Observation of Refractive Index Profiles with GPS Radio Occultation from an Airplane

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INTRODUCTION

In recent decades, climate changes, such as global warming and El Nino, have significantly influenced the stable living environment and sustainable development of human society. Floods, severe rains and huge typhoons connected to climate change have caused a great deal of destruction. In order to improve. the forecasting of severe weather, such as heavy rain, accurate observations of water vapor (WV) distributions having large time and spatial variations should be incorporated into the numerical weather prediction (NWP) model (data assimilation). The Global Positioning System (GPS) radio occultation (RO) technique is a useful application of the precise satellite positioning system for monitoring the Earth's atmosphere (GPS meteorology).

METHODS AND EXPERIMENTS

The GPS RO technique is based on measurement of the bending and delay of GPS radio waves when passing through the atmosphere (Fig. 1). The bending and delay in the neutral atmosphere are converted to a refractive index profile for each occultation event. Since the refractivity is the function of atmospheric temperature and WV mixing ratio, GPS RO data can provide a detailed WV profile with a high vertical resolution. This observation may be done in the space with a GPS receiver on low-earth-orbit satellites or within the atmosphere by situating a receiver on mountaintop or airplane. In the present study, the GPS RO technique for a receiver located in an airplane was developed for the first time. The technique was applied to field experiments using a GPS receiver newly developed for airborne GPS occultation measurements onboard an aircraft of the Electronic Navigation Research Institute (Fig. 2).

RESULTS AND CONCLUSIONS

For the GPS RO observation from the airplane, the following were developed: (1) a new GPS receiver system that has a high sensitivity capable of detecting a weak GPS RO signal at a high sampling rate, (2) an accurate positioning system by combining the GPS and an Inertial Measurement Unit (IMU) in order to determine the airplane velocity with an accuracy of up to 5 mm/sec, and (3) the retrieval software for the refractive index profile, in particular, a technique by which to derive the bending angle around zero elevation angle. More than 70 occultation events were obtained from nine airborne GPS RO campaign experiments conducted from Oct. 2003 to Feb. 2005. Analyzing the experimental data by the software developed herein, the refractive index profiles, which were consistent with the balloon-based observations (radiosonde) and NWP model, were retrieved. An example is shown in Fig.3. The application of this technique to all available commercial airplanes in the future is expected to enable a tremendous amount of WV information to be routinely obtained.

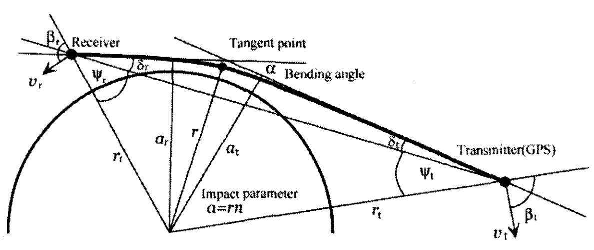

Figure 1 Schematic illustration of the GPS RO

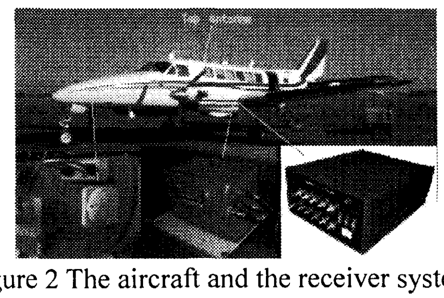

Figure 2 The aircraft and the receiver system.

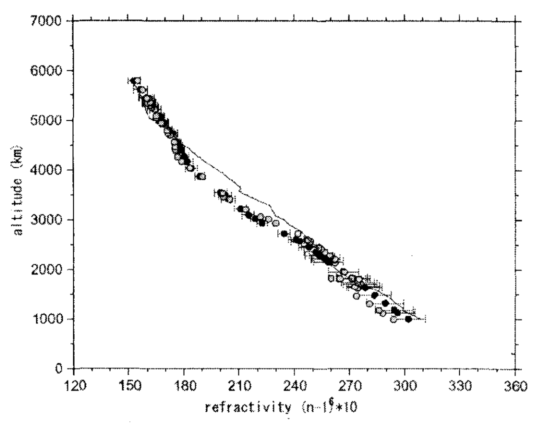

Figure 3 Example of the derived refractivity profiles. Solid: Derived from GPS RO. Circles: reference data for comparison (numerical weather prediction data)