

GPS/GNSS Meteorology in JAPAN - Overview and future scope -

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The Global Positioning System was developed during 1970-80 in the United States. In 1994, The Geographical Survey Institute of Japan (GSI) (the official english appellation is changed to "Geospatial Information Authority of Japan" in April 2010) began partial services of the nationwide GPS network named GEONET (GPS Earth Observation NETwork). Prior to the start of the GEONET service, Japanese geodesists and meteorologists held the first workshop on "GPS Tropospheric Delay" at the National Astronomical Observatory Mizusawa and recognized the importance of GPS meteorology with a suggestion of N. Mannoji from the Japan Meteorological Agency (JMA).

After one year feasibility study based on a concept proposed by H. Tsuji of GSI, Japanese GPS meteorology project "GPS/MET JAPAN" was launched in 1997. This five year project from April 1997 to March 2002 was aiming at two birds with one stone; an application of precipitable water vapor (PWV) from the GEONET to data assimilation system in numerical weather predictions (NWP), and an improvement of geodetic accuracy of GPS based on NWP data. At the dawn of the project, accuracy of PWV from GEONET was statistically tested, and GEONET vividly monitored various atmospheric phenomena. All these analyses, however, attested critical necessity of knowing a few km-scale water vapor variations to improve the accuracy of GPS positioning and PWV retrieval. This led us to conduct a dense GPS network campaign with 75 receivers in a 400 km² area. A tomography analysis of slant path delays (SPD) of GPS signals revealed a 3-D distribution of water vapors. Improvement of geodetic accuracy of GEONET was also tried using high resolution NWP data. GPS radio occultation (RO) method applied to GPS data observed by space-borne GPS receivers yielded a global-scale distribution of temperature and humidity, which shed light on a vertical propagation process of atmospheric gravity waves in the tropics. GPS RO technique was also applied to mountain-based GPS downward-looking observation and succeeded in obtaining fine vertical temperature structure in the lower troposphere.

The researchers of the "GPS/MET JAPAN" sustained their researches after the project period and practical usage of GPS data in weather prediction model was started in the late 2000s. German GPS RO satellite CHAMP data was began to be used in JMA's global analysis (GA) in March 2007. A near-real-time (NRT) retrieval procedure of PWV retrieved from ground-based GPS observations was developed and confirmed its benefits for mesoscale NWP. On October 28, 2009, JMA started the operational use of PWV derived from GEONET in its mesoscale DA system. In the field of geodesy, researches which aiming to achieve mm accuracy using high resolution NWP model has been advancing.

Currently, we are in multi-GNSS (Global Navigation Satellite System) era. Not only U.S. GPS, but also Russian GLONASS, and JAXA's QZSS are available in GEONET. Also, development of streaming data exchange protocol has been creating new research fields and ideas in GNSS meteorology. GNSS reflexology should also be highlighted. Several applications, for example retrieval of snow depth, soil moisture, and wind over the ocean, have been conducted worldwide.

In this presentation, we summarize results of the "GPS/MET Japan" project, review subsequent relevant researches, and look at the future. We hope that this paper will encourage new studies aiming for further progresses not only on numerical weather prediction but also on the interdisciplinary sciences for understanding the global changes.

Keywords: GPS/GNSS Meteorology, Satellite Geodesy, Water vapor