A Numerical Study on the Effects of Dry Air Aloft on Rotating Convection

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- Motivation & Goals
- Experiment setup
- Typical evolution
- Dry air aloft on convection
- Vorticity production
- Conclusions

- James and Markowski (2009) show dry air aloft exerts detrimental effects on convection
- An aim of PREDICT Experiment was to test the “marsupial paradigm” for cyclogenesis as proposed by Dunkerton *et al.* (2009)
- This paradigm proposes that hurricanes form in a “pouch”, consisting of a closed cyclonic circulation
- Wissmeier and Smith (2011) show that large amplitudes of the ambient vertical vorticity are produced by single cell rotating convective clouds

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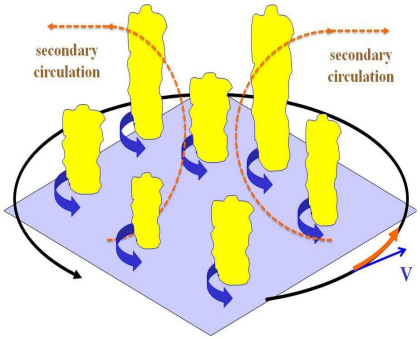
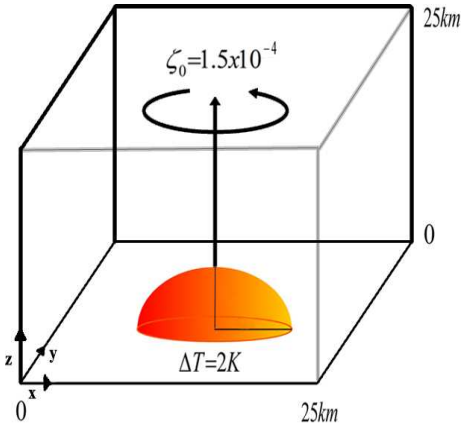
Montgomery and Smith (2010) proposed that patches of enhanced vorticity from such cells can interact and merge

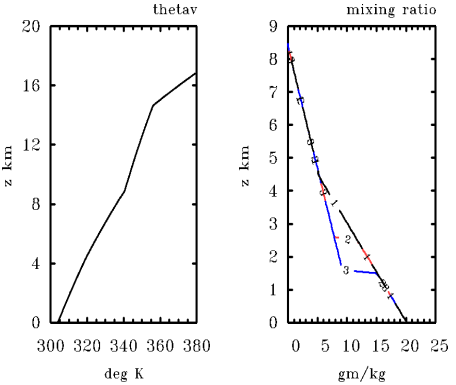


- Was dry air aloft the reason tropical storm Gaston (2010) failed to develop?
- What is the effect of dry air aloft on a convective cell?
- What are the effects of dry air on the generation of vertical vorticity?

- George Bryan's Cloud Model
- Three-dimensional, non-hydrostatic, non-linear, time-dependent numerical model
- Gilmore's microphysics scheme
- "Open" boundary conditions at lateral boundaries
- Integration time 2 hours
- No background wind field
- No Radiation, no surface fluxes, no friction

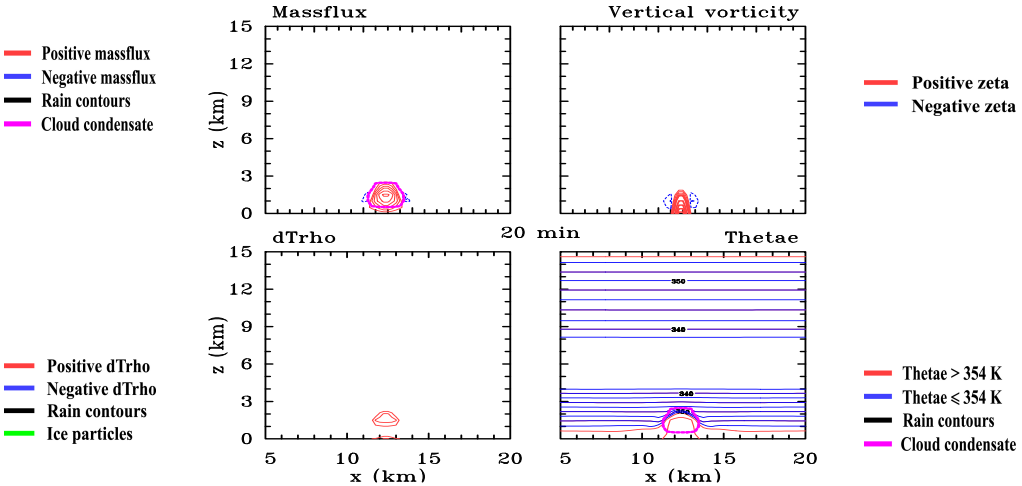


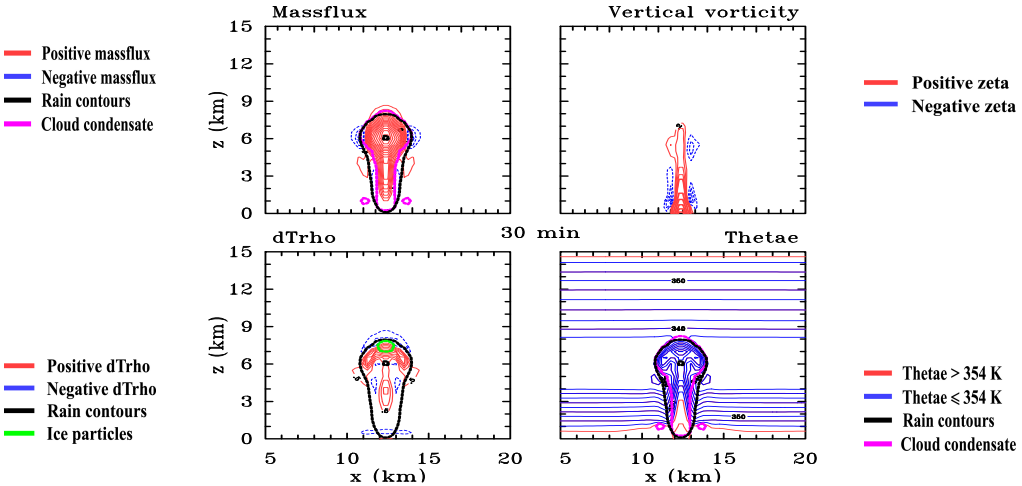
Idealised soundings approximating that from PREDICT on 5 September, 18:20 UTC.



- CAPE: 2770 $J\ kg^{-1}$
- CIN: 40 $J\ kg^{-1}$
- TPW Exp. 1: 62.3 $kg\ m^{-2}$
- TPW Exp. 2: 59.3 $kg\ m^{-2}$
- TPW Exp. 3: 54.8 $kg\ m^{-2}$

Cloud Evolution


Positive massflux
Negative massflux
Rain contours
Cloud condensate
Massflux
Vertical vorticity
Positive zeta
Negative zeta
z (km)
20 min
dTrho
Thetae
Positive dTrho
Negative dTrho
Rain contours
Ice particles
Thetae > 354 K
Thetae ⩽ 354 K
Rain contours
Cloud condensate
x (km)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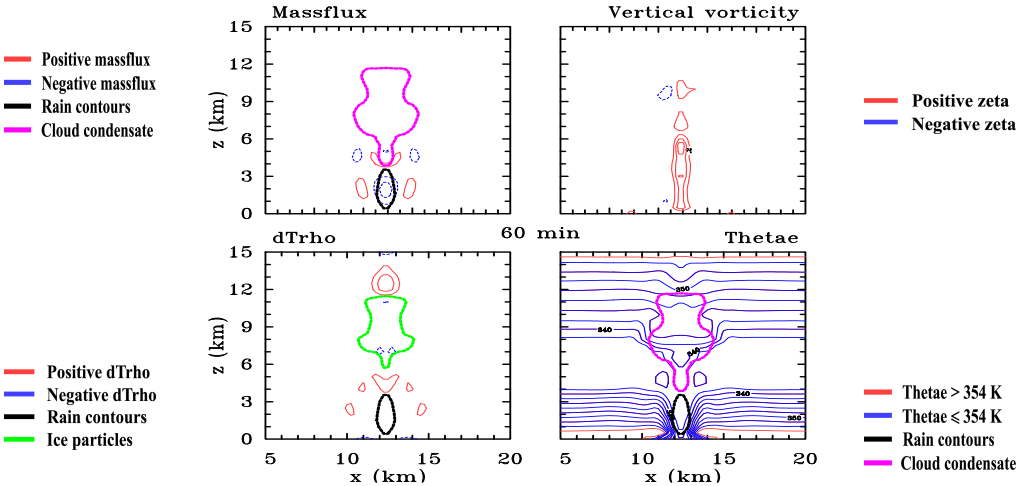
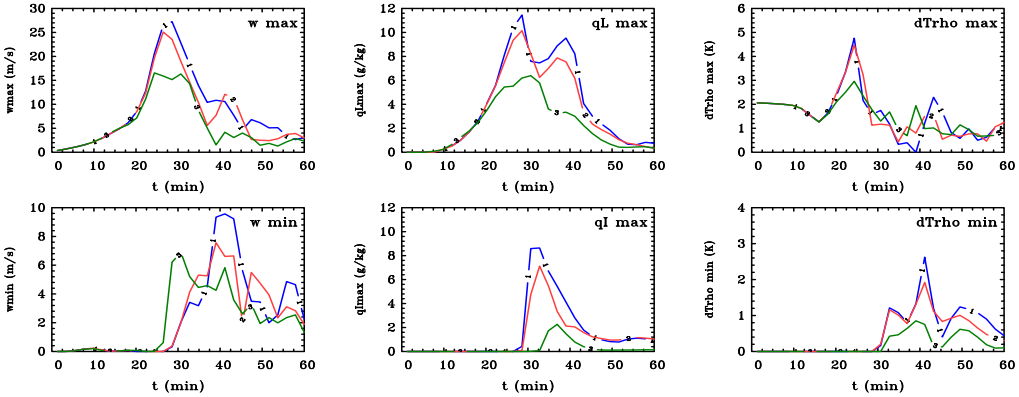
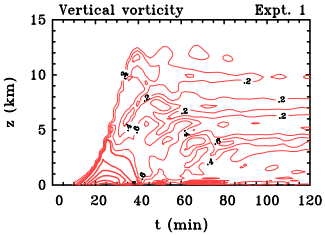


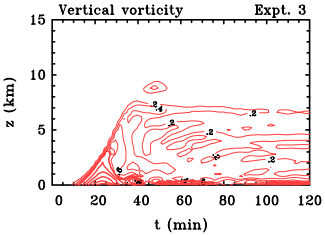
Animated Evolution

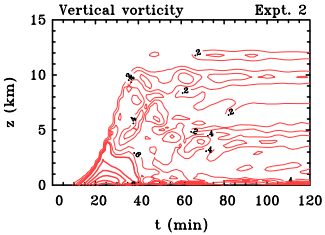
Evolution of maximum & minimum values

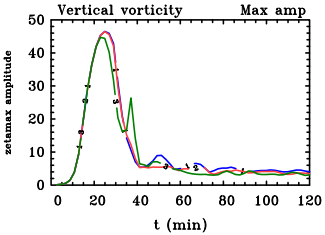
Expt. 1 Moist → **Expt. 2** Drier → **Expt. 3** Driest




Vertical vorticity
Expt. 1
z (km)
t (min)


Vertical vorticity
Expt. 3
z (km)
t (min)


Vertical vorticity
Expt. 2
z (km)
t (min)


Vertical vorticity
Max amp
zetamax amplitude
t (min)

- We find the entrainment of dry air aloft was found to weaken convection, as in James and Markowski (2009)
- Dry air aloft may have weakened Gaston (2010) by weakening overall convection, not by strengthening convective downdraughts
- Convective cells amplify the ambient rotation at low levels by more than an order of magnitude as shown in Wissmeier and Smith (2011)
- This vorticity persists long after the initial updraught has decayed
- The maximum amplification of vorticity is insensitive to the presence of dry air aloft
- Dry air does reduce the depth to which there is significant amplification of vorticity

Thank You!

A numerical study of rotating convection during tropical cyclogenesis

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