Science Drivers as Guides for Model Development

- How do the hydrological cycle, and water resources, interact with the climate system on local to global scales?
- How do biogeochemical cycles interact with global climate change?
- How do rapid changes in cryospheric systems interact with the climate system?
- How do short-term variations in natural and anthropogenic forcings interact with natural variability and contribute to regional and global environmental change?
**Science Drivers ➔ questions ➔ hypotheses**

- **Driver:** How do short-term variations in natural and anthropogenic forcings interact with natural variability and the rates of global environmental change?

- **Question:** What are the relative contributions of human perturbations through changes in greenhouse gases, aerosols, land use/land cover, human water systems, and urbanization to climate extremes in the past?
  - What are the signatures of human perturbations on climate extremes? Are they distinguishable from each other and from the noise?

- **Falsifiable Hypotheses:** Human perturbations have contributed to detectable changes in climate extremes such as floods, droughts, heat waves in the past.
  - Global warming has increased land-atmosphere coupling strength, leading to more extreme heat waves and droughts in hot spots of land-atmosphere feedbacks.
Computational Driver: Preparation for Exascale

- **2002**
- **2004**
- **2006**
- **2008**
- **2010**
- **2012**
- **2014**
- **2016**
- **2018**
- **2020**
- **2022**
- **2024**
- **2026**
- **2028**
- **2030**

- **fastest computer's operations per second**
  - **terascale (2000s)**
  - **petascale (today)**
  - **exascale (2022?)**

- **projected growth**
- **actual growth**

- **2006**
- **~200km**

- **2012**
- **~25km**

- **2022**
- **~1km**
Computational Challenges

- Reasonable time to solution for experiments supporting DOE’s climate-science mission.
- Performance portability to rapidly evolving petascale to exascale architectures.
- Attainment of greater accuracy, portability, and scalability using advanced SciDAC math methods.
- New multiscale methods for ocean/atmosphere/ice dynamics required for science experiments.
- New methods to address model complexity and extensibility with proven testing capability.