Climate Science for a Sustainable Energy Future (CSSEF)

Project Objectives:

- Accelerate incorporation of new knowledge, including process data and observations, into climate models.
- Develop new methods for rapid evaluation of improved models.
- Develop novel approaches to exploit computing at the level of tens of petaflops in climate models.

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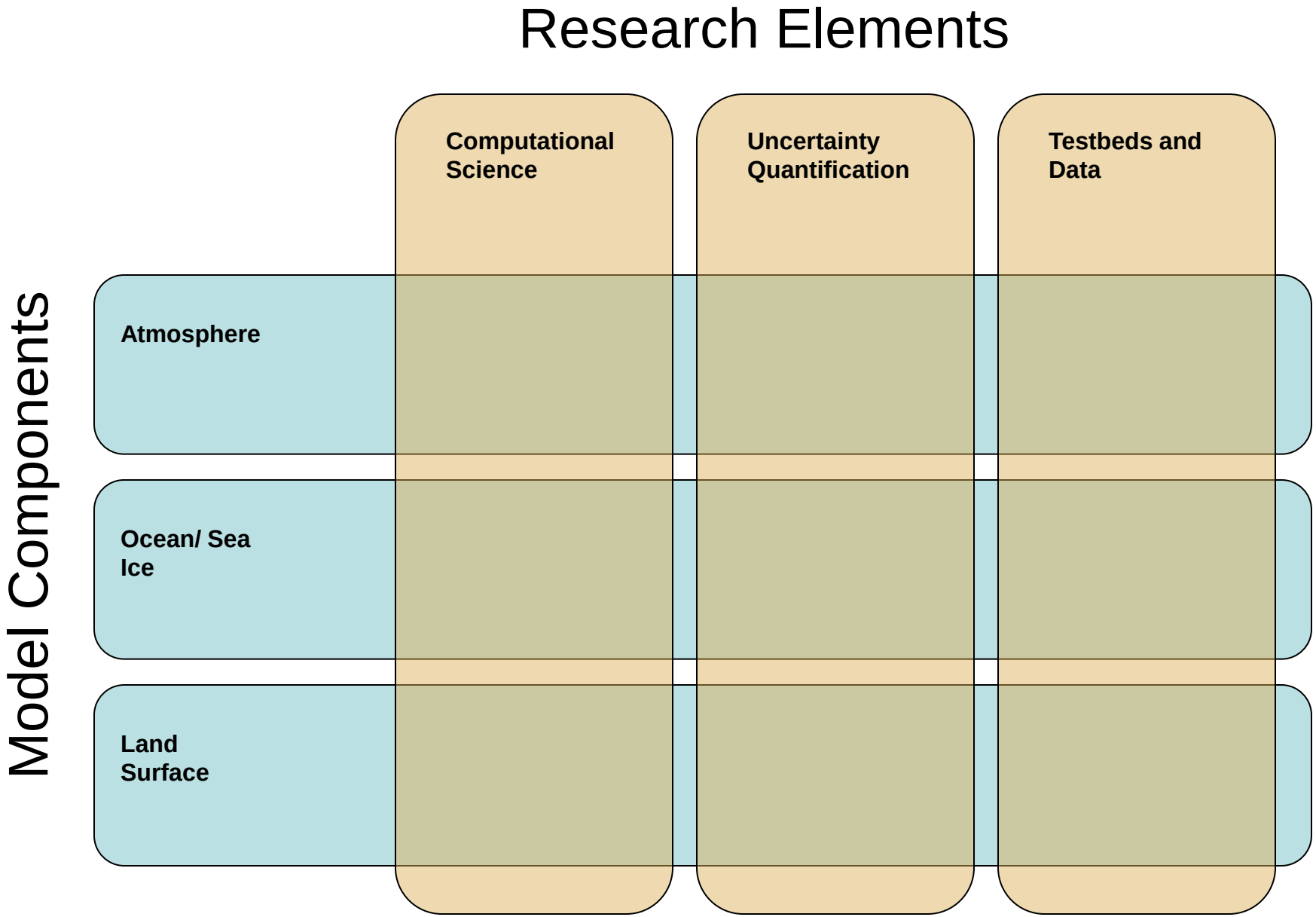
- Goal – Develop predictive capability to address key climate change science drivers in the 2015-2020 time period, i.e. to answer questions posed in the period after the publication of the IPCC 5th Assessment Report

- Directed toward the development of CCSM6 / CESM3 – two generations from current models

- 5 years, ~$15M/yr, nine institutions
- PI: Dave Bader, ORNL


Research Elements
Model Components
Computational Science
Uncertainty Quantification
Testbeds and Data
Atmosphere
Ocean/ Sea Ice
Land Surface

Land surface component

- Critical science questions
  - What are the magnitudes and dynamics of ecosystem-climate feedbacks?
  - How do land sub-grid hydrologic processes affect land-ocean-atmosphere interactions?
- For each of these questions:
  - What are the most important unresolved processes?
  - What are the critical underutilized datasets?
  - What are the connections to uncertainty quantification?
  - What are the implications for exa-scale computation?

What are the most important unresolved processes?

- Ecosystem-climate feedbacks
  - *Prognostic* land use (ag, biofuels, C plantation)
  - Age-class dynamics (incl. mortality, succession)
  - Soil C dynamics (*includes permafrost, CH_4*)
  - CO_2 and nutrient interactions (*includes warming effects*)
- Sub-grid land hydrology
  - Soil moisture and snow dynamics
  - In-stream transport of BGC species
  - Surface flows and distribution (connecting lakes and rivers, complex *and* flat terrain)

Uncertainty quantification

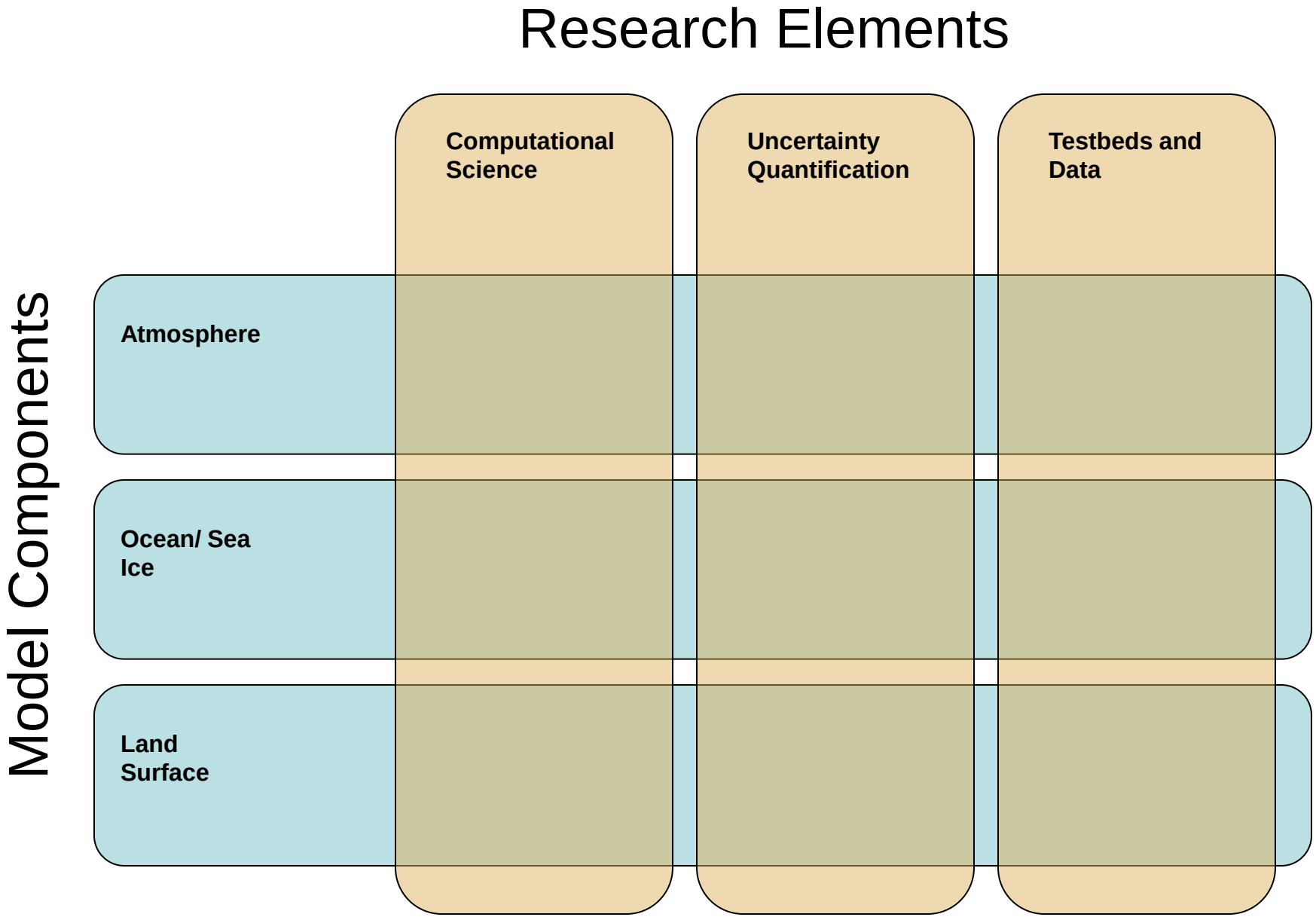
- Comprehensive sensitivity analysis
- Multi-variate, multi-site parameter optimization, with formal parametric uncertainty estimates.
- Characterize effects of forcing biases – error propagation.
- Re-evaluation of parametric uncertainty as model structure changes (during process development work).
- Scaling uncertainty (point to gridcell)
- Coupled model dynamics (feedbacks)

What are the critical underutilized datasets?

- Get existing CLM/CLAMP datasets into ESG
- High-resolution weather forcing (space and time)
- Remote sensing obs of surface characteristics
- Flux observations (FluxNet, soil respiration)
- Inventory (age, biomass, soil C/N, ^{14}C)
- Nested watershed measurements
- Land cover history (high-resolution, 20 yrs)
- Field campaigns (FIFE, BOREAS, LBA)
- Atmospheric trace gas concentrations
- Ecosystem response expts (FACE, warming, fertilization, new multi-factor expts)
- New dataset: plant functional types

Testbed development

- Organize new datasets and code base for push-button model evaluation, point and grid-based UQ
- Demonstrate this capability with new model development on a small number of critical unresolved processes
- Provide guidance to new observations/experimentation
- Testbed extensible to new datasets
- Interaction with other component model testbeds – coupled system evaluation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