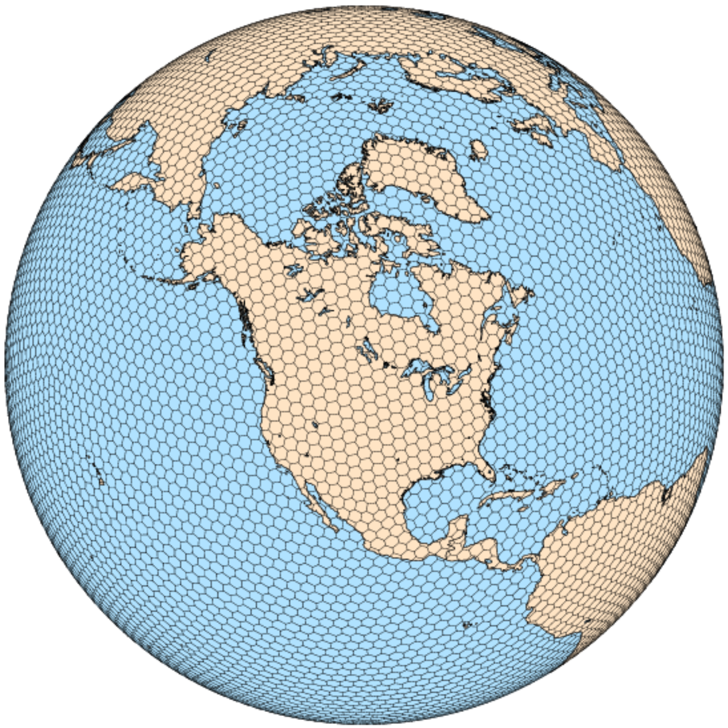
Convection Permitting Global Prediction: Evaluation for Operational Application in NOAA.



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November 6th

NOAA NGGPS Presentation

The Project

- Evaluate the impacts of global convection allowing resolution for weather and subseasonal prediction in NOAA
- Evaluate various model configurations for potential use by NOAA to move to convection permitting resolution for global models.
- Started with MPAS and hopefully will move to FV-3

Important Note

- Attempted to use the public release of FV-3
- Not ready for prime time
  - Computer dependencies
  - Inadequate pre and post processors
- No support
- Minimal documentation
- Thus, decided to do all simulations with MPAS.
- Hopefully, FV-3 will be ready for outside users in the future.

Our simulations

- The model: MPAS v5.1 (global)
- Physics: ‘convection_permitting’ suite
- Four cases (all integrated 28 days):
    - November 22, 2011 (DYNAMO)
    - February 8, 2013
    - December 2, 2003
    - December 8, 2013

MPAS
Model for Prediction Across Scales

Convection-permitting suite

- Scale-aware convection parameterization of Grell and Freitas (2014)
- Cloud microphysics scheme developed by Thompson and Eidhammer (2014).
- Gravity wave drag over orography: GWDO (WRF 3.6.1).
- Long- and short-wave radiation: RRTMG (WRF 3.9.1), except for climatological aerosols.
- PBL and surface layer: MYNN (WRF 3.9.1).
- Land surface model: NOAH (WRF 3.9.1).

Our simulations

- **Configurations:**
  - 15-km resolution, nTiedke cumulus scheme
  - 3-km resolution, no cumulus scheme
  - 15-km resolution, no cumulus scheme
  - 15-to-3-km tropical channel, Grell-Freitas
- **NCEP FNL analyses used for ICs and BCs**
- **SSTs fixed at initial value**

Computer resources per 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**

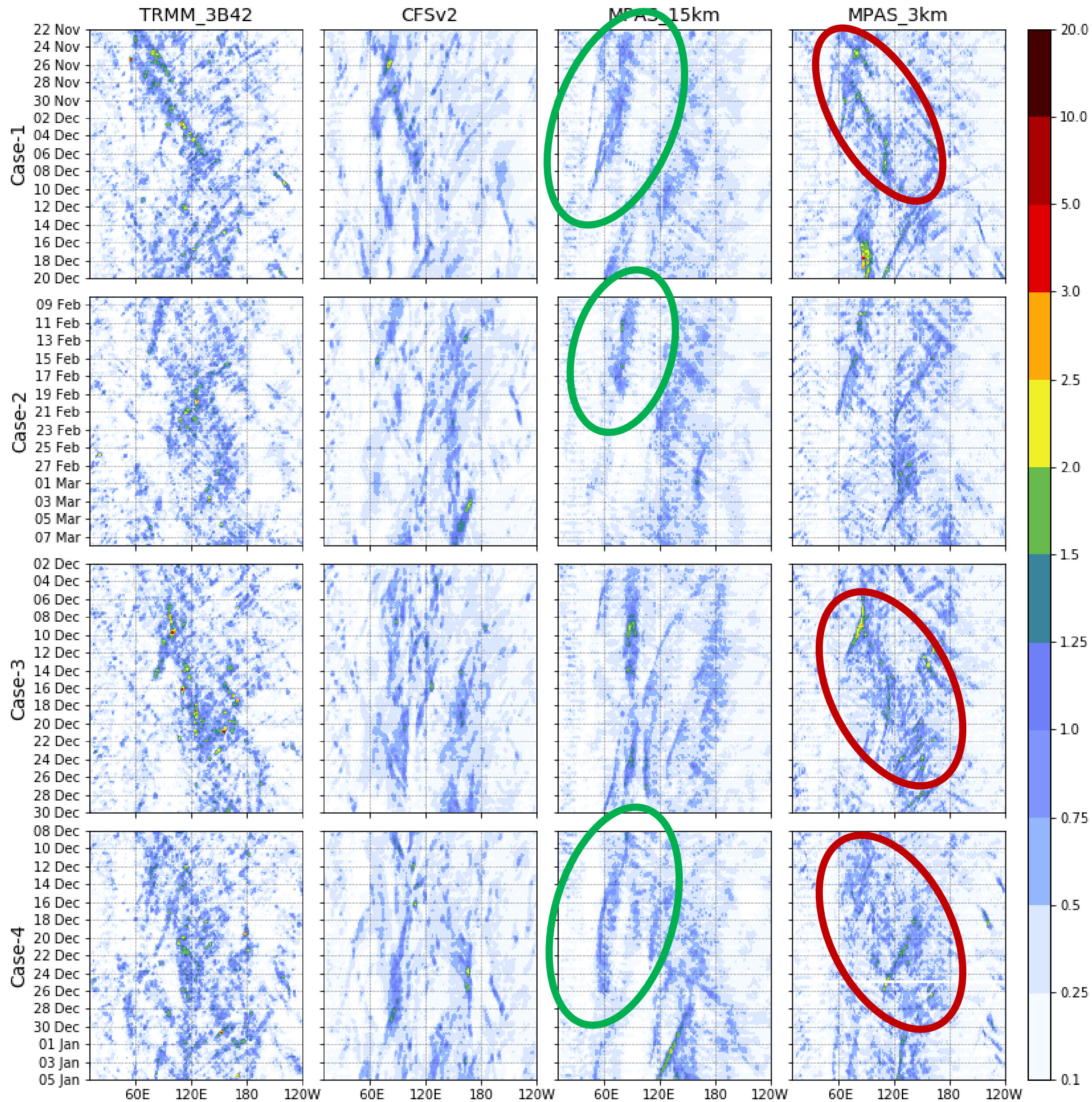
Section 2

Tropical verification

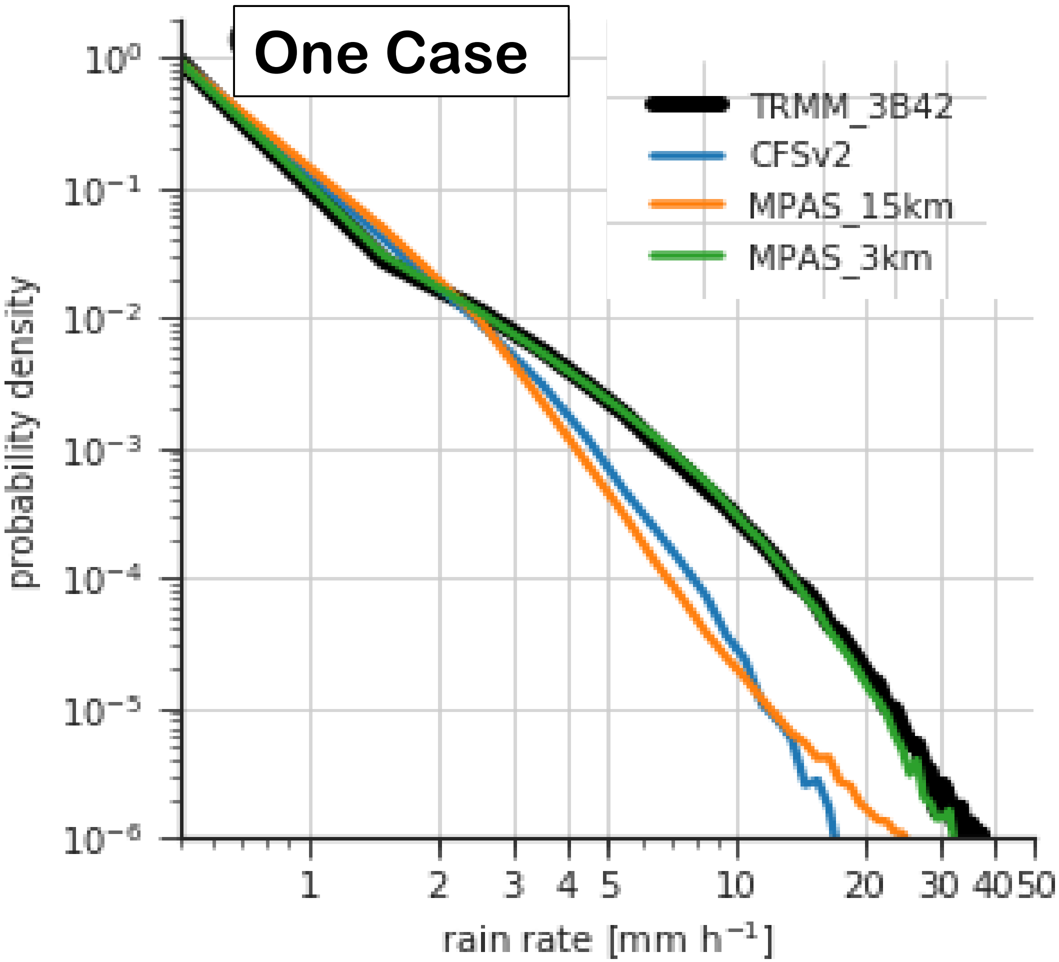
MJO propagation

Precipitation (mm/h) Hovmöllers (15S-15N) reveal:

- Weaker, more widespread rain in models with parameterized convection
- Improved eastward MJO propagation in 3km model for three cases
- Problematic westwar propagation in 15km simulations

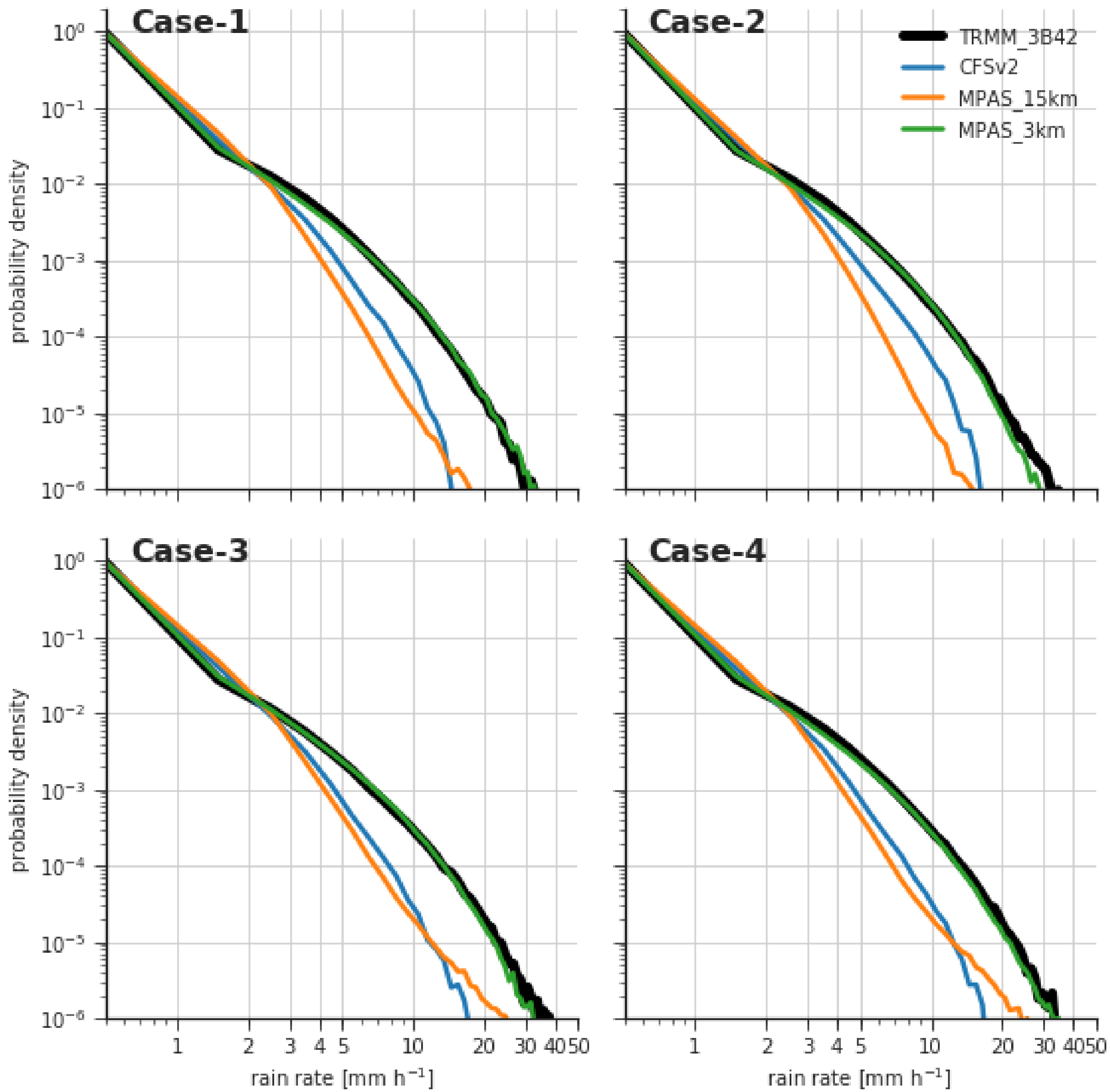


Precip. statistics: Rain rate distribution



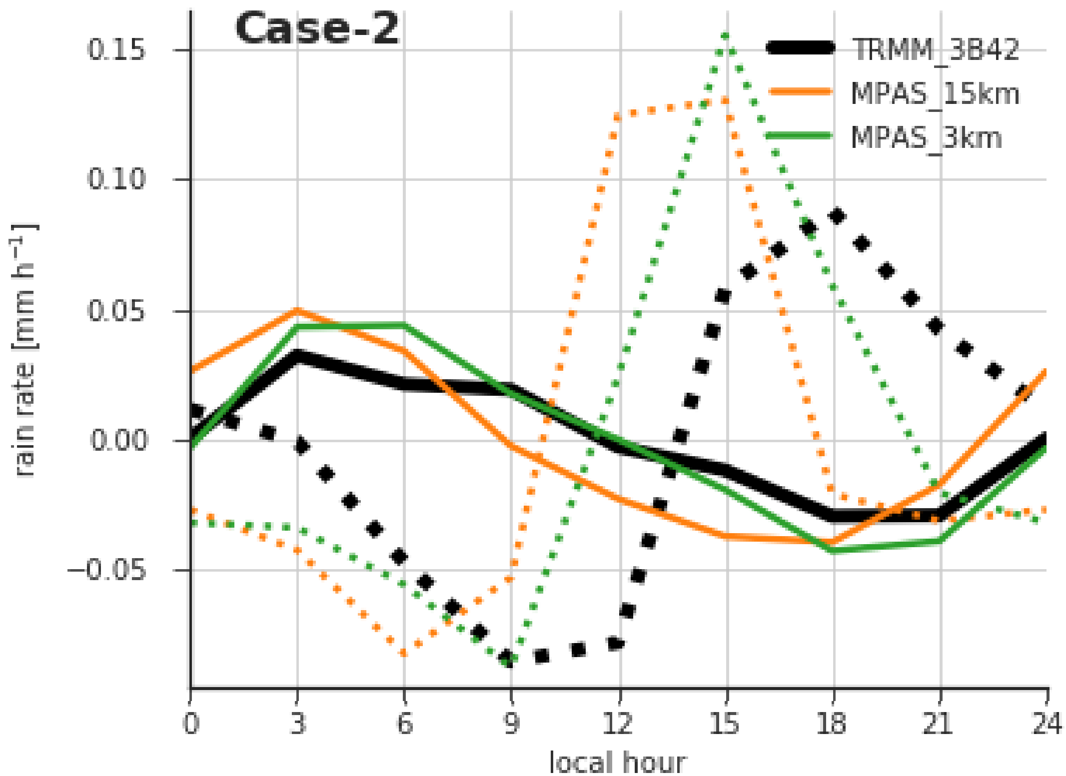
- **CFS and 15km MPAS produce too much (little) light (heavy) precipitation**
- **3km MPAS closely matches TRMM estimates**
- **Same result for all four cases!**

Precip. statistics: Rain rate distribution



Precip. statistics: Diurnal cycle

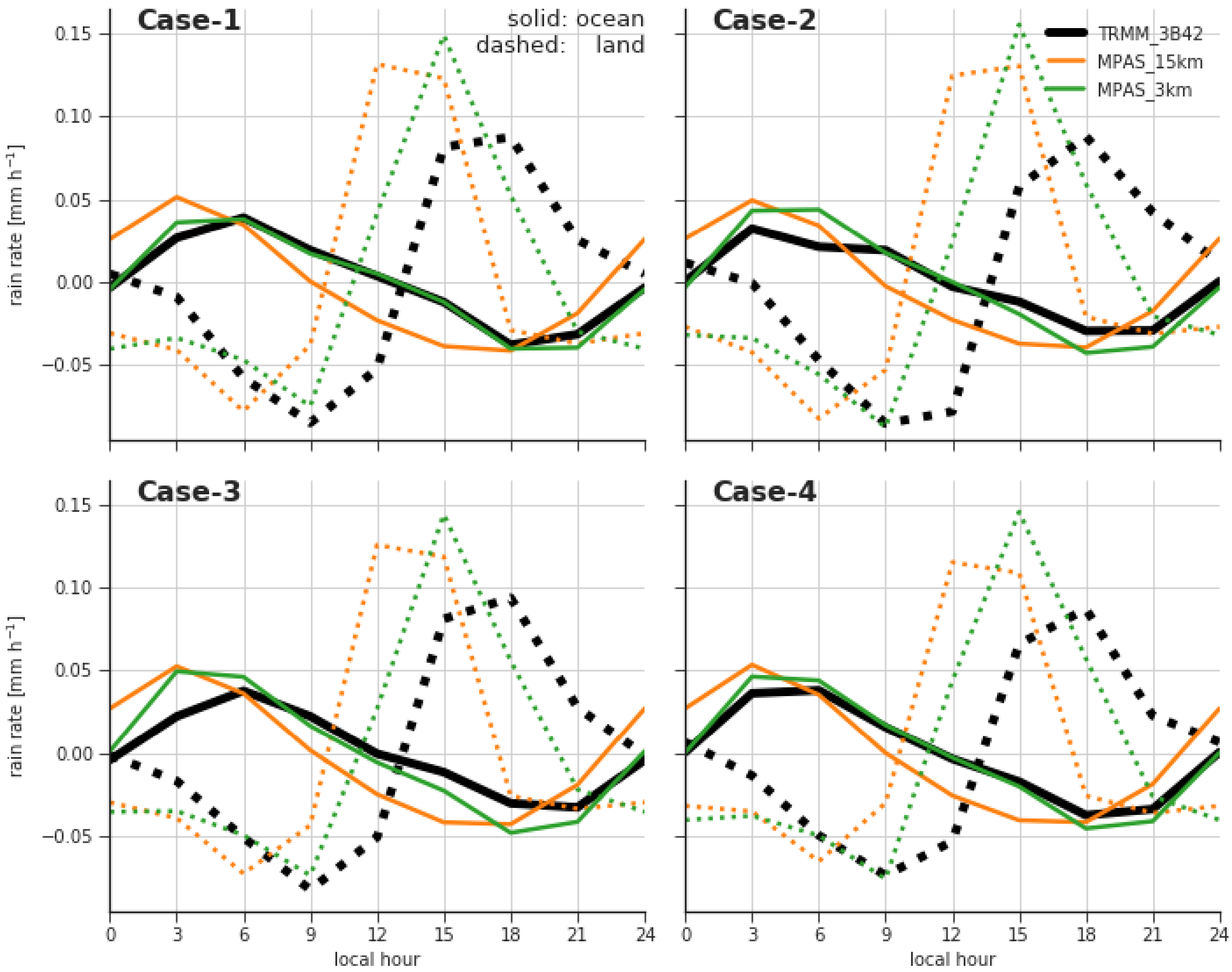
One Case



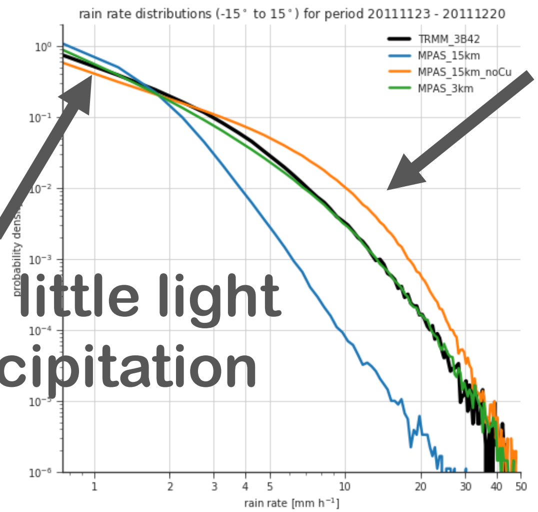
solid = ocean
dashed = land

- **Improvement in diurnal timing over both land and water**
- **Amplitude over land is still overestimated**
- **Same result for all four cases**

Precip. statistics: Diurnal cycle



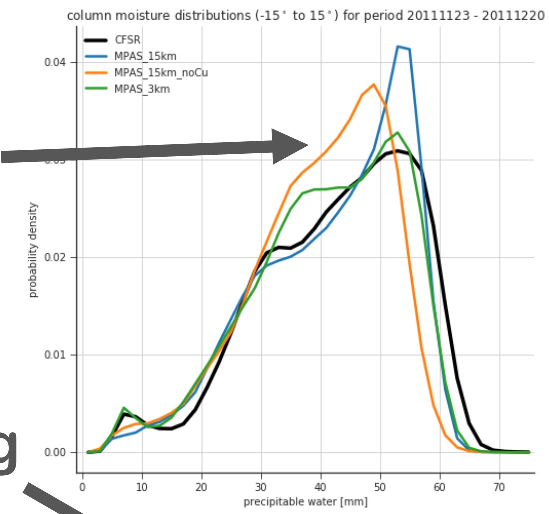
What about the 15-km simulations *without* Cu parameterization?



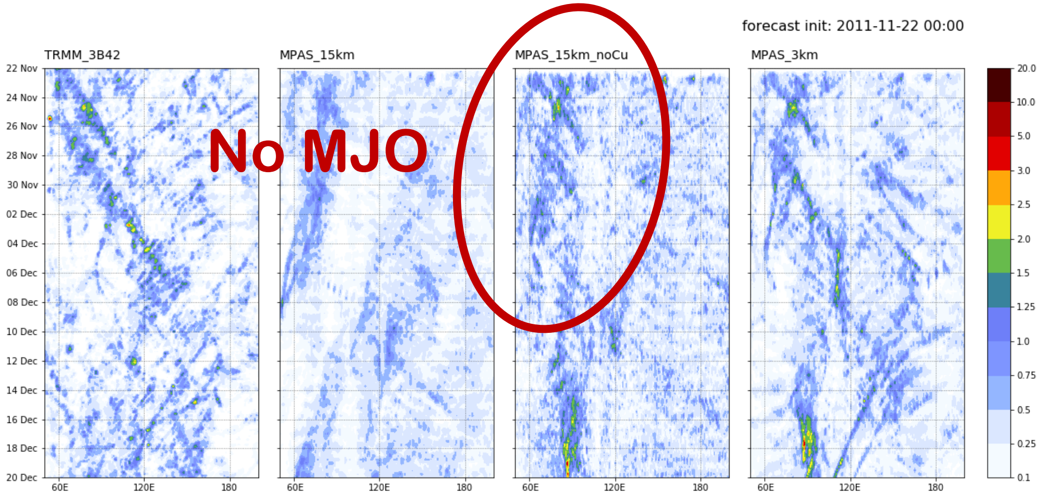
Too much heavy precipitation

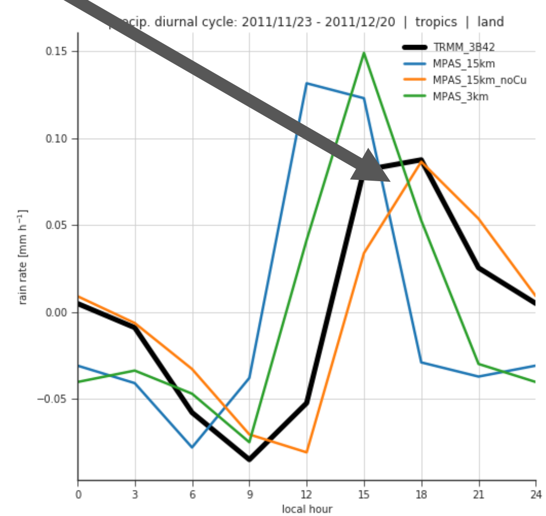
Too little light precipitation

Way too dry



Improved diurnal timing

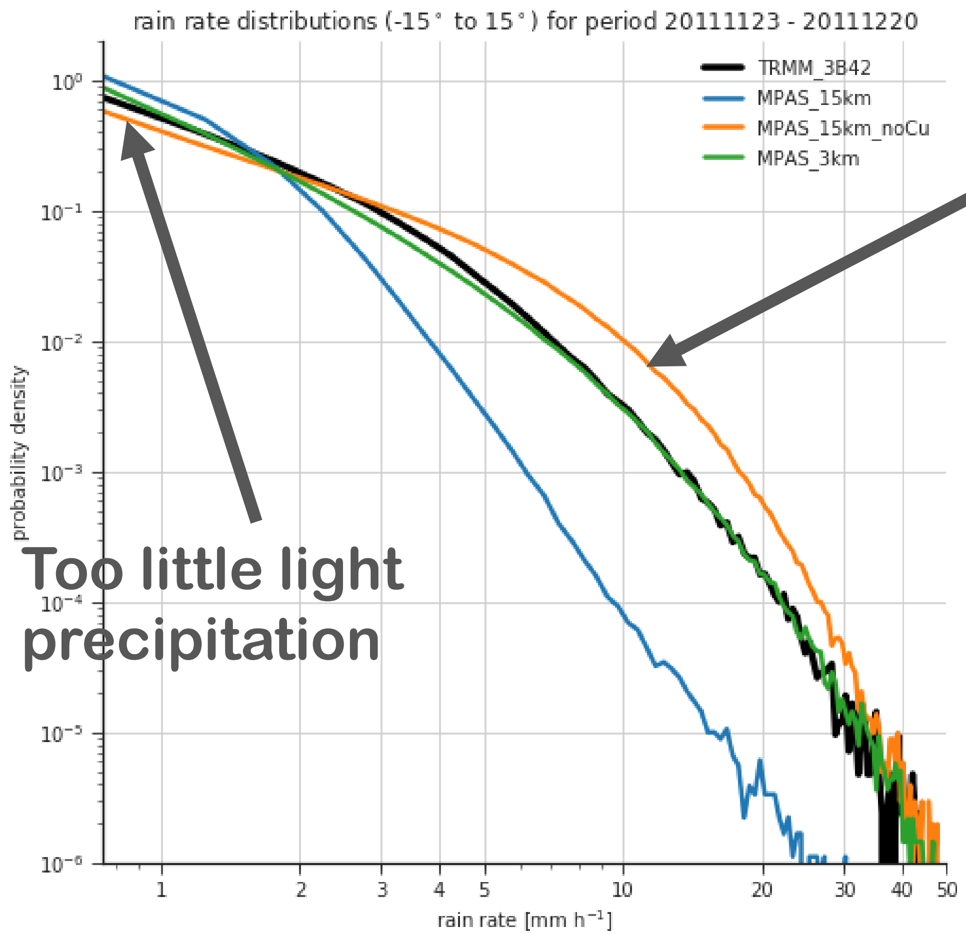




*Identical results for all four cases

What about the 15-km simulations *without* Cu parameterization?

Too much heavy precipitation



Too little light precipitation

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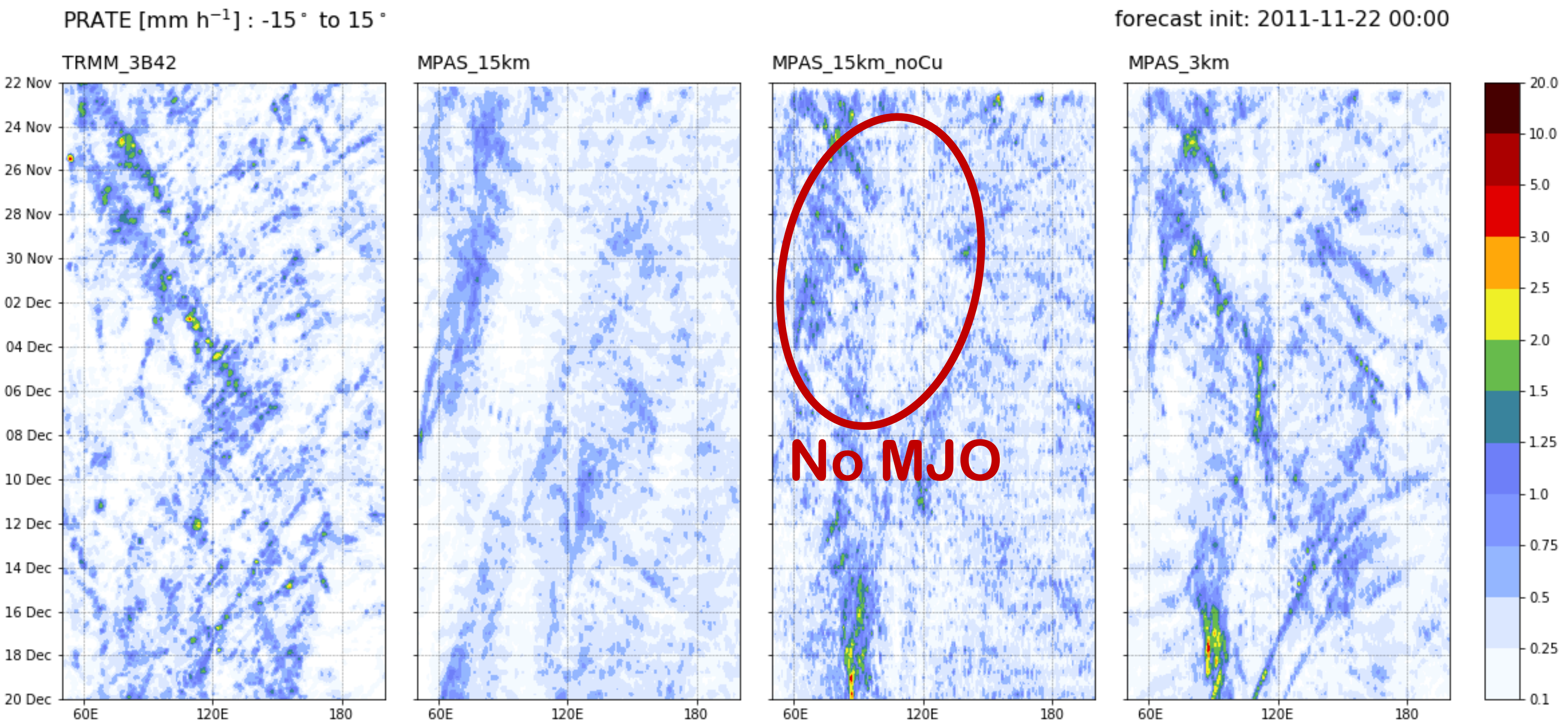
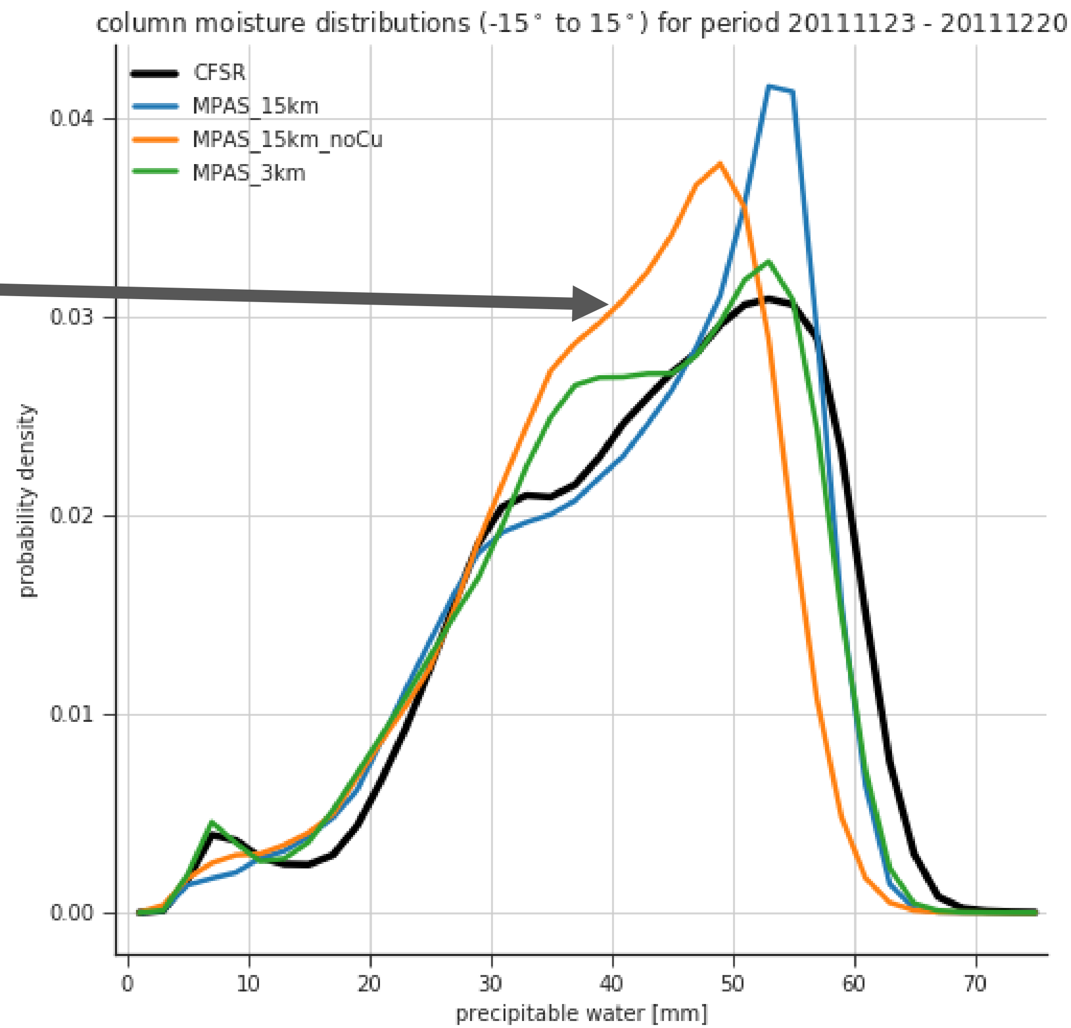


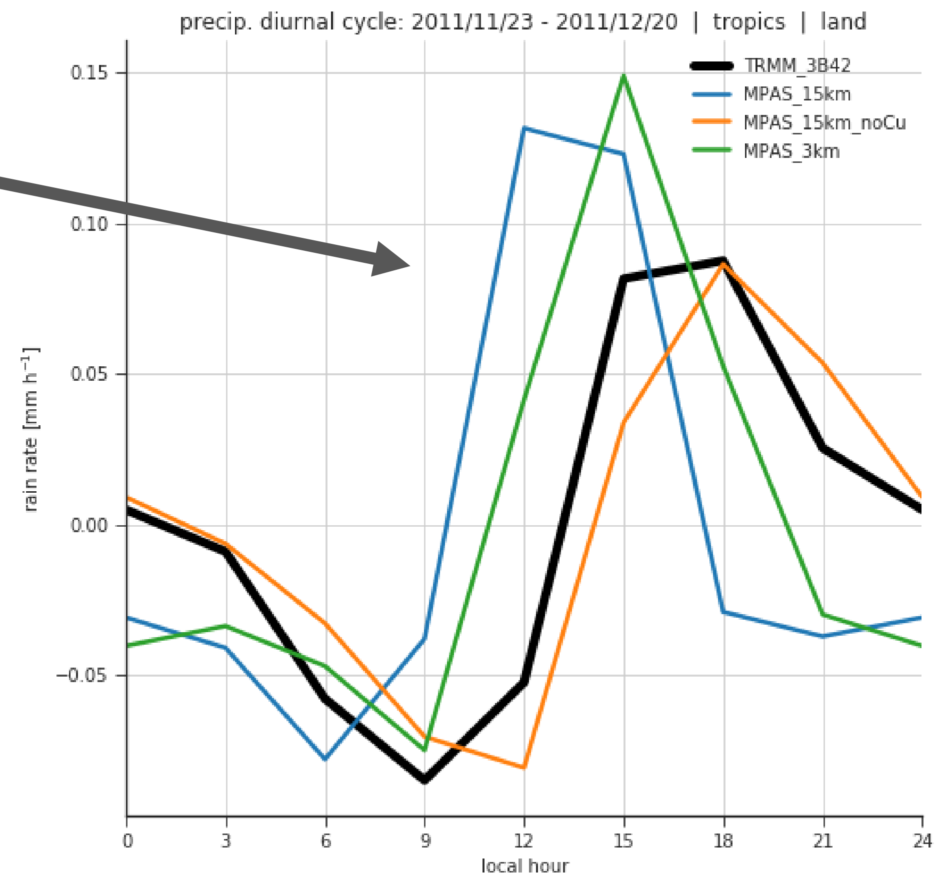
What about the 15-km simulations *without* Cu parameterization?

too dry



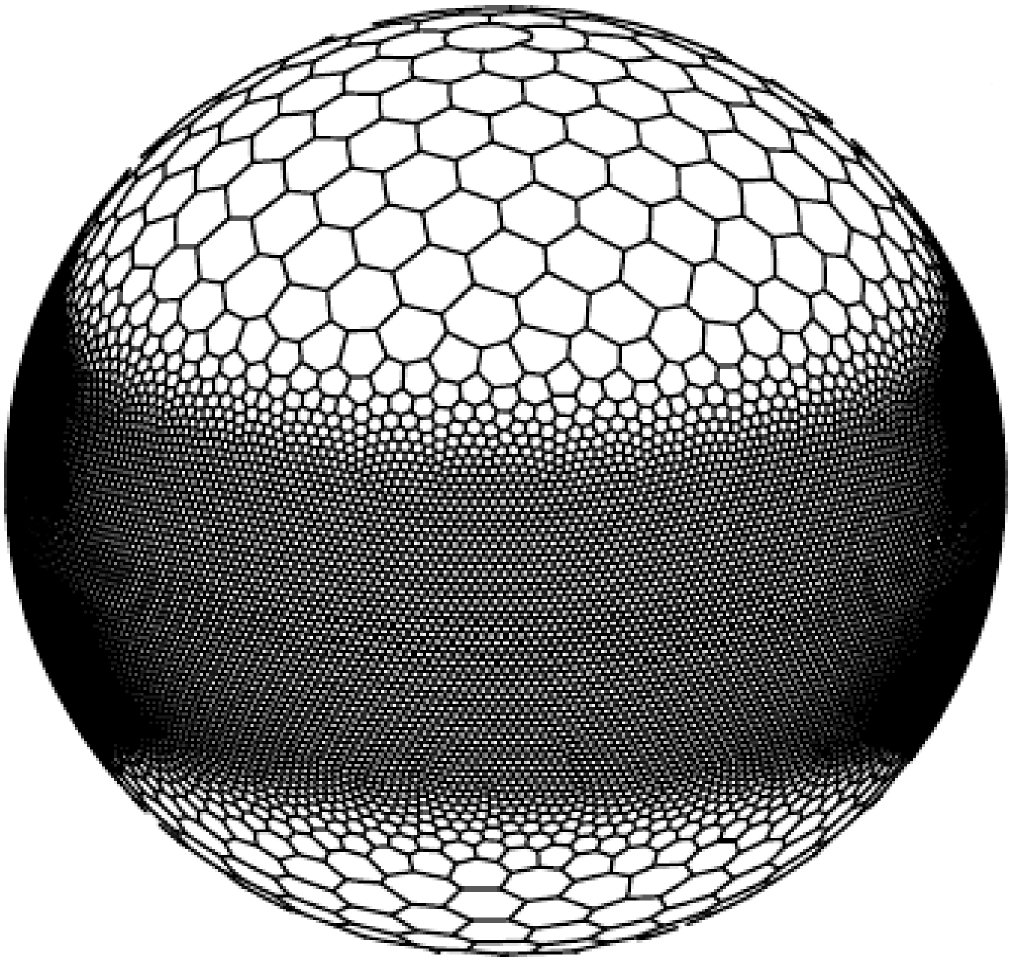
What about the 15-km simulations *without* Cu parameterization?

Improved **diurnal timing**



What if we use 3-km resolution in the *tropics only*?

15-km resolution



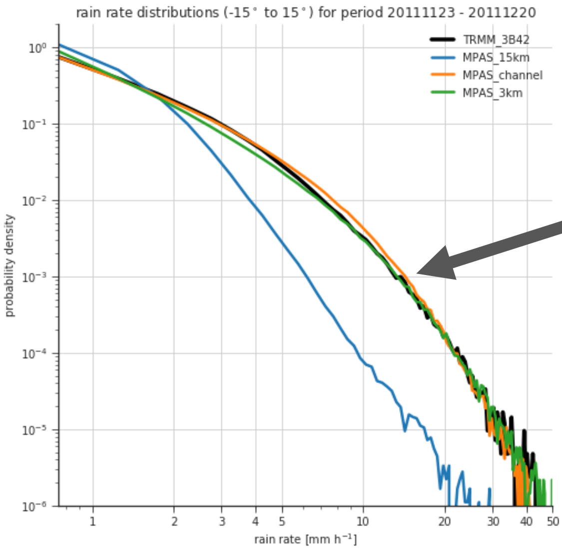
3-km resolution

20N

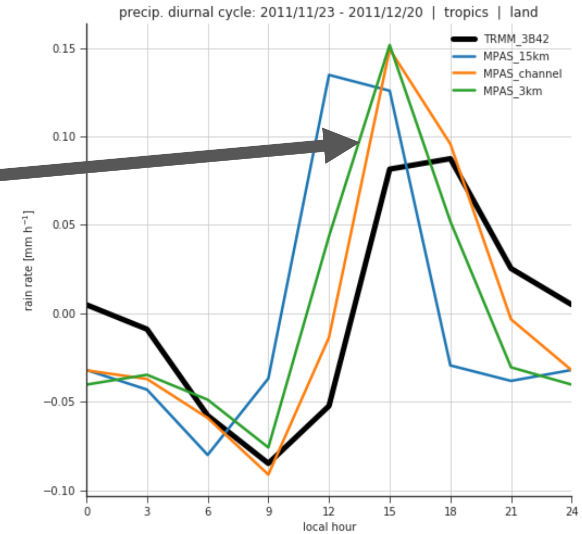
20S

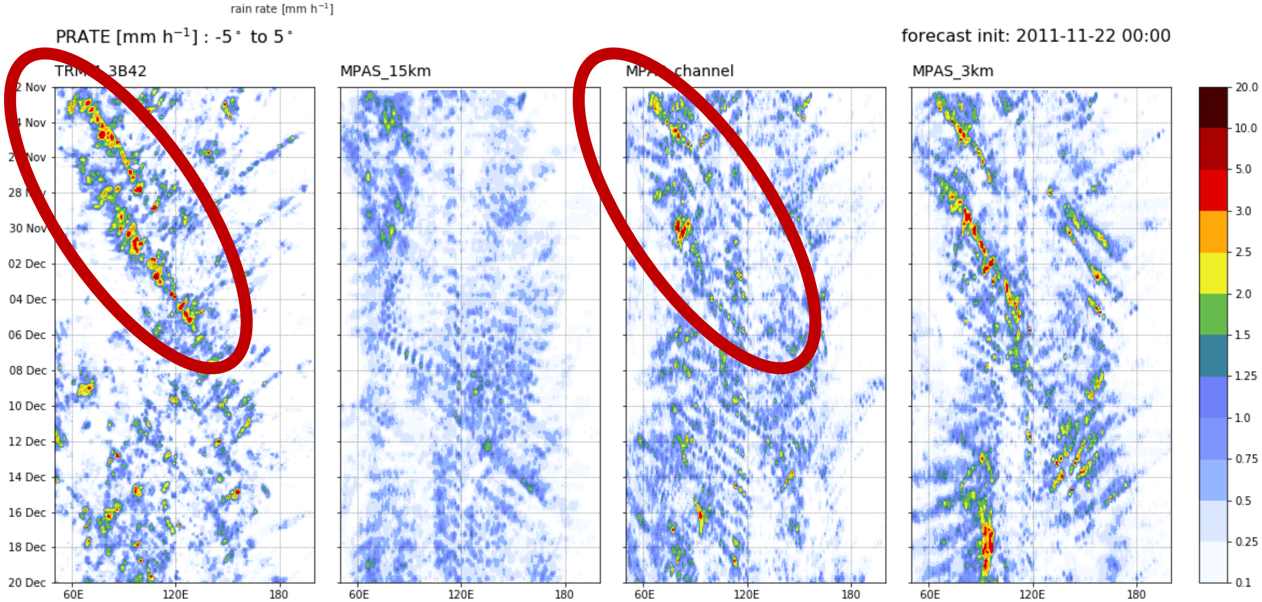
15-km resolution

What if we use 3-km resolution in the *tropics only*?



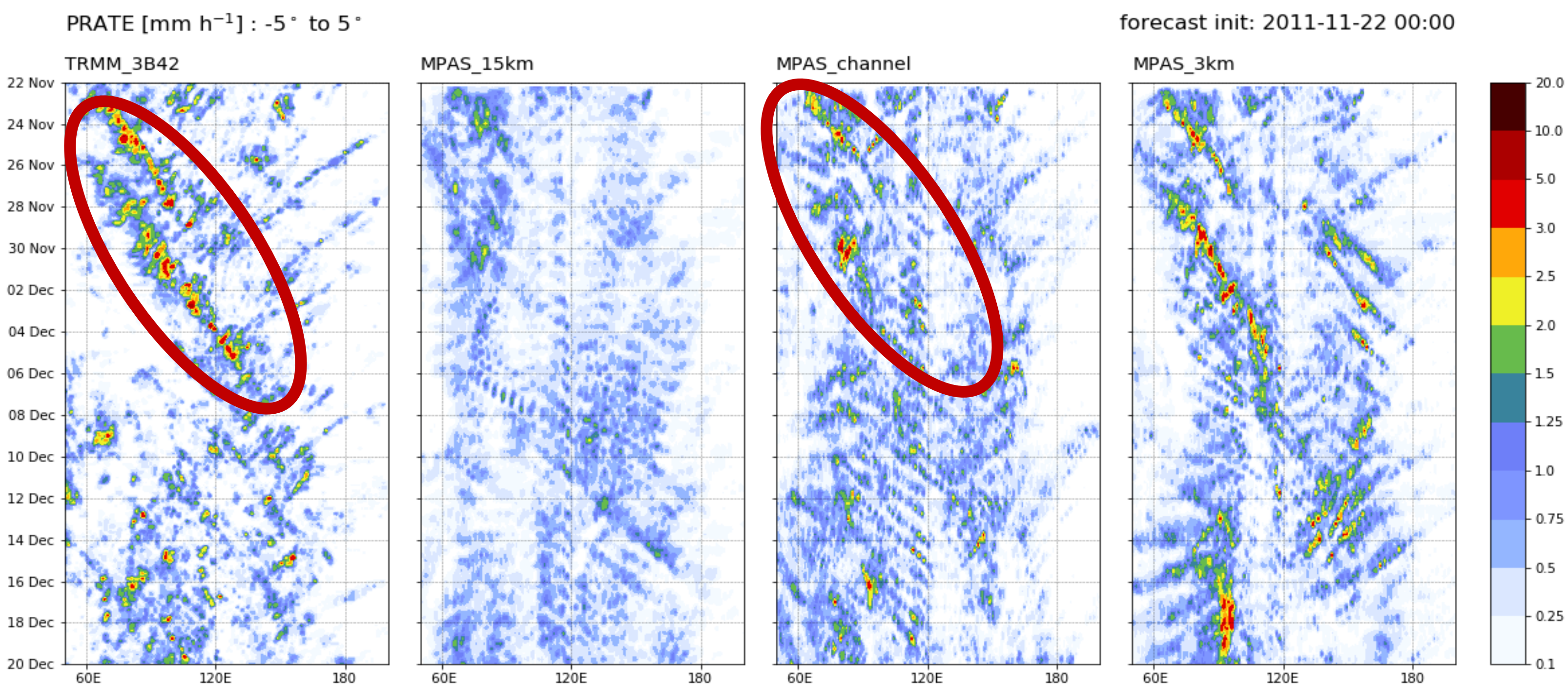
Same benefits to tropical precipitation statistics





MJO propagation is not as well-captured as in the 3-km global run

What if we use 3-km resolution in the *tropics only*?

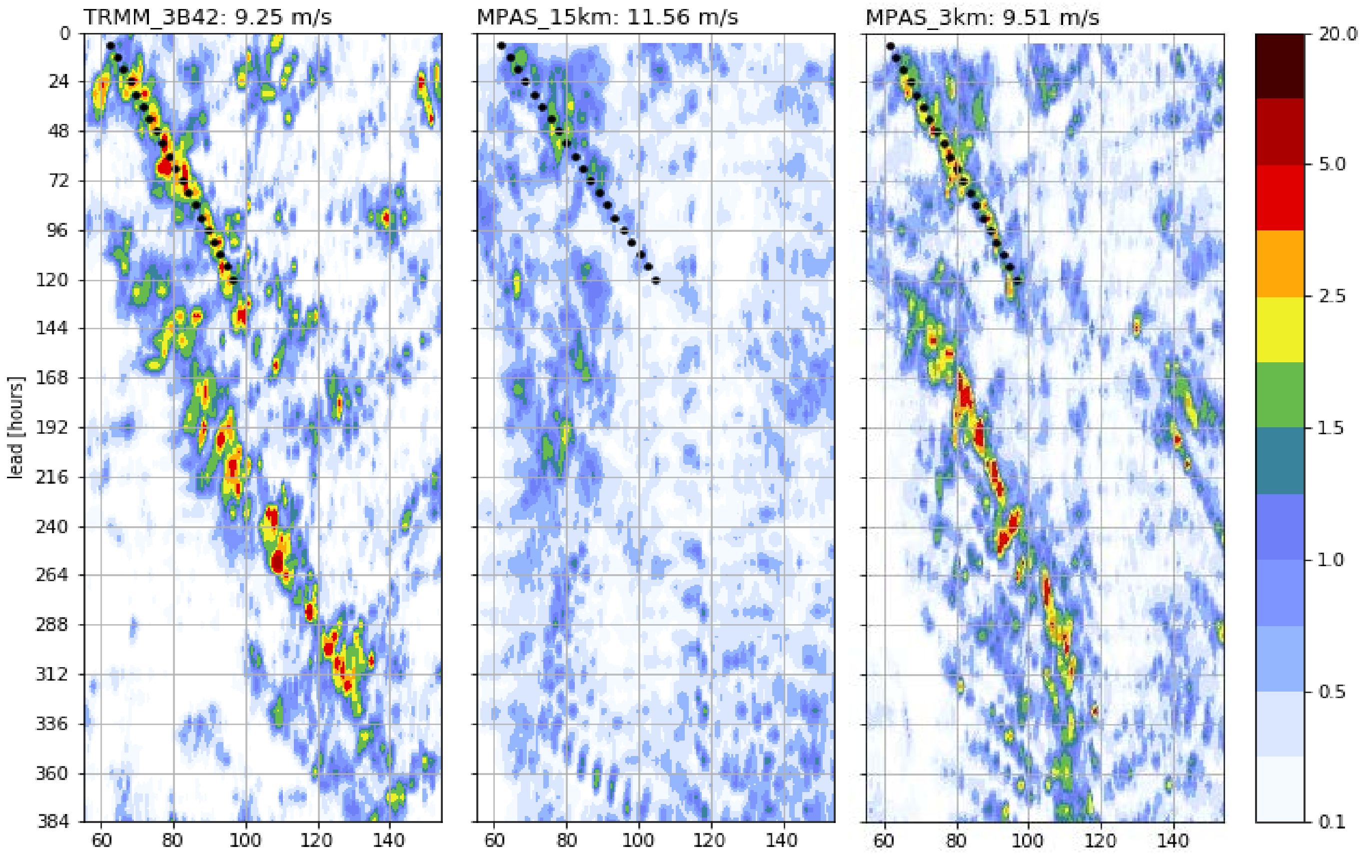


There seems to be some advantage to having global convection-permitting

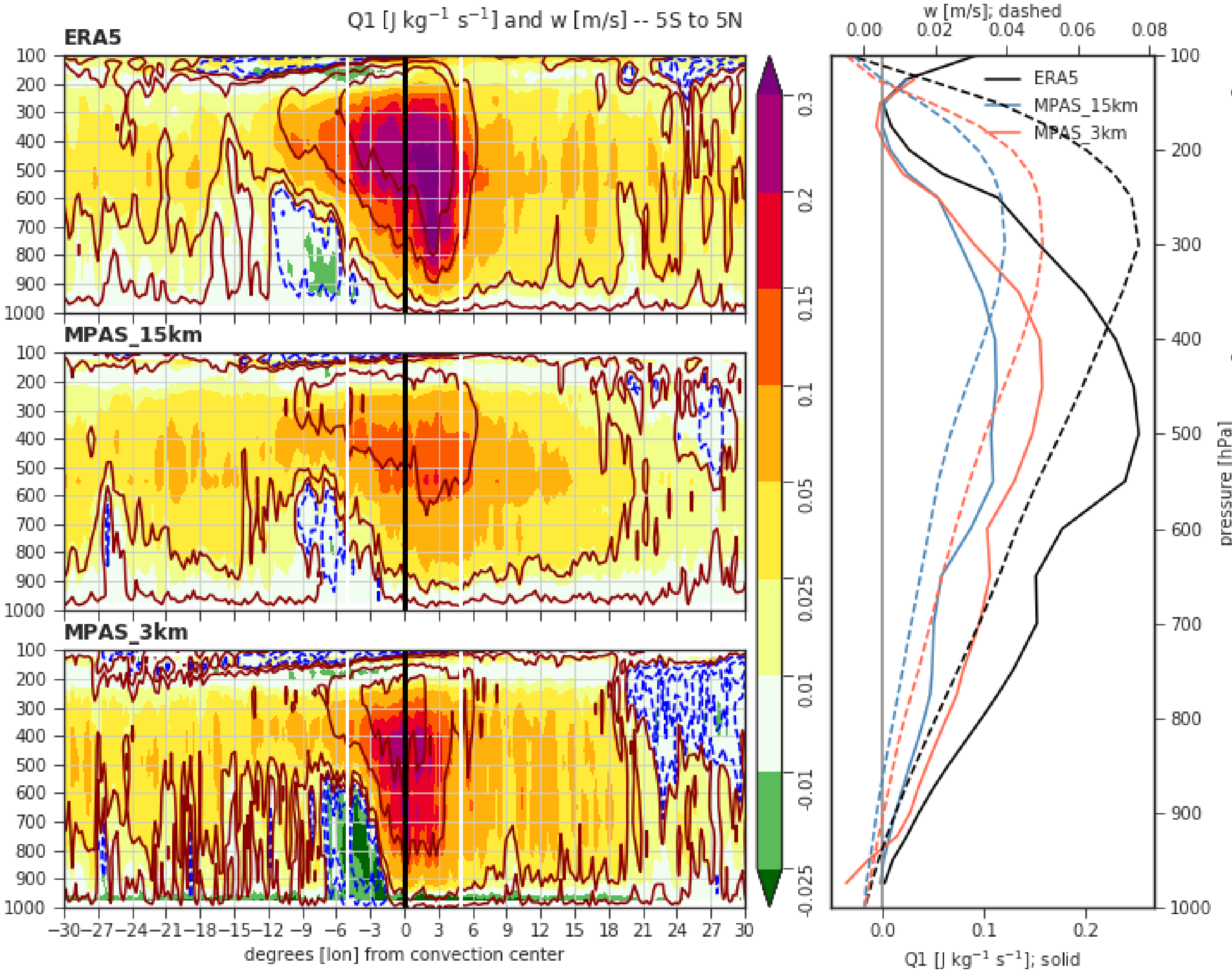
Section 3

Structure of organized tropical convection

Consider the the “Kelvin” wave in Case-1:

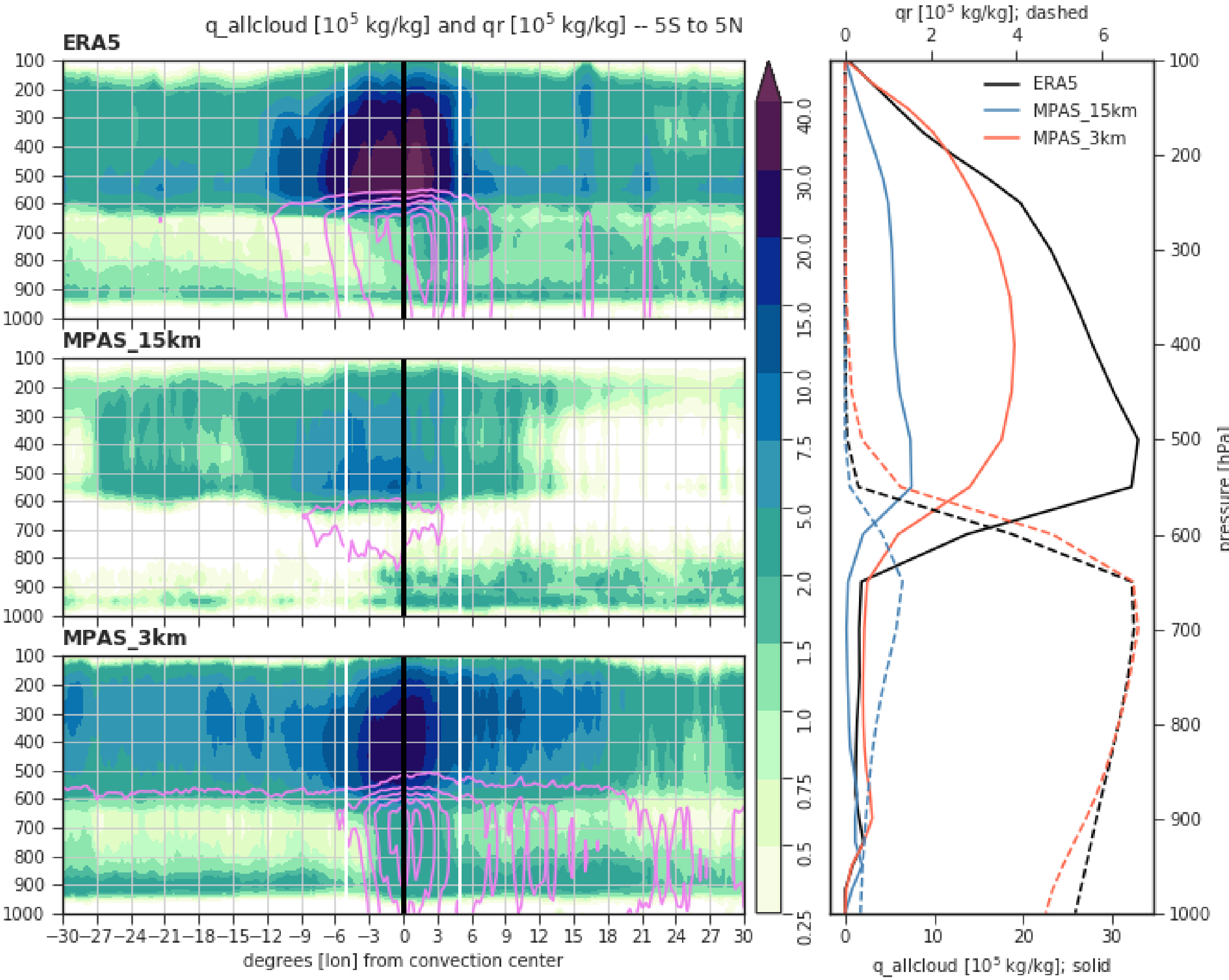


Latent heating and vertical motion:



- Stronger LH release and vertical motions in 3-km run
- Stronger downward motion behind the updraft:

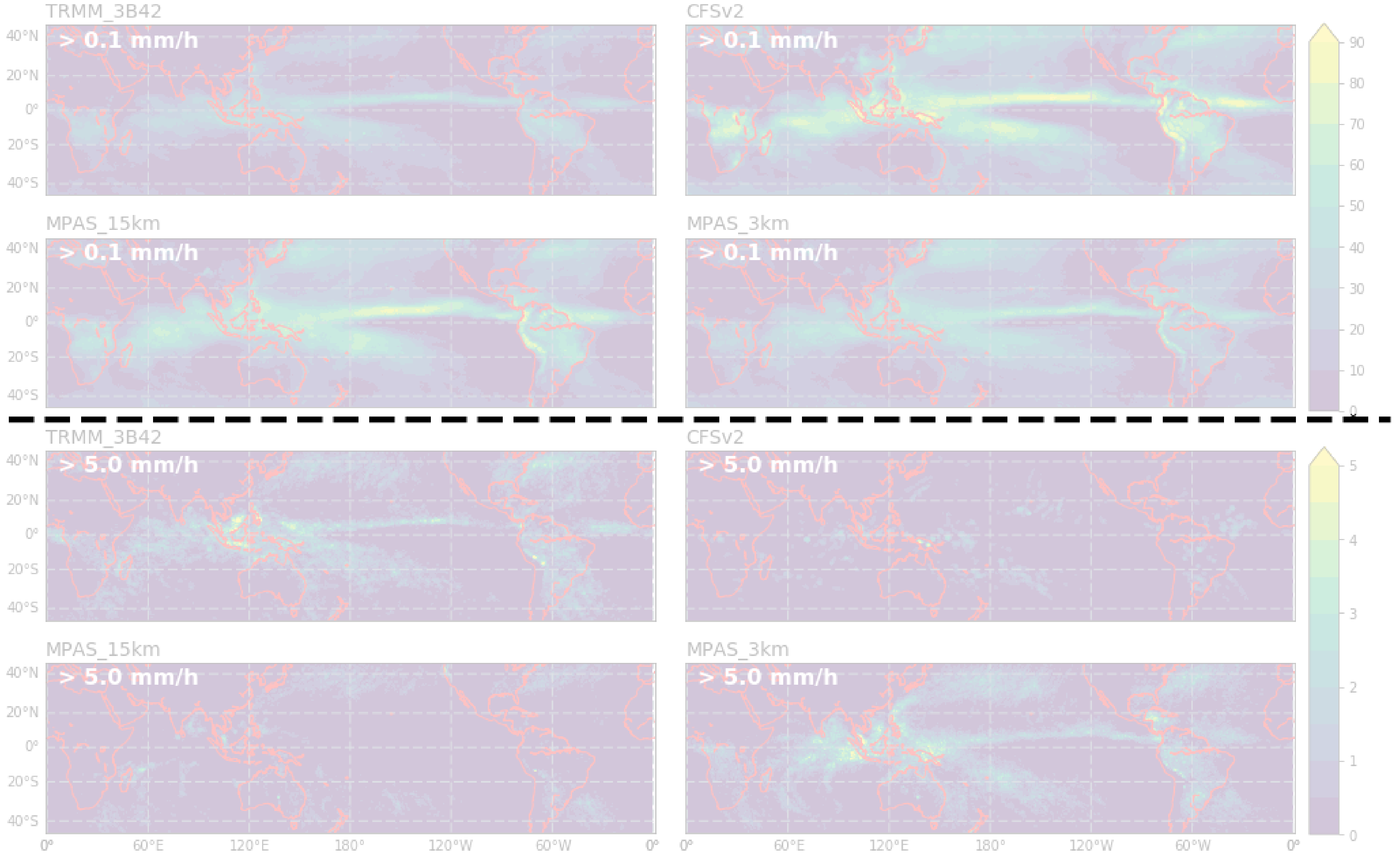
Cloud water and rain water



- More widespread cloud ice in 3-km simulation
- More intense precipitation

Precip. statistics: Rain frequency (%)

E X T R A



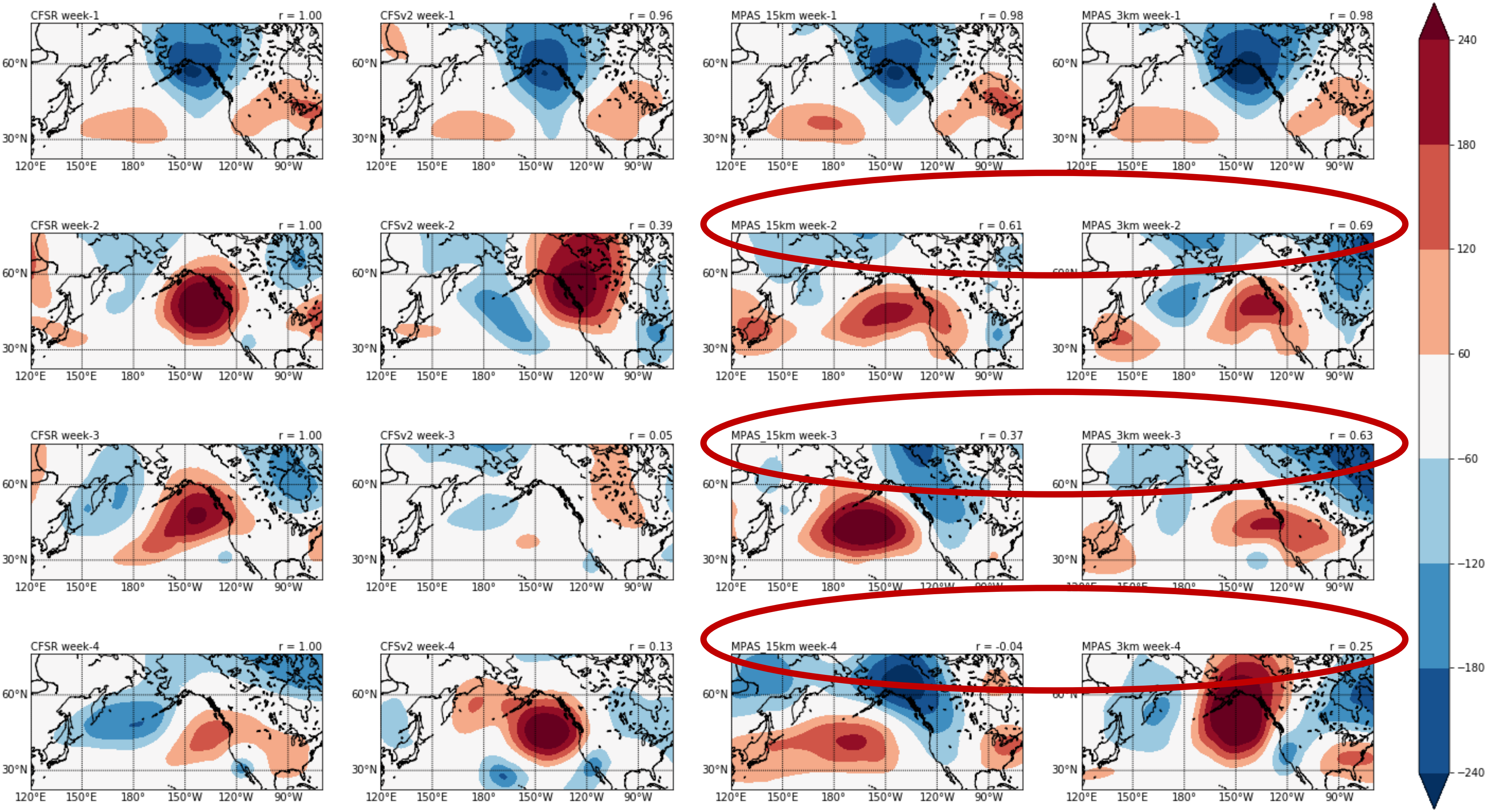
Section 4

Extratropical verification

Subseasonal extratropical skill: PNA

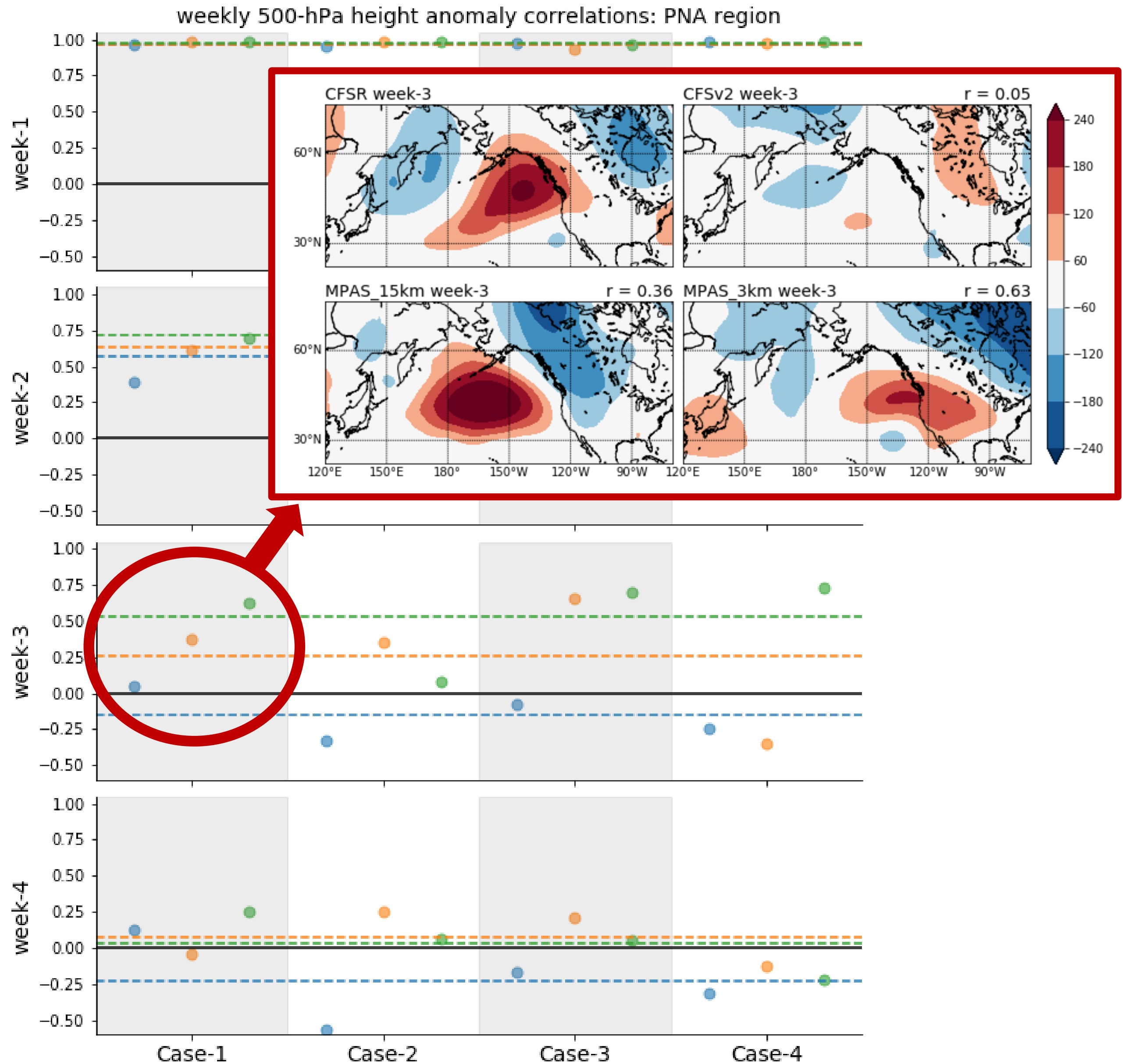
CASE-1

weekly 500-hPa height anomalies [m]

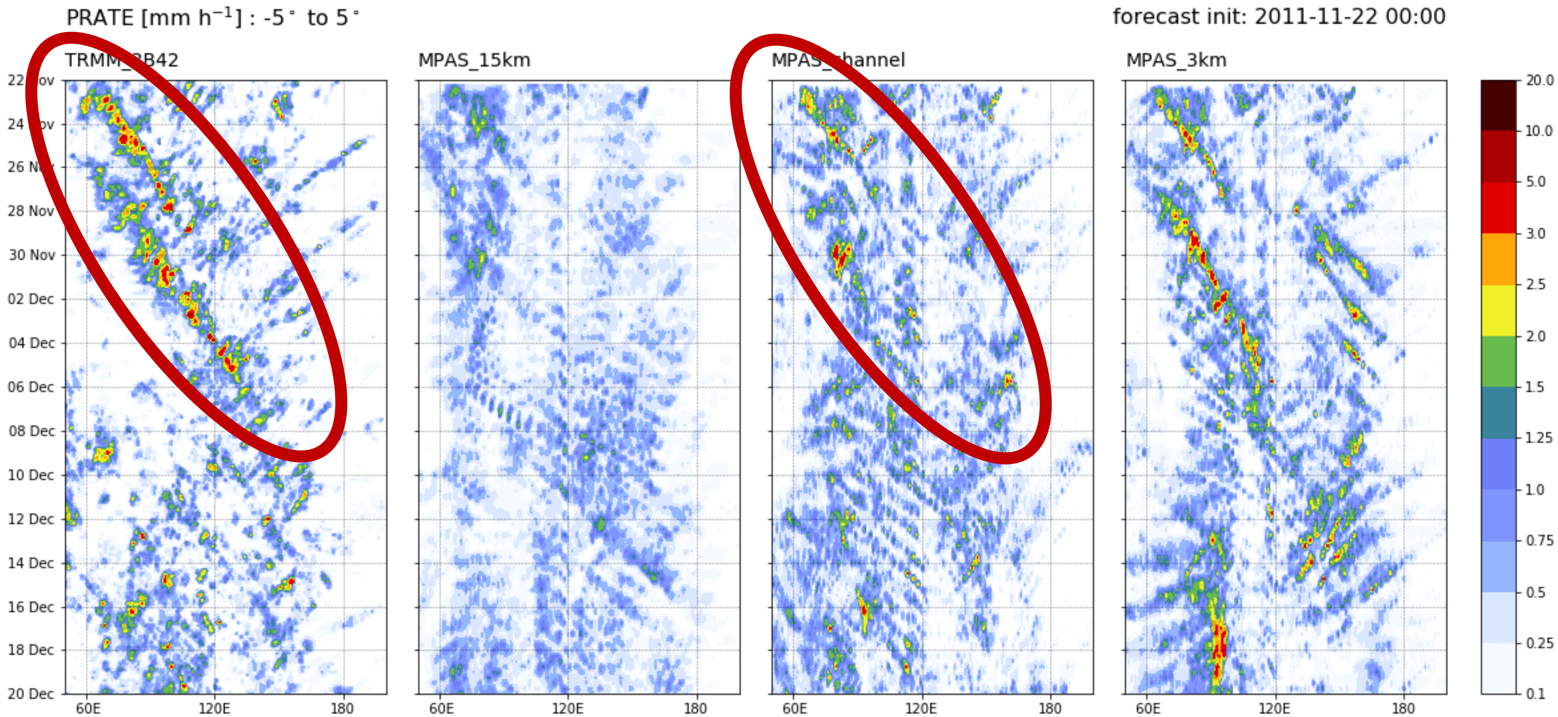


ALL CASES

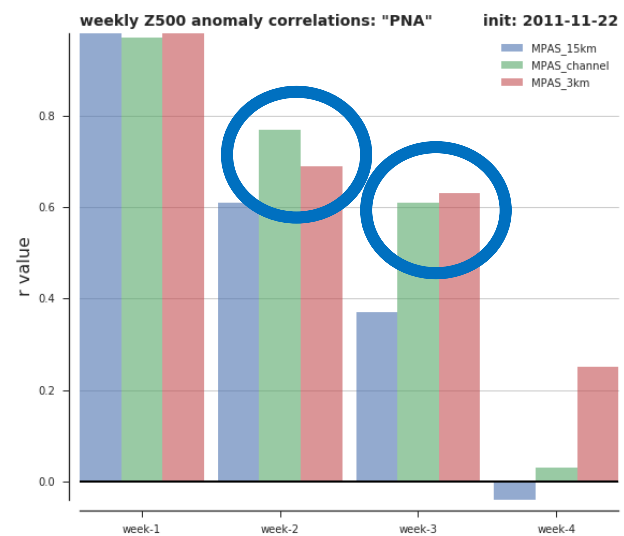
- The bulk of the improvement is in week-3
- Similar results over the entire Northern Hemisphere
- 15-km no-Cu run performs worse than other MPAS configurations



Channel MJO and subseasonal PNA skill



- **MJO propagation not well-captured in the channel run**
- **But good Z500 prediction in the PNA region for week-2 and week-3**

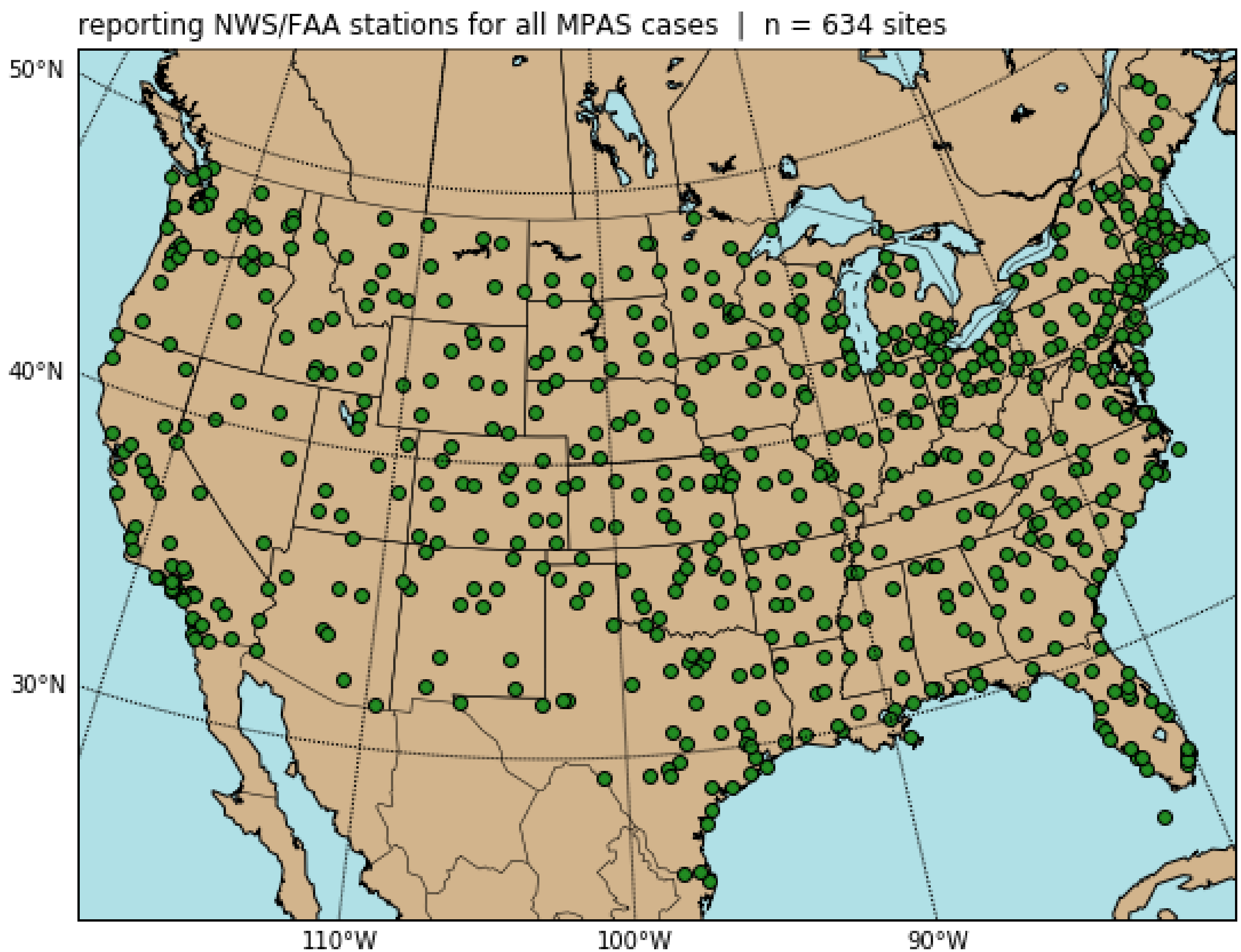


Comparison to GOES satellite imagery over south America

- https://atmos.washington.edu/~njweber2/figures_cheyenne/papers/mpas_overview/sat_comparison/SouthAmerica_w_obs/alooper/

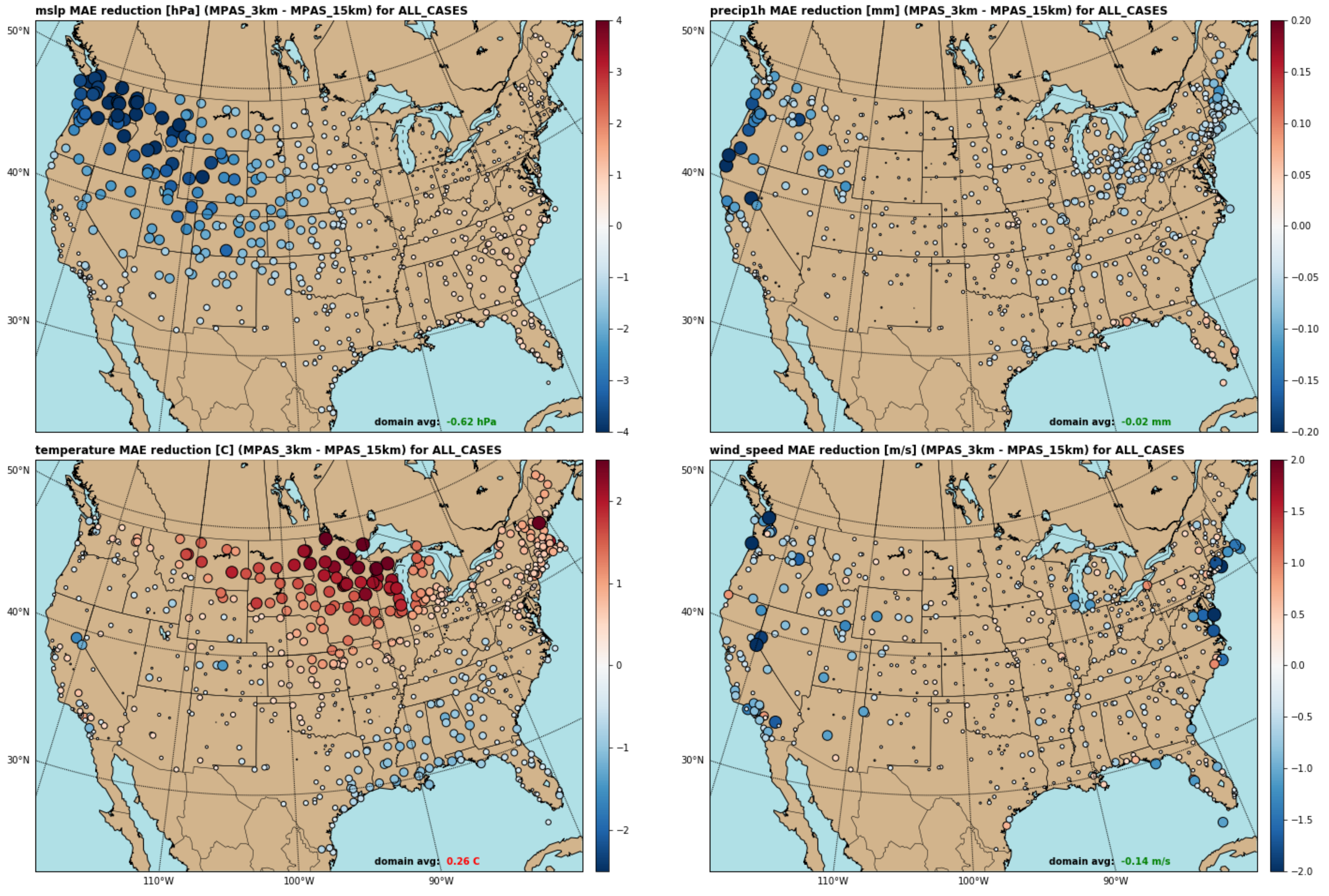
Surface verification: CONUS

E X T R A



CONUS error reduction: MPAS_3km – MPAS_15km

E X T R A



Section 5

Discussion

Conclusions

- **The global convection-permitting MPAS improves upon the 15-km configuration in several regards:**
  - **Tropical precipitation statistics**
  - **MJO propagation**
  - **Vertical structure of organized tropical convection**
  - **Weekly extratropical circulation forecast skill**

- **Omitting the convection scheme at coarse (15-km) resolution and running a channel grid configuration both have their benefits, but were unable to replicate the MJO skill of the global 3-km configuration**

Conclusions

- Convection-permitting resolution has substantial benefits
- Now evaluating improvements in the midlatitudes of both hemispheres.
- Looking forward to using a viable version of FV-3
- **Bottom Line: Global convection-permitting resolution is going to be the future of global NWP.**
- **The computational resources are not unreasonable…NOAA could do this once a week…but really could use additional computer resources to make this a reality.**

The End of the Beginning