National Aeronautics and
Space Administration

Integrated Earth System Modeling

ESD Modeling Strategy, IMVI and ESD Modeling Coordination

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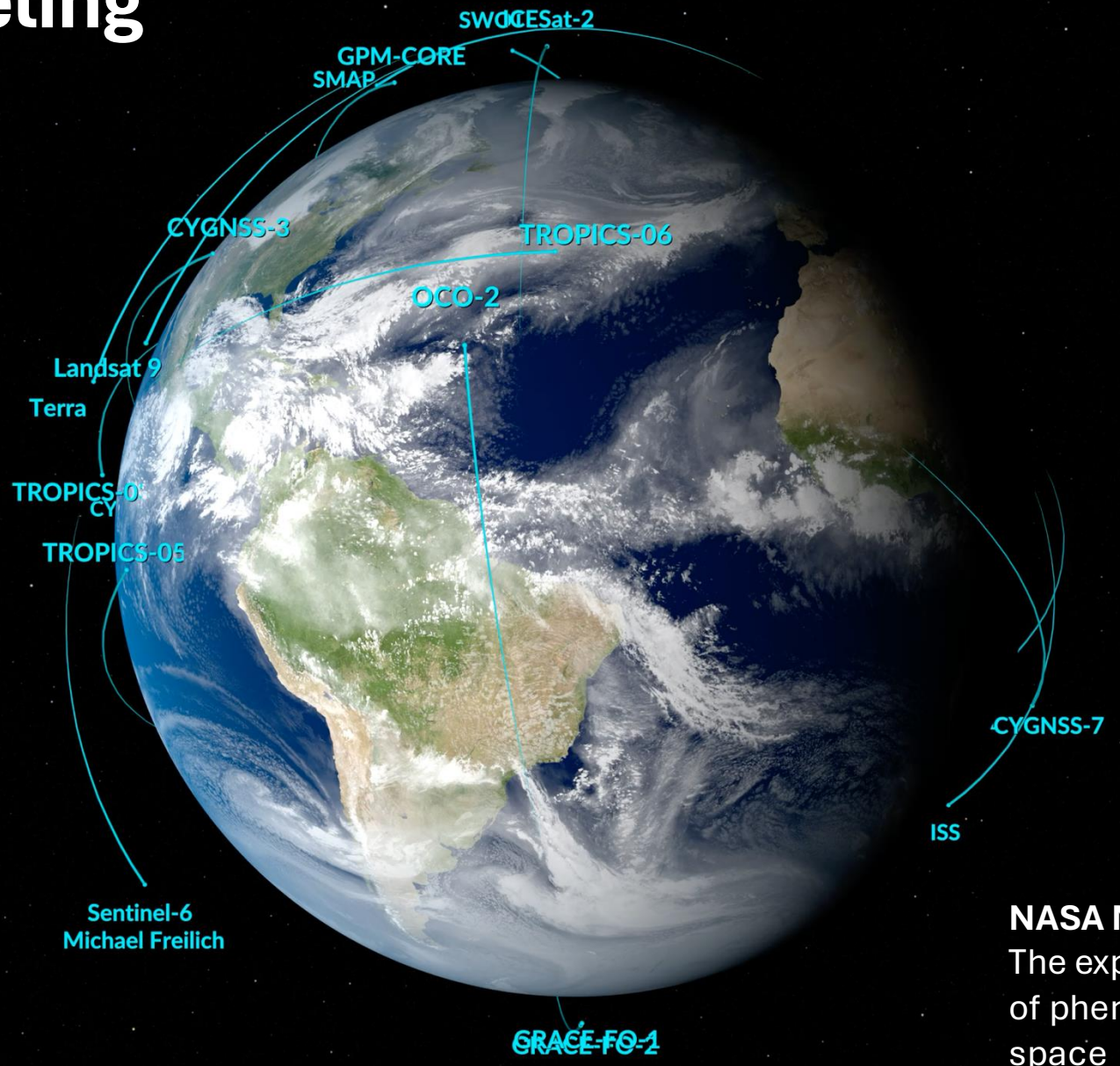
Treating Modeling as Mission Critical



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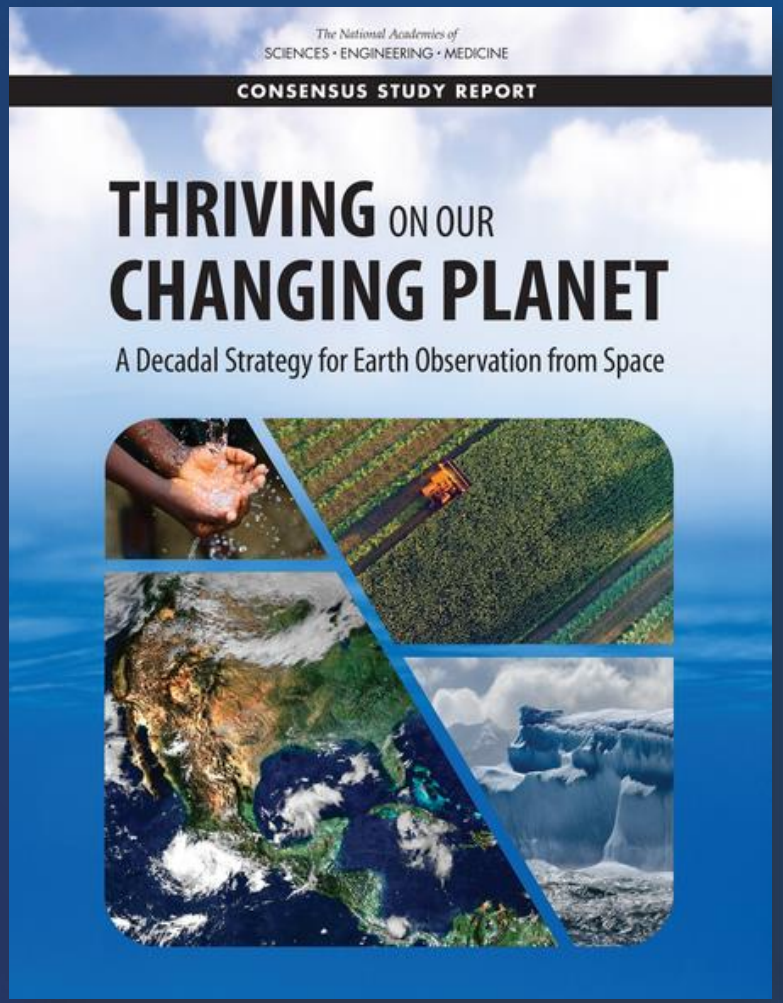
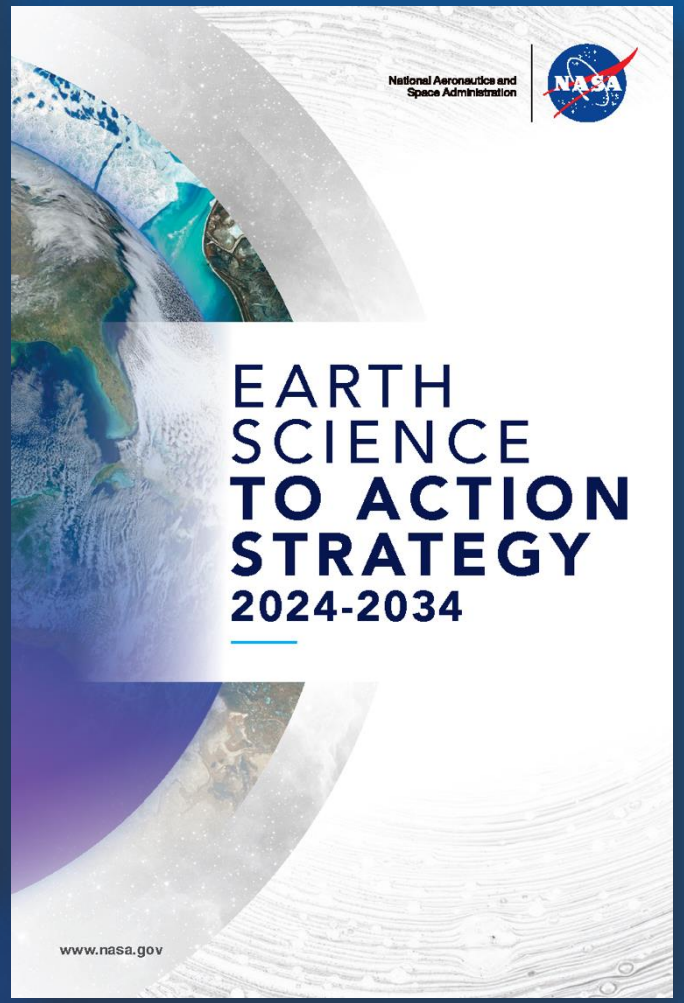
NASA Mission Statement (1958):
The expansion of human knowledge of phenomena in the atmosphere and space

Key Guidance for Earth Science Modeling Strategy

"Pursue increasingly ambitious objectives and innovative solutions that enhance and accelerate the science/applications value of space-based Earth observations and analysis to the nation and the world in a way that delivers great value, even when resources are constrained, and ensures that further investment will pay substantial dividends."

- Thriving on Our Changing Planet: A Decadal Survey for Earth Observations from Space, 2017





Integrated Earth System Modeling Strategy

Models underpin state-of-the-art prediction and risk assessment to support economic growth, national priorities and national security

STREAMLINE

Involve the best experts where they are and consolidate workflows for greater effectiveness

PRIORITIZE

Align investments around advanced technologies and techniques

FLEXIBLE & SCALABLE

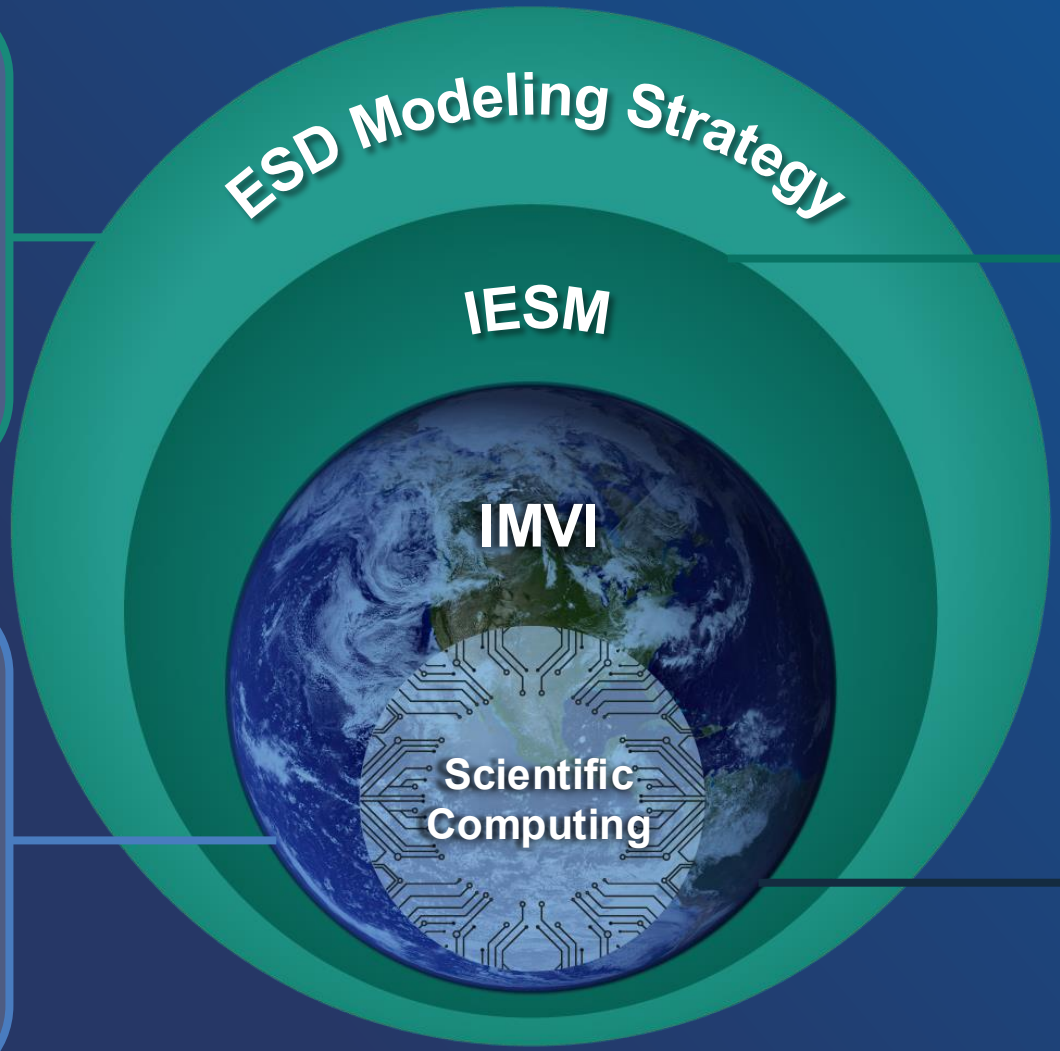
Link models to supporting scientific computing systems

ESD Modeling Strategy, IESM, and IMVI

ESD Modeling Strategy

Framework for streamlining NASA modeling

Opportunities for increasing connectivity across ESD



IESM

Includes core modeling (IMVI)

Competed elements connect research to IMVI systems

Coordinates modeling across elements

IMVI

Multi-center effort, develops NASA's Modeling Framework

Provides reference model products across timescales

Supports modeling standards, implementation of strategy

Scientific Computing

Alignment of Scientific Computing with modeling

- Increases accountability for resource utilization
- Agility to adapt new technology

From Independent to Integrated

Independent Models Today

Land — LIS (Land Information System)

Atmosphere — Including chemistry, turbulence, cloud processes

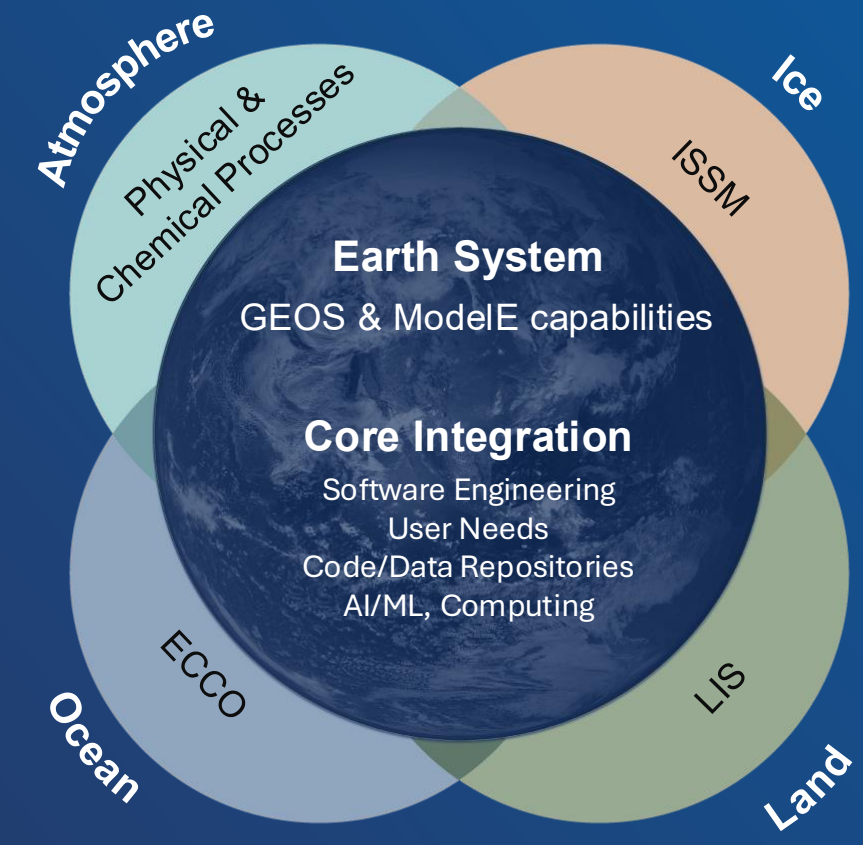
Ocean — ECCO (Estimating the Circulation and Climate of Ocean)

Ice — ISSM (Ice Sheet and Sea-Level System Model)

Earth System
Reanalysis and short-term and seasonal prediction
— GEOS (Global Earth Observing System Model)

Earth System
Decadal and long-term prediction and planetary atmospheres
— ModelE (Global Earth Observing System Model)

Integrated Modeling with IMVI



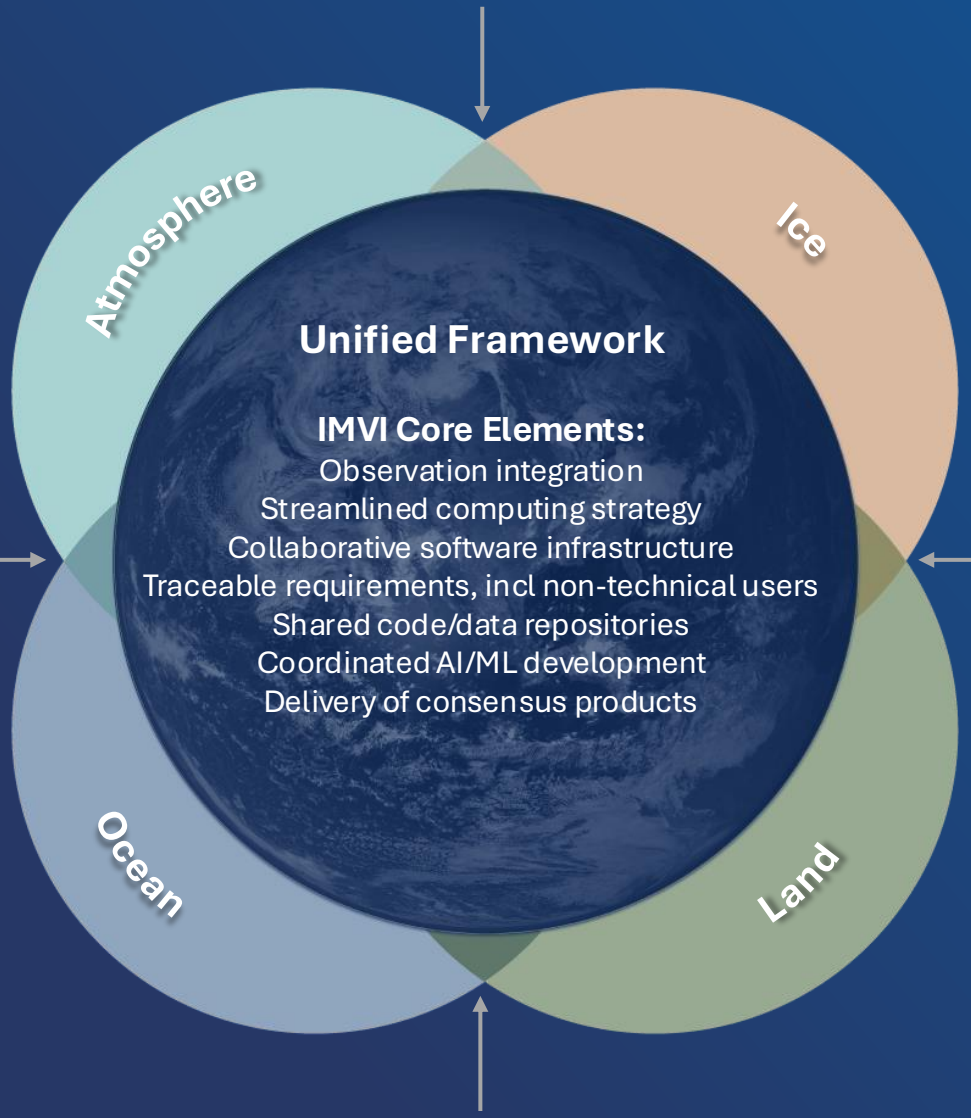
Foundational Models & Partnerships

IMVI Approach to Scientific Co-Development

Focused Co-development:
- Radiative Transfer
- Composition
- Dynamics
- Aerosol microphysics
- Emissions
- Weather (incl. precip.)

Increased opportunity to represent cross-disciplinary interactions

Focused Co-development:
- Hydrology
- Circulation
- Waves
- Sea level
- Ocean biology



Focused Co-development:
- Land ice
- Sea ice
- Ice sheets
- Geodesy

Opportunities for competed work aligned with Earth Science spheres

Focused Co-development:
- Ecology
- Agriculture
- Fire
- Biodiversity

IMVI: Leveraging Complementary Strengths

EARTH SYSTEM MODELS

Goddard Earth Observing System (GEOS)

ModelE

SCIENTIFIC COMPUTING

Model-focused compute (Discover, coordination with HEC, cloud)

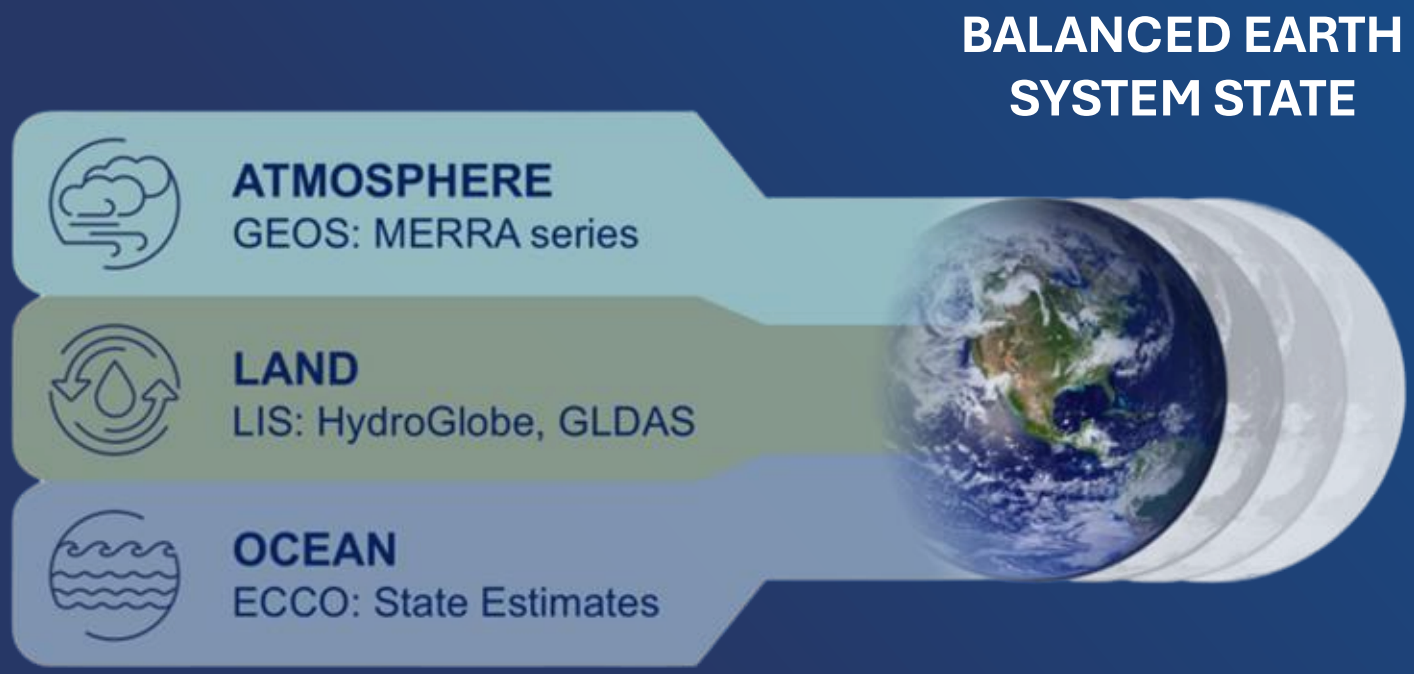
EARTH SYSTEM COMPONENT AND PROCESS MODELS

Land Information System (LIS)

Ice Sheet and Sea-Level System Model (ISSM)

Estimating the Circulation and Climate of the Ocean (ECCO)

Systematic Understanding Anchors Predictions Across Timescales



IMPROVED LONG-LEAD PREDICTION

- Extends predictive skill across timescales
- Reduced uncertainty and better characterizes uncertainty
- Decadal focus incorporates ModelE, ISSM expertise

NEAR-TERM OPPORTUNITIES:

- GEOS-S2Sv3 – now available, MERRA-21C, Q4 FY26 RELEASE
- Opportunity to update surface forcing data, improve consistency with state estimates

NASA Integrated Modeling Components

Unified, modular framework

Mission support/ concept development tools

Best estimates of Earth's past, present, and future based on all available observations

Earth system understanding and reanalysis

Observation-backed future risk projections

Integrated Earth analysis and prediction

IMVI

Integration Pathways

EXPLORATORY

INTEGRATION

ENTERPRISE

IMVI

Enterprise system stability
Advancing in step with research

Improved core products
& prediction capabilities

Potential for Model Readiness Levels
to guide transition process
(see: **ECMWF**)

Subset of approaches
Integration
Testing

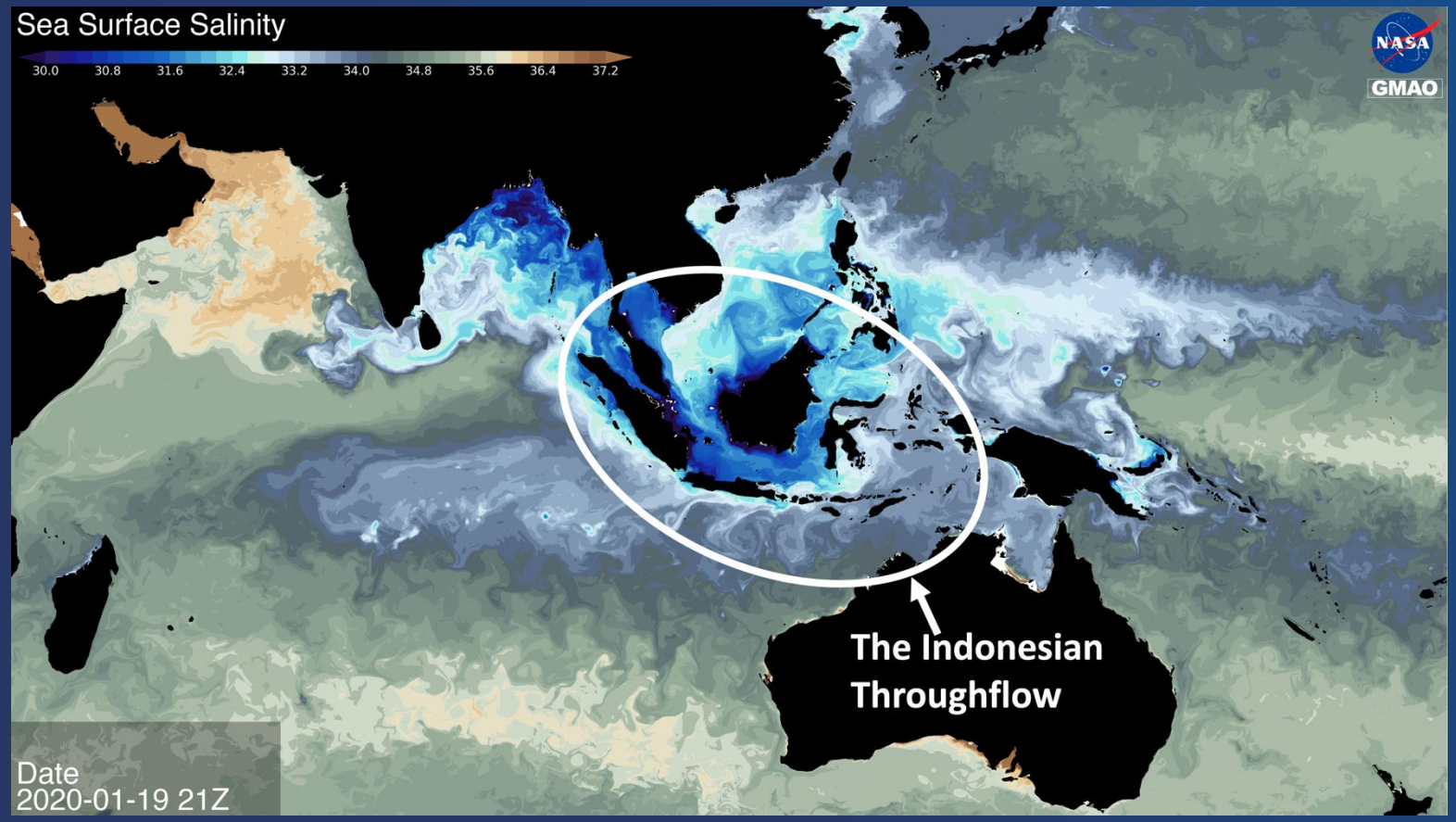
Research Innovation

Prototype components
Evaluation & benchmarking

Continued development
Process studies

IMVI Capability Focus: Earth System Interactions

Example: High-resolution GEOS-MITgcm sea surface salinity



Challenges:

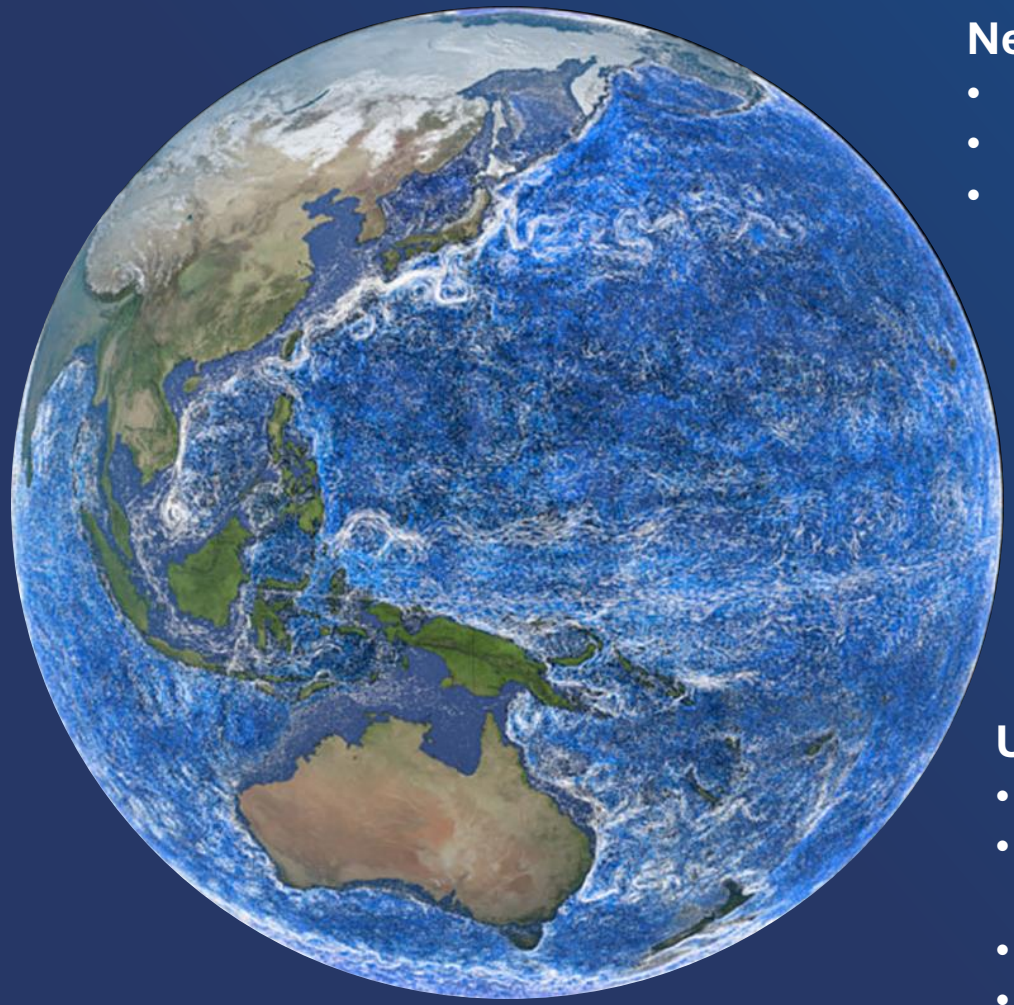
- Biggest science questions, societally relevant decisions are coupled problems
- Discipline-specific models cannot represent feedbacks, constraints across Earth system

IMVI enables coupled modeling, state estimation across atmosphere, land, ocean, & ice – and adoption of system –level constraints (water, energy, carbon). New opportunities:

- Land-atmosphere coupling -> extremes, predictability
- Ocean, stratospheric composition -> S2S (science of STRIVE)
- Land/ocean, atmosphere -> carbon cycle constraint on future projections

Flexible modeling framework allows new opportunities for NASA community to investigate coupled questions – and feed back on next generation of reanalysis/state estimates, long range predictions

Pathways to advance Earth system modeling capability together



Near-Term Scientific Focus

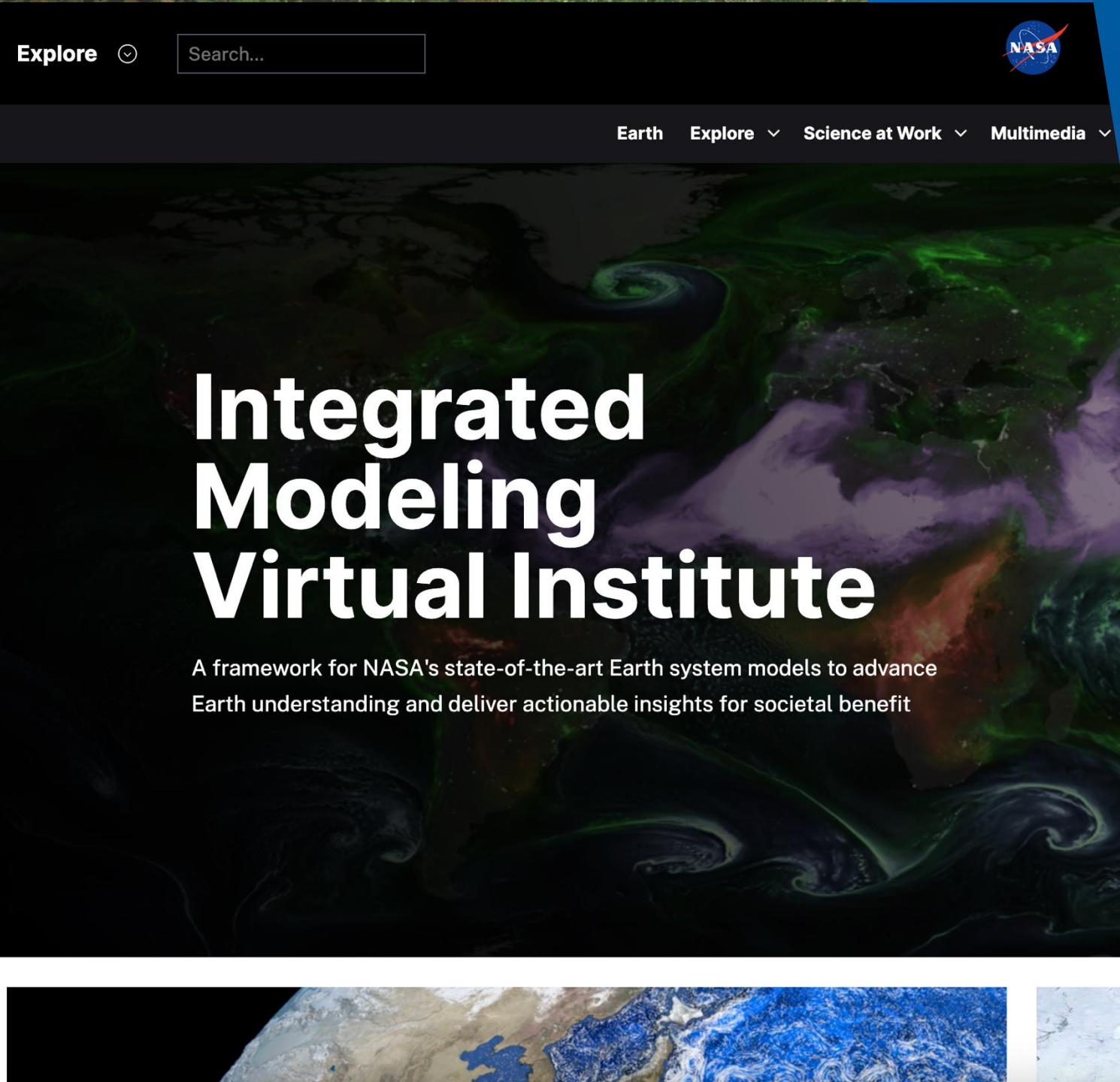
- Consistent Earth system constraints across land, atmosphere, ocean
- Continued focus on coupled GEOS-ECCO-ISSM configurations
- Increasing focus on using systems to understand S2D predictability

Emerging Opportunities

- Coupled ocean-atmosphere state estimation
- Systematic water, energy, carbon closure constraints
- Consistent UQ, benchmarking across timescales
- AI-assisted workflows and components
- Multi-scale modeling capabilities

Upcoming Milestones, Engagement

- Modeling Strategy rollout ~September 2026
- Continued dialogue and updates through NASA Sphere community meetings (summer-fall)
- NASA community modeling meeting winter 2026/27 (tbc)
- AGU sessions, town hall



Scan the QR code or go to go.nasa.gov/IMVI