

Software Integration & Visualization Office

Goddard Space Flight Center

Capabilities Overview & MAP Technology Roadmap Status

MAP Science Team Meeting, March 2007

Michael Seablom - Office Head

Who We Are

Advanced Software Technology Group

Tom Clune

- †Develops & maintains application software
- †Provides performance tuning of science codes
- †Advocates professional software engineering practices
- †Coordinates software integration efforts across Goddard and across NASA

Scientific Visualization Studio

Horace Mitchell

- †Provides visualization services for a wide range of Earth and Space science customers
- †Provides scientific visualizations targeted at NASA managers, policy makers, and the general public
- †Develops visualization applications for use as analysis tools by scientists

MAP Integration Group

Gail McConaughy

- †Serves the MAP program by selecting and implementing appropriate technologies that will benefit the development of Earth System models
- †Develop software in support of Observing System Simulation Experiments (OSSEs)

Education & Public Outreach

David Herring

- †Provides freely-available Earth Science visualizations through web-based publications
- †Develops products for educators
- †Coordinates Goddard Education & Public Outreach activities

Software Support via NASA High End Computing

Optimization of scientific codes for high-end computing

Identification and mitigation of performance bottlenecks

Optimization for multiple hardware platforms

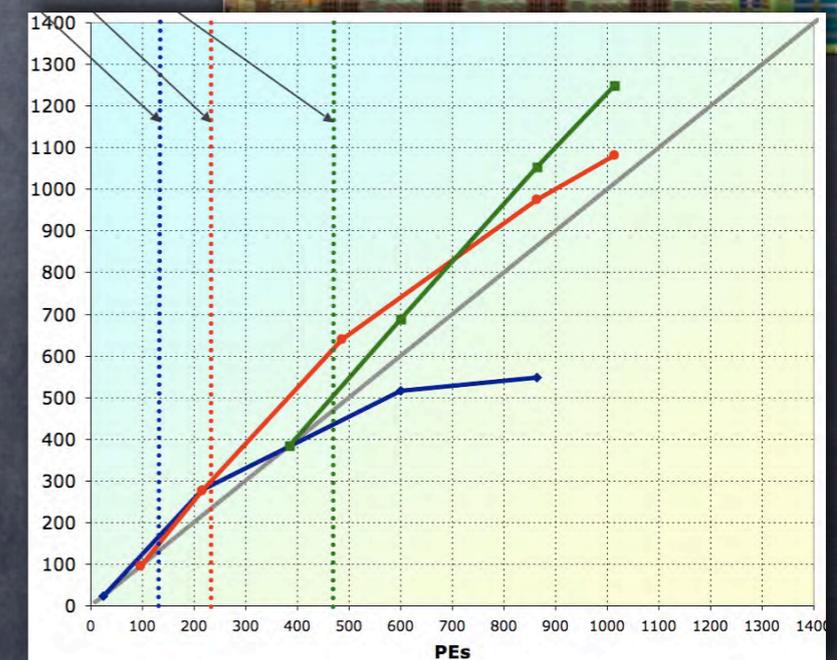
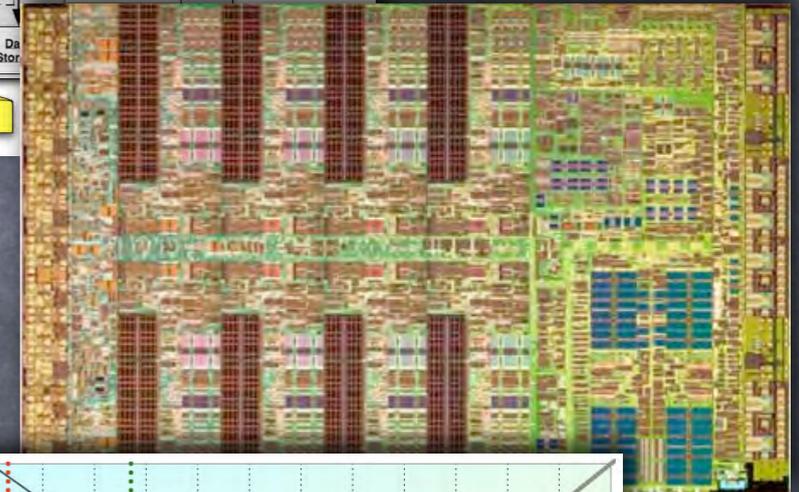
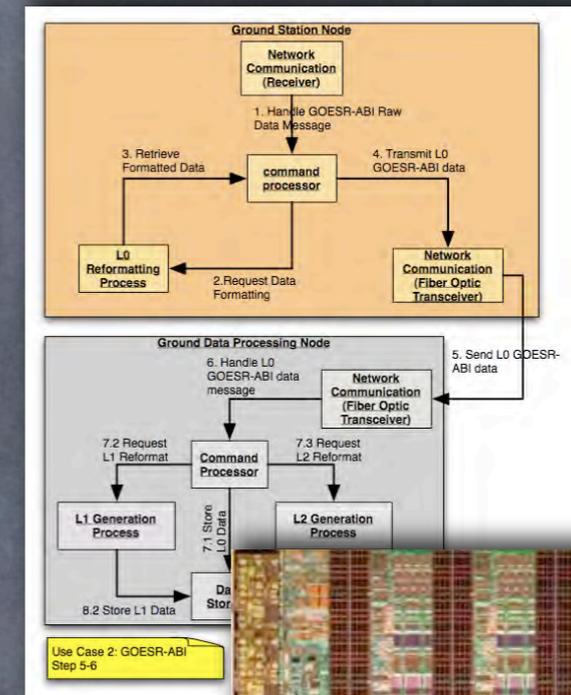
Porting codes to new hardware

Assessment of granularity

Technology outlook for hardware & software (current examples include the Cell Broadband Engine Architecture and the Field Programmable Gate Array)

Maintenance and execution of benchmarking suite

Access to wide range of vendors, hardware



Software Engineering Support

Motivation

Cost, Risk

Study by Hatton¹ of scientific software found on average 12 defects for every 1000 lines of code (mostly Fortran codes)

Leadership in current software engineering practices

New design methods

User training for current techniques (OO design, unit and system level testing, rapid prototyping, configuration management)

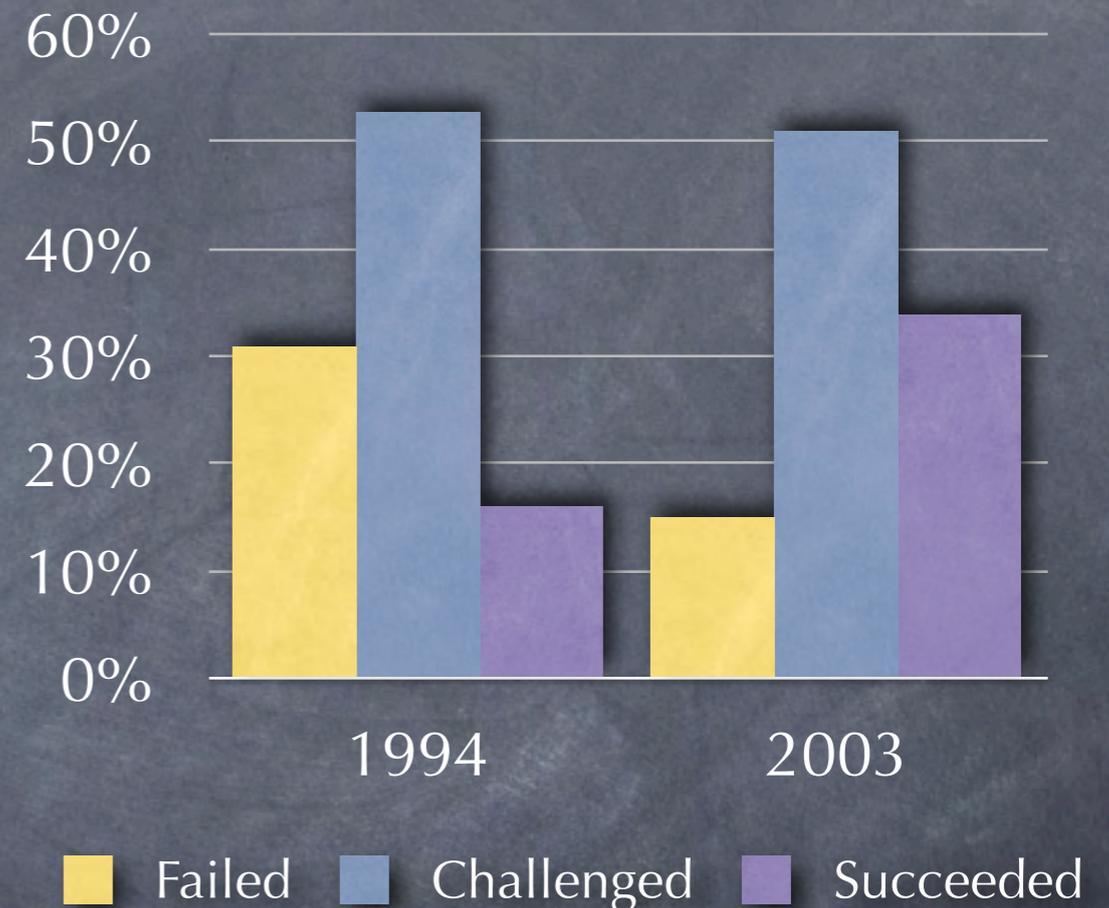
Risk assessment

Re-engineering of legacy codes

Redesign for improved modularization (removal of global variables, better use of user-defined data structures, etc.)

Assistance with implementation of Earth System Modeling Framework (ESMF)

2003 Standish Group Study of Commercial Software Projects²

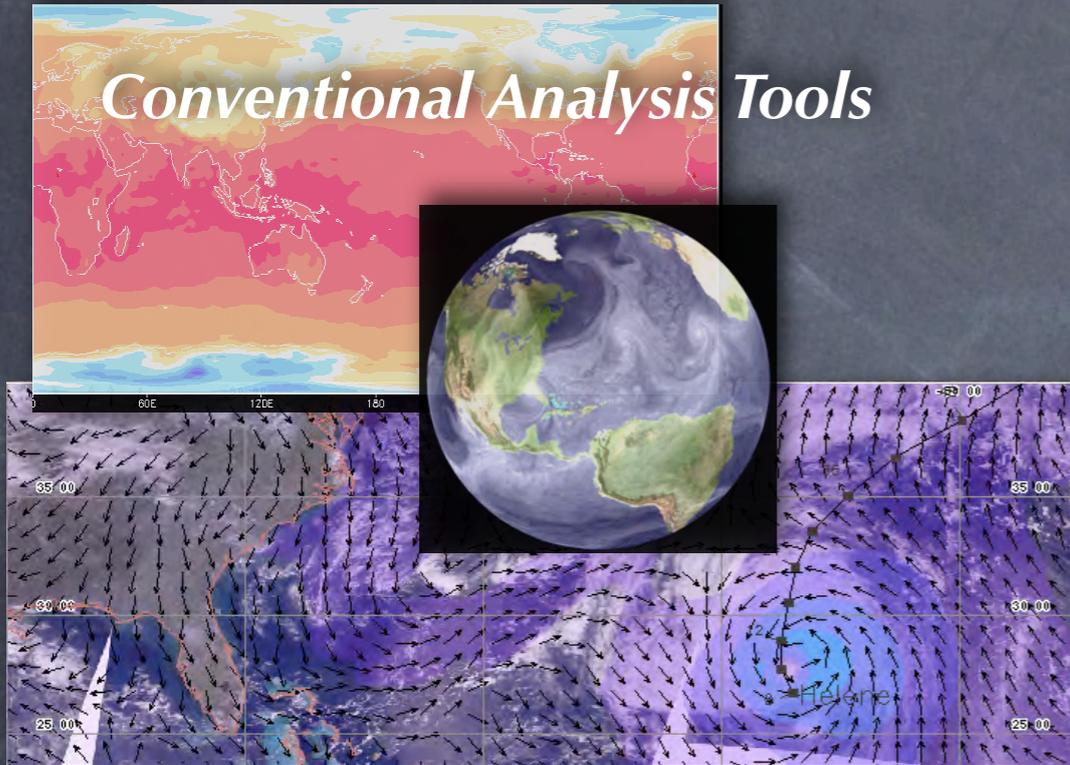


1. Hatton, L., 1997: The T Experiments: Errors in scientific software, IEEE Comp. Sci. & Eng., 4, No. 2, 27.

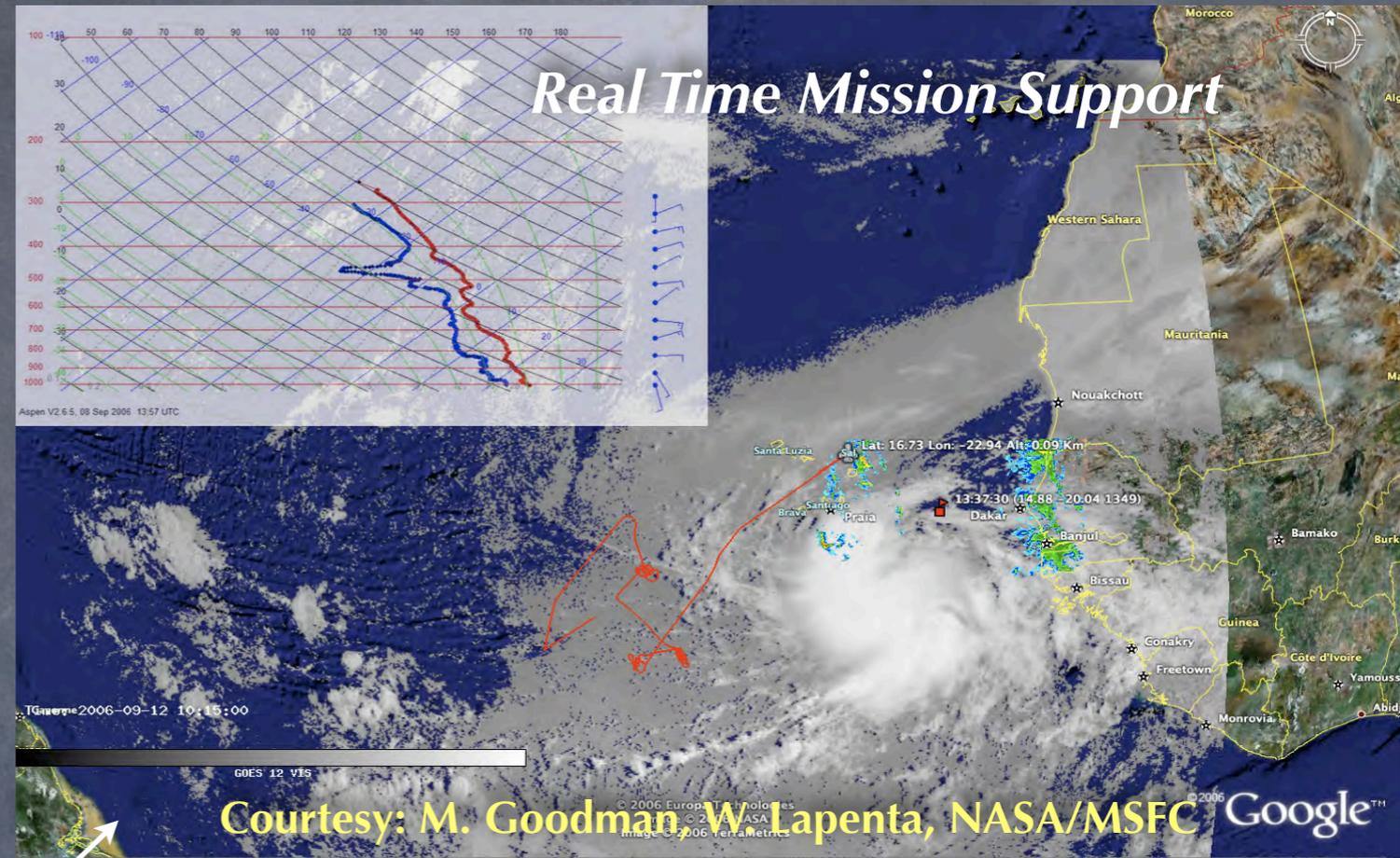
2. The Standish Group, 2003: "Chaos Report 2003".

Scientific Visualization Studio

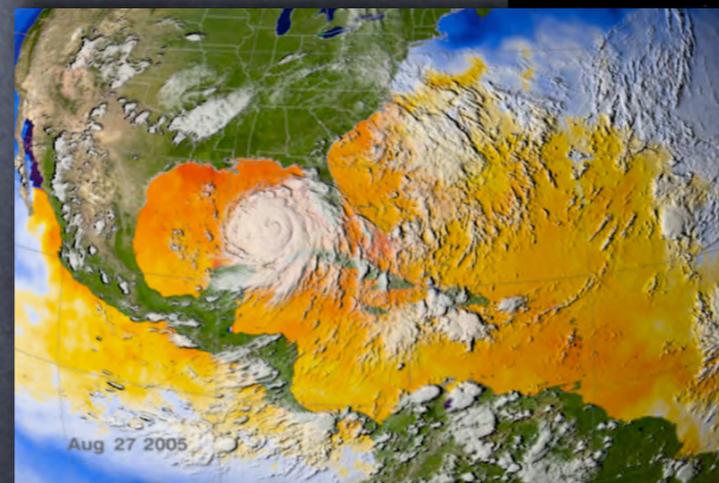
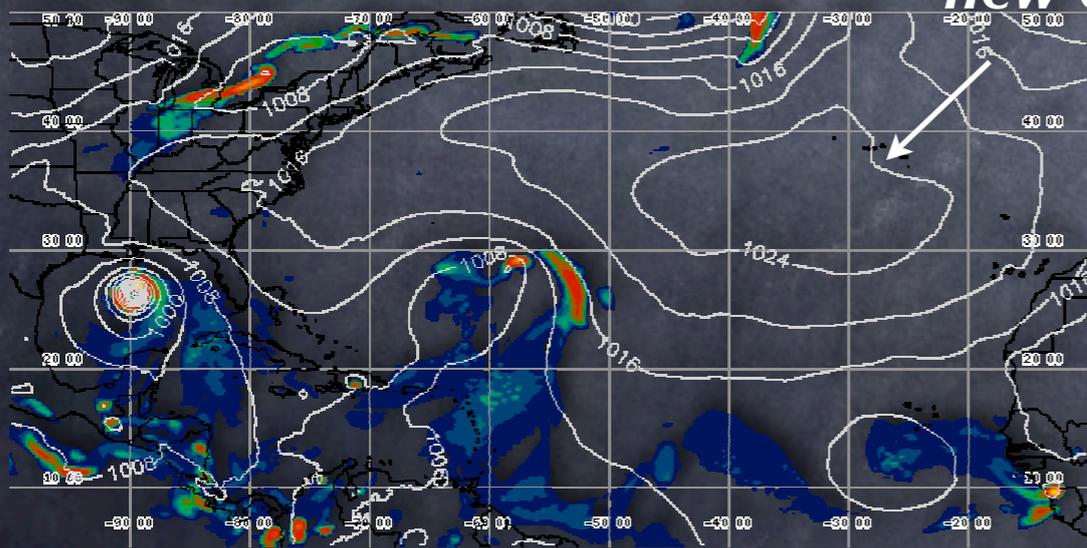
Conventional Analysis Tools



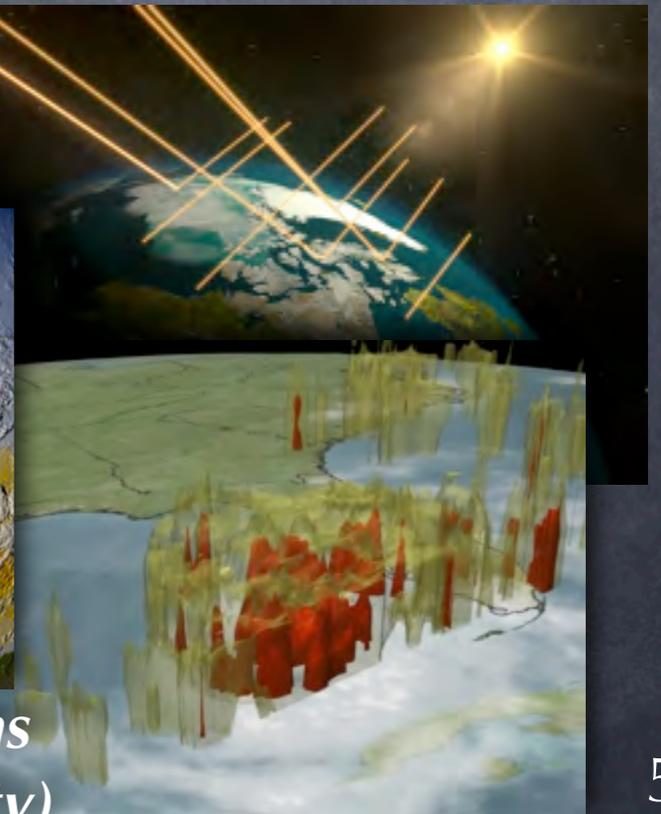
Real Time Mission Support



Emerging (OGC) Tools (focus for new capabilities)



High End Visualizations (existing core capability)



MAP-Specific Software Support



“NASA plans to initiate an integration of its research modeling activities to focus the research among NASA crosscutting themes...”

“MAP will enhance ESMF-compliant modeling and assimilation resources to support the broader research programs...this will require the delivery and maintenance of software for the MAP program...”

“[MAP] will support a Core Integration Team that will have responsibility to assist funded scientists in this software delivery...”

“...In the third year of the current proposal cycle the activities residing in the multi-investigator proposals will converge into a shared MAP modeling environment [that] will be ESMF compliant and investigators will be able to configure model and assimilation systems to support specific applications...”

Main Drivers (2011 MAP Vision)

Coupled Earth System Models

Models easily reconfigured
Contributions to climate model development for diverse expert group
Implementation of 4D Var DAS with new data types
Open standards

Increased Model/Analysis Fidelity

Enhanced resolution (horizontal, vertical, temporal, spectral)
Better estimates of uncertainty/reliability
Large, single- and multi-model ensembles

Enhanced Validation

Better tools for testing new methods
Observing System Simulation Experiments (OSSEs)
Rapid, seamless access to data
Better access to high-end visualization tools

Collaborative Research

Process Models

Stovepipe Research

Coupled Models

Earth System Ensembles

Model-Directed Sensor Webs

The MAP Modeling Environment (MAPME)

Better Access & Reconfigurability

Turn on/off components on/off outputs, user switchable via web service

Service-Based Compute Resources

Load balanced; scheduled vs. queued; transparent site selection

Cross Site Workflow

Remotely initiated via web schedule; monitor, manage across multiple sites

Enhanced Visualization & Analysis

Servers providing on-demand support

ESMF

MAP Repository

Curator Project

Service Layers (SOAs)

Next-Generation Networks

Customized ECMWF tools

Web-Based Analysis Tools

HEC-linked Resources

Advanced Rendering

OGC - GrADS

Crosscutting research themes are emphasized by the MAP Program, enabled by MAP-ME

Goal is to provide an environment in which MAP investigators can configure, obtain, contribute source, and experiment with systems of model elements

Web-based MAP-ME repository **FEEDBACK NEEDED!**

SIVO staff works with project scientists to provide programming support for integrating model elements (e.g., atmosphere with ocean, insertion of new dynamical core, etc.)

SIVO to provide independent testing

Software verification

System validation (metrics to be provided by scientists)

Standardized documentation

Integration tools

Source: McConaughy, G., 2006, "Modeling, Analysis, and Prediction Program Technology Roadmap", presentation to NASA Headquarters

MAP Information Portal

“One stop shopping” for models, tools, and general information about MAP-sponsored activities

Publications

Upcoming Events

Software Downloads

Help

NASA National Aeronautics and Space Administration [+ Visit NASA.gov](#)

Modeling, Analysis, and Prediction (MAP) Program

[+ NEWS](#) [+ MANAGEMENT](#) [+ RESEARCH](#) [+ PROJECTS](#) [+ SOFTWARE](#) [+ PUBLICATIONS](#) [+ SIVO](#)

MAP Program

- [+ DOCUMENTATION](#)
- [+ SCHEDULE](#)
- [+ SOLICITATIONS](#)

NEWS HIGHLIGHT

- [+ GMAO Releases GEOS-5 V.1](#)

MEETINGS & EVENTS

- [+ MAP Science Team Meeting, March 7-9, 2007, University of Maryland Inn and Conference Center, College Park, Maryland - All PIs and Co-Is are invited to attend](#)

NASA's Modeling, Analysis and Prediction (MAP) Program

NASA's Modeling, Analysis, and Prediction (MAP) program funds research efforts focused on the study of the Earth's climate and weather, with particular emphasis on global change. To understand fully how and why the Earth climate is changing and the potential long-term implications requires research efforts to be focused upon end-to-end Earth system science. Exploration of interactions between the oceans, the atmosphere, the cryosphere, and the biosphere is accomplished through space-based and in situ observations and through the application of numerical models. In 2005 the MAP program awarded funding for 65 investigations focused on high-priority science areas, including integration of satellite observations with global models to evaluate model development, test the value of specific observations, and consider new observation concepts, with emphasis on addressing the following questions:

- How is global precipitation, evaporation, and the cycling of water changing?
- How is the global ocean circulation varying on interannual, decadal, and longer time scales?
- What trends in atmospheric constituents and solar radiation are driving global climate?
- What are the effects of clouds and surface hydrologic processes on Earth's climate?
- What are the effects of regional pollution on the global atmosphere, and the effects of global chemical and climate changes on regional air quality?
- How can weather forecast duration and reliability be improved?
- How can predictions of climate variability and change be improved?
- How well can transient climate variations be understood and predicted?
- How well can long-term climatic trends be assessed or predicted?
- How well can future atmospheric chemical impacts on ozone and climate be predicted?

The development of consistent, coupled Earth system models is a major goal of the MAP program. Validation of a wide range of Earth observations, with particular emphasis of NASA's satellite data program, is also a priority. In order to assist investigators with the challenging task of developing, integrating, and maintaining complex numerical modeling software, the MAP program is requiring compliance with the US multiagency Earth System Modeling Framework (ESMF; <http://www.esmf.ucar.edu/>). The program is providing resources through the [NASA Goddard Software Integration & Visualization Office \(SIVO\)](#) to assist investigators with the adaptation of ESMF into their numerical models.

Large investigations include the [Global Modeling and Assimilation Office \(GMAO\)](#), the [Global Modeling Initiative \(GMI\)](#), the [Goddard Institute for Space Studies \(GISS\)](#), support for the ESMF core development team, a [Cloud Modeling and Analysis Initiative \(CMAI\)](#), along with many other smaller-scale research efforts in data assimilation to support global model evaluation and testing. The total funding for these investigations, over a period of 5 years, is approximately \$150 million. Investigators and collaborators represent more than 17 states and the District of Columbia.

[USA.gov](#) Government Made Easy [+ Privacy Policy and Important Notices](#) Curator: [Lara Clemence](#)
NASA Official: [Donald Anderson](#)
Last Updated: 12/07/2006

MAP Software

PROPOSED - FEEDBACK NEEDED!

Goal is to create a portal to major model development projects (initial set of models are in place)

We are proposing two types of support:

1. "Internal Collaborators"

Work with PIs core development team & have access to project developer's repository (eventually the MAP repository), AND have access to resources as do External Investigators

2. "External Investigators"

Have the ability to register for downloads, can request help from SIVO for training and to build and execute the model, can access visualization tools developed by the SVS

Links provided to home web sites for complete project information, documentation

NASA National Aeronautics and Space Administration + Visit NASA.gov

Modeling, Analysis, and Prediction (MAP) Program

+ NEWS + MANAGEMENT + RESEARCH + PROJECTS - SOFTWARE + PUBLICATIONS + SIVO

+ Home

Software

- + ECCO
- + GEOS-5 (GMAO)
- + GEOS-CHEM
- + GMI
- + MODEL E (GISS)
- + COMPONENTS
- + TOOLS

As part of the overall MAP "Modeling Environment," or MAPME, access to funded modeling software that has been deemed public domain is being provided to investigators. For assistance in accessing and deploying MAP software please contact SIVO.

The goal of MAPME is to integrate research modeling activities to focus efforts among NASA crosscutting themes. Over the tenure of the grants the MAP program will enhance ESMF-compliant modeling and assimilation resources to support the broader research programs of the Science Mission Directorate and the Intergovernmental Panel on Climate Change (IPCC). It is anticipated that activities residing in the multi-investigator proposals will converge into a robust shared software environment.

NASA encourages and anticipates increased collaboration across its scientific modeling fields and will provide support for such collaboration through SIVO and other resources provided by the MAP program. Collaboration with large MAP development efforts is defined at two levels of interaction: "Model/Component Collaborators" and "External Investigators."

Collaborators work in concert with the core software development teams and will be able to obtain software and commit modifications back to the model or component. This level of collaboration will require:

- Registration for downloads
- Formal approval by lead investigator as a "collaborator"
- User name/password permission on the development platform
- Access to "sourcemotel" a CVS-based repository
- Permission to commit to a CVS branch
- Direct interaction with the development team via a designated interface person

Please note that at present support is limited to execution of the model or model elements on the development team's platform of choice. Collaborators also have access to visualization tools and scientific analysis packages developed by investigator-led teams and/or SIVO's Scientific Visualization Studio (SVS).

External Investigators are those who wish to either use the models as "black boxes" and/or download local versions to make modifications. This type of user is not a direct collaborator with the core development team. Characteristics of this environment include:

- Registration for downloads
- Downloads available for local hosting of software, but no access to core development software repository
- Investigators may request SIVO help to build and run on the development team's designated platform or other platforms, pending availability of resources
- Access to visualization tools and scientific analysis packages developed by investigator-led teams and/or the SVS
- Code modifications performed locally but investigators may eventually propose to become Collaborators

Please note that the individual project web pages contain important information about modeling software, including documentation and user manuals. These sites also contain links to important publications that may be useful to investigators.

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