

living planet symposium | BONN

23–27 May
2022

TAKING THE PULSE
OF OUR PLANET FROM SPACE



Three years of operations of the ALADIN instrument on Aeolus

Denny Wernham¹, Trismono Candra Krisna¹, Aditi Sathe¹, Tommaso Parrinello¹, Viet Duc Tran¹, Thomas Kanitz¹, Elena Checa¹, Didier Bon², Oliver Lux³, Marc Schillinger², Christian Lemmerz³, Karsten Schmidt³, Michael Rennie⁴, Valeria De Sanctis⁵, Alessandro D'Ottavi⁵, Oliver Reitebuch³, Jon Marshall², Fabian Weiler³, Sophie Jallade², Olivier Lecrenier², Paolo Bravetti², and many more...

¹ The European Space Agency, ² Airbus Defense & Space, ³ DLR, ⁴ ECMWF, ⁵ Leonardo

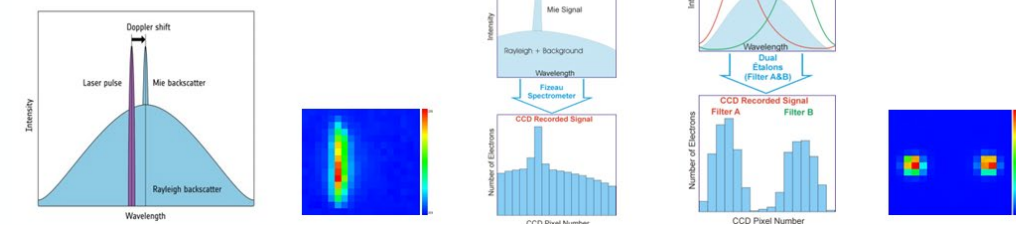
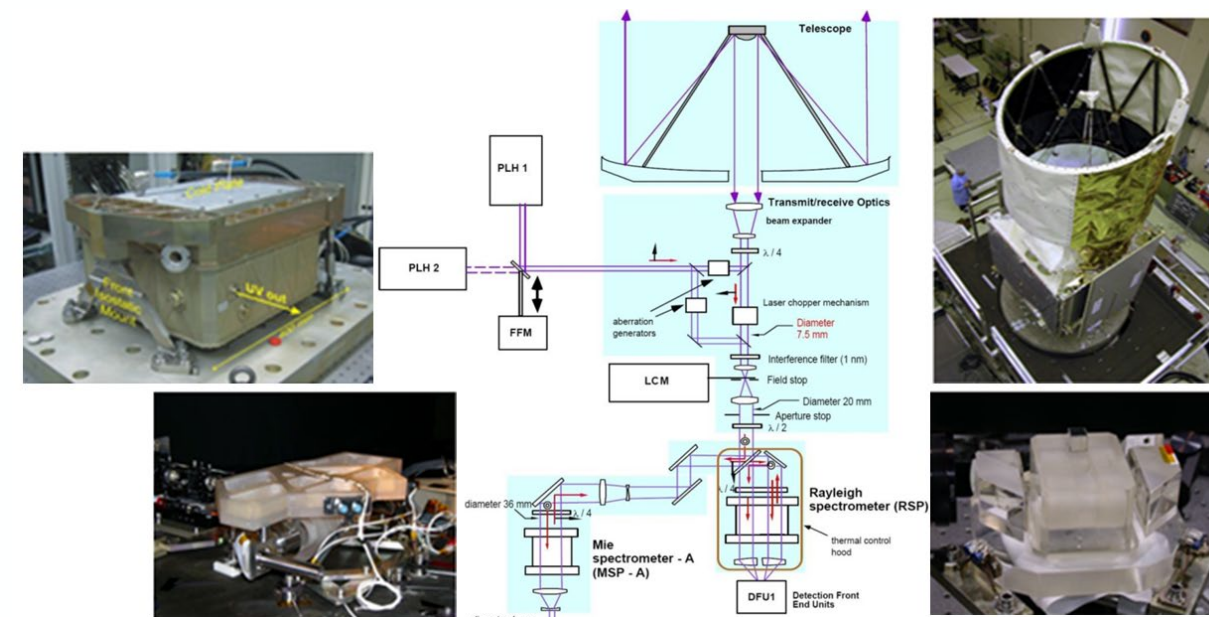
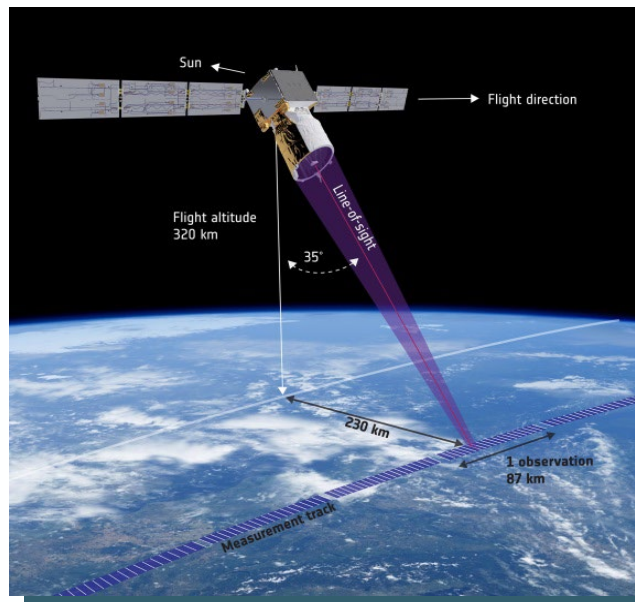
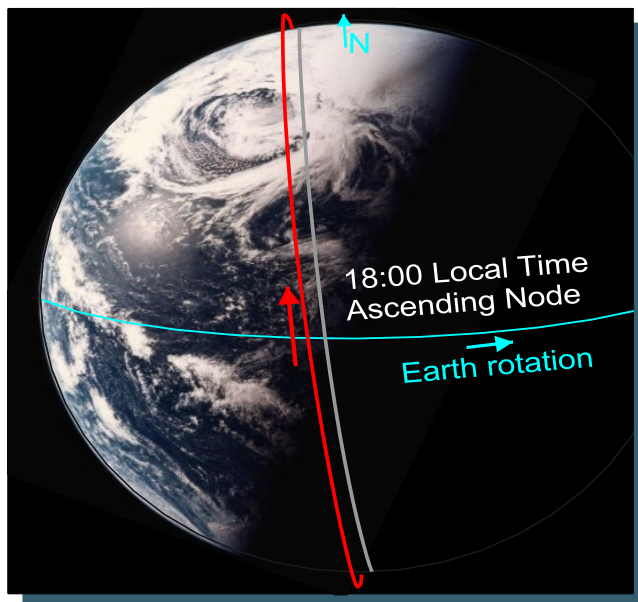
25th May 2022

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1. Recall of the ALADIN Doppler Wind LIDAR Instrument
2. Timeline – Launch (Aug 2018) to FM-A Laser Switch-Off (Jun 2019)
3. Timeline – FM-B Laser Switch-On to Current
4. Major Performance Challenges and their Resolution...
5. Summary

Recall of the ALADIN Doppler Wind LIDAR Instrument



Schematic of the ALADIN instrument along with the direct detection of winds from aerosols (Mie spectrometer) and molecules (Rayleigh spectrometer) (Courtesy Airbus)

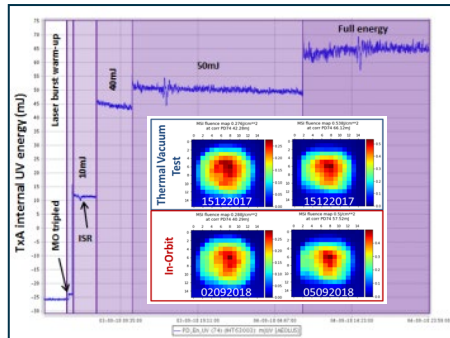
- LTAN = 18:00
- Ground track speed = 7.2km/s
- Repeat cycle = 111 orbits = 7 days
- 1 orbit = 90 minutes
- 3 year nominal mission lifetime
- Altitude = 320km
- Roll angle = 35° off nadir
- PRF = 50Hz
- Laser UV energy = 40 – 90mJ (355nm)
- 1 Observation = 12 seconds = 87km = 600 laser shots
- Measurement durations adjusted between 2.9km and 17.4km
- 7,200 Observations/day

ALADIN timeline – Launch (Aug 2018) to FM-A laser Switch-Off (Jun 2019)

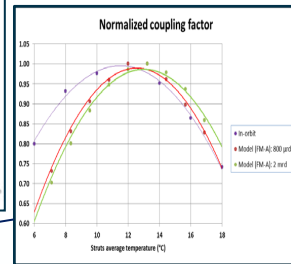
Launch
22/8/2018



FM-A slow switch-on to full energy (L+11)



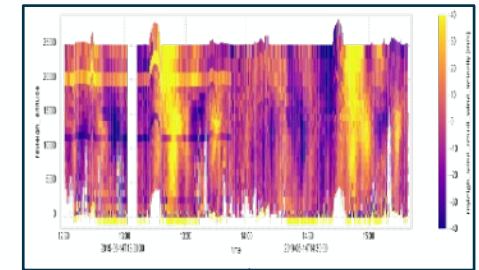
Telescope focus adjustment (L+18)



CALVAL workshop (26-29/03/2019)



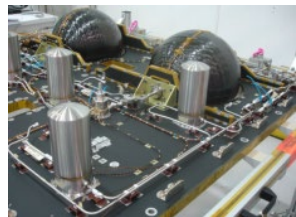
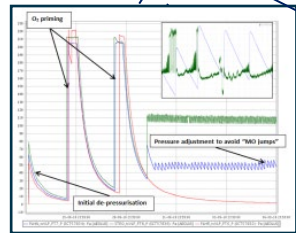
First dynamic bias correction (14/06/2019)



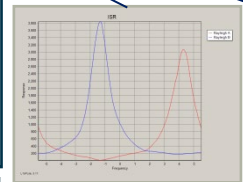
IOCR (30/01/2019)
Switch from Phase E1 to E2

GPS reboot anomaly (13/01/2019 to 14/02/2019)

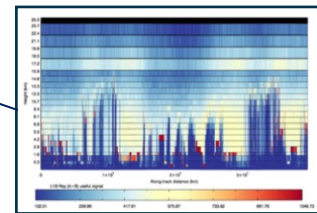
End of FM-A operation (16/06/2019)



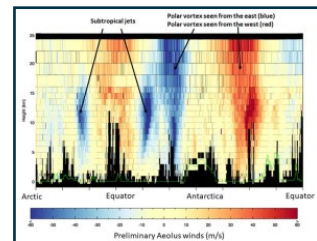
ICS priming (L+7)



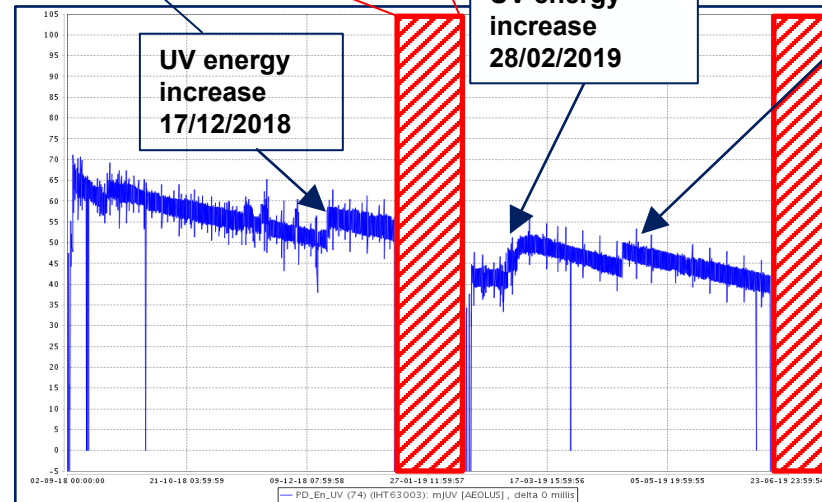
Instrument spectral registration (L+11)



First Aeolus returns (L+14)



First Aeolus winds (L+21)

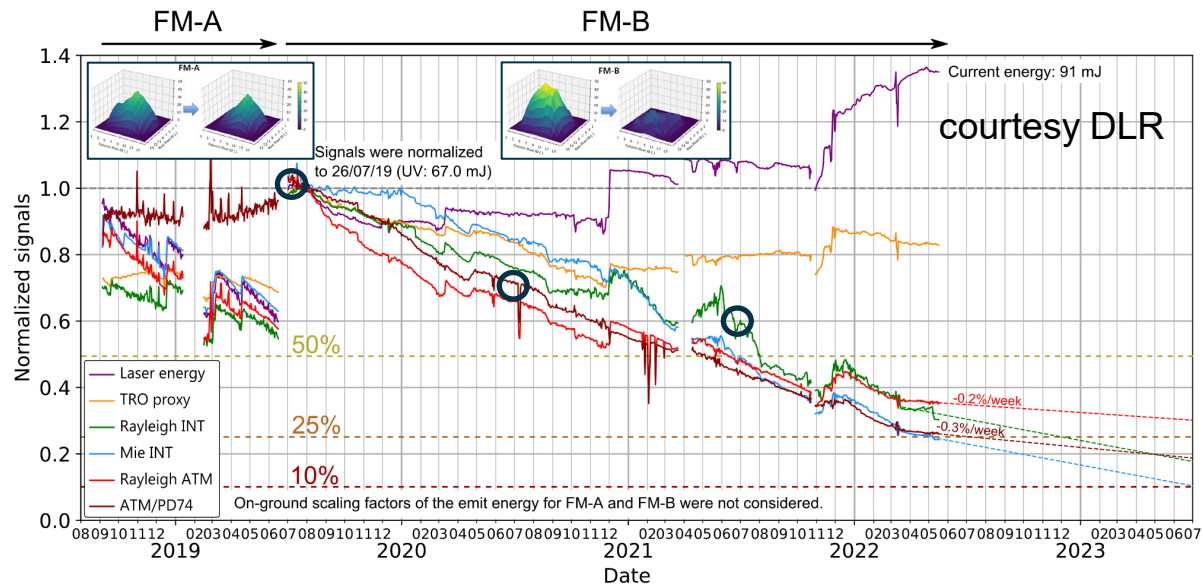


UV energy increase 17/12/2018

UV energy increase 28/02/2019

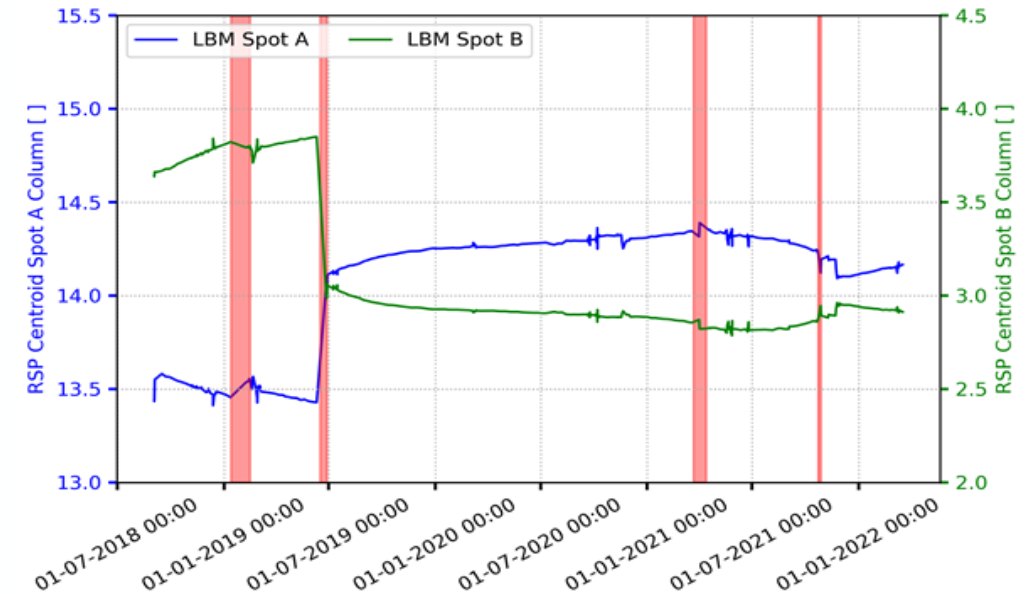
UV energy increase 17/04/2019

- FM-A had some 9 months of operations (with 1 month non-operational) accumulating around 1 billion laser shots.



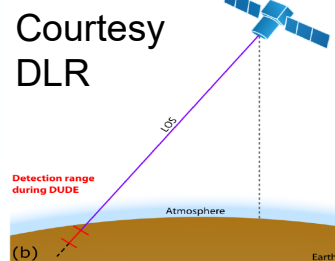
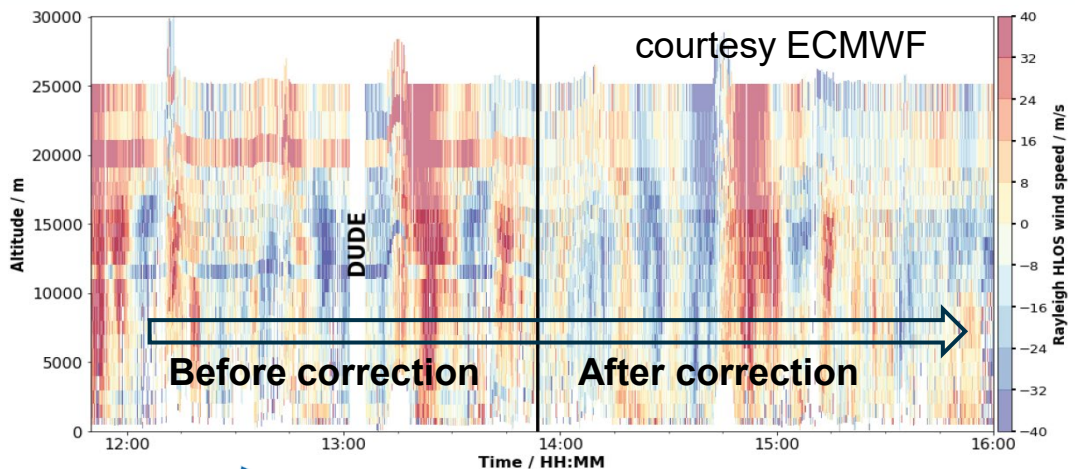
Atmospheric signal decrease over lifetime

- For FM-A we observe a monotonic decrease consistent with the laser energy reduction \Rightarrow misalignment of the master oscillator leading to laser energy decrease (this can be potentially at least partially recovered when we switch back to the FM-A).
- For the FM-B, we see the return signal decreasing even though the laser energy is constant.
- The Pierre Auger Observatory results (black circles) show that this decrease is in the instrument emit path upstream of the laser \Rightarrow increase laser energy and then switch to FM-A

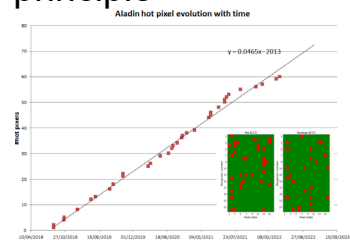


Long term beam drifts over the mission leading to measurement bias

- We have observed long term drifts in the Rayleigh spot positions due to drift of the laser line of sight.
- This introduced significant bias to the wind measurements \Rightarrow correct with the ECMWF bias correction.



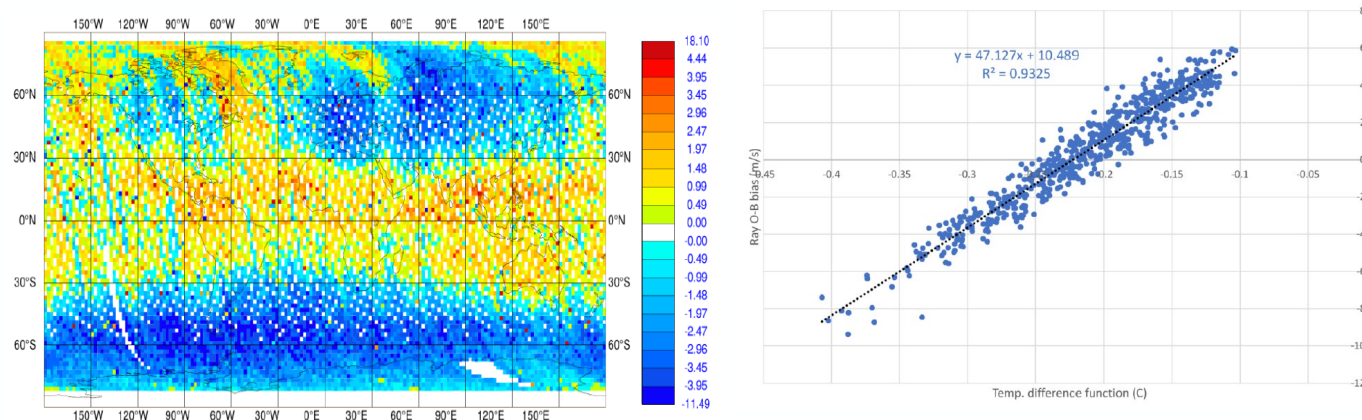
DUDE measurement principle



Hot pixels vs. time

Hot pixels causing bias

- In the L2B wind data it became clear that there was a bias introduced to discrete atmospheric bin heights.
- The root cause was found to be specific pixels in the memory zone of the ACCD that suddenly exhibited elevated signal levels \Rightarrow perform regular pseudo dark current measurements that can be used to correct the hot pixels



Correlation between Rayleigh wind bias and the ALADIN M1 radial temperature gradients (courtesy ECMWF, DLR)

Fluctuating bias on sub-orbital timescales

- Also from the L2B data, it was noticed that there were significant biases in the wind measurements which were found to be correlated to the temperature gradient between the centre and the edge of the ALADIN primary mirror.
- This is caused by thermo-elastic distortions of the M1 due to differing amounts of IR and albedo from the Earth \Rightarrow apply the temperature gradient correction for the M1.

- The ALADIN instrument on Aeolus has successfully operated for around 3.5 years, beyond the nominal mission lifetime of 3 years producing wind measurements almost from the very beginning of the mission.
- It is the first Doppler Wind Lidar to be successfully operated in space
- It is the first spacecraft to successfully operate a high power UV laser in space for any significant time (the FM-B laser is nearing 3 years of operations at over 60mJ UV energy accumulating some 4.5 billion laser shots)
- Although there have been issues with both the return signal levels and systematic errors caused by a number of different reasons, these have largely been resolved by some ingenious fixes/workarounds and Aeolus is still providing positive NWP impact.
- The issues that have been found on ALADIN have been transferred as lessons learned to both ATLID on EarthCARE and Aeolus-2
- This has been due to the commitment, excellent collaboration and skills of a great many people, together with the support of the NWP scientific community and delegations, and hopefully is just the beginning of many future active laser missions.

I would like to thank them all on behalf of ESA for what has been a truly ground breaking and inspiring Earth Observation mission!!!