FREQUENT MEASUREMENTS OF ATMOSPHERIC CO_2 AND OTHER TRACE SPECIES USING COMMERCIAL AIRLINES

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ABSTRACT
A new research project has started in 2003 to develop Continuous CO_2 Measurement Equipment (CME) and Automatic Air Sampling Equipment (ASE) for commercial airlines. CMEs are planning to be installed on five aircrafts and fly to South East Asia, East Asia, Europe, North America, Pacific and Australia. Routine air sampling by ASE will be done twice a month between Japan and Australia. After issuing the certification, first observation flight by Boeing 747-400 will be conducted in October, 2005. Preliminary observation by small research aircraft indicates that CME produces reasonable results.

INTRODUCTION
Regular air sampling using Boeing 747 commercial airliner has been carried out since 1993 to observe CO_2, CH_4 and CO mixing ratios between Japan and Australia [*Matsueda et al.*, 2003]. The observation is advanced to conduct the in-situ CO_2 measurement onboard the aircraft. A new research project "Atmospheric Measurement by Airliners for Trace Species: AMATRAS" has started in 2003 to develop Continuous CO_2 Measurement Equipment (CME) and improved Automatic Air Sampling Equipment (ASE) for Boeing 747-400 and Boeing 777-200 aircrafts operated by Japan Airlines (JAL).

INSTRUMENTS AND OBSERVATION PLAN
CME consists of single-cell NDIR (LI-840, LI-COR), flow controller, pressure controller, pump, drier, data logger and two high-pressure cylinders for standard gas (Fig. 1). Flight information, such as latitude, longitude, pressure altitude, radio altitude and ground speed, and environmental information, such as wind speed, wind direction and static air temperature are acquired from ARINC data bus on the aircraft. Air sample is taken from the air conditioning duct upstream of the recirculation fan. CO_2 mixing ratio in sample air is measured every 10 seconds during ascent and descent, and every 1 minute during level flight. Overall precision is estimated to be ±0.2 ppm when we use 10 second averaged data. Standard gas cylinders and chemical drier are replaced every 600 hours flight, which corresponds about two month. The data recorded in logger are recovered at this time.

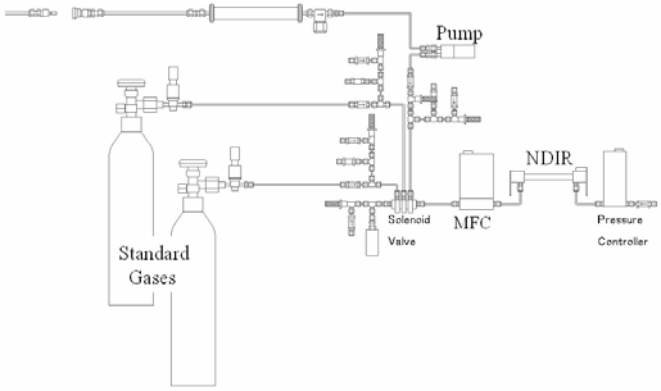

Fig. 1 Schematic diagram for CME.

The improved ASE has twelve of 1.7L titanium flasks equipped with two solenoid valves at both ends. Small board computer operates valves at presetting latitude, longitude or altitude. ARINC data are recorded into board computer. The air samples are analyzed not only for CO_2, CH_4 and CO mixing ratios but also N_2O, H_2 and SF_6 mixing ratios and stable isotope ratio of CO_2.

CMEs are planning to be installed on two 747-400 aircrafts and three 777-200 aircrafts. At the beginning stage, aircrafts will mainly fly to South East Asia and East Asia with the frequency of 60-70 times per month. Other 50-60 flights will be delivered to Europe, North America, Pacific and Australia (Fig. 2). Routine air sampling by improved ASE will be done twice a month between Japan and Australia. Special sampling is also available by setting the targeted observation area.

Fig.2 Estimated flight route (left) and estimated distributions of destination (right) for the CME observation flight.

The Supplemental Type Certificate (STC) to install CME and ASE will be issued by US Federal Aviation Administration (FAA) and Japan Civil Aviation Bureau (JCAB) in October, 2005 and the first observation flight by 747-400 will be conducted just after its issue.

PRELIMINARY OBSERVATION

To evaluate the reliability for CME, preliminary observations are conducted by using a small research aircraft, B-65, operated by Japan Aerospace Exploration Agency (JAXA). Aircraft ascends up to 7 km altitude over Sagami bay, Japan (35°N, 139°E).

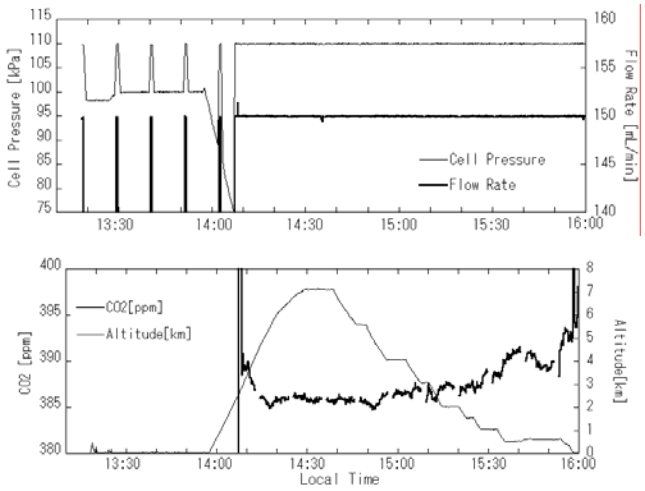

Fig.3 Cell pressure, flow rate, observed CO_2 value and altitude in the test flight.

Figure 3 shows the temporal variations of pressure in NDIR cell, flow rate, observed CO_2 mixing ratio and altitude obtained by CME during the test flight #4 conducted on April 15, 2005. Two standard gases were introduced into NDIR every 11 minutes throughout the CME operation. Aircraft took off at 13:57 local time and cell pressure has decreased by air release from the vent port equipped near the pump. While the sample air had been supplied by the pump (after 14:07), both cell pressure and flow rate were kept constant even though the altitude was changed between 7km and 0km. CO_2 mixing ratios measured by CME shows reasonable profile, being lower values in higher altitude and higher values near the surface.

REFERENCES

Matsueda, H., et al. (2002), Tellus 54B, 1-21.