Abstract submitted to: *WFMN 2009, Chemnitz, Germany, 25–27 November 2009*
Suggested topic: *Microwave Measurements in Propagation*

Atmospheric Transmission Measurements for Precipitation Quantification

Susanne Hipp*, Christian Chwala†, Uwe Siart*, Thomas Eibert*, Harald Kunstmann†
*Institute for High-Frequency Engineering
Technische Universität München
Arcisstr. 21, 80333 München, Germany
Tel.: +49 89 289-23375, E-Mail: susanne.hipp@tum.de
†Institute for Meteorology and Climate Research IMK-IFU
Karlsruhe Institute of Technology
Kreuzeckbahnstr. 19, 82467 Garmisch-Partenkirchen, Germany

Introduction

In order to improve water resources quantification and sustainable management the accurate and high resolution estimation of spatial and temporal distributions of precipitation is still an important issue. The attenuation of microwave signals of cellular networks offers a completely new and highly innovative method to quantify ground-level precipitation. The joint virtual institute "Regional Precipitation Observation by Cellular Network Microwave Attenuation and Application to Water Resources Management" (PROCEMA) aims at the development, optimization and exploitation of this methodology in hydrological and meteorological sciences.

Within the PROCEMA project partners from Israel and Germany and from different scientific fields work together on this challenge. In their research program they focus on development of algorithms for relating the attenuation rate of cellular network back-haul link signals to rainfall intensity and on development of algorithms to convert line integrals into spatial rainfall fields. Furthermore experimental investigation on impact of atmospheric conditions on microwave propagation and validation and performance analysis of the methodology for applications in water balance analysis and integrated pilot test site intercomparison will be carried through. PROCEMA particularly addresses the scientific challenge of rainfall estimations in mountainous environments, where both station- and radar based techniques often fail. Therefore the methods under development will also provide valuable supplementary data in addition to established monitoring devices like radar, rain gauges, and satellite measurements.

In this contribution the scope of the PROCEMA project and the measurement systems under development will be introduced.

Description

Together with the Institute for Meteorology and Climate Research a polarimetric transmission measurement at frequencies 22 GHz and 35 GHz is currently being set up. We chose a monostatic configuration using a tetrahedral reflector to mirror the transmitted electromagnetic wave back to the receiver. Total path length is 1000 m and the measurement system is fully coherent and polarization agile. Discrimination between reflected and transmitted energy is achieved by timing control and range gating. Besides attenuation in H- and V-polarization this system can also record amplitude and phase noise (scintillations) produced by the hydrometeors with a single-sideband bandwidth of up to 25 kHz. It is expected that the noise statistics provide significant information for both precipitation classification and rain rate estimation.

In addition to the coherent transmission measurement system data logging modules on selected commercial point-to-point back-haul links are being installed. They will record instantaneous values of transmit power and AGC level to allow for a monitoring of the overall link attenuation. The software behind was designed to record averaged values every minute and send the data via FTP to a dedicated server. With this data and algorithms already existing or developed by the simulation team precipitation maps of different kinds will be constructed.

The precipitation estimates obtained from data provided by the new transmission measurement system as well as from attenuation monitoring at back-haul links will be compared, calibrated, and verified with data from collateral meteorological measurements accomplished by the Institute for Meteorology and Climate Research in research areas nearby.

Acknowledgment

This work is funded by the Helmholtz Association of German Research Centres under grant VH-VI-314 entitled "Regional Precipitation Observation by Cellular Network Microwave Attenuation and Application to Water Resources Management" (PROCEMA).

References

[1] Bahrami, M., J. Rashed-Mohassel, and M. Mohammad-Taheri: *An Exact Solution of Coherent Wave Propagation in Rain Medium with Realistic Raindrop Shapes*. Progress In Electromagnetics Research, PIER 79:107–118, 2008.

[2] Goldshtein, O., H. Messer, and A. Zinevich: *Rain Rate Estimation Using Measurements From Commercial Telecommunications Links*. IEEE Trans. Signal Process., SP-57(4):1616–1625, April 2009.

[3] Hendrantoro, G. and I. Zawadzki: *Derivation of Parameters of Y-Z Power-Law Relation From Raindrop Size Distribution Measurements and Its Application in the Calculation of Rain Attenuation From Radar Reflectivity Factor Measurements*. IEEE Trans. Antennas Propag., AP-51(1):12–22, January 2003.

[4] Rahimi, A. R., A. R. Holt, G. J. G. Upton, and R. J. Cummings: *Use of dual-frequency microwave links for measuring path-averaged rainfall*. Journal of Geophysical Research, 108(D15):8–1–8–12, 2003.

[5] Rahimi, A. R., G. J. G. Upton, and A. R. Holt: *Dual-frequency links—a complement to gauges and radar for the measurement of rain*. Journal of Hydrology, 288:3–12, 2004.