

Stony Brook University

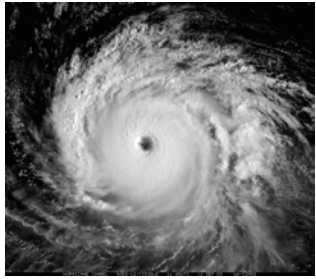
# Continued efforts in reduced complexity modeling with CAM

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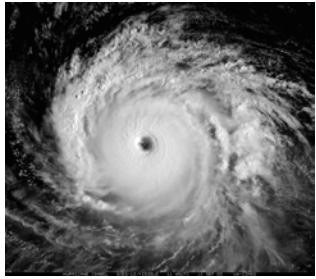
*and collaborators*

*Brian Medeiros (NCAR), Daniel R. Chavas (Purdue Univ.), Julio Bacmeister (NCAR), Christiane Jablonowski (Univ. of Michigan), Adam Herrington (Stony Brook Univ.) and Peter Lauritzen (NCAR)*



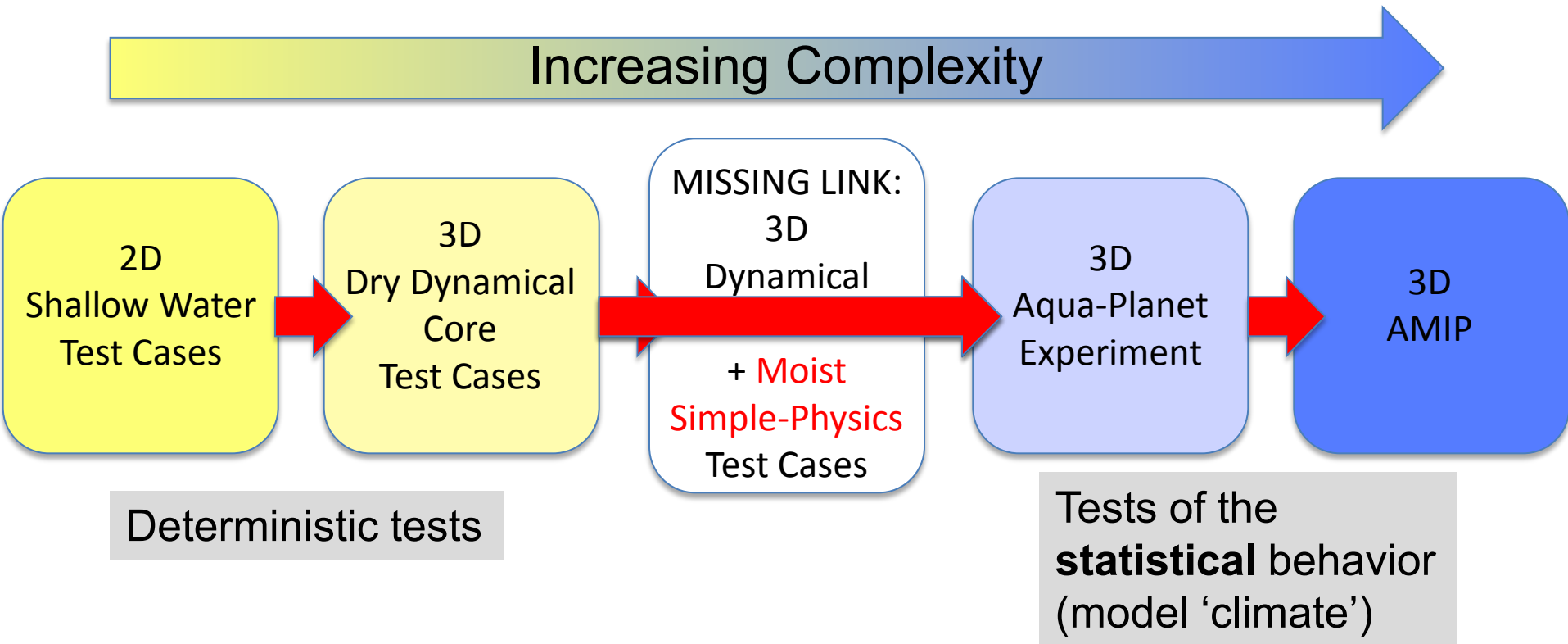
# Main Points

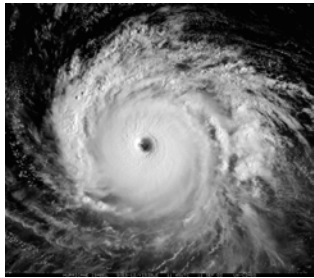
1. Reduced complexity testbeds can aid in our **understanding of robust behaviors** of the Earth system and our ability to model them.
1. These **simplified frameworks** can aid in model development by isolating model ‘deficiencies’ and studying them in detail.



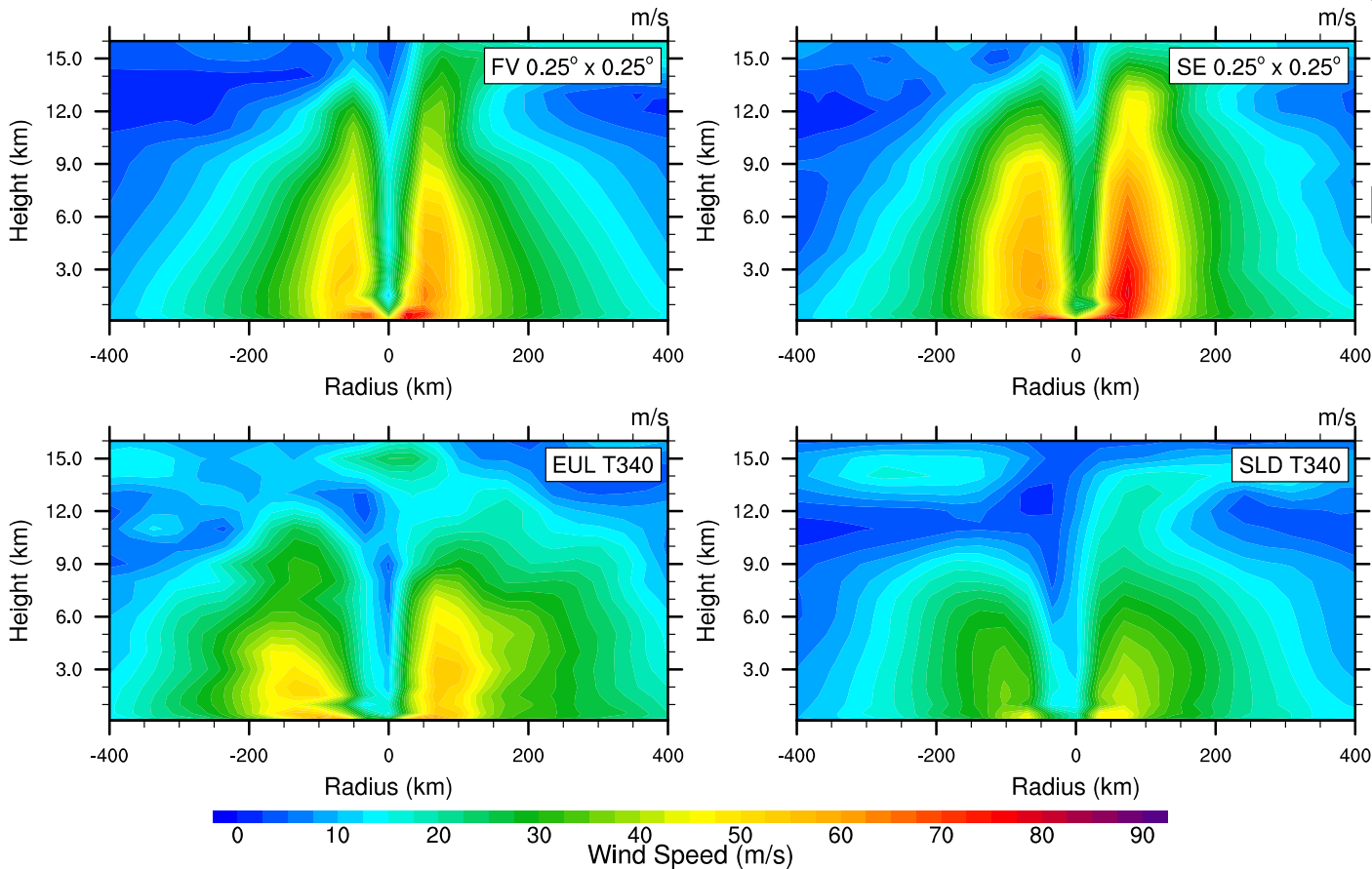
# How Do We Evaluate GCMs?

- Utilize a test hierarchy





# Intercomparison: Simple-Physics Simulations



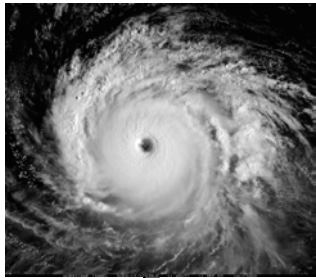
Wind Speed (m/s)  
At Day 10

Differing strengths  
and shapes:

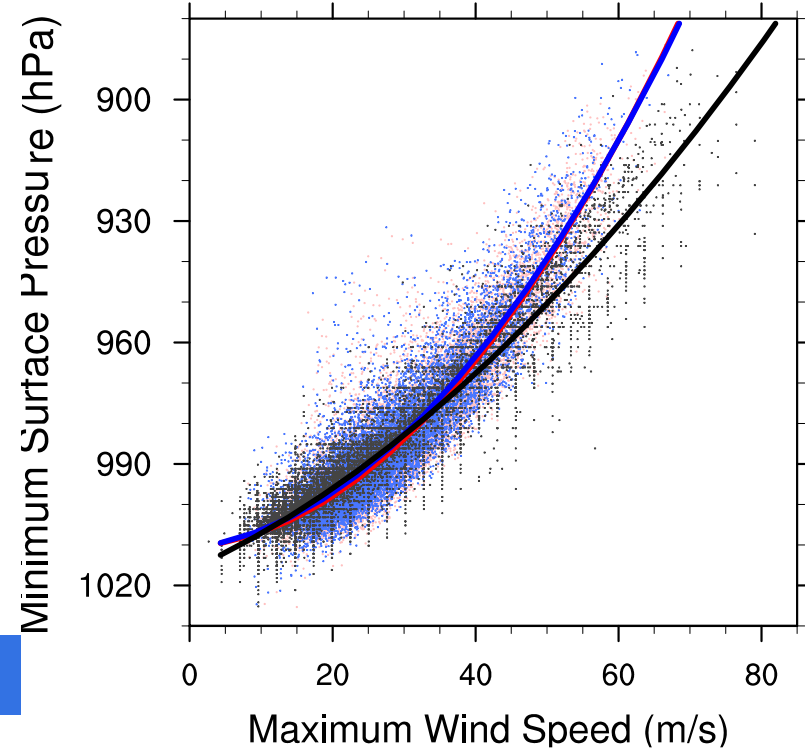
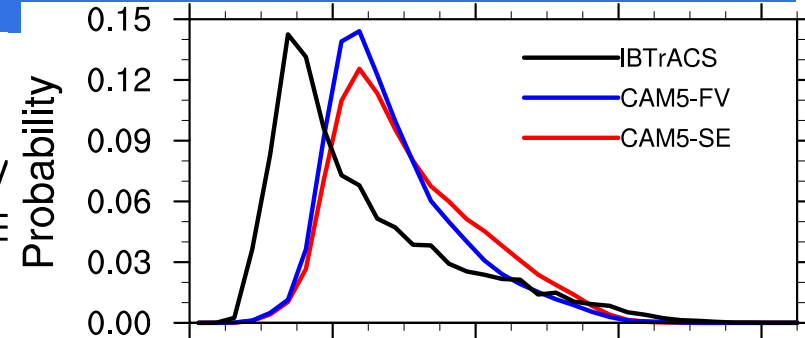
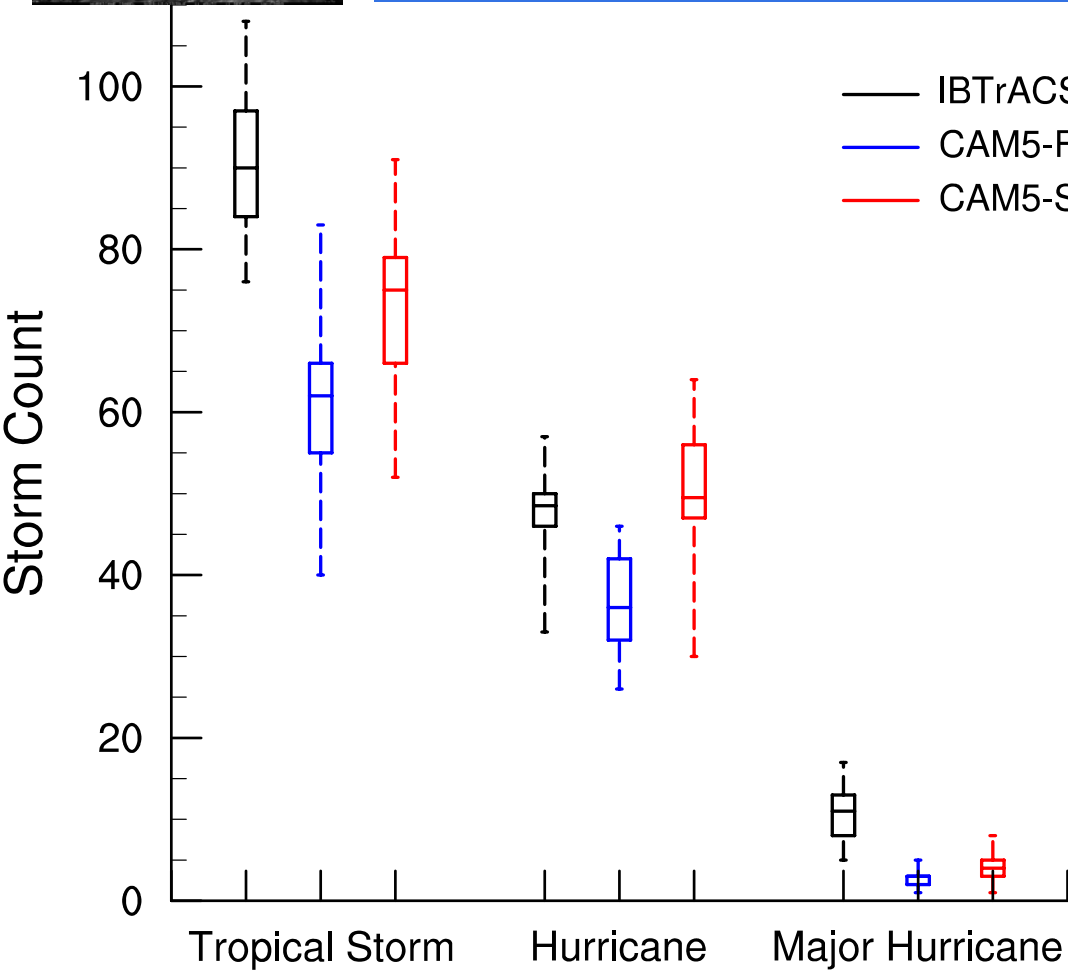
FV & SE  
at 0.25°  
( $\approx 28$  km)

EUL & SLD  
at T340  
( $\approx 39$  km)



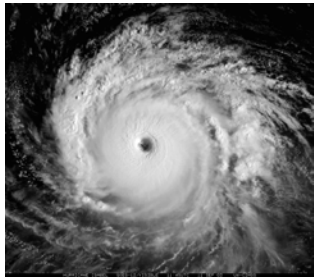


# Comparison to Full Decadal AMIP Simulations



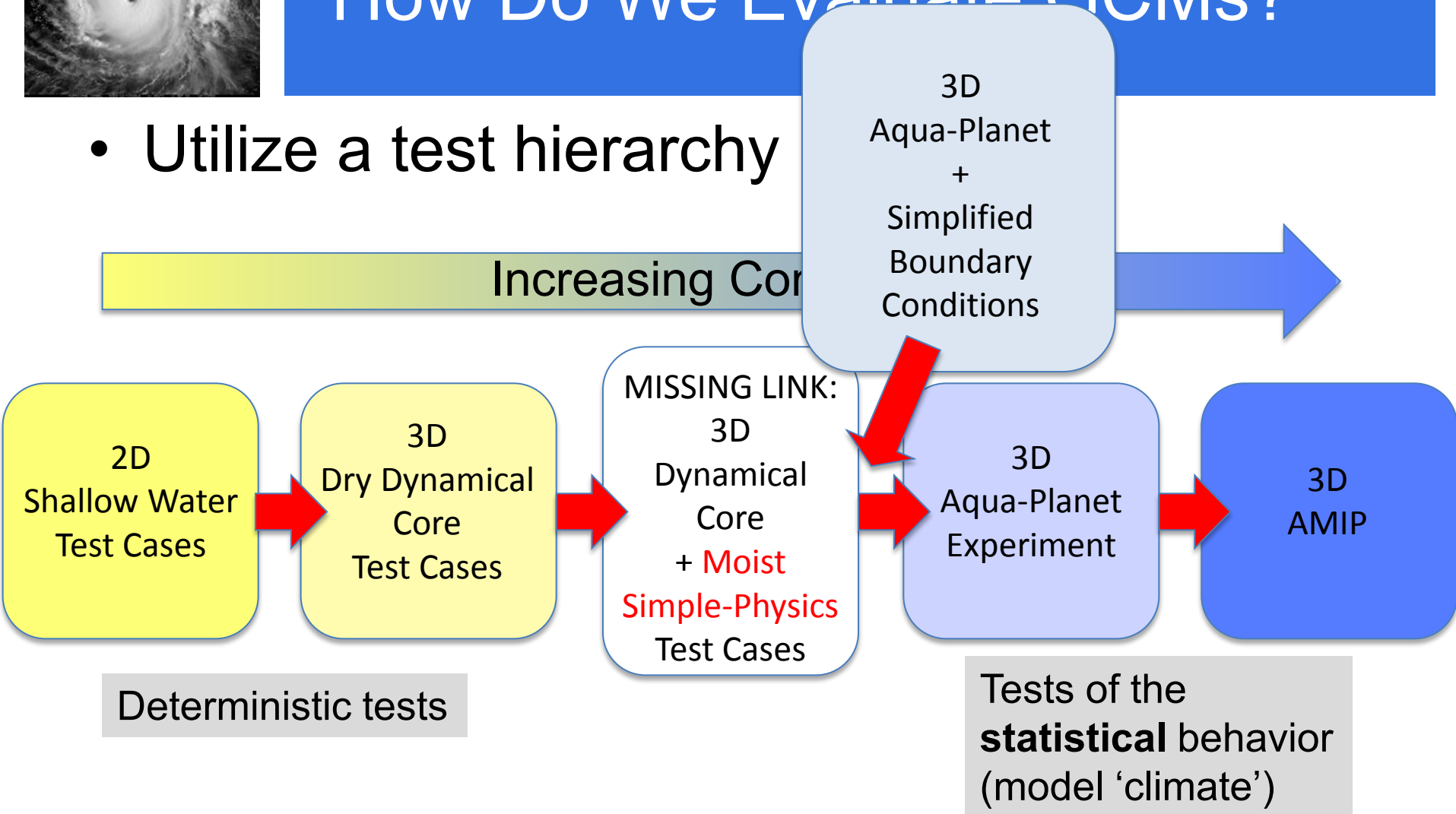
February 9th, 2016

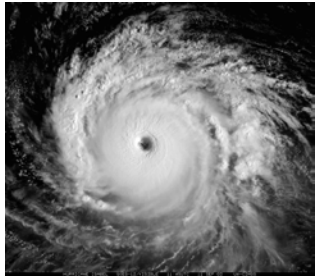
[Reed et al. 2015, GRL]



# How Do We Evaluate GCMs?

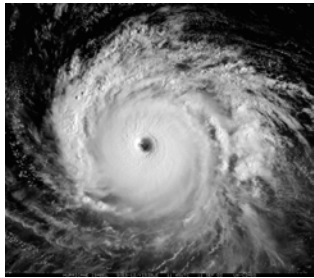
- Utilize a test hierarchy





# Design of Experiments

- NCAR's Community Atmosphere Model version 5.3 (CAM 5.3).
- The **SE** dynamical core with 30 vertical levels is used at the **horizontal resolutions** of:
  - ne=30 (~100 km)
  - ne=120 (~25 km)
- Full physics in Aquaplanet mode is used, with a simplified ocean covered Earth and constant SST of **29° C**.
- **No or uniform rotation** effects (i.e., 10 deg. N).
- Diurnally varying, spatially uniform **insolation** (~340 W/m<sup>2</sup>).
- No direct and indirect effects of aerosols.
- Tuning parameters are set to ne=30 configuration for all simulations.
- Such a setup mimics similar simulations with limited-area or cloud-resolving models, but at a relatively lower resolution.



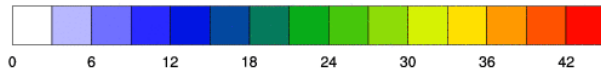
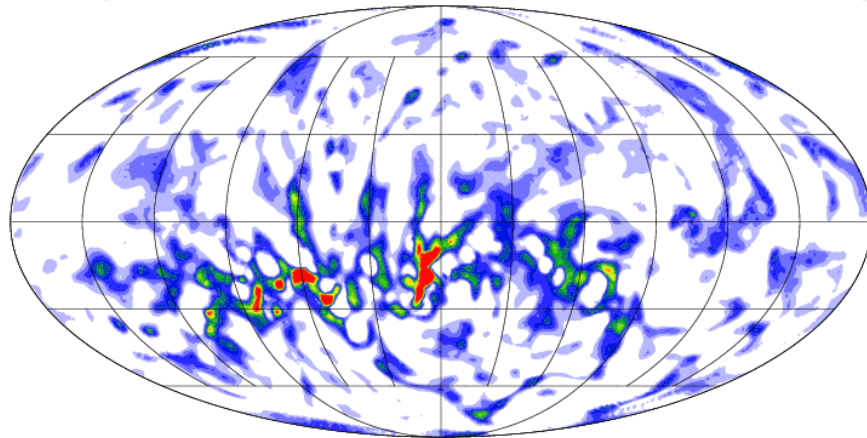
# No Rotation: Resolution Comparison

## 6-hr Avg. Precipitation (mm/day)

Day 365

Total Precipitation Rate

mm/day

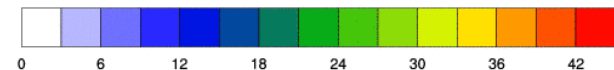
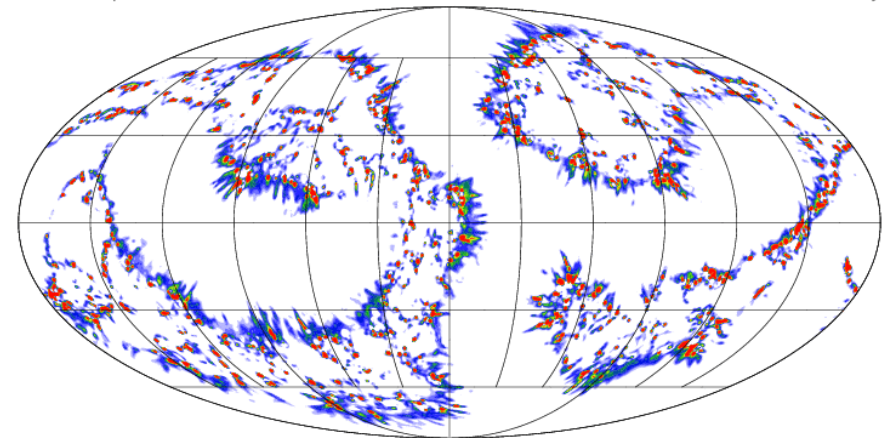


**ne30 (~100 km)**

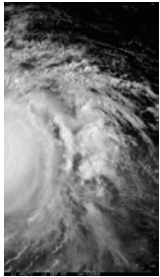
Day 365

Total Precipitation Rate

mm/day



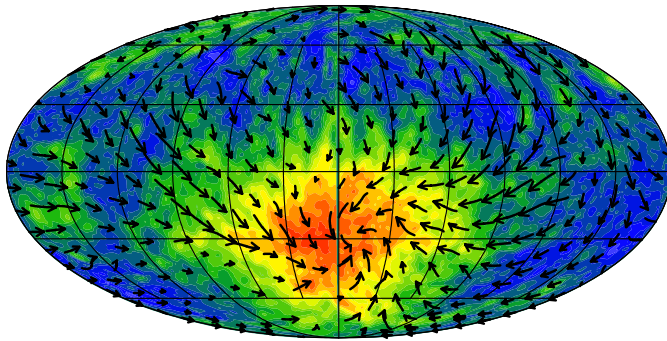
**ne120 (~25 km)**

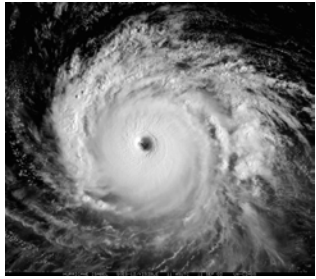


# No Rotation: Structure

**ne30 (~100 km)**

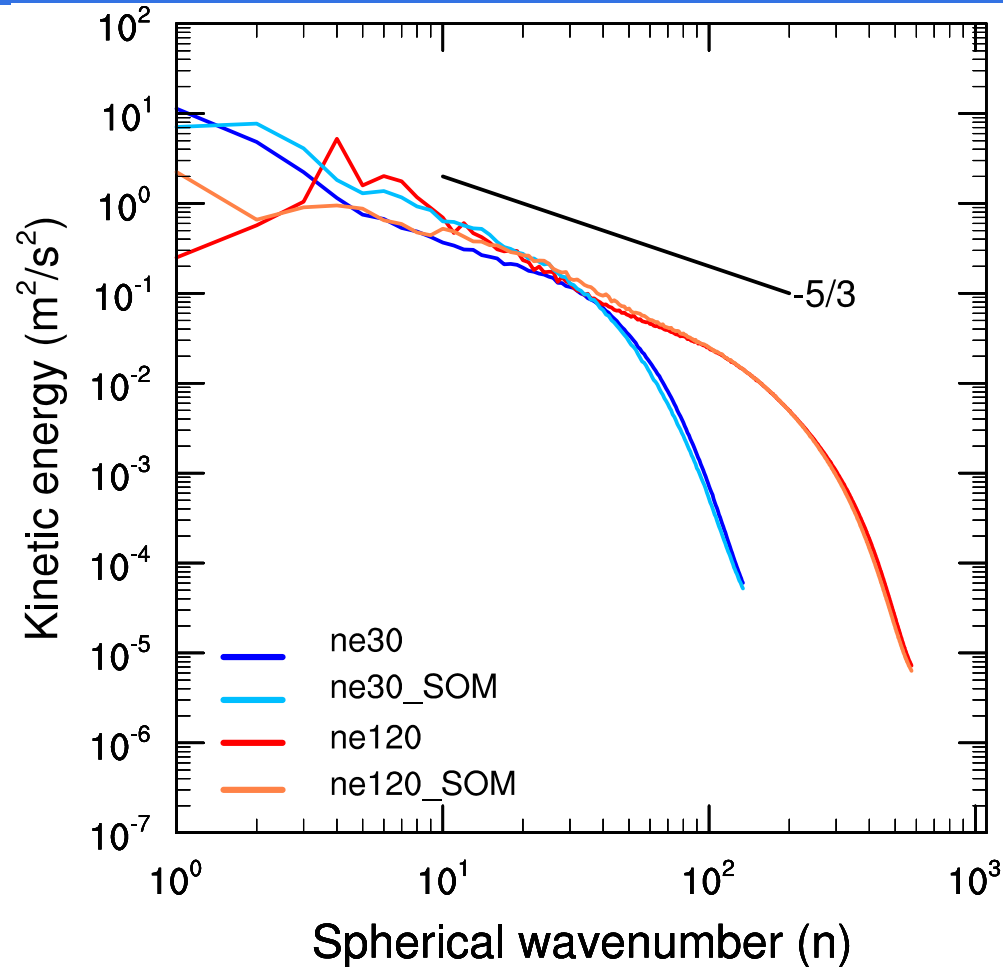
**ne120 (~25 km)**

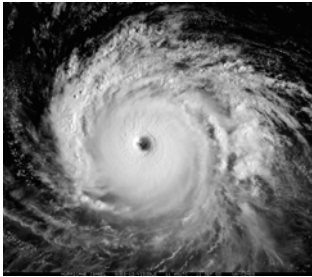




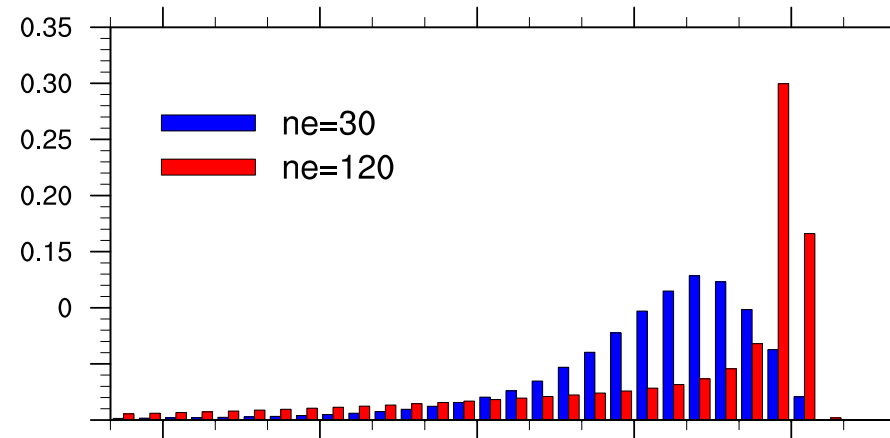
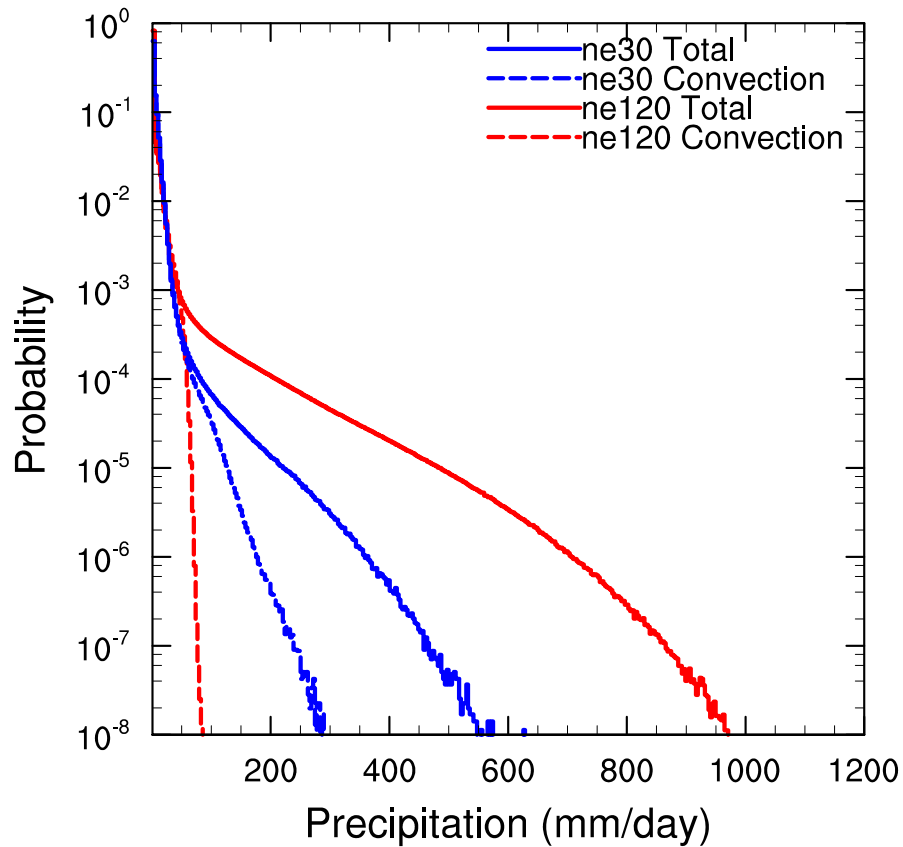
# This Simulations Are Unique

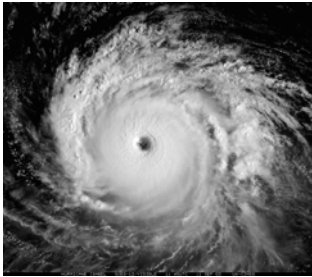
Exhibit behavior consistent with **mesoscale dynamics** and **turbulence**





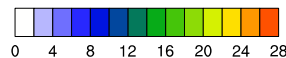
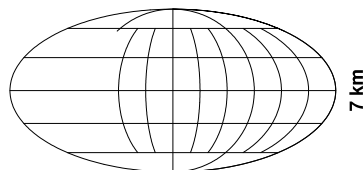
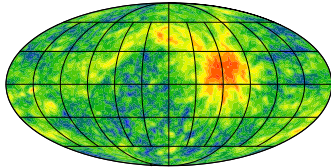
# No Rotation: Precipitation Extremes



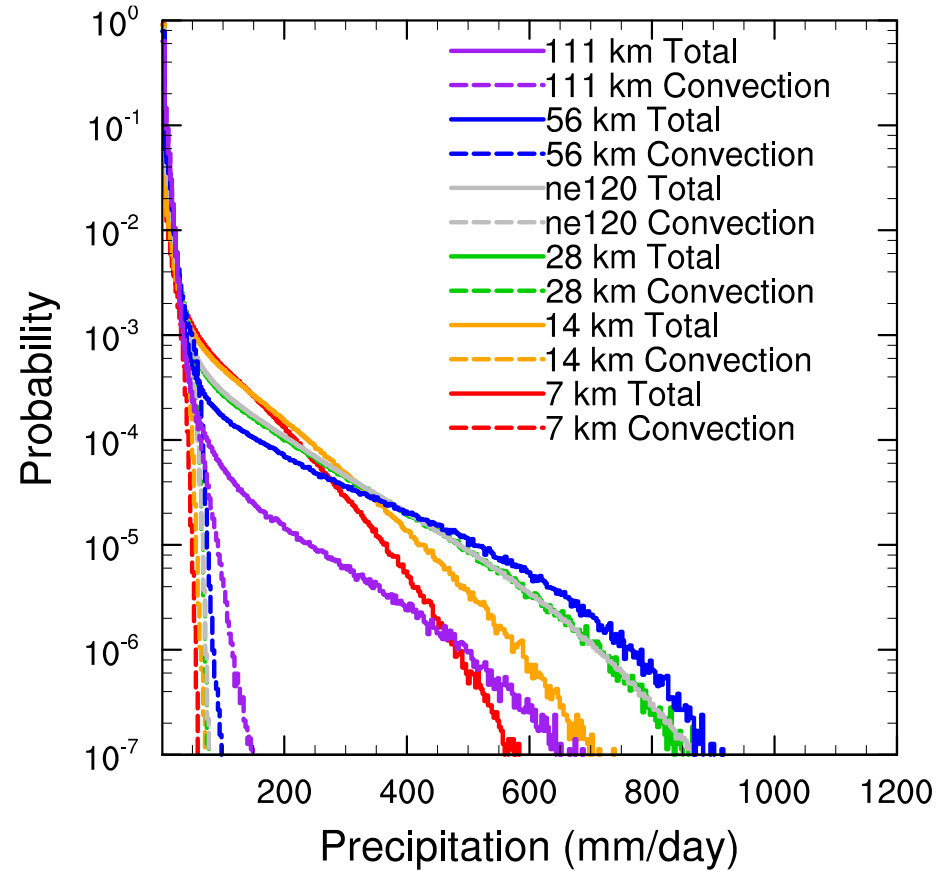


# Reduced Planet RCE

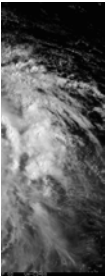
Total Precipitation



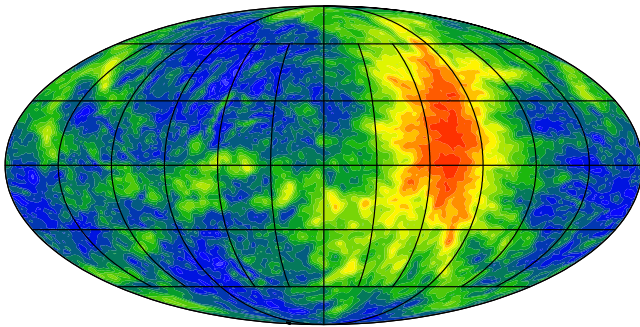
Precipitation (mm/day)

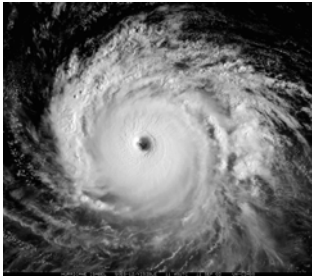






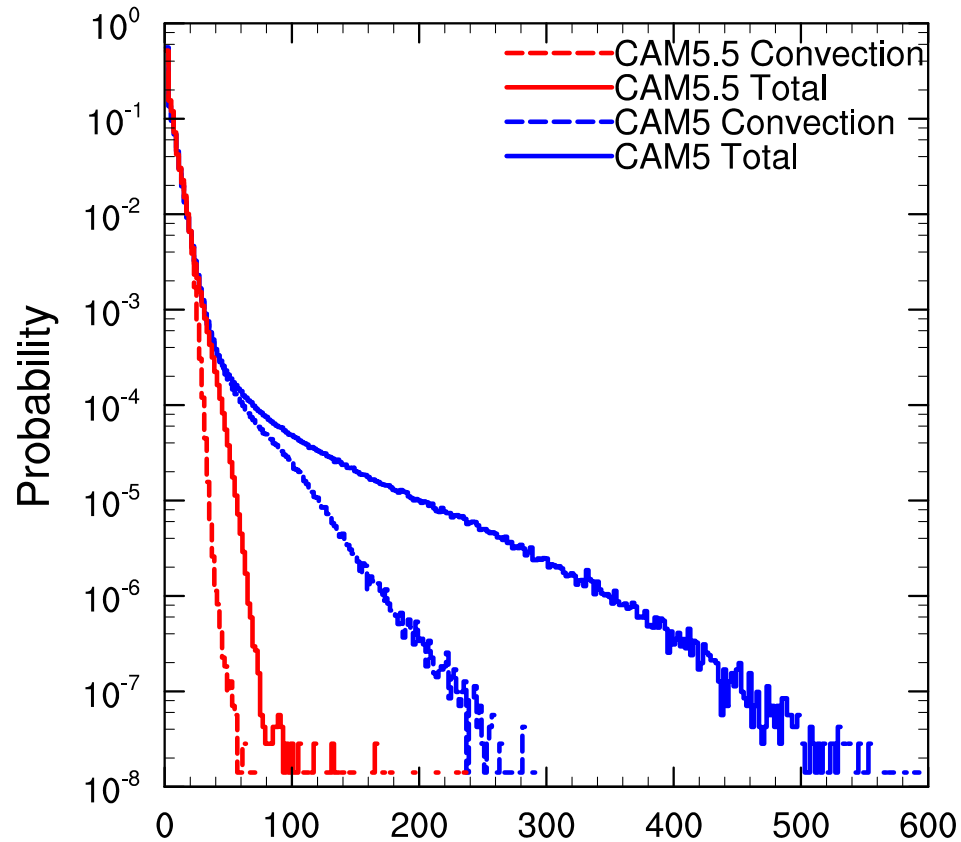
# Impact of Parameterizations

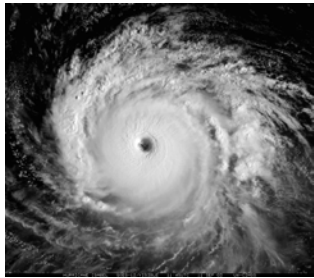




# Impact of Parameterizations

CAM-SE ne30 (111 km)





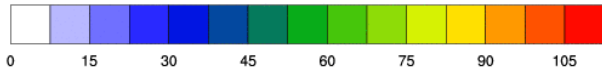
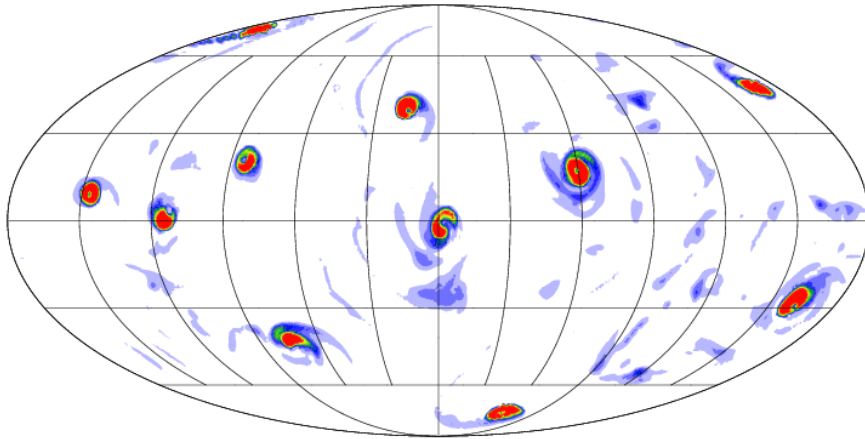
# Resulting TC World

## 6-hr Avg. Precipitation (mm/day)

Day 365

Total Precipitation Rate

mm/day

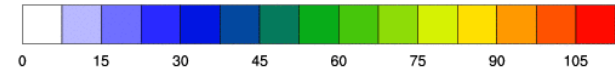
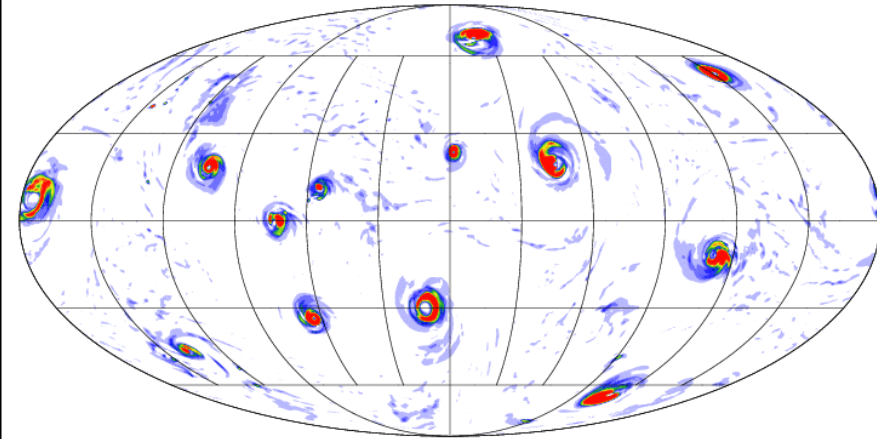


**ne30 (~100 km)**

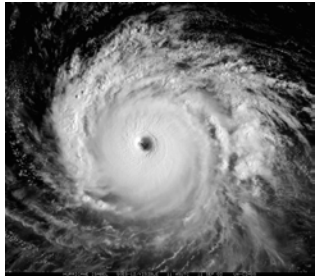
Day 365

Total Precipitation Rate

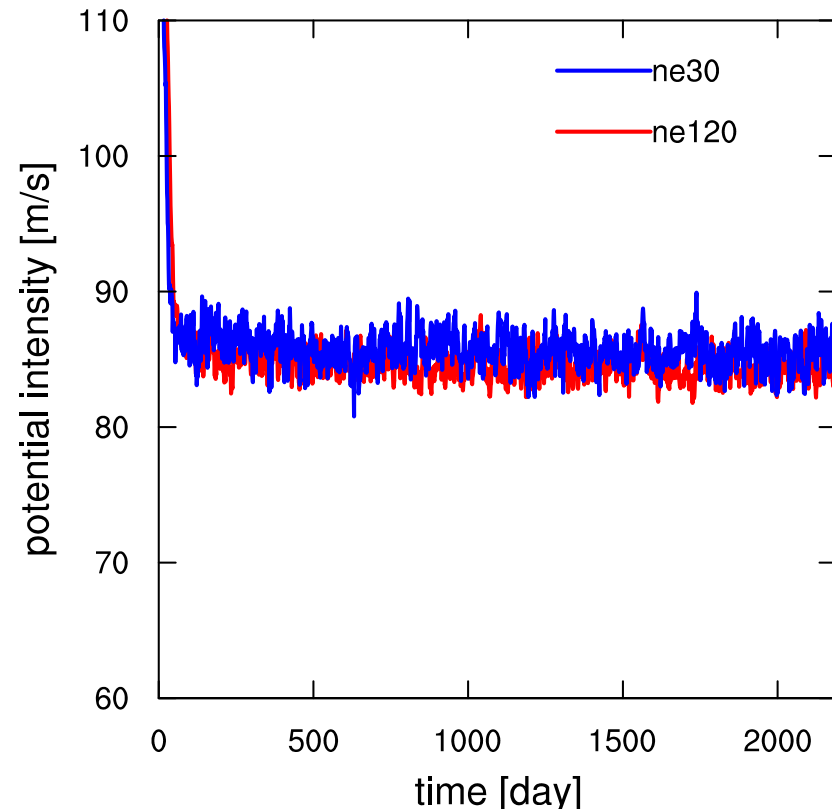
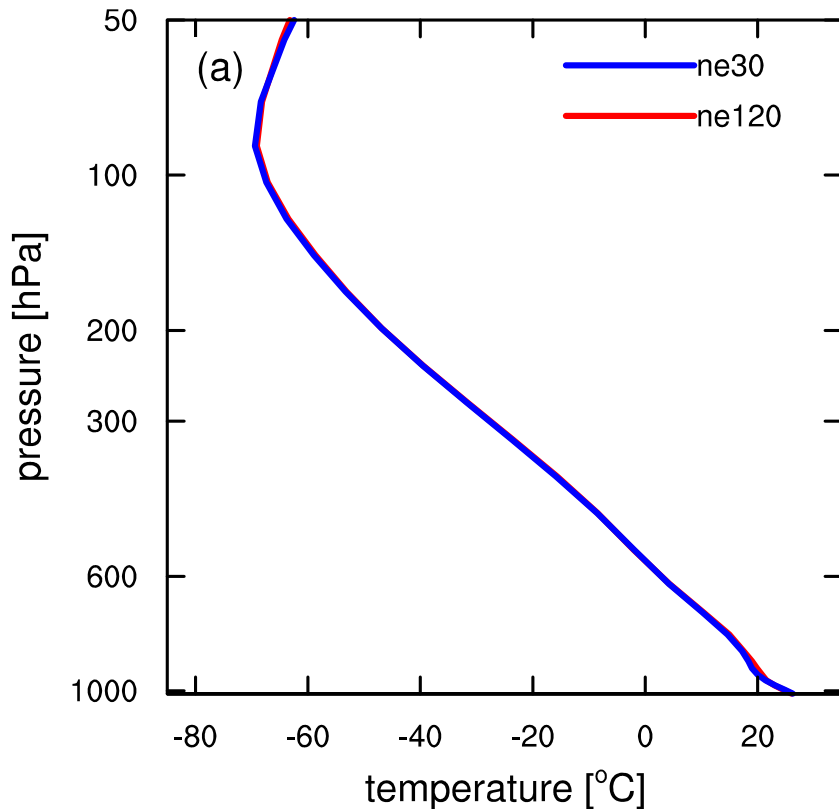
mm/day



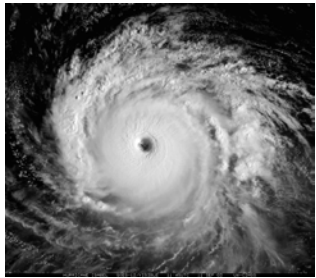
**ne120 (~25 km)**



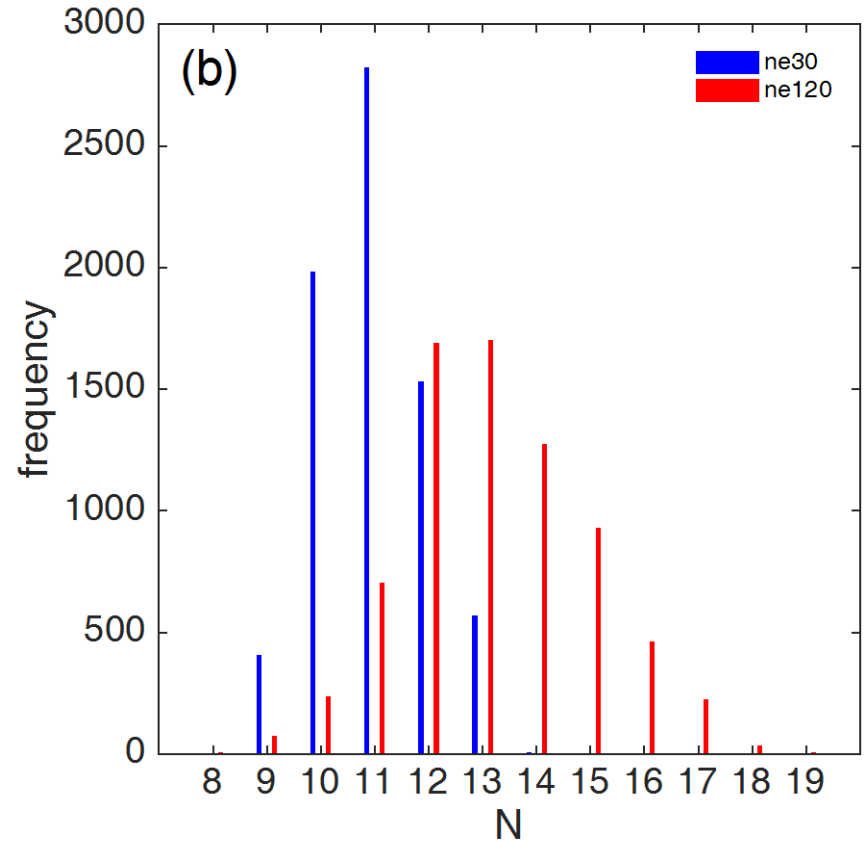
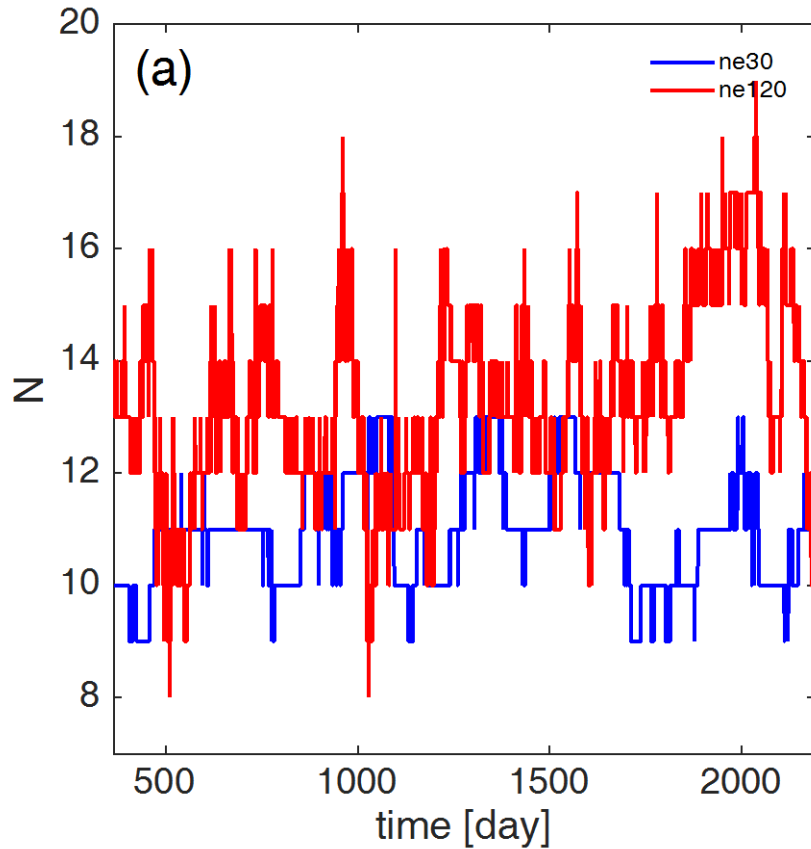
# Mean Environment

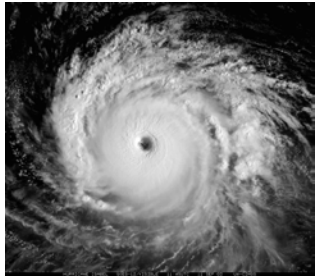


The mean environment is very **similar** in the rotating case

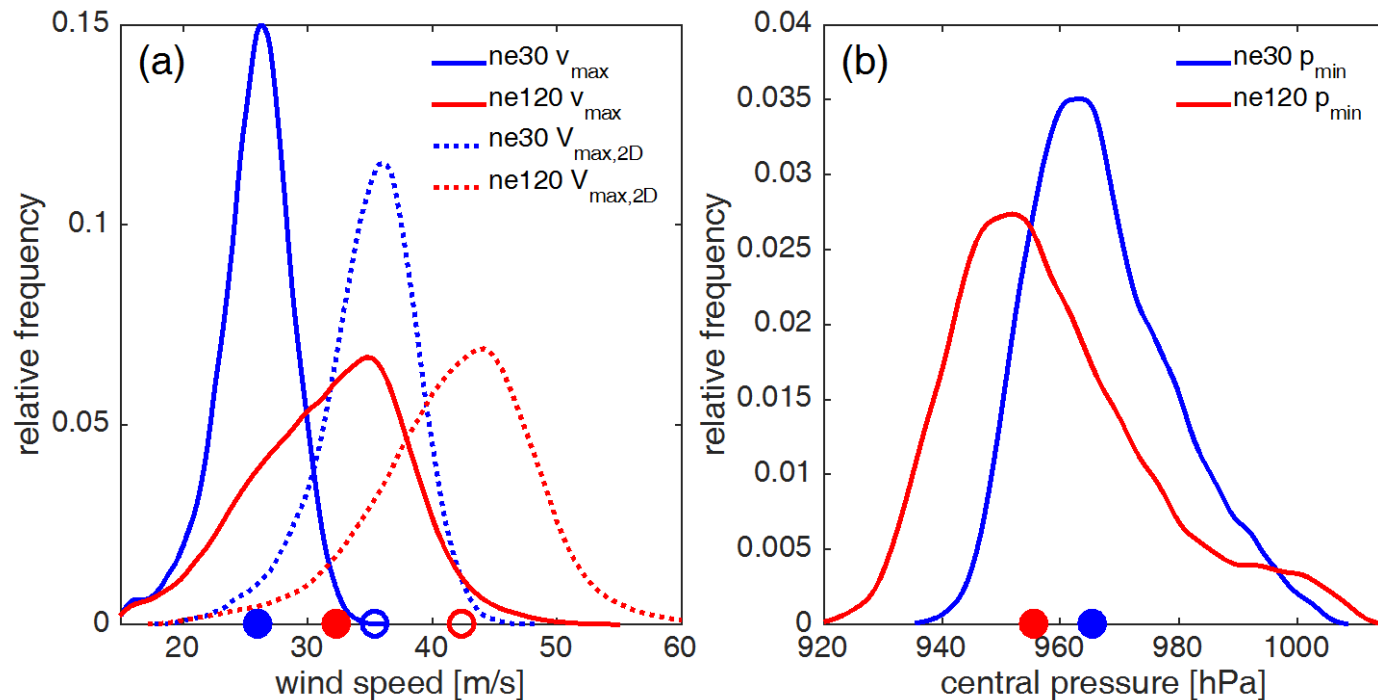


# Storm Count

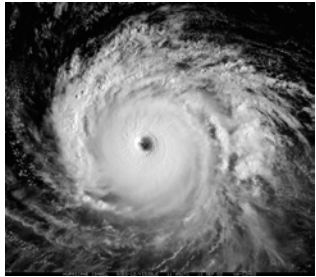




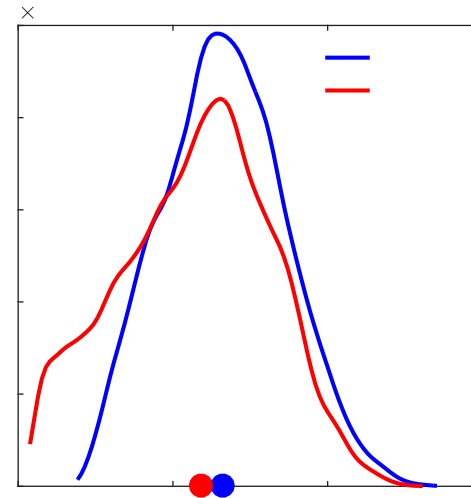
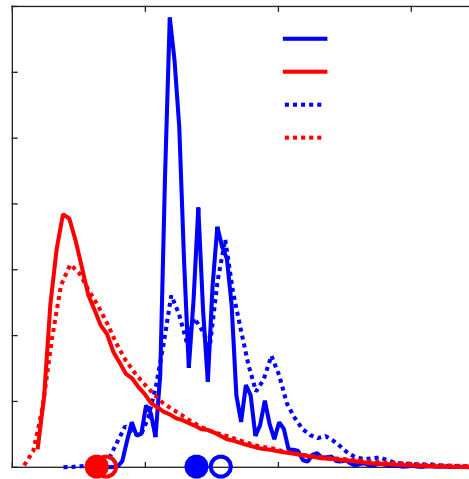
# Intensity Distributions



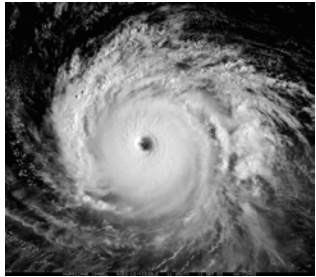
- Intensity **increases** with resolution.
- Absolute maximum wind behaves similarly to azimuthal wind, but with higher values



# TC Size Distributions

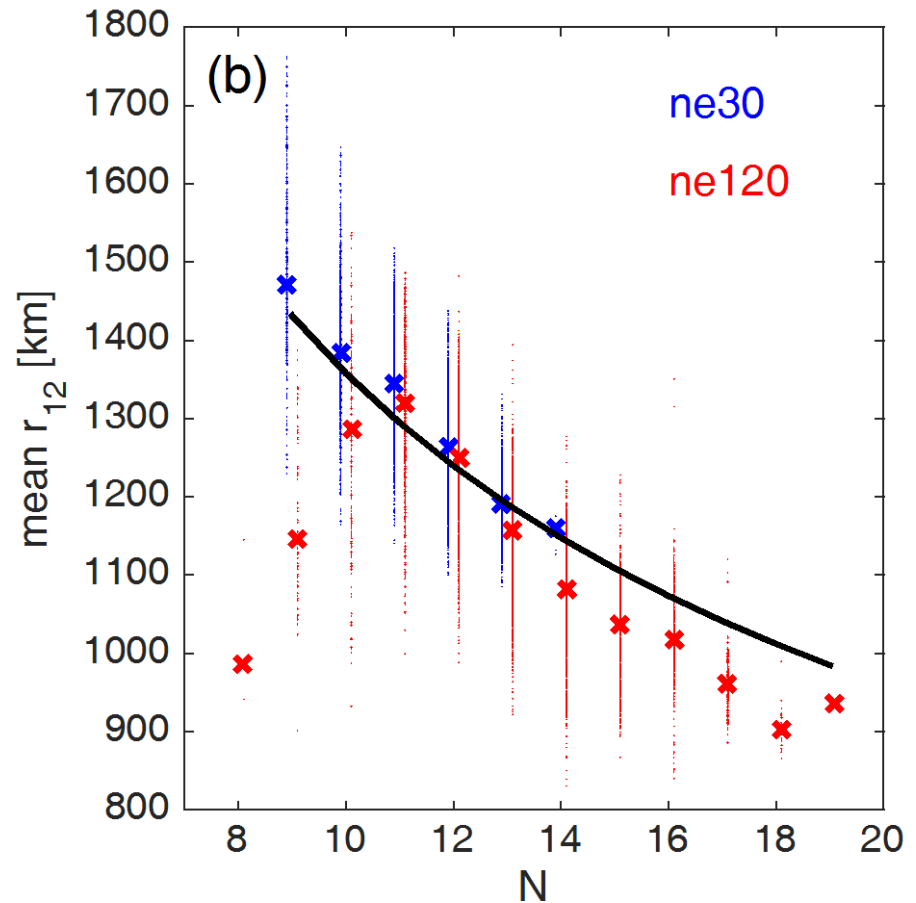


- The difference in  $r_{\max}$  between the two resolutions is large.
- While the difference in the  $r_{12}$  distribution is not as large and with a consistent shape of the distributions.

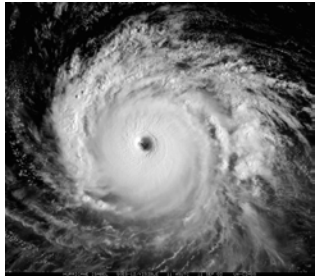


# Storm Coverage

- Strongly anti-correlated.
- Consistent with the scaling that would be predicted by assuming constant global areal coverage.

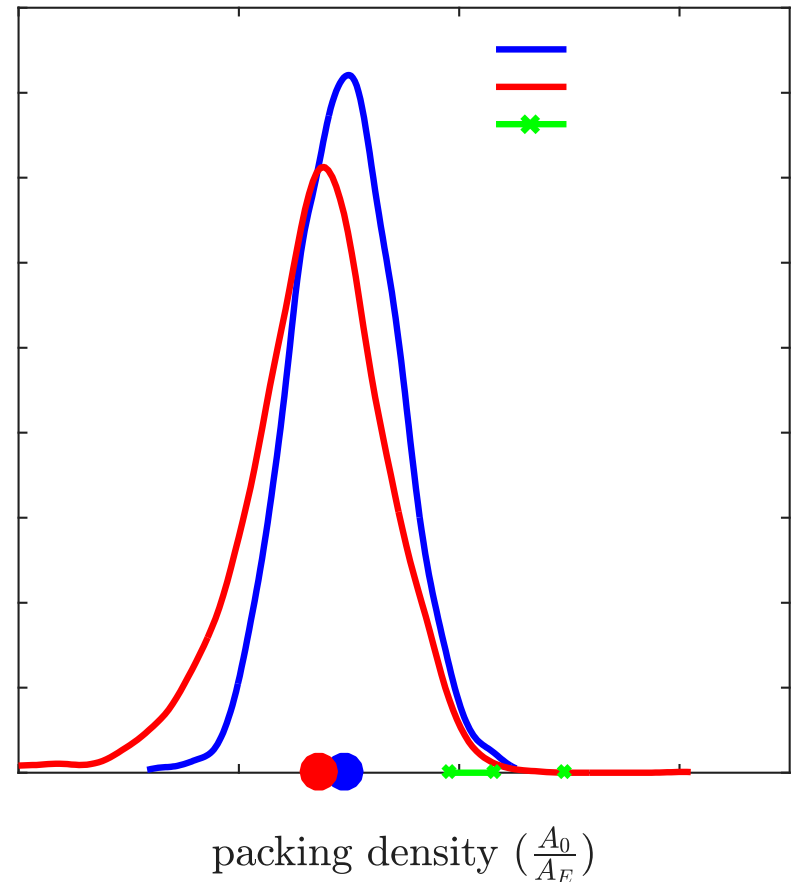


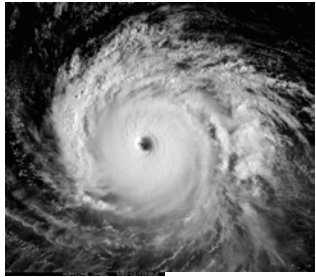




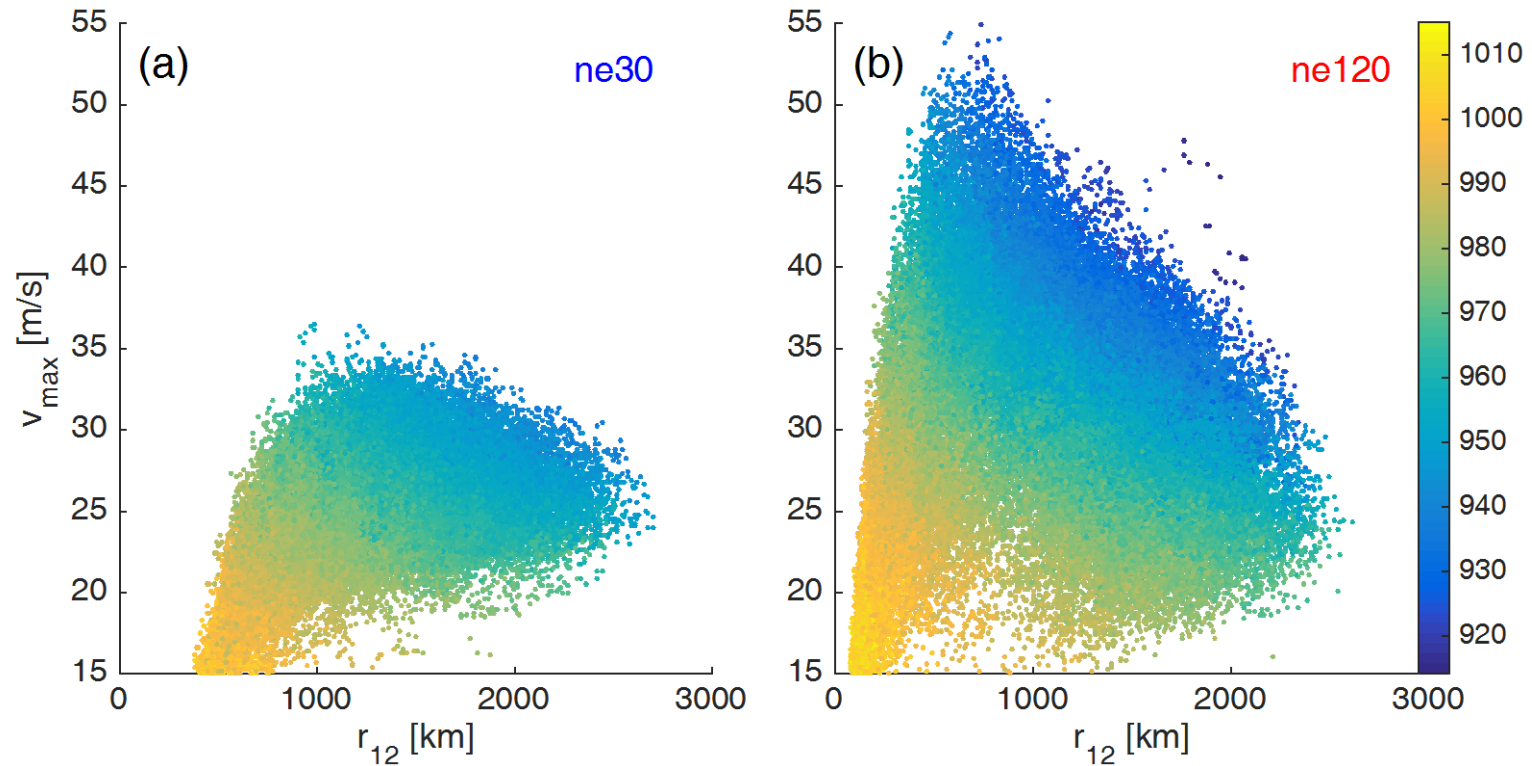
# Storm Coverage

- Packing density: the theoretical maximum packing density of circles on the surface a sphere [Clare and Kepert, 1991].
- Theoretical maximum packing density values appears to provide a credible prediction for the upper bound on our packing density.

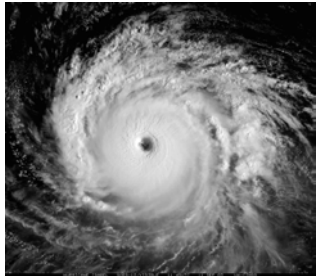




# What Determines Intensity?



- The two covariates captures 92% and 94% of variance of minimum surface pressure.



# Final Thoughts

- A **hierarchical** approach is crucial to understanding the simulation of **extreme events** in high-resolution GCMs.
- **Reduced complexity** configurations are ideal candidates for process studies and understanding of:
  - GCM model resolution
  - GCM model physics
  - GCM model dynamical core
  - Different GCMs

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