Air Force Weather Agency

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Contributions of the DoD HPCMP to WRF Model Development

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U.S. AIR FORCE

Overview

- AFWA and FNMOC Missions
- What is WRF?
- HPCMP Mission and Contributions

AFWA Mission

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Maximize our nation's aerospace and ground combat effectiveness by providing accurate, relevant and timely air and space weather information to Department of Defense, coalition, and national users, and by providing standardized training and equipment to Air Force Weather.
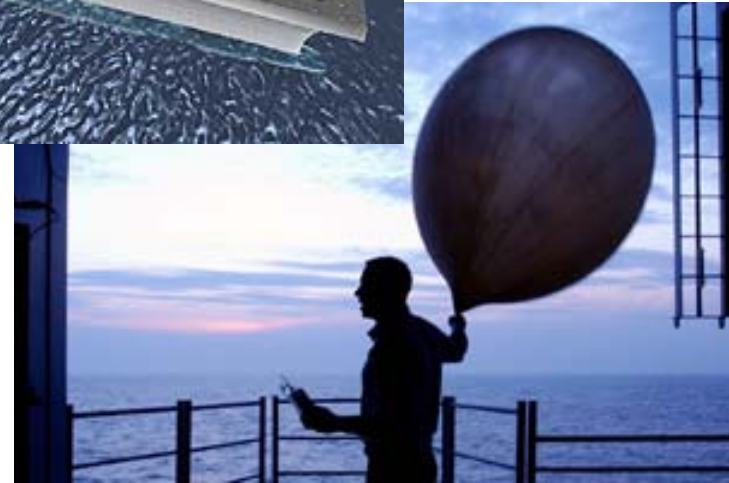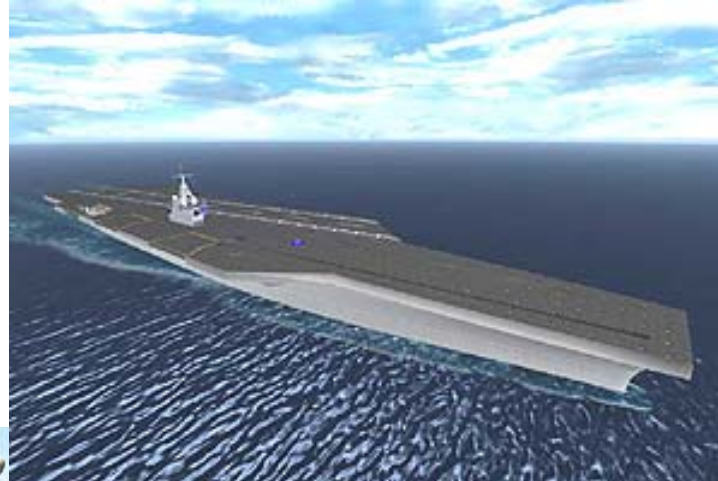
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FNMOC Mission

https://www.fnmoc.navy.mil

To combine innovative technology with the best available science in order to provide the best weather and oceanographic products, data and services to the operating and support forces of the DoD anywhere, anytime.

What is WRF?

Weather Research and Forecast (WRF) is…
an inter-organizational partnership to create and sustain…

- The **next-generation mesoscale NWP modeling system** for research and operations

- A **common modeling infrastructure** that facilitates operational NWP collaboration, scientific "interoperability" and accelerates the transfer of new science from research into operations

- A **repeatable process** that continuously infuses innovations and capabilities into the community mesoscale NWP modeling system
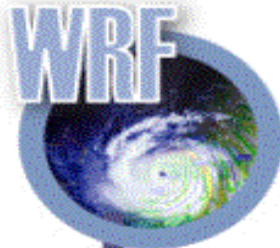
What is WRF?

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Weather Research and Forecasting Model

Goals: Develop an advanced mesoscale forecast and assimilation system, and accelerate research advances into operations

■ Signatory Partners:
- NCAR Mesoscale and Microscale Meteorology Division
- NOAA National Centers for Environmental Prediction
- NOAA Forecast Systems Laboratory
- Air Force Weather Agency
- Federal Aviation Administration
- Navy NRL Marine Meteorology Division

■ Additional Collaborators:
- OU Center for the Analysis and Prediction of Storms
- Department of Defense HPCMO
- CMA Chinese Academy for Meteorological Sciences
- NOAA Geophysical Fluid Dynamics Laboratory
- NASA GSFC Atmospheric Sciences Division
- NOAA National Severe Storms Laboratory
- EPA Atmospheric Modeling Division
- University Community

36h WRF Precip Forecast

Analyzed Precip

27 Sept. 2002
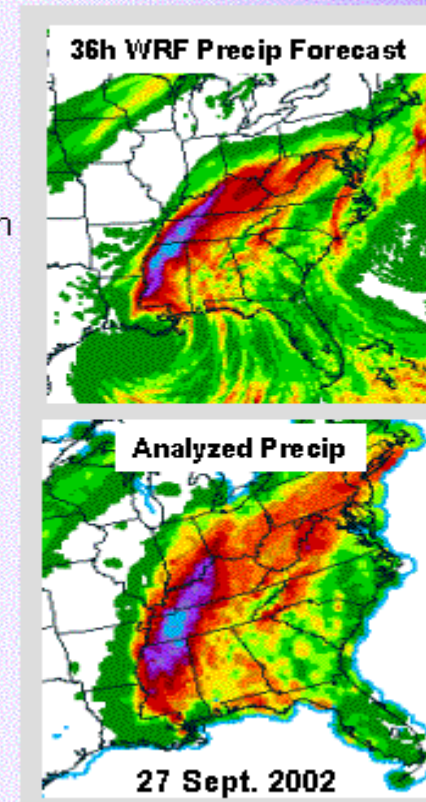
Mesoscale & Microscale Meteorology Division

NCAR

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WRF User Community

Registered Users (6/18/04)

WRF Principal Partners

NCAR	70
NCEP	21
FSL	23
AFWA	15
Navy	11

U.S. Universities	381
U.S. Government Labs	192
Private Sector	229
Foreign (64 countries)	1063

Total	2005

870 active subscribers to wrf-news@ucar.edu

Courtesy NCAR

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WRF Research and Training

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Year-to-Year WRF Users Workshop and Tutorial Attendance

	Workshop	Tutorial
2000	100	
2001	110	80
2002	124	80
2003	120	70
2004	173	115
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Total	627	345

NCAR

2004 WRF Users Workshop and Tutorial Participants

	Workshop	Tutorial
Principal Partners		
NCAR	25	9
NCEP	7	1
FSL	13	4
AFWA	9	1
Navy	4	1
U.S. Universities	46	42
U.S. Government Labs	18	20
Private Sector	13	7
Foreign	38	30
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Total	173	115

	Workshop	Tutorial
Institutions represented in 2004	*93*	*75*
Foreign countries represented in 2004	*20*	*17*

Courtesy NCAR

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WRF Projected Timeline

Development Task	2000	2001	2002	2003	2004	2005-08
Basic WRF model (limited physics, standard initialization)	🔴					
Implementation and evaluation of alternative prototypes				🔴		
Model physics	Simple 🔴	Research suite		🔴	Advanced	🟢
Research quality NWP version of WRF				🔴		
3D-Var assimilation system	Basic		🔴 Research	🔴	Advanced	🟢
4D-Var assimilation system, ensemble techniques			Basic	🔴	Advanced	
Testing for operational use at NCEP & AFWA					🟢	
Diagnosis of operational performance, refinements						🟢

🔴 Release and support to community   🟢 Operational deployment

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Operational Implementation

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NCEP Announces the Implementation of the Weather Research and Forecast (WRF) Model for Operational Forecasting

The long-awaited operational implementation of the WRF modeling system became a reality at the National Centers for Environmental Prediction (NCEP) at 1200 UTC on September 21, 2004. On September 16th, the WRF implementation plan was briefed to NWS Director D.L. Johnson, who approved this step following endorsement of the plan by the NWS Corporate Board. WRF represents an inter-organizational partnership to create the next-generation mesoscale numerical weather prediction (NWP) modeling system for research and operations that will facilitate operational NWP collaboration and accelerate the transfer of new science from research into operations. The implementation consists of both the Non-hydrostatic Mesoscale Model (NMM) WRF core run with NCEP-supplied physics, and the Advanced Research (AR) WRF core (formerly known as the Eulerian Mass core) run with National Center for Atmospheric Research (NCAR)-supplied physics. Both versions of WRF receive initial conditions and lateral boundary conditions interpolated from the 12-km operational Eta model using the WRF Standard Initialization software developed by NOAA.s Forecast Systems Laboratory. The WRF is replacing the current High Resolution Window (HRW) run, which has been providing 8 km Eta model guidance over four windows covering the Eastern U.S., Western U.S., Central U.S., and Alaska. Guidance will be provided from two WRF runs for each of these regions once per day. One run will be the NCEP 8 km Non-Hydrostatic Meso-scale Model and the other will be the NCAR 10 km Eulerian Mass Model. NCEP's new WRF-based modeling system represents the first U.S. operational implementation of WRF and is the first step on the way to an implementation of a WRF-based NCEP HRW mesoscale ensemble, which is scheduled for implementation next spring. The WRF program is managed through the NWS Office of Science and Technology.
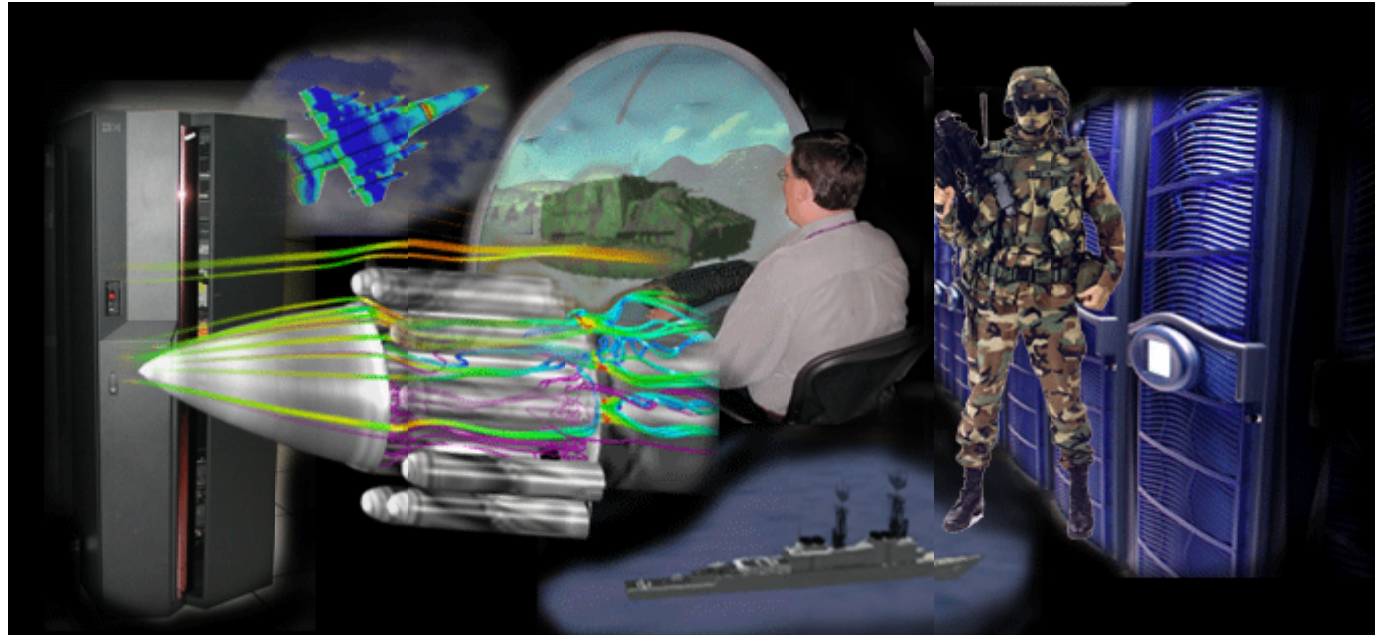
HPCMP Mission

hpcmo   msrc   dc   dren   chssi

The Department of Defense (DoD) High Performance Computing Modernization Program's (HPCMP) mission is to deliver world-class commercial, high-end, high performance computational capability to the DoD's science and technology (S&T) and test and evaluation (T&E) communities, facilitating the rapid application of advanced technology into superior war-fighting capabilities.

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HPCMP

The High Performance Computing Modernization Program (HPCMP) was initiated in 1992 in response to congressional direction to modernize the Department of Defense (DoD) laboratories' high performance computing (HPC) capabilities. The HPCMP was assembled out of a collection of small high performance computing departments each with a rich history of supercomputing experience that had independently evolved within the Army, Air Force, and Navy laboratories and test centers.

The HPCMP provides the supercomputer services, high-speed network communications, and computational science expertise that enables the Defense laboratories and test centers to conduct a wide range of focused research, development, and test activities. This partnership puts advanced technology in the hands of U.S. forces more quickly, less expensively, and with greater certainty of success. Today's weapons programs, such as the Joint Strike Fighter, Unmanned Aerial Vehicles, Medium Tactical Vehicle Replacement, and the Javelin Missile program, have benefited through innovative materials, advanced design concepts, improved and faster modification programs, higher fidelity simulations, and more efficient tests. Future weapons systems, such as radio frequency weapons, the airborne laser, and the Army's future combat system, are benefiting through basic and applied research in plasma physics, turbulence modeling, molecular engineering, high-energy materials, and advanced signal processing.

The HPCMP is organized into three components to achieve its goals. These components are: HPCMP HPC Centers, Networking, and Software Application Support.
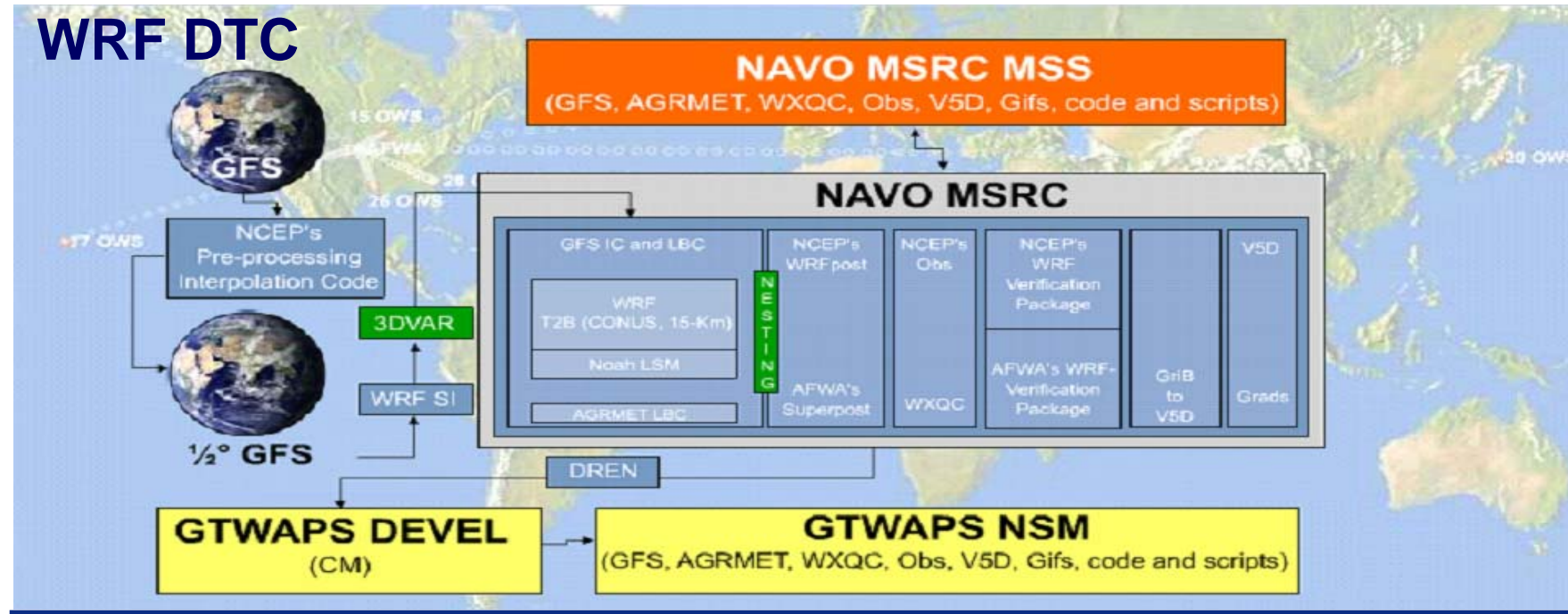
Component 1: HPC Centers

Major Shared Resource Centers: There are four MSRCs that currently operate large HPC systems available to the entire DoD HPC community. Each MSRC has been designated to provide a complete HPC environment, data storage, including a full range of resources including hardware, software, data storage, archiving, visualization, training, and expertise in specific computational technology areas.

ARL ASC ERDC NAVO

http://www-ad.fsl.noaa.gov/fvb/rtvs/wrf/retro_runs/
http://www-ad.fsl.noaa.gov/users/loughe/projects/wrf/DTC_presentations/

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Component 1:
HPC Centers

Distributed Centers: DCs have been established to provide HPC capability to a specified local and remote portion of the HPC community. These are typically modest-sized systems where there is a significant advantage to having a local HPC system where there is a potential for advancing DoD applications using investments in HPC capabilities and resources.

"Joint Operational Test Bed for the Weather Research and Forecast (WRF) Modeling Framework"
Field a platform for conducting operational tests of WRF, including the multiple configurations of the model made possible by its interchangeable dynamic cores and physics packages. Perform these operational tests to arrive at WRF configurations that best meet unique Navy and unique Air Force mesoscale numerical weather prediction (NWP) requirements. Test operationally capable mesoscale ensemble runs using varying WRF configurations, perturbed initial conditions, and differing lateral boundary conditions. Prototype and test Grid Computing concepts and tools applied to the stringent and unique requirements of NWP, with the WRF Joint Operational Test Bed system physically split between the FNMOC and AFWA sites, yet linked to form a distributed "weather grid" computing platform. Use the WRF Joint Operational Test Bed, and its grid-computing capability, to enhance collaboration between Navy and Air Force weather R&D and operations. Transition the science and technology resulting from work performed on the WRF Joint Operational Test Bed rapidly into improved high-resolution operational weather prediction capabilities at both AFWA and FNMOC.

http://www.hpcmo.hpc.mil/Htdocs/DC/index.html

Component 2: Networking

Defense Research and Engineering Network: In order for the consolidated set of MSRCs to successfully address the computational workload of DoDs HPC community, a robust, high speed network is essential. The DREN provides advanced networking capability to a greater customer base and at faster communication speeds than previously available on a wide basis.

Current Sites

Updated: March 2004
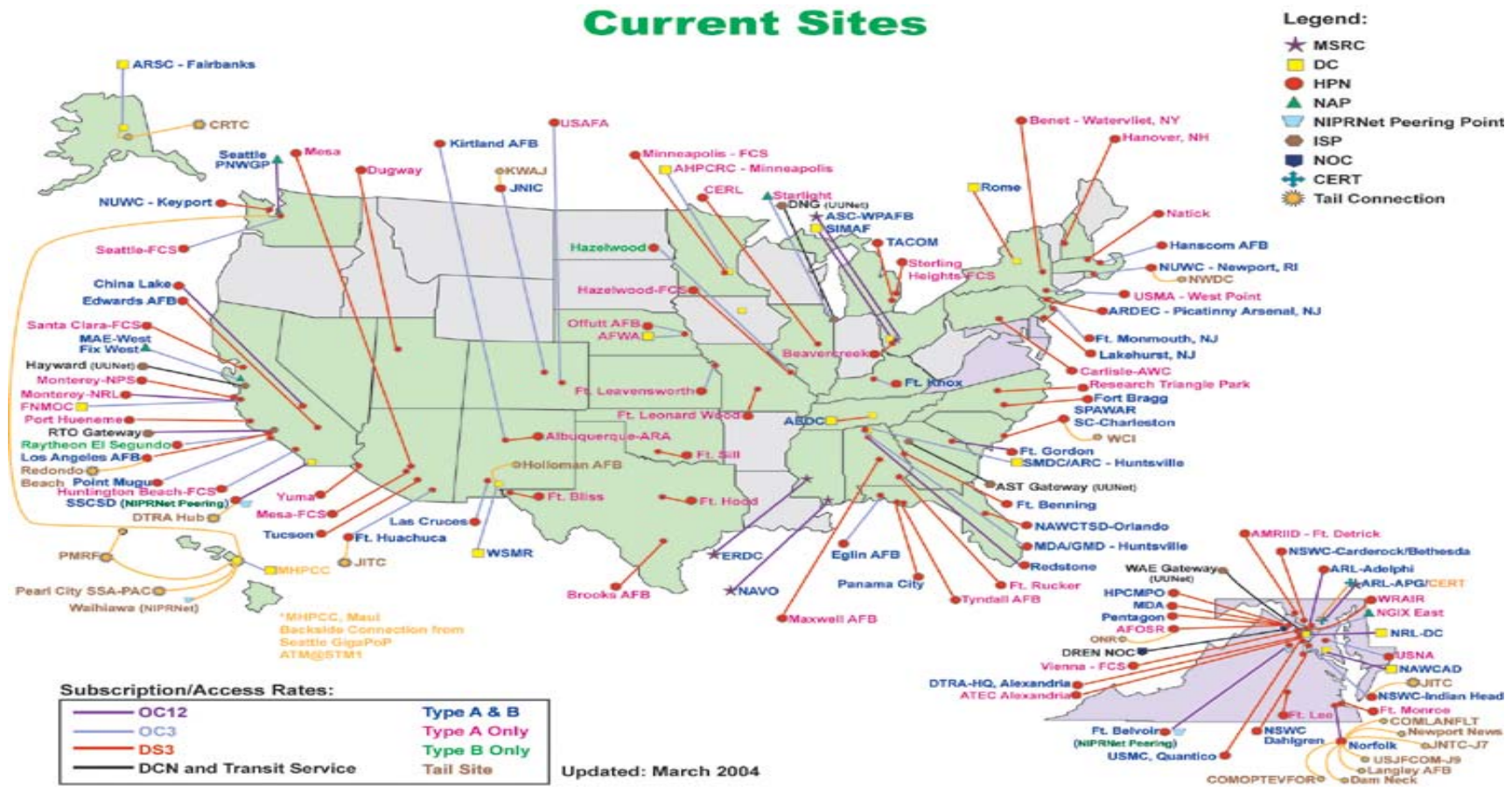
Component 3:
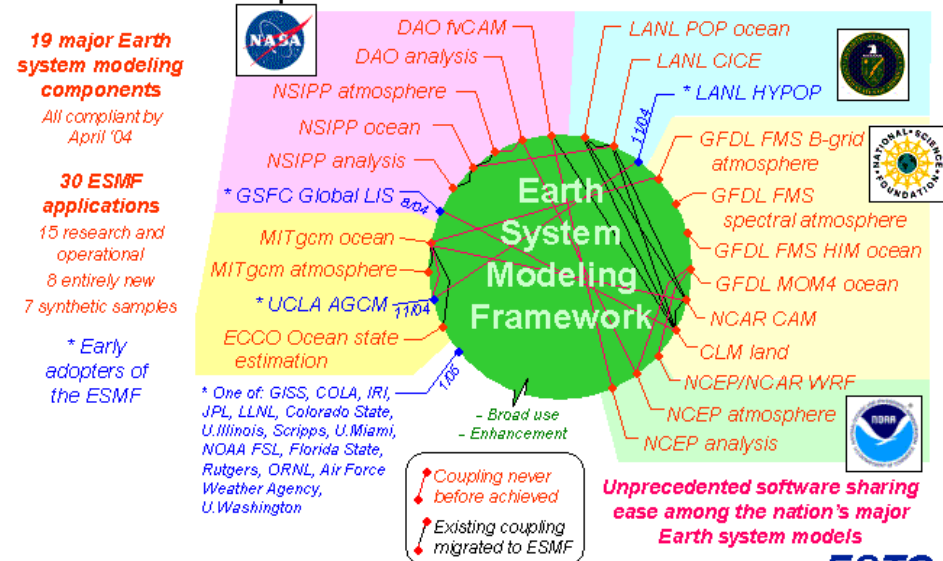# Software Applications Support

Institutes: The first High Performance Computing Software Applications Institutes (HSAI) were selected by the Deputy Under Secretary of Defense (Science and Technology) on August 20, 2004. Each institute will form a critical mass of experts keenly focused on using computational science and high performance computing to accelerate solving the Department's highest priority challenges. With cross-Service and Agency teaming and multi-disciplinary approaches, the institutes have a strong potential to transform the DoD's science and technology and test and evaluation communities and to make the important advances in research, development, test, and evaluation.

Battlespace Environments Institute (BEI):
The BEI will migrate existing DoD CWO, EQM and space weather applications to the ESMF and assist in transitioning non-DoD ESMF applications to DoD. The Institute will also augment ESMF with capabilities needed for the DoD battlespace environment. The BEI will become the primary means to couple earth system components within DoD. Stakeholders include the U.S. Navy, U.S. Air Force, U.S. Army, National Aeronautics and Space Administration, Department of Energy, Department of Commerce, and the National Science Foundation.

Earth System Modeling Framework
http://www.esmf.ucar.edu/

DRAFT: Material Compiled by NASA SSC   \\Kingfish\vse\DSS Evaluation\NASAModels\ESMF models summaries.ppt
1-May-03

Component 3:
Software Applications Support

Portfolios: Focused software development products assist Service and Agency research, development, test and evaluation efforts by providing robust production-level software for modeling, simulation and computation in HPC application areas of highest impact to DoD. These products facilitate a large fraction of the DoD science and technology and developmental test and evaluation computational workload in support of DoD war-fighting requirements.

Common High-performance Software Support Initiative (CHSSI) Climate/Weather/Ocean Modeling and Simulation (CWO) -06: *Scalable Weather Research and Forecast Model Development* This project was designed to accelerate and enhance the development of the Weather Research and Forecast (WRF) model by providing additional technical assistance and funding to the WRF integrated project team. A team of skilled computer scientists and computational fluid dynamicists well versed in parallel processing and FORTRAN 90 provided this technical assistance. Funding marked DoD's entry into the WRF effort, which ensured specific DoD needs for mesoscale modeling systems were addressed without developing a separate and distinct system. In addition, teaming with key organizations assured technology transfer to the DoD modeling community and resulted in more rapid exploitation of scientific developments.
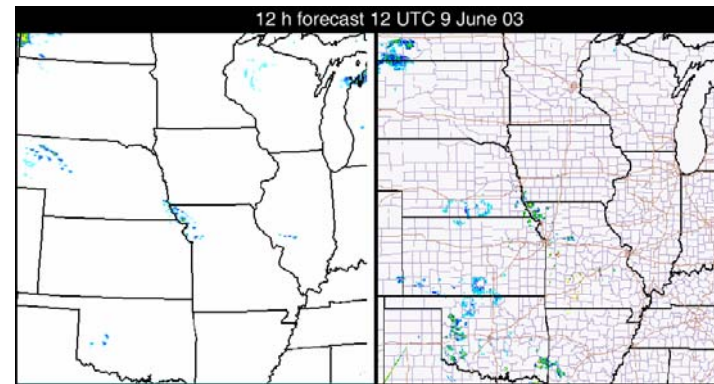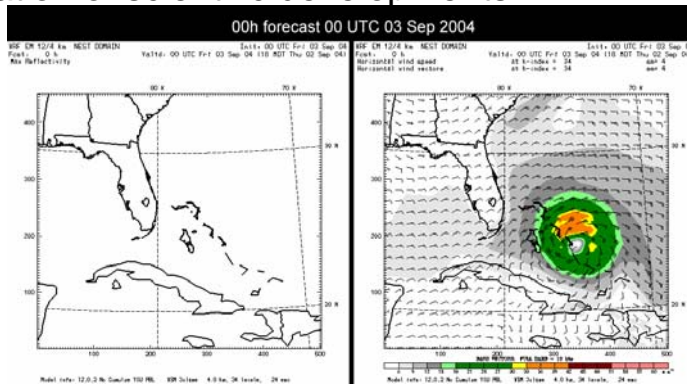
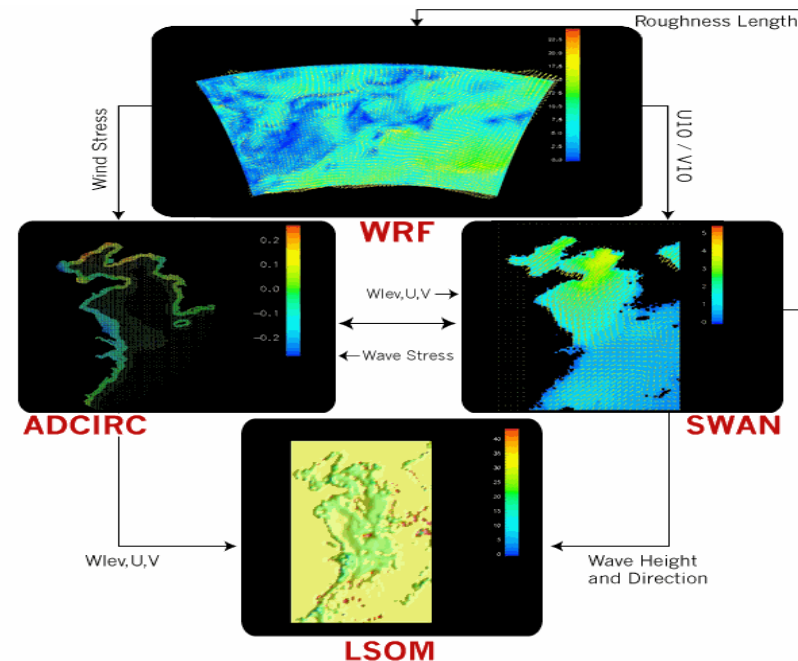# Component 3:
Software Applications Support

Programming Environment and Training: The Programming Environment and Training (PET) initiative enables the DoD HPC user community to make the best use of the computing capacity the HPCMP provides and to extend the range of DoD technical problems solved on HPC systems. PET is enhancing the total capability and productivity of the program's user community through training, collaboration, tool development, support for software development, technology tracking, technology transfer, and outreach to users.

Mission: Gather and deploy the best ideas, algorithms, and software tools emerging from the national high performance computing infrastructure into the DoD user community.

Computational Technology Area Support:
Technical support is available to users in the form of functional area points of contact (FAPOCs) (pronounced "F" "A" POC) and their teams of on-site personnel, technically proficient in the ten computational technology areas.
• Technical Support
• Productivity Enhancements
• Technology Transfer and Transition Support
• Training Content
• Community Development
• **On-Site Support**

CWO 001: Infrastructure Development for Regional Coupled Modeling Environments

Summary

Contribution	Impact	Result
CHSSI CWO-06 (FY00-03)	$1.5M	Beta WRF and 3DVAR
WRF DTC (FY03-04)	400,000 high priority hours	RDT&E of WRF V2.0
PET-CWO (FY03-04)	$400K	A grid-enabled, concurrent, multi-executable, parallel, coupling capability through a common, model independent interface to NRL Stennis for use in Research and/or Operations.
PET-CWO on-site support (FY04 >)	2 FTE or ~$400K per year	DoD Operational Testbed Center
Dedicated Distributed Center (FY04-06)	$4.2M	DoD Operational Testbed Center
Battlespace Environments Institute (FY05-10)	$11.5M	Migrates existing DoD CWO, EQM and space weather applications to the ESMF and assists in transitioning non-DoD ESMF applications to DoD.

Bottom line

• The DoD High Performance Computing Modernization Program has played a tremendous role in the development of the WRF modeling system by reducing RDT&E costs and promoting an environment conducive for inter- agency/service strategic partnering.