NSA ground-based observations for GCM evaluation:

Arctic cloud phase
within the context of cloud vertical structure

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Science application and approach

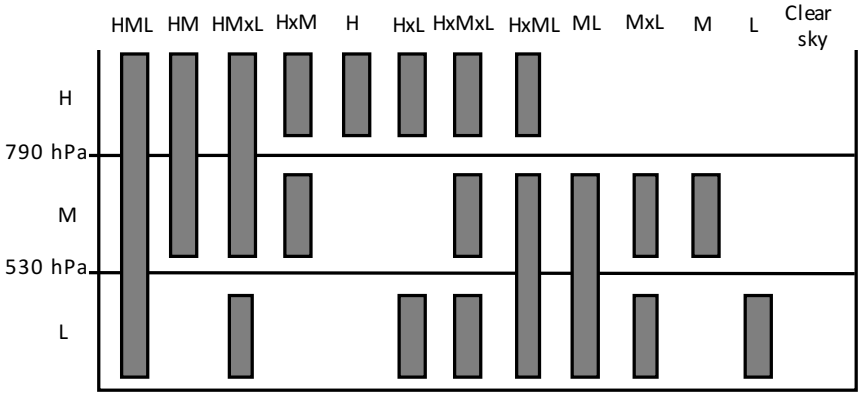
Ground-based observations for GCM evaluation:

- Of **Arctic cloud type** frequency of occurrence and **hydrometeor phase**
- Use the **cloud vertical structure approach** [*Tselioudis et al.* 2013, *Remillard and Tselioudis* 2015], **appropriate resampling** and **new model diagnostics**

An approach where **BOTH observations** and **GCM model output are tailored for comparison**

Such an approach is not feasible using current products such as ARMBE or ARSCL

Schematic of 13 Arctic cloud vertical structure types



[Lamer et al. 2017, in preparation]

Science application – Cloud Vertical Structure

Resampling of observations to a GCM-appropriate spatio-temporal resolution

Radar-lidar observations:

dt = 3 s

dz = 30 m

ModelE:

dt = 30 min

dx = 2.0 º x 2.5 º

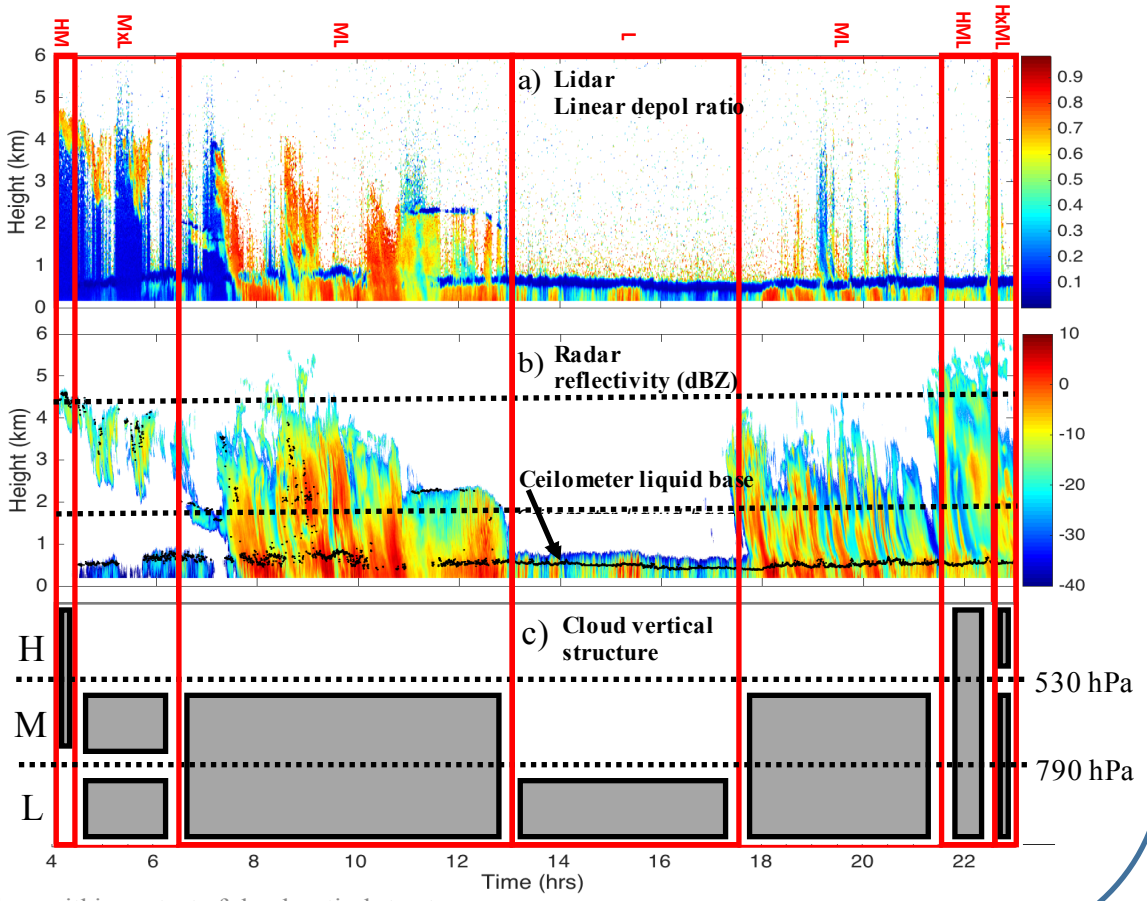
dz = 74-666 m

apply radar-lidar simulator

New benchmark:

dz = 3 regions: 790 hPa, 530 hPa

dt = 30-min samples



Science application – Hydrometeor layer phase

Creating a "rough" phase assignment

- High resolution phase assignment:

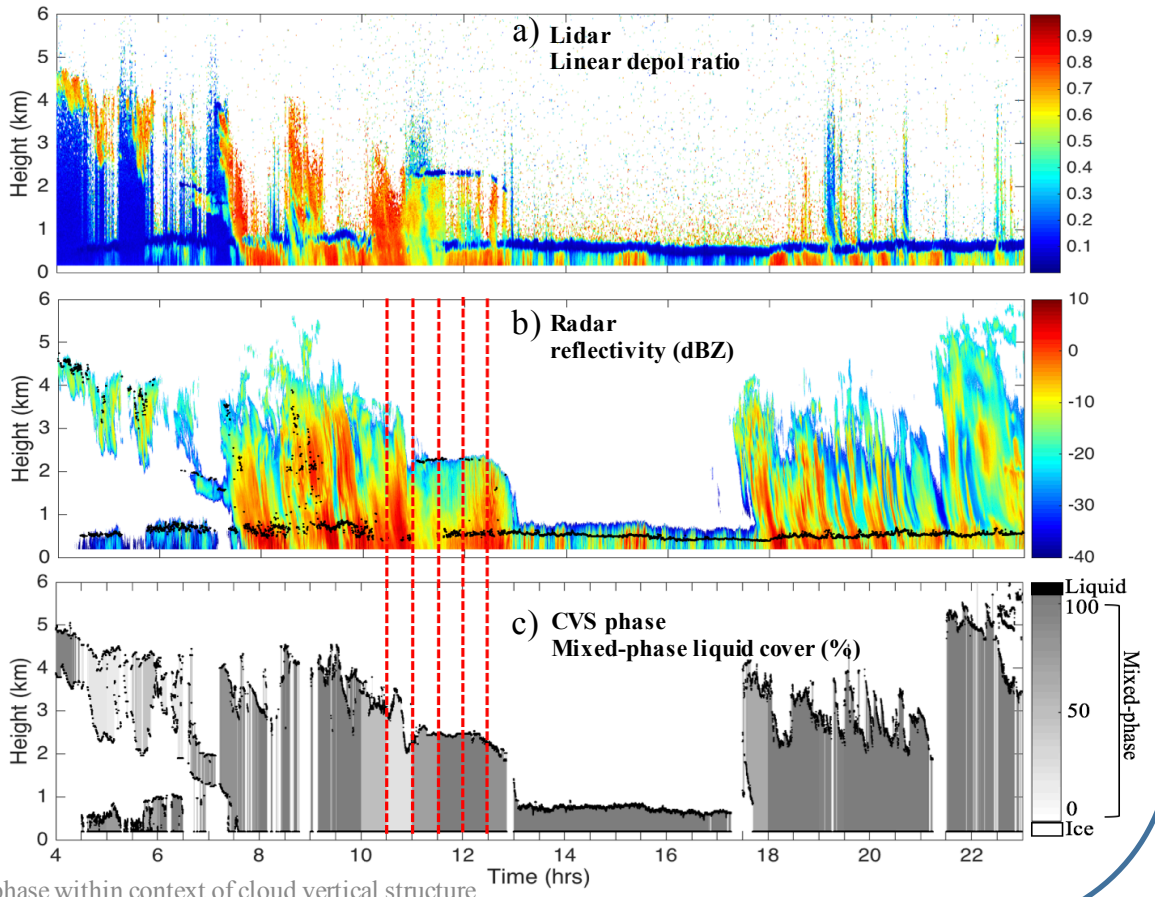
  Shupe [2007] multi-sensor cloud phase classifier

  Radar-lidar based

- Rough phase:

  30-min layer-based phase assignment

  Mixed-phase is defined as ice and liquid present within the layer (not necessarily at the same time and location)



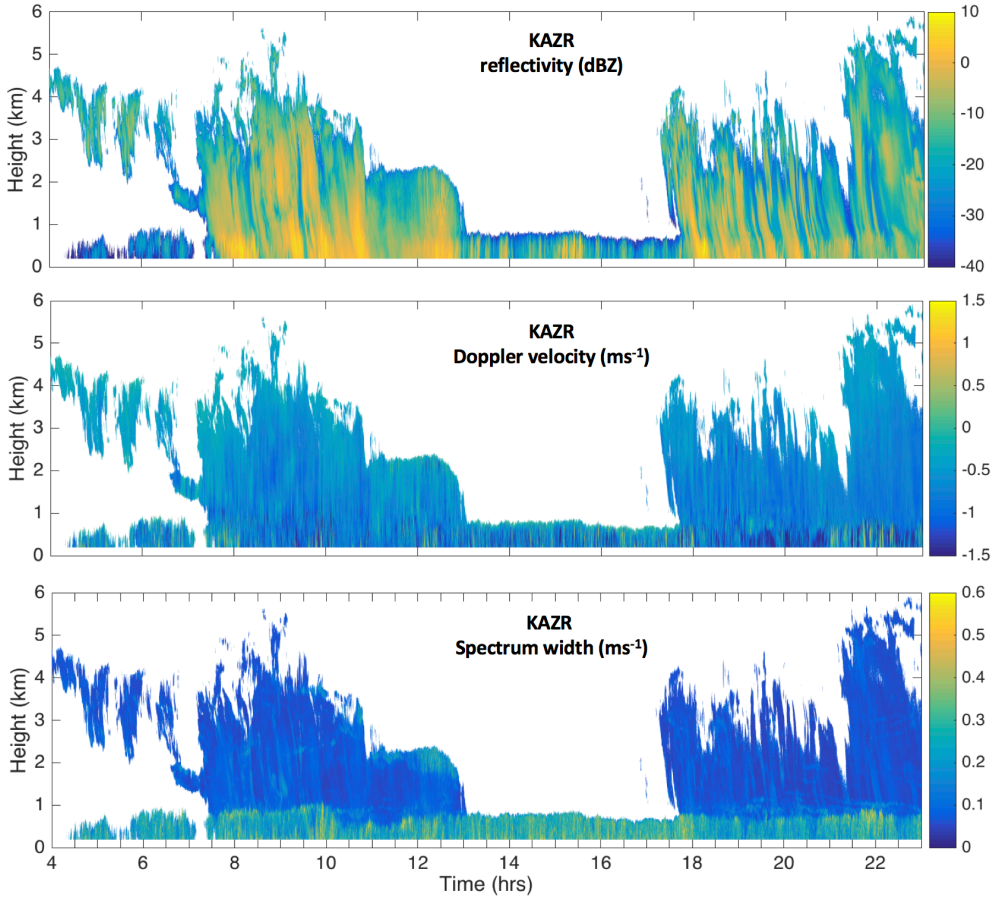
KAZRGE minimum requirement

Data quality

- Small blind zone (a few hundred meters at most)
- Well characterized artifacts (if any)
- **Calibrated KAZR Reflectivity**

Datastreams (Moments)

- Signal-to-noise ratio
- Reflectivity
- Doppler velocity
- Spectrum width



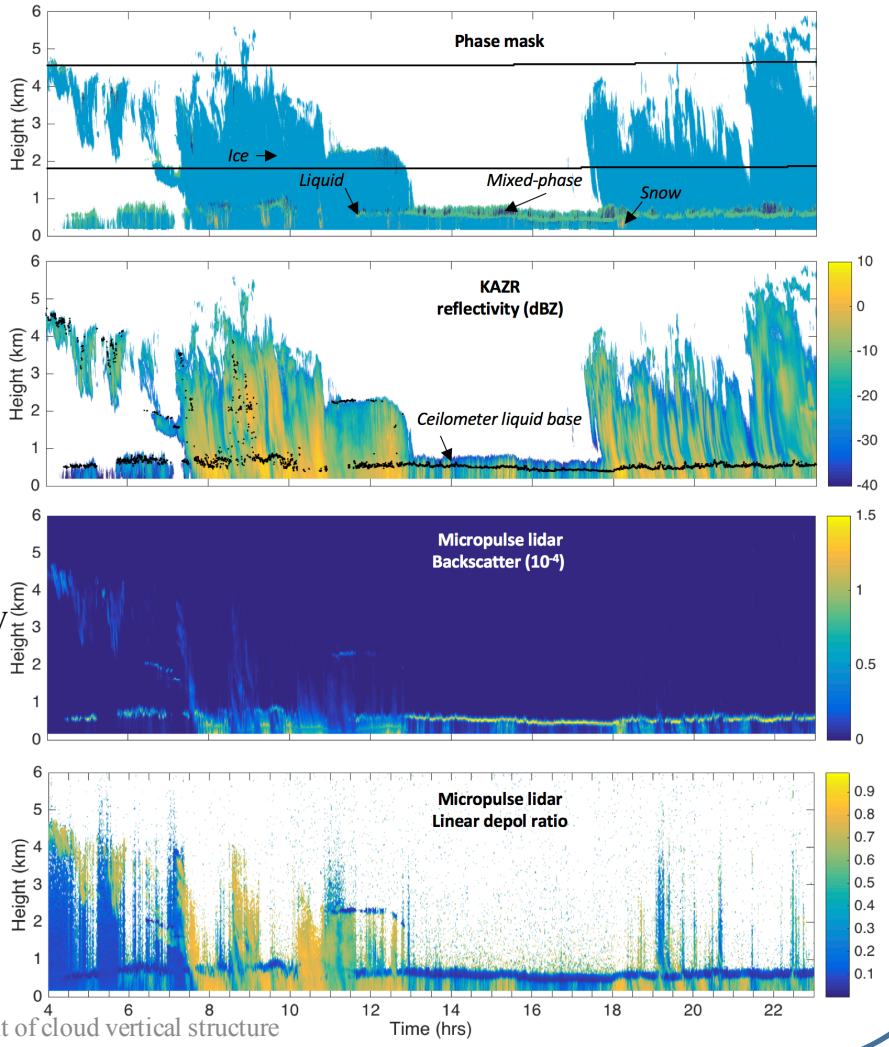
Instruments and datastreams – necessary supporting sensors

For cloud vertical structure

- MPLCMASK cloud boundaries

For phase

- **Calibrated micropulse lidar backscatter**
- Micropulse lidar linear depolarization ratio
- Microwave radiometer liquid water path and wet window
- Sonde temperature



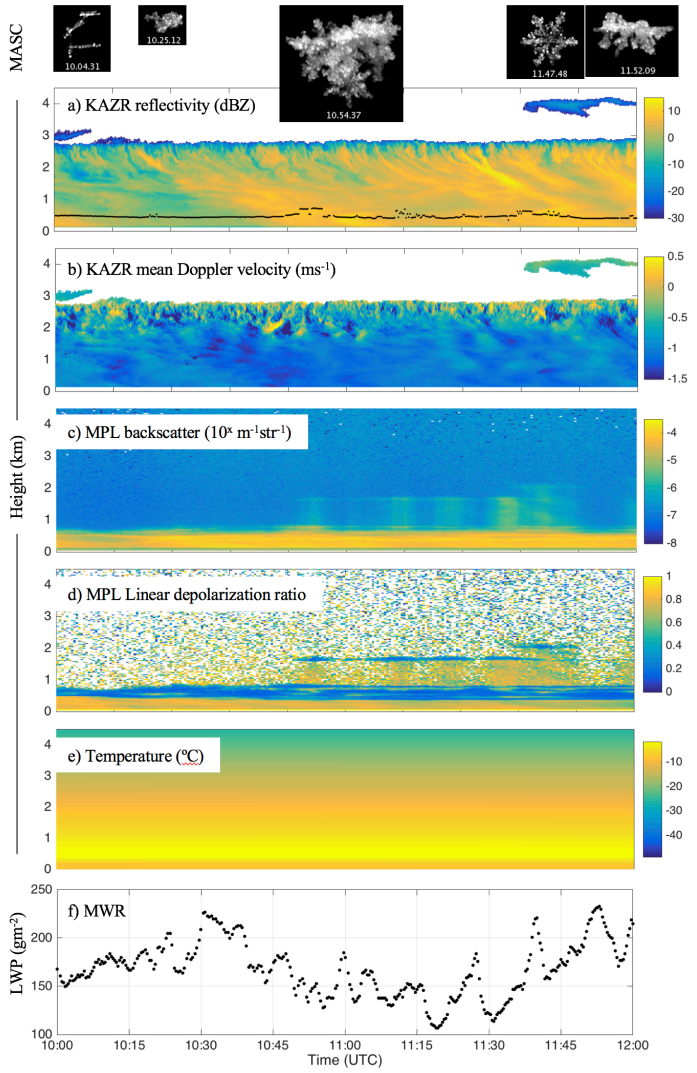
Instruments and datastreams – additional supporting sensors

For environmental characterization

- ECMWF omega

For microphysical process understanding

- Mergesonde temperature
- Multi-angle Snowflake Camera (MASC) images
- Cloud condensation nuclei (CCN) number concentration



Instrument streams	Datastreams	Note	Good periods
nsakazrgeC1.b1.	signal_to_noise_ratio_copol		2011-11-11 to 2012-12-16; 2013-03-16 to 2014-02-08; 2014-04-16 to 2016-10-01;
	reflectivity_copol	requires calibration	
	mean_doppler_velocity_copol		
	spectral_width_copol		
nsa30smplcmask1wangC1.	cloud_top_layer		
	cloud_base_layer		
	backscatter	requires calibration	
	linear_depol_ratio		
nsaceilC1.b1.	first_cbh		
nsamwrlosC1.b1.	liq		
	wet_window		
nsamergesonde1maceC1.c1.	tdry	when not available substituted for nsasondewnpnC1.b1.	
nsaecmwfvarX1.c1.	w		