Final Report on the progress of the research at the CNRM/GMAP of Météo-France in the scope of the RESEAU FORMATION-RECHERCHE for five PhD students from countries of Central and Eastern Europe

(Prof. Joze RAKOVEC, done in Toulouse and in Ljubljana, in February 1999)

I have been nominated the external co-ordinator for the RESEAU FORMATION-RECHERCHE at the CNRM/GMAP of Météo-France, which started on 1st of February 1996 with the duration of 72 months (3 years). So the action formally finished on 31st of January this year. The aim of the action was to help the students from different countries of Central and Eastern Europe to perform their research at GMAP of CNRM of Mitio-France with the final goal to reach the PhD degree.

Different students joined to the action at different times. The first four in 1996: Doina Banciu (Romania) and Filip Vaña (Czech Rep.) on 15th of August 1996, Mark Zagar (Slovenia) on the 1st of October 1996, and Marta Janiskova (Slovakia) on the 1st of November 1996. With one year of delay also Ilian Gospodinov joined the research on the 15th of August 1997. They also had different support from the ministry, ranging from 10 to 16 months of scholarship for the stay in Toulouse. Some of them used all of the awarded scholarship, the other did not - due to objective reasons (Ilian Gospodinov was not able to use all the grant due to his late start), subjective (Mark Zagar, due to his duties at his institute in Slovenia, used from the beginning only a few months per year and so towards the end he was not able to use the whole grant), or other reasons (as Filip Vana was not able to use all of his grant due to administrative obstacles, two of "his" months were used by Doina Banciu). Altogether 72 months of schollarship were granted and 63 months were actually used. Beside these 63 months the researchers/students of course worked on their research subjects in their home countries as well.

In a function of the external co-ordinator I visited Toulouse for the first time in the period of 2-10 June 1997, after the first year and a half of the work (see my first report to the Ministère). Now, after next year and a half time this is my second visit: in the period 6-13 February1999.

After several discussions with the five PhD students (in meantime also Mr. Ilian Gospodinov from Bulgaria joined the team), and with some researchers of the staff of Météo-France with whom the students collaborate, I am giving this second report to the Ministère. In the first part is given a short report and an over-all opinion. In appendix the detailed description of the progress of four students is added.

Short report and results of the research of the five candidates

From my first report the group of four researchers, candidates for the PhD has increased for a new colleague: Mr. Ilian Gospodinov from Bulgaria joined the group and has started his research at Météo-France. On the other hand Miss Marta Janiskova has already prepared her thesis and has successfully defended it in Bratislava in the so-called "co-tutelle" arrangement. So is in the appendix the detailed description again given for four, and not for five candidates.

As mentioned: **Miss Marta Janiskova has** on 9th of November 1998 in Slovakia **successfully defended her thesis** "Realisation of a simplified, differentiable and realistic physical parameterisation for incremental four-dimensional variational data assimilation". The defence was organised by the Geofizikalny zstav Slovenskej akadimie vied in Bratislava, and, as her study was organised in the co-tutelle, she **will receive the PhD degree** from both universities: from the Comenius University of Bratislava and from L'Université Paul Sabatier in Toulouse. Her supervisors were: at Météo-France Mr. Jean-Noël Thépaut and Jean-François Geleyn, at Univ. Paul Sabatier Prof. Robert Rosset, and at Slovak Academy of Sciences Doc.

Ferdinand Hesek. Her research resulted in the development of the simplified package of the physical processes to be used in direct and in adjoint numerical models of the atmosphere. She tested the simplifications of several processes and has succeeded to find such, if possible linear; formulations which still offer results comparable to the full, non-simplified versions. She has formulated the processes also in numerical form and has inserted them into numerical models. The greatest achievement of her work is perhaps that she has found an efficient way to smooth the singularities (caused by the thresholds, the discontinuities, and the discontinuities of the derivatives of the functions describing the processes) to that extent, that these functions do not cause the model to experience strong shocks in the neighbourhood of the singularity points in the model's space. As the research and the study of Miss Janiskova resulted in the successful defence of the PhD thesis, it is not necessary to report here on further details and on a status and the plans of her future research work.

The other four candidates are at different stages of their research. But the common fact for all of them is that their scholarships by the ministry finish at the end of this month (Febr. 1999). As their plans originally did not consider this strict deadline, some of the scholarships will not be used. In spite of this all students will continue with the research according to their particular arrangements: some will still be able to stay in Toulouse under some other agreements of funding, others will continue with their research at home. All will continue with theoretical work, and to experiment with the models towards their respective aims: either using their home computing resources, or using communication means to reach the host computer in Toulouse. And what is most important - all have firm and realistic plans to bring their work towards the successful finish with PhD thesis and degree.

Ms. Doina Banciu has slightly modified her field of research, concentrating upon the processes connected with convective clouds and precipitation, and omitting the non-precipitation processes. She has almost finished with parameterisations and she is continuing in the field of explicit treatment of the cloud water with a separate equation of the model. It is reasonable to expect to finish with her PhD in the year 2000.

Mr. Ilian Gospodinov has proved with experiments that his and Spriridonov's new semi-Lagrangian and semi-implicit scheme works well, in some cases better than other schemes. He will continue with proper numerical formulation of the terms representing forces, and with the influence of orography in the model. After performing extensive and essential tests he will reach to the phase of finishing a relatively complete, selfstanding thematic. Mr. Gospodinov plans to perform the mentioned tasks still in this year; so it is quite realistic to expect that he could finish his PhD in a year 2000.

Mr. Filip Vaña has done some experiments with different semi-Lagrangian interpolators to determine to what degree these, beside their main feature of interpolating, produce also dissipative effects. In that way he could introduce into a spectral model a flow-dependant diffusion effect. He has already determined the diffusive characteristics of some interpolators and has used them in several experiments. Most of the further experiments will be done in this year so his PhD could be ready in the year 2000 as well.

Mr. Mark Zagar has finished first part of the work (dynamical adaptation of the wind to the finer grid) and has started with the second part: adaptation of precipitation to the finer grid. In this field of research he plans to proceed in three different directions: with statistical adaptation of precipitation on the basis of the new, dynamically adapted wind, with computation of precipitation with the new adapted vertical velocity using the analytical equation, and with a 1-D model. It is realistic to expect that he will submit his PhD still in 1999.

General remarks and conclusion

The action in scope of the Reseau formation-recherche is a quite successful one: one PhD has already been completed and four are on the horizon for this or next year (or two). The main reason for such successful progress are the personal qualities of the students, and the fruitful collaboration with their supervisors.

As in my previous report I must also stress the importance of the pleasant research environment being enabled at Météo-France in Toulouse. Not only the logistics and the efficient equipment: each candidate has

his own X-terminal with all communicational capabilities, access to all libraries of the model and to the initial and boundary conditions, access to the Météo-France's library with main journals and textbooks. Also the friendly atmosphere is one of the important supporting factors for a fruitful research work. What is for some of the students a constraining factor is the sometimes limited possibility to run the model quickly, at each desirable time immediately. Namely bigger jobs which demand great computing power are normally waiting in a queue to be executed (which is a rather common situation in every shared and busy computing environment).

Next important factor, contributing to the efficient work of the candidates is certainly the fact that model ALADIN (or the system Arpège/ALADIN), with which most of the research is connected, was developed by the international team in which most of the students also participated. The model has become operational for most of the students' countries and so they feel the model to be "their" model. Such personal involvement is certainly a very positive and supporting factor for the success.

The side effect of the research work in Toulouse, not being connected with the students' research, is also the improving ability of using foreign languages. The researchers and their supervisors communicate in English and in French. And outside offices the language is of course French. This does not mean that the candidates will learn the "high" French with all grammatical finesses - but already now are all of them more or less capable to communicate with their environment in Toulouse.

As already stressed in my first report: a progress of the researchers who are supported by the program RESEAU FORMATION-RECHERCHE of the French "Ministère de l'education nationale, de l'enseignement supirieur et de la recherche" is successful. The decision of the ministry to give the support to the candidates and to the CNRM/GMAPof the Météo-France was a proper one. It is quite obvious that most of the students, probably all of them, will successfully finish their PhD studies - although some of them with some delay of one year or so. But on the other hand - they are doing their research mainly parallel to their operational duties in their respective countries.

Taking into account also the fact that all students of the previous group being also granted from the ministry have finished their PhD successfully, we may conclude that altogether 5 of 9 students have already finished with a success and 4 of them have realistic perspectives to follow their predecessors. So granting them to perform research in a scope of CNMR/GMAP of Météo France has a very positive outcome. My opinion on their progress and on the decision of the ministry is completely positive and I suggest that the ministry should continue with such grants.

Appendix: Detailed reports on the research of the four researchers

Doina Banciu (Romania) : SPECIFIC SMALL-SCALE DIABATIC FORCINGS AT THE LIMIT OF THE HYDROSTATIC ASSUMPTION

Scientific supervisor at the Météo-France: Jean-Frangois Geleyn
Mentor at the University of Bucharest: Prof. Vasile Cuculeanu

Ms. Doina Banciu has finished with the part of the research, being planned for her PhD thesis - that part which is connected with parameterisation of condensation/evaporation and/or deposition/sublimation of water in the atmosphere. So the scope of her research deals with convection, with precipitation, and with these two processes connected ones: with downdraft and updraft, entrainment of the surrounding air into clouds and detrainment of the cloudy mass to the environmental one. For formulation of these effects in the model she uses parameterisations which she adapted according to the specific needs of small scale. Among them it is important to mention two crucial: 1. that the large-scale (stratiform) precipitation is removed from the atmosphere in a form of rain or snow before the parameterisation of the convection starts, and 2. that downdraft is parameterised. What is interesting is that experiments show, that already the removal of the

large-scale precipitation water in a form of rain or snow before the parameterisations of convective events causes considerable downdraft (by evaporative cooling and by drag). Downdraft is so, in a fact, resolved explicitly (which I find to be a "clean" physical solution). The additional parameterisation of the downdraft contributes to the enhancement of the process. She has performed some numerical experiments (Vaison la Romaine flood case, the 7th June 1987 squall line over southern France, and the "Cleopatra" squall line over southern Germany). Her results show more realistic simulation than the "normal" operational prediction. For example in vertical cross-sections the already mentioned downdraft appears. As regards the precipitation amount and the wind field the results are not so much different from the "normal" simulation.

Somewhat different approach to the problem of convection and precipitation in the model is a quite complementary issue to the mentioned processes: namely the description of the cloud water content by a separate prognostic equation. This equation together with parameterisation of convective clouds, of precipitation processes, and of related dynamic processes is a rather complete, closed system. So she has abandoned the idea of the former plan to parameterise also some other processes (radiation heating at the ground, land surface processes, turbulence etc.). She will, according to the new orientation, rather continue in the described direction: partly parameterisation, partly explicit treatment of the clouds-connected processes.

Ms. Doina Banciu is a PhD student at the University of Bucharest, so she is doing in France only her research, without formal connections to the French educational institutions. As regards her thesis, it is planned that she will present and defend it in Romania.

It is quite realistic to expect that she will complete most of the research in this year or perhaps in the beginning of the next year. So her PhD can be expected for the year 2000

Ilian Gospodinov (Bulgaria): CONSERVING PROPERTIES OF TWO-TIME-LEVEL, SEMI-IMPLICIT AND SEMI-LAGRANGIAN SCHEME IN THE FRAMEWORK OF THE LIMITED AREA MODEL

Scientific supervisor at the Météo-France: Claude Fischer
Mentor at the Univ. Paul Sabatier in Toulouse: Prof. Alain Rigal
Mentor at the Nat. Inst. Meteorol. Hydrol. Sofia: Valery Spiridonov

Mr. Ilian Gospodinov has joined the research group only after my first report. But his progress is quite promising: he has (with Valery Spridonov) formulated a new version of the numerical scheme for use in weather prediction models, being mass, momentum and energy conserving. The scheme is semi-implicit and semi-Lagragian, it is a two-time-level, and of the first-order accuracy in time. The test on the system of shallow water equations shows that the scheme has some important advantages in comparison to some other semi-Lagrangian schemes (conservation of momentum, energy and mass also in cases when some other schemes fail to conserve them). The 3-D tests of the new semi-Lagrangian scheme with the operational, existing version of the influence of the forces show in a case of a strong zonal flow in the atmosphere less noise as with some other schemes. The case of a development of a deep cyclone in the Atlantic shows that the new scheme enables to produce deeper cyclone than the other schemes.

Mr. Gospodinov, according to my opinion, has already made a first, essential step towards the success in the research. It still remains to properly formulate the terms, which represent the influence of forces in the model, and to formulate the model also to work properly in the presence of orography. Next remains to perform extensive and essential tests with the model with whole system of equations. When the scheme will perform well also with these new developments, it will be ready for full use in the model. At this step the result of the research will reach to the phase of finishing a relatively complete, selfstanding thematic - and then the results will be also certainly sufficient to be presented as a PhD thesis.

Mr. Gospodinov is a regular PhD student at the University of Sofia as well as at the Universiti Paul Sabatier in Toulouse. Although the "co-tutelle" has not yet been agreed formally between the two universities, it is reasonable to expect that such an agreement will be signed. Mr. Gospodinov plans to bring his research on

the described thematic to the finish in a next year and a half or so, and to defend in Sofia his PhD and in a year 2000.

Mr. Filip Vaña (Czech Republic) : THE DYNAMICAL AND PHYSICAL CONTROL OF KINETIC ENERGY SPECTRA IN A NWP SPECTRAL SEMI-LAGRANGIAN MODEL

Scientific supervisor at the Météo-France: Pierre Binard
Mentor at the Univ. Paul Sabatier in Toulouse: Prof. Evelyne Richard
Mentor at the Univ. Karlova in Prague: Doc. Michal Bat'ka

Mr. Filip Vaña's objective is to determine to what extent some different semi-Lagrangian interpolators, beside their main feature of interpolating, produce also dissipative effects. In that way he could introduce the appropriate interpolator into a spectral model with an aim that the diffusion in the model is properly flow-dependant. His first experiment is the one of the cyclogenesis in a baroclinic environment, in a longitudinally homogeneous and infinite channel. He proved that after the growth of kinetic energy during the cyclogenesis the level of this energy gradually becomes saturated (low resolution can not produce high gradients, which could cause strong winds). He has also tested the nesting of the finer scale into a coarser model. He showed that with finer resolution also the level of saturation of the energy becomes higher. He has tested the energy spectrum to see the difference in energy being attributed to the small-scale part of it: semi-Lagrangian approach enables the transport also to the small-scale features, acting in this way dissipative. With different semi-Lagrangian interpolators (high, medium, or low order formulation) there is a possibility to control the diffusivity of the model. So his plan is to determine which interpolator (of which order, and which formulation of it) is the most appropriate for a particular type of the flow. With a proper choice of the interpolator he intends in this way to control a diffusivity to be flow dependant.

Mr. Vaña has already done many experiments with adiabatic version of the model. He will continue after returning to Prague. There he has access to the model, and to the powerful computer of the ALADIN/LACE group - so very good availability as regards computing (as his experiments are rather demanding as regards the computing power, they have to compete in Toulouse's busy computer with other great computing jobs). He intends to introduce the diabatic part of the processes into a model and to perform the tests with the "physics" present in the model.

Most of the further experiments will be done in this year so his PhD could be ready in the year 2000.

Mark Zagar (Slovenia): SECOND-ORDER DYNAMIC ADAPTATION FOR PREDICTING OF SMALL-SCALE WEATHER EVENTS

Scientific supervisor at the Météo-France: Jean-Frangois Geleyn
Mentor at he Univ. Paul Sabatier in Toulouse: Prof. Patrick Mascart
Mentor at the University of Ljubljana: Prof. Joze Rakovec

Mr. Mark Zagar has, after the first part of his research, defended his M.Sc. thesis at the University of Ljubljana and has achieved the degree of Master of Sciences in Meteorology. Now he is continuing with the second part of the research as a regular student at the University Paul Sabatier in Toulouse (and in co-tutelle with the University of Ljubljana).

His first part of research deals with dynamical adaptation of the wind towards the finer scale, when denser grid is introduced into a nested model. The wind has to accommodate to this new topography. This is done in a model by running it with high horizontal resolution, with lower vertical resolution at upper levels of the atmosphere, and with a simplified so called "physics" in the model (which is, in a complete formulation quite time consuming). He has determined the time, needed for the adaptation with some theoretical considerations, and has confirmed it also with a series of experiments of the adaptations of the wind: channelling trough valleys, flowing over the hills, etc. The time needed is shorter in cases when much of the

pressure mountain drag should be relaxed in the new topography, and longer if frictional adaptation prevails. All of the testing simulations show good results and so has his approach become a semi-operational product (for internal use) at the Slovenian weatherservice.

In the second part of his research, which he has started, he intends to deal with precipitation in a fine scale. His plan is to test three approaches: 1. the one with statistical adaptation of precipitation on the basis of the new, dynamically adapted wind, 2. with computation of precipitation with the new adapted vertical velocity using the analytical equation, and 3. with a 1-D model to be run in the field of a new vertical wind of the fine mesh.

According to (perhaps slightly optimistic) expectations he could perform the majority of the research in next couple of months and to have the text of the PhD thesis ready in summer or in early autumn this year. So he could defend the thesis (unless some unexpected troubles happen) towards the end of September 1999 in Ljubljana. (September is also his deadline at the University Paul Sabatier for finishing there in normal time).