Karlsruhe Institute of Technology

KIT-Campus Alpin
IMK-IFU: Atmospheric Environmental Research

Improving QPE with commercial microwave links

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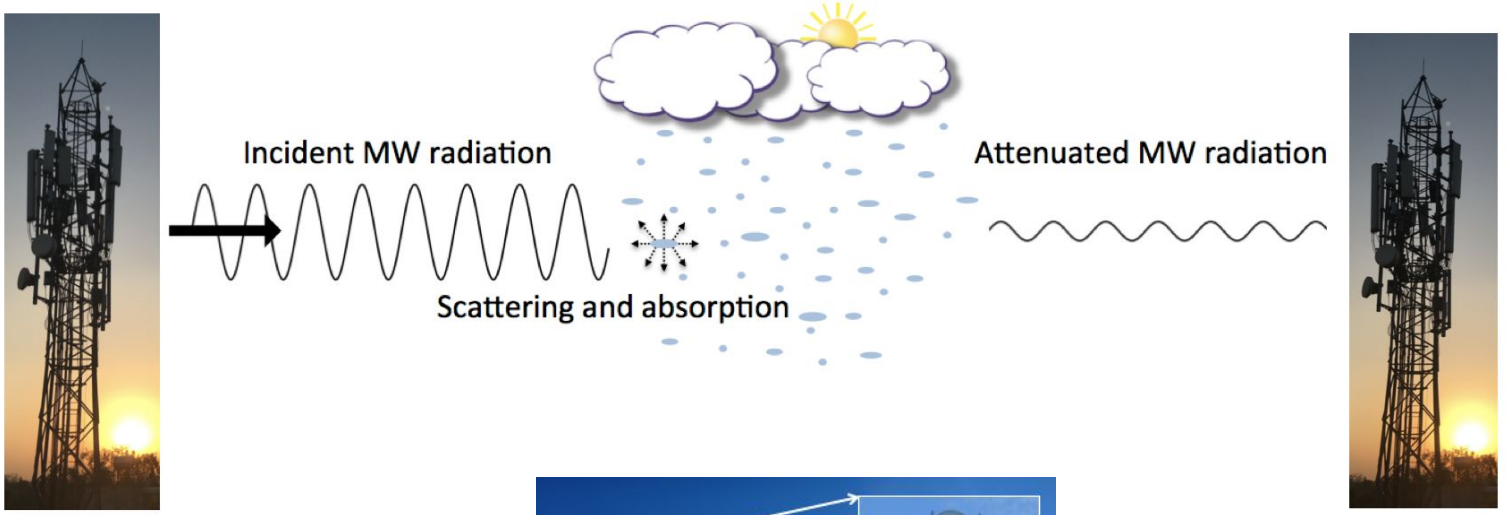
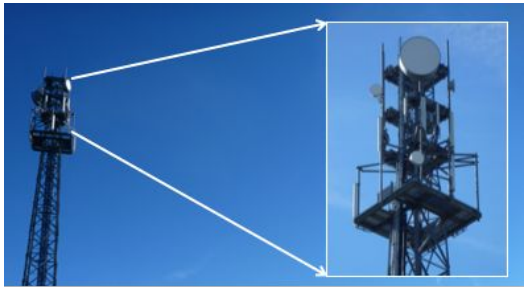
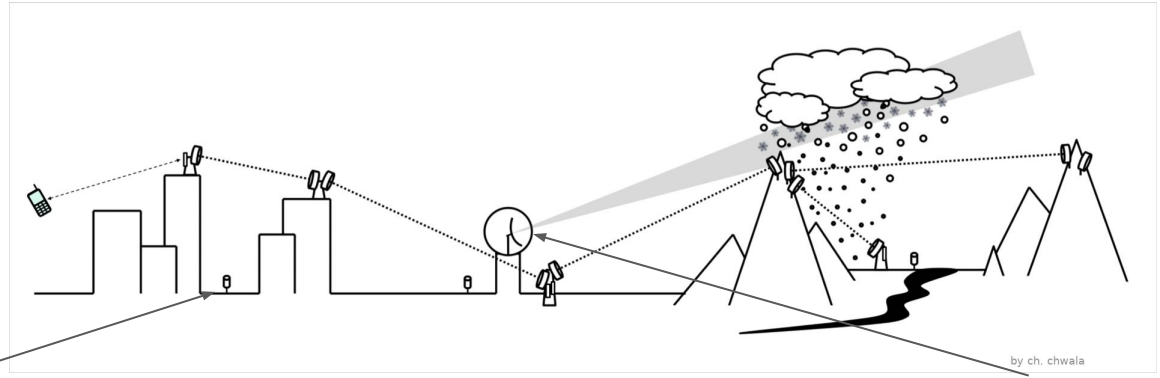

Incident MW radiation
Attenuated MW radiation
Scattering and absorption

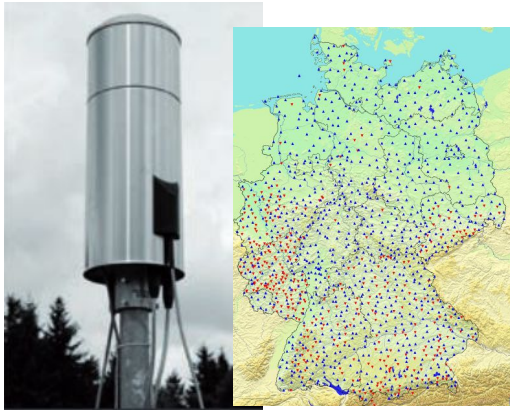


Rainfall estimation in Germany



Rain Gauge

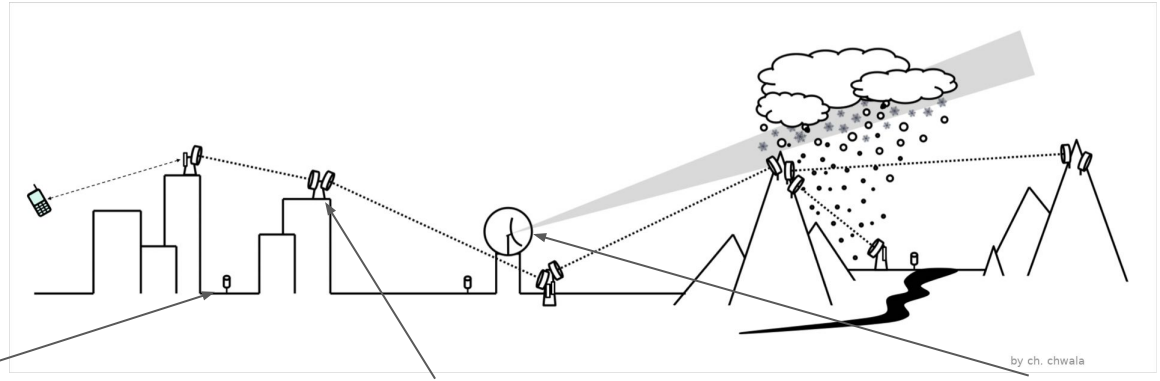
Dual-pol weather radar



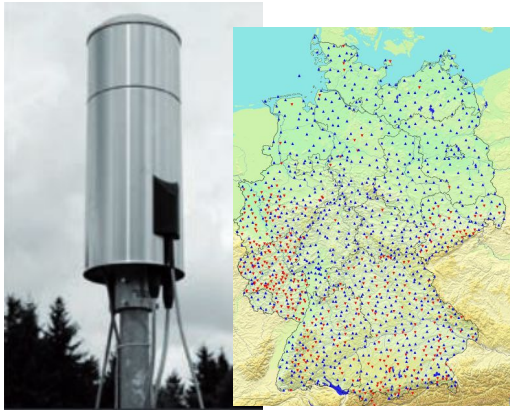
Source: DWD

Source: DWD

Rainfall estimation in Germany

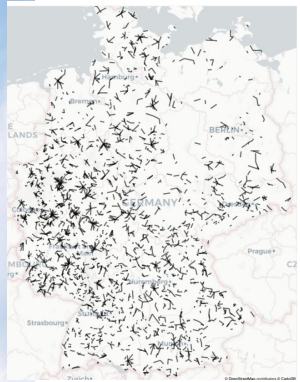


Rain Gauge



Source: DWD

Commercial microwave link (CML)

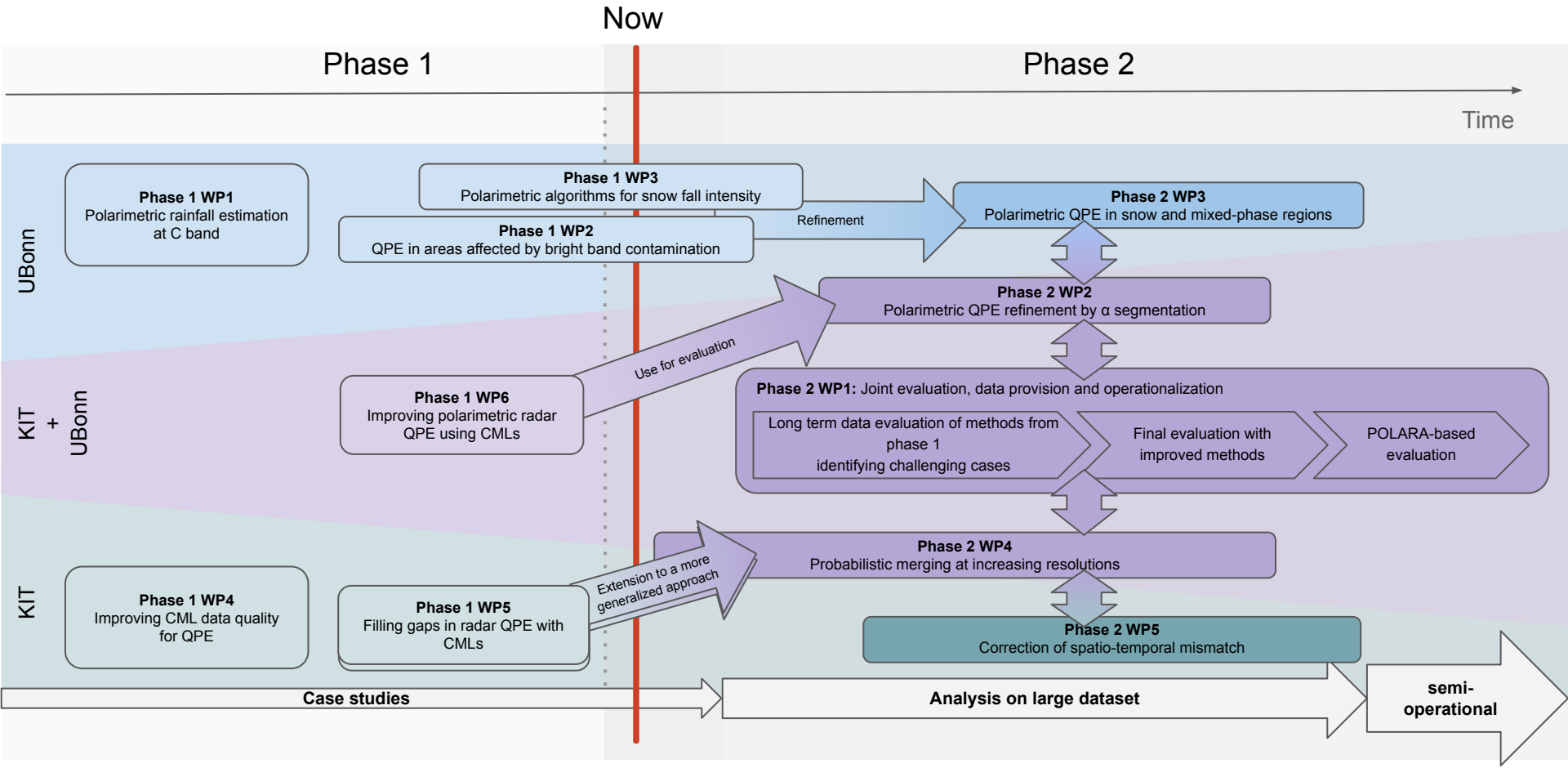


Source: C. Ruf, KIT

Dual-pol weather radar

Source: DWD

P1 Flowchart



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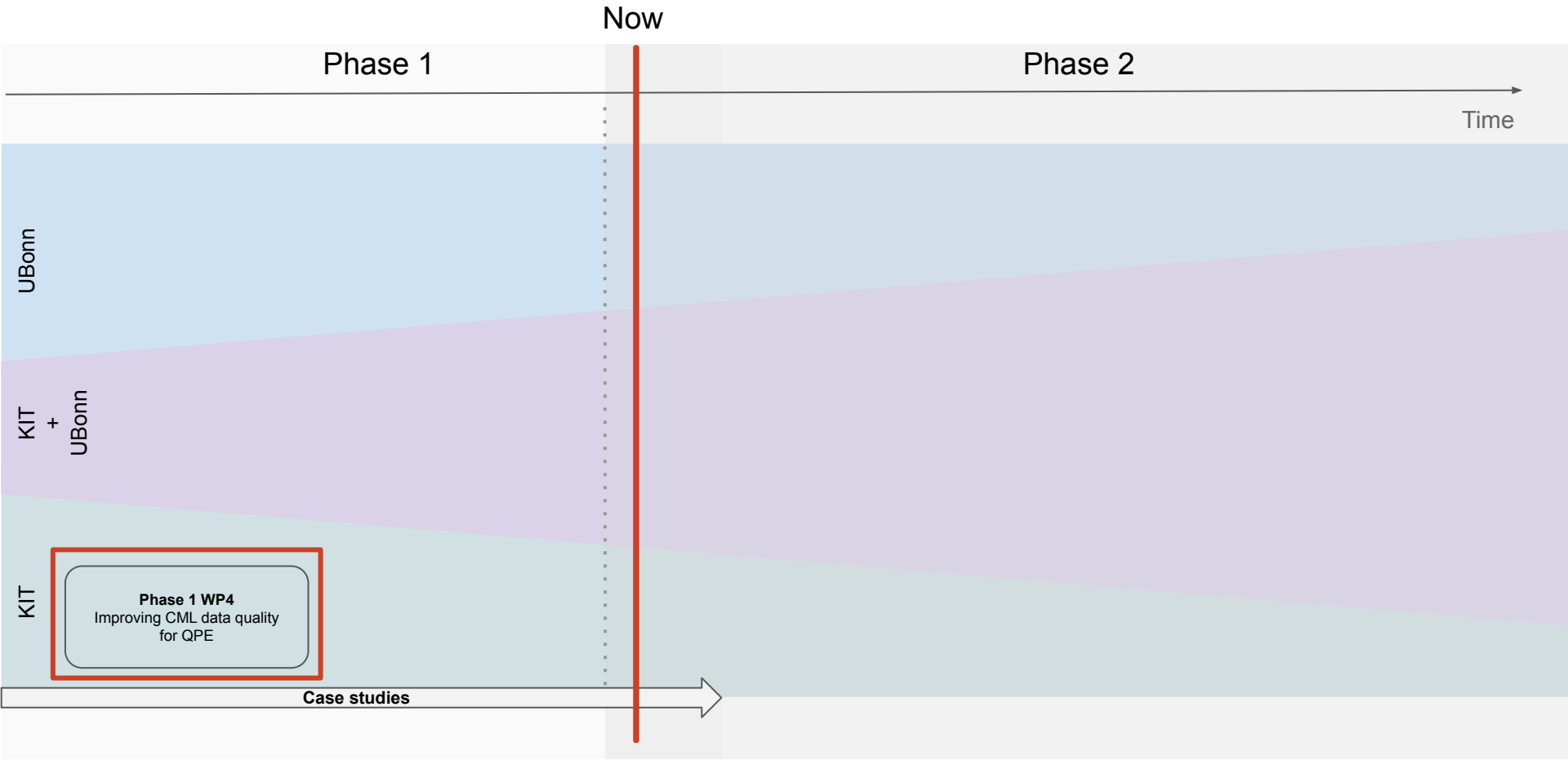
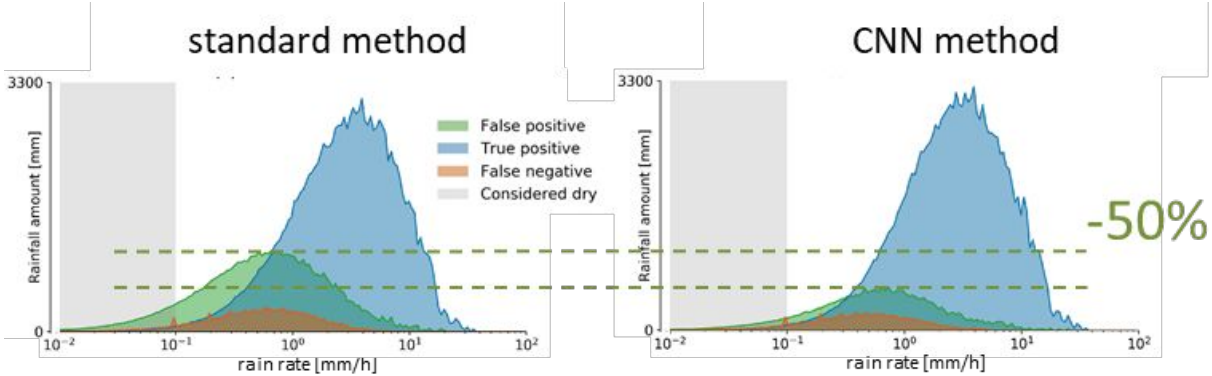


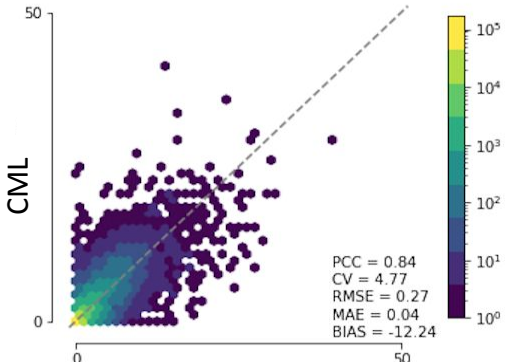
Phase 1 WP4
Improving CML data quality for QPE

Improved detection of wet periods

Significant reduction of false-positive rain events with CNN method



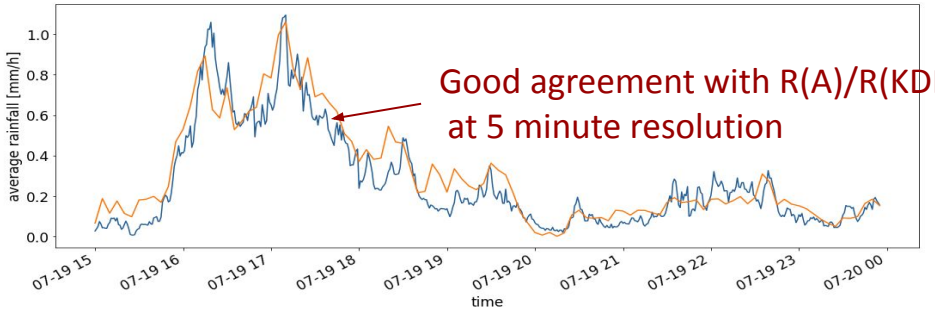
Large scale evaluation demonstrated good CML performance



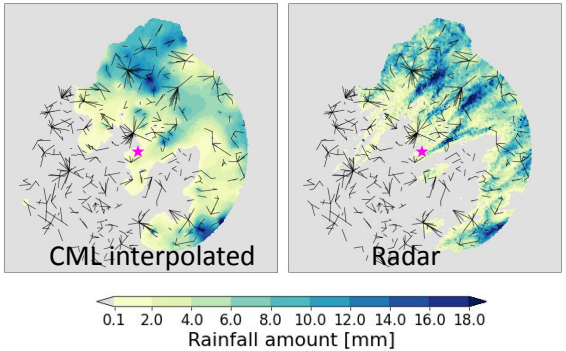
Phase 1: CML+Radar Case study days

Average intensity over all CML paths

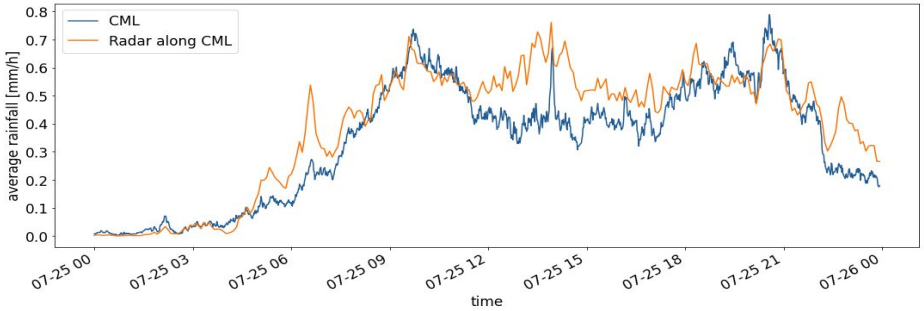
2017-07-19 - Convective rainfall - OFT Radar



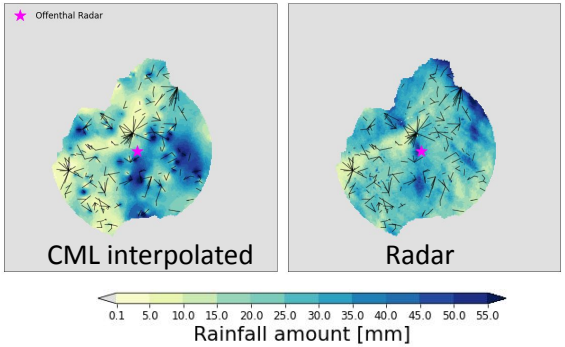
Sum over event



2017-07-25 - Stratiform rainfall - OFT Radar



Sum over event



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Average intensity over all CML paths

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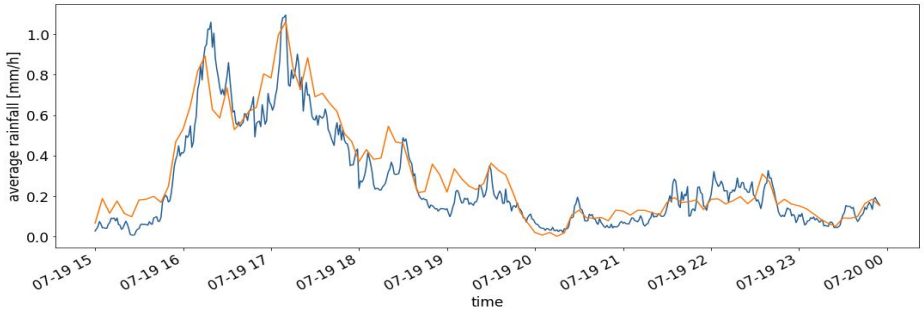
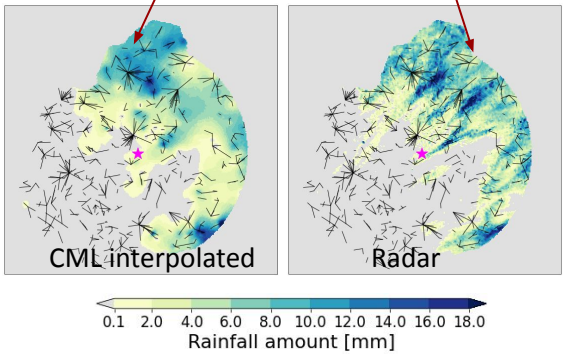


Good agreement of event sum

Sum over event



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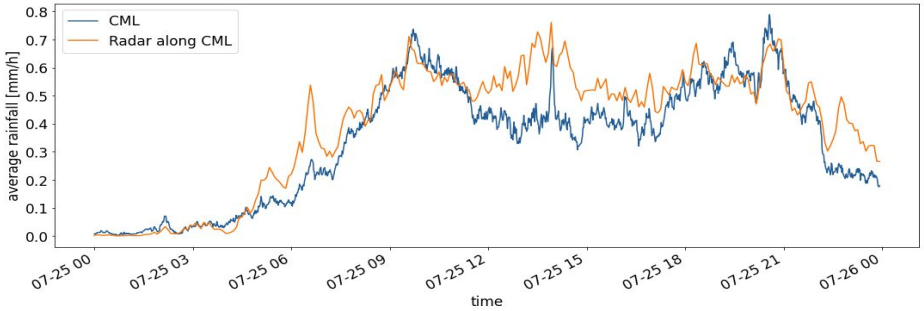
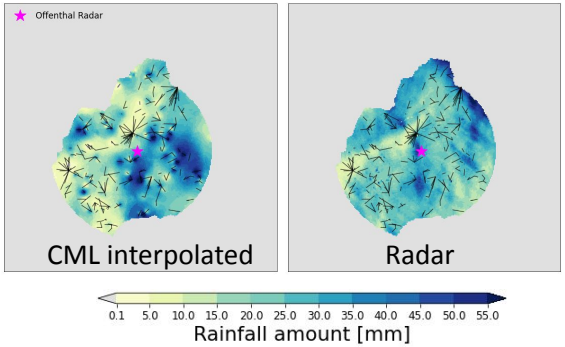
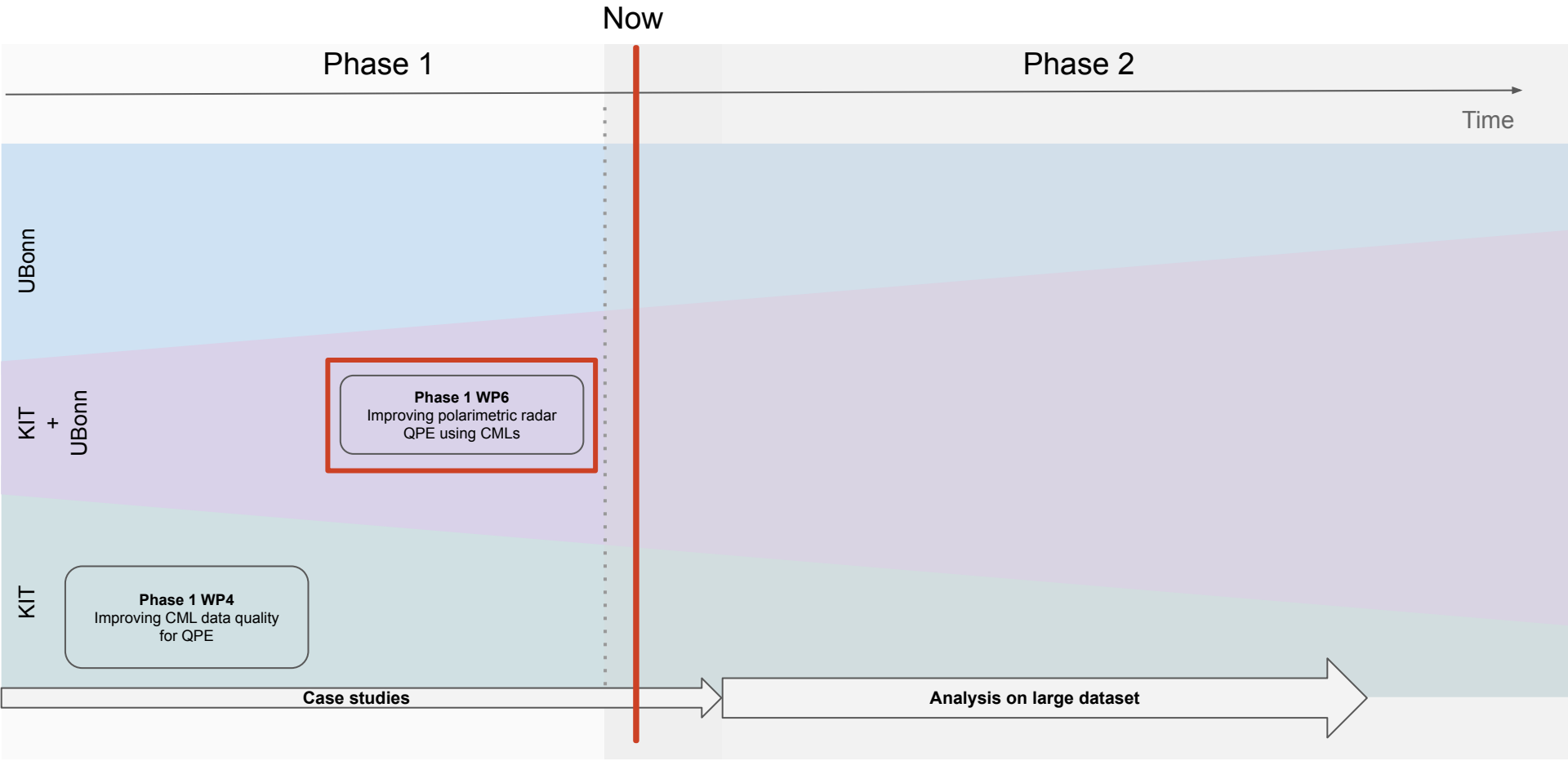


Sum over event

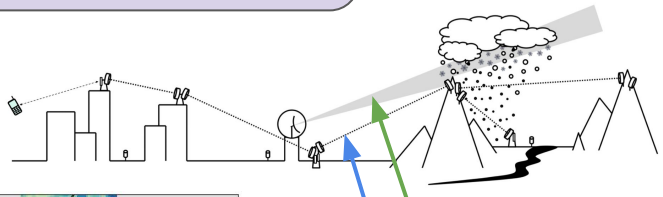


P1 Flowchart

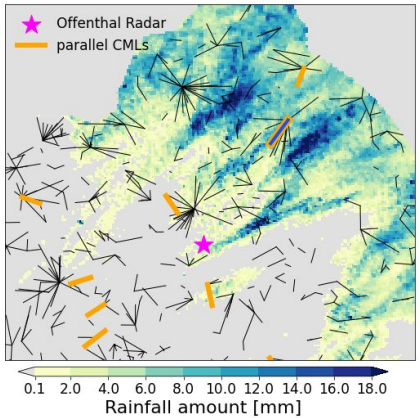


Phase 1 WP6
Improving polarimetric radar QPE using CMLs

Temporal shift needs compensation



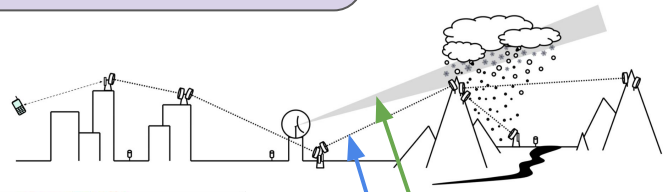
$$\alpha = \frac{2PIA_1(5.66GHz)}{\Delta\varphi_{DP}}$$



Trömel et al. 2014

Phase 1 WP6
Improving polarimetric radar QPE using CMLs

Temporal shift needs compensation



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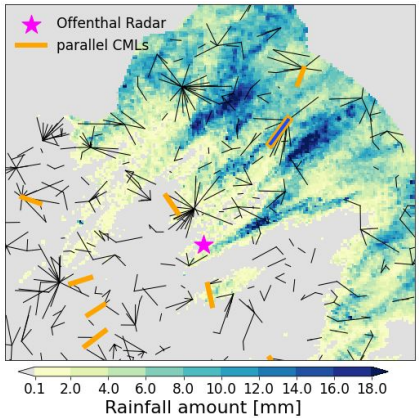

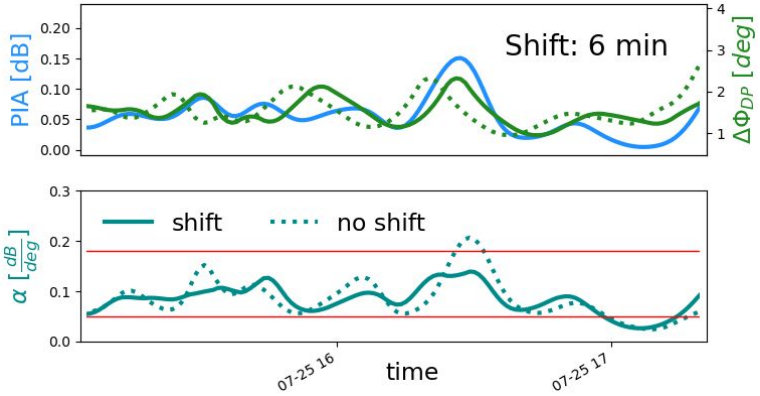

Trömel et al. 2014

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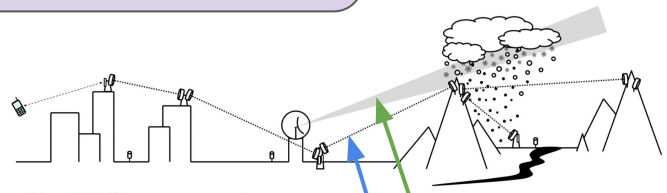
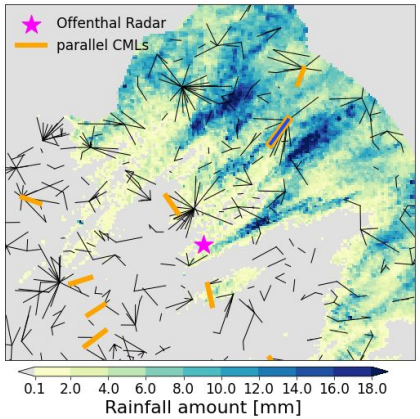
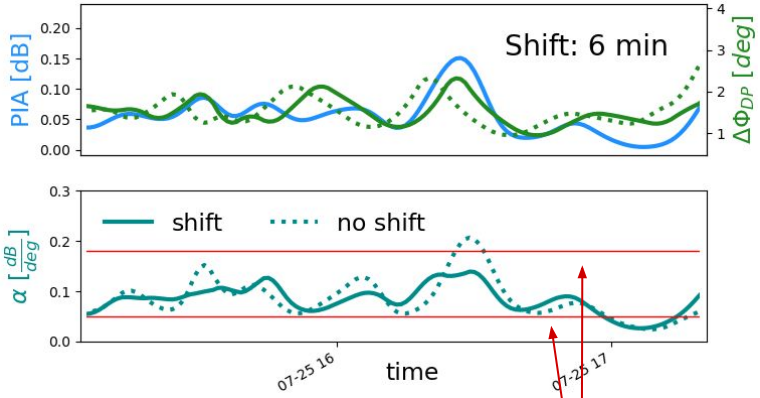
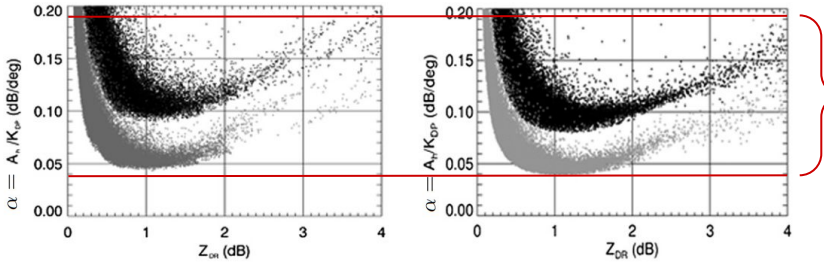


$$\alpha = \frac{2PIA_1(5.66GHz)}{\Delta\varphi_{DP}}$$





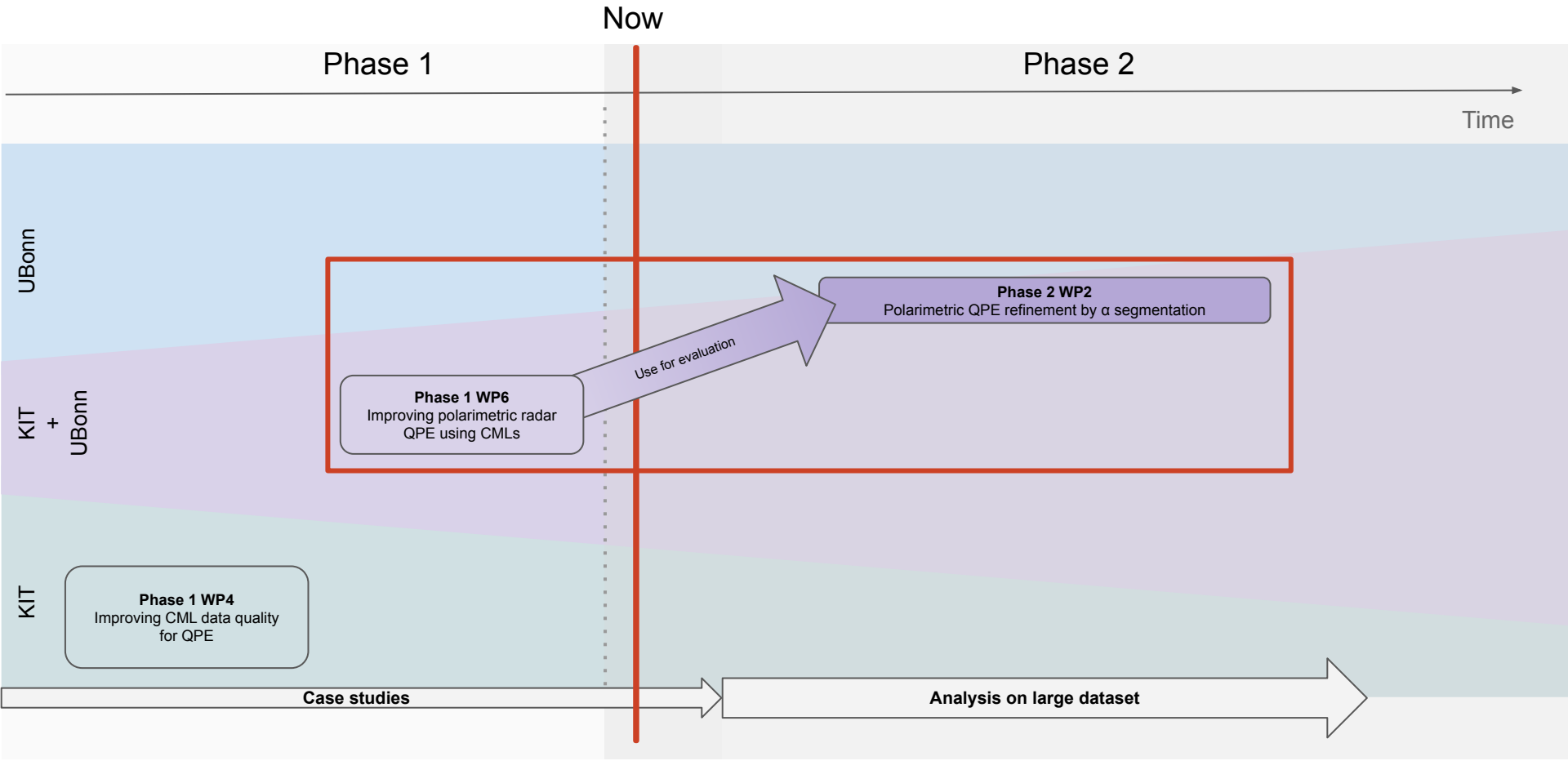


physical bounds

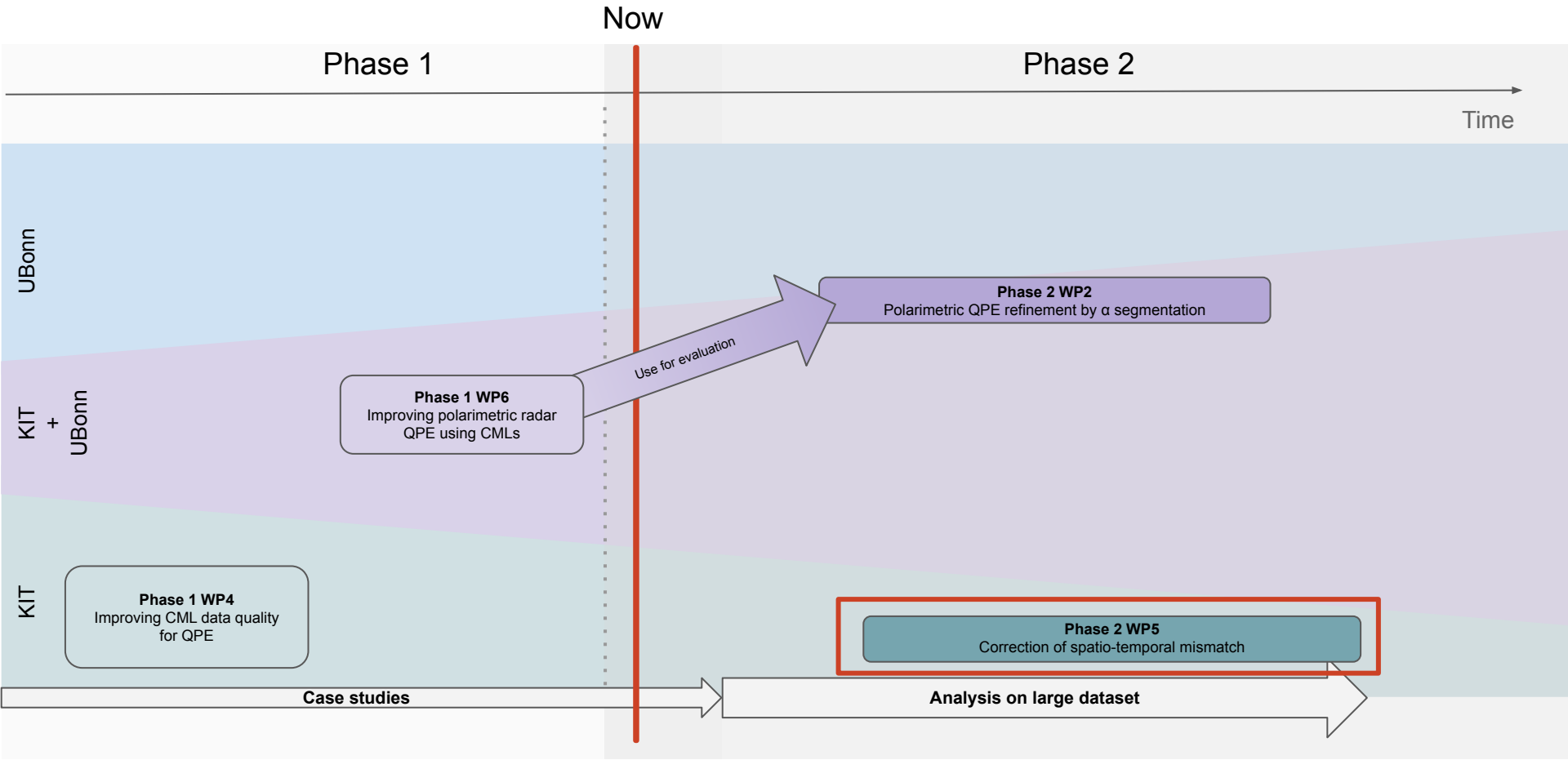
FIG. 2. Scatterplots of $\alpha = A_H/K_{DP}$ vs Z_{DR} at C band based on disdrometer measurements in (left) Bonn and (right) Oklahoma at 0° (black dots) and 30°C (gray dots).

Trömel et al. 2014

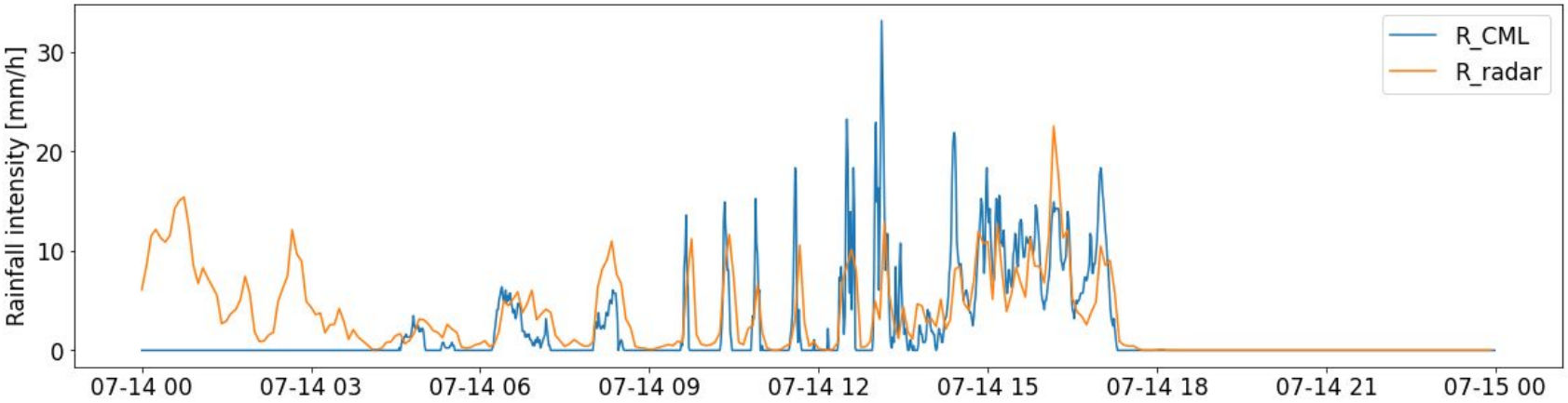
P1 Flowchart



P1 Flowchart

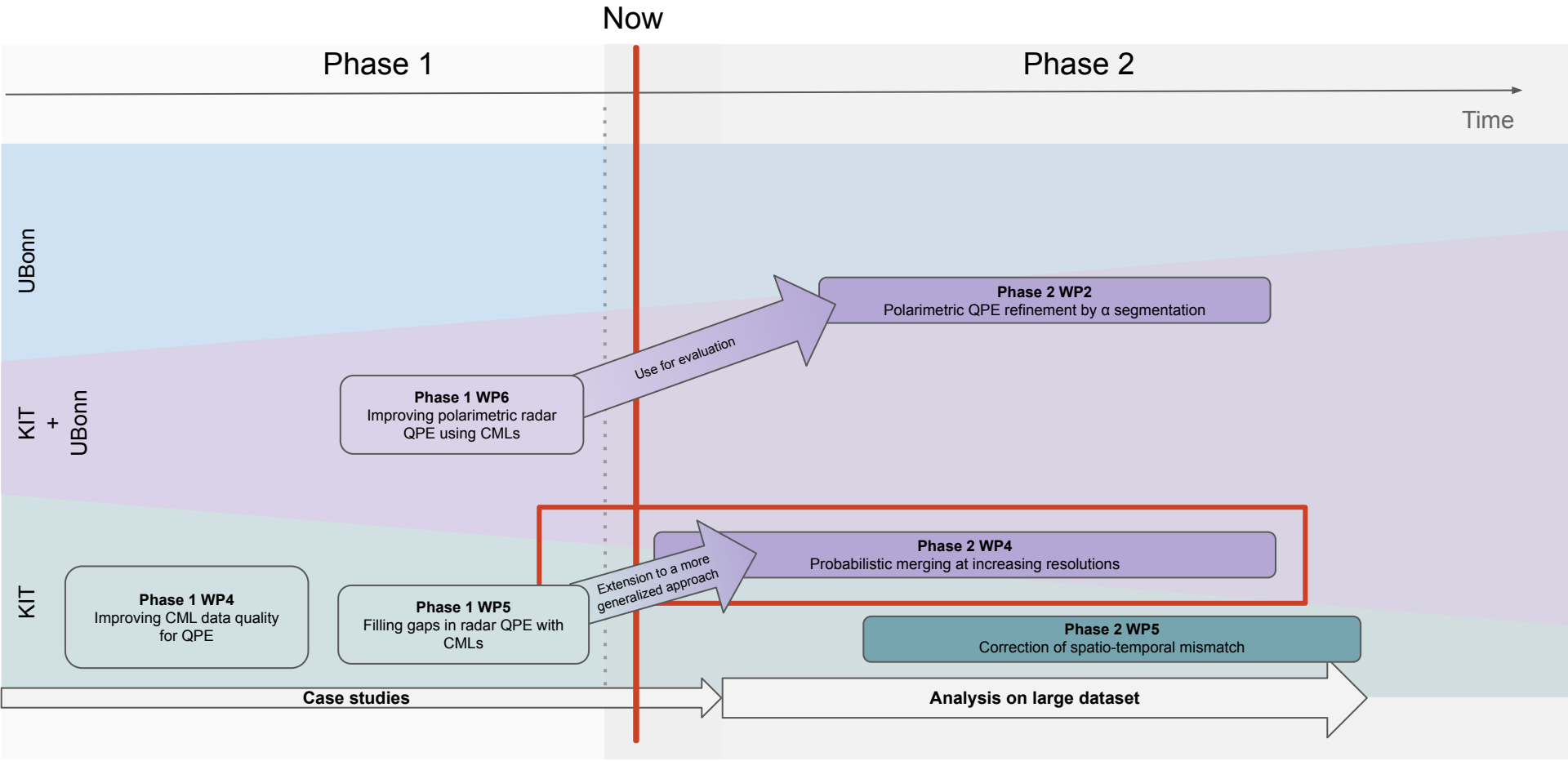


Radar can also be delayed → solve matching problem in Phase 2

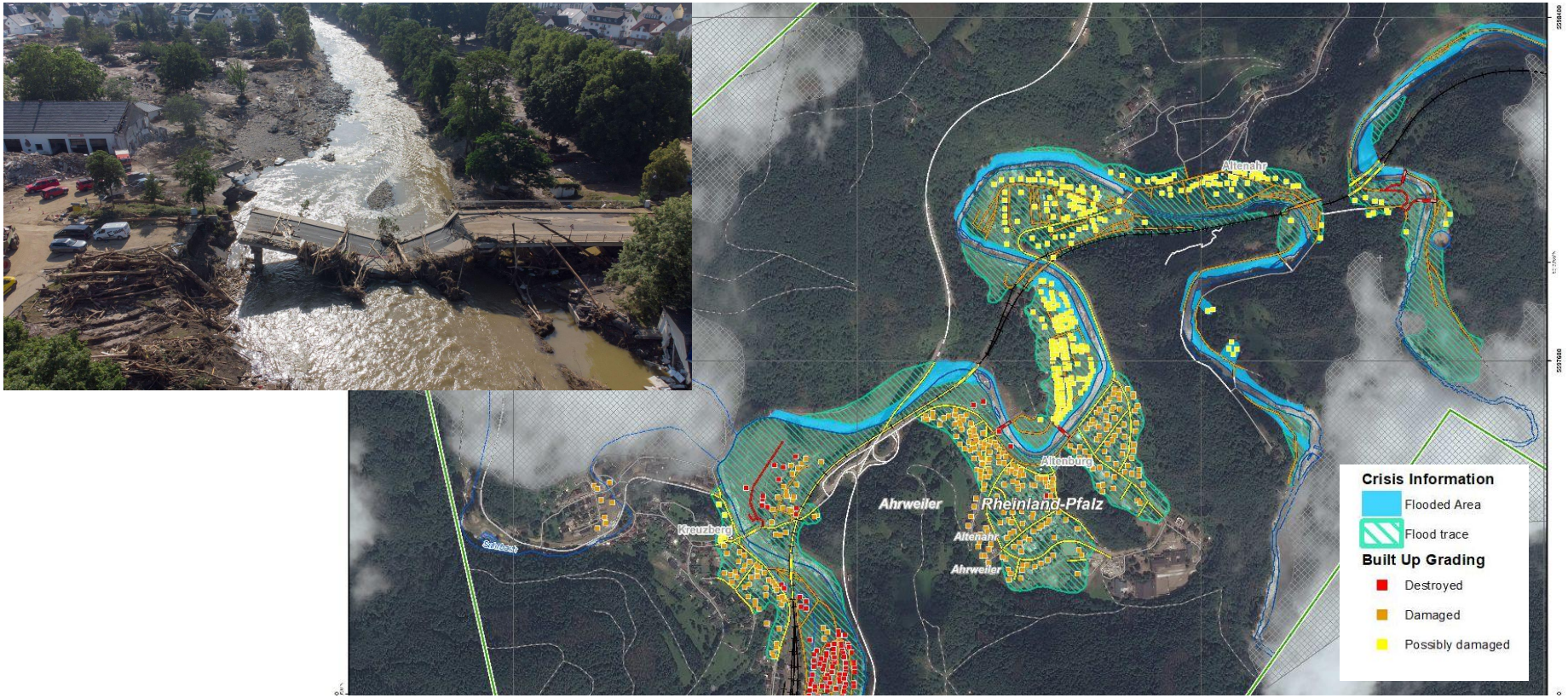


Case study event in July 2021. CML vs. R(AH)/R(KDP) along one CML path

P1 Flowchart

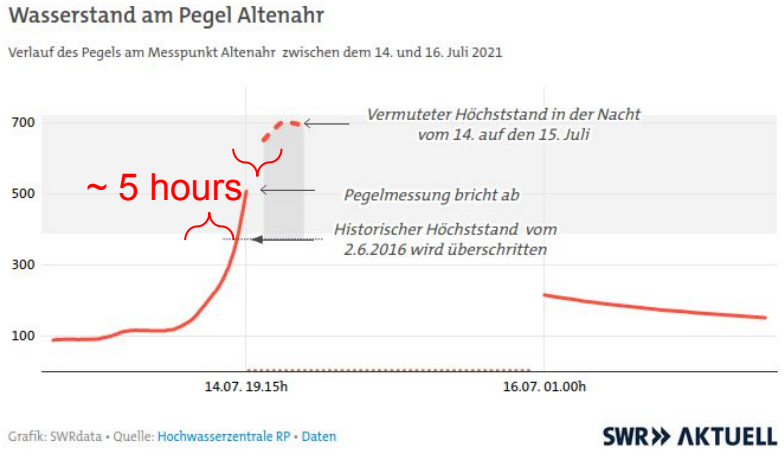


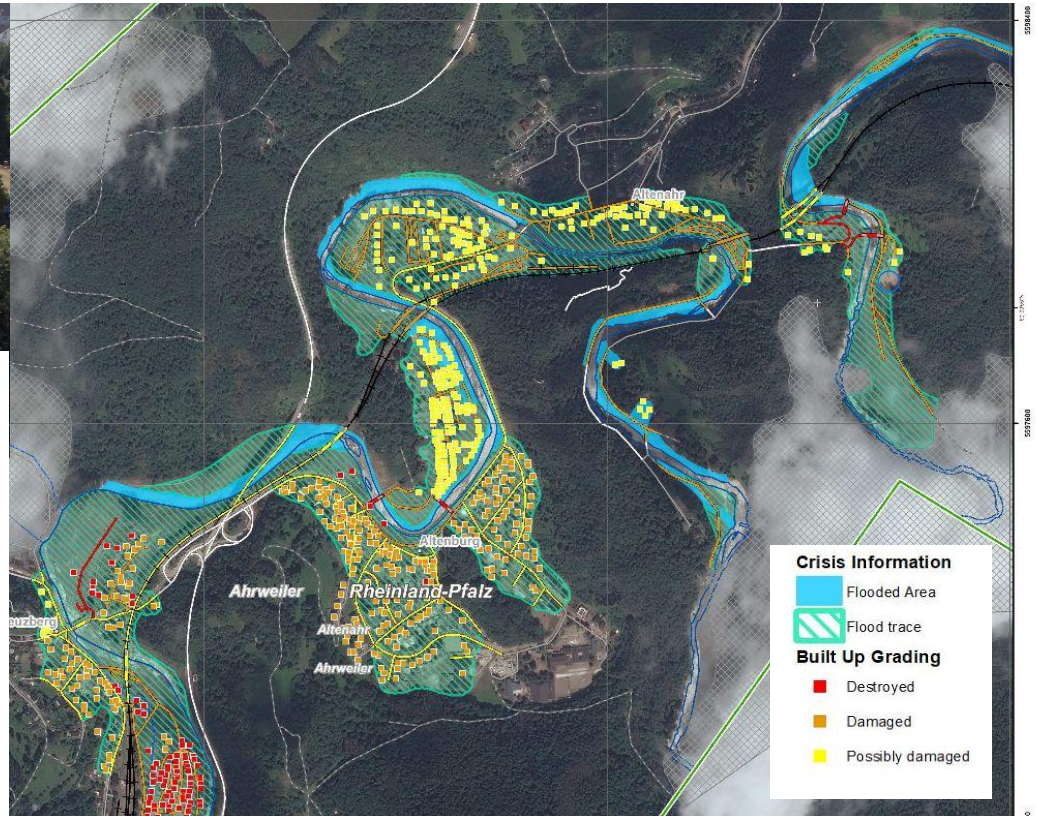
Ahrweiler, Germany, Situation as of 18.07.2021



Source: https://emergency.copernicus.eu/mapping/list-of-components/EMSR517/GRADING/EMSR517_AOI15

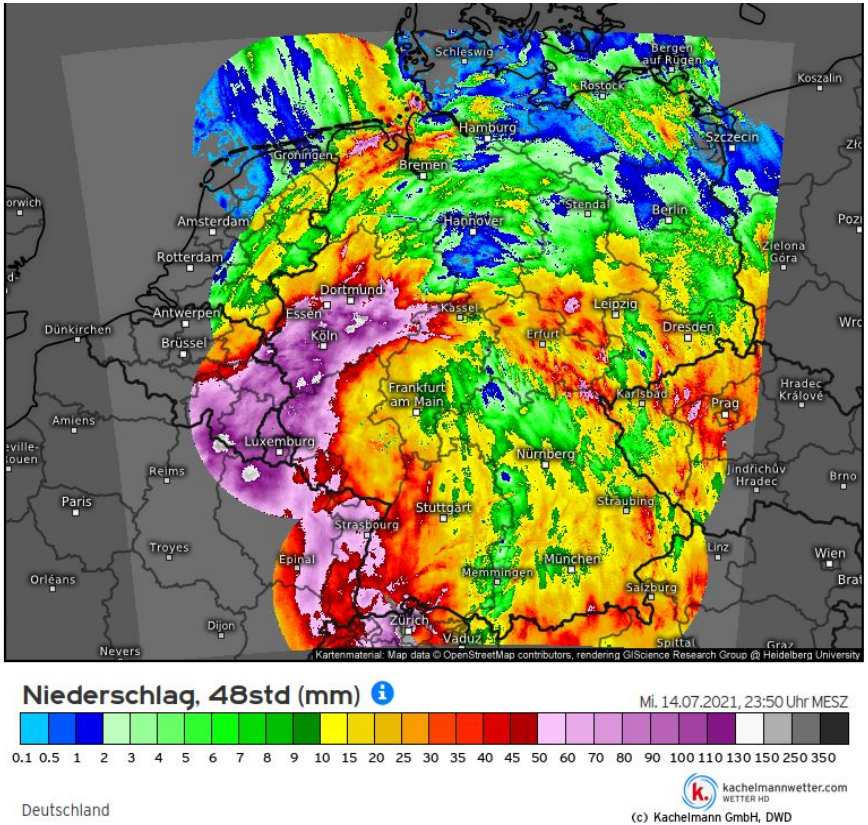
Ahrweiler, Germany, Situation as of 18.07.2021

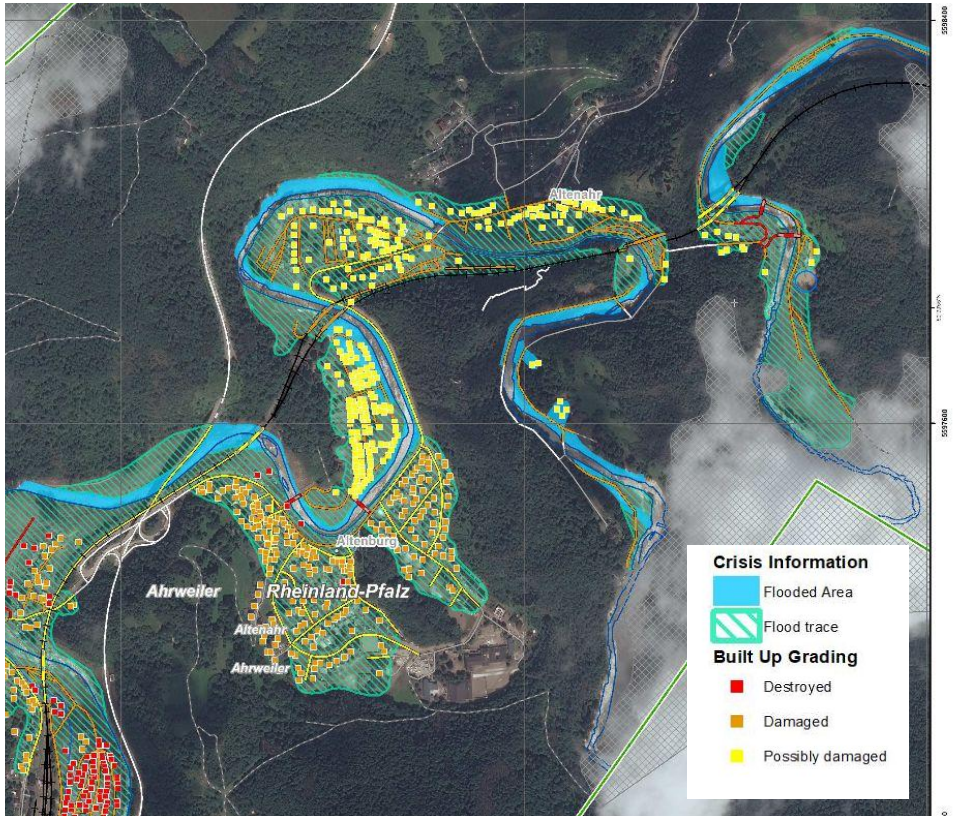




Source: https://emergency.copernicus.eu/mapping/list-of-components/EMSR517/GRADING/EMSR517_AOI15

Germany, 48h rainfall sum until 14.07.2021 11:50PM

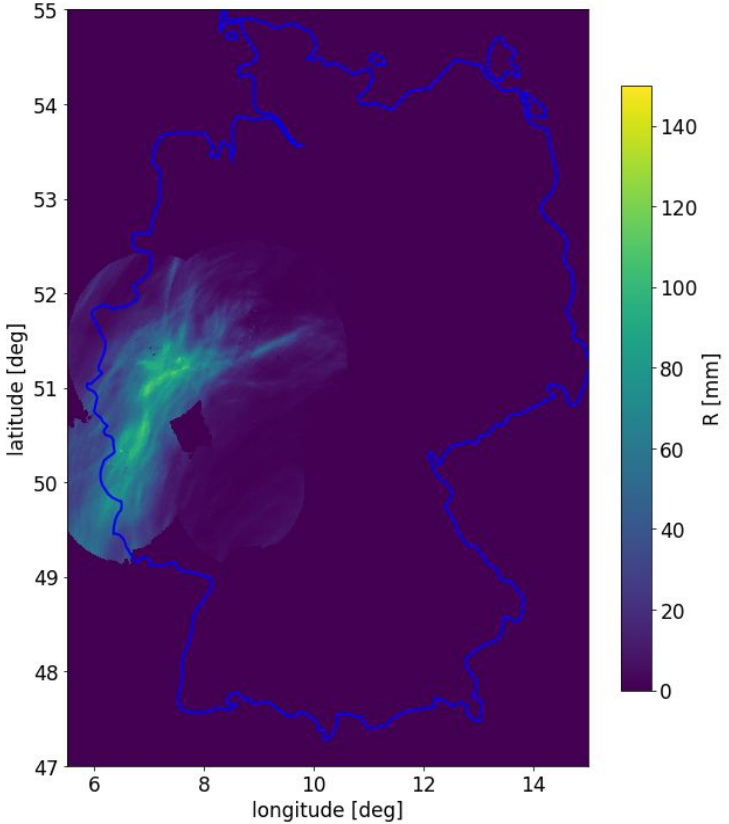




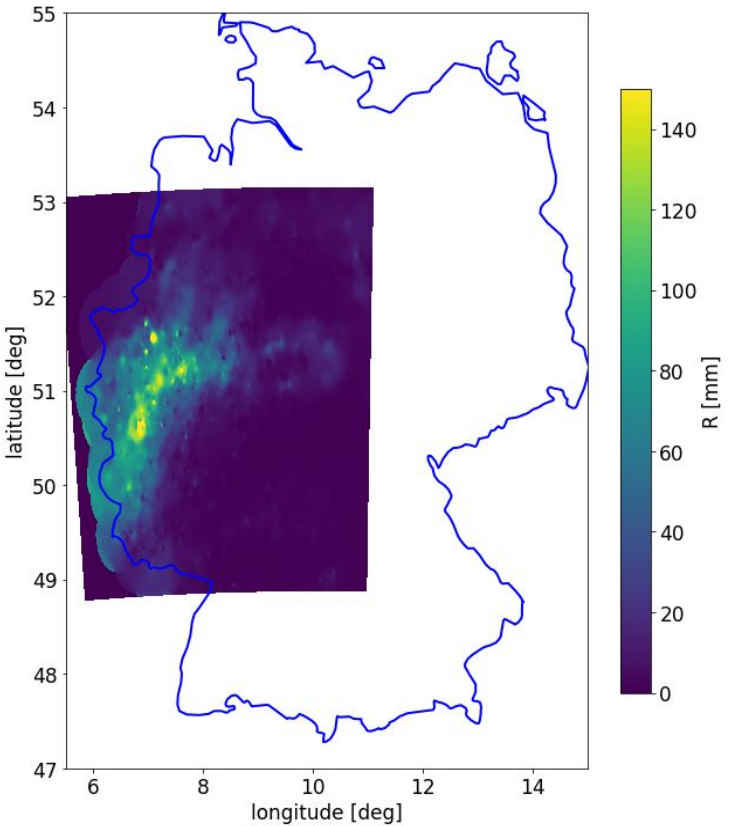
Source: https://emergency.copernicus.eu/mapping/list-of-components/EMSR517/GRADING/EMSR517_AOI15

24h rainfall sum on 14.07.2021

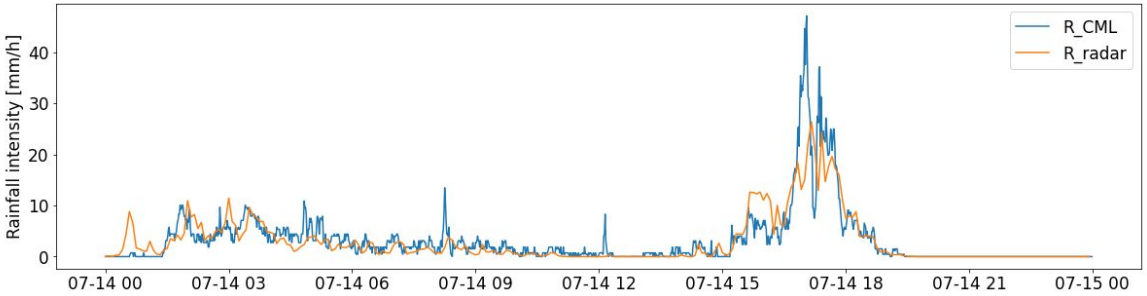
RAHKDP

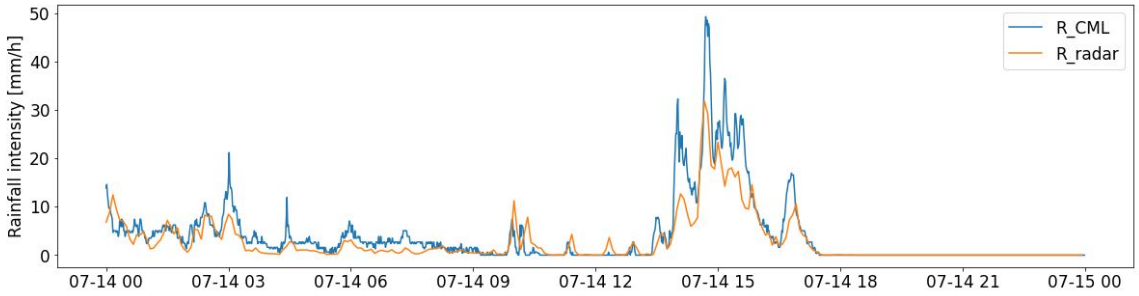


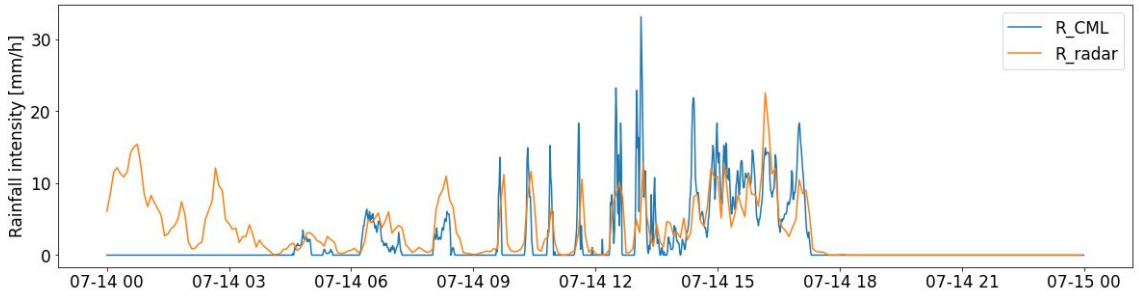
CML



Radar underestimation!?







24h rainfall sum on 14.07.2021

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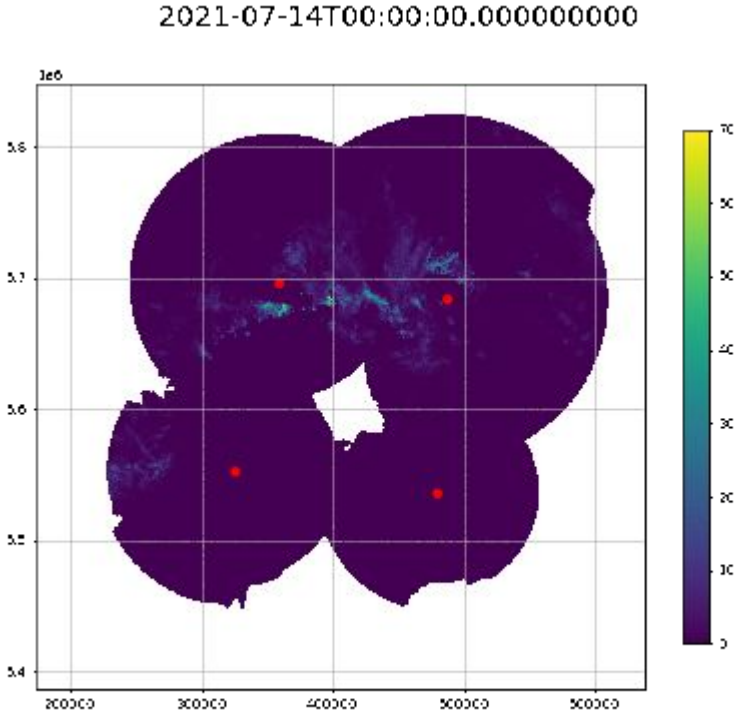
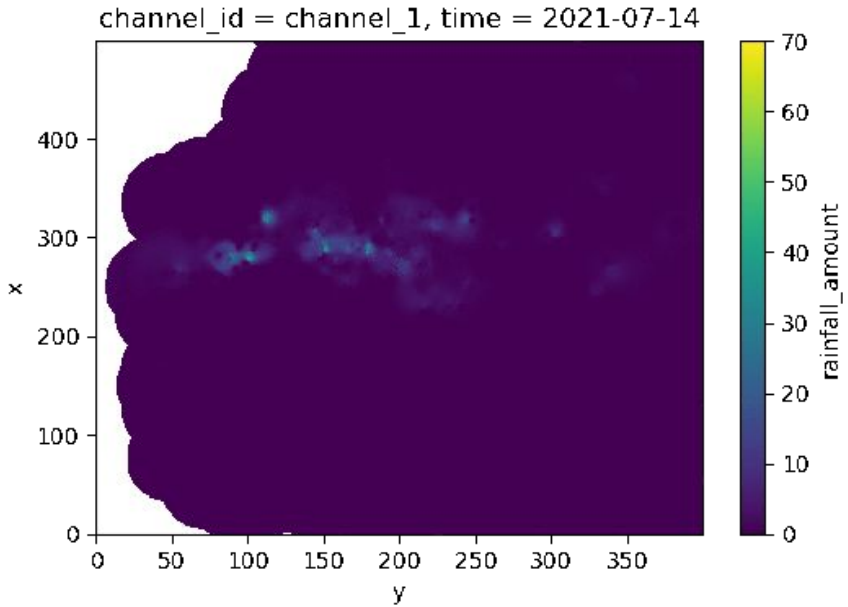
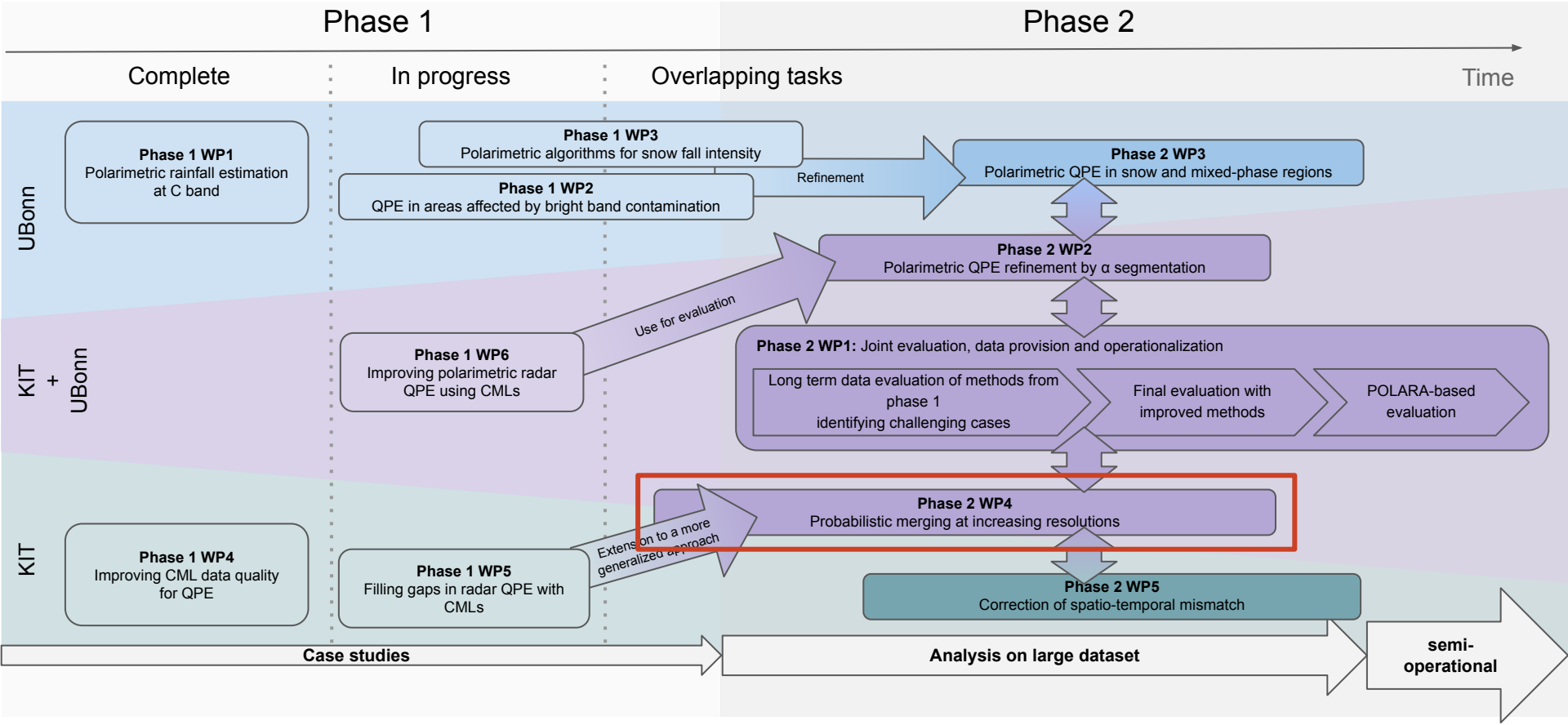


CML




Phase 1
Phase 2
Complete
In progress
Overlapping tasks
Time
UBonn
KIT + UBonn
KIT
Phase 1 WP1
Polarimetric rainfall estimation at C band
Phase 1 WP3
Polarimetric algorithms for snow fall intensity
Phase 1 WP2
QPE in areas affected by bright band contamination
Refinement
Phase 2 WP3
Polarimetric QPE in snow and mixed-phase regions
Phase 2 WP2
Polarimetric QPE refinement by α segmentation
Use for evaluation
Phase 1 WP6
Improving polarimetric radar QPE using CMLs
Phase 2 WP1: Joint evaluation, data provision and operationalization
Long term data evaluation of methods from phase 1 identifying challenging cases
Final evaluation with improved methods
POLARA-based evaluation
Phase 2 WP4
Probabilistic merging at increasing resolutions
Extension to a more generalized approach
Phase 1 WP4
Improving CML data quality for QPE
Phase 1 WP5
Filling gaps in radar QPE with CMLs
Phase 2 WP5
Correction of spatio-temporal mismatch
Case studies
Analysis on large dataset
semi-operational

WP-P1-4: Probabilistic merging at increasing resolutions (UBonn and KIT, months 1 - 33)

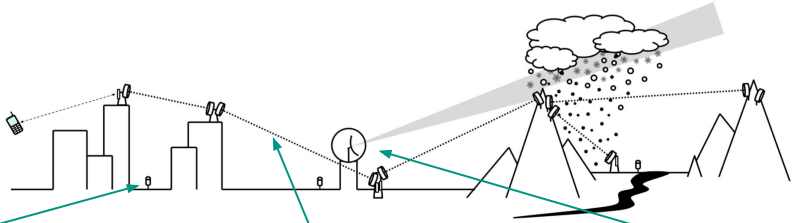
“Each measurement device has different uncertainties and spatial and temporal integration characteristics. We want to find a merging algorithm that also combines uncertainties at increasing temporal resolutions up to 1 minute”

M-P1-10: Precipitation estimates from different sensors are compared at a 1-minute resolution (month 6)

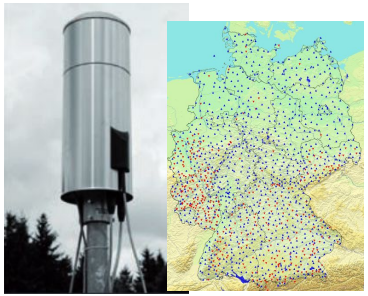
M-P1-11: First version of a probabilistic QPE is implemented (month 18)

M-P1-12: Merged ensemble QPE fields are available (month 24)

Different integration characteristics



Rain Gauge



Source: DWD

QPE + Random error

Commercial microwave link (CML)

Source: C. Ruf, KIT

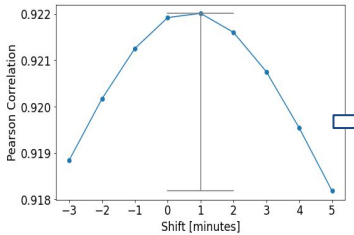
QPE + Random error

Dual-pol weather radar

Source: DWD

QPE + Random error

Bayesian merging framework

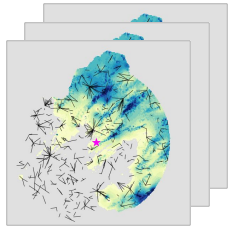


QPE

+ correct systematic error
+ compensate mismatch

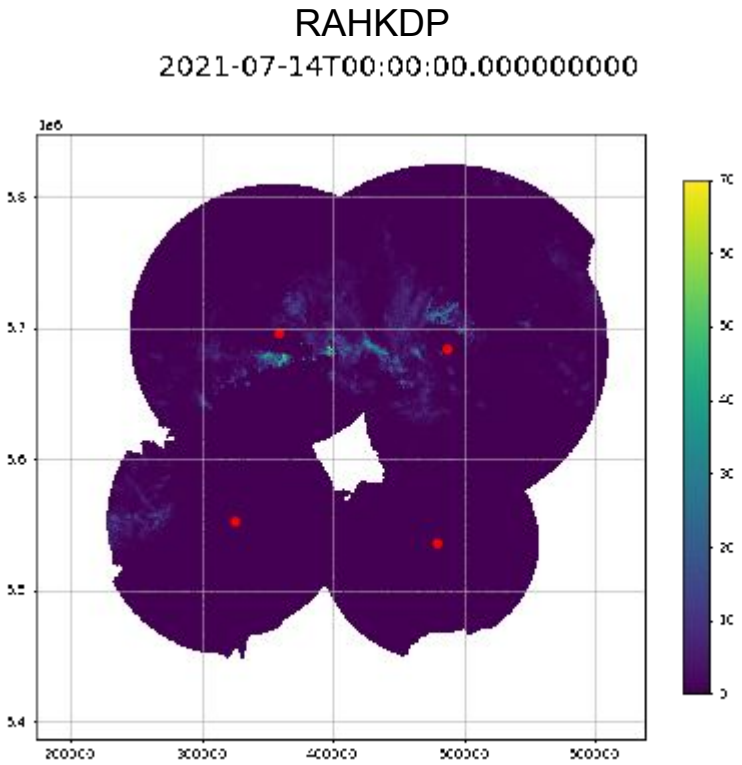
Random error

+ combine individual error models



WP-P1-4: Probabilistic merging at increasing resolutions (UBonn and KIT, months 1 - 33)

M-P1-10: Precipitation estimates from different sensors are compared at a 1-minute resolution (month 6)



Next step:

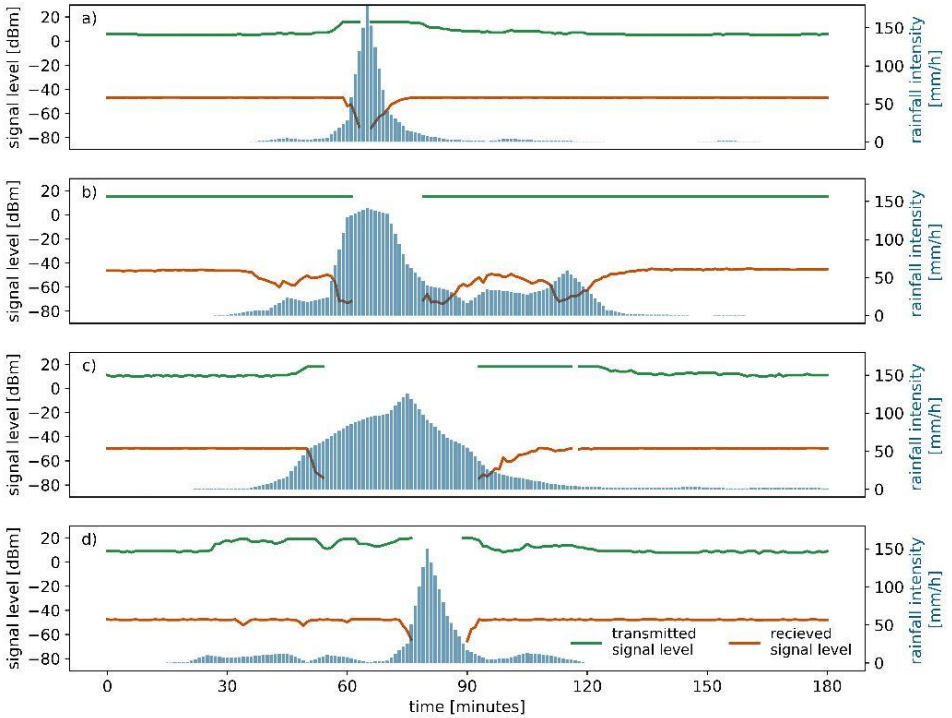
Use PySTEPS advection correction to produce “intermediate” steps at a 1 minute resolution.

Lucas-Kanade optical flow algorithm is ready, but results are not. More advanced algorithms to be tested

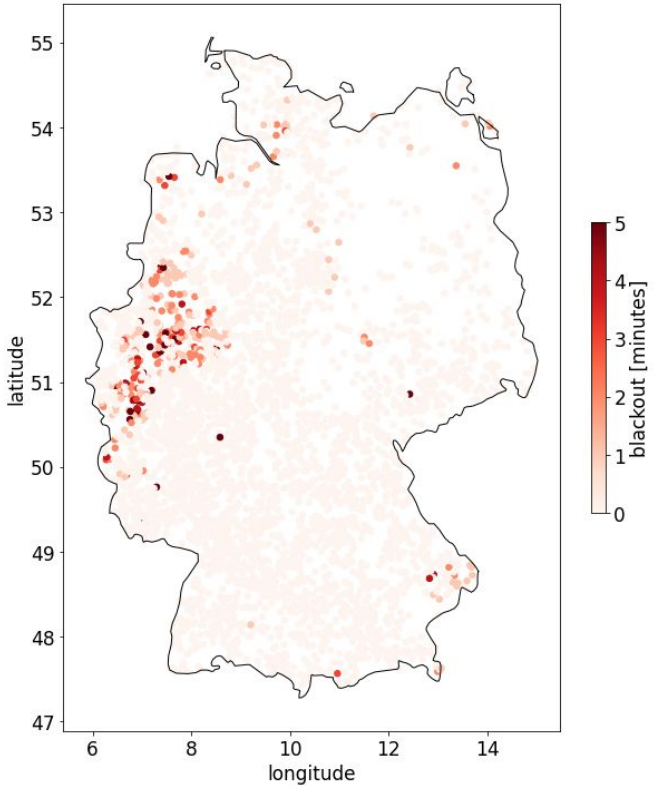
⟶ Prepare to process 3 months of data

CML “blackouts” on 14.07.2021

Extreme example blackouts - Path averaged Intensity from RADKLIM-YW

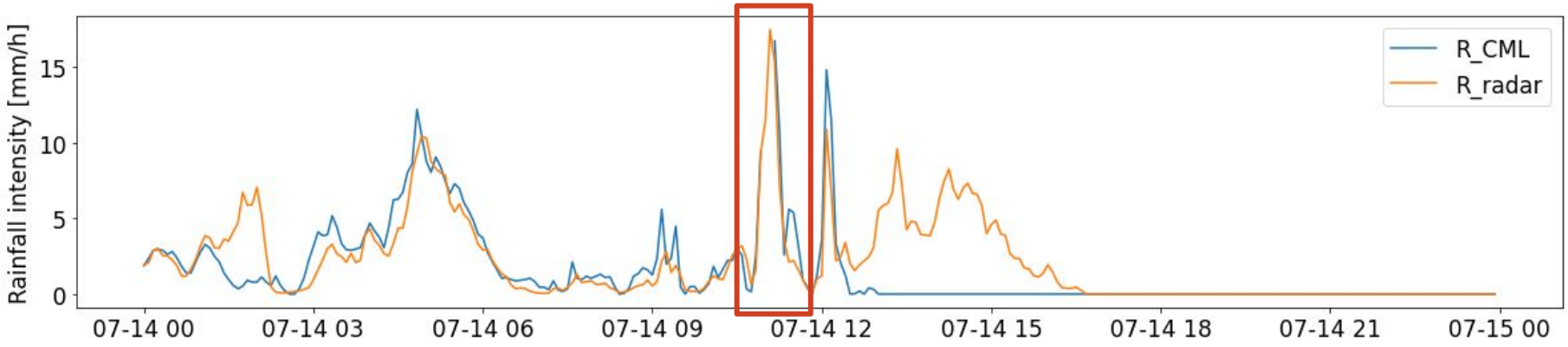


Cumulative blackouts



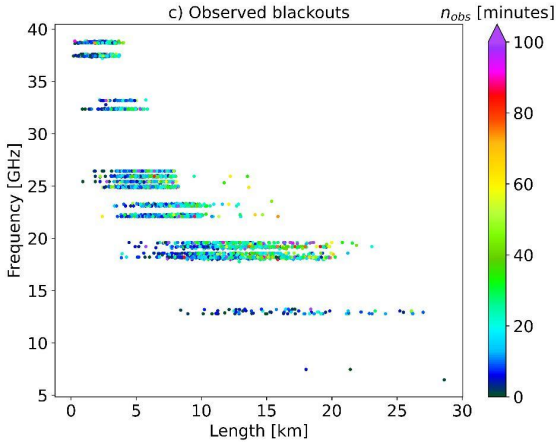
CML “blackouts” on 14.07.2021

Missing CML rainfall peak →new QPE algorithm will assume maximum attenuation

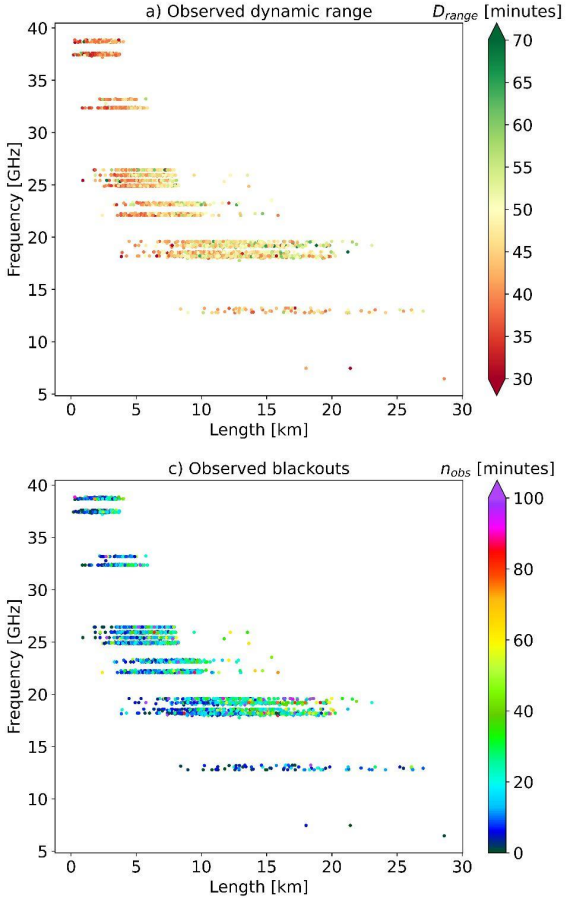


CML “blackout” climatology

Observed CML blackout minutes per year from 2018 to 2020

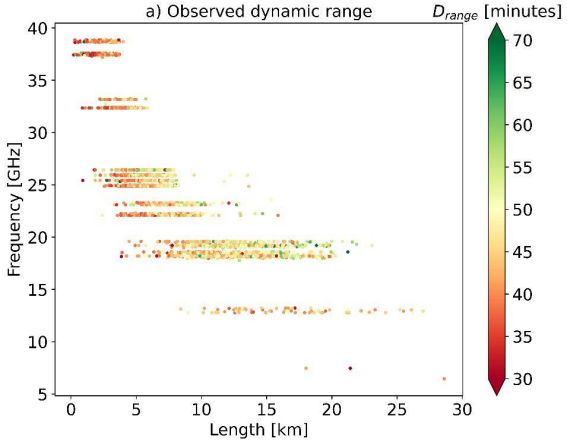


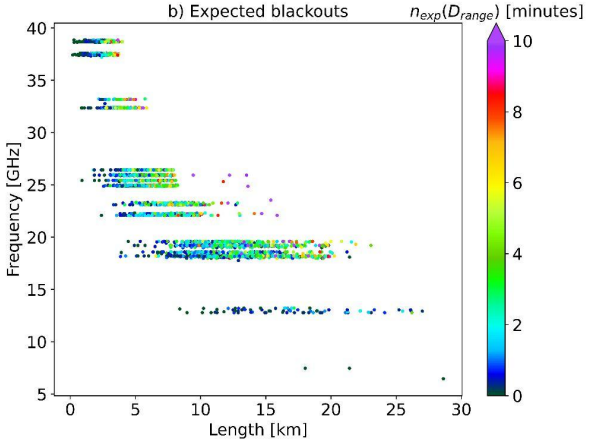
CML “blackout” climatology

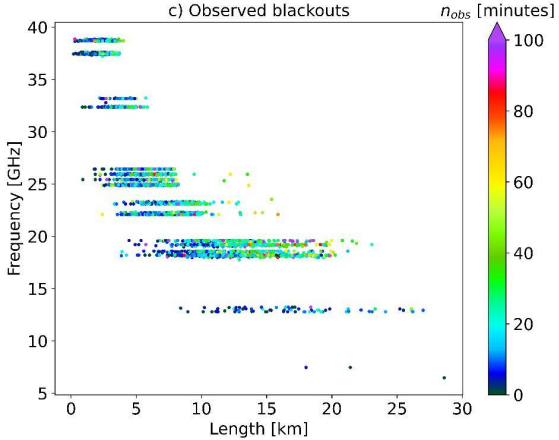


Dynamic range is the maximal PIA that can be measured before a blackout occurs

CML “blackout” climatology

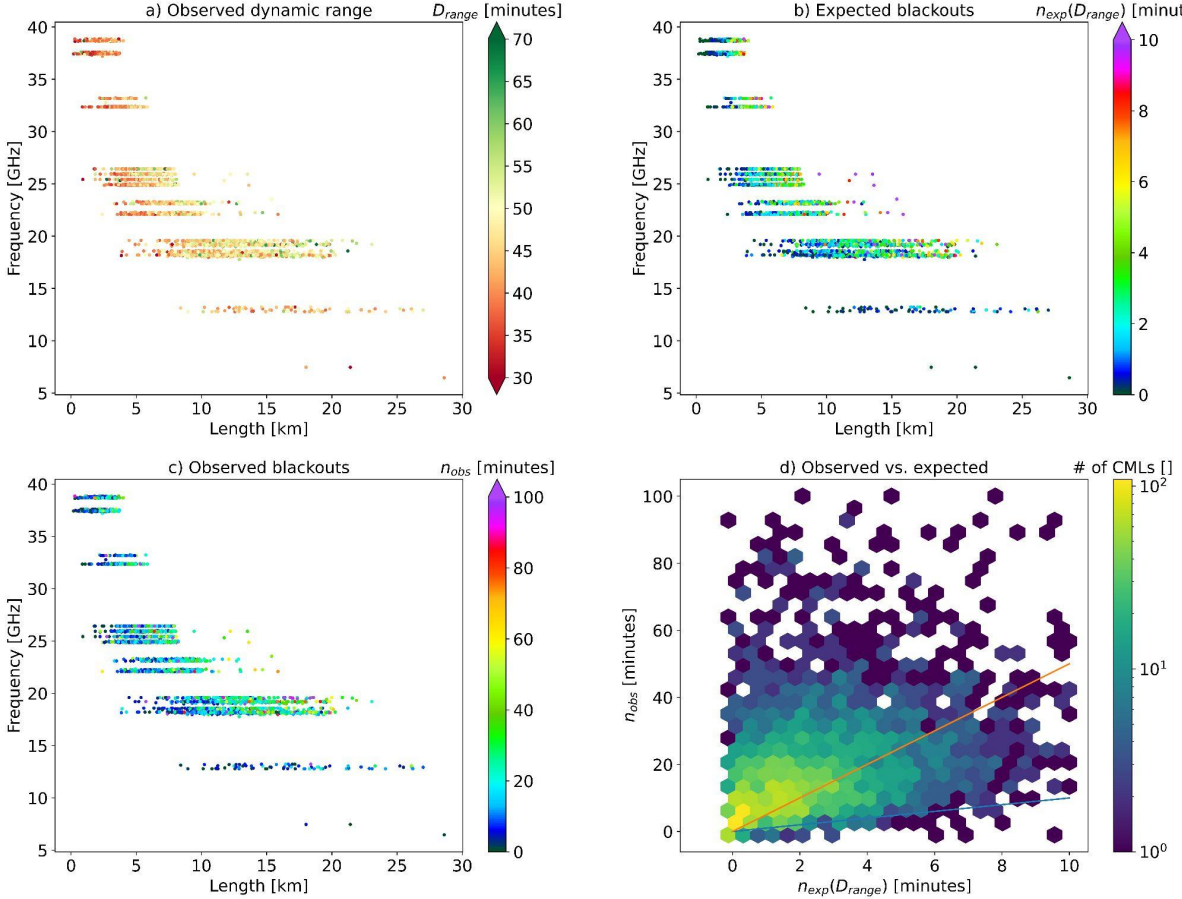




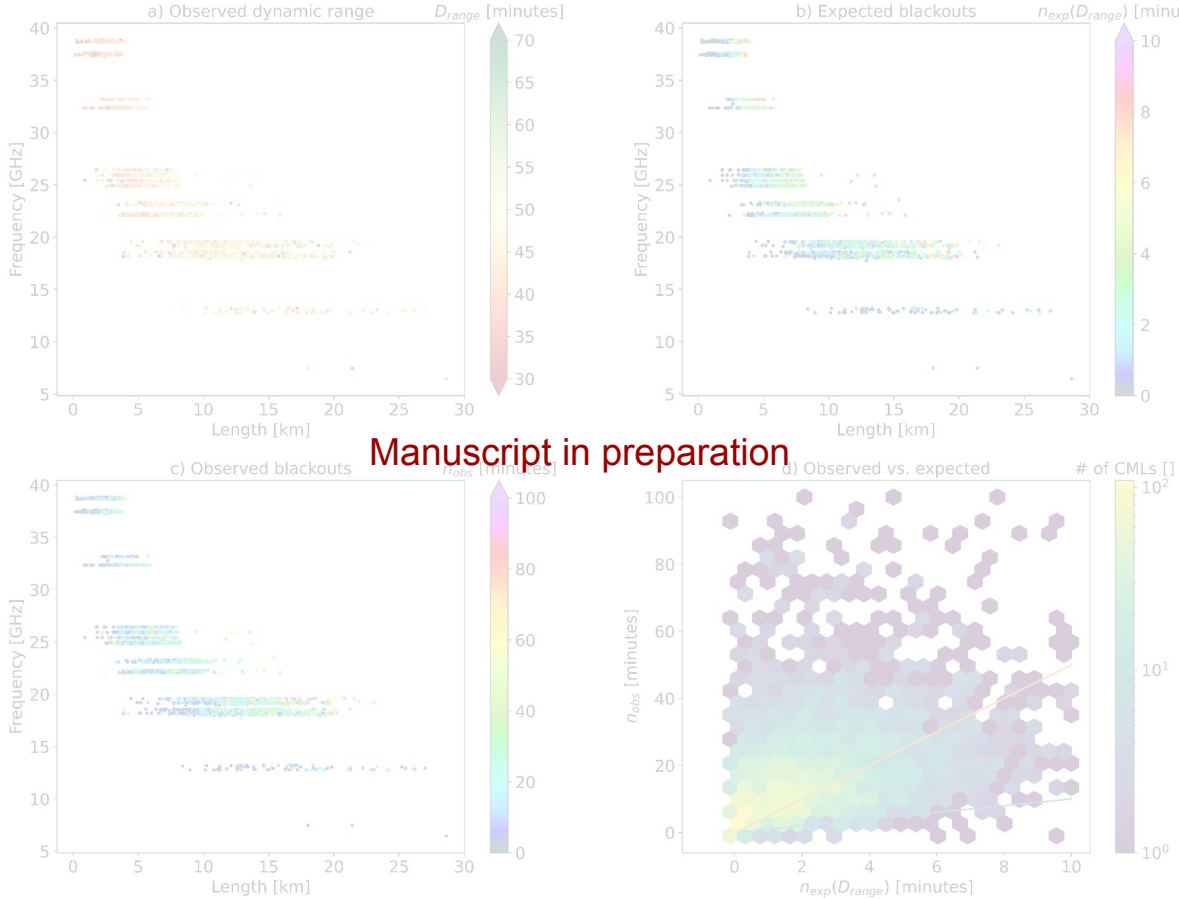


20 years of RADKLIM derived PIA suggests much less blackouts than actually occurring.

CML “blackout” climatology

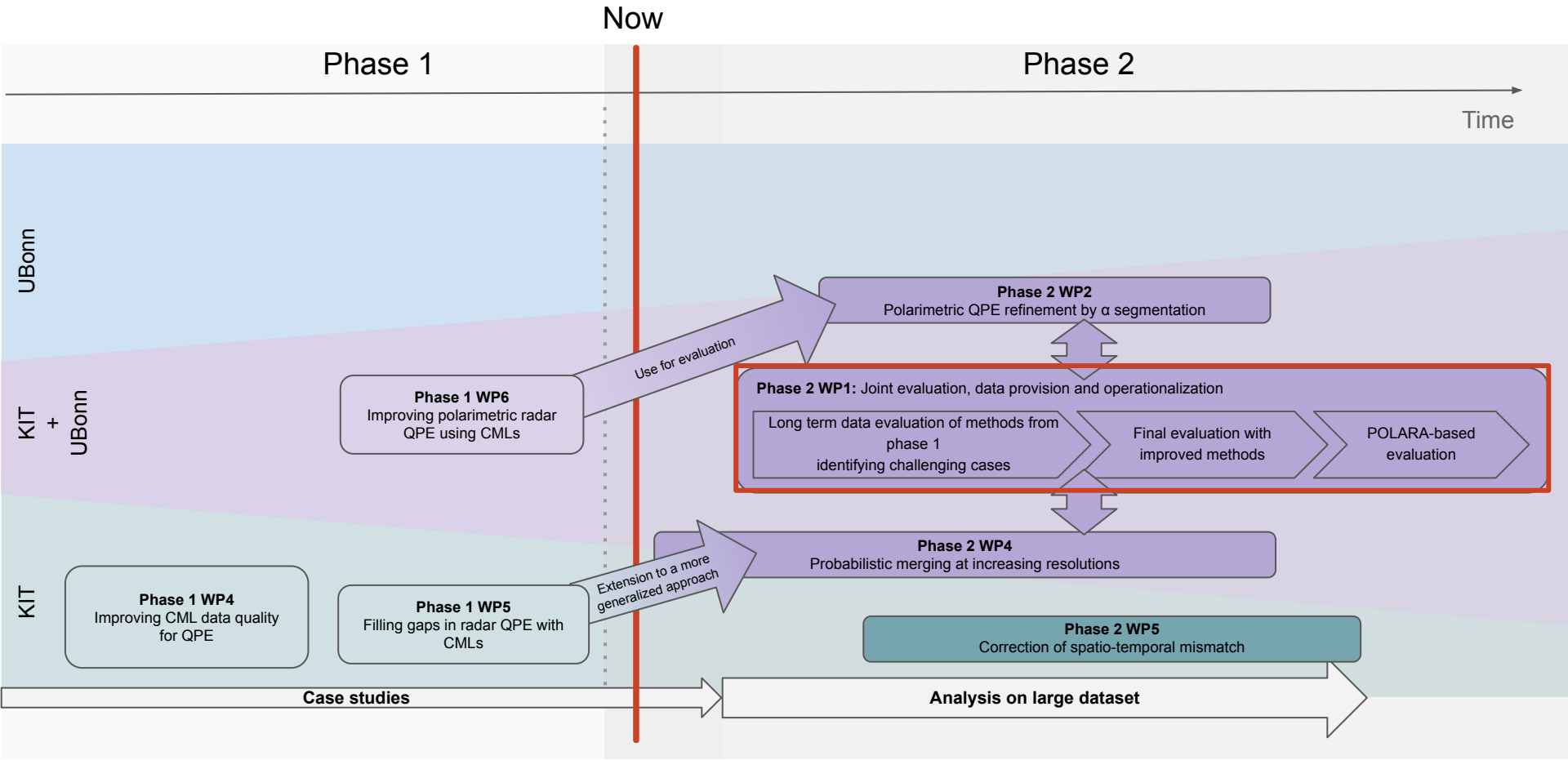


CML “blackout” climatology

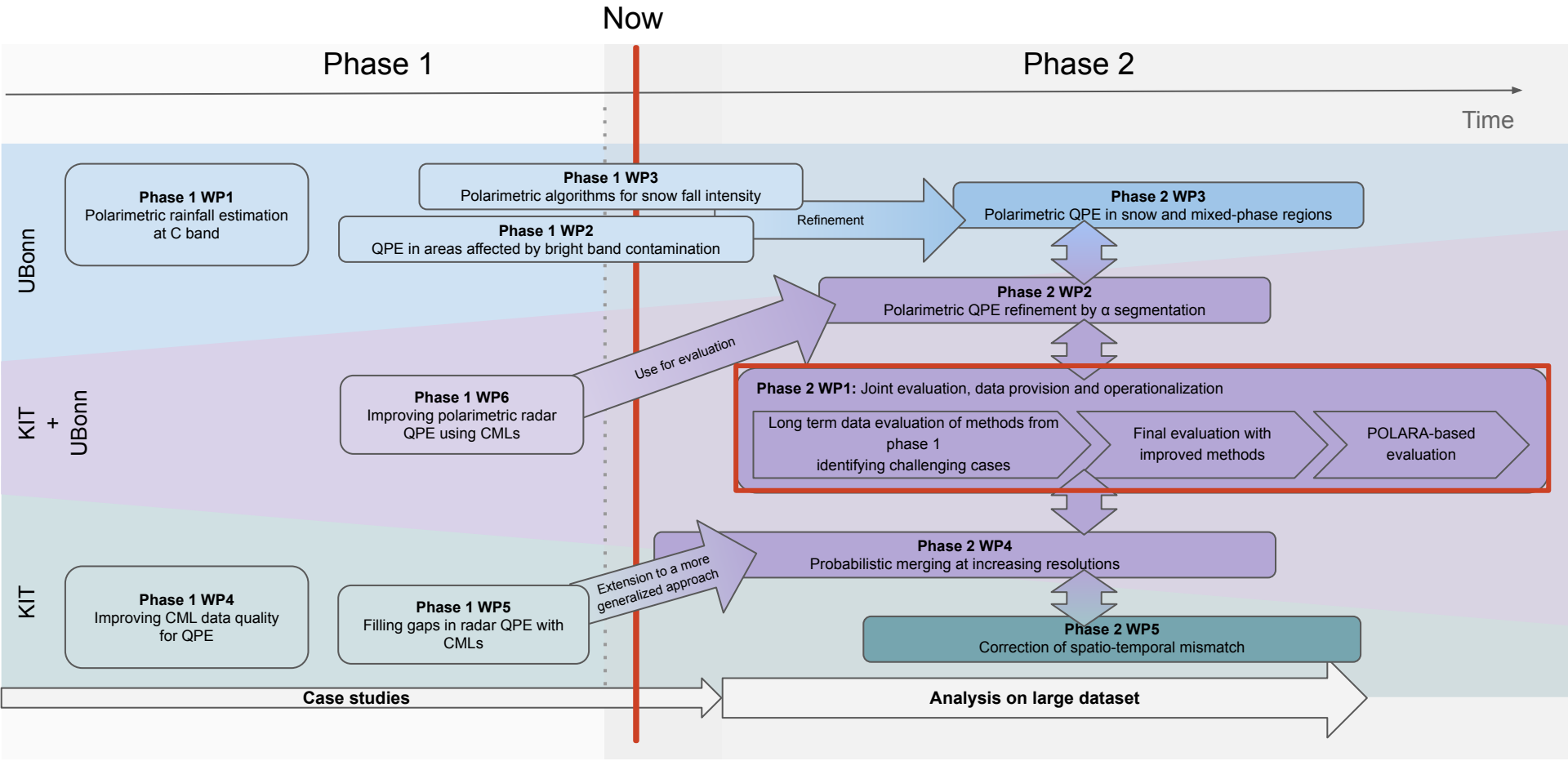


Manuscript in preparation

P1 Flowchart



P1 Flowchart



News:

- HoWa-pro will move CML data acquisition to DWD
  - increase of temporal resolution to 10 seconds
  - possible increase of CMLs by up to 20k
    - ➢ benefit for merging and mismatch correction in RealPEP
- Ongoing MSc thesis for AI based radar adjustment
- Ongoing MSc thesis for AI based radar downscaling

Discussion points:

- Date for possible Bonn/Garmisch visit/exchange for multiple days to accelerate progress
  - I could travel in March or April
- Who can share experience with PySTEPS?
- Phase 2: Who started when and are we aligned?
- 3 month data: discuss later?
- Joint case study paper: What is the objective? RealPEP showcase or “competition” for best analysis? 😉