ATLID Layer Products (A-LAY), ATLID-MSI Synergy (AM-COL) & Hybrid End-to-End Aerosol Classification (HETEAC)

APRIL – Final Presentation
10 March 2021

Moritz Haarig, Ulla Wandinger, Anja Hünerbein, Florian Schneider, Stefan Horn
TROPOS
haarig@tropos.de, ulla@tropos.de

ATLID Layer Products (A-LAY)

Geometrical layer detection
based on Wavelet Covariance Transform
applied to ATLID Mie co-polar signal

Clouds

Aerosol

Dimension: along track x height ("Curtain")

ATLID-MSI Synergy Products (AM-COL)

Combines height-resolved information from ATLID
with MSI column products on swath

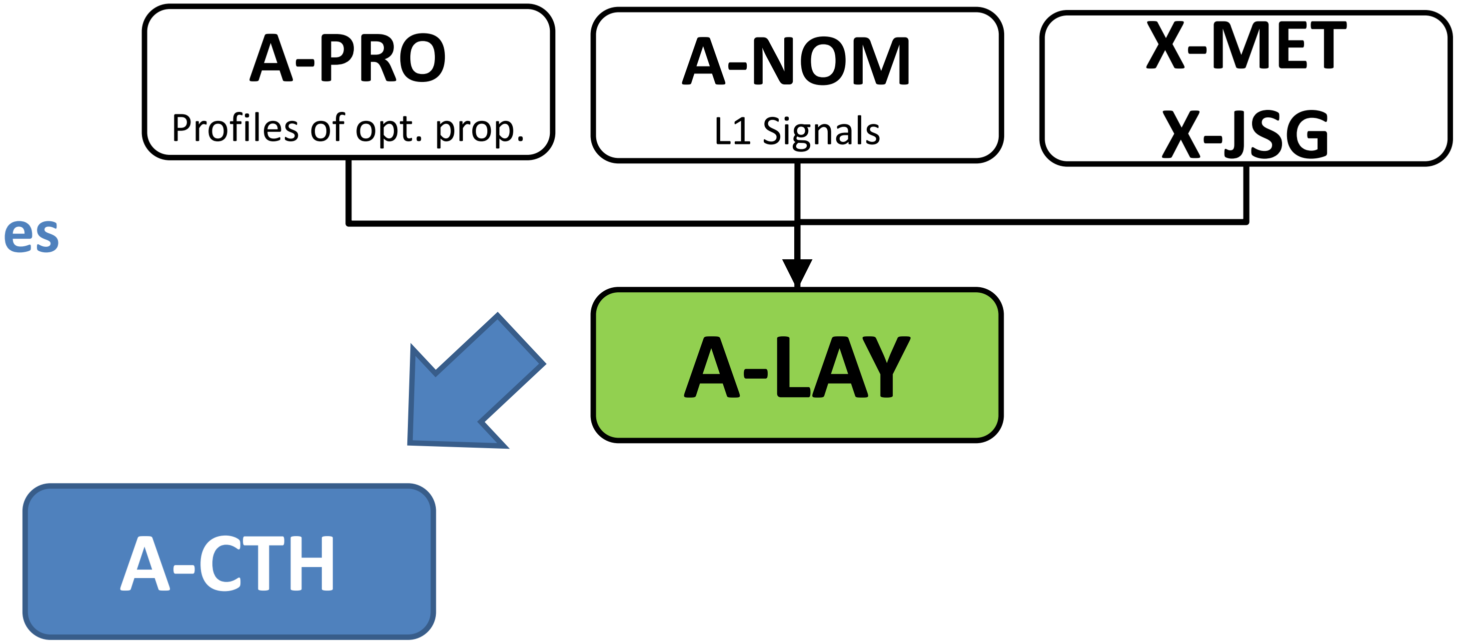
Clouds

Aerosol

Dimension: along track x across track ("Carpet")

Cloudy profiles
- Clouds -

Cloud free profiles
- Aerosol -

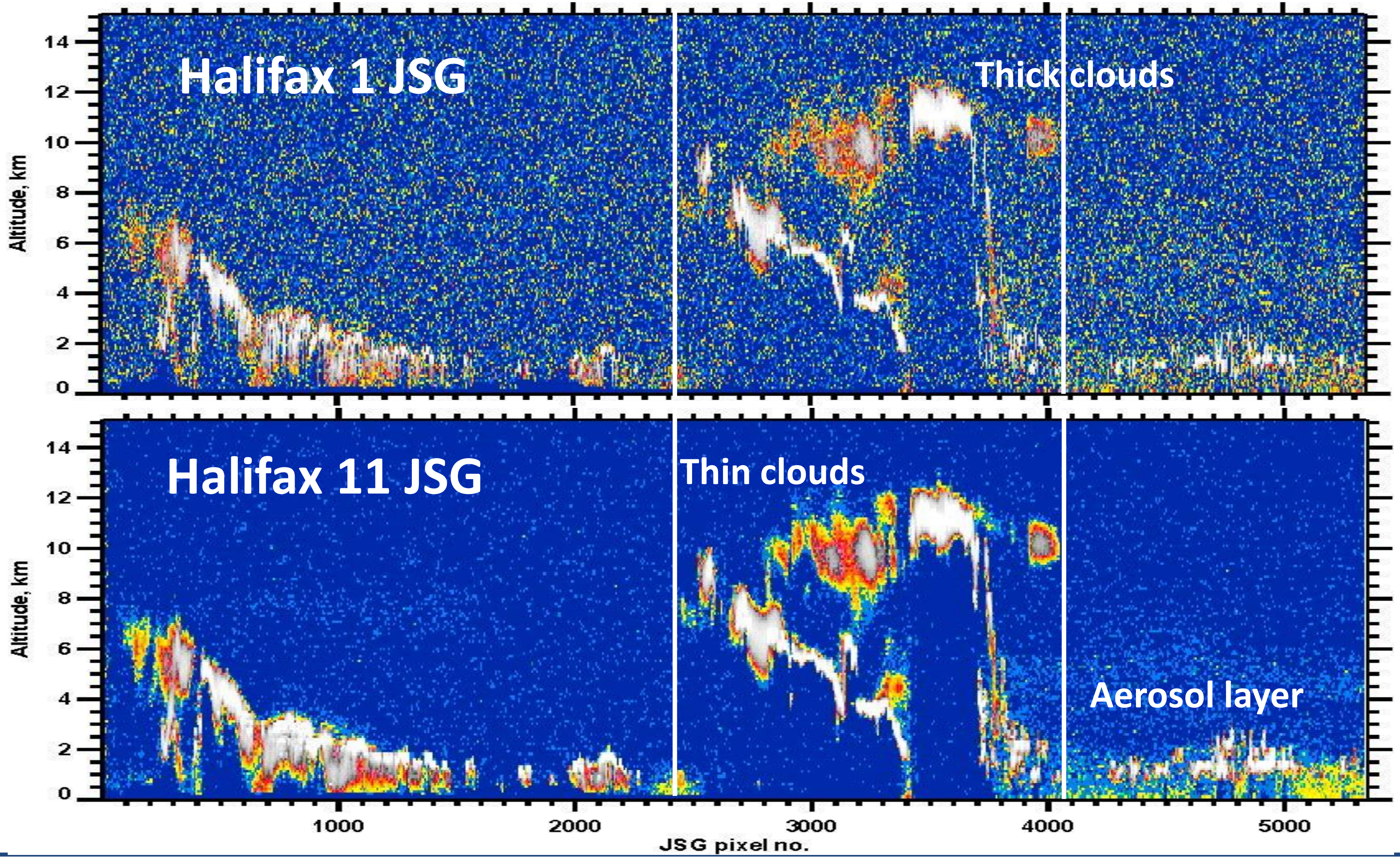


Output:

Cloud Top Height

- Thick clouds at 1 JSG pixel horizontal resolution
- Thin clouds at 11 JSG pixel horizontal resolution
- Classification of multilayer clouds

Finding layers – a matter of horizontal resolution

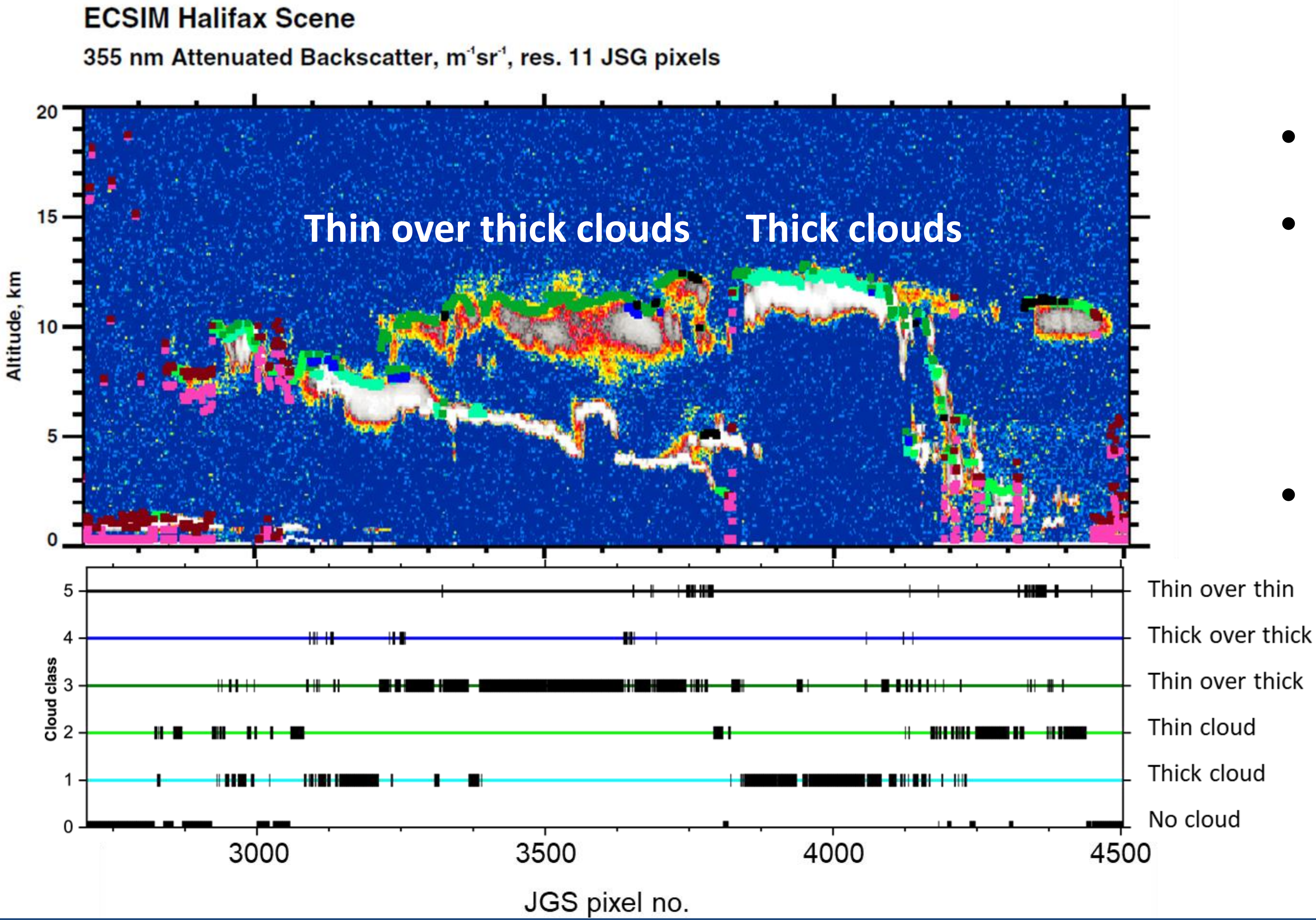


First search at 1 JSG pixel

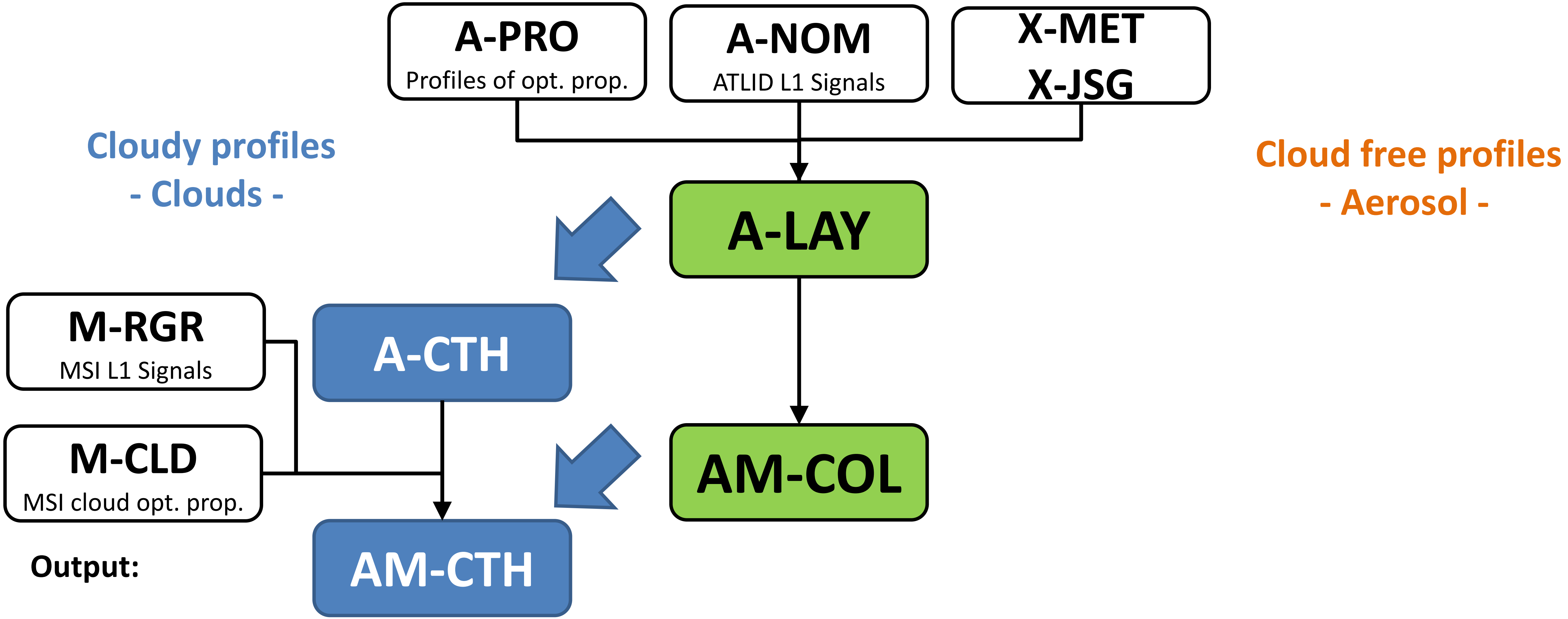
Second search at 11 JSG pixel

→ Retrieve cloudy profiles

Multilayer cloud scenarios



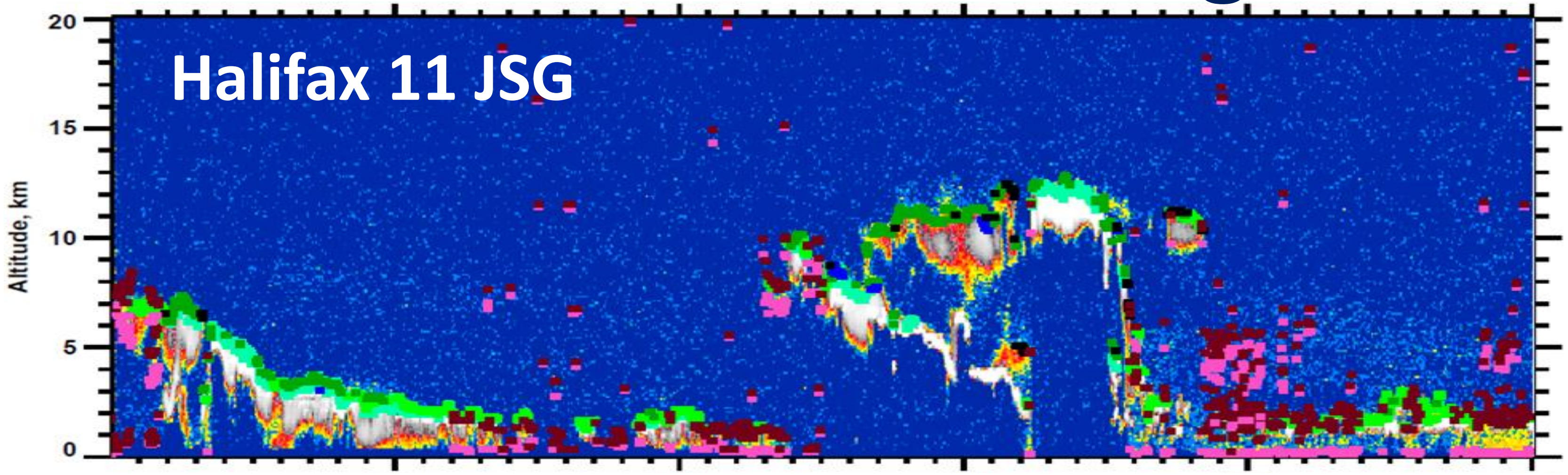
- Detected cloud top height
- Compare with A-PRO target classification (A-TC) → Derive level of consistency
- Define multilayer scenarios → important for synergy with MSI

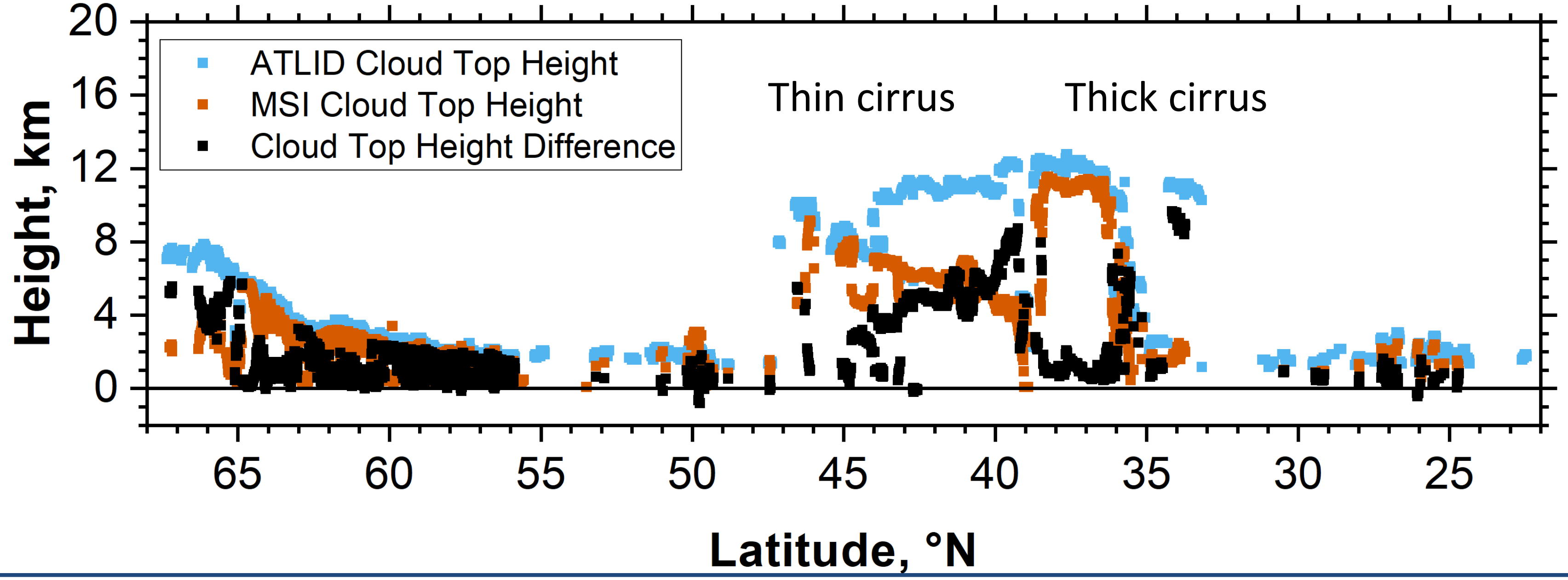


Cloud Top Height

- Synergistic Cloud Top Height Difference derived from A-CTH and M-CTH L2 products
- Extend CTH difference from track to swath

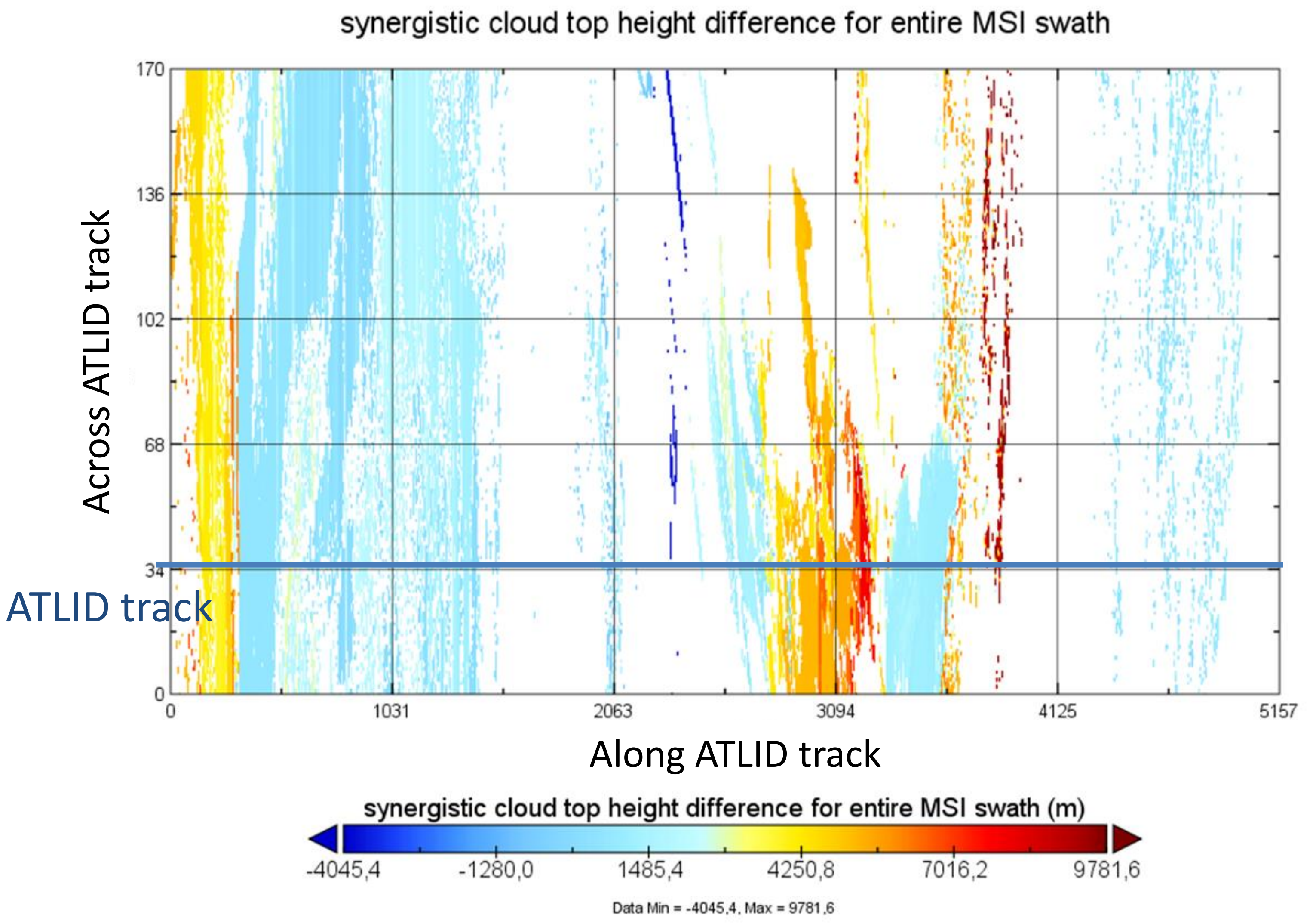
ΔCTH along track





CTH Difference on Track

ΔCTH on the swath



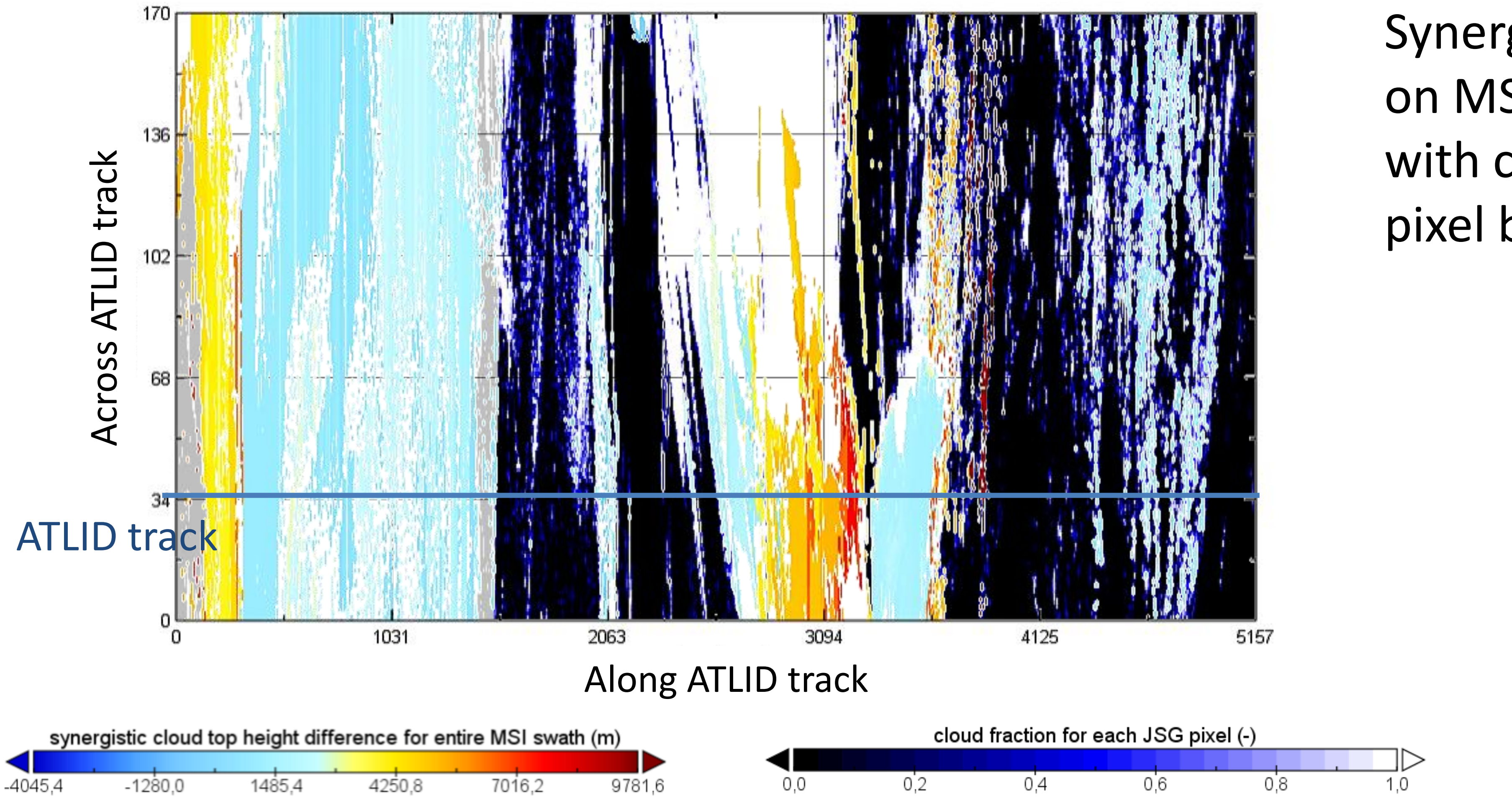
Extend ΔCTH from track to swath using the criteria:

1. ΔBRT at 10.8µm
   $\left| T_{B\_10.8,t} - T_{B\_10.8,s} \right| < \Delta T_{th\_10.8}$
2. Same cloud phase
3. Same surface type
4. Δ Reflectance at 0.67µm
   $\left| \rho_{0.6,t} - \rho_{0.6,s} \right| < \rho_{th}$
5. Same cloud type (ISCCP)

Additional criteria at daytime

→ Reflected in quality flag

ΔCTH on the swath

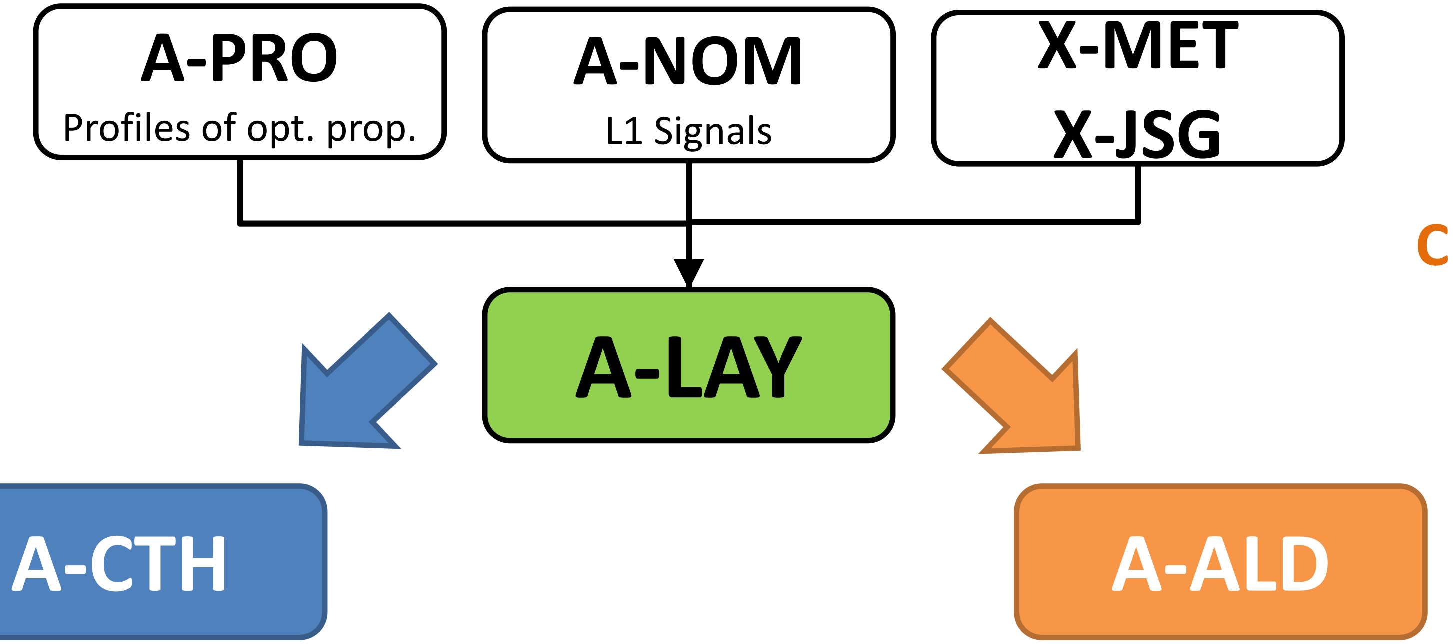


Synergistic ΔCTH
on MSI swath
with cloud fraction per JSG
pixel behind

Cloudy profiles
- Clouds -

Cloud free profiles
- Aerosol -

Output:



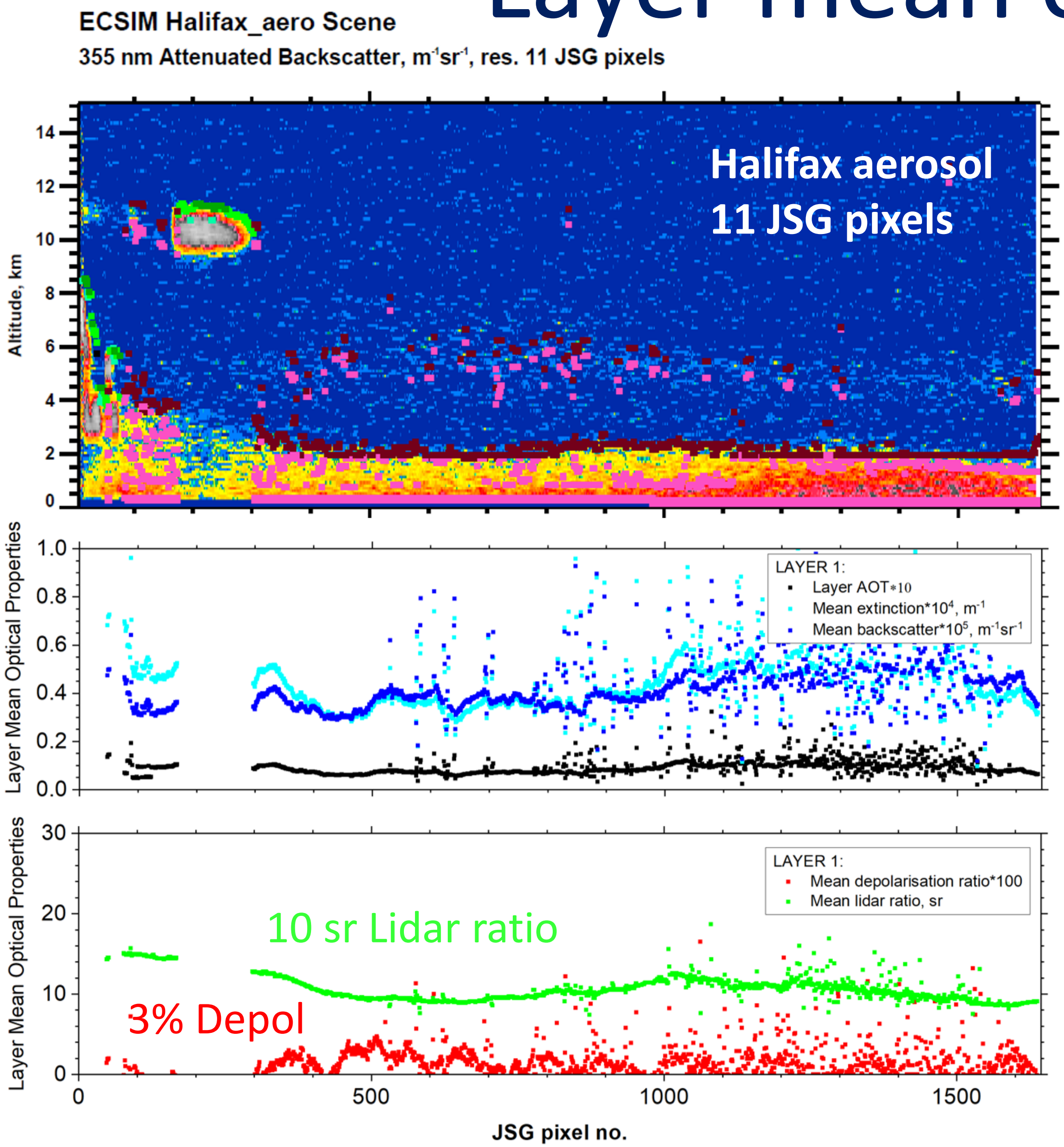
Cloud Top Height

- Thick clouds at 1 JSG pixel horizontal resolution
- Thin clouds at 11 JSG pixel horizontal resolution
- Classification of multilayer clouds

Aerosol Layer Descriptor

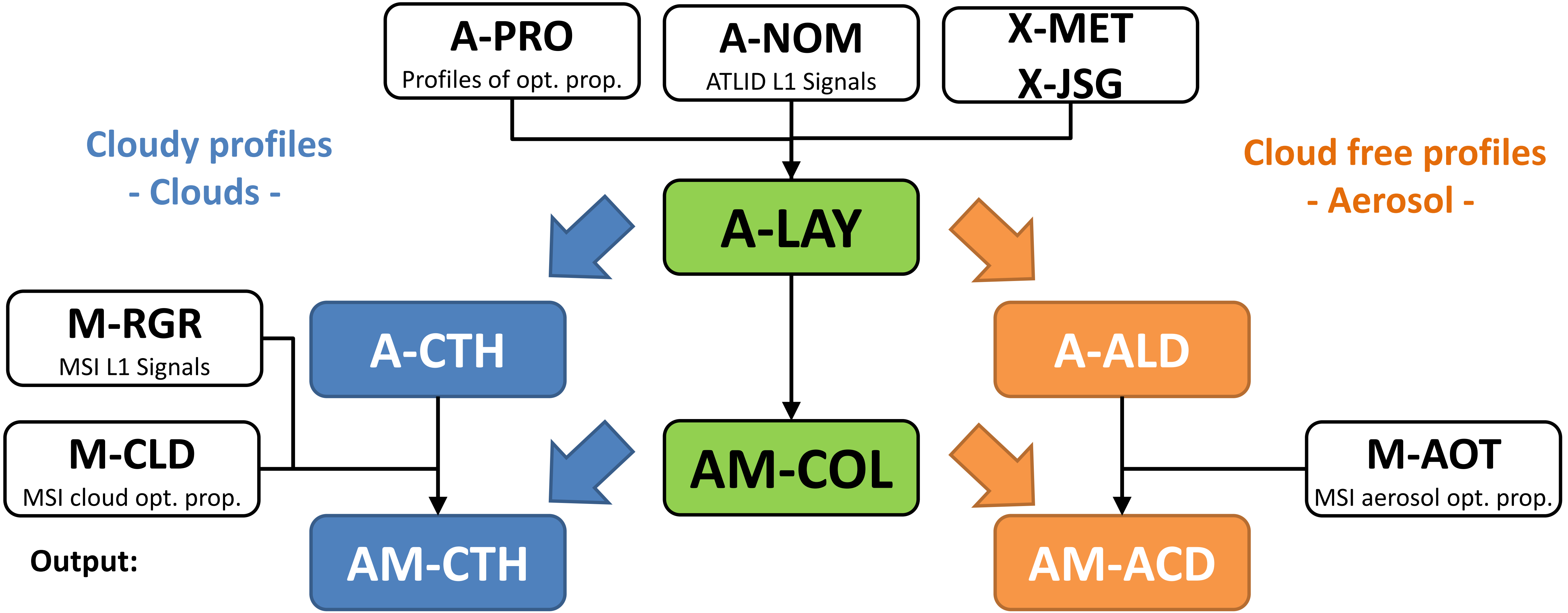
- Aerosol layer boundaries
- Column and layer-mean optical properties (AOT, bsc, ext, LR, depol)
- 11 JSG pixel horizontal pixel resolution (configurable)

Layer mean optical properties



- Layer boundaries found with Wavelet Covariance Transform method
- Determine layer mean optical properties
- Calculate columnar integrated aerosol classification probabilities from A-TC product (A-PRO)
  → important for synergy with M-AOT

→ marine aerosol



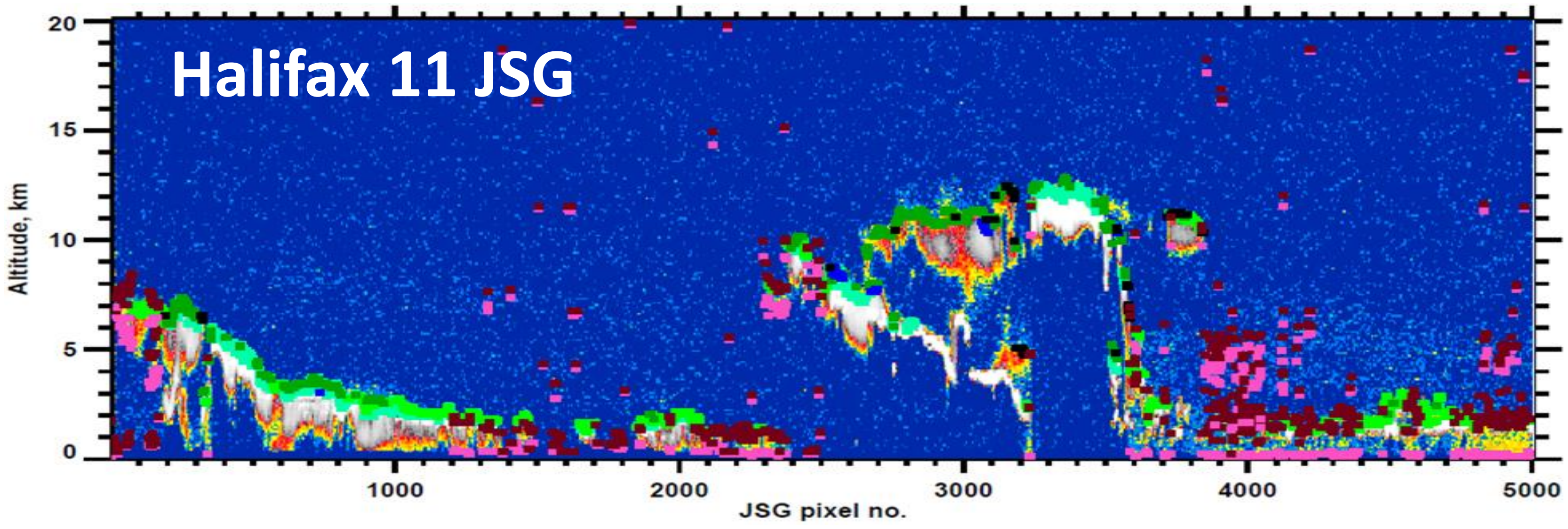
Cloud Top Height

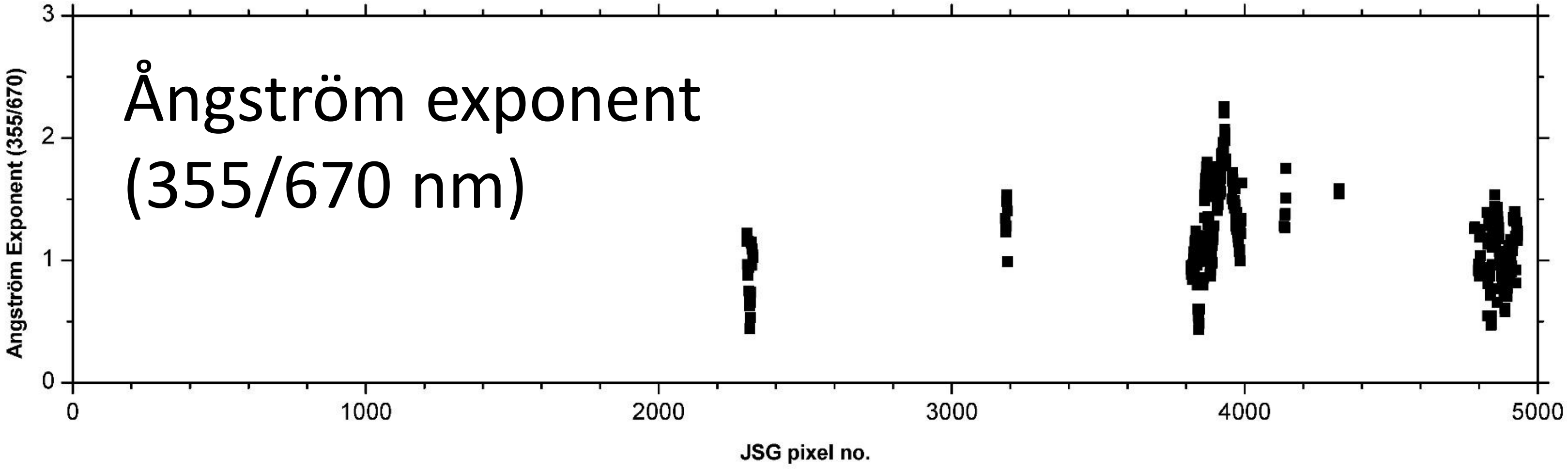
- Synergistic Cloud Top Height Difference derived from A-CTH and M-CTH L2 products
- Extend CTH difference from track to swath

Aerosol Column Descriptor

- AOT and Ångström exponent (355/670/865 nm), dominant aerosol type
- Extend ATLID information from track to swath

MSI-ATLID Synergy along track





Spectral AOT
at 355, 670, 870 nm

Added value to single wavelength ATLID

Hybrid End-to-End Aerosol Classification (HETEAC)

Hybrid End-to-End Aerosol Classification

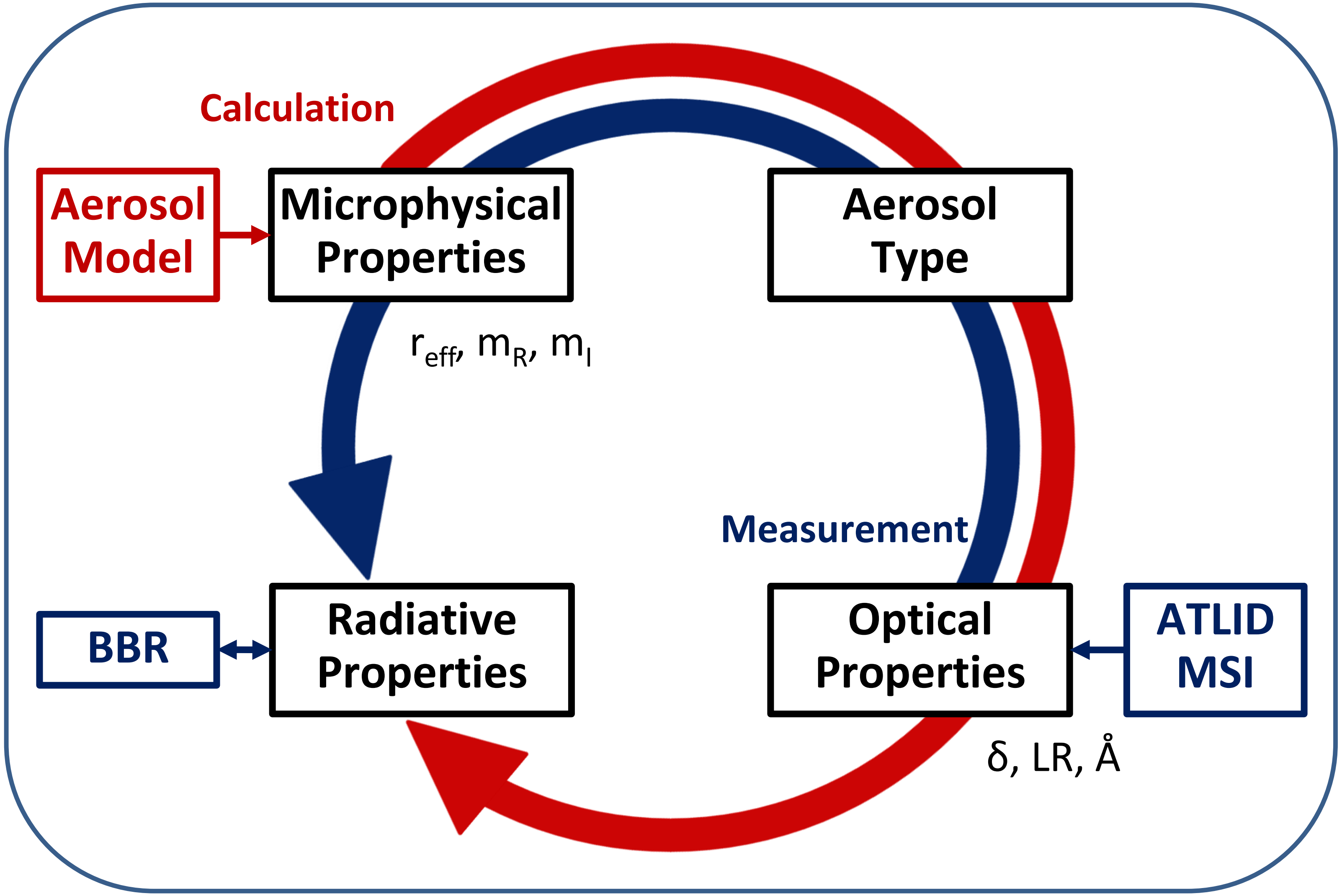
To connect **microphysical**, **optical** and **radiative** properties of pre-defined aerosol components

Why **hybrid**?

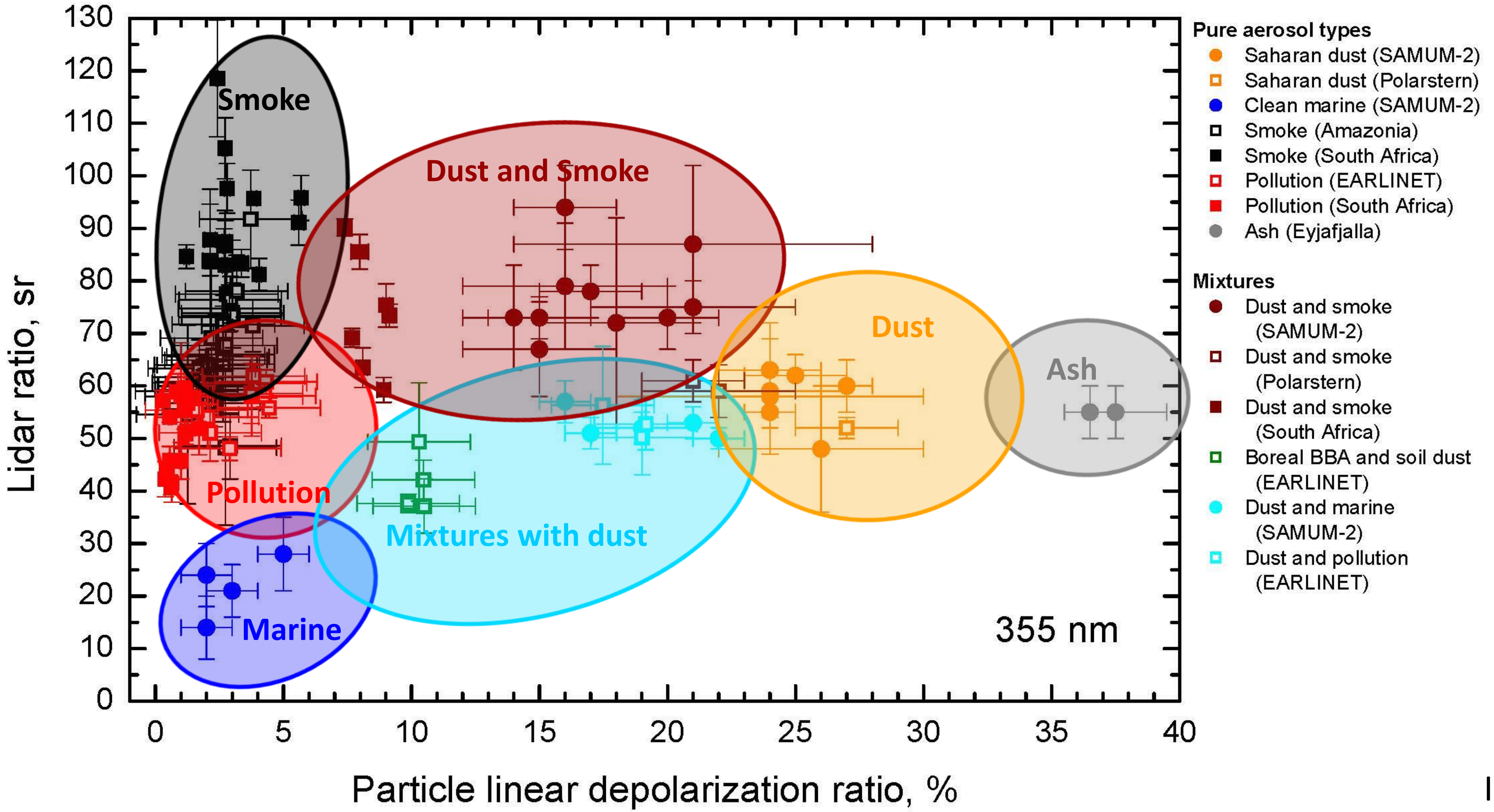
- **Theoretical** microphysical description that fits the **experimental** findings

Why **end-to-end**?

- Close the loop from microphysics to radiation



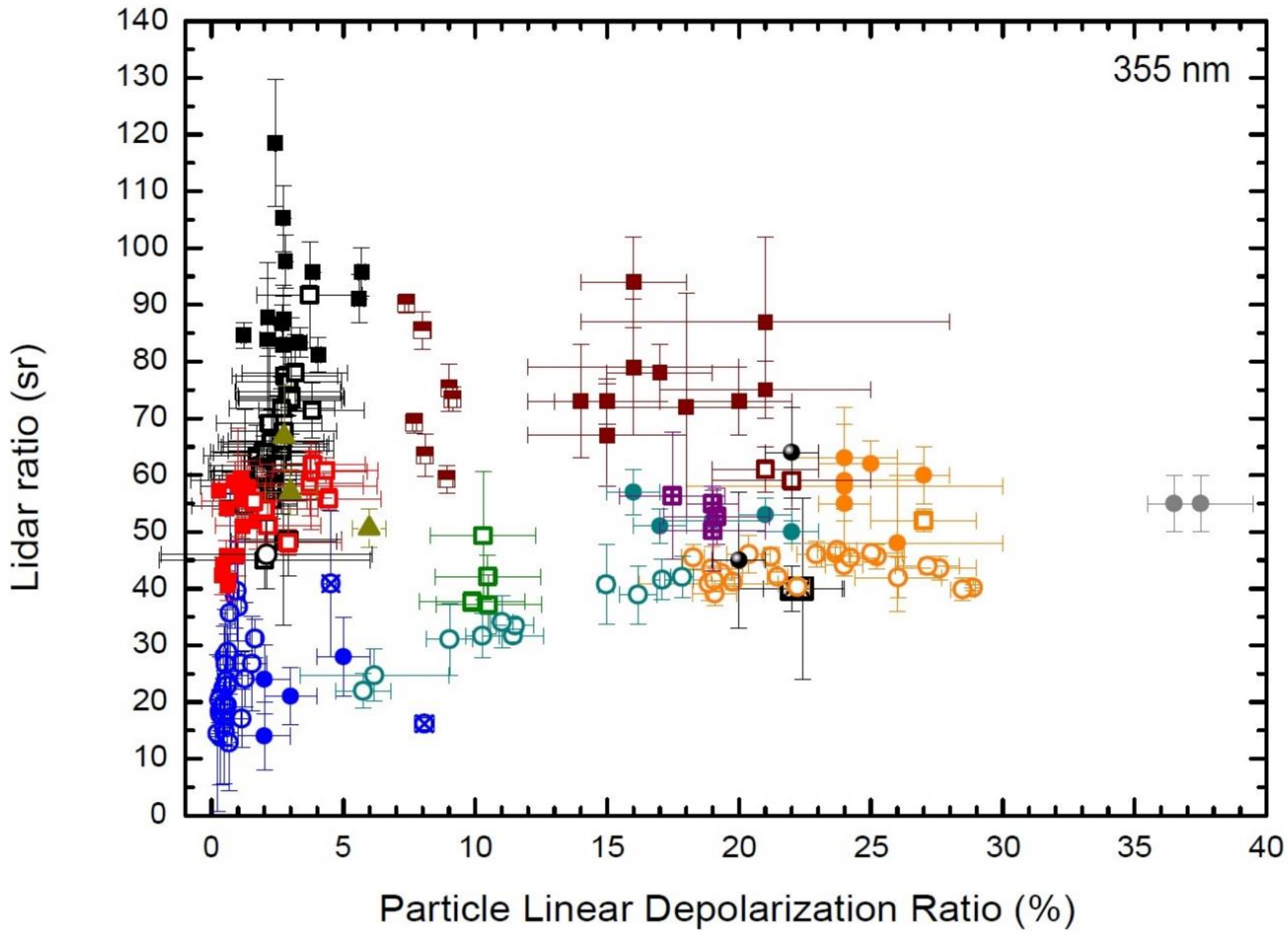
Experimental Basis for Aerosol Classification



Illingworth et al., BAMS 2015

Recent updates

New datasets

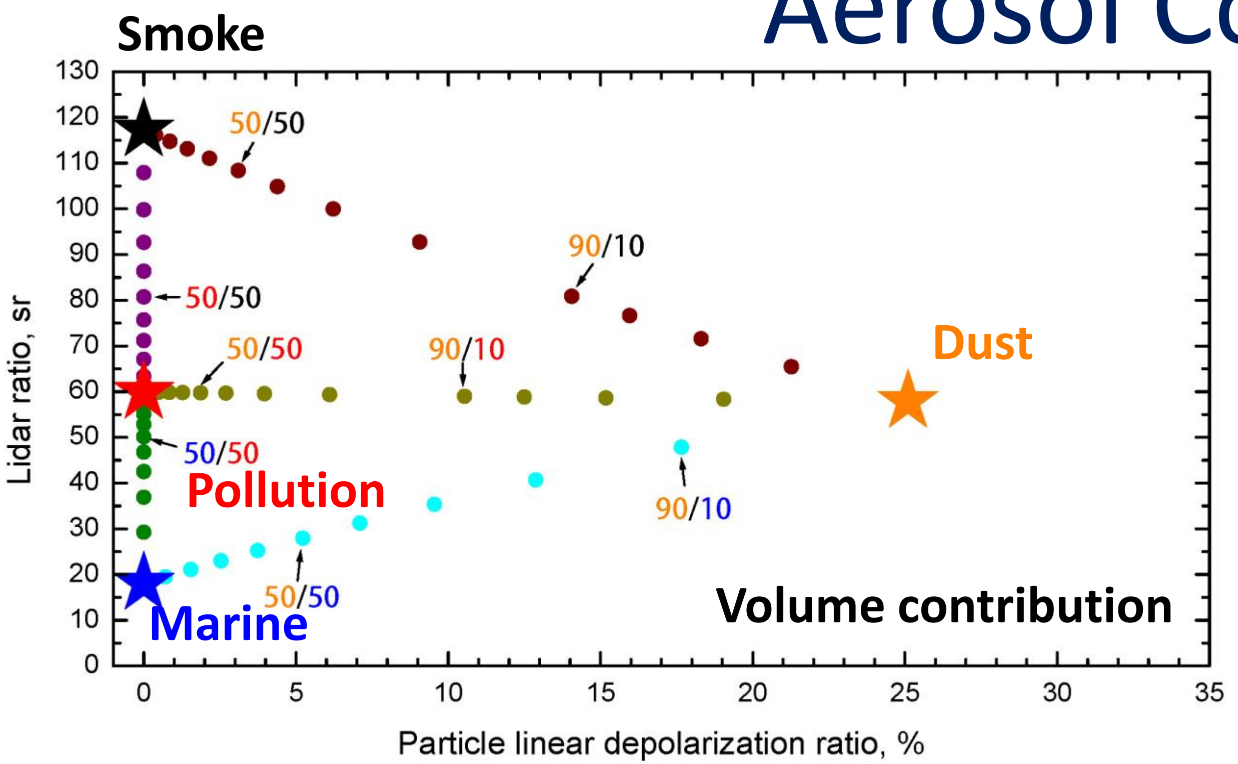


Continuously updated (Athena Floutsi)

Pure aerosol types
- Smoke (Amazonia)
- Smoke (South Africa)
- Smoke (Central Europe)
- Smoke (Stratospheric)
- Aged smoke (Canadian and Siberian)
- Saharan dust (SAMUM-2)
- Saharan dust (Polarstern)
- Central Asian dust (CADEX)
- Clean marine (SAMUM-2)
- Clean marine (Polarstern)
- Dried marine (Polarstern)
- Pollution (South Africa)
- Pollution (EARLINET)
- Ash (Eyjafjalla)

Mixtures
- Central European background aerosol (Leipzig)
- Dust and smoke (SAMUM-2)
- Dust and smoke (Polarstern)
- Dust and smoke (South Africa)
- Saharan dust and African BBA
- Boreal BBA and soil dust (EARLINET)
- Dust and marine (SAMUM-2)
- MBL mixture (Polarstern)
- Dust and pollution (EARLINET)

Aerosol Components



- 4 (pure) **aerosol components** to calculate mixing states
- Define **microphysical properties** for each component
- Calculate effective radius & refractive index of the **mixture**
  → Input for radiation calculation

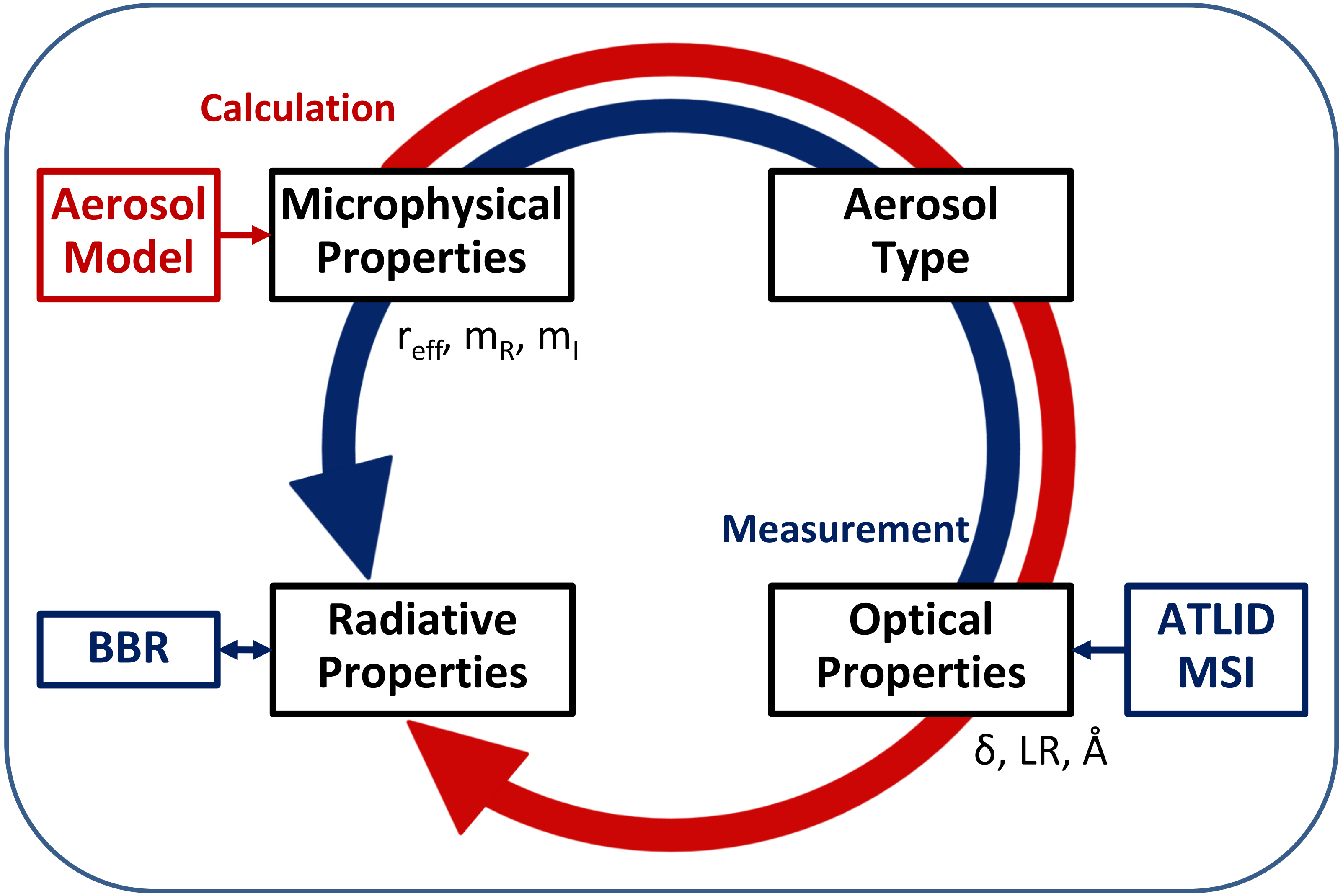
	Dust Coarse mode	Sea salt Coarse mode	Pollution Fine mode	Smoke Fine mode
r_{eff}, µm	1.94	1.94	0.14	0.14
m_R (355 nm)	1.54	1.37	1.45	1.50
m_I (355 nm)	0.006	4.e-8	1.e-3	0.043
Shape	Spheroid	Spherical	Spherical	Spherical

Effective radius

Refractive index

Validation by aircraft + lidar campaigns A-LIFE, Cyprus 2017

HETEAC - Conclusion



- **Aerosol classification** model developed for EarthCARE and implemented in ECSIM
- 4 basic aerosol components with **prescribed microphysical properties** to calculate mixtures
- **Radiation closure for aerosol** from ATLID & MSI with BBR