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Development of Pedestrian Navigation System Using Short-Term Rainfall Prediction on Smartphone

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Nowcasting is good for short-term weather prediction because its description of the current state of the atmosphere and the prediction of how the atmosphere will evolve during the next several hour (Clifford Mass, 2012).

With advanced features such as high-speed Internet connection device, Global Positioning System (GPS), high-resolution screen, and good computational capabilities, nowadays smartphone can be one of solution for distributing real-time weather information in almost any location. This system is expected able to help students planning their trip from campus to train station by providing specific rainfall prediction, in order to avoid getting rain in the middle of their trip, and can take part in disseminating weather information.

In this study, we would like to combine short-term rainfall prediction from Furuno X-Band Doppler Radar that located at Kobe University and smartphone's advanced features, together with apple's API services to produce a specific rainfall prediction. This system will check rainfall prediction for the next 30 minutes, turn-by-turn based on walking route from departure place to user-selected train station. Final output of this system is giving user advice whether start the trip now or wait for certain minus to avoid rainfall.

Currently, this system is developed using XCode Swift Framework and running only on Apple devices. At the beginning system will identify user's location/departure location by utilizing GPS features on smartphone, then using apple's API system smartphone gets full address of departure location through reverse geo-location method. Process continued by requesting nearby station from departure location, user select one of station as their destination location. Using departure and destination data, system generates walking route and combine route information with short-term rainfall prediction data to check minute-by-minute rainfall along user's walking route.

Current result is that system able to combine two kind of information: user location, map, route direction with rainfall prediction data and giving advise to user best time to start their trip. The next development plan is allowing user to stop in the middle of their trip for example convenience store or bus stop.

キーワード: navigation system, short-term predicition, smartphone
Keywords: navigation system, short-term predicition, smartphone

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船舶による GNSS 可降水量観測
Water vapor monitoring over the ocean using a shipborne GNSS receiver

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Experimental cruises were conducted with a global navigation satellite system (GNSS) antenna installed facing the zenith on the deck of the research vessel to investigate the accuracy of precipitable water vapor (PWV) and benefits of multi-GNSS processing. Also, more than 100 profiles were observed by radiosondes released from the ship during the experiment. Using multi-GNSS signals improved the estimation accuracy of PWV on the vessel. The root means square (rms) and bias of PWV between GPS and radiosonde observations was smaller in the case of multi-GNSS.

Although some microwave satellites observe oceanic water vapor, they are insufficient for in-depth study of air-sea interaction. GNSS-PWV is advantageous because of its high accuracy and temporal resolution, and it would be useful for numerical weather predictions, such as for typhoons or hurricanes.

キーワード: GNSS, 可降水量
Keywords: GNSS, precipitable water vapor

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稠密 GNSS 受信ネットワークを用いた可降水量の時間・空間変動特性に関する研究
Characteristics of time and spatial variations of precipitable water vapor observed with a dense GNSS receiver network

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According to the IPCC report, the number of localized torrential rain is projected to increase recently because of global warming, which sometimes gives serious weather hazards to our society. It is requested to establish an early warning system for severe rain events. Although a meteorological radar and surface rain gauge (AMeDAS) can detect rain clouds and precipitation, respectively, they can only detect rain clouds after their formation. We aim at developing an observation system to monitor the behavior of water vapor before it condenses to form a cloud, by employing the GPS meteorology technique.

We estimate PWV (Precipitable Water Vapor) from the radio propagation delay of GPS signals. We deployed a dense GNSS receiver network in Uji for this study using 15 receivers with 1-2 km horizontal spacing. We obtained the GNSS data from April 2011 to March 2013. We also downloaded the surface precipitation data observed at AMeDAS station in Nagaoka-city.

We computed PWV at every observation points, and analyzed time and spatial variations of PWV.We compared these parameters with the AMeDAS data. In order to investigate a relationship between PWV and local torrential rain, we analyzed PWV on 40 days when much precipitation was found in the AMeDAS data. In particular, we selected three cases on August 13, 18 and September 15, 2012. We found both the averaged PWV value and the variance of PWV between GNSS points increased before a passage of a rain cloud which was detected by the meteorological radar. When more precipitation occurred, both the averaged PWV value and the PWV variance increased more rapidly, suggesting their positive correlation.

We analyzed the 40 cases statistically. Then the maximum value of the average PWV and the amount of precipitation show a linier relationship. In addition, we noticed that precipitation occurred when the variance of PWV between observation points was large. Thus, we consider that we have to analyze both the averaged PWV value and the variance of PWV, therefore, the dense GNSS network is useful for forecasting a local heavy rain.

キーワード: GPS, 可降水量, 宇治稠密観測
Keywords: GPS, PWV, dense network observation at Uji

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視線遅延量を用いたGNSS観測点周囲の可降水量分布解析-手法と検証-
Estimation of Local-scale PWV Distribution Around Each GNSS Station Using Slant Path Delay -Method and Evaluation-

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全球航法衛星システム (GNSS) 観測点周囲の数 km スケールの可降水量 (PWV) 変動を推定する手法を提案する．この手法は GNSS 解析で得られる天頂遅延量 (ZTD) と，各衛星方向の視線遅延量 (Slant Path Delay: SPD) を天頂方向の値に換算した時の差を利用する．この推定は，水蒸気勾配が指数関数的に高度とともに減少するとの仮定のもとに行われる．

この手法を利用して，2012 年 5 月 6 日，つくばに大きな被害をもたらした F3 竜巻の親雲の解析に適用した．この事例では，竜巻発生の 1 時間ほど前から，気象研究所 C-バンド二重偏波レーダーで，反射因子差（Zdr）が強い，10 km スケール程度の領域の存在を観測していた．高解像度数値シミュレーションでは，同様のスケールで強い PWV 勾配が再現されている．国土地理院の GNSS 電子基準点観測網は平均 17 km 間隔で配置されており，上記のような局地的な PWV 勾配は解像できない．今回提案する手法では，強い PWV 勾配と，その強化を表現できた．

この新手法の有効性を評価するため、水平解像度 250m の非静力学モデルの結果を用い、SPD をシミュレートし、従来手法と新手法で PWV を解析した。モデル結果の PWV を真値として比較したところ、以下の知見が得られ、新手法の有効性を確認できた。

1. 従来手法は RMS で 0.5mm の誤差を生じさせる。
2. 従来手法による PWV を外挿し、観測点周囲の PWV 推定値とすると、誤差は距離と共に増大し、1km 離れると 1.5mm に達する。
3. 新しい手法では、低い仰角の SPD で推定した PWV ほど、観測点から離れた場所での誤差が小さくなる。仰角 15 度の場合は観測点から SPD の方位角方向 6km の位置で 1.5mm 程度の誤差となる。

キーワード: GPS/GNSS 気象学, メソスケール気象学, 衛星測位, 可降水量, 視線遅延量, 積雲対流
Keywords: GPS/GNSS Meteorology, Mesoscale Meteorology, Satellite Geodesy, Precipitable Water vapor, Slant path delay, Cumulus convection