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

AGU Chapman Conference on Atmospheric Gravity Waves

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Introduction

Outline

- Non-orographic GWs in the MetUM tropics (HadGEM climate 2.5^{o}x3.75^{o} N48L60 – 85km)
- GWs in forecast MetUM (40km 0.5625^{o}x0.375^{o} N320L70 – 80km)
- Vertical resolution (HadGEM climate 1.25^{o}x1.875^{o} N96L85 – 85km) with Summer Placement student : Siân Williams

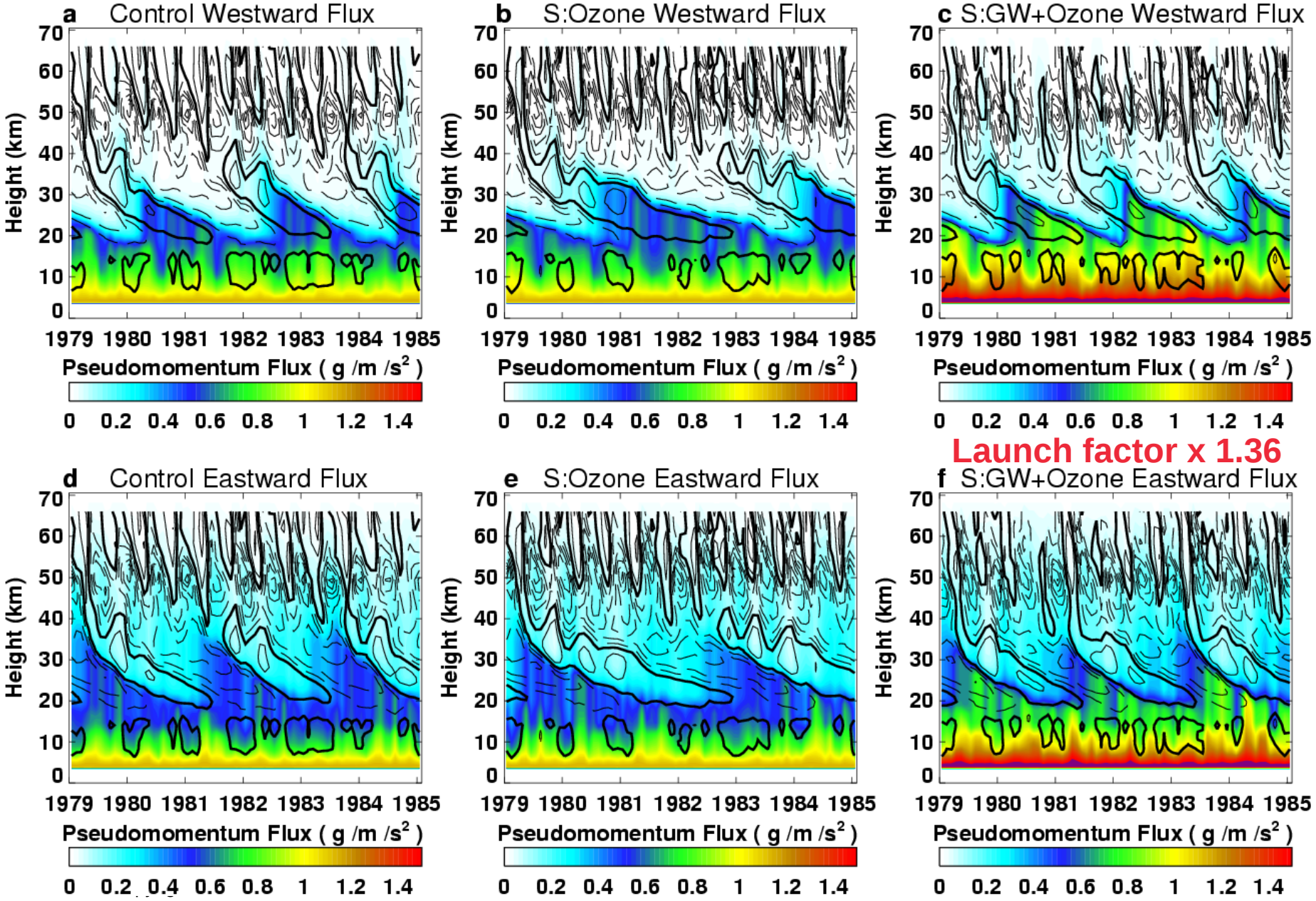
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Non-orographic gravity waves

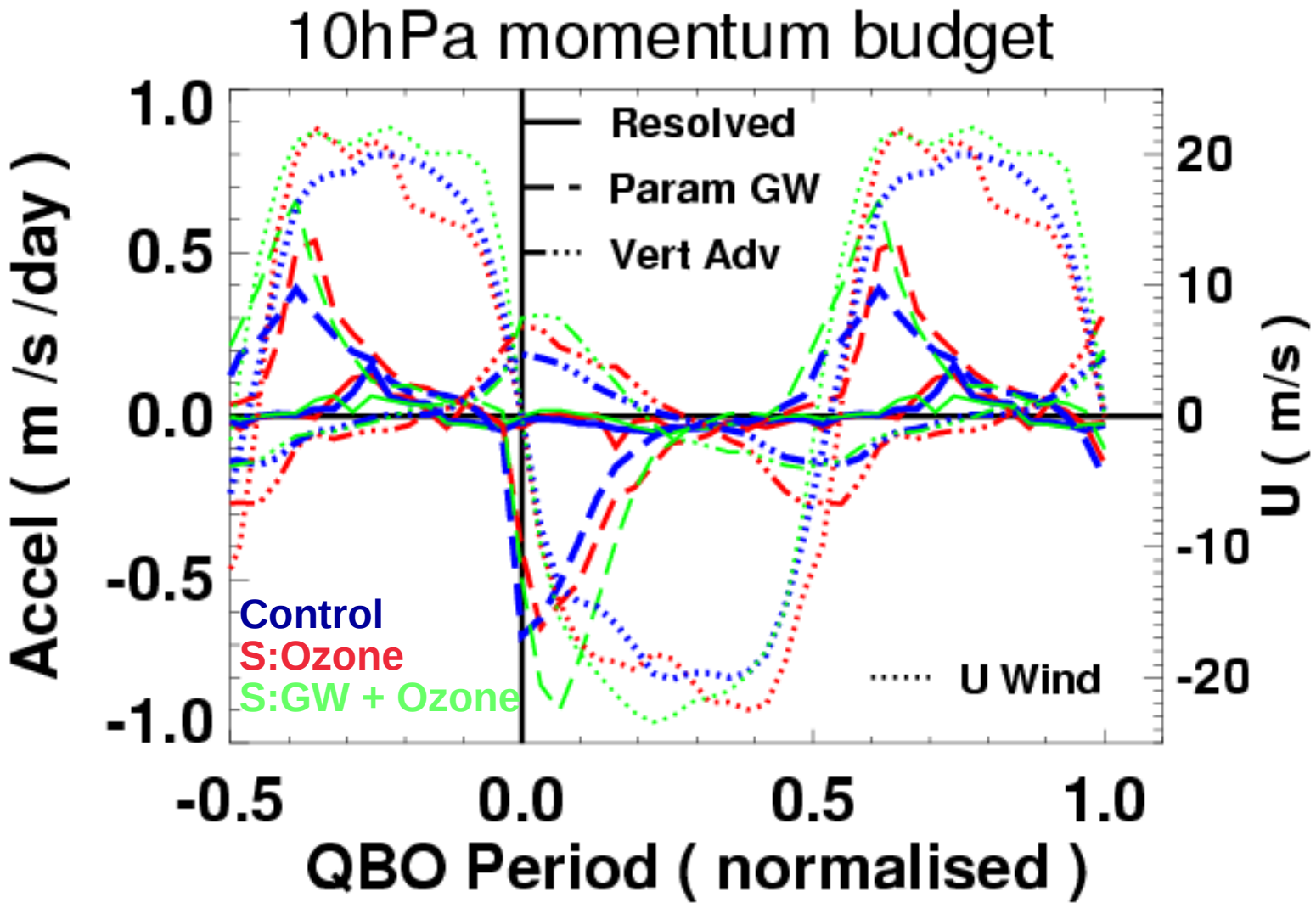
- **Type:** Warner & McIntyre [2001] 2-part spectrum.
- Wave generation
  - Isotropic source spectra (W, N, E, S - net zero momentum)
  - Opaque lid – zero vertical flux through top layer boundary
  - Global launch amplitude, unsaturated, lower troposphere
- Conservative propagation
  - Mid-frequency 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.

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Parametrized GW Flux Timeseries



Equatorial Momentum Budget



Bushell et al. (2010) JGR

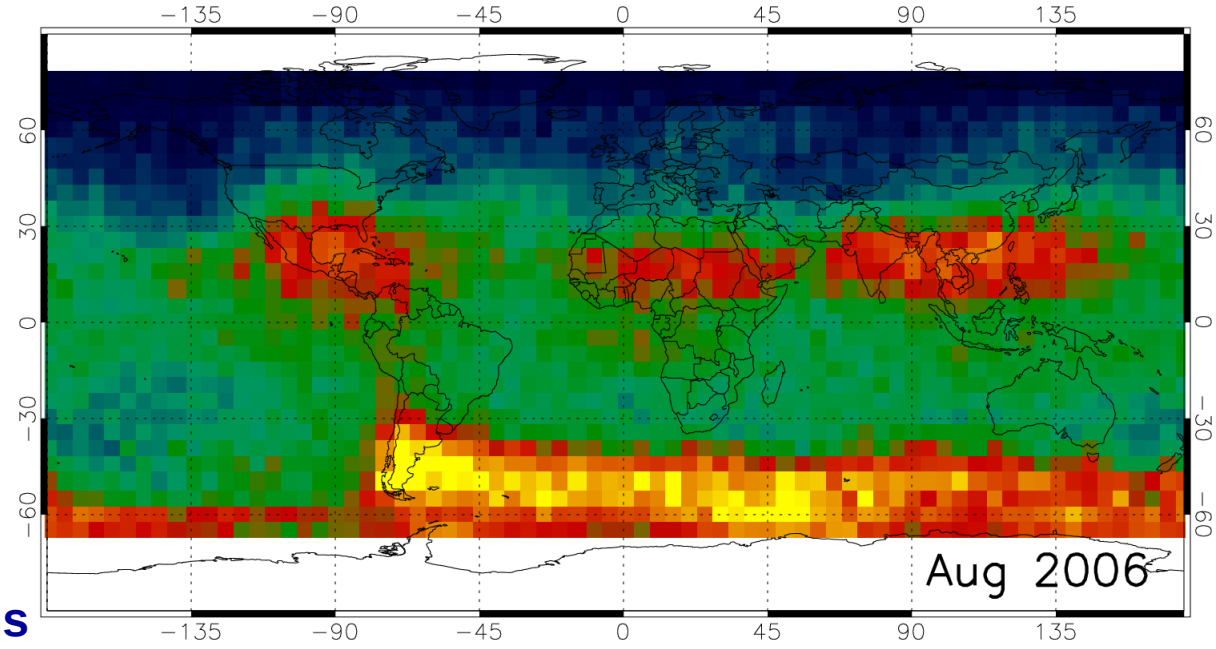
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Issue : resolved vs. sub-grid?

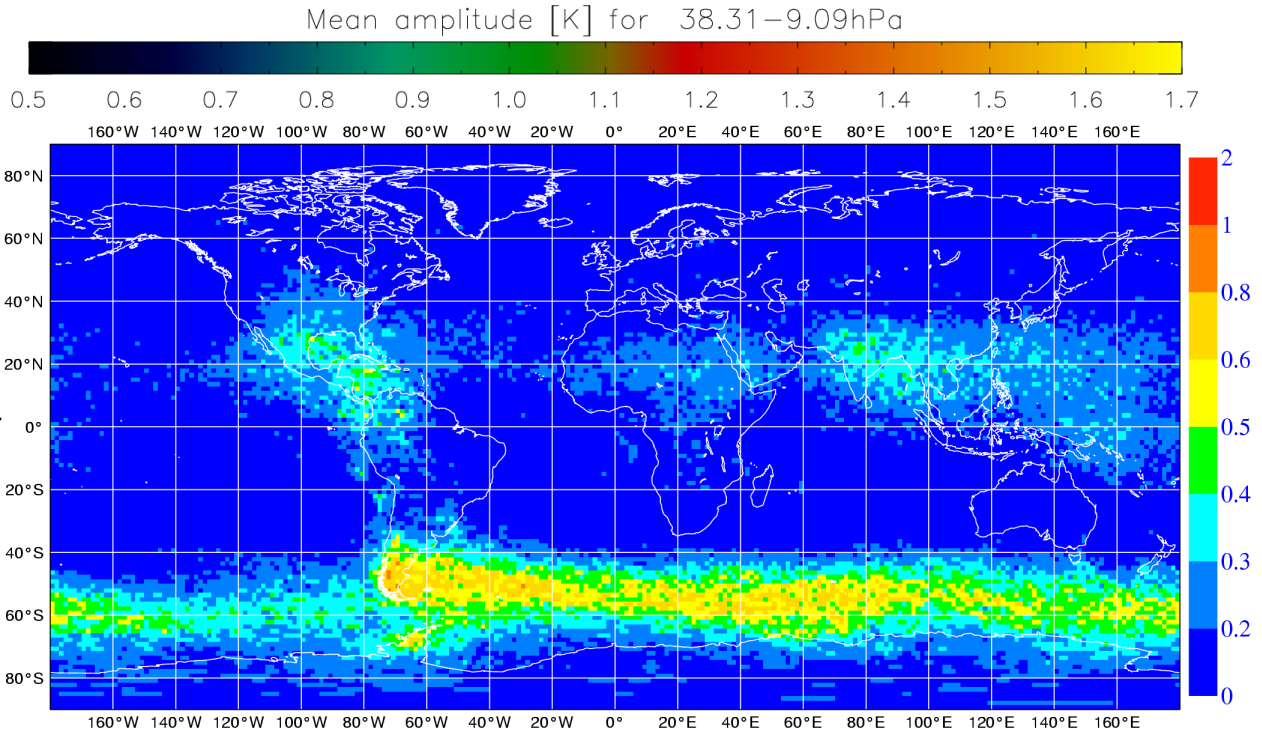
- Parametrized (subgrid) gravity waves contribution HadGEM2-A appears to dominate resolved waves
  - Strong sensitivity of QBO to GW launch amplitude
  - Stronger than Scaife et al.(2000)
  - Damping effects of semi-implicit off-centring in time
  - Vertical resolution seems enough to propagate Kelvin waves
- Are subgrid waves doing too much?
  - Resolved wave feedback interactions with tropical convection

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Mean T wave amplitude

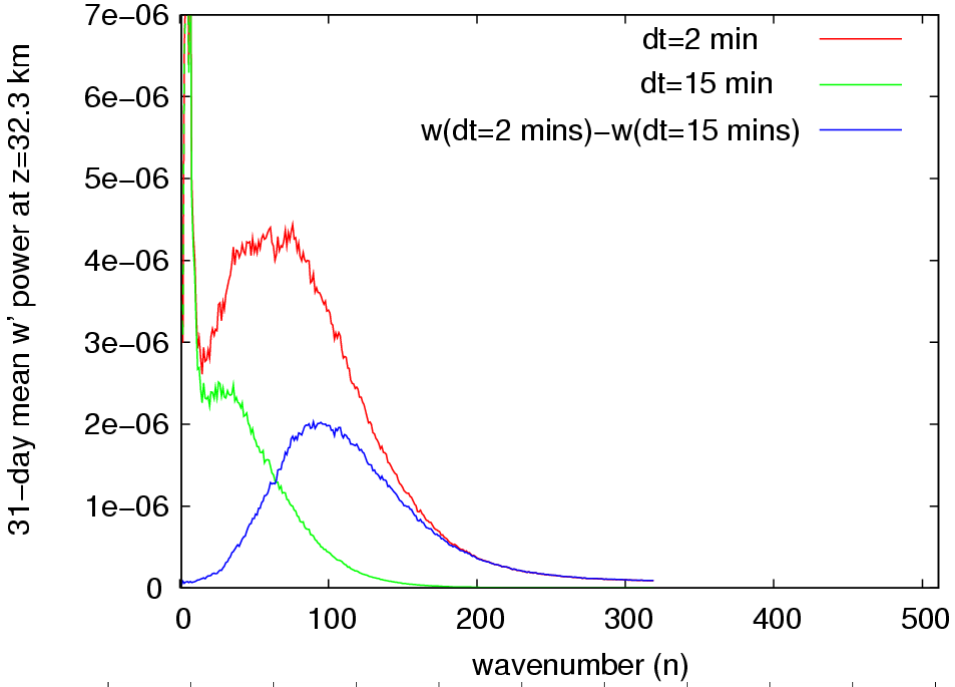


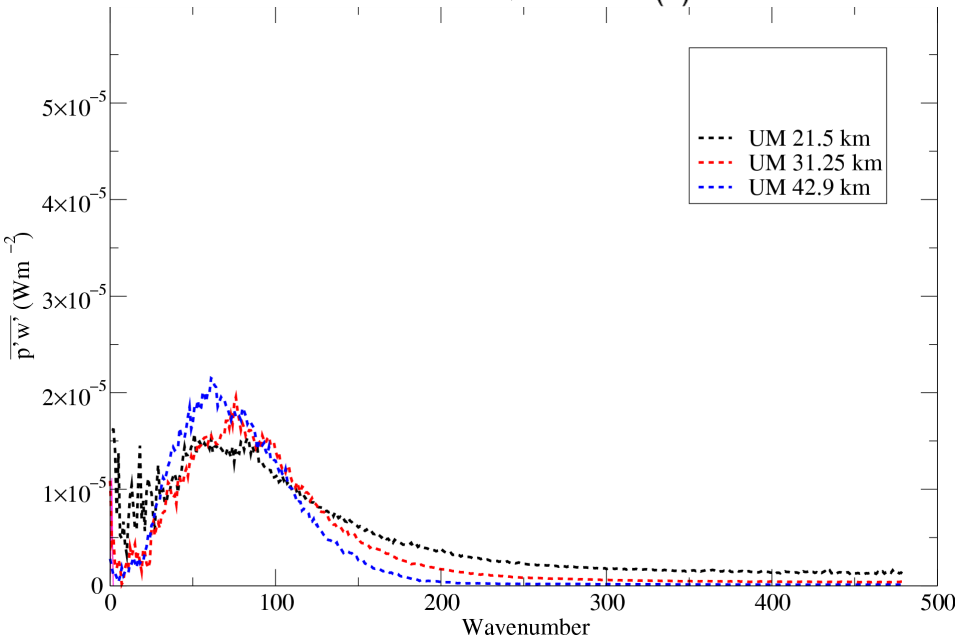
HIRDLS Observations
Yan et al. (2010) JGR



MetUM Model
Shutts & Vosper (2011) QJRMS

Wave spectra in MetUM forecast model

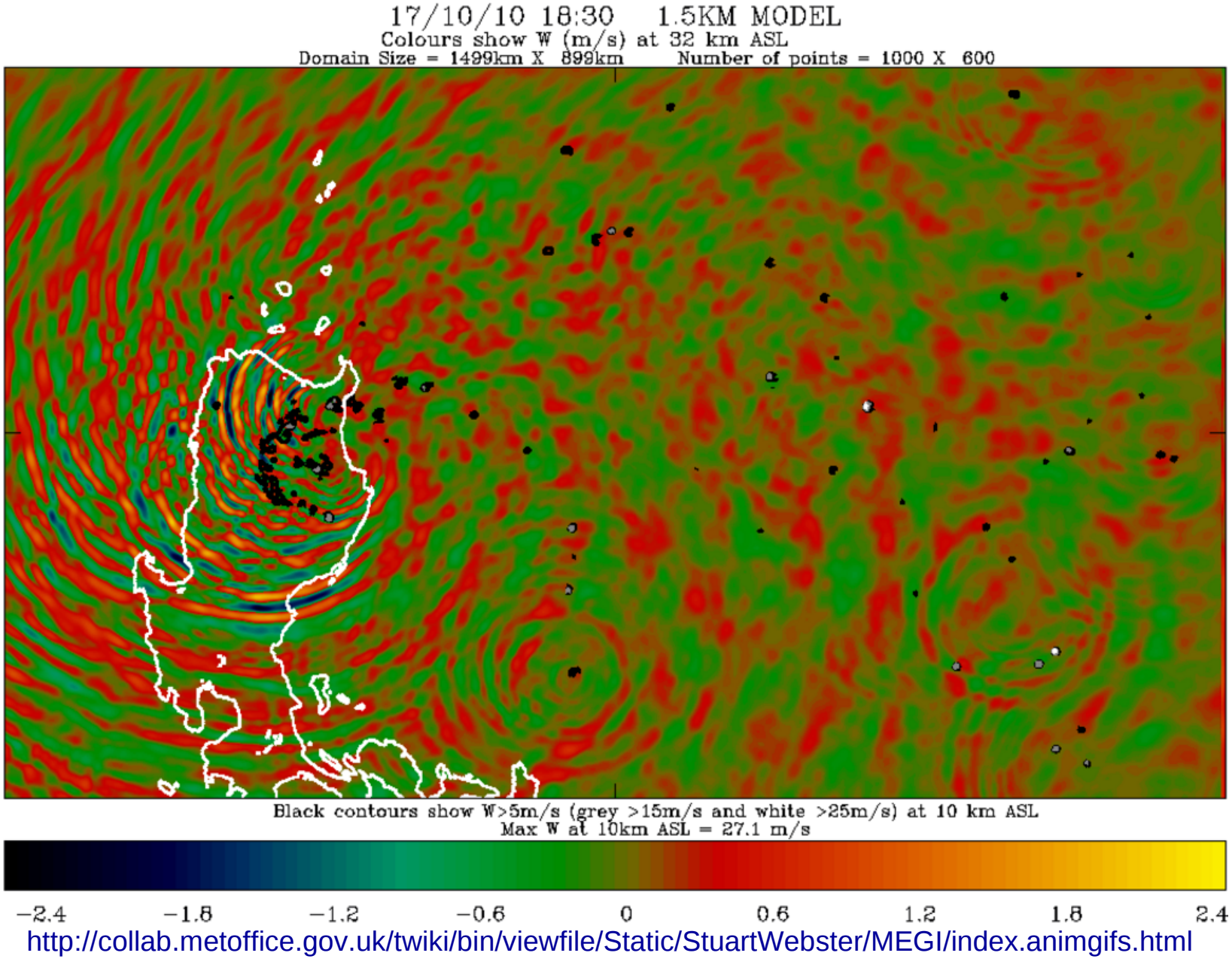




Shutts & Vosper (2011) QJRMS

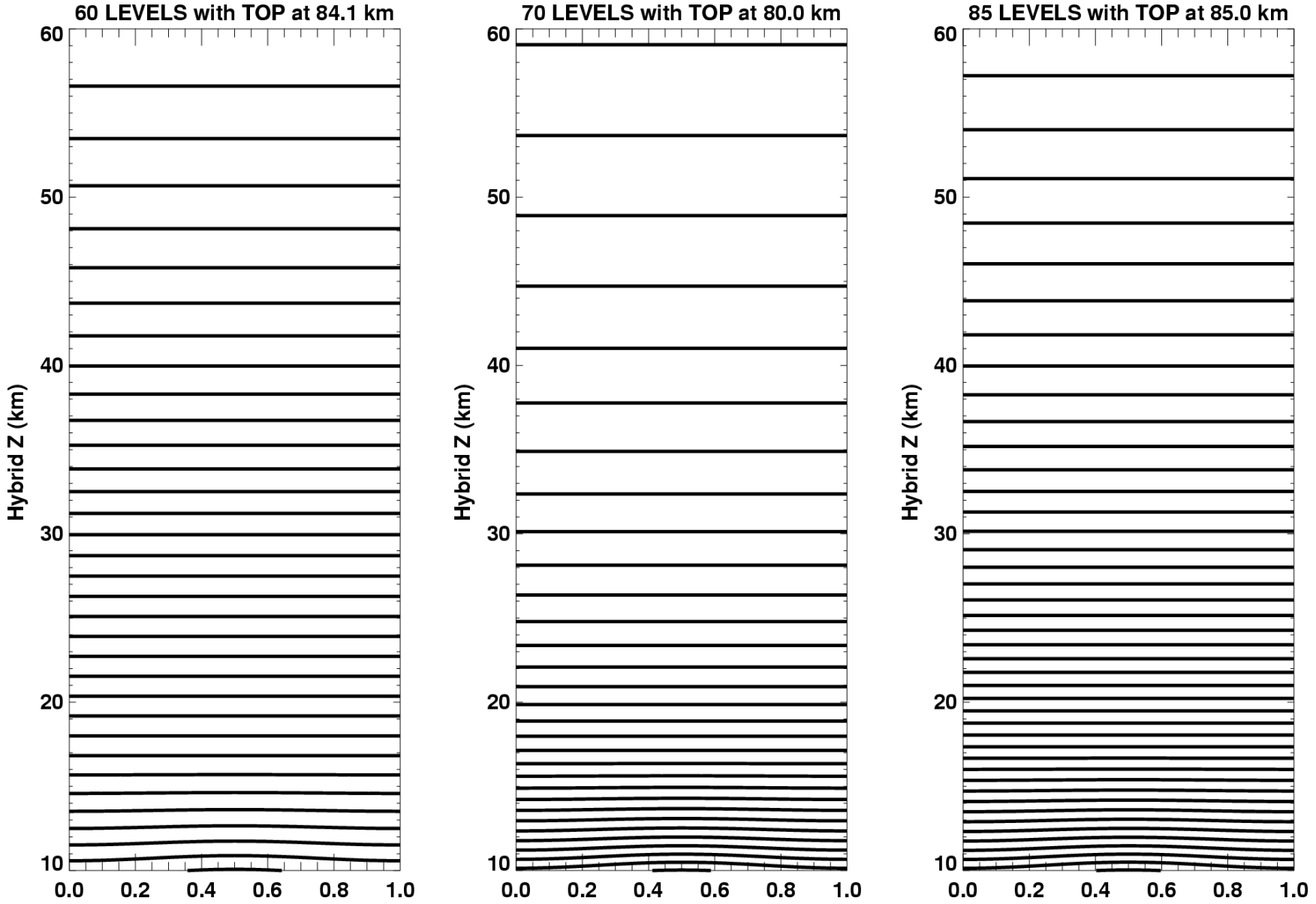
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Supertyphoon MEGI - Philippines



http://collab.metoffice.gov.uk/twiki/bin/viewfile/Static/StuartWebster/MEGI/index.animgifs.html

Stratosphere vertical levels

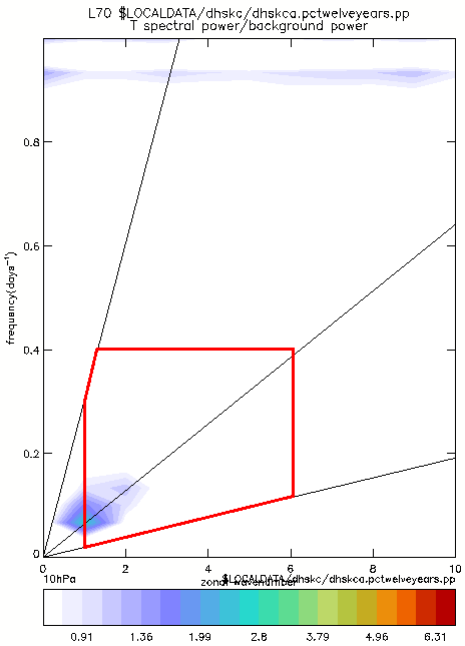


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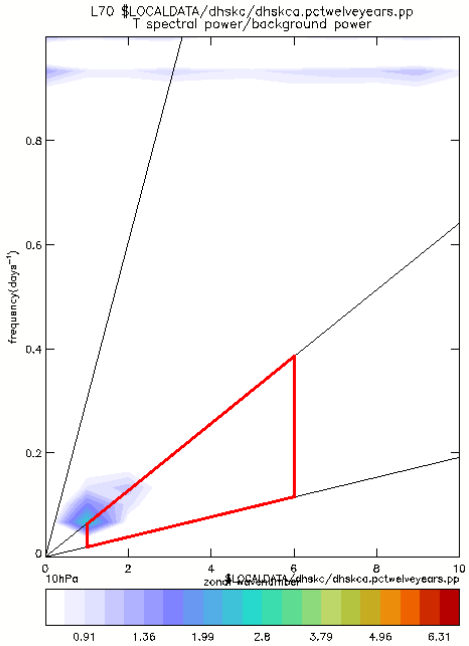
Spectral Analysis: altitude-time cross sections for Kelvin wave T variances

- 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):

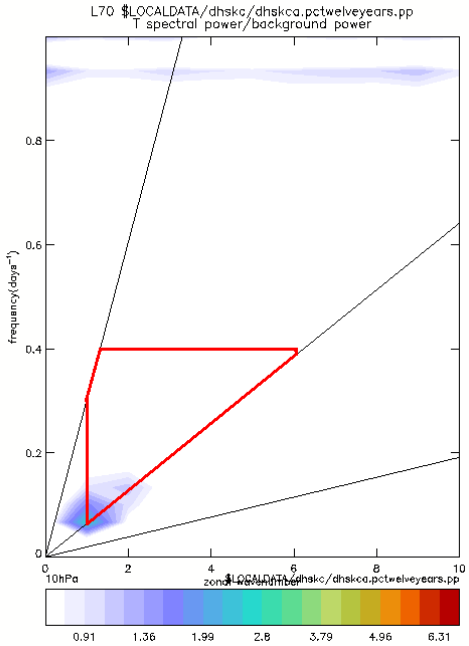
Total



Slow



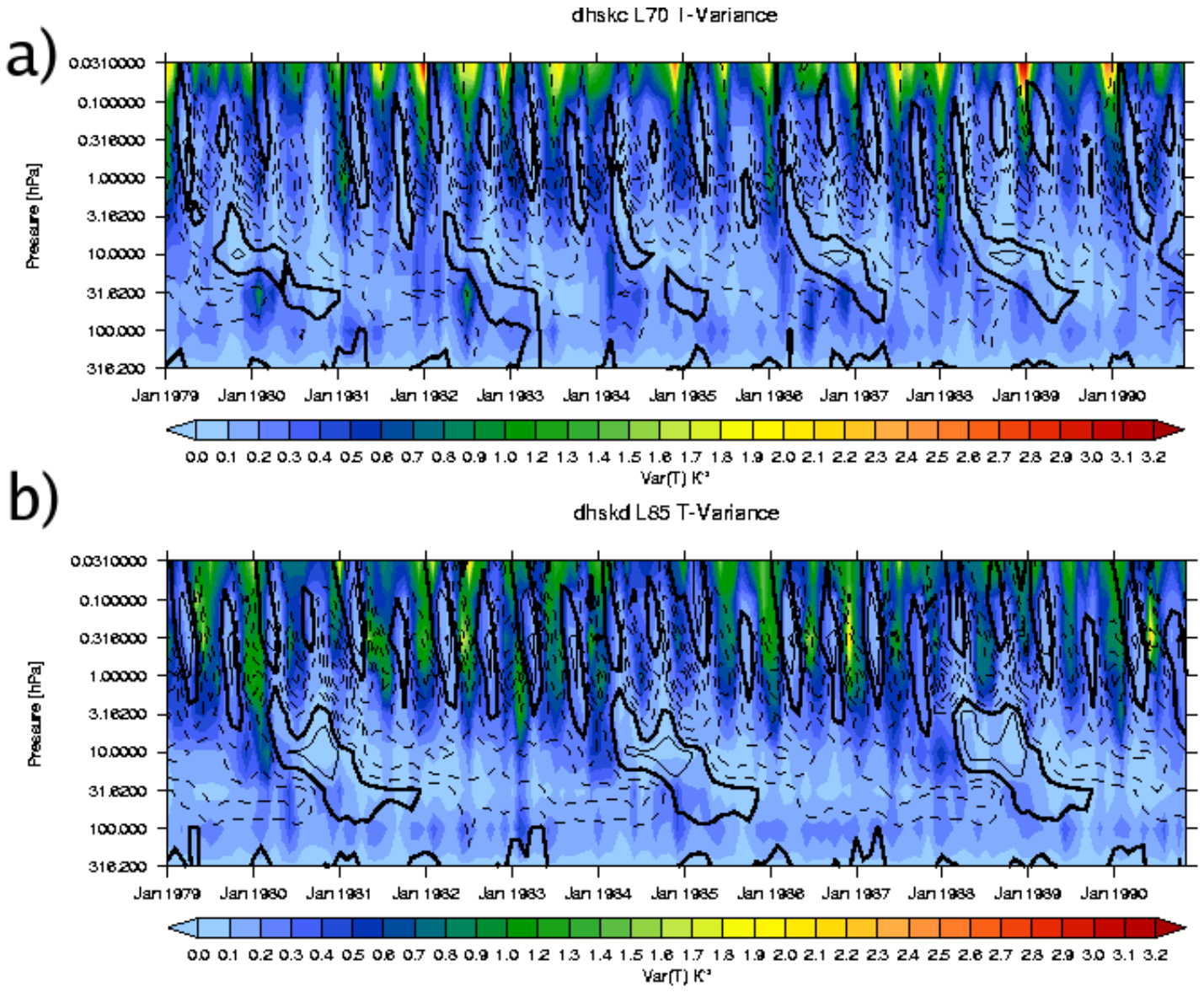
Fast



Siân Williams

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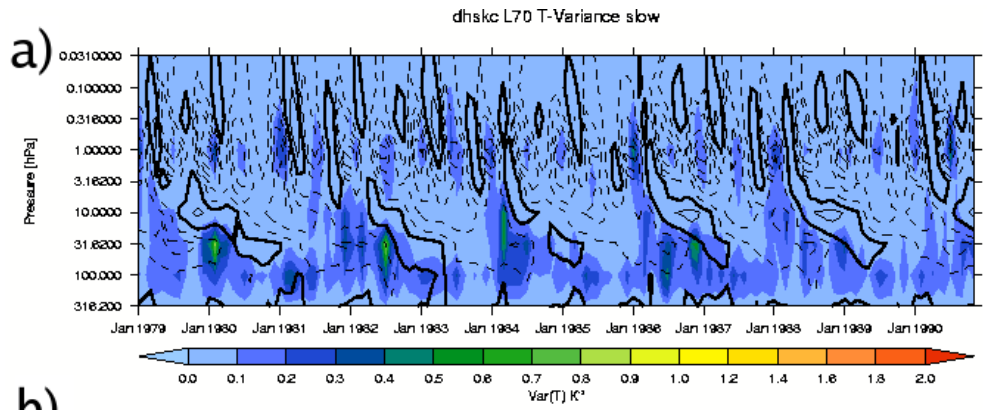
Kelvin Wave T variances – total wave band

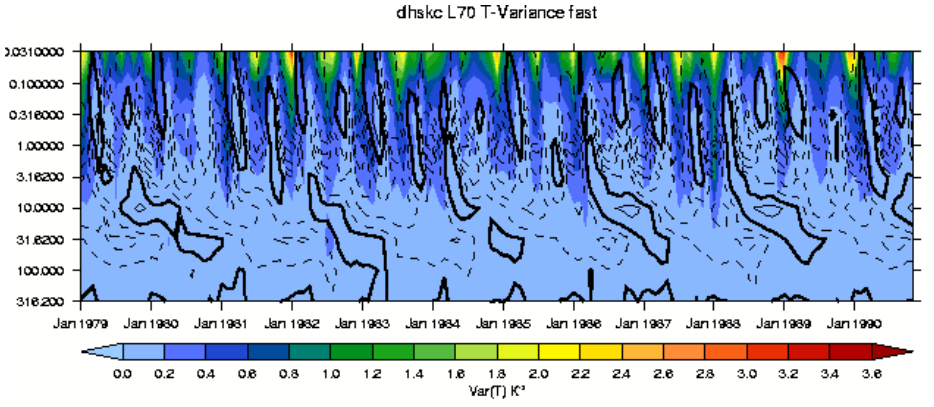


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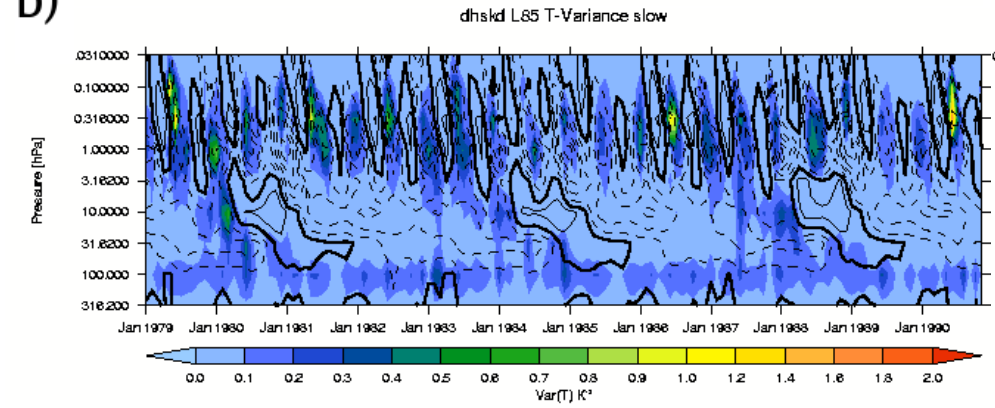
Kelvin wave T variances – Slow vs. Fast wave band

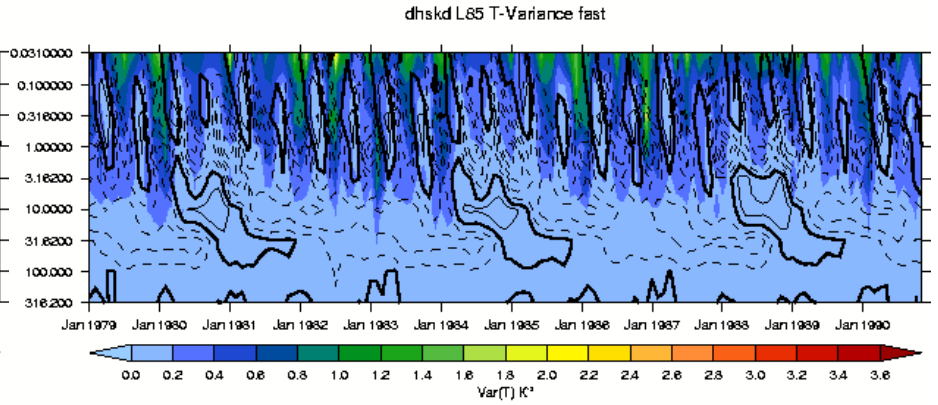
a)





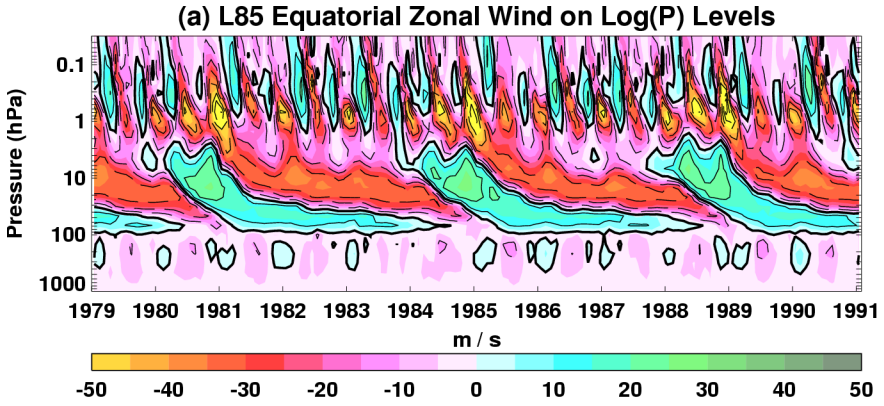
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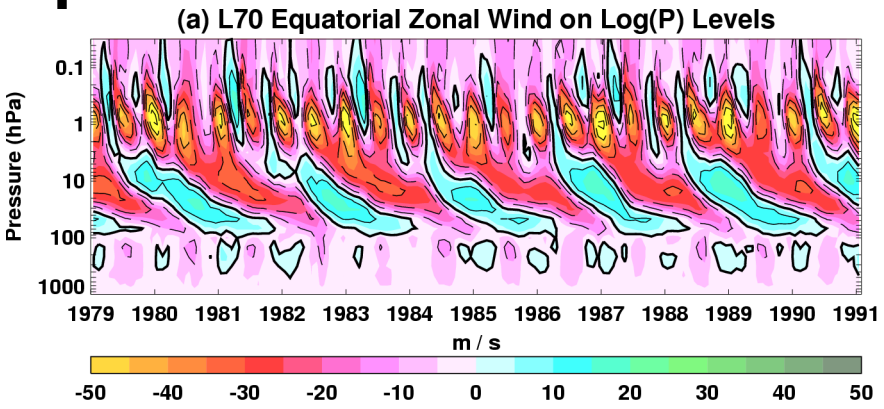


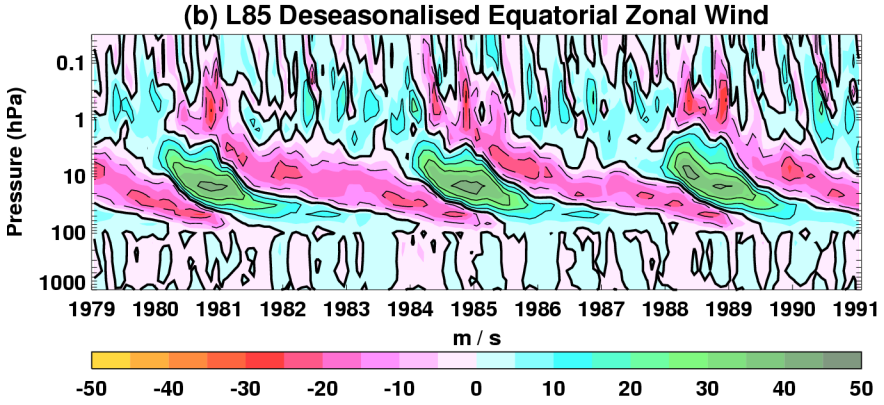


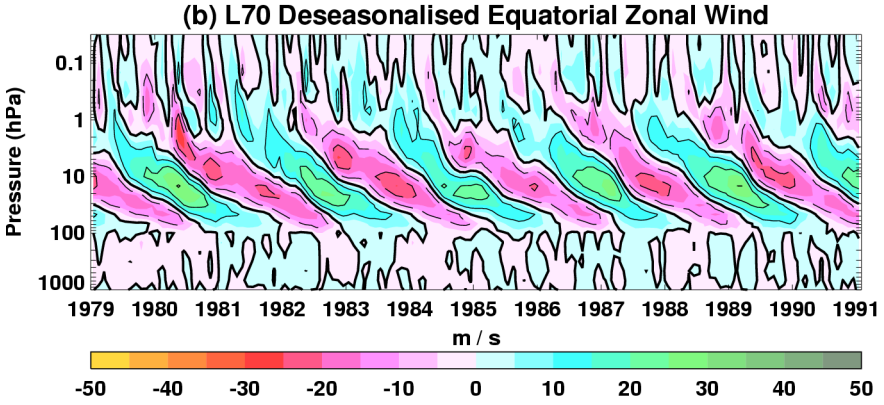
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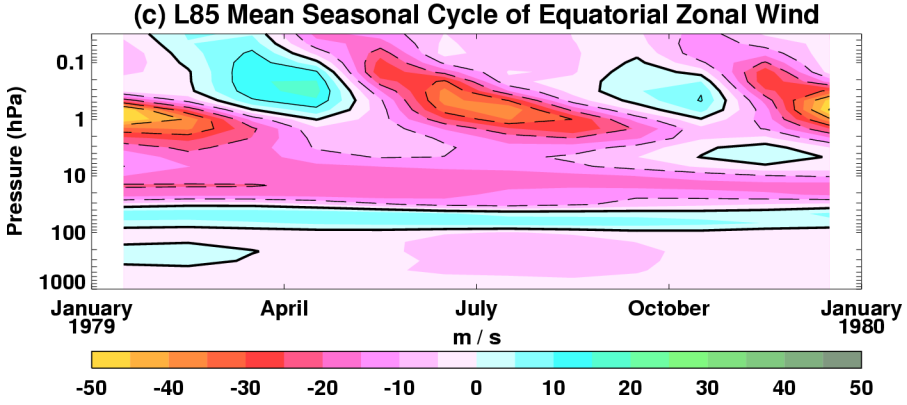
L85 vs L70 Equatorial U-wind

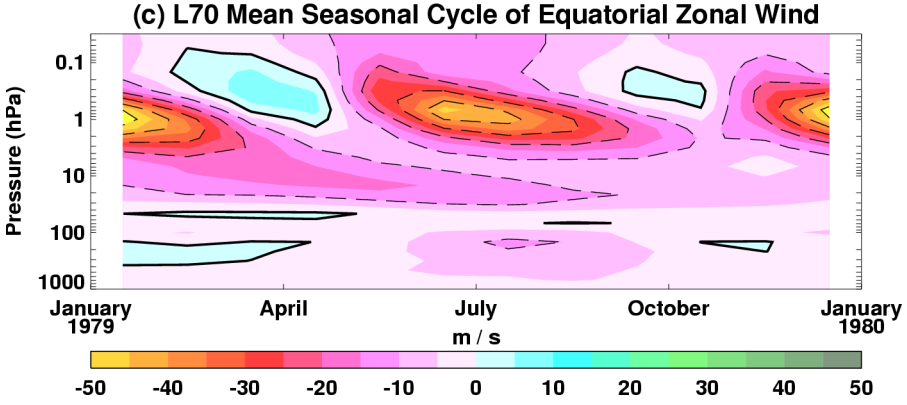












Future Activity & Interests

- 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?!)
- Propagation into upper mesosphere / thermosphere?

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Questions and answers

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References

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Vertical Levels

