Algorithm developer needs from ECVT (snapshot taken from interactive validation team portal on 08-SEP-2021 12:02)

	Collect in advance:		1. The EarthCARE retrieved geophysical parameters and their correlation with each other (e.g. IWC & PSD) and the model assumption used for the retrievals (e.g. optical properties)	2. Please provide a ranked list of the major uncertainties in each product, either based on evaluation of the synthetic scenes , or identifying regimes/processes that aren't well-represented in the scenes. What are remaining gaps in the algorithms performance (e.g. in understanding, in a-priori etc) with focus on "where the cal/val could contribute".	3. What you consider useful measurements to have, which could help you in the products (for calibration, validation, improving the parameterisations in the algorithms etc.).
APRIL: ATLID, MSI, and ATLID/MSI synergy	A-FM	Gerd-Jan van Zadelhoff	• Feature detection of aerosol and clouds, i.e. boundary detection of aerosol and cloud regions • Surface detection from collocated aircraft measurements	Verification of feature detection, this has a direct impact on the inferred horizontal smoothing length to be used in A-PRO	• High-quality lidar profiles of attenuated backscatter. Preferred wavelength is at 355 nm but other wavelength will be good as well.
	A-PRO	David Donovan	Aerosol and cloud profiles of : • Extinction • Lidar-ratio • Target-type (e.g. ice cloud,water cloud, aerosol etc..) • Aerosol type (Marine, etc..)	Verification of target classification scheme.	• High-quality profiles of extinction, backscatter and depolarization at 355 nm. • In-situ aerosol sampling co-located with lidar measurements.
	A-LAY	Moritz Haarig	**Clouds (A-CTH)** • Cloud top height and classification of thick or thin clouds with layering information **Aerosol (A-ALD)** • Aerosol layer boundaries • Aerosol layer mean optical properties • AOT (columnar, stratospheric, tropospheric) • Column aerosol classification probabilities Products provided on ATLID track. Layer detection based on Wavelet Covariance Transform technique combined with a threshold approach is applied to the Mie co-polar signal.	Aerosol-cloud discrimination using real EarthCARE data and SNR. Adapt thresholds to determine boundaries of clouds and aerosol using real data and SNR for all heights, but especially for stratospheric clouds and aerosol. tbc	Ground-based or airborne lidar measurements: • Detection of the planetary boundary layer height. • Multilayer aerosol scenarios (two distinct layers or aerosol layers with a strong internal structure) Aerosol optical properties and layer boundaries • Broken cloud scenes embedded in aerosol layer to test the cloud detection algorithm and the aerosol layer mean optical properties. Airborne lidar measurements of: • Multilayer cloud scenarios (cirrus above opaque water clouds) to test the multilayer detection.
	AM-COL	Moritz Haarig	**Clouds (AM-CTH)** • Synergistic cloud top height difference (ATL-MSI) **Aerosol (AM-ACD)** • Spectral AOT • Ångström exponent (355/670, and over ocean only 355/865) • Aerosol type Products provided on MSI swath. Combining vertical information at 355 nm from ATLID and spatial and radiative information on MSI swath.	Proper detection of multilayer cloud scenarios with MSI to consider them in the synergistic cloud top height. Extension of a specific aerosol plume from the track to the swath in order to prescribe the aerosol type detected on the track to the swath. tbc	As a synergistic product, it requires the validation of ATLID and MSI products as described in the corresponding sections.

	M-AOT	Nicole Docter	**Aerosol** Retrieved quantities: • Aerosol optical thickness at 670 nm (over ocean and land) • Aerosol optical thickness at 865 nm (over ocean only) Diagnostic quantities: • Angstrom parameter (670 nm, 865 nm) (over ocean only) Priors and underlying assumptions: • Internal, predefined mixing of HETEAC components in LUTs • Aerosol climatology (MAC v1 Kinne et al., 2013) • Fixed vertical distribution of HETAC types according to Aerosol cci (Holzer-Popp et al., 2013) • De-coupling of gases (H2O, O3, CO2, CH4) • Ocean surface parameterization following Cox and Munk (1954) • Lambertian surfaces over land using black sky albedo of MODIS MCD43 climatology as prior for SWIR-2	• Higher AOT uncertainties expected over land than over ocean due to the stronger TOA signal contribution of the surface than the aerosol • Aerosol type assumption can lead to additional large uncertainties over land	AOT at 670 nm over land (in different biomes) and over ocean and AOT at 865 nm over ocean based on: • Ground-based measurements (e.g. AERONET, AERONET-OC) • Ship-based sun photometer measurements (e.g. MAN) • Satellite based imager measurements (e.g. MODIS, VIIRS, 3MI)
	M-CLD	Anja Hunerbein	**Clouds (M-CLD)** Identification and classification of clouds on a pixel basis (500x500m) per frame for the entire MSI swath (150km) **Cloud Mask (M-CM):** • Cloud flag distinguish between clear-sky and cloudy pixels • Cloud type classifier differentiate between thin and thick clouds, as well as describing ISCCP related cloud type • Cloud top thermodynamical phase distinguish between water, ice phased clouds Surface classification **Cloud Optical and Physical properties (M-COP):** for water and ice clouds • Cloud optical thickness • Effective radius/particle size • Cloud top temperature/pressure/height • Liquid/ice/cloud water path	Cloud mask spectral thresholds should be verify by variety of defined scene types and compared to different cloud detection method from various instruments Validation needs: M-CM: • cloud edge detection over different surfaces (e.g. snow, desert) • day/night • MSI smile effect- MSI viewing zenith angle dependency should be taken into account	• imagers of geostationary satellites and polar orbiting satellite • synoptic observations from ground to validate time series • ground-based remote sensing along track - to get cloud properties • Assessment of M-CM comparison of cloud size distribution with high resolution satellite images, e.g., from collocated Sentinel-2 scenes
DORSY: CPR and ATLID/CPR /MSI synergy	C-PRO	Pavlos Kollias			
	C-CLD	Pavlos Kollias			
	C-APC	Pavlos Kollias Bernat Puigdomènech	CPR Antenna Pointing Correction Characterization of the antenna mispointing angle (mispointing model parameters, residuals and evaluation of the goodness of fit) Assumptions: - The mispointing due to the attitude control system errors and temperature variations has an harmonic behaviour and the mispointing angle can be parametrized by a regression fit taking into account the residuals (Battaglia et al. 2015) - The climatology of high cloud dynamics (Kalesse et al. 2013)	The ice clouds reflectivity-Doppler velocity climatology from space measurements. This unknown relationship brings uncertainties in the C-APC "ice clouds" correction technique	• Ground-based reflectivity and Doppler velocity measurements along the EarthCare track that would help validate and intercompare the ice clouds velocity climatology measured from space. • The onboard temperature telemetries that will model the thermoelastic antenna distortions. This will allow us to have a better understanding of the temperature variations associated with the sun-illumination changes along the orbit and the associated antenna mispointing corrected in the L1 products. Reverse-engineering is important if errors in the sensors impact the antenna pointing calibration
	AC-TC	Julien Delanoe			
	ACM-CAP	Shannon Mason	**Ice clouds and snow:** Retrieved (independent) quantities: • extinction (geometric optics approximation) • primed number concentration (Delanoe & Hogan, 2008) • extinction-to-backscatter ratio • density factor (Mason et al., 2018) Key derived quantities (& correlations with retrieved quantities): • Ice water content (extinction & primed number concentration) • Snow rate (extinction, primed number concentration, density factor) • Effective radius (extinction, primed number concentration, density factor) • Median volume diameter (extinction, primed number concentration, density factor) Priors and underlying assumptions:	1. Liquid cloud co-located with rain and embedded in ice clouds • Evaluation of AC-TC in the nominal scenes suggests EarthCARE active instruments detect about 25% of liquid clouds by volume, and less than 10% by liquid water content. • In ACM-CAP we can assume the presen ce of liquid clouds in rain, but need observational support for physical representation: e.g. vertical distribution of liquid clouds, profile of liquid water content, relation of liquid water path to rain rate. • Note that ACM-CAP is the only product including an active retrieval of liquid water content (C-CLD very rarely identifies liquid cloud), and that un-/misdiagnosed liquid cloud will result in large biases in shortwave cloud radiative effect. It is therefore very important to evaluate these assumptions.	**Aircraft underflights of EarthCARE:** *In situ measurements of hydrometeor and bulk cloud properties through the vertical profile will provide critical evaluation datasets, especially in ice and mixed-phase clouds where retrieval uncertainties are greatest.* Measurements: • in situ measurements of hydrometeor size distributions (up to mm scale for ice particles) • bulk water and liquid water content • Airborne microwave radiometer retrievals of liquid water path above and below aircraft, if available, would help to context ualise the in-situ measurements within th e profile of liquid cloud undiagnosed by E arthCARE active instruments Configuration:

- Normalized PSD with shape factor mu=2 (Field et al., 2005)
- mass-size relation (Brown & Francis, 1995)
- area-size relation (Frances et al., 1998)
- terminal velocity (Heymsfield & Westbrook 2010); assuming vertical air velocity contribution to mean Doppler velocity sums to zero with spatial smoothing
- microwave: horizontally-aligned oblate spheroidal aggregates of bullet rosettes with aspect ratio 0.6 (SSRGA; Hogan et al. 2017), transitioning to spheroids of solid ice (Mason et al. 2018)
- Infrared & visible: Baran (2003)

Uncertainties & assumptions:

- Undiagnosed supercooled liquid: supercooled cloud-tops in layered scenes; mixed-phase layers embedded in stratiform cloud; convective cores; melting snow; supercooled drizzle & rain processes.
- Continuity of mass flux (& size distribution) across the melting layer (interactions with “cold” rain)
- Scattering and particle properties across the melting layer
- Aerosol/ice misdetection at cloud edge

Liquid clouds:

Retrieved (independent) quantities:

- Liquid water content
- Total number concentration

Key derived quantities (& correlations with retrieved quantities):

- extinction (water content & number concentration)
- effective radius (water content & number concentration)

Priors and underlying assumptions:

- Log-normal size distribution (shape factor 0.38)
- Land/sea flags used for cloud droplet number concentration priors
- Microwave, infrared & visible: Mie

Uncertainties & assumptions:

- Physical depth of liquid cloud layers (i.e. cloud base height) after lidar is extinguished
- Liquid clouds often completely undiagnosed in deep and layered scenes
- When can we assume liquid cloud within cold rain?
- When can we assume supercooled liquid in convective cores?
- Are there any conditions under which embedded mixed-phase clouds can be diagnosed?

Drizzle and rain:

Retrieved (independent) quantities:

- Rain rate
- Number concentration scaling parameter (divergence from Abel & Boutle 2012 DSD)

Key derived quantities (& correlations with retrieved quantities):

- Rain water content (rain rate & number concentration scaling)
- Median volume diameter (rain rate & number concentration scaling)

Priors and underlying assumptions:

- Normalized gamma DSD (mu=5)
- Spherical drops (Mie scattering)
- Terminal velocity: Beard (1976)

Uncertainties & assumptions:

2. Drizzling stratocumulus & warm rain (not included in nominal scenes):

- Simultaneous retrieval of drizzle/rain and liquid cloud; both cloud and rain contribute to CPR backscatter and attenuation. Need to evaluate rain DSD and liquid cloud properties.
- Cloud-base is undetected by EarthCARE active instruments, so vertical structure of cloud and warm rain is poorly constrained.

3. Stratiform rimed snowfall (not included in nominal scenes):

- ACM-CAP can use mean Doppler velocity to diagnose faster-falling rimed snowfall when velocity measurements are not dominated by convective vertical air motion (Mason et al. 2018), but this capability---and its sensitivity to CPR Doppler velocity measurements---has not been evaluated in the nominal scenes.

4. Polar mixed-phase clouds:

- ACM-CAP retrievals of high-latitude mixed-phase clouds were subject to under-estimates of LWP (over-estimates of IWC) in the test scenes.
- Large uncertainties in retrieved mixed-phase cloud properties, with higher uncertainties in information from MSI visible channel at high solar zenith angles.
- Many different microphysical growth and multiplication processes can be at play in mixed-phase clouds, so the cloud and precipitation properties will have very high uncertainties in this regime.

5. Ice microphysics:

- Ice particle and snowflake structure, scattering properties and size distributions are inherently uncertain, have significant impacts on cloud radiative effects, and require ongoing evaluation and observational constraints across all locations and regimes.

- Prioritize close coordination with EarthCARE tracks
- Profiling flights to resolve vertical structure of clouds and precipitation

Ground-based remote-sensing along EarthCARE track:

EarthCARE precipitation retrievals are promising, especially over the ocean, but very difficult to validate robustly. Where EarthCARE passes near or over a scanning dual-polarization precipitation radar, there is good potential to generate large correlative datasets over O100km of flight track, including information about precipitation microphysics.

Measurements:

- Precipitation radar scans of rain and snowfall along the EarthCARE track
- Polarimetric radar variables provide insights into hydrometeor microphysics, especially ice growth processes such as aggregation and riming.

Configuration:

- A range of scanning strategies can be used to maximise correlative data: vertical (RHI) scans along the EarthCARE track for overpasses, and horizontal scans (PPI) across the EarthCARE track whenever within range of the radar.
- Prioritize scans of precipitation over the ocean or bodies of water, where EarthCARE precipitation retrievals make use of CPR path-integrated attenuation.
- Zenith-pointing ground-based instruments provide additional information of interest (e.g. vertical Doppler velocity, cloud-base height from ceilometers) in conjunction with in-situ measurements at the surface, but *focusing on rare EarthCARE overpasses of ground stations severely limits the amount of correlative data available*. This may be overcome by collating data across a network of sites.

			• Profile of rain rate is near-constant through the ground clutter to the surface • Mass flux (& size distribution) continuity with snow across the melting layer (“cold” rain) • Treatment of melting (e.g. do rimed ice particles take longer to melt?) • Retrievals of rain when radar is extinguished (PIA saturated) • Retrievals when PIA is not available /has large observational error (over land, sea ice, etc.) **Aerosols:** Retrieved (independent) quantities: • Number concentration Key derived quantities (& correlations with retrieved quantities) • Extinction (number concentration) Priors and underlying assumptions: • Extinction-to-backscatter ratio prescribed according to aerosol classification • Pre-defined admixtures of log-normal size distributions of HETEAC aerosols • Vertical and horizontal smoothing constraints		

CLARA:
 	
BBR, radiation, and closure assessment
	BM-RAD	Almudena Velazquez	**Radiation**
			
			For each telescope: FORE, NADIR, AFT
			
			• solar radiances (stand-alone and msi-based)
			• thermal radiances
			
			Provided at different resolutions:
			
			in the BBR grid: sampling 1km alongtrack
			
			• Standard: 10x10 km^2
			• Small: 10x(<10)km^2
			• Full
			  ◦ 10 x 28 km^2 (along/across-track, oblique views)
			  ◦ 10 x 17 km^2 (along/across-track, nadir view)
			
			In the JSG grid: sampling 1JSG pixel
			
			• Assessment Domain (5x21 JSG) resolutions
			
			PSF weighted variables:
			
			• MSI cloud cover
			• MSI cloud phase
			• X-MET snow cover
			• fraction of IGBP surface type in BBR PSF
				Using test scenes (Baja and Halifax)
				
				• SW unfiltering RMS ~ 0.7 W m-2 sr-1
				• LW unfiltering RMS ~ 0.3 W m-2 sr-1
				
				Snow covered regions present in average higher uncertainties that need to be further studied (either to improve LUT for the unfiltering or detection)	

	BMA-FLX	Carlos Almudena Velazquez	**Radiation** • solar fluxes for each telescope (FORE, NADIR, AFT) • thermal fluxes (FORE, NADIR, AFT) • coregistered solar and thermal radiances at a Reference Level • views-combined solar and thermal fluxes	Using Baja scene • LW flux estimation RMS ~ 6 W m-2, stddev = 5 W m-2	
	ACM-COM	Howard Barker	Augmentation of L2a and L2b retrievals with X-MET data that enables them to be operated on by broadband solar and thermal radiative transfer models	When constructing the "composite" alternative to ACM-CAP, L2a products from CPR and ATLID are used. The choice, however, of which to select remains a partially open issue. Relative uncertainties associated with water content and effective size must be considered.	No special needs

	ACM-3D	Howard Barker	**3D scene construction** Construction of 3D surface-atmosphere conditions around the active-passive retrieved cross-section (RXS) of aerosol and cloud properties for the purpose of: (i) averaging 1D RT flux profiles computed for each RXS column; and applying 3D RT models to domains in which the RXS is just the central transect. Production of indices at off-RXS pixels (in the JSG) that reference a column on the RXS. **Definition of buffer-zones** In order to facilitate 3D RT on a small constructed domain (default size of these "assessment domains" is 5 x 21 km) it is necessary to perform RT on an expanded domain that includes, as a subset, the assessment domain. Definition of the "buffer-zone", along- and across-track, depends on viewing geometry, cloud conditions adjacent to the assessment domain, and solar position. **Ranking of assessment domains** Due to anticipated computer resource limitations for real-time processing of EarthCARE products, it is expected that 3D RT models will not be able to operate on all of the assessment domains in a ~6,000 km "frame". As such, assessment domains have to be prioritized for 3D RT application.	As yet, all verifications of the scene construction algorithm have been based on numerical simulation. We have not been able, as yet, to verify the crediblity of nadir - to - off-nadir allocations.	**Aircraft underflights of EarthCARE:** *In situ measurements of vertical profiles of hydrometeor and bulk cloud properties to enable evaluation of the 3D scene construction algorithm.* Measurements: · in situ measurements of hydrometeor size distributions (up to mm scale for ice particles) and bulk water and liquid water content Configuration: · Prioritize close coordination with EarthCARE tracks · Profiling flights to resolve vertical structure of clouds and precipitation. This should include flights *along the RXS* as well as *off-RXS*; without the latter, the scene construction algorithm cannot be assessed. **Ground-based remote-sensing along EarthCARE track:** *Where EarthCARE passes near or over surface sites that measure broadband surface radiation quantities and also make measurements that allow inference of both profiles and vertically-integrated cloud properties.* Measurements: · Precipitation radar scans of rain and snowfall along, or near, the EarthCARE track · Active-passive measurements (CPR, lidar, narrowband radiances) that provide estimates of cloud properties. · Broadband pyranometers and pyrgeometers located at sites either on or, ideally, removed from the RXS.
	ACM-RT	Howard Barker	**1D radiative transfer** 1D broadband solar and thermal RT models are applied to each RXS profile that emerges from ACM-COM. Pristine, clear-sky, and all-sky simulations are performed with fluxes and heating rates produced and saved. **3D radiative transfer** 3D broadband solar and thermal RT models are applied to assessment domains (plus their buffer-zones) that are defined and ranked in ACM-3D. Only all-sky conditions are considered. Domain-average top-of-atmosphere (TOA) radiances towards the BBR sensors as well as profiles of solar fluxes are produced and saved. For the thermal, only radiances toward BBR sensors at a designated (co-registration) altitude are produced and saved.	Since RT products, notably fluxes at atmospheric levels, depend in part on fields dictated by ACM-3D, flux verifications using observations are subject to the same uncertainties and problems as are the geophysical fields in ACM-3D. RT flux profiles depend to a great extent on profiles of temperature and humidity (especially in the LW) as well as on surface optical properties. These variables are, however, outside the purview of EarthCARE's observations and must come from other sources. If they are in much error, they will render the radiative closure assessment (ACMB-DF) useless.	**Aircraft underflights of EarthCARE:** *In situ measurements of vertical profiles of broadband radiative fluxes.* Measurements: • in situ measurements of broadband up- and down-welling fluxes Configuration: • Prioritize close coordination with EarthCARE tracks • Profiling flights to resolve vertical fluxes and gradients. This should include flights *along the RXS* as well as *off-RXS*. The latter are not as crucial as they are for ACM-3D, but would nevertheless be helpful. **Ground-based remote-sensing along EarthCARE track:** *Where EarthCARE passes near or over surface sites that measure broadband surface radiation quantities (including surface conditions such as albedo and emissivity) at high temporal resolution.*
	(ACMB-DF)	Howard Barker	Comparison of measured and inferred BBR radiances and TOA fluxes against corresponding estimates from ACM-RT.	To do a proper (i.e., statistically satisfying) radiative closure assessment of simulated radiative quantities against corresponding measurements, the assessment should include reliable estimates of model input, measurements, and values inferred from measurements. This includes retrieved geophysical parameters, model inputs from sources other than EarthCARE, and EarthCARE's radiometric observations. Many of these errors and uncertainties are still poorly defined.	Measured data used for assessment of products generated in ACM-3D and ACM-RT can be used here to assess this process were necessary.

Table 2. Correlative measurements needed in support of algorithm developent

Category	Variable	Unit	Comment	Feedback from Algorithm developers on needs
Radar	- radarReflectivityFactor	[dBZ]		
	- dopplerVelocity	[m/s]		
	- spectrumWidth	[m/s]		

	- signalToNoiseRatio	[dB]		
Backscatter Lidar	- attenuatedBackscatter	[sr-1 km-1]	with corrections applied or respective information delivered (see below)	
	- depolarizationRatio or	[-]	with corrections/calibration applied or respective information delivered (see below)	
	- cross-polar attenuatedBackscatter	[sr-1 km-1]	with corrections applied or respective information delivered (see below)	
HSRL/Raman lidar	- Mie and Rayleigh/Raman attenuated Backscatter		with corrections applied or respective information delivered (see below)	
HSRL/Raman multi wavelength 355. 532 (+1064)	3x- Mie and Rayleigh/Raman attenuated Backscatter 2x extinction 2x depolarization	[sr-1 km-1] [km-1] [-]	aerosol retrievals + typing with corrections applied or respective information delivered (see below)	
Radiometer	- IR and solar radiances			
			ground based BSRN like	
	- surface direct-beam shortwave irradiance	[W m-2]		
	- surface diffuse shortwave irradiance			
	- surface longwave irradiance			
	- level radiative fluxes on aircraft (SW and LW)			
	- (spectral) surface direct & diffuse albedo	[-]		
	- (spectral) surface emissivity			
Sunphotometer	AOD		ground based aeronet	
Hyperspectral Imager	- IR and solar radiances		MSI smile	
Instrument properties	- radarWaveLength	[GHz]	(94 and/or 35GHz)	
	- pitchAngle / elevation	[deg]	(aircraft/ground-based radar, lidar)	
	- observation geometry	[deg]	(e.g. viewing angle)	
	- lidarWaveLength	[nm]	(355, 532, 1064 nm or other)	
	- lidarFOV	[mrad]		
	- calibration and correction parameters		(e.g. spectral and polarization cross talk, dead-time, dark current, overlap)	
Thermodynamic (specify source)	- temperature	[K]		
	-temperature profile	[K]		
	- surfaceTemperature	[K]		
	- pressure	[hPa]		
	- relativeHumidity	[%]		
	- humidity profile	[g/g]		
	- surfaceRelativeHumidity	[%]		
	- winds	[m/s]		
	- surfaceWinds	[m/s]		
	- navigationLandSeaFlag		(land type/water)	
	- atmospheric gases		(e.g. H2O,O3,O2,CH4 ...)	
Retrievals (for ice and rain)	- Detailed information about all assumptions used		(model, PSD, etc.)	
	- Information about particle size and density			
	- meanMassDiameter	[mm]		
	- waterContent	[g/m3]		
	- massFlux	[mm/h]		
	- surface precipitation occurrence			

Retrievals/In situ observations for aerosol	- particle size distribution/effective particle size	[µm]		
	- refractive index	[-]		
	- absorption and scattering coefficients and/or single-scattering albedo	[1/m]		
	- particle shape information (non-sphericity)			

3) The table below (thanks Shannon Mason) relates geophysical parameters to EarthCARE data products. The table was created for the purpose of algorithm intercomparison. Please provide your recommentations (in the comment field at the bottom of this page) how this table can be re-purposed /adapted to support the Principal Investigators (for example: " indicate when/how to use which of these products, by placing them in columns per validation method")?

Table 3: Geophysical Parameters vs EarthCARE Products

	Cloud-top, vertically integrated and layerwise retrieval product			**Vertical profiles at nadir**	
	Quantity	**At nadir**	**Across-track**	**Quantity**	**Products**
Target classification	**Cloud-top height**	M-COP, A-CTH, *A-TC,* C-TC, AC-TC	M-COP, AM-CTH	**Cloud/precipitation fraction**	A-TC, C-TC, AC-TC
	Cloud-top phase	M-CM, A-TC, C-TC, AC-TC	M-CM, AM-CTH	**Cloud/precipitation phase**	A-TC, C-TC, AC-TC
	Aerosol layer height /depth	A-ALD, A-TC	AM-ACD	**Aerosol fraction**	A-TC, ACM-COM
	Aerosol layer classification	A-ALD, A-TC	AM-ACD	**Aerosol species**	A-TC, ACM-COM
Ice cloud & snow	**Optical thickness**	M-COP, A-EBD, ACM-CAP	M-COP	**Extinction**	A-EBD, ACM-COM, ACM-CAP
	Effective radius	M-COP, A-ICE, ACM-CAP	M-COP	**Effective radius**	A-ICE, ACM-COM ACM-CAP
	Water path	M-COP, A-ICE, C-CLD, ACM-CAP	M-COP	**Water content**	A-ICE, ACM-COM, ACM-CAP
	Surface snow rate	C-CLD, ACM-CAP		**Snow rate**	C-CLD, ACM-CAP
				Snow median diameter	C-CLD, ACM-CAP
				Extinction-to- backscatter ratio	A-EBD, ACM-CAP
Liquid cloud	**Optical thickness**	M-COP, A-EBD, ACM-CAP	M-COP	**Extinction**	A-EBD, ACM-COM, ACM-CAP
	Effective radius	M-COP, ACM-CAP	M-COP	**Effective radius**	ACM-COM, ACM-CAP
	Water path	M-COP, ACM-CAP	M-COP	**Water content**	C-CLD, ACM-COM, ACM-CAP
Rain	**Surface rain rate**	C-CLD, ACM-CAP		**Rain rate**	C-CLD, ACM-CAP
	Rain water path	C-CLD, ACM-CAP		**Rain water content**	C-CLD, ACM-CAP
				Median drop size	C-CLD, ACM-CAP
Aerosol (per species)	**Aerosol optical thickness**	M-AOT, A-ALD, A-AER, A-EBD, ACM-CAP	M-AOT, AM-ACD	**Aerosol extinction**	A-AER, A-EBD, ACM-COM, ACM-CAP
				Extinction-to- backscatter ratio	A-AER, A-EBD, ACM-CAP
	Ångström exponent	M-AOT (670/865nm), AM-ACD (355/670nm)	M-AOT (670 /865nm), AM-ACD (355 /670nm)	**Particle linear depolarization ratio**	A-AER, A-EBD