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Energy dissipation rates in the stratosphere derived from in-situ soundings with very high spatial resolution

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Even in the stably stratified stratosphere turbulence occurs due to the dissipation of gravity waves. Although stratospheric turbulence is weak on average compared e.g. to mesospheric turbulence, breaking gravity waves in the stratosphere can modify the energy transfer from the troposphere into the mesosphere. Therefore examinations of small scale structures are not only important for the stratosphere itself but for the understanding of the energy budget of the whole middle atmosphere. Moreover stratospheric turbulence is an important process in the vertical mixing of trace species. In-situ soundings still provide the only possibility for high-resolved turbulence measurements up to 35 km altitude. But these soundings are technically challenging and the number of soundings is sparse. We have developed a new compact balloon-borne payload for wind turbulence soundings from the ground up to the middle stratosphere (35 km). The wind measurements are performed with a constant temperature anemometer (CTA) and have a vertical resolution of 2.5 mm. The whole payload weights less than 5 kg and can be launched at any radiosonde station. Since autumn 2007 the balloon payload has been successfully launched several times from our site at the Leibniz-Institute of Atmospheric Physics (IAP) in Kühlungsborn, Germany (54°N, 12°E). Two additional soundings are carried out in 2008 and 2009 at Kiruna, Sweden (67°N, 21°E) as part of the BEXUS program. We observed thin turbulent layers of 20-100 m thickness, partly up to 500 m, in a mainly non-turbulent stratosphere. The turbulent regions are separated by sharp boundaries to the non-turbulent regions. Due to the high vertical resolution of the measurements (2.5 mm) it is possible for the first time to study the whole turbulence spectrum down to the viscous subrange in the stratosphere. Power spectral densities of turbulent layers reveal slopes with exponents of -5/3 and -7, which are indicative of the inertial and viscous subrange. By fitting a theoretical model to the measured turbulent spectrum we determine the transition between the inertial and viscous subrange (inner scale) and therewith the energy dissipation rates (ε). Within the examined turbulent layers ε-values strongly vary between $5x10^{-5}$ W/kg (weak turbulence) and $2x10^{-2}$ W/kg (strong turbulence). These energy dissipation rates deviate by a maximum factor of 100 from earlier indirect measurements. Furthermore the measurements reveal that highly fluctuating raw data are not directly related to high energy dissipation rates. We will show examples of detected turbulent layers and the corresponding altitude-resolved ε-profiles. We will discuss the occurrence of these turbulent layers and their relation to atmospheric background parameters.