An Integrated Study of Gravity Wave Generation and Propagation

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Introduction

• The Tropical Warm Pool-International Cloud Experiment (TWP-ICE) held in Darwin (12°S, 131°E) in January-February 2006 offered an opportunity to investigate gravity wave generation by convection. The study involved
  – Radars
  – Middle atmosphere dynamics
  – Planetary waves and tides
  – Gravity waves
  – Modelling
Instruments and Coverage

- 50 MHz boundary layer radar (300 m – 6 km)
- 33 MHz meteor radar (80-100 km)
- Bureau of Meteorology polarized weather radar (C-Pol) (500m-18 km)
- High resolution numerical model: 600 km x 600 km domain (Alexander)
C-Pol Observations
23 Jan 2006

Spatial distribution and cloud top heights used to determine relative magnitudes and depth of latent heating.
The VHF Boundary Layer radar detects echoes from both the clear air and hydrometeors. Using the rain echoes it is possible to derive rain rates in the lower troposphere. The BL radar observations can be used to calibrate the C-Pol radar reflectivities.
Rainrates and Heating Rates

Grimsdell et al., 2010
Computed Wave Fluxes – 20 km
Background Atmosphere

- Profiles derived using:
  - Radiosondes
  - UKMO assimilations
  - Aura satellite temperatures
  - Meteor radar winds
Gravity Wave Ray Tracing:
Wave Fluxes at 92 km at 19 UT

Chapman Conference Honolulu March 2011
Meteors occur randomly in space and time.

How accurately can the mean winds and gravity wave parameters be estimated?

\( \Delta \theta, \Delta \varphi \sim \pm 1.5^\circ \)

\( \Delta v \sim \pm 0.7 \text{ m/s} \)
Meteor Observations

Echo rate 92 km

Meteor occurrence and Doppler shift
18 UT 23 Jan
Modelling Meteor Observations of Gravity Waves

- Establish mean wind and gravity wave field with known parameters
- Sample with observed angular and range characteristics of meteor system over a 1 hr time interval
- Let meteors occur randomly in space and time
- Sample using 10, 20, 50, 100 and 200 meteors/hr
- Repeat 500 times to study statistics of retrieved wind and wave parameters.
- See Vincent et al, GRL 2010 for details
Mean Wind Accuracies

Percentage Errors in Mean Wind vs Meteor Rate

- Percentage Error vs Meteor Rate (hr⁻¹)
  - Percentage Error on the y-axis
  - Meteor Rate on the x-axis
  - Data points showing the relationship between percentage error and meteor rate.
Retrieval of Gravity Wave Fluxes: Mean Values

See Vincent et al, GRL, 2010
MLT Winds 92 km

![Graph showing velocity vs. day (UT)]
Total Wind Variance 91-93 km

Meteorology: Stratiform rain on 22\(^{nd}\), active convection 23\(^{rd}\) and weak convection on 24\(^{th}\)
Computed and Measured Wave Variances

![Graph showing computed and measured wave variances over time. The graph plots total horizontal variance (m² s⁻²) against hour (UT). The measured variance is shown with a solid line, and the computed variance is shown with a dashed line. There is a peak in the measured variance around the 18th hour.](image)
Summary and Conclusions

• Study of mesoscale convective event using multiple radars to characterise the latent heat release
• LH results used to seed high-resolution mesoscale model of gravity wave generation
• Temporal variation of wave energies in MLT deduced from meteor radar and model output agree well within limitations of radar uncertainties.
• Source generates high phase speed waves.
• Significant lateral and temporal dispersion of waves in MLT.