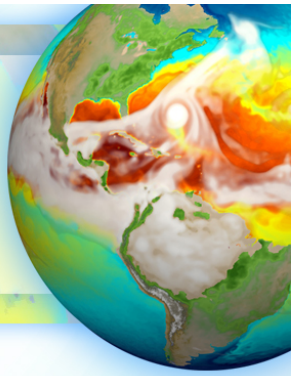


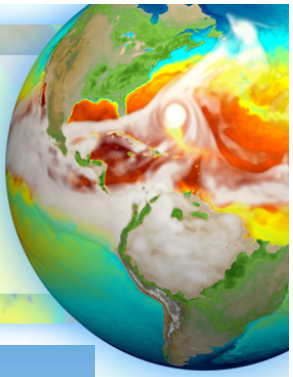
E3SM Next Generation Development (NGD): Land and Energy

Ben Bond-Lamberty

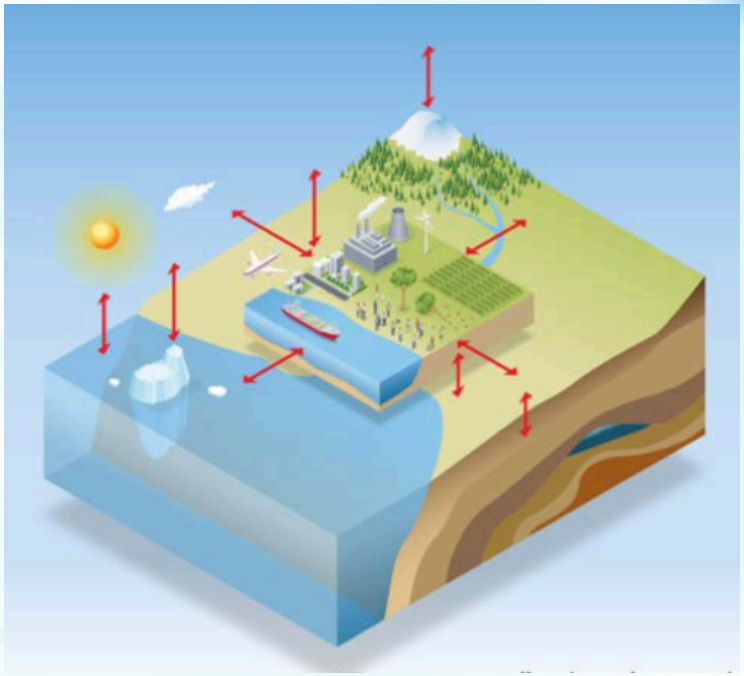
(on behalf of many)

E3SM All-Hands – October 26, 2020

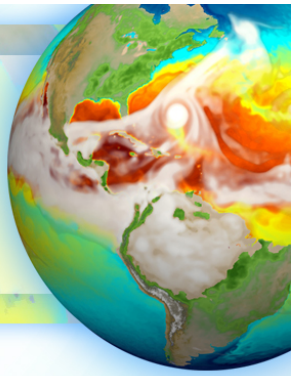
v3/v4 science questions



- **Water cycle**: How will the moisture sources and precipitation over land change?
- **Biogeochemistry**: What are the impacts of different energy and land use on land biogeochemistry and terrestrial-aquatic processes?
- **Cryosphere**: What are the implications of sea level rise and extreme storms for coastal inundation?

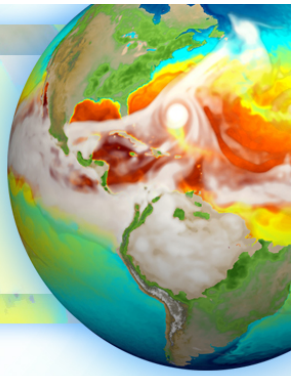


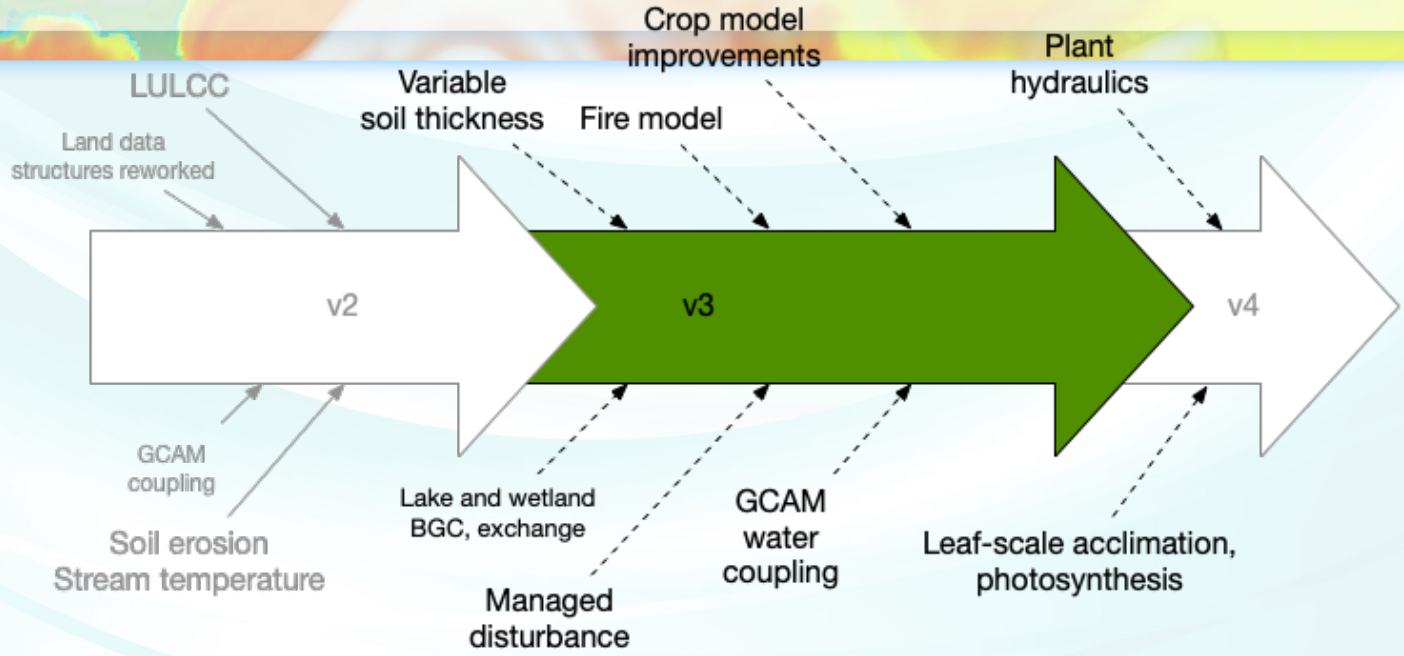
Model capability gaps



- For *water cycle* questions:
  - No subsurface lateral flow or influence of hydraulic traits on hydraulic mortality; these influence evapotranspiration
- For *biogeochemistry* questions:
  - Land use change and disturbance effects have known biases
  - Limited wetland/floodplain and no hyporheic zone
  - Limited interaction between vegetation dynamics and mortality
  - Known problems with photosynthesis/stomatal controls (again ET)
- For *cryosphere* questions:
  - Land-water interfaces not well modeled (above)

Land-Energy NGD overview





High-res NA GPU

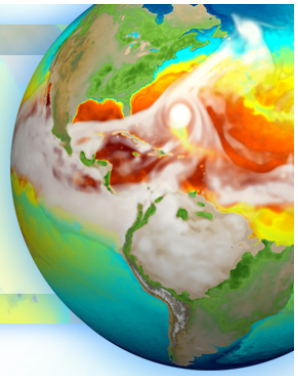
FATES

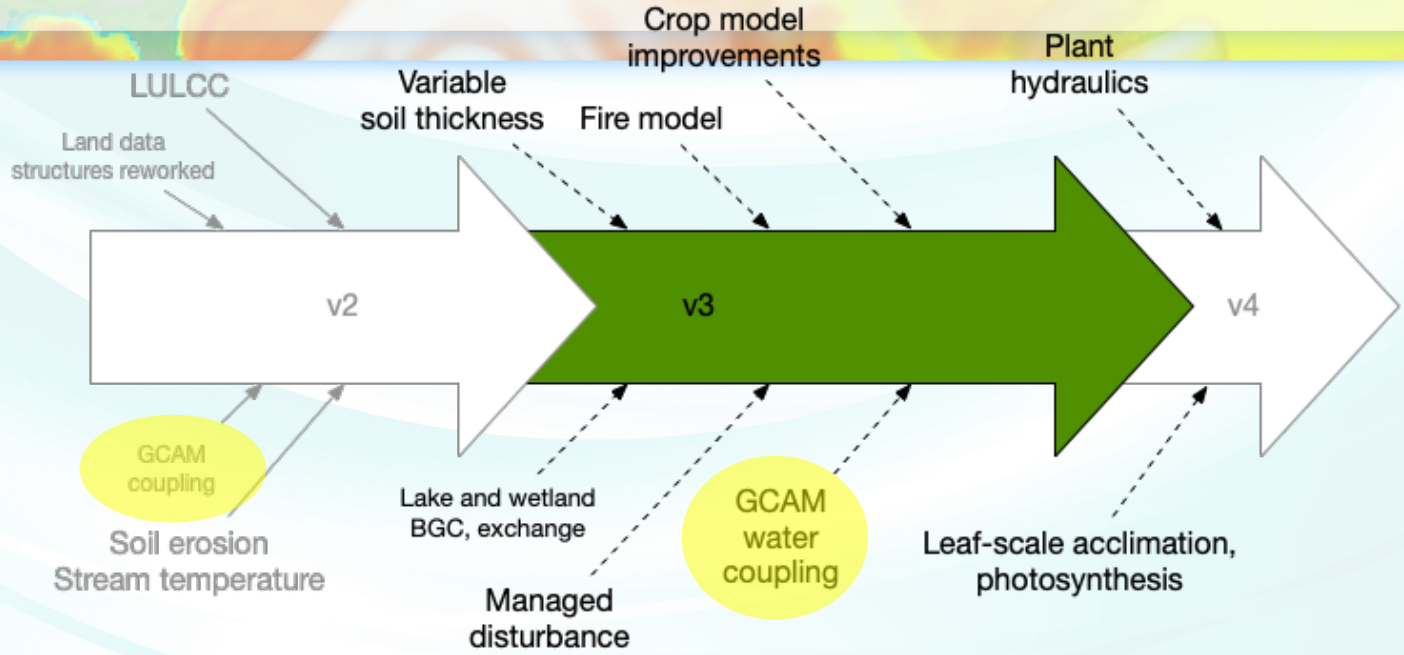
External model interface

E3SM Energy Exascale Earth System Model

U.S. DEPARTMENT OF ENERGY

Land-Energy NGD overview





High-res NA GPU

FATES

External model interface

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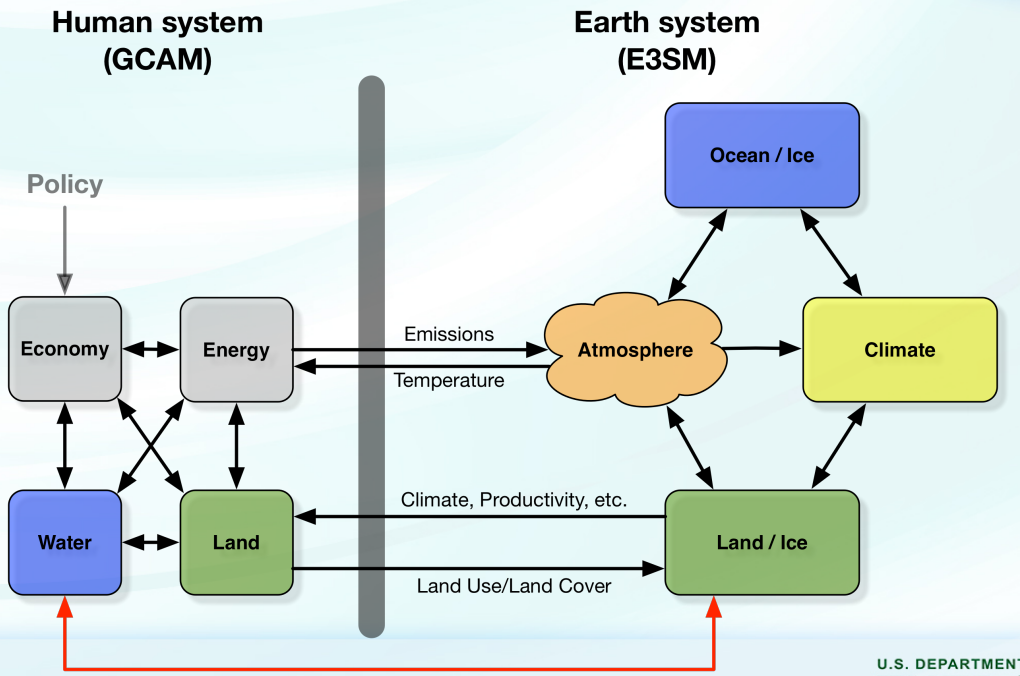
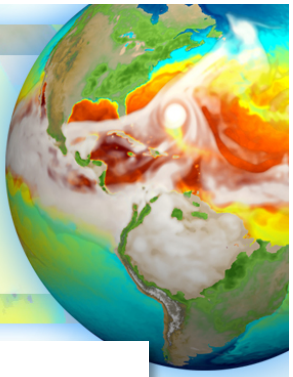
E3SM-GCAM coupling

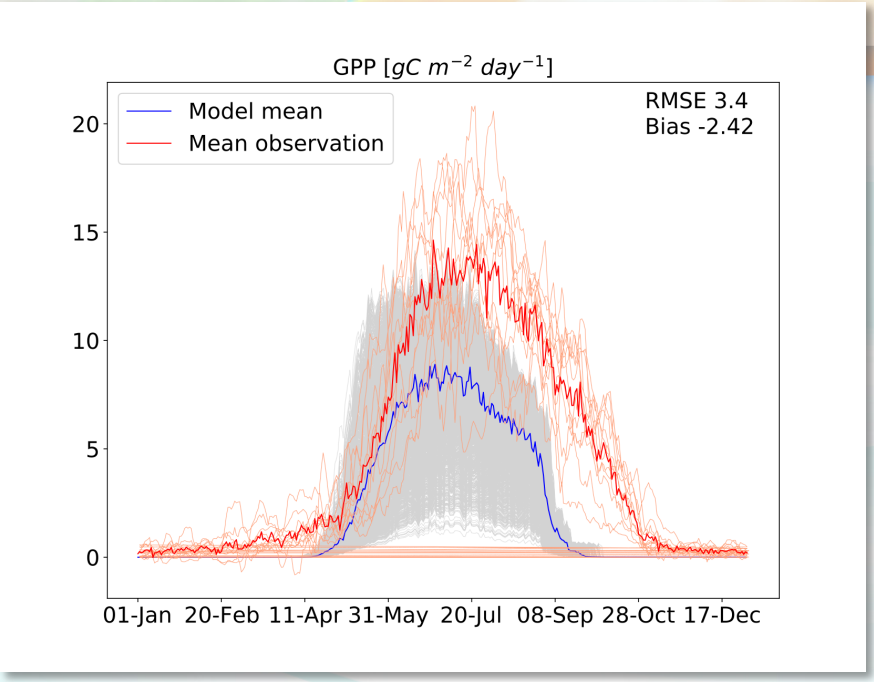
Land/energy
Water cycle
Biogeochemistry

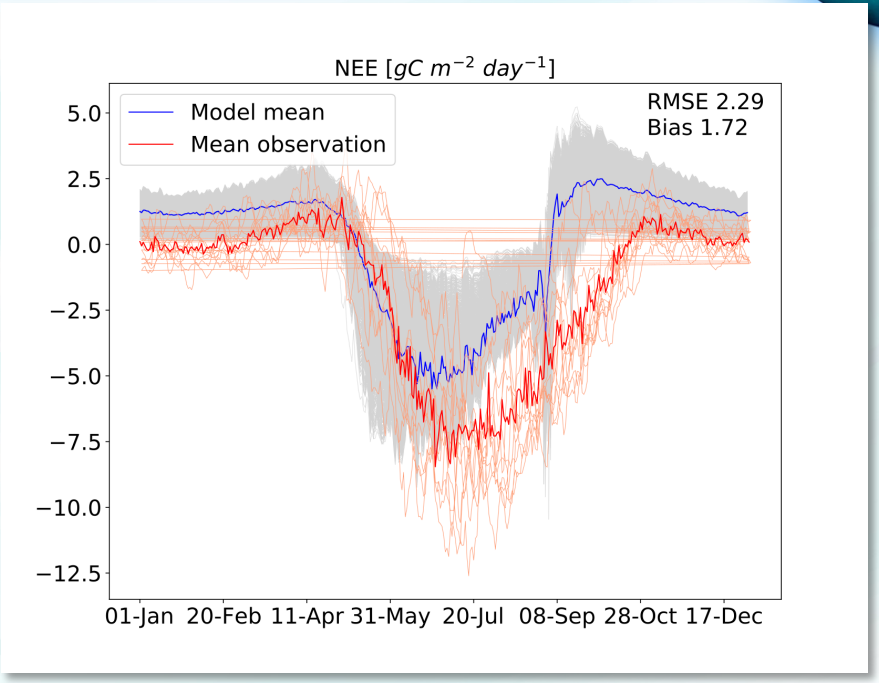
- v2 tasks finishing now
- For v3 will want to step back and re-think approach and tools (e.g. GLM)



Modeling Bioenergy Crops in ELM

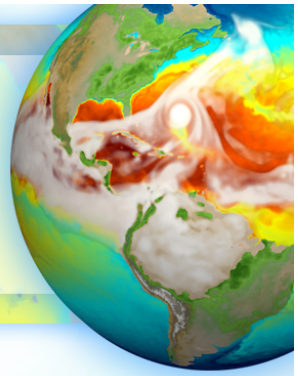


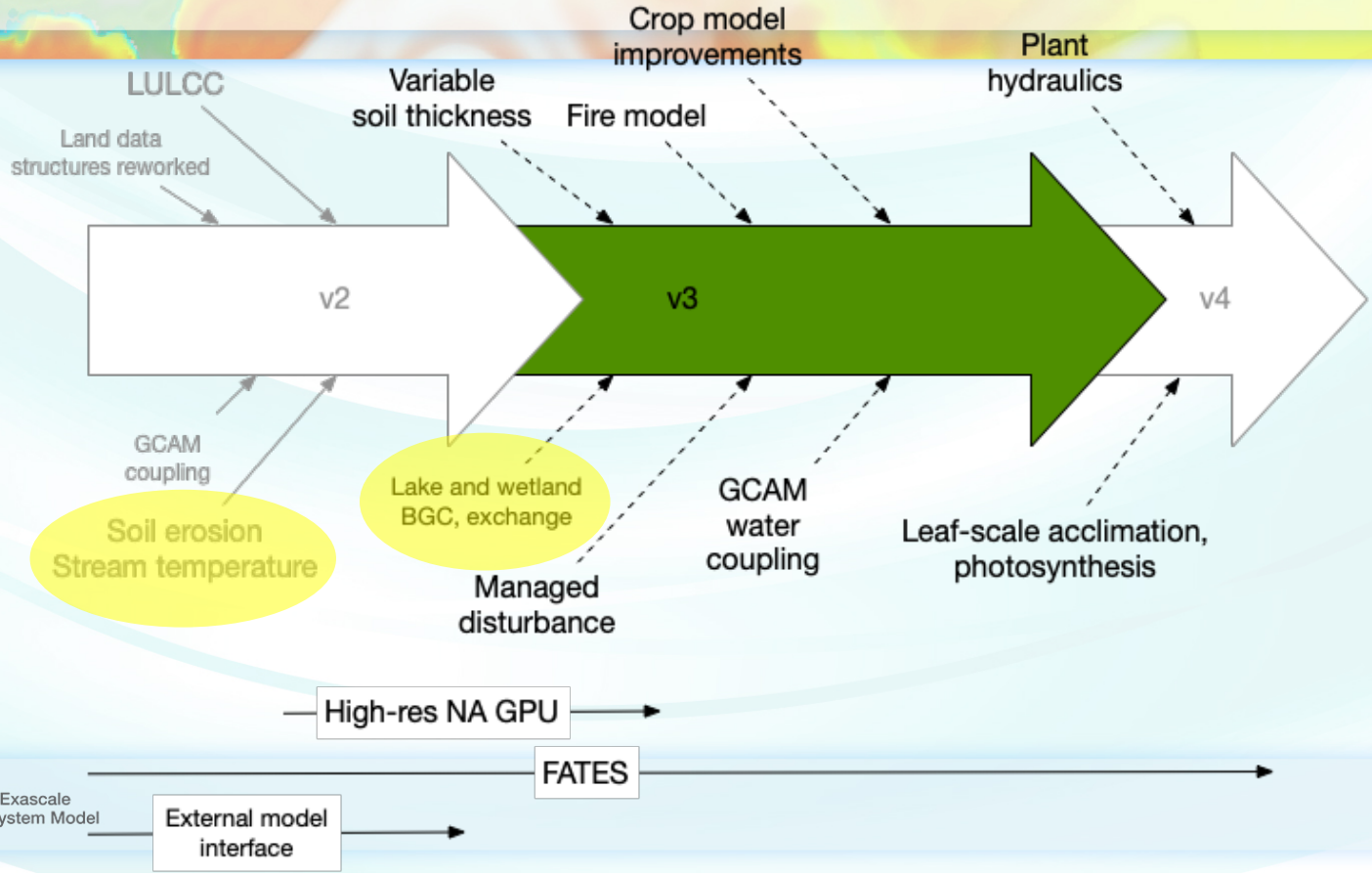




See Eva Sinha's poster on Tuesday (PS1)

Land-Energy NGD overview





E3SM Energy Exascale Earth System Model

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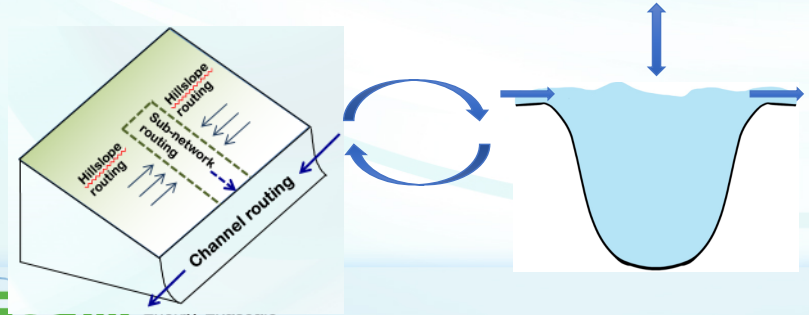
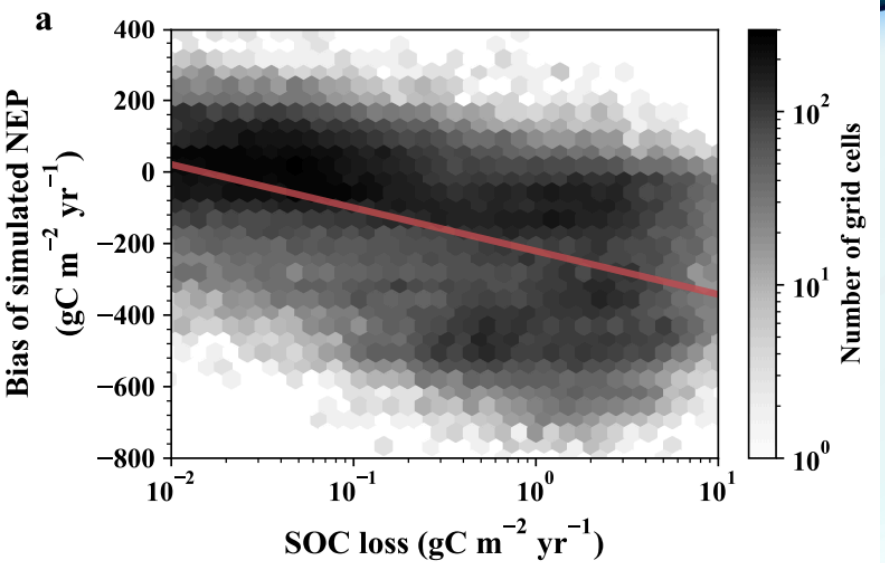
Progress - MOSART

Hydrology and plant hydraulics
Water cycle
Cryosphere

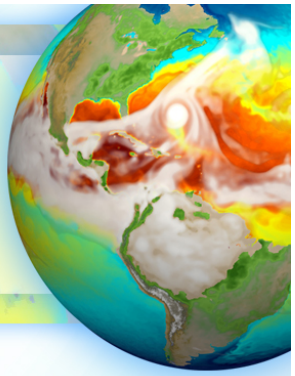
- MOSART-carbon, MOSART-lake, MOSART-wm etc. progressing on multiple fronts
- Papers on erosion, sediment transport, links with heterotrophic respiration in model

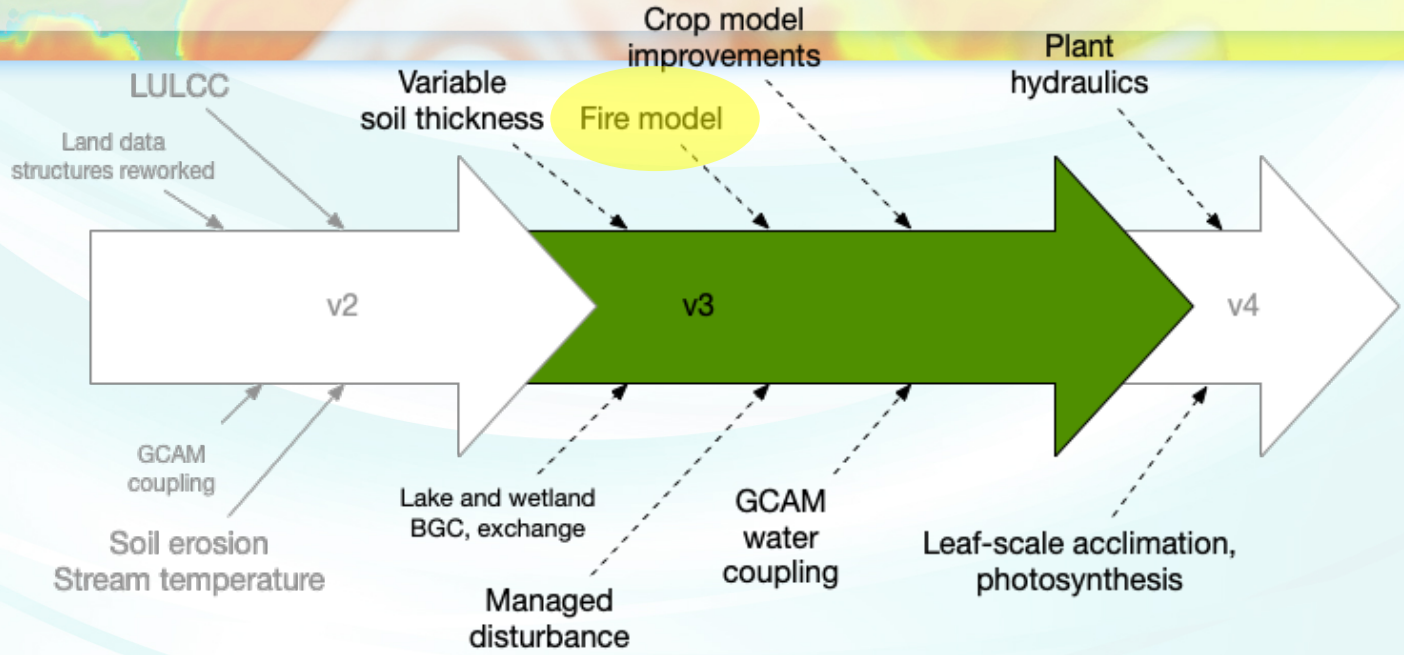




Tan et al. 2020 *Global Change Biology*

Land-Energy NGD overview





High-res NA GPU

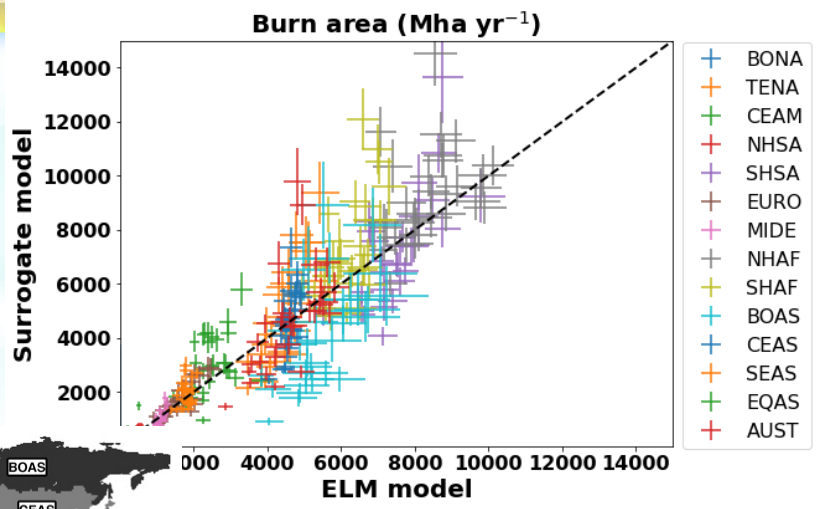
FATES

External model interface

Improving and simplifying the ELM fire model

Disturbances
Water cycle
Biogeochemistry

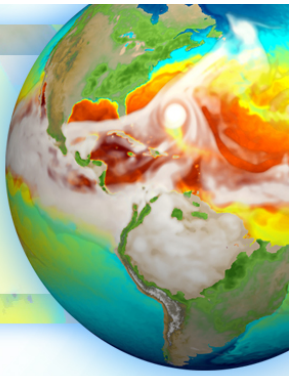
- Improve realism, and simplify structure, of the fire model
- First manuscript: fire emission effects
- Second phase
  - improving the fire model with GFED observations
  - ML fire model

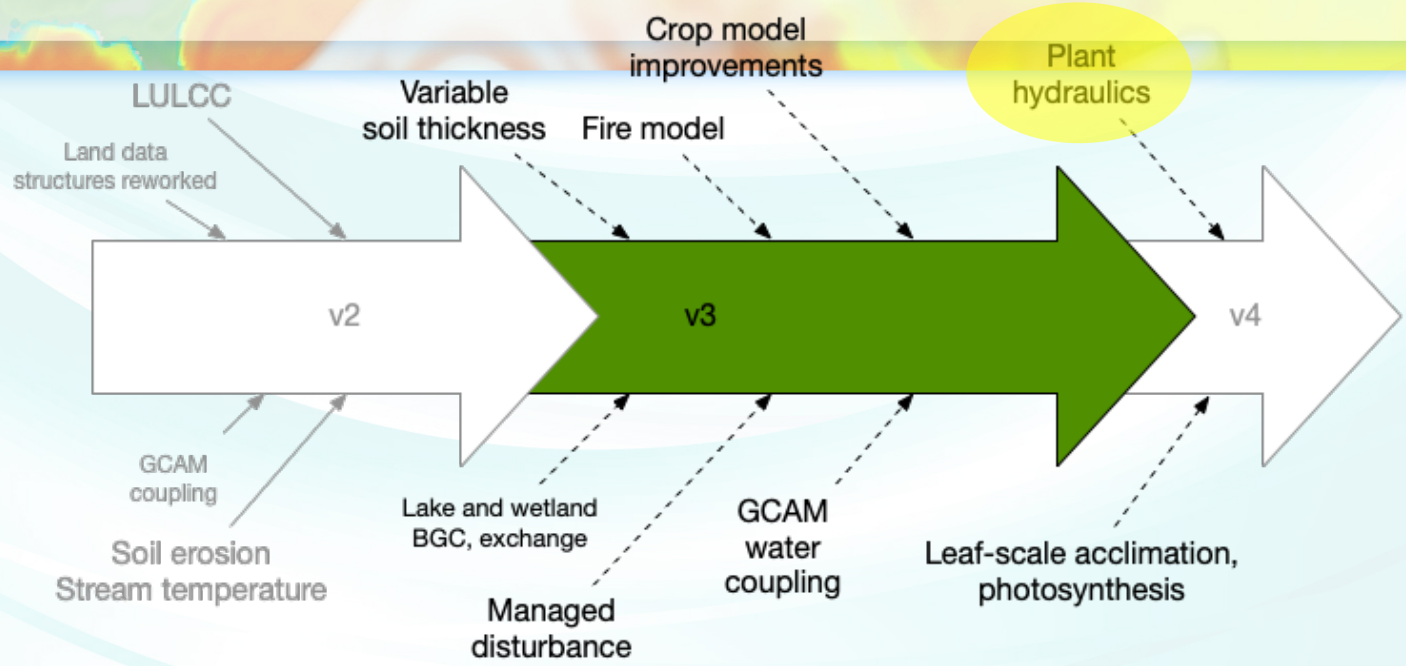


BONA	Boreal North America	NHAF	Northern Hemisphere Africa
TENA	Temperate North America	SHAF	Southern Hemisphere Africa
CEAM	Central America	BOAS	Boreal Asia
NHSA	Northern Hemisphere South America	CEAS	Central Asia
SHSA	Southern Hemisphere South America	SEAS	Southeast Asia
EURO	Europe	EQAS	Equatorial Asia
MIDE	Middle East	AUST	Australia and New Zealand

See Qing Zhu's talk on Thursday (D4S2 – BR#2)

Land-Energy NGD overview





E3SM Energy Exascale Earth System Model

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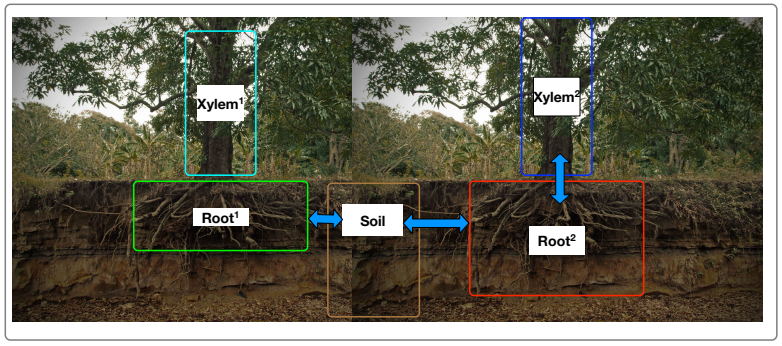
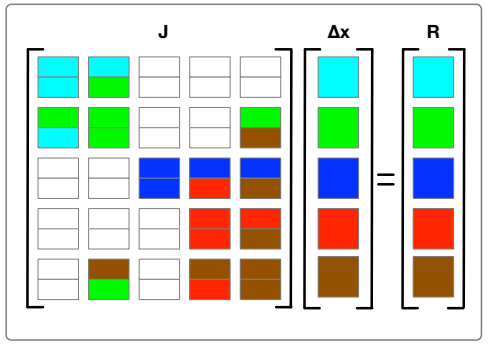
Development of a tree-level hydrodynamic model for ELM

Hydrology and plant hydraulics
Water cycle
Cryosphere

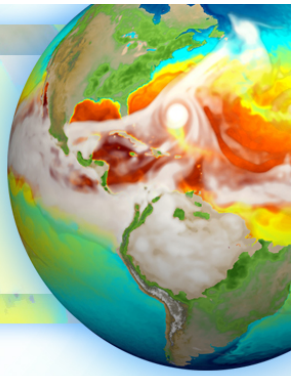
- Increasing vegetation mortality due to drought and temperature
- ELM-v1.0 excludes transport of water through vegetation structure and excludes competition for water
- Developed a tree-level hydrodynamic model that exploits PETSc's *DMComposite* to flexibly solve tightly coupled multi-physics problems

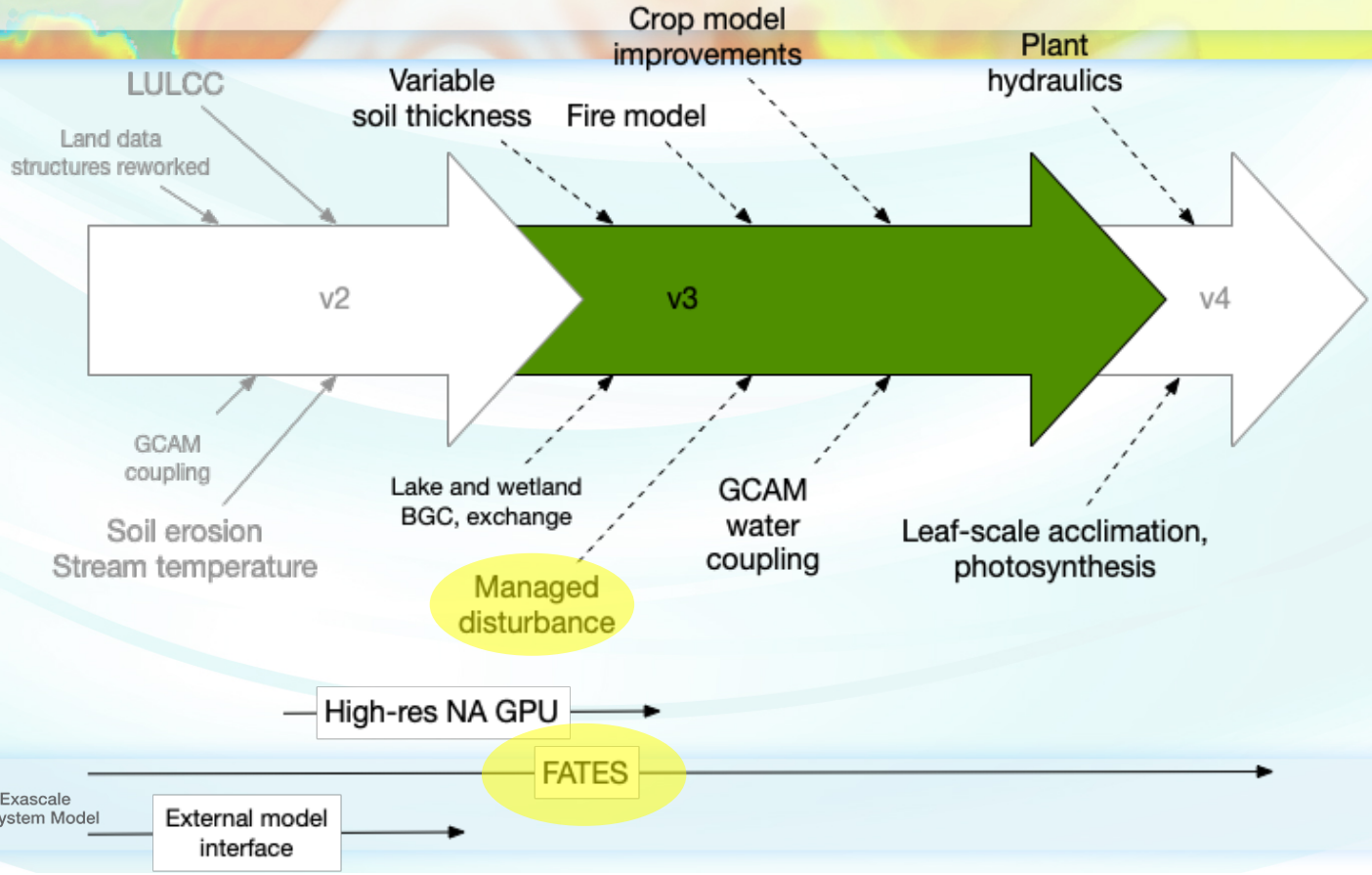




See Gautam Bisht's talk on Wednesday (D3S1 SciDAC #2)

Land-Energy NGD overview





E3SM Energy Exascale Earth System Model

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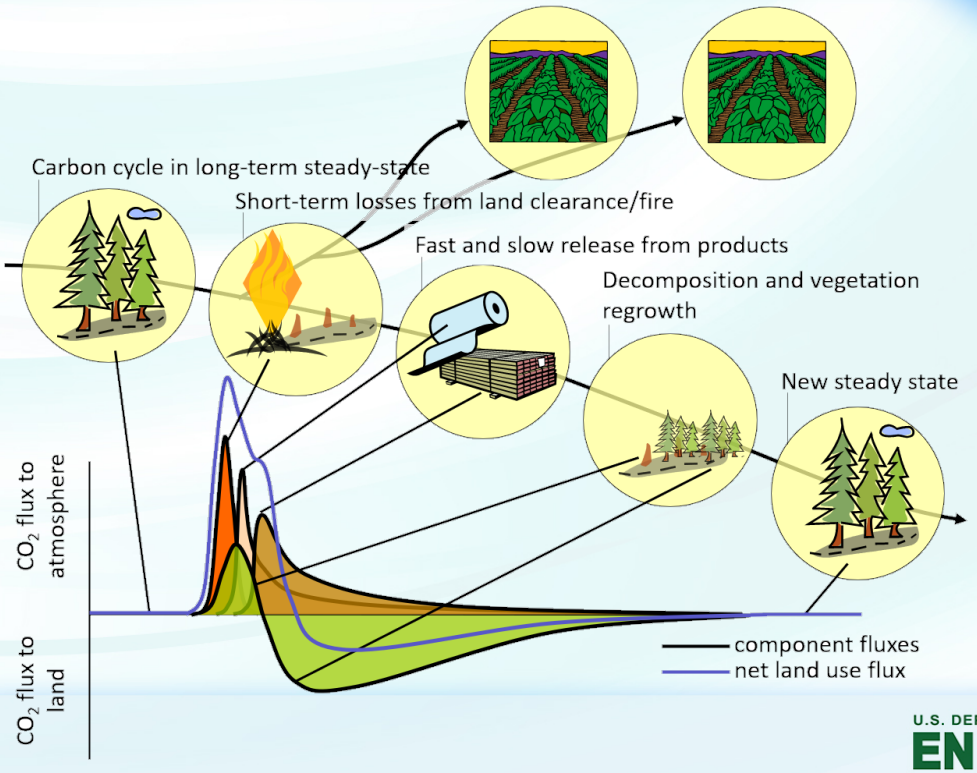
Managed disturbances

Disturbances
Water cycle
Biogeochemistry

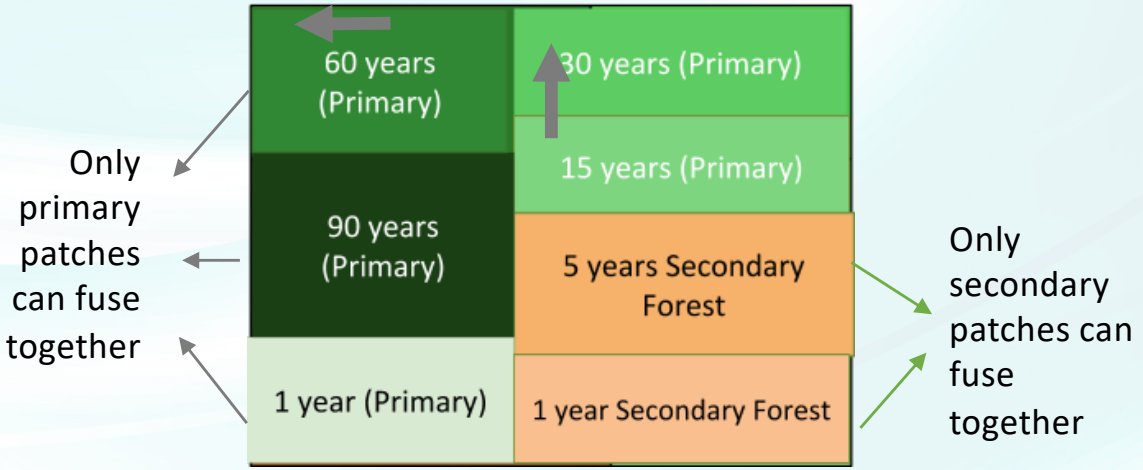
- ORNL coordinating with ANL on the use of LUH2 classes at the landunit level, including crop classes



First LULCC capabilities in ELM-FATES

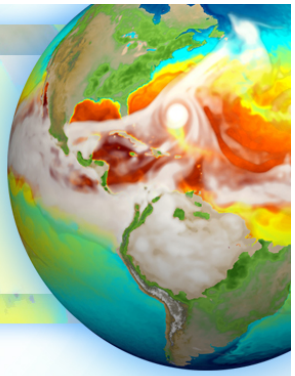
Vegetation dynamics
Biogeochemistry

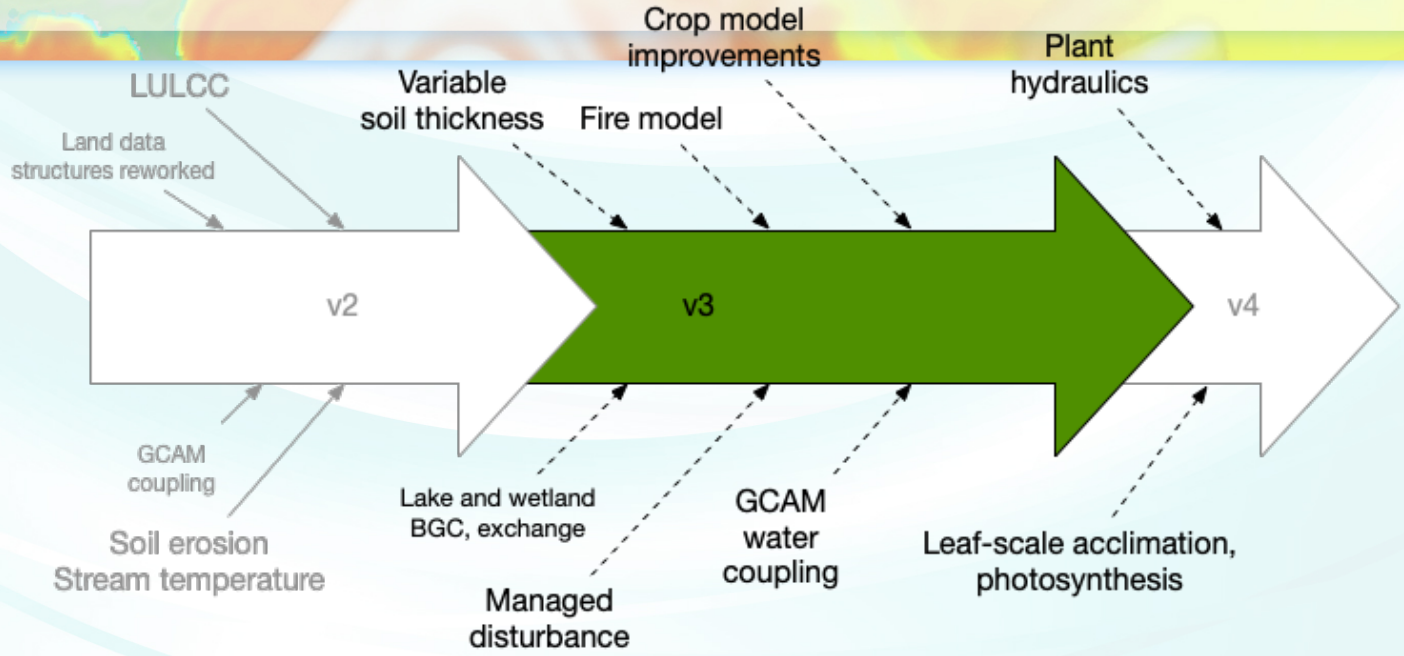
- Working on getting harvest into FATES; one benchmark run completed and a global one in progress
- Testing global run on Cori: CN-Harvest works the same as before (FATES not active, just ran for a couple of years)
  - Currently regrowing forest for testing FATES harvest



See Jennifer Holm's poster on Tuesday (PS1)

Land-Energy NGD overview





High-res NA GPU

FATES

External model interface

E3SM Energy Exascale Earth System Model

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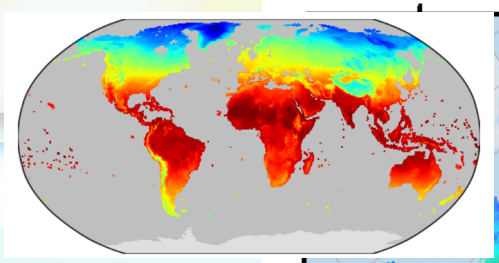
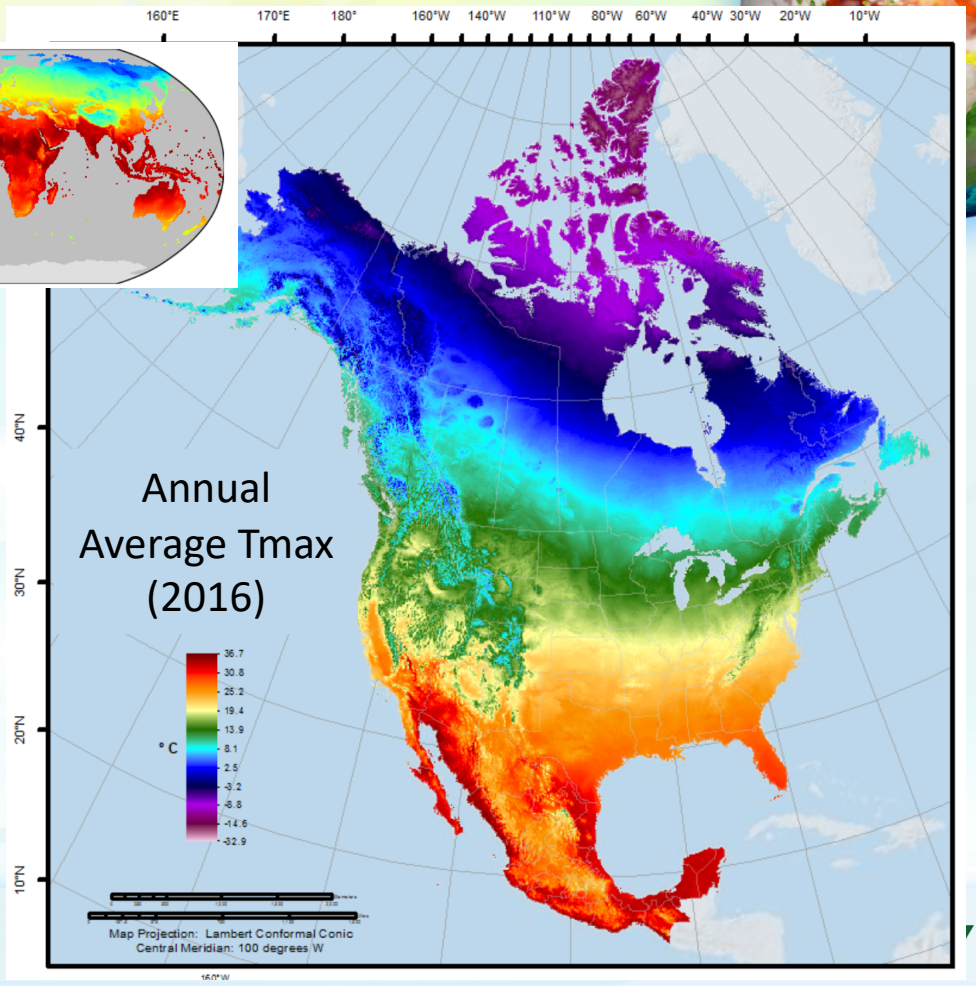
Target: 1 km^2 grid resolution over N. America

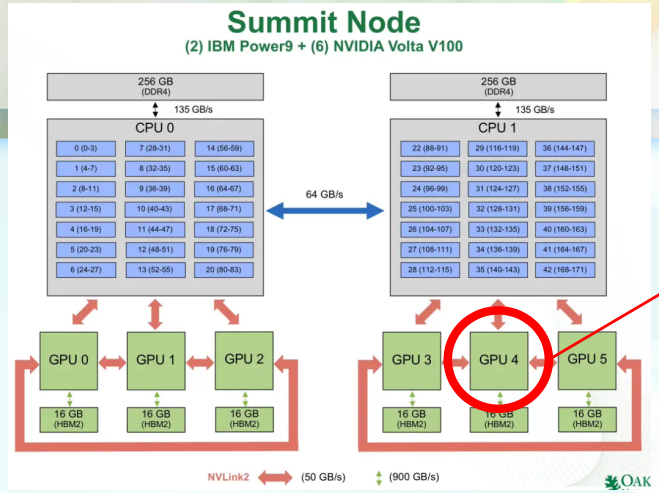


- Massively parallel ELM runs on Summit
- Refactoring, GPU performance optimization

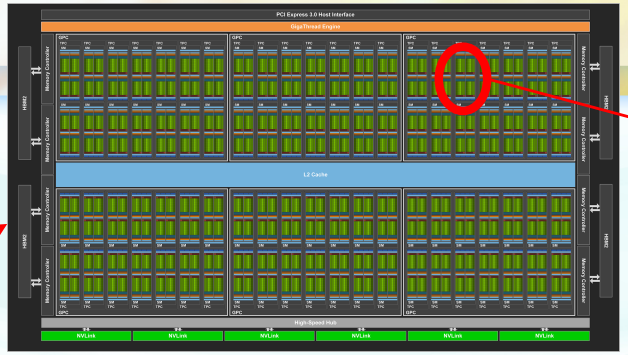


See Dali Wang's poster on Tuesday (PS1)

Computational strategy: OpenACC on Summit



Each Summit node has 6 NVIDIA Volta V100 GPUs. We plan to have 1 ELM MPI task per GPU, so 6 MPI tasks per node



Each GPU has 80+ Streaming Multiprocessors (SMs) and 16 GB of shared memory (HBM2)

Each SM has 32 double precision cores, which can be "over-subscribed" with threads to an extent that depends in part on availability of register space and heap space.

See Dali Wang's poster on Tuesday (PS1)

Questions?