



Progress in Tropical Weather Prediction with Global km-scale Models

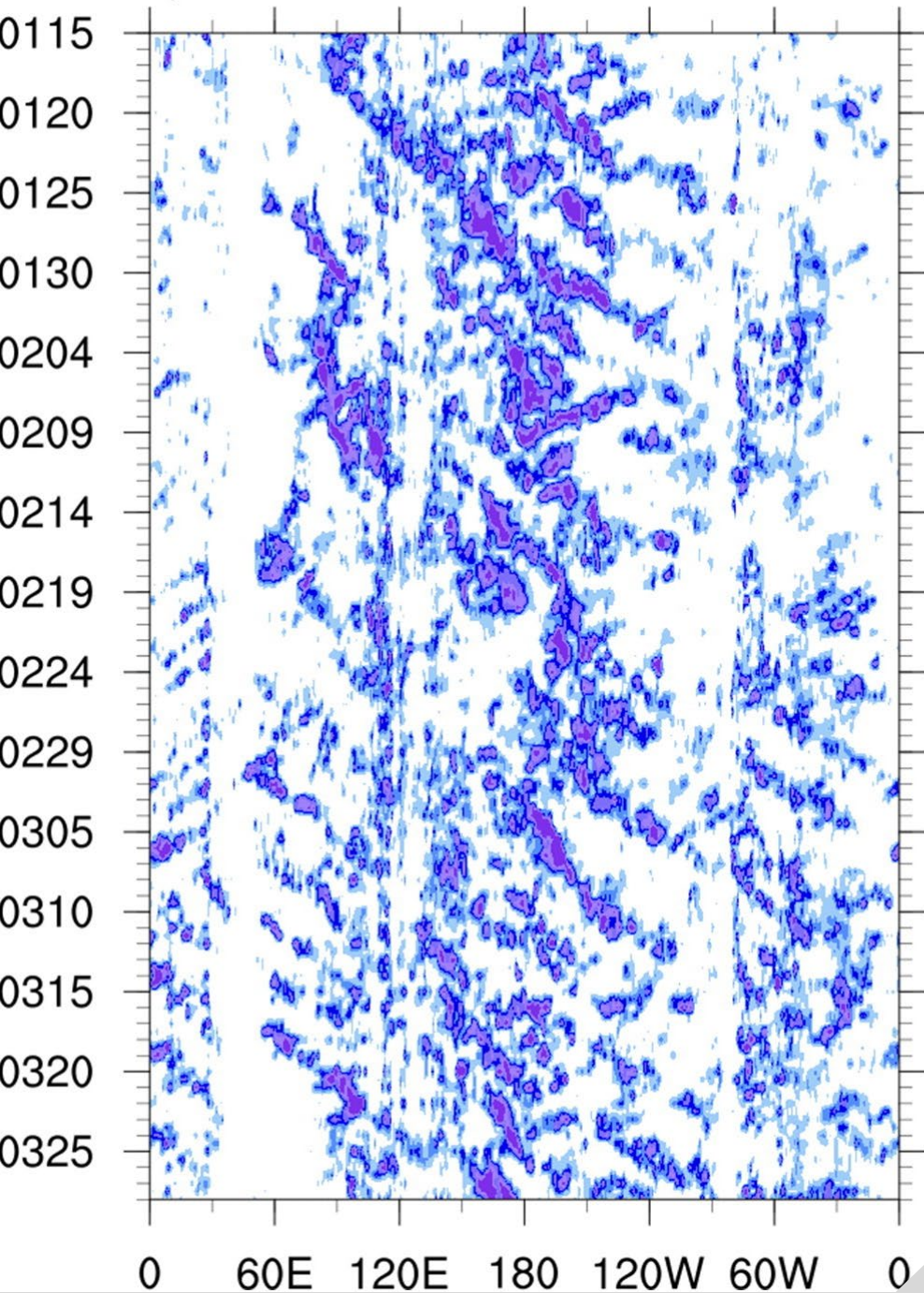
Falko Judt

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METEOROLOGY

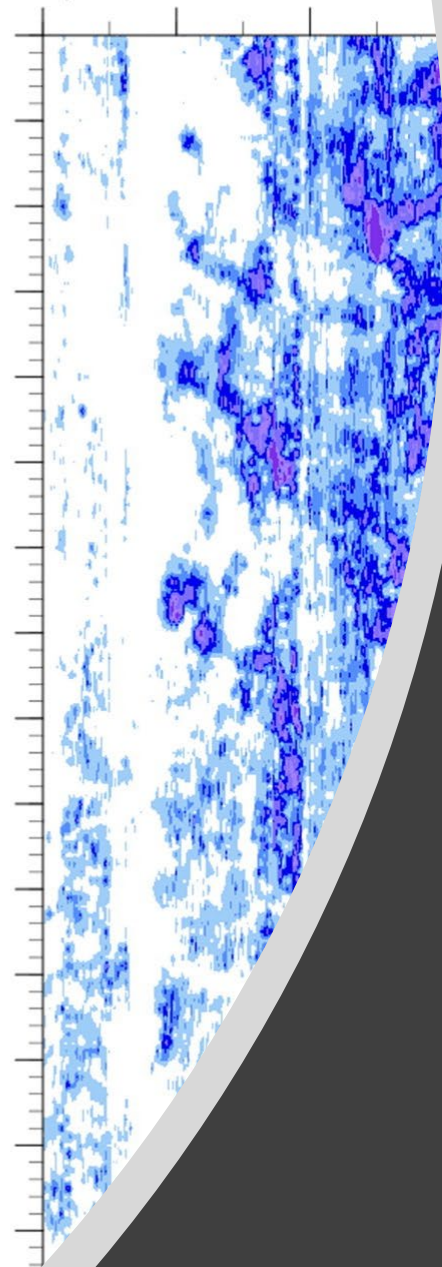




d) CMORPH 0.5d



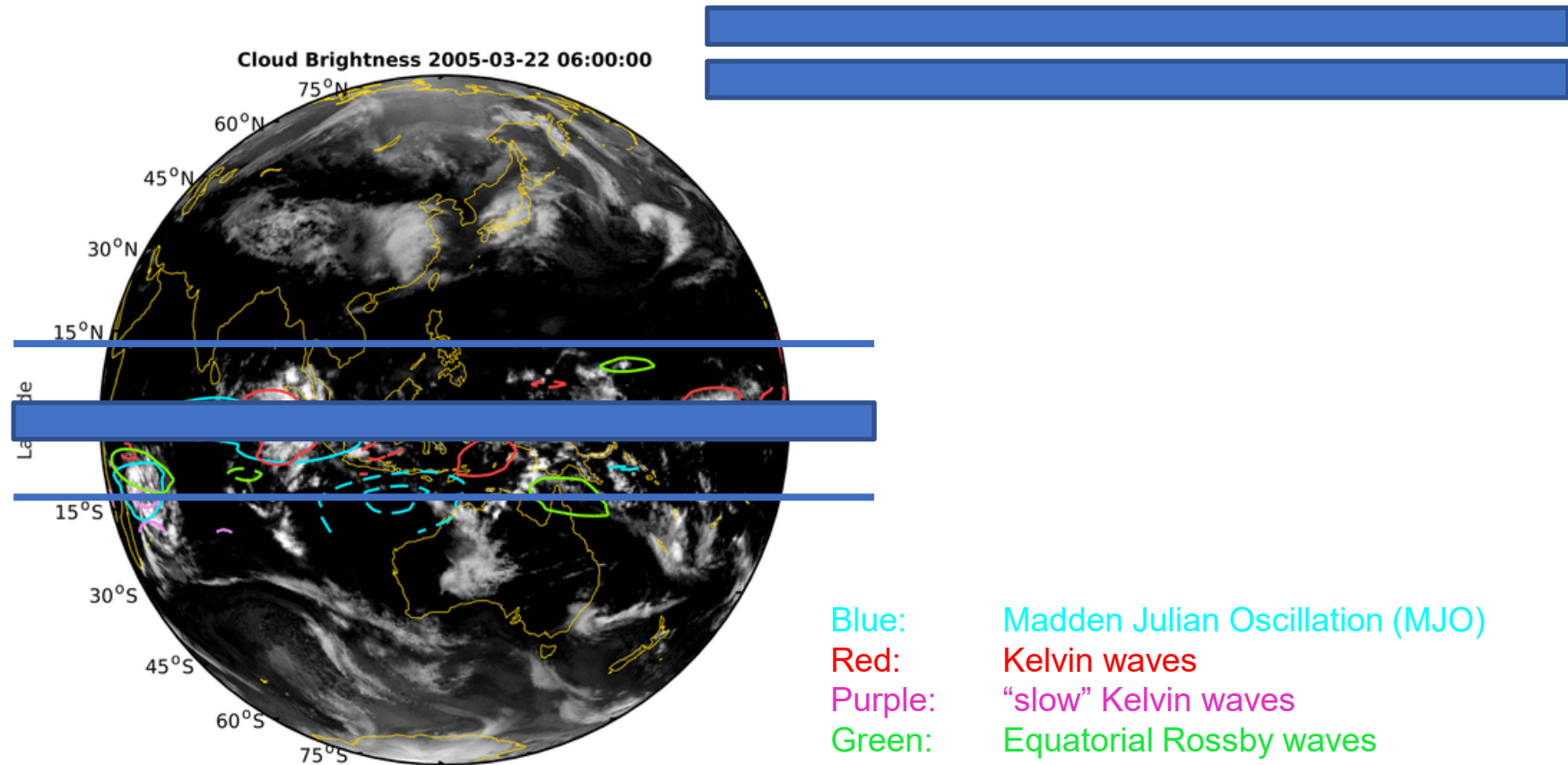
e) GFS 5d0.5d



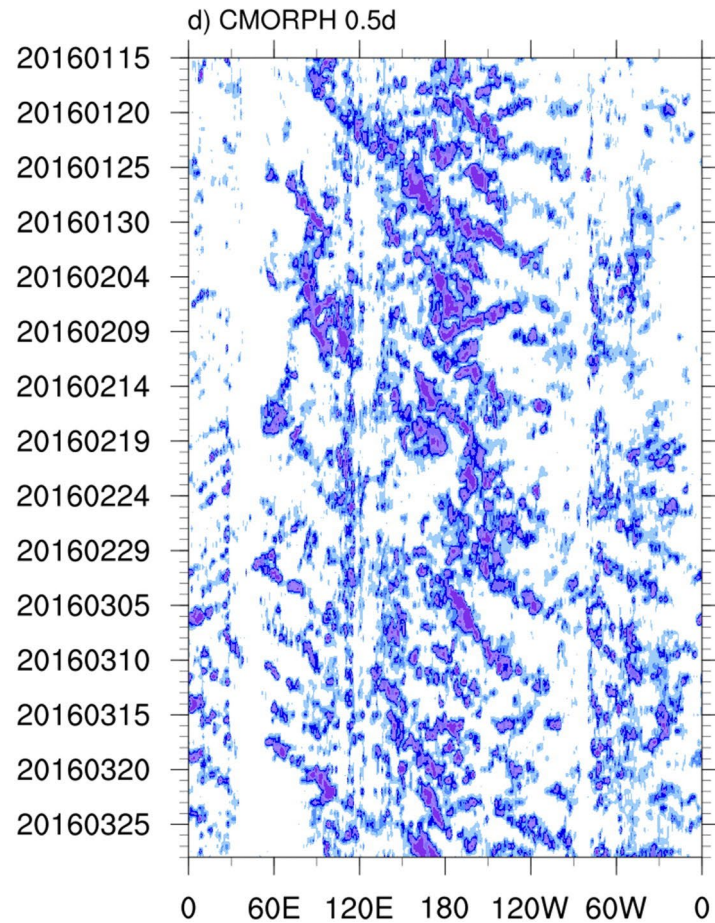
1. Tropical waves

2. Tropical cyclones

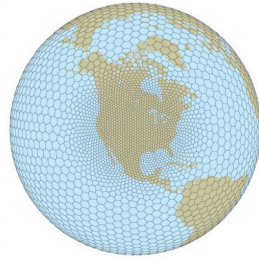
The weather in the tropics is made by a medley of waves and wave-like disturbances



Current NWP models struggle with simulating tropical weather

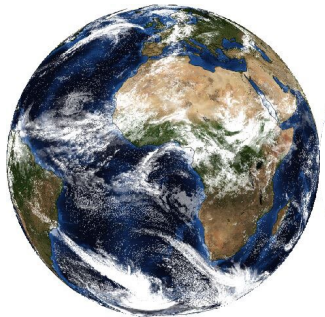


MPAS Resolution Ensemble (DYAMOND)

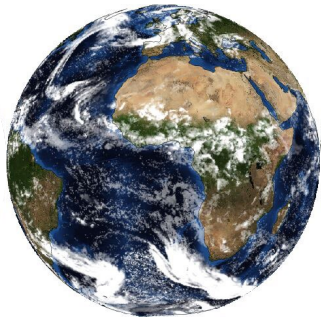


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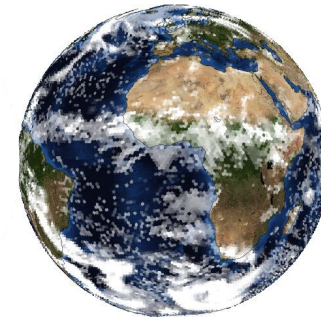
- “resolution ensemble” with 10 simulations
 - min dx: 3.75 km (convection mostly resolved)
 - max dx: 480 km (convection mostly parameterized)
- 40 days (1 Aug–10 Sep 2016)
- Initial conditions & SST from ECMWF



3.75 km

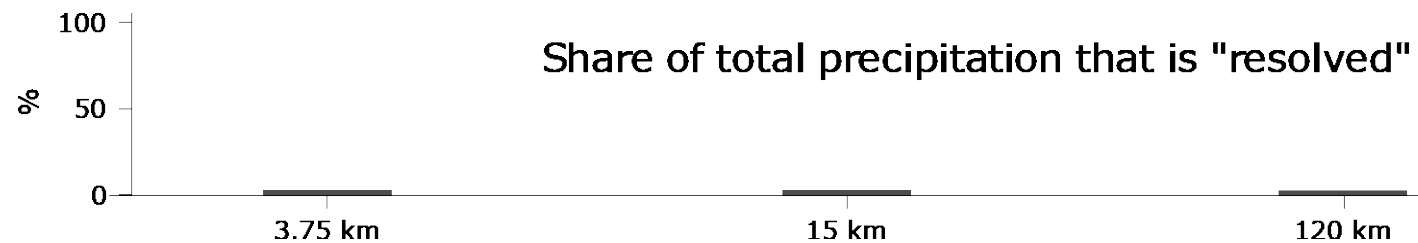


15 km

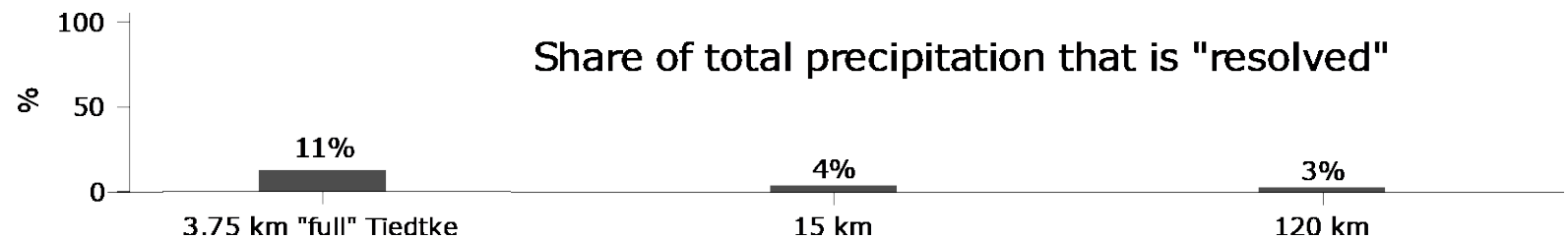
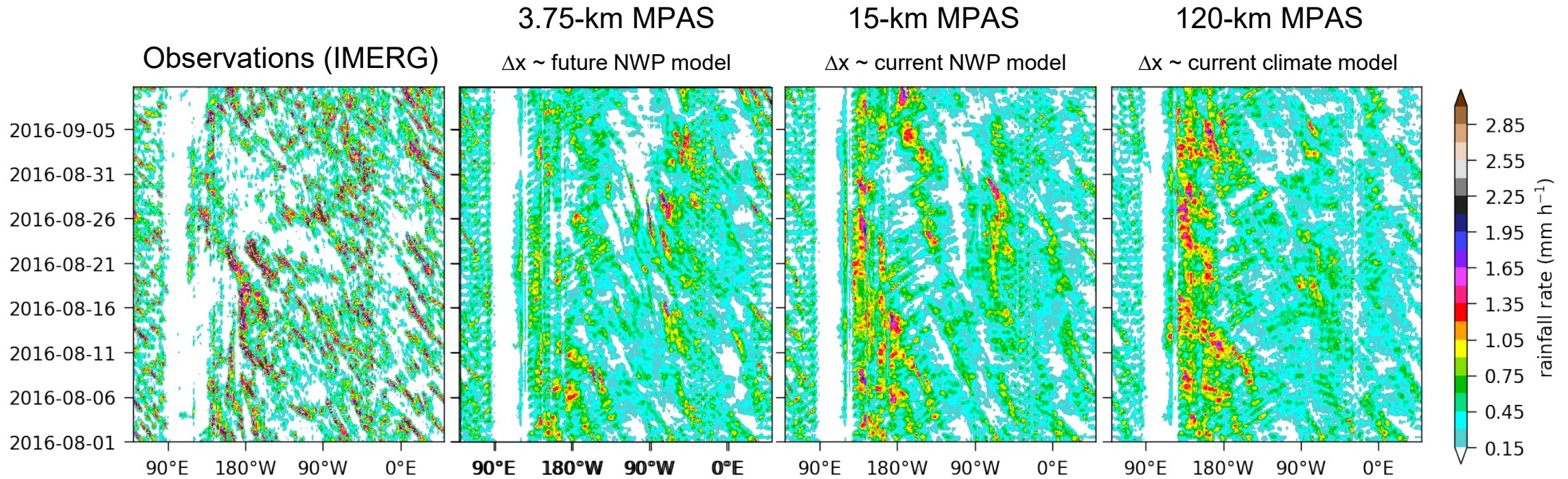


120 km

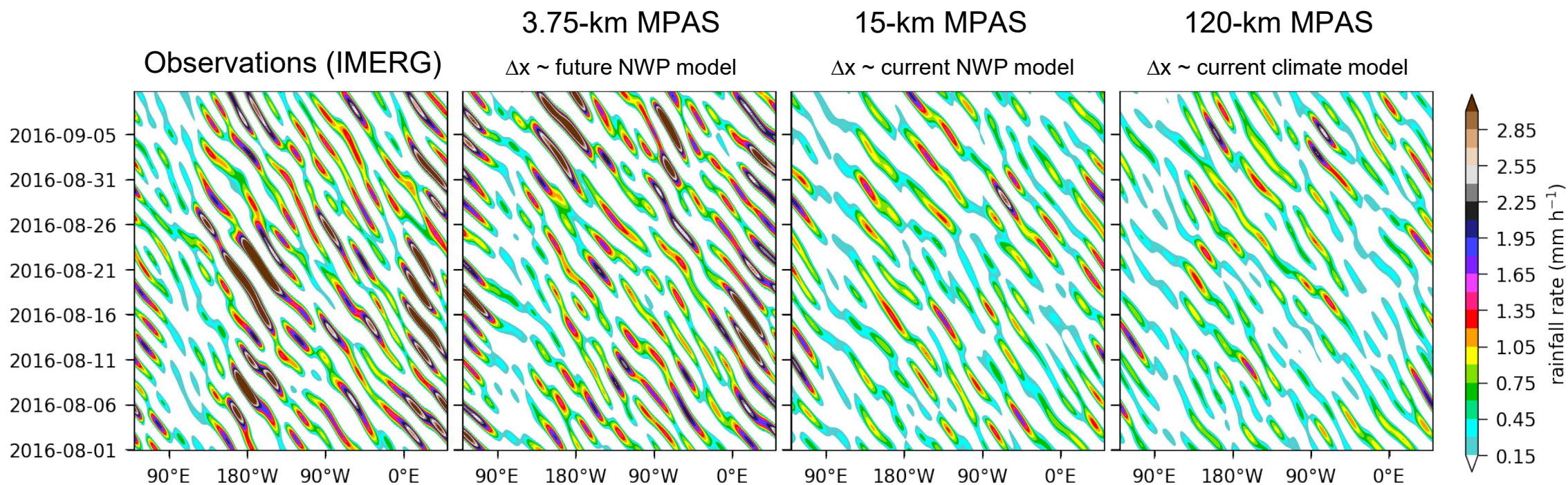
Explicit convection → more realistic rainfall patterns



Explicit convection → more realistic rainfall patterns

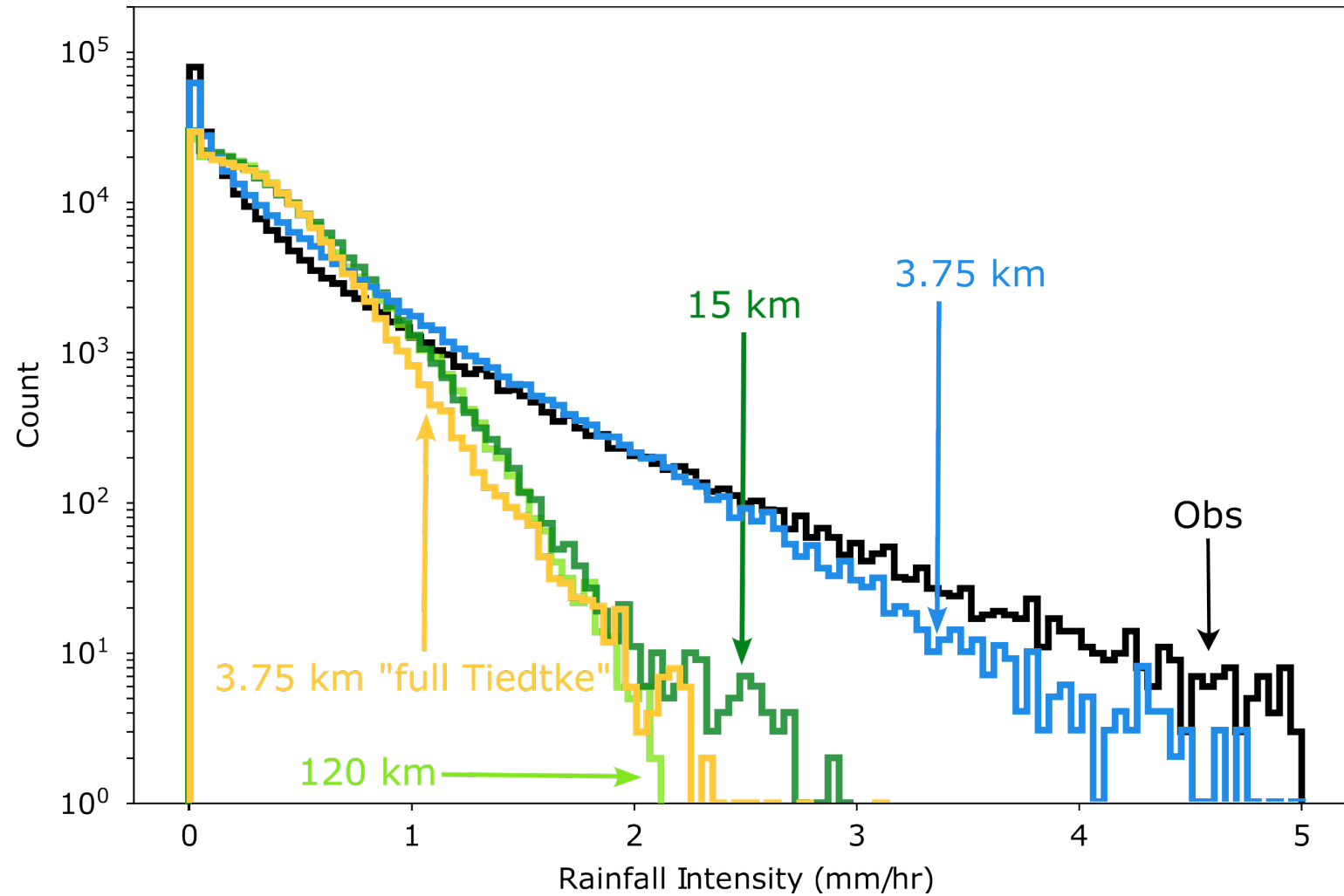


Explicit convection → more realistic tropical waves

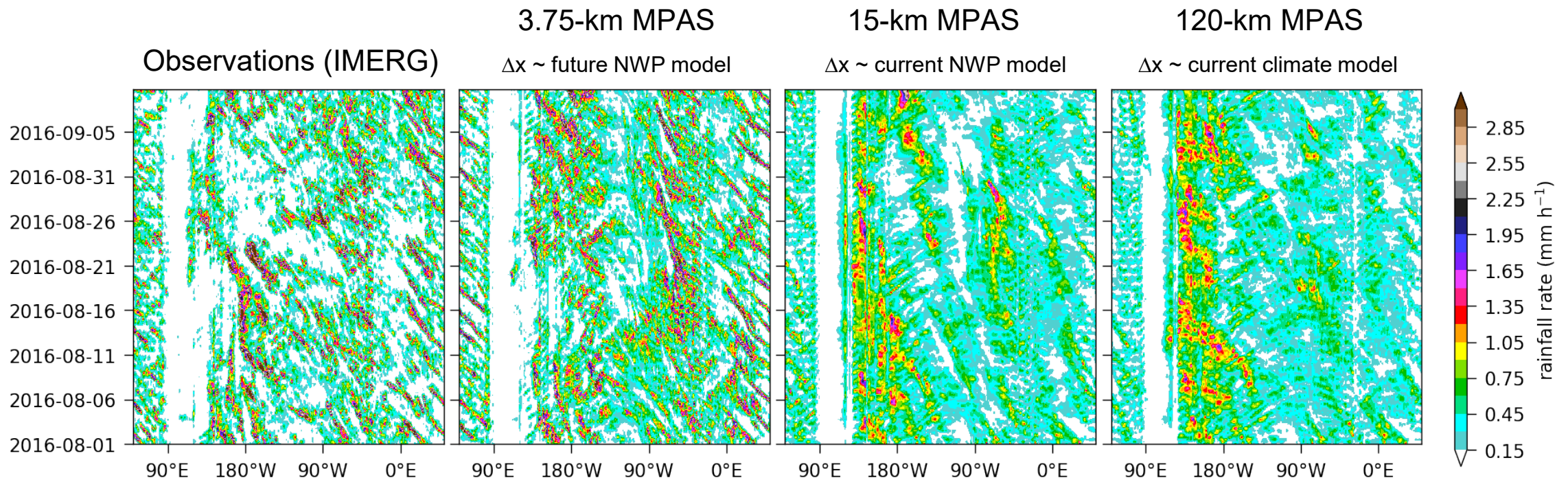


Tropical depression-type waves
(e.g., African Easterly Waves)

Explicit convection → *much* improved rainfall intensity distribution

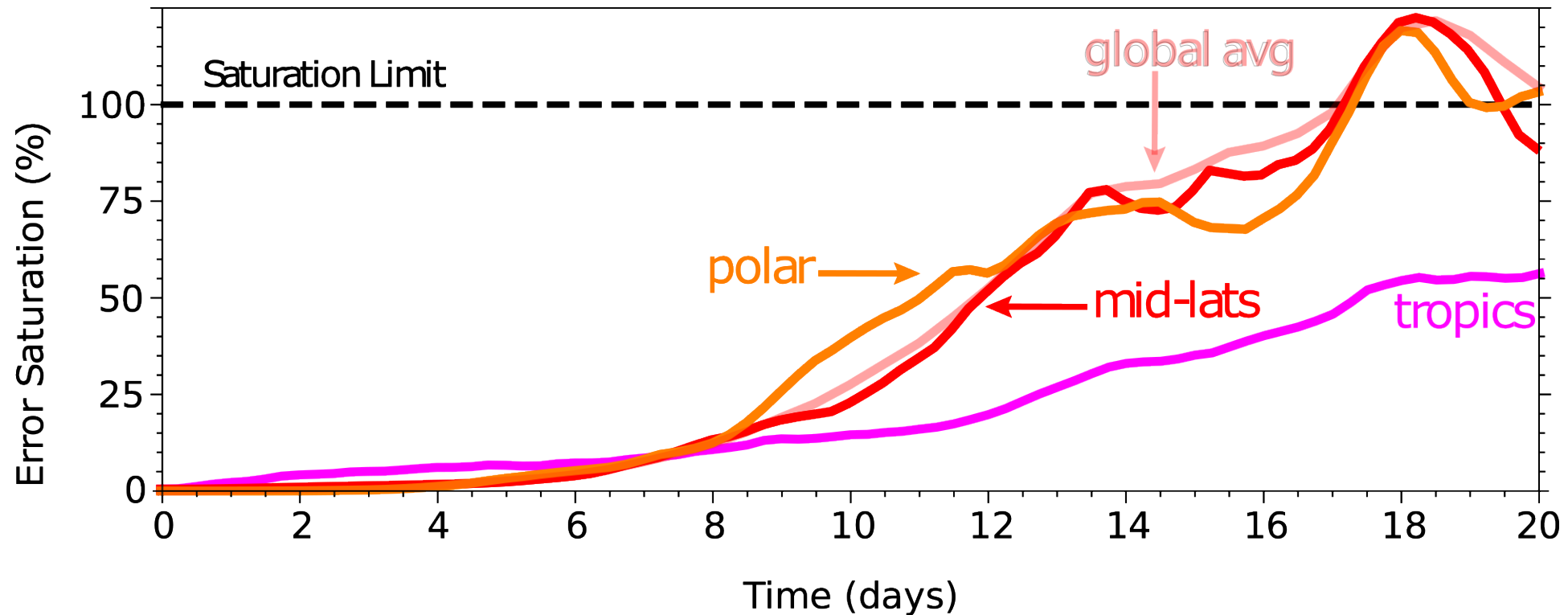


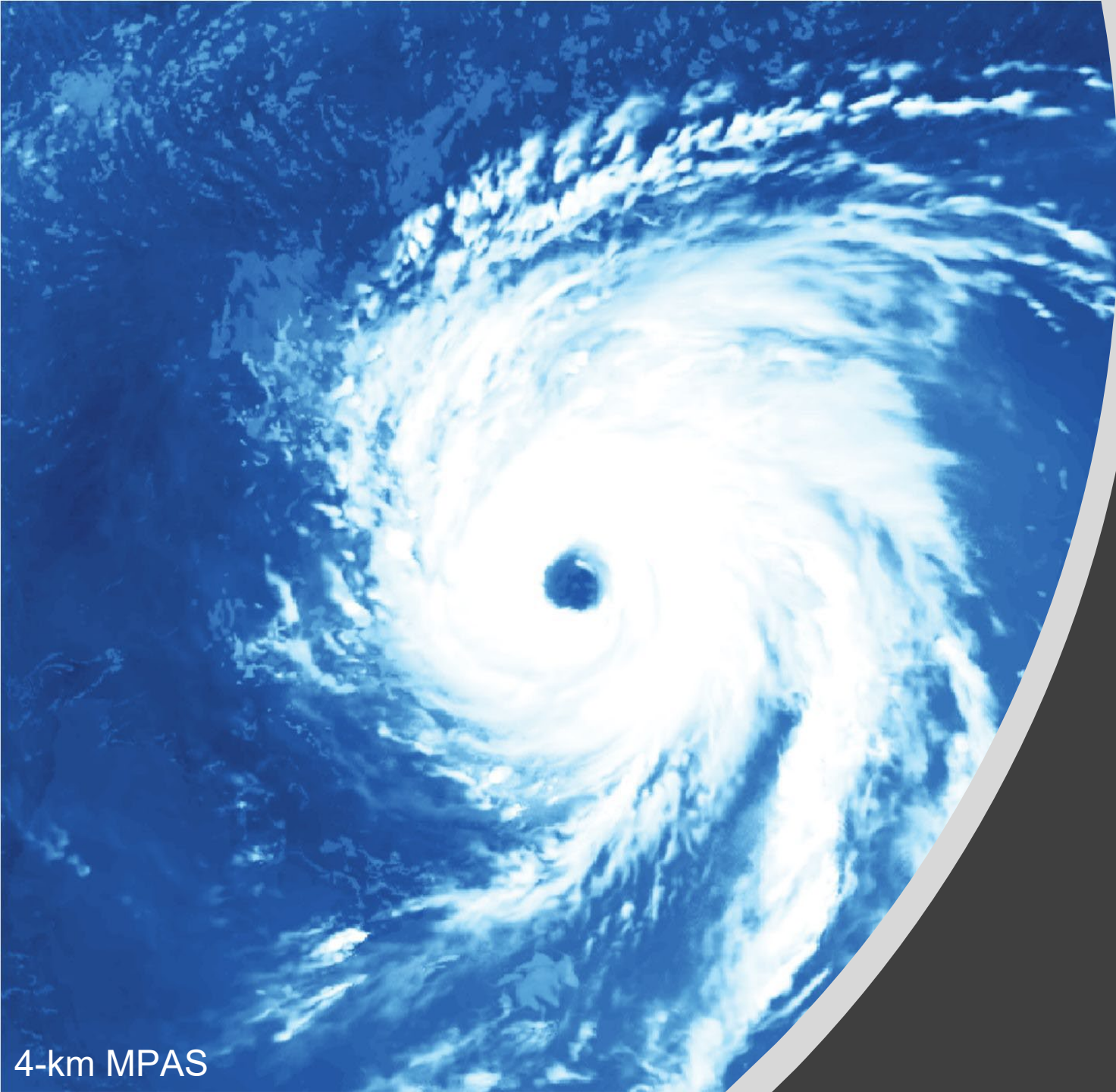
Explicit time steps to improve realistic evaporation & of infiltration waves?
→ Untapped predictability potential!



Why is it import to improve representation of tropical waves? → Untapped predictability potential!

Error (Difference Kinetic Energy) as function of time from 4-km MPAS Identical Twin Experiment





1. Tropical waves

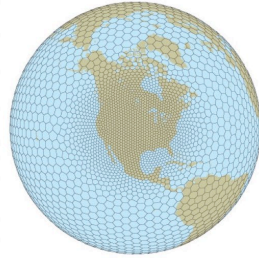
2. Tropical cyclones

Tropical Cyclones — Sensitivity to Resolution

3.75-km MPAS
DYAMOND run

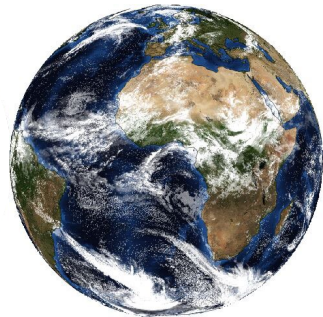


MPAS Resolution Ensemble (DYAMOND)

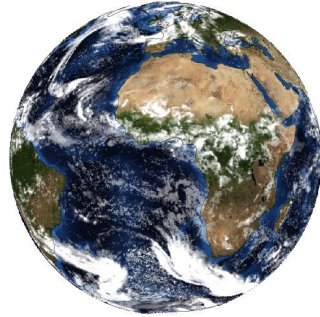
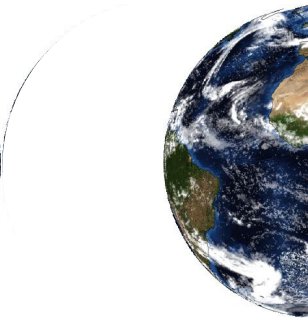


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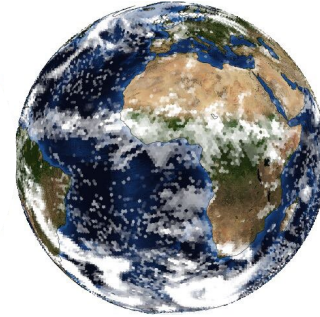
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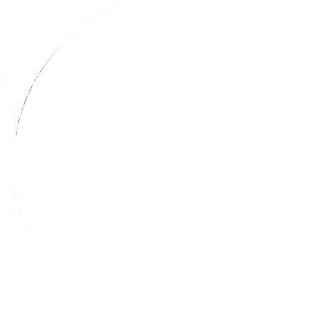
3.75 km



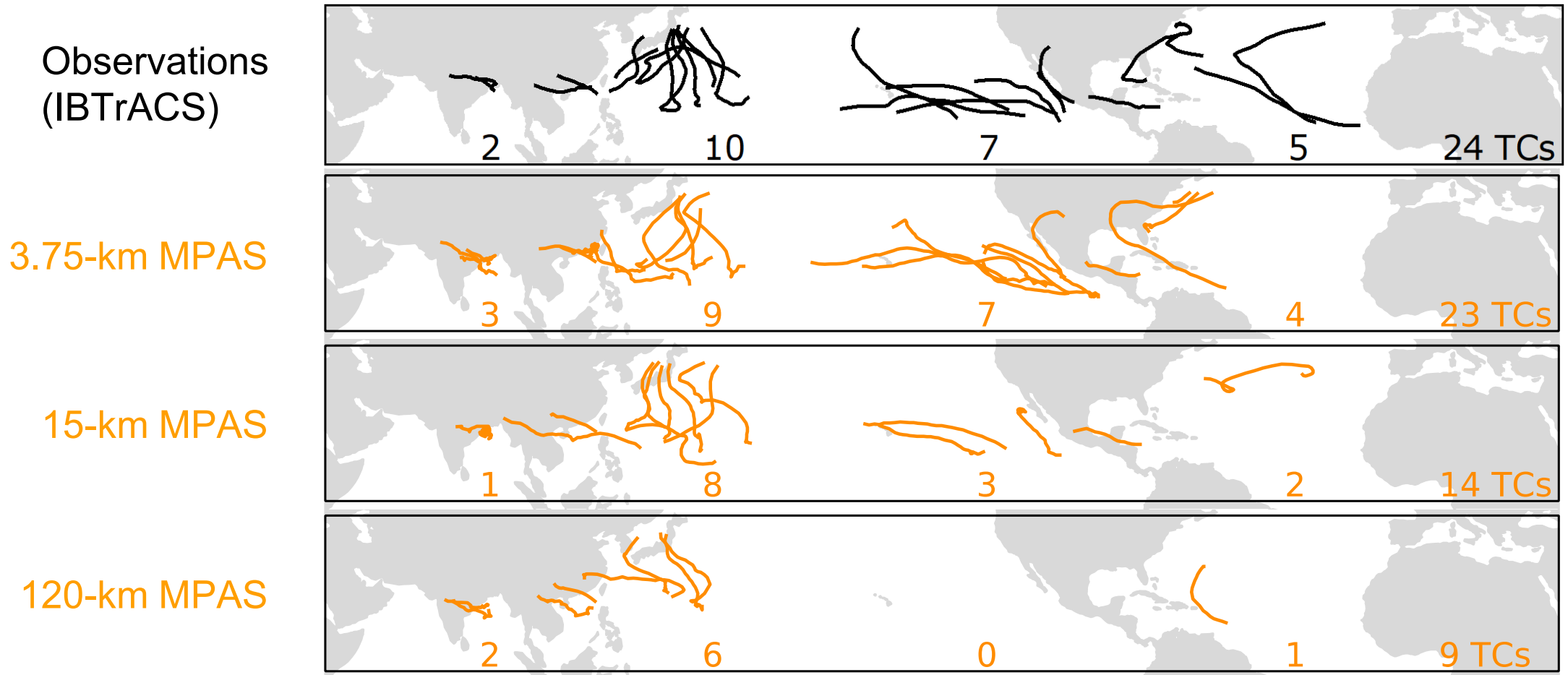
15 km



120 km

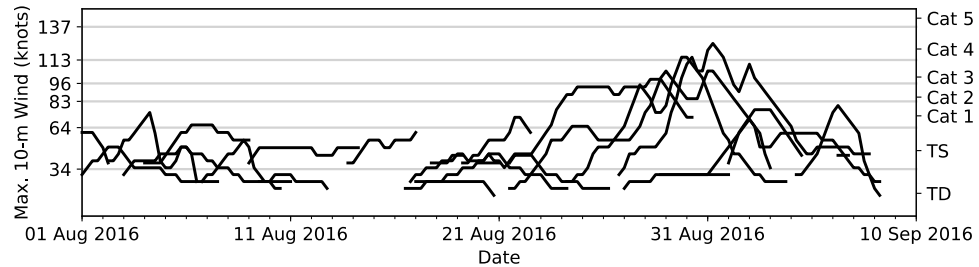


Higher resolution → more accurate number of TC

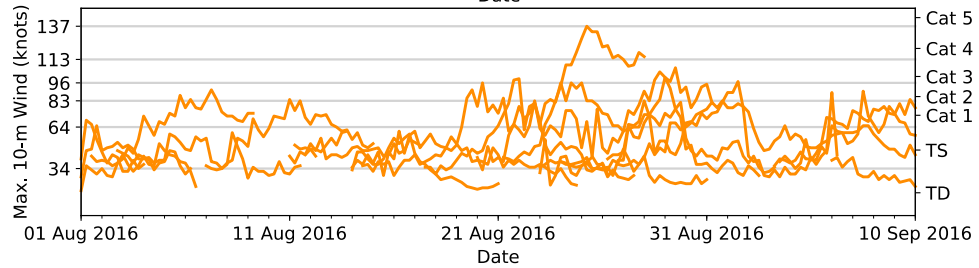


Higher resolution → better representation of TC intensity

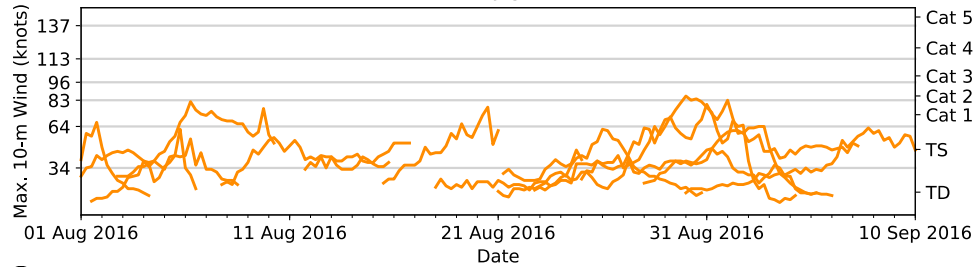
Observations
(IBTrACS)



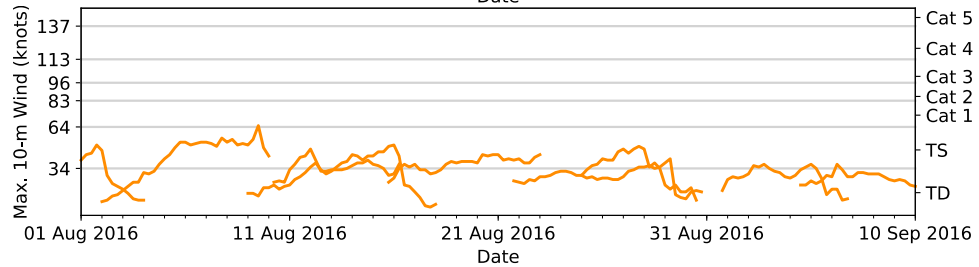
3.75-km MPAS



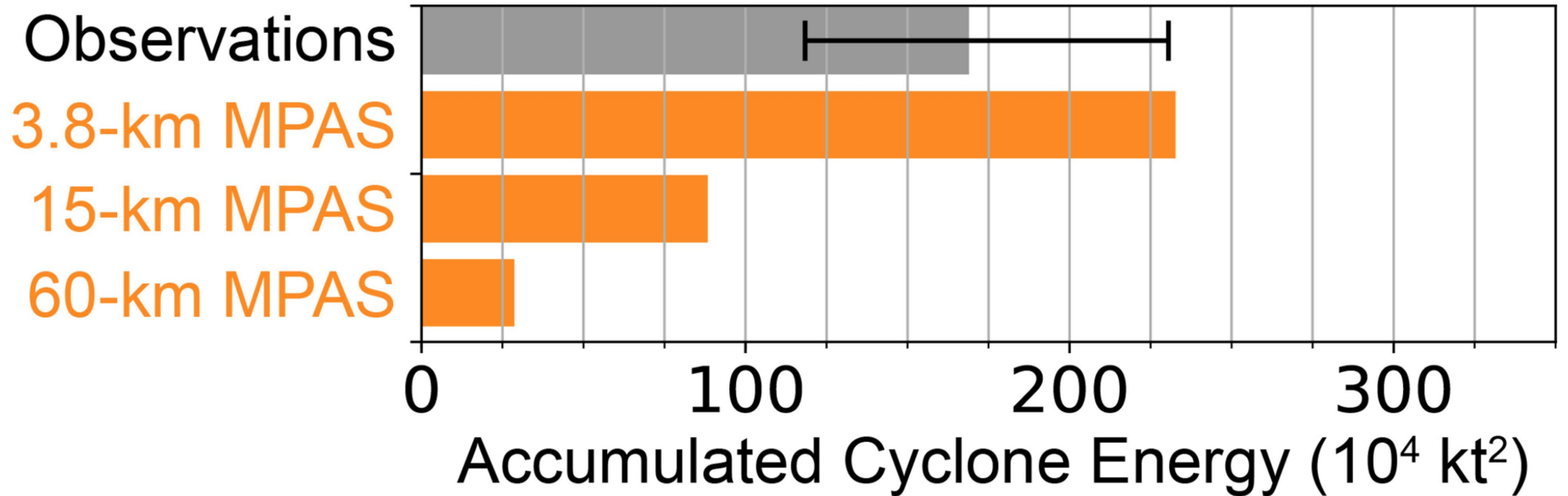
15-km MPAS



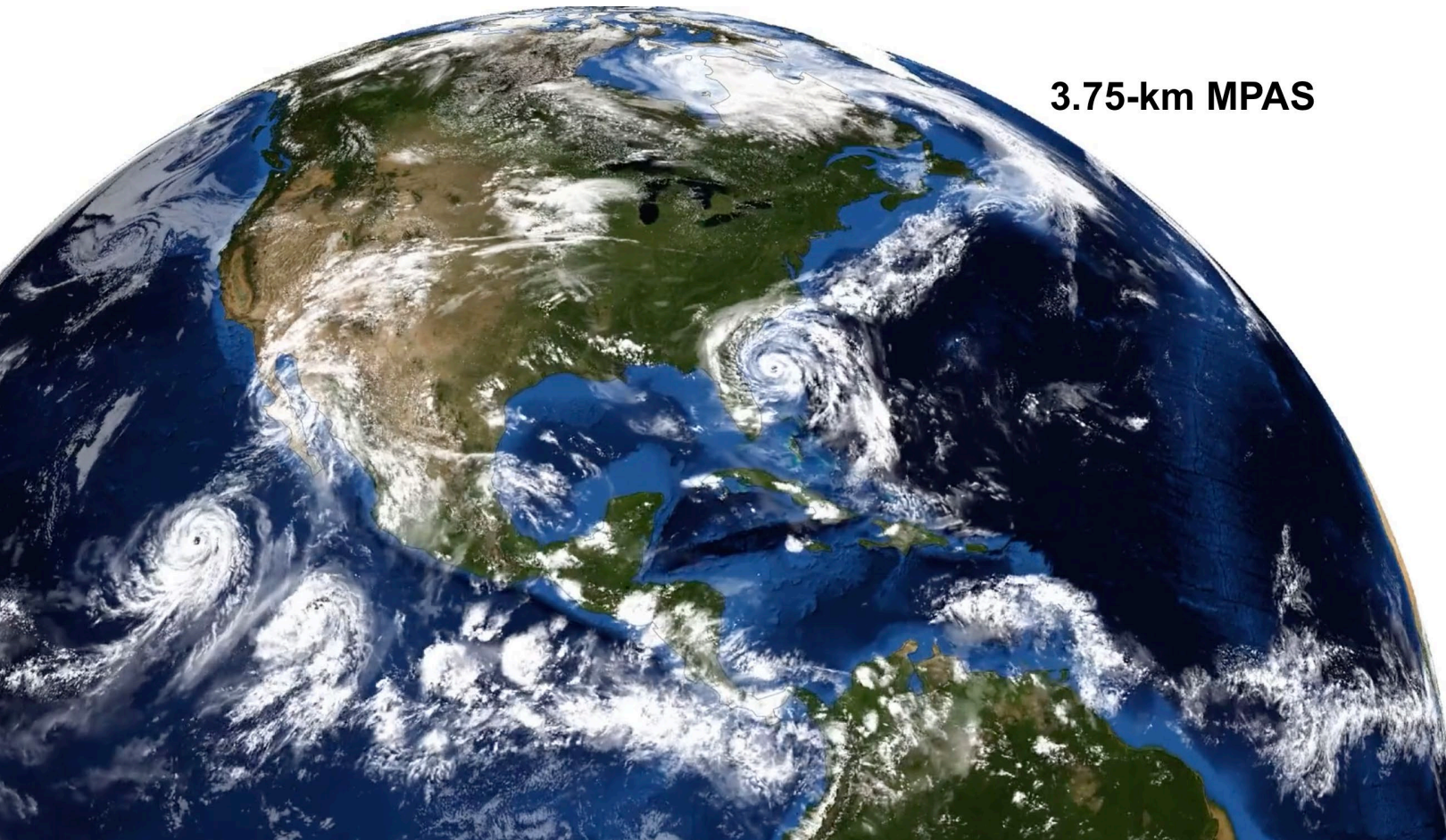
120-km MPAS



Higher resolution → better representation of TC intensity

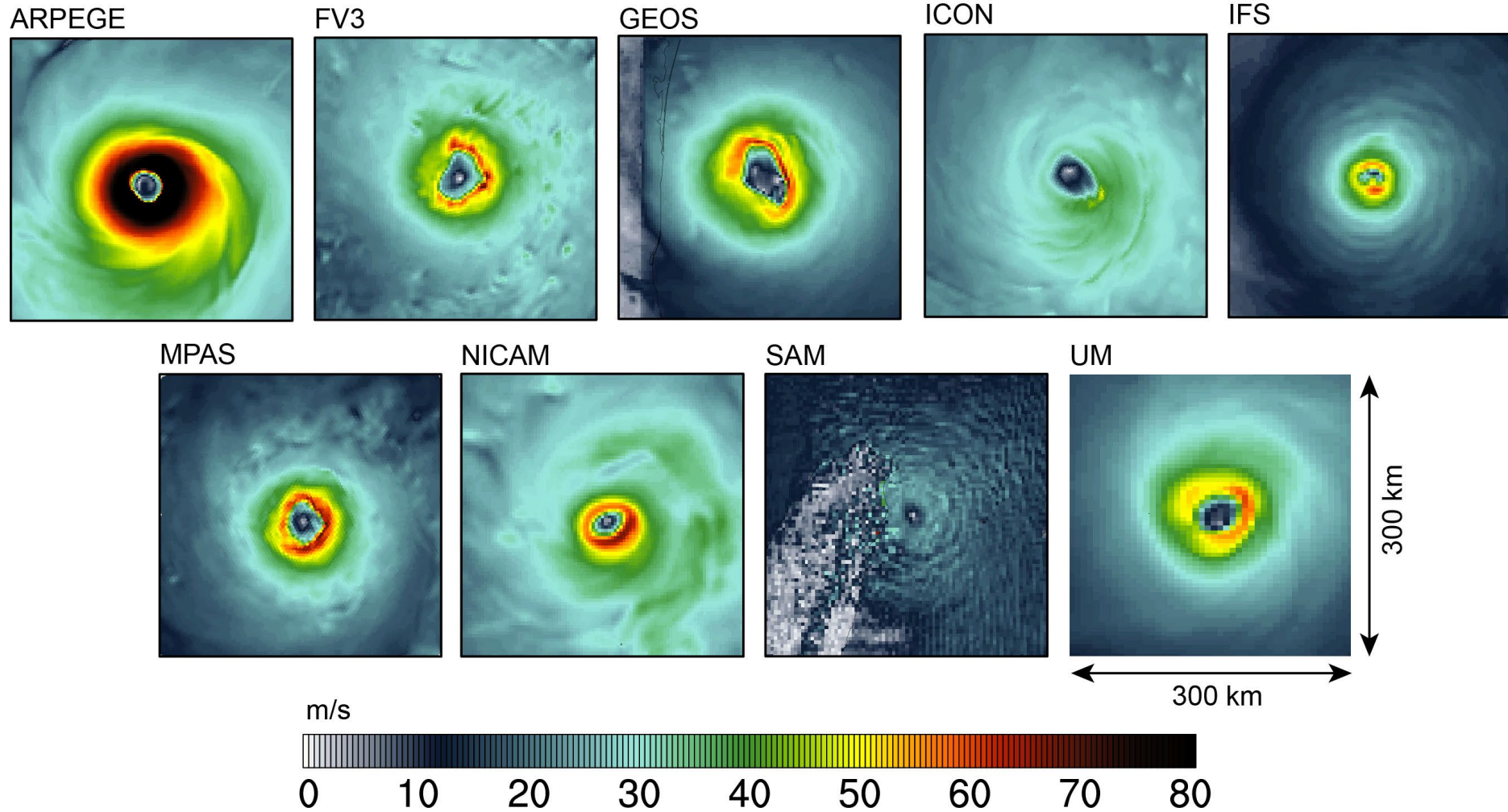


TCs — Model Intercomparison (DYAMOND)



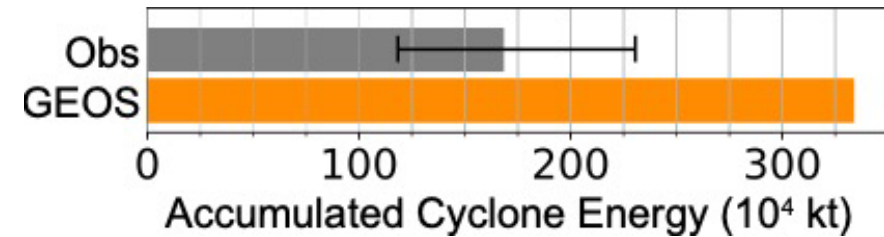
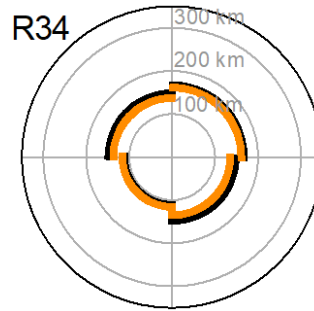
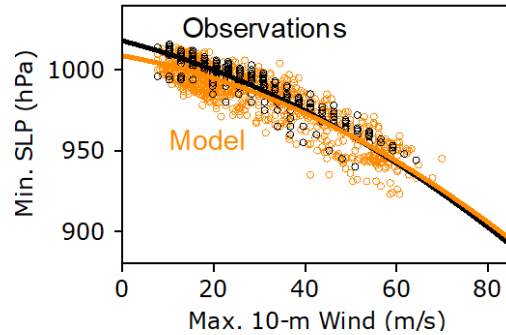
3.75-km MPAS

The Hurricanes of DYAMOND

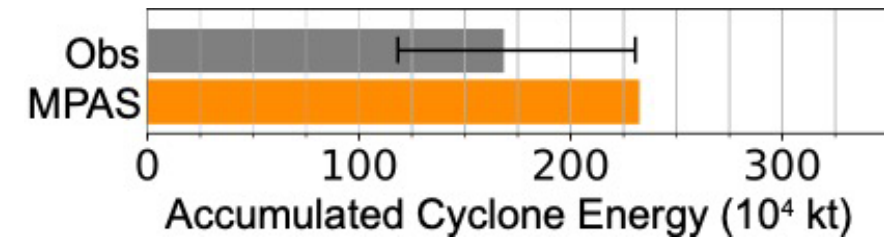
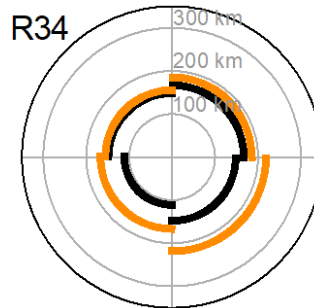
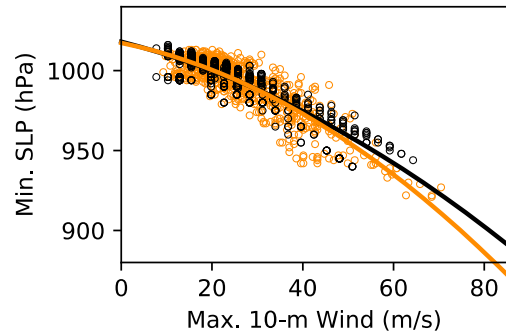


One model to rule them all? No, each model has its own biases.

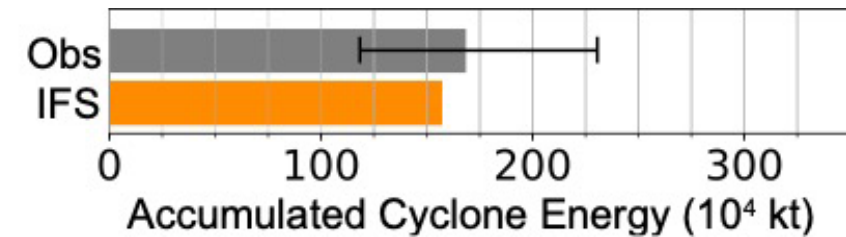
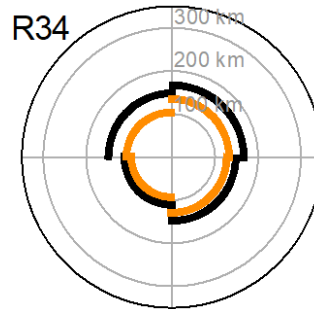
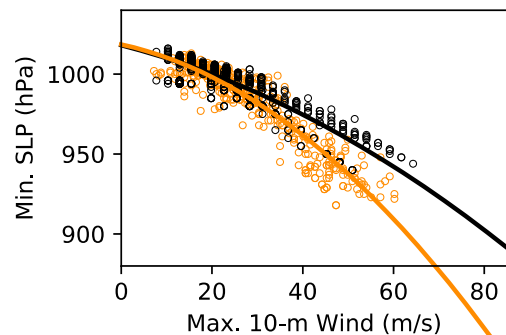
GEOS
3.3 km



MPAS
3.75 km



IFS
4.8 km



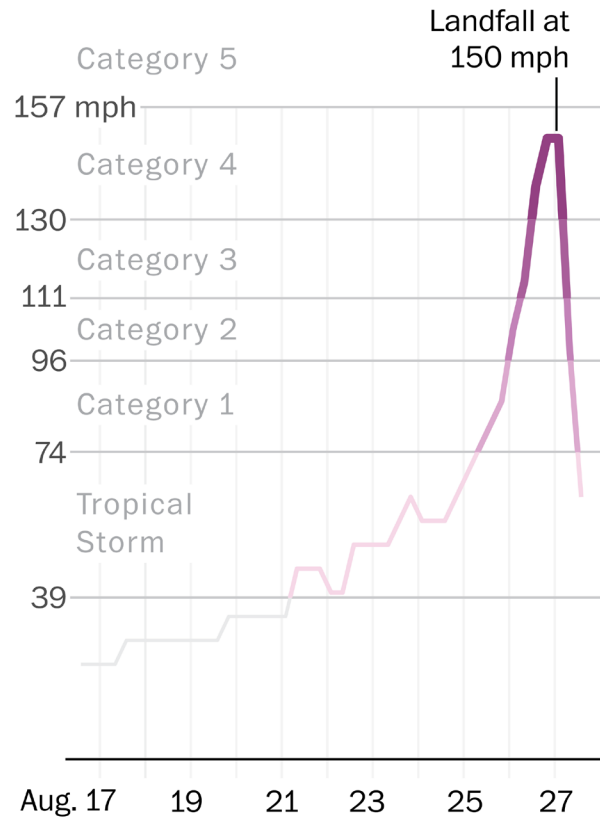
km-scale simulations as resource for cutting-edge TC science

3.75-km MPAS
DYAMOND run



Rapid intensification

Laura strengthened from a tropical storm to a Category 4 in 36 hours

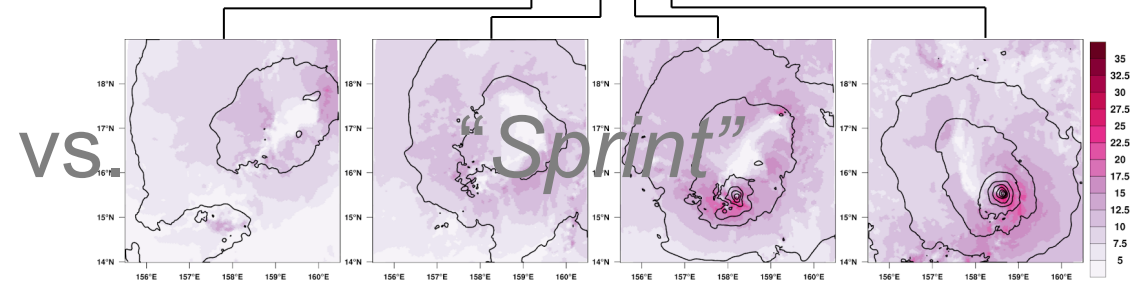
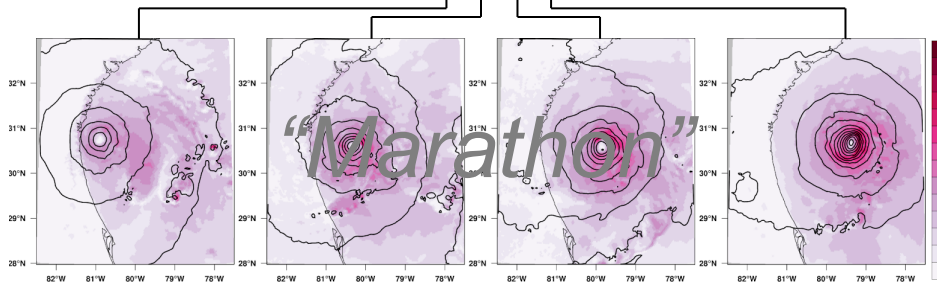
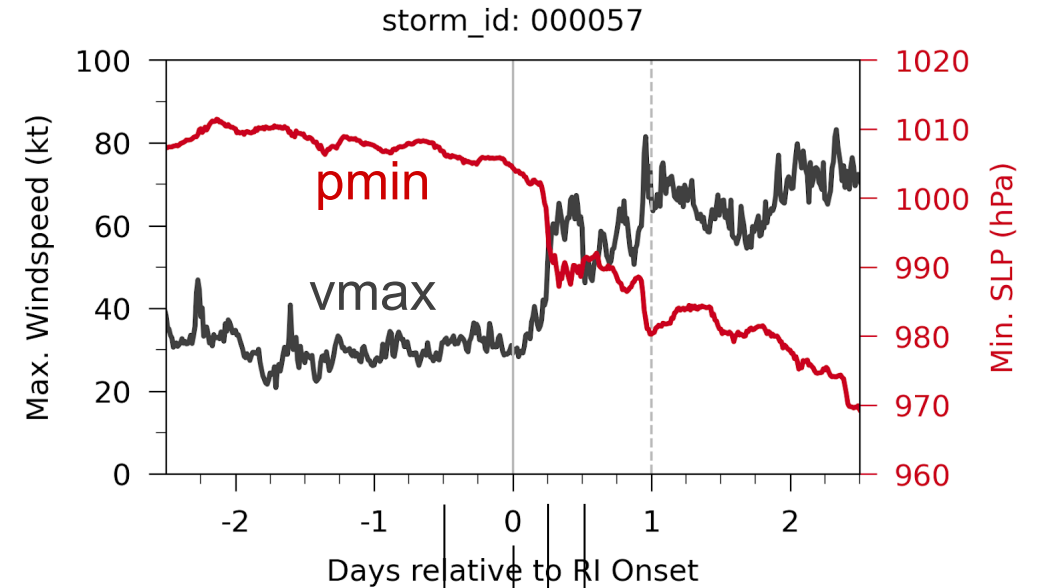
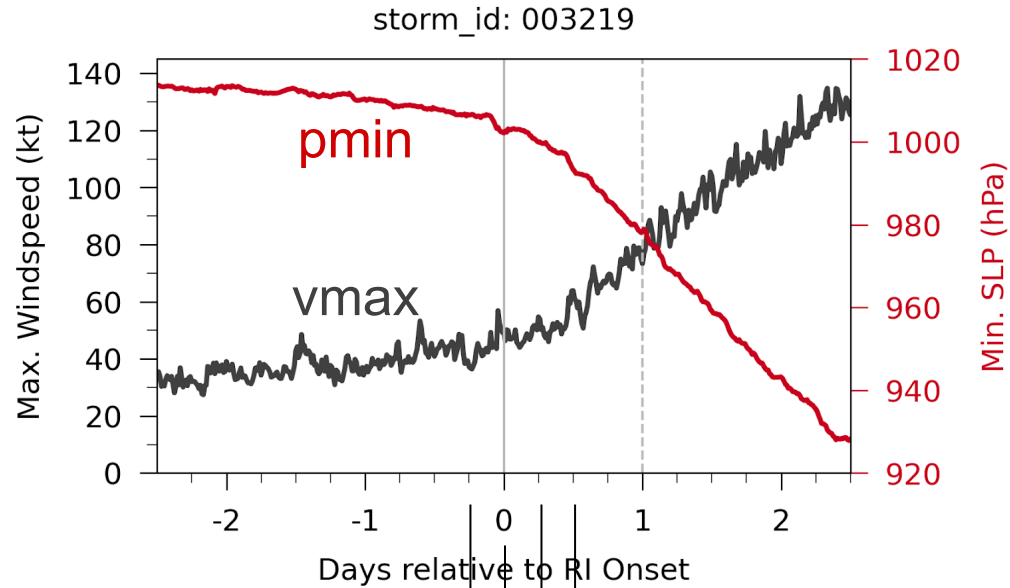


Source: National Hurricane Center

JOHN MUYSKENS/THE WASHINGTON POST



Two Modes of Rapid Intensification



Shading: 10-m wind speed
Contours: sea level pressure

Concluding remarks

- Resolved convection improves tropical rainfall variability and tropical waves.
- High-res global models have smaller tropical cyclone-related biases, such as intensity too low.
- Is it worth it (computational cost, big data)? Probably yes.

