DEVELOPMENT OF A MASSIVELY PARALLEL NOGAPS FORECAST MODEL PE 0602435N (035-71)

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LONG-TERM GOALS:

Develop an advanced global atmospheric forecast system designed to exploit massively parallel processor (MPP), distributed memory computer architectures. Future increases in computer power from MPP's will allow substantial increases in model resolution, more realistic physical processes, and more sophisticated data assimilation methods, all of which will improve operational numerical weather predictions and provide better simulations of the Earth's climate.

OBJECTIVES:

The current Navy operational global atmospheric prediction system (NOGAPS 3.4) is a highly optimized Fortran code designed to run on parallel vector, shared memory machines (CRAY's). The prototype new system is NOGAPS 4.0. The immediate objective of the project is to redesign the model's numerical algorithms and data structures to allow efficient execution on MPP architectures and clusters of shared memory processors. Message passing (MPI) is the paradigm chosen for communication between distributed memory processors. This work is support by ONR Marine Meteorology, PE 0602435N (035-71).

APPROACH:

Use control integration's of the current operational NOGAPS to ensure reproducibility of results with the newly designed Fortran 90 code. Design efficient spectral transform algorithms for both shared memory and distributed memory architectures. For distributed memory architectures use message passing library modules in communication intensive spectral transforms and horizontal interpolation routines.

WORK COMPLETED:

The Fortran 90 version of NOGAPS 4.0 has been multi-tasked to run on both the CRAY 90 and the in-house 6-processor DEC Alpha SMP. The code complies with all Fleet Numerical Meteorology and Oceanography Center (FNMOC) and DOD documentation requirements. Original plans were to use High Performance Fortran (HPF) as the mechanism for porting NOGAPS 4.0 to distributed memory architectures. However, immature HPF compilers, disappointing performance, and general lack of HPF support in the meteorological modeling community has lead us to switch to explicit message passing instead. MPI is now the de-facto standard for distributed memory architectures and is well

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
30 SEP 1997		**00-00-1997 to 00-00-1997**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Development of a Massively Parallel NOGAPS Forecast Model PE 0602435N (035-71)	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Research Laboratory,Monterey,CA,93943-5502**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

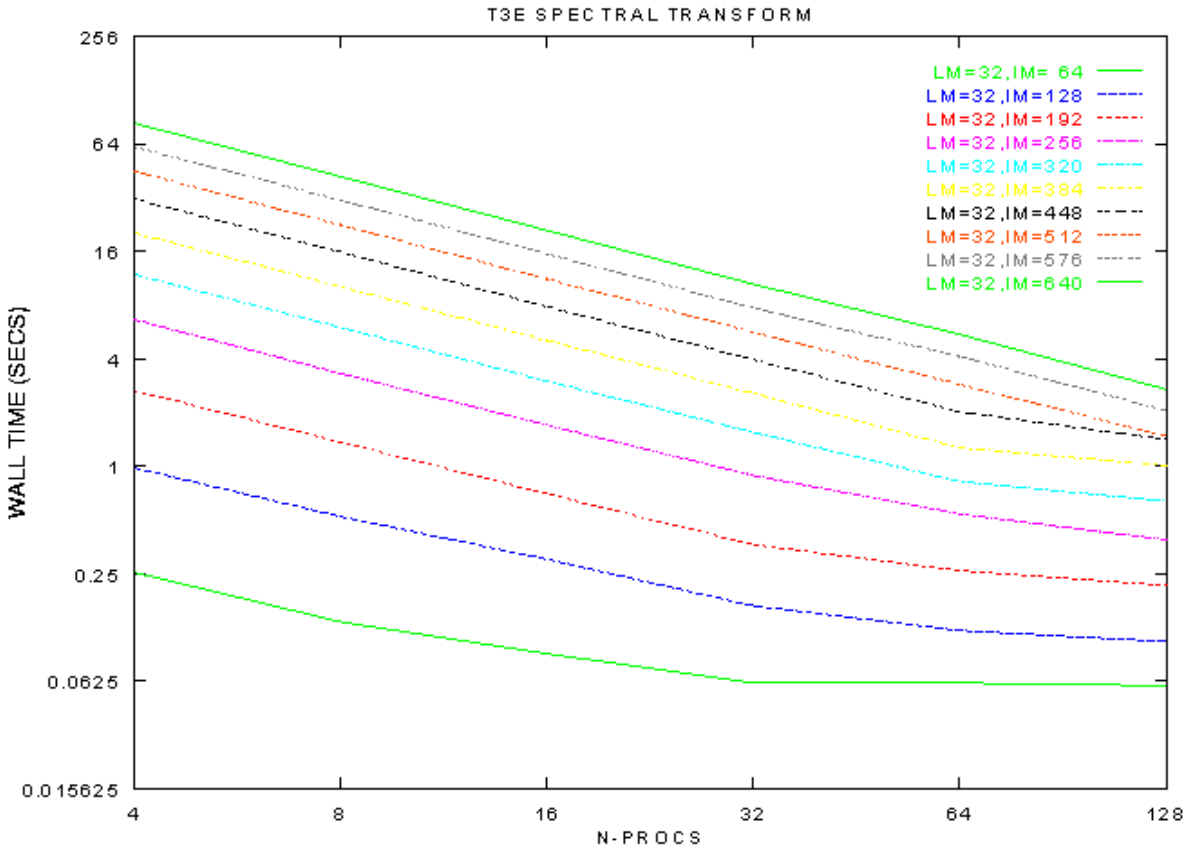
15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**3**	

supported by virtually every computer vendor. We now have an MPI version of NOGAPS 4.0 running in test mode on the DEC Alpha. The spherical harmonic transforms have been ported to several distributed memory architectures to ensure scalability, portability, and robustness of the MPI code.

RESULTS:

The MPI version of NOGAPS 4.0 is now running on the DEC Alpha SMP. The operational model, NOGAPS 3.4, is being used as a control to ensure reproducibility of results. In spite of radically different algorithm design for the spherical harmonic transforms, 8-10 decimal place reproducibility is being achieved for 12 hour forecasts. Virtually all inter-processor communication is concentrated in the spherical harmonic transforms. The figure below shows T3E scalability results for a wide range of processor numbers and model resolutions. The top line corresponds to a T213, 32 level model, the bottom line a T21 model. A straight line indicates perfect scalability from 4 to 128 processors. The higher resolution cases achieve this goal. The lower resolution results indicate there is insufficient 'granularity' to give good scalability, especially for the 128 processor cases. However, because these results are for the transforms only, we can expect much better scalability for the complete model when the embarrassingly parallel diabatic processes are added.



IMPACT:

NOGAPS is run operationally by FNMOC and is the heart of the Navy's operational weather prediction support to nearly all DOD users worldwide. It is also run by many NRL and other Navy researchers to study atmospheric dynamics, atmosphere/ocean interaction, and climate variability. NOGAPS 4.0 is the next generation of this system being targeted for the next generation of computer architectures. These architectures are expected to be distributed memory, commodity based systems with enormous theoretical computational power. However, exploiting this capability will require drastically redesigning many important model algorithms.

TRANSITIONS:

Improved algorithms for model processes will be transitioned to 6.4 (PE 0603207N) as they are ready, and will ultimately be transitioned to FNMOC with future NOGAPS upgrades. Development of the MPI NOGAPS code has necessitated close examination of the algorithms used in the operational model, and in some cases uncovered design weaknesses and bugs that are being promptly corrected in the operational NOGAPS.

RELATED PROJECTS:

(1) NOGAPS 4.0 Evaluation (X0513-01): Advanced development and transition of the NOGAPS 4.0 forecast model to operational status at FNMOC. (2) The DOD CHSSI Scaled Software algorithm development for meteorological models (HPCM-96-032): Development of numerical algorithms appropriate for massively parallel computer architectures. These algorithms will be critical for inter-processor communication dependent and computationally intensive model processes. An important component of this effort is to have the MPI version of NOGAPS available by 3Q FY98 for use as a benchmark code for use in the FNMOC/CNOC computer procurement.

REFERENCES:

None