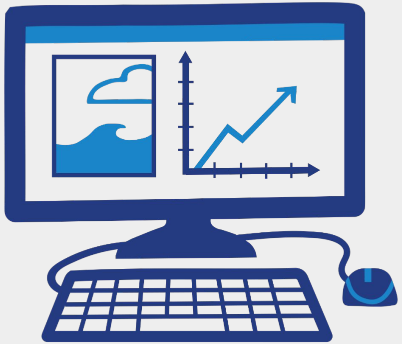
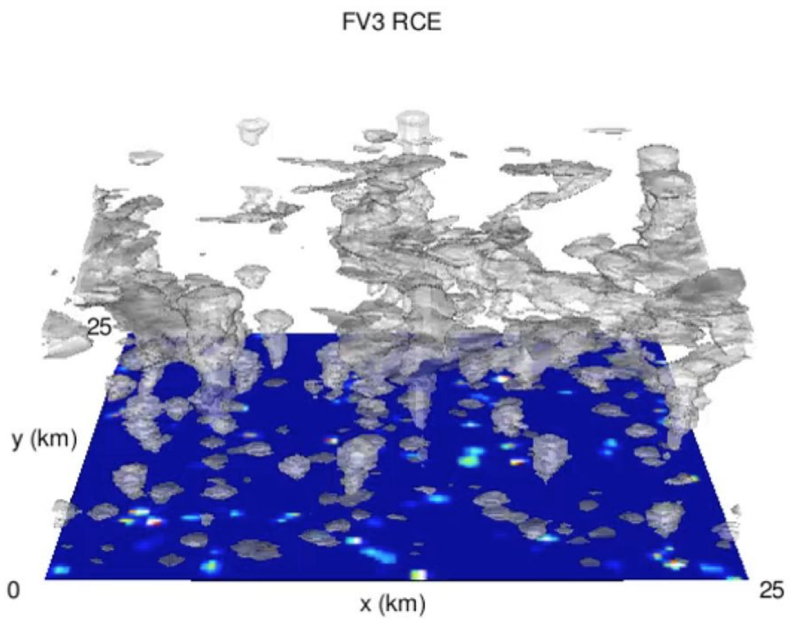


Q1: Process modeling of atmospheric convection

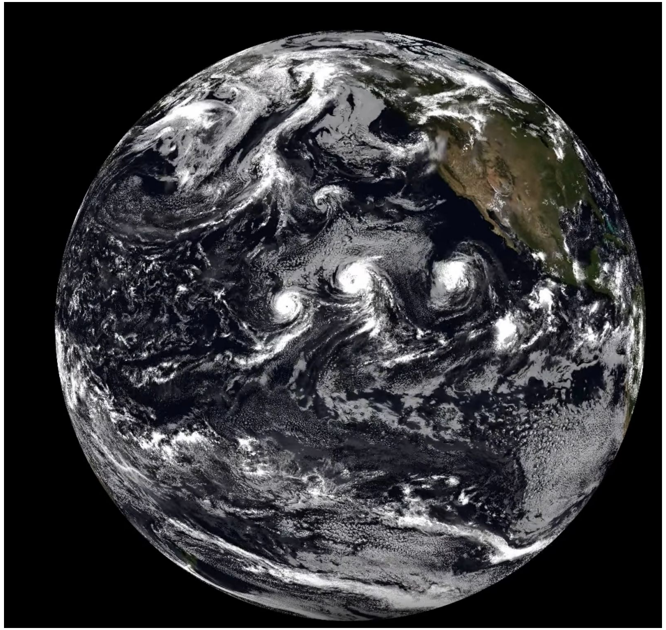
Nadir Jeevanjee
GFDL Research Physical Scientist

Q1: Concerning GFDL's core strength of building and improving models of the weather, oceans, and climate for societal benefits, how can GFDL leverage advances in science and computational capabilities to improve its key models? What are the strengths, gaps, and new frontiers?

Limited-Area and Global Capabilities



Doubly-periodic FV3 run in Radiative-Convective Equilibrium (RCE) @ fixed, uniform SST



X-SHiELD: Global Storm-Resolving Model (GSRM) @ dx=3 km. Multi-week runs initialized from analysis with nudged SSTs

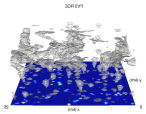
FV3 RCE documentation: Jeevanjee 2017
https://doi.org/10.1002/2017MS001059
X-SHiELD documentation: Harris et al. 2023
https://doi.org/10.1029/2022JD037823

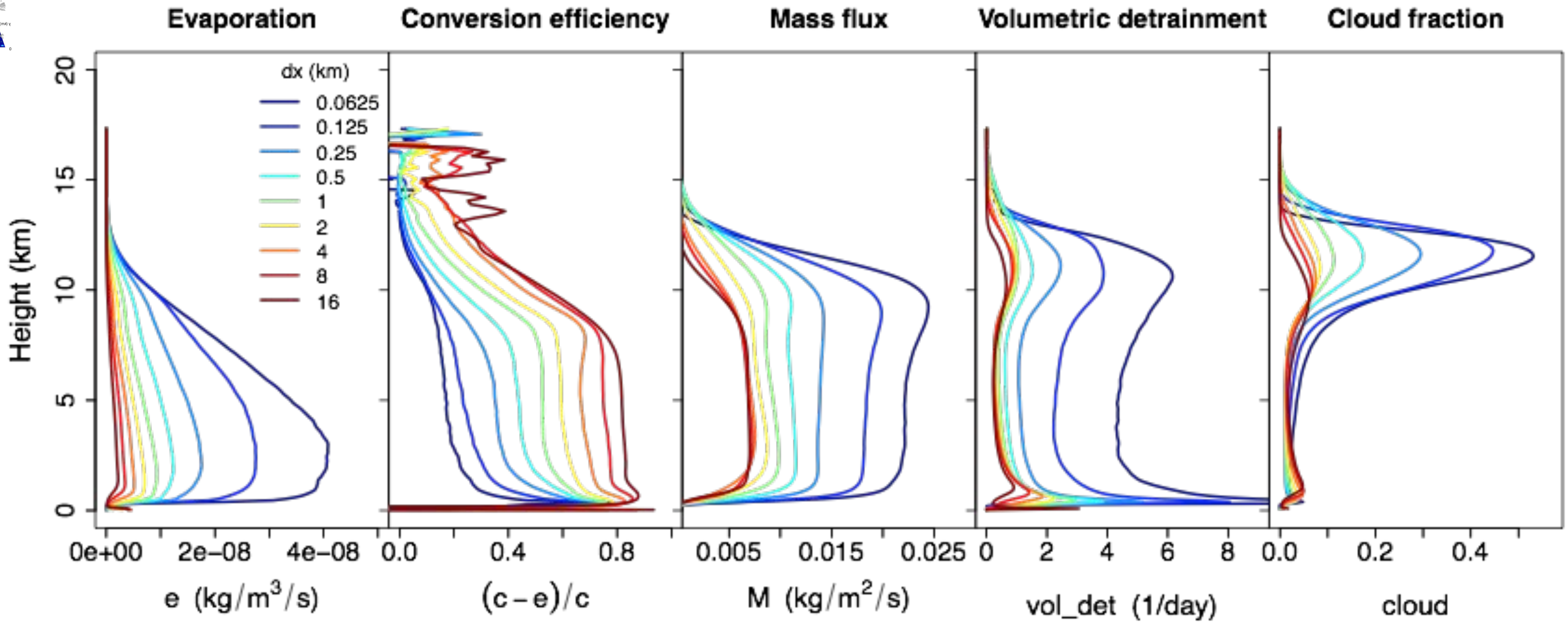
Resolution dependence in FV3-RCE

Basic, interconnected dependence of convective dynamics on horizontal resolution

As resolution gets finer, we find:

More evap → reduced PE → more mass flux → more detrainment → more cloud



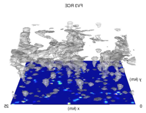


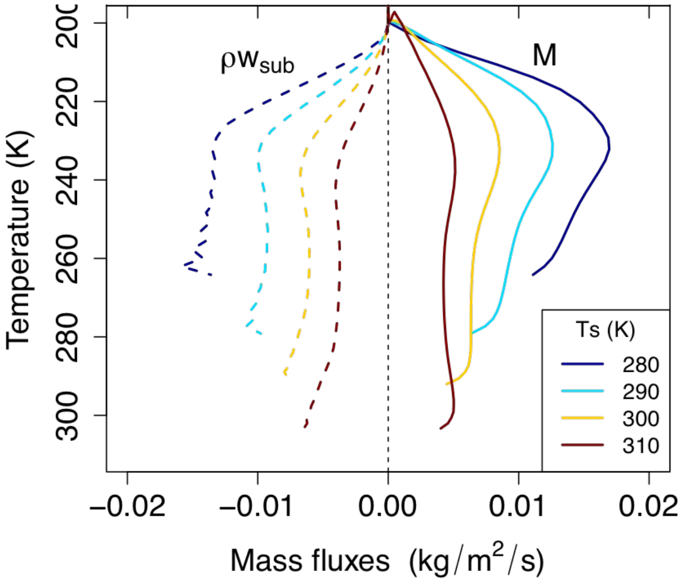
Jeevanjee and Zhou 2022

https://doi.org/10.1029/2021MS002759

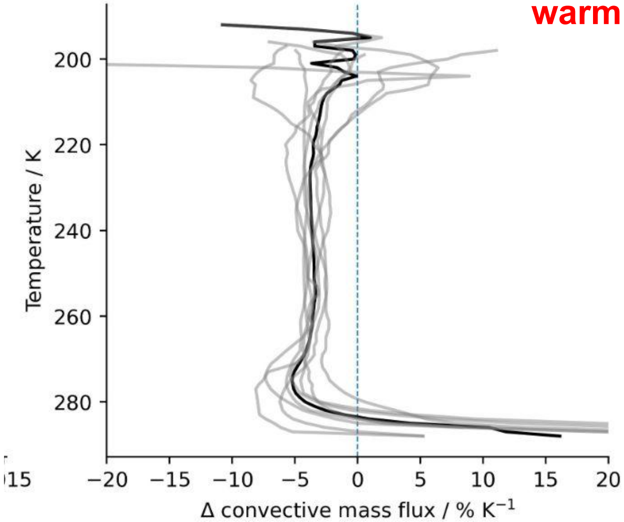
A robust constraint on convective mass fluxes

Fundamental constraint on how convection will respond to global warming





Convective mass flux decreases with surface warming when evaluated on *isotherms*. Robust across theory, cloud-resolving models, and GCMs.

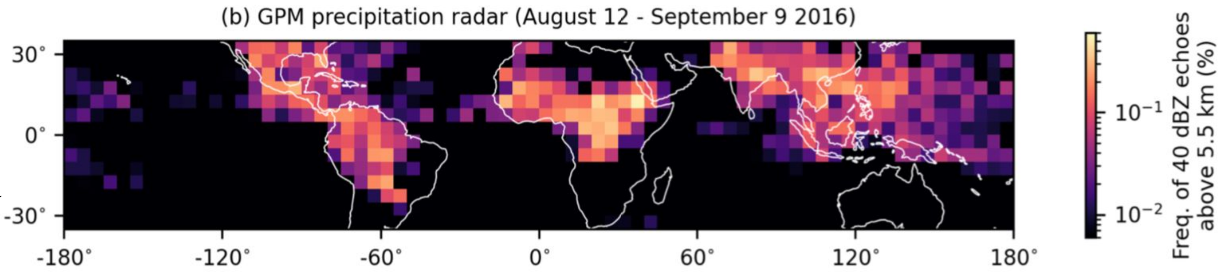


Multi-model RCEMIP ensemble of cloud-resolving models shows robust *fractional* change in mass flux of **~ 4% K^{-1}**

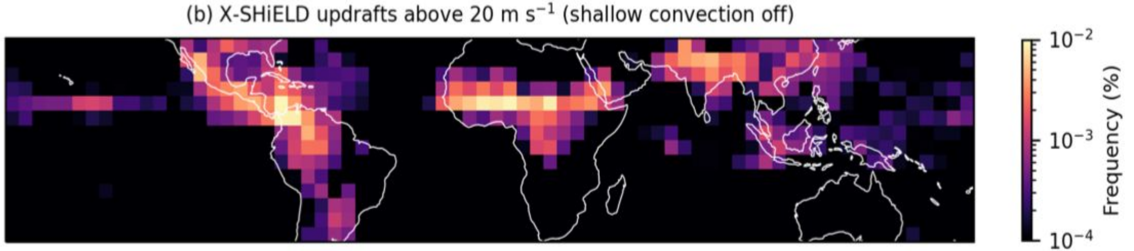
Jeevanjee 2022b https://doi.org/10.1029/2022MS003285
Williams and Jeevanjee 2025
10.22541/essoar.172574431.13170821/v1

Land-ocean contrast in convective intensity

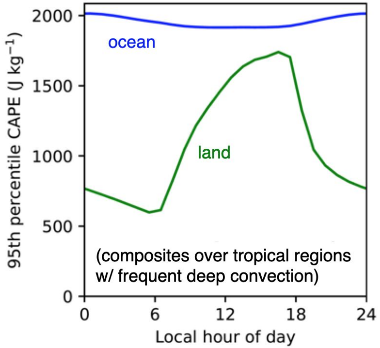
Satellite obs exhibit strong land-ocean contrast in intense convection



X-SHiELD (3 km global storm-resolving model) **can** reproduce this

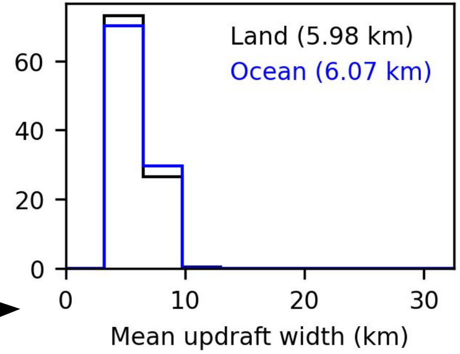


X-SHiELD matches striking observed signal, also poised to test current hypotheses:



Land-ocean contrast **not** due to

- CAPE (instability)
- Updraft width



Abbott, Jeevanjee, Chen, Zhou, Harris 2025

10.22541/essoar.172021737.79807737/v1