Recent developments in numerical methods
(part 1)

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Workshops on numerical issues

1) NCAR summer school – in Michael's talk
2) PDEs on the sphere – 2012 (Cambridge, 09/2012) – in Michael's talk
3) **Weather and Climate Prediction on Next Generation Supercomputers: Numerical and Computational Aspects (22-25/10/2012)**

Weather and Climate Prediction on Next Generation Supercomputers: Numerical and Computational Aspects

(Exeter, UK Met Office, 22-25/10/2012)

More than 50 participants: academic community, operational weather and climate centers, supercomputer vendors. Main topics:

- Developments in operational dynamical cores, including the ones related to scalability
- Use of accelerators (GPUs, Intel Many integrated cores chip (MIC))
- Time stepping schemes, including scalable solvers for the semi-implicit algorithms
- Unstructured meshes
- Discrete Galerkin methods
- Mesh refinement

Trends in supercomputing

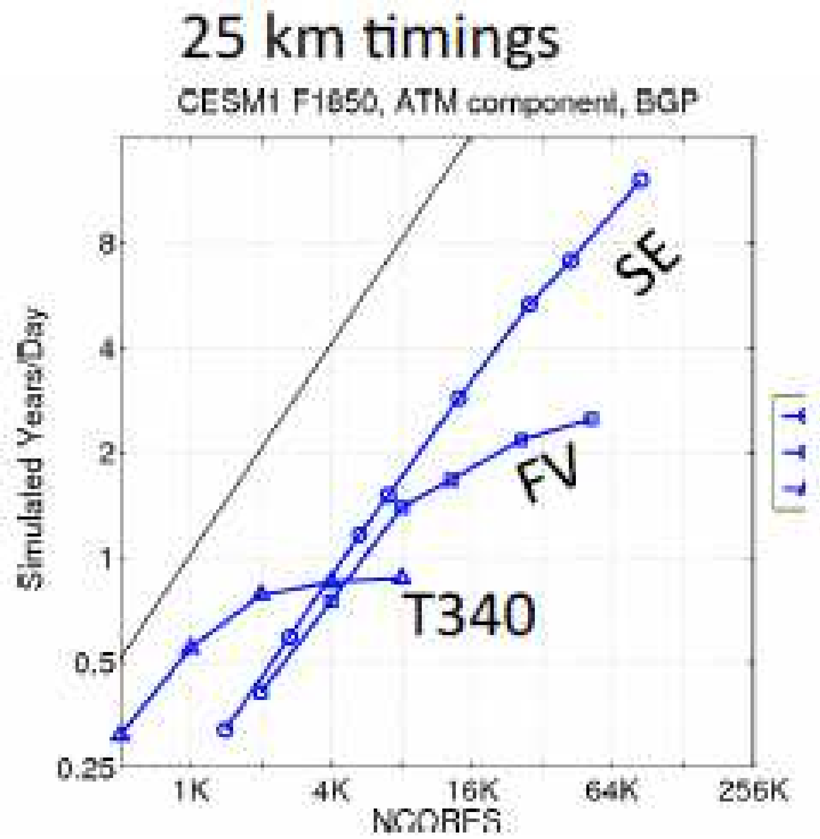
- **Multicore processors (incl. accelerators)**
- **0.2-0.5 Bytes transferred /1 flop**
- **1 DP flop – 10pJ, 1DP word transferred to memort – 2000 pJ!**
- **Reuse cache memory whenever possible!**
- **Consequences not only for dynamical core developers, but also for parameterization developers!**

Use of accelerators (GPU and Intel Xeon Phi (MIC))

- Rich Loft’s (NCAR) presentation on the subject. Included ’12 ways to cheat when speaking on use of GPUs’
- Only linear codes (dynamics) are easy to port
- Programming language (CUDA gives the best results, but our codes are too huge to rewrite. OpenACC is an alternative)
- Maximum acceleration for real codes is limited technically by factor of 4.5

General impressions

- Sometimes the scalability issue may become a fetish
- We need better accuracy for smaller time in a **wide range** of model resolutions!



From WGNE27 NCAR presentation, J. Bachmeister

Semi-implicit time-integration schemes

- Semi-implicit time integration scheme seems to survive the scalability issue: geometric multigrid solver involving only local communications has shown to scale up to 16000 cores at least. There is a freeware code.
- They are more difficult to code and debug,
- Setup phase can take up to 10 min with O(10k) cores
- But allow 5-10 times longer timesteps

Unstructured grids

- Technical problems with O(10k) cores due to indirect addressing A(I(J)). Probable solution: block-structured grids

WGNE Survey of dynamical core developments 2012 (1)

Questions about current and future dynamical core:

- numerics (finite-difference/spectral/…)
- grid (lat-lon/cubed sphere/…)
- time integration scheme (semi-implicit/horizontally explicit-vertically implicit)
- advection type (Eulerian/semi-Lagrangian)
- mass conservation for tracers (yes/no)
- particular features

WGNE Survey of dynamical core developments 2012 (2)

- 11 NWP centers responded
- Most centers either work or plan to work on development of new dynamical cores or essential modifications of the existing cores.
- 4 centers develop 2 versions of their dynamical core!
- Slow future decrease in number of spectral models
- Different horizontal representations (FD, FV, FE, spectral) are used and planned to use. So far, no center considers discrete Galerkin method for horizontal discretization

WGNE Survey of dynamical core developments 2012 (3)

- The regular lat-lon **grid** is used by many centers, but not in dycores under development. Icosahedral grid is used by DWD, is considered by 2 centers.Yin-Yang grid is considered by 3 centers. The reduced lat-lon grid is used by spectral models and will be implemented in Russian grid-point model
- **Time integration scheme**: ~half opted for semi-implicit, ~half considers horizontally explicit – vertically implicit. Some centers consider both. None considers split-explicit.
- SL **advection** is used currently in many current global models, not so much in models under development. (scalable implementation White, Dongarra JCP 2011)

Thank you for attention!