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Characteristics of inertia- gravity waves over Gadanki during the passage of deep depression over the Bay of Bengal

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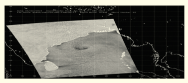
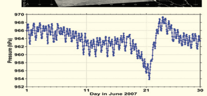
Objective : To study the gravity wave characteristics over Gadanki during the passage of deep depression over the Bay of Bengal.

Introduction

During the period of southwest monsoon (June–September) over the Indian subcontinent a number of lows and depressions form over the Bay of Bengal and mostly they move west–northwestward direction. Monsoon depressions producing large amounts of rainfall over India are among the important components of monsoon circulation.





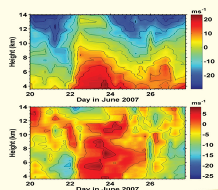
- QuickSCAT image showing the Low–pressure area over west–central Bay of Bengal (~15⁰ N 86°E) on 20 June 2007 23:57 UTC
- A 10 hPa dip is observed in surface pressure level taken from Automatic Weather Station at Gadanki (13.5° N 79.2°E)

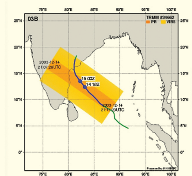
Strong westerly winds are observed in the lower troposphere between 22-24 June 2007.

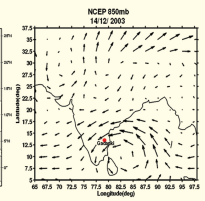
This is expected, since the vortex of the depression rotates counter clockwise in the northern hemisphere.

Strong southerly winds are observed after 22 June when the depression crosses Andhra Pradesh coast.

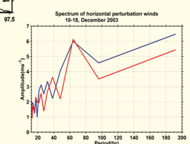
This indicates that the depression moves west–northwestward.







- Figures indicating the track of the TC during the 12-15 December, 2003 and NCEP vector wind at 850mb pressure level respectively.

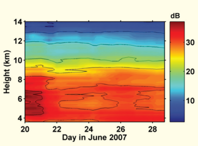


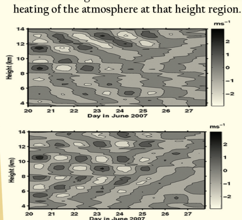
- Figure shows the mean spectrum calculated from Fast Fourier transforming the zonal and meridional wind perturbations observed from the Indian MST Radar in the height range 13-15km. The spectrum shows large spectral amplitudes peaking near 64h period in both zonal and meridional directions

Clear enhancement in the Range corrected SNR in zonal direction between 4–6km heights during the passage of the depression.

The maximum heating occurs at ~ 400–500 hPa (~4–5 km) in case of monsoon depression.
(e.g., Krishnamurti et al., JMSJ, 1975; Ramanathan, JAS, 1980)

Thus the strong SNR between 4–6 km is a manifestation of latent heating of the atmosphere at that height region.

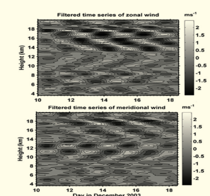


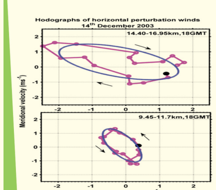


Both figures correspond to the filtered (40–60hrs) time series with vertical scales less than 5km in (a) zonal and (b) meridional components.

A clear downward phase propagation of the waves with respect to time can be seen in both the components above 6-7 km.

- Figures showing the Band pass filtered time series (centered at 64h) in both zonal and meridional directions. A clear downward and upward phase propagation waves is seen above and below ~12km respectively indicating the source region lies ~12km region.

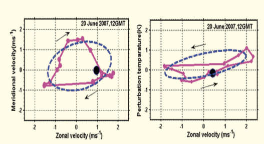




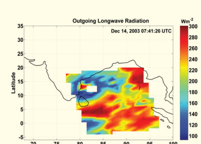
A clear anti clock-wise rotation below 12km and clock-wise rotation above also support that source region of the waves is lies in ~12-14km.

The clockwise rotation and greater magnitude of horizontal wave vector above the source region and the anti-clock wise rotation and smaller magnitude of the wind vector below the source region leads us to believe that the observed 64hr wind oscillation is manifestation of inertia-gravity wave.

- Hodograph of horizontal wind perturbations (Clock-wise rotation in Northern Hemispere) in the height range 8.4-11.10km indicate, there is an upward propagation of the gravity wave energy and also the direction of horizontal propagation of the wave is along the NE or SW direction.
- The 180° ambiguity in the determination of horizontal wave propagation can be resolved by using the dispersion relation between the temperature and horizontal wind fluctuations, given by

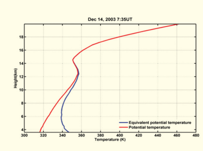


Parameter	Altitude Region (8.4–11.10km)
Ratio of minor to major axis	0.7062
Intrinsic period (hours)	32.47±1.03
Horizontal wavelength (km)	240 ± 39
Vertical wavelength (km)	2.19±0.30
Horizontal group velocity (m/s)	1.33±0.19
Vertical group velocity (cm/s)	2.39±0.02
Horizontal phase velocity (m/s)	2.02±0.30
Vertical phase velocity (cm/s)	2.75±0.01



Outgoing Long wave Radiation (OLR) contour maps, taken from Atmospheric Infrared Souder (AIRS), clearly depicting the center of the eye surrounded by eye wall.

The comparison of the equivalent potential (and potential) temperature of air parcels at different pressures provides a measure of the instability of the column of air. Figure indicating that there is convective instability in the height range of 12-14km might be cause for the generation of the waves.



SUMMARY

The study reports the generation of inertia-gravity waves from latent heating of the atmosphere during the passage of deep depression is reported . Hodograph analyses of horizontal winds indicates the upward energy propagation above the latent heating region of 4–6 km, which is manifested as significant enhancement in signal to noise ratio observed by the MST radar in this height range. The observation of horizontal propagation of inertia-gravity waves in South west direction before the passage of deep depression from the observational site indicates that these waves are associated with it and propagated outward.

During the passage of the TC, it is observed that upward and downward propagating gravity wave disturbances from the height range of 12-14km and it is suggested that convective instability near the eye-wall region might be the cause for the generation of the waves in that height range.

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