TAbMEP Assessment: ICARTT CH_4 Measurements

1. Introduction

Here we provide the assessment for the methane (CH_4) measurements during the summer 2004 ICARTT field campaign [*Fehsenfeld et al.*, 2006, *Singh et al*., 2006]. This assessment is based upon the three wing-tip-to-wing-tip intercomparison flights conducted during the field campaign. Recommendations provided here offer TAbMEP assessed biases for each of the measurements and a systematic approach to unifying the ICARTT CH_4 data for any integrated analysis. These recommendations are directly derived from the instrument performance demonstrated during the ICARTT measurement comparison exercises and are not to be extrapolated beyond this campaign.

2. ICARTT CH_4 Measurements

During the ICARTT campaign, there were two CH_4 measurements deployed on NASA DC-8 and NOAA WP-3D aircraft. Table 1 summarizes these techniques and gives references for more information.

Table 1. CH_4 measurements deployed on aircraft during ICARTT

Aircraft	Instrument	Reference
NASA DC-8	Whole Air Sampler (WAS)	*Simpson et al.* [2002, 2006]
NOAA WP-3D	Whole Air Sampler (WAS)	Contact PI: eatlas@rsmas.miami.edu

3. Summary of Results

Table 2 summarizes the assessed biases as well as PI reported uncertainties for each of the two CH_4 measurements involved in the intercomparisons. More detailed descriptions are provided to illustrate the process for the bias assessment in Section 4.1. The TAbMEP-prescribed IEIP procedures cannot be applied to the ICARTT CH_4 measurement for precision assessments. This is because the reported data have large time gaps and a small data population (see Section 3.1 of the introduction). The assessed bias reported in Table 2 (see Section 4.1 for details) can be applied to maximize the consistency between the data sets, by subtracting the bias value from the reported data to 'unify' the data sets. If one assumes instrument performance remained constant throughout the mission, the assessed bias may be extrapolated to the entire mission although it is derived from intercomparison periods only.

Table 2. Recommended ICARTT CH_4 measurement treatment

Aircraft/ Instrument	Reported 2σ Uncertainty	Assessed Bias (ppbv)
NASA DC-8 WAS	Precision: 0.2% Accuracy: 1%	$-38.86 + 0.0249\ CH_{4\ \mathrm{DC\text{-}8}}$
NOAA WP-3D WAS	Precision: 0.4% Accuracy: 1%	$40.90 - 0.0262\ CH_{4\ \mathrm{WP\text{-}3D}}$

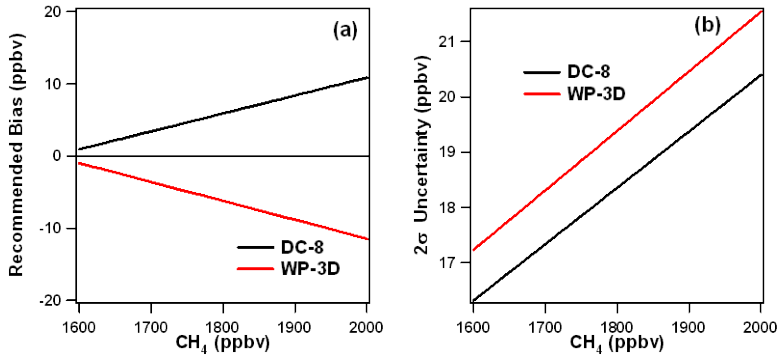

Figure 1. Recommended bias (panel a) and PI reported 2σ uncertainty (panel b) for DC-8 (black) and WP-3D (red) as a function of CH_4 level. Values were calculated based upon data shown in Table 2.

4. Results and Discussion

4.1 Bias Analysis

Section 3.3 in the introduction describes the process used to determine the best estimate bias. Figure 2 shows the time series plots for each of the three WP-3D vs. DC-8 comparisons. As shown in the Figure, the data sets have similar trends for 07/22 and 07/31. There are some differences in trend for 08/07, but the absolute difference is less than 25 ppbv for points in which the DC-8 and WP-3D sampling intervals overlapped. Figure 4 displays the residuals (i.e., the difference between DC-8 and WP-3D) which are less than 25 ppbv, which is about 1.3%, well within the combined uncertainties. Unlike the DC-8 data, the WP-3D CH_4 is not reported under dry conditions. The WP-3D PI also noted potential condensation problems in the canister and sampling lines. It was determined that there was insufficient information to appropriately account for the moisture level for the wet to dry conversion. This is one of the factors contributing to the differences between WP-3D and DC-8 measurements. For 2 out of 3 flights, there are only 3 or 4 overlapping points with a small range of variation (3 - 5 ppbv). It is not statistically significant to show the linear regression for these flights. Therefore, linear regression is performed over the data combined from all three flights. The linear relationships listed in Table 3 were derived from the regression equation found in Figure 3. The reference standard for comparison (RSC), as defined in the introduction, is constructed by averaging the NOAA WP-3D and NASA DC-8 measurements with equal weights. The resulting RSC can be expressed as a function of the DC-8 CH_4 measurement by the following:

$$RSC_{CH4} = 38.861 + 0.975\ CH_{4\text{-}DC8}$$

The RSC is then used to calculate the best estimate bias as described in Section 3.3 of the introduction. It should be noted that the initial choice of the reference instrument (DC-8 WAS) is arbitrary, and has no impact on the final recommendations. Table 3 summarizes the assessed measurement bias for each of the two ICARTT CH_4 measurements. Note that additional decimal places were carried in the calculations to ensure better precision. It is also noted that the intercept in the equations listed in Table 3 should not be viewed as an offset. These linear equations are used to best describe the linear relation between the WP-3D and DC-8 measurements.

The WAS technique for measuring VOCs presents some challenges in analyzing the data. The DC-8 data have an integration time of approximately 60-70 seconds, while the WP-3D data have an integration time between 6-11 seconds. For these measurements to be considered

simultaneous and correlated, the start and stop times of the WP-3D data must fall within the start and stop times of the DC-8 data. In order to maximize the data coverage for statistical analysis, one exception is made to this rule. If the shorter (WP-3D) integration time falls outside the longer integration time by no more than two seconds, the data points are also considered to be simultaneous. Only the PI reported data are used in this assessment, and no interpolation is included. It is noted here the integration time difference may potentially be another factor leading to the difference between the DC-8 and WP-3D measurements.

Table 3. ICARTT CH_4 bias estimates

Aircraft/ Instrument	**Linear Relationships**	**Best Estimate Bias ($a + b\ CH_4$) (ppbv)**
NASA DC-8 WAS	$CH_{4\ DC\text{-}8} = 0.00 + 1.000\ CH_{4\ DC\text{-}8}$	$-38.86 + 0.0249\ CH_{4\ DC\text{-}8}$
NASA WP-3D WAS	$CH_{4\ WP\text{-}3D} = 77.72 + 0.950\ CH_{4\ DC\text{-}8}$	$40.90 - 0.0262\ CH_{4\ WP\text{-}3D}$

4.2 Precision Analysis

A detailed description of the precision assessment is given in Section 3.1 of the introduction. The IEIP precision, expected variability, and adjusted precision could not be calculated for CH_4 because of the small number of points and large time gaps between measurements.

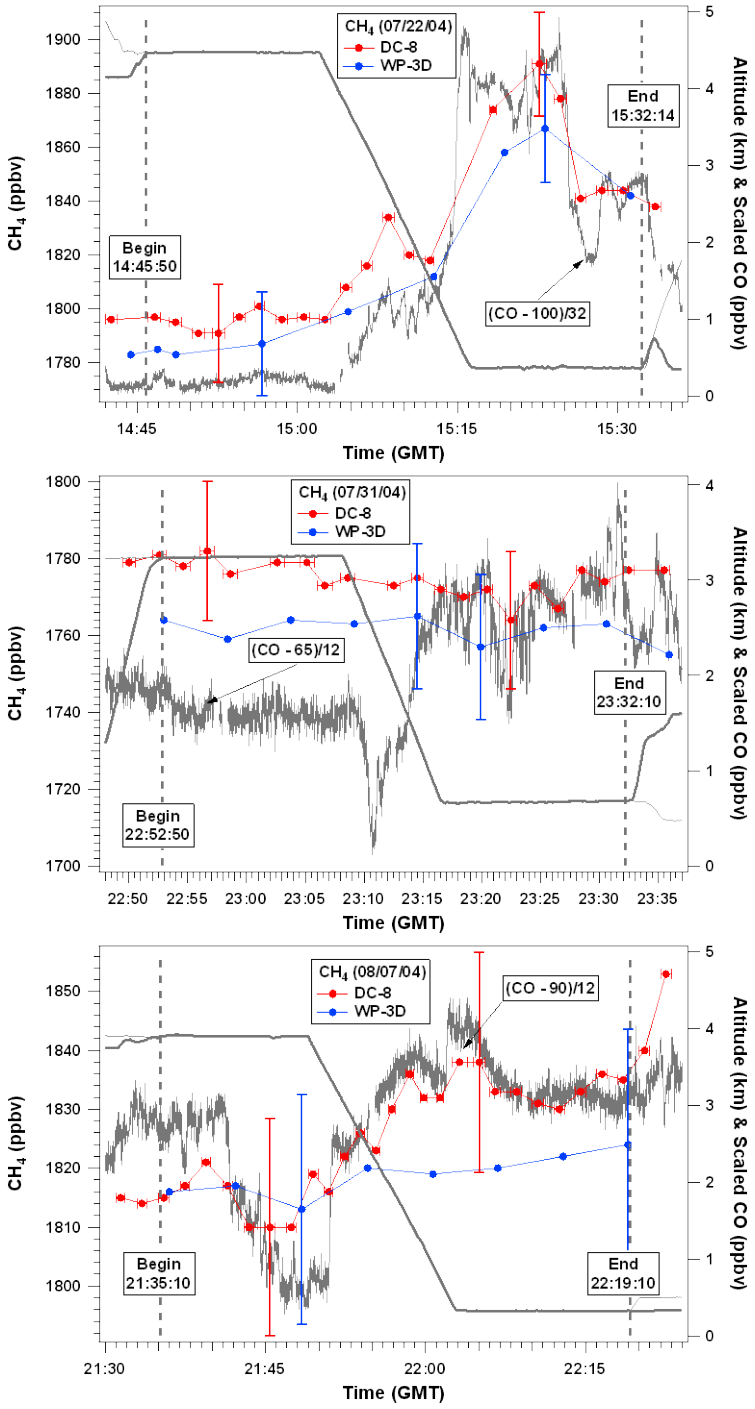

Figure 2. Time series of CH_4 measurements and aircraft altitudes from two aircraft on the three intercomparison flights between the NASA DC-8 and the NOAA WP-3D. Y-axis error bars represent the PI reported uncertainty and x-axis error bars represent the instrument integration time. X-axis error bars were not included for the WP-3D due to the small integration times.

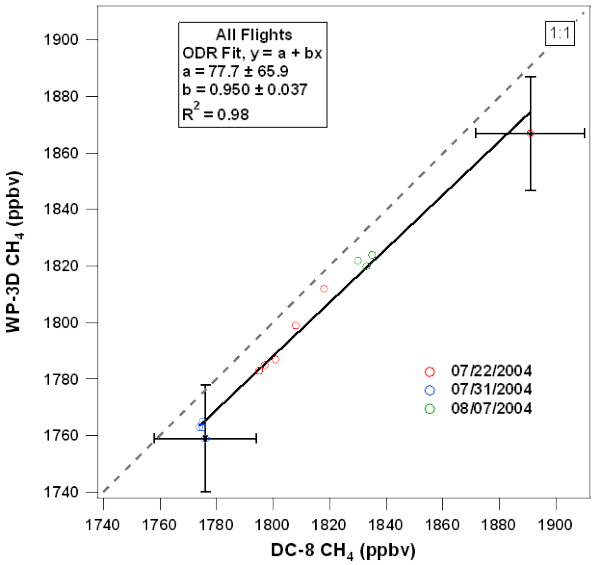

Figure 3. Combined correlation for the CH_4 measurements on NASA DC-8 and the NOAA WP-3D for 7/22, 7/31, and 8/07 2004. Error bars represent the PI reported uncertainty.

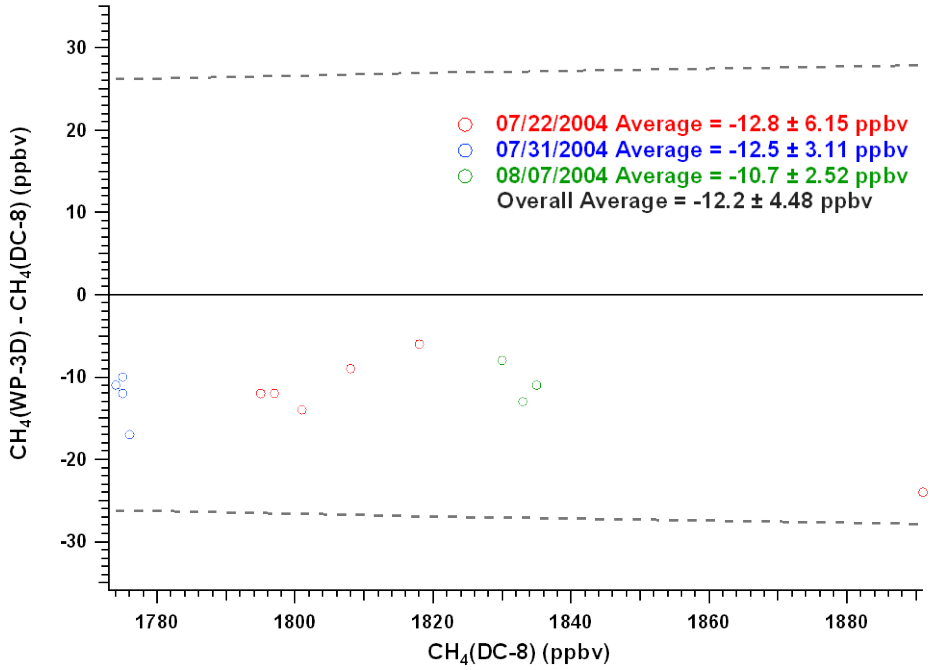

Figure 4. Difference between CH_4 measurements from the three DC-8/WP-3D intercomparison flights as a function of the DC-8 CH_4. The dashed lines indicate the range of the results expected from the reported measurement uncertainties.

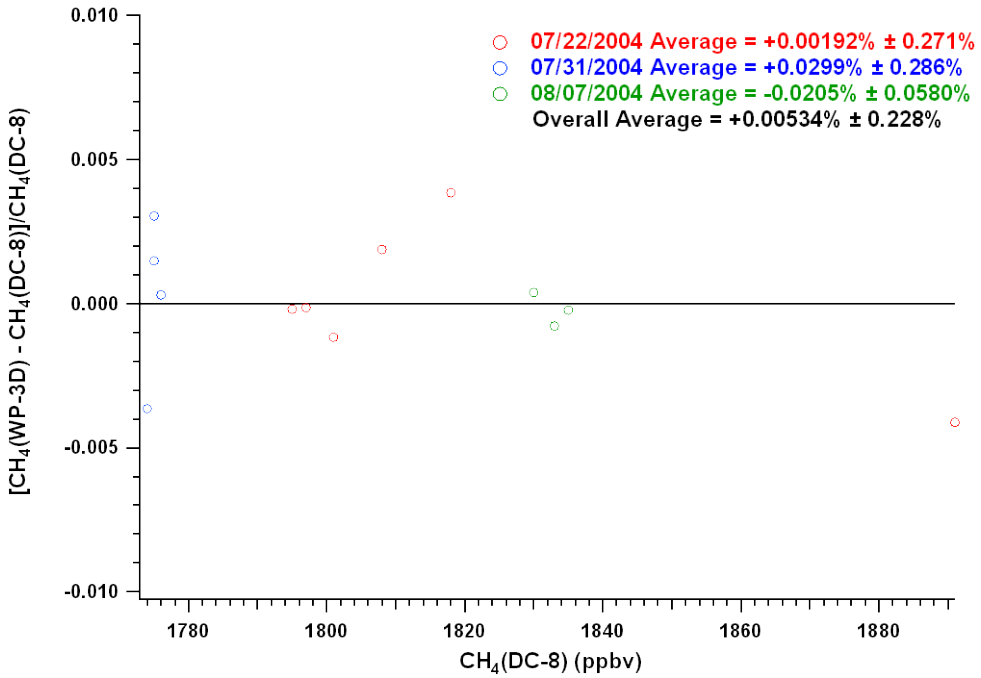

Figure 5. Relative difference between CH_4 measurements from the three DC-8/WP-3D intercomparison flights as a function of DC-8 CH_4. A correction was made to account for bias.

References

Fehsenfeld, F. C., et al. (2006), International Consortium for Atmospheric Research on Transport and Transformation (ICARTT): North America to Europe—Overview of the 2004 summer field study, *J. Geophys. Res., 111*, D23S01, doi:10.1029/2006JD007829.

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