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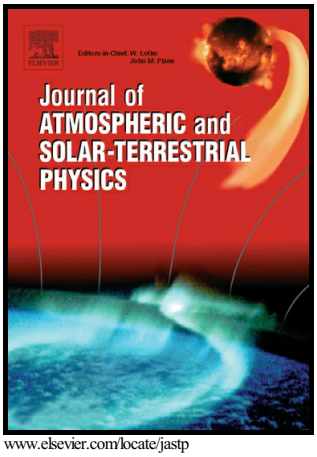

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Analysis of small-scale structures in lidar observations of noctilucent clouds using a pattern recognition method

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Abstract

Noctilucent clouds (NLC) have been observed with the ALOMAR Rayleigh/Mie/Raman lidar at 69° N using a temporal resolution of 30 s since 2008. We present an approach to identify and analyze the localized small scale wave structures of the varying altitude of the NLC layers in the range of 5–30 min that may be caused by gravity waves. Small scale gravity waves breaking in the mesopause region contribute notably to the momentum flux but are difficult to observe and to characterize. The approach is based on a template matching method using generalized structures to be identified in the NLC observations. The new method permits the identification of structures that are present in NLC only for a time too short to appear in a Fourier or wavelet spectrum. Without the need for a continuous time series the method can handle multiple NLC layers and data gaps. In the 2000 h of NLC data from the years 2008–2015, we find almost 5000 single wave structures with a total length of 738 h. The structures are found on average 400 m below the NLC centroid altitude and a large number of the structures has a length at the lower limit of 5 min. With the background wind from the meteor radar near ALOMAR a horizontal scale is estimated based on the length of the individual structures. The distribution of horizontal scales shows a peak of wave structures at 15–20 km in accordance with the horizontal wavelengths found by ground-based camera observations of NLC.

Key words: Noctilucent clouds, Polar mesospheric clouds, Lidar, Gravity waves, Dynamics

1. Introduction

Noctilucent clouds (NLC) are mesospheric clouds first observed in 1885 (e.g. Jesse, 1885; Backhouse, 1885; Leslie, 1885), that exist at an altitude of about 83 km in the Northern Hemisphere and are composed of ice particles (e.g. Jesse, 1896; von Zahn et al., 1998; Lübken et al., 2008; Hervig et al., 2001). They are an important tracer for the processes in the mesosphere, an altitude region that is difficult to study otherwise. Gravity waves of different scales influence the brightness of the clouds and generate their characteristic, highly structured appearance that is visible from the ground (Hines, 1968; Fritts et al., 1993). Wave breaking near the mesopause is a crucial driver of atmospheric dynamics (e.g. Holton, 1983; Geller, 1983), but their scales and propagation properties are still not sufficiently known. Regarding small scales (here: horizontal scales of up to 100 km and temporal scales up to 30 min) the observation methods of NLC are limited and even high

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