9th International SRNWP-Workshop on Nonhydrostatic Modelling 2011
Short summary on Working group 2

"Numerical aspects of global high resolution modelling"

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Computational performance

future of spectral approach (IFS):
computers are designed to do linear algebra ← spectral transforms do exactly this. But about 50% of time are used for transforms (this will even increase in the future)
Parallelization: data transport increases more and more
different goals: for NWP mesh refinement necessary; for ECMWF not

Which **computer architectures** will be important in the future?
graphical processing units (GPUs), processors for mobile phones (small energy consumption)?
no consolidation or a real standard yet (programming in CUDA or other languages , by compiler directives, …)
can it change the way we are programming: use of libraries which can automatically implement discretizations of operators ?

Different approaches for grid refinements

comparison MPAS, ICON:
2-way nesting + smoothed grid refinement both lead to a comparable increase in Jablonowski-Williamson baroclinic test case amplitude

different strategic goals:
70% of MPAS are in high resolved area
can be different e.g. in Europe (ICON: 2nd stage 10 km global → 5 km most GPs are 'coarse')
2-way nesting has advantages for certain types of simulations of idealized flows
but it can have problems with conservation if used with overlapping regions. These can be treated by a correction term (e.g. ICON)
Clark's model is conservative even with 2-way nesting.

Smooth grid transition produces much less disturbances than abrupt change
time integration in smoothed grid transition should be easy (temporal sum of fluxes equals flux on coarser grid element)

→ Conservation:

mass and tracers: clear
others are not clear (see appropriate discussion during the ECMWF workshop in Nov. 2010)

Which equations to use?

vector invariant form (Lamb form of the momentum advection) compared to flux form:
better conservation of higher order variables (potential vorticity, enstrophy)

ICON: 3D variant of Lamb transform is much more expensive than a 2D approach

Experience between MPAS and 3D invariant form of ICON: no differences visible

Tracer advection schemes:
There are a lot of properties to obey: conservation, accuracy, positive definiteness, monotonicity, mass consistency, …
In general, the velocity field must be correct before you see benefits of a 'better' tracer advection scheme.

general problem of numerics:
it's usually difficult to see benefits from higher order (higher than 2nd order) in real case simulations, unless there are special problems to cure (e.g. higher order lower boundary conditions to cure stability problems in steep terrain,
in general: you often don't see improvements of better schemes in scores
example: introduction of RK vs Leapfrog in COSMO
IFS: Semi-Lagrange (perhaps one of the weakest points in IFS?)

Test cases, test suites:
also one linking element in the numerics community.
Originally : those tests are designed to get rid of basic problems in the numerics.
The whole world can change if you start to abandon the dry simulations and include moist processes and phase transition.
For the development of MPAS it was very important to have flat cartesian plane toy models.
Collection: Bill Skamarock's homepage for non-hydrostatic tests.

Number of tests is increasing: community should concentrate on the most important ones.
Why do I perform a certain test?

e.g. which quantities are conserved? (up to now there does not exist an explicit test of PV)
kinetic energy spectra are very helpful
linear mountain flow should be performed well by any numerics (apart from coding errors)