Analysis of the potential of CML data for nowcasting forecasts in Poland

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Background and study area

The growing network of telecommunication stations and commercial microwave links (CMLs) in last years has opened a window into a new way of rainfall estimation. This is a relatively new approach in precipitation estimation field, and it gives reasonably good results, and so have become a valuable source of precipitation information which can successfully supplement other existing observations. The potential of CMLs lies in their high temporal resolution (reaching one minute) and high abundance, so they are increasingly used for short-term forecasting (nowcasting). Like any type of data, data from commercial microwave links are subject to quality control to isolate non-functioning stations and those links that systematically give erroneous results. Such a pilot analysis and quality control was recently carried out (Pasierb et al., 2024) on 66 CMLs from the Opole Voivodeship (Fig.1), Poland. It was analysed to what extent the precipitation derived from CML attenuation data is useful in estimation of the precipitation field with the high temporal and spatial resolution required in nowcasting models.

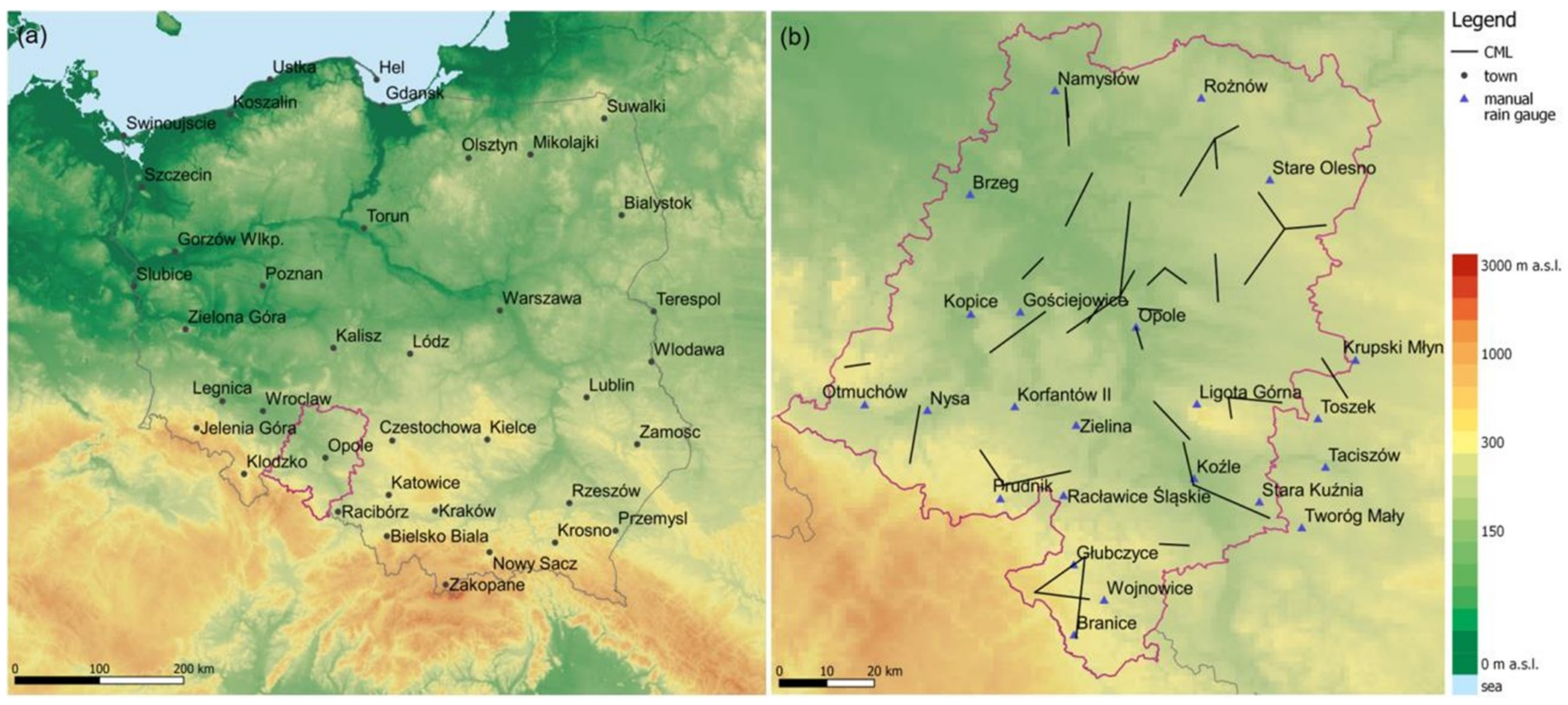

Fig.1. (a) Opole Voivodeship marked with pink borders, (b) locations of CMLs and manual rain gauges.

Quality control (QC) and precipitation estimation

Quality control of precipitation data obtained from CML data is performed for each sublink separately, based on multi-source precipitation estimates (QPEs) provided by the RainGRS system. For each link, the precipitation accumulation is determined from *GRS* values in pixels along the entire link, considering grids of 3 pixels x 3 pixels. For each grid a mean precipitation value and mean of quality index are calculated.

If $(CML < 0.3\,\text{mm}$ and $GRS_{CML} > 1.0\,\text{mm})$ or $(CML > 1.0\,\text{mm}$ and $GRS_{CML} < 0.3\,\text{mm})$ => $CML = \text{NODATA}$

or:

If $(CML > 80\,\text{mm}$ and $CML > 3.0 \cdot GRS_{CML})$ => $CML = \text{NODATA}$

Otherwise, precipitation values in individual sublinks are left unchanged.

For each link the precipitation value should be assigned to a specific point or set of pixels, here called virtual rain gauges. This is particularly important when having data from longer links and in the case of a more spatially variable precipitation field. The following three ways of assigning appropriate precipitation values to individual links are proposed:

- ***CML-1*** *(Fig.2b)*: The mean CML-based precipitation along the entire link is assigned to the pixel at its centre.
- ***CML-2*** *(Fig.2c)*: The CML based precipitation is distributed along the entire link based on the distribution of radar precipitation along this link (Fig.2a). Thus, linear sequence of virtual rain gauges is created, spaced every pixel along this CML. Each virtual rain gauge is given a precipitation value and weight of:

$$CML\text{-}2_i = CML \cdot \frac{R_i}{\sum_{i=1}^{N_{CML}} R_i} \qquad w = \frac{1}{N_{CML}}$$

where i is a number of virtual rain gauge; N_{CML} is the number of the virtual rain gauges. The total weight of all virtual rain gauges along a given link is always 1.0.

- ***CML-3*** *(Fig.2d)*: The CML-based precipitation is also distributed along the entire link based on the radar precipitation distribution, but the precipitation from only one virtual rain gauge located at the pixel in the centre of the link is taken for interpolation.

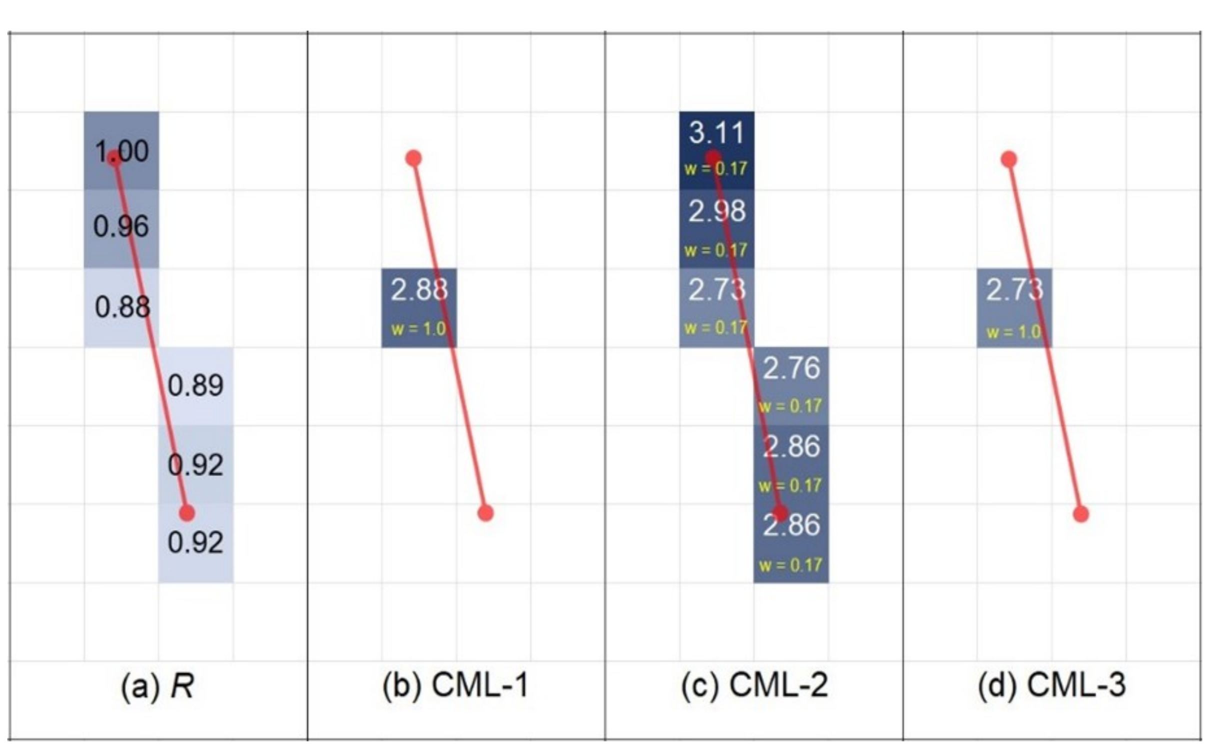

Fig.2. Example of (a) radar-based precipitation field, and assigning precipitation values to individual CML obtained by methods: (b) CML-1, (c) CML-2, and (d) CML-3. The smaller yellow font indicates the weight values (*w*) of the individual virtual rain gauges. Link located near the town of Opole is marked by a red line. Half-hourly accumulation from 30 July 2022, 10:30 UTC.

Results

The CML-based estimates were compared to observations from manual rain gauges and multi-source precipitation fields. The maps below (Fig.3) show differences in the precipitation fields obtained by the various measurement and estimation techniques. They clearly show the impact of the applied data quality control procedure used, comparing Fig.3a and Fig.3b with the references in Fig.3c and Fig.3d. It can be noticed that the highest values of raw CML-based precipitation were significantly reduced after QC. Some of these inconsistencies between CML-based estimates and other precipitation field estimates are due to the fact that the CML network in the study area is not very dense.

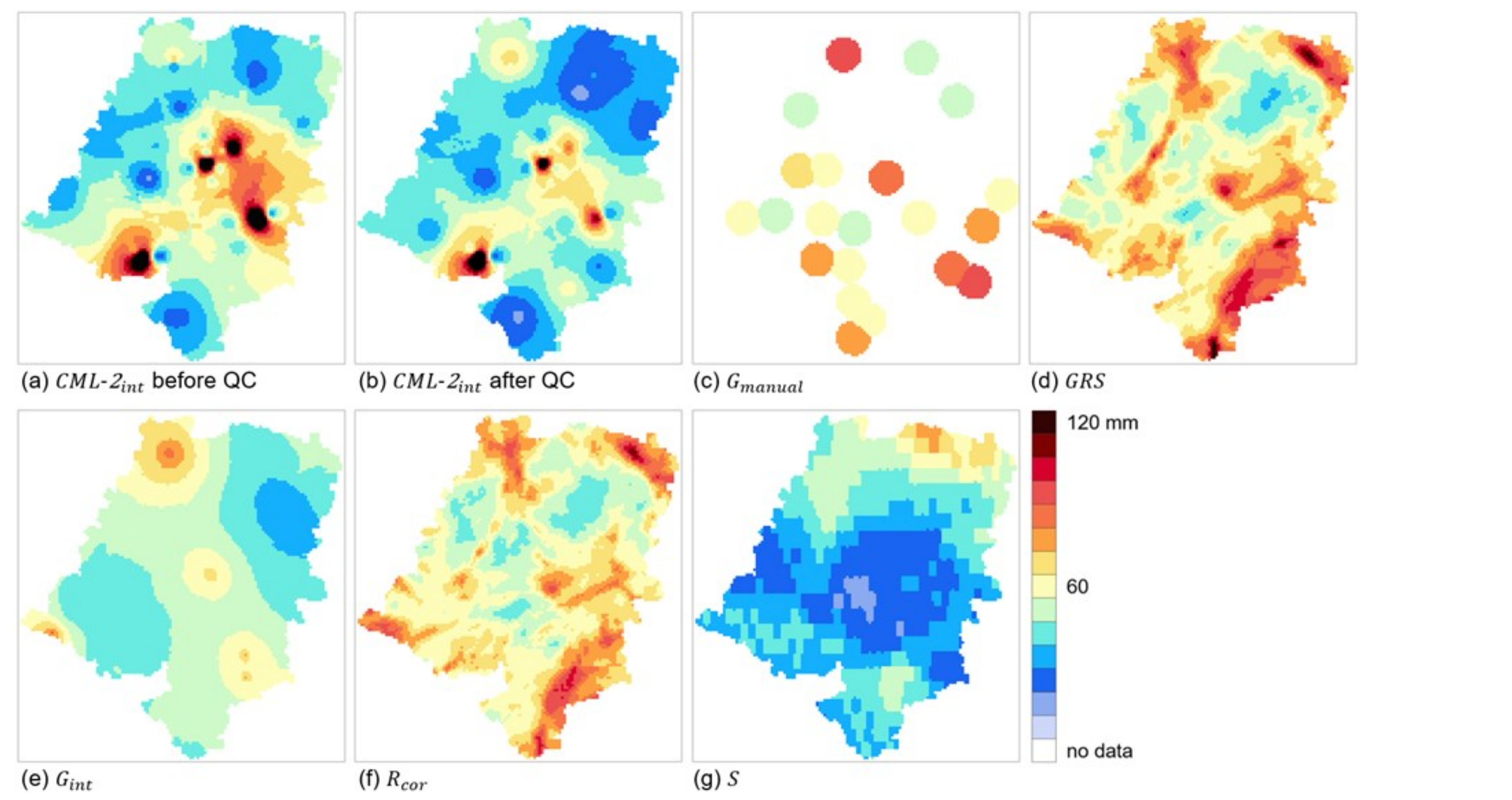

Fig.3. Long-term precipitation accumulations of CML-based precipitation *CML-2*$_{int}$ using *CML-2* method: (a) before quality control and (b) after quality control; data used as reference: (c) observations from manual rain gauges G_{manual} and (d) reanalysis of the RainGRS estimate *GRS*, and other estimates: (e) interpolated data from telemetric gauges G_{int}, (f) weather radar estimate R_{cor}, and (g) satellite estimate *S*. Accumulations from July 19 – August 18, 2022.

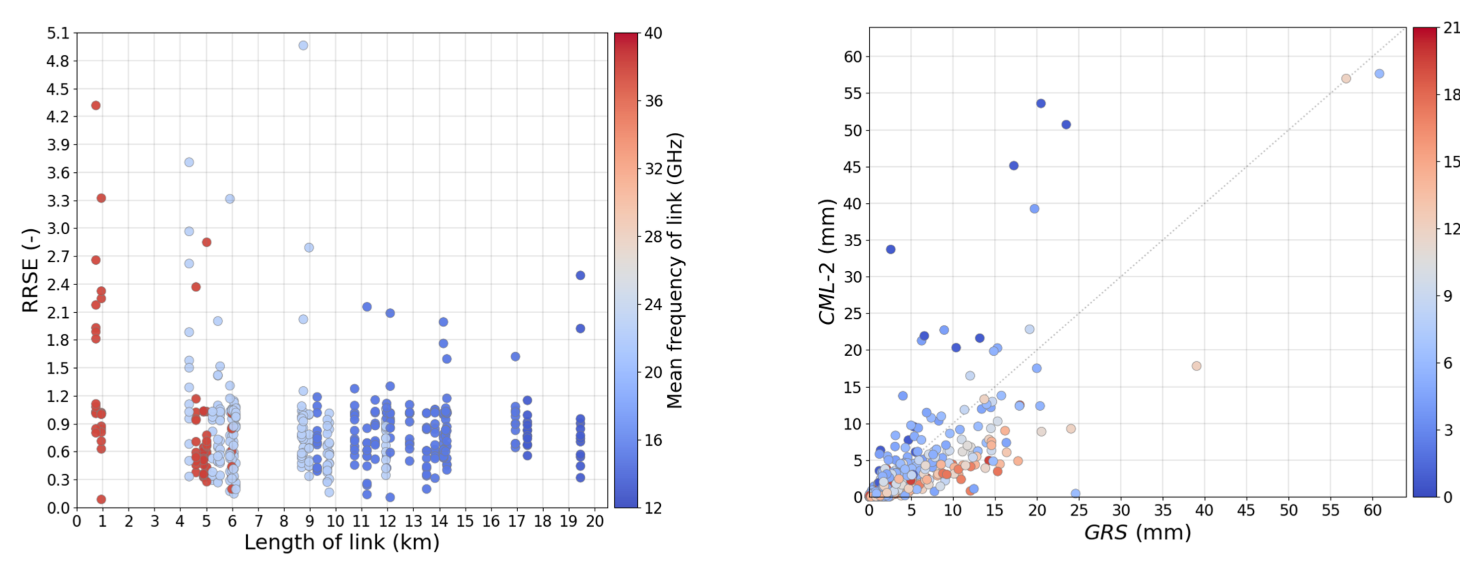

Fig.4. Relationship between the relative error of precipitation estimation RRSE and link length (left) and relationship of the precipitation estimated by the CML-2 method and the GRS reference value (right).

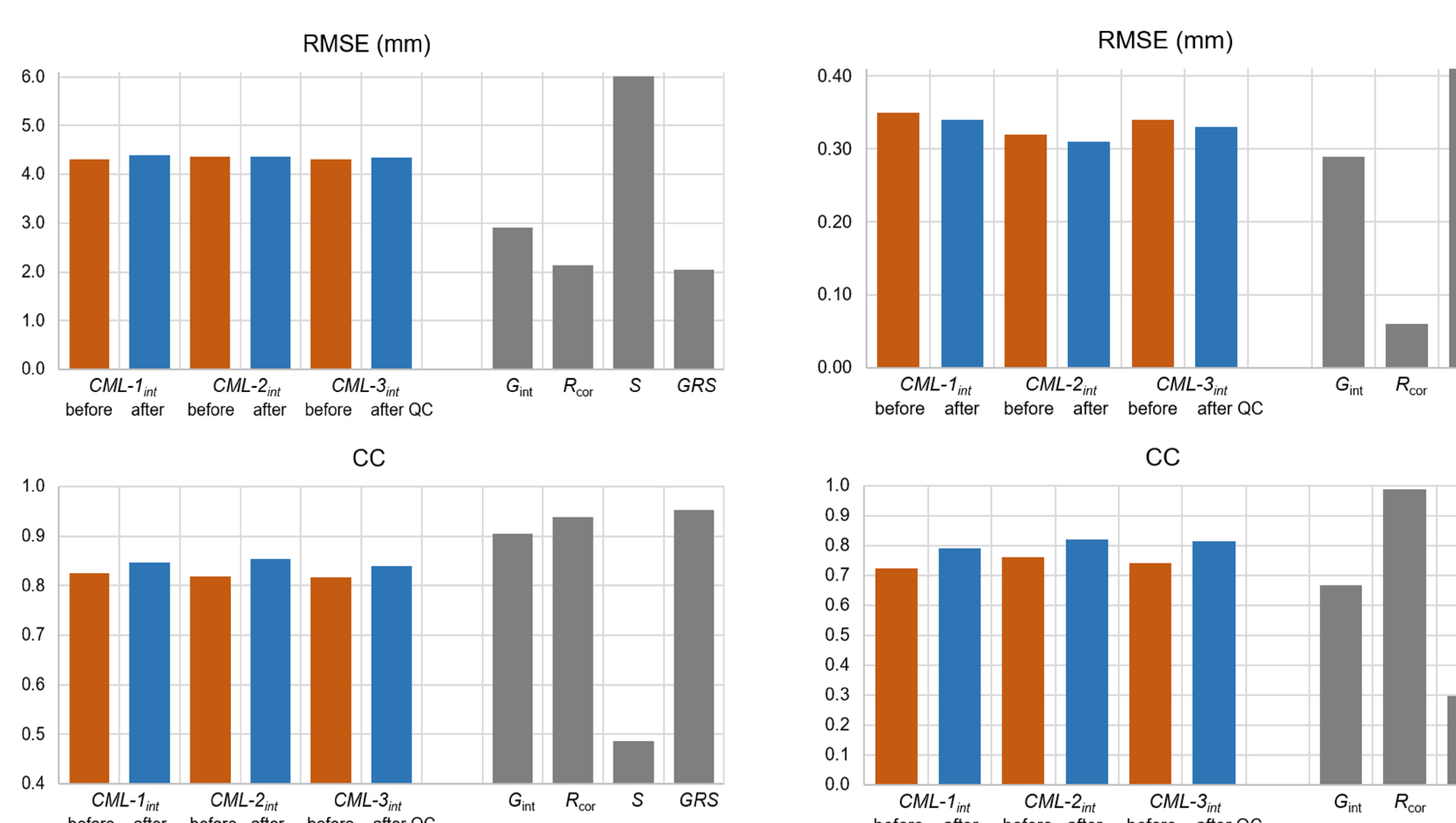

Fig.5. Statistical characteristics for daily accumulations with manual rain gauge data as a reference (left) and for half-hourly accumulations with RainGRS as a reference (right). Data aggregations from July 19 – August 18, 2022 .

Conclusions and recommendations for further work

- Shorter links (generally with higher frequency) are more likely to provide less reliable rainfall estimates (Fig.4, left), while longer links are much more likely to underestimate rainfall (Fig.4, right).
- Comparison of metrics computed for CML-based data with statistics for other precipitation estimates shows that the CML-based precipitation fields are distinctly worse than radar-based estimates, they had slightly poorer reliability than spatially interpolated telemetric rain gauge data and significantly higher reliability than satellite estimates (Fig.5).
- Based on calculated statistics (Fig.5) it is not clear which method of precipitation calculation (*CML-1*, *CML-2*, *CML-3*) from available sublinks is better.
- It is planned to tailor the RainGaugeQC system (Ośródka et al., 2022) for quality control of CML-based precipitation data.
- Further works will be carried out towards combining these data with data from standard measurement tech-

References:

Pasierb, M., Bałdysz, Z., Szturc, J., Nykiel, G., Jurczyk, A., Ośródka, K., Figurski, M., Wojtczak, M., & Wojtkowski, C. (2024). Application of commercial microwave links (CMLs) attenuation for quantitative estimation of precipitation. *Meteorological Applications*, 31(3), e2218. https://doi.org/10.1002/met.2218

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