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Parallel implementation of block circulant type preconditioner for all-at-once systems of linear time-dependent PDEs

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Parallel-in-time approaches solve all-at-once systems obtained by solving all time-dependent PDEs at once in order to extract temporal parallelism. Assuming linear and constant-in-time integrators for all time steps, the resulting systems have a block Toeplitz structure. Consequently block circulant preconditioners have attracted much attention for these systems. In particular, block epsilon-circulant preconditioners, introducing a weighting coefficient, have achieved convergence independent from the spatial size, thus they are promising parallel-in-time approaches. This work focuses on parallel implementations of block circulant type preconditioners. The primary operations of these preconditioners are FFTs on one-dimensional time-step-sized vectors and solving spatial-sized linear systems with complex-valued coefficient matrices. We use FFTW and Trilinos packages with their MPI implementation and investigate their parallel performance. Additionally, we propose an alternative parallelization strategy to execute the one-dimensional FFTs. Numerical experiments demonstrate good scaling behavior for linear diffusion and advection-diffusion problems.

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