Hydraulic jump dynamics above supercell thunderstorms

Friday, March 29th, 2024
12:30 PM
Bowen Hall Room 222

MAE Seminar Series

Morgan O'Neill
University of Toronto

The presence of water vapor in the lower stratosphere is enormously consequential for the climate. Strong thunderstorms are known to be an important secondary source of water vapor to the lower stratosphere, and how they may feedback to large scales in a warming climate is unknown. The most severe midlatitude supercell thunderstorms often feature an Above-Anvil Cirrus Plume (AACP), which is a wake of ice and water vapor downstream of overshooting deep convection. The AACP is uniquely capable of lofting water high above the tropopause. Using high-resolution large eddy simulations, we show that the AACP is formed by the development of a new type of hydraulic jump at the tropopause. The `effective topography' that forces the jump is the storm top, which is permeable, evolving and experiencing water phase changes. Upon jump onset, the simulated water vapor injection rate into the stratospheric overworld increases from less than 1 tonne/s to more than 7 tonne/s, accompanied by windspeeds that exceed 110 m/s at the tropopause. Both tropospheric and stratospheric air participates in the fast jet at the tropopause and the jump downstream. The presence of a threshold past which some storms become effective hydrators of the lower stratosphere suggests a blind spot in large-scale climate models unable to resolve this behavior.

Morgan O'Neill is an assistant professor in the Department of Physics at the University of Toronto. She received her Ph.D. in Atmospheric Science at MIT, and then held postdoctoral fellowships at the Weizmann Institute of Science and the University of Chicago before joining the Earth System Science Department at Stanford University as a faculty member until 2023. Morgan studies the moist thermodynamics and fluid dynamics of severe storms, to better understand how they will co-evolve with and feedback on a warming climate.

PRINCETON
Mechanical & Aerospace Engineering