Parallel Calculations of Dynamics and Physics Blocks in Atmospheric General Circulation Model

V.P. Parkhomenko

Computing Centre of the Russia Academy of Sciences

Vavilov Str. 40 Moscow 119967 Russian Federation

E-mail: parhom@ccas.ru

The purpose of the work is to analyze components of AGCM algorithm and their parallel performance depending on computing efficiency of the program, to find bottlenecks which interfere with efficiency of parallel algorithm and to use the best procedures and more effective parallel strategy of performance, to increase speed of AGCM running on parallel systems.

A two-dimensional grid partition in the horizontal plane is used in the parallel implementation of the AGCM model. In this case there are basically two types of processor data exchanges. Data exchanges are necessary between logically coupled processors at calculations of finite differences; the removed data exchanges are necessary to carry out operations of spectral filtering, in particular.

The offered parallelization method assumes simultaneous calculation of the contribution of physics and dynamics blocks of model equations accordingly on two groups of processors from the same input data. Method realization demands change of the numerical scheme of time integration. The original scalar program was modified according to the reasons stated above. Model calculations were carried out up to steady state on the original and modified variants of the program for check of method correctness. They began from identical initial conditions.

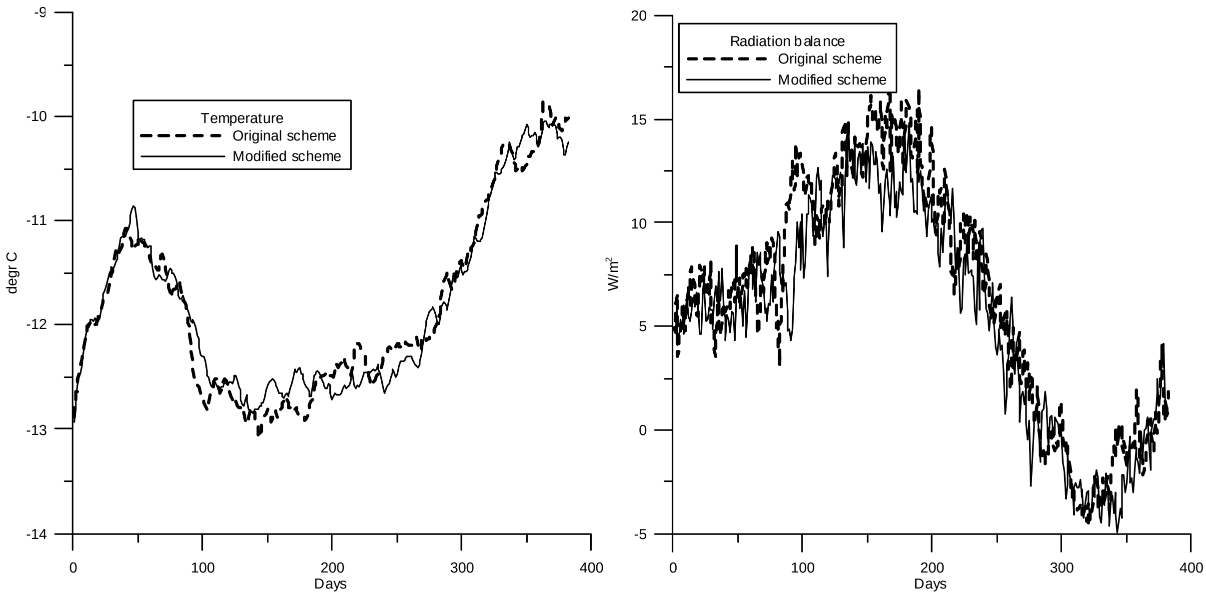

Fig. 1. Dependences of mean global temperature (at the left) and radiation balance (on the right) on the top border of an atmosphere from time for the original and modified schemes

The general feature of distributions of the basic climatic characteristics designed under initial and modified time integration scheme - the peak differences of results are observed in high latitudes in the winter season. It is connected, apparently, with snow distribution changes, and intensive non-stationary convective processes in an atmosphere. Ground temperatures differences in more than 90 % of cells are less then 2^{o}Ñ. Only in two cells in the winter in Northern hemisphere above the continents the difference is 10^{Î}Ñ. For winter season in the Southern hemisphere the similar picture is observed: appreciable differences exist in three cells in Antarctica. Sea level pressure differences do not exceed 15 mb in several cells and basically make less than 5 mb.

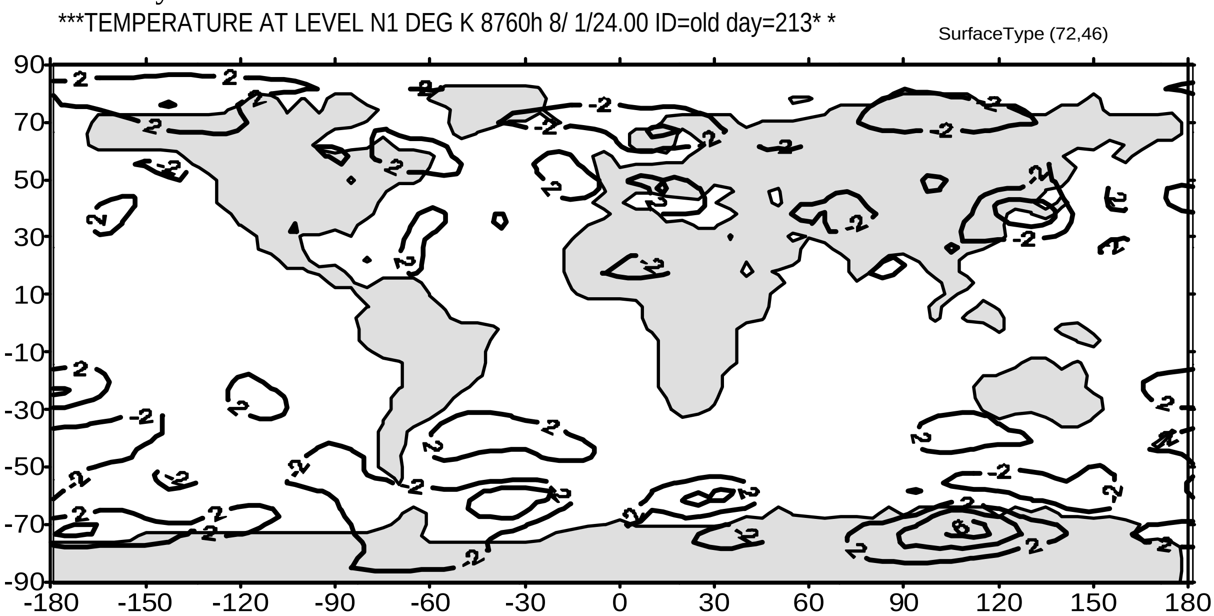

Fig. 2. July air temperature differences at 400 mb level for original and modified schemes.

At a level 400 mb air temperature differences do not exceed everywhere 2^{Î}Ñ, except for one point where achieve 6^{Î}Ñ. At a level 800 mb a picture is similar. It is possible to assert, that differences in results are more essential in surface areas.

Realization of the parallel program for various ways of splitting of global area on processors in climatic model is carried out. Updating of the time integration numerical scheme for an opportunity of realization of parallel calculations of dynamics and physics blocks with an estimation of computation efficiency is carried out. The analysis shows, that results of calculations under the modified scheme yields satisfactory results and its application is possible. In the scalar program physics block run time takes 38%, and dynamics block run time - 62%. It means that parallel program acceleration in one and a half time can be achieved. Offered procedure is used together with parallel computations of dynamics and physics blocks on the basis of global area decomposition. It allows to optimize loading of processors and to increase program efficiency. Results of application of loading balance of the physics block of AGCM enable additional reduction of running time on 15-20 %. Other opportunity of method application is a complication of the physics block without increasing of total computational time.

References

A. Arakawa and V. Lamb, "Computational Design of the Basic Dynamical Processes of the UCLA General Circulation Model.", Methods in Comp. Phys. 17 (1977) 173-265.

Lou, J. Z., J. D. Farrara, Performance Analysis and Optimization on a Parallel Atmospheric General Circulation Model Code, ISSN 1063-7133/97, 1997.

V.P. Parkhomenko Parallel Atmospheric General Circulation Model Code Analysis and Optimization. Research activities in atmospheric and oceanic modelling. World Meteorological Organization Geneva Switzerland 2005, V. 35, p. 3.19 – 3.20.