

Tightening the belt

investigating the impact of high resolution at reduced computational cost



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Thanks to: Max Bouman, John Truesdale, Patrick Callaghan, Adam Herrington, Rich Neale, Peter Lauritzen



[Slides and supplementary materials](#)



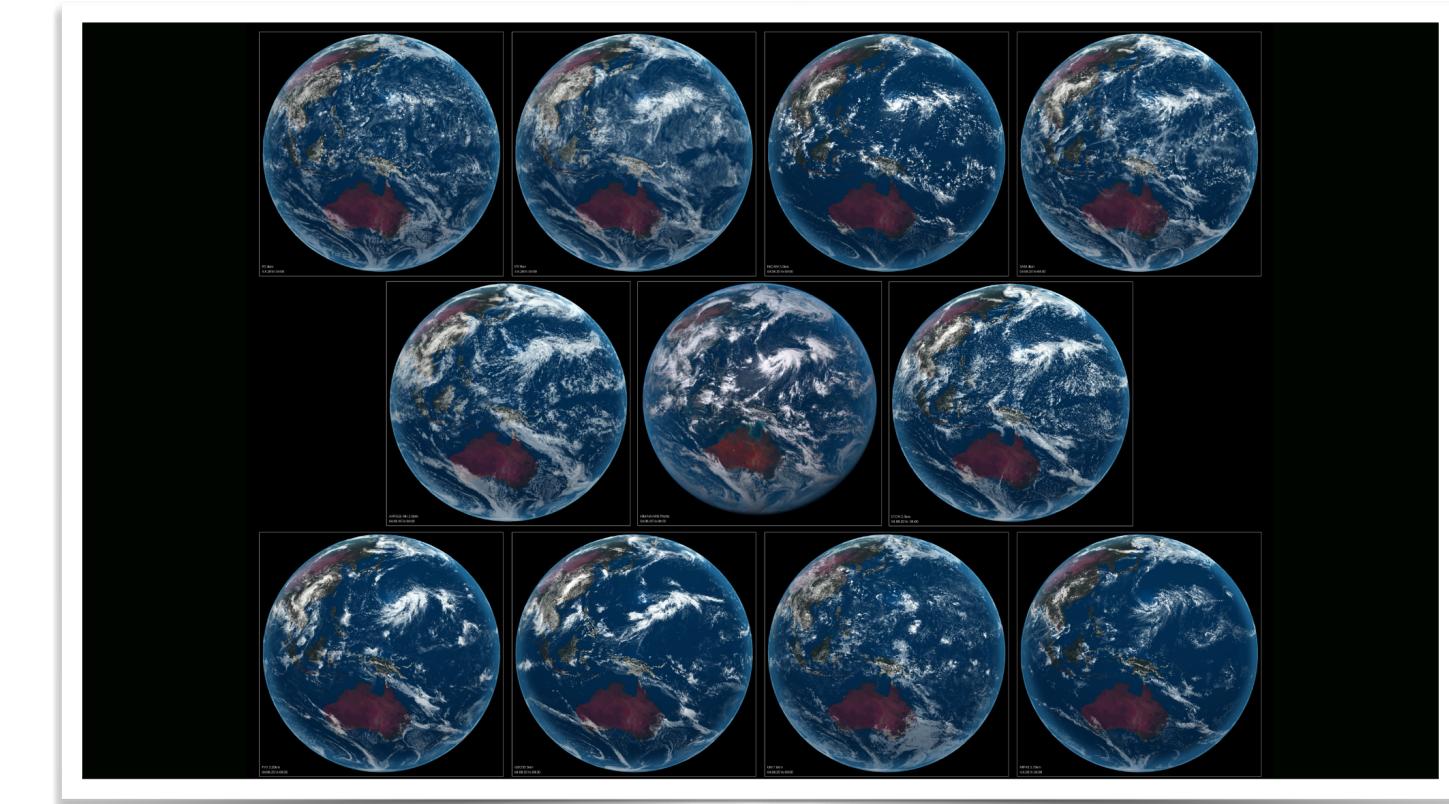
Office of
Science

catalyst

High resolution is expensive

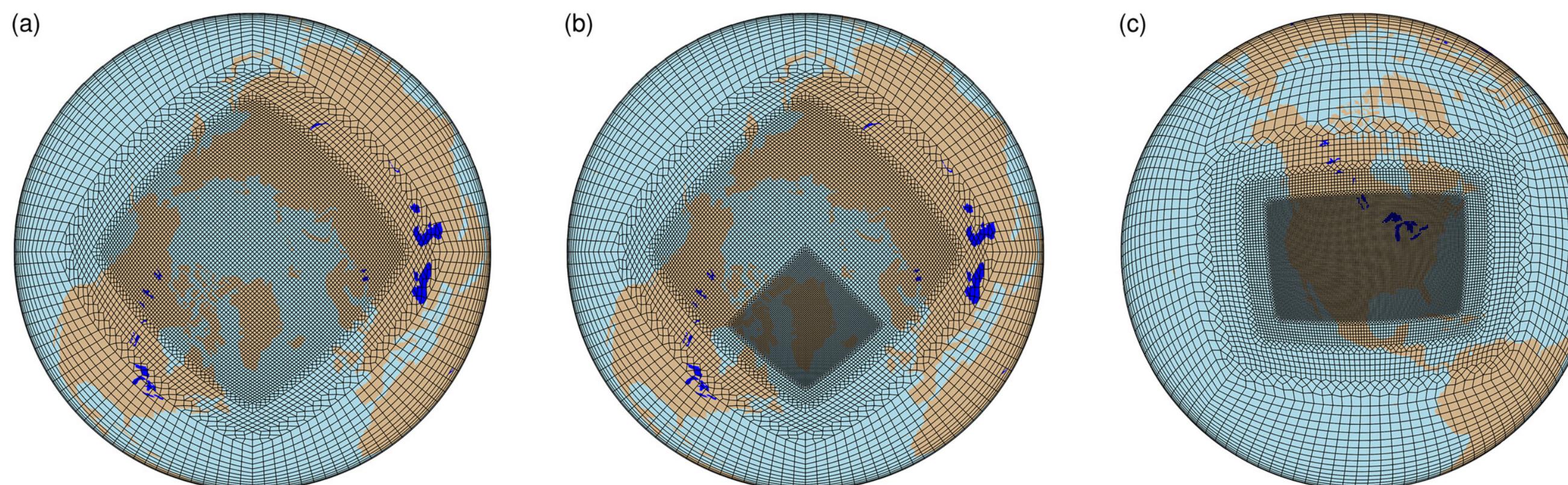
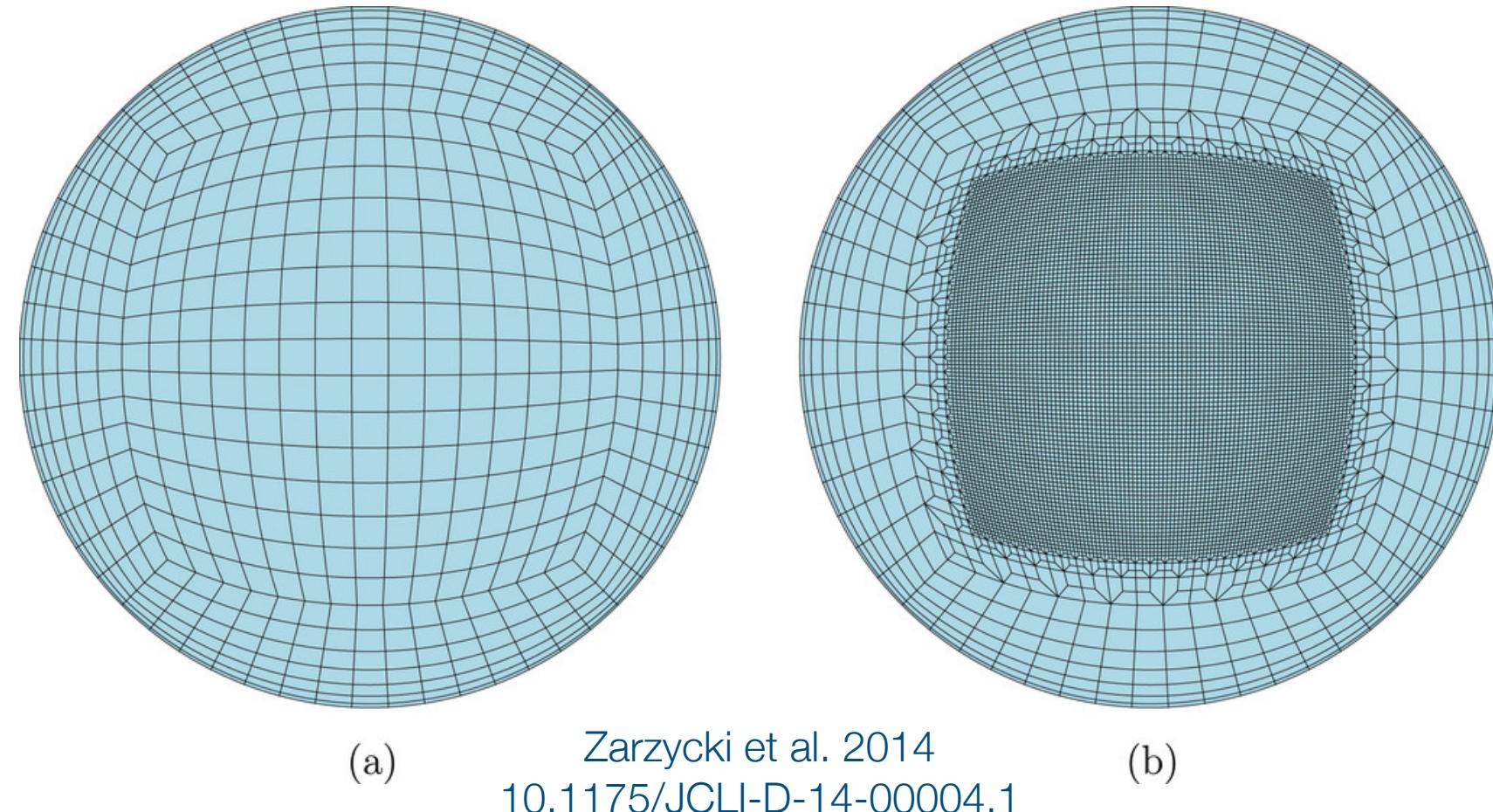


| | dx | #columns |
|--------------|-------|------------|
| ne30 (SHOWN) | 110km | 48,600 |
| ne60 | 54km | 194,400 |
| ne120 | 27km | 777,600 |
| ne240 | 15km | 3,110,400 |
| ne480 | 7.5km | 12,441,600 |

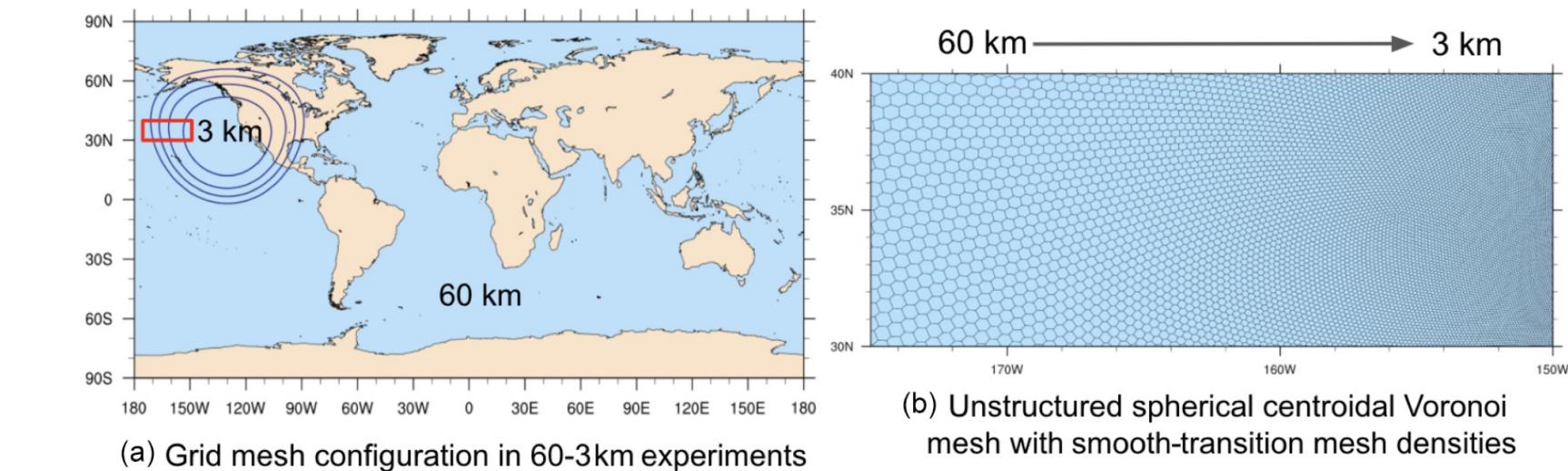


Regionally refined grids

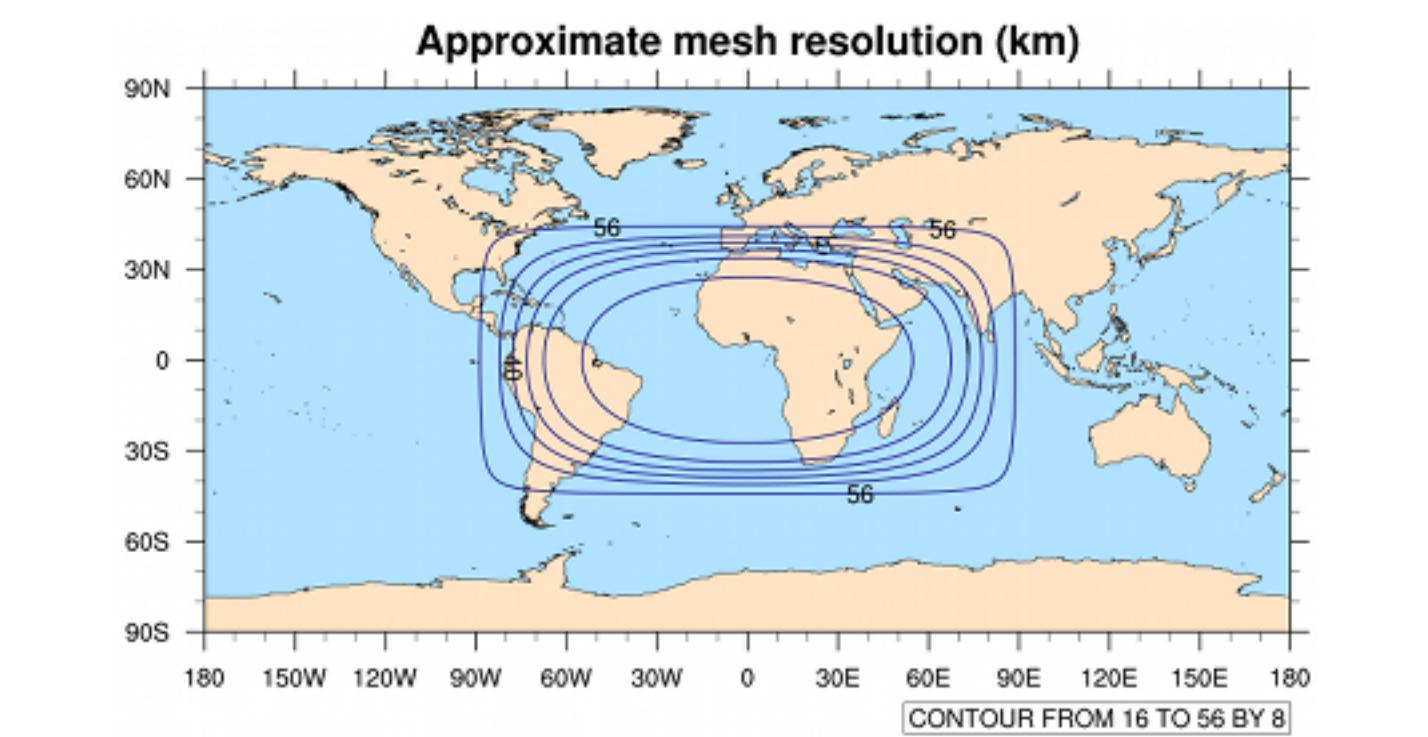
CAM Spectral Element (SE)



MPAS & CAM-MPAS



Huang et al. 2022
<https://doi.org/10.5194/gmd-15-8135-2022>



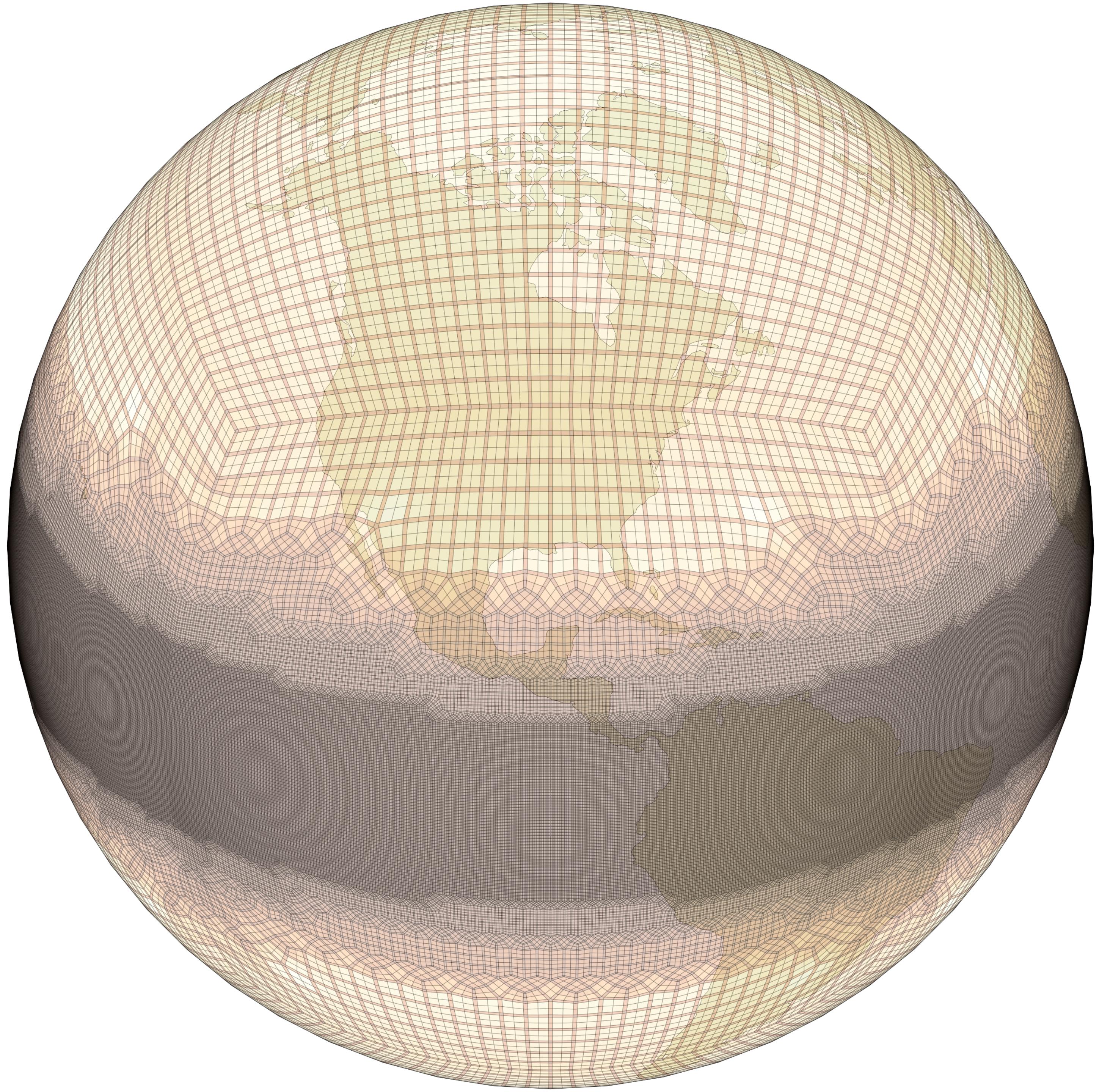
https://mpas-dev.github.io/atmosphere/atmosphere_meshes.html
Example: Rios-Berrios et al. 2022, MPAS-A aquaplanet with explicit convection in tropical belt

Similar capabilities with E3SM

<https://e3sm.org/library-of-regionally-refined-model-rrm-grids-for-the-e3sm-atmosphere-model/>

CAM-SE Tropical Belt

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| TRBELT | 100→15km | 710,858 |



CAM-SE Tropical Belt: what is it good for?

- ▶ Local processes
- ▶ Regional features at high-resolution
- ▶ Remote impacts (i.e., teleconnections)

Experimental Design

- ▶ **TRBELT**

15km Δx in 15S-15N;

7-year simulation with annually repeating SST & ice;

last 5 years used for analysis

- ▶ **Control**

standard ne30 (1-degree) mesh

- ▶ **Small Δt**

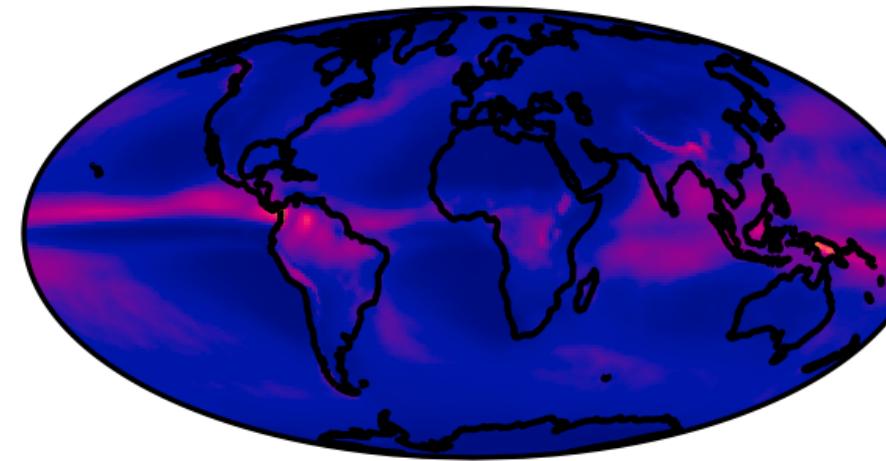
same as Control (ne30 mesh), but with the time step reduced to match TRBELT (5min)

- ▶ **Methodological note:**

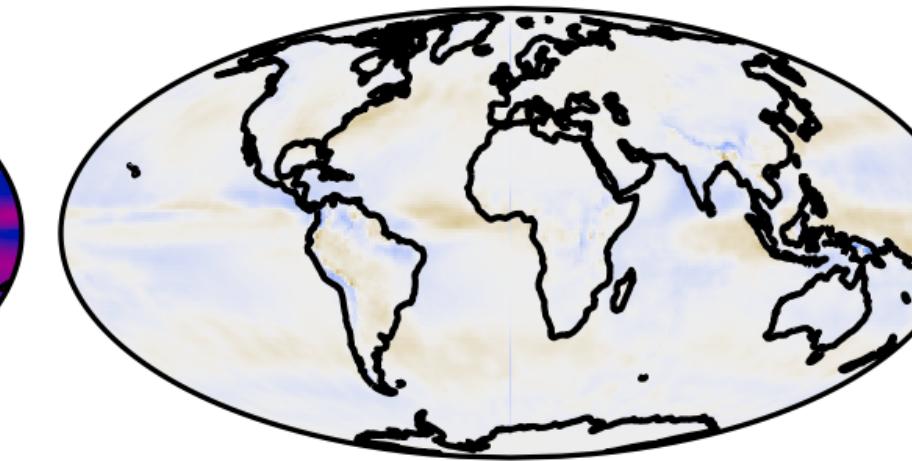
use native output when possible, but for direct comparisons, regrid to latitude-longitude

Precipitation climatology and distribution

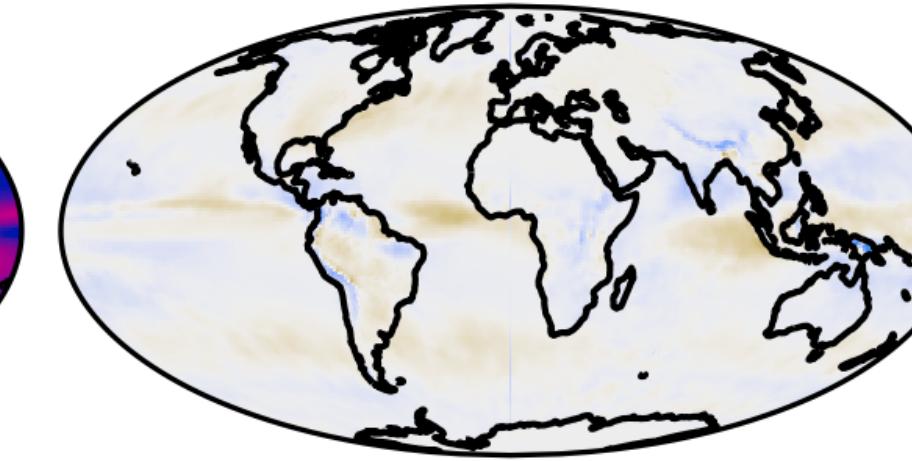
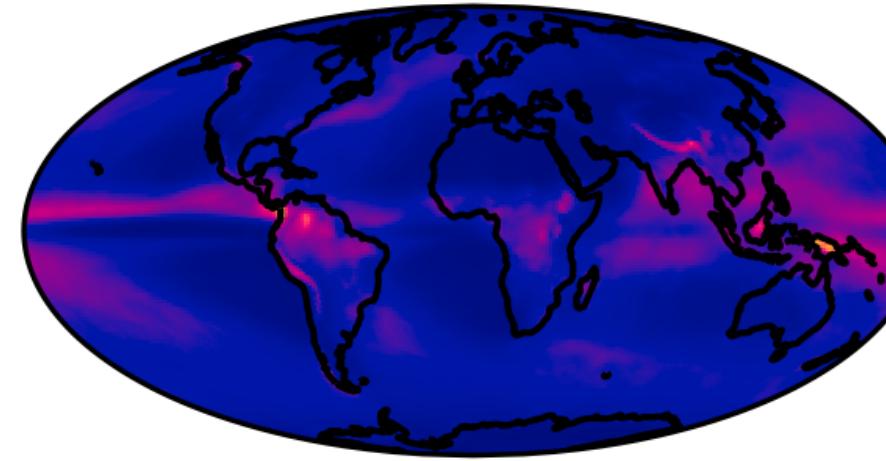
Control



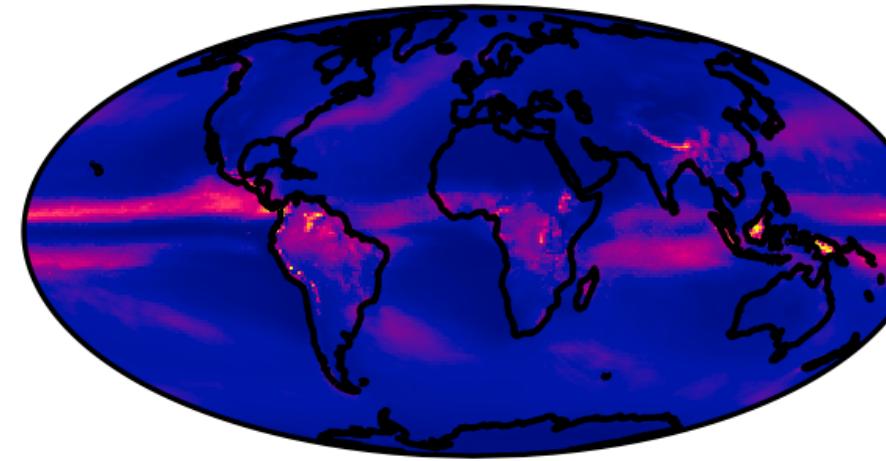
Difference wrt GPCP



Small Δt



TRBELT



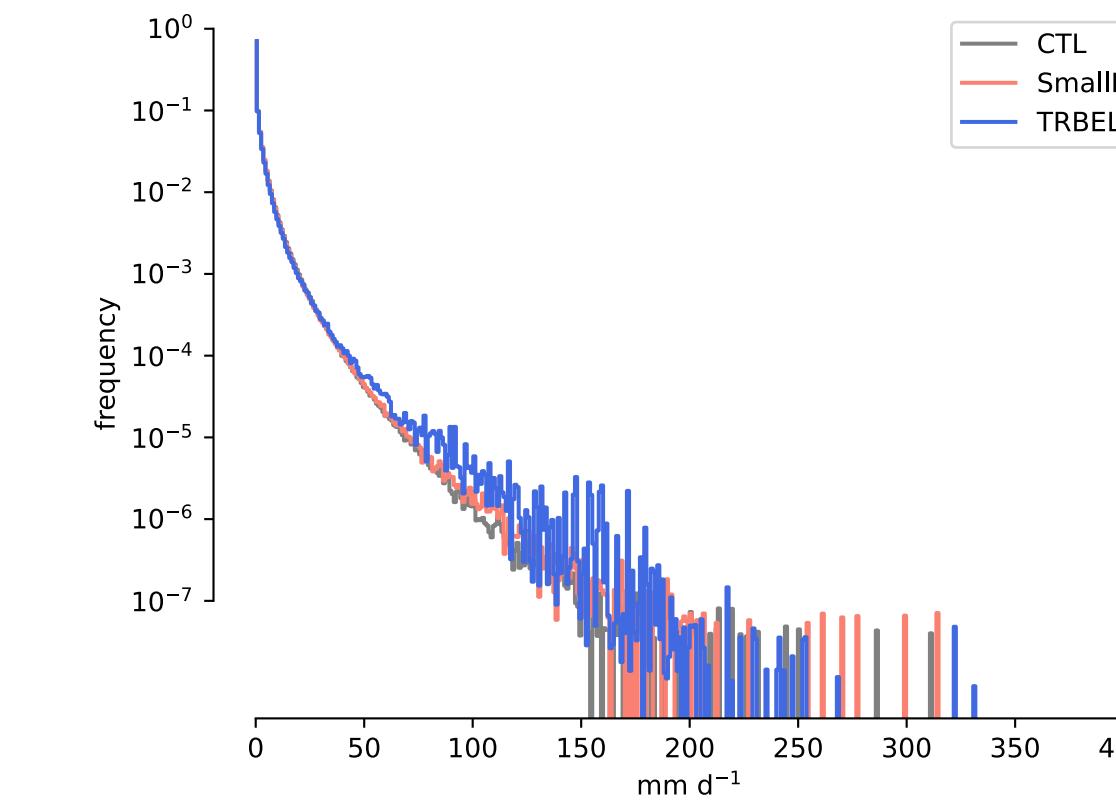
0 20

mm d⁻¹

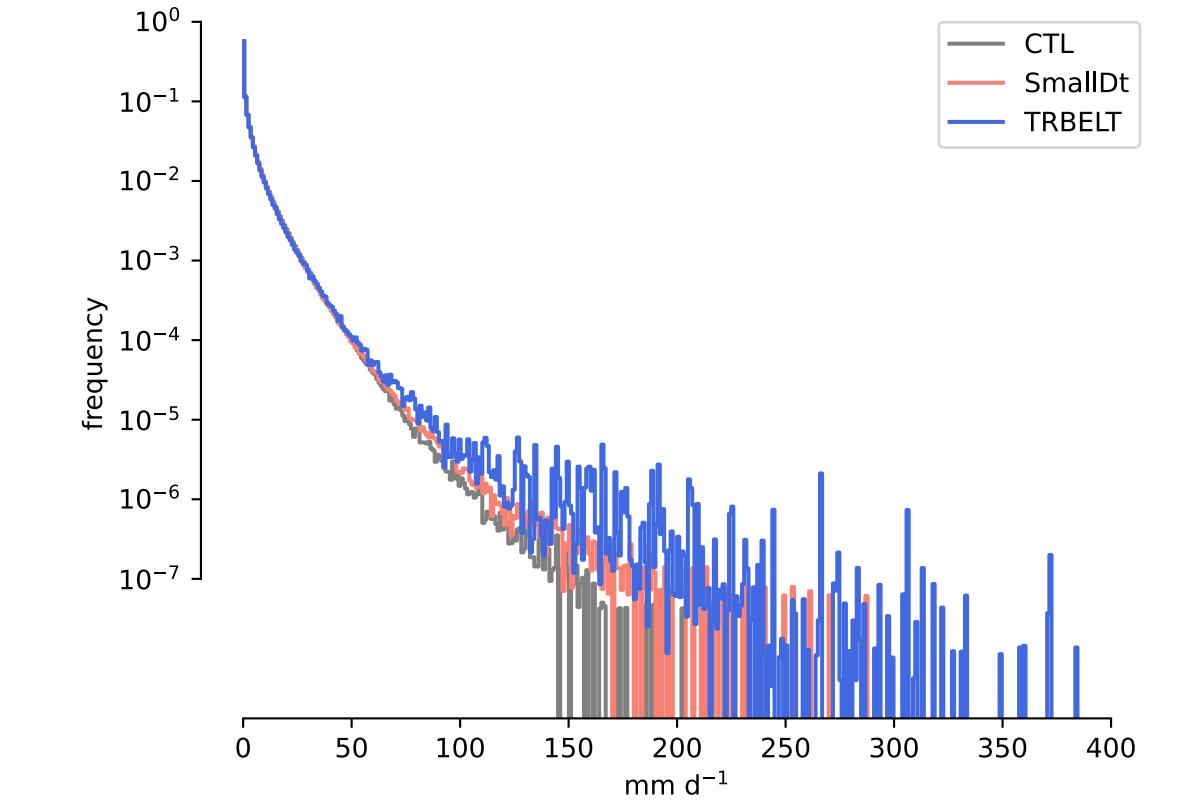
-10 0 10

mm d⁻¹

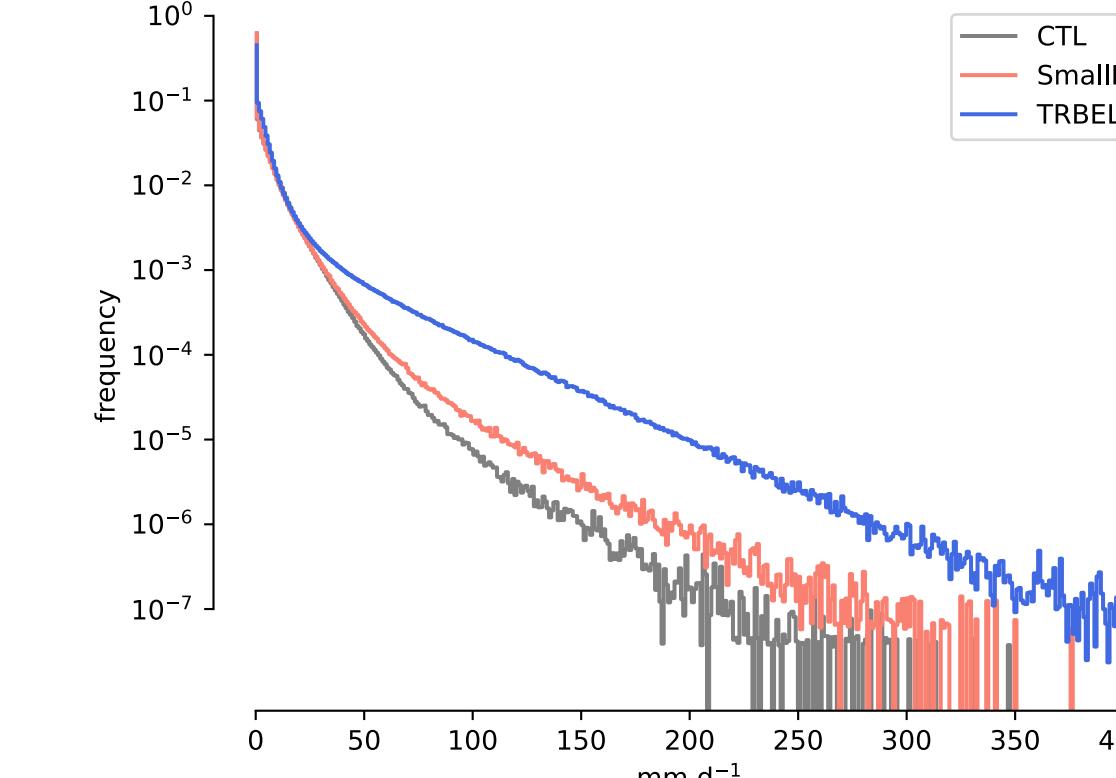
6-hourly Precipitation, NH Extratropical Land



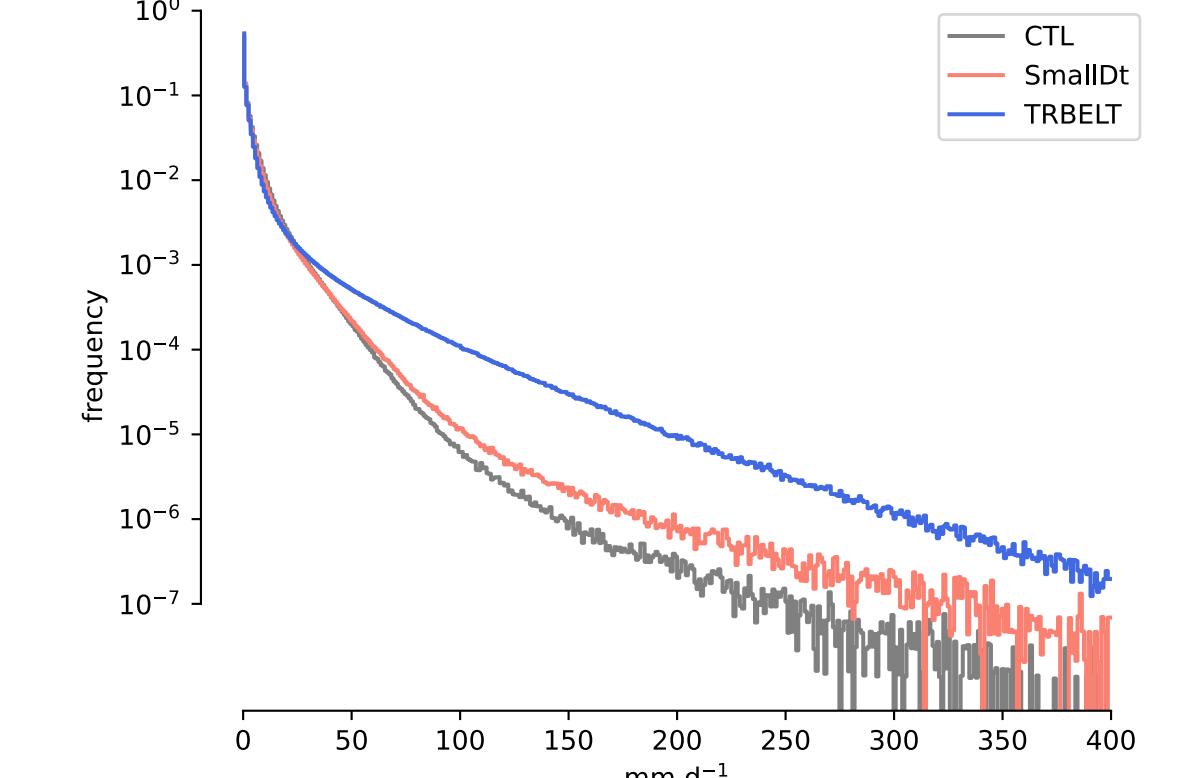
6-hourly Precipitation, NH Extratropical Ocean



6-hourly Precipitation, Tropical Land

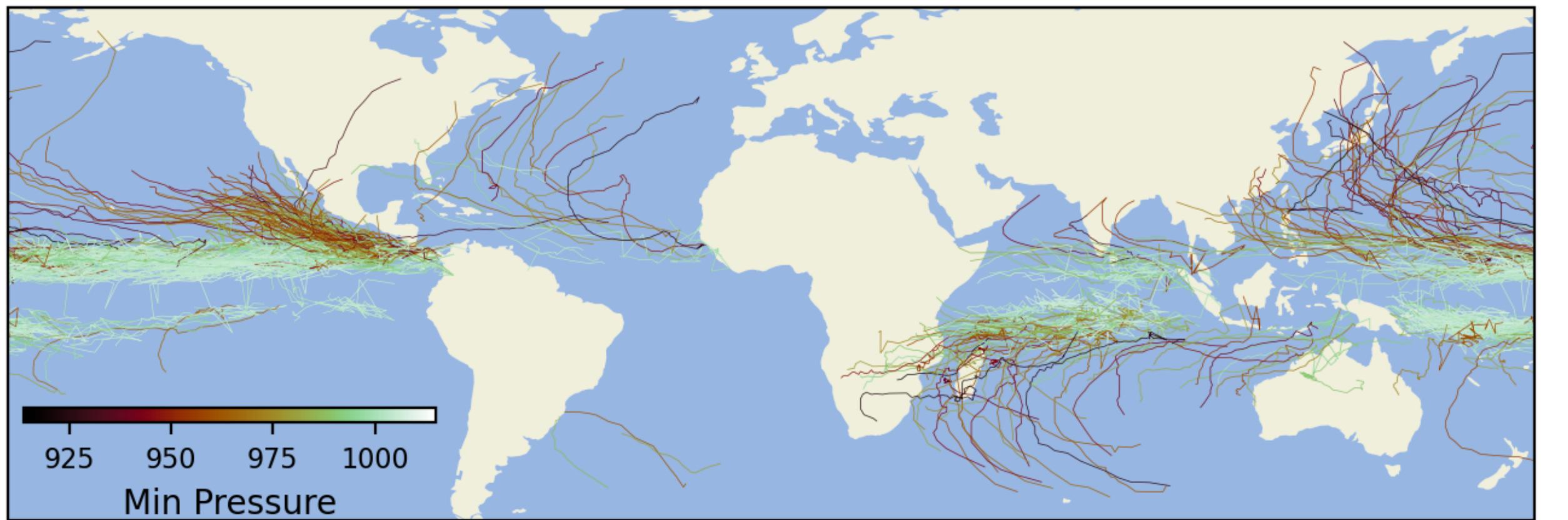


6-hourly Precipitation, Tropical Ocean



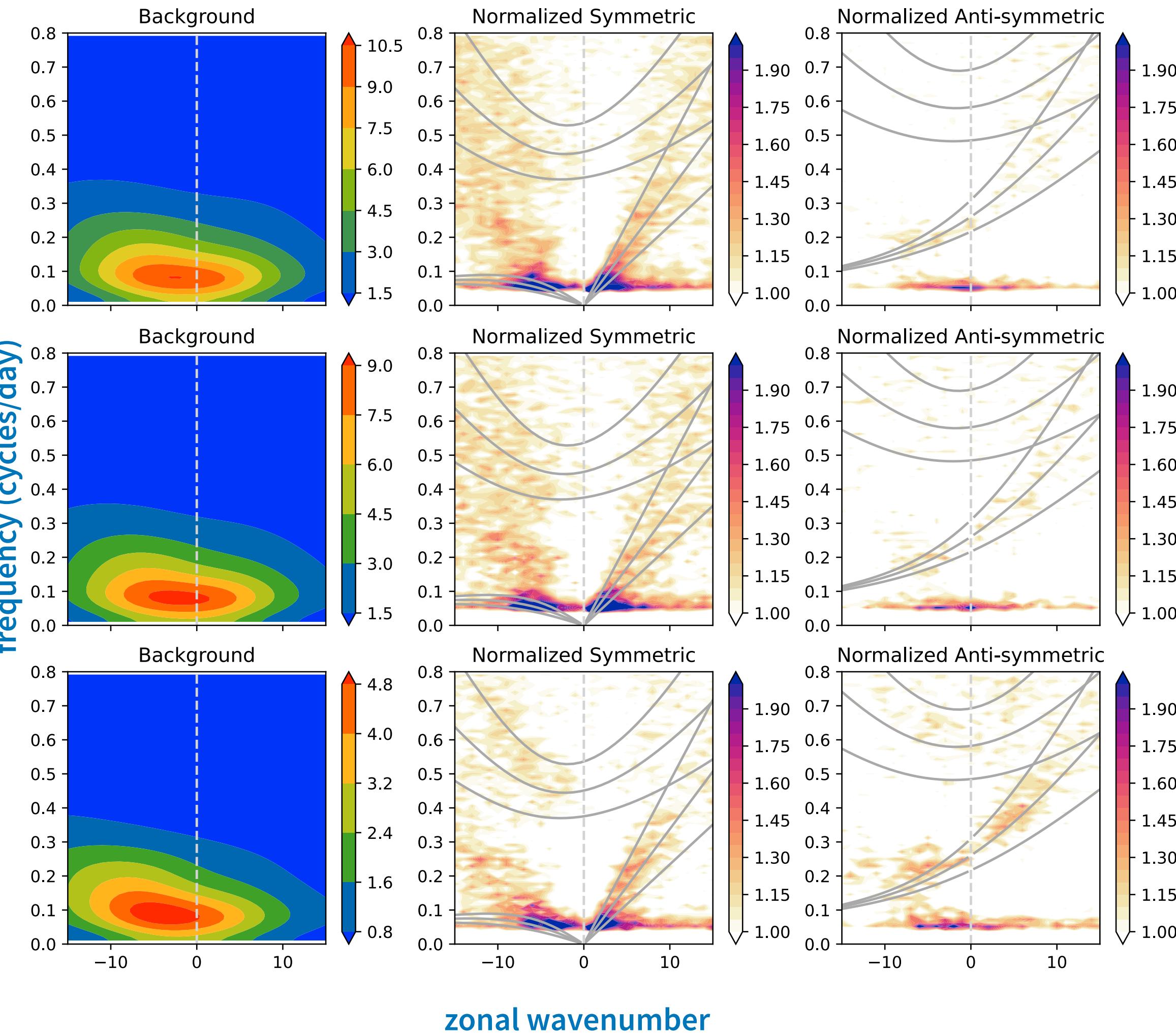
Tropical Variability

Tropical Cyclone Tracks

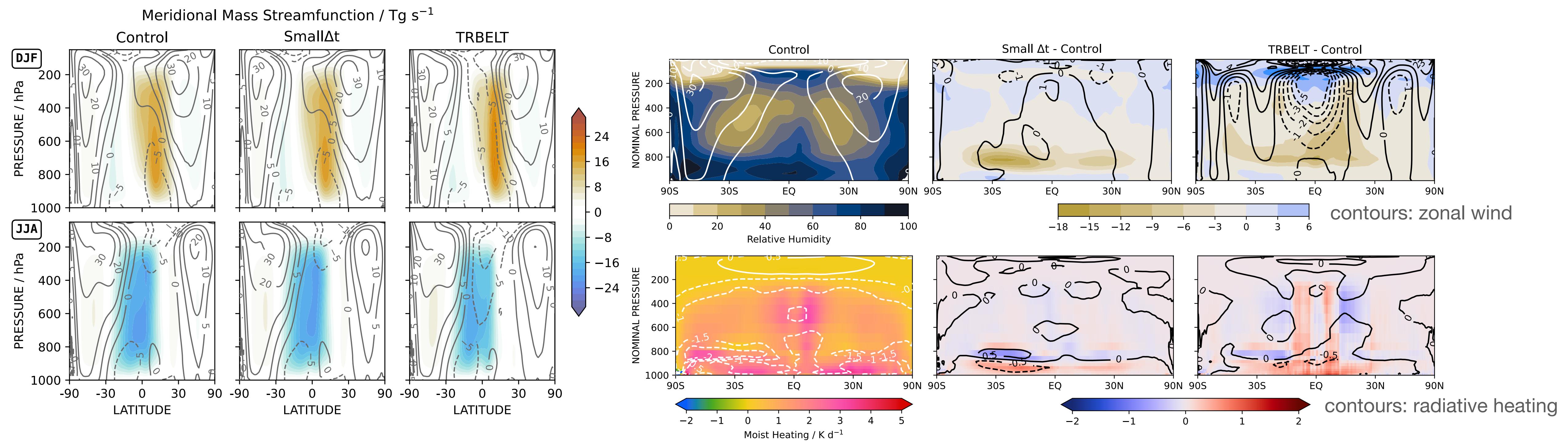


TRBELT Smallldt Control

Total Precipitation, 15°S - 15°N

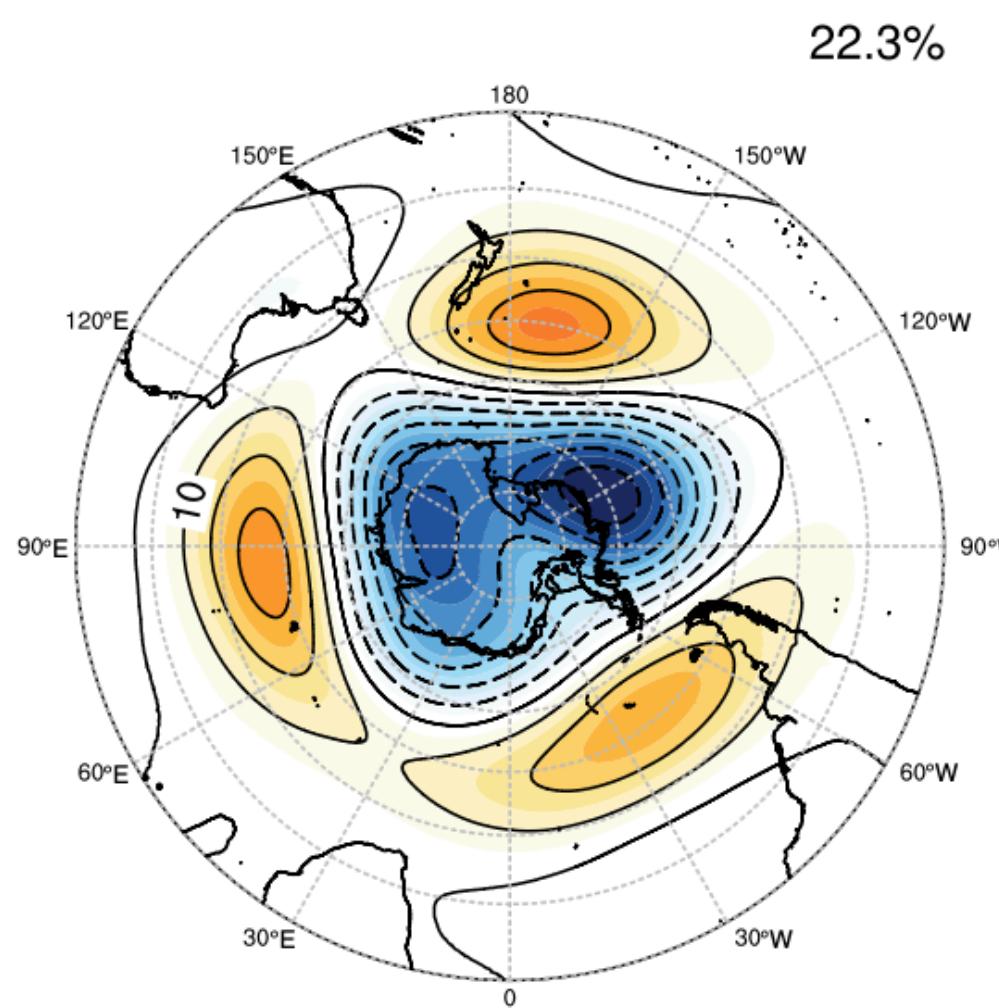


Zonal mean climate

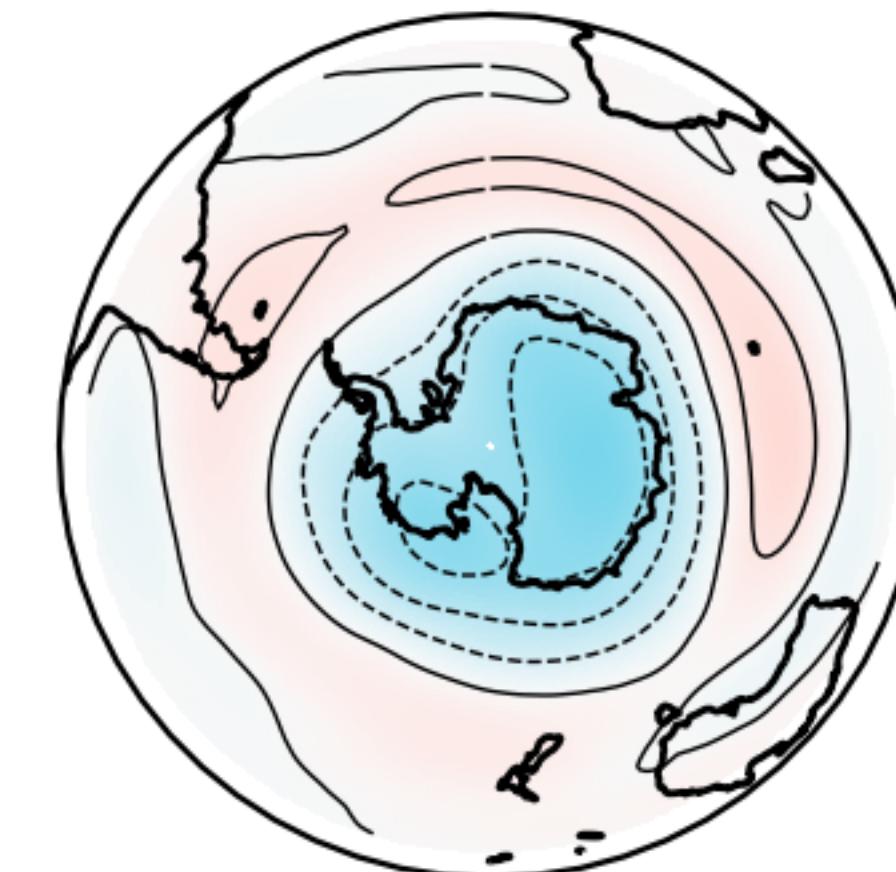


Teleconnections: southern annular mode

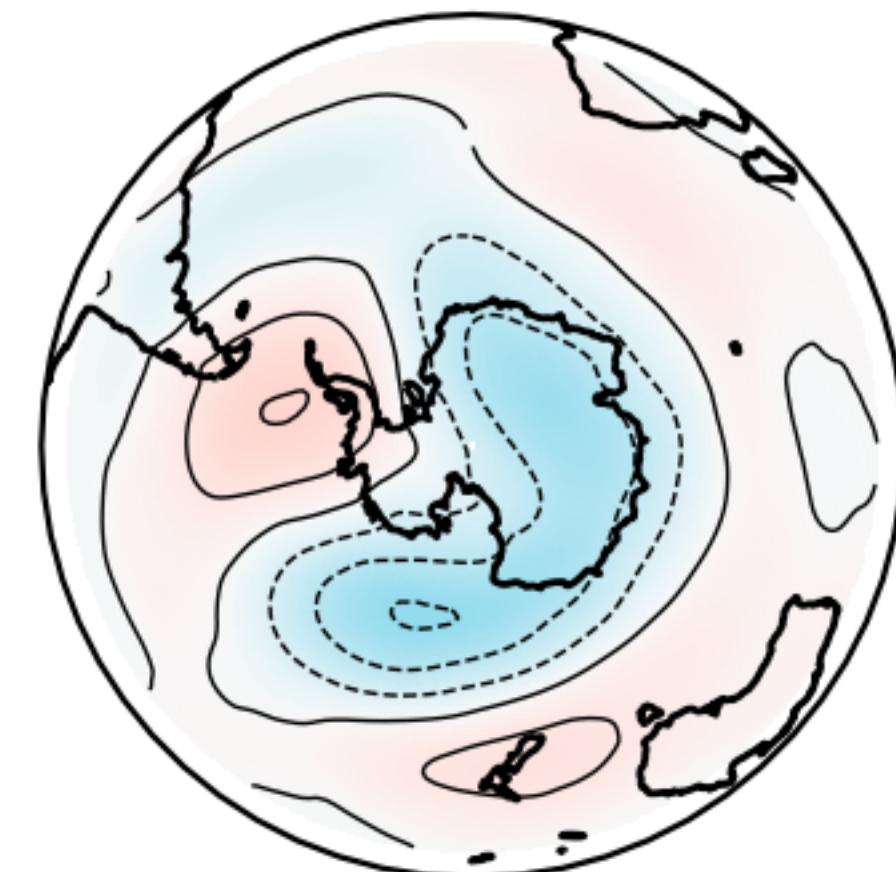
Reanalysis



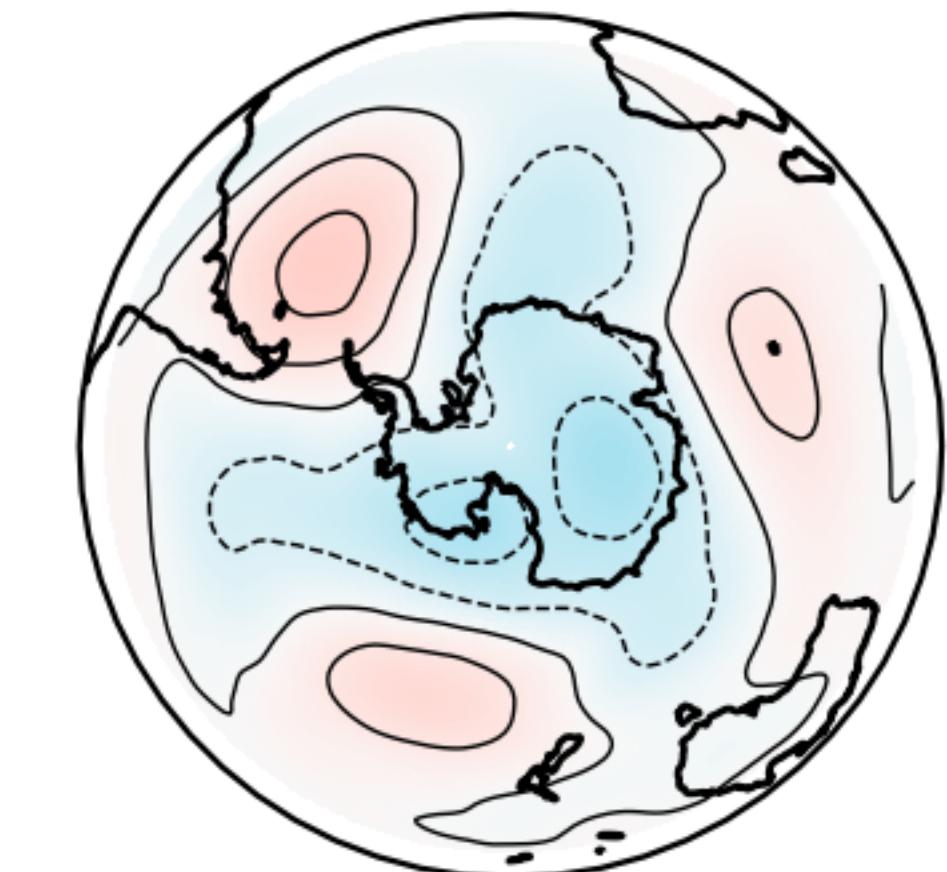
Control (21.63%)



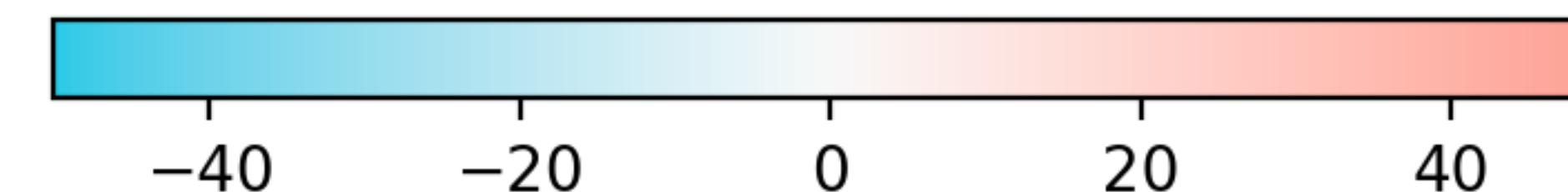
Small Δt (16.21%)



TRBELT (19.64%)



Fogt & Marshall 2020
<https://dx.doi.org/10.1002/wcc.652>



- ▶ **regionally refined configurations offer some capability to use high resolution in global models**

pro: a more self-consistent way to do regional climate experiments

con: still expensive, may expose structural errors (scale sensitive parameterizations)

- ▶ **Tropical belt configuration as example**

15km grid spacing over a very large area, but 23% of the columns of global 15km

- ▶ **Results from 7-year, untuned, “F2000” case are mixed:**

extreme precipitation is more extreme

tropical cyclones form

tropical waves show subtle changes

Double ITCZ is severe

Troposphere dries, circulation doesn't change dramatically

Southern Annular Mode might improve

