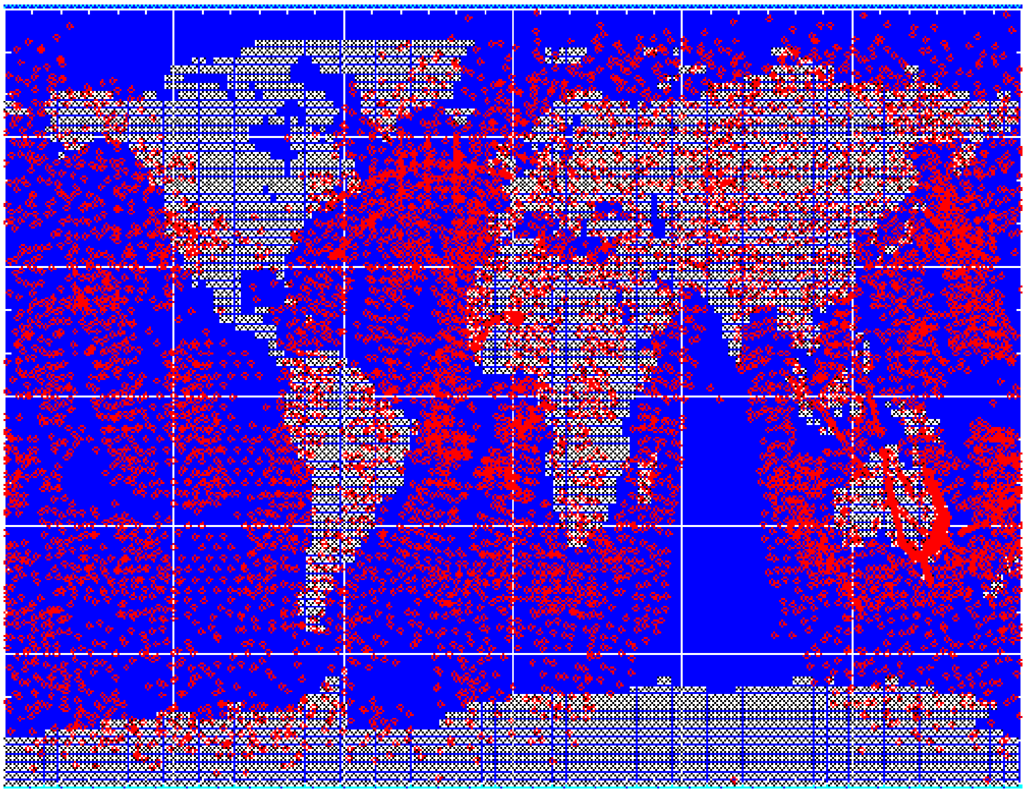
High Performance Computing and Four–Dimensional Data Assimilation: The Impact on Future and Current Problems

SUMMARY

This is a project to study problems of four–dimensional data assimilation in a parallel computing environment in order to assure that future data assimilation systems can meet their required uses. This includes extending assimilation analyses to data types that have not traditionally been considered (e.g. atmospheric constituent measurements).



Distribution of Observational Data used for Optimal Interpolation Analysis

PARTICIPATING INSTITUTIONS

- NASA Goddard Space Flight Center/DAO/ACDB
- NPAC, Syracuse University
- Jet Propulsion Laboratory
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IMPACT

Existing techniques for assimilation will benefit greatly from state–of–the art parallel hardware, software and algorithms. New data assimilation technologies will be explored, which can be implemented only on parallel machines. Optimal parallel system, defined as a system with best possible performance with portability, ease of maintenance and scalability constraints, will be able to meet the future goals of data assimilation.

PROJECT DESCRIPTION

The project focuses on the grand challenge of four−dimensional data assimilation to produce research−quality data sets for Earth Science studies. This involves the collection of diverse earth−observational data sets, and the incorporation of these data into models of the ocean, land surface and atmosphere, including chemical processes. Ultimately, the goal of data assimilation is the calculation of consistent, uniform, spatial and temporal representations of the Earth environment that can be used for scientific analysis and synthesis. There are two major thrusts of the proposal:

- We will apply leading research in parallel software and algorithms to a number of exisiting techniques for assimilation. The operational global atmospheric data assimilation system of the Data Assimilation Office at the Goddard Space Flight Center, along with techniques for tracer advection and chemical analysis, will be implemented on parallel software/hardware systems and assessed both for performance and for development effort required. The product of our work will be a new generation of integrated, operational models running on heterogeneous parallel systems at orders of magnitude greater performance than the current operational system. The assimilation of reactive constituents is a high priority in NASA environmental observation programs, including the Upper Atmosphere Research Satellite (UARS) and the Earth Observing System (EOS), and this will be an important step in making the assimilation of reactive constituents computationally viable.
- We will explore new data assimilation methodologies that can only be implemented with computers that far exceed the capacity of today's machines. We will emphasize the development of the first three−dimensional full Kalman filter scheme. We expect to exploit existing parallel systems software as well as to develop techniques that arise out of the special requirements of data assimilation. Three−dimensional Kalman filtering scheme will challenge the limits of teraFLOP machines for the foreseeable future.

The data assimilation effort at NASA requires the extension of atmospheric data assimilation techniques to many disciplines of Earth Science. In order to develop a successful assimilation system for Earth Science, there will be a continual need to process and reprocess data sets with ever−improving and more complete assimilation systems. There will also be a requirement to diagnose the quality of the data sets. Data assimilation provides the most computer−intensive undertaking in NASA Earth Science research. It is essential that assimilation algorithms and models be able to exploit the future computing environment.

The problems described in this project provide a basis for future assimilation work. The first thrust of the project provides mechanism to study the implementation of both the fluid−dynamical and physical parametrization components of our Erath system models. The second thrust investigates the assimilation technique that theory says is the most powerful. Together they define a core from which assimilation techniques can be extended to further applications. The development of these systems in a parallel computing environment now assures the computational vitality of future assimilation systems.

COMPONENT PROJECTS AT NPAC

- Optimal Interpolation Analysis (OI)
- Eulerian Transport Models
- Semi−Lagrangian General Circulation Model

SIMULATIONS ON DEMAND

- Atmospheric Transport (Van Leer/Prather Algorithm)

REFERENCES

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