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Academic Degree	dr hab. inż. (DSc.)
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UPWr Base of Knowledge - link	https://bazawiedzy.upwr.edu.pl/info.seam?affil=&id=UPWr4d682756bd1243c58f310f8e07f263af&lang=en&cid=1061108
Researchgate:	https://www.researchgate.net/profile/Witold-Rohm
Personal website / Working group website:	https://spaceos.igig.upwr.edu.pl
Projects in last 5 years (chronological; with distinction into PI (kierownik) and RF (wykonawca)):	2021 - 2025 NCN-OPUS Three-dimensional integrated observations of the troposphere using ground and satellite GNSS observations - PI 2020 - 2024 NCN-Preludium BIS Beyond machine learning in mobility prediction - PI 2019 - 2022 H2020, GATHERS - Integration of Geodetic and imAging TecHniques for monitoring and modelling the Earth's surface defoRmations and Seismic risk - Innovation and data manager 2017 - 2022 OPI - POIR, EPOS - European Plate Observing System - PI 2015 - 2019 NCBiR TANGO, GNSS tomography as an important meteorological data source - results comercialisation, PI
Research topic and funding	
1) PhD topic:	Integrated 3D model of troposphere using ground-based and space-based GNSS observations
2) Research discipline in Doctoral School	Civil Engineering and Transport
3) Short description of the research problem to be solved in the PhD:	Global Navigation Satellite Systems (GNSS) were not initially designed as a source of troposphere information. However, as signal travel time is measured using atomic clocks, its propagation effects are known within a fraction of a nanosecond. These effects in the troposphere result from bending and slowing of the signals. Continues efforts of the GNSS and Numerical Weather Prediction (NWP) communities made the resulting GNSS refractive delays a valuable data source for global, regional, and local weather models [1]. Therefore, two major GNSS data types can be distinguished for assimilation into NWPs: 1) radio occultation (RO) profiles, i.e. bended GNSS signal as observed by space platforms while traversing Earth's limb, and 2) integrated troposphere delays (TD), i.e. GNSS signal delays caused by refraction in the Earth's atmosphere, and received by ground-based GNSS receivers. RO refractivity profiles are very dense in the vertical direction but have two major limitations: low horizontal resolution (150-300 km) and low reliability in the first 3-5 km of the troposphere [2]. In contrast, TDs are point observations, linked to the location of high-end positioning receivers. TD can improve humidity and rain forecasts, but as it is an integrated measure of the troposphere state over the station, NWPs have difficulties to distribute the corrections introduced by TD over specific model heights [3]. Current developments of low-cost GNSS technology are paving a way to ubiquitous sensing of the troposphere using GNSS signals. Internet of Things (IoT) GNSS ground stations worth couple hundred of dollars may be established and powered with wind turbines or solar panels. They will provide high- density troposphere delays (TD) by transmitting observations over LoRa Wide Area Networks (low bandwidth, low power, long-distance connection) and thus, allow a densification of existing networks with mean station distances of 3-5 km. The space counterpart (RO) is also rapidly developing. Private companies, such as Spire global, GeoOpitcs, or PlanetiQ, are sending currently tenths, and in the future hundredths CubeSats into space. They will allow for complementing existing constellations based on standard scale satellites, such as MetOp A/B or COSMIC-1/2. These satellites are equipped with GNSS receivers for orbit determinations, radio-occultations, reflectivity and polarimetric observations. Simply using the same type of observations – RO profiles and TD estimates, the numerical weather predictions will slightly improve due to the higher temporal and spatial resolution. However, the technique-specific limitations for both, RO and TD, will remain. One of the promising technologies that could alleviate the limitations of RO and TD observations is GNSS tomography. This technology is based on an inverse Radon transform, that allows for conversion of integral observations like tropospheric delays into refractivity distributions. In this project we will test the following hypothesis: "Use of the inverse Radon transform on the dense space-based (RO) and ground-based (TD) GNSS observations will provide integrated 3D model of troposphere that will improve precipitation and humidity forecasts." GNSS tomography with dense (3-5km) ground-based network and space-based observations, that traverse the troposphere in the horizontal direction, will make this technology suitable for application in high-density weather predictions. To reach this goal, the following research questions will be tackled: 1. Can the severe or local scale (e.g. Urban Heat Island, UHI) weather features be predicted more accurately if novel GNSS information is assimilated in the NWP?
4) Professional skills for PhD candidate (e.g. master program, specializations, softwares, language, analytical techniques):	•MSc in geodesy, geomatics, physics, computer science or mathematics, •GNSS processing skills in one of the following software: Bernese GPS Software, GIPSY-OASIS, GNSS WARP, RTK LIB, goGPS •Understanding of atmosphere physics is essential •Good command in English •Programming skills in one of the following: Matlab, Python, Fortran •Willing to undertake long-term (3 months+) internships in foreign research
5) Details of the project to support PhD research	
a) Project title:	3D integrated sensing of troposphere using ground and space-based GNSS observations
b) Agreement number:	2020/37/B/ST10/03703
c) Number of months in the project to support PhD (in months; starting from 1st of October 2021):	48
6) Project webside:	https://spaceos.igig.upwr.edu.pl/atmosphere/