Temperature dissipation in convective clouds during EUREC⁴A

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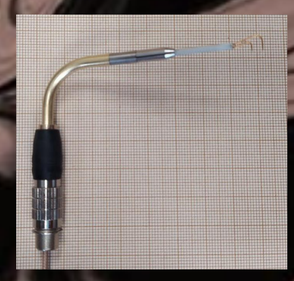
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UltraFast Thermometers (UFT's), developed at the Institute of Geophysics, University of Warsaw, allow for airborne measurements of temperature fluctuations in turbulent atmosphere with the resolution better than 1 cm, which provides insight into small-scale turbulent mixing in clouds, atmospheric boundary layer and clear air.

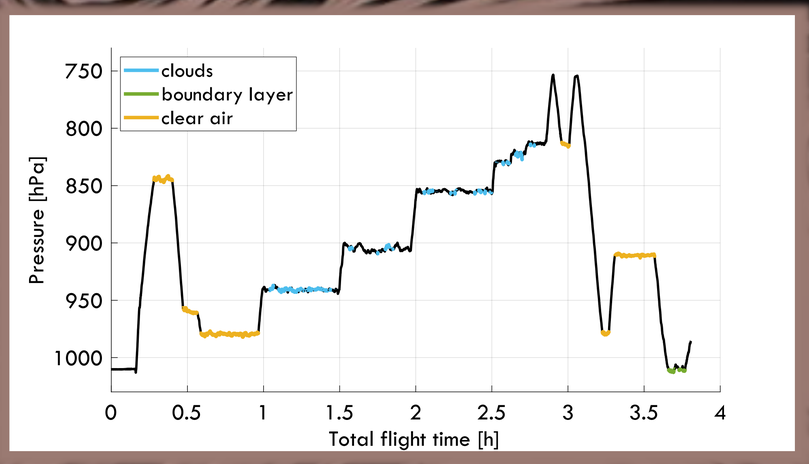
In recent years new versions of UFT thermometers (UFT-2 family) were used in a few measurement campaigns including EUREC⁴A. The instrument, with the resolution reaching 3 mm and the sampling frequency of 20 kHz, was deployed onboard the BAS Twin Otter aircraft (average speed of 60 m/s) in the subtropical low atmosphere, in and between trade wind warm cumulus clouds. Data, resolving scales down the dissipation range, allow to estimate directly the normalised temperature dissipation rate (*ND*) in cloud interiors, cloud shells, air spaces between the clouds, and in the atmospheric boundary layer.

Until now, no experimental data on temperature dissipation in free atmosphere and in clouds from in situ measurements have ever been published. Such data may help to understand cloud microphysical processes with phase changes. Classically, during turbulent mixing of air masses, temperature is considered as a passive scalar. In clouds, in the course of condensation/evaporation heat is released/absorbed, which may affect fine-scale fluctuations of temperature. Thus, statistical properties of temperature dissipation should differ from situations in which the temperature is just a passive scalar.





The figure on the right presents static pressure in the course of the analysed flight. Segments on which *ND* was calculated, including cloud interiors (CL), clear air (CA) and boundary layer (BL, 30 m altitude) are marked on the plot.



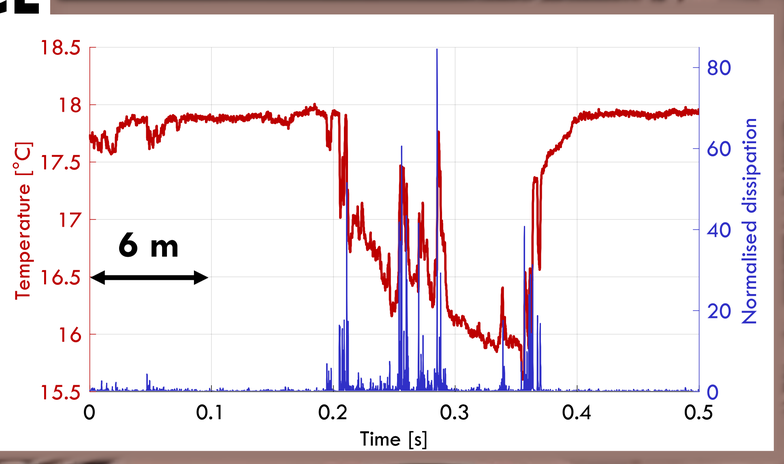
Microphysical records from The Meteorological Airborne Science INstrumentation (MASIN) mounted on the BAS Twin Otter was used to select the segments containing clouds.

We used the following estimate of the normalised temperature dissipation rate:

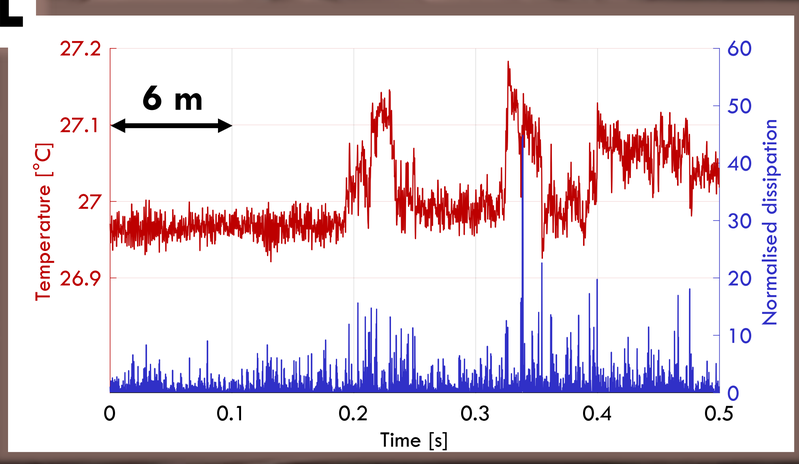
$$ND = \frac{\Delta T^2}{\langle \Delta T \rangle^2}$$

ΔT is the temperature change between consecutive samples (corresponding to 3 mm distance), averaging <> is performed on the selected segments.

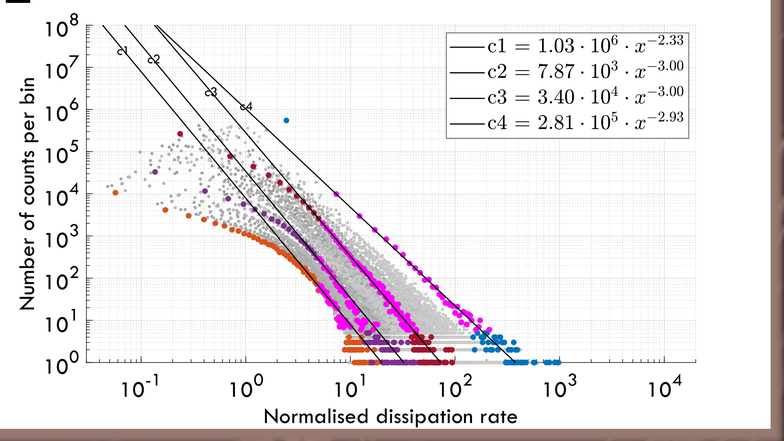
CL



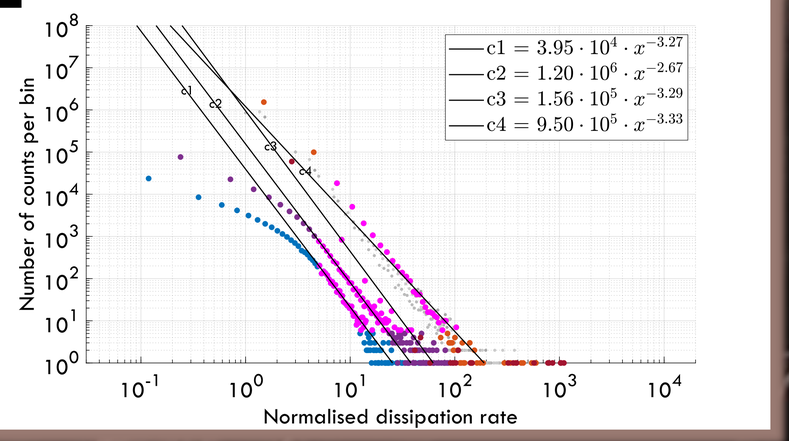
BL



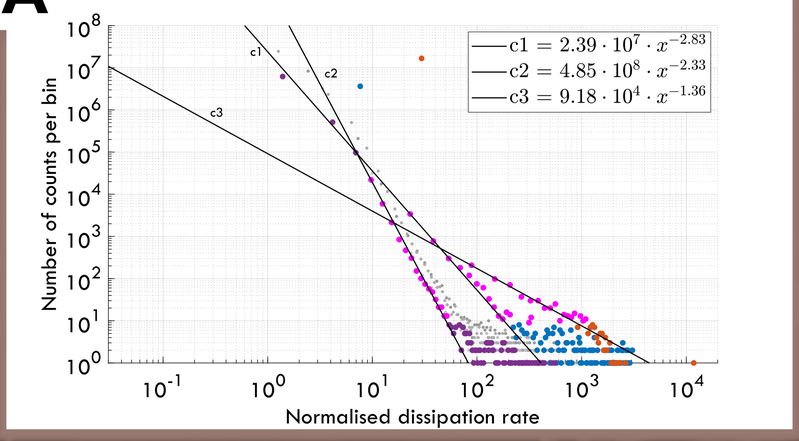
CL



BL



CA



During the analysis, 113 cloud segments, 7 segments in the boundary layer (>1010 hPa) and 6 segments collected in the clear air were selected. The above graphs were created from histograms of the normalised temperature dissipation rate versus numer of counts per bin. Each graph contains sample fits. Their limits were set on the *ND* (CL, BL: >8, CA: >30) and the number of counts (CL, BL: >8, CA: >8 & $<10^6$). There is a substantial variability in the exponents of fits among the segments but no obvious differences between clouds and turbulent segments in BL are present in the analysed distributions of *ND*.

Literature

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