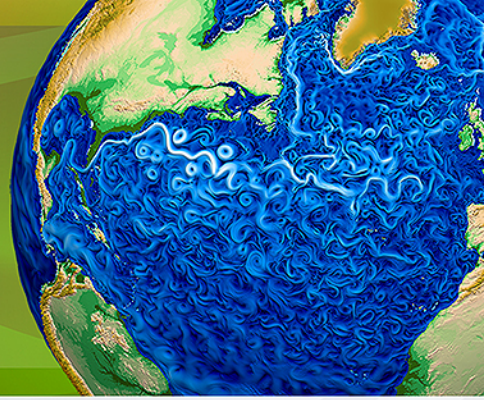
ACME
Accelerated Climate Modeling for Energy



ACME-Atmos Development Plans and their Relation to CAM

Peter Caldwell, Phil Rasch, Dave Bader, Dorothy Koch, Bill Collins, Mark Taylor, and the rest of the ACME team

Goals:

1. What is ACME?
2. Why is ACME needed?
3. How is ACME related to CAM?
4. What are plans for ACME-Atmos?

U.S. DEPARTMENT OF ENERGY

Prepared by LLNL under Contract DE-AC52-07NA27344. LLNL-PRES-667184

BNL ORNL SNL ANL U. Maryland NCAR

What is ACME?

UCI LLNL NYPU LBNL LANL PNNL Kitware

ACME is a new $19M/yr multi-lab project aimed at building a climate model to fit DOE's needs. It is:

- targeted specifically at next-generation DOE supercomputers
  - standard atmos resolution will be ~25 km
  - MPAS Ocean and CICE resolution equivalent to 0.1 deg POP
- narrower in scope than CESM. It currently has 3 drivers:
  - How do the **hydrological cycle** and water resources interact with the climate system on local to global scales?
  - How do **biogeochemical cycles** interact with climate change?
  - How do rapid changes in **cryospheric systems** interact with the climate system?
- Has a focus on end-to-end infrastructure for developing, running, analyzing, and documenting the model

Why is ACME Needed?

- By going ‘all-in’ on new architectures, ACME can become an early adopter of new machines and programming models
- DOE requires a model its lab scientists can configure and run on machines it owns for answering the science questions the agency deems relevant (“a DOE Model run on DOE computers for DOE needs”)

How Does ACME Benefit CESM

- Another model = more opportunities to try things + share what works
- ACME adds funding and expertise to CESM (through funding NCAR staff and development of a sister model)
- provides an alternative venue for getting schemes into a model release

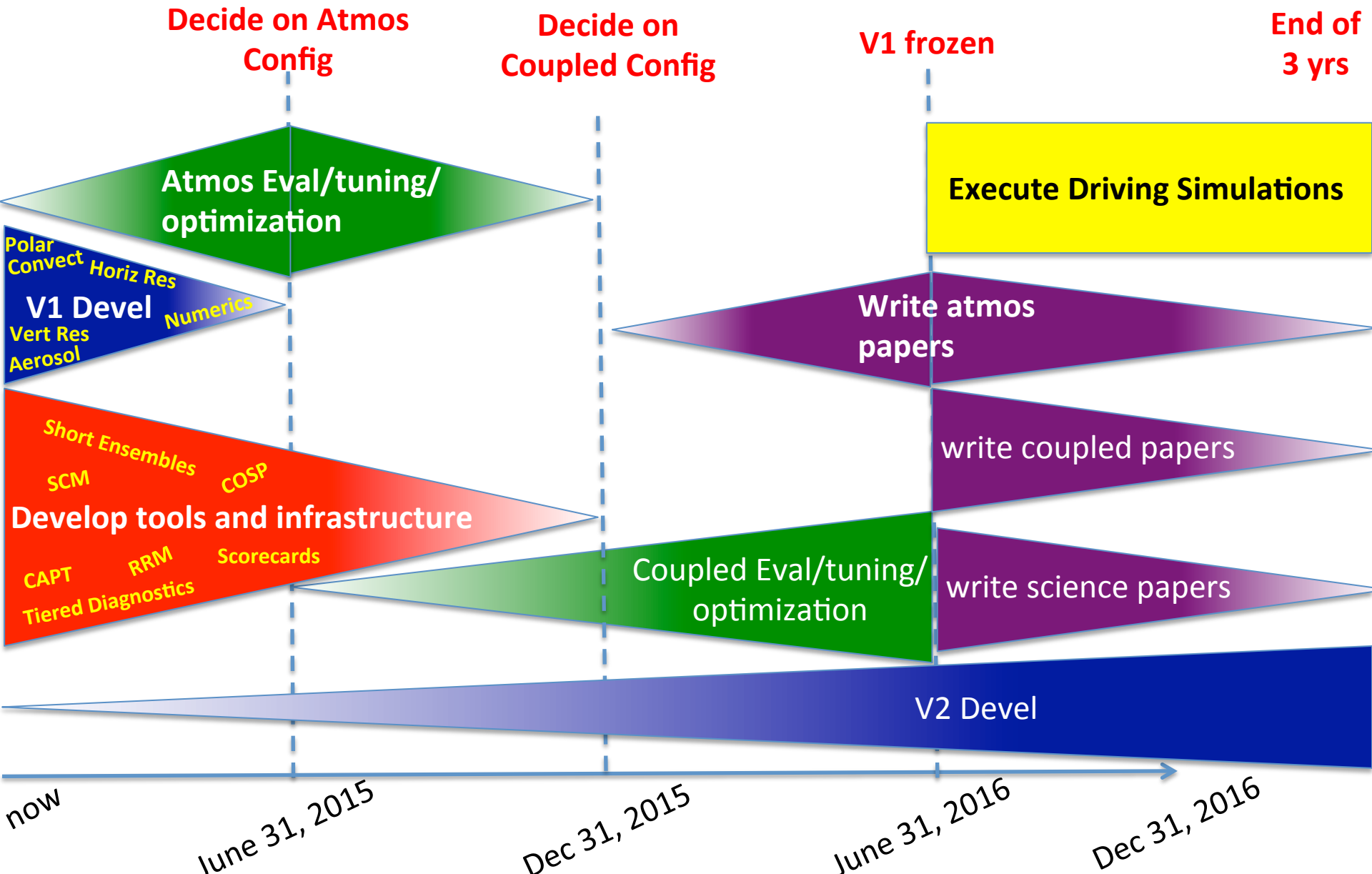
How is ACME related to CAM?

ACME:

- is branched off of CESM1 (CAM5.3)
- is narrower in scope
  - driven by hydrology, cryo, and BGC questions
  - aimed at high resolution/shorter (~50 yr) timescale
  - optimized for next-generation supercomputers
- will ***collaborate*** with NCAR on some tasks, ***diverge*** on others, and work separately on some ***parallel*** tasks
  - the relationship between ACME and NCAR is actively managed by Bill Large and Dave Bader

ACME Atmos Timeline

Height of box indicates effort level for given time



Tools/Evaluation

How do you test a model you can barely afford to run?

- Single Column Model
  - we envision a suite of standard test cases
  - we are still deciding on best implementation plan
- Regional refinement (top Fig)
  - Puts resolution where you want it
  - Can be 90% cheaper than uniform global runs
- Ensembles of short simulations (bottom Fig)
  - capture many rapidly-developing features (< 5days)
  - cost ~6% of a 5 year global simulation
- CAPT
  - short 'weather forecast' runs are cheaper and can be compared to time-varying obs
- Modular diagnostics using UVCDAT
  - diagnostic tiers collect all obs needed to understand particular physical processes
  - new framework should scale better to high-res

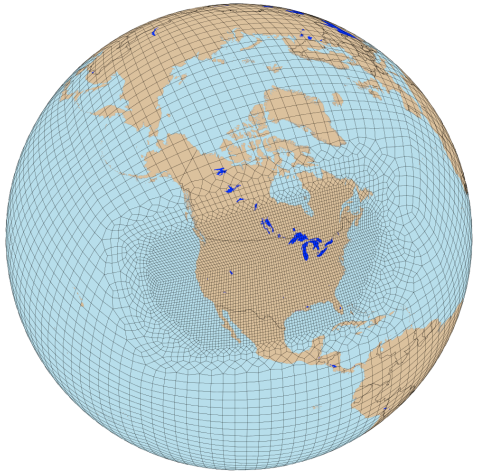


Fig: Example of a regionally-refined grid (Klein, Roesler, Tang, Loy, Taylor, et al., in prep)

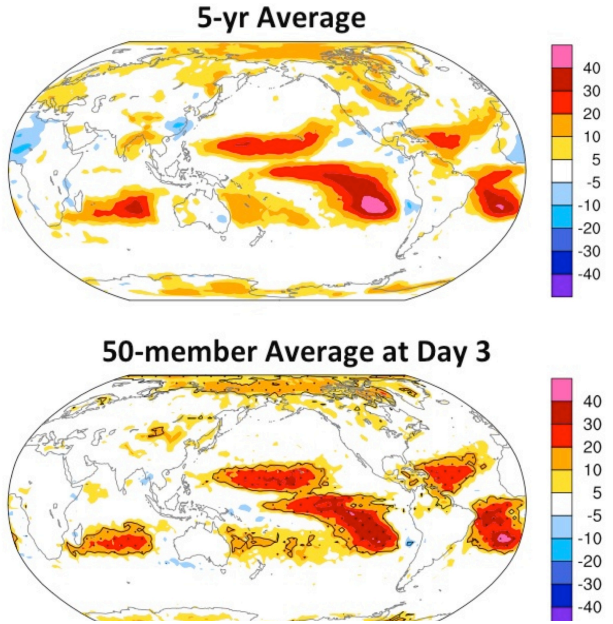


Fig: Cloud cover difference between dt=4 min and dt=30 min runs using traditional and short ensemble strategies (Wan, Rasch, Qian, Ma, Xie, Lin, 2014)

V1 Model Development

Black = completed, Red = in the works.

- Effect of pre-existing crystals on aerosol IN activation
- Treatment of sub-grid vertical velocity on ice nucleation
- Improved aerosol deposition on snow and ice
- Improved convective transport/activation/removal of aerosols
- Additional mode added to capture black carbon aging
- Improve H_2SO_4 gas (numerics, diurnal cycle) and SOA treatment
- sea spray organic matter + DMS emissions

aerosol changes

- Increased horizontal and vertical resolution
- Simple PDF macrophysics + macro/micro substepping
- **Improved pressure gradient treatment to reduce precip biases associated with topography**
- **Subgrid elevation classes for improved precipitation/hydrology**
- COSP simulator (improvements + aerosol lidar simulator)

physics changes

- **Convection (test ZM with improved triggering, Unicon, CLUBB-ZM)**

Driving Questions

Short-term (3+ yr) questions:

- How will more realistic portrayals of the water cycle affect river flow and associated freshwater supplies at the watershed scale?

- How do carbon, nitrogen, and phosphorus cycles regulate climate system feedbacks, and how sensitive are these feedbacks to model structural uncertainty?

- Could a dynamical instability in the Antarctic Ice Sheet be triggered within the next 40 years?

Driving Questions

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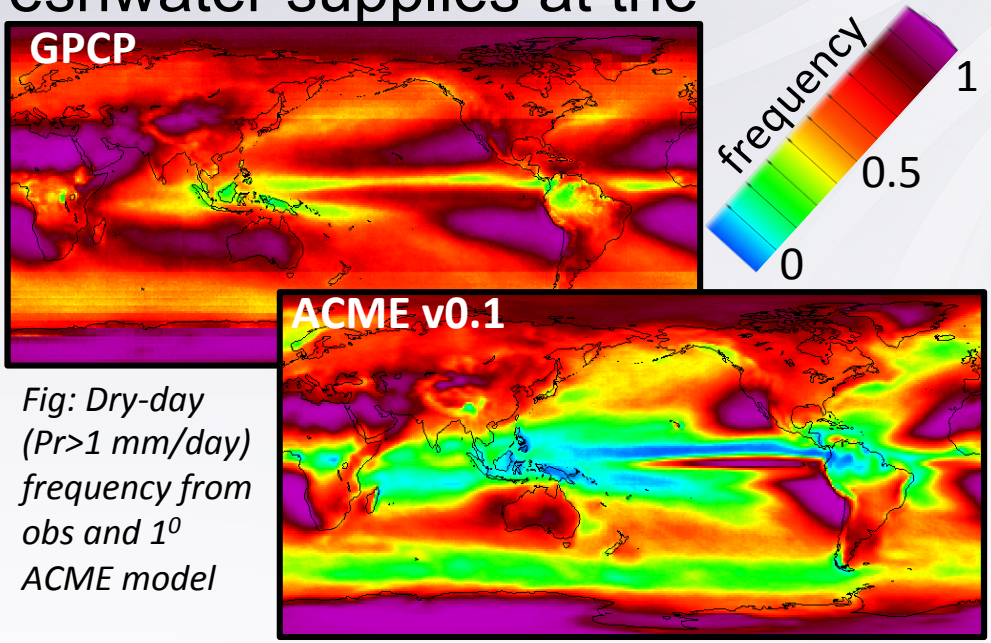


Fig: Dry-day (Pr>1 mm/day) frequency from obs and 1^0 ACME model

Test the following w/ sensitivity studies:

- resolution (dx and dz) ← Coupled Runs
- ocean/atmos interaction
- clouds/aerosol scheme
- SGS orography scheme
- surface/subsurface hydrology
- human activities (CO_2, aerosol, land use, water use)

Atmos-Only Runs

- far-field meteorology ← RRM

- Will analyze ≤6 major rivers
- Output will be publicly available

Summary

- ACME is narrower in scope than CESM
  - focused on next-gen DOE supercomputers ⇒ high-res
  - aimed at hydrology, cryo, BGC (and energy) questions
- ACME is synergistic to CESM
  - lets us try different things and share what works
  - acts as guinea pig for new computer architectures
- ACME is doing cool stuff
  - tuning/testing at high resolution
  - model development
  - addressing science questions

extra slides

Choosing a Convection Scheme

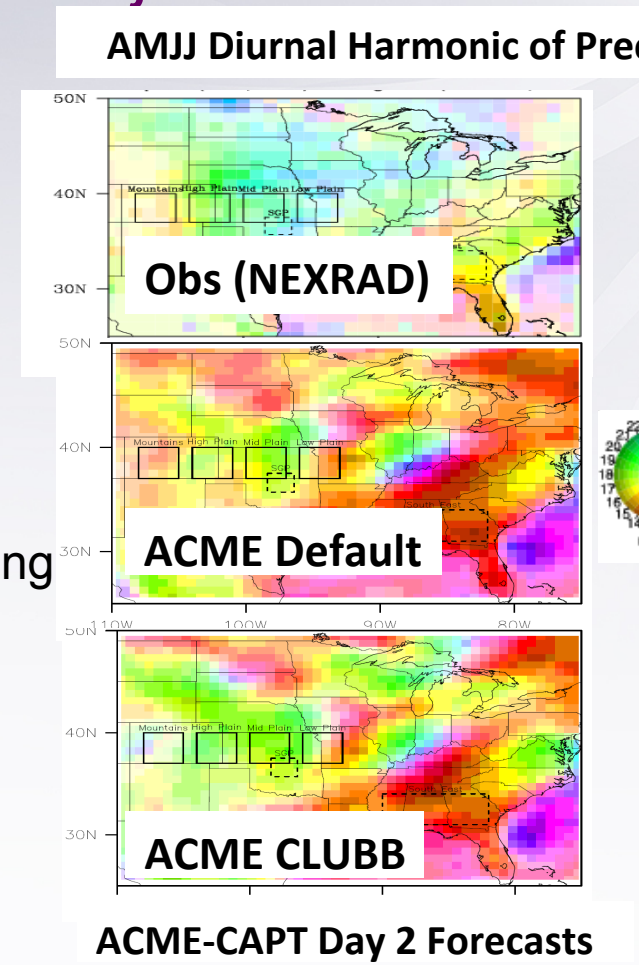
Convection has a critical impact on precipitation and coupled model variability, so improving convection parameterization is critical for ACME success

We will evaluate several candidate configurations: (still under discussion/working out details):

1. CLUBB Shallow + ZM Deep
2. UNICON
3. ZM variants (with/without CLUBB):
   a. Neale's changes (Bechtold et al 2008 convective gustiness)
   b. G. Zhang's innovations (Triggering and closure)

So far, we have developed a convection testbed including
- convection-specific diagnostics
- ability to run in single-column and CAPT mode

One-year 5-Day CAPT hindcasts done for 2008



Diagnostics/Metrics

We are developing diagnostics tailored for ACME science

Diagnostics organized into overlapping groups centered around science questions:

- *Tier 1a = 'top 10' that we always try to optimize*
- *Tier 1b = collections of fields relevant to ACME regions or phenomena:*
  - *{Amazon, US, Asia} Hydrologic Cycle*
  - *S. Ocean/Antarctic meteorology,*
  - *Tropical/Extratropical modes of variability with strong influence on water cycle,*
  - *Global clouds and the water cycle*
- Tier 2 = other diagnostics (e.g. everything in AMWG diagnostics)

- ACME is developing diagnostics in the UV-CDAT framework

Tier 1a Diags (from Classic Viewer)

	ERAI Interim Reanalysis	
PSL	Sea-level pressure	plot
U	Zonal Wind	plot
T	Temperature	plot
RELHUM	Relative humidity	plot
	GPCP 1979-2003	
PRECT	Precipitation rate	plot
	ERS Scatterometer 1992-2000	
SURF_STRESS	Surface wind stress (ocean)	plot
	CERES_EBAF	
LWCF	TOA longwave cloud forcing	plot
SWCF	TOA shortwave cloud forcing	plot
	AOD_550	
AODVIS	Aerosol optical depth	plot
	Willmott and Matsuura 1950-99	
TREFHT	2-meter air temperature (land)	plot

How you can interact with ACME:

- NCAR is already working closely with ACME
- ACME is a model *integration* effort. ACME *development* will be funded primarily through SciDAC and ASCR projects.
  - so apply for funding
- Become an ACME collaborator
  - collaboration policy ≈ CESM policy, but coauthorship should be negotiated beforehand (to the extent possible)
- Join a national lab (several are hiring)!

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P. Rasch

About ACME-Atmos


P. Caldwell

- Candidate config for next coupled release due **Dec 31, 2015**
  - *Code* changes for v1 atmos are fairly modest but *behavior* may not be (because of resolution changes and code choices)
  - *Coupled* model will be very different due to MPAS ocean+ice

- We are spending a lot of time setting up structures that already exist for CESM (like how to analyze output and who's job that is)
  - ACME is an opportunity to try new approaches