TROPICAL CONVECTION AND SUBSEASONAL PREDICTION IN A GLOBAL CONVECTION-PERMITTING MODEL

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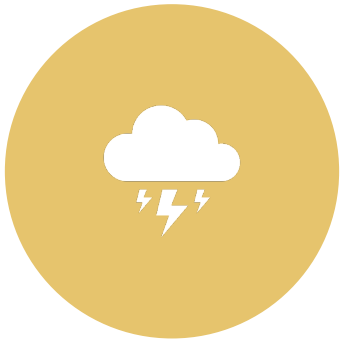
WRF/MPAS USERS WORKSHOP -- WEDNESDAY, JUNE 9, 2021

MOTIVATION

GLOBAL EXTENDED FORECASTS ARE DEGRADED BY POORLY SIMULATED TROPICAL CONVECTION



LARGE SCALE TROPICAL VARIABILITY IS NOT WELL CAPTURED

- MJO
- Convectively coupled waves

DEFICIENT SIMULATION OF IMPORTANT PROCESSES

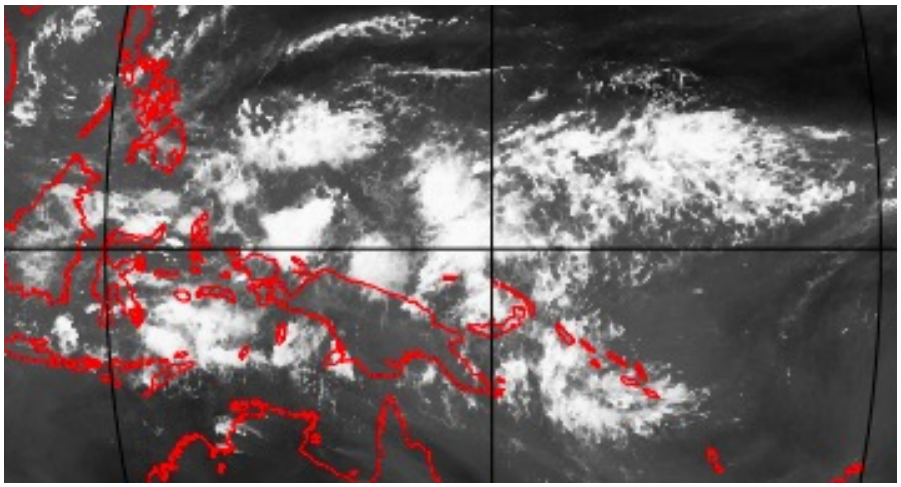
- Diurnal cycle
- Widespread light rain
- Moisture-precipitation relationship[s]

HOW CAN WE IMPROVE SIMULATED CONVECTION IN THE TROPICS?

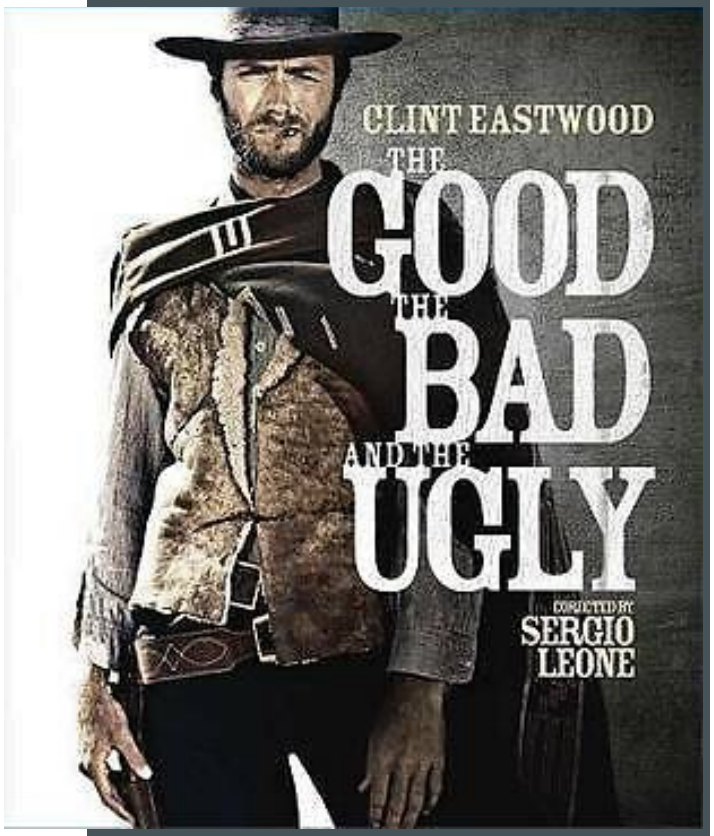
- Improve cumulus parameterizations
- Use a convection-permitting model

CONVECTION-PERMITTING MODELS (CPM'S)

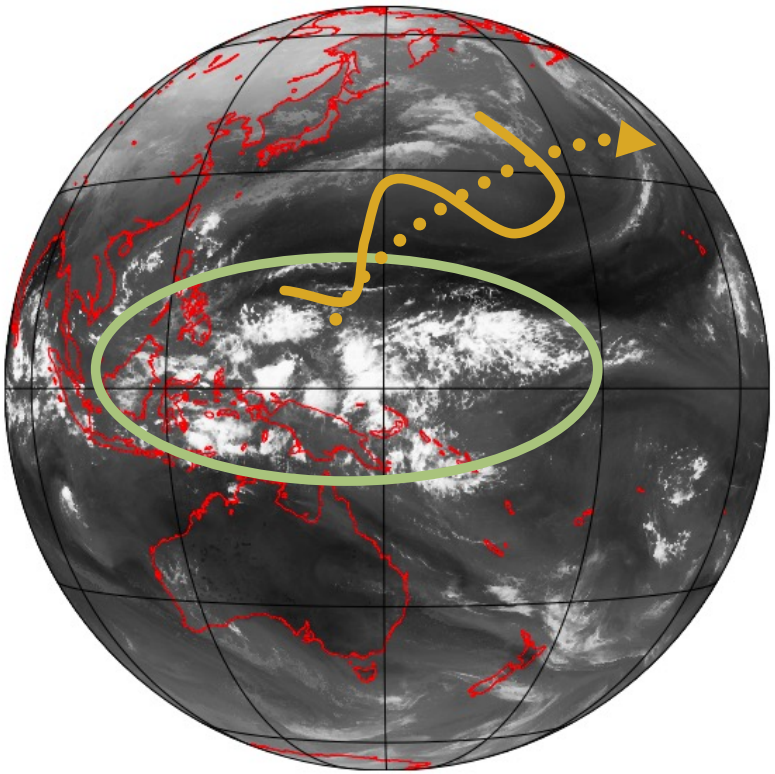
- More realistically simulate numerous aspects of tropical convection
- High computational cost typically results in **compromises:**
  - "Gray zone" resolution
  - Small domains
  - Short integrations




Compromise


CLINT EASTWOOD
THE
GOOD
THE
BAD
AND THE
UGLY
DIRECTED BY
SERGIO
LEONE

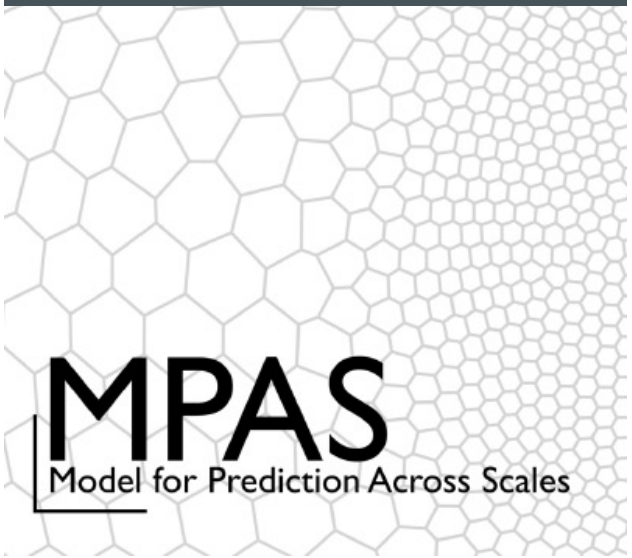
NO COMPROMISE EXPERIMENT



Extended GLOBAL CPM

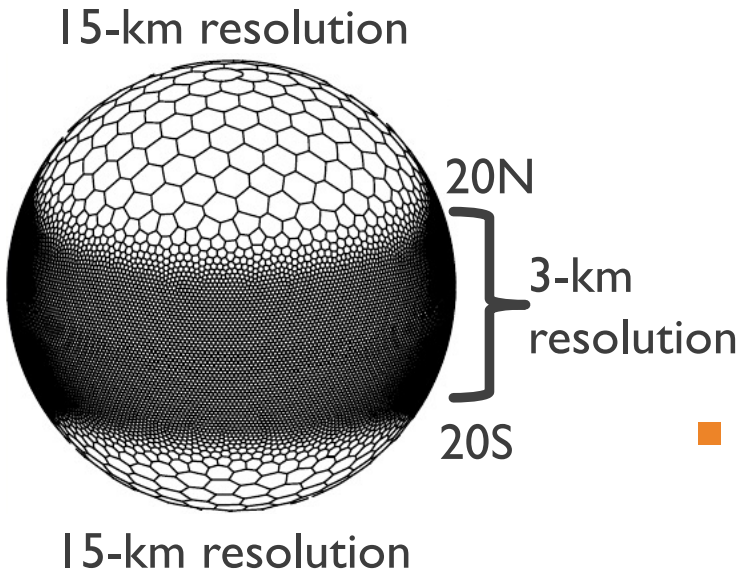
- Few such simulations in the literature
- Examine the potential for extended prediction
- Captures both tropical convection and its teleconnections

SIMULATIONS



- The model: MPAS v5.1 (global)
- Physics: 'convection_permitting' suite
- GFS analyses used for initialization
- **Sea surface temperatures (SSTs) fixed at initial value**
- Four cases (all integrated 28 days):
  - November 22, 2011 (DYNAMO)
  - February 8, 2013
  - December 2, 2003
  - December 8, 2013

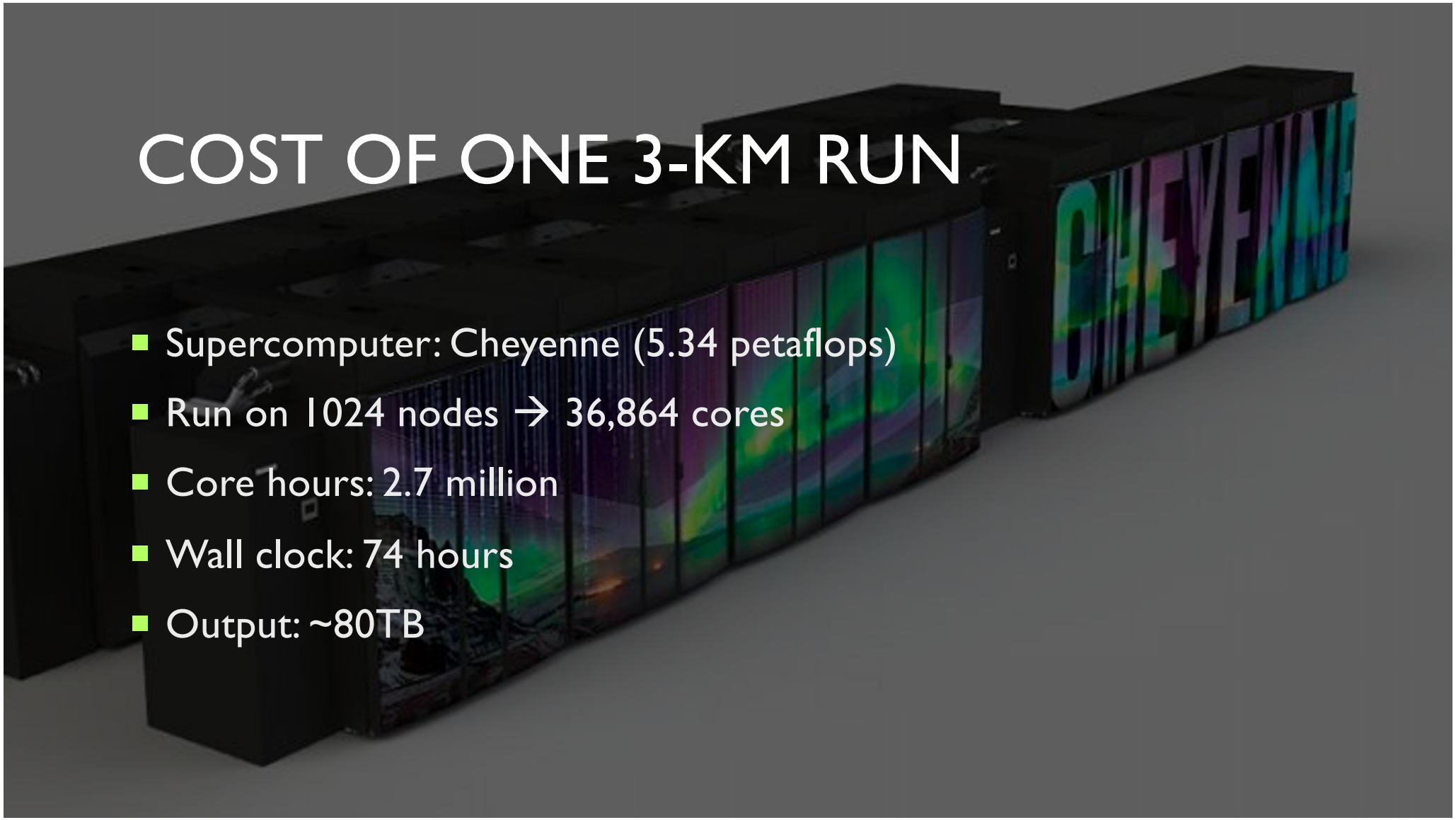
SIMULATIONS



- Configurations:
  - 15-km resolution, nTiedke Cu scheme (**M15**)
  - 3-km resolution, no Cu scheme (**M3**)
  - 15-km resolution, no Cu scheme (**M15noCu**)
  - 15-to-3-km tropical channel, Grell-Freitas (**Mchannel**)*
- Verification: satellite measurements, ERA5 reanalysis

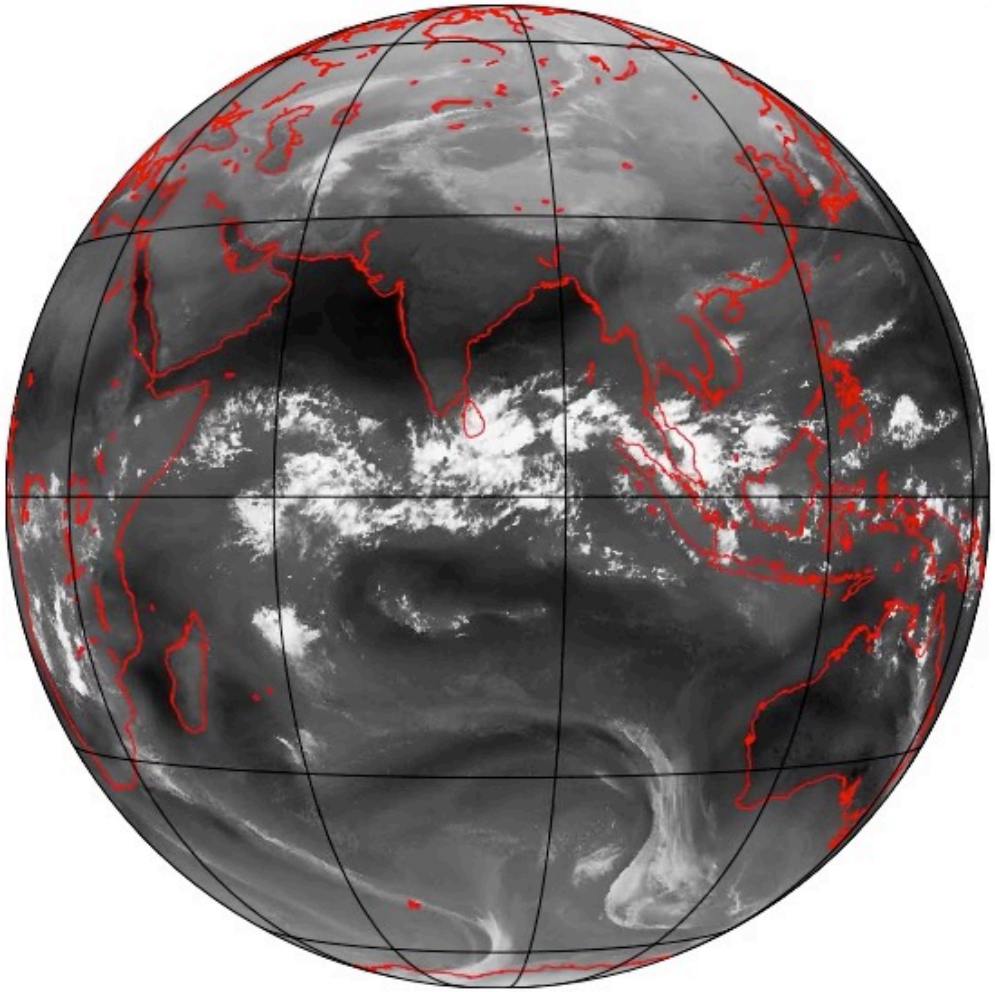
*only for case 1

COST OF ONE 3-KM RUN



- Supercomputer: Cheyenne (5.34 petaflops)
- Run on 1024 nodes → 36,864 cores
- Core hours: 2.7 million
- Wall clock: 74 hours
- Output: ~80TB

SATELLITE OR MODEL?

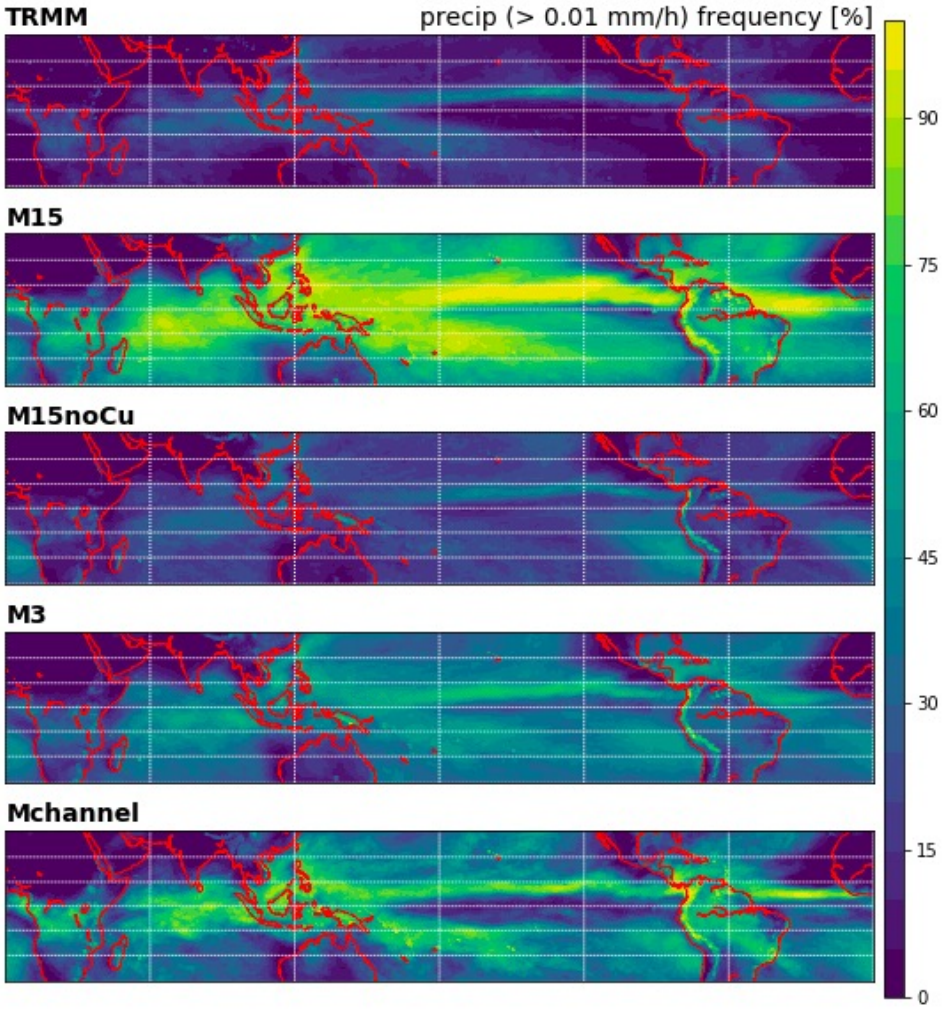


PRECIPITATION STATISTICS

Frequency of

> light

precipitation

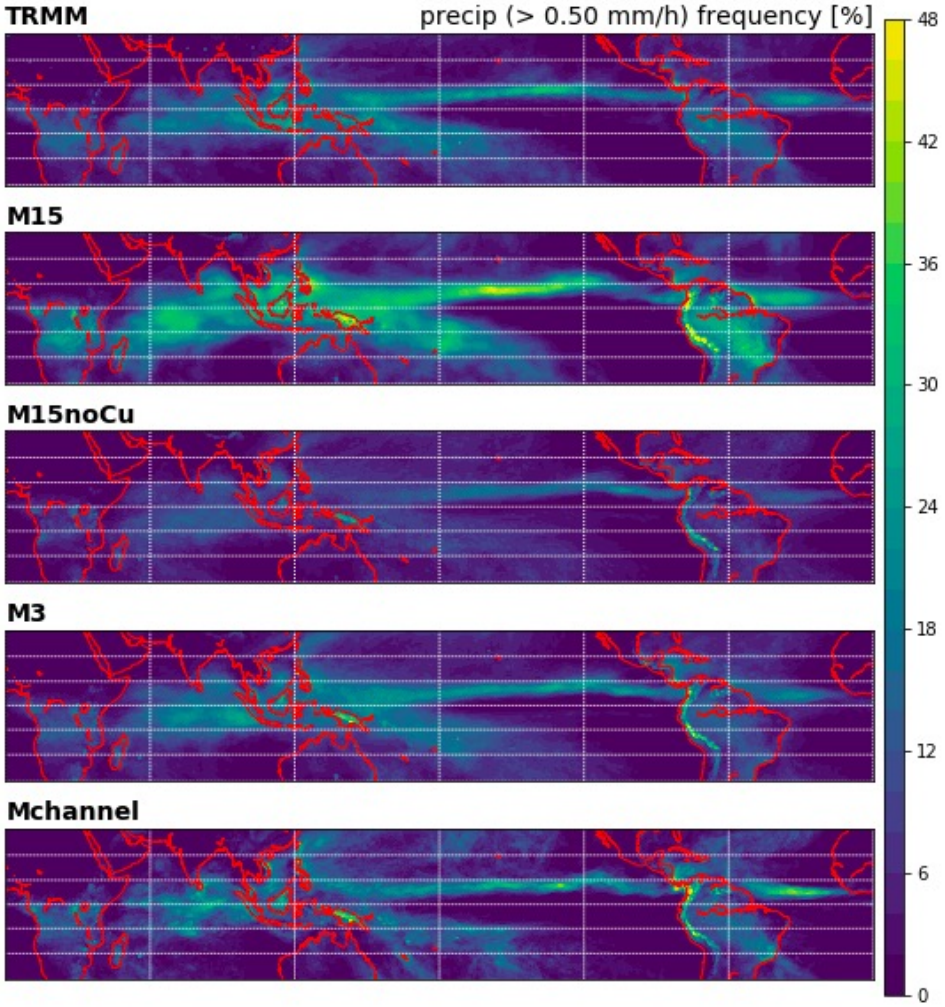


PRECIPITATION STATISTICS

Probability of

> moderate

precipitation

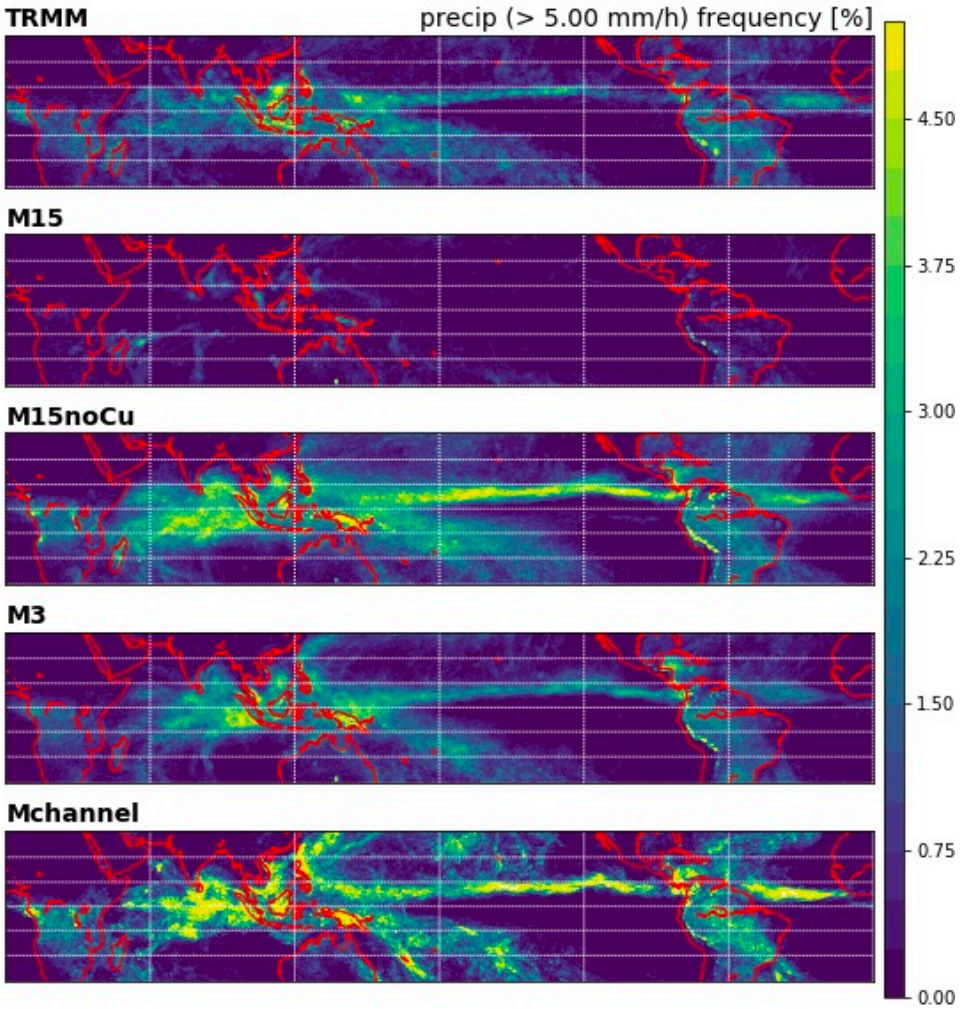


PRECIPITATION STATISTICS

Probability of

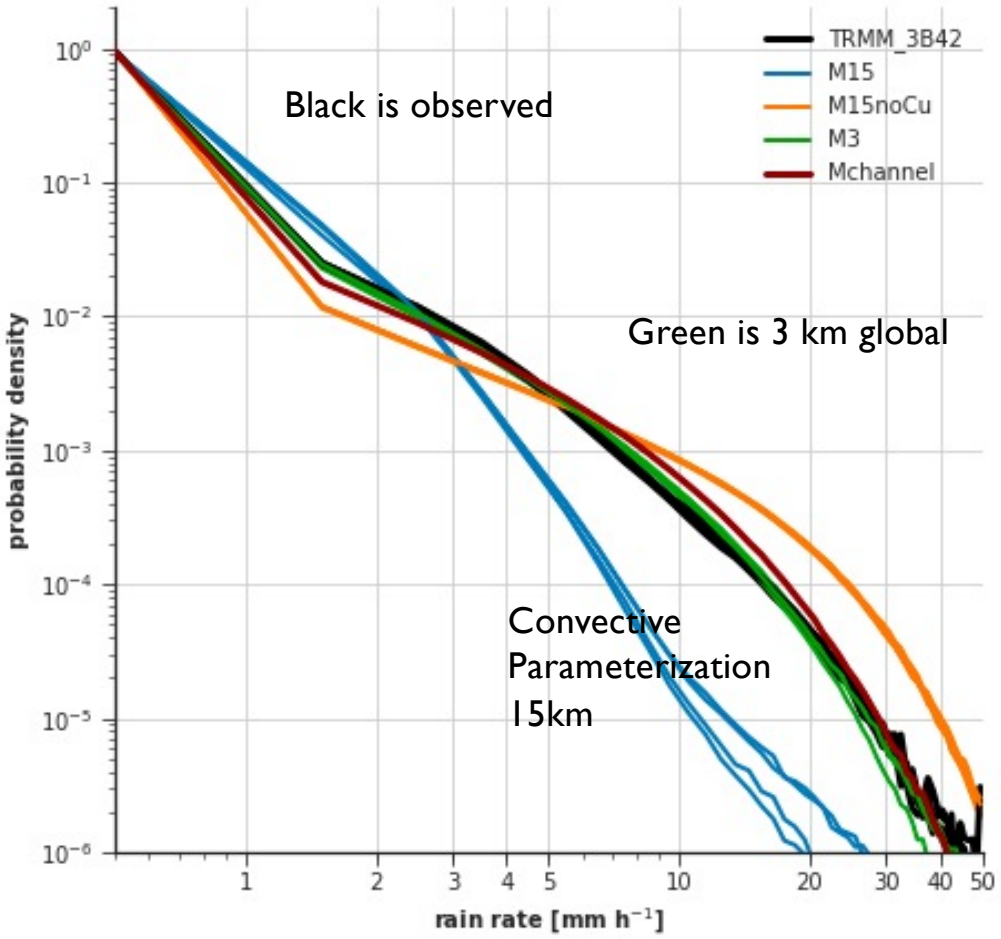
> heavy

precipitation



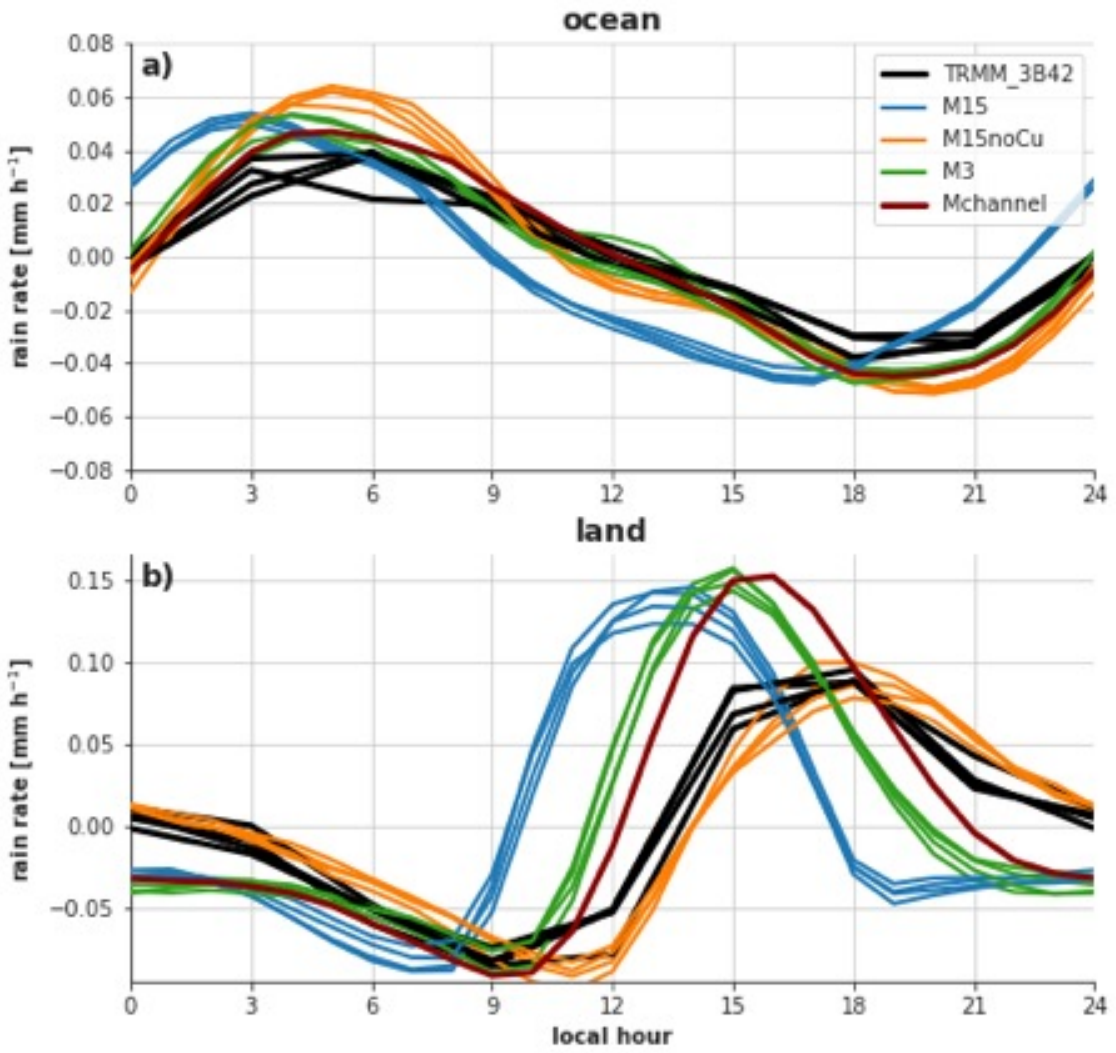
PRECIPITATION STATISTICS

- M15 produces too much (little) light (heavy) precipitation
- Opposite issue when you take away the Cu scheme (M15noCu)
- M3 and Mchannel closely match TRMM estimates



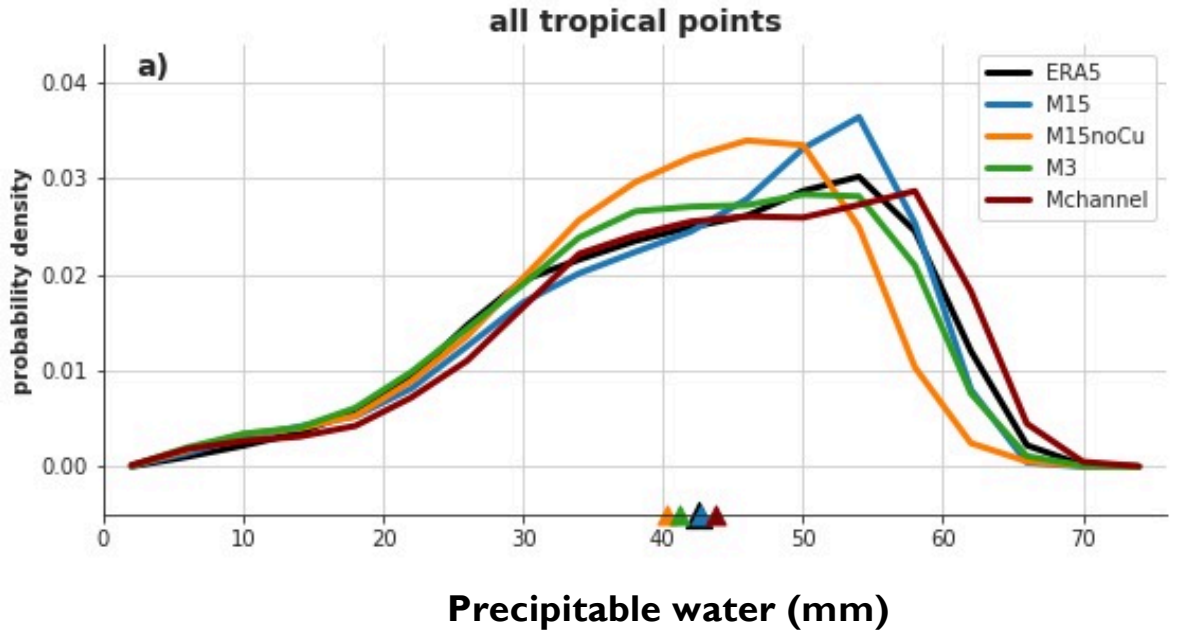
DIURNAL PRECIPITATION

- Over ocean, diurnal timing is improved when parameterization is not used in the tropics
- Over land, 3 km explicit helps, but noCU is better!



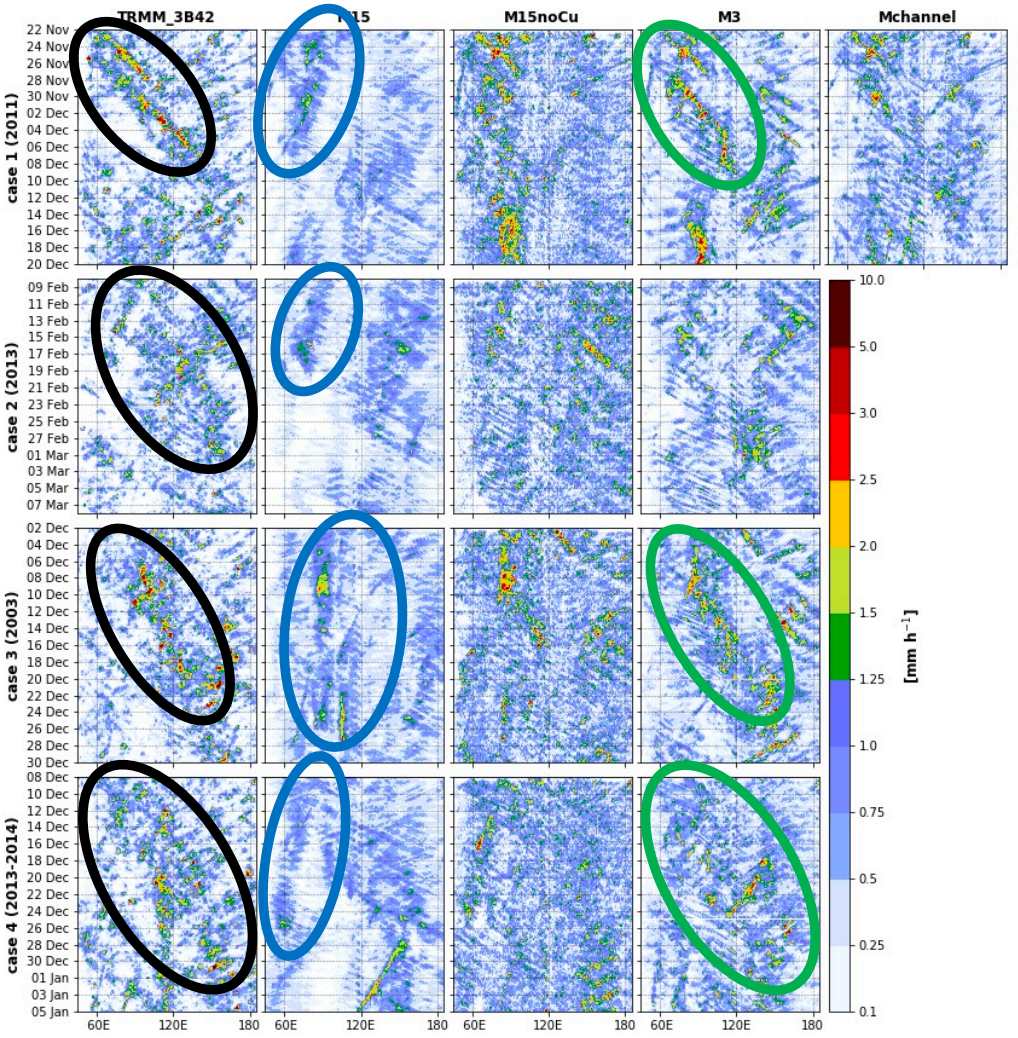
PRECIPITABLE WATER IN THE TROPICS

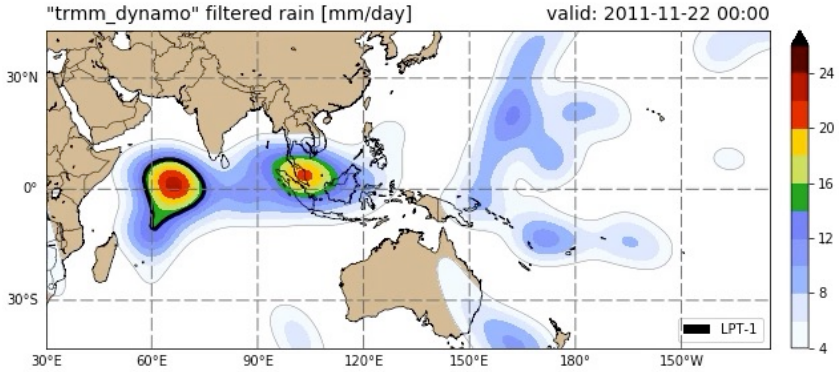
- 3-km global is best, with 15-km no convection underplaying moisture



- Eastward-propagating MJO in observations
- The global CPM (M3) is the only configuration able to capture its eastward propagation
- M15 favors stationary or westward-moving convection

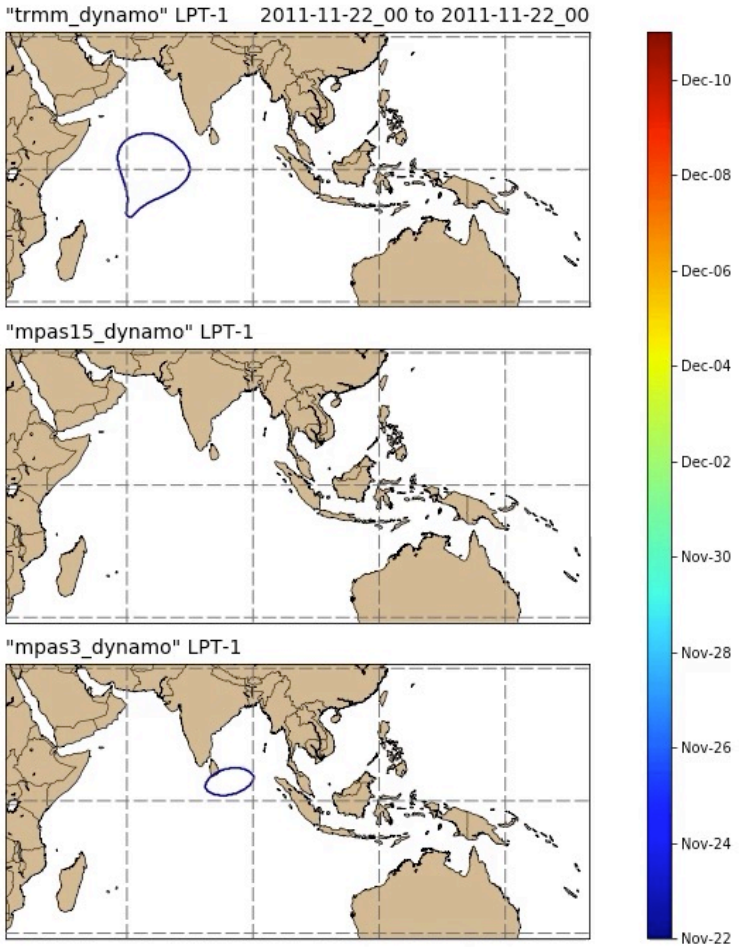
THE MJO:
PROPAGATION CHARACTERISTICS





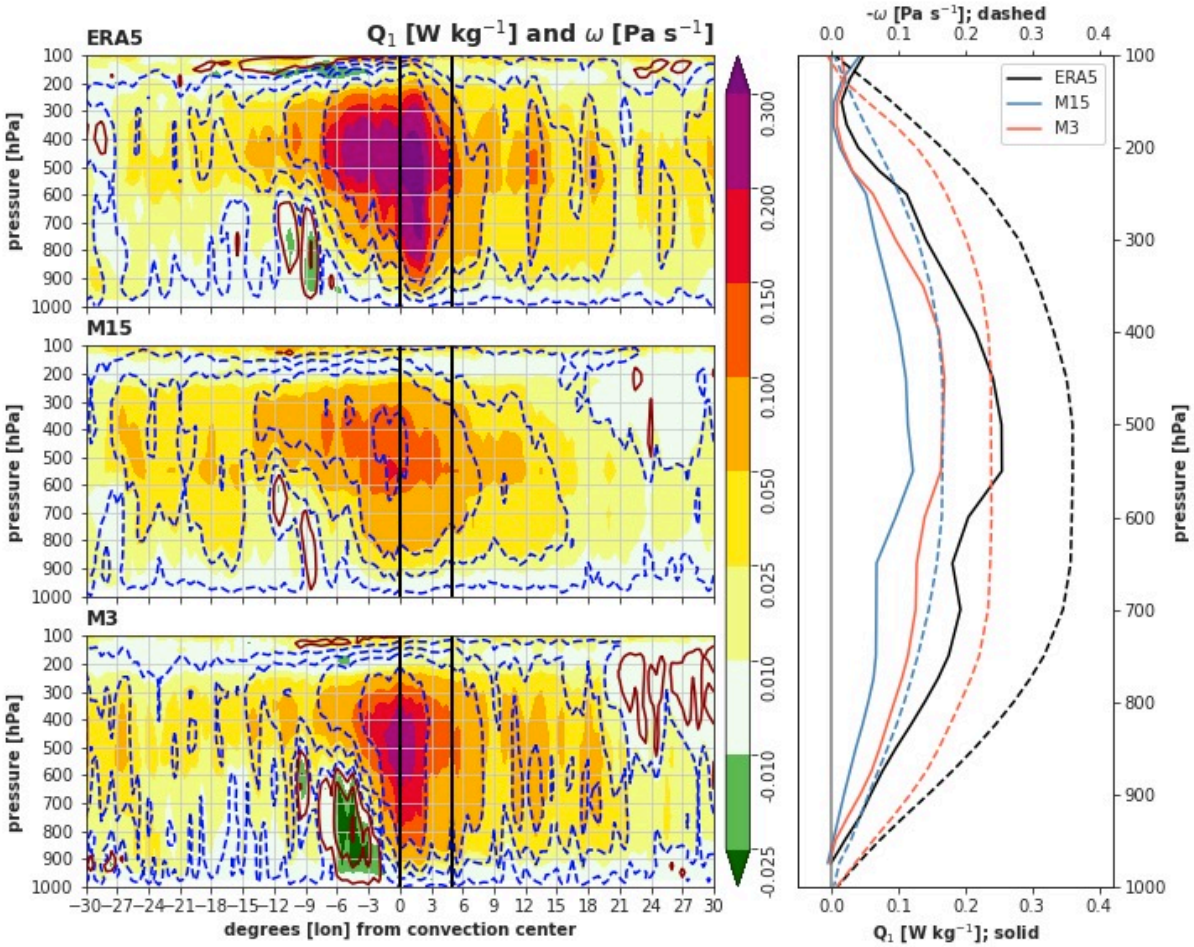
- Large-scale precipitation tracking (LPT)[1]

THE MJO: ANOTHER PERSPECTIVE



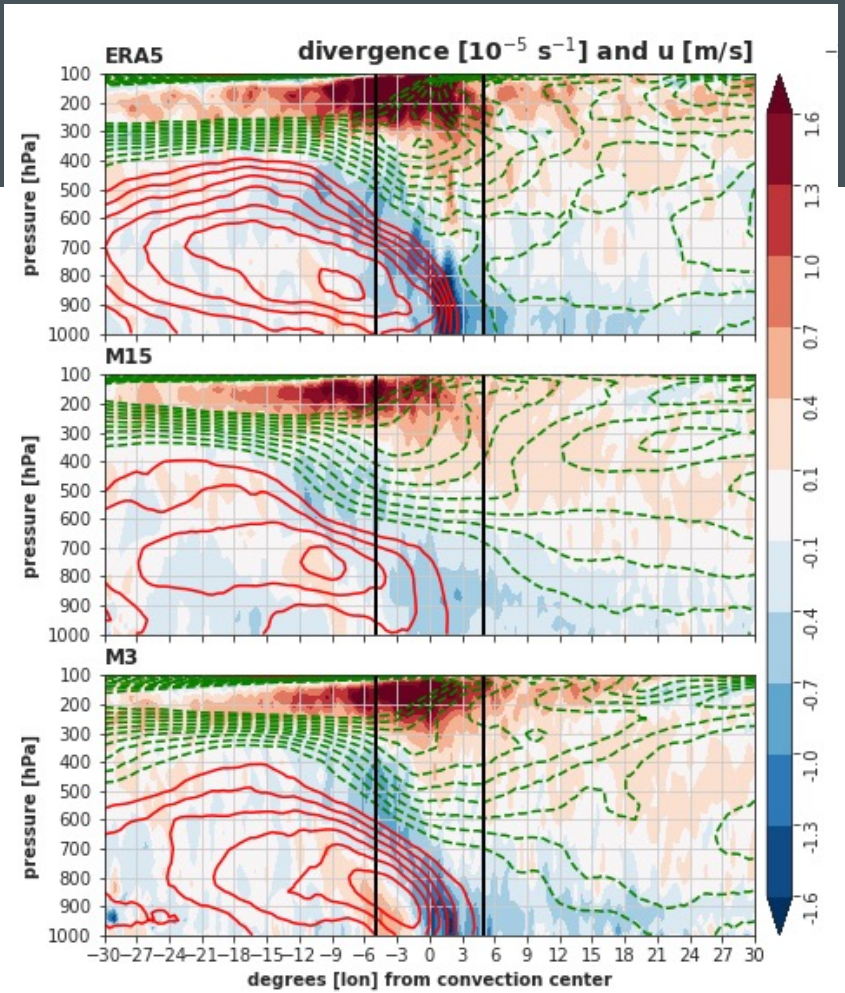
[1]Kerns and Chen 2016

THE DYNAMO KELVIN WAVE



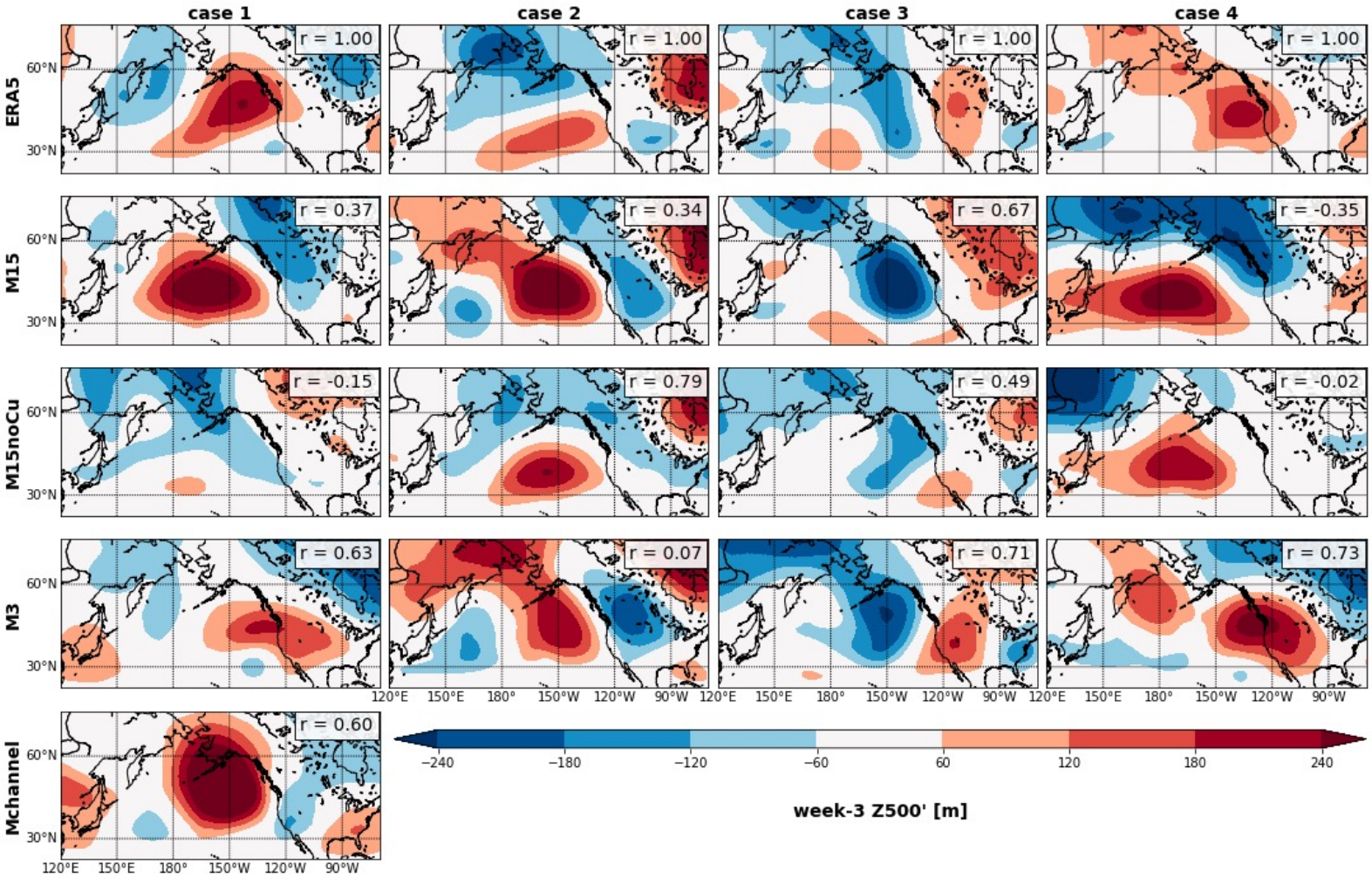
- Stronger convective response in M3

KELVIN WAVE STRUCTURE



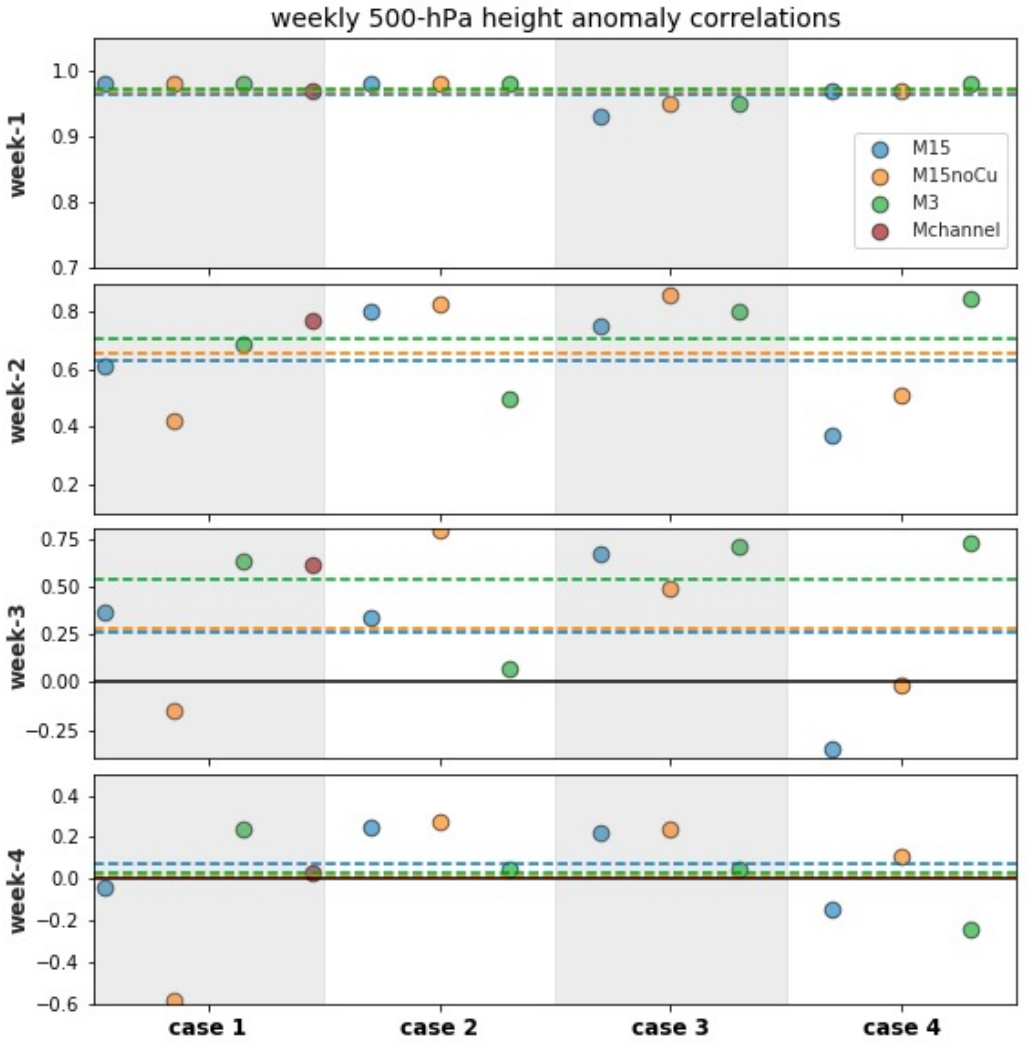
- U, DIVERGENCE

EXTRA-TROPICAL PREDICTION SKILL WEEK 3



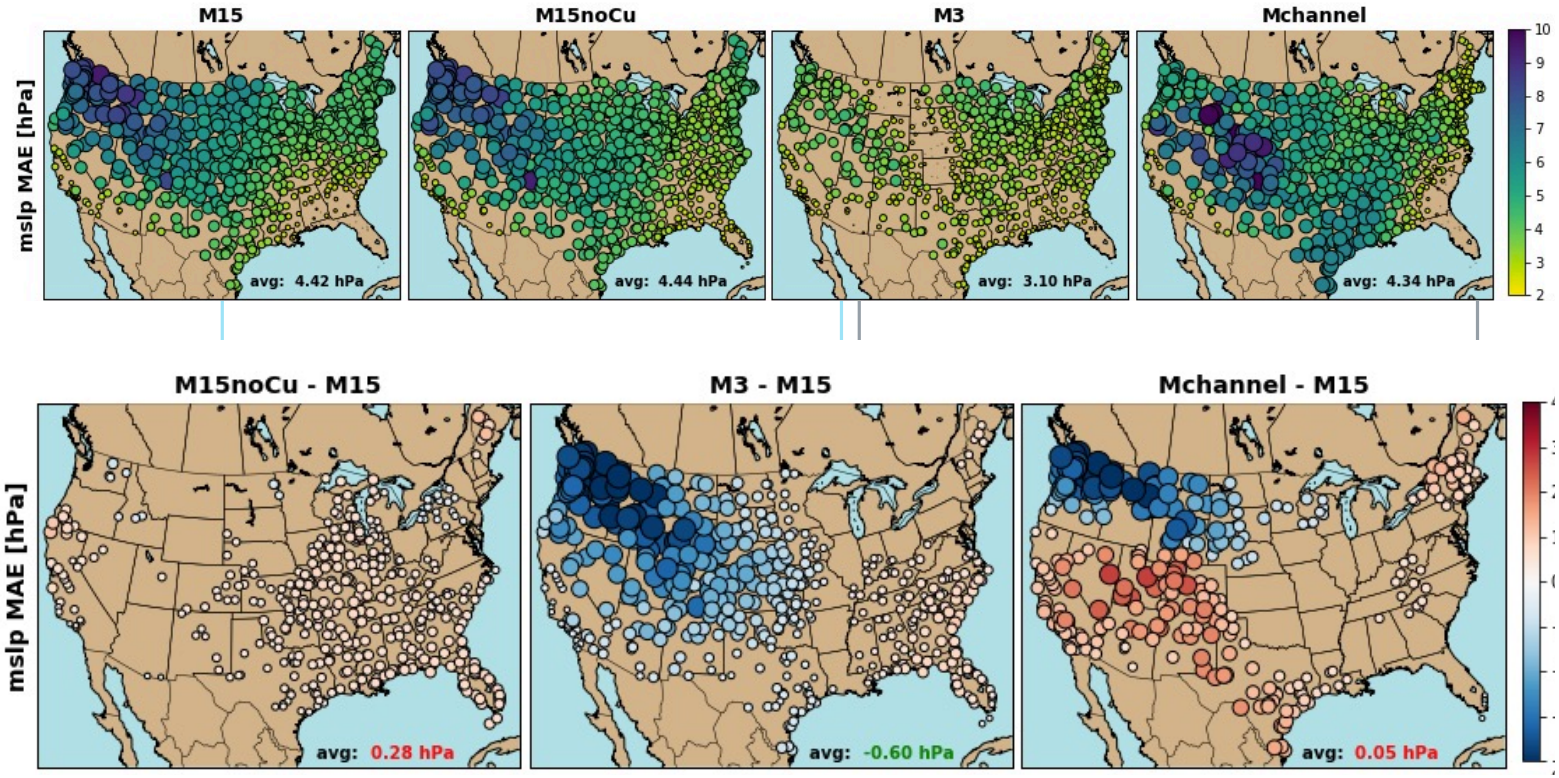
WEEKLY Z500 PERFORMANCE

- The M3 configuration, on average, improved large-scale midlatitude forecasts
- A promising result, motivating more cases



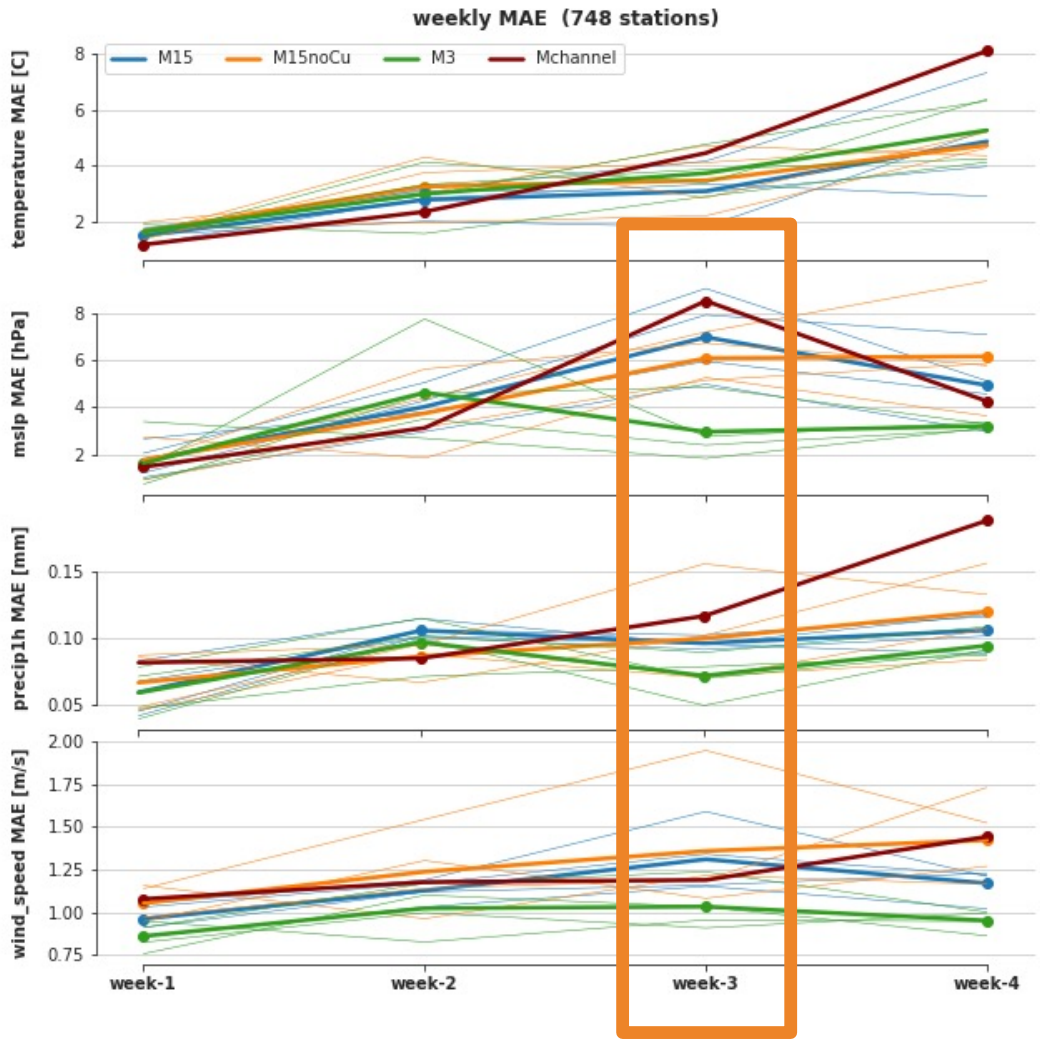
WHAT ABOUT SKILL AT THE SURFACE?

- Errors in pressure, wind, and precip. are generally reduced
- Especially near terrain, coastlines



WHAT ABOUT SKILL AT THE SURFACE?

- Largest error reduction occurs in week-3



Summary

- **Good:** Global 3-km, no convective parameterization
- **Bad:** 15-km global, with parameterization
- **The Ugly**: 15-km, no parameterization; tropical 3-km channel

TAKE-AWAYS

- Global CPMs have become a viable tool for research (and soon NWP) applications
- Their realistic simulation of large-scale tropical phenomena is rooted in improved convective processes
- MJO and Z500 verification results are consistent with improved simulation of tropical convection
- More cases and coupled CPMs/ocean models are needed

THANK YOU!

Appreciate substantial assistance of
Bill Skamarock and Michel Duda