# Building An Online System For Managing, Analyzing And Serving Of Geospatial And Geodynamic Data Of Turkey Based On The User Preferences

*Deniz Basar[1], Rahmi Nurhan Celik[1], Onur Gorgun[2]

1. Istanbul Technical University, 2. Nokia Turkey

A geospatial data infrastructure comprises geospatial databases and data handling facilities, also data producer and consumer interactions. Geospatial data’ s being produced, managed and served globally is depend on the technical policies, standards, human resources, and technology.
The aim of the study is to propose a Geospatial Data Infrastructure to make geodetic and geodynamic data of Turkey manageable and analyzable on web. Proposed Geospatial Data Infrastructure has a multi-tier architecture which is compliant with INSPIRE, including data layer, service layer and application layer. Data layer consists of records, data and metadata about user generated and GNSS related data. For this purpose, PostgreSQL object-relational database is used, and PostGIS is also used to extend PostgreSQL capabilities to store, manage and serve geospatial data on online platforms.
Service layer follows the principles of Service Oriented Architecture (SOA) to build Network Service Architecture. SOA consists of different services with different purposes, and these services work with harmonization and exchange data easily. Interoperability and continuity of these services can be achieved by Extended Markup Language (XML) based Open Geospatial Consortium (OGC) Standard Services; such as Web Map Service (WMS), Web Feature Services (WFS), Web Processing Service (WPS), Web Coordinate Transform Service (WCTS), Web Map Tile Service (WMTS). In SOA architecture data transfer in between client and server is provided by Representational State Transfer (REST) which is proxy independent and uses Hyper Text transfer Protocol (HTTP) Methods. GeoServer is being employed to interpret and to respond user requests, as a web map server.
Application layer offers two main and many other sub-functionalities that only main functionalities are emphasized here; collecting user request and user data, and visualizing response which is interpreted with respect to user preference.

Keywords: GNSS/GPS, Geospatial Data, Web Based System Architecture, OGC web services

# Calibration technique for water vapor Raman lidar using GNSS PWV and meso-scale model

*Hayato Kakihara[1], Masanori Yabuki[1], Toshitaka Tsuda[1], Makoto Tsukamoto[2], Toshikazu Hasegawa[2]

1. Research Institute for Sustainable Humanosphere, Kyoto University, 2. EKO INSTRUMENTS. Co., Ltd.

Water vapor is an important component in atmospheric processes, such as thermodynamic influences on convection initiation and localized extreme weather events associated with severe weather disasters. Accurate observations of water vapor in the atmospheric boundary layer are essential for improved weather forecasting. Raman lidar techniques are useful for observing water vapor profiles. However, the calibration factor based on the system constants of both nitrogen and water vapor channels must be determined before estimating the water vapor from Raman signals. Because the calibration factor is usually evaluated by comparing the results of independent measurements (e.g., radiosonde) of water vapor mixing ratio, it is difficult to apply lidar observations at sites where radiosonde observations cannot be carried out.

In this study, we propose a new calibration technique for water vapor Raman lidar using global navigation satellite system (GNSS)-derived precipitable water vapor (PWV) and the Japan Meteorological Agency Meso-Scale Model (MSM). The analysis was accomplished by directly fitting the GNSS-PWV to integrated water vapor profiles combined with the MSM and the results of the Raman lidar observation. This method can be applied to lidar signals under a limited height range due to weather conditions and lidar specifications. For example, Raman lidar using a laser operating in the ultraviolet C (UV-C) region has the advantage of having no daytime solar background radiation in the system. However, the observation range is limited at altitudes lower than 1–3 km because of the strong ozone absorption in the UV-C region. The new calibration method will allow the utilization of various types of Raman lidar systems. In this paper, we will introduce our proposed calibration techniques as well as the preliminary results on the accuracy of the estimated calibration factor based on numerical simulations.

Keywords: water vapor, lidar, GNSS, MSM

# Long-term monitoring of water vapor by using a next generation microwave radiometer "KUMODeS"

*Taketo Nagasaki[1], Kentaro Araki[2], Hiroshi Ishimoto[2], Ryuichi Ichikawa[3], Hiroshi Takiguchi[3], Osamu Tajima[1]

1. High Energy Accelerator Research Organization, IPNS, 2. Meteorological Research Institute, Forecast research department, 3. National Institute of Information and Communications Technology

Weather forecasts in the early stage are important to minimize damages caused by natural disasters.
In particular, the forecast of sudden natural disasters (e.g. tornadoes, heavy snowfalls, heavy rainfalls) is an important subject. The sudden natural disasters follow the rapid change of atmospheric thermodynamic field. Precise monitoring of the atmosphere in high rate is essential to understand its variation.
"KUMODeS" is a next-generation microwave radiometer. It simultaneously measures the atmospheric radiation at 20 - 30 GHz range and 50 - 60 GHz range. The radiation spectrum at 20 - 30 GHz range by using a cryogenic receiver allows us to measure the quantity of water vapor as well as the thickness of clouds. The cryogenic system provides us the low noise data. The spectrum at 50 - 60 GHz range allows us to measure the vertical profile of the physical temperature for Oxygen molecule. Novel calibration technique using a blackbody material maintained at 50 K is useful for long-term observations.
Configuration for the atmospheric observation or calibration is switched by using an optical path selector. A direction of wiregrid selects each signal. We can remotely control the configuration by using the mechanical drive for the selector. This technique guarantees the quality of the data in long-term without any special work during the observation.
Towards the research about the atmospheric thermodynamic field, we have observed atmosphere by using KUMODeS in Tsukuba city. In this presentation, we will report the status of our long-term observation including comparisons with other monitors. We will also introduce a hand-carry version of KUMODeS which is under development.
This research has been funded by "Program for Creating STart-ups from Advance Research and Technology (START Program)" from the Ministry of Education, Culture, Sports, Science and Technology, Japan, http://www.jst.go.jp/start/en/index.html.

Keywords: atmospheric water vapor, radiometer, thermodynamic environment

# A comparison of precipitable water vapor retrieved with novel ground-based microwave radiometer, GPS and analysis data in Tsukuba during a cold front passage

*Ryuichi Ichikawa[1], Hiroshi TAKIGUCHI[1], Taketo NAGASAKI[2], Osamu TAJIMA[2], Kentaro ARAKI[3]

1. National Institute of Information and Communications Technology, 2. High Energy Accelerator Research Organization (KEK), 3. Meteorological Research Institute

We have developed a state-of-the-art microwave radiometer named KUMODeS (KEK Universal Moisture and Oxygen Detection System) using the technology of millimeter-wave spectroscopy for the high-resolution and high-precision monitoring of water vapor behavior. We have carried out comparative measurements of precipitable water vapor (PWV) in order to investigate the potential of KUMODeS/PWV measurements.

KUMODeS measures spectra using two receivers with frequency bands of 20–30 GHz and 50–60 GHz. The low-noise amplifier of the first receiver and a cold calibration source are implemented in a cryostat, which is maintained at 10 K in order to improve the sensitivity in the detection of the characteristic broad peak of water vapor at around 22 GHz. The second receiver is used to measure the absorption peaks of oxygen (~60 GHz).

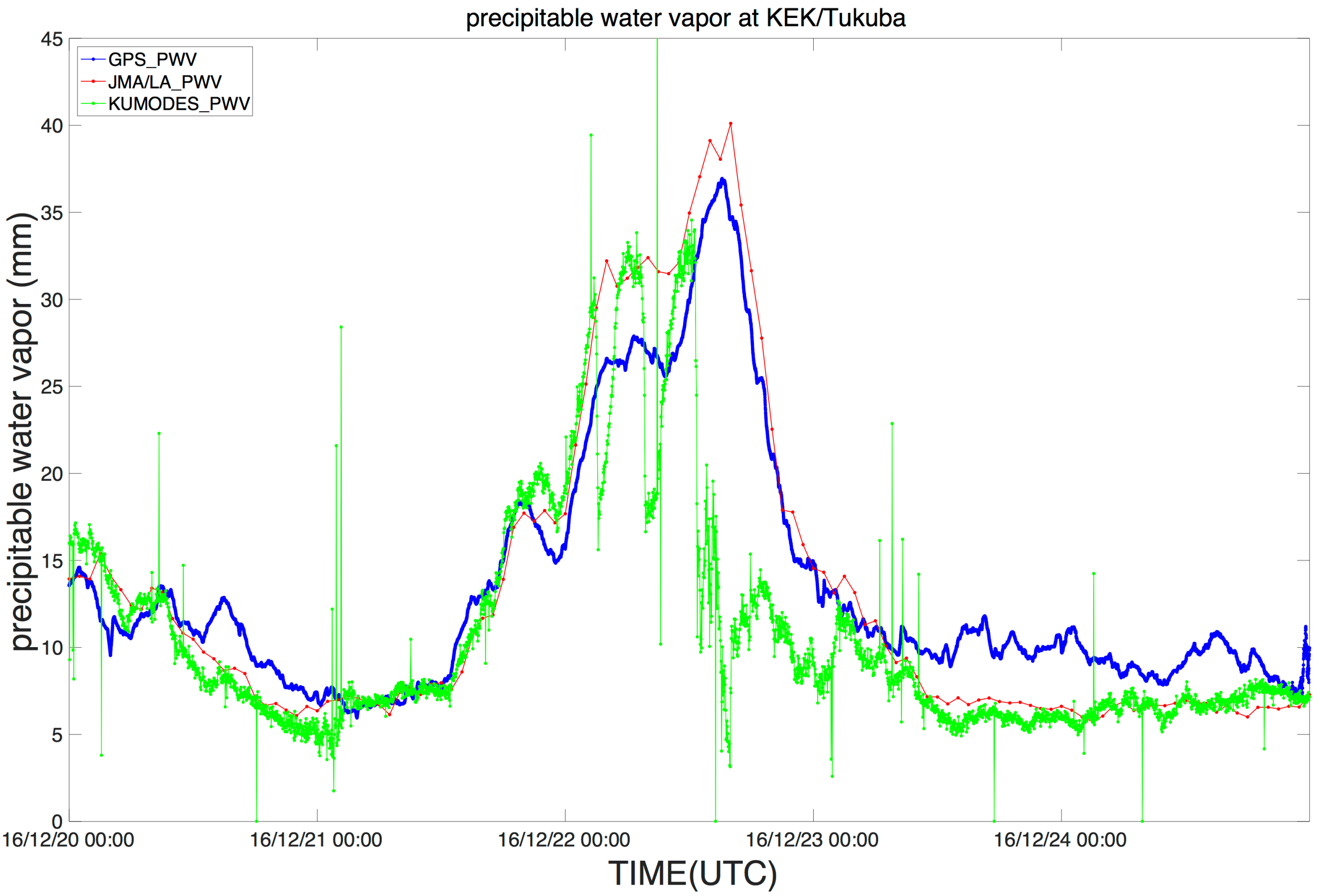
The GPS-based PWV is estimated reliably with 1–2 mm accuracy according to previous studies. The GPS PWV values are retrieved from zenith wet delays (ZWDs), which are computed by subtracting the zenith hydrostatic delays (ZHDs) from GPS-based zenith total delays (ZTDs). In this procedure, the ZHDs are obtained from the surface pressure and temperature.

We analyzed the PWV variation in Tsukuba, Japan, derived from three techniques, i.e., using KUMODeS, GPS and JMA operational local analysis (LA), during a cold front passage. The PWV measurements derived from GPS and KUMODeS have temporal resolutions of 30 s and about 2 min, respectively. The estimates from the LA have a temporal resolution of 1 h. A comparison of time series shows good agreement between the PWV measurements retrieved from KUMODeS, GPS and the LA between 20 and 22 December 2016. On the other hand, some differences between them appeared after the heavy rainfall of 22 December.

Although further investigation is required to evaluate the performance of KUMODeS, the preliminary result of the comparison implies the consistency and potential of KUMODeS measurements.

Keywords: microwave radiometer, precipitable water vapor, GNSS


precipitable water vapor at KEK/Tukuba
GPS_PWV
JMA/LA_PWV
KUMODES_PWV
precipitable water vapor (mm)
45
40
35
30
25
20
15
10
5
0
16/12/20 00:00
16/12/21 00:00
16/12/22 00:00
16/12/23 00:00
16/12/24 00:00
TIME(UTC)

# Long-term behavior of precipitable water vapor over the last 20 years and regionality of atmospheric delay gradient

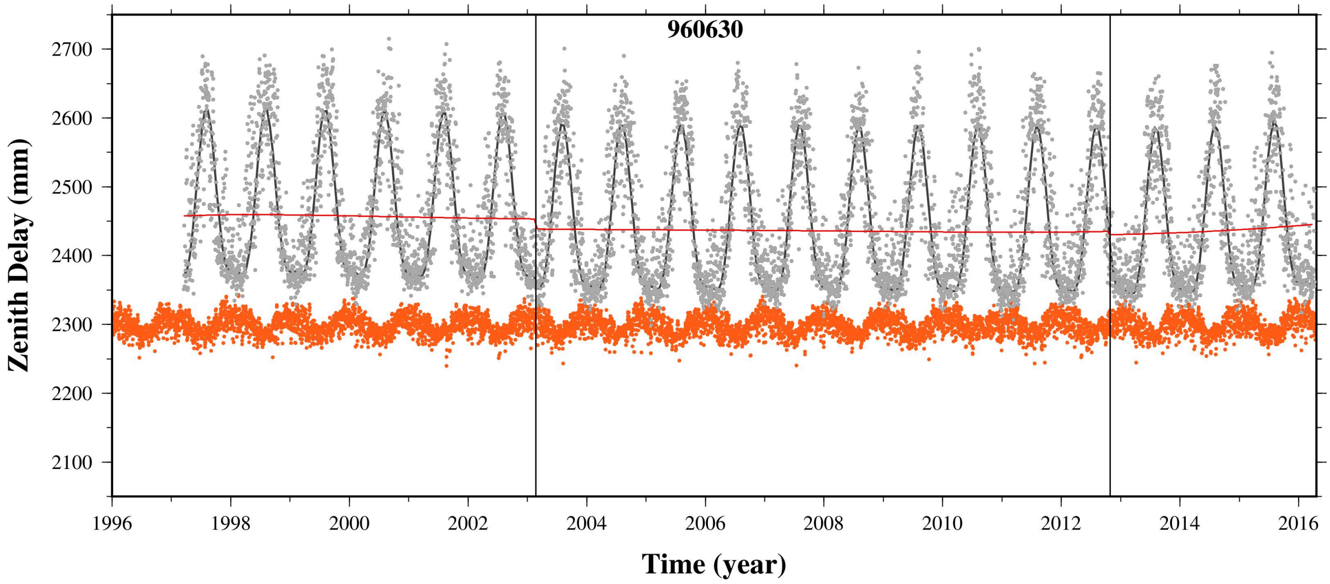
*Ryota Sato[1], Kosuke Heki[1]

1. Hokkaido University department of natural history scienses

Recent increase of extreme climate events has been a focus of debate all over the world, and they believe that global warming is responsible for the increase. IPCC AR5 (Intergovernmental Panel on Climate Change Fifth Assessment Report) suggested that the average temperature on Earth increased by 0.85℃ from 1880 to 2012 and the average temperature over the last 30 years is higher than any decadal averages since 1850. There is little doubt concerning the reality of the on-going global warming.
It is an important meteorological issue to understand how the changes of atmospheric water vapor influence global warming. By observing the distribution and dynamics of atmospheric water vapor, we can understand its link to the climate change. It will also contribute to improve the accuracy of forecasting precipitation. Precise knowledge of the long-term behavior of water vapor would enable us to predict future climate changes over centuries.
Microwave signals from GNSS satellites experience delays when they propagate the neutral atmosphere. We can infer the amount of wet atmospheric delay (delay caused by water vapor) by subtracting the hydrostatic delay (delay caused by dry atmosphere) from the total delay. In this research, I estimated changes of atmospheric water vapor from 1996 to 2016 by combining the atmospheric delays from the Japanese dense GNSS array GEONET (GNSS Earth Observation NETwork) with the surface atmospheric pressure data from the Japan Meteorological Agency. I then found that the atmospheric water vapor shows complicated inter-annual variations rather than simple monotonous increase. By comparing the behaviors of the atmospheric delays at various points in Japan, I found that multiple factors, e.g. latitude and height, influence the amount of delay.
Atmospheric delay gradient is an important factor to reduce positioning errors when atmospheric delays are not in azimuthal symmetry. In the early days of positioning with GNSS, they assumed that the atmospheric delay depends only on the elevation angle. Now it became standard to model its azimuthal dependence by introducing the atmospheric delay gradient as a new parameter. Estimating the gradients all over the Japanese Islands also made it possible to assess the non-uniform distribution of water vapor not canceled by taking long-term averages. I found several general tendencies in the time-averaged atmospheric delay gradient vectors, e.g. they often show significant southward components, and they are often perpendicular to the coastline and tend from ocean to land.

Keywords: GNSS, PWV, Long term variation


960630
Zenith Delay (mm)
2700
2600
2500
2400
2300
2200
2100
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Time (year)

# Relationships among Rainfall Distribution, Surface Wind, and Precipitable Water Vapor derived from GNSS during Localized Heavy Rainfall in Tokyo in Summer

*Yoshihito Seto[1], Hitoshi Yokoyama[2], Tsuyoshi Nakatani[2], Haruo Ando[3], Nobumitsu Tsunematsu[3], Yoshinori Shoji[4], Kenichi Kusunoki[4], Masaya Nakayama[5], Yuto Saitoh[6], Hideo Takahashi[1]

1. Department of Geography, Graduate School of Urban Environmental Sciences, Tokyo Metropolitan University, 2. National Research Institute for Earth Science and Disaster Resilience, 3. Tokyo Metropolitan Research Institute for Environmental Protection, 4. Meteorological Research Institute, 5. Information Technology Center, the University of Tokyo, 6. West Nippon Expressway Company Limited

In recent years, short-term heavy-rainfall events that have caused various damages such as flooding have frequently occurred in the Tokyo Metropolitan area in summer. This study aims to clarify the evolutionary process of short-term heavy rainfall as a contribution to short-range forecasting of heavy rainfall that occurs locally.

The relationships between the occurrence of intense rainfall and the convergence of surface winds and water vapor concentration for typical heavy-rainfall cases were examined using data from July to August in 2011–2013 obtained from high-density meteorological observations in Tokyo, Japan. Additionally, the differences in the temporal variations in wind convergence and water vapor between days with and without heavy rainfall events were compared.

Corresponding to the heavy-rainfall area, the convergence of surface winds tended to increase for several tens of minutes prior to the heavy rainfall. The peak of convergence was observed 10–30 min before the heavy-rainfall occurrence, and increasing of convergence continued for approximately 30 min until the convergence peak time. Around the heavy-rainfall area, the increase in the water vapor concentration index was observed coincide with the increasing of convergence. From these results, by monitoring the temporal variations and distributions of these parameters using a high-density observation network, it should be possible to predict the occurrence of heavy rainfall rapidly and accurately.

This study is supported by the S-8 Project, Comprehensive Research on Climate Change Impact Assessment and Adaptation Policies, implemented by the Environment Research and Technology Development Fund of the Ministry of the Environment, Japan and Tokyo Metropolitan Area Convection Study for Extreme Weather Resilient Cities (TOMACS) under the Funds for Integrated Promotion of Social System Reform and Research and Development by the Ministry of Education, Culture, Sports, Science and Technology, Japan.

Keywords: localized heavy rainfall, wind convergence, water vapor, high-density observation network

# The Multi-path Effect on PWV Retrieved from Shipborne GNSS Measurements

*Yoshinori Shoji[1], Kazutoshi Sato[2], Masanori Yabuki[3], Toshitaka Tsuda[3]

1. The Second Laboratory of Meteorological Satellite and Observation System Research Department, Meteorological Research Institute, 2. Japan Aerospace Exploration Agency, 3. Research Institute for Sustainable Humanosphere

Water vapor plays a significant role on development of hazardous cumulus convection. Water vapor monitoring with high temporal and spatial resolution is indispensable for both predicting and monitoring of such disastrous weather phenomenon. In Japan, a nationwide dense continuous ground based GNSS (global navigation satellite system) network named GEONET (GNSS Earth Observation Network, http://www.gsi.go.jp/ENGLISH/page_e30030.html) has also been utilized as a continuous water vapor monitoring network by the Japan Meteorological Agency since 2009.

In order to capture finer water vapor variation, we have been developing observation system of water vapor over the ocean using GNSS receivers equipped on top of floating buoys and vessels (Shoji et al. 2016). One of the most important points of the application is its real-time availability. We have tested MADOCA (Multi-GNSS Advanced Demonstration tool for Orbit and Clock Analysis) real-time ephemerides (https://ssl.tksc.jaxa.jp/madoca/public/public_index_en.html) applied to the program package for GNSS positioning "RTKLIB (http://www.rtklib.com/)" version 2.4.2 (patch 11).

In year 2015, we conducted observations using four shipborne GNSS receivers on three research vessels and one passenger ferry to assess the real-time practicality of measuring GNSS-derived precipitable water vapor (PWV) over the ocean. All antennas were equipped on the upper-most deck of each vessel. A kinematic precise point positioning strategy was used for the GNSS analysis with a real-time GNSS satellite ephemerides (orbit and clock information).

The analyzed time series of PWV was contaminated with unrealistic sharp variations that occasionally occurred. Periodic occurrence of a spiky variation with a cycle of one sidereal day, along with post-fit phase residuals averaged at each elevation and azimuth, indicated that one of the causes of the unrealistically large time variation was interference of reflected signals (multi-path).

A simple quality control (QC) procedure based on the amount of PWV time variation was proposed. After the QC was applied, the retrieved PWVs had 3.4 –5.4mm root mean square (RMS) differences against radiosonde observations, and 2.3 –3.7mm RMS against those retrieved at nearby ground GNSS stations. The proposed QC procedure rejected more than 60 percent of retrieved PWV on research vessels and 6 – 11 percent on a passenger ferry. The results demonstrate the great potential of the real-time ephemerides and the necessity for careful consideration of the observation environment.

On 20 October 2016, we introduced an additional GNSS antenna on top of the mast of a vessel and conducted campaign observation till March 2017. Comparison with PWVs analyzed at nearby GEONET stations resulted that both antennas (mast top and deck) show about 2 mm RMS. In the case of the mast top observation, about 1 percent of retrieved PWV were rejected while more than 30 percent were rejected in the case of the deck observation.

Keywords: Watervapor, GNSS, Kinematic