

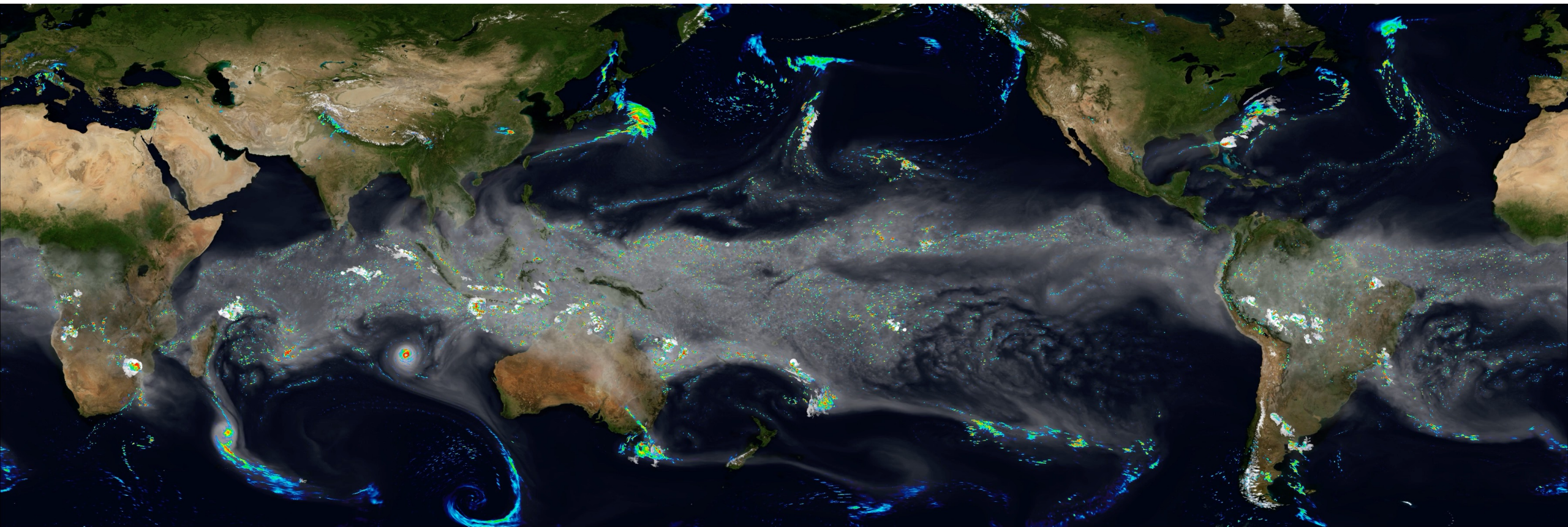
The Regionally Refined and Doubly-Periodic Configurations: Running SCREAM Without Breaking the Bank

Peter Bogenschutz¹ and significant contributions from many others...

¹Lawrence Livermore National Laboratory, Livermore, CA

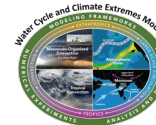
E3SM all hands, March 14th, 2024





Displayed is total precipitable water (gray) and precipitation (color) from a **40-day global simulation with 3 km resolution** using SCREAM = Simplified Convection Resolving E3SM Atmosphere Model v0 (Caldwell et al. 2021)

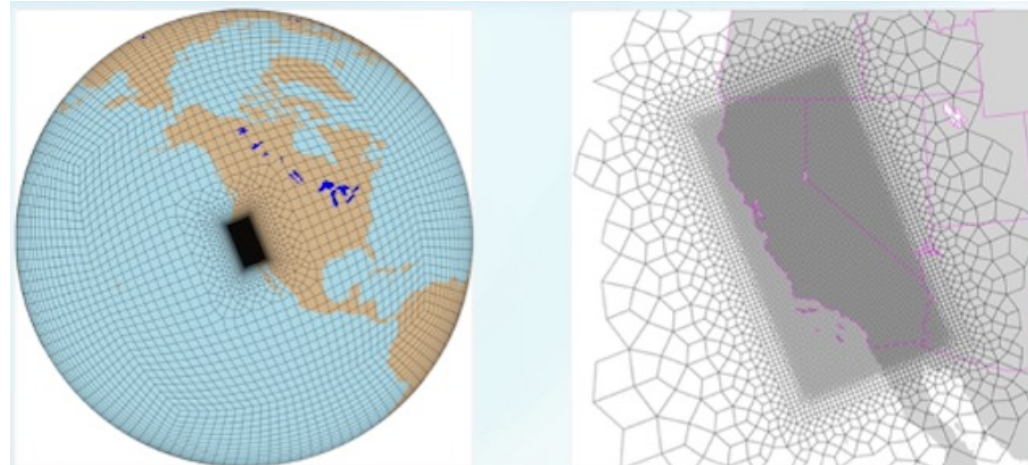
Animation created by Zhe Feng (GRL; 2023)



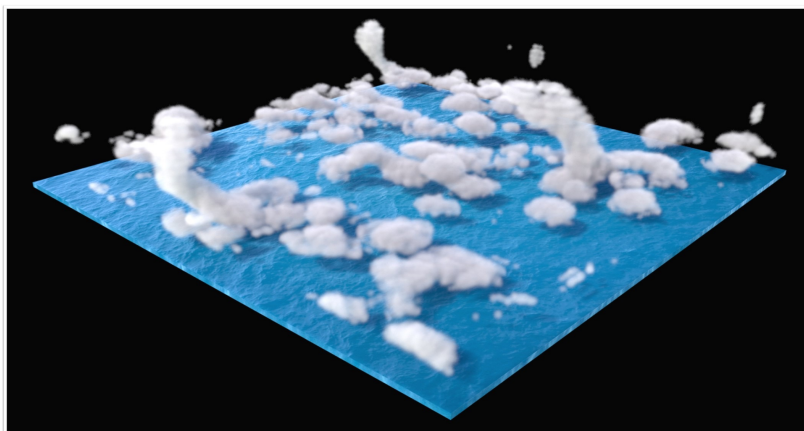
RRM vs. DP-SCREAM

- SCREAM-RRM (Liu et al. 2022; Zhang et al. 2024) is in the spirit of a “limited area model” or “regional climate model”.

SCREAM – RRM



Doubly Periodic SCREAM (DP-SCREAM)



- DP-SCREAM (Bogenschutz et al. 2023) is in the spirit of a “single-column model”.
- The two configurations are complimentary and both essential to support SCREAM development/evaluation.

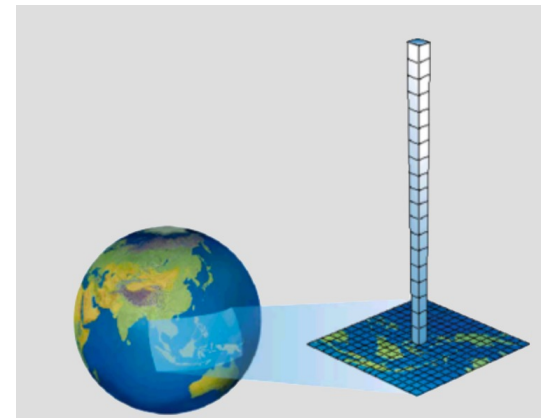
Horizontal Resolution Sensitivity of the Simple Convection-Permitting E3SM Atmosphere Model in a Doubly-Periodic Configuration JAMES; 2023

P. A. Bogenschutz✉, C. Eldred, P. M. Caldwell

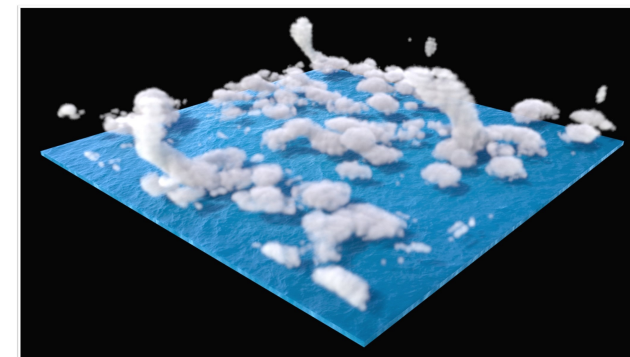
- DP-SCREAM developed to fill the need for an “**efficient configuration**” (Bogenschutz et al. 2023)
- Represents a “single-point” three-dimensional cloud resolving model.
- Support and scripts for over 30 cases provided.
- Trivial to change domain size and resolution (via namelist).
- Cost of one simulated day:
 - DP-SCREAMv0: **4 minutes on 6 nodes***
 - SCREAMv0: **5 hours on 1536 nodes**

DP-SCREAMv1 now
in initial testing!

E3SM SCM view



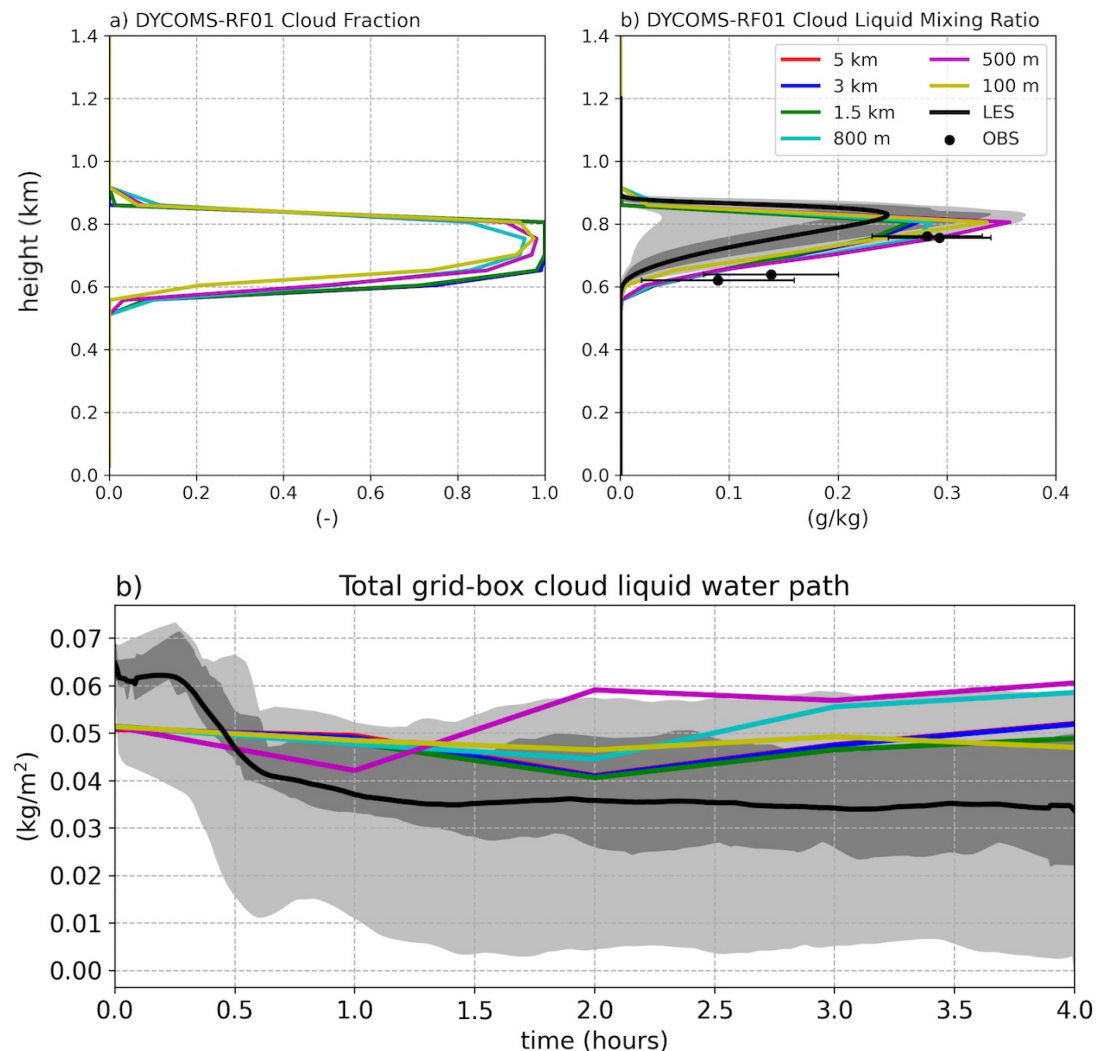
DP-SCREAM view



*DP-SCREAM cost assumes a 200 km x 200 km domain; all timings from retired Cori-KNL

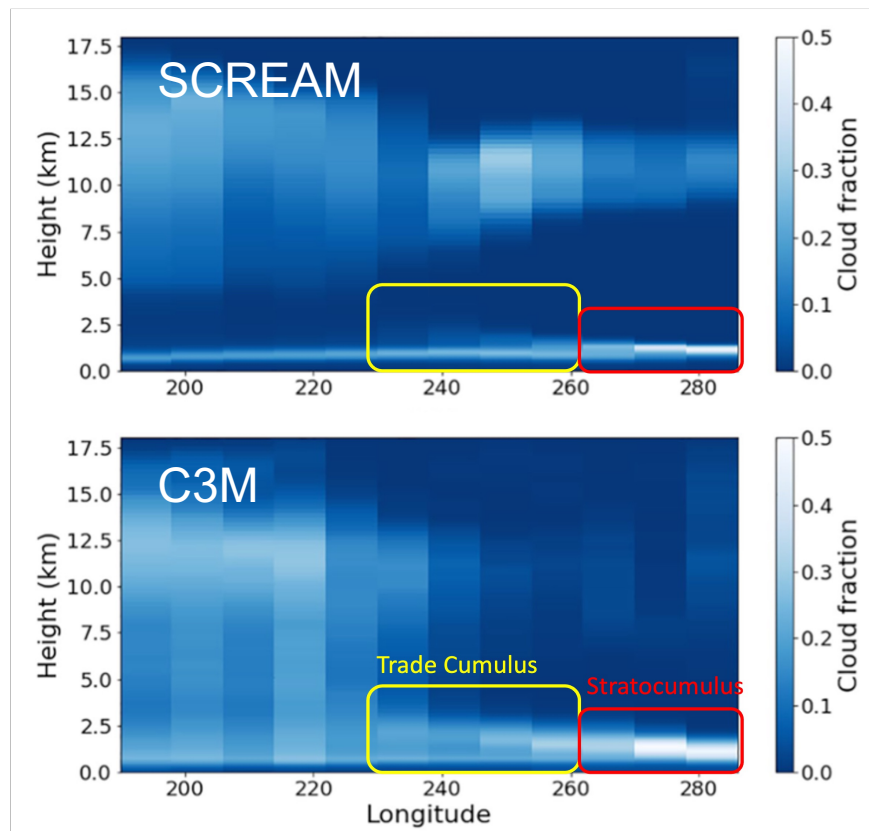
Studying Resolution Sensitivity

- DYCOMS-RF01 marine stratocumulus case.
- Where available LES (Stevens et al. 2005) results plotted:
 - LES mean (solid black line)
 - LES spread (light shading)
 - LES spread, central half (dark shading)
- SCREAM is relatively **scale insensitive** for this case, exhibiting less spread than LES members.
- SCREAM simulations are in good agreement with observations.



Bogenschutz et al. (2023; JAMES)

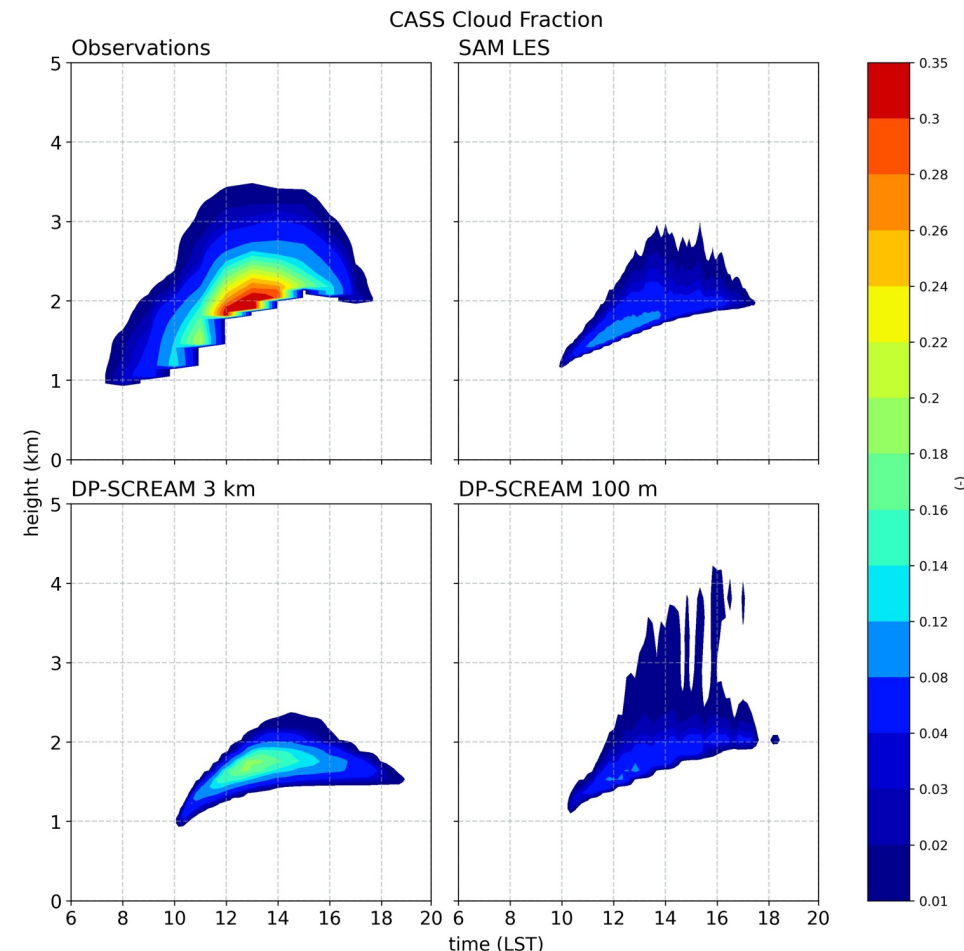
Replicating Global Biases



- SCREAM struggles to simulate shallow cumulus.
- Clouds are too shallow in depth and resemble stratocumulus.
- DP-SCREAM can well replicate this problem.

Cloud fraction along 20°S transect across Sc to deep Cu transition (Caldwell et al. 2021).

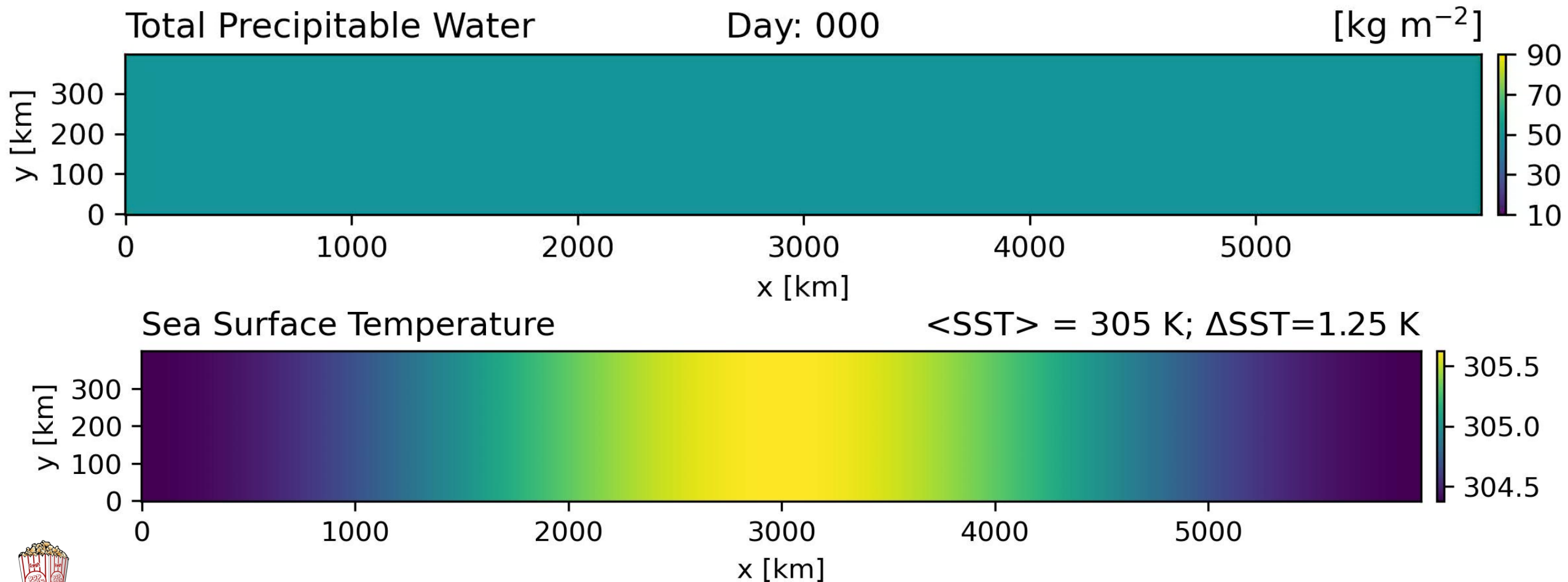
Shallow convection over ARM Southern Great Plains (SGP; Zhang et al. 2017)



Bogenschutz et al.
(2024; in prep)



Contributing DP-SCREAM to RCEMIP2 (Wing et al. 2024) – Mock Walker

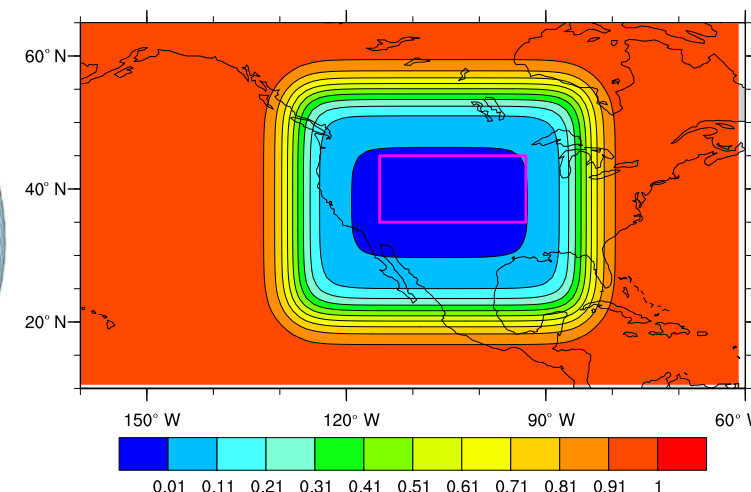
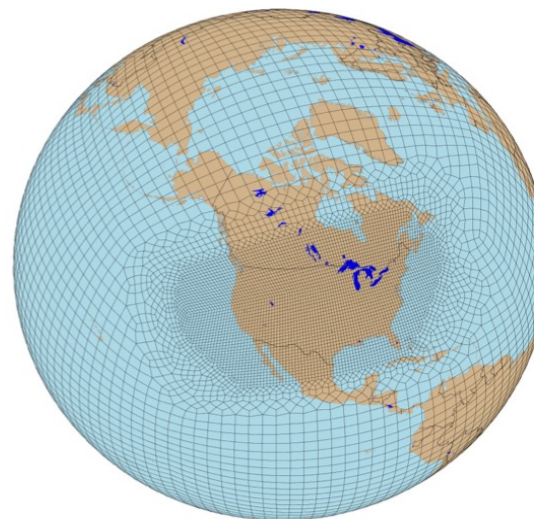


Replicating the “popcorn problem”

SCREAM Regionally Refined Mesh (RRM)

- Functionality inherited from E3SM (Tang et al. 2019; 2023).
- Cost of RRM is proportional to the size of the refined mesh.
- All results shown today from SCREAMv0-RRM
 - RRM is now functional in SCREAMv1!

Example of using **E3SM RRM** capability to refine area of interest to **25 km**, with the remainder of the globe at **100 km** (left) and option to apply nudging weights (right).



Tang et al. (2019)

Running E3SM on New Atmosphere Grids



Owned by Ben Hillman








Last updated: Jun 08, 2023 by [Walter Hannah](#) • 24 min read • 154 people viewed • Attachments

The purpose of this page is to document the procedure for adding support for new atmosphere grids. This includes regionally-refined meshes, although some settings will need to be changed for new regionally-refined meshes. The process is refined and (eventually) made more automated. This documentation is an update of a document

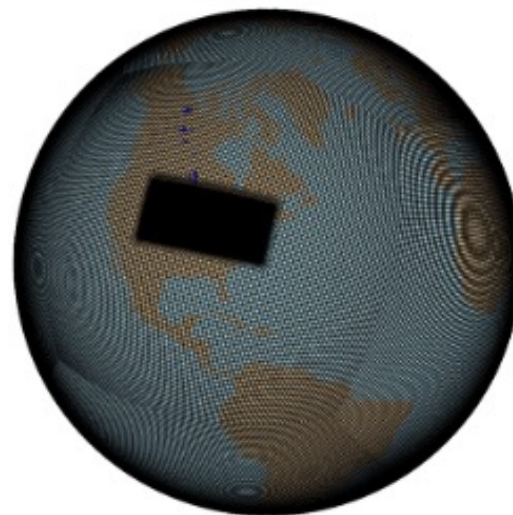
Resource page to make
new grids

The June 2012 North American Derecho: A Testbed for Evaluating Regional and Global Climate Modeling Systems at Cloud-Resolving Scales

JAMES 2022

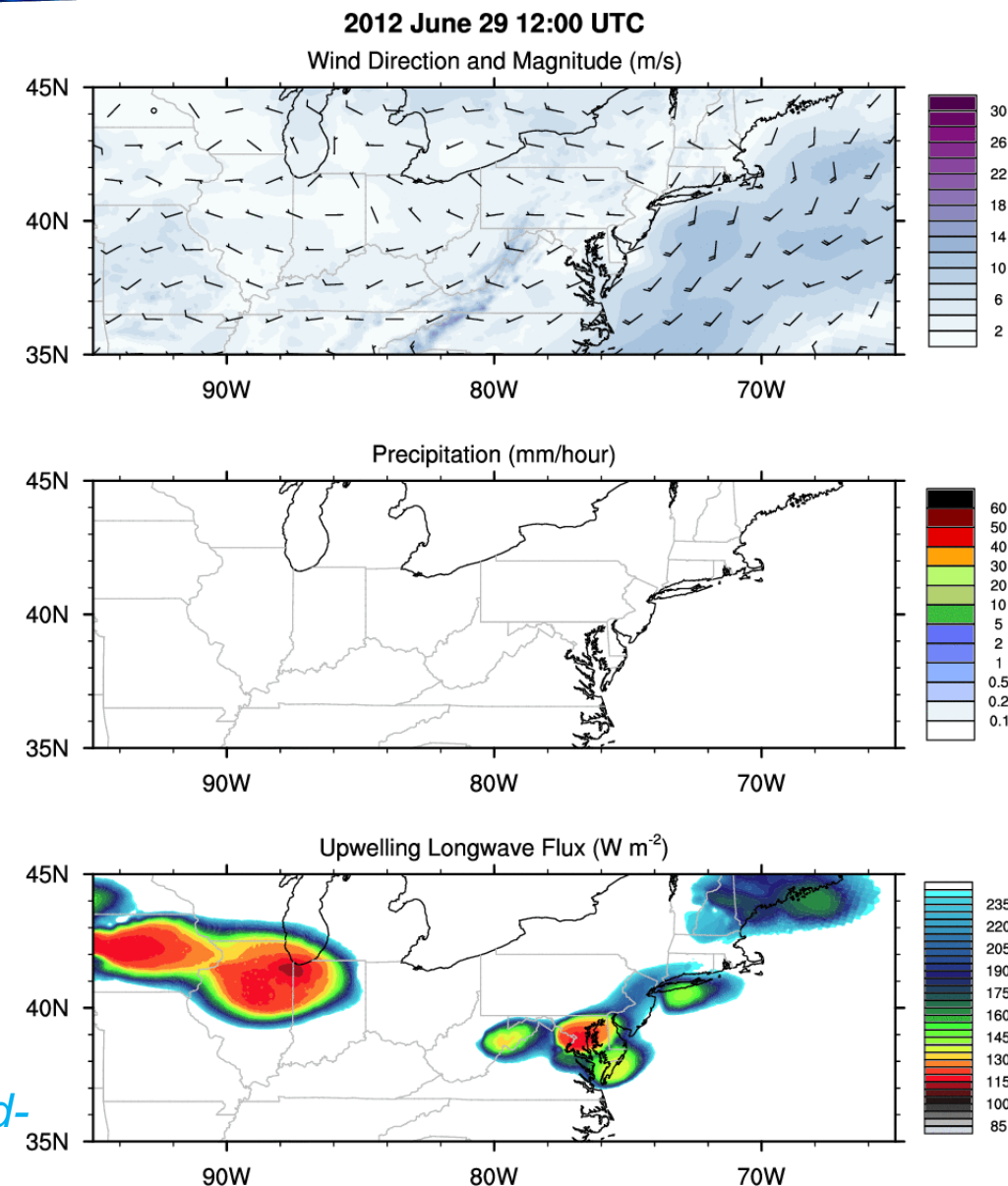
W. Liu¹ , P. A. Ullrich¹ , J. Li² , C. Zarzycki³ , P. M. Caldwell⁴ , L. R. Leung² , and Y. Qian² 

- Liu et al. (2022) pioneered the utilization of SCREAM RRM.
- Simulated the 2012 North American Derecho.
- SCREAM simulations done at 6.5, 3.25, and 1.6 km refined resolutions.



3 km refined mesh; 25 km outer mesh

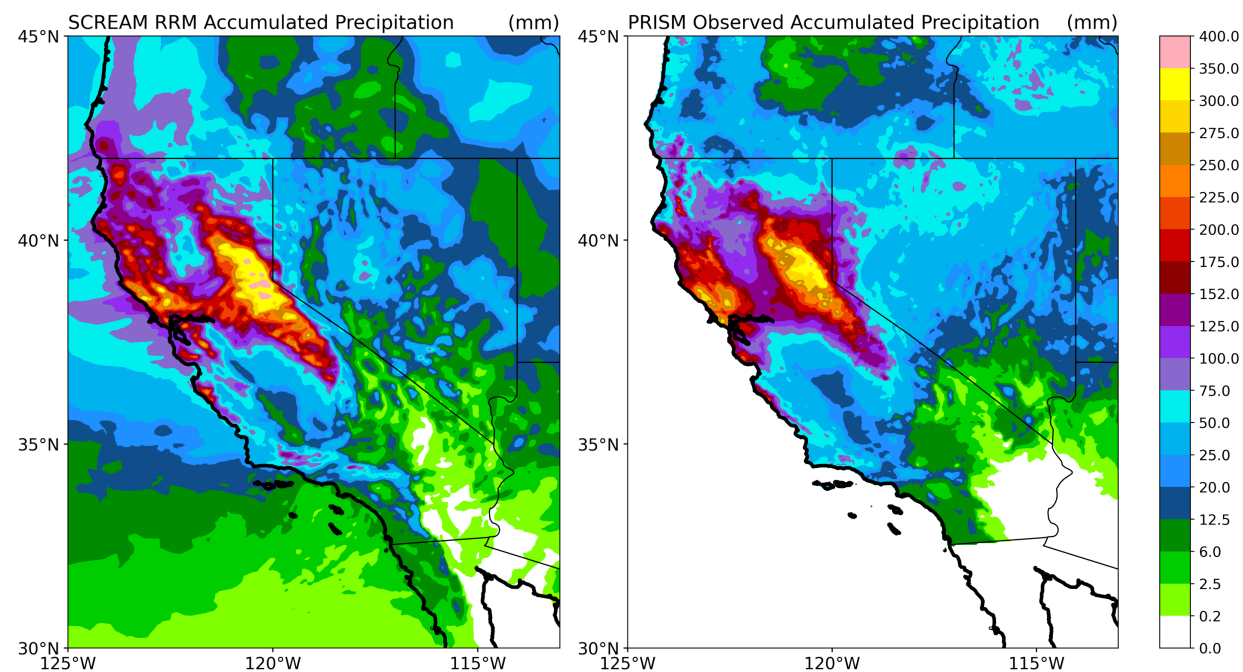
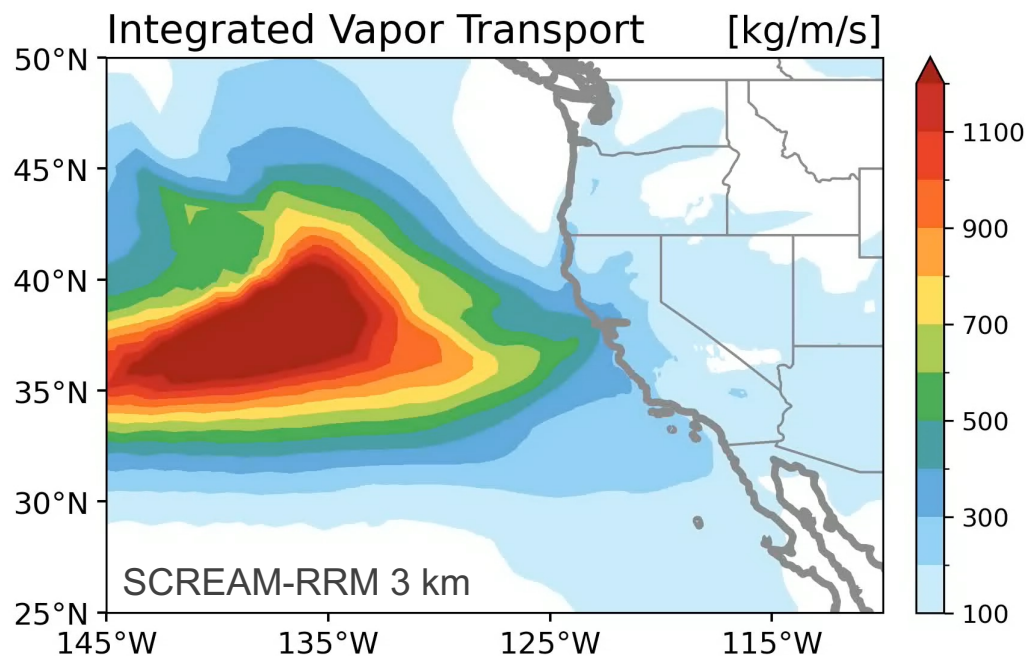
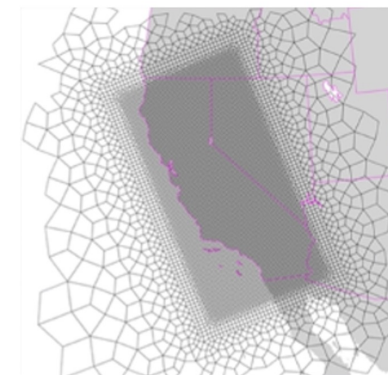
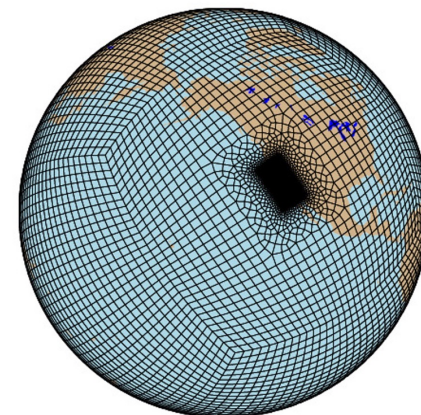
Animation: June 29th 2012 derecho over the Midwest/Mid-Atlantic US as simulated by SCREAM at 3 km



Atmospheric River Hindcasts

- Bogenschutz et al. (2024; in prep.) simulated four atmospheric river events over CA initialized by ERA5.
- Displayed here is a category 5 AR from October 2021.
- Various refined mesh sizes and resolutions (800 m to 3.25 km) tested.

CA-3km: ne32 -> ne1024

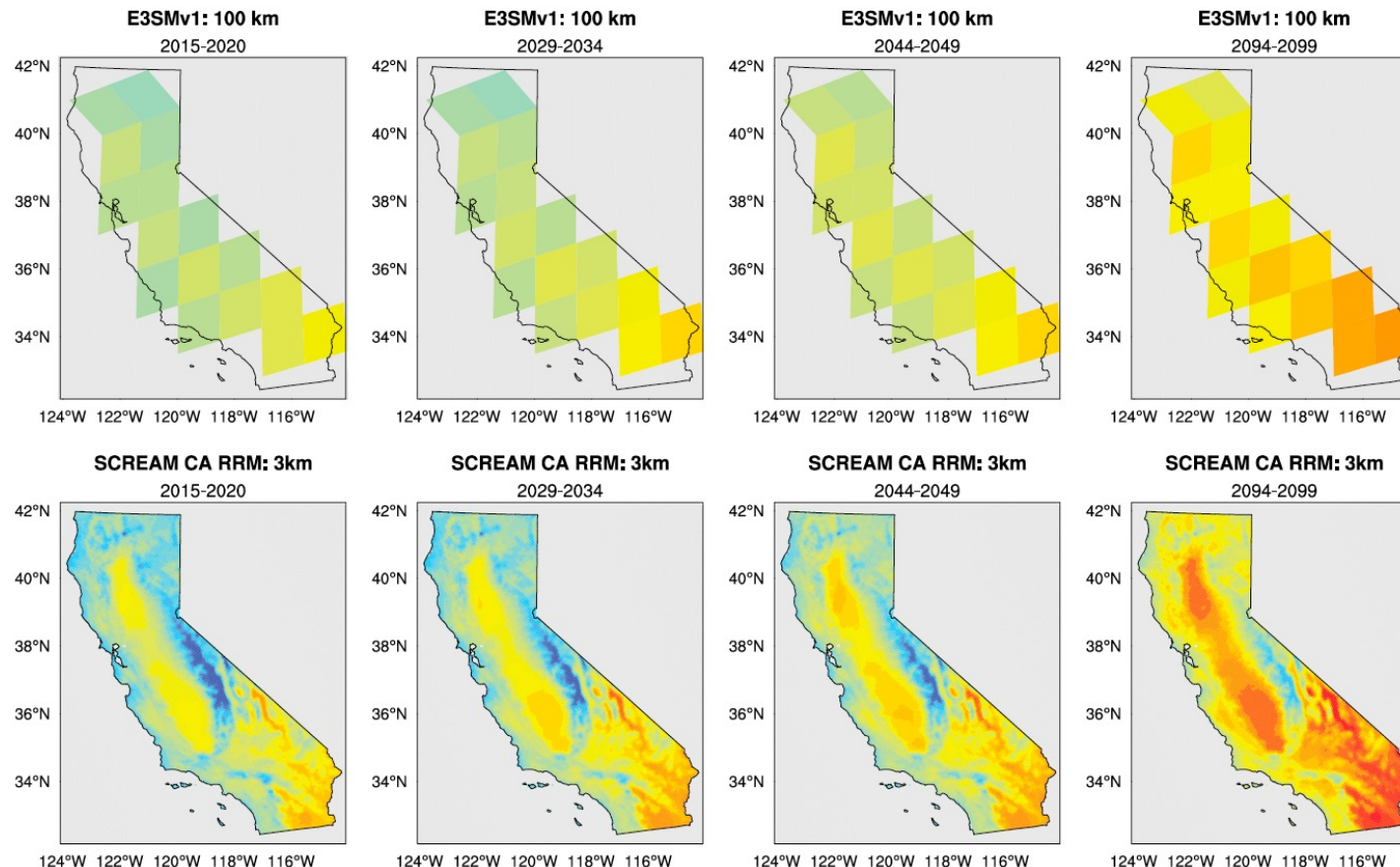


Leveraging Regional Mesh Refinement to Simulate Future Climate Projections for California Using the Simplified Convection Permitting E3SM Atmosphere Model Version 0

Jishi Zhang, Peter Bogenschütz, Qi Tang, Philip Cameron-Smith, and Chengzhu Zhang

- An example of using SCREAM RRM as a high-res regional climate model.
- In this example the coarse 100 km domain is forced from E3SMv1 simulation (Zheng et al. 2021).
 - High-res region free-running.
 - SSP-585 scenario.
- Four five-year segments simulated.
- SCREAM can well represent the numerous microclimates of CA.

GMD; 2024 (preprints)



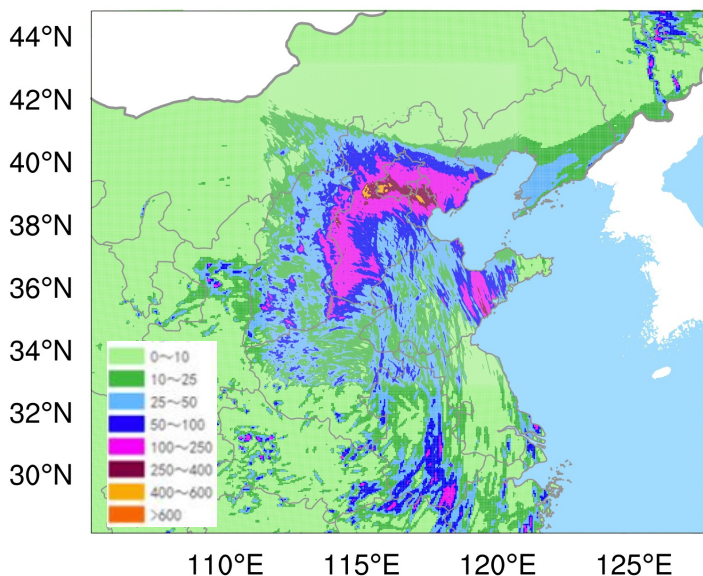
Average Daily Maximum Reference Height Temperature, degC (JJA)

12 13.5 15 16.5 18 19.5 21 22.5 24 25.5 27 28.5 30 31.5 33 34.5 36 37.5 39 40.5 42 43.5 45 46.5 48

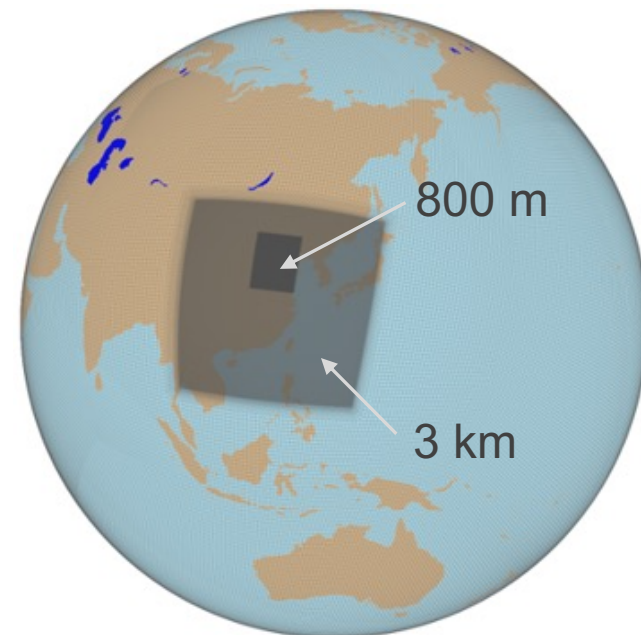
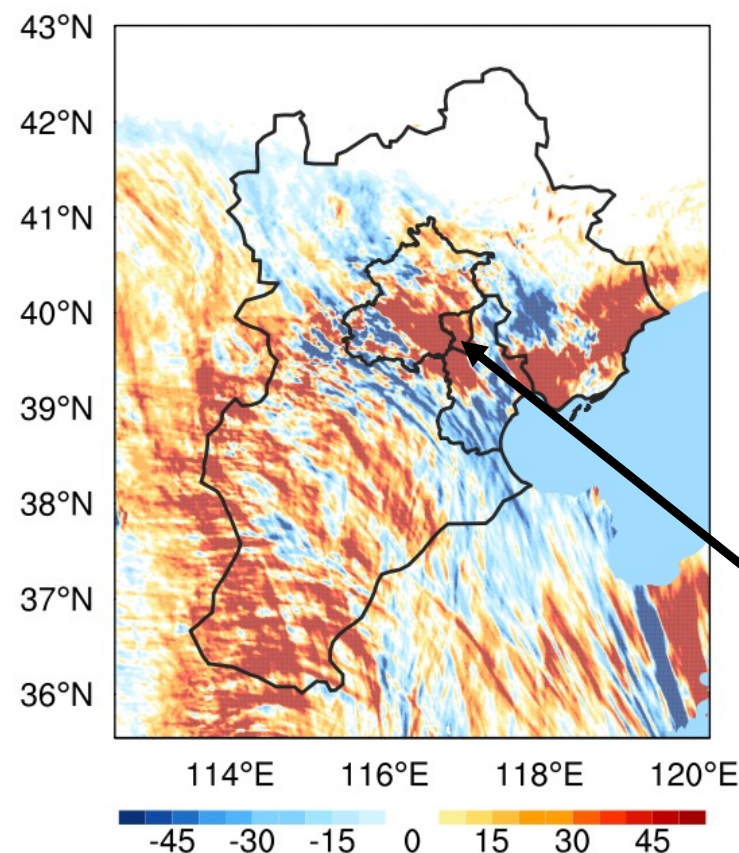
Beijing Flood – “Storyline” Simulation Example

- Zhang et al. (2024; in prep) simulated the 2023 flood.
- Re-ran it for future conditions by increasing temperature and greenhouse gases by amount expected for a given time in the future.

SCREAM 800 m Accumulated Rainfall

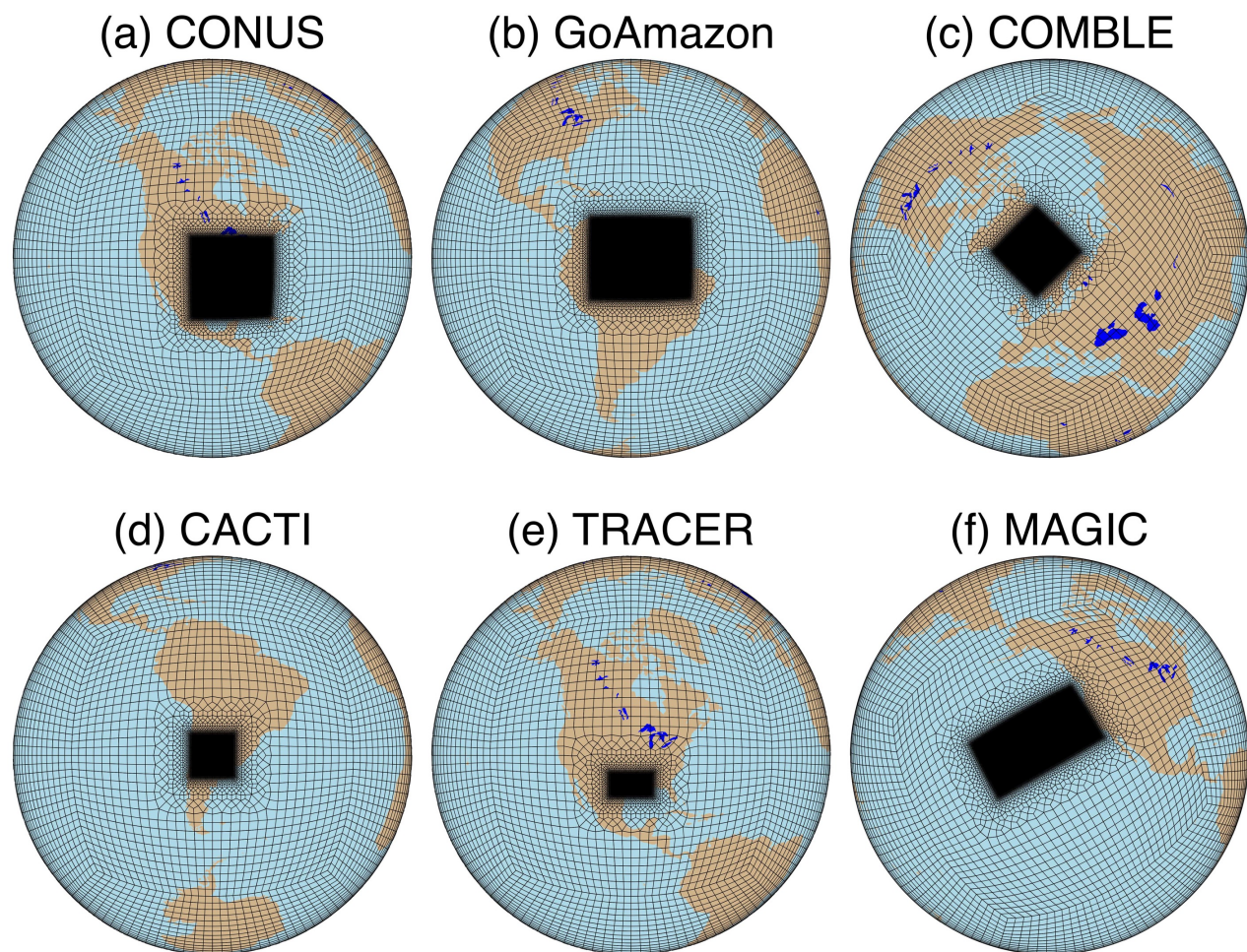


Change in accumulated rainfall (2050 vs 2023)



Figures courtesy *Jishi Zhang* (2024; in prep.)

Beijing



New Grid Development is Active!

- THREAD project is adding many new grids.
- Enables the comparison of SCREAM against ARM field campaigns.
- Naturally synergizes well with cases added to DP-SCREAM (and fills the gaps).

Figure courtesy **Hsi-Yen Ma**



Resources to Get Running!



- DP-SCREAM:
 - <https://github.com/E3SM-Project/scmlib/wiki/Doubly-Periodic-SCREAM-Home>
- RRM:
 - Documentation to create new grids:
 - <https://acme-climate.atlassian.net/wiki/spaces/DOC/pages/872579110/Running+E3SM+on+New+Atmosphere+Grids>
 - Library of existing grids:
 - <https://acme-climate.atlassian.net/wiki/spaces/DOC/pages/3690397775/Library+of+Regionally-Refined+Model+RRM+Grids>

e3sm.org