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Temporal variation of gravity waves and thermal tides during a record long 10-day continuous lidar sounding at mid-latitudes

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Gravity waves (GW) as well as thermal tides are a key driving mechanism for the circulation in the Earth's atmosphere. The propagation of gravity waves is strongly affected by tidal waves as they modulate the mean background wind field and vice versa. These interactions are not yet fully understood and not adequately implemented in many circulation models. The daylight capable Rayleigh-Mie-Raman (RMR) lidar at Kühlungsborn (54°N, 12°E) typically provides temperature data to investigate waves during one full day or several consecutive days in the middle atmosphere between 30 and 75km altitude. Exceptional weather conditions in May 2016 allowed for an unprecedented 10-day continuous lidar measurement which shows a large variability of gravity waves and tides on time scales of days. Using a spectral filtering technique, gravity and tidal waves are separated and their temporal evolution is studied. During the measurement period a strong 24h-wave occurs mainly between 40 and 60km and vanishes after a few days. The disappearance is related to an enhancement of gravity waves with periods of 4-8h from temperature data. Short periodic GW with periods of a several minutes to 4h are extracted by using the high resolution lidar raw data instead of temperature data. These waves show a similar enhancement during the last days. Wind data provided by ECMWF are used to analyze the meteorological situation at our site. The local wind structure changes during the observation period, which leads to different propagation conditions for gravity waves in the last days of the measurement period and therefore a strong GW activity. The analysis indicates a further change in wave-wave interaction resulting in a minimum of the 24h tide. The observed variability of tides and gravity waves on timescales of a few days clearly demonstrates the importance of continuous measurements with high temporal and spatial resolution to detect interaction phenomena.