Working Group for Dynamics & Coupling:

fulfilment of 2007 plan

February 15, 2008

NOTIFICATION: This document is the supplement of the Research plan for the year 2007. The topic descriptions and objectives are not explained once again here. In case of need they can be referred directly from the Research plan. Moreover the listed topics are restricted to just those for which any progress was achieved.

NH dynamics

Vertical finite element discretization scheme : Before her SHMI departure Emelyn performed real atmospheric studies with the VFE code. The results again confirm there is still a residual problem in the scheme implementation generating a spurious non meteorological signal. Otherwise the scheme seemed to offer stable performance with results highly comparable to the original finite difference method.

As the outcome from the Météo-France initiative for joint cooperation with ECMWF on stabilization of the NH core, it turned out that there are more problems in the present VFE code. Thanks to this activity the valuable parts of the first version of VFE code were phased to the actual model cycle (the SI iterative solver).

After his stay at ZAMG, Jozef moved his development to the most recent code. There several formulations were analyzed. For the moment none of them posses all the following qualities, required for successful VFE implementation:

- stable for general vertical levels distribution,
- sufficiently accurate near top and bottom boundaries,
- preserving monotonicity for monotonic fields,
- preserves small C1 eigenvalues in order to ensure iterative solver convergence and
- eigenvalues of C2 have positive real components with small imaginary components.

The work has to continue.
Means: 4 months (1 month supported by LACE)
People involved: ELR, JV
Code implications: Part of the research branch (based on CY30T1) phased to the common code (KY).
References: E. Larrieu Rosina: First results on NH SI VFE 3D testing

Other (not only NH) dynamics

New interpolators for semi-Lagrangian advection : Work is well progressing. After first stay of Jan at CHMI a preliminary version (ready for real tests) of the new data-flow is coded. The first experiments confirm the expectation that the redesigned data flow brings more freedom and accuracy to the SL and SLHD schemes. There is also a good chance to reduce the computational cost for both schemes. The work continued during the second stay of Jan at CHMI. The non-linear code was completed (at the level of CY31T1) and preliminary validated including stability and accuracy issues of various options of the new formulation.

In the further work those changes should be projected to the TL/AD counterpart. After precise validation all has to be phased into the common cycle.

Means: 3.5 months (2 months supported by LACE)
People involved: JM, FV
Code implications: The 4-p splines were removed from the common code at the level of CY32T3.
References: J. Mašek: Test implementation of new semi-Lagrangian interpolators in ARPEGE/ALADIN cycle 32t1alr01

Physics / dynamics coupling : The work is slowly progressing.
Means: 1 month of local work
People involved: MT
Code implications: research branch based on CY29T2
References: nothing new

TL/AD of the semi-Lagrangian scheme : The AD code has been successfully phased into CY32T2. Since that another increase of performance was achieved (around 13% of performance gain for the most expensive AD routine) for mainly vector platforms and the code was further rationalized to be as close to the global one as possible. On request from EPS people the new code has been successfully activated for configuration e601 (SV generation) allowing higher computational efficiency and hopefully also increased accuracy. Similarly the new advection scheme was also tested with e801 configuration (the adjoint sensitivity). It turned out that one SL time step in AD code is around three times more expensive to CPU and memory requirements with respect to the Eulerian advection. This is easily compensated by the experienced ability of SL to run with 10 times longer time step.
Means: 3.5 months (0.5 month supported by Météo-France)
People involved: FV, RM
Code implications: complete code available since CY32T2, it is further optimized from CY32T3
References: documentation to CY32T2 and CY32T3; F. Váňa - Validation of e801 configuration (adjoint sensitivity) in ALADIN

Thermodynamics consistency in the model equations : The code has been checked and found consistent with the new multi-phasic system. In addition the flux-conservative thermodynamic equations for the multi-phase system are extended for the fully compressible atmosphere (NH dynamics). This extension encounters the set of prognostic equations in the following points: 1. the impact of the vertical moving water species in the thermodynamic equation, with the kinetic energy contribution extended to the vertical component, 2. the projection of the addition or removal of heat on pressure tendency, 3. the projection on vertical velocity (pressure departure respectively) tendency. The given concept was elaborated in more details with regard to the ARPEGE/ALADIN/ALARO system and technical aspects of the implementation to this system were considered and widely discussed. The consequences of making the hypothesis that any mass flux due to the motion of moisture is compensated by a counter-flux of dry air ($\delta m = 0$) were also considered.

The implementation is finished however producing not yet satisfactory results.
Means: 2 months of local work
People involved: PS, RB
Code implications: private branch based on CY32T1
References: nothing so far

Optimization of SL advection buffers : In order to reduce the memory conflicts (which is especially important for vector machines) the size of SL buffers used for parallel computation is slightly extended. The procedure doing this is related to the size of memory banks register of a given platform and an empirically found offset. The aim of this work was to re-checked and further optimize this empirical procedure with respect to NEC SX computers (exclusively used as the only vector platform within the ALADIN/ARPEGE community) knowing that the last tuning was done with respect to VPP machines. It was found that the old tuning offers quite good performance also for the NEC computers. The further retuning improves this situation by just slightly more than 0.5%. (To give some estimate the worst tuning for this procedure slows down the whole model performance by 51%.)
Means: 2 weeks of local work
People involved: FV
Code implications: new tuning available since CY32T3
References: documentation to CY32T3

Coupling

Boyd's method in SL space : This study was oriented toward testing fresh approaches (or their combinations) for LB coupling with the diagnostic environment developed by Jan in 2006. One of the tested approaches was an implementation of Boyd ideas (MWR paper from 2005) in the SL space. It seems to offer some skills but not convincingly outperforming the reference Davies' technique. Especially for the out flow areas the Davies scheme is significantly more efficient. Perhaps some further tuning or combination of this technique with the relaxation for the outflow areas could still be beneficial. The tuning of the SLHD seems to offer more potential to improve quality of the LB coupling. When SLHD is increased near the lateral boundaries the observed error caused by LBC techniques is noticeably reduced with respect to the reference one. There were however still some periods for which the reference scheme offered better results. A logical conclusion can be that the increased SLHD is able to offer better coupling performance but depending to some condition (in flow/out flow?). A more detailed analysis might be profitable in order to activate this technique just for the cases where it is beneficial.

As there is another project focused on coupling within the ALADIN community this kind of quick win oriented study has been frozen.
Means: 0.5 month of local work
People involved: FV
Code implications: none for the moment
References: none