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Discoveries
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Cyberinfrastructure for the Solid Earth Sciences

Instrumentation & Facilities Program
Division of Earth Sciences
Directorate for Geosciences

David D. Lambert

CIG/IRIS Workshop on Computational Seismology

June 8, 2005

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Infrastructure Opportunities

- **NSF has mid-size infrastructure funding gap** (NSB 02-190)
- **NSB estimates 50% of need is in $1-50M range**
- **Important new opportunities for EAR:**
  - *EarthScope* – InSAR "L band" satellite (NASA lead)
  - *Hydroview* – hydrologic instrumentation, informatics, synthesis
  - *EarthTime* – distributed network of geochronology labs
  - *EarthLab* – DUSEL for geology, biology, engineering, physics
  - *Geoscience collections* – data / sample preservation (curation)
  - *Geoinformatics* – cyberinfrastructure for the Earth sciences
  - *HEC* needs – PACI centers, teragrid, petascale supercomputer

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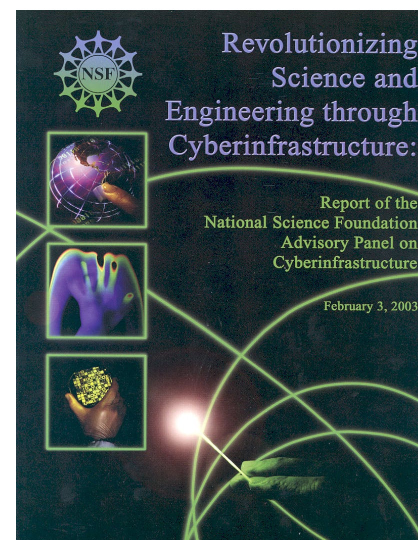
Atkins Report Recommendations

(NSF Blue Ribbon Advisory Panel on Cyberinfrastructure)

Central recommendation: *NSF should establish & lead a large-scale, interagency, internationally-coordinated Advanced Cyberinfrastructure Program (ACP) – <u>sustained new NSF investment of $1B p.a.</u>*

1. Fundamental research to create advanced CI ($60M)
2. Research on application of CI to domain science research ($100M)
3. Acquisition & development of software for CI ($200M)
4. Provisioning & operations ($660M)
    - Computational centers ($375M)
    - Data repositories ($185M)
    - Digital libraries ($30M)
    - Networking ($60M)
    - Application support ($10M)

<u>Management</u>: ACP office @ NSF



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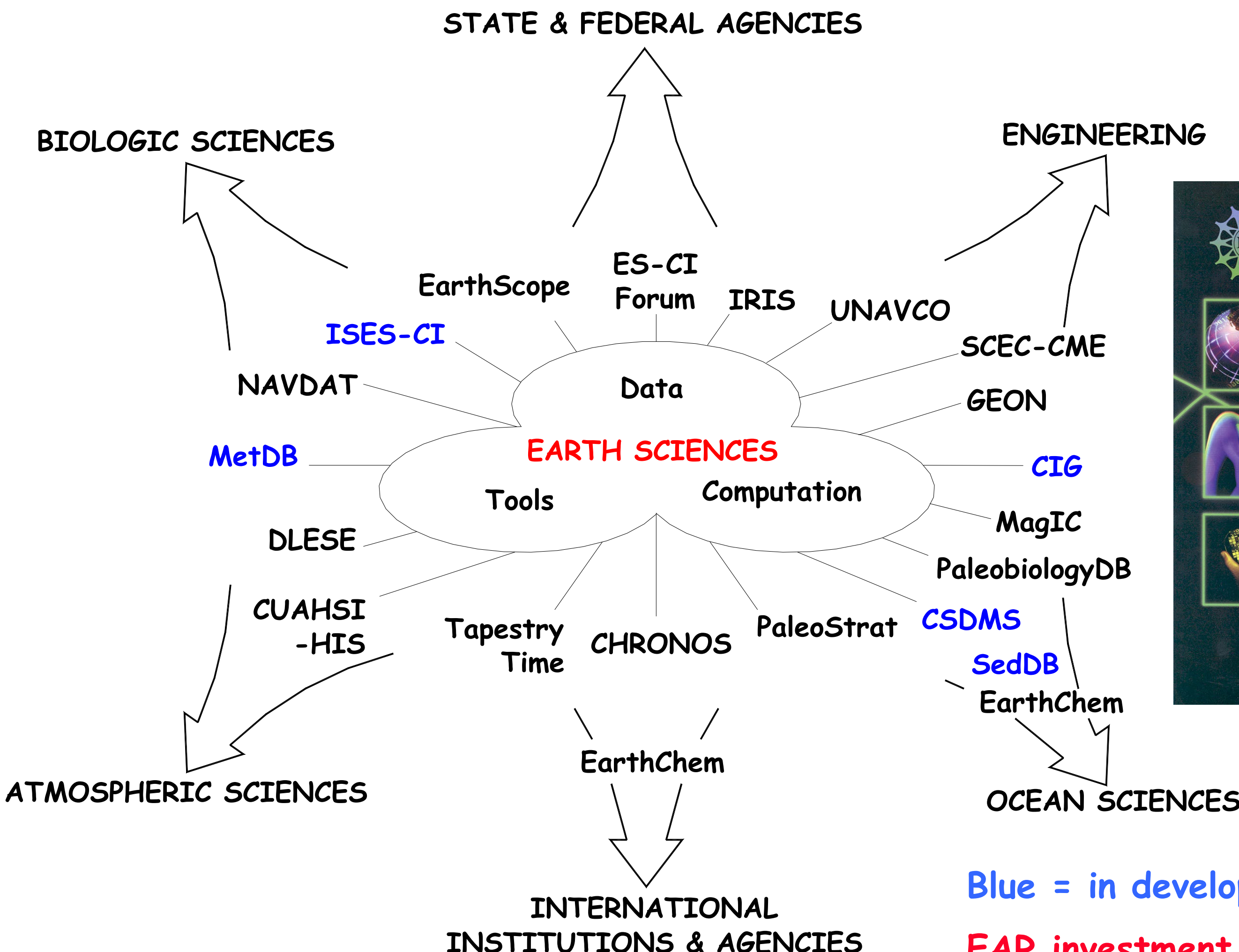
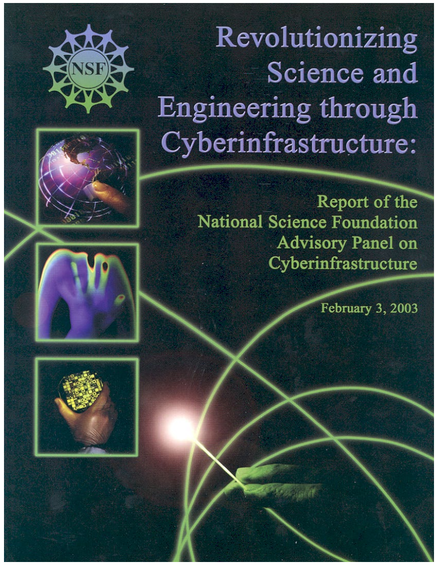
Geoinformatics Communities





Blue = in development

EAR investment ~ $10M p.a.

EAR/IF Areas of Support

(New Solicitation 05-587)

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EA	*Acquisition / upgrade of commercially-available equipment & instrumentation*
ITD	*Development of new instruments & techniques*
FS	*Support of national, multi-user facilities*
TS	*Support of technicians*
EC	*EA & TS for early-career PI's (new opportunity in FY 04)*
GI	*Geoinformatics (Cyberinfrastructure for EAR)*

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Geoinformatics

- **WHAT IS IT?** Enabling platform for the next generation of Earth science research
- **MISSION**: Provide tools & facilities to receive, organize, share, visualize & analyze data ("interoperability")

- Build a community for sharing data, tools & science in research & education (free & open access)
- Proposed activities could include: databases, networks, visualization, analytical tools, modeling software, computational resources, dedicated E&O (sociology change)
- Particularly interested in proposals that address priorities identified by the research & education communities
- Platform activities that are transformative & with impacts that extend beyond an individual investigator or small group of investigators are encouraged

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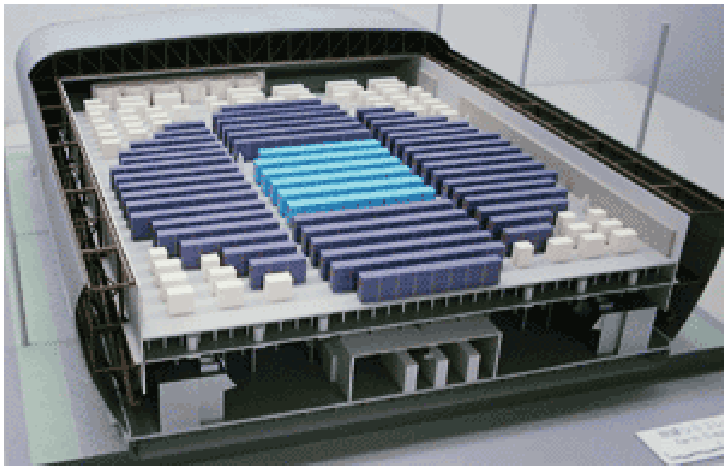
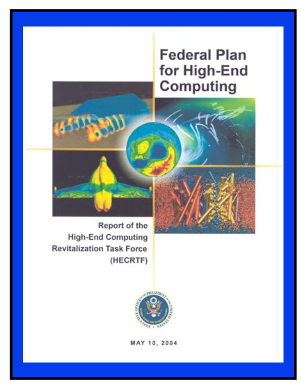
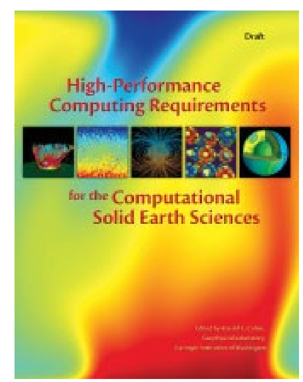
A Petascale HEC for GEO?



Earth Simulator (Japan)
NEC "*custom vector cluster*" (2002)
5120 processors / 640 cabinets
Peak: **41.1 Tflops**
High fraction of peak: 30% sustained
Interconnect: 5185 pins (vs. 478 Pentium 4)
No on-chip cache memory
Heat / power consumption huge issues
Cost: $350M ($1-5M p.a. for power)



May 2004



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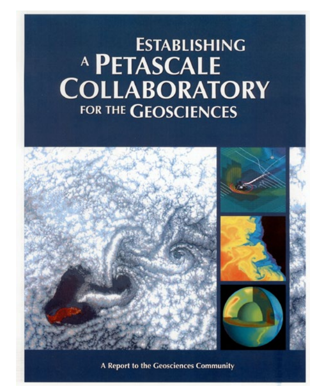


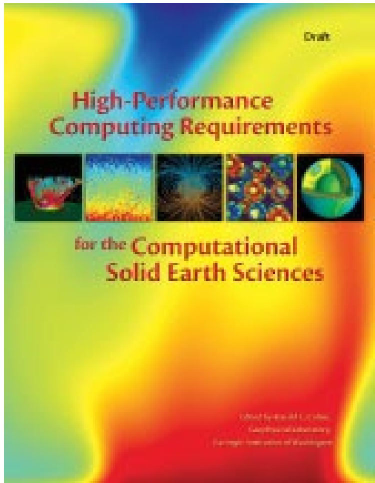
June 2005

EAR Recommendations

(Workshop on Computational Geoinformatics, May 2004)

1. Build a national facility for computational Earth science (dynamic – purchase “performance curve”)
2. Fund 10 regional computation, data storage & visualization clusters (networked; includes PACI centers)
3. Increase funding for research group & departmental clusters ($1.5M – $3M p.a.)
4. Change policies at existing national centers (PACI)
5. Increase funding for education & training in computational Earth science
6. Software development needed (CIG)

Timescale for implementation: 5 – 10 years



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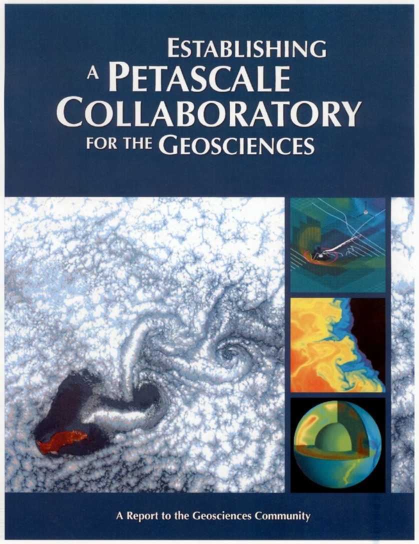
GEO Recommendations

(Ad Hoc Committee for a Petascale Collaboratory for Geosciences)

Central recommendation: *Establish a petascale collaboratory for the geosciences (PCG) with the mission to provide leadership-class computational resources that will make it possible to address, & minimize the time to solution of, the most challenging, large-scale problems facing the geosciences.*

Leadship-class systems: *Peak speeds of one petaflop & memory capacities in the petabyte range (systems with these characteristics are termed "petascale").*

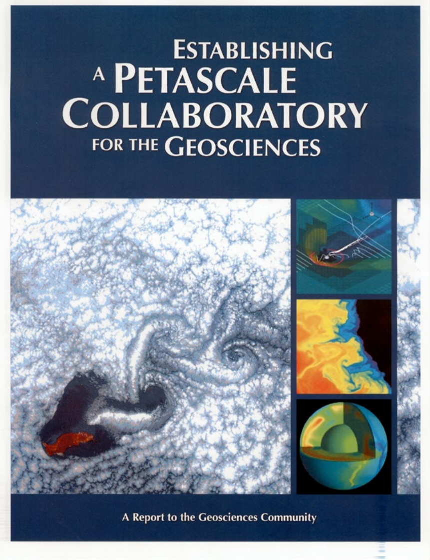
Ad Hoc Committee and Technical Working Group for a Petascale Collaboratory for the Geosciences: UCAR/JOSS, 132 pp. (2005).



Collaboratory Concept

Collaboratory describes a community-specific computational environment for research & education that provides high-performance computing services; data, information, & knowledge management services; human interface & visualization services; & collaboration services.

Important <u>scientific breakthroughs</u> could be made with a system capable of sustaining 100-200 TFLOPS on a single geofluids-type application by 2010.



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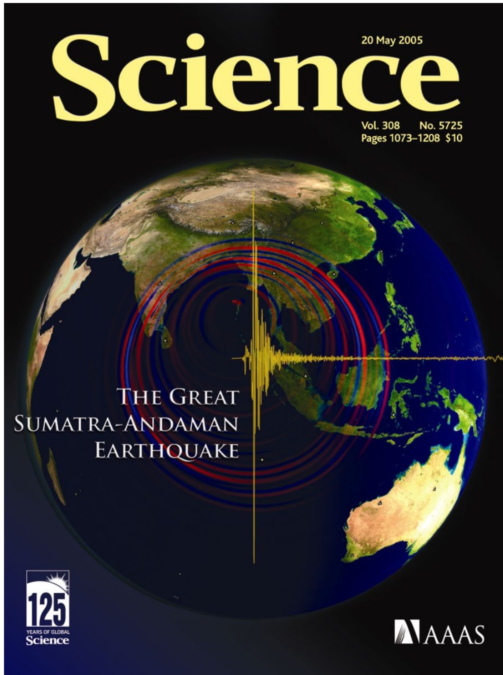
Frontiers in Computational Geosciences

1. Global seismology – 3D modeling for improved tomography
2. Earthquake simulations – multiple spatial / temporal scales
3. Mantle convection – 3D including dynamic plates
4. Geodynamo simulations – turbulent convection of the core
5. Mineral physics – first principles simulations
6. Ocean turbulence – salinity effects
7. Carbon cycle & climate models
8. Space weather – solar flare simulations

CAPTION: Spectral-element simulation of surface ground velocities (red up, blue down) 15.8 minutes after rupture initiation of the great 2004 Sumatra-Andaman earthquake. Seismogram is 160 minutes of actual-amplitude vertical ground displacement recorded at GSN station PALK (Pallekele, Sri Lanka). [Image: Santiago Lombeyda/*Caltech Center for Advanced Computing Research*; Vala Hjorleifsdottir and Jeroen Tromp/*Caltech Seismological Laboratory*; Richard Aster/*New Mexico Tech*].



NSF's Cyberinfrastructure Vision

(Arden Bement – NSB, May 25, 2005)

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NSF HPC Strategy:

- ✓ Focused on science & engineering frontiers
- ✓ Serves all fields, communities & organizations
- ✓ Delivers coordinated, interoperable services
- ✓ Harvests continuing computing innovations
- ✓ Complements HPC investments of partners (PACI)
- ✓ Results in balanced hardware-software investments

Next Steps:

- Complete HPC requirements analysis (8-2005)
- Release solicitation for initial HPC acquisition (9-2005)
- First award(s) for HPC acquisition (9-2006)
- Create new "Office of Cyberinfrastructure" in OD
- New activity in FY 2007 (budget request summer 2005)

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