

CCSM-HOMME AMIP Simulations

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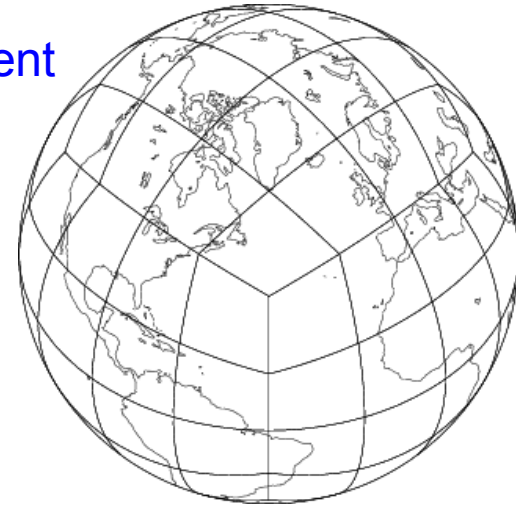
Office of Science



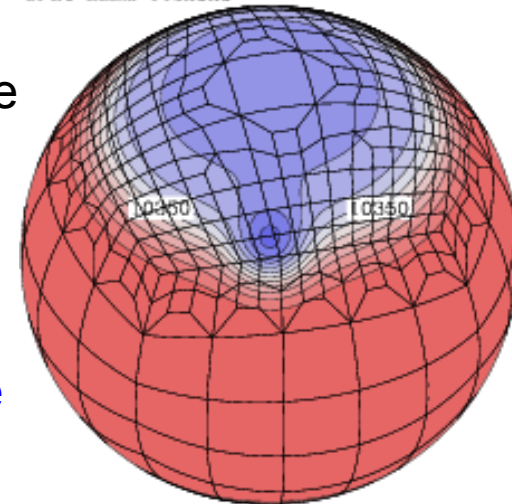
SciDAC
Scientific Discovery through
Advanced Computing

HOMME experimental dynamical core option in CCSM4

- HOMME: NCAR's High-Order Method Modeling Environment
- Dynamics
 - Hydrostatic finite-element based dynamical core
 - 4'th order accurate finite element method (quadrilateral elements) coupled with SB81 vertical coordinate
 - Locally conserves mass, PV(2d) and moist energy
 - Enstrophy/KE dissipation: CAM-Eulerian type hyper-viscosity
- Transport
 - 3'rd order accurate, locally conservative, quasi-monotone finite element advection for horizontal
 - Vertically-Lagrangian w/UKMO conservative monotone reconstruction
- All properties preserved on arbitrary unstructured quadrilateral grids (CCSM configurations use cubed-sphere grid)



SPEC ELEM 442x8x8



Two tri-grid configurations included in CCSM4

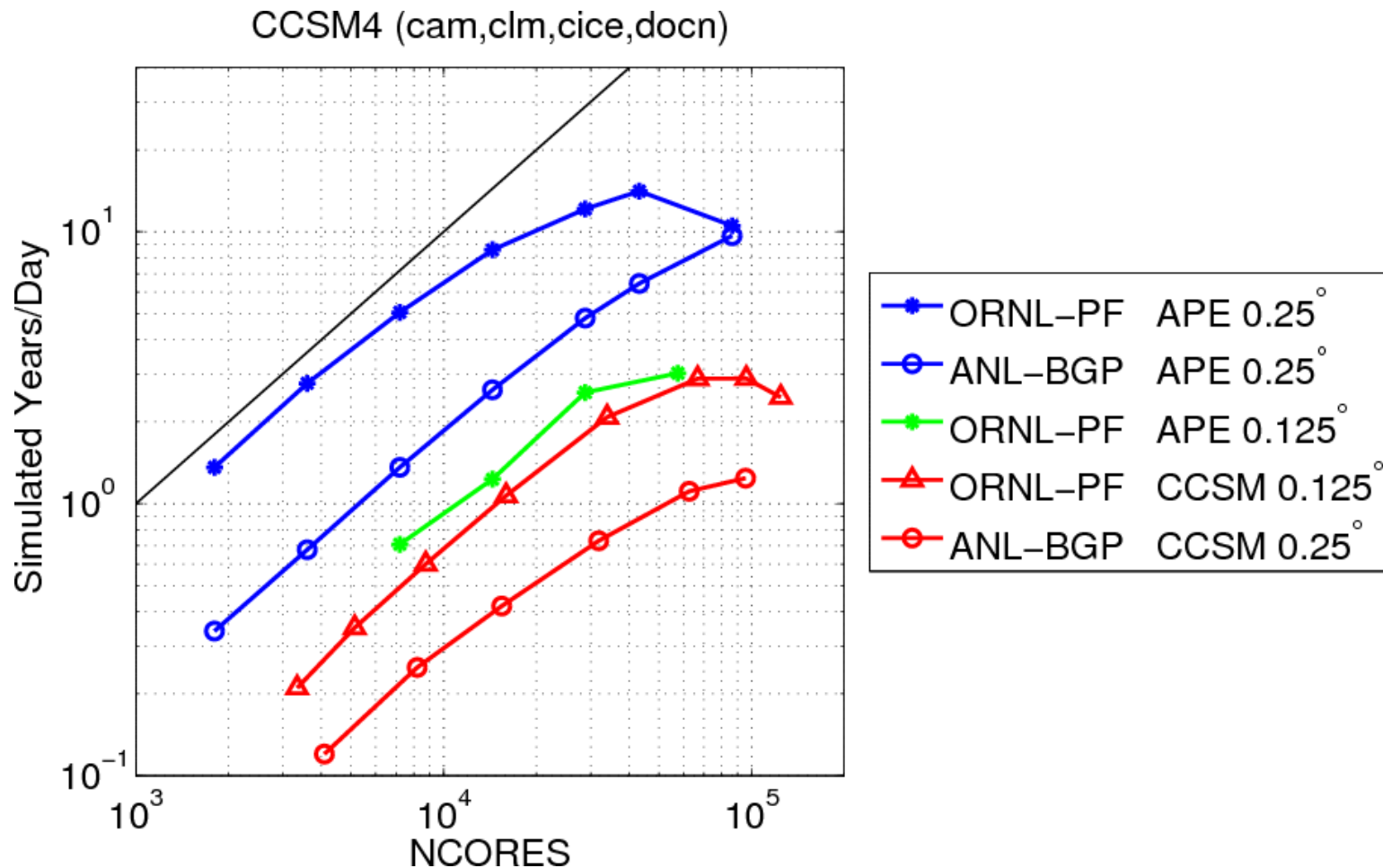
- 1 Degree

- Atmosphere: cubed-sphere grid, equatorial grid spacing 1°
- Land: 2° lat-lon
- Data ocean + cice (prescribed ice extent) gx1v6
- Physics/Tracer/Dynamics timesteps: 1800 / 360 / 90s
- AMWG Diagnostics: <http://users.nccs.gov/~taylor>

- 1/8 Degree

- Atmosphere: cubed-sphere grid, equatorial grid spacing $1/8^\circ$
- Land: $1/4^\circ$ lat-lon
- Data ocean + cice (prescribed ice extent) gx1v6
- Physics/Tracer/Dynamics timesteps: 900 / 45 / 11.25s
- For testing scalability out to O(400,000) cores

CCSM/HOMME Scalability



- BGP (4 cores/node): Excellent scalability down to 1 element per processor (86,200 processors at 0.25 degree resolution).
- JaguarPF (12 cores/node): 2-3x faster per core than BGP, scaling not as good
- 1/8 degree run losing scalability at 4 elements per processor

Global Means

	EUL-T85	HOMME 1.0	FV 0.9x1.25
RESTOM	1.517	1.983	1.468
RESSURF	1.512	1.940	1.437
CLDHGH	25.6	23.5	23.7
CLDLOW	34.6	34.9	31.6
CLDMED	16.8	15.7	16.4
EKE-850mb	40.3	39.6	36.7
EP	-1.2E-04	3.5E-03	2.6E-04

- HOMME running without fixer (conserves moist energy) gives RESTOM=1.8, RESSURF=2.2 because CAM physics conserves dry energy. Results above are with a dry energy fixer in HOMME.
- EP is sensitive to interpolation errors. Interpolating to a ½ degree grid before running AMWG diagnostics gives EP=2.1e-4

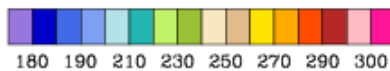
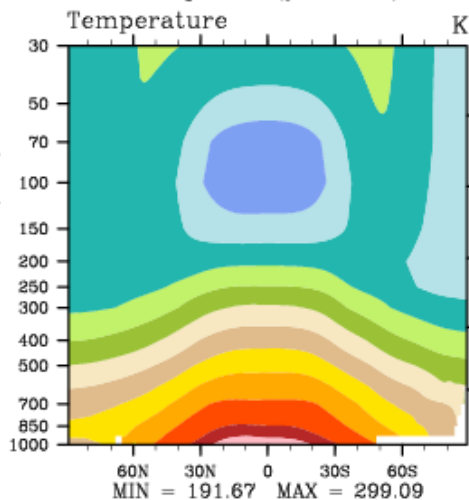
Real Planet: Zonal Means (Annual)

CCSM-EUL

T85

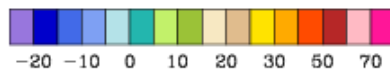
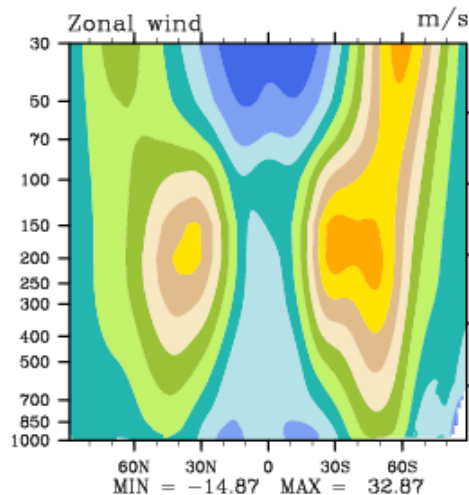
amipne30g (yrs 2-6)

Temperature
Pressure (mb)



amipne30g (yrs 2-6)

Zonal Wind

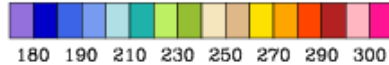
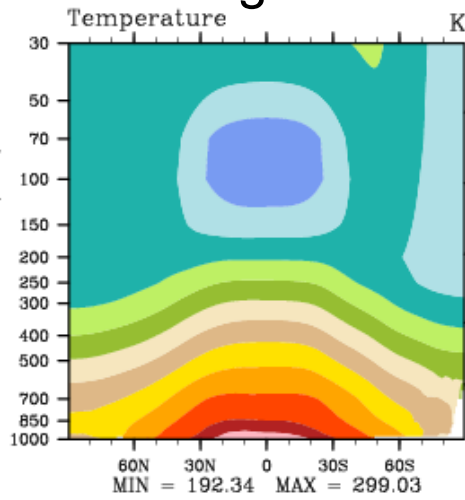


CCSM-HOMME

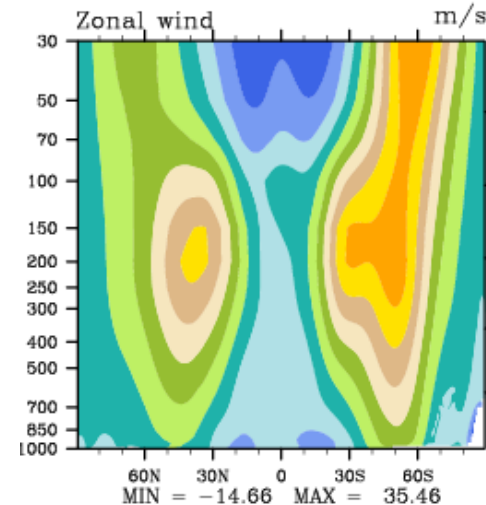
1 Degree

amipne30g (yrs 2-6)

Temperature
Pressure (mb)



amipne30g (yrs 2-6)

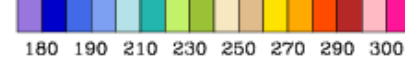
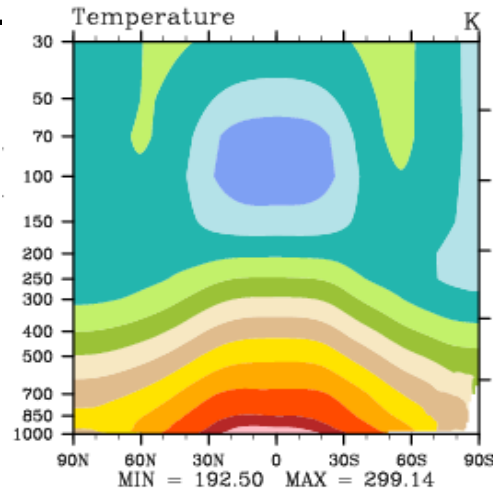


CAM-FV

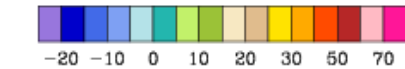
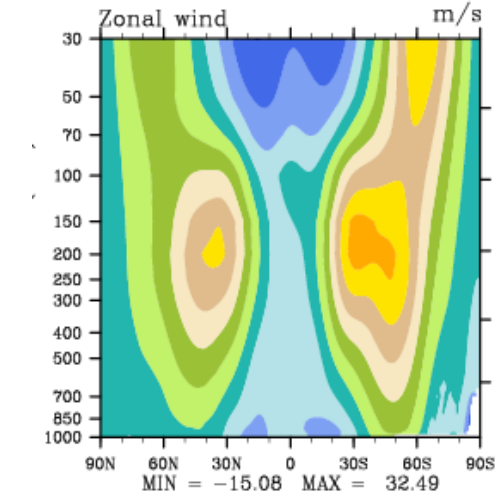
0.9x1.25

fv09a (yrs 2-6)

Temperature
Pressure (mb)



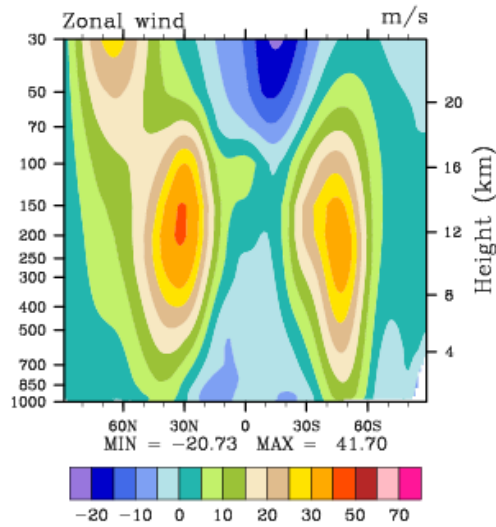
fv09a (yrs 2-6)



Real Planet: Zonal Means (DJF, JJA)

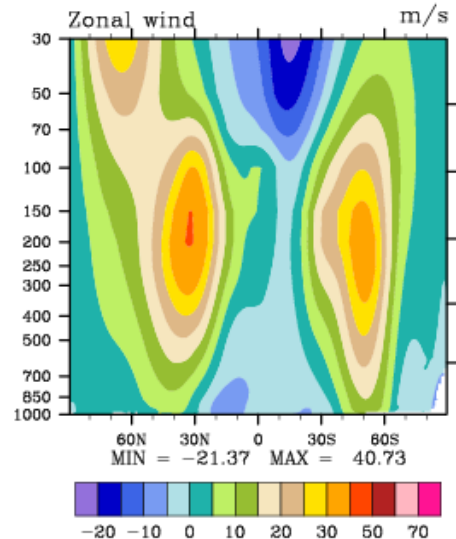
CCSM-EUL
T85

amipt85b (yrs 2-6)



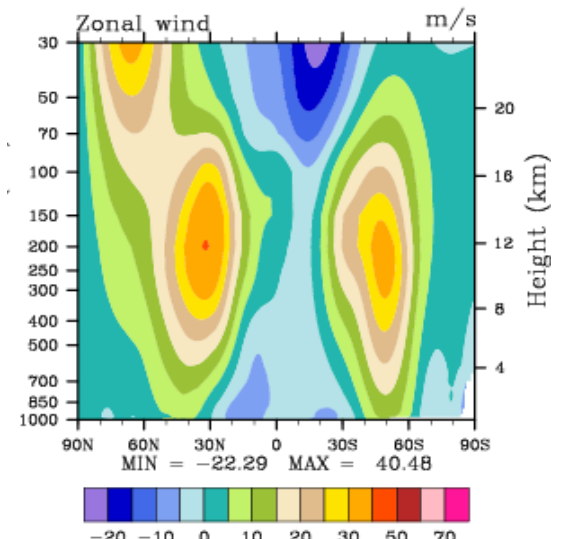
CCSM-HOMME
1 Degree

amipne30g (yrs 2-6)



CAM-FV
0.9x1.25

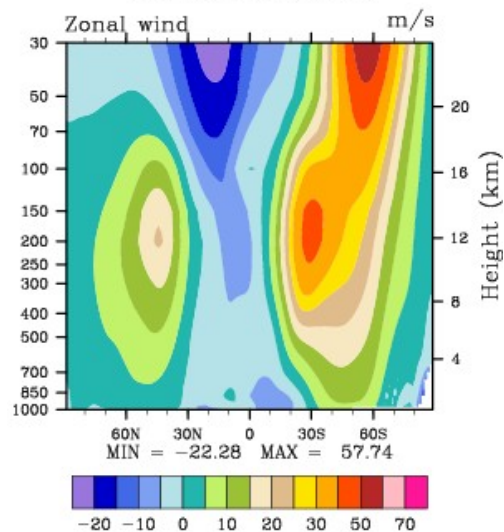
fv09a (yrs 2-6)



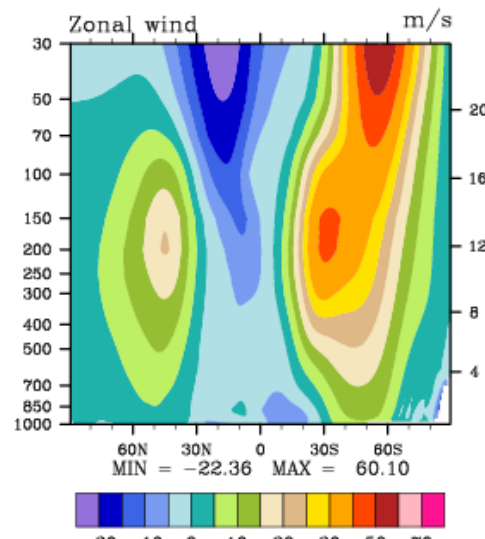
Zonal Wind DJF

Zonal Wind JJA

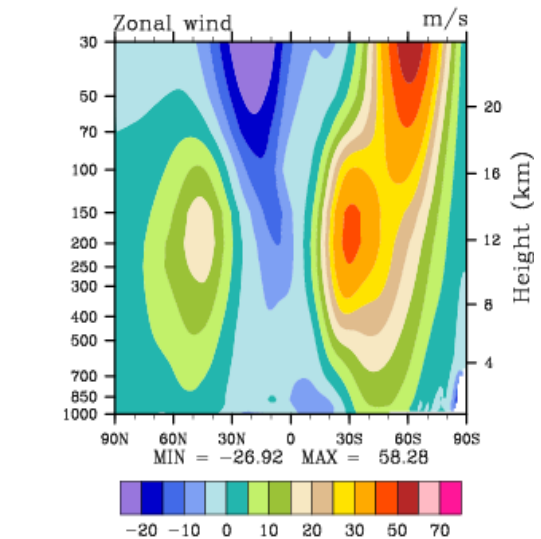
amipt85b (yrs 2-6)



amipne30g (yrs 2-6)

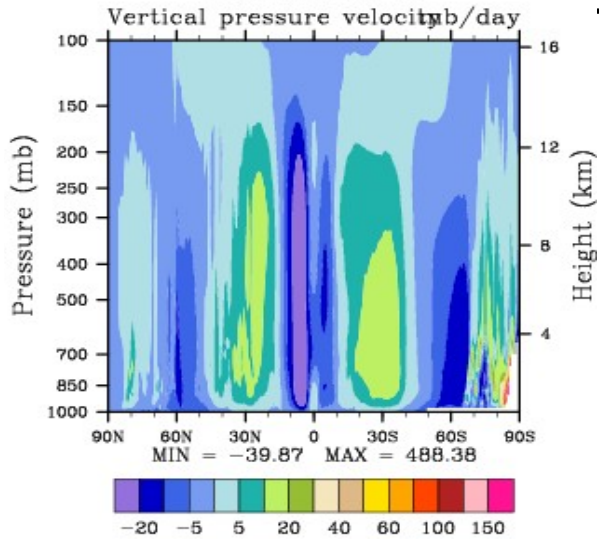


fv09a (yrs 2-6)

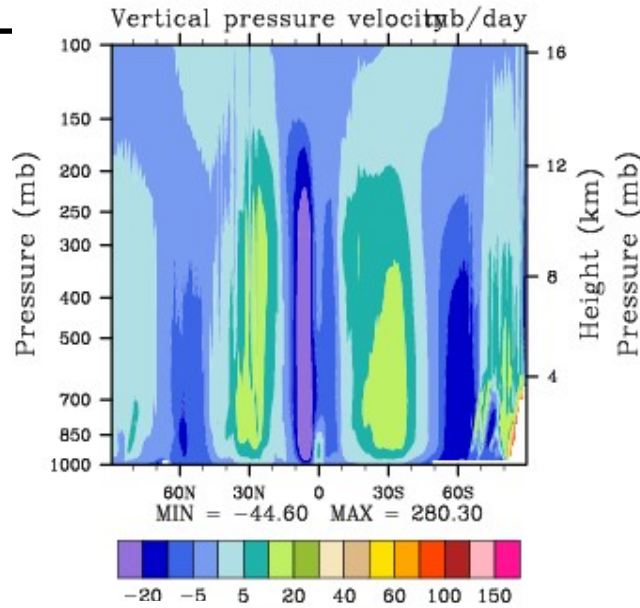


Vertical Pressure Velocity

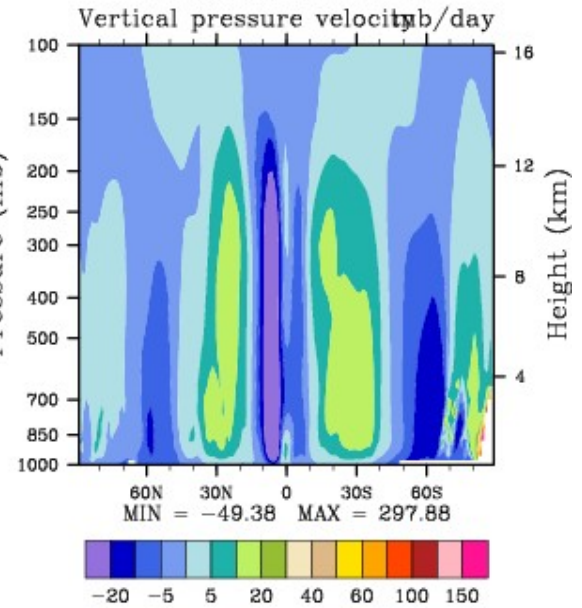
CAM-FV



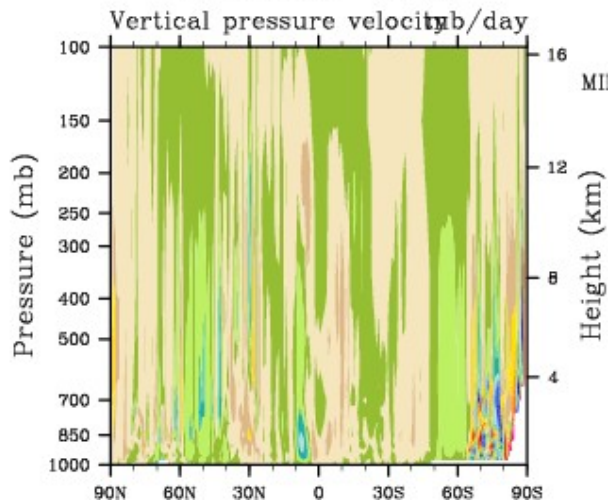
CCSM-HOMME



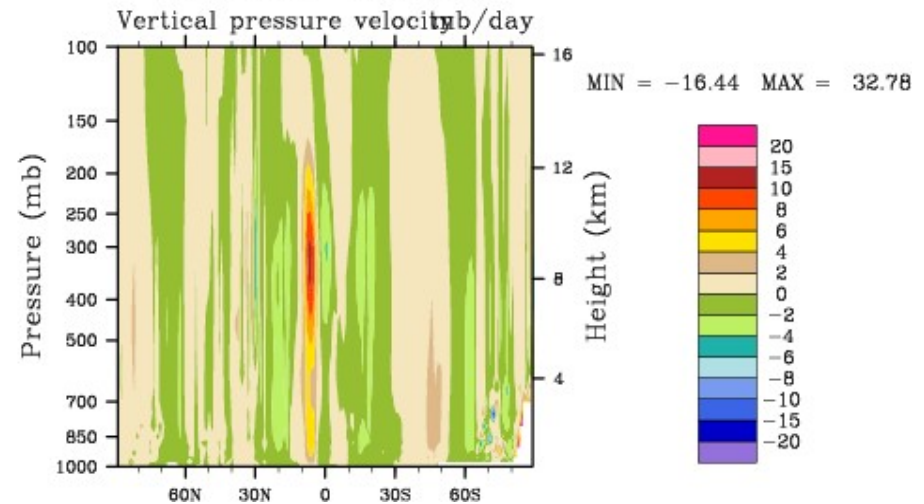
CCSM-EUL



amipne30d - fv09a

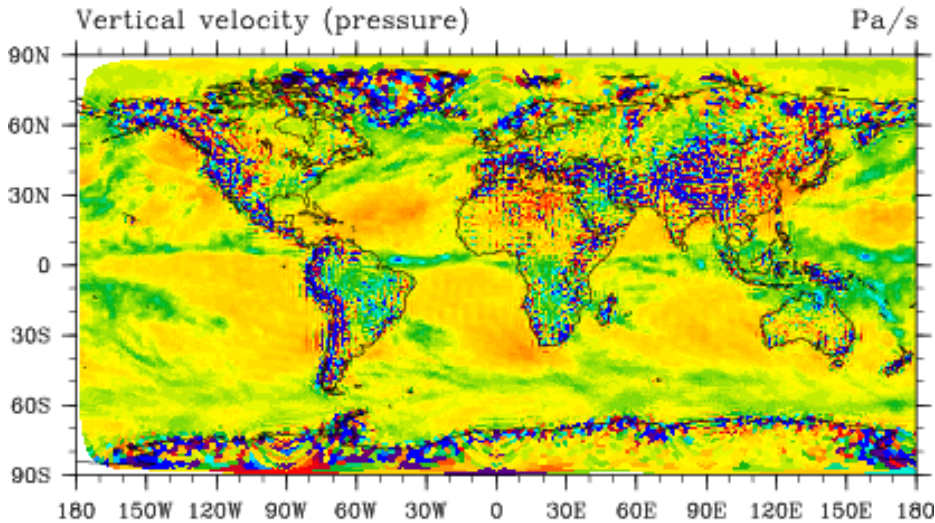


amipne30g - amipt85b

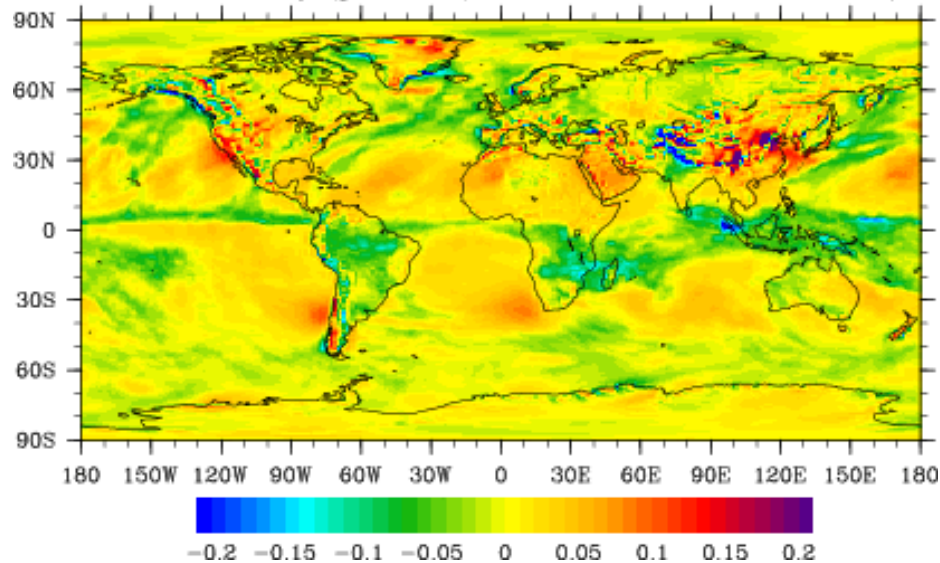
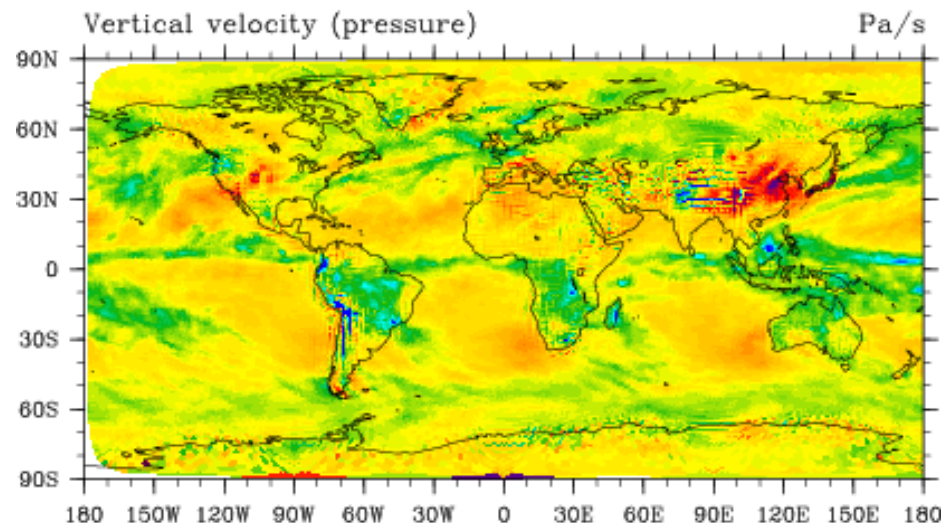


Vertical Pressure Velocity January Average Sensitivity to topography

Using topography interpolated from 0.9x1.25



Using topography interpolated from T85



FV 0.9x1.25

Surface Albedo Mapped to Atmosphere Grid

DJF

amipne30g (yrs 2-6)

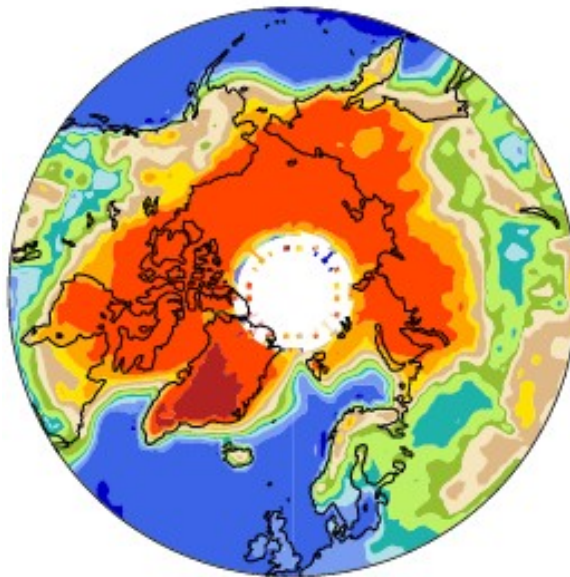
amipt85b (yrs 2-6)

Surface albedo

dimensionless

Surface albedo

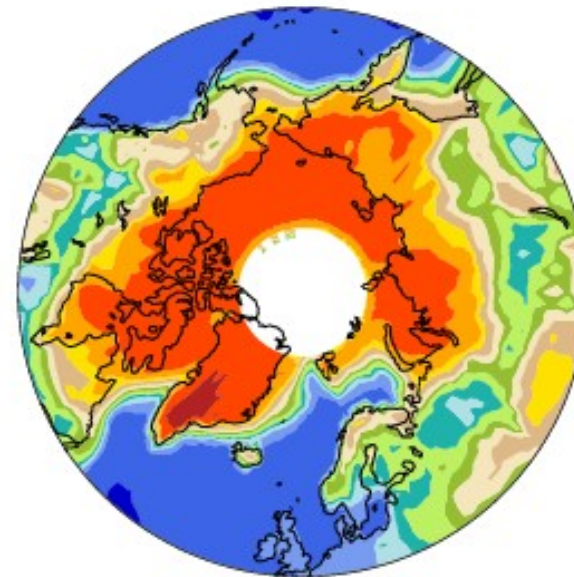
dimensionless



MEAN= 0.51 Min= -181.44 Max= 1.00



0.05 0.15 0.25 0.4 0.6 0.75 0.85 0.95



MEAN= 0.51 Min= 0.10 Max= 0.86

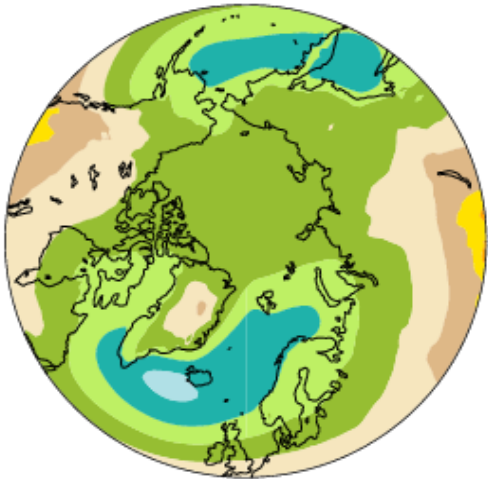


0.05 0.15 0.25 0.4 0.6 0.75 0.85 0.95

Sea Level Pressure

CAM-FV

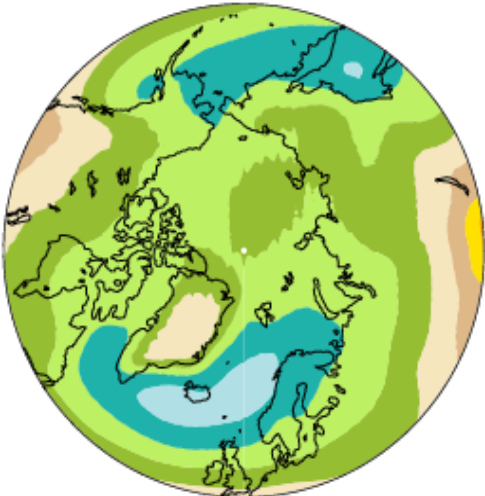
Sea-level pressure millibars



MEAN= 1010.10 Min= 1002.32 Max= 1021.62
991 997 1003 1009 1015 1021 1027 1033

CCSM-HOMME

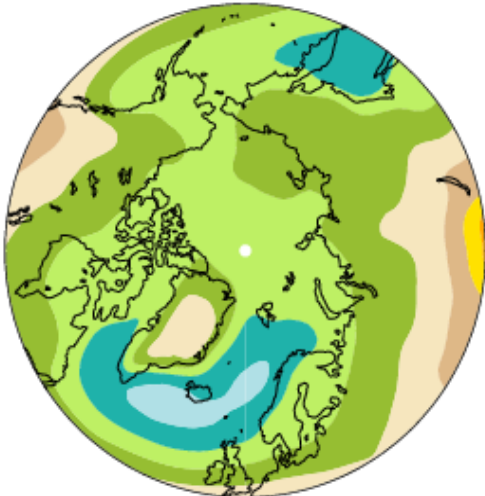
Sea-level pressure millibars



MEAN= 1008.67 Min= 1001.67 Max= 1021.65
991 997 1003 1009 1015 1021 1027 1033

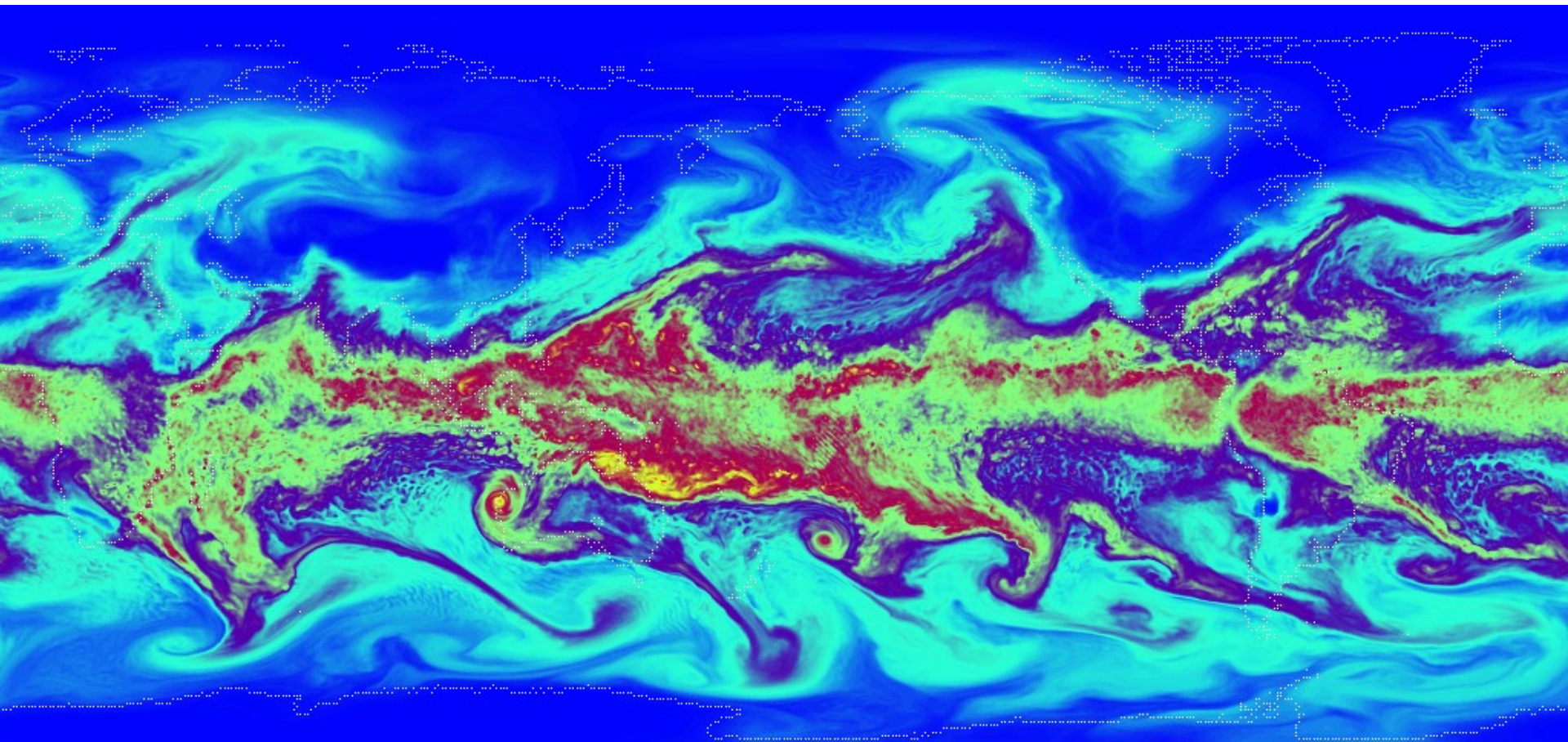
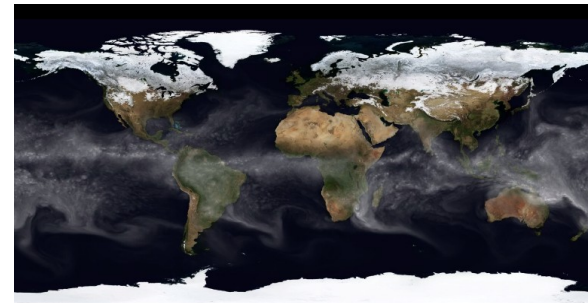
CCSM-EUL

Sea-level pressure millibars



MEAN= 1009.10 Min= 1001.80 Max= 1020.5
991 997 1003 1009 1015 1021 1027 1033

1/8 degree simulations running on Intrepid & Jaguar



Conclusions

- **CCSM-HOMME**

- Excellent scalability: 1/8 degree running at 3 SYPD on Jaguar
- Excellent conservation w/o fixers: mass, tracer mass, moist energy to $< 0.02 \text{ W/m}^2$.
- Large scale features agree well with Eulerian and FV dycores

- **Remaining issues:**

- Minor remaining issue with mapping files (scrip vs. model area calculation)
- Need HOMME specific topography and SGH fields
- In-cloud ice water path noise