New pathways for high-resolution weather radar products in the Hamburg metropolitan region

Finn Burgemeister, Tobias Sebastian Finn, Tobias Machnitzki, Marco Clemens, and Felix Ament
finn.burgemeister@uni-hamburg.de

EGU2020: Sharing Geoscience Online
HS7.8 - Precipitation and Urban Hydrology
04.05.2020
New pathways for high-resolution weather radar products in the Hamburg metropolitan region

Keywords: Weather Radar; Urban Hydrology; X-band; Observation Network; Single Polarization; Small Scale Precipitation Structure; High Spatial and Temporal Scale, Attenuation Correction; Deep Learning Approach; Neural Network, Error Minimization, Python Package; CliCCS – Climate, Climatic Change, and Society
Focus on Networked Observations in Urban Area

- X-band weather radars
  - spacious high-resolution precipitation measurements
  - supplement nationwide C-band radars
  - HHG radar operational since 2013
  - (ALT radar will start mid 2020)
- (K-band) Micro Rain Radars
  - vertical profiles
  - as calibration reference in relevant height levels
  - calibration of MRRs with rain gauges

Greater Hamburg, Germany
Low cost local area weather radar

- single-polarized X-band weather radar
  - modified ship navigation radar with parabolic dish
    - time resolution 30 s
    - range resolution 60 m
    - sampling resolution in azimuth 1°
    - maximum range 20 km
    - low elevation angle ~4°
  - high sample of 12 rotations include ~67 pulses per 1° and 30 s

Further tech. details Lengfeld et. al (2014)
Higher temporal and spatial resolution

• valuable information on the small-scale structure of rain events in urban region (this example shows a tornado in a rain event)
Single polarization and small wavelength is challenging issue

Initial disturbed weather radar observation:

• strong attenuation
• background noise (induced by the atmosphere or the internal electronic)
• variety of non-meteorological echoes (increased in urban environment)
How to derive an undisturbed product?
How to derive a undisturbed product?

Our operational software¹

¹pylawr – A python package for operational weather radar processing
Burgemeister, F., T. S. Finn, M. Schaper, Y. Büchau, M. Clemens, and F. Ament, 2020, in prep.
Dynamic estimation of background noise

- noise (spatially independent)
Dynamic estimation of non-meteorological echoes

multiple applications of Gradient-based filters + Optical filters + Time-dependent filters
Interpolation of missing values

Adaptive Kriging including time-dependent update of parameters
Implemented correction methods for significant attenuation caused by water at X-band

- iterative correction over the range integrated from `wradlib` (Heistermann, Jacobi and Pfaff, 2013)
- correction by less attenuated C-band radars using isotonic regression of ratios (Lengfeld et al., 2016)
- at this example: extreme rain rates probably because of hail
Outlook: Convolutional Neural Network for Radar Data

Training of Neural Network

Synthetic rain field (Gaussian random)

+ Disturbed real rain-free field (Noise and Clutter is additive)

• combines time-consuming, present steps of processing
  • NN uses raw reflectivity measurements as input and results in clean data, which is free of noise and non-meteorological echoes, but is still attenuated
  • computationally intensive training, but processing with trained network less computational than pylawr.
  • good at structures, but amplitudes differ
  • further research needed for explicit application

Machnitzki, 2019
Summary

• high-resolution X-band weather radars supplements the nationwide, coarser C-band observations within the greater urban area of Hamburg, Germany

• We are capable to **minimize the errors of single-polarized X-band weather radar** observations with our python package *pylawr* combining well-established algorithms:
  • Background noise + Non-meteorological echoes + Attenuation correction

• **neural network can process radar observations** resulting in images, free of noise and non-meteorological echoes
  • trained neural network is significant faster than *pylawr*
  • NN results in better structure of rain field, but *pylawr* results in more accurate values
  • suggest combination of NN and *pylawr* (example NN for detection of non-meteorological echoes)

• recent research focuses on **uncertainty of precipitation estimation from weather radar observations** oriented on urban hydrology within the **Cluster of Excellence CliCCS – Climate, Climatic Change, and Society** and **Universität Hamburg**