

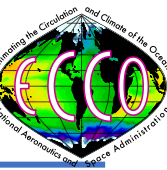
ECCO Version 5 Progress

Multi-grid optimization

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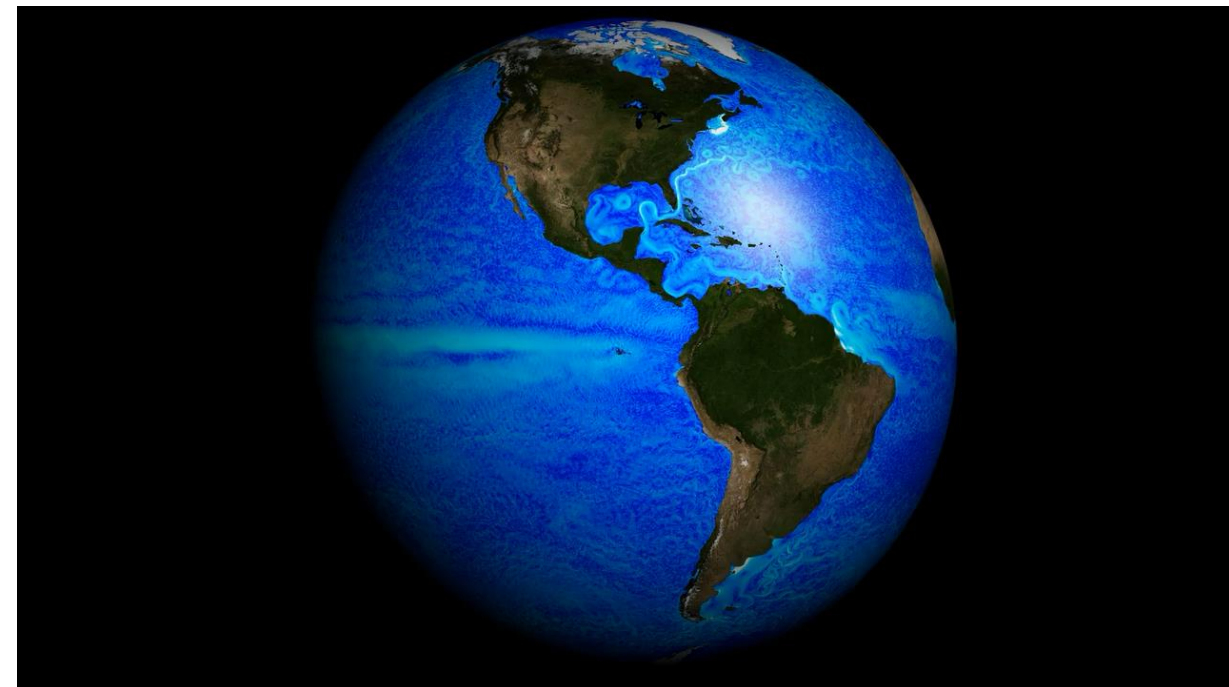
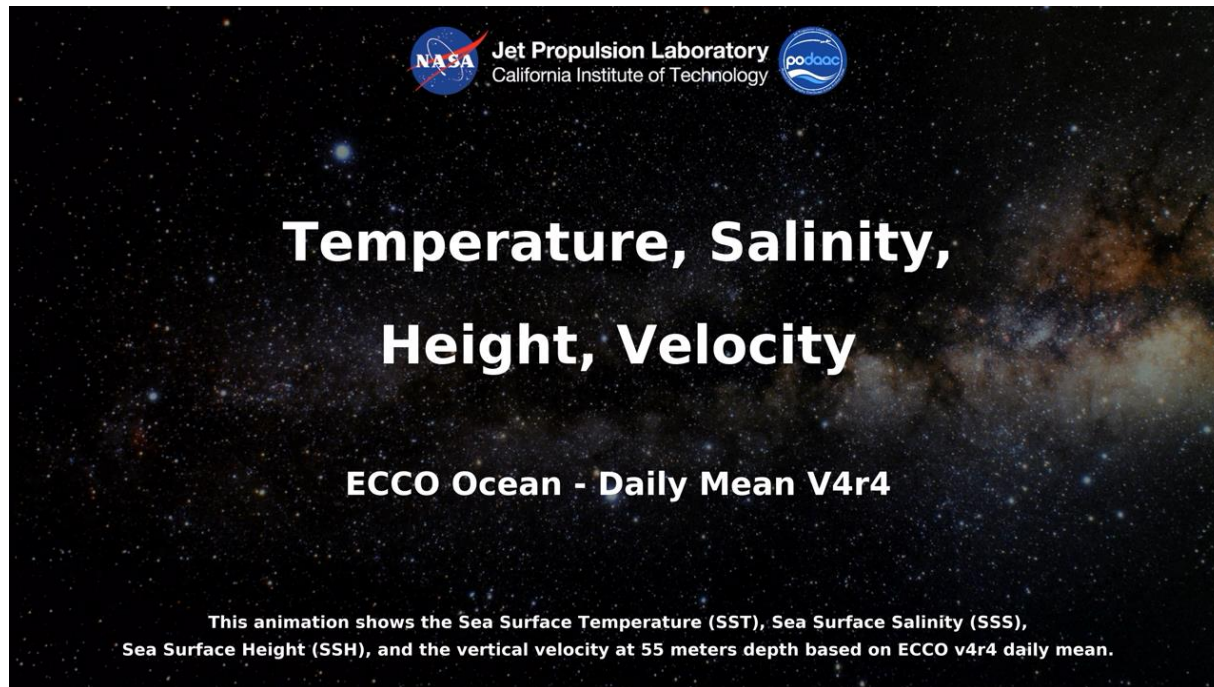
Growing demand and interest for higher resolution



- Version 4: LLC90 grid with nominal 1° horizontal resolution and a time-step size of 3600 seconds

1° resolution

$1/48^\circ$ resolution



- Version 5: LLC270 grid with $1/3^\circ$ resolution; time-step size is 1200 seconds
- Version 6: LLC540 grid with $1/6^\circ$ resolution; time-step size is 600 seconds

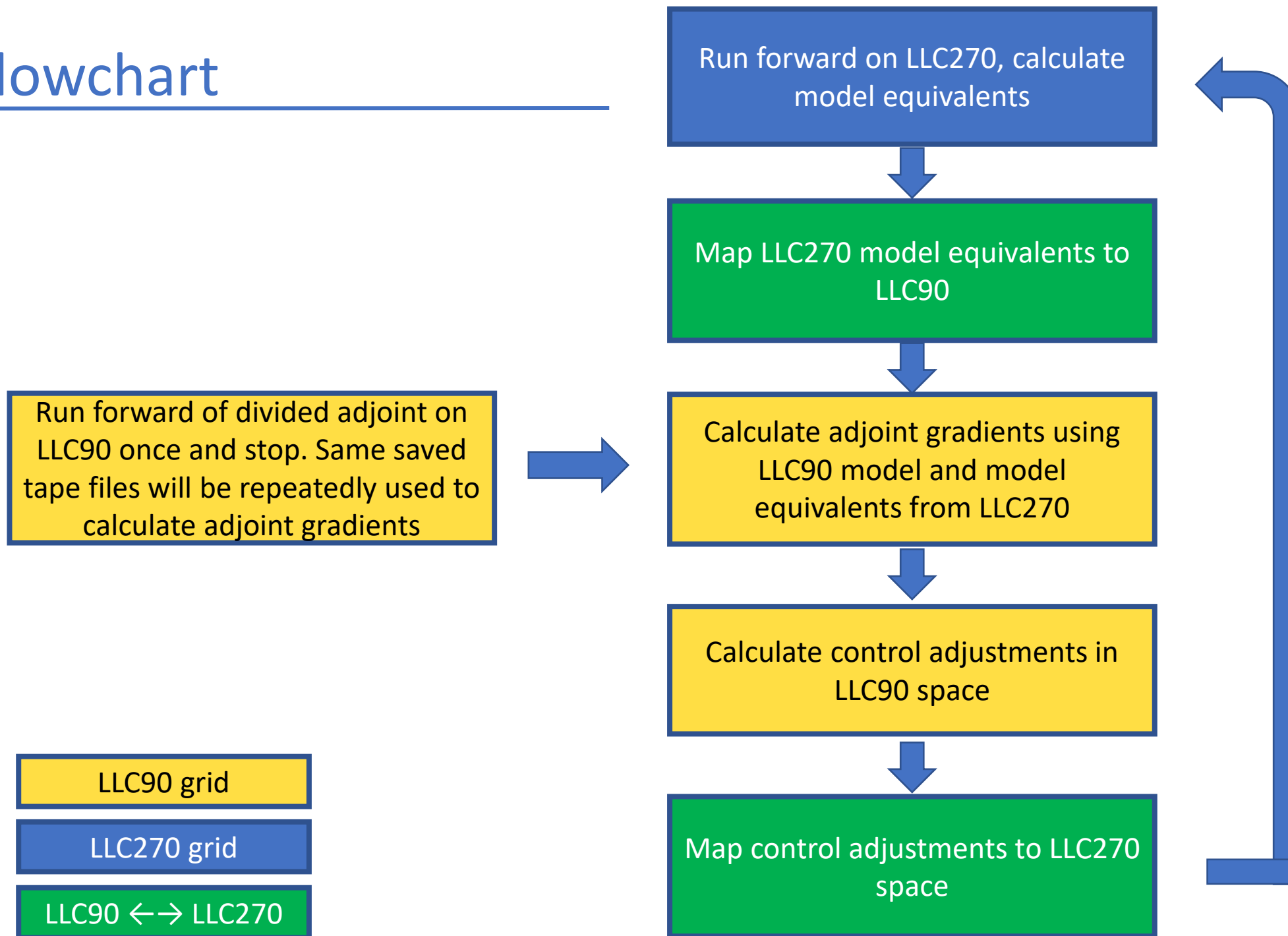
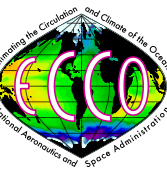
Challenges for Higher Resolution Optimization

- Exponentially-increasing computational requirements
- Inaccuracies of adjoint gradients due to nonlinearity

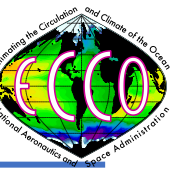
Multi-grid optimization approach

- Forward to calculate model-data misfit on high-resolution (e.g., LLC270, LLC540)
- Adjoint and calculation of control variables on low-resolution (LLC90)

Flowchart

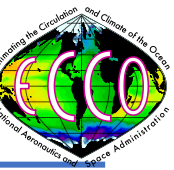


Completed: Test with 2-year runs



- 1993-1994
- Altimetry data only; Large-scale SSH (Isc) and mean dynamic topography costs
- Atmospheric controls only; starting from MERRA2 forcing
- Starting from no control adjustments

Questions to answer for multi-grid approach



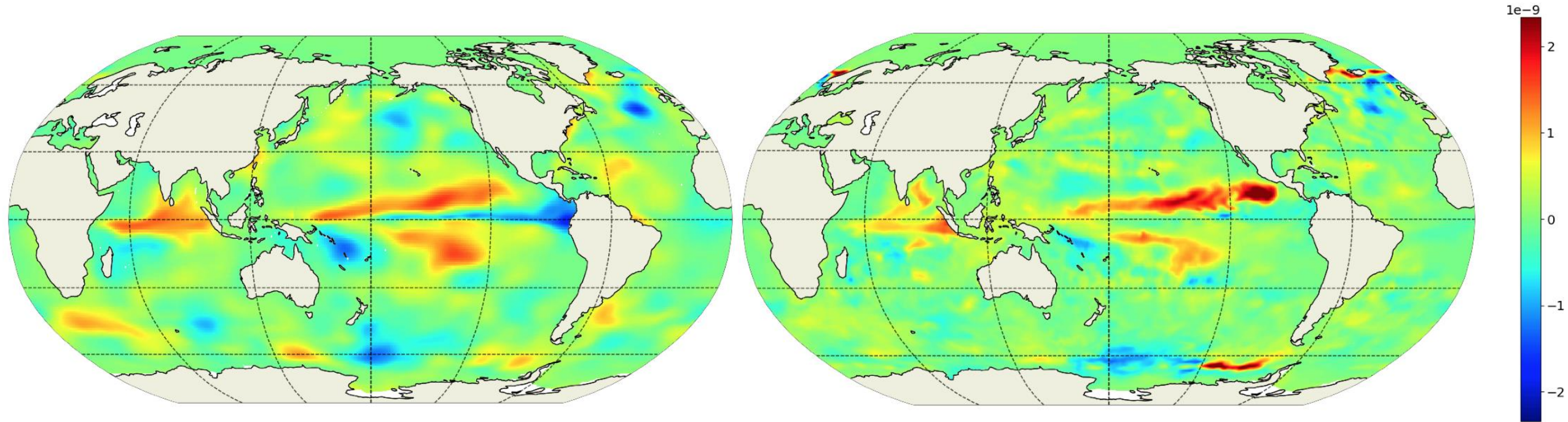
- Can multi-grid optimization reduce LLC270 cost?
- What is the speedup by using multigrid optimization?
- How does multi-grid optimization compare with native LLC270 optimization in terms of cost reduction?

Adjoint gradients broadly agree between models

Adjoint gradient with regard to altimetry data

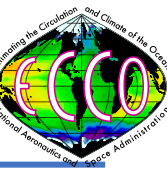
LLC 90

LLC 270

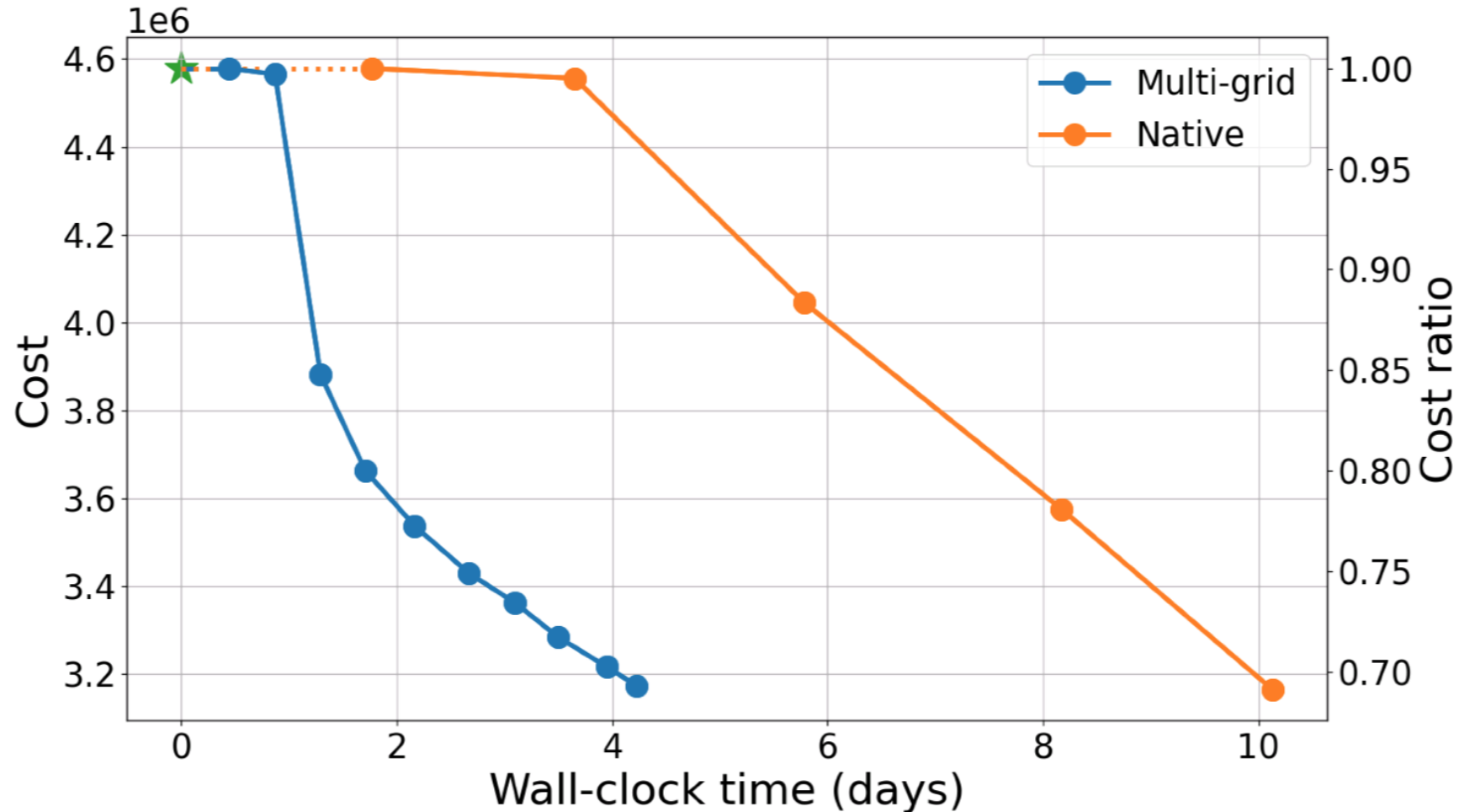


- Large-scale features are broadly agree, indicating optimizing controls on LLC90 would be helpful to reduce model-data difference on LLC 270.

Multigrid 400% faster than native optimization



Cost vs wall-clock time: Multi-grid vs. Native LLC 270 optimization



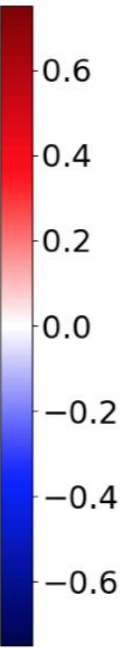
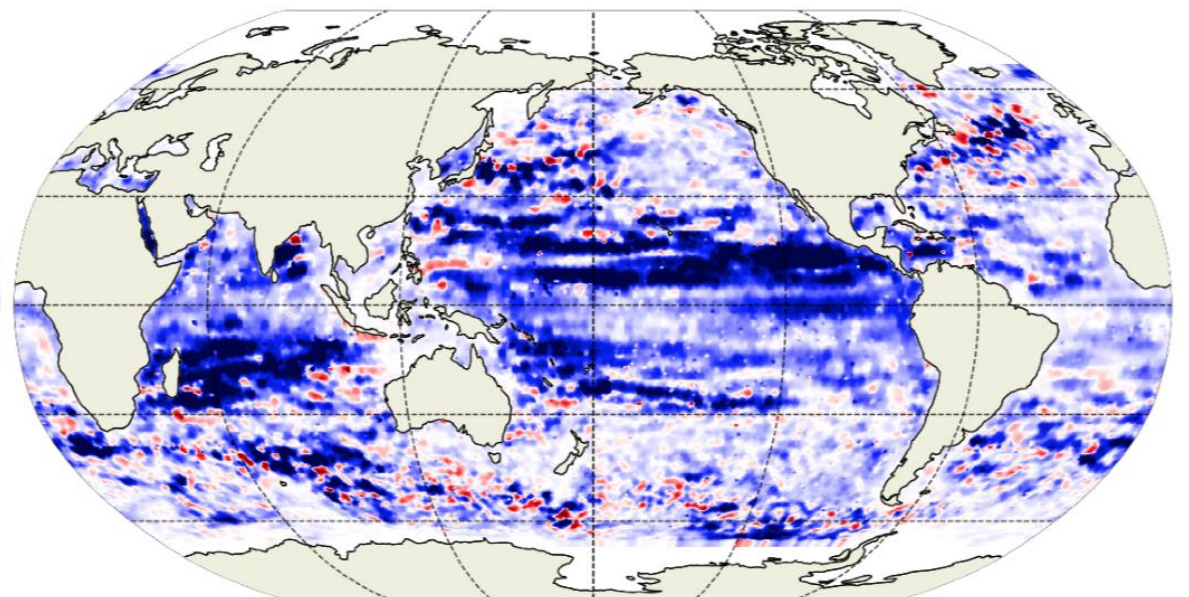
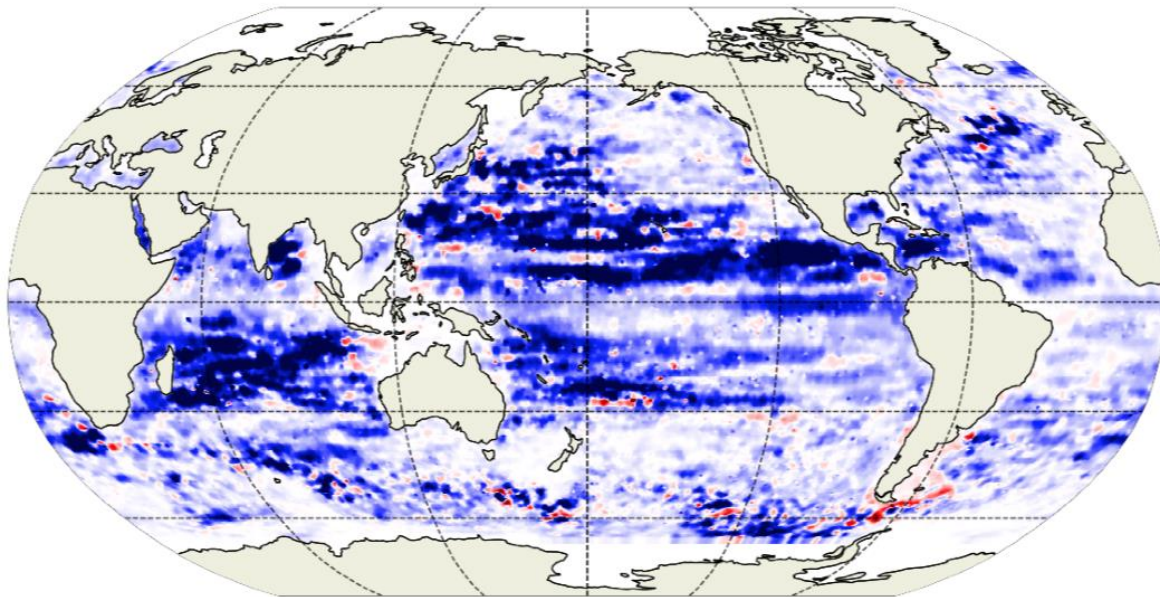
- Multi-grid optimization can reduce cost reasonably well;
- Timing information: MG takes **11.5** hours for one iteration, while LLC 270 takes **44** hours!

Cost reduction nearly identical between multi-grid and native

Cost reduction with regard to iteration 0

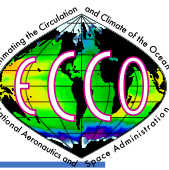
Native

Multi-grid



- Same magnitude and spatial patterns between multi-grid and native optimization approaches

Summary



- Multi-grid optimization can reduce cost for the two-year runs;
- Multi-grid optimization 250%-400% faster than native optimization.

Timeline for multi-grid estimation

- 1992-2023 V5 Release in Q1 2024
- V6 Release in Q1 2025

Testing multi-grid optimization for the full V4r4 integration period (1992-2017)

- Starting from a pre-V4r4 iteration (optimized forcing) and run a few iterations;
- Using all constraining data as in V4r4;
- Will share results in regular ECCO telecons;
- Will implement it for V5 production.