

CAM5 at Global High Resolution and Regionally Refined High Resolution

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High Resolution in the Community Atmosphere Model (CAM5)

We describe the computational performance of several high resolution configurations of the CESM using CAM's Spectral Element Dynamical Core

Global Uniform High Resolution

- 27km CAM, prescribed SST and ice extent
- 27km CAM, coupled to 10km POP and CICE
- 13km CAM, prescribed SST and ice extent

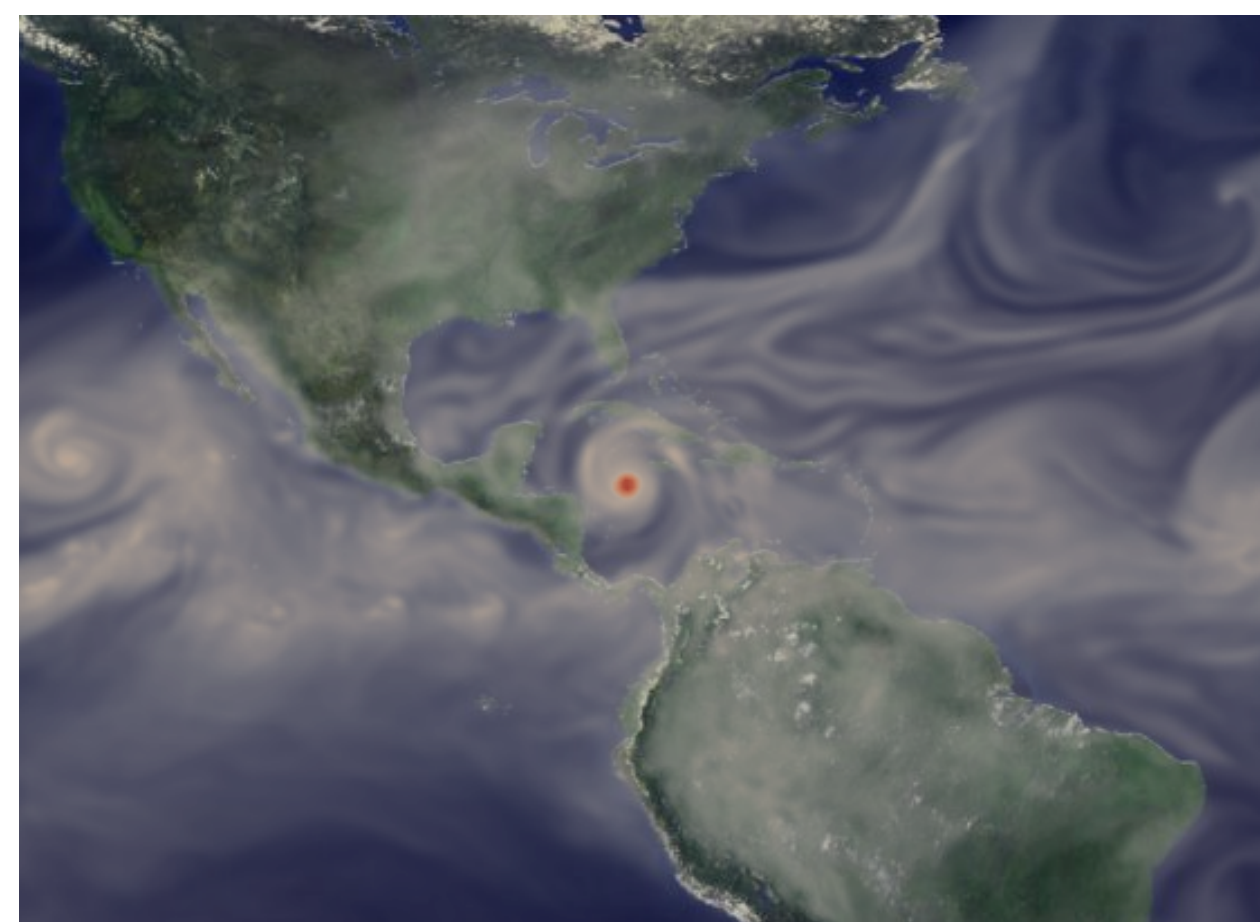
Variable-resolution:

- 110km transitioning to 13km CAM

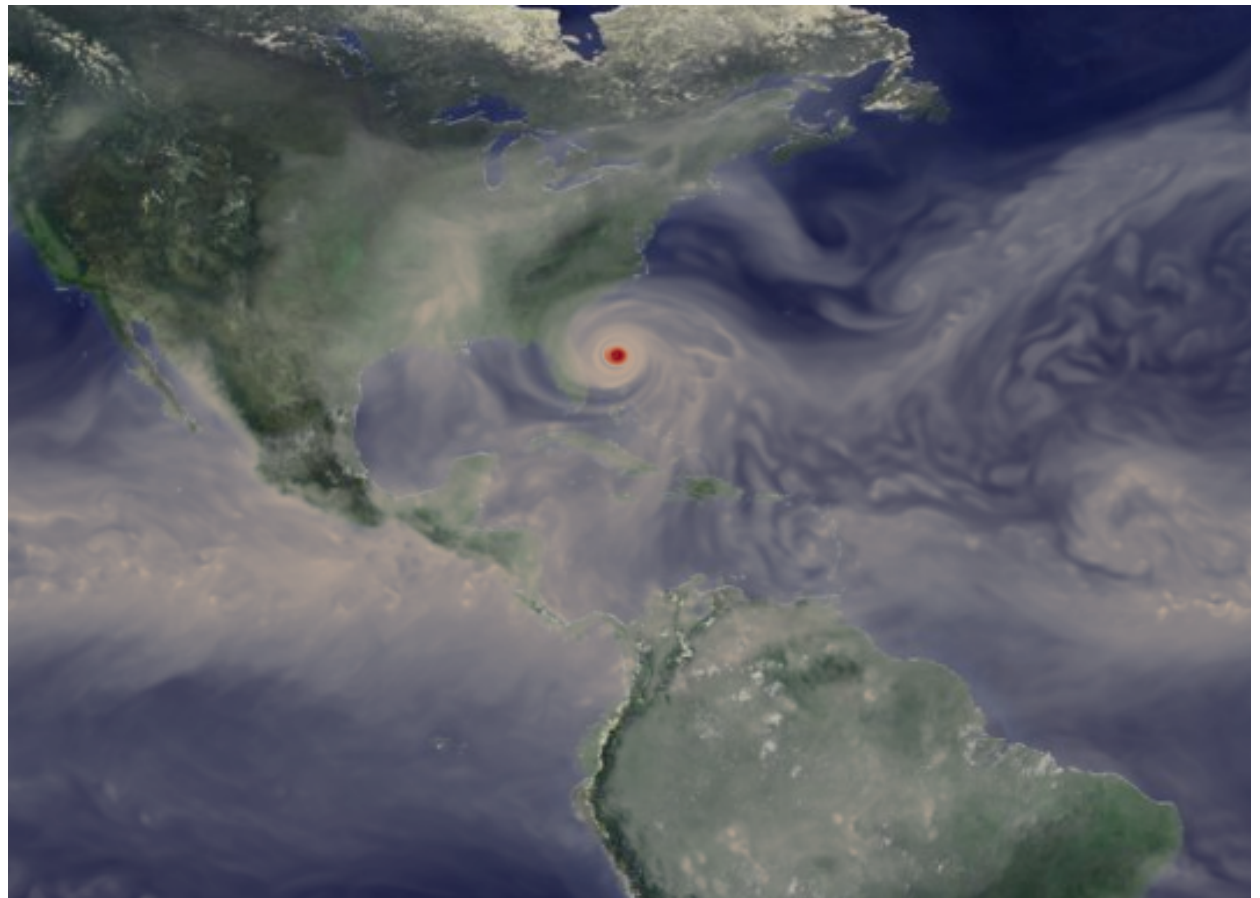
CESM Configuration:

- Proposed ACME v0 model
- CESM1_2 release + CAM5_3_07
- F1850 and B1850 compsets
- POP & CICE initial conditions (for fully coupled simulations)
 - From CAM4 T341 DOE high-res project
 - Atmospheric reanalysis forced CESM simulation using equivalently configured POP and CICE.

27km resolution



13km resolution



Snapshot of precipitable water, showing typical category 5 hurricane captured by the CESM running at 27km and 13.5km resolutions.

Acknowledgements:

- DOE-BER: Climate Science for a Sustainable Energy Future
- DOE-BER: Development of Frameworks for Robust Regional Climate Modeling
- ASCR/BER SciDAC: Multiscale Methods for Efficient, and Scale-Aware Models of the Earth System
- DOE-BER: Ultra-High Resolution Global Climate Simulation

27km CAM (1/4 degree) / Prescribed SST

Performance on Mira

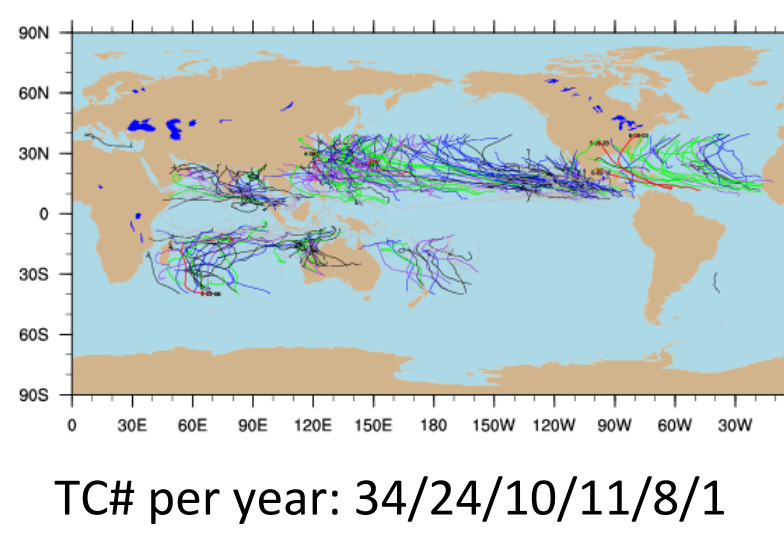
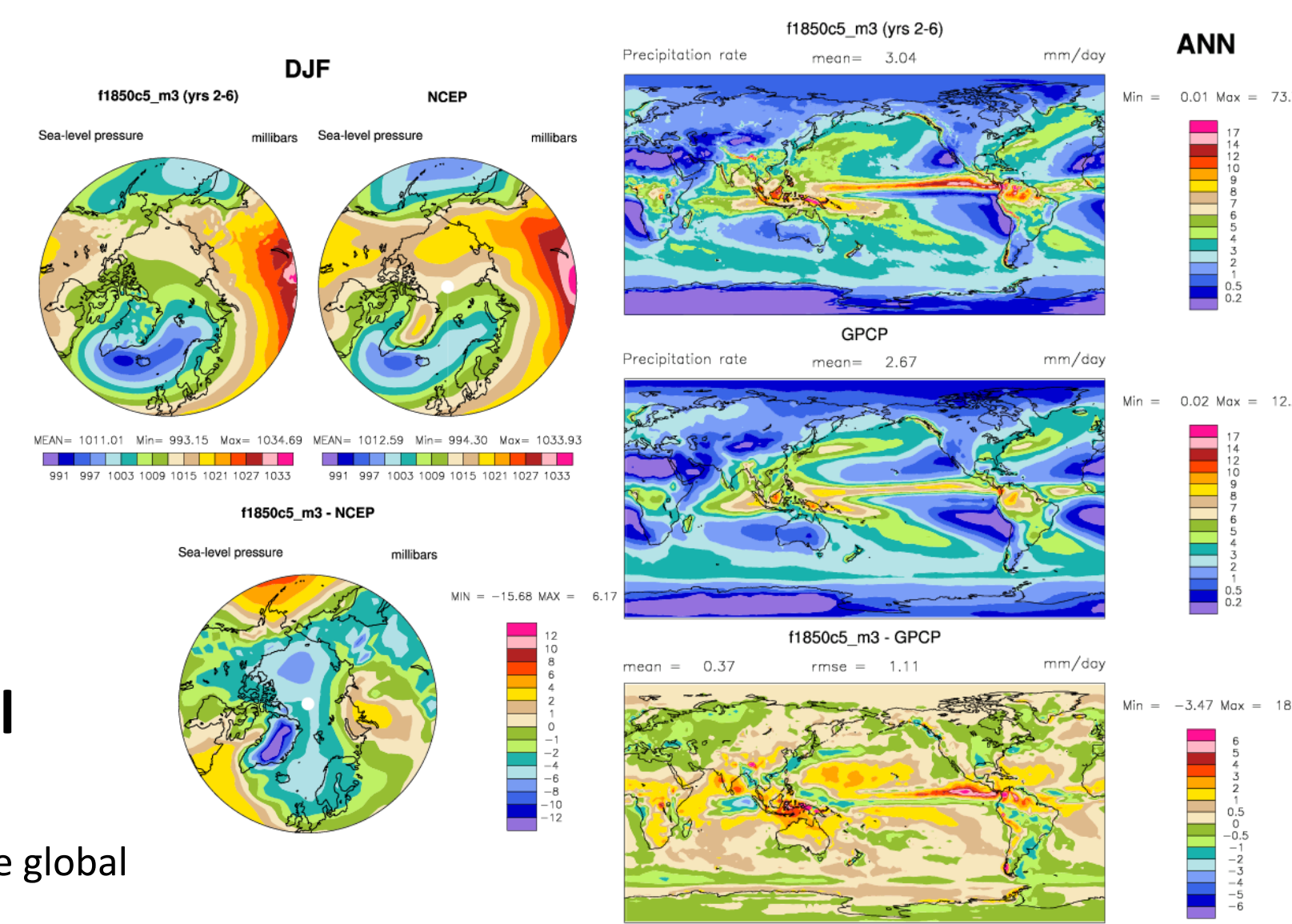
- CESM: 32K cores 1.34 SYPD
- CAM: 29K cores, 4 threads/core, 1.6 SYPD
- Cost: 0.6M core-hours per year

Performance on Titan

- CESM: 60K cores, 2.79 SYPD
- CAM: 43K cores, 1 thread/core, 3.34 SYPD
- Cost: 0.5M core-hours per year

Tuned for balance using pre-industrial conditions:

- Adjusted dust_emis_fact and seasalt scale factor to tune global aerosol loading.
- Increasing low cloud relative humidity threshold (rhminl) to 0.91
- Used ZM cloud fraction (dp1) to tune for RESTOM ~ 0 (instead of c0)
- Kept the ZM autoconversion coefficient (c0_ind, c0_ocr) low (0.0035)
- Ice autoconversion threshold (DCS) increased 50%. Improves LWCF with minimal impact on RESTOM
- ZM timescale (zmconv_tau) reduced slightly (to 3000s from 3600)



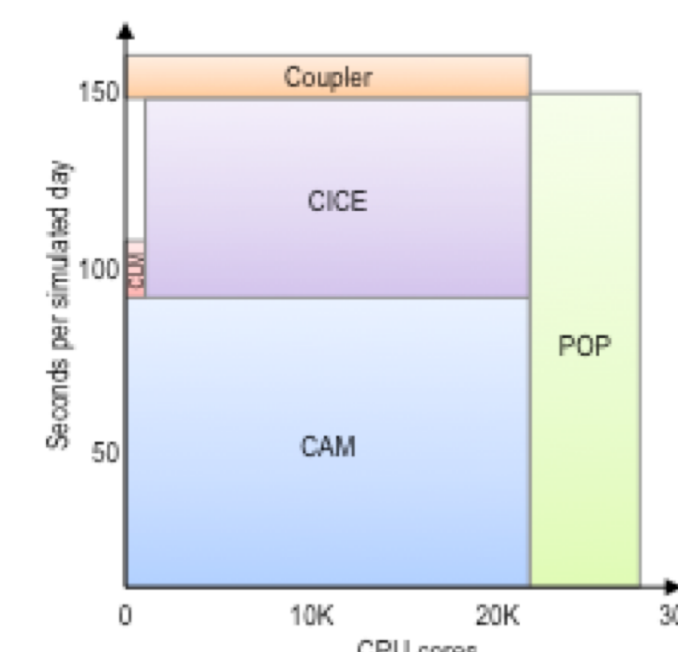
27km CAM (1/4 degree) / 10km POP/CICE

Performance on Mira

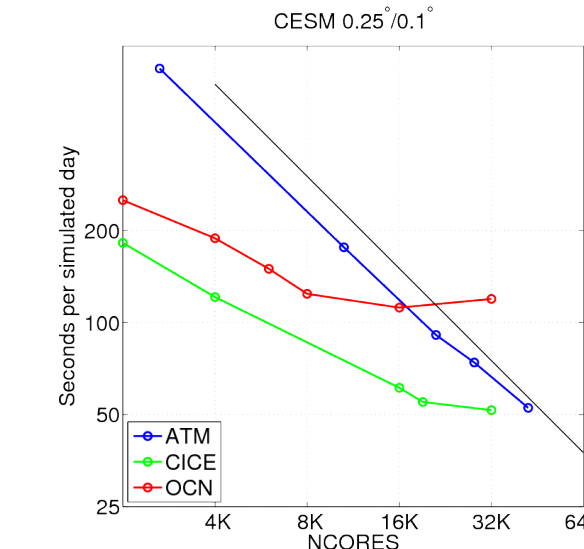
- CESM: 32K cores, 0.75 SYPD
- CAM: 29K cores, 1.5 SYPD
- Cost: 1.0M core-hours per year

Performance on Titan

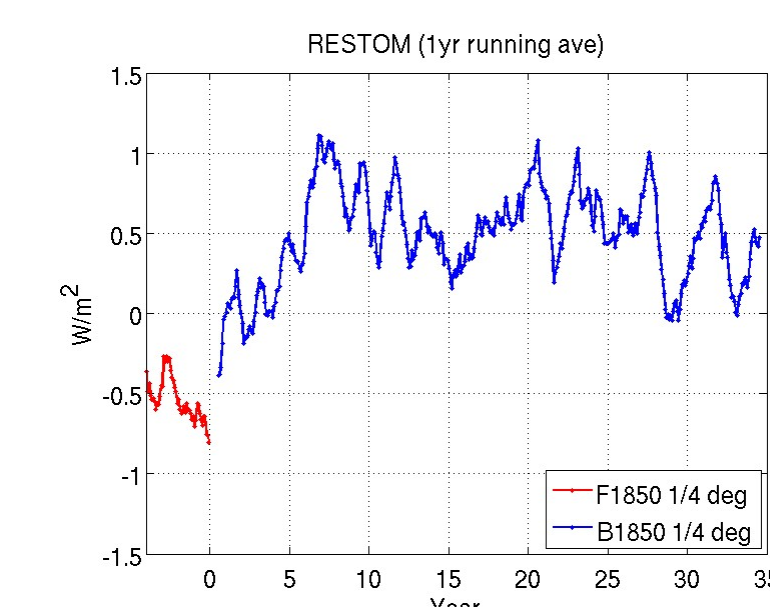
- CESM: 68K cores, 1.61 SYPD
- CAM: 43K cores, 3.27 SYPD
- Cost: 1M core-hours per year



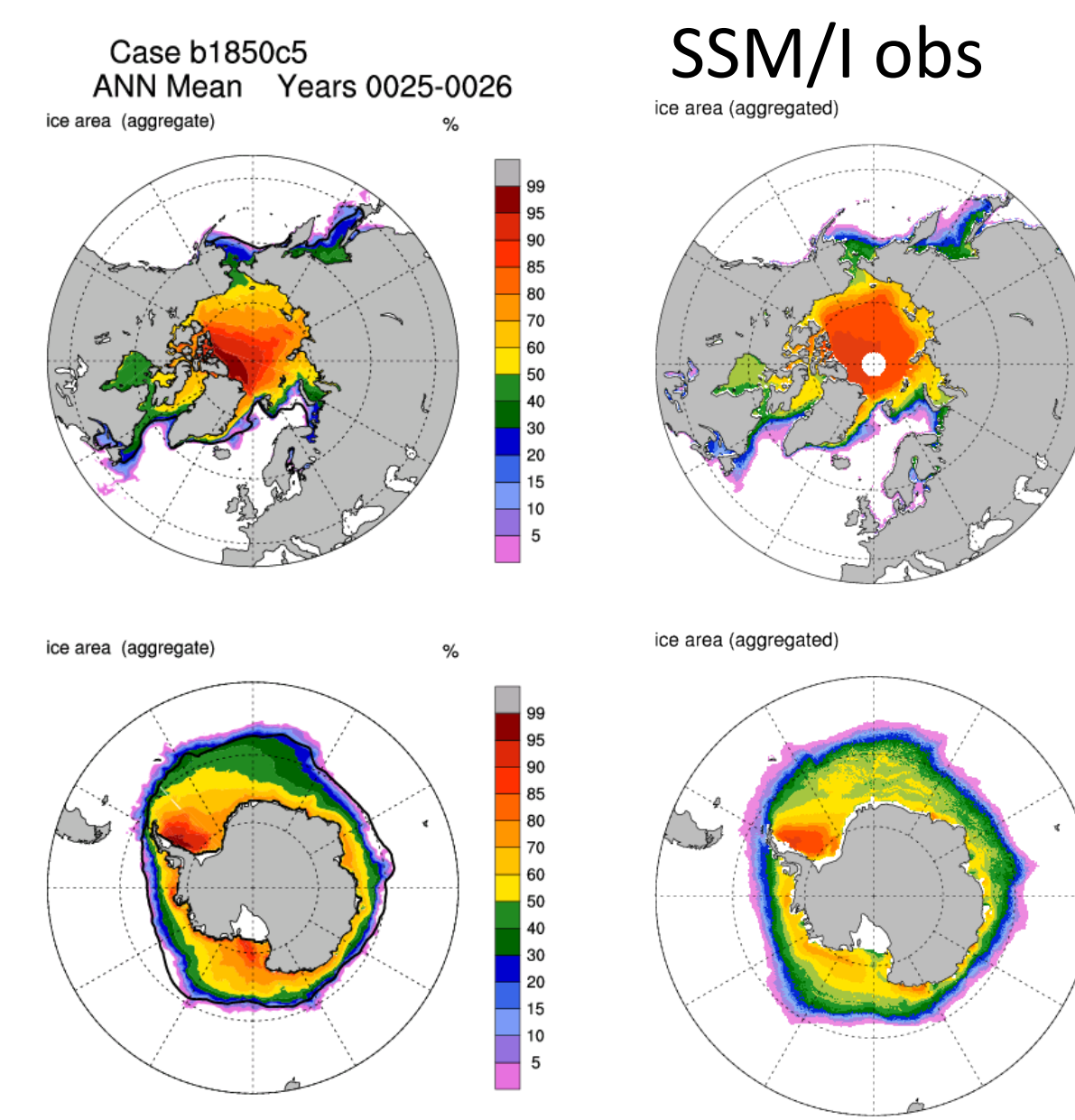
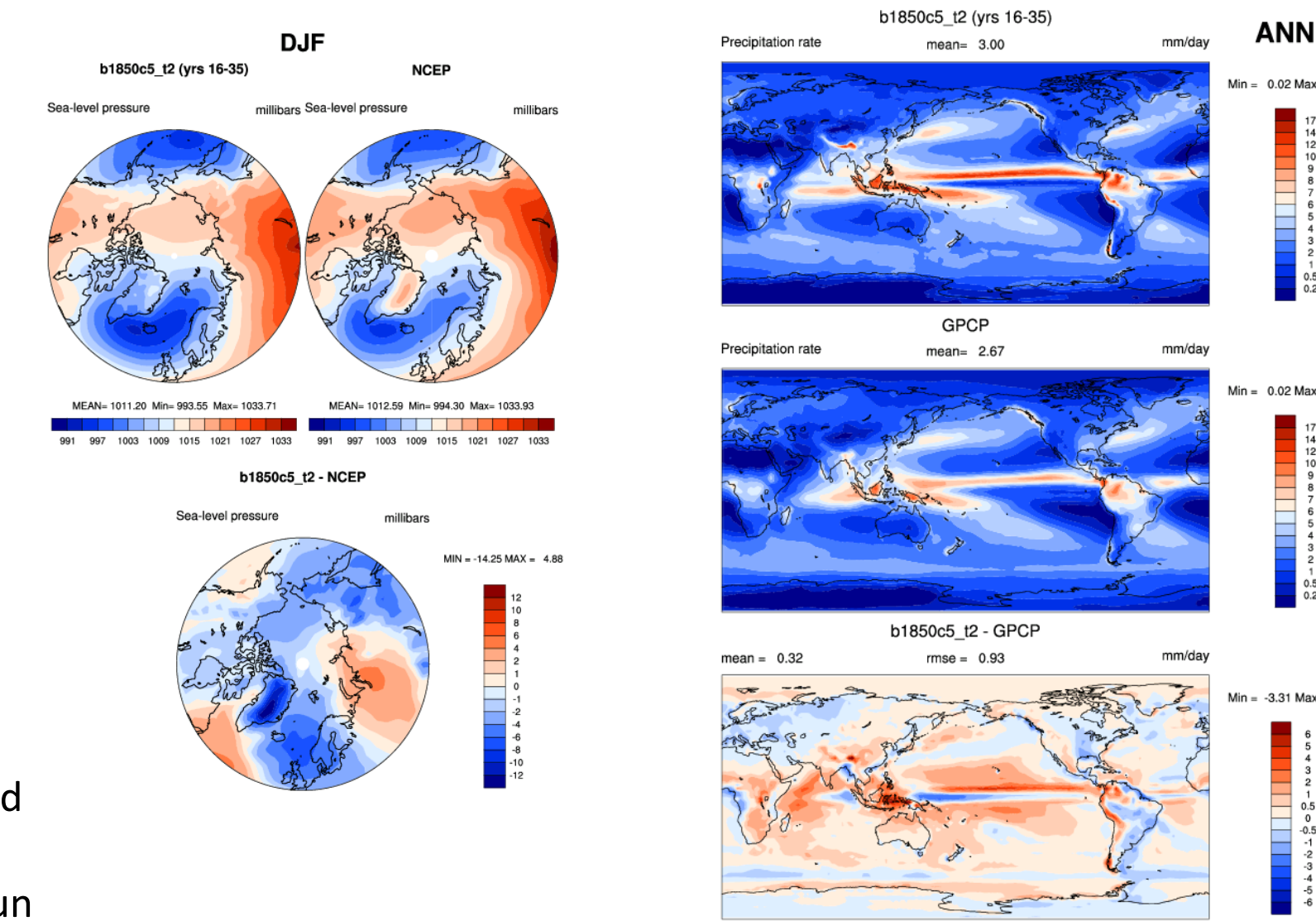
CESM processor layout and run time concurrency diagram. CAM and POP run concurrently, while CICE and CLM run sequentially with CAM.



CESM strong scaling of CAM, CICE and POP at this resolution



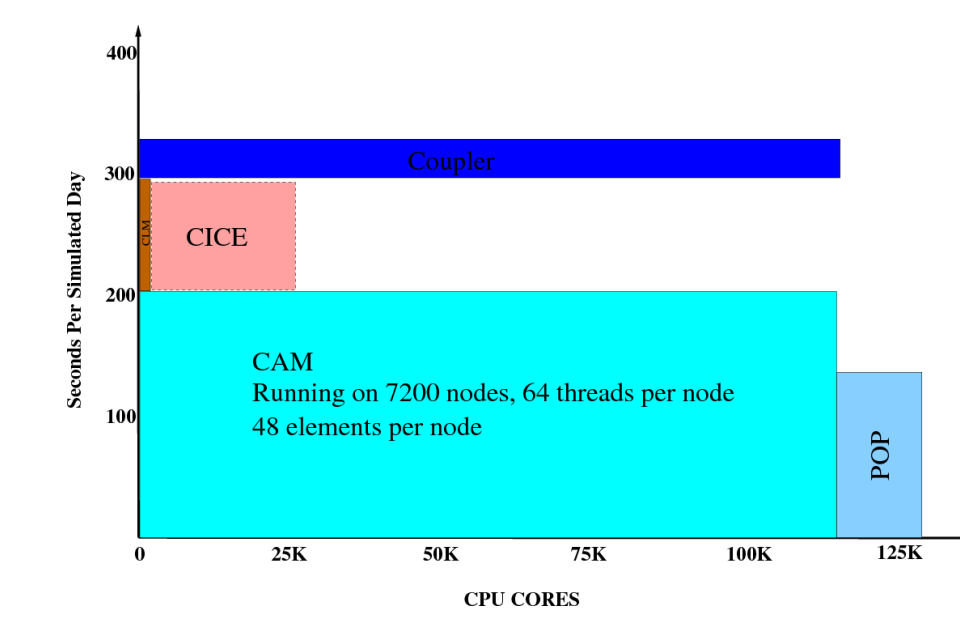
Residual forcing (W/m²) at the top of model showing the slowly equilibrating coupled model.



13km CAM (1/8 degree) / Prescribed SST

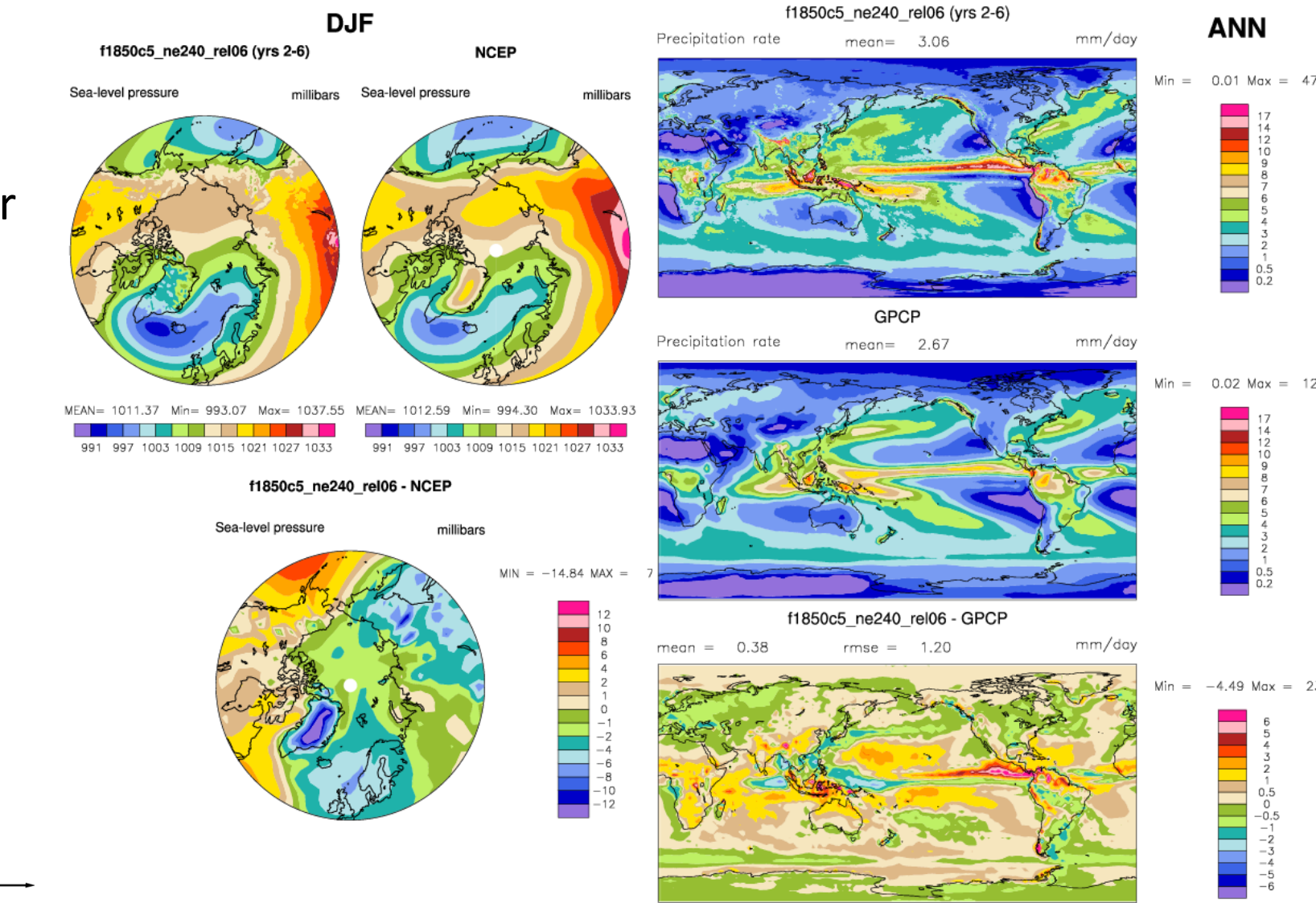
Performance on Mira

- CESM: 128K cores 0.72 SYPD
- CAM: 115K cores, 4 threads per core, 0.84 SYPD
- Cost: 4.4M core-hours per year



CESM processor layout and run time concurrency diagram. CAM and POP run concurrently, while CICE and CLM run sequentially with CAM. At this resolution, CAM is the most expensive component and is allocated most of the processors.

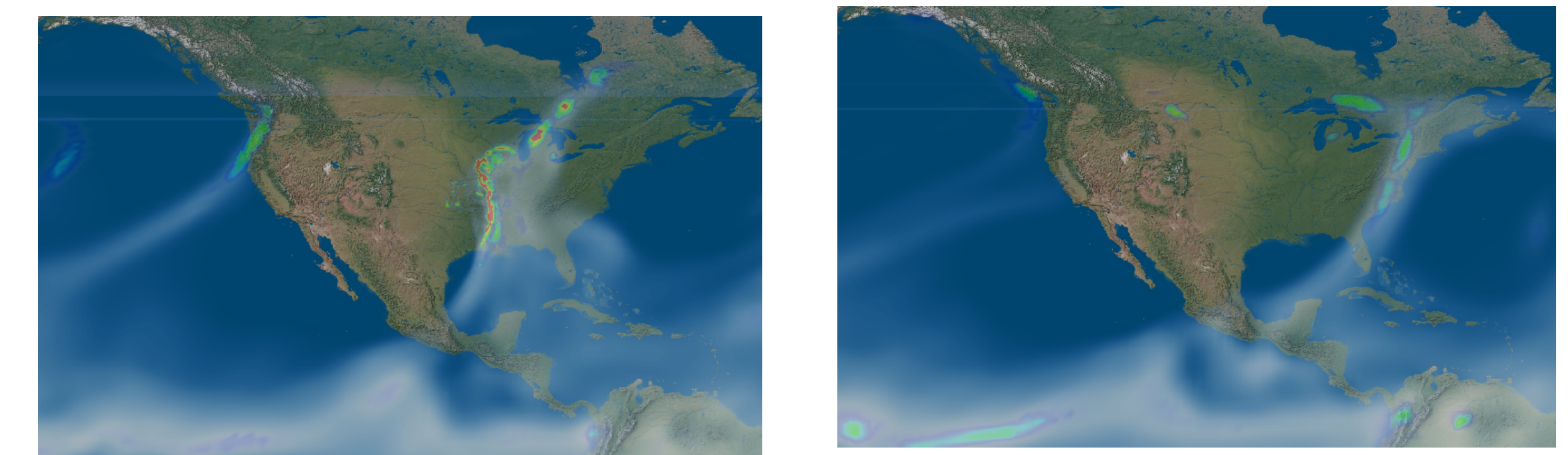
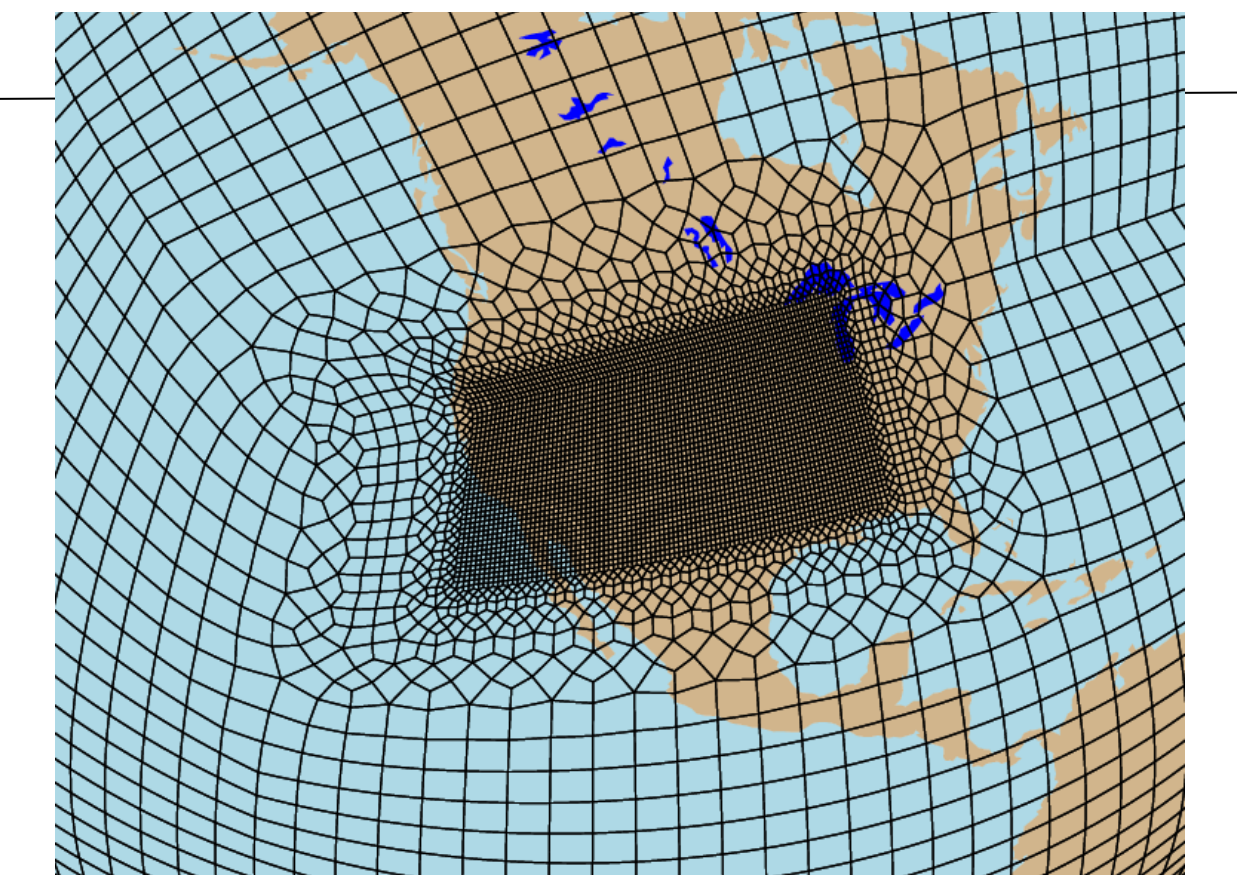
TC# per year: 30/26/10/14/18/7



110km -> 13km Variable Resolution CAM / Prescribed SST

Performance on Mira

- CESM: 8K cores 1.3 SYPD
- CAM: 6K cores, 4 threads per core, 1.4 SYPD
- Cost: 0.1M core-hours per year



Snapshot of precipitable water (white) and precipitation rate (colors) from a CAM5 variable resolution on the grid shown above. Note the type of convective system that is resolved by the high (13km) resolution region (left) as compared to a typical convective system at lower resolution (right).

Conclusions

- CESM at high resolution (27 and 13km) can run at reasonable integration rates on both DOE Leadership Computing Facilities.
- Due in large part to the scalability of CAM's spectral element dynamical core
- Simulations are quite expensive, millions of core hours per simulated year
- CAM's spectral element dynamical core also supports variable resolution simulations, making 13km resolution in selected regions very affordable.