The Effect of Cloud Heating on Storm Rotation

The Problem

Heating takes place inside of clouds due to condensation of water vapor.

The heating in turn can drive motion in and around the clouds.

How does heating modify the evolution of rotating convective storms?

Project Design

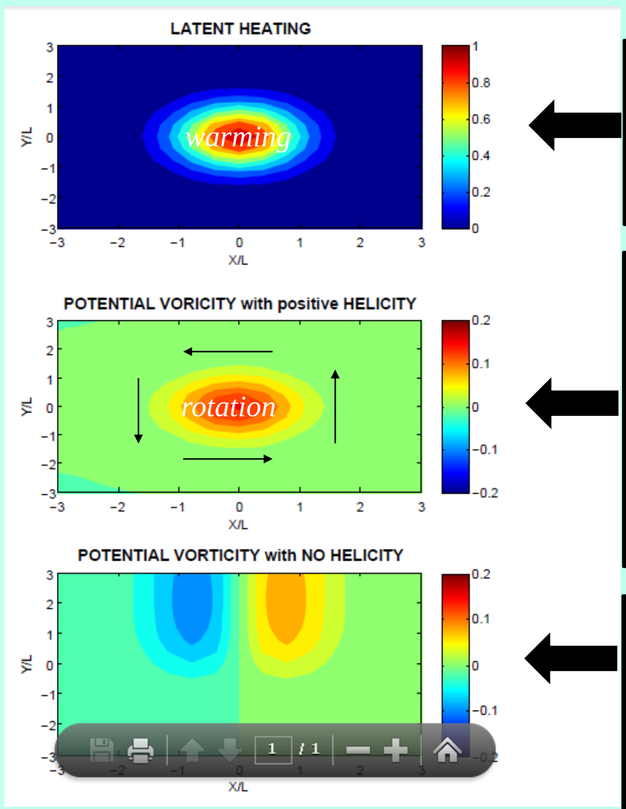
Theory: A mathematical analysis of the fundamental link between heating and storm rotation was performed using a fluid dynamical quantity called potential vorticity.

Simulation: High resolution simulations of rotating thunderstorms were performed using the Weather Research and Forecasting (WRF) model in order to test the theory.

Results

Storm rotation is amplified by heating if the pre-storm winds turn with altitude. This challenges the existing theory on the origin of storm rotation and points to a source of forecast error.

THEORY

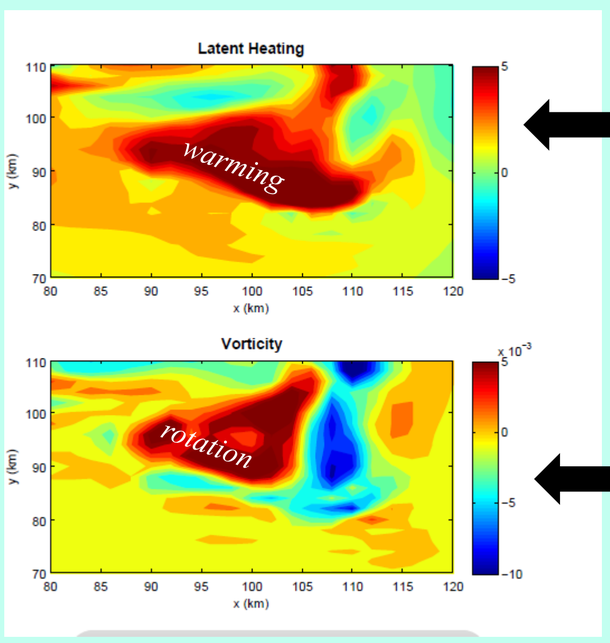


A hypothetical region of heating shown on a horizontal plane (e.g., through the middle of a convective storm). Red colors correspond to warmed air.

The pattern of potential vorticity (i.e, storm rotation) implied by heating, predicted by the new theoretical model. Red colors correspond to counter-clockwise spin. In this calculation, it is assumed that the pre-storm winds turn with altitude.

As above, but with pre-storm winds out of the south that DO NOT turn with altitude (i.e., no helicity). Consequently, rotation does not amplify within the heated region.

SIMULATION



Net heating in the core of a simulated supercell thunderstorm. Red colors correspond to warming. Storm simulated using the WRF model. Pre-storm winds turn with height.

As predicted by the theory, vorticity (i.e., storm rotation) accumulates in the region of heating. Red colors correspond to counter-clockwise spin.

Ongoing Work

Dr. Chagnon's research group is identifying biases in weather and climate models due to cloud-scale processes using the theory and diagnostic tools developed in this project.

Want to know more?

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