Active and Passive Radiative Transfer Modeling of the Olympic Mountains Experiment

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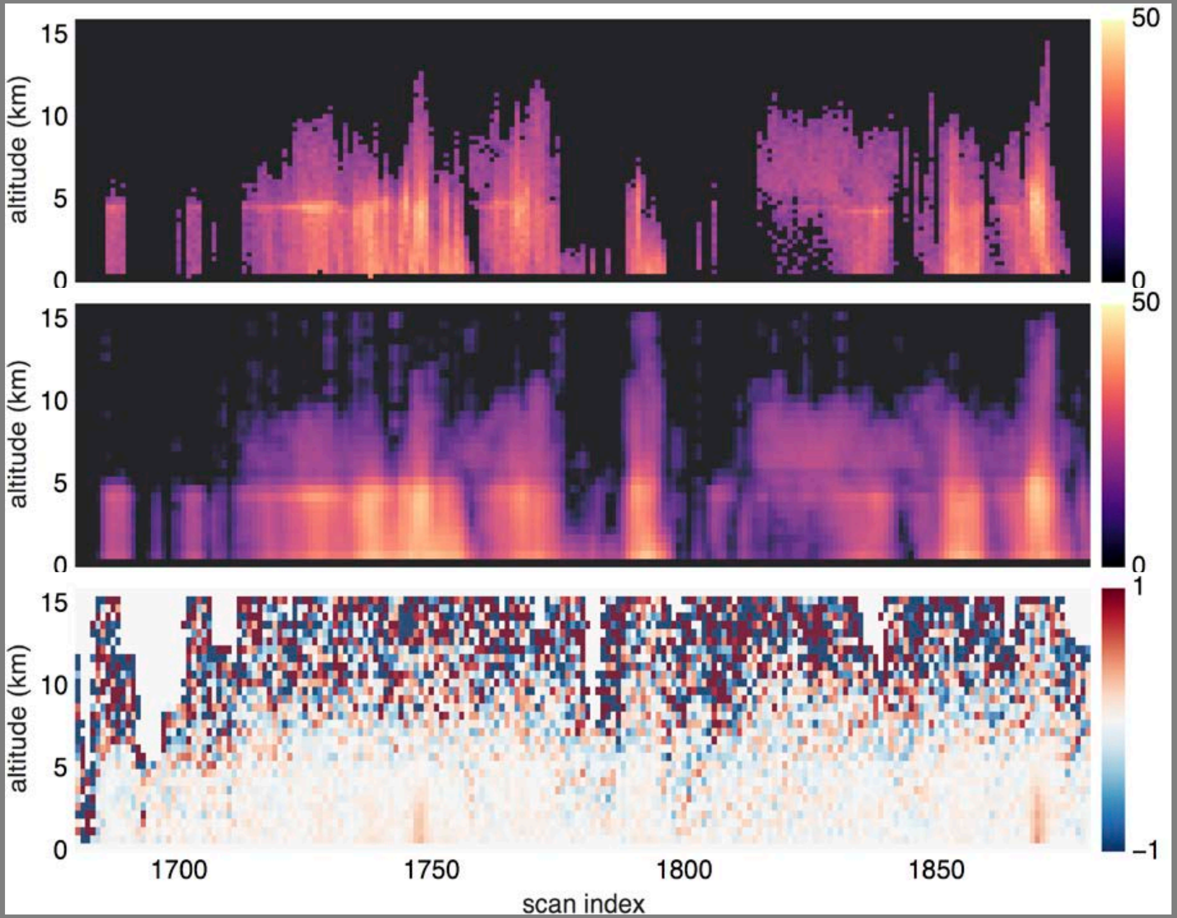
MIIST 3D Forward Model

TRMM Overpass of Tropical Cyclone Asma

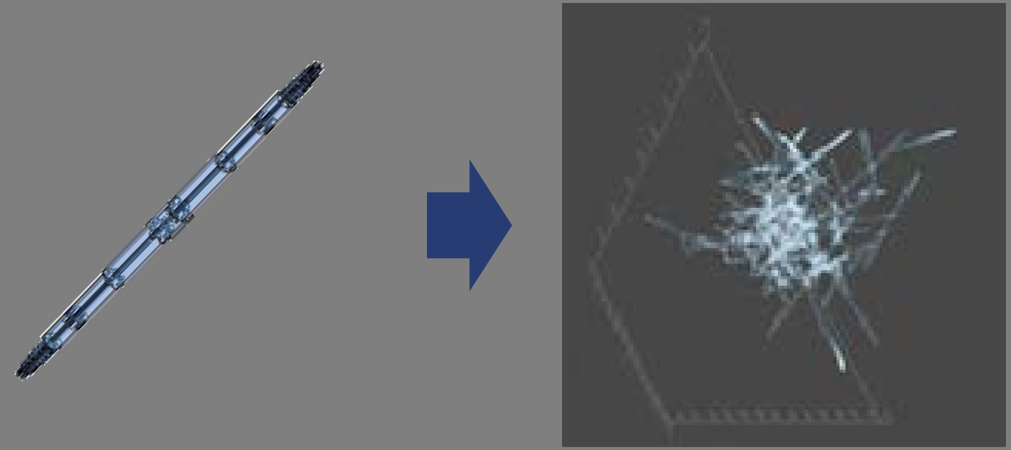


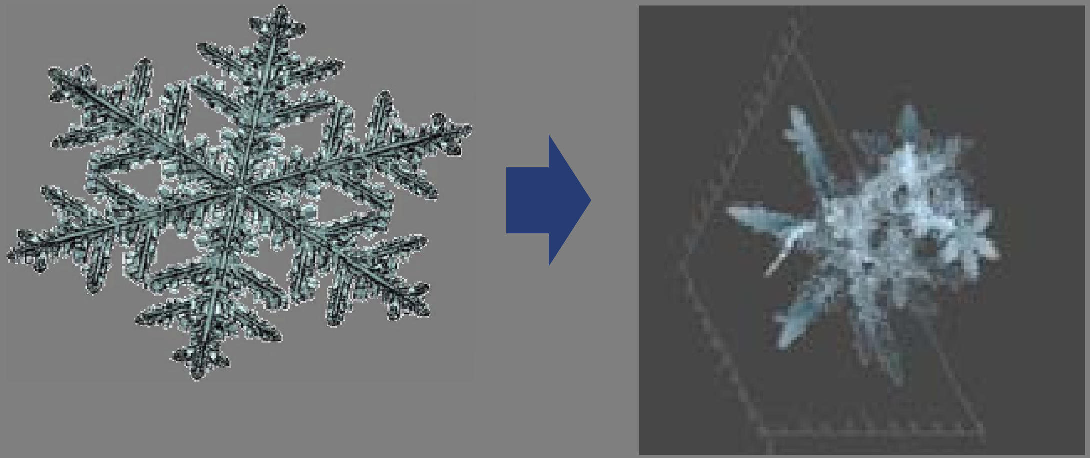
The Multi-Instrument Inverse Solver Testbed (MIIST) uses the Atmospheric Radiative Transfer Simulator (ARTS) for solving the vector radiative transfer (RT) equation in up to three spatial dimensions within a spherical geometry

- 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)

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

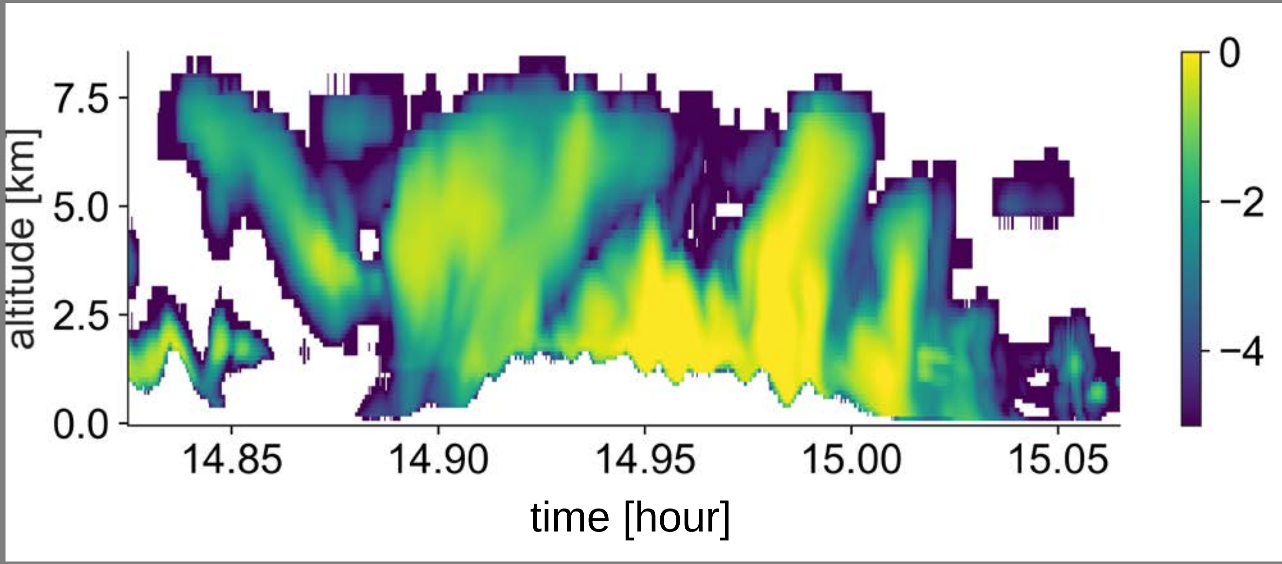
- Requires full Stokes matrices
  - And absorption vector
- Randomly oriented particles
  - Discrete Dipole Approximation
  - Characteristic Basis Function Method (coming soon)
- Horizontally-oriented plates
  - Invariant Imbedding T-matrix Method

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

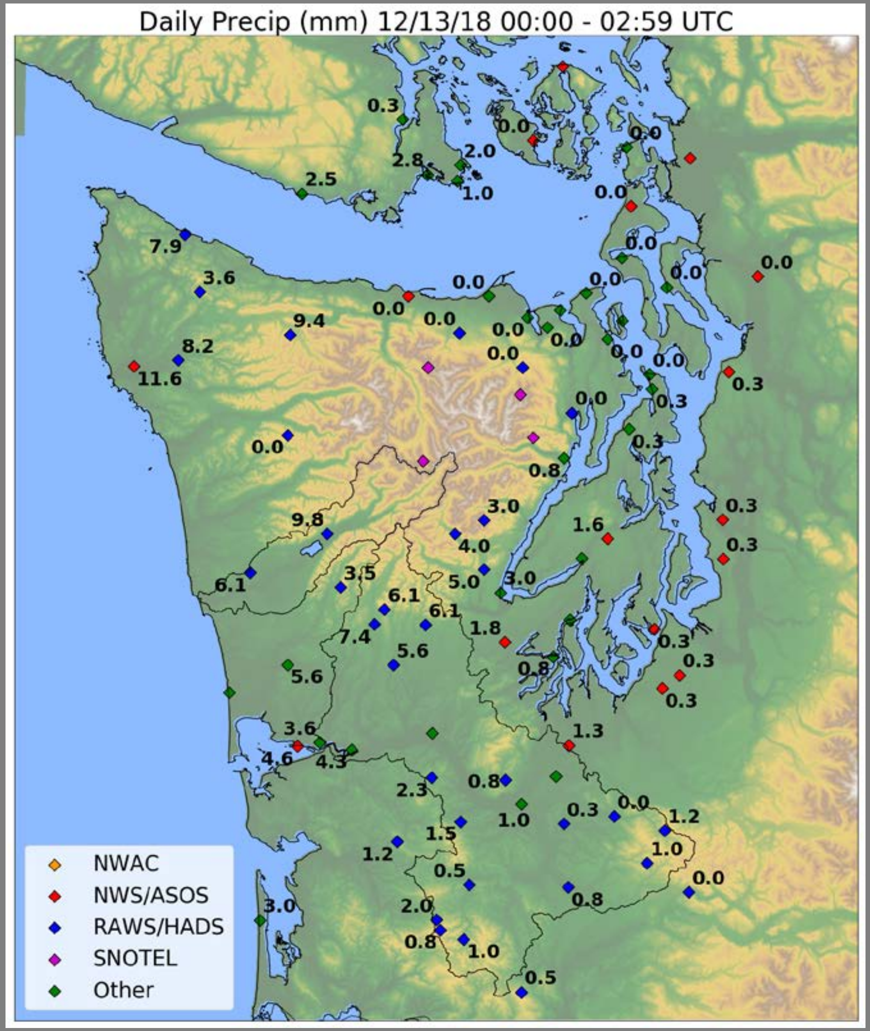
Total Water Mixing Ratio



The Olympic Mountains Experiment (OLYMPEX)

Validation for GPM of mid-latitude frontal systems approaching near-coastal mountains from the ocean

- Large collection of ground-based and airborne sensors
  - Radars
  - Radiometers
  - In situ
- Contemporaneous with RADEX
  - Two sets of radar at same frequencies



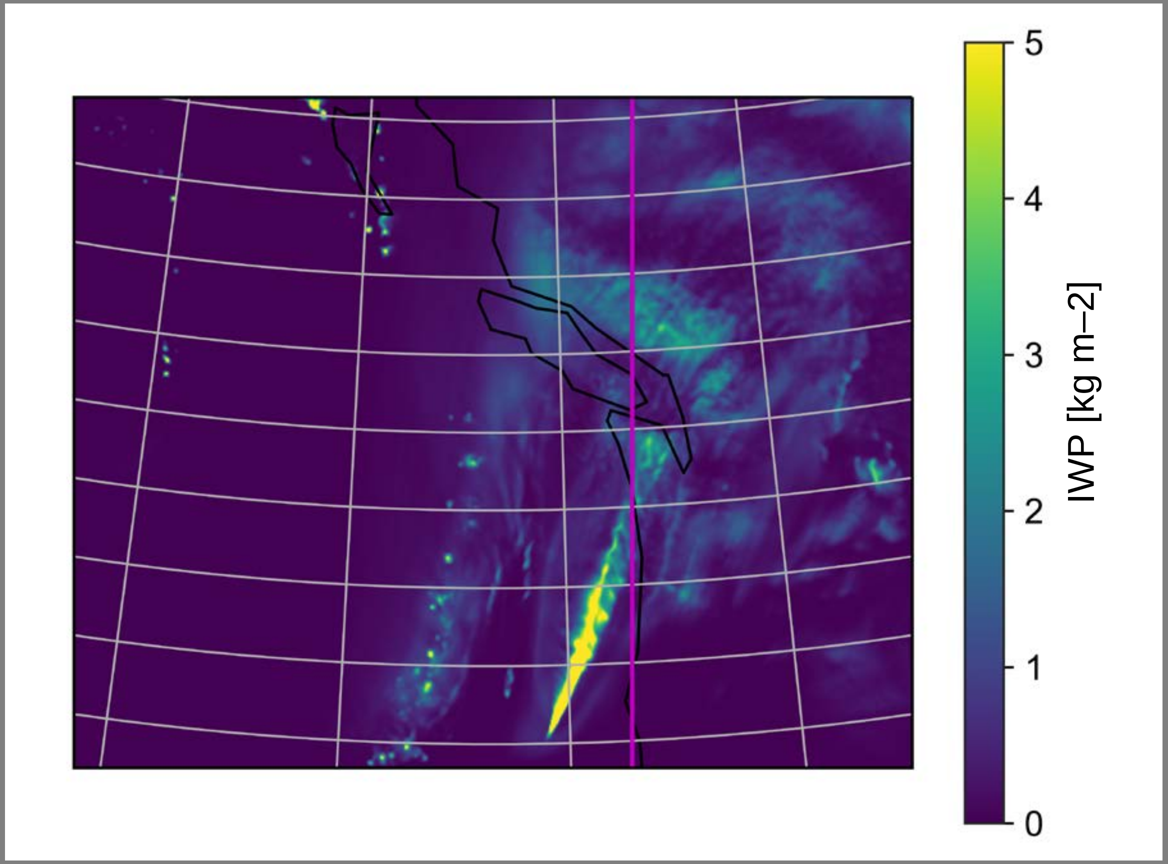
Olympic Mountains Experiment (OLYMPEX)

DC-8	Citation	ER-2 (Radar Definition Experiment)
CoSMIR 50, 89, 165, 183 +/- 1, 3, 8 GHz Conical and cross track scans Fixed polarization basis	**King Hot Wire Probe** LWC	**AMPR** 10.7, 19.35, 37.1, 85.5 GHz
	CDP Cloud droplet size distribution	**HIWRAP** Ku, Ka bands; Nadir pointing
	2D-S Particle images	**CRS** W band; Nadir pointing
APR-3 Ku, Ka, W bands (dual polarization) Cross-track scan	**HVPS-3 (x2)** Particle images	**EXRAD** X band; Nadir pointing; Conical scan
	Cloud Particle Imager (CPI)	**AirMSPI** 8 bands (355-935 nm)
	CSI Cloud water content	**CPL** 355, 532, 1064 nm
Dropsondes Pressure Temperature Relative humidity Wind	**2DC** Particle images	**eMAS** 38 bands (0.4-15 µm)
	Nevzorov Total water content	
	Rosemonunt Icing Probe	

Radiometer Simulation (3 km NUWRF, 20151203, 15:00)

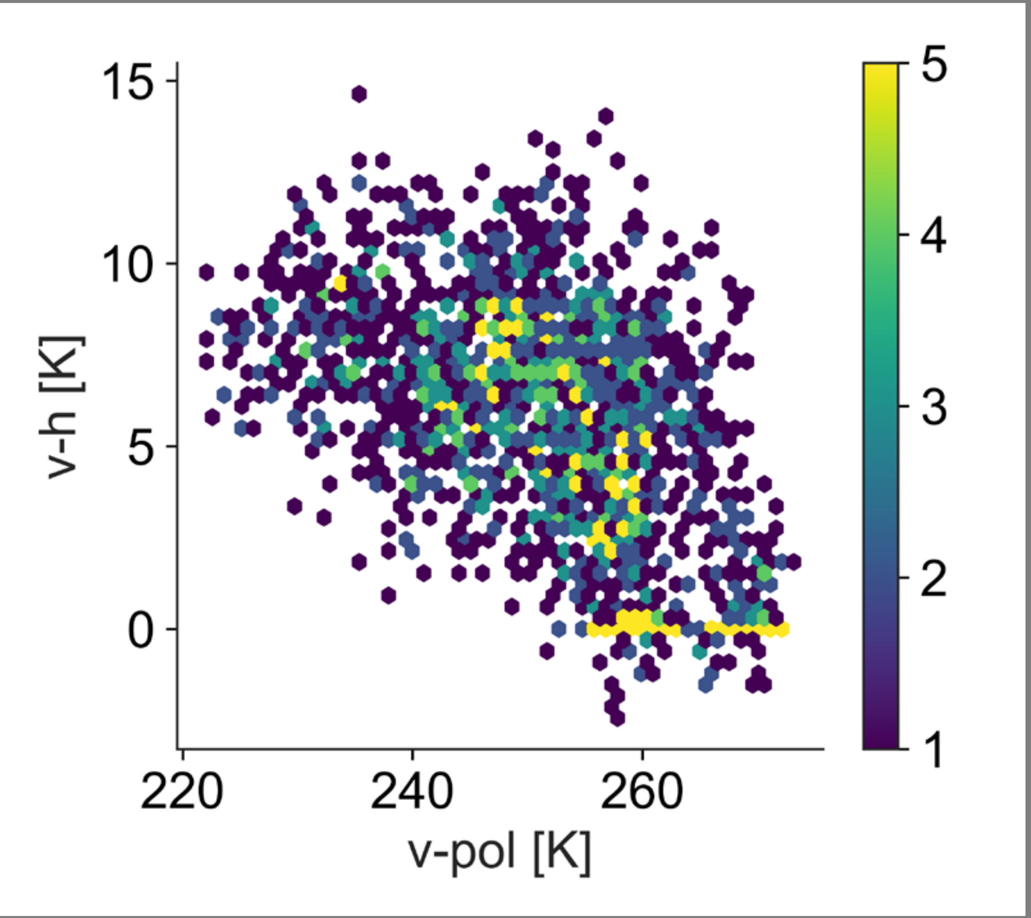
Simulate 166 GHz polarization difference

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

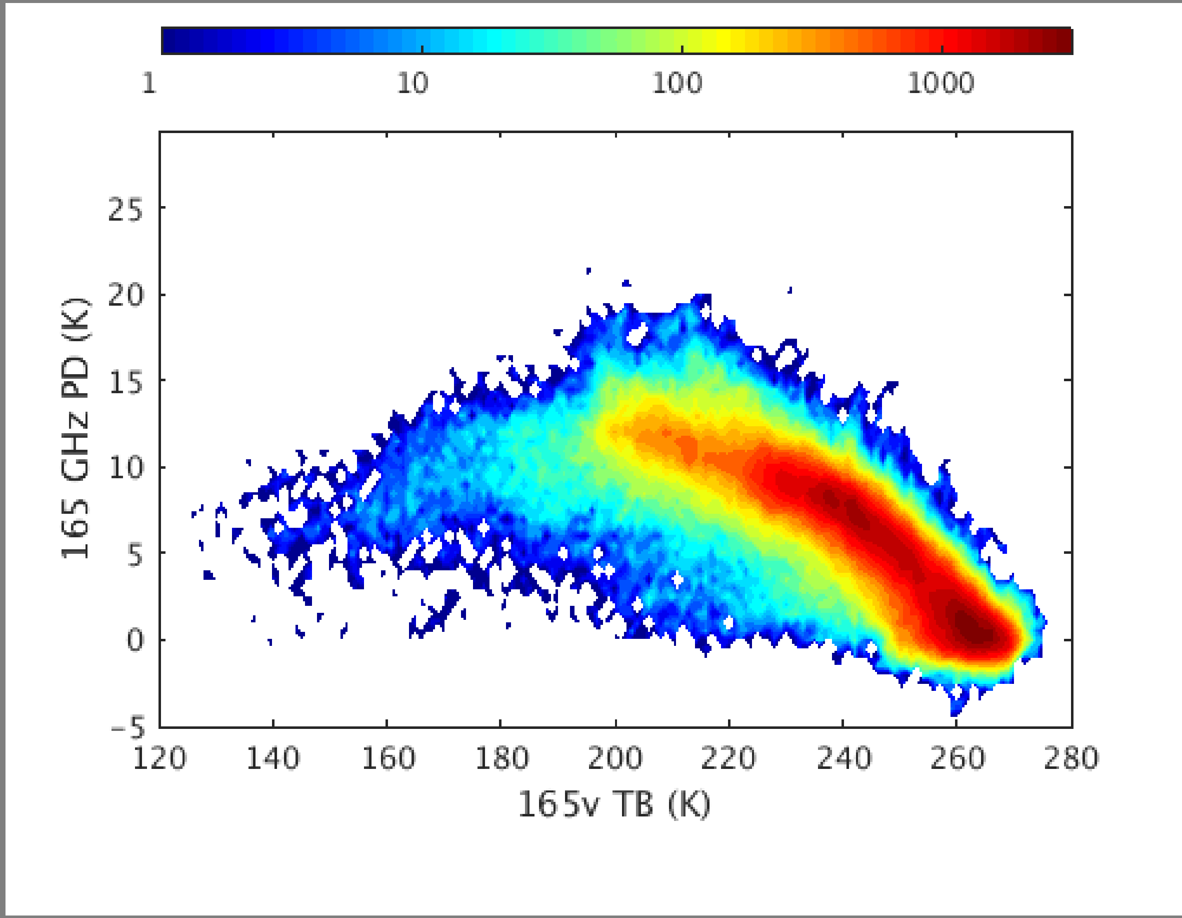


Radiometer Simulation (3 km NUWRF, 20151203, 15:00)

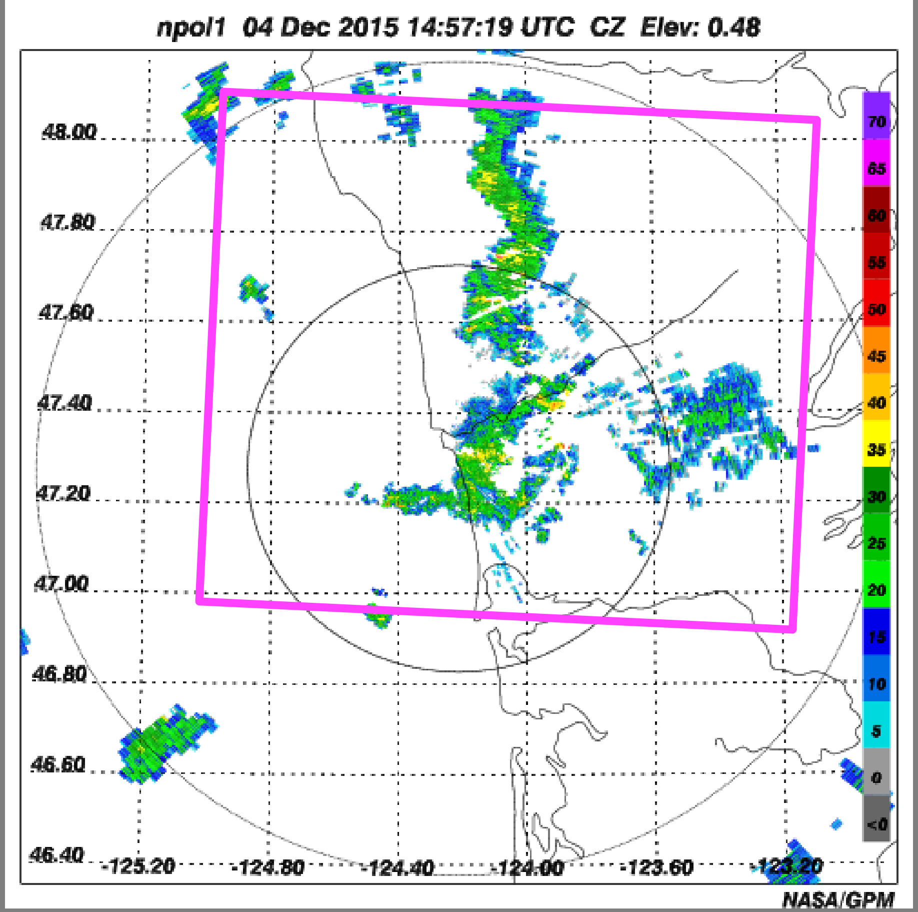
Simulations

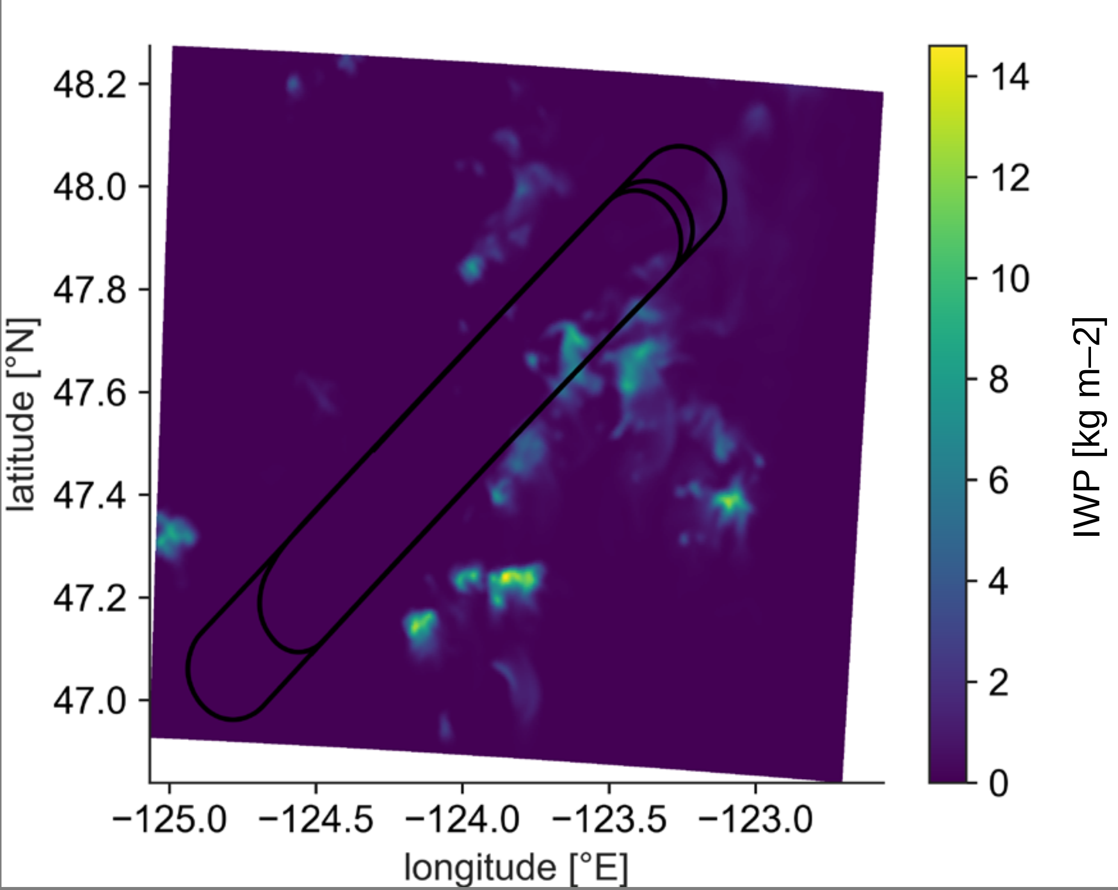


CoSSIR Observations (Entire Campaign)

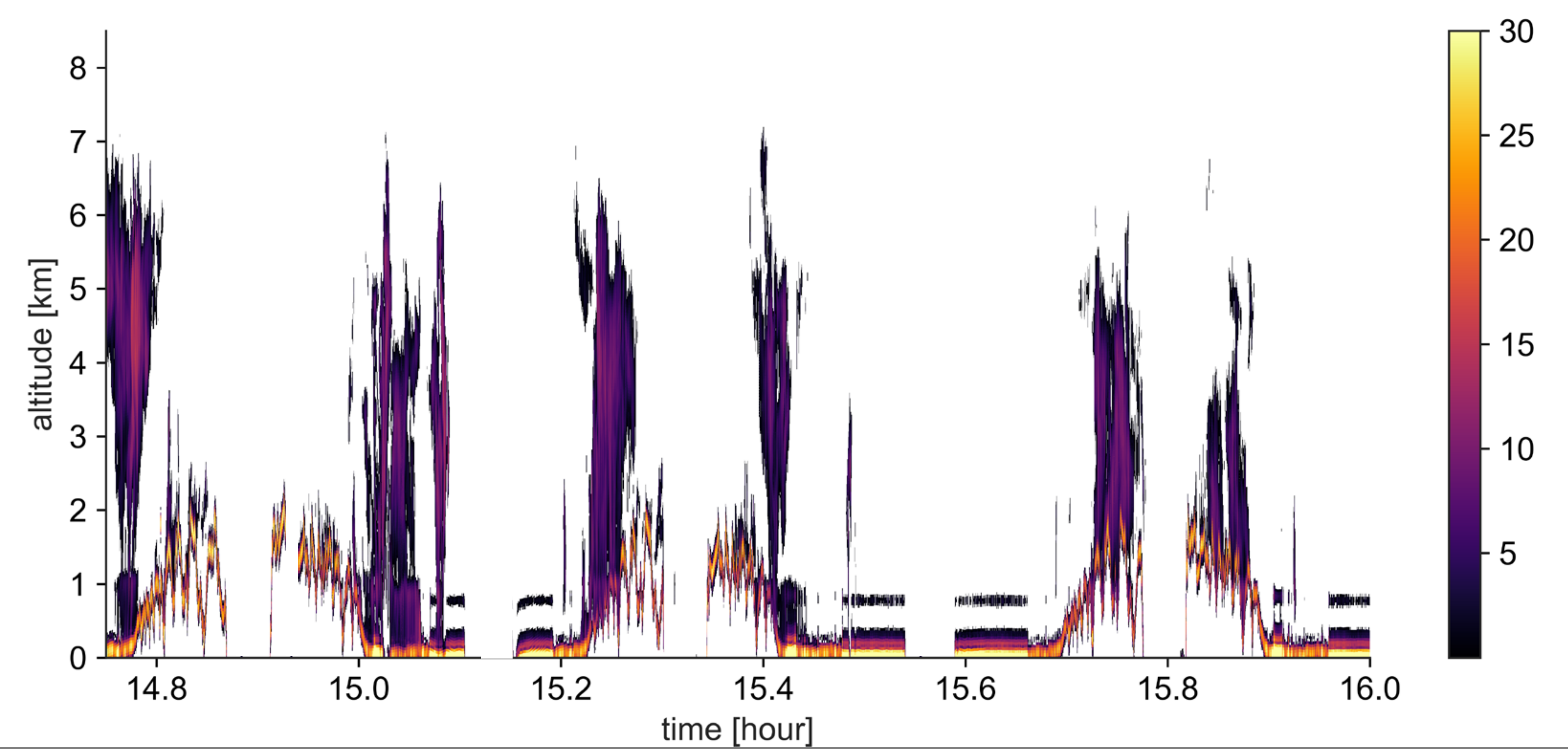


Radar Simulation (0.5 km NUWRF, 20151204, 15:00)

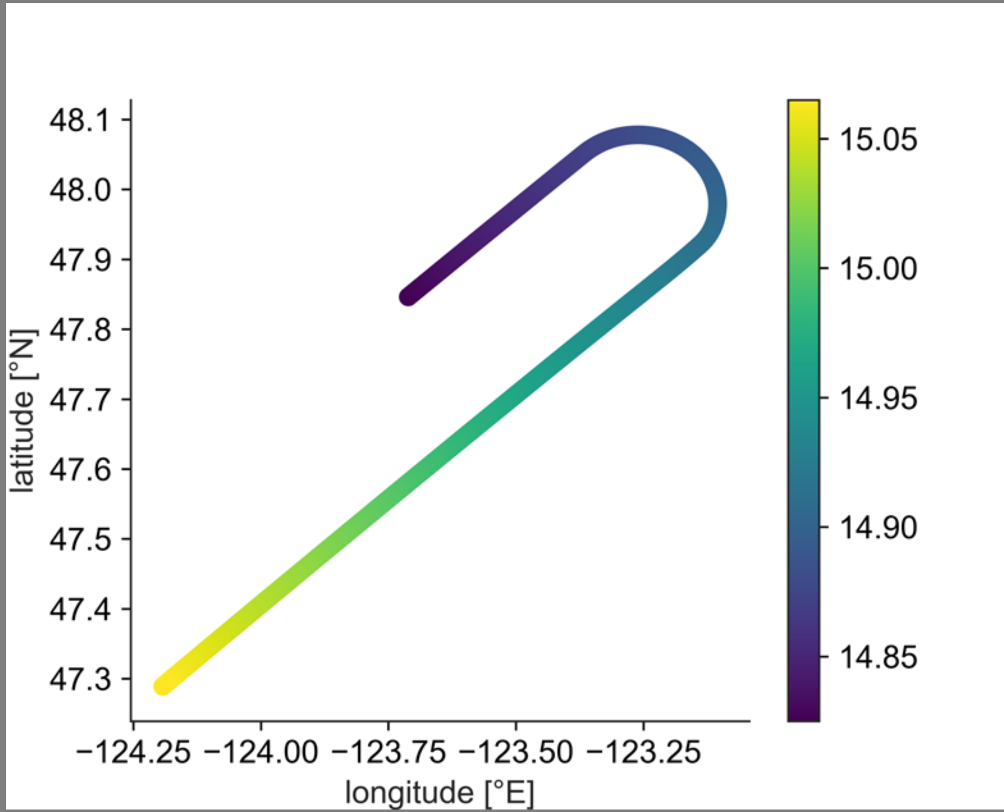


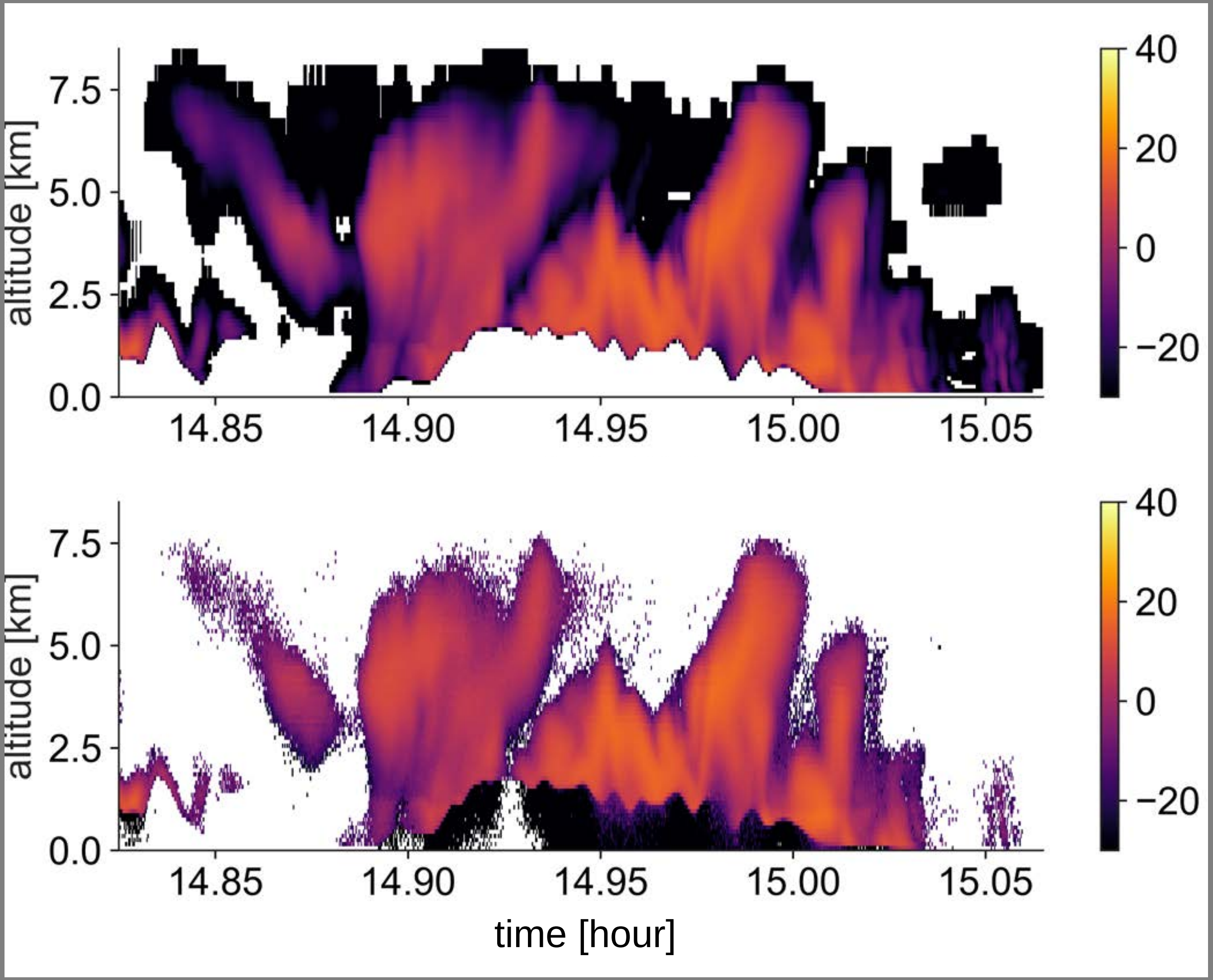


Cloud Radar System Observations

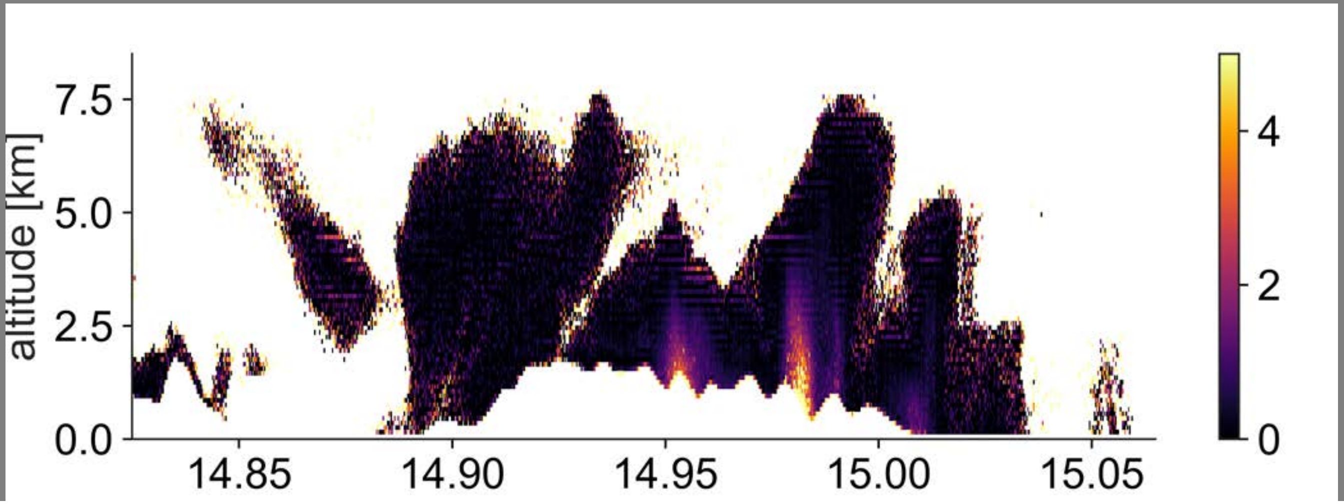


W-band Simulation

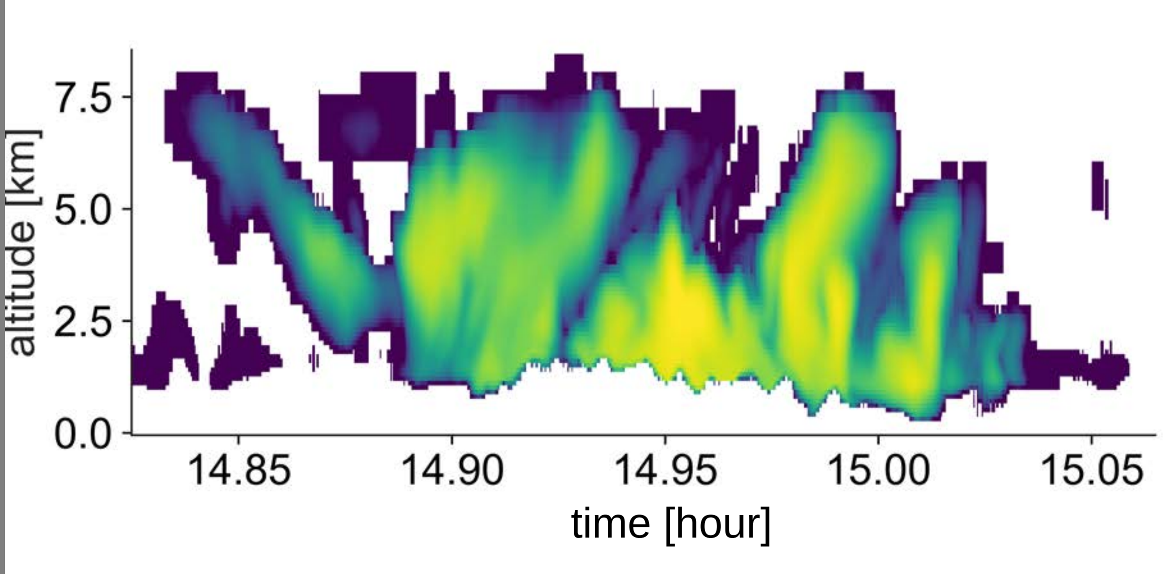




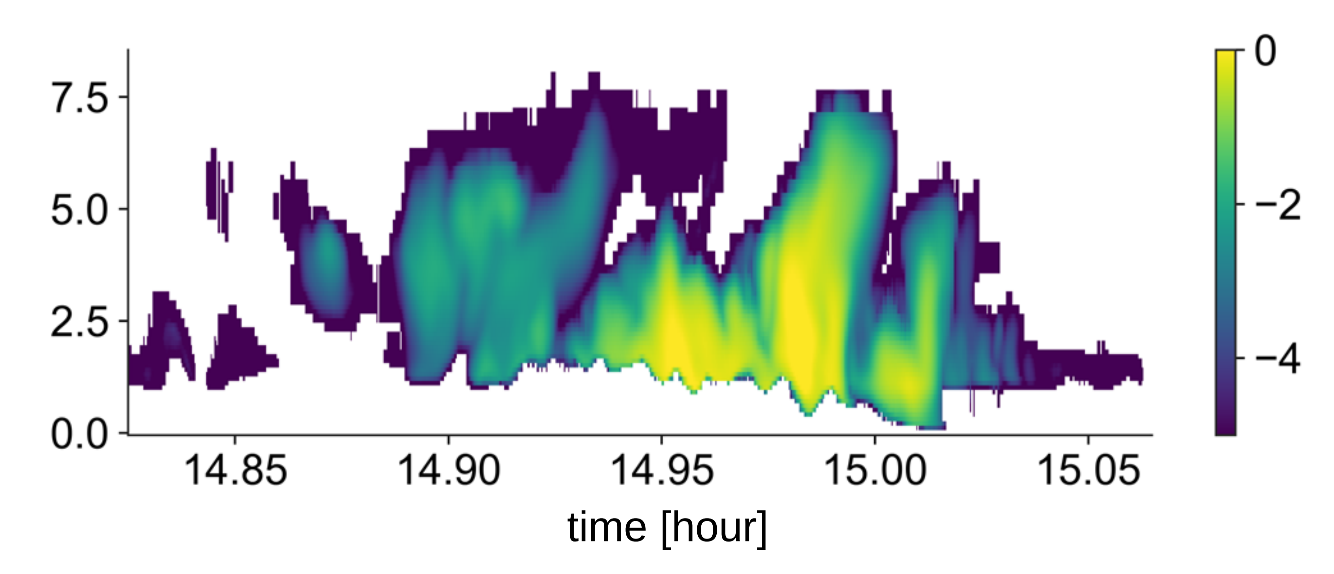
Multiple Scattering Enhancement



Snow Mixing Ratio



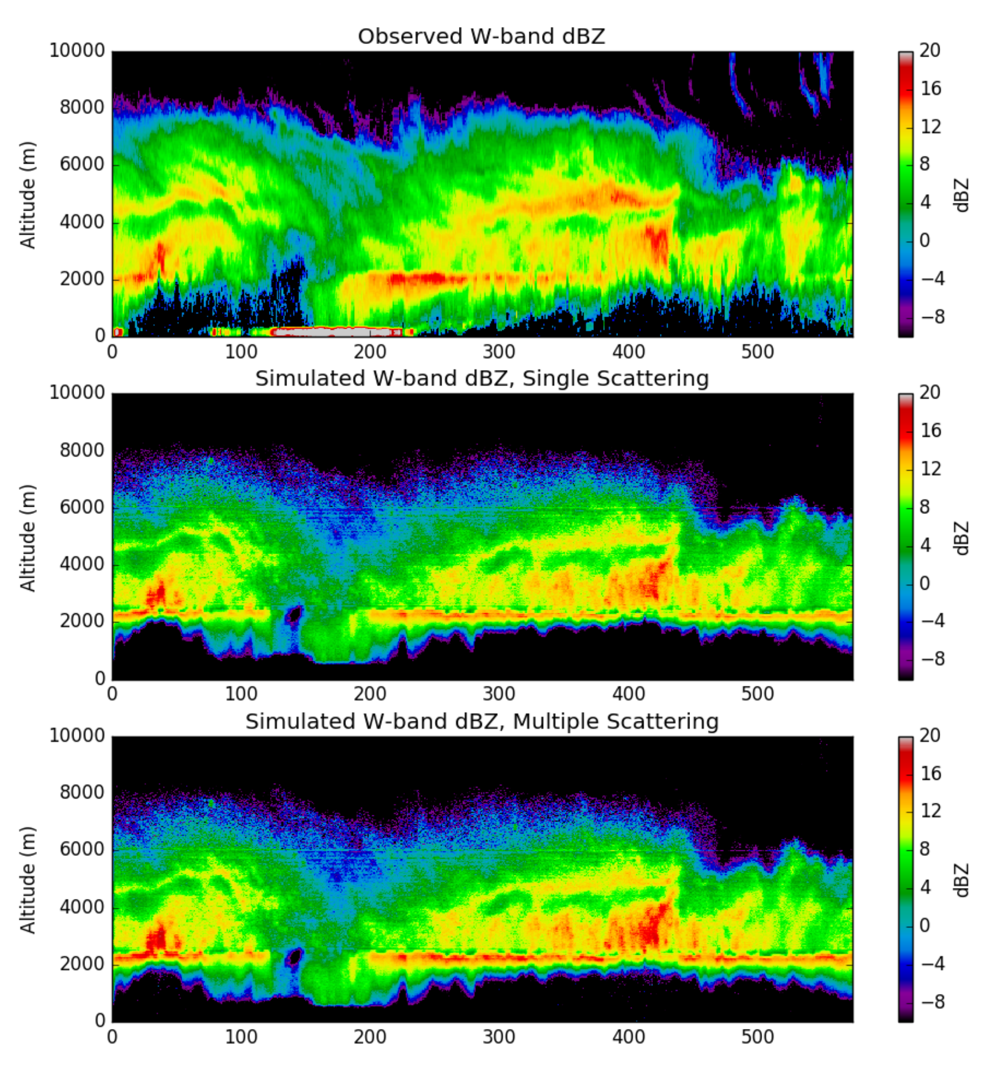
Graupel Mixing Ratio



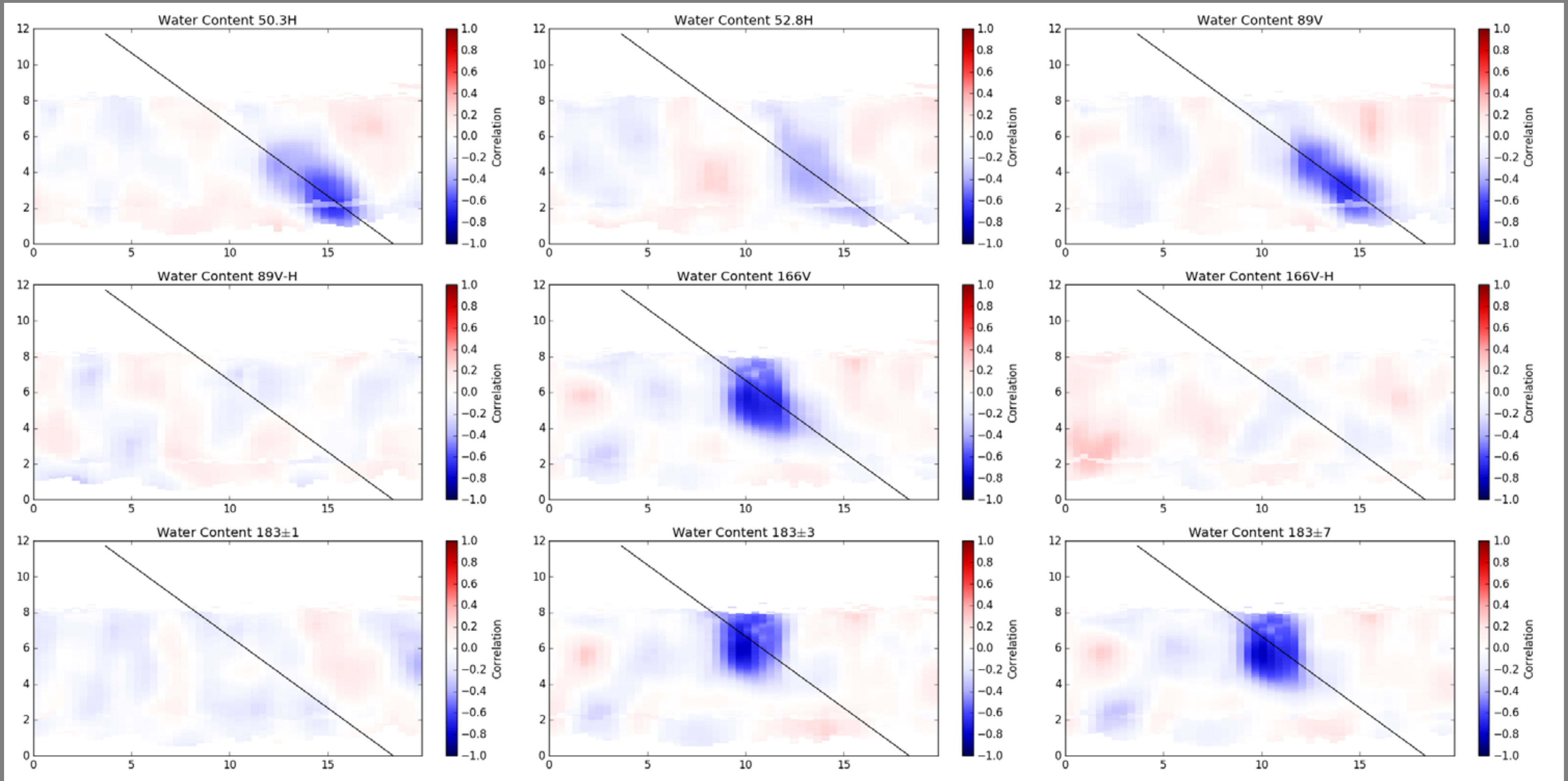
Simulations from Observations: OLYMPEX

Simulate sensor response using geophysical retrievals as input

- Single frequency radar retrievals
- Multiple scattering enhancement apparent at W band
- Spatially dependent phenomenon



Sensitivity Study (CoSMIR in OLYMPEX)

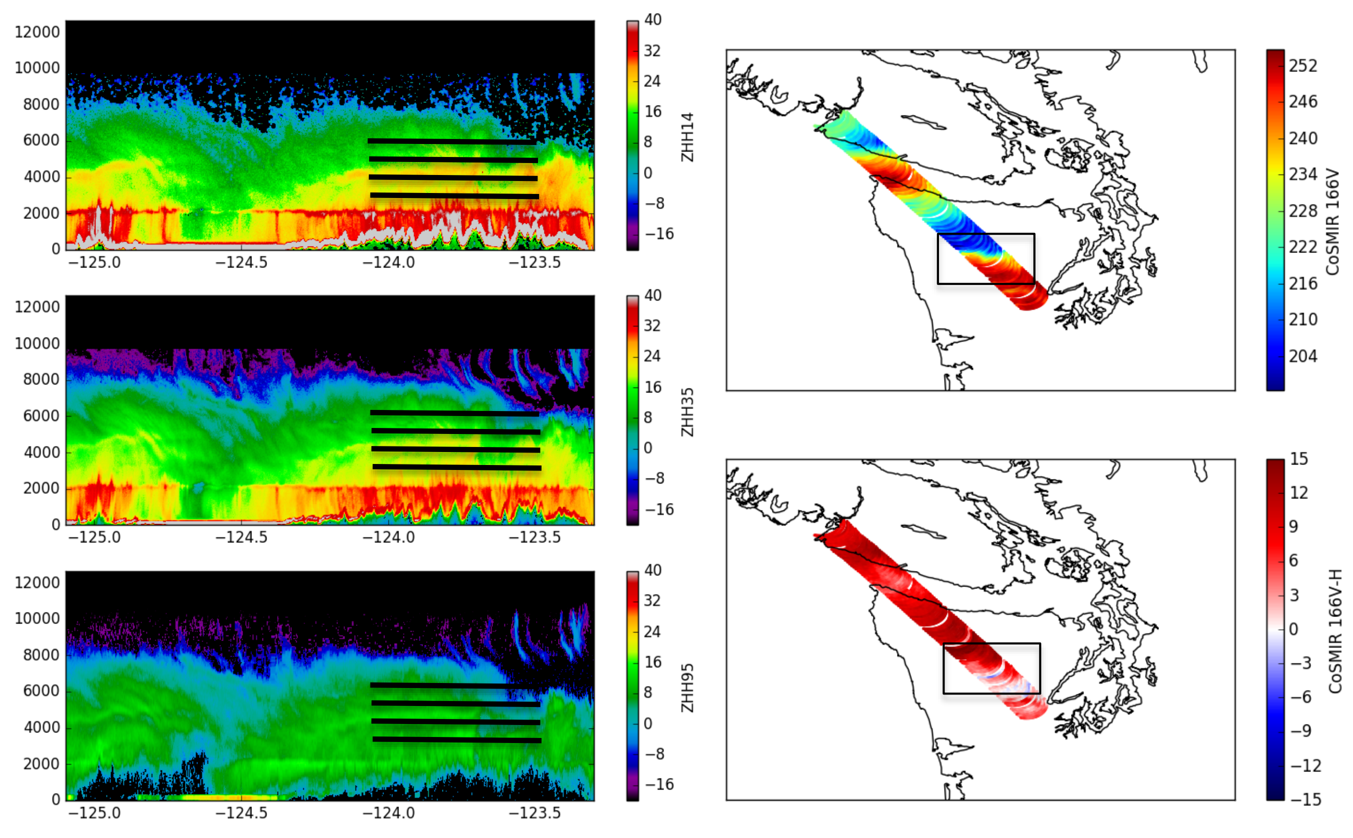


Modeling Application: 1D Retrievals

03 December 2015

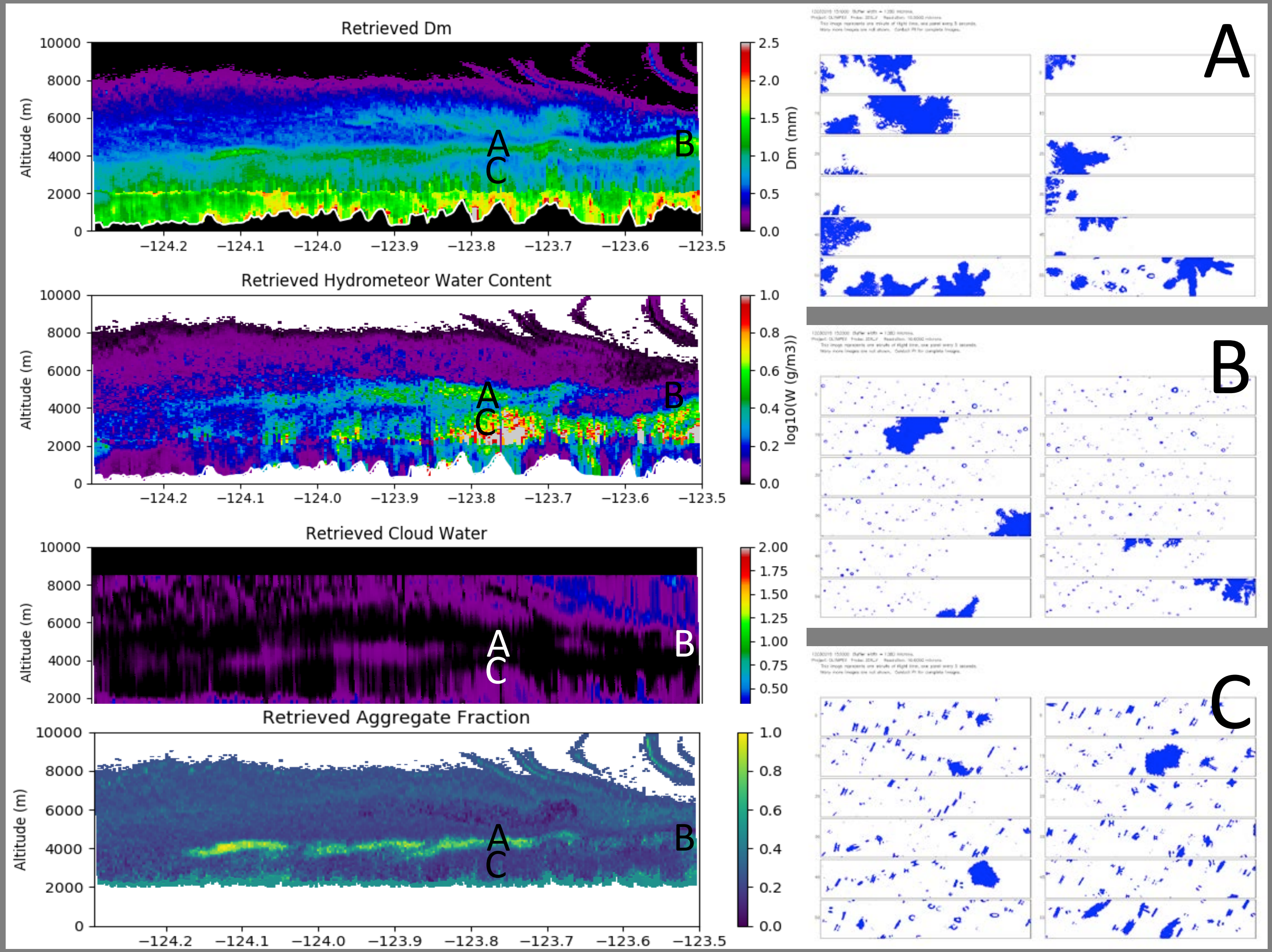
- DC-8 and ER-2 flights
  - o Focus on APR-3 (DC-8)
- Citation
  - o Stacked microphysics legs
  - o Qualitative comparisons
  - o Range of frozen habits
  - o Presence of supercooled liquid clouds

APR-3 CoSMIR



Results

- Retrievals match probes
  - Good qualitative match
- Bands of increased reflectivity correspond to large D_m and high aggregate fraction
- Significant amounts of supercooled liquid water



Future Work

- Interesting microphysics
  - Riming
  - Polycrystals
- Incorporate Inversions
  - 3D Estimation
  - Multi-sensors retrievals
- Extend polarization statistics
  - Full dynamic range
- Melting particles
- More aligned ice
  - Scattering using IITM