Assessing the impact of gravity waves on the tropical middle atmosphere in a General Circulation Model

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Introduction

Outline

• Non-orographic GWs in the MetUM tropics (HadGEM climate 2.5°x3.75° N48L60 – 85km)

• GWs in forecast MetUM (40km 0.5625°x0.375° N320L70 – 80km)

• Vertical resolution (HadGEM climate 1.25°x1.875° N96L85 – 85km) with Summer Placement student: Siân Williams
Non-orographic gravity waves

• **Type:** Warner & McIntyre [2001] 2-part spectrum.
• Wave generation
  • Isotropic source spectra (W, N, E, S - net zero momentum)
  • Opaque lid – zero vertical flux through top layer boundary
  • Global launch amplitude, unsaturated, lower troposphere
• Conservative propagation
  • Mid-frequency approximation to dispersion equation
  • Doppler shift, increased amplitude as density decreases
• Dissipation
  • Erosion of launch spectrum to local saturation spectrum
  • Chop launch spectrum to match back-propagated saturation
  • Prior identification of Chop Cases
  • Require integrated flux at layer top ≤ at layer base.
Parametrized GW Flux Timeseries

Launch factor x 1.36
Equatorial Momentum Budget

10hPa momentum budget

- Resolved
- Param GW
- Vert Adv

Control
S:Ozone
S:GW + Ozone

U (m/s)

Accel (m/s/day)

QBO Period (normalised)

Bushell et al. (2010) JGR
Issue: resolved vs. sub-grid?

- Parametrized (subgrid) gravity waves contribution HadGEM2-A appears to dominate resolved waves
  - Strong sensitivity of QBO to GW launch amplitude
  - Stronger than Scaife et al. (2000)
  - Damping effects of semi-implicit off-centring in time
  - Vertical resolution seems enough to propagate Kelvin waves

- Are subgrid waves doing too much?
  - Resolved wave feedback interactions with tropical convection
Mean T wave amplitude

HIRDLS Observations
Yan et al. (2010) JGR

MetUM Model
Shutts & Vosper (2011) QJRMS
Wave spectra in MetUM forecast model

Shutts & Vosper (2011) QJRMS
Stratosphere vertical levels

60 LEVELS with TOP at 84.1 km

70 LEVELS with TOP at 80.0 km

85 LEVELS with TOP at 85.0 km

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Spectral Analysis: altitude-time cross sections for Kelvin wave T variances

- Integration carried out over areas within the wavenumber-frequency domain to obtain temperature variances
- Same criteria for wave bands used as in Ern et al. (2008):
Kelvin Wave T variances – total wave band

(a)

(dhskc L70 T-Variance)

(b)

(dhskd L65 T-Variance)
Kelvin wave T variances – Slow vs. Fast wave band
L85 vs L70 Equatorial U-wind

(a) L85 Equatorial Zonal Wind on Log(P) Levels

(b) L85 Deseasonalised Equatorial Zonal Wind

(c) L85 Mean Seasonal Cycle of Equatorial Zonal Wind

(a) L70 Equatorial Zonal Wind on Log(P) Levels

(b) L70 Deseasonalised Equatorial Zonal Wind

(c) L70 Mean Seasonal Cycle of Equatorial Zonal Wind
Future Activity & Interests

- Exploit NWP/Climate MetUM “seamlessness”
  - Explore GW resolved behaviour in high resolution models
  - Use results / insight to develop subgrid parametrizations for lower resolution models
- How best to use observed global satellite GW data at potentially-resolvable scales for NWP models
- Install & test gravity wave generation by convection
  - Song & Chun (2005) JAS, other ESM parametrizations …
- Midlatitude vs. Tropics (balance of interests?!)
Questions and answers
References


  • http://www.agu.org/journals/jd/jd1010/2008JD011511/

Vertical Levels

60 LEVELS with TOP at 84.1 km

70 LEVELS with TOP at 80.0 km

85 LEVELS with TOP at 85.0 km

Hybrid Z (km)