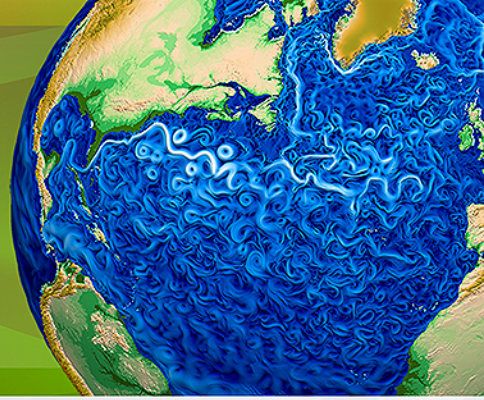
ACME
Accelerated Climate Modeling for Energy



Update on v1 DECK and water cycle high-res experiments

Chris Golaz, Peter Caldwell and the entire Coupled Task.

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ACME v1 low-res water-cycle simulations

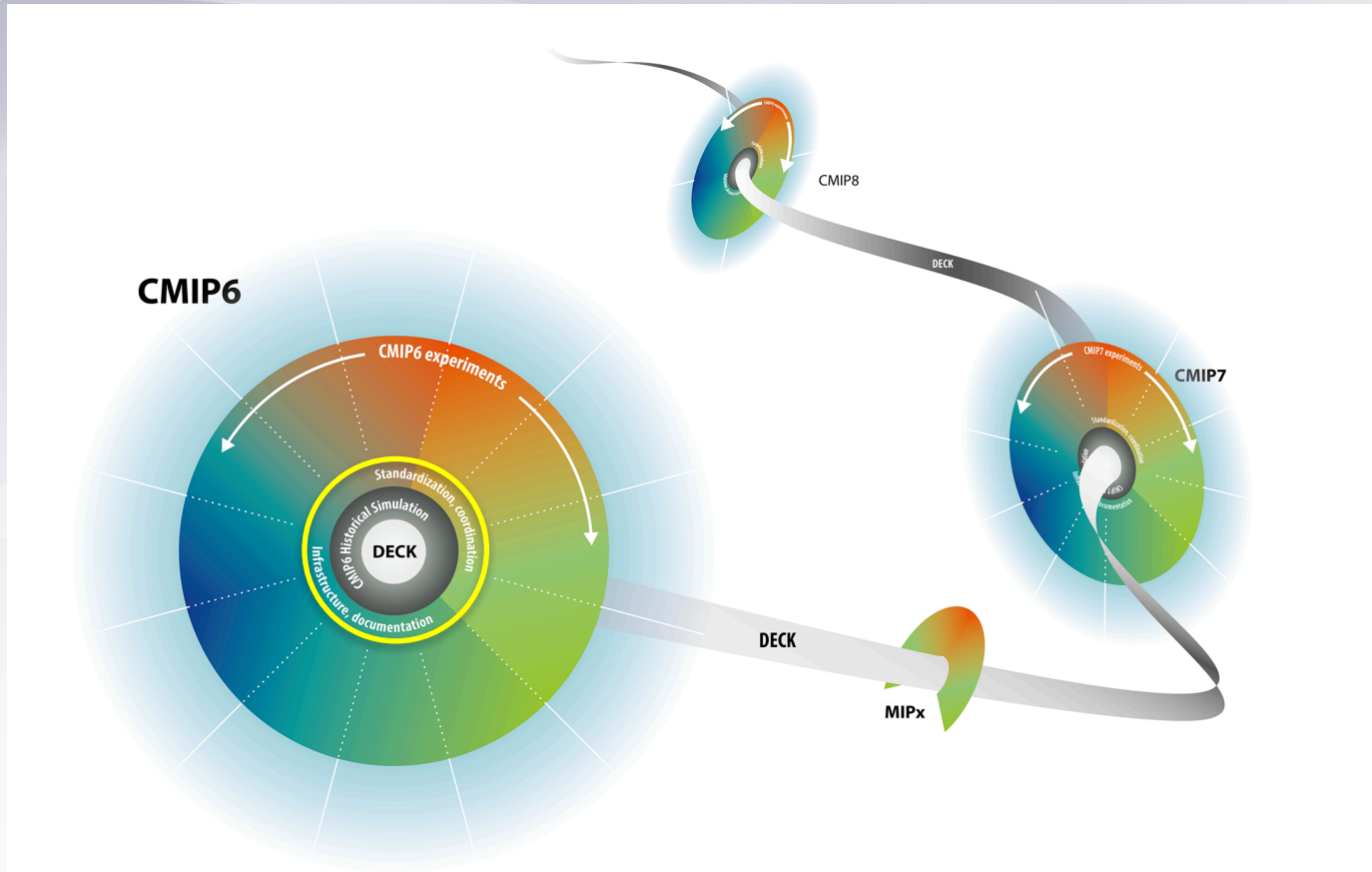


Figure 1. CMIP evolution. CMIP will evolve but the DECK will provide continuity across phases.

Eyring et al. (2016, doi:10.5194/gmd-9-1937-2016)

ACME v1 low-res water-cycle simulations (DECK)

Experiment short name	CMIP6 label	Experiment description	Forcing methods	Start year	End year	Minimum no. years per simulation	Major purpose
DECK experiments							
AMIP	*amip*	Observed SSTs and SICs prescribed	All; CO_2 concentration prescribed	1979	2014	36	Evaluation, variability
Pre-industrial control	*piControl* or *esm-piControl*	Coupled atmosphere–ocean pre-industrial control	CO_2 concentration prescribed or calculated	n/a	n/a	500	Evaluation, unforced variability
Abrupt quadrupling of CO_2 concentration	*abrupt-4×CO2*	CO_2 abruptly quadrupled and then held constant	CO_2 concentration prescribed	n/a	n/a	150	Climate sensitivity, feedback, fast responses
1 % yr^{-1} CO_2 concentration increase	*1pctCO2*	CO_2 prescribed to increase at 1 % yr^{-1}	CO_2 concentration prescribed	n/a	n/a	150	Climate sensitivity, feedback, idealized benchmark
CMIP6 historical simulation							
Past ~ 1.5 centuries	*historical* or *esm-hist*	Simulation of the recent past	All; CO_2 concentration prescribed or calculated	1850	2014	165	Evaluation

3-5 members

Total: 1331 – 1661 + spin-up

Note: no future scenario included here!

Eyring et al. (2016, doi:10.5194/gmd-9-1937-2016)

DECK: status

In order to be successful, an entire ecosystem needs to be in place and functional.

- Low-res coupled model
- Software tools
  - Configure and execute simulations: run_acme scripts.
  - Short and long term archiving.
  - Automated post-processing workflow (Sterling Balwin, poster #W02)
  - Diagnostics (A-Prime, ACME Diagnostics, MPAS-Analysis, Ilamb, …)
- Compsets (Philip Cameron-Smith)
  - Adhere to CMIP6 requirements as closely as possible.
- Output (Kate's talk Wednesday)
  - What to save and at what frequency to meet CMIP6 requirements.
- **Note:** CMORization is not part of current plan (Dean's talk Wednesday)
  - To be done later.
  - Probably cannot publish to CMIP6 without it.

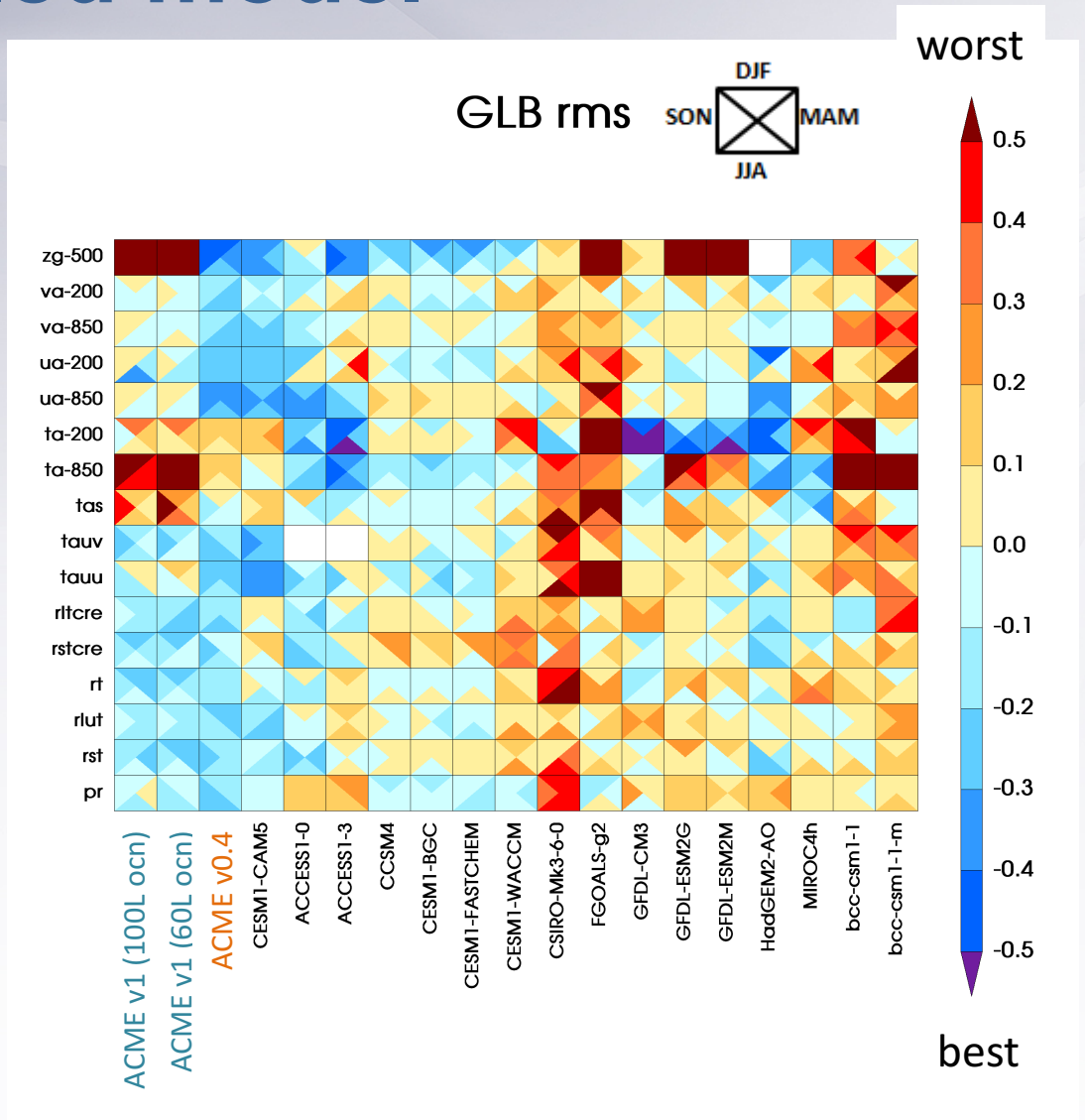
DECK: execution

- Cost estimate (NERSC Edison)
  - 265 nodes @ 8 SYPD: ~40,000 core hours / SY
  - 1500 years: 60 M core hours; 2000 years: 80 M core hours
  - More if *anything* goes wrong
  - Need advice from Chief Computational Scientist and Performance team.
- Storage estimate
  - Unknown (Kate's talk Wednesday)
- Time estimate
  - Should not expect sustained throughput of more than 5 SYPD per stream.
  - Single stream: 300 to 400 days.
  - Parallel streams: several months at the minimum. Getting through the queues will be a challenge.
    - Larger 'special_acme' QOS (>4x?)
    - Brute force
- Anvil could be alternate option (but max 2 streams)

Low-res coupled model

Gleckler plots

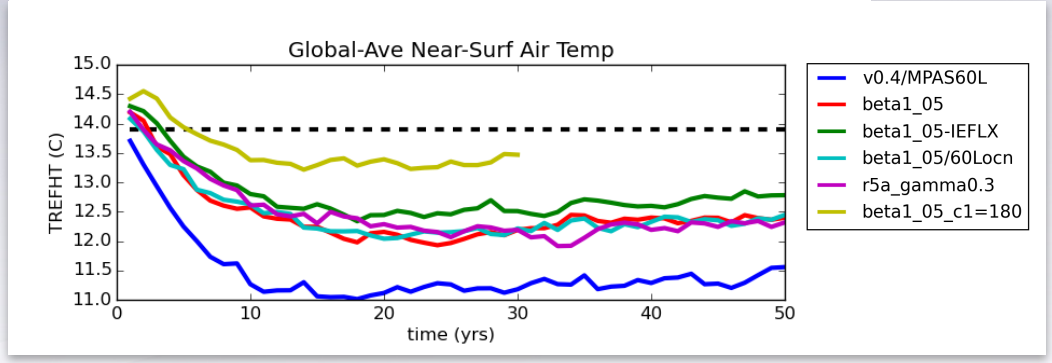
- Normalized global RMSE for coupled simulations
- ACME v1 (100, 60 level ocean)
- ACME v0.4
- CIMP5



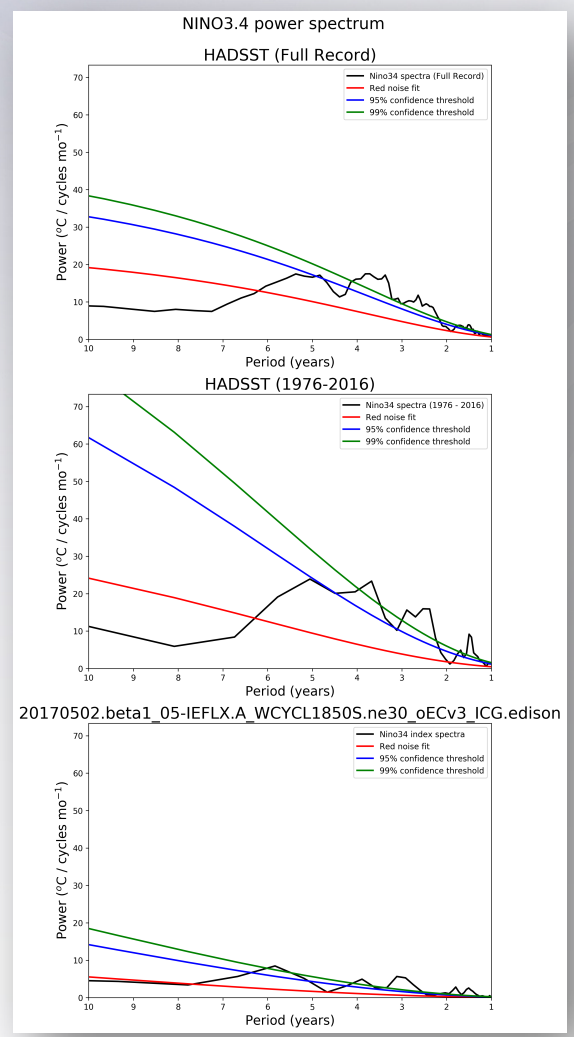
Qi Tang

Low-res coupled model Outstanding problems

Initial cooling



ENSO



Much more on this Wednesday!

Low-res coupled model
Other issues that could derail progress

- Long term drift in control simulation
  - Net TOA radiation, OHC, surface temperature, sea-ice.
- Historical simulations that do not warm enough.
  - Would need to quickly reduce AIE magnitude and start over.
- Computer issues
  - NERSC machines misbehaving (it happened before)
  - Insufficient allocations (compute, storage)
- Post-processing machines not up to the task.
  - acme1, others?
- The list goes on…

High-Resolution model

Why a "High-Resolution" Model?

- High resolution is needed to capture topographic effects on rainfall (top row)
- and topography has an important effect on rainfall changes (bottom row)!

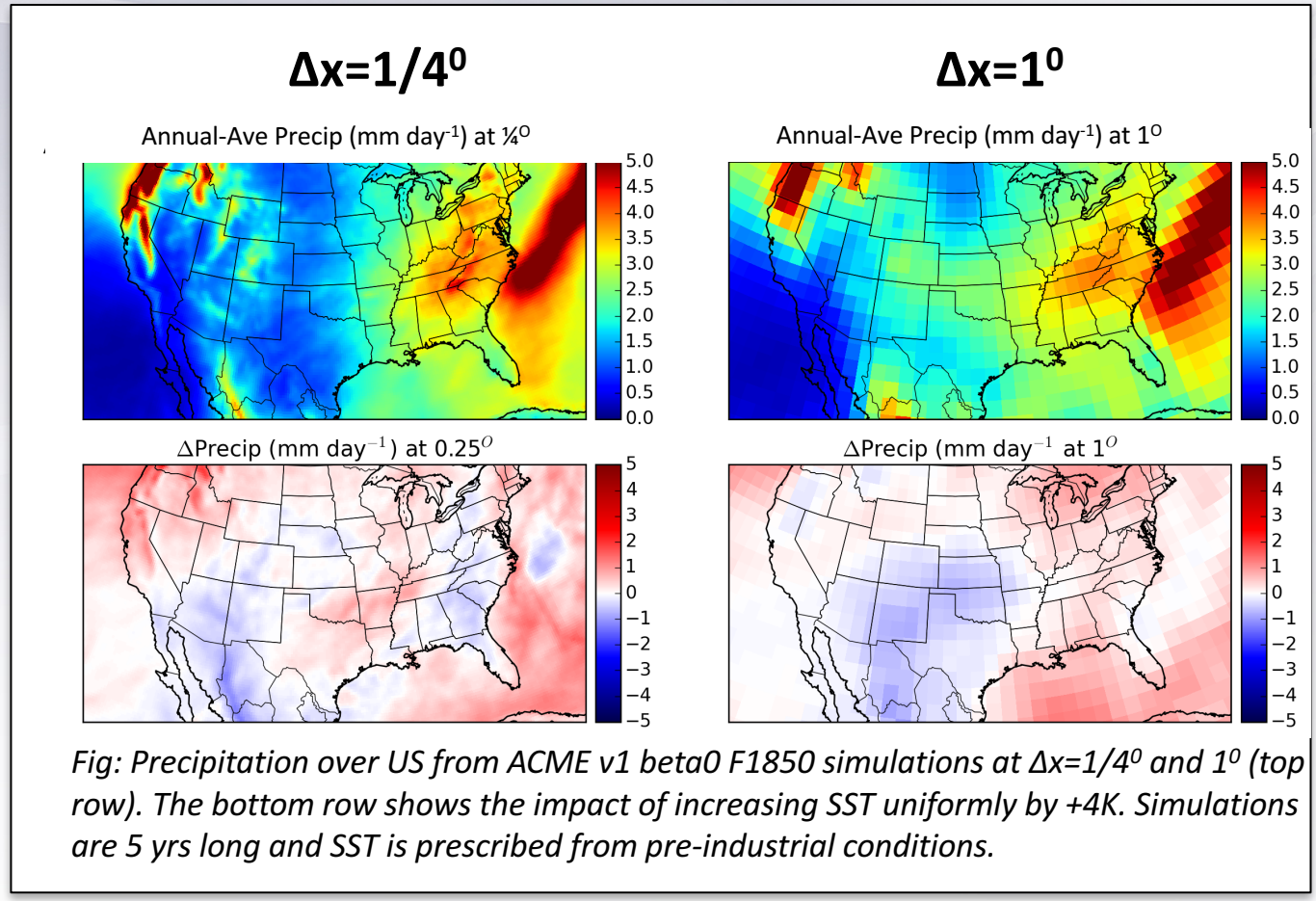


Fig: Precipitation over US from ACME v1 beta0 F1850 simulations at Δx=1/4⁰ and 1⁰ (top row). The bottom row shows the impact of increasing SST uniformly by +4K. Simulations are 5 yrs long and SST is prescribed from pre-industrial conditions.

Runs by Noel Keen

Atmosphere Model Skill

- High-res atm looks good!
- v1 has an unfair advantage because other models were tuned for *coupled* skill

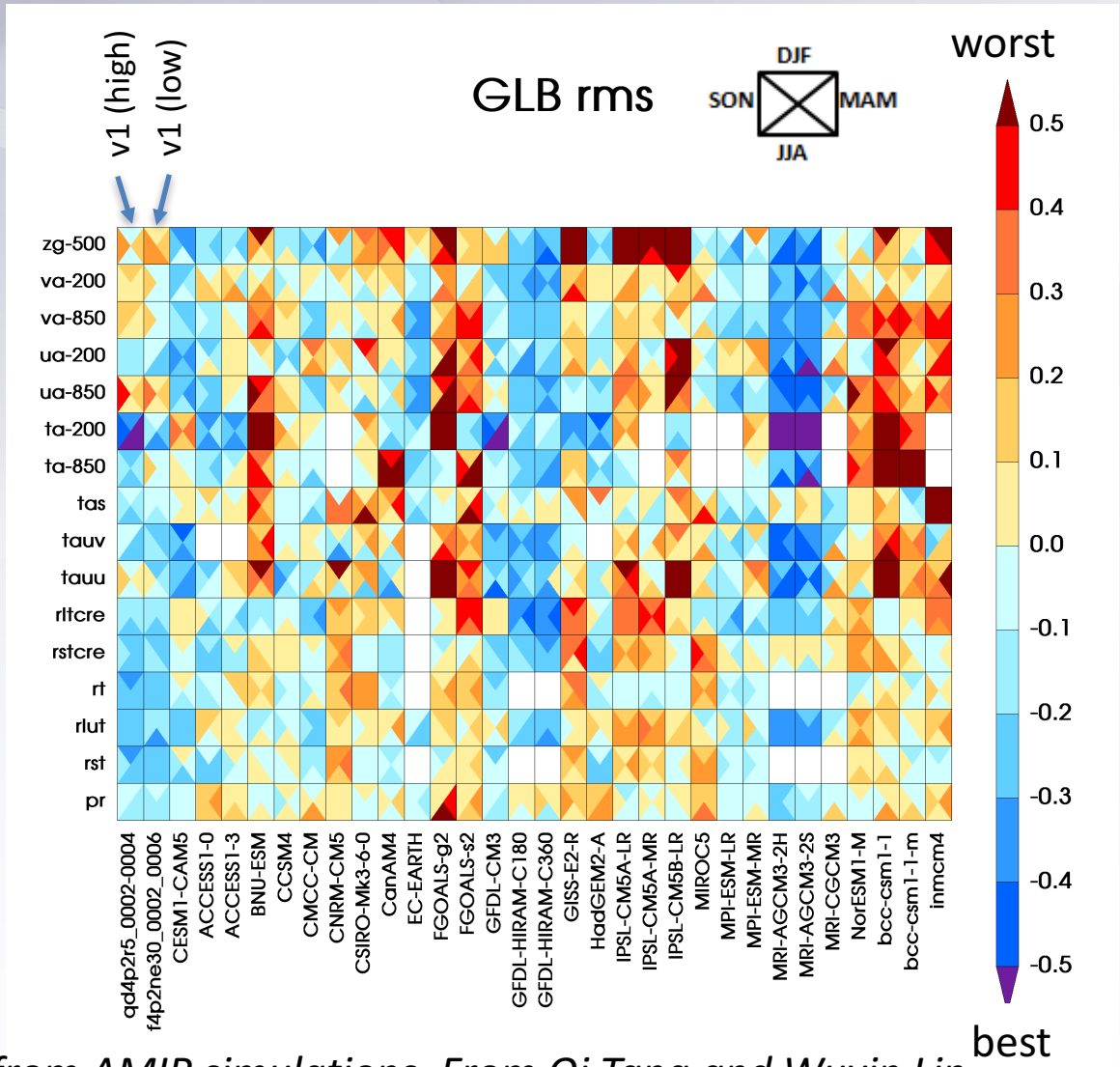


Fig: Gleckler plot for global RMSE from AMIP simulations. From Qi Tang and Wuyin Lin

Coupled High-Res Status

Team: Peter Caldwell, Noel Keen, Jon Wolfe, & Qi Tang with help from other Performance team members

- We have completed 5 day test runs on mira, titan, and cori-KNL
  - COSP seems to work fine
- ~~Initialization takes hours, preventing us from using debug queues~~. Fixed?
- We are unable to write restart files on any machine, which prevents us from doing longer tests
  - The longest simulation we've done is 45 days on cori-KNL
- Writing output ruins performance on KNL (see table)
- High-Res Coupled progress suffers from a lack of dedicated staff – everyone is focused on fixing low-res problems

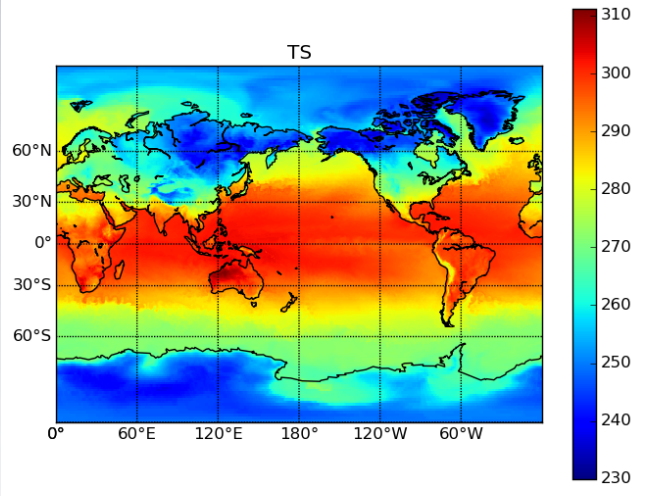


Fig: Output from 5 day high-res coupled runs looks like Earth.

Machine	SYPD	Output?	Cores Used
mira	0.12	none	32768
titan	0.52	none	28000
cori-KNL	0.92	none	52800
mira	0.09	daily atm	32768
cori-KNL	0.66	1 mo atm	62400

Table: Timings from 5-day high-res coupled runs (except last, which is 1 month)

High-Res Sensitivity

A series of 5 yr fixed-SST ne120 beta0 runs were performed as a preliminary check on aerosol and GHG sensitivity. Results:

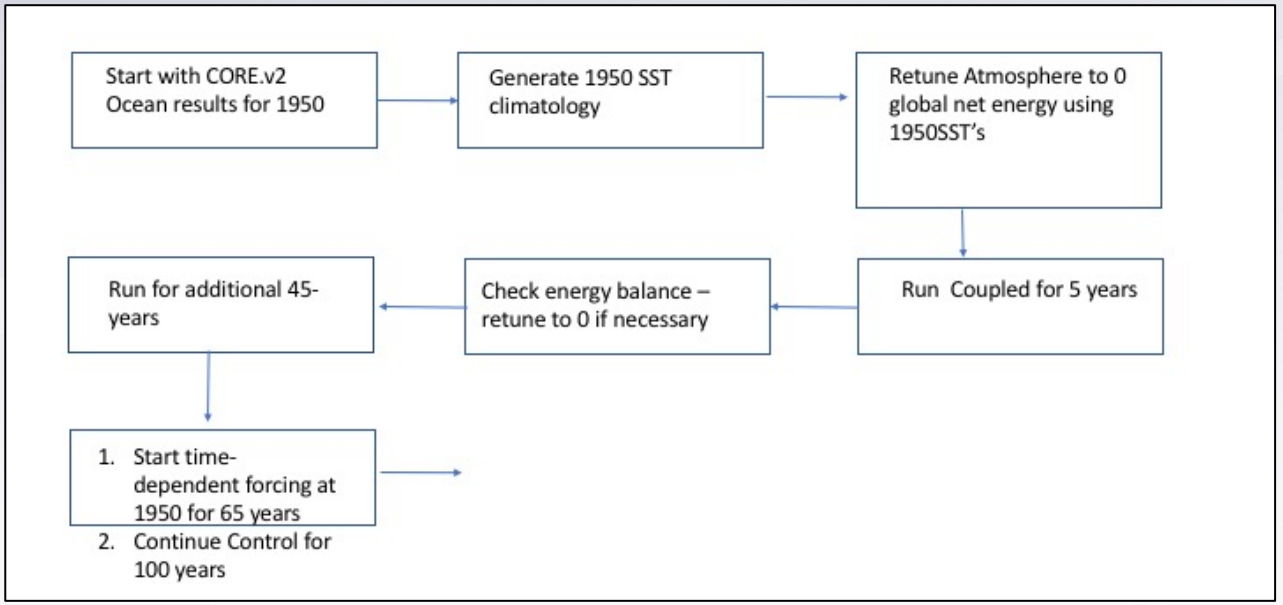
- Net feedback (from 1850+4K vs 1850 SST runs) is about -1.2 W m^{-2} K^{-1}
  - CMIP5 had a range of -1.05 to -1.95 with a mean of -1.6 W m^{-2} K^{-1}
  - ne30 had a value of -1.44 W m^{-2} K^{-1}
  - Less negative feedback means more warming… our high-res model will probably warm a lot

- Total adjusted forcing (TAF, the TOA rad imbalance for F2000AF vs F1850) is 1.9 W m^{-2}
  - CMIP5 average TAF was 1.7 W m^{-2}
  - ne30 had a a value of 1.2 W m^{-2}
  - TAF is the sum of GHG trapping and aerosol reflection, so large TAF means the ne120 aerosol effect is relatively weak

Weak aerosol sensitivity combined with strong climate sensitivity means that our ne120 model will probably warm too much over the 20th century.

High-Resolution Water Cycle Experiment

- **Plan for this year:** Perform a single 1950 control simulation following the "Modified High-Res MIP v1.0 Procedure":



- **Longer-range plans:** Perform 1950-2050 transient simulation