ALATNET developments during the second half of 2002 in ALATNET centres

1. In Toulouse

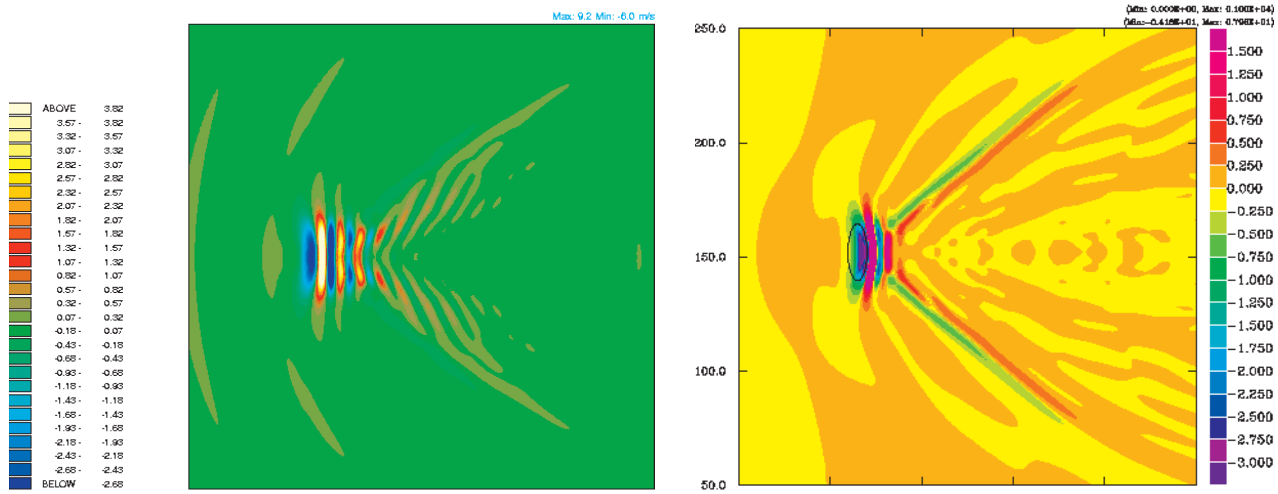
The work of the five ALATNET PhD students in Toulouse, Gianpaolo Balsamo, Margarida Belo Pereira, André Simon, Cornel Soci and Malgorzata Szczech, is described in separate reports, as well as other PhD reports. The summary hereafter corresponds to the joint efforts of the other visitors and the permanent staff.

1. <u>Theoretical aspects of non-hydrostatism (NH)</u> *(many persons !)*

A large part of the work in this domain is extensively described through 3 articles in this Newsletter (2 by Pierre Bénard, 1 by François et al.), completed by the papers written by Petra Smolikova and Jozef Vivoda.

As a summary, the latest developments performed by the Prague and Toulouse teams were merged within a new reference library, allowing to combine the use of the new NH prognostic variables or the alternative handling of vertical velocity with the predictor/corrector scheme. The newest version of the ALADIN NH dynamics was intensively tested and successfully compared to that of some other limited-area models.

The 2d vertical-plane tests (with respect to a standard oscillating trapped lee-wave situation) which are described in Bouttier et al. were extended to the 3d (still semi academic) case by Jean-François Geleyn. The mountain is therefore not any more a transversal "wall" but gets an elliptical shape in the middle of the domain. The rest of the setup is the same. Thanks to this new geometry one gets the combination of two phenomena : the trapped lee-wave (that attenuates quicker than in the 2d case) and a V-form wake (see Fig1 hereafter). The welcome smaller attenuation rate of the wave in ALADIN-NH than in Meso-NH appears like it was already the case in the vertical plane experiments but there is an even more interesting feature. There exists with ALADIN-NH a wavy pattern in both branches of the wake, absent from the Meso-NH simulation. While there is this time no exact knowledge of the true solution, similarity with cloud structures in the lee of isolated islands seem to indicate that this is another "plus" for ALADIN-NH in this very demanding test (made here at 2 km resolution for 6 h with an Eulerian scheme on both sides).



ALADIN-NH MESO-NH

Figure 1 : Horizontal cross-sections of the vertical-velocity field at 2000m after a 6h forecast.

As a conclusion, we may say that the robustness, accuracy and efficiency of the ALADIN non-hydrostatic dynamics were demonstrated and it proved at least as good as the most advanced schemes.

2. Case studies aspects of NH *(K. Yessad)*

The stability of NH dynamics was tested on a past situation (14 July 1999, 00 h UTC) with ALADIN-France, along a 48-h adiabatic forecast. Neither the situation nor the resolution, around 10 km, were critical, allowing a simple comparison with the efficiency of hydrostatic (H) dynamics.

Several combinations of the two possible prognostic NH variables ($\mathcal{P}$ for pressure departure and d for vertical divergence), with and without a predictor/corrector approach, were evaluated for both two-time-level (2TL) and three-time-level (3TL) schemes, looking for the maximum allowed time-step each time. The results obtained in simpler experimental frameworks were confirmed :

- d_1, d_2, d_3, d_4 lead to more stable runs than d_0 ,
- $\mathcal{P}_1$, $\mathcal{P}_2$ lead to more stable runs than $\mathcal{P}_0$,
- for the pair ($\mathcal{P}_2$, d_3) :
    - 3TL : NH is less stable than H but the time-step is still acceptable,
    - 2TL : the maximum time-step for NH is far lower than the H one,
- for the pair ($\mathcal{P}_2$, d_4), similar time-steps as for H can be used, both in 3TL and 2TL.

This last proposal was again proved to be the best combination.

3. Noise control in high-resolution dynamics

This topic was addressed only in the framework of non-hydrostatism (topics 1 and 2).

4. Removal of the thin layer hypothesis *(A. Nmiri, K. Yessad)*

This issue has now come to an end, temporarily. The required code modifications, following the proposal of White and Bromley (1995), were coded and validated both in ARPEGE and ALADIN. Sensitivity studies with ARPEGE, i.e. at the global scale and with a rather low resolution, showed hardly any impact of the change on global budgets.

Experiments based on the ALADIN-Réunion model, covering part of the Indian Ocean, were launched recently. A more noticeable impact was expected in tropical regions and at higher resolutions. Forecasts with and without relaxation of the thin layer hypothesis were launched, for a 48 h range, with the operational resolution of the model (33 km), both coupled to the same global forecasts each time. Six cyclonic situations were chosen along the first semester of 2002, two of them (Guillaume and Dina) being described in a paper by Eiselt and Lasserre-Bigorry in this Newsletter. Results were again quite deceiving, even when going to a still higher resolution (7 km).

The trajectory and depth of tropical cyclones seem to be presently governed essentially by problems in physics and data assimilation. The impact of such a small refinement in dynamics will have to be evaluated later, once the forecast skill significantly improved.

In the meantime, a new approach was proposed by Wood and Staniforth (2003), fully consistent with the ALADIN NH dynamics, and more easy to implement (see the "check-up" report by Pierre Bénard). The work is likely to restart from the very beginning, but only once all present developments in NH dynamics achieved.

References :

White, A., and R. Bromley, 1995 : Dynamical consistent, quasi-hydrostatic equations for global models with a complete representation of the Coriolis force, *Q. J. R. Meteor. Soc.*, **121**, 399-418.

Wood, N., and A. Staniforth, 2003 : The deep-atmosphere Euler equations with a mass-based vertical coordinate, *Q. J. R. Meteor. Soc.* **129**, 1289-1300.

6. Specific coupling problems

a) Blending (P. Riber)

Tests have started with ALADIN-France in a quasi-operational framework. Two long (15 days) summer and winter periods were covered, as well as some situations such as rising of local wind gusts (Autan). The sensitivity to an extra digital filter initialization (with variants) was also investigated : no, standard with a rather strong filter (stop-band edge period 3h), incremental or standard with a light filter (stop-band edge period 1h½). Final results show a small positive impact, as happened for the LACE model. However this was not considered worth introducing such deep changes in the operational suite.

b) Tendency coupling for surface pressure (J.M. Audoin, C. Moussy)

Porting and debugging tasks, once again as the reference source code was updated, followed by more sensitivity studies. No positive impact was noticed up to now.

7. Reformulation of the physics-dynamics interface

a) Sensitivity of physics to time-stepping (M. Jerczynski)

An analysis of the stability of physics and its relationship with the advection scheme started, focusing on the gravity wave drag parameterisation first. Several configurations were tested, with the physics reduced to this sole scheme : two-time-level and three-time-level semi-Lagrangian advection, computation of physical tendencies at various points of the trajectory (departure, final, "average"). The impact of the internal safety locks against linear and nonlinear instabilities were checked, as well as that of the specific tuning parameter of the parameterisation (GWDSE).

It appears necessary to keep the safety lock against nonlinear instability, while the location of physical computations within the time-step is not important in this case.

b) Solving some unstability problems in the physics (D. Banciu, J.F. Geleyn)

The parameterisation of shallow convection was initially designed for a low-resolution model, and only conditionally stable due to a mixed explicit-implicit formulation. Indeed problems appeared as the vertical resolution increased and the time-step decreased. This was solved through an implicit formulation of the contribution of shallow convection to the vertical exchange coefficients, the "classical" part keeping unchanged (still computed explicitly). This has a drastic positive impact, described in the joint paper on recent changes in ARPEGE physics.

8. Adaptation of physics to higher resolution

a) Resolution and the description of subgrid-scale convective precipitations
(S. Sbii, E. Bazile, F. Bouyssel, J.F. Geleyn)

A test-bed was designed to evaluate the impact of horizontal resolution and time-step on the behaviour of physical parameterisations. It includes 4 identical ALADIN domains, covering France, at increasing resolutions, i.e. with mesh-sizes of 20 km, 15 km, 10 km and 5 km respectively. Initial and boundary conditions are the same. The impact of the horizontal resolution and of the time-step (usually decreasing with the mesh-size) may be uncoupled performing experiments with the minimum time-step (that corresponding to 5 km).

The first investigations concerned the partition between large-scale and subgrid scale precipitations, focusing on a well-documented situation with floods in Southern France (8th of September, 2002). A former change, moving from an explicit modulation with resolution of the moisture convergence used as input to the deep-convection scheme to a mixed implicit-explicit one (with a preliminary elimination of the large-scale precipitation contribution), was proved to be reconsidered.

Experiments clearly confirmed the problem : with the operational formulation, as the mesh-size or the time-step increase, resolved precipitations increased significantly, while unresolved ones did not decrease in similar proportions, slightly increasing. This led to an overall very large increase in the total precipitations, indicating an excessive dependency of rainfalls on horizontal resolution. The behaviour of various contributions was analysed. For instance, a positive impact of the stabilization of the shallow-convection scheme (see 7b) was exhibited, with smoother (and more sensible) variations on the vertical.

Research around this problem led to go back to the initial explicit formulation, with a strong retuning however, while improving the internal consistency of the deep-convection scheme : full balance between convective and turbulent fluxes, additional safety constraints.

b) Improved representation of the boundary layer (many persons !)

Important progress was achieved in two directions : the stability of the involved parameterisations was improved; the previous refinements and tunings (concerning mainly stable cases) were deeply reconsidered. Changes are described in the paper on recent changes in physics and in the PhD report of André Simon.

c) Improved representation of orographic effects

(M. Rousseva, Y. Wang, E. Bazile, B. Catry, J.F. Geleyn)

The formulation of the thermal roughness length was revised. Up to now, it is fixed to one tenth of that for momentum, according to a former study. However not only the impact of vegetation and urbanisation is taken into account, but also that of mountains. This is quite convenient for momentum, but not for the formulation of heat and water fluxes near the surface. The impact of a simple modification, i.e. not considering the orographic contribution in the computation of the thermal roughness length, was evaluated. Two sets of 10 96-h forecasts, on a summer and a winter cases, were performed. As expected, latent and sensible heat fluxes are modified, as well as the diurnal cycle of surface temperature (higher maxima), especially over desert or mountainous areas. However, the overall impact, on scores against observations or on global budgets, is very small.

The impact on precipitations (too much upslope) of the "envelope" orography was investigated in ALADIN-Vienna, after that of some other parameterisations. A strong retuning started, going to the so-called "semi-envelope" to keep part of the blocking effect without increasing height so much. This experiment underlined how much such refinements depend on the model (extension, resolution, location).

See also the ALATNET report for Bruxelles.

9. Design of new physical parameterisations

a) Implementation of a new parameterisation of turbulence (J.M. Piriou, P. Marquet)

A prognostic "Turbulent Kinetic Energy" (TKE) scheme has been implemented in the vertical 1d version of ARPEGE/ALADIN, and interfaced with EUROCS datasets, for a preliminary evaluation before more in-depth adaptations for use in the 3d model. The first simulations, on a dry desert case, provided encouraging results.

b) Refinements in the parameterisations of radiation and cloudiness

(H. Toth, Y. Bouteloup, J.F. Geleyn, J.M. Piriou, F. Bouyssel)

Work on radiation started on two directions along the last 6 months. First the previous (6 years old) developments aiming at an exact computation of radiative exchanges with the surface (EWS) were tested once again, for longer forecast ranges and in data assimilation mode, and proved to bring significant improvements. Second a longer-term study started, aiming at first identifying the most critical / detrimental assumptions in the present scheme, then going to a more sophisticated but still cheap parameterisation. A paper dedicated to the developments in this domain along the last year is published in the present Newsletter.

The main drawbacks of the former operational physics : not enough low-level clouds at mid-latitudes and high-level ones in the Tropics, were solved by the combination of two changes :

- an improved consistency between cloudiness and condensed water, using diagnostic liquid water and ice as input to the Xu-Randall scheme (which previously proved quite efficient in the prediction of marine stratocumulus),
- an improved consistency between cloudiness and precipitations, through a modified description of the involved large-scale processes.

Careful retunings ensured that the cyclogenetic activity of the model (whose stability is strongly influence by low-level cloudiness) keeps close to that of the atmosphere. Changes are drastic, as described in the joint paper on physics.

c) Test of new parameterisations (Y. Bouteloup, P. Marquet)

The physics of the climate version of the ARPEGE model was tested in NWP mode, in the global model only. The main differences lie in the more sophisticated description of radiation, the use of a TKE scheme, a "statistical" description of cloudiness, another parameterisation of precipitations. This package does not lead to better results (scores, global budgets, ...) than the physics tested at the beginning of 2003, but the comparison fostered many improvements in the ARPEGE/ALADIN parameterisations set.

10. Use of new observations

a) Quality control and selection of observations for a mesoscale LAM

First the ALADIN specific features for the selection of observations are now available in an official library, as well as the adaptations required to use raw radiances (mainly including surface temperature in the 3d-var control variable for ALADIN). Second Z. Sahlaoui, R. Randriamampianina and E. Gérard designed a tool to eliminate the bias of raw ATOVS data for a limited-area model (LAM), using statistics of the distance between model and observations. The whole pre-processing suite for observations in ALADIN is described in the joint paper by R. Randriamampianina.

b) More extensive and accurate use of conventional observations (P. Moll)

Feasibility analyses, developments and impact studies (in the global model) were performed for the following innovations :

- improved use of radiosonde data (considering temperature rather than geopotential observations),
- use of wind-profilers data.

These studies should be completed by experiments in ALADIN, delayed until a version of 3d-var is operational.

c) Use of satellite data

The major step forward was performed by enabling the use of raw radiances. See also the paper by T. Montmerle.

11. 3D-Var analysis and variational applications

a) Description of background error statistics (F. Hdidou, C. Fischer, V. Guidard, L. Berre)

The standard and lagged background error statistics have been computed for the ALADIN/NORAF domain. A set of 95 days of 36 minus 12 hour forecasts (the latter using the same boundary conditions as the 36 hour integrations) was used to sample the error statistics based on the NMC method. The structure functions show very similar structures when compared with ALADIN/FRANCE or ALADIN/LACE. The most significant difference is for the T/Divu and q/Divu couplings, where the error variance is dominated by the large scales in the NORAF domain, while this signal usually is stronger at small scales. We propose that this particular result is linked to the Hadley cell circulation, which is rather well inserted in the NORAF domain.

A specific work was done in order to allow for some "gridpoint flavour" inside the Jb structure functions. An in-depth investigation of the gridpoint correlation functions derived from the ALADIN/FRANCE spectral Jb suggested that the use of compactly supported correlation functions could force more local analysis increments, and benefit more from the mesoscale nature of the lagged Jb. The implementation of compact supports was worked out by systematic bi-Fourier transforms forth and back, and application of a mask. The alternative approach, by 1d Bessel transforms, is not tractable since it requires to store both 1st and 2nd order Bessel functions, and a precise number of periods of zeros of the Bessel basis along the gridpoint axis.

b) Investigation of the problems related to biperiodicity (C. Fischer, L. Berre, V. Guidard)

Recent results have stressed that the biperiodic formulation of the variational analysis increments still causes some undesired, if not unrealistic, features in 3d-var :

- analysis of biased satellite data strips causes a spurious increment over the full domain (as noticed by Roger Randriamampianina),
- analysis of bands of observations also causes unrealistic large-scale increments, and increments that wrap around the extension zone,
- there is around 5 to 10 % of energy in a single-observation increment which spreads throughout the full domain.

Several solutions have been proposed so far, some being investigated and others not so far (but perhaps needed in the last extreme) :

+ compact support for correlation structures : The code is ready, but the compact support cannot force a full analysis increment to be compact on the ALADIN torus. The use of this method probably must be coupled with some other ingredient.
+ modification of the spectral shape of the power spectra : An ad-hoc modification does not make sense. Moreover, compact support already performs a modification of the power spectra, in a way which is consistent with a spectral convolution.
+ force background error variances to be almost zero in a rim zone around the extension zone : This technique has some impact, but it is limited at least by the very short width of the usual ALADIN extension (E) zones (roughly 10 times the mesh-size).
+ an indirect benefit from the off-diagonal B-matrix terms, as proposed by Simona Stefanescu and Loïk Berre, could also help to distinguish the E-zone in the structure functions.
+ larger E-zones (with a longer physical lengths) : although the increase of the E-zone requires some careful technical overview, it is not impossible that some of the possible solutions listed above only really work when the E-zone is more significantly increased, with respect to the typical length-scales of the correlations

c) Intensive scientific validation (V. Guidard, C. Fischer)

Further work on the MAP IOP14 situation was achieved. See the "ALADIN PhD studies" part.

d) Cycling strategy (F. Hdidou, C. Fischer)

The definition of an assimilation suite for the ALADIN-NORAF model started, based on Blendvar (a combination of spectral DFI-blending and 3d-var analysis). Beside the computation and evaluation of background error statistics, the resolution of the intermediate grid (for the filtering of the large-scale analysis increments provided by the coupling model, ARPEGE) was defined. An "assimilation" suite based on blending only, was launched over the whole month of November 2001, and compared both to ARPEGE and the present assimilation suite for ALADIN-Morocco.

e) A-posteriori evaluation of assimilation schemes using variational tools (W. Sadiki, C. Fischer)

See the "ALADIN PhD studies" part.

12. 4d-var assimilation *(C. Fischer, V. Guidard)*

The implementation of 3d-FGAT (First Guess at Appropriate Time) in ALADIN started. 4d-screening, where the distance between the forecast and the observations is computed at the observation time, no longer assuming that all observations are valid at the middle of the assimilation window, is ready. But the corresponding changes in the minimization process were not addressed, since it appeared necessary to focus first on the shape of analysis increments and the problems related to biperiodicity.

2. In Bruxelles

1. Coupling problems (topics 5 & 6)

a) Time-interpolation of coupling data (Piet Termonia)

The work on the "quality control" of coupling frequency was pursued. A paper presenting all the ideas around the "acceleration term", entitled "Monitoring and Improving the Temporal Interpolation of Lateral-Boundary Coupling Data for Limited-Area Models", was accepted to *Monthly Weather Review.*

During a 2-months stay in Budapest, last summer, a method was developed, to quantify the corruption of the spectrum due to the temporal interpolation of coupling data. A paper on this topic should be ready soon.

b) Well-posed lateral boundary conditions (Chantal Moussy, Piet Termonia)

The idea is to resume the work of Aidan Mc Donald, who is studying the problem of "transparent" boundary conditions and searching for an alternative to the Davies' relaxation scheme for some years in the (gridpoint) HIRLAM model.

To start with, the results of Mc Donald (2002) will be tested in a simple 2d (barotropic) version of ALADIN. The last months were therefore devoted to bibliography and the setup of the experimental framework, which is now ready. A program was built from some ALADIN elements, allowing to choose the LAM domain, change the geometry, define "normal modes" (an option not present in the model), so as to enable a prescription of lateral boundary conditions.

Reference :

Mc Donald, A., 2002 : A Step Toward Transparent Boundary Conditions for Meteorological Models, *Mon. Wea. Rev.*, **130**, 140-151

2. Reformulation of the physics-dynamics interface (topic 7, Ilian Gospodinov)

The dedicated Post-Doc stay is now finished, and a description of the corresponding results is expected for the next Newsletter.

3. Refinements in physical parameterisations (topics 8 & 9)

a) Introduction of prognostic cloud water in a refined convection scheme (Luc Gerard)

Developments aimed at a more coherent treatment of cloud water and convection at high resolution. The work included bibliographies and testing several possible hypotheses and paths for parameterisation.

The following steps were achieved in 2002:

➤ Adaptation of the cloud-water scheme developed by Philippe Lopez to the ALADIN context, with personal contributions in separating 2 prognostic cloud-phases and changing the precipitation content from a prognostic to a pseudo-historic variable. It required also restructuring the interface routine to the physics (*aplpar*). The code, based on cycle AL15, and documentation were made available to ALADIN partners.

➤ Porting the previously developed prognostic convection scheme (Gerard, 2001) to cycle AL15. This brought particular difficulties : the introduction of new prognostic variables implies wide adaptations, and the lack of documentation and of "debugging-friendliness" of some codings makes the things worse. These could only be solved with the arrival of a more powerful PC in August 2002.

➤ Raw combination of the prognostic convection and the prognostic cloud-water schemes (without adaptation of some contradictory hypotheses)

➤ Development of a new treatment of convection, compatible with the presence of cloud water, and implying the separation of updraught and downdraught calculations, with the microphysics computations in-between. Many different ideas were developed and tested, and the first viable solutions emerged in early 2003.

b) Improved representation of boundary layer, based on a parameterization of Turbulent Kinetic energy (Martin Gera)

The work is described in the ALATNET reports from Young Researchers.

c) Improved representation of orographic effects (Bart Catry)

The following text covers the work performed both in Belgium and during the stay in Toulouse.

Our main problem for the subgrid scale orographic forcing at high resolution and in the lower part of the atmosphere is currently the following : not only is such a forcing highly nonlinear and multiform (roughness effect on PBL, form-drag, lift, blocking effect of barriers), in the model as in nature, but it also does not scale correctly when the horizontal resolution is modified. Said differently, between runs at different resolutions what changes in the parameterized forcing is not the mirror image of what is taken over by the resolved dynamics that "sees" further details of the orography. This result, unknown at larger scales from the little results we have there, is confirmed by a wealth of tests. Bart Catry is trying to find the reasons of this odd behaviour of ALADIN in a novel way : using the ALPIA semi-academic environment he wants to reproduce the problem in a model without baroclinic forcing and encompassing only dynamics, turbulence and drag, on a variety of mesh-sizes and for a domain encompassing the strongest slopes of the Alpine region at the 10 km scale.

<u>4. 3D-Var analysis and variational applications</u> (topic 11) : Wavelet representation of background error covariances (Alex Deckmyn)

First of all, the Meyer wavelet transform, which in general is only valid when the number of gridpoints in each direction is a power of 2, was generalized to (any) non-dyadic configuration, which allows us to define the wavelet transform on any ALADIN domain. A paper entitled "On orthogonal Wavelet transforms with variable dilation factor" was submitted to *Applied and Computational Harmonic Analysis.*

Another problem was that the variance was too much concentrated around a few points of the large-scale grid. This was partially solved by keeping the variance in gridpoint space and (effectively) working with a wavelet representation of correlations instead of covariances. This improves the representation a lot, but the shape of structure functions is still slightly skewed towards points of the large-scale grid.

Further studies addressed the local (horizontal) correlation length at different levels. A diagonal-B matrix in wavelet space is able to represent the local variations in correlation length quite well although there is an underestimation in absolute values.

3. In Prague

<u>1 Theoretical aspects of non-hydrostatism</u>

1a) Top and bottom boundary conditions *(C. Smith)*

In the second half of 2002 the so-called *w* scheme was phased into the main trunk of the ALADIN library. This *w* scheme means that vertical wind *w* (*dz/dt*) is advected in case of the semi-Lagrangian scheme and not the vertical divergence type of variables (derived $\partial w/\partial \eta$ quantities). As it was mentioned in the previous newsletter, this scheme solves the problem of spurious standing wave above the mountains when the semi-Lagrangian scheme is used. This wave is well noticeable both in the 2d (mountain wave) and 3d (SCANIA/ALPIA type) academic experiments. However, the *w* scheme is technically difficult to maintain due to the advection of half-level quantity *w*. Even worse drawback is the problem how to restitute tendencies for the vertical divergence variables (except the one where $\partial w/\partial \eta$ is simply scaled by quantities constant in time) from the *w* tendencies.

Since the research stay of C. Smith has finished and since this topic is very important in the research plan, the following of this work is mainly taken by P. Smolikova and R. Brozkova.

Further research will go along two main lines: **i)** investigation of the true diagnostic formulation of the cinematic bottom boundary condition as reporting from the w scheme to the pseudo-vertical divergence scheme; **ii)** investigation of possible source term problem in case of the pseudo-vertical divergence scheme.

1b) Predictor-Corrector scheme *(J. Vivoda)*

The Predictor-Corrector (PC) scheme for two-time-level semi-Lagrangian non-hydrostatic ALADIN is phased and working for almost all options in the library cycle CY25T2. It is not yet fully harmonised with the ECMWF PC hydrostatic scheme.

In order to increase the stability of the scheme, an investigation was made for a non-isothermal reference profile. The results are mitigated: while one could intuitively expect a better stability thanks to the diminished amplitude of the linear residuals, there is not much gain observed in the experiments. Another subject was to look also to the problem of the computation of pseudo-divergence tendencies (see a contribution in this Newsletter).

1c) Test of new prognostic variables *(J. Masek)*

This work was mainly done in the first half of 2002 and was reported in the previous Newsletter. Recently, however, a bug was found in the coding of sponge which was used for these academic experiments on mountain waves. Some tests were rerun with a correct sponge code. The bug improved results for the variables *d4* and *d5* which were those affected by the error. Now then seems that *d4* variable is a best candidate to be retained as a basic option.

1d) Clean introduction of the prognostic variable d4 *(P. Smolikova)*

A clean introduction of the *d4* variable was technically quite difficult task due to the necessary introduction of a pseudo prognostic spectral variable needed for the computation of horizontal derivatives. This additional variable is simply diagnosed within the gridpoint computations and needs to be biperiodicised before getting transformed to the spectral space. Due to the fact that the externalisation of the biperiodicising operator has not yet been done, one part of it was dropped when used here in order to avoid additional transpositions of data on the processors. The extension in the x-direction is made still in the gridpoint space while the one in y-direction is applied on

Fourier coefficients (before the y-direction transform). The transversal smoothing is the skipped part.

The code of *d4* was first validated for 2d vertical plane model and also for 3d model. It is phased with the PC scheme in a working branch of CY25T2 and this branch will be introduced in CY26. The tests were made for the PYREX case and compared to the results obtained with the *d3* variable. It was shown that the *d4* variable provides better stability. More details can be seen in a contribution on this topic.

(Note: trapped lee wave experiments in 2d (Bouttier) and in 3d (Geleyn, Brozkova) should be reported by Toulouse)

2. Data assimilation related issues

2.a) Comparison of data assimilation, blending and Blendvar *(G. Boloni, R. Brozkova)*

This work was a continuation of the 3d-var cycling experiments including the Digital Filter (DF) blending. An experiment was set up in order to assess the relative performance of each ingredient of the system, starting by the dynamical adaptation, then adding the DF-blending and then 3d-var analysis (in Blendvar configuration). The dynamical adaptation technique did not use any observations, while for the next step of the DF-blending a surface OI analysis was performed (configuration DF-blending and surface CANARI, known as Blendcan) and in the next step the DF-blending was topped by the 3d-var analysis using the lagged background error statistics (configuration Blendvar). The observations used inside the analysis were the conventional observations used already by ARPEGE. This time there was not a special case study but a short like parallel suite was run and the classical scores were looked at. We can say that the scores of all the three experiments were not significantly different from each other and that the signal they contained was rather week. When making the relative comparison, we can say that each step brought some improvement. First, when looking to the dynamical adaptation and Blendcan, then we could notice an improvement in some scores up to 24h forecast range in case of Blendcan. Then, when adding the 3d-var step, there was another little improvement, certainly at the initial time when the fit to observations is ensured by the analysis. For the following ranges there was a relatively weaker improvement compared to the pair of the dynamical adaptation versus Blendcan noticeable only up to 12h range. We may conclude that this experiment gave expected results and also that the weak signal in the scores shows once more that we get only little information out of them on the behaviour of the schemes. The scores serve us as an indicator, but their should not be used blindly.

2.b) Test of the variance coefficient in nested 3d-var *(G. Boloni)*

When the lagged statistics are computed for a nested and quite small domain (of about 1200km large), the resulting background error variance is quite small, even in comparison to the one computed for the larger domain by the same method. The LACE domain and the Hungarian domain (nested in and coupled with ALADIN/LACE) were used for this computation. The goal of a little study was to examine how the potential increase of this variance by the multiplication coefficient (usually taken as 0.9 but here bigger than 1.0) influences the analysis results. Three small suites were cycled, the first one with the coefficient equal to 1.0, the second one with the increased coefficients of 2.6 and the third one was using the standard background errors matrix with a default coefficient. No suite was using blending (any kind), since this technique was not developed for the nested domain. The result was a bit surprising, since there was only a little sensitivity to the tested options. First, the vertical velocities at the initial time were examined at the level of 500 hPa. When using the lagged statistics, they were weaker than in the standard case, due to the absence of blending. But they were not much different, even in the amplitudes, when using the value of 1.0 or 2.6 to multiply the variances. The vertical velocities in the standard experiment were stronger and having a bit different structure. It should be noted that also the scores were looked at again, and that there was almost no difference for the three suites after the range of 12 hours. This experiment simply shows that the strategy to be chosen for an analysis at quite small domains is not obvious, since the role of the lateral boundary conditions is here even more important.

2.c) 3d-var analysis of screen-level humidity *(L. Gaytandjieva, M. Jurasek, R. Brozkova)*

In spring 2002 the operational application of ALADIN/LACE was switched to the 37 vertical levels. Consequently, the background error statistics for 37 levels were computed. They were computed both by the standard method (to be able to make comparisons) and also by the lagged method. Then the experiments were made to assimilate screen level humidity. As a first exercise, a single observation experiment was made, where the increments were looked at for humidity and temperature (the humidity is coupled to the other variables in the Jb term). The single observation experiments were using a negative increment in relative humidity of 41%, the observation was put nearby a middle of the domain. The resulting increments in relative humidity and temperature for both the standard and lagged statistics are shown on Figure 1.

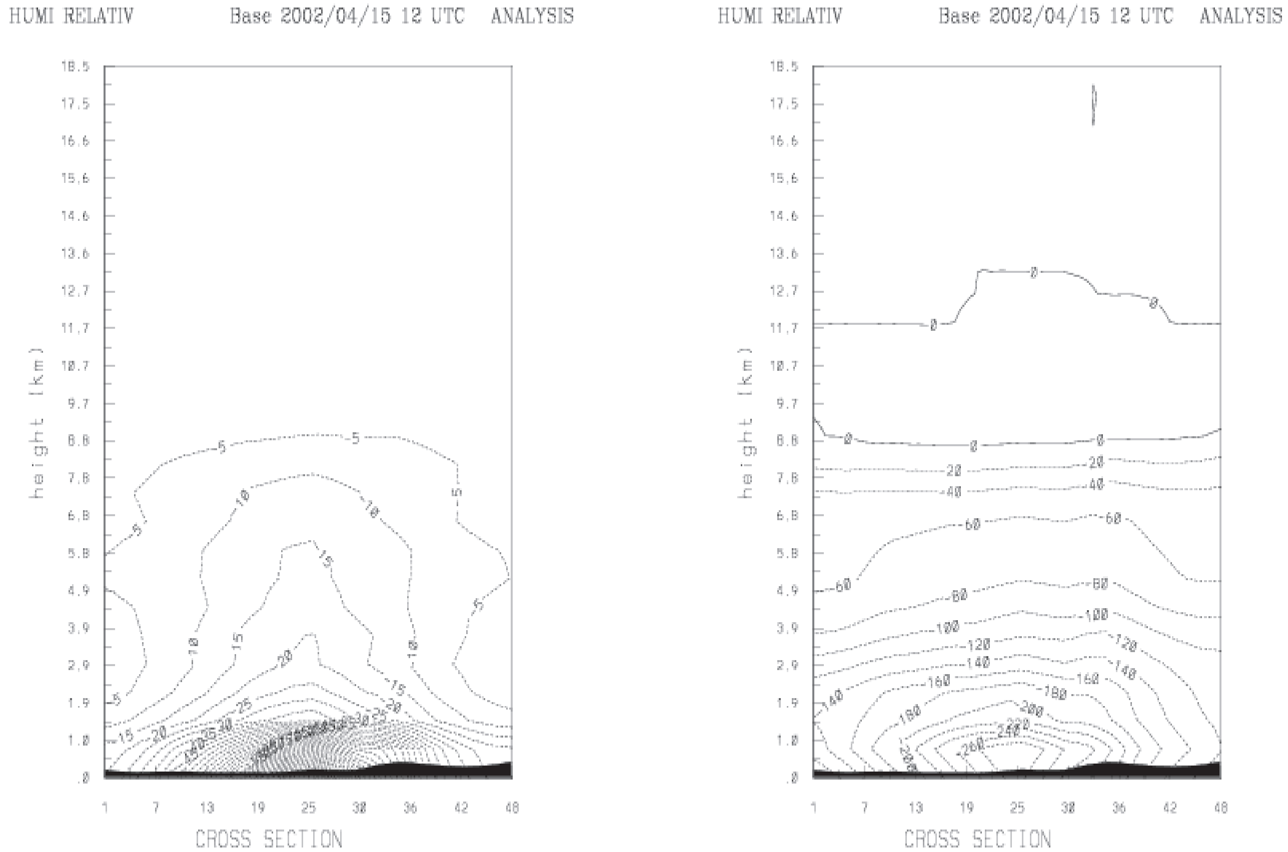


Figure 1: *Vertical cross-sections of the relative humidity increments. The values are in % multiplied by the scaling factor of 10. The case of the standard statistics is shown on the left (contour interval 20), the case of the lagged statistics is shown on the right (contour interval 5).*

The shape and amplitude of increments show that in case of the lagged statistics the impact of the observation is more local, both in vertical and horizontal directions. This is a desirable feature, since the screen level observations should not influence higher model levels too much, and also they should not have too wide horizontal impact. In vertical, a reasonable demand is that the increments become negligible at about 3km height. At this height the increments are around 14% in case of the standard statistics, which is certainly too much, while it is about 2% in case of the lagged statistics. At the height of 1,5 km (top of PBL), the increments are about 24% in the standard case while only 3,5 % in the lagged case. We may than hope that in case of the lagged Jb the increments will remain meteorologically reasonable.

Then some full observation experiments were performed, when assimilating either the humidity observations only, or assimilating also the other usually assimilated observations (from the conventional TEMP and SYNOP types). Again, both standard and lagged statistics were used, but this time the lagged Jb was used together with the digital filter blending, since these were real case studies. The results were similar to those obtained with a single observations, but the increments are a bit stronger. In the standard case the temperature increments are non negligible in the whole depth of the atmosphere (with the amplitude of 0.6K at the model level number 10). Their biperiodic feature can be easily checked. The standard Jb in its current formulation is unusable. The lagged Jb case is less catastrophic: the biperiodicity of increments is still visible, since it is an intrinsic feature of the current spectral Jb, but the amplitudes are much smaller (for temperature about 0.05 K at the model level number 10). However, according to the shape of the temperature-humidity cross-covariances, we can see in both cases maybe not very physical change of sign of the increments in the vertical. It is then questionable, whether it would be safer to decouple the temperature and humidity in the Jb term. Finally, a short assimilation cycle was run when assimilating only the relative humidity screen data. The results were not yet evaluated.

3. Horizontal diffusion related issues

Tuning of the Semi Lagrangian Horizontal Diffusion (SLHD) scheme *(R. Glavac-Sah, F. Vana)*

In the first part of study the scale and time-step dependence of the SLHD scheme has been tested. The four different domains covering the geographic area of the ALADIN/LACE domain were defined with resolutions of around 17, 15, 12 and 9 km. As a first step the mesh dependence of the current spectral HD scheme was investigated in order to re-validate the commonly used convention and to have an estimation of acceptance for the scale dependency of a horizontal diffusion scheme.

Then the SLHD scheme was tested with intention to define the two scale dependent tuning parameters (P1 and P2). It was found that the scale dependency of the scheme really exists but is of very low magnitude. When just P1 was adjusted (the finer refinement P2 is not really needed), the SLHD scheme became completely scale independent, i.e. far better than the spectral HD.

Next step will just to verify the expected independent performance of the SLHD with respect to the chosen time-step. Then the scheme will be tested on very high resolution simulation (2.5 km of horizontal mesh) where the nonlinearity of it becomes to play an important role.

4. Interface physics-dynamics related issues

4.a) Linear and nonlinear instability tests for physics package *(M. Tudor)*

The stability or 'stiffness' tests were made for various parameterizations, using ARPEGE global model. Each tested scheme used a halved length of the usual time-step and then the time-oscillations were examined between the reference and the test solutions. It was shown that the parameterization of the large scale rain (*acpluie*) suffers from the fibrillations (par example around the Bering Strait and also in the Baltics for the chosen date).

Another test was made to check for a nonlinear instability, when the pressure thickness of model layers was increased or decreased by about 10% in the tested schemes. While decreasing the pressure thickness did not show any significant change, the convection routines (*accvimp* and *accvimpd*) make the model blow depending on the degree of increasing the pressure thickness of layers.

4.b) Changes in the subgrid-scale orographic gravity wave drag representation *(D. Drvar)*

The aim of this study was to try to replace the effect of the envelope orography by a better and more accurate parameterisations of the effect of mountain drag. Altogether, four changes are needed: to release the use of envelope orography, to activate the orographic lift, to decrease the low level drag and to increase the aspect ratio coefficient at the surface. Case study tests were made first, for which the cases were carefully chosen with a strong large scale flow in the Alpine area. In comparison to the reference the tested solutions were looking a bit more realistic and closer to the observations (at least for rain and surface winds). Although it would be a bit dangerous to conclude on these few cases, the proposed changes seem quite promising: the obtained results encourage further testing, maybe in a parallel suite.

4.c) Tests of the δm term in the mass conservation control *(A. Trojakova, P. Smolikova)*

Since a long time there is a sleeping option in the ARPEGE/ALADIN code, with a working notation δm term. This term enables to take into account the mass of water taken out of the atmosphere by the precipitation flux, compensated by the evaporation flux in the budget. In the past some tests were performed but without any real conclusion (there was hardly any sensitivity to this term) for NWP model (the climate version is using δm). Recently, tests were made in ALADIN using two cases of tropical cyclones in Indian Ocean. This extreme phenomenon was chosen on purpose: if the term has some effects, then it has to show here, otherwise it can be considered as negligible for NWP forecasts. The performed experiments has shown some differences in the forecasts; the activation of this δm term lead in general to a bit deeper cyclone and more precipitation. On the other hand it cannot be said that these results are better and more validation effort is needed. The work on this topic was initiated by the training course on ARPEGE/ALADIN physics (Prague, 16/09-04/10/2002) and shared with the department on tropical cyclones research in the Réunion island.

5. Physics related issues

5.a) Radiation scheme tuning *(H. Toth)*

This work is in fact a continuity of the experiments made already last year. The long-wave radiation fluxes computed by the operational radiation scheme were compared to results of a comprehensive but quite expensive scheme (this time a scheme developed at DWD was used for the expensive reference). A trial was made to change the absorption interval and/or optical depth of three gases (water vapour, carbon dioxide and ozone) in order to fit better the reference flux profiles. The comparison was evaluated for something like 400 profiles, representing patterns from around the Earth, but the statistics did not show any significant improvement. When looking to the vertical shape of the profiles, it turned out that for some tunings we may obtain a nice fit to the reference in the lower atmosphere while a divergence occurs nearby the tropopause, for example. This explains that no real improvement was seen in the whole statistics. It shows also that a simple tuning cannot improve the deficiencies observed in the currently used scheme. See also the paper on radiation.

5.b) Tests of the prognostic convection scheme *(S. Greilberger, T. Haiden)*

Some case studies were conducted using the prognostic convection scheme, developed by Luc Gerard. This study was a continuation of the previous effort. Here some more convective cases were added and the prognostic convection scheme was tested as well for the flood period in Central Europe. The results of precipitation forecasts were compared to the operational version (CYCORA BIS). The conclusion is that the prognostic convection scheme provides in general more realistic results and this was true for all six convective cases which were studied. In general, the amount of precipitation is decreased in case of the prognostic convection scheme and often these forecasts are closer to observations. On the other hand it does not help for some cases of unrealistic early morning convection. For the flood cases we may say that the prognostic convection scheme provides the same quality as the operational scheme and that there is no significant difference.

4. In Budapest

The most important ALADIN-related activities at the Hungarian Meteorological Service are concentrating on the scientific topics defined in the ALATNET research plan. Our Service is active in the following ALATNET sub-topics (in parenthesis the topic number refers to the ALATNET research plan) : coupling and high resolution modes (topic 5), specific coupling problems (topic 6), design of new physical parameterisations (topic 9), use of new observations (topic 10), 3d-var analysis and variational applications (topic 11).

Hereafter the main activities in these subtopics will be briefly described.

5. Coupling and high resolution modes

Piet Termonia from the Belgian Meteorological Institute was invited for a two-months stay in Budapest to work together with Gabor Radnoti on the coupling problem of the ALADIN model with special emphasis on such meteorological situations, where the evolving meteorological objects are passing very fast through the boundary relaxation zone making extremely difficult their consideration through the lateral boundaries of the limited area models. Piet Termonia was trying to find an alternative description of the fast propagating waves taking into account the lessons learned from the 1999 Xmas storms. The cornerstone of his idea is the decomposition of the model state variables into moving and growing parts. After this decomposition a spectral transformation is performed, and a functional is derived and minimised in order to ensure the best fit to the real data. The basic conclusion of his work that it is very difficult to find a new formulation for the temporal interpolation needed for the consideration of LBC information at every time-step, however a diagnostic tool can be developed, which provides the necessary lateral boundary frequency to be used in the given situation (it means a dynamic approach, where according to the meteorological situation always the sufficient boundary conditions are used for the limited area model). See more details about the work of Piet elsewhere in this Newsletter.

The development of the spectral coupling scheme had been continued in Ljubljana and close information exchange was ensured between the two centres regarding the latest progresses in this field.

6. Specific coupling problems

The investigations of the coupling problems in relation with the three-dimensional variational data assimilation (3d-var) scheme had been continued. Different schemes were tried and tested: space consistency (where the initial information is in agreement with the first boundary information, therefore the LBC information is consistent in space), time consistency (where the initial information and the first boundary information is different and the lateral boundary information are coming from the same model run, therefore the boundary information is consistent in time), Moroccan solution (where the first two boundary files for the cycling are analysis fields, therefore always the most exact possible boundary information is imposed). The investigations confirmed that in spite of the small differences between the performance of the three schemes the best strategy is probably the solution proposed in Morocco, where the boundary condition files are always coming from analyses fields.

The blending assimilation cycle was systematically compared with the "Blendvar" solution (see more details at topic 11).

9. Design of new physical parameterisations

The involvement of the Hungarian Meteorological Service in the field of physical parameterisations is increased in 2002 with the employment of a new physicists in the NWP team. The first activities of this new colleague was concerning the training on the physical parameterisation packages of the ALADIN model. Then a 3 weeks training course (organised in Prague) further supplemented his knowledge on the problems related to parameterisations. During and after this training action a small exercise was studied: the parameterisation of roughness length ratio. The problem is related to the fact that the ratio of the momentum and heat roughness length depends on the friction velocity and this dependency is not taken into account in the model (especially areas over land and sea ice are considered).

Some further activities were performed around the radiation scheme of the ALADIN model. The main weaknesses of the recent radiation scheme was identified and a strategy was adopted to test their improvements. For studying the tuning possibilities of the ALADIN radiation scheme (where single spectral interval is used for the mean characterisation of the absorption properties) a new scheme (GRAALS a German radiation scheme) was implemented for the Single Column Model version of the ALADIN model. This scheme was considered as a reference one for the comparison. The ALADIN radiation scheme is tried to be tuned in such a way, where the results of the scheme (radiative flux-divergence profiles) are approaching to the solution of the GRAALS scheme. Unfortunately this exercise didn't bring sufficiently satisfactory results showing that the tuning of the ALADIN radiation scheme is not a trivial task in case of the usage of single spectral interval for absorption properties.

In the future it is planned to extend our activities for the problem of dynamic-physics interface (topic 7) and to the study of the prognostic cloud scheme (liquid water and ice as prognostic variable) beside some further work on the radiation scheme of the model.

10. Use of new observations

It is of great importance to use new observations into the 3d-var data assimilation scheme and it is especially true for the scheme applied at the Hungarian Meteorological Service, where only SYNOP (surface) and TEMP (upperair) measurements are used. Due to the limited spatial resolution of the radiosonde network the enhancement of the upperair description of the atmosphere is highly desirable for the further improvements of the performance of the scheme. The applicability of two new information sources is investigated: locally received ATOVS data and AMDAR aircraft data. Regarding ATOVS data there is significant progress achieved (see the detailed report of Roger Randriamampianina in this Newsletter) and the scheme is ready for impact studies. Regarding measurements from the taking off and landing aircrafts (AMDAR data) until now only technical achievements were performed, therefore new results are to be expected during 2003. More distinct plan is the work on radar data, this activity is planned to be started during 2003.

11. 3d-var analysis and variational applications

This topic is the most important one for the Hungarian Meteorological Service in the framework of the ALATNET project.

Our ALATNET fellow Steluta Alexandru continued her work with her second 7 month stay in Budapest working on the "Scientific strategy for the implementation of a 3d-var data assimilation scheme for a double nested limited area model". The more detailed report of Steluta can be also found in this Newsletter.

A systematic comparison study was performed in order to study the general performance of the blending suite with respect to dynamical adaptation, Blendvar and Varblend experiments. The main emphasis was put on studying whether the 3d-var scheme executing after the blending procedure brings additional benefits or not. According to the results an additional improvement on the top of blending is noticeable until the first 12 hours of the integration, however in the longer ranges this gain is lost, which means that there is a mesoscale signal present in the available observations, however their effect can be maintained only until maximum 12 hours. Probably the impacts of lateral boundary conditions are overwhelming the solution afterwards, therefore there is a need of improvements of the applied tools in order to preserve the improvements all along the short range integration.

The work started on the background error statistics had been continued with a further study of the double nested aspects of the background error covariance matrices. It was found that for the

ALADIN/HU double-nested model due to the small resolution ratio between the coupled and coupling models the lateral boundaries are dominating on the forecasts, i.e. the lagged method cannot be efficiently used in such case (the decrease in variance is too high resulting too small increments in the analyses). An alternative solution was tried when the lagged background error statistics were tuned in order to compensate the variance reduction with a multiplication factor (REDNMC).

Important developments were concentrating on the application of the best possible strategy for the ALADIN/HU (in its new model domain) 3d-var data assimilation scheme. Also based on the experiments of Steluta Alexandru the final settings of the scheme had the following main characteristics:

-- First guess: the 6h forecast of the ALADIN/HU model (it is the classical and most straightforward choice).

-- Initialisation: digital filter initialisation in cycling and production.

-- Background error statistics: standard NMC method with 36h - 12h forecast differences.

-- Coupling strategy: the "Moroccan" solution is adopted, where the 6h boundary information is also an analyses (it is noted that for the cycling boundary update frequency is 6h, while in production it is 3h).

After the technical realisation of the options mentioned above a throughout study had been started in order to evaluate the performance of the scheme with respect to the dynamical adaptation (longer periods for general performance and some case studies for extreme behaviour are going to be studied). In the near future the emphasis will be put in the further development and tuning of the 3d-var scheme with special emphasis on new data sources as satellite and aircraft data.

A work had been initiated during the second part of 2002 in order to continue the work on sensitivity studies using the adjoint of the ALADIN model (this work is to be carried out by a university student and can be considered as the continuation of the work of Cornel Soci in the same field). Until now the basic tangent linear and adjoint tests were performed and the sensitivity configuration (with and without simplified physical parameterisations) are started to be tested. In the future sensitivity studies will be conducted in such meteorological situations, where the ALADIN model provided very poor forecasts and the causes of the poor forecasts are planned to be investigated with the adjoint tool.

5. In Ljubljana

The preparation activities for the ALATNET workshop on coupling started in December. A report from the workshop will be available in the next Newsletter.

Other ALATNET activities are covered in detail in the reports from Raluca Radu and Klaus Stadlbacher.