Exploration of Atmospheric Oscillations with a hierarchy of models: A focus on scale and geographic location

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Key Questions:

1. What is the smallest scale at which the BAM signal appears?
2. Do different geographic regions of the Southern Hemisphere contribute more than others to the BAM?

Motivation

Recent research reveals unexpected dynamical variability in the extratropical atmosphere. Work by Thompson & Woodworth (2013) and Thompson & Barnes (2014) has demonstrated the existence of a baroclinic annular mode (BAM), a 20-30 day oscillation of the zonally averaged eddy-kinetic energy (EKE).

Power spectra for EKE zonally averaged:
Peak within frequency between 20-30 days

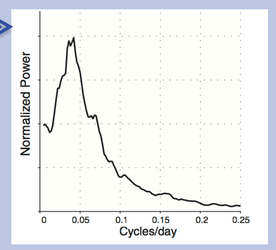
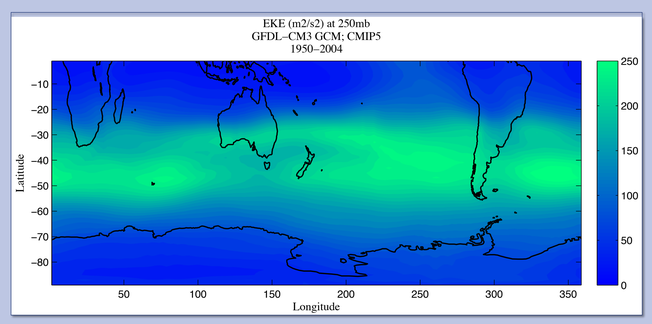


Figure from Thompson and Barnes (2014)

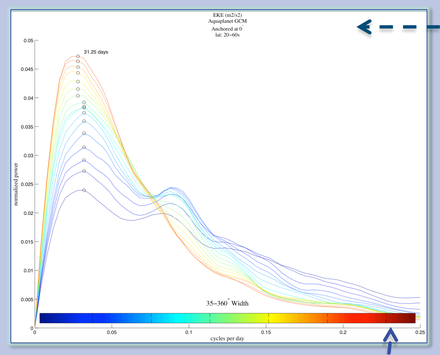
This research seeks to find the smallest range in the zonal domain where the BAM signal persists in the power spectra. And, determine how the EKE power spectra differs throughout the Southern Hemisphere.



Results

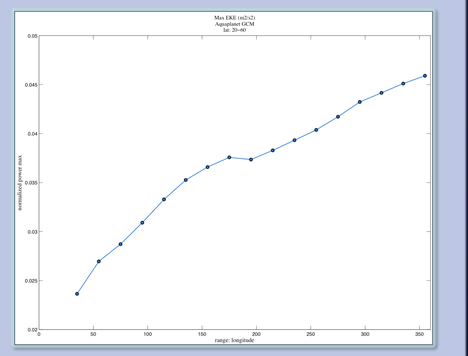
1. Scale of BAM

Aquaplanet GCM



Largest peak in power spectra 0-360°
Significance of peak verified in Thompson & Barnes (2014)

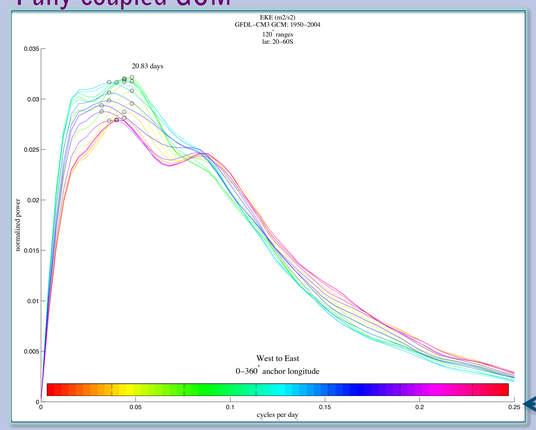
EKE power spectra of varying widths of the zonal domain
Color indicates gradual change of width
Widths starting at 35°



Summary plot of Eddy-Kinetic Energy power spectra:
Points correspond to max EKE of spectra at varying widths

2. Distribution of BAM

Fully-coupled GCM



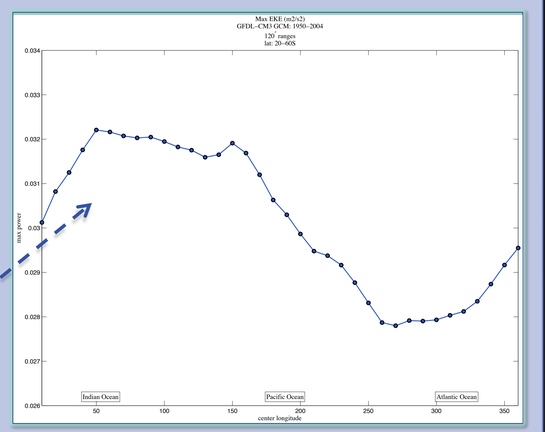
EKE power spectra varying locations
All spectral lines 120° width in zonal domain

EKE power spectra as function of location in Southern Hemisphere

Color-bar indicates gradual change in anchor longitude (west edge of zonal domain) for each 120° EKE average

Summary plot of Eddy-Kinetic Energy power spectra:
Points correspond to max EKE of 120° zonal width of spectra in different regions of the Southern Hemisphere

Indian Ocean region and West Pacific Ocean region higher max EKE; Atlantic Ocean region lower max EKE



Concluding Thoughts

1. The BAM signal is strongest when averaged over the entire zonal domain (0-360°), but continues to persist with smaller zonal domains
   - 0-35° for the EKE power spectra in the GFDL Aquaplanet
   - 0-120° for the EKE power spectra in the GFDL-CM3
2. The BAM signal is not evenly distributed throughout the Southern Hemisphere.
   - EKE power spectra indicate that the Indian Ocean and West Pacific Ocean regions have higher power oscillations

Future Questions

- Statistical significance of spectral peaks at smaller range of longitudes
- Frequency/period of EKE oscillations as function of geographic location
- Comparison with observations
- Application to precipitation at regional scales

Methods

- Spectral Analysis of Eddy-Kinetic Energy; latitudes 20-60S
- GFDL gray-radiation aquaplanet GCM
- GFDL-CM3 fully-coupled GCM

Acknowledgements

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