

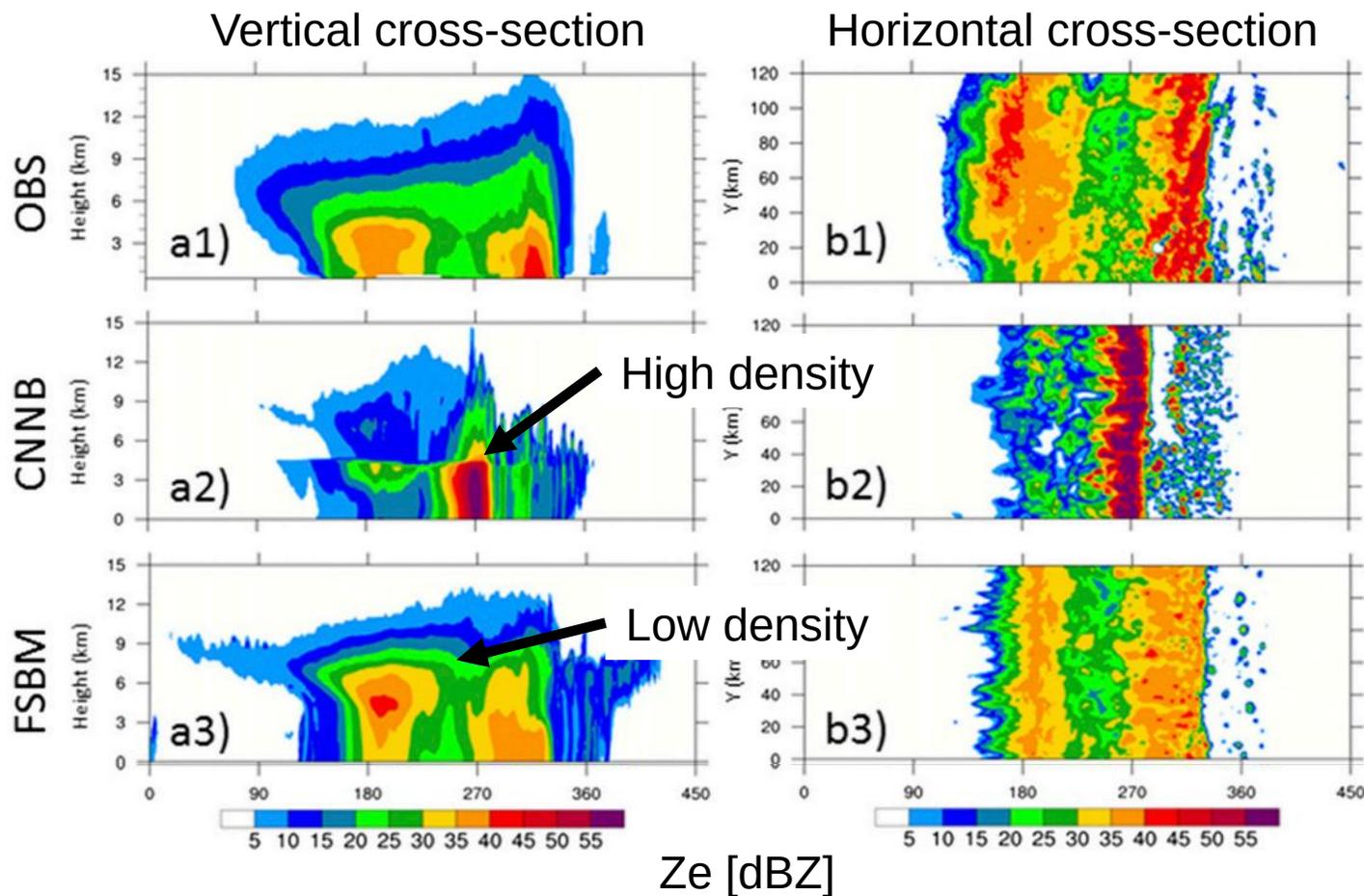
Towards developing a microphysical retrieval based on beam-aware columnar vertical profiles: Combining side-looking polarimetry with vertical radar measurements

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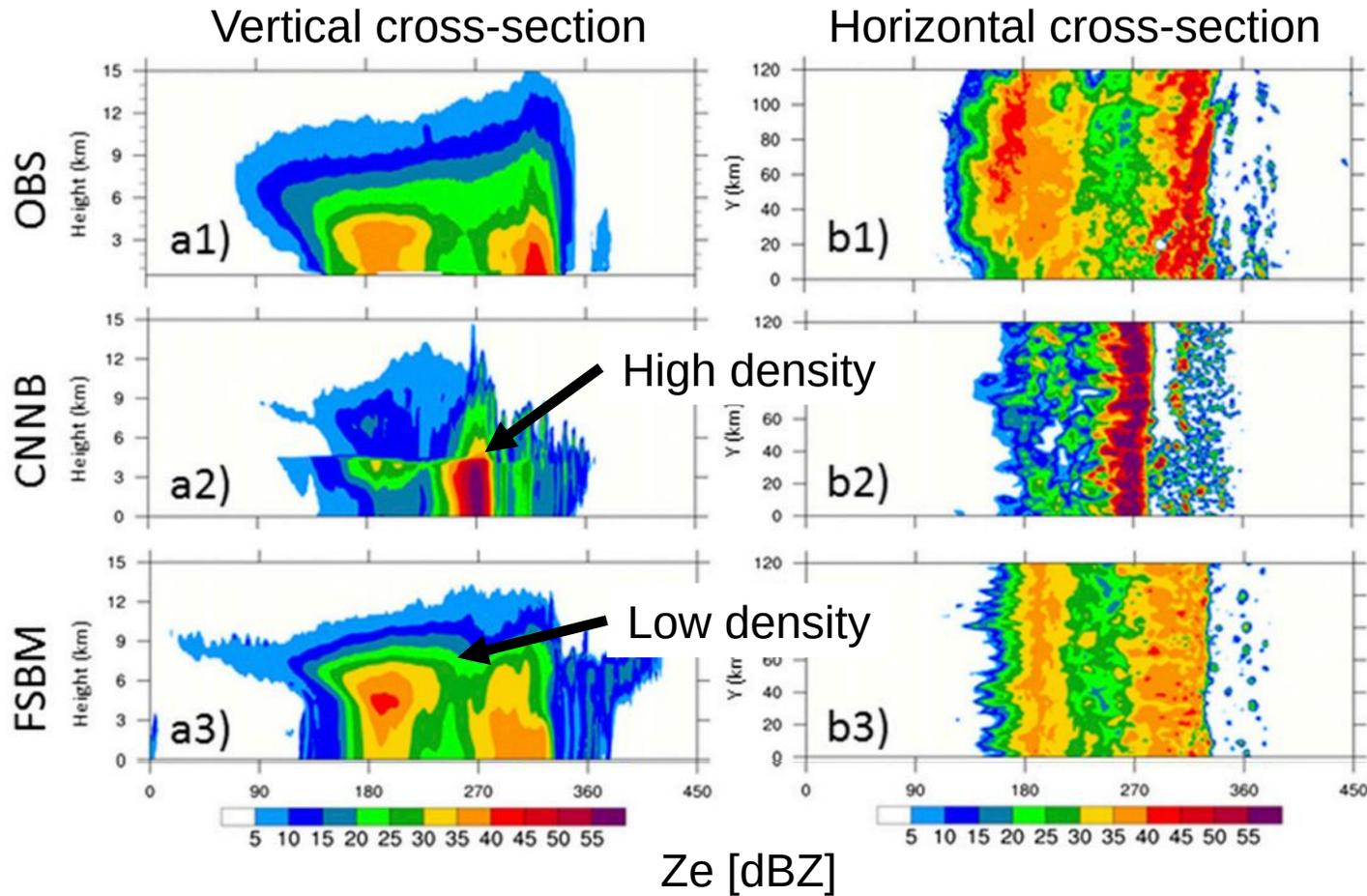
Motivation



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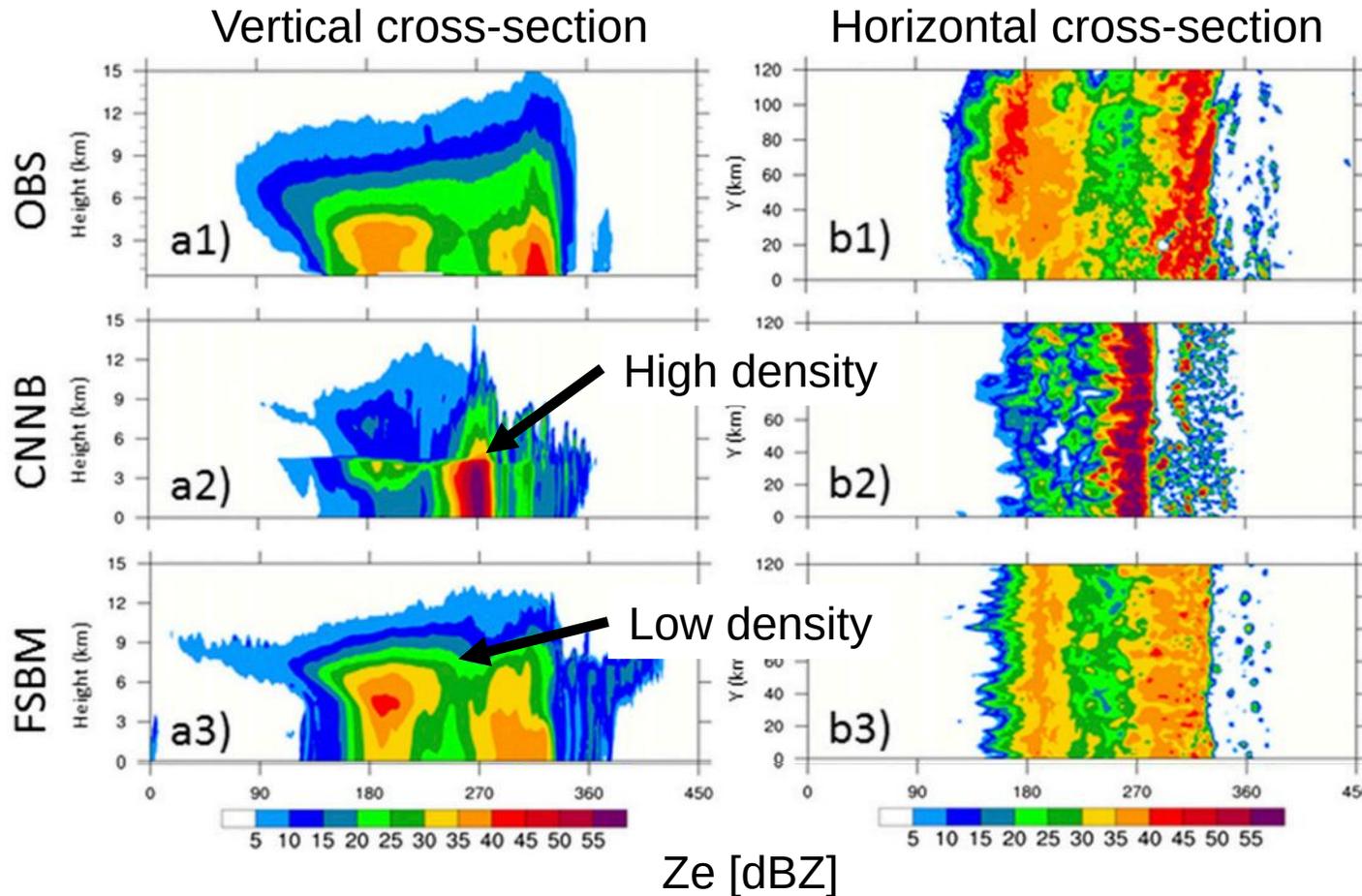
Research Gap
What role do ice particle properties play in the partitioning in convective and stratiform regions?



Motivation



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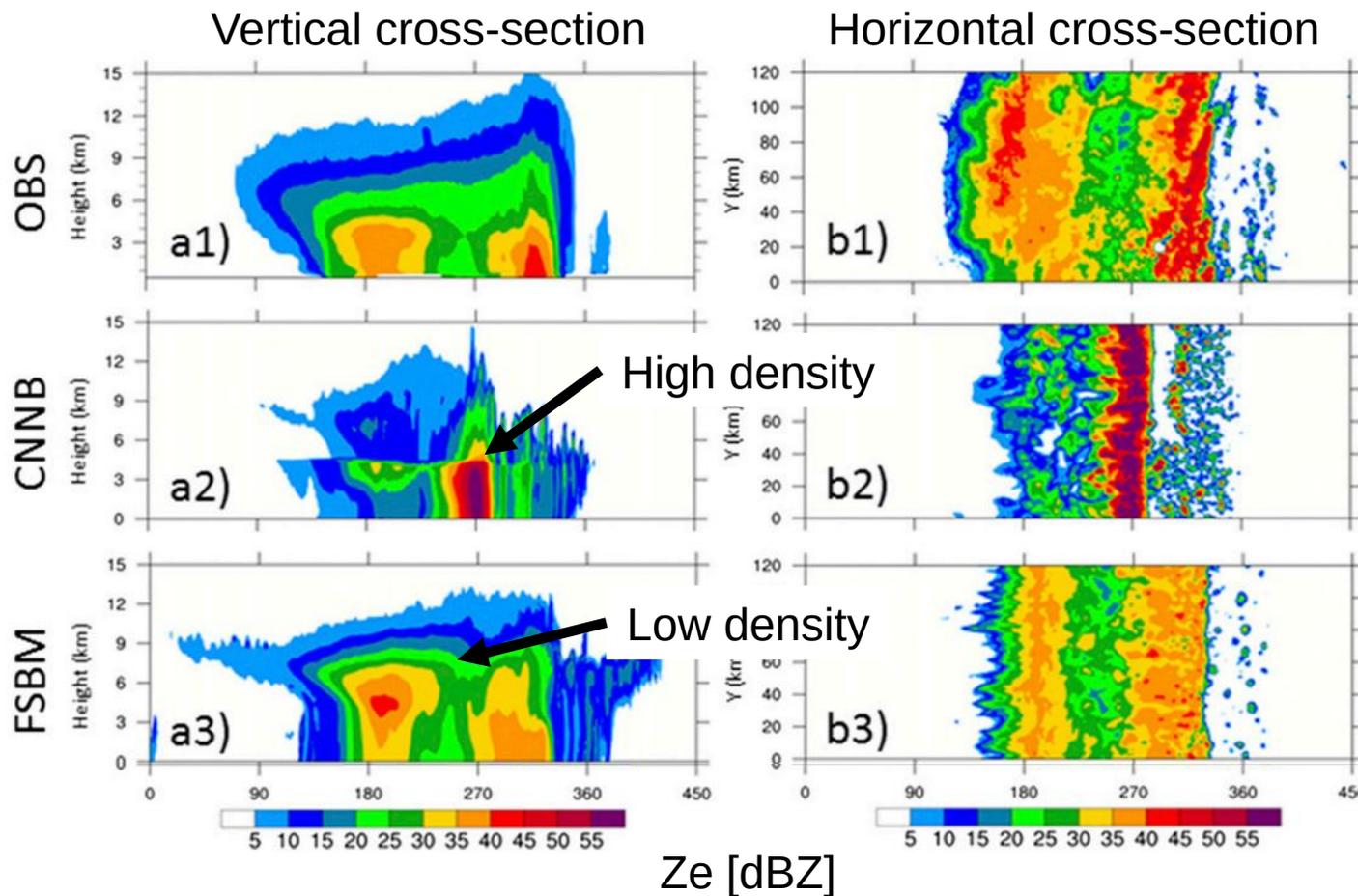
Scientific objective:

- 1) Observe how **convective and stratiform regions** evolve over time
→ horizontal statistics (Obs. vs WRF)

Motivation



Research Gap
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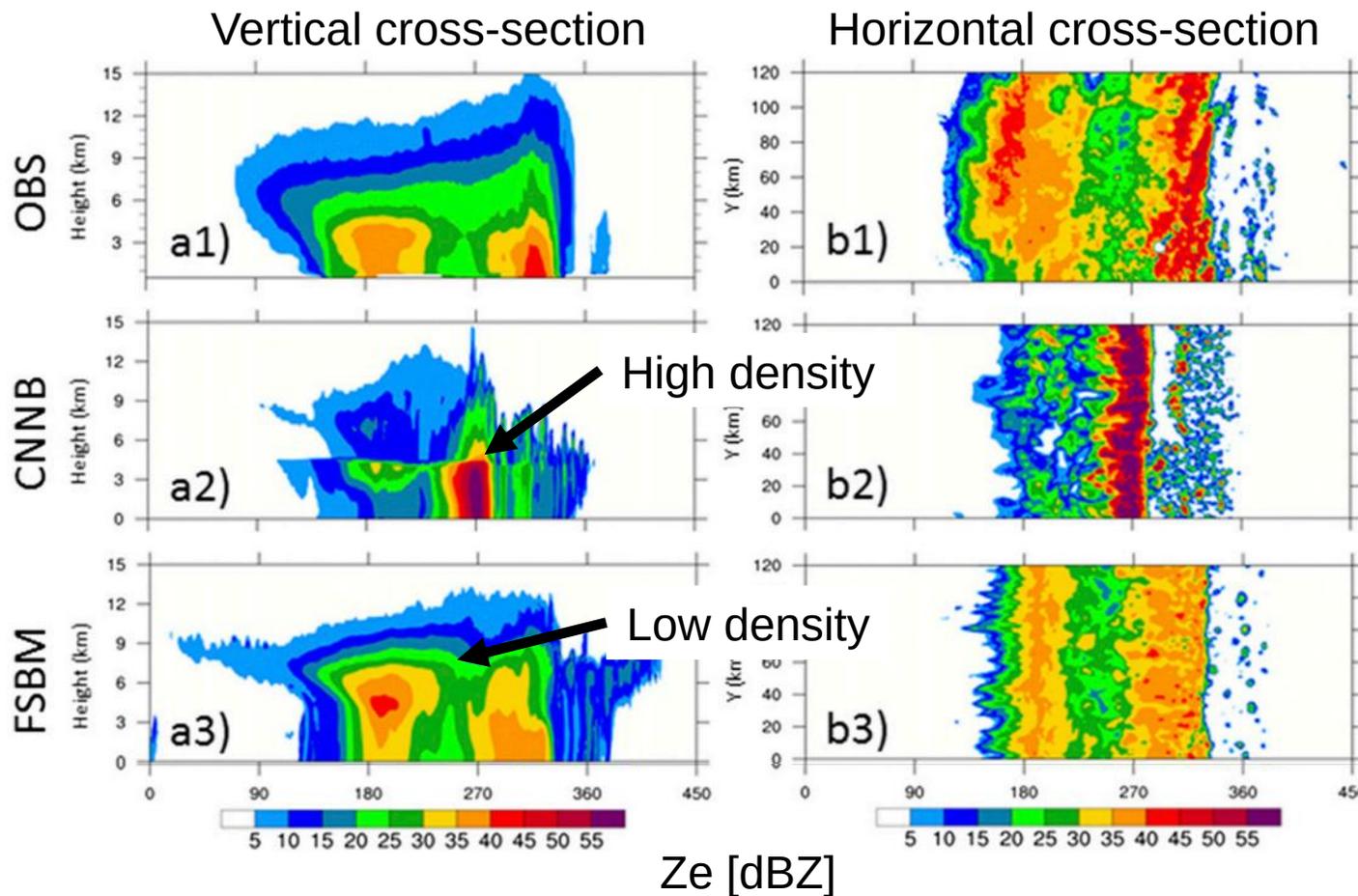
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- 2) Retrieve **ice particle shape and density** from DWR + ZDR and LDR + VEL
→ vertical statistics of cloud microphysics

Motivation

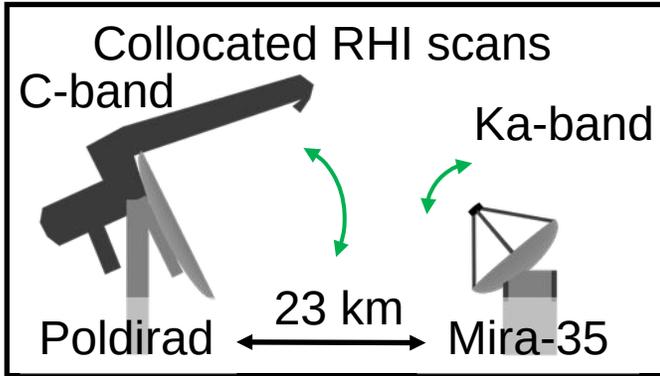


Research Gap
What role do ice particle properties play in the partitioning in convective and stratiform regions?



- Scientific objective:**
- 1) Observe how **convective and stratiform regions** evolve over time
→ horizontal statistics (Obs. vs WRF)
 - 2) Retrieve **ice particle shape and density** from DWR + ZDR and LDR + VEL
→ vertical statistics of cloud microphysics
 - 3) Are **models right for of the right reasons?**
→ connect microphysical profiles with horizontal context

IcePolCKa phase 1: Microphysical retrieval

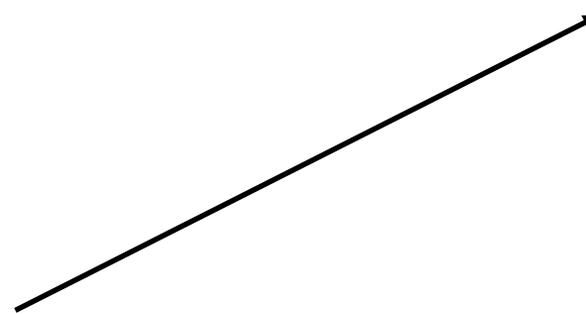


T-Matrix scattering calculations

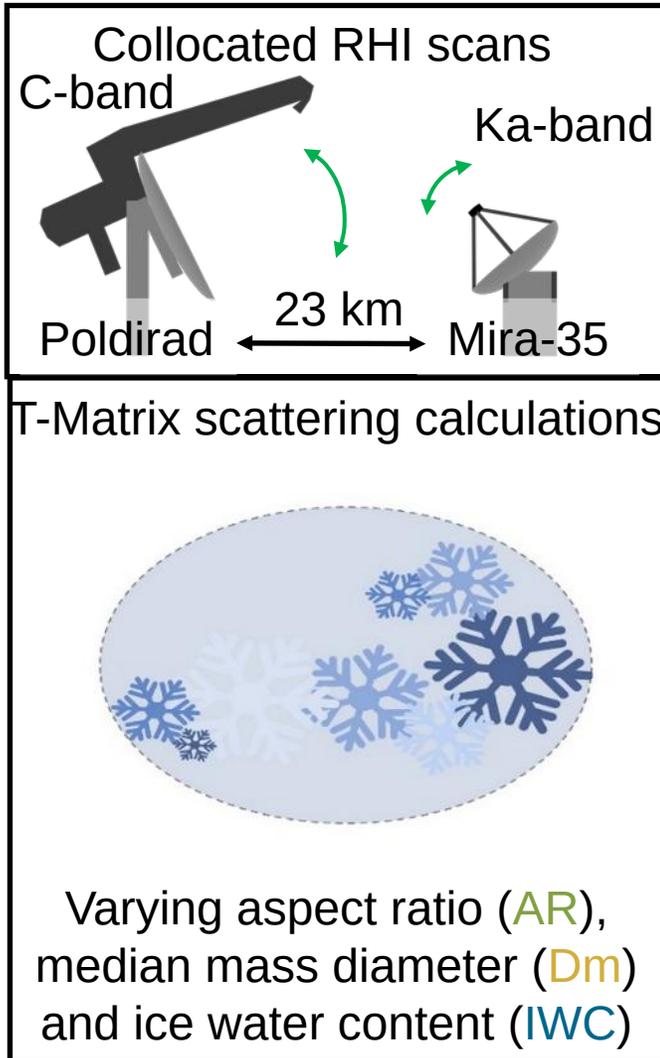


Varying aspect ratio (**AR**),
median mass diameter (**Dm**)
and ice water content (**IWC**)

Retrieval
Ze, **DWR**, **ZDR** -> **IWC**, **Dm**, **AR**



IcePolCKa phase 1: Microphysical retrieval

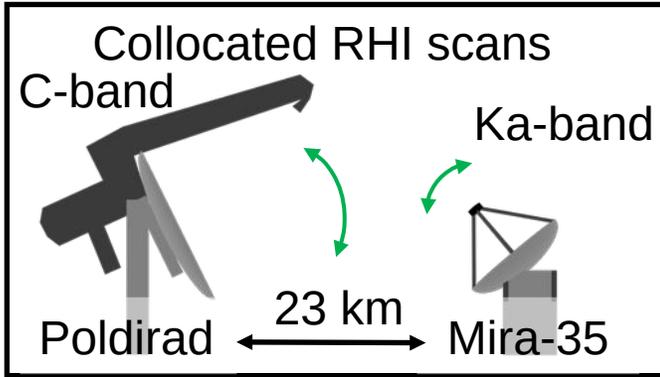


Retrieval
Ze, DWR, ZDR -> **IWC, Dm, AR**

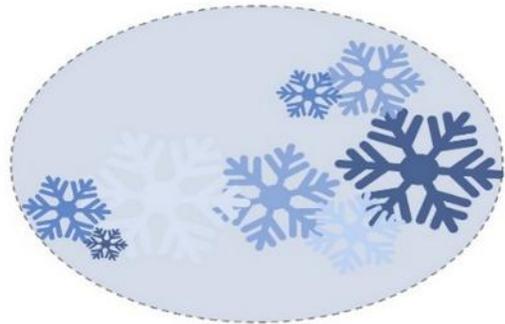
Limitations:

1. Soft Spheroid
↓
oblates ⇔ horizontally aligned prolates
2. Mass-Size-Relationship
↓ ↓
Limited to one kind of particle No sensitivity towards riming
3. T-Matrix
↓
Polarimetry of complex particles

IcePolCKa phase 1: Microphysical retrieval



T-Matrix scattering calculations



Varying aspect ratio (AR),
median mass diameter (Dm)
and ice water content (IWC)

Retrieval
Ze, DWR, ZDR -> IWC, Dm, AR

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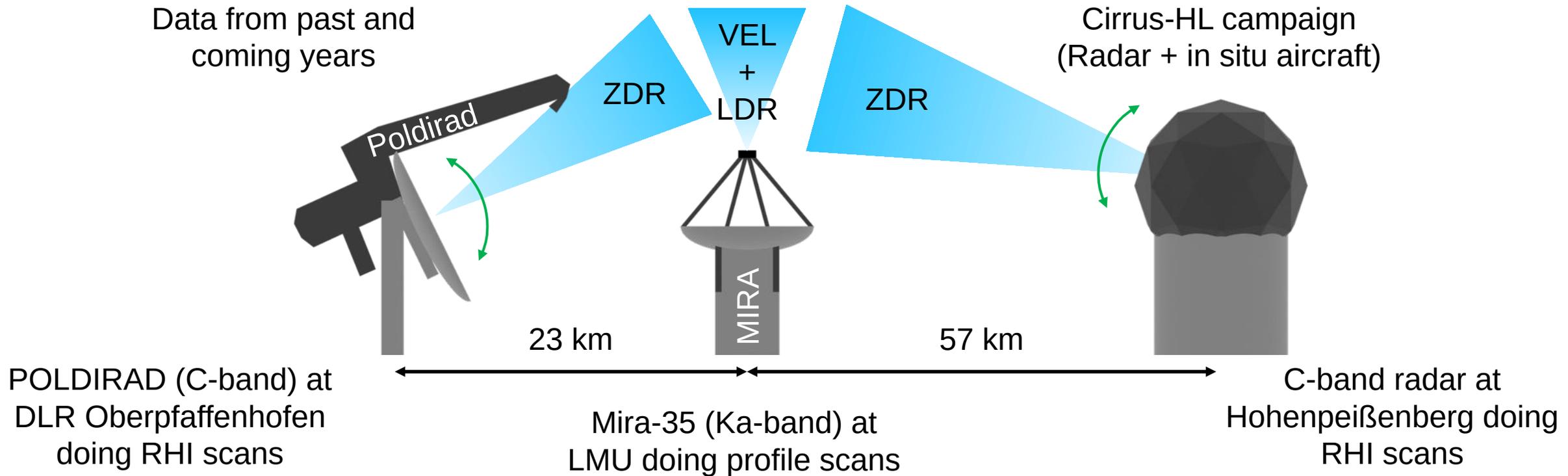
Resolution approaches for phase 2:

Introduction of vertically pointing LDR measurements

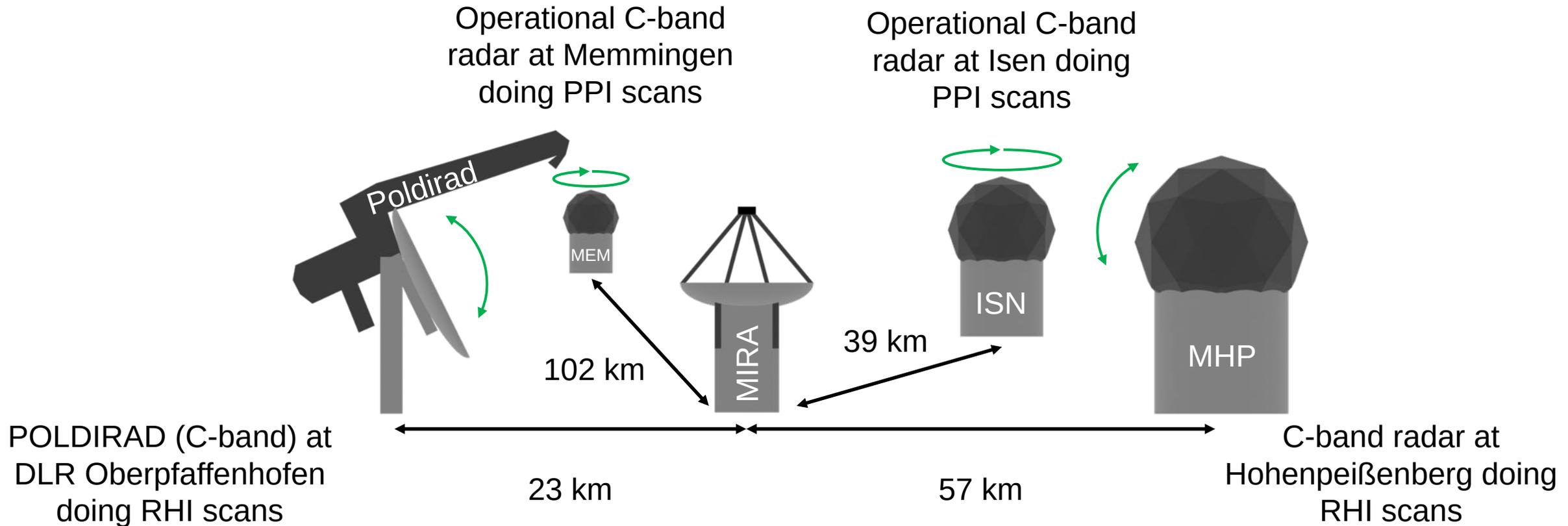
Introduction of the p3-model and VEL simulations + measurements

Discrete Dipole Approximation

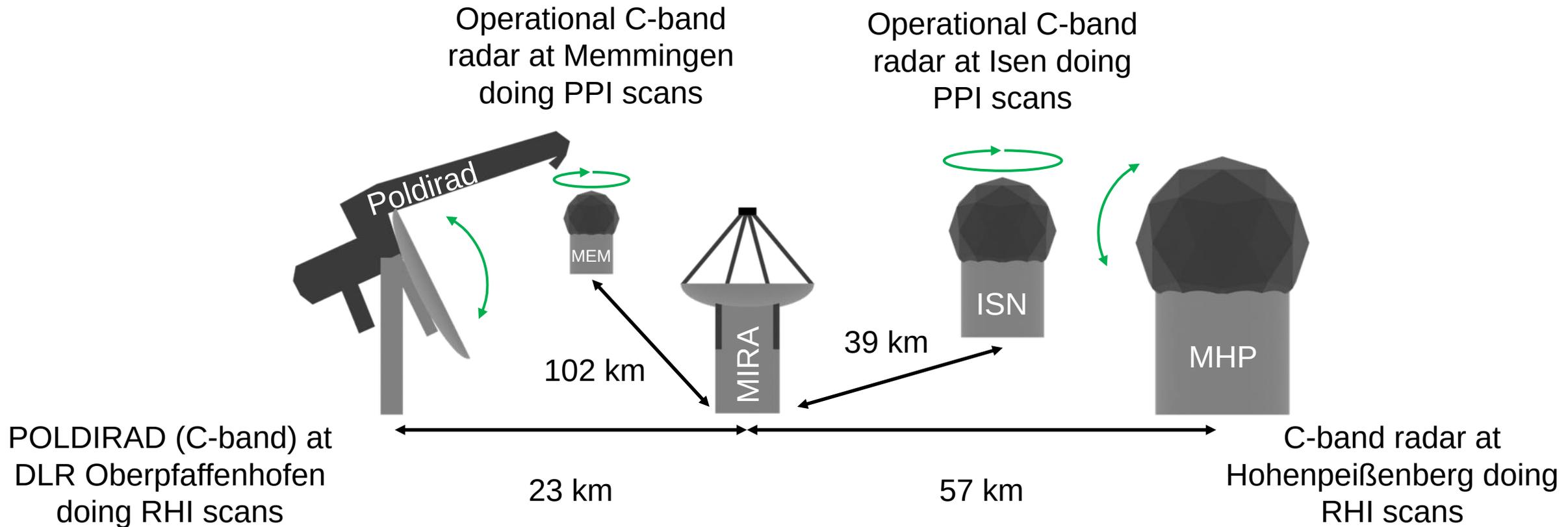
Phase 2: Towards operational application



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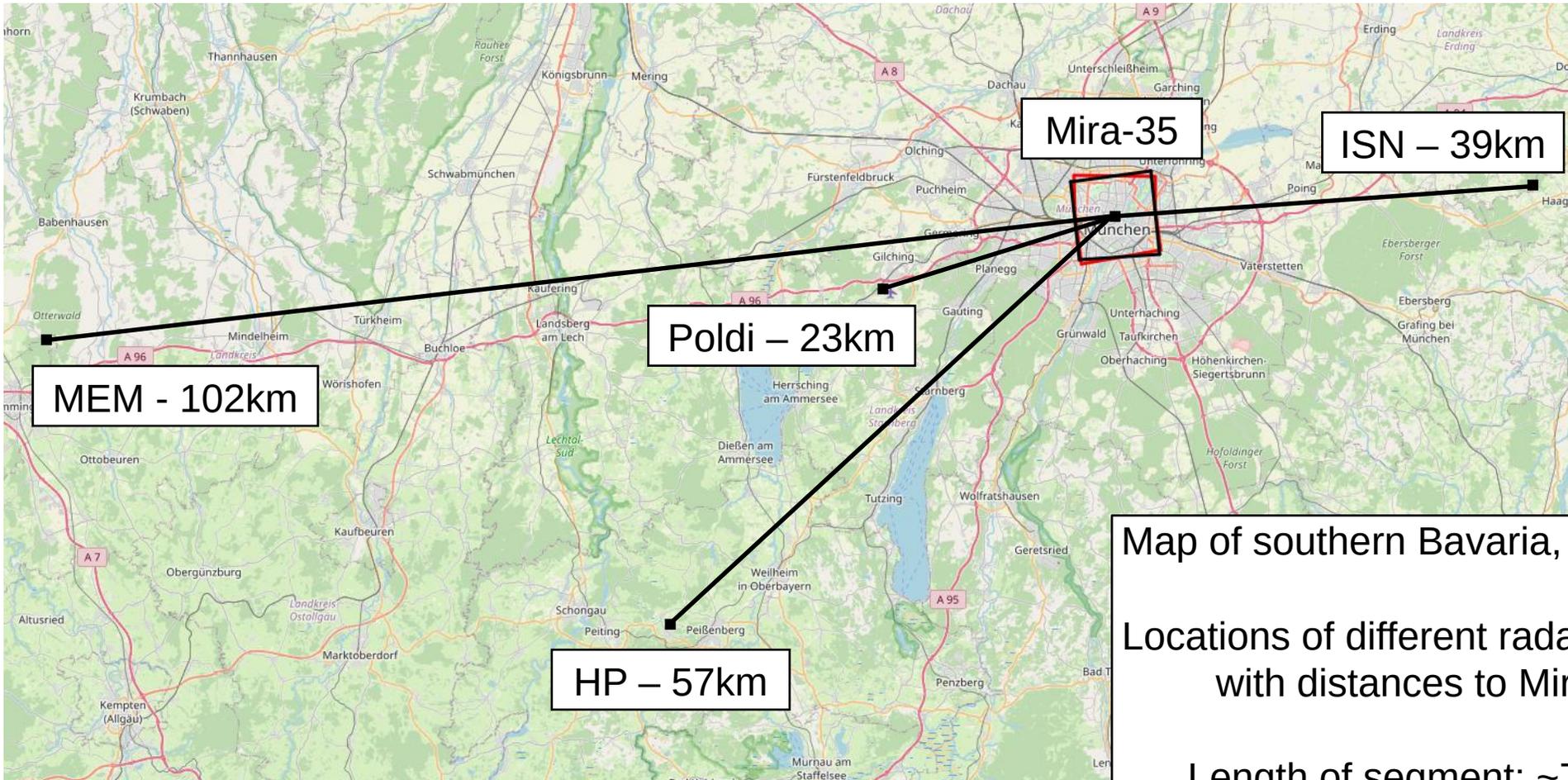
Phase 2: Towards operational application



Profile scans + RHIs + PPIs -> how to combine for good comparison and usability in future retrieval?

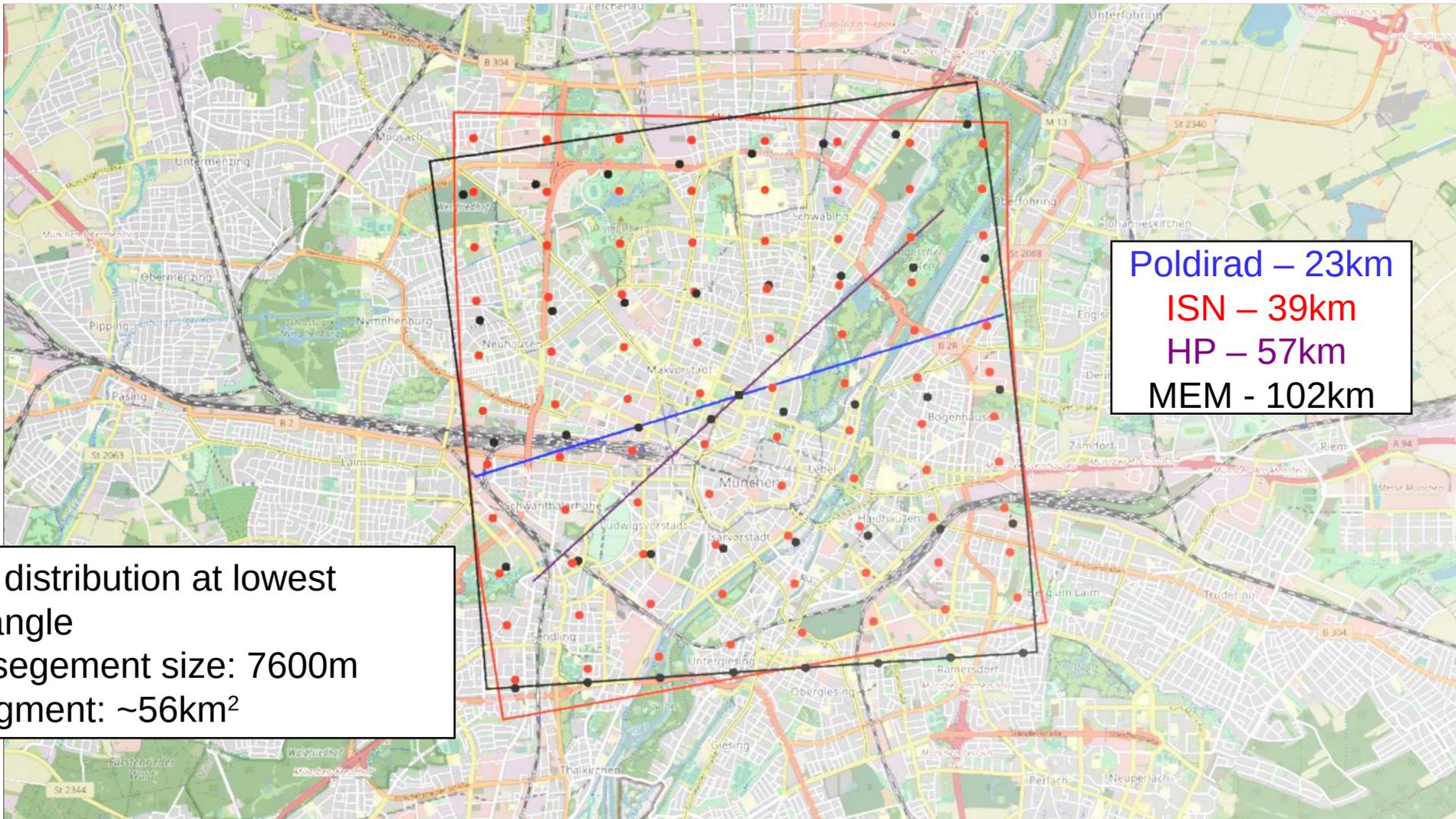
BA-CVPs for operational radars

Phase 2: Towards operational application



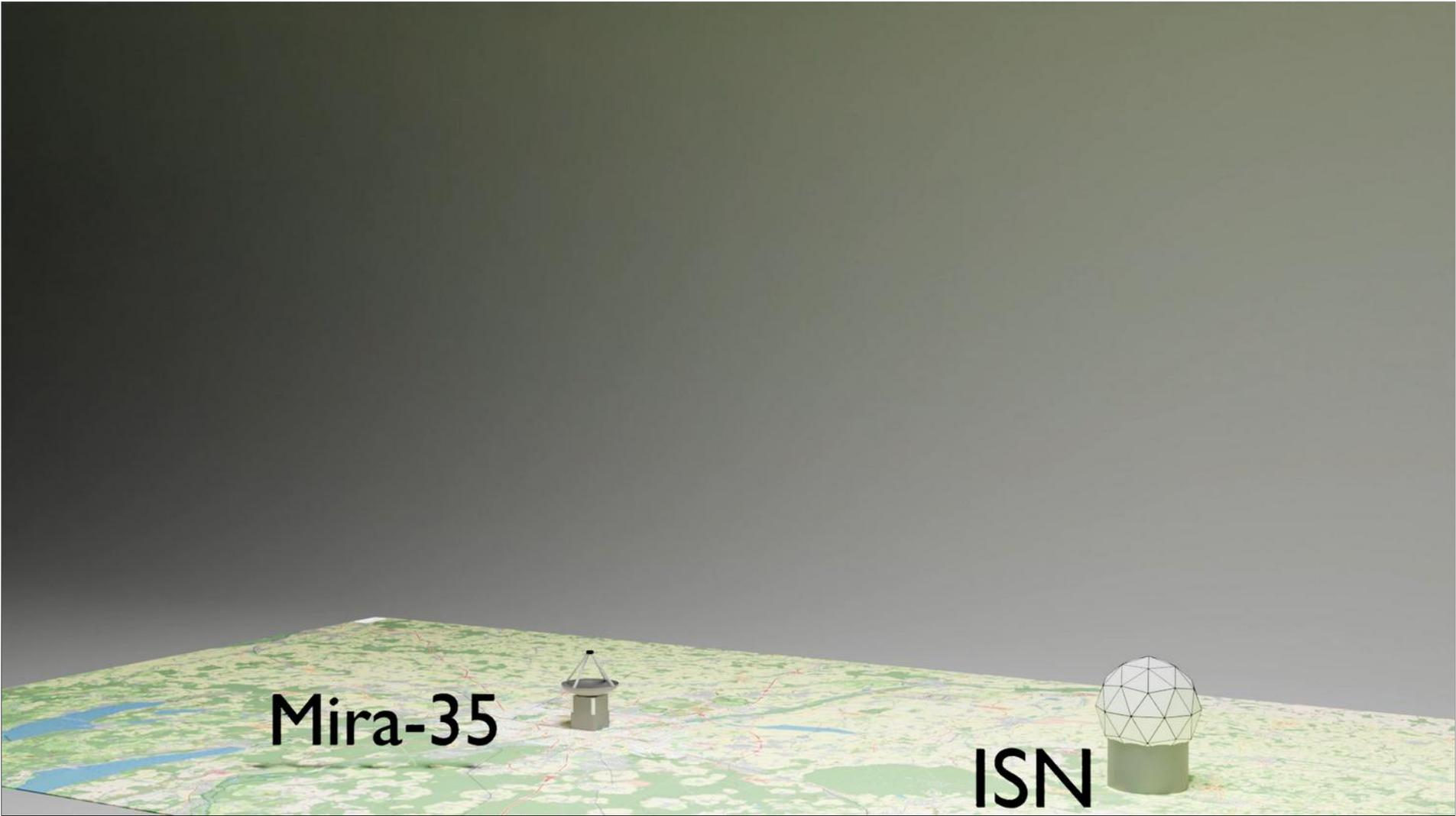
Map of southern Bavaria, Germany
Locations of different radar systems with distances to Mira-35
Length of segment: ~7600m
Area of segment: ~58km²

Phase 2: Towards operational application

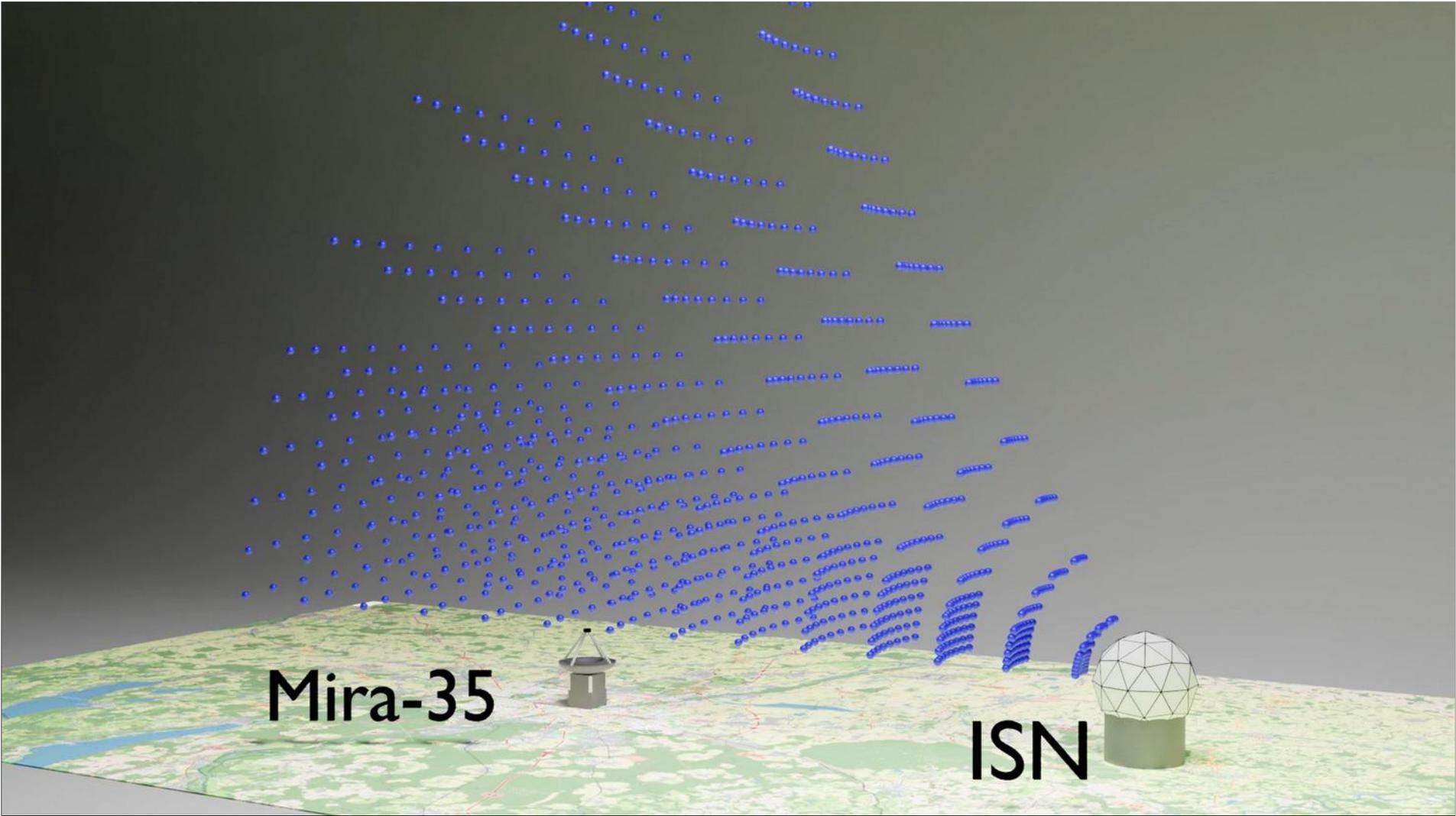


Data point distribution at lowest elevation angle
Length of segment size: 7600m
Area of segment: ~56km²

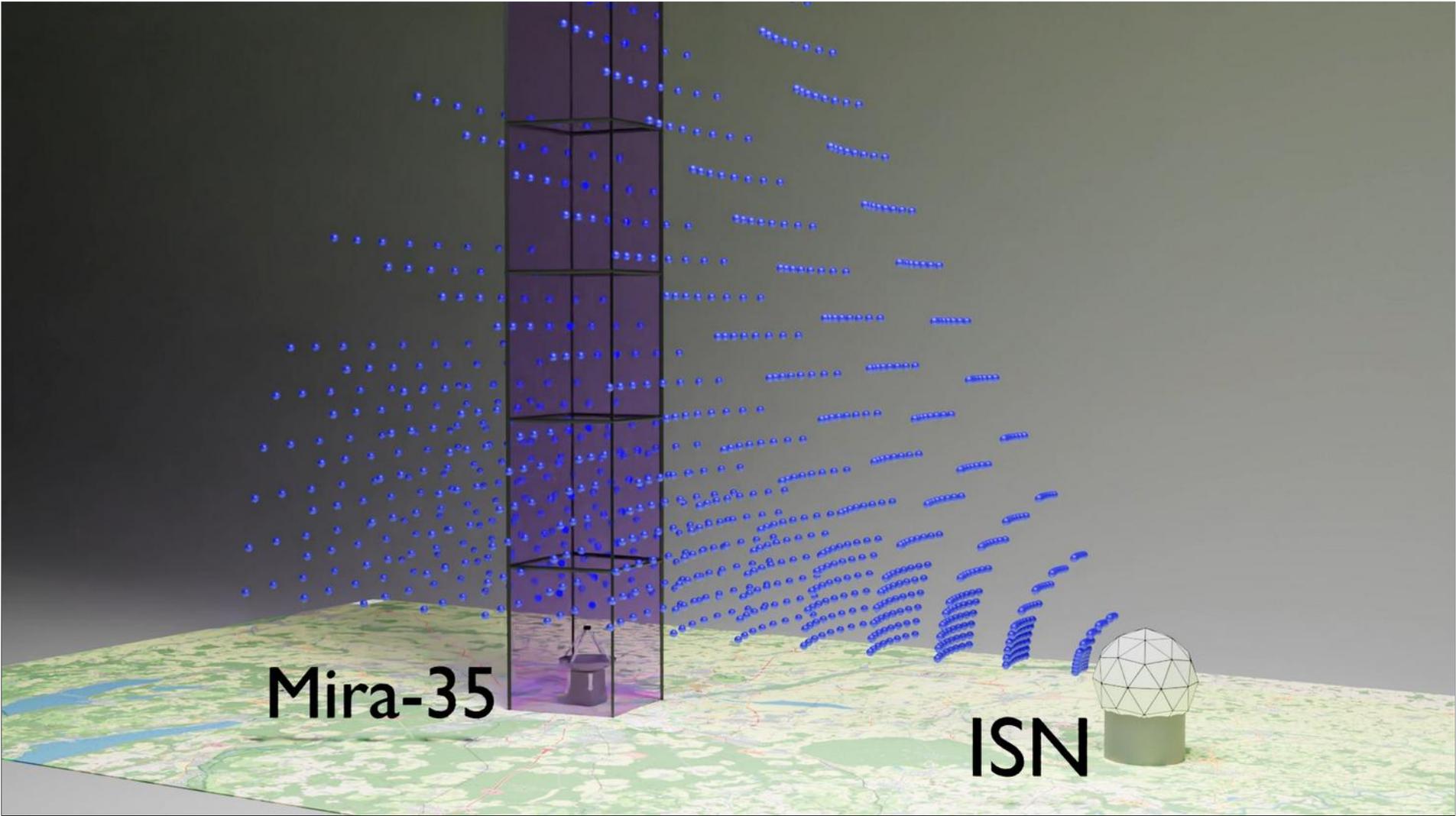
Phase 2: Towards operational application – BA-CVPs



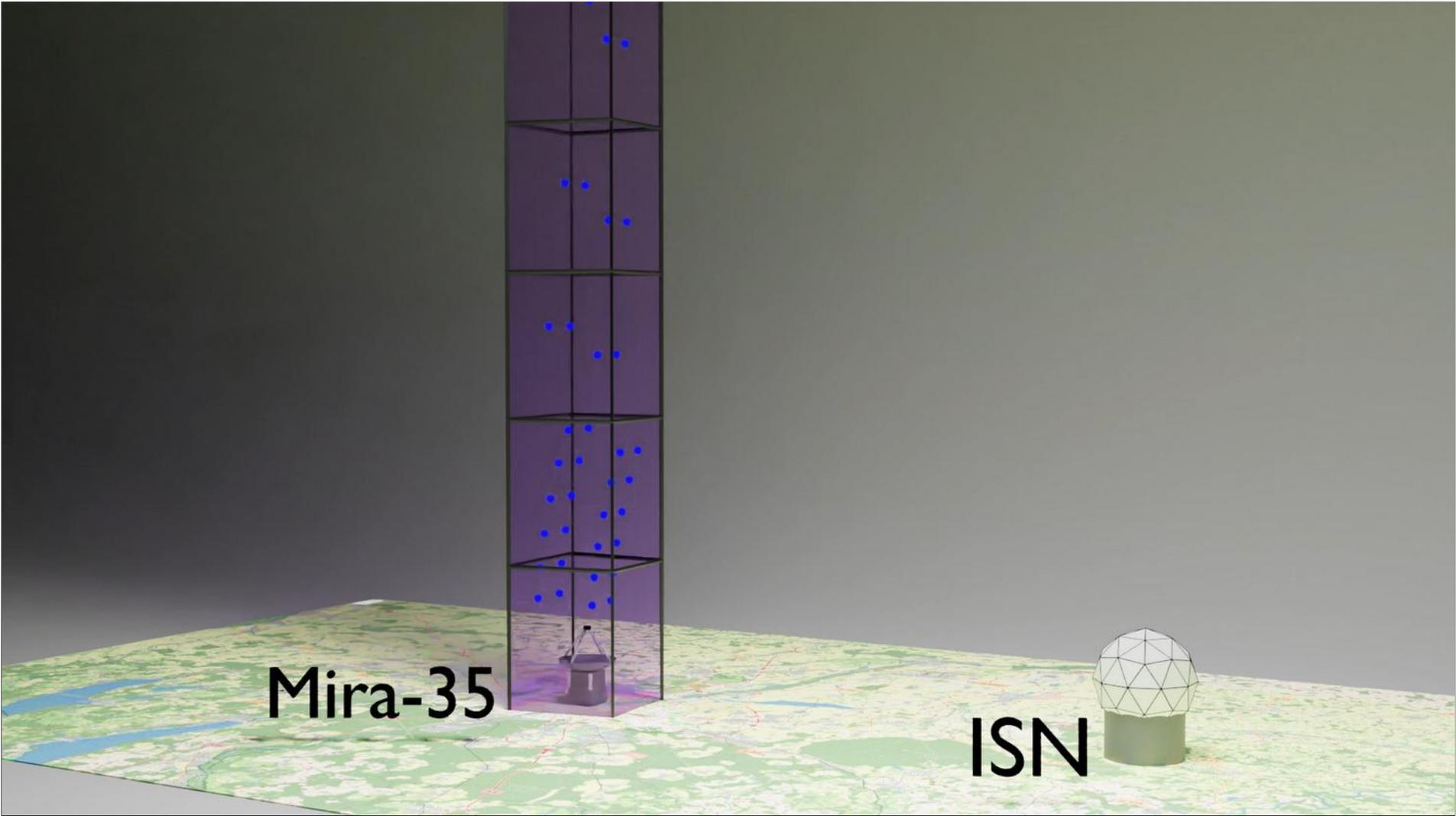
Phase 2: Towards operational application – BA-CVPs



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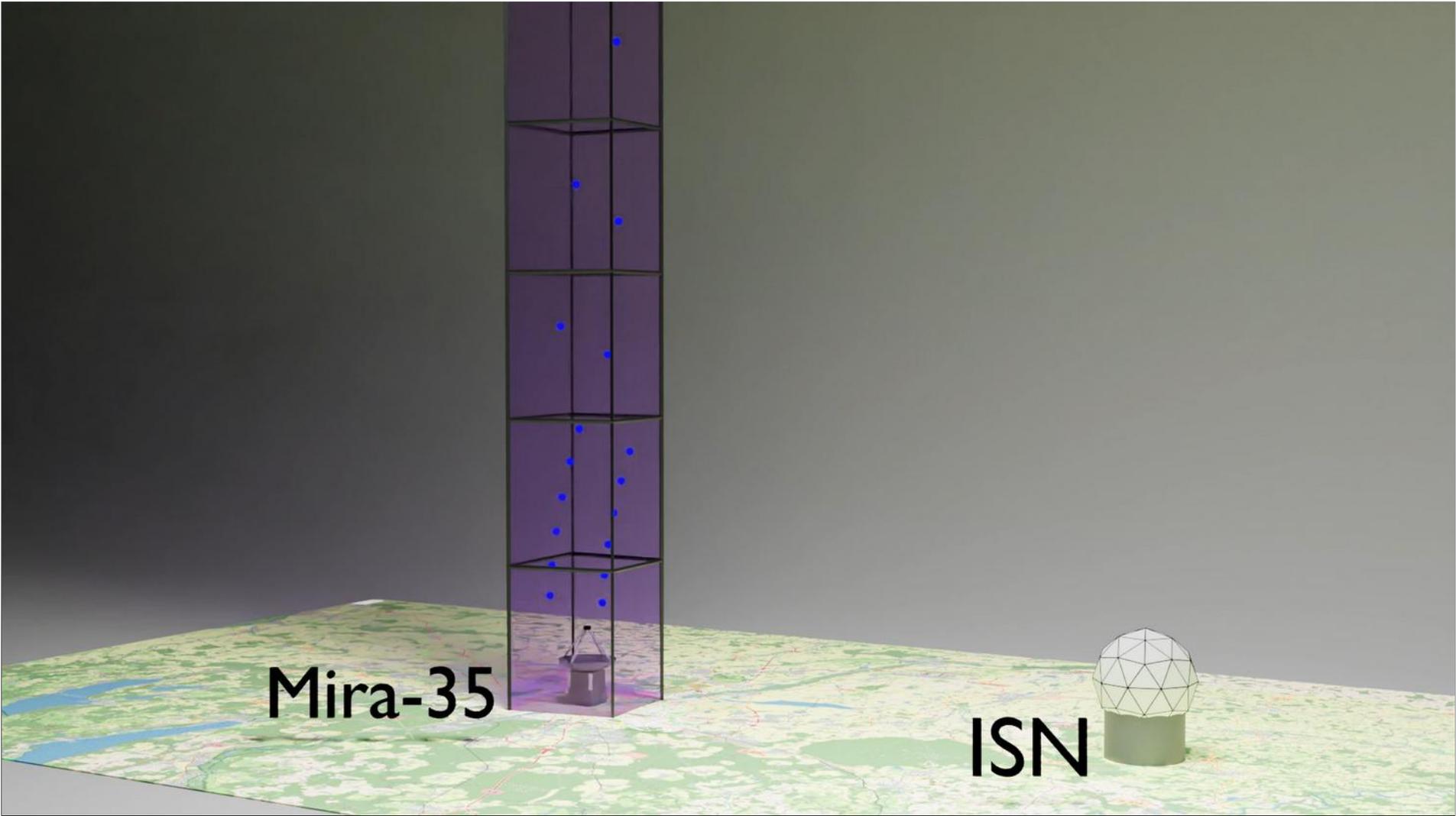
Phase 2: Towards operational application – BA-CVPs



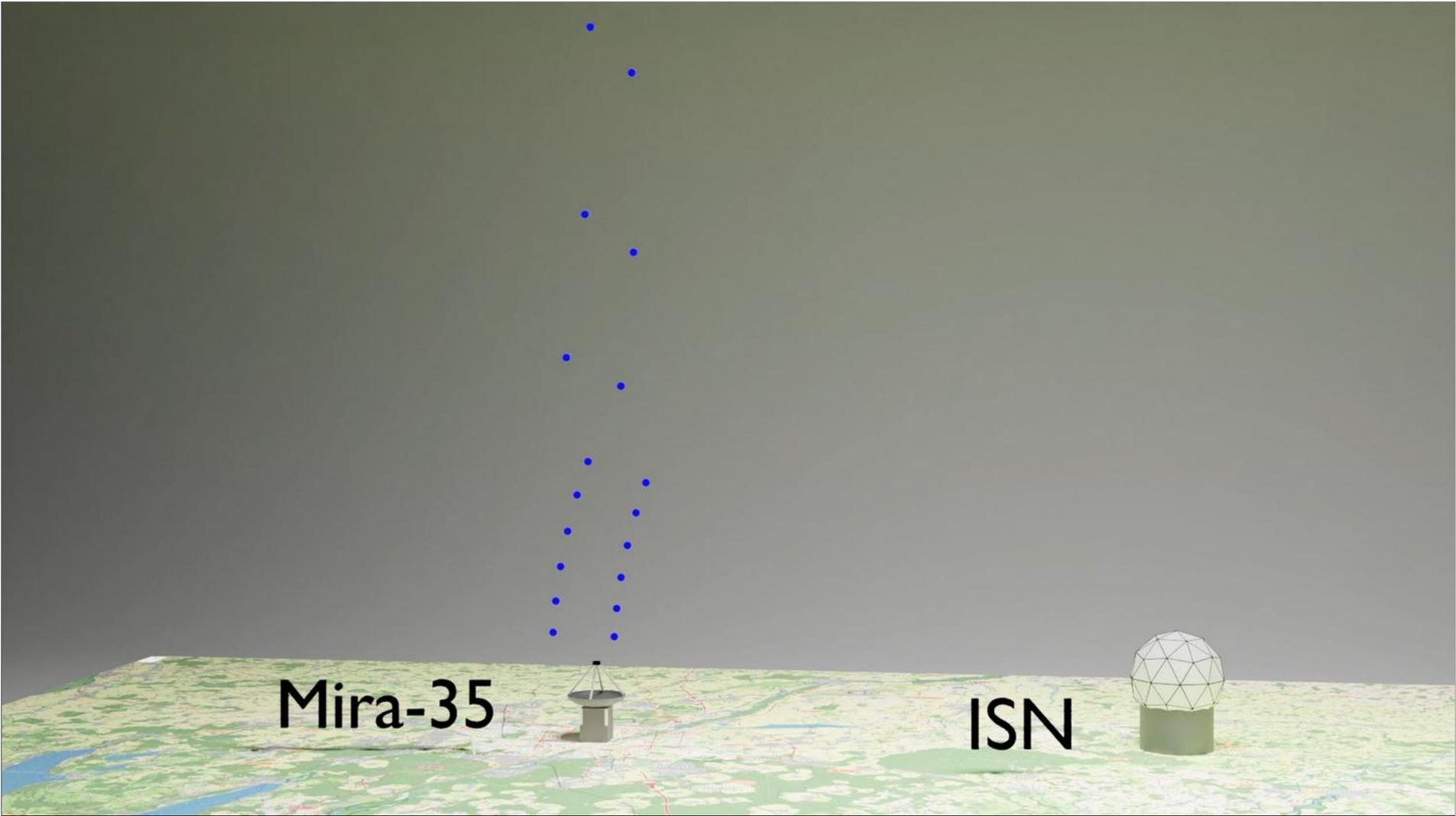
Mira-35

ISN

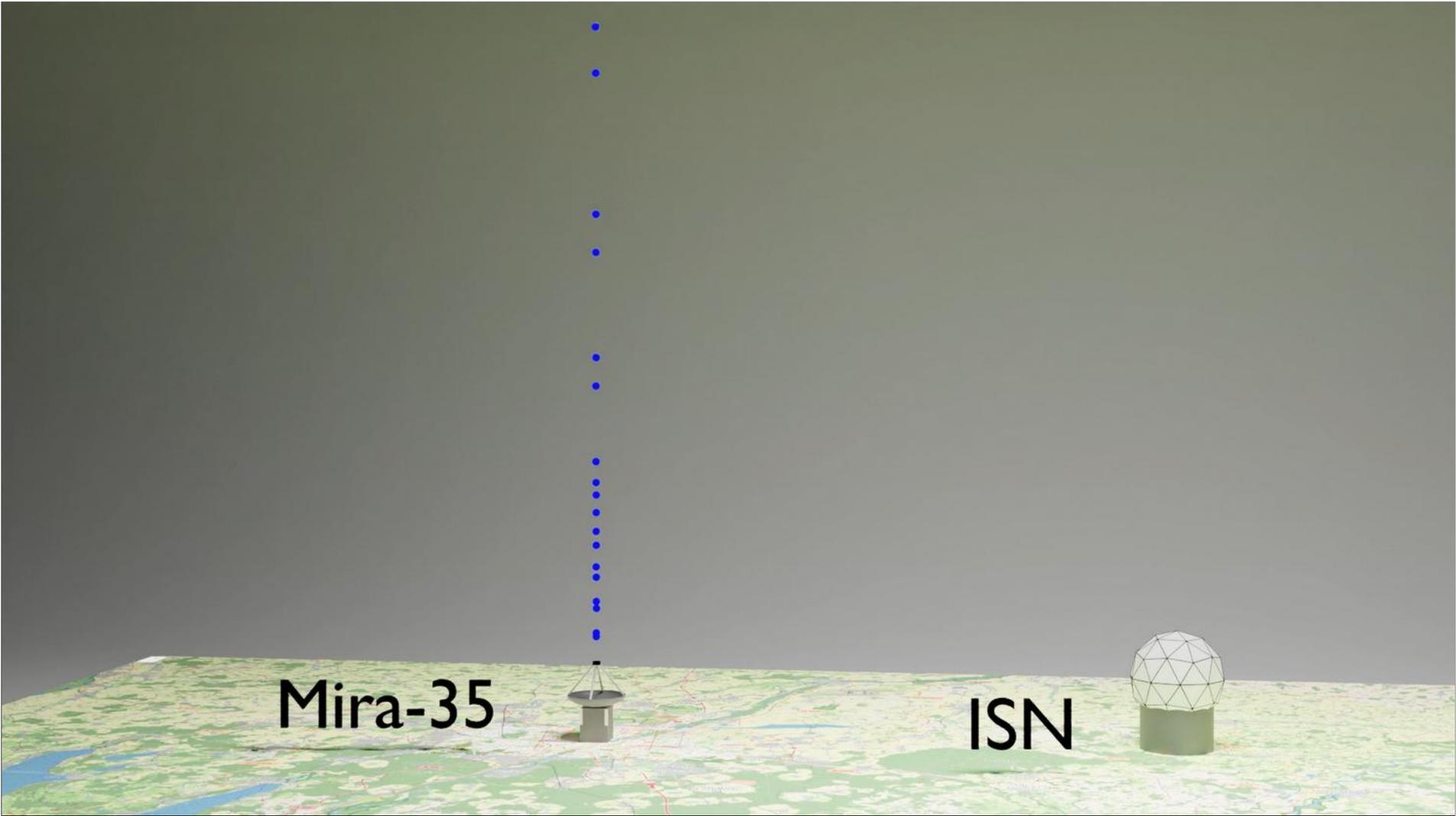
Phase 2: Towards operational application – BA-CVPs



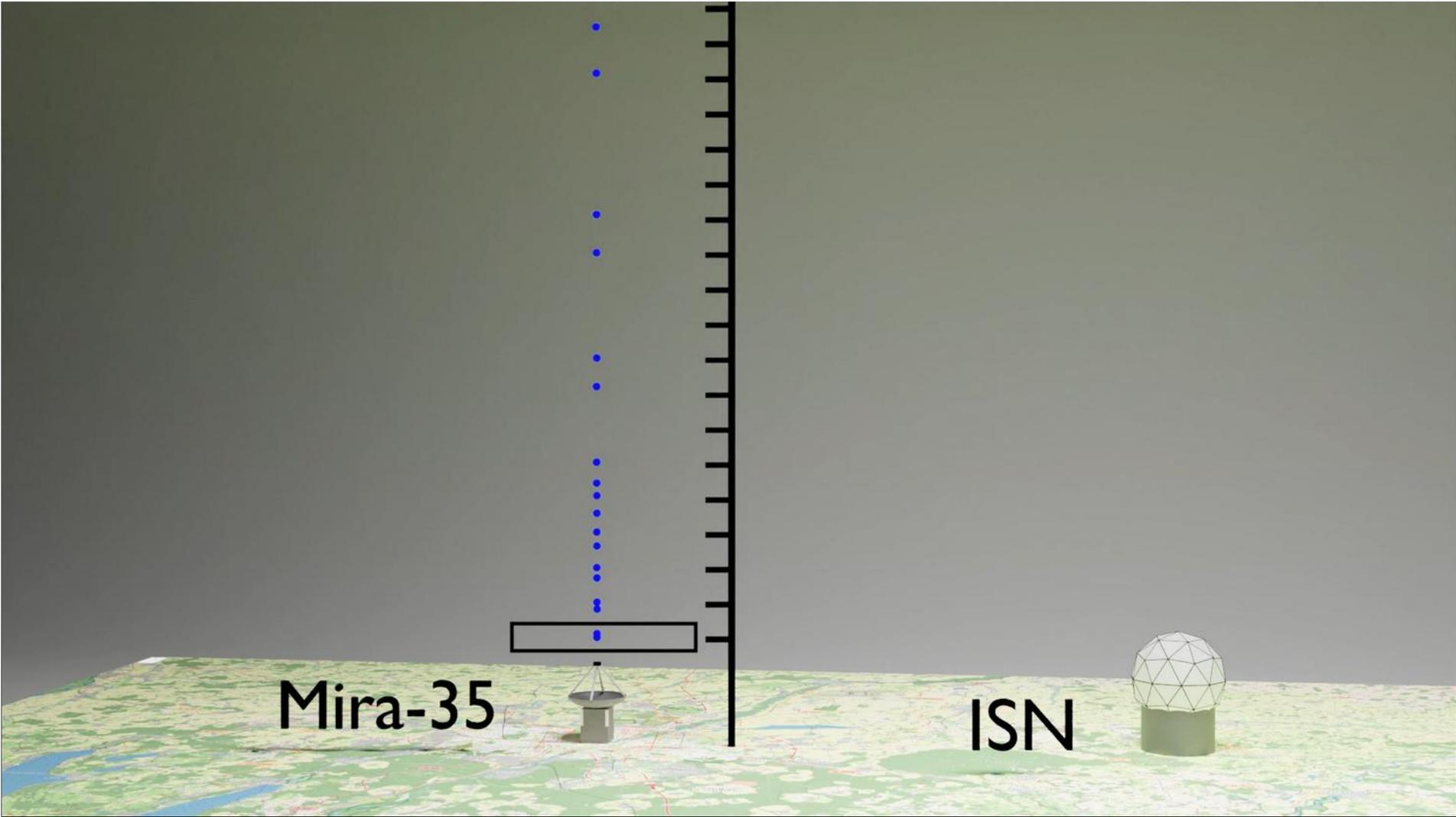
Phase 2: Towards operational application – BA-CVPs



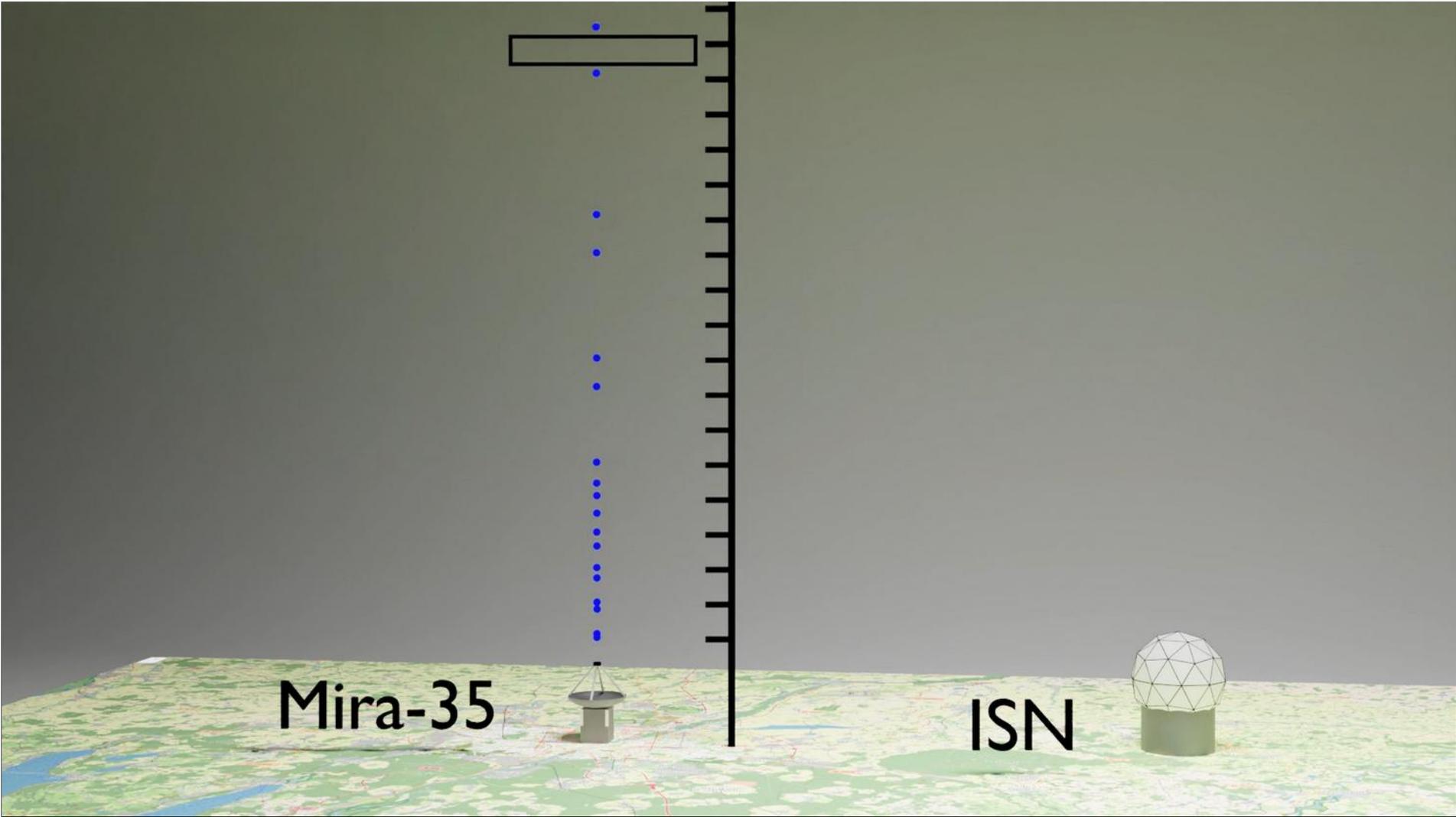
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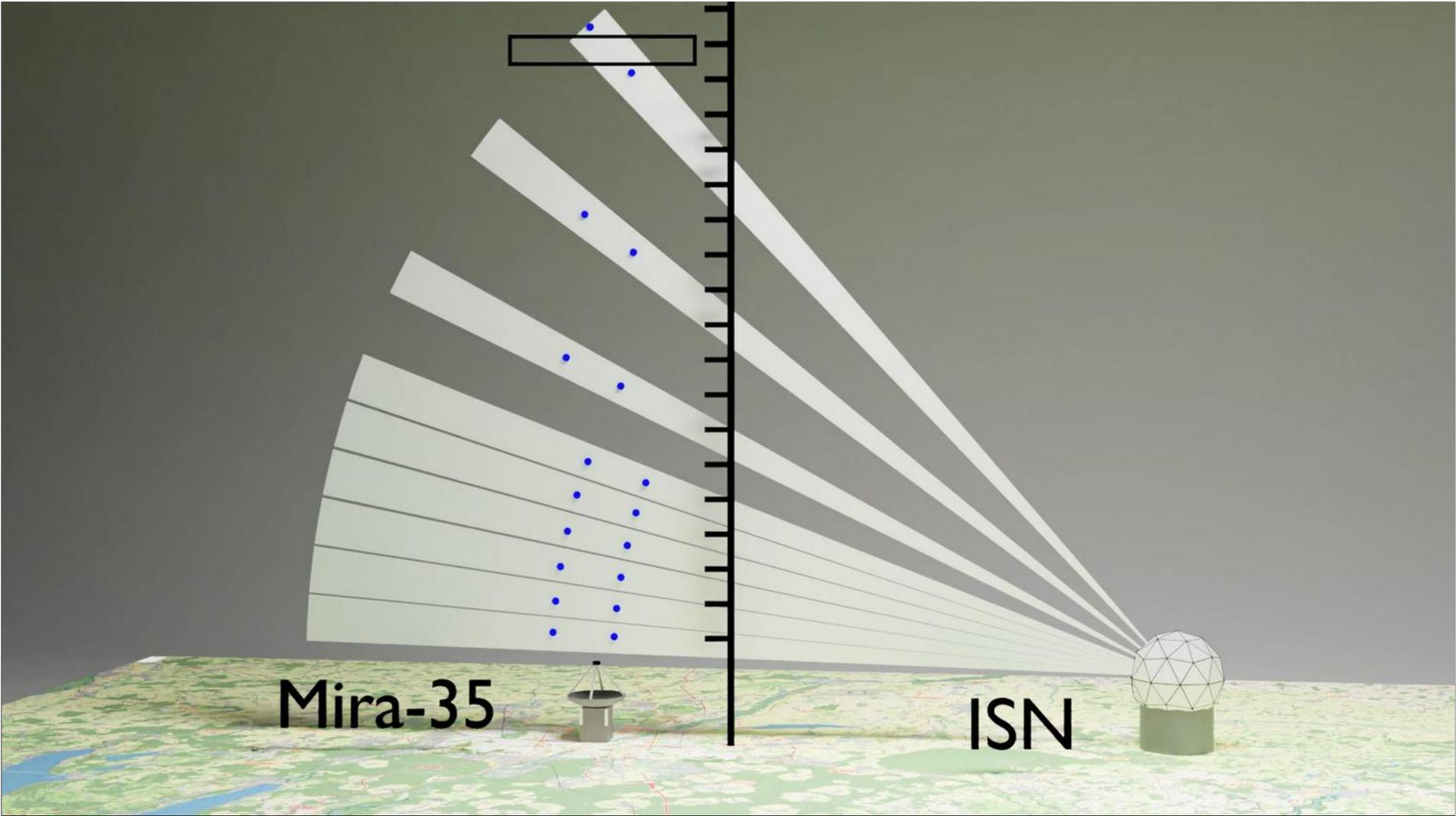
Phase 2: Towards operational application – BA-CVPs



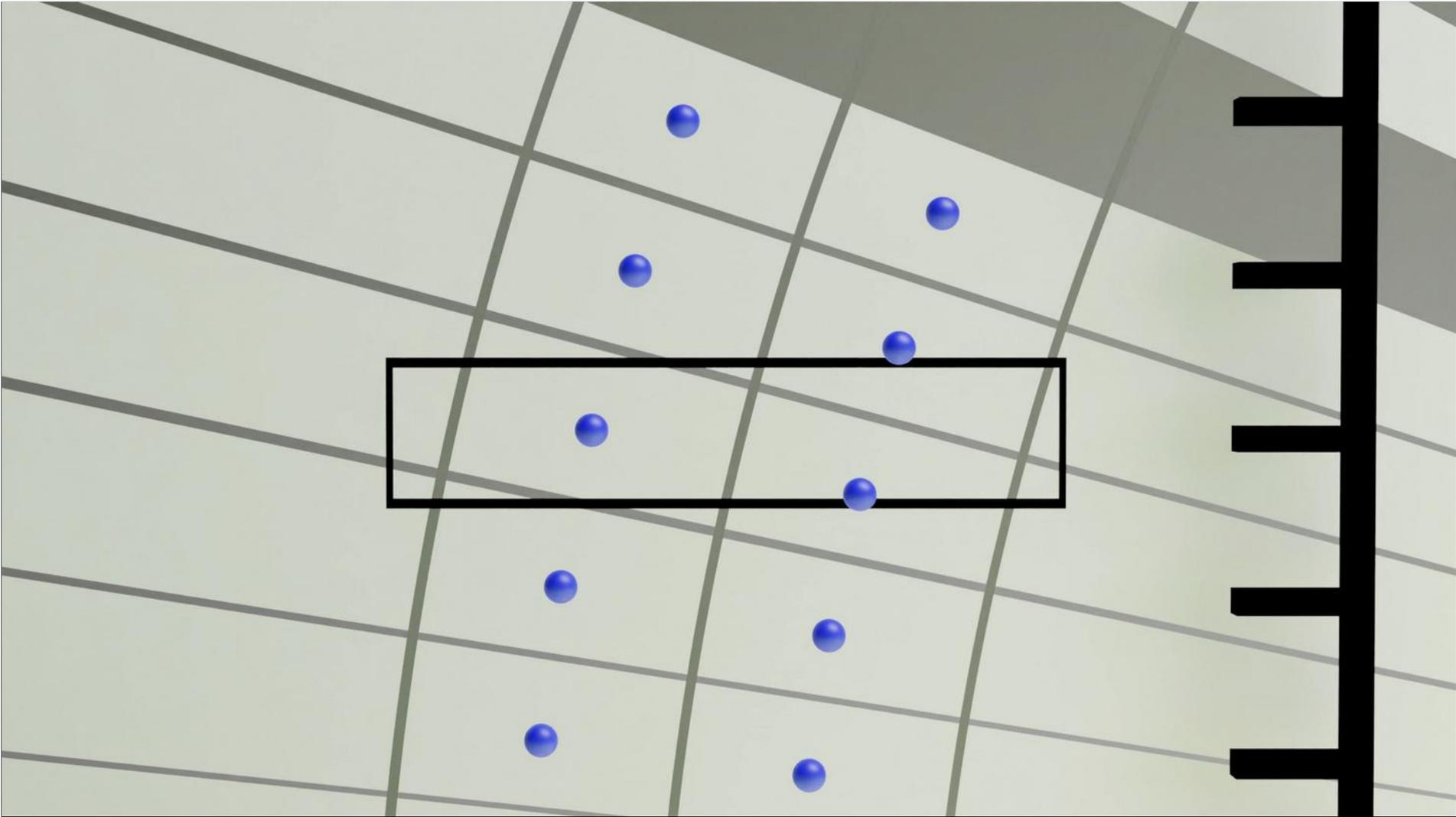
Phase 2: Towards operational application – BA-CVPs



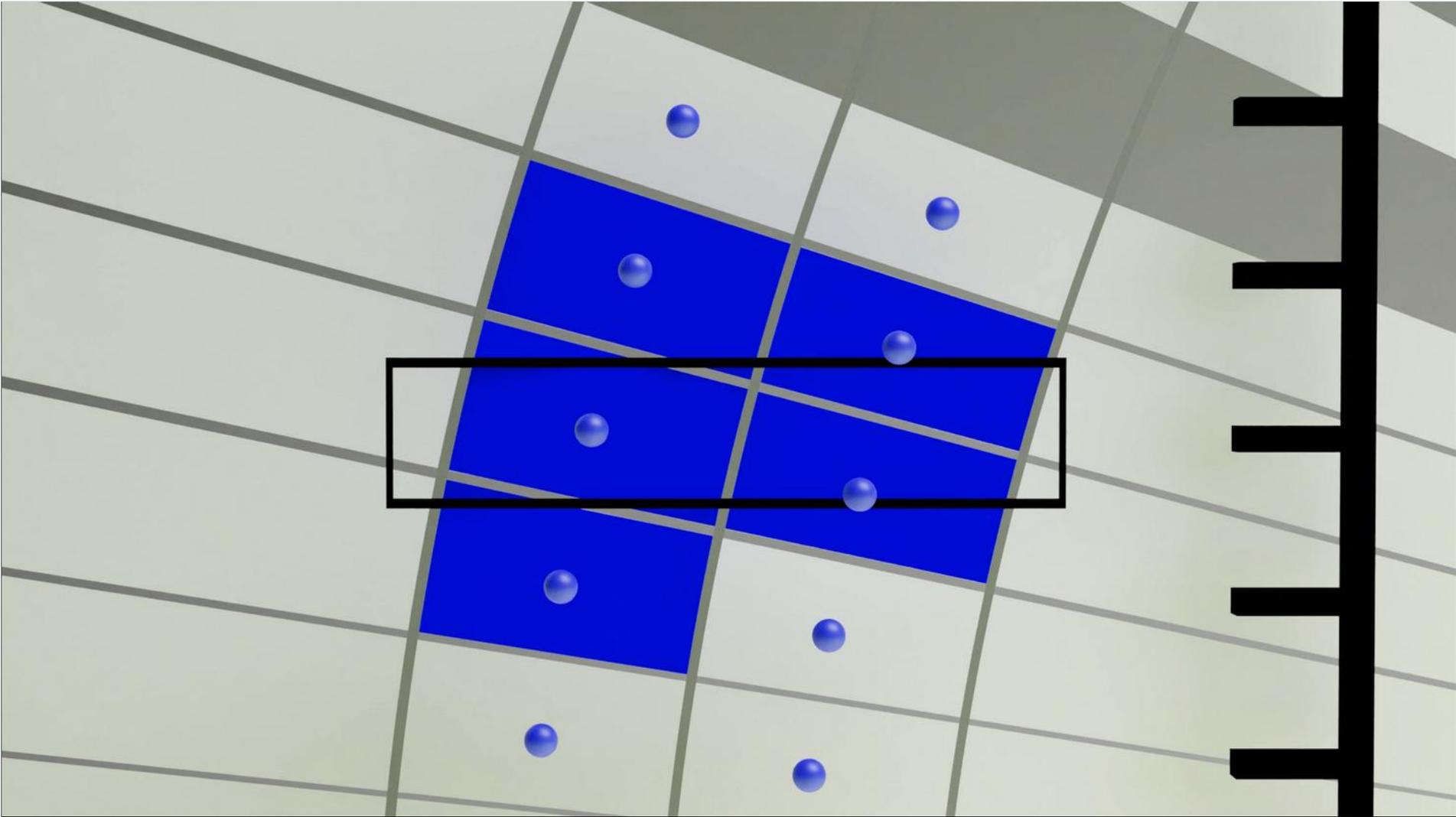
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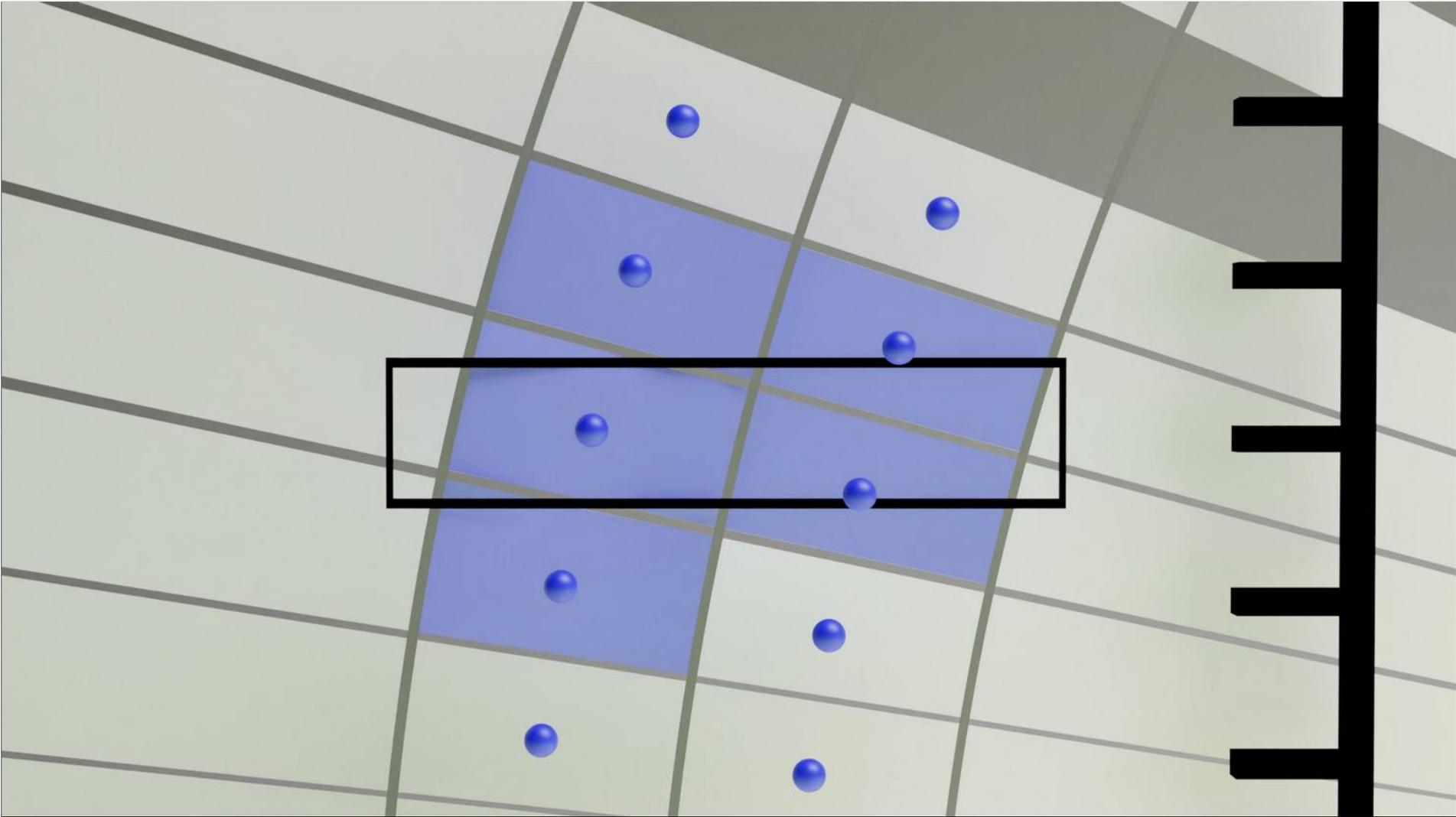
Phase 2: Towards operational application – BA-CVPs



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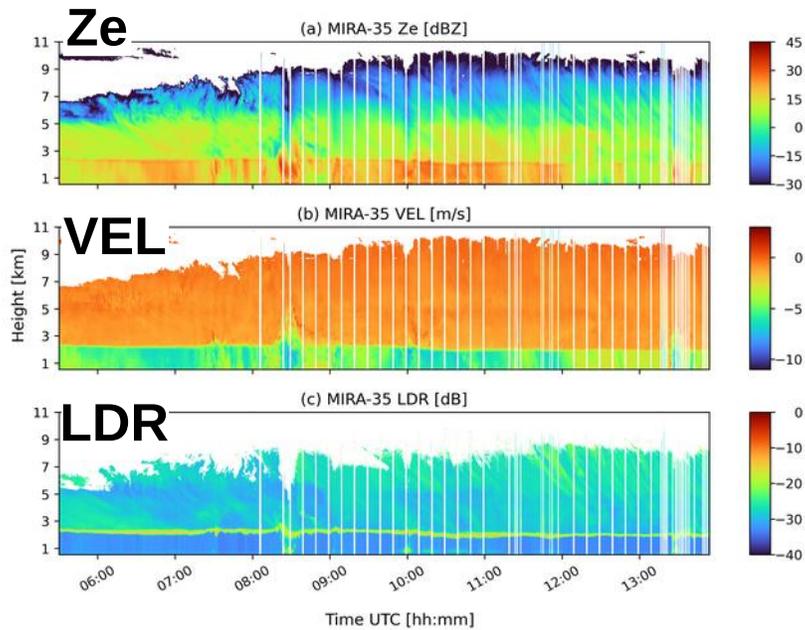
Phase 2: Towards operational application – BA-CVPs



Extracted BA-CVPs: Case study of 28.05.2019



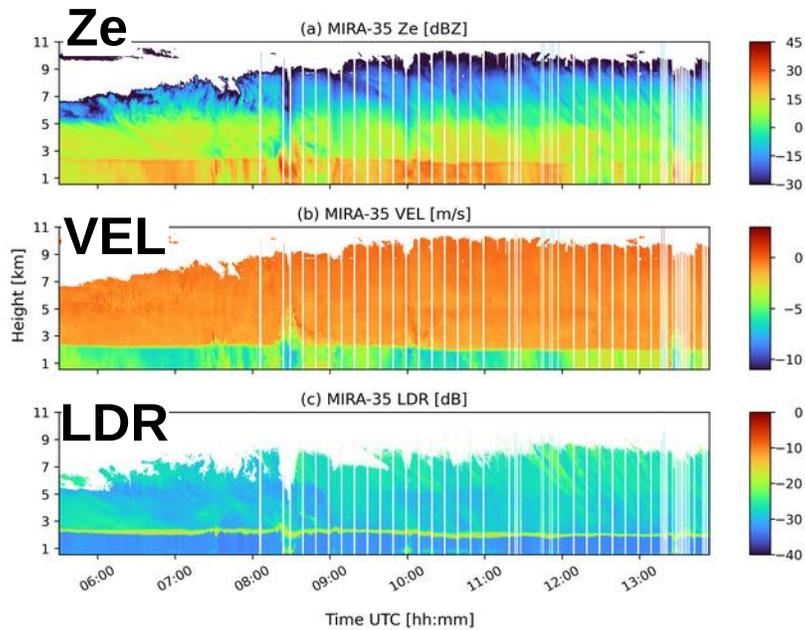
Mira-35



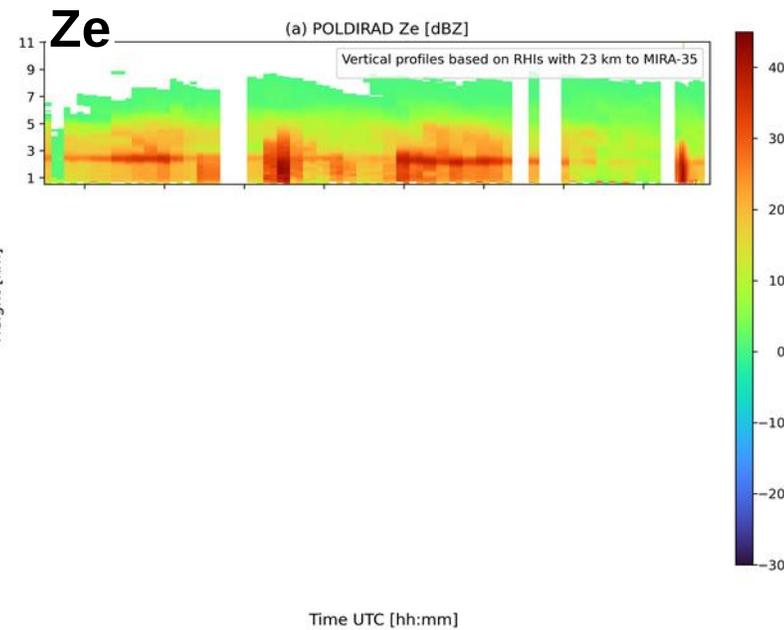
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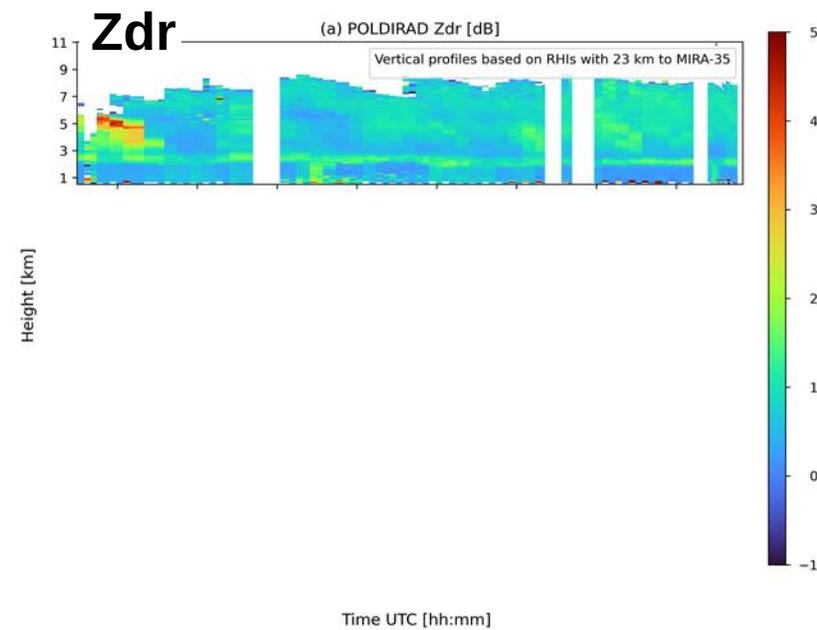
Mira-35



C-band Ze



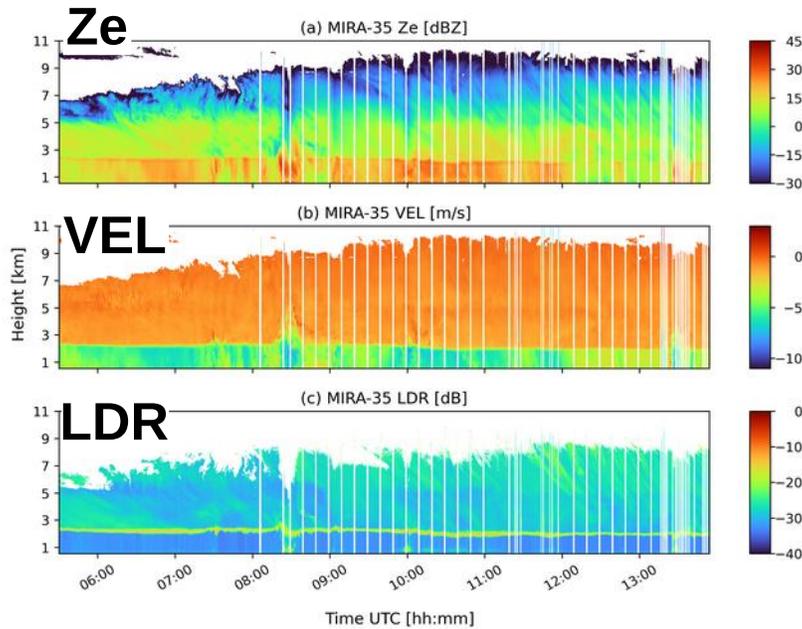
C-band Zdr



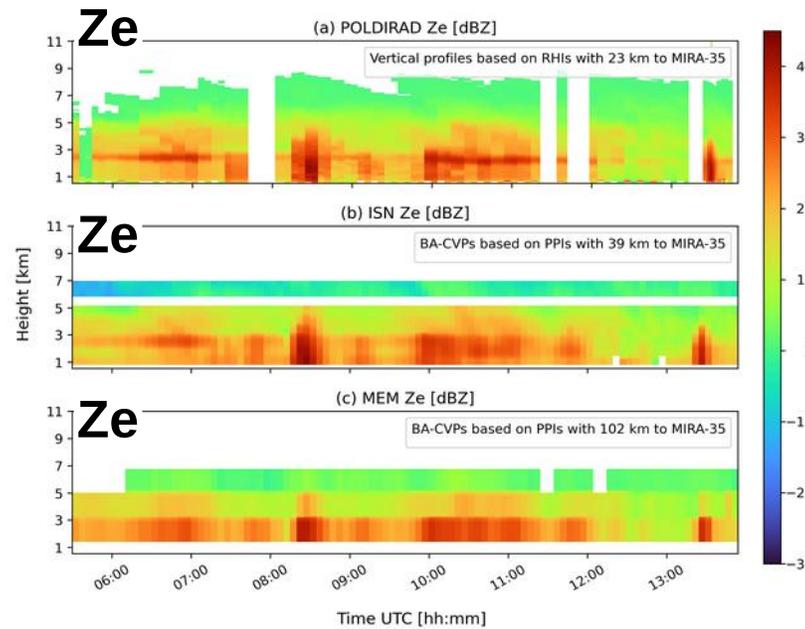
Extracted BA-CVPs: Case study of 28.05.2019



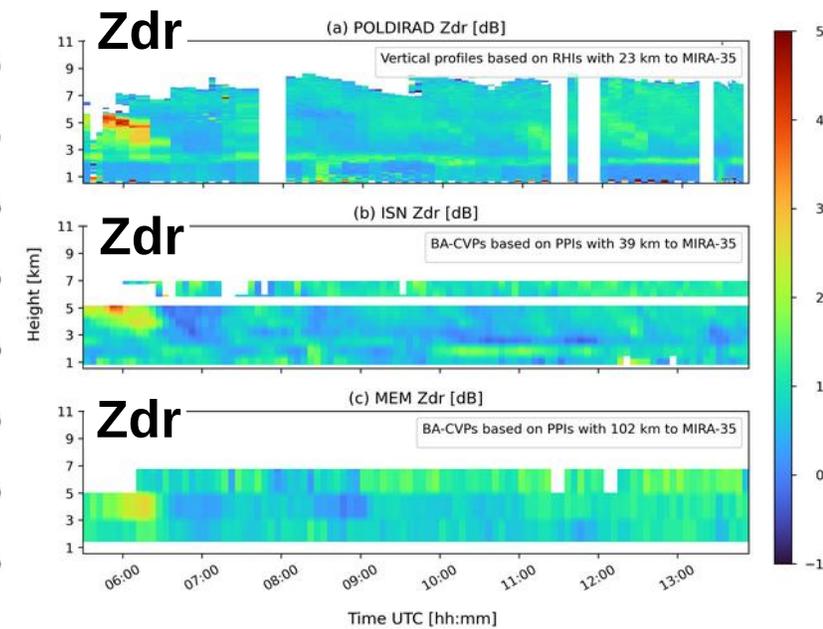
Mira-35



C-band Ze



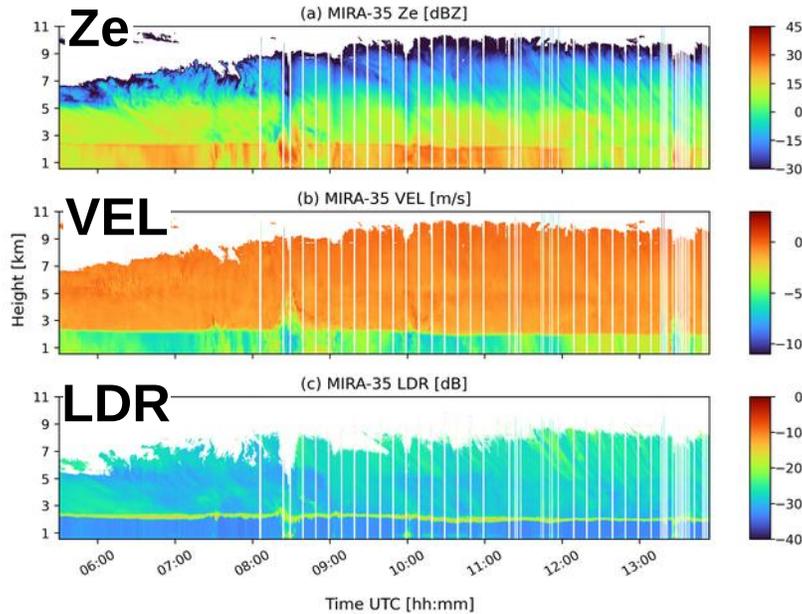
C-band Zdr



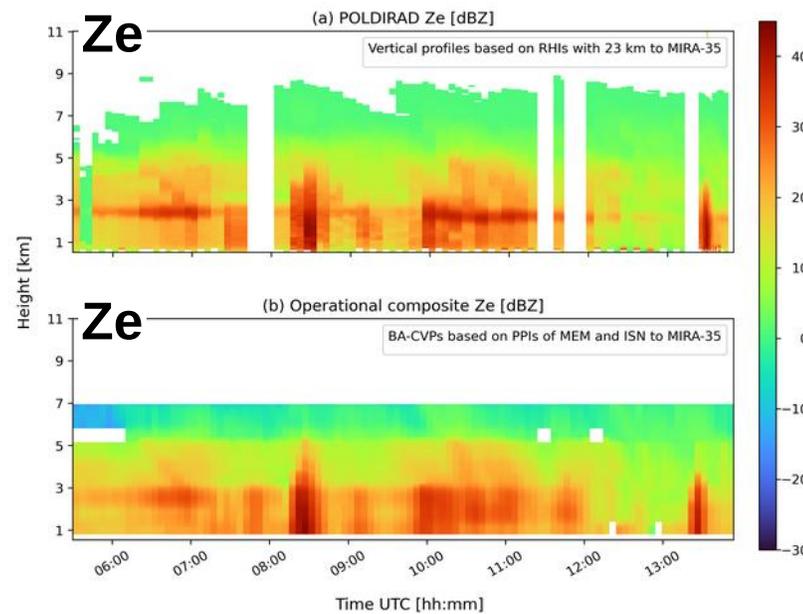
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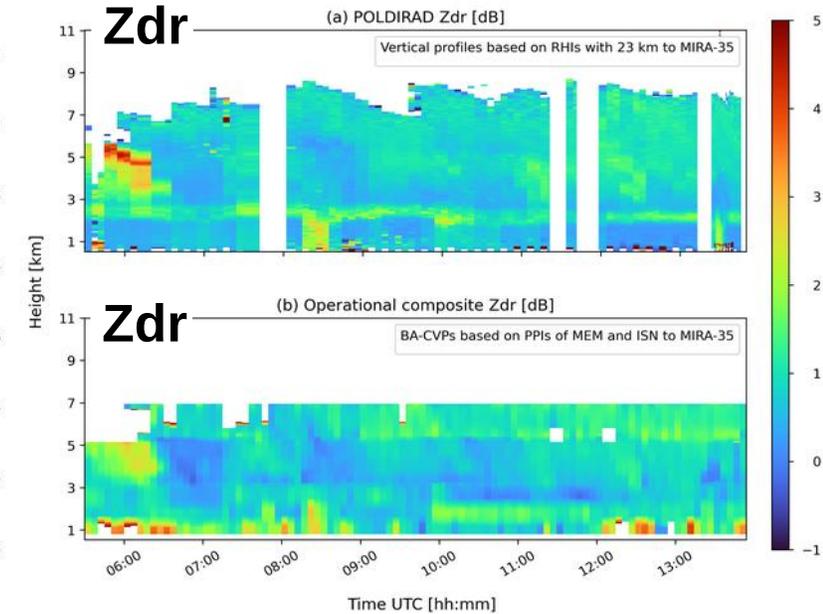
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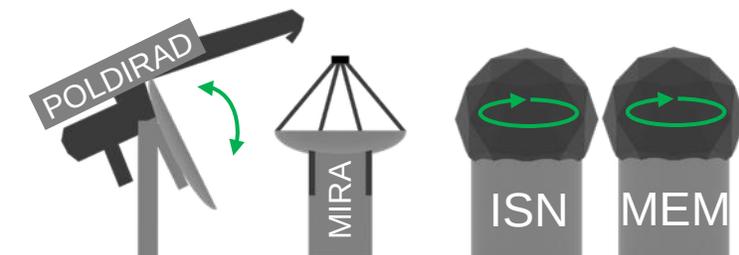
C-band Ze



C-band Zdr



- BA-CVPs deliver good results and are similar to dedicated measurements
- Finer details are resolvable but melting layer detection capability is limited

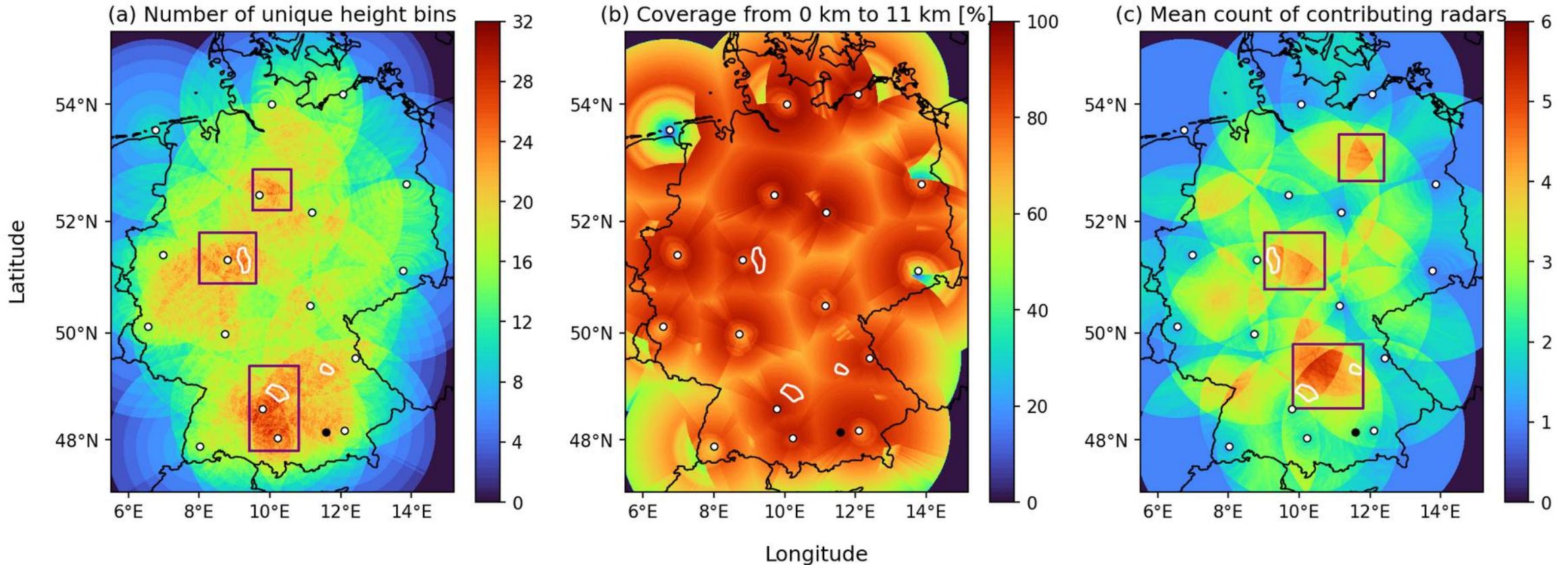


- Possibility to extract beam-aware columnar vertical profiles (BA-CVPs) averaged over variable-size segments from operational volume data using the DWD C-band radar network with good results
- Data of multiple operational radars in range of point of interest can be used

Current work and outlook:

- Study of promising radar variable combinations (Zdr-LDR, Zdr-VEL, ...)
- Combination of dataset with simulations from T-Matrix and DDA
- Inclusion of now accessible radar variables (VEL, LDR) into retrieval
- Operational application on a number of past and future cases

Consequences for the German radar network: Ideal locations for additional vertically pointing instruments



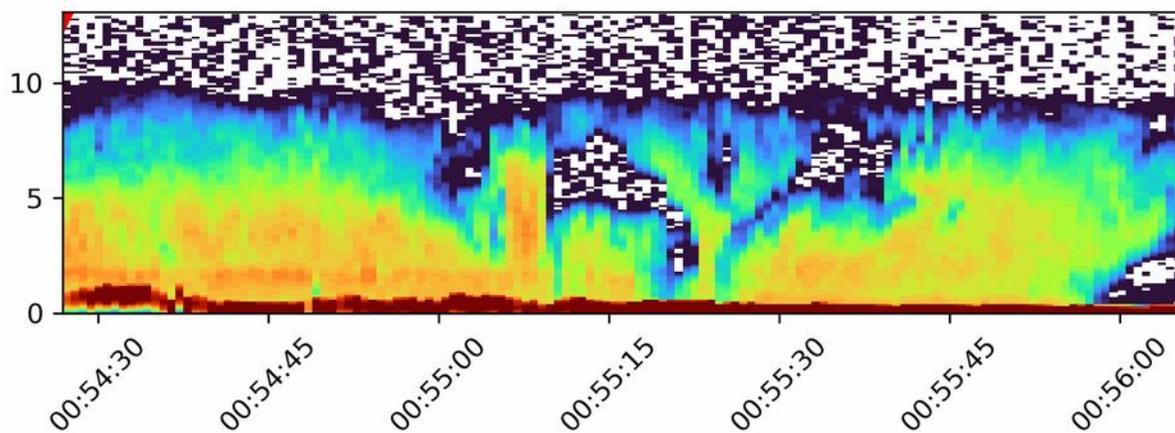
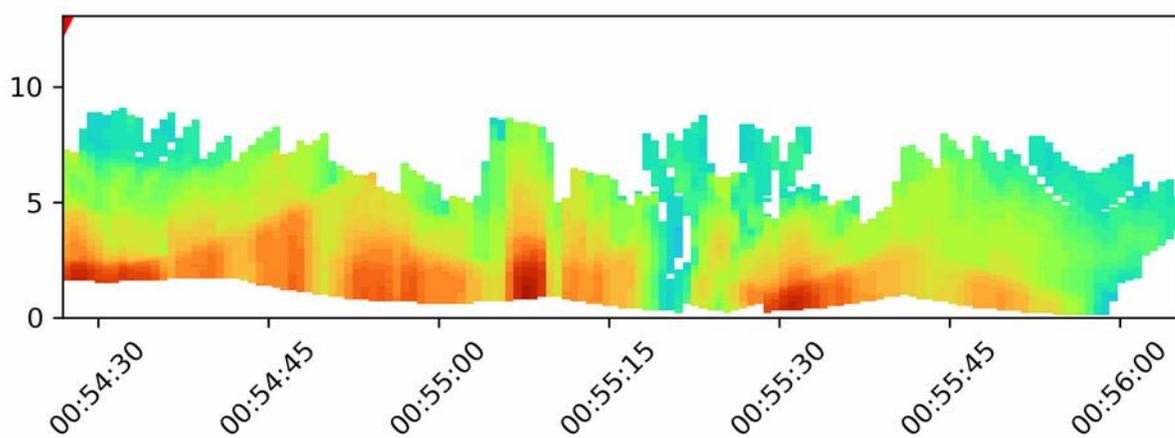
- Expected vertical resolution varies and depends on location (a)
- Good coverage between 0 km and 11 km over whole Germany (b)
- Mostly three or more radars can contribute (c)
- Case study location (black dot) good example for average situation in Germany
- High-interest locations with above-average operational coverage for additional instruments (white)

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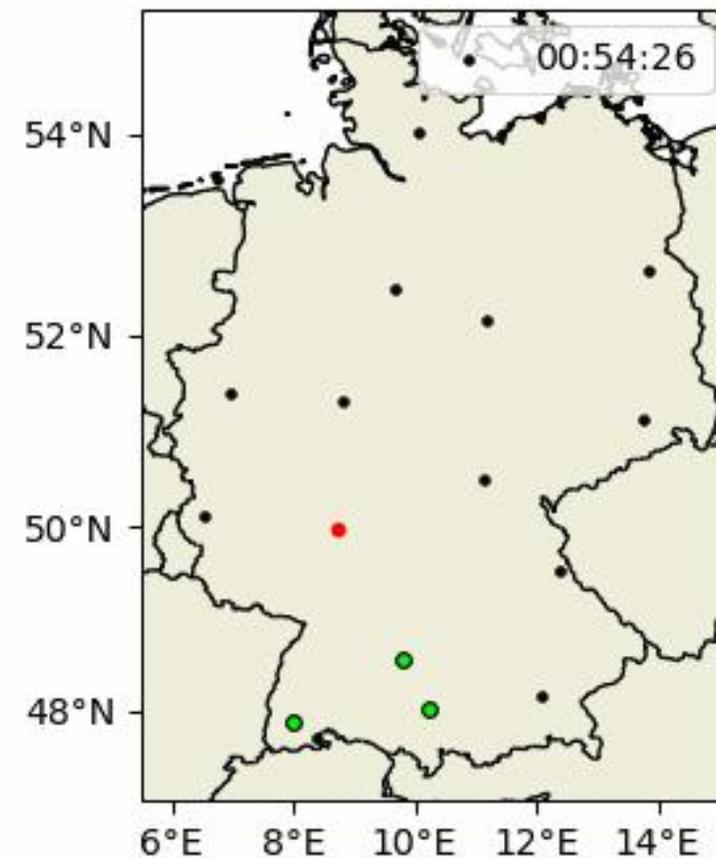
CPR following BA-CVPs



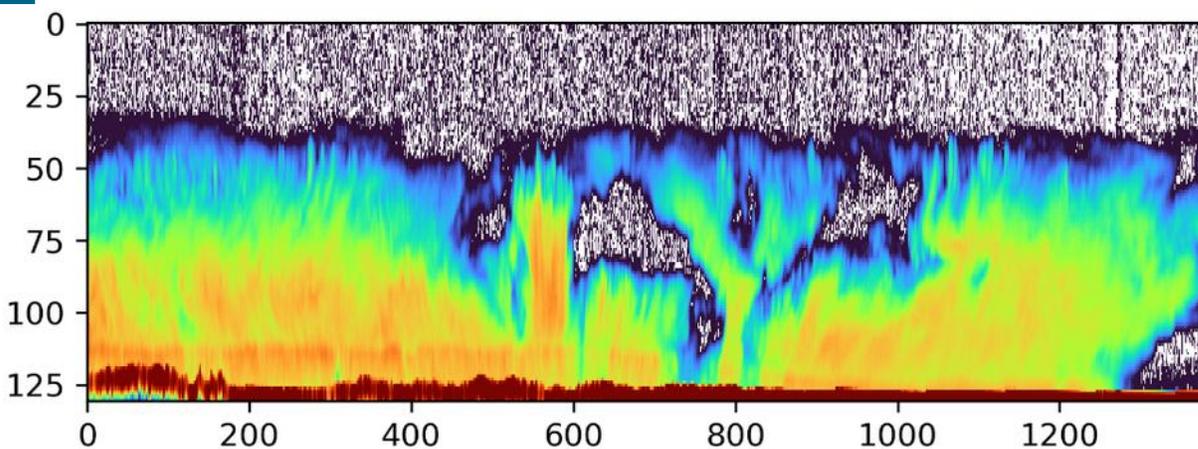
-30 -> 45



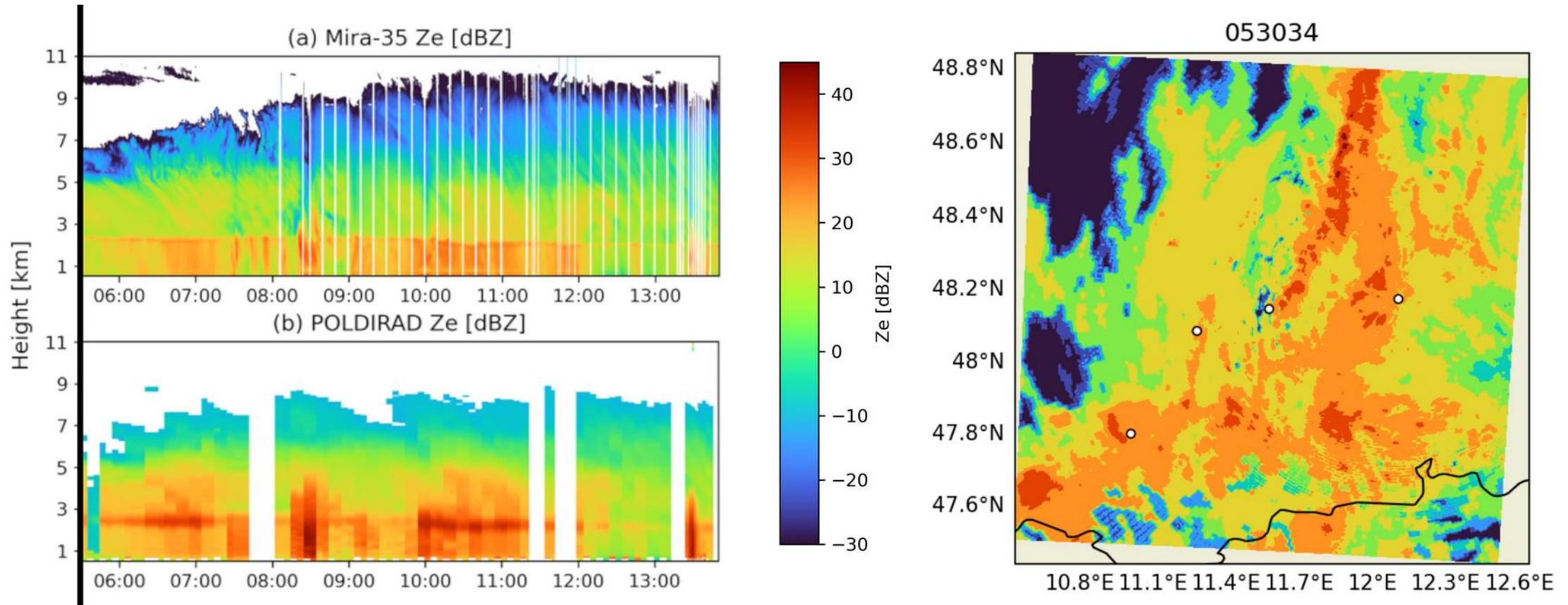
Zmax = 13000
R_value = 4km
Nzs = 131
Z_radius = 400
Every 10th point
Of footprint



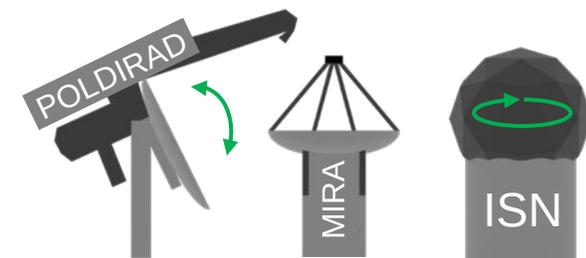
-30 -> 30



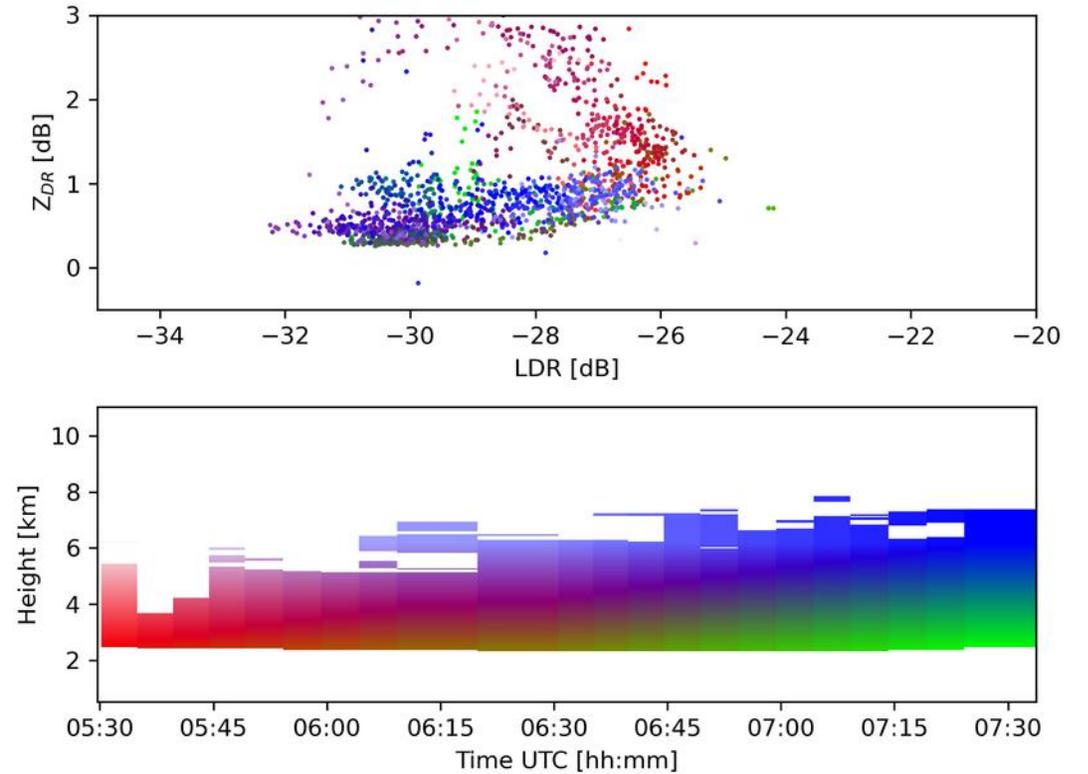
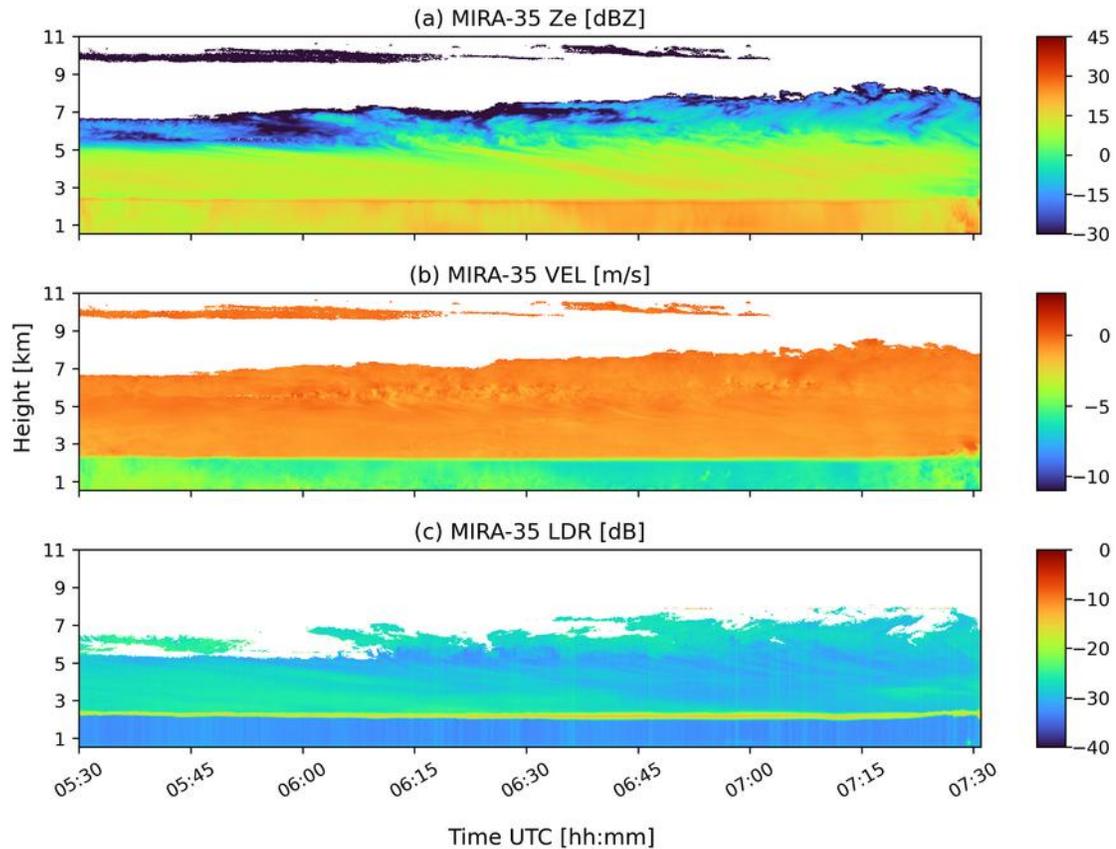
Extracted Profiles: Case study of 28.05.2019



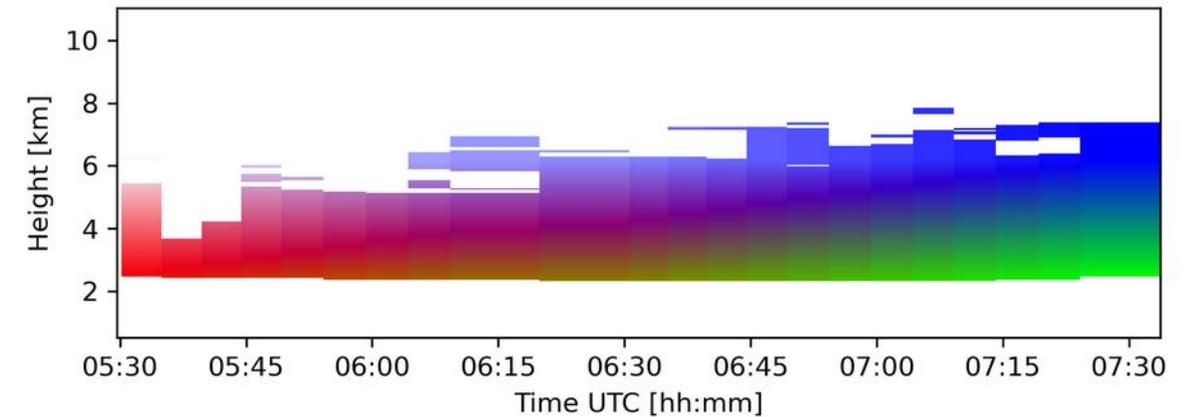
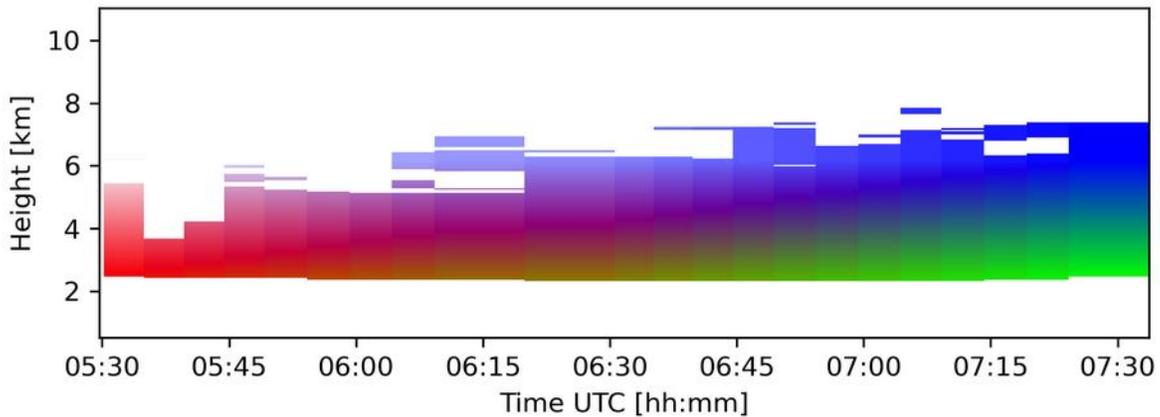
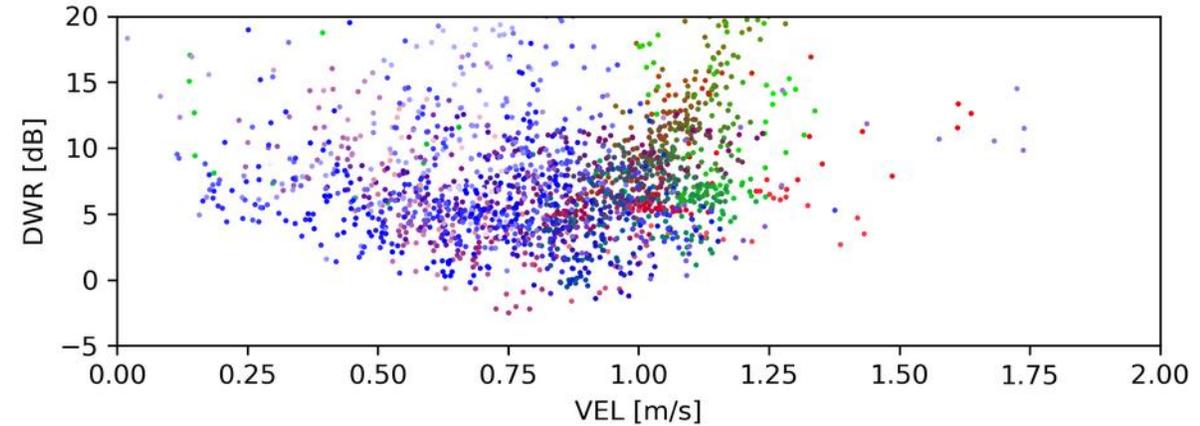
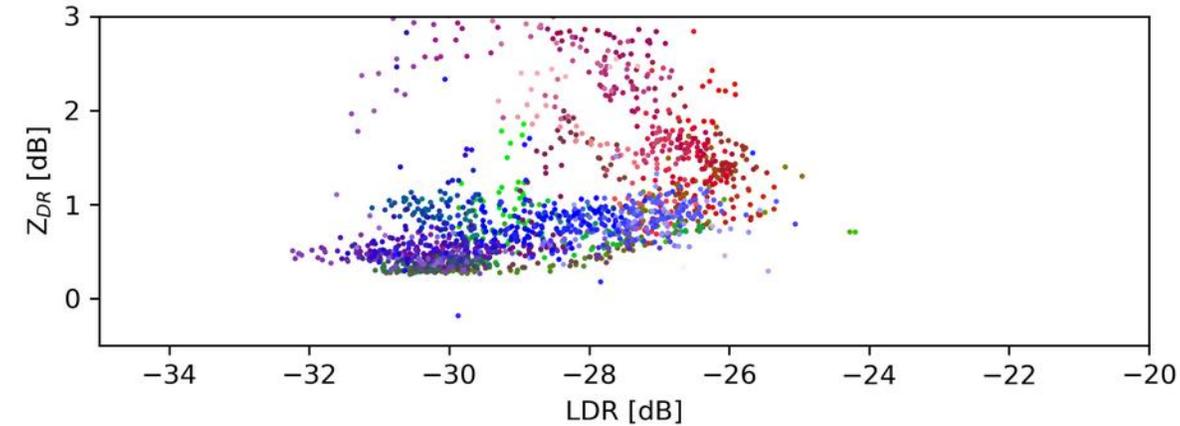
Stratiform and convective precipitation in varying intensity



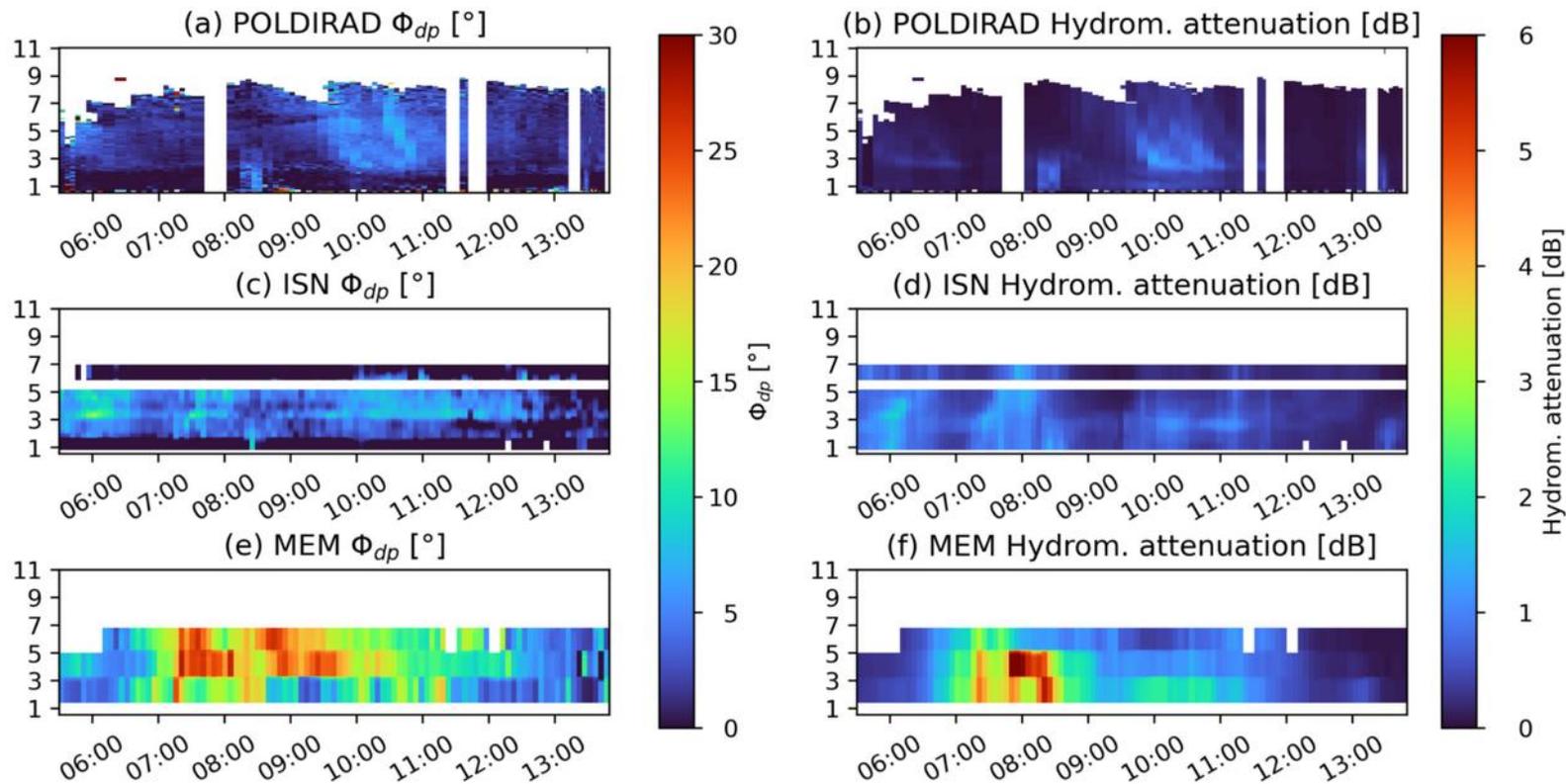
Towards an advanced microphysical retrieval



Towards an advanced microphysical retrieval



Effects of attenuation: Phidp as marker for high hydrometeor attenuation along radar path

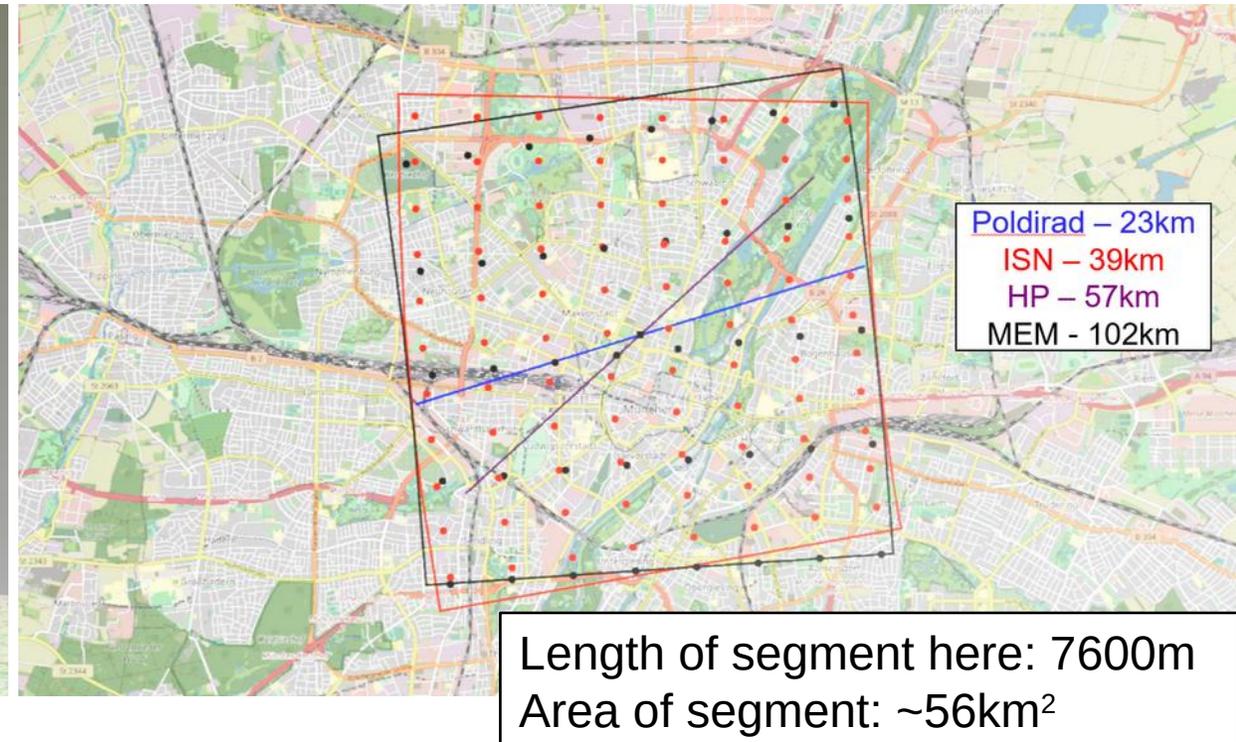
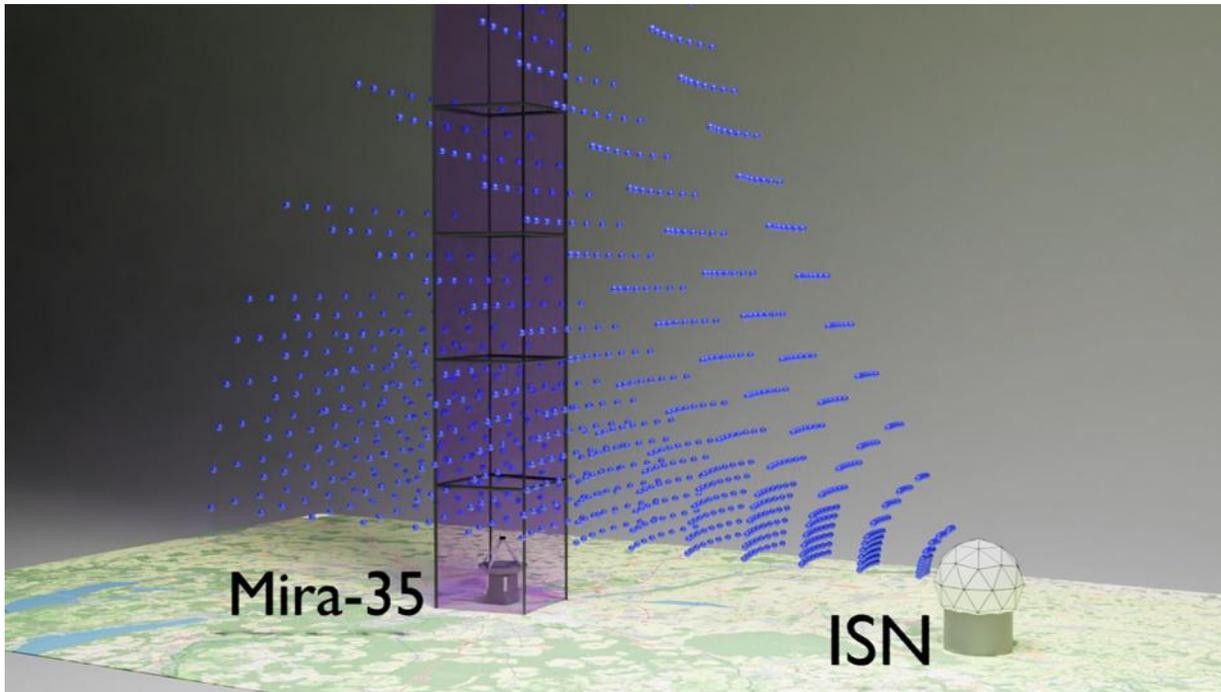


- Comparison between measured phidp and calculated liquid hydrometeor attenuation
- POLDIRAD and ISN Phidp can be used as marker for high hydrometeor attenuation
- Long distance and less data density lead to noise for MEM
- Combination of spatially separated radars for DWR if Phidp is low

Choice of segment: column in volume of operational data

3D-segment selection in operational volume data of ISN at point of interest (MIRA-35)

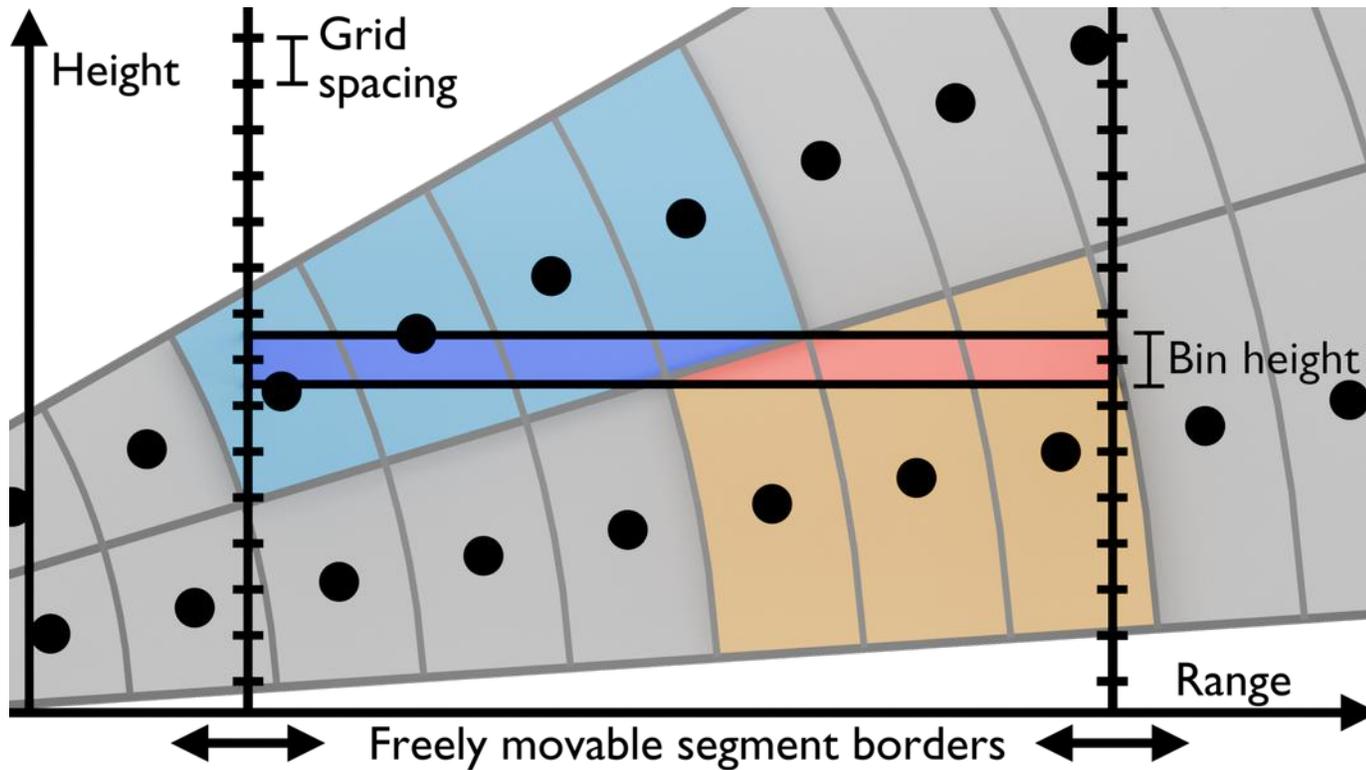
Distribution of data points of lowest elevation angle for dedicated radars (line) and operational radars (segment)



Challenges:

- Density of data points decreases with distance (ISN vs. MEM)
- Limited amount of measured elevation angles in operational measurement schemes
- Gaps between rays that are not spaced beam-width apart

Beam-aware columnar vertical profiles



Columnar vertical profile

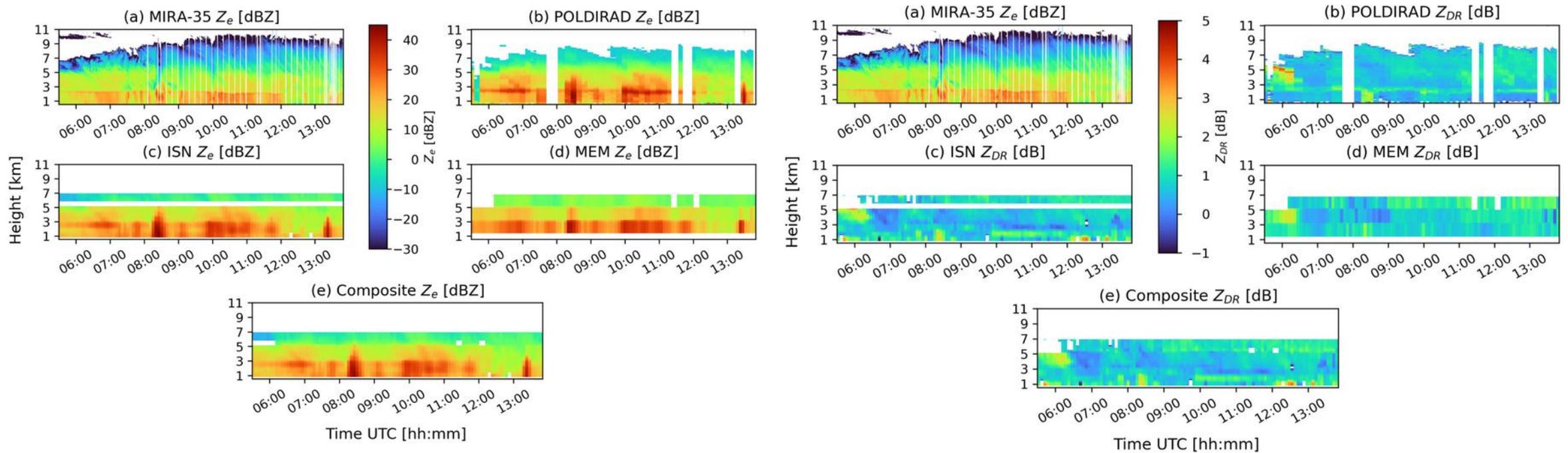
- Data in segment is azimuthally averaged
- All data points within column are considered

Beam-aware

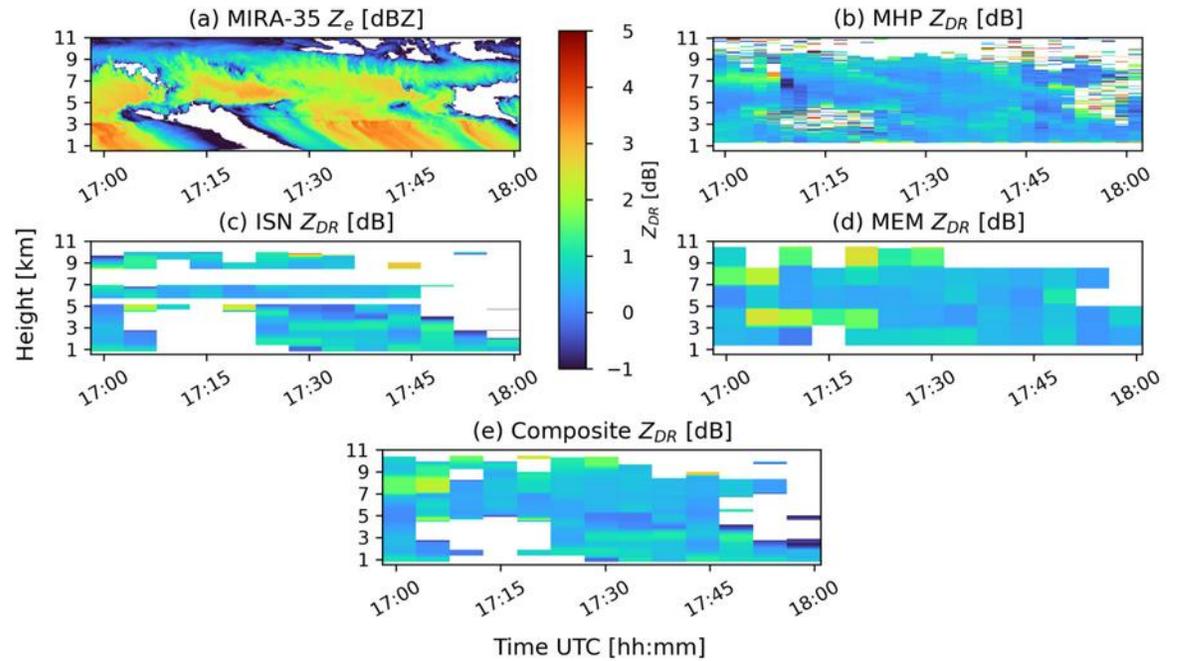
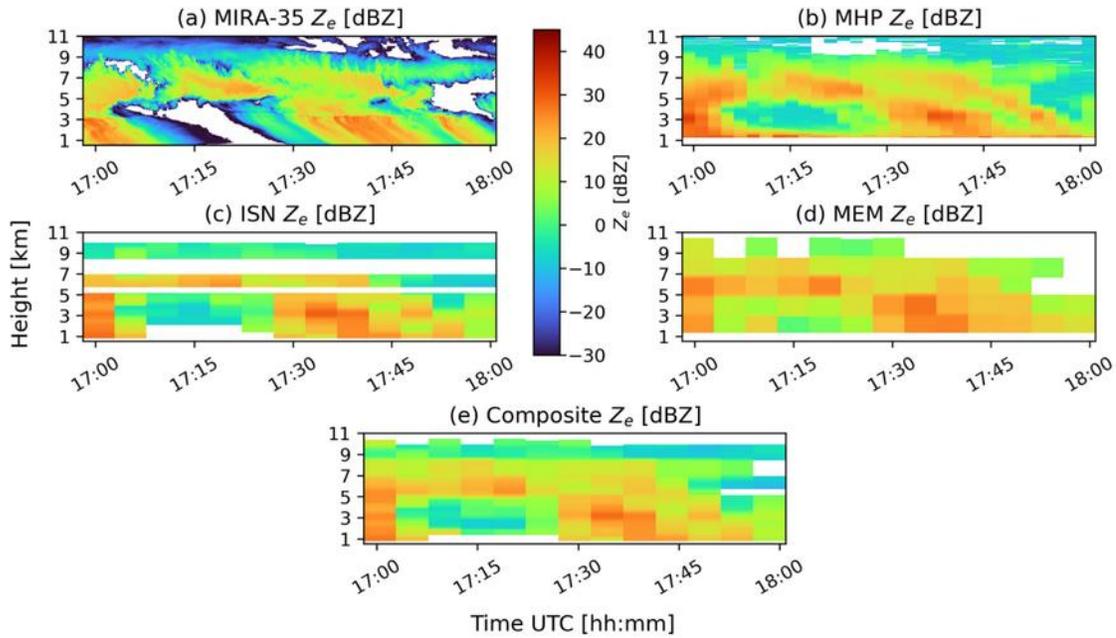
- Beam broadening, refraction and earth curvature are considered
- Intersection of individual range gate and height bin is computed
- All range gates intersecting height bin contribute with according weights

- Higher statistical accuracy
- No artificial gaps
- Possibility to include data of several operational radars

Importance of composites: Case study of 28.05.2019



Importance of composites: Case study of 08.07.2021



Composite of operational radars

