The Moist Entropy Change in Hurricane Nadine

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The Entropy Change

- Moist entropy, $s$

- 3-D divergence of entropy flux: includes input/output on the sides + at the top
  - Positive = export
  - Negative = import
• Only one part of entropy budget
  ➢ No surface or radiative fluxes
  ➢ No irreversible generation of entropy

• Contains information about moistening/drying of the system

• Raymond et al. (2011) – if entropy export is small or negative – potential for development
Data

• QC dropsonde data from HS3 missions into Nadine

• Good data coverage – vertical and horizontal

• Covers the entire system

• Problem: some data missing close to the surface – those drops not used
• 4 missions (2012) used in analysis:
  1. September 14: TS becoming a hurricane
  2. September 19: TS, intensified later
  3. September 22: low becoming TS again
  4. September 26: TS, became a hurricane 2 days later
Methods

• Data interpolated onto regular grid: 3D-VAR analysis

• Mass continuity imposed

• Grid points distance:
  - Horizontal: 0.5° x 0.5°
  - Vertical: 0.625 km

• Vertical domain: 0-17 km

• Horizontal domain: specific area selected, to cover the storm – from vorticity field
Methods – calculating the entropy change

• Divergence of moist entropy flux:

\[ \vec{\nabla} \cdot (\rho \vec{v} (s - s_0)) \]

\( \rho = \text{density} \)

\( s-s_0 = \text{moist entropy perturbation (per unit mass)} \)

\( \vec{v} = (u,v,w) = \text{wind vector} \)

• Horizontally averaged and vertically integrated \(\rightarrow\) Entropy export
Results
Vertical profiles of horizontal export (Nadine)

[Graphs showing vertical profiles for Sept 14, Sept 19, Sept 22, Sept 26 with altitude on the y-axis and moist entropy export on the x-axis.]
Moist Entropy Export (Nadine)
Comparison to other cases

![Graph showing comparison to other cases](image-url)
Conclusion

- During 2 missions into Nadine (Sept 19 and Sept 26) moist entropy increased due to overall import

- At the time of other 2 missions (Sept 14 and Sept 22) moist entropy slightly decreased due to overall export

- Agrees with the assumption that the moist entropy export should be small or negative to strengthen the storm (except Sept 22)

- However, other parameters need to be considered as well
Thank you!