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Extremely thin Tropical Cirrus Clouds and Equatorial Kelvin Waves

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Introduction:

Cirrus clouds, including extremely thin cirrus, can be observed with AWIs mobile lidar systems MARL and ComCAL that were deployed aboard Polarstern and at Paramaribo, Suriname (5.8°N, 55.2°W)þ

Cirrus clouds occur frequently in the TTL. The extremely thin clouds above 15 km altitude (base hight) are according to our observations generally not directly related to deep convection.

In a recent paper (Immler et al., JGR, 2007) we have shown, that cirrus in the TTL generally form during slow ascent and dehydrate the air effectively.

Equatorial Kelvin cause eastward and downward propagating temperature anomalies in the lowermost stratosphere and the TTL (Fig. 1). We observed a close correlation between Kelvin waves and the occurrence of thin cirrus at the tropopause (Fig. 2).

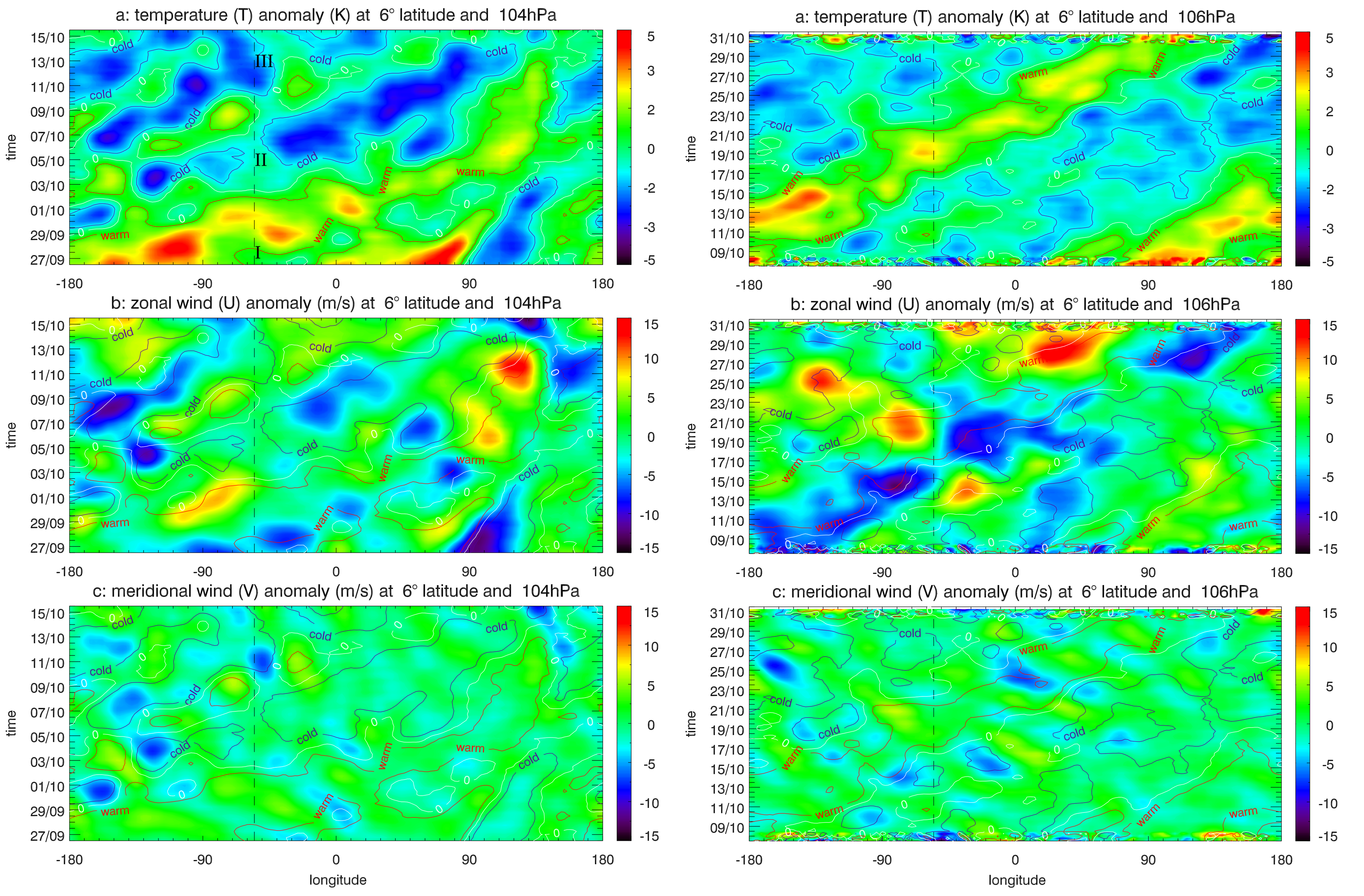

Fig. 1 Longitude– time sections of the temperature (a), zonal (b) and meridional (c) wind anomalies for the time periods of the STAR (left) and ACLIT (right) campaigns close to the latitude of Paramaribo (5.4°N). Kelvin waves cause eastward and downward propagating temperatures anomalies (a) and zonal wind anomalies (b) the temperature anomalies lead the U anomalies by a quarter wavelength (b). Kelvin waves have no zonal wind component (c) . The date are retrieved from the ECMWF operational analysis.

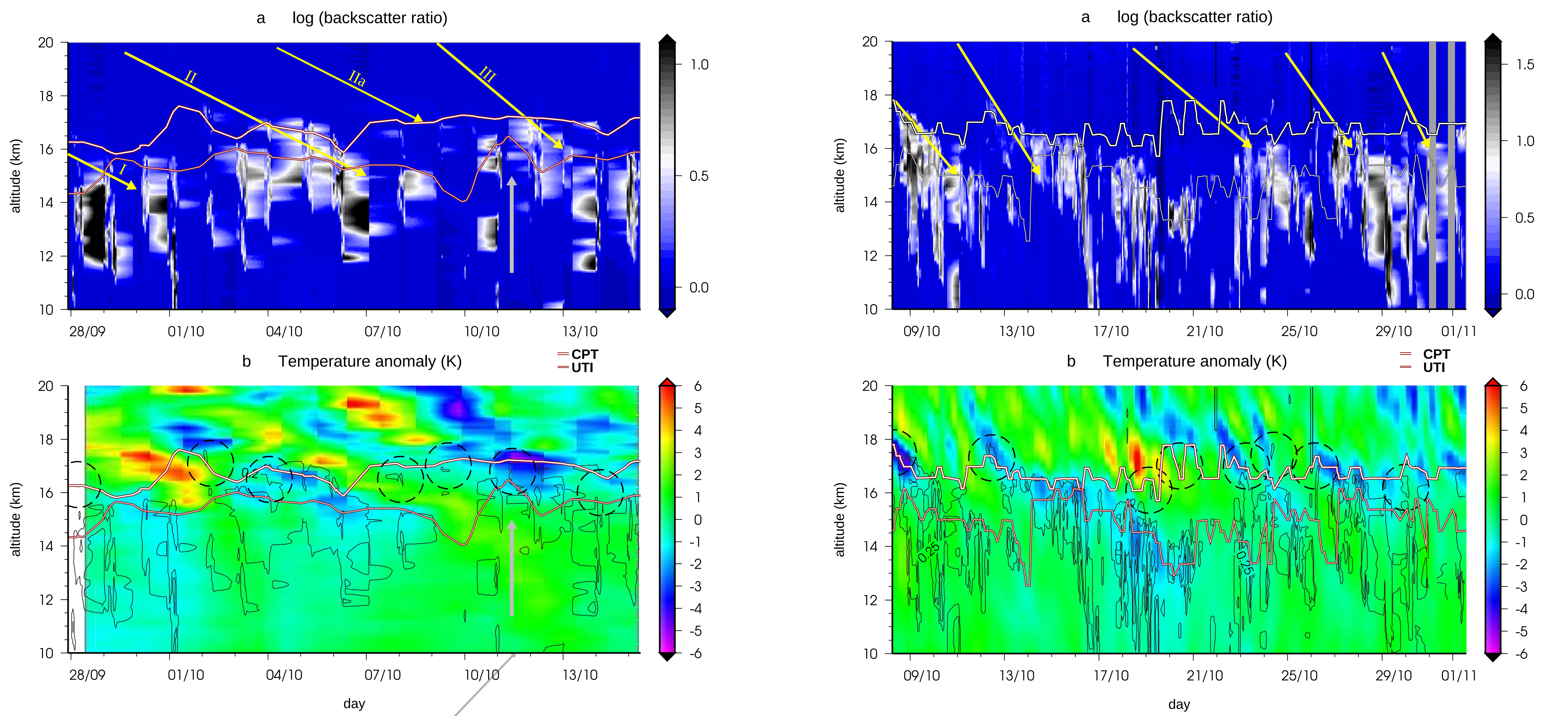

Fig. 2 Lidar –observations of clouds during the STAR (a, left) and ACLIT (a, right) campaigns, October 2004 and 2006, respectively . The lower plots (b) show the temperature anomalies retrieved from radiosonde data (left) or ECMWF operational analysis data (right). The arrows in a mark the propagation of the cold phases of Kelvin waves as determined from b. The contour lines in B mark the occurrence of clouds as determined from A. Circles highlight the occurrence of extremely thin cirrus (OD < 10-3) which were observed frequently in the cold phase of downward propagating cold anomalies.

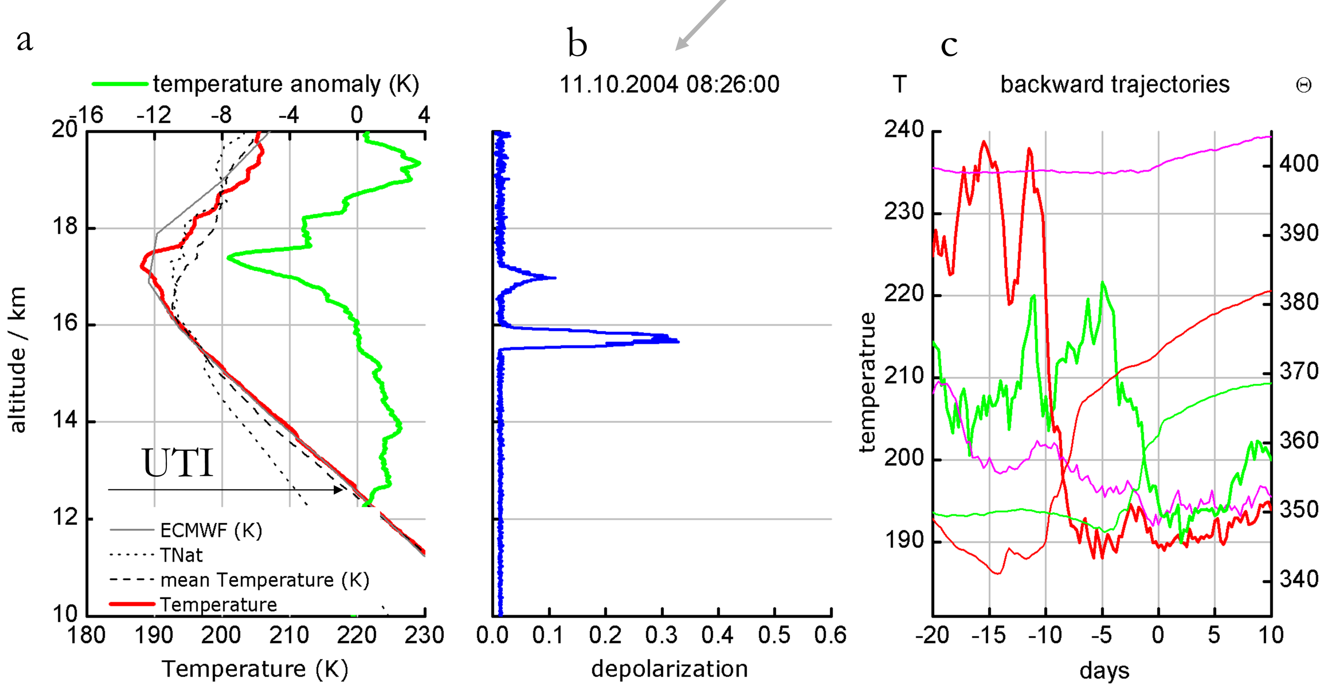

Fig. 4 Temperature (a, red line), temperature anomaly (a, green), and lidar depolarisation (b, blue). The lower part of the TTL is influenced by the warm phase of a Kelvin wave and is therefore cloud free. The upper part is cooled by a downward propagating cold phase. Cirrus is present in the region of a negative temperature anomaly suggesting that its formation was forced by the Kelvin wave. The plot on the right hand side shows back- and forward trajectories calculated by the AWI trajectory code where vertical transport is retrieved from radiative heating rates. The red line shows the temperature history the air parcel containing the thin upper cloud, the green line of the lower cloud in b. The thin lines depict the potential temperature.

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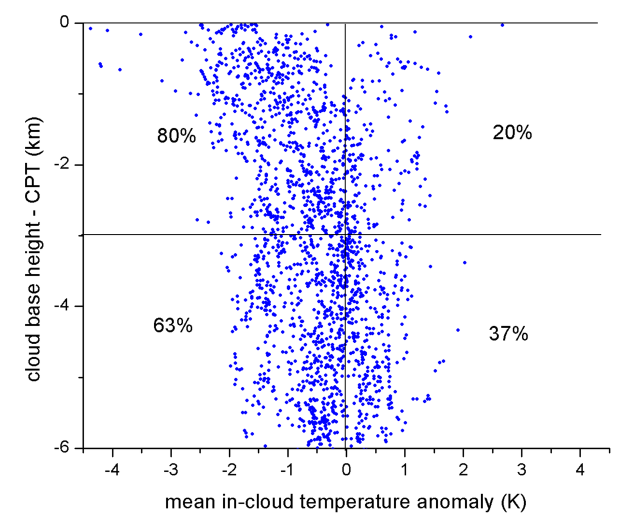

Fig. 5 Scatter plot of the cloud base height determined from lidar observations (with respect to the CPT) versus the mean in-cloud tempera-ture anomaly determined from ECMWF data for the entire ACLIT campaign (29.9.2006 to 29.11.2006). Within 3 km of the CPT cirrus occurrence is corre-lated with negative temperature anomalies, which to a large extent are caused by Kelvin waves (Fig.4).

Results and Conclusions

•Based on radiosonde observations and operational ECMWF analysis we demonstrate that equatorial Kelvin waves influence the thermal structure of the tropical tropopause layer (TTL).

•In the TTL the temperature anomalies induced by Kelvin waves correlate with the occurrence of cirrus clouds.

•Cirrus in the TTL are obviously formed in situ by synoptic temperature disturbance caused by Kelvin waves.

•As observational data (Immler et al., JGR 2007) and model studies suggest (Jensen&Pfister, JGR, 2004), in situ formed cirrus efficiently dehydrate the ascending air in the TTL.

Kelvin waves play an important role for the dehydration mechanism of the TTL and thus for the stratospheric water vapor concentration.

Deutscher Wetterdienst