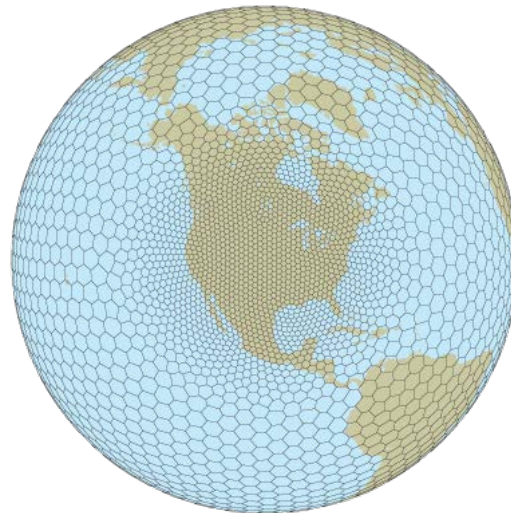
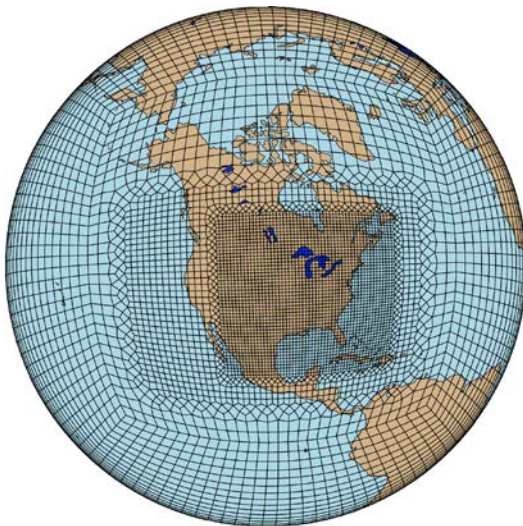


Variable-resolution CESM updates: CAM-SE and CAM-MPAS



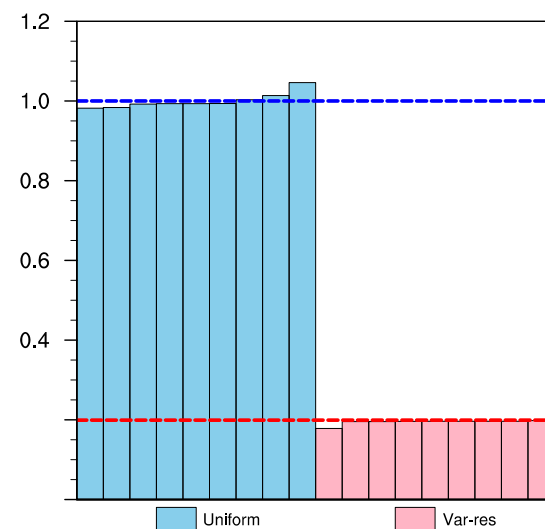
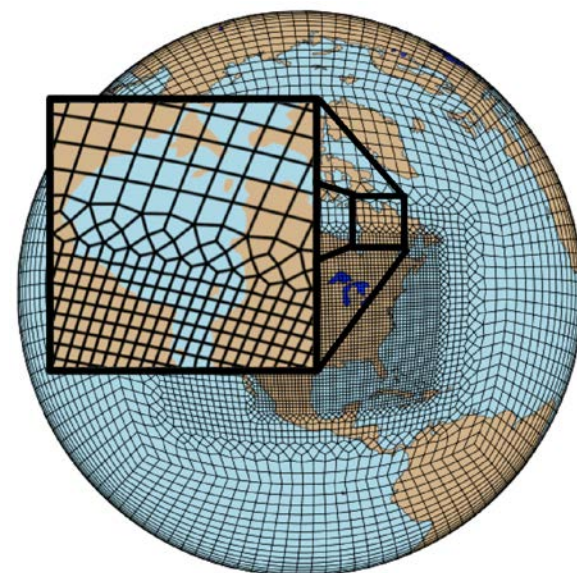
Colin Zarzycki
CGD/MMM

(and many, many others)

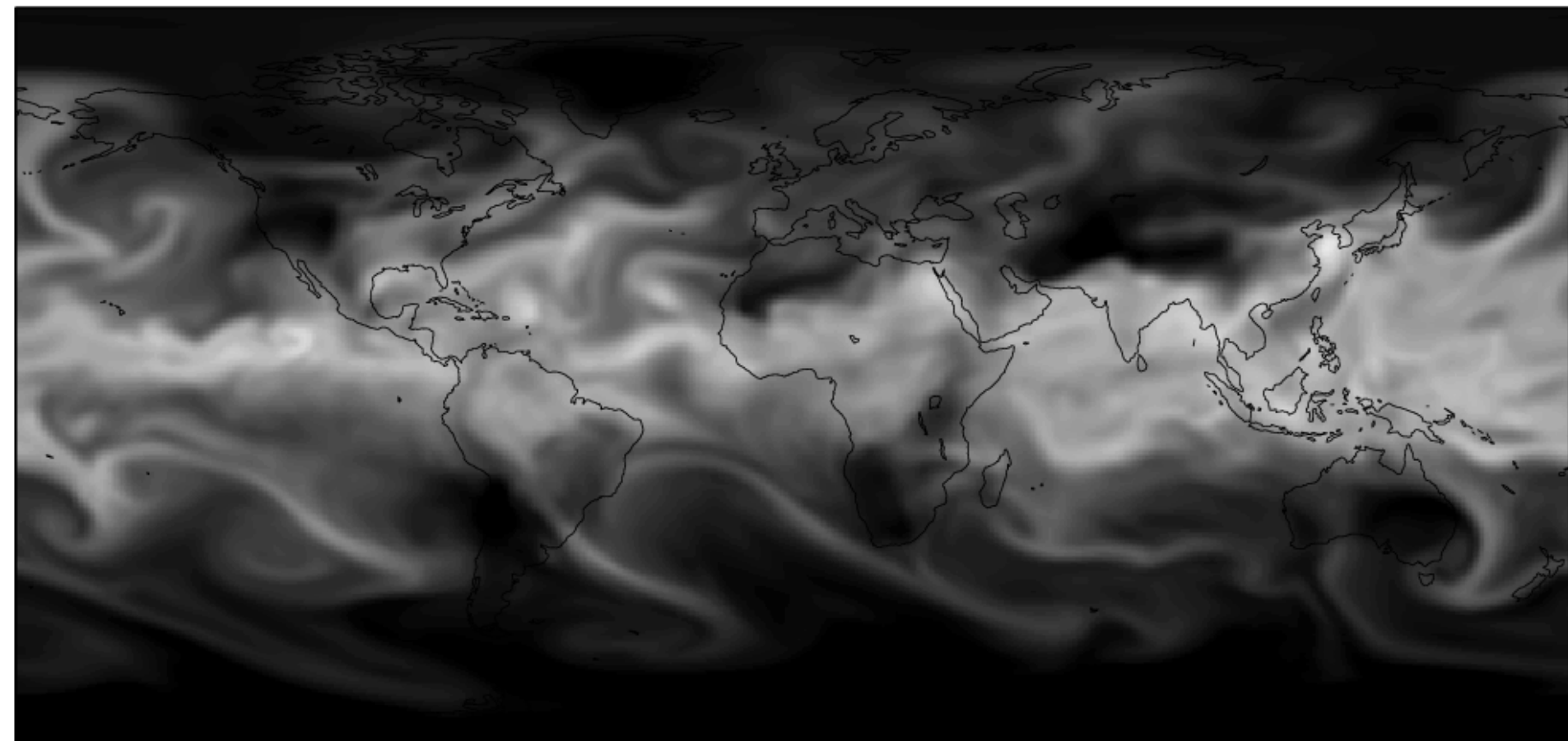
AMWG winter meeting
February 28th, 2017

Variable-resolution CAM-SE

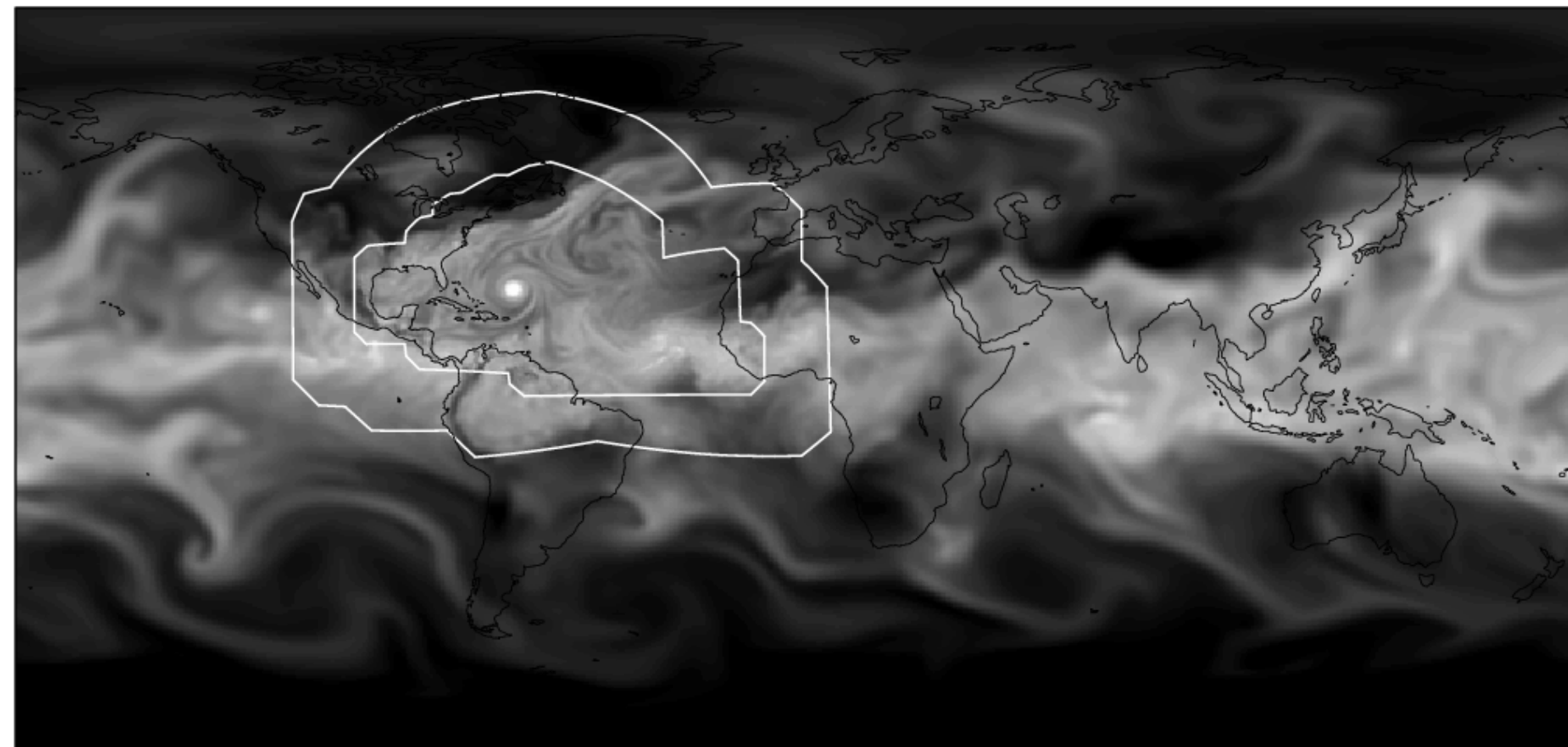
- “Regional refinement” capability of CAM-SE
- Unstructured grids only require conforming quads
- Globally-unified
 - No boundary conditions
 - Every point is covered by only one cell
- High-resolution
 - Targeted resources
 - Dycore scales ~linearly with number of elements
- “Low-hanging fruit” in push towards **unification of climate and weather** (S2S forecasting, regional climate, etc.)



Uniform global simulation

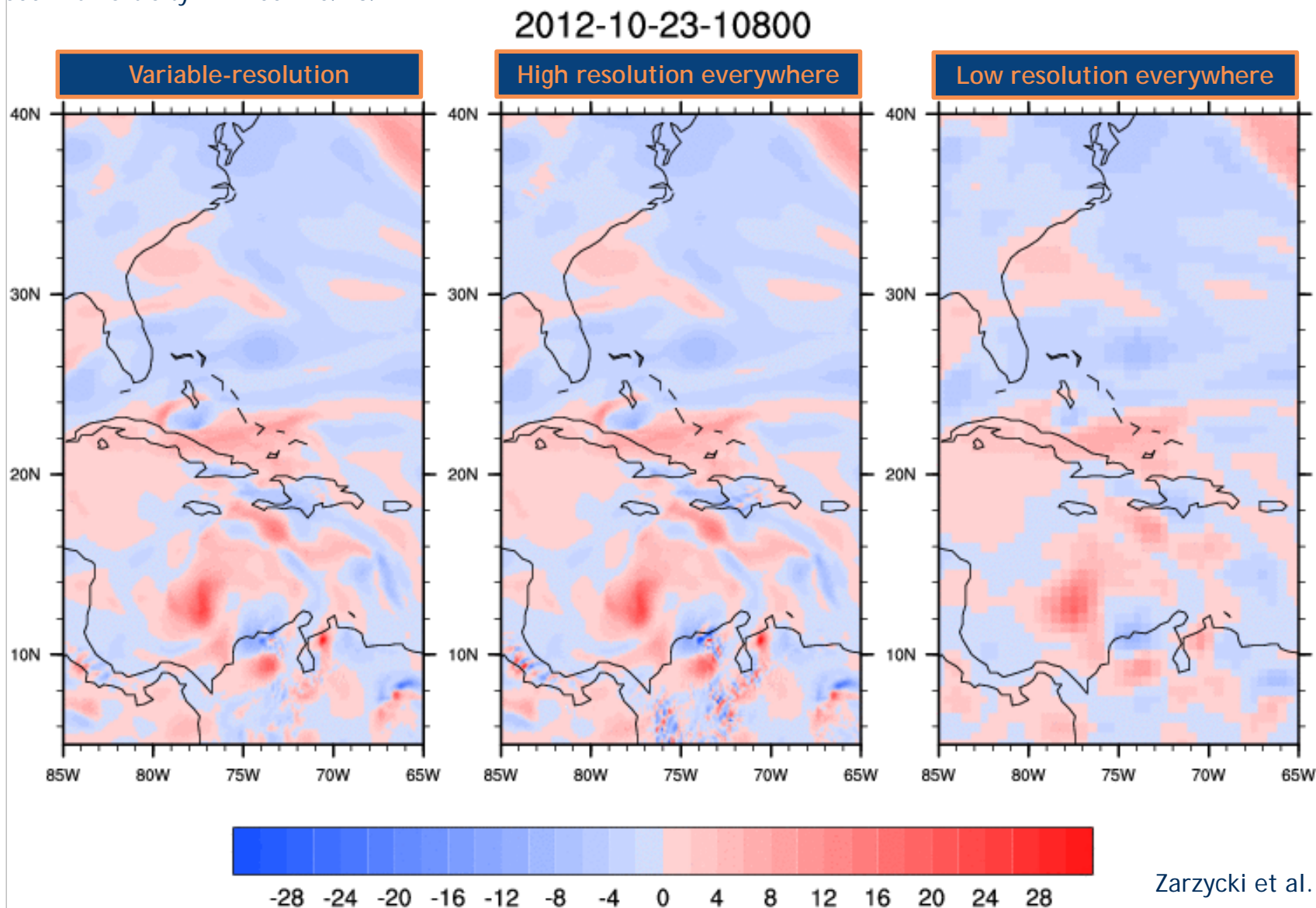


Multi-resolution global circulation



V-R: "same" solution, reduced cost

Sandy 500 hPa vorticity: INIT 00Z 10/23/12

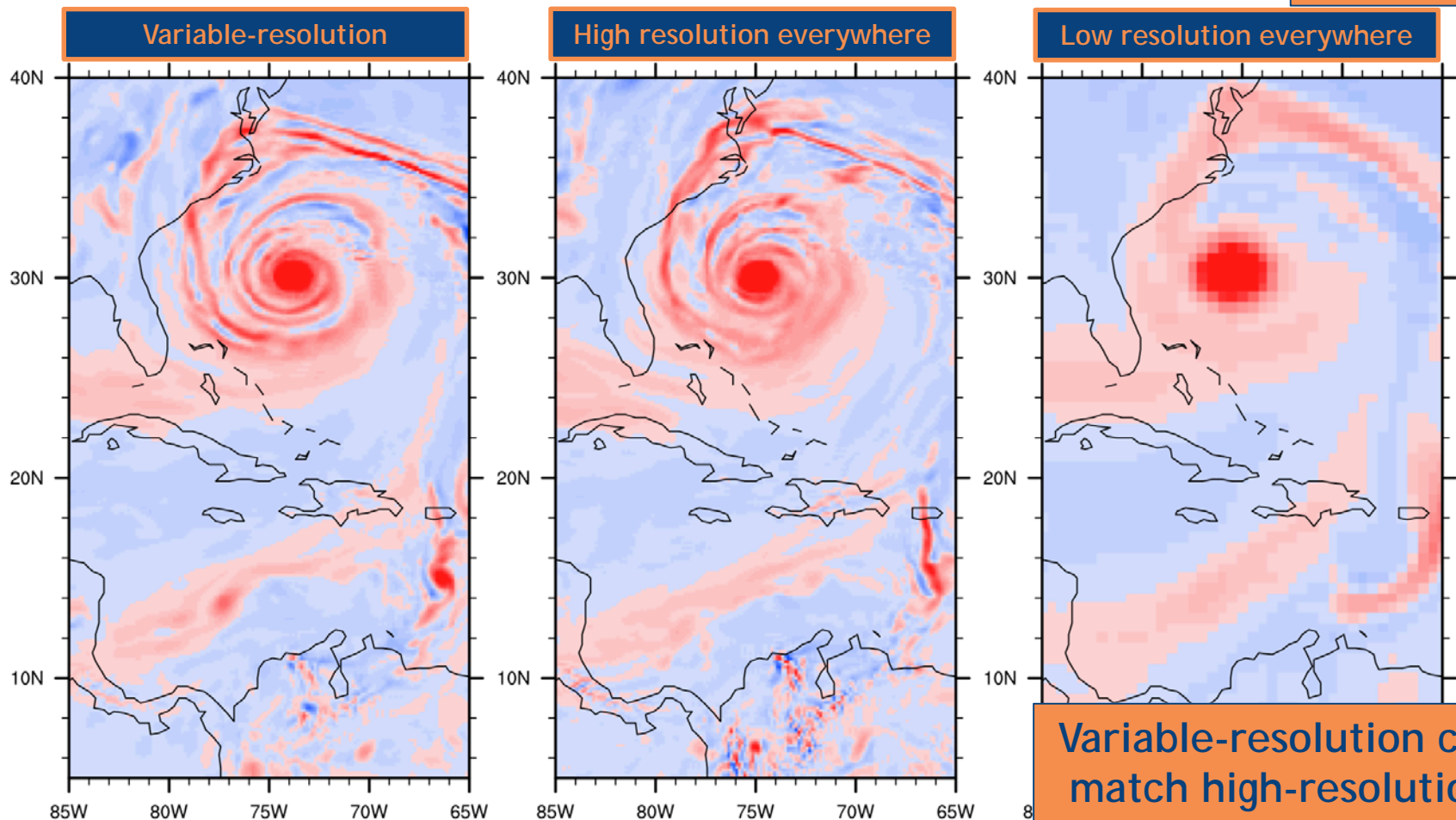


Resolution comparison

Sandy 500 hPa vorticity: INIT 00Z 10/23/12

2012-10-28-00000

+120 hours



Variable-resolution can match high-resolution dynamics -> platform for testing CESM at high-resolution

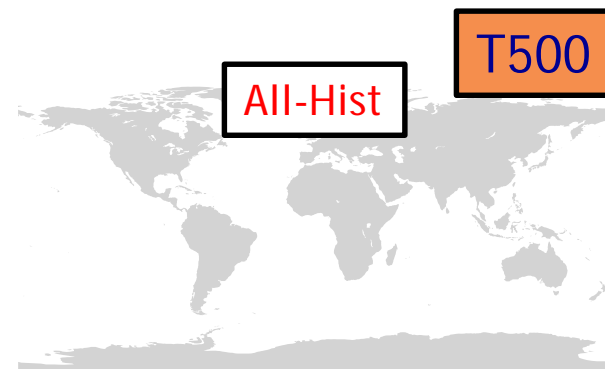
"The year in review"



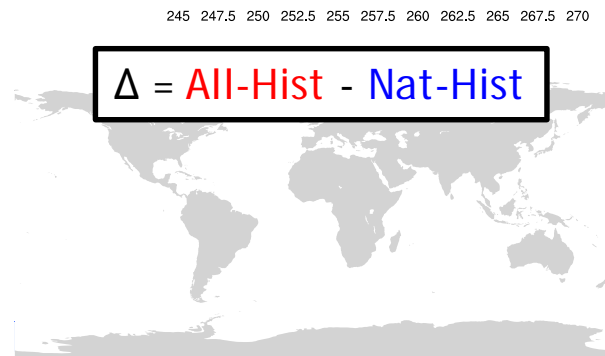
* Only a selection of results

Detection and attribution

- Detection - *demonstrating climate has changed in some defined statistical sense*
- Attribution - *establishing most likely causes for the detected change*
- C20C+ Detection and Attribution Project (led by Michael Wehner, Daithi Stone, LBNL, CASCADE)
- Two global CESM simulations
 - All-Hist (control)
 - Nat-Hist (no anthropogenic)
- Apply Δ in ATM + SSTs to observed state (*counterfactual*)
 - “If (EVENT) had occurred without human activities, would it have evolved differently?”

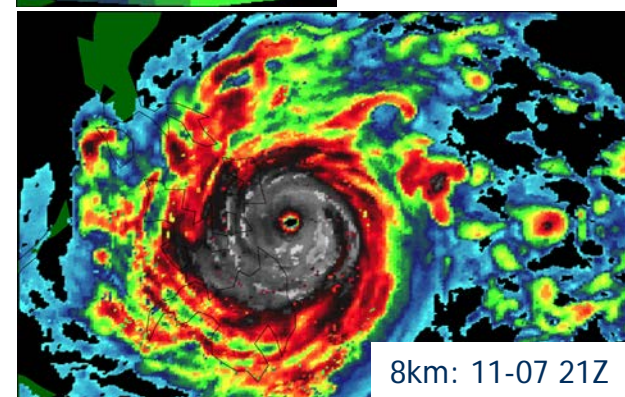
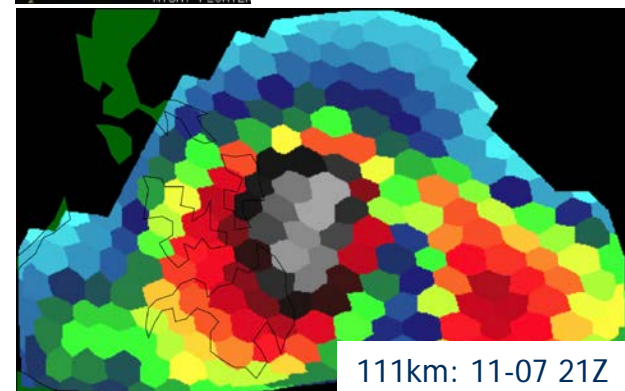
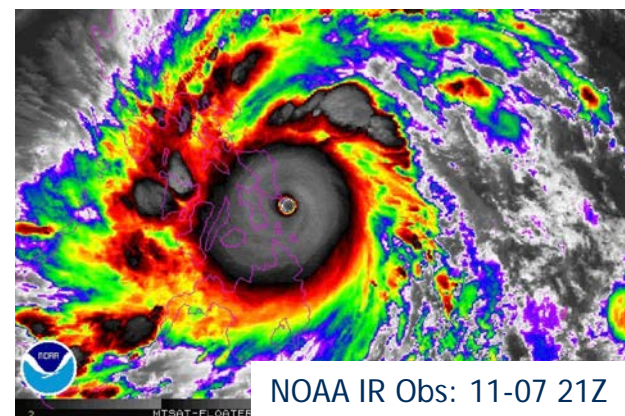
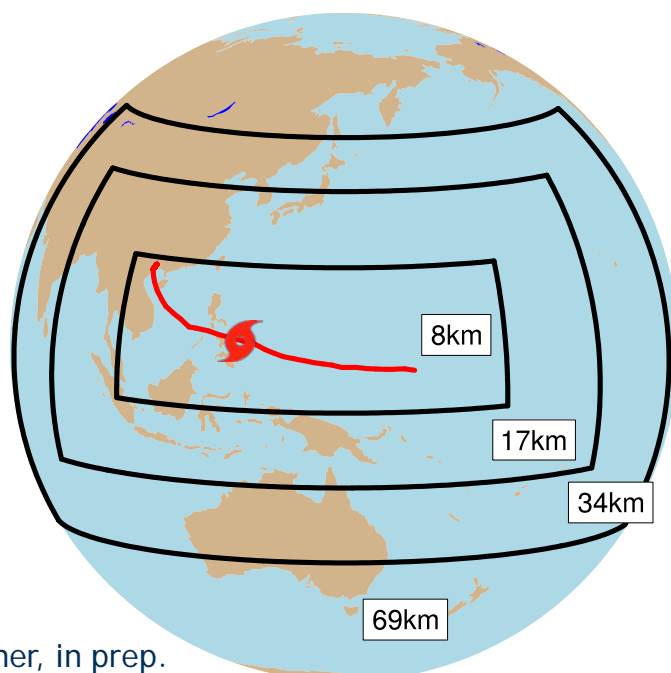


Nat-Hist



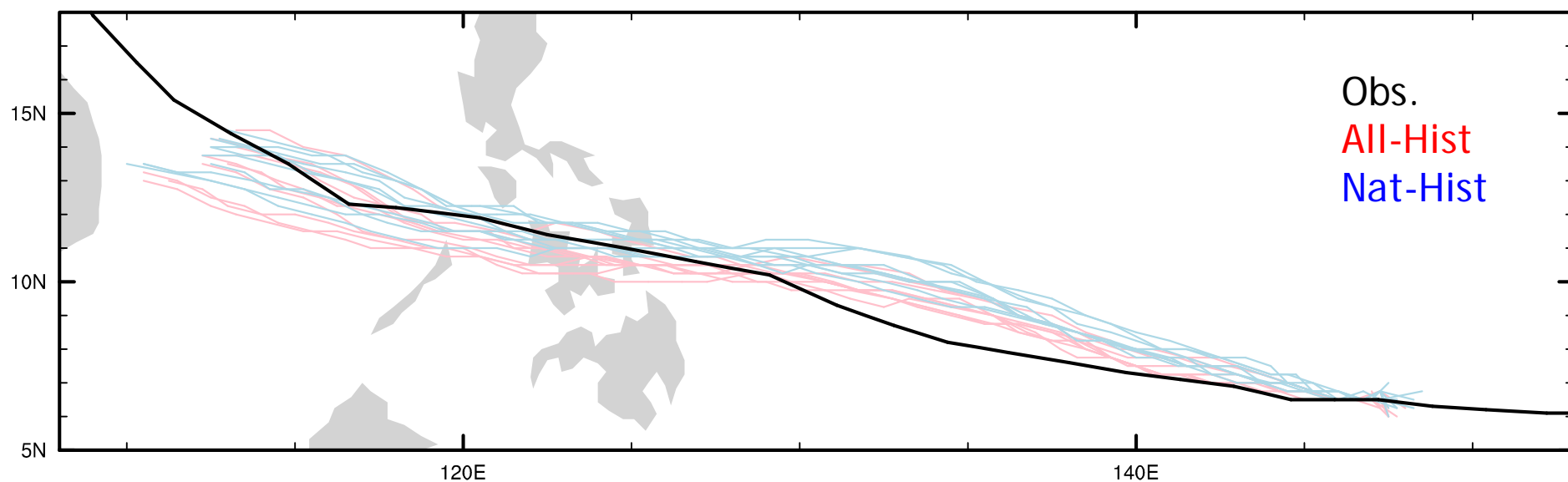
Haiyan: D&A

- Use VR-CESM in “forecast mode”
 - ATM: GFS analysis
 - OCN: NOAA OI
- Ensembles of 120 hr forecasts
- 8% cost of 8km global simulation



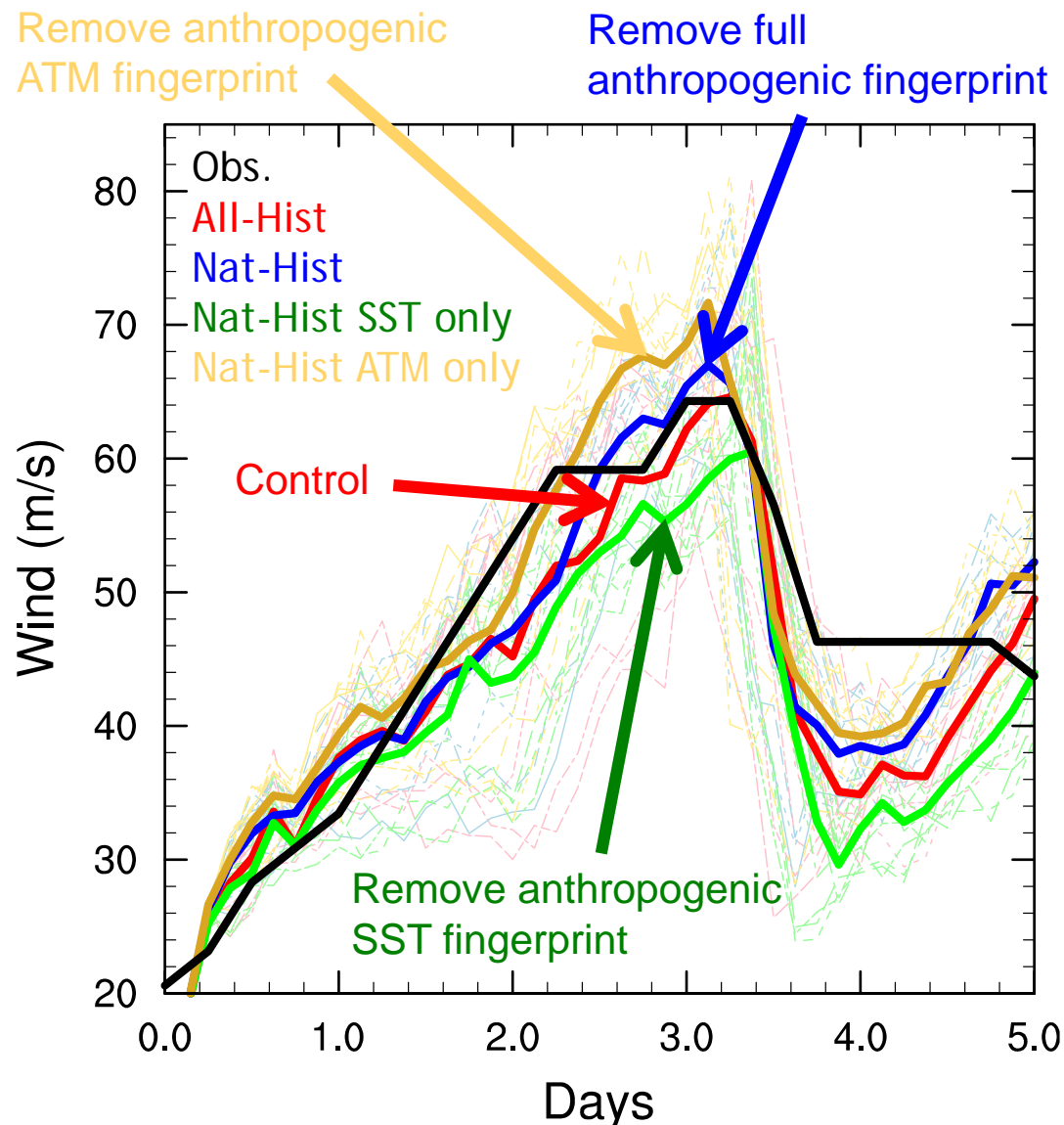
Haiyan: D&A

- Forecast pretty good!
- Little overall change in forecast track

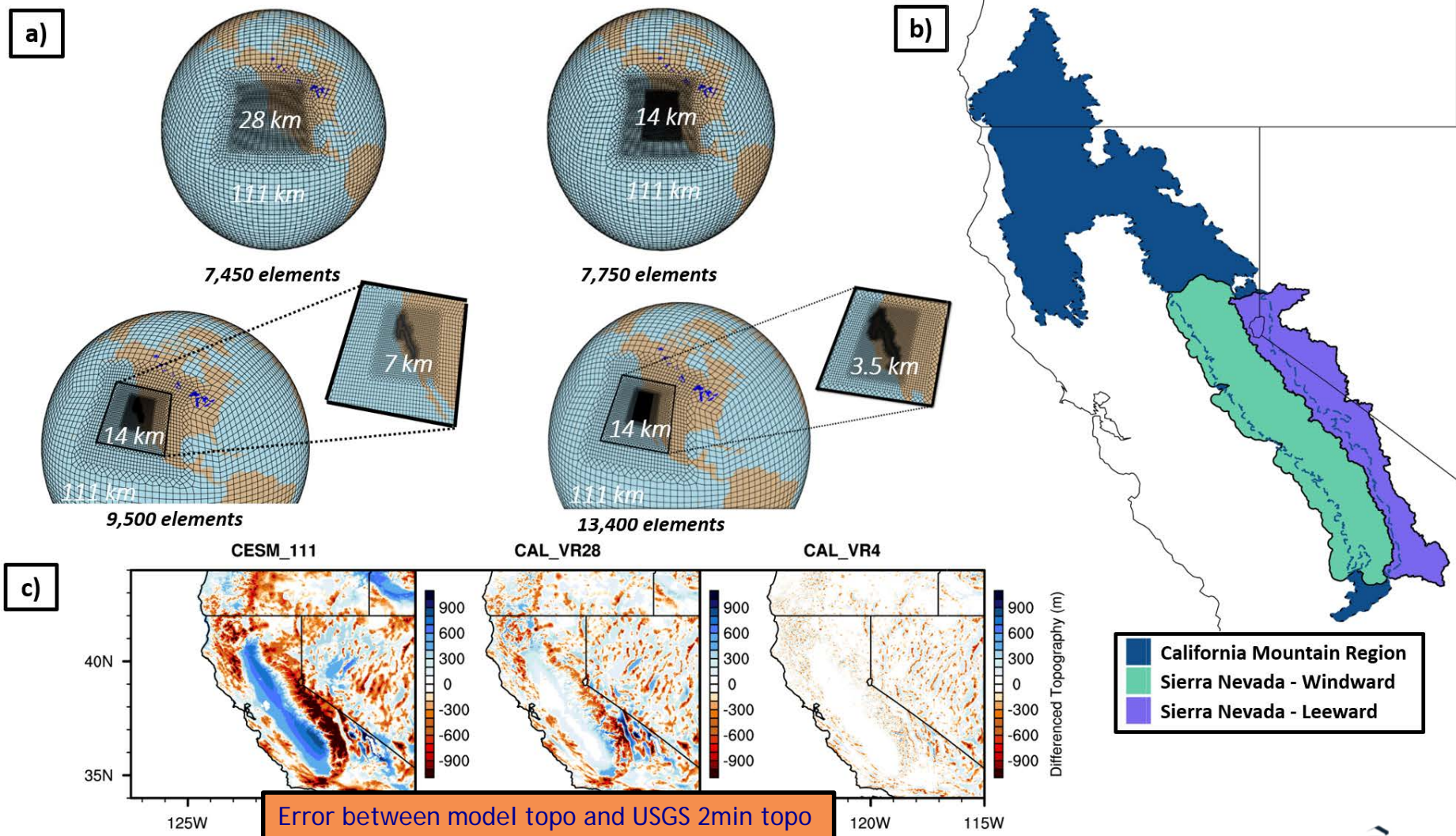


Haiyan: D&A

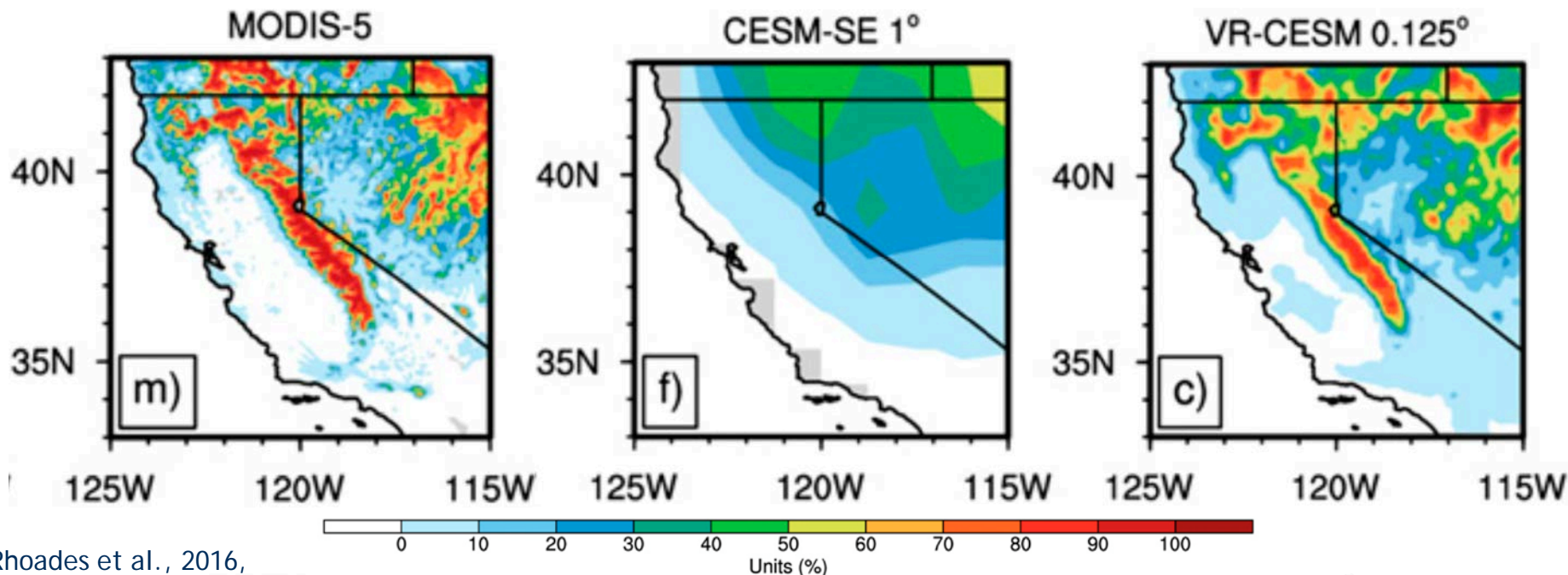
- **Single-model framework!**
- **Nat-Hist** (no anthro), produces *stronger* TC than **All-Hist** (control, present day)
- Opposite response applying **Nat-Hist SST only** and **Nat-Hist ATM only**
- Response to anthropogenic forcing may be non-intuitive
 - *Moister, warmer, atmosphere + increased SSTs leads to weaker TC!*



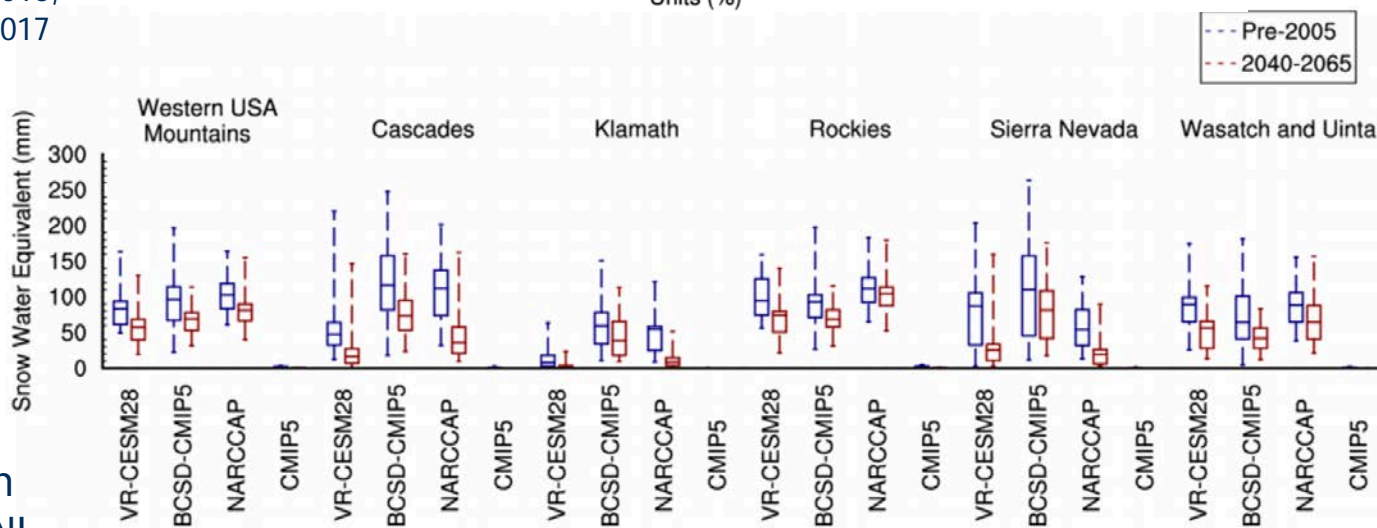
What resolution buys...



Modeling snowpack in CESM

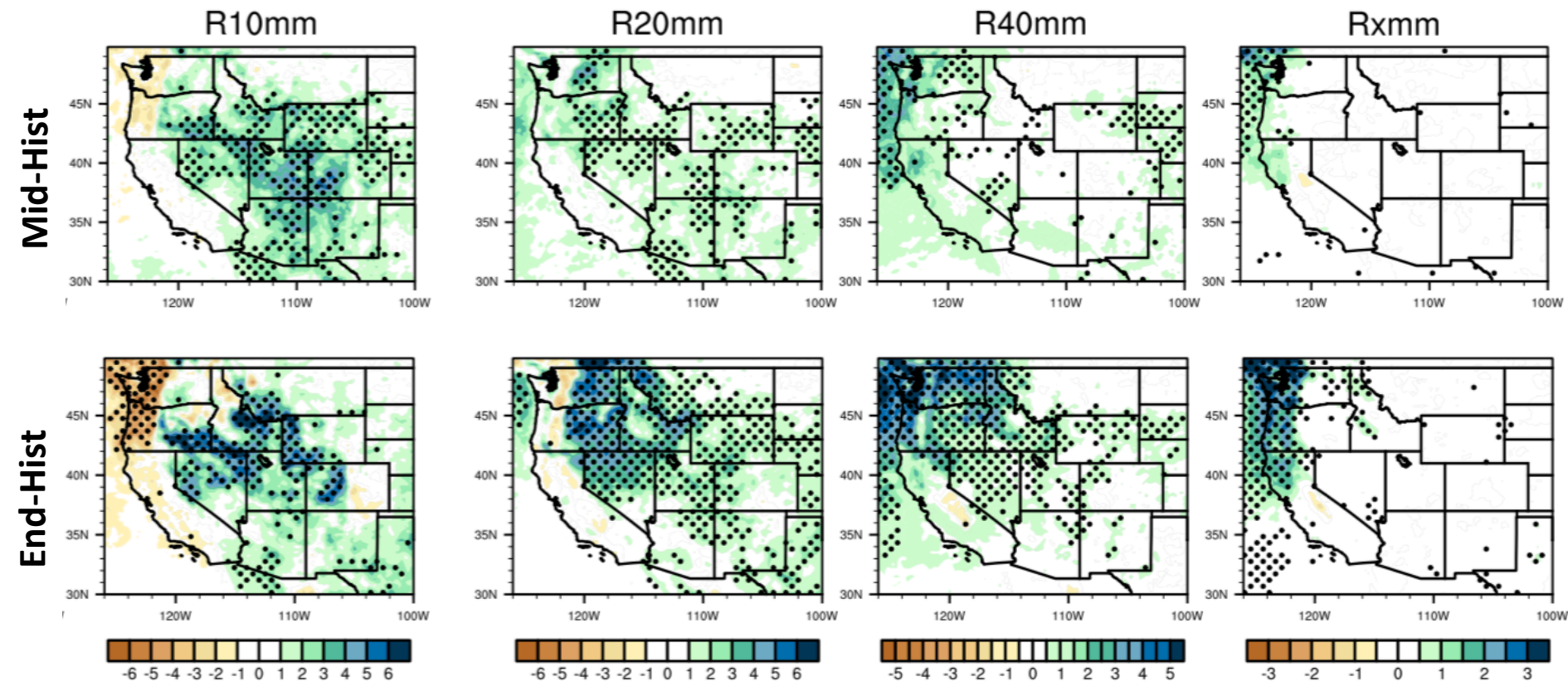


Rhoades et al., 2016,
Rhoades et al., 2017



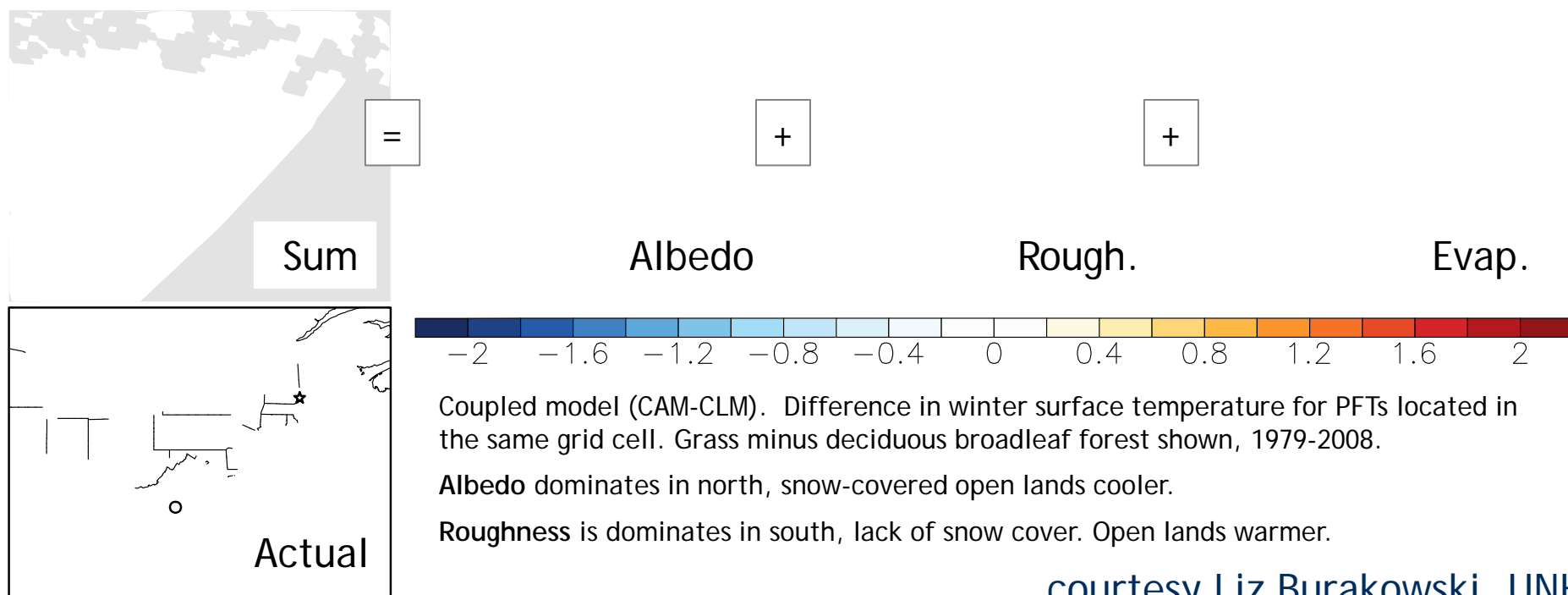
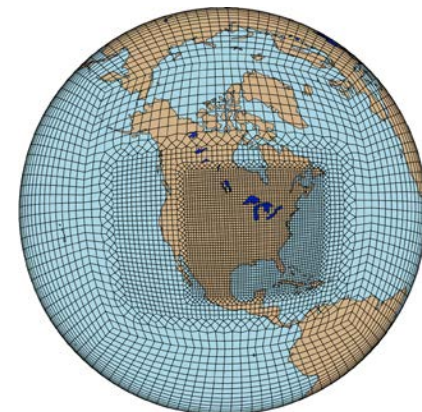
courtesy Alan
Rhoades, LBNL

Projected changes in W. USA extremes



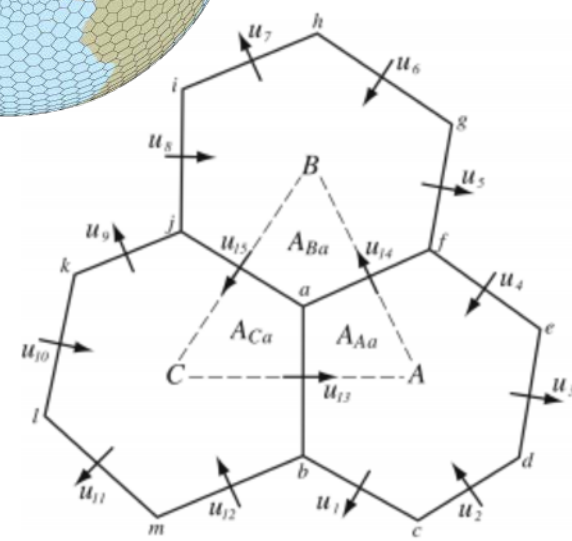
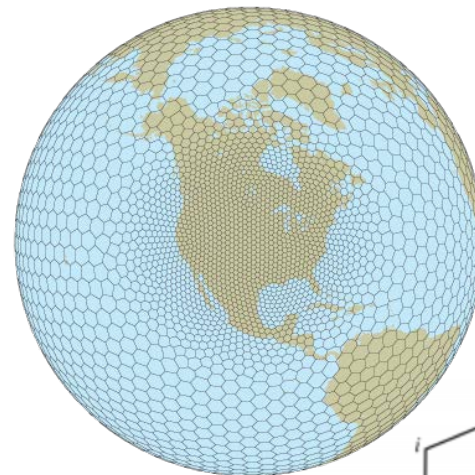
Application to other CESM components

- Because CLM column-based, can run land on same variable-resolution grid as atmosphere
- New work looking at high-resolution land surface interactions

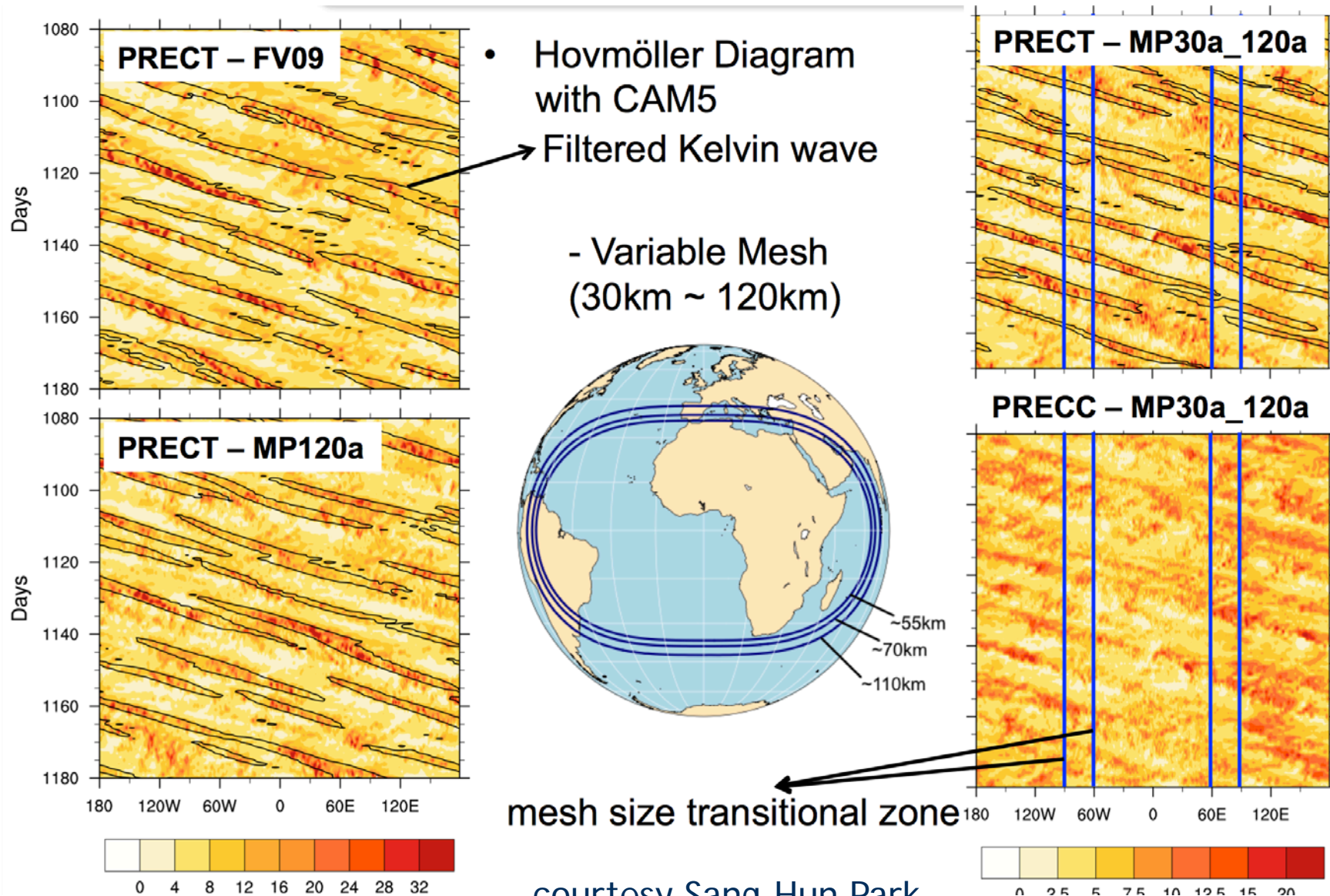


Variable-resolution MPAS

- Experimental (pre-alpha?) version of CESM-MPAS
 - Sang-Hun Park, Michael Duda, Jihyeon Jang, Bill Skamarock, others
- **Non-hydrostatic**
- CESM using MPASv4 (released 5/22/15)
- MPASv5 - performance improvements
- *Very preliminary implementation*



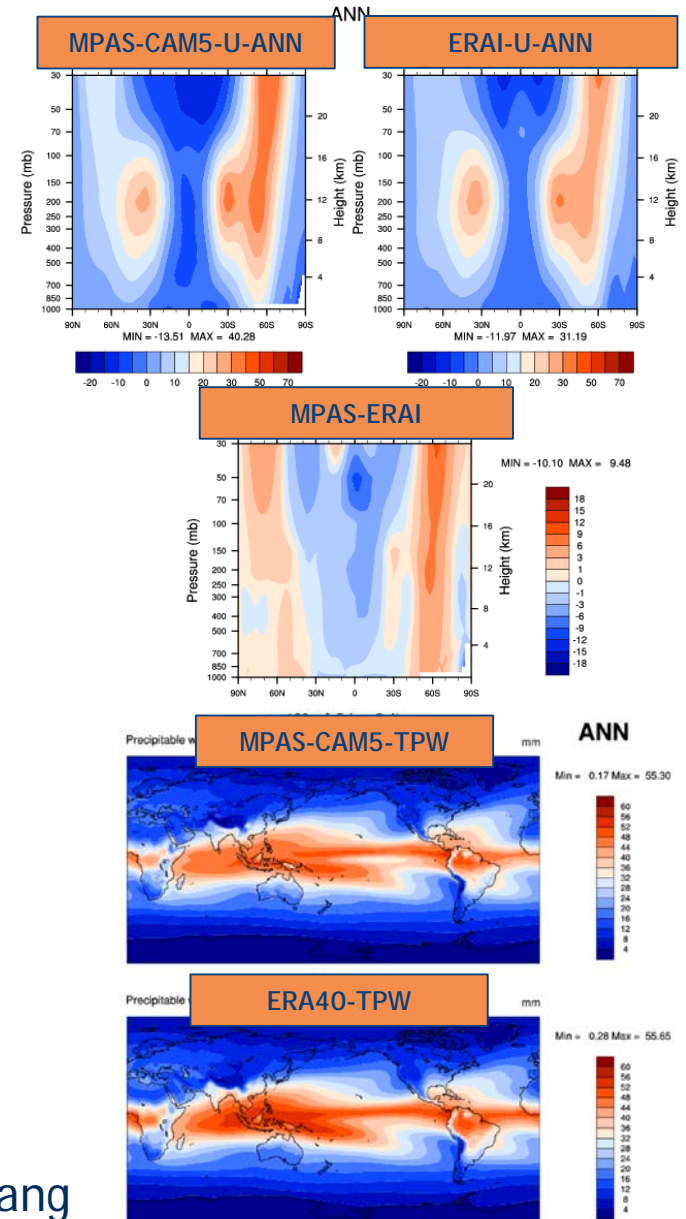
MPAS(v2.3) aquaplanet / CAM5



courtesy Sang-Hun Park

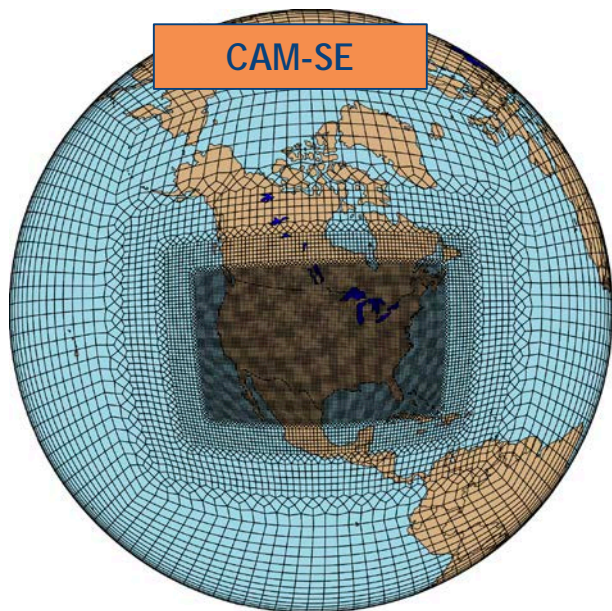
MPASv4-CAM5 climatology

- “First cut” results of MPAS 120km (1deg) look “similar” to other CAM dycores
- Ongoing challenges
 - Physics-dynamics coupling
 - Vert. coordinate: height-based hybrid terrain following
 - Sponge layer
 - Explicit diffusion



A word from our sponsors...

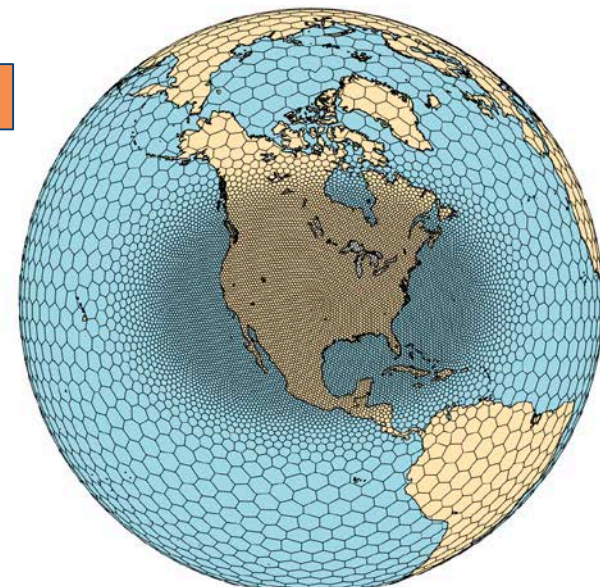
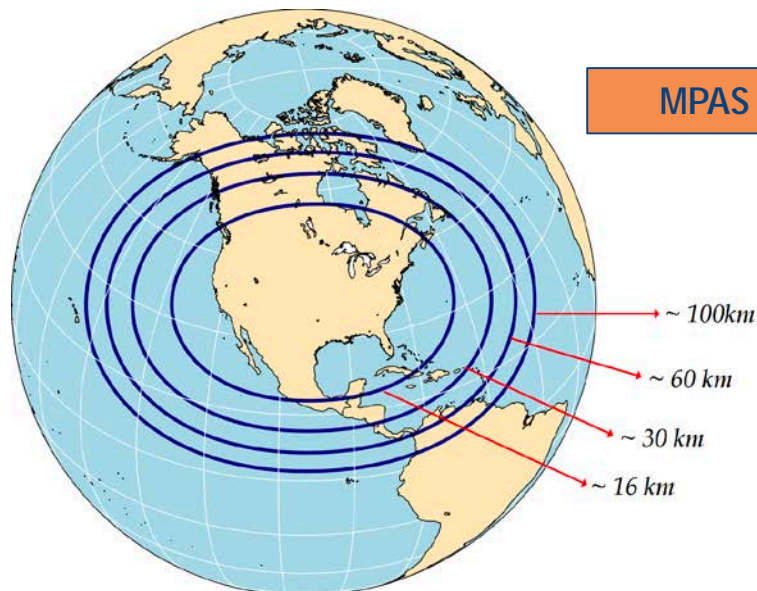
CAM-SE



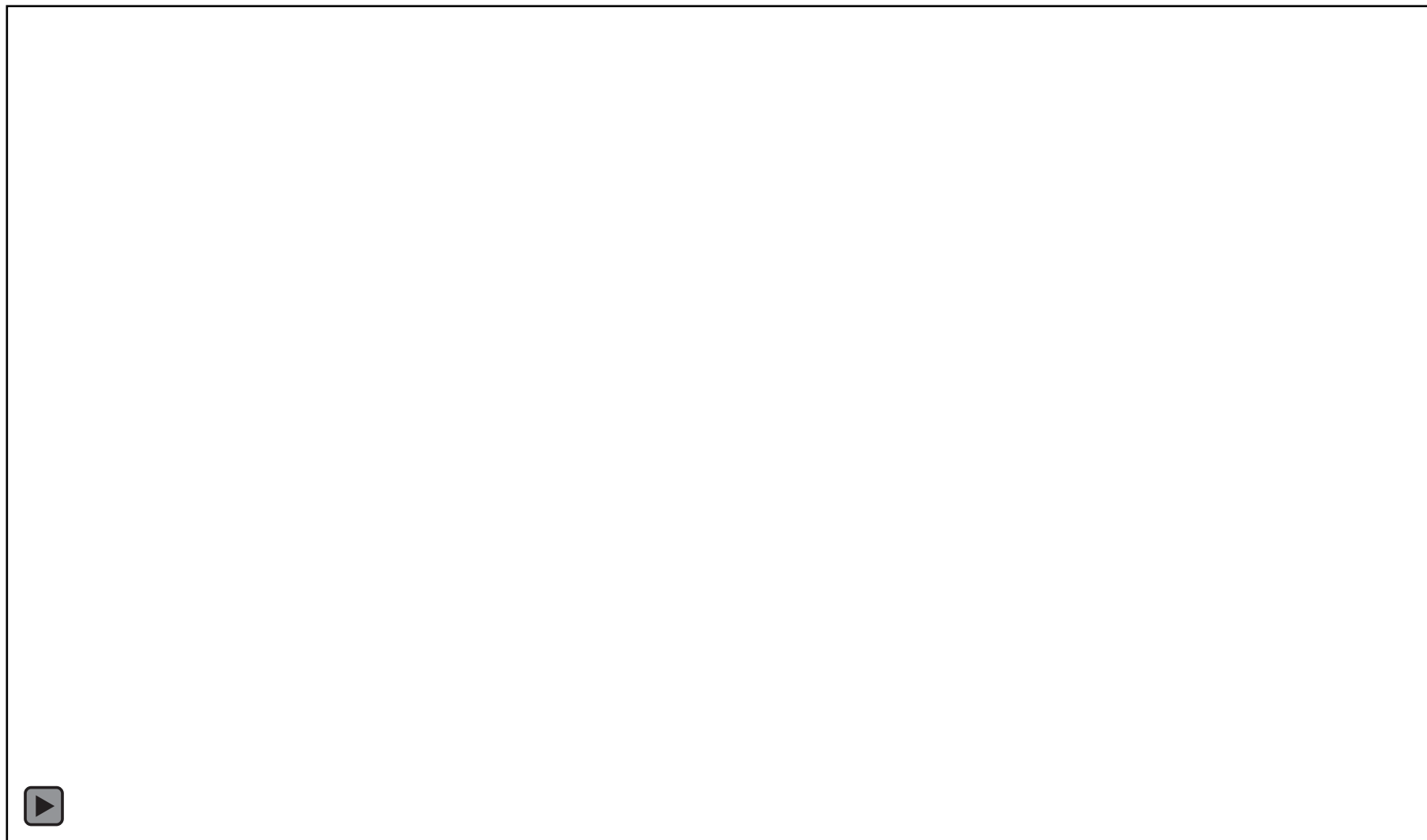
- **Advanced Scientific Discovery (Cheyenne) simulations**

- Andrew Gettelman, Colin Zarzycki, Bill Skamarock, Julio Bacmeister, Peter Lauritzen, Richard Neale, JeanFrançois Lamarque, David Lawrence
- 13.1m CPU hours
- CAM6CLM5 (~CESM2) with both MPAS and SE dycores
- 30-year simulations (1980-2010 SST forcing)
- 15km refined grid spacing over CONUS

MPAS

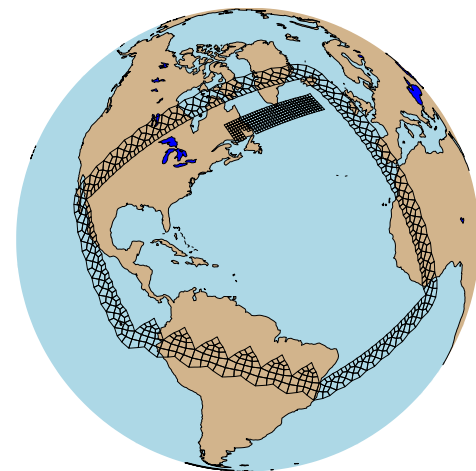
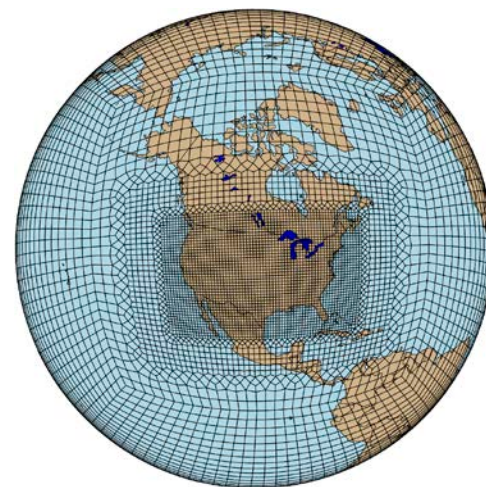


14km VR sneak peek



Near-term VR-CESM plans

- Most of req. for VR-CAM-SE on trunk
 - No more “hacking” namelist defaults (Steve Goldhaber)
- Put grids into CESM/repo, hopefully for CESM2
 - Preliminary plans to add:
 - **CONUS-refinement** (14km and 28km - ASD runs)
 - **North Atlantic refinement?** (14km and 28km)
- Turnkey support for CAM5/CAM6
 - Any options for standard “uniform” SE should be available to VR (e.g., new condensate loading - Peter Lauritzen)
 - Still some minor “tuning” needed
 - Ridgeline code (Bacmeister)
 - Tensor versus scalar hypervis
 - nu_div multiplier...



Summary



- Variable-resolution SE used increasingly for scientific application over last 12 months
 - Tropical cyclones
 - Mountain snowpack
 - Land-atmosphere interactions
 - Dycore testing
 - Parameterization development/validation
- Spectral Element (SE)
 - Ongoing 14km ASD science runs
 - Short-term plan to add handful of “supported” configurations
 - Targeted towards S2S, regional climate, model development, university researchers
- Model for Prediction Across Scales (MPAS)
 - Internal NCAR initiative to test MPAS within CESM
 - Collaboration with Ruby Leung (PNNL)
 - Preliminary results promising, ASD runs soon-to-be ongoing, more work in PD coupling

