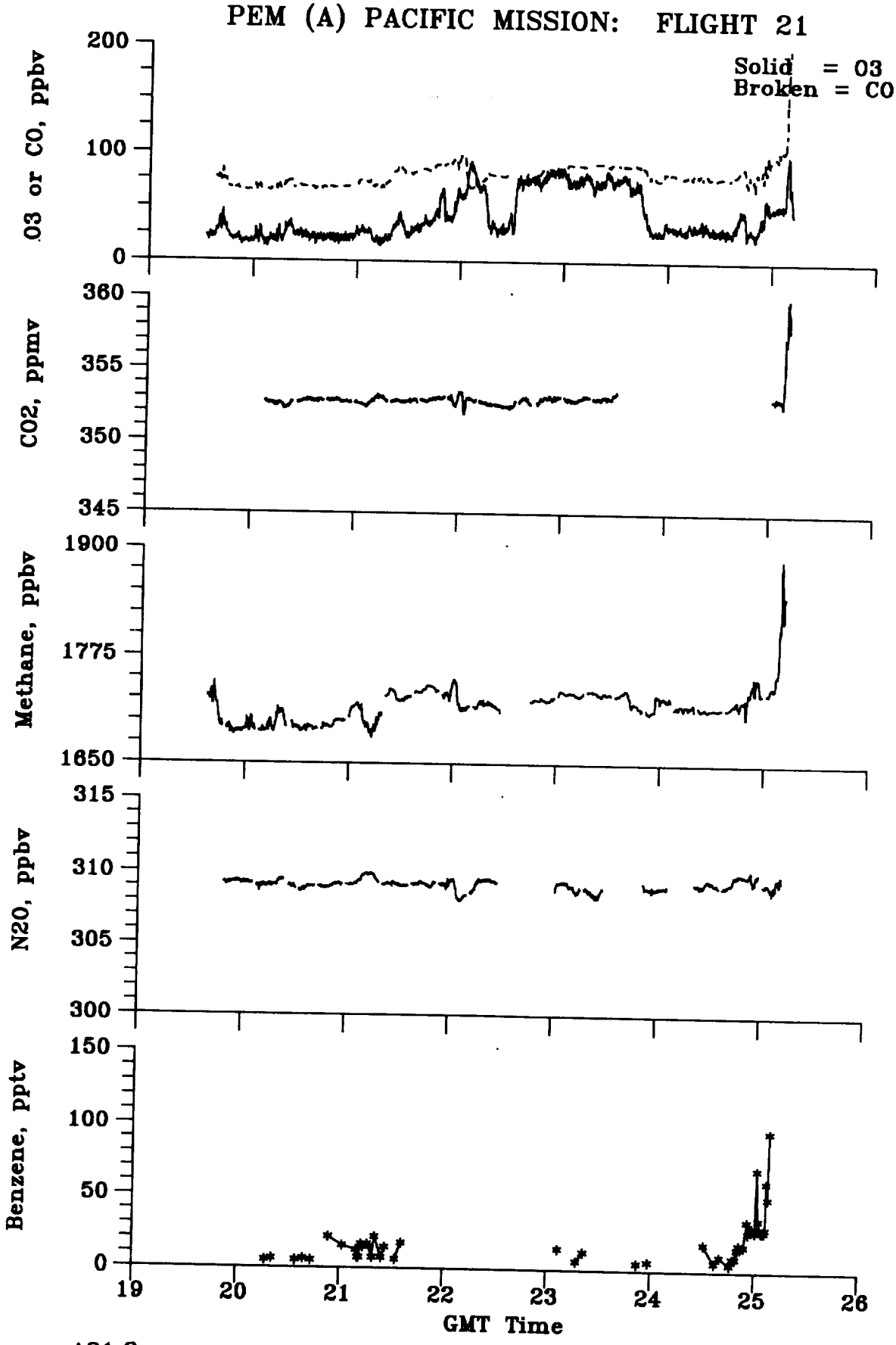

PEM (A) PACIFIC MISSION: FLIGHT 21
Solid = 03
Broken = CO
03 or CO, ppbv
200
100
0
CO2, ppmv
360
355
350
345
Methane, ppbv
1900
1775
1650
N20, ppbv
315
310
305
300
Benzene, pptv
150
100
50
0
19
20
21
22
23
24
25
26
GMT Time

Figure A21.2

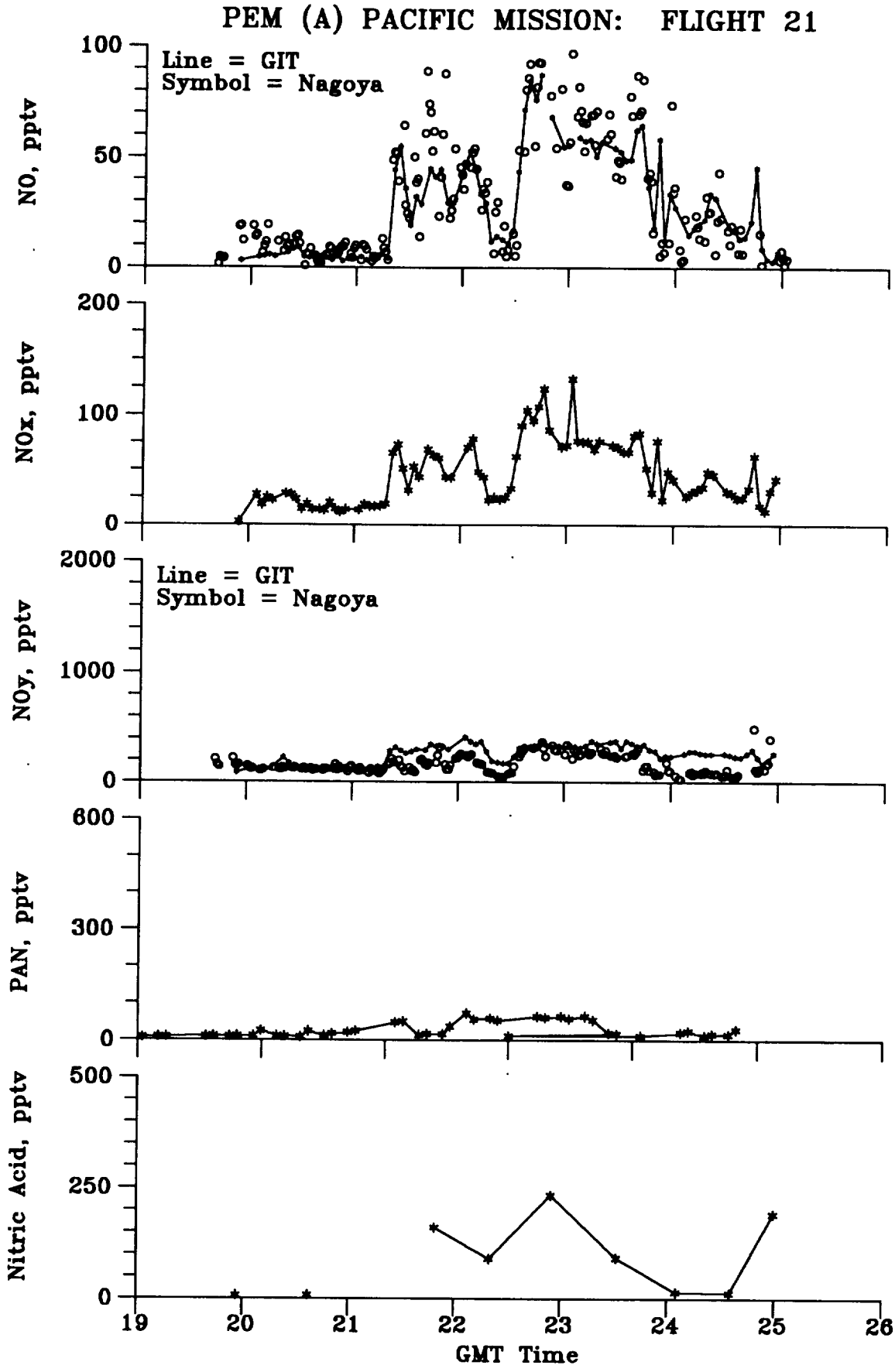

PEM (A) PACIFIC MISSION: FLIGHT 21
Line = GIT
Symbol = Nagoya
NO, pptv
100
50
0
NOx, pptv
200
100
0
Line = GIT
Symbol = Nagoya
NOy, pptv
2000
1000
0
PAN, pptv
600
300
0
Nitric Acid, pptv
500
250
0
19
20
21
22
23
24
25
26
GMT Time

Figure A21.3

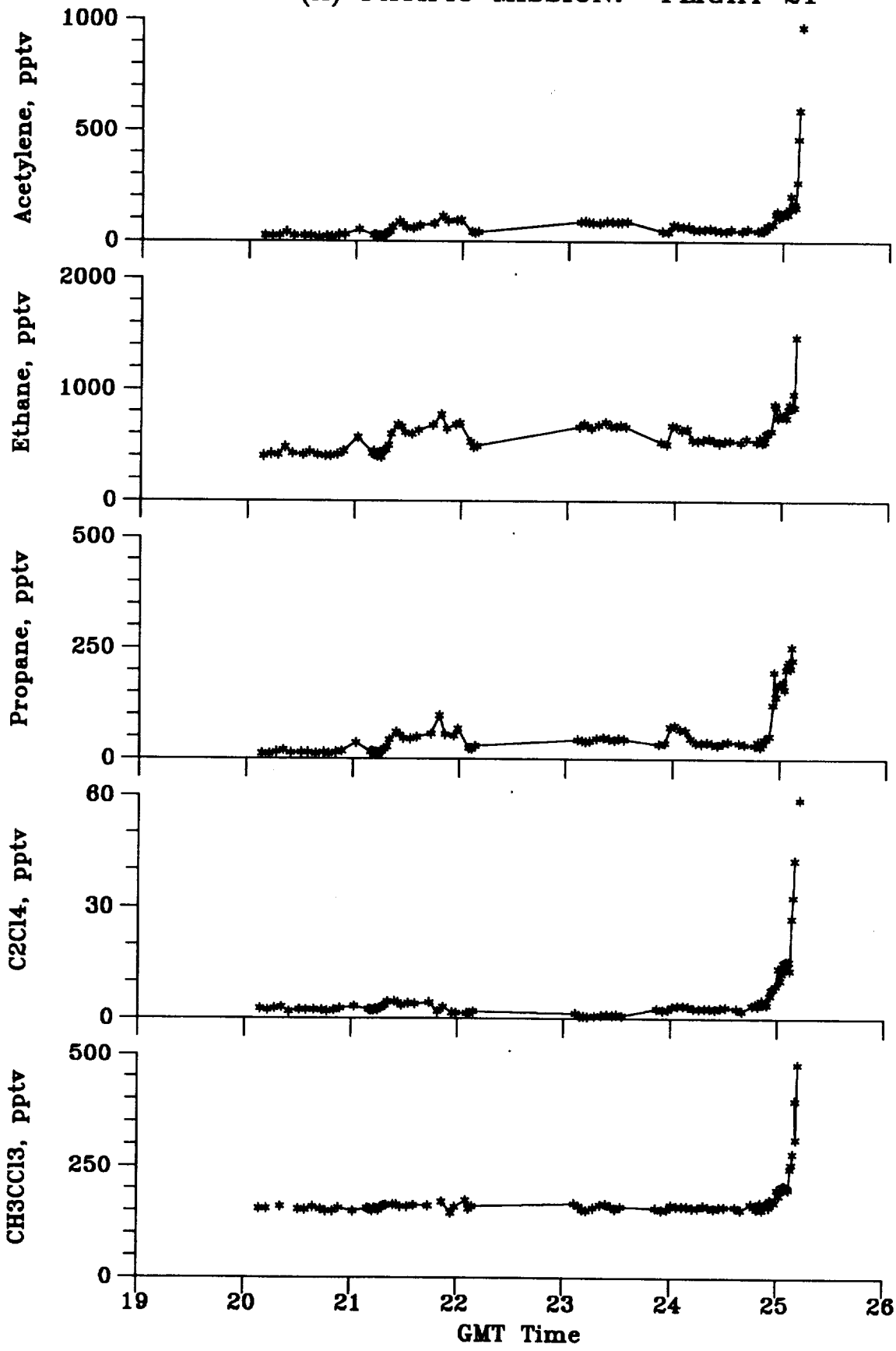

PEM (A) PACIFIC MISSION: FLIGHT 21
Acetylene, pptv
1000
500
0
Ethane, pptv
2000
1000
0
Propane, pptv
500
250
0
C2Cl4, pptv
60
30
0
CH3CCl3, pptv
500
250
0
19
20
21
22
23
24
25
26
GMT Time

Figure A21.4

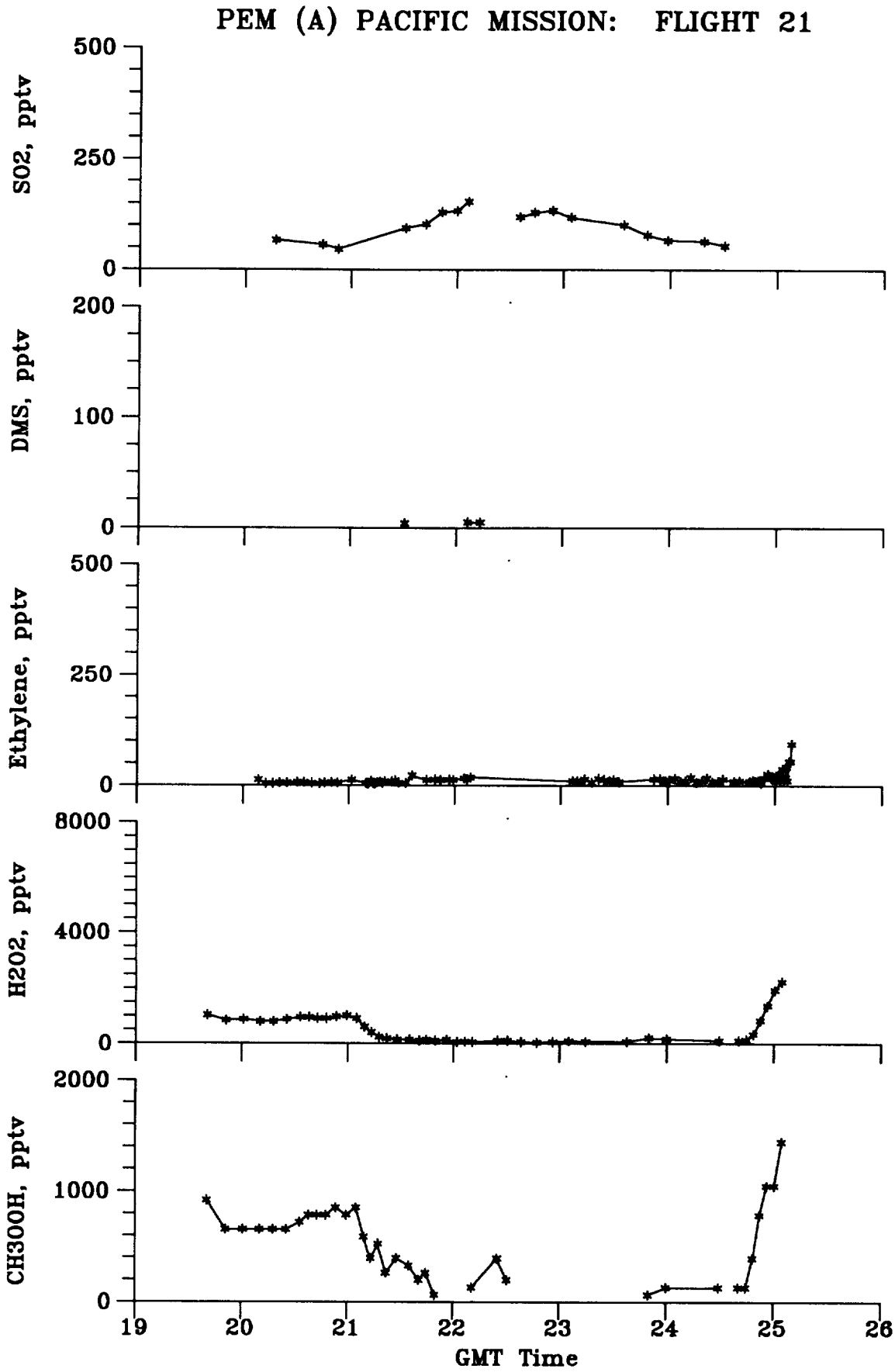

PEM (A) PACIFIC MISSION: FLIGHT 21
SO2, pptv
500
250
0
DMS, pptv
200
100
0
Ethylene, pptv
500
250
0
H2O2, pptv
8000
4000
0
CH3OOH, pptv
2000
1000
0
19
20
21
22
23
24
25
26
GMT Time

Figure A21.5

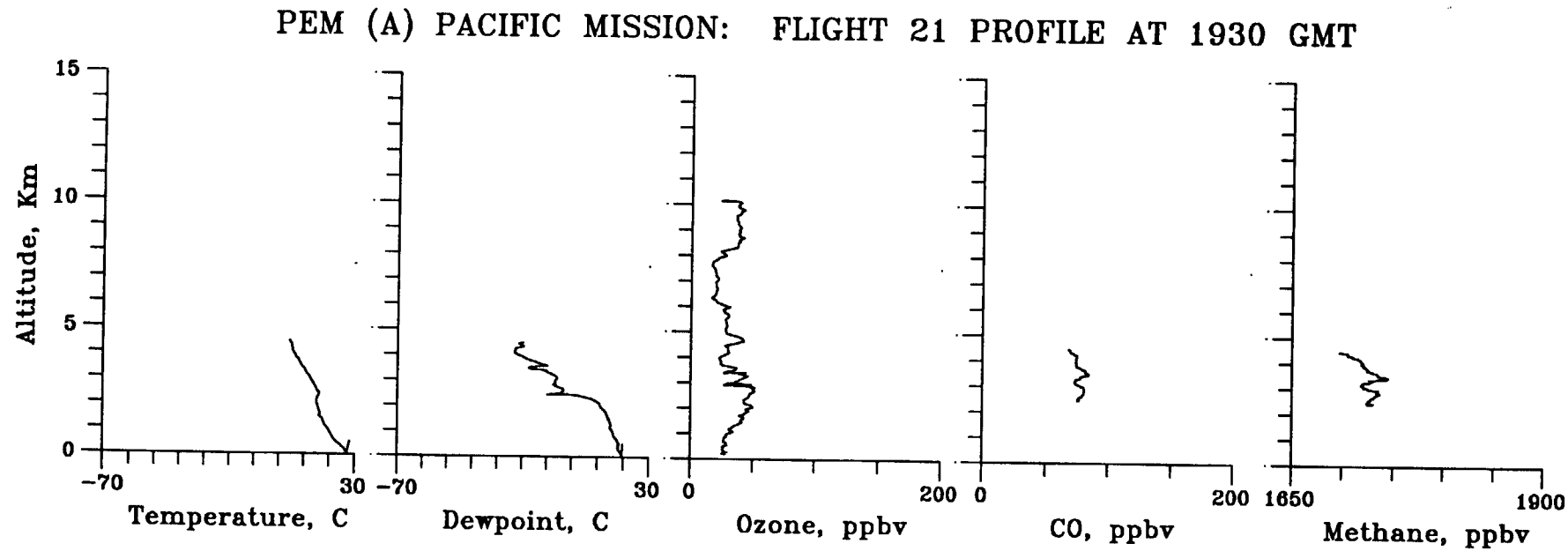

PEM (A) PACIFIC MISSION: FLIGHT 21 PROFILE AT 1930 GMT
Altitude, Km
15
10
5
0
-70
30
Temperature, C
-70
30
Dewpoint, C
0
200
Ozone, ppbv
0
200
CO, ppbv
1650
1900
Methane, ppbv

Figure A21.6

APPENDIX B: LANGLEY DAAC DATA ARCHIVE

System Description

The Langley Distributed Active Archive Center (DAAC), located at the NASA Langley Research Center in Hampton, Virginia, is responsible for archiving and distributing NASA science data in the areas of radiation budget, clouds, aerosols, and tropospheric chemistry. This DAAC will also archive some of the data sets which result from the EOS program and other elements of Mission to Planet Earth. The DAAC has developed an on-line computer system which allows the user to log on, search through the DAAC's data inventory, choose the desired data sets, and place an order. Data may be received either electronically (via FTP) or on media such as 4mm tape, 8mm tape, or CD-ROM (prepackaged datasets only).

Log On Procedures

1. Users with an X-Windows terminal (e.g., Motif) or a Sun Open Windows display system with access to Internet, may log onto the system by entering:

```
xhost + eosdis.larc.nasa.gov
(or: xhost + 192.107.191.17)
telnet eosdis.larc.nasa.gov
login name: ims
password: larcims
```

At the prompts, enter x for the X-Windows interface and then your display name (name of your workstation followed by ":0" or Internet address followed by ":0").

2. Users with access to NCSA Mosaic can use the following URL address:

```
http://eosdis.larc.nasa.gov/
```

3. Users without access to a terminal with an X-Windows display system but who have access to Internet may log onto the system by entering:

telnet eosdis.larc.nasa.gov

login name: ims

password: larcims

At the prompt, enter c for the character interface and then press return.

4. Users who cannot access the system or who have any questions concerning the Langley DAAC may contact:

Langley DAAC User and Data Services

Mail Stop 157B

NASA Langley Research Center

Hampton, VA 23681-0001

Phone: (804) 864-8656

FAX: (804) 864-8807

email: larc@eos.nasa.gov

DAAC Data Bases

1. ERBE (Earth Radiation Budget Experiment)--Data were collected from three satellites (ERBS, NOAA-9, NOAA-10) carrying two ERBE instruments (scanner, nonscanner). The objective is to measure global albedo, fluxes, and solar incidence.

2. ISCCP (International Satellite Cloud Climatology Project)--ISCCP focuses on the study of the distribution and variation of cloud radiative properties. The objective is to improve the understanding and modeling of the effects of clouds on climate and also to elucidate the role of clouds in the radiation balance and improve our knowledge of the long-term global hydrologic cycle.

3. SAGE (Stratospheric Aerosol and Gas Experiment)--SAGE I gathered data concerning the spatial distribution of stratospheric aerosols, ozone, and nitrogen dioxide on a global scale. The goals of SAGE II are to determine the spatial distributions of stratospheric aerosols, ozone, nitrogen dioxide, water vapor, and cloud occurrence by mapping vertical profiles and calculating monthly averages of each.

4. SRB (Surface Radiation Budget)--The SRB data sets were calculated using inputs from ISCCP and ERBE data. They are designed to give global daily and monthly averages of the albedo, irradiance, cloud properties, and meteorology.

5. FIRE (First ISCCP Regional Experiment)--This series of experiments includes aircraft, satellite, and surface-based measurements of cirrus and marine stratocumulus cloud parameters. The purpose of this program is to validate and improve ISCCP data products and cloud/radiation parameterizations used in general circulation models (GCMs).

6. GTE (Global Tropospheric Experiment)--Data were collected primarily from aircraft and ground-based instruments from a variety of areas such as the Amazon Rain Forest and the northern tundra and boreal forest. Many parameters were measured including O_3, CH_4, PAN, CO, NO, NO_2, CO_2, and aerosols.

7. MAPS (Measurement of Air Pollution from Satellites)--Data were collected during Space Shuttle flights in 1981, 1984, and 1994. The main pollutant measured was carbon monoxide (CO).

8. SAM II (Stratospheric Aerosol Measurement)--This instrument was flown on board the Nimbus-7 satellite and consisted of a one-spectral channel Sun photometer, centered at 1.0 um, which viewed a small portion of the Sun through the Earth's atmosphere during spacecraft sunrise and sunset. The data obtained from this instrument were used to determine the vertical distribution of stratospheric aerosols in the polar regions of both hemispheres.

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13. ABSTRACT ***(Maximum 200 words)***

This compendium describes aircraft data that are available from NASA's Pacific Exploratory Mission West-A (PEM West-A). PEM West is a component of the International Global Atmospheric Chemistry's (IGAC) East Asia/North Pacific Regional Study (APARE) project. The PEM- West program encompassed two expeditions to study contrasting meteorological regimes in the Pacific. Objectives of PEM West are to investigate the atmospheric chemistry of ozone over the northwest Pacific--natural budgets and the impact of anthropogenic sources; and to investigate sulfur chemistry--continental versus marine sulfur sources. PEM West-A was conducted in September 1991 during which the predominance of tropspheric air is from the mid-Pacific (marine) regions, but (at times) is modified/mixed with Asian continental outflow. PEM West-B was conducted during February 1994, a period characterized by maximum continental outflow. PEM-B data (not included) will become public domain during the Summer of 1995. PEM West-A flight experiments were based at Japan, Hong Kong, and Guam. This document provides a representation of NASA DC-8 aircraft data that are available from NASA Langley's Distributed Active Archive Center (DAAC), which include numerous data such as meteorological observations, modeling products, results from surface studies, satellite observations, and sonde releases.

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Aircraft tropospheric meaurements

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