Numerical Model Generation of Test Frames for Pre-launch Studies of EarthCARE's Retrieval Algorithms and Data Management System

- *Supplementary Material* -

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1. Mapping of CAMS aerosols to ECSIM scatting types

The scattering species contained in scenes are listed in Table S1 and their lognormal widths and effective radii are listed in Table S2. To construct the scene, a mapping between the GEM cloud and precipitation fields, the CAMS aerosol mass content fields and the ECSIM scattering types, respectively, was implemented. Details of this mapping are given in Table S3. More details about the use of ECSIM and the component scattering types can be found in a companion paper (Donovan et al, 2022a). It should be noted that in this work, the goal was limited to producing `realistic enough' aerosol fields for the purposes for the algorithm development and testing activities, hence, a large degree of tolerance for ad-hoc choices and procedures was accommodated.

To map the CAMS fields to ECSIM scattering types the CAMS mass fields were first scaled by a simple ``Dry-to-Wet factor''. The CAMS aerosol types where then mapped to mixtures of ECSIM aerosol types. These types are based on the HETEAC framework basic types which are described in Wandinger, 2022a. The CAMS fields are then mapped to various mixtures which correspond to 4 different aerosol mixtures. The refractive indices and densities of each base type are described within Wandinger, 2022a. Table S3 specifies the Dry-to-Wet factors, the size ranges, the volume mixing ratios corresponding to each basic type and the connection to the CAMS mass field used as `inspiration'.

Table S1: ECSIM *Scattering types used for the GEM-CAMS scenes*

No.	Scattering type	Source	ECSIM scattering type
1	Ice Cloud	GEM	Baum Aggregated solid columns
2	Snow	GEM	Baum General Habit mixture
3	Cloud Water	GEM	Water
4	Rain	GEM	Rain
5	Coarse mode non-spherical absorbing aerosol	CAMS	Heteac Coarse Dust (spheroids)
6	Coarse mode non-absorbing aerosol	CAMS	Heteac Coarse Salt
7	Fine-mode weakly absorbing aerosol	CAMS	Heteac Fine Weak
8	Fine-mode strongly absorbing aerosol	CAMS	Heteac Fine Strong

Table S2: Effective radii and lognormal width parameter for the aerosol basis types

ECSIM Aerosol Type	R_{eff} [microns]	Width parameter [microns]
Coarse Dust	1.1	0.3
Coarse Salt	1.94	0.6
Fine Weak	0.14	0.53
Fine Strong	0.14	0.53

Table S3: Characteristics of the aerosol representation and its relationships with the utilized CAMS fields

CAMS Field	DD1-DD3	SS1-SS2	SO4	BCB	OMB
Dry-to-Wet mass factor	1	2	2	2	2
R_{min},R_{max} [microns]					
Coarse Dust	0.0—2000.0	0.0→100	0.0→100	0.0→100	0.0→100
Coarse Salt		0.0→100			
Fine Weak		0.0→100	0.0→100		
Fine Strong				0.0→100	0.0→10
Vol. Fraction					
Coarse Dust	100	9	5	3	3
Coarse Salt		90			
Fine Weak		1	95		
Fine Strong				97	97

2. Nadir Cross-Sections

In this section various cross-sections of relevant optical and physical quantities of interest are shown. These cross-sections follow simulated EarthCARE orbits. The optical properties (extinction, linear depolarization ratio and lidar-ratio (also known as the extinction-to-backscatter ratio) are not generated by the GEM model but rather are generated by ECSIM based on the GEM /CAMS inputs of particle type and size distributions. (Donovan et al., 2022a). All of the presented fields correspond to the adjusted fields as described in the main paper.

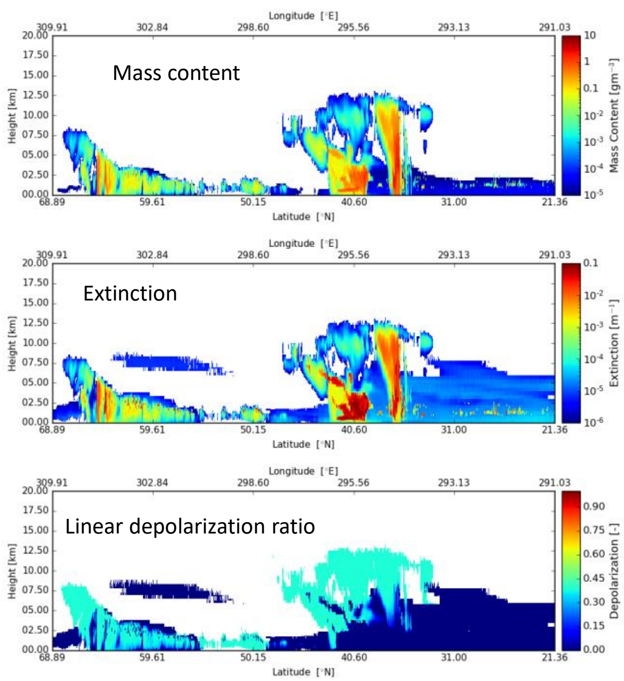
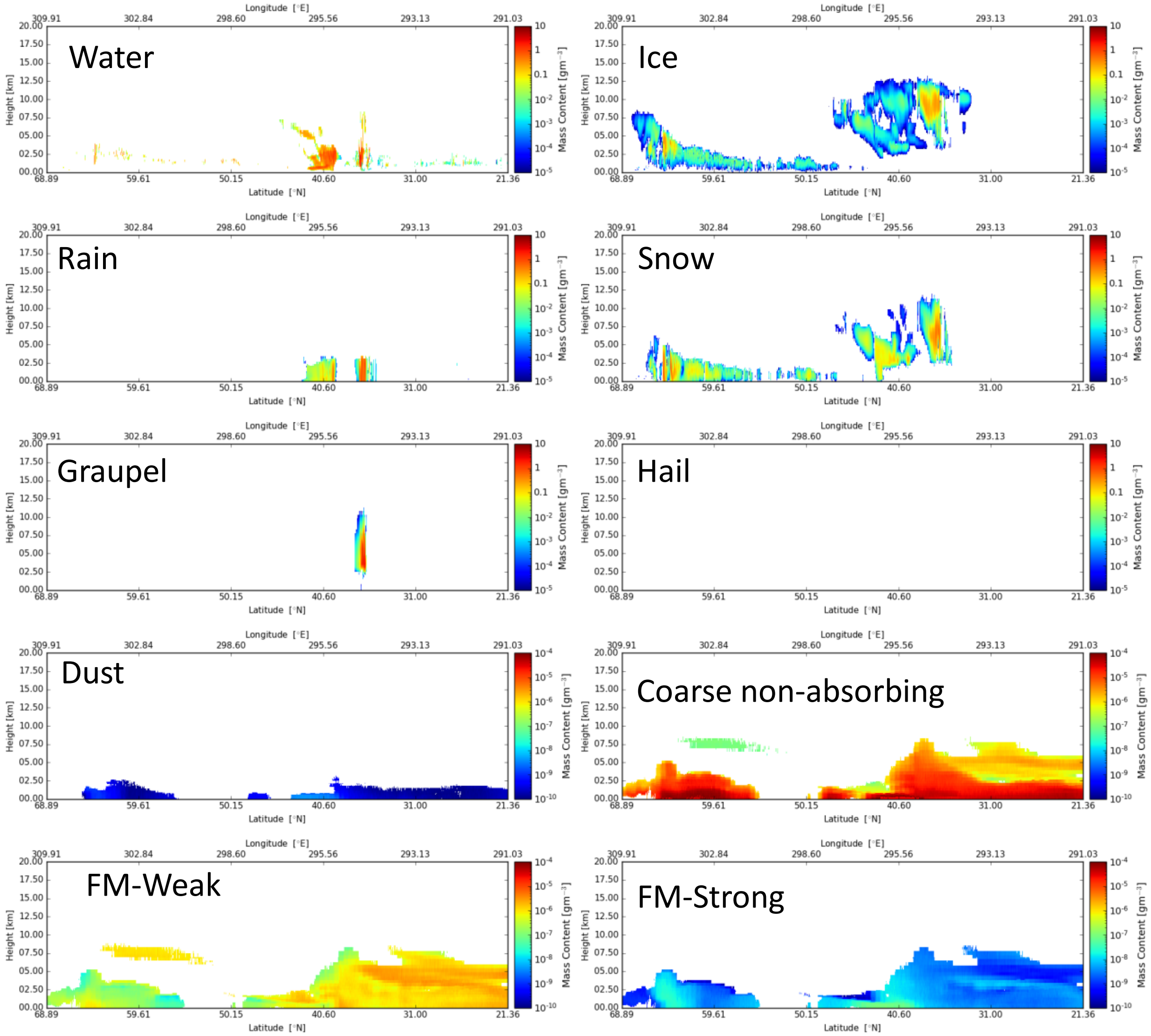


Figure S1: Total Mass content, effective radius, Extinction (355nm), lidar-ratio (355nm) and linear depolarization ratio (355nm) for the Halifax scene at Nadir.



45 Figure S2: Mass content per species for the Halifax scene.

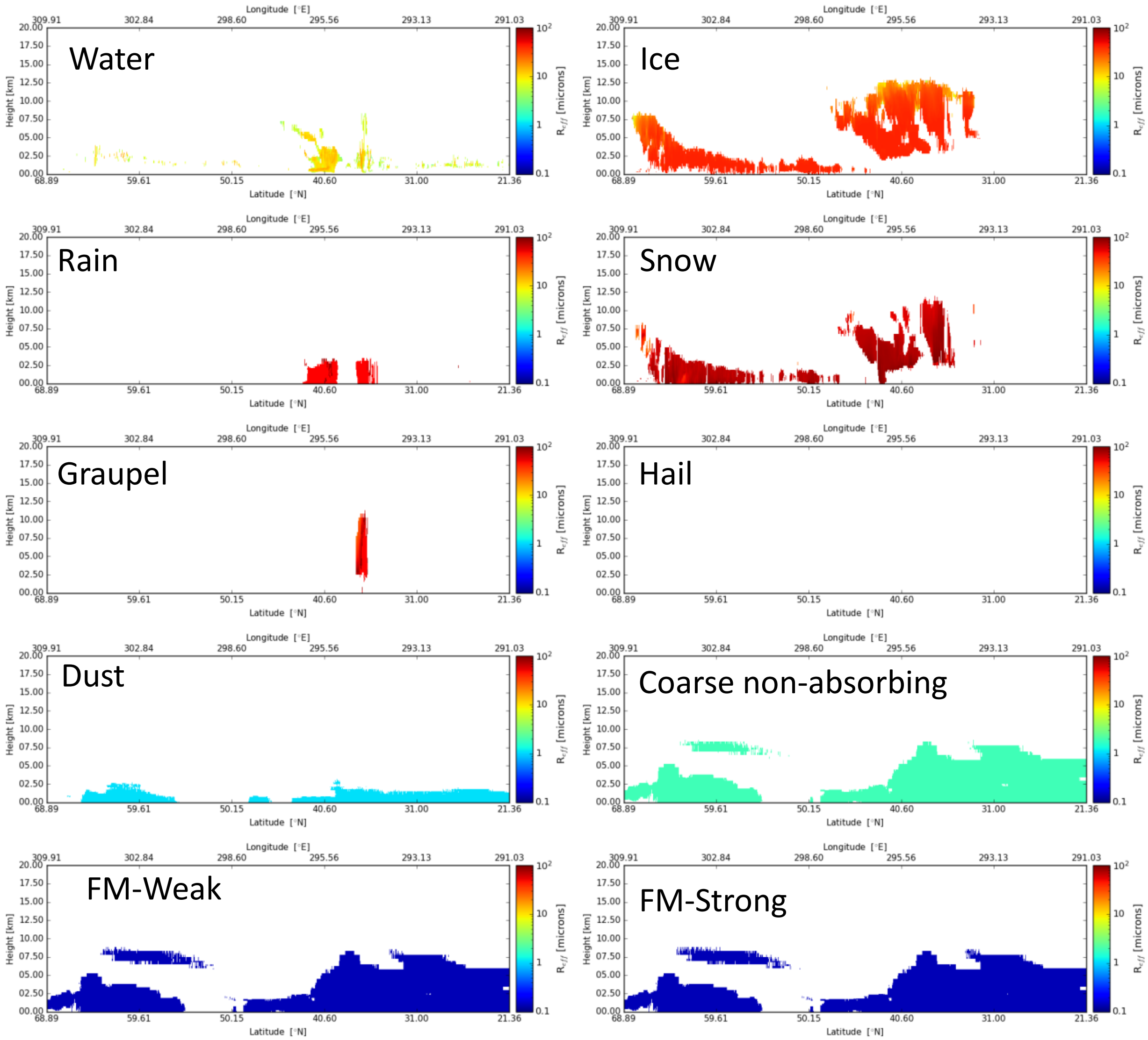


Figure S3: Effective Radius per species for the Halifax scene.

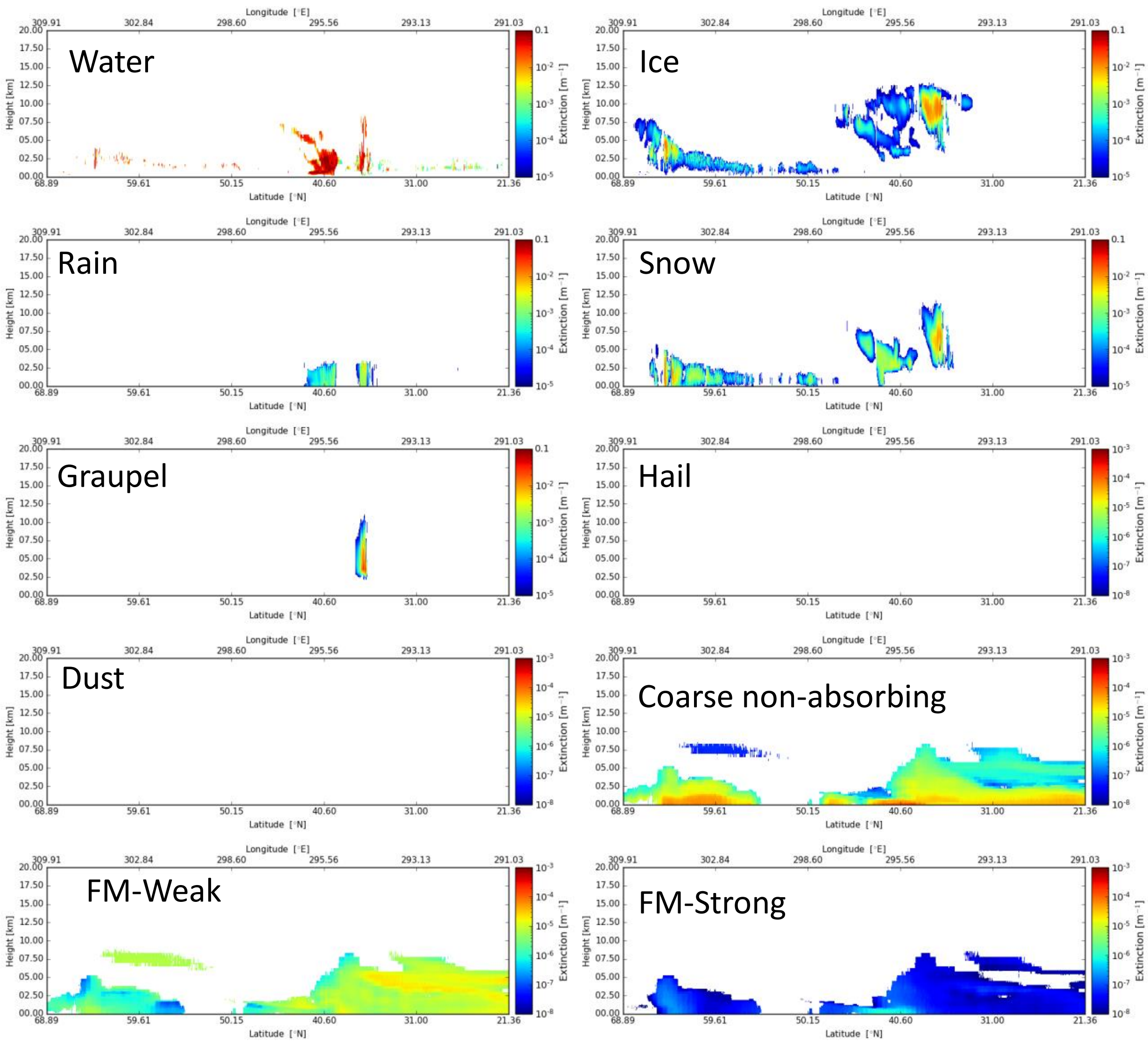


Figure S4: Extinction at 355nm per species for the Halifax scene.

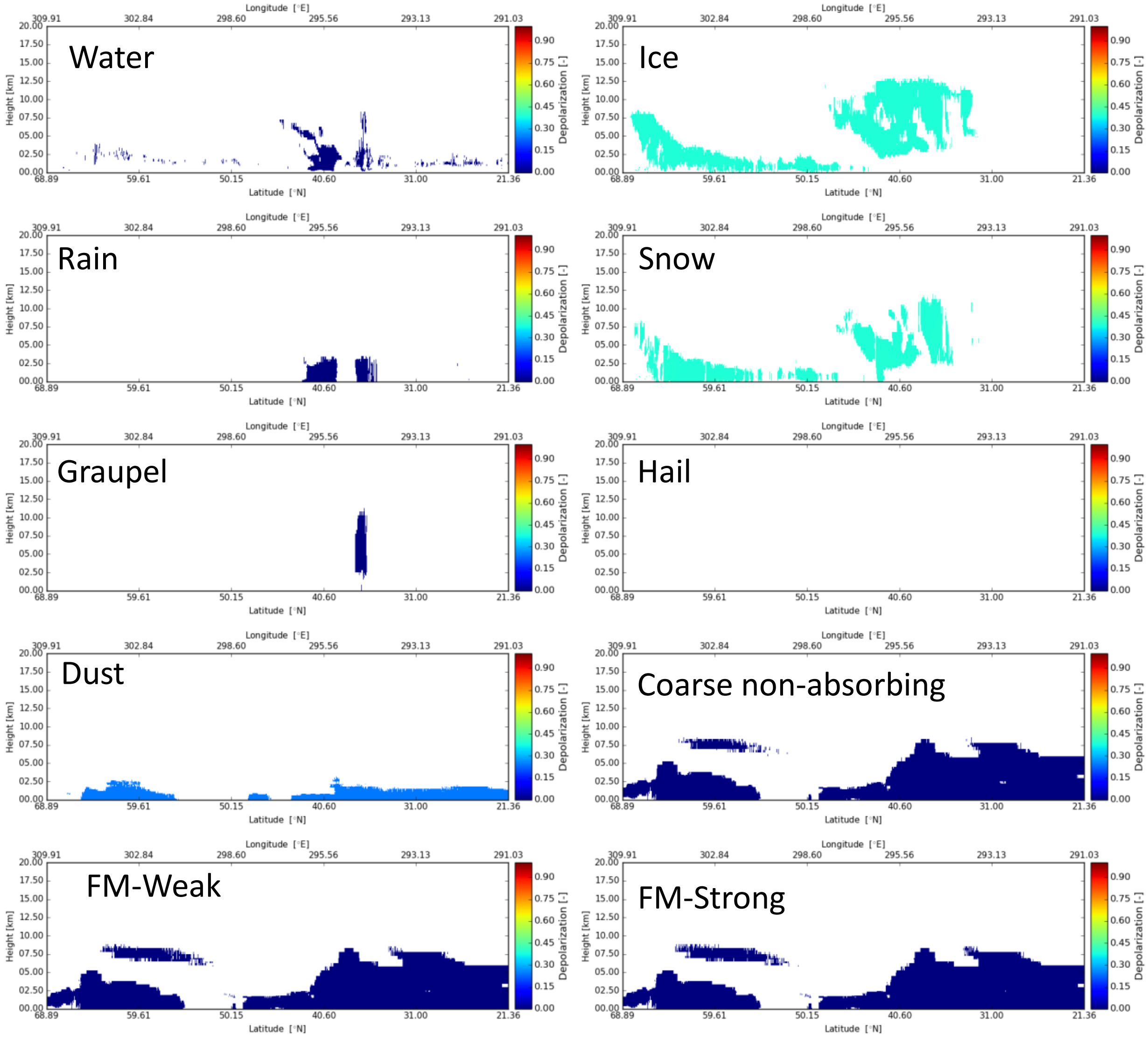


Figure S5: Linear depolarization ratio at 355nm per species for the Halifax scene.

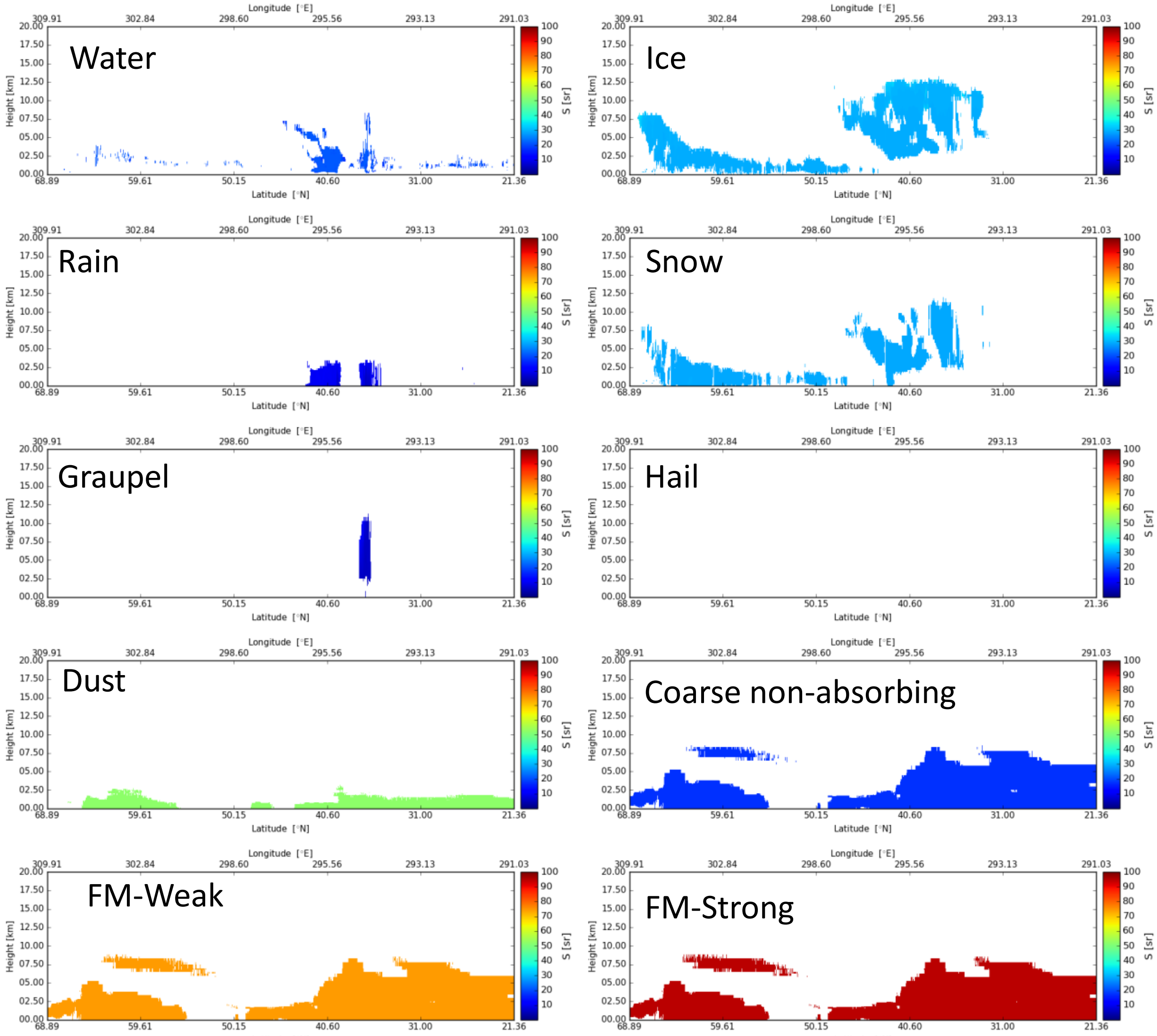


Figure S6: Lidar-ratio per species for the Halifax scene.

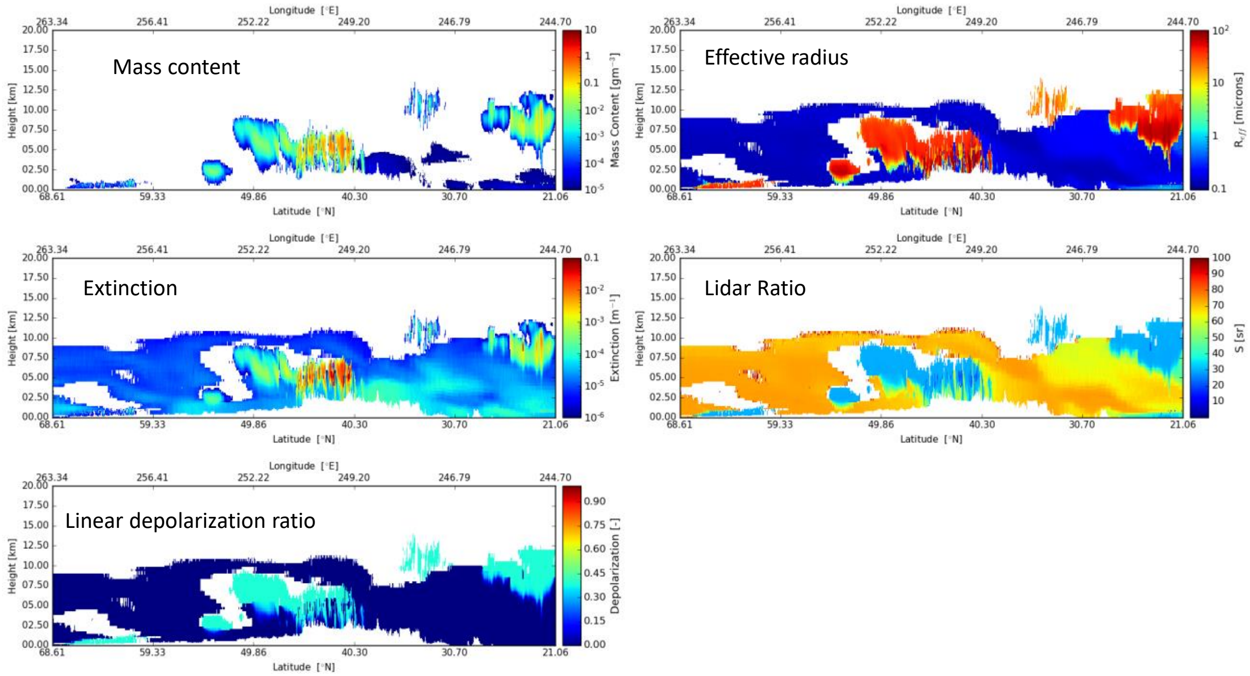


Figure S7: Total Mass content, effective radius, Extinction (355nm), lidar-ratio (355nm) and linear depolarization ratio (355nm) for the Baja scene at Nadir.

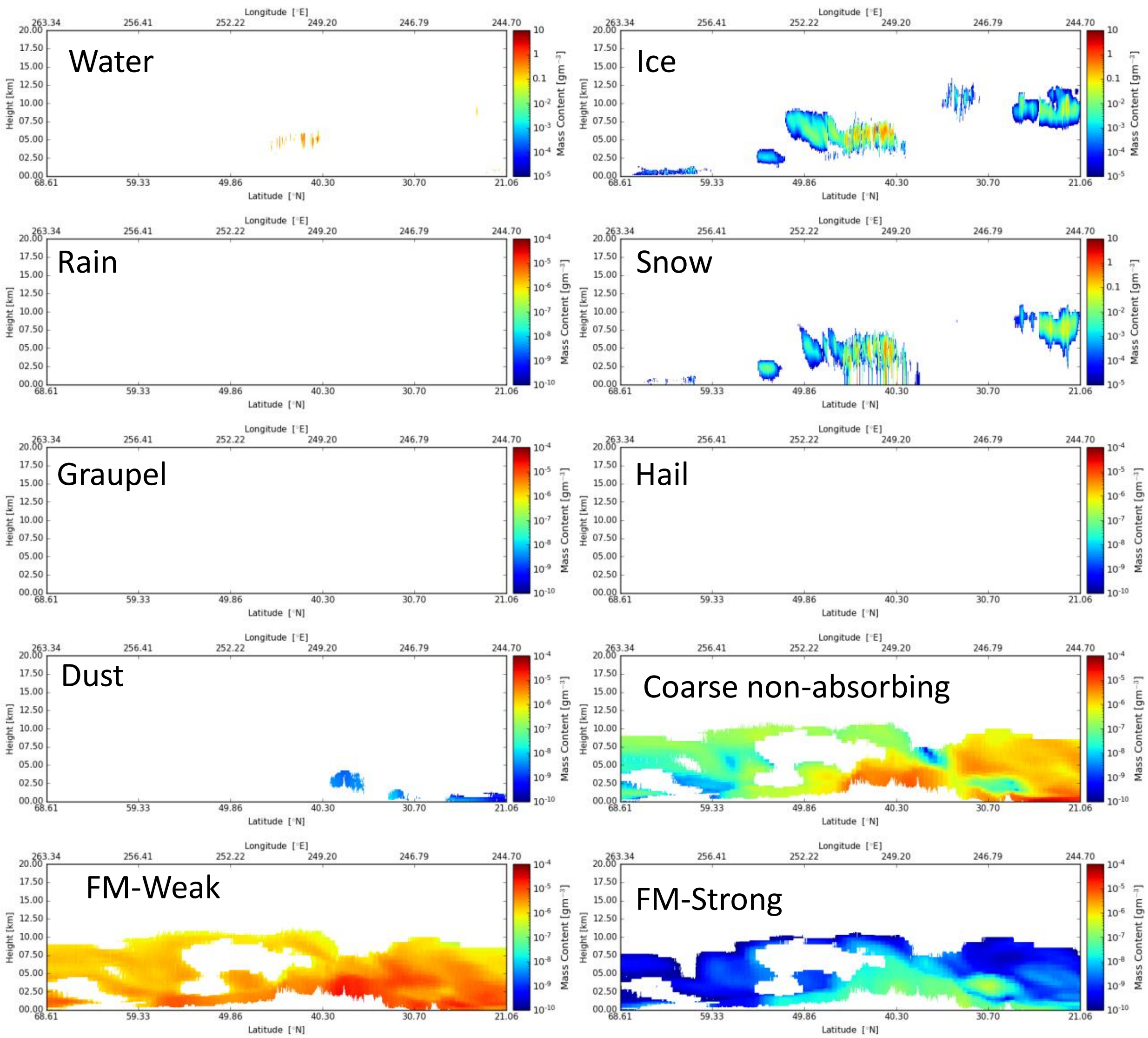


Figure S8: Mass content per species for the Baja scene.

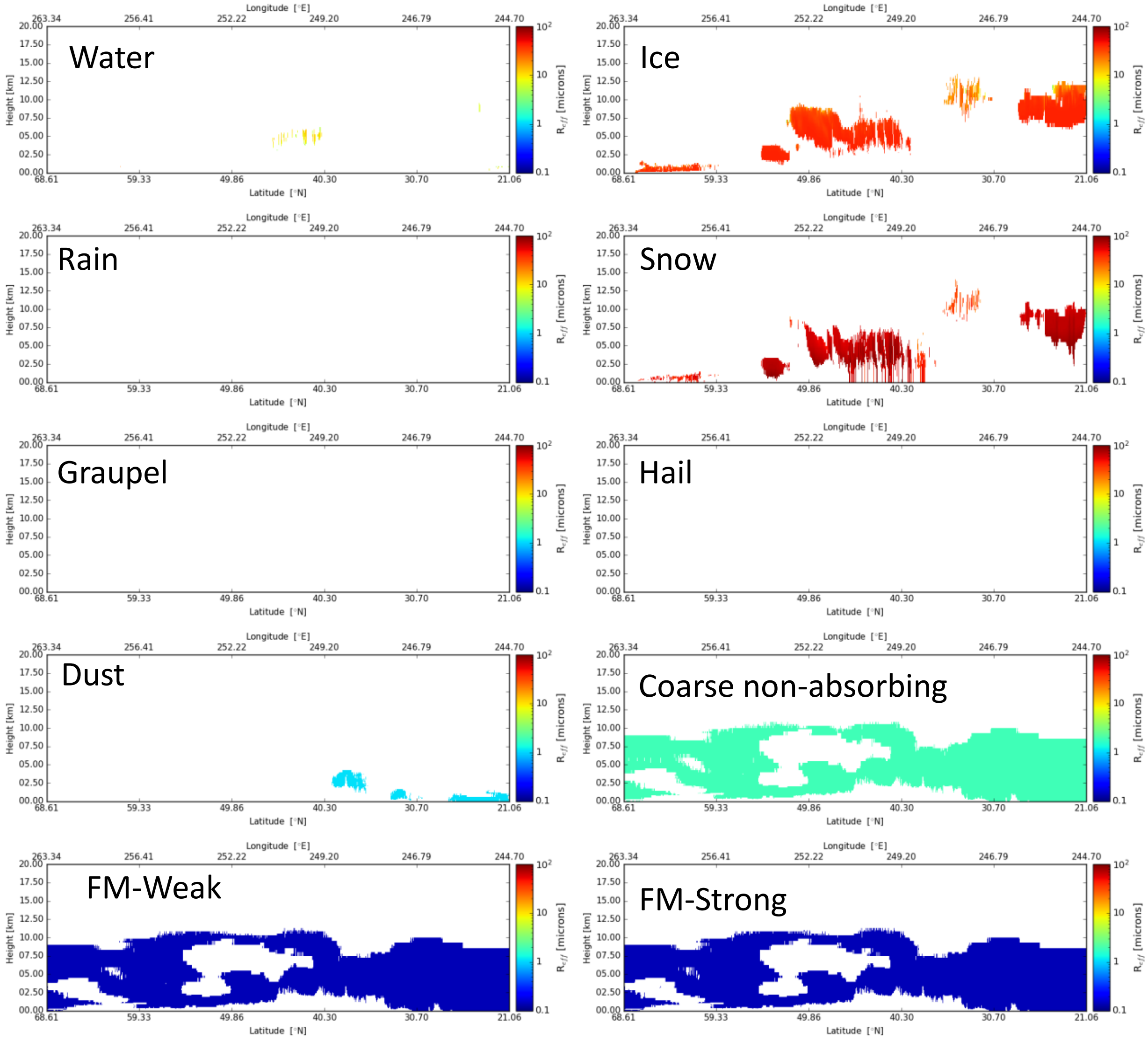


Figure S9: Effective Radius per species for the Baja scene.

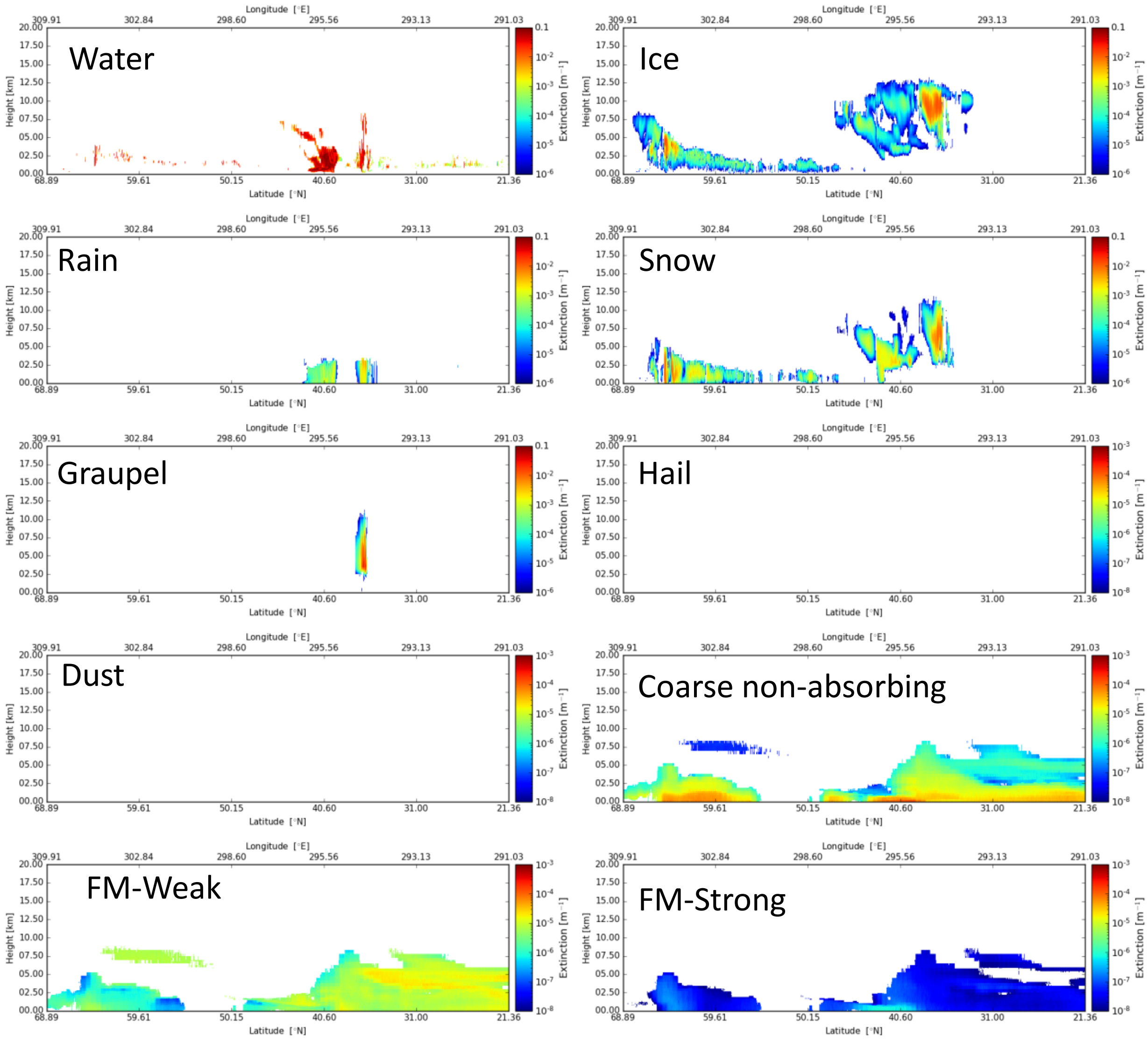


Figure S10: Extinction at 355nm per species for the Baja scene.

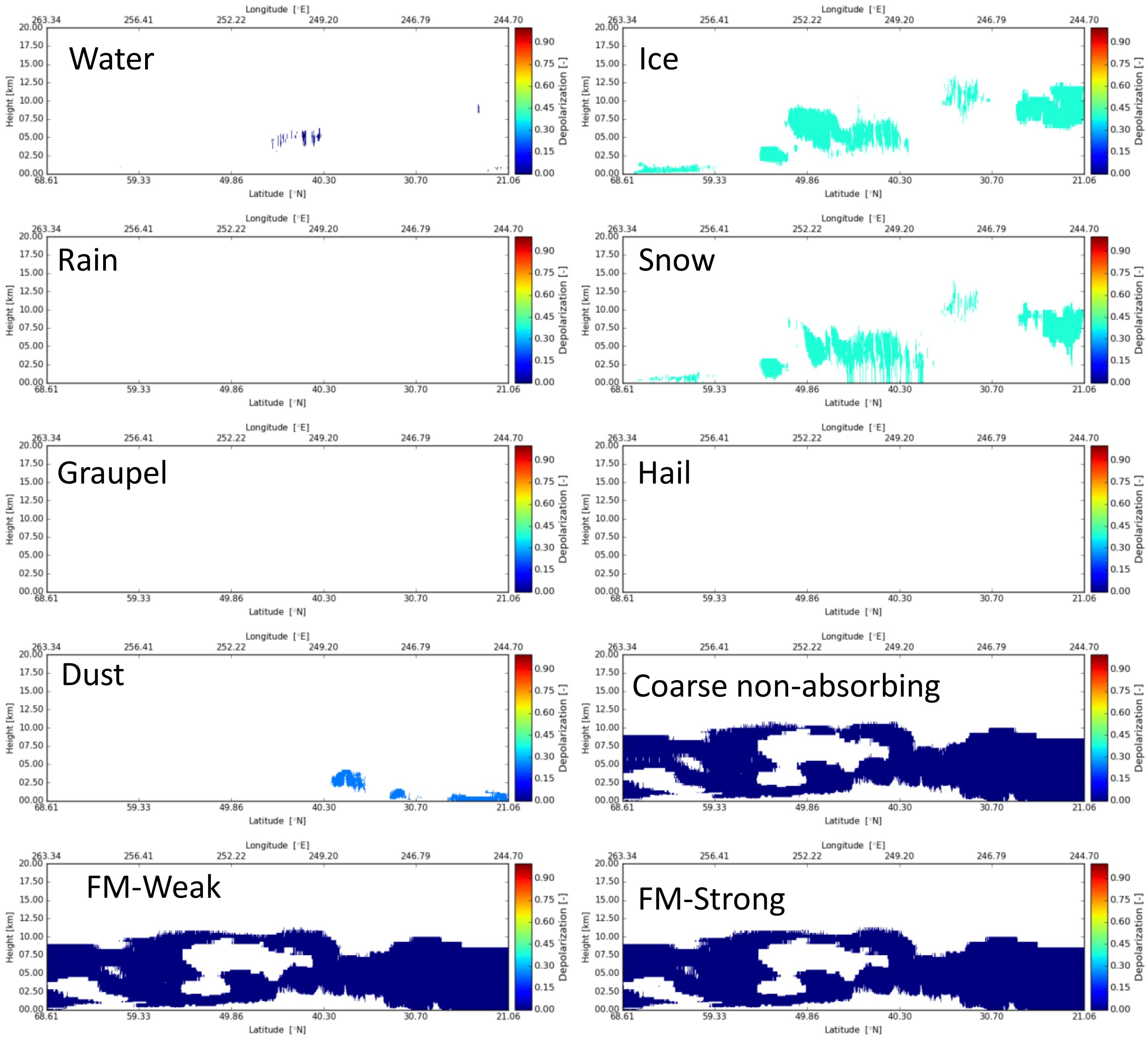


Figure S11: Linear depolarization ratio at 355nm per species for the Baja scene.

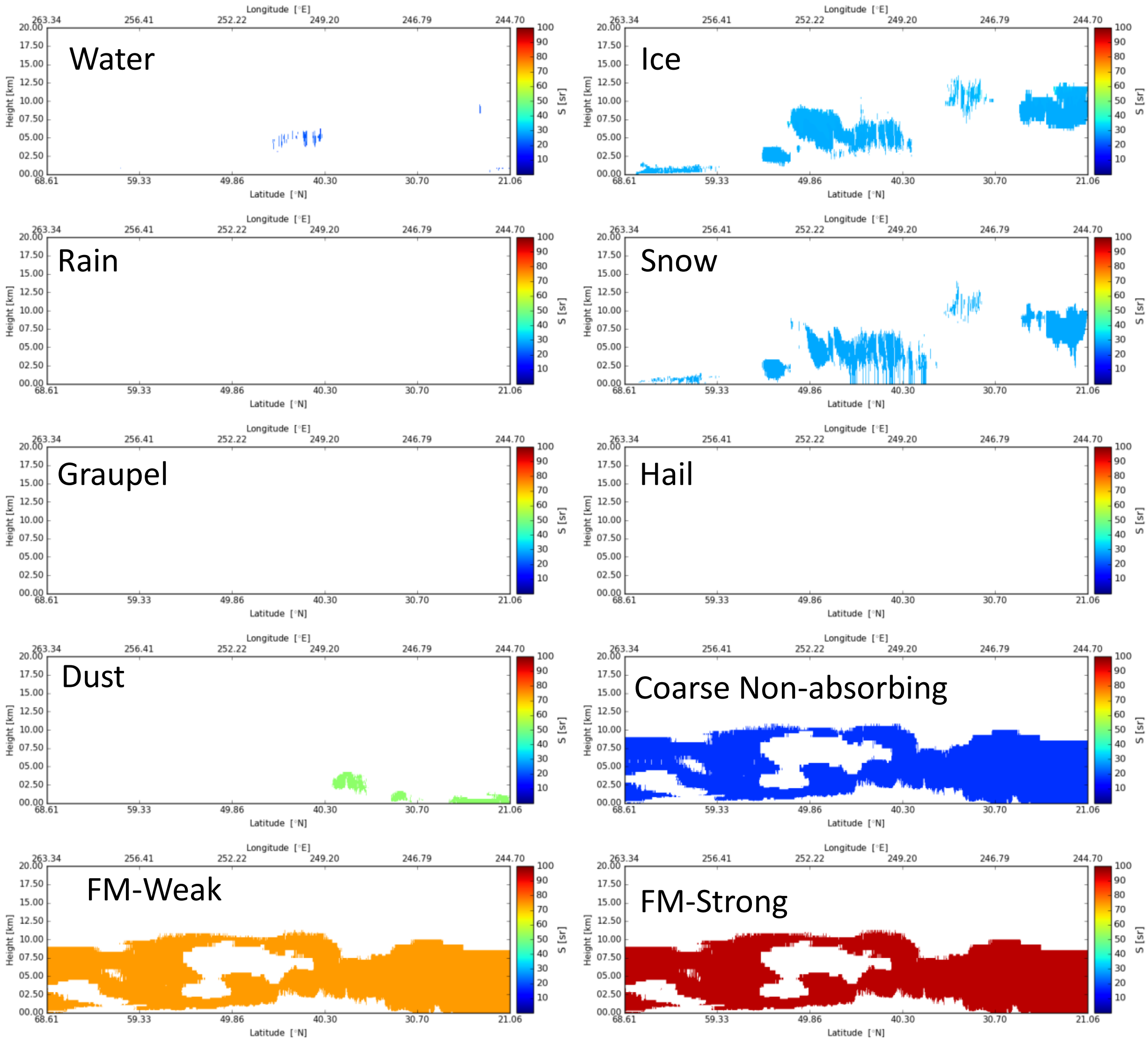


Figure S12: Lidar-ratio per species for the Baja scene.

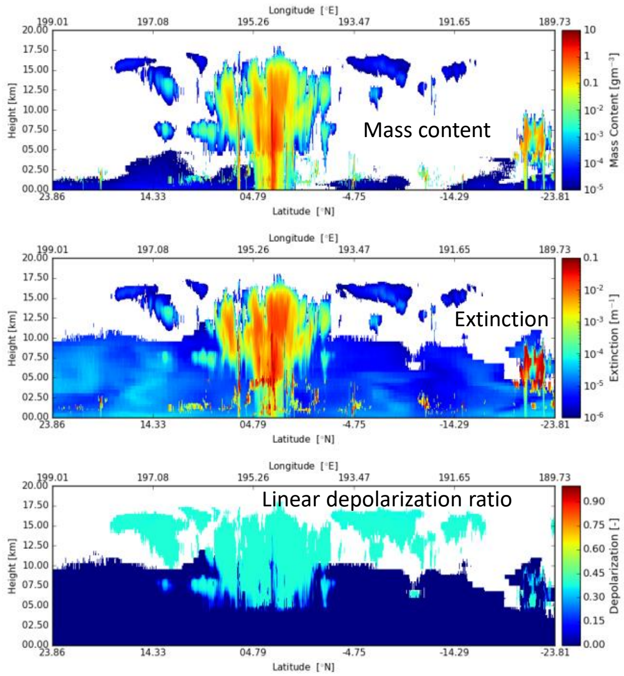


Figure S13: Total Mass content, effective radius, Extinction (355nm), lidar-ratio (355nm) and linear depolarization ratio (355nm) for the Hawaii scene at Nadir.

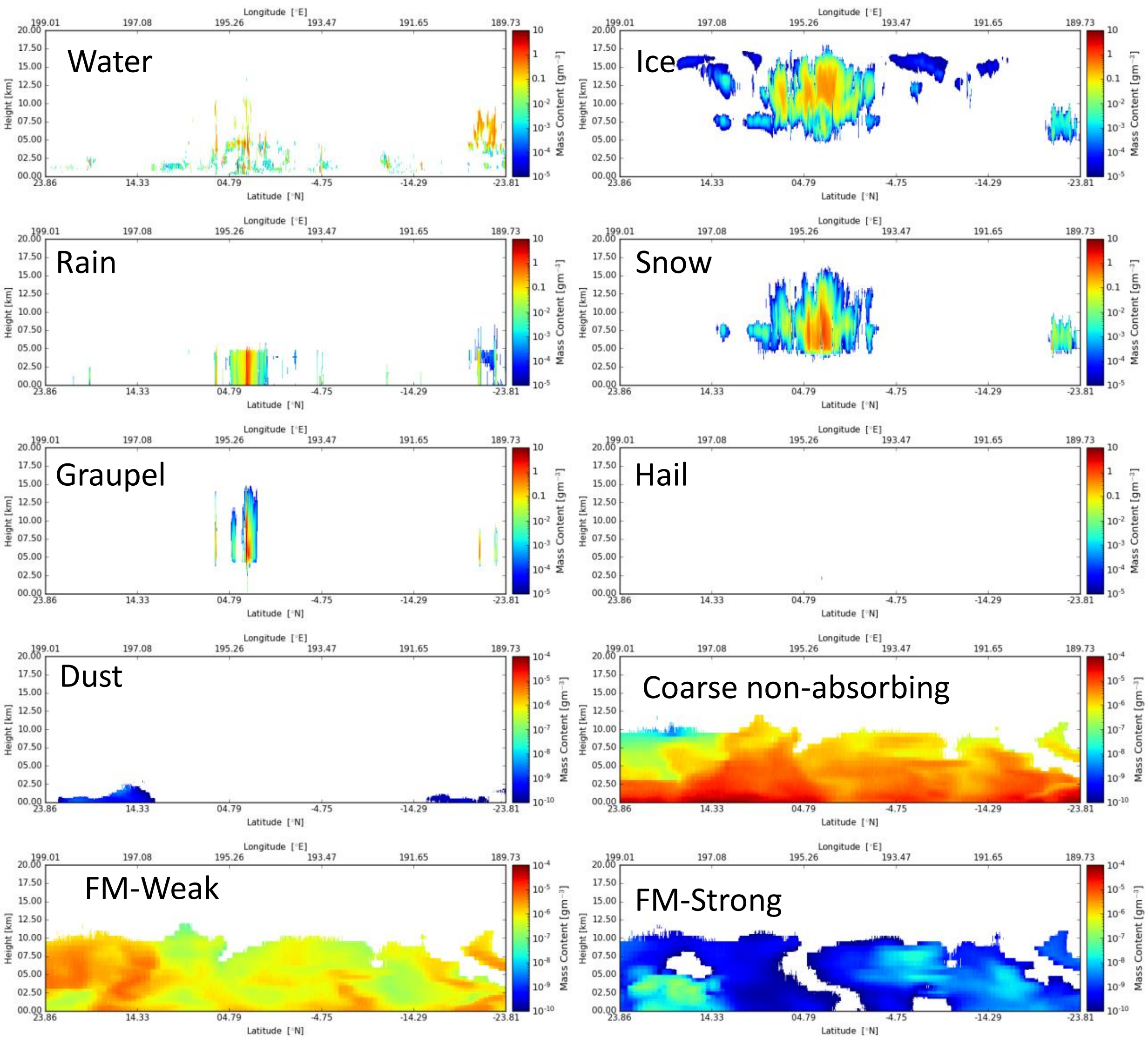


Figure S14: Mass content per species for the Hawaii scene.

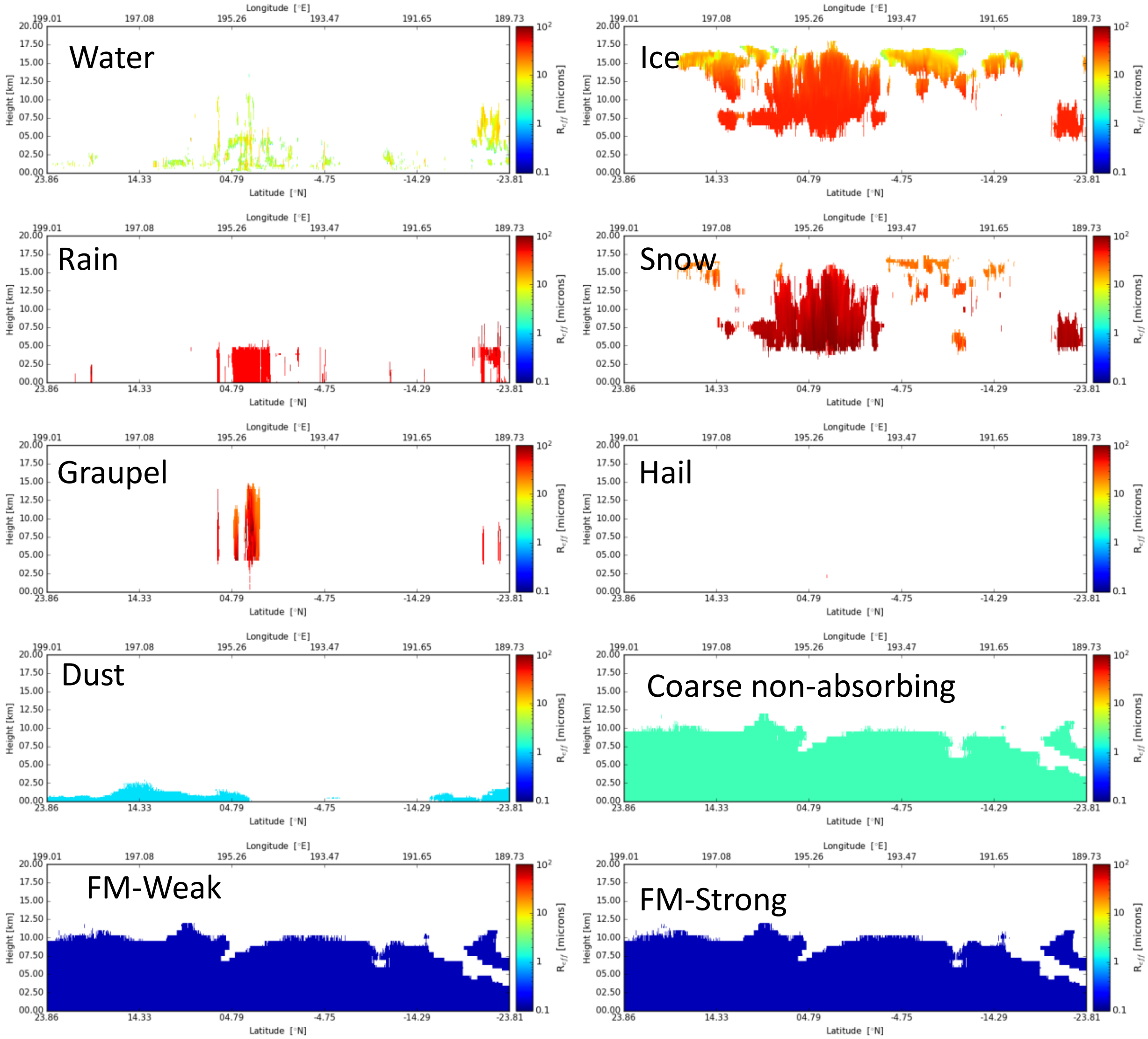


Figure S15: Effective radius per species for the Hawaii scene.

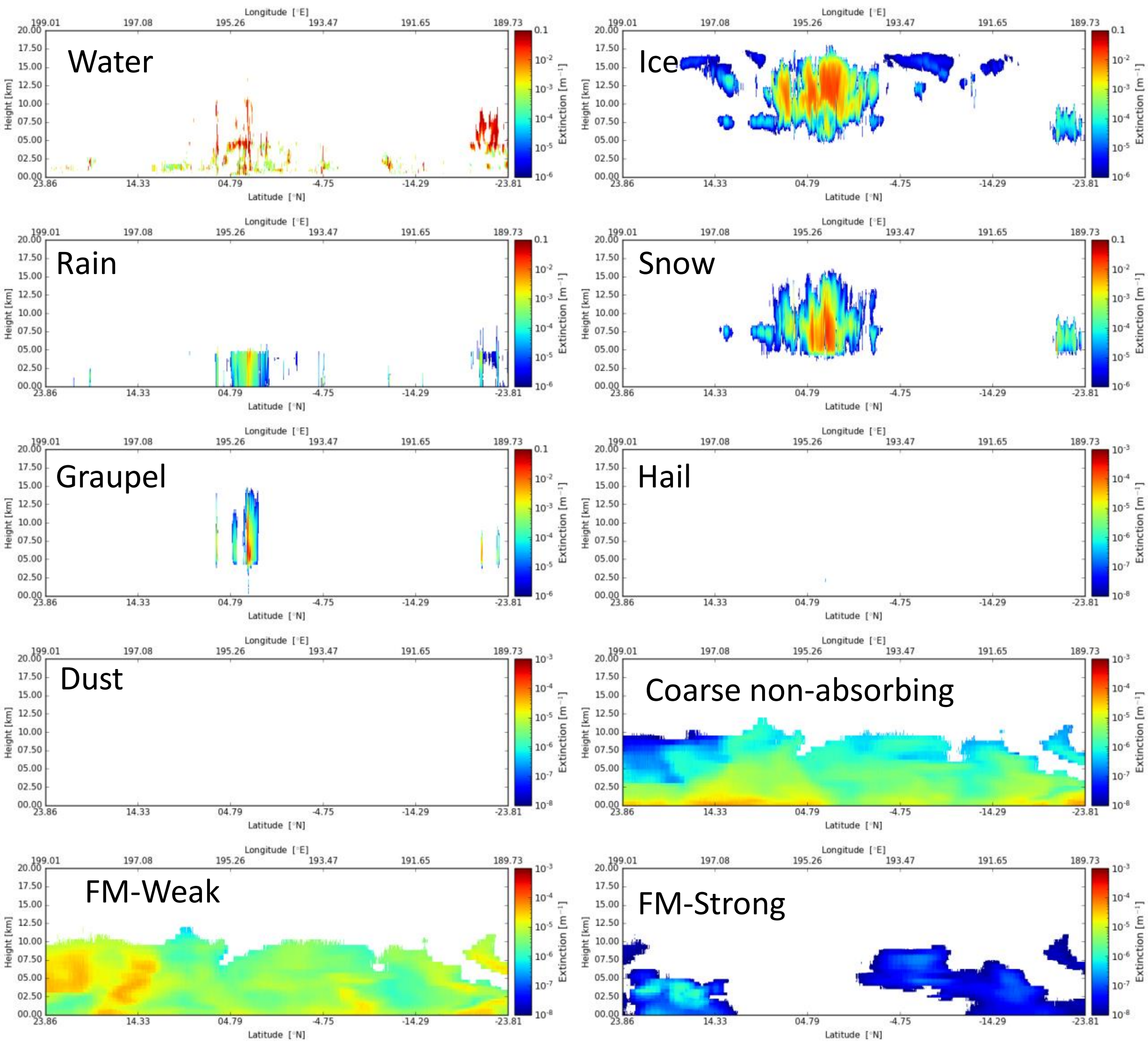


Figure S16: Extinction per species for the Hawaii scene.

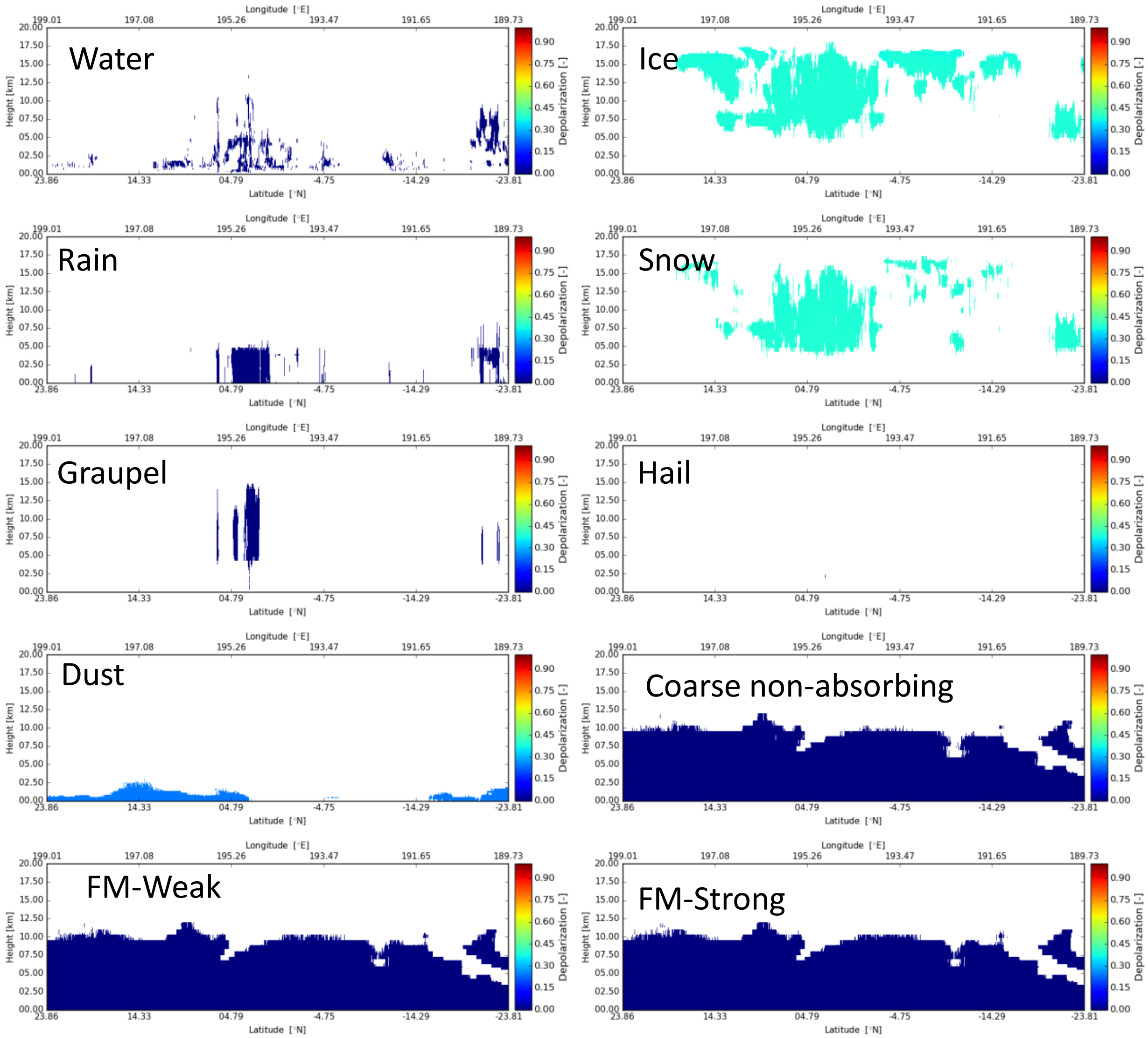


Figure S17: Linear depolarization ratio per species for the Hawaii scene.

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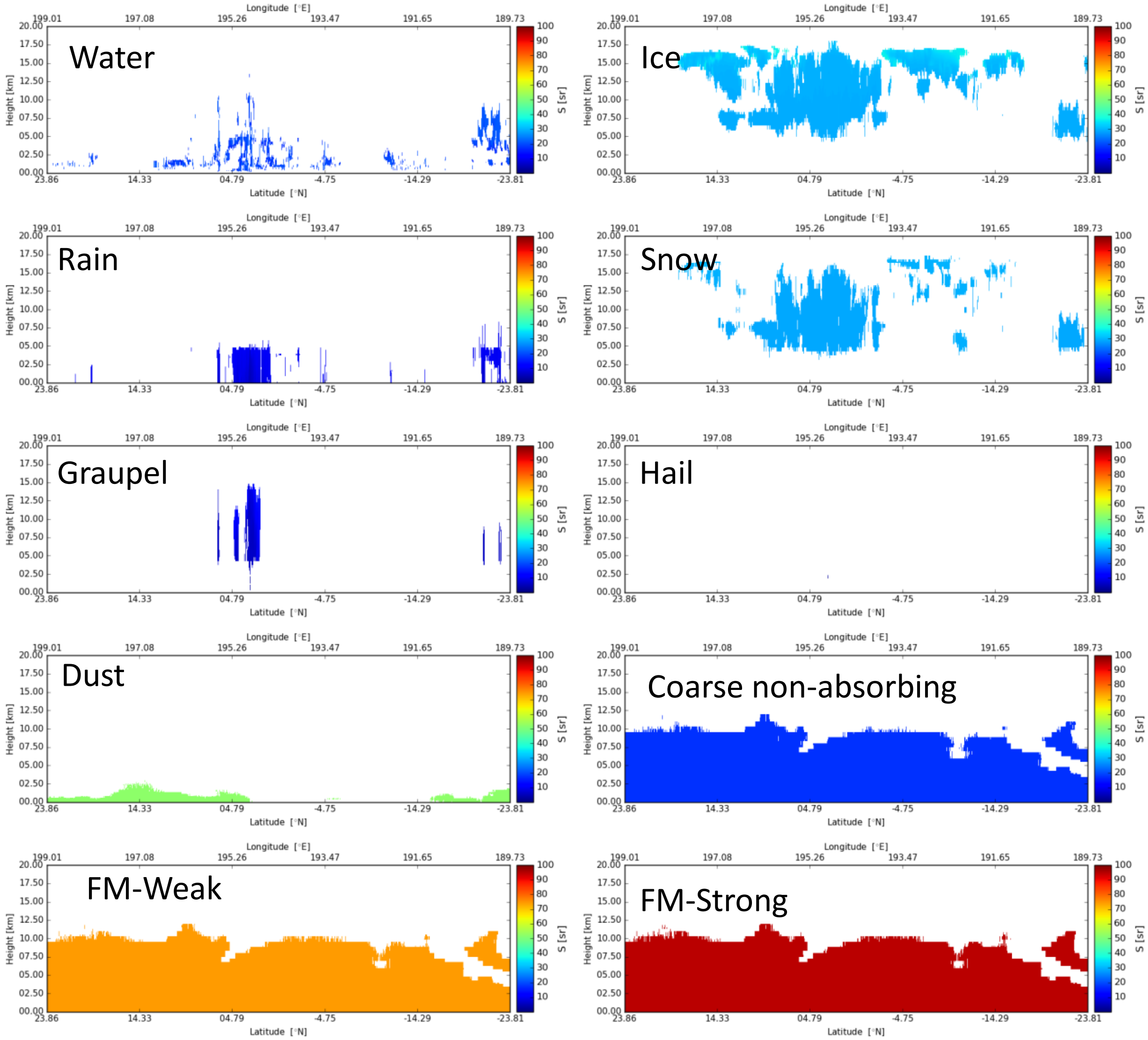

Figure S18: Lidar ratio per species for the Hawaii scene.

References

Donovan D. P., Kollias P., and van Zadelhoff G-J., 2022: The Generation of EarthCARE L1 Test Data sets Using Atmospheric Model Data Sets. *Atmos. Meas. Tech*., *This issue*.

Flemming, J., Benedetti, A., Inness, A., Engelen, R. J., Jones, L., Huijnen, V., Remy, S., Parrington, M., Suttie, M., Bozzo, A., Peuch, V.-H., Akritidis, D., and Katragkou, E.: The CAMS interim Reanalysis of Carbon Monoxide, Ozone and Aerosol for 2003–2015, *Atmos. Chem. Phys.*, **17**, 1945–1983, https://doi.org/10.5194/acp-17-1945-2017, 2017.

Wandinger U., Floutsi A., Baars H., Haarig M., Hünerbein A., Docter N., Donovan D., van Zadelhoff G.-J., HETEAC -- The Hybrid End-To-End Aerosol Classification model for EarthCARE. *Atmos. Meas. Tech*., *This issue*.