EULAG 2016 - status and challenges

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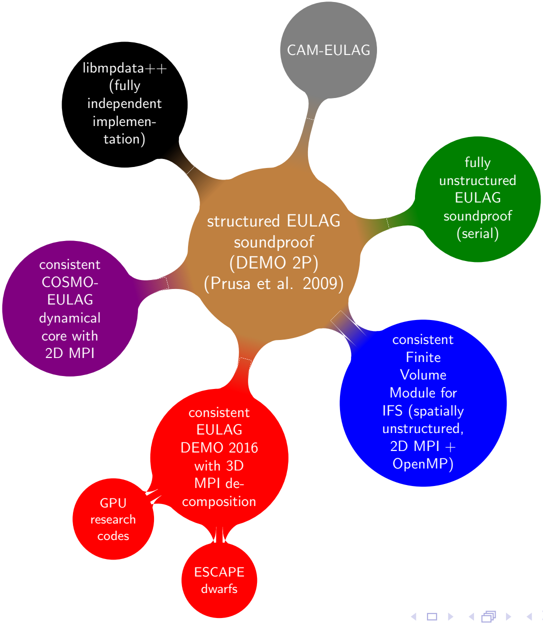
October 5, 2016

EULAG model family - an overview



EULAG DEMO 2016

- Changes to the EULAG code since the EULAG workshop in 2014 are mostly cosmetic.
- The 2014 DEMO and later codes are already being applied by several research groups.
- Important new functionality relates to the possibility of the concurrent integration of several dynamical solvers, thanks to the developments originally aiming at the optimization of the MHD EULAG version (with HD and MHD solvers).
- Overall, the majority of the numerical and computational development takes place in the offspring codes.
- So, is it the "evening of EULAG life" ?

EULAG core development

- Some Fortran 77 strategies are becoming dangerous and obsolete !
- Implementation of the MPI module dependency instead of mpif.h
- Overall code cleanup to address and remove warnings and remarks from various compilers (PGI/INTEL/GNU/CRAY/PATHSCALE/NAG)
- Poor's man object orientation for the pressure solver: additional index allowing for independent processing and storage of several implicit problems inside EULAG, e.g. HD + MHD solver or HD solvers with cyclic and open boundary conditions, see Andreas/Zbig talk tommorow.
- Further polishing and testing of the Alternating Direction Implicit preconditioners took place

Constructing the preconditioner to mitigate the anisotropy of grids on the sphere

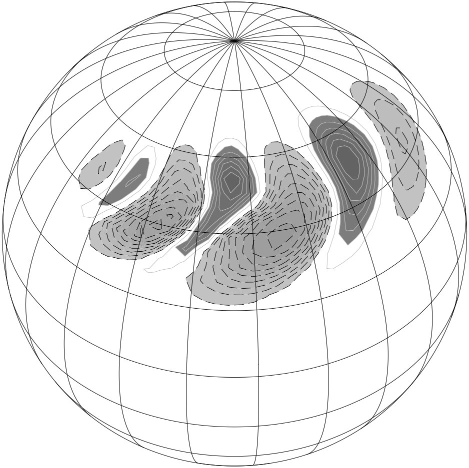


Figure: Evolution of baroclinic wave on the sphere - a prototype for global weather. Contours denote potential temperature perturbation.

10-day dry benchmark (dynamics only) - time-to-solution.

No complete scalability analysis was done so far. The new preconditioner allows to run high resolution experiments in reasonable time.

Grid	Time to solution [s]
512x256x48/512 cores	1581(ECMWF)
2048x1024x48/4096 cores	2048(ECMWF)
4096x2048x48/2048 cores	16 431 (XC40 ICM)/15 741 (ECMWF)

Note that timestep had to modify to ensure the $CFL < 1$.

COSMO-EULAG dynamical core development

- Extensive work conducted to provide competetive computation performance for regional NWP
- In the first place, the memory bandwidth wall was addressed.
- Stencil operations of MPDATA and preconditioned GCR solver are available in the completely rewritten form, along with the stencils from model initialization (e.g. computation of metric coefficients)
- As a result, EULAG dynamical core is about 10% faster, as measured 04.2016. We are evwn further today.

Breakdown of the COSMO-EULAG compressible vs. anelastic computational cost.

Compressible model is a bit cheaper when it comes to solve the implicit problem thanks to lower number of otherwise more expensive iterations, but needs to run more advection.

	Total compressible	Total anelastic
COSMO-EULAG dyn. core	$6 * 10^4$	$4.9 * 10^4$
MPDATA dry advection	$14 * 10^4$	$7 * 10^4$
MPDATA moist advection	$12 * 10^4$	$12 * 10^4$
GCR iterative solver	$20 * 10^4$	$22 * 10^4$

Significant improvements to MPDATA perfromance were introduced since this measurement was taken.

Computational performance

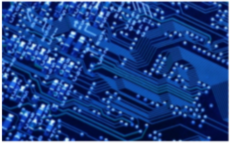
The actual computational performance for the test setup that alludes to the operational 2.2 km horizontal resolution setup over the Alps on 800 cores shows about 10% performance improvement of the implicit-compressible COSMO-EULAG.

Dynamical core	Time to solution
Operational Runge-Kutta (no horizontal diffusion)	1460
EULAG compressible	1312
EULAG anelastic (low solver accuracy)	1183

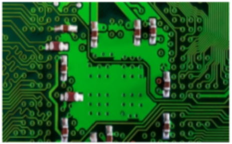
The low solver accuracy in anelastic model is probably unacceptable for operations, however it shows that a good preconditioner can make the anelastic approximation unbeatable for the regional NWP.

Funded by the European Union

Co-ordinated by ECMWF






This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 671627

ESCAPE dwarfs - structured MPDATA dwarf

Dwarf is a mini-application that can be used for all three:

- the algorithmic development,
- computational investigations, optimizations and accelerator ports,
- hardware and software co-design.

So far, only the MPDATA mini-application (modern Fortran) is ready, set up to repeat rotating sphere benchmarks in cubic domain or mimick the domain characteristic for the current and future NWP. The single core time-to-solutions for a standard rotating sphere benchmark on 41^3 domain using second-order MPDATA FCT schemes are:

	Original[s]	Optimized[s]
MPDATA gauge	8.1	3.9
MPDATA standard	9.0	5.8

GPU research codes

The research conducted at the Technical University of Czestochowa is based on the MPDATA gauge algorithm for structured grids and soundproof integrations in stationary coordinates. The research directions are:

- Optimal perfromance on NVIDIA GPU with CUDA
- Efficient integration on mixed CPU/GPU nodes
- Optimization of energy to solution on CPU, e.g. how to optimize energy usage for given time-to-solution, potential energy savings vs. loss of performance.
- Load balancing techniques to optimize performance on Xeon Phi

The future of EULAG (as I see it)

So far, there were no resources recently to work on the EULAG code. But there are many EULAG children, that can help in making EULAG young again.

- The structured MPDATA (existing) and implict solver(future) dwarfs of ESCAPE will serve as a vehicle towards improving coding standards (modern Fortran) and offer significant performance increase
- They can be further backported to the original EULAG code, they will also serve for the community and universities as relatively simple test problems.
- COSMO-EULAG modern Fortran implementations can be backported in case of performancewise non-critical pieces of the code
- Remaining issues: the EULAG diffusion module and modern architectures implementation

The new EULAG project: funding and context

The **Numerical Weather Prediction for Sustainable Europe (PROPOZE)** project is financed by the European fund within the **Smart Growth Operational Programme 2014–2020**, Measure 4.4. "Boosting human potential in R&D sector", through the **First Team** 1/2016 award of **Foundation for Polish Science** with budget close to 500 000 EUR for three years, starting this month. The project aims at accelerating the operationalization of the EULAG dynamical core of COSMO model, complementary to the CELO priority project of COSMO Consortium.

PROPOZE project motivation

- "The resources available to IMGW and COSMO effort in the frame of priority project CELO ... are not sufficient to cover several areas that are vital to bring COSMO-EULAG to the level of the fully mature commercial product."
- "The project goals are ... to accelerate the energy-efficient implementation of the COSMO-EULAG model for the numerical weather prediction in Europe."
- "To work with MeteoSwiss and DWD ... to reach the stage of commercial-grade software ... "

Work package 1 - technical development of EULAG dynamical cores

- Recoding of boundary conditions and implementation of the cartesian (SGS 1) and general (spherical) diffusion operator (SGS 2) into COSMO. Implementation of EULAG TKE scheme into COSMO-EULAG.
- Research and implementation of physical parameterizations at the surface, including the turbulent surface fluxes.
- Can the regional NWP rely on ILES property of EULAG ?

Work package 2 - EULAG dynamical core on accelerator

- Port of EULAG DC to STELLA/GRIDTOOLS library abstracting algorithms from the implementation details on particular accelerators.
- Preparation of OpenACC port of EULAG dynamical core
- Within this task we will establish EULAG Git repository and the developers space.

People

- PhD/Postdoc for GridTools/STELLA/GPU (2 years)
- Phd student to work on the lowest model layer/surface transport (3 years)
- Project scientist to work on EnKF for EULAG
- Contracting a forecaster to analyze deterministic COSMO-EULAG over Poland daily
- At least two master students

Conclusions

- PROPOZE project will contribute to the implementation of the core EULAG algorithms.
- Continuous input from FVM/ECMWF and ESCAPE is expected, with regards to the algorithms.
- We count on feedback from the community, your help and support is greatly appreciated.