Gravity waves generated by thunderstorms

Abstract

The atmospheric layers and regions are strongly coupled with each other. The dynamic processes in the troposphere affect the other layers of the atmosphere by energy transport through gravity waves. In order to understand and model these interactions, it is important to understand and quantify the role of gravity waves and their generation. In tropical region, thunderstorms occur frequently which are known to generate gravity waves with wide range of frequencies and scales. Over the years, various studies have highlighted and characterised the gravity waves that are generated by the latent heat release in the thunderstorms, yet there is no established and quantified relationship between them.

In this study, model has been developed which quantifies the phase velocity and amplitudes of gravity waves generated by the latent heat in thunderstorms in South-East Asian region. This is based on identifying the waves with wavelet transform, tracing their sources using ray tracing methods, and running cloud-resolving simulations at the identified convective source locations. Ten of years of radiosonde data (2007-2016) is analysed for waves at Singapore station and the conclusions are derived based on various instances spanning the decade.

In the last few two decades, the importance of latent heat release in the atmosphere is realised, yet there are no instruments which can directly measure the atmospheric latent heat. Therefore, methods are developed for estimating latent heat for A-Train satellite instruments – CloudSat radar and MODIS. In order to monitor and understanding the impact of latent heat in the atmosphere, consistent global estimates of latent heat are required which can only be obtained efficiently using satellites. Previous methods for latent heat retrieval using radars are extended for CloudSat W-band radar and using this result, MODIS spectral images are trained using neural network. Since MODIS has a wide coverage with high resolution, frequently occurring thunderstorms in the tropical region can be monitored with one additional variable – latent heat. Finally, using the MODIS latent heat maps developed, the study develops models to quantify gravity wave properties using similar approach as mentioned before for two regions – South-East Asian region and West African tropical region. This time, instead of cloud-resolving simulations, MODIS images are used for latent heat. The models are validated with local radiosonde stations.

The thunderstorms have significant impact in the atmosphere by driving winds and effecting circulation. The gravity waves generated by them propagate up to middle atmosphere, and wave dissipation and breaking results in large alteration in the energy and momentum budgets affecting local atmospheric constituents. This study hopes to bring forth renewed understanding of the coupling between latent heat and gravity waves, and hopefully improve the current weather forecasting and modelling.

Publications

Naren Athreyas, K., Gunawan, E. & Tay, B.K., 2018. Source tracing of thunderstorm generated inertia-gravity waves observed during the RADAGAST campaign in Niamey, Niger. Journal of Atmospheric and Solar-Terrestrial Physics, 172(January), pp.1–9. Available at: https://doi.org/10.1016/j.jastp.2018.03.003.

Naren Athreyas, K., Gunawan, E. & Tay, B .K. Estimating latent heat profiles of deep convective clouds using CloudSat radar, *IEEE Radar Conference,* 2018.