Validation of Cloud microphysics from LES with EarthCARE Products and Ground-Based Remote sensing

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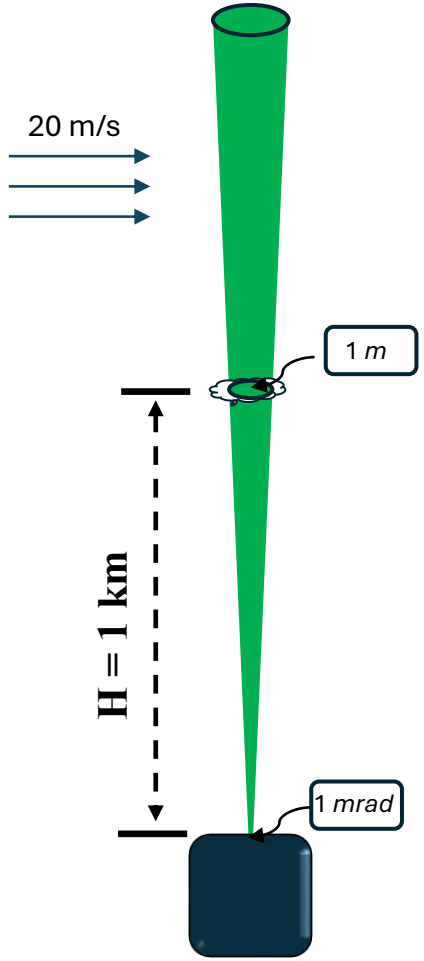
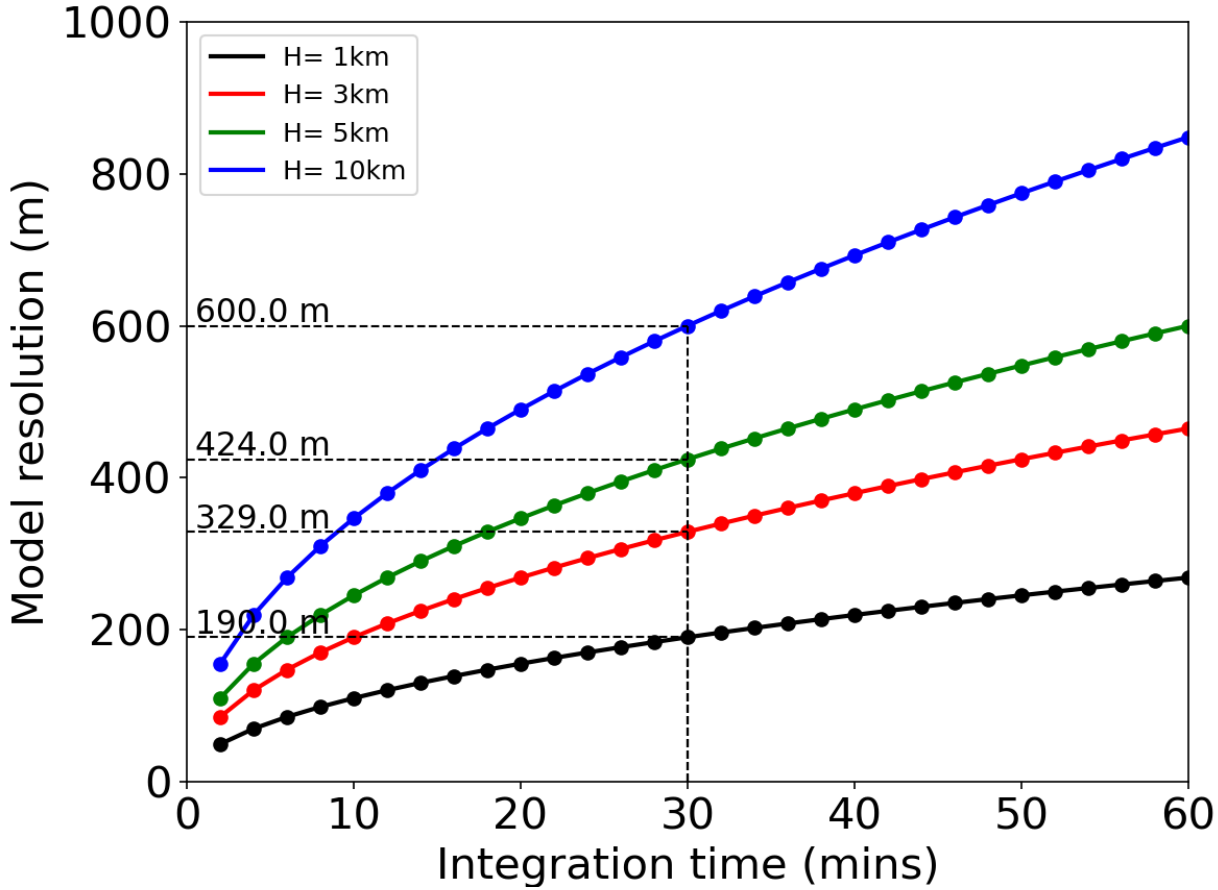
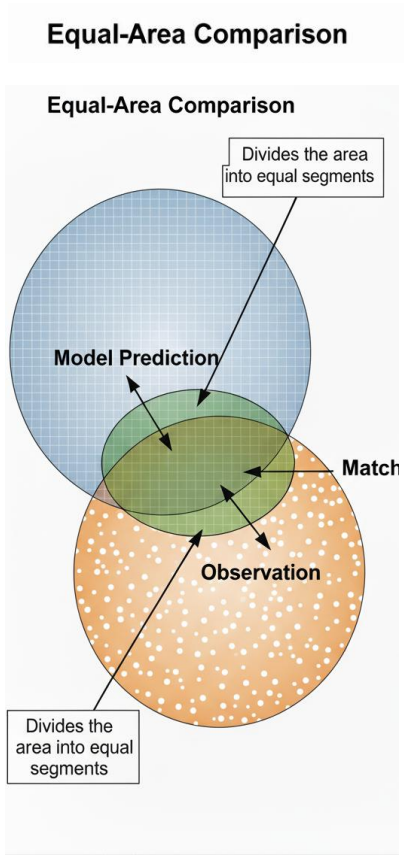
Comparable Model Resolution to LIDAR Measurements

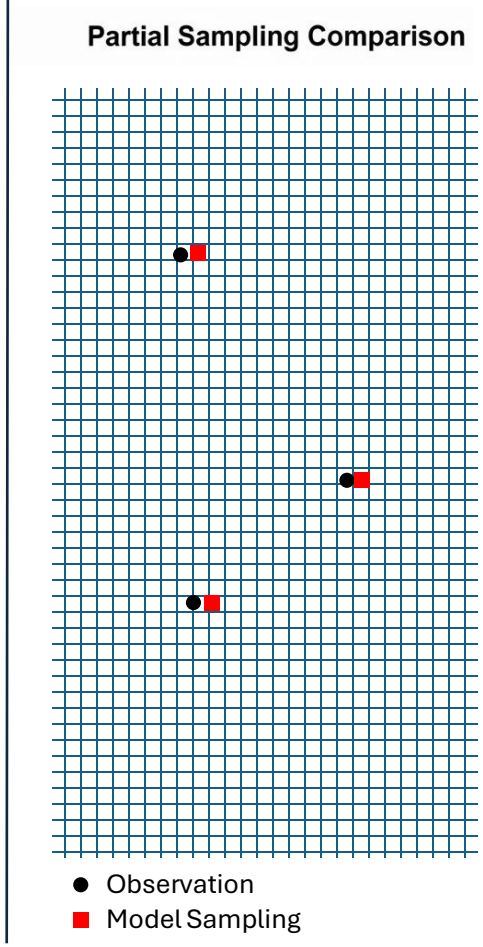


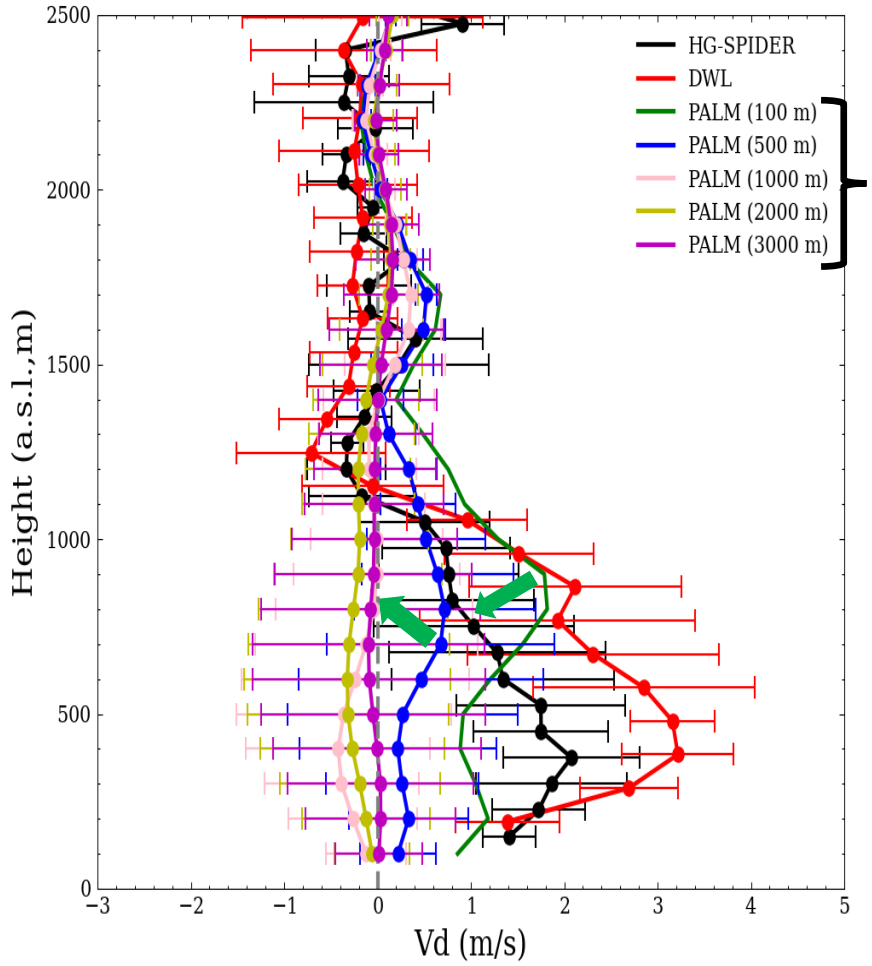


- The required model resolutions are smaller than traditional mesoscale model resolution (> 3 km)

Comparing Methods: Equal-Area vs. Sample-Point Approaches







Model grid resolution

- Coarse model resolution (> 1km) cannot resolve updraft due to average.

Theoretical Explanation – Subgrid-Scale Energy Resolution

Reynolds' equations

$$\frac{\partial \bar{u}}{\partial t} = -\bar{u}\frac{\partial \bar{u}}{\partial x} - \bar{v}\frac{\partial \bar{u}}{\partial y} - \bar{w}\frac{\partial \bar{u}}{\partial z} - \frac{1}{\bar{\rho}}\frac{\partial \bar{p}}{\partial x} + f\bar{v}$$

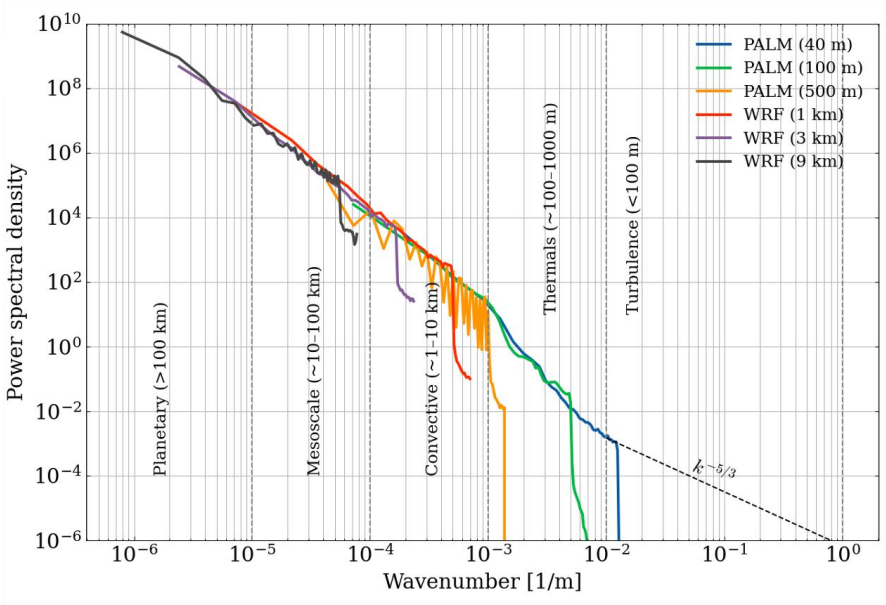
→ Model resolved

$$+ \frac{1}{\bar{\rho}}\left(\frac{\partial}{\partial x}(\tau_{xx} + T_{xx}) + \frac{\partial}{\partial y}(\tau_{yx} + T_{yx}) + \frac{\partial}{\partial z}(\tau_{zx} + T_{zx})\right)$$

molecular viscosity

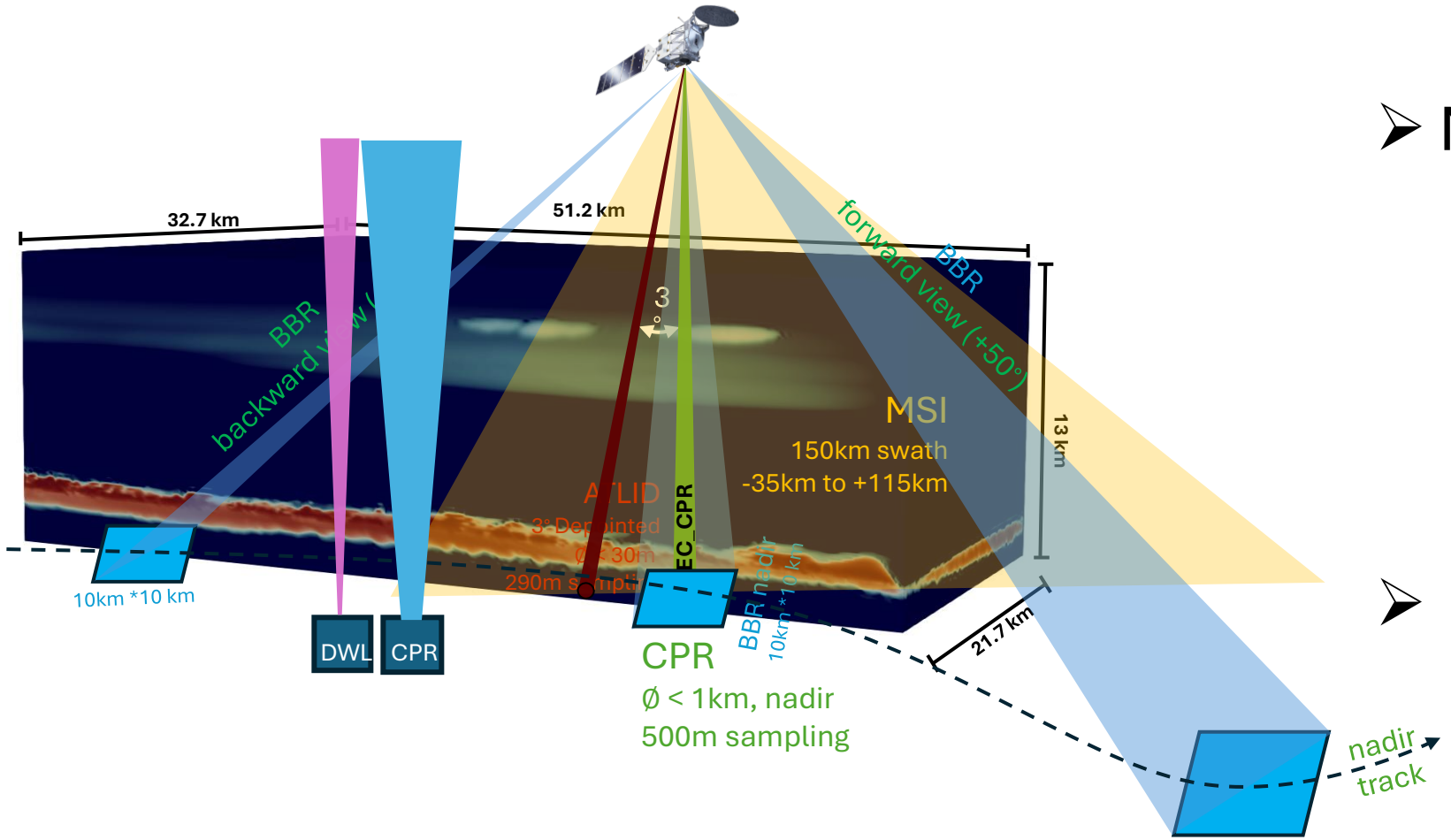
Turbulence

Parameterization



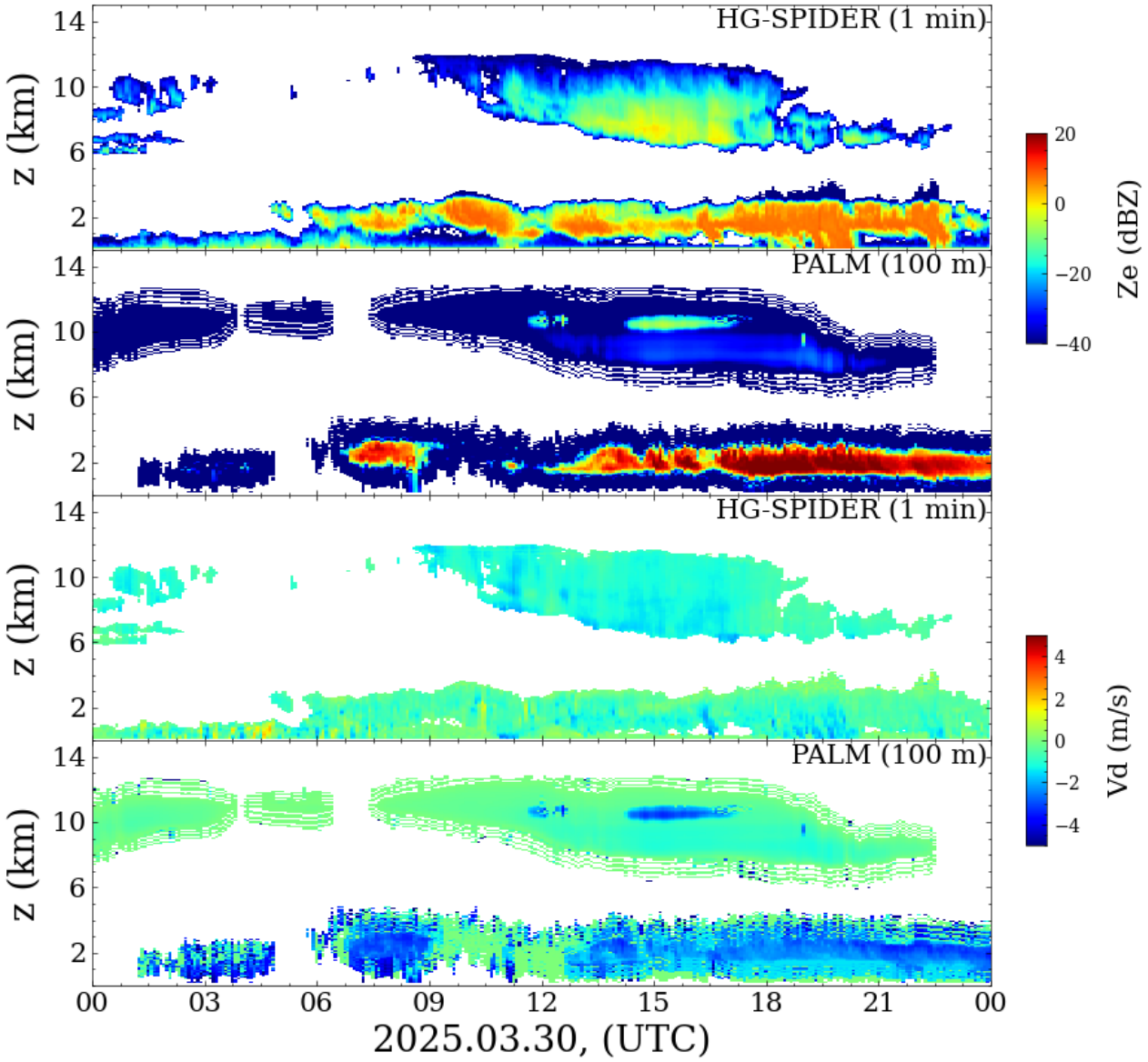
- LES on at resolution of around 100 m can resolve large turbulence eddy to avoid uncertainty from parametrization

Methods



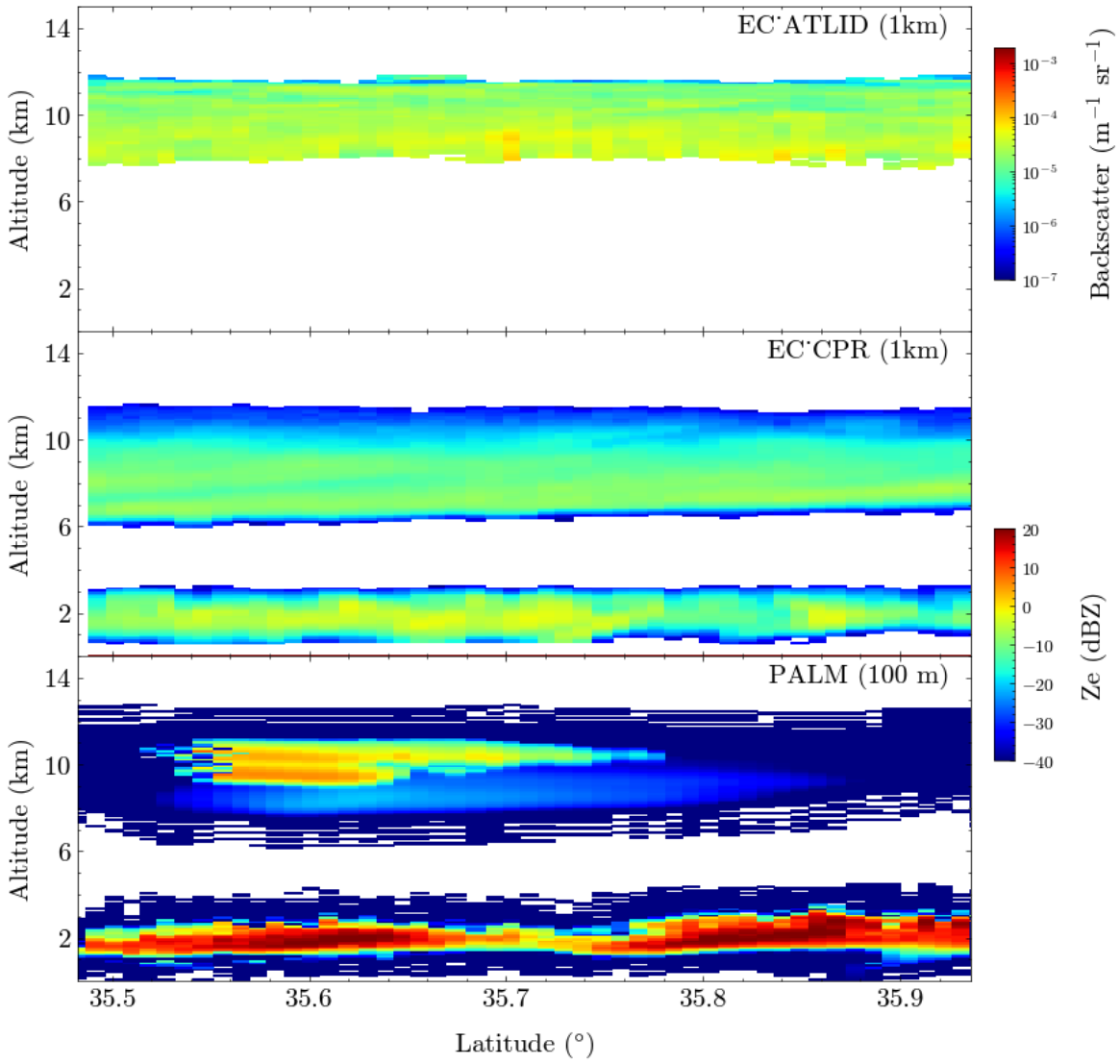
- Observation location
  - NICT, Koganei, Tokyo
- Measurements
  - EarthCARE (JAXA & ESA)
  - Doppler wind lidar (NICT)
  - HG-SPIDER (CPR, NICT)
  - HSRL (NIES)
  - WPR (NICT)
- Models
  - WRF (Forced by ERA5)
  - PALM (Forced By WRF)

HG-SPIDER v.s. PALM simulation



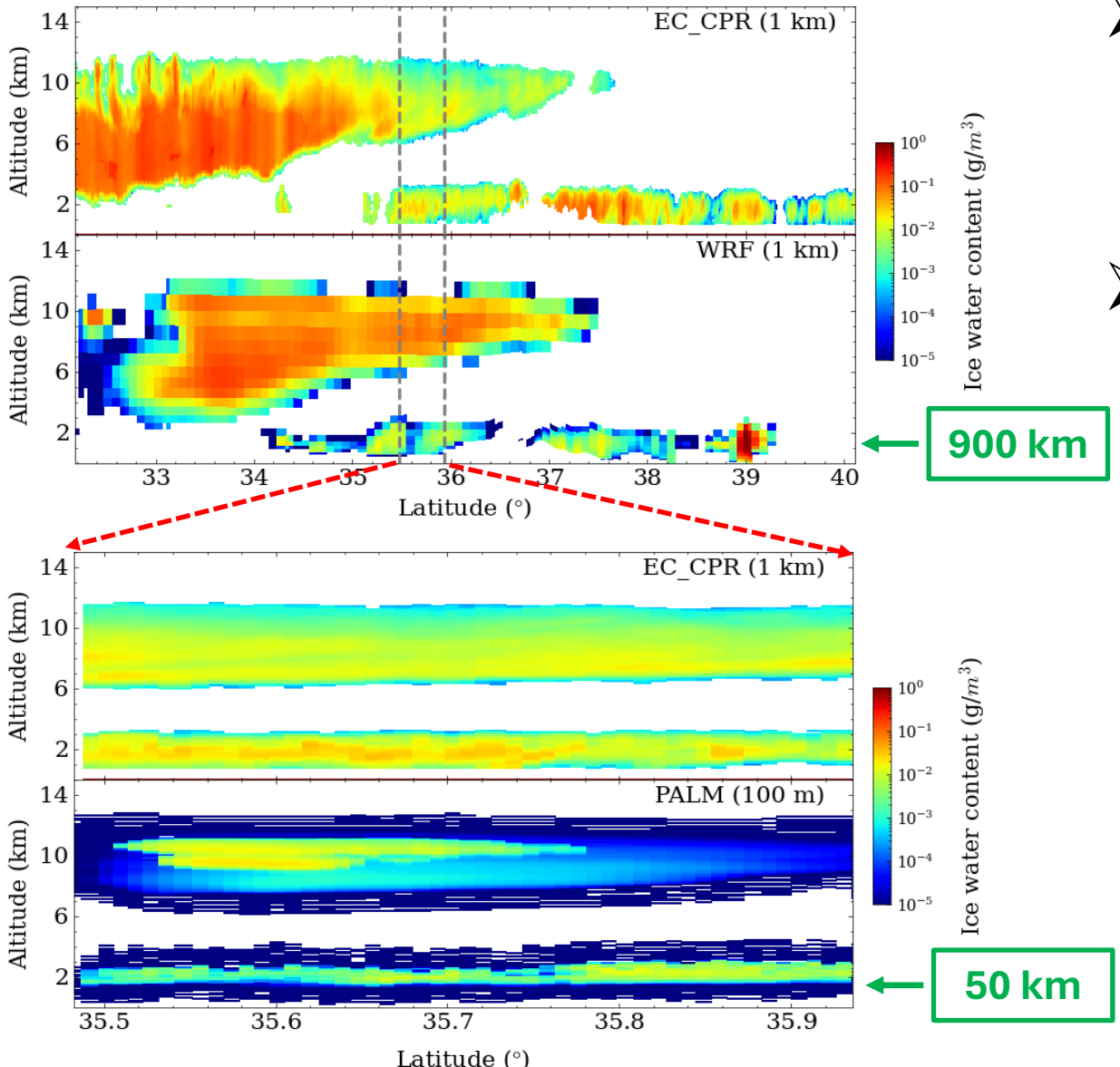
- PALM simulation predicted cloud height, cloud lifetime, and cloud structure well for PALM simulations.
- PALM simulation overestimates ze for low level cloud and underestimates ze for high level cloud.

CPR_CLP v.s. PALM simulation

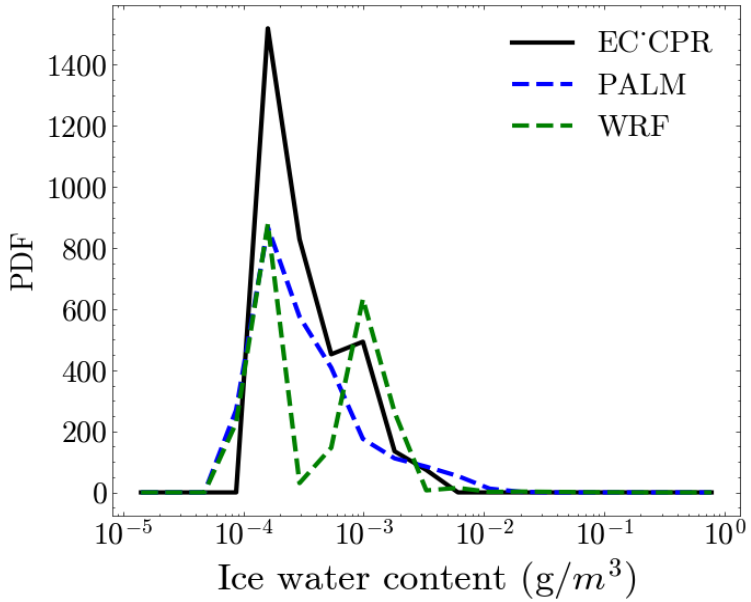


- Spatial consistency between PALM simulation and EC_CPR
- PALM simulation overestimates ze for low level cloud and underestimates ze for high level cloud.

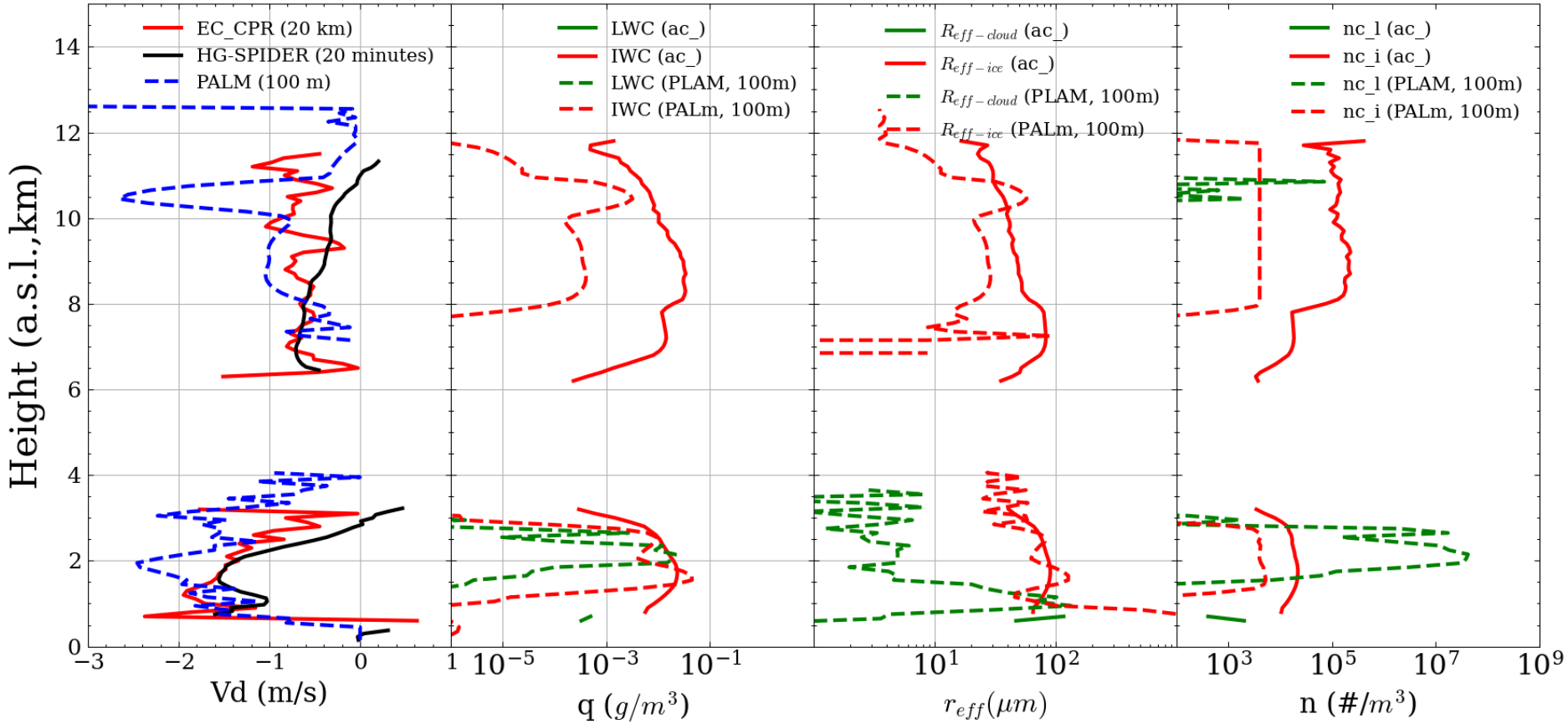
CPR_CLP v.s. WRF & PALM simulation



- Both WRF and PALM show similar cloud structure as EC_CPR measurement.
- Both WRF and PALM shows the same order of magnitude in ice water content prediction.



CPR_CLP v.s. HG-SPIDER v.s. PALM simulation



- EarthCARE CPR product was validated at NICT.
- PALM overestimates the LWC for low level cloud and underestimates IWC for high level cloud.

Conclusion

- We built a novel method to compare high resolution remote sensing observation with Large eddy simulation.
- High-resolution PALM simulations successfully reproduced observed cloud structures and vertical velocity profiles.
- The PALM simulation overestimates ze for low level cloud (mixed phase) and underestimate ze for high level cloud (ice cloud).
- The simulated ice water content show similar structures and same order of magnitude as EC_CPR retrieval.
- ATLID and other ground-based lidars such as 355nm-HSRL and 355nm-MFMSPL will be used in further study.

Data Visualization

Acknowledgements

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