インドネシアにおける成層圏大気サンプリング気球実験の計画

Balloon Experiment Plan for Stratospheric Air Sampling over Indonesia

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1. Objective

Modern human activities influence atmospheric environment by releasing varieties of exhaust gases such as carbon dioxide (CO_2) near the ground. These gases flow into the stratosphere through the tropical tropopause and spread in the stratosphere under the influence of photochemical processes. They reach high latitudes and finally return to the troposphere. The climate models are capable of simulating gross features of this general circulation. However, the driving mechanisms of some key processes on the climate time-scales are not well understood. For example, the diagnosis of the long-term trend of the "age" of air in the models indicates decrease in contrast to the observed increase in the real atmosphere; the decadal variation of the stratospheric water vapor, that is, the long-term increase in the 1980s and the stepwise drop in 2001, is left unresolved. In order to attain more confidence on the prediction of future climate change, these uncertainties must be resolved. The improvement of our understanding on the variability of stratospheric processes and the global behavior of greenhouse gases requires synthetic description of dynamics and chemistry in the stratosphere and the Tropical Tropopause Layer (TTL); the atmospheric region critical for the air entering the stratosphere. The objective of this research proposal is to construct synthetic view by conducting detailed observations and model simulations as a collaboration of specialists on atmospheric dynamics and chemistry including those in Indonesia. What is specific for this project is the first attempt of stratospheric air sampling by means of cryogenic samplers at Biak observatory of LAPAN. This balloon experiment is conducted within the ISAS research project "Synthesis of Dynamics and Chemistry for the Understanding of Atmospheric Processes in the Tropical Tropopause Layer over Indonesia". The compact cryogenic samplers are launched by large plastic balloons filled with helium and are recovered on the ocean after a slow descent with a parachute. Concentrations and isotopic ratios of various greenhouse gases of the air samples will be measured by high precision analytical systems at the laboratories in Japan. Our mission in this study is defined as the following three points; (a) collection of air samples in the tropical stratosphere over Indonesia, (b) high precision analyses of sample air for various gas concentrations and isotopic ratios, and (c) elucidation of dynamics and chemical process in the TTL and the stratosphere. The results of this experiment will be compared with the data obtained by our former air sampling experiments in the stratosphere over Japan, the Arctic and the Antarctic, and the eastern part of equatorial Pacific. These data will be used to clarify exchange process of greenhouse gases between the troposphere and the stratosphere.

2. An Outline of Experimental Procedure

The main balloon campaign will be conducted in February 2015 with a possibility of prior test operations beginning in December 2014.

(1) Balloon experiment procedure

Eight sets of the compact cryogenic air sampler will be launched from the experiment field in LAPAN observatory using large plastic balloons. Since each gondola will be equipped with two air samplers to collect stratospheric air at two different altitudes, four balloon experiments are planned in this period. As shown in Fig. 1, each sampler will collect an air sample at assigned altitudes between tropopause height - 30 km-ASL. Position and status of the sampler are transmitted by a radio transmitter onboard the sampler and received at the ground station in LAPAN observatory. After collecting two air samples at the assigned altitudes, the gondola will land on the sea by using parachute and will be recovered by a ship. To surely perform the gondola recovery even after a possible drifting, each gondola will be equipped with an Iridium buoy that will send us its position by a satellite link and the internet connection.

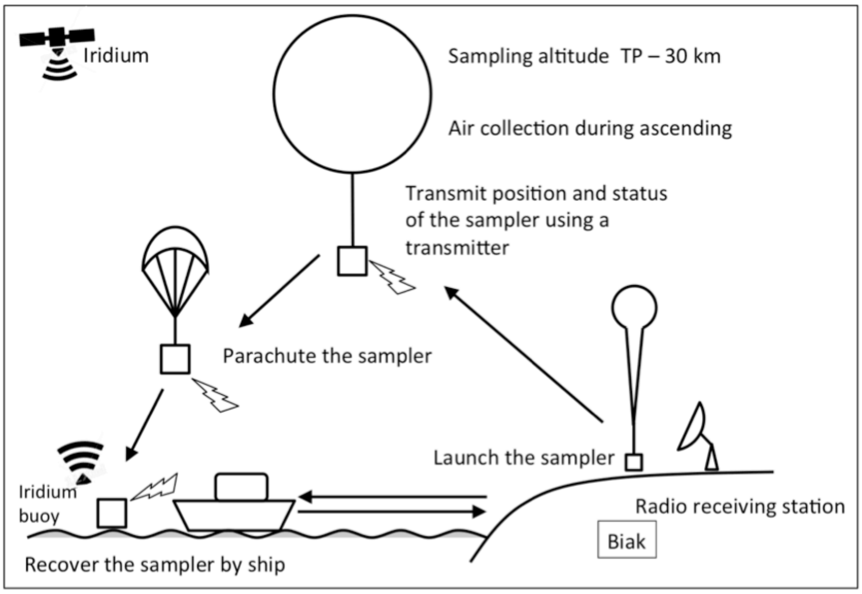

Fig. 1. Schematic diagram of stratospheric air sampling.

(2) Balloon and payload compositions
Two kinds of balloons, i.e. FB5B and FB9B balloons are prepared for the experiment. Helium gas is used for inflating the balloons. Payload of the balloon consists of a timer, two rope cutters, a flasher, a parachute, two air samplers, and an Iridium buoy. Total length of the balloon-borne air sampler will be 52 m and 58 m for the FB5B and FB9B balloon systems, respectively.

(3) Flight and splashdown area
The balloon flight and splashdown will be made in the sea area to the south of Biak, within a 100-km radius of LAPAN observatory. For the safety, balloon will not be operated over land except just after the takeoff at LAPAN observatory. For this purpose, the balloon trajectory will be predicted by using sounding balloon data in advance. The balloon will be launched only when it is predicted to fly and splash down safely in the sea area. The balloon trajectory will be calculated by supporting team in ISAS balloon engineering group, Japan.

(4) A balloon-borne air sampling system
Fig. 2 shows schematic composition of the balloon-borne air sampling system. One gondola is equipped with two air samplers to collect air samples at two different altitudes. Dimension of the gondola is 60 cm × 35 cm × 75 cm (L×W×H), and total weight is about 40 kg. As shown in this figure, the air sampling system consists of a cryogenic air sampler, a 2-liter high-pressure neon gas cylinder, pneumatic and solenoid valves, a high-pressure N_2 gas cylinder used for a motive force that drives the pneumatic valves, a controller with a GPS receiver, a telemetry transmitter and batteries. The cryogenic air sampler contains a cooling device called 'Joule-Thomson (J-T) mini cooler'. The J-T mini cooler can produce liquefied neon from high-pressure neon gas pre-cooled by liquid nitrogen. The sampler employs liquid neon as refrigerant to solidify or liquefy sampled atmospheric constituents.

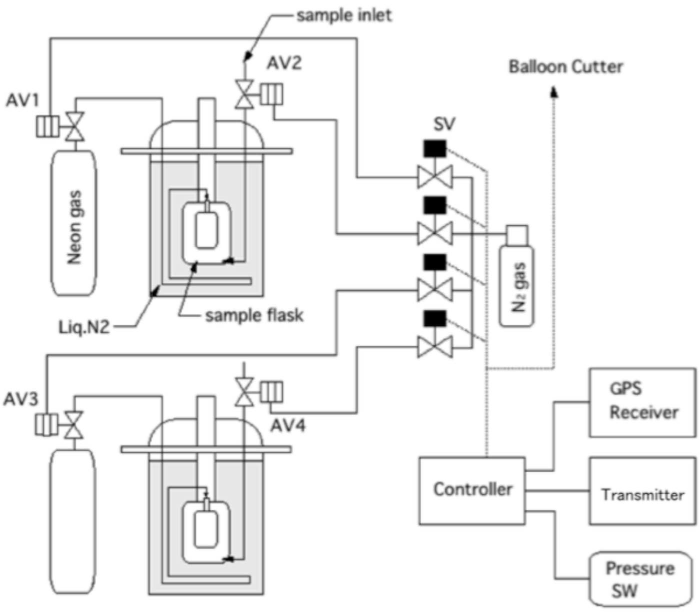

Fig. 2. Schematic diagram of the balloon-borne air sampling system. SV and AV mean solenoid valve and pneumatic valve, respectively. A sample flask is set in a dewar filled with liquid nitrogen. The J-T mini cooler is fixed in the sample flask.

(5) Flight patterns and air sampling

Stratospheric air will be collected, at the altitudes assigned in advance, during the balloon ascending. Therefore, flight plans will be selected by considering suitable combinations of two types of balloons and two sampling altitudes. Typical flight patterns are shown in Fig. 3. The launching order and sampling altitudes will be decided at the site, considering the total assessment of the experiment conditions such as upper atmospheric wind and sea condition.

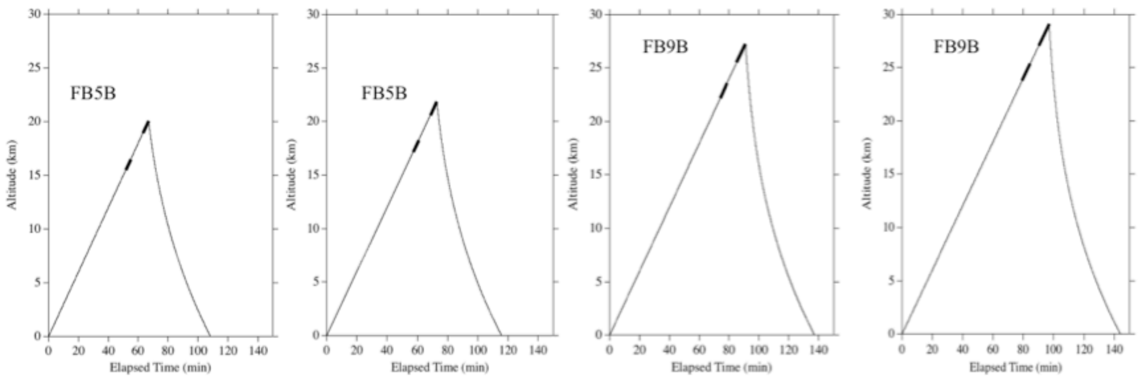

Fig. 3. Flight pattern and air sampling. Thin and thick lines represent altitude changes of gondola and air sampling position, respectively.