Aeolus aerosol and cloud product

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ALADIN is a High Spectral Resolution Lidar !

That means we don't need any hypothesis on the lidar ratio to retrieve aerosols extinction and backscatter coefficient.

$$S_{Ray} = K_{ray} \frac{E_0}{R^2} [C_1 \beta_{mol} + C_2 \beta_{part}] T^2_{mol} T^2_{part}$$

$$S_{Mie} = K_{Mie} \frac{E_0}{R^2} [C_4 \beta_{mol} + C_3 \beta_{part}] T^2_{mol} T^2_{part}$$

Calibration mode data

AUX_MET
$P(z), T(z), \nu(z)$

Cal coeffs :
C1(P,T,ν), C4(P,T,ν)
C2(ν) ,C3(ν)
Kray, KMie

β_{mol}
T^2_{mol}

Crosstalk corrected signals

$$\beta^{Att}_{mol} = \beta_{mol} T^2_{mol} T^2_{part}$$
$$\beta^{Att}_{part} = \beta_{part} T^2_{mol} T^2_{part}$$

Predicted molecular signals

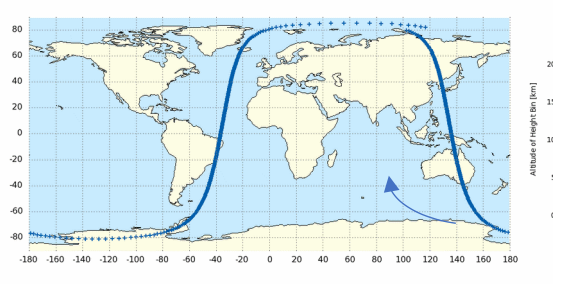
Output :

$$\hat{\beta}_{part} = \frac{\beta^{Att}_{part}}{\beta^{Att}_{mol}} \beta_{mol}$$

$$\hat{\alpha}_{part} = \frac{-1}{2} \frac{d}{dz} \left[\log \left(\frac{\beta^{att}_{mol}}{\beta_{mol} T^2_{mol}} \right) \right]$$

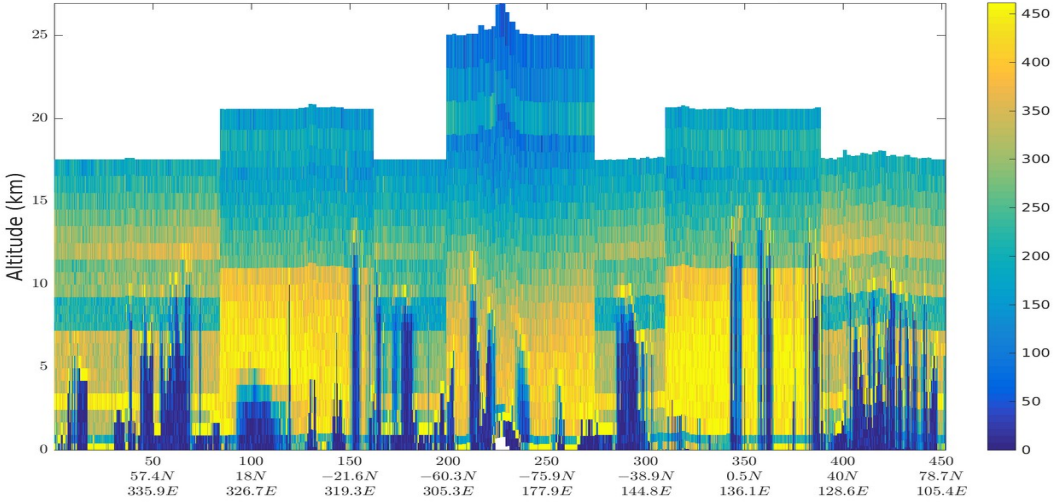
The quality of L2A products depends on the cross-talk correction, which itself depends on AUX_CAL data and NWP model.

First idea on product quality: cross-talk correction

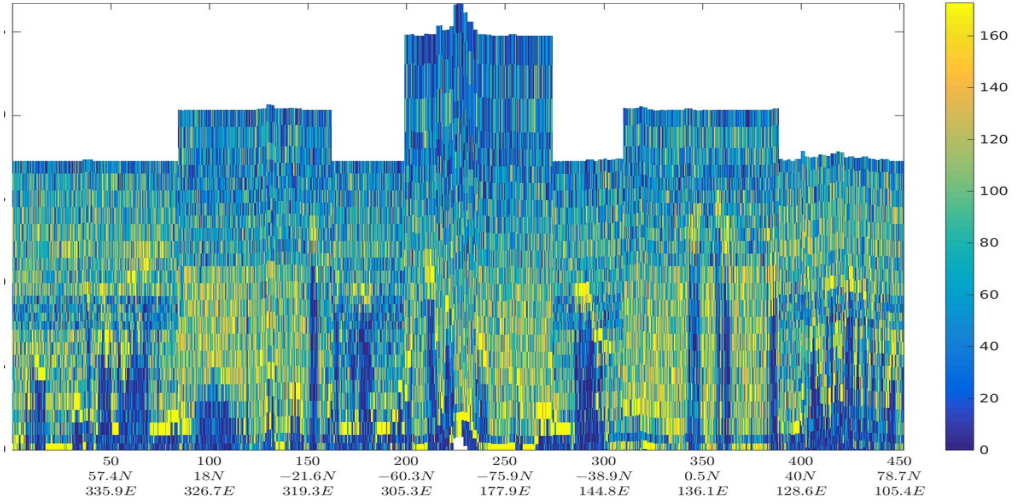


"Raw" Rayleigh and Mie channel signals:
Orbit 10568 – 16 June 2019

Rayleigh channel signal

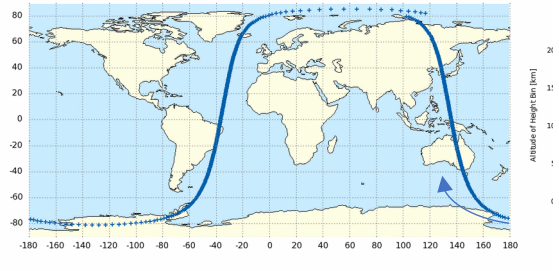


Mie channel signal

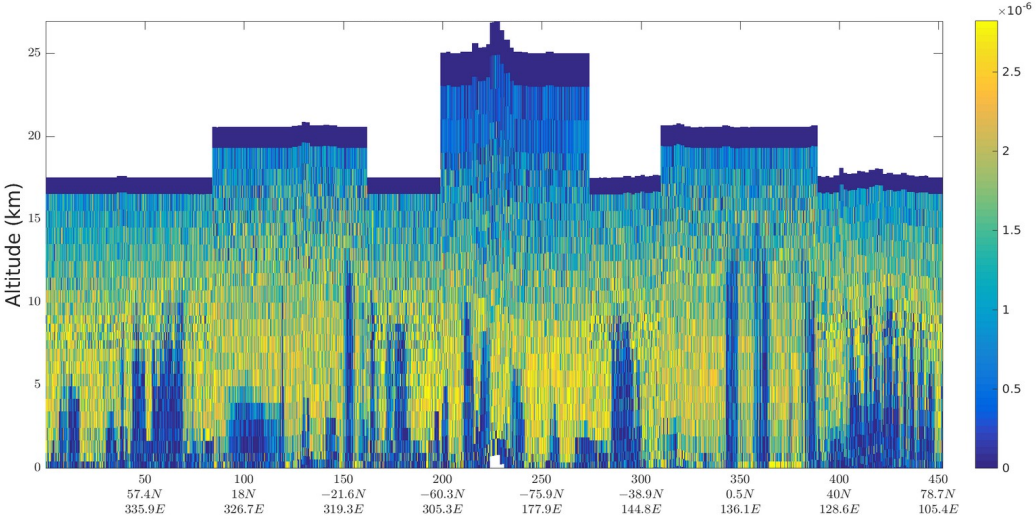


First idea on product quality: cross-talk correction

- After cross-talk correction:
  Orbit 10568 – 16 June 2019

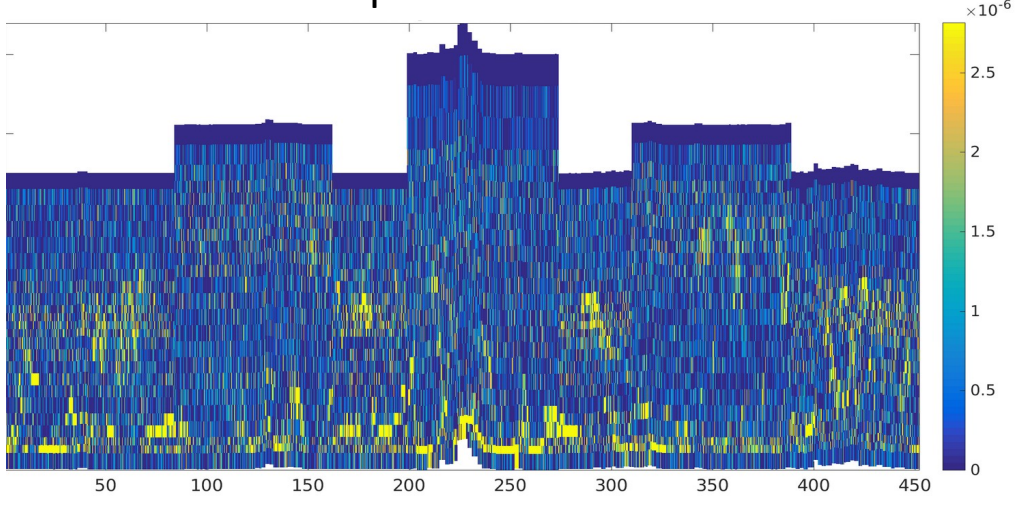


Attenuated molecular backscatter



No visible clouds (Mie signal removed)

Attenuated particulate backscatter

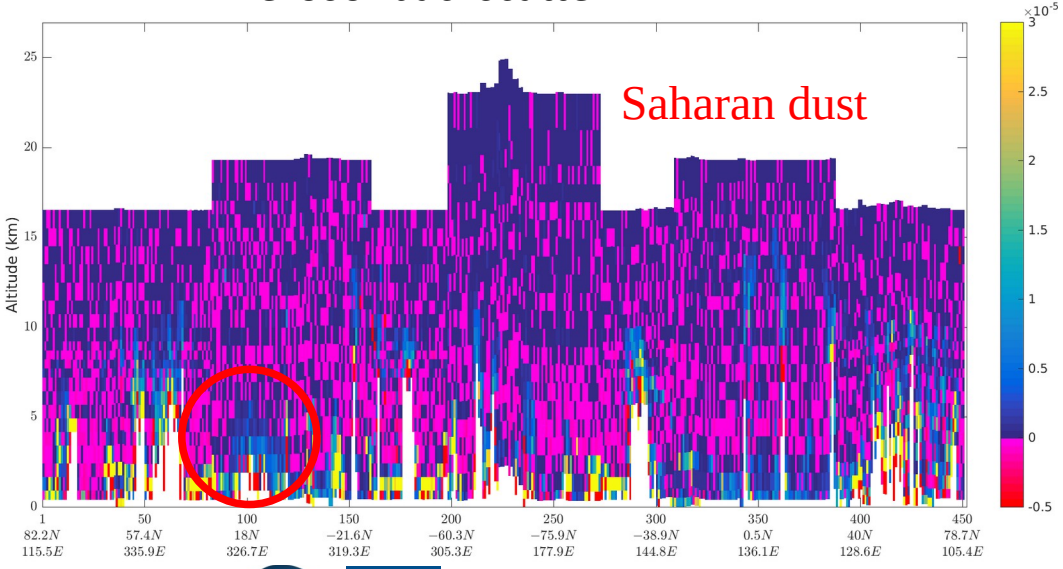


No background (molecular signal removed)

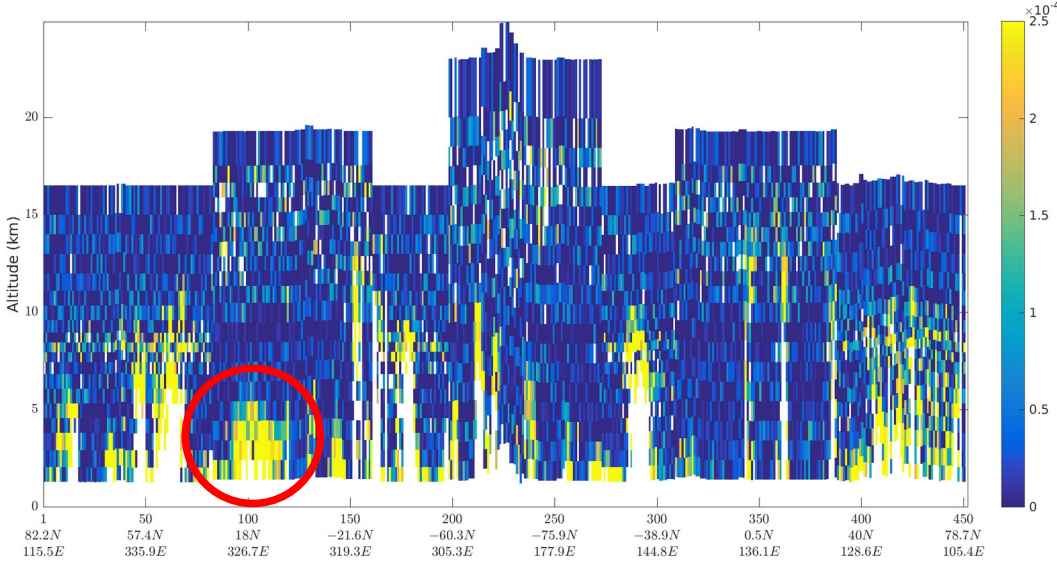
Standard Correct Algorithm

- Uses both Mie and Rayleigh channel taking advantage of the high spectral resolution of ALADIN
- Proper calibration allows to discriminate molecular and particulate contributions to the signal
- Allows independent measurement of extinction and backscatter coefficients

Aerosol backscatter

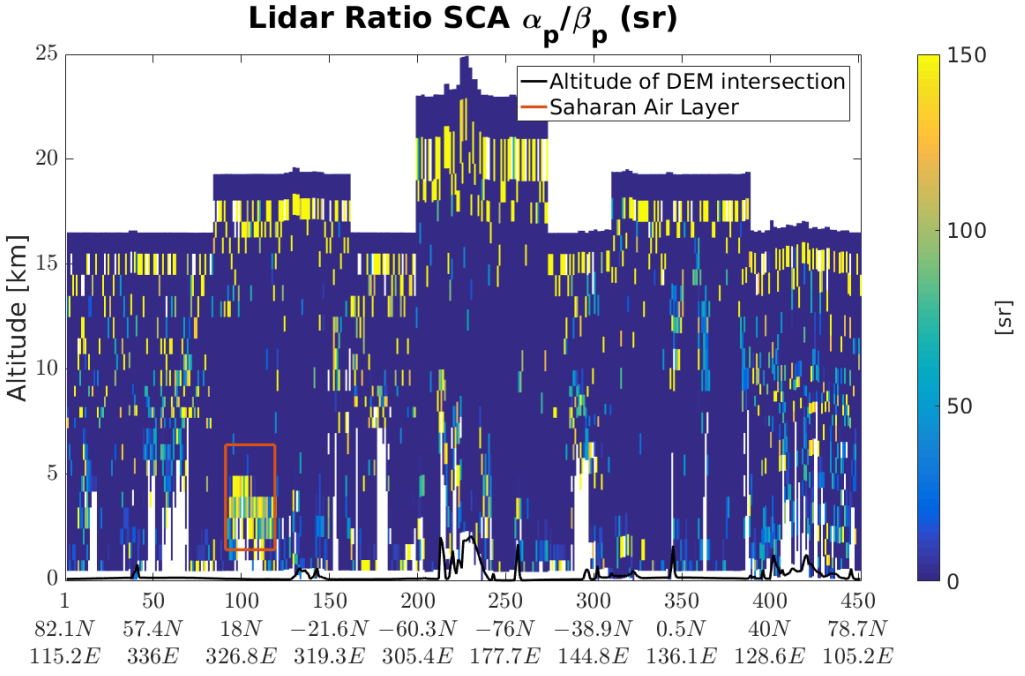


Aerosol extinction



Standard Correct Algorithm

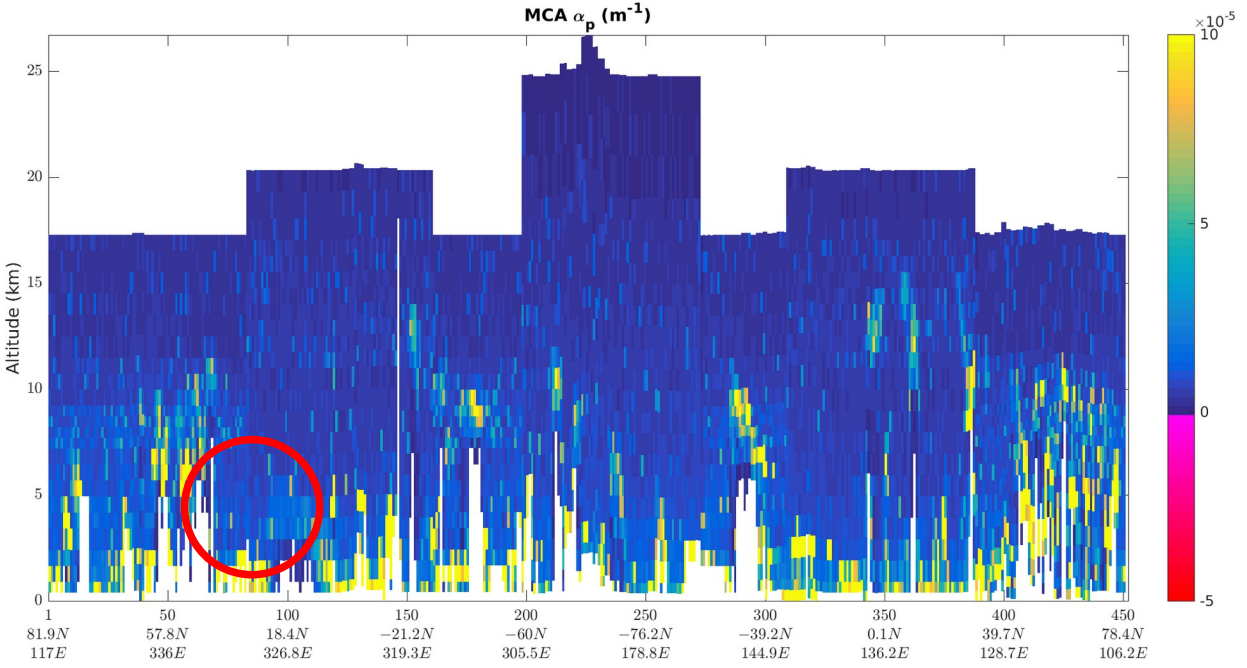
- Uses both Mie and Rayleigh channel, taking advantage of the high spectral resolution of ALADIN
- Proper calibration allows to discriminate molecular and particulate contributions to the signal
- Allows independent measurement of extinction and backscatter coefficients, and thus the measurement of “lidar ratios” that give an information on the particle type.



Mie Correct Algorithm

- The Mie channel it self it able to measure the scattering ratio.
- Prescribed lidar ratio
- Less noisy, better discrimination of features

MCA extinction coefficient



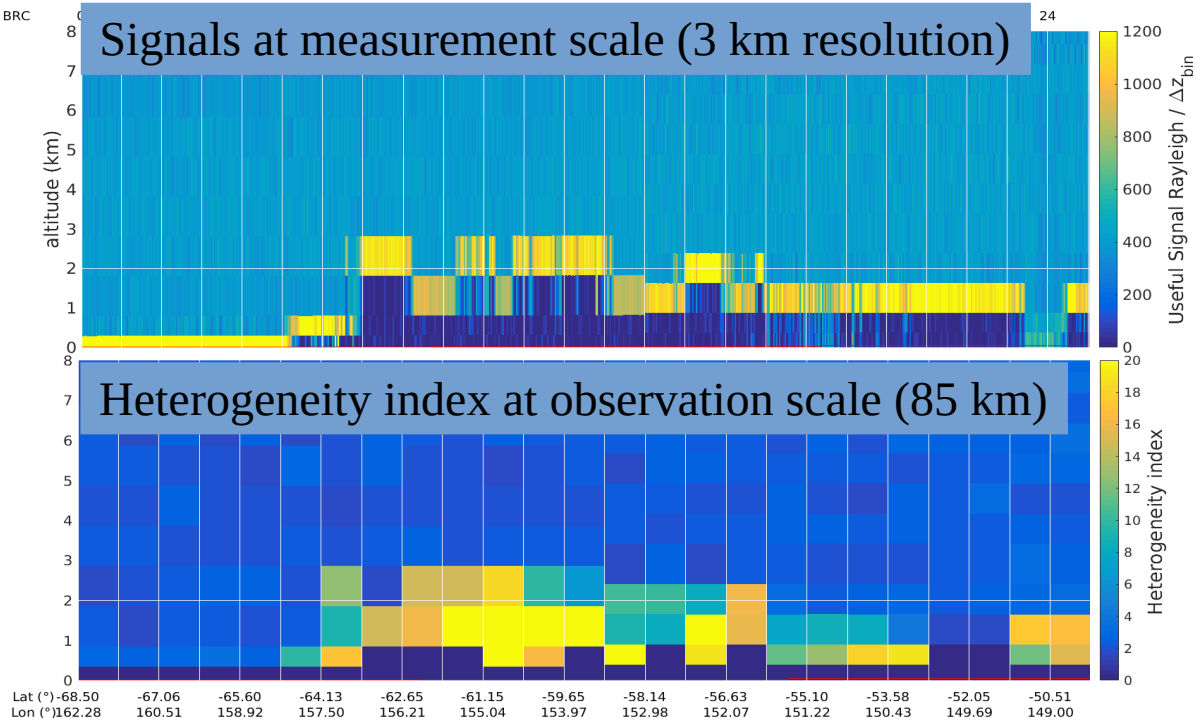
Saharan dust

Visible but extinction is too low

Heterogeneity within one observation

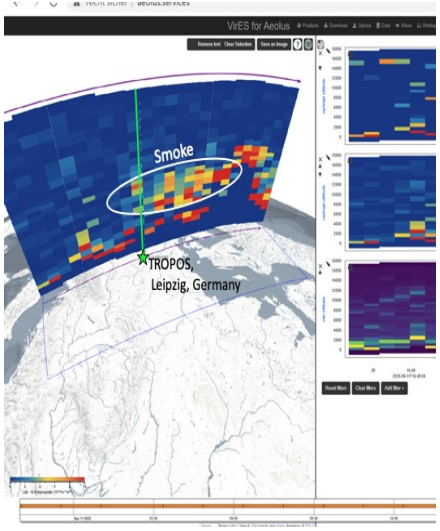
- In one observation, signals are accumulated over ~85 km horizontally. The L2A contains an heterogeneity indicator to help the user decide of the pertinence of the retrieval.

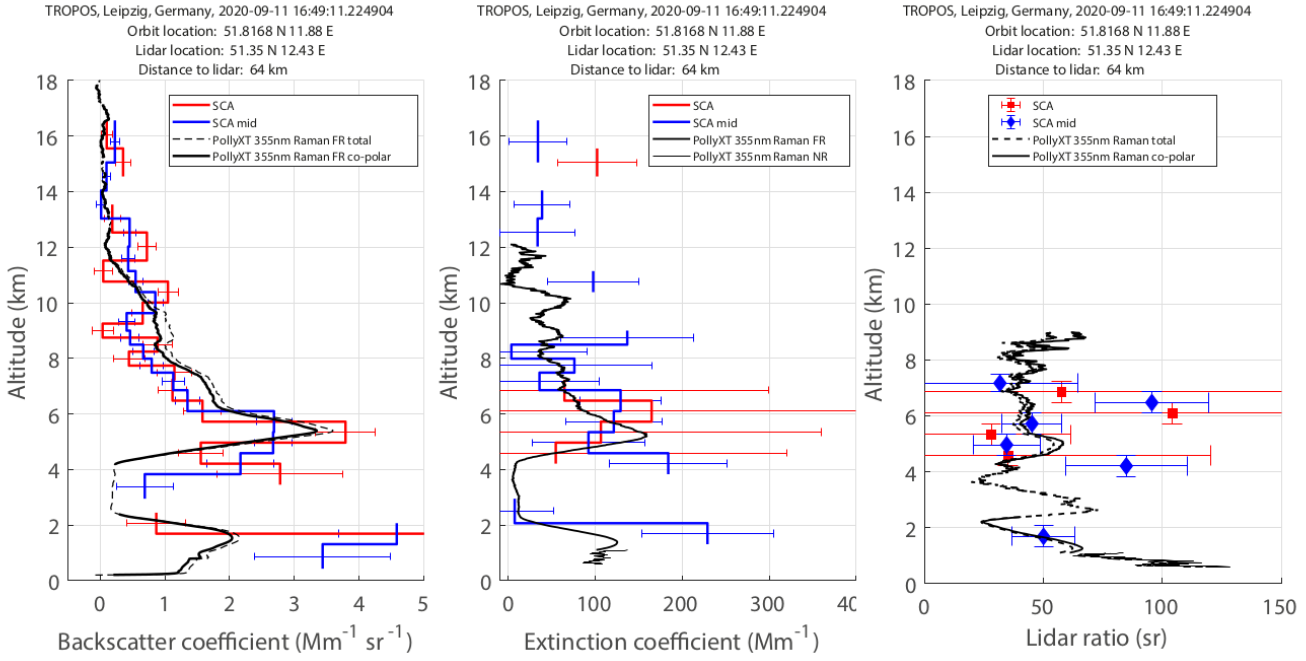
Up to 3-4 => homogeneous
Above 4 => heterogeneous



Ground validation by CalVal teams

- Comparison to ground lidar yielded good results in carefully selected cases where measures can be compared (time span, horizontal extent, presence of clouds).
- Note that error bars are provided for main products, as shown on the figure below





From Baars et al. 2021, https://doi.org/10.1029/2020GL092194

Public release:

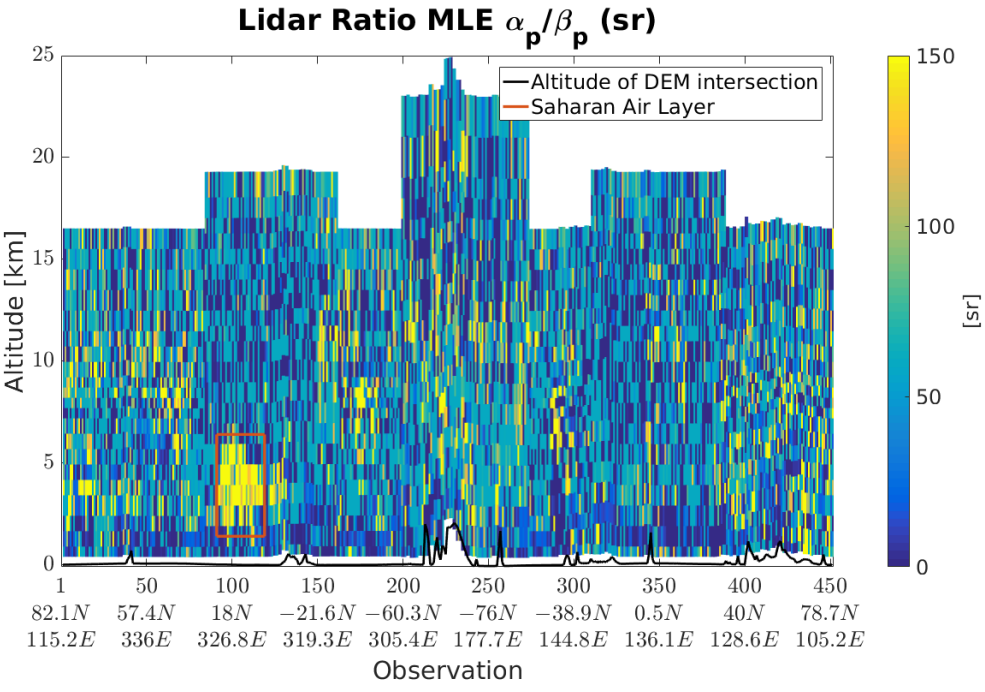
- L2A data should be available soon (slightly delayed due to instrument restart)

- Documentation for users
- User Guide:
  - A document written as support for getting hands on the data
  - Updated with every new version of the processors
- Algorithm Theoretical Basis Document:
  - Contains theoretical description and equations used in the processor
  - Will be available with public release

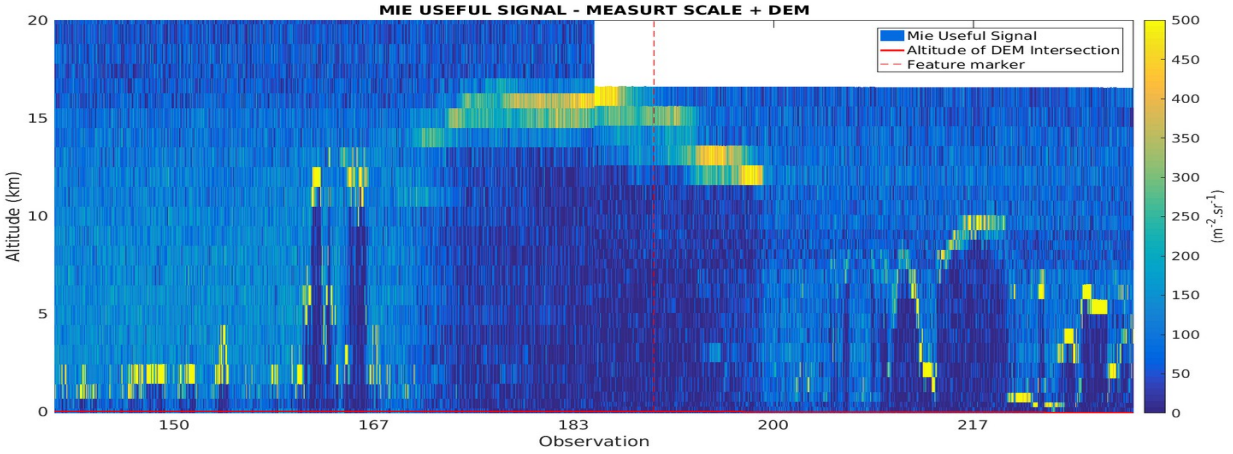
Future improvements

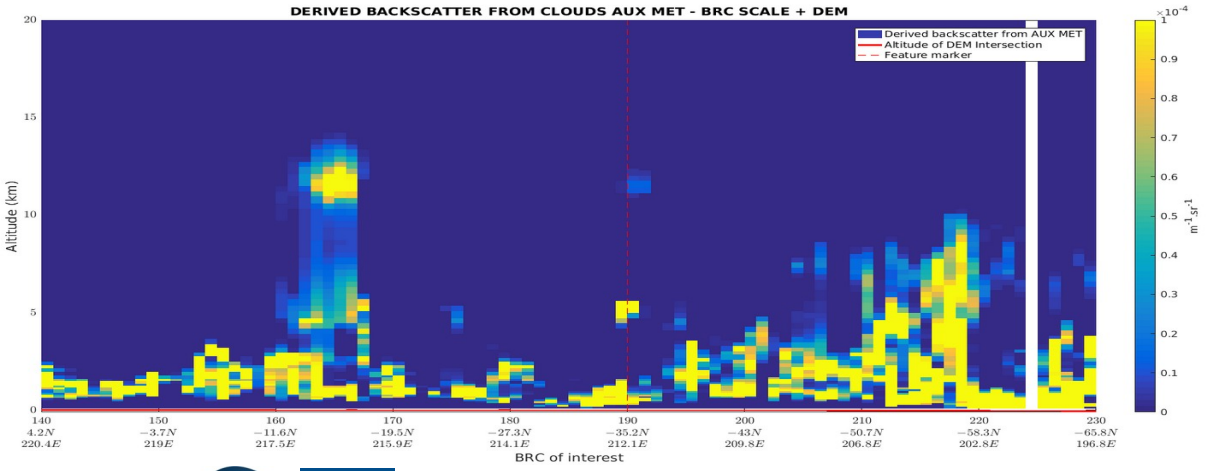
- Cloud screening from auxiliary meteorological data (detailed in following slides)
- Optimal and maximum likelihood estimation algorithms (see following presentations)
- Still working on improving calibration

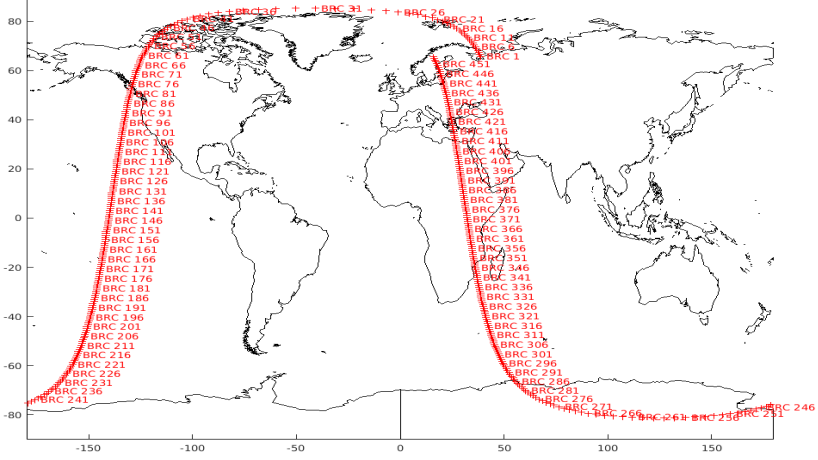
A Maximum Likelihood Estimation of optical properties is being developed →



2020 Australian wildfires: example cloud sccreening







Curtain plot of Aeolus Mie channel signal, showing a large, ~2500-km wide feature.

Predicted cloud coverage from ECMWF NWP model, shows nothing like the feature.

→ Aeolus detected the smoke from the fires in the middle of the Pacific ocean

Future: Cloud screening

In a study to prepare assimilation of aerosol backscatter, a cloud screening based model cloud water content proved to be useful.

