MSM 89 - Atmospheric Turbulence and Clouds in the Tropics: Shipborne Lidar Measurements of Dynamics and Thermodynamics During EUREC4A

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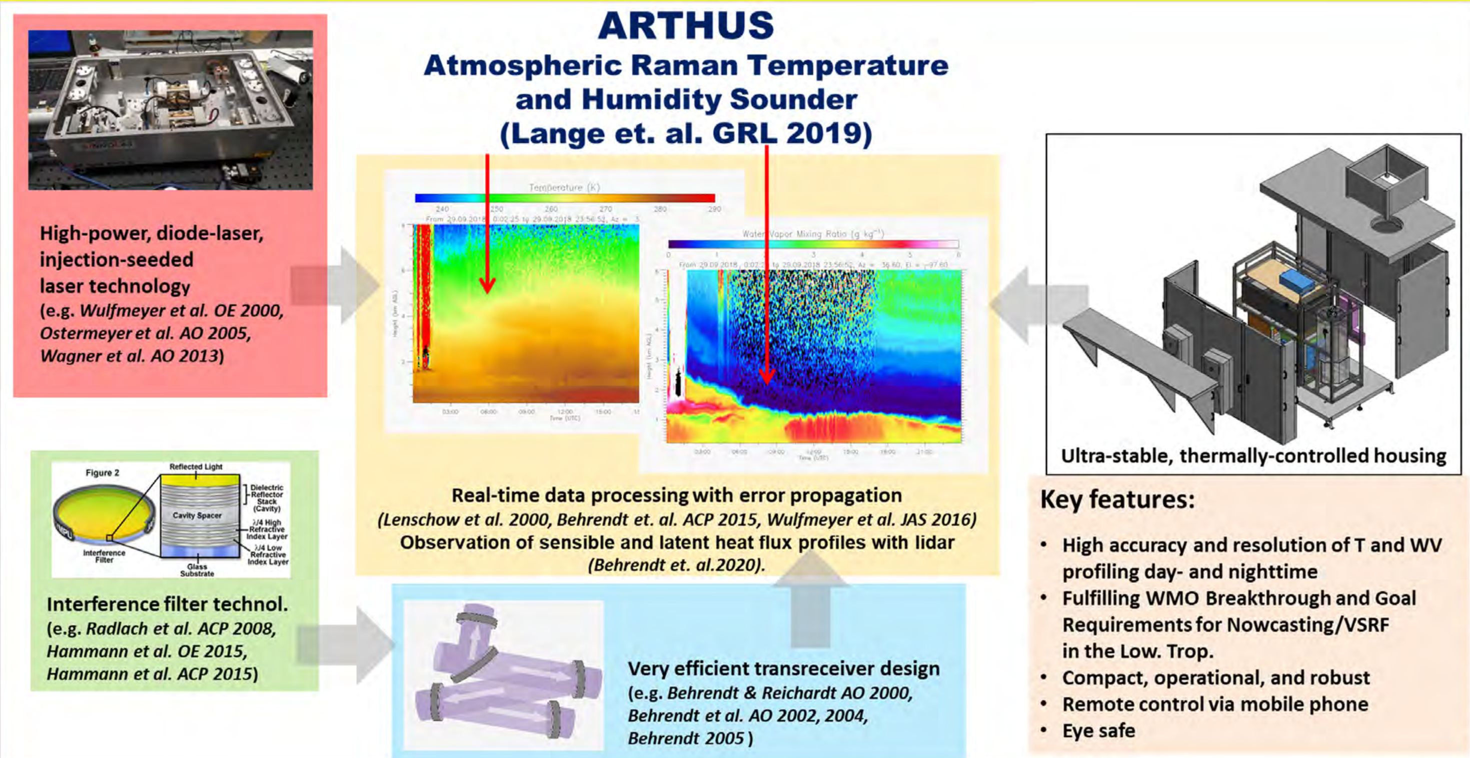
Introduction

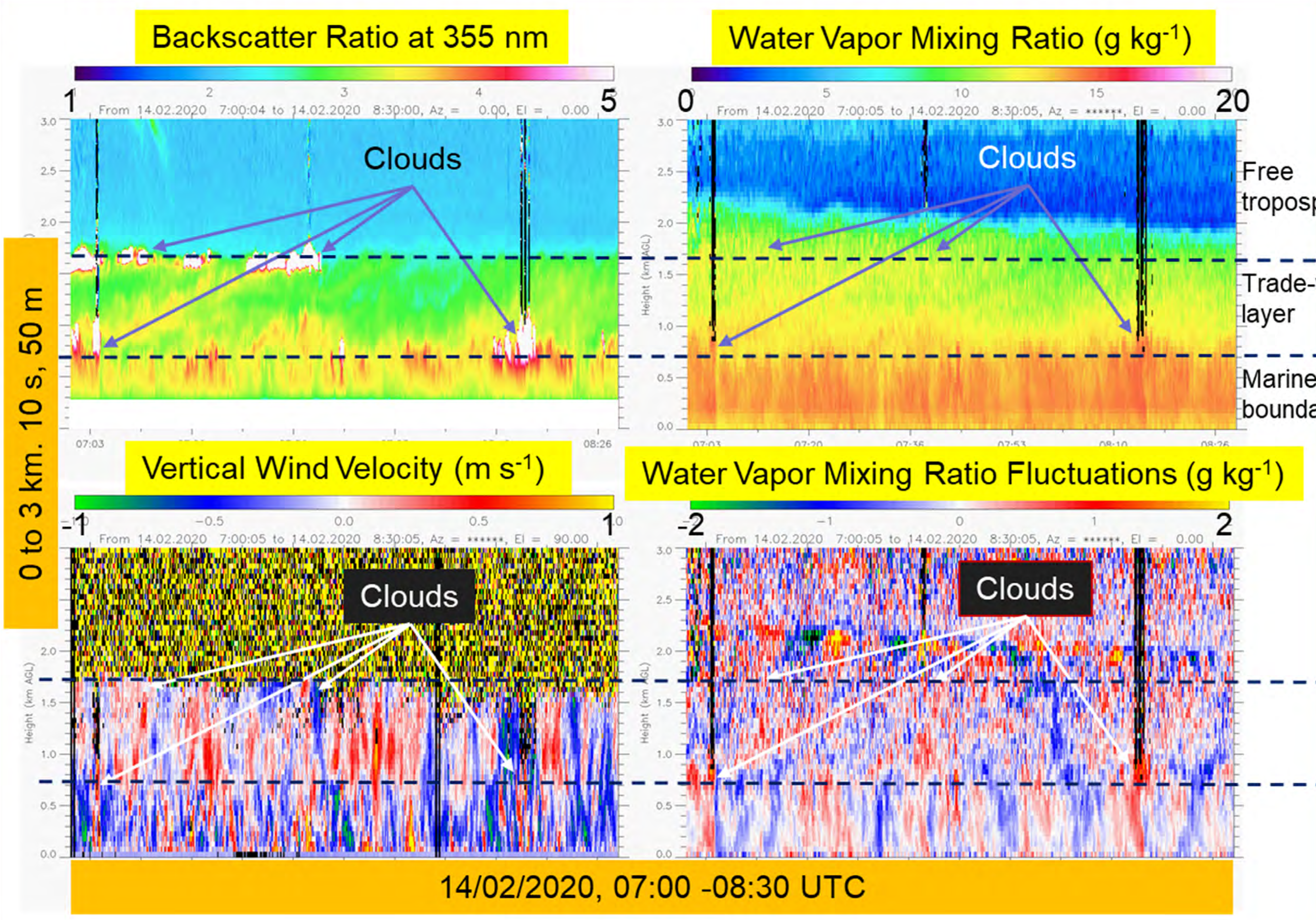
During the EUREC4A campaign, a unique combination of lidar systems for temperature, humidity and wind measurements was operated on the German research vessel R/V Maria S Merian between 18 January and 18 February 2020 in the trade wind alley east of Barbados and in the "Boulevard des Tourbillons" east of Venezuela. These systems observed the maritime boundary layer (MBL) with turbulence-resolving resolution. The data will be used to investigate the dependence of cloud evolution on sea surface temperature and MBL properties as well as the interaction with the trade wind layer.

For the first time a temperature and humidity lidar, the **Atmospheric Raman Temperature and Humidity Sounder (ARTHUS)** (Lange et al. 2019), was operated on a shipborne platform. The measurements were made in vertically staring mode. ARTHUS provides water-vapor, temperature, and aerosol profiles with resolutions of 7.5 m and 10 s in the lower troposphere. This lidar was combined with one Doppler lidar in vertically staring mode and a second one in 6-beam scanning mode, both with resolutions of 1 s and 15 m. The Doppler lidars provide vertical and horizontal wind profiles as well as the statistics of higher-order moments of turbulent fluctuations of these parameters and thus, e.g., turbulent kinetic energy (TKE) and momentum flux. Synergetic parameters from the combination of all three lidars are, e.g., sensible and latent heat flux profiles (Behrendt et al. 2020).

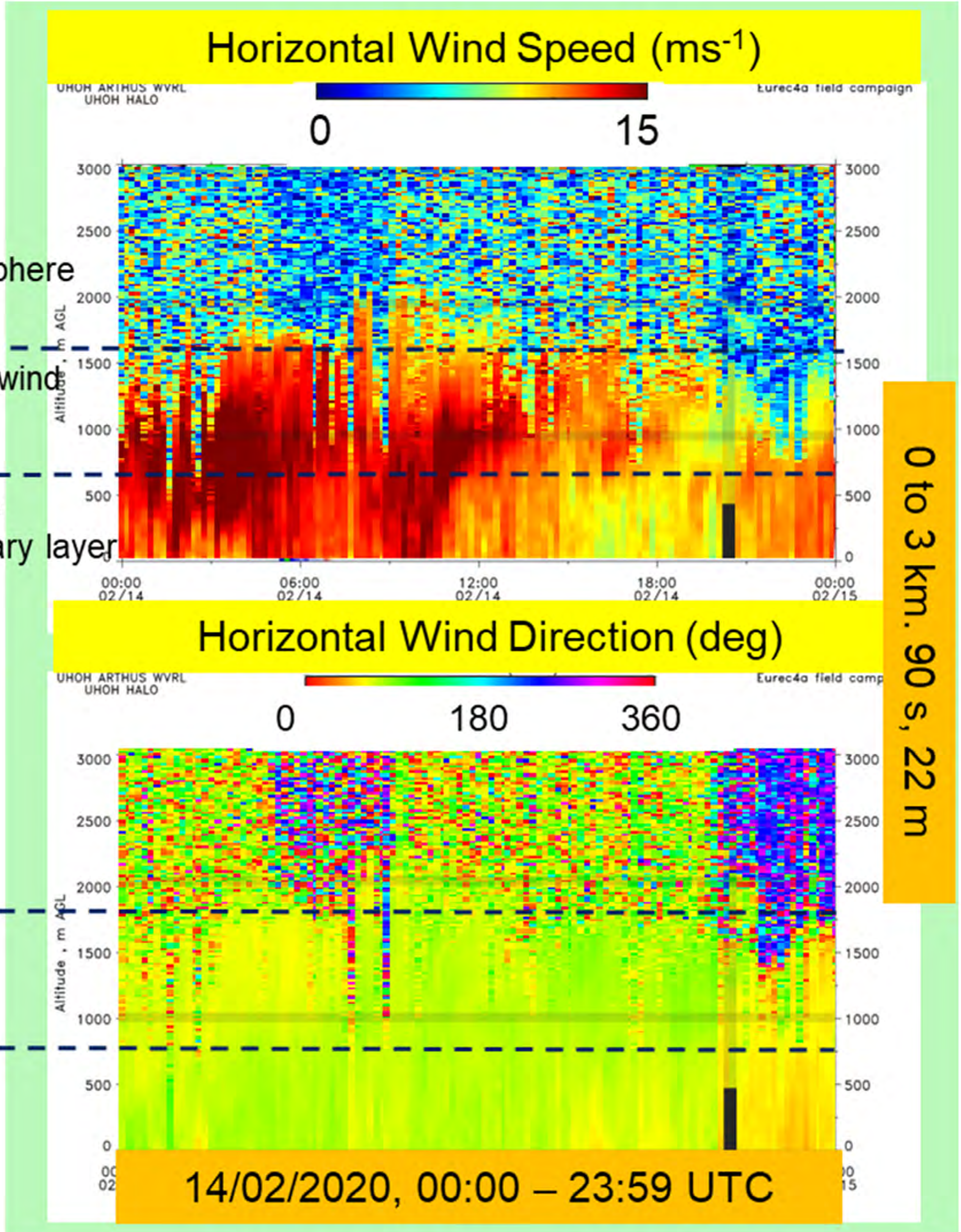
ARTHUS



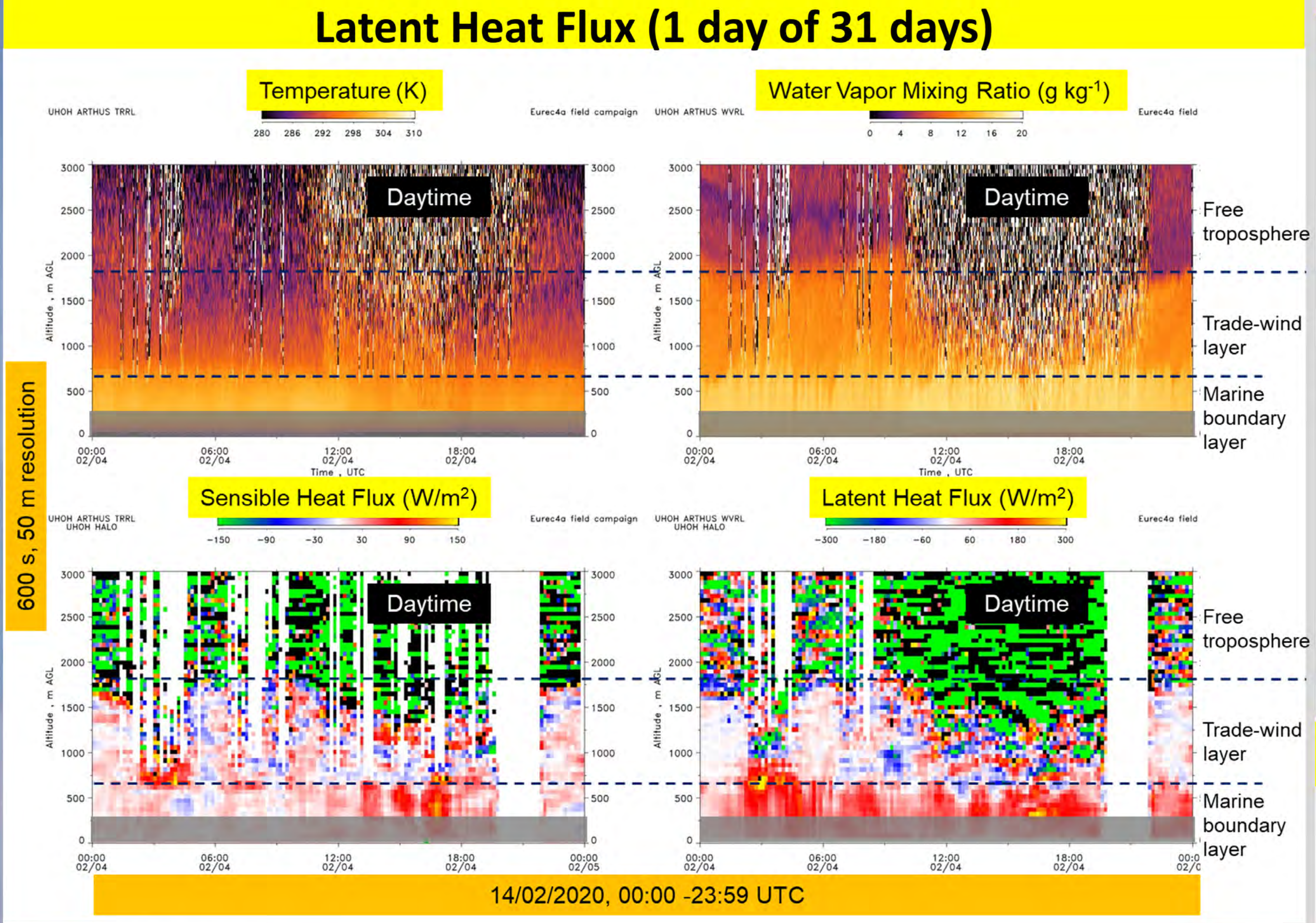
Moisture and Latent Heat Flux example (90-minutes case)



Horizontal Wind



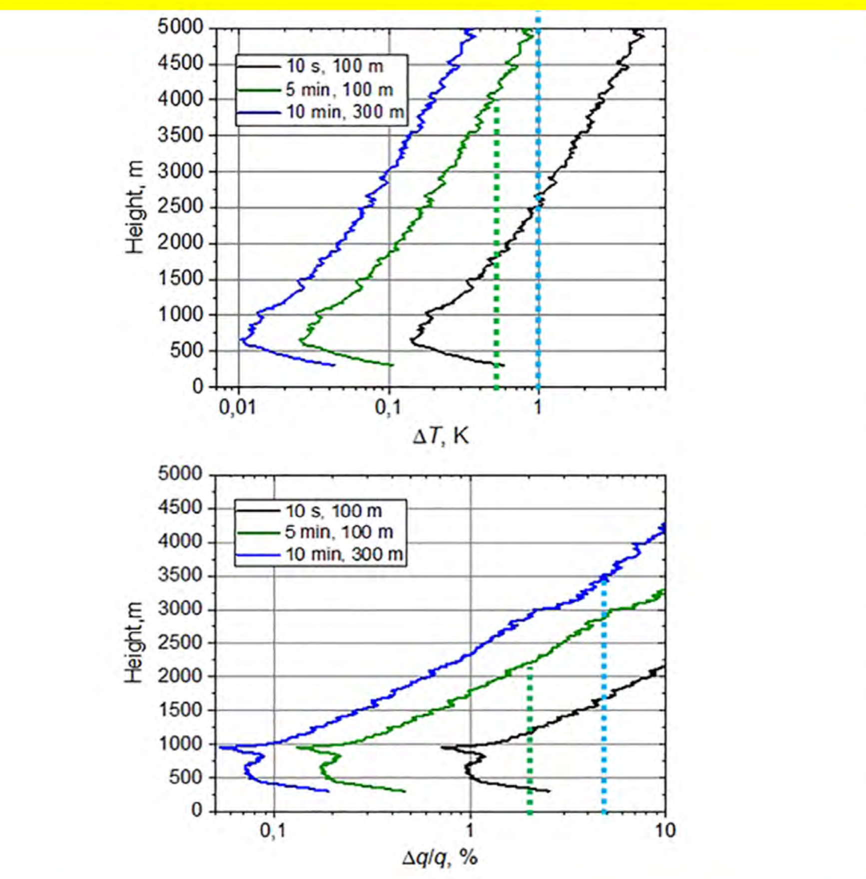
Temperature, Moisture, Sensible and Latent Heat Flux (1 day of 31 days)



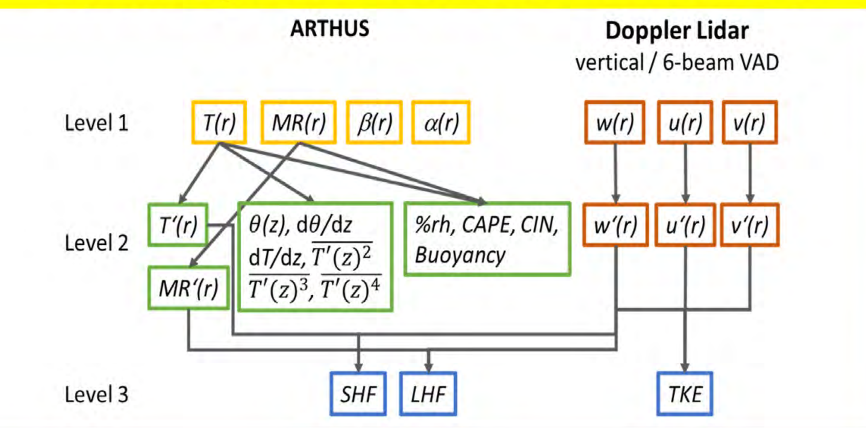
Research in progress:

- Latent and sensible heat flux daily cycle over the Northwestern Tropical Atlantic
- Atmospheric imprint of a cold sea patch in the Northwestern Tropical Atlantic
- Investigation on the impact of environmental parameters on ship-based observations of trade wind shallow cumuli and precipitation

Total Statistical Uncertainties



Primary and Derived Products



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Summary

- First ship-based campaign with a water vapor and temperature lidar
- Two Doppler lidars operated simultaneously
- ARTHUS behaved extremely stable despite the ship motion and vibration, high elevation of the sun over the horizon, or salty atmosphere
- Data have turbulent resolution: ARTHUS (10 s, 7.5 m) and DL (1 s, 30 m)
- 24/7 automatic lidar operation with real-time data analysis
- Data availability: 23 January 2020 – 18 February 2020
- Data products: mean thermodynamic profiles, higher order moments of turb. fluctuations and fluxes
- Robust, mobile, well suited for case studies and data assimilation
- Next field campaign: WaLiNeAs

References

About ARTHUS:

Lange, D., et. al. (2019). ***Compact operational tropospheric water vapor and temperature Raman lidar with turbulence resolution.*** *Geophysical Research Letters, 46, 14,844–14,853.* https://doi.org/10.1029/2019GL085774

About latent and sensible heat fluxes measured with Raman lidar – Doppler lidar synergy:

Behrendt, A., et. al.(2020). **Observation of sensible and latent heat flux profiles with lidar**. *Atmospheric Measurement Techniques*, *13*(6), 3221–3233. https://doi.org/10.5194/amt-13-3221-2020

About data processing with error propagation:

Wulfmeyer, V., et.al. (2016). **Determination of Convective Boundary Layer Entrainment Fluxes, Dissipation Rates, and the Molecular Destruction of Variances: Theoretical Description and a Strategy for Its Confirmation with a Novel Lidar System Synergy**. *Journal of the Atmospheric Sciences*, *73*(2), 667–692. https://doi.org/10.1175/JAS-D-14-0392.1

About EUREC4A (showing ARTHUS – DL latent heat flux example):

Stevens, B., et.al. (2021). **EUREC4A**. *Earth System Science Data*. https://doi.org/10.5194/essd-2021-18

About *WaLiNeAs* (Water vapor Lidar Network Assimilation project):

Flamant, C., Chazette, P., Caumont, O. et al. **A network of water vapor Raman lidars for improving heavy precipitation forecasting in southern France: introducing the WaLiNeAs initiative.** *Bull. of Atmos. Sci.& Technol. 2, 10 (2021).* https://doi.org/10.1007/s42865-021-00037-6

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