How does the v3.HR Atmosphere differ from and v3.LR and how do resolution vs configuration differences contribute?

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How does the v3.HR configuration differ from v3.LR?

Our initial intent was to keep the ne120 v3.HR configuration mostly unchanged from v3.LR but scale sensitivities required several changes.

They include:

- Replacing the default orographic wave drag scheme[1] with a new scheme[2] and adding flow-blocking drag[2], small-scale GWD[3], and turbulent-scale orographic form drag[4]
- Turning off ZM mass flux adjustment enhancement
- Dust emission cap
- Parameter tuning changes (in P3, frontal gravity wave drag, sponge layer thickness, dust & sea salt emission, Linoz O_3 loss T threshold, lightning NOx production factor)

Given these configuration difference between v3.LR and v3.HR, this poster explores the role of resolution vs configuration change in explaining the differences between LR and HR.

Mean-state climate

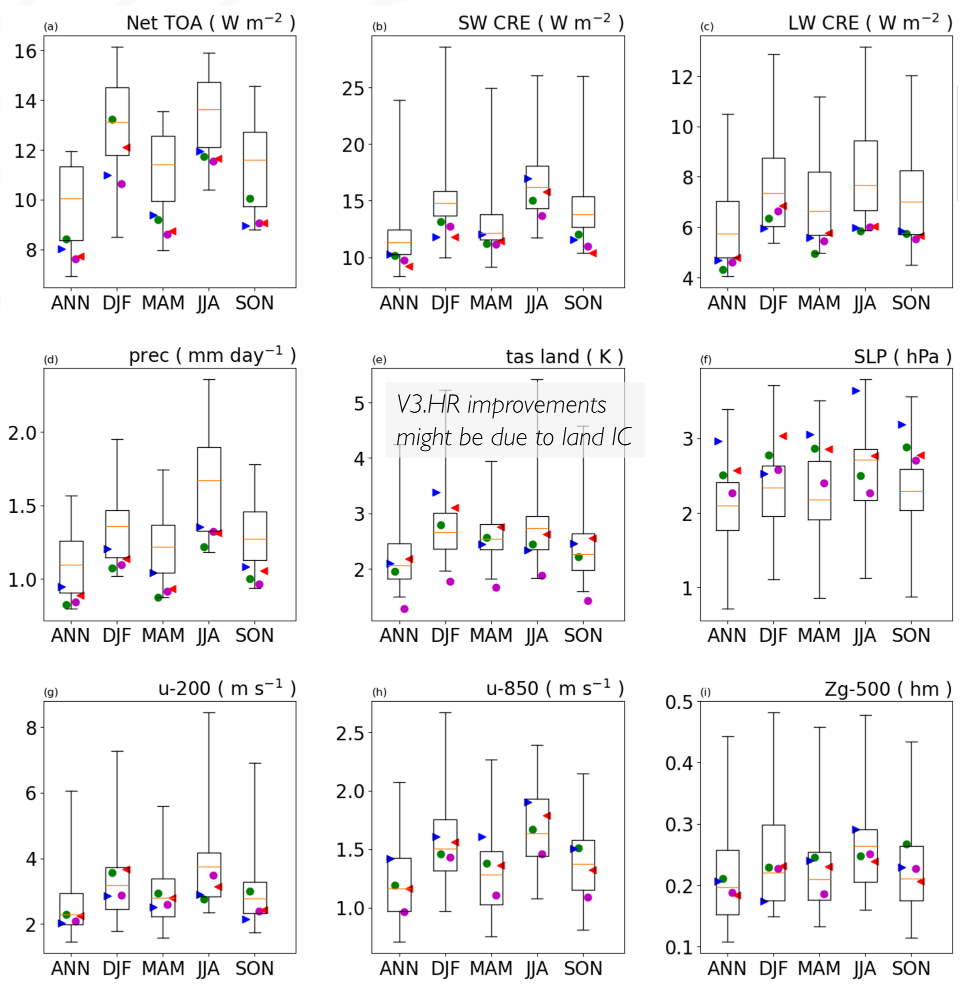

Figure 1. Comparison of RMSE (1985-2014) of an ensemble of CMIP6 models (amip r1i1p1f1 ensemble) against 10-year simulations(1995-2004) with EAMv3.LR (green) and EAMv3.HR (magenta).

Box and whiskers show 25th, 75th percentile, minimum and maximum RMSE of the ensemble. CMIP6 data access: 2022/06

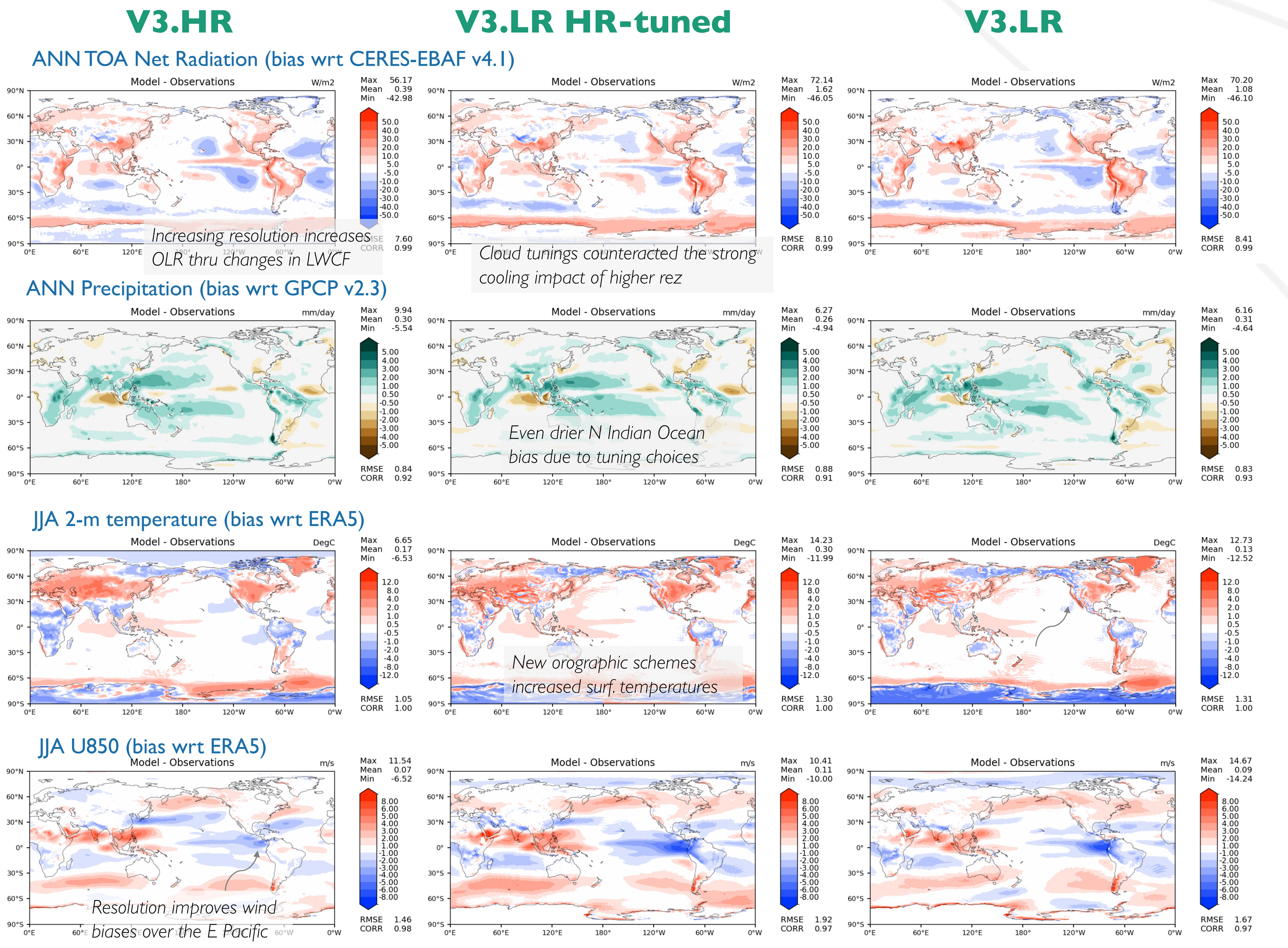

Figure 2. Bias in 10-year averaged climatological mean fields from v3.HR (left column), v3.LR simulation using HR configuration (middle column), and v3.LR (right column) with respect to various observational datasets.

Modes of variability

Quasi-Biennial Oscillation

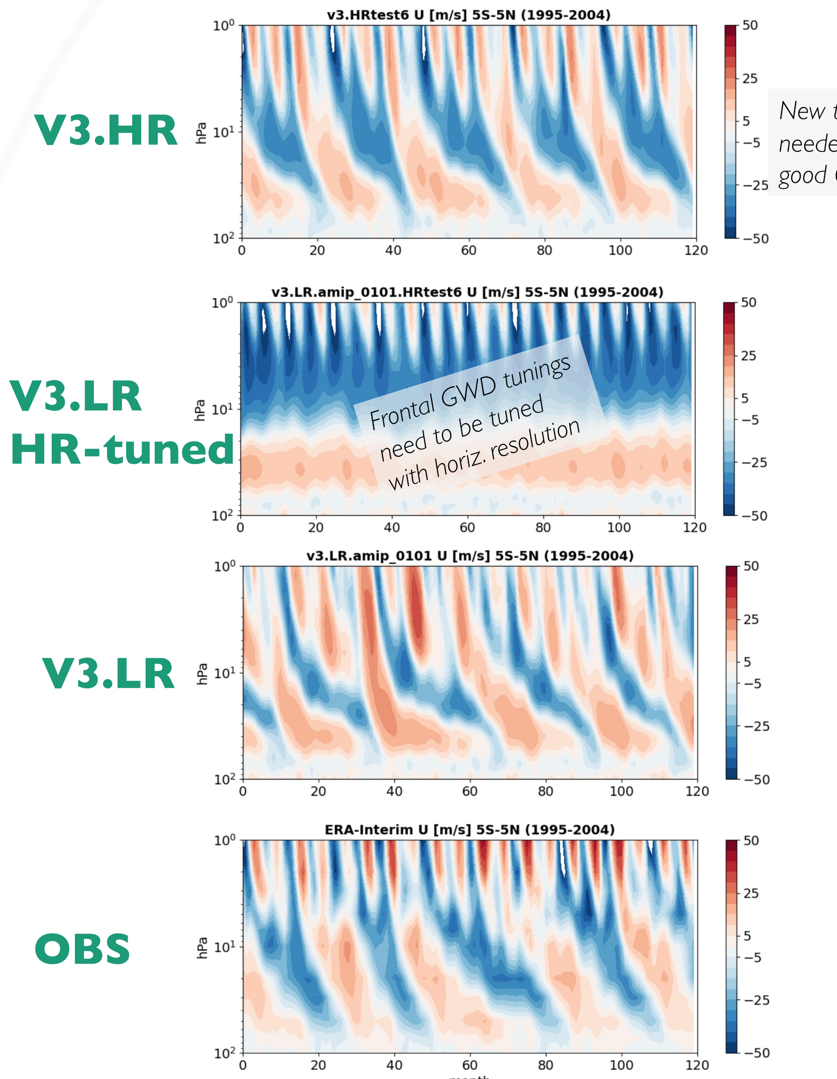

Figure 3. Pressure vs. time Hovmoller diagram of zonal wind averaged over 5°S and 5°N in the various model configurations and ERA5.

Tropical subseasonal variability

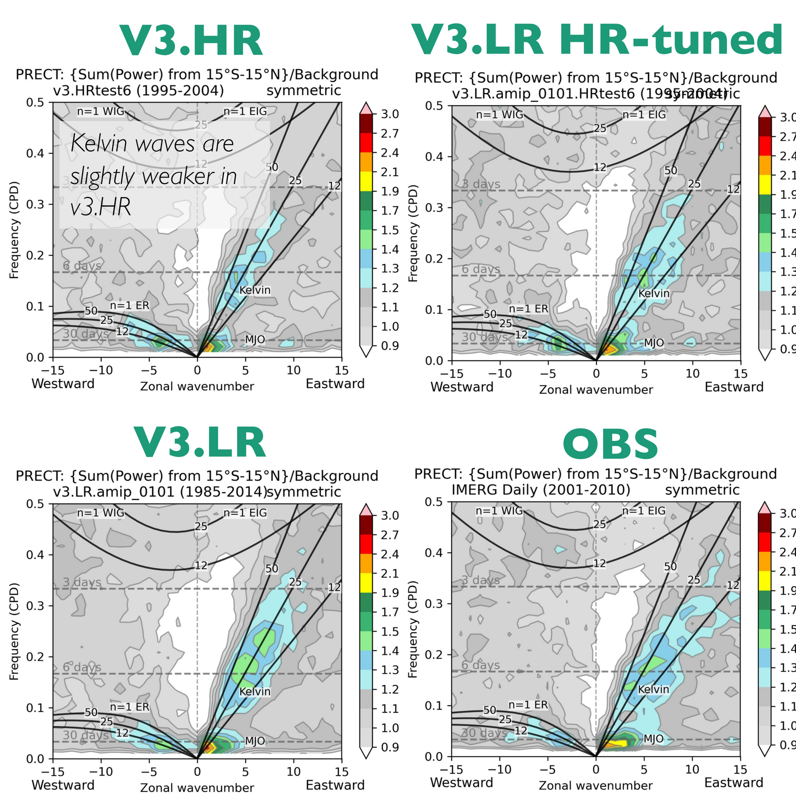

Figure 4: The symmetric component of the frequency-zonal wavenumber spectra for precipitation rate averaged over 15°S and 15°N based on various model configurations and GPM-IMERG satellite retrievals.

Diurnal cycle

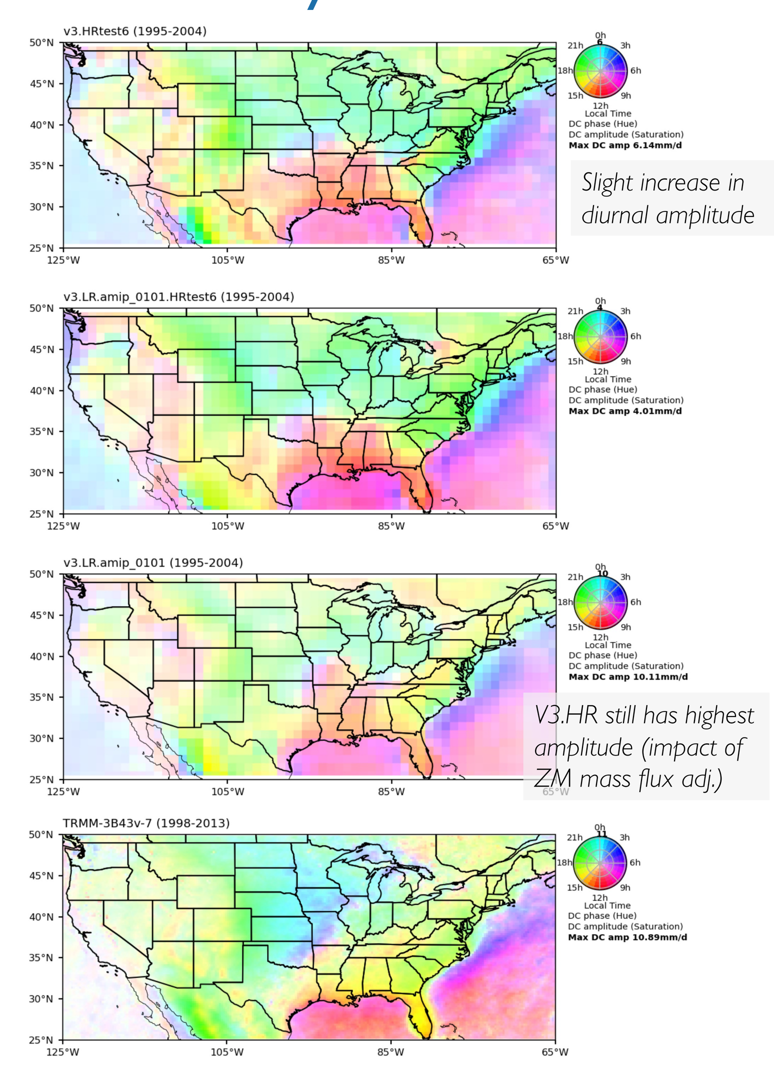

Figure 5: Diurnal cycle of precipitation over the continental US over the JJA months in the various model configurations and TRMM satellite retrievals.

Tropical cyclones

Model / Obs	Tropical Cyclone Count	
v3.HR.amip	~55 per year	more TCs with none of the new ZM enhancements[5]
v3.LR.amip	~5 per year	
v1.HR.1950Ctl	~64 per year	v1.HR produced more TCs per year
IBTrACS	~83 per year	

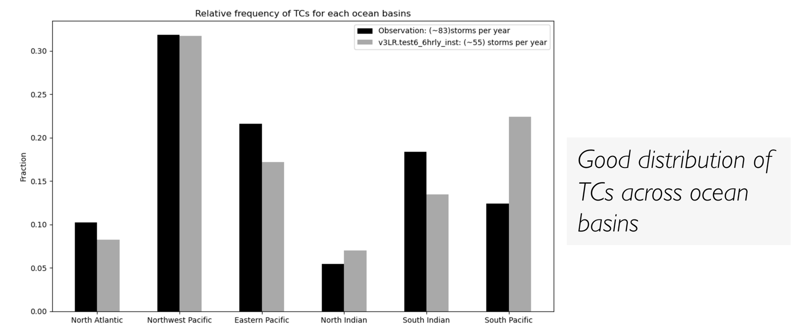

Figure 6: Relative frequency of tropical cyclones across 6 ocean basins.

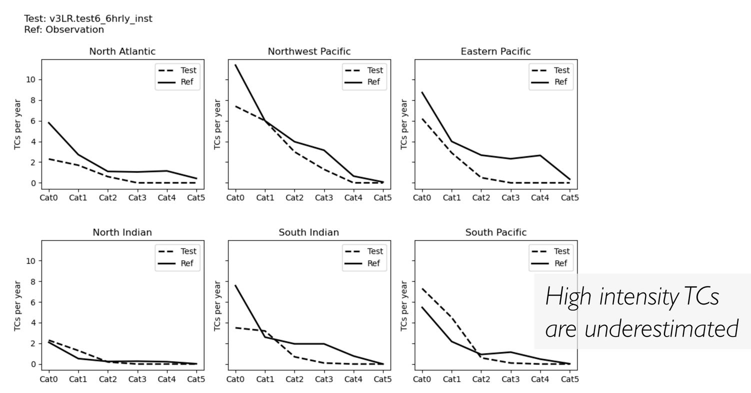

Figure 7: Tropical cyclones counts across the 6 ocean basins, as a function of TC intensity.

Frequency of daily-mean precipitation rates

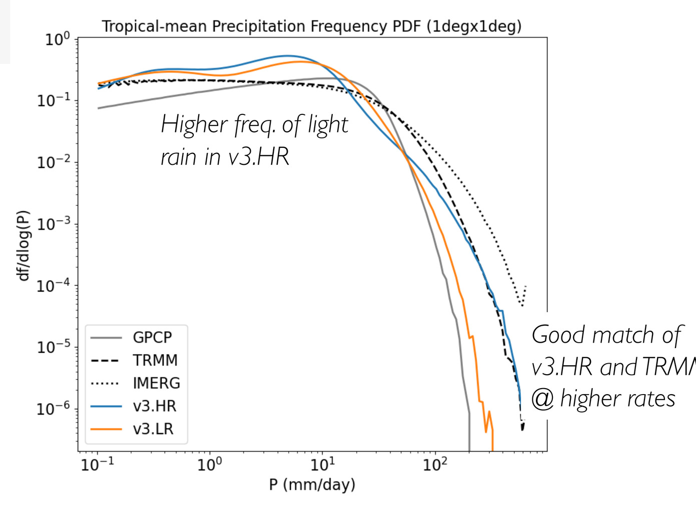

Figure 9: Frequency distribution of daily-, 1° × 1°-averaged precipitation rate over the tropics (30°S - 30°N) in v3.HR, v3.LR and various satellite retrievals.

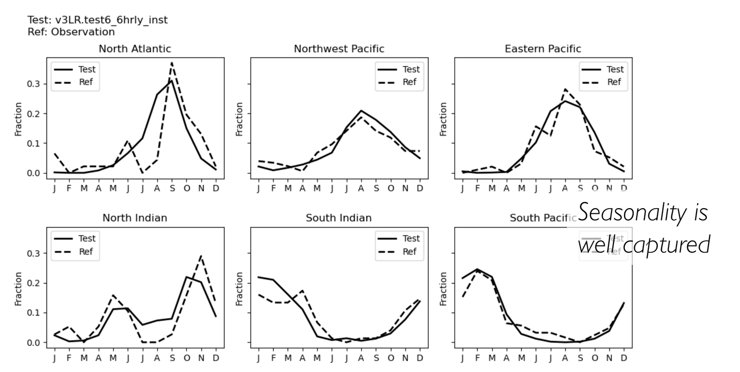

Figure 8: Seasonality of tropical cyclone occurrence across the 6 ocean basins (relative frequency).

Takeaways

- v3.HR improves on v3.LR in many, even in the mean state
- BUT, they required changes to physics and numerous tunings
- Crashes from stronger surface winds necessitated an orographic form drag scheme & dust emission cap
- ZM mass flux adjustment reduced TC # and impacted diurnal cycle
- Resolution improves mean-state dynamical fields, tropical cyclones, and frequency of strong precipitation
- Resolution might improve amplitude of diurnal cycle but didn't improve diurnal cycle phase, tropical variability, or QBO (by itself).

References

1 MacFarlane (1987) The effect of orographically excited gravity wave drag on the general circulation of the lower stratosphere and troposphere. *Journal of the Atmospheric Sciences.*
2 Xie et al. (2020) An orographic-drag parametrization scheme including orographic anisotropy for all flow directions. *Journal of Advances in Modeling Earth Systems.*
3 Tsiringakis et al. (2017) Small-scale orographic gravity wave drag in stable boundary layers and its impact on synoptic systems and near-surface meteorology. *Quarterly Journal of the Royal Meteorological Society,*
4 Beljaars et al., (2004) A new parametrization of turbulent orographic form drag. *Quarterly Journal of the Royal Meteorological Society.*
5 Song et al. (2024) Incorporating the Effect of Large-Scale Vertical Motion on Convection Through Convective Mass Flux Adjustment in E3SMv2. *Journal of Advances in Modeling Earth Systems.*

E3SM
Energy Exascale Earth System Model

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