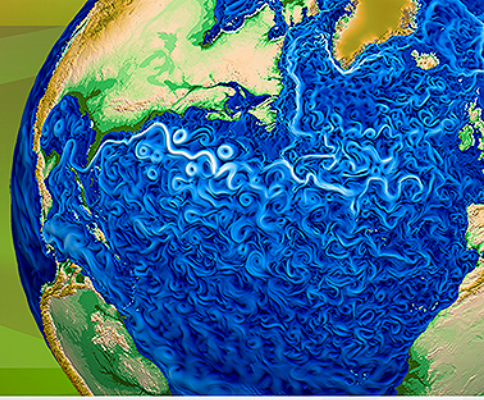
ACME
Accelerated Climate Modeling for Energy



Atmos Group Progress

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U.S. DEPARTMENT OF ENERGY

Overview

Goals:

- Get staff working as a team
- Re-align our activities to create a model-development enterprise
- Produce a good model for ACME science

Plan:

Phase 1: Spin up capabilities/infrastructure

- Continue parameterization development
- Develop tools needed for high-resolution global modeling
- Establish protocols/procedures for code development/model evaluation
- Build ACME-specific diagnostics
- Coordinate with other ACME groups

Phase 2: Build a better model

- Improve physics for ACME
- High resolution modeling present new challenges to model development.

Phase 3: Contribute to ACME coupled model and Science questions

Model Development

Features distinguishing ACME-atmos from CAM5.3. Below is a list of changes we proposed. Black = completed, Red = in the works.

- Effect of pre-existing crystals on aerosol activation
- Treatment of sub-grid vertical velocity on ice nucleation
- Improved aerosol deposition on snow and ice
- Improved convective aerosol transport/activation/removal
- Additional mode added to capture black carbon aging
- New sulfuric acid treatment (nucleation, numerics, d. cycle)
- 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 orography for improved precipitation/hydrology
- COSP simulator (improvements + aerosol lidar simulator)
- Convection (see next page)

physics changes

Choosing a Convection Scheme

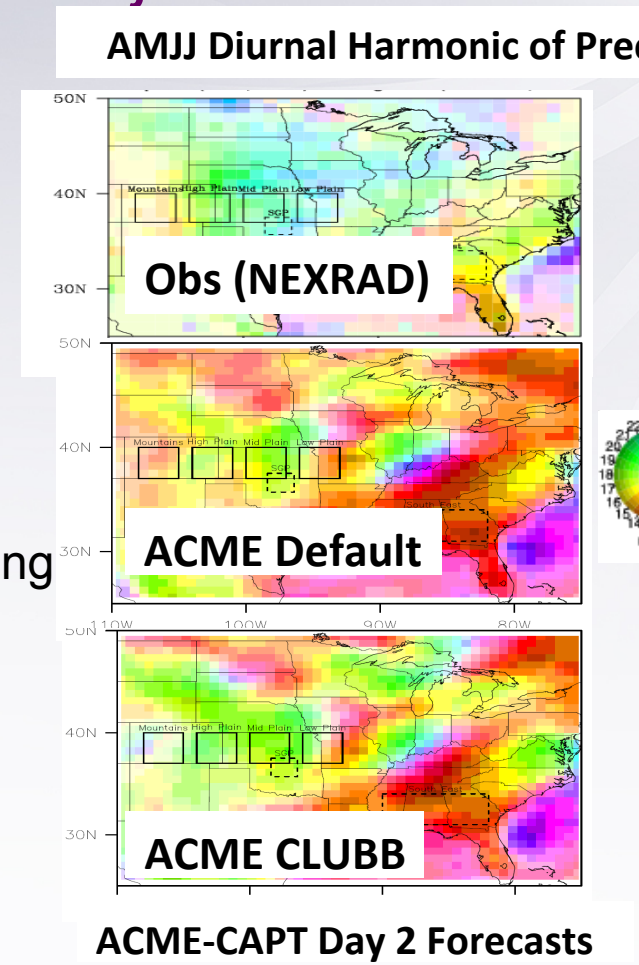
Convection has a critical impact on precipitation and coupled model variability, so improving convection parameterization is critical for ACME success

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



Testing Strategies

Developing a high-resolution climate model requires new ways to efficiently test model changes

- Regional refinement
  - Puts resolution where you want it (see top fig)
  - Can be 90% cheaper than uniform global runs
- Ensembles of short simulations
  - capture many rapidly-developing features (<5days)
  - cost ~6% of a 5 year global simulation
- Single Column Model
  - we envision a suite of standard test cases
  - we are still deciding on best implementation plan

New strategies will ensure our code is behaving well

- Convergence tests
  - run 1 step with Δt of decreasing size
  - tests appropriateness of mathematical formulation
- Novel unit tests
  - ensure parameterizations are working correctly

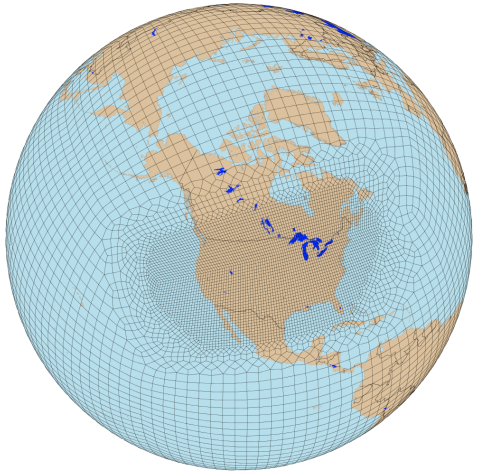


Fig: Example of a regionally-refined grid (Klein, Roesler, Tang, Loy, Taylor, et al., in prep)

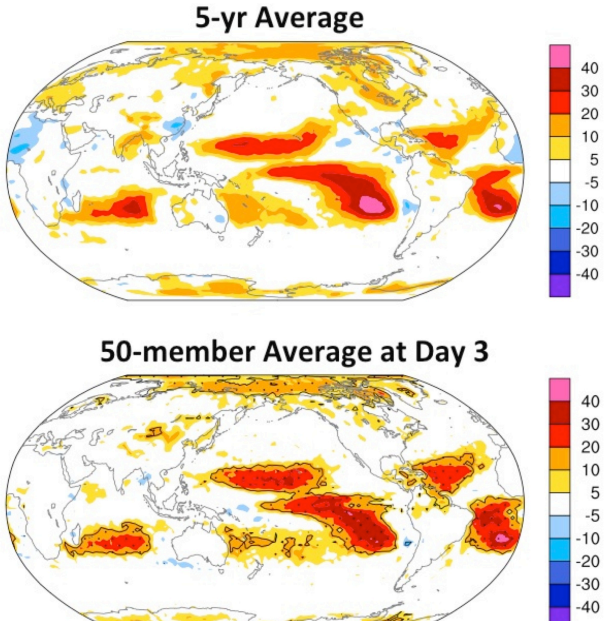


Fig: Cloud cover difference between dt=4 min and dt=30 min runs using traditional and short ensemble strategies (Wan, Rasch, Qian, Ma, Xie, Lin, 2014)

Diagnostics/Metrics

We are developing diagnostics tailored for ACME science

We organized diagnostics 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:*
  - *Clouds*
  - *{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

Timeline for Atmos development:

ACME plans require alpha-release of ATM at end of Q6

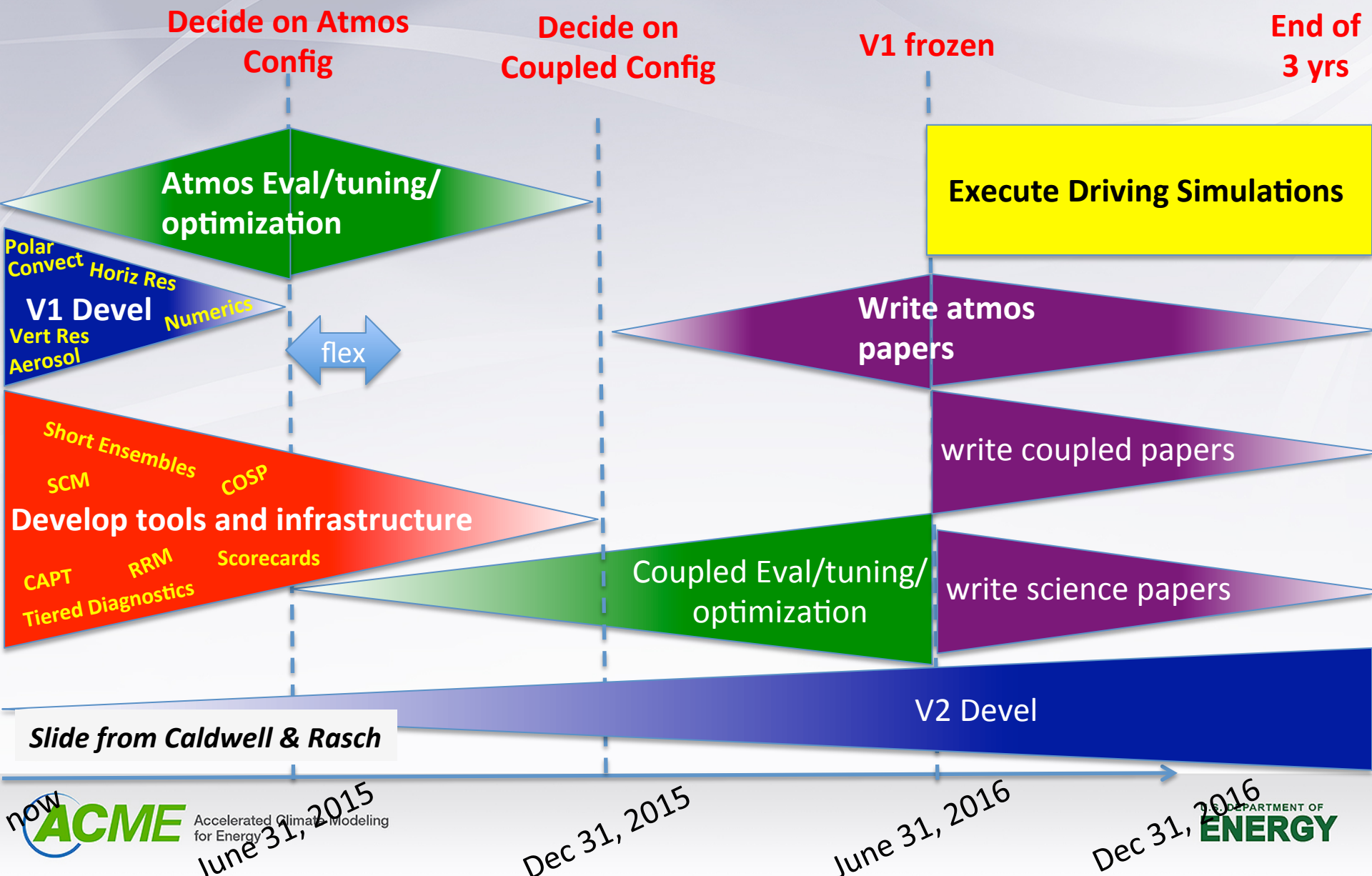
- Q1, Q2: see Phase 1 slide
- Q3, Q4: begin Phase 2
  - Build confidence and skill in testing, evaluation procedures
  - Make most Tier 1b diagnostics fully functional, attempt to prioritize them
  - Serious assessment of
    - convection schemes, ready & most likely to succeed (UNICON, revised ZM, revised ZM+CLUBB,?)
    - Vertical resolution
    - High horizontal resolution
  - Continued development of
    - aerosol, cloud improvements, elevation class decomposition
    - Short simulation strategies for assessment/calibration
- Q5
  - Choose convection, assemble viable parameterization collection
  - First assessment of candidate collection (CC)
  - Establish viability of innovative eval and tuning procedures.
  - Attempt a credible 1 degree simulation with CC
- Q6 all out attempt to produce alpha release

Timeline, part II:

- Q7-Q8: Concerted attempt to move from alpha to beta to V1 (complete integration with other components).
  - Identification of deficiencies
  - Assess needed compromises
  - Final tuning of coupled model
- Q9-Q12
  - Coupled simulations with V1 for science problems
  - Characterization of final model configuration behavior with papers
  - Begin analysis of coupled simulations for science problems
  - First paper on coupled simulations

ACME Atmos Timeline

Height of box indicates effort level for given time



Opportunities, Bottlenecks, Unresolved issues.

- We are now about 10 months in
- It takes some time to spin up
  - People are still settling in
  - Procedures, protocols, metrics, tools are still being explored and in development.
- Our plan is quite ambitious
- Things which fell through the cracks are becoming evident and being dealt with

What has & has-not been happening

- Lots of model development:
  - Buried inside the development has been some testing/evaluation/
- Some evaluation
  - Continued work on collections
  - Observational Datasets
  - No scorecards yet
- Production run scripts are not yet robust
- Tuning. This task will need to start by Q5.
- Workflow is evolving. Currently many things are still taking place via “sneakernet”
- Bugtracking
  - Bugs are being fixed on CESM that we care about but are not grabbing
- Combining parameterizations, e.g.
  - probably have not turned on polar mods with convection
  - Probably have not run high vertical res with polar mods
- Testing?
  - (COSP failure on MIRA is a recent example of a problem)
  - Need to define procedures for making innovations the default
- Performance
- Need:
  - A schedule
  - People to volunteer for some of the tasks that are not currently covered, or Shaocheng and I will start searching for solutions (this means reprioritizing activities to make sure the critical issues are covered).