Active and Passive Radiative Transfer Simulations for GPM-Related Field Campaigns

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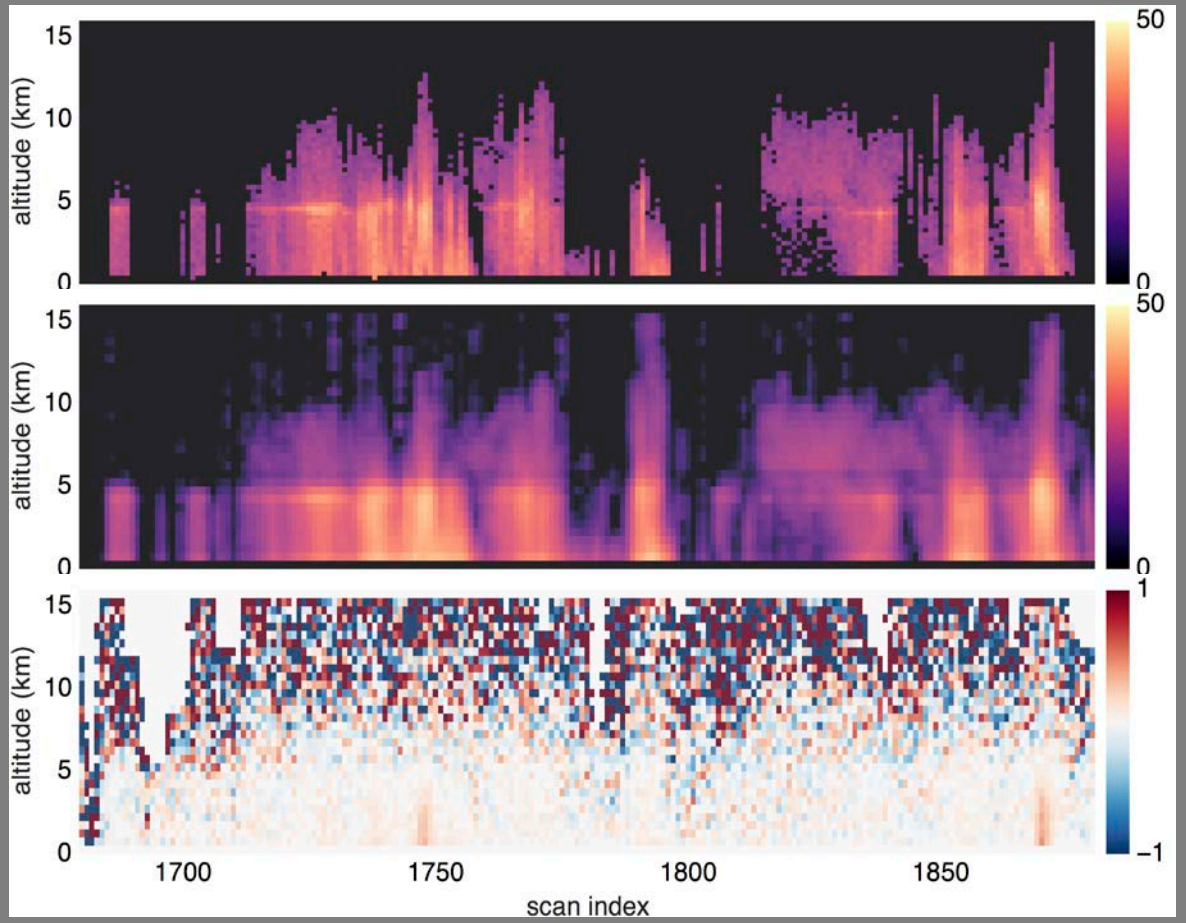
MIIST 3D Forward Model

The Multi-Instrument Inverse Solver Testbed (MIIST) uses the Atmospheric Radiative Transfer Simulator (ARTS) for solving the vector radiative transfer (RT) equation in up to three spatial dimensions within a spherical geometry

- Gas absorption
  - Line-by-line calculations
  - Fast transmittance tables
- Hydrometeor scattering solvers
  - Discrete ordinate
  - RT4 (Evans, 1D)
  - Radar Single Scattering (1D or 3D)
  - Monte Carlo (3D)

TRMM Overpass of Tropical Cyclone Asma

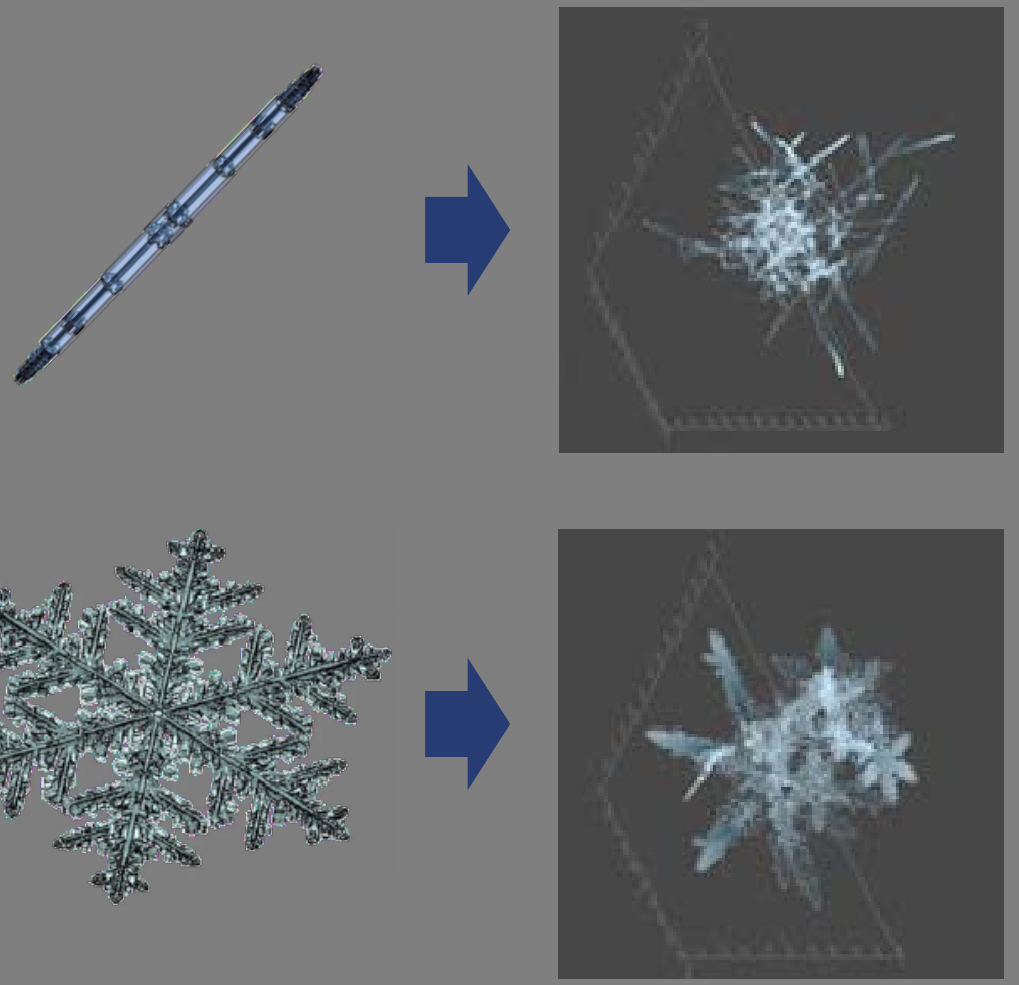


Scattering Tables

https://storm.pps.eosdis.nasa.gov/storm/OpenSSP.jsp

High-fidelity hydrometeor scattering tables are necessary for accurate and consistent forward modeling of multi-frequency observations

- Requires full Stokes matrices
  - And absorption vector
- Randomly oriented particles
  - Discrete Dipole Approximation
  - Characteristic Basis Function Method (coming soon)
- Horizontally-oriented plates
  - Invariant Imbedding T-matrix Method

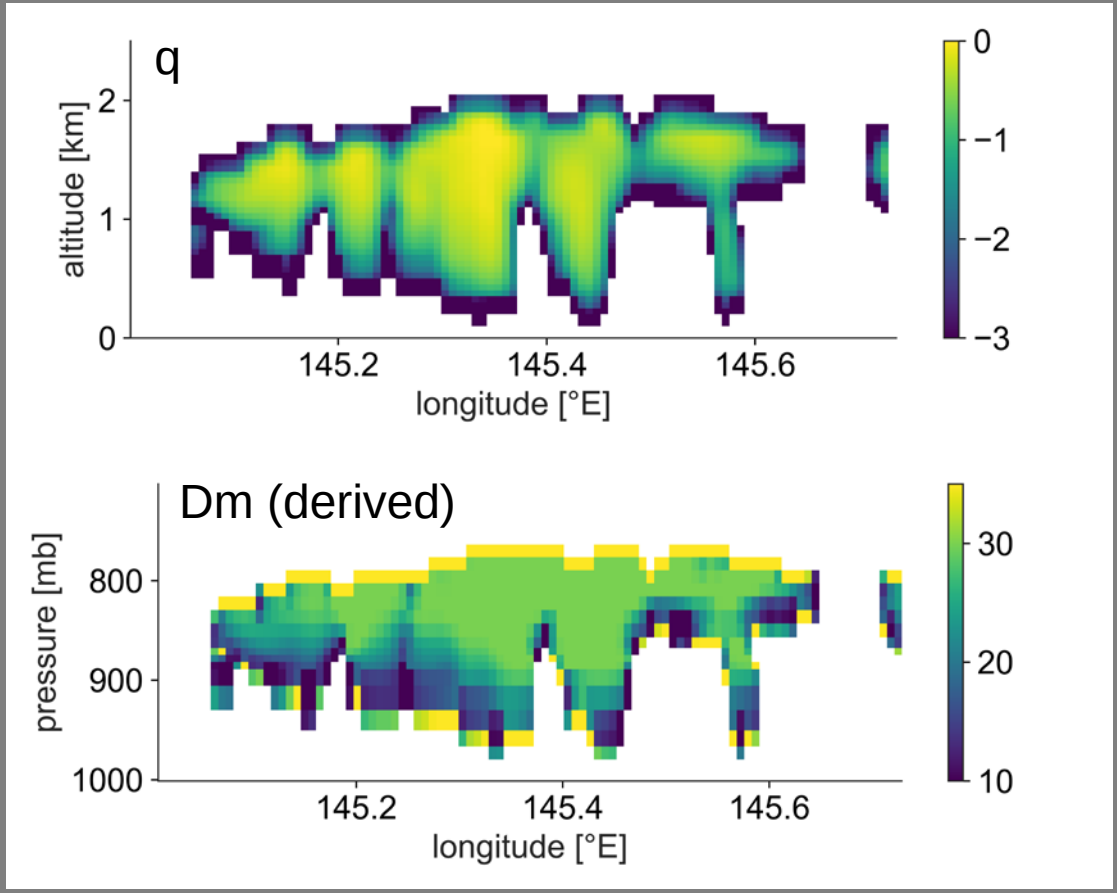


Cloud Resolving Simulations

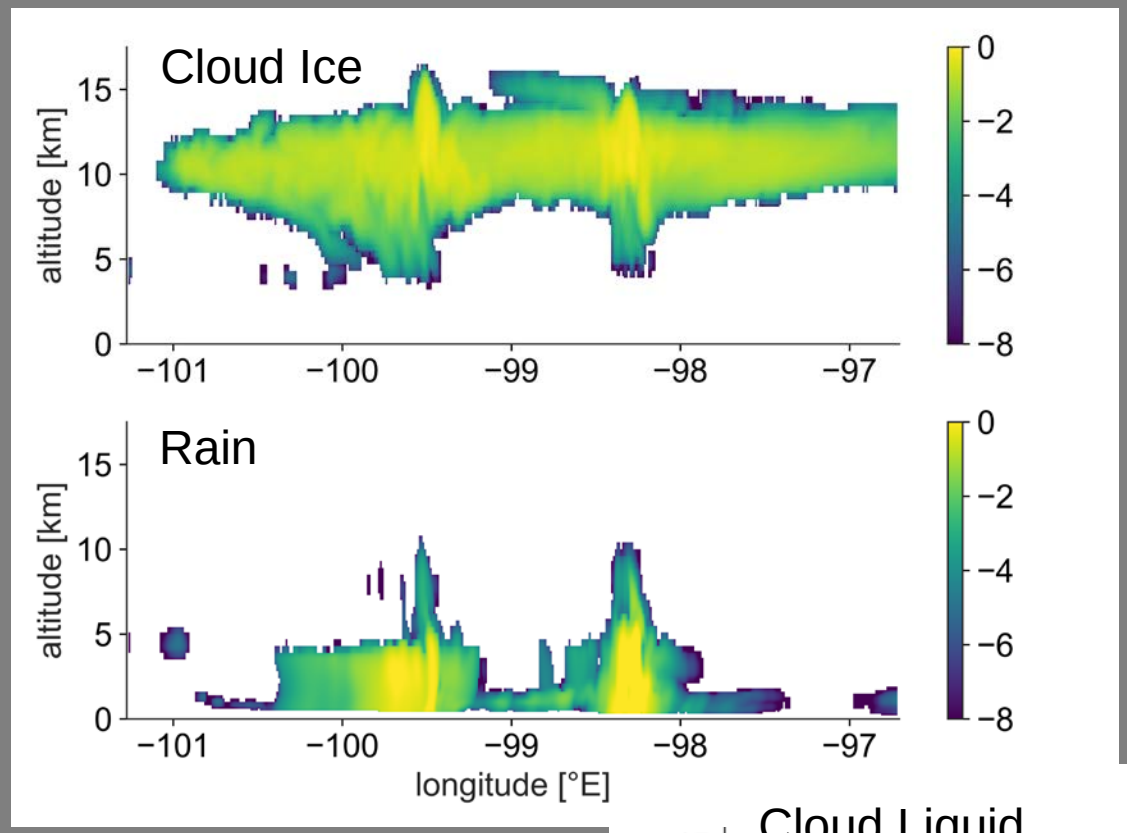
Cloud resolving simulations (e.g., NU-WRF) supply output consistent with ARTS needs

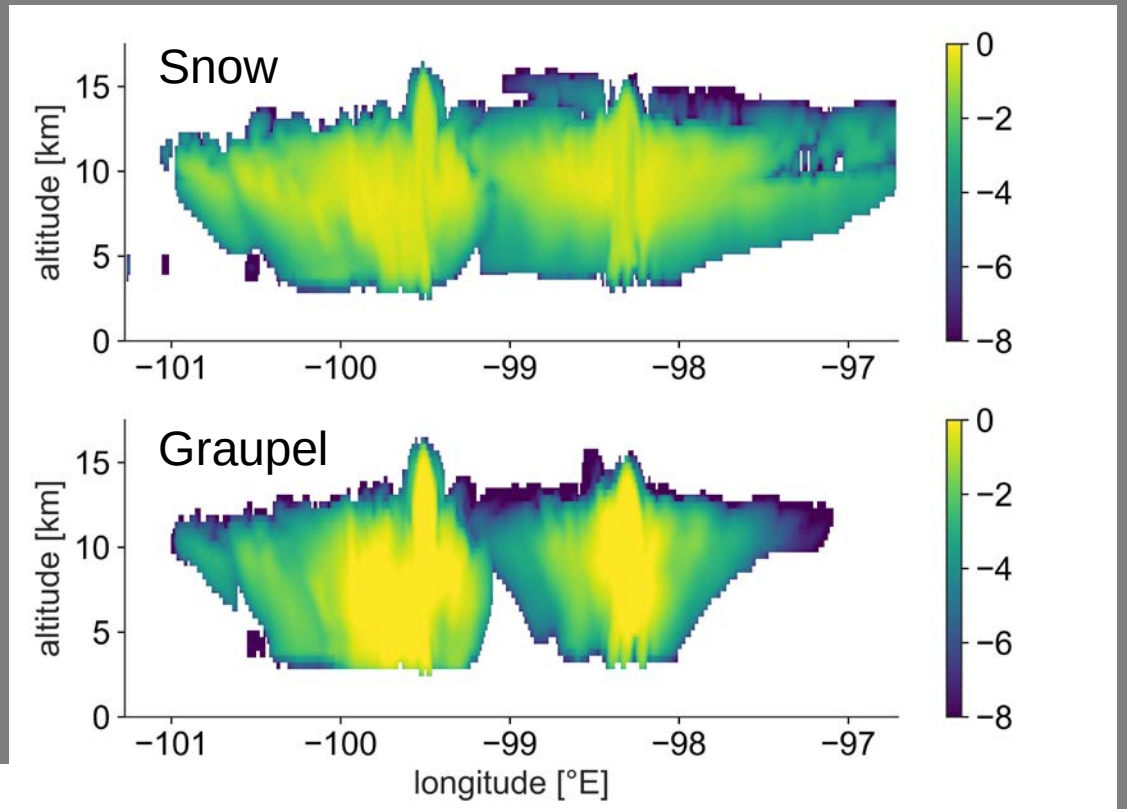
- Atmospheric Information
  - Temperature
  - Pressure / height
  - Water vapor
- Hydrometeor Profiles
  - ARTS architecture ripe for explicit bin microphysics
- Examples use Morrison 2M scheme

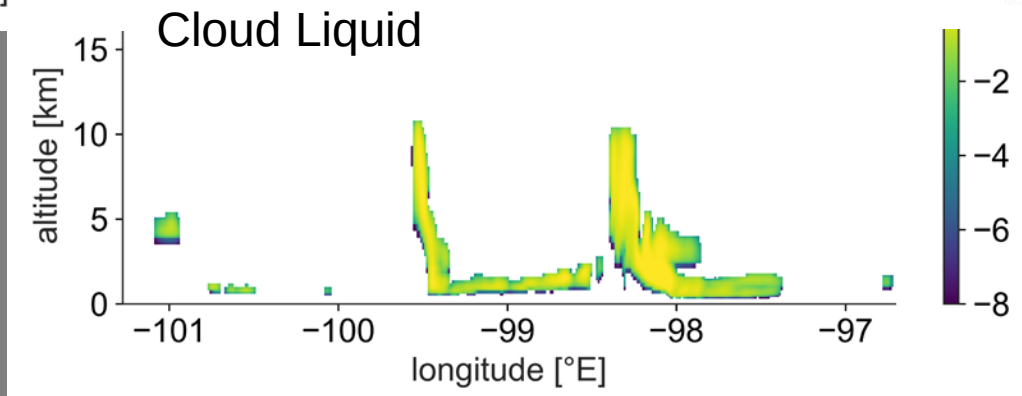
Cloud Liquid



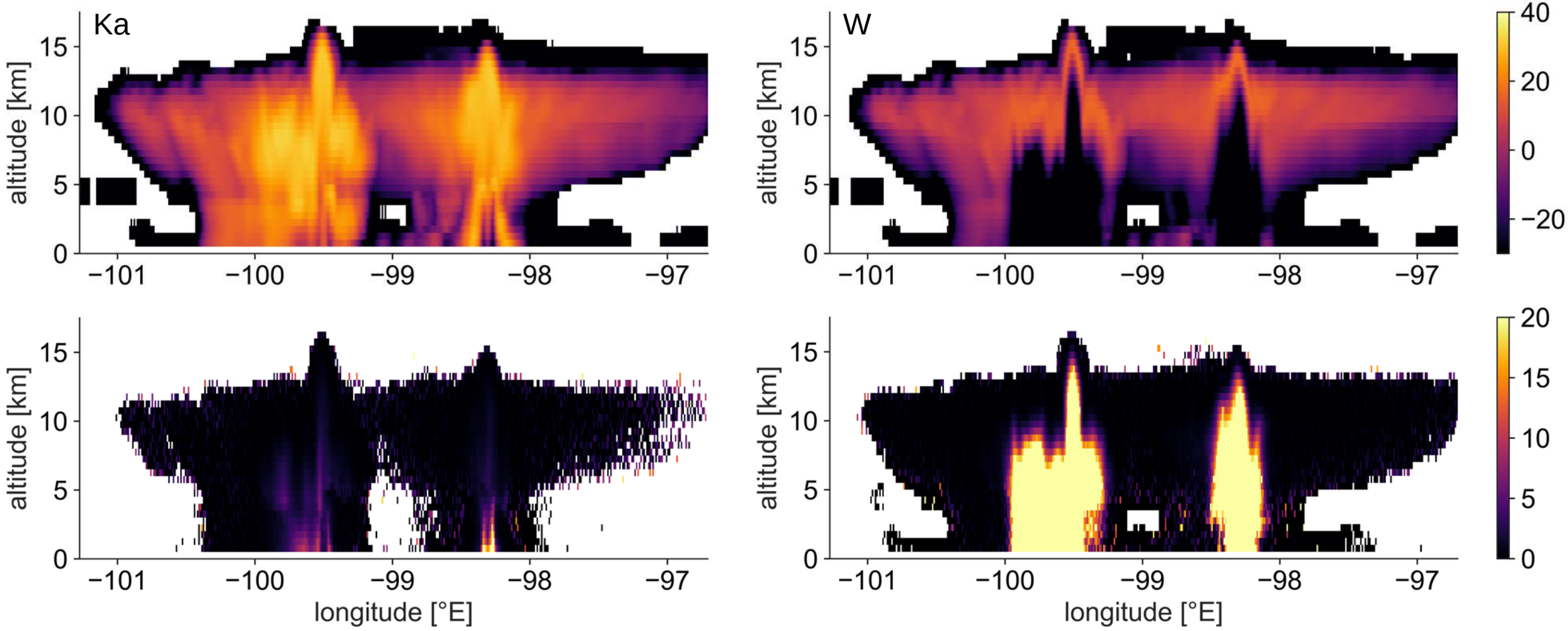
Radar Simulations: (MC3E 20110520, 0600 UTC)



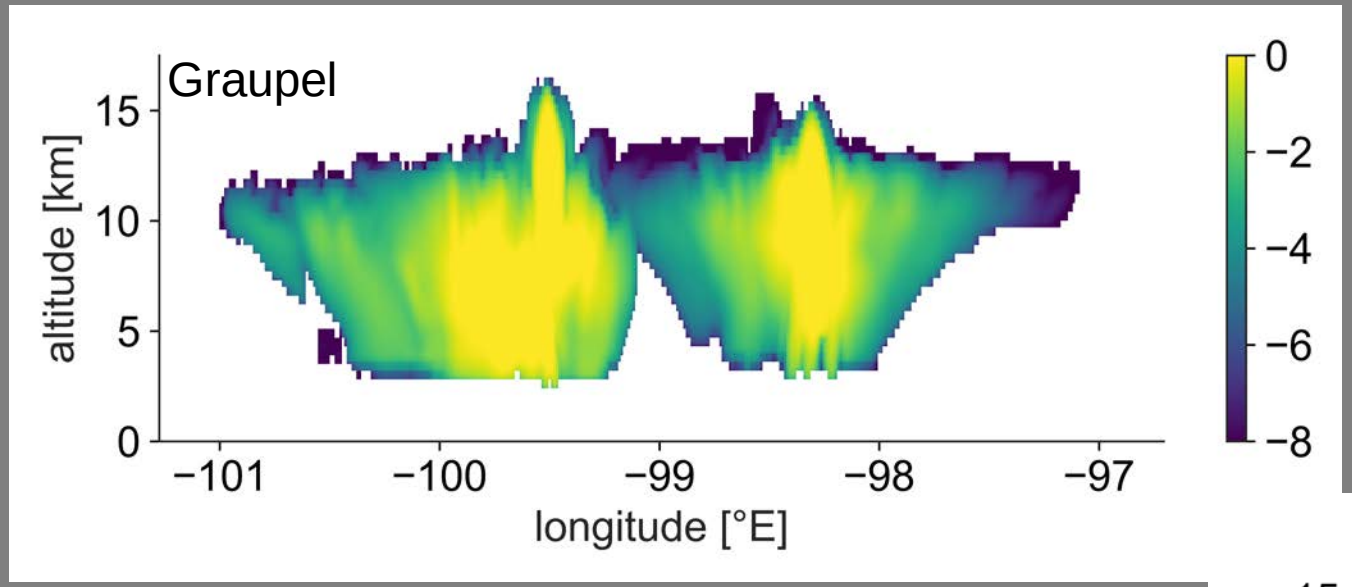


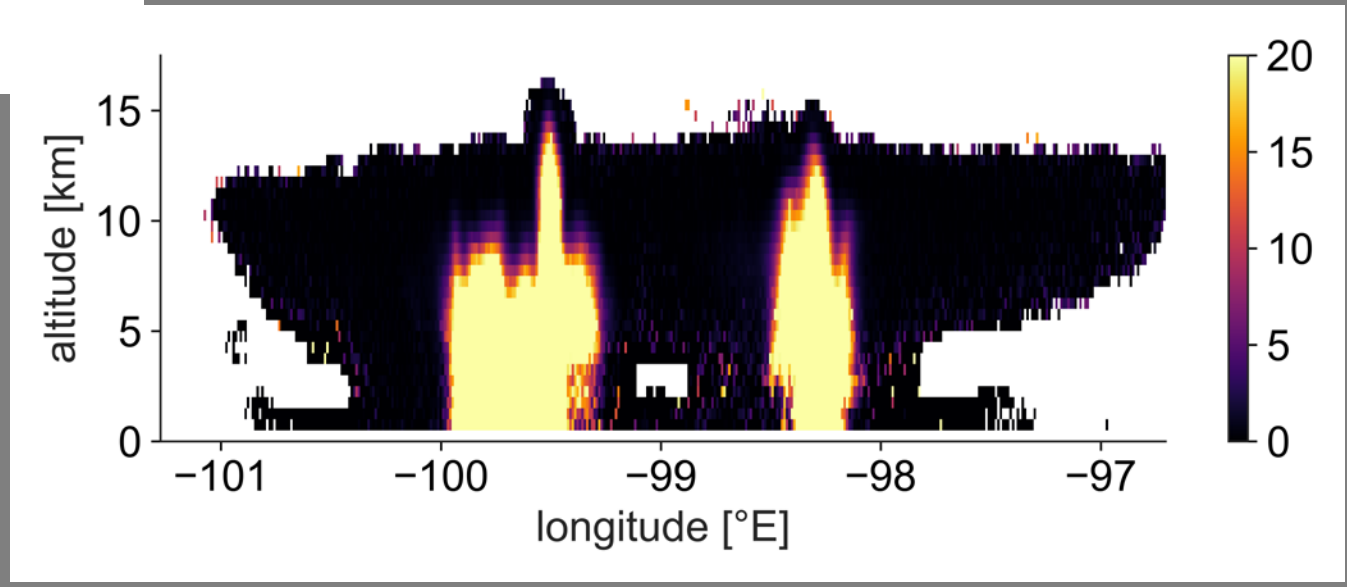


Spaceborne Radar Simulations (CloudSat-Like Sensor)

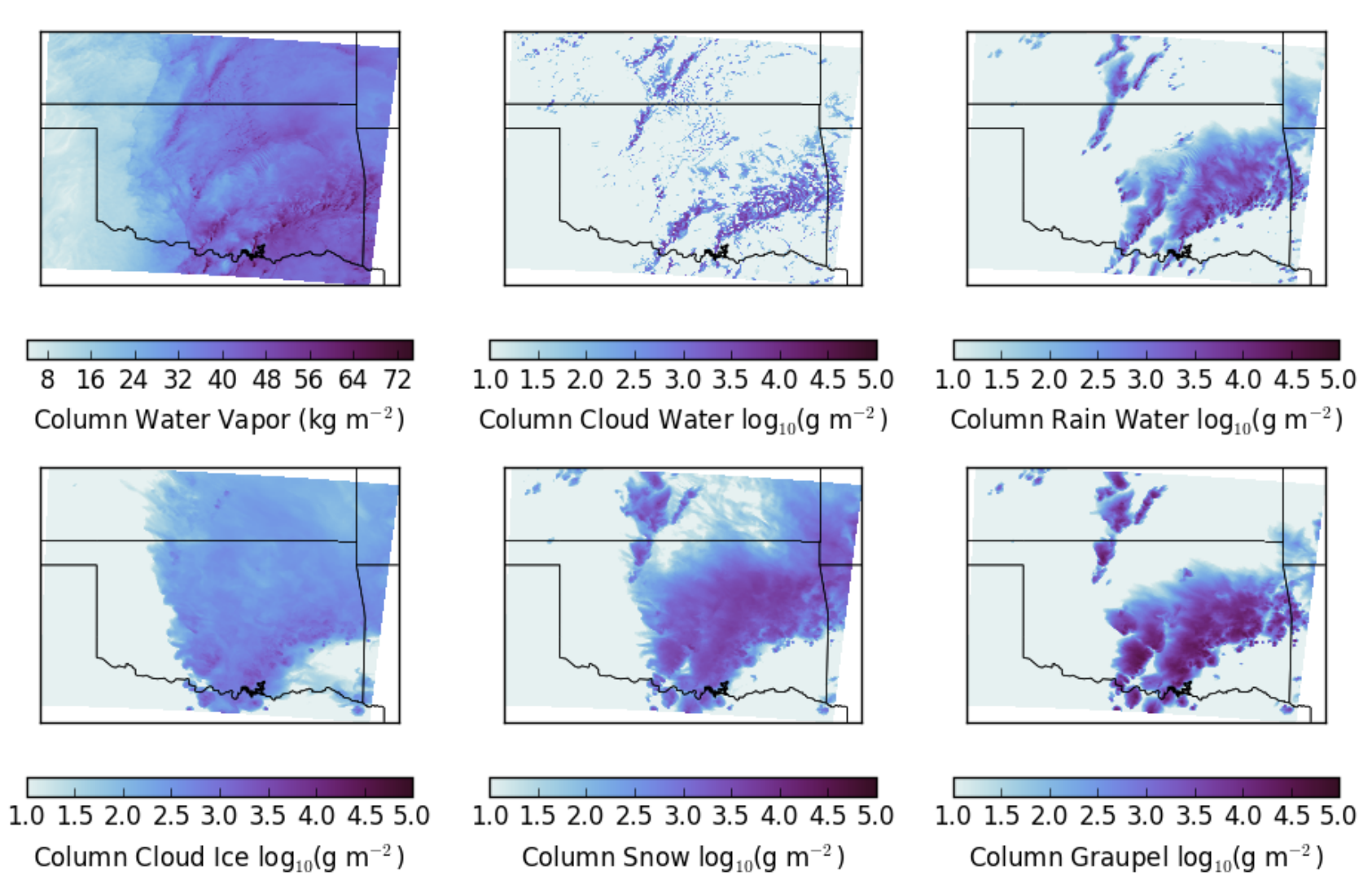


Multiple Scattering Corresponds to Graupel

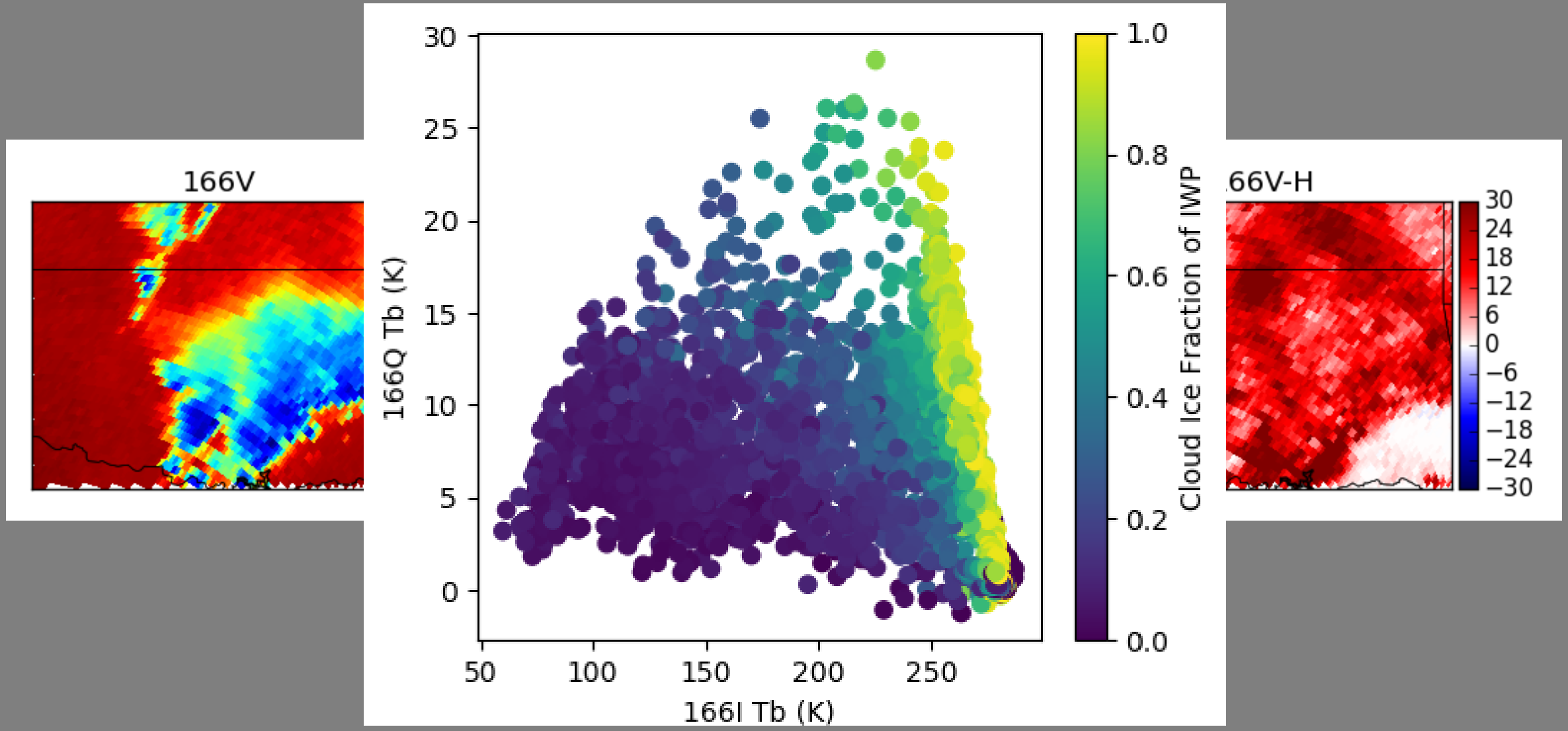




Radiometer Simulations: (MC3E 20110520, 2300 UTC)



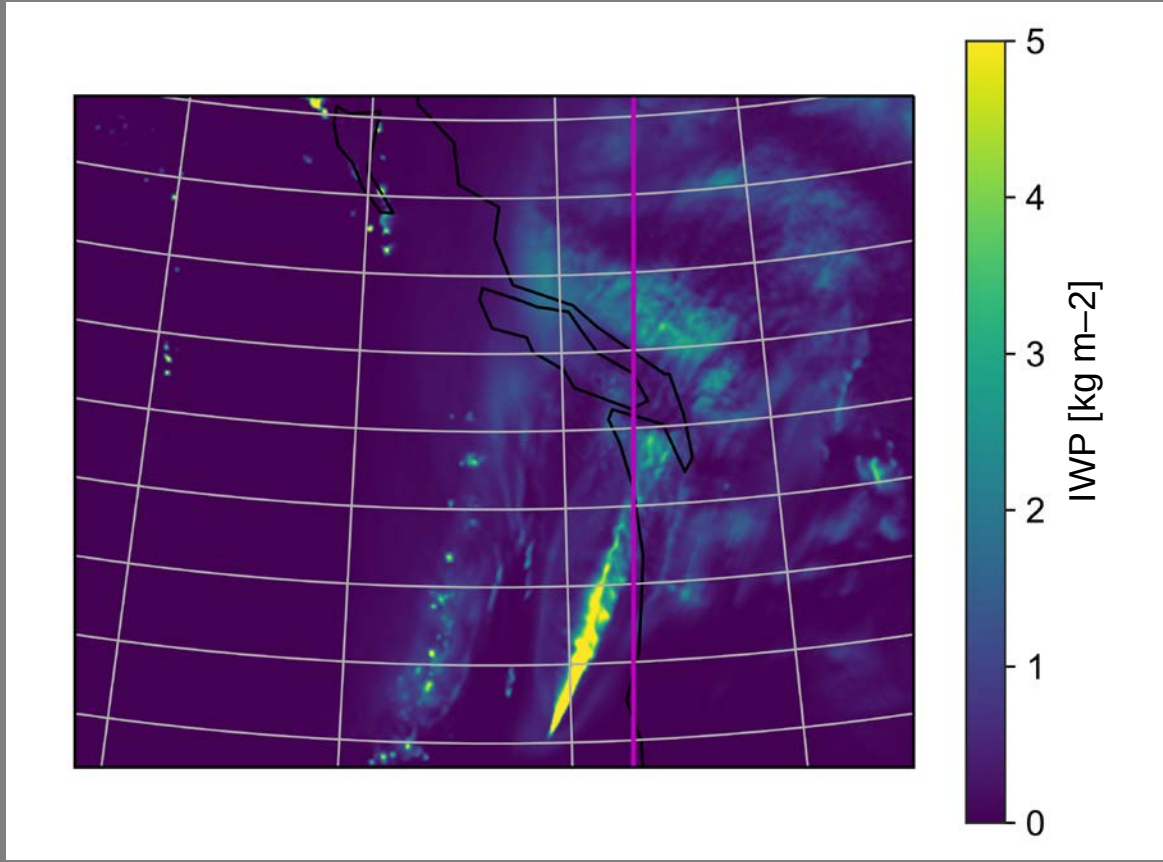
GMI-Like 166 GHz Polarization Difference



Radiometer Simulation (OLYMPEX, 20151203, 1500 UTC)

Simulate 166 GHz polarization difference

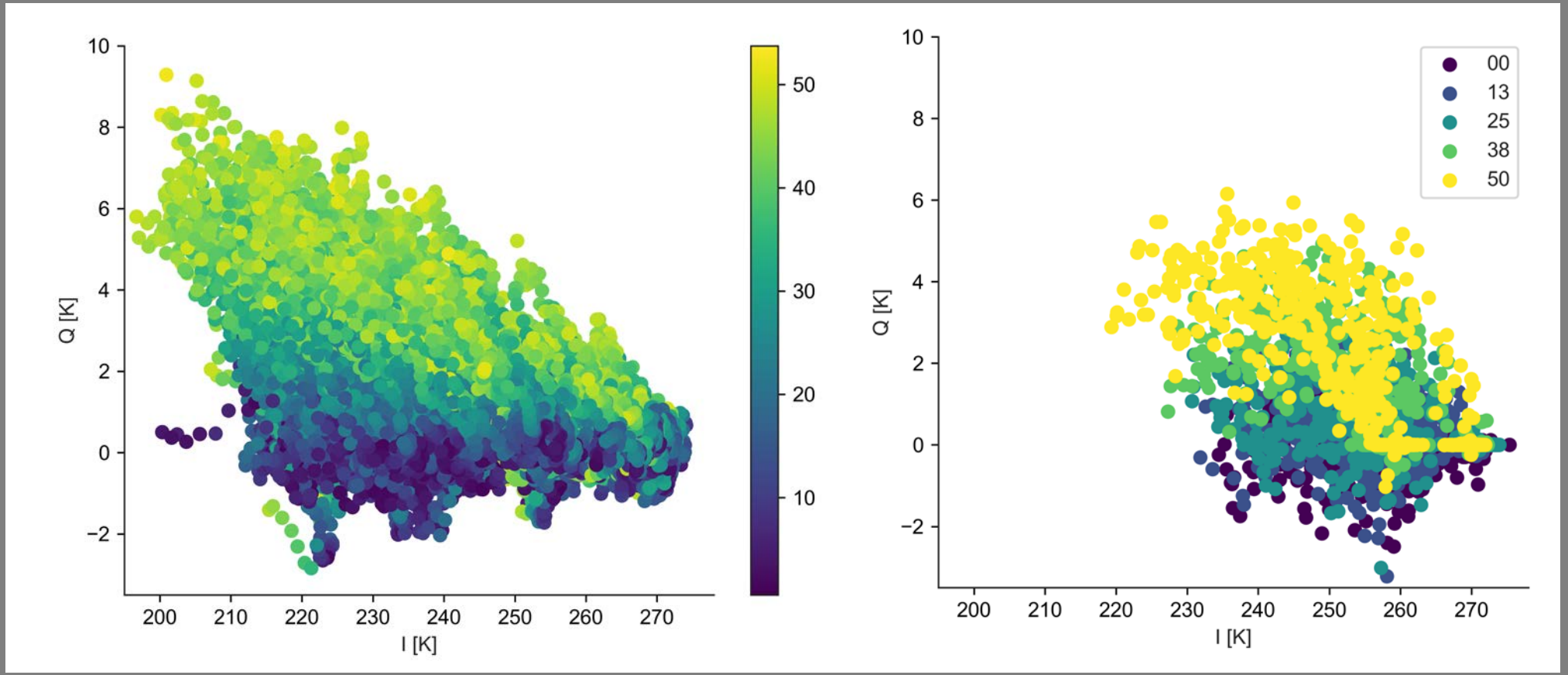
- Corresponds to the presence of aligned ice crystals
- Look at trends for both simulations and observations
- Simulations can tolerate lower resolution
  - Larger domain



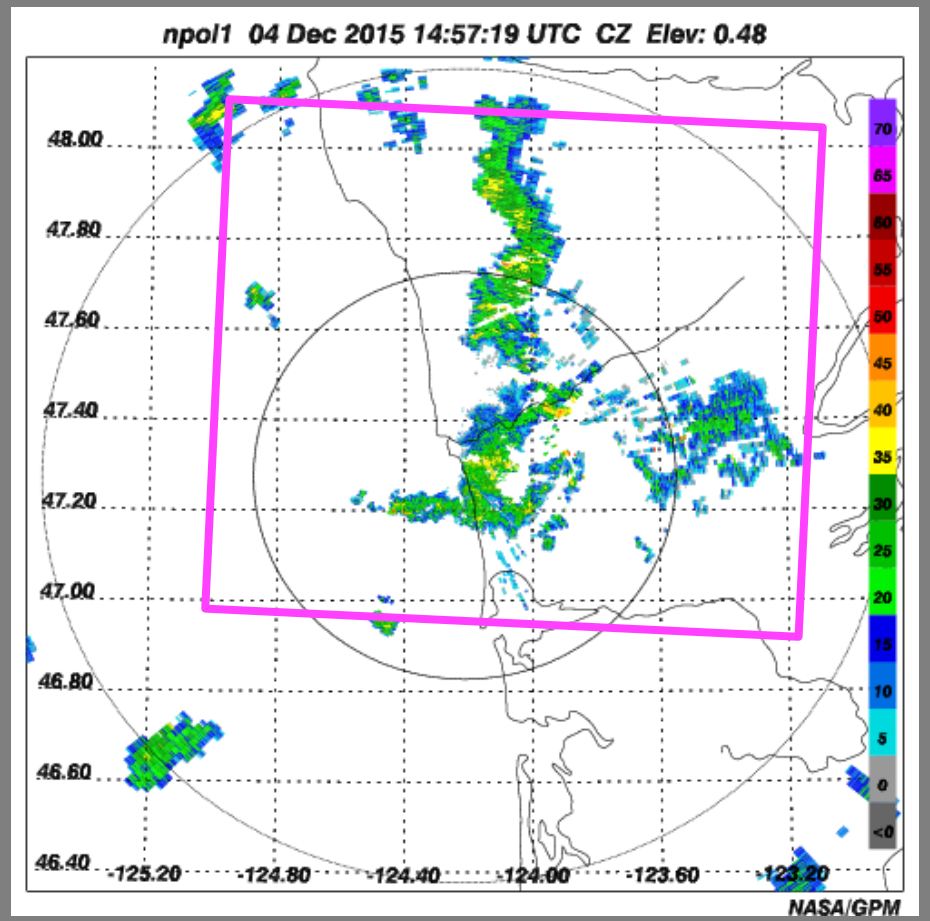
Radiometer Simulation (OLYMPEX, 20151203, 1500 UTC)

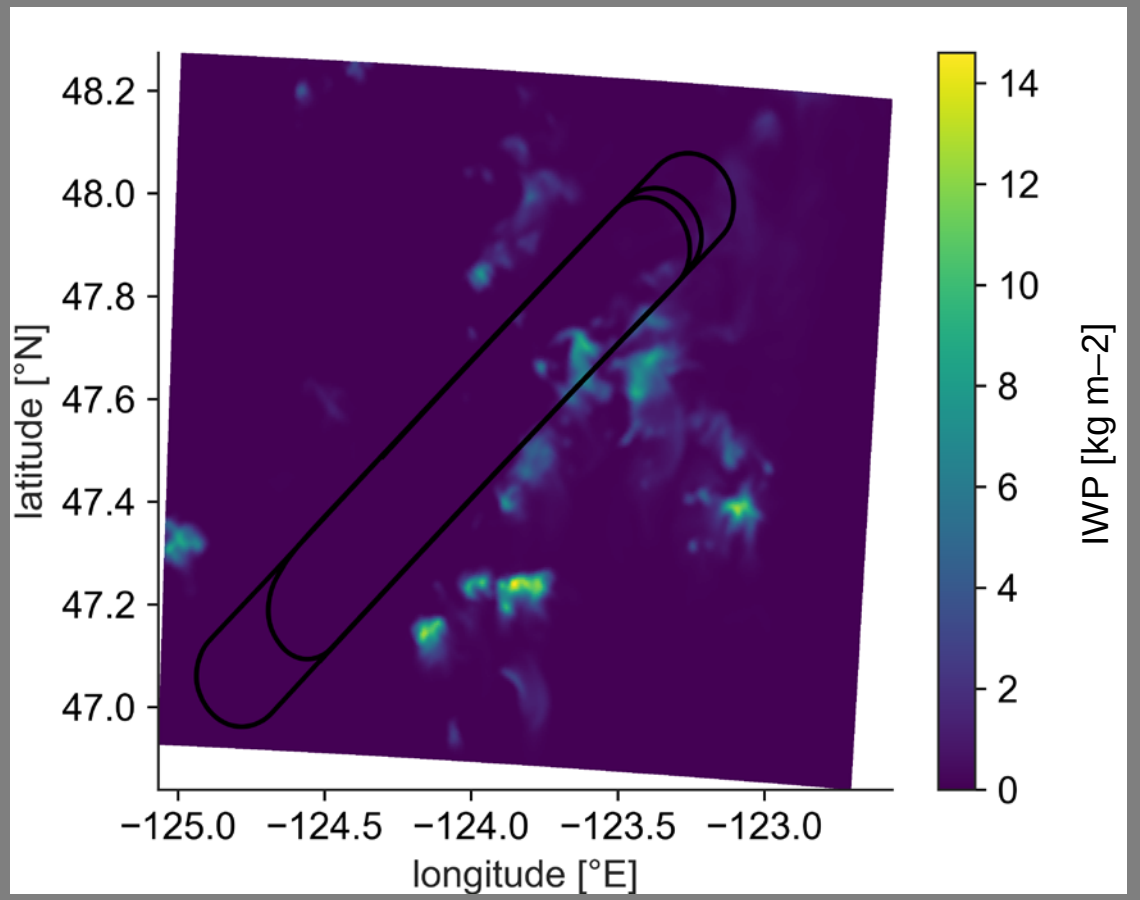
CoSMIR Observations

Simulations

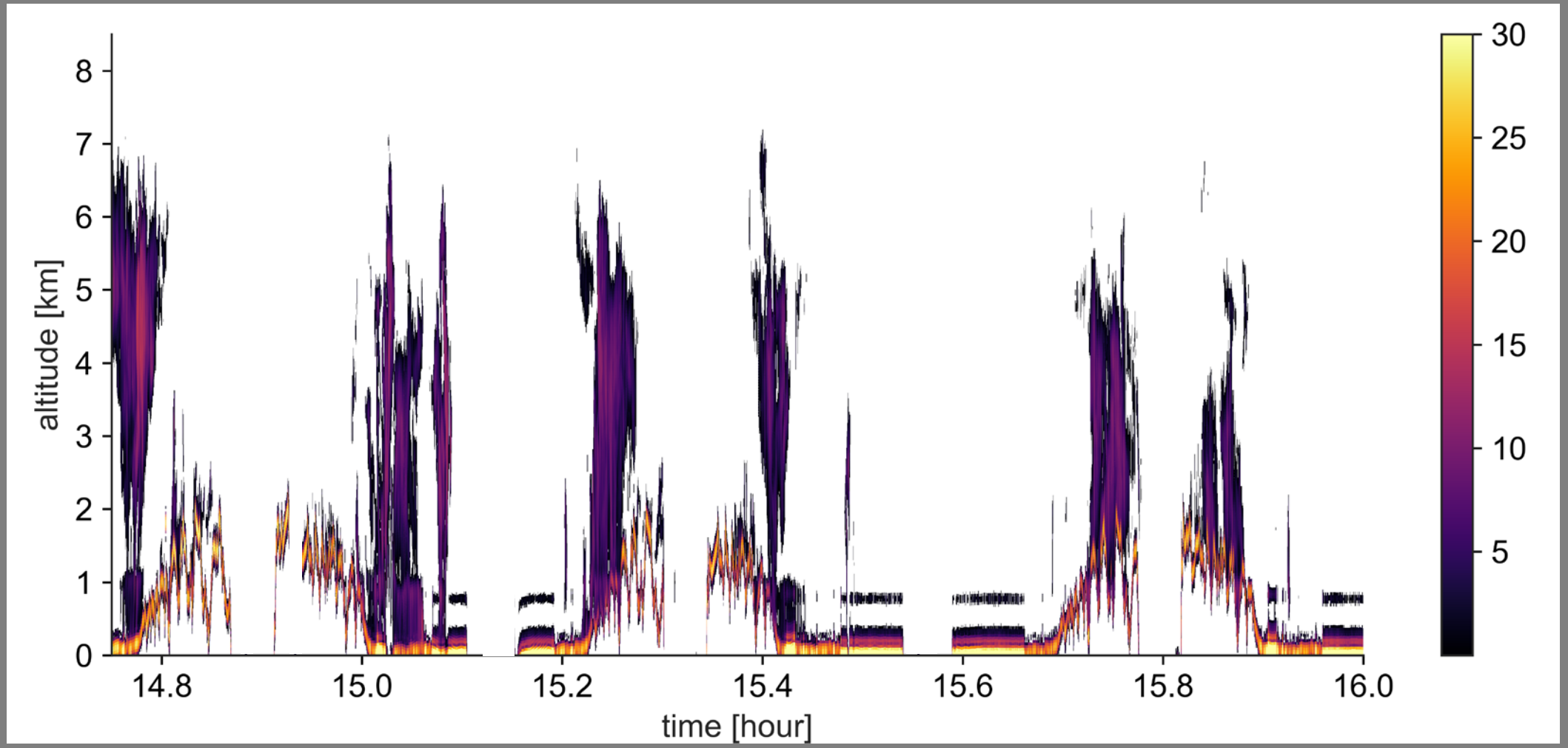


Radar Simulation (OLYMPEX, 20151204, 15:00)

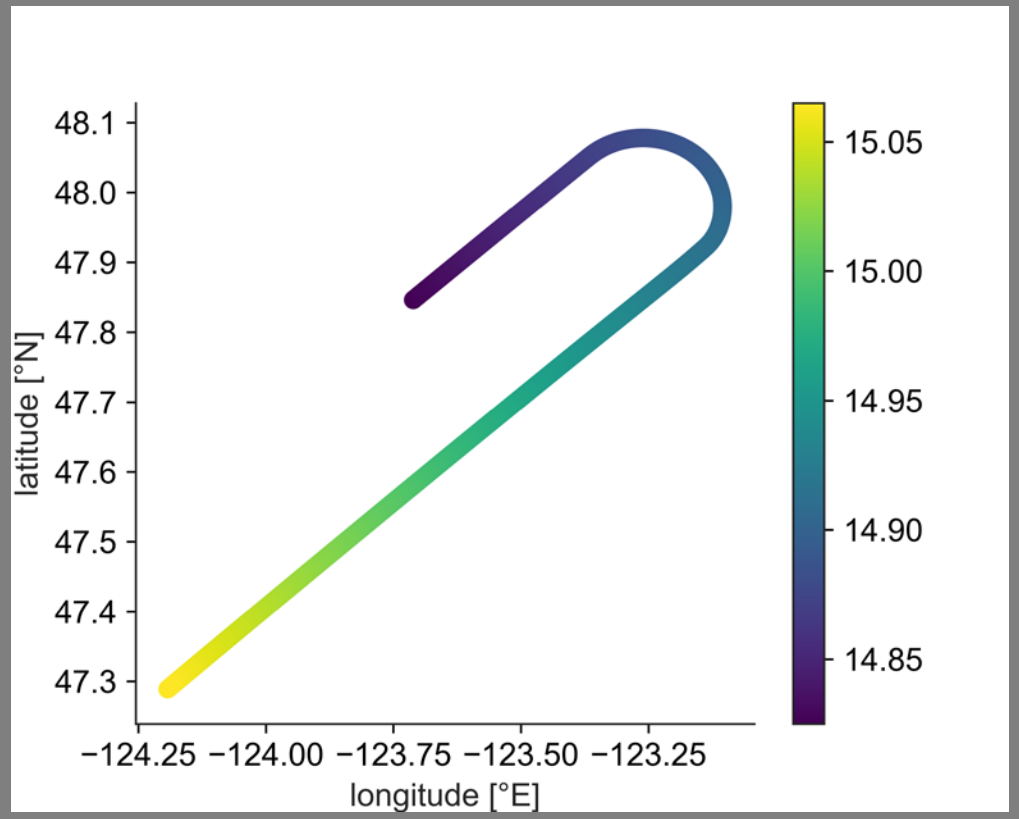


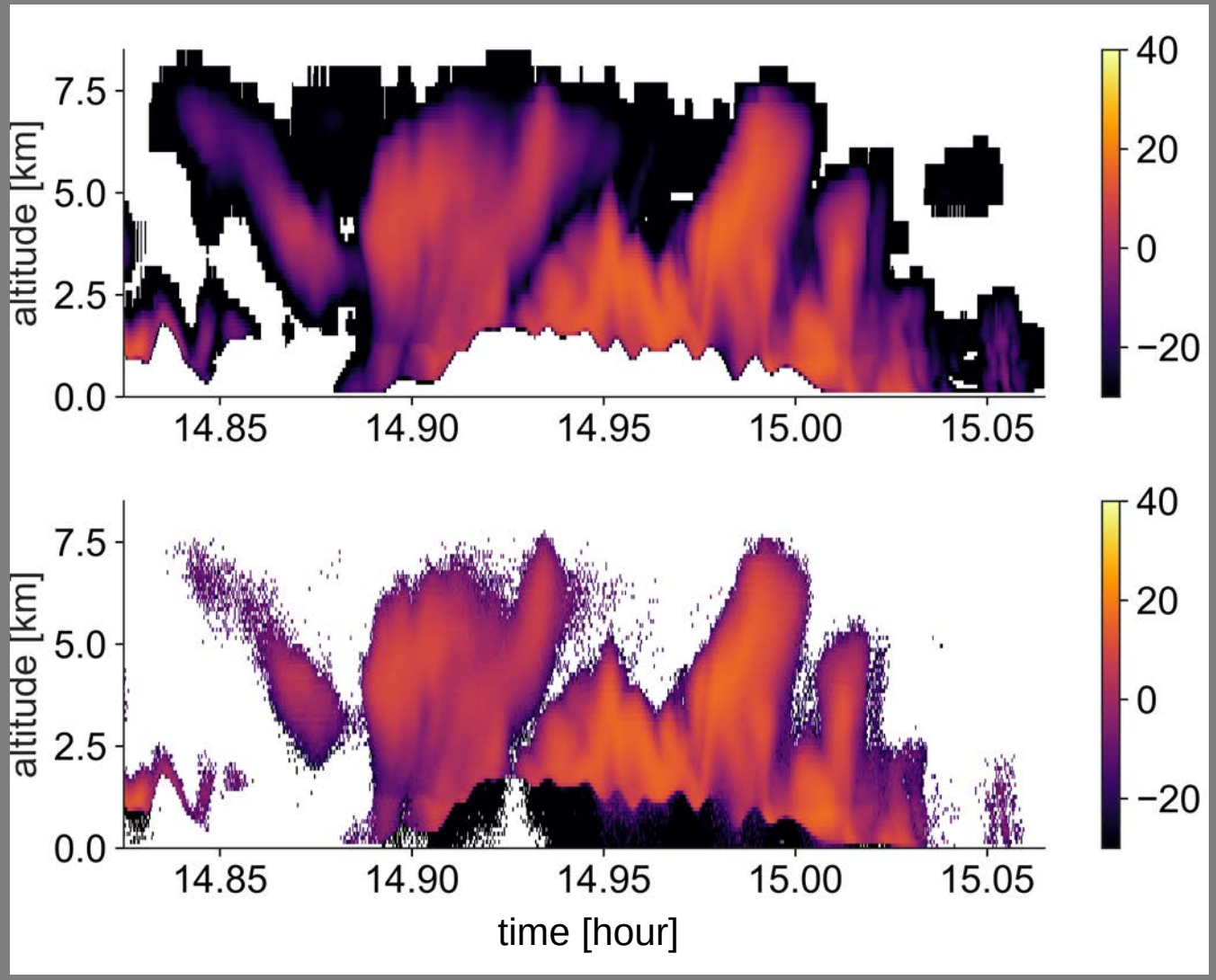


Cloud Radar System Observations

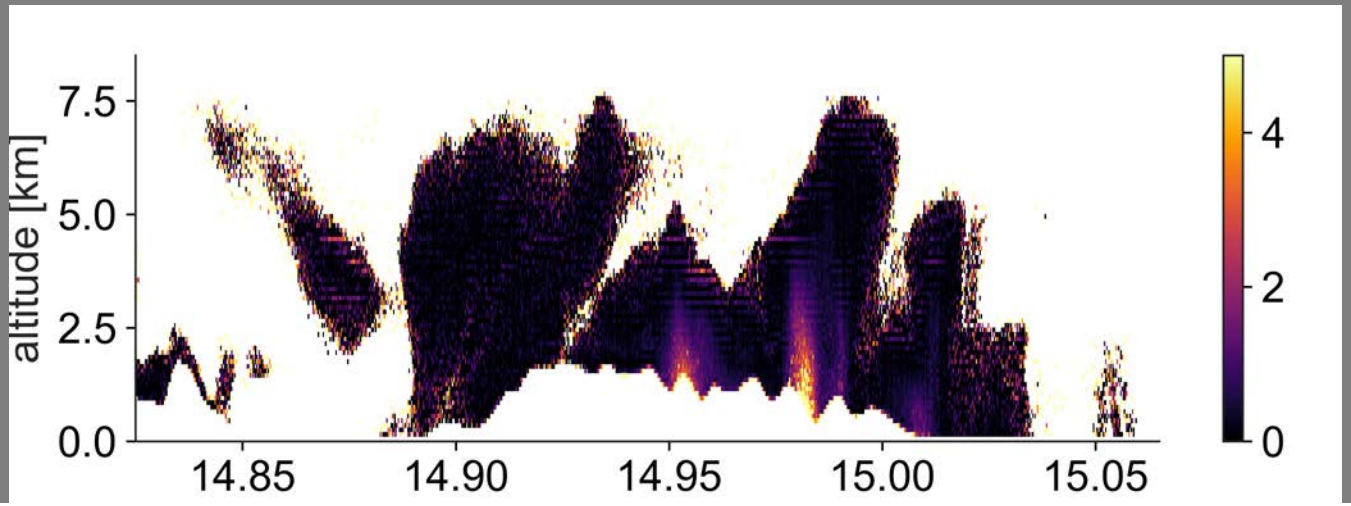


W-band Simulation



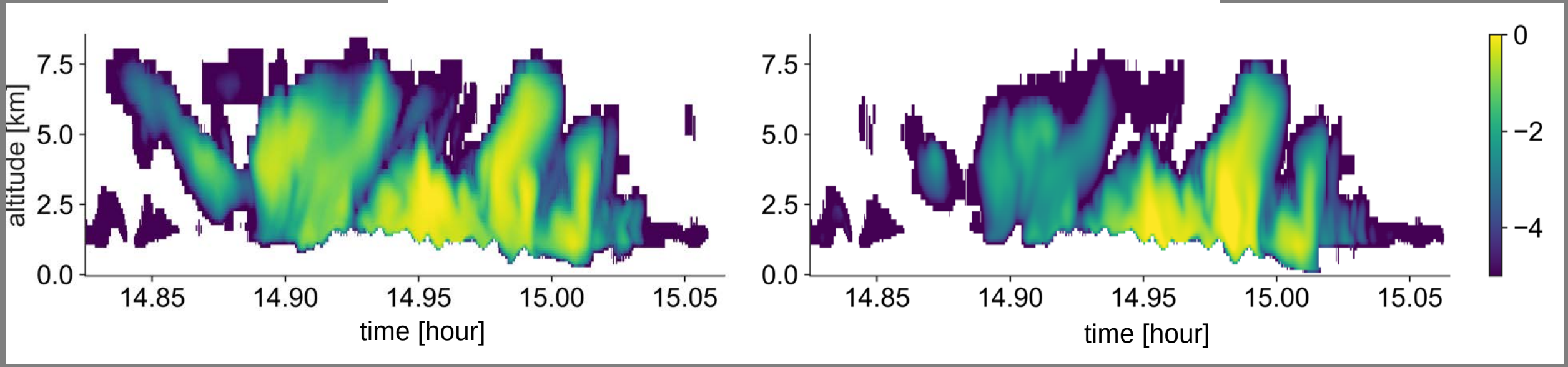


Multiple Scattering Enhancement

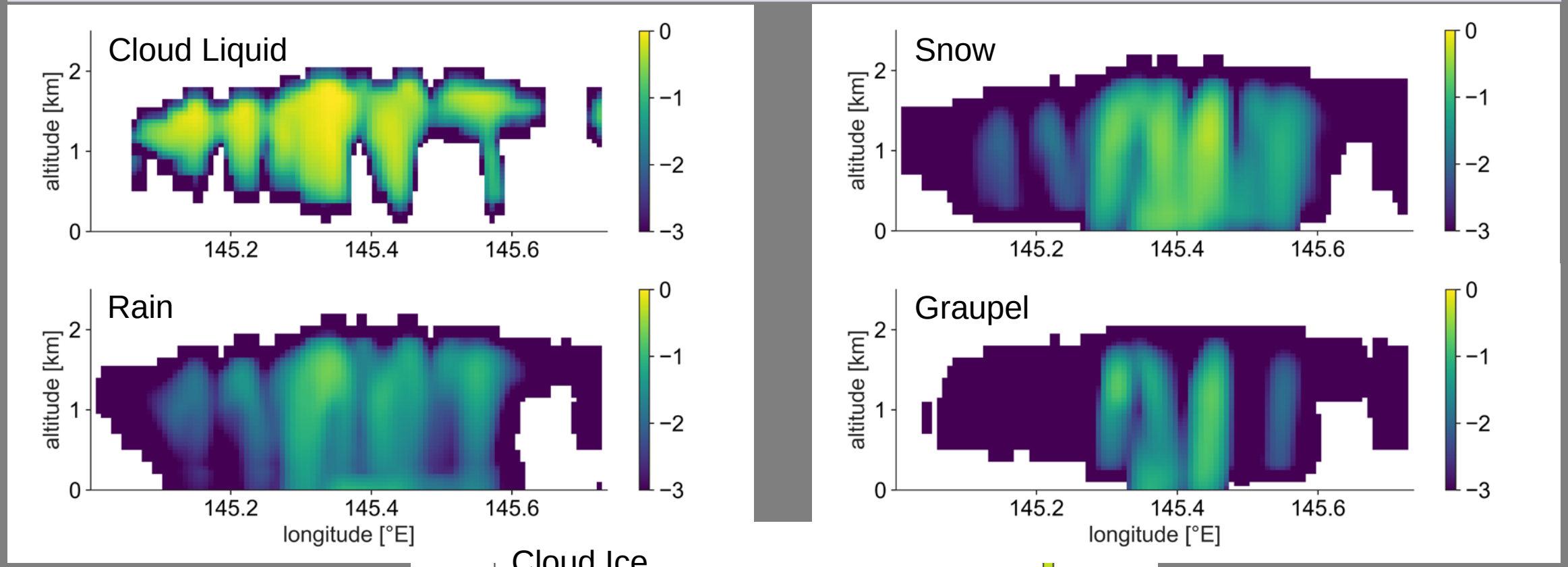


Snow Mixing Ratio

Graupel Mixing Ratio

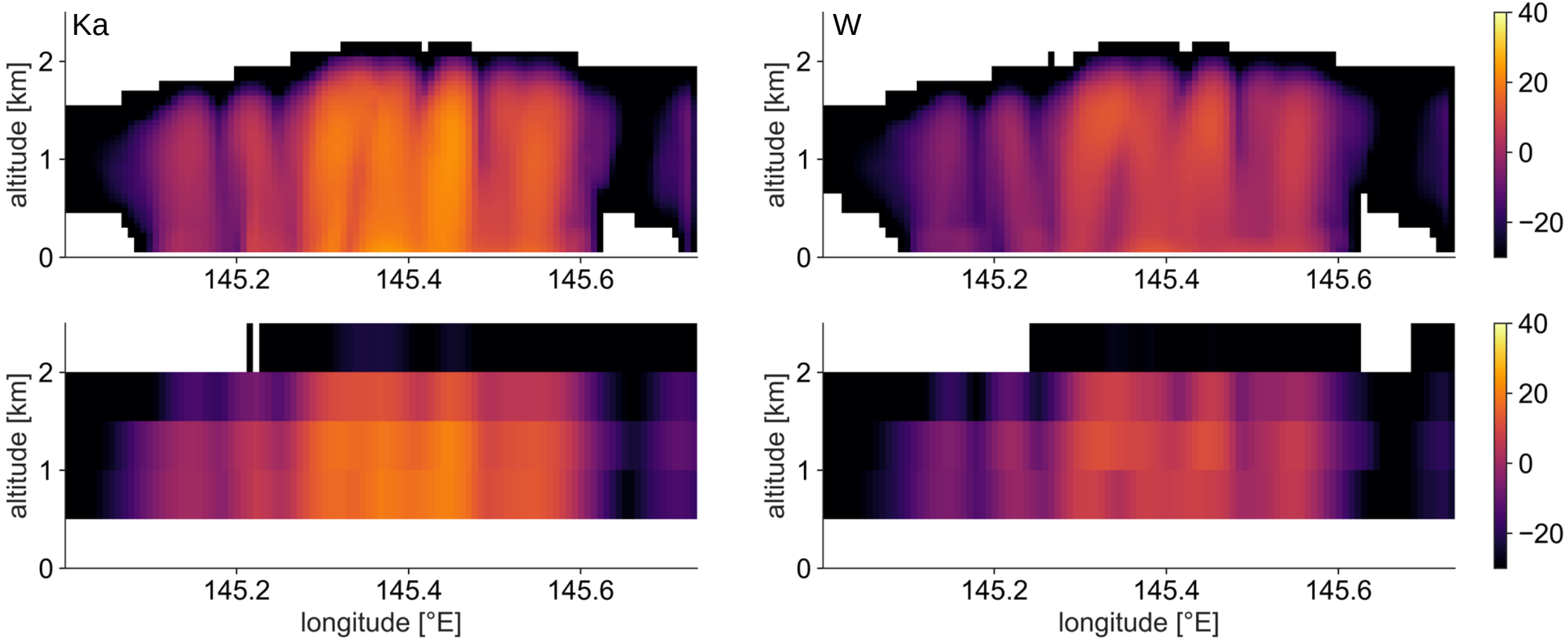


Shallow System: CAPRICORN (06 April 2016, 0200 UTC)



NU-WRF simulation provided by Adrian Loftus

Airborne versus Spaceborne



Future Work

- Interesting microphysics
  - Riming
  - Polycrystals
- Incorporate Inversions
  - 3D Estimation
  - Multi-sensors retrievals
- Include ground radar
- Melting particles
- More aligned ice