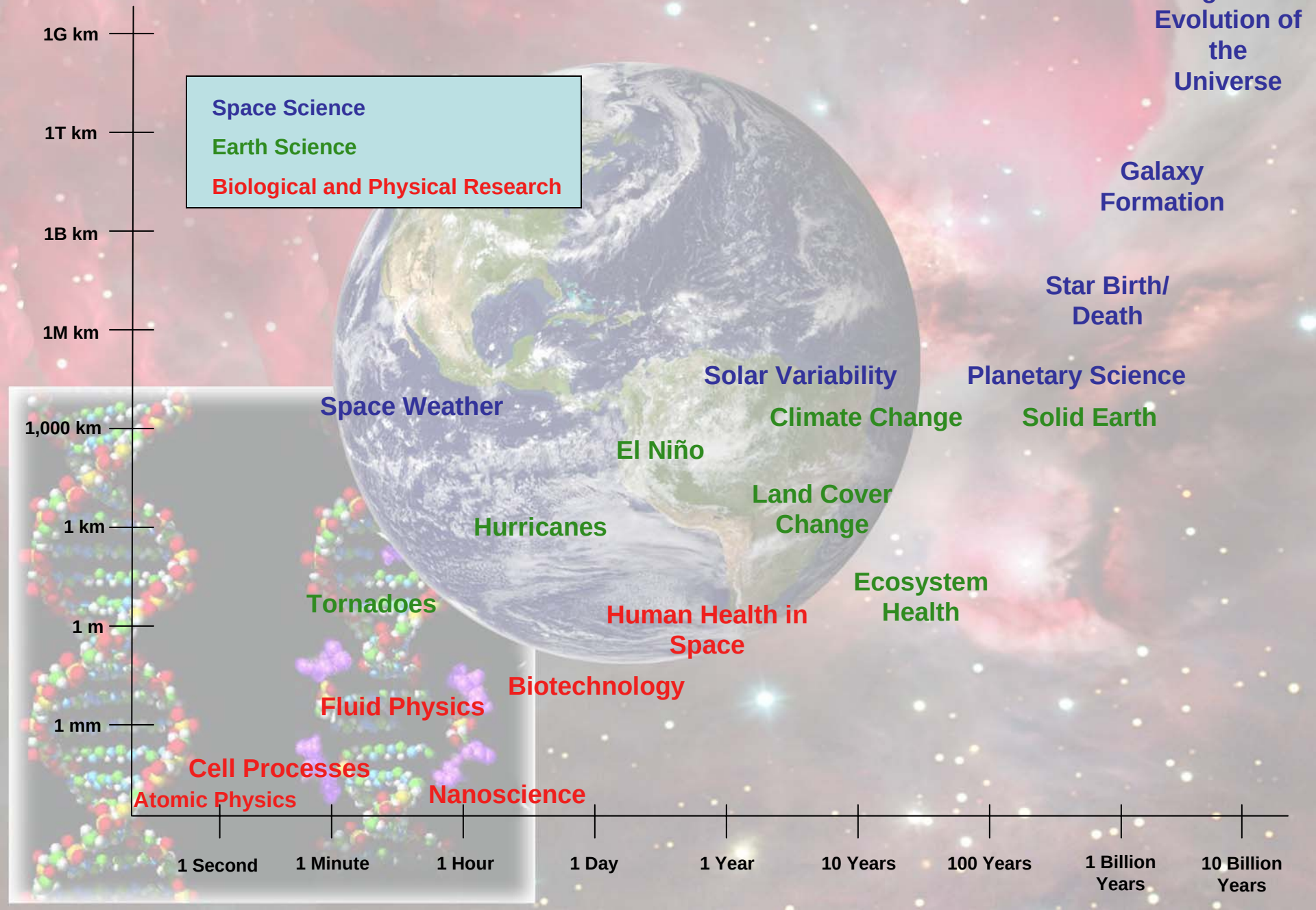
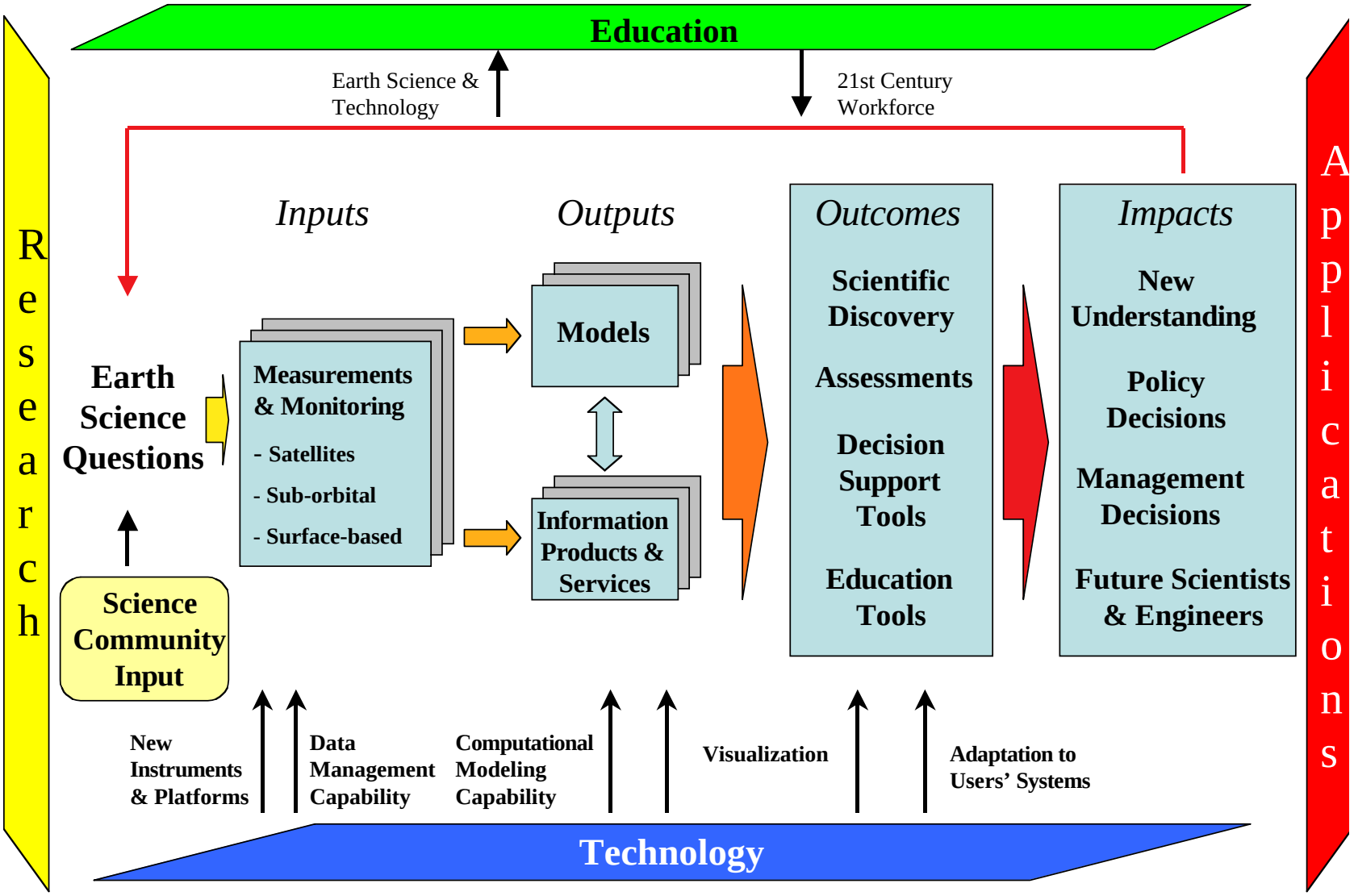
NASA's Research Spans Space and Time



From Science to Societal Impact (and Back)



Managing the End-to-End Information Flow

Petabytes 10^{15}

Multi-platform, multi-parameter, high spatial and temporal resolution, remote & in-situ sensing

Calibration, Transformation To Characterized Geophysical Parameters

Terabytes 10^{12}

Interaction Between Modeling/Forecasting and Observation Systems

Gigabytes 10^{9}

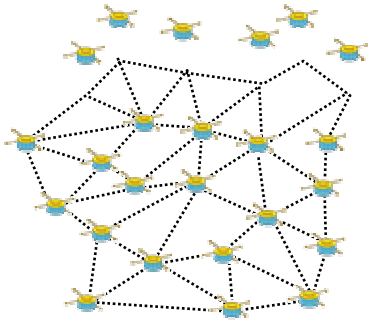
Interactive Dissemination

Predictions

Megabytes 10^{6}

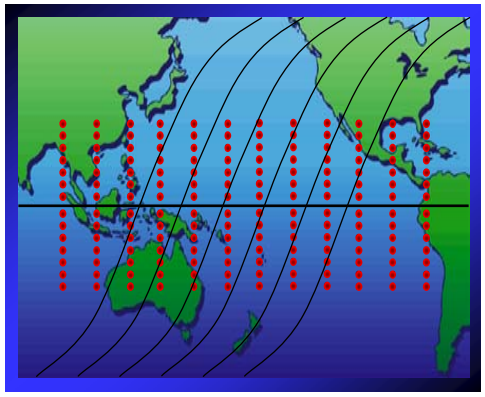
Advanced Sensors

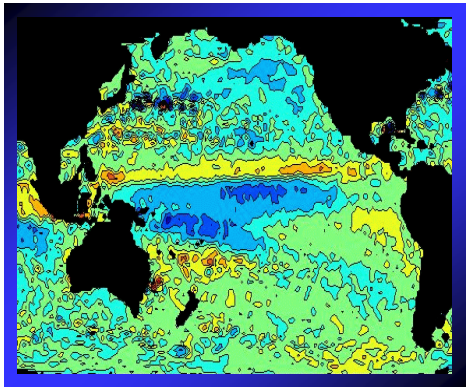
Data Processing & Analysis

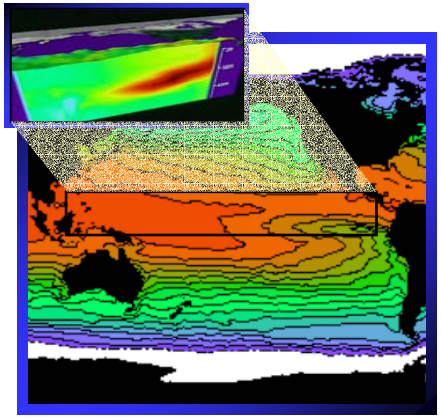


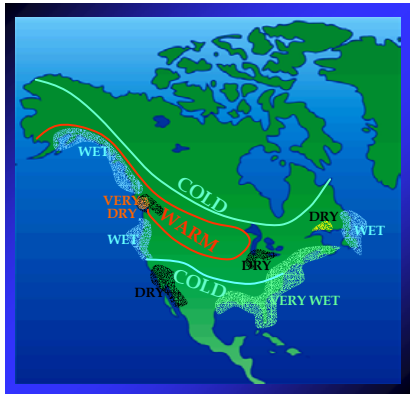
Information Synthesis

Access to Knowledge







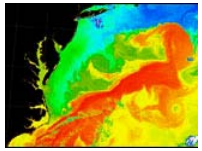


Projected Computing Power Requirements

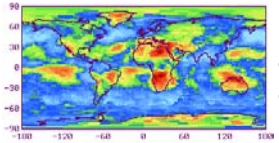
YEAR	Model Resolution/ Physical Processes (lat/long degrees)	SCIENCE EMPHASIS	SIMULATION Years/Wall clock day	Improvement Required
At 2001*	2.0 x 2.0 x 33-layers	Suitable for global climate. Resolves synoptic scales only	5	--
By 2005	0.25 X 0.25 X 90-layers.	Resolves meso-scales, i.e., individual storms, and weather systems	0.1	$>10^2$
By 2010	0.25 x 0.25 x 90-layers + improved Physics Clouds, Chemistry	Resolves interactions among clouds, atmo-spheric constituents, and radiation	0.01	$>10^3$
By 2015	Adding interactive Biology/hydrology	Includes feedback between Atmosphere and Biosphere	0.001	$>10^4$

Computational Climate Modeling

Computational Modeling in Two Stages; Driving Evolution & Enabling Revolution



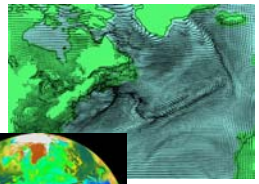
Fully interactive (biology, chemistry, physics) ensemble simulations in an operational mode

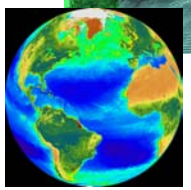


.25 x .25 resolution; add cloud, chemistry, & radiation effects

2015

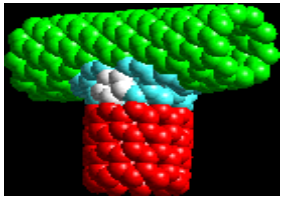
2020





.25 x .25 resolution; hurricanes, storm fronts

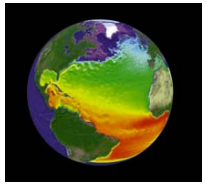
2010



Nanotechnology

2005

2 x 2 resolution; synoptic scales



Interactive physics, biology, chemistry; assimilation of satellite data

Information Power Grid

Revolutionary

2001

Homogeneous Cluster

Heterogeneous Cluster

Evolutionary

Data Size, Bytes

10^{9} 10^{10} 10^{11} 10^{12} 10^{13} 10^{14} 10^{15} 10^{16}

GigaFLOPS

TeraFLOPS

PetaFLOPS

ExaFLOPS

10^{9} 10^{10} 10^{11} 10^{12} 10^{13} 10^{14} 10^{15} 10^{16} 10^{17} 10^{18}

Compute Speed, FLOPS

Real Demonstrated Performance doing useful Science

Summary: Grand Challenges in Computational Climate Modeling

- **Near term: Computing power and software tools to enable assimilation into models of the large and diverse data sets now becoming available**

- **Mid-term: Integration of models of Earth system components, and capacity to enable sufficient runs (at regionally-discerning resolutions) of climate scenarios of interest**

- **Long-term: Creation of a complete Earth system model, and the capacity to run the model(s) in both research and operational modes**

Near, mid-, and long-term designations connote emphases; we will need to be working on all of these in all three time frames!