CONSTRUCTION OF GPS VAPOR INFORMATION SYSTEM FOR INTERDISCIPLINARY STUDIES

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INTRODUCTION

GPS Meteorology is the study that includes the observation of precipitable water, its application to weather forecast or observation of global warming by using Global Positioning System(Businger, 1996; Ware *et al.*, 1996; Naito, 1996). Recent developments of the accuracy of satellite orbit forecasting and of software for analyzing GPS data enable the estimation of precipitable water(PW). Precipitable water data from GPS stations by Geographical Survey Institute(GSI), of which number of stations are compatible with AMeDAS stations, are available in Japan(Hatanaka *et al.*, 1996; Aonashi *et al.*, 1997).

This paper outlines the data base construction for interdeciplinary use of GPS water vapor information for environmental sciences. The objectives of GPS Meteorology Project(GPS/MET JAPAN) started this year, characteristics of GPS vapor information by GSI and the changes in vapor over Japan islands detected by GPS are also explained in the paper.

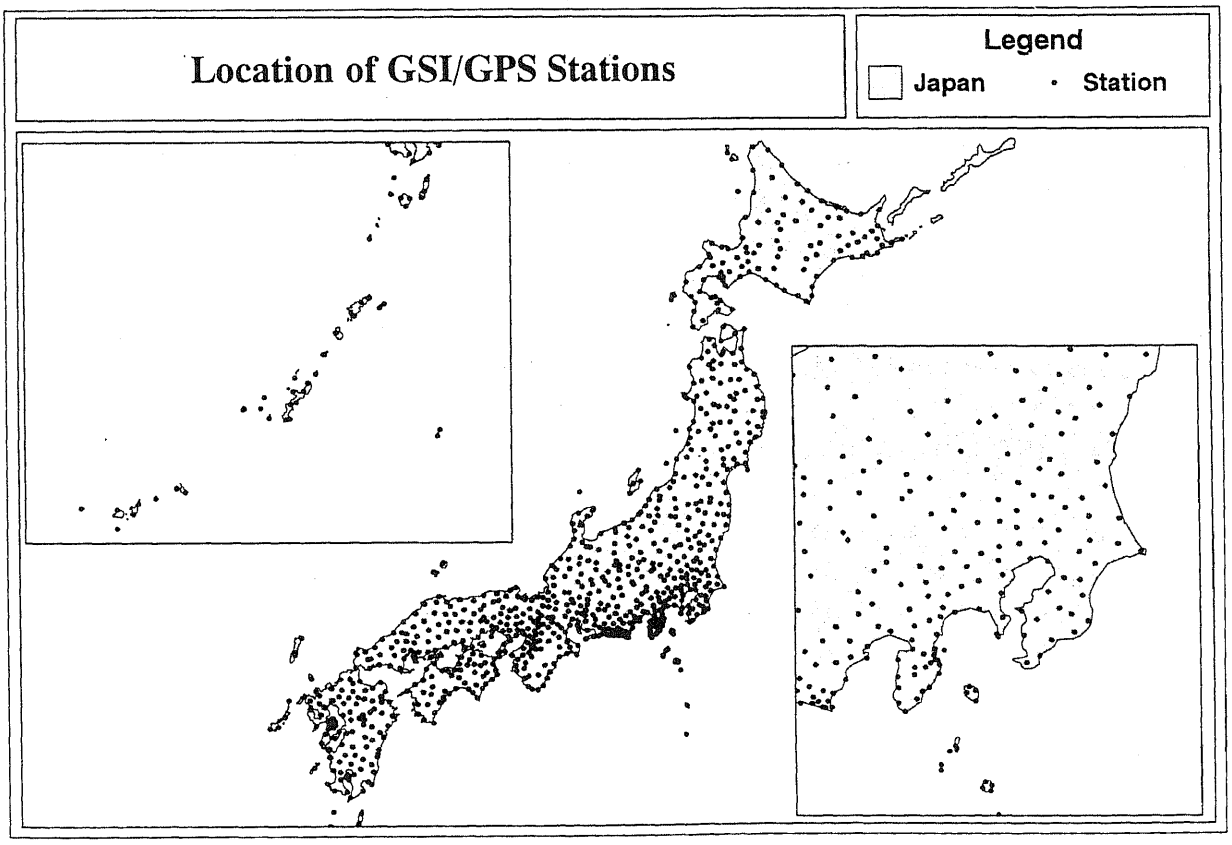

Fig.1 The locations of GPS Stations by GSI, Japan.

OBJECTIVES OF GPS/MET JAPAN

Fig.1 shows the locations of GSI/GPS stations. GPS/MET Japan utilizes the data from these densely distributed GPS stations. It is rare in other countries, and it will enable the distinctive studies in Japan.

There are several objectives in GPS/MET JAPAN as follows:

- To combine GPS vapor information to the numerical weather forecast system of Japan Meteorological Agency(JMA), and uses for meso scale weather forecast.
- To feedback weather forecast data to land surveys, and to improve accuracy of space geodetic methods, including GPS and VLBI.
- To construct vapor information data base for the interdisciplinary research, such as environmental sciences.

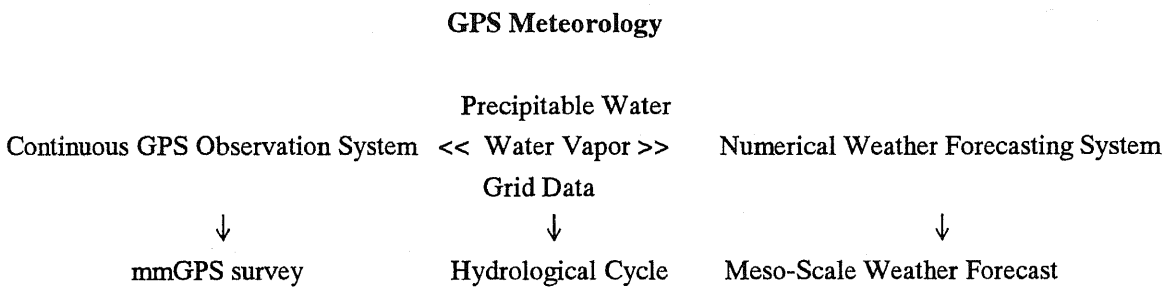

Fig.2 A concept of GPS/MET Japan(STA, 1997).

Fig.2 shows the concept of the GPS/MET Japan project. The project is promoted by six sub-programs. Each program includes, (1) a study on the estimation and assessment of GPS derived precipitable water, (2) a study on the weather forecast based on the GPS precipitable water, (3) a study on the improvement of space surveys, (4) development of real time analysis technology, (5) construction of GPS vapor data base and (6) a study on the usage and assessment of vapor information for interdeciplinary fields. The GPS vapor information system contained in the title is taken in the subjects (5) and (6).

CHARACTERISTICS OF GPS VAPOR INFORMATION

The nature of the GPS vapor information is as follows:

(1) Only the precipitable water is available from GPS, which is vertically integrated vapor of the air column.
(2) The precipitable water is vertically integrated water vapor averaged by the area of the circle of which radius is nearly the same as the height.
(3) Resolution of time is principally possible up to 10 minutes, however, an actual interval will be practically one or three hours.
(4) Spatial resolution is about 25km in the case of GSI/GPS networks, although it is different in the area.
(5) Accuracy of the precipitable water is about 1.5mm, which is not affected by rain.
(6) The GPS stations are located only on the land, not on the sea, and is installed in the basin in mountainous

area.

Above are the characteristics of GPS precipitable water itself. As the construction of vapor information based on the 4DDA data from numerical weather forecast system of JMA is one of the objectives in GPS/MET Japan, three-dimensional vapor information will be available in near future.

ACTUAL CONDITIONS OF PRECIPITABLE WATER DEPICTED BY GSI/GPS OBSERVATION

Fig.3 is the comparison of precipitable water estimated from the radiosonde and from GPS observations at Tsukuba. The zenith hydrostatic delay, which can be calculated from atmospheric pressure, is subtracted from zenith neutral delay to calculate zenith wet delay. It can be converted to precipitable water by applying a constant. The correlation is considerably high. The average difference between them is 0.4mm, and standard deviation is 2.1mm. It shows that the GPS is functioning well as a vapor sensor. Small disagreement will be disappearing by introducing vapor oriented GPS analysis system.

Fig.4 denotes the time changes in precipitable water at Shionomisaki station. Sudden increases in precipitable water are clearly delineated, while regular observation of the radiosonde could not detect such abrupt changes.

Fig.5 shows the transition of precipitable water when the autumnal rain front slowly passed over the Japan island, which is calculated from regular GIS/GPS observation data. Although the zenith hydrostatic delay is not excluded in Fig.5, almost all the variation can be explained by precipitable water because the change in atmospheric pressure is within several hPa at that time. The location of the front is clearly delineated as dark parts in the figure, which means humid.

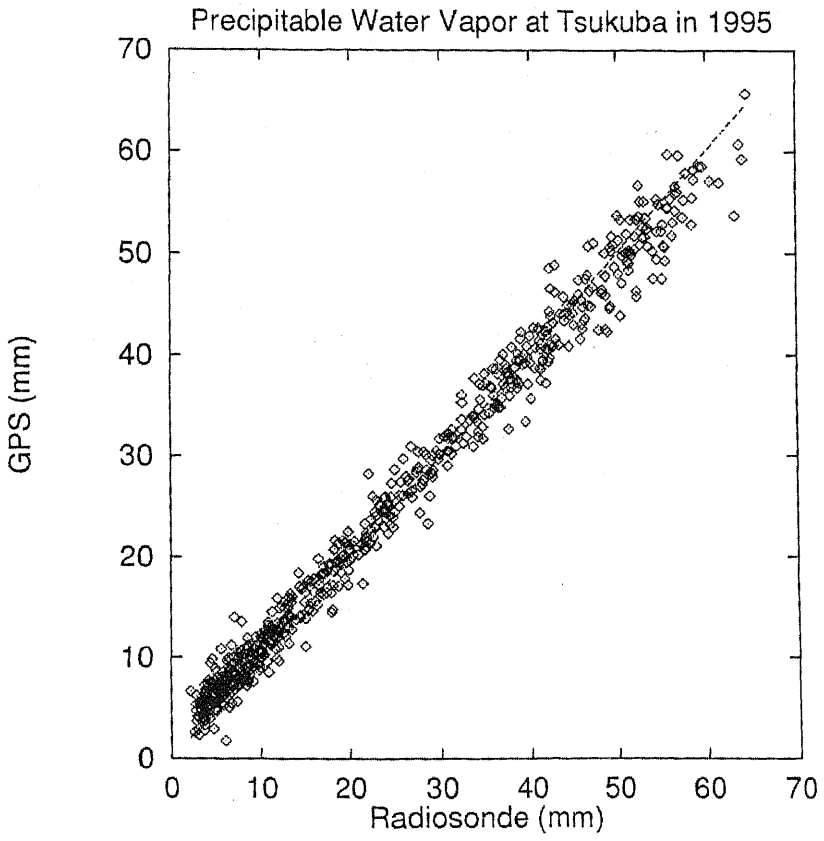

Fig.3 Comparison between observed and GPS derived precipitable water at Tateno, Tsukuba.

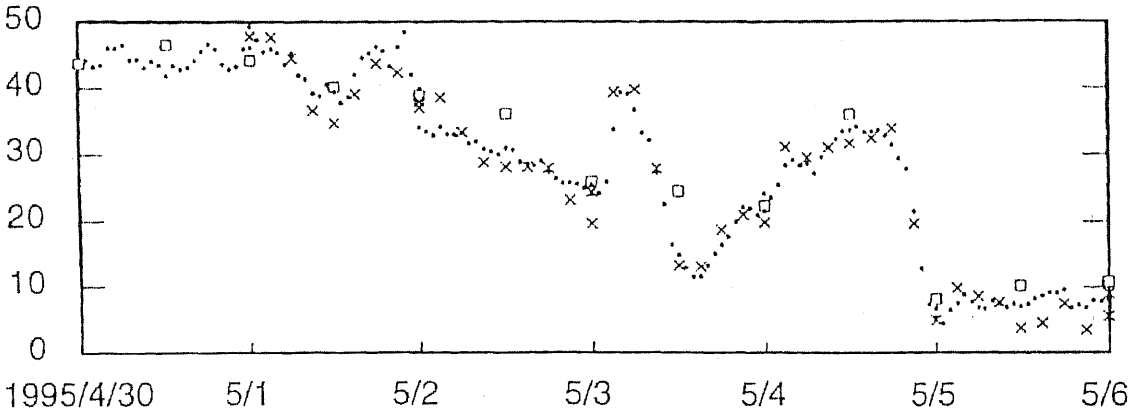

Fig.4 Time change in precipitable water at Shionomisaki station. ● and × show the precipitable water calculated from GIPSY and GAMITT softwares respectively. □ denotes the radiosonde derived precipitable water.

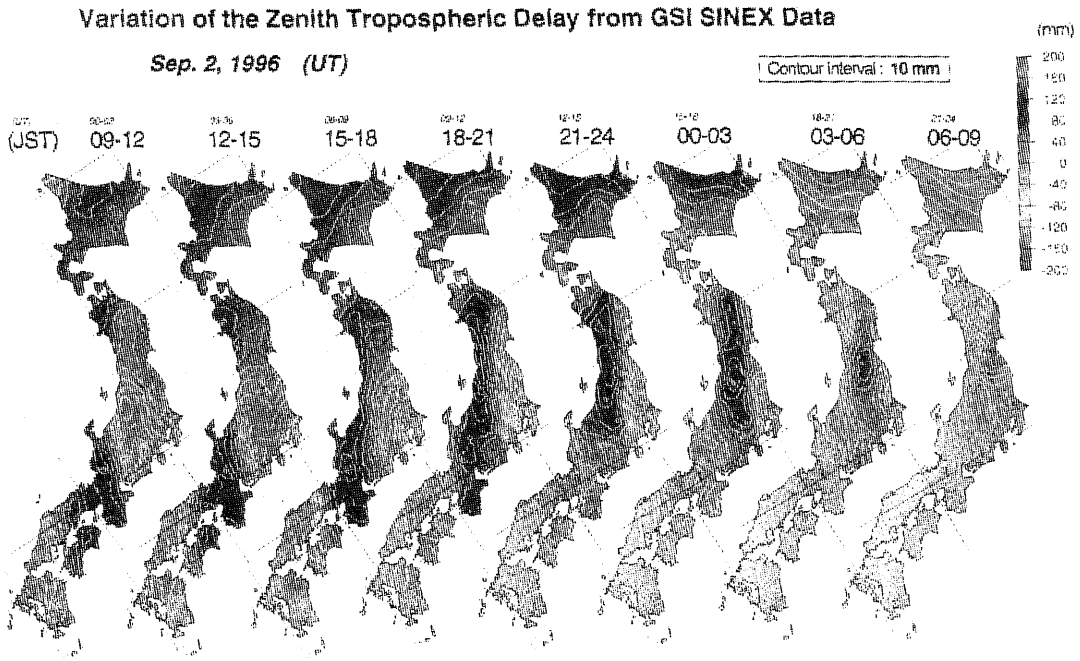

Fig.5 An example of time changes in the zenith tropospheric delay over Japan island.

CONSTRUCTION OF GPS VAPOR INFORMATION DATA BASE

GPS information in GSI is archived in two formats. One is RINEX file, which is raw observational data. The other is SINEX file. It is the analyzed data by the GPS software. The use in vapor information is based on SINEX file. Users can access the data through a computer network.

The large capacity data archive system was installed in the center for environmental remote sensing(CEReS) in Chiba University. It is originally designed to store satellite data directly received in CEReS, which are NOAA and GMS. Various geographic information including meteorological data is also planning to archive in it, and to construct a data base system.

GPS vapor information is one of the geographic information, namely it has the information on the location it is observed. The geographic information should be stored and analyzed on the geographic information system(GIS). Fig.1 is drawn by using GIS, and it enables the spatial analysis.

For example, Fig. 6 shows the location of GSI/GPS Stations on the land use map. GPS vapor variations inherent in the local characteristics, such as land use, topography, etc., can be analyzed by superimposing various spatial information on the GPS vapor data. The GIS oriented GPS water vapor information system is currently planning to construct in CEReS, Chiba University, for interdisciplinary environmental studies.

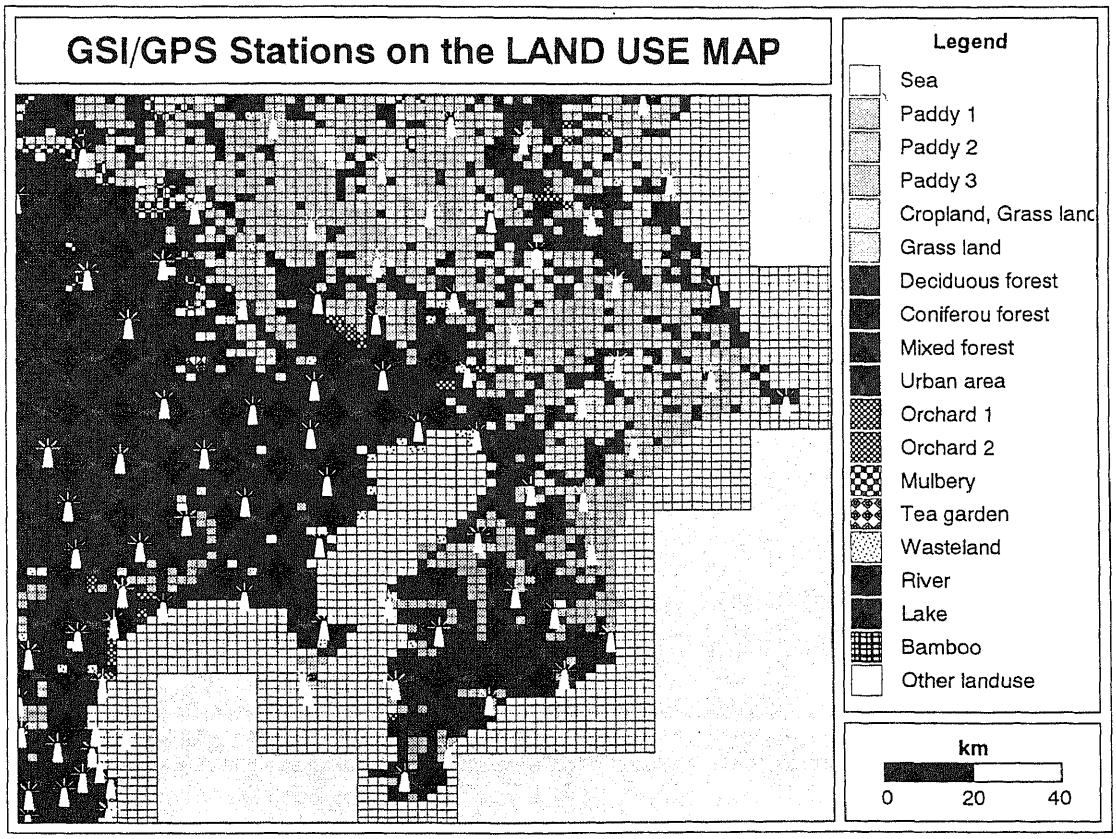

Fig.6 GPS stations in Kanto Palin, Japan over land use map.

CONCLUDING REMARKS

There is another project in the field of GPS meteorology in USA. Its objective is to observe the vertical profiles of air temperature and vapor by GPS receiver on board low orbit satellite. These projects are in complementary relationship with GPS/MET Japan in the spatial scale treated. It is certain that both projects contribute to the monitoring the global warming and its influences. GPS gets a great expectation in that it will be a indispensable sensor to monitor the changes in Earth system.

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