"LambdaGrids--Earth and Planetary Sciences Driving High Performance Networks and High Resolution Visualizations"

Invited Talk to the
NASA Jet Propulsion Laboratory
Pasadena, CA
February 4, 2005

Dr. Larry Smarr

Director, California Institute for Telecommunications and Information Technology

Harry E. Gruber Professor,

Dept. of Computer Science and Engineering

Jacobs School of Engineering, UCSD

Chair, NASA Earth System Science and Applications Advisory Committee

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Abstract

While the Internet and the World Wide Web have become ubiquitous, their shared nature severely limits the bandwidth available to an individual user. However, during the last few years, a radical restructuring of optical networks supporting e-Science projects is beginning to occur around the world. Amazingly, scientists are now able to acquire the technological capability for private 1-10 Gbps light pipes (termed "lambdas"), which create deterministic network connections coming right into their laboratories.

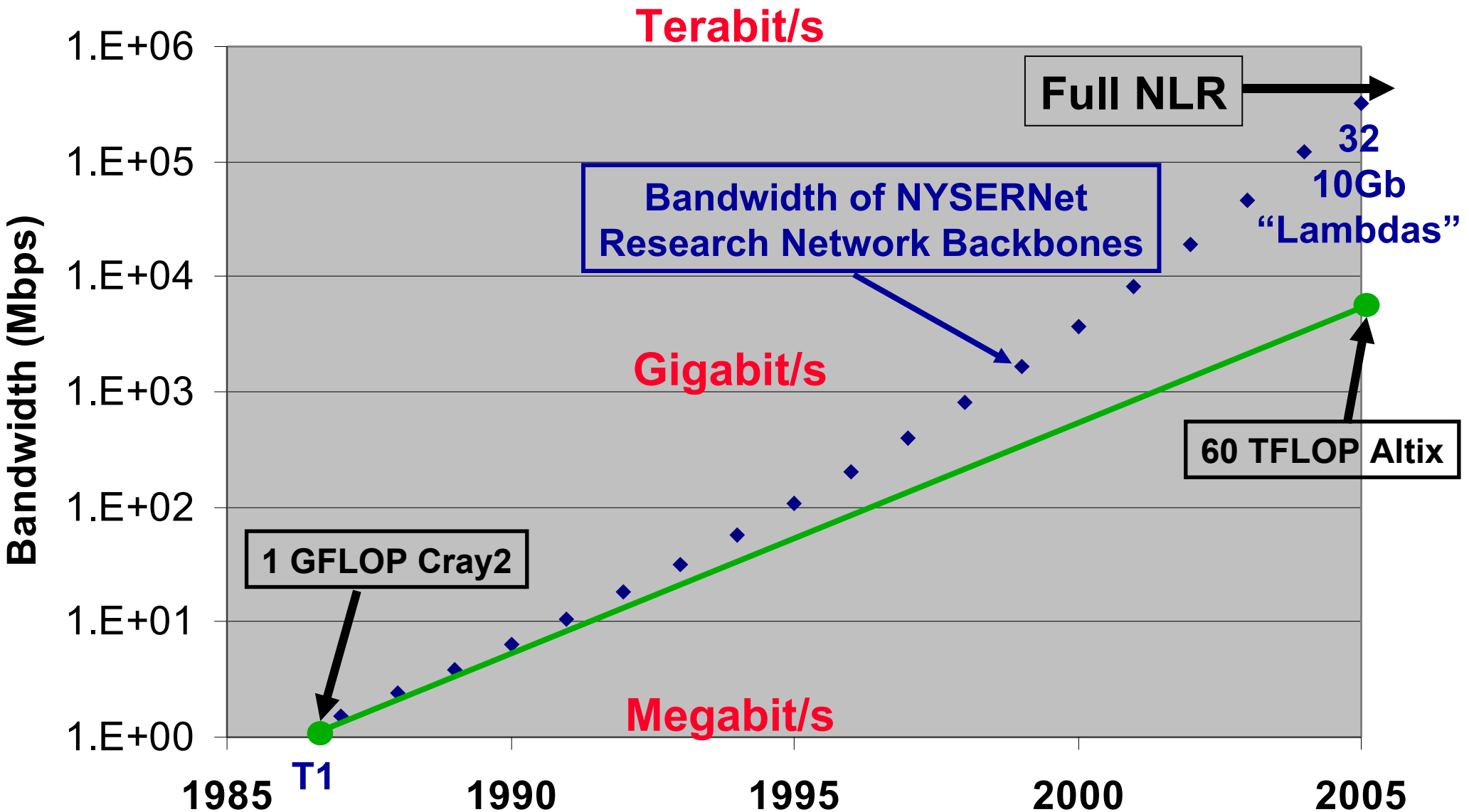
Two of the largest research projects on LambdaGrids are the NSF- funded OptIPuter (www.optiputer.net) and its new companion LOOKING (http://lookingtosea.ucsd.edu/), which is prototyping an interactive ocean observatory. The OptIPuter has two regional cores, one in Southern California and one in Chicago, which has now been extended to Amsterdam. One aim of the OptIPuter project is to make interactive visualization of remote gigabyte data objects as easy as the Web makes manipulating megabyte-size data objects today

As earth and planetary sciences move toward an interactive global observation capability, a new generation of cyberinfrastructure is required, based on LambdaGrids. LOOKING and OptIPuter are prototyping realtime control of remote instruments, remote visualization or large data objects, metadata searching of federated data repositories, and collaborative analysis of complex simulations and observations. Calit2 is currently expanding its OptIPuter collaboration partners to include the NASA Science centers, JPL, Ames, and Goddard -- coupling ocean and climate supercomputer simulations with global earth satellite repositories and interactive viewing tens of megapixels of Mars Rover scenes.

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Optical WAN Research Bandwidth Has Grown Much Faster than Supercomputer Speed!

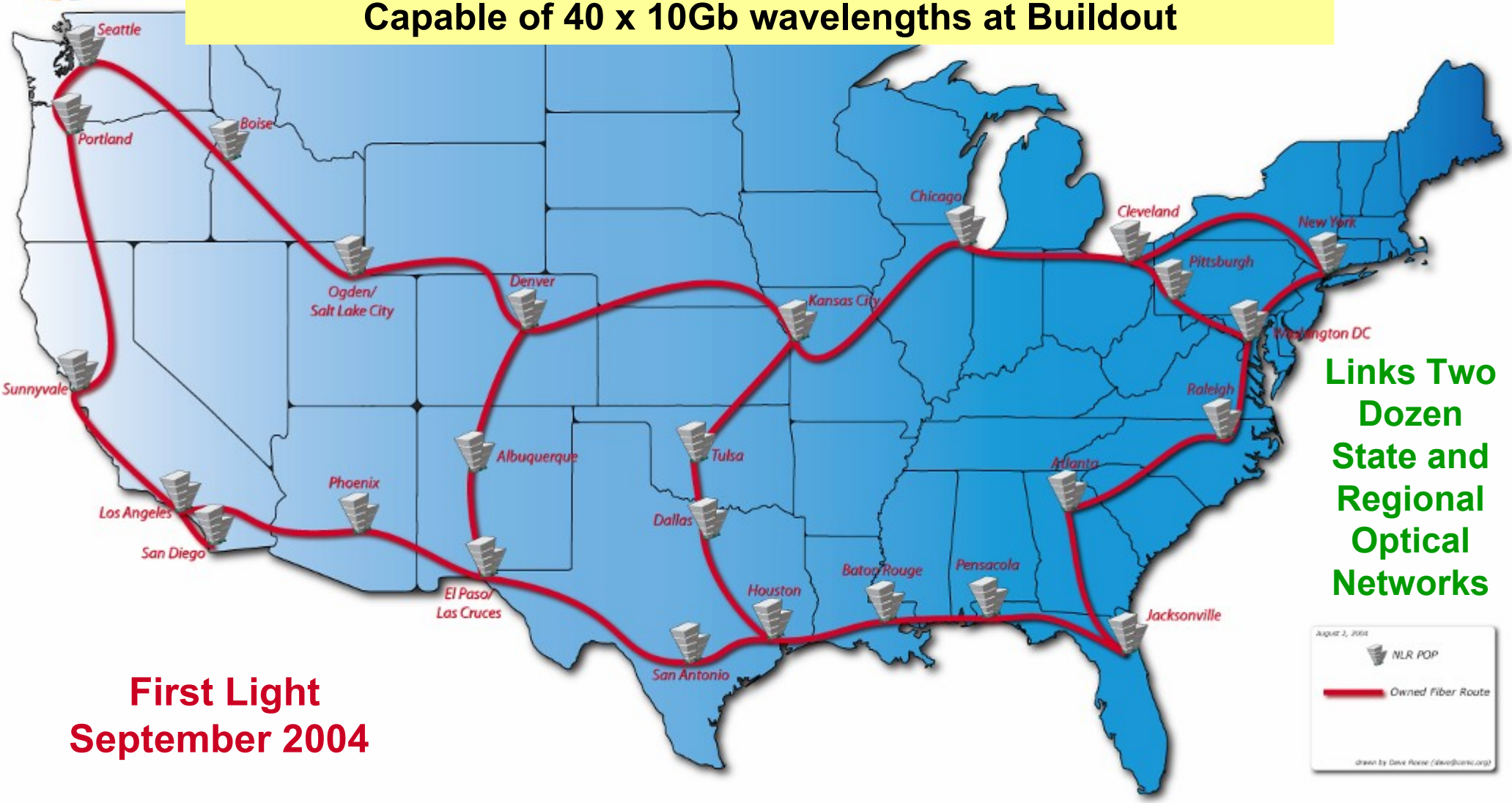


Source: Timothy Lance, President, NYSERNet

NLR Will Provide an Experimental Network Infrastructure for U.S. Scientists & Researchers

"National LambdaRail" Partnership

Serves Very High-End Experimental and Research Applications
4 x 10Gb Wavelengths Initially
Capable of 40 x 10Gb wavelengths at Buildout



Links Two Dozen State and Regional Optical Networks

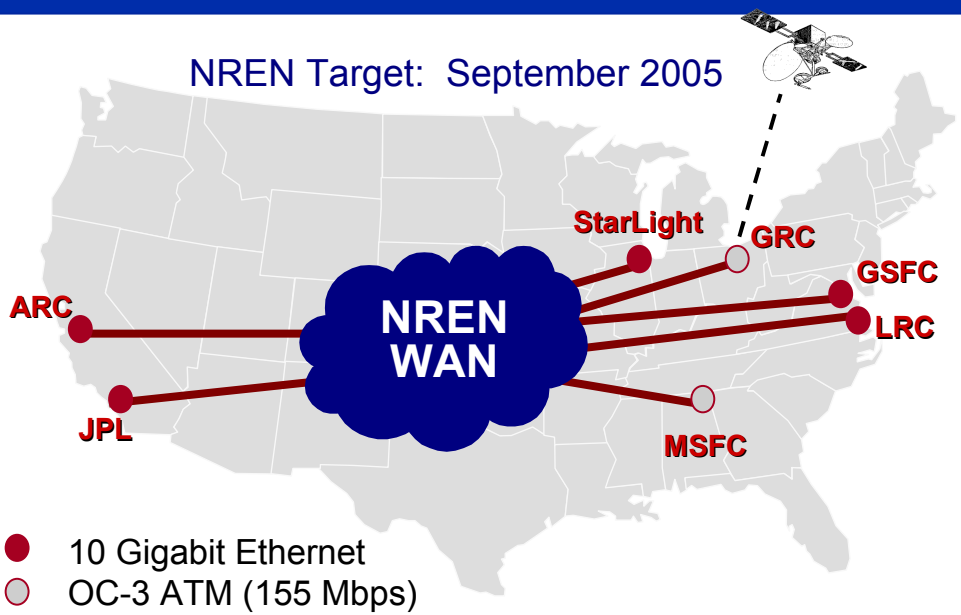
First Light September 2004

For more information regarding NLR see http://www.nlr.net or contact info@nlr.net

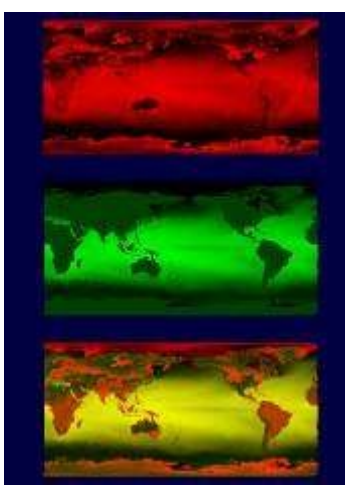
NASA Research and Engineering Network (NREN) Overview

- NREN Goal
  - Provide a Wide Area, High-speed Network for Large Data Distribution and Real-time Interactive Applications
  - Provide Access to NASA Research & Engineering Communities - Primary Focus: Supporting Distributed Data Access to/ from Project Columbia





- Sample Application: Estimating the Circulation and Climate of the Ocean (ECCO)
  - ~78 Million Data Points
  - 1/6 Degree Latitude-Longitude Grid
  - Decadal Grids ~ 0.5 Terabytes / Day
  - Sites: NASA JPL, MIT, NASA Ames



- **Next Steps**
  - **1 Gbps (JPL to ARC) Across CENIC (February 2005)**
  - **10 Gbps ARC, JPL & GSFC Across NLR (May 2005)**
  - **StarLight Peering (May 2005)**
  - **10 Gbps LRC (Sep 2005)**

OptIPuter

Source: Kevin Jones, Walter Brooks, ARC



Global Lambda Integrated Facility (GLIF)
Integrated Research Lambda Network

Many Countries are Interconnecting Optical Research Networks

to form a Global SuperNetwork



OptIPuter

Visualization courtesy of
Bob Patterson, NCSA

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Announcing…

Call for Applications Using the GLIF SuperNetwork

iGrid 2005

THE GLOBAL LAMBDA INTEGRATED FACILITY

www.startap.net/igrid2005/

September 26-30, 2005
University of California, San Diego
California Institute for Telecommunications and Information Technology

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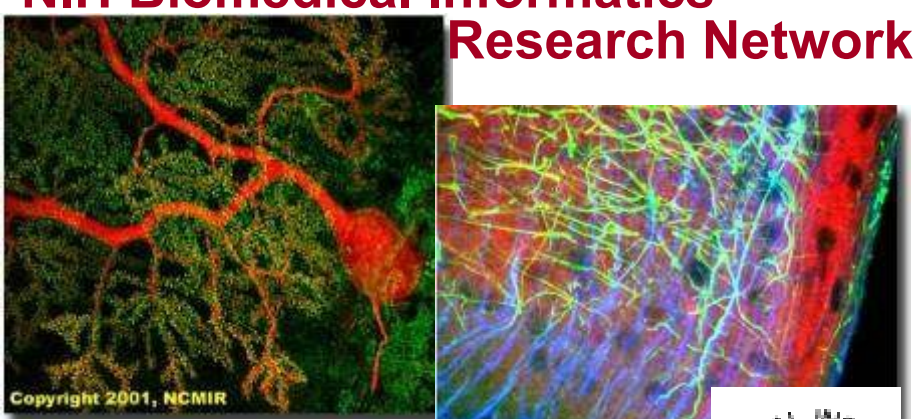
Maxine Brown, Tom DeFanti, Co-Organizers

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The OptIPuter Project –
Creating a LambdaGrid "Web" for Gigabyte Data Objects

- NSF Large Information Technology Research Proposal
  - Cal-(IT)^2 and UIC Lead Campuses—Larry Smarr PI
  - USC, SDSU, NW, Texas A&M, Univ. Amsterdam Partnering Campuses
- Industrial Partners
  - IBM, Sun, Telcordia, Chiaro, Calient, Glimmerglass, Lucent
- $13.5 Million Over Five Years
- Optical IP Streams From Lab Clusters to Large Data Objects

NIH Biomedical Informatics Research Network

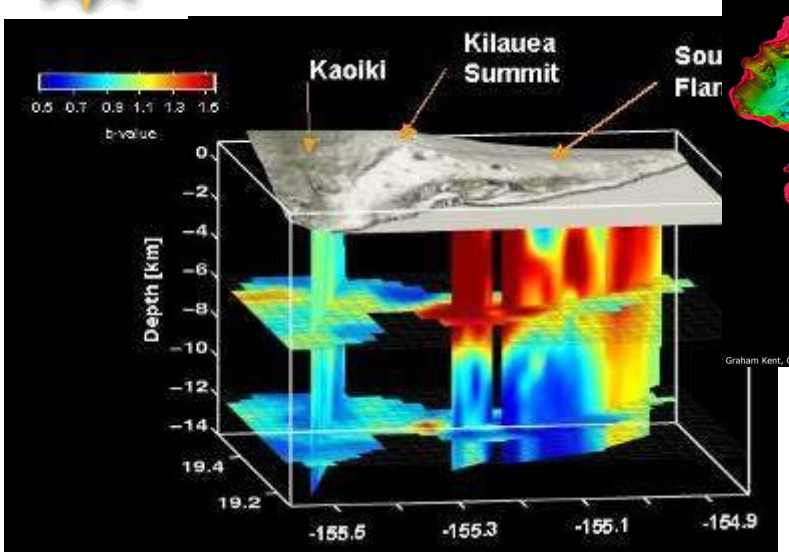


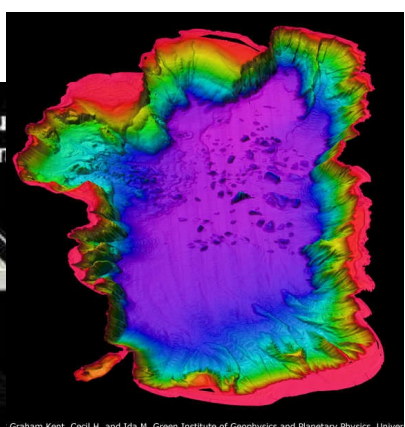
NCMIR
NATIONAL CENTER for MICROSCOPY and IMAGING RESEARCH
at San Diego, an NIH supported resource center

NATIONAL INSTITUTES OF HEALTH

http://ncmir.ucsd.edu/gallery.html

NSF EarthScope and ORION





siovizcenter.ucsd.edu/library/gallery/shoot1/index.shtml

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Optical Networking, Internet Protocol, Computer
Bringing the Power of Lambdas to Users

- **Extending Grid Middleware to Control:**
  - Jitter-Free, Fixed Latency, Predictable Optical Circuits
    - One or Parallel Dedicated Light-Pipes (1 or 10 Gbps WAN Lambdas)
    - Uses Internet Protocol, But Does NOT Require TCP
    - Exploring Both Intelligent Routers and Passive Switches
  - Clusters Optimized for Storage, Visualization, and Computing
    - Linux Clusters With 1 or 10 Gbps I/O per Node
    - Scalable Visualization Displays Driven By OptIPuter Clusters
- **Applications Drivers:**
  - Earth and Ocean Sciences
  - Biomedical Imaging
  - Digital Media at SHD resolutions (Comparable to 4K Digital Cinema)

The OptIPuter Envisions a Future When the Central Architectural Element Becomes Optical Networks-NOT Computers - Creating "SuperNetworks"

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History of NASA and the OptIPuter

- Feb 2001 Starlight Lambda Open Exchange Point for USA--Initial Implementation
- Oct 2001 OptIPuter Planning Begins
- Sept 2002 iGRID 2002 in Amsterdam
- Oct 2002 NSF OptIPuter Project Begins
- May 2003 GSFC Visit-Diaz Asks Milt Halem to Define NASA OptIPuter Project
- Aug 2003 Global Lambda Integrated Facility Formed
- Nov 2003 SC03 Discussions
- Feb 2004 GSFC IRAD Funded to Create GSFC/SIO Lambda Collab
- Feb 2004 ESSAAC Meeting at SIO
- Mar 2004 Presentation to NAC on IT Survey
- May 2004 Presentation of IT Recommendations to NAC
- July 2004 Project Columbia Approved
- Aug 2004 ARC Visit
- Oct 2004 NLR and CAVEwave First Light
- Nov 2004 GSFC at SC04 Becomes Early User of NLR
- Jan 2005 NASA Commits to NREN Use of NLR for Multiple Sites
- Today JPL Visit

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GSFC IRAD Proposal "Preparing Goddard for Large Scale Team Science in the 21st Century: Enabling an All Optical Goddard Network Cyberinfrastructure"

Funded February 2004

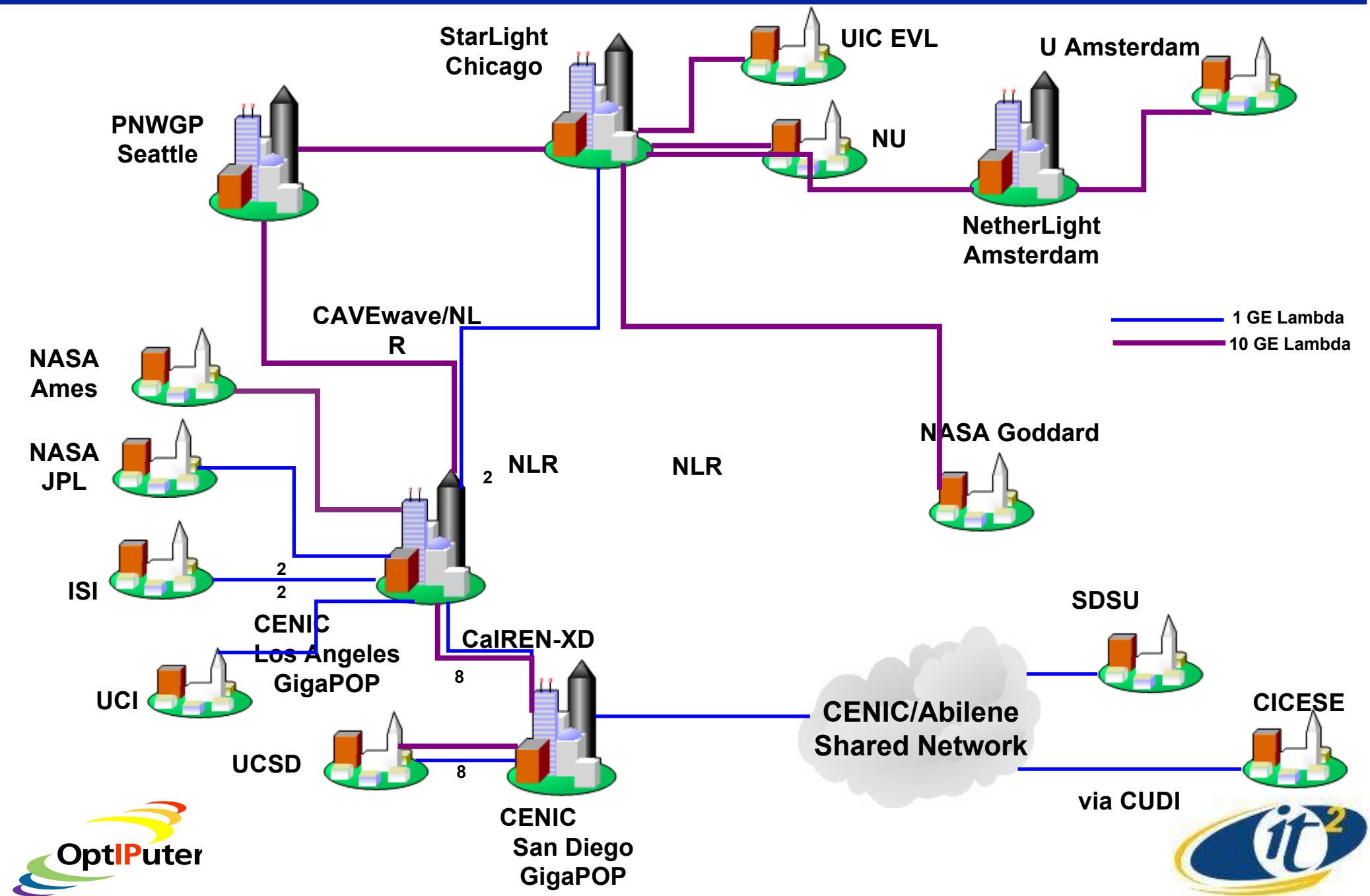
Objectives Summary

- "…establish a 10 Gbps Lambda Network from GSFC's Earth Science Greenbelt facility in MD to the Scripps Institute of Oceanography (SIO) over the National Lambda Rail (NLR)"
- "…make data residing on Goddard's high speed computer disks available to SIO with access speeds as if the data were on their own desktop servers or PC's."
- "…enable scientists at both institutions to share and use compute intensive community models, complex data base mining and multi-dimensional streaming visualization over this highly distributed, virtual working environment."

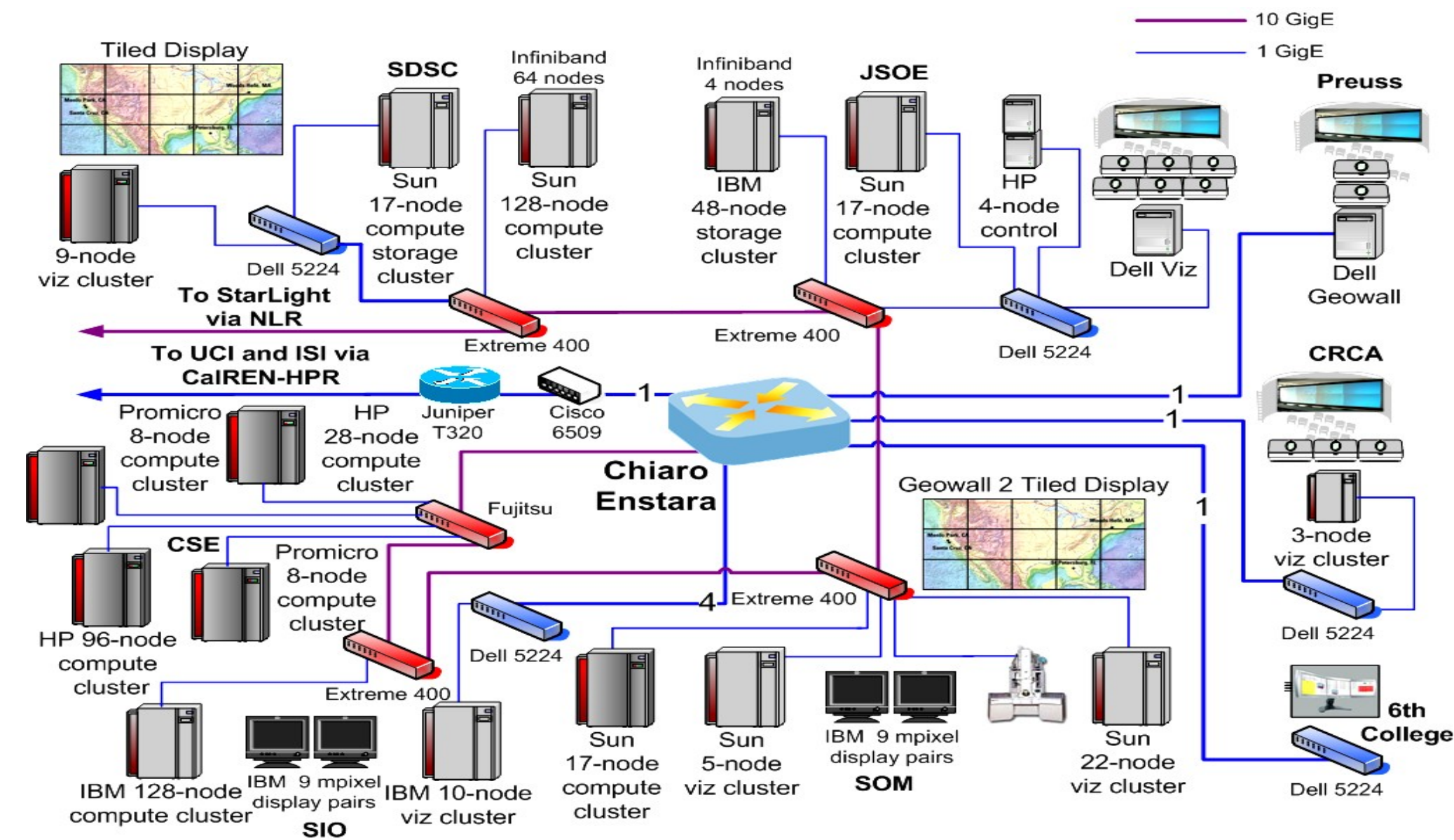
Current Goal-
Add in ARC and JPL

Source: Milt Halem, GSFC

Expanding the OptIPuter LambdaGrid



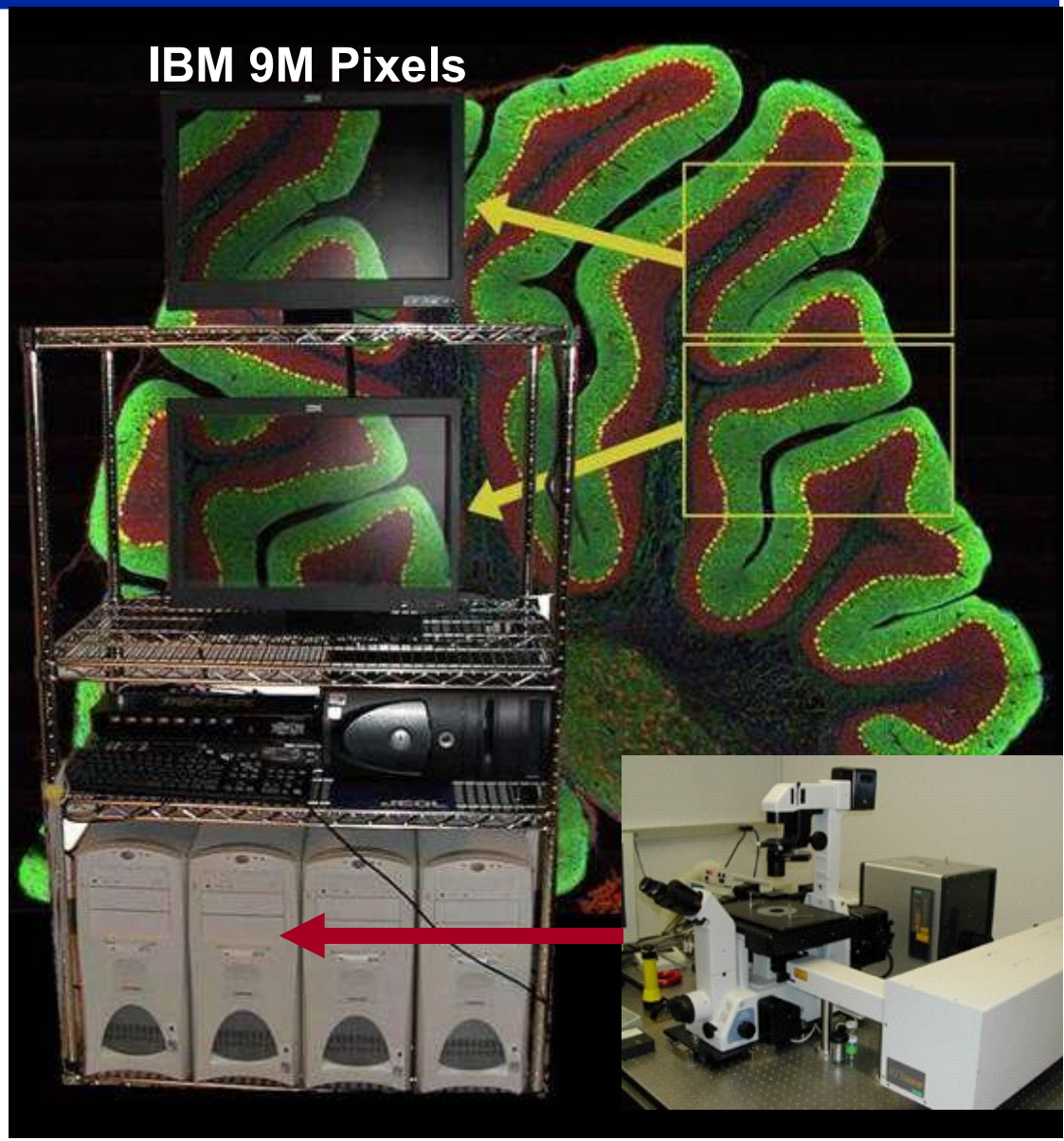
UCSD Campus-Scale Routed OptIPuter with Nodes for Storage, Computation and Visualization



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OptIPuter Driver: On-Line Microscopes Creating Very Large Biological Montage Images

- 2-Photon Laser Confocal Microscope
  - High Speed On-line Capability
- Montage Image Sizes Exceed 16x Highest Resolution Monitors
  - ~150 Million Pixels!
- Use Graphics Cluster with Multiple GigEs to Drive Tiled Displays



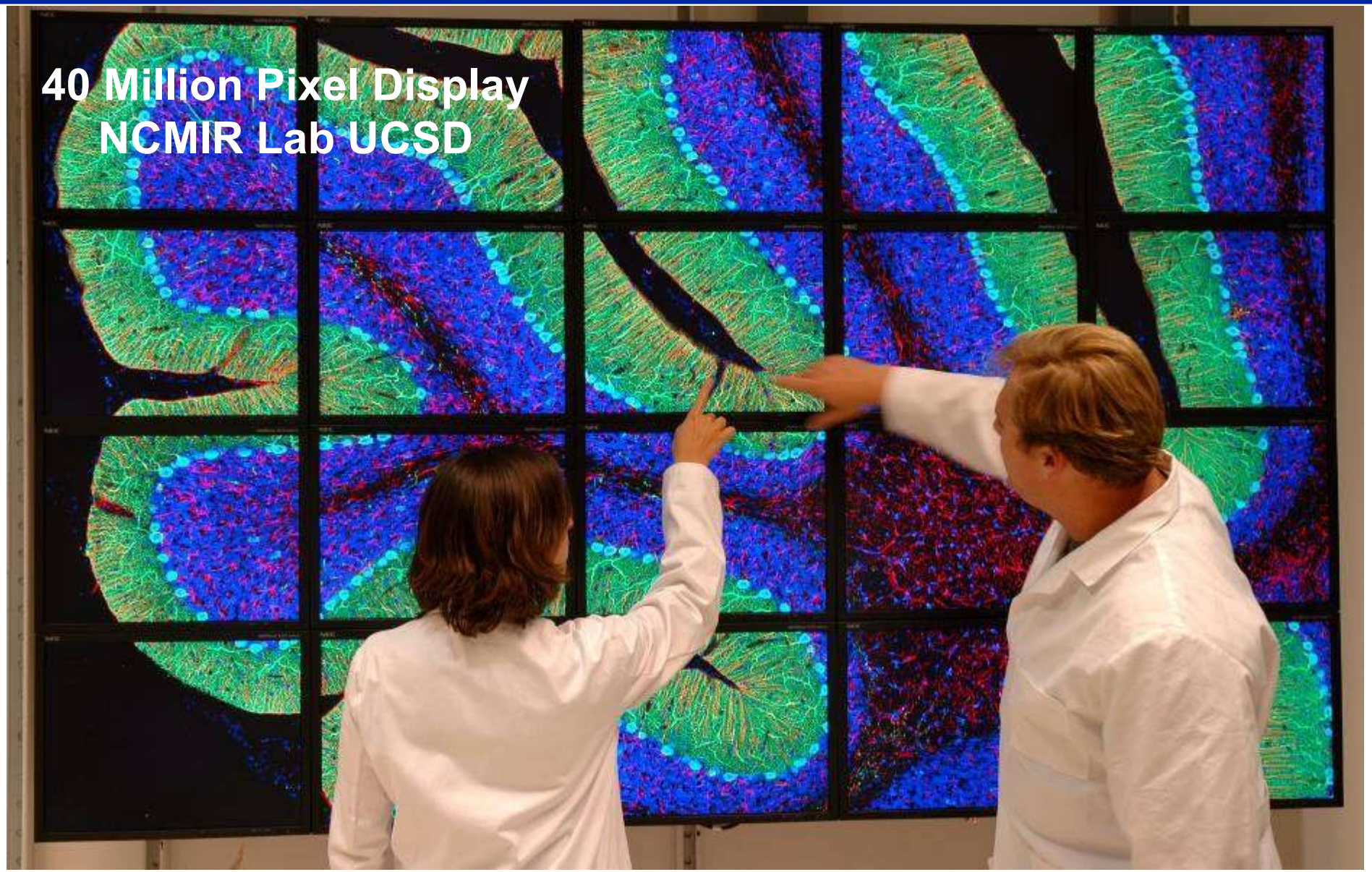
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NCMIR
NATIONAL CENTER for MICROSCOPY and IMAGING RESEARCH
at San Diego, an NIH supported resource center

Source: David Lee, NCMIR, UCSD

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GeoWall2: OptIPuter JuxtaView Software for Viewing High Resolution Images on Tiled Displays



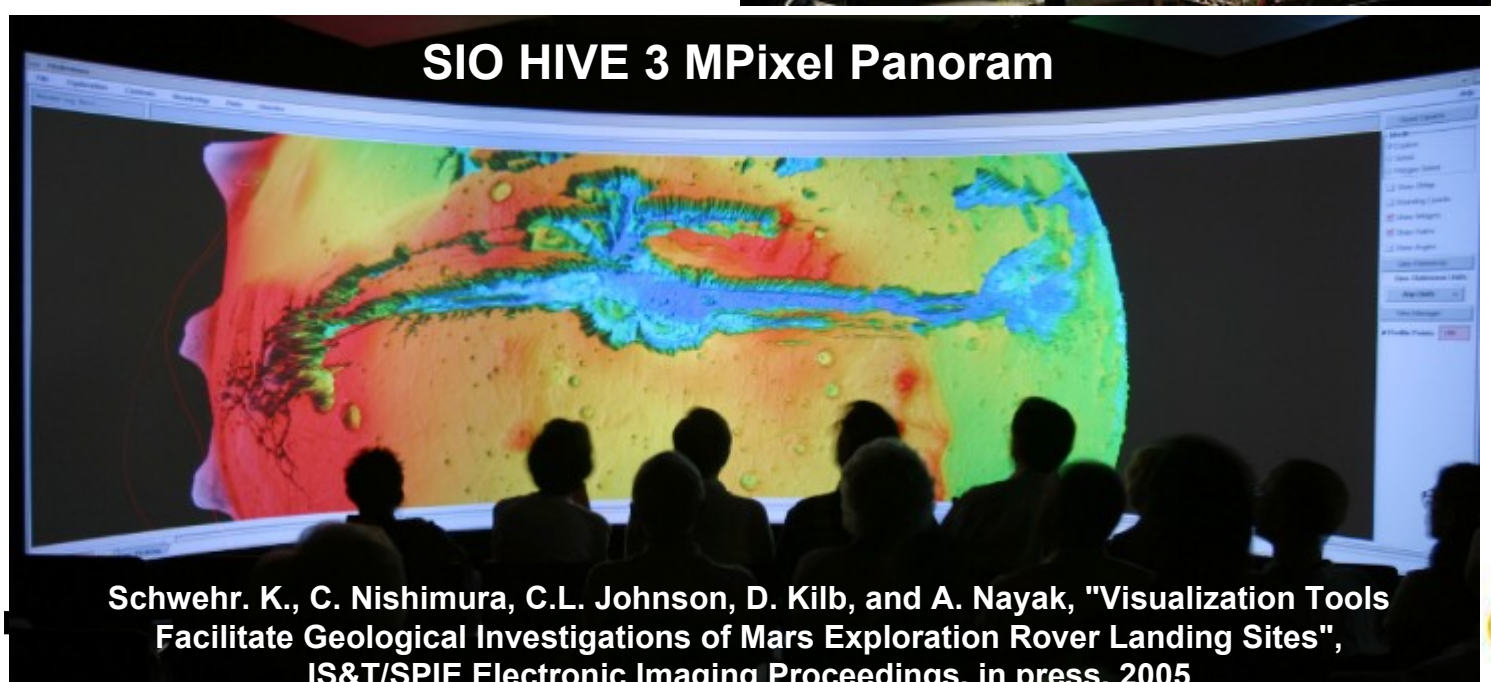
Display Driven by a 20-node Sun Opteron Visualization Cluster

Source: David Lee, Jason Leigh

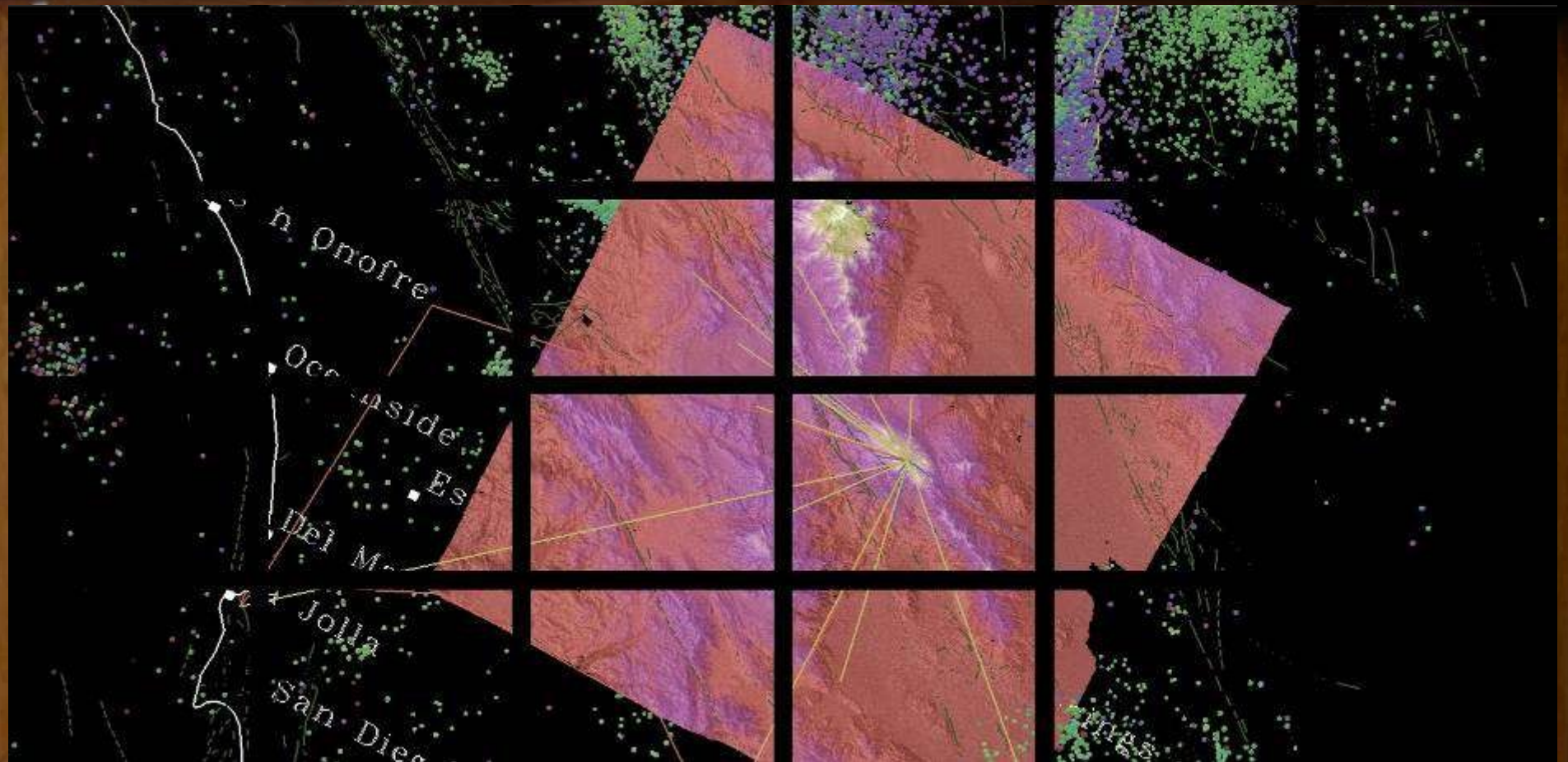
Earth and Planetary Sciences are an OptIPuter Large Data Object Visualization Driver







Schwehr. K., C. Nishimura, C.L. Johnson, D. Kilb, and A. Nayak, "Visualization Tools Facilitate Geological Investigations of Mars Exploration Rover Landing Sites", IS&T/SPIE Electronic Imaging Proceedings, in press, 2005

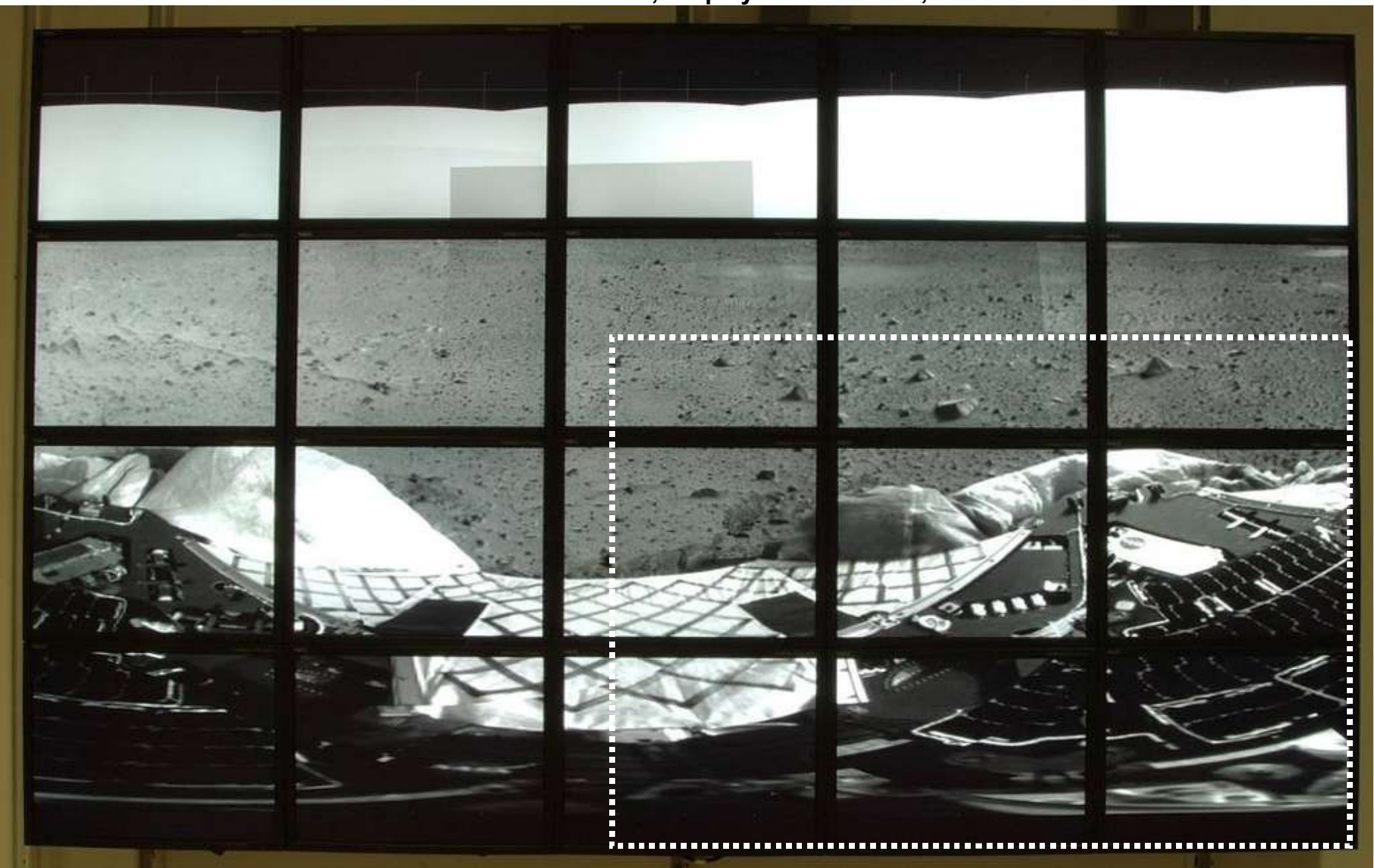


USArray on the GeoWall 2

- Calit2 & SIO are Building
  - a 4 x 6 Macintosh 30” LCD Tiled Display Driven by a Mac G5 Cluster
  - High Resolution Real Time Visualizations of USArray Waveform Data Represented as 3D Glyphs and Combined with Near Real Time Camera Images
  - Provide Health Monitoring of Entire Network.

Tiled Displays Allow for Both Global Context and High Levels of Detail—150 MPixel Rover Image on 40 MPixel OptIPuter Visualization Node Display

"Source: Data from JPL/Mica; Display UCSD NCMIR, David Lee"



Interactively Zooming In Using EVL's JuxtaView on NCMIR's Sun Microsystems Visualization Node

"Source: Data from JPL/Mica; Display UCSD NCMIR, David Lee"



Highest Resolution Zoom on NCMIR 40 MPixel OptIPuter Display Node

"Source: Data from JPL/Mica; Display UCSD NCMIR, David Lee"



The UIC Electronic Visualization Lab is Prototyping the LambdaTable Version of the Tiled Display

"Source: Data from JPL/Mica; Display UIC EVL, Luc Renambot, Nicholas Schwarz"



Desktop 18 MPixel Interactive Displays Using SIO's OptIPuter IBM Visualization Node

"Source: Data from JPL Rover Team--Spirit Landing Site; Display UCSD SIO, Atul Nayak"



OptIPuter is Prototyping The PC of 2010

- Terabits to the Desktop…
- 100 Megapixels Display
  - 55-Panel
- 1/3 Terabit/sec I/O
  - 30 x 10GE interfaces
  - Linked to OptIPuter
- 1/4 TeraFLOP
  - Driven by 30 Node Cluster of 64 bit Dual Opterons
- 1/8 TB RAM
- 60 TB Disk



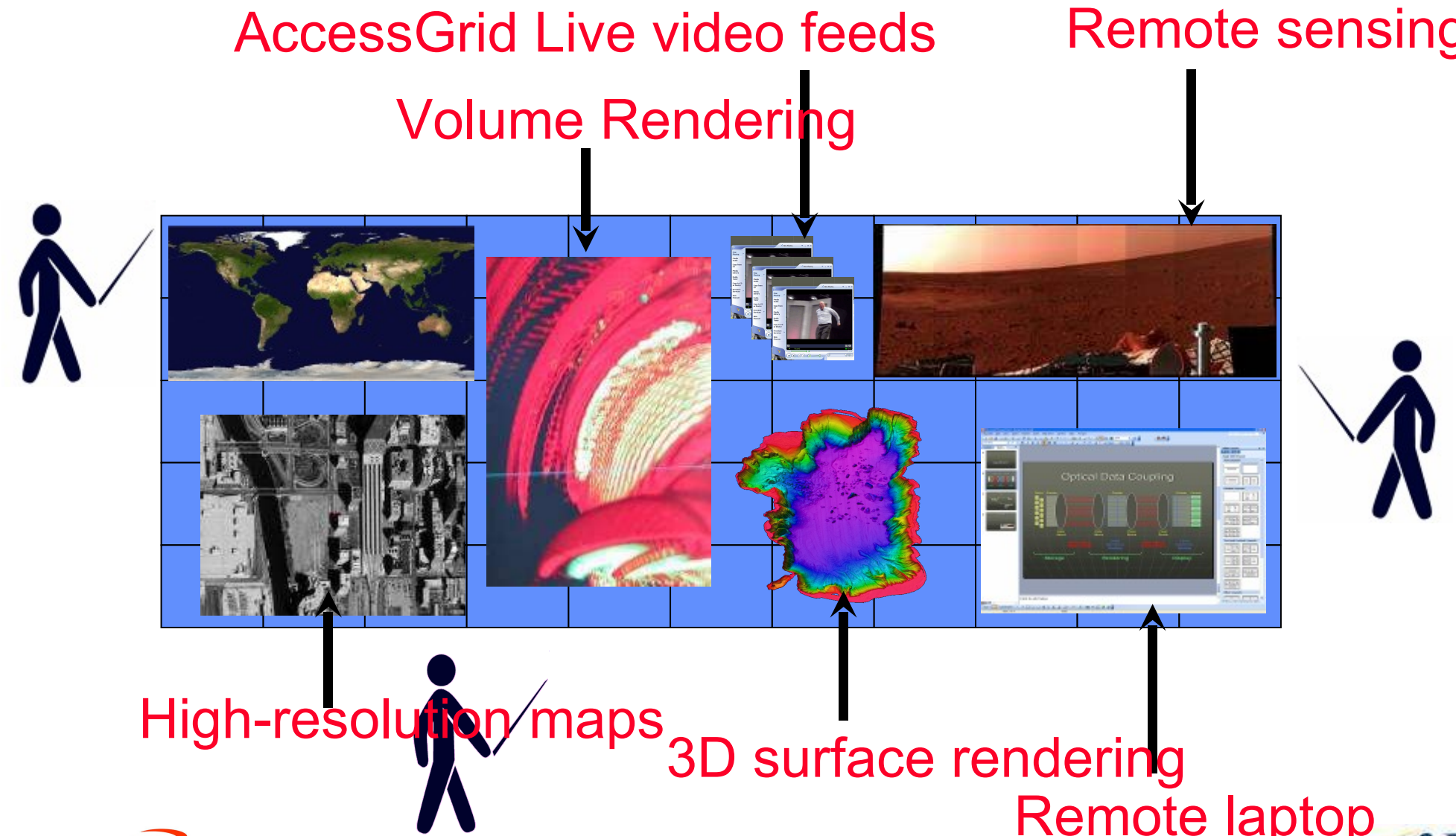
OptIPuter

Source: Jason Leigh, Tom DeFanti, EVL@UIC
OptIPuter Co-PIs

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Scalable Adaptive Graphics Environment (SAGE) Required for Working in Display-Rich Environments

Information Must Be Able To Flexibly Move Around The Wall

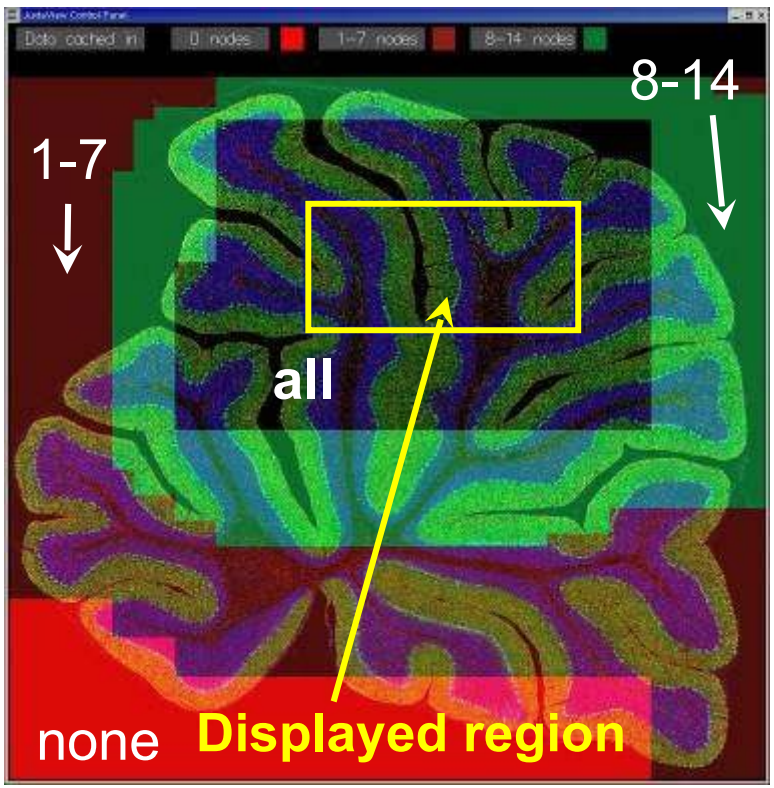


Source: Jason Leigh, UIC

LambdaRAM: Clustered Memory To Provide Low Latency Access To Large Remote Data Sets

- Giant Pool of Cluster Memory Provides Low-Latency Access to Large Remote Data Sets
  - Data Is Prefetched Dynamically
  - LambdaStream Protocol Integrated into JuxtaView Montage Viewer
- 3 Gbps Experiments from Chicago to Amsterdam to UIC
  - LambdaRAM Accessed Data From Amsterdam Faster Than From Local Disk

Visualization of the Pre-Fetch Algorithm

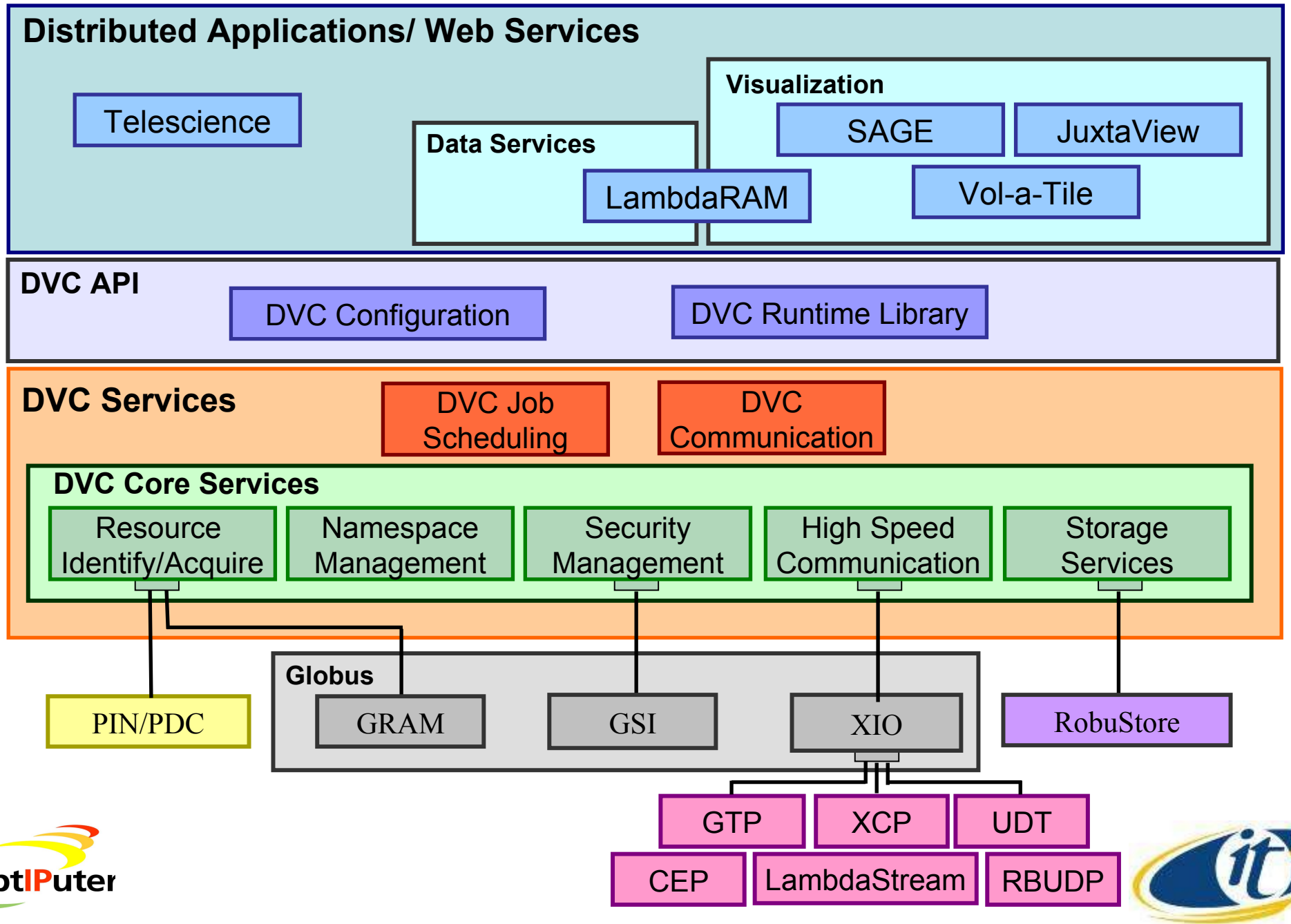




Data on Disk in Amsterdam

Source: David Lee, Jason Leigh

OptIPuter Software Architecture
A Service-Oriented Architecture (SOA)



Two New Calit2 Buildings Will Become Collaboration Laboratories



- Will Create New Laboratory Facilities
- International Conferences and Testbeds
- 800 Researchers in Two Buildings

Calit2@UCSD Building Is Connected To Outside With 140 Optical Fibers



Extend to NASA Science Centers

In 2005 Calit2 will Link Its Two Buildings via Dedicated Fiber over 75 Miles Using OptIPuter Architecture to Create a Distributed Collaboration Laboratory

Telepresence Using Uncompressed HDTV Streaming Over IP on Fiber Optics







OptIPuter

JGN II Workshop
January 2005

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An OptIPuter LambdaVision Collaboration Room as Imagined By 2006



OptIPuter

Source: Jason Leigh, EVL, UIC

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Three Classes of LambdaGrid Applications

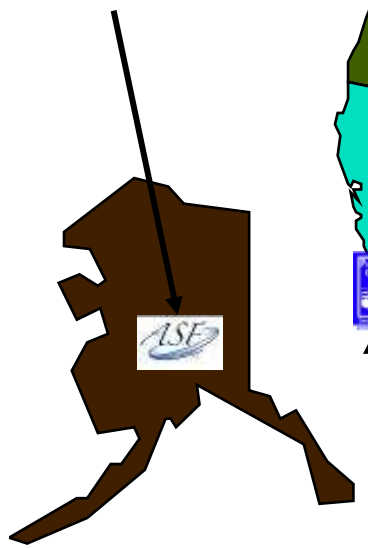
- Browsing & Analysis of Multiple Large Remote Data Objects
- Assimilating Data—Linking Supercomputers with Data Sets
- Interacting with Coastal Observatories

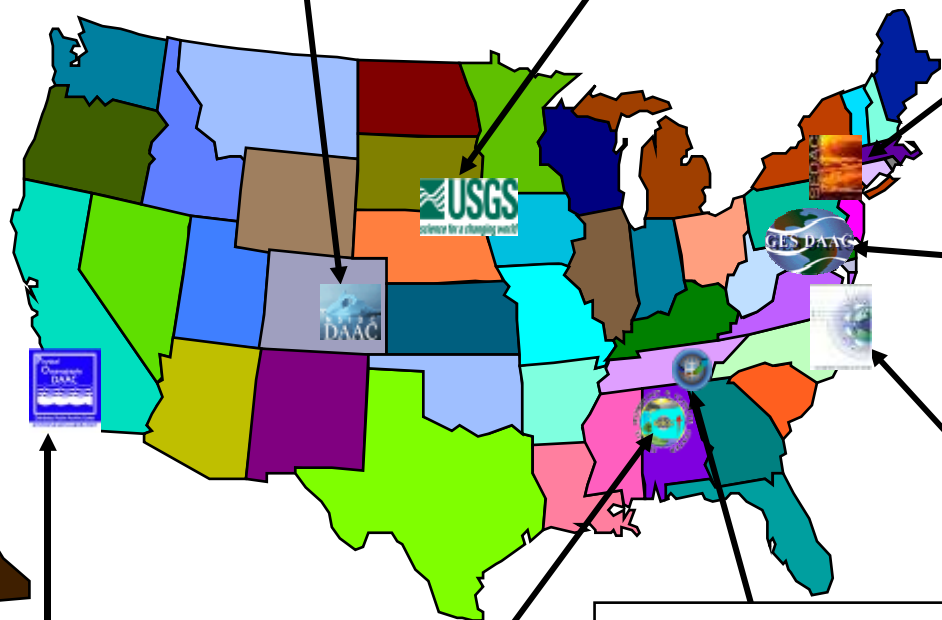
NASA OptIPuter Application Drivers

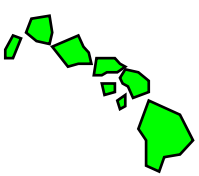
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Earth System Enterprise-Data Lives in Distributed Active Archive Centers (DAAC)







NSIDC (67 TB)
Cryosphere
Polar Processes

LPDAAC-EDC (1143 TB)
Land Processes
& Features

ASF (256 TB)
SAR Products
Sea Ice
Polar Processes

SEDAC (0.1 TB)
Human Interactions in
Global Change

GES DAAC-GSFC (1334 TB)
Upper Atmosphere
Atmospheric Dynamics, Ocean Color, Global Biosphere, Hydrology, Radiance Data

ASDC-LaRC (340 TB)
Radiation Budget,Clouds
Aerosols, Tropospheric
Chemistry

ORNL (1 TB)
Biogeochemical
Dynamics
EOS Land Validation

GHRC (4TB)
Global
Hydrology

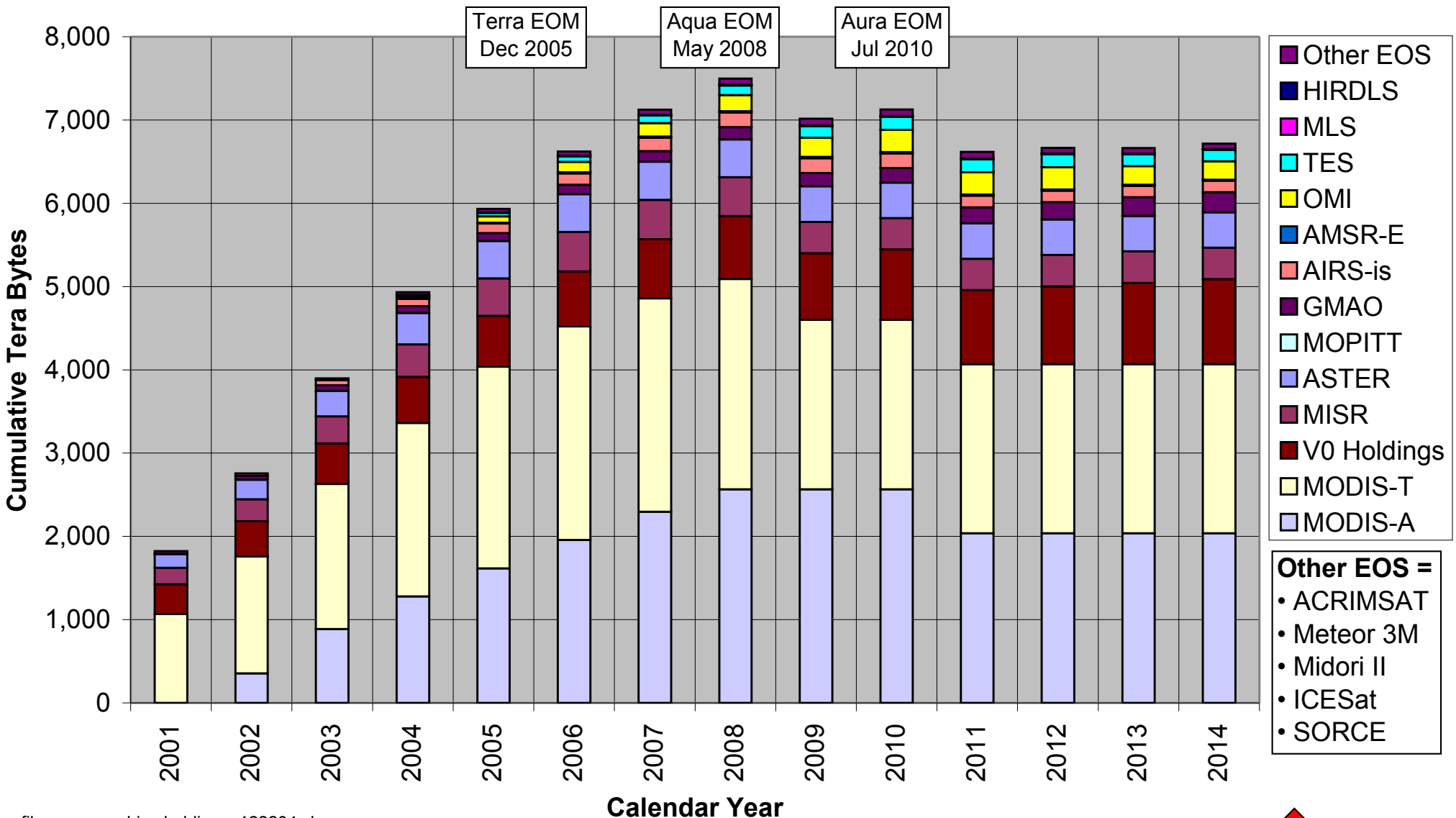
PODAAC-JPL (6 TB)
Ocean Circulation
Air-Sea Interactions

EOS Aura Satellite Has Been Launched
Challenge is How to Evolve to New Technologies

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Cumulative EOSDIS Archive Holdings--Adding Several TBs per Day



file name: archive holdings_122204.xls
tab: all instr bar

NOTE: Data remains in the archive pending transition to LTA

Source: Glenn Iona, EOSDIS Element Evolution Technical Working Group January 6-7, 2005

EOSDIS in 2010: Trends in Data System Development

- Away from Centrally Designed, Implemented & Maintained Systems
- Toward
- The Integration of Independently Designed, Implemented and Maintained System Elements
  - The Data Delivery System will be Hidden from the User
  - Data Access Through a Data System Integrator which Provides Access to a Large Spectrum of Other Repositories as Well
  - Most Access Performed Automatically by Other Computers
    - e.g. Web/ Grid Services

Source:Peter Cornillon
Graduate School of Oceanography, Univ. of Rhode Island

OceanColor WEB

http://oceancolor.gsfc.nasa.gov/

Data Access

Level 1 and 2 Browser
Visually search the ocean color data archive and directly download and/or order data from single files to the entire mission. Extensive online HELP and tutorials available.

Level 3 Browser
Browse the entire Level 3 global ocean color data set for many parameters and time periods and download either JPEG images or digital data in HDF format.

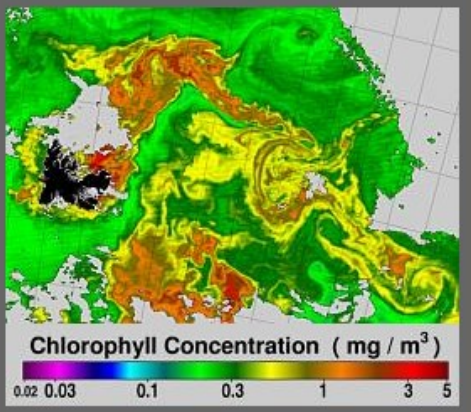
Data Subscriptions
Request a subscription for Aqua data to be staged on an FTP site.
You can check the status of an existing subscription.

Data by FTP
The Project maintains several FTP sites containing the most popular data products including the complete Level 3 data archive.

GES DAAC
The GES DAAC hosts the recently reprocessed MODIS/Terra ocean color data, the SeaWiFS, OCTS, and CZCS data sets and Terra and Aqua SST data (in conventional MODIS format).

Ocean Color Web Feature

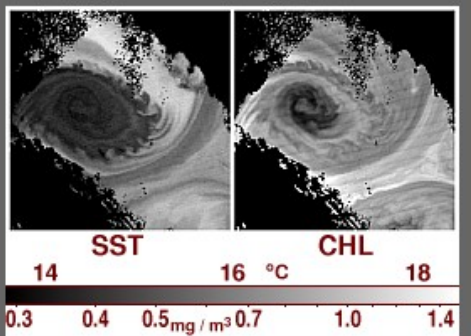
This section features links to recent topics, stories and imagery of interest to the OceanColor community.



The Kerguelen Islands in the southern Indian Ocean lie in the path of the Antarctic circumpolar current. Nutrients -- either from the islands themselves or from deeper water mixed to the surface by turbulence around the Kerguelen Plateau -- support more vigorous phytoplankton growth in the wake of the islands. This shows up in the image above as higher chlorophyll concentration. Further discussion of the region is available.

Larger images showing chlorophyll and sea surface temperature over a wider area are also available. These data were collected on January 27, 2005 by MODIS aboard the Aqua satellite.

Also of particular interest in the aforementioned larger images is the following eddy which exhibits characteristics of current shear along its edges. Click on the left or right panels to see a slightly larger version.



Support Services

SeaDAS
SeaDAS is a comprehensive image analysis package for the processing, display, analysis, and quality control of ocean color data.

SeaBASS
SeaBASS is an archive of in situ oceanographic and atmospheric data used for algorithm development and satellite validation.

Cruise Support Services
Overflight predictions; Near real-time imagery and data for cruise support.

MQABI
MODIS (Ocean) Quality Assurance Browse Imagery Tool that allows access to MODIS Sea Surface Temperature products and statistics.

SeaWiFS User Authorization
Use this online form to request authorization for SeaWiFS data access. Currently authorized researchers can request a password to download data from this website.

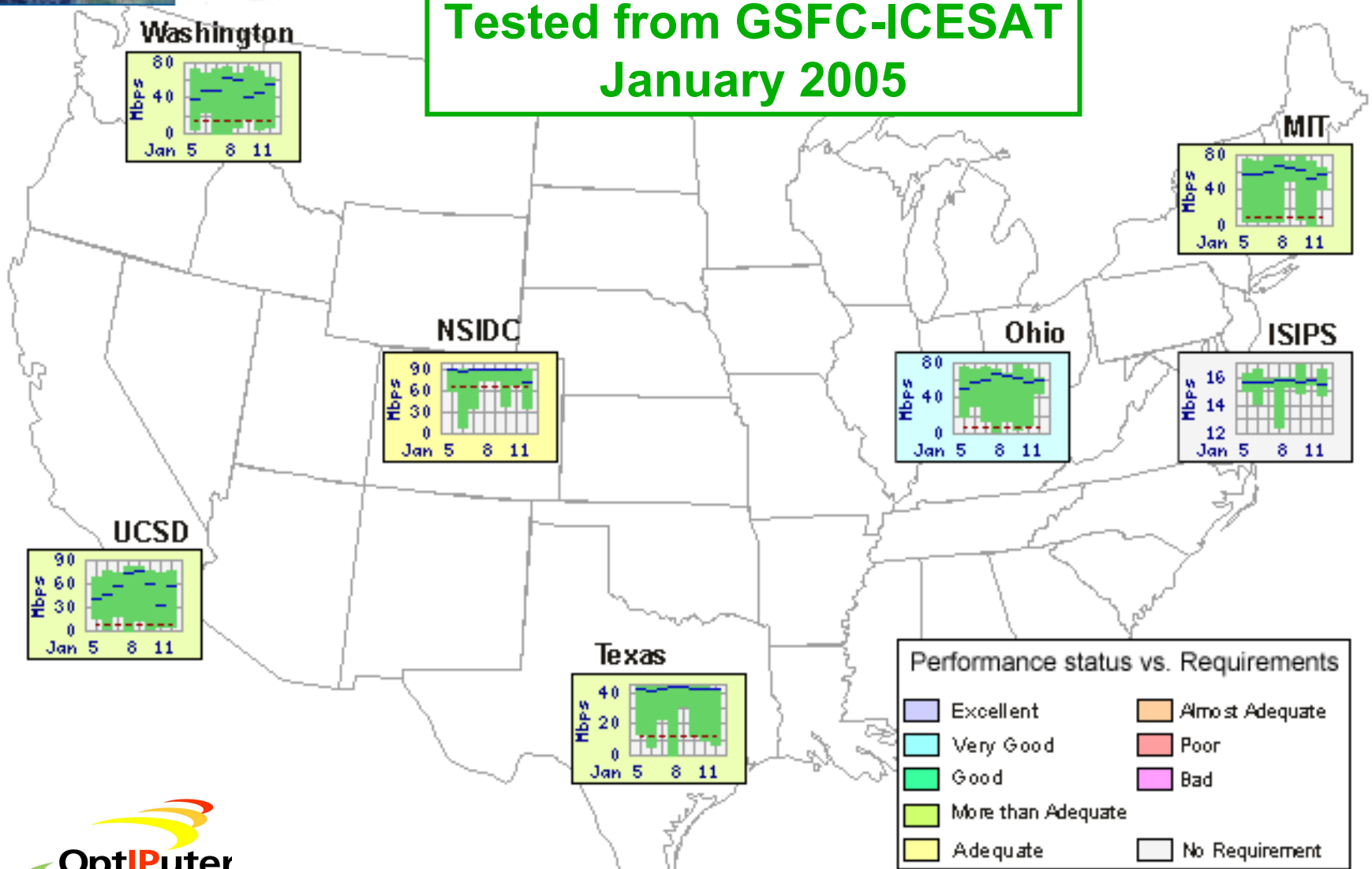
Employment Opportunities
(IOCCG listings)

Challenge: Average Throughput of NASA Data Products to End User is Only < 50 Megabits/s



ENSIGHT Active Testing ICESat Destinations

Tested from GSFC-ICESAT January 2005



http://ensight.eos.nasa.gov/Missions/icesat/index.shtml

Interactive Retrieval and Hyperwall Display of Earth Sciences Images Using NLR

Enables Scientists To Perform Coordinated Studies Of Multiple Remote-Sensing Datasets

Source: Milt Halem & Randall Jones, NASA GSFC
& Maxine Brown, UIC EVL





Earth science data sets created by GSFC's Scientific Visualization Studio were retrieved across the NLR in real time from OptIPuter servers in Chicago and San Diego and from GSFC servers in McLean, VA, and displayed at the SC2004 in Pittsburgh

OptIPuter

http://esdcd.gsfc.nasa.gov/LNetphoto3.html

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NASA is Moving Towards
a Service-Oriented Architecture for Earth Sciences Data

- **ECHO is an Open Source Interoperability Middleware Solution Providing a Marketplace of Resource Offerings**
  - Metadata Clearinghouse & Order Broker with Open, XML-based APIs
  - Being Built by NASA's Earth Science Data and Information System
- **New Paradigm for Access to EOS Data**
  - Service-Oriented Enterprise
  - Net-Centric Computing
    - Pushing Power to the Participants - Producers and Consumers
  - GEOSS (Global Earth Observation System of Systems) Momentum
- **Current Availability:**
  - Over 40 Million Data Granules
  - Over 6 Million Browse Images



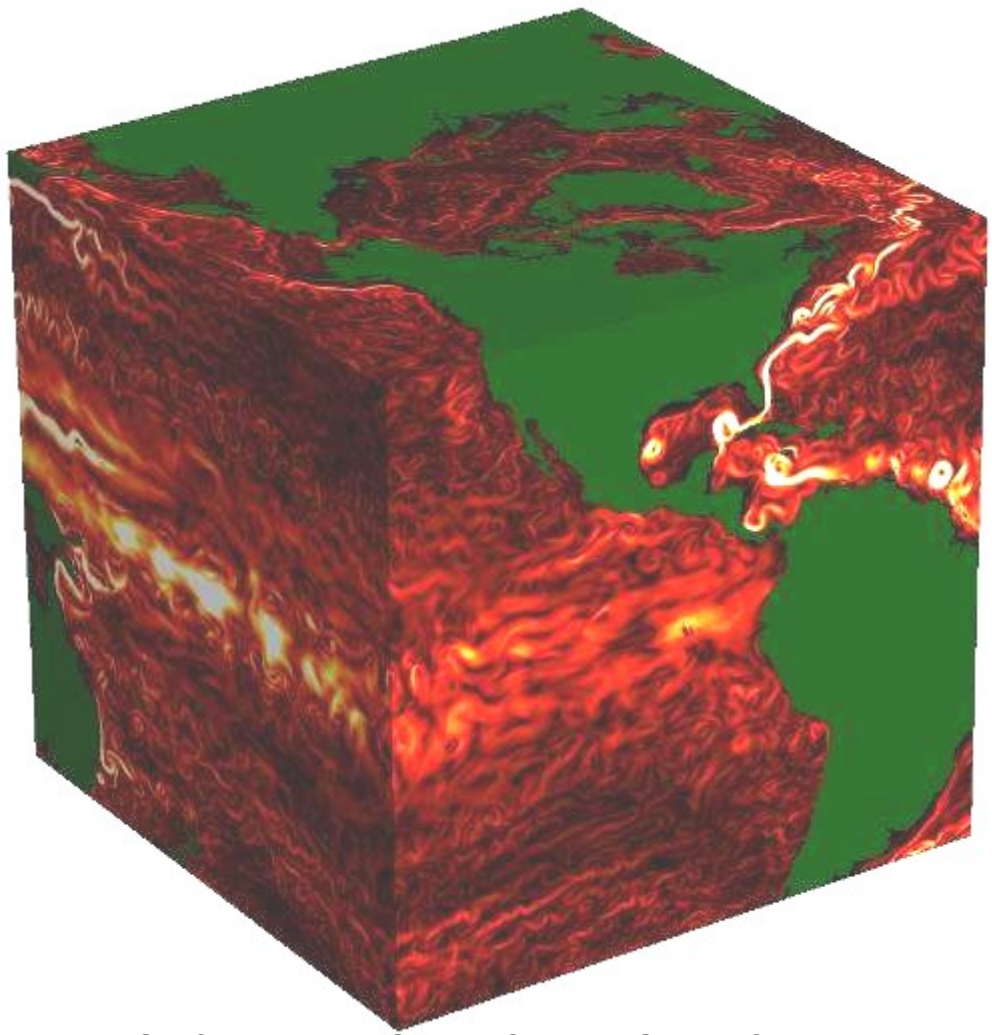
OptIPuter

www.echo.eos.nasa.gov

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NLR GSFC/JPL Applications: Remote Viewing and Manipulation of Large Earth Science Data Sets

- GSFC's ECHO and JPL's GENESIS Prototype Science Analysis System (iEarth) will be Connected via NLR
  - Enables Comparison of Hundreds of Terabytes of Data, Generating Large, Multi-year Climate Records
- Initially will Focus on the Estimating the Circulation and Climate of the Ocean (ECCO) Modeling Team
- Will need Versatile Subsetting & Grid-Accessible Statistical Analysis & Modeling Operators to Refine and Validate the ECCO Models
- Key Contacts: ECHO Metadata Gateway Team, GSFC; GENESIS Team, led by Tom Yunck, JPL.



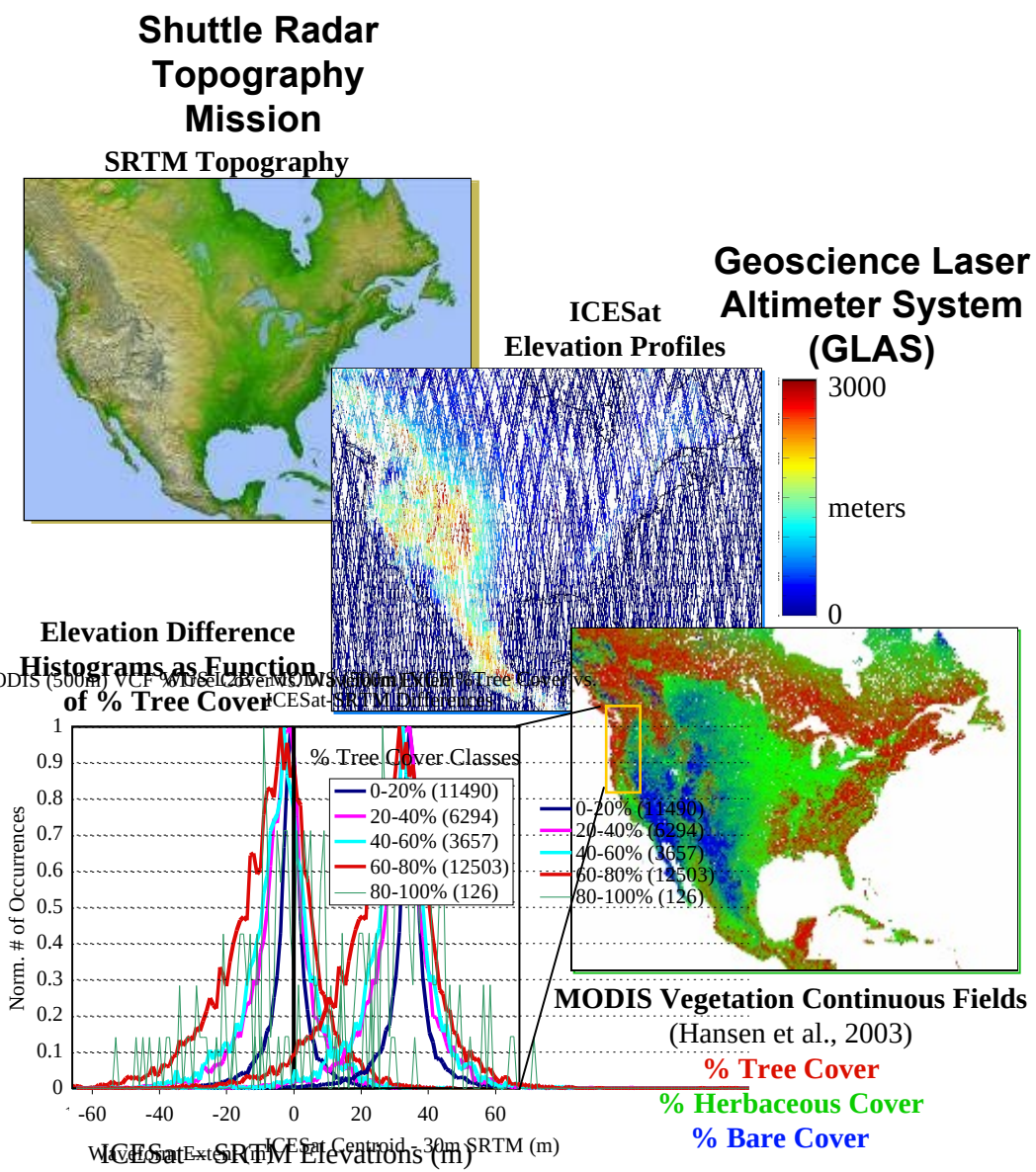
Near-Surface (15-m) Ocean Current Speed from an Eddy-Permitting Integration of the Cubed-Sphere ECCO Ocean Circulation Model.
Research by JPL and MIT. Visualization by C. Henze, Ames.

OptIPuter

http://www.ecco-group.org

NLR GSFC/JPL/SIO Application: Integration of Laser and Radar Topographic Data with Land Cover Data

- Merge the 2 Data Sets, Using SRTM to Achieve Good Coverage & GLAS to Generate Calibrated Profiles
- Interpretation Requires Extracting Land Cover Information from Landsat, MODIS, ASTER, and Other Data Archived in Multiple DAACs
- Use of the NLR and Local Data Mining and Sub-Setting Tools will Permit Systematic Fusion Of Global Data Sets, Which are Not Possible with Current Bandwidth
- Key Contacts: Bernard Minster, SIO; Tom Yunck, JPL; Dave Harding, Claudia Carabajal, GSFC



http://icesat.gsfc.nasa.gov
http://www2.jpl.nasa.gov/srtm
http://glcf.umiacs.umd.edu/data/modis/vc

Three Classes of LambdaGrid Applications

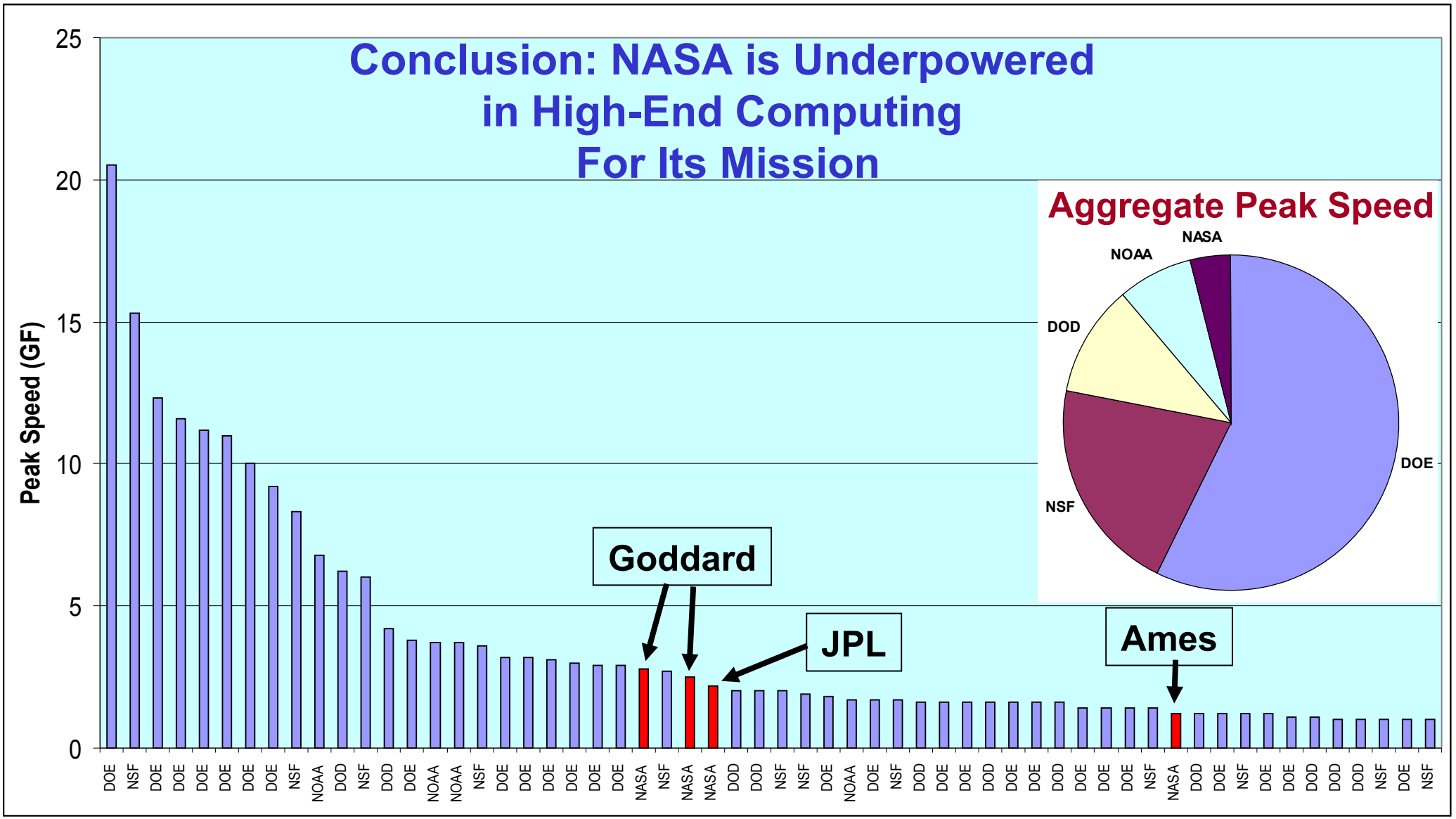
- Browsing & Analysis of Multiple Large Remote Data Objects
- Assimilating Data—Linking Supercomputers with Data Sets
- Interacting with Coastal Observatories

NASA OptIPuter Application Drivers

OptIPuter

it²

Federal Agency Supercomputers Faster Than 1TeraFLOP Nov 2003



From Smarr March 2004 NAC Talk

Data From Top500 List (November 2003) Excluding No-name Agencies

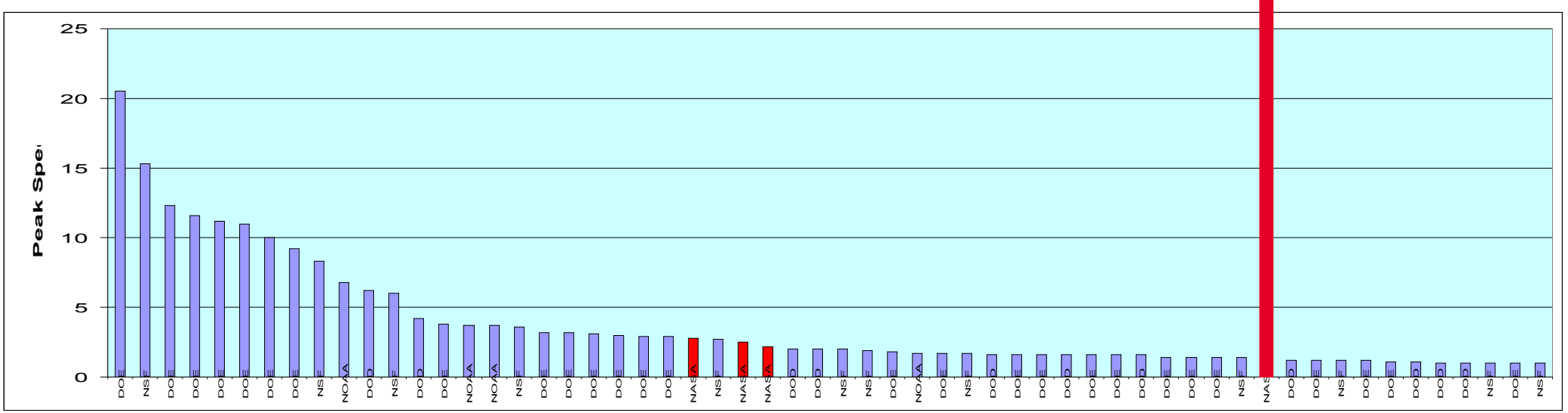
NASA Ames Brings Leadership to High-End Computing

Estimated #1 or 2
Top500 (Nov. 2004)

Project Columbia!

60TF

20 x 512-Processor
SGI Altix Single-System Image
Supercomputers
= 10,240 Intel IA-64 Processors



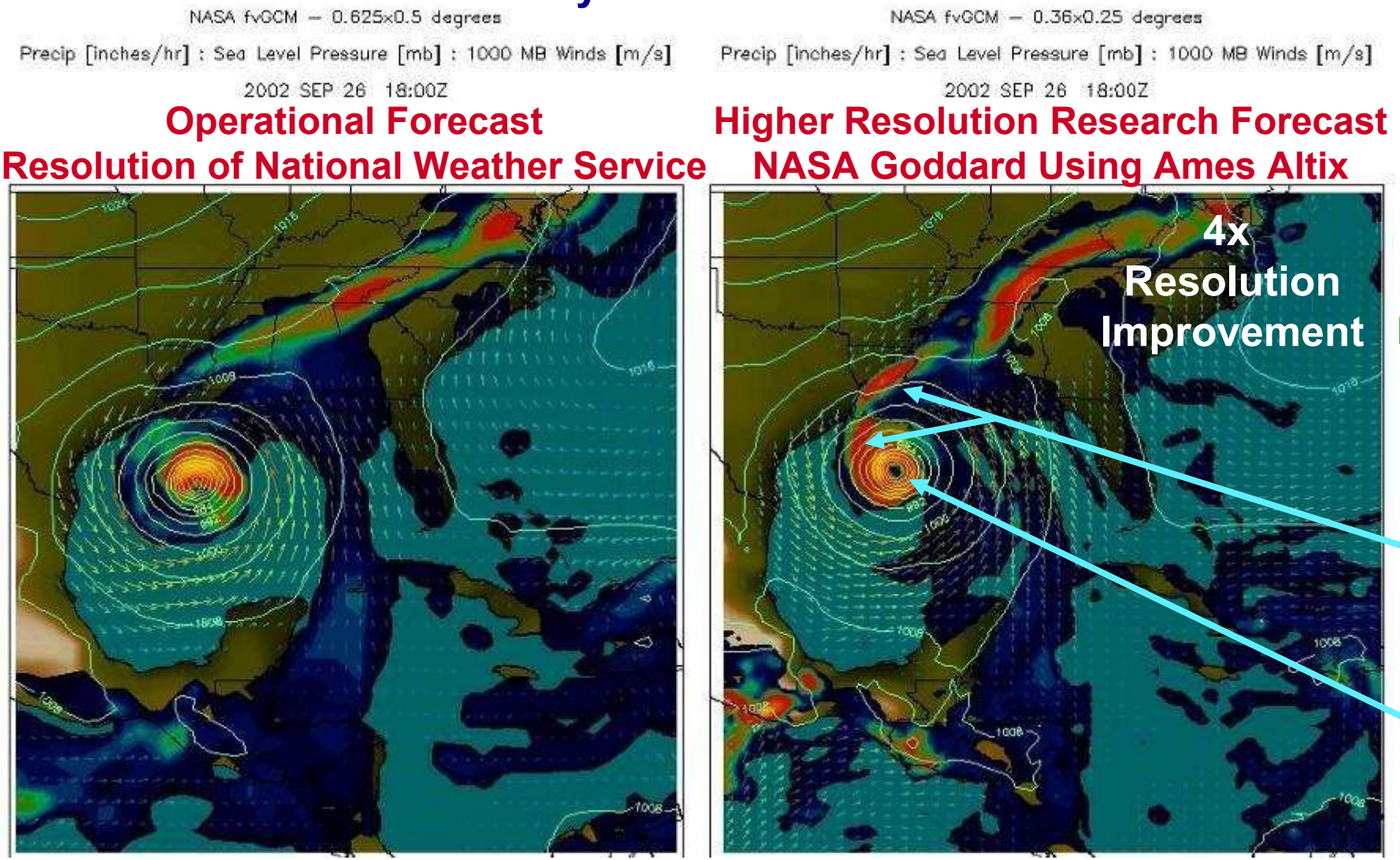
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it2

Increasing Accuracy in Hurricane Forecasts

Real Time Diagnostics in GSFC of Ensemble Runs on ARC Project Columbia

5.75 Day Forecast of Hurricane Isidore



Operational Forecast Resolution of National Weather Service

Higher Resolution Research Forecast NASA Goddard Using Ames Altix

NLR will Remove the InterCenter Networking Bottleneck

Intense Rain-Bands

Resolved Eye Wall

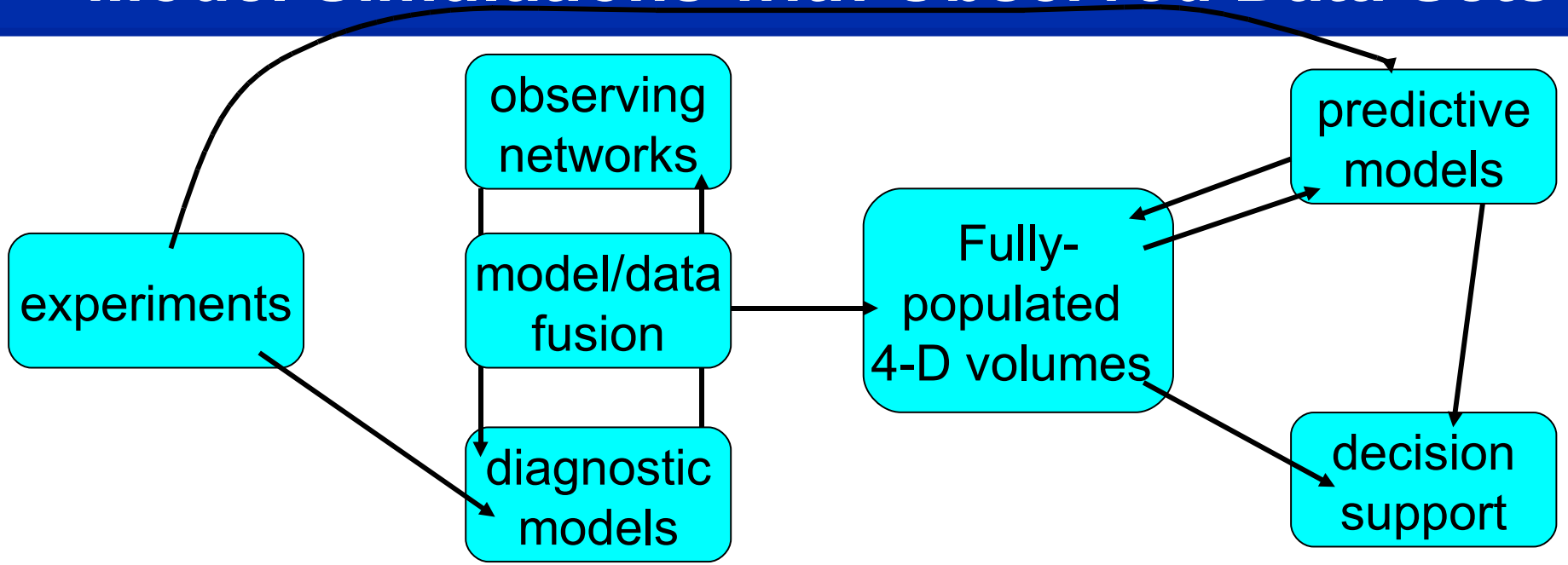
Source: Bill Putman, Bob Atlas, GFSC

OptIPuter

Project Contacts: Ricky Rood, Bob Atlas, Horace Mitchell, GSFC; Chris Henze, ARC

it2

OptIPuter Needed to Couple Analysis of Model Simulations with Observed Data Sets



- **Process Studies and Manipulative Experiments Inform Improved Models**
- **Systematic Observations Used to Evaluate Models**
  - **e.g. Sun, Atmosphere, Land, Ocean**
- **Model-Data Fusion (Data Assimilation) Produces Optimal Estimates of Time Mean and Spatial and Temporal Variations in Thousands of Variables**
- **Improved Models Used to Predict Future Variations**
  - **Tested Against Ongoing Diagnostic Analyses**
- **Predictive Models & Continuing Analyses to Enhance Decision Support**

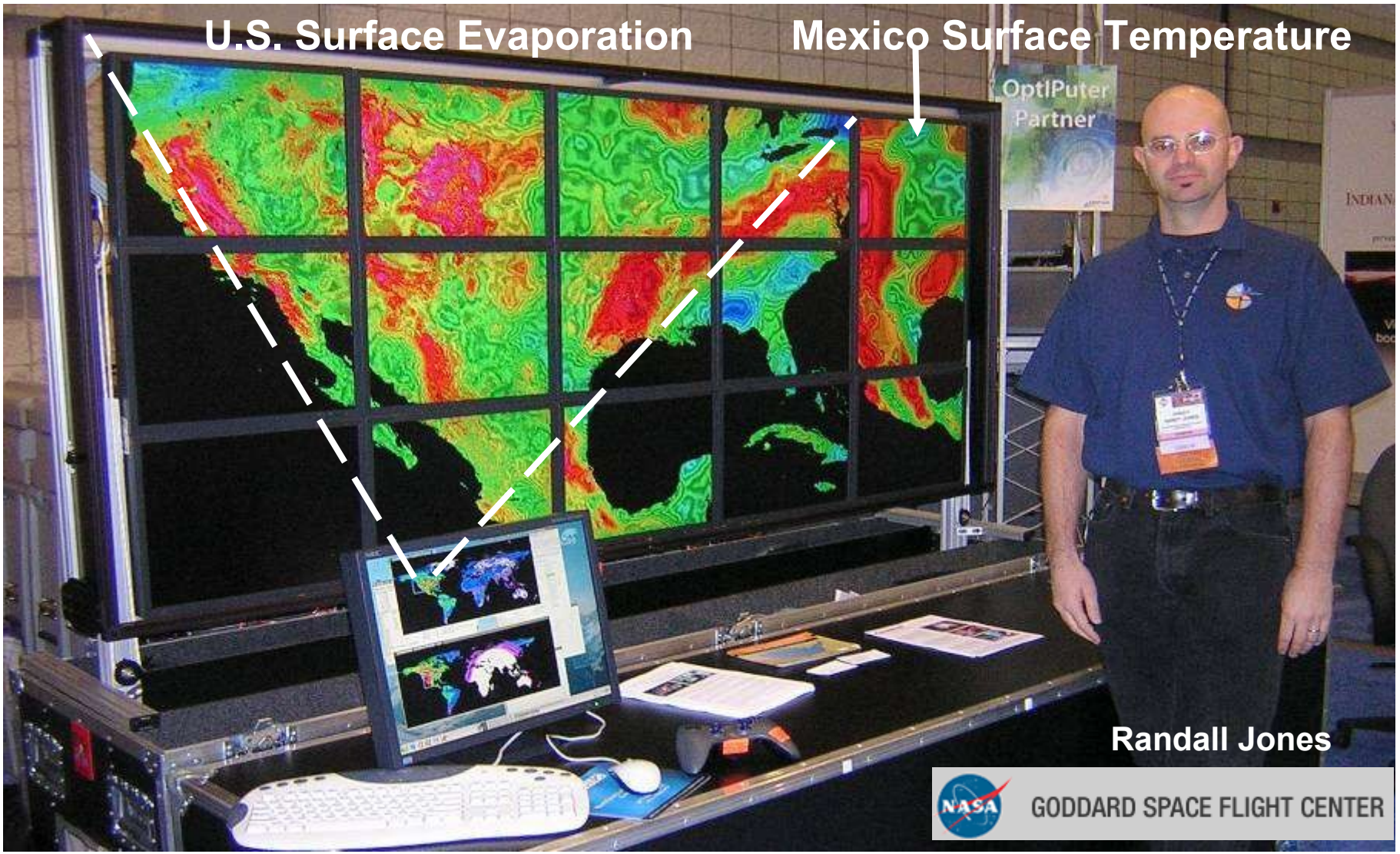
OptIPuter

Source:Scott Denning
Colorado State University

it²

NASA's Land Information System at SC04 Over NLR

Remote Analysis of Global 1 km x 1 km Assimilated Surface Observations



Data Sets were Retrieved from OptIPuter Servers in Chicago, San Diego, & Amsterdam

Remotely Viewing ~ 50 GB per Parameter

OptIPuter

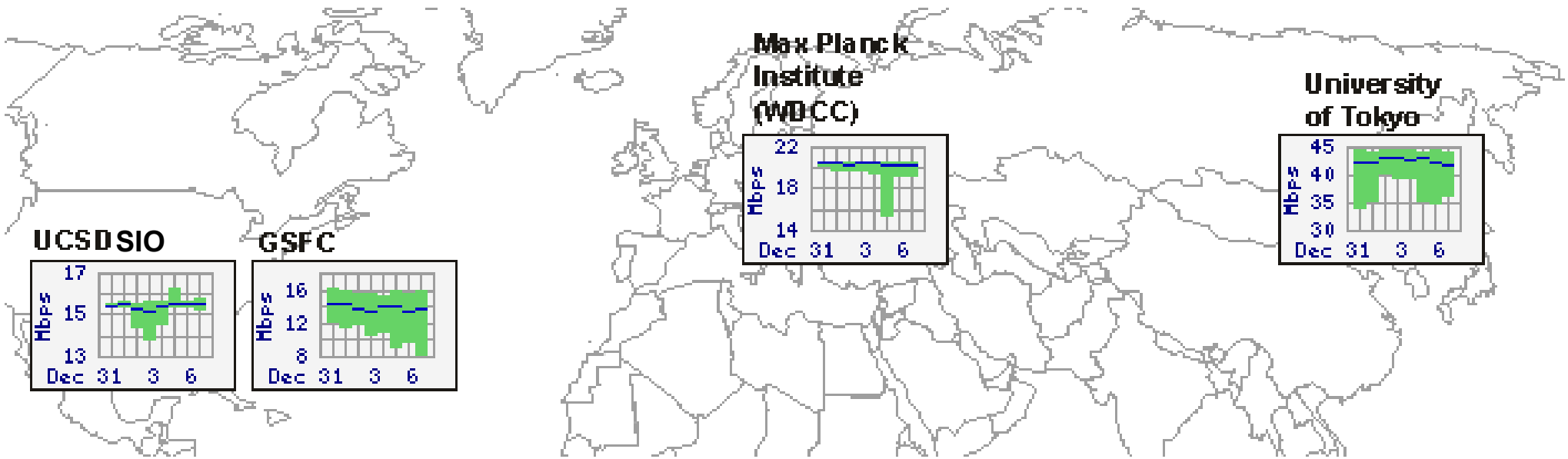
http://lis.gsfc.nasa.gov

it2

Next Step: OptIPuter, NLR, and Starlight Enabling Coordinated Earth Observing Program (CEOP)

Source: Milt Halem, NASA GSFC

Accessing 300TB's of Observational Data in Tokyo and 100TB's of Model Assimilation Data in MPI in Hamburg -- Analyzing Remote Data Using GRaD-DODS at These Sites Using OptIPuter Technology Over the NLR and Starlight



Note Current Throughput 15-45 Mbps: OptIPuter 2005 Goal is ~1-10 Gbps!

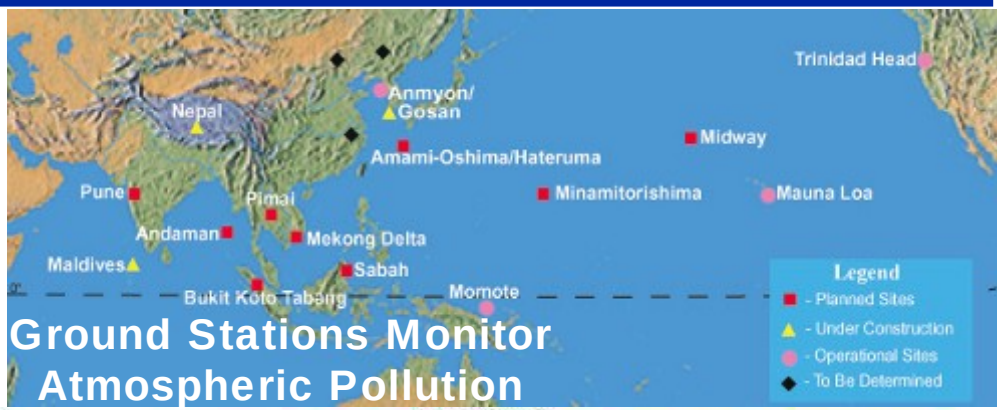
OptIPuter

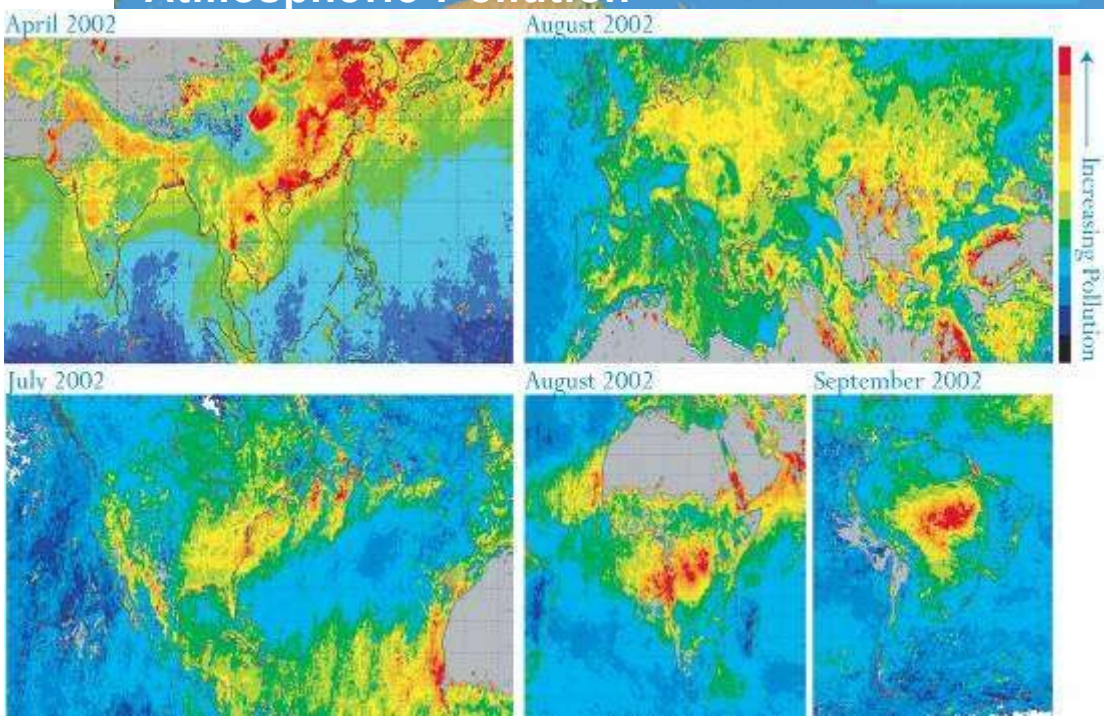
http://ensight.eos.nasa.gov/Organizations/ceop/index.shtml

it2

Project Atmospheric Brown Clouds (ABC) -- NLR Linking GSFC and UCSD/SIO

- A Collaboration to Predict the Flow of Aerosols from Asia Across the Pacific to the U.S. on Timescales of Days to a Week
- GSFC will Provide an Aerosol Chemical Tracer Model (GOCAR) Embedded in a High-Resolution Regional Model (MM5) that can Assimilate Data from Indo-Asian and Pacific Ground Stations, Satellites, and Aircraft
- Remote Computing and Analysis Tools Running over NLR will Enable Acquisition & Assimilation of the Project ABC Data
- Key Contacts: Yoram Kaufman, William Lau, GSFC; V. Ramanathan, Chul Chung, SIO





The Global Nature of Brown Clouds is Apparent in Analysis of NASA MODIS Data. Research by V. Ramanathan, C. Corrigan, and M. Ramana, SIO

http://www-abc-asia.ucsd.edu

Three Classes of LambdaGrid Applications

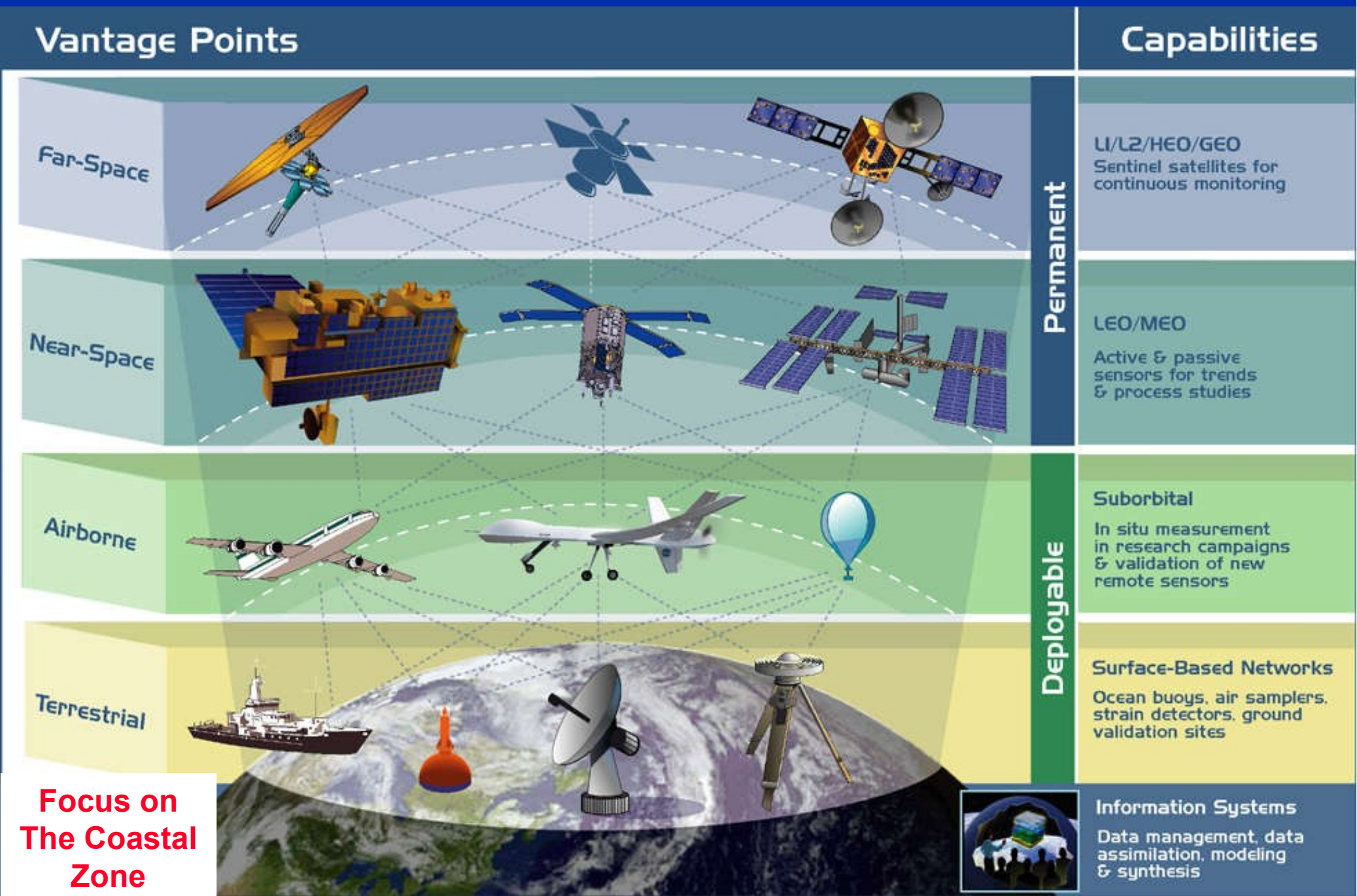
- Browsing & Analysis of Multiple Large Remote Data Objects
- Assimilating Data—Linking Supercomputers with Data Sets
- Interacting with Coastal Observatories

NASA OptIPuter Application Drivers

OptIPuter

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Creating an Integrated Interactive Information System for Earth Exploration



Focus on The Coastal Zone

Grand Challenge: A Total Knowledge Integration System for the Coastal Zone

- Moorings
- Ships
- Autonomous Vehicles
- Satellite Remote Sensing
- Drifters
- Long Range HF Radar
- Near-Shore Waves/Currents (CDIP)
- COAMPS Wind Model
- Nested ROMS Models
- Data Assimilation and Modeling
- Data Systems



Southern California Coastal Ocean Observing System

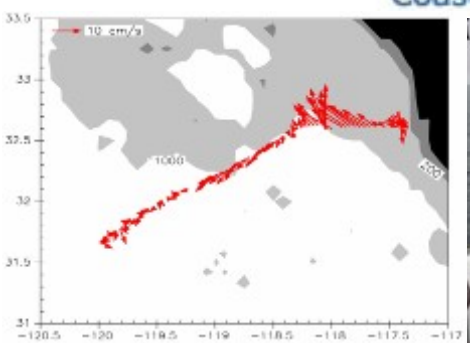
ROADNet

OptIPuter

www.sccoos.org/

COCMP

Coastal Ocean Currents Monitoring Program

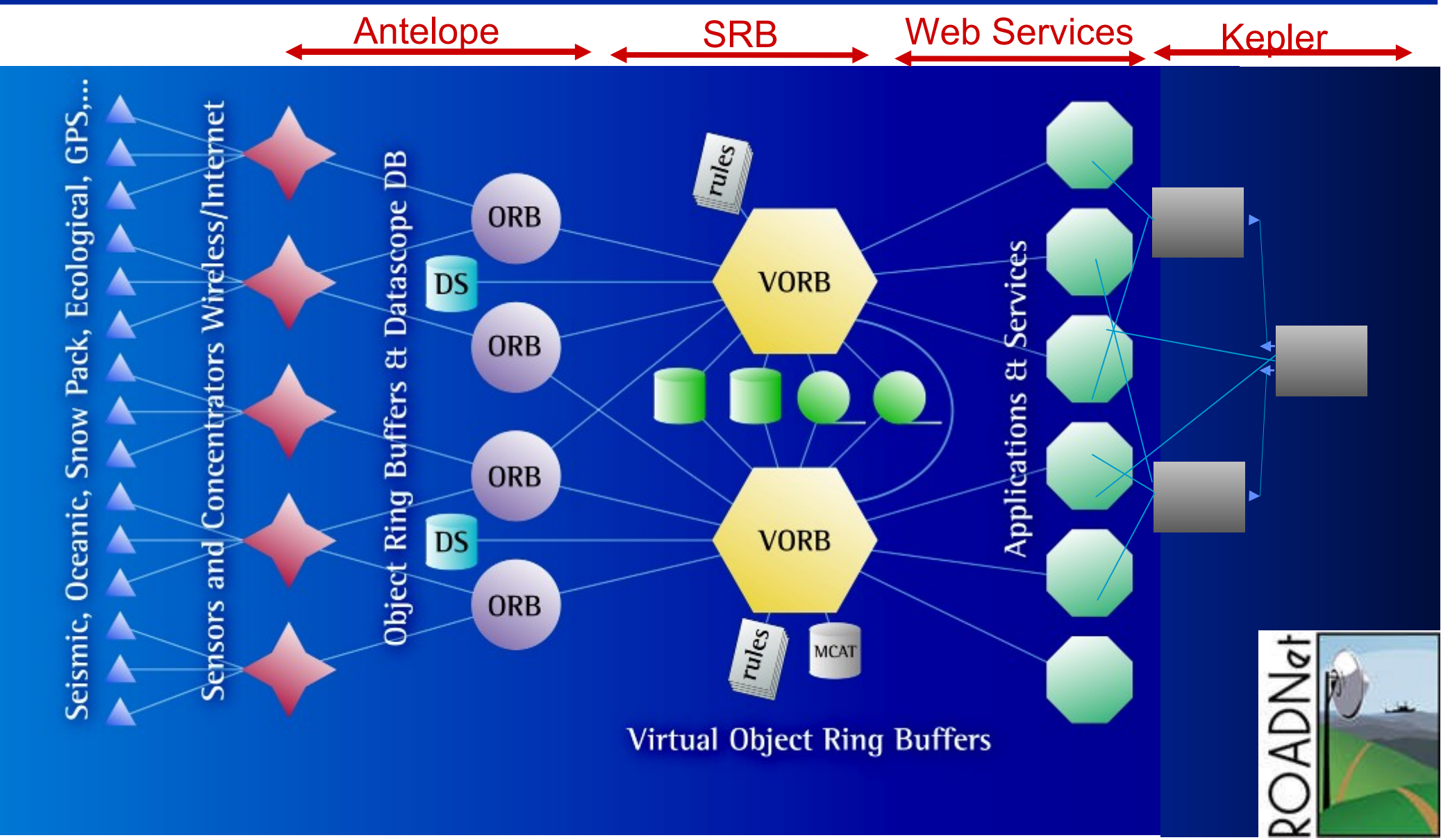




it²

ROADNet Architecture:

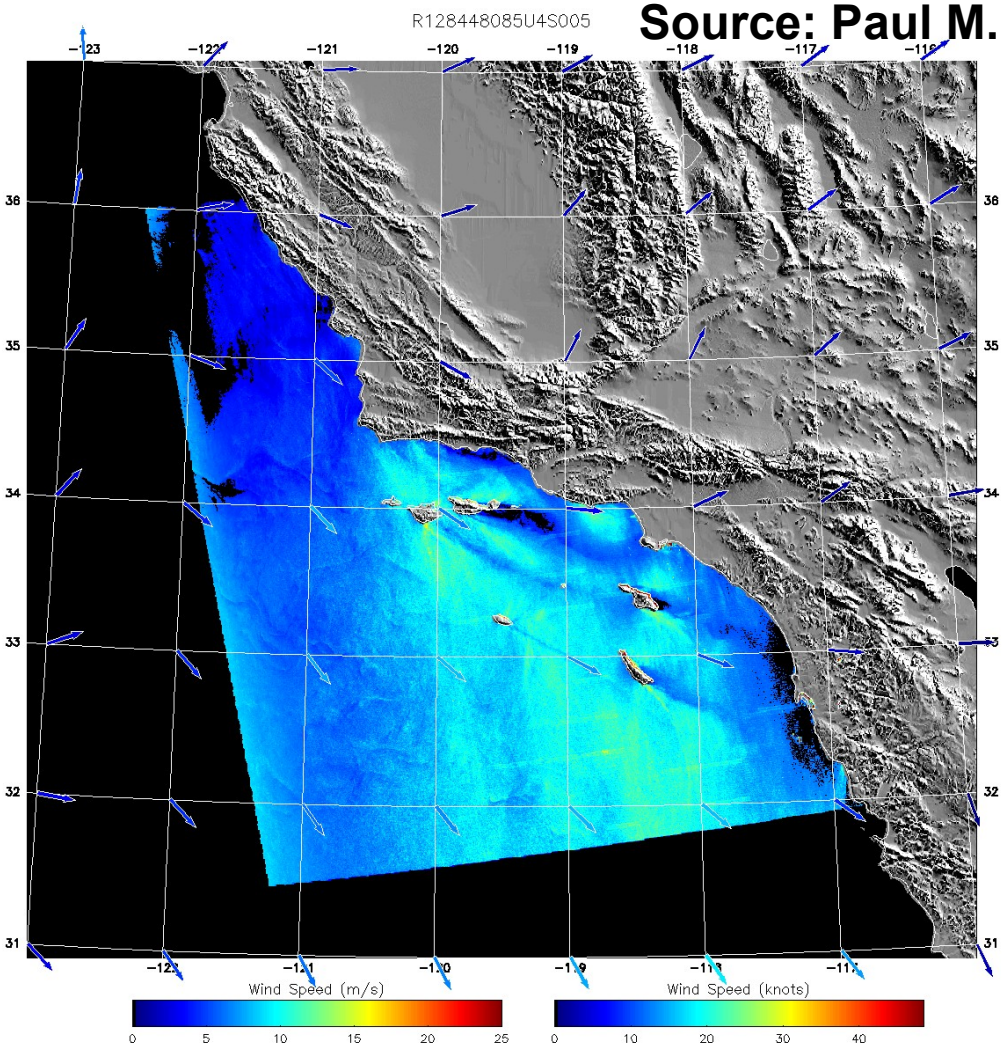
SensorNets, Storage Research Broker, Web Services, Work Flow



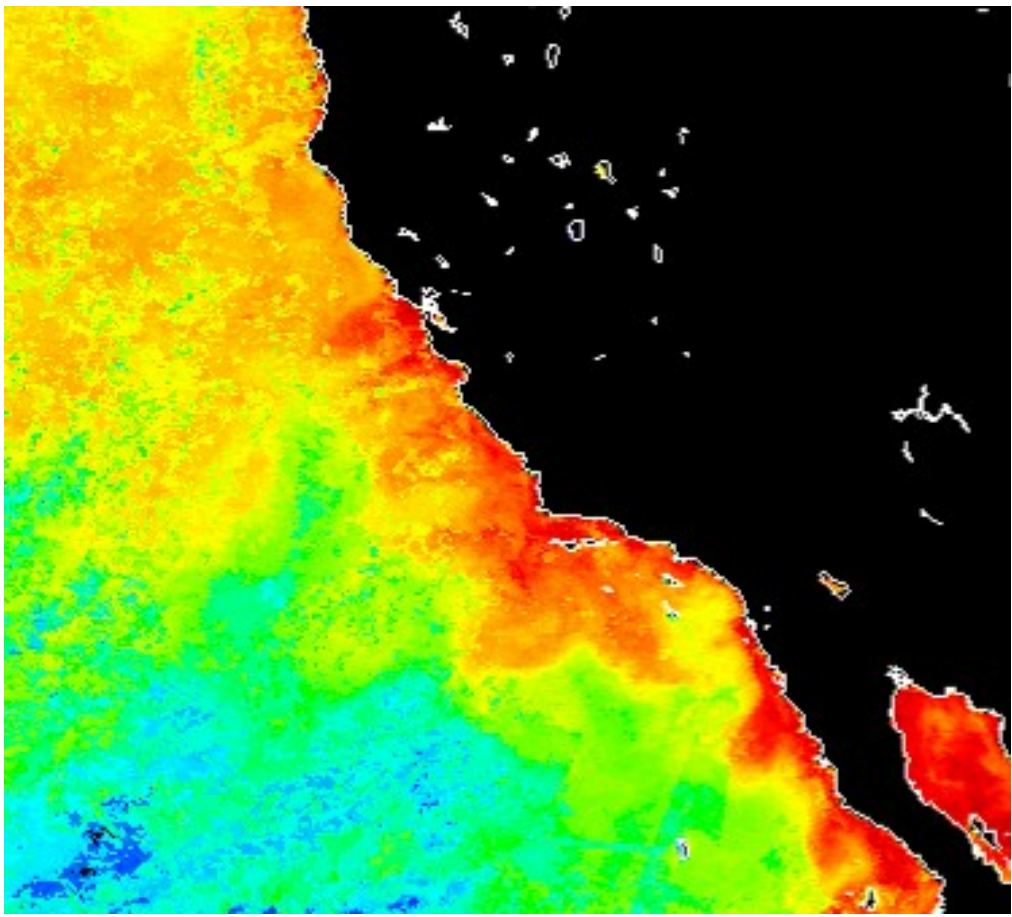
Frank Vernon, SIO; Tony Fountain, Ilkay Altintas, SDSC

Goal: Integrate All Remote Sensing Data Objects Over SoCal Coastal Zone in Real Time

Source: Paul M. DiGiacomo, JPL



Synthetic Aperture Radar (SAR) Derived High-Resolution Coastal Ocean Winds in Southern California Bight



NASA MODIS Mean Primary Productivity for April 2001 in California Current System

Challenge: Large Data Objects in Distributed Repositories

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it²

Use SCCOOS As Prototype for Coastal Zone Data Assimilation Testbed

Goal:

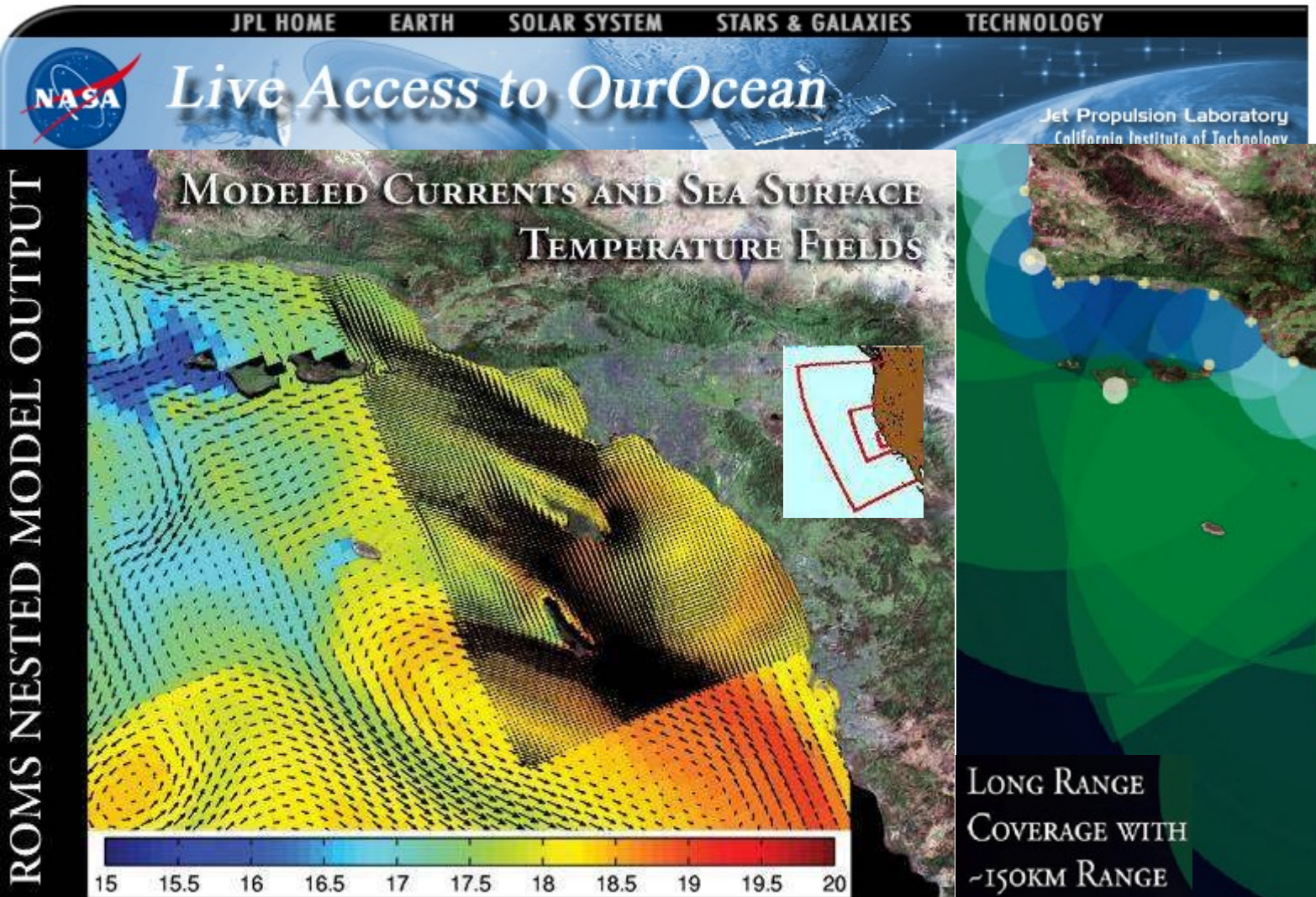
Link SCCOOS Sites with OptIPuter to Prototype Future LambdaGrid For Ocean and Earth Sciences

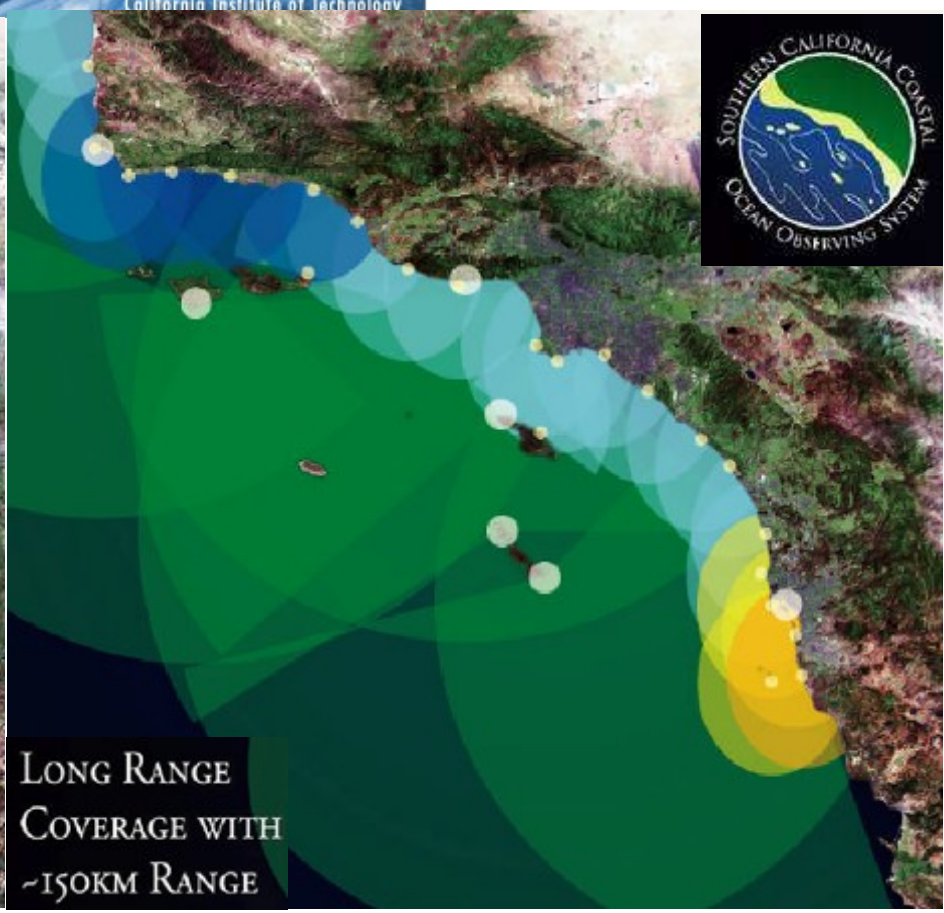


Yellow—Proposed Initial OptIPuter Backbone

OptIPuter

Use OptIPuter to Couple Data Assimilation Models to Remote Data Sources and Analysis





JPL ONR MBARI California Institute of Technology

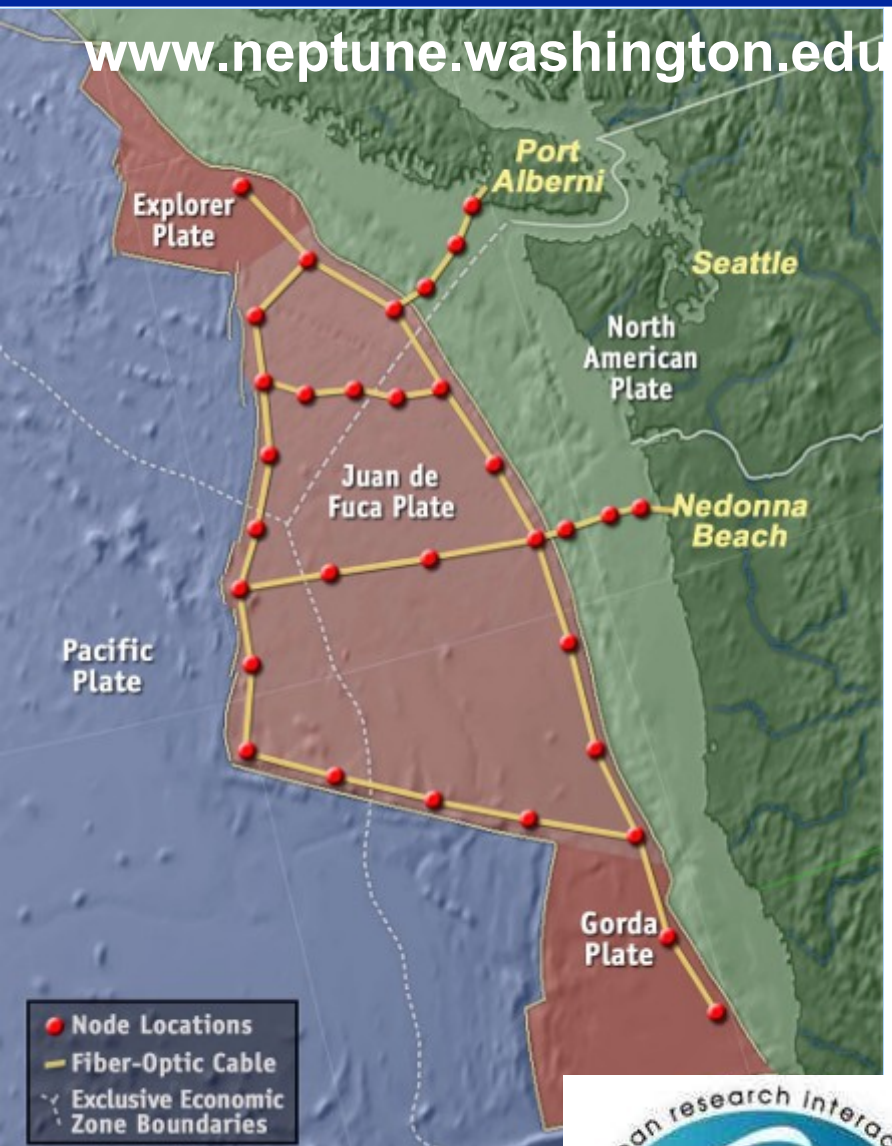
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Regional Ocean Modeling System (ROMS)

http://ourocean.jpl.nasa.gov/

it2

New Instrument Infrastructure: Gigabit Fibers on the Ocean Floor



LOOKING:
(Laboratory for the Ocean Observatory Knowledge Integration Grid)

- **LOOKING NSF ITR with PIs:**
  - **John Orcutt & Larry Smarr - UCSD**
  - **John Delaney & Ed Lazowska –UW**
  - **Mark Abbott – OSU**
- **Collaborators at:**
  - **MBARI, WHOI, NCSA, UIC, CalPoly, UVic, CANARIE, Microsoft, NEPTUNE-Canarie**
- **Extend SCCOOS to the Ocean Floor**

LOOKING--
Integrate Instruments & Sensors (Real Time Data Sources) Into a LambdaGrid Computing Environment With Web Services Interfaces

OptIPuter NSF ORION ocean research interactive observatory networks it2

Goal – From Expedition to Cable Observatories with Streaming Stereo HDTV Robotic Cameras

http://disney.go.com/disneypictures/aliensofthedeep/alienseduguide.pdf

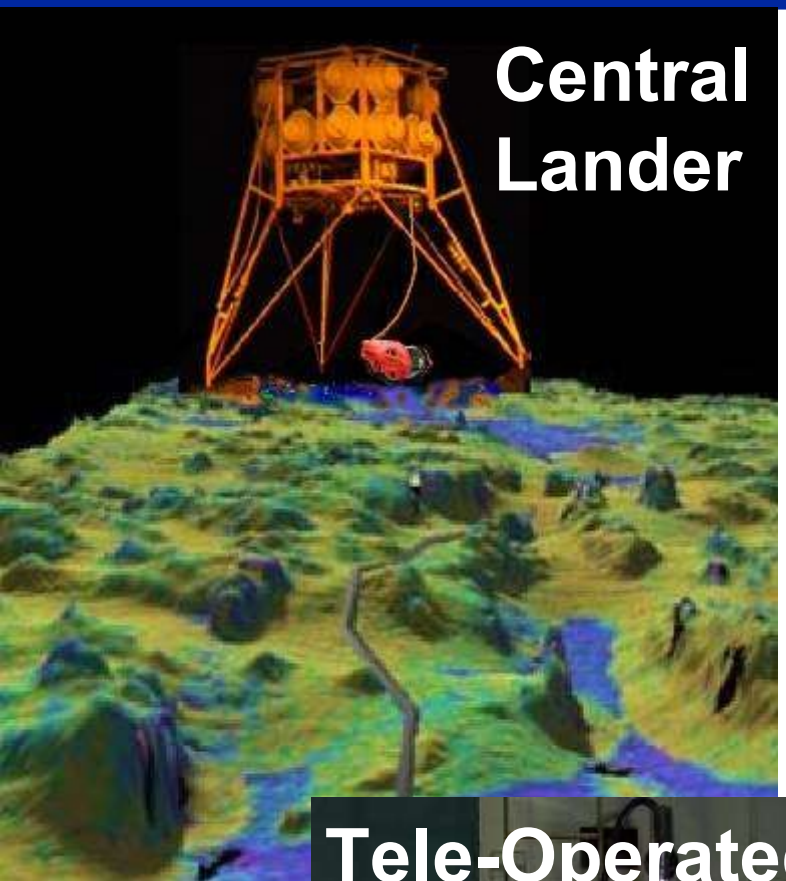




Scenes from The Aliens of the Deep, Directed by James Cameron & Steven Quale

OptIPuter

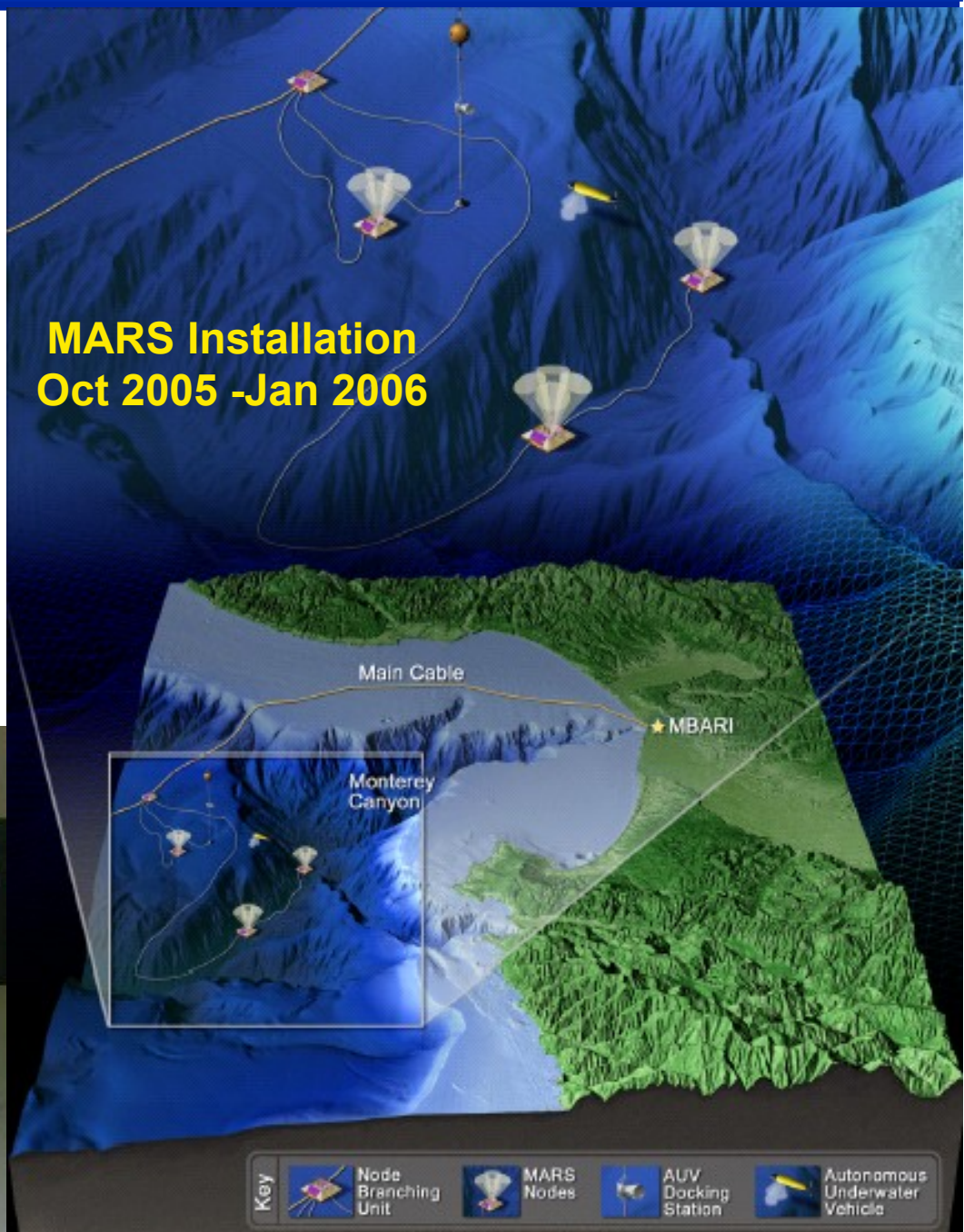
MARS Cable Observatory Testbed – LOOKING Living Laboratory



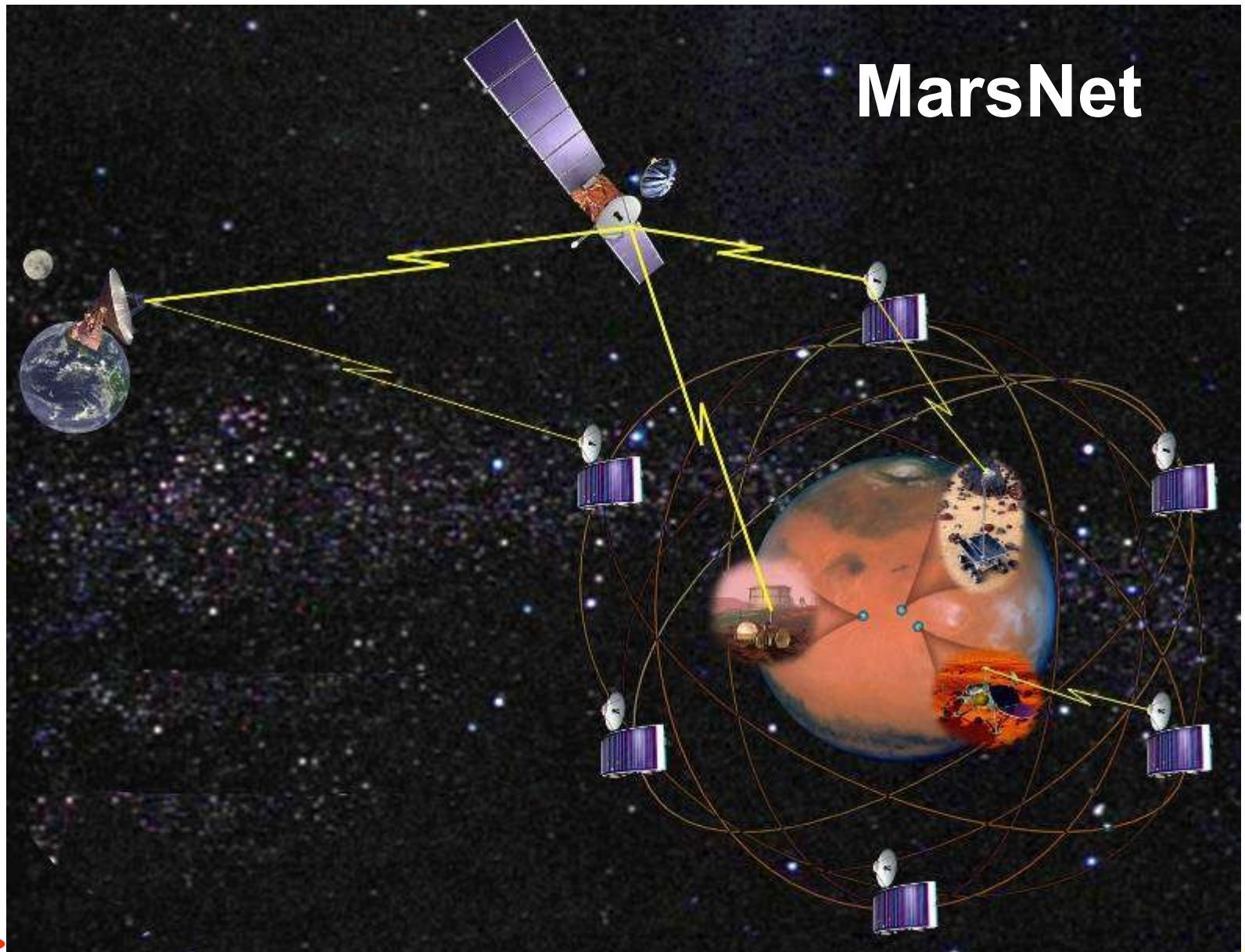


Source:
Jim
Bellingham,
MBARI

OptIPuter

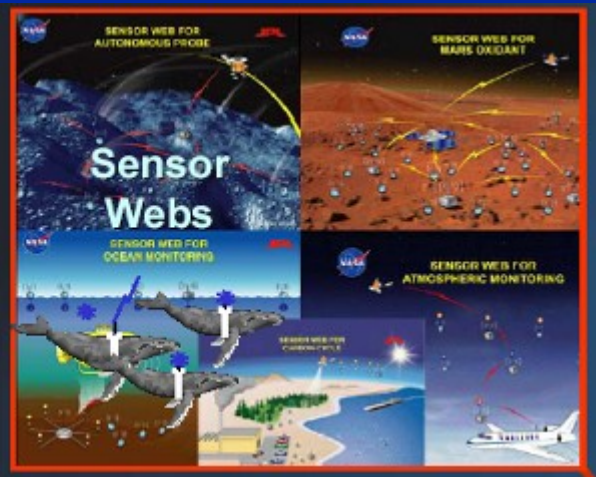


InterPlaNetary Internet—Extending the Interactive Integrated Vision to the Exploration Initiative



Source: JPL, Vint Cerf, MCI

New Frontier: General Theory of Such Integrated Networked Systems





- "Non-chatty" message-oriented communications
- Store-and-forward between nodes
- Routing algorithms cognizant of scheduled connectivity
- Use transport and network technologies appropriate to the environment
- Integral infrastructure protection









Realization:
Broader applicability
Nearer term utility
Larger research community

Source: JPL, Vint Cerf, MCI