



TROPICAL CYCLONE GENESIS FROM THE PERSPECTIVE OF THE LORENZ ENERGY CYCLE

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THE LORENZ ENERGY CYCLE

- The interaction between mean and eddy flow can be interpreted as changes among kinetic energy and potential energy. The Lorenz Energy Cycle is categorized into four different types of energy:
 - Zonal Available Potential Energy: Measure of the latitudinal variation of temperature. Generated by uneven heating of the globe.
 - Zonal Kinetic Energy: Measure of the latitudinal variation of parcel motion. Generated via momentum fluxes or large scale vertical overturnings.
 - Eddy Available Potential Energy: Measure of the longitudinal variance of temperature. Generated by meridional heat transport by eddies.
 - Eddy Kinetic Energy: Measure of the longitudinal variance of parcel motion. Generated via momentum fluxes or thermally direct eddy circulations.

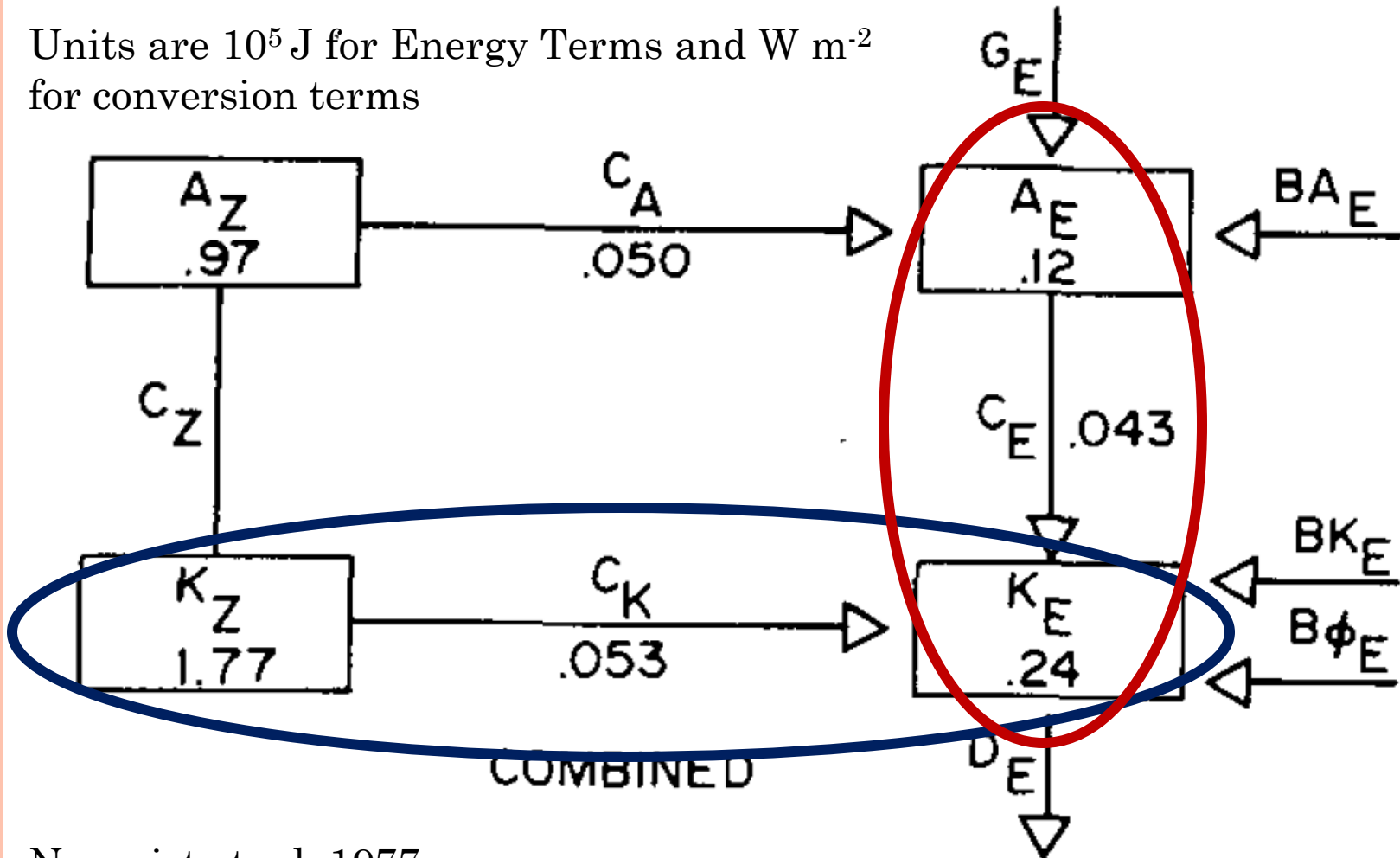


LORENZ ENERGY CYCLE CASCADES

Barotropic Conversion Term $\propto -u'v' \frac{\partial[u]}{\partial y}$

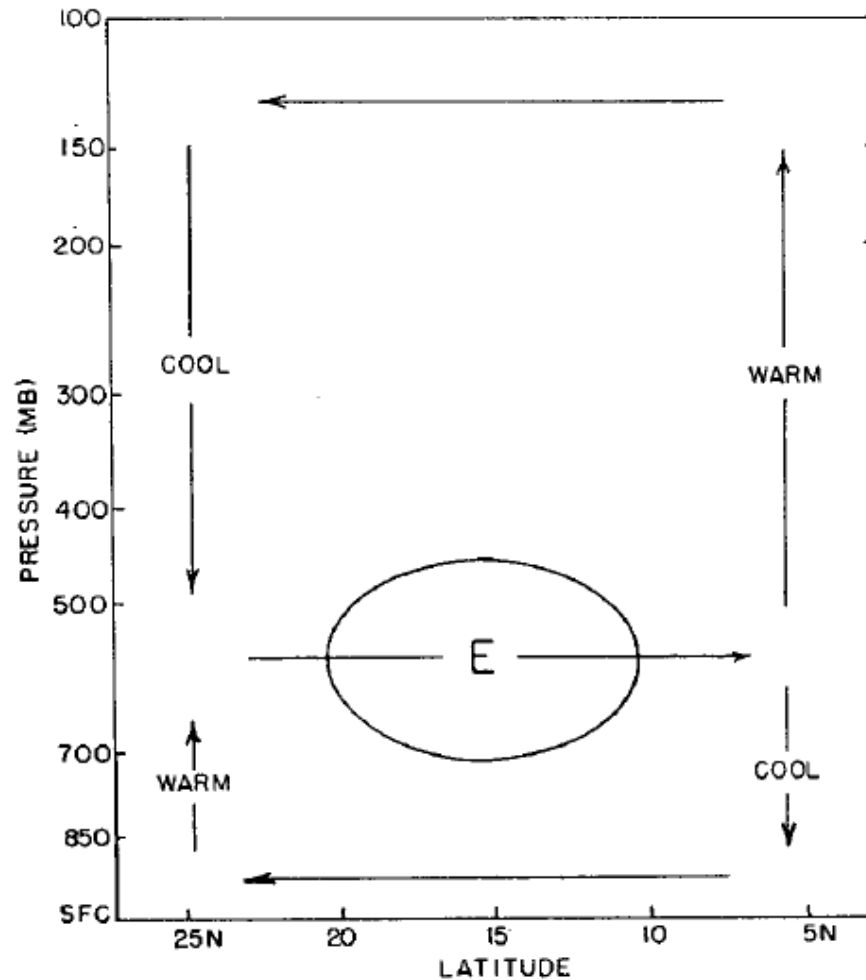
Baroclinic Conversion Term $\propto -\omega'T'$

Units are 10^5 J for Energy Terms and W m^{-2} for conversion terms



ENERGETICS OF WAVE GENERATION

- Moisture and temperature gradient across Africa provides zonal APE necessary for formation of African Easterly Jet (AEJ)
- Jet maintained via thermally direct, ageostrophic circulation
- Waves remove zonal APE by transfer by conversion of eddy APE via meridional moisture and temperature fluxes.
- Eddy kinetic energy generated via baroclinic processes from eddy APE and through barotropic processes from zonal KE.
- Latter process removes zonal kinetic energy from jet.

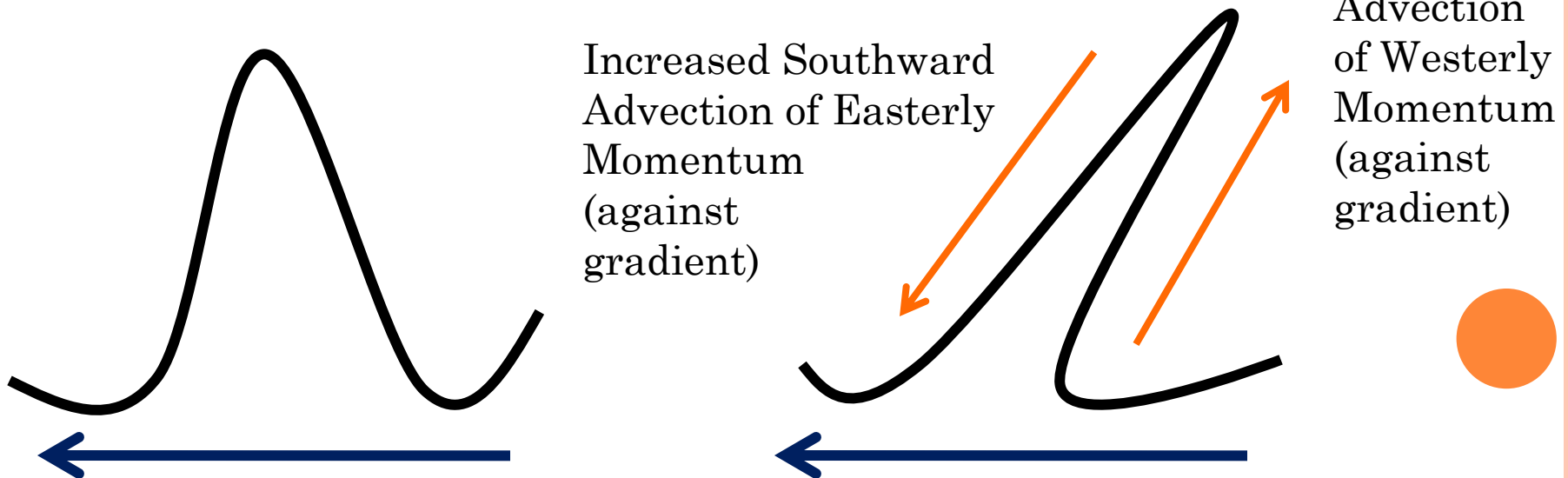


Burpee 1972



WAVE BEHAVIOR: LAND VERSUS WATER

- According to Norquist et. al. 1977, a regime change occurs for wave over water
- Over land, wave predominantly formation, growth, and maintenance by baroclinic processes due to meridional temperature gradient
- Over water maintenance due to barotropic processes due to stronger horizontal shear and more pronounced wave tilt



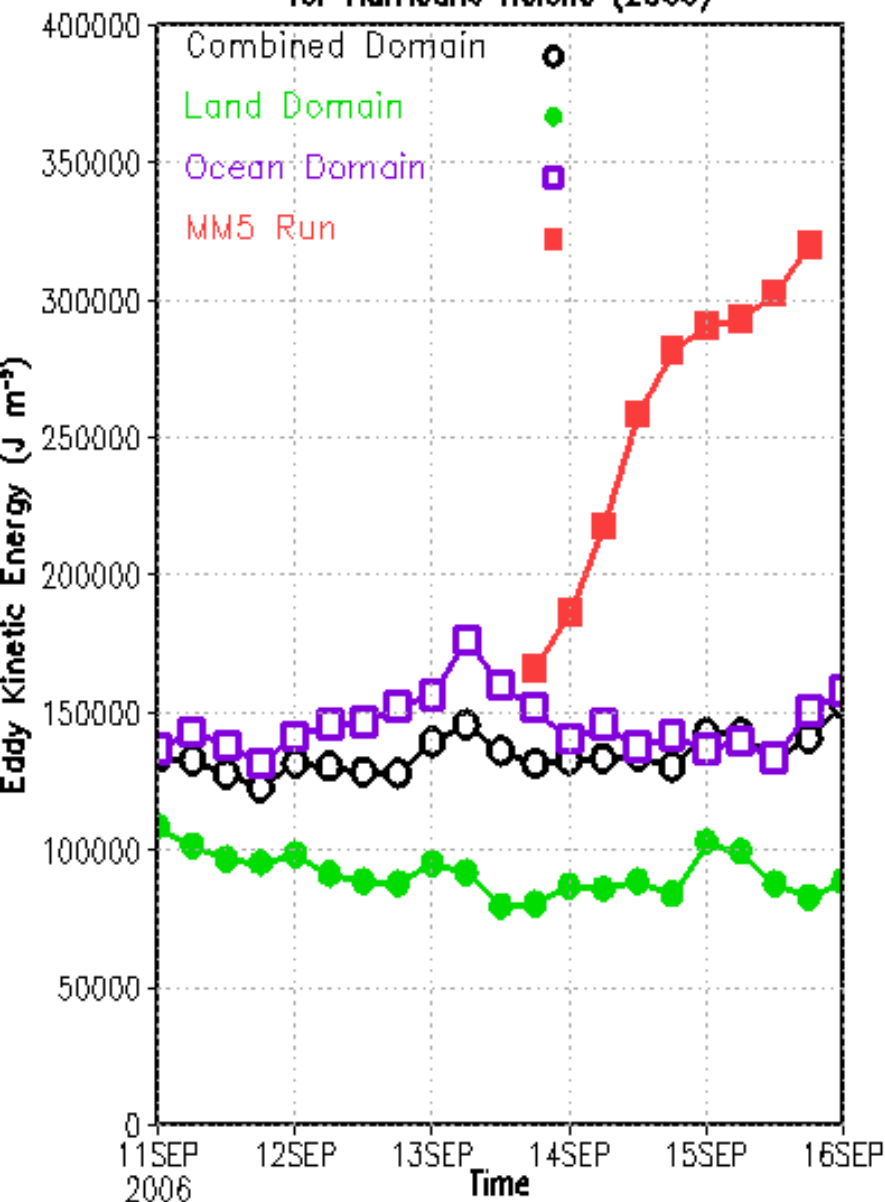
METHODOLOGY

- Calculations computed as given in Norquist et. al. 1977
- Two cases were examined in this study:
 - Hurricane Helene (00Z 9/10/06 – 00Z 9/16/06)
 - NAMMA Wave #3 (00Z 8/23/06 – 00Z 8/29/06)
- Study separated into four parts for each case:
 1. Over domain from 1°S to 26°N and 50°W to 30°E computed over 5 days with 1° x 1° NCEP Global Tropospheric Analysis used for calculations of all terms (“combined domain”).
 2. Over domain from 1°S to 26°N and 15°W to 30°E computed over 5 days with 1° x 1° NCEP Global Tropospheric Analysis used for calculations of all terms (“coarse land domain”).
 3. Over domain from 1°S to 26°N and 50°W to 15°W computed over 5 days with 1° x 1° NCEP Global Tropospheric Analysis used for calculations of all terms (“coarse ocean domain”).
 4. Over domain from contained within domain of part two with 3 km resolution MM5 data using explicit convection (“MM5 Run”).

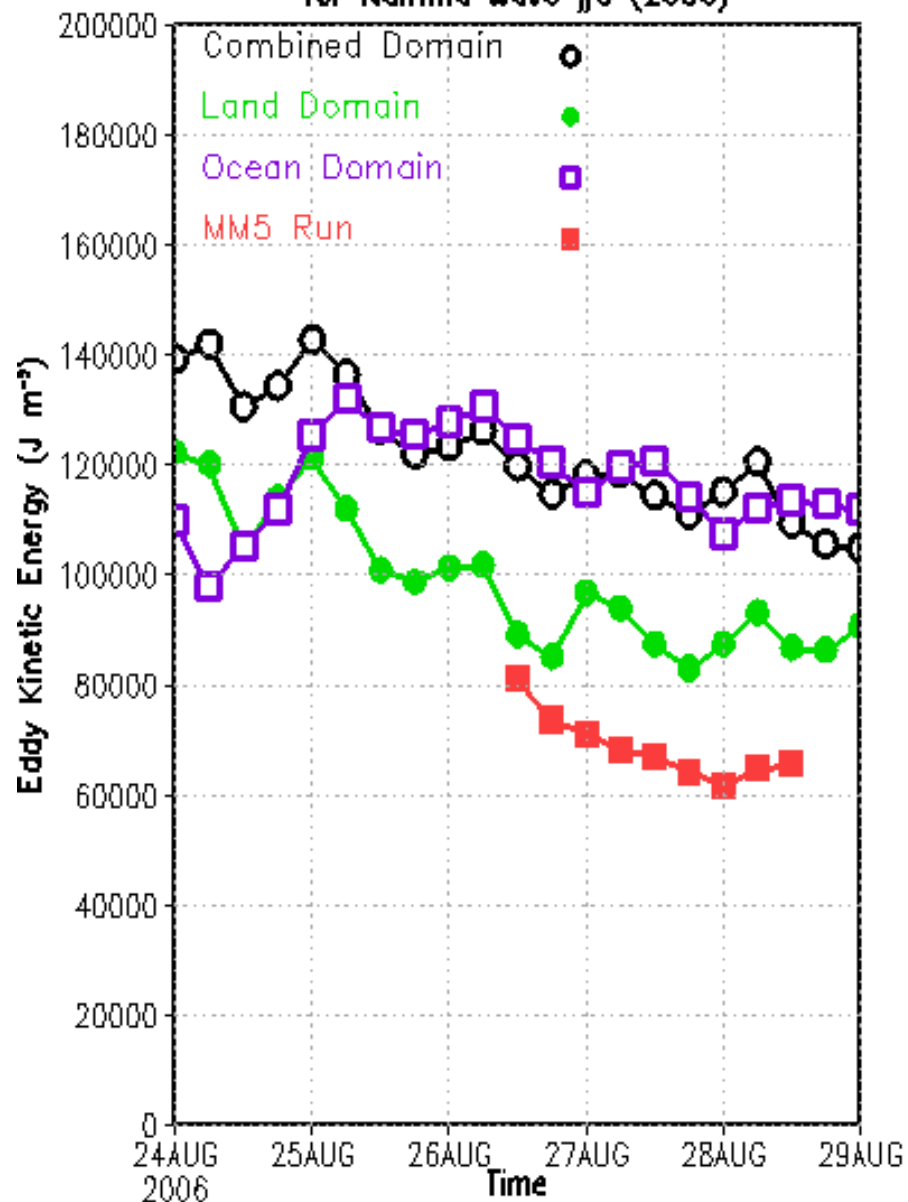


EDDY KINETIC ENERGY

Domain Integrated Eddy Kinetic Energy
for Hurricane Helene (2006)

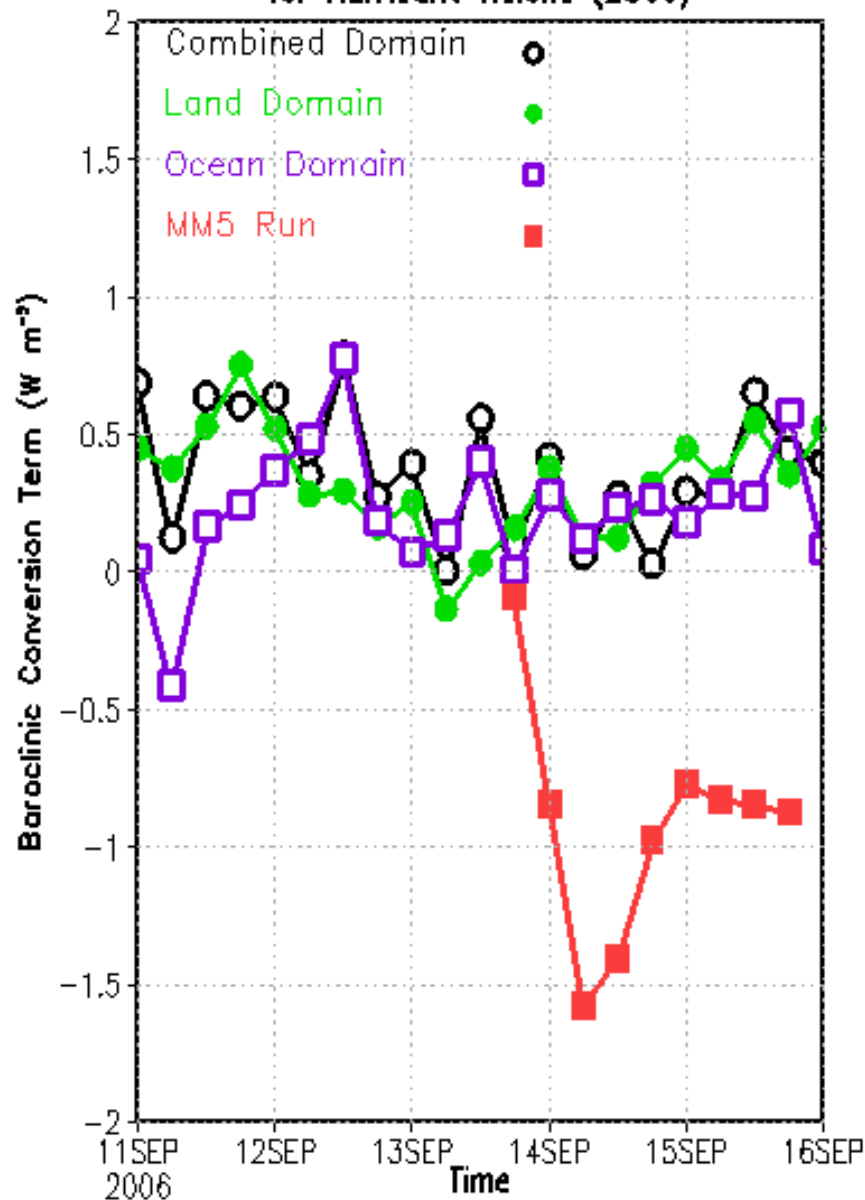


Domain Integrated Eddy Kinetic Energy
for Namma Wave #3 (2006)

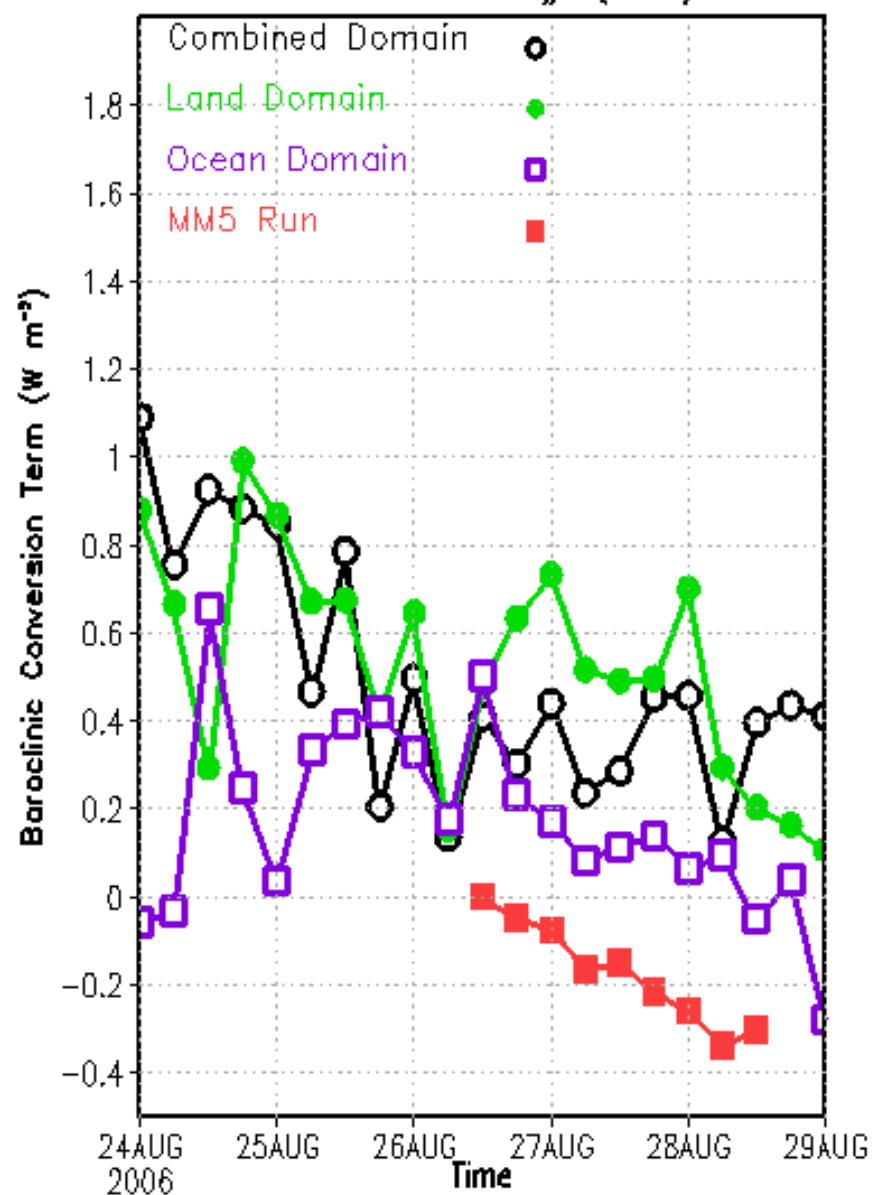


BAROCLINIC CONVERSION TERM

Domain Integrated Baroclinic Conversion Term
for Hurricane Helene (2006)

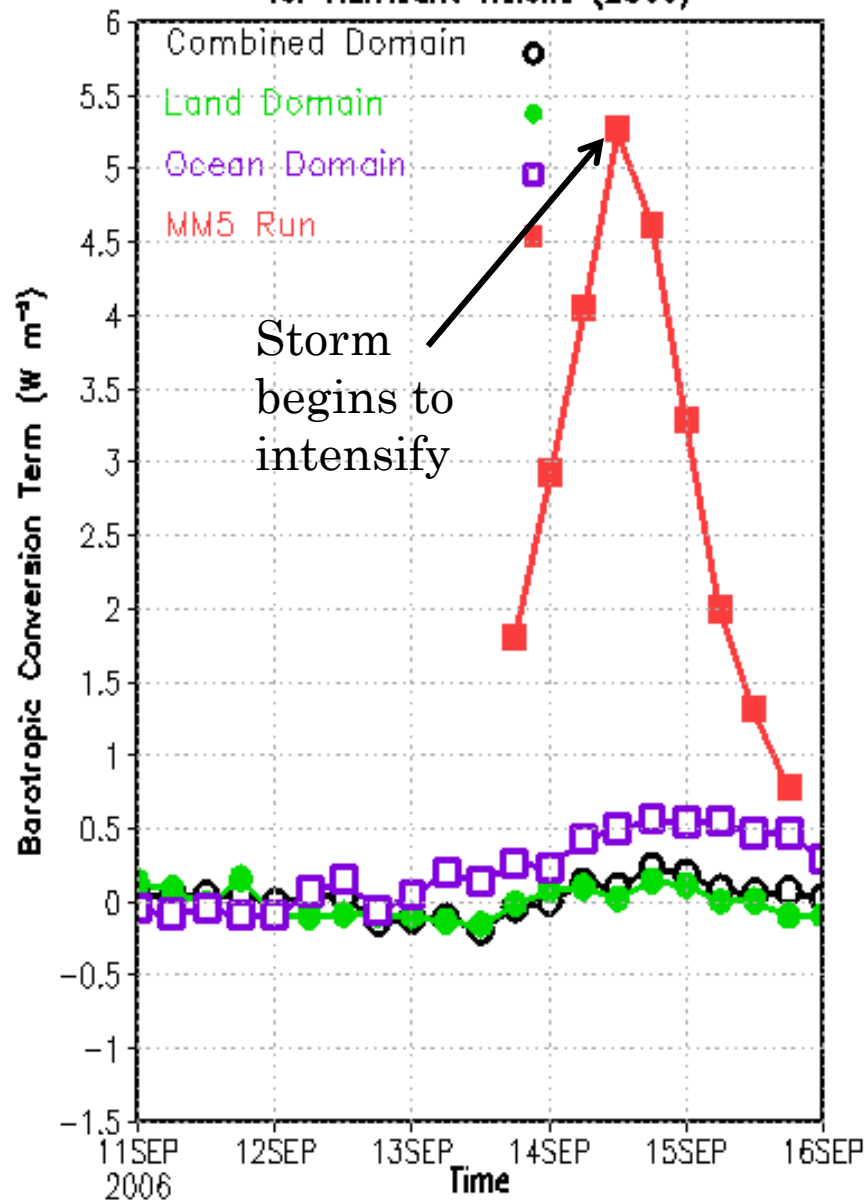


Domain Integrated Baroclinic Conversion Term
for Namma Wave #3 (2006)

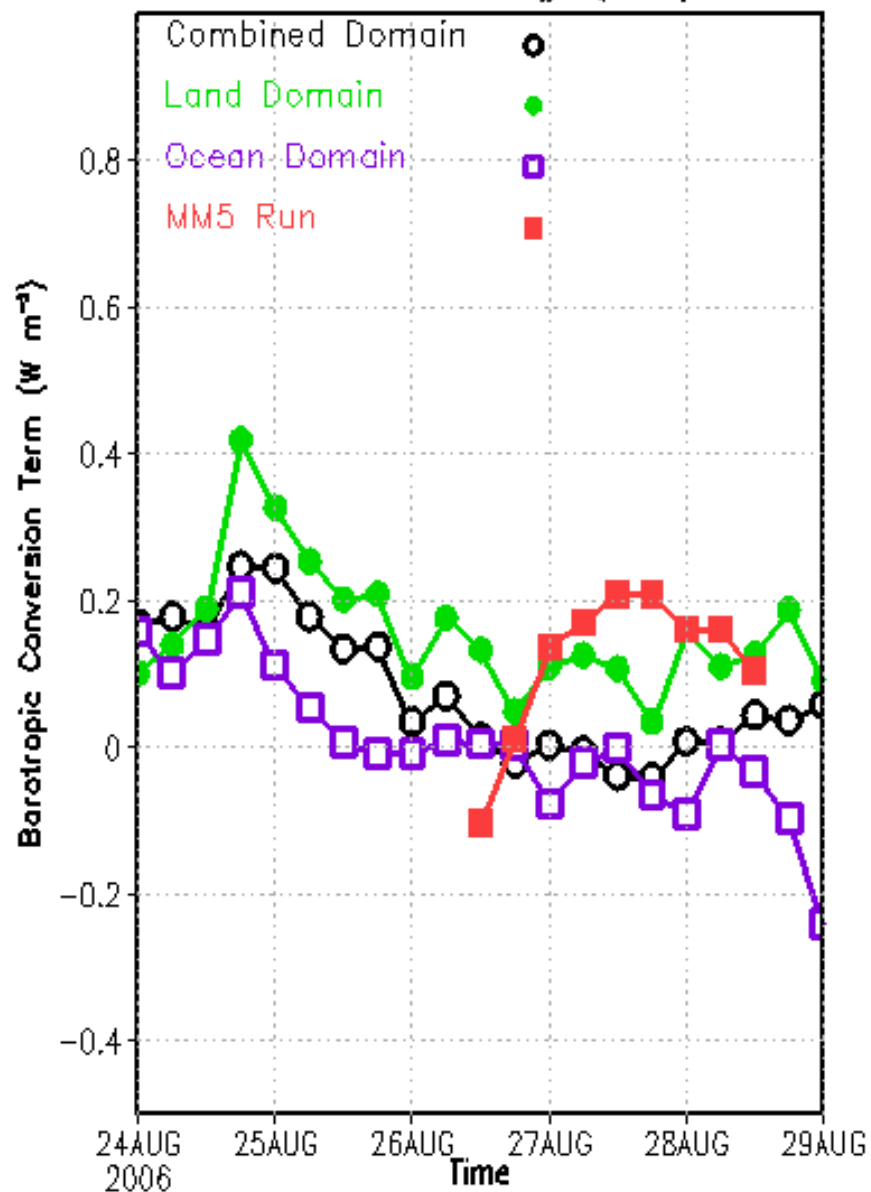


BAROTROPIC CONVERSION TERM

Domain Integrated Barotropic Conversion Term
for Hurricane Helene (2006)

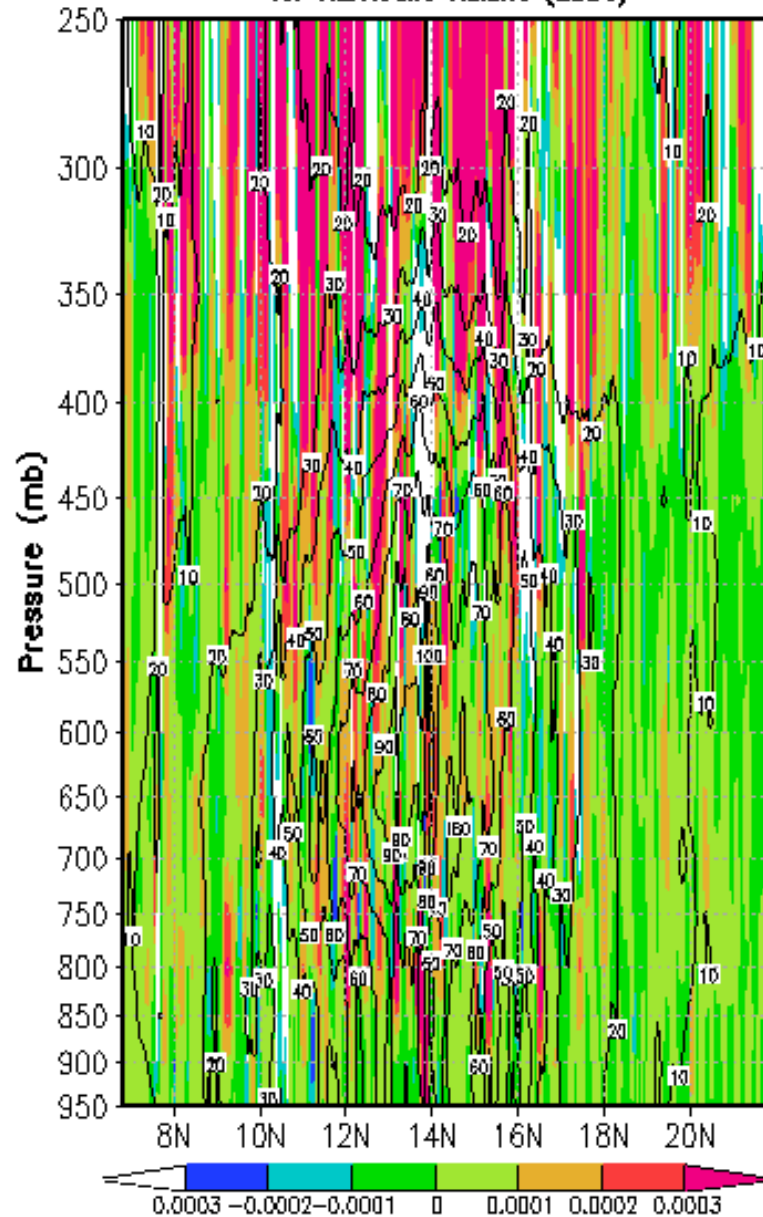


Domain Integrated Barotropic Conversion Term
for Namma Wave #3 (2006)



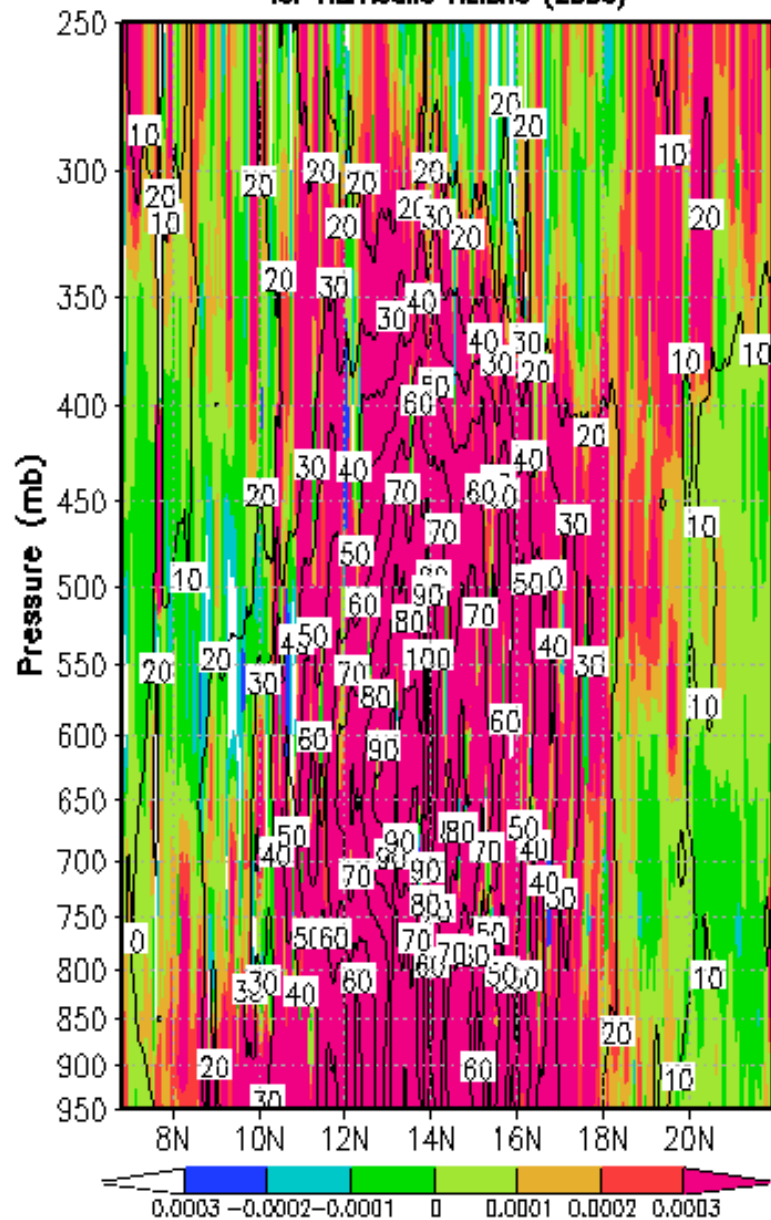
MEAN VERTICAL CROSS SECTIONS

Mean Temporal Vertical Cross Section for
Eddy Kinetic Energy and Baroclinic Conversion Term
for Hurricane Helene (2006)

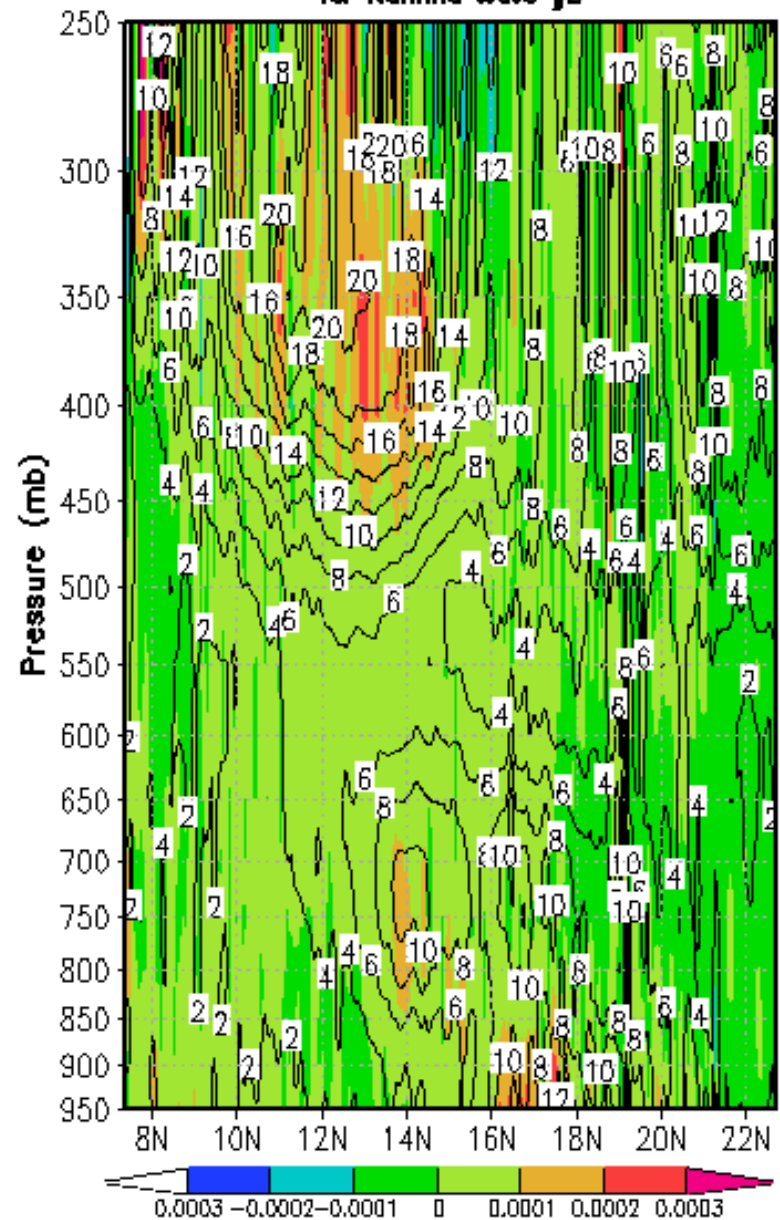


MEAN VERTICAL CROSS SECTIONS

Mean Temporal Vertical Cross Section for
Eddy Kinetic Energy and Barotropic Conversion Term
for Hurricane Helene (2006)



Mean Temporal Vertical Cross Section for
Eddy Kinetic Energy and Barotropic Conversion Term
for Namma Wave #3



CONCLUSION

- Barotropic energy conversions appear to be much more important than baroclinic conversions
- Zonal kinetic energy is being converted into eddy kinetic energy indicating energy transfer from the jet to the wave
- Drawbacks in use of various data makes it difficult to make any conclusions anything more than tentative
- Future work should involve running a larger domain with a mesoscale model using explicit convection to resolve energy budget issues...



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