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

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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

GNSS可降水量とMSMを用いた水蒸気ラマンライダーの校正
Calibration technique for water vapor Raman lidar using GNSS PWV and meso-scale model

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豪雨などの局所的な大気現象の理解や、気象予報精度の向上のためには、高い時空間分解能での水蒸気の定量計測が欠かせない。光を使ったリモートセンシング手法であるラマンライダーは、水蒸気の鉛直分布計測に適している。ラマン散乱信号から水蒸気量を推定するには、窒素分子や水蒸気分子のラマン散乱波長の受光効率等に関係した校正係数を定める必要がある。一般的には、ラジオゾンデのような水蒸気混合比を観測する別の手法と比較することにより校正係数を決定している。そのため、ラジオゾンデ観測ができないような場所においては、ラマンライダーによる高精度の水蒸気計測を行うことが難しい。

本研究では、全地球航法衛星システム(GNSS)を用いて推定される可降水量と気象庁メソスケールモデル(MSM)を利用した水蒸気ラマンライダーの校正手法を提案する。本手法ではMSMとラマンライダー観測を統合して得られる水蒸気混合比の鉛直分布積算量が、GNSS可降水量と一致するようにして校正係数を決定する。この手法は、観測可能な高度の制約があるライダー信号においても適用できるという特徴がある。例えば、紫外線C(UV-C)領域のレーザーを使用したラマンライダーは、昼間の太陽背景光の影響を受けないという利点を有するが、UV-C領域におけるオゾンの強力な吸収効果により観測可能高度は1～3km以下となる。また、雲があるときは、ライダー信号の減衰により雲高度以上の解析ができなくなるが、本手法では雲底下までの水蒸気分布を用いて校正係数が導出できる。本稿では、提案する校正手法の校正係数推定精度に関して、シミュレーション研究に基づき説明する。

キーワード：水蒸気、ライダー、GNSS、MSM
Keywords: water vapor, lidar, GNSS, MSM

次世代放射計KUMODeSによる冬季水蒸気量観測
Long-term monitoring of water vapor by using a next generation microwave radiometer “KUMODeS”

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大雨や積乱雲下で生じる竜巻・大雪などの局所的・突発的自然災害による被害を最小化するには、気象事象の早期予測が重要である。その実現に向けて、大気の熱力学場を高頻度・高精度に観測する手段と、その他の予報・ナウキャスト情報を用いた解析が求められている。

次世代放射計”KUMODeS(クモデス)”は地上設置型のマイクロ波帯放射計であり、大気中に存在する水分子から放射される輝線 (20 - 30 GHz 帯)ならびに酸素分子からの輝線 (50 - 60 GHz 帯) をマルチバンド受信する。前者の帯域には冷却受信機を採用し、高感度(低雑音)な観測を実現する。加えて、冷凍機の余剰冷却能力を用いて５０Kに冷却した温度較正源を搭載しており、機械的な駆動によって２周波数帯を同時較正する機能を有する。これにより、気温変動等を補正した高精度な屋外観測を実現している。感度向上は大気の熱力学場、雲物理量の推定を短時間で広域観測を実現し、熱力学場の急激な不安定化や、雲物理量の変化の察知に役立つ。現在、試作機を用いて２０１６年度冬季の長期観測をつくば市にて実施している。

本講演では、システムの概要ならびに大気観測の結果を報告する。また小型・低電力化を目指した二号機の開発状況も報告する。なお、本研究は文部科学省・大学発新産業創出拠点プロジェクト「START」(http://www.jst.go.jp/start/) に平成２６年度より採択され、その援助のもとに開発を行った。

キーワード：大気水蒸気量、放射系、大気熱力学場
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

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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.

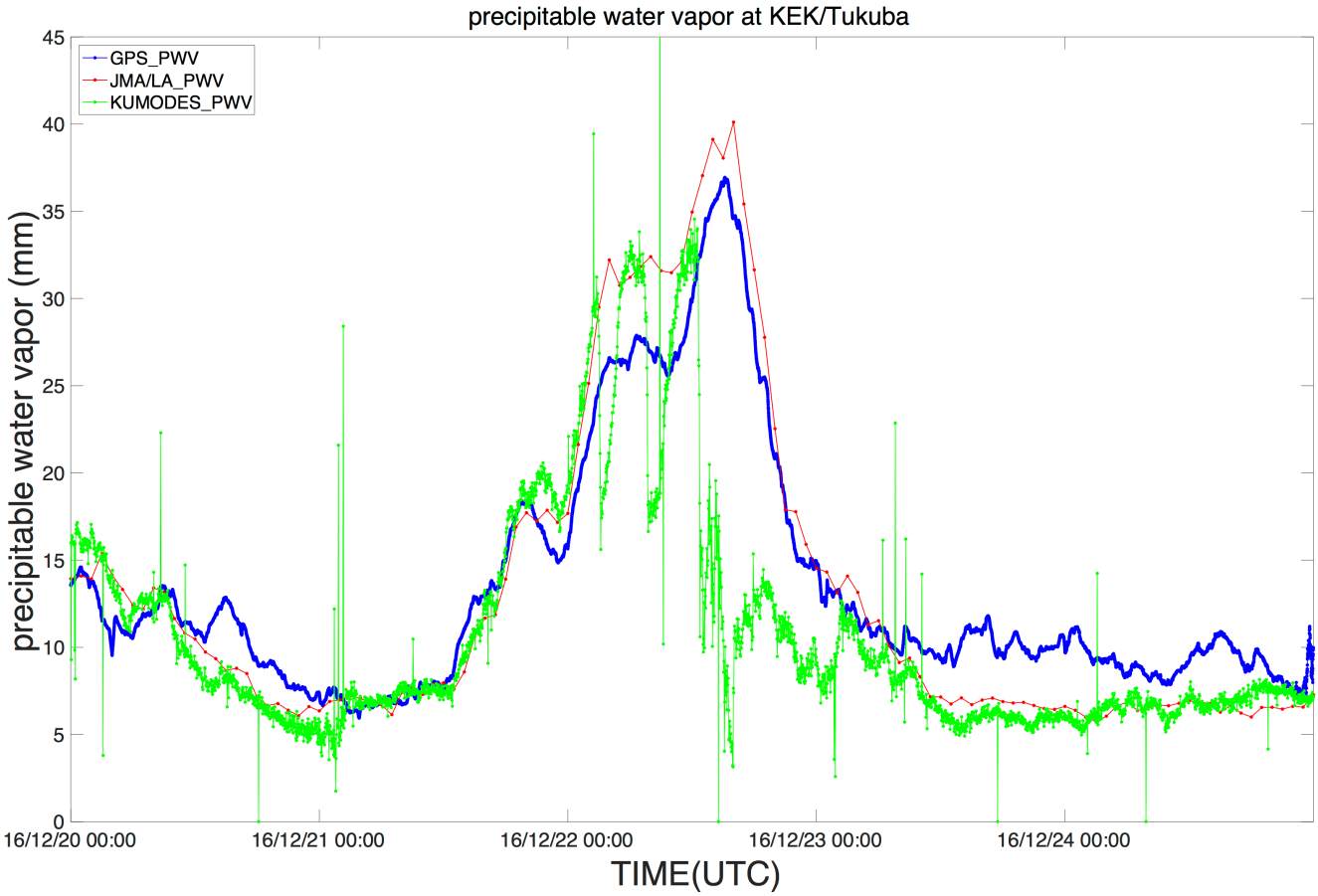
KUMODeS measures spectra using two receivers with frequency bands of 20–30 GHz and 50–60 GHz. The low-noise amplifier of the first receiver and a cold calibration source are implemented in a cryostat, which is maintained at 10 K in order to improve the sensitivity in the detection of the characteristic 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.

キーワード：マイクロ波放射計、可降水量、衛星測位システム
Keywords: microwave radiometer, precipitable water vapor, GNSS



過去20年間の可降水量の長期変動と大気遅延勾配の地域性
Long-term behavior of precipitable water vapor over the last 20 years and regionality of atmospheric delay gradient

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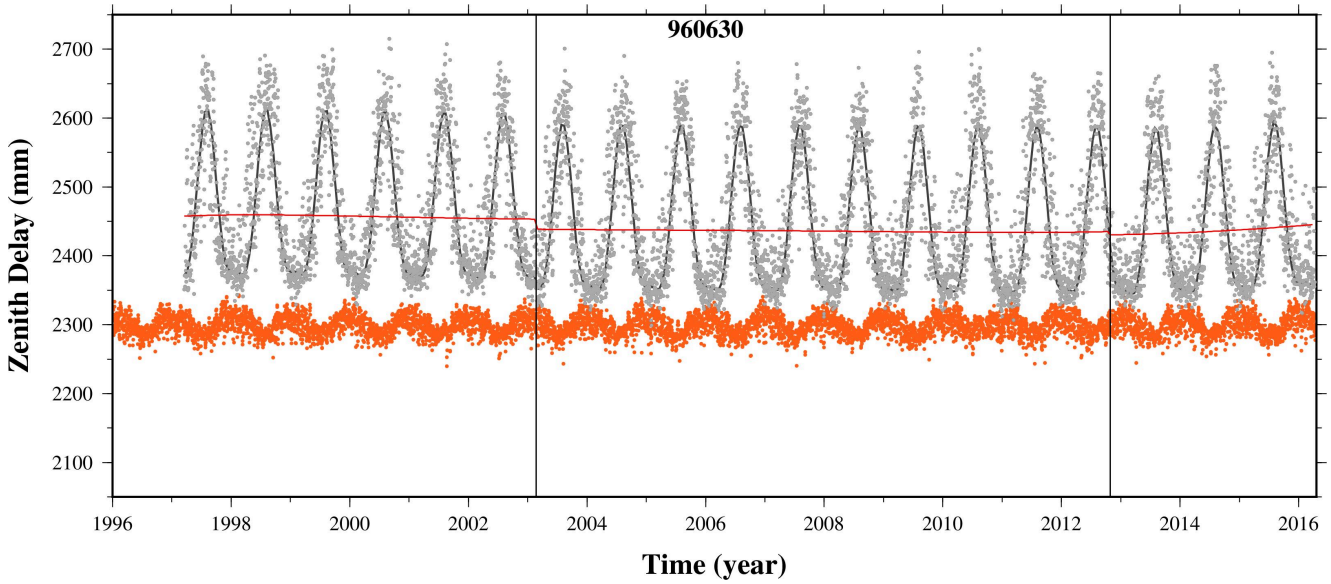
Recent increase of extreme climate events has been a focus of debate all over the world, and they believe that global warming is responsible for the increase. IPCC AR5 (Intergovernmental Panel on Climate Change Fifth Assessment Report) suggested that the average temperature on Earth increased by 0.85℃ 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.

キーワード：GNSS、可降水量、長期変動
Keywords: GNSS, PWV, Long term variation



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

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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.

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キーワード：短時間強雨、地上風収束、水蒸気量、高密度観測網
Keywords: localized heavy rainfall, wind convergence, water vapor, high-density observation network

船舶搭載GNSS水蒸気観測への反射波の影響
The Multi-path Effect on PWV Retrieved from Shipborne GNSS Measurements

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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.

キーワード：水蒸気、GNSS、キネマティック
Keywords: Watervapor, GNSS, Kinematic

