CAM Sub-Column Approaches: Building a Flexible Future

Andrew Gettelman & Collaborators
(Larson, Morrison, Randall, Park)

Outline: Description of Projects

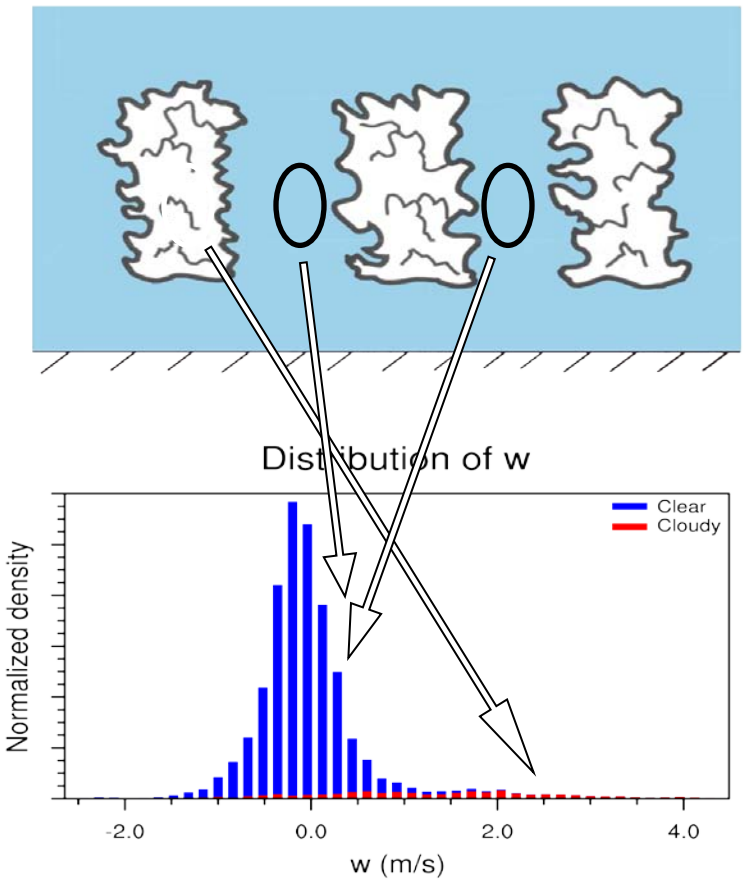
- Concept of Sub-Columns
- Non-Independent Sub-Columns: SPCAM
- Independent Sub-Columns: CLUBB
- Future flexible interface for unified treatments

- at least 3 funded projects
- mostly vaporware now
- Good ideas and collaborations are welcome!

Sub-Column Philosophy

- Cannot resolve fine scale processes, so parameterize.
- Grid scale means may not be appropriate due to non-linearities
- Goal: framework for consistent treatment of non-linear difference of regimes.
- Examples: Microphysics, Radiation, Convection
- Two paths: independent (ICA) or not.

Sub-Columns and PDF sampling

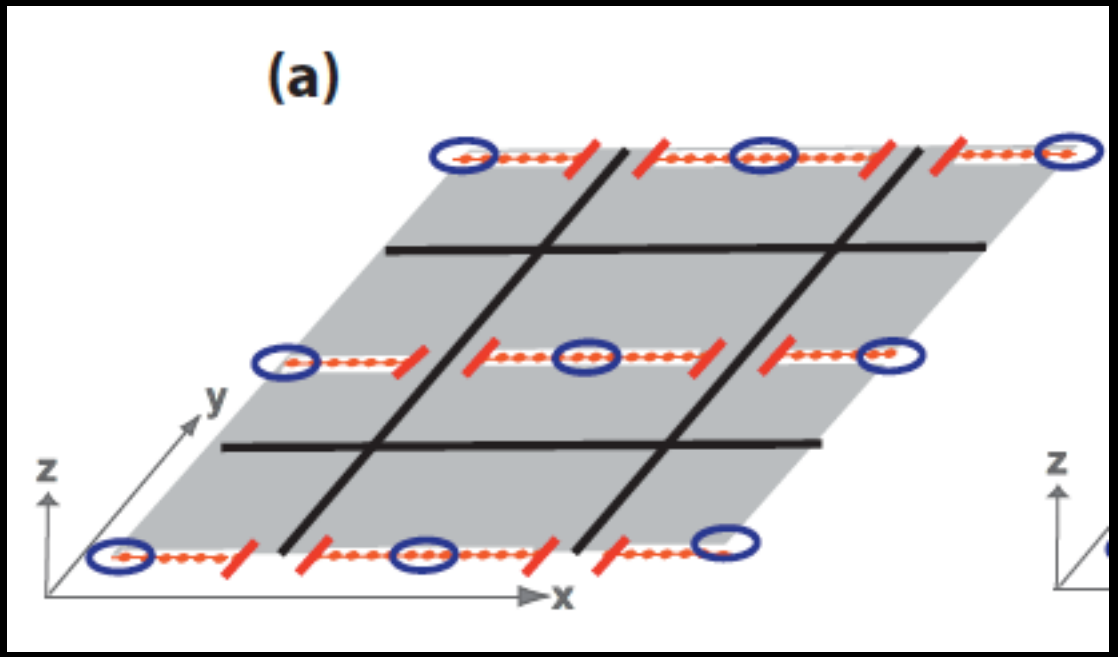


- Describe PDF
- Pick sub-columns
- Run physics on sub-columns
- Sub-columns could interact (cloud model) or independent

Non-Independent Columns

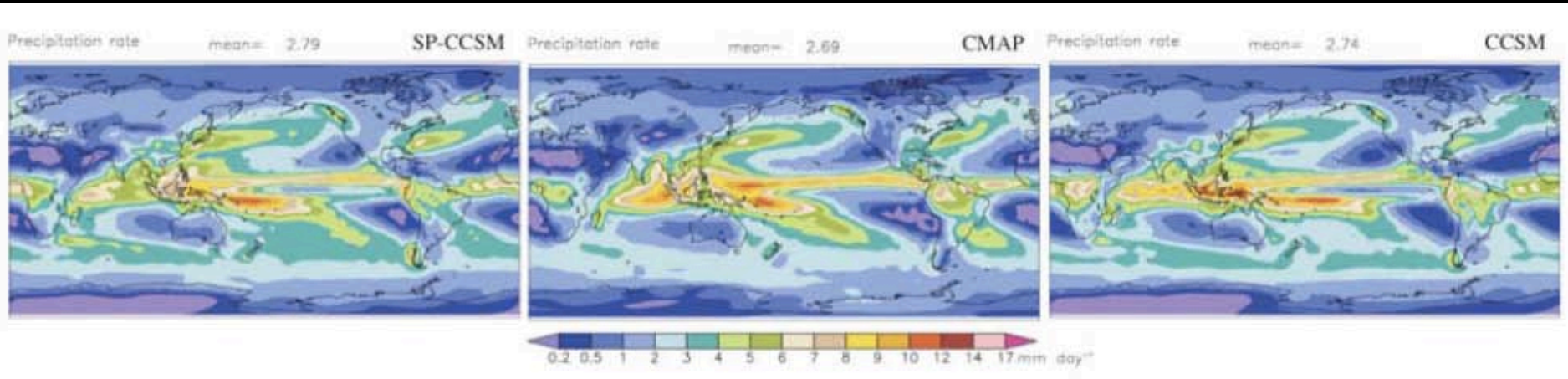
- Adjacent columns affect each other
- Example, Super-Parameterized CAM (SPCAM)
- Put a cloud resolving model (SAM) into CAM, replacing moist physics
- Several development efforts. Unifying under a consistent framework, putting SP-CAM as an option into CAM5 code base
- Run SP-CAM for IPCC AR5
- Investigate SP-CAM version with aerosols. Lower AIE

SPCAM Schematic



Run a cloud resolving model (SAM) within each CAM grid box

SPCAM Precip

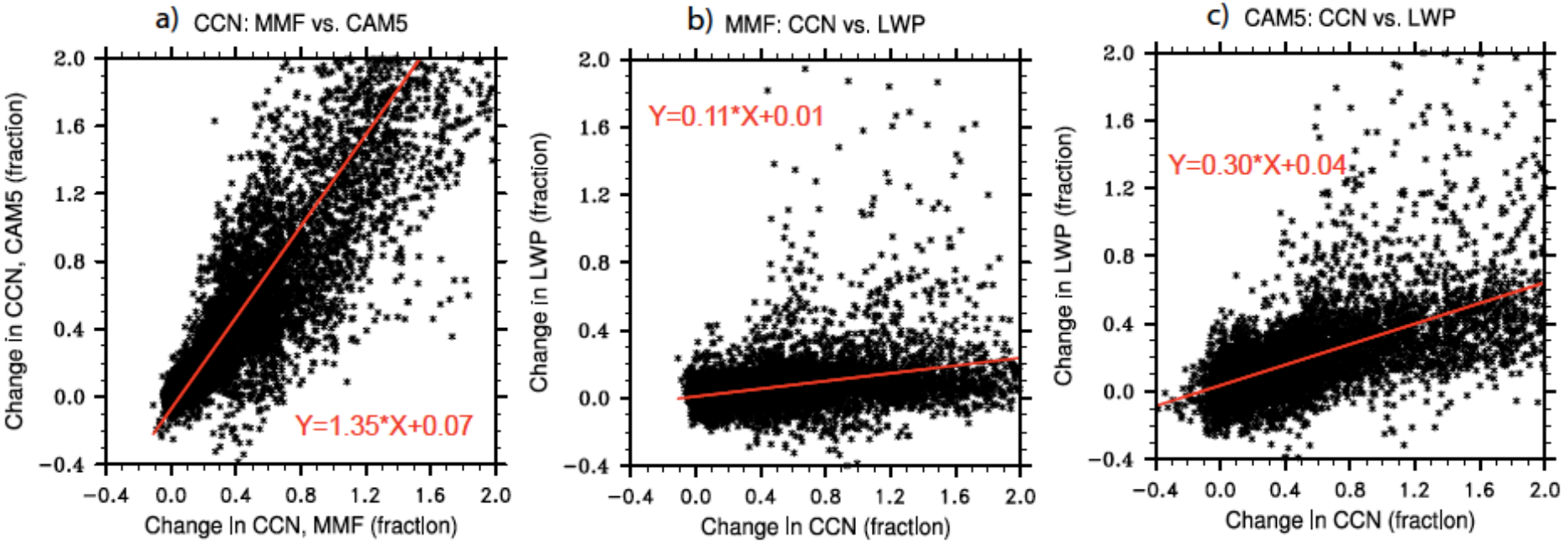


SPCAM is running in CCSM

Results are quite good in many regions

Some differences (some good, some bad)

SPCAM With Aerosols



M. Wang et al 2011, ACPD (Also GMD)

PNNL Led effort: Wang, Liu, Ghan, Rasch

SP-CAM w/ modal aerosols, new scavenging

What are we Doing?

- 2 Funded EaSM proposals collaborating
- Randall: Base SP-CAM integration for AR5
- Russell: Aerosols and AIE in SP-CAM using DOE-PNNL aerosol code and developments, also convection in microphysics
- Integrate with other efforts

Independent Sub-Columns

- Example: McICA generates independent columns for radiative transfer in CAM5
- Goal 1: Integrate ICA with a sub-column generator that can also be consistent with CAM microphysics
- Essentially move the Sub-columns to ‘macrophysics’. Provide a layer to generate columns.

Plans: CLUBB

- Cloud Layers Unified By Binormals (CLUBB) is a multivariate driver for cloud schemes (macrophysics) developed by Larson.
- CPT project to implement it in CAM.
- Will discuss tomorrow.
- Will have someone (Pete Bogenschutz) working on it
- Integrating it sequentially.

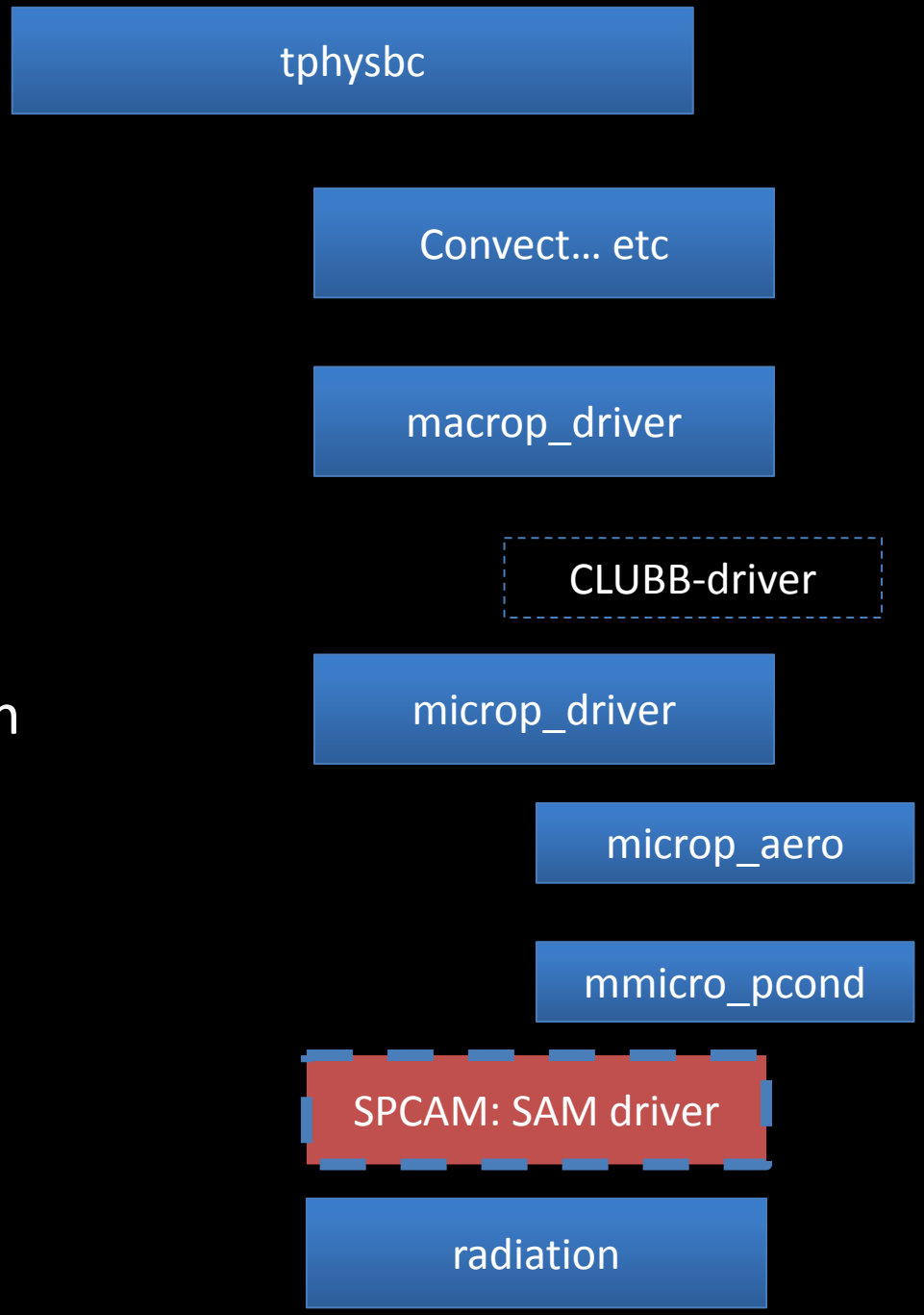
Current Code Status

- CAM5 physics has been made much more modular since CAM5.0 and CAM5.0.1 release
- Aerosol activation in a separate routine
  - microp_aero_ts
- Macrophysics and microphysics separate
  - Stratiform → microp_driver, macrop_driver
  - Stratiform stripped down to CAM4
- MG microphysics now has a ‘sub-column’ flag
  - Will run with bi-modal cloud fraction

CAM5_0_29+

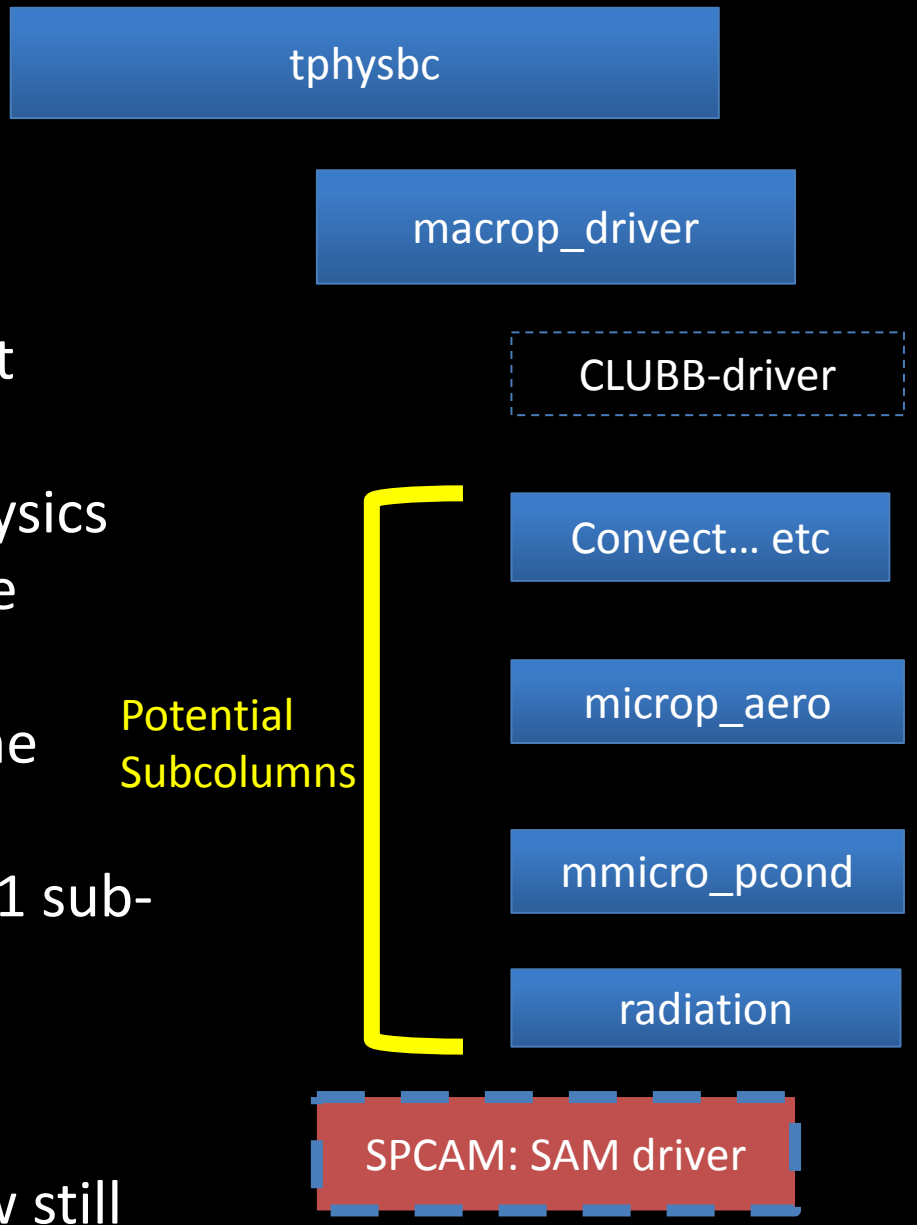
Current CAM Code

- Macrop_driver + microp driver replace stratiform
- CLUBB will be an optional call
- Microp calls aerosol activation separately from microphysics (in CESM1_0_1 & 2, cam5_0_6)
- SPCAM put in as a driver



CAM Evolution

- Macrop can ride on top of moist physics and treat consistently
- Aerosol activation and microphysics codes called once, or same code multiple times
- SPCAM could be an option: same radiation code
- Might be able to reduce this to 1 sub-column (backward compatible)
- Implies Stochastic element to macrophysics
- Note: just a schematic right now still needs some development



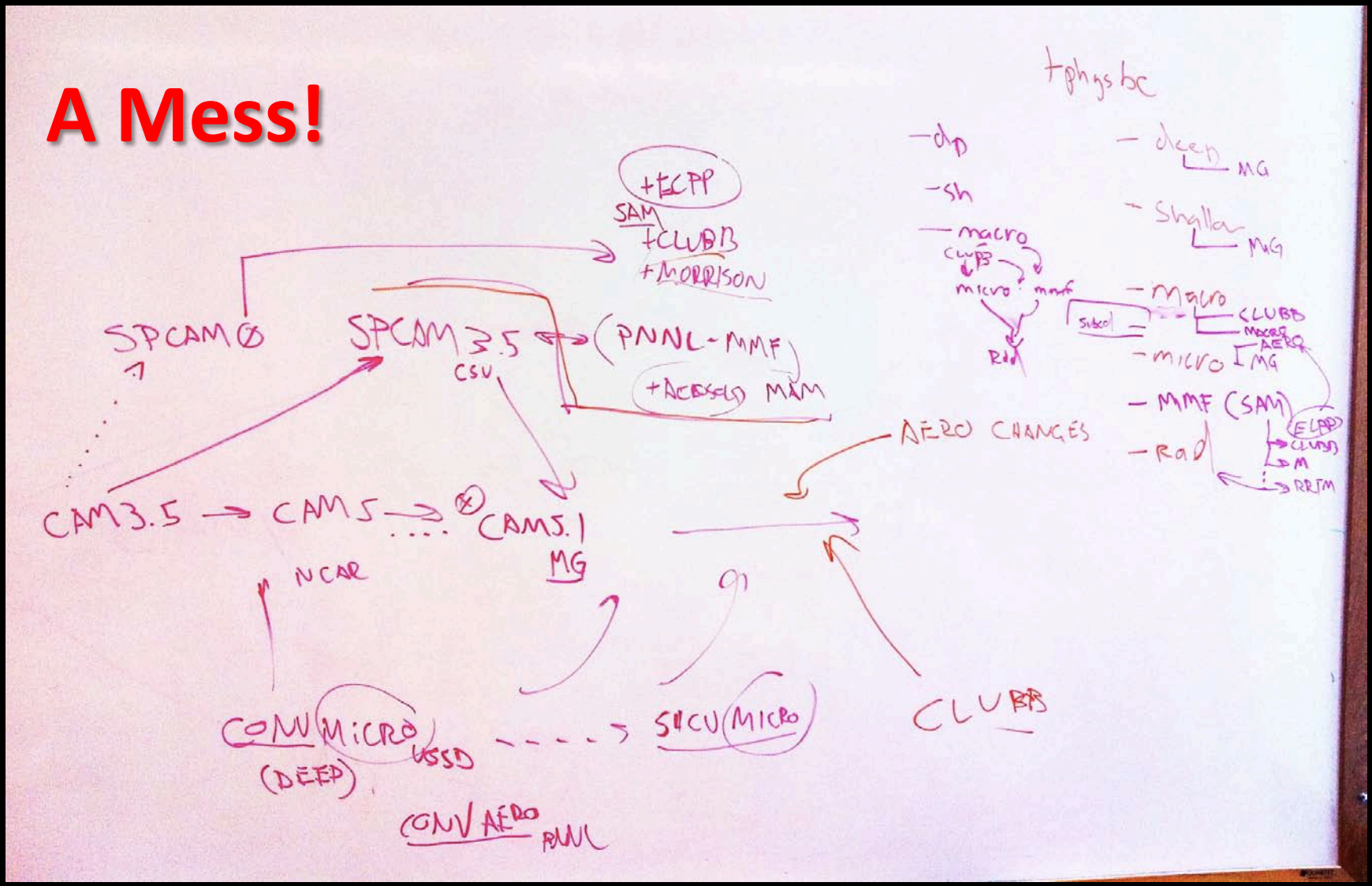
Plans

- Sub-columns need (want) another dimension for output [*groan*: cam_history.F90]
- Make sure independent (CLUBB) and dependent (SP-CAM: SAM) formulations play nice with each other, and can be put on trunk
- Not going to support multiple options for science. Will support functionality.

Goals

- Minimize duplicate code (e.g.: Multiple Aerosol or Microphysics codes)
- Unify MG microphysics across all current and future CAM physics.
  - Zhang convective microphysics,
  - new shallow-cu microphysics,
  - CLUBB implementation,
  - other macrophysics
- Will explore MG use within SAM as well
- MG going to prognostic precipitation this year
- Select a configuration for climate runs once these tools and frameworks are built

What does this look like?



Collaborations

- Have funding for several projects
- Need everyone's help to do this rationally and cleanly
- Still welcome collaborations and strong science
- 'We' = Me, Sungsu, Rich, Cecile
- Mandate (NSF): we need to make all these incredible efforts usable for the community. Not one-offs.
- Avoid Malcom X software ('By any means necessary')
- We can help make decisions about code versions that can minimize work for all. Save trouble later.

Comments?