Royal Netherlands Meteorological Institute
Ministry of Infrastructure and Water Management

TU Delft

Publicly available four-year CML dataset for the Netherlands

ID: 7

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We present a publicly available 4-year dataset of commercial microwave link (CML) 15-min minimum and maximum received signal levels for the Netherlands, with on average 3070 sub-links over 1818 unique link paths, that can be used to estimate path-average rainfall between telephone towers[1].

The CML dataset

The CML dataset spans the period 13 January 2011 up to and including 15 March 2015. It contains part of the network from one of the three mobile network operators in the Netherlands during this 4-year period. The data have been provided by the mobile network operator (MNO) T-Mobile NL (since 5 September 2023 called Odido). Note that the transmitted signal levels were not available and are nearly constant (±0.2 dB). No adaptive power control (ADPC) was used. For each CML one or two sub-links are available. The majority of the links use vertically polarized signals (but polarization was not provided). Data were obtained from two different CML vendors: Nokia (1 dB power resolution) and NEC (0.1 dB power resolution).

The CML dataset contains:

- microwave frequency
- end date & time of reading
- minimum & maximum received power
- path length
- coordinates
- link identifier
- number of errored seconds
- number of severely errored seconds

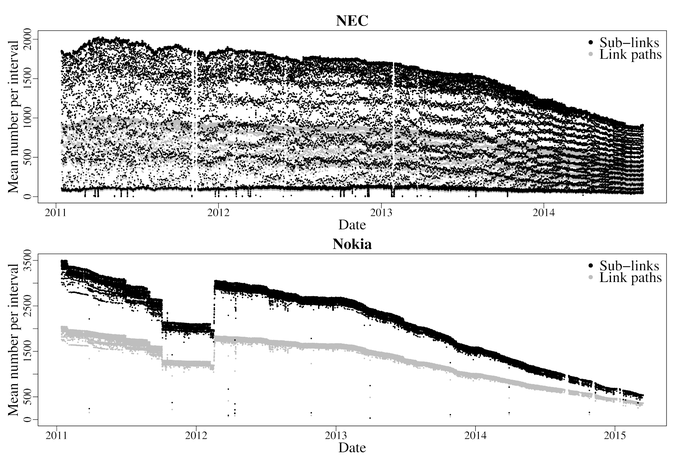

Figure 1: *Numbers of available sub-links and link paths per 15 min time interval over the entire period for NEC (top) and Nokia (bottom) links for the 2011-2015 period.*

Two datasets are provided:

- The original raw data files as obtained from MNO T-Mobile NL.
- Processed data file readable by the open-source R package RAINLINK[2], which can be used to estimate path-averaged rainfall and to obtain interpolated rainfall maps.

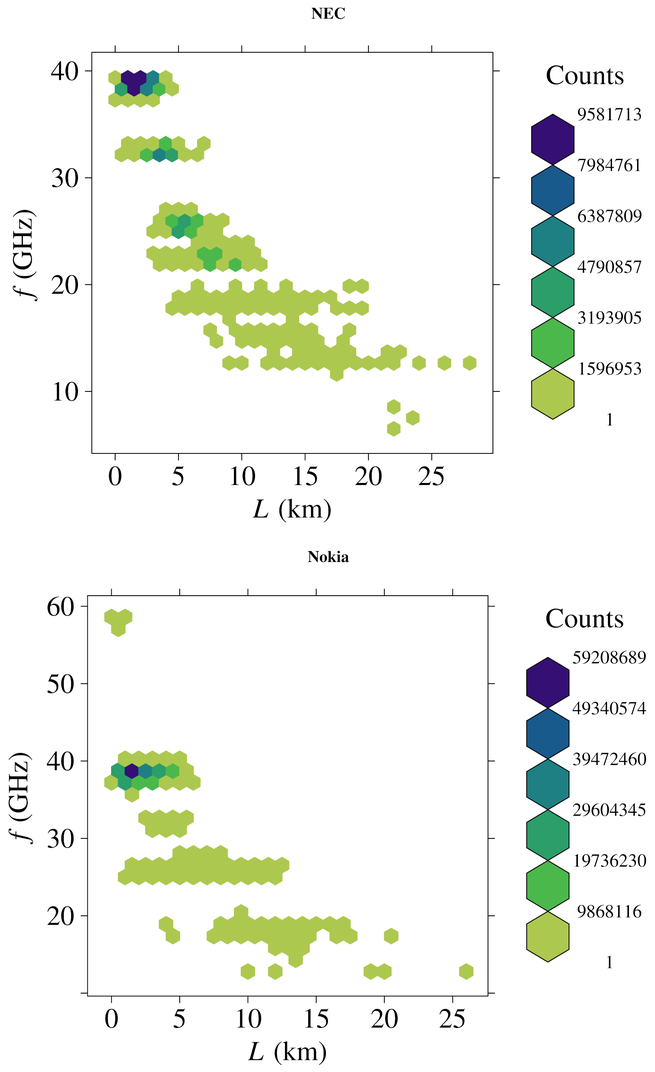

Figure 2: *Scatter density plots of microwave frequency f (GHz) against path length L (km) for NEC (top) and Nokia (bottom) links for the 2011-2015 period.*

Characteristics

The number of sub-links and link paths with data gradually declines in time (Fig. 1) being related to network renewal and replacement by fiber-optic cables. Missing data were caused by data storage problems at the MNO and is not related to malfunctioning of CMLs. The availability per 15-min interval is highly fluctuating for the NEC links because of low(er) data availability from ~15:00-~01:00 UTC caused by data storage problems at the MNO. Scatter density plots of microwave frequency versus link length show that path lengths up to ~5 km and microwave frequencies from 37-40 GHz are most common (Fig. 2). The mean availability per link path per year shows quite some spatial variability, mainly due to the lower availability for NEC links (Fig. 3). The spatial distribution and network density decline during the course of the period. The mean country-wide link path density for the total dataset is ~0.2 km km^2. Note that for all results, availability has been computed over those time intervals that have data.

Conclusions

A raw 4-year CML dataset and the processing script to convert it to a more readable dataset are provided, making research more reproducible. Several publications use subsets of the presented CML dataset, e.g.[3]. These use the same raw files, but the processing of raw files was slightly different. The current network is expected to be very different and have a lower density.

Specific details on the raw and derived CML dataset, the processing and the obtained results are provided in a readme file[1]. We hope that this CML dataset will contribute to comparing the performance of CML rainfall retrieval algorithms on a common dataset and will lead to improved algorithms. Moreover, a publicly available reference dataset of gauge-adjusted radar rainfall accumulations is available covering the same period and area[4].

Ideally, the CML dataset would be converted to a standardized format[5] that can be read by other rainfall retrieval packages, such as pycomlink.

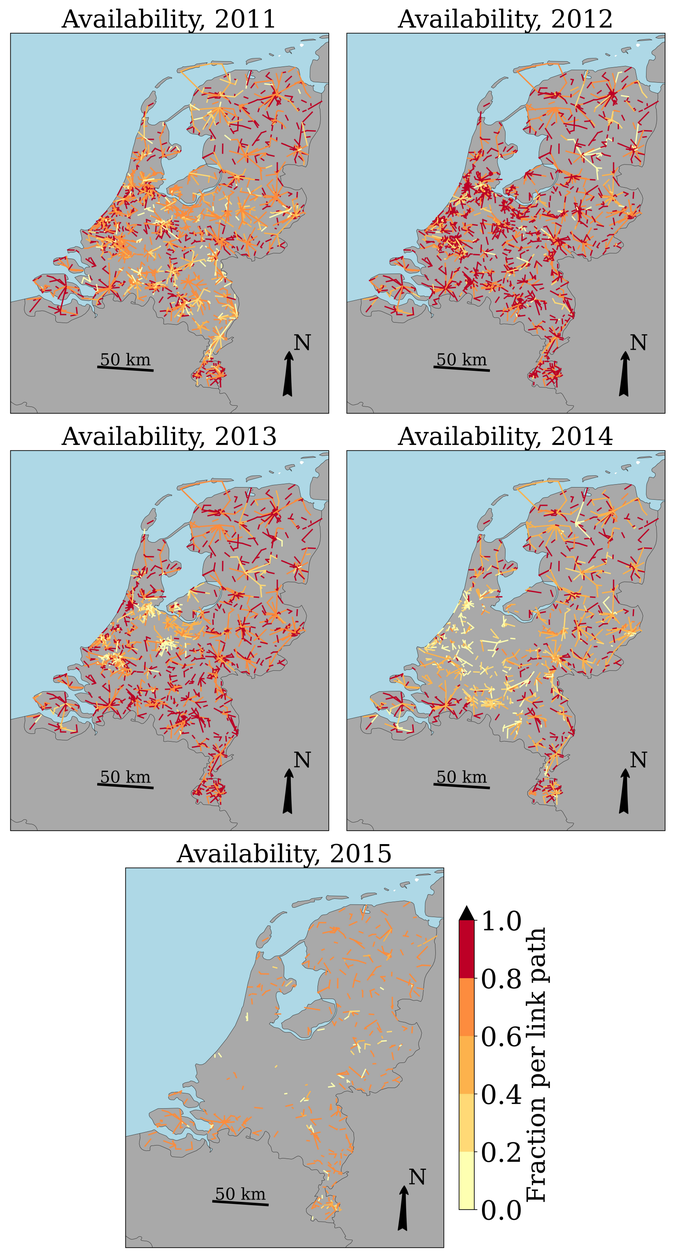

Figure 3: *Maps of the Netherlands with availability of the used link paths from the cellular telecommunication network for Nokia + NEC links for each year.*

We thank Ronald Kloeg and Ralph Koppelaar from T-Mobile NL (since 5 September 2023 called Odido) for providing the CML data.

References

1. Overeem, A., Walraven, B., Leijnse, H. & Uijlenhoet, R., 2024. Four-year commercial microwave link dataset for the Netherlands (Version 1) [Data set]. 4TU.ResearchData. https://doi.org/10.4121/BE252844-B672-471E-8D69-27269A862EC1.V1

2. Overeem, A., Leijnse, H., De Vos, L.W. & Silver, M., 2024. RAINLINK (v.1.31), https://doi.org/10.5281/zenodo.12211069

3. Overeem, A., Leijnse, H. & Uijlenhoet, R., 2016. Two and a half years of country-wide rainfall maps using radio links from commercial cellular telecommunication networks. Water Resour. Res., https://doi.org/10.1002/2016WR019412

4. KNMI, 2025. 5 minute precipitation accumulations from climatological gauge-adjusted radar dataset for The Netherlands (1 km, extended mask) in KNMI HDF5 format. https://dataplatform.knmi.nl/dataset/rad-nl25-rac-mfbs-em-5min-2-0.

5. Fencl, M. et al., 2024. Data formats and standards for opportunistic rainfall sensors [version 2], Open Research Europe, https://open-research-europe.ec.europa.eu/articles/3-169/v2

The first International Conference on Opportunistic Sensing of Precipitation, 25-26 June 2025, Offenbach, Germany

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