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# GLOBALVIEW-$CO_2$, 2003
# Cooperative Atmospheric Data Integration Project

**** Documentation File ****
August 14, 2003

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In order to use GLOBALVIEW-$CO_2$ as it was intended, users should read and understand this documentation file. It is also highly recommended that users consult the relevant published literature (a partial list is provided in Section 10 (REFERENCES)).

GLOBALVIEW-$CO_2$ is derived from measurements but contains no actual data. To facilitate use with carbon cycle modeling studies, the measurements have been processed (smoothed, interpolated, and extrapolated) resulting in extended records that are evenly incremented in time. Be aware that information contained in the actual data may be lost in this process. Users are encouraged to review the actual data in the literature, in data archives (CDIAC, WDCGG), or by contacting the participating laboratories identified below.

Smoothed, interpolated, and extrapolated values in the extended records are determined with varying degrees of confidence. We strongly encourage users to consider the relative weights assigned to these values when using this product.

GLOBALVIEW-$CO_2$ is subject to change as members of the Cooperative Atmospheric Data Integration Project reserve the right to adjust individual measurement records based on recalibrations of standard gases and instruments.

The GLOBALVIEW-$CO_2$ data product continues to evolve. Extended records and statistical summaries may change as techniques are refined and new data are added.

Comments regarding clarity and ease-of-use are encouraged. Please send comments to the e-mail address provided in Section 8 (COMMENTS/QUESTIONS).

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## HOW TO CITE GLOBALVIEW-$CO_2$

Anyone using GLOBALVIEW-$CO_2$ is agreeing to acknowledge its authors. The list of cooperating scientists and their organizations and institutions is large and would be cumbersome to include as a reference, thus GLOBALVIEW-$CO_2$ and its contributors should be referenced as **[*GLOBALVIEW-$CO_2$*, 2003]**, and in a list of references as

> **GLOBALVIEW-$CO_2$: Cooperative Atmospheric Data Integration Project - Carbon Dioxide. CD-ROM, NOAA CMDL, Boulder, Colorado [Also available on Internet via anonymous FTP to ftp.cmdl.noaa.gov, Path: ccg/co2/GLOBALVIEW], 2003.**

which complies with the recommended reference styles of both the American Geophysical Union and the American Meteorological Society. See Section 2 (PARTICIPANTS) for a complete list of authors and contributors.

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**CONTENTS**



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## Cooperative Atmospheric Data Integration Project

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## 1. OVERVIEW

GLOBALVIEW-$CO_2$ is a product of the Cooperative Atmospheric Data Integration Project. While the project is coordinated and maintained by the Carbon Cycle Greenhouse Gases Group of the National Oceanic and Atmospheric Administration, Climate Monitoring and Diagnostics Laboratory (NOAA CMDL), it is a cooperative effort among the many organizations and institutions making high-quality atmospheric $CO_2$ measurements (see Section 2 (PARTICIPANTS).

GLOBALVIEW-$CO_2$ is derived using the data extension and integration techniques described by *Masarie and Tans*, [1995] (reprints available upon request, see Section 8 (COMMENTS/QUESTIONS)). These techniques were developed using $CO_2$ measurements from the NOAA CMDL cooperative air sampling network. Carbon dioxide measurement records from other laboratories have been extended and integrated with the NOAA CMDL measurements into GLOBALVIEW-$CO_2$ with careful attention to both methodology and standard scales.

The impetus for the work done by the many cooperating organizations and institutions is to make atmospheric measurements of trace gas species that will facilitate a better understanding of the processes controlling their abundance. These and other measurements have been widely used to constrain atmospheric models that derive plausible source/sink scenarios. Serious obstacles to this approach are the paucity of sampling sites and the lack of temporal continuity among observations from different locations. Consequently, there is the potential for models to misinterpret these spatial and temporal gaps resulting in derived source/sink scenarios that are unduly influenced by the sampling distribution. GLOBALVIEW-$CO_2$ is an attempt to address these issues of temporal discontinuity and data sparseness and is a tool intended for use in carbon cycle modeling.

## 2. PARTICIPANTS

GLOBALVIEW-$CO_2$ is freely available to anyone. Its suggested use has been outlined above. Anyone using GLOBALVIEW-$CO_2$ is agreeing to acknowledge its authors. The list of cooperating scientists and their organizations and institutions is large and would be cumbersome to include as a reference, thus GLOBALVIEW-$CO_2$ and its contributors should be referenced as [***GLOBALVIEW-CO$_2$*****, 2003**], and in a list of references as

**GLOBALVIEW-CO$_2$: Cooperative Atmospheric Data Integration Project - Carbon Dioxide. CD-ROM, NOAA CMDL, Boulder, Colorado [Also available on Internet via anonymous FTP to ftp.cmdl.noaa.gov, Path: ccg/co2/GLOBALVIEW], 2003.**

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## 3. STANDARD SCALES AND METHODOLOGY

The majority of laboratories contributing to the GLOBALVIEW-$CO_2$ data product are members of the World Meteorological Organization (WMO) Global Atmospheric Watch (GAW) network. Data from the GAW network are reported relative to the WMO $CO_2$ mole fraction scale, which is maintained and propagated by the Central $CO_2$ Laboratory (CCL). GAW laboratories are required to maintain a direct link between their internal calibration scale and the CCL. A few laboratories contributing to the data product are not part of the WMO GAW program and thus provide data referenced to some other scale. This section describes ongoing efforts to assess the comparability of calibration scales and atmospheric observations.

### 3.1 The WMO $CO_2$ Mole Fraction Scale

The current WMO scale is based on routine absolute calibrations of $CO_2$ in dry air from a set of 15 primary standards using a high precision manometric system [*Zhao et al.*, 1997]. Absolute accuracy is estimated to be ~0.1 µmol $mol^{-1}$. Measurement precision is also on the order of 0.1 µmol $mol^{-1}$ based on repeated manometric analyses. The scale as defined by the primary standards (projected 30 year average lifetime) is subsequently propagated to a set of 9 secondary (transfer) standards (3-4 year average lifetime) using relative nondispersive infrared (NDIR) measurement techniques.  NDIR measurement precision is ~0.02 μmol $mol^{-1}$.  Cylinders are calibrated for other laboratories against the transfer standards using the NDIR methodology.  The use of a calibration hierarchy enables the CCL to occasionally re-assign the value of a primary or secondary standard and propagate the change, in a straightforward manner, to all dependent calibrations.

**Recent History**

In 1995, the WMO designated NOAA CMDL as the Central $CO_2$ Laboratory (CCL) responsible for the maintenance of the absolute WMO mole fraction scale for carbon dioxide.  Before that time, the scale had been maintained by the Scripps Institution of Oceanography (SIO) [*Tans et al.*, 2003].

In 1990, CMDL prepared 15 $CO_2$-in-air reference gas mixtures in large aluminum high pressure cylinders primary standards, ranging in $CO_2$ mole fraction from approximately 250 to 520 μmol $mol^{-1}$.  These cylinders were repeatedly calibrated at SIO by the NDIR method from mid-1991 to early 1993.  In 1996, CMDL began making absolute manometric determinations of its 15 "primary" standards.  Between 1996 and 2001, values assigned to the 15 primaries were based on both SIO NDIR measurements and CMDL manometric determinations.  Thus, any changes to the WMO scale maintained by SIO affect the WMO scale currently maintained by CMDL.

Work is underway to finalize the WMO scale during the years leading up to 1996.  Overall, the SIO values (based on the most recent revision to the scale maintained by SIO) are lower than CMDL values by 0.05 μmol $mol^{-1}$, but in the ambient range (345-415 μmol $mol^{-1}$) the average difference is -0.02 μmol $mol^{-1}$.  It is too early to determine whether this is a systematic difference between the SIO and CMDL scales or if the CMDL primary standards are drifting by a few hundredths of a μmol $mol^{-1}$ per year.

Beginning 2002, the WMO mole fraction is based on the CMDL calibrations alone.  This scale is called the WMO x2002 scale and assumes the suite of primary standards has not drifted.  It is likely that further revisions will be required in the future.  As the history of manometric calibrations becomes longer, there may be enough statistical evidence of drift in one or more of the primaries in which case retroactive revisions will need to be made.

## 3.2 Traceability to the WMO Scale

Not all data contributed to the Cooperative Atmospheric Data Integration Project for $CO_2$ are directly traceable to the WMO mole fraction scale.  A few laboratories have never had their standard gases calibrated by the CCL and report $CO_2$ measurements relative to some other scale (see Table 1).  Measurements from these laboratories are not directly traceable to the WMO mole fraction scale.  Several other laboratories have, at one time, had their standards calibrated by the CCL but have not maintained a routine recalibration schedule.  Because the mole fraction of $CO_2$ contained in high-pressure cylinders can potentially change with time due to $CO_2$ adsorption or production within the cylinder or regulator, or through other effects, the WMO scale as well as a laboratory's internal scale may potentially change with time. Without routine recalibration by the CCL to reestablish direct traceability to the absolute scale, laboratories contribute $CO_2$ data that are no longer directly traceable to the WMO scale.

**Table 1.** Traceability to the WMO scale based on calibration by the CCL.

| LABORATORY [LAB #] | CALIBRATION DATE[1] | # of CYLINDERS[3] | CALIBRATION SCALE |
|---|---|---|---|
| CMDL [00] | 2002 07 | 9 (recal) | WMO |
| | 2003 04 | 9 (recal) | |
| CSIRO [02] | 1994 08[2] | 7 (cal) | WMO |
| | 2001 11 | 7 (recal) | |
| SIO [04] | -- | -- | Scripps |
| MSC [06] | 2000 03 | 9 (cal) | WMO |
| | 2001 12 | 9 (recal) | |
| NIPR [09] | -- | -- | Tohoku Univ. |
| MRI [10] | -- | -- | WMO[6] |
| LSCE [11] | 2002 02 | 3 (cal) | WMO |
| | 2002 10 | 9 (cal) | |
| NIWA [15] | 1994 09[2] | 4 (cal) | WMO[4] |
| | 1995 11[2] | 5 (cal) | |
| IMS [17] | 1998 10 | 5 (cal) | WMO[4] |
| JMA [19] | 1999 01 | 13 (cal) | WMO |
| | 2002 03 | 14 (cal) | |
| NIES [20] | 2001 09 | 4 (cal) | NIES 95 |
| CESI [21] | 1997 07 | 5 (cal) | WMO |
| | 2001 12 | 5 (cal) | |
| IUP-HD [23] | 2001 12 | 3 (cal) | WMO |
| | 2002 10 | 5 (cal) | |
| SNU [24] | 2002 07 | 4 (cal) | WMO[6] |
| | 2003 04 | 5 (cal) | |
| INM [27] | 1997 01 | 4 (cal) | WMO |
| | 2002 03 | 9 (cal) | |
| ENEA [28] | 2000 07 | 4 (cal) | WMO |
| PNRA/DNA [29] | 2000 12 | 3 (cal) | |
| FMI [30] | 2000 04 | 7 (cal) | WMO |
| MISU [31] | 1996 07 | 10 (cal) | WMO[4] |
| CAMS [33] | 1994 01[2] | 9 (cal) | WMO[4] |
| HMS [35] | 2000 03 | 7 (cal) | WMO |
| | 2000 05 | 5 (recal) | |
| SAWS [36] | 1997 06 | 2 (cal) | WMO[5] |

| | 2002 07 | 2 (cal) | |
|---|---|---|---|

[1]Only the two most recent calibration events are shown.
[2]Calibration made at CMDL relative to the CMDL secondary standards.
[3]Initial (cal)ibration and subsequent (recal)ibration by the CCL (NOAA) are specified.
[4]Traceability to the WMO mole fraction scale has lapsed. A recalibration schedule of every 3 years is thought to be the minimum frequency for maintaining traceability to the WMO scale.
[5]Insufficient number of cylinders calibrated to properly link laboratory internal scale to WMO mole fraction scale. The minimum number of standards required to establish traceability to the WMO mole fraction scale is three.
[6]Internal scale is indirectly linked to WMO mole fraction scale.

### 3.3 Comparisons of Standard Scales

In an attempt to assess differences in standard scales among organizations making $CO_2$ measurements, laboratories contributing to GLOBALVIEW-$CO_2$ have participated in recent interlaboratory intercomparison or round robin (RR) experiments endorsed by the WMO. Based on results from the 1995/1996 intercomparison of standard gases, the majority of participating laboratories agreed to within 0.2 μmol mol$^{-1}$ [*Peterson et al.*, 1999, see Table 2]. Preliminary results from the most recent standard gas intercomparison (1998/1999) show similar levels of agreement. Final results from the 1998/1999 round-robin are pending and will be posted to the GLOBALVIEW-$CO_2$ Web page when they are made available. Another round-robin experiment, begun in 2002, is underway.

**Table 2.** 1995-1996 Round Robin Results: Differences from NOAA CMDL (Laboratory minus CMDL) (μmol mol$^{-1}$).

| **LABORATORY [LAB #]** | **ANALYSIS DATE** | **DIFFERENCE FROM NOAA CMDL (μmol mol$^{-1}$)** | | |
|---|---|---|---|---|
| **Nominal Tank Concentration** | | **345** | **360** | **375** |
| CSIRO [02] | May 1996 | -0.07 | -0.02 | -0.02 |
| SIO[3] [04] | -- | -- | -- | -- |
| MSC [06] | Jun 1997 | -0.04 | 0.00 | -0.02 |
| MRI [10] | Dec 1996 | 0.04 | 0.07 | 0.14 |
| LSCE [11] | Jan 1996 | 0.10 | 0.08 | 0.16 |
| NIWA [15] | Feb 1996 | 0.02 | 0.10 | 0.20 |
| IMS [17] | Mar 1996 | 0.04 | 0.06 | 0.07 |
| JMA [19] | Jan 1997 | 0.07 | 0.31 | 0.30 |
| NIES [20] | Aug 1996 | -0.02 | 0.09 | 0.12 |
| CESI[3] [ 21] | -- | -- | -- | -- |
| IUP-HD [23] | Sep 1996 | -0.15 | -0.09 | -0.09 |
| SNU [24] | Mar 1997 | 0.24 | 0.13 | 0.29 |
| INM[2] [27] | -- | -- | -- | -- |
| ENEA [28] | Apr 1996 | -0.29 | -0.06 | 0.19 |
| PNRA/DNA[3] [29] | -- | -- | -- | -- |

| | | | | |
|---|---|---|---|---|
| FMI[3] [30] | -- | -- | -- | -- |
| MISU[2] [31] | -- | -- | -- | -- |
| CAMS [33] | Dec 1995 | -0.07 | -0.01 | -0.02 |
| HMS[1] [35] | Dec 1996 | -1.22 | -1.04 | -0.80 |
| SAWS[3] [36] | -- | -- | -- | -- |

[1]Results from the analysis of RR cylinders against HMS standards used in the K-puszta measurement program. Based on these results, the K-puszta observations have been excluded from GLOBALVIEW. HMS [35] standards used in the Hegyhatsal tower program (filled and calibrated by the CCL) have been used for the 1998/1999 RR experiment.
[2]Due to lengthy delays in the analysis and shipping of cylinders during the 1995/1996 RR experiment, MISU [31] and INM [27] were unable to analyze the RR cylinders.
[3]Did not participate in the 1995/1996 RR experiment.

Every attempt has been made to ensure that the data sets used to derive the GLOBALVIEW-$CO_2$ data product are comparable to within 0.2 μmol $mol^{-1}$. At present, the Cooperative Atmospheric Data Integration Project for $CO_2$ has made **no standard scale adjustments** to any of the measurement records integrated into GLOBALVIEW-$CO_2$. Records that appear to be affected by a serious scale discrepancy have been omitted at this time.

### 3.4 Methodology

Each measurement record used to derive GLOBALVIEW-$CO_2$ has been carefully edited and selected by the organization or institution contributing the observations. The measurement records are accumulated at NOAA CMDL along with documentation and references. Wherever possible, NOAA CMDL attempts to reproduce the selected data set based on descriptions in the literature. Details of methodology and standard scale can often be obtained from the documentation and literature. Selected measurements are then compared to other measurement records that are nearby in latitude as an additional assessment of potential calibration or sampling problems. Occasionally, two or more organizations make observations at the same location, providing an opportunity to directly compare independent measurement programs [*Masarie et al.*, 2001].

## 4. CONTENT AND FORMATS

GLOBALVIEW-$CO_2$, 2003 includes extended records for the synchronization period:

**January 1, 1979 to January 1, 2003** (Requires ~13.5 Mbytes of disk space)

For a complete description of the data extension procedure, see *Masarie and Tans* [1995].

GLOBALVIEW-$CO_2$ consists of several hundred text files. Encoded in each file name is the sampling location, platform, and strategy, contributing laboratory, file content, and gas identifier. All file names use the following naming scheme:

```
 1          2               3     4                  5      6      7
[site/prog][data grouping]_[lab#][sampling strategy][plat]_[qual].[gas]
```

1. [**Sampling site/program**]

A 3-character alphanumeric field that specifies site or program code.

2. [**Grouping of data within the file**]

If not specified then the sampling site is at a single fixed position.
(ex) brw_, prs_

If the sampling platform is an aircraft then identifier is a 3-character numeric field with units of $10^2$ meters (hm) above sea level.
(ex) car040_, aia005_

If the sampling platform is a tower then identifier is a 3-character numeric field with units of meters (m) above sea level.
(ex) lef051_, hun048_

If the sampling platform is a ship and binned by longitude then identifier is a 3-character numeric with units of degrees (000-360)
(ex) npo140_, nao350_

If the sampling platform is a ship and binned by latitude then identifier is a 3-character alphanumeric field with units of degrees (00-90). Bins in the northern and southern hemispheres are denoted as n## and s## respectively. The equatorial bin is denoted as 000.
(ex) pocs25_, poc000_, scsn03_

Note:
A binned file requires further explanation regarding the bin width, e.g., car050 is a 1000m bin centered on 5km. See Section 9 (SAMPLING LOCATIONS).

3. [**Contributing laboratory**]

Two character numeric field identifies the measurement laboratory (00-99). See Section 2 (PARTICIPANTS).

4. [**Sampling strategy**]

Single alphanumeric character (0-9,a-z,A-Z) indicates the sampling strategy.

| | |
|---|---|
| _??D | Discrete |
| _??C | Continuous/Quasi-continuous |
| _??E | Event |

| | |
|---|---|
| _??I | Integrated |

5. [**Sampling platform**]

Single alphanumeric character (0-9,a-z,A-Z) indicates the sampling platform.

| | |
|---|---|
| _???0 | Single Fixed Position |
| _???1 | Ship |
| _???2 | Aircraft |
| _???3 | Tower |
| _???4 | Kite |
| _???5 | Balloon |
| _???6 | Firn/Ice Core |

6. [**Qualifier**]

Multiple alphanumeric character field (0-9,a-z,A-Z) identifies the file's contents (see discussion below).

| | |
|---|---|
| _????_ext | Extended Record |
| _????_wts | Extension Weights |
| _????_var | Atmospheric Variability Statistics |
| _????_seas | Seasonal Cycle Statistics |
| _????_diu | Diurnal Cycle Statistics |
| _????_tod | Sampling Time-Of-Day Summary |
| _????_mtx | MBL Reference Matrix |

7. [**Gas**]

Identifies the trace gas species.

| | |
|---|---|
| _????_???.co2 | Carbon dioxide |
| _????_???.ch4 | Methane |

EXAMPLES

| | |
|---|---|
| cgo_02D0_ext.co2 | Extended $CO_2$ record derived from CSIRO discrete measurements at Cape Grim. |
| mlo_00D0_ext.co2 | Extended $CO_2$ record derived from CMDL discrete measurements at Mauna Loa. |
| mlo_00C0_ext.co2 | Extended $CO_2$ record derived from CMDL continuous measurements at Mauna Loa. |

| | |
|---|---|
| mlo_02D0_ext.co2 | Extended $CO_2$ record derived from CSIRO discrete measurements at Mauna Loa. |
| | |
| pocn30_00D1_wts.co2 | Extension $CO_2$ weight file derived from CMDL discrete measurements from POC centered at 30° N. |
| poc000_00D1_wts.co2 | Extension $CO_2$ weight file derived from CMDL discrete measurements from POC centered at the equator. |
| | |
| orl035_11D2_seas.co2 | Average seasonal cycle of $CO_2$ derived from the LSCE discrete measurements from aircraft. Altitude bin is centered at 3.5 km. |
| orl035_11D2_var.co2 | Average atmospheric variability of $CO_2$ derived from the LSCE discrete measurements from aircraft. Altitude bin is centered at 3.5 km. |
| lef011_00C3_diu.co2 | Average diurnal cycle of $CO_2$ derived from CMDL continuous measurements from a tower. Sampling height is 11 m. |

There are 6 types of files that are included in GLOBALVIEW-$CO_2$. Each type is distinguished by its file name qualifier (see above). Files with an "ext" qualifier contain extended records, i.e., records that contain synchronized smoothed values, and interpolated and extrapolated values derived using the latitude reference data extension method. Files with a "wts" qualifier contain weights that were applied by CMDL when fitting smooth curves to weekly distributions of $CO_2$ mole fraction as a function of latitude. Files with a "var" qualifier contain a statistical summary of atmospheric variability by month. Files with a "seas" qualifier contain a statistical summary of the average seasonal pattern by month. Files with a "diu" qualifier contain a statistical summary of average diurnal cycle patterns by month accumulated for all complete measurement years. Files with a "tod" qualifier contain a summary of sample collection times for discrete measurement records.

Files with the "ext", "wts", "var", and "seas" qualifier exist for all sites described in GLOBALVIEW-$CO_2$. Files with the "diu" qualifier accompany a subset of extended records derived from high-resolution measurement records where the diurnal cycle is a dominant feature of the observations. Files with the "tod" qualifier accompany a subset of extended records derived from discrete measurements where sample collection times have been made available.

All file types (except for reference MBL matrix) have 16 lines of descriptive information that include

+ Extended record name
+ Measurement organization or institution
+ Type of measurement program
+ Type of sampling site
+ Name of organization collecting air
+ Position of sampling site

- \+ Conversion from Universal Coordinated Time (UTC) to Local Standard Time (LST)
- \+ Creation date of the file
- \+ Number of rows in the file following the column description
- \+ Column descriptions

Following the descriptive information detailed above, the format of each type of file is as follows:

| | | |
|---|---|---|
| Extended | “ext” | F12.6, 3(F12.4) |
| Weight | “wts” | F12.6, 3(F12.4) |
| Atmospheric Variability | “var” | I5, 4(F12.4), I6 |
| Seasonal Cycle | “seas” | I5, 3(F12.4), I6 |
| Diurnal Cycle | “diu” | 2(I5), 3(F9.4), I6 |
| Sample Collection Times | “tod” | I10, F10.2, I10 |
| Reference Matrix | “mtx” | F12.6, 41(1X,F12.4) |

There are no blank fields in any column. Missing values are denoted with a standard default value, -999.999. All units are μmol $mol^{-1}$ $CO_2$ unless otherwise specified.

## 4.1 EXTENDED RECORD

Following the descriptive information detailed above, the four (4) columns in the extended record files are:

COLUMN 1: [UTC] "Weekly" synchronized time steps in Universal Coordinated Time (UTC) as decimal dates, i.e., year plus fraction of the year. Each year has 48 "weekly" steps. "Synchronized" means that the synchronization period and the time steps are the same for all extended record files.

COLUMN 2: [S(t)] Smoothed values extracted from a curve fitted to measurement data that have been selected for conditions where the sampled air is thought to be representative of large well-mixed air parcels. Internal and external gaps in the measurement record are denoted as default values.

COLUMN 3: [REF(t)] The latitude reference time-series, based on marine boundary layer sites, constructed at the sine (latitude) of the measurement site. The latitude reference is defined at all time steps.

COLUMN 4: [diff] The difference climatology describes how the site differs from marine boundary layer (MBL) sites that are nearby in latitude. The difference climatology is defined at all time steps.

The length of the files depends on the number of years in the synchronization period.

## 4.2 WEIGHT FILE

Any method used to fill spatial and temporal gaps in observational records is forced to make assumptions creating uncertainty in the resulting data product. Each extended record included in GLOBALVIEW-$CO_2$ has a corresponding weight file that suggests a relative significance for each value in the extended file. All smooth values (derived directly from the actual measurements) receive a relative weight (ranging from 2 to 10) that depends on sampling density and measurement variability. All filled values (interpolated and extrapolated) receive a fixed weight of 1.

We strongly recommend that users of this data product consider the weight files, which provide an estimate of the relative significance of each value in the extended record.

Following the descriptive information detailed above, the four (4) columns in the weight files are:

COLUMN 1: [UTC] Synchronization year where the number of years is determined by the synchronization period.

COLUMN 2: [rsd] Residual standard deviation (RSD) of the measurements about the smooth curve, S(t), with annual resolution. Years with fewer than six (6) measurements are assigned default values.

COLUMN 3: [#] The number of residuals per year used in the RSD determination.

COLUMN 4: [weight] Scaled weights determined using the relative weighting scheme described by *Masarie and Tans*, [1995]. Years where weights cannot be determined are assigned a default minimum weight of one (1).

The length of the files depends on the number of years in the synchronization period. The first row past the descriptive information specifies the residual standard deviation, number of residuals, and derived weight for all years, all observations.

## 4.3 STATISTICAL SUMMARY - AVERAGE MONTHLY VARIABILITY

A statistical summary of average atmospheric variability is provided for each measurement record. A residual distribution is determined by fitting a smooth curve, S(t), to the observations, C(t), and computing residuals C(t)-S(t). The residuals for all Januarys, Februarys, etc are aggregated and statistics are determined with monthly resolution. The aggregated monthly statistics include within month and year-to-year variability. Information pertaining to the diurnal cycle is not considered here. Following the descriptive information detailed above, the six (6) columns in the "var" files are:

COLUMN 1: [mo] Month (1-12) specification.

COLUMN 2: [stdev] Standard deviation of the residual distribution computed monthly for all years.

COLUMN 3: [50%ile] The $50^{th}$ percentile or median of the residual distribution.

COLUMN 4: [16%ile] The $16^{th}$ percentile of the residual distribution.

COLUMN 5: [84%ile] The $84^{th}$ percentile of the residual distribution.

COLUMN 6: [#] The number of aggregated monthly residual values used to compute the monthly statistics.

## 4.4 STATISTICAL SUMMARY - AVERAGE SEASONAL CYCLE

A statistical summary of the average seasonal cycle is provided for each measurement record. Monthly means are computed from a detrended smooth fit, S(t)–T(t), to the observations. The monthly means for all Januarys, Februarys, etc. are aggregated and statistics are determined with monthly resolution. The standard deviation of each aggregated monthly mean value is a measure of the year-to-year variability in the monthly mean values. The standard error of the aggregated monthly mean value is an estimate of the uncertainty in the aggregated monthly mean value. Following the descriptive information detailed above, the five (5) columns in the "seas" files are:

COLUMN 1: [mo] Month (1-12) specification.

COLUMN 2: [mean] Mean of the aggregated detrended monthly means for all years.

COLUMN 3: [stdev] Standard deviation of the aggregated monthly mean distribution.

COLUMN 4: [stderr] Standard error of the aggregated monthly mean distribution.

COLUMN 5: [#] The number of monthly mean values used to compute the aggregated monthly statistics.

## 4.5 STATISTICAL SUMMARY - AVERAGE DIURNAL CYCLE

A statistical summary of average diurnal cycles by month compiled using data from complete years is provided for each measurement record with hour resolution and where the diurnal cycle is a dominant feature in the observations. At tower sites where measurements are made of air sampled at several heights (e.g., ITN, LEF, WKT, and HUN), the residual distribution is determined by subtracting the **24-hour average mixing ratio at the highest**

**level** for each day from every observation for that day. At tower sites where measurements are made from a single height (e.g., FRD), the residual distribution is determined by subtracting a **3-hour average mixing ratio using only afternoon hours** for each day from every observation for that day. These statistics provide an estimate of the variability in the diurnal patterns within each month that is due primarily to planetary boundary layer mixing and transport. Following the descriptive information detailed above, the six (6) columns in the "diu" files are

COLUMN 1: [mo] Month (1-12) specification.

COLUMN 2: [hr in UTC] Hour (0-23) specification.

COLUMN 3: [50%ile] The 50$^{th}$ percentile or median of the residual distribution computed monthly for all complete years.

COLUMN 4: [16%ile] The 16$^{th}$ percentile of the residual distribution.

COLUMN 5: [84%ile] The 84$^{th}$ percentile of the residual distribution.

COLUMN 6: [#] The number of residual values from complete years used to compute the monthly statistics.

## 4.6 SUMMARY - SAMPLE COLLECTION TIMES

A summary of sample collection times (in LST) for discrete measurement records where sampling times have been made available. Following the descriptive information detailed above, the three (3) columns in the "tod" files are

COLUMN 1: [hr in LST] Sample collection hour (0-23) specification.

COLUMN 2: [fract] Fraction (of the total number of samples) collected within the hour.

COLUMN 3: [#] Number of samples collected within the hour.

## 4.7 REFERENCE MARINE BOUNDARY LAYER MATRIX

The reference marine boundary layer matrix contains $CO_2$ mixing ratios as a function of time and sine of latitude and is a by-product of the data extension procedure (see *Masarie and Tans*, [1995] and Appendix A (RELEASE NOTES) for details). Be aware that significant information contained in the actual data may be lost in this matrix. In addition, the reference MBL matrix itself may give an unrealistic impression of the comprehensiveness of global atmospheric $CO_2$ measurements since it contains $CO_2$ values at locations and times when no measurements exist.

There is a single header line in the matrix file that specifies the format of the reference matrix.

+ Matrix format: FORMAT=”(F12.6, 41(1X,F12.4))”

Following the single header line above, the 42 columns are

COLUMN 1: [UTC] "Weekly" synchronized time steps in Universal Coordinated Time (UTC) as decimal dates, i.e., year plus fraction of the year. Each year has 48 "weekly" steps. "Synchronized" means that the synchronization period and time steps in the matrix are identical to those in the extended record files.

COLUMNS 2-42: [sine of latitude] There are 41 even intervals of 0.05 sine of latitude from 90°S to 90°N, i.e., column 2 represents a reference MBL value at –1.00 (90°S), column 3 at –0.95 (71.8°S), column 4 at –0.90 (64.2°S), and so on.

The number of rows in the matrix depends on the number of years in the synchronization period.

## 5. HOW TO USE GLOBALVIEW-$CO_2$

The extended records (files with an “ext” qualifier) are comprised of smoothed values, and interpolated and extrapolated values defined at each time step of the synchronization period. Those who wish to use extended records in their modeling application must simply add the reference MBL vector (COLUMN 3) to the difference climatology (COLUMN 4), i.e., extended record = REF + diff. Users will notice that S(t) = REF + diff wherever smoothed values (COLUMN 2) exist.

You may also choose to use only the smoothed values (COLUMN 2) from the sites that are synchronized which will have assigned default values where there are no measurements.

PLEASE NOTE: Occasional discontinuities at the transition between smoothed values and extrapolated values may be significant in certain modeling applications. These occur when values derived from data extension techniques (based on average behavior) join actual measurements that depart from average behavior. Discontinuities may occur at either end of the smoothed measurement record.

PLEASE NOTE: Discontinuities within periods of interpolated or extrapolated values may occur when MBL measurement records begin, end, or are interrupted for long periods of time (See Appendix A (RELEASE NOTES) for details). Some discontinuities may be significant in certain modeling applications. Serious discontinuities are identified below.

| Time step | Latitude[a] | Cause |
|---|---|---|
| 1979.666667 | 10°S | CMDL sampling program at Ascension Island begins |

| | | |
|---|---|---|
| 1981.062500 | 35°S | LSCE sampling program at Amsterdam Island begins |
| 1984.208333 | 5°N | CMDL sampling program at Christmas Island, Kiribati begins |
| 1987.000000 | 25°S | CMDL shipboard sampling in Pacific Ocean begins |
| 1991.229167 | 45°S | CMDL sampling program at Crozet begins |
| 2000.812500 | 20°S | CMDL shipboard sampling in Pacific Ocean ends |

[a]Specifies the 5° latitude band most strongly influenced by the change in the MBL measurement distribution

PLEASE NOTE: The data extension procedure requires at least 2 years of observations.

Relative weighting of each value in an extended record can be important because some points are better determined than others. Confidence in the smoothed values depends on the density of the data, the relative occurrence of rejected data, the "scatter" in the data, the type and number of corrections applied, and the length of the measurement period. *Masarie and Tans* [1995] describe in detail the relative weighting scheme and provide an example of how extended records and relative weights have been used in a 2-D modeling application. Users may choose to ignore our weighting scheme; sufficient information is included in the weight files so that users may devise their own weighting scheme.

## 6. GLOBALVIEW-$CO_2$ ACCESS POINTS

The current release of GLOBALVIEW-$CO_2$ is available on

**(a)** **World Wide Web** access at

http://www.cmdl.noaa.gov/ccgg/globalview/index.html.

**(b)** **Internet** via anonymous FTP to ftp.cmdl.noaa.gov, Path: ccg/co2/GLOBALVIEW.

To retrieve GLOBALVIEW-$CO_2$, execute the following FTP command sequence:

```
ftp> binary
ftp> cd ccg/co2/GLOBALVIEW/gv
ftp> mget *
ftp> bye
```

or

The file "GLOBALVIEW.tar.Z" is a compressed tar file containing all of the files in the 'GLOBALVIEW/gv' directory. In this case, execute the following:

```
ftp> binary
ftp> cd ccg/co2/GLOBALVIEW
ftp> get GLOBALVIEW.tar.Z
```

```
ftp> bye
```

Then on your system:

```
$ uncompress GLOBALVIEW.tar.Z
$ tar xvf GLOBALVIEW.tar
```

<u>or</u>

The file "GLOBALVIEW.zip" is a zipped file containing all of the files in the 'GLOBALVIEW/gv' directory. In this case, transfer the file to the local system (as above) and “unzip”.

**(c)** **<u>CD-ROM</u>** from NOAA CMDL, Boulder, Colorado. Contact Ken Masarie: Phone (303) 497-6270, E-mail Kenneth.Masarie@noaa.gov.

## 7. UPDATES

GLOBALVIEW-$CO_2$ is updated once per year.
Last Update: August 14, 2003

## 8. COMMENTS/QUESTIONS

Comments and/or questions should be directed to:

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325 Broadway
Boulder, Colorado, 80305-3328
U.S.A.

E-mail: Kenneth.Masarie@noaa.gov
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Fax: (303) 497-6290

## 9. SAMPLING LOCATIONS

The following list provides general information on sampling locations for measurement records used to derive GLOBALVIEW-$CO_2$. The descriptive information includes

+ Sample location identification code (3-6 character fields, upper case). Note that in some instances the identification code indicates position.
+ Location of the sampling site.
+ Organization collecting the air sample or making the measurements.

+ General description of the sampling program.
+ Position of the sampling site where latitude is in degrees (000 is at the equator, north of the equator is positive (+), and south of the equator negative (-)), longitude is in degrees (east of Meridian of Greenwich is positive (+), and west of Meridian of Greenwich is negative (-)), and the altitude is in meters above sea level (masl).
+ General description of available measurements including contributing laboratory (see Section 2 (PARTICIPANTS) for details), sampling strategy, resolution of measurements used in GLOBALVIEW-$CO_2$, and time period of the measurements.

---

AIA005, Bass Strait/Cape Grim, Australia
CSIRO, Division of Atmospheric Research
Aircraft site -40.53, 144.30 [0-1000][a]
*CSIRO, Flask/Monthly 1992 05 – 2000 09

AIA015, Bass Strait/Cape Grim, Australia
CSIRO, Division of Atmospheric Research
Aircraft site -40.53, 144.30 [1000-2000][a]
*CSIRO, Flask/Monthly 1992 05 – 2000 09

AIA025, Bass Strait/Cape Grim, Australia
CSIRO, Division of Atmospheric Research
Aircraft site -40.53, 144.30 [2000-3000][a]
*CSIRO, Flask/Monthly 1992 05 – 2000 09

AIA035, Bass Strait/Cape Grim, Australia
CSIRO, Division of Atmospheric Research
Aircraft site -40.53, 144.30 [3000-4000][a]
*CSIRO, Flask/Monthly 1992 05 – 2000 09

AIA045, Bass Strait/Cape Grim, Australia
CSIRO, Division of Atmospheric Research
Aircraft site -40.53, 144.30 [4000-5000][a]
*CSIRO, Flask/Monthly 1992 05 – 2000 09

AIA055, Bass Strait/Cape Grim, Australia
CSIRO, Division of Atmospheric Research
Aircraft site -40.53, 144.30 [5000-6000][a]
*CSIRO, Flask/Monthly 1992 05 – 2000 09

AIA065, Bass Strait/Cape Grim, Australia
CSIRO, Division of Atmospheric Research
Aircraft site -40.53, 144.30 [6000-7000][a]
*CSIRO, Flask/Monthly 1992 05 – 2000 09

| | | |
|---|---|---|
| ALT, Alert, Nunavut, Canada | | |
| Environment Canada/Meteorological Service of Canada | | |
| Land site | 82.45, -62.52 | 210 |
| *MSC, Flask/Weekly | 1975 07 – 2002 12 | |
| *MSC, Continuous/Daily averages | 1988 01 – 2002 12 | |
| *CMDL, Flask/Weekly | 1985 06 – 2002 12 | |
| *CSIRO, Flask/Bi-weekly | 1991 04 – 2002 12 | |
| *SIO, Flask/Bi-weekly | 1989 11 – 2001 12 | |
| | | |
| AMS, Amsterdam Island, France | | |
| Laboratoire des Sciences du Climat et de l'Environnement (LSCE) | | |
| Land site | -37.95, 77.53 | 150 |
| *LSCE, Continuous/Daily averages | 1980 05 – 2002 12 | |
| *CMDL, Flask/Weekly | 1979 01 – 1990 12 | |
| | | |
| ASC, Ascension Island, U.K. | | |
| DOD/U.S.A.F. and Pan American World Airways | | |
| Land site | -7.92, -14.42 | 54 |
| *CMDL, Flask/Weekly | 1979 08 – 2002 12 | |
| | | |
| ASK, Assekrem, Algeria | | |
| Tamanrasset GAW Observatory | | |
| Land site | 23.18, 5.42 | 2728 |
| *CMDL, Flask/Weekly | 1995 09 – 2002 12 | |
| | | |
| AVI, St. Croix, Virgin Islands, U.S.A. | | |
| Fairleigh Dickinson University | | |
| Land site | 17.75, -64.75 | 3 |
| *CMDL, Flask/Weekly | 1979 02 – 1990 08 | |
| | | |
| AZR, Terceira Island, Azores, Portugal | | |
| DOD/U.S.A.F. (7th Weather Wing) | | |
| Land site | 38.75, -27.08 | 30 |
| *CMDL, Flask/Weekly | 1979 12 – 2002 12 | |
| | | |
| BAL, Baltic Sea, Poland | | |
| MIR, Sea Fisheries Institute | | |
| Shipboard - fixed position | 55.50, 16.67 | 7 |
| *CMDL, Flask/Weekly | 1992 09 – 2002 12 | |
| | | |
| BGU, Begur, Spain | | |
| Climate Research Group, Center for Meteorology and Climatology, University of Barcelona | | |
| Land site | 41.83, 3.33 | 30 |
| *LSCE, Flask/~Weekly | 2001 02 – 2003 02 | |

| | | |
|---|---|---|
| BHD, Baring Head Station, New Zealand | | |
| National Institute for Water and Atmospheric Research (NIWA) | | |
| Land site | -41.41, 174.87 | 80 |
| *NIWA, Continuous/~Weekly | 1970 11 – 2001 12 | |
| | | |
| BME, St. David's Head, Bermuda, U.K. | | |
| Bermuda Biological Station | | |
| Land site | 32.37, -64.65 | 30 |
| *CMDL, Flask/Weekly | 1989 02 – 2002 12 | |
| | | |
| BMW, Southhampton, Bermuda, U.K. | | |
| Bermuda Biological Station (AEROCE) | | |
| Land site | 32.27, -64.88 | 30 |
| *CMDL, Flask/Weekly | 1989 05 – 2002 12 | |
| | | |
| BRW, Barrow, Alaska, U.S.A. | | |
| NOAA/Office of Oceanic and Atmospheric Research (CMDL Observatory) | | |
| Land site | 71.32, -156.60 | 11 |
| *CMDL, Flask/Weekly | 1971 04 – 2002 12 | |
| *CMDL, Continuous/Daily averages | 1973 07 – 2002 12 | |
| | | |
| BSC, Black Sea, Constanta, Romania | | |
| Romanian Marine Research Institute | | |
| Land site | 44.17, 28.68 | 3 |
| *CMDL, Flask/Weekly | 1994 10 – 2002 12 | |
| | | |
| CAR030, Carr, Colorado, U.S.A. | | |
| NOAA CMDL Carbon Cycle Greenhouse Gases Group | | |
| Aircraft site | 40.90, -104.80 | [2500-3500][a] |
| *CMDL, Flask/Weekly | 1992 11 – 2002 12 | |
| | | |
| CAR040, Carr, Colorado, U.S.A. | | |
| NOAA CMDL Carbon Cycle Greenhouse Gases Group | | |
| Aircraft site | 40.90, -104.80 | [3500-4500][a] |
| *CMDL, Flask/Weekly | 1992 11 – 2002 12 | |
| | | |
| CAR050, Carr, Colorado, U.S.A. | | |
| NOAA CMDL Carbon Cycle Greenhouse Gases Group | | |
| Aircraft site | 40.90, -104.80 | [4500-5500][a] |
| *CMDL, Flask/Weekly | 1992 11 – 2002 12 | |
| | | |
| CAR060, Carr, Colorado, U.S.A. | | |
| NOAA CMDL Carbon Cycle Greenhouse Gases Group | | |

| | | |
|---|---|---|
| Aircraft site | 40.90, -104.80 | [5500-6500][a] |
| *CMDL, Flask/Weekly | 1995 06 – 2002 12 | |
| | | |
| CAR070, Carr, Colorado, U.S.A. | | |
| NOAA CMDL Carbon Cycle Greenhouse Gases Group | | |
| Aircraft site | 40.90, -104.80 | [6500-7500][a] |
| *CMDL, Flask/Weekly | 1995 06 – 2002 12 | |
| | | |
| CAR080, Carr, Colorado, U.S.A. | | |
| NOAA CMDL Carbon Cycle Greenhouse Gases Group | | |
| Aircraft site | 40.90, -104.80 | [7500-8500][a] |
| *CMDL, Flask/Weekly | 1995 06 – 2002 12 | |
| | | |
| CBA, Cold Bay, Alaska, U.S.A. | | |
| NOAA/National Weather Service | | |
| Land site | 55.20, -162.72 | 25 |
| *CMDL, Flask/Weekly | 1978 08 – 2002 12 | |
| *SIO, Flask/Bi-weekly | 1995 08 – 2001 12 | |
| | | |
| CFA, Cape Ferguson, Queensland, Australia | | |
| CSIRO, Division of Atmospheric Research | | |
| Land site | -19.28, 147.06 | 2 |
| *CSIRO, Flask/Bi-weekly | 1991 06 – 2002 12 | |
| | | |
| CGO, Cape Grim, Tasmania, Australia | | |
| CSIRO, Division of Atmospheric Research | | |
| Land site | -40.68, 144.68 | 94 |
| *CMDL, Flask/Weekly | 1984 04 – 2002 12 | |
| *CSIRO, Flask/Weekly | 1991 06 – 2002 12 | |
| *SIO, Flask/Bi-Weekly | 1991 01 – 2001 12 | |
| | | |
| CHR, Christmas Island, Kiribati | | |
| Scripps Institution of Oceanography | | |
| Land site | 1.70, -157.17 | 3 |
| *CMDL, Flask/Weekly | 1984 04 – 2002 12 | |
| | | |
| CMN, Mt. Cimone Station, Italy | | |
| Italian Meteorological Service (IMS) | | |
| Land site | 44.18, 10.70 | 2165 |
| *IMS, Continuous/Daily averages | 1979 03 – 2002 12 | |
| | | |
| CMO, Cape Meares, Oregon, U.S.A. | | |
| Oregon Graduate Institute of Science and Technology | | |
| Land site | 45.48, -123.97 | 30 |

| | | |
|---|---|---|
| *CMDL, Flask/Weekly | 1982 05 – 1998 03 | |
| | | |
| COI, Cape Ochi-ishi, Japan | | |
| National Institute for Environmental Studies | | |
| Land site | 43.15, 145.50 | 100 |
| *NIES, Continuous/Daily averages | 1995 08 – 2002 12 | |
| | | |
| CPT, Cape Point, South Africa | | |
| South African Weather Service | | |
| Land site | -34.35, 18.49 | 230+30 |
| *SAWS, Continuous/Daily averages | 1983 09 – 2002 12 | |
| | | |
| CRI, Cape Rama, India | | |
| CSIRO, Division of Atmospheric Research | | |
| Land site | 15.08, 73.83 | 60 |
| *CSIRO, Flask/Bi-weekly | 1993 02 – 2001 04 | |
| | | |
| CRZ, Crozet, Indian Ocean, France | | |
| Laboratoire des Sciences du Climat et de l'Environnement (LSCE) | | |
| Land site | -46.45, 51.85 | 120 |
| *CMDL, Flask/Weekly | 1991 03 – 2002 12 | |
| | | |
| CSJ, Cape St. James, British Columbia, Canada | | |
| Environment Canada/Meteorological Service of Canada | | |
| Land site | 51.93, -131.02 | 89 |
| *MSC, Flask/Weekly | 1979 05 – 1992 07 | |
| | | |
| DAA, Darwin (Charles Point), Northern Territory, Australia | | |
| CSIRO, Division of Atmospheric Research | | |
| Land site | -12.42, 130.57 | 3 |
| *CSIRO, Flask/Bi-weekly | 1992 10 – 1998 12 | |
| | | |
| EIC, Easter Island, Chile | | |
| Direccion Meteorologica de Chile | | |
| Land site | -29.15, -109.43 | 50 |
| *CMDL, Flask/Weekly | 1994 01 – 2002 12 | |
| | | |
| ESP, Estevan Point, British Columbia, Canada | | |
| Environment Canada/Meteorological Service of Canada | | |
| Land site | 49.38, -126.53, | 39 |
| *MSC, Flask/Weekly | 1992 06 – 2002 12 | |
| *CSIRO, Flask/Tri-weekly | 1993 06 – 2002 01 | |
| | | |
| FRD, Fraserdale, Ontario, Canada | | |

| | | |
|---|---|---|
| Environment Canada/Meteorological Service of Canada | | |
| Land site | 49.88, -81.57 | 250 |
| *MSC, Continuous/Daily averages | 1998 06 – 2002 12 | |
| | | |
| FRDRBC, Fraserdale, Ontario, Canada (Restricted Baseline Condition) | | |
| Environment Canada/Meteorological Service of Canada | | |
| Land site | 49.88, -81.57 | 250 |
| *MSC, Continuous/Daily averages | 1998 06 – 2002 12 | |
| | | |
| GMI, Guam, Mariana Islands, U.S.A. | | |
| University of Guam/Marine Laboratory | | |
| Land site | 13.43, 144.78 | 2 |
| *CMDL, Flask/Weekly | 1978 09 – 2002 12 | |
| | | |
| GOZ, Dwejra Point, Gozo, Malta | | |
| Ministry of Environment, PCCU | | |
| Land site | 36.05, 14.18 | 30 |
| *CMDL, Flask/Weekly | 1993 10 – 1999 02 | |
| | | |
| GSN, Gosan, Republic of Korea | | |
| Korean Meteorological Research Institute/Seoul National University | | |
| Land site | 33.28, 126.15 | 72 |
| *SNU, Flask/Weekly | 1990 08 – 2001 01 | |
| | | |
| HAA005, Molokai Island, Hawaii, U.S.A. | | |
| Hawaii Air Ambulance | | |
| Aircraft site | 21.23, -158.95 | [0-1000][a] |
| *CMDL, Flask/Tri-Weekly | 1999 05 – 2002 12 | |
| | | |
| HAA015, Molokai Island, Hawaii, U.S.A. | | |
| Hawaii Air Ambulance | | |
| Aircraft site | 21.23, -158.95 | [1000-2000][a] |
| *CMDL, Flask/Tri-weekly | 1999 05 – 2002 12 | |
| | | |
| HAA025, Molokai Island, Hawaii, U.S.A. | | |
| Hawaii Air Ambulance | | |
| Aircraft site | 21.23, -158.95 | [2000-3000][a] |
| *CMDL, Flask/Tri-weekly | 1999 05 – 2002 12 | |
| | | |
| HAA035, Molokai Island, Hawaii, U.S.A. | | |
| Hawaii Air Ambulance | | |
| Aircraft site | 21.23, -158.95 | [3000-4000][a] |
| *CMDL, Flask/Tri-weekly | 1999 05 – 2002 12 | |

| | | |
|---|---|---|
| HAA045, Molokai Island, Hawaii, U.S.A. | | |
| Hawaii Air Ambulance | | |
| Aircraft site | 21.23, -158.95 | [4000-5000][a] |
| *CMDL, Flask/Tri-weekly | 1999 05 – 2002 12 | |
| HAA055, Molokai Island, Hawaii, U.S.A. | | |
| Hawaii Air Ambulance | | |
| Aircraft site | 21.23, -158.95 | [5000-6000][a] |
| *CMDL, Flask/Tri-weekly | 1999 05 – 2002 12 | |
| HAA065, Molokai Island, Hawaii, U.S.A. | | |
| Hawaii Air Ambulance | | |
| Aircraft site | 21.23, -158.95 | [6000-7000][a] |
| *CMDL, Flask/Tri-weekly | 1999 05 – 2002 12 | |
| HAA075, Molokai Island, Hawaii, U.S.A. | | |
| Hawaii Air Ambulance | | |
| Aircraft site | 21.23, -158.95 | [7000-8000][a] |
| *CMDL, Flask/Tri-weekly | 1999 05 – 2002 12 | |
| HAT, Hateruma Island, Japan | | |
| National Institute for Environmental Studies | | |
| Land site | 24.05, 123.80 | 47 |
| *NIES, Continuous/Daily averages | 1993 10 – 2002 12 | |
| HBA, Halley Bay, Antarctica, U.K. | | |
| British Antarctic Survey | | |
| Land site | -75.67, -25.50 | 10 |
| *CMDL, Flask/Weekly | 1983 01 – 2002 12 | |
| HUN, Hegyhatsal, Hungary | | |
| Hungarian Meteorological Service | | |
| Land site | 46.95, 16.65 | 248+96 |
| *CMDL, Flask/Weekly | 1993 03 – 2002 12 | |
| HUN010, Hegyhatsal, Hungary | | |
| Hungarian Meteorological Service | | |
| Tower site | 46.95, 16.65 | 248+10 |
| *HMS, Continuous/Daily averages | 1994 09 – 2002 12 | |
| HUN048, Hegyhatsal, Hungary | | |
| Hungarian Meteorological Service | | |
| Tower site | 46.95, 16.65 | 248+48 |
| *HMS, Continuous/Daily averages | 1994 09 – 2002 12 | |

| | | |
|---|---|---|
| HUN082, Hegyhatsal, Hungary | | |
| Hungarian Meteorological Service | | |
| Tower site | 46.95, 16.65 | 248+82 |
| *HMS, Continuous/Daily averages | 1994 09 – 2002 12 | |
| | | |
| HUN115, Hegyhatsal, Hungary | | |
| Hungarian Meteorological Service | | |
| Tower site | 46.95, 16.65 | 248+115 |
| *HMS, Continuous/Daily averages | 1994 09 – 2002 12 | |
| | | |
| ICE, Storhofdi, Heimaey, Vestmannaeyjar | | |
| Icelandic Meteorological Service | | |
| Land site | 63.25, -20.15 | 100 |
| *CMDL, Flask/Weekly | 1992 10 – 2002 12 | |
| | | |
| ITN, Grifton, North Carolina, U.S.A. | | |
| NOAA CMDL Carbon Cycle Greenhouse Gases Group | | |
| Tower site | 35.35, -77.38 | 9+496 |
| *CMDL, Flask/Weekly | 1992 07 – 1999 06 | |
| | | |
| ITN051, Grifton, North Carolina, U.S.A. | | |
| NOAA CMDL Carbon Cycle Greenhouse Gases Group | | |
| Tower site | 35.35, -77.38 | 9+51 |
| *CMDL, Continuous/Daily averages | 1992 06 – 1999 05 | |
| | | |
| ITN123, Grifton, North Carolina, U.S.A. | | |
| NOAA CMDL Carbon Cycle Greenhouse Gases Group | | |
| Tower site | 35.35, -77.38 | 9+123 |
| *CMDL, Continuous/Daily averages | 1992 06 – 1999 05 | |
| | | |
| ITN496, Grifton, North Carolina, U.S.A. | | |
| NOAA CMDL Carbon Cycle Greenhouse Gases Group | | |
| Tower site | 35.35, -77.38 | 9+496 |
| *CMDL, Continuous/Daily averages | 1992 06 – 1999 05 | |
| | | |
| IZO, Tenerife, Canary Islands, Spain | | |
| Izana Observatory | | |
| Land site | 28.30, -16.48 | 2360 |
| *CMDL, Flask/Weekly | 1991 11 – 2002 12 | |
| *INM, Continuous/Daily averages | 1984 06 – 2002 12 | |
| | | |
| JBN, Jubany Station, Antarctica | | |
| PNRA, Italy and DNA, Argentine | | |

| | | |
|---|---|---|
| Land site | -62.23, -58.82 | 15 |
| *PNRA/DNA, Continuous/Daily averages | 1994 01 – 2002 12 | |

KEY, Key Biscayne, Florida, U.S.A.
NOAA/Environmental Research Laboratory (AOML)

| | | |
|---|---|---|
| Land site | 25.67, -80.20 | 3 |
| *CMDL, Flask/Weekly | 1972 12 – 2002 12 | |

KUM, Cape Kumukahi, Hawaii, U.S.A.
NOAA/Office of Oceanic and Atmospheric Research (CMDL Sampling Site)

| | | |
|---|---|---|
| Land site | 19.52, -154.82 | 3 |
| *CMDL, Flask/Weekly | 1971 01 – 2002 12 | |
| *SIO, Flask/Bi-weekly | 1993 06 – 2001 12 | |

KZD, Sary Taukum, Kazakstan
Kazakh Scientific Institute of Environmental Monitoring and Climate

| | | |
|---|---|---|
| Land site | 44.45, 77.57 | 412 |
| *CMDL, Flask/Weekly | 1997 10 – 2002 12 | |

KZM, Plateau Assy, Kazakstan
Kazakh Scientific Institute of Environmental Monitoring and Climate

| | | |
|---|---|---|
| Land site | 43.25, 77.88 | 2519 |
| *CMDL, Flask/Weekly | 1997 10 – 2002 12 | |

LEF, Park Falls, Wisconsin, U.S.A.
NOAA CMDL Carbon Cycle Greenhouse Gases Group

| | | |
|---|---|---|
| Tower site | 45.93, -90.27 | 472+396 |
| *CMDL, Flask/Weekly | 1994 11 – 2002 12 | |

LEF011, Park Falls, Wisconsin, U.S.A.
NOAA CMDL Carbon Cycle Greenhouse Gases Group

| | | |
|---|---|---|
| Tower site | 45.93, -90.27 | 472+11 |
| *CMDL, Continuous/Daily averages | 1994 10 – 2002 12 | |

LEF030, Park Falls, Wisconsin, U.S.A.
NOAA CMDL Carbon Cycle Greenhouse Gases Group

| | | |
|---|---|---|
| Tower site | 45.93, -90.27 | 472+30 |
| *CMDL, Continuous/Daily averages | 1994 10 – 2002 12 | |

LEF076, Park Falls, Wisconsin, U.S.A.
NOAA CMDL Carbon Cycle Greenhouse Gases Group

| | | |
|---|---|---|
| Tower site | 45.93, -90.27 | 472+76 |
| *CMDL, Continuous/Daily averages | 1994 10 – 2002 12 | |

| | | |
|---|---|---|
| LEF122, Park Falls, Wisconsin, U.S.A. | | |
| NOAA CMDL Carbon Cycle Greenhouse Gases Group | | |
| Tower site | 45.93, -90.27 | 472+122 |
| *CMDL, Continuous/Daily averages | 1994 10 – 2002 12 | |
| | | |
| LEF244, Park Falls, Wisconsin, U.S.A. | | |
| NOAA CMDL Carbon Cycle Greenhouse Gases Group | | |
| Tower site | 45.93, -90.27 | 472+244 |
| *CMDL, Continuous/Daily averages | 1994 10 – 2002 12 | |
| | | |
| LEF396, Park Falls, Wisconsin, U.S.A. | | |
| NOAA CMDL Carbon Cycle Greenhouse Gases Group | | |
| Tower site | 45.93, -90.27 | 472+396 |
| *CMDL, Continuous/Daily averages | 1994 10 – 2002 12 | |
| | | |
| LJO, La Jolla, California, U.S.A. | | |
| Scripps Institution of Oceanography | | |
| Land site | 32.90, -117.30 | 10 |
| *SIO, Flask/Bi-Weekly | 1989 05 – 2001 12 | |
| | | |
| LMP, Lampedusa, Italy | | |
| ENEA, Italy | | |
| Land site | 35.52, 12.62 | 45 |
| *ENEA, Flask/Weekly | 1996 01 – 2002 12 | |
| | | |
| MAA, Mawson Station, Antarctica | | |
| CSIRO, Division of Atmospheric Research | | |
| Land site | -67.62, 62.87 | 32 |
| *CSIRO, Flask/Bi-weekly | 1990 06 – 2001 12 | |
| | | |
| MBC, Mould Bay, Nunavut, Canada | | |
| Environment Canada/Meteorological Service of Canada | | |
| Land site | 76.25, -119.35 | 58 |
| *CMDL, Flask/Weekly | 1980 04 – 1997 05 | |
| | | |
| MHD, Mace Head, County Galway, Ireland | | |
| University College Atmospheric Research Station (AEROCE) | | |
| Land site | 53.33, -9.90 | 25 |
| *CMDL, Flask/Weekly | 1991 06 – 2002 12 | |
| | | |
| MHDCBC, Mace Head, County Galway, Ireland (Continental Baseline Condition) | | |
| University College Atmospheric Research Station (AEROCE) | | |
| Land site | 53.33, -9.90 | 25 |
| *LSCE, Continuous/Daily averages | 1992 07 – 2002 12 | |

| | | |
|---|---|---|
| MHDRBC, Mace Head, Ireland (Restricted (Marine) Baseline Condition) | | |
| University College Atmospheric Research Station (AEROCE) | | |
| Land site | 53.33, -9.90 | 25 |
| *LSCE, Continuous/Daily averages | 1992 07 – 2002 12 | |
| | | |
| MID, Sand Island, Midway, U.S.A. | | |
| DOD/U.S.N. | | |
| Land site | 28.22, -177.37 | 4 |
| *CMDL, Flask/Weekly | 1985 05 – 2002 12 | |
| | | |
| MLO, Mauna Loa, Hawaii, U.S.A. | | |
| NOAA/Office of Oceanic and Atmospheric Research (CMDL Observatory) | | |
| Land site | 19.53, -155.58 | 3397 |
| *CMDL, Flask/Weekly | 1969 08 – 2002 12 | |
| *CMDL, Continuous/Daily averages | 1974 05 – 2002 12 | |
| *CSIRO, Flask/Bi-weekly | 1991 05 – 2002 12 | |
| *SIO, Flask/Bi-weekly | 1991 01 – 2001 12 | |
| | | |
| MNM, Minamitorishima, Japan | | |
| Japan Meteorological Agency (JMA) | | |
| Land site | 24.30, 153.97 | 8 |
| *JMA, Continuous/Daily averages | 1993 03 – 2001 12 | |
| | | |
| MQA, Macquarie Island, South Pacific Ocean | | |
| CSIRO, Division of Atmospheric Research | | |
| Land site | -54.48, 158.97 | 12 |
| *CSIRO, Flask/Bi-weekly | 1992 01 – 2002 12 | |
| | | |
| NWR, Niwot Ridge, Colorado, U.S.A. | | |
| University of Colorado/INSTAAR | | |
| Land site | 40.05, -105.58 | 3475 |
| *CMDL, Flask/Weekly | 1967 05 – 2002 12 | |
| | | |
| OPW, Olympic Peninsula, Washington, U.S.A. | | |
| University of Washington | | |
| Land site | 48.25, -124.42 | 488 |
| *CMDL, Flask/Weekly | 1984 11 – 1990 05 | |
| | | |
| ORL005, Orleans, France | | |
| Laboratoire des Sciences du Climat et de l’Environnement (LSCE) | | |
| Aircraft site | 47.80, 2.50 | [0-1000][a] |
| *LSCE, Flask/Weekly | 1996 04 – 2002 12 | |

| | | |
|---|---|---|
| ORL015, Orleans, France | | |
| Laboratoire des Sciences du Climat et de l'Environnement (LSCE) | | |
| Aircraft site | 47.80, 2.50 | [1000-2000][a] |
| *LSCE, Flask/Weekly | 1996 09 – 2002 12 | |
| | | |
| ORL025, Orleans, France | | |
| Laboratoire des Sciences du Climat et de l'Environnement (LSCE) | | |
| Aircraft site | 47.80, 2.50 | [2000-3000][a] |
| *LSCE, Flask/Weekly | 1996 09 – 2002 12 | |
| | | |
| ORL035, Orleans, France | | |
| Laboratoire des Sciences du Climat et de l'Environnement (LSCE) | | |
| Aircraft site | 47.80, 2.50 | [3000-4000][a] |
| *LSCE, Flask/Weekly | 1997 01 – 2002 12 | |
| | | |
| PALCBC, Pallas-Sammaltunturi, GAW Station, Finland (Continental Baseline Condition) | | |
| Finnish Meteorological Institute (FMI) | | |
| Land site | 67.97, 24.12 | 560 |
| *FMI, Continuous/Daily averages | 1999 01 – 2002 12 | |
| | | |
| PALMBC, Pallas-Sammaltunturi, GAW Station, Finland (Marine Baseline Condition) | | |
| Finnish Meteorological Institute (FMI) | | |
| Land site | 67.97, 24.12 | 560 |
| *FMI, Continuous/Daily averages | 1999 01 – 2002 12 | |
| | | |
| PFA015, Poker Flats, Alaska, U.S.A. | | |
| Warbelows Air Ventures, Inc. | | |
| Aircraft site | 65.07, -147.29 | [1000-2000][a] |
| *CMDL, Flask/Monthly | 1999 06 – 2002 12 | |
| | | |
| PFA025, Poker Flats, Alaska, U.S.A. | | |
| Warbelows Air Ventures, Inc. | | |
| Aircraft site | 65.07, -147.29 | [2000-3000][a] |
| *CMDL, Flask/ Monthly | 1999 06 – 2002 12 | |
| | | |
| PFA035, Poker Flats, Alaska, U.S.A. | | |
| Warbelows Air Ventures, Inc. | | |
| Aircraft site | 65.07, -147.29 | [3000-4000][a] |
| *CMDL, Flask/ Monthly | 1999 06 – 2002 12 | |
| | | |
| PFA045, Poker Flats, Alaska, U.S.A. | | |
| Warbelows Air Ventures, Inc. | | |
| Aircraft site | 65.07, -147.29 | [4000-5000][a] |
| *CMDL, Flask/ Monthly | 1999 06 – 2002 12 | |

| | | |
|---|---|---|
| PFA055, Poker Flats, Alaska, U.S.A. | | |
| Warbelows Air Ventures, Inc. | | |
| Aircraft site | 65.07, -147.29 | [5000-6000][a] |
| *CMDL, Flask/ Monthly | 1999 06 – 2002 12 | |
| PFA065, Poker Flats, Alaska, U.S.A. | | |
| Warbelows Air Ventures, Inc. | | |
| Aircraft site | 65.07, -147.29 | [6000-7000][a] |
| *CMDL, Flask/ Monthly | 1999 06 – 2002 12 | |
| PFA075, Poker Flats, Alaska, U.S.A. | | |
| Warbelows Air Ventures, Inc. | | |
| Aircraft site | 65.07, -147.29 | [7000-8000][a] |
| *CMDL, Flask/ Monthly | 1999 06 – 2002 12 | |
| POCN45, Pacific Ocean | | |
| Blue Star Line, Ltd. | | |
| Shipboard site | [42.50 .. 47.50], [-134.0 .. -128.0][a] | 10 |
| *CMDL, Flask/Tri-weekly | 1986 12 – 1996 08 | |
| POCN40, Pacific Ocean | | |
| Blue Star Line, Ltd. | | |
| Shipboard site | [37.50 .. 42.50], [-140.0 .. -132.0][a] | 10 |
| *CMDL, Flask/Tri-weekly | 1986 12 – 1996 08 | |
| POCN35, Pacific Ocean | | |
| Blue Star Line, Ltd. | | |
| Shipboard site | [32.50 .. 37.50], [-148.0 .. -126.0][a] | 10 |
| *CMDL, Flask/Tri-weekly | 1986 12 – 2002 04 | |
| POCN30, Pacific Ocean | | |
| Blue Star Line, Ltd. | | |
| Shipboard site | [27.50 .. 32.50], [-150.0 .. -120.0][a] | 10 |
| *CMDL, Flask/Tri-weekly | 1986 12 – 2002 12 | |
| POCN25, Pacific Ocean | | |
| Blue Star Line, Ltd. | | |
| Shipboard site | [22.50 .. 27.50], [-156.0 .. -122.0][a] | 10 |
| *CMDL, Flask/Tri-weekly | 1986 12 – 2002 12 | |
| POCN20, Pacific Ocean | | |
| Blue Star Line, Ltd. | | |
| Shipboard site | [17.50 .. 22.50], [-158.0 .. -124.0][a] | 10 |

| | | |
|---|---|---|
| *CMDL, Flask/Tri-weekly | 1986 12 – 2002 12 | |
| | | |
| POCN15, Pacific Ocean | | |
| Blue Star Line, Ltd. | | |
| Shipboard site | [12.50 .. 17.50], [-162.0 .. -128.0][a] | 10 |
| *CMDL, Flask/Tri-weekly | 1986 12 – 2002 12 | |
| | | |
| POCN10, Pacific Ocean | | |
| Blue Star Line, Ltd. | | |
| Shipboard site | [7.50 .. 12.50], [-166.0 .. -132.0][a] | 10 |
| *CMDL, Flask/Tri-weekly | 1986 12 – 2002 12 | |
| | | |
| POCN05, Pacific Ocean | | |
| Blue Star Line, Ltd. | | |
| Shipboard site | [2.50 .. 7.50], [-168.0 .. -134.0][a] | 10 |
| *CMDL, Flask/Tri-weekly | 1986 12 – 2002 12 | |
| | | |
| POC000, Pacific Ocean | | |
| Blue Star Line, Ltd. | | |
| Shipboard site | [-2.50 .. +2.50], [-172.0 .. -138.0][a] | 10 |
| *CMDL, Flask/Tri-weekly | 1986 12 – 2002 12 | |
| | | |
| POCS05, Pacific Ocean | | |
| Blue Star Line, Ltd. | | |
| Shipboard site | [-7.50 .. -2.50], [-176.0 .. -142.0][a] | 10 |
| *CMDL, Flask/Tri-weekly | 1986 12 – 2002 12 | |
| | | |
| POCS10, Pacific Ocean | | |
| Blue Star Line, Ltd. | | |
| Shipboard site | [-12.50 .. -7.50], [-178.0 .. -144.0][a] | 10 |
| *CMDL, Flask/Tri-weekly | 1986 12 – 2002 12 | |
| | | |
| POCS15, Pacific Ocean | | |
| Blue Star Line, Ltd. | | |
| Shipboard site | [-17.50 .. -12.50], [178.0 .. -160.0][a] | 10 |
| *CMDL, Flask/Tri-weekly | 1986 12 – 2002 12 | |
| | | |
| POCS20, Pacific Ocean | | |
| Blue Star Line, Ltd. | | |
| Shipboard site | [-22.50 .. -17.50], [176.0 .. -164.0][a] | 10 |
| *CMDL, Flask/Tri-weekly | 1986 12 – 2002 12 | |
| | | |
| POCS25, Pacific Ocean | | |
| Blue Star Line, Ltd. | | |

| | | |
|---|---|---|
| Shipboard site | [-27.50 .. -22.50], [178.0 .. -160.0][a] | 10 |
| *CMDL, Flask/Tri-weekly | 1986 12 – 2002 12 | |
| | | |
| POCS30, Pacific Ocean | | |
| Blue Star Line, Ltd. | | |
| Shipboard site | [-32.50 .. -27.50], [176.0 .. -168.0][a] | 10 |
| *CMDL, Flask/Tri-weekly | 1986 12 – 2002 12 | |
| | | |
| POCS35, Pacific Ocean | | |
| Blue Star Line, Ltd. | | |
| Shipboard site | [-37.50 .. -32.50], [160.0 .. -176.0][a] | 10 |
| *CMDL, Flask/Tri-weekly | 1986 12 – 2002 12 | |
| | | |
| PRS, Plateau Rosa Station (CNR), Italy | | |
| Italian Electrical Experimental Center (CESI) | | |
| Land site | 45.93, 7.70 | 3480 |
| *CESI, Flask/Weekly | 1989 04 - 1994 06 | |
| *CESI, Continuous/Daily averages | 1993 04 – 2001 06 | |
| | | |
| PSA, Palmer Station, Antarctica, U.S.A. | | |
| National Science Foundation | | |
| Land site | -64.92, -64.00 | 10 |
| *CMDL, Flask/Weekly | 1978 01 – 2002 12 | |
| *SIO, Flask/Bi-weekly | 1996 09 – 2001 08 | |
| | | |
| RPB, Ragged Point, St. Phillip's Parish, Barbados | | |
| University of Bristol | | |
| Land site | 13.17, -59.43 | 3 |
| *CMDL, Flask/Weekly | 1987 11 – 2002 12 | |
| | | |
| RTA005, Rarotonga, Cook Islands | | |
| Air Rarotonga LTD. | | |
| Aircraft site | -21.25, -159.93 | [0-1000][a] |
| *CMDL, Flask/Monthly | 2000 04 – 2002 12 | |
| | | |
| RTA015, Rarotonga, Cook Islands | | |
| Air Rarotonga LTD. | | |
| Aircraft site | -21.25, -159.93 | [1000-2000][a] |
| *CMDL, Flask/Monthly | 2000 04 – 2002 12 | |
| | | |
| RTA025, Rarotonga, Cook Islands | | |
| Air Rarotonga LTD. | | |
| Aircraft site | -21.25, -159.93 | [2000-3000][a] |
| *CMDL, Flask/Monthly | 2000 04 – 2002 12 | |

| | | |
|---|---|---|
| RTA035, Rarotonga, Cook Islands | | |
| Air Rarotonga LTD. | | |
| Aircraft site | -21.25, -159.93 | [3000-4000][a] |
| *CMDL, Flask/Monthly | 2000 04 – 2002 12 | |
| | | |
| RTA045, Rarotonga, Cook Islands | | |
| Air Rarotonga LTD. | | |
| Aircraft site | -21.25, -159.93 | [4000-5000][a] |
| *CMDL, Flask/Monthly | 2000 04 – 2002 12 | |
| | | |
| RYO, Ryori Atmospheric Environment Observatory, Japan | | |
| Japan Meteorological Agency (JMA) | | |
| Land site | 39.03, 141.83 | 230 |
| *JMA, Continuous/Daily averages | 1987 01 – 2001 12 | |
| | | |
| SBL, Sable Island, Nova Scotia, Canada | | |
| Environment Canada/Meteorological Service of Canada | | |
| Land site | 43.93, -60.02, | 5 |
| *MSC, Flask/Weekly | 1975 03 – 2002 12 | |
| | | |
| SCH, Schauinsland, Germany | | |
| Umweltbundesamt Schauinsland/Institut fur Umweltphysik, University Heidelberg | | |
| Land site | 48.00, 8.00 | 1205 |
| *UBA/IUP-HD, Continuous/Daily averages | 1972 01 – 2000 12 | |
| | | |
| SCSN21, South China Sea | | |
| Chevron/Nippon Yusen Kaisha (NYK) | | |
| Shipboard site | [19.50 .. 22.50][a], 117.00 | 15 |
| *CMDL, Flask/Weekly | 1991 07 – 1998 10 | |
| | | |
| SCSN18, South China Sea | | |
| Chevron/Nippon Yusen Kaisha (NYK) | | |
| Shipboard site | [16.50 .. 19.50][a], 115.00 | 15 |
| *CMDL, Flask/Weekly | 1991 07 – 1998 10 | |
| | | |
| SCSN15, South China Sea | | |
| Chevron/Nippon Yusen Kaisha (NYK) | | |
| Shipboard site | [13.50 .. 16.50][a], 113.00 | 15 |
| *CMDL, Flask/Weekly | 1991 07 – 1998 10 | |
| | | |
| SCSN12, South China Sea | | |
| Chevron/Nippon Yusen Kaisha (NYK) | | |
| Shipboard site | [10.50 .. 13.50][a], 111.00 | 15 |

| | | |
|---|---|---|
| *CMDL, Flask/Weekly | 1991 07 – 1998 10 | |
| | | |
| SCSN09, South China Sea | | |
| Chevron/Nippon Yusen Kaisha (NYK) | | |
| Shipboard site | [7.50 .. 10.50][a], 109.00 | 15 |
| *CMDL, Flask/Weekly | 1991 07 – 1998 10, | |
| | | |
| SCSN06, South China Sea | | |
| Chevron/Nippon Yusen Kaisha (NYK) | | |
| Shipboard site | [4.50 .. 7.50][a], 107.00 | 15 |
| *CMDL, Flask/Weekly | 1991 07 – 1998 10 | |
| | | |
| SCSN03, South China Sea | | |
| Chevron/Nippon Yusen Kaisha (NYK) | | |
| Shipboard site | [1.50 .. 4.50][a], 105.00 | 15 |
| *CMDL, Flask/Weekly | 1991 07 – 1998 10 | |
| | | |
| SEY, Mahe Island, Seychelles | | |
| DOD/U.S.A.F. | | |
| Land site | -4.67, 55.17 | 3 |
| *CMDL, Flask/Weekly | 1980 01 – 2002 12 | |
| | | |
| SHM, Shemya Island, Alaska, U.S.A. | | |
| DOD/U.S.A.F. | | |
| Land site | 52.72, 174.10 | 40 |
| *CMDL, Flask/Weekly | 1985 09 – 2002 12 | |
| | | |
| SIS, Shetland Islands, Scotland | | |
| CSIRO, Division of Atmospheric Research | | |
| Land site | 60.17, -1.17 | 30 |
| *CSIRO, Flask/Bi-weekly | 1992 11 – 2002 09 | |
| | | |
| SMO, Tutuila, American Samoa, U.S.A. | | |
| NOAA/Office of Oceanic and Atmospheric Research (CMDL Observatory) | | |
| Land site | -14.25, -170.57 | 42 |
| *CMDL, Flask/Weekly | 1972 01 – 2002 12 | |
| *CMDL, Continuous/Daily averages | 1976 01 – 2002 12 | |
| *SIO, Flask/Bi-weekly | 1989 11 – 2001 12 | |
| | | |
| SPO, South Pole, Antarctica, U.S.A. | | |
| (CMDL Observatory)/N.S.F. | | |
| Land site | -89.98, -24.80 | 2810 |
| *CMDL, Flask/Weekly | 1975 01 – 2002 12 | |
| *CMDL, Continuous/Daily averages | 1975 03 – 2002 12 | |

| | | |
|---|---|---|
| *CSIRO, Flask/Bi-weekly | 1993 06 – 2002 12 | |
| *SIO, Flask/Bi-weekly | 1991 11 – 2001 12 | |
| | | |
| STM, Atlantic Ocean (Polarfront), Norway | | |
| Norway Meteorological Institute (Ocean Station "M") | | |
| Shipboard - fixed position | 66.00, 2.00 | 7 |
| *CMDL, Flask/Weekly | 1981 03 – 2002 12 | |
| | | |
| STMEBC, Atlantic Ocean (Polarfront), Norway (Extended Baseline Condition) | | |
| Norway Meteorological Institute (Ocean Station "M") | | |
| Shipboard - fixed position | 66.00, 2.00 | 7 |
| *CMDL, Flask/Weekly | 1981 03 – 2002 12 | |
| | | |
| STP, Pacific Ocean, Canada | | |
| Institute of Ocean Sciences (Ocean Weather Station "P") | | |
| Shipboard - fixed position | 50.00, -145.00 | 7 |
| *IOS, Flask/Weekly | 1969 05 - 1981 06 | |
| | | |
| SUM, Summit, Greenland | | |
| Department of Hydrology and Water Resources, Univ. of Arizona/NSF | | |
| Land site | 72.58, -38.48 | 3238 |
| *CMDL, Flask/Weekly | 1997 06 - 2002 12 | |
| | | |
| SYO, Syowa Station, Antarctica, Japan | | |
| National Institute of Polar research (NIPR) | | |
| Land site | -69.00, 39.58 | 11 |
| *CMDL, Flask/Weekly | 1986 01 – 2002 12 | |
| *NIPR, Continuous/Daily averages | 1984 02 – 2001 01 | |
| | | |
| TAP, Tae-ahn Peninsula, Korea | | |
| Korea National University of Education | | |
| Land site | 36.73, 126.13 | 20 |
| *CMDL, Flask/Weekly | 1990 11 – 2002 12 | |
| | | |
| TDF, Tierra Del Fuego, La Redonda Isla, Argentina | | |
| Servicio Meteorologico Nacional | | |
| Land site | -54.87, -68.48 | 20 |
| *CMDL, Flask/Weekly | 1994 09 – 2002 12 | |
| | | |
| TRM, Tromelin Island, France | | |
| Meteo France | | |
| Land site | -15.88, 54.52 | 20 |
| *LSCE, Flask/Weekly | 1998 06 – 2002 12 | |

| | | |
|---|---|---|
| UTA, Wendover, Utah, U.S.A. | | |
| NOAA/National Weather Service | | |
| Land site | 39.90, -113.72 | 1320 |
| *CMDL, Flask/Weekly | 1995 05 – 2002 12 | |
| | | |
| UUM, Ulaan Uul, Mongolia | | |
| Mongolian Hydrometeorological Research Institute | | |
| Land site | 44.45, 111.10 | 914 |
| *CMDL, Flask/Weekly | 1992 01 – 2002 12 | |
| | | |
| WES, Westerland, North Sea, Germany | | |
| Umweltbundesamt Schauinsland/Institut fur Umweltphysik, University Heidelberg | | |
| Land site | 55.00, 8.00 | 8 |
| *UBA/IUP-HD, Continuous/Daily averages | 1972 11 – 2000 12 | |
| | | |
| WIS, Sede Boker (Negev Desert), Israel | | |
| Weizmann Institute of Science | | |
| Land site | 31.13, 34.88 | 400 |
| *CMDL, Flask/Weekly | 1995 11 – 2002 12 | |
| | | |
| WLG, Mt. Waliguan Baseline Observatory, Peoples Republic of China | | |
| Chinese Academy of Meteorological Sciences (CAMS) | | |
| Land site | 36.27, 100.92 | 3810 |
| *CAMS, Continuous/Daily averages | 1994 11 – 1999 12 | |
| *CMDL, Flask/Weekly | 1990 08 – 2002 12 | |
| | | |
| WKT009, Moody, Texas, U.S.A. | | |
| NOAA CMDL Carbon Cycle Greenhouse Gases Group | | |
| Tower site | 31.32, -97.33 | 251+9 |
| *CMDL, Continuous/Daily averages | 2001 02 – 2003 06 | |
| | | |
| WKT030, Moody, Texas, U.S.A. | | |
| NOAA CMDL Carbon Cycle Greenhouse Gases Group | | |
| Tower site | 31.32, -97.33 | 251+30 |
| *CMDL, Continuous/Daily averages | 2001 02 – 2003 06 | |
| | | |
| WKT061, Moody, Texas, U.S.A. | | |
| NOAA CMDL Carbon Cycle Greenhouse Gases Group | | |
| Tower site | 31.32, -97.33 | 251+61 |
| *CMDL, Continuous/Daily averages | 2001 02 – 2003 06 | |
| | | |
| WKT122, Moody, Texas, U.S.A. | | |
| NOAA CMDL Carbon Cycle Greenhouse Gases Group | | |
| Tower site | 31.32, -97.33 | 251+122 |

*CMDL, Continuous/Daily averages 2001 02 – 2003 06

WKT244, Moody, Texas, U.S.A.
NOAA CMDL Carbon Cycle Greenhouse Gases Group
Tower site 31.32, -97.33 251+244
*CMDL, Continuous/Daily averages 2001 02 – 2003 06

WKT457, Moody, Texas, U.S.A.
NOAA CMDL Carbon Cycle Greenhouse Gases Group
Tower site 31.32, -97.33 251+457
*CMDL, Continuous/Daily averages 2001 02 – 2003 06

WPON30, Western Pacific Ocean
JAL Foundation
Aircraft site [30.0 .. 25.0][a], [140.0 .. 152.0][a] [8000-13000][a]
*MRI, Flask/Bi-weekly 1993 04 – 2002 12

WPON25, Western Pacific Ocean
JAL Foundation
Aircraft site [25.0 .. 20.0][a], [140.0 .. 152.0][a] [8000-13000][a]
*MRI, Flask/Bi-weekly 1993 04 – 2002 12

WPON20, Western Pacific Ocean
JAL Foundation
Aircraft site [20.0 .. 15.0][a], [140.0 .. 152.0][a] [8000-13000][a]
*MRI, Flask/Bi-weekly 1993 04 – 2002 12

WPON15, Western Pacific Ocean
JAL Foundation
Aircraft site [15.0 .. 10.0][a], [140.0 .. 152.0][a] [8000-13000][a]
*MRI, Flask/Bi-weekly 1993 04 – 2002 12

WPON10, Western Pacific Ocean
JAL Foundation
Aircraft site [10.0 .. 5.0][a], [140.0 .. 152.0][a] [8000-13000][a]
*MRI, Flask/Bi-weekly 1993 04 – 2002 12

WPON05, Western Pacific Ocean
JAL Foundation
Aircraft site [5.0 .. 0.0][a], [140.0 .. 152.0][a] [8000-13000][a]
*MRI, Flask/Bi-weekly 1993 04 – 2002 12

WPO000, Western Pacific Ocean
JAL Foundation

| | | |
|---|---|---|
| Aircraft site | [0.0 .. -5.0][a], [140.0 .. 152.0][a] | [8000-13000][a] |
| *MRI, Flask/Bi-weekly | 1993 04 – 2002 12 | |
| WPOS05, Western Pacific Ocean | | |
| JAL Foundation | | |
| Aircraft site | [-5.0 .. -10.0][a], [140.0 .. 152.0][a] | [8000-13000][a] |
| *MRI, Flask/Bi-weekly | 1993 04 – 2002 12 | |
| WPOS10, Western Pacific Ocean | | |
| JAL Foundation | | |
| Aircraft site | [-10.0 .. -15.0][a], [140.0 .. 152.0][a] | [8000-13000][a] |
| *MRI, Flask/Bi-weekly | 1993 04 – 2002 12 | |
| WPOS15, Western Pacific Ocean | | |
| JAL Foundation | | |
| Aircraft site | [-15.0 .. -20.0][a], [140.0 .. 152.0][a] | [8000-13000][a] |
| *MRI, Flask/Bi-weekly | 1993 04 – 2002 12 | |
| WPOS20, Western Pacific Ocean | | |
| JAL Foundation | | |
| Aircraft site | [-20.0 .. -25.0][a], [140.0 .. 152.0][a] | [8000-13000][a] |
| *MRI, Flask/Bi-weekly | 1993 04 – 2002 12 | |
| WPOS25, Western Pacific Ocean | | |
| JAL Foundation | | |
| Aircraft site | [-25.0 .. -30.0][a], [140.0 .. 152.0][a] | [8000-13000][a] |
| *MRI, Flask/Bi-weekly | 1993 04 – 2002 03 | |
| YON, Yonagunijima, Japan | | |
| Japan Meteorological Agency (JMA) | | |
| Land site | 24.47, 123.02 | 30 |
| *JMA, Continuous/Daily averages | 1997 01 – 2001 12 | |
| ZEP, Zeppelin Station, Ny-Alesund, Svalbard (Spitsbergen), Norway | | |
| Department of Meteorology, Stockholm University (MISU), Sweden | | |
| Land site | 78.90, 11.88 | 474 |
| *CMDL, Flask/Weekly | 1994 02 – 2002 12 | |
| *MISU, Continuous/Daily averages | 1991 03 – 1995 12 | |

[a]Samples are collected within the range specified.

## 10. REFERENCES

### Data Extension and Integration Techniques

Masarie, K.A., P. Tans, and T. Conway, "GLOBALVIEW-$CO_2$: Past, Present and Future" in Report of the Eleventh WMO Meeting of Experts on Carbon Dioxide Concentration and Related Tracer Measurement Techniques, Tokyo, Japan, 25-28 September 2001, edited by S. Toru and S. Kazuto, World Meteorological Organization, Geneva, 2003.

Masarie, K.A., R.L. Langenfelds, C.E. Allison, T.J. Conway, E.J. Dlugokencky, R.J. Francey, P.C. Novelli, L.P. Steele, P.P. Tans, B. Vaughn, and J.W.C. White, "The NOAA/CSIRO Flask-Air Intercomparison Program: A strategy for directly assessing consistency among atmospheric measurements derived from independent laboratories." Journal of Geophysical Research, Vol. 106, No. D17, p. 20445-20464, 2001.

Masarie, K.A. and P.P Tans, "Extension and Integration of Atmospheric Carbon Dioxide Data into a Globally Consistent Measurement Record." Journal of Geophysical Research, Vol. 100, No. D6, p. 11593-11610. June 1995.

Peterson, J., P. Tans, and D. Kitzis, "$CO_2$ Round-Robin Reference Gas Intercomparison" in Report of the Ninth WMO Meeting of Experts on Carbon Dioxide Concentration and Related Tracer Measurement Techniques, Aspendale, Vic. Australia, 1 - 4 September 1997, edited by R. Francey, World Meteorological Organization, Geneva, 1999.

Tans, P., C. Zhao, and K. Masarie, "Maintenance and propagation of the WMO Mole Fraction Scale for carbon dioxide in air" in Report of the Eleventh WMO Meeting of Experts on Carbon Dioxide Concentration and Related Tracer Measurement Techniques, Tokyo, Japan, 25-28 September 2001, edited by S. Toru and S. Kazuto, World Meteorological Organization, Geneva, 2003.

Zhao, C.L., P.P Tans, and K.W. Thoning, A high precision manometric system for absolute calibrations of $CO_2$ in dry air, *J. Geophys. Res.*, *102*, 5885-5894, 1997.

**Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia**

Francey, R.J., L.P. Steele, R.L. Langenfelds, M.P. Lucarelli, C.E. Allison, D.J. Beardsmore, S.A. Coram, N. Derek, F.R. deSilva, D.M. Etheridge, P.J. Fraser, R.J. Henry, B. Turner, E.D. Welch, D.A. Spencer and L.N. Cooper. Global Atmospheric Sampling Laboratory (GASLAB): supporting and extending the Cape Grim trace gas programs. Baseline Atmospheric Program (Australia) 1993, edited by R.J. Francey, A.L. Dick and N. Derek, pp 8 - 29, Bureau of Meteorology and CSIRO Division of Atmospheric Research, Melbourne, Australia, 1996.

Francey, R.J., L.P. Steele, R.L. Langenfelds, C.E. Allison, L.N. Cooper, B.L. Dunse, B.G. Bell, T.D. Murray, H.S. Tait, L. Thompson and K.A. Masarie, Atmospheric carbon dioxide and its stable isotope ratios, methane, carbon monoxide and hydrogen from Shetland, Atmos. Environ., Vol. 32, No. 19, 3331-3338, 1998.

Francey, R.J., L.P. Steele, R.L. Langenfelds and B.C. Pak, High precision long-term monitoring of radiatively-active trace gases at surface sites and from ships and aircraft in the Southern Hemisphere atmosphere. J. Atmos. Science., 56, 279-285, 1999.

Francey, R.J., C.E. Allison, D.M. Etheridge, C.M. Trudinger, I.G. Enting, M. Leuenberger, R.L. Langenfelds, E. Michel and L.P. Steele, A 1000-year high precision record of $\delta^{13}C$ in atmospheric $CO_2$, Tellus, 51B, 170-193, 1999.

Francey, R.J., L.P. Steele, D.A. Spencer, R.L. Langenfelds, R.M. Law, P.B. Krummel, P.J. Fraser, D.M. Etheridge, N. Derek, S.A. Coram, L.N. Cooper, C.E. Allison, L. Porter and S. Baly, The CSIRO (Australia) measurement of greenhouse gases in the global atmosphere, report of the 11th WMO/IAEA Meeting of Experts on Carbon Dioxide Concentration and Related Tracer Measurement Techniques, Tokyo, Japan, September 2001, S.Toru and S. Kazuto (editors), World Meteorological Organization Global Atmosphere Watch, 97-111, 2003.

Langenfelds, R.L., R.J. Francey, L.P. Steele, P.J. Fraser, S.A. Coram, M.R. Hayes, D.J. Beardsmore, M.P. Lucarelli, and F.R. de Silva, Improved vertical sampling of the trace gas composition of the troposphere above Cape Grim since 1991, in Baseline Atmospheric Program (Australia) 1993, edited by R.J. Francey, A.L. Dick and N. Derek, pp 45-56, Bureau of Meteorology and CSIRO Division of Atmospheric Research, Melbourne, Australia, 1996.

Langenfelds, R.L., R.J. Francey, B.C. Pak, L.P. Steele, J. Lloyd, C.M. Trudinger and C.E. Allison, Interannual growth rate variations of atmospheric CO2 and its d13C, H2, CH4 and CO between 1992 and 1999 linked to biomass burning, Global Biogeochem. Cycles, 16(3), 1048, doi:10.1029/2001GB001466, 2002.

Pak, B.C., Langenfelds, R.L., R.J. Francey, L.P. Steele and I.Simmonds, A climatology of trace gases from the Cape Grim overflights, 1992 - 1995, in Baseline Atmospheric Program (Australia) 1994-5, edited by R.J. Francey, A.L. Dick and N. Derek, pp 41 - 52, Bureau of Meteorology and CSIRO Division of Atmospheric Research, Melbourne, Australia, 1996.

Pak, B.C., M. Ramonet, P. Monfray, R.J. Francey and I.Simmonds, Assessment of the spatial and temporal representativeness of the Cape Grim overflight $CO_2$ data, in Baseline Atmospheric Program (Australia) 1996, edited by J. L. Gras, N. Derek, N. W. Tindale, and A. L. Dick, pp. 36-44, Bureau of Meteorology and CSIRO Atmospheric Research, Melbourne, Australia, 1999.

Pak, B. C., R.L. Langenfelds, S.A. Young, R.J. Francey, C.P. Meyer, L.M. Kivlighon, L.N. Cooper, B.L. Dunse, C.E. Allison, L.P. Steele, I.E. Galbally and I.A. Weeks, Measurements of biomass burning influences in the troposphere over southeast Australia during the

SAFARI 2000 dry season campaign, J. Geophys. Res., 108(D13), 8480, doi:10.1029/2002JD002343, 2003.

**Meteorological Service of Canada (MSC), Canada**

Higuchi, K., D. Worthy, D. Chan, and A. Shashkov, 2003. Regional source/sink impact on the diurnal, seasonal and inter-annual variations in atmospheric $CO_2$ at a boreal forest site in Canada. Tellus 55B, 115-125.

Worthy, D.E., K.Higuchi, and D. Chan, 2003. North American influence on atmospheric carbon dioxide data collected at Sable Island, Canada. Tellus 55B, 105-114.

**Finnish Meteorological Institute (FMI), Finland**

Aalto, T., J. Hatakka, I Paatero, J.P. Touvinen, M. Aurela, T. Laurila, K. Holmen, N. Trivett, and Y. Viisanen, 2002. Tropospheric carbon dioxide concentrations at a northern boreal site in Finland: basic variations and source areas. Tellus 54(2), 110.

Hatakka J., Aalto T. and Viisanen Y. Carbon Dioxide Measurements at the Pallas GAW Station, Finland. In: Report of the 11th WMO/IAEA Meeting of Experts on Carbon Dioxide Concentration and Related Tracer Techniques, Tokyo, Japan (25-28 September 201). WMO/GAW Report No. 148, pp. 132-135.[Contains technical description of the measurement system]

**Laboratoire des Sciences du Climat et de l'Environnement (LSCE) and Unité Mixte de Recherche CEA-CNRS, France**

Biraud, S., P. Ciais, M. Ramonet, P. Simmonds, V. Kazan, P. Monfray, S. O'Doherty, T.G. Spain, and S.J. Jennings, 2002. Quantification of Carbon Dioxide, Methane, Nitrous Oxide, and Chloroform emissions over Ireland from atmospheric observations at Mace Head. Tellus 54(1), 41-60.

Derwent, R.G., R.D. B., A.J. Manning, P.G. Simmonds, S. O'Doherty, S. Biraud, P. Ciais, M. Ramonet, and S.G. Jennings, 2002. Continuous observations of Carbon Dioxide at Mace Head, Ireland from 1995-1999 and its net european ecosystem exchange. Atmospheric Environment 36 (17), p. 2799-2807.

Biraud, S., P. Ciais, M. Ramonet, P. Simmonds, V. Kazan, P. Monfray, S. O'Doherty, T.G. Spain, and S.J. Jennings, 2000. European greenhouse gas emissions estimated from continuous atmospheric measurements and Radon-222 at Mace Head, Ireland. JGR 105(D1), 1351-1366.

Bousquet, P., A. Gaudry, P. Ciais, V. Kazan, P. Monfray, P.G. Simmonds, S.G. Jennings, and T.C. O'Connor, 1996. Atmospheric $CO_2$ concentration variations recorded at Mace Head, Ireland, from 1992 to 1994. Phys. Chem. Earth. 21, 477-481.

Gaudry, A., J.M. Ascencio, and G. Lambert, 1983. Preliminary study of CO2 Variations at Amsterdam Island (Territoires des Terres Australes et Antarctiques Francaises). JGR 88, 1323-1329.

Gaudry, A., P. Monfray, G. Polian, G. Bonsang, B. Ardouin, A. Jegou, and G. Lambert, 1991. Non-seasonnal variations of atmospheric $CO_2$ concentrations at Amsterdam Island. Tellus 43B, 136-143.

Gaudry, A., P. Monfray, G. Polian, and G. Lambert, 1990. Radon-calibrated emissions of $CO_2$ from South Africa. Tellus 42B, 9-19.

Monfray, P., A. Gaudry, G. Polian, and G. Lambert, 1987. Seasonnal variations of atmospheric CO2 in the Southern Indian Ocean. Tellus 39B, 67-71.

Ramonet, M., and P. Monfray, 1996. $CO_2$ Baseline concept in 3-D atmospheric transport models. Tellus 48B, 502-520.

**Umweltbundsamt Schauinsland (UBA) /Institut fuer Umweltphysik, University Heidelberg (IUP-HD), Germany**

Schmidt, M., Graul, R., Sartorius, H, and Levin, I., 1996. Carbon dioxide and methane in continental Europe: A climatology and 222Radon-based emission estimates. Tellus. 48B, 457-473.

Levin, I., Graul, R., and Trivett, N.B.A., 1995. Long term observations of atmospheric CO2 and carbon isotopes at continental sites in Germany. Tellus. 47B, 23-34.

**Hungarian Meteorological Service (HMS), Institute for Atmospheric Physics, Hungary**

Haszpra, L., Barcza, Z., Bakwin, P. S., Berger, B. W., Davis, K. J., Weidinger, T., 2001: Measuring system for the long-term monitoring of biosphere/atmosphere exchange of carbon dioxide. J. of Geophysical Research 106D, 3057-3070.

**Italian Electrical Experimental Center (CESI), Italy**

Apadula F., A. Gotti, A. Pigini, A. Longhetto, F. Rocchetti, S. Ferrarese, C. Cassardo, R. Forza., 2003. Localization of source and sink regions of carbon dioxide through the method of the synoptic air trajectory statistics, Atmospheric Environment, volume 37, Issue 27, September 2003, Pages 3757-3770.

Ferrarese S., A. Longhetto, C. Cassardo, F. Apadula, D. Bertoni, C. Giraud, A. Gotti, 2002. A study of seasonal and yearly modulation of carbon dioxide sources and sinks, with a particular attention to the Boreal Atlantic Ocean, Atmospheric Environment, volume 36, No. 35, pagg. 5517-5526, Novembre 2002.

Levin I., F. Apadula, P. Ciais, L. Ciattaglia, T. Colombo, R. Graul, L. Haszpra, A. Hensen, L. Jourd'Heuil, M. Ramonet, R. Santaguida, M. Schmidt, and A. T. Vermeulen, 2001. Dedicated monitoring of atmospheric $CO_2$ in western Europe - A concerted action in AEROCARB. Sixth International Carbon Dioxide Conference, Sendai, Japan, October 1-5, 2001.

Apadula F., M. Arpini, M. Maspero, F. Rocchetti, C. Vannini, 2000. Greenhouse gases monitoring at Plateau Rosa station, Workshop Nazionale International Geosphere Biosphere Programme (IGBP), 27 - 29 Novembre, Roma.

Longhetto, C. Cassardo, S. Ferrarese, C. Giraud, F. Apadula, P. Bacci, P. Bonelli, A.Marzorati. Relationships between Atmospheric Circulation Patterns and $CO_2$ Greenhouse-Gas Concentration Levels in the Alpine Troposphere, Advances in Atmospheric Sciences - Vol.14, No 3, August 1997.

Longhetto, A., F. Apadula, P. Bacci, P. Bonelli, C. Cassardo, S. Ferrarese, C. Giraud, and C. Vannini, "A Study of Greenhouse Gases and Air Trajectories at Plateau Rosa." Il Nuovo Cimento, Vol. 18C, N. 6, Novembre-Dicembre 1995.

Apadula, F., P. Bacci, M. Borgarello, C. Giraud, and A. Longhetto, "Measurements of the Background Concentrations of some important Greenhouse Gases at Plateau Rosa, Italian Alps.", WMO Region VI Conference on the Measurement and Modelling of Atmospheric Composition Changes including Pollution Transport, No. 91, October 1993.

Apadula, F., P. Bacci, M. Borgarello, V. Cundari, C. Giraud, and A. Longhetto, "Greenhouse Gas Measurements at Plateau Rosa, Italian Alps Preliminary Results." Report of the Seventh WMO Meeting of Experts on Carbon Dioxide Concentration and Isotopic Measurement Techniques, No. 88, September 1993.

**National Agency for New Technology, Energy, and Environment of Italy (ENEA)**

Anav A., Ciattaglia L., Guerrini A., Chamard P., Joint CNR-ENEA laboratory for measuring of atmospheric trace gases with climatic impact: technical aspects of instrumentation, sampling and measurements, in *Proceedings of the IV Workshop Italian Research on Antarctic Atmosphere,* edited by M. Colacino, G. Giovanelli, L. Stefanutti, Vol. 35, 257-260, Compositori, Bologna, 1992.

Ciattaglia L., Guerrini A., Chamard P., Greenhouse gases measurements and monitoring in Italy, *Report of the Seventh WMO Meeting of Experts on Carbon Dioxide Concentration and Isotopic measurement techniques*, N.88, 55-60, edited by G.I. Pearman and J.T. Petersen, WMO-GAW, 1994.

Ciattaglia L., Chamard P., Atmospheric $CO_2$ from flask measurements from Lampedusa island, in *Trend 93: A Compendium of Data on Global Change*, edited by T.A: Boden, D.P. Kaiser, R.J. Stepanski, e F.W: Stoss, 165-168, ORNL/CDIAC-65. Oak Ridge, Tenn., USA 1994.

Chamard P., Ciattaglia L., Monteleone F., di Sarra A., The station for climate observations at Lampedusa: greenhouse gas measurements, in *Proceedings of the 10th WMO $CO_2$ Expert Meeting*, Stockholm, Sweeden, 1999.

Chamard P., Ciattaglia L., di Sarra A., Monteleone F., Atmospheric $CO_2$ record from flask measurements at Lampedusa Island, *in "Trends: A Compendium of Data on Global Change"*, Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A. http://cdiac.esd.ornl.gov/home.html.

Thiery F., Chamard P., Ciattaglia L., De Silvestri L., di Sarra A., Grigioni P., Monteleone F., Piacentino S., $CO_2$ concentration in the mediterranean: measurements at the island of Lampedusa in the period 1992-2001, *Proceedings of the Sixth International Carbon Dioxide Conference, Sendai (Japan)* 93-96, 2001.

P.Chamard, F. Thiery, A. di Sarra, L. Ciattaglia, L. De Silvestri, P. Grigioni, F. Monteleone, and S. Piacentino, Interannual variability of atmospheric $CO_2$ in the mediterranean: measurements at the island of Lampedusa, Tellus (2003), 55B, 83-93.

**Italian Meteorological Service, (IMS), Italy**

V. Cundari, T. Colombo and G. Fiore. Atmospheric carbon dioxide transport at Mt. Cimone. Rivista di Met. Aeron. XLV N 2-3 1985.

L. Ciattaglia, V. Cundari and T. Colombo. Further measurements of atmospheric carbon dioxide at Mt. Cimone, Italy : 1979-1985. Proceedings of international conference in Kandersteg (Swiss) 1985.

V. Cundari and T. Colombo. Atmospheric carbon dioxide measurements at Mt. Cimone, Italy (1979-1983). Annales Geoph. Vol 4 B 1986.

L. Ciattaglia, V. Cundari and T. Colombo. Further measurements of atmospheric carbon dioxide at Mt. Cimone, Italy: 1979-1985. Tellus 39B 1987.

V. Cundari, T. Colombo and L. Ciattaglia. Some considerations on atmospheric measurement technique at Mt. Cimone, Italy. W.M.O. Report No. 77. 1990.

V. Cundari, T. Colombo, G. Papini and G. Benedicti. Recent improvements on atmospheric CO2 measurements at Mt. Cimone observatory, Italy. Il Nuovo Cimento Vol 13 C, N5.1990.

V. Cundari and T. Colombo. Mt. Cimone. Trends '91.

T. Colombo and R. Santaguida. Mt. Cimone. Trends '93.

V. Cundari, T. Colombo and L. Ciattaglia. Thirteen years of atmospheric carbon dioxide measurements at Mt.Cimone station, Italy. Il Nuovo Cimento vol 18 C N 1. 1995.

L. Ciattaglia, A. Guerrini, CNR-IFA Rome, T. Colombo, R. Santaguida, P. Chamard, Italian Met Service, ENEA Amb. Clim. Rome. Behaviour of the atmospheric CO2 and Methane concentrations in 2 Italian stations representing different type of biosphere: Mt. Cimone and Lampedusa. Poster no. 650 IUGG-IAMAS-MJS6, Boulder , 2-4 July 1995. Atmospheric $CO_2$: breathing of the Earth. Poster nx650.

P. Bonasoni, T. Colombo, R. Lenaz, G. Tesi, F. Evangelisti, G. Giovanelli, F. Ravegnani, R. Santaguida. Effect of Saharan dust transport on ozone and carbon dioxide concentration. Published on The impact of desert dust across the Mediterranean edited by Stefano Guerzoni and Roy Chester. 1996 Kluwer Academic Publishers.

P. Bonasoni, G. Tesi, T. Colombo, R. Santaguida, F. Evangelisti, U. Bonaf. Effects of Saharan dust transport on the concentration of trace gases. Presented to "Quadrennial ozone symposium, L'Aquila 12-21 Sept. 1996"

T.Colombo, R. Santaguida. Explanatory note for Monte Cimone station, Italy. WMO WDCGG DATA REPORT, WDCGG No.9. GAW DATA Volume IV - Greenhouse Gases and Other Atmospheric Gases. September 1995.

P.Bonasoni, F. Evangelisti, G. Giovanelli, F. Calzolari, T. Colombo, R. Santaguida, O. Tubertini, M.G. Bettoli, L. Tositti, G. Tesi, E. Corazza. Mt. Cimone Observatory: Baseline Station for the measurement of gaseous substances and radioactive tracers in the atmosphere. Journal of Environmental Pathology, Toxicology and Oncology vol. 15, Nx4, 1996.

P. Bonasoni, F. Calzolari, T. Colombo, E. Corazza, R. Santaguida, G. Tesi. Continuous CO and $H_2$ measurements at Mt.Cimone ( ITALY): preliminary results. Atmospheric Environment 1997, vol 31, 7, pp. 959-967.

**National Research Program in Antarctica (PNRA), Italy, and National Department of Antarctica (DNA), Argentina**

Ciattaglia, L., First 3 years of Atmospheric CO2 Concentration Measurements at Jubany station: characteristics, growth rate and relationship with the origin of air masses, VII Workshop on Antarctic Atmosphere , Bologna , 22-24 Oct, 1997.

Ciattaglia, L, T. Colombo, and K.A. Masarie, Continuous Measurements of Atmospheric $CO_2$ at Jubany Station, Antarctica, Tellus 1999, 51B, 713-721.

Anav, A., L. Ciattaglia, and C. Rafanelli, Was en Niño 1997-98 responsible for the anomalous $CO_2$ trend in the Antarctic atmosphere? VIII Workshop on Antarctic Atmosphere, conf. proc.v.69 pp.375-385, Bologna, Oct. 1999.

**Japan Meteorological Agency (JMA), Japan**

"The annual report of background air pollution observation of JMA", JMA (Japan Meteorological Agency), annual report of background air pollution observation: 1988-1995, JMA, Tokyo, 1988-1995.

Watanabe, F., O. Uchino, Y. Joo, M. Aono, K. Higashijima, Y. Hirano, K. Tsuboi and K. Suda: Interannual variation of growth rate of atmospheric carbon dioxide concentration observed at the JMA's three monitoring stations: Large increase in concentration of atmospheric carbon dioxide in 1998. Journal of Meteorological Society of Japan, Vol.78, No.5. 673-682, 2000.

**Meteorological Research Institute (MRI), Japan**

Matsueda, H., and H.Y. Inoue, Measurements of atmospheric $CO_2$ and $CH_4$ using a commercial airliner from 1993 to 1994, Atmos. Environ., 30, 1647-1655, 1996.

Matsueda, H., H.Y. Inoue, and M. Ishii, Aircraft observation of carbon dioxide at 8-13 km altitude over the western Pacific from 1993 to 1999, Tellus, 54B, 1-21, 2002.

Matsueda, H., S. Taguchi, H.Y. Inoue, and M. Ishii, A large impact of tropical biomass burning on CO and CO2 in the upper troposphere, Science in China (Series C), 45 Supp., 116-125, 2002.

**National Institute of Polar Research (NIPR), Japan**

Tanaka, M., T. Nakazawa, M. Shiobara, H. Ohshima, S. Aoki, M. Fukabori, S. Kawaguchi, T. Yamanouchi, Y. Makino and H. Murayama, Variations of atmospheric carbon dioxide concentration at Syowa Station (69!#00'S, 39!#35'E), Antarctica. Tellus 39B, 72-79,1987.

Nakazawa, T., S. Aoki, S. Murayama, M. Fukabori, T. Yamanouchi, H. Murayama, M. Shiobara, G. Hashida, S. Kawaguchi and M. Tanaka, The concentration of atmospheric carbon dioxide at the Japanese Antarctic Station, Syowa., Tellus 43B, 126-135, 1991.

Aoki, S., and T. Nakazawa, Continuous measurement of atmospheric $CO_2$ concentration at Syowa Station., Antarctic Rec., 41, 161-176, 1997.

Aoki, S., T. Nakazawa, S. Morimoto, G. Hashida, M. Shiobara and T. Yamanouchi, Atmospheric CO2 concentration data observed at Syowa Station from 1984 to 1992., JARE Data Reports No. 251 (Meteorology 34), National Institute of Polar Research, Tokyo, p. 55, 2000.

Morimoto, S., S. Aoki, T. Nakazawa, G. Hashida and T. Yamanouchi, Atmospheric CO2 concentration data observed at Syowa Station from 1992 to 2000., JARE Data Reports No. 269 (Meteorology 35), National Institute of Polar Research, Tokyo, 62p, 2003.

Morimoto, S., T. Nakazawa, S. Aoki, G. Hashida and T. Yamanouchi, Concentration variation of the atmospheric CO2 observed at Syowa Station, Antarctica from 1984 to 2000., Tellus 55B 170-177, 2003.

**National Institute of Water and Atmospheric Research (NIWA), New Zealand**

Manning, M.R., A.J. Gomez, and K.P. Pohl, Atmospheric CO2 record from in-situ measurements at Baring Head, pp 174-178. In T.A. Boden, D.P. Kaiser, R.J. Sepanski and F.W. Stoess (eds), Trends '93, A compendium of data on global change, ORNL/CDIAC-65, Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, Tenn, USA, 1994.

Manning, M.R., and K.P. Pohl, Atmospheric $CO_2$ measurements in New Zealand, 1971-1985, Institute of Nuclear Sciences, DSIR, 1986.

Manning, M.R., and K.P. Pohl, A review of CO2 in air calibration gas mixtures used at Baring Head, New Zealand, Institute of Nuclear Sciences, DSIR, Wellington, 1986.

Manning, M.R., and K.P. Pohl, A review of analyser calibration procedures and calibration gas mixtures used in the New Zealand CO2 measurement programme, DSIR Institute of Nuclear Sciences, Lower Hutt, New Zealand, 1987.

Manning, M.R., K.P. Pohl, and A.J. Gomez, Status of the New Zealand CO2 measurement programme, in Report of the Seventh WMO Meeting of Experts on Carbon Dioxide Concentration and Isotopic Measurement Techniques, Rome, Italy, 7 – 10 September 1993, edited by G.I. Pearman, and J.T. Peterson, World Meteorological Organization, Geneva, 1993.

Monfray, P., M. Ramonet, A. Gaudry, G. Pearman, D. Beardsmore, M. Manning, and P. Pohl, An intercalibration of CO2 measurements between France, Australia and New Zealand, in Report of the WMO meeting of experts on carbon dioxide concentration and isotopic measurement techniques, Lake Arrowhead California, 14-19 Oct 1990, edited by P.P. Tans, World Meteorological Organization, Geneva, 1991.

Gomez, A., Baring Head Atmospheric Data Summary. Wellington, NIWA, 1996.

Manning, M. R., A. J. Gomez and G. W. Brailsford, Changes in atmospheric CO2. Workshop on the Science of Atmospheric Trace Gases, Wellington, New Zealand, NIWA Technical Report 15, 1998.

Gomez, A. J., The CO2 remote control system at Baring Head. Report of the Ninth WMO Meeting of Experts on Carbon Dioxide Concentration and Related Tracer Measurement Techniques, Aspendale, Victoria, Australia, WMO, Global Atmosphere Watch, No 132, 1999.

Manning, M. R., A. J. Gomez and G. W. Brailsford, The New Zealand CO2 measurement programme. Ninth WMO Meeting of Experts on Carbon Dioxide Concentration and Related Tracer Measurement Techniques, Aspendale, Victoria, Australia, WMO Global Atmosphere Watch No 132, 1999.

Manning, M., New Zealand greenhouse gas programmes. WMO CO2 Experts Meeting. Stockholm, World Meteorological Organisation, Geneva, 1999.

Manning, M., G. Brailsford, A. Gomez and S. Nichol, CO2 mixing ratio in South Pacific maritime air, 1970 - 1998. WMO CO2 Experts Meeting, Stockholm, World Meteorological Organisation, Geneva, 1999.

Manning, A. C., M. R. Manning, G. W. Brailsford, A. J. Gomez and R. F. Keeling (2000). “Oceanic and terrestrial contributions to atmospheric O2 and CO2 variability derived from continuous measurements at Baring Head, New Zealand (abs).” EOS Transactions American Geophysical Union 81(48): F276.

Lowe, D. C., Atmospheric CO2 and the active carbon cycle. Water and Atmosphere. 8: 14-16, 2000.

Gomez, A., M. Manning, G. Brailsford and R. Martin, Automated Systems: Measuring Climate Change over the Internet. Water & Atmosphere. 9: 16-18, 2001.

Manning, A. C., M. R. Manning, G. W. Brailsford, A. J. Gomez and R. F. Keeling, Hourly, daily, and seasonal variability in the oceanic and land biotic influences on atmospheric O2 and CO2 derived from continuous measurements made at Baring Head, New Zealand. Sixth International Carbon Dioxide Conference, Sendai, Tohoku University, Sendai, Japan, 2001

Manning, M. R., S. E. Nichol, A. J. Gomez and G. W. Brailsford, Identifying regional sources and sinks of CO2 from trajectory information (Ext Abs). Sixth International Carbon Dioxide Conference, Sendai, Tohoku University, Sendai, Japan, 2001.

Nichol, S. and M. Manning, Baring Head back-trajectories: cluster analysis and CO2 source/sink identification. Meteorological Society Conference, Wellington, New Zealand, 2001.

**South African Weather Service (SAWS), South Africa**

J.M. Harris, S.J. Oltmans, E.J. Dlugokencky, P.C. Novelli, K.A. Masarie, H.E. Scheel, E.-G. Brunke, "CO and $O_3$ Measurements at Cape Point", Climate Monitoring and Diagnostics Laboratory, Annual Meeting, May 3-4, 2000, Boulder, Colorado, Abstracts p. 2.

J.M. Harris, "Analysis of CO and $O_3$ data from Cape Point Observatory (1994-1998)" in: Climate Monitoring and Diagnostics Laboratory, Summary Report No. 25, 1998-1999, (R. Schnell, D. King, eds.), U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Boulder, Colorado, January 2001, pp. 87-88.)

Labuschagne, C., Brunke, E-G. and Scheel, H.E. (1999). Cape Point trace gas observations under baseline and non-baseline conditions. NOAA Climate Monitoring and Diagnostics Laboratory Annual Meeting, Boulder, Colorado, U.S.A., 12-13.05.1999 [poster P-4, page 37]. In “Abstracts of Climate Monitoring & Diagnostics Laboratory annual Meeting, May 12-13, 1999.

**Instituto Nacional de Meteorologia (INM), Spain**

Romero, M.C., Rípodas, P., Ramos, R., Cuevas, E., "The 1984-2001 carbon dioxide series at the free-troposphere Izaña Observatory". CARINA conference, Gran Canaria, Spain, 2003. In press.

Ripodas, P., Ramos, R., Cuevas, E., Calbet, X., "1984-1999 CO2 time series at Izana (Tenerife). Long range transport effects". Report of the "2 Asamblea Hispano Portuguesa de Geodesia y Geofisica", Lagos, Portugal, 2000, page. 467.

Ripodas, P., Ramos, R., Cuevas, E., Calbet, X., "1984-1999 CO2 measurements at Izana (Tenerife). Relationship between the $CO_2$ short-term variability and the latitude origin of air masses". Report of the "WMO 10th CO2 experts meeting", Stockholm, 1999.

**Department of Meteorology, Stockholm University (SU), Sweden**

Engardt, M. 1996. On the interpretation of rapid variations in atmospheric carbon dioxide concentration at the Zeppelinfjellet station, Spitsbergen. Filosofie Licentiate Thesis, International Meteorological Institute in Stockholm, Report CM, 108 pp.

Engardt, M., Holmen, K. and Heintzenberg, J. 1996. Short-term variations in atmospheric $CO_2$ at Ny-Alesund, Spitsbergen, during spring and summer. Tellus 48B, 33-43.

Holmen K., Engardt, M. and Odh, S.-A. 1995. The carbon dioxide measurement program at the Department of Meteorology at Stockholm University, International Meteorological Institute in Stockholm, Report CM-84, 38 pp.

**NOAA/Climate Monitoring and Diagnostics Laboratory (CMDL), United States - Flask measurements**

Conway, T.J., P.P. Tans, L.S. Waterman, K.W. Thoning, D.R. Kitzis, K.A. Masarie, and N. Zhang, Evidence for interannual variability of the carbon cycle from the NOAA/CMDL global air sampling network, J. Geophys. Res.,99,22831-22855, 1994.

Conway, T.J., P. Tans, L.S. Waterman, K.W. Thoning, K.A. Masarie, and R.H. Gammon, Atmospheric carbon dioxide measurements in the remote global troposphere, 1981-1984, Tellus, 40B, 81-115, 1988.

Komhyr, W.D., L.S. Waterman, and W.R. Taylor, Semiautomatic nondispersive infrared analyzer apparatus for $CO_2$ air sample analyses, J. Geophys. Res., 88, 1315-1322, 1983.

Komhyr, W.D., R.H. Gammon, T.B. Harris, L.S. Waterman, T.J. Conway, W.R. Taylor, and K.W. Thoning, Global atmospheric $CO_2$ distribution and variations from 1968-1982 NOAA/GMCC $CO_2$ flask sample data, J. Geophys. Res., 90, 5567-5596, 1985.

Tans, P.P., T.J. Conway, and T. Nakazawa, Latitudinal distribution of the sources and sinks of atmospheric carbon dioxide from surface observations and an atmospheric transport model, J. Geophys. Res., 94, 5151-5172, 1989a.

Tans, P.P, K.W. Thoning, W.P. Elliott, and T.J. Conway, Background atmospheric $CO_2$ patterns from weekly flask samples at Barrow, Alaska: Optimal signal recovery and error estimates, in NOAA Tech. Memo. (ERL ARL-173). Environmental Research Laboratories, Boulder, CO, 131 pp, 1989b.

Tans, P.P., I.Y. Fung, and T. Takahashi, Observational constraints on the global atmospheric $CO_2$ budget, Science, 247, 1431-1438, 1990.

Thoning, K.W., P. Tans, T.J. Conway, and L.S. Waterman, NOAA/GMCC calibrations of $CO_2$-in-air reference gases: 1979-1985. NOAA Tech. Memo. (ERL ARL-150). Environmental Research Laboratories, Boulder, CO, 63 pp, 1987.

**NOAA/Climate Monitoring and Diagnostics Laboratory (CMDL), United States - In situ measurements**

Thoning, K.W., P.P. Tans, and W.D. Komhyr, Atmospheric carbon dioxide at Mauna Loa Observatory 2. Analysis of the NOAA GMCC data, 1974-1985, J. Geophys. Res., 94, 8549-8565, 1989.

Peterson, J.T., W.D. Komhyr, L.S. Waterman, R.H. Gammon, K.W. Thoning, and T.J. Conway, Atmospheric $CO_2$ variations at Barrow, Alaska, 1973-1982, J. Atmos. Chem., 4, 491-510, 1986.

Herbert, G.A., E.R. Green, J.M. Harris, G.L. Koenig, S.J. Roughton, and K.W. Thaut, Control and monitoring instrumentation for the continuous measurement of atmospheric $CO_2$ and meteorological variables, J. Atmos. Oceanic Technol., 3, 414-421, 1986.

Gillette, D.A., W.D. Komhyr, L.S. Waterman, L.P. Steele, and R.H. Gammon, The NOAA/GMCC continuous $CO_2$ record at the South Pole, 1975-1982, J. Geophys. Res., 92, 4231-4240, 1987.

Halter, B.C., Harris, J.M., and Conway, T.J., Component signals in the record of atmospheric carbon dioxide concentration at American Samoa, J. Geophys. Res., 93, 15914-15918, 1988.

Komhyr, W.D., T.B. Harris, L.S. Waterman, J.F.S. Chin, and K.W. Thoning, Atmospheric carbon dioxide at Mauna Loa Observatory: 1. NOAA Global Monitoring for Climatic Change measurements with a nondispersive infrared analyzer, 1974-1985, J. Geophys. Res., 94, 8533-8547, 1989.

Thoning, K.W., T.J. Conway, N. Zhang, and D. Kitzis, Analysis System for Measurement of $CO_2$ Mixing Ratios in Flask Air Samples, Journal of Atmospheric and Oceanic Technology, Vol. 12, No. 6, 1349-1356, 1995.

Thoning, K.W., P.P. Tans, and W.D. Komhyr, Atmospheric carbon dioxide at Mauna Loa Observatory, 2. Analysis of the NOAA/GMCC data, 1974-1985., J. Geophys. Res. ,94, 8549-8565, 1989.

Thoning, K.W. Selection of NOAA/GMCC $CO_2$ data from Mauna Loa Observatory, In The Statistical Treatment of $CO_2$ Data Records, NOAA Tech. Mem. (ERL-ARL-173), Environ. Res. Lab., 131 pp., 1989

Waterman, L.S., D. W. Nelson, W.D. Komhyr, T.B. Harris, and K.W. Thoning, Atmospheric carbon dioxide measurements at Cape Matatula, American Samoa, 1976-1984., J. Geophys. Res., 94, 14817-14829, 1989.

**NOAA/Climate Monitoring and Diagnostics Laboratory (CMDL), United States - Tall-tower measurements**

Bakwin, P.S, P.P. Tans, C. Zhao, W. Ussler III, and E. Quesnell, Measurements of carbon dioxide on a very tall tower, Tellus. 47B, 535-549, 1995.

**NOAA/Climate Monitoring and Diagnostics Laboratory (CMDL), United States - Aircraft measurements**

Bakwin, P.S., Conway, T.J., Dlugokencky, E.J., Guenther, D.W., Kitzis, D, Lang, P.M., Masarie, K.A., Novelli, P.C., Thoning, K.W., Tans, P.P., and Waterman, L.S., in Climate Monitoring and Diagnostics Laboratory CMDL NO. 22 Summary Report 1994, edited by J.T. Peterson and R.M. Rosson, pp 18-30, US Department of Commerce, NOAA, Boulder, Colorado, 1994.

**Scripps Institution of Oceanography (SIO), United States - Flask measurements**

Keeling, R. F., S. R. Shertz, 1992, "Seasonal and interannual variations in atmospheric oxygen and implications for the global carbon cycle" Nature, 358, 723-727.

Keeling, R.F., Piper, S.C., Heimann, M., 1996, "Global and hemispheric CO2 sinks deduced from changes in atmospheric O2 concentration", Nature, 381, 218-221.

Keeling, R.F., Stephens, B.B., Najjar, R.G., Doney, S.C., Archer, D., Heimann, M., 1998, "Seasonal Variations in the atmospheric O2/N2 ratio in relation to kinetics of air-sea gas exchange", Global Biogeochemical Cycles, 12, 141-163.

Keeling, R.F., McEvoy, E., Manning, A.C., Shertz, S.R., 1998, "Methods for measuring changes in atmospheric O2 concentration and their application to southern hemisphere air", Journal of Geophysical Research, 103, 3381-3397.

Stephens, B.B., Keeling, R.F., Heimann, M., Six, K.D., Murnane, R.,K. Caldeira, 1988, "Testing global ocean carbon cycle models using measurements of atmospheric O2 and CO2 concentration", Global Biogeochemical Cycles, 12, 213-230.

Manning, A.C., Temporal variability of atmospheric oxygen from both continuous measurements and a flask sampling network: tools for studying the global carbon cycle, Ph.D. Thesis, University of California, San Diego, 202pp, 2001.

## APPENDIX A. RELEASE NOTES

## A.2003 Modifications to GLOBALVIEW-$CO_2$

### A.2003.1 Data additions to GLOBALVIEW-$CO_2$

Discrete surface measurements:

| | |
|---|---|
| BGU | Begur, Spain (LSCE) |
| SUM | Summit, Greenland (CMDL) |

Continuous surface measurements:

| | |
|---|---|
| FRD | Fraserdale, Ontario, Canada (MSC) |
| FRDRBC | Fraserdale, Ontario, Canada (Restricted Baseline Condition, MSC) |
| PALCBC | Pallas, Finland (Continental Baseline Condition, FMI) |
| PALMBC | Pallas, Finland (Marine Baseline Condition, FMI) |

Continuous measurements from a tall tower:

| | |
|---|---|
| WKT | Moody, Texas, United States (CMDL) |

See Section 9 (SAMPLING LOCATIONS) for details.

## A.2002 Modifications to GLOBALVIEW-$CO_2$

### A.2002.1 Change to the release policy

Participants of the Cooperative Atmospheric Data Integration Project-$CO_2$ agreed to change the current release policy of the GLOBALVIEW-$CO_2$ data product. A single "complete" version of the data product will now be freely available to everyone [*Masarie et al., 2003*].

### A.2002.1 Site Code Change

The Kosan, Republic of Korea (KSN) site was renamed Gosan, Republic of Korea (GSN).

### A.2002.2 Summary of Sample Collection Times

This update includes a summary of sample collection times for discrete measurement records. See Section 4.6 (SUMMARY - SAMPLE COLLECTION TIMES) for details.

### A.2002.3 Data additions to GLOBALVIEW-$CO_2$

Discrete surface measurements:

| | |
|---|---|
| ALT | Alert, Nunavut, Canada (SIO) |
| CBA | Cold Bay, Alaska, United States (SIO) |

CGO Cape Grim, Tasmania, Australia (SIO)
KUM Cape Kumukahi, Hawaii, United States (SIO)
LJO La Jolla, California, United States (SIO)
PSA Palmer Station, Antarctica, United States (SIO)
SBL Sable Island, Nova Scotia, Canada (MSC)
SMO American Samoa (SIO)
SPO South Pole, Antarctica, United States (SIO)
TRM Tromelin Island, France (LSCE)

Discrete measurements from aircraft:
WPO Western Pacific Ocean (MRI)
RTA Rarotonga, Rarotonga (CMDL)

See Section 9 (SAMPLING LOCATIONS) for details.

A.2001 Data additions to GLOBALVIEW-$CO_2$

Continuous surface measurements:
COI Cape Ochi-ishi, Japan (NIES)
HAT Hateruma Island, Japan (NIES)
CPT Cape Point, South Africa (SAWS)

Discrete surface measurements:
KZD Sary Taukum, Kazakstan (CMDL)
KZM Plateau Assy, Kazakstan (CMDL)
TDF Tierra Del Fuego, Argentina (CMDL)

Discrete measurements from aircraft:
HAA Molokai Island, Hawaii, United States (CMDL)
PKA Poker Flats, Alaska, United States (CMDL)

See Section 9 (SAMPLING LOCATIONS) for details.

A.2000 Modifications to the Data Extension procedure

The data extension approach used to prepare the GLOBALVIEW product extends measurement time series by filling periods of missing data for a specific site with values based on knowledge gained from measurements at the site itself and from measurements from marine boundary layer (MBL) sites at comparable latitude. This “latitude reference” method has been improved upon over that described in *Masarie and Tans,* [1995] (hereafter MT95).

In GLOBALVIEW-$CO_2$, 1999 we improved the technique used to construct reference MBL time series to reduce their sensitivity to changes in the distribution of sites and to minimize discontinuities in these reference curves resulting from periods of sporadic or interrupted sampling with existing MBL records. In GLOBALVIEW-$CO_2$, 2000, we have made a minor change to the construction of the difference climatology to minimize discontinuities between smooth values and interpolated and extrapolated values.

A.2000.1 Summary of the difference climatology described by MT95

Data were prepared by fitting a function, f(t) [Equation 1 in MT95 consisting of harmonics and a polynomial] to each measurement record. The residuals from this fit are smoothed to capture interannual variations in the seasonal cycle. These variations are added to f(t) to produce a smooth curve, $S_{STA}(t)$ [Equation 2, MT95], which is our best fit representation of the data The reference MBL time series, $MBL_{STA}(t)$, is constructed for the latitude of each sampling location using the methods described by MT95 and modified according to A.1999.2 (see below). The difference distribution, $\Delta_{STA,REF}(t)=S_{STA}(t)-MBL_{STA}(t)$, highlights features that distinguish the individual record from the reference. A difference climatology was then described by fitting a function, $d_{STA,REF}(t)$ [Equation 9, MT95] to $\Delta_{STA,REF}(t)$. This difference climatology describes the average difference between the smooth curve, $S_{STA}(t)$, and the reference $MBL_{STA}(t)$. To account for interannual variability in the difference distribution, $\Delta_{STA,REF}(t)$, we digitally filter the residuals, $\Delta_{STA,REF}(t)$- $d_{STA,REF}(t)$ using a low-pass filter with FWHM of 40 days. The smoothed residuals are then combined with the difference climatology according to Equation 10, MT95 to produce a smoothed difference climatology, $S_{STA,REF}(t)$.

Data extension relies on the assumption that the difference climatology described by $d_{STA,REF}(t)$ is valid for periods when there are no actual measurements. Limitations of the assumption are discussed in Sections 4 and 5 of MT95. Finally, the extended record is constructed using $S_{STA}(t)$ where measurements exist and by combining $MBL_{STA}(t)$ and the difference climatology where measurements do not exist. Specifically, interpolated values are constructed by combining the MBL reference, $MBL_{STA}(t)$, with the smoothed difference climatology, $S_{STA,REF}(t)$. Extrapolated values are constructed by combining the MBL reference, $MBL_{STA}(t)$, with the difference climatology, $d_{STA,REF}(t)$.

A.2000.2. Modifications to the use of the difference climatology

The difference climatology, $d_{STA,REF}(t)$, is computed from the difference distribution, $\Delta_{STA,REF}(t)$, as described by MT95 and summarized above. The method described by MT95 to construct *extrapolated* values, however, had a tendency to introduce discontinuities at the transition between smoothed values, S(t), and extrapolated values (Figure 1b). These discontinuities arise when extrapolated values based on average behavior join values derived from observations, which do not reflect average behavior. The largest discontinuities occur when the seasonal pattern of actual data at a transition deviates significantly from the long-term average seasonal cycle (Figure 1a). To minimize discontinuities at the boundary between extrapolated values and smooth values, we smooth the transitions between the difference climatology, $d_{STA,REF}(t)$, and the difference distribution, $\Delta_{STA,REF}(t)$.  This is accomplished by defining a relaxation period (RELAX=8 weeks) whereby we force the difference climatology to "relax" linearly from its value RELAX weeks away to the first value from the difference distribution following a gap or to the last value from a difference distribution before a gap in the actual data begins.

Extrapolated values are required to "fill" external gaps in the observations that occur when a data record begins or ends within the data extension synchronization period.  For example, since the CMDL [lab# 00] flask sampling effort on container ships in the Pacific Ocean (POC) began in 1987 and the synchronization period for GLOBALVIEW-$CO_2$, 2000 is 1979 through 1999, there exists an external gap at the beginning of the POC extended record.  The transition between $d_{POCN30,REF}(t_i)$ and $\Delta_{POCN30,REF}(t_i)$ where $t_i$ is the weekly time step corresponding to the first actual observation in the POCN30 record is smoothed using the following strategy.  Values from $d_{POCN30,REF}(t)$ are used (as in MT95) for time steps before $t_i$-RELAX.  Between the time steps $t_i$-RELAX and $t_i$, we use values from linear interpolation between $d_{POCN30,REF}(t_i\text{-RELAX})$ and $\Delta_{POCN30,REF}(t_i)$.  Figure 1c illustrates this technique.

The method to construct *interpolated* values (described by MT95) did not introduce discontinuities at transitions.  By using the smoothed difference climatology, $S_{STA,REF}(t)$, continuity was imposed at the transition between $S_{STA,REF}(t)$ and $\Delta_{STA,REF}(t)$ by the curve fitting methods as described by Thoning et al. [1989].  A more defensible approach for the extension of data records is to use only the difference climatology, $d_{STA,REF}(t)$, which describes the average difference between all actual observations and the MBL reference.  Thus, we now apply the smoothing strategy described above to the construction of interpolated values.

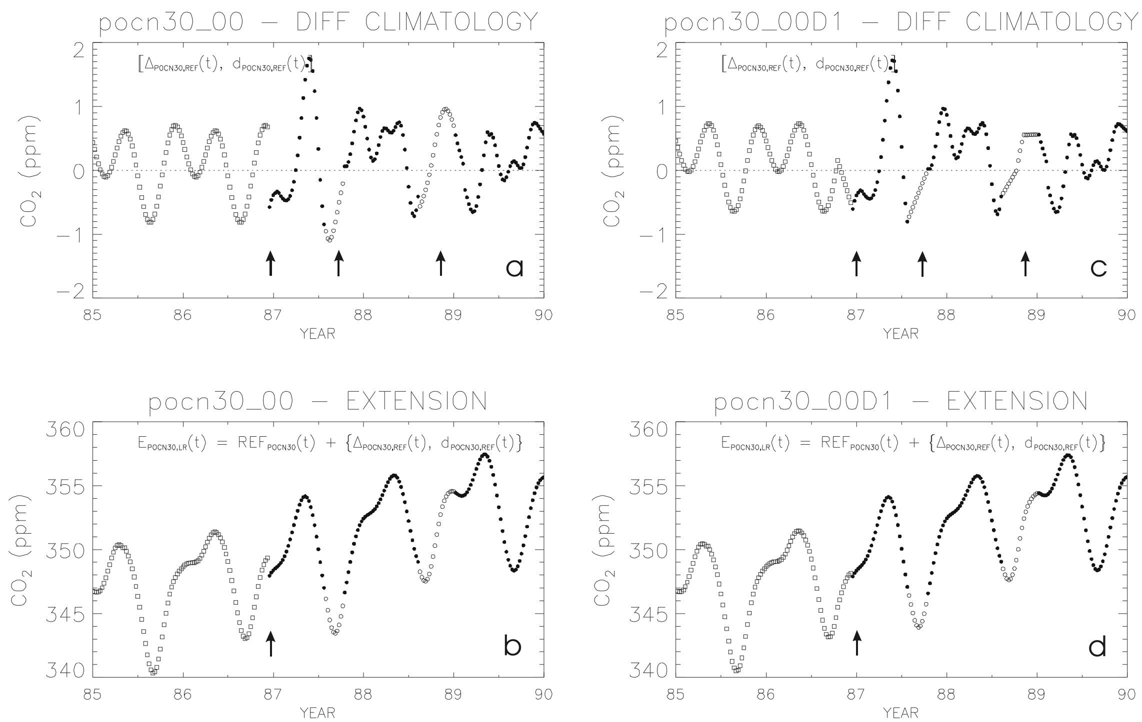


Figure 1. (a) Portion of the POCN30 difference climatology (squares) derived using the method described by MT95. (b) POCN30 extended record derived from (a). (c) Portion of POCN30 difference climatology derived using the modified method described in the text. (d) POCN30 extended record derived from (b) showing minimal discontinuity at the transition between extrapolated values (squares) and smoothed values (circles).

Interpolated values are required to “fill” internal gaps in a data record that occur when an interruption in the observations exceeds 8 weeks (as described in MT95). There are two cases to consider, which again, can be best illustrated using the CMDL POCN30 record. First, there are internal gaps in the POCN30 record that exceed 8 weeks but are less than 2∗RELAX weeks (e.g., 1987). In these cases, we linear interpolate between $\Delta_{POCN30,REF}(t_i)$ and $\Delta_{POCN30,REF}(t_{ii})$ where $t_i$ corresponds to the weekly time step before the gap in the record begins and $t_{ii}$ is the weekly time step when the observations restart. Second, there are internal gaps exceeding 2∗RELAX weeks in length (e.g., 1988). In these cases, we linear interpolate between $\Delta_{POCN30,REF}(t_i)$ and $d_{POCN30,REF}(t_i\text{+RELAX})$ and $d_{POCN30,REF}(t_{ii}\text{-RELAX})$ and $\Delta_{POCN30,REF}(t_{ii})$. Between $d_{POCN30,REF}(t_i\text{+RELAX})$ and $d_{POCN30,REF}(t_{ii}\text{-RELAX})$, we use the values $d_{POCN30,REF}(t_i\text{+RELAX} : t_{ii}\text{-RELAX})$. Figure 1c illustrates each of these cases.

Discontinuities in extended records caused by jumps at transitions between the difference climatology and the difference distribution are artifacts of the data extension method and do not reflect instantaneous sources and sinks of carbon. It is reasonable then to minimize these discontinuities since models “inverting” GLOBALVIEW-$CO_2$ will be required to interpret these jumps. To smooth these discontinuities, we assume that the transition to the actual difference distribution will be gradual and not instantaneous.

Because we cannot justify using one model over another, we have chosen linear interpolation.

By smoothing the transition between the difference climatology and the difference distribution at external and internal gaps, we have minimized discontinuities caused by the non-average behavior of actual observations (Figure 1d). This improvement is apparent in the extended records included in this data product. These modifications, however, still cannot overcome certain discontinuities in the extended records caused by limitations in the observational network itself (see discussion in A.1999.2).

## A.1999 Modifications to the Data Extension procedure

The data extension approach used to prepare the GLOBALVIEW product extends measurement time series by filling periods of missing data for a specific site with values based on knowledge gained from measurements at the site itself and from measurements from marine boundary layer (MBL) sites at comparable latitude. This “latitude reference” method has been improved upon over that described in *Masarie and Tans,* [1995] (hereafter MT95). Specifically, the technique used to construct reference MBL time series has been modified to reduce their sensitivity to changes in the distribution of sites and to minimize discontinuities in these reference curves resulting from periods of sporadic or interrupted sampling within existing MBL records.

### A.1999.1 Summary of latitude reference method described by MT95

Data were prepared by fitting a function, f(t) [Equation 1 in MT95 consisting of harmonics and a polynomial] to each measurement record. The residuals from this fit are smoothed to capture interannual variations in the seasonal cycle. These variations are added to f(t) to produce a smooth curve, S(t) [Equation 2, MT95], which is our best fit representation of the data The residuals are also smoothed to capture variations in the long-term trend only and these are added to the polynomial terms of f(t) to give the deseasonalized long-term trend, T(t) [Equation 3, MT95]. A detrended seasonal cycle is computed as S(t)-T(t), and the average seasonal cycle, H(t), is represented by the harmonic components of f(t) [see Equation 1].

A single measurement record extended using the latitude reference method (as described in Section 4.2, MT95) utilized the record itself as well as information gleaned from additional measurements available from the observational network. Fundamental to this approach is the difference climatology that characterizes the uniqueness of a site record relative to a MBL reference calculated at the site’s latitude. Differences between the smooth curve, $S_{STA}(t)$, and the MBL reference, $MBL_{STA}(t)$ are calculated (Equation 8, MT95). This distribution, $\Delta_{STA,REF}(t)$, highlights features in the site record that are not represented by the MBL reference. A curve [Equation 9, MT95] is then fitted to this distribution to characterize the average offset and average seasonal cycle of $\Delta_{STA,REF}(t)$ and represents the difference climatology for the site. We then assume the difference climatology is valid for periods where there are no measurements; limitations of this assumption are discussed in Sections 4 and 5 of MT95. Finally, the extended record is constructed using $S_{STA}(t)$ where measurements exist and by combining $MBL_{STA}(t)$ and the difference climatology where measurements do not exist.

A.1999.2. Modifications to the derivation of the MBL reference

Reference MBL time series continue to be constructed using observations from active MBL sampling sites during the synchronization period (fixed span of time into which measurement records will be extended, e.g., 1979-1998). The method described in MT95, however, had a tendency to introduce discontinuities into the derived reference time series that were due to changes in the distribution of MBL measurements. For example, during construction of reference MBL time series, each MBL measurement record contributed its smooth values, S(t), everywhere measurements existed; no values from the site were contributed if an interruption in the observations exceeded 8 weeks. Further, the smooth curve was not defined before sampling at a location begins or after it ends. Thus, during construction of reference MBL time series, values from the smooth curves from MBL sites would abruptly appear, disappear, and reappear depending on the continuity and distribution of actual MBL measurements. This was particularly a problem in the equatorial and southern tropical regions where sampling is already sparse. In these regions, site additions, deletions, or gaps in the few existing MBL records had considerable impact on the reference MBL time series and added noise to existing variability due to changes in carbon exchange and atmospheric circulation.

Modifications to the latitude reference procedure minimize the affects of a changing observational network on the derived reference MBL time series. This is accomplished in two ways. First, instead of using the smooth curve, S(t), from MBL measurement records as described by MT95, we use the long-term trend, T(t), the detrended seasonal cycle, S(t)-T(t), and the average seasonal cycle, H(t) derived from each MBL measurement record. Because the trend curve is, by definition, less sensitive than the smooth curve to short-term interruptions, we utilize interpolated values from the trend curve during problematic sampling periods. The seasonal component of the measurement record is represented by the detrended seasonal cycle where there are measurements and by the average seasonal cycle where there are short-term interruptions in the record. By using average seasonal cycle patterns, interruptions or periods of infrequent sampling in a MBL record where the seasonal cycle may be poorly defined or entirely missing have minimal impact on the derived MBL reference. Second, instead of using weights (which depend on sampling density and measurement variability) with annual resolution as described, we now use a single weight at each site that is determined using the entire measurement record. This eliminates variability in the MBL reference that arises when assigned weights may change abruptly from one year to the next, again, due to changes in the observational network. Considered together, these modifications to the latitude reference procedure ensure that once measurements at a MBL location commence, they contribute uninterrupted to the construction of the reference MBL time series until sampling is discontinued. This point is clarified in the description that follows.

First, weekly latitudinal distributions (mixing ratio versus latitude) of values extracted from the long-term trends, T(t), at MBL sites are compiled. A weighted curve as described by *Tans et al.* [JGR, Vol. 94, p. 5151-5172, 1989] is then fitted to each weekly distribution to approximate the meridional distribution of trends. At each time step, values are extracted from the curve at intervals of 0.05 sine of latitude from 90°S to 90°N producing a matrix (T(t,l)) of trends as a function of time and latitude.

Second, using the same MBL sites, weekly latitudinal distributions of values extracted from the detrended seasonal cycle where measurements exist and from the average seasonal cycle where there are interruptions in the data record are compiled. A weighted curve is then fitted to each weekly distribution to approximate the meridional distribution of seasonal cycle patterns. At each time step, values are extracted from the curve at intervals of 0.05 sine latitude from 90°S to 90°N producing a matrix [S(t,l)-T(t,l); H(t,l)] of detrended seasonal cycle patterns as a function of time and latitude.

Third, we construct the MBL matrix REF(t,l) = T(t,l) + {S(t,l)-T(t,l); H(t,l)}. This matrix contains derived model fits to the latitude distribution of long-term trends and detrended average or actual seasonal cycles from all MBL sites at each time step and latitude interval.

Finally, a reference MBL time series can be extracted from the MBL matrix at any latitude using linear interpolation. For example, as described in Section 4.2 of MT95, a reference MBL time series is constructed at Cape Grim (CGO), $REF_{CGO}(t)$, by extracting, at each time step, a mixing ratio from the MBL matrix at the sine (latitude) of CGO. The MBL reference at CGO is most influenced by CGO itself (because it is designated as a MBL site) during the period of measurements, by MBL sites nearby in latitude to CGO, and to a lesser extent by all other MBL values used in the curve fits. The MBL reference at CGO is included in the CGO extension file. Reference MBL time series are included in data extension files for all MBL and non-MBL sampling locations. The reference MBL matrix is also included in this GLOBALVIEW product (See Section 4.7 (REFERENCE MARINE BOUNDARY LAYER MATRIX) of this document for details).

The reference MBL time series constructed using this technique are considerably smoother and more stable than those generated using the original technique. This new technique, however, still cannot overcome certain limitations in the observational network itself. For example, in late-1990, the NOAA sampling at AMS (38°S) was terminated. NOAA sample collection began at CRZ (46°S) in early-1991 as a replacement to the AMS location. The 4-month gap in MBL measurements in this latitude region, however, results in a discontinuous period of low $CO_2$ values in the reference MBL time series at CGO (41°S) that is bracketed in latitude by CRZ to the south and AMS to the north. This discontinuity in the MBL reference at the latitude of

CGO is substantially attenuated in GLOBALVIEW-$CO_2$ where continuous measurements at AMS [1980-1997] contributed by the LSCE laboratory in France provide the continuity that was lacking in the NOAA sampling network.

## APPENDIX B. TABLE: GLOBALVIEW-$CO_2$ SAMPLING LOCATIONS

Summary of information provided in Sections 2 (PARTICIPANTS) and 9 (SAMPLING LOCATIONS). This table is also available as a text file (gv_table.co2)

| Site/lab code | latitude | longitude | Elev., m[a] | MBL[b] | Measurement Laboratory |
|---|---|---|---|---|---|
| aia005_02D2 | -40.53 | 144.30 | 500[c] | 0 | CSIRO |
| aia015_02D2 | -40.53 | 144.30 | 1500[c] | 0 | CSIRO |
| aia025_02D2 | -40.53 | 144.30 | 2500[c] | 0 | CSIRO |
| aia035_02D2 | -40.53 | 144.30 | 3500[c] | 0 | CSIRO |
| aia045_02D2 | -40.53 | 144.30 | 4500[c] | 0 | CSIRO |
| aia055_02D2 | -40.53 | 144.30 | 5500[c] | 0 | CSIRO |
| aia065_02D2 | -40.53 | 144.30 | 6500[c] | 0 | CSIRO |
| alt_00D0 | 82.45 | -62.52 | 210 | 1 | CMDL |
| alt_02D0 | 82.45 | -62.52 | 210 | 1 | CSIRO |
| alt_06D0 | 82.45 | -62.52 | 210 | 1 | MSC |
| alt_06C0 | 82.45 | -62.52 | 210 | 1 | MSC |
| alt_04D0 | 82.45 | -62.52 | 210 | 1 | SIO |
| ams_00D0 | -37.95 | 77.53 | 150 | 1 | CMDL |
| ams_11C0 | -37.95 | 77.53 | 150 | 1 | LSCE |
| asc_00D0 | -7.92 | -14.42 | 54 | 1 | CMDL |
| ask_00D0 | 23.18 | 5.42 | 2728 | 0 | CMDL |
| avi_00D0 | 17.75 | -64.75 | 3 | 1 | CMDL |
| azr_00D0 | 38.75 | -27.08 | 30 | 1 | CMDL |
| bal_00D0 | 55.50 | 16.67 | 7 | 0 | CMDL |
| bgu_11D0 | 41.83 | 3.33 | 30 | 0 | LSCE |
| bhd_15C0 | -41.41 | 174.87 | 80 | 1 | NIWA |
| bme_00D0 | 32.37 | -64.65 | 30 | 1 | CMDL |
| bmw_00D0 | 32.27 | -64.88 | 30 | 1 | CMDL |
| brw_00D0 | 71.32 | -156.60 | 11 | 1 | CMDL |
| brw_00C0 | 71.32 | -156.60 | 11 | 1 | CMDL |
| bsc_00D0 | 44.17 | 28.68 | 3 | 0 | CMDL |
| car030_00D2 | 40.90 | -104.80 | 3000[c] | 0 | CMDL |
| car040_00D2 | 40.90 | -104.80 | 4000[c] | 0 | CMDL |
| car050_00D2 | 40.90 | -104.80 | 5000[c] | 0 | CMDL |
| car060_00D2 | 40.90 | -104.80 | 6000[c] | 0 | CMDL |
| car070_00D2 | 40.90 | -104.80 | 7000[c] | 0 | CMDL |
| car080_00D2 | 40.90 | -104.80 | 8000[c] | 0 | CMDL |

| | | | | | |
|---|---|---|---|---|---|
| cba_00D0 | 55.20 | -162.72 | 25 | 1 | CMDL |
| cba_04D0 | 55.20 | -162.72 | 25 | 1 | SIO |
| cfa_02D0 | -19.28 | 147.06 | 2 | 0 | CSIRO |
| cgo_00D0 | -40.68 | 144.68 | 94 | 1 | CMDL |
| cgo_02D0 | -40.68 | 144.68 | 94 | 1 | CSIRO |
| cgo_04D0 | -40.68 | 144.68 | 94 | 1 | SIO |
| chr_00D0 | 1.70 | -157.17 | 3 | 1 | CMDL |
| cmn_17C0 | 44.18 | 10.70 | 2165 | 0 | IMS |
| cmo_00D0 | 45.48 | -123.97 | 30 | 0 | CMDL |
| coi_20C0 | 43.15 | 145.50 | 100 | 0 | NIES |
| cpt_36C0 | -34.35 | 18.49 | 260 | 1 | SAWS |
| cri_02D0 | 15.08 | 73.83 | 60 | 0 | CSIRO |
| crz_00D0 | -46.45 | 51.85 | 120 | 1 | CMDL |
| csj_06D0 | 51.93 | -131.02 | 89 | 1 | MSC |
| daa_02D0 | -12.42 | 130.57 | 3 | 0 | CSIRO |
| eic_00D0 | -29.15 | -109.43 | 50 | 0 | CMDL |
| esp_02D0 | 49.38 | -126.55 | 39 | 1 | CSIRO |
| esp_06D0 | 49.38 | -126.55 | 39 | 1 | MSC |
| frd_06C0 | 49.88 | -81.57 | 250 | 0 | MSC |
| frdrbc_06C0 | 49.88 | -81.57 | 250 | 0 | MSC |
| gmi_00D0 | 13.43 | 144.78 | 2 | 1 | CMDL |
| goz_00D0 | 36.05 | 14.18 | 30 | 0 | CMDL |
| gsn_24D0 | 33.28 | 126.15 | 72 | 0 | SNU |
| haa005_00D2 | 21.23 | -158.95 | 500[c] | 0 | CMDL |
| haa015_00D2 | 21.23 | -158.95 | 1500[c] | 0 | CMDL |
| haa025_00D2 | 21.23 | -158.95 | 2500[c] | 0 | CMDL |
| haa035_00D2 | 21.23 | -158.95 | 3500[c] | 0 | CMDL |
| haa045_00D2 | 21.23 | -158.95 | 4500[c] | 0 | CMDL |
| haa055_00D2 | 21.23 | -158.95 | 5500[c] | 0 | CMDL |
| haa065_00D2 | 21.23 | -158.95 | 6500[c] | 0 | CMDL |
| haa075_00D2 | 21.23 | -158.95 | 7500[c] | 0 | CMDL |
| hat_20C0 | 24.05 | 123.80 | 47 | 0 | NIES |
| hba_00D0 | -75.67 | -25.50 | 10 | 1 | CMDL |
| hun_00D0 | 46.95 | 16.65 | 344 | 0 | CMDL |
| hun010_35C3 | 46.95 | 16.65 | 258 | 0 | HMS |
| hun048_35C3 | 46.95 | 16.65 | 296 | 0 | HMS |
| hun082_35C3 | 46.95 | 16.65 | 330 | 0 | HMS |
| hun115_35C3 | 46.95 | 16.65 | 363 | 0 | HMS |
| ice_00D0 | 63.25 | -20.15 | 100 | 1 | CMDL |
| itn_00D0 | 35.35 | -77.38 | 505 | 0 | CMDL |
| itn051_00C3 | 35.35 | -77.38 | 60 | 0 | CMDL |
| itn123_00C3 | 35.35 | -77.38 | 132 | 0 | CMDL |
| itn496_00C3 | 35.35 | -77.38 | 505 | 0 | CMDL |
| izo_00D0 | 28.30 | -16.48 | 2367 | 0 | CMDL |

| | | | | | |
|---|---|---|---|---|---|
| izo_27C0 | 28.30 | -16.48 | 2367 | 0 | INM |
| jbn_29C0 | -62.23 | -58.82 | 15 | 1 | PNRA/DNA |
| key_00D0 | 25.67 | -80.20 | 3 | 1 | CMDL |
| kum_00D0 | 19.52 | -154.82 | 3 | 1 | CMDL |
| kum_04D0 | 19.52 | -154.82 | 3 | 1 | SIO |
| kzd_00D0 | 44.45 | 77.57 | 412 | 0 | CMDL |
| kzm_00D0 | 43.25 | 77.88 | 2519 | 0 | CMDL |
| lef_00D0 | 45.93 | -90.27 | 868 | 0 | CMDL |
| lef011_00C3 | 45.93 | -90.27 | 483 | 0 | CMDL |
| lef030_00C3 | 45.93 | -90.27 | 502 | 0 | CMDL |
| lef076_00C3 | 45.93 | -90.27 | 548 | 0 | CMDL |
| lef122_00C3 | 45.93 | -90.27 | 594 | 0 | CMDL |
| lef244_00C3 | 45.93 | -90.27 | 716 | 0 | CMDL |
| lef396_00C3 | 45.93 | -90.27 | 868 | 0 | CMDL |
| ljo_04D0 | 32.90 | -117.30 | 10 | 1 | SIO |
| lmp_28D0 | 35.52 | 12.62 | 45 | 0 | ENEA |
| maa_02D0 | -67.62 | 62.87 | 32 | 1 | CSIRO |
| mbc_00D0 | 76.25 | -119.35 | 58 | 1 | CMDL |
| mhd_00D0 | 53.33 | -9.90 | 25 | 1 | CMDL |
| mhdcbc_11C0 | 53.33 | -9.90 | 25 | 0 | LSCE |
| mhdrbc_11C0 | 53.33 | -9.90 | 25 | 1 | LSCE |
| mid_00D0 | 28.22 | -177.37 | 4 | 1 | CMDL |
| mlo_00D0 | 19.53 | -155.58 | 3397 | 0 | CMDL |
| mlo_00C0 | 19.53 | -155.58 | 3397 | 0 | CMDL |
| mlo_02D0 | 19.53 | -155.58 | 3397 | 0 | CSIRO |
| mlo_04D0 | 19.53 | -155.58 | 3397 | 0 | SIO |
| mnm_19C0 | 24.30 | 153.97 | 8 | 1 | JMA |
| mqa_02D0 | -54.48 | 158.97 | 12 | 1 | CSIRO |
| nwr_00D0 | 40.05 | -105.58 | 3475 | 0 | CMDL |
| opw_00D0 | 48.25 | -124.42 | 488 | 0 | CMDL |
| orl005_11D2 | 47.80 | 2.50 | 500[c] | 0 | LSCE |
| orl015_11D2 | 47.80 | 2.50 | 1500[c] | 0 | LSCE |
| orl025_11D2 | 47.80 | 2.50 | 2500[c] | 0 | LSCE |
| orl035_11D2 | 47.80 | 2.50 | 3500[c] | 0 | LSCE |
| palcbc_30C0 | 67.97 | 24.12 | 560 | 0 | FMI |
| palmbc_30C0 | 67.97 | 24.12 | 560 | 1 | FMI |
| pfa015_00D2 | 65.07 | -147.29 | 1500[c] | 0 | CMDL |
| pfa025_00D2 | 65.07 | -147.29 | 2500[c] | 0 | CMDL |
| pfa035_00D2 | 65.07 | -147.29 | 3500[c] | 0 | CMDL |
| pfa045_00D2 | 65.07 | -147.29 | 4500[c] | 0 | CMDL |
| pfa055_00D2 | 65.07 | -147.29 | 5500[c] | 0 | CMDL |
| pfa065_00D2 | 65.07 | -147.29 | 6500[c] | 0 | CMDL |
| pfa075_00D2 | 65.07 | -147.29 | 7500[c] | 0 | CMDL |
| pocs35_00D1 | -35.00[c] | 172.00[c] | 10 | 1 | CMDL |

| | | | | | |
|---|---|---|---|---|---|
| pocs30_00D1 | -30.00[c] | -176.00[c] | 10 | 1 | CMDL |
| pocs25_00D1 | -25.00[c] | -171.00[c] | 10 | 1 | CMDL |
| pocs20_00D1 | -20.00[c] | -174.00[c] | 10 | 1 | CMDL |
| pocs15_00D1 | -15.00[c] | -171.00[c] | 10 | 1 | CMDL |
| pocs10_00D1 | -10.00[c] | -161.00[c] | 10 | 1 | CMDL |
| pocs05_00D1 | -5.00[c] | -159.00[c] | 10 | 1 | CMDL |
| poc000_00D1 | 0.00[c] | -155.00[c] | 10 | 1 | CMDL |
| pocn05_00D1 | 5.00[c] | -151.00[c] | 10 | 1 | CMDL |
| pocn10_00D1 | 10.00[c] | -149.00[c] | 10 | 1 | CMDL |
| pocn15_00D1 | 15.00[c] | -145.00[c] | 10 | 1 | CMDL |
| pocn20_00D1 | 20.00[c] | -141.00[c] | 10 | 1 | CMDL |
| pocn25_00D1 | 25.00[c] | -139.00[c] | 10 | 1 | CMDL |
| pocn30_00D1 | 30.00[c] | -135.00[c] | 10 | 1 | CMDL |
| pocn35_00D1 | 35.00[c] | -137.00[c] | 10 | 0 | CMDL |
| pocn40_00D1 | 40.00[c] | -136.00[c] | 10 | 0 | CMDL |
| pocn45_00D1 | 45.00[c] | -131.00[c] | 10 | 0 | CMDL |
| prs_21D0 | 45.93 | 7.70 | 3480 | 0 | CESI |
| prs_21C0 | 45.93 | 7.70 | 3480 | 0 | CESI |
| psa_00D0 | -64.92 | -64.00 | 10 | 1 | CMDL |
| psa_04D0 | -64.92 | -64.00 | 10 | 1 | SIO |
| rpb_00D0 | 13.17 | -59.43 | 3 | 1 | CMDL |
| rta005_00D2 | -21.25 | -159.83 | 500[c] | 0 | CMDL |
| rta015_00D2 | -21.25 | -159.83 | 1500[c] | 0 | CMDL |
| rta025_00D2 | -21.25 | -159.83 | 2500[c] | 0 | CMDL |
| rta035_00D2 | -21.25 | -159.83 | 3500[c] | 0 | CMDL |
| rta045_00D2 | -21.25 | -159.83 | 4500[c] | 0 | CMDL |
| ryo_19C0 | 39.03 | 141.83 | 230 | 0 | JMA |
| sbl_06D0 | 43.93 | -60.02 | 5 | 0 | MSC |
| sch_23C0 | 48.00 | 8.00 | 1205 | 0 | UBA/IUP-HD |
| scsn03_00D1 | 3.00[c] | 105.00 | 15 | 0 | CMDL |
| scsn06_00D1 | 6.00[c] | 107.00 | 15 | 0 | CMDL |
| scsn09_00D1 | 9.00[c] | 109.00 | 15 | 0 | CMDL |
| scsn12_00D1 | 12.00[c] | 111.00 | 15 | 0 | CMDL |
| scsn15_00D1 | 15.00[c] | 113.00 | 15 | 0 | CMDL |
| scsn18_00D1 | 18.00[c] | 115.00 | 15 | 0 | CMDL |
| scsn21_00D1 | 21.00[c] | 117.00 | 15 | 0 | CMDL |
| sey_00D0 | -4.67 | 55.17 | 3 | 0 | CMDL |
| shm_00D0 | 52.72 | 174.10 | 40 | 1 | CMDL |
| sis_02D0 | 60.17 | -1.17 | 30 | 1 | CSIRO |
| smo_00D0 | -14.25 | -170.57 | 42 | 1 | CMDL |
| smo_00C0 | -14.25 | -170.57 | 42 | 1 | CMDL |
| smo_04D0 | -14.25 | -170.57 | 42 | 1 | SIO |
| spo_00D0 | -89.98 | -24.80 | 2810 | 1 | CMDL |
| spo_00C0 | -89.98 | -24.80 | 2810 | 1 | CMDL |

| | | | | | |
|---|---|---|---|---|---|
| spo_02D0 | -89.98 | -24.80 | 2810 | 1 | CSIRO |
| spo_04D0 | -89.98 | -24.80 | 2810 | 1 | SIO |
| stm_00D0 | 66.00 | 2.00 | 7 | 1 | CMDL |
| stmebc_00D0 | 66.00 | 2.00 | 7 | 0 | CMDL |
| stp_12D0 | 50.00 | -145.00 | 7 | 1 | IOS |
| sum_00D0 | 72.58 | -38.48 | 3238 | 0 | CMDL |
| syo_00D0 | -69.00 | 39.58 | 11 | 1 | CMDL |
| syo_09C0 | -69.00 | 39.58 | 11 | 1 | NIPR |
| tap_00D0 | 36.73 | 126.13 | 20 | 0 | CMDL |
| tdf_00D0 | -54.87 | -68.48 | 20 | 0 | CMDL |
| trm_11D0 | -15.88 | 54.52 | 20 | 0 | LSCE |
| uta_00D0 | 39.90 | -113.72 | 1320 | 0 | CMDL |
| uum_00D0 | 44.45 | 111.10 | 914 | 0 | CMDL |
| wes_23C0 | 55.00 | 8.00 | 8 | 0 | UBA/IUP-HD |
| wis_00D0 | 31.13 | 34.88 | 400 | 0 | CMDL |
| wkt009_00C3 | 31.32 | -97.33 | 260 | 0 | CMDL |
| wkt030_00C3 | 31.32 | -97.33 | 281 | 0 | CMDL |
| wkt061_00C3 | 31.32 | -97.33 | 312 | 0 | CMDL |
| wkt122_00C3 | 31.32 | -97.33 | 373 | 0 | CMDL |
| wkt244_00C3 | 31.32 | -97.33 | 495 | 0 | CMDL |
| wkt457_00C3 | 31.32 | -97.33 | 708 | 0 | CMDL |
| wlg_00D0 | 36.27 | 100.92 | 3810 | 0 | CMDL |
| wlg_33C0 | 36.27 | 100.92 | 3810 | 0 | CAMS |
| wpon30_10D2 | 30.00[c] | 146.00[c] | 10500[c] | 0 | MRI |
| wpon25_10D2 | 25.00[c] | 146.00[c] | 10500[c] | 0 | MRI |
| wpon20_10D2 | 20.00[c] | 146.00[c] | 10500[c] | 0 | MRI |
| wpon15_10D2 | 15.00[c] | 146.00[c] | 10500[c] | 0 | MRI |
| wpon10_10D2 | 10.00[c] | 146.00[c] | 10500[c] | 0 | MRI |
| wpon05_10D2 | 5.00[c] | 146.00[c] | 10500[c] | 0 | MRI |
| wpo000_10D2 | 0.00[c] | 146.00[c] | 10500[c] | 0 | MRI |
| wpos05_10D2 | -5.00[c] | 146.00[c] | 10500[c] | 0 | MRI |
| wpos10_10D2 | -10.00[c] | 146.00[c] | 10500[c] | 0 | MRI |
| wpos15_10D2 | -15.00[c] | 146.00[c] | 10500[c] | 0 | MRI |
| wpos20_10D2 | -20.00[c] | 146.00[c] | 10500[c] | 0 | MRI |
| wpos25_10D2 | -25.00[c] | 146.00[c] | 10500[c] | 0 | MRI |
| yon_19C0 | 24.47 | 123.02 | 30 | 0 | JMA |
| zep_00D0 | 78.90 | 11.88 | 474 | 1 | CMDL |
| zep_31C0 | 78.90 | 11.88 | 474 | 1 | MISU |

[a]Elevation in meters above mean sea level.
[b]Marine boundary layer sites used in weekly latitude distributions (0≡NO, i.e., not used in constructing reference MBL matrix, 1≡YES). See *Masarie and Tans*, [1995].
[c]Approximate position. Samples are collected in the range of positions specified in Section 9 (SAMPLING LOCATIONS).

## APPENDIX C. ESTIMATION OF GLOBALVIEW UNCERTAINTIES

### C.2000 Initial Error Estimates

Potential sources of uncertainty in the GLOBALVIEW-$CO_2$ data product arise from either the integration of atmospheric $CO_2$ data produced by independent laboratories or from the extension of individual data records. We have estimated the uncertainty of potential sources of error in GLOBALVIEW-$CO_2$ and summarize the results here (a complete analysis is in preparation).

Smooth values (derived directly from data) have an estimated uncertainty of $\leq$ 0.2 $\mu$mol mol$^{-1}$ based on results from intercomparison experiments and analysis of curve fitting methods.

We cannot assign an overall uncertainty to interpolated and extrapolated values because uncertainty varies in both time and space. The average uncertainty in "manufactured" values is estimated to be ~0.3 $\mu$mol mol$^{-1}$. Prior to 1992, the uncertainty in filled values at tropical and mid-northern latitudes showed significant seasonal variability ranging from 0-1.0 $\mu$mol mol$^{-1}$ caused by sparse sampling at these latitudes. Since 1992, variability in the uncertainty of filled values at these latitudes has dramatically decreased and stabilized due to the significant increase in observations made by new or expanding measurement programs.

Interpolated and extrapolated values derived from the data extension procedure capture large-scale patterns reasonably well. They do not capture synoptic-scale events. We strongly recommend that users of this data product consider the weight files, which provide an estimate of the relative significance of each value in the extended record.

Overall uncertainties in the GLOBALVIEW data product will be reduced as we 1) improve comparability among integrated measurement records, and 2) increase the number of MBL measurement records in the tropics and mid-northern latitudes.