

E3SM Energy Exascale Earth System Model

U.S. DEPARTMENT OF ENERGY · OFFICE OF SCIENCE

# The Energy Exascale Earth System Model

## Project Overview · 2026

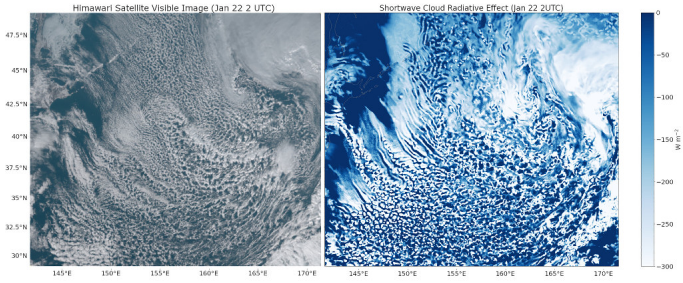
The Energy Exascale Earth System Model (E3SM, e3sm.org) is the U.S. Department of Energy's flagship Earth system model. Built to run efficiently on DOE's leadership supercomputers, it gives a broad research community the tools and knowledge to prepare for weather-related disasters, optimize U.S. energy use and production, and ensure water security.

### WHAT IS E3SM?

E3SM is a fully coupled model of the atmosphere, ocean, sea ice, land, rivers, land ice, and human systems, built by about 100 scientists and engineers at DOE laboratories and universities. E3SM is known for technological innovation: it won a 2023 Gordon Bell Prize and has practiced open development since 2018.

### CURRENT FOCUS

- Seasonal-to-decadal (S2D; 3 months to 10 years) prediction for energy and water security.
- High-resolution global simulations, needed to understand extreme events that disrupt energy supply, demand, and infrastructure.
- Transformative technology (exascale, SI, and quantum), such as SI emulators that make ensembles of fine-scale global simulations possible.




**Comparison between satellite and SCREAM simulation.** Cold-air outbreak off Siberia on January 22, 2020 at 2:00:00 UTC (~local noon) from a Himawari visible satellite image (left) and shortwave cloud radiative effect from SCREAM (right). Visualization is over a region bounded by 29°–49°N and 141.5° to 171.5°E.

### FUTURE GOALS

- **v4 release in 2028:** ~10 km grid spacing in all components, a single grid for all surface components, exascale-ready (C++/Kokkos) atmosphere and ocean, and swappable SI emulators.
- **v5 release in 2031:** fuses the OMEGA ocean model with a new particle-based sea-ice model and weaves SI into physics processes for drastically improved skill.
- Initialized hindcast ensembles, publicly available for predictability research.
- Sensitivity studies and explainable SI to answer the science questions below.

### MOTIVATING SCIENCE QUESTIONS

**Q1** How do ocean–cryosphere memory reservoirs and their teleconnection pathways modulate North American S2D predictability?

**Q2** Is local land–atmosphere interaction more important for S2D skill over land than land-induced remote teleconnections?

**Q3** How do large-scale environments, local feedbacks, and human systems such as urbanization and irrigation drive extreme and compound events?

**Collaborate with E3SM**
Scan to submit a collaboration request

# Model Versions

## E3SM RELEASES

- **v3.0 low resolution** is the most recent model release (v3.0 tag, May 2024).
- **v3 high resolution** is midway through its simulation campaign (v3.2 tag, November 2026).
- **v4** will be released in January 2028.

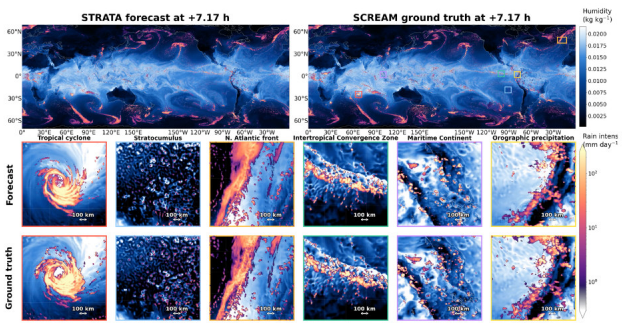
| Resolution | Atmosphere | Ocean / sea ice | Land |
|---|---|---|---|
| **v3 Low res** | 100 km | 30–60 km | 0.5° |
| **v3 High res** | 25 km | 6–18 km | 0.25° |
| **SCREAM** | 3 km | N/A | 3 km |
| **v4** | 12 km | 6–18 km | 10 km |

## NOVEL CAPABILITIES

- An SI emulator for every future physics-based release
- Two-way coupling with human systems (GCAM)
- Prognostic Greenland ice sheet (MALI)
- High-resolution atmosphere component (SCREAM)
- Coupled irrigation and water management
- Coupled biogeochemistry
- Regionally refined grids for all components
- Two-way coupling with ocean waves (WW3)
- Ice-shelf cavities
- Prognostic modal aerosols (MAM4) in SCREAM
- Expanded crop types and crop management

## SI EMULATORS

Starting with v4, E3SM will release emulators alongside its physics-based model. The E3SM model will also have the ability to run with some components emulated and others physics-based. Establishing what the emulators are and aren't good for will be an important line of scientific inquiry.




E3SM v3 physics (SCREAM) vs. its SI emulator (STRATA, developed in partnership with NVIDIA).



E3SM Energy Exascale Earth System Model

Scan for code, documentation, and data:

GitHub | Docs | Data

**e3sm.org**
**github.com/E3SM-Project**
**docs.e3sm.org**
**docs.e3sm.org/e3sm_data_docs**
**e3sm.org/news/newsletter-archive**

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