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# Meteorological Observation Station at the summit of Mt. Tsukuba

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**Abstract**

In regional scale, to answer a wide range of meteorological and hydrological subjects, University of Tsukuba decided to conduct a research project entitled "Multi Monitoring of Meteorological and Hydrological Elements at Mt. Tsukuba and Analyses for Atmosphere and Water Cycles" in 2005. To perform this objective, research activities by means of an automated weather system (AWS) have been performed at the summit of Mt. Tsukuba, i.e. at an altitude of 871m, since January 1, 2006.

Sections of measurement of hydro-meteorological processes and data communication were designed for long term environmental monitoring by multiple sensors and simultaneous transportation of the real time data by internet facilities. Also scientific interests focus on synoptic futures of the meteorological and hydrological statuses influencing regional environmental changes in the lower part of the atmospheric boundary layer. The site-specific database observed at the summit of Mt. Tsukuba also contributes to use temporal and spatial information not only on scientific approaches but on practical use for weather interpretation.

Currently, sixteen items of meteorological and hydrological terms are available for several integrated data files. It is expected that the observation succeeds the academic legacies from the past achievements provided by great deal of labor through this 100 years.

**Key words:** Mt. Tsukuba, water cycle, global warming, multiple measurements, environment monitoring

## 1. Introduction

As global warming and other environmental problems worsen, it is becoming increasingly important to obtain an accurate apprehension of the status of our environment. Especially, changes in meteorological and hydrological processes are matters of concern under ongoing global warming. The first step on an approach should be promoted is to make observations at a standard location representing the surrounding conditions.

The meteorology and hydrology research group at the graduate school of life and environmental sciences, University of Tsukuba, launched a meteorological observation station in January 2006 in the former Tsukuba-san AMeDAS (Automated Meteorological Data Acquisition System) facility on the top of Nantai-san (871m), the west peak of Mt. Tsukuba (Photo 1), as an intramural research project (S) for 2005, in University of Tsukuba. This project is entitled "Multi Monitoring of Meteorological and Hydrological Elements at Mt. Tsukuba and Analyses for Atmosphere and Water Cycles", and headed by Professor Y. Hayashi with eight researchers listed in the last part. Currently, the following home page address has been open to the public; http://mtstukuba.suiri.tsukuba.ac.jp/.

## 2. Scientific function

It is expected that the observation succeeds the academic legacies from the past achievements provided by great deal of labor through this 100 years at Mt. Tsukuba. The most practical and valuable feature of the observation at Mt. Tsukuba is that they can carefully observe the lower part of atmospheric boundary layer lying over the Kanto plains, which are including individual atmospheric events and backgrounds of water cycles characterized by an extent of the Tsukuba-Kasumigaura area.

Research subjects expected are represented by the following two topics. Firstly, due to the very high temporal and spatial variability, there is insufficient

Photo 1 Distant view of Mt. Tsukuba

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information about details of the hydrological cycle. The lack of empirical data leads to specific problems of how to incorporate hydrological processes in regional weather and local climate systems. To improve our understanding and predicting abilities of the energy and hydrological cycle, the current observation station will work as a research platform. The hydrological and meteorological observed data are basically important for this purpose. Also, isotope tracer is very effective to investigate the hydrological and meteorological path and flux in an area. Prior research projects were carried out under external research fund of JSPS since 2002. To follow these academic activities in University of Tsukuba, the present observation can provide new scientific findings.

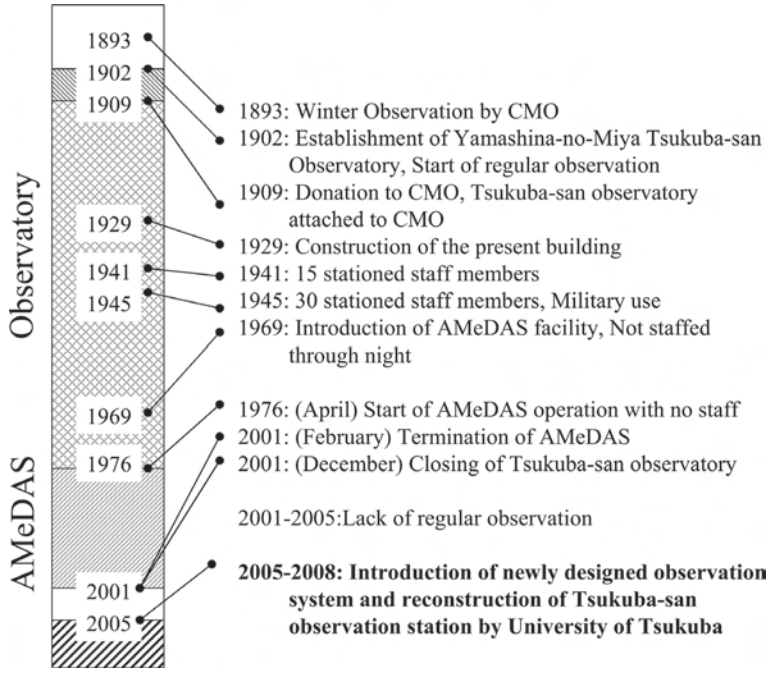
Secondly, partition of magnitude in recent temperature rise into two causes of heat island effect and of globally rising temperature regime. The past database observed at Mt. Tsukuba through 1976 to 2004 indicates a clear increment of monthly mean temperature in both winter and summer seasons. Here, it can be deduced that ordinary defined temperature rise by global warming is calculated using available data distributed generally in urban area. When we can compare temperature changes at Mt. Tsukuba with such an urban station's, subtracted values between two stations corresponds conceptually with the heating by urbanization itself. In this manner, when it is comparing at Mt. Tsukuba and at Tokyo in winter, the tendency of the temperature rise arose by 2.5 times faster at Tokyo than at Mt. Tsukuba. It is expected that the newly acquired database at Mt. Tsukuba is giving a support to this fact.

## 3. History of the meteorological observation at Mt. Tsukuba

Meteorological service in Japan was initiated in 1875 by the Tokyo Meteorological Observatory within the Ministry of the Interior. This was renamed as the Central Meteorological Observatory (CMO) in 1887 and was transferred to the Ministry of Education in 1956. As modernization progresses, the Meteorological Agency of Japan (JMA) placed under the Ministry of Land, Infrastructure and Transport, serves as one of the most advanced and leading National Meteorological Services in the world and discharges both national and international responsibilities.

History of meteorological observation at Mt. Tsukuba goes back to the 1900's when the CMO was constructed and is listed in Table 1. In 1902, an equipped meteorological observatory at the summit of Mt. Tsukuba, said Yamashina-no-Miya Tukuba-san Observatory, was designed and realized by a house of an imperial prince. In those days, Mt. Tsukuba was recognized as an observation tower sounding atmospheric boundary layer. However, automated systems were not yet being conducted. The station was donated from Yamashina-no-Miya to the CMO in 1906, and used for observing meteorological conditions of strategic importance. After that, under the Ministry of Land, Infrastructure and Transport, regular observation by

Table 1 History of meteorological observation at Mt. Tsukuba



automated facilities continued till 2001.

The JMA has operated automatic meteorological observation stations over whole of the Japanese islands, which have been known as the AMeDAS. Four meteorological elements of air temperature, wind speed and wind direction, sunshine duration and precipitation had been available. A station named Tsukuba-san was constructed as one of the AMeDAS network in 1976, but it was terminated in 2001. Closing of this station was due mainly to development of measuring systems of wind-profiler, although observation records at Tsukuba-san had covered officially over last 100 years.

## 4. Facility of the new observation station at Mt. Tsukuba

The newly designed meteorological observation station was equipped at the summit of Mt. Tsukuba, where is located approximately 20 km north of Kasumigaura, Ibaraki Prefecture (Fig. 1). It enables to act as a role substituting for the above mentioned historical observation at the summit of Mt. Tsukuba. Instruments attached were approved their accuracy by the JMA. Mt. Tsukuba constructs a mountainous area along fringe of the northern part of the Kanto Plains and forms an isolated mountain. The body of the mountain consists of two peaks of Nantai-san (871 m) and Nyotai-san (877m). In order to take over the assets of observation records, which lasted for over 100 years, the instruments were installed at observation filed of the former AMeDAS located at the summit of Nantai-san.

Even now, the building of the old observatory is very solid architecture having a three-storied structure (Photo 2). Since the termination of the AMeDAS in 2001, preservation of the building is under a religious corporation of the Tsukuba Shinto shrine. Accordingly, to promote this project, University of Tsukuba exchanged a practical contract with the religious corporation.

The plane view and vertical view of the observation station are shown in Fig. 2 and Fig. 3 respectively. From a point of view of continuity from the AMeDAS in quality, the ground level observation set up at a field locating the southwest side of the building (Photo 3). Sensors for wind and radiation were installed at housetop of the building. Data logging and communication parts of the system occupied a small room on the first floor of the building nearby the ground observation field. All instruments were installed referring to the prior condition of the field instrumentation of the former AMeDAS as possible. Table 2 indicates observation elements and related information

Photo 2 Building of the old Tsukuba-san meteorological observatory constructed by CMO in 1929

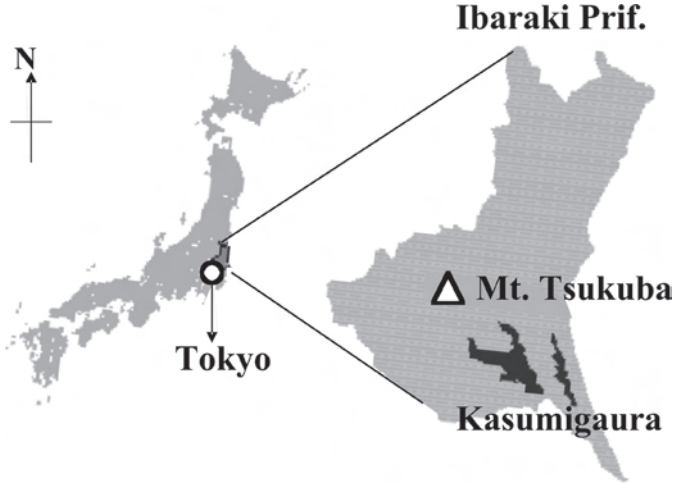



Fig. 1 Location of Mt. Tsukuba

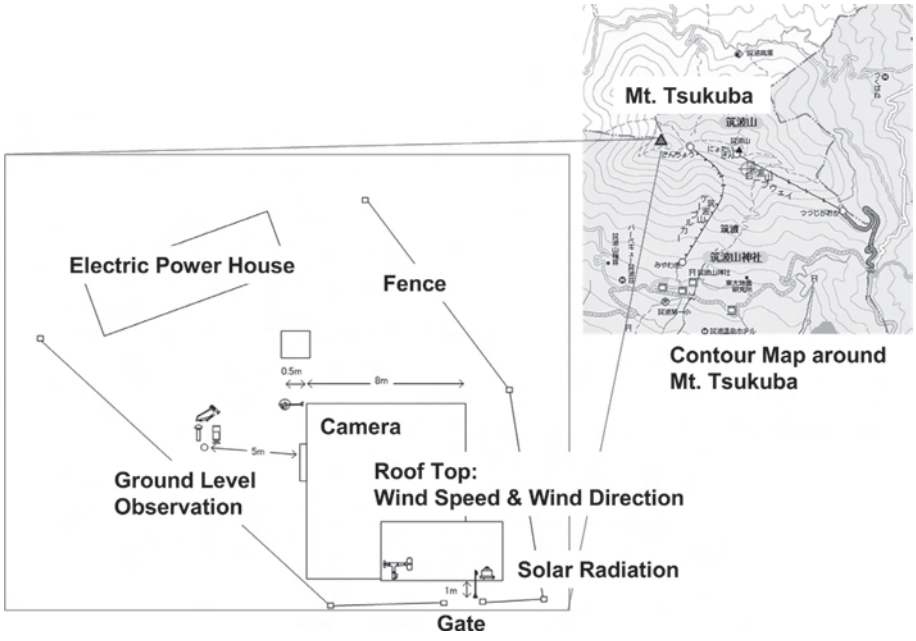



Fig. 2 Plane view of the observation station

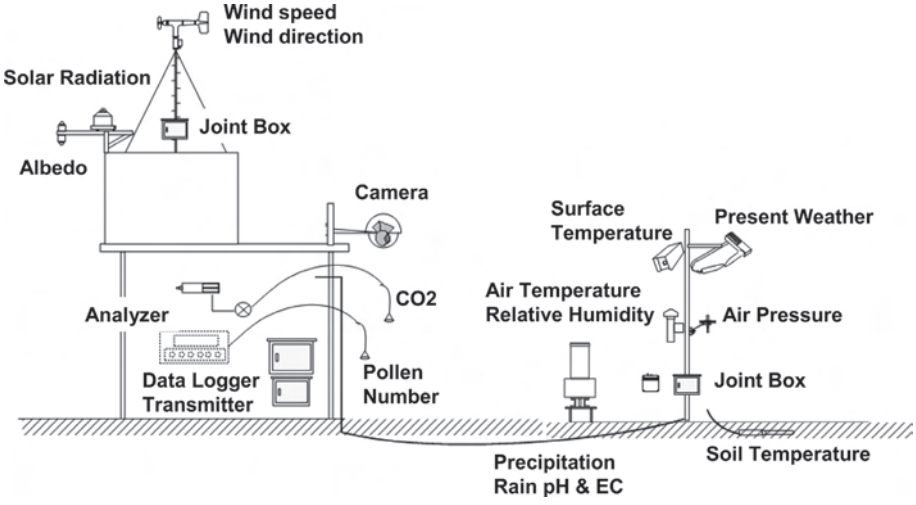



Fig. 3 Vertical view of the observation station and equipments

for installation. Principal elements are wind direction (WD), wind speed (WS), air temperature (Ta), relative humidity (RH), soil temperature (Ts), surface temperature (Tsf), solar radiation (Rs), downward short wave radiation (Rs-down), upward short wave radiation (Rs-up), air pressure (P), precipitation (Pr), rain pH (pH), electric conductivity of rain (EC), $CO_2$ concentration ($CO_2$), pollen number suspended (KFN), and weather conditions (PDW) including weather type and visibility.

Apart from physical aspects, the summit of Mt. Tsukuba has been widely praised for it scenic view of the Kanto plains. Then, in order to watch the phenological changes of the surrounding ecosystems, such as buds of Japanese

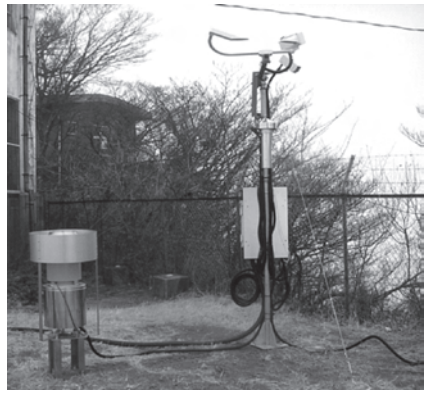


Photo 3 Ground level observation at the summit of Mt. Tsukuba

Table 2 Measuring elements of the new observation station at Mt. Tsukuba

| Element | Sensor Location | Sensor/Method |
|---|---|---|
| Wind direction/Wind Speed | 3m above the loof top * | RM.Young/Wind vane |
| Air temperature | 1.5m above the ground | Climatec/Electorical-registance |
| Relative humidity | 1.5m above the ground | Vaisala/High polymar film |
| Soil temperature | 1cm under the ground | Climatec/Electorical-registance |
| Ground surface temperature | 2.4m above the ground | Tasco/Infrared thermosensor |
| Solar radiation | 1.55m above the loof top * | Kip & Zonen/Termocouple |
| Downward short wave radiation | 1.4m above the loof top * | EKO/Photo diode |
| Upward shor wave radiation | 1.4m above the loof top * | EKO/Photo diode |
| Air pressure | 1.45m above the ground | Vaisala/Silicon capacitance |
| Precipitation | 1.1m above the ground | Ogasawara/Tipping-bucket/Heater |
| Rain acidity | 1.1m above the ground | Kyoto Denshi Kogyo/Glass electrode |
| Rain electric conductivity | 1.1m above the ground | Kyoto Denshi Kogyo/Four electrodes |
| Concentration of carbon dioxide | 3.1m above the ground | Vaisala/Two single beam |
| Pollen number suspended | 1.9m above the ground | Yamato Seisakusho/Semiconductor laser |
| Present weather | 2.4m above the ground | Vaisala/Forward scattering |
| Camera image | 8.5m above the ground | SONY/Network |

* height of the loof top: 12m

beech or rice planting season, a web camera was attached at the southwestern corner of the building. Format of the image is JPEG and corded by time and date. Important flames of the images are preset with 10 minutes interval.
These multi monitoring system designed by the present project will cover almost all of phenomena representing environmental conditions in the atmospheric boundary layer around Mt.Tsukuba.

Observation was started officially on January 1, 2006. Data recording categories are shown by the following types of data; 10 minutes base data set (MtTsukuba_TBL100), hourly base data set (MTTsukuba_TBL160) and daily base data set (MtTsukuba_TBL124) for every element. And data sets of pollen count number and water quality are named as MtTsukuba_KFN and MtTsukuba_RAIN respectively, which are provided by the same time stamps as meteorological data.

**5. Remarks**

Physically based descriptions of the environmental changes are important. The newly designed observation station provides benchmarks for meteorology and hydrology under changing environmental conditions.

The launch of the meteorological observation station at Mt. Tsukuba not only revives the function of AMeDAS eliminated in 2001, but also starts a new comprehensive atmosphere and water circulation field research project, incorporating new meteorological instruments, image cameras, $CO_2$ and acid rain observation equipments, and other systems that take monitoring of the global environment into consideration.

In this project, University of Tsukuba takes over 100 years of valuable meteorological observation. And the project group will clarify meso-scale atmospheric circulation around Mt. Tsukuba, and studies water and material circulation in the region ranging from Mt. Tsukuba to the Kasumigaura watershed, and conduct analyses to distinguish global warming from temperature rises due to the heat island effect. The project will also contribute to regional society through use of observation equipment and data in meteorological, hydrological, and environmental education and quasi real-time data disclosure.

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