NOAA: Science, Service, Stewardship

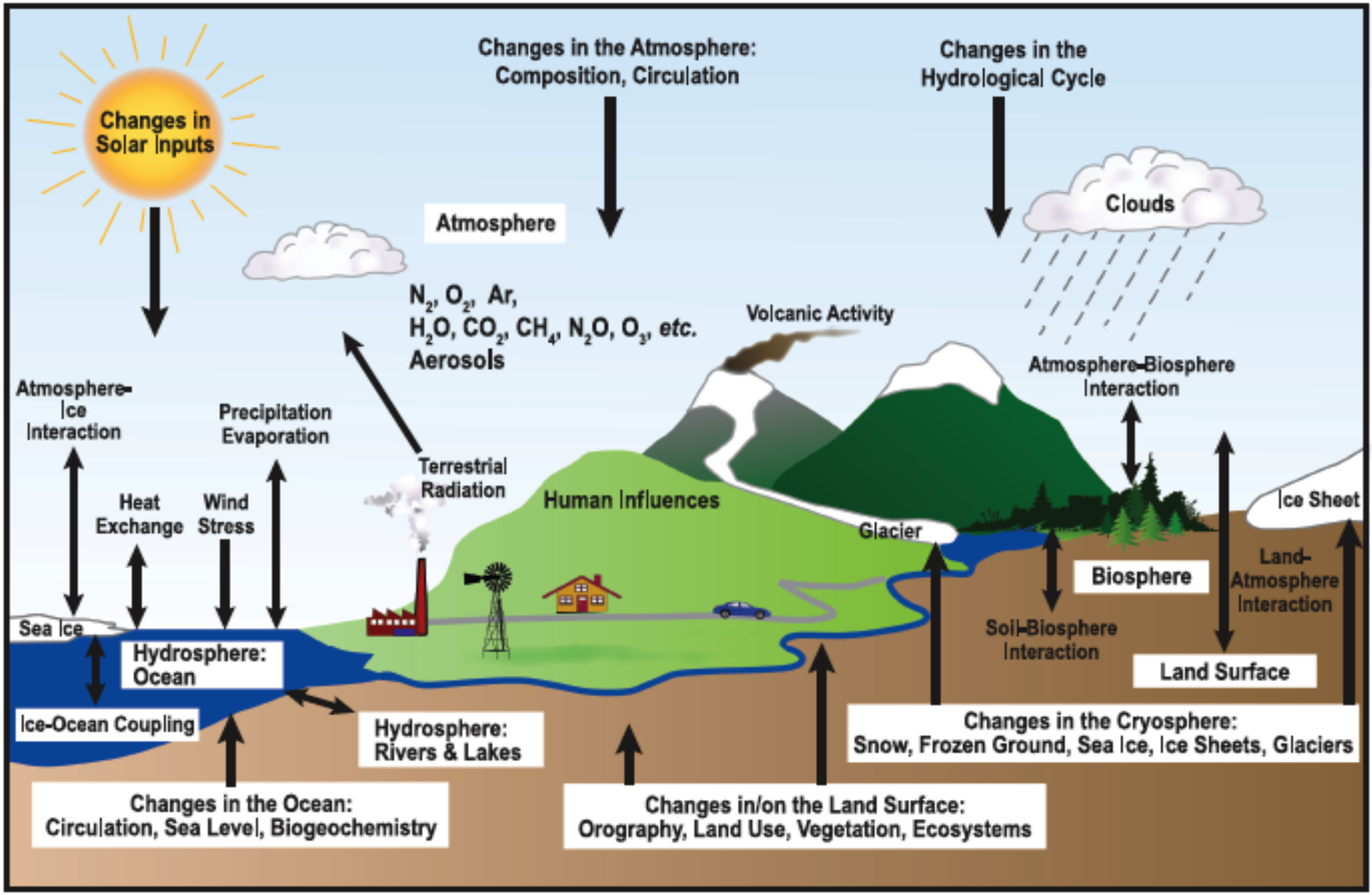
GFDL
(Founded 1955)

GFDL Research ➔ supporting the DOC, NOAA and OAR Objectives

"To advance scientific understanding of climate and its natural and anthropogenic variations and impacts, and improve NOAA's predictive capabilities, through the development and use of world-leading computer models of the Earth System."

Partnership with Princeton University since 1968

The Earth System
(Atmosphere, Oceans, Biosphere, Cryosphere, Ecosystems)



The Earth System
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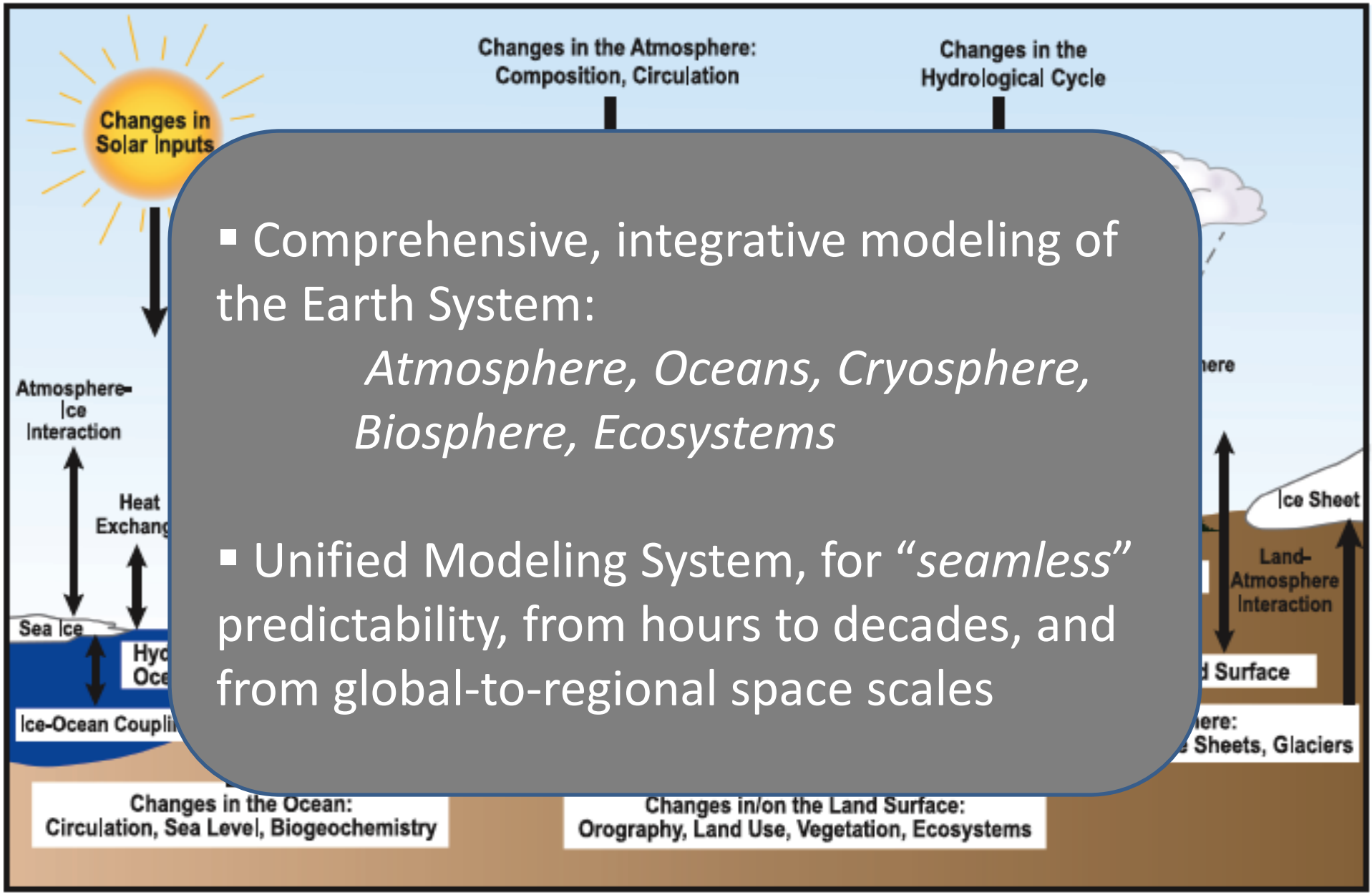


- Comprehensive, integrative modeling of the Earth System:

  Atmosphere, Oceans, Cryosphere, Biosphere, Ecosystems

- Unified Modeling System, for "*seamless*" predictability, from hours to decades, and from global-to-regional space scales

Major advancements in weather and climate science have come about with

- **Improvements in theory & observations;**
- **Improved understanding of processes; and**
- **Advances in computational modeling**

Oceans, Atmosphere, Biosphere, Cryosphere, Ecosystems

Mathematical Modeling

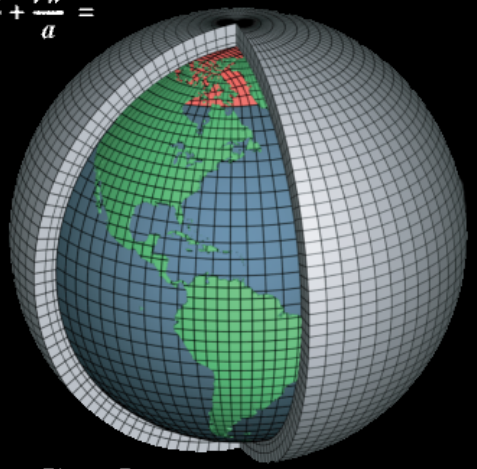
$$\frac{\partial v}{\partial t} + \frac{u}{a\cos\phi}\frac{\partial v}{\partial \lambda} + \frac{v}{a}\frac{\partial v}{\partial \phi} + w\frac{\partial v}{\partial z} + \frac{u^2\tan\phi}{a} + \frac{vw}{a} = -\frac{1}{\rho_0 a}\frac{\partial p}{\partial \phi} - fu + F^{\phi}$$

$$f = 2\Omega\sin\phi$$

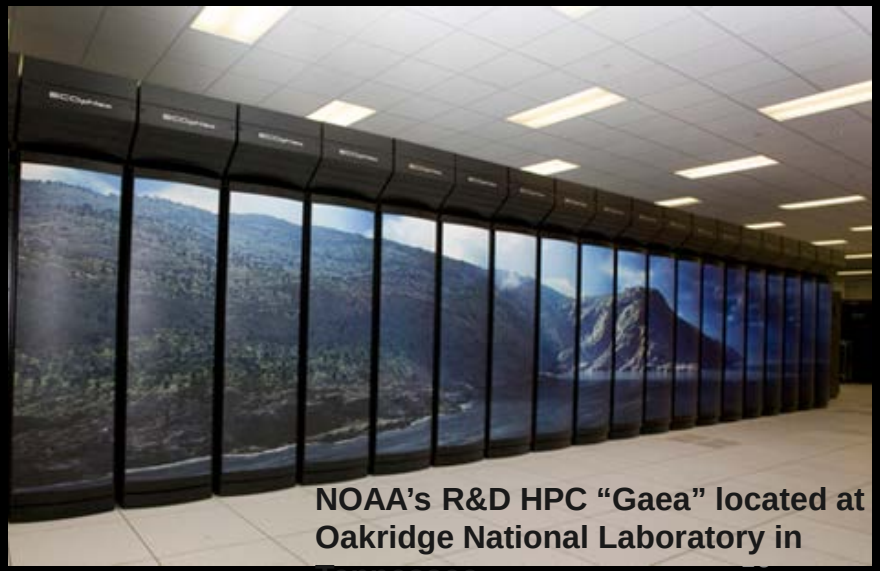
$$p(z) = \int_z^0 \rho g\,dz + p_s$$

$$\frac{1}{a\cos\phi}\frac{\partial u}{\partial \lambda} + \frac{1}{a}\frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0$$

$$\frac{dT}{dt} = \frac{u}{a\cos\phi}\frac{\partial T}{\partial \lambda} + \frac{v}{a}\frac{\partial T}{\partial \phi} + w\frac{\partial T}{\partial z} + D^{T\lambda} + D^{T\phi} + D^{Tz}$$



High-Performance Computing

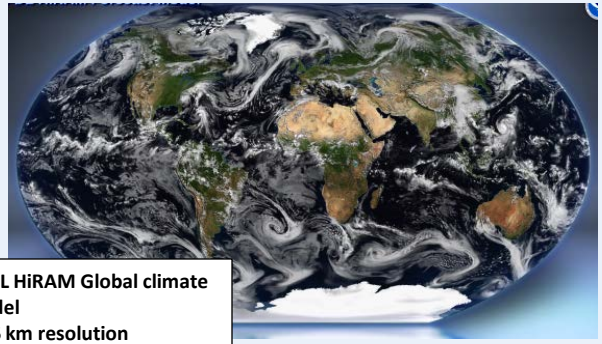


NOAA's R&D HPC "Gaea" located at Oakridge National Laboratory in Tennessee

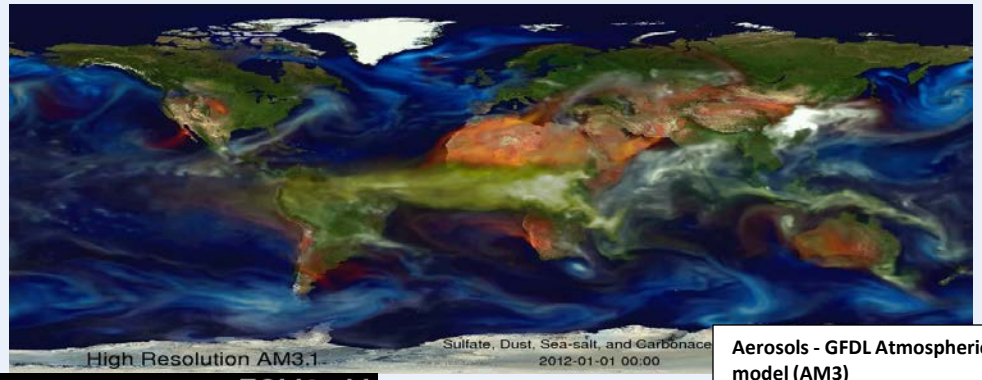
Use-inspired Research →

"Seamless" models across weather to climate timescales

[powered by the NOAA "FV3" atmospheric dynamical core, and MOM]



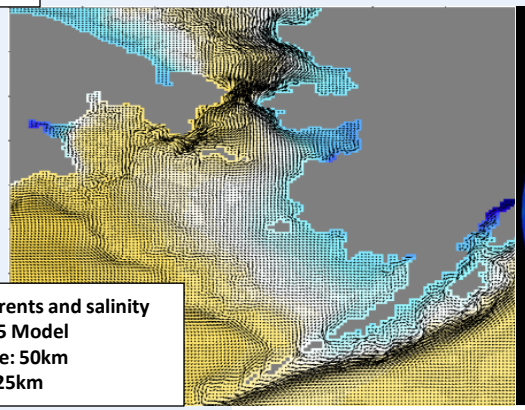
GFDL HiRAM Global climate model
12.5 km resolution



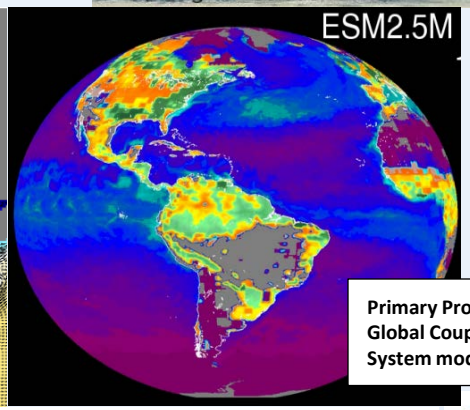
Aerosols - GFDL Atmospheric model (AM3)

Resolution

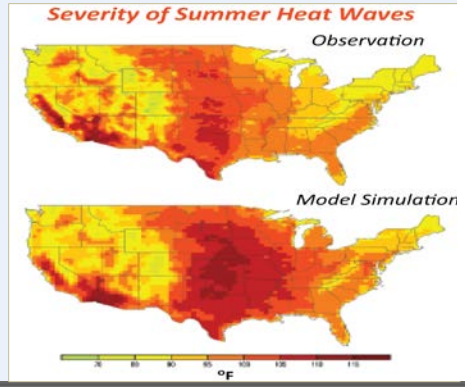
Earth System Complexity

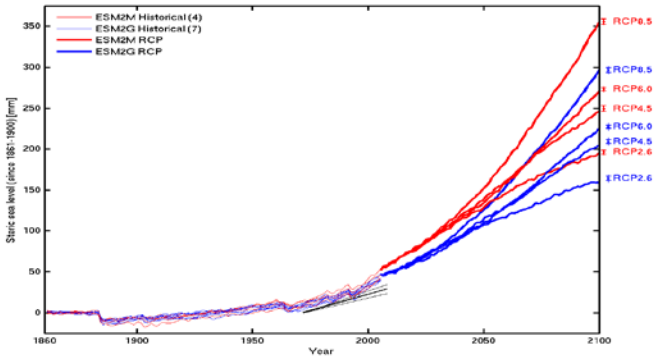


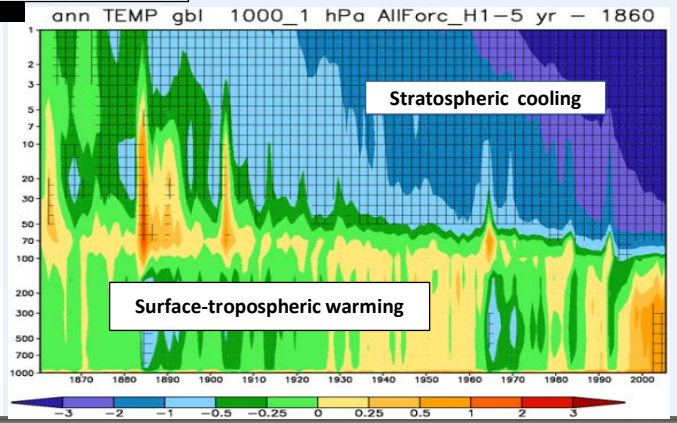
Surface currents and salinity
GFDL CM2.5 Model
Atmosphere: 50km
Ocean: 10-25km



Primary Productivity GFDL Global Coupled Earth System model







Multiple weather-climate phenomena to be addressed
Quantify variability, extremes, and change

National Research Council (2012) Recommendation:
"Unified" modeling approaches

Internal Variability and External Forcings

Tornadoes
Snowstorms
Hurricanes
Typhoons

Heat Waves
Storm Track Variations
Madden-Julian Oscillation

El Niño-Southern Oscillation Precipitation extreme
Intra- & Inter-season Variation
Changes in the Arctic

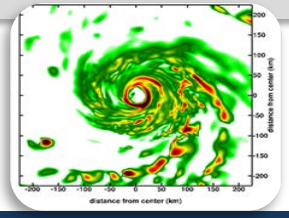
Decadal to Multi-decadal Variability
Cryospheric
Solar Variability

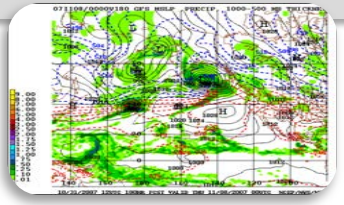
Ocean: Circulation, SLR, Heat Content
Greenhouse Gases and Aerosols

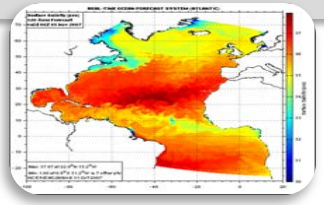
1 DAY | **30 DAYS** | **1 SEASON** | **3 YEARS** | **10 YEARS** | **30 YEARS** | **100 YEARS**

WEATHER | **SHORT-TERM** | **INTERANNUAL** | **DECADE-TO-CENTURY**

Sub-seasonal-to - Seasonal | **Seasonal-to-Interannual** | **Interannual-to-Decadal** | **Decadal-to-Multidecadal**







Weather to Climate is "Seamless"