Technical report; TR-209

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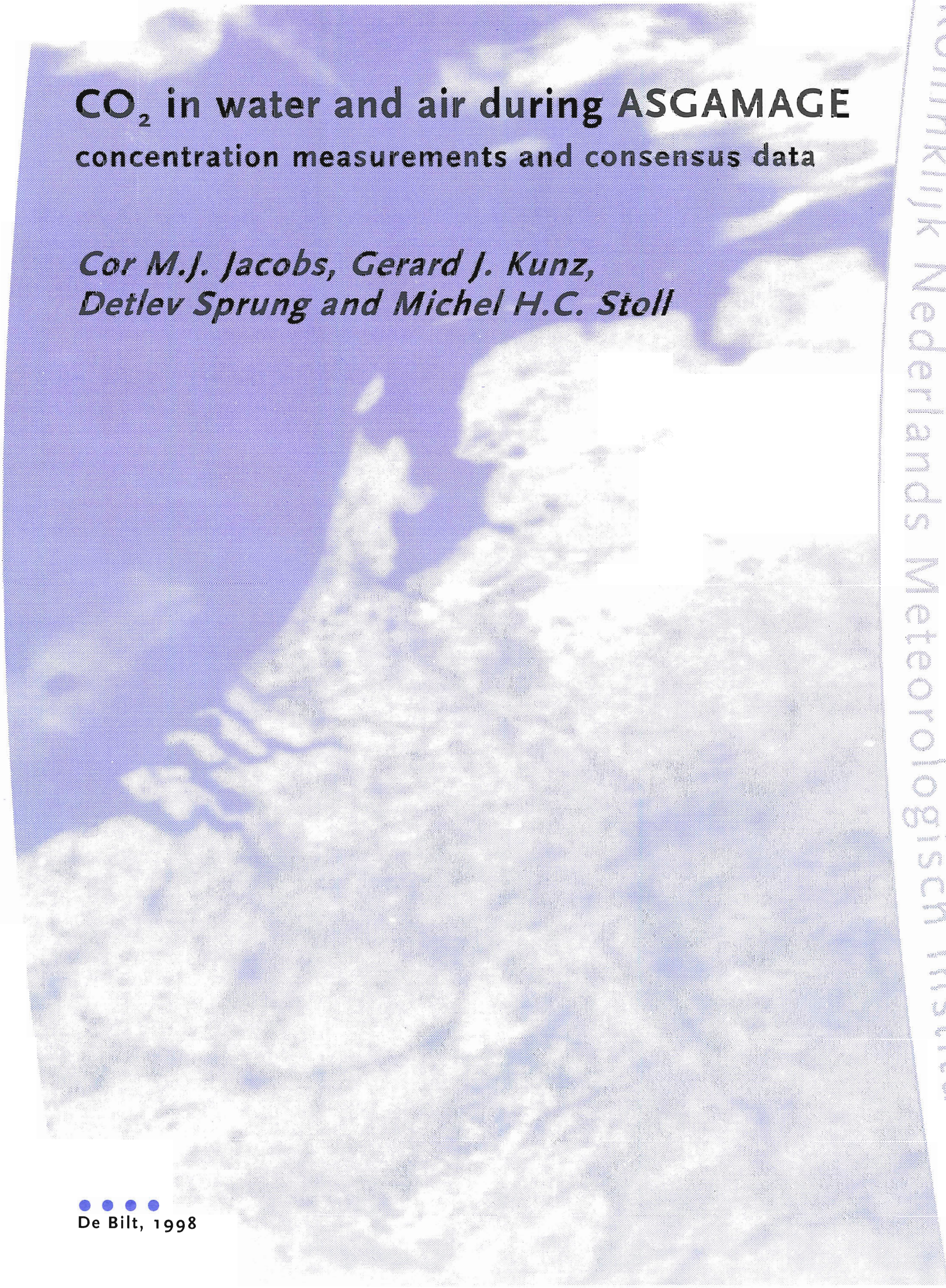

Koninklijk Nederlands Meteorologisch Instituut

De Bilt, 1998

Technical report = technisch rapport; TR - 209

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PO Box 201
3730 AE De Bilt
Wilhelminalaan 10
De Bilt
The Netherlands
Telephone + 31(0)30-220 69 11
Telefax + 31 (0)30-221 04 07

Authors: Cor M.J. Jacobs, Gerard J. Kunz,
Delev Sprung and Michel H.C. Stoll

UDC: 551.506.24
551.526.63
546.26

ISSN: 0169-1708

ISBN: 90-369-2144-9

CO_2 in water and air during ASGAMAGE: concentration measurements and consensus data

Cor M.J. Jacobs[1], Gerard J. Kunz[2], Detlev Sprung[3] and Michel H.C. Stoll[4]

[1] Royal Netherlands Meteorological Institute (KNMI), P.O.Box 201, 3730 AE De Bilt, The Netherlands; E-mail: jacobsc@knmi.nl

[2] TNO Physics and Electronics Laboratory (TNO-FEL), P.O.Box 96864 2509 JG Den Haag, The Netherlands; E-mail: kunz@fel.tno.nl

[3] Max Planck Institute for Chemistry (MPIC), Dept. of Biochemistry, P.O.Box 3060, 55020 Mainz, Germany; E-mail sprung@diane.mpch-mainz.mpg.de

[4] Netherlands Institute for Sea Research (NIOZ), P.O.Box 59, 1790 AB Den Burg, The Netherlands; E-mail: mstoll@nioz.nl

1. Introduction

In 1996 the ASGAMAGE program was started. The acronym ASGAMAGE is a contraction of ASGASEX (for air-sea gas exchange), an earlier experiment in the field of air-sea interaction, and MAGE (Marine Aerosol and Gas Exchange), a subgroup of the International Global Atmospheric Chemistry program, IGAC. Four main goals have been defined for ASGAMAGE (Oost and Huebert, 1995; Oost, 1998):

- to test new methods for the measurement of air-sea fluxes of CO_2 and DMS;
- to compare these methods with established methods for estimating transfer velocities of trace gases over sea;
- to find relationships between the transport coefficients for the gas fluxes and relevant geophysical parameters;
- to investigate whether significant vertical CO_2 concentration gradients can exist in the upper meters of the water column.

ASGAMAGE involves the co-operation of 14 research groups from Europe, Canada and the United States of America. Measurements were performed at "Meetpost Noordwijk" (MPN), a research platform some 9 km off the Dutch coast in the North Sea (52° 16' N, 04° 18'E) and on the UK ship RRS "Challenger" during a cruise in the area near MPN. The experiment consisted of two intensive observation periods, ASGAMAGE-A and ASGAMAGE-B. Many geophysical parameters were determined, and many measurement techniques were applied. The reader is referred to Oost (1998) and to the ASGAMAGE internet site (http://www.knmi.nl/asgamage/) for an overview of the experiment and for a presentation of preliminary results.
One of the crucial observations during ASGAMAGE was the measurement of the concentration of CO_2 in water and in air at MPN. A combination of these data with measured CO_2 fluxes allows the direct determination of the air-to-sea transfer velocity of CO_2, as described in Jacobs *et al.* (1997; 1998a). The CO_2 concentration measurements were performed by the Royal Netherlands Meteorological Institute (KNMI, The Netherlands), the Max Planck Institut für Chemie (MPIC, Germany), the Netherlands Institute for Sea Research (NIOZ, The Netherlands) and the TNO Physics and Electronics Laboratory (TNO-FEL, The Netherlands).
A comparison of preliminary results from ASGAMAGE-B at the ASGAMAGE workshop in September 1997 (Oost, 1998) revealed that the measured CO_2 concentrations agreed only within about 25-30 ppm (Jacobs *et al.*, 1998b). However, at that time some re-calibrations still had to be carried out. Because of the importance of the CO_2 concentration data the ASGAMAGE participants agreed to construct a set of consensus CO_2 concentration data. The present report describes the construction of this set of CO_2 concentration data. Data used here are flagged "final" by the individual institutes.
The structure of the report is as follows. Chapter 2 describes the experimental set-up used to determine the various concentrations. In Chapter 3 the actual procedure used to construct

the consensus data is presented. Results are given graphically in Chapter 3, and a table with the data is given in Appendix A for ASGAMAGE-A and in Appendix B for ASGAMAGE-B. This listing includes air temperature, sea water temperature and atmospheric pressure, which must be known to convert the units of the observed CO_2 concentrations from parts per million by volume (ppm) to milligrams per cubic metre (mg m^{-3}) of air or water, respectively. Chapter 4 gives a short summary and discussion.

2. Experimental set-up, processing and selection of data

2.1. *General*

The experimental part of ASGAMAGE reported on here was performed at MPN. Measurements of the CO_2 concentrations were carried out during both experimental phases of ASGAMAGE. ASGAMAGE-A started on 6 May 1996 and lasted until 6 June 1996. During this period, CO_2 concentrations of water and air were measured by KNMI, MPIC and TNO-FEL. ASGAMAGE-B started on 7 October 1996 and carried on until 8 November 1996. KNMI, MPIC, NIOZ and TNO-FEL all performed CO_2 concentration measurements in water and air.

In what follows the results of the measurements are given as averages for one KNMI measurement run. This choice is made because the KNMI runs are the basic framework for the ASGAMAGE participants to perform common analyses of the data. Each measurement run lasted about 55 minutes. The number of runs performed during ASGAMAGE was 412, of which 130 runs were performed during ASGAMAGE-A and 282 during ASGAMAGE-B. An overview of the runs can be found in Appendix A for ASGAMAGE-A and in Appendix B for ASGAMAGE-B.

2.2. *Analysing equipment*

2.2.1. General

Open air was sampled continuously at various heights. Results presented below refer to air sampled at 12 m (MPIC, KNMI), 20 m (NIOZ) or 30 m (TNO-FEL) above mean sea level (msl). The air samples were led directly to an infrared gas analyser (IRGA) to determine the CO_2 content. More details on the instruments used are given in Sections 2.2.2 to 2.2.5.

To determine the CO_2 concentration in water, submerged pumps were used to obtain water from a depth of 2, 3.5, 5, 7, 11 or 15 m below msl. During ASGAMAGE-A, samples from an additional level at 0.5 m below the actual sea level could be obtained. The sample levels were controlled manually. MPIC continuously took samples from 0.5 m (A-phase) or 2 m (B-phase) below msl. The other institutes (KNMI, NIOZ and TNO-FEL) occasionally varied the sample level. They usually sampled a particular level between 3.5 and 11 m. On some occasions, preferably around slack tide, CO_2 concentration profiles in the water were measured by switching along all the available levels.

The sampled water was led to the laboratory level, located about 12 m above msl. At the standard pumping rate of about 3.3 m^3 h^{-1}, it took less than 20 s for water from the deepest level to reach the analysing equipment. To determine the CO_2 concentration of the samples, water was sprayed continuously into an equilibrator (Bakker, 1998). The air in the equilibrator headspace and the sample water are assumed to be in equilibrium with each other. Air was drawn from the equilibrator and its CO_2 content was determined using the same instruments and procedures as in the case of open air. The actual CO_2 concentration in the water can be computed from the CO_2 concentration in the equilibrator air, as explained in Jacobs *et al.* (1997, 1998a), or can be converted to CO_2 fugacity of the water as described in Bakker (1998). However, in this report the results will be presented as the CO_2 concentration in the equilibrator headspace *air*, which provides the most direct way to compare the results from the various institutes.

2.2.2. KNMI (A and B period)

During ASGAMAGE-A an ADC Mk3 IRGA (The Analytical Development Company, 1988) was applied to determine the CO_2 concentration. In the case of open air samples the effect of water vapour dilution on the CO_2 concentration was corrected for using the measured vapour pressure of the open air. The latter quantity was determined by means of an aspirated Väisälä thermo-hygrometer. A similar correction was applied in the case of equilibrator air, but now using the saturation vapour pressure at the water temperature measured near the platform at a maximum depth of 30 cm below the water surface. This temperature was measured by means of a PT100 resistance thermometer. No corrections were made for the effect of pressure broadening and for radiative absorption by water vapour in the passband of CO_2 absorption. According to the manufacturer's specification, the related error in the measured CO_2 concentration due to interference with water vapour is about 2% of the water vapour concentration, corresponding to less than 0.5 ppm CO_2 in the data from ASGAMAGE-A.

During ASGAMAGE-B KNMI measured the CO_2 concentration by means of a LI-6262 IRGA (Li-Cor, 1991). The water vapour content of the sample air was also determined by means of this instrument and used to correct for the influence of water vapour on the CO_2 concentration measurements. These effects are related to the effect of pressure broadening and to water vapour dilution. The internal software of the LI-6262 was applied to correct for this effect *in situ* (Li-Cor, 1991).

Both detectors operated by KNMI were calibrated on a daily basis by means of a span gas (358 ppm CO_2) and a CO_2-free nitrogen gas. Only minor adjustments were needed during calibration to obtain the correct values for the calibration gases.

KNMI analysed equilibrator air most of the time. During the A-phase the CO_2 concentration of open air was measured a number of times per day. During the B-phase open air was analysed only occasionally.

2.2.3. MPIC (A and B period)

MPIC applied a LI-6262 IRGA (Li-Cor, 1991) to measure the CO_2 concentration of the air samples. The instrument was calibrated four times during the A-phase and four times during the B-phase, using span gases of 249, 331 and 373 (ASGAMAGE-A) or 402 (ASGAMAGE-B) ppm, respectively. The calibration curve was determined from a linear interpolation between the responses of the span gases. In between these calibrations, the stability of the instrument was checked during the automated measurement cycle by means of one of the span gases. There appeared to be hardly any drift in the calibration curves during the experiment. Insofar as this was the case, the actual calibration curve was determined from a linear interpolation with respect to time between two calibration curves.

Every half an hour a fully automated sampling cycle was operated. Each cycle took 10 minutes. At the start of a cycle the concentration of a reference gas was determined. Next, the CO_2 concentration in open air was determined and then again the concentration of the reference gas. Finally, the CO_2 concentration in the equilibrator air was measured, followed again by a measurement of the reference gas concentration. The reference measurements served to check the stability of the instrument, which appeared to be excellent.

All samples were dried completely before the analysis. This implies that no correction for the influence of water vapour on the CO_2 concentration was needed.

2.2.4. NIOZ (B period)

NIOZ analysed air samples by means of a LI-6252 IRGA. The samples were dried completely before the analysis, so that no correction for the influence of water vapour on the CO_2 concentration was needed.

NIOZ used a fully automated sampling and calibration cycle, which was completed in about 25 minutes. Span gases of 250, 368 and 444 ppm, respectively, were used for calibration. A second-order polynomial response curve was fitted through the calibration data. The concentration of the actual samples taken between two calibrations was computed using a calibration curve that was determined from linear interpolation with respect to time. During each cycle, the CO_2 concentration in the equilibrator air usually was measured five times, whereas the concentration of the open air was measured once.

2.2.5. TNO-FEL (A and B period)

TNO-FEL also used a LI-6262 IRGA (Li-Cor, 1991) to the determine the CO_2 concentrations as well as the water vapour content of the samples. Measurements were performed in an automated sampling and calibration cycle. Calibration was performed every two hours, using span gases of 248 and 454 ppm respectively, and using CO_2-free nitrogen gas. Between two calibrations, samples from the equilibrator air and open air were sequentially analysed in cycles of 20 minutes, thereby flushing the measurement system prior to each separate analysis. The instrumental software correction provided with the IRGA was used to account for the influence of water vapour. Afterwards, the calibration data were analysed to determine offset and gain drift. Appropriate corrections of the CO_2 concentration to account for these features were applied as well (Kunz *et al.*, 1998).

2.3. *Initial processing and selection of data*

Analysis of the water concentration data by Jacobs *et al* (1997, 1998a) showed that in general, the vertical stratification with respect to CO_2 concentration was insignificant. Therefore, no distinction was made anymore between sample water from different levels.

Further, an analysis of the air concentration data by Kunz *et al.* (1998) revealed that concentration gradients in the air may be considered as insignificant as well. Thus, air concentration data were also treated as being from one and the same level.

The KNMI measurement runs are the basic time framework in which the CO_2 concentration measurements are going to be processed and used for common analyses by ASGAMAGE participants. Therefore, the results from each institute were converted to run averages. However, relatively few data points were available per run in case the automated calibration-sampling cycles had been applied (MPIC, NIOZ, TNO-FEL). In order to increase the number of data points from which a run-average is computed, data points are also considered as belonging to a run if they were obtained within 15 minutes before or after a run. An average was accepted as a run average if at least two observations per run were available.

Unfortunately, relatively few MPIC data are available due to malfunctioning of the data logging system. Available MPIC data had been logged manually, but only a few of these coincided with KNMI runs. Therefore, it was decided to use the MPIC data set in an unprocessed way as a reference data set, that is, to check general trends. The consensus data will therefore only consist of a combination of KNMI, NIOZ and TNO-FEL data. The resulting run averages for these institutes are listed in the Appendices A and B, respectively.

3. Results and construction of consensus data

3.1. *General*

In order to construct the set of ASGAMAGE consensus data the results from the two observation periods were treated separately. Furthermore, open air and equilibrator air data were processed separately. Below, the symbol C will be used to denote concentration. The subscripts I or J ($I \neq J$) denote KNMI data (I or J = "K"), NIOZ data (I or J = "N") or TNO-FEL data (I or J = "T"). In addition, the subscript C denotes the resulting consensus concentration. The superscripts, x, are used to distinguish open air concentration (x = a), or equilibrator air concentration (x = e).

The following steps were taken to construct the consensus data:

Step (1) Identify data that are unreliable and discard these data. This resulted in runs with either zero, one or two independent observations left;

Step (2) Flag runs without CO_2 concentration data by means of the number -99 (ASGAMAGE-A) or -99.99 (ASGAMAGE-B);

Step (3) Compute the consensus concentration for runs with paired data as the average of the two observations: $C_C^x = (C_I^x + C_J^x)/2$

Step (4) Determine the differences, $C_I^x - C_J^x$, of paired observations and find a suitable measure δ for the observed differences. In doing so, it appeared appropriate to subdivide the main experimental phases (A or B) into a number of smaller periods and to treat these periods separately. In most cases δ was taken equal to the median difference of a sub-period.

Step (5) Adjust unpaired observations by means of δ to obtain the consensus values for these runs: $C_C^x = C_I^x - \delta/2$ if C_I^x is available or $C_C^x = C_J^x + \delta/2$, if C_J^x is available.

3.2. CO_2 concentration in equilibrator air

3.2.1. ASGAMAGE-A

The CO_2 concentration of the equilibrator air observed during ASGAMAGE-A is shown in Figure 1. Results from KNMI and TNO-FEL are plotted as run averages and correspond to the data listed in Appendix A. Available KNMI data had been rounded off to a full ppm.

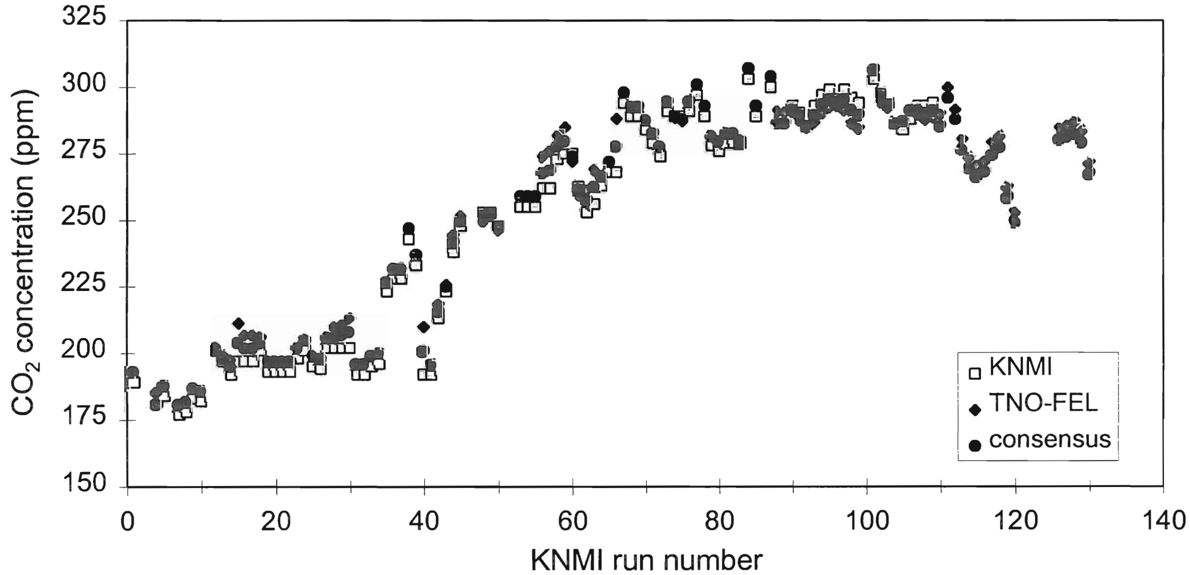

Figure 1. Run averaged CO_2 concentration in equilibrator air as observed by KNMI (squares) and TNO-FEL (diamonds), and consensus data (solid circles).

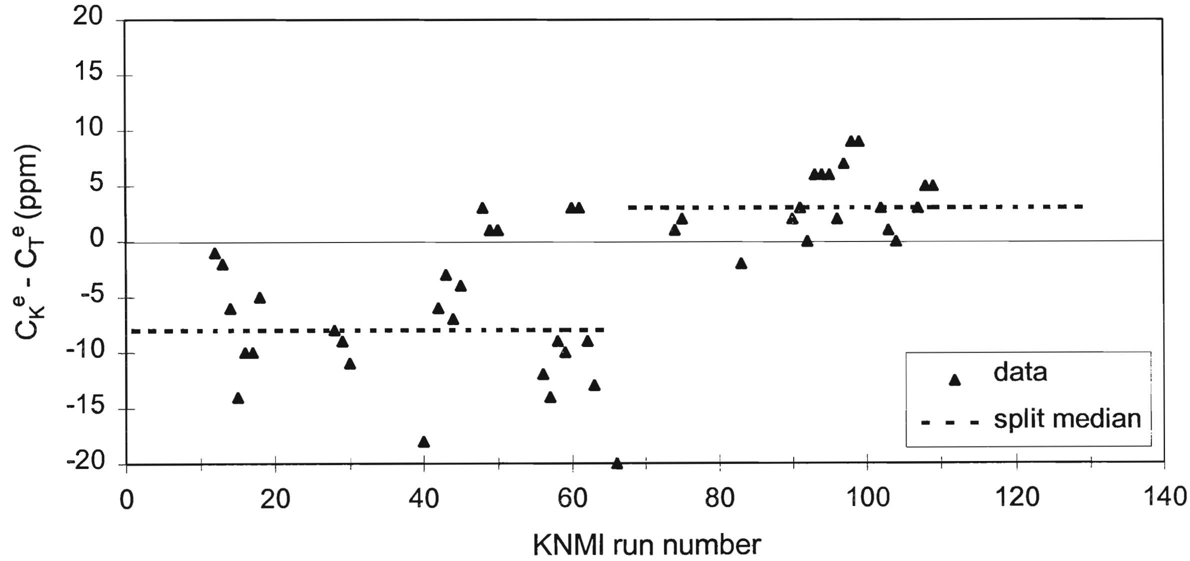

Figure 2. Difference between run-averaged CO_2 concentration in equilibrator air according to KNMI (C_K^e) and TNO-FEL (C_T^e), respectively, during ASGAMAGE-A. The split median differences δ are -8 ppm for runs 1-66 and +3 ppm for runs 67-130 (dashed lines).

Therefore, TNO-FEL data were also rounded off before further processing. No NIOZ or MPIC equilibrator data are available during this period. The difference C_K^e - C_T^e for runs with paired observations is shown in Fig. 2.

It can be seen that the agreement of the data is satisfactory in general. In most cases, the difference remains between -14 and +10 ppm. Further, two periods can be distinguished. The first period corresponds to the runs 1-66, and the second period to runs 67-130. In the first period the differences tend to be negative. Their absolute value is somewhat larger than in the second period, where the values are generally positive. The median difference is -8 ppm in the first period and +3 ppm in the second period. Thes values are used to obtain the consensus values according to Step (5), with δ = -8 and δ = +3 ppm respectively. The resulting consensus concentrations are also shown in Fig. 1 and listed in Appendix A.

3.2.2. ASGAMAGE-B

The observed CO_2 concentration in the equilibrator air during ASGAMAGE-B is shown in Fig. 3. Results from KNMI, NIOZ and TNO-FEL are plotted as run averages and correspond to the data listed in Appendix B. MPIC data shown in the figure are unprocessed and only serve as a reference (see Section 2.3). To facilitate a comparison with the MPIC data the concentrations are plotted versus time in Day Of the Year 1996 (DOY) instead of versus KNMI run number. It appeared useful to distinguish two parts of ASGAMAGE-B. The first part covers DOY 289 to 297 and KNMI runs 1 to 112. The second part covers DOY 302 to 311 and KNMI runs 113 to 282.

At the start of the first part of ASGAMAGE-B (DOY 289 to 297, runs 1 to 112) the scatter is relatively large. Nevertheless, results from all institutes agree reasonably well, with some

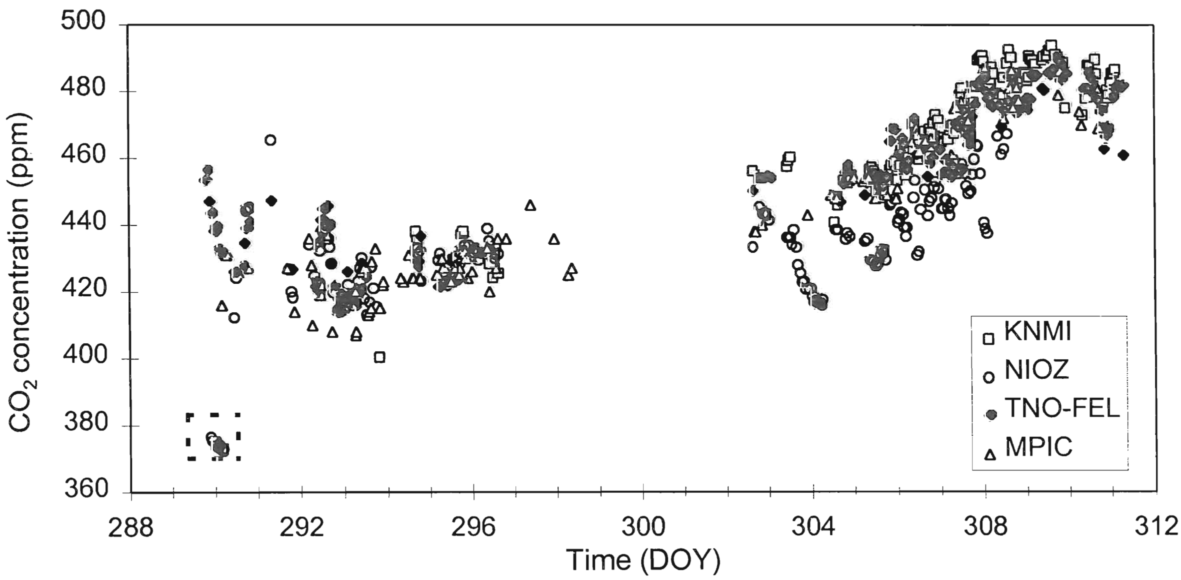

Figure 3. Run averaged CO_2 concentration in equilibrator air as observed by KNMI (squares), NIOZ (open circles) and TNO-FEL (diamonds), and CO_2 concentration of the equilibrator air as determined by MPIC (triangles). Data are plotted versus time in day of the year 1996 (DOY) in order to facilitate a comparison with the unprocessed MPIC data. The latter data were used for reference only. NIOZ averages for runs 9-16 (rejected) are marked by means of the dashed square.

exceptions. A closer examination of the few KNMI data for this period revealed a trend in the concentration that was not observed by other institutes. Therefore, it was decided to ignore all KNMI data for runs 1 to 112, leaving only NIOZ and TNO-FEL data to be used during this part of ASGAMAGE-B. From the remaining data the NIOZ data for Runs 9-16 (marked in Fig. 3 by means of a dashed square) were discarded as well.

The differences between the NIOZ and the TNO-FEL data, C_N^e - C_T^e, for this period are plotted in Fig. 4, along with the median difference. In most cases, the results agree within ± 10 ppm. The median difference, used as δ in Step (5) to compute the consensus value for runs 1 to 112 is -1.75 ppm.

For the ASGAMAGE-B period after DOY 302 a different pattern arises (see Figure 3). For the first part in this period of ASGAMAGE-B (DOY 302.5 to 304.5, run numbers 113 to 152) no clear judgement of the quality of the data could be made. Because many other crucial data (fluxes of momentum, sensible heat, water vapour and CO_2) for these runs where also lacking it was decided to flag these runs as "unreliable" and to discard the corresponding CO_2 concentration data.

After DOY 304.5 the NIOZ results were systematically lower than those of the other institutes. C_K^e and C_T^e agreed mostly within 5 to 10 ppm. Concentrations measured by MPIC tended to be in between C_K^e and C_T^e. Deviations of C_N^e from the *minimum* of C_K^e and C_T^e varied between -7.6 and -42.3 ppm, with an average and median deviation of -17.4 and -16.0 ppm, respectively. Therefore, the NIOZ data for this period where rejected for further processing, which left the KNMI and TNO-FEL data to construct the consensus data set.

In Fig. 5 the difference C_K^e - C_T^e is plotted versus time. It can be seen that a further two periods must be distinguished. From DOY 304.5 until DOY 306, corresponding with runs 153-188, the difference is generally negative. By contrast, the differences from DOY 307 onwards, corresponding with runs 189-282, appear to be positive in general. The median differences used in Step (5) are δ = -1.88 ppm for runs 153-188 and δ= + 6.74 ppm for runs 189-282.

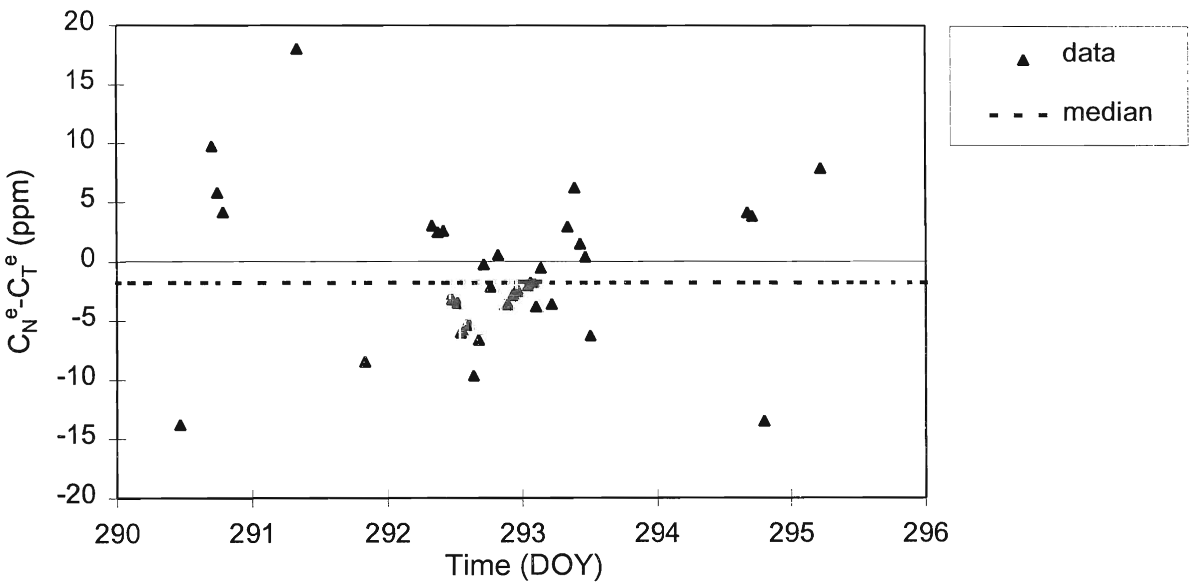

Figure 4. Difference between run-averaged CO_2 concentration in equilibrator air according to NIOZ (C_N^e) and TNO-FEL (C_T^e), respectively, during the first part of ASGAMAGE-B. The median difference δ= -1.75 ppm is indicated by means of the dashed line.

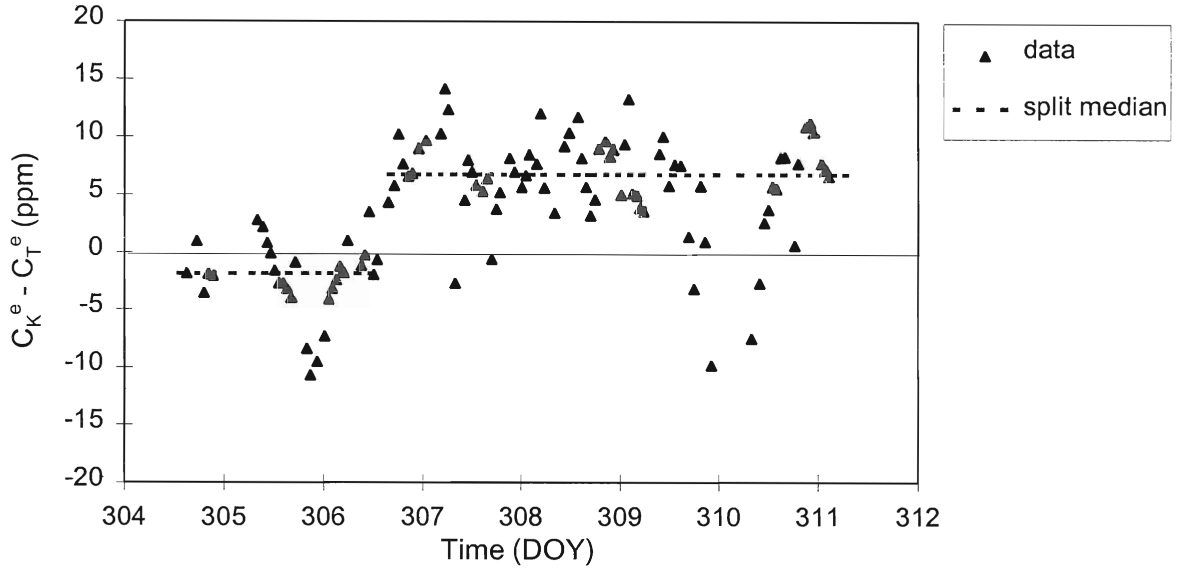

Figure 5. *Difference between run-averaged CO_2 concentration in equilibrator air from KNMI (C_K^e) and TNO-FEL (C_t^e) data during the second part of ASGAMAGE-B. The split median differences δ = -1.88 ppm (DOY 304-306; runs 153-188) or δ = +6.74 ppm (DOY 307-311; runs 189-282) are indicated by means of the dashed lines.*

Figure 6 shows the data used to compute the consensus CO_2 concentration in the equilibrator air during ASGAMAGE-B along with the resulting consensus data. Note that the data are plotted versus run number again. Also note the concentration scale difference between Fig. 3 and Fig. 6. In summary, consensus data for runs 1-112 are obtained from C_n^e and C_T^e, using δ = -1.75 ppm in Step (5), and from C_K^e and C_t^e in runs 153-188 and 189-282 with δ = -1.88 ppm and +6.74 ppm, respectively.

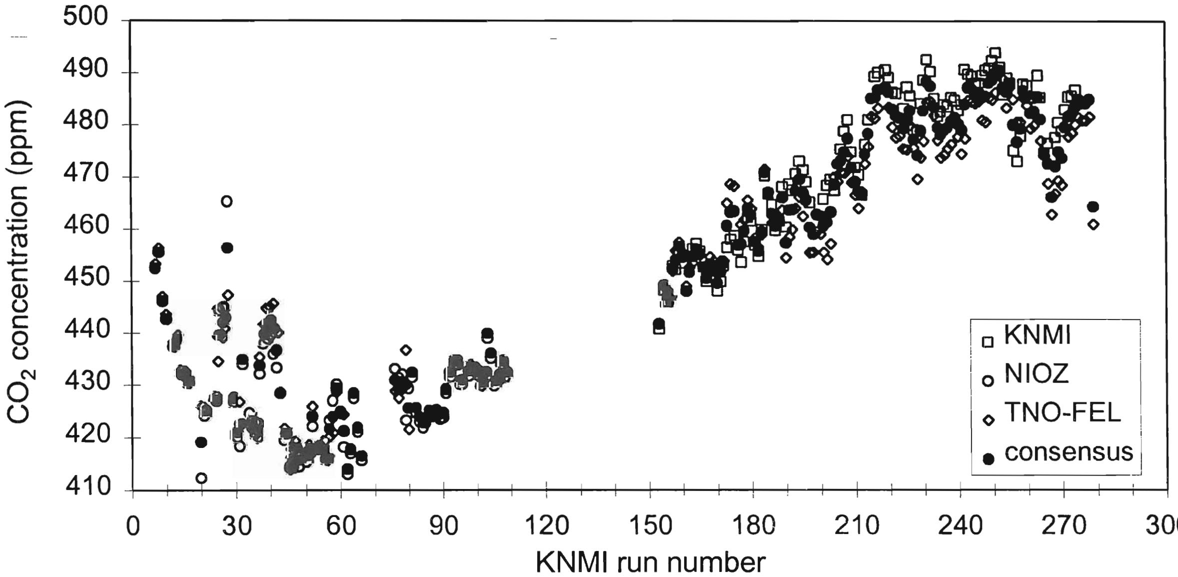

Figure 6. *CO_2 concentration data used to compute the consensus CO_2 concentration in the equilibrator air during ASGAMAGE-B (squares: KNMI data; open circles: NIOZ data; diamonds: TNO-FEL data) and resulting consensus data (solid circles).*

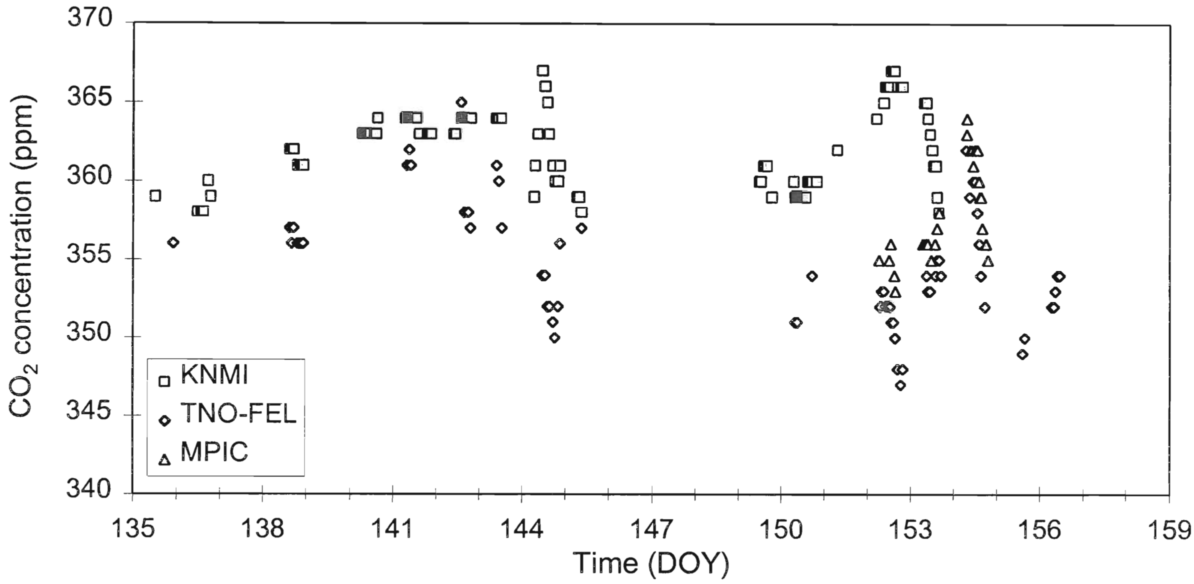

Figure 7. Run averaged CO_2 concentration in open air as observed during ASGAMAGE-A by KNMI (squares) and TNO-FEL (diamonds), and unprocessed MPIC data (triangles).

3.3. CO_2 concentration in open air

3.3.1. ASGAMAGE-A

The CO_2 concentration in open air as observed during ASGAMAGE-A is depicted in Figure 7. Results from KNMI and TNO-FEL are plotted as run averages and correspond to the data listed in Appendix A. Available KNMI data had been rounded off to a full ppm. Therefore, TNO-FEL data were also rounded off before further processing. No NIOZ data were available here, and only a few MPIC data could be recovered. Again, the latter data set

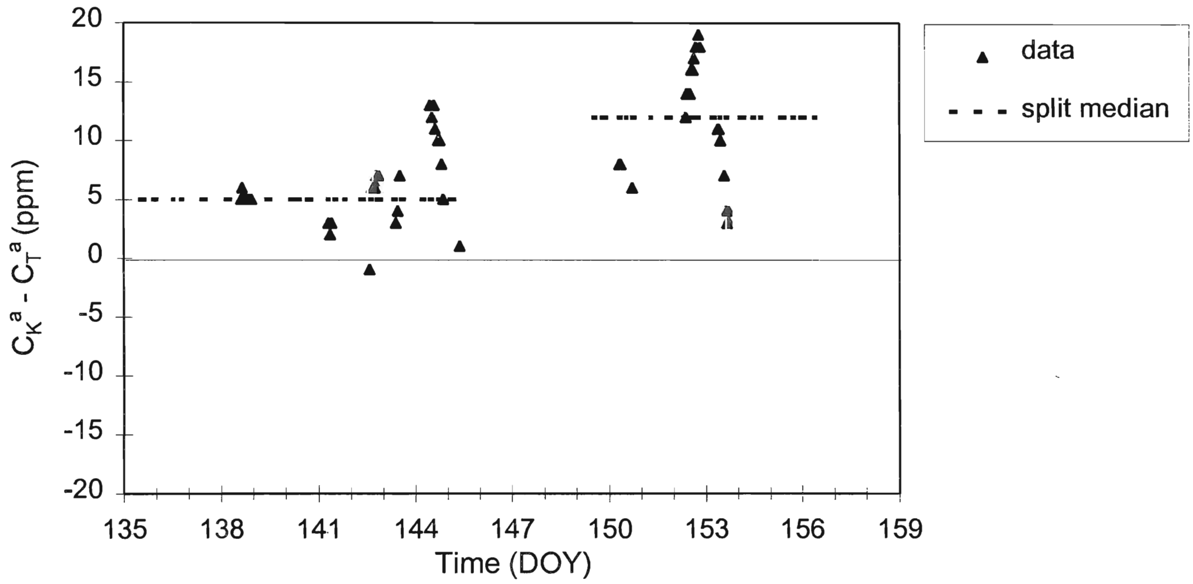

Figure 8. Difference between run-averaged CO_2 concentration in outside air as obtained by KNMI (C_K^a) and TNO-FEL (C_T^a), respectively. The split median difference δ = +5 ppm (runs 1-66) or δ = +12 ppm (runs 67-130) is indicated by means of the dashed lines.

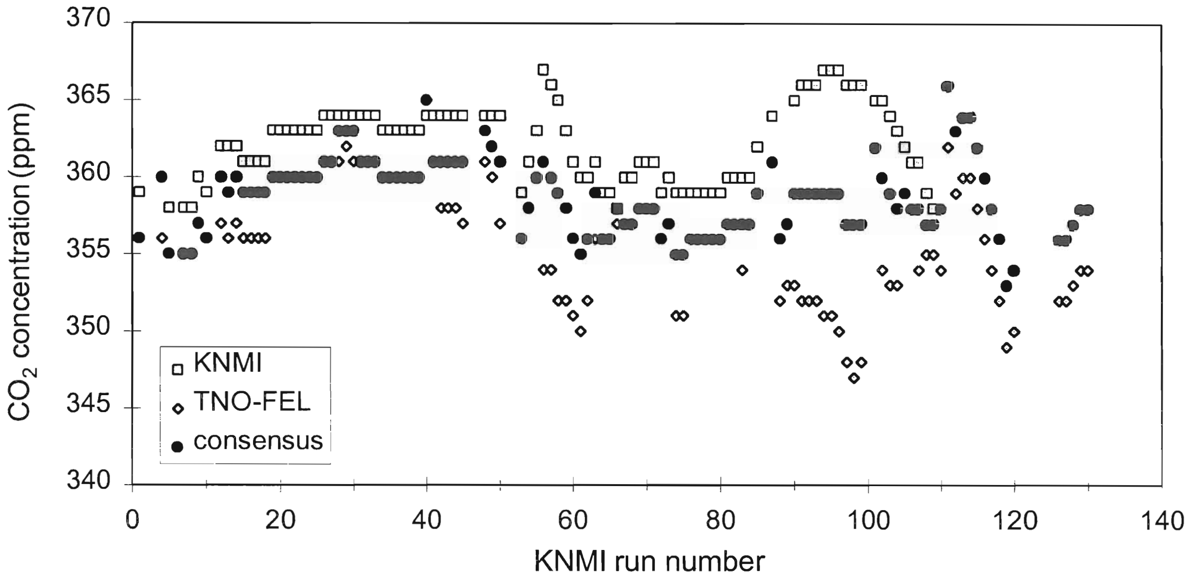

Figure 9. Run averaged CO_2 concentrations in open air (C_i^a) used to computed the consensus data for ASGAMAGE-A. KNMI data: squares; TNO-FEL data: diamonds; consensus data: solid circles.

is used in an unprocessed way and concentrations are therefore plotted versus time in DOY again. The difference $C_K^a - C_T^a$ for runs with paired observations is shown in Fig. 8.

It can be seen that there are periods with satisfactory agreement between the data from KNMI and TNO-FEL, but also periods with marked differences. The difference is especially surprising in the second half of ASGAMAGE-A, from DOY 150 to DOY 154. In this period, the MPIC data agree slightly better with the TNO-FEL data but are in general in between both other data sets. Therefore, no decisive judgement between KNMI data and TNO-FEL data can be made here. Precisely at the moment that the observations seem to come into agreement again the KNMI observations stop. But from this moment on the MPIC data and the TNO-FEL data agree reasonably well. In conclusion, there was no good reason to reject part of one of the data sets, and the procedure to construct consensus data was adhered to as in the previous cases.

In general, the difference $C_K^a - C_T^a$ remains within 0 and +13 ppm. Further, two periods can be distinguished again. As for the equilibrator data, the first period corresponds to DOY 135 to 146 and runs 1 to 66, while the second period extends from DOY 149 to 157 and runs 67 to 130. The first period shows somewhat more consistency between the data sets than the second one. The median differences are + 5 ppm and +12 ppm in the first and second period, respectively. The consensus concentrations with δ in Step (5) equal to these median values are plotted versus run number in Fig. 9 and listed in Appendix A.

3.3.2. ASGAMAGE-B

The observed run-averaged CO_2 concentration in open air during ASGAMAGE-B is shown in Fig. 10. Again, the results are plotted versus time in order to facilitate a comparison with the unprocessed MPIC data. It can be seen that there are only a few KNMI data and it was decided to taken these data not into consideration here.

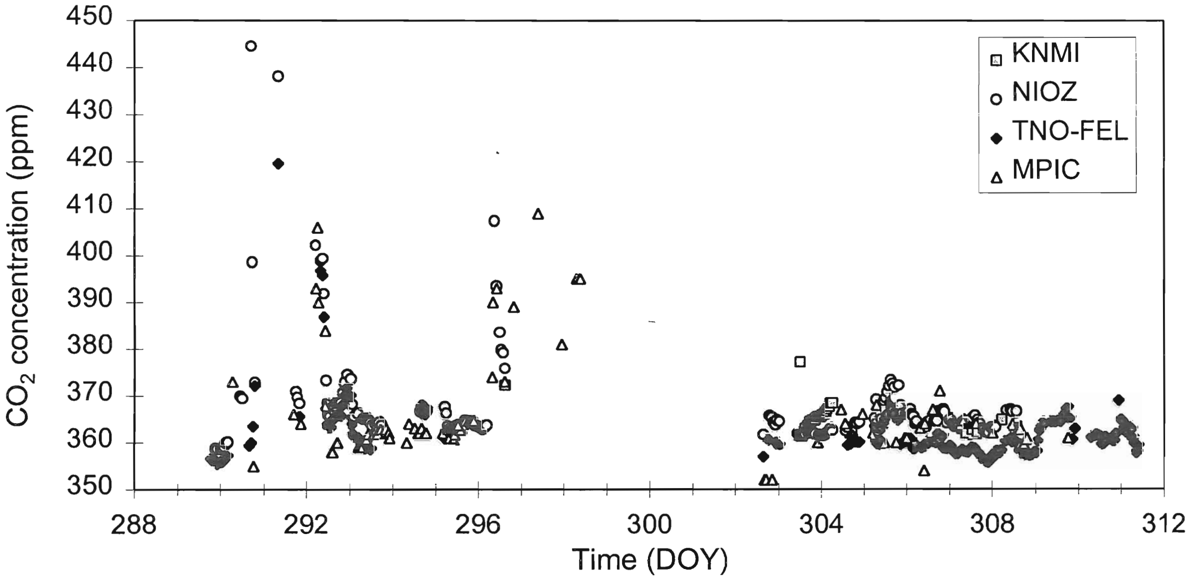

Figure 10. *Run averaged CO_2 concentration in open air during ASGAMAGE-B according to KNMI (squares), NIOZ (open circles) and TNO-FEL (diamonds), and CO_2 concentration of open air determined by MPIC (triangles). Data are plotted versus time in day of the year 1996 (DOY) in order to facilitate a comparison with the unprocessed MPIC data, which were used for reference.*

The agreement between the data for concentrations less than 375 ppm is generally good, with a slight offset but with a trends that are almost the same for the NIOZ and TNO-FEL data. In some instances MPIC data agree more with NIOZ data, in others more with TNO-FEL data.

The scatter is larger for concentrations higher than 375 ppm. A closer examination showed

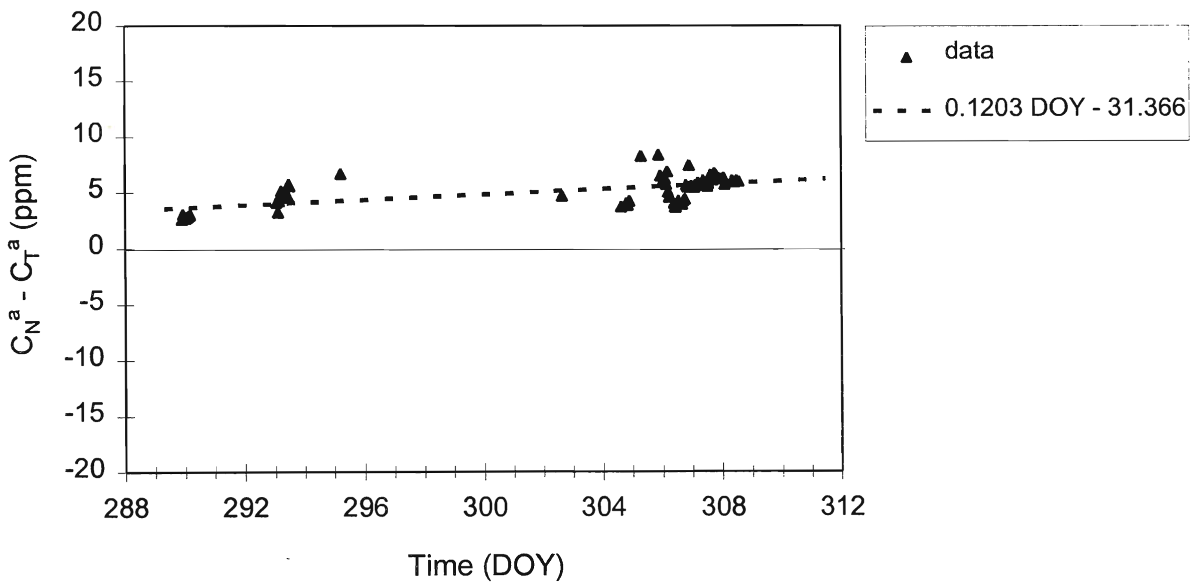

Figure 11. *Difference between run-averaged CO_2 concentration in outside air as obtained by NIOZ (C_N^a) and TNO-FEL (C_T^a), respectively. The dashed line corresponds to the fit of δ in ppm versus time in DOY, giving δ = 0.1203DOY - 31.366 ppm.*

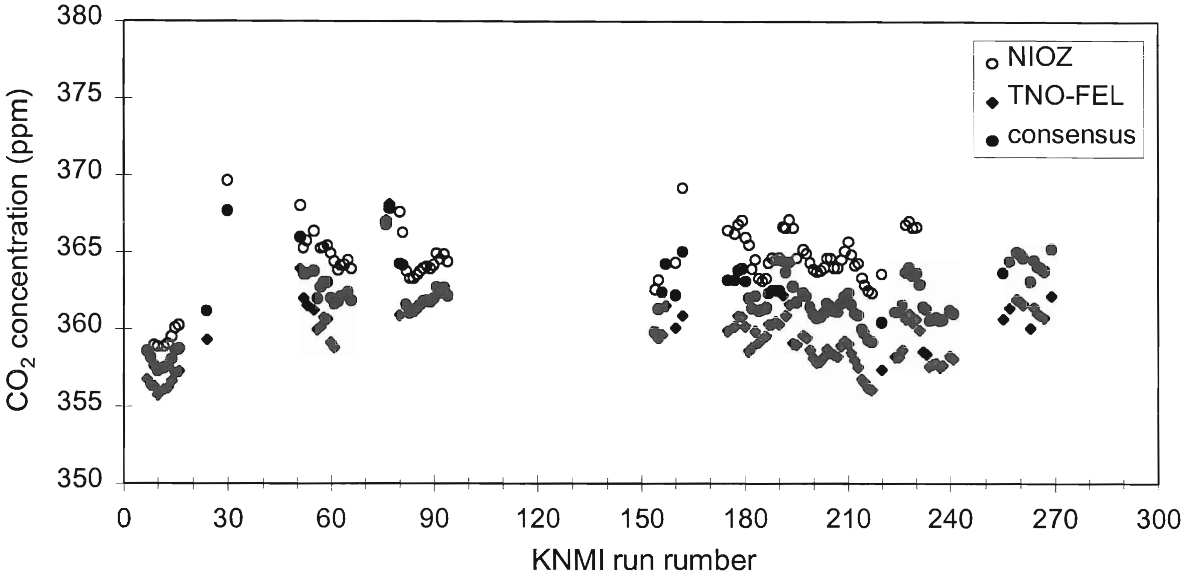

Figure 12. Run averaged CO_2 concentration in open air used to computed the consensus data for ASGAMAGE-B. NIOZ data: open circles; TNO-FEL data: diamonds; consensus data: solid circles.

that these particular data were obtained at a wind direction of less than 220 degrees. Such data are possibly affected by CO_2 sources over land (Kunz *et al.*, 1998), which would imply relatively unreliable CO_2 flux and concentration data. Therefore, it was decided to reject these data.

For the remaining data, the difference between the NIOZ result and the TNO-FEL result, C_N^a - C_T^a, is depicted in Fig 11. It is seen that most of the differences remain within 8 ppm. In fact, there are a number of data clusters here. One possibility would be to determine the median difference for all of these clusters. However, slightly better results for the consensus data - that is, trends in consensus data agree better with trends in observations - can be obtained by boldly regressing the differences in ppm versus time in DOY. It is stressed that this regression analysis serves no physical or statistical purpose and is only applied to obtain reasonable *numbers* for δ in Step (5). The linear regression yields δ = 0.1203DOY - 31.366 ppm. The result for the consensus data is shown versus run number in Fig. 12. Note the difference in concentration scaling between Fig. 10 and Fig 12.

4. Summary and Discussion

During the ASGAMAGE observation periods the CO_2 concentration in water and air at the research platform MPN was determined by various institutes. In all cases, open air was continuously sampled and its CO_2 concentration was determined by means of Infrared Gas Analysers (IRGAs). To determine the concentration in the water equilibrators were continuously flushed with sample water and the CO_2 concentration in the air of the headspace of the equilibrators was measured by means of the IRGA that was also used for open air. Although all institutes relied on the same principle for their measurements, the actual details of the measurements were different, as described in Section 2. As such, three

independent sets of observations where obtained during ASGAMAGE-A (observations by KNMI, MPIC and TNO-FEL) and four during ASGAMAGE-B (observations by KNMI, MPIC, NIOZ and TNO-FEL). Unfortunately, only a few MPIC data appeared to be available in the end. Nevertheless, the MPIC data proved to be valuable as a reference data set.
Per individual institute the available data were converted to averages for KNMI measurement runs. Such runs were initiated at a wind direction between 180 and 360 degrees, and lasted about 55 minutes. In the case of the water concentration measurements the CO_2 concentration observed in the air of the equilibrator headspace was used to compare results from the different institutes. The independent run averages were compared and seemingly unreliable data were rejected. From the remaining data a set of consensus CO_2 concentrations could be constructed as follows.
After the initial screening for unreliable data both the ASGAMAGE-A and the ASGAMAGE-B experiment could be subdivided into a number of smaller periods. During each of these periods zero, one or two independent observations were available per run. For runs with two observations the mean was taken to be the consensus concentration in open or equilibrator air. The differences between the two results for such runs were used to adjust the result for runs with only one observation. Usually, the median difference was used for this adjustment. However, in the case of the open air concentration during ASGAMAGE-B the size of the adjustment was determined from a linear regression of the differences against time, the single goal of this procedure being to obtain a reasonable adjustment. Runs with zero reliable observations left were flagged off. The resulting consensus data are shown in Figures 1, 6, 9 and 12, and are also listed in the appendices.
To this end, we feel that the consensus data represent a reasonably reliable set of concentration data for both ASGAMAGE observation periods. However, the reliability differs somewhat per period of ASGAMAGE-A and ASGAMAGE-B. This is indicated by means of Table 1 for the concentration in equilibrator air and by means of Table 2 for the open air data. For the runs indicated in the first column of these tables, the mean difference of paired observations is given, along with the observed range and two times the standard deviation of the differences between two independent observations. Assuming that the systematic part of the differences are corrected for during the construction of the consensus data, the numbers given in column 4 and 5 of the tables provide an indication of the remaining differences in the observed CO_2 concentrations.

Table 1. Characterisation of the observed differences in paired concentration data for equilibrator air.

Runs[1)]	**n**[2)]	**Mean**[3)]	**Range**[3,4)]	**2σ**[5)]
A:1-66	27	-7	[-20,+3]	12
A:67-130	19	+4	[-2,+9]	6
B:1-112	35	-1	[-14,+18]	13
B:154-188	30	-2	[-11,+4]	7
B:189-282	74	+6	[-10,+14]	9

1)A: ASGAMAGE-A; B: ASGAMAGE-B
2)n: number of *paired* observations
3)Units: ppm
4)[minimum, maximum]
5)σ: standard deviation of differences in ppm

Table 2. Characterisation of the observed differences in paired concentration data for open air.

Runs[1)]	n[2)]	Mean[3)]	Max-Min[3,4)]	2σ[5)]
A:1-66	27	+6	[-1,+13]	7
A:67-130	19	+12	[+3,+19]	10
B:1-282	72	+5	[+3,+8]	3

1)A: ASGAMAGE-A; B: ASGAMAGE-B
2)n: number of *paired* observations
3)Units: ppm
4)[minimum,maximum]
5)σ: standard deviation of differences in ppm

These results can be used to construct errorbars that depend on the period under consideration. Furthermore, assuming that the standard deviation of the differences is an appropriate measure of the quality of the consensus data and that the data from ASGAMAGE-A can be compared directly to those from ASGAMAGE-B, the reliability of the data for equilibrator air is found to decrease in the following order: A:67-130; B:153-188; B:189-282; A:1-66; B:1-112. Note that runs B:113-152 were discarded as being too unreliable. For CO_2 concentration in open air the following order can be established: B:1-282; A:1-66; A:67-130.

Finally, we attempt to find an overall accuracy of the measurement method, that is, in the case of a point measurement with one system. In this case it is in principle not known whether the observation is performed in a period with high or low accuracy. Thus, assuming that data with a truly inferior quality can be rejected in all cases, the accuracy of such a measurement could be estimated from the present data by regarding all differences of paired observations as being from a single population of data.

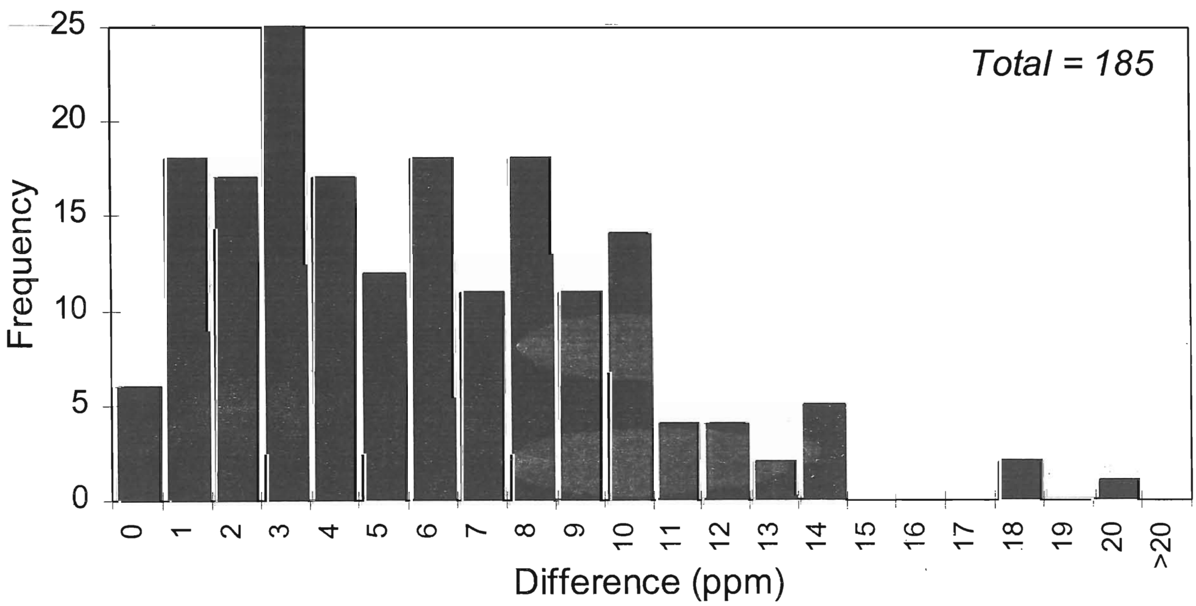

Figure 13. Frequency distribution of differences in paired observations on CO_2 concentration in equilibrator air (all available differences from ASGAMAGE A and B).

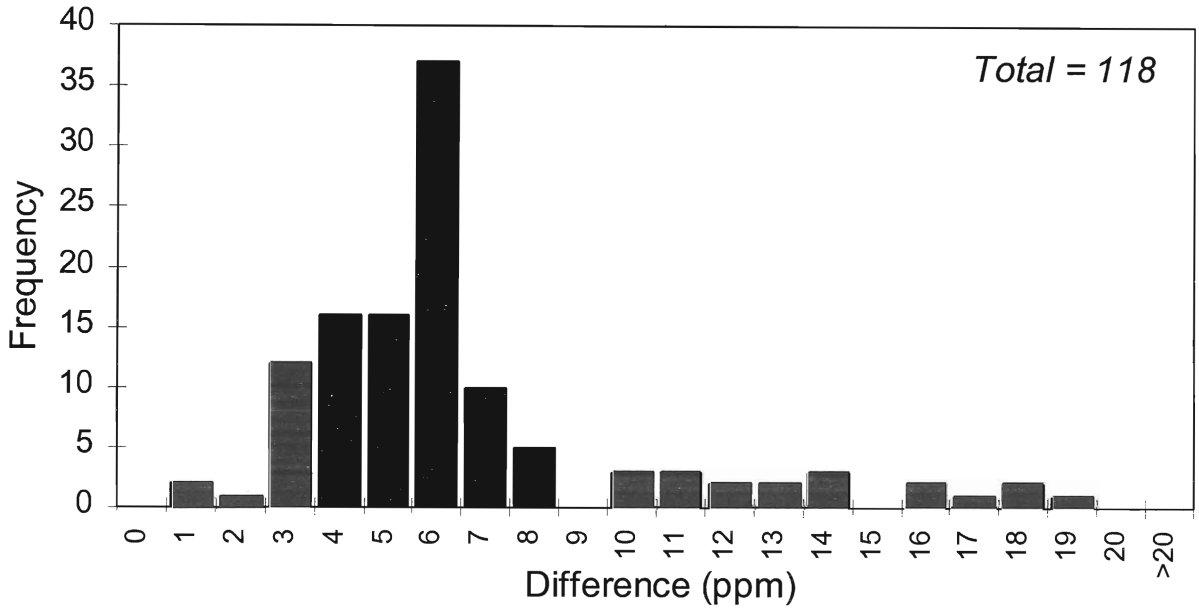

Figure 14. Frequency distribution of differences in paired observations on CO_2 concentration in open air (all available differences from ASGAMAGE A and B).

Figure 13 shows the frequency distribution of the absolute value of the differences in observed concentration, rounded off to a full ppm. More than 98% of the differences appear to be less than 14 ppm. There are three rather extreme differences of 18, 18 and 20 ppm, respectively. Excluding these extremes as atypical, the method may be characterised as accurate within 14 ppm.

The frequency distribution of differences in the case of open air, depicted in Fig. 14, reveals a pattern completely different from equilibrator air. Most of the differences remain within 8 ppm, but there is a rather large number of differences over 10 ppm. However, it is felt that it would be unfair to assign an accuracy of only 19 ppm to these measurements, because the large differences arose from a rather peculiar period during ASGAMAGE-A (see Figure 7 and Table 2). During ASGAMAGE-B and in 21 out of 27 cases during the first part of ASGAMAGE-A the difference remained within 8 ppm. Thus, it is felt that the accuracy of the measurement of open air is better estimated as ± 8 ppm.

Acknowledgements

This research has been undertaken in the framework of the ASGAMAGE project. We acknowledge the support from the European Commission's Marine Science and Technology Programme (MAST III) under contract MAS3-CT95-0044. Special thanks are due to Wim Kohsiek (KNMI), who took care of KNMI's CO_2 concentration measurement system, and to Spyros Rapsomanikis who designed the MPIC measurement system. We also thank Hendrik Wallbrink (KNMI) and Edwin de Jong (NIOZ) for their assistance in obtaining CO_2 data, and Cor van Oort and Ed Worrell (KNMI) for their technical support.

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Appendix A. Results from ASGAMAGE-A

Key to Appendix A

RUN_ID	=	KNMI run number	[-]
DATE	=	Date of start of the run	[day/month/year]
START	=	Start time of the run	[UTC]
END	=	End time of the run	[UTC]
C_c^e	**=**	**Consensus CO_2 concentration of equilibrator air**	**[ppm]**
C_c^a	**=**	**Consensus CO_2 concentration of open air**	**[ppm]**
ddd	=	Wind direction	[degrees]
ppp	=	Atmospheric surface pressure	[hPa]
Ta	=	Air temperature	[°C]
Ts	=	Sea water temperature	[°C]
C_K^e	=	CO_2 concentration in equilibrator air according to KNMI	[ppm]
C_K^a	=	CO_2 concentration in open air according to KNMI	[ppm]
C_T^e	=	CO_2 concentration in equilibrator air according to TNO-FEL	[ppm]
C_T^a	=	CO_2 concentration in open air according to TNO-FEL	[ppm]

Note: to convert air concentrations to water concentrations a salinity of 31 $^{o}/_{oo}$ may be used (Jacobs *et al.*, 1997, 1998b).

Appendix A (Continued)

RUN-ID	DATE	START	END	**C_C^e**	**C_C^a**	ddd	PPP	Ta	Ts	C_K^e	C_K^a	C_T^e	C_T^a
-		UTC	UTC	**ppm**	**ppm**	degr.	hPa	°C	°C	ppm	ppm	ppm	ppm
1	14/05/96	12:14:59	13:09:36	**193**	**357**	0.3	1019.7	8.99	9.51	189	359		
2	14/05/96	17:21:08	18:15:45	**-99**	**-99**	9.7	1019.1	8.93	9.46				
3	14/05/96	19:28:20	20:22:57	**-99**	**-99**	12.1	1019.2	9.01	9.40				
4	14/05/96	21:57:33	22:52:10	**181**	**359**	18.4	1019.2	8.77	9.40			185	356
5	15/05/96	11:30:33	12:25:10	**188**	**356**	359.0	1018.2	9.04	9.51	184	358		
6	15/05/96	12:30:05	13:24:42	**-99**	**-99**	1.8	1018.0	8.69	9.58				
7	15/05/96	13:33:47	14:28:24	**181**	**356**	1.4	1017.8	8.35	9.71	177	358		
8	15/05/96	14:53:53	15:48:30	**182**	**356**	1.0	1017.6	8.47	9.67	178	358		
9	15/05/96	17:12:35	18:07:12	**187**	**358**	3.6	1017.3	8.71	8.27	183	360		
10	15/05/96	18:55:52	19:50:29	**186**	**357**	9.8	1017.5	7.71	6.94	182	359		
11	17/05/96	11:46:52	11:46:52	**-99**	**-99**		1004.2						
12	17/05/96	14:38:53	15:33:30	**202**	**360**	341.8	1004.8	8.44	9.55	201	362	202	357
13	17/05/96	15:39:17	16:33:54	**198**	**359**	339.1	1004.6	8.58	9.46	197	362	199	356
14	17/05/96	16:54:07	17:48:44	**195**	**360**	340.7	1004.3	8.38	9.13	192	362	198	357
15	17/05/96	19:06:04	20:00:41	**204**	**359**	352.0	1004.7	8.14	9.47	197	361	211	356
16	17/05/96	20:12:40	21:07:17	**202**	**359**	358.6	1005.3	8.14	9.46	197	361	207	356
17	17/05/96	21:08:44	22:03:21	**202**	**359**	1.5	1005.4	8.09	9.50	197	361	207	356
18	17/05/96	22:18:43	23:13:20	**204**	**359**	8.7	1005.4	8.05	9.54	201	361	206	356
19	19/05/96	06:23:27	07:18:04	**197**	**361**	210.5	1000.3	11.31	9.45	193	363		
20	19/05/96	07:20:12	08:14:49	**197**	**361**	205.6	1001.2	11.26	9.47	193	363		
21	19/05/96	08:30:46	09:25:23	**197**	**361**	207.1	1001.8	11.56	9.52	193	363		
22	19/05/96	09:31:41	10:26:18	**197**	**361**	210.1	1002.4	11.30	9.63	193	363		
23	19/05/96	10:40:08	11:34:45	**202**	**361**	238.2	1003.7	10.71	9.72	198	363		
24	19/05/96	13:07:37	14:02:14	**205**	**361**	244.6	1004.5	10.33	9.85	201	363		
25	19/05/96	14:09:22	15:03:59	**199**	**361**	245.1	1004.9	10.65	9.92	195	363		
26	19/05/96	15:05:38	16:00:15	**198**	**362**	254.5	1005.2	10.68	9.80	194	364		
27	20/05/96	06:21:32	07:16:09	**206**	**362**	224.4	1011.1	9.35	9.73	202	364		
28	20/05/96	07:18:50	08:13:27	**206**	**363**	220.0	1011.7	9.46	9.77	202	364	210	361
29	20/05/96	08:38:11	09:32:48	**207**	**363**	217.2	1012.7	10.07	9.78	202	364	211	362
30	20/05/96	09:34:39	10:29:16	**208**	**363**	214.8	1013.0	10.47	9.81	202	364	213	361
31	20/05/96	10:49:19	11:43:56	**196**	**362**	215.5	1013.8	10.44	10.04	192	364		
32	20/05/96	11:45:41	12:40:18	**196**	**362**	221.1	1014.1	10.47	10.13	192	364		
33	20/05/96	12:55:42	13:50:19	**199**	**362**	218.0	1014.4	10.76	10.05	195	364		

Appendix A (Continued)

RUN-ID	DATE	START	END	C_C^e	C_C^a	ddd	PPP	Ta	Ts	C_K^e	C_K^a	C_T^e	C_T^a
-		UTC	UTC	**ppm**	**ppm**	degr.	hPa	°C	°C	ppm	ppm	ppm	ppm
34	20/05/96	14:26:33	15:21:10	**200**	**361**	228.3	1014.7	11.04	10.45	196	363		
35	20/05/96	18:51:33	19:46:10	**227**	**361**	225.7	1014.0	10.38	10.09	223	363		
36	20/05/96	19:51:17	20:45:54	**232**	**361**	205.1	1015.2	10.24	10.07	228	363		
37	20/05/96	20:52:12	21:46:49	**232**	**361**	206.6	1015.5	10.59	10.08	228	363		
38	21/05/96	09:25:31	10:20:08	**247**	**361**	223.1	1016.8	11.93	10.14	243	363		
39	21/05/96	10:35:53	11:30:30	**237**	**361**	228.4	1016.8	12.61	10.46	233	363		
40	21/05/96	13:30:12	14:24:49	**201**	**365**	260.2	1016.6	11.25	10.55	192	364	210	365
41	21/05/96	14:26:19	15:20:56	**196**	**362**	227.1	1017.5	10.91	10.80	192	364		
42	21/05/96	15:26:22	16:20:59	**216**	**361**	218.1	1018.1	10.59	10.40	213	364	219	358
43	21/05/96	16:46:46	17:41:23	**225**	**361**	227.7	1018.0	10.77	10.48	223	364	226	358
44	21/05/96	17:44:03	18:38:40	**242**	**361**	222.3	1018.0	10.58	10.80	238	364	245	358
45	21/05/96	18:51:12	19:45:49	**250**	**361**	221.3	1018.4	10.19	10.36	248	364	252	357
46	22/05/96	06:30:02	07:24:39	**-99**	**-99**	227.3	1020.5	10.05	9.98				
47	22/05/96	07:27:56	08:22:33	**-99**	**-99**	221.5	1020.8	9.99	9.94				
48	22/05/96	09:09:03	10:03:40	**252**	**363**	211.2	1020.7	10.62	9.94	253	364	250	361
49	22/05/96	10:37:11	11:31:48	**253**	**362**	212.1	1020.5	11.74	10.22	253	364	252	360
50	22/05/96	12:15:51	13:10:28	**248**	**361**	226.9	1019.5	11.61	10.53	248	364	247	357
51	22/05/96	13:27:00	13:27:00	**-99**	**-99**		1018.7						
52	22/05/96	15:20:04	15:20:04	**-99**	**-99**		1017.6						
53	23/05/96	06:21:26	07:16:03	**259**	**357**	228.4	1010.7	10.66	10.01	255	359		
54	23/05/96	07:21:04	08:15:41	**259**	**359**	230.6	1011.2	10.73	9.96	255	361		
55	23/05/96	08:46:27	09:41:04	**259**	**361**	234.0	1012.1	10.74	9.90	255	363		
56	23/05/96	10:58:39	11:53:16	**268**	**361**	234.0	1013.6	11.28	10.06	262	367	274	354
57	23/05/96	12:20:31	13:15:08	**269**	**360**	232.6	1013.7	11.51	10.23	262	366	276	354
58	23/05/96	13:43:00	14:37:37	**278**	**359**	224.3	1013.9	11.52	10.38	273	365	282	352
59	23/05/96	14:47:59	15:42:36	**280**	**358**	224.7	1013.7	11.83	10.48	275	363	285	352
60	23/05/96	16:52:17	17:46:54	**274**	**356**	218.8	1013.7	11.93	10.36	275	361	272	351
61	23/05/96	18:03:25	18:58:02	**262**	**355**	218.2	1013.7	11.23	10.10	263	360	260	350
62	23/05/96	19:30:55	20:25:32	**258**	**356**	218.8	1013.4	10.93	10.02	253	360	262	352
63	23/05/96	20:44:10	21:38:47	**263**	**359**	201.4	1012.9	11.41	10.05	256	361	269	356
64	24/05/96	06:29:03	07:23:40	**267**	**357**	217.5	1009.2	11.76	9.99	263	359		
65	24/05/96	07:26:54	08:21:31	**272**	**357**	217.7	1009.1	11.93	10.04	268	359		
66	24/05/96	08:35:57	09:30:34	**278**	**358**	221.6	1008.9	12.07	10.10	268	358	288	357

Appendix A (Continued)

RUN-ID	DATE	START	END	C_C^e	C_C^a	ddd	PPP	Ta	Ts	C_K^e	C_K^a	C_T^e	C_T^a
-		UTC	UTC	**ppm**	**ppm**	degr.	hPa	°C	°C	ppm	ppm	ppm	ppm
67	28/05/96	11:40:44	12:35:21	**298**	**354**	255.8	1024.8	10.38	11.57	294	360		
68	28/05/96	12:36:31	13:31:08	**293**	**354**	246.1	1024.7	10.46	11.64	289	360		
69	28/05/96	13:49:02	14:43:39	**293**	**355**	235.8	1024.3	10.79	11.66	289	361		
70	28/05/96	14:58:37	15:53:14	**288**	**355**	231.1	1023.7	10.66	11.73	284	361		
71	28/05/96	15:56:47	16:51:24	**283**	**355**	221.5	1023.2	10.94	11.74	279	361		
72	28/05/96	18:30:44	19:25:21	**278**	**353**	192.9	1022.2	12.14	11.39	274	359		
73	29/05/96	06:46:09	07:40:46	**295**	**354**	220.7	1017.9	11.65	11.11	291	360		
74	29/05/96	07:42:58	08:37:35	**289**	**355**	221.1	1017.9	11.75	11.16	289	359	288	351
75	29/05/96	08:53:51	09:48:28	**288**	**355**	224.1	1018.3	11.60	11.15	289	359	287	351
76	29/05/96	09:49:16	10:43:53	**295**	**353**	226.3	1018.6	11.62	11.12	291	359		
77	29/05/96	10:49:50	11:44:27	**301**	**353**	225.3	1018.6	11.62	10.69	297	359		
78	29/05/96	11:54:31	12:49:08	**293**	**353**	226.1	1019.3	11.70	10.55	289	359		
79	29/05/96	12:52:55	13:47:32	**282**	**353**	224.0	1019.1	12.36	10.52	278	359		
80	29/05/96	13:51:29	14:46:06	**280**	**353**	226.1	1019.1	12.44	11.11	276	359		
81	29/05/96	14:51:17	15:45:54	**283**	**354**	225.3	1018.9	12.40	10.91	279	360		
82	29/05/96	15:49:31	16:44:08	**283**	**354**	228.9	1019.2	12.11	10.74	279	360		
83	29/05/96	16:59:51	17:54:28	**280**	**357**	229.8	1019.0	12.03	10.64	279	360	281	354
84	29/05/96	19:26:46	20:21:23	**307**	**354**	235.7	1019.2	11.93	11.08	303	360		
85	30/05/96	07:02:43	07:57:20	**293**	**356**	188.7	1018.5	14.11	10.99	289	362		
86	30/05/96	12:06:06	12:06:06	**-99**	**-99**		1016.5						
87	31/05/96	05:15:40	06:10:17	**304**	**358**	236.8	1012.1	12.15	10.95	300	364		
88	31/05/96	06:53:34	07:48:11	**287**	**358**	229.3	1014.1	11.85	11.03			291	352
89	31/05/96	07:50:27	08:45:04	**287**	**359**	226.0	1015.1	11.91	11.07			291	353
90	31/05/96	08:55:44	09:50:21	**292**	**359**	225.8	1016.0	12.40	11.24	293	365	291	353
91	31/05/96	09:59:29	10:54:06	**290**	**359**	221.7	1016.9	12.71	11.38	291	366	288	352
92	31/05/96	11:05:58	12:00:35	**286**	**359**	222.4	1017.8	12.61	11.45	286	366	286	352
93	31/05/96	12:09:52	13:04:29	**290**	**359**	225.6	1018.4	12.47	11.35	293	366	287	352
94	31/05/96	13:04:57	13:59:34	**294**	**359**	225.8	1018.5	12.40	11.09	297	367	291	351
95	31/05/96	14:13:37	15:08:14	**296**	**359**	226.6	1018.7	12.55	11.01	299	367	293	351
96	31/05/96	15:16:25	16:11:02	**295**	**359**	226.1	1018.6	12.99	11.05	296	367	294	350
97	31/05/96	16:49:24	17:44:01	**296**	**357**	224.7	1018.4	12.60	11.09	299	366	292	348
98	31/05/96	18:30:17	19:24:54	**292**	**357**	223.1	1018.3	12.40	11.07	296	366	287	347
99	31/05/96	19:35:03	20:29:40	**290**	**357**	218.3	1018.4	12.21	11.13	294	366	285	348

Appendix A (Continued)

RUN-ID	DATE	START	END	C_C^e	C_C^a	ddd	PPP	Ta	Ts	C_K^e	C_K^a	C_T^e	C_T^a
-		UTC	UTC	**ppm**	**ppm**	degr.	hPa	°C	°C	ppm	ppm	ppm	ppm
100	01/06/96	06:46:15	07:40:52	**-99**	**-99**	232.3	1018.4	11.23	11.02				
101	01/06/96	07:42:05	08:36:42	**307**	**359**	231.5	1018.5	11.52	11.14	303	365		
102	01/06/96	08:42:01	09:36:38	**297**	**360**	224.7	1018.4	12.00	11.35	298	365	295	354
103	01/06/96	09:41:27	10:36:04	**294**	**359**	226.0	1018.5	12.04	11.52	294	364	293	353
104	01/06/96	10:41:50	11:36:27	**287**	**358**	225.7	1018.8	12.28	11.62	287	363	287	353
105	01/06/96	11:54:36	12:49:13	**288**	**356**	229.1	1018.8	12.12	11.69	284	362		
106	01/06/96	12:52:09	13:46:47	**292**	**355**	233.9	1018.9	12.63	11.59	288	361		
107	01/06/96	13:52:55	14:47:32	**292**	**358**	234.1	1019.0	12.83	11.47	293	361	290	354
108	01/06/96	14:52:05	15:46:42	**291**	**357**	234.4	1019.0	12.20	11.49	293	359	288	355
109	01/06/96	15:51:06	16:45:43	**292**	**357**	234.1	1018.7	12.47	11.39	294	358	289	355
110	01/06/96	16:52:47	17:47:24	**286**	**360**	236.2	1018.4	12.50	11.36			290	354
111	02/06/96	06:57:52	07:52:29	**296**	**368**	235.1	1018.1	11.16	11.34			300	362
112	02/06/96	08:40:28	09:35:05	**288**	**365**	263.3	1018.3	11.76	11.67			292	359
113	02/06/96	10:45:26	11:40:03	**277**	**366**	298.7	1018.1	12.68	12.48			281	360
114	02/06/96	11:51:38	12:46:15	**270**	**366**	313.6	1018.0	13.68	12.82			274	360
115	02/06/96	13:07:18	14:01:55	**267**	**364**	316.7	1017.6	14.48	12.99			271	358
116	02/06/96	14:07:11	15:01:48	**269**	**362**	316.1	1017.5	14.54	12.90			273	356
117	02/06/96	15:05:06	15:59:43	**275**	**360**	318.6	1017.4	14.74	13.09			279	354
118	02/06/96	17:12:32	18:07:09	**278**	**358**	328.6	1017.3	12.83	12.15			282	352
119	03/06/96	14:18:23	15:13:00	**259**	**355**	255.8	1020.1	13.92	13.28			263	349
120	03/06/96	15:38:51	15:38:51	**250**	**356**	238.9	1020.3	13.54	13.26			254	350
121	03/06/96	16:48:57	16:48:57	**-99**	**-99**	223.4	1020.2	14.18	13.51				
122	03/06/96	17:53:28	18:48:05	**-99**	**-99**	230.8	1020.3	13.98	13.57				
123	03/06/96	18:56:55	19:51:32	**-99**	**-99**	221.3	1020.5	13.34	13.50				
124	03/06/96	20:49:43	21:44:20	**-99**	**-99**	215.0	1021.1	13.21	12.43				
125	03/06/96	21:50:39	22:45:16	**-99**	**-99**	220.3	1021.5	12.90	11.78				
126	04/06/96	06:54:33	07:49:10	**281**	**358**	225.8	1025.1	12.05	11.77			285	352
127	04/06/96	07:49:46	08:44:23	**282**	**358**	230.4	1025.6	12.30	11.65			286	352
128	04/06/96	08:49:48	09:44:25	**283**	**359**	222.5	1026.3	12.72	11.79			287	353
129	04/06/96	09:52:02	10:46:39	**280**	**360**	219.3	1026.4	13.06	12.13			284	354
130	04/06/96	11:03:34	11:58:11	**268**	**360**	221.3	1026.8	13.17	12.42			272	354

Appendix B. Results from ASGAMAGE-B

Key to Appendix B

RUN_ID	=	KNMI run number	[-]
DATE	=	Date of start of the run	[day/month/year]
START	=	Start time of the run	[UTC]
END	=	End time of the run	[UTC]
C_c^e	**=**	**Consensus CO_2 concentration of equilibrator air**	**[ppm]**
C_c^a	**=**	**Consensus CO_2 concentration of open air**	**[ppm]**
ddd	=	Wind direction	[degrees]
ppp	=	Atmospheric surface pressure	[hPa]
Ta	=	Air temperature	[°C]
Ts	=	Sea water temperature	[°C]
C_K^e	=	CO_2 concentration in equilibrator air according to KNMI	[ppm]
C_K^a	=	CO_2 concentration in open air according to KNMI	[ppm]
C_N^e	=	CO_2 concentration in equilibrator air according to NIOZ	[ppm]
C_N^a	=	CO_2 concentration in open air according to NIOZ	[ppm]
C_T^e	=	CO_2 concentration in equilibrator air according to TNO-FEL	[ppm]
C_T^a	=	CO_2 concentration in open air according to TNO-FEL	[ppm]

Note: to convert air concentrations to water concentrations a salinity of 31 $^o/_{oo}$ may be used (Jacobs *et al.*, 1997, 1998b).

Appendix B (Continued)

RUN-ID	DATE	START	END	C_C^e	C_C^a	PN_dd	PPP	ASP_TS	Tss	C_K^e	C_K^a	C_N^e	C_N^a	C_T^e	C_T^a
-		UTC	UTC	**ppm**	**ppm**	degr.	hPa	°C	°C	ppm	ppm	ppm	ppm	ppm	ppm
1	15/10/96	09:31:07	10:25:44	**-99.99**	**-99.99**	210.7	1003.4	14.61	14.66						
2	15/10/96	11:00:08	11:54:45	**-99.99**	**-99.99**	218.3	1004.2	14.92	14.66						
3	15/10/96	12:50:02	13:44:39	**-99.99**	**-99.99**	230.1	1005.0	15.05	14.62						
4	15/10/96	14:59:05	15:53:42	**-99.99**	**-99.99**	230.4	1005.4	14.88	14.68						
5	15/10/96	16:00:55	16:55:32	**-99.99**	**-99.99**	220.9	1005.8	14.47	14.69						
6	15/10/96	18:01:05	18:55:42	**-99.99**	**-99.99**	225.3	1006.5	14.49	14.73						
7	15/10/96	19:17:03	20:11:40	**452.40**	**358.58**	255.1	1007.2	14.34	14.72					453.27	356.77
8	15/10/96	20:24:07	21:18:44	**455.47**	**358.20**	254.7	1007.8	14.24	14.70					456.35	356.39
9	15/10/96	21:45:01	22:39:31	**446.16**	**357.64**	255.6	1007.8	14.18	14.65			376.53	358.95	447.03	356.34
10	15/10/96	22:39:37	23:34:07	**442.69**	**357.32**	251.3	1007.6	14.01	14.62			375.24	358.85	443.57	355.79
11	15/10/96	23:34:12	00:28:42	**-99.99**	**-99.99**	254.0	1007.7	13.81	14.61						
12	16/10/96	00:28:46	01:23:16	**437.34**	**357.51**	249.1	1007.9	13.68	14.55			373.36	358.86	438.22	356.16
13	16/10/96	01:23:20	02:17:50	**438.64**	**357.65**	244.8	1007.9	13.51	14.49			373.95	359.04	439.51	356.25
14	16/10/96	02:17:54	03:12:24	**431.95**	**358.07**	240.8	1008.0	13.45	14.53			372.57	359.50	432.83	356.65
15	16/10/96	03:12:28	04:06:58	**431.66**	**358.63**	242.0	1008.0	13.40	14.58			372.39	360.09	432.53	357.18
16	16/10/96	04:07:03	05:01:40	**430.36**	**358.77**	244.3	1007.6	13.22	14.64			372.86	360.26	431.23	357.27
20	16/10/96	11:06:36	11:37:37	**419.14**	**-99.99**	200.6	1007.7	13.10	14.62			412.24	369.93	426.04	
21	16/10/96	11:55:08	12:49:45	**425.11**	**-99.99**	211.5	1007.6	13.49	14.63			424.23	369.47		
22	16/10/96	12:50:14	13:44:51	**-99.99**	**-99.99**	222.1	1007.2	13.68	14.60						
23	16/10/96	14:23:04	15:17:41	**-99.99**	**-99.99**	223.2	1006.8	13.67	14.59						
24	16/10/96	16:00:00	16:54:37	**426.96**	**361.17**	219.9	1006.7	13.44	14.63					427.83	359.31
25	16/10/96	16:58:11	17:52:48	**439.47**	**-99.99**	205.2	1007.0	13.45	14.61			444.36	444.47	434.59	359.98
26	16/10/96	18:01:00	18:55:37	**441.95**	**-99.99**	197.3	1007.1	13.48	14.65			444.87	398.71	439.03	363.49
27	16/10/96	19:00:40	19:55:17	**442.93**	**-99.99**	169.7	1007.2	13.14	14.65			445.01	372.89	440.86	372.10
28	17/10/96	08:00:08	08:54:44	**456.34**	**-99.99**	166.8	1007.1	11.20	14.56			465.36	438.13	447.33	419.54
29	17/10/96	18:00:12	18:54:49	**427.58**	**-99.99**	216.4	1008.9	12.76	14.54			426.70	370.86		
30	17/10/96	19:00:18	19:54:55	**420.96**	**367.73**	221.1	1009.2	12.31	14.59			420.08	369.66		
31	17/10/96	19:58:14	20:52:51	**422.53**	**-99.99**	206.1	1009.4	12.41	14.57			418.30	368.38	426.76	365.58
32	18/10/96	05:23:05	06:17:42	**434.85**	**-99.99**	180.8	1009.2	10.38	14.31			433.97	402.23		
33	18/10/96	06:27:41	07:22:18	**-99.99**	**-99.99**	184.9	1009.2	10.32	14.48						
34	18/10/96	07:59:58	08:54:35	**423.09**	**-99.99**	178.7	1009.3	9.78	14.55			424.62	398.96	421.56	396.72
35	18/10/96	08:59:59	09:54:36	**421.66**	**-99.99**	186.0	1009.2	9.20	14.54			422.91	399.31	420.40	395.76
36	18/10/96	09:59:59	10:54:36	**421.26**	**-99.99**	175.9	1009.1	10.04	14.52			422.58	391.86	419.95	386.83

Appendix B (Continued)

RUN-ID -	DATE	START UTC	END UTC	C_C^e ppm	C_C^a ppm	ddd degr.	PPP hPa	Ta °C	Ts °C	C_K^e ppm	C_K^a ppm	C_N^e ppm	C_N^a ppm	C_T^e ppm	C_T^a ppm
37	18/10/96	11:06:23	12:01:00	**433.72**	**-99.99**	186.3	1008.6	11.80	14.45			432.10	373.29	435.34	367.24
38	18/10/96	12:03:43	12:58:20	**439.71**	**-99.99**	189.8	1007.8	12.82	14.36			437.95	368.41	441.46	363.83
39	18/10/96	13:02:08	13:56:45	**441.75**	**-99.99**	186.8	1006.6	13.39	14.29			438.75	366.15	444.76	363.40
40	18/10/96	14:04:23	14:59:00	**442.36**	**-99.99**	186.8	1006.6	13.39	14.29			439.68	365.76	445.03	363.45
41	18/10/96	15:23:44	16:18:14	**440.79**	**-99.99**	185.2	1005.9	12.10	14.29			435.97	367.66	445.62	365.02
42	18/10/96	16:18:21	17:12:58	**436.65**	**-99.99**	183.2	1005.6	11.95	14.29			433.34	367.17	439.97	365.34
43	18/10/96	17:14:24	18:09:01	**428.49**	**-99.99**	185.5	1005.4	11.59	14.34			428.37	368.61	428.61	367.16
44	18/10/96	18:23:22	19:17:59	**420.70**	**-99.99**	193.2	1005.2	11.52	14.45			419.63	368.09	421.76	365.97
45	18/10/96	19:44:38	20:39:15	**414.17**	**-99.99**	202.9	1004.8	12.08	14.43			414.47	368.71	413.88	365.95
46	18/10/96	20:53:17	21:47:54	**415.92**	**-99.99**	200.3	1005.0	12.18	14.41			414.08	370.71	417.75	368.30
47	18/10/96	21:50:23	22:45:00	**417.89**	**-99.99**	196.2	1004.7	12.11	14.41			416.45	373.02	419.33	370.19
48	18/10/96	22:45:01	23:39:31	**415.64**	**-99.99**	199.9	1004.5	12.24	14.40			414.36	374.53	416.92	371.68
49	18/10/96	23:39:34	00:34:04	**-99.99**	**-99.99**	193.5	1004.3	11.92	14.40						
50	19/10/96	00:34:09	01:28:39	**416.51**	**-99.99**	206.3	1004.0	12.55	14.34			415.46	373.65	417.55	370.10
51	19/10/96	01:28:43	02:23:13	**417.73**	**365.98**	244.5	1004.1	13.90	14.28			416.86	368.02	418.61	363.94
52	19/10/96	02:23:17	03:17:47	**424.05**	**363.62**	270.9	1004.5	14.09	14.01			422.13	365.25	425.96	362.00
53	19/10/96	03:17:51	04:12:28	**418.07**	**363.64**	278.4	1005.0	13.95	14.21			417.80	365.75	418.35	361.52
55	19/10/96	05:06:59	06:01:36	**417.59**	**363.80**	295.2	1006.4	13.62	14.25			415.80	366.37	419.38	361.24
56	19/10/96	07:03:11	07:57:48	**415.56**	**361.99**	296.1	1009.0	13.36	14.34					416.43	359.97
57	19/10/96	08:04:53	08:59:30	**421.70**	**362.70**	294.4	1010.7	13.36	14.35			423.18	365.22	420.22	360.17
58	19/10/96	09:17:35	10:12:05	**424.00**	**363.03**	290.2	1012.5	13.37	14.36			427.13	365.31	420.88	360.75
59	19/10/96	10:12:12	11:06:42	**429.36**	**363.03**	287.7	1013.3	13.53	14.36			430.11	365.41	428.61	360.66
60	19/10/96	11:06:46	12:01:23	**424.79**	**362.02**	284.9	1014.3	13.72	14.36			424.98	364.89	424.60	359.14
61	19/10/96	12:02:10	12:56:47	**421.26**	**361.62**	283.9	1015.3	13.88	14.37			418.12	364.41	424.39	358.83
62	19/10/96	13:00:00	13:54:37	**413.96**	**361.82**	280.3	1015.7	14.05	14.35			413.09	363.86		
63	19/10/96	14:30:01	15:24:38	**417.77**	**362.12**	265.5	1016.7	13.57	14.25			416.89	364.16		
64	19/10/96	15:43:10	16:37:47	**428.41**	**362.16**	260.2	1017.3	13.76	14.17			427.53	364.20		
65	19/10/96	16:49:29	17:44:06	**421.92**	**362.43**	264.2	1017.9	13.88	14.15			421.05	364.48		
66	19/10/96	18:00:00	18:54:37	**416.40**	**361.85**	257.6	1018.0	14.16	14.16			415.52	363.90		
67	19/10/96	18:56:06	19:50:43	**-99.99**	**-99.99**	252.1	1018.7	14.41	14.25						
68	19/10/96	19:56:43	20:51:20	**-99.99**	**-99.99**	249.2	1018.5	14.47	14.33	400.37					
76	20/10/96	16:14:20	17:08:50	**430.88**	**366.97**	224.9	1014.8	14.25	14.23	438.04		432.96	366.83	428.81	367.10
77	20/10/96	17:08:54	18:03:31	**429.38**	**367.97**	218.6	1014.6	14.17	14.21	435.25		431.32	367.80	427.44	368.15

Appendix B (Continued)

RUN-ID -	DATE	START UTC	END UTC	C_C^e ppm	C_C^a ppm	ddd degr.	PPP hPa	Ta °C	Ts °C	C_K^e ppm	C_K^a ppm	C_N^e ppm	C_N^a ppm	C_T^e ppm	C_T^a ppm
78	20/10/96	18:09:11	19:03:48	**430.59**	**366.58**	217.5	1014.5	13.14	14.24			432.00	367.17	429.19	365.98
79	20/10/96	19:15:14	20:09:51	**429.99**	**-99.99**	201.8	1013.5	12.17	14.30			423.24	366.82	436.74	367.40
80	21/10/96	05:20:26	06:15:03	**425.49**	**364.26**	299.6	1010.3	15.24	14.27			429.45	367.61	421.53	360.91
81	21/10/96	06:15:43	07:10:20	**432.37**	**364.15**	308.8	1010.9	14.71	14.27			431.50	366.29		
82	21/10/96	07:37:26	08:32:03	**425.64**	**361.60**	316.0	1012.8	14.02	14.23			424.77	363.75		
83	21/10/96	08:34:34	09:29:11	**423.91**	**361.12**	319.3	1013.9	14.00	14.22			423.03	363.27		
84	21/10/96	09:45:43	10:40:20	**422.70**	**361.13**	315.6	1015.1	13.96	14.21			421.82	363.28		
85	21/10/96	10:44:05	11:38:42	**423.59**	**361.36**	314.4	1016.3	13.87	14.21			422.71	363.51		
86	21/10/96	11:39:13	12:33:50	**425.13**	**361.57**	312.5	1017.0	13.90	14.23			424.25	363.72		
87	21/10/96	12:36:46	13:31:23	**424.93**	**361.81**	312.9	1017.5	13.90	14.23			424.06	363.97		
88	21/10/96	13:33:35	14:28:12	**425.25**	**361.90**	314.5	1018.4	13.85	14.22	429.56		424.38	364.06		
89	21/10/96	14:29:28	15:24:05	**424.36**	**361.81**	317.1	1019.1	13.75	14.23	429.12		423.49	363.97		
90	21/10/96	15:26:34	16:21:11	**424.64**	**362.03**	318.0	1019.5	13.55	14.24	430.41		423.76	364.19		
91	21/10/96	17:16:19	18:10:56	**429.24**	**362.73**	312.1	1020.9	13.42	14.22	432.09		428.36	364.90		
92	21/10/96	18:10:57	19:05:27	**432.30**	**362.37**	313.9	1021.4	13.37	14.12	437.11		431.42	364.54		
93	21/10/96	19:05:31	20:00:08	**434.60**	**362.70**	315.1	1021.9	13.33	14.09	437.99		433.72	364.87		
94	21/10/96	21:19:07	22:13:37	**434.59**	**362.23**	305.3	1022.9	13.22	14.16			433.71	364.41		
95	21/10/96	22:13:41	23:08:11	**430.88**	**361.95**	308.4	1023.2	13.20	14.15			430.01	364.13		
96	21/10/96	23:08:16	00:02:46	**-99.99**	**-99.99**	312.2	1023.4	13.24	14.08						
97	22/10/96	00:02:51	00:57:21	**432.55**	**361.57**	320.8	1023.4	13.28	14.05			431.68	363.76		
98	22/10/96	00:57:25	01:51:55	**433.65**	**361.51**	321.1	1023.2	13.27	14.01			432.77	363.69		
99	22/10/96	01:52:00	02:46:30	**433.24**	**361.30**	299.4	1023.4	13.25	13.98			432.37	363.49		
100	22/10/96	02:46:34	03:41:04	**432.48**	**361.13**	275.7	1023.5	13.25	14.03			431.61	363.32		
101	22/10/96	03:41:08	04:35:38	**430.56**	**361.26**	255.7	1023.5	13.26	14.10			429.68	363.46		
102	19/10/96	14:30:01	15:24:38	**417.77**	**362.12**	265.5	1016.7	13.57	14.25			416.89	364.16		
103	19/10/96	15:43:10	16:37:47	**428.41**	**362.16**	260.2	1017.3	13.76	14.17			427.53	364.20		
104	19/10/96	16:49:29	17:44:06	**421.92**	**362.43**	264.2	1017.9	13.88	14.15			421.05	364.48		
105	22/10/96	12:00:33	12:55:10	**430.68**	**381.39**	220.1	1026.0	13.43	14.07	424.17		429.81	383.60		
106	22/10/96	12:59:47	13:54:24	**431.83**	**377.66**	222.6	1026.0	13.66	14.09	431.71		430.95	379.88		
107	22/10/96	14:00:00	14:54:37	**434.52**	**377.02**	227.0	1026.0	13.84	14.06	433.69		433.65	379.24		
108	22/10/96	15:00:00	15:54:37	**432.35**	**373.60**	229.1	1026.0	13.57	14.07	425.56	372.27	431.47	375.82		
113	28/10/96	15:30:47	16:25:24	**-99.99**	**359.31**	223.2	996.9	14.51	13.67	456.20		433.42	361.66	450.15	356.96
116	28/10/96	19:09:33	20:04:10	**-99.99**	**-99.99**	208.8	994.9	14.34	13.56	453.57		445.36	365.68	453.81	361.02

Appendix B (Continued)

RUN-ID -	DATE	START UTC	END UTC	**C_C^e ppm**	**C_C^a ppm**	ddd degr.	PPP hPa	Ta °C	Ts °C	C_K^e ppm	C_K^a ppm	C_N^e ppm	C_N^a ppm	C_T^e ppm	C_T^a ppm
117	28/10/96	20:15:36	21:10:13	**-99.99**	**-99.99**	207.8		14.14				443.09	365.38		
118	28/10/96	21:20:45	22:15:22	**-99.99**	**-99.99**	204.8	991.8	14.09	13.57			443.25	364.26		
119	28/10/96	22:16:11	22:48:23	**-99.99**	**-99.99**	202.1	990.0	13.86	13.56			442.94	363.91		
120	28/10/96	22:59:27	23:54:04	**-99.99**	**-99.99**	197.0	988.5	13.44	13.50			442.95	364.88	454.18	360.44
122	29/10/96	00:48:39	01:43:16	**-99.99**	**-99.99**	205.3	984.9	11.72	13.55			441.29	364.51	453.85	359.71
131	29/10/96	10:33:26	11:27:56	**-99.99**	**359.34**	321.9	1001.7	12.19	13.41	457.51		436.18	361.97		
132	29/10/96	11:28:01	12:22:38	**-99.99**	**359.22**	320.3	1003.2	11.46	13.42	459.42		436.12	361.85		
133	29/10/96	12:22:53	13:17:30	**-99.99**	**359.34**	315.3	1004.8	12.11	13.43	460.27	377.19	436.27	361.98		
134	29/10/96	13:19:15	14:13:45	**-99.99**	**359.62**	313.5	1006.1	11.47	13.44		361.60	434.07	362.26		
135	29/10/96	14:13:52	15:08:29	**-99.99**	**359.76**	307.8	1007.3	11.59	13.38		362.26	438.51	362.40		
137	29/10/96	15:34:40	16:29:17	**-99.99**	**359.64**	305.3	1008.7	11.07	13.36		363.35	433.25	362.28		
138	29/10/96	16:52:03	17:46:40	**-99.99**	**359.98**	305.8	1009.3	10.97	12.95		364.02	428.01	362.63		
139	29/10/96	17:57:03	18:51:40	**-99.99**	**359.88**	307.9	1010.7	10.63	13.20		364.68	425.54	362.53		
140	29/10/96	18:56:53	19:51:30	**-99.99**	**359.75**	303.5	1012.1	10.73	13.05		364.97	422.91	362.40		
141	29/10/96	19:54:16	20:48:53	**-99.99**	**359.66**	303.1	1013.4	10.95	12.86		365.06	423.04	362.31		
142	29/10/96	20:51:56	21:46:33	**-99.99**	**359.55**	305.8	1013.9	10.83	12.84		365.41	420.61	362.21		
143	29/10/96	21:55:54	22:50:24	**-99.99**	**-99.99**	307.1	1014.9	11.14	12.72		365.65				
144	29/10/96	22:50:31	23:45:01	**-99.99**	**359.35**	306.0	1015.7	11.17	12.55		365.76	420.55	362.02		
145	29/10/96	23:45:06	00:39:36	**-99.99**	**-99.99**	303.1	1016.5	11.12	12.48		365.82				
146	30/10/96	00:39:40	01:34:10	**-99.99**	**359.18**	305.4	1016.9	11.19	12.53		366.06	418.47	361.84		
147	30/10/96	01:34:15	02:28:45	**-99.99**	**359.35**	302.0	1017.5	11.24	12.72		366.33	417.01	362.02		
148	30/10/96	02:28:49	03:23:19	**-99.99**	**359.52**	298.3	1018.0	11.13	12.83		366.67	416.51	362.20		
149	30/10/96	03:23:23	04:17:53	**-99.99**	**359.64**	291.2	1018.3	11.00	13.11		367.05	416.24	362.32		
150	30/10/96	04:17:57	05:12:27	**-99.99**	**359.97**	292.0	1018.9	10.83	13.20		367.58	416.39	362.65		
151	30/10/96	05:12:32	06:07:02	**-99.99**	**360.54**	290.2	1019.2	10.64	13.18		368.38	415.76	363.22		
152	30/10/96	06:07:06	07:01:43	**-99.99**	**360.05**	289.0	1019.7	10.62	13.15		368.37	417.58	362.73		
153	30/10/96	13:00:00	13:54:37	**441.70**	**-99.99**	261.0	1019.9	11.70	13.15	440.76					
154	30/10/96	14:00:01	14:54:38	**448.99**	**359.88**	260.0	1022.5	11.96	13.19	448.05		438.55	362.58		
155	30/10/96	15:03:58	15:58:35	**446.98**	**361.34**	263.0	1022.0	12.04	13.18	446.04		438.48	363.21	447.92	359.48
156	30/10/96	16:36:20	17:30:57	**445.91**	**362.43**	268.6	1022.0	12.08	13.12		361.82			446.85	359.72
157	30/10/96	17:30:58	18:25:35	**452.46**	**364.26**	266.9	1022.3	12.16	13.08	452.95	362.62			451.98	361.55
158	30/10/96	19:22:00	20:16:37	**454.03**	**362.14**	271.8	1022.2	12.22	13.05	452.27		435.81	364.16	455.80	360.11
159	30/10/96	20:17:40	21:12:17	**456.56**	**362.08**	270.5	1021.9	12.27	13.05	455.62		437.51	364.01	457.50	360.15

Appendix B (Continued)

RUN-ID -	DATE	START UTC	END UTC	C_C^e ppm	C_C^a ppm	ddd degr.	PPP hPa	Ta °C	Ts °C	C_K^e ppm	C_K^a ppm	C_N^e ppm	C_N^a ppm	C_T^e ppm	C_T^a ppm
160	30/10/96	21:29:57	22:24:34	**454.52**	**362.23**	271.2	1021.8	12.28	13.05	453.50		436.56	364.34	455.55	360.11
161	31/10/96	06:09:14	07:03:51	**448.08**	**-99.99**	215.3	1022.0	11.77	12.98			435.05	365.18	449.02	363.41
162	31/10/96	07:07:54	08:02:31	**451.64**	**365.03**	221.7	1018.3	11.39	12.98			435.99	369.17	452.58	360.90
163	31/10/96	08:10:10	09:04:47	**454.84**	**-99.99**	218.1	1018.0	11.86	12.92	456.23		429.03	364.52	453.46	360.09
164	31/10/96	09:25:22	10:19:59	**456.10**	**-99.99**	214.6	1017.3	11.02	12.91	457.19		428.73	363.41	455.02	360.88
165	31/10/96	10:31:29	11:25:59	**455.36**	**-99.99**	212.8	1016.8	9.86	12.94	455.75		427.48	365.39	454.97	363.31
166	31/10/96	11:26:06	12:20:36	**452.67**	**-99.99**	208.2	1016.4	9.59	12.90	452.61		428.23	368.78	452.74	364.44
167	31/10/96	12:20:40	13:15:17	**450.59**	**-99.99**	204.6	1015.3	9.55	12.84	449.78		428.24	369.44	451.39	365.25
168	31/10/96	13:20:47	14:15:24	**453.33**	**-99.99**	204.8	1014.1	9.43	12.85	451.96		430.52	370.59	454.70	366.21
169	31/10/96	14:15:25	15:10:02	**452.56**	**-99.99**	206.3	1012.7	9.44	12.89	451.18		432.20	371.90	453.93	368.50
170	31/10/96	15:13:27	16:08:04	**449.70**	**-99.99**	204.8	1011.9	9.56	12.89	448.07		431.10	373.37	451.33	368.12
171	31/10/96	16:16:01	17:10:31	**451.89**	**-99.99**	205.8	1010.6	9.94	12.84	449.88		432.07	372.59	453.89	367.40
172	31/10/96	17:10:38	18:05:15	**453.49**	**-99.99**	204.8	1009.5	10.25	12.79	453.05		429.67	371.85	453.92	366.31
173	31/10/96	19:51:01	20:45:31	**460.71**	**-99.99**	210.1	1008.8	11.76	12.65	456.49		446.16	372.18	464.93	365.02
174	31/10/96	20:45:36	21:40:13	**463.27**	**363.77**	246.2	1005.7	13.31	12.63	457.92		446.78	367.98	468.61	359.56
175	31/10/96	22:26:06	23:20:43	**463.50**	**363.20**	264.7	1005.6	13.73	12.68	458.73		447.83	366.45	468.27	359.95
176	31/10/96	23:20:45	00:15:15	**456.93**	**-99.99**	270.7	1005.8	13.74	12.71	455.99					
177	01/11/96	00:15:17	01:09:47	**457.20**	**363.21**	276.9	1006.1	13.73	12.74	453.55		440.72	366.21	460.84	360.22
178	01/11/96	01:09:51	02:04:28	**459.66**	**363.84**	282.1	1006.9	13.78	12.76	457.59		441.78	366.80	461.73	360.87
179	01/11/96	02:04:29	02:58:59	**463.98**	**363.97**	291.0	1007.8	13.71	12.78	462.37		443.77	367.09	465.58	360.86
180	01/11/96	02:58:59	03:53:29	**462.71**	**363.11**	296.8	1008.9	13.29	12.78	461.49		443.31	365.99	463.92	360.24
181	01/11/96	03:53:34	04:48:11	**457.61**	**362.05**	300.0	1009.8	12.98	12.76	456.97		439.20	365.48	458.24	358.62
182	01/11/96	04:48:12	05:42:42	**455.63**	**361.41**	302.4	1011.4	12.51	12.73	454.72		436.58	363.94	456.54	358.89
183	01/11/96	05:42:42	06:37:19	**459.43**	**362.19**	300.0	1012.7	12.53	12.67	459.92		439.18	364.50	458.94	359.89
184	01/11/96	09:00:00	09:54:37	**470.85**	**361.26**	300.9	1013.8	12.15	12.50	470.26		448.27	363.30	471.44	359.23
185	01/11/96	09:55:17	10:49:54	**466.96**	**361.30**	301.0	1018.0	12.17	12.49	466.82		453.26	363.15	467.10	359.45
186	01/11/96	11:00:00	11:54:37	**462.91**	**361.45**	292.6	1018.7	12.21	12.52	464.67		431.02	363.29	461.15	359.61
187	01/11/96	12:00:45	12:55:22	**460.56**	**362.33**	279.5	1019.6	12.09	12.52	459.58		431.99	364.30	461.54	360.36
188	01/11/96	12:56:45	13:51:22	**461.78**	**362.50**	262.6	1020.2	12.23	12.64	461.46		444.64	364.65	462.11	360.35
189	01/11/96	15:36:29	16:31:06	**465.88**	**362.51**	249.2	1020.6	12.19	12.73	468.03		450.61	364.50	463.73	360.52
190	01/11/96	17:00:30	17:55:07	**457.38**	**362.52**	242.7	1021.1	12.50	12.68	460.27		442.81	364.67	454.49	360.37
191	01/11/96	18:06:25	19:01:02	**463.55**	**364.44**	235.6	1021.2	12.75	12.53	468.66		447.19	366.66	458.44	362.23
192	01/11/96	19:01:03	19:55:40	**463.70**	**363.75**	225.4	1021.4	12.68	12.53	467.52		448.13	366.58	459.87	360.92

Appendix B (Continued)

RUN-ID	DATE	START	END	**C_C^e**	**C_C^a**	ddd	PPP	Ta	Ts	C_K^e	C_K^a	C_N^e	C_N^a	C_T^e	C_T^a
-		UTC	UTC	**ppm**	**ppm**	degr.	hPa	°C	°C	ppm	ppm	ppm	ppm	ppm	ppm
193	01/11/96	20:21:32	21:16:09	**467.25**	**364.39**	221.4	1021.3	12.80	12.54	470.54		451.35	367.13	463.96	361.65
194	01/11/96	21:18:42	22:13:19	**469.56**	**362.85**	227.2	1020.9	13.63	12.56	472.97		452.90	366.57	466.15	359.12
195	01/11/96	22:54:32	23:49:02	**466.89**	**361.83**	225.4	1020.9	13.47	12.54	471.38		450.77	364.62	462.40	359.05
196	01/11/96	23:49:07	00:43:44	**465.67**	**-99.99**	231.4	1020.3	13.55	12.55	469.04					
197	02/11/96	00:43:44	01:38:14	**460.28**	**362.42**	233.2	1020.3	13.60	12.59	465.11		445.01	365.18	455.45	359.65
198	02/11/96	01:38:18	02:32:48	**458.94**	**362.20**	231.6	1020.0	13.57	12.67			444.82	364.92	455.57	359.48
199	02/11/96	02:32:53	03:27:23	**462.84**	**361.51**	228.3	1019.9	13.66	12.70			447.56	364.34	459.47	358.68
200	02/11/96	03:27:27	04:21:57	**462.43**	**361.03**	228.5	1019.4	13.75	12.70			447.73	363.88	459.06	358.19
201	02/11/96	04:22:01	05:16:31	**460.64**	**360.80**	229.8	1019.0	13.79	12.69	465.77		445.14	363.72	455.50	357.87
202	02/11/96	05:16:35	06:11:05	**461.29**	**360.87**	226.5	1018.8	13.79	12.61	468.37		443.01	363.81	454.22	357.94
203	02/11/96	06:11:09	07:05:46	**463.33**	**361.12**	226.4	1018.5	13.81	12.55	469.52		446.55	364.01	457.14	358.24
204	02/11/96	07:54:27	08:49:04	**468.63**	**361.69**	226.4	1018.8	13.84	12.53	467.29	363.31	456.13	364.61	469.97	358.77
205	02/11/96	08:55:17	09:49:54	**472.45**	**361.55**	229.3	1018.3	13.97	12.59			455.15	364.60	469.08	358.50
206	02/11/96	10:09:22	11:03:52	**473.10**	**361.20**	226.4	1018.7	13.98	12.61	475.36	361.92	456.45	364.01	470.84	358.39
207	02/11/96	11:03:58	11:58:35	**474.79**	**361.15**	225.9	1018.6	13.93	12.60	478.78		456.45	364.03	470.79	358.27
208	02/11/96	11:59:12	12:53:49	**477.46**	**361.74**	228.7	1018.4	13.94	12.55	480.94		458.22	364.52	473.97	358.96
209	02/11/96	12:59:29	13:54:06	**471.85**	**362.20**	225.3	1017.9	13.89	12.58	474.76	362.77	455.13	365.11	468.93	359.28
210	02/11/96	14:32:20	15:26:57	**469.13**	**362.39**	225.7	1017.9	13.83	12.62	471.77		451.73	365.68	466.49	359.10
211	02/11/96	15:39:16	16:33:53	**467.16**	**361.66**	227.8	1017.4	14.00	12.62	470.34	362.26	449.53	364.83	463.99	358.50
212	02/11/96	16:50:07	17:44:44	**466.85**	**361.09**	230.4	1017.2	14.13	12.59	466.54		450.19	364.16	467.15	358.03
213	02/11/96	17:55:07	18:49:44	**474.36**	**360.93**	233.4	1017.5	14.09	12.63	476.24		455.20	364.29	472.48	357.57
214	02/11/96	18:54:15	19:48:52	**478.39**	**360.07**	231.1	1017.6	14.14	12.63	480.96		459.78	363.34	475.81	356.80
215	02/11/96	19:58:53	20:53:30	**485.04**	**359.73**	231.4	1017.3	14.24	12.61			464.02	362.88	481.67	356.58
216	02/11/96	21:15:51	22:10:28	**485.27**	**359.38**	230.9	1017.0	14.32	12.65	489.32		463.74	362.53	481.22	356.22
217	02/11/96	22:30:06	23:24:36	**486.66**	**359.22**	229.2	1017.4	14.08	12.65	490.14		455.37	362.34	483.19	356.11
219	02/11/96	23:24:40	00:19:00	**487.26**	**-99.99**	228.9	1016.9	13.90	12.61	490.63					
220	03/11/96	00:19:16	01:13:46	**486.26**	**360.49**	233.4	1016.5	13.94	12.63	489.08		440.72	363.60	483.43	357.37
221	03/11/96	01:13:50	02:08:20	**482.97**	**360.36**	229.7	1015.8	13.80	12.64	486.30		438.92	363.53	479.64	357.19
222	03/11/96	02:08:24	03:02:54	**481.77**	**360.41**	226.5	1015.5	13.58	12.65	486.00		437.45	363.27	477.54	357.55
223	03/11/96	03:02:59	03:57:29	**481.37**	**361.47**	226.4	1015.2	13.77	12.65					478.00	358.56
224	03/11/96	03:57:33	04:52:03	**479.29**	**361.15**	229.0	1014.6	13.96	12.66	483.11				475.47	358.23
225	03/11/96	04:52:07	05:46:37	**481.22**	**361.14**	225.2	1014.4	13.82	12.63	487.24				475.20	358.22
226	03/11/96	05:46:41	06:41:18	**482.72**	**361.60**	224.6	1014.1	13.82	12.74	485.51	364.80			479.93	358.68

Appendix B (Continued)

RUN-ID -	DATE	START UTC	END UTC	C_C^e **ppm**	C_C^a **ppm**	ddd degr.	PPP hPa	Ta °C	Ts °C	C_K^e ppm	C_K^a ppm	C_N^e ppm	C_N^a ppm	C_T^e ppm	C_T^a ppm
227	03/11/96	08:11:55	09:06:32	**477.30**	**363.74**	224.1	1013.7	13.56	12.81	479.01		466.49	366.80	475.59	360.68
228	03/11/96	10:23:52	11:18:29	**474.16**	**364.04**	222.6	1013.2	13.65	12.81	478.76		461.12	367.02	469.57	361.05
229	03/11/96	11:39:17	12:33:54	**478.91**	**363.54**	220.4	1012.7	13.51	12.75	484.09		462.72	366.59	473.73	360.48
230	03/11/96	13:40:29	14:35:06	**482.76**	**363.68**	219.7	1012.7	13.55	12.72	488.62	363.37	467.35	366.67	476.90	360.69
231	03/11/96	14:42:50	15:37:27	**488.46**	**362.96**	225.7	1012.3	13.85	12.72	492.51				484.40	360.02
232	03/11/96	15:47:06	16:41:43	**487.43**	**361.52**	227.8	1011.9	13.96	12.72	490.25				484.61	358.57
233	03/11/96	16:51:00	17:45:37	**483.43**	**361.35**	227.3	1012.0	14.03	12.77	485.03				481.83	358.40
234	03/11/96	17:57:42	18:52:19	**479.38**	**360.61**	227.3	1012.0	13.94	12.82	481.66				477.09	357.65
235	03/11/96	18:56:19	19:50:56	**478.11**	**360.73**	224.1	1011.8	13.87	12.85	482.58				473.64	357.77
236	03/11/96	20:25:50	21:20:27	**479.07**	**360.82**	223.0	1011.3	13.80	12.88	483.86				474.29	357.86
237	03/11/96	21:25:49	22:20:26	**479.51**	**360.58**	220.8	1011.1	13.72	12.89	483.64				475.39	357.62
238	03/11/96	22:20:29	23:14:59	**480.79**	**360.67**	220.1	1010.9	13.60	12.88	485.23				476.36	357.71
239	03/11/96	23:15:00	00:09:30	**481.43**	**-99.99**	222.3	1010.5	13.53	12.89	484.80					
240	04/11/96	00:09:35	01:04:12	**480.24**	**361.28**	221.8	1010.0	13.63	12.89	482.71				477.77	358.32
241	04/11/96	01:04:12	01:58:42	**479.17**	**361.11**	223.7	1009.0	13.49	12.84	483.85				474.49	358.14
242	04/11/96	01:58:43	02:53:13	**484.01**	**363.64**	204.7	1007.6	13.36	12.85	490.65				477.37	360.67
243	04/11/96	02:53:17	03:47:48	**487.27**	**-99.99**	202.2	1006.5	13.77	12.82	489.82				484.72	362.92
244	04/11/96	03:47:54	04:42:24	**486.94**	**-99.99**	198.9	1005.4	14.07	12.81	489.39				484.50	363.64
245	04/11/96	04:42:26	05:36:56	**486.12**	**-99.99**	198.7	1004.2	14.09	12.79	488.03				484.21	364.40
246	04/11/96	05:37:00	06:31:37	**486.32**	**-99.99**	200.4	1001.8	13.80	12.85	488.09				484.55	364.23
247	04/11/96	09:29:00	10:23:37	**485.24**	**-99.99**	199.9	1001.3	13.38	12.84	489.50				480.98	364.74
248	04/11/96	10:23:51	11:18:28	**485.56**	**-99.99**	202.8	999.3	13.65	12.83	490.57				480.55	364.85
249	04/11/96	11:51:25	12:46:02	**488.11**	**-99.99**	204.5	998.4	13.74	12.82	491.00				485.22	364.68
250	04/11/96	13:15:26	14:10:03	**488.62**	**-99.99**	213.4	997.9	13.33	12.80	492.42				484.82	364.93
251	04/11/96	14:40:01	15:34:38	**490.12**	**-99.99**	203.5	997.3	13.40	12.78	493.89				486.35	364.79
252	04/11/96	16:36:36	17:31:13	**490.56**	**-99.99**	199.8	996.3	13.29	12.79	491.21				489.92	366.21
253	04/11/96	18:00:06	18:54:43	**487.32**	**-99.99**	203.8	995.1	12.98	12.87	485.72				488.92	367.58
254	04/11/96	19:30:36	20:25:13	**486.18**	**-99.99**	218.8	994.9	12.94	12.85	489.06				483.31	365.43
255	04/11/96	20:42:24	21:37:01	**487.66**	**363.70**	210.7	994.9	12.86	12.88	488.11				487.21	360.68
256	04/11/96	22:07:31	23:02:08	**480.05**	**-99.99**	261.8	995.9	12.08	12.88	475.12				484.98	362.93
257	05/11/96	07:54:25	08:49:02	**476.79**	**364.44**	266.9	997.0	11.71	12.87	473.02				480.56	361.39
258	05/11/96	09:49:36	10:44:13	**479.23**	**364.79**	270.6	998.3	11.49	12.87	477.89				480.57	361.74
259	05/11/96	10:55:07	11:49:44	**486.57**	**365.05**	278.0	999.9	11.53	12.78	487.85				485.29	361.99

Appendix B (Continued)

RUN-ID	DATE	START	END	C_C^e	C_C^a	ddd	PPP	Ta	Ts	C_K^e	C_K^a	C_N^e	C_N^a	C_T^e	C_T^a
-		UTC	UTC	**ppm**	**ppm**	degr.	hPa	°C	°C	ppm	ppm	ppm	ppm	ppm	ppm
260	05/11/96	12:01:01	12:55:38	**485.67**	**364.93**	279.6	1001.5	11.67	12.79	487.53				483.81	361.87
261	05/11/96	12:58:36	13:53:13	**482.20**	**364.71**	279.3	1003.1	11.64	12.83	485.04				479.35	361.65
262	05/11/96	13:56:29	14:51:06	**482.65**	**363.08**	286.3	1005.2	10.96	12.82	485.40				479.91	360.02
263	05/11/96	15:03:35	15:58:12	**485.47**	**363.17**	295.3	1006.9	10.95	12.76	489.58				481.37	360.10
264	05/11/96	15:58:43	16:53:20	**481.12**	**364.53**	289.7	1008.4	10.86	12.77	485.25				476.99	361.46
265	05/11/96	18:21:05	19:15:35	**474.37**	**364.14**	268.1	1010.2	11.68	12.83	474.65				474.08	361.07
266	05/11/96	19:15:40	20:10:17	**472.61**	**364.04**	257.8	1010.7	11.71	12.65	476.46				468.76	360.96
267	05/11/96	20:10:17	21:04:47	**466.15**	**363.85**	245.5	1010.2	11.80	11.87					462.78	360.78
268	05/11/96	21:04:50	21:59:20	**472.15**	**363.83**	234.1	1010.3	11.92	12.67	477.56				466.75	360.75
269	05/11/96	21:59:25	22:53:55	**474.87**	**365.27**	236.1	1009.6	12.13	12.68	480.44				469.30	362.19
270	05/11/96	22:53:59	23:48:29	**473.64**	**-99.99**	208.3	1008.3	10.84	12.76	478.83				468.44	368.91
271	05/11/96	23:48:35	00:43:05	**479.57**	**-99.99**	206.2	1007.2	10.95	12.72	482.94					
272	06/11/96	00:43:08	01:37:38	**481.61**	**-99.99**	208.1	1005.9	11.37	12.66	485.43				477.79	365.20
273	06/11/96	01:37:42	02:32:12	**482.05**	**-99.99**	209.8	1004.1	11.61	12.60	485.62				478.48	364.68
274	06/11/96	02:32:16	03:26:46	**483.42**	**-99.99**	211.5	1002.8	11.74	12.55	486.72				480.12	363.43
275	06/11/96	03:26:50	04:21:20	**484.84**	**-99.99**	214.3	1001.0	11.86	12.51					481.47	362.48
276	06/11/96	04:21:24	05:16:01	**484.22**	**-99.99**	213.3	999.9	12.05	12.49					480.85	362.40
277	06/11/96	05:16:01	06:10:31	**484.27**	**-99.99**	212.4	998.8	12.04	12.48					480.90	363.59
278	06/11/96	06:10:33	07:05:03	**484.95**	**-99.99**	212.1	997.6	11.79	12.48					481.58	363.14
279	06/11/96	07:05:07	07:55:15	**464.30**	**-99.99**	216.5	996.5	12.26	12.54					460.93	361.19
280	06/11/96	08:03:15	08:57:45	**-99.99**	**363.22**	228.4	997.7	12.47	12.58						360.11
281	06/11/96	08:57:51	09:52:28	**-99.99**	**361.28**	248.8	996.9	13.00	12.49						358.17
282	06/11/96	09:52:28	10:46:58	**-99.99**	**362.61**	246.0	997.9	13.37	12.49						359.49

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