The Thermodynamic Environment Produced by a Mid-Level Vortex and Tropical Cyclogenesis[1]

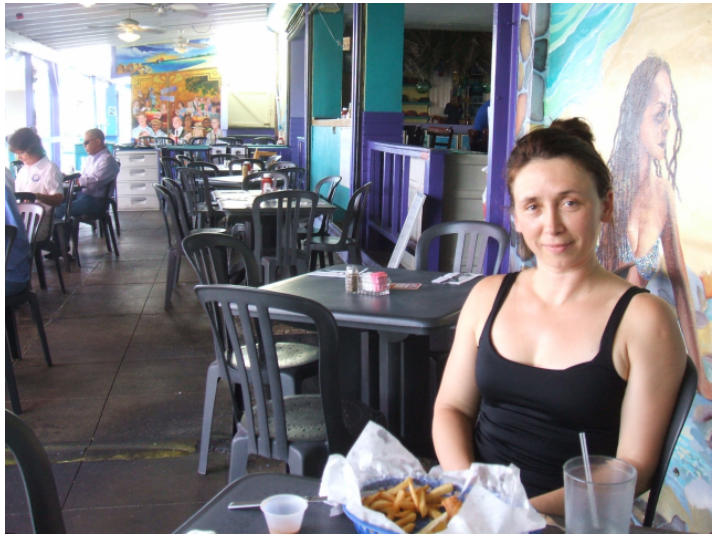
David J. Raymond, Saška Gjorgjievska, and Sharon Sessions

Physics Department and Geophysical Research Center
New Mexico Tech

16 April 2012

[1]Work supported by the Office of Naval Research and the National Science Foundation

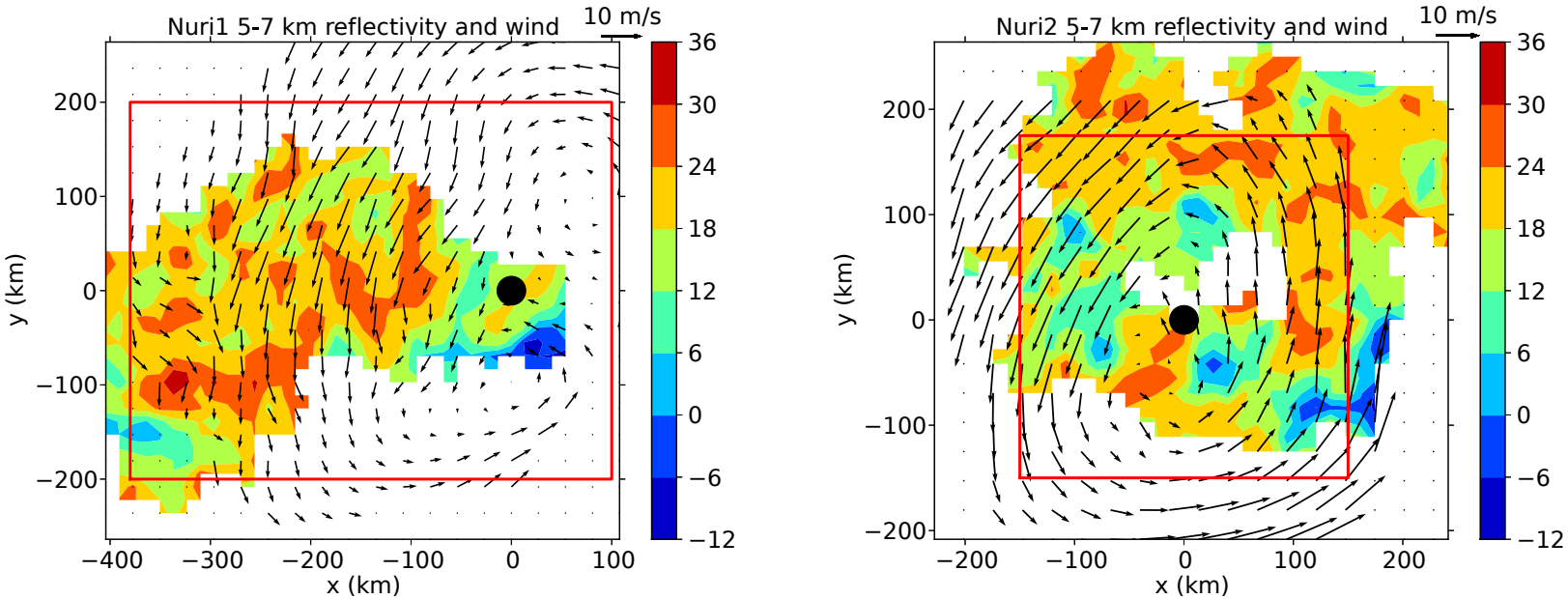
Thanks to co-authors:



Three West Pacific cases (TPARC/TCS08):

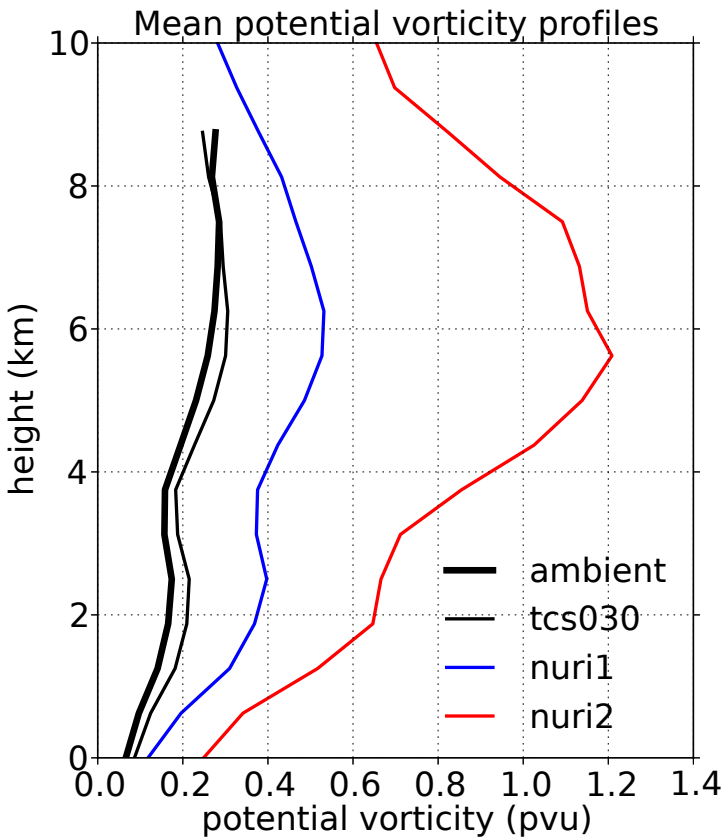
- Cases studied:
  - TCS030: Weak, non-intensifying wave (null case)
  - Nuri1: Intensifying wave
  - Nuri2: Rapidly intensifying tropical depression (24 hr after Nuri1)
- Analysis method:
  - Perform 3D-VAR analysis using ELDORA Doppler radar data and dropsondes.
  - Study convection within a few hundred kilometers of the $5-7$ km circulation center.

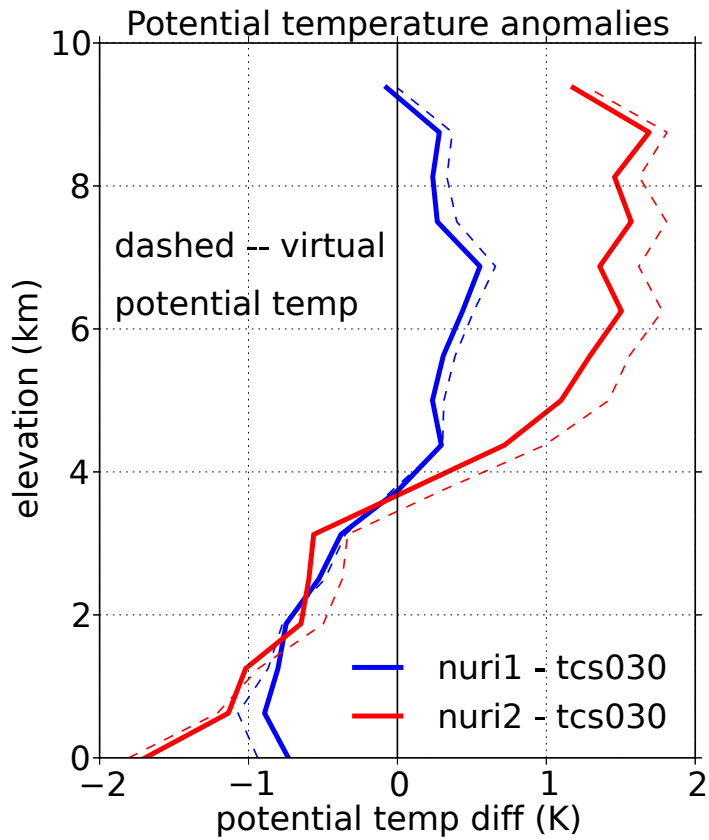
Analysis regions (red boxes):



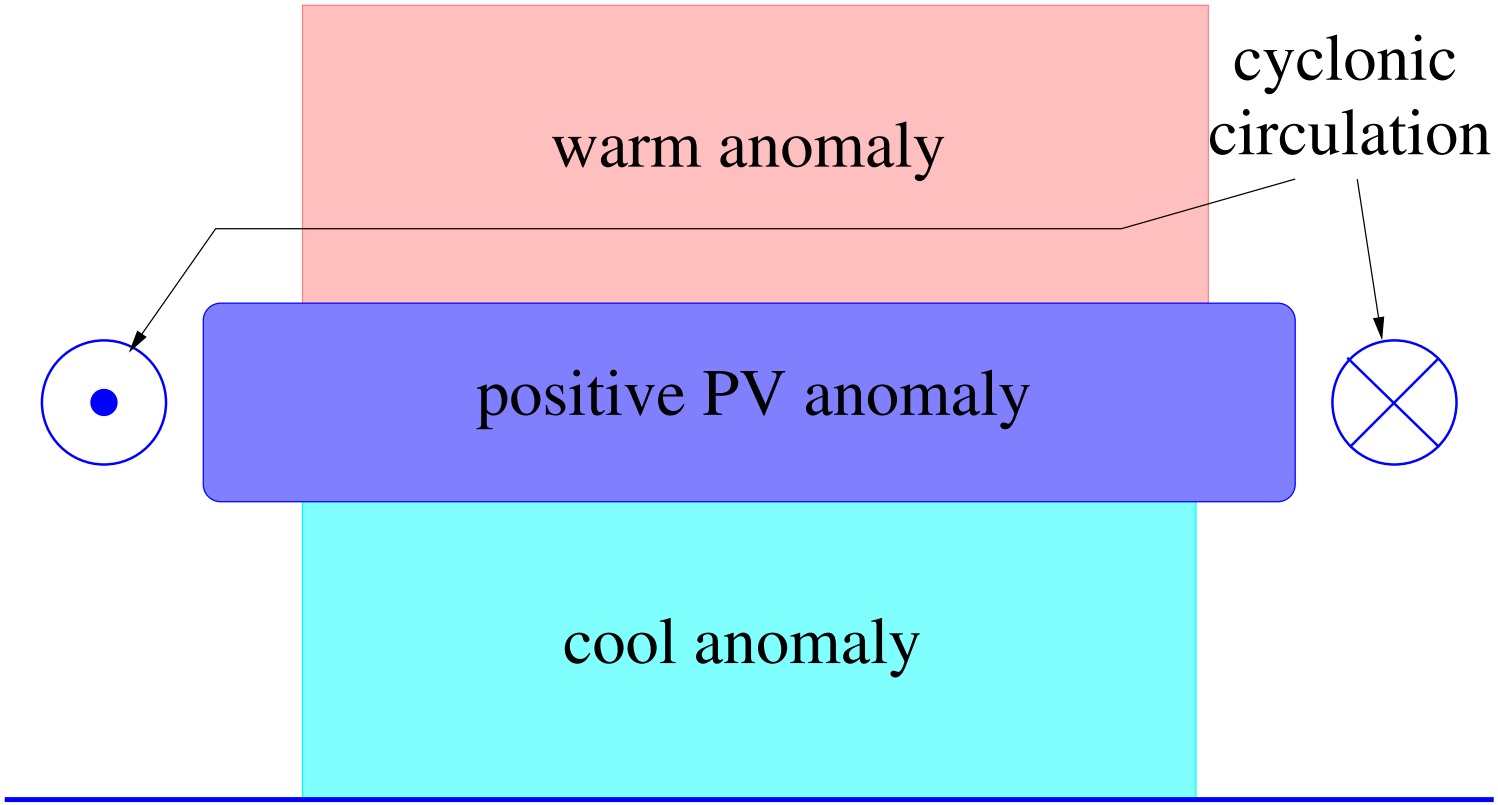
Wind vectors show area of dropsonde coverage. Reflectivity shading shows radar coverage.

Potential temperature and potential vorticity profiles:





Inversion of midlevel PV anomaly:

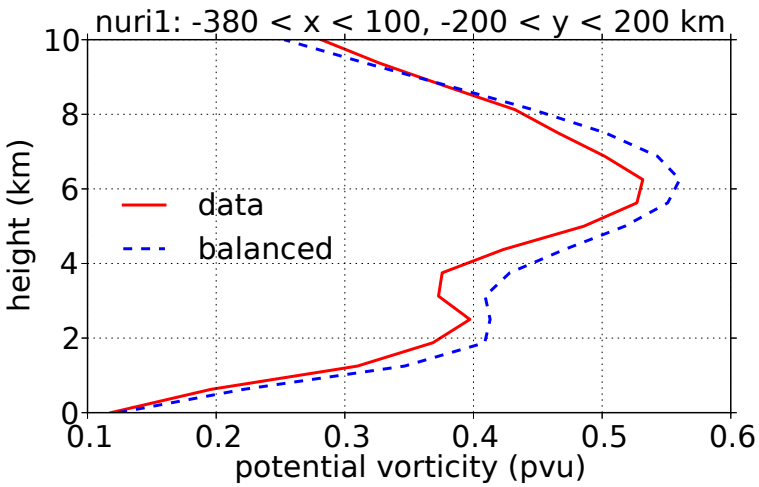


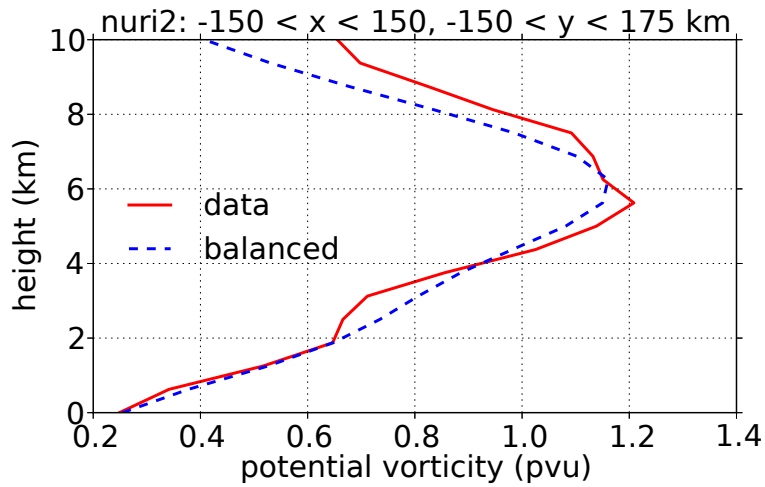
Nonlinear balance PV inversion:

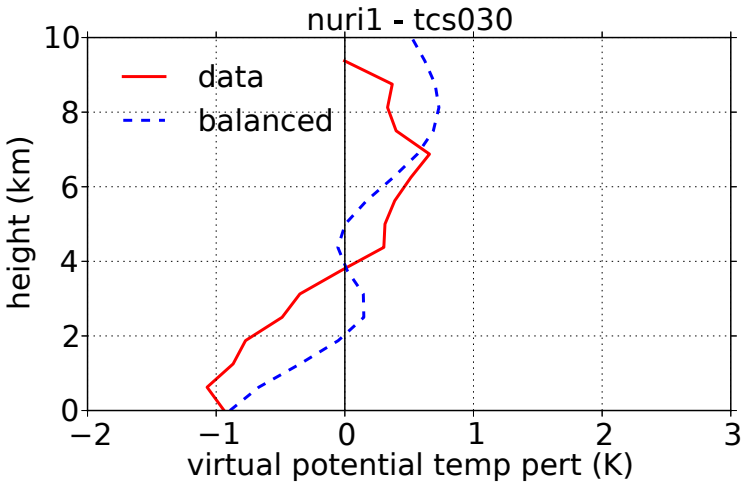
- Approximate the PV by an axially symmetric distribution with a decay length of 300 km from the center of the $5-7$ km storm-relative circulation.
- Use the nonlinear balance inversion method[2] to obtain the mean balanced virtual potential temperature distribution.
- Assume a -2 K surface potential temperature anomaly for Nuri1 and Nuri2 (roughly consistent with observations).

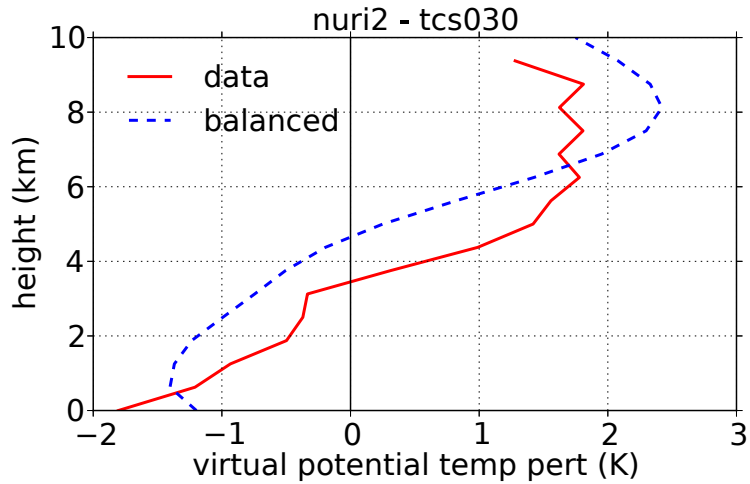
[2] Raymond, D. J., 1992: Nonlinear balance and potential-vorticity thinking at large Rossby number. *Quart. J. Roy. Meteor. Soc.*, **118**, 987-1015.

Inversion results:

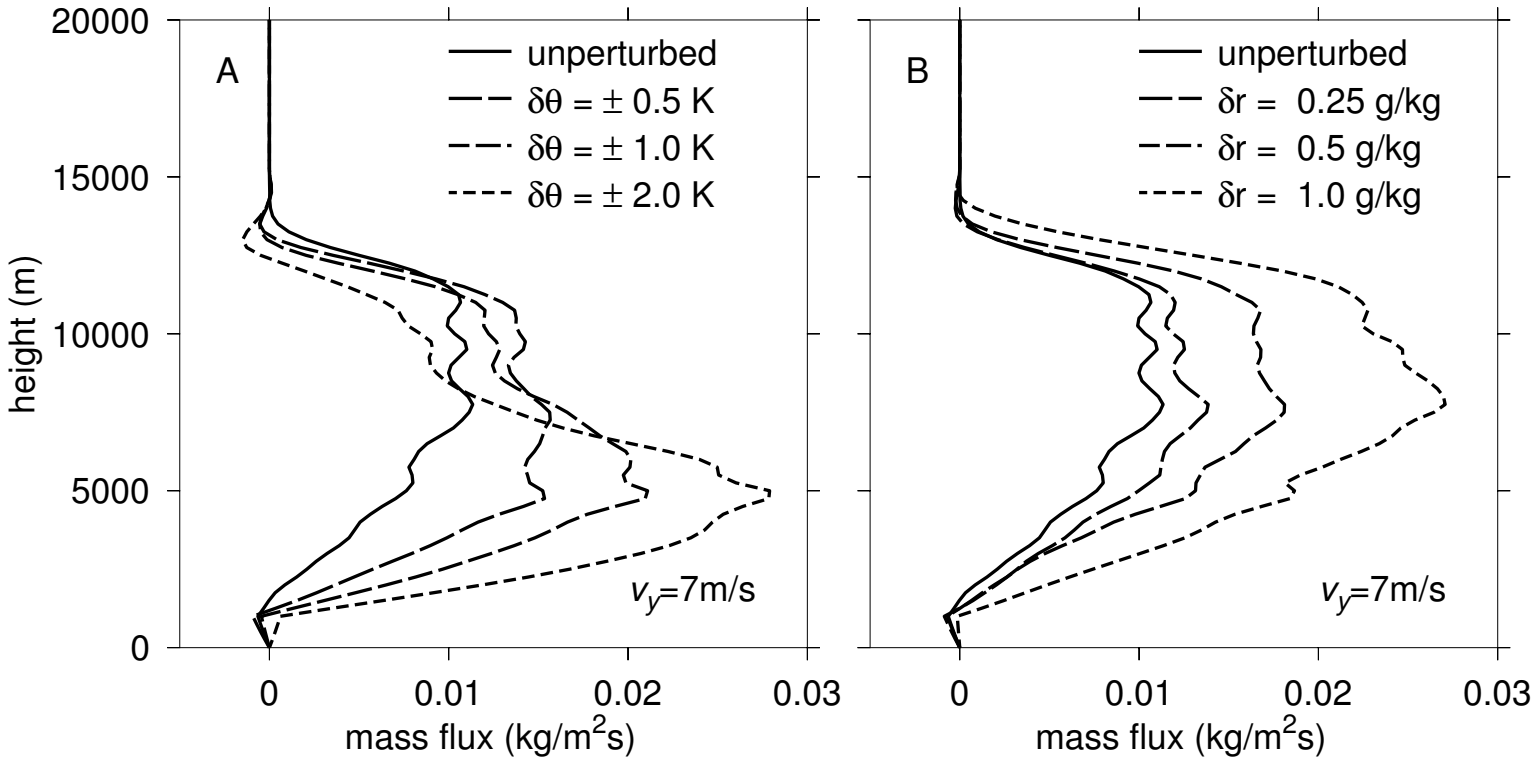






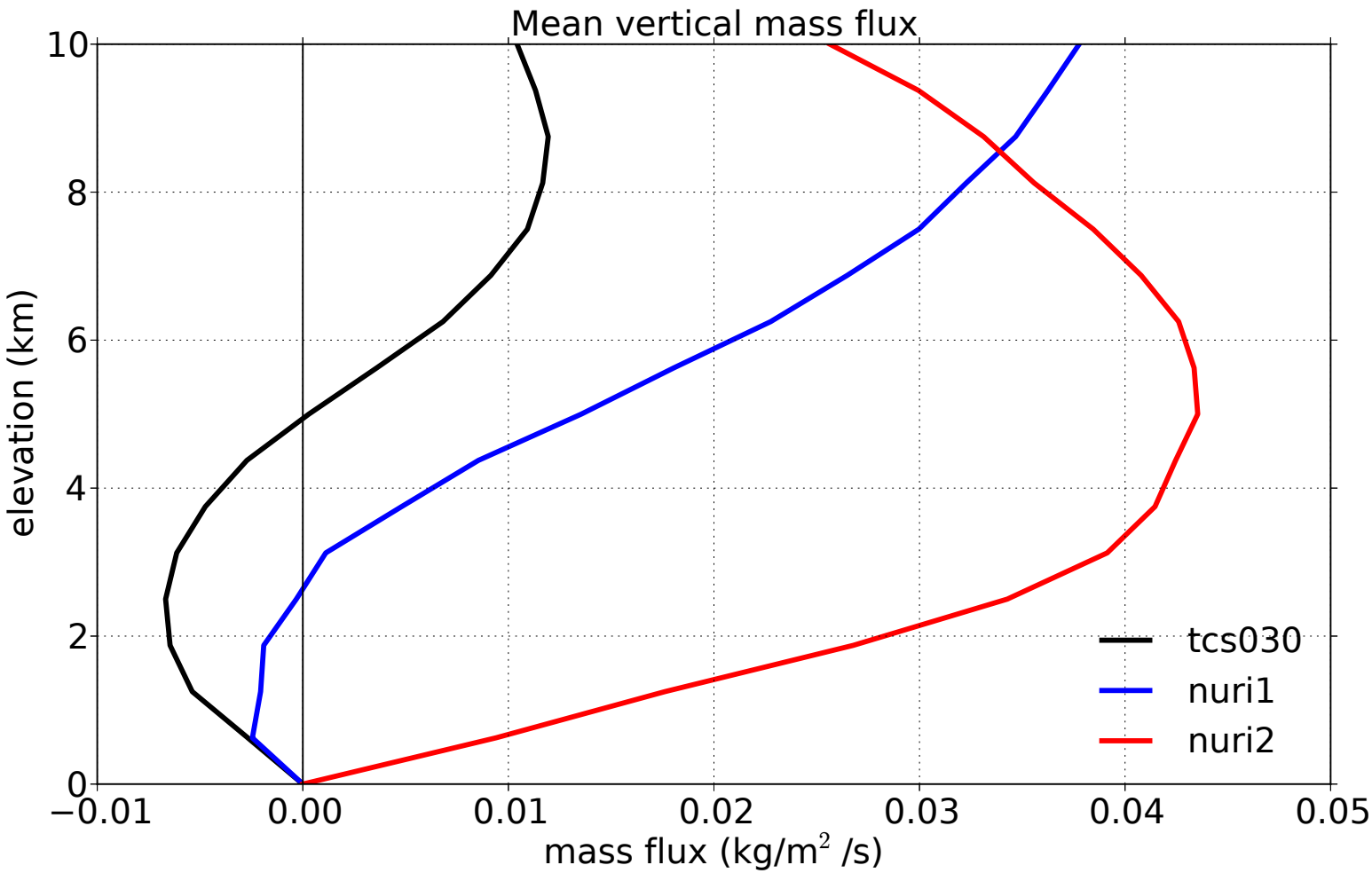


WTG calculations with CRM[3] – mass flux profiles:



[3]Raymond, D. J., and S. L. Sessions, 2007: Evolution of convection during tropical cyclogenesis. *Geophys. Res. Letters*, **34**, L06811, doi:10.1029/2006GL028607.

Entropy and vertical mass flux profiles:



Conclusions:

- Mid-level vortex ==> balanced, warm-over-cool thermodynamic response.
- Actual temperature dipole approximates balanced state.
- Temperature dipole and higher humidity ==> increased vertical mass flux.
- Temperature dipole ==> more bottom-heavy mass flux profile.
- Bottom-heavy profile ==> tropical cyclone spinup – see Saška's talk tomorrow!