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A satellite perspective on interactions between convective storms and the upper atmosphere

Martin Setvak (1), Xavier Calbet (2), and Steven Miller (3)

(1) Czech Hydrometeorological Institute, Satellite Department, Prague, Czech Republic (martin.setvak@chmi.cz), (2) Agencia Estatal de Meteorología (AEMET), Madrid, Spain, (3) Cooperative Institute for Research in the Atmosphere (CIRA), Colorado State University, Fort Collins, USA

By the end of 1980's, convective storms had been identified as the principal source of concentric gravity waves (CGW), occasionally manifesting as modulations to atmospheric nightglow near the mesopause (at about 85-100km levels). Since then, various methods of gravity wave detection in the upper stratosphere and mesosphere have significantly evolved and improved, including satellite observations. Among the latter, nocturnal low-light observations by Day/Night Band (DNB) of the Suomi-NPP and NOAA-20 (JPSS-1) satellites, and observations by hyperspectral sounders such as AIRS (aboard Aqua satellite) and IASI (on Metop), have begun to revolutionize the way we are able to observe and characterize this important atmospheric energy transfer mechanism.

This work focuses on DNB observations of CGW (generated by convective storms) in nightglow emissions, and preliminary statistics of their global occurrence. To date, we have collected about 100 worldwide CGW cases (2014/4 cases, 2015/13 cases, 2016/14 cases, 2017/33 cases, and 2018/48 cases). While the cases during 2014 – 2016 were gathered unmethodically (based on scrutiny of DNB imagery in correlation with deep convection as identified in various infrared band imagery), the cases from 2017 and 2018 result from a global systematic survey of NPP-DNB imagery, available through NASA's EOSDIS Worldview service since December 2016. The majority of these cases come from north subtropics of Africa (56 cases), followed by Australia (16 cases), Mediterranean (11 cases), Argentina (7 cases), and the remainder coming from elsewhere. However, these numbers are compromised and biased by a significant non-meteorological factor: heavy light pollution in some of the otherwise storm-rich areas, such as the U.S. or China, where the bright background adversly impacts DNB-based CWG detection.

Besides the statistics above, we will present some of the characteristics of CGW seen by the DNB in nightglow, including typical horizontal wavelengths (resolved by the 0.74 km pixel resolution of the DNB) and their horizontal extent (reaching up to 2500-3000 km from their source in the most extreme cases). For selected cases mentioned above we will also present their corresponding manifestation in AIRS and IASI data, which show the CGW at lower altitudes than DNB, in the upper stratosphere (at about 40km). This analysis yields the first basic statistics on the simultaneous occurrence of CGWs spanning the stratosphere through the mesosphere. As such, this study illustrates the promising potential of multisensor observations of CWG throughout the middle atmosphere at spatial and temporal resolutions previously unavailable at the global scale.