EGU21-7063

Impacts of long-range-transported Saharan dust layers on atmospheric stability and turbulence in the trades

Manuel Gutleben, Silke Groß and Martin Wirth

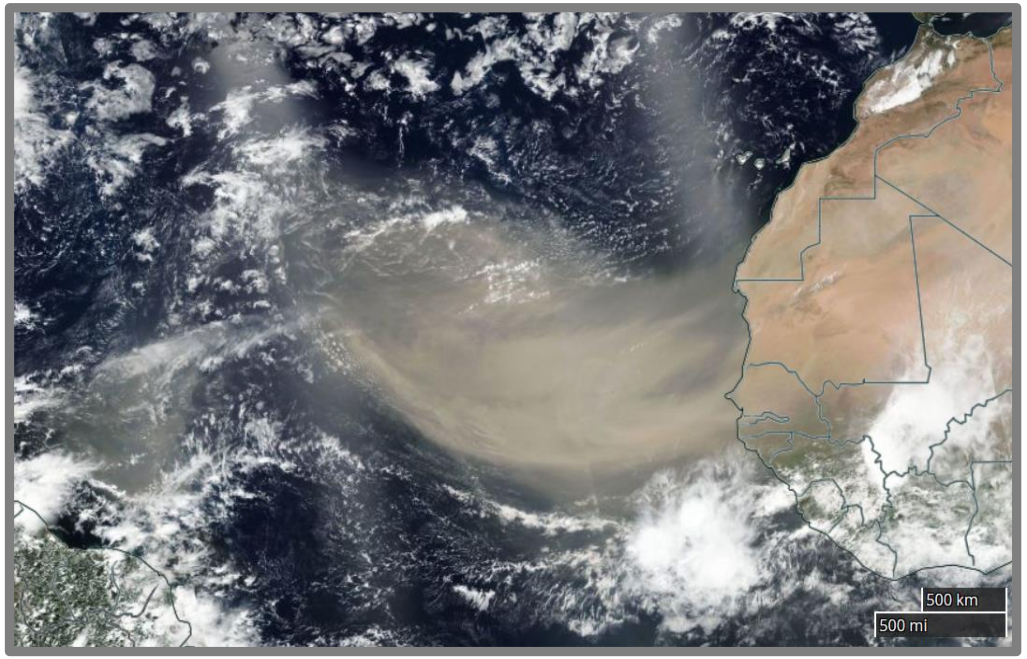
German Aerospace Center (DLR), Institute of Atmospheric Physics, Weßling, Germany



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NARVAL
next-generation aircraft remote-sensing for validation studies

Motivation



Source: NASA Worldview

- The **summer months mark the peak season** of transatlantic Saharan dust transport
- Summer-transport predominantly occurs in elevated dust layers, termed **Saharan air layers (SALs)**

Saharan dust particles of great diameters (<20 micron) were found in the Caribbean

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According to theory they should fall to the surface already at the beginning of their long range transport

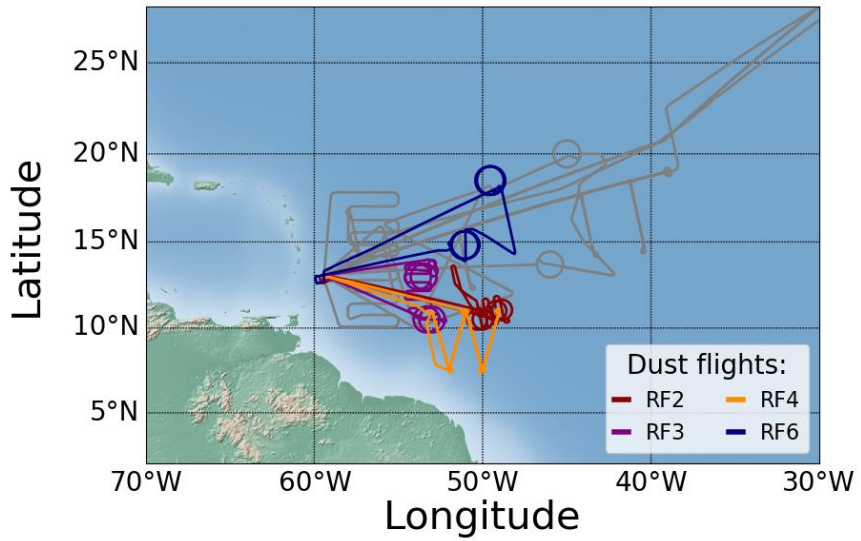
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Are turbulent processes counteracting dust gravitational settling during transport?

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NARVAL-II

Gutleben et al. (2019, ACP)





- Study the turbulent features of SALs during the **N**ext-generation **A**ircraft **R**emote-Sensing for **Val**idation studies**-II**
- **8 to 30 August** 2016,
- Air base: Grantley Adams International (**Barbados**, TBPB),
- 85 flight hours within 10 research flights with the German **HALO research aircraft**,
- **4 flights** were specifically designed for **investigations of SALs**,
- **16 flight hours** in Saharan dust laden trades,
- Remote-sensing payload, including the **airborne lidar system WALES**.



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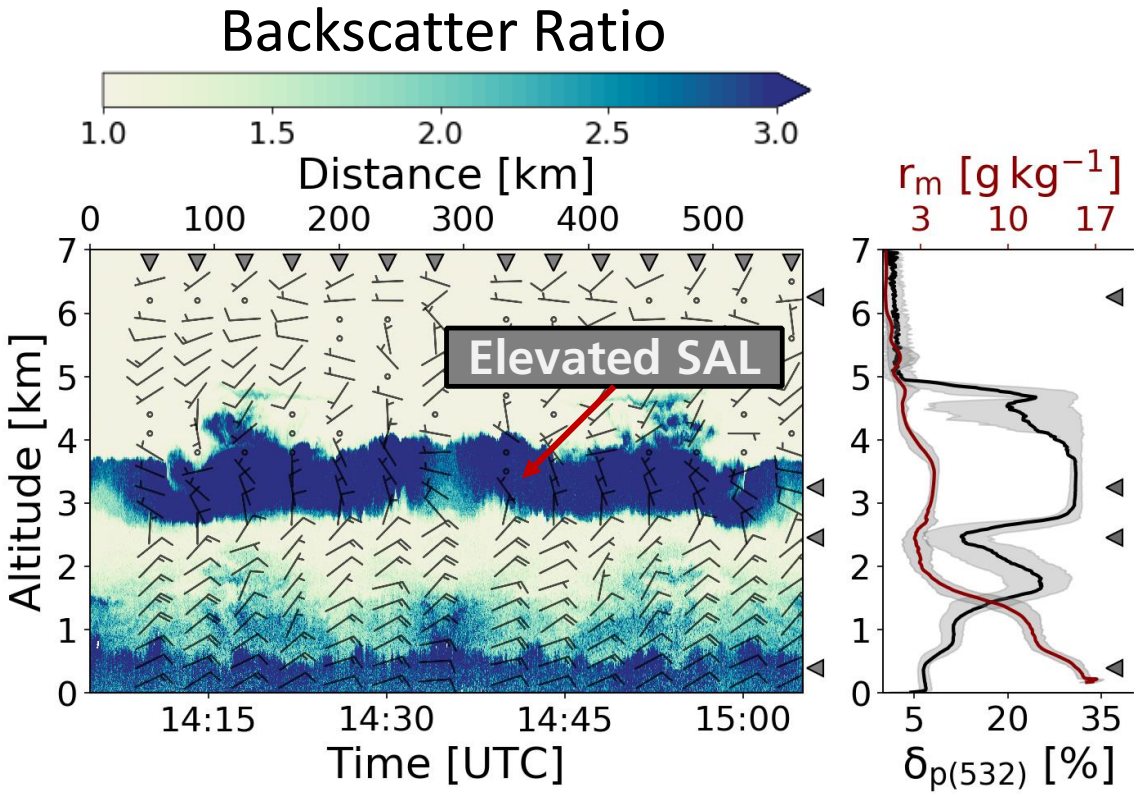
WALES

Combined Differential Absorption (DIAL), High Spectral Resolution Lidar (HSRL) and Depolarization lidar:

DIAL: vertically highly resolved measurements of atmospheric water vapor mixing ratios ($\mathbf{r_m}$)

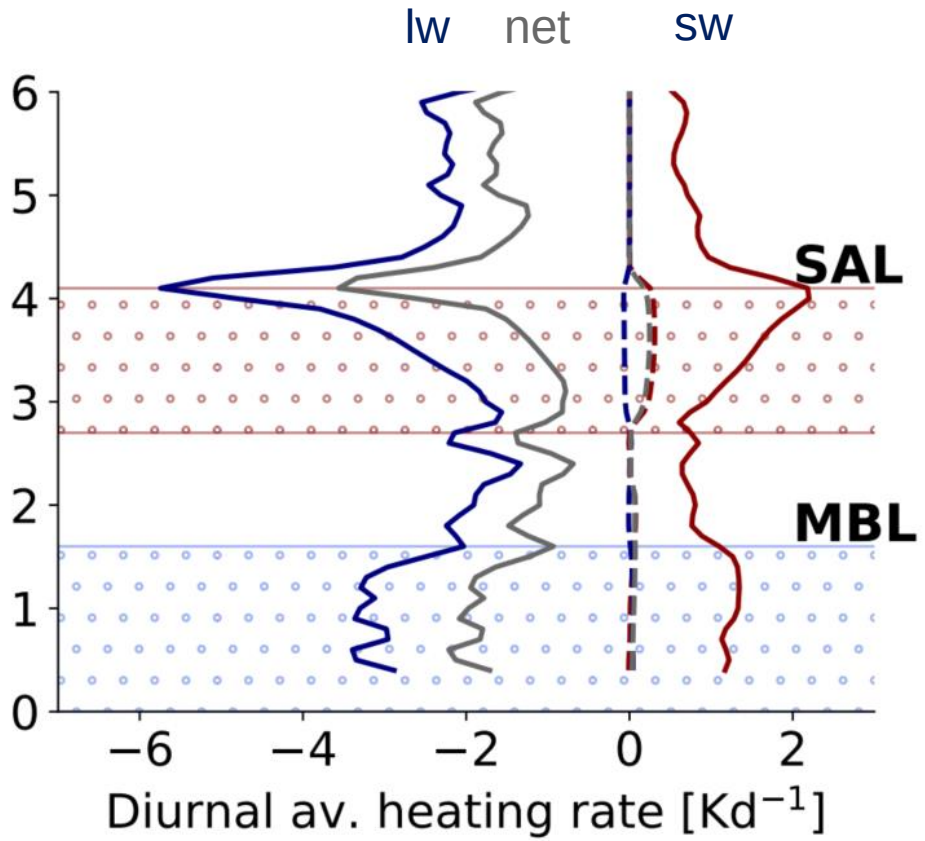
HSRL: direct measurements of particle extinction ($\alpha_{\mathbf{p(532)}}$), linear depolarization ($\delta_{\mathbf{p(532)}}$) and backscatter ($\beta_{\mathbf{p(532)}}$)

Depolarization lidar: measurements of particle linear depolarization ratio ($\delta_{\mathbf{p(532)}}$)



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Heating Rate calculations using WALES data

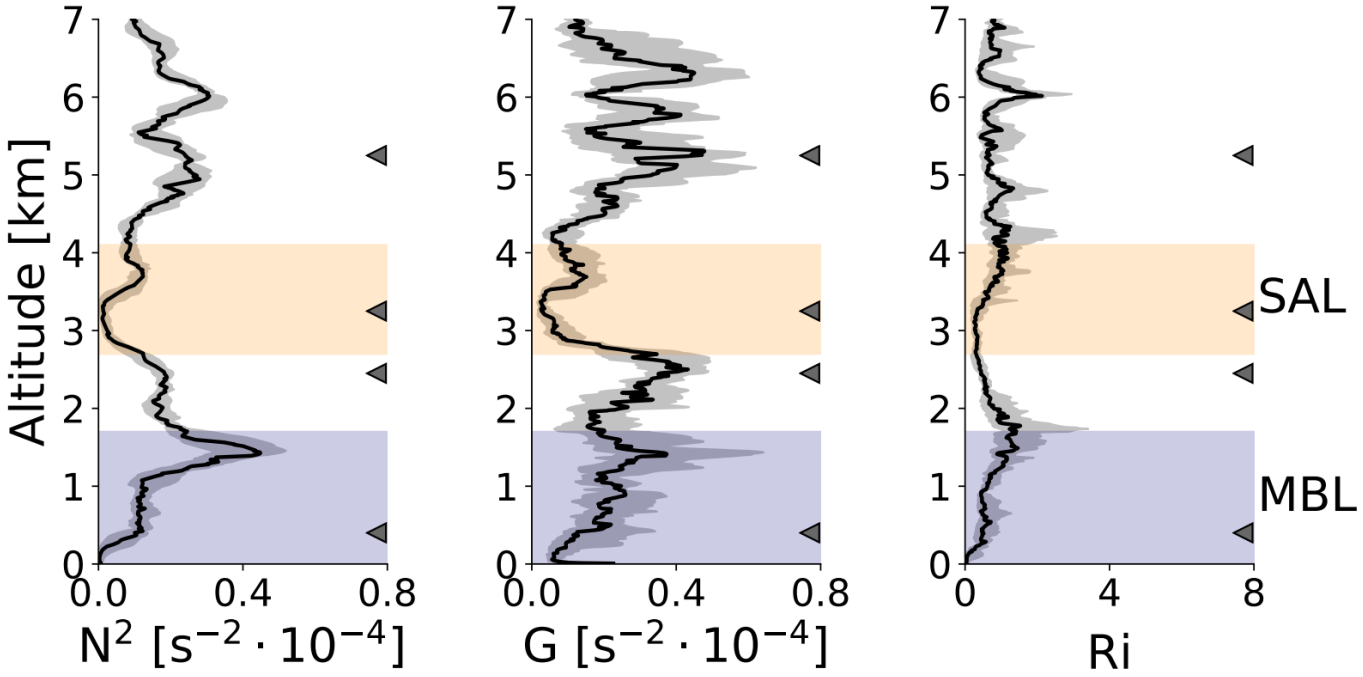


- **Effect of water vapor** on radiative heating rate **stronger than aerosol effect (dashed)**
- Water vapor effect **strongest at top of the dust layer**
- Decrease of SAL net heating rate (solid-grey) with height → **indication of vertical mixing** (θ = const.)
- **Water vapor heating can explain why large particles 'stay' inside the SAL until they reach the Caribbean**

Gutleben et al. (2020a GRL), Gutleben et al. (2020b ACP)

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Stability analysis



Analysis of **squared Bruunt Väisälä (N^2) frequency**, **Wind shear (G)** and **Richardson number (Ri) from dropsondes**

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Low static stability and wind shear associated with SAL

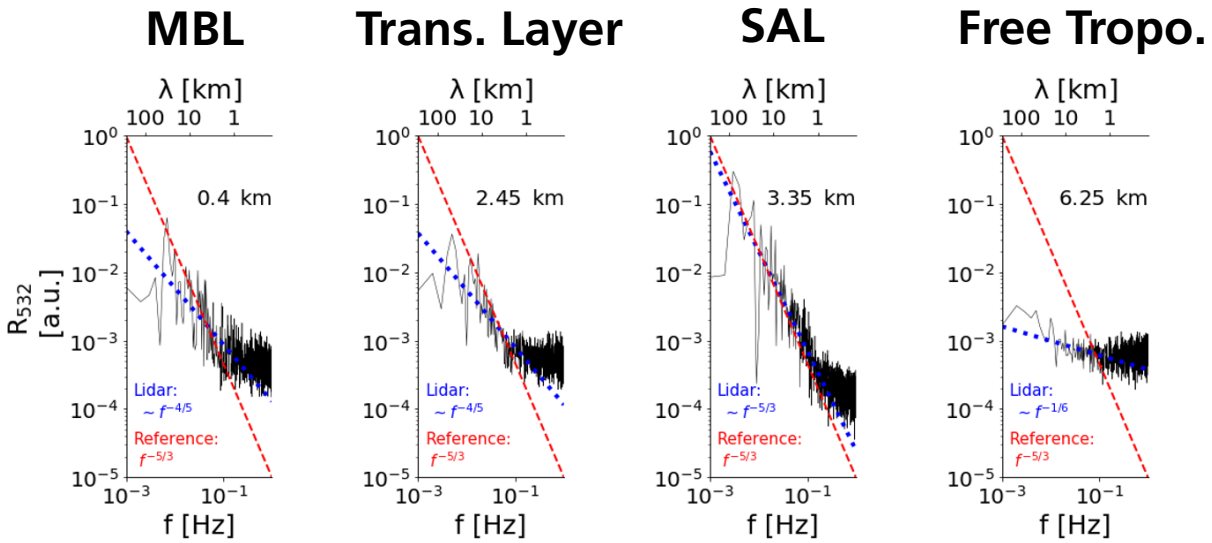
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Small Richardson numbers suggest presence of turbulence in SALs



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Power Spectra



Power spectra of WALES backscatter calculated using the Lomb Scargle algorithm data allow to investigate meso-scale turbulence

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Turbulence cascade in dust layer well established
showing a **slope of of -5/3** (Kolmogorov (1941), Lilly (1983))

Spectra below and above the SAL flatter, but especially the derived spectrum in the free troposphere is affected by low SNR

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