

# Path to CESM2

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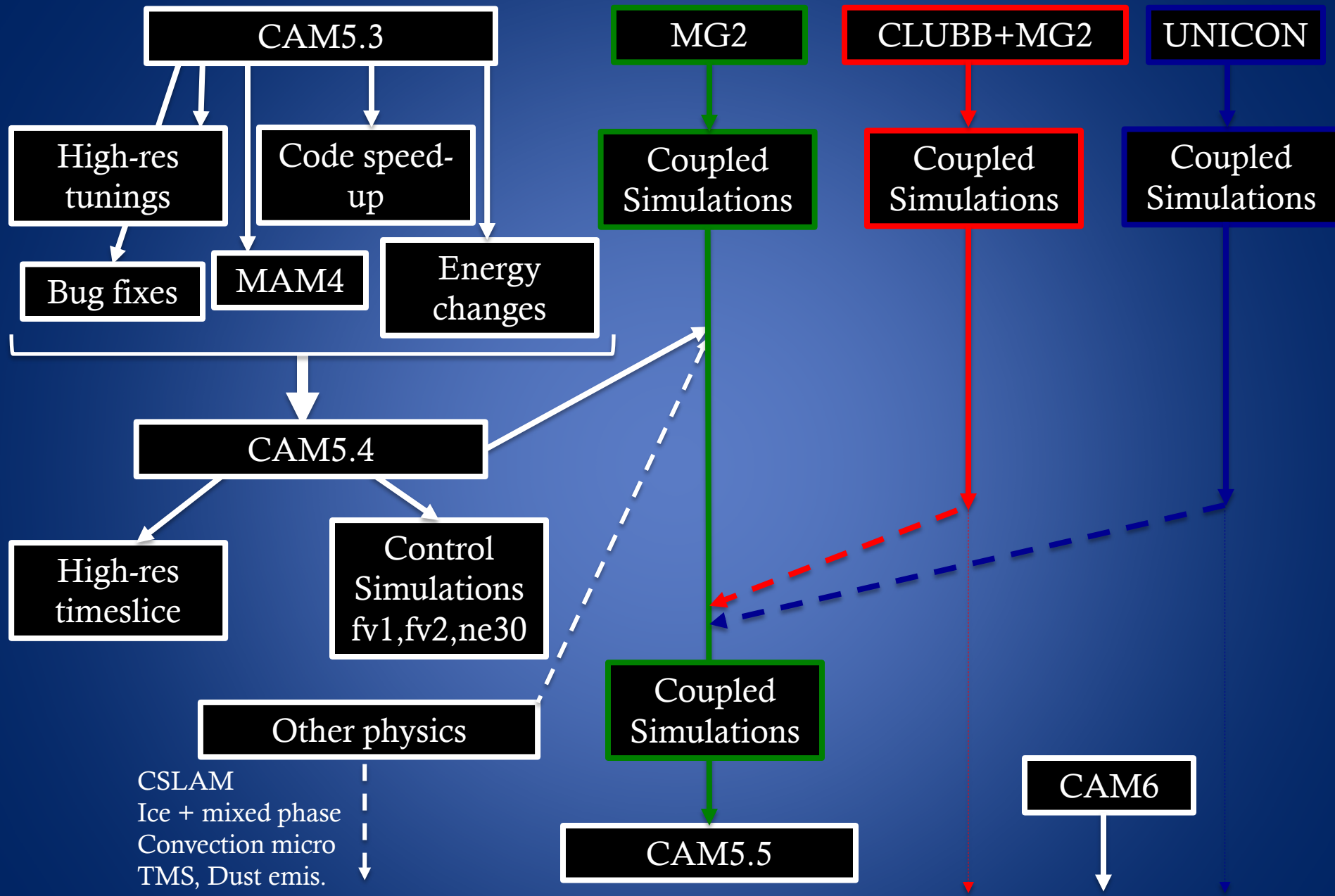
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NCAR Earth Systems Laboratory



# CESM2 targets and timeline

- CESM2 release June 2016
- Many developments across CESM are coming to maturity
- 2 main target configurations for CMIP6
  - 1-degree CAM5.5-FV 1-degree POP2
    - ➔ for BGC/Chemistry/WACCM/Paleo/...
  - 1/4-degree CAM6-SE 1-degree POP2
- CAM5.5 to be finalized by winter AMWG 2015 and released by June 2015 to allow for testing and development of other components





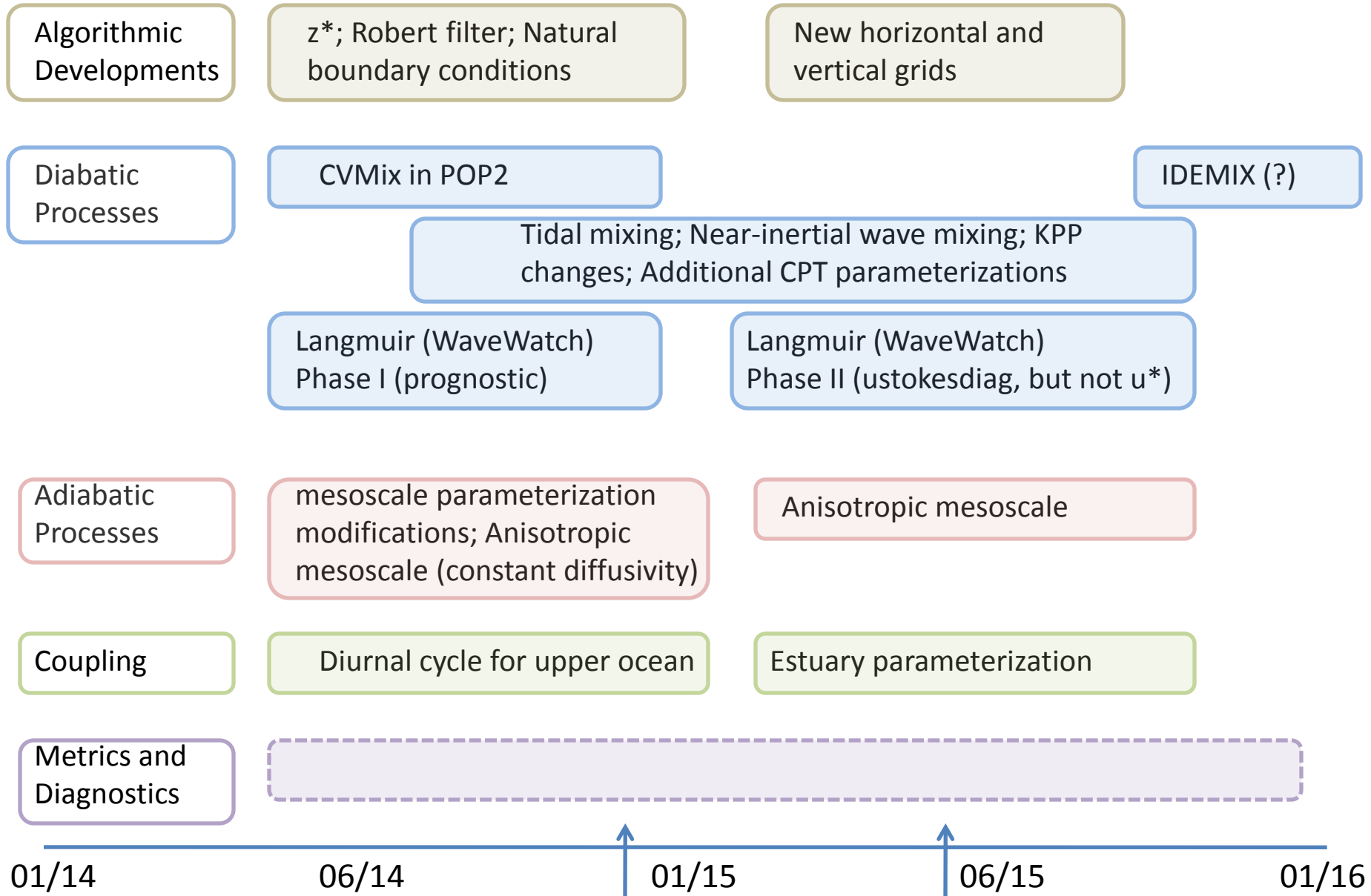
# CLUBB-UNICON Evaluation

- Scientific evaluation through external panel (A. Capotondi, S. Klein, P. Kushner, B. Mapes and M. Miller)
- Evaluation for inclusion in CAM5.5 only
- Specific simulations and diagnostics requested
- Code delivery requested to allow for the panel and developers to access proposed
- Upcoming steps
  - Feb. 9: Release of the panel recommendation (with documentation) to the CESM community.
  - Feb. 18-20: Discussion at AMWG winter meeting. It is expected that a decision of which (if any) new parameterization (CLUBB or UNICON) to be included in CAM5.5 will be made at the AMWG. If this is not the case, then the CESM SSC will make the decision.



# CESM OMWG Development Timeline – Path Towards CESM2

Focus Topics



Arrows indicate completion points for more detailed evaluation with BGCWG

# CLM Development Timelines: *The path towards CLM5/CESM2*

Biogeochem

Ecosystem Demography (CLM-ED) development

CLM5(ED) ready for coupled sims 1/2017?

C, N refactor and param updates

Extension of crops to global, fertilization

Biogeohys

Soil hydrology and snow refactor and updates  
(reactive transport modeling, water isotopes)

CLM5 BGC  
eval/tune (fire,  
CH<sub>4</sub>, flood, dust)

Urban updates

RTM

MOSART river model

Flood/wetland full implement

Fully coupled BGC  
eval/tune of CLM5  
and/or CAM5.5

Coupled model/  
capabilities

Dynamic landunits

CLM5 control sims  
(BGC-crop, SP, ED?)

Land model processes benchmark system

CAM5-CLM4.5BGC eval/tuning

Fully coupled CESM1.2 BGC simulations

**CLM5 in CESM2  
(CAM5.5, CAM6)**

1/2014

6/2014

1/2015

CAM5.5

6/2015

CESM1.3

1/2016

6/2016

CESM2



# Moving forward

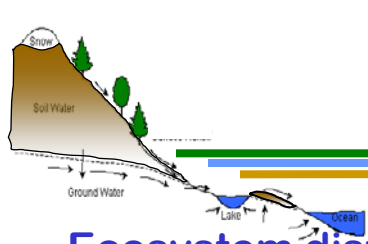
- Frequent testing in coupled mode
  - CAM5.4-CLM4.5-BGC on-going
  - Focusing on coarse-resolution target
- P. Gent has agreed to lead the evaluation of the coupled model







# Development targets for CLM5



## Ecosystem disturbance

- ED; add soil BGC (Charlie), land use change (LBNL???), N (Chonggang/Rosie), +???
- Fire model; trace gas and aerosol emissions (Fang, Francis Vitt)

## Landscape dynamics

- Dynamic landunits (Bill S)
- iESM infrastructure (Andy Jones ???)

## Evapotranspiration, partitioning of ET

- Soil evap (Sean, Jinyun), canopy intercept/evap (Sean)
- Soil moisture stress (Pierre Gentine)
- Rooting depth (Dave)

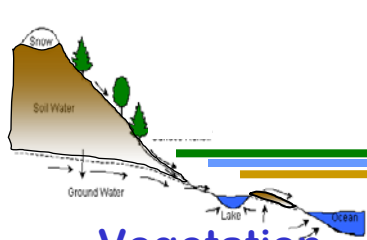
## Hydrology

- MOSART routing model (Hongyi, ???)
- Revised solution to Richard's eqn, variably sat flow (Gautam, Martyn)
- Wetland distribution, flooding (Sean)
- Water isotopes (Bill R, Bette, Tony W, Ben A)

## Dust emissions

- Revised dust emissions algorithm (Natalie)

# Development targets for CLM5



## Vegetation

- Stress deciduous phenology (Kyla)
- Ozone damage (Danica)
- Allocation, dyn to fixed (Charlie); canopy trimming or constant SLAI (Rosie)

## Carbon and Nutrient dynamics

- Default deep soil decomposability parameter change (Charlie/Dave)
- Plant N uptake / competition (LBNL, Chonggang)
- N-gas emissions, natural/agriculture (???)
- Leaching and riverine transport (Cindy)

## Agriculture

- Extend crops to global (Sam)
- Fertilization and manure (Sam, Beth)
- Pasture on agriculture landunit (???)

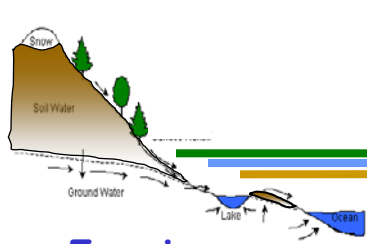
## Urban

- New building energy model, surface dataset (Keith)

## Snow

- Canopy snow radiation, unloading (Justin/Mark F)
- Snow vertical absorption (Mark F), permit deeper snowpack (Bill S)

# Development targets for CLM5



## Forcing

- GSWP3 dataset (available soon)
- Forcing humidity during precip (Sean, Dave)

## Datasets

- Shrub/tundra distribution in Arctic
- High resolution (Ben A ???)

## Infrastructure

- Hydro refactor including new solver options (Jinyun, Bill R, Gautam)
- N-competition refactor (Jinyun)
- Subgrid output (SE)
- Output levels (SE)
- Irrigation, fertilization transient data
- Hydro/energy params into params file (Maoyi)
- Remove CLM4?

# Task: Develop subgrid data archiving for selected key variables as default for CLM/CMIP

## Preliminary Subgrid Variable List

**tas\_sg** – near-surface air temperature  
**huss\_sg** – near-surface specific humidity  
**hfls\_sg** – latent heat flux  
**hfss\_sg** – sensible heat flux  
**rsus\_sg** – surface upwelling shortwave (albedo)  
**lai\_sg** – leaf area index  
  
**gpp\_sg** – gross primary productivity  
**npp\_sg** – net primary productivity  
**nee\_sg** – net ecosystem exchange (or NEP)  
**cSoil\_sg** – carbon mass in soil pool  
**cVeg\_sg** – carbon mass in vegetation  
**cLitter\_sg** – carbon mass in litter pool

<b>G</b> sgi=3	<b>Pasture</b> sgi=6	<b>Nat veg</b> sgi=1
<b>L</b> sgi=2	<b>V</b> PFT3	<b>V</b> PFT1
	<b>Crop</b> sgi=5	<b>V</b> PFT3
<b>U<sub>T,H,M</sub></b> sgi=4	<b>C1I</b>   <b>C1U</b>	
	<b>C2I</b>   <b>C2U</b>	

CLM  
str

Land



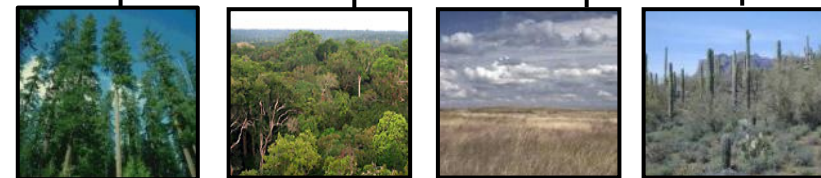
V

Column



SOIL

PFT



PFT1 PFT2 PFT3 PFT4 ...



pp



Unirrig



Irrig



Unirrig



Irrig



Crop1



Crop1



Crop2



Crop2 ...

# Dynamic Landunits: Current Status

Fast deglaciation experiment: 100% to 0% in 5 years

Year 1

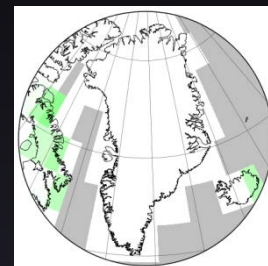
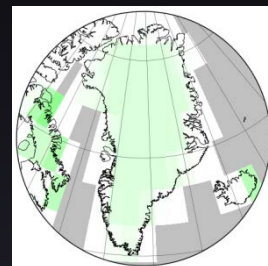
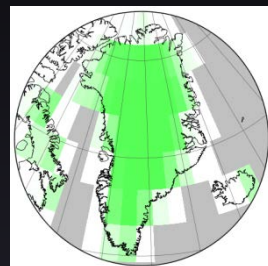
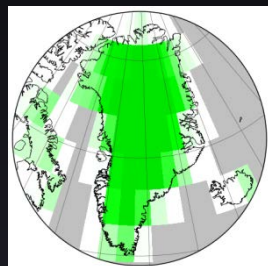
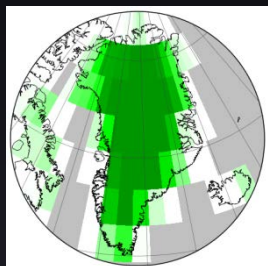
Year 2

Year 3

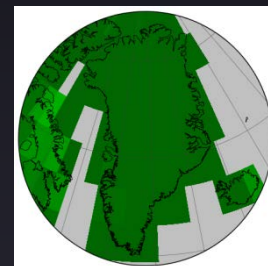
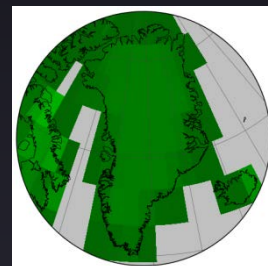
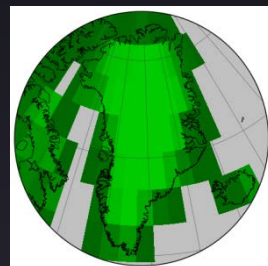
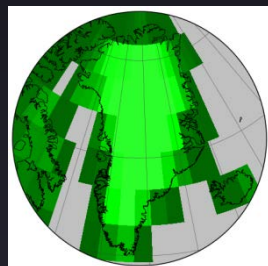
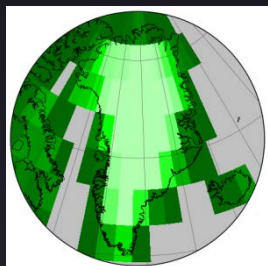
Year 4

Year 5

Glacier Area



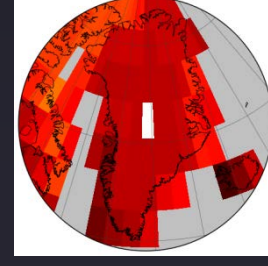
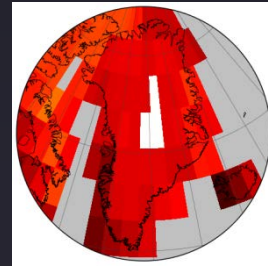
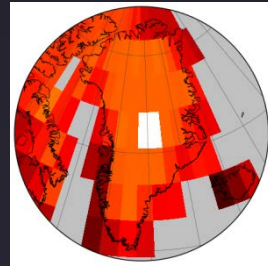
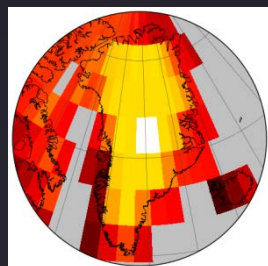
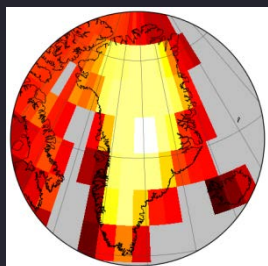
Natural Veg. Area



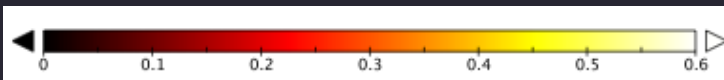
% of grid cell



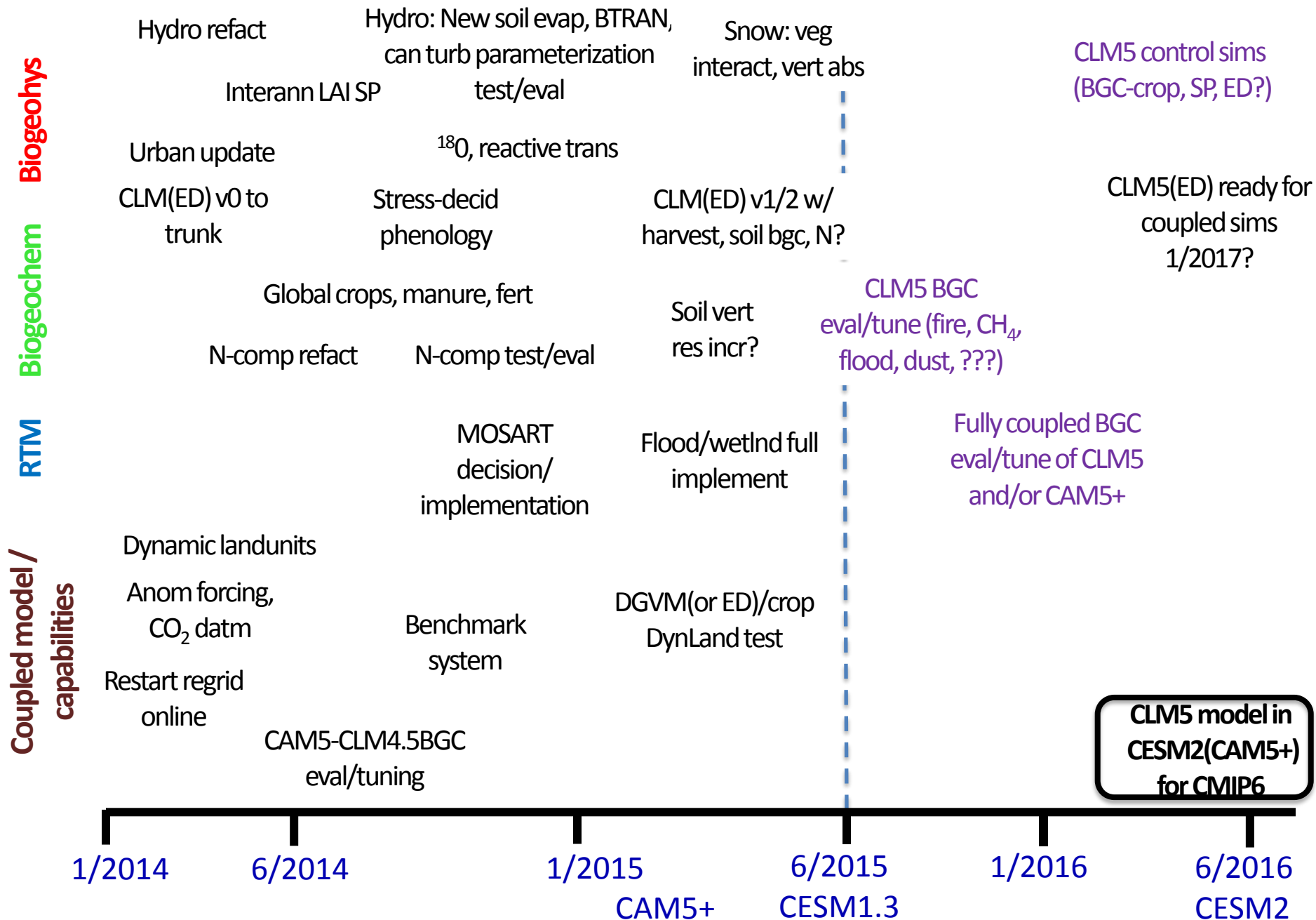
No-snow Albedo



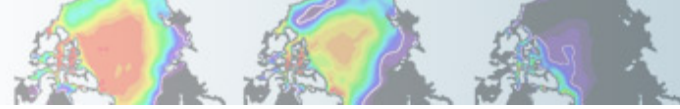
Albedo (fraction)



# CLM Development Timelines: *The path towards CLM5/CESM2*



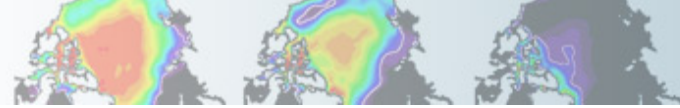




## WACCM Progress

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- Simulations for Chemistry Climate Model Initiative (CCMI)
- Internally generated Quasi-Biennial Oscillation (QBO)
  - High Vertical Resolution
- Developmental version of WACCM5 (CAM5 physics)
- WACCM-CARMA with sectional (bin) aerosols developed
- WACCM Last Millennium Simulation
- WACCM high spatial (25km, 0.1 scale height) resolution simulations
- WACCM-X ionosphere modules
- WACCM-DART data assimilation for the upper atmosphere
- WACCM Specified Chemistry (WACCM-SC): dynamics only
- WACCM-SE works, but production with SE depends on CSLAM

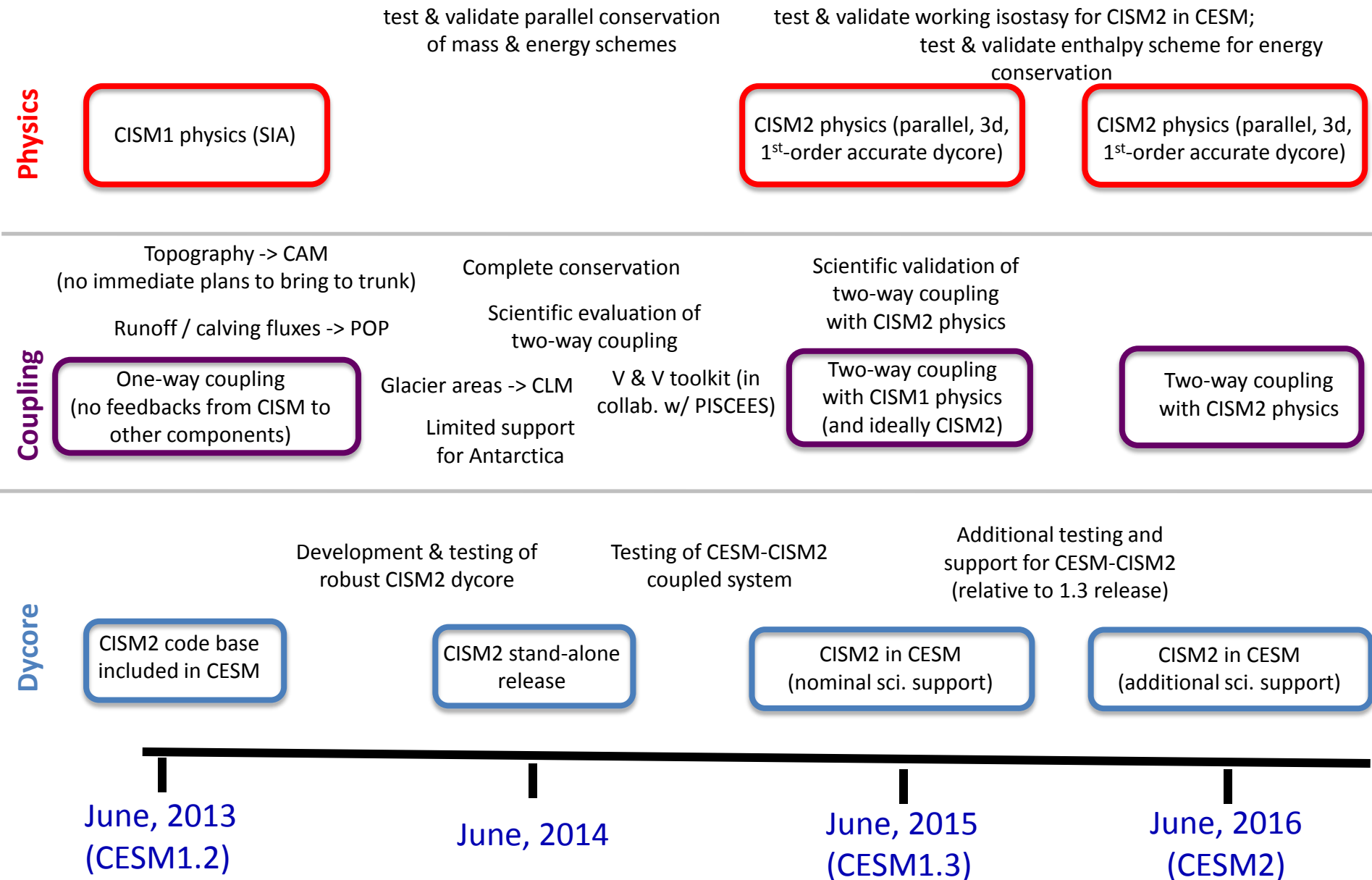


## WACCM Plans for CESM2

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- Prognostic Volcanic Sulfate
  - Better simulation of Volcanoes in ALL CESM2 configurations
- WACCM6 = CAM6+
  - CAM and WACCM use the same code base (including GW)
  - Same levels up to lower stratosphere (32 level CAM)
  - WACCM CMIP6 DECK experiments to provide forcing for non-chemistry versions
- WACCM-X Interactive Ionosphere
  - Goal: Represent (a) lower atmosphere drivers of space weather & climate and (b) downward impacts of upper atmosphere processes
- Updated 'Unified' Chemistry
  - Includes Halogens, Tropospheric & Stratospheric Chemistry
- Updated Gravity Waves
  - Inertial gravity waves (IGWs). Updated convective & orographic GW.

# CISM Development Timeline



# Chemistry-Climate WG development for CESM2

- Improve chemistry representation:
  - Implementation of FAST-J photolysis scheme, with CLOUD-J, accounting for impact of aerosols on photolysis
  - Evaluation of simple chemistry used in CAM5-MAM
  - Improvements to secondary organic aerosol (SOA) formation
  - Addition of nitrate aerosol
- Test CSLAM in Spectral Element dynamical core with chemistry
- Test couplings of land, biogeochemistry and atmospheric chemistry
  - Including methane, biogenic VOCs, fire emissions
- Test chemical representation in CAM5.5 at 1-degree