Rayleigh lidar observations of gravity wave seasonal variability over a tropical site

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Data Statistics over Gadanki (13.5N, 79.2E)
Analysis method

- Lidar temperature data are received with vertical and temporal resolution 300 m and 250 s

- Mean nocturnal profile is subtracted from each individual profiles

- Data is undergone a bandpass filter of cutoff ~0.5-4 h to obtain fluctuation profiles to calculate potential energy, dissipation rate and momentum flux.

- Vertical wavenumber spectra are calculated from normalized temperature profiles (T’/T ).
Potential energy

\[ E_P = \frac{1}{2} \left( \frac{g}{N} \right)^2 \left( \frac{T'}{T} \right)^2 \]

\[ N^2 = \left( \frac{g}{T} \right) \left( \frac{dT}{dz} - \Gamma \right) \]
Dissipation of gravity waves with altitude

\[ E(z) = E_0(z_0) \exp\left[\frac{(z-z_0)}{H(z)}\right] \]

\[ H(z) = \frac{kT(z)}{mg(z)} \]

\[ \text{Dissipation} = \frac{(E_{\text{theory}} - E_{\text{obs}})}{E_{\text{theory}}} \]

Percentage dissipation

\[ PD = \left(1 - e^{-\frac{(z-z_0)}{H_1/H_0}}\right) \times 100 \]

\[ H_1 = \text{observational SH} \]
\[ H_0 = \text{theoretical SH} \]
Vertical component of horizontal momentum flux

\[ F = \langle u' w' \rangle \approx \frac{\omega}{N} \left( \frac{g}{N} \right)^2 \left( \frac{T'}{T} \right)^2 \]

Valid for \( N \gg \omega \gg f, \quad \frac{k}{m} = \frac{\omega}{N} \)

\[ \omega \approx \frac{1}{\omega_2 - \omega_1} \int_{\omega_1}^{\omega_2} \omega \, d\omega = \frac{\omega_1 + \omega_2}{2} = \pi \left( \frac{1}{P_1} + \frac{1}{P_2} \right) \]
Lomb Scargle periodogram

- Mesosphere energy
- Stratosphere energy
- Mesosphere flux
- Stratosphere flux

Normalized Power vs. Period (month)
Vertical wavenumber spectrum

\[ F(m) = \frac{N^2}{6m^3} \]
Logarithmic slope variability

[Graph showing slope variability over months for Mesosphere and Stratosphere]
Summary and conclusions

- Potential energy and dissipation rate shows large values in the mesosphere.
- During autumn equinox there is a strong indication of Planetary wave and gravity wave interaction.
- Annual oscillation (AO) is observed in the energy and momentum flux pattern.
- Stratospheric vertical wavenumber slope shows higher magnitude (close to theoretical value) with compared to mesosphere.
- Maximum difference of slope with and without PWPC of ~ 0.2 and 0.3 for mesosphere and upper stratosphere, respectively.