Firenadoes!

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Wildfires in Canada increasingly exhibit extreme behavior. Wildfires can create massive thunderstorms above themselves (Fromm et al. 2006, 2010), called pyrocumulonimbus (pyroCb), which can spread the fire further through strong surface winds, fire vortices (Lareau et al. 2018), and lightning bolts, endangering communities and wildland firefighting crews (Werth et al., 2011). These storms also have enormous negative downstream air quality impacts on population centers, producing dangerous amounts of pollution. However, their fluid dynamics are not well understood. I hypothesize that pyroCb storms have strong unexplored similarities to typical supercell thunderstorms. Understanding these similarities and their physical basis will improve our ability to forecast extreme wildfire behavior and smoke spread, as well as their impact on climate change.

I seek up to two undergraduate students to set up and run WRF-Fire, an open-source state-of-the-art computer model that couples local atmospheric dynamics to a wildfire land surface model during the summers of 2024 and 2025. First, they will set up a modeling environment that allows us to drive the horizontal boundaries of the regional model with global forecasting datasets, so that retrospective analyses of historical wildfires can be run. This requires running simulations on the Trillium supercomputer (no prior experience necessary, but comfort with working in a terminal is useful). We will also learn about wildfire fuels and land surface models in order to force the model realistically.

Once the model is running on Trillium, we will simulate the 2023 Northern Territories wildfire and study how the pyroCb, identified already by satellite, formed and spread downstream. We will then vary the upper-level winds (at storm-top) to determine how wildfire pollution in the lower stratosphere (just above the weather layer where we live) is impacted by turbulence and waves, as in Homeyer et al. (2017) and O'Neill et al. (2021).

These realistic simulations will be compared with highly idealized simulations without topography and with very simplified surface heating functions. The goal will be to isolate the essential physics required to produce a pyroCb storm that reaches a similar altitude and strength as the Northern Territories wildfire. We will ask: was it unique? What were meteorological commonalities with other megafires? Is the role of upper level winds comparable to supercell thunderstorms?

Familiarity with python is necessary.

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