NOAA Technical Memorandum ERL CMDL-11

ATMOSPHERIC CH_4 SEASONAL CYCLES AND LATITUDE GRADIENT FROM THE NOAA CMDL COOPERATIVE AIR SAMPLING NETWORK

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Boulder, Colorado
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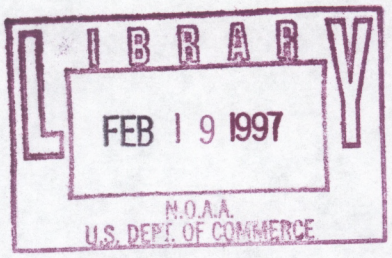

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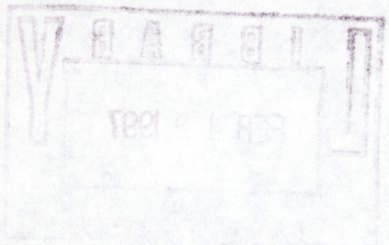

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ABSTRACT. Methane has been measured in air samples collected as part of the NOAA CMDL Carbon Cycle Group Cooperative Air Sampling Network since 1983. The data from each site are used to determine two important parameters that are useful in constraining the global CH_4 budget: seasonal cycles and the latitude gradient. Average seasonal cycles are determined using 2 to 13 years of data, depending on the site. The average latitude gradient is determined as the annually averaged mixing ratios for each site minus the annual average at the South Pole. Seasonal cycles and the latitude gradient are tabulated and shown graphically. Interannual variations in both parameters are quantified as standard deviations.

1. Introduction

Measurements of methane (CH_4) in air extracted from ice cores from Antarctica and Greenland show that the atmospheric burden of CH_4 has doubled in the past 100 years [*Etheridge et al.*, 1992], and that CH_4 and climate indicators were strongly correlated over the past 160,000 years [*Chappellaz et al.*, 1990]. Methane strongly absorbs infrared radiation at 7.66 μm, a region where CO_2 and H_2O absorb only weakly, so it has a direct effect on Earth's radiative balance. Because of methane's increased atmospheric burden, its contribution to climate forcing has increased by 30% since 1860 [*Mitchell*, 1989]. Methane's atmospheric chemistry also plays an important role in determining the composition of the troposphere and stratosphere and indirectly affects climate. Most of the CH_4 emitted into the atmosphere is removed with a 10-year lifetime by

$$OH + CH_4 \rightarrow CH_3 + H_2O \ . \qquad (1)$$

Globally, reaction (1) is second only to reaction of OH with carbon monoxide (CO) as a loss process for OH. In the southern hemisphere, low CO concentrations result in nearly equal losses of OH through reactions with CH_4 and CO. In the stratosphere CH_4 is also oxidized by

$$O(^1D) + CH_4 \rightarrow CH_3 + H_2O \quad (2)$$

and

$$Cl + CH_4 \rightarrow CH_3 + HCl \ . \quad (3)$$

Reaction (2) may add to the stratospheric loading of H_2O, which has implications for heterogeneous reactions that destroy ozone (O_3). Reaction (3) is a termination step in the Cl-catalyzed destruction of O_3.

Clearly, CH_4 is an important atmospheric species. Its major sources were identified as rice agriculture; natural wetlands; ruminant animals; natural gas emissions from venting, flaring, leakage in distribution systems, and coal mining; landfills; and biomass burning [see *Dlugokencky et al.*, 1994 for details]. The details of its budget of sources and sinks are still poorly known because the absolute magnitudes of individual sources are poorly known. Quantifying these sources is difficult since many sources such as natural wetlands are distributed over large areas and the emission rates are highly variable even over small (meters) spatial scales. Since atmospheric mixing of CH_4 is incomplete, large signals of CH_4 near source and sink regions exist [*Dlugokencky, et al.*, 1994]. These signals, including the variation of CH_4 with latitude and the CH_4 seasonal cycle at specific locations, are an important constraint on the global CH_4 budget. *Fung et al.* [1991] compared model-derived distributions of CH_4 determined with various scenarios of CH_4 sources and sinks with measurements of CH_4 from the CMDL Carbon Cycle Group cooperative air sampling network (described below) to constrain the global budget of CH_4. Their favored scenario was in reasonable agreement with the existing measurements, but they speculated that additional sampling sites located nearer to strong source regions would further constrain the possible scenarios of CH_4 budgets.

Average seasonal cycles, their variability, and the average latitudinal gradient for atmospheric CH_4 determined from 59 sampling sites in the CMDL network are reported in this Technical Memorandum. The results are based on measurements from 1983 to 1995. The number of sites and distribution of the network changed almost yearly over this period with reported parameters better determined for sites with longer time-series.

2. Air Sampling Network and Sampling Procedures

The CMDL global air sampling network is shown in Figure 1, and the sites are listed by their 3-letter site codes and full names in Table 1. Three-letter site codes are used throughout this report to identify sampling sites. The network consisted of fixed sites, where air samples were collected approximately weekly, and regular ship's cruises, where the sampling frequency varied through the measurement period and with each ship. In Table 1, locations of fixed sites are indicated by their latitude and longitude; for ship's cruise samples the general location (e.g., Pacific Ocean) and spacing between samples, in degrees latitude, are given. BAL samples were

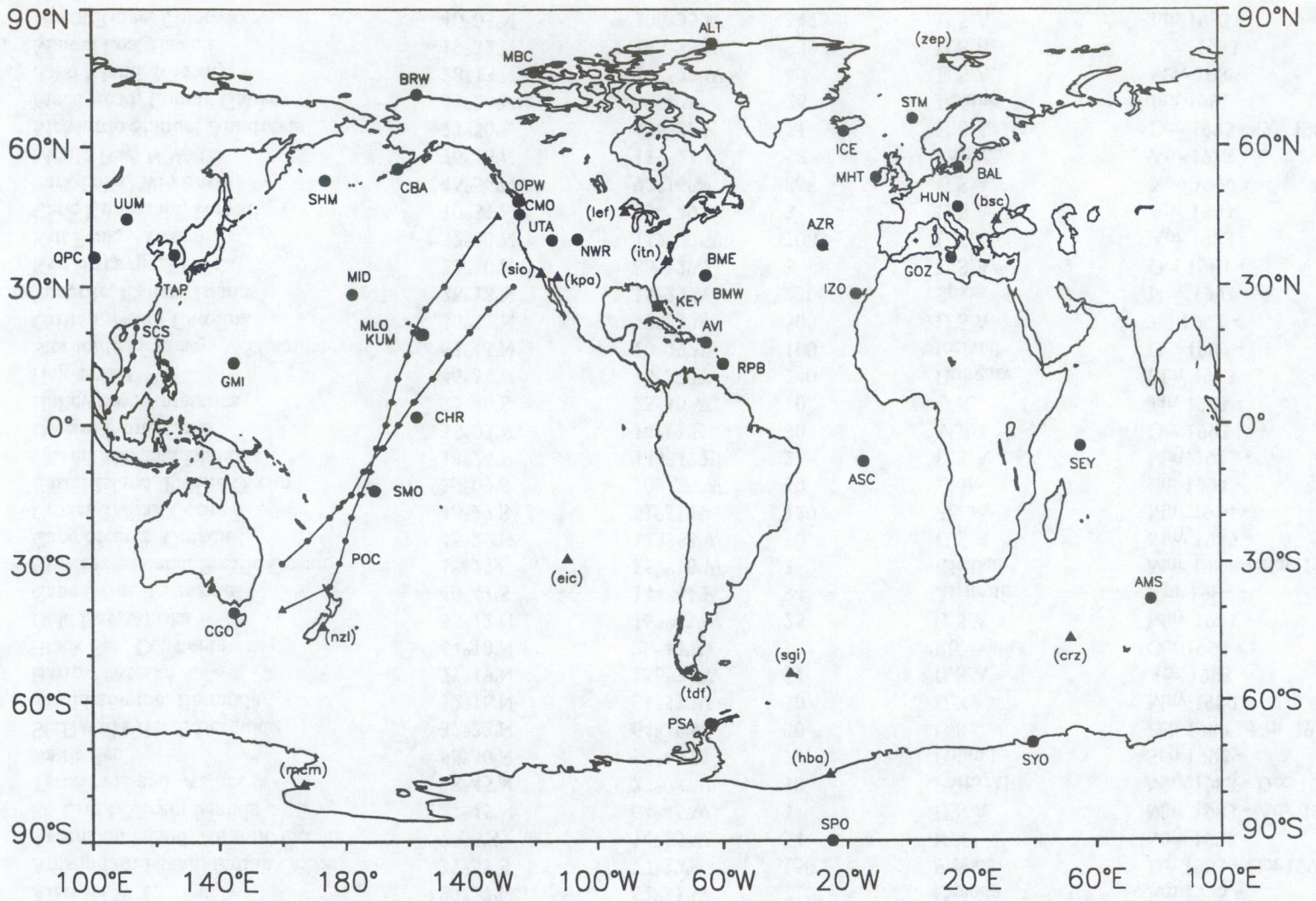

Figure 1: Locations of the sampling sites in the CMDL cooperative air sampling network. The circles indicate sites for which CH_4 seasonal cycles are included. Large circles indicate fixed sampling sites, and the small circles represent the sampling locations used along ship cruise tracks indicated by the connecting line segments. Cruise tracks vary depending on the ports of call. The triangles indicate sites for which CH_4 data are available, but are not included in this Technical Memorandum.

Table 1: Summary of air sampling sites

Code	Station	Latitude	Longitude	Altitude(m)	Country	Years in Operation
ALT	Alert, N.W.T.	82°27'N	62°31'W	210	Canada	Jun 1985 -
AMS	Amsterdam Island, Indian Ocean	37°57'S	77°32'E	150	France	Jan 1983 - Oct 1990
ASC	Ascension Island, Atlantic Ocean	7°55'S	14°25'W	54	U.K.	May 1983 -
AVI	St. Croix, Virgin Islands	17°45'N	64°45'W	3	U.S.A.	May 1983 - Aug 1990
AZR	Terceira Island, Azores	38°45'N	27°05'W	30	Portugal	May 1983 - Dec 1991
BAL	Baltic Sea	55°30'N	16°40'E	7	Poland	Sep 1992 -
BME	St. David's Head, Bermuda	32°22'N	64°39'W	30	U.K.	Feb 1989 - Nov 1994
BMW	Southhampton, Bermuda	32°16'N	64°53'W	30	U.K.	May 1989 -
BRW	Barrow, Alaska	71°19'N	156°36'W	11	U.S.A.	Apr 1983 -
BSC	Black Sea, Constanta	44°10'N	28°41'E	3	Romania	Oct 1994 -
CBA	Cold Bay, Alaska	55°12'N	162°43'W	25	U.S.A.	May 1983 -
CGO	Cape Grim, Tasmania	40°41'S	144°41'E	94	Australia	Apr 1984 -
CHR	Christmas Island, Pacific Ocean	1°42'N	157°10'W	3	Kiribati	Mar 1984 - May 1994
CMO	Cape Meares, Oregon	45°29'N	123°58'W	30	U.S.A.	May 1983 -
CRZ	Crozet, Indian Ocean	46°27'S	51°51'E	120	France	Mar 1994 -
EIC	Easter Island, Pacific Ocean	29°09'S	109°26'W	50	Chile	Jan 1994 -
GMI	Guam, Mariana Islands	13°26'N	144°47'E	2	U.S.A.	May 1983 -
GOZ	Dwejra Point, Gozo	36°03'N	14°11'E	30	Malta	Oct 1993 -
HBA	Halley Bay, Antarctica	75°40'S	25°30'W	10	U.K.	Jan 1983 -
HUN	Hegyhatsal	46°58'N	16°23'E	240	Hungary	Mar 1993 -
ICE	Storhofdi, Heimaey, Vestmannaeyjar	63°15'N	20°09'W	100	Iceland	Oct 1992 -
ITN	Grifton, North Carolina	35°21'N	77°23'W	505	U.S.A.	Jul 1992 -
IZO	Tenerife, Canary Islands	28°18'N	16°29'W	2300	Spain	Nov 1991 -
KEY	Key Biscayne, Florida	25°40'N	80°12'W	3	U.S.A.	Oct 1983 -
KPA	Kitt Peak, Arizona	32°00'N	112°00'W	2083	U.S.A.	Apr 1983 -
KUM	Cape Kumukahi, Hawaii	19°31'N	154°49'W	3	U.S.A.	Apr 1983 -
LEF	Park Falls, Wisconsin	45°56'N	90°16'W	868	U.S.A.	Nov 1994 -
MBC	Mould Bay, N.W.T.	76°15'N	119°21'W	58	Canada	Apr 1983 -
MCM	McMurdo Station, Antarctica	77°50'S	166°36'E	11	U.S.A.	Dec 1985 - Oct 1987
MHT	Mace Head, County Galway	53°20'N	9°54'W	26	Ireland	Jun 1991 -
MID	Sand Island, Midway	28°13'N	177°22'W	4	U.S.A.	May 1985 -
MLO	Mauna Loa, Hawaii	19°32'N	155°35'W	3397	U.S.A.	May 1983 -
NWR	Niwot Ridge, Colorado	40°03'N	105°35'W	3475	U.S.A.	Jun 1983 -

Table 1: Summary of air sampling sites (continued)

Code	Station	Latitude	Longitude	Altitude(m)	Country	Years in Operation
NZL	Kaitorete Spit	43°50'S	172°38'E	3	New Zealand	Jan 1983 - Apr 1985
OPC	Pacific Ocean (California Star)	5° lat. intervals	0	45°N-35°S		Oct 1993 -
OPW	Olympic Peninsula, Washington	48°15'N	124°25'W	488	U.S.A.	Nov 1984 - May 1990
PAC	Pacific Ocean (Southland Star)	5° lat. intervals	0	45°N-35°S		Dec 1986 - Aug 1993
PAW	Pacific Ocean (Wellington Star)	5° lat. intervals	0	45°N-35°S		May 1990 - Jul 1993
PSA	Palmer Station, Antarctica	64°55'S	64°00'W	10	U.S.A.	Jan 1983 -
QPC	Qinghai Province	36°16'N	100°55'E	3810	P.R.C.	May 1991 -
RPB	Ragged Point, St. Phillip's Parish	13°10'N	59°26'W	3	Barbados	Nov 1987 -
SCS	South China Sea (Carla A. Hills)	3° lat. intervals	0	21°N-3°N		Jul 1991 - Feb 1993
SCS	South China Sea (Great Promise)	3° lat. intervals	0	21°N-3°N		Nov 1993 -
SEY	Mahe Island	4°40'S	55°10'E	3	Seychelles	May 1983 -
SGI	Bird Island, S. Georgia, Atlantic Ocean	54°00'S	38°03'W	30	U.K.	Feb 1989 - Aug 1992
SHM	Shemya Island, Alaska	52°43'N	174°06'E	40	U.S.A.	Sep 1985 -
SIO	La Jolla, California	32°50'N	117°16'W	14	U.S.A.	Jan 1983 - Sep 1986
SMO	Tutuila, American Samoa	14°15'S	170°34'W	42	U.S.A.	Apr 1983 -
SPO	South Pole, Antarctica	89°59'S	24°48'W	2810	U.S.A.	Feb 1983 -
STM	Atlantic Ocean (Polarfront)	66°00'N	2°00'E	7	Norway	Apr 1983 -
SYO	Syowa Station, Antarctica	69°00'S	39°35'E	11	Japan	Apr 1986 -
TAP	Tae-ahn Peninsula	36°44'N	126°08'E	20	Korea	Nov 1990 -
TDF	Tierra Del Fuego, La Redonda Isla	54°52'S	68°29'W	20	Argentina	Sep 1994 -
UTA	Wendover, Utah	39°54'N	113°43'W	1320	U.S.A.	May 1993 -
UUM	Ulaan Uul	44°27'N	111°06'E	914	Mongolia	Jan 1992 -
ZEP	Ny-Alesund, Svalbard (Spitsbergen)	78°54'N	11°53'E	475	Norway/Sweden	Feb 1994 -

collected from a sea-going ferry but listed with latitude and longitude because they were always collected at the same location. The number and density of sites in the sampling network has changed significantly since CH_4 measurements started in 1983. The time periods spanned with CH_4 data are listed in Table 1. End dates are given only for sites no longer operational at the end of 1995. Results are not included for all sites in Table 1 and Figure 1. Those sites for which results are not included are listed in Table 2 with the reason for their exclusion, and they are identified in Figure 1 as filled triangles with site codes in lower case letters.

Table 2: Network sites excluded from analysis.

Site	Reason for exclusion
BSC	Record does not contain 1 full year of data.
CRZ	Gaps in each year of data.
EIC	Large gaps in each year of data.
HBA	Large gaps in data.
ITN	Too few years of data to define average seasonal cycle at highly variable site.
KPA	Too few data to define seasonal cycle.
LEF	Record contains only 1 full year.
MCM	Record contains only 1 full year.
NZL	Only six acceptable measurements in record.
SGI	Large gaps in data.
SIO	Too few data to define seasonal cycle.
TDF	Record does not contain 1 full year of data.
ZEP	Record contains only 1 full year

Preferred wind directions were specified for air sampling at each site to avoid influences from local trace gas sources and sinks; therefore, the air samples are representative of large well-mixed volumes of the atmosphere. This is necessary for data to be compared with model results where the grid size is large (e.g., the 4° latitude by 5° longitude used by *Fung et al.* [1991]).

The sample collection procedures used were described in detail by *Dlugokencky et al.* [1994] and references therein. Samples were collected approximately once a week in glass sample flasks. Seven flask types used from 1983 to 1989 were summarized by *Lang et al.* [1990a]. Until 1989, most air samples were collected in 0.5-L, cylindrical, Pyrex flasks fitted with a solid-plug, greased, ground-glass stopcock on each end. In 1989, cylindrical, 2.5-L Pyrex flasks with two glass-piston stopcocks sealed with Teflon O-rings were introduced. Laboratory and field tests showed that mixing ratios of CO, CH_4, CO_2, and stable isotope ratios in CO_2 were better conserved after long storage periods in the 2.5-L flasks than in other designs [*Komhyr and Rosson,* 1990; *Ferguson and Rosson,* 1991]. Both stopcocks are on one end of the flask, and a dip-tube inlet extends down to within 5 cm of the flask bottom to ensure proper flushing. All flask designs use male, ground-glass, 14/35 standard taper joints to make vacuum-tight connections to the sampling and analytical systems.

Before the flasks were shipped to the sampling sites, they were evacuated, leak checked, and filled to a slight overpressure with dry synthetic air containing ~330 ppm CO_2 and no detectable CH_4. The fill-gas composition was chosen so that the flask's glass and Teflon surfaces were conditioned with near-ambient levels of CO_2 and to indicate when the flasks received inadequate flushing (evidenced by low CO_2 and CH_4 mixing ratios).

A portable sampling apparatus was used to flush and fill two flasks connected in series to an absolute pressure of 1.2 to 1.5 atmospheres. This was to meet the analytical requirements in Boulder that the flasks have above ambient pressure (Boulder, at ~1700 m, has an average pressure of ~630 Torr). Female, standard-taper glass joints with vacuum grease were used until 1991 to produce a vacuum-tight seal between the pumping unit and the flasks and between the two flasks connected in series. Since 1991, Teflon standard taper joints were used to make these seals without grease. The grease can create problems because sand and dirt sticks to it, making it difficult to get a good seal. Prior to 1990, the pumping unit was the portable pumping package (P3) [*Komhyr et al.*, 1985]. In 1990, the portable Martin and Kitzis Sampler (MAKS) began replacing the P3. The new design included a more powerful pump and battery and several other modifications that increased the probability of collecting an uncontaminated sample. New features in the MAKS included a light shield to avoid exposing the flasks to sunlight (a potential source for CO and H_2 contamination), a 5-m tall intake line, and a back-pressure regulator to ensure that the final pressure in the flasks holds constant after shutting off power to the pump, allowing the operator to check for leaks. The procedure for collecting a pair of samples is as follows: (1) The sampling unit is set up well away from anything that might affect the air flow to the inlet or contaminate the sample. (2) The stopcocks are opened, and a 5-min flushing period is started. Once the flow rate and battery voltage are recorded on the sample sheet, the operator moves at least 10 m downwind of the sampler. (3) After 5 min, the operator moves back to the sampler, holding his or her breath, and pressurizes the samples. (4) The stopcocks are closed and the flasks are removed from the case, avoiding exposure to light.

For some sites, there are deviations from the standard sampling procedures. Since January 1984, samples at NWR were collected with a metal bellows pump because the P3 underperformed at high altitude (3475 m). At CHR, evacuated flasks are used to collect samples without a portable sampling unit. The flasks are ~3 L and similar in design to the 2.5-L flasks, but with a single glass-piston, O-ring-sealed stopcock, and they are evacuated to a pressure of less than 10 mTorr. To collect a sample, the sample taker points the flask into the wind, repeatedly purges the air in the dead volume of the ground-glass tapered joint with a wooden dowel, opens the stopcock allowing the flask to fill to ambient pressure, and then closes the stopcock, while holding his or her breath the entire time. A pair of samples is collected in rapid succession using this technique. A relatively small fraction of the samples were collected with methods other than the portable sampler. Usually these are samples collected in addition to the ones collected with the portable sampling unit. For example, during part of the SMO record, additional flask pairs were collected through the CO_2 continuous analyzer system and in evacuated 3-L flasks. No significant

differences were seen among CH_4 mixing ratios for samples collected nearly simultaneously with different sampling methods.

Shipboard sampling procedures are different from those used at most fixed sites to limit the amount of time the ships' officers are removed from their normal duties. Flasks and sampling procedures are very similar to those used at CHR [*Lang et al.*, 1992]. Samples are collected from the windward side of the ship, and two samples are obtained in rapid succession with the technique described previously. The low ambient pressure in Boulder relative to that found at CHR and on the ships results in sufficient overpressure for analysis.

3. Analytical Procedures and Calibration

All CH_4 measurements reported here were made by gas chromatography with flame ionization detection (FID). Since the start of the program in 1983, five different gas chromatographs (GCs) were used, but the basic chromatographic technique and calibration procedures have remained the same. Significant improvements in data acquisition and automation of the flask analyses occurred and are described by *Steele et al.* [1987] and *Lang et al.* [1990a,b]. In November 1990, measurements began with the latest version of the CH_4 flask analysis system [*Lang et al.*, 1992]. Its major components are a Carle Series 400, microprocessor-controlled GC; a computer-controlled, fully automated sample inlet system used for introduction of air from any one of eight pressurized flask samples or a single tank of calibration gas; a mass flow meter to regulate the volume of air sample used to flush and fill the sample loop; a Hewlett-Packard (HP) model 332 workstation; software to run the system; and an HP3393A computing integrator for methane peak recording and quantification. Two columns constructed from 0.32-cm o.d. stainless steel tubing are used to achieve CH_4 separation. A 2.4 m silica gel column is used as a precolumn to prevent CO_2 and traces of H_2O from reaching the analytical column by reversing the sequence of the columns after CH_4 elutes. Methane is separated from the remainder of the components in the air sample on a 1.1-m long molecular sieve 5A column. The sample loop volume is 5 mL. Helium is used as carrier gas. The flame is fueled by H_2 and supported by 40% O_2 in N_2.

Through most of the period 1983-1991, one air sample of a pair collected simultaneously was analyzed for CH_4, and, whenever the overpressure was sufficient, at least two aliquots were taken from each flask. The difference in CH_4 mixing ratio between the first and second aliquot was used to establish the precision of the measurement. Over the full period of the record described here, the average precision was ~0.2%. In October 1991, the analysis procedure was altered; a single aliquot was analyzed from both members of the flask sample pair. The principal reasons for the change were to simplify flask handling procedures (both flasks of the sample pair are measured for CO_2) and to use pair agreement (the difference in CH_4 mixing ratio between two samples collected simultaneously) as an additional diagnostic in evaluating the quality of the sample. The precision of the analytical instrument is now assessed by two approaches. The first is an intercomparison of primary reference gases approximately once per month, and the second is

to determine the relative stability of the reference gas aliquots measued during each day of flask measurements.

Because water vapor is highly variable in the atmosphere, all CH_4 measurements reported here are in units of parts per billion (10^9) by volume (ppb) in dry air. Air samples and standard gases were dried using a Nafion drier until August 1983 [*Foulger and Simmonds*, 1979] (dew point ~ -30°C) and since then by passing the gas stream through a coil of 0.32-cm o.d. copper or stainless steel tubing immersed in an ethanol bath maintained at <-70°C. *Steele et al.* [1987] showed that there were no significant differences between CH_4 measurements made using the two drying methods. Methane mixing ratios are calculated from peak heights where two bracketing standards are averaged and then divided into the CH_4 peak height obtained for the air sample. This ratio is multiplied by the assigned mixing ratio for the standard gas. The validity of this method was discussed by *Steele et al.* [1987]. Internal precision of the analytical system can be calculated similarly by using groups of three adjacent aliquots of calibration gas.

All standards are natural air. The standard scale is based on two reference gas cylinders purchased from Biospherics (Portland, Oregon) in 1983 (O-245) and 1984 (O-259). These were 35-L (water volume), stainless steel, internally electropolished cylinders. The air was collected cryogenically, and, after warming to ambient temperature and settling, the condensed water was blown out through a valve at the bottom [*Rasmussen and Lovelock*, 1983]. Since 1987, CMDL has prepared standards by filling aluminum cylinders with dry, natural air at Niwot Ridge, Colorado. Each aluminum cylinder was treated using a proprietary process to make its internal surface inert. The air was chemically dried to less than 1 ppm H_2O using P_2O_5 on an inert support. A molybdenum steel cylinder from the CMDL CO_2 measurement program was also calibrated and added as a primary standard to extend the types of cylinder materials used. The CH_4 scale was propagated to these standards by intense direct comparison. Currently, the calibration scale is defined by seven calibration gases that are identified as primary standards. These are defined as those calibration gases used solely for flask analysis and tank calibrations. The only exception is cylinder 3075, which did not have a contemporary CH_4 mixing ratio or sufficient pressure when obtained to be used as a reference gas. The six primary standards were retired after their pressures dropped to approximately 25% of their original starting pressures. For O-245 and O-259, the pressure at retirement was approximately 600 kPa. For the aluminum cylinders, it was approximately 3.4 MPa. This strategy was adopted to allow long-term studies of the stability of CH_4 in these containers and for future conversion of the calibration scale to an accurate gravimetric scale.

Frequent and continuing comparisons of the CH_4 calibration gases to each other using the same GC/FID systems used for flask analyses have shown that there are negligible relative changes in their CH_4 mixing ratios. Therefore the calibration scale defined by this set of gases was shown experimentally to have internal stability. From analyses of all our CH_4 calibration gases (not simply the primary standards) the CH_4 scale was determined to have internal stability to (0±0.1) ppb yr^{-1}. The absolute stability of the CH_4 calibration scale can be addressed only

indirectly, since there are no absolute measurements of the CH_4 mixing ratios in the calibration gases. Arguably because our extended suite of CH_4 calibration gases consists of over 20 different natural air standards over a range of CH_4 mixing ratios (~1600 to 1800 ppb), and they are contained in three types of high-pressure cylinders (stainless steel, molybdenum steel, and aluminum) at pressures ranging from ~500 kPa to ~14 Mpa, observations of internal stability can be consistent with only two hypotheses: first, that the CH_4 calibration gases exhibit absolute stability over this period of time; second, that in each of the standards, the CH_4 mixing ratio drifted steadily in the same direction by an amount exactly proportional to its CH_4 mixing ratio. Because of the number and variety of our calibration standards, it is believed that the latter possibility is so remote that it can be safely discounted. Thus we proceed on the basis that the observed internal stability in the CH_4 calibration scale also means that it has absolute stability to (0±0.1) ppb yr^{-1}. Compared with the globally-averaged increase over the period of the measurements, the estimated uncertainty is about 1%.

The CMDL methane scale was compared to an absolute gravimetric scale [*Aoki et al.*, 1992] and it was found that the CMDL scale is lower than this gravimetric scale by ~1.5%. This 1.5% difference, although small, leads to an underestimate of the trend averaged over the period of measurements, and it cannot be ignored. A gravimetric scale is currently being established. Once it is completed, all CMDL measurements will be transferred to this scale.

4. Data Editing and Selection

The variability in CH_4 observed at each site is due to natural atmospheric variations occurring over large spatial scales and to other factors including improper sample collection techniques, failure of a stopcock to maintain a seal, influence of local sources and sinks of CH_4, and analytical errors. The goal of these measurements is to determine the CH_4 time series and the spatial variability for well-mixed air representative of large volumes of the atmosphere. Therefore the data are carefully examined with a two-step procedure to identify samples that do not meet this goal. The criteria used to flag data are somewhat subjective; even though the selection process is not completely reproducible, information derived from the measurements (trends, annual global means, seasonal cycles, etc.) would be nearly identical with each application of the selection process.

The first step, editing, is a quality assurance step. Samples that are collected improperly (i.e., that are affected by an equipment failure or are analyzed when the analytical system is running less than optimally) are excluded from the data analysis. Unacceptable chromatographic baseline codes are flagged immediately by the integrator and abnormalities in the chromatographic parameters or peak shapes are noted. Sampling problems are also identified. Some common examples are a low flow rate used to flush the flasks, indicated by notes left on the sample sheet by the MAKS operator; no overpressure in the sample flask, indicating the stopcocks may have leaked; high levels of CO or H_2, indicating contamination, usually because of exposure of greased stopcocks to sunlight; and unreasonably low values of CH_4 and CO_2, indicating improper flushing

of the fill gas. *Lang et al.* [1990b] has detailed explanations of the reasons air samples are flagged as unacceptable. During the selection step, samples considered not representative of well-mixed background air are flagged and excluded from further analysis. The criteria for flagging a measurement in this step are sometimes subjective, but often the nonbackground sample is identified by a note on the sample sheet that the sample was not collected from a predetermined clean-air wind sector and could be contaminated by a local trace gas source or sink. Data editing serves to reject all samples that have unambiguous analytical or sampling problems, and data selection attempts to ensure that samples contaminated by local sources are excluded from data analysis.

5. Curve Fitting

Sample collection is not synchronized among the sampling sites, nor is it evenly distributed in time at any single site. The data are fit with curves to smooth short-term natural variations and provide a representation of the data that is evenly spaced, synchronized in time among all sampling sites, and suitable for calculating weighted means. The curve-fitting methods used here are based on the methods developed by *Thoning et al.* [1989] for the CMDL CO_2 measurement program. Curve fits are manipulated mathematically to obtain components in the signal such as the trend and seasonal cycle.

As described previously [*Steele et al.*, 1992], the basic components of the curve are a quadratic polynomial representing the average long-term trend, a series of four harmonics (equation (4)),

$$f(t) = a_1 + a_2 t + a_3 t^2 + \sum_{i=1}^{4} [a_{2i+2} \sin(2\pi i t) + a_{2i+3} \cos(2\pi i t)] \qquad (4)$$

and digital filtering of the residuals to determine interannual variations in the average trend and seasonal cycle. The term t is time in years, where $t = 0$ on January 1, 1983, and the a_i values are coefficients determined by the fit. The function is fit to the data using a least squares method. Deviations from the average trend and seasonal cycle are examined by calculating the residuals of the original data about the function, converting from the time domain to the frequency domain with a fast Fourier transform algorithm, and filtering in two ways. Filtering is done by multiplying the residuals (in the frequency domain) by low-pass filters where the filter cutoffs are either 4.57 yr^{-1} or 0.55 yr^{-1}. Filter cutoffs are defined as the point where the transmission of the filter function is 0.5. Filtering is equivalent to multiplying the residuals by convolution filters in the time domain with full width at half maxima (FWHM) of approximately 40 days and 1 year. Adding the result from the short-term low-pass filter (40-day FWHM) to equation (4) results in smoothed curves, F(t). These curves include the average seasonal cycle and trend determined by f(t) and interannual variations identified by the filtering process. Only variations occurring on time scales of less than 40 days are removed. For the seasonal cycle analysis presented here, the trend in CH_4 was determined and then removed. To do this, the quadratic portion of equation (4) was combined with the result obtained from filtering the residuals with the low-pass filter having a

cutoff of 0.55 yr^{-1} to yield G(t). G(t) includes the average long term trend and its interannual variations.

6. Seasonal Cycles

Seasonal cycles are tabulated in Table 3, shown graphically in Appendix A, and ordered from northern-most to southern-most. Values listed under each month are detrended monthly mean mixing ratios in ppb. Each monthly entry is calculated as the average of all detrended monthly means determined during the measurement period for that particular site. Monthly means are calculated from the detrended smooth curve (F(t)-G(t)) at weekly resolution. With this approach, months that do not contain measurement data are supplied with values from the curve fit. The values in parentheses are standard deviations, which give an indication of the interannual variability in the detrended monthly means. The detrended monthly means are shown graphically as symbols (with $\pm 1\sigma$ error bars) in Appendix A. A summary page is given for each site that includes a plot of the average seasonal cycle, position information for that site, the amount of data used in determining the seasonal cycle (in some cases, the period includes gaps in the measurement record), and a "site table." The site tables include the amplitude of the seasonal cycle and the dates and values (in ppb) of the maximum and minimum mixing ratios in each complete calendar year. These parameters were determined from the detrended smoothed curve (i.e., F(t)-G(t)). The summary page also lists two entries for the amplitude from each site. The "average amplitude" and "standard deviation" are determined as the mean and standard deviation of the amplitudes in the site tables. The "harmonic amplitude" is determined as the difference between the maximum and minimum values of the harmonic portion of equation (4). One annual cycle of the harmonic curve is plotted as the solid line in the site figures.

For most sites in Appendix A, there is good agreement between the harmonic curves and the detrended monthly means. Agreement between the two methods used to represent the average seasonal cycle is not as good for sites with large gaps in their records. In those cases, the smooth curves fitted through the periods of low data density are poorly constrained. For example, all South China Sea sites have large gaps in 1993 and 1995. The poorly constrained curve fits lead to detrended monthly means with large standard deviations and poor agreement between the monthly means and the harmonics. These sites were included because of the paucity of CH_4 data for the southeast Asian region where strong CH_4 sources exist. The reader is urged to use the South China Sea seasonal cycles cautiously and refer to the original data (obtained from the CMDL ftp server at ftp.cmdl.noaa.gov) to gain a better understanding of the limitations of these measurements. In cases where large gaps are present in the data (indicated by large uncertainties in the monthly means and poor agreement between the monthly means and the harmonics), the harmonic curves are the preferred representation of the average seasonal cycle.

Agreement between the "average" and "harmonic" amplitudes is best for sites in the high southern hemisphere where the phase of the seasonal cycle is fairly consistent. At tropical and northern latitudes, the phase of the cycle is observed to have significant interannual variability.

Table 3: Summary of the average seasonal cycles and annual mean CH_4 mixing ratios relative to the South Pole for CMDL air sampling sites.

Site	Latitude	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Avg.
ALT	82°27'N	20.2	21.0	19.7	10.7	-4.2	-19.2	-29.7	-26.8	-12.0	0.7	6.4	14.2	138.9
		(7.1)	(6.1)	(6.0)	(3.9)	(4.2)	(4.1)	(4.1)	(5.8)	(4.9)	(7.2)	(4.0)	(7.3)	(5.3)
MBC	76°15'N	24.7	21.3	19.5	9.3	-8.4	-24.5	-31.1	-25.4	-11.9	0.4	7.7	19.4	141.4
		(8.2)	(6.7)	(6.5)	(5.7)	(5.5)	(4.0)	(2.9)	(5.2)	(4.5)	(6.2)	(3.5)	(6.2)	(6.6)
BRW	71°19'N	16.7	23.6	20.7	5.3	-11.8	-24.1	-25.6	-19.1	-7.8	4.4	8.5	11.2	149.0
		(9.2)	(9.0)	(6.3)	(6.0)	(5.9)	(4.2)	(6.5)	(12.1)	(5.8)	(11.9)	(5.9)	(9.6)	(5.8)
STM	66°00'N	10.3	10.7	14.2	8.2	-3.0	-15.1	-23.2	-17.7	-2.3	5.0	4.4	7.9	133.7
		(6.7)	(6.4)	(4.7)	(6.6)	(4.6)	(4.1)	(4.8)	(6.2)	(5.4)	(8.8)	(3.2)	(6.8)	(5.2)
ICE	63°15'N	13.3	7.5	10.1	8.5	0.3	-11.6	-22.7	-22.5	-9.2	3.6	6.8	15.0	127.3
		(8.4)	(6.4)	(8.5)	(4.9)	(7.7)	(4.1)	(1.0)	(4.3)	(1.7)	(3.1)	(2.2)	(13.1)	(2.3)
BAL	55°30'N	8.1	13.4	13.9	15.7	9.1	-6.9	-17.6	-18.1	-0.1	1.7	-4.5	-3.4	147.3
		(14.6)	(26.9)	(17.6)	(21.1)	(15.9)	(20.9)	(6.7)	(11.8)	(13.2)	(7.7)	(6.0)	(8.3)	(6.6)
CBA	55°12'N	6.7	8.9	9.8	8.5	2.3	-12.5	-27.6	-17.8	3.1	8.7	5.8	5.2	131.9
		(5.3)	(7.0)	(6.1)	(4.6)	(4.4)	(3.3)	(5.3)	(4.8)	(5.5)	(4.8)	(4.9)	(5.0)	(4.6)
MHT	53°20'N	2.4	0.4	3.2	9.1	5.1	-10.9	-16.2	-9.5	-2.1	7.2	8.1	3.6	118.1
		(4.3)	(4.9)	(3.4)	(3.1)	(4.3)	(7.2)	(5.1)	(1.7)	(6.4)	(6.6)	(4.1)	(4.8)	(3.5)
SHM	52°43'N	11.3	9.1	6.3	7.5	1.3	-17.1	-27.5	-15.7	1.0	8.3	8.5	8.7	134.0
		(5.2)	(4.6)	(3.8)	(4.5)	(4.2)	(5.0)	(3.2)	(8.8)	(7.5)	(5.8)	(3.6)	(4.9)	(6.2)
OPW	48°15'N	9.2	9.8	9.1	11.3	8.7	-5.4	-28.0	-31.2	-2.0	14.7	4.1	2.4	N/A
		(7.0)	(8.2)	(6.4)	(3.7)	(5.5)	(6.3)	(6.1)	(10.1)	(6.7)	(6.1)	(6.0)	(5.4)	N/A
HUN	46°58'N	5.7	13.3	1.6	-14.6	-13.6	-35.3	-34.8	-25.1	-8.0	31.9	54.5	23.8	185.6
		(7.0)	(14.3)	(17.3)	(3.3)	(5.6)	(3.8)	(10.7)	(2.5)	(10.8)	(4.8)	(16.8)	(6.1)	(7.3)
CMO	45°29'N	8.0	3.5	7.6	10.6	3.7	-8.8	-24.7	-25.1	-3.2	9.2	8.1	10.4	117.9
		(7.2)	(7.3)	(5.2)	(6.3)	(4.4)	(6.0)	(8.5)	(7.6)	(10.4)	(8.2)	(6.0)	(4.3)	(5.8)
UUM	44°27'N	3.2	8.3	12.6	3.9	-6.4	-12.0	-11.3	-9.1	-6.4	-3.5	6.9	13.3	129.5
		(5.4)	(4.5)	(7.9)	(9.3)	(2.7)	(3.5)	(3.7)	(4.2)	(1.1)	(7.0)	(5.7)	(4.3)	(3.7)
NWR	40°03'N	6.8	9.4	10.0	8.3	1.1	-11.5	-18.1	-20.0	-9.0	4.9	9.8	8.4	94.0
		(4.7)	(5.1)	(6.6)	(6.1)	(5.5)	(6.1)	(6.5)	(5.0)	(4.0)	(6.7)	(4.3)	(5.0)	(4.3)
UTA	39°54'N	15.3	7.8	15.3	12.1	-6.6	-14.7	-22.2	-22.5	-11.3	2.0	9.6	14.7	107.3
		(14.5)	(7.5)	(13.9)	(2.9)	(3.8)	(3.1)	(4.9)	(7.9)	(5.5)	(7.2)	(9.9)	(12.7)	(1.3)
AZR	38°45'N	8.7	7.4	4.1	7.1	4.1	-13.6	-21.2	-15.0	-7.7	5.1	12.5	9.2	116.0
		(5.8)	(6.3)	(5.4)	(6.6)	(5.7)	(5.6)	(5.7)	(10.4)	(4.4)	(6.5)	(6.3)	(7.5)	(4.5)
TAP	36°44'N	6.1	3.3	4.8	-6.7	-3.6	10.8	-6.9	-4.4	8.3	-7.5	-5.4	6.8	159.4
		(3.6)	(5.0)	(8.8)	(16.1)	(12.6)	(21.1)	(26.7)	(39.8)	(27.4)	(10.7)	(20.8)	(12.6)	(7.7)

Table 3: Summary of the average seasonal cycles and annual mean CH_4 mixing ratios relative to the South Pole for CMDL air sampling sites (continued)

Site	Latitude	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Avg.
QPC	36°16'N	-2.9	3.2	1.5	-2.2	3.1	4.7	1.4	4.6	4.2	-3.4	-6.4	-7.9	101.3
		(7.4)	(3.3)	(9.3)	(9.0)	(6.0)	(6.6)	(8.5)	(8.9)	(3.5)	(5.9)	(4.2)	(7.1)	(4.3)
GOZ	36°03'N	14.0	6.1	3.6	14.7	5.0	1.1	5.6	-20.4	-27.2	-5.9	-0.7	4.1	127.1
		(2.1)	(6.1)	(8.9)	(3.0)	(16.2)	(2.0)	(11.1)	(8.1)	(3.1)	(3.1)	(3.0)	(1.0)	(1.1)
BME	32°22'N	18.8	16.8	14.2	14.7	1.5	-18.7	-33.9	-33.7	-10.3	7.8	10.0	14.1	104.4
		(13.2)	(12.3)	(6.4)	(7.2)	(5.2)	(8.8)	(8.5)	(12.7)	(12.0)	(7.8)	(7.4)	(9.9)	(4.2)
BMW	32°16'N	21.1	19.7	24.8	21.3	-1.1	-25.4	-37.5	-35.1	-11.2	6.2	5.4	14.1	99.4
		(8.0)	(7.8)	(7.4)	(7.3)	(8.3)	(11.5)	(10.9)	(6.3)	(11.1)	(10.6)	(5.8)	(5.1)	(6.1)
POC	30°00'N	12.4	9.1	10.0	7.1	4.0	-1.9	-21.4	-27.2	-8.7	1.5	3.4	9.6	99.5
		(7.3)	(7.7)	(8.1)	(8.4)	(5.4)	(7.3)	(4.4)	(7.7)	(6.0)	(6.9)	(4.9)	(8.3)	(6.2)
IZO	28°18'N	10.7	8.0	7.3	2.7	-1.8	-7.9	-19.6	-19.7	-2.7	6.5	6.6	10.9	80.9
		(6.6)	(4.1)	(10.6)	(8.2)	(8.2)	(5.9)	(8.8)	(5.0)	(1.9)	(7.4)	(5.6)	(8.2)	(3.8)
MID	28°13'N	14.2	17.5	15.2	13.4	6.8	-14.1	-33.2	-34.5	-12.8	7.5	10.5	10.5	97.7
		(4.3)	(5.6)	(6.1)	(7.3)	(4.6)	(4.8)	(5.2)	(6.4)	(10.0)	(5.9)	(5.6)	(3.9)	(7.1)
KEY	25°40'N	16.8	12.9	11.1	13.7	1.2	-19.0	-28.4	-30.8	-15.7	8.3	16.5	16.2	89.3
		(8.6)	(8.5)	(12.5)	(9.6)	(7.8)	(6.7)	(7.6)	(7.2)	(10.3)	(10.7)	(11.5)	(9.3)	(5.9)
POC	25°00'N	4.1	1.2	6.5	7.4	6.5	0.6	-18.1	-24.4	-8.6	5.2	9.2	9.4	90.4
		(12.1)	(13.1)	(9.9)	(8.6)	(7.2)	(9.3)	(7.2)	(6.7)	(11.6)	(8.1)	(7.5)	(6.2)	(4.6)
SCS	21°00'N	21.8	34.1	26.6	-4.0	-17.6	-41.6	-76.7	-60.1	0.3	35.1	34.7	31.5	92.4
		(14.2)	(16.6)	(20.2)	(11.6)	(13.2)	(12.8)	(17.5)	(19.0)	(20.5)	(9.7)	(19.3)	(25.0)	(6.3)
POC	20°00'N	9.2	5.4	8.0	11.1	11.4	2.7	-17.3	-23.3	-14.1	-8.0	3.4	13.0	80.4
		(10.8)	(9.1)	(7.3)	(6.9)	(7.6)	(11.3)	(7.5)	(9.4)	(11.3)	(10.2)	(8.2)	(6.3)	(3.4)
MLO	19°32'N	3.7	-0.4	3.7	6.3	1.5	-6.0	-14.5	-16.1	-4.7	6.3	10.0	9.7	62.4
		(4.2)	(4.3)	(4.7)	(3.1)	(4.2)	(6.1)	(6.3)	(3.5)	(5.1)	(6.2)	(5.7)	(4.4)	(3.3)
KUM	19°31'N	8.3	4.5	6.7	9.9	7.8	-3.8	-20.5	-23.2	-8.7	1.8	6.8	9.7	79.0
		(6.8)	(7.2)	(5.0)	(6.9)	(5.9)	(4.8)	(5.1)	(4.2)	(8.8)	(8.8)	(5.8)	(6.7)	(3.9)
SCS	18°00'N	35.3	32.4	11.7	-13.2	-31.2	-46.5	-51.6	-39.9	-5.7	32.8	41.8	34.7	79.4
		(9.9)	(5.4)	(12.4)	(10.7)	(5.6)	(2.7)	(6.8)	(12.6)	(20.1)	(14.4)	(7.2)	(15.0)	(3.3)
AVI	17°45'N	12.5	10.0	8.3	3.7	-5.1	-9.8	-11.9	-10.7	-11.0	-6.8	5.9	14.4	76.2
		(2.4)	(3.5)	(4.9)	(5.4)	(9.6)	(4.6)	(3.2)	(5.1)	(5.2)	(5.4)	(6.0)	(5.8)	(4.0)
POC	15°00'N	7.6	10.0	11.6	8.4	7.4	0.5	-16.0	-22.1	-12.6	-3.3	2.8	6.9	70.3
		(9.3)	(8.8)	(7.0)	(7.2)	(7.7)	(6.4)	(9.1)	(6.0)	(10.3)	(9.5)	(7.8)	(9.5)	(2.7)
SCS	15°00'N	26.2	20.5	4.7	-11.0	-25.3	-33.7	-34.2	-29.4	-6.1	31.1	38.2	26.9	70.3
		(5.1)	(4.8)	(5.8)	(5.8)	(18.9)	(16.1)	(3.8)	(8.3)	(20.8)	(13.4)	(7.2)	(8.6)	(2.7)

Table 3: Summary of the average seasonal cycles and annual mean CH_4 mixing ratios relative to the South Pole for CMDL air sampling sites (continued)

Site	Latitude	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Avg.
GMI	13°26'N	15.0	18.0	14.8	7.6	-0.5	-11.0	-22.0	-27.6	-18.5	-0.9	12.5	14.5	62.3
		(5.0)	(5.5)	(6.7)	(5.2)	(6.0)	(5.6)	(5.5)	(5.9)	(5.6)	(6.0)	(5.3)	(5.6)	(7.4)
RPB	13°10'N	13.5	10.5	8.2	5.0	-1.2	-7.4	-10.7	-10.2	-11.7	-9.8	2.7	12.1	68.1
		(4.7)	(4.5)	(4.8)	(4.5)	(2.1)	(4.3)	(4.0)	(3.5)	(3.5)	(5.5)	(3.5)	(3.2)	(3.8)
SCS	12°00'N	30.2	21.8	7.6	-5.9	-28.6	-40.0	-33.9	-27.6	-5.4	24.5	31.4	28.0	72.4
		(3.9)	(9.3)	(8.4)	(8.3)	(5.5)	(5.6)	(8.3)	(7.6)	(14.3)	(12.7)	(11.7)	(8.1)	(6.3)
POC	10°00'N	12.2	10.8	13.4	11.6	9.6	0.5	-17.4	-24.3	-20.7	-12.7	-0.2	11.8	54.1
		(6.3)	(6.9)	(4.9)	(5.8)	(3.4)	(3.8)	(2.5)	(5.0)	(8.5)	(7.1)	(10.0)	(10.1)	(6.8)
SCS	9°00'N	31.5	29.6	17.2	1.5	-19.6	-36.4	-33.8	-33.0	-27.9	6.8	33.9	33.8	60.4
		(8.2)	(8.5)	(8.4)	(6.9)	(8.2)	(2.5)	(3.2)	(5.6)	(11.1)	(14.6)	(10.4)	(10.5)	(1.8)
SCS	6°00'N	25.9	28.4	18.6	2.3	-18.8	-31.9	-32.4	-33.3	-30.5	5.0	39.2	32.6	55.5
		(3.0)	(9.7)	(9.0)	(4.8)	(7.6)	(1.9)	(3.0)	(5.8)	(5.9)	(14.6)	(8.2)	(11.0)	(2.3)
POC	5°00'N	9.2	17.6	19.1	13.2	2.7	-7.2	-12.8	-13.0	-12.7	-11.7	-5.2	0.8	35.4
		(10.0)	(9.1)	(12.5)	(8.4)	(9.1)	(6.7)	(2.7)	(4.9)	(3.3)	(5.1)	(9.5)	(9.7)	(3.4)
SCS	3°00'N	25.1	33.1	22.8	6.7	-10.0	-29.1	-34.2	-30.3	-29.4	-3.3	28.1	26.3	50.1
		(7.2)	(13.0)	(8.5)	(3.9)	(7.2)	(1.9)	(3.9)	(5.1)	(5.6)	(14.4)	(8.5)	(9.8)	(2.5)
CHR	1°42'N	7.1	11.8	14.3	11.4	0.0	-8.6	-7.2	-6.0	-8.1	-7.5	-5.0	-0.1	28.5
		(4.6)	(6.5)	(5.8)	(9.2)	(6.0)	(3.6)	(3.3)	(3.1)	(2.9)	(2.7)	(3.4)	(4.0)	(2.9)
POC	0°00'N	7.8	13.8	15.4	7.5	-3.9	-8.6	-8.0	-7.2	-5.9	-6.6	-4.4	1.4	26.1
		(6.9)	(7.0)	(9.5)	(6.6)	(5.9)	(4.9)	(2.4)	(5.0)	(6.5)	(4.1)	(3.6)	(6.3)	(5.2)
SEY	4°40'S	36.9	33.4	12.1	-9.2	-19.2	-16.1	-11.2	-9.4	-7.0	-9.0	-10.7	10.5	21.7
		(8.5)	(8.3)	(9.6)	(7.6)	(5.3)	(4.2)	(3.9)	(5.2)	(3.8)	(7.4)	(10.4)	(11.6)	(3.9)
POC	5°00'S	7.7	11.9	8.5	-1.3	-7.1	-7.3	-5.6	-4.1	-3.5	-4.5	-0.2	5.3	20.0
		(5.5)	(4.1)	(9.1)	(7.3)	(3.8)	(2.8)	(4.0)	(2.8)	(4.3)	(2.9)	(6.2)	(6.4)	(5.2)
ASC	7°55'S	-10.1	-12.3	-8.3	-2.7	1.5	4.3	6.6	7.9	7.7	5.3	2.1	-2.6	13.5
		(3.6)	(2.1)	(2.0)	(2.6)	(2.9)	(3.3)	(2.5)	(2.4)	(2.7)	(2.4)	(4.7)	(4.2)	(3.8)
POC	10°00'S	8.5	8.8	-0.6	-7.2	-8.8	-6.2	-0.2	2.2	1.7	0.9	-0.0	2.5	13.0
		(4.5)	(5.2)	(6.1)	(3.1)	(3.7)	(3.6)	(2.0)	(3.7)	(4.9)	(4.7)	(3.1)	(3.5)	(5.2)
SMO	14°15'S	-0.2	2.2	-1.0	-6.7	-5.2	-0.9	2.7	4.2	3.9	2.2	-0.6	-1.8	7.6
		(6.1)	(5.9)	(5.4)	(4.9)	(3.3)	(2.9)	(2.7)	(1.9)	(1.8)	(1.9)	(2.7)	(3.9)	(3.8)
POC	15°00'S	0.3	3.8	-4.6	-8.7	-3.7	0.1	4.1	7.8	6.2	3.4	-1.5	-5.7	6.5
		(3.5)	(3.6)	(2.9)	(3.8)	(4.2)	(2.0)	(2.9)	(1.7)	(3.4)	(1.7)	(1.5)	(3.6)	(4.7)
POC	20°00'S	-7.3	-7.1	-6.5	-7.5	-3.8	2.4	6.0	8.5	9.9	8.1	1.6	-4.8	4.7
		(4.1)	(6.5)	(3.5)	(2.7)	(2.3)	(2.5)	(2.4)	(2.2)	(2.4)	(2.0)	(2.9)	(2.5)	(3.5)

Table 3: Summary of the average seasonal cycles and annual mean CH_4 mixing ratios relative to the South Pole for CMDL air sampling sites (continued)

Site	Latitude	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Avg.
POC	25°00'S	-9.9	-9.6	-10.8	-7.4	-1.5	2.2	7.0	10.7	11.1	9.8	3.9	-5.6	2.1
		(1.6)	(3.0)	(2.5)	(1.7)	(3.2)	(2.3)	(1.8)	(1.4)	(0.8)	(2.1)	(2.2)	(2.3)	(3.0)
POC	30°00'S	-11.6	-14.9	-13.9	-9.2	-2.5	3.2	8.8	12.3	11.9	10.4	6.8	-2.4	1.7
		(2.0)	(1.1)	(3.3)	(3.6)	(1.9)	(2.9)	(1.9)	(2.5)	(1.6)	(2.2)	(2.3)	(3.2)	(1.0)
POC	35°00'S	-12.1	-15.9	-13.6	-9.6	-3.0	2.3	6.9	12.5	12.7	9.5	8.7	0.1	3.9
		(2.4)	(2.2)	(3.1)	(4.1)	(2.1)	(2.7)	(2.1)	(4.2)	(3.4)	(2.3)	(2.6)	(3.1)	(0.7)
AMS	37°57'S	-11.0	-14.9	-14.4	-8.2	-1.3	3.4	8.0	11.7	12.1	10.6	5.8	-3.0	4.9
		(2.1)	(2.0)	(2.4)	(2.2)	(1.5)	(1.9)	(2.4)	(1.4)	(2.6)	(2.5)	(4.0)	(2.7)	(0.0)
CGO	40°41'S	-10.0	-14.9	-14.7	-10.5	-3.8	2.6	7.9	11.6	12.5	11.6	7.7	-0.6	1.7
		(2.1)	(1.5)	(1.8)	(1.8)	(1.1)	(0.9)	(1.7)	(1.4)	(0.9)	(1.3)	(1.0)	(0.6)	(3.3)
PSA	64°55'S	-8.6	-15.0	-15.2	-11.4	-6.2	0.8	6.7	11.1	13.9	12.8	8.5	1.1	-0.1
		(2.9)	(2.4)	(1.8)	(1.5)	(1.4)	(1.3)	(1.7)	(1.8)	(1.8)	(1.7)	(1.6)	(2.2)	(2.7)
SYO	69°00'S	-7.9	-13.8	-15.0	-11.9	-5.5	0.6	6.4	11.2	12.6	11.8	8.5	1.2	1.0
		(1.7)	(1.6)	(1.1)	(1.7)	(0.9)	(1.3)	(1.5)	(1.8)	(1.8)	(1.4)	(1.3)	(1.9)	(1.0)
SPO	89°59'S	-8.8	-14.1	-14.3	-11.1	-5.7	0.6	6.3	10.7	13.3	12.8	8.3	0.7	0.0
		(1.0)	(1.9)	(1.2)	(1.6)	(1.1)	(1.0)	(1.4)	(1.7)	(0.9)	(0.9)	(1.3)	(1.6)	(0.0)

*Units are parts in 10^9 by volume, dry air (ppbv). Values in parentheses are $\pm 1\delta$. Positive monthly values represent positive deviations from the annual mean.

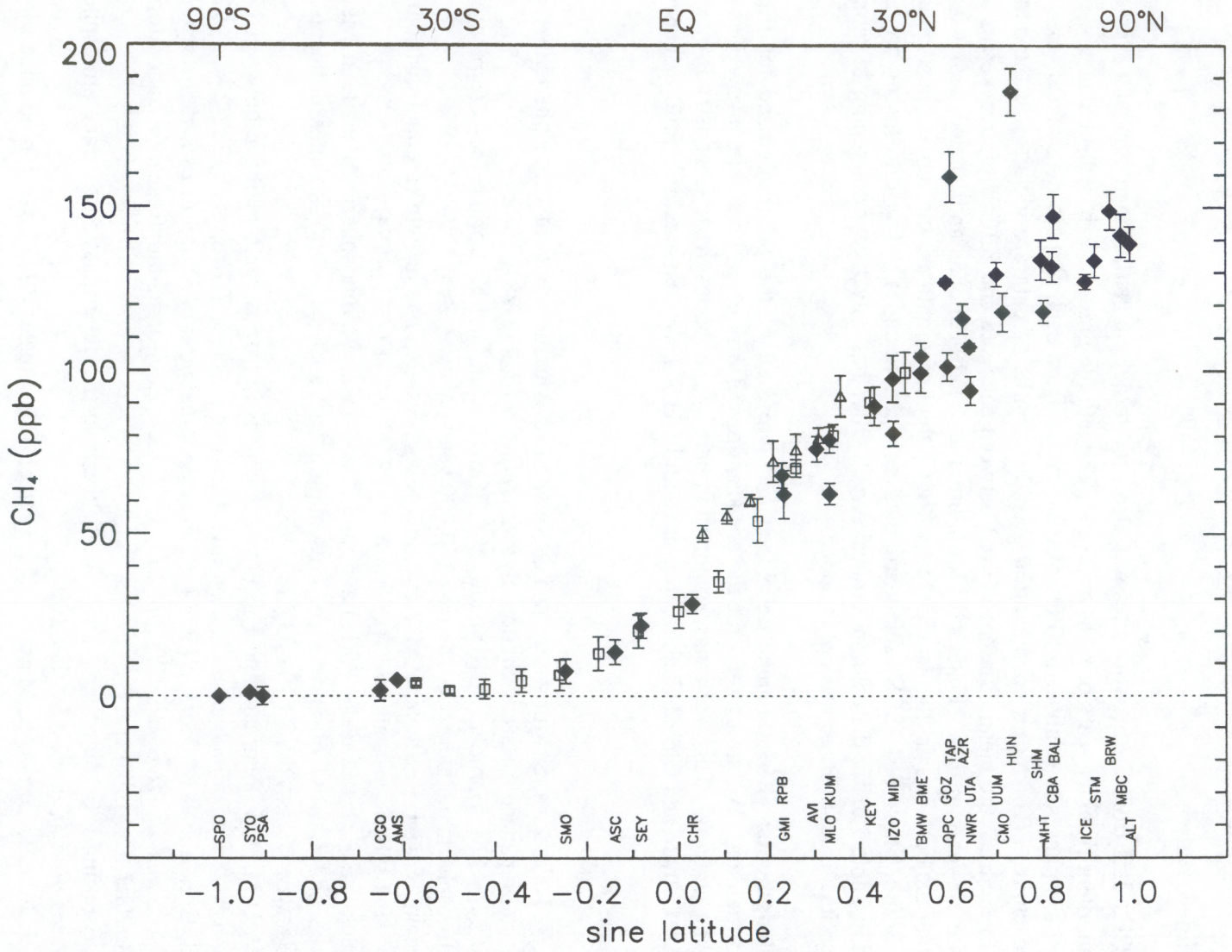

Figure 2: Average annual mean differences between CMDL network sampling sites and the South Pole. Uncertainties are ±1δ. Solid symbols are from fixed sites. Open squares are from Pacific Ocean shipboard samples and open triangles are from South China Sea shipboard samples. The annual means were calculated from curves fitted to the data.

When averaged by a harmonic curve, the extremities in the cycle are ignored [*Dlugokencky et al.*, 1995].

7. Latitude Gradient

The CH_4 data from the network sites was also used to determine the mean, annually averaged latitude gradient from all years of measurements. The latitude gradient is based on annual means from each sampling site relative to SPO. Annual means from each site are determined from the smoothed curve, F(t). Years containing at least 11 months of data are included in the annual means. In Figure 2 the mean difference ($\pm 1\sigma$) between each site and SPO is plotted versus sine latitude for all years of data. Fixed sites are plotted as filled diamonds and labeled with 3-letter codes along the bottom axis; the Pacific Ocean (POC) shipboard data are plotted as open squares, and the South China Sea (SCS) shipboard data as open triangles. The differences are also tabulated in Table 3 under the column "Annual Avg." OPW has only 1 year containing 11 months of data, so its annual average was not included.

Acknowledgments: Kirk Thoning developed and wrote all of the programs used for fitting curves to the data. We are grateful for the conscientious efforts of all personnel involved in the air sampling network. This work was supported in part by the Atmospheric Chemistry Project of the NOAA Climate and Global Change Program and the U.S. Environmental Protection Agency.

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Appendix A
Individual Seasonal Cycles and Amplitudes of Annual Cycles

In this appendix, seasonal amplitude information is presented for each site included in the document. Each page contains information for one site. The pages are arranged according to latitude, starting with the northern-most site.

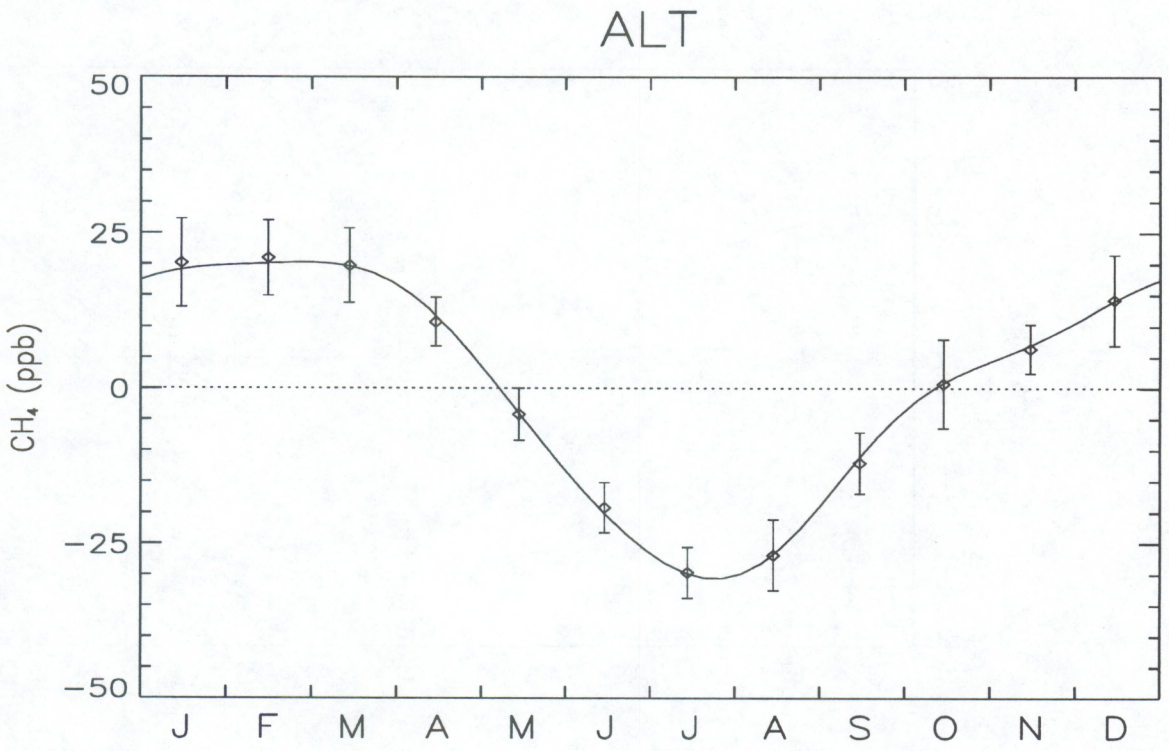
In each graph, the average seasonal cycle is shown using two different methods. The solid line depicts one cycle of the harmonic curve determined by equation (4). The symbols, shown with their standard deviation, are the average detrended monthly means determined from the smoothed curve (equation (4) plus the result of the short-term low-pass filter). Since the means were generated using values from the detrended smoothed curve (taken at a weekly resolution), gaps in the original data are filled in with values from the curve. The standard deviations reflect interannual variability. The y-axis range of most graphs is the same to allow for easy comparison between sites. However, four sites (HUN, POCN21, POCN18, POCN06) had such large amplitudes that the ranges of these plots were extended. When comparing graphs, the reader should remain conscious of these changes.

Below each graph, the site code, latitude, and the start and end dates for the site are summarized. Measurements made during 1983-1995 were used; the specific start and end dates for each site are reported on the appropriate page. Sites remaining active after 1995 were given an end date of December 1995. The number of acceptable samples used to determine the curves is aso included.

Below the general information a "site table" is included. The maximum and minimum values and their respective dates, determined from the detrended smoothed curve, are reported for each year containing original data for at least 11 months of the year. The amplitudes of all complete cycles are averaged and reported as the "average amplitude," along with the standard deviation. An amplitude for the harmonic curve is also given. It is determined as the difference between the maximum and minimum values of the harmonic cycle plotted in the figure. Harmonic curves that are well defined due to long, continuous records and a high signal-to-noise ratio result in good agreement between the harmonic and average amplitudes. Synoptic scale variability in CH_4 mixing ratios can lead to poor agreement between the two amplitudes.

For South China Sea sites, there is poor agreement between the average detrended monthly means and the harmonic curve. This occurs because of large gaps in these time series, particularly in late summer and early fall. For South China Sea sites then, the harmonic curve is a better representation of the average seasonal cycle than the average detrended monthly means.

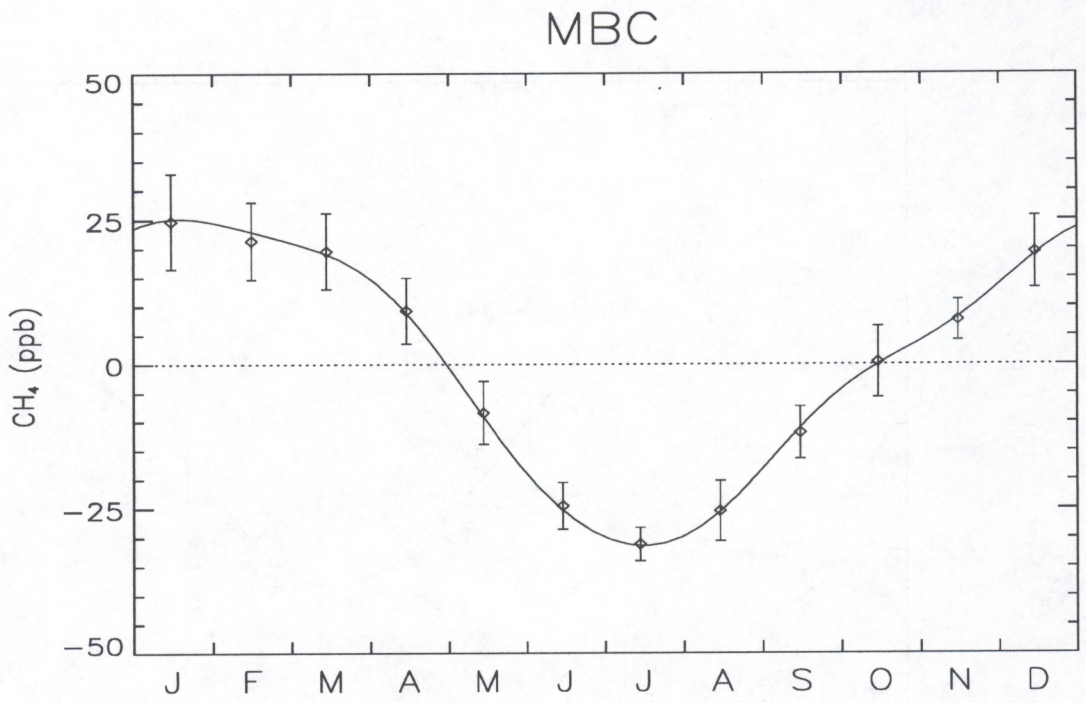
The original data used for this memorandum can be obtained from the CMDL ftp server at ftp.cmdl.noaa.gov.



Station Name:	Alert, NWT, Canada
Station Code:	ALT
Latitude:	82°27'N
Beginning Date:	Jun 1985
Ending Date:	Dec 1995
Number of Data Points:	495

Year	Amplitude	Maximum	Date	Minimum	Date
1986	56.34	26.85	Mar 17	-29.49	Jul 21
1987	36.38	12.61	Mar 16	-23.77	Jul 20
1988	58.57	18.07	Jan 25	-40.50	Aug 2
1989	55.07	28.56	Dec 26	-26.51	Jul 25
1990	57.81	27.72	Jan 2	-30.10	Aug 7
1991	67.49	30.56	Jan 22	-36.92	Jul 16
1992	64.19	32.51	Jan 14	-31.68	Jul 29
1993	58.15	23.83	Jan 6	-34.32	Jul 14
1994	69.13	34.58	Mar 2	-34.55	Aug 3
1995	52.99	25.01	Mar 1	-27.98	Jul 12

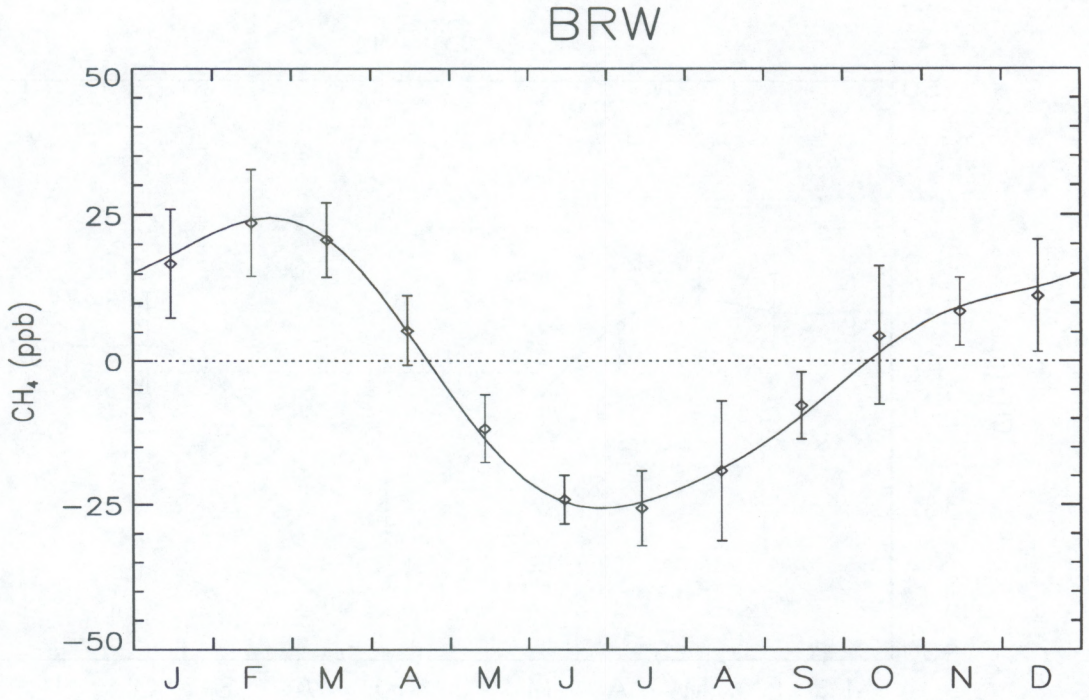
Average Amplitude:	57.5
Standard Deviation:	9.2
Harmonic Amplitude:	50.8



Station Name:	Mould Bay, Canada
Station Code:	MBC
Latitude:	76°15'N
Beginning Date:	Apr 1983
Ending Date:	Dec 1995
Number of Data Points:	816

Year	Amplitude	Maximum	Date	Minimum	Date
1984	58.48	29.21	Jan 24	-29.27	Jul 24
1985	56.06	23.42	Jan 9	-32.64	Jul 24
1986	60.18	26.04	Dec 31	-34.14	Aug 13
1987	61.66	29.54	Jan 14	-32.12	Jul 8
1988	75.09	37.90	Dec 29	-37.19	Jul 20
1989	71.86	37.76	Jan 5	-34.10	Jul 13
1990	65.56	31.47	Dec 27	-34.09	Jul 19
1991	76.76	44.01	Jan 17	-32.75	Jul 4
1992	63.59	37.80	Dec 25	-25.79	Jul 16
1993	72.14	38.52	Jan 1	-33.62	Jul 9
1994	64.56	33.00	Mar 11	-31.56	Jul 29
1995	65.44	31.97	Mar 3	-33.48	Jul 14

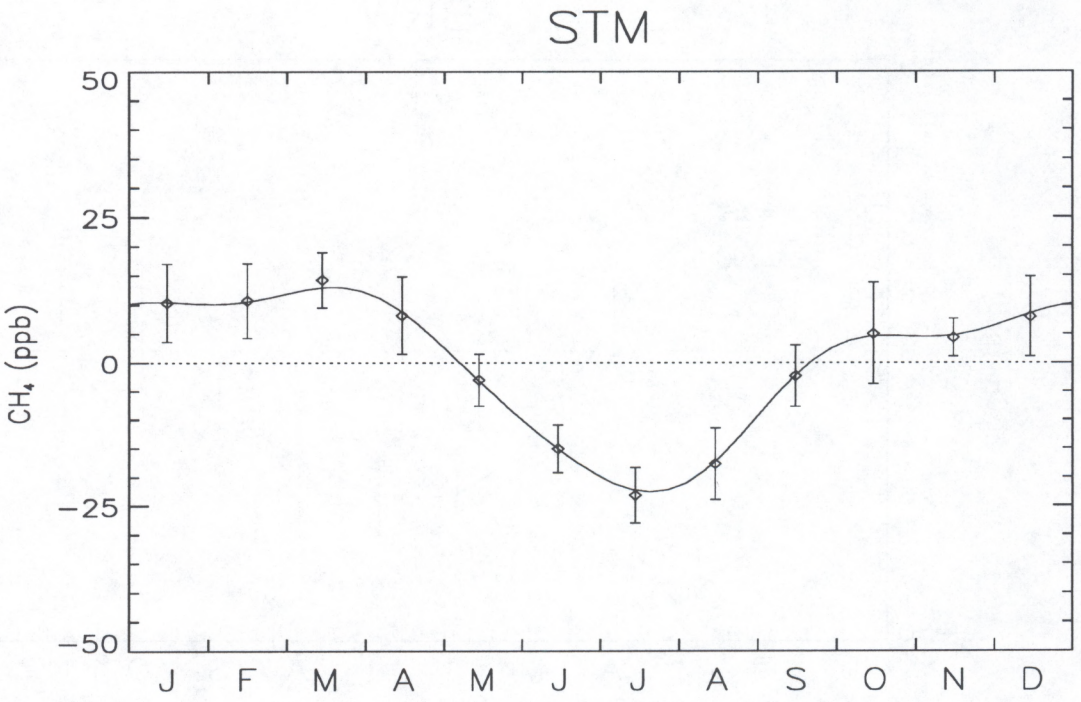
Average Amplitude:	65.9
Standard Deviation:	6.7
Harmonic Amplitude:	56.6



Station Name:	Barrow, Alaska, USA
Station Code:	BRW
Latitude:	71°19'N
Beginning Date:	Apr 1983
Ending Date:	Dec 1995
Number of Data Points:	908

Year	Amplitude	Maximum	Date	Minimum	Date
1984	65.43	40.20	Feb 9	-25.23	Jul 5
1985	56.76	20.52	Jan 3	-36.23	Jul 25
1986	76.98	40.36	Oct 23	-36.62	Aug 7
1987	49.09	20.03	Mar 5	-29.06	Jun 25
1988	76.17	41.64	Feb 19	-34.52	Jul 29
1989	59.33	24.46	Jan 6	-34.87	Jun 16
1990	64.12	30.46	Dec 28	-33.66	Jul 20
1991	56.53	29.56	Jan 4	-26.97	Jun 14
1992	50.28	29.30	Jan 24	-20.98	Aug 15
1993	47.96	23.02	Mar 13	-24.94	Jun 26
1994	59.05	29.59	Mar 5	-29.46	Jun 18
1995	62.29	29.42	Feb 18	-32.86	Jul 22

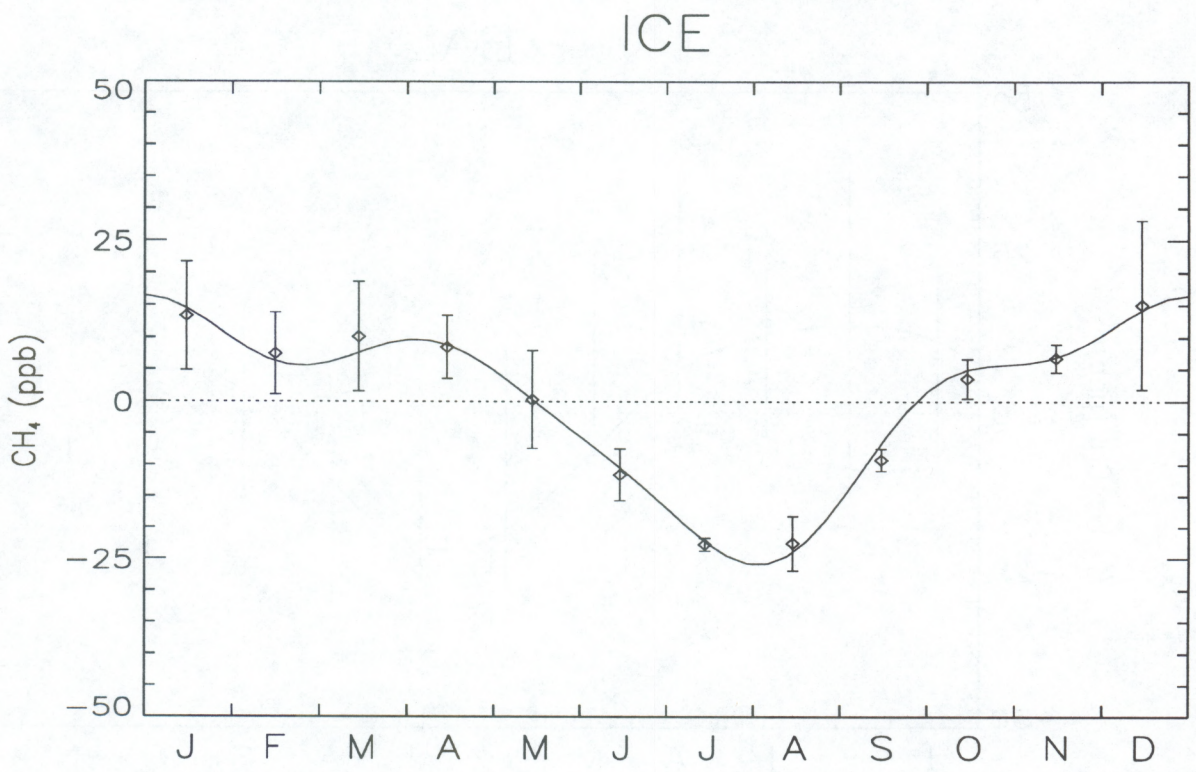
Average Amplitude:	60.3
Standard Deviation:	9.5
Harmonic Amplitude:	50.0



Station Name:	Station 'M'
Station Code:	STM
Latitude:	66°00'N
Beginning Date:	Apr 1983
Ending Date:	Dec 1995
Number of Data Points:	1010

Year	Amplitude	Maximum	Date	Minimum	Date
1984	61.84	24.28	Oct 6	-37.56	Jul 28
1985	48.43	20.12	Jan 19	-28.31	Jul 27
1986	42.56	18.01	Apr 5	-24.55	Jul 12
1987	57.93	30.33	Mar 7	-27.60	Aug 1
1988	44.88	19.28	Mar 27	-25.60	Jul 10
1989	40.82	17.07	Dec 31	-23.75	Jul 16
1990	47.18	21.09	Feb 11	-26.09	Jul 15
1991	39.53	15.41	Mar 3	-24.12	Jul 7
1992	34.55	14.08	Mar 23	-20.47	Jul 20
1993	41.78	25.14	Dec 27	-16.64	Jul 5
1994	48.89	23.97	Jan 3	-24.92	Aug 1
1995	32.91	14.89	Mar 20	-18.02	Jun 26

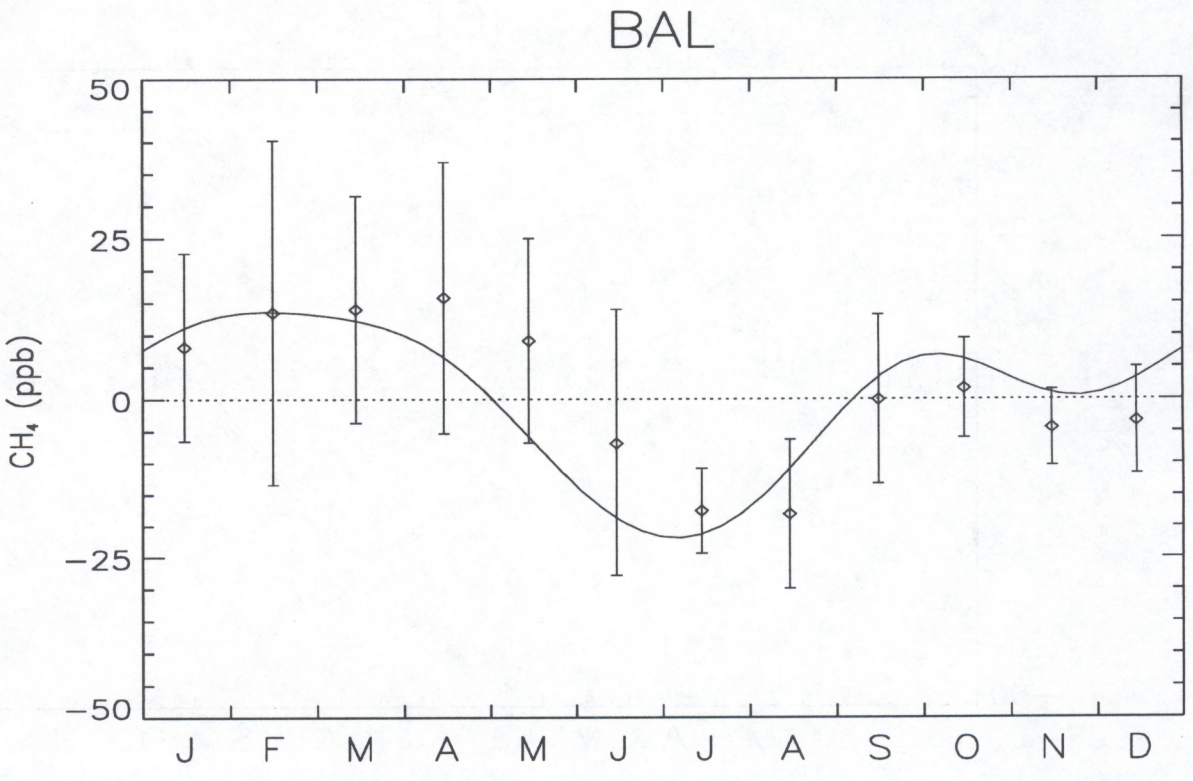
Average Amplitude:	45.1
Standard Deviation:	8.5
Harmonic Amplitude:	35.6



Station Name:	Vestmannaeyjar, Iceland
Station Code:	ICE
Latitude:	63°15'N
Beginning Date:	Oct 1992
Ending Date:	Dec 1995
Number of Data Points:	113

Year	Amplitude	Maximum	Date	Minimum	Date
1993	62.67	33.98	Dec 31	-28.69	Aug 6
1994	56.31	30.97	Jan 7	-25.33	Aug 5
1995	--Incomplete Data--				

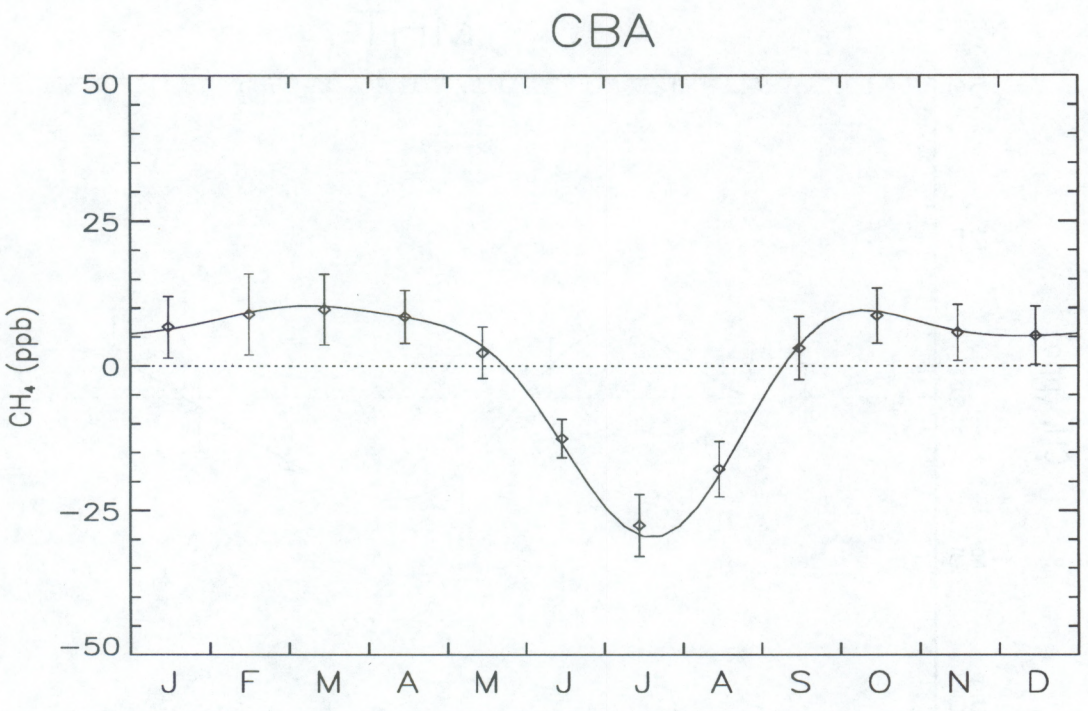
Average Amplitude:	59.4
Standard Deviation:	4.5
Harmonic Amplitude:	42.3



Station Name:	Baltic Sea
Station Code:	BAL
Latitude:	55°30'N
Beginning Date:	Sep 1992
Ending Date:	Dec 1995
Number of Data Points:	260

Year	Amplitude	Maximum	Date	Minimum	Date
1993	34.24	13.51	Apr 29	-20.73	Jun 24
1994	73.51	46.73	Feb 17	-26.78	Jun 30
1995	--Incomplete Data--				

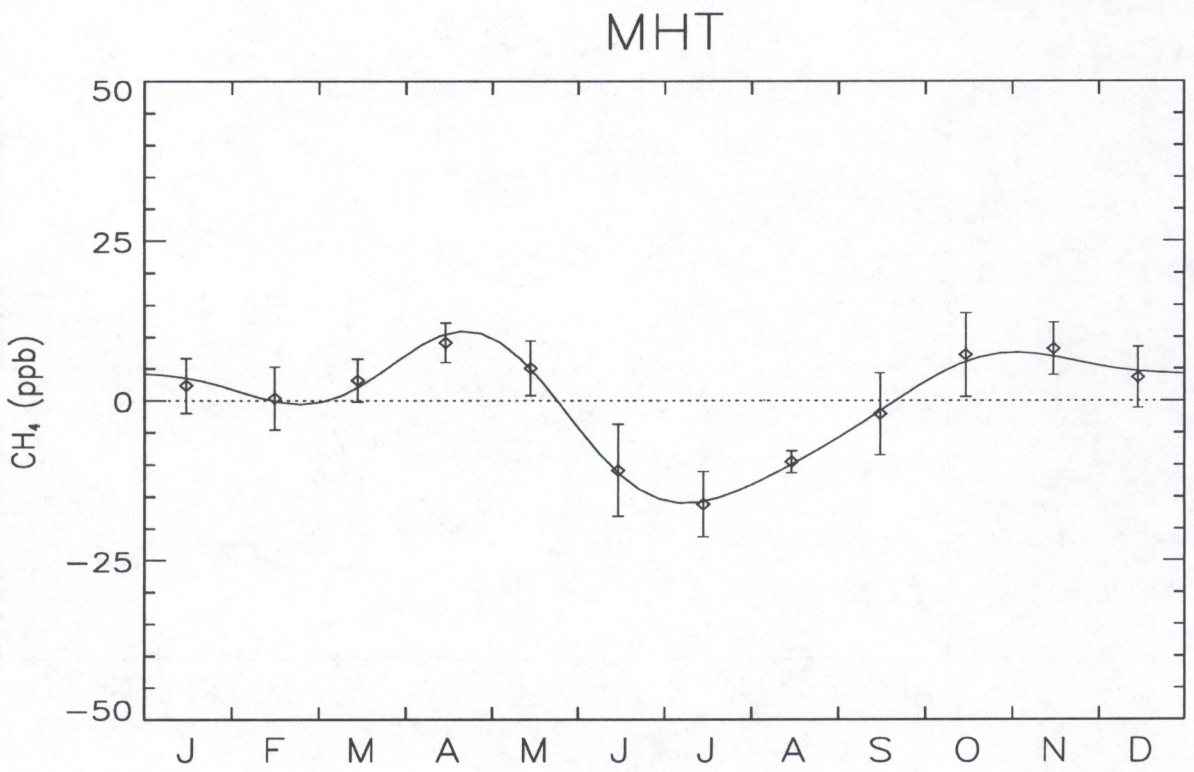
Average Amplitude:	53.8
Standard Deviation:	27.8
Harmonic Amplitude:	35.5



Station Name:	Cold Bay, Alaska, USA
Station Code:	CBA
Latitude:	55°12'N
Beginning Date:	May 1983
Ending Date:	Dec 1995
Number of Data Points:	756

Year	Amplitude	Maximum	Date	Minimum	Date
1984	63.29	29.52	Feb 27	-33.77	Jul 16
1985	49.81	18.17	Mar 18	-31.64	Jul 22
1986	52.33	22.41	Sep 30	-29.91	Jul 22
1987	45.87	15.35	Oct 6	-30.51	Jul 28
1988	32.62	14.42	Dec 27	-18.20	Jul 5
1989	49.11	16.63	Jan 11	-32.48	Jul 19
1990	42.62	16.34	Jan 31	-26.28	Jul 18
1991	39.96	12.70	Dec 25	-27.26	Jul 10
1992	37.13	12.13	Jan 1	-25.00	Jul 22
1993	45.36	14.84	Oct 14	-30.52	Jul 15
1994	62.21	18.45	Mar 17	-43.76	Jul 20
1995	43.09	14.49	Apr 5	-28.61	Jul 20

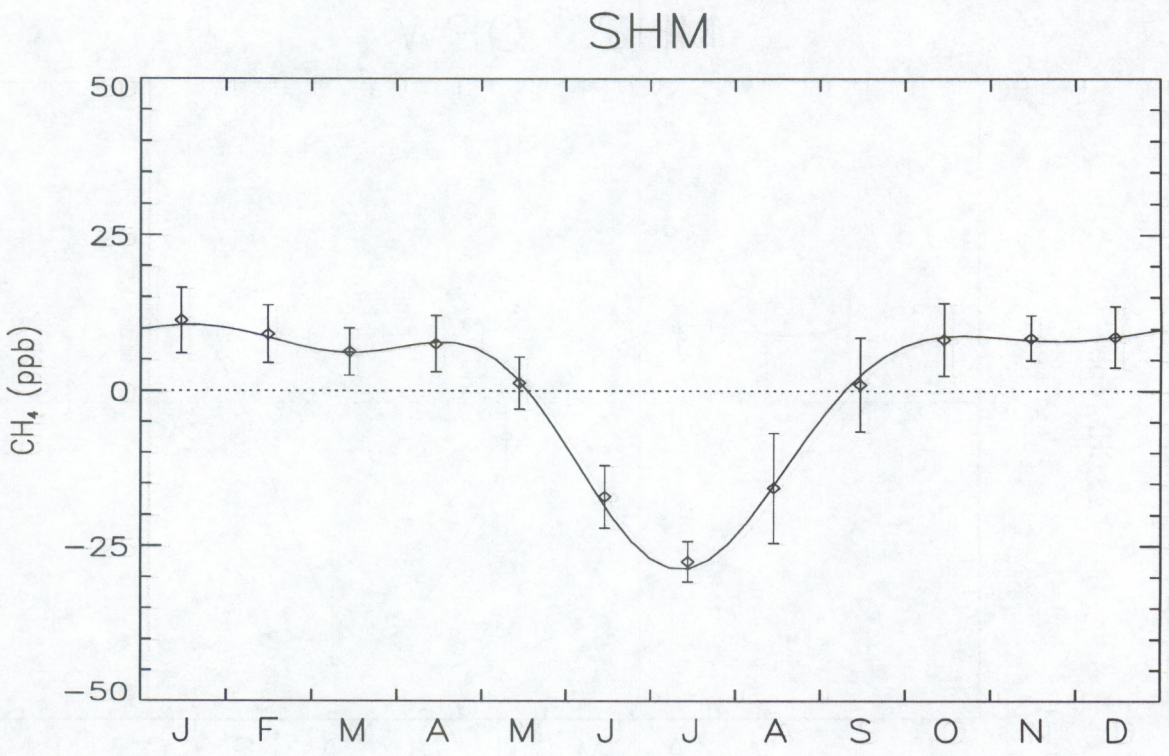
Average Amplitude:	46.9
Standard Deviation:	9.2
Harmonic Amplitude:	40.0



Station Name:	Mace Head, Ireland
Station Code:	MHT
Latitude:	53°20'N
Beginning Date:	Jun 1991
Ending Date:	Dec 1995
Number of Data Points:	201

Year	Amplitude	Maximum	Date	Minimum	Date
1992	19.82	9.25	Dec 15	-10.57	Aug 4
1993	47.30	18.96	Oct 12	-28.33	Jun 29
1994	27.57	10.75	Apr 26	-16.82	Jul 19
1995	34.14	13.39	Nov 7	-20.75	Jun 27

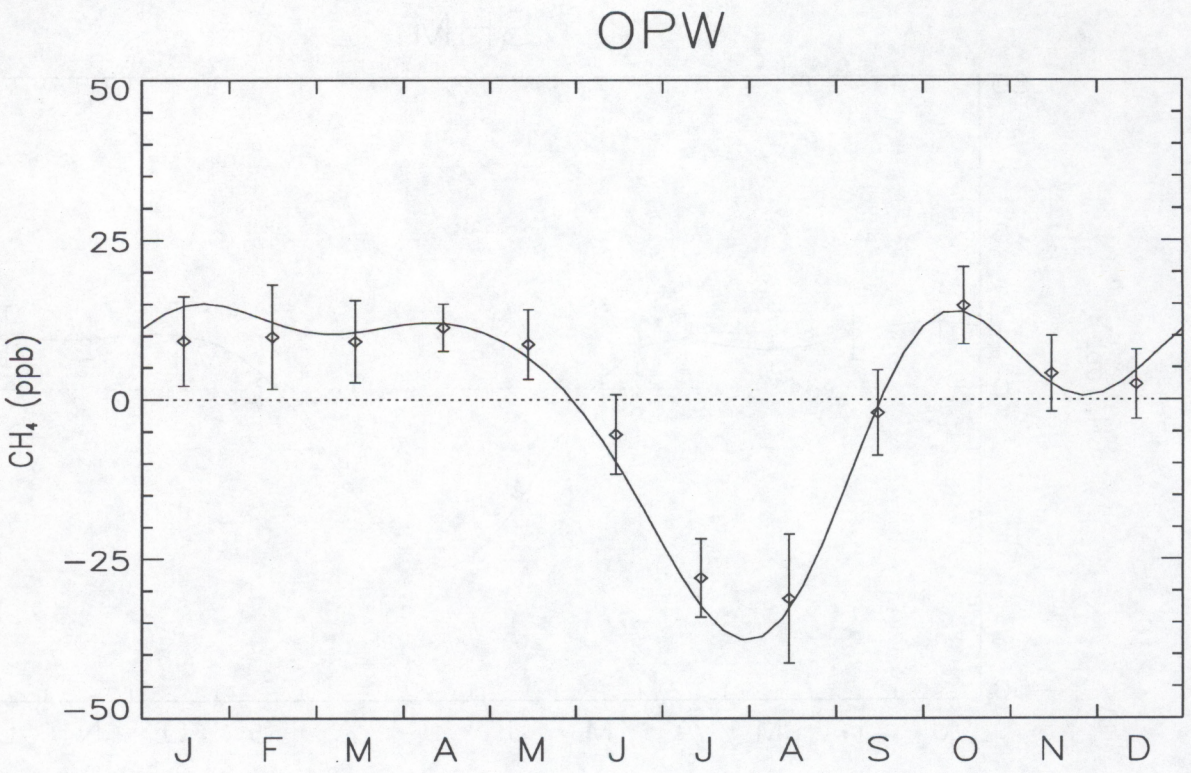
Average Amplitude:	32.2
Standard Deviation:	11.7
Harmonic Amplitude:	26.9



Station Name:	Shemya Island, Alaska, USA
Station Code:	SHM
Latitude:	52°43'N
Beginning Date:	Sep 1985
Ending Date:	Dec 1995
Number of Data Points:	383

Year	Amplitude	Maximum	Date	Minimum	Date
1986	49.22	18.57	Oct 15	-30.65	Jul 9
1987	46.67	14.50	Dec 2	-32.17	Aug 5
1988	47.29	17.72	Apr 14	-29.57	Jul 21
1989	43.21	14.46	Jan 26	-28.74	Jun 29
1990	53.87	18.77	Jan 25	-35.10	Jul 5
1991	45.28	14.90	Jan 10	-30.38	Jul 18
1992	34.53	12.81	Jan 2	-21.72	Jul 3
1993	45.29	13.08	Nov 5	-32.20	Jul 9
1994	51.29	18.06	Dec 30	-33.23	Jul 22
1995	45.90	18.53	Jan 6	-27.37	Jul 28

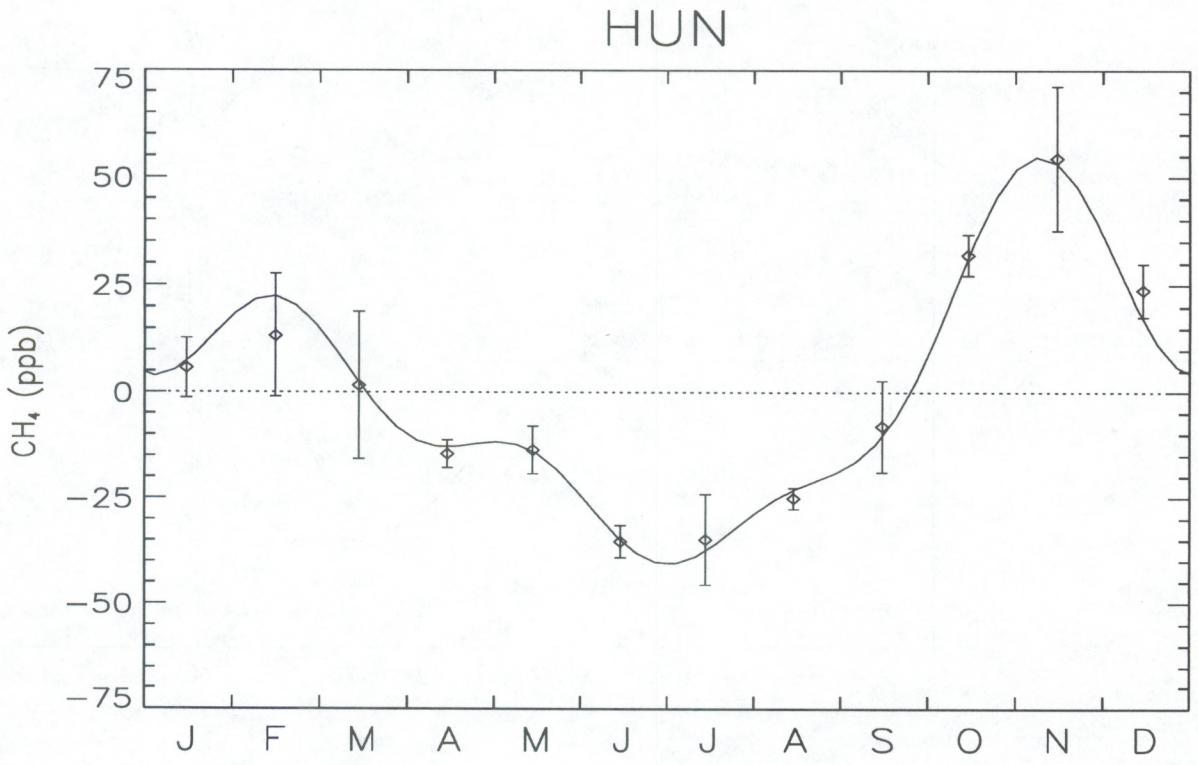
Average Amplitude:	46.2
Standard Deviation:	5.2
Harmonic Amplitude:	39.3



Station Name:	Olympic Peninsula, Washington, USA
Station Code:	OPW
Latitude:	48°15'N
Beginning Date:	Nov 1984
Ending Date:	May 1990
Number of Data Points:	143

Year	Amplitude	Maximum	Date	Minimum	Date
1985	--Incomplete Data--				
1986	58.09	21.95	Apr 30	-36.14	Aug 6
1987	71.30	25.45	Oct 14	-45.85	Aug 5
1988	60.54	20.23	Mar 16	-40.31	Aug 3
1989	57.27	20.50	Jan 26	-36.76	Jul 27

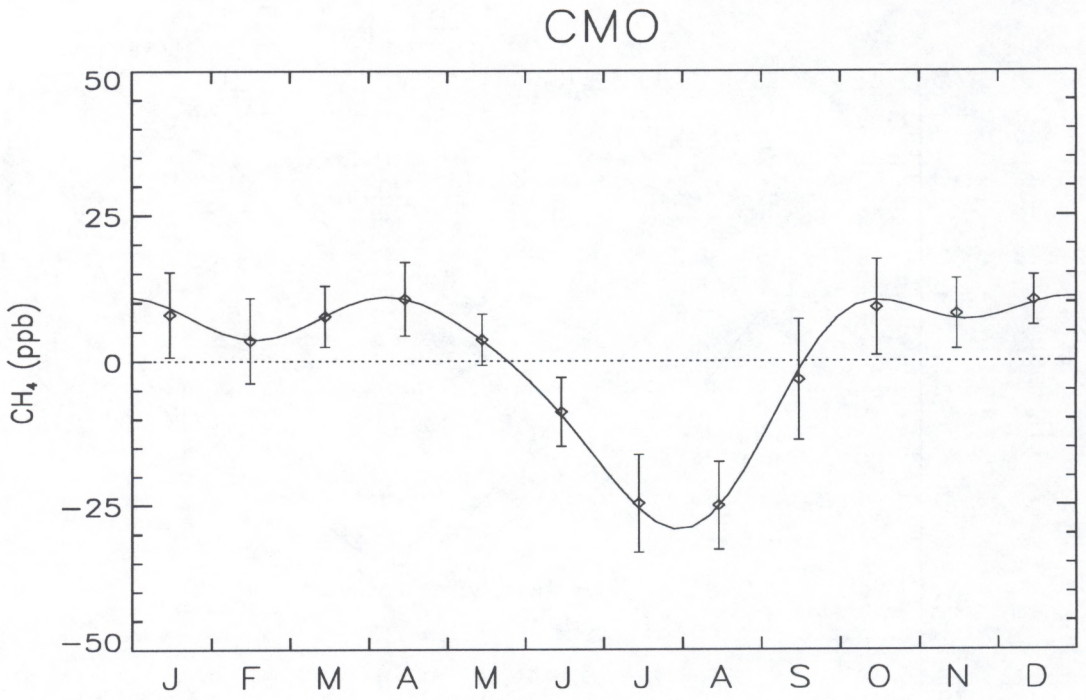
Average Amplitude:	52.4
Standard Deviation:	21.6
Harmonic Amplitude:	52.7



Station Name:	Hegyhatsal, Hungary
Station Code:	HUN
Latitude:	46°58'N
Beginning Date:	Mar 1993
Ending Date:	Dec 1995
Number of Data Points:	138

Year	Amplitude	Maximum	Date	Minimum	Date
1994	96.88	62.53	Nov 15	-34.35	Jun 14
1995	85.28	43.29	Oct 24	-41.99	Jul 4

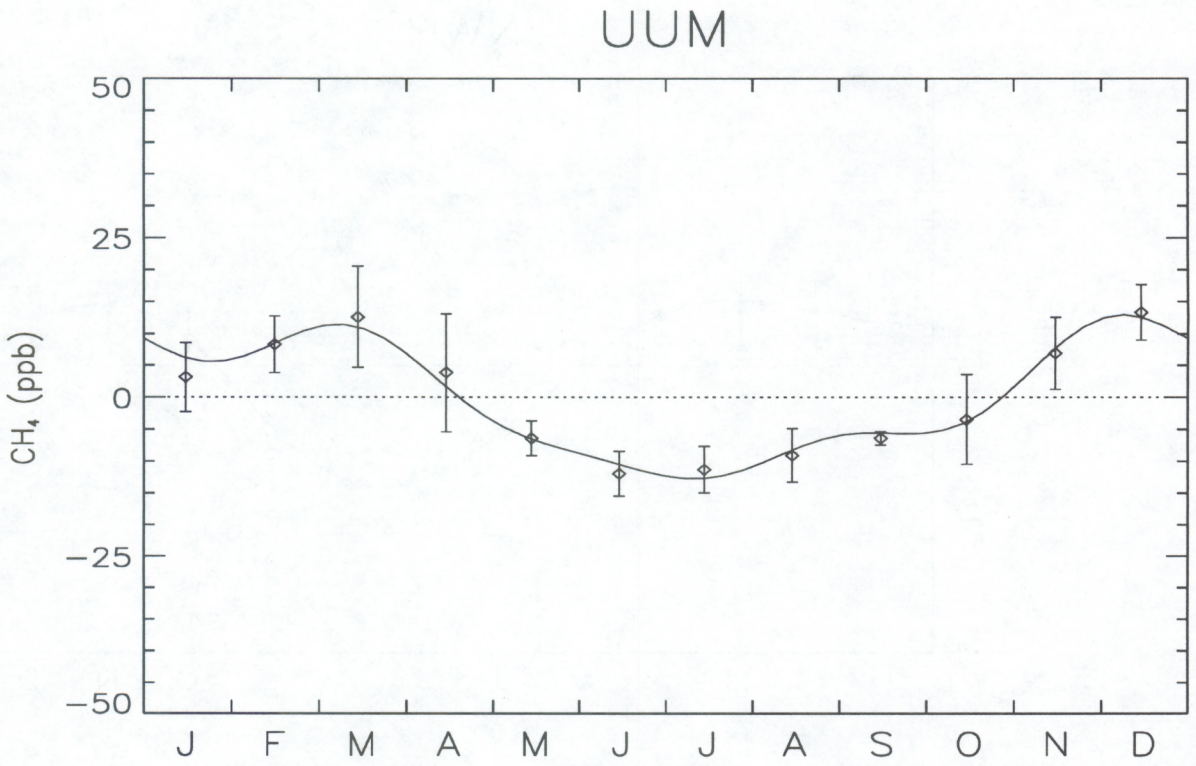
Average Amplitude:	91.0
Standard Deviation:	8.2
Harmonic Amplitude:	95.4



Station Name:	Cape Meares, Oregon, USA
Station Code:	CMO
Latitude:	45°29'N
Beginning Date:	May 1983
Ending Date:	Dec 1995
Number of Data Points:	465

Year	Amplitude	Maximum	Date	Minimum	Date
1984	66.58	28.99	Oct 14	-37.58	Aug 5
1985	64.67	24.27	Apr 7	-40.40	Jul 21
1986	66.54	22.91	Oct 12	-43.63	Aug 10
1987	51.60	15.20	Dec 27	-36.39	Aug 9
1988	40.86	17.53	Jan 10	-23.33	Aug 8
1989	40.08	17.84	Jan 30	-22.25	Jul 31
1990	47.76	15.89	Dec 10	-31.87	Jul 30
1991	51.08	15.24	Nov 11	-35.85	Sep 9
1992	43.85	19.19	Dec 29	-24.66	Jul 14
1993	52.53	20.33	Jan 5	-32.20	Jul 27
1994	59.13	15.74	Mar 22	-43.39	Jul 19
1995	--Incomplete Data--				

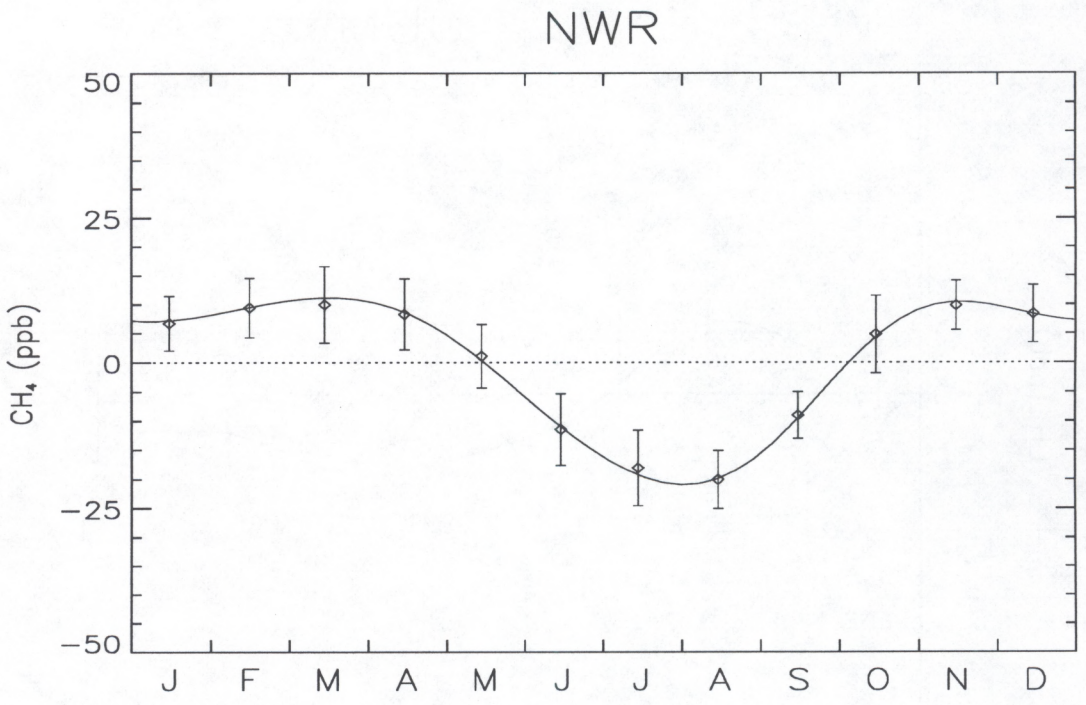
Average Amplitude:	53.1
Standard Deviation:	9.9
Harmonic Amplitude:	40.2



Station Name:	Ulaan Uul, Mongolia
Station Code:	UUM
Latitude:	44°27'N
Beginning Date:	Jan 1992
Ending Date:	Dec 1995
Number of Data Points:	167

Year	Amplitude	Maximum	Date	Minimum	Date
1992	40.23	22.77	Mar 18	-17.45	Jun 17
1993	23.13	9.62	Nov 4	-13.52	Aug 5
1994	37.70	24.46	Dec 1	-13.24	Oct 6
1995	30.57	18.48	Mar 9	-12.09	Jun 22

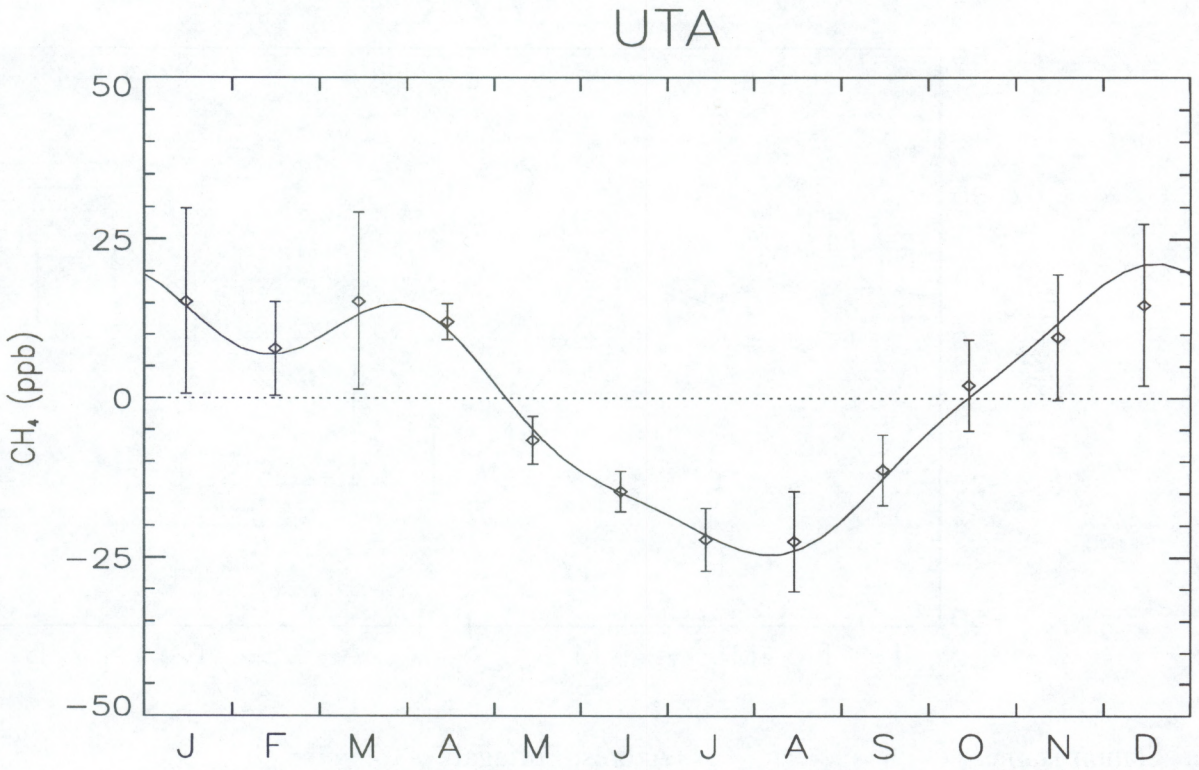
Average Amplitude:	32.9
Standard Deviation:	7.7
Harmonic Amplitude:	25.7



Station Name:	Niwot Ridge, Colorado, USA
Station Code:	NWR
Latitude:	40°03'N
Beginning Date:	Jun 1983
Ending Date:	Dec 1995
Number of Data Points:	678

Year	Amplitude	Maximum	Date	Minimum	Date
1984	36.91	14.98	Oct 24	-21.93	Aug 22
1985	52.59	21.49	Nov 20	-31.09	Jul 17
1986	43.20	15.86	Feb 26	-27.34	Jul 23
1987	45.08	25.56	Mar 4	-19.51	Aug 12
1988	36.87	15.67	Dec 8	-21.20	Jul 28
1989	28.83	15.94	Nov 23	-12.88	Aug 24
1990	31.84	10.49	Nov 29	-21.35	Jun 21
1991	33.87	12.32	Dec 5	-21.55	Aug 1
1992	37.95	15.58	Mar 12	-22.37	Jul 31
1993	36.38	18.19	Apr 9	-18.19	Aug 13
1994	48.87	18.94	Apr 8	-29.94	Aug 12
1995	33.52	17.04	Apr 14	-16.47	Aug 25

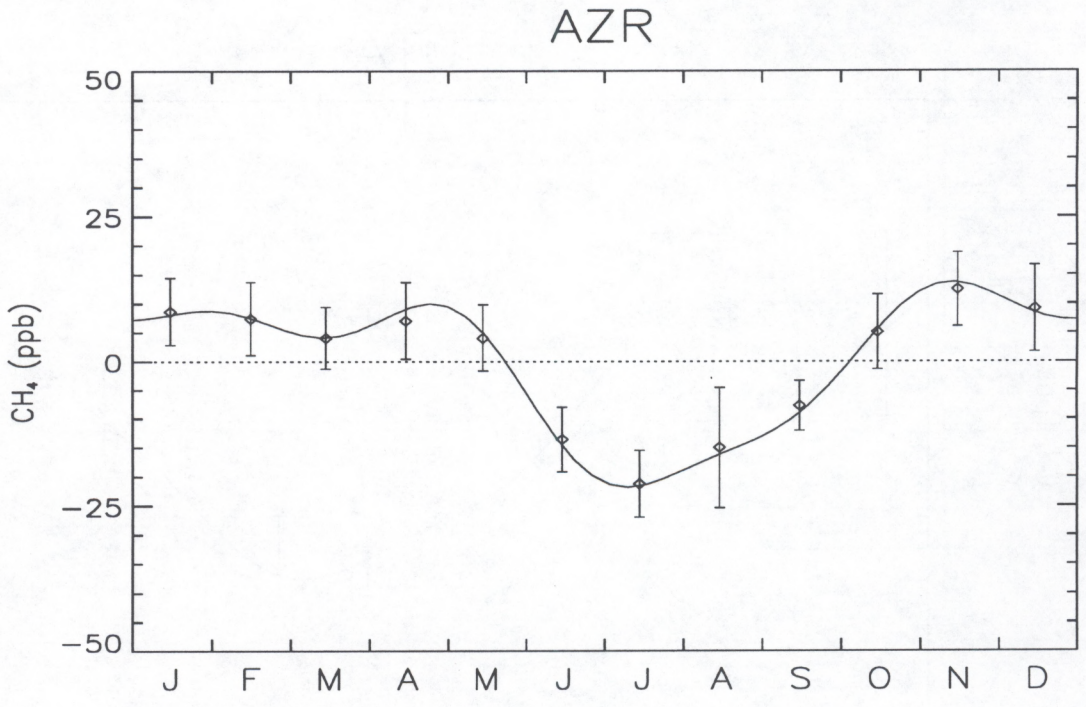
Average Amplitude:	38.8
Standard Deviation:	7.1
Harmonic Amplitude:	32.0



Station Name:	Wendover, Utah, USA
Station Code:	UTA
Latitude:	39°54'N
Beginning Date:	May 1993
Ending Date:	Dec 1995
Number of Data Points:	115

Year	Amplitude	Maximum	Date	Minimum	Date
1994	66.05	33.08	Dec 29	-32.98	Aug 4
1995	56.33	32.19	Jan 5	-24.14	Jul 13

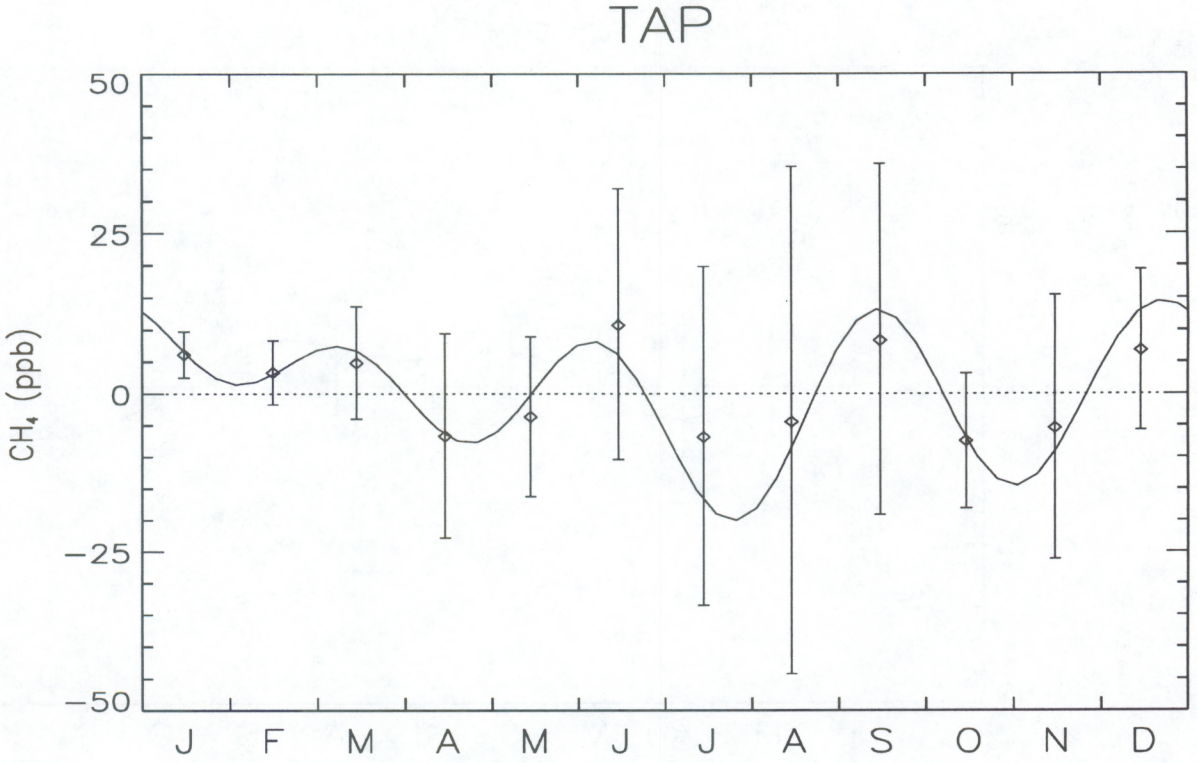
Average Amplitude:	61.2
Standard Deviation:	6.9
Harmonic Amplitude:	45.8



Station Name:	Azores, Portugal
Station Code:	AZR
Latitude:	38°45'N
Beginning Date:	May 1983
Ending Date:	Dec 1995
Number of Data Points:	213

Year	Amplitude	Maximum	Date	Minimum	Date
1984	50.01	21.00	Feb 21	-29.01	Jul 10
1985	39.66	16.81	May 8	-22.85	Jul 3
1986	28.12	14.95	Jan 29	-13.17	Jul 2
1987	46.68	15.86	Dec 23	-30.82	Aug 5
1988	56.81	21.69	Apr 20	-35.12	Aug 4
1989	37.14	15.06	Nov 16	-22.08	Jul 20
1990	46.18	18.49	Oct 25	-27.68	Aug 23
1991	61.07	28.01	Nov 21	-33.06	Jun 27
1992	--Incomplete Data--				
1993	--Incomplete Data--				
1994	--Incomplete Data--				
1995	27.89	12.31	Nov 17	-15.58	Jun 30

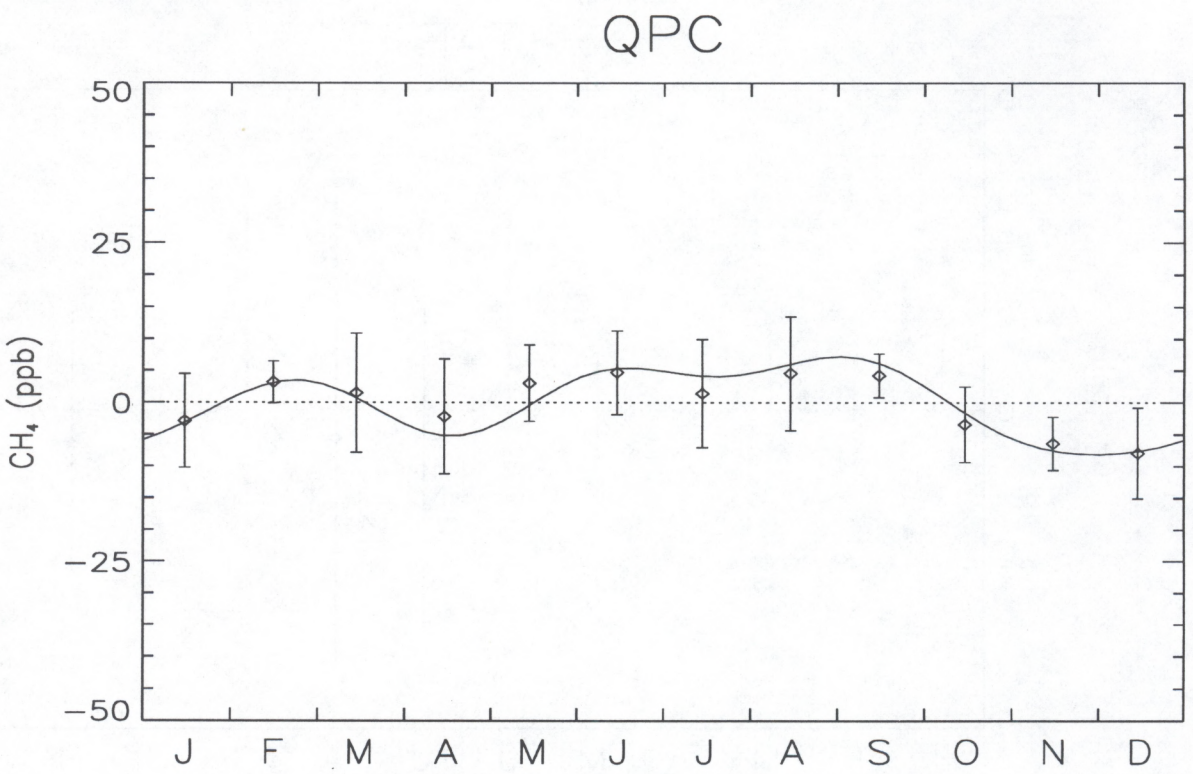
Average Amplitude:	43.7
Standard Deviation:	11.6
Harmonic Amplitude:	35.4



Station Name:	Tae-ahn Peninsula, Korea
Station Code:	TAP
Latitude:	36°44'N
Beginning Date:	Nov 1990
Ending Date:	Dec 1995
Number of Data Points:	171

Year	Amplitude	Maximum	Date	Minimum	Date
1991	118.19	77.02	Aug 31	-41.18	Nov 9
1992	32.47	17.78	Jun 13	-14.69	Nov 1
1993	71.22	43.17	Jul 4	-28.04	Apr 25
1994	50.30	14.55	Sep 4	-35.74	Jul 17
1995	94.87	26.82	Jun 18	-68.05	Aug 13

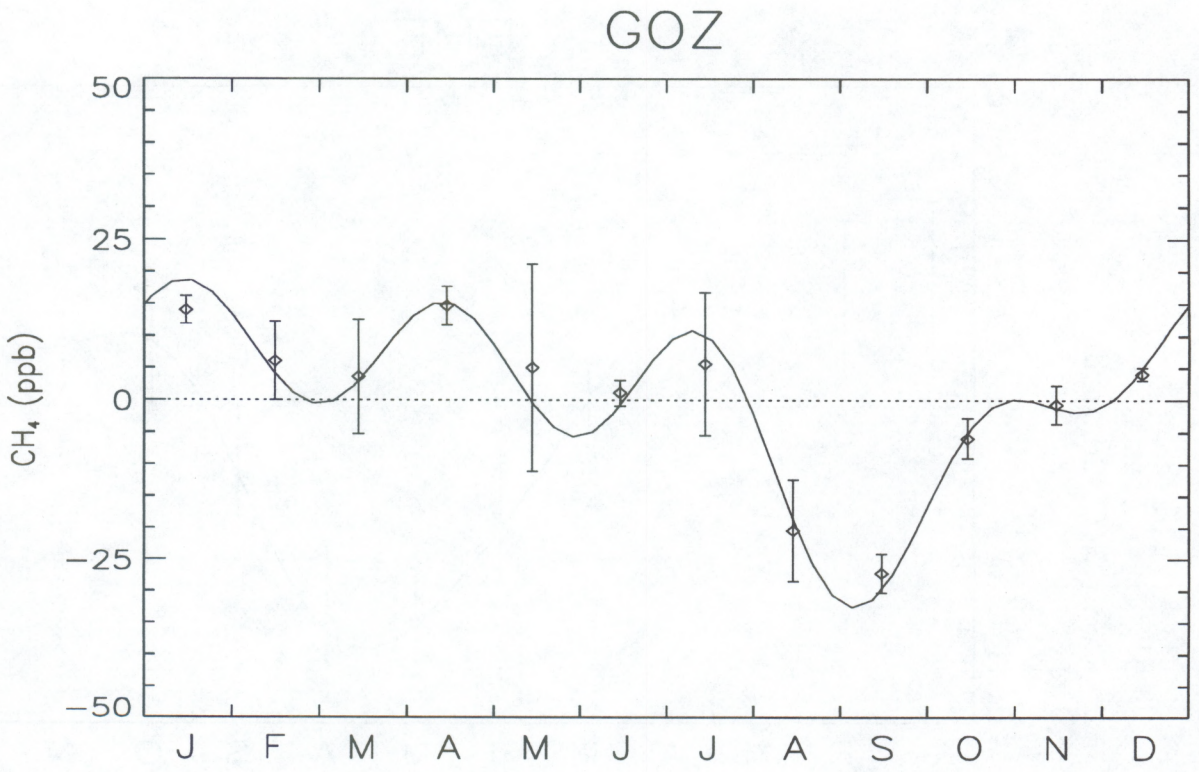
Average Amplitude:	73.4
Standard Deviation:	34.2
Harmonic Amplitude:	34.6



Station Name:	Qinghai Province, China
Station Code:	QPC
Latitude:	36°16'N
Beginning Date:	May 1991
Ending Date:	Dec 1995
Number of Data Points:	329

Year	Amplitude	Maximum	Date	Minimum	Date
1992	27.63	10.72	Feb 25	-16.91	Jan 7
1993	28.23	14.86	Aug 4	-13.36	Apr 7
1994	23.23	11.57	Sep 7	-11.66	Jul 13
1995	26.53	13.46	Aug 23	-13.06	Oct 25

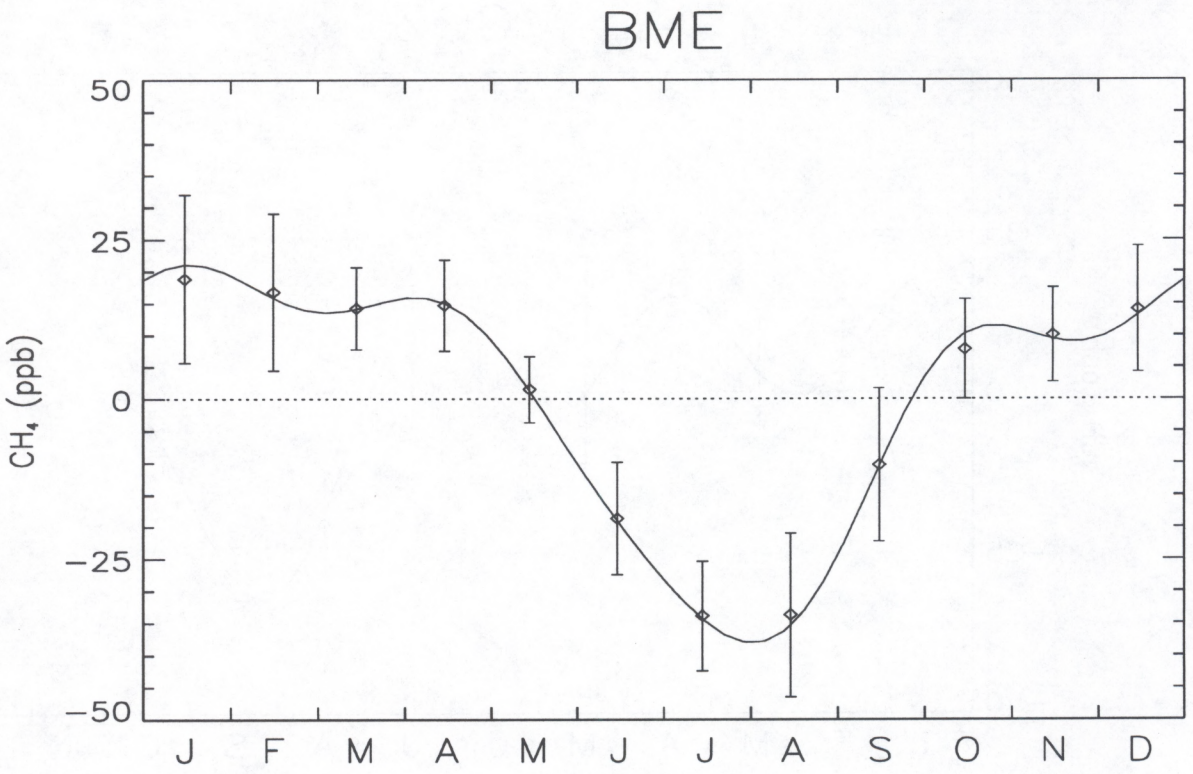
Average Amplitude:	26.4
Standard Deviation:	2.2
Harmonic Amplitude:	15.3



Station Name:	Gozo, Malta
Station Code:	GOZ
Latitude:	36°03'N
Beginning Date:	Oct 1993
Ending Date:	Dec 1995
Number of Data Points:	72

Year	Amplitude	Maximum	Date	Minimum	Date
1994	45.50	15.99	Jul 11	-29.52	Sep 5
1995	59.51	23.09	May 1	-36.42	Sep 4

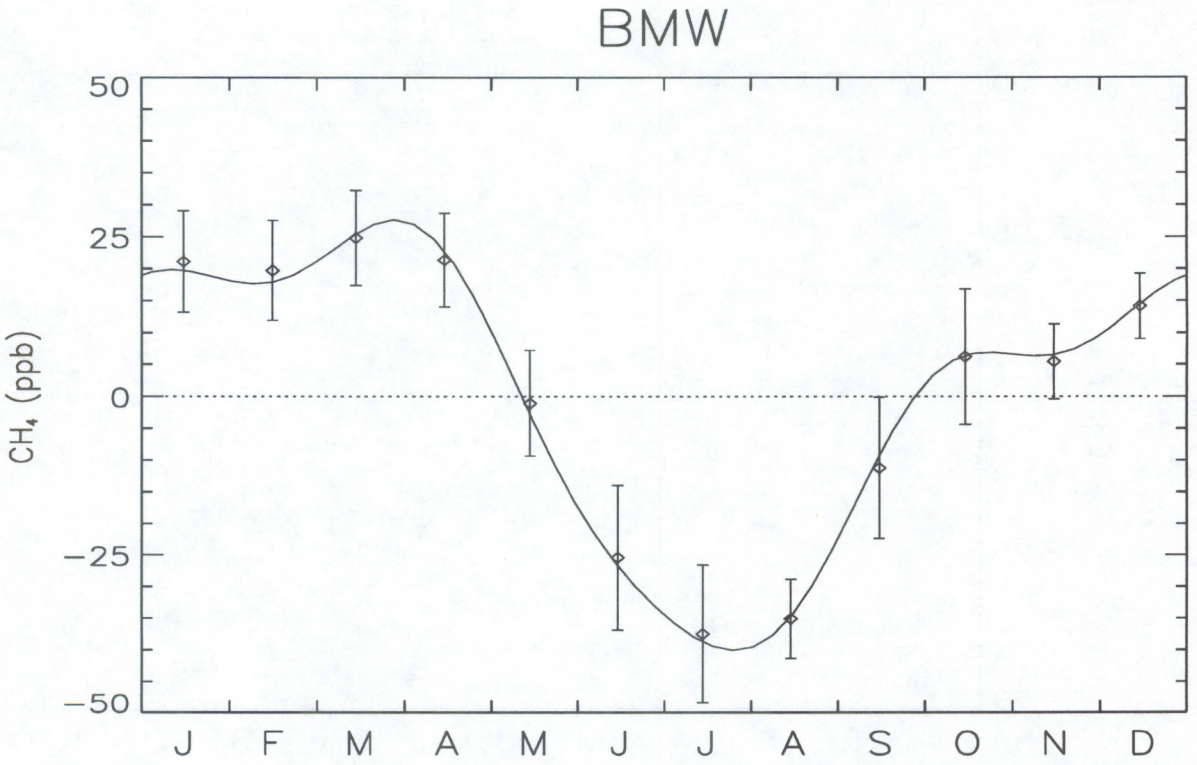
Average Amplitude:	52.5
Standard Deviation:	9.9
Harmonic Amplitude:	51.2



Station Name:	Bermuda (East)
Station Code:	BME
Latitude:	32°22'N
Beginning Date:	Feb 1989
Ending Date:	Dec 1995
Number of Data Points:	303

Year	Amplitude	Maximum	Date	Minimum	Date
1990	59.68	20.64	Jan 1	-39.04	Jul 9
1991	79.12	27.01	Apr 1	-52.11	Aug 5
1992	93.18	50.65	Feb 3	-42.53	Jul 28
1993	52.06	19.81	Dec 28	-32.26	Aug 17
1994	69.33	24.85	Dec 27	-44.48	Aug 9
1995	63.79	25.57	Jan 3	-38.22	Jul 11

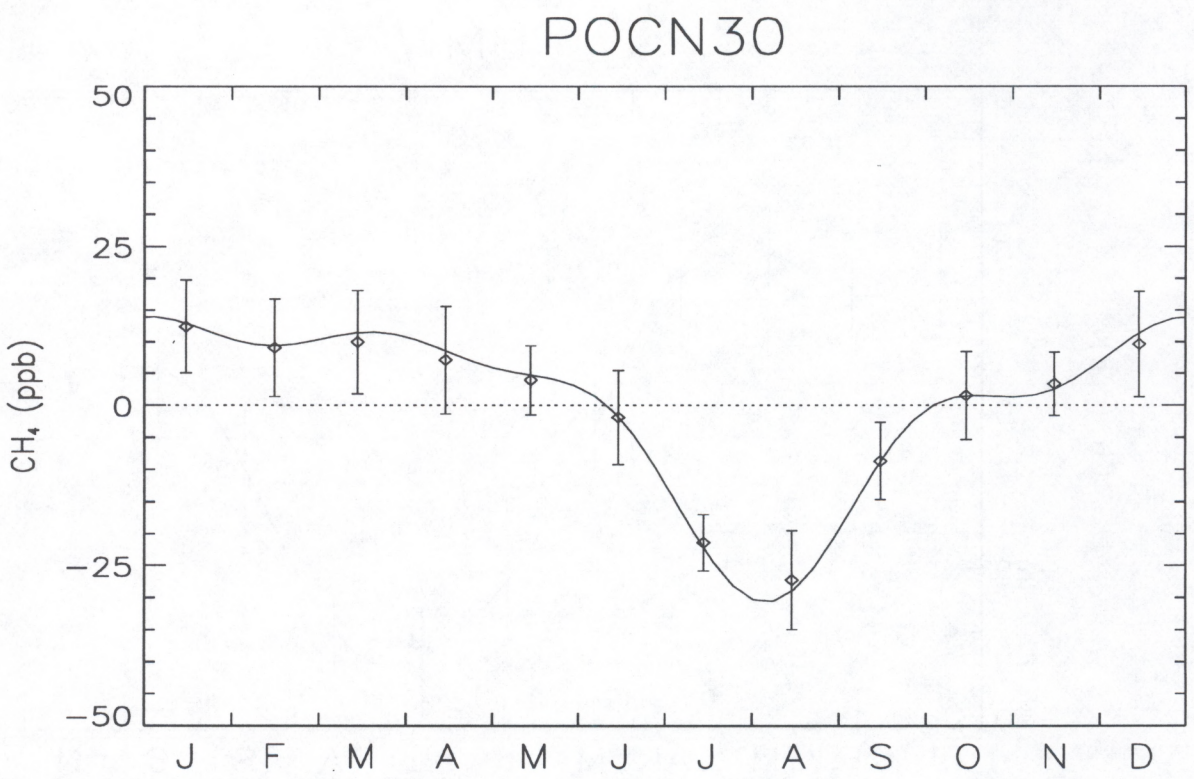
Average Amplitude:	69.5
Standard Deviation:	14.7
Harmonic Amplitude:	59.1



Station Name:	Bermuda (West)
Station Code:	BMW
Latitude:	32°16'N
Beginning Date:	May 1989
Ending Date:	Dec 1995
Number of Data Points:	255

Year	Amplitude	Maximum	Date	Minimum	Date
1990	76.42	40.70	Mar 29	-35.72	Aug 2
1991	91.93	35.33	Apr 18	-56.60	Jul 11
1992	78.84	27.71	Mar 19	-51.12	Jul 17
1993	77.29	30.46	Feb 26	-46.83	Aug 6
1994	77.56	31.07	Dec 30	-46.49	Aug 5
1995	71.46	35.24	Jan 13	-36.22	Aug 25

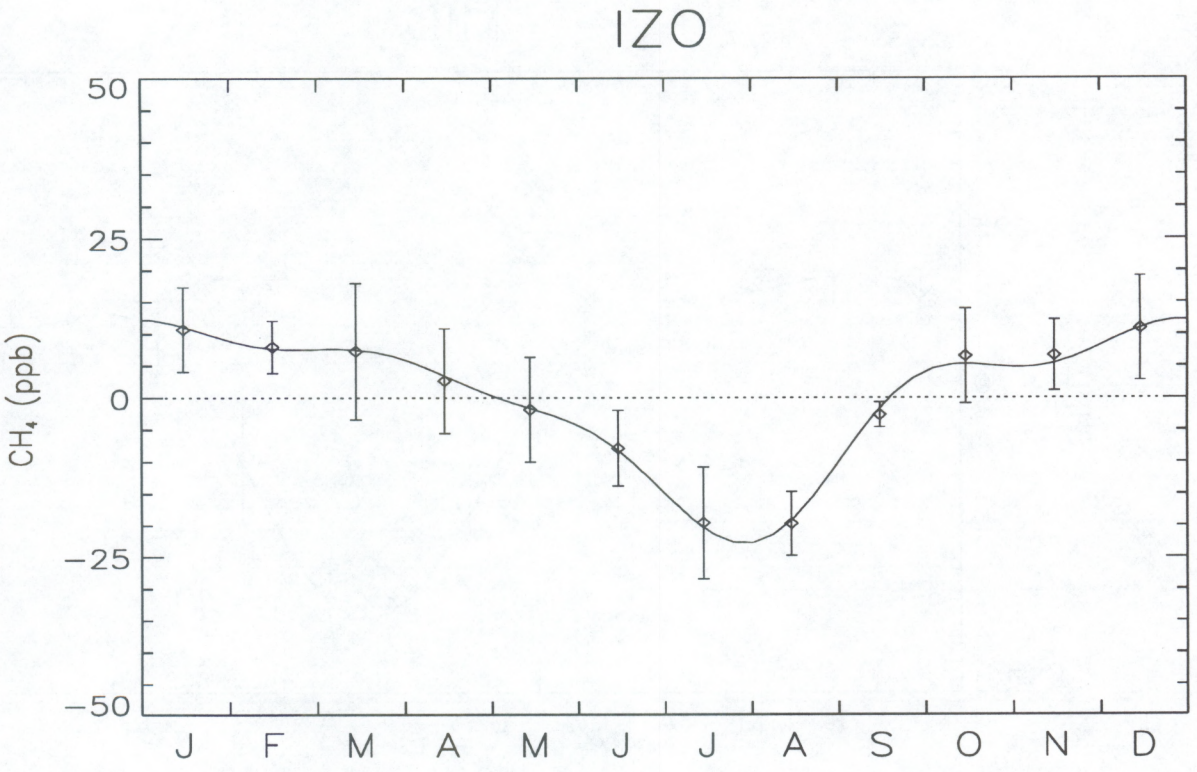
Average Amplitude:	78.9
Standard Deviation:	6.9
Harmonic Amplitude:	67.5



Station Name:	Pacific Ocean, Shipboard
Station Code:	POCN30
Latitude:	30°00'N
Beginning Date:	Dec 1986
Ending Date:	Dec 1995
Number of Data Points:	172

Year	Amplitude	Maximum	Date	Minimum	Date
1987	49.13	26.41	Dec 27	-22.71	Aug 9
1988	66.21	27.45	Jan 3	-38.76	Aug 8
1989	41.02	10.59	Jan 2	-30.44	Aug 7
1990	58.58	24.60	Feb 5	-33.98	Aug 6
1991	53.97	22.31	Mar 11	-31.67	Jul 22
1992	51.65	19.98	Dec 15	-31.67	Aug 11
1993	46.83	18.38	Dec 21	-28.45	Jul 27
1994	65.36	20.34	Mar 1	-45.02	Aug 9
1995	37.70	19.57	Apr 18	-18.13	Jul 11

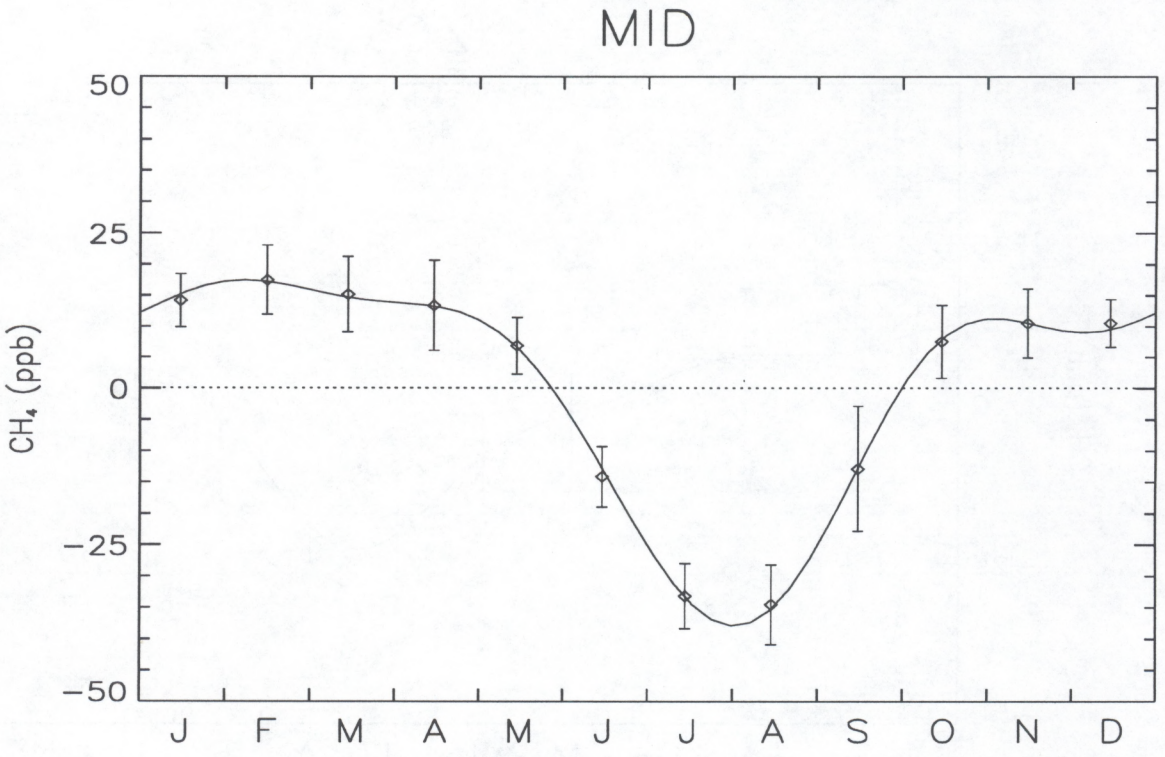
Average Amplitude:	52.2
Standard Deviation:	9.9
Harmonic Amplitude:	44.6



Station Name:	Izana Observatory, Tenerife, Spain
Station Code:	IZO
Latitude:	28°18'N
Beginning Date:	Nov 1991
Ending Date:	Dec 1995
Number of Data Points:	158

Year	Amplitude	Maximum	Date	Minimum	Date
1992	31.48	10.43	Jan 4	-21.05	Aug 2
1993	55.20	22.95	Dec 26	-32.25	Jul 25
1994	51.10	22.86	Jan 2	-28.24	Jul 31
1995	34.44	17.87	Dec 24	-16.57	May 21

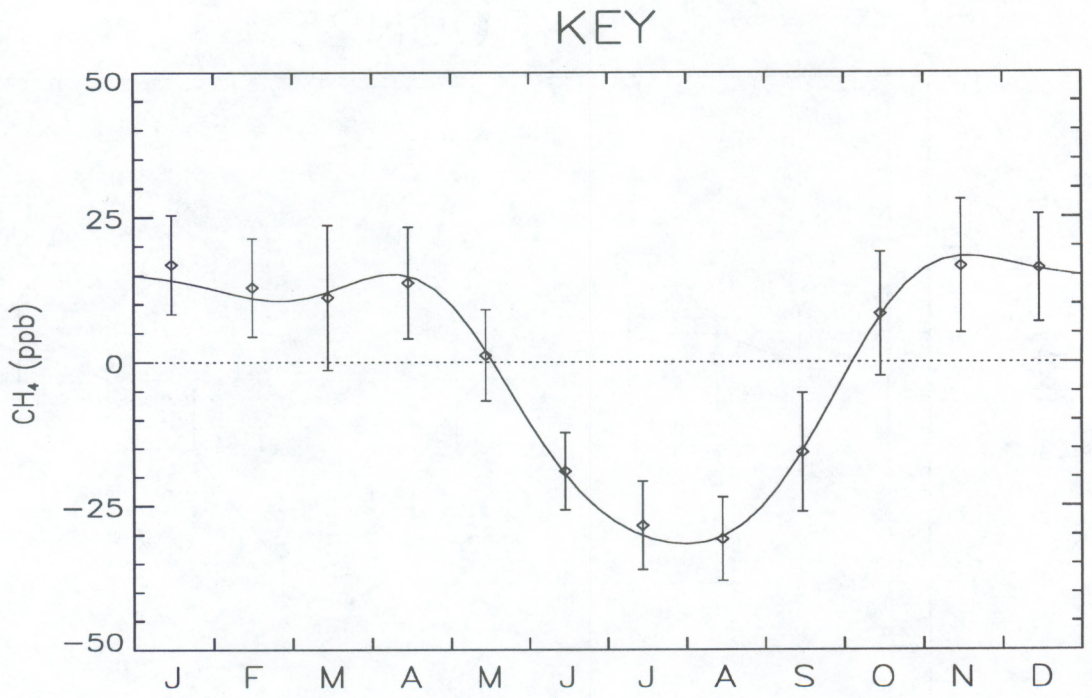
Average Amplitude:	43.0
Standard Deviation:	11.9
Harmonic Amplitude:	35.1



Station Name:	Sand Island, Midway
Station Code:	MID
Latitude:	28°13'N
Beginning Date:	May 1985
Ending Date:	Dec 1995
Number of Data Points:	527

Year	Amplitude	Maximum	Date	Minimum	Date
1986	64.48	26.23	Feb 14	-38.25	Aug 1
1987	51.61	16.43	Jan 2	-35.18	Jul 31
1988	53.19	21.52	Feb 5	-31.67	Aug 5
1989	63.00	24.19	Mar 25	-38.81	Jul 29
1990	57.69	21.82	Mar 24	-35.88	Jul 14
1991	76.42	26.05	Feb 23	-50.37	Aug 17
1992	58.03	22.38	Feb 29	-35.65	Aug 8
1993	69.78	19.18	Jan 17	-50.59	Aug 1
1994	60.45	17.18	Feb 6	-43.26	Aug 7
1995	51.30	20.59	Apr 23	-30.71	Aug 13

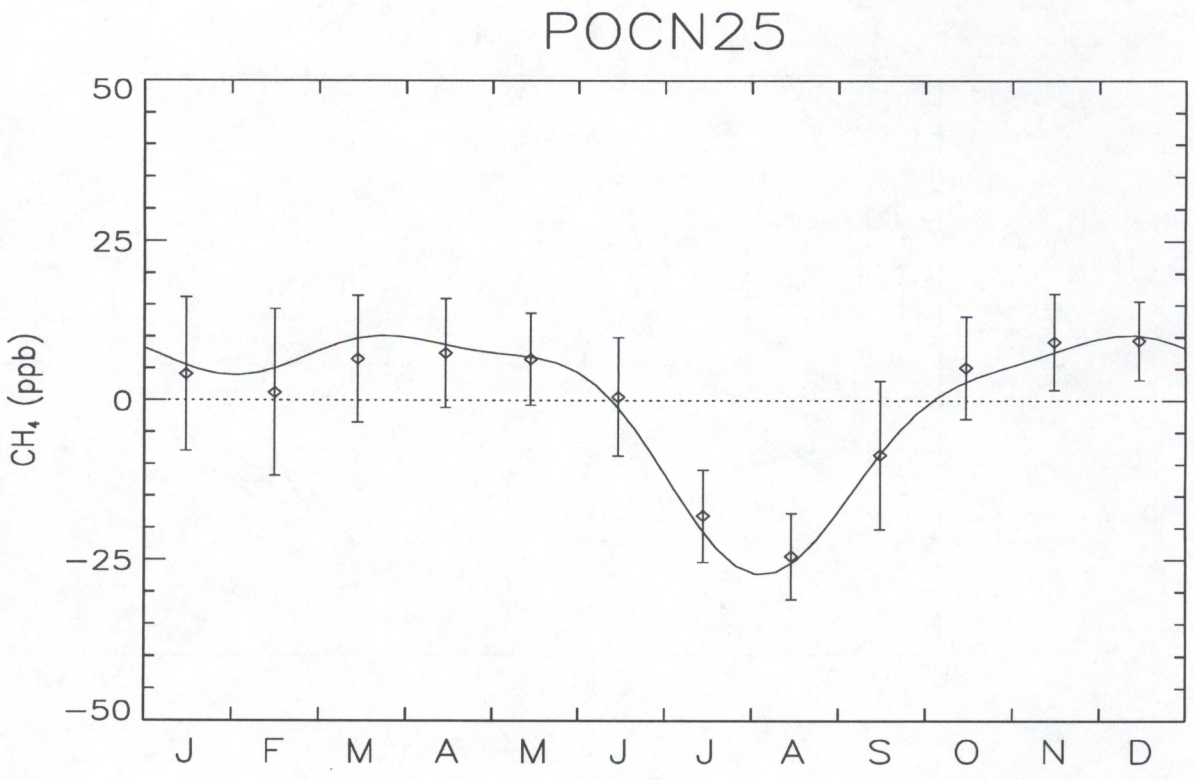
Average Amplitude:	60.5
Standard Deviation:	8.1
Harmonic Amplitude:	55.3



Station Name:	Key Biscayne, Florida, USA
Station Code:	KEY
Latitude:	25°40'N
Beginning Date:	Oct 1983
Ending Date:	Dec 1995
Number of Data Points:	352

Year	Amplitude	Maximum	Date	Minimum	Date
1984	57.03	28.76	Jan 25	-28.27	Jul 26
1985	62.65	22.92	Jan 24	-39.73	Jul 25
1986	73.90	35.61	Apr 10	-38.30	Aug 21
1987	57.26	25.46	Oct 15	-31.81	Jun 25
1988	68.44	31.49	Oct 28	-36.95	Aug 19
1989	58.14	23.91	Nov 24	-34.24	Aug 11
1990	66.02	36.17	Nov 9	-29.85	Aug 31
1991	71.35	34.81	Dec 27	-36.54	Jul 26
1992	83.19	34.87	Jan 3	-48.32	Aug 15
1993	58.51	31.12	Mar 27	-27.40	Sep 4
1994	48.49	18.91	Oct 22	-29.58	Aug 6
1995	78.68	42.55	Nov 18	-36.12	Sep 9

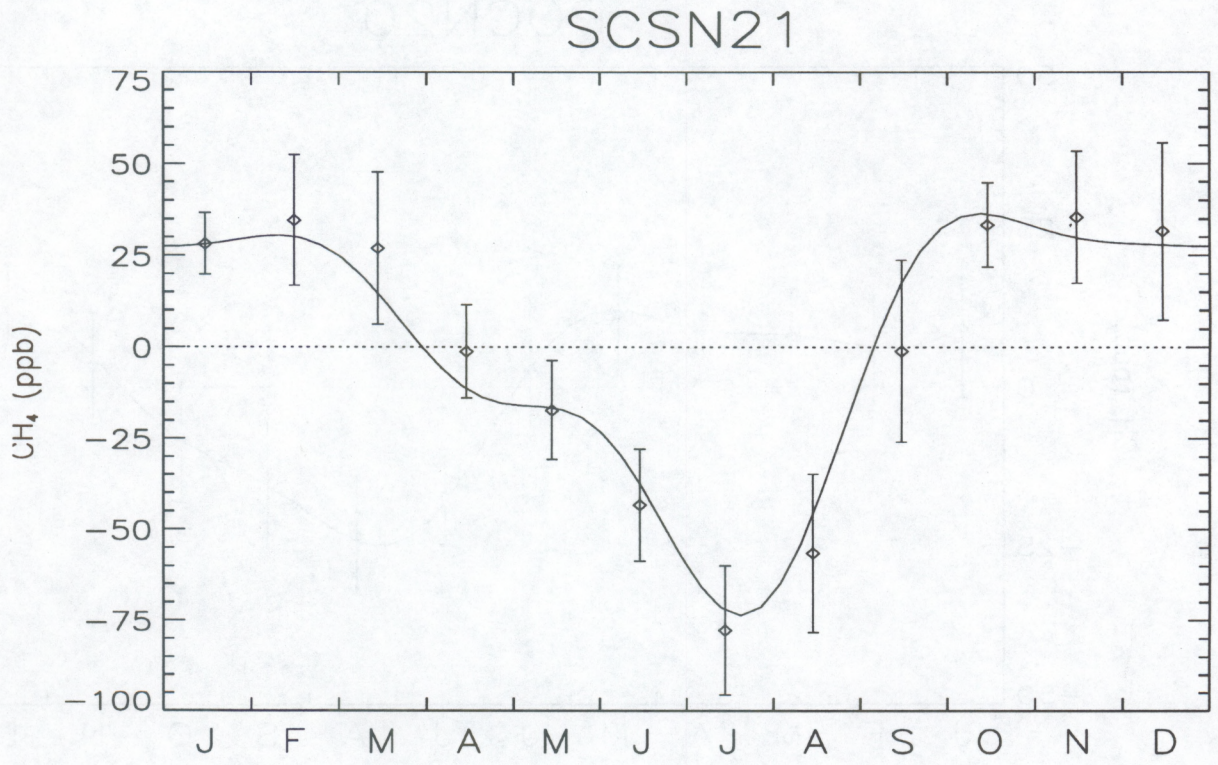
Average Amplitude:	65.3
Standard Deviation:	10.2
Harmonic Amplitude:	49.8



Station Name:	Pacific Ocean, Shipboard
Station Code:	POCN25
Latitude:	25°00'N
Beginning Date:	Dec 1986
Ending Date:	Dec 1995
Number of Data Points:	174

Year	Amplitude	Maximum	Date	Minimum	Date
1987	38.26	12.79	Feb 9	-25.47	Aug 24
1988	40.37	14.98	Oct 11	-25.39	Jul 19
1989	48.28	20.85	Jun 6	-27.42	Feb 14
1990	48.89	18.77	Nov 20	-30.12	Aug 7
1991	50.11	19.65	May 21	-30.46	Jul 30
1992	53.33	22.77	Jan 21	-30.56	Aug 19
1993	50.99	24.99	Dec 15	-26.00	Jul 28
1994	58.64	22.95	Jan 5	-35.69	Aug 17
1995	55.95	20.68	Apr 5	-35.27	Aug 2

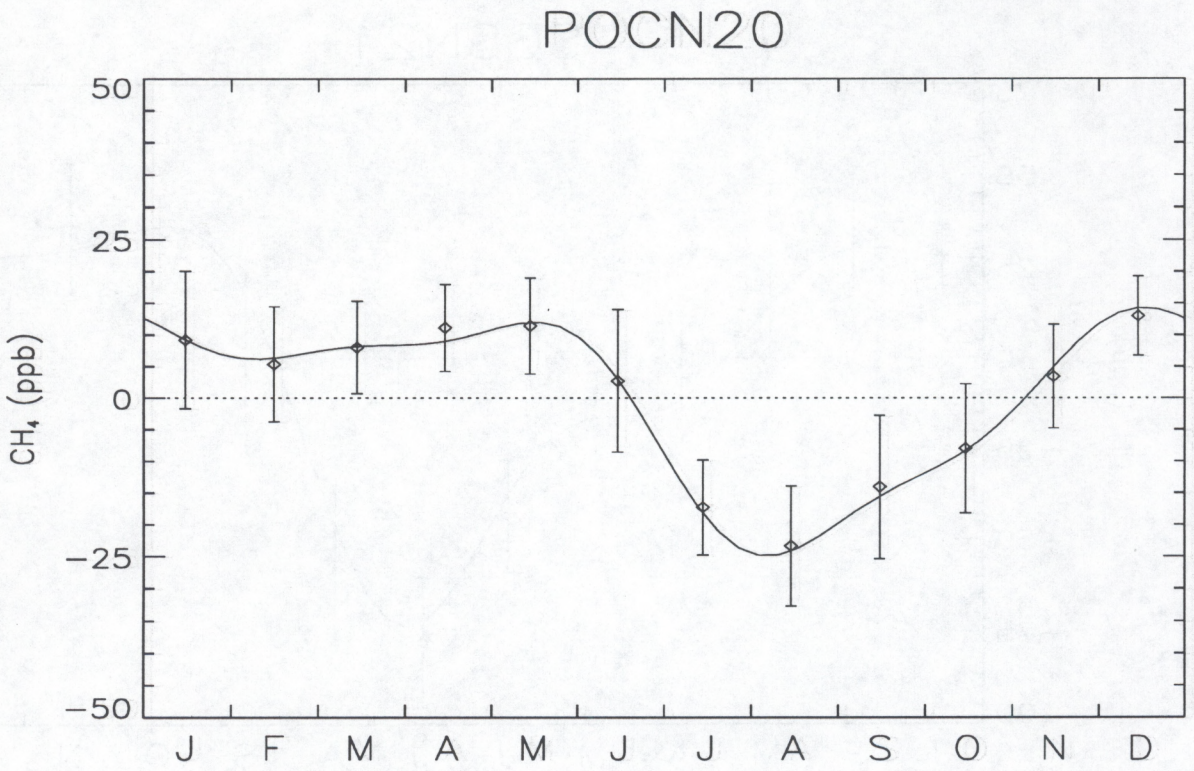
Average Amplitude:	49.4
Standard Deviation:	6.7
Harmonic Amplitude:	37.5



Station Name:	South China Sea, Shipboard
Station Code:	SCSN21
Latitude:	21°00'N
Beginning Date:	Jul 1991
Ending Date:	Dec 1995
Number of Data Points:	120

Year	Amplitude	Maximum	Date	Minimum	Date
1992	101.02	32.41	Oct 20	-68.61	Jul 21
1993	--Incomplete Data--				
1994	111.44	49.35	Oct 25	-62.09	Jul 19
1995	--Incomplete Data--				

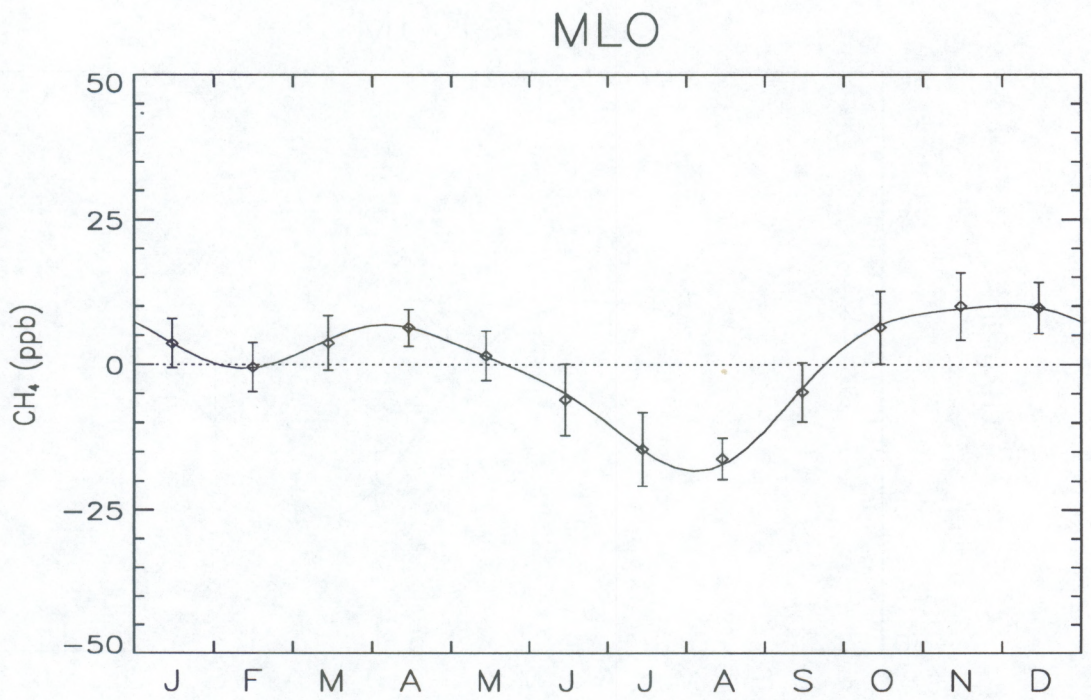
Average Amplitude:	106.2
Standard Deviation:	7.4
Harmonic Amplitude:	110.0



Station Name:	Pacific Ocean, Shipboard
Station Code:	POCN20
Latitude:	20°00'N
Beginning Date:	Dec 1986
Ending Date:	Dec 1995
Number of Data Points:	161

Year	Amplitude	Maximum	Date	Minimum	Date
1987	53.88	20.82	Dec 29	-33.06	Sep 15
1988	35.77	19.76	Jan 5	-16.01	Jul 27
1989	64.85	31.58	Jun 7	-33.28	Aug 9
1990	60.16	26.49	Jan 24	-33.67	Aug 8
1991	52.49	19.79	May 22	-32.71	Jul 31
1992	47.93	19.87	Jan 8	-28.06	Sep 17
1993	38.23	20.56	Dec 9	-17.67	Jul 15
1994	54.12	21.62	May 5	-32.50	Aug 4
1995	50.52	18.53	Mar 23	-31.99	Jul 27

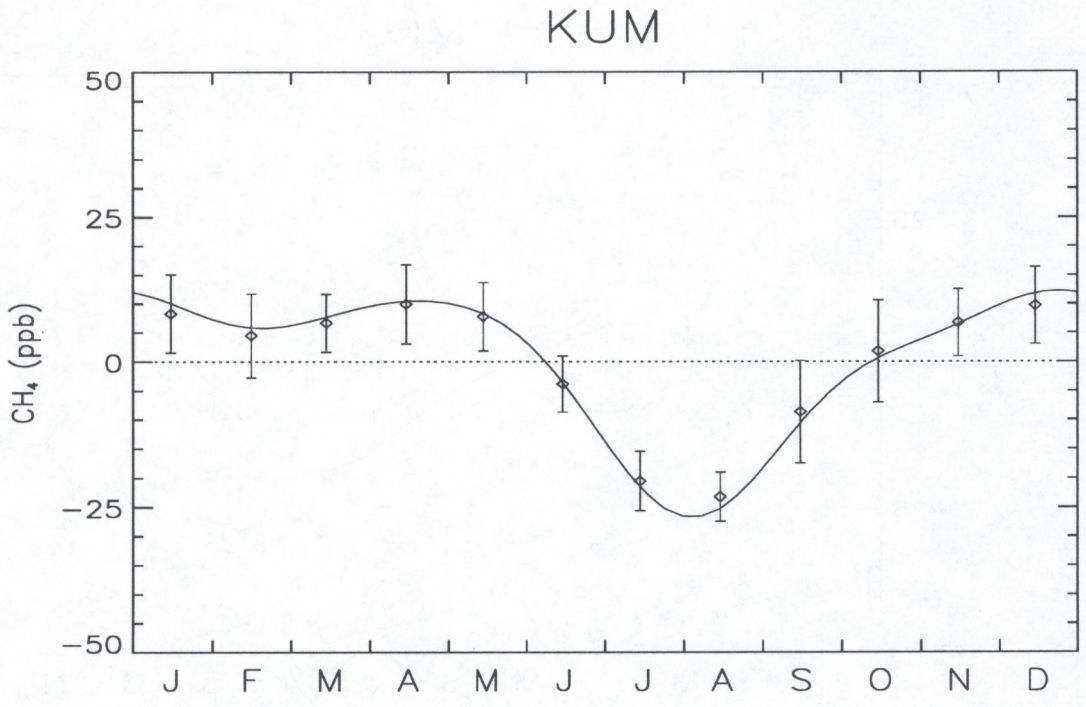
Average Amplitude:	50.8
Standard Deviation:	9.4
Harmonic Amplitude:	39.2



Station Name:	Mauna Loa, Hawaii, USA
Station Code:	MLO
Latitude:	19°32'N
Beginning Date:	May 1983
Ending Date:	Dec 1995
Number of Data Points:	643

Year	Amplitude	Maximum	Date	Minimum	Date
1984	43.30	15.64	Nov 3	-27.66	Jul 7
1985	32.01	14.43	Mar 23	-17.57	Aug 3
1986	26.90	11.29	Apr 19	-15.61	Aug 23
1987	36.75	20.56	Nov 14	-16.18	Aug 29
1988	34.77	15.08	Dec 18	-19.69	Jul 24
1989	33.69	13.21	Jan 1	-20.47	Jul 23
1990	34.07	15.02	Dec 9	-19.05	Jul 29
1991	33.36	10.29	Mar 31	-23.07	Aug 18
1992	34.76	16.07	Dec 7	-18.69	Aug 17
1993	36.65	16.75	Nov 8	-19.90	Aug 2
1994	46.99	19.88	Oct 31	-27.11	Aug 8
1995	26.45	11.19	Jan 2	-15.26	Jul 24

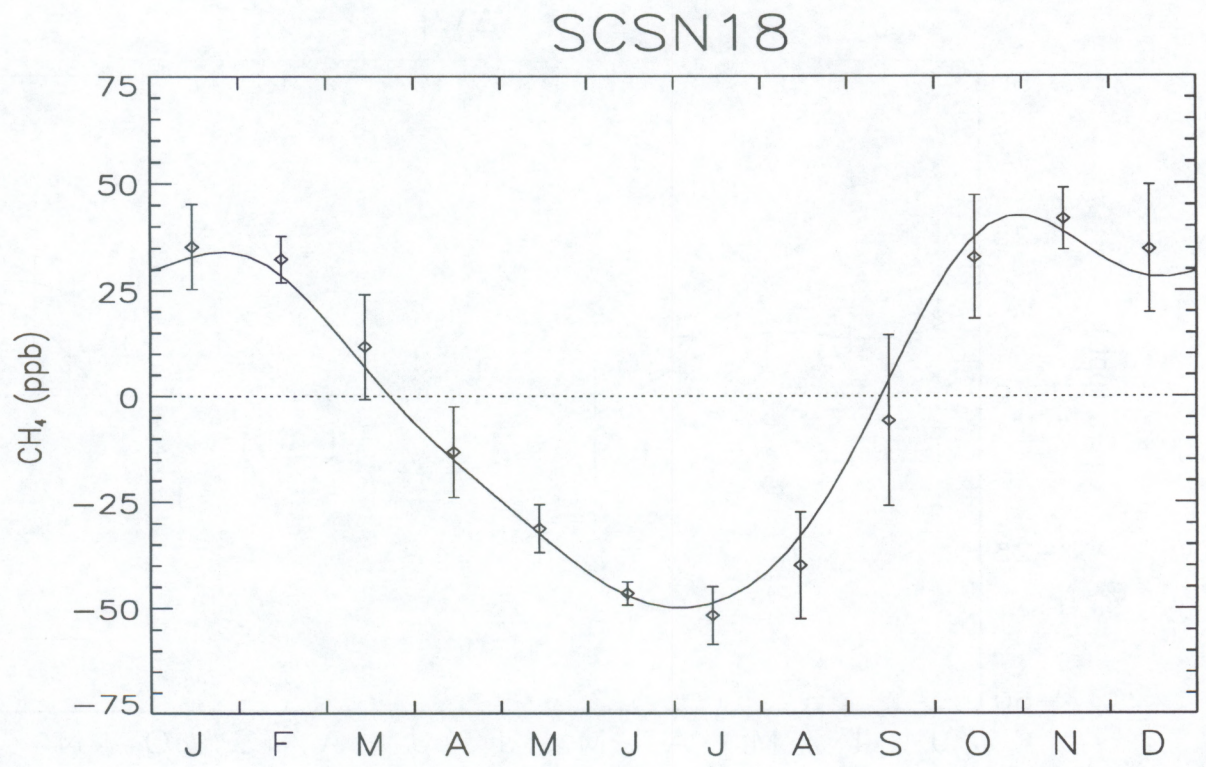
Average Amplitude:	34.9
Standard Deviation:	5.8
Harmonic Amplitude:	28.4



Station Name:	Cape Kumukahi, Hawaii, USA
Station Code:	KUM
Latitude:	19°31'N
Beginning Date:	Apr 1983
Ending Date:	Dec 1995
Number of Data Points:	1043

Year	Amplitude	Maximum	Date	Minimum	Date
1984	38.27	13.31	Apr 17	-24.96	Jul 24
1985	46.76	19.59	Apr 30	-27.17	Jul 31
1986	43.76	20.40	Dec 31	-23.37	Aug 12
1987	49.47	21.11	Jan 7	-28.36	Aug 18
1988	39.32	16.14	Apr 13	-23.18	Jul 27
1989	40.79	23.69	Apr 27	-17.10	Jul 27
1990	50.70	16.28	Feb 21	-34.43	Aug 9
1991	46.13	16.50	May 9	-29.63	Jul 31
1992	44.70	16.67	Jan 23	-28.03	Aug 6
1993	50.43	21.23	Dec 24	-29.20	Jul 29
1994	50.65	20.20	Dec 2	-30.45	Aug 5
1995	42.33	16.37	Apr 28	-25.97	Aug 11

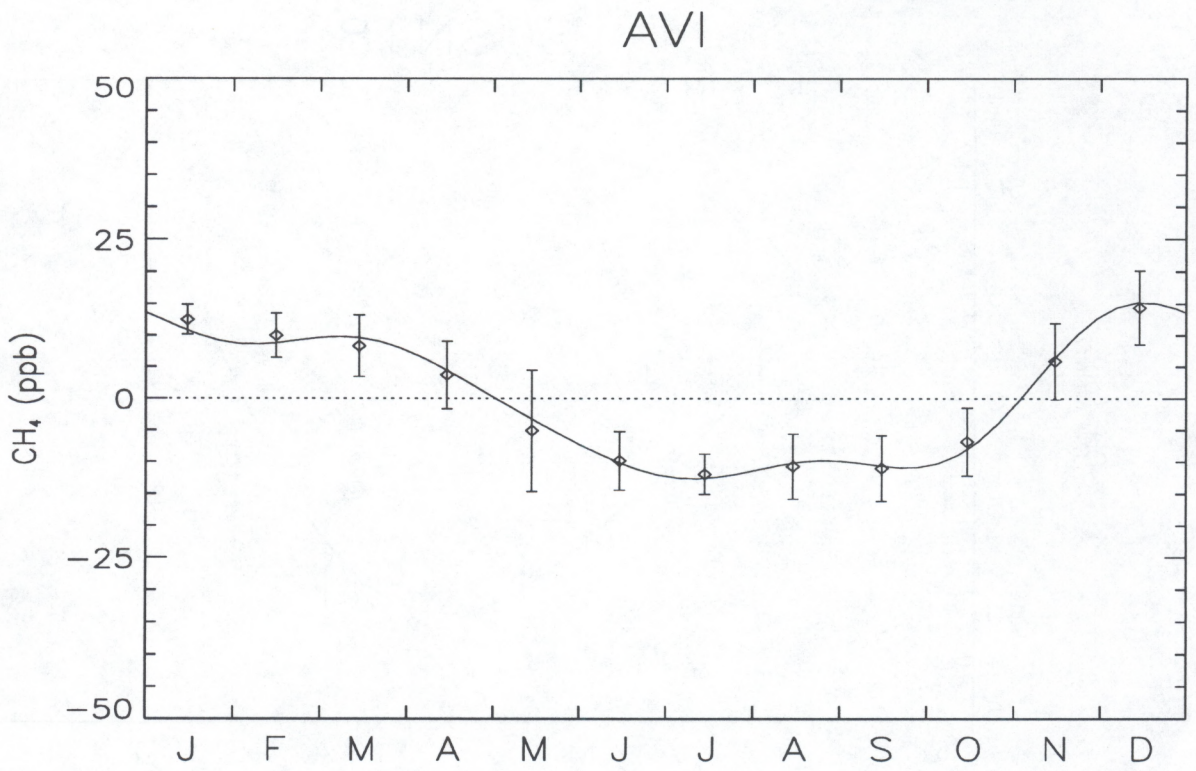
Average Amplitude:	45.2
Standard Deviation:	4.5
Harmonic Amplitude:	39.0



Station Name:	South China Sea, Shipboard
Station Code:	SCSN18
Latitude:	18°00'N
Beginning Date:	Jul 1991
Ending Date:	Dec 1995
Number of Data Points:	145

Year	Amplitude	Maximum	Date	Minimum	Date
1992	94.59	45.76	Oct 19	-48.83	Jun 29
1993	--Incomplete Data--				
1994	94.75	49.05	Jan 3	-45.70	Jun 21
1995	--Incomplete Data--				

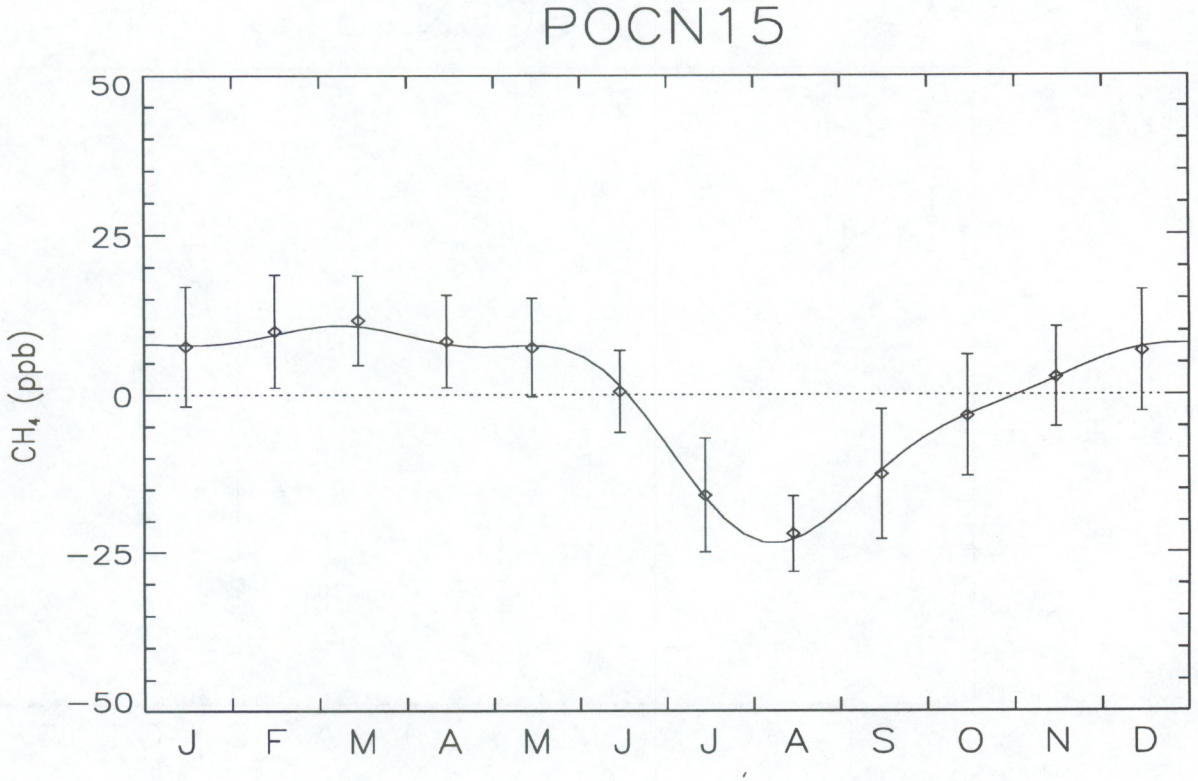
Average Amplitude:	94.6
Standard Deviation:	0.1
Harmonic Amplitude:	92.4



Station Name:	St. Croix, Virgin Islands
Station Code:	AVI
Latitude:	17°45'N
Beginning Date:	May 1983
Ending Date:	Aug 1990
Number of Data Points:	375

Year	Amplitude	Maximum	Date	Minimum	Date
1984	36.81	22.46	Dec 21	-14.35	Oct 12
1985	40.84	22.00	Dec 6	-18.84	Aug 30
1986	38.03	20.82	Dec 19	-17.21	Aug 29
1987	29.44	17.85	Jan 2	-11.59	Sep 25
1988	31.38	16.44	Dec 10	-14.93	Oct 1
1989	29.48	13.73	Feb 4	-15.74	Jul 29

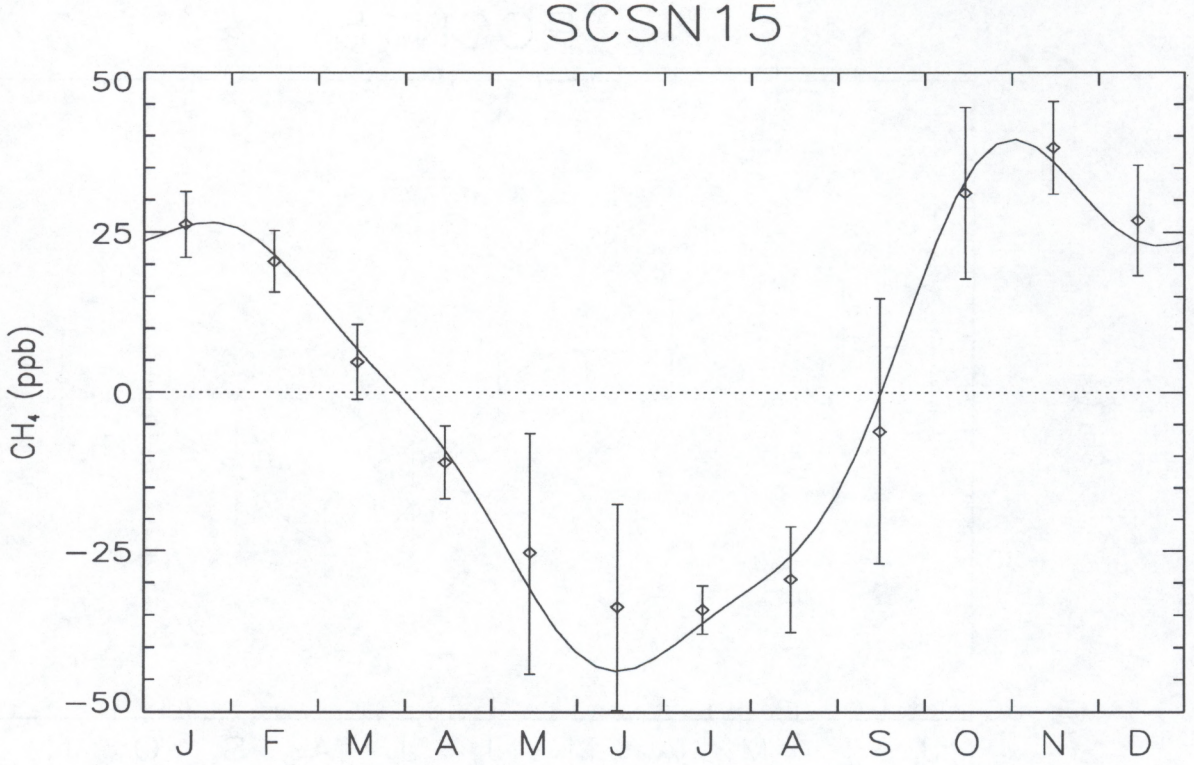
Average Amplitude:	34.0
Standard Deviation:	4.5
Harmonic Amplitude:	27.9



Station Name:	Pacific Ocean, Shipboard
Station Code:	POCN15
Latitude:	15°00'N
Beginning Date:	Dec 1986
Ending Date:	Dec 1995
Number of Data Points:	174

Year	Amplitude	Maximum	Date	Minimum	Date
1987	50.19	24.40	Mar 25	-25.79	Aug 26
1988	39.05	18.33	Feb 24	-20.72	Jul 28
1989	27.61	14.13	Feb 16	-13.48	Aug 10
1990	43.64	15.43	Apr 26	-28.21	Aug 9
1991	48.83	15.49	Dec 26	-33.33	Aug 1
1992	51.30	24.75	Jan 16	-26.55	Sep 18
1993	51.73	26.13	Dec 3	-25.60	Sep 24
1994	59.94	21.96	Dec 23	-37.98	Jul 29
1995	45.07	20.71	Jan 6	-24.35	Aug 4

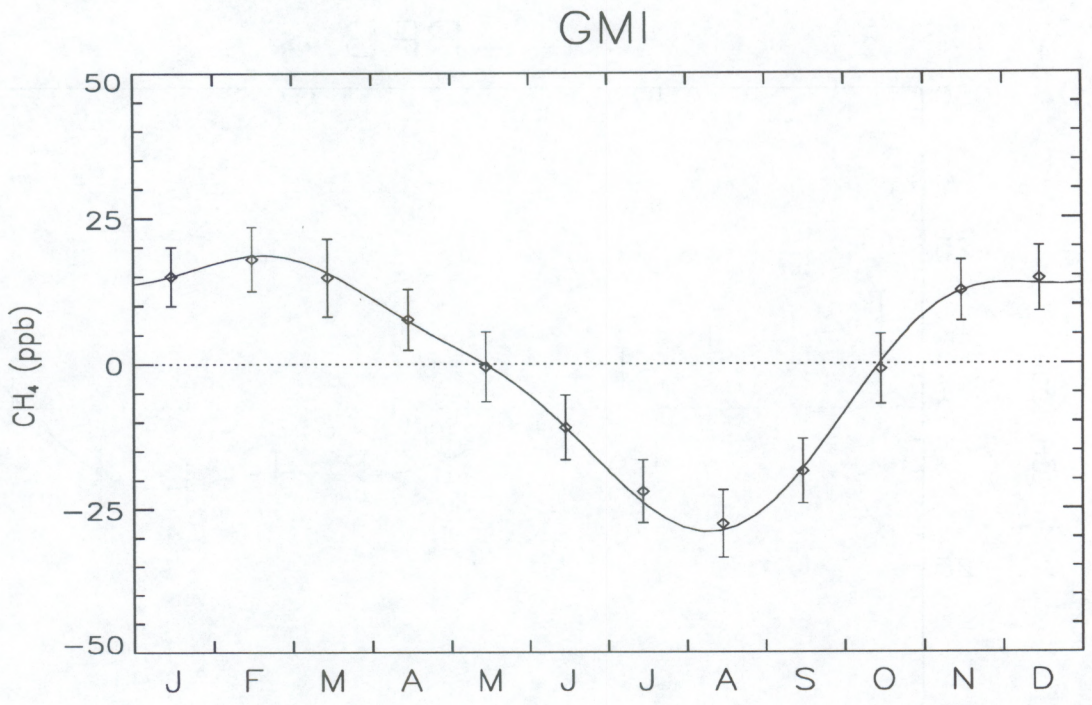
Average Amplitude:	46.3
Standard Deviation:	9.2
Harmonic Amplitude:	34.4



Station Name:	South China Sea, Shipboard
Station Code:	SCSN15
Latitude:	15°00'N
Beginning Date:	Jul 1991
Ending Date:	Dec 1995
Number of Data Points:	152

Year	Amplitude	Maximum	Date	Minimum	Date
1992	84.30	40.53	Oct 26	-43.77	Jun 21
1993	--Incomplete Data--				
1994	78.04	32.27	Oct 31	-45.77	May 23
1995	--Incomplete Data--				

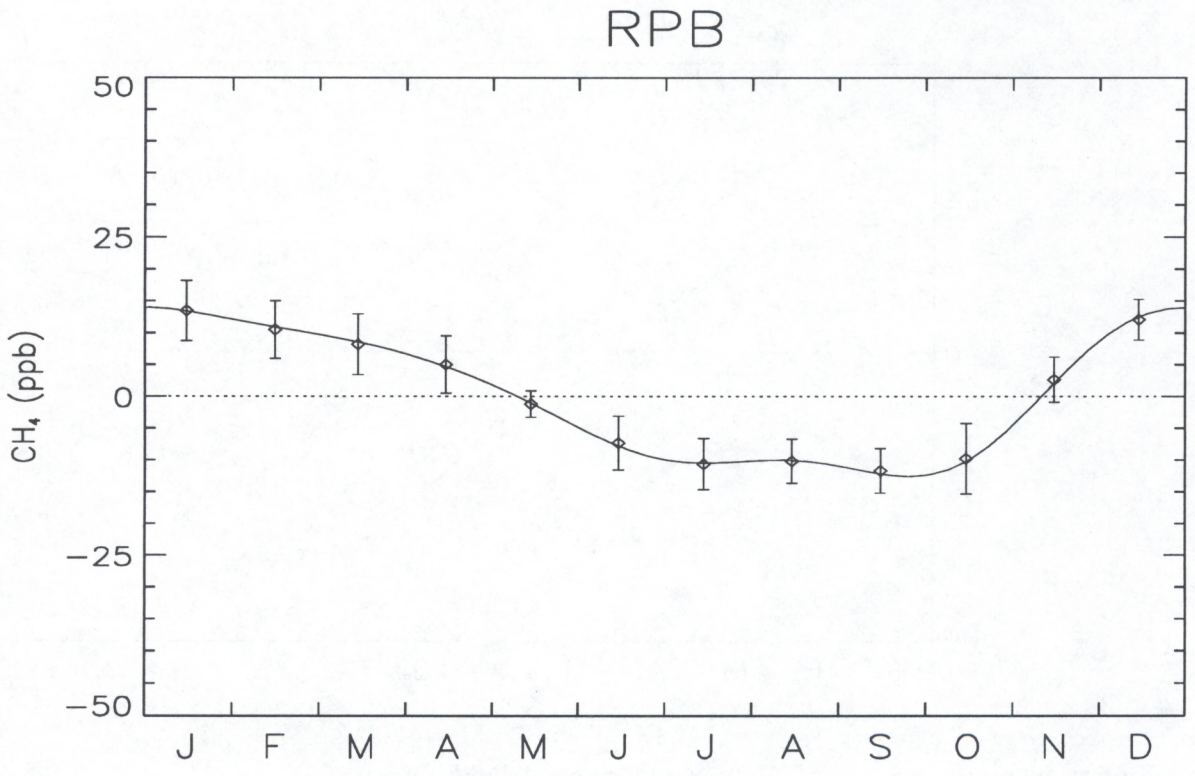
Average Amplitude:	81.2
Standard Deviation:	4.5
Harmonic Amplitude:	83.1



Station Name:	Marianas Island, Guam
Station Code:	GMI
Latitude:	13°26'N
Beginning Date:	May 1983
Ending Date:	Dec 1995
Number of Data Points:	724

Year	Amplitude	Maximum	Date	Minimum	Date
1984	42.64	17.89	Dec 25	-24.76	Aug 13
1985	50.41	25.82	Mar 5	-24.58	Aug 6
1986	40.88	14.64	Feb 4	-26.24	Sep 2
1987	47.50	20.20	Dec 29	-27.30	Aug 18
1988	48.44	20.40	Feb 16	-28.05	Sep 20
1989	63.05	30.80	Mar 1	-32.24	Aug 9
1990	49.77	19.42	Dec 5	-30.35	Jul 25
1991	62.39	29.19	Feb 13	-33.20	Aug 14
1992	51.93	24.22	Dec 31	-27.71	Aug 5
1993	49.77	26.48	Nov 18	-23.29	Jul 22
1994	57.47	15.75	Nov 10	-41.71	Aug 18
1995	51.86	20.60	Feb 16	-31.26	Aug 24

Average Amplitude:	51.3
Standard Deviation:	6.8
Harmonic Amplitude:	47.6

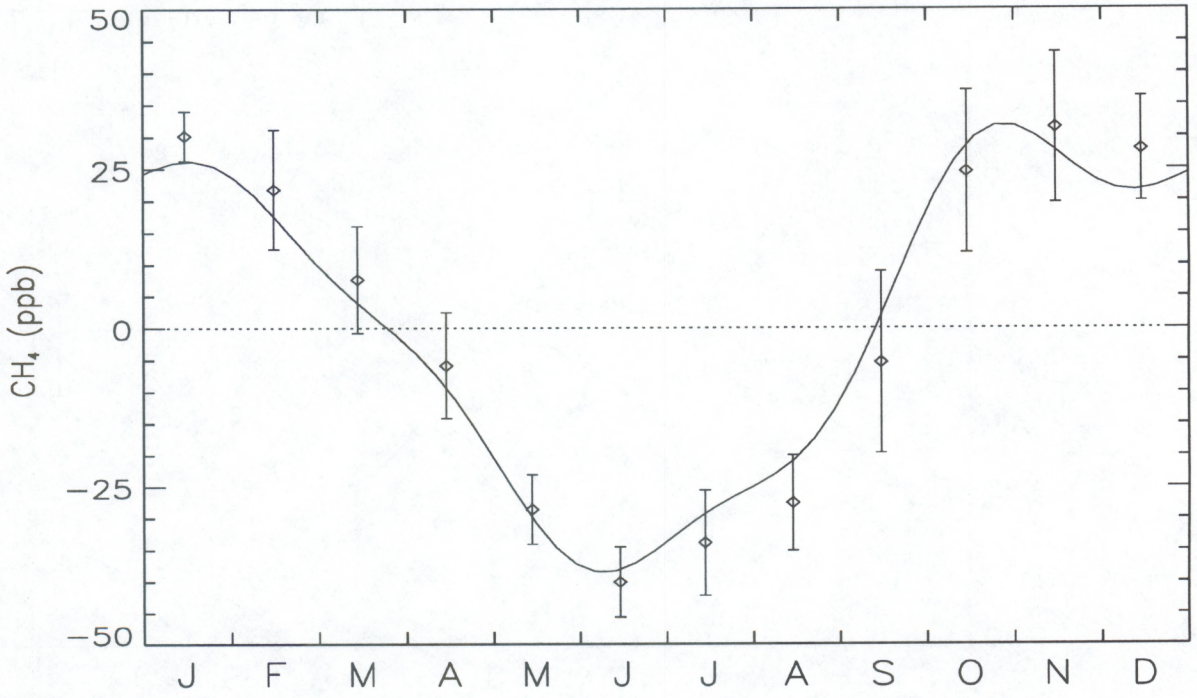


Station Name:	Ragged Point, Barbados
Station Code:	RPB
Latitude:	13°10'N
Beginning Date:	Nov 1987
Ending Date:	Dec 1995
Number of Data Points:	374

Year	Amplitude	Maximum	Date	Minimum	Date
1988	35.50	22.41	Jan 23	-13.09	Jul 10
1989	27.99	12.12	Jan 1	-15.87	Jul 2
1990	36.72	18.35	Feb 4	-18.37	Oct 7
1991	35.68	19.15	Dec 29	-16.53	Jul 7
1992	38.43	18.94	Jan 5	-19.49	Sep 28
1993	31.35	15.80	Dec 27	-15.55	Aug 23
1994	26.52	16.07	Jan 3	-10.45	Oct 17
1995	32.39	14.00	Dec 11	-18.39	Oct 9

Average Amplitude:	33.0
Standard Deviation:	4.3
Harmonic Amplitude:	26.6

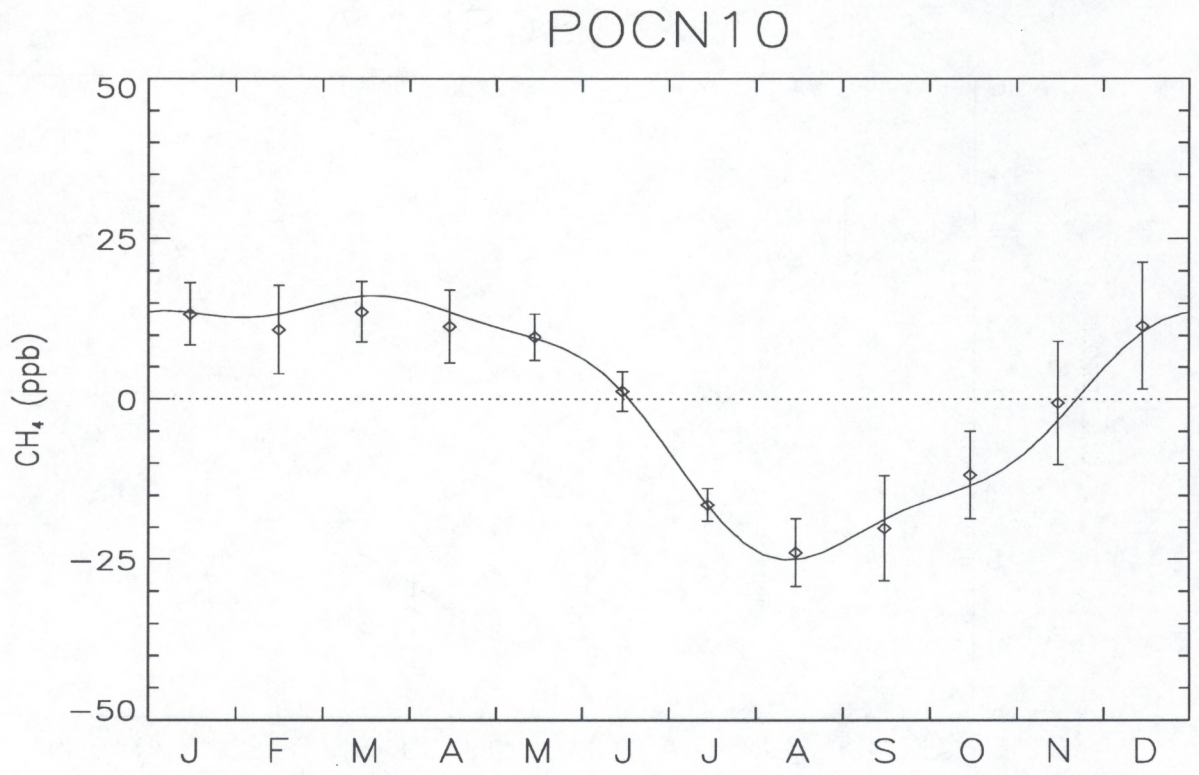
SCSN12



Station Name:	South China Sea, Shipboard
Station Code:	SCSN12
Latitude:	12°00'N
Beginning Date:	Jul 1991
Ending Date:	Dec 1995
Number of Data Points:	154

Year	Amplitude	Maximum	Date	Minimum	Date
1992	87.71	44.08	Nov 1	-43.63	Jun 21
1993	--Incomplete Data--				
1994	73.47	35.07	Jan 9	-38.41	May 22
1995	--Incomplete Data--				

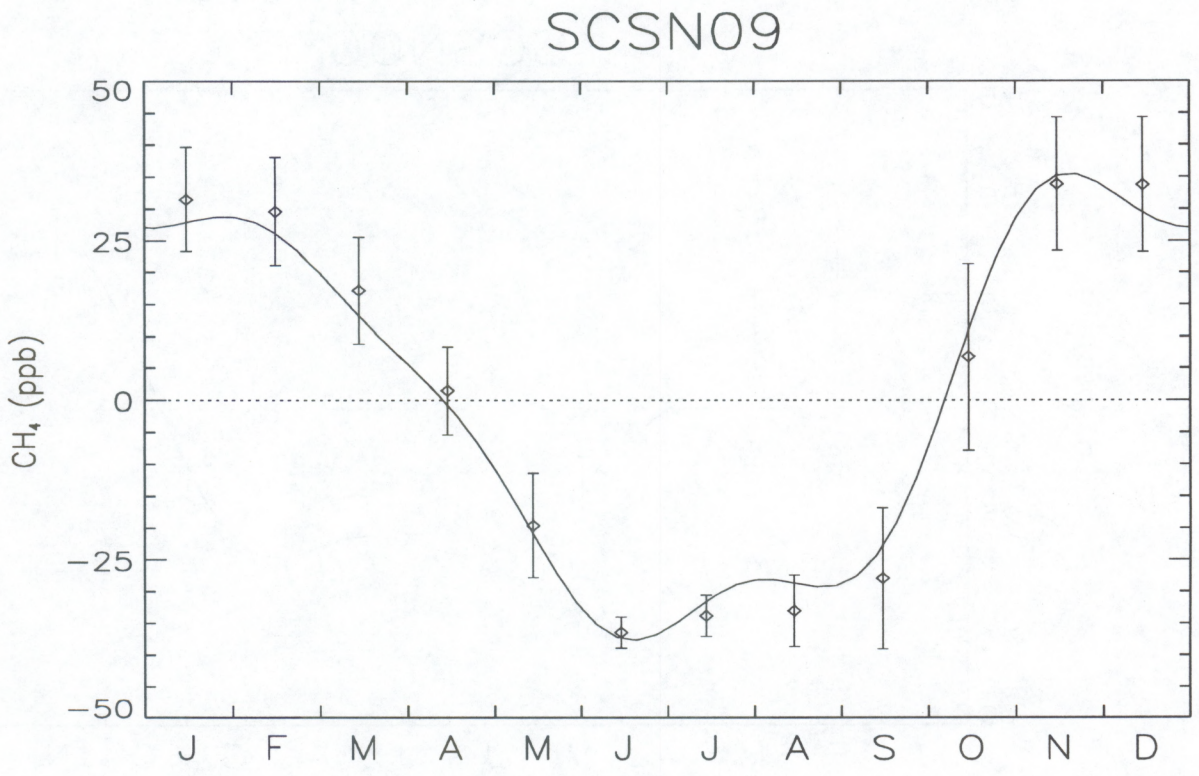
Average Amplitude:	80.6
Standard Deviation:	10.1
Harmonic Amplitude:	70.3



Station Name:	Pacific Ocean, Shipboard
Station Code:	POCN10
Latitude:	10°00'N
Beginning Date:	Dec 1986
Ending Date:	Dec 1995
Number of Data Points:	168

Year	Amplitude	Maximum	Date	Minimum	Date
1988	50.46	24.38	Feb 18	-26.08	Aug 11
1989	43.13	17.30	Jan 5	-25.83	Sep 21
1990	53.60	27.17	Dec 20	-26.44	Oct 11
1991	50.76	22.82	Jan 3	-27.94	Sep 5
1992	52.07	19.82	Mar 20	-32.25	Aug 21
1993	55.98	24.26	Dec 10	-31.73	Aug 27
1994	51.78	22.02	Dec 30	-29.77	Aug 12
1995	46.09	22.76	Jan 6	-23.33	Jul 28

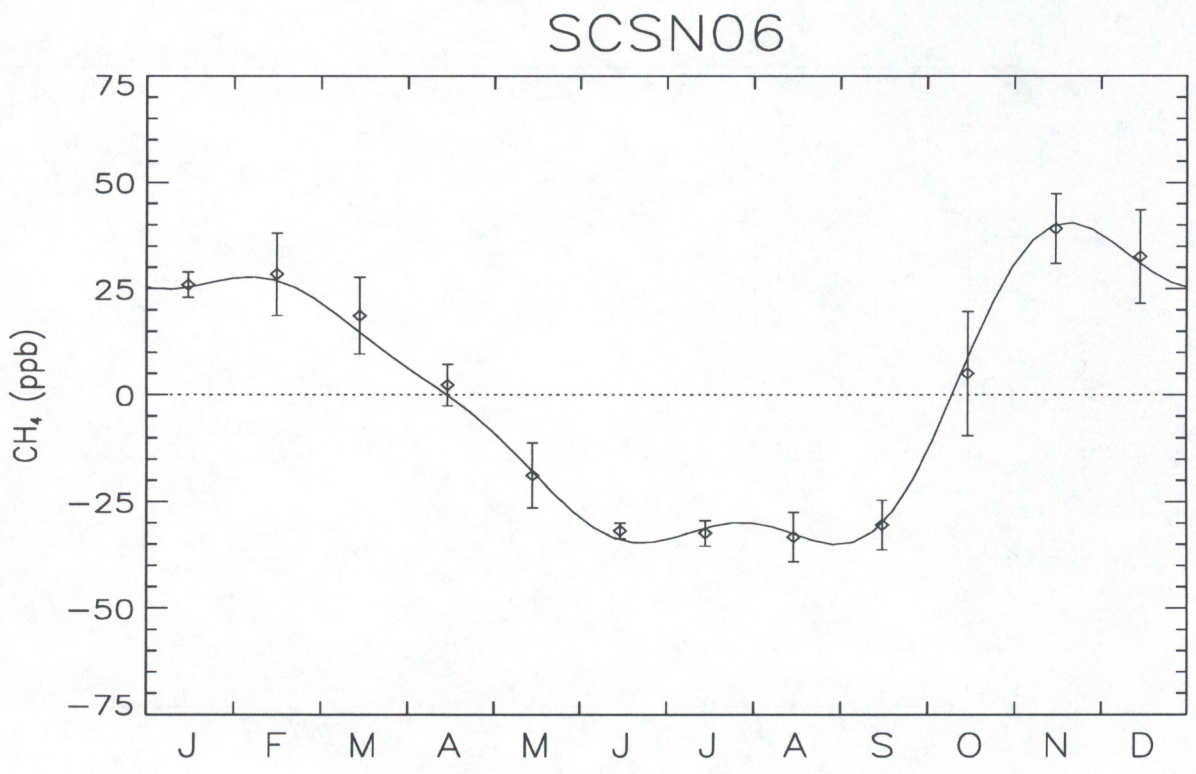
Average Amplitude:	50.4
Standard Deviation:	4.1
Harmonic Amplitude:	41.3



Station Name:	South China Sea, Shipboard
Station Code:	SCSN09
Latitude:	9°00'N
Beginning Date:	Jul 1991
Ending Date:	Dec 1995
Number of Data Points:	146

Year	Amplitude	Maximum	Date	Minimum	Date
1992	73.84	34.14	Nov 15	-39.70	Jun 20
1993	--Incomplete Data--				
1994	80.01	43.73	Jan 2	-36.28	Jun 12
1995	--Incomplete Data--				

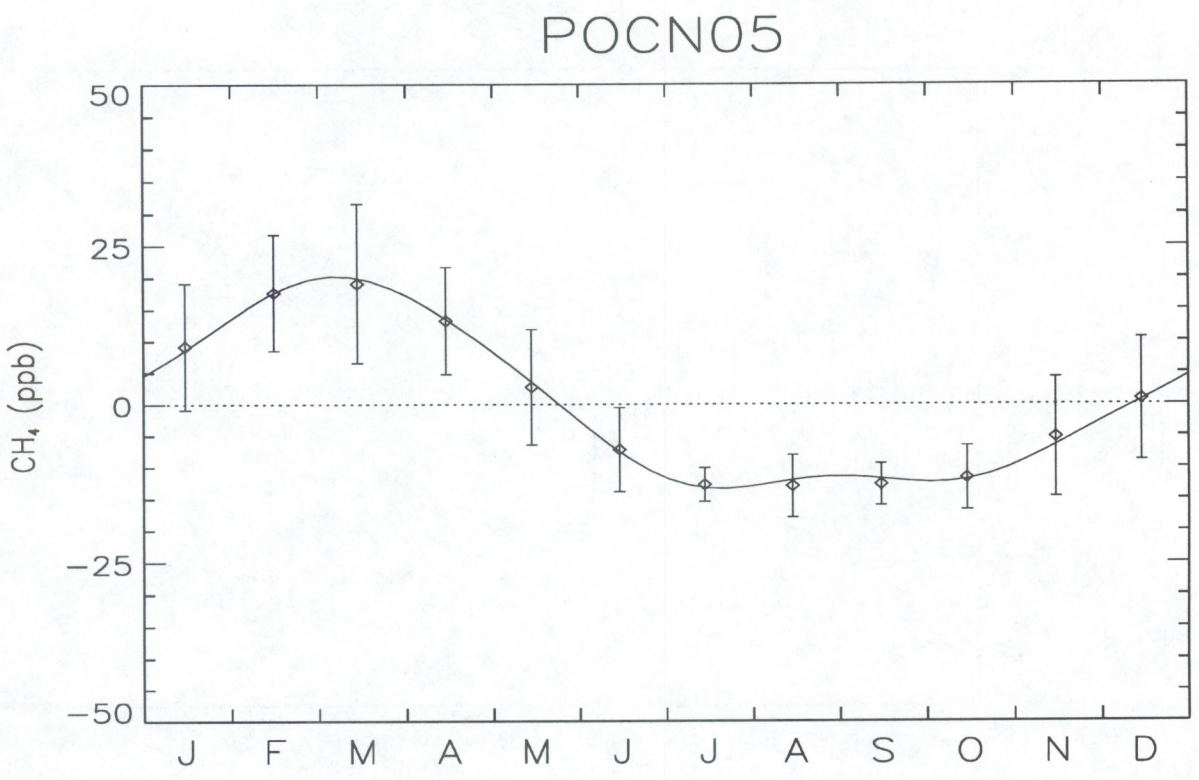
Average Amplitude:	76.9
Standard Deviation:	4.4
Harmonic Amplitude:	73.2



Station Name:	South China Sea, Shipboard
Station Code:	SCSN06
Latitude:	6°00'N
Beginning Date:	Jul 1991
Ending Date:	Dec 1995
Number of Data Points:	149

Year	Amplitude	Maximum	Date	Minimum	Date
1992	75.27	39.13	Nov 21	-36.14	Jul 4
1993	--Incomplete Data--				
1994	97.07	55.39	Nov 12	-41.68	Aug 27
1995	--Incomplete Data--				

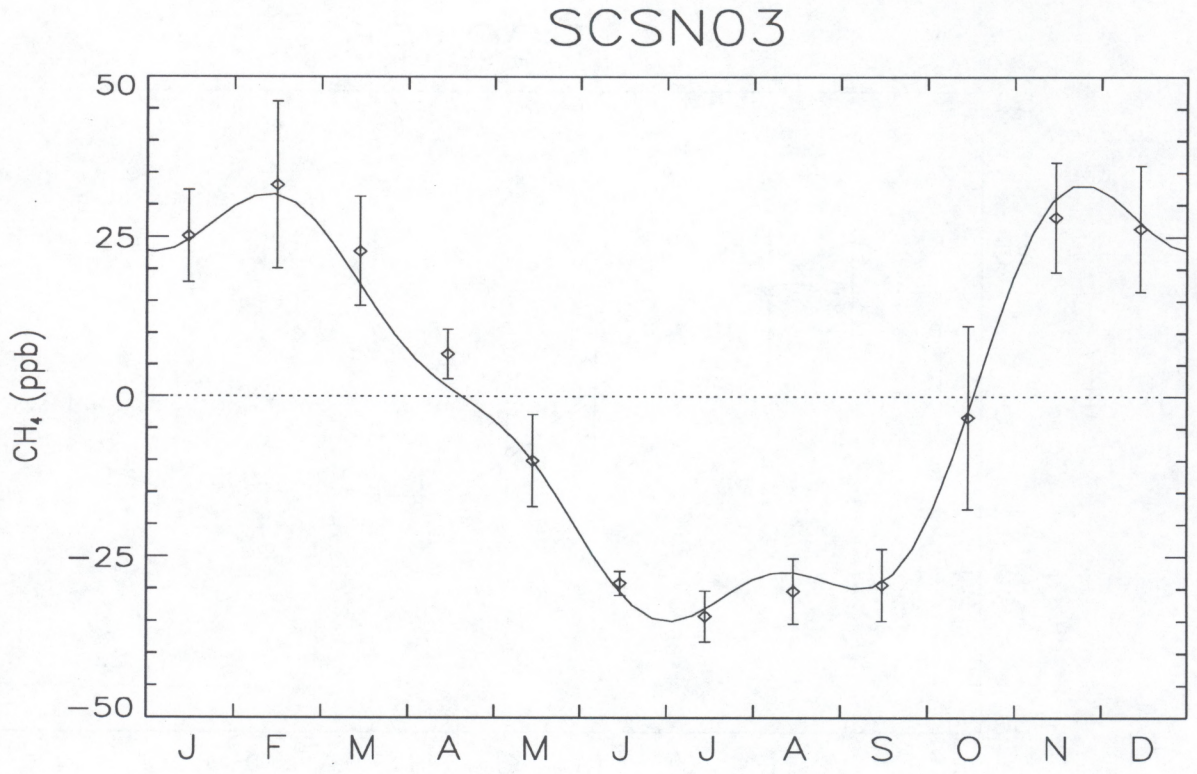
Average Amplitude:	86.1
Standard Deviation:	15.4
Harmonic Amplitude:	75.7



Station Name:	Pacific Ocean, Shipboard
Station Code:	POCN05
Latitude:	5°00'N
Beginning Date:	Dec 1986
Ending Date:	Dec 1995
Number of Data Points:	173

Year	Amplitude	Maximum	Date	Minimum	Date
1987	47.74	28.63	Jan 30	-19.12	Oct 30
1988	66.10	46.15	Mar 12	-19.95	Jun 4
1989	42.76	24.86	Mar 18	-17.90	Sep 23
1990	44.38	30.80	Mar 24	-13.59	Jul 7
1991	43.73	23.85	Dec 21	-19.88	Oct 5
1992	39.21	23.38	Feb 16	-15.83	Jul 19
1993	39.79	25.17	Apr 18	-14.62	Sep 12
1994	38.85	21.30	Feb 27	-17.56	Aug 14
1995	38.37	18.92	Jan 22	-19.46	Jul 30

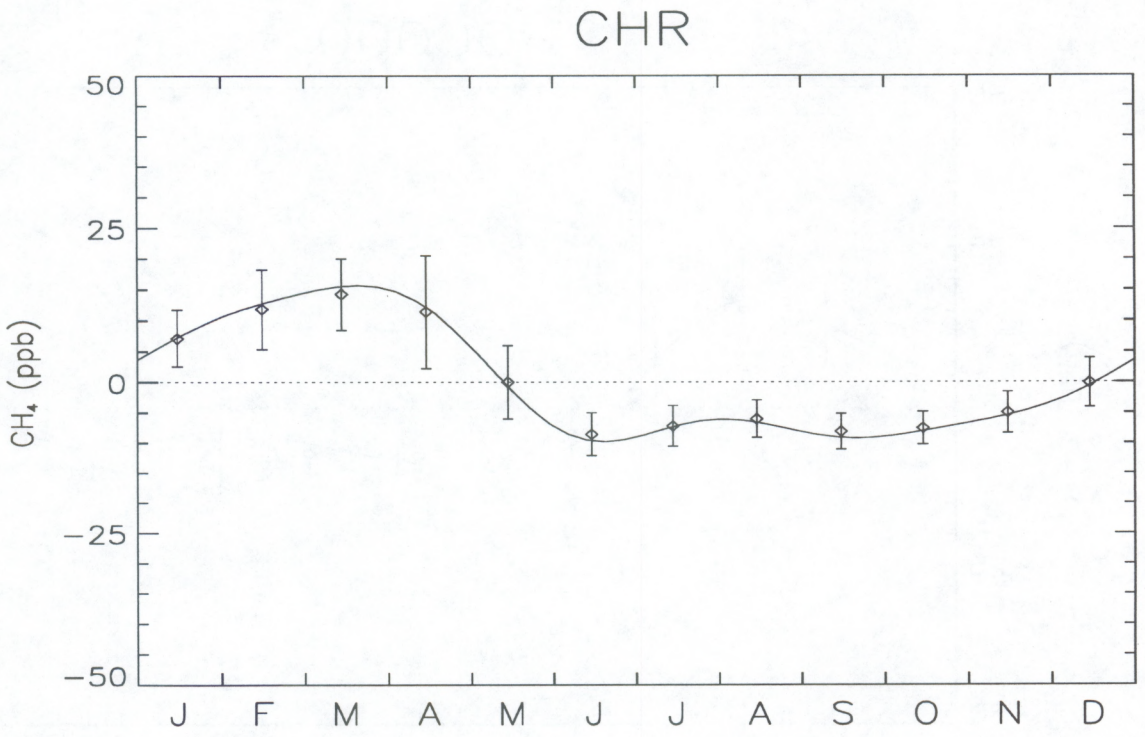
Average Amplitude:	44.5
Standard Deviation:	8.7
Harmonic Amplitude:	33.6



Station Name:	South China Sea, Shipboard
Station Code:	SCSN03
Latitude:	3°00'N
Beginning Date:	Jul 1991
Ending Date:	Dec 1995
Number of Data Points:	145

Year	Amplitude	Maximum	Date	Minimum	Date
1992	63.13	28.30	Nov 20	-34.83	Jul 10
1993	--Incomplete Data--				
1994	63.86	32.24	Jan 1	-31.63	Jun 25
1995	--Incomplete Data--				

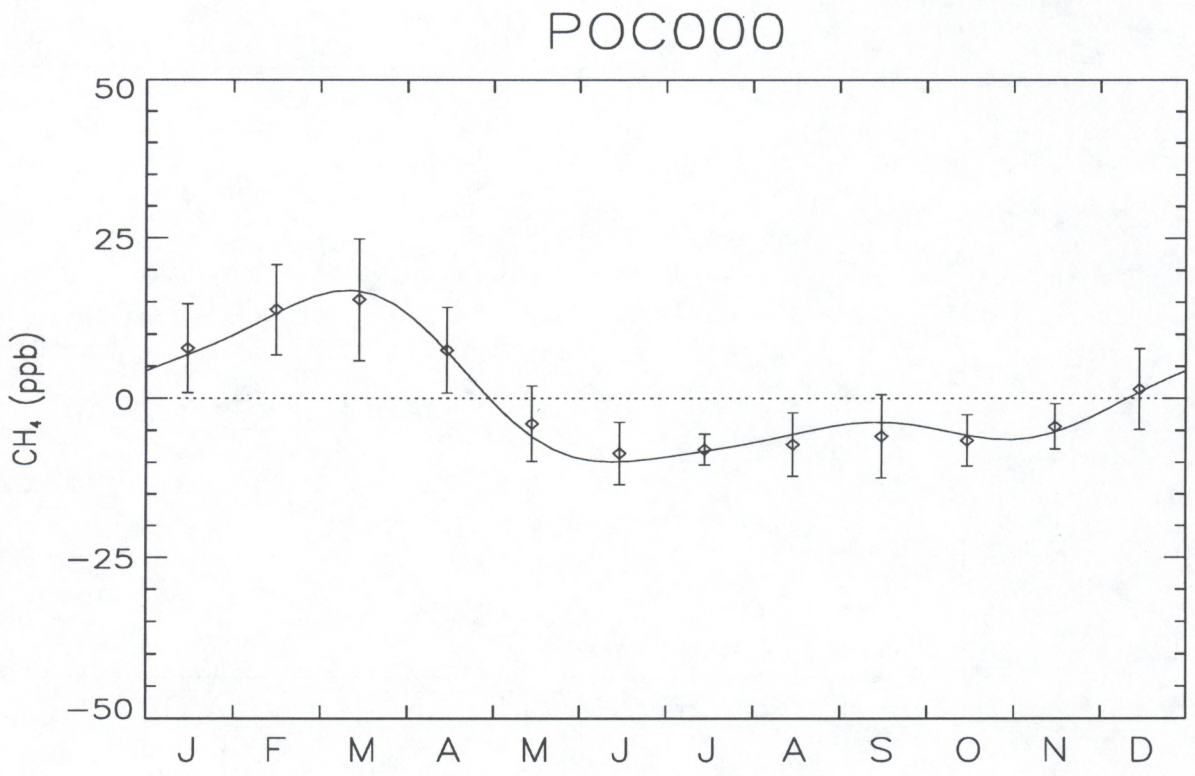
Average Amplitude:	63.4
Standard Deviation:	0.5
Harmonic Amplitude:	68.2



Station Name:	Christmas Island, Kiribati
Station Code:	CHR
Latitude:	1°42'N
Beginning Date:	Mar 1984
Ending Date:	Dec 1995
Number of Data Points:	418

Year	Amplitude	Maximum	Date	Minimum	Date
1985	25.49	16.01	Mar 21	-9.48	Aug 1
1986	40.30	26.61	Apr 3	-13.69	Oct 23
1987	34.06	22.53	Apr 2	-11.53	Sep 17
1988	34.40	21.34	Feb 19	-13.06	Jun 10
1989	34.08	22.55	Mar 17	-11.52	Sep 22
1990	34.74	24.37	Mar 2	-10.37	May 11
1991	18.89	9.03	Jan 25	-9.86	Oct 11
1992	34.80	22.05	Jan 31	-12.75	Jul 4
1993	32.38	19.09	Apr 17	-13.29	Jun 19
1994	--Incomplete Data--				
1995	--Incomplete Data--				

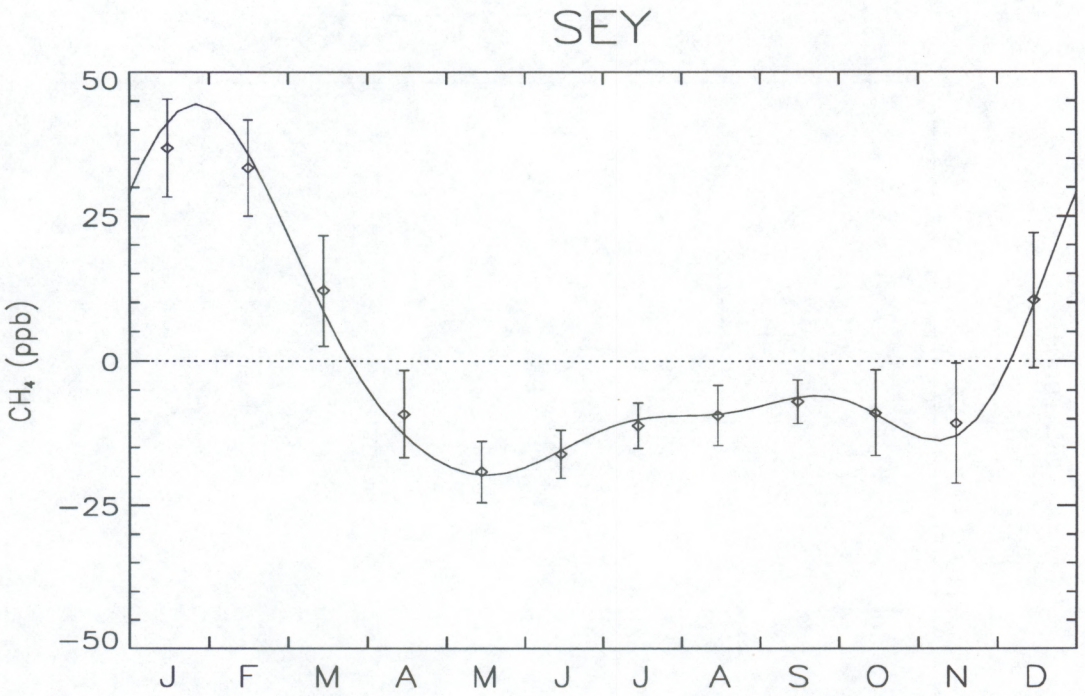
Average Amplitude:	32.1
Standard Deviation:	6.3
Harmonic Amplitude:	25.4



Station Name:	Pacific Ocean, Shipboard
Station Code:	POC000
Latitude:	0°00'N
Beginning Date:	Dec 1986
Ending Date:	Dec 1995
Number of Data Points:	171

Year	Amplitude	Maximum	Date	Minimum	Date
1987	26.55	12.48	Apr 18	-14.07	Jul 18
1988	42.94	27.32	Feb 28	-15.62	Aug 21
1989	45.30	28.95	Mar 5	-16.35	Jun 11
1990	30.17	22.01	Mar 11	-8.16	Jul 8
1991	20.60	11.54	Dec 8	-9.06	Aug 4
1992	42.69	25.70	Mar 9	-17.00	Jun 1
1993	37.33	21.57	Mar 29	-15.76	May 31
1994	34.56	19.24	Mar 21	-15.32	Aug 29
1995	33.74	25.70	Jan 16	-8.03	Nov 6

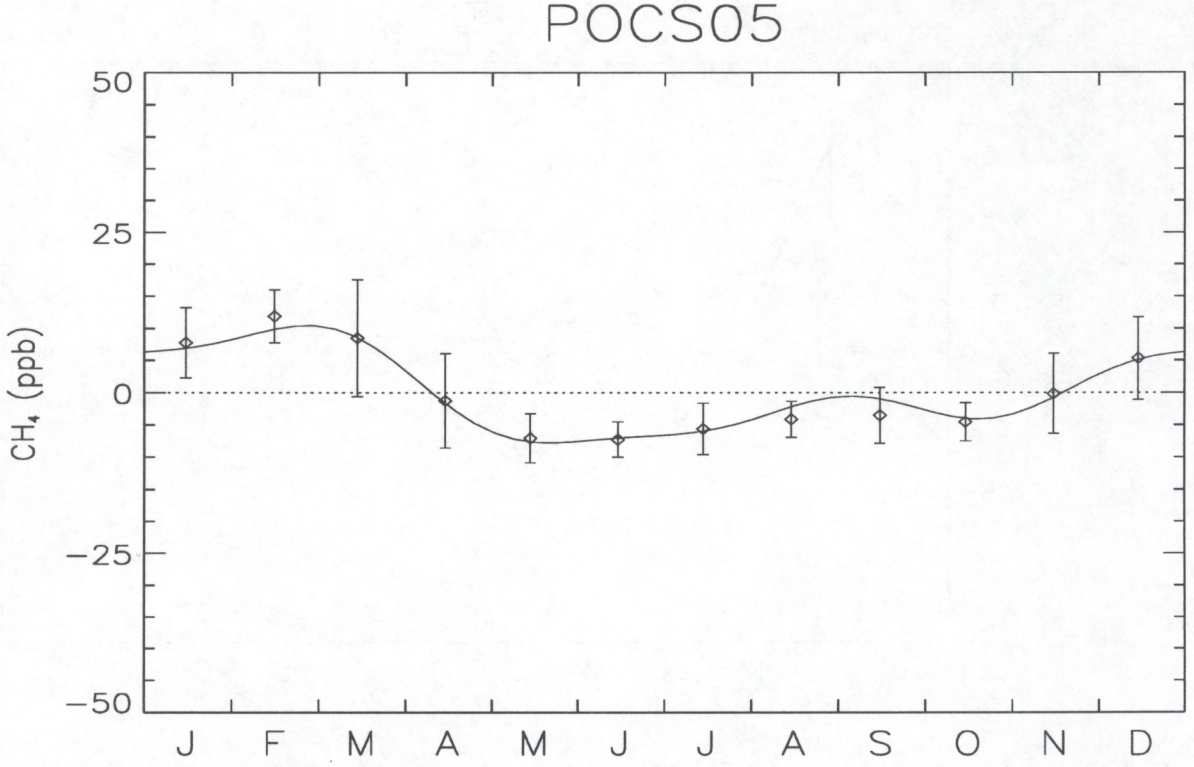
Average Amplitude:	34.8
Standard Deviation:	8.2
Harmonic Amplitude:	26.7



Station Name:	Mahe Island, Seychelles
Station Code:	SEY
Latitude:	4°40'S
Beginning Date:	May 1983
Ending Date:	Dec 1995
Number of Data Points:	577

Year	Amplitude	Maximum	Date	Minimum	Date
1984	58.88	34.09	Dec 28	-24.79	May 17
1985	63.18	43.70	Jan 25	-19.48	Apr 12
1986	63.12	37.22	Feb 21	-25.91	May 9
1987	62.63	41.42	Jan 16	-21.21	Nov 6
1988	68.43	41.31	Jan 29	-27.12	May 20
1989	68.63	45.25	Jan 21	-23.38	May 20
1990	57.59	36.82	Jan 27	-20.78	Nov 17
1991	67.17	46.93	Jan 26	-20.25	Apr 20
1992	64.59	41.75	Feb 1	-22.83	Nov 22
1993	64.55	45.28	Jan 31	-19.28	Oct 31
1994	71.09	47.22	Jan 16	-23.87	May 15
1995	73.54	52.28	Jan 29	-21.26	May 21

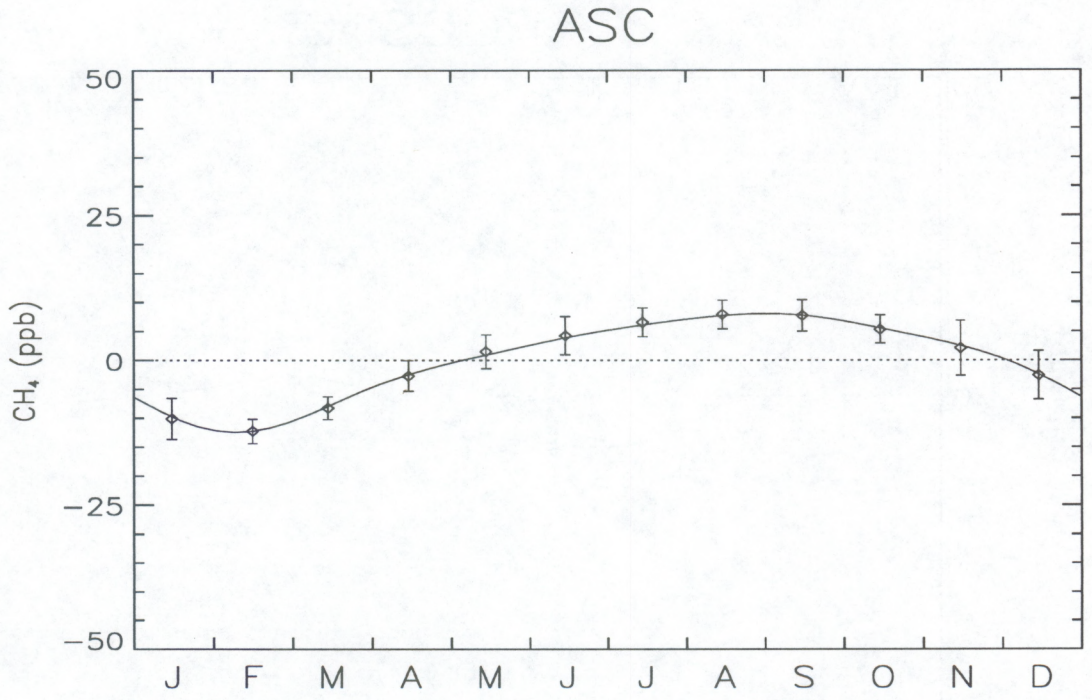
Average Amplitude:	65.2
Standard Deviation:	4.7
Harmonic Amplitude:	64.2



Station Name:	Pacific Ocean, Shipboard
Station Code:	POCS05
Latitude:	5°00'S
Beginning Date:	Dec 1986
Ending Date:	Dec 1995
Number of Data Points:	174

Year	Amplitude	Maximum	Date	Minimum	Date
1987	29.88	16.58	Feb 22	-13.30	Jul 12
1988	30.67	18.78	Feb 22	-11.89	Jun 6
1989	36.87	25.25	Mar 13	-11.62	Oct 2
1990	31.27	22.76	Mar 19	-8.51	Jul 23
1991	31.79	22.83	Dec 2	-8.97	May 20
1992	21.00	9.96	Feb 18	-11.04	Jun 9
1993	19.47	12.66	Jan 26	-6.81	May 25
1994	20.76	13.90	Jan 25	-6.86	May 17
1995	34.75	19.47	Jan 31	-15.28	May 2

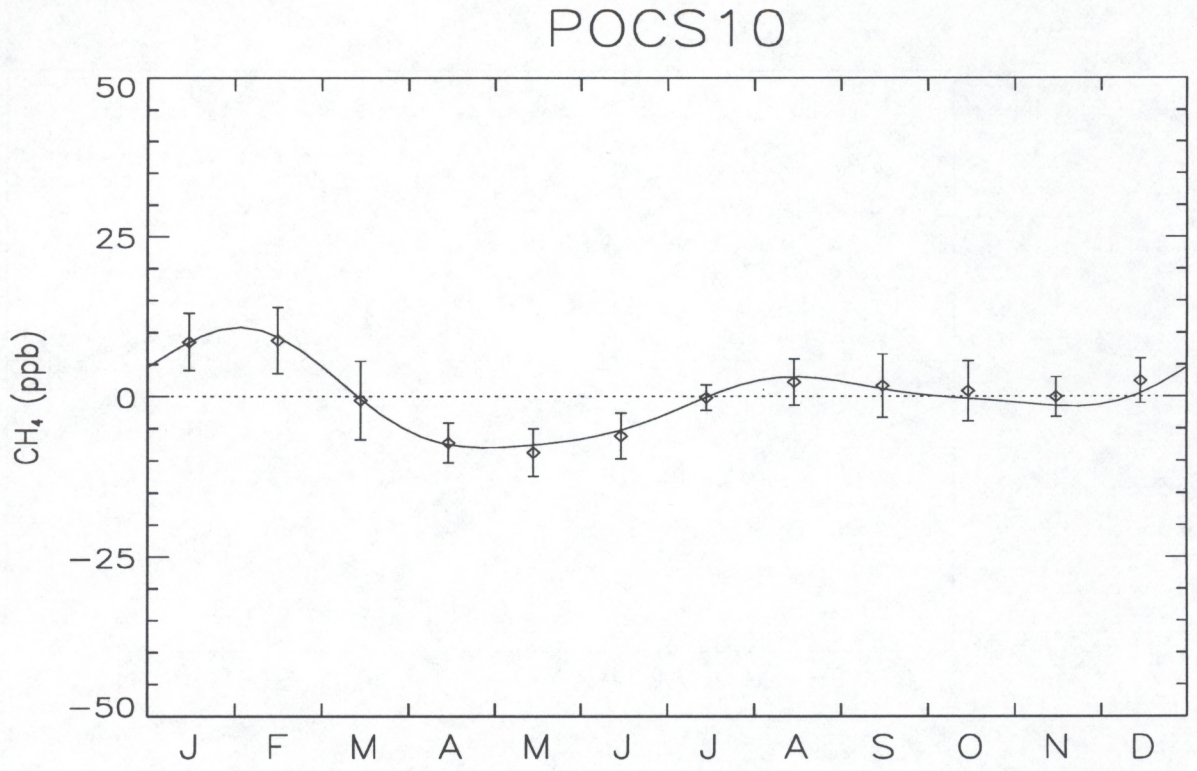
Average Amplitude:	28.4
Standard Deviation:	6.4
Harmonic Amplitude:	18.2



Station Name:	Ascension Island
Station Code:	ASC
Latitude:	7°55'S
Beginning Date:	May 1983
Ending Date:	Dec 1995
Number of Data Points:	843

Year	Amplitude	Maximum	Date	Minimum	Date
1984	26.58	11.48	Jul 26	-15.10	Feb 15
1985	28.11	13.04	Aug 29	-15.07	Feb 7
1986	23.83	10.65	Oct 30	-13.18	Feb 6
1987	23.63	9.94	Sep 3	-13.69	Feb 19
1988	29.19	11.56	Aug 19	-17.63	Jan 28
1989	21.78	8.20	Nov 10	-13.58	Jan 27
1990	22.75	9.04	Sep 28	-13.70	Feb 2
1991	24.26	12.71	Nov 29	-11.55	Mar 1
1992	21.82	7.67	Aug 8	-14.15	Feb 14
1993	23.84	10.03	Sep 11	-13.81	Jan 30
1994	17.86	8.91	Aug 13	-8.95	Jan 29
1995	20.11	9.41	Sep 2	-10.70	Feb 4

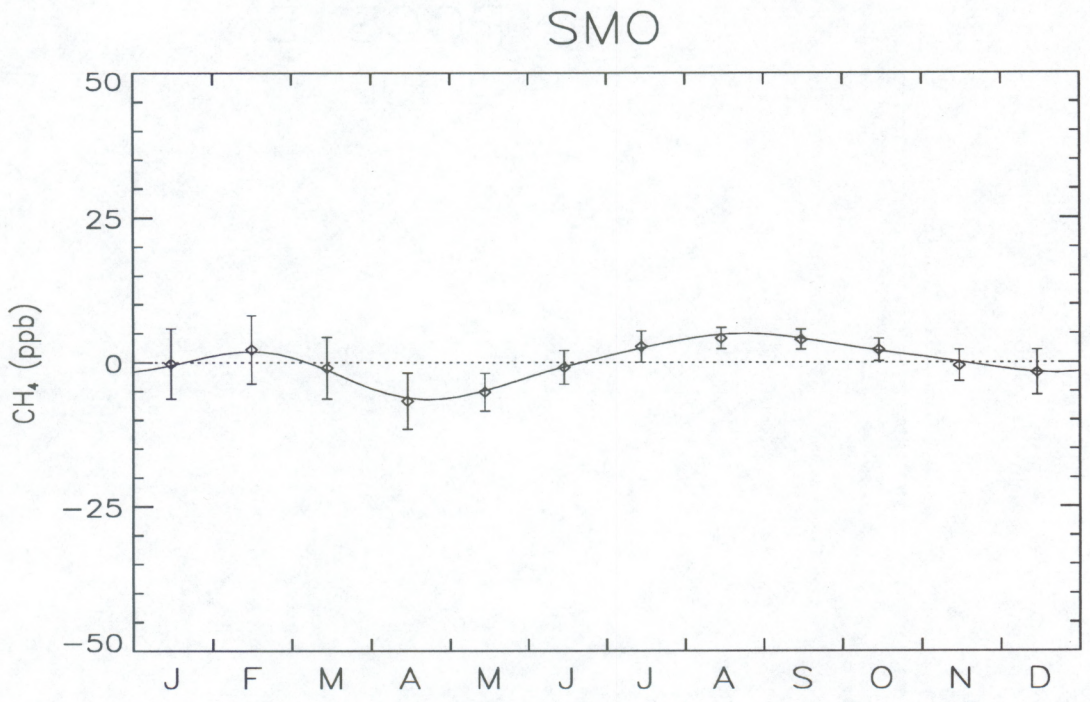
Average Amplitude:	23.6
Standard Deviation:	3.2
Harmonic Amplitude:	20.5



Station Name:	Pacific Ocean, Shipboard
Station Code:	POCS10
Latitude:	10°00'S
Beginning Date:	Dec 1986
Ending Date:	Dec 1995
Number of Data Points:	176

Year	Amplitude	Maximum	Date	Minimum	Date
1987	33.71	21.74	Jan 26	-11.97	May 11
1988	27.41	13.83	Sep 13	-13.58	May 31
1989	22.14	9.81	Jan 17	-12.33	Mar 21
1990	26.63	14.49	Mar 6	-12.13	May 8
1991	13.80	6.74	Jan 15	-7.06	Jun 4
1992	11.28	3.94	Jul 29	-7.34	Apr 22
1993	29.99	16.87	Feb 10	-13.13	May 19
1994	24.59	11.82	Feb 9	-12.77	May 4
1995	20.02	12.10	Jan 11	-7.92	Apr 12

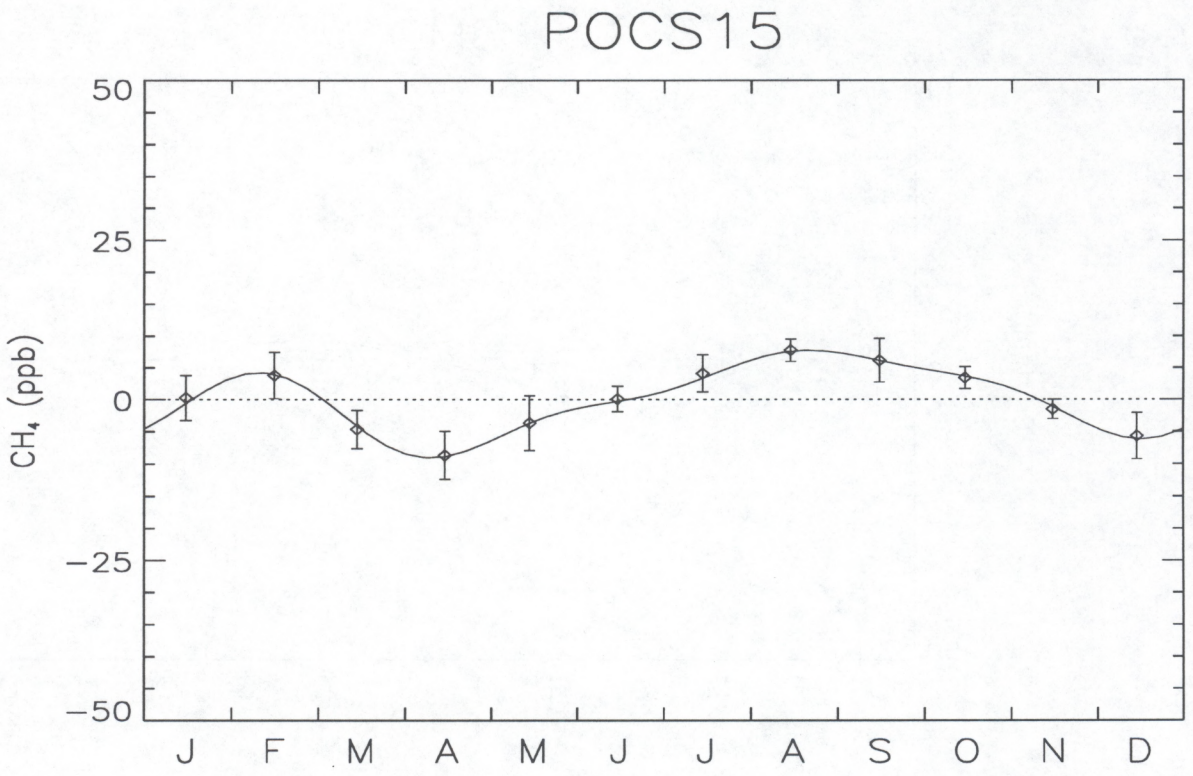
Average Amplitude:	23.2
Standard Deviation:	7.3
Harmonic Amplitude:	18.8



Station Name:	Matatula Point, American Samoa
Station Code:	SMO
Latitude:	14°15'S
Beginning Date:	Apr 1983
Ending Date:	Dec 1995
Number of Data Points:	1110

Year	Amplitude	Maximum	Date	Minimum	Date
1984	25.27	11.62	Jan 21	-13.66	Mar 24
1985	17.18	7.99	Feb 3	-9.19	Dec 8
1986	23.43	15.06	Feb 23	-8.37	Dec 20
1987	20.12	9.23	Feb 21	-10.89	Apr 25
1988	14.95	4.46	Feb 14	-10.49	May 29
1989	13.13	6.32	Aug 21	-6.81	Mar 27
1990	15.21	5.10	Jul 30	-10.11	Jan 29
1991	19.39	7.58	Feb 18	-11.81	Apr 15
1992	16.26	6.74	Aug 17	-9.52	Jan 27
1993	14.39	6.01	Jul 20	-8.38	Jan 5
1994	11.88	6.27	Aug 23	-5.62	Apr 5
1995	13.81	6.66	Sep 26	-7.15	Apr 4

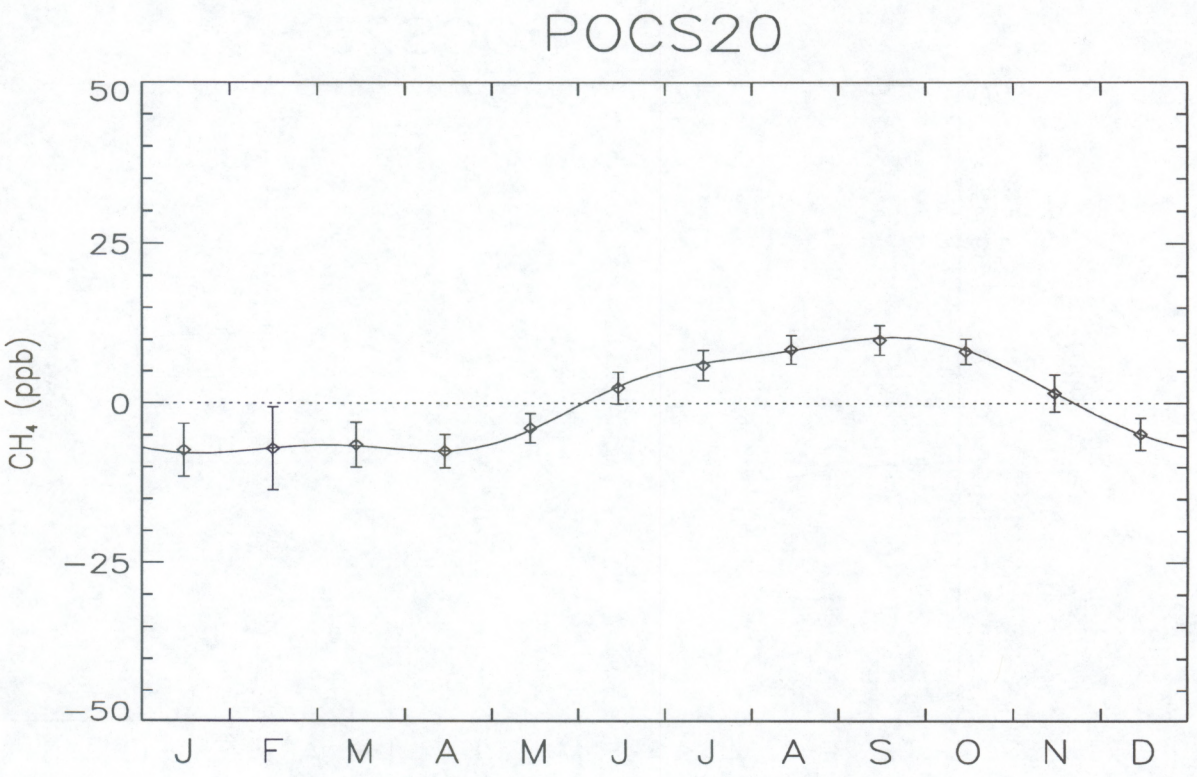
Average Amplitude:	17.0
Standard Deviation:	4.2
Harmonic Amplitude:	11.4



Station Name:	Pacific Ocean, Shipboard
Station Code:	POCS15
Latitude:	15°00'S
Beginning Date:	Dec 1986
Ending Date:	Dec 1995
Number of Data Points:	178

Year	Amplitude	Maximum	Date	Minimum	Date
1987	26.35	12.95	Aug 27	-13.40	Apr 9
1988	20.88	9.39	Jul 29	-11.49	Apr 7
1989	16.18	7.73	May 12	-8.44	Dec 8
1990	19.22	9.09	Aug 3	-10.14	Mar 30
1991	23.51	11.67	Sep 6	-11.84	Apr 19
1992	17.02	7.18	Aug 15	-9.83	Jan 3
1993	19.94	8.09	Jan 30	-11.85	Dec 18
1994	23.88	12.23	Feb 12	-11.65	Apr 16
1995	16.75	10.23	Sep 2	-6.52	Dec 23

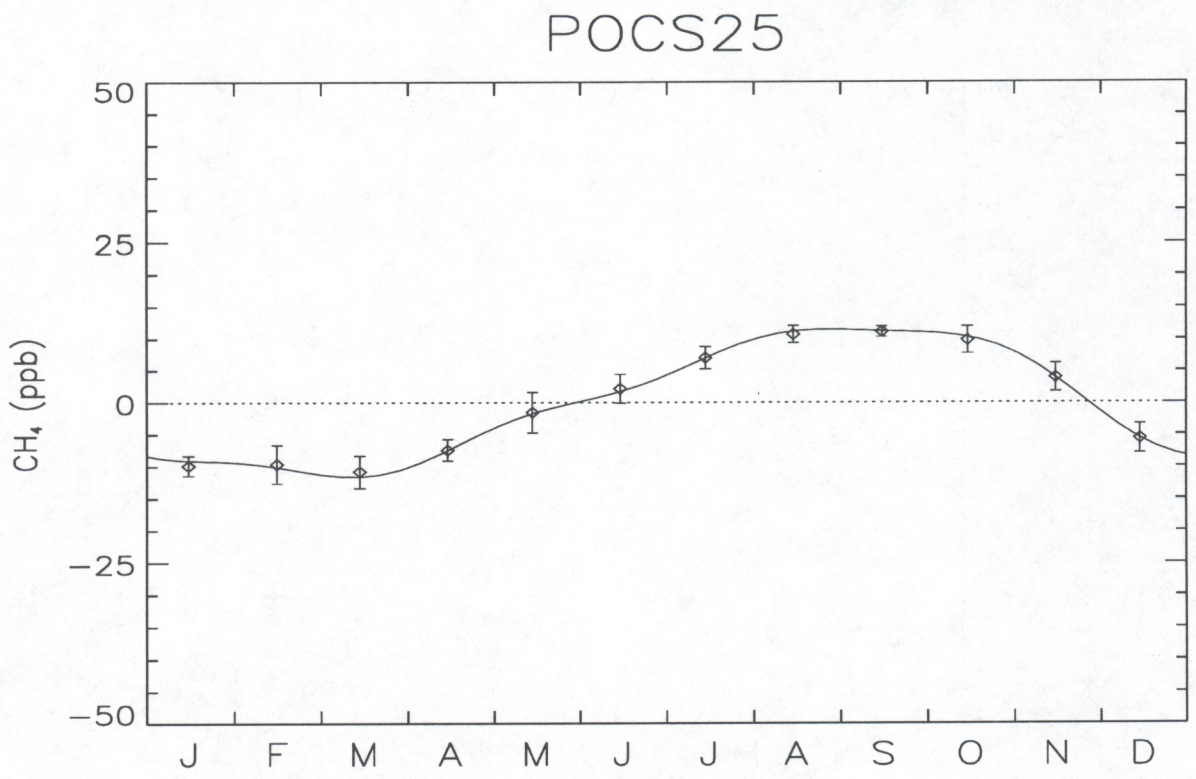
Average Amplitude:	20.4
Standard Deviation:	3.6
Harmonic Amplitude:	16.8



Station Name:	Pacific Ocean, Shipboard
Station Code:	POCS20
Latitude:	20°00'S
Beginning Date:	Dec 1986
Ending Date:	Dec 1995
Number of Data Points:	169

Year	Amplitude	Maximum	Date	Minimum	Date
1987	21.75	9.78	Sep 6	-11.97	Feb 1
1988	20.81	10.90	Sep 12	-9.91	Mar 27
1989	21.32	7.39	Oct 2	-13.93	Apr 10
1990	21.51	10.96	Sep 24	-10.55	Apr 23
1991	20.63	9.50	Sep 30	-11.13	Feb 18
1992	20.54	9.49	Jul 21	-11.06	Jan 27
1993	28.78	14.07	Sep 21	-14.71	Jan 26
1994	28.06	13.02	Aug 30	-15.04	Feb 8
1995	23.41	12.49	Sep 26	-10.92	Dec 26

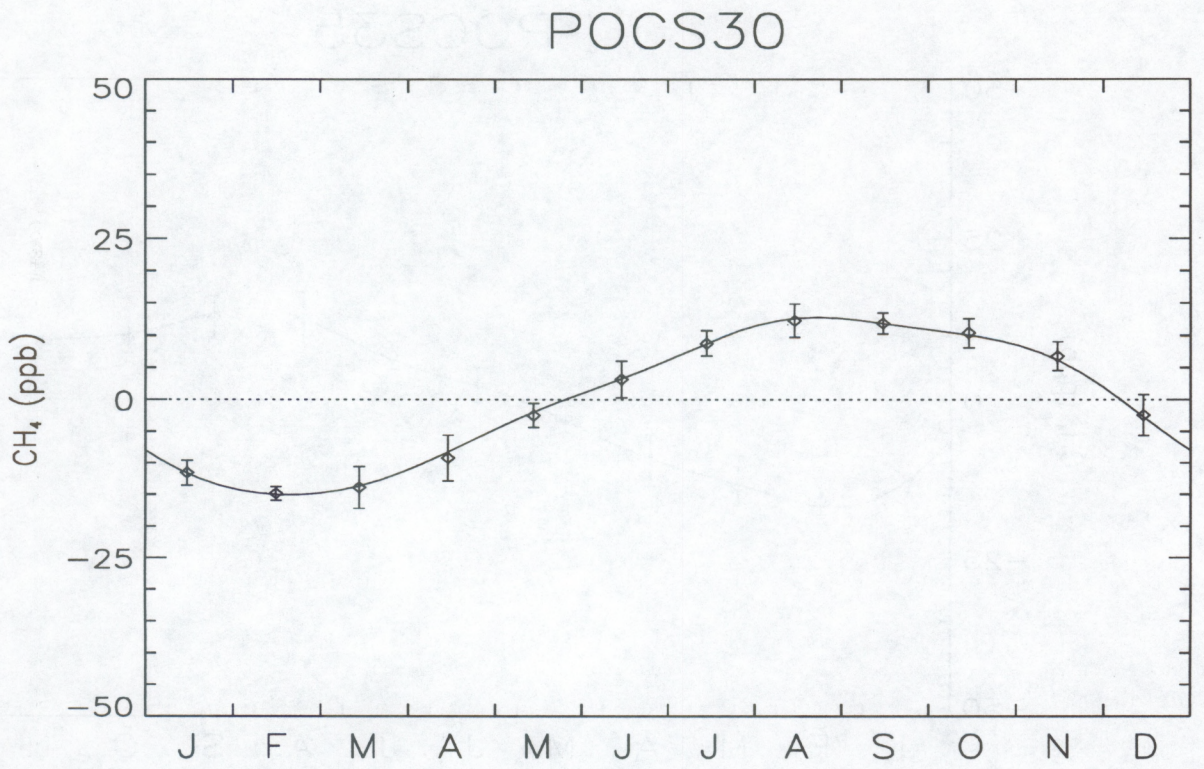
Average Amplitude:	22.9
Standard Deviation:	3.2
Harmonic Amplitude:	18.3



Station Name:	Pacific Ocean, Shipboard
Station Code:	POCS25
Latitude:	25°00'S
Beginning Date:	Dec 1986
Ending Date:	Dec 1995
Number of Data Points:	169

Year	Amplitude	Maximum	Date	Minimum	Date
1987	25.96	11.47	Sep 7	-14.49	Mar 2
1988	--Incomplete Data--				
1989	27.44	12.56	Aug 29	-14.89	Mar 20
1990	23.36	11.57	Aug 21	-11.79	Jan 16
1991	23.37	12.78	Sep 23	-10.59	Jan 29
1992	24.52	11.47	Jul 28	-13.05	Feb 25
1993	26.74	12.66	Aug 25	-14.07	Mar 17
1994	27.24	14.50	Oct 11	-12.74	Mar 16
1995	24.51	11.75	Sep 5	-12.76	Jan 25

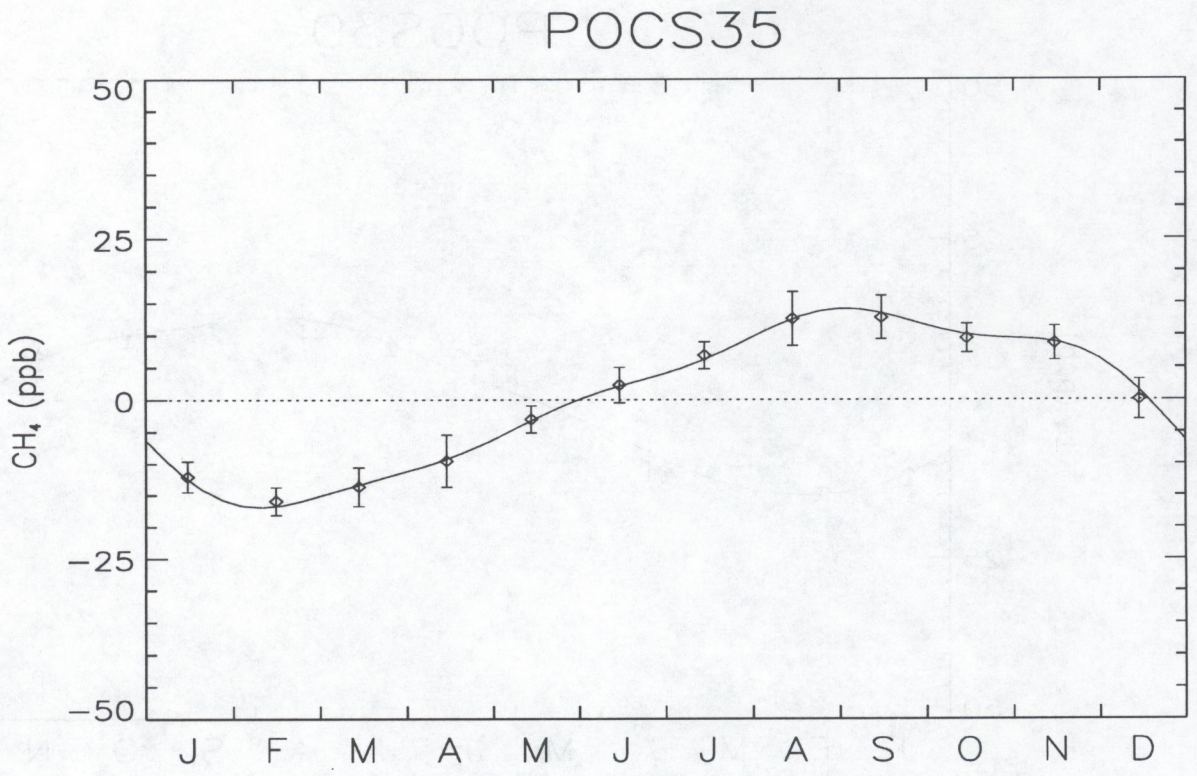
Average Amplitude:	25.3
Standard Deviation:	1.7
Harmonic Amplitude:	23.1



Station Name:	Pacific Ocean, Shipboard
Station Code:	POCS30
Latitude:	30°00'S
Beginning Date:	Dec 1986
Ending Date:	Dec 1995
Number of Data Points:	164

Year	Amplitude	Maximum	Date	Minimum	Date
1987	30.06	12.71	Oct 19	-17.34	Feb 23
1988	--Incomplete Data--				
1989	30.11	13.02	Aug 22	-17.09	Feb 21
1990	30.21	16.40	Aug 7	-13.81	Feb 13
1991	27.21	10.29	Sep 3	-16.93	Mar 12
1992	27.32	12.97	Aug 26	-14.36	Feb 18
1993	28.63	13.53	Aug 18	-15.10	Jan 20
1994	29.49	13.37	Oct 12	-16.11	Jan 26
1995	27.52	12.52	Aug 16	-15.01	Feb 15

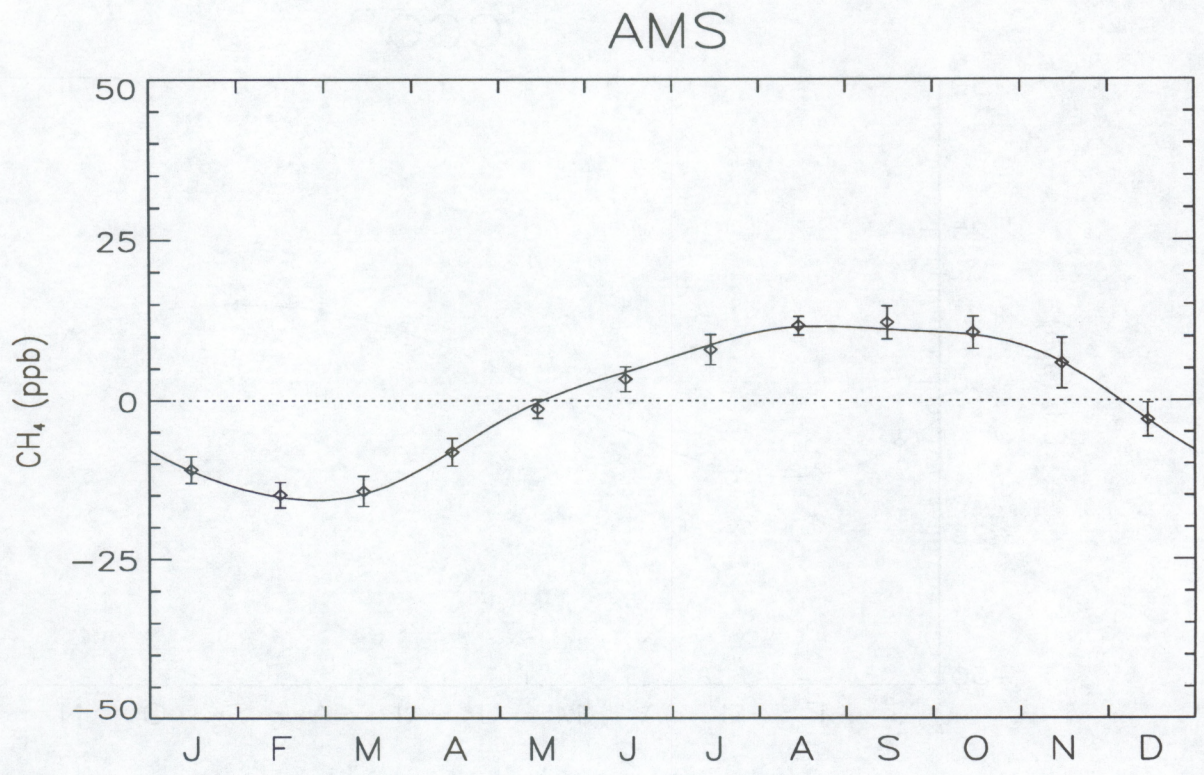
Average Amplitude:	28.8
Standard Deviation:	1.3
Harmonic Amplitude:	27.9



Station Name:	Pacific Ocean, Shipboard
Station Code:	POCS35
Latitude:	35°00'S
Beginning Date:	Dec 1986
Ending Date:	Dec 1995
Number of Data Points:	150

Year	Amplitude	Maximum	Date	Minimum	Date
1987	32.69	14.18	Sep 15	-18.50	Feb 10
1988	--Incomplete Data--				
1989	28.44	12.35	Aug 9	-16.09	Feb 8
1990	31.11	13.60	Aug 15	-17.51	Feb 14
1991	27.16	12.13	Sep 18	-15.03	Mar 20
1992	27.15	14.59	Sep 3	-12.57	Feb 12
1993	--Incomplete Data--				
1994	--Incomplete Data--				
1995	40.51	25.58	Aug 24	-14.94	Feb 9

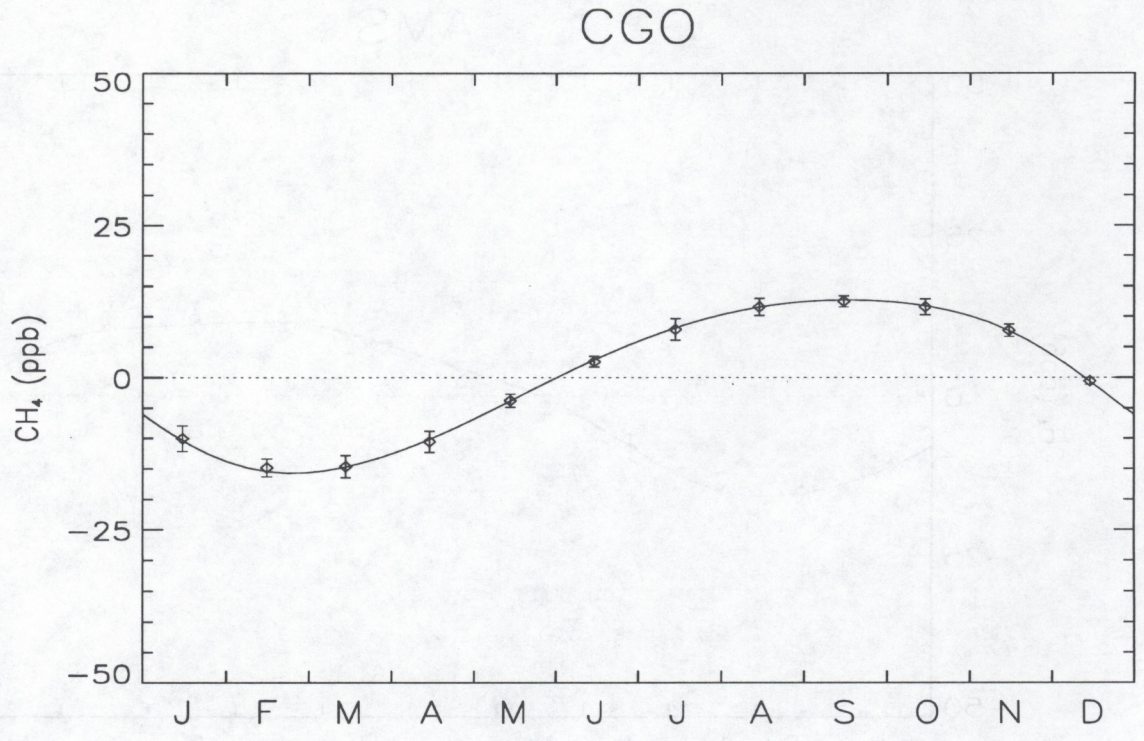
Average Amplitude:	31.1
Standard Deviation:	5.1
Harmonic Amplitude:	30.9



Station Name:	Amsterdam Island
Station Code:	AMS
Latitude:	37°57'S
Beginning Date:	Jan 1983
Ending Date:	Oct 1990
Number of Data Points:	223

Year	Amplitude	Maximum	Date	Minimum	Date
1983	26.04	11.08	Aug 12	-14.97	Feb 25
1984	24.03	10.49	Aug 11	-13.54	Feb 10
1985	36.66	18.33	Sep 7	-18.33	Mar 2
1986	27.66	12.99	Aug 30	-14.67	Feb 15
1987	36.09	16.98	Oct 24	-19.10	Mar 7
1988	29.79	11.95	Sep 18	-17.83	Feb 6
1989	29.47	12.57	Aug 20	-16.90	Feb 26

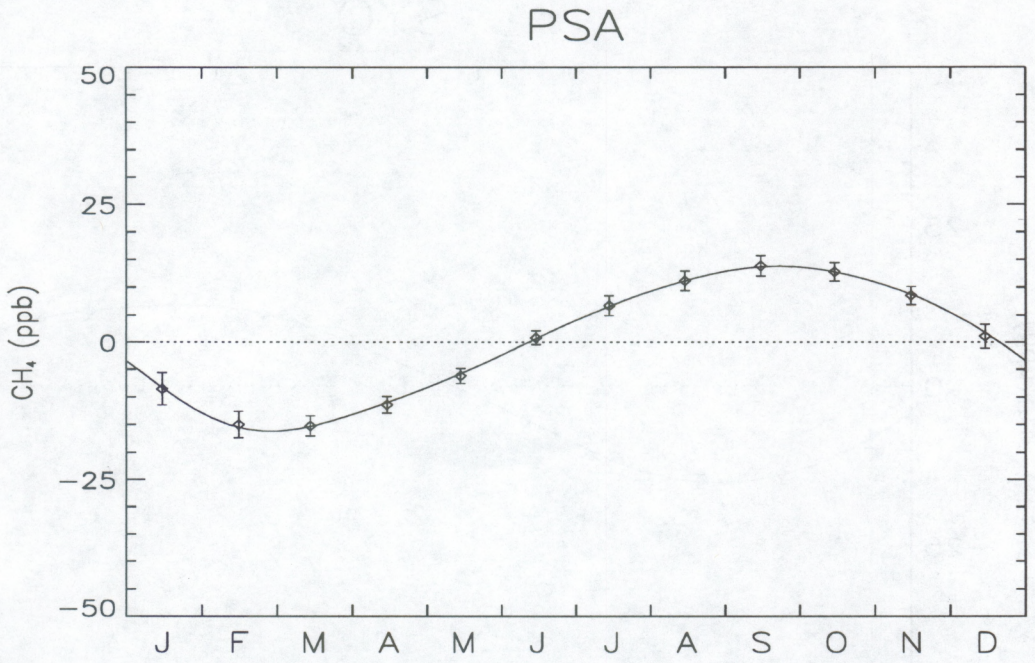
Average Amplitude:	29.7
Standard Deviation:	4.5
Harmonic Amplitude:	27.3



Station Name:	Cape Grim, Tasmania, Australia
Station Code:	CGO
Latitude:	40°41'S
Beginning Date:	Apr 1984
Ending Date:	Dec 1995
Number of Data Points:	587

Year	Amplitude	Maximum	Date	Minimum	Date
1985	29.31	13.44	Sep 12	-15.87	Feb 28
1986	27.90	13.11	Aug 28	-14.79	Mar 6
1987	30.19	14.39	Sep 24	-15.80	Feb 19
1988	33.00	13.89	Sep 2	-19.11	Mar 18
1989	30.49	13.40	Aug 18	-17.10	Feb 3
1990	29.60	13.59	Oct 12	-16.01	Mar 9
1991	27.30	11.37	Oct 4	-15.93	Feb 15
1992	26.57	12.83	Sep 12	-13.73	Mar 6
1993	30.82	13.27	Sep 18	-17.55	Feb 20
1994	28.29	11.93	Oct 8	-16.36	Feb 12
1995	27.67	12.94	Sep 23	-14.73	Mar 11

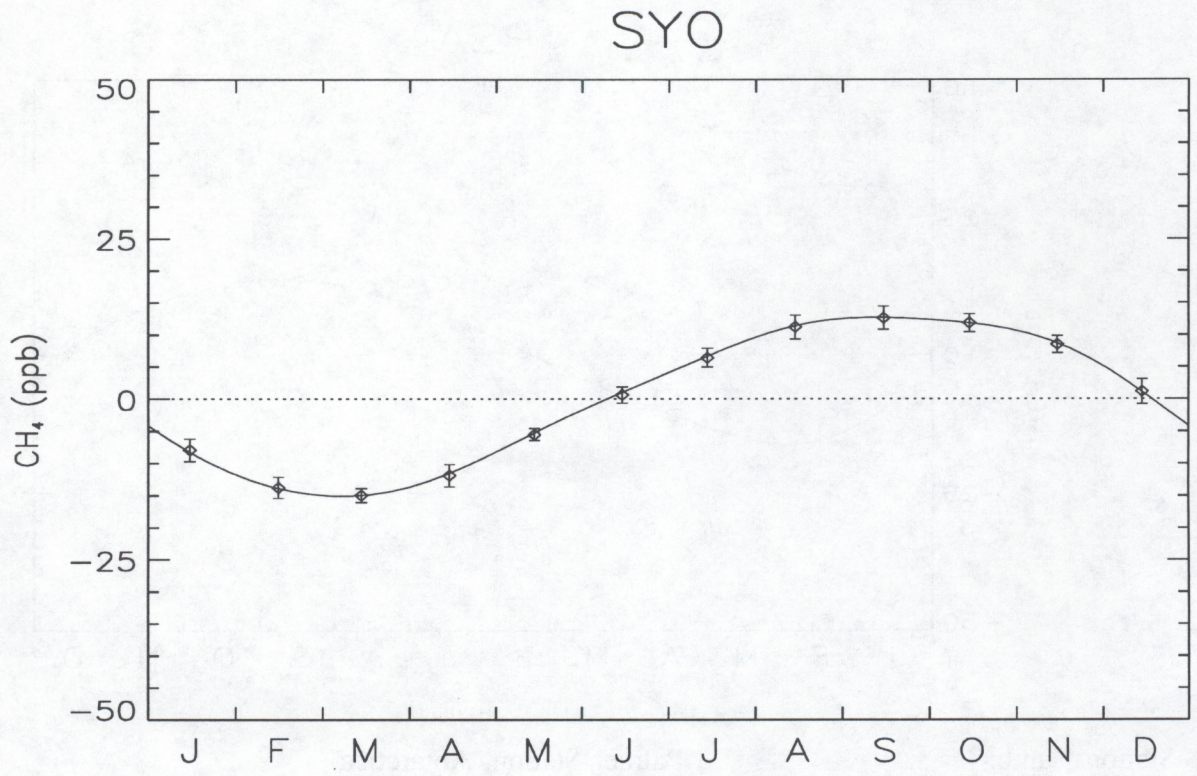
Average Amplitude:	29.2
Standard Deviation:	1.9
Harmonic Amplitude:	28.4



Station Name:	Palmer Station, Antarctica
Station Code:	PSA
Latitude:	64°55'S
Beginning Date:	Jan 1983
Ending Date:	Dec 1995
Number of Data Points:	482

Year	Amplitude	Maximum	Date	Minimum	Date
1983	35.50	14.41	Sep 3	-21.09	Feb 19
1984	27.54	14.03	Sep 2	-13.51	Feb 26
1985	32.93	15.73	Oct 6	-17.19	Mar 3
1986	32.78	13.91	Sep 28	-18.86	Mar 9
1987	29.75	12.99	Oct 4	-16.76	Feb 22
1988	34.85	17.49	Sep 19	-17.36	Mar 21
1989	36.08	17.75	Sep 18	-18.33	Feb 6
1990	31.97	15.19	Sep 24	-16.79	Feb 19
1991	29.81	12.41	Sep 30	-17.39	Mar 4
1992	26.09	13.47	Sep 8	-12.62	Mar 17
1993	30.58	13.89	Sep 21	-16.69	Mar 2
1994	28.37	12.21	Sep 13	-16.16	Feb 22
1995	27.51	13.81	Sep 26	-13.69	Mar 7

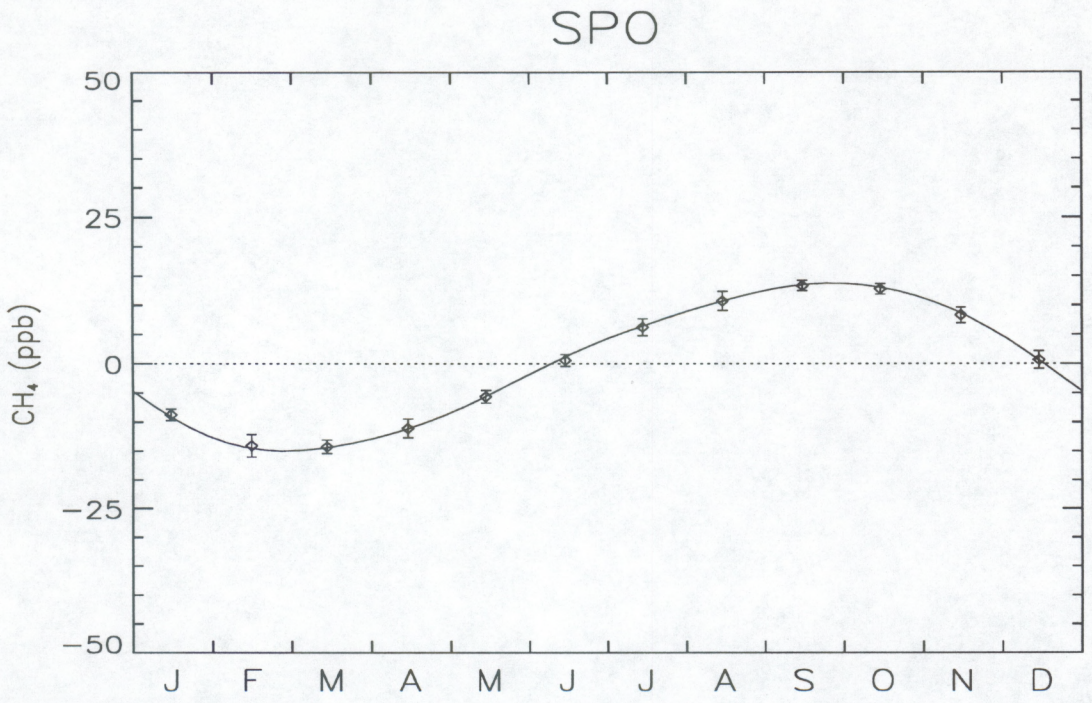
Average Amplitude:	31.0
Standard Deviation:	3.3
Harmonic Amplitude:	30.0



Station Name:	Syowa Station, Antarctica
Station Code:	SYO
Latitude:	69°00'S
Beginning Date:	Apr 1986
Ending Date:	Dec 1995
Number of Data Points:	163

Year	Amplitude	Maximum	Date	Minimum	Date
1987	--Incomplete Data--				
1988	26.76	11.32	Sep 15	-15.44	Mar 24
1989	29.90	14.54	Sep 1	-15.36	Mar 3
1990	28.95	13.57	Oct 12	-15.38	Mar 2
1991	25.20	10.80	Nov 8	-14.40	Mar 1
1992	28.39	14.37	Sep 26	-14.02	Mar 6
1993	31.09	13.67	Sep 25	-17.41	Mar 6
1994	28.86	12.18	Sep 3	-16.68	Mar 5
1995	26.94	12.51	Oct 7	-14.43	Mar 18

Average Amplitude:	28.2
Standard Deviation:	1.9
Harmonic Amplitude:	27.8



Station Name:	South Pole, Antarctica
Station Code:	SPO
Latitude:	89°59'S
Beginning Date:	Feb 1983
Ending Date:	Dec 1995
Number of Data Points:	637

Year	Amplitude	Maximum	Date	Minimum	Date
1984	28.35	13.88	Sep 30	-14.47	Feb 26
1985	31.01	15.09	Sep 30	-15.91	Mar 25
1986	28.00	12.60	Sep 29	-15.40	Feb 24
1987	29.29	13.35	Sep 28	-15.94	Feb 16
1988	31.51	14.72	Oct 17	-16.79	Feb 22
1989	31.71	14.66	Sep 12	-17.05	Mar 7
1990	28.28	14.06	Sep 25	-14.22	Feb 20
1991	28.20	12.95	Oct 1	-15.24	Apr 2
1992	27.96	14.09	Sep 8	-13.87	Mar 10
1993	29.75	14.73	Sep 22	-15.01	Feb 17
1994	29.67	14.09	Sep 28	-15.57	Mar 2
1995	28.05	13.80	Oct 4	-14.25	Mar 1

Average Amplitude:	29.3
Standard Deviation:	1.4
Harmonic Amplitude:	28.7