Aeolus aerosol and cloud product

Thomas Flament, Alain Dabas, Dimitri Trapon, Dorit Huber

ALADIN is an 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 modes data (ISR, IRC)

AUX_MET

$P(z), T(z), v(z)$

Cal coeffs :
C1(P,T,v), C4(P,T,v)
C2(v) ,C3(v)
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 quality of the cross-talk correction, which itself depends on the quality of AUX_CAL data and models.

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Lidar equations for Rayleigh and Mie channels :
linear combination of molecular and particulate attenuated backscatter.

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The linear system can easily be inverted provided C1-C4 and Kray and Kmie coefficients are known.

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Calibration modes of operations are executed regularly (1/week) to get calibration coefficients.

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Predicted signals are β_{mol} and T^2_{mol}. They are computed from numerical weather predictions.

n can easily be inverted provided
and Kmie coefficients are known.

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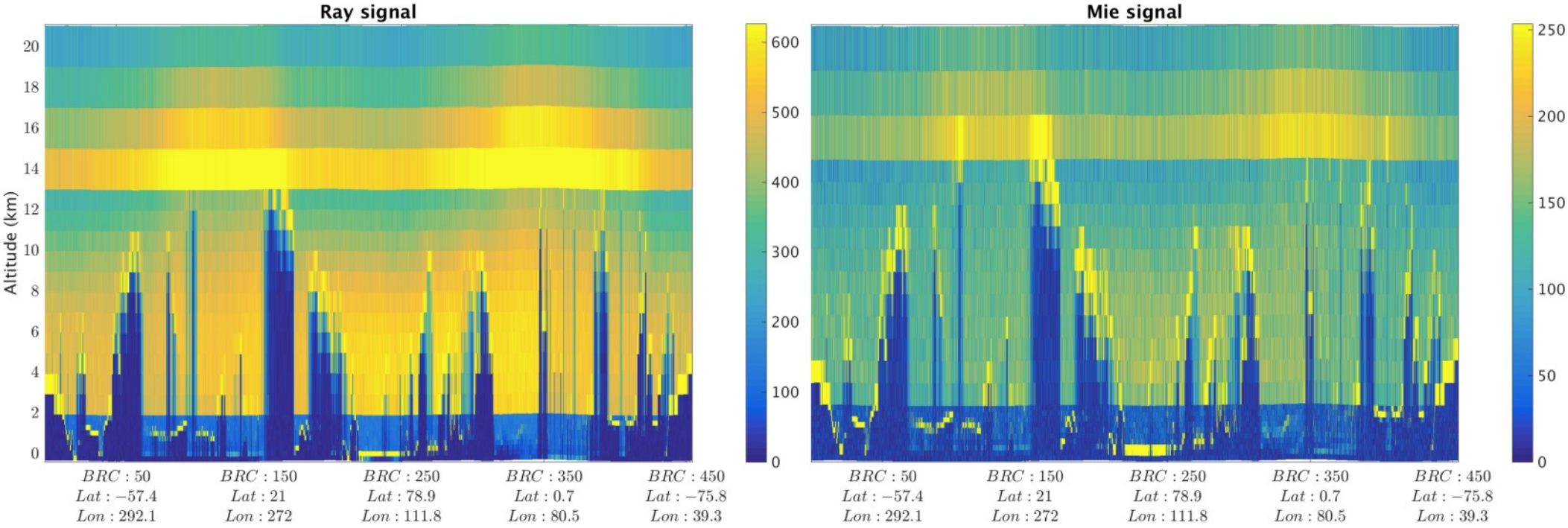
The particulate backscatter and extinction can easily be inverted. The key is to have good calibration coefficients…

First idea on product quality: cross-talk correction

"Raw" Rayleigh and Mie channel signals:

Orbit 2110 - 02 Jan 2019 @ 23h19'38''

Rayleigh channel (left) and Mie channel (right) signals

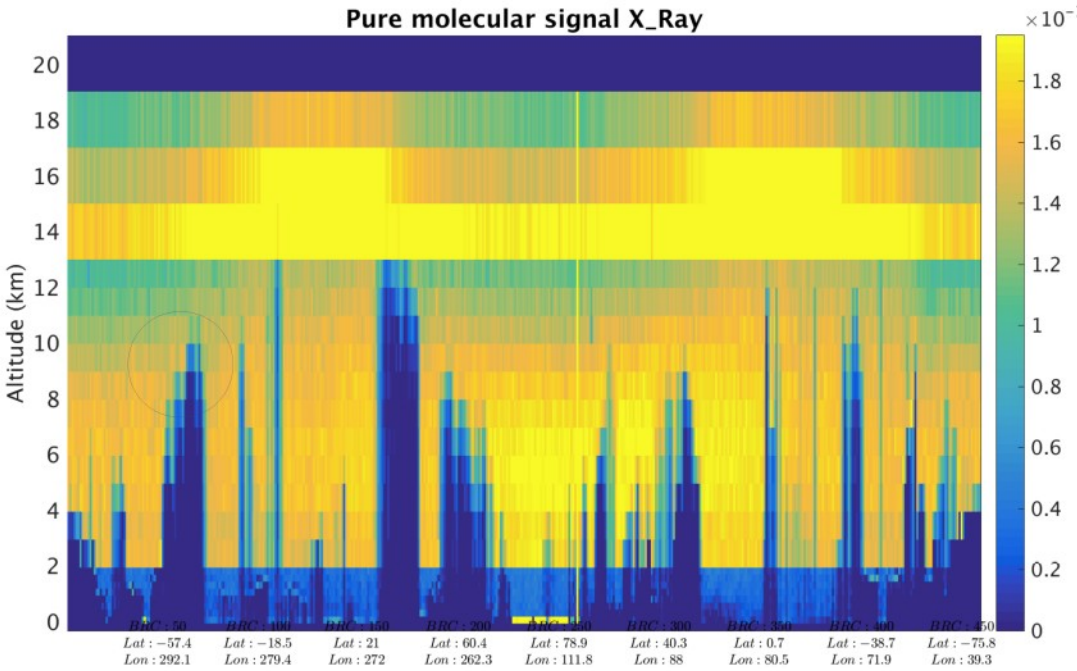


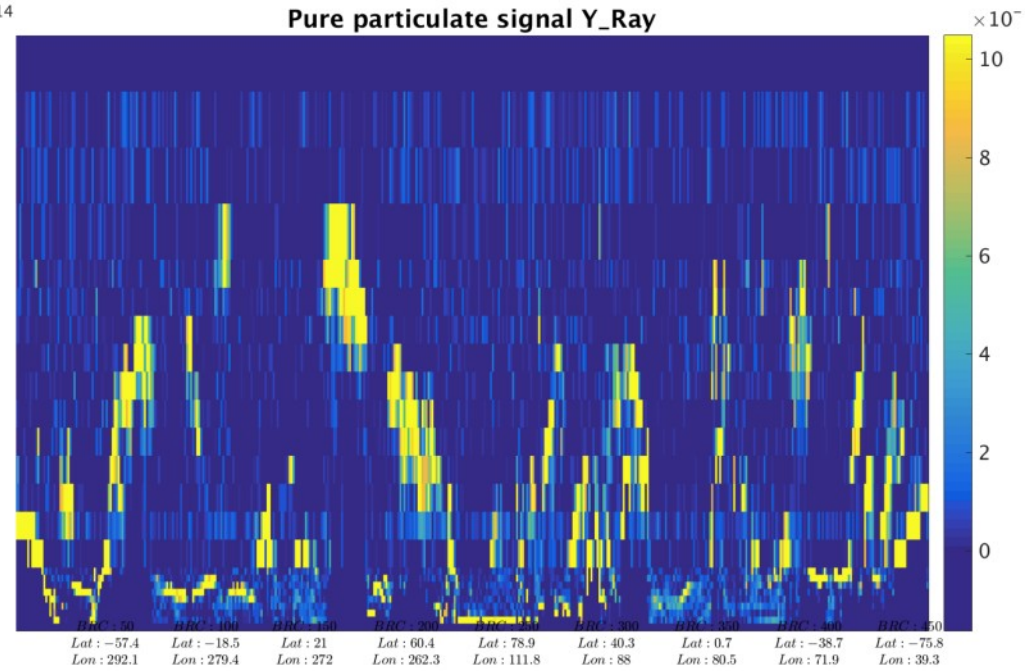
First idea on product quality: cross-talk correction

- After cross-talk correction:

Orbit 2110 - 02 Jan 2019 @ 23h19’38’’

Attenuated molecular (left) and particle (right) backscatter.

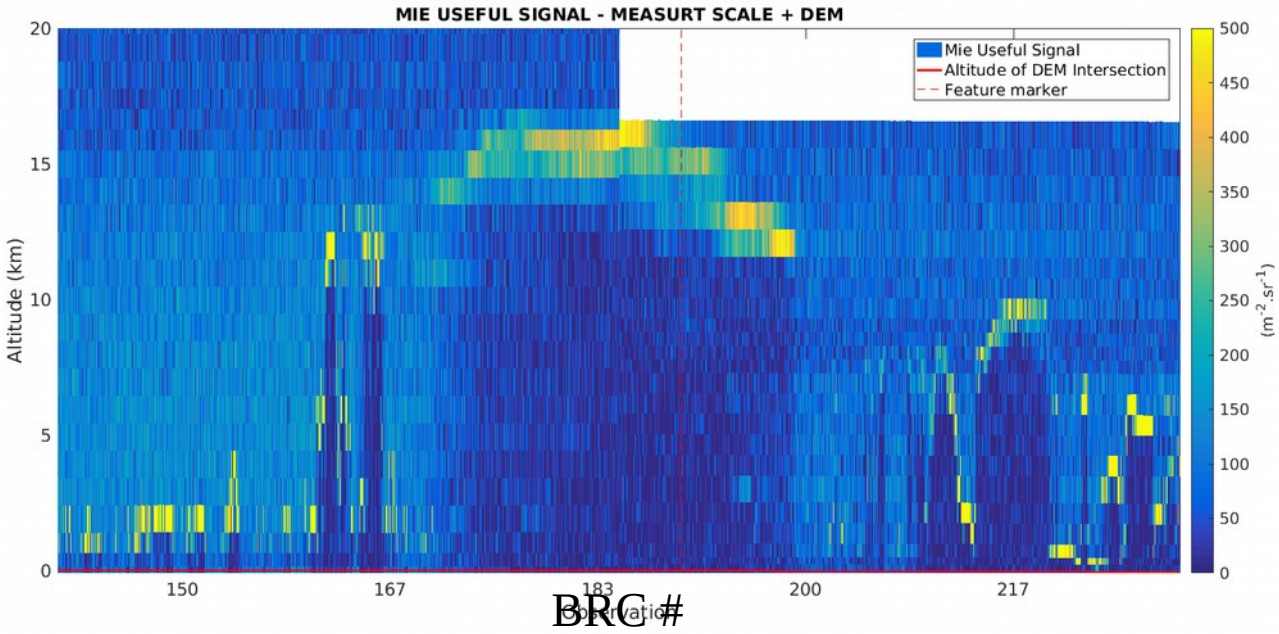


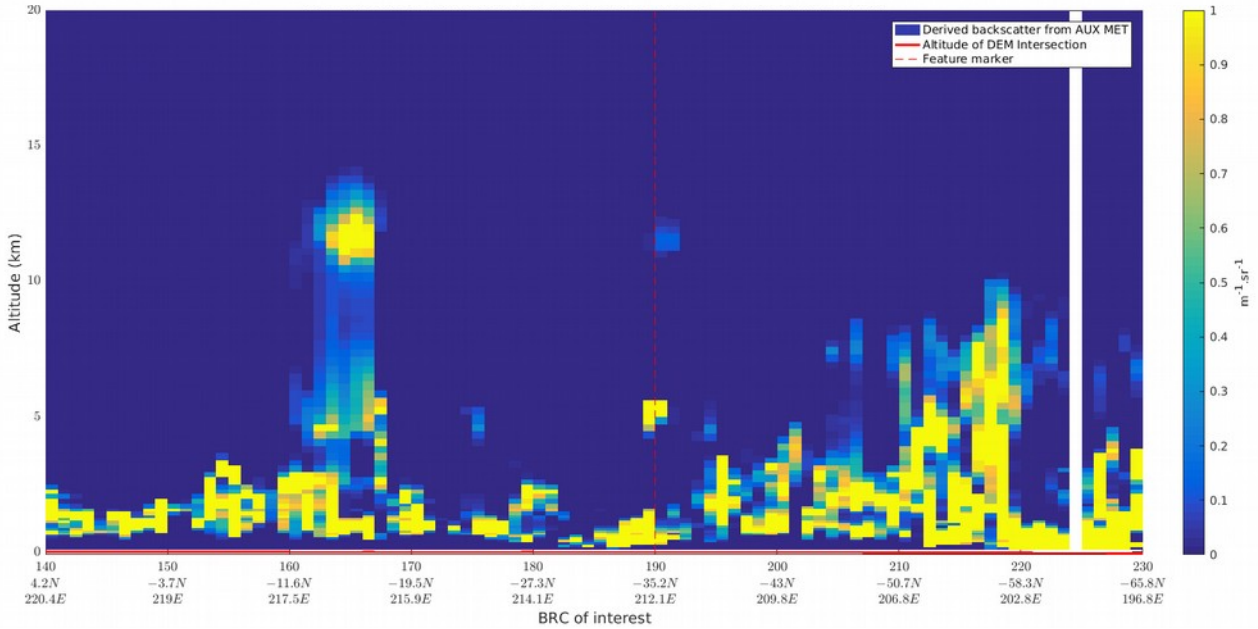


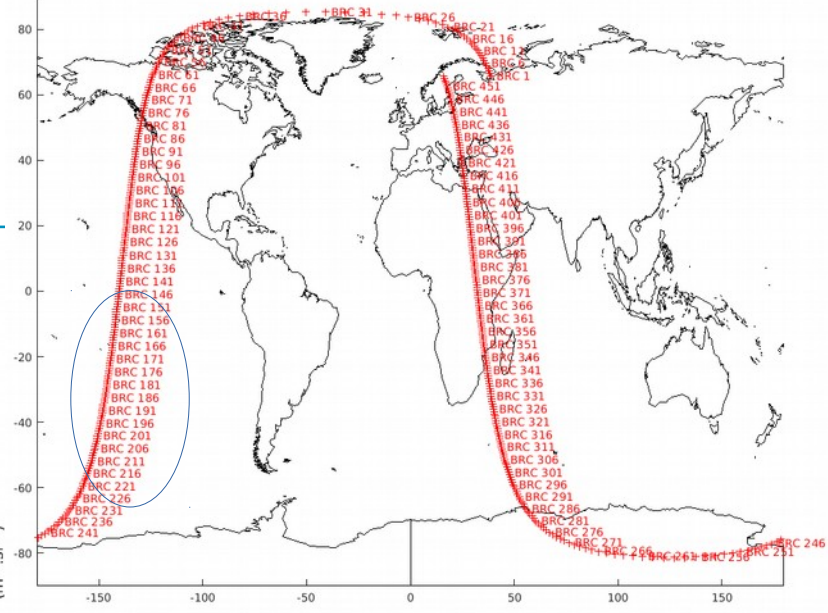
No visible clouds (Mie signal removed)

No background(molecular signal removed)

2020 Australian wildfires







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

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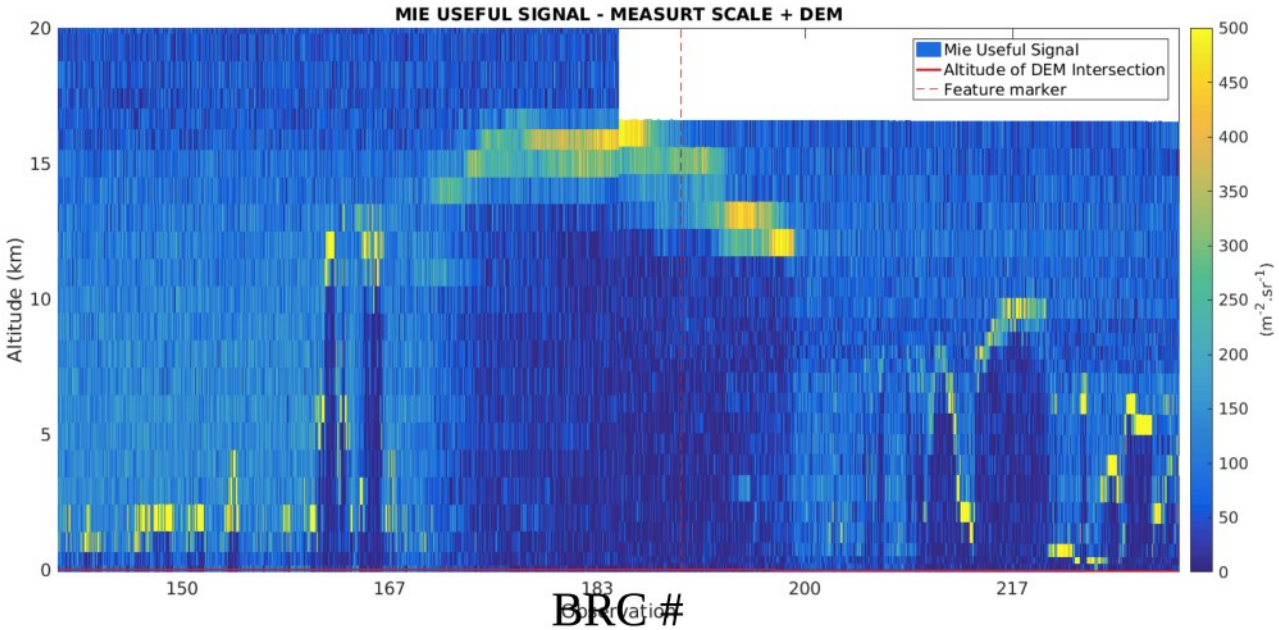
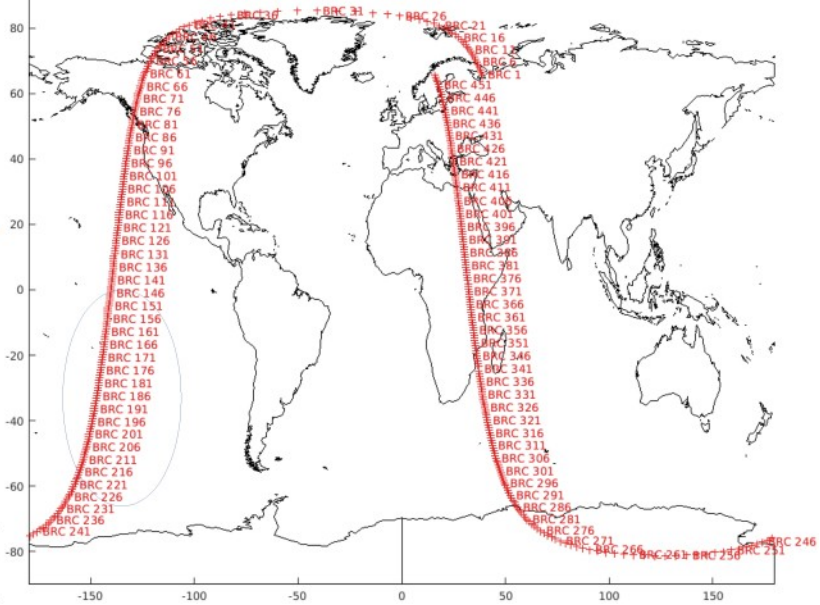
2020 Australian wildfires





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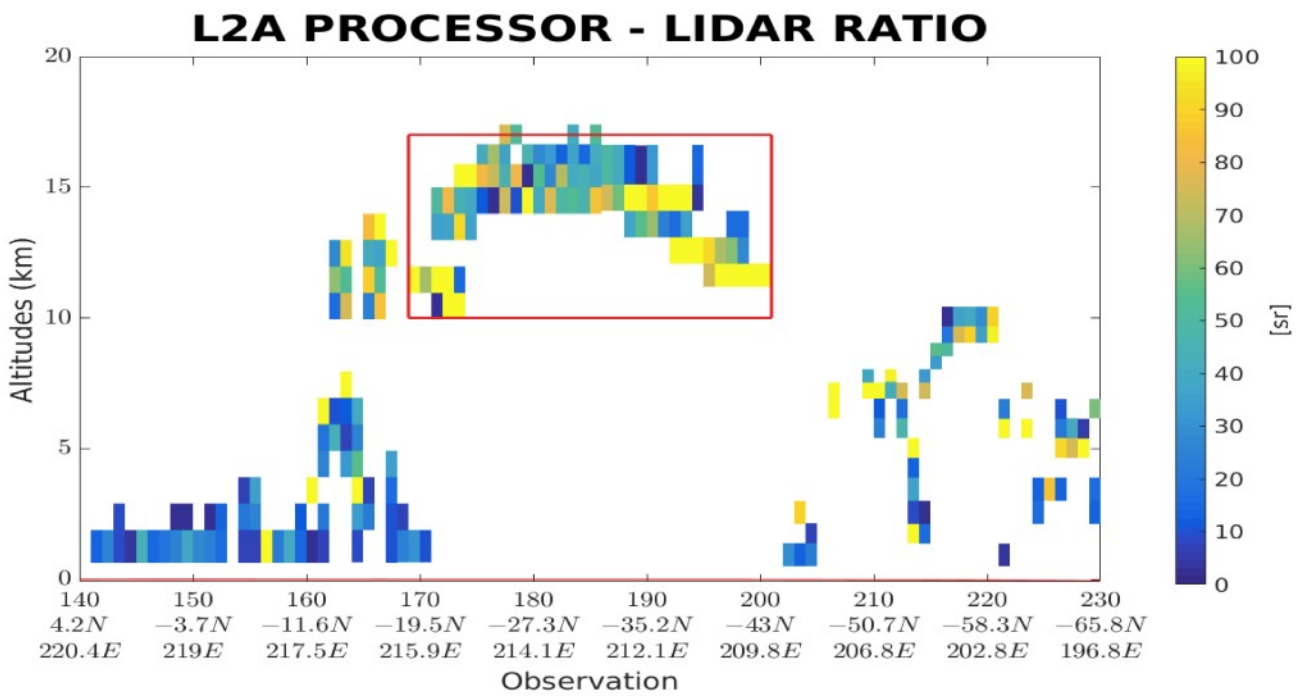

Lidar ratio measured by AEOLUS. Its median value is 51.4 sr.

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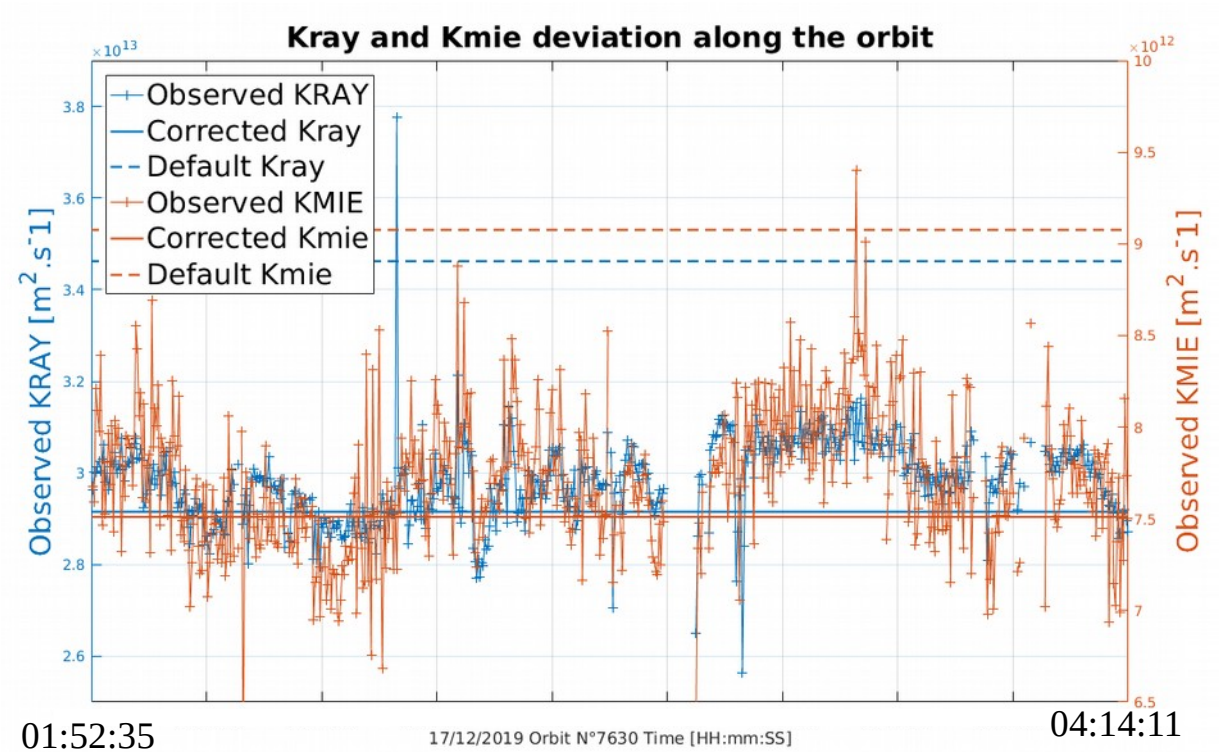
Challenges ahead

- ALADIN, the Aeolus instrument is extremely sensitive. The varying thermal constraints along the orbit and from orbit to orbit seem to act on the the radiometric performance.
- The L2A is affected by a ~10 % variation of radiometric performance, on time scales of a few minutes...
- Compensation is being studied and gradually implemented.

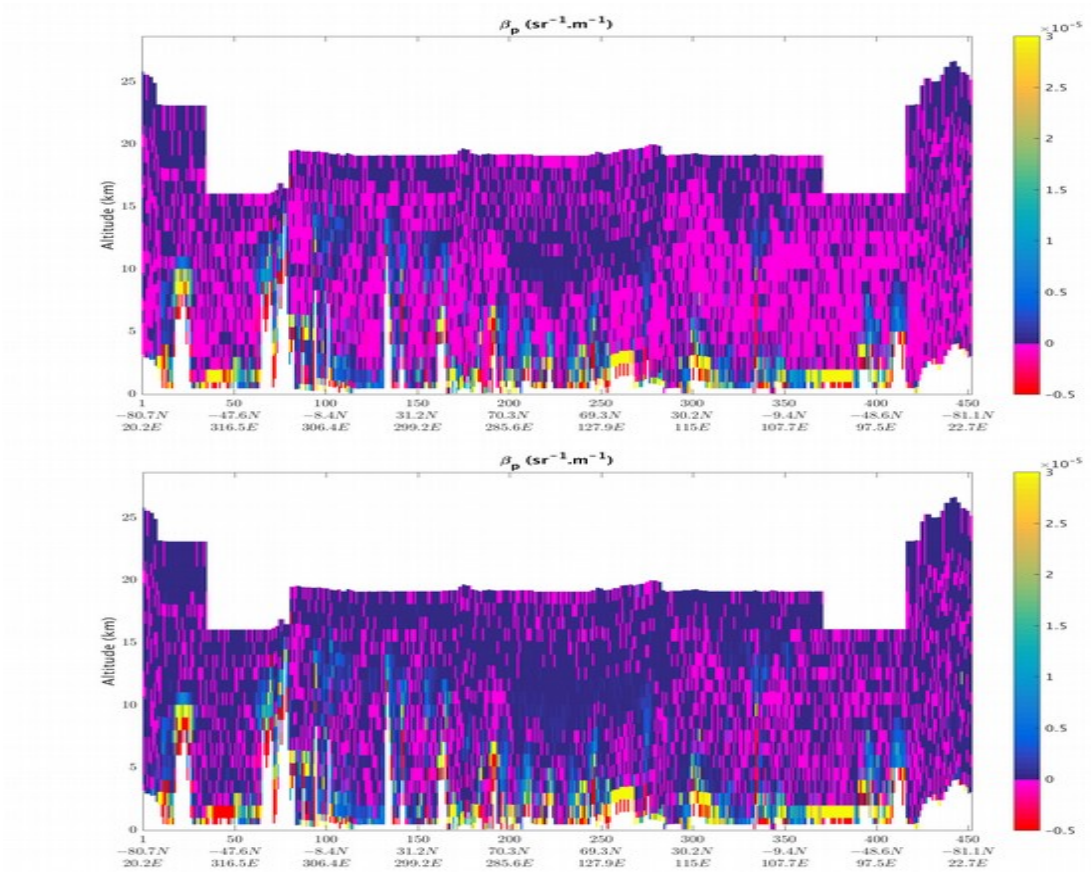


Kray
Kmie

Mie and Rayleigh channel sensitivity as :
- estimated from calibration mode (« Default »)
- « Corrected » from an orbit averaged method
- « observed » from the intensity of molecular signal, at each observation

Challenges ahead

- The first step is to correct Kray and Kmie at the orbit scale : Kray and Kmie remain constant along the orbit but are much closer to their actual (varying values).



Before the correction of Kray and Kmie : due to an underestimation of these coefficients, inverted backscatter coefficients tend to be negative and particle-free regions of the atmosphere.

One the correction is done, the negative bias is greatly reduced !

The correction has been implemented in L2A v3.10.

Conclusion

- Aeolus can observe clouds and aerosols.
- The ability to measure backscatter and extinction independantly, and thus the lidar ratio, has been proven. It opens the possibility to acquire an information on the nature of the particles.
- Quantitative calibration and validation is progressing as we gain knowledge of the instrument behaviour in space.
  - 6-month of L2A data with Kray and Kmie corrected at orbit scale are available.
  - A correction of Kray and Kmie along the orbits should become available this year.
- Next step will be to improve the feature finder and scene classification of the L2A.