Assimilation of 3D polarimetric microphysical retrievals using the operational ICON model framework of DWD

ablanke1@uni-bonn.de

Armin Blanke[1], Roland Potthast[2], Silke Trömel[1,3]

[1] Institute of Geosciences, Department of Meteorology, University of Bonn
[2] German Meteorological Service (DWD, Deutscher Wetterdienst), Data Assimilation Unit
[3] Laboratory for Clouds and Precipitation Exploration, Geoverbund ABC/J

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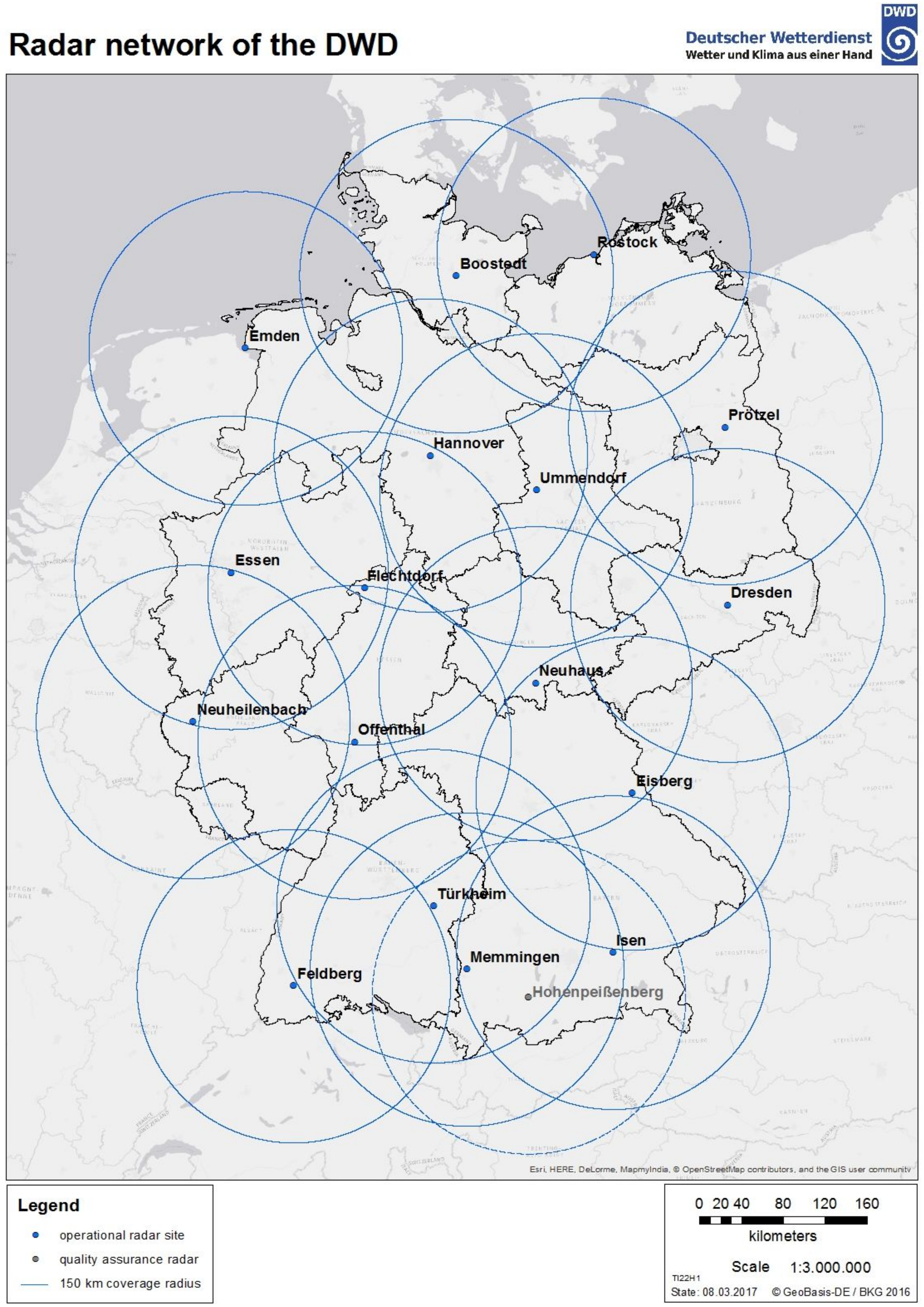
BACKGROUND AND HYPOTHESIS

HYPOTHESIS:

The assimilation of refined hydrometeor mixing ratios **(HMRs)** can further improve quantitative precipitation forecasts **(QPFs)** with respect to the assimilation of radar reflectivity alone

- Assimilation of polarimetric data from the entire German national C-band radar network (3D volume scans every 5 minutes)
- Dual-polarization moments contain additional information
- Microphysical retrievals already assimilated with single moment scheme: 3D IWC (Carlin et al., 2021) and LWC (Reimann et al., 2023)
- Starting point: Ahr flooding case 2021 with modified retrievals for new assimilation results



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GENERAL APPROACH

1. **Derivation** of HMRs as liquid/ice water contents (LWCs/IWCs)

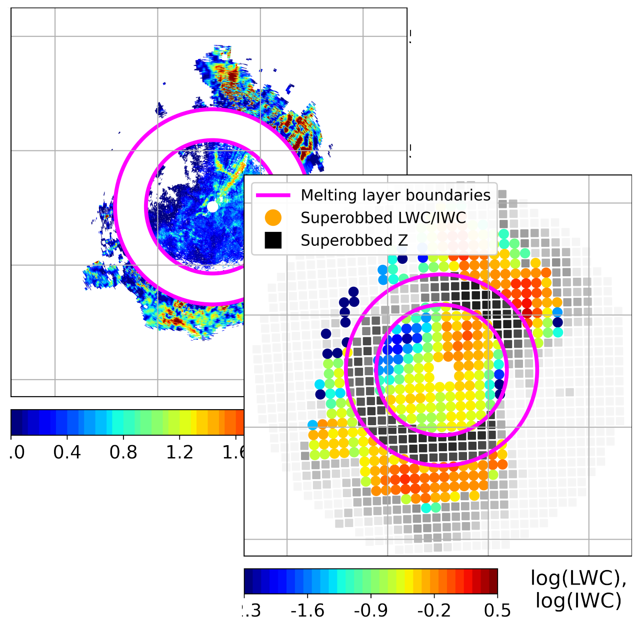
2. **„Superobbing“** of derived data: Spatial elevation-wise averaging of LWC/IWC data to cartesian grid with 10 km resolution

3. **First guess** LWC/IWC projected, linearly interpolated and superobbed onto same grid

4. **Assimilation** of superobbed HMRs with KENDA in DWD’s ICON-D2 model

5. **Evaluation** of first guesses and generated QPFs with DWD’s RADOLAN-RW product

NWP model



improved QPF

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CHALLENGES

1. TECHNICAL

- New operating system at DWD: RedHat8
- Adaptation of existing routines to the new system
- Issues occurred on the DWD system due to missing dependencies
- Solution: adjustable container

2. PROCESSING

- Identification of inaccuracies and missing steps in the processing of radar data
- Z_{DR} calibration, noise correction, K_{DP} window size
- Check for negative IWC and LWC values
- Obtain more data below melting layer (ground clutter treatment)

CONTAINER SOLUTION

ENGINE: APPTAINER (KRUTZER ET AL., 2017)

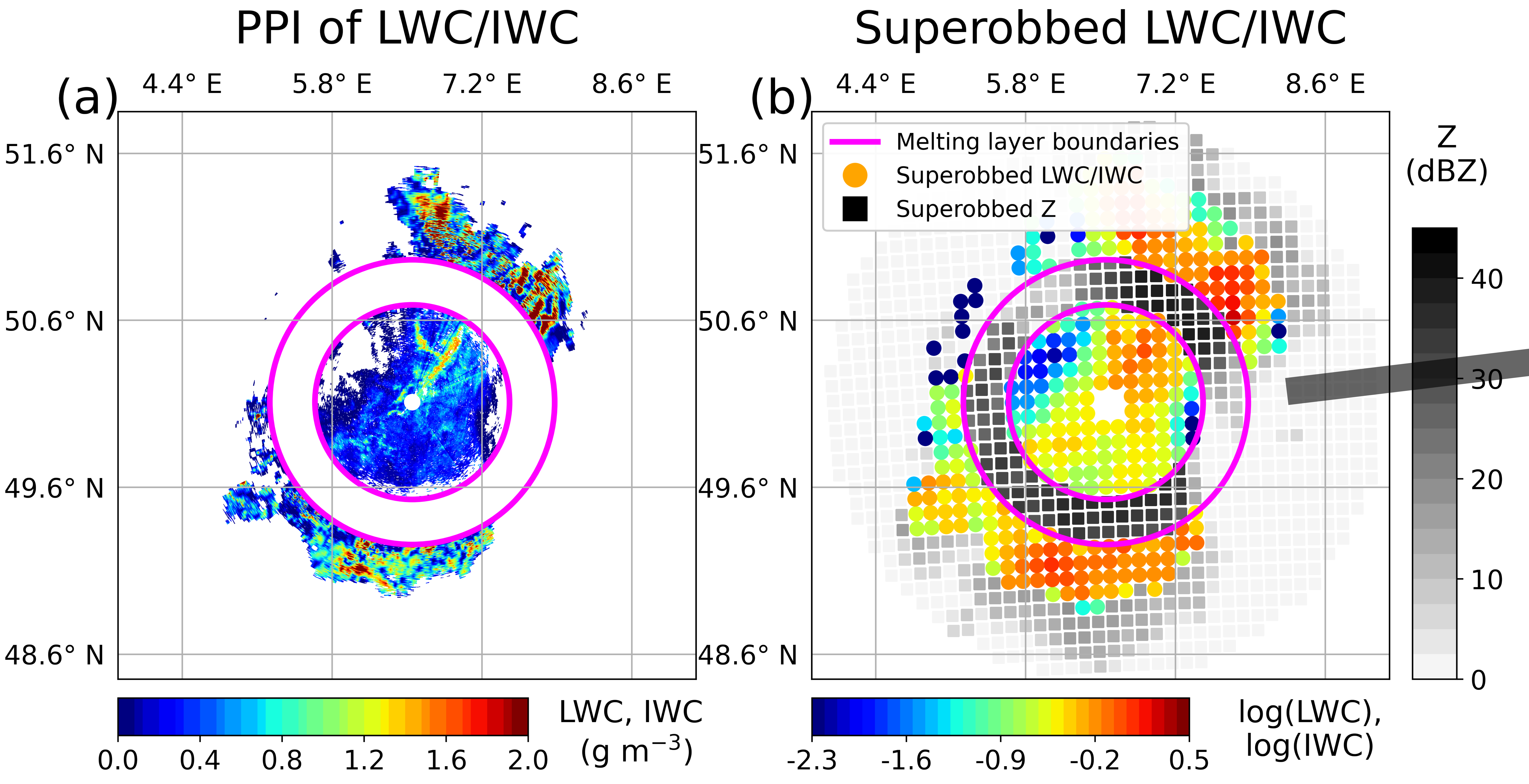
- Reason: Errors due to module GDAL and libspatialite (necessary for wradlib)
- Needed for generating HMR feedback/fof files and „superobbing“ (Bick et al., 2016)
- Workaround with a container solution using Apptainer (build Singularity Image File: gdal.sif)
- python3 commands via execution of container:

```
apptainer exec -B /hpc/uwork/extablan:/mnt/extablan:rw \
        --env ECCODES_DEFINITION_PATH=definitions.edzw \
       gdal.sif \
        python3 /mnt/extablan/dace_bacy_shell/my_routine/python_files/
make_fofradar_container.py $exp_dir $fcst_dtime $ens_size $OE $LS $LL
$MV $HMRMODE
```

- But: Change of variable names (ecCodes): new via ECMWF parameter database
- Contained codes run stable ✔

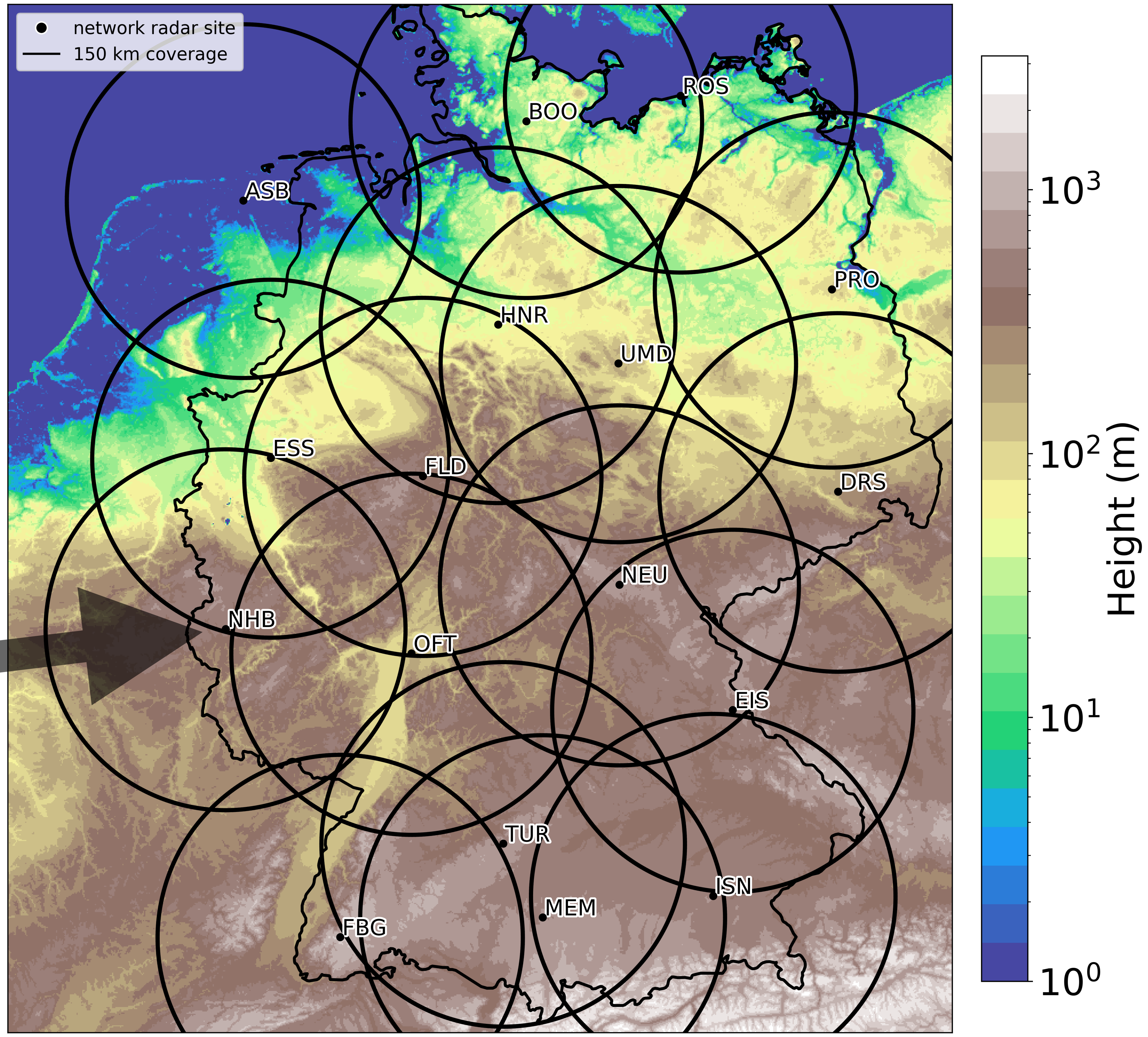
RESULTS

ASSIMILATION STRATEGY



PPI 1.5° NHB

14 July 2021



Assimilation of 3D LWC/IWC:
5 elevation angles
1.5, 3.5, 5.5, 8.0, and 12 degrees

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3D RETRIEVAL ASSIMILATION: CORE NAMELIST SETTINGS

Configuration used:

40-member ensemble

CONV+(LWC+IWC)/Z

Data Assimilation Parameter (DAP) used:

LH (km): 8
LV (ln(p)): 0.2
OE: 0.25
LS (km): 10
LL: -2.3
MV: 3

DAP acronyms:

LH: horizontal localization length scale

LV: vertical localization length scale

OE: observation error standard deviation

LS: superobbing window size

LL: lower limit

MV: minimum number of valid values for superobbing

Comparative configurations:	Reimann et al. (2023)
CONV	*Conventional data*
CONV+Z	*Conventional data + 3D Z*
CONV+LWC/Z	*Conventional data + 3D LWC instead of Z where possible*
CONV+IWC/Z	*Conventional data + 3D IWC instead of Z where possible*
CONV+LWC+IWC+Z	*All together (parallel)*

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RESULTS

FIRST GUESS (FG) - FRACTION SKILL SCORE (FSS)

FG (hourly) QPFs for Ahrtal-flood case 14 July 2021

- **New assimilation systematically improves the deterministic precipitation forecast for lower thresholds**
- **It is less successful for some assimilation cycles for a threshold of 4mm/h**

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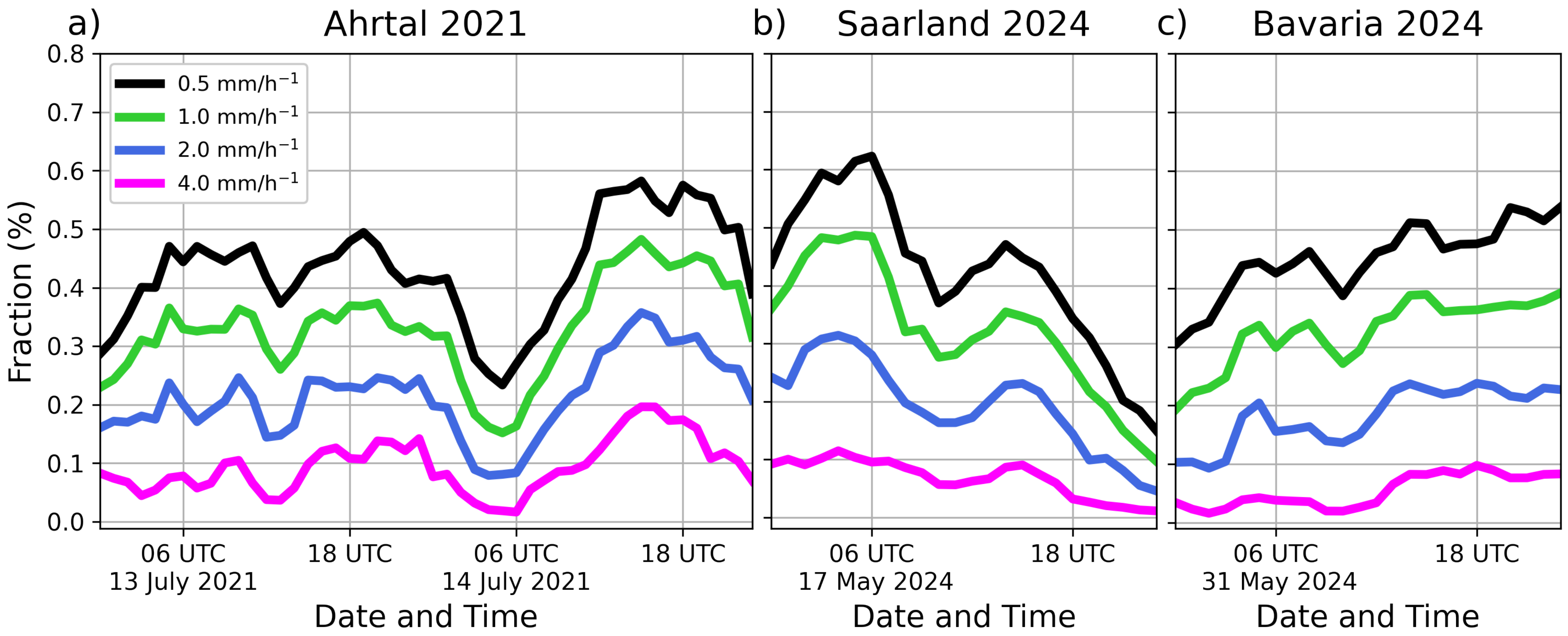
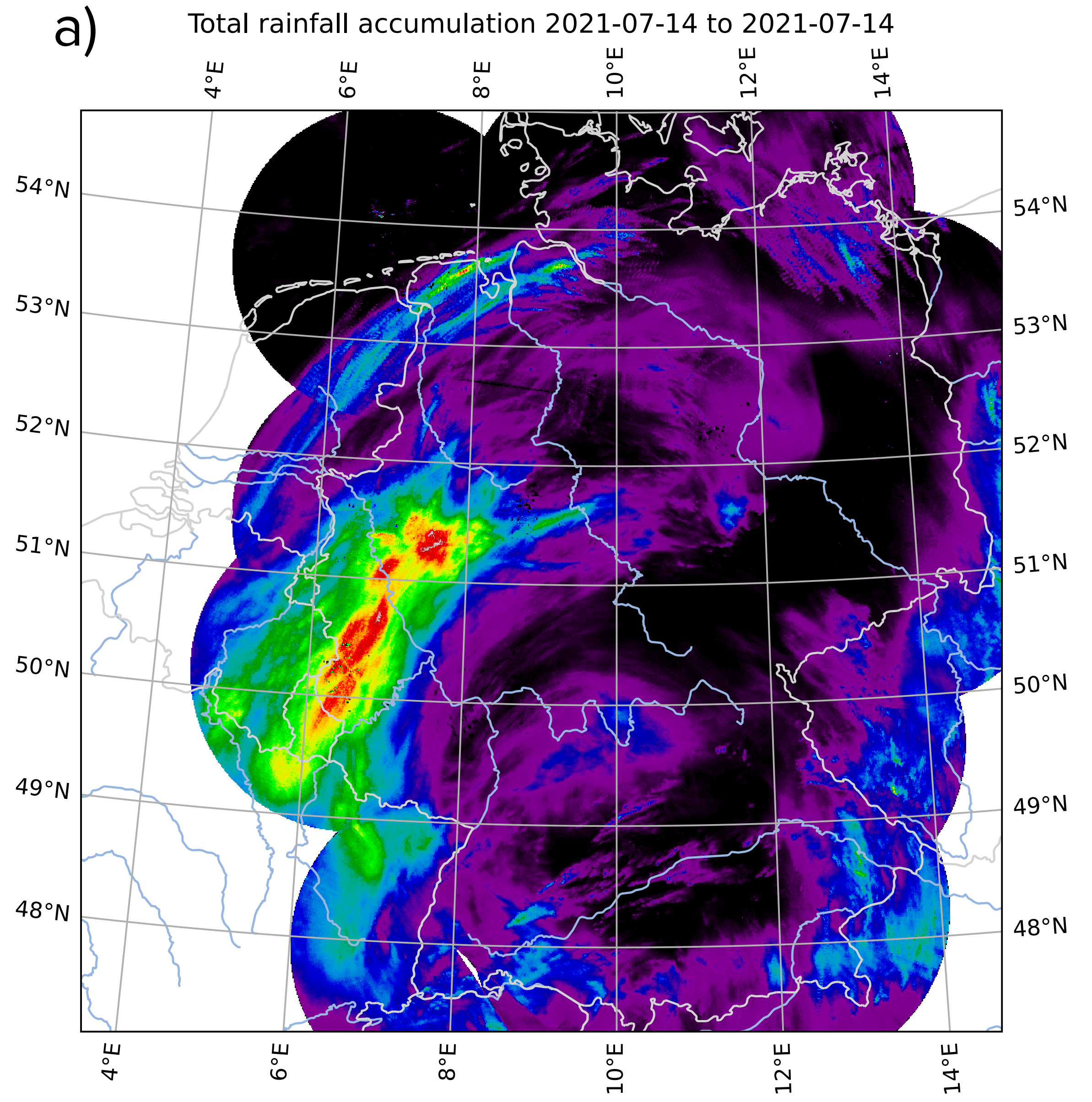
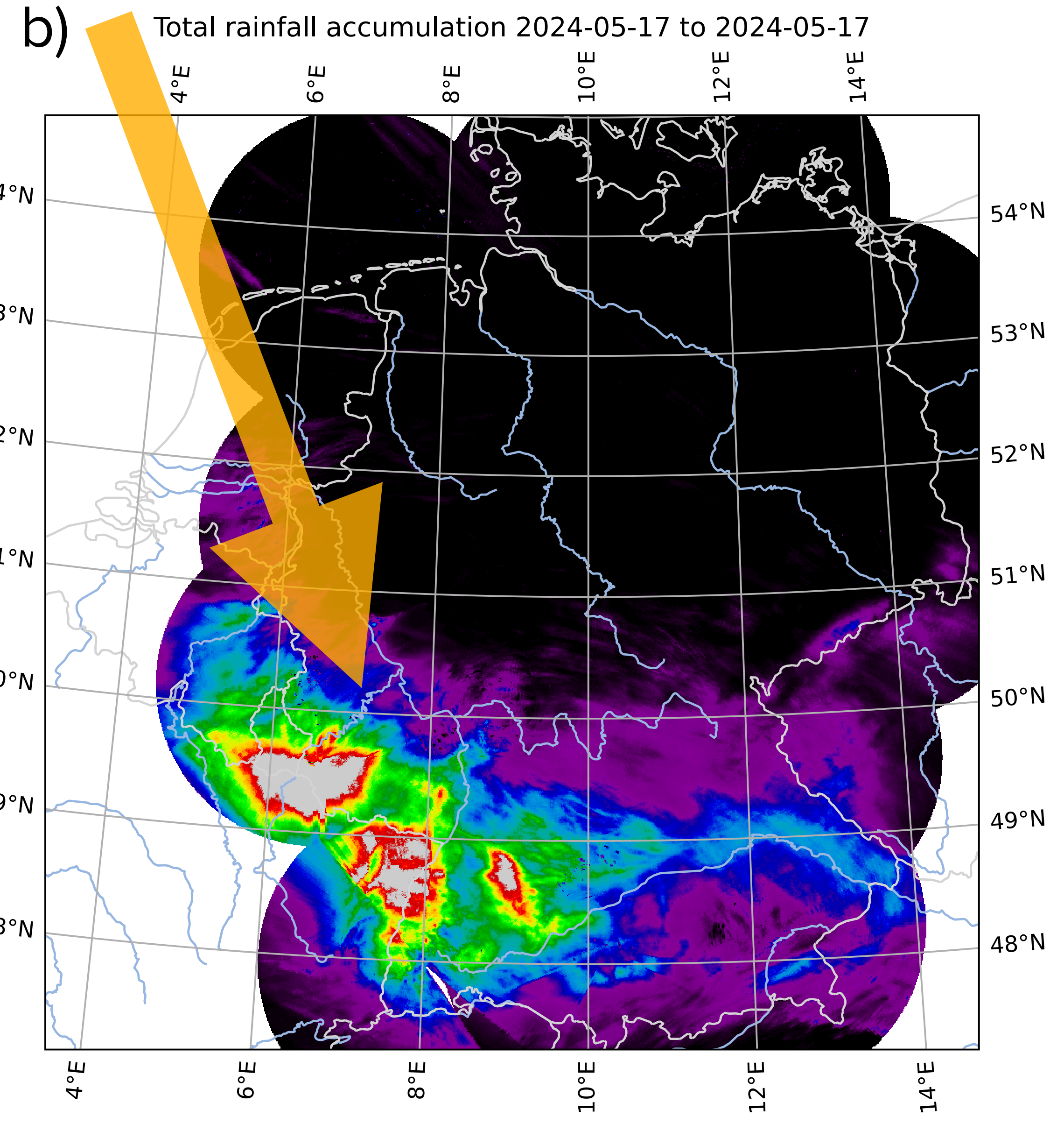
EXTENSION: NEW TEST CASES

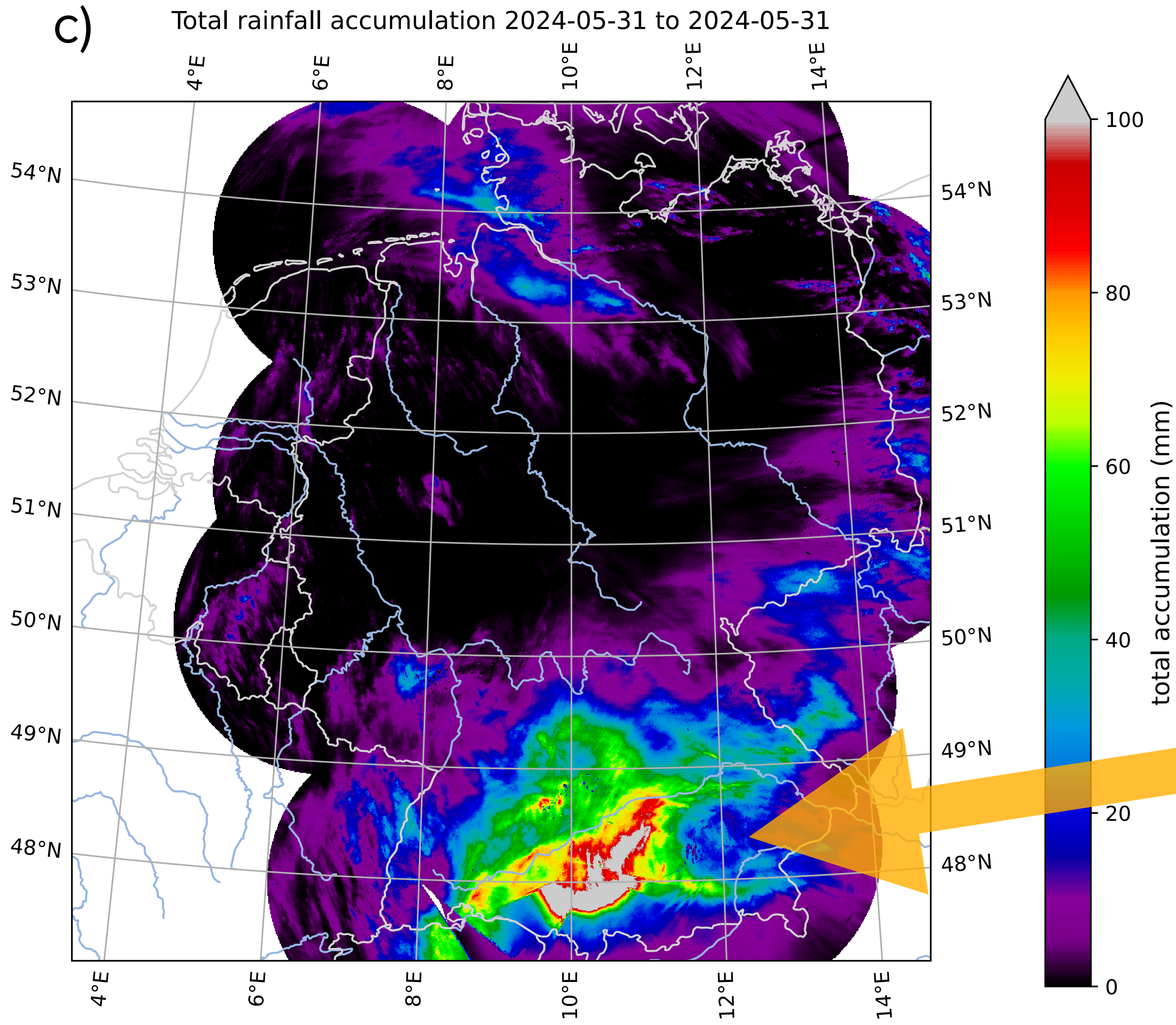
MORE RECENT FLOODING EVENTS

Higher radial resolution of 0.25 km leads to better K_{DP} than former coarser resolution: increase in retrieval accuracy









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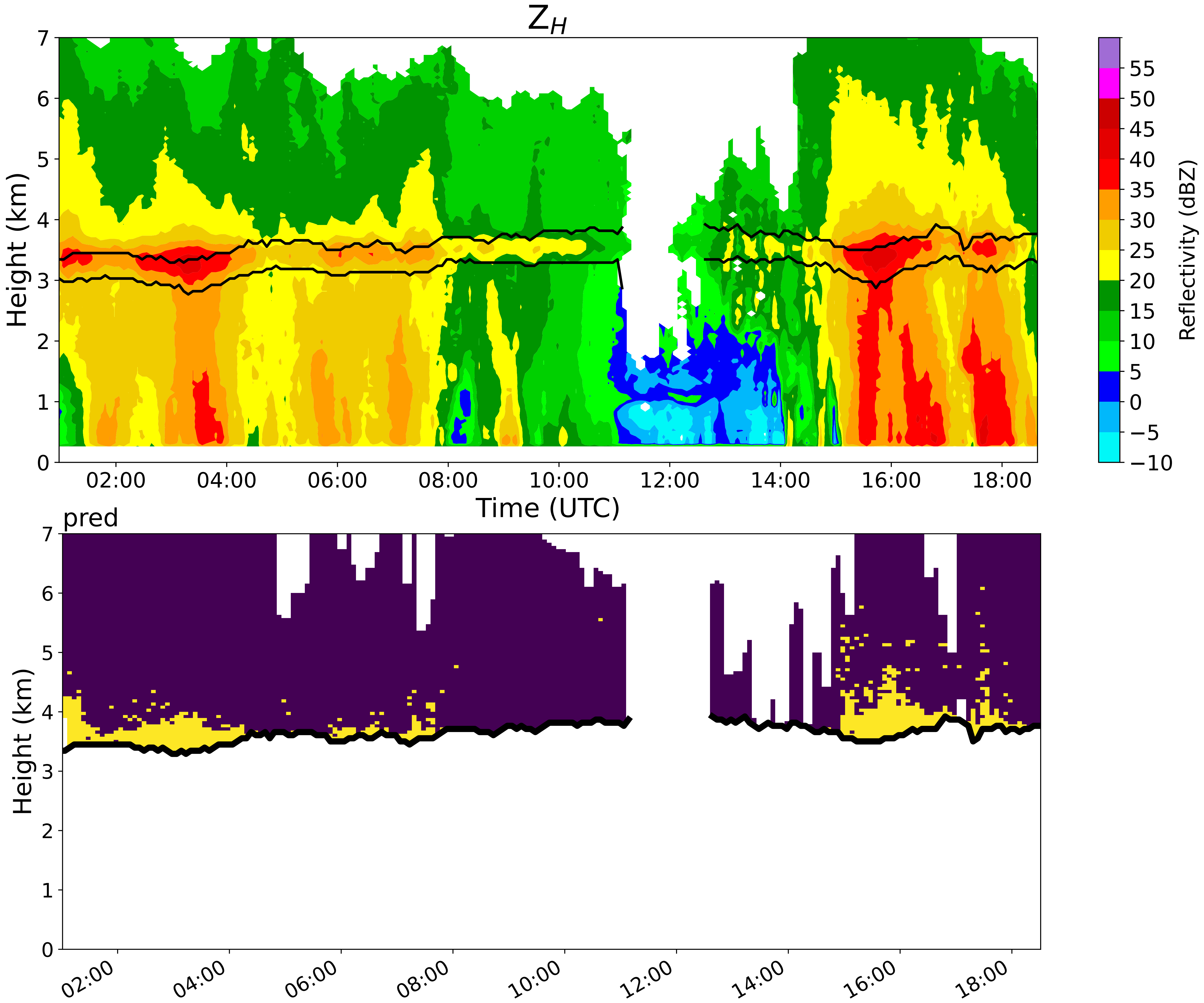
A NEW RIMING ALGORITHM

RIMING DETECTION



Essen radar 12°

14 July 2021

- Accuracy of state-of-the-art polarimetric retrievals is still reduced in the presence of riming (Blanke et al., 2023)
- Masking rimed areas via newly developed area-wide riming algorithm based on polarimetric radar data only (Blanke et al., 2024)
- Perform and test modified HMR assimilations in which reflectivity is assimilated in predicted rimed areas instead

riming

no riming

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CONCLUSIONS & NEXT STEPS

Summary

- Successfully adapted the routines to new system
- Improved radar data processing: updated retrievals
- Improved first guesses for most accumulation thresholds w.r.t. to all configurations of Reimann et al. (2023)

Near future work

- Revision of optimal DAP settings and configurations with high-resolution data only
- Perform and evaluated reforecasts
- Testing assimilation of best performing N_t and D_m retrievals evaluated with airborne in situ measurements (Blanke et al., 2023)
- Applying double-moment scheme

Contact:
ablanke1@uni-bonn.de

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REFERENCES

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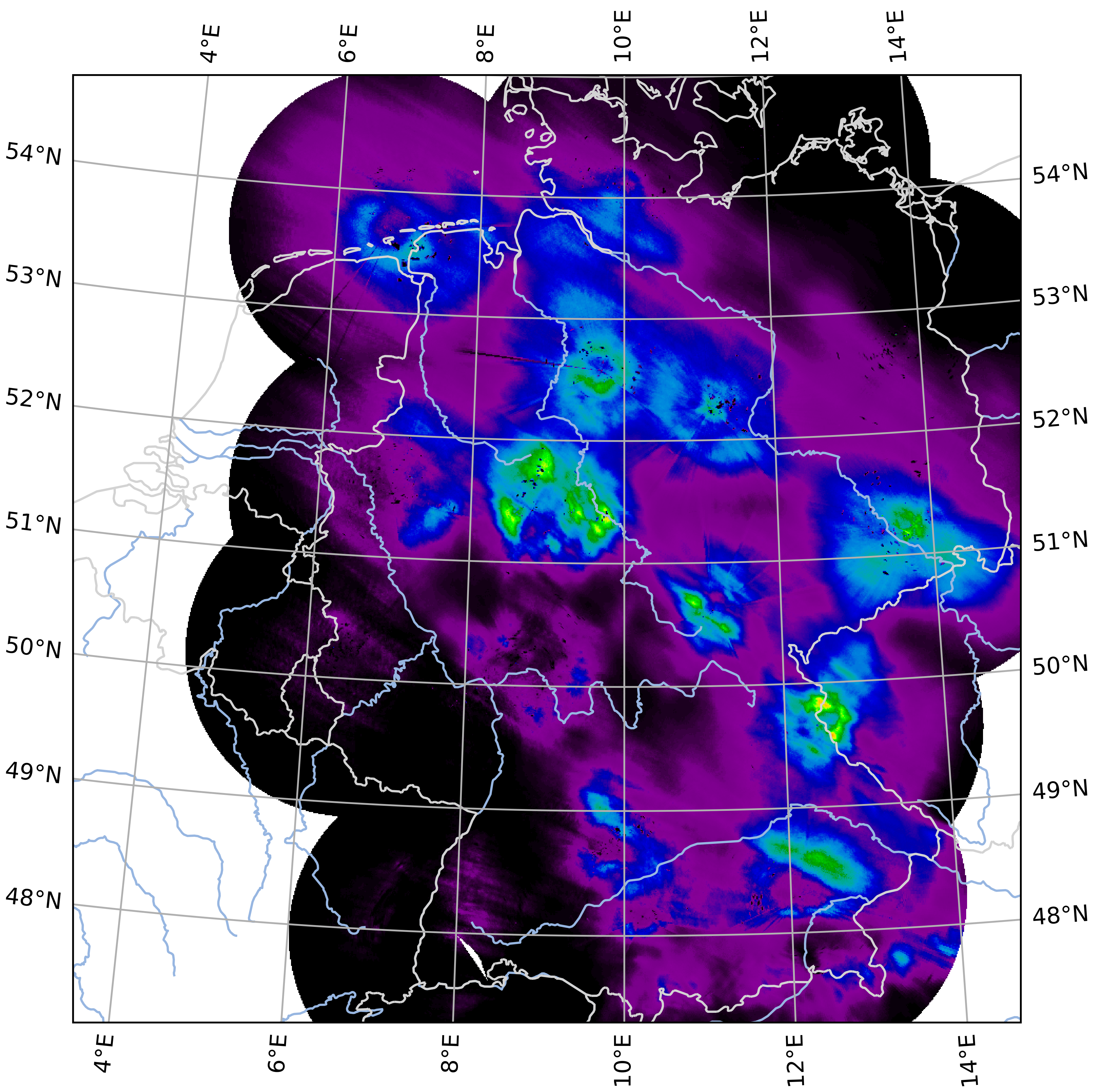
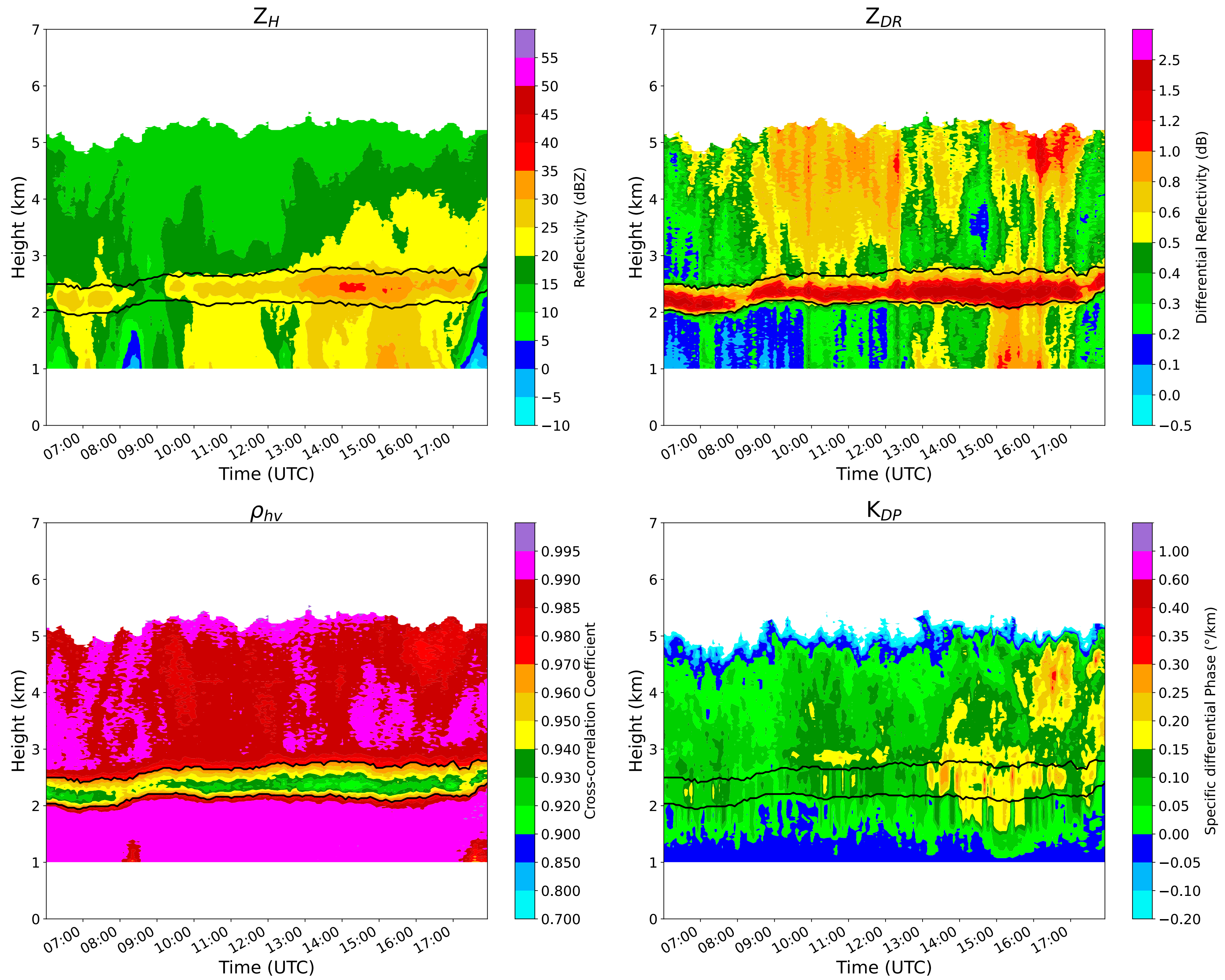
APPENDIX

- **Further extension of data base: recent winter flooding case**



Neuheilenbach radar 5.5°
17.05.2024



- **Quality controlled, calibrated and preprocessed radar data**
- **Accurate ML detection via Wolfensberger et al. (2016) adjusted with Giagrande et al. (2008)**
- **Higher elevations (e.g. 12°): radials of phi are horizontal: too negative K_{DP} below ML**

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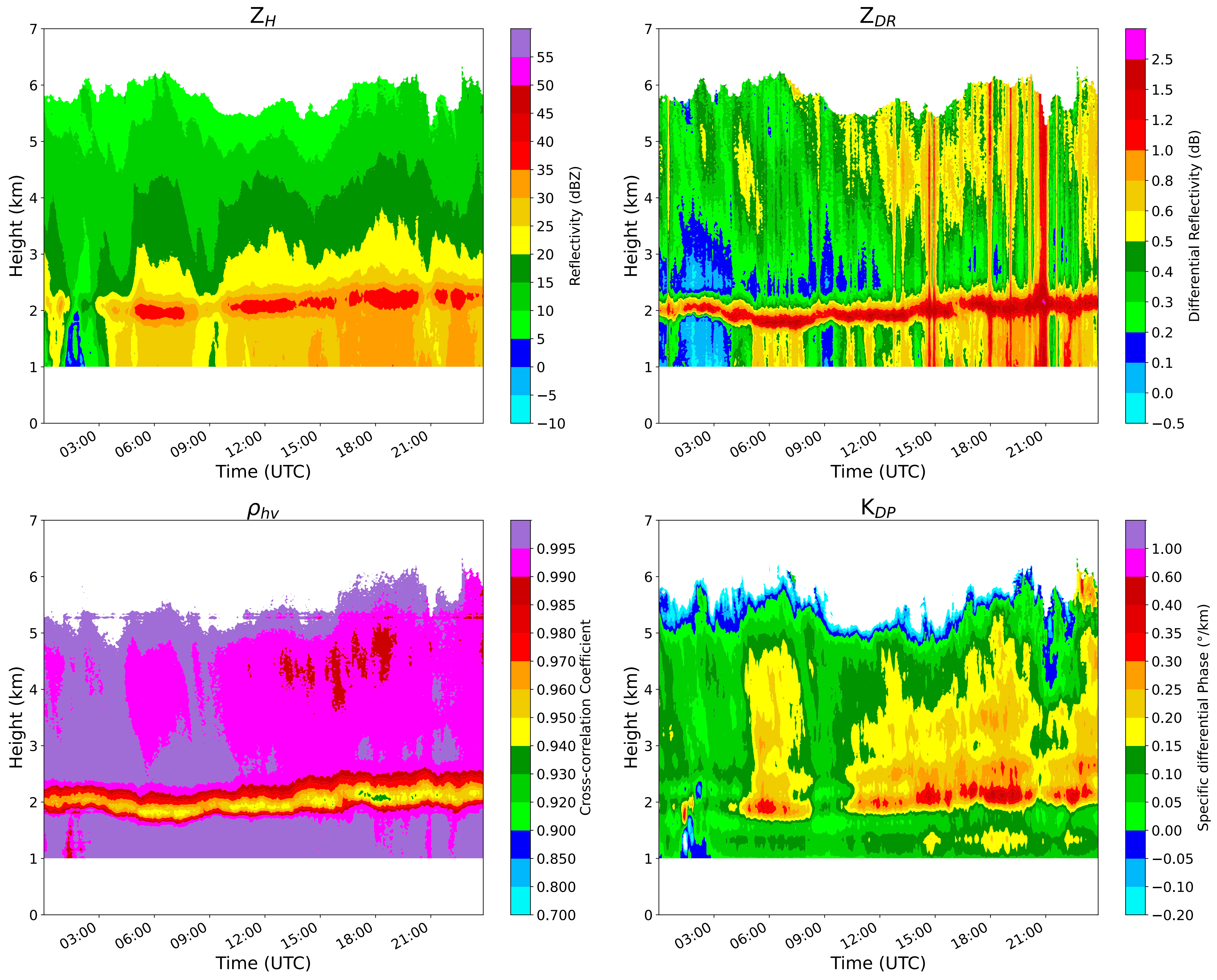
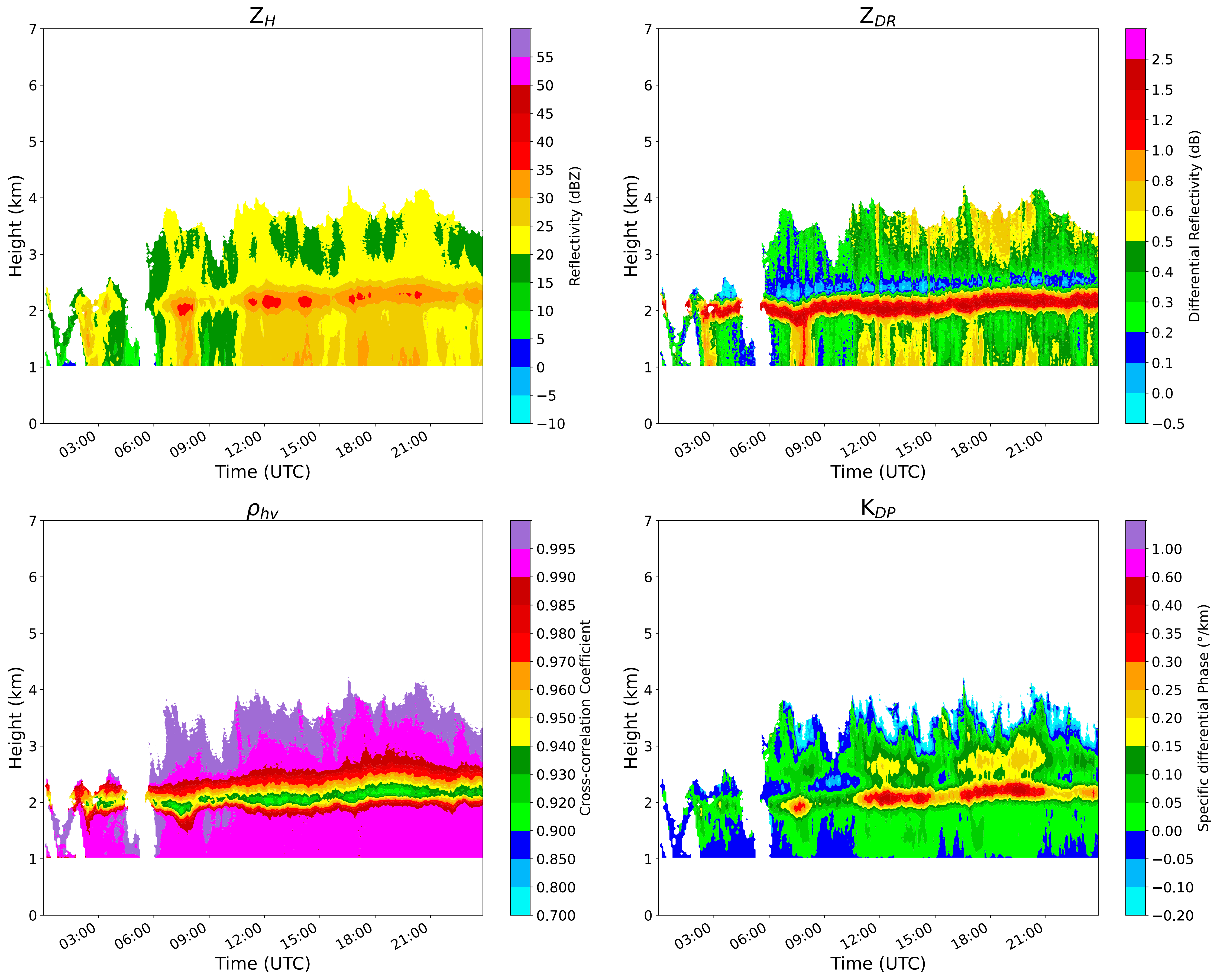
APPENDIX

Memmingen radar 5.5°
31.05.2024

Türkheim radar 5.5°
31.05.2024





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