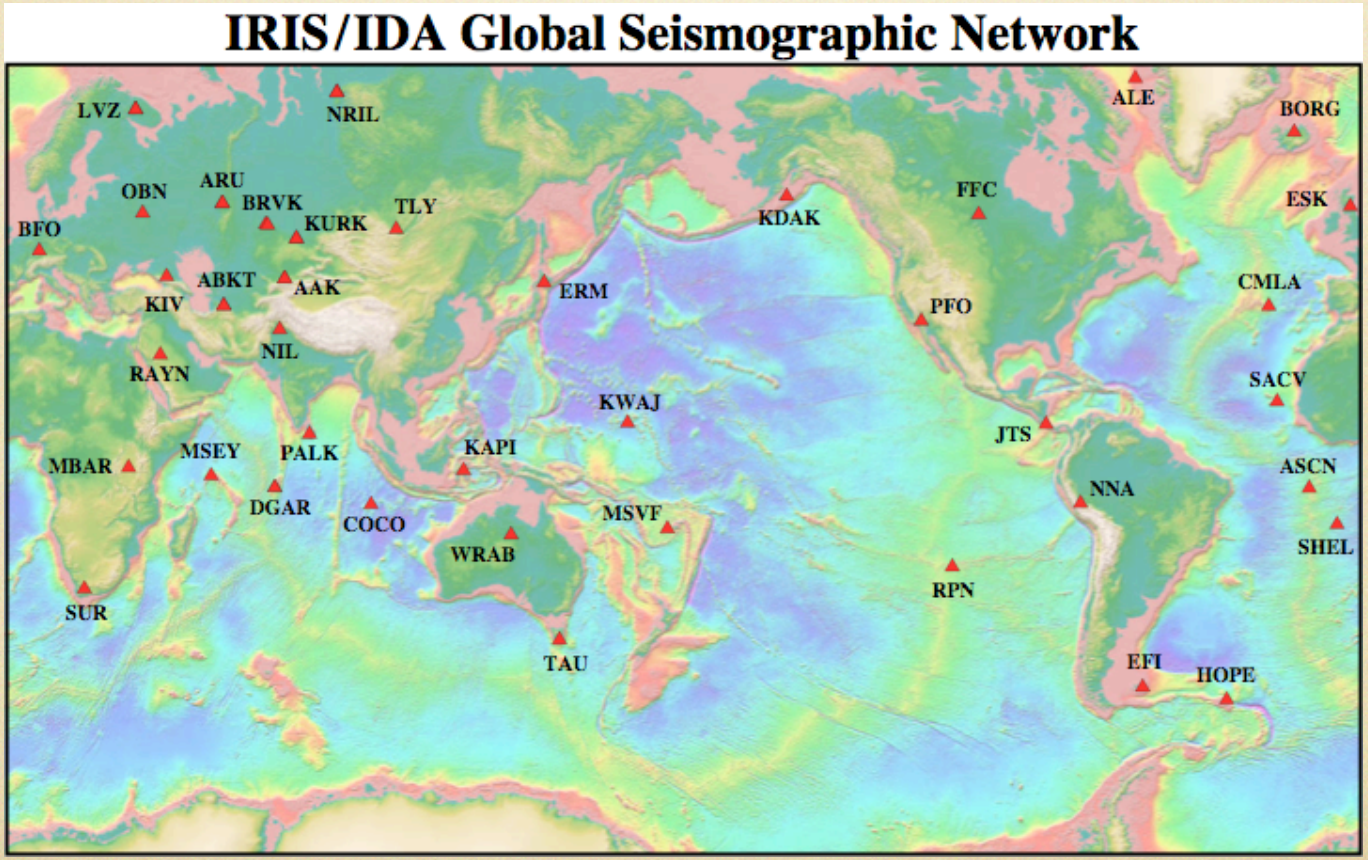
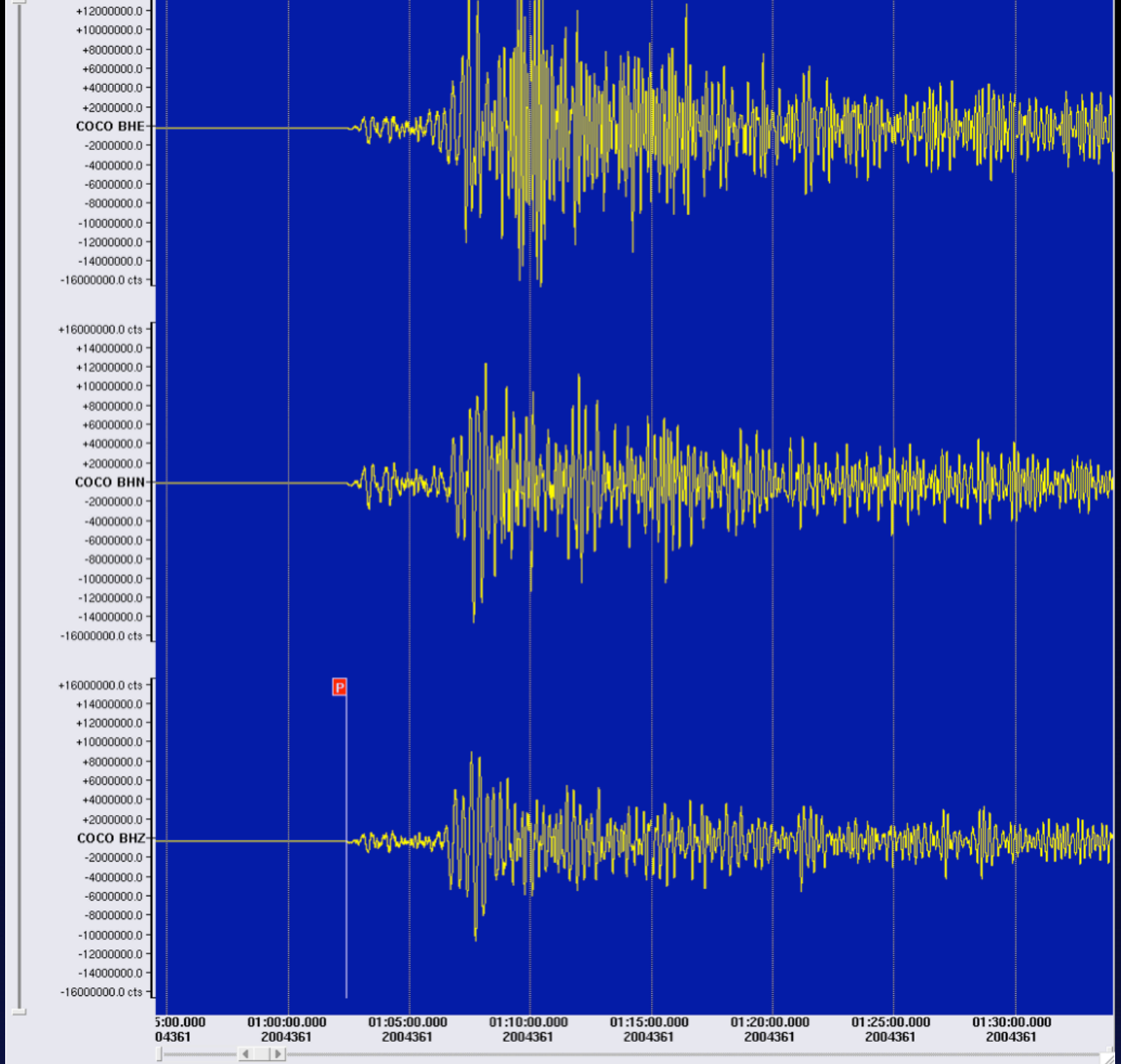
Global Scale Sensor Networks

Opportunities & Challenges

John Orcutt
President, AGU

Scripps Global Seismic Stations

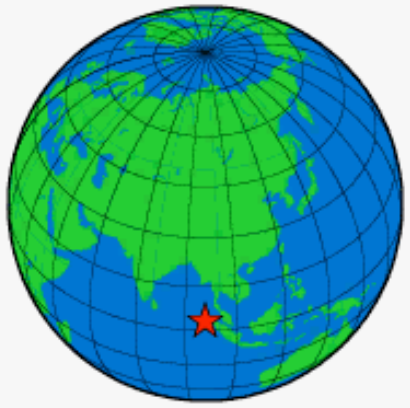



+12000000.0
+10000000.0
+8000000.0
+6000000.0
+4000000.0
+2000000.0
COCO BHE
-2000000.0
-4000000.0
-6000000.0
-8000000.0
-10000000.0
-12000000.0
-14000000.0
-16000000.0 cts
+16000000.0 cts
+14000000.0
+12000000.0
+10000000.0
+8000000.0
+6000000.0
+4000000.0
+2000000.0
COCO BHN
-2000000.0
-4000000.0
-6000000.0
-8000000.0
-10000000.0
-12000000.0
-14000000.0
-16000000.0 cts
+16000000.0 cts
+14000000.0
+12000000.0
+10000000.0
+8000000.0
+6000000.0
+4000000.0
+2000000.0
COCO BHZ
-2000000.0
-4000000.0
-6000000.0
-8000000.0
-10000000.0
-12000000.0
-14000000.0
-16000000.0 cts
P
5:00.000
04361
01:00:00.000
2004361
01:05:00.000
2004361
01:10:00.000
2004361
01:15:00.000
2004361
01:20:00.000
2004361
01:25:00.000
2004361
01:30:00.000
2004361

PROJECT IDA

SPECIAL EVENTS

REPLAY OF THE DECEMBER 26TH, 2004 MAGNITUDE 9.0 SUMATRA-ANDAMAN EARTHQUAKE ALL STATIONS, VERTICAL COMPONENTS



Latitude	3.3160
Longitude	95.8550
Origin time (UTC)	12/26/04 (361) 00:58:530
Depth	30km (18.6 miles)
Mw	9.0

This Quicktime movie is a replay of the December 26th 2004 Sumatra-Andaman Islands earthquake. The waveforms in the replay are recorded by Project IDA stations which form a global network of broadband and very long period seismometers. The stations closest to the epicenter of the earthquake are closer to the top of the replay. The waveforms move to right to left, with the most recent data plotted at the right-hand side of the movie. The time scale along the foot of the movie is in Universal Time Co-ordinates (UTC).

Only vertical (Z) components of the raw counts are plotted.

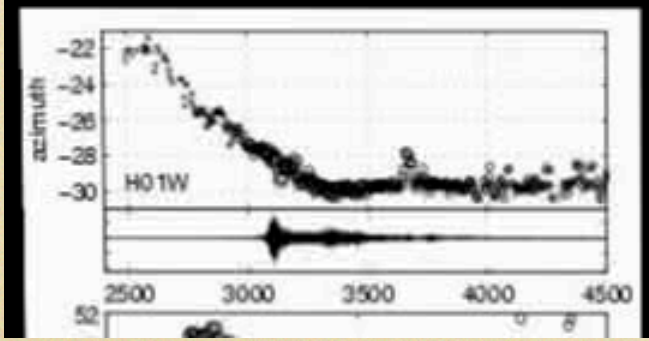
More information can be found at :

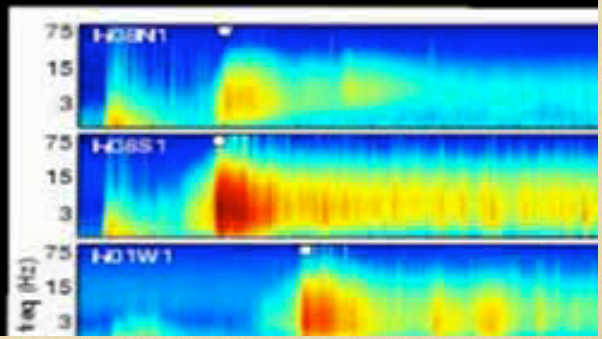
http://ida.ucsd.edu/SpecialEvents/2004/361/a/index.shtml

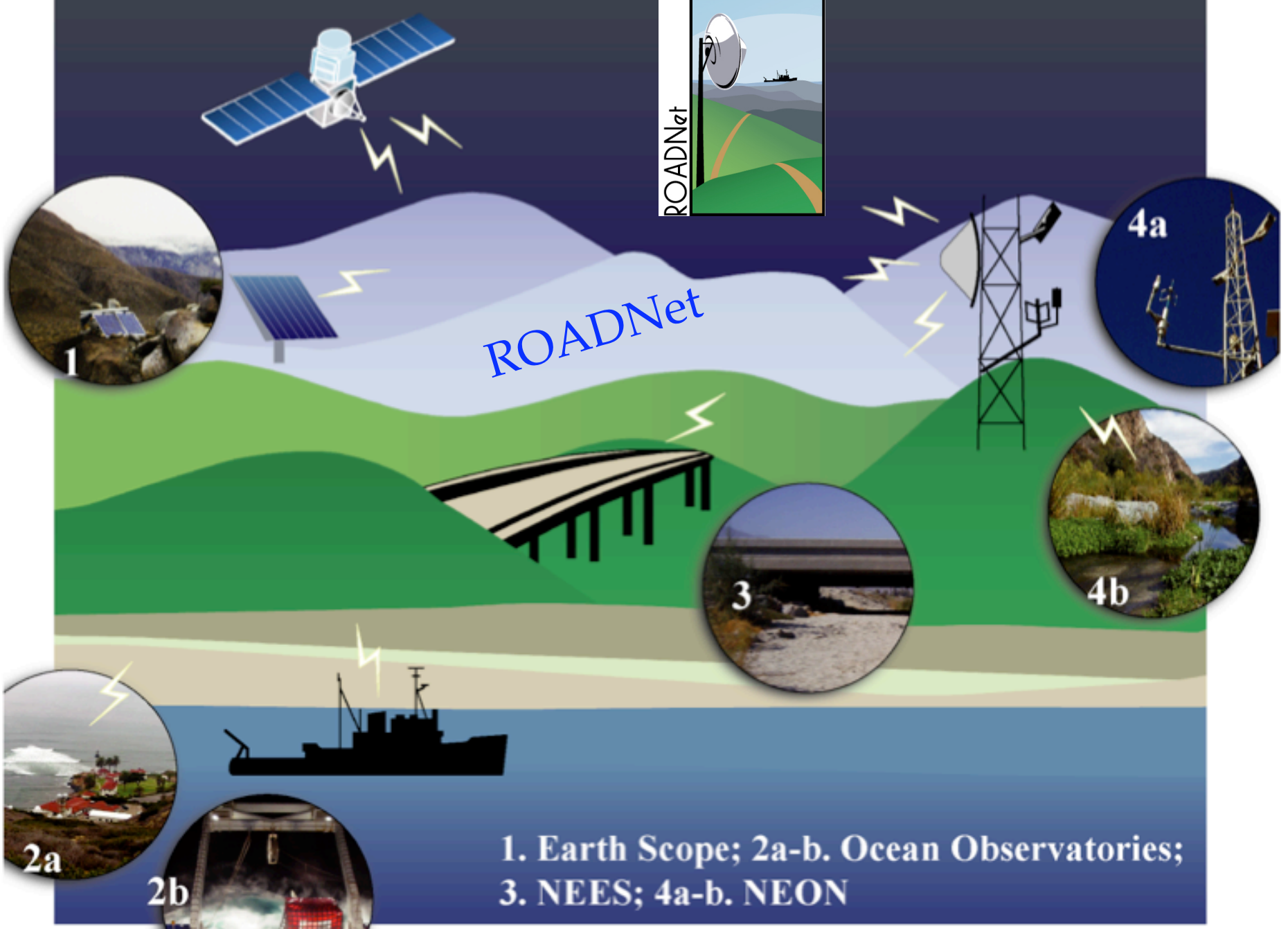
Estimation of the Rupture Length and Velocity of the Great Sumatra E
of Dec 26, 2004, Using Hydroacoustic Signals.

Geophysical Research Letters (submitted), by Catherine D. de Groot-He

Visualization created at the SIO Visualizatoin Center
www.siovizcenter.ucsd.edu





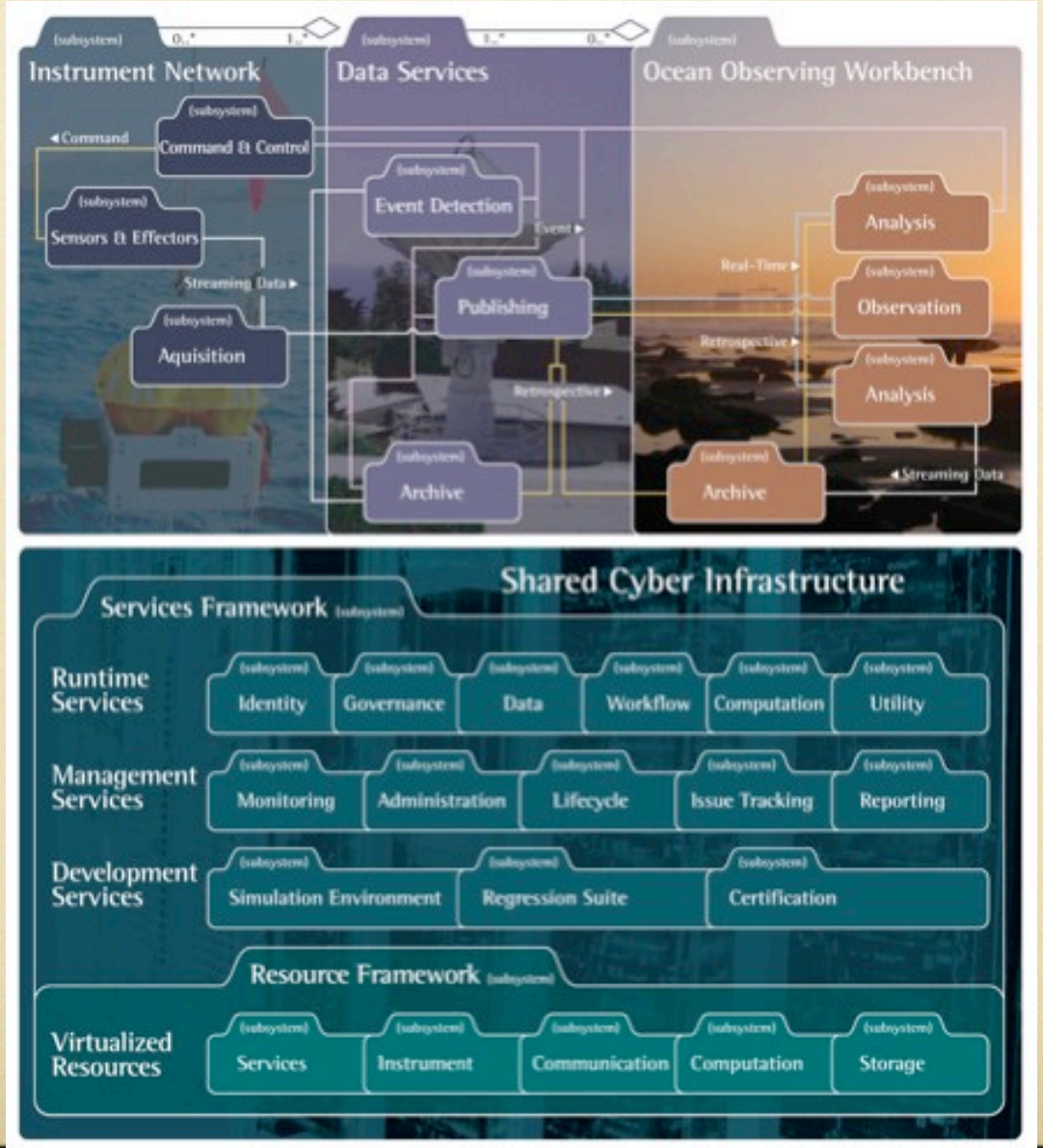


Real-time Observatories, Applications & Data management Networks

Laboratory
for Ocean
Observatory
Knowledge
& INformation
Grid
LOOKING

Text

LOOKING Architecture



Storage Resource Broker (SRB)

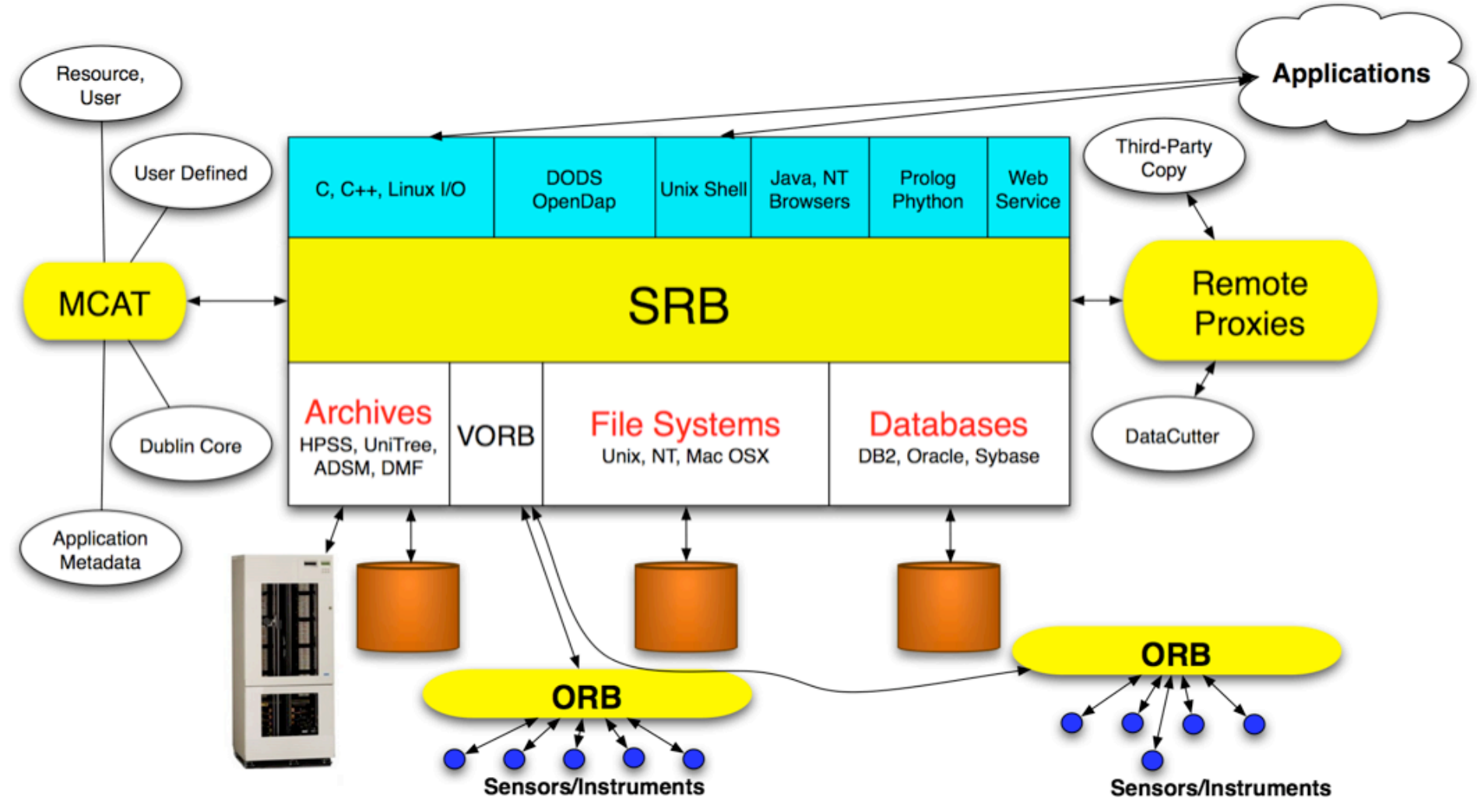
- Collaborative client-server system that federates distributed heterogeneous resources using *uniform interfaces* and *metadata*.
- Provides a simple tool to integrate data and metadata handling - *attribute-based access*
- Blends browsing and searching
- Developed at SDSC
  - Operational for 8 years

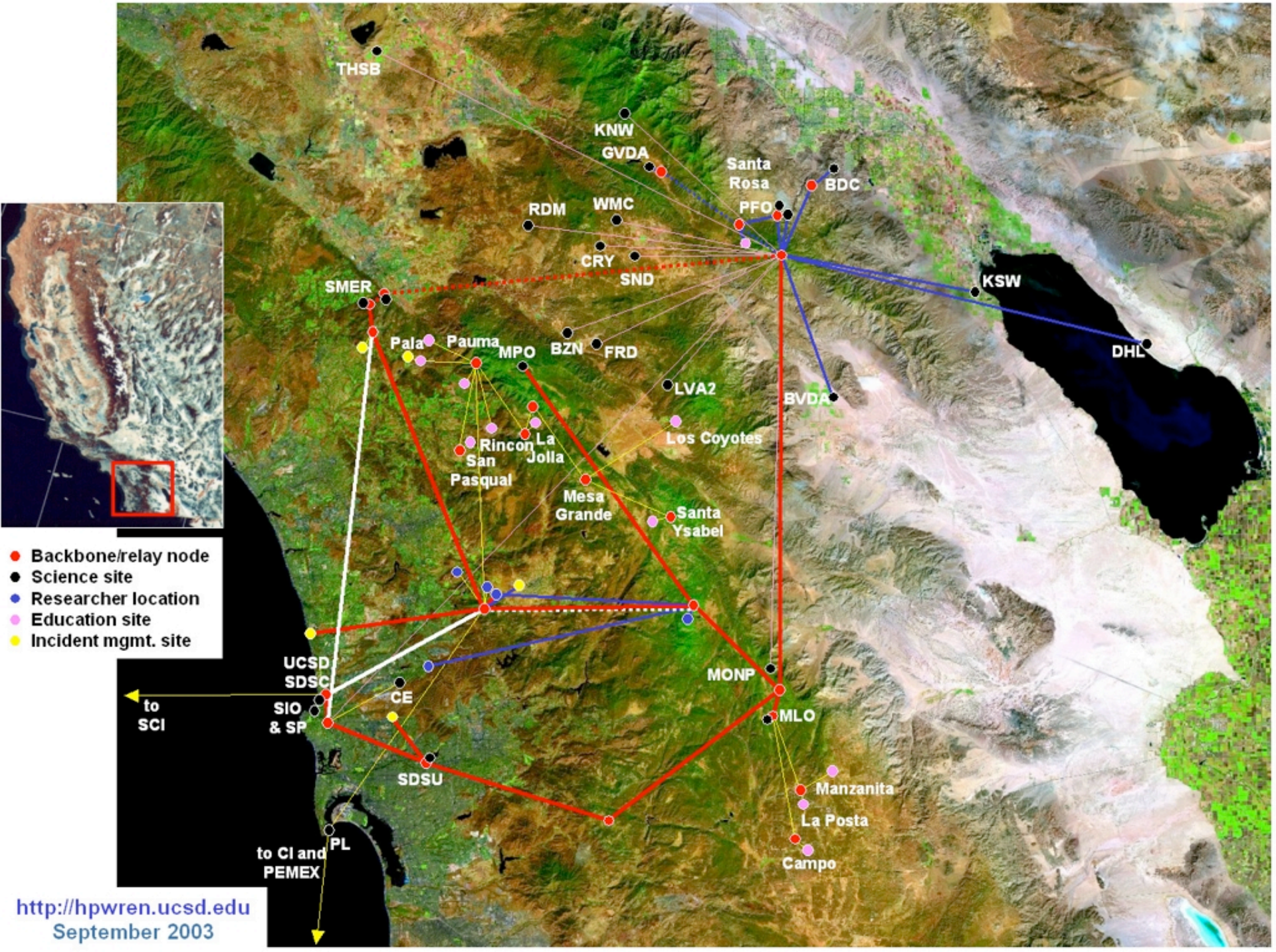
SRB Attributes

- Abstraction of Data and Collections – Virtual Data Organization
  - Virtual Collections: Persistent Identifier and Global Name Space
  - Organization independent of physical location & resource type
- Virtual Data Management and Movement
  - Replication & Consistency Maintenance
  - Data Aggregation: Containers
  - Seamless Cache Management and Data Placement
  - Copy, Move, Link
- Metadata & Data Discovery – semantic linking
  - System Metadata - metadata needed to run a data grid
  - User-defined Metadata – Structural & Descriptive
  - Application, Schema-based, Domain-centric
  - extensible and dynamic
  - Attribute-based Access (path names become irrelevant)

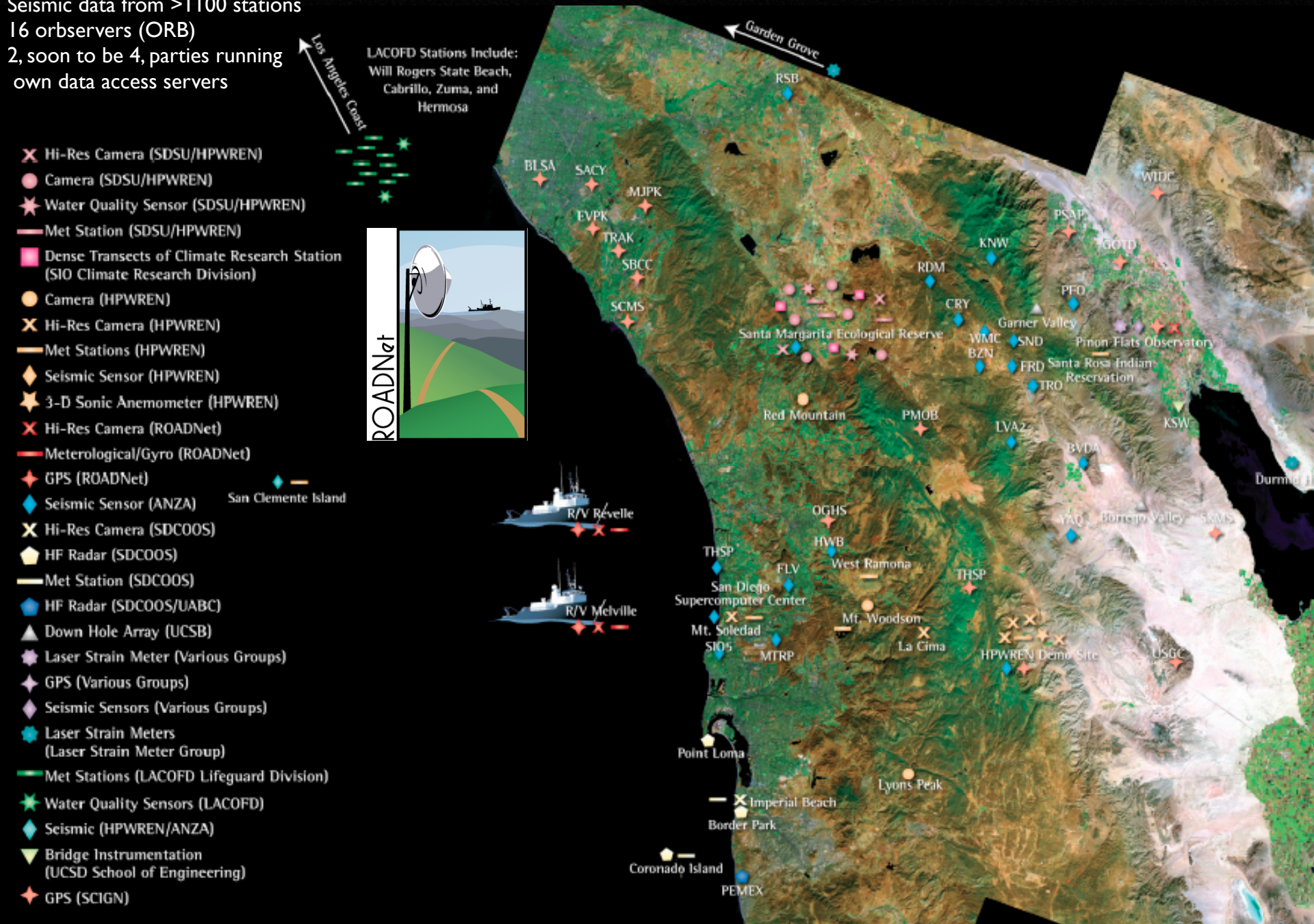
San Diego Supercomputer Center = SDSC

SDSC Storage Resource Broker



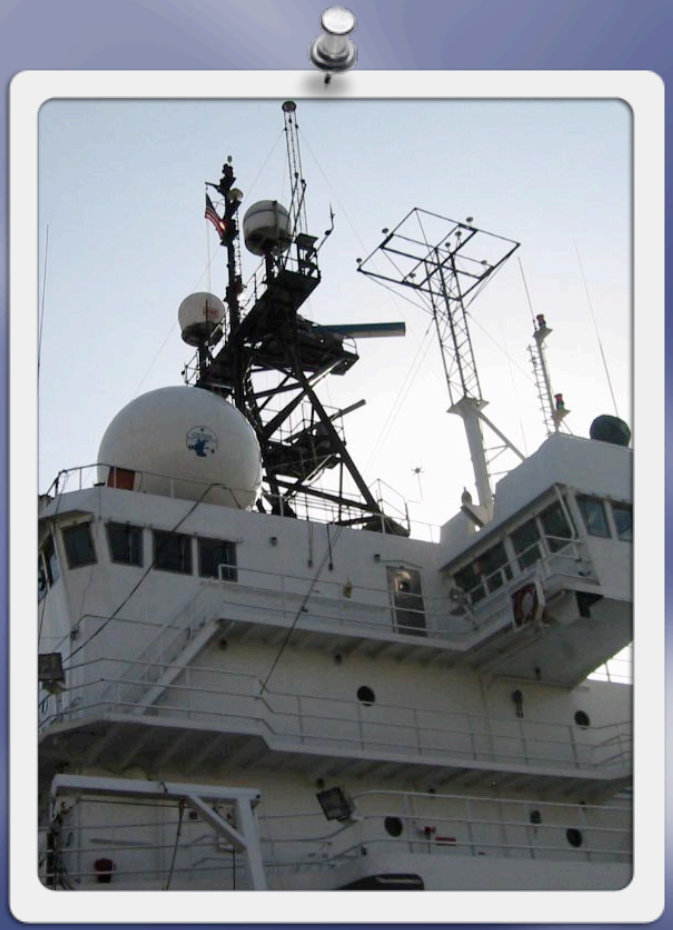

THSB
KNW
GVDA
Santa Rosa
BDC
RDM
WMC
PFO
CRY
SND
SMER
KSW
DHL
Pala
Pauma
MPO
BZN
FRD
LVA2
BVDA
Los Coyotes
Rincon
La Jolla
San Pasqual
Mesa Grande
Santa Ysabel
UCSD
SDSC
to SCI
SIO & SP
CE
MONP
MLO
SDSU
Manzanita
La Posta
Campo
PL
to CI and PEMEX
Backbone/relay node
Science site
Researcher location
Education site
Incident mgmt. site
http://hpwren.ucsd.edu
September 2003

29 in situ cameras
85 distinct streams from camers, GPS, meteorology stations, CODAR, etc.
Seismic data from >1100 stations
16 orbservers (ORB)
2, soon to be 4, parties running own data access servers



HiSeasNet

Currently installed on R/V Roger Revelle, R/V Melville, WHOI's Atlantis, and UW's R/V Thomas Thompson. A communications hub has been installed on the roof of the San Diego Supercomputer Center.




HiSeasNet

HiSeasNet Satellite Modems

Ku/Ka-Band

HiSeaNET

Internet for Oceanographic Ships at Sea

Funded to install on all large academic research ships and two intermediates

NATIONAL ECOLOGICAL OBSERVATORY NETWORK

NEON CI Functions

5. **Access via customized interfaces**
portals for science, education, public, system management

6. **Collaboration**
videoconference, collaboration with data and models

Web services interfaces

Internet2, National Lambda Rail, Lambda Grids

3. **Data Storage**
curation, long-term preservation

NEON auxiliary data, Derived products, etc.

Replicated storage capability

4. **Analysis and Visualization**
models, forecasting, model-based integration

2. **Networking**
transmit data

NEON Standard Web services interfaces

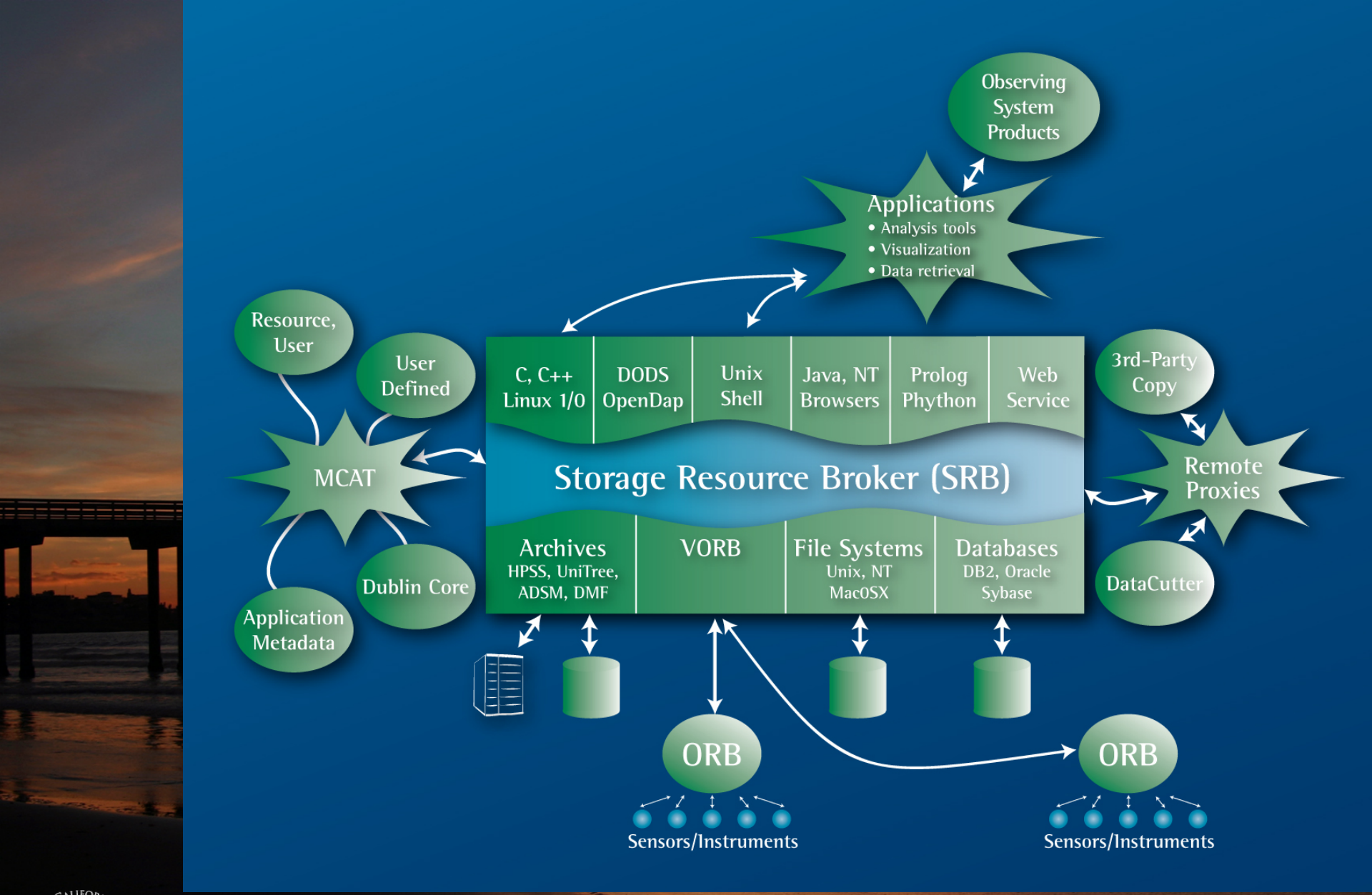
NEON Networking: Internet2, NLR, Lambda-Grids

NEON Sensornets

1. **Embedded CI**
infield operation, sensornet tasking

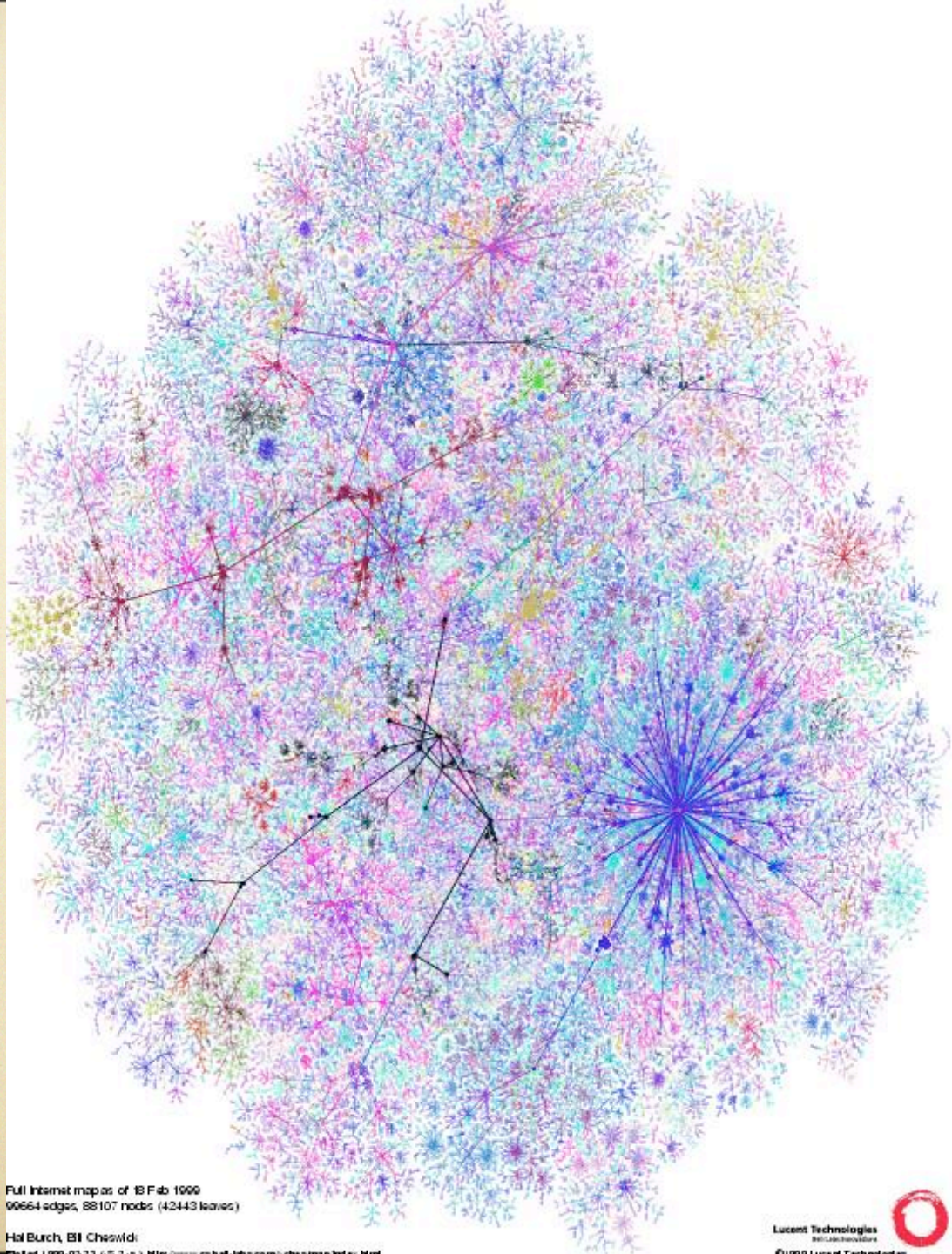
Other remote services

3rd-party (Non-NEON) sensornets, data, services


Observing System Products
Applications
• Analysis tools
• Visualization
• Data retrieval
Resource, User
User Defined
MCAT
Dublin Core
Application Metadata
C, C++ Linux I/O
DODS OpenDap
Unix Shell
Java, NT Browsers
Prolog Phython
Web Service
Storage Resource Broker (SRB)
Archives
HPSS, UniTree, ADSM, DMF
VORB
File Systems
Unix, NT MacOSX
Databases
DB2, Oracle Sybase
3rd-Party Copy
Remote Proxies
DataCutter
ORB
ORB
Sensors/Instruments
Sensors/Instruments

Bill Cheswick
Hal Burch
Lumeta Corp

Traceroute path probes
100,000 nodes



MIT's Technology Review - March '05

- Mike Liebhold, *Infrastructure for the New Geography*
- Wireless networks can flesh out the physical world - We've got huge amounts of data about the planet, but most stay walled off in proprietary databases or people's heads. Wireless networks let us make that information not just visible, but visible in place.

Environmental Data

- Importance of open, real-time data becomes obvious following events like the Sumatra Great Earthquake and tsunami
- Global sensor networks are critical and open data are essential
- No single center nor person/lab is capable of dealing with the nuances of large, rare events in the Earth system

Ocean Observatories Initiative

Basic Infrastructure:
Network providing high bandwidth communications and electrical power

Three primary components:

- **Global-scale moored buoy systems**
- **Regional-scale seafloor fiber optic cable system**
- **Coastal observatories**

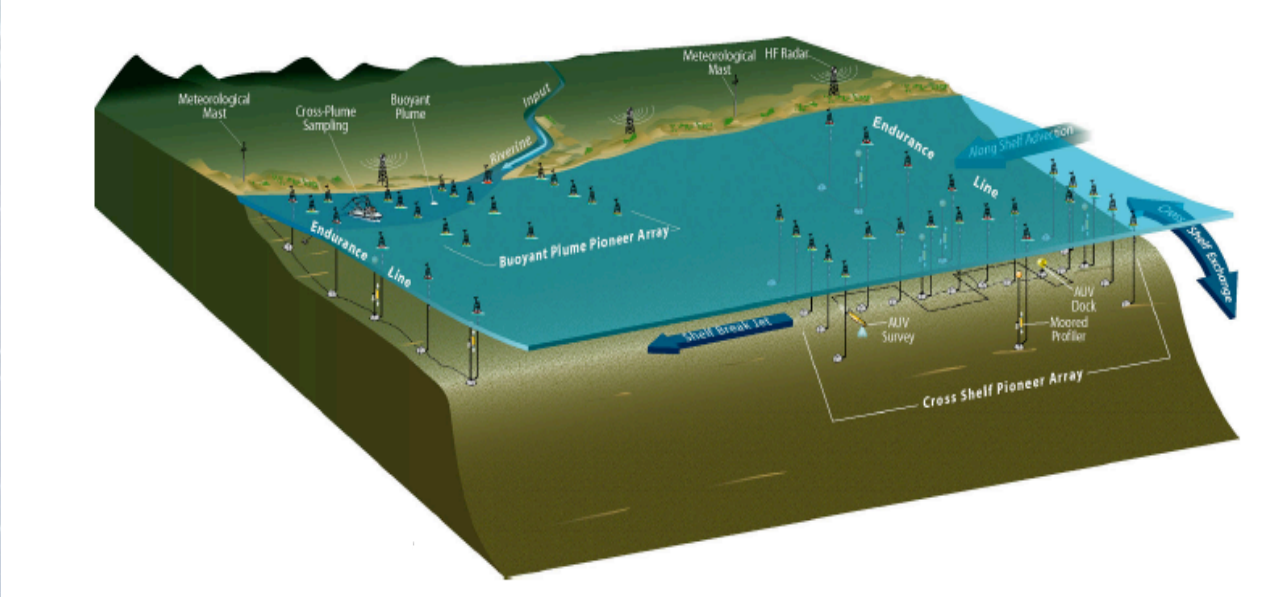
Cyberinfrastructure **will a tely control their instruments, pe riments, construct virtual observatori a in near-real-time**

The OOI will provide the ability to investigate processes at the scales at which they occur

FY07 (October 2006)
$268M over 6 Years

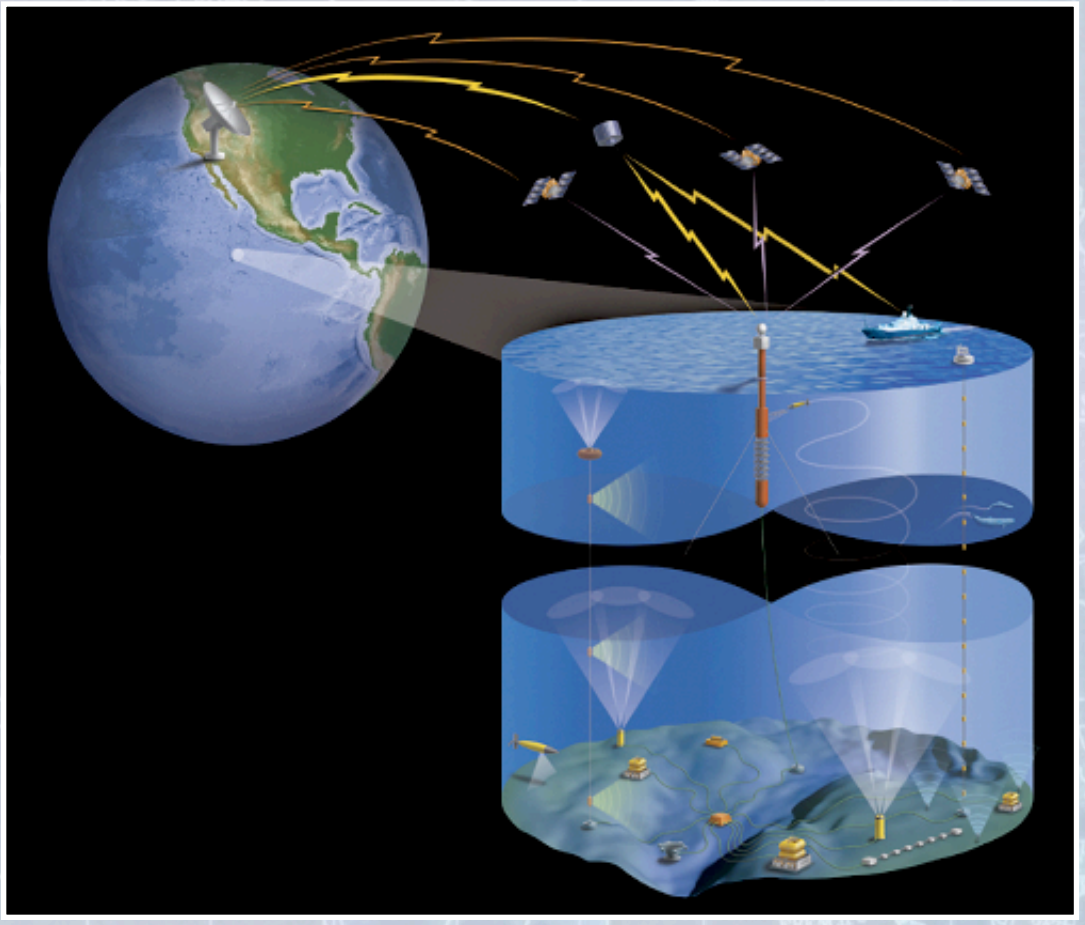
Coastal Array

Endurance Arrays – Fixed, permanent observing array arranged as cross-shelf lines and individual moorings



Pioneer Arrays – Relocatable arrays for process-oriented studies

Global Array

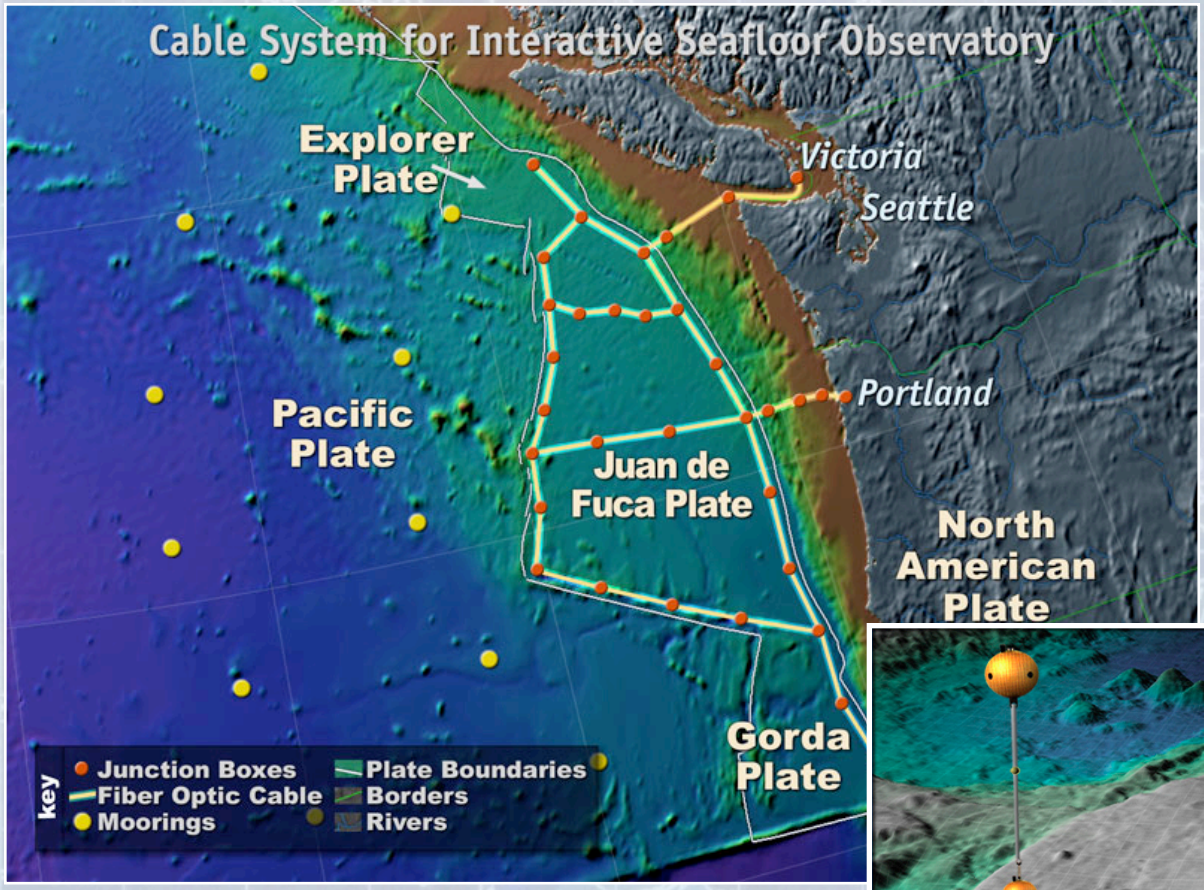


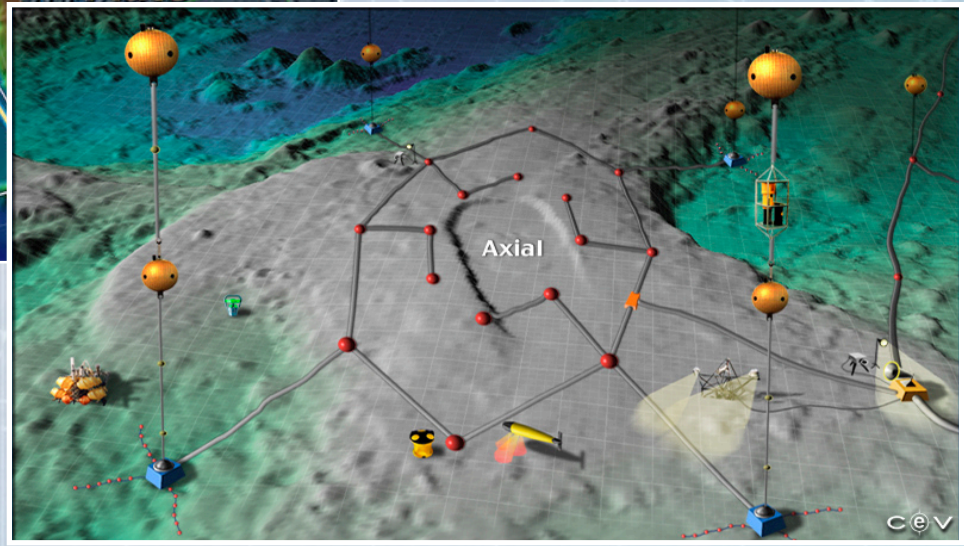
Active programs:

NOAA's Office of Climate Observation
Ocean SITES: http://www.oceansites.org/

HiSeasNet
http://hiseasnet.ucsd.edu/

Regional Cabled Observatory





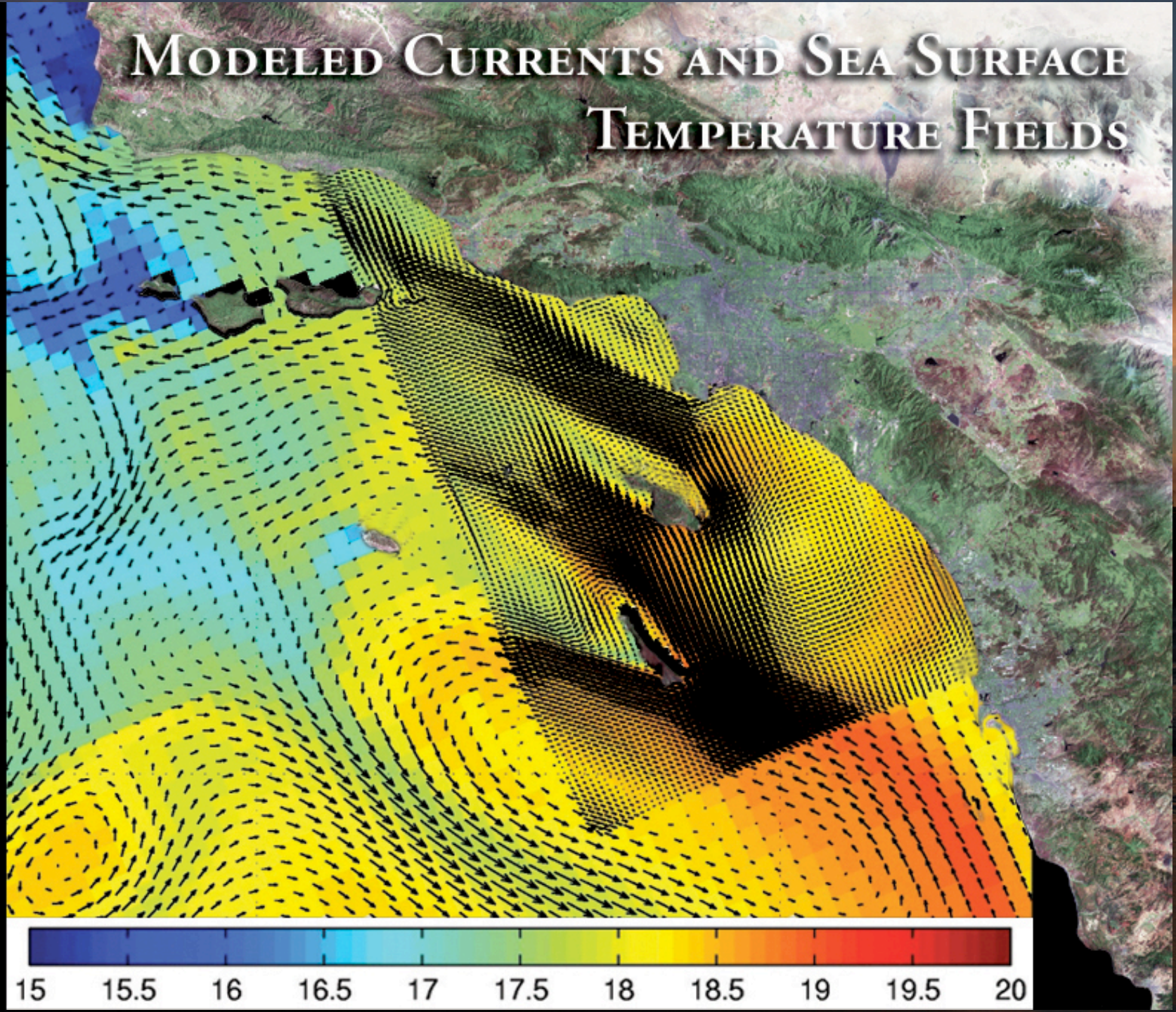

CALPOLY-SLO
UCSB
JPL-NASA
UCLA
CSLA
USC
SCCWRP
UCI
SIO-UCSD
CICESE
UABC
Alaska Region
Pacific Northwest Region
Great Lakes Region
Northeast Region
Central and Northern California Region
Mid-Atlantic Region
Hawaiian Islands Region
Southern California Region
Southeast Region
Gulf of Mexico Region
Caribbean Region
SOUTHERN CALIFORNIA COASTAL OCEAN OBSERVING SYSTEM
WWW.SCCOOS.ORG

Southern California

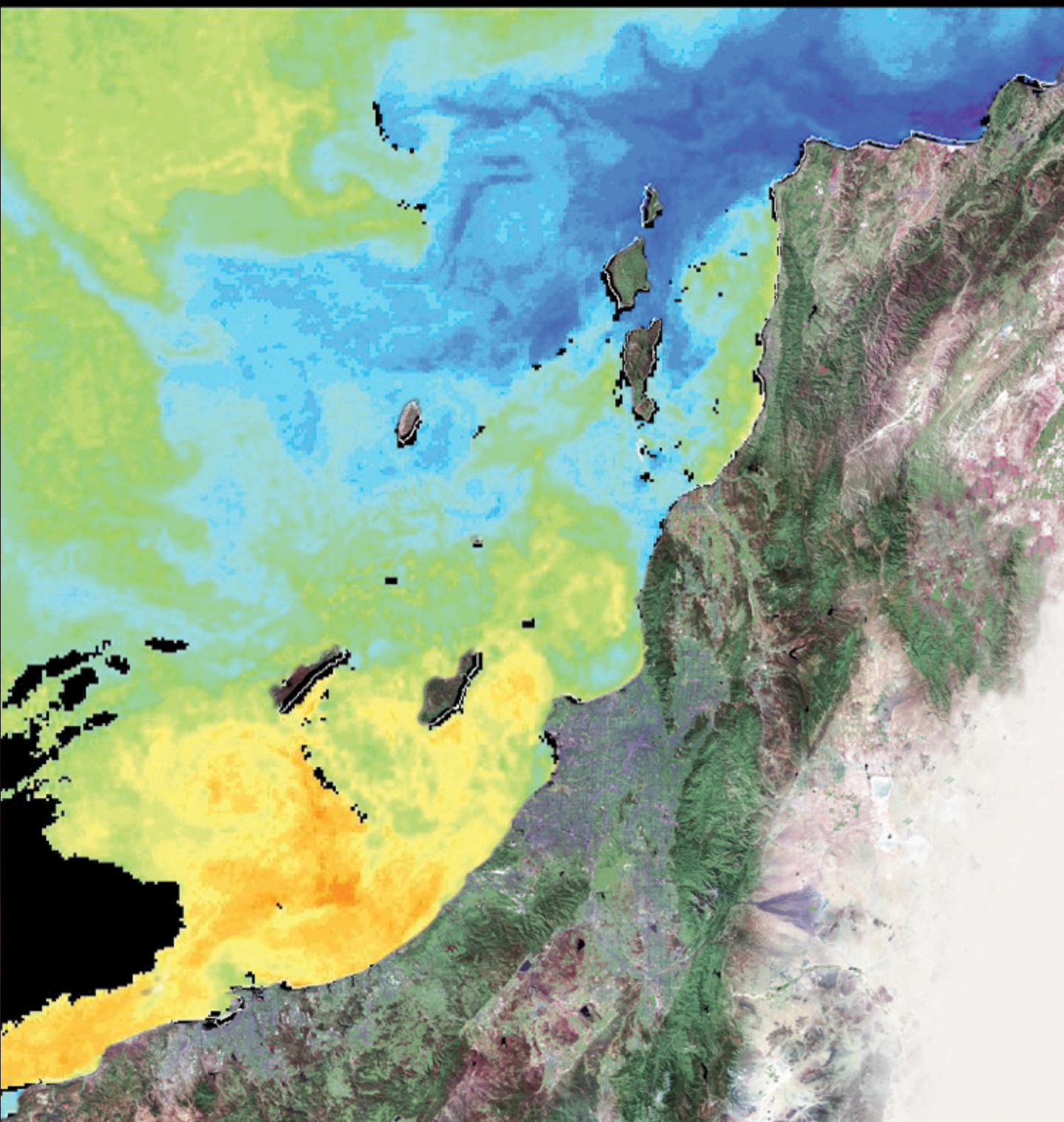

COCMP
HF Radar Coverage
CA Prop 40/50
$21M for funding
Coastal current
Monitoring program
Southern California Coastal Ocean Observing System
Coastal Conservancy
CENCOOS

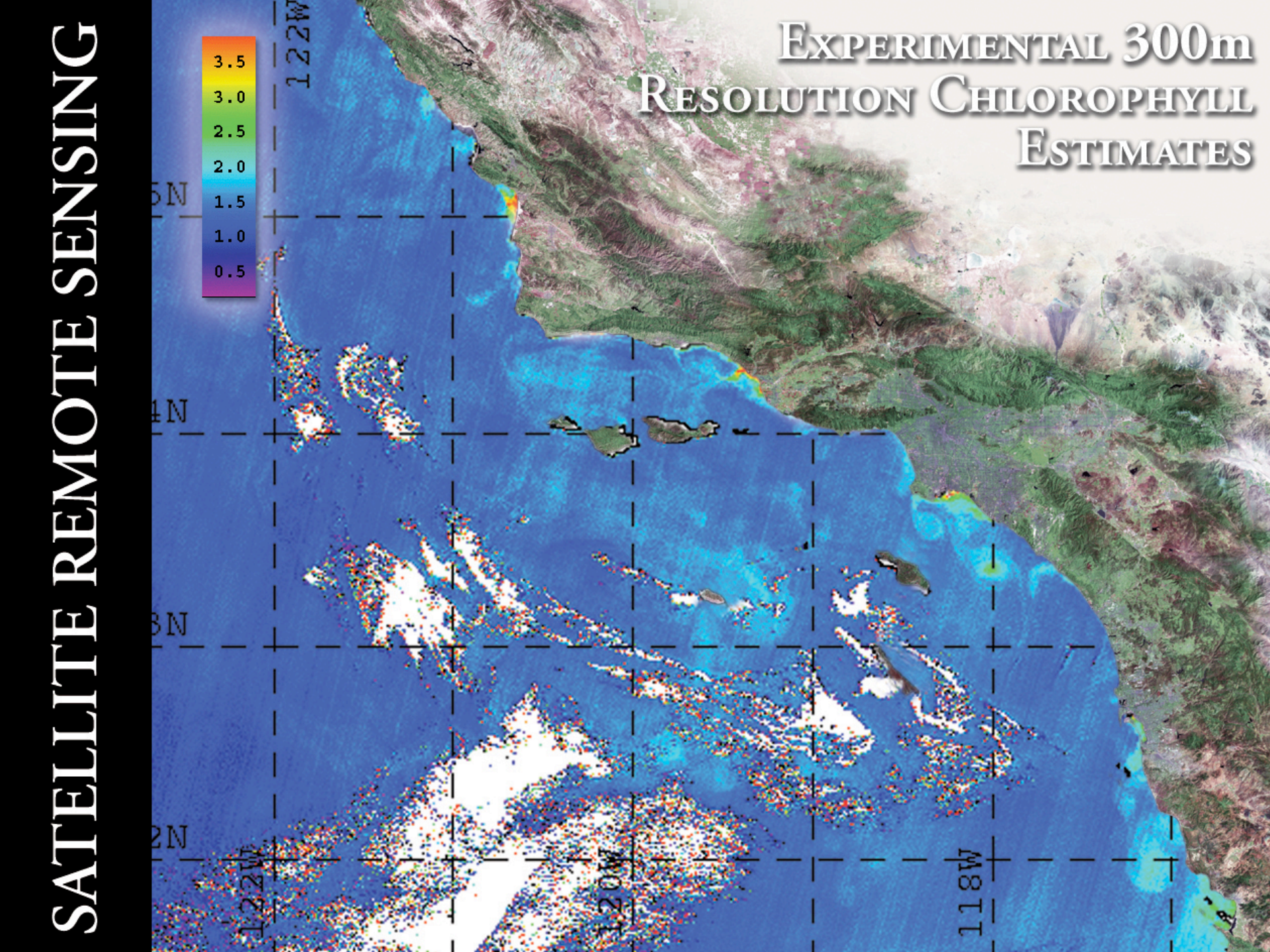
ROMS NESTED MODEL OUTPUT

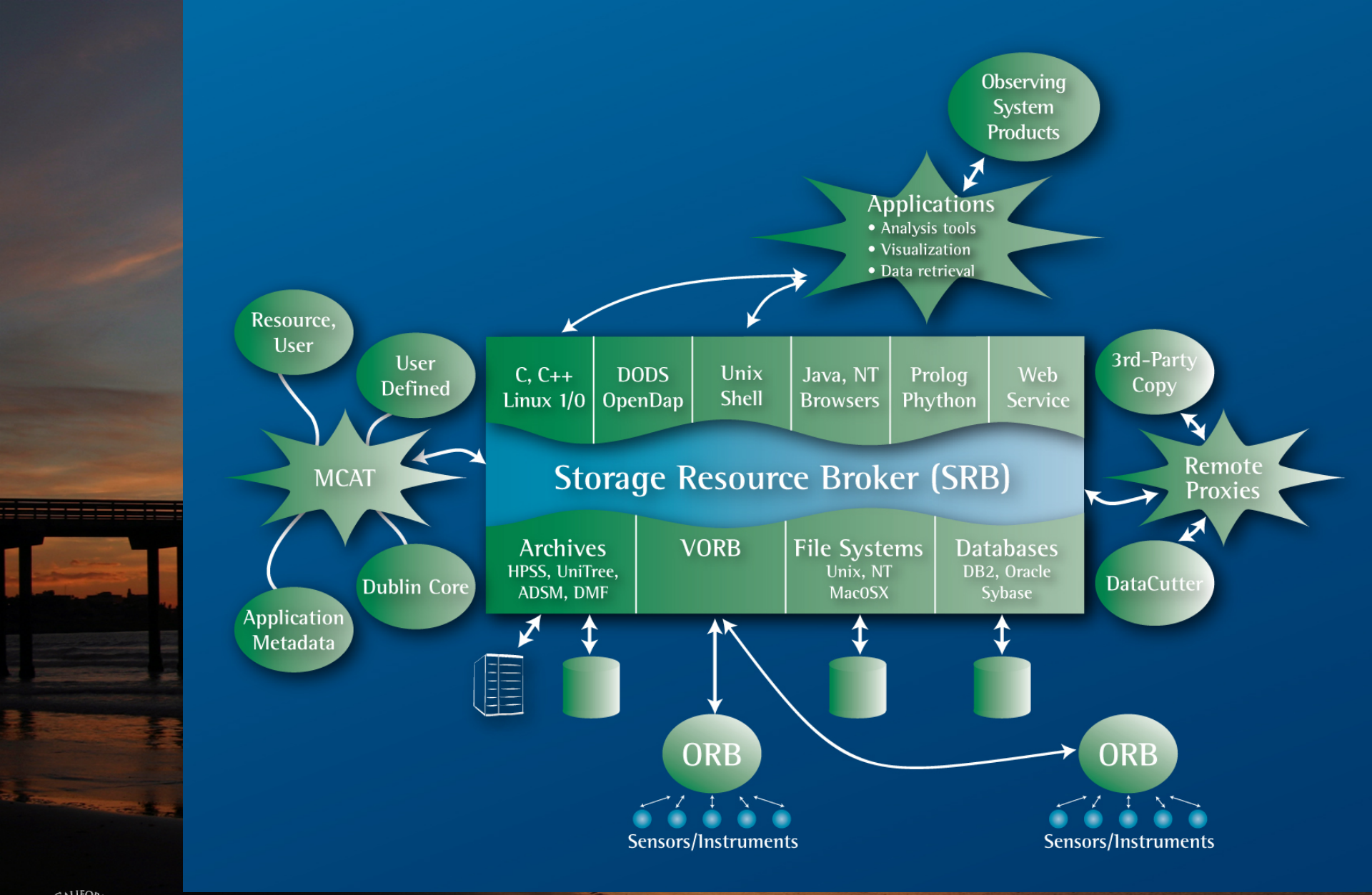
Modeled Currents and Sea Surface Temperature Fields



SATELLITE REMOTE SENSING OCEAN TEMPERATURE FIELDS




SATELLITE REMOTE SENSING
EXPERIMENTAL 300m
RESOLUTION CHLOROPHYLL
ESTIMATES
3.5
3.0
2.5
2.0
1.5
1.0
0.5
122W
5N
4N
3N
2N
122W
118W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• Visualization
• Data retrieval
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User Defined
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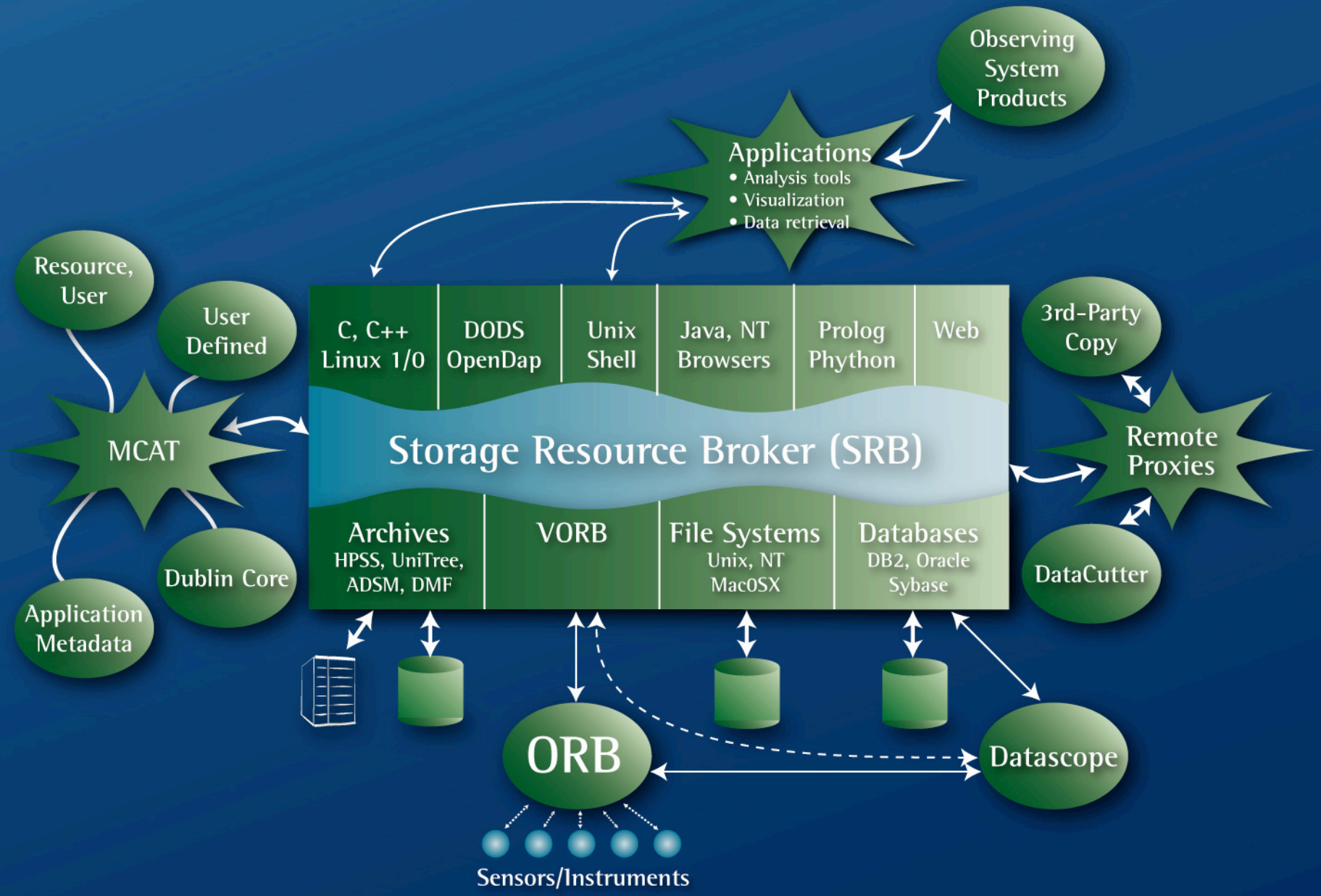
Dublin Core
Application Metadata
C, C++ Linux I/O
DODS OpenDap
Unix Shell
Java, NT Browsers
Prolog Phython
Web Service
Storage Resource Broker (SRB)
Archives
HPSS, UniTree, ADSM, DMF
VORB
File Systems
Unix, NT MacOSX
Databases
DB2, Oracle Sybase
3rd-Party Copy
Remote Proxies
DataCutter
ORB
ORB
Sensors/Instruments
Sensors/Instruments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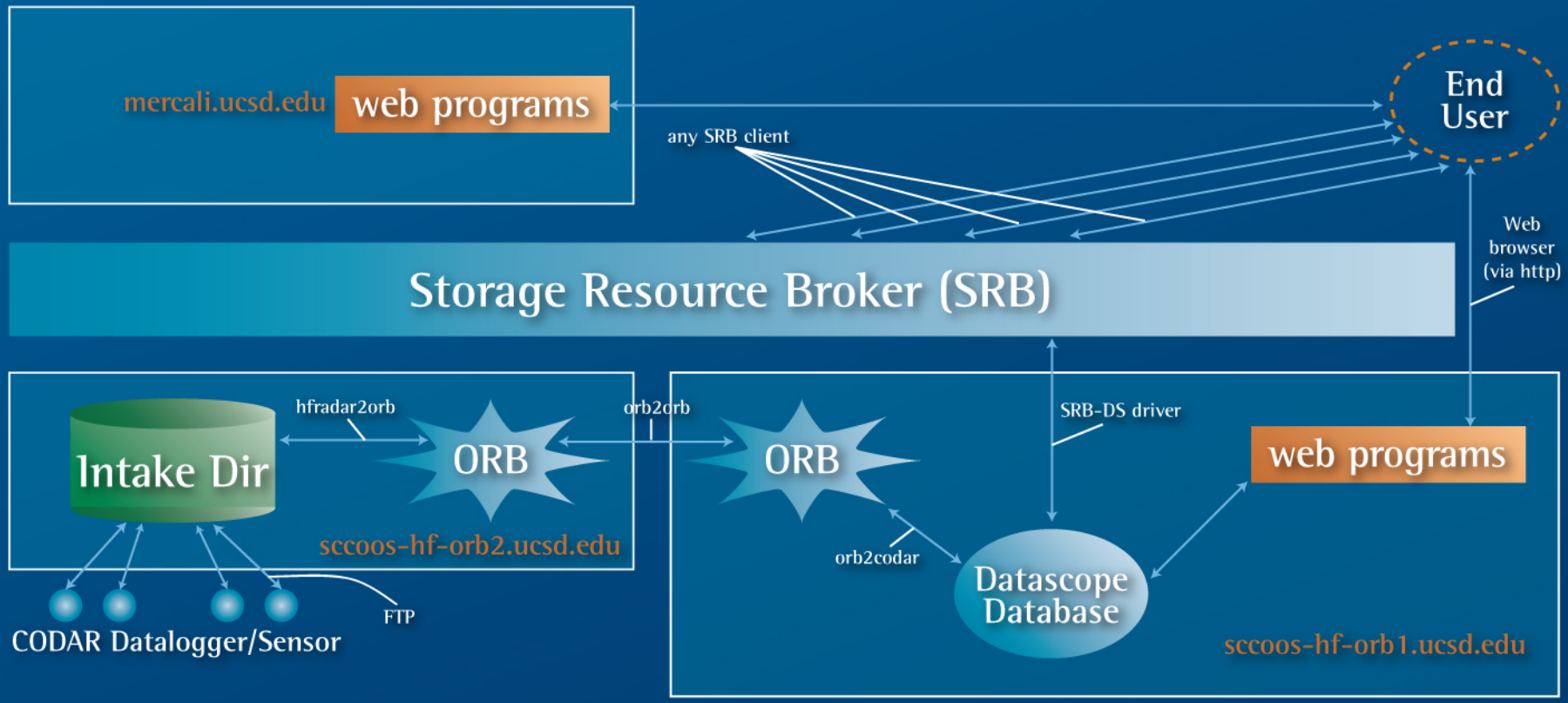
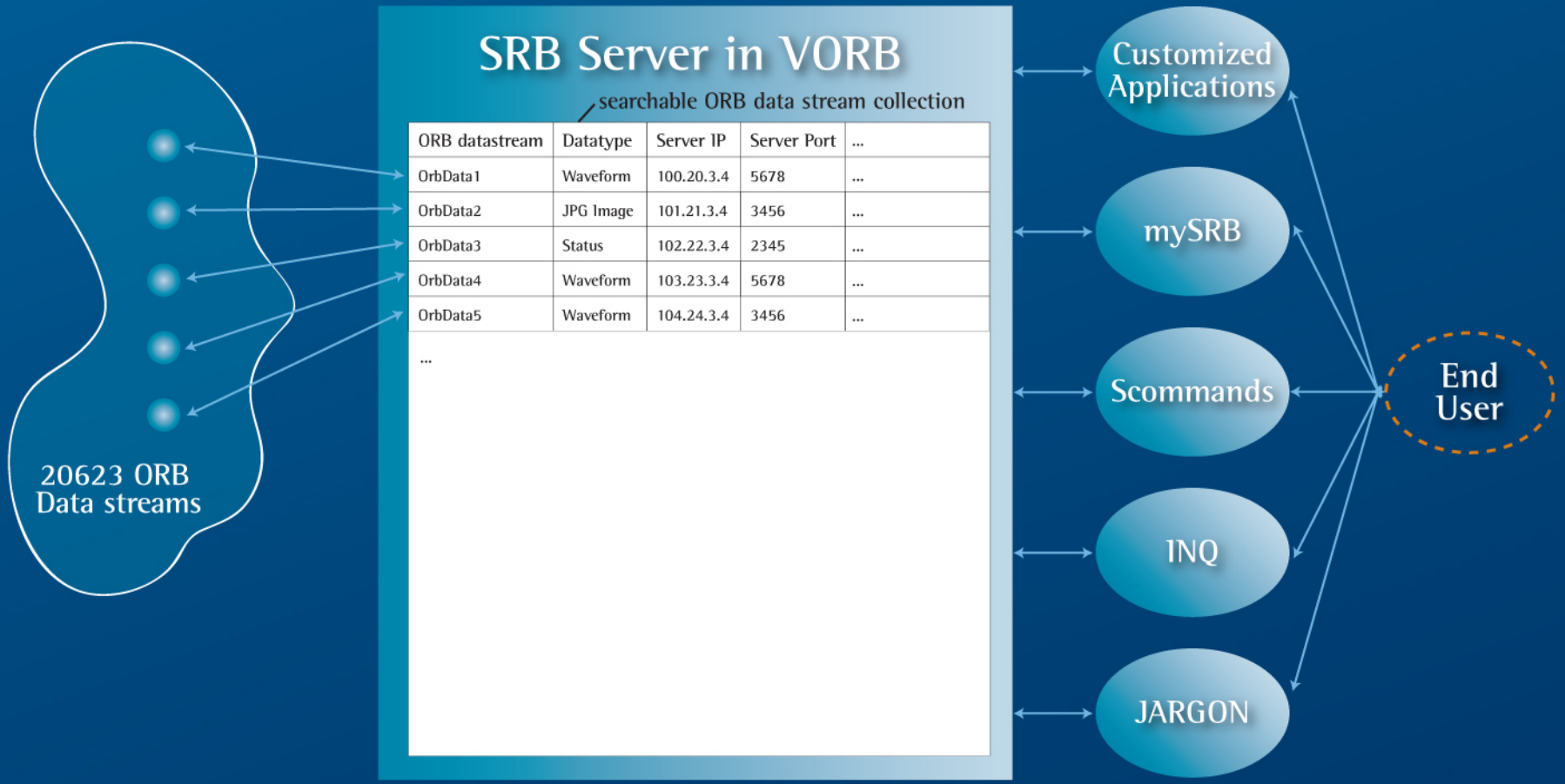
File Systems
Unix, NT MacOSX
Databases
DB2, Oracle Sybase
3rd-Party Copy
Remote Proxies
DataCutter
ORB
Datascope
Sensors/Instruments

Example: VORB Usage At SCCOOS



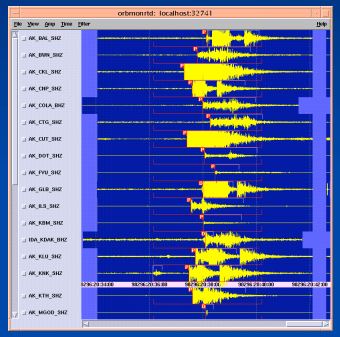
On Going Effort: New ORB data stream organizing/access tool



ROADNet / Kepler
Real-time Scientific Workflows

Architecture:

Seismic Waveforms



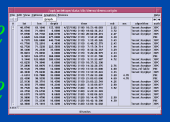
Images

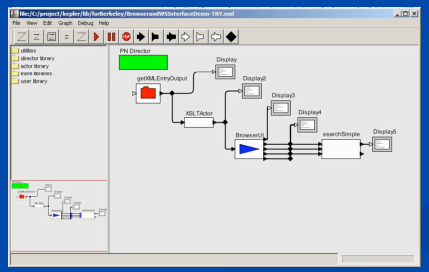
Many Datatypes

Orbserver

Real-time Packet Buffer

Near-real-time Database

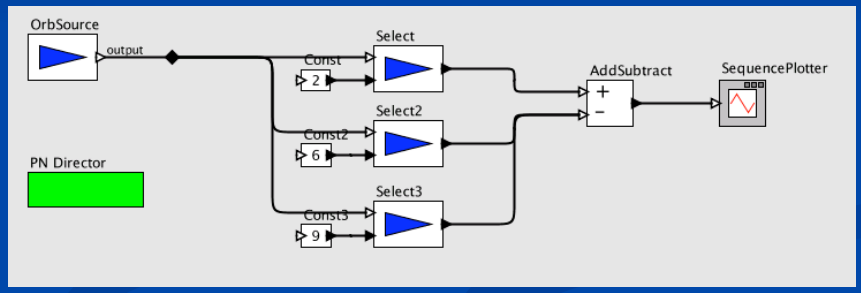




Scientific Work Flow

Straightforward Example:

Laser Strainmeter Channels in;
Scientific Workflow;
Earth-tide signal out



Target Directions:

- *Complex Processing Results*
- *Cross-disciplinary signals analysis*
- *Geophysical Stream Algebras*