

High Performance Computing and GFDL Research

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<http://www.gfdl.noaa.gov>



GFDL Mission Statement

Department of Commerce Order 2-B
July 29, 1969

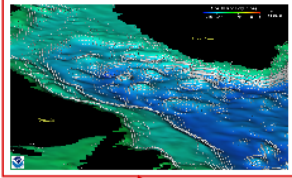
"... the Geophysical Fluid Dynamics Laboratory is to conduct investigations of the dynamics and physics of geophysical fluid systems to develop a theoretical basis, *by mathematical modeling and computer simulation*, for the behavior and properties of the *atmosphere and oceans*."



GFDL SCIENTIFIC COMPUTING ENVIRONMENT

The Computational Research Process

MODELING COLLABORATIONS

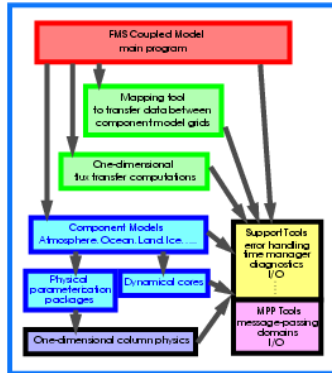


DATA STORAGE



PRODUCTION COMPUTING

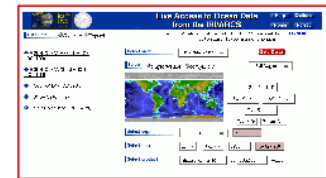
MODEL DEVELOPMENT



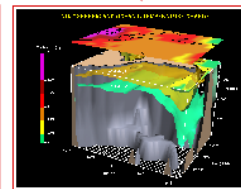
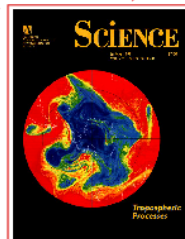
ANALYSIS COMPUTING



COLLABORATIVE DATA-SHARING



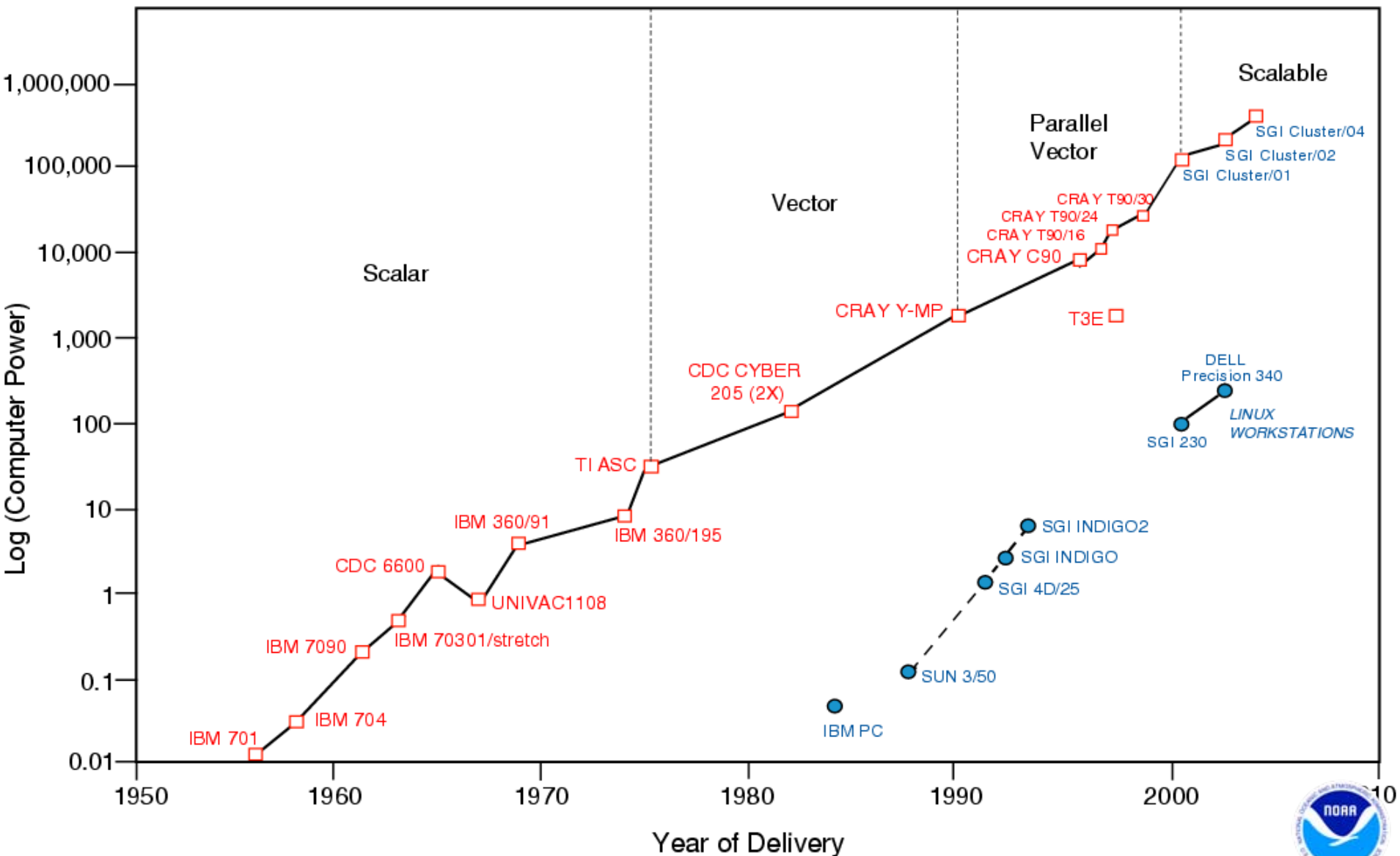
**SCIENTIFIC KNOWLEDGE
 and OUTREACH**



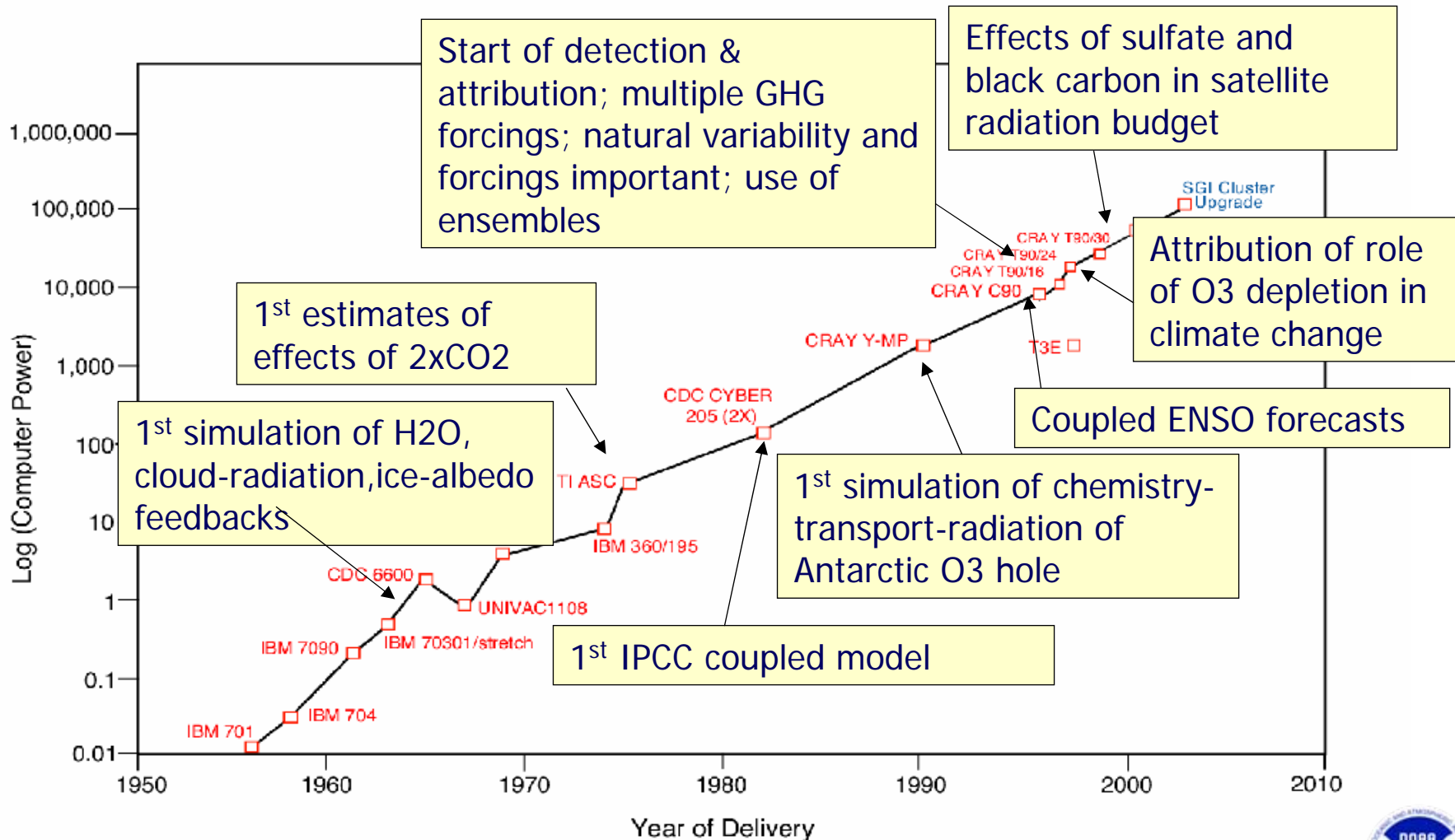
**DIAGNOSTIC
 COLLABORATIONS**

HISTORY OF GFDL COMPUTING

Growth of Computational Power with Time



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





GFDL HPCS

October 2003

Large Scale Cluster (LSC)

SGI Origin 3800 + 3900, 600MHz

2 Nodes x 512 PE + 512GB + 2.9TB disk

5 Nodes x 256 PE + 256GB + .9TB disk

1 Node x 128 PE + 128GB + .9TB disk

SAN Bandwidth: 2GB/s per LSC Node

CXFS, PCP, Workshop Pro, GridEngine, S-Plus,

TotalView, Matlab, NAG SMP, Mathematica

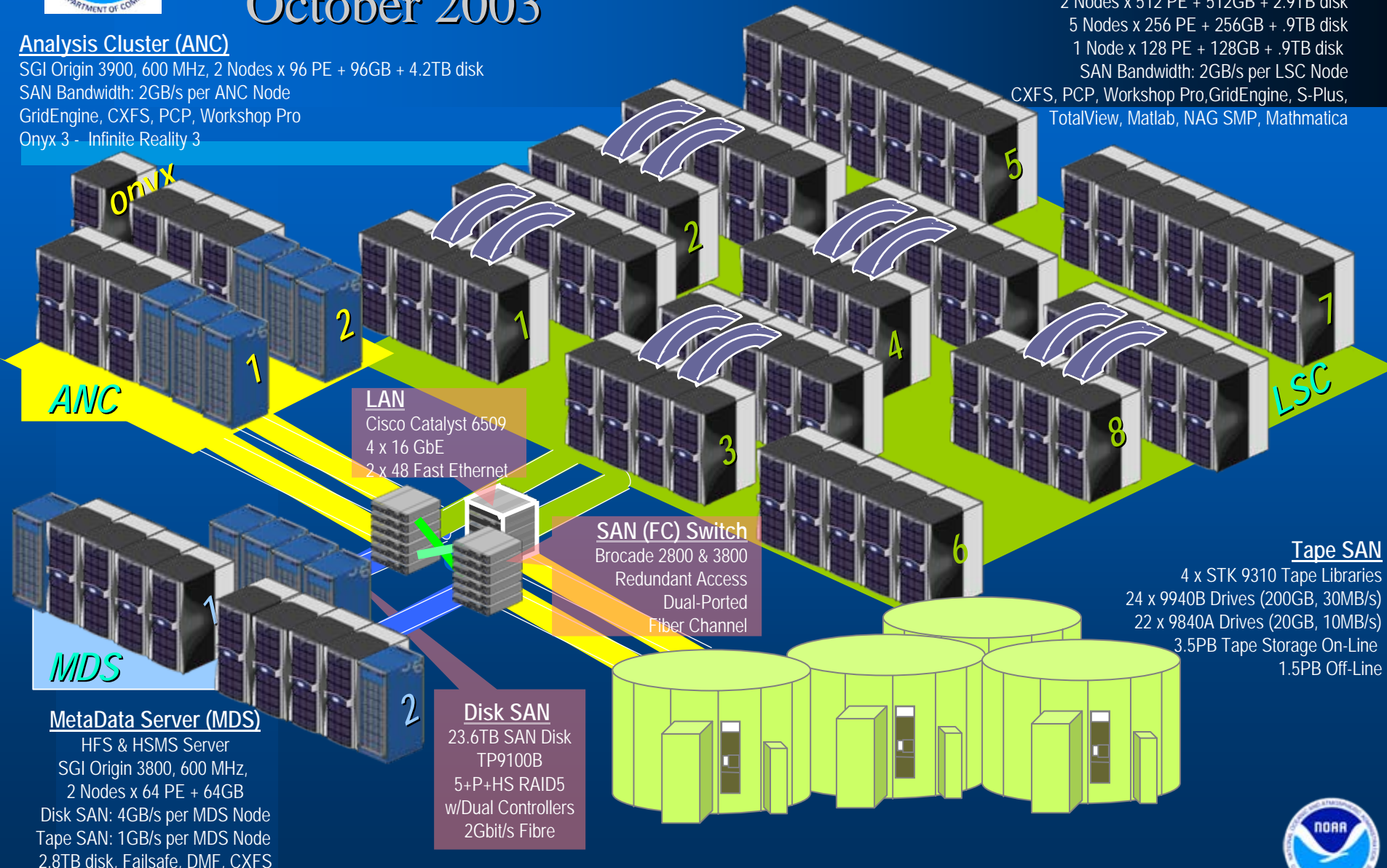
Analysis Cluster (ANC)

SGI Origin 3900, 600 MHz, 2 Nodes x 96 PE + 96GB + 4.2TB disk

SAN Bandwidth: 2GB/s per ANC Node

GridEngine, CXFS, PCP, Workshop Pro

Onyx 3 - Infinite Reality 3



LAN
Cisco Catalyst 6509
4 x 16 GbE
2 x 48 Fast Ethernet

SAN (FC) Switch
Brocade 2800 & 3800
Redundant Access
Dual-Ported
Fiber Channel

Disk SAN
23.6TB SAN Disk
TP9100B
5+P+HS RAID5
w/Dual Controllers
2Gbit/s Fibre

Tape SAN

4 x STK 9310 Tape Libraries

24 x 9940B Drives (200GB, 30MB/s)

22 x 9840A Drives (20GB, 10MB/s)

3.5PB Tape Storage On-Line

1.5PB Off-Line

MetaData Server (MDS)

HFS & HSMS Server

SGI Origin 3800, 600 MHz,

2 Nodes x 64 PE + 64GB

Disk SAN: 4GB/s per MDS Node

Tape SAN: 1GB/s per MDS Node

2.8TB disk, Failsafe, DMF, CXFS

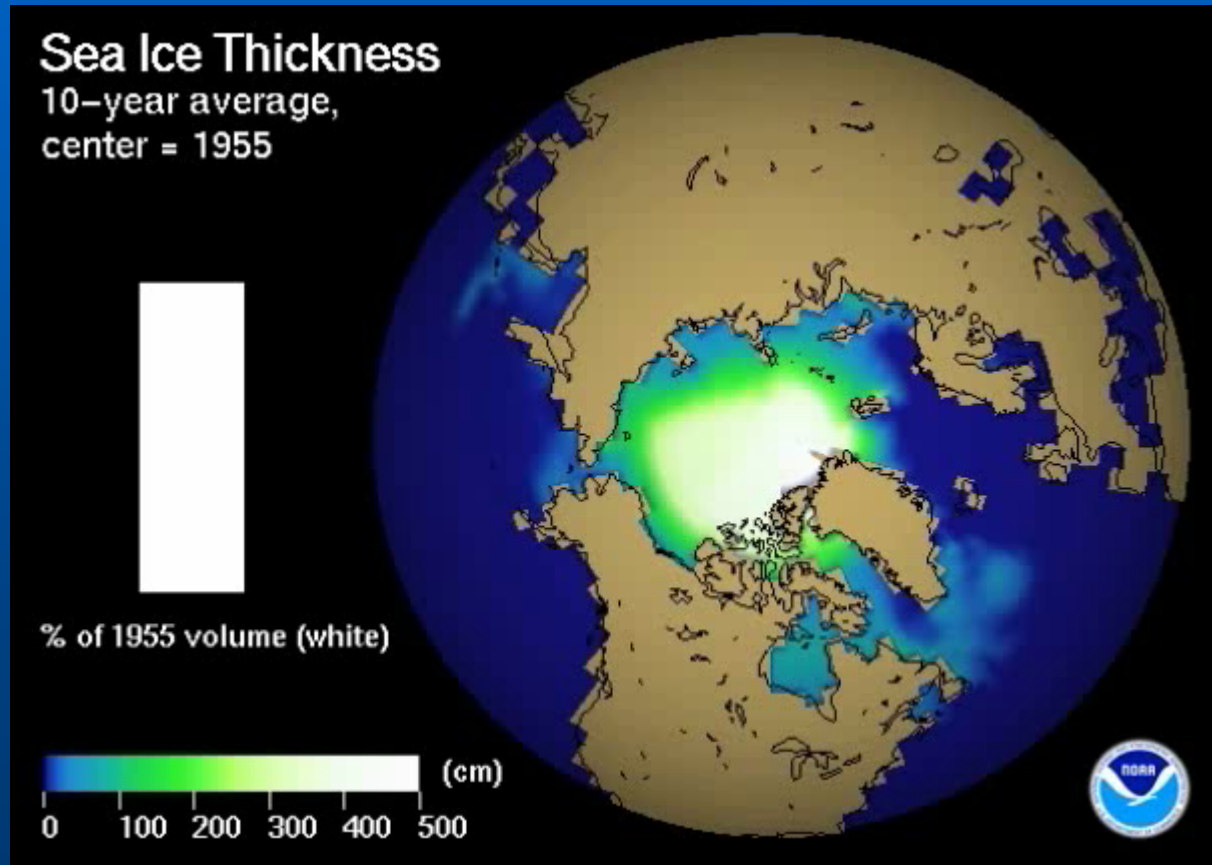


Selected Research Results

- **Climate Change Impact on Arctic Sea Ice**
- **High-Resolution Ocean Model**
- **GFDL Hurricane Model**
- **High-Resolution Global Mesoscale Circulation Model (GMCM)**



Climate Change Impact on Arctic Sea Ice



Modeling Eddies in the Southern Oceans

Ocean Eddies:

- Of fundamental importance to ocean dynamics and climate
- Small scales (10-100 miles) require high resolution models
- Eddies in the southern oceans control heat storage deep In the World Oceans



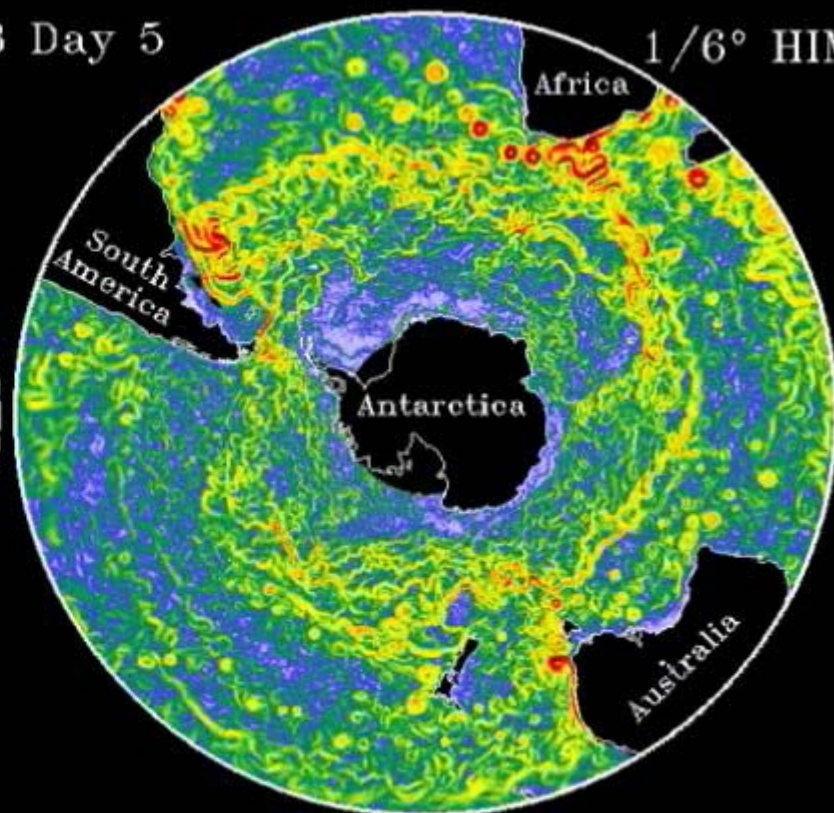
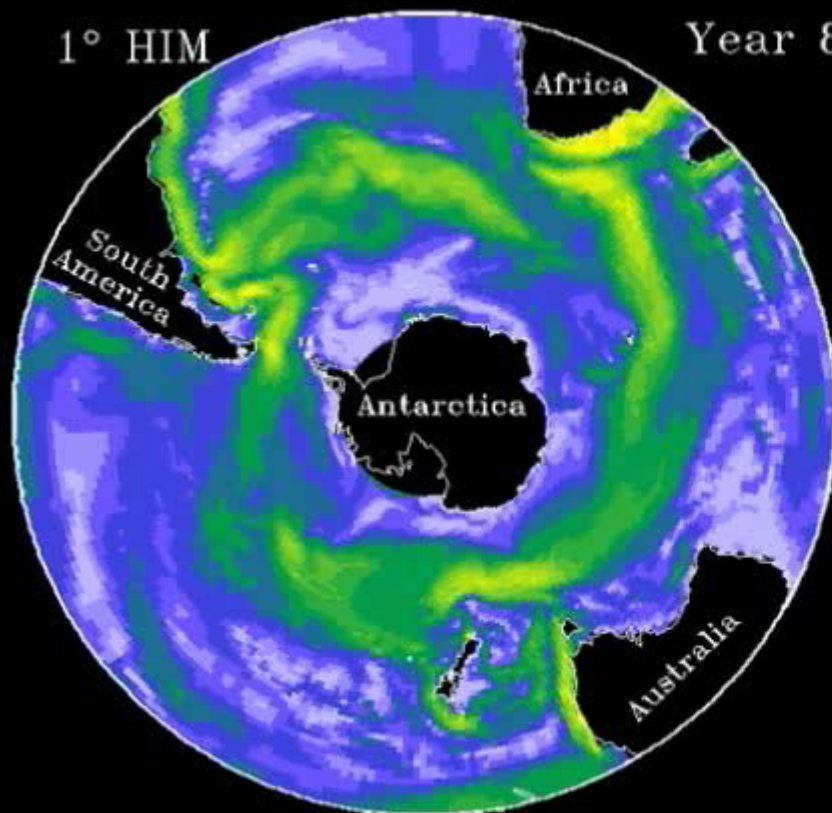
Southern Ocean Eddies: Potentially Important but Poorly Understood

Ocean Surface Speed in NOAA/GFDL Southern Ocean Simulations

1° HIM

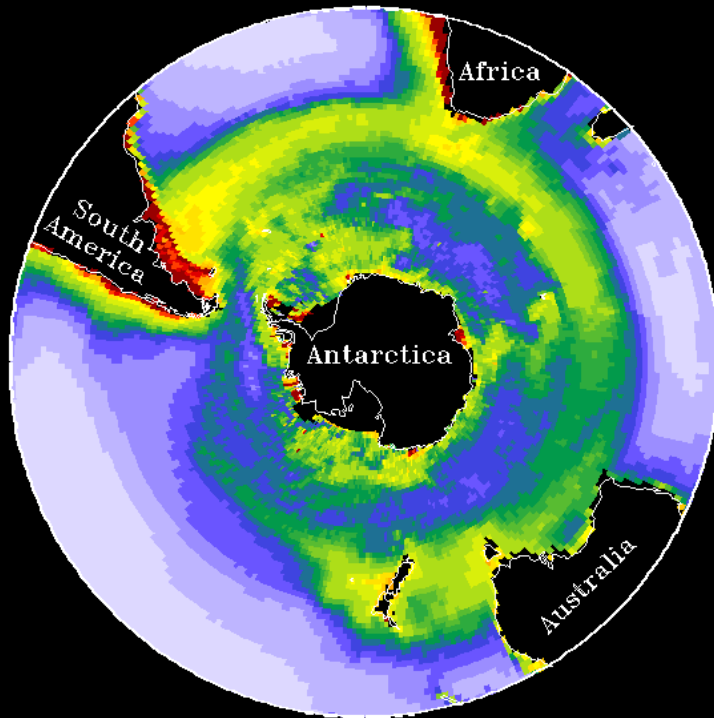
Year 8 Day 5

1/6° HIM

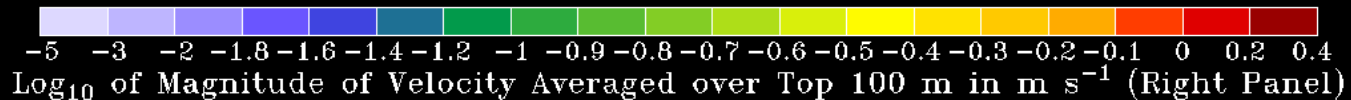
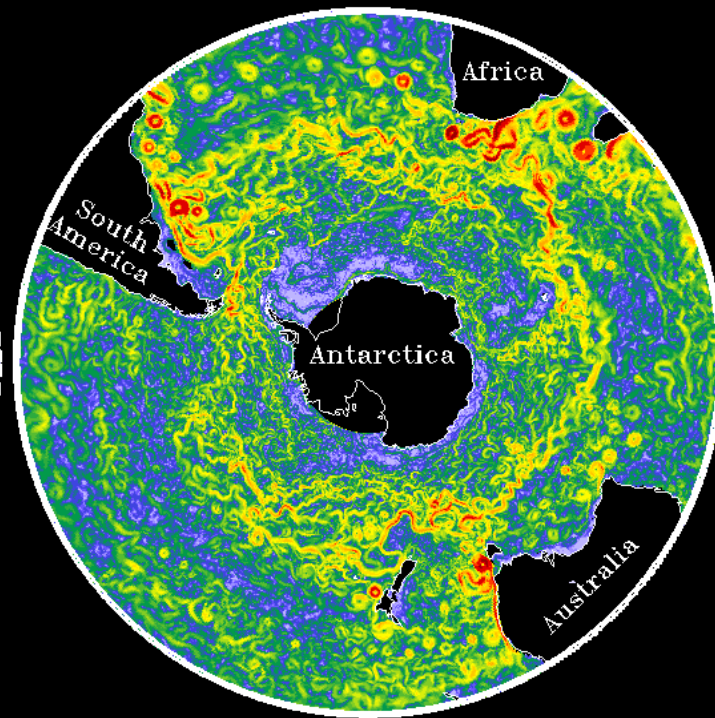


Southern Ocean Productivity May Be Linked To Ocean Eddy Activity

SeaWiFS Productivity



Instantaneous Surface Speed in NOAA/GFDL Southern Ocean Model

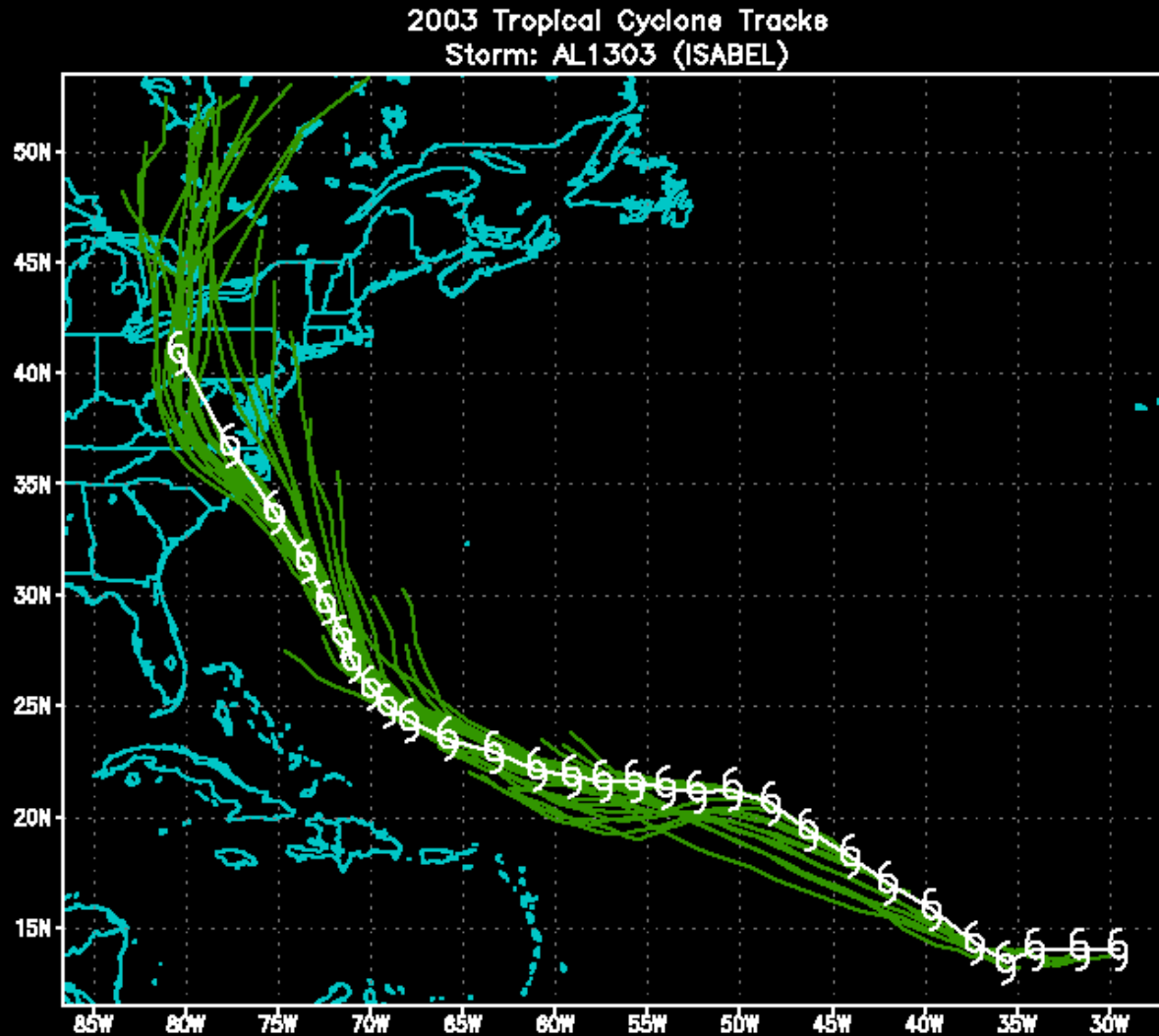


Forecasting Hurricane Isabel

- **GFDL Hurricane Model, 2003 season**
 - Increased resolution
 - Improved physics
- **Forecast-to-forecast consistency**
- **Best forecast in operational suite**



GFDL Isabel 5-Day Track Forecasts



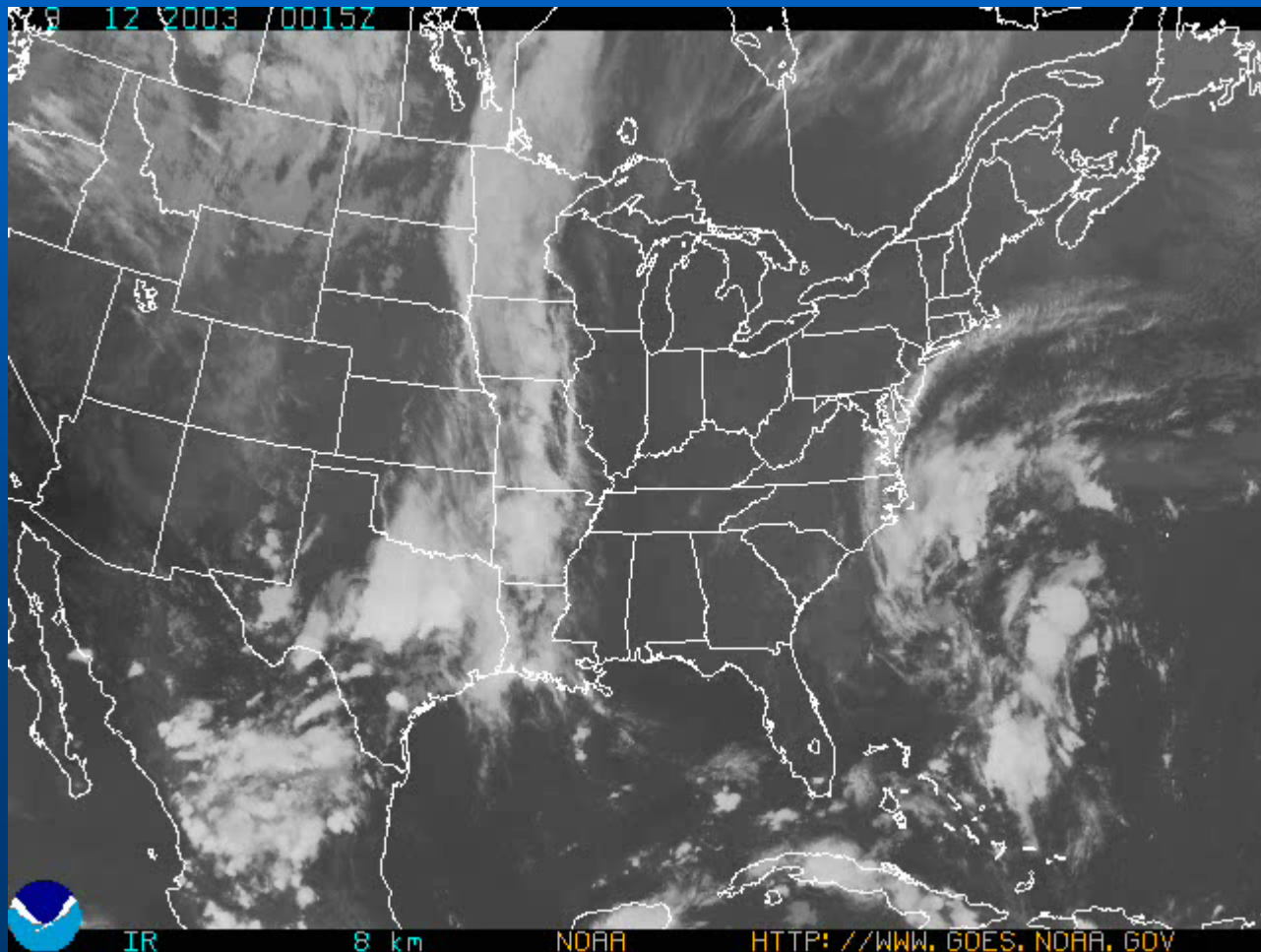
Forecasts: Beginning 2003090512 for GFDL model

Observed: Beginning 2003080512, every 12 hours

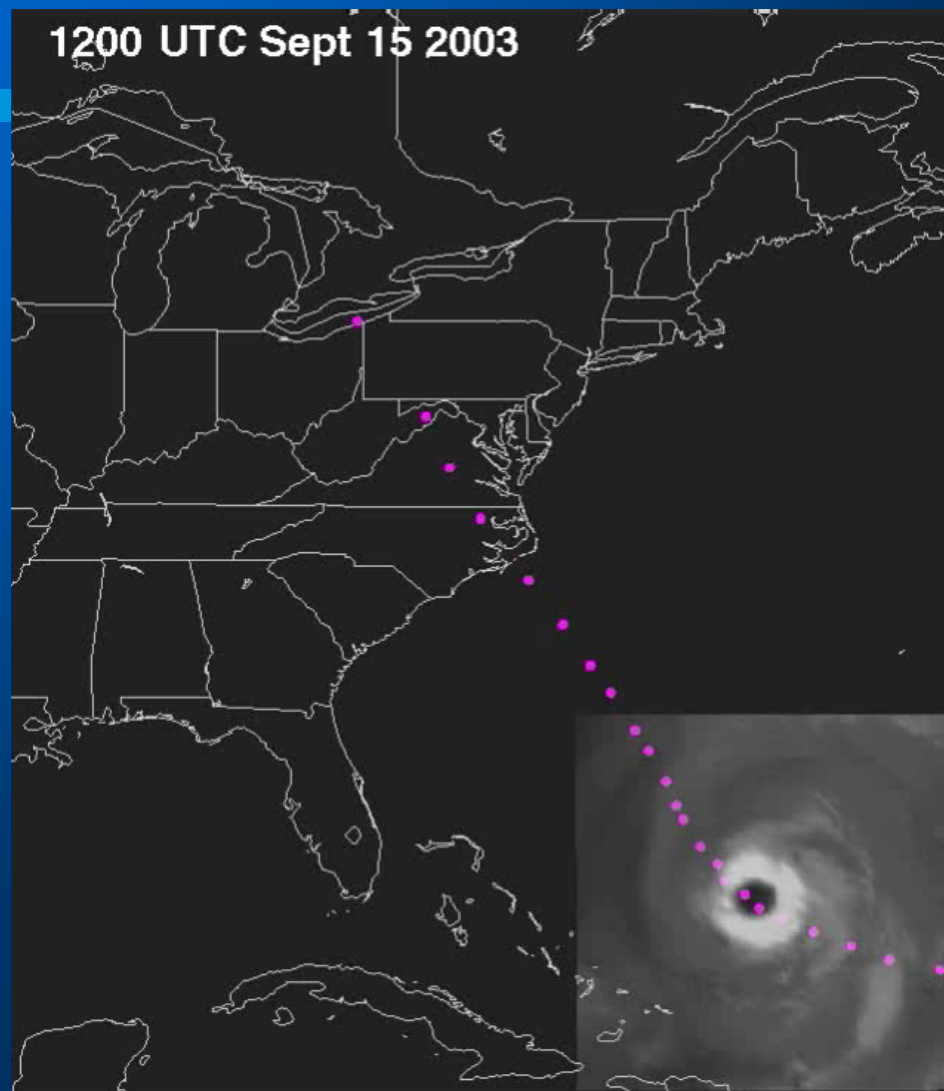
GFDL Hurricane Dynamics Group



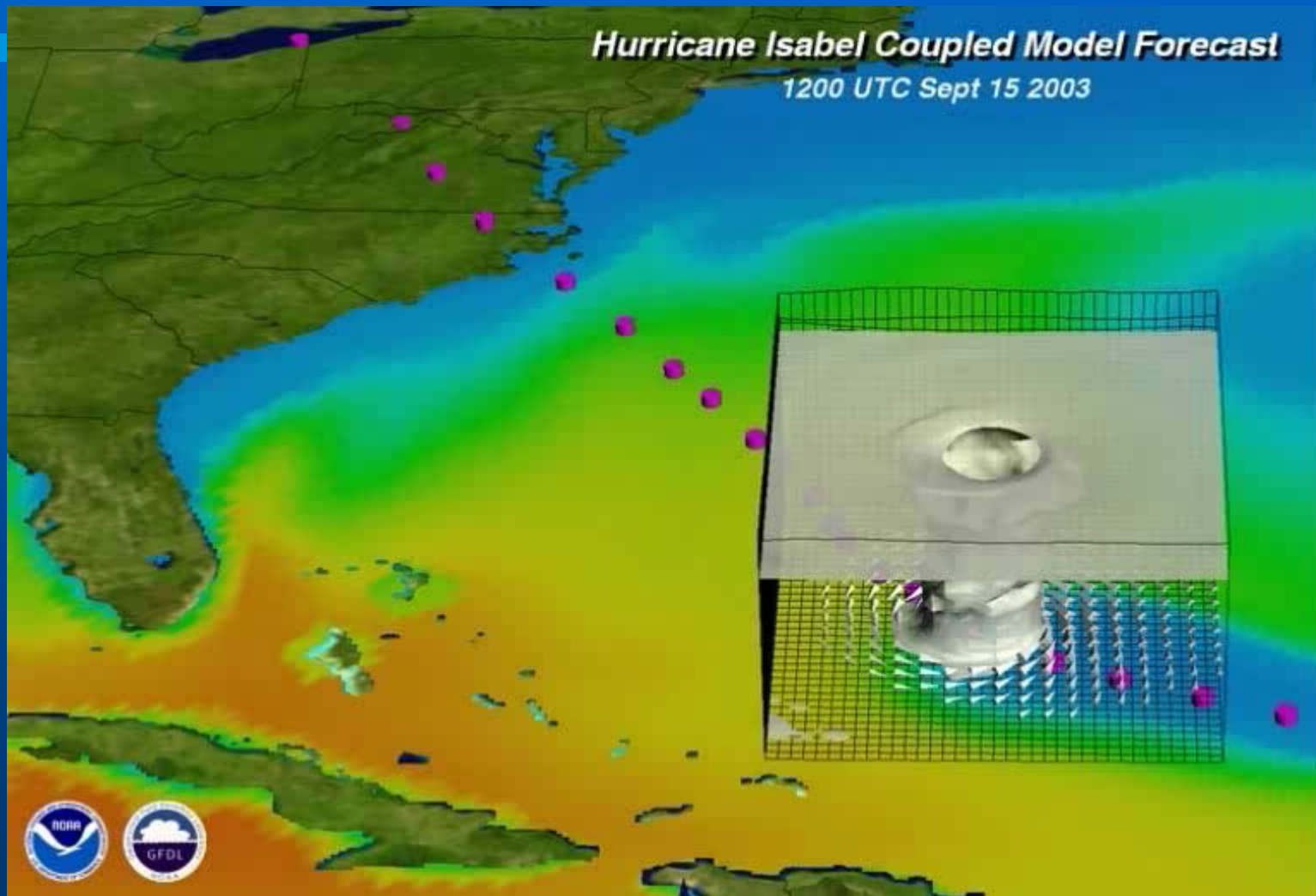
Hurricane Isabel Satellite Loop



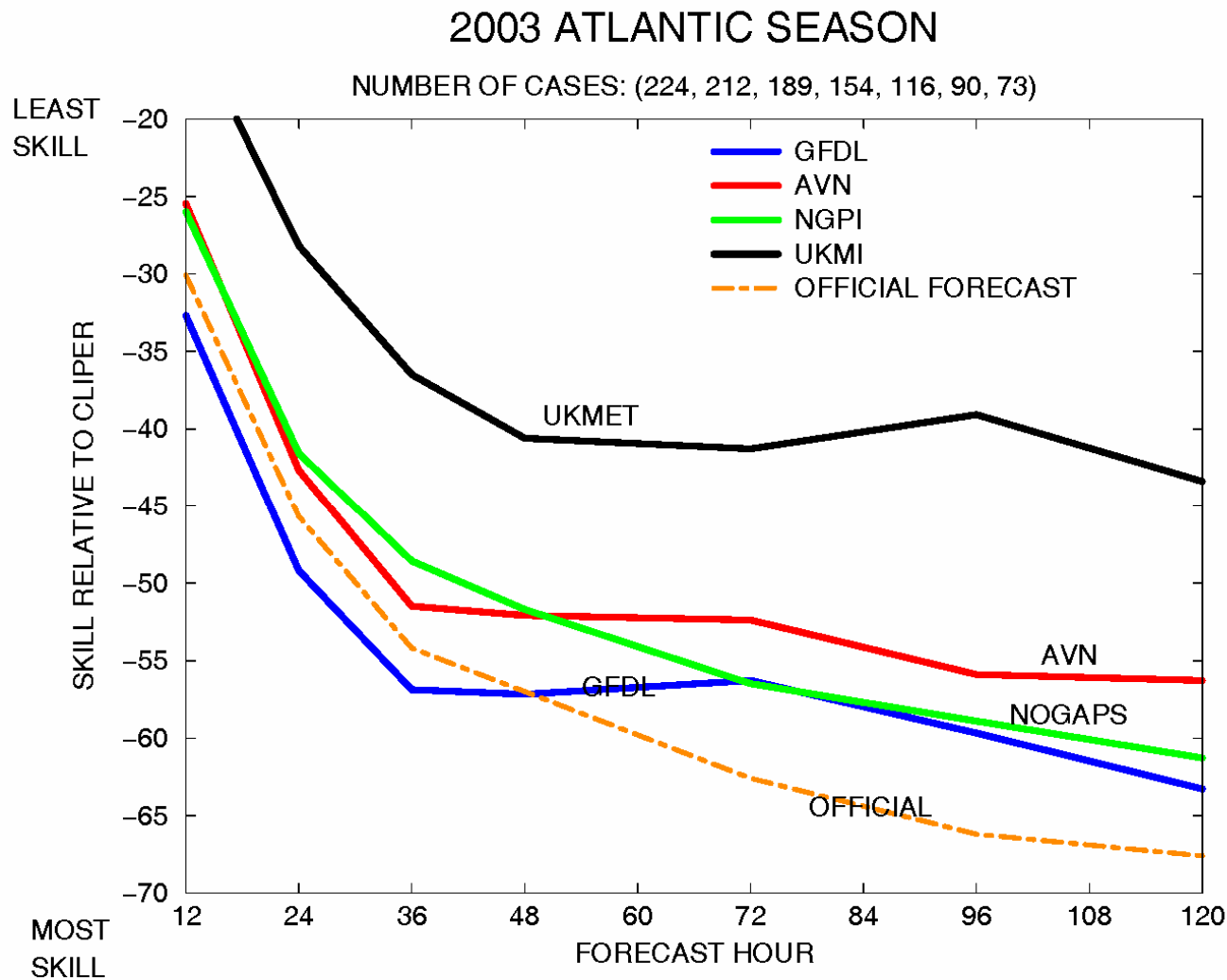
Isabel Explorer animation, RH, top view



Isabel ThetaE animation, oblique view



2003 Hurricane Season Skill

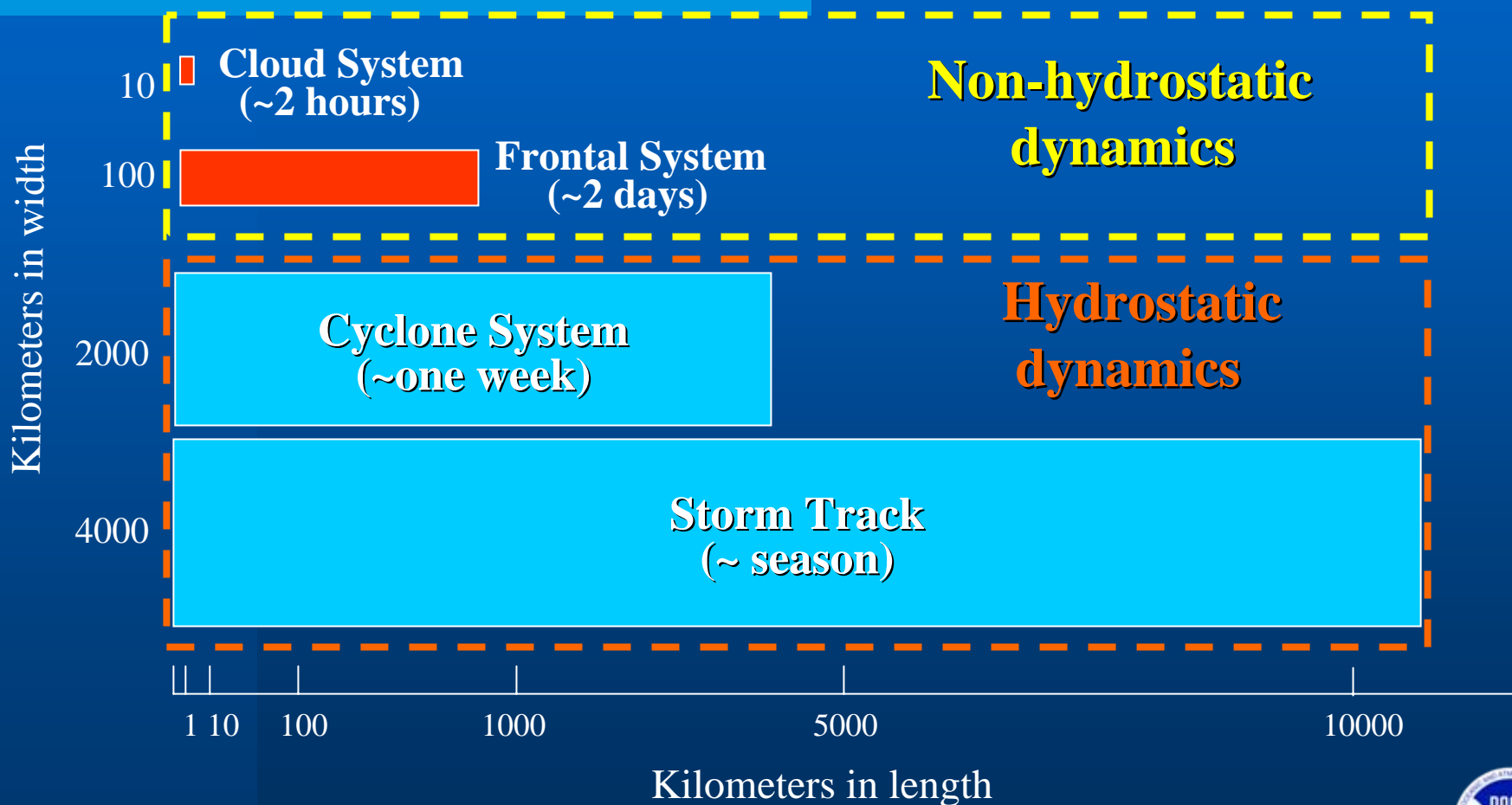


Characteristics of the Climate System

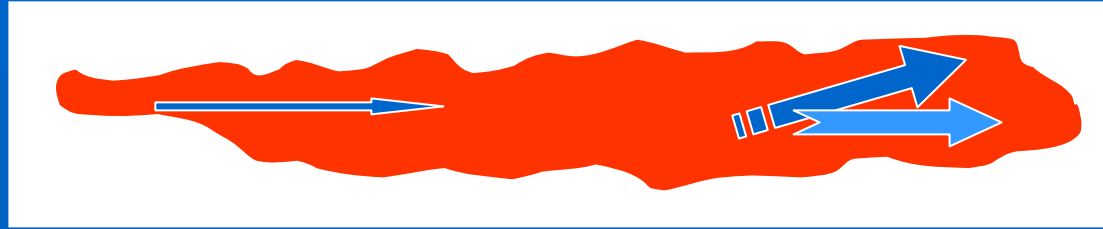
- **Forced Chaotic System**
 - Small initial perturbations cause significant changes to climate projections
 - Need for ensemble forecasts
- **Important Unresolved Phenomena**
 - Huge range of scales currently requires algorithmic representation of key small-scale physics (convection, ocean eddies, cloud-radiative interaction)



Time-space scale of atmospheric systems



The mechanics of a storm track and its feedback

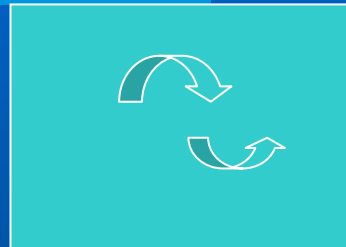


Environment
for cyclone
development.

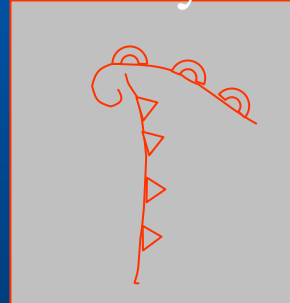
Produce
frontal systems
and low level
convergence

Strong vertical
ascent associated
with the front,
Upward transport
of moisture
and other tracers

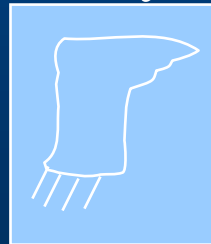
Cyclone system



Frontal system



Cloud system



Intense cyclone
waves can modify
the storm track

Intense fronts
produce more
cyclogenesis

Cloud
System
releases latent
heat that further
intensifies the front

Well resolved by present GCM's

Fairly resolved

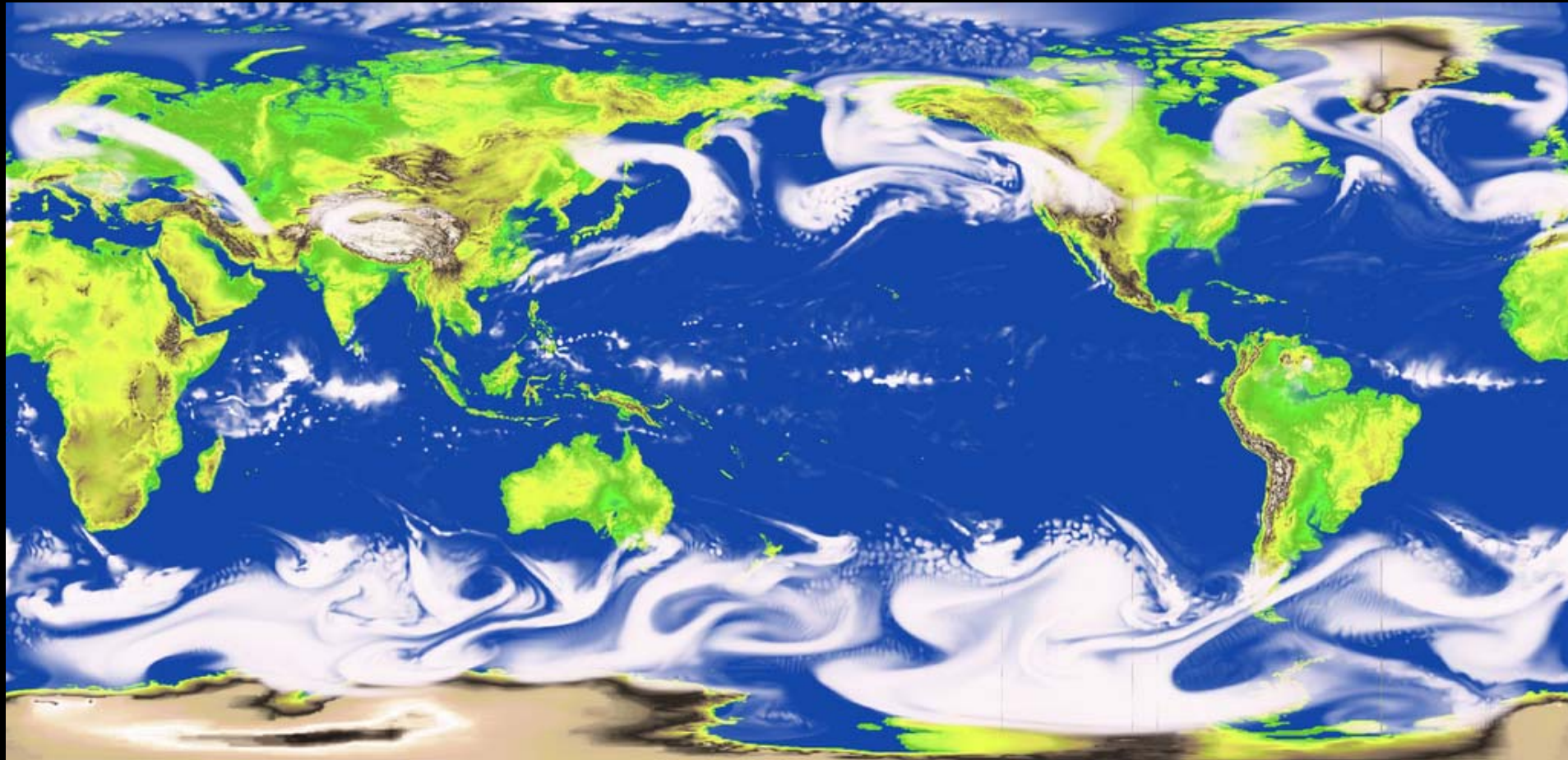
Parameterized, not resolved





General Mesoscale Circulation Model at GFDL

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
Geophysical Fluid Dynamics Laboratory
Princeton, New Jersey 08542
<http://www.gfdl.noaa.gov>



Scientists at the Geophysical Fluid Dynamics Laboratory have recently completed Project TERRA. Project TERRA was conceived* as a 1-day Simulation of the cloud resolving nonhydrostatic ZETAC model. This model is the first Global Mesoscale Circulation Model (GMCM) run at GFDL and perhaps the first global cloud resolving model run anywhere that uses a grid resolution of 10~12km.

*Conceived and executed by Isidoro Orlanski and Christopher Kerr.