# NOAA
# High Performance Computing

## A Presentation to the
## NOAA Science Advisory Board

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March 9, 2006

# Outline

- Purpose
- Issue
- Presentation of Briefing
- NOAA Coordination and Views
- Desired Outcome

# Purpose

*To provide general information to the SAB regarding NOAA's High Performance Computing (HPC) program.*

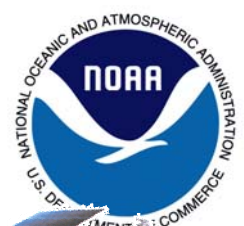*To set the stage for a future request for advice from the SAB.*

# Issue

- Current requirements far outstrip HPC resources.

# What is HPC?

- **High Performance Computing - The unified system for solving NOAA's largest computational problems, composed of supercomputers and associated communications, analysis, visualization and storage systems, and application and systems software with all components well integrated and linked over a high speed network.**

- **Why use HPC ?**

  – **To run applications and generate models faster**

  – **To assimilate large amounts of data**

  – **To handle more complex calculations**

HPC

Weather Prediction
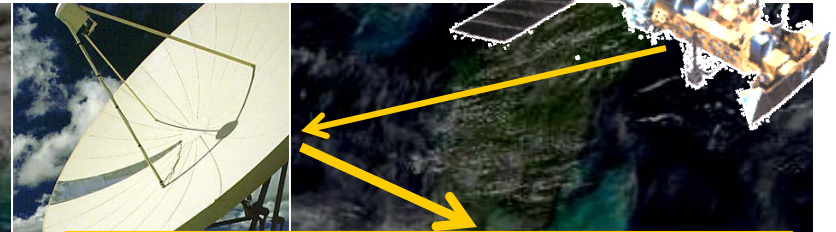
# Why Does NOAA Need HPC?

- ## NOAA's mission is…

  *"To **understand and predict changes** in the Earth's environment and conserve and manage coastal and marine resources..."*

  ↪ NOAA develops, produces and **uses models to *understand and predict*** the Earth's environment…

  ↪ NOAA **uses HPC assets to develop and generate advanced models**…

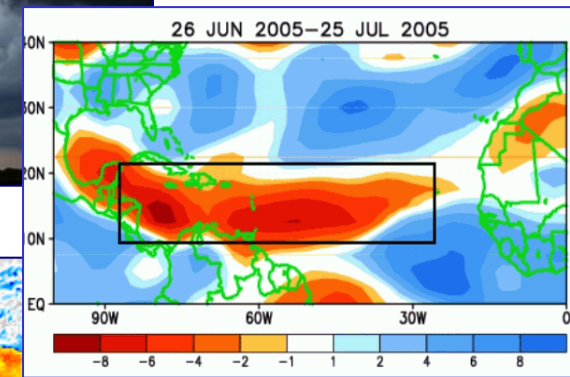  ↪ NOAA's requirements for modeling would require NOAA to have one of the **top 5** worldwide HPC systems



FSL Intel 64-bit System

GFDL Large-Scale Cluster

NCEP Operational Platform

# How Does NOAA Use HPC?

**Operations**

- HPC enables improvements for delivery of weather and water related warnings
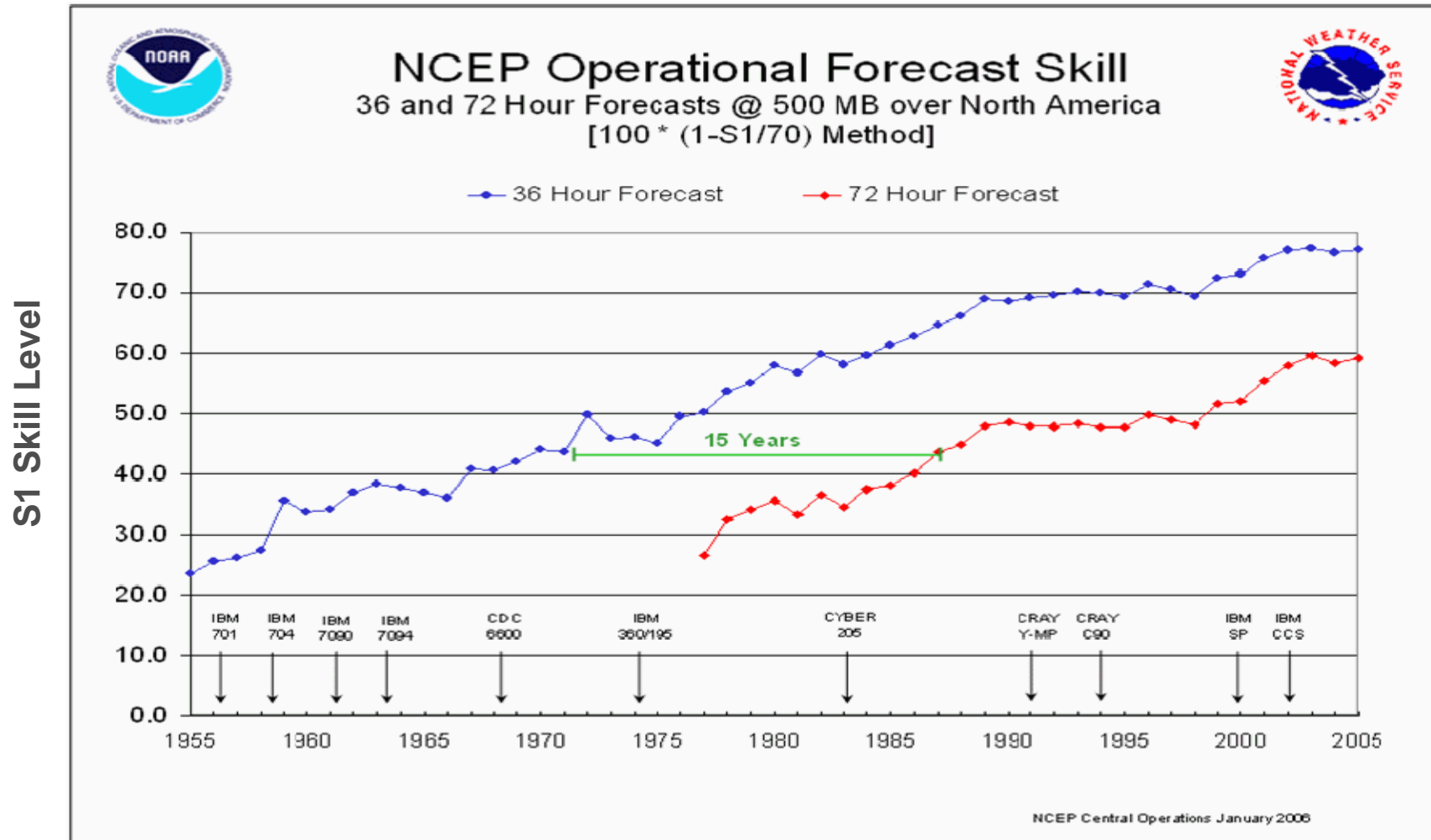  - Earlier
  - Increased accuracy

**Research and Development**

- HPC allows development of the most comprehensive environmental models

- HPC maximizes data use in research and development

- Integrated management of HPC resources decreases time needed to transition models from research to operations
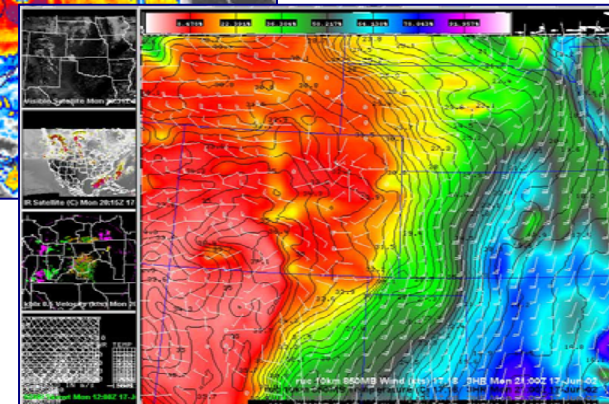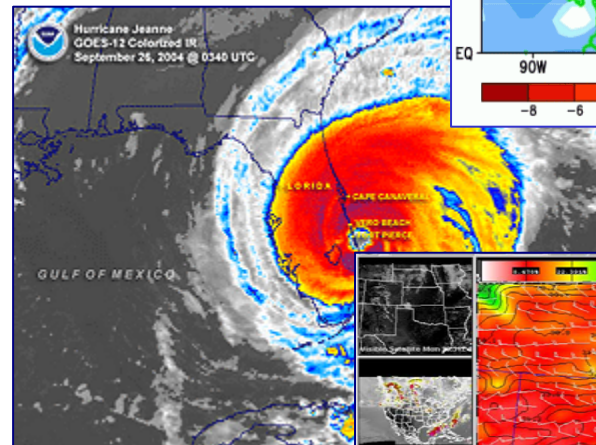
# How Does NOAA Use HPC?

# How Does NOAA Use HPC?

Scientific Advances in Climate Dynamics and Prediction are Linked to Computer Power



Role of climate variability in hurricane activity

Detection & attribution of climate change to natural and anthropogenic forcing

1st estimates of effects of $2 \times CO_2$

1st simulation of Antarctic ozone hole

SGI Cluster Upgrade
SGI Cluster
CRAY T90/30
CRAY T90/24
CRAY T90/16
CRAY C90
CRAY Y-MP
T3E
CDC CYBER 205 (2X)
TI ASC
IBM 360/91
IBM 360/195
CDC 6600
UNIVAC1108
IBM 70301/stretch
IBM 7090
IBM 704
IBM 701

Log (Computer Power)

Year of Delivery

# Sample Unmet Requirements

- *Regional climate information using a high resolution atmosphere (minimum 1/2° resolution) model*
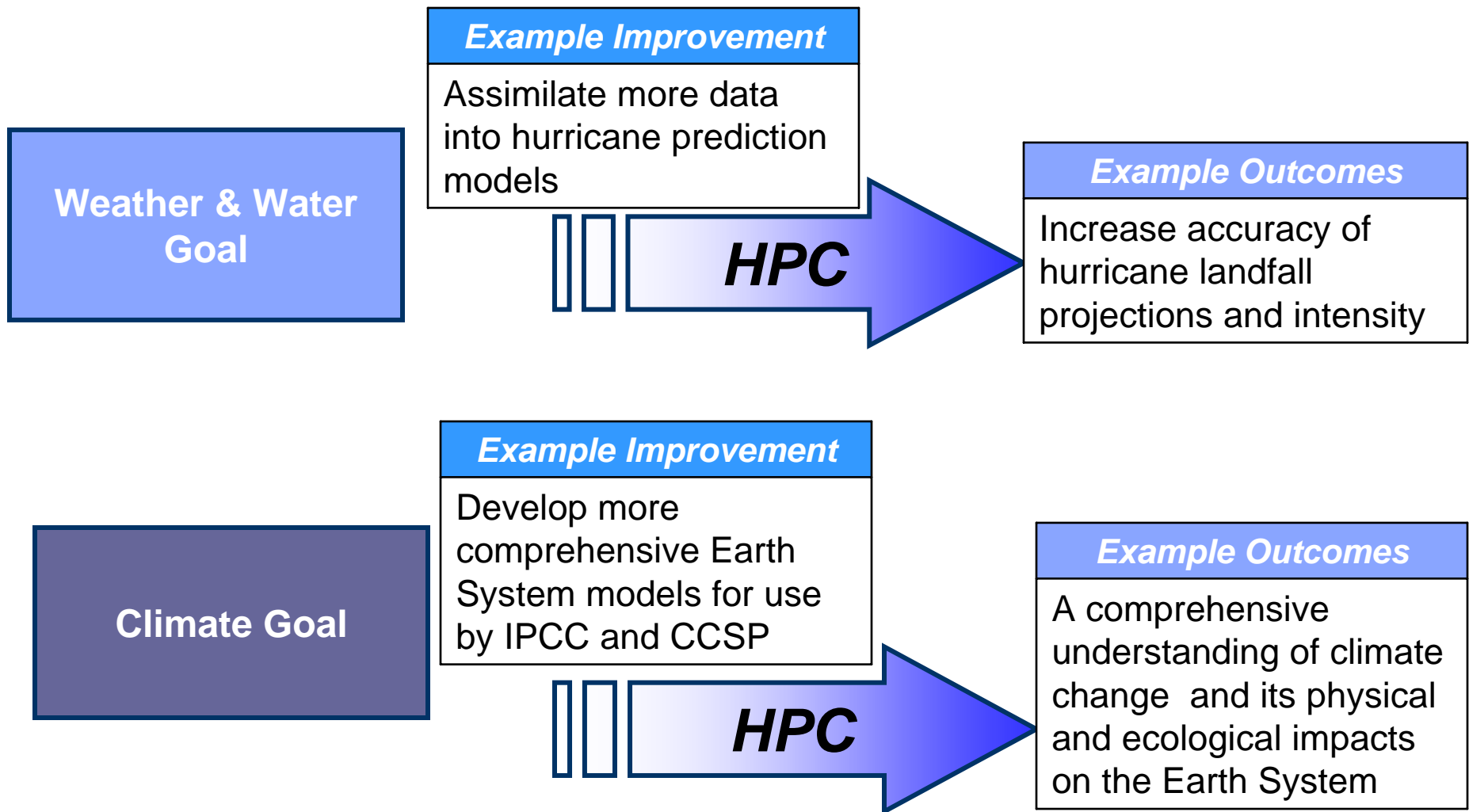- *0-24 hour severe weather forecasts that fully resolve the convective motion (1KM or less)*
- *Address human health issues with forecasts of the full range of important chemicals, particulates, and aerosols using comprehensive air quality models*
- *Concurrent global and regional operational forecasts to advance global product delivery by almost 2 hours in NPOESS era*
- *Climate and extreme events (e.g., hurricanes, drought, coastal inundation)*
- *Continuous environmental monitoring and analysis using a 4-D Data Assimilation System*
- *Ensemble-based guidance for all operational suites (global and regional atmosphere, ocean, hurricane, air quality, waves, coastal ocean and ecosystems)*
- *Periodic Reanalysis and Seasonal/Interannual Climate calibration runs for operational implementation*
- *Ocean ecosystem forecasts and climate projections using an eddy resolving ocean model (minimum 1/12° resolution)*
- *Comprehensive hurricane impacts with nested atmospheric hurricane model coupled to ocean, wave, coastal surge, and water runoff models (1KM or less)*
- *Research and Development typically require about 4x operations for weather and 10x for climate*

# What Benefits Does HPC Bring to the Mission Goals?

**Weather & Water Goal**

**Example Improvement**

Assimilate more data into hurricane prediction models

*HPC*

**Example Outcomes**

Increase accuracy of hurricane landfall projections and intensity

**Climate Goal**

**Example Improvement**

Develop more comprehensive Earth System models for use by IPCC and CCSP

*HPC*

**Example Outcomes**

A comprehensive understanding of climate change and its physical and ecological impacts on the Earth System
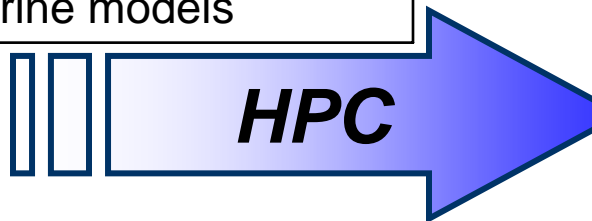
**Ecosystems Goal**

**Example Improvement**

Develop an ecological forecasting capability

**HPC**
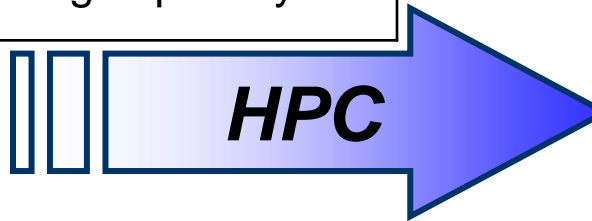
**Example Outcomes**

Predict forcing conditions for ecological related hazards, such as harmful algal blooms

**Commerce and Transportation Goal**

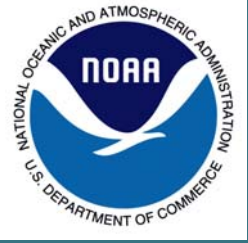**Example Improvement**

Couple operational ocean, coastal and estuarine models

**HPC**

**Example Outcomes**

Improved accuracy of water level and current predictions to aid import and export of goods in our Nation's ports

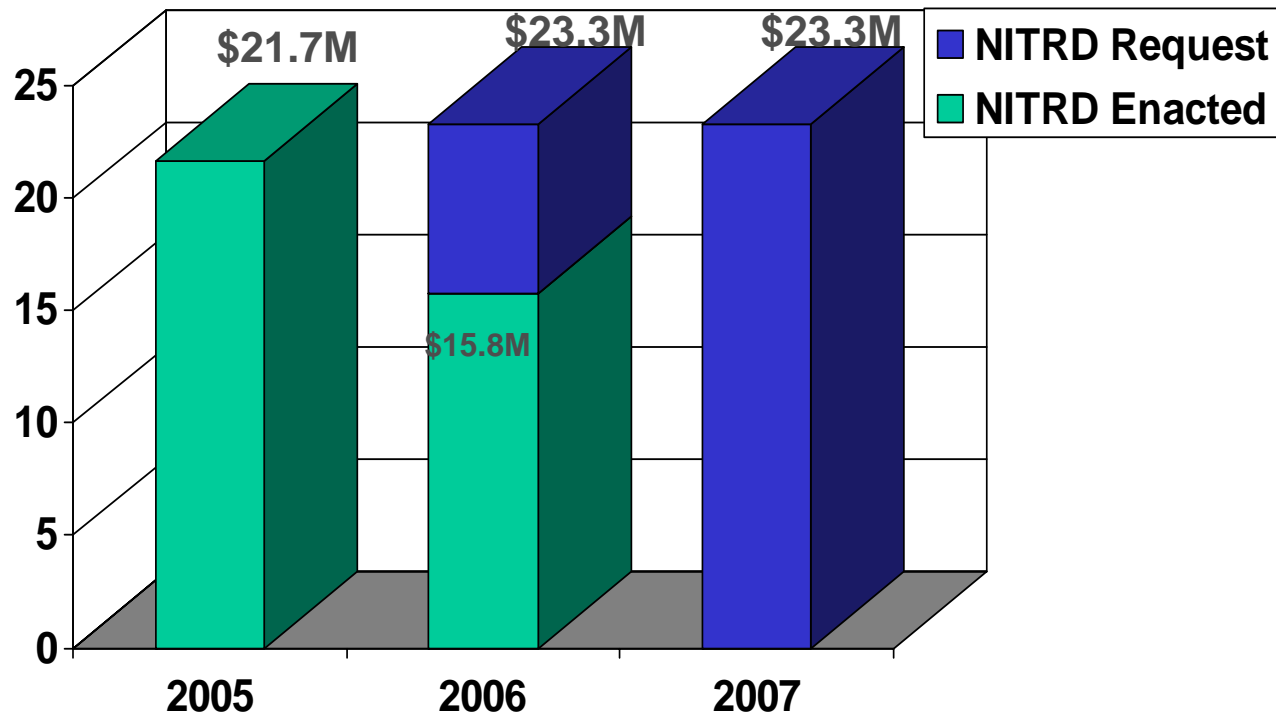# Factors driving changes to NOAA's HPC architecture

- Technology changes and advancements
- Pressures from Capitol Hill, OMB and DoC to
  - achieve greater economies of scale
  - increase overall efficiency
- National and Global Responsibilities
  - Climate Change Program
  - Ocean Commission Action Plan
  - Intergovernmental Panel on Climate Change
- NOAA management advocating a "One NOAA" approach
- NOAA's experience and knowledge gained from working with both heterogeneous and homogenous computational platforms
- Recognized need to improve collaboration with organizations external to NOAA such as Universities and the Federal research community.
- Requirements exceed available HPC capacity.
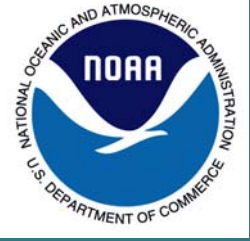
# NITRD Funding

- ## Network and Information Technology R&D
  - (the current evolution of the High Performance Computing and Communications program)

# HPC Architecture

**As Is**

**To Be**

ESRL*

NCEP

GFDL

HPC

HPC

HPC

*To*

**Integrated Management Processes**

*Mission Goals*

EMP Modeling Requirements
HPC Board Management & Execution
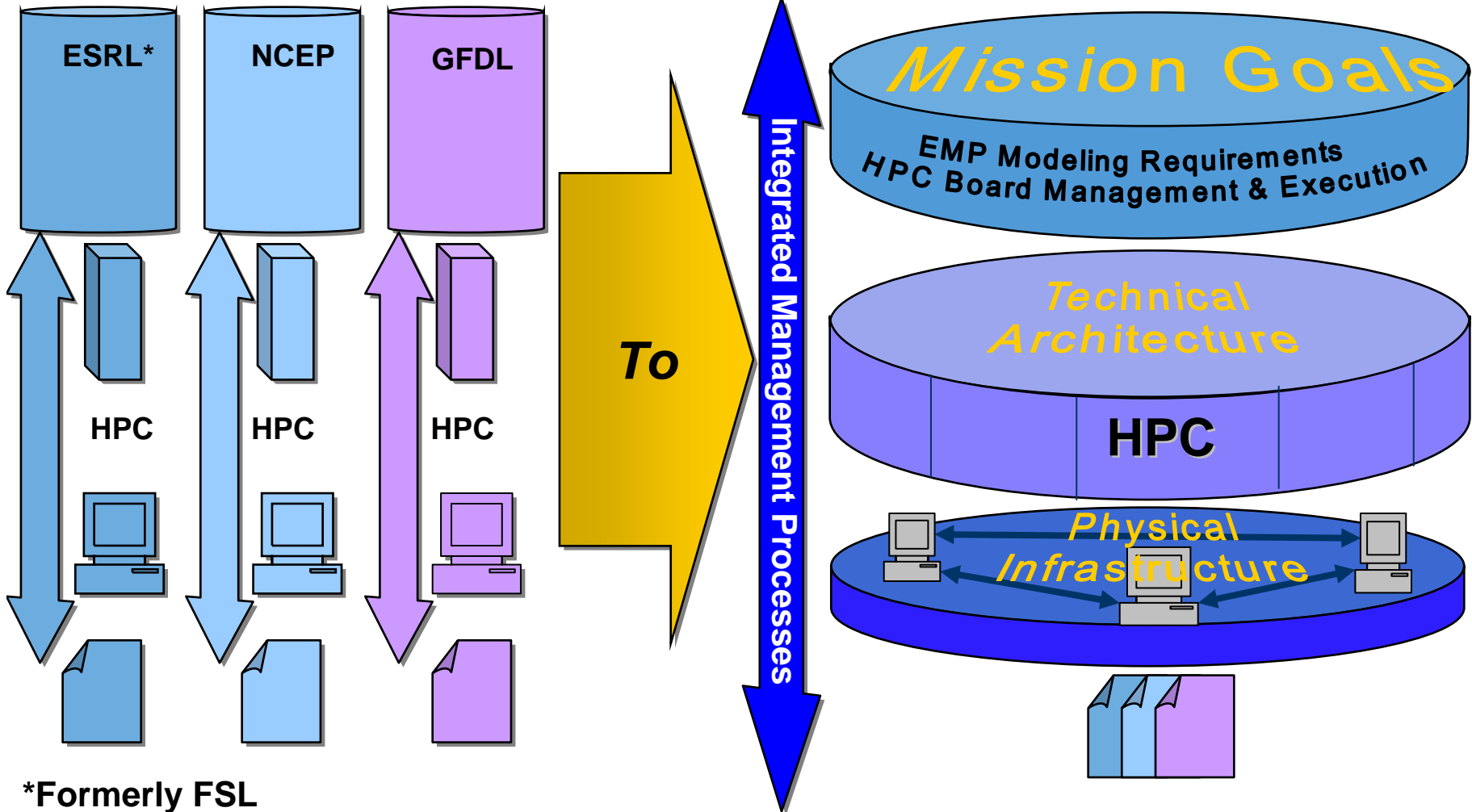
*Technical Architecture*

**HPC**

*Physical Infrastructure*

**\*Formerly FSL**

15

# HPC Architecture

**IT Security**

Ops

Research

**Integrated Data Storage and Access**

**Integrated Data Distribution and Archival**

**Data Archival System**

**Integrated Communications**

**Model Development**

**Modeling Systems**

**Integrated HPC Processing**

**Redundant**

**Visualization**

**Decision Analysis**

16
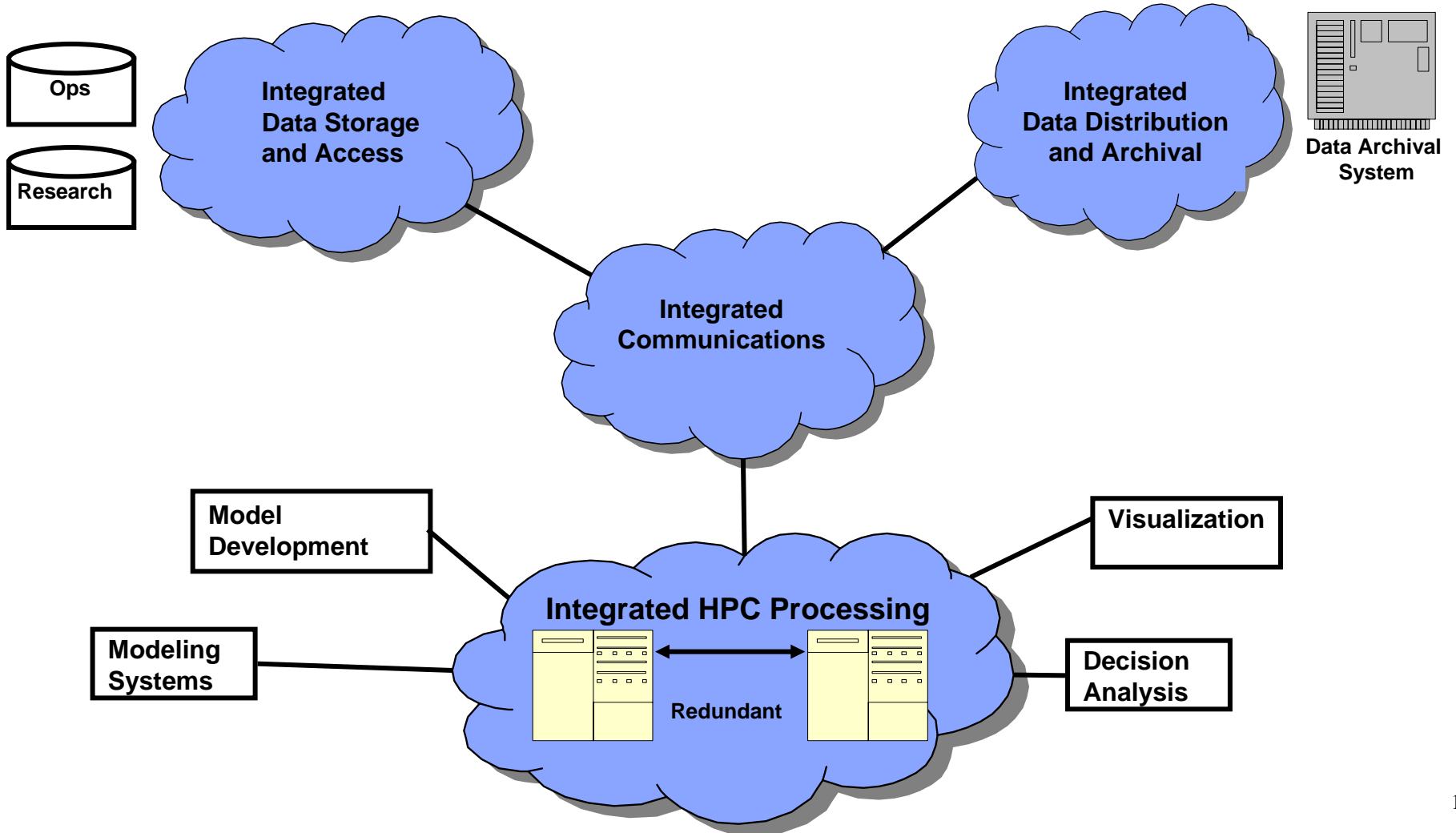
# HPC Architecture

## HPC System's Architecture Relationship Diagram



```
Stakeholder/User  --Drives-->  Mission Goals  --Drives the need for-->  Programs
                                                                           |
                                                                         Have
                                                                           |
                                                                           v
Products & Services  <--Produces--  Forecast Systems/Scientists     Mission & Capability Requirements
       ^                                      ^                              |
   Provided to                         Transmitted to                    Include
       |                                      |                              |
                                                                            v
Modeling Results  <--Produces--  HPC Systems  <--Drive the need for--  Environmental Modeling Requirements
```
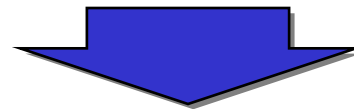
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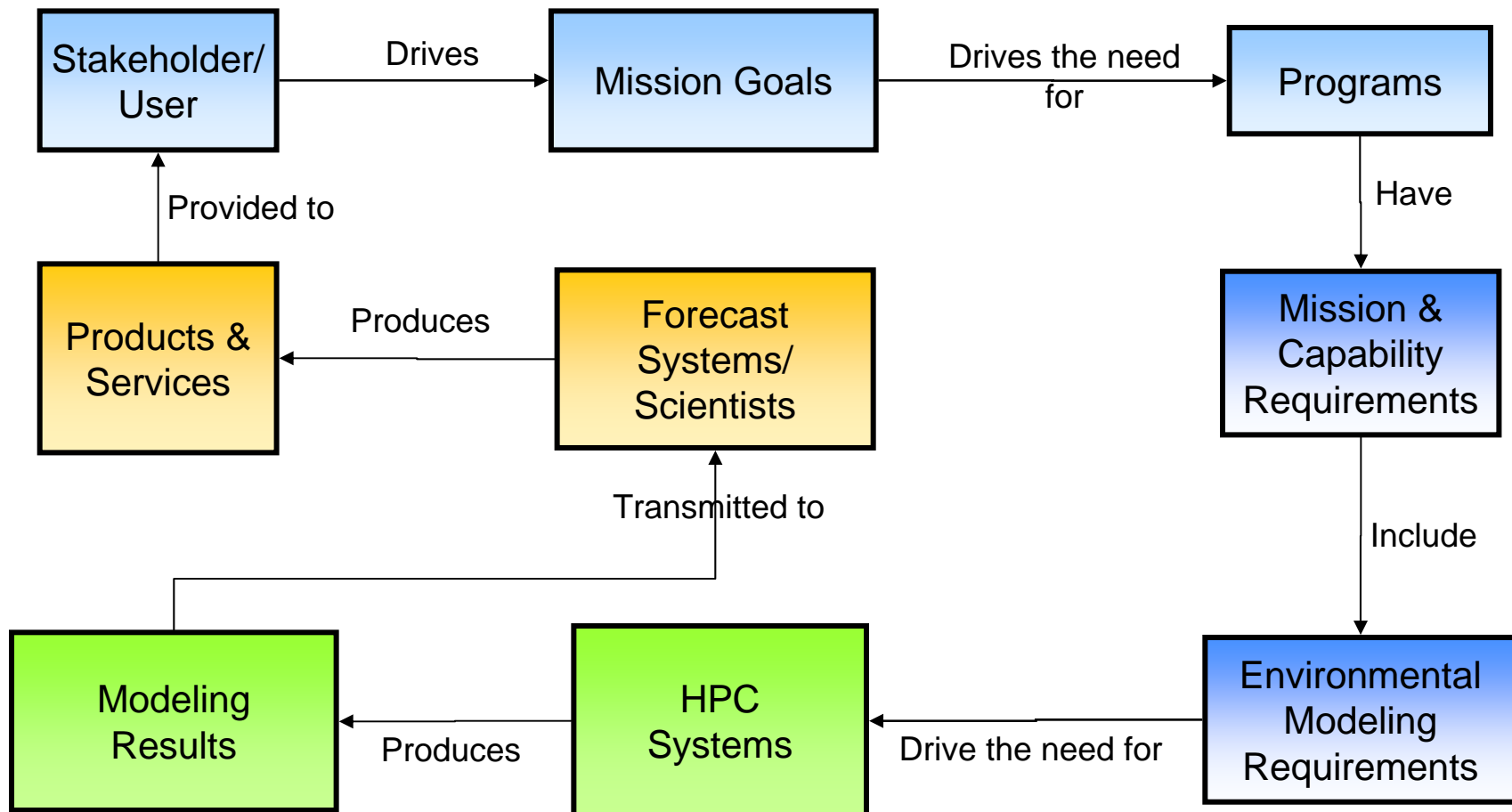
# NOAA HPC Management

**HPC Management Concept**

## PPBES
## Environmental Modeling Program
## HPC Board
## Integrated Management

- Oversee Performance
- Coordinate Execution-year Plan

- Facilitate Execution
- General NOAA HPC Education

**Resource Management**
- Technical Estimating
- Allocation Planning
- Execute Allocation Plan
- Monitor & Evaluate
- IT Security

**Architecture Management**
- Lifecycle management
- IT Security

**Acquisition**
- Administrative oversight
- Acquisition execution
- Selection process

# HPC Integrated Management Outcomes

**Outcomes**

- **NOAA-wide access**

- **Access driven by NOAA priorities**

- **Flexibility in capacity usage**

- **Joint decision making regarding allocations**

- **No more stovepipes**

- **Larger pool of shared resources and capability**

# NOAA Coordination & Views

- Coordination with:

  NOAA Executive Panel, NOAA Research Council, Line Office  Assistant Administrators, NOAA Chief Information Officer Council, Program Analysis and Evaluation office, Program Planning and Integration office

  Commerce Information Technology (IT) Review Board, Industry Representatives, National IT Research and Development Sub-Committee

- What has NOAA done to address this issue
  - Initiated the HPC Board
  - Developed an integrated architecture
  - Developed a Integrated Management plan
  - Executed an integrated HPC R&D acquisition

- What are NOAA's views on the subject?
  - NOAA is taking steps to effectively and efficiently manage the HPC resources it has and we recognize that these resources are insufficient to meet current requirements

# Desired Outcome
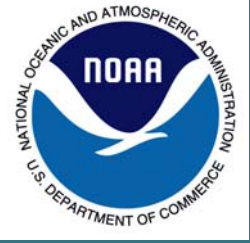
- In the next presentation to the SAB (July 2006), we intend to provide information on HPC utilization and the requirements for HPC resources.

- The NOAA HPC community will seek advice from the SAB on how to address the gap that exists between available HPC resources and requirements.

# Questions