Global Climate Modeling Research

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RAMS Presentation
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OAK RIDGE NATIONAL LABORATORY
U.S. DEPARTMENT OF ENERGY

UT-BATTELLE

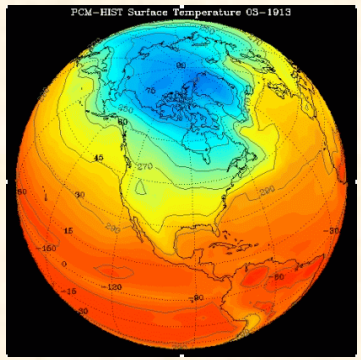
Climate and Carbon Research Institute

How will the Earth's climate respond to physical, chemical and biological changes produced by global alterations of the atmosphere, ocean and land?

- SciDAC climate and computer science projects
- Model development and climate prediction applications
- Support long climate scenario runs with dedicated resources: Washington (NCAR) input to policy
- Develop specialized tools, prototype and evaluate
  - Climate code and data repositories
  - Climate analysis software
  - Visualization
- Provide project scientific staff and post-docs
- Workshops
  - Working Groups
  - Science and policy issues

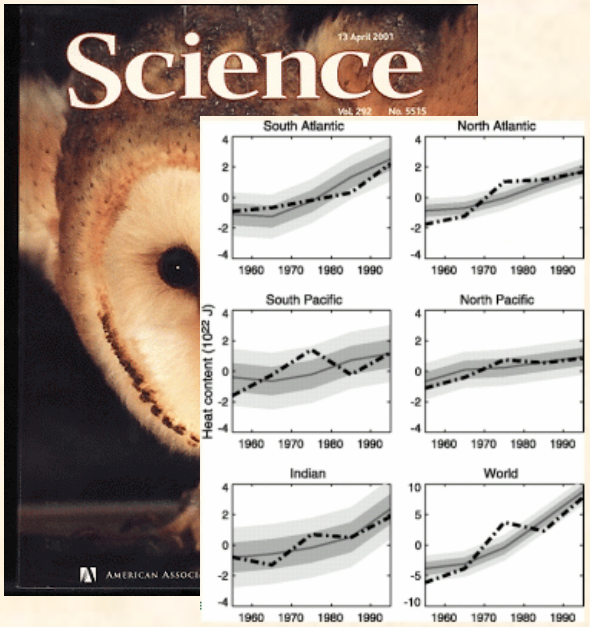
Climate Science Enabled by CCS-CCRI

Method: Ensemble simulations of the DOE Parallel Climate Model (PCM)



Results:

- Detection of Anthropogenic Climate Change in the Worlds Oceans
- Ensembles establish 95% confidence intervals of model predictions
- Simulated ocean heat storage matches historical record of rising ocean temperatures



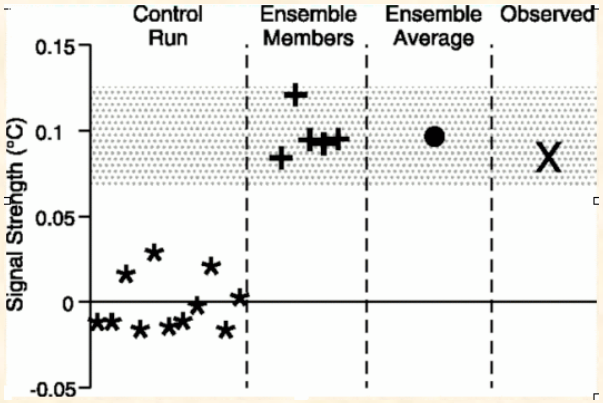
Science 13April 2001: "Detection of Anthropogenic Climate Change in the Worlds Oceans," Barnett, Pierce, Schnur

Firsts:

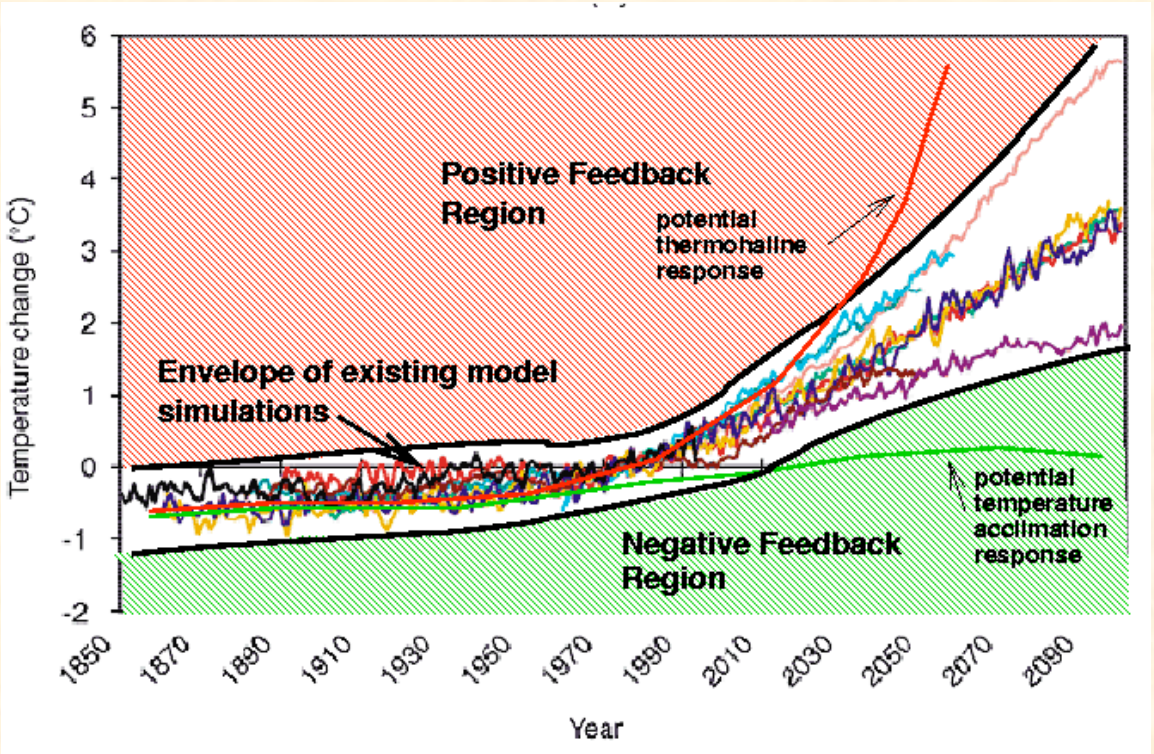
- Ensemble study with US model and computers
- Coupled model reproducing ocean response
- Establishing new level of US model quality

Enabling Technology:

- Parallel Climate Model developed in collaborative effort lead by Warren Washington (NCAR)
- Terascale computing resources



Climate Feedbacks May Result in 'Outside the Envelope' Results

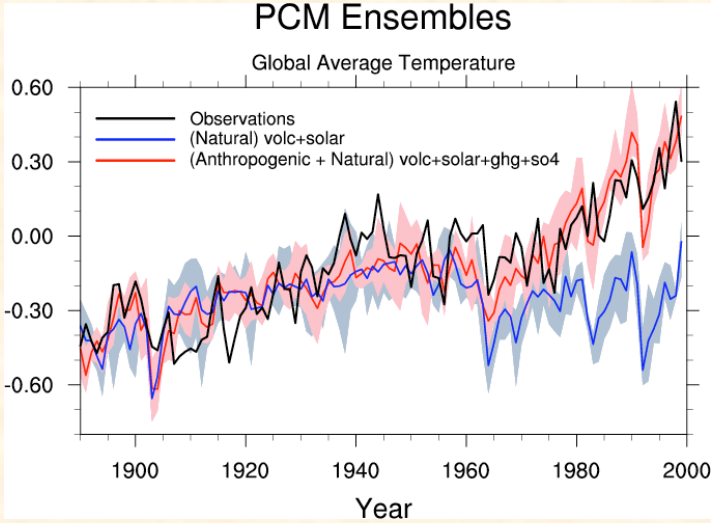


Computed global mean temperature for the time period 1850 – 2100

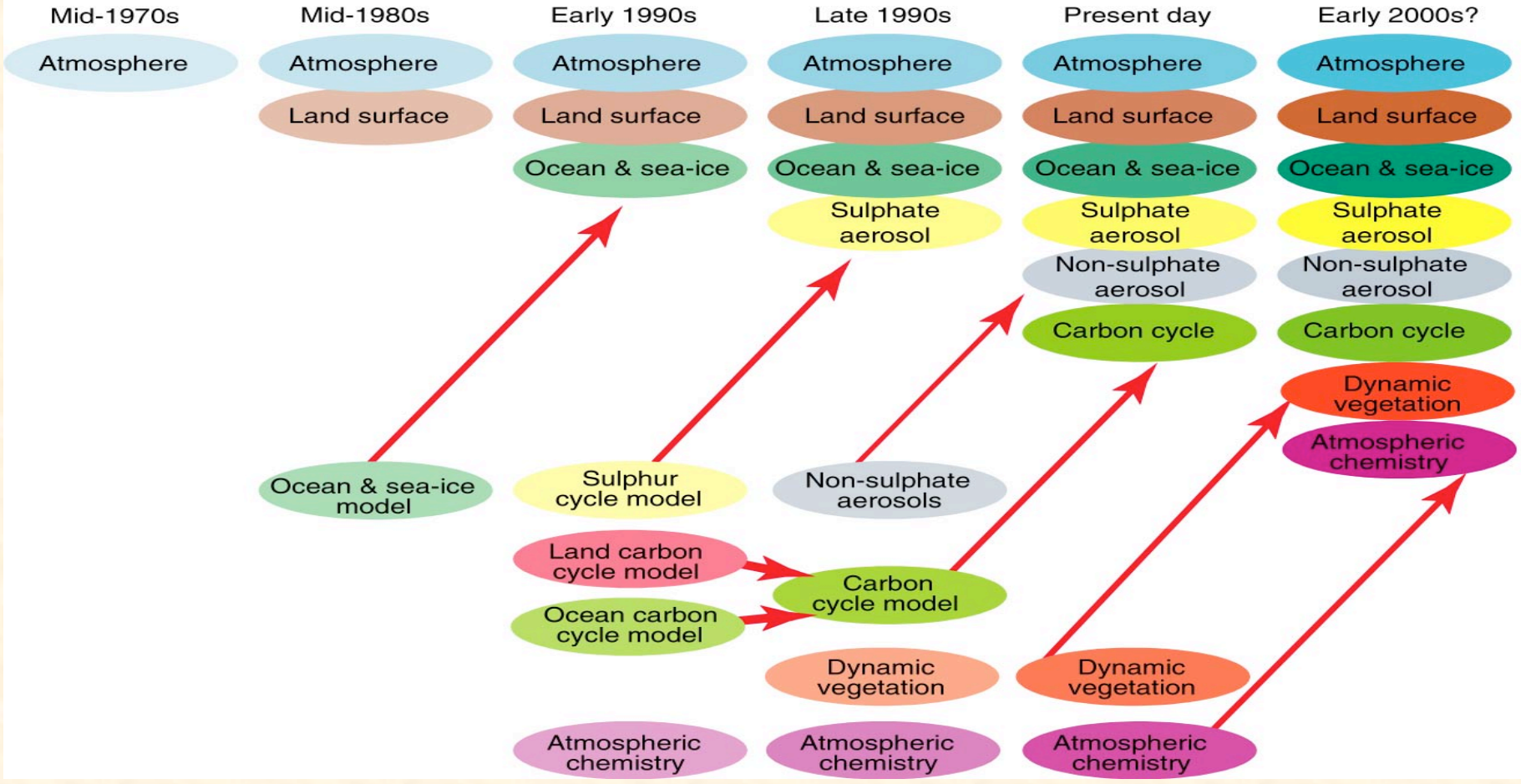
SciDAC: Community Climate System Model Development

SciDAC
Scientific Discovery through Advanced Computing
DOE Office of Science ASCR BER BES FE HENP MICS

- CCSM Model Development
  - Global change simulations – Washington (NCAR)
  - SciDAC/ CCSM Collaboration – Drake(ORNL), Malone(LANL), Keihl (NCAR)
    - Atmospheric Dynamical Cores – S-J Lin (NASA-GSFC)
    - POP Ocean Code Optimization – Jones (LANL)
    - Atmospheric Chemistry – Rotman (LLNL)
    - Land and River Modeling – Bonan (NCAR)
    - Biogeochemistry -- Erickson(ORNL)
- Performance Evaluation
  - Climate benchmarking– Worley (ORNL)
  - Vectorization (CRAY, NEC)
- Grids and Frameworks:
  - Earth System Grid – Middleton(NCAR)
  - Earth System Modeling Framework –Suarez(NASA-GSFC), Deluca(NCAR)
- Other SciDAC projects: CCA, TOPS, TSTT, …

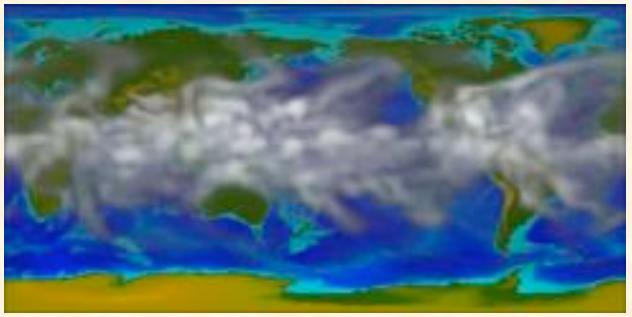


The Development of Climate models, Past, Present and Future



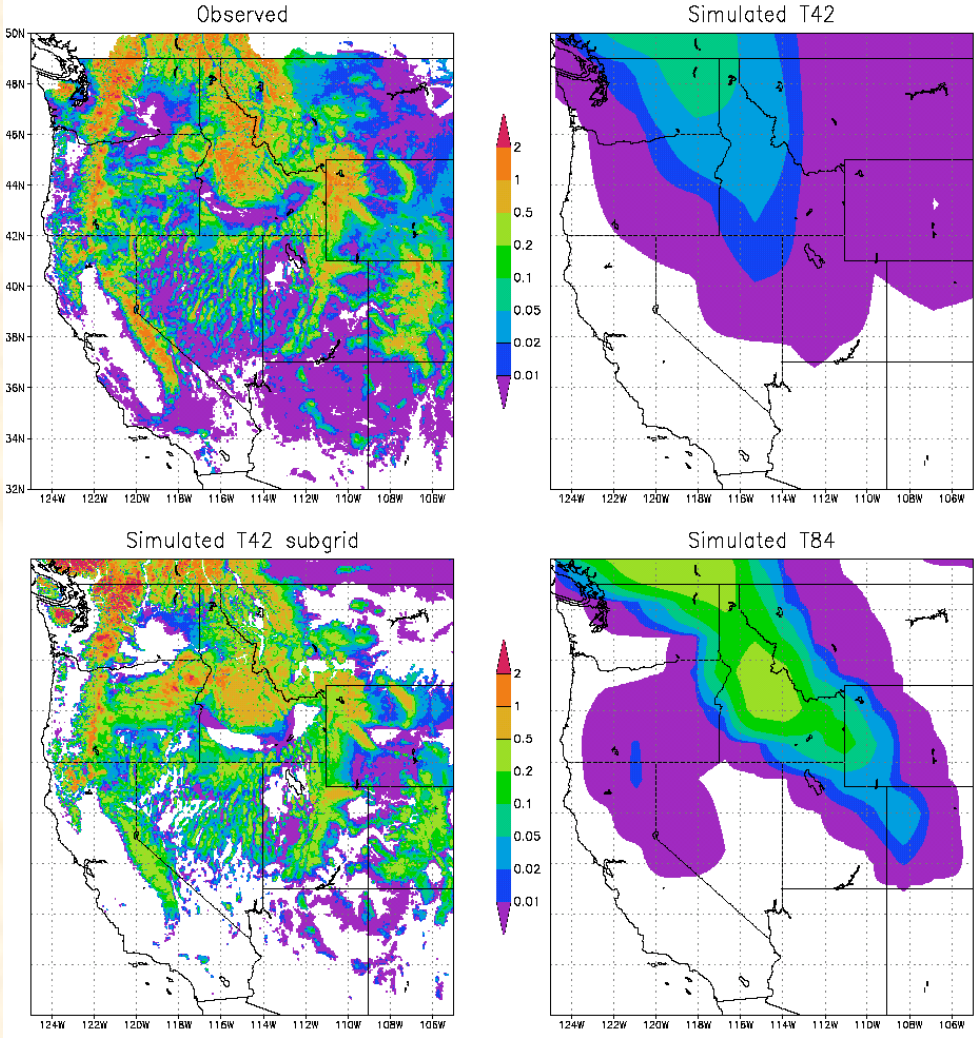
DOE SciDAC Workshop on Porting CCSM to the CRAY X1

- **Goals**
  - Identify individuals and organizations engaged in porting one or more of the CCSM component models
  - Report progress and problems in current CCSM vectorization activities.
  - Identify gaps or issues in the current efforts.
  - Establish lines of communication between the different efforts and NCAR software engineers to encourage sharing of results and code.
  - Begin defining requirements and procedures for the adoption ofvector-friendly code in future released versions of CCSM.
- **Represented: NCAR, NASA-GSFC, ORNL, LANL, LBNL, Cray, NEC, Fujitsu, CRIEPI**



Subgrid Orography Scheme

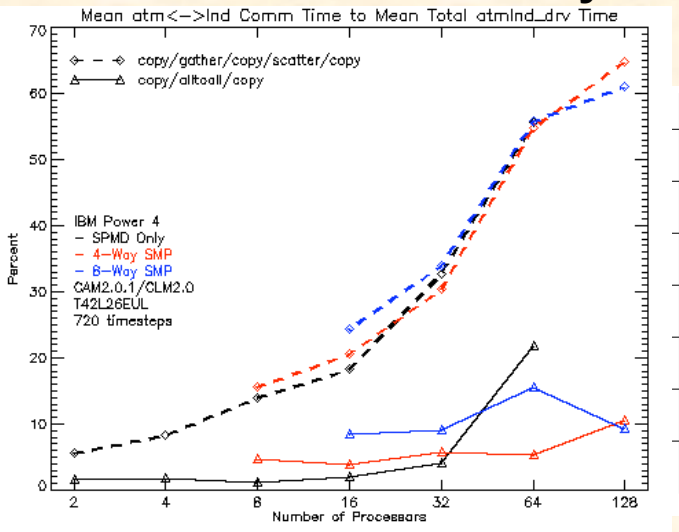
- Reproduces orographic signature without increasing dynamic resolution
- Realisitic precipitation, snowcover, runoff
- Month of March simulated with CCSM

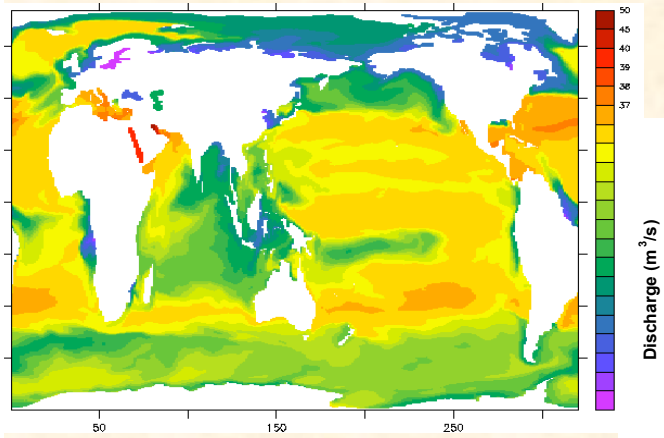


Land Surface and River Transport Model

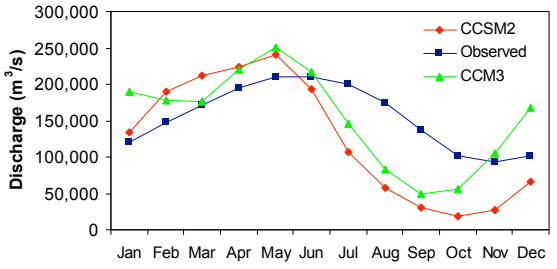
Community Land Model (CLM2.1) Released

- SciDAC software engineering is focused on the interface and reduction of gather/scatters; communications bottleneck removed
- RTM is currently single processor -- designing parallel implementation and data structures
- Analysis of runoff in CCSM control simulation. Effect on July ocean salinity.



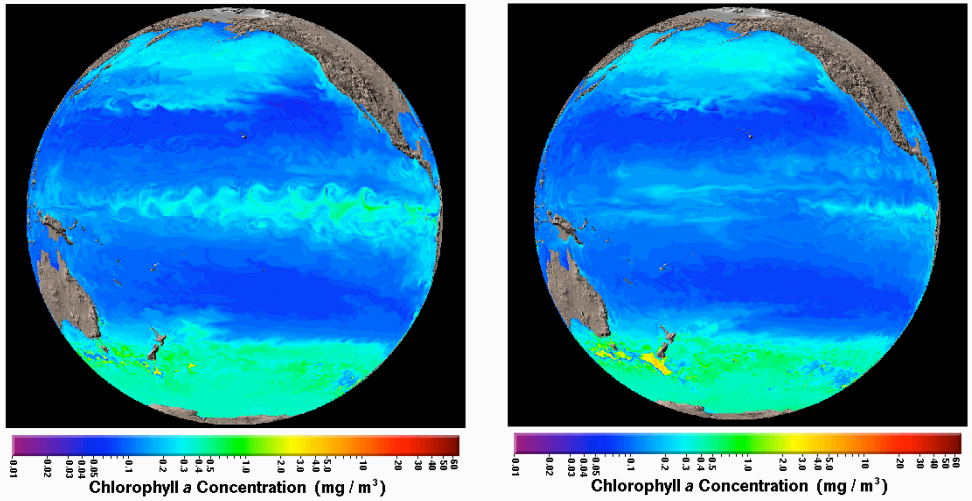


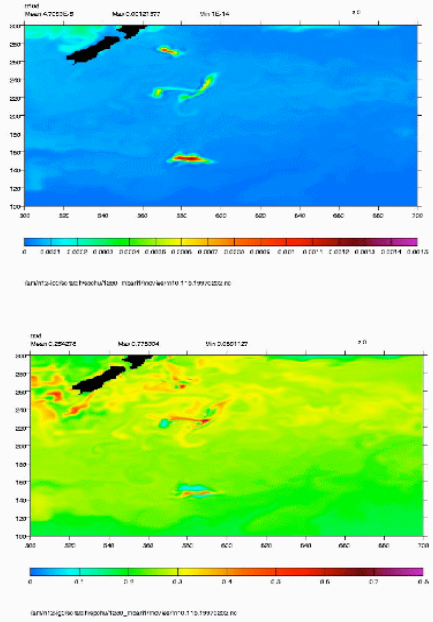
Amazon



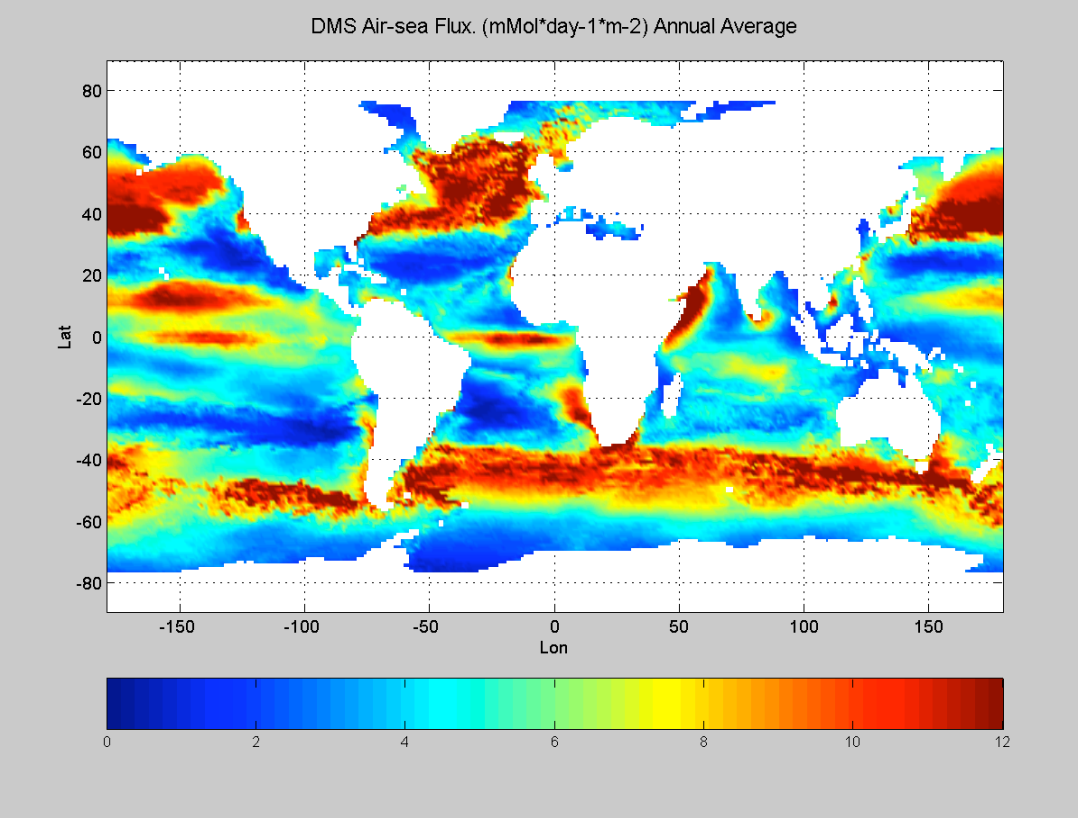
Ocean Biogeochemistry

- Iron Enrichment in the Parallel Ocean Program
- Surface chlorophyll distributions in POP for 1996 La Niña and 1997 El Niño





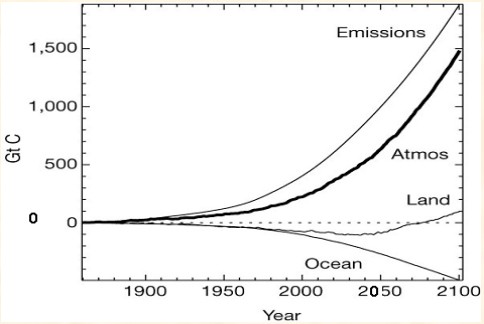
Global DMS Flux from the Ocean using POP

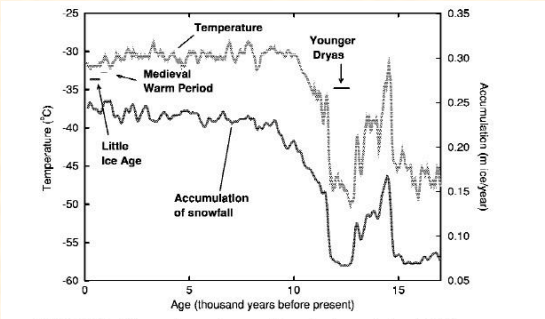


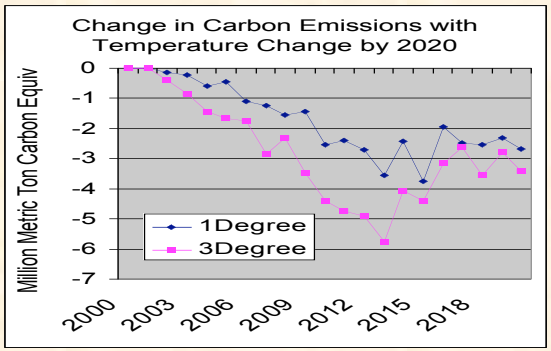
The global flux of DMS from the ocean to the atmosphere is shown as an annual mean. The globally integrated flux of DMS from the ocean to the atmosphere is 23.8 Tg S yr-1 .

Three Focused Basic Science Research Tasks

- **Carbon cycle feedbacks**
  - a) temperature acclimation
  - b) diffuse radiation
- **Water cycle feedbacks**
  - a) ocean circulation
  - b) soil moisture
- **Energy/economics feedbacks**
  - a) heating/cooling day change
  - b) technology adaptation







ORNL Directions in Computational Climate Science

- DOE mission is to predict climate on decadal to century time scales
- Global carbon cycle prediction is an imperative for DOE/OBER
- Significant resources allocated to the hardware side of computational sciences by DOE/ MICS
- Cray X1Vector performance
- IPCC 4th Assessment has started and ORNL/CCRI is supporting basic science and simulations