Proposed Research of LACE WG Physics for the year 2003

17 February 2003

Introductory remarks

- An important part of the work in 2003 will be the build-up of both theoretical and technical expertise within WG Physics on the most pressing topics (cloudiness, deep convection, etc.). This will be accomplished by (a) focusing on a limited number of specific processes and (b) specialized workshops, small informal meetings, e-mail exchange.

- The latest developments with regarding to the AROME project are taken into account in the sense that we will build on methods developed in MESO-NH where appropriate and avoid 're-inventing the wheel'. At the same time we will, and this makes our task somewhat different from that of AROME, seek computationally rather less expensive solutions, applicable to the 3-7 km range. Also, work will be started on a new physics/dynamics interface.

- In all proposed projects the determination of resolution dependency of the parameterizations both in the horizontal (from 10 km down to 4 km) and in the vertical will be an important part of the work.

- Involved 'risk': the notation introduced by P. Smolikova has been adopted: 3 = risky, 2 = at least partial results expected, 1 = no risk.

Proposed projects page

Other tasks

A. Shallow convection / PBL cloudiness

A.1 Statement of the problem

Low-level cloudiness is poorly represented in the current ALADIN model. In particular during the winter half-year, the underprediction of low stratus over eastern central Europe is a major forecasting problem. As a result of the missing cloud cover, diurnal temperature variations are overestimated. Low stratus events are typically of large scale in the horizontal (affecting several LACE countries at the same time), and often quasi-stationary over several days. Thus part of the phenomen can be well studied using 1-d modelling.

In the real atmosphere there is a continuous spectrum of cloud types ranging from low stratus to stratocumulus, and shallow cumulus. These clouds are driven (in vastly different proportion) by longwave radiative cooling, evaporation cooling, and sub-grid vertical mixing. In contrast to middle-tropospheric stratiform clouds they are only weakly tied to resolved vertical motion, and often occur under conditions of general subsidence. A physically satisfactory parameterization should aim at treating them in a unified manner, including a consistent transition between overcast (fully resolved) and partial cloud cover (subgrid cloudiness).

In the current ALADIN model, low stratus is hardly represented at all, stratocumulus exists in the form of modifications to the vertical diffusion and cloudiness schemes, and shallow cumulus clouds are to some extent represented by the deep convection scheme. All mentioned schemes are diagnostic, with no storage or advection of cloud water.

A.2 Link to the ALADIN research plan

The proposed project fits quite well into the ALADIN research plan since it addresses the high-priority topics ‘Prognostic cloud water’, ‘Microphysics’, ‘Vertical diffusion’, ‘Low cloudiness’, which are all part of the larger issue of the ‘Use of new prognostic variables’.

A.3 Method, means

Building (and tuning) a unified PBL cloudiness scheme with prognostic cloud water and some cloud microphysics is a task that will take more than 1 year. However, by proceeding in steps we expect first practical benefits from the project at the end of 2003. During this year the following tasks should be completed

Prognostic cloud water (L. Kullmann, A. Kann, H. Seidl), risk=1

- Implementation of prognostic cloud water +Lopez scheme in 1-d and 3-d at participating NWSs (partially completed)
- Tests of prognostic cloud water + Lopez scheme in 1-d and 3-d
- Study of the effect on inversion structure and cloudiness persistence, to see to what extent the current vertical diffusion scheme is able to handle the cloud-topped PBL

Subgrid-scale cloudiness (A. Kann, T. Haiden), risk=2

- Tests with a subgrid-scale cloudiness scheme similar to the one used in MESO-NH, with liquid water potential temperature and total water content as quasi-conservative variables

Non-local vertical transport (A. Kann, T. Haiden), risk=2

- Development of a mass-flux scheme for the (cloud-free and cloudy) unstable PBL
- Investigation to what extent the current deep convection scheme ACCVIMP can be adapted (with modified entrainment, closure, etc.) for simulating shallow convection

Radiation (H. Toth), risk=1

- 1-d diagnostic studies of in-cloud radiation flux divergence (both short- and longwave), comparison with published results of more sophisticated models, to see to what extent the current radiation scheme is able to handle the cloudy PBL.

Necessary tools: Off-line high-resolution 1-d model (under development), ALADIN SCM, ALADIN, special obs datasets, satellite obs (NOAA)

Proposed contributors (months): L. Kullmann (3), H. Toth (3), A. Kann (3), H. Seidl (1), T. Haiden (2). Total person x months: 12

Workshop: in March 2003, a small kick-off meeting of the people working on shallow convection / PBL cloudiness will be organized at ZAMG (LACE travel funding?)

A.4 Interactions with other WGs and ALADIN groups

Cooperation with WG Data Assimilation on the problem of incorrect initial temperature profiles in low stratus cases. Tests with white-listed raob stations in 3-d.

E-mail exchange with L. Gerard and his group concerning the Lopez scheme, and with regard to the possible adaptation of the deep convection scheme for shallow convection. E-mail exchange with E. Bazile and J.-M. Piriou on shallow convection.

A.5 Connection with AROME

Our goal is to develop an improved scheme for shallow convection / PBL cloudiness that is not too computationally expensive. As part of the project we will study and test the relevant schemes used in MESO-NH.

A.6 Expected results in 2003

- Detailed evaluation of PBL cloudiness forecast improvements associated with the use of prognostic cloud water, based on case studies and parallel runs

- A working (but not yet final or fine-tuned) version of the shallow convection mass-flux scheme

- Build-up of LACE WG Physics expertise on shallow convection and PBL cloudiness mechansims and parameterizations

B. CAPE & deep convection triggering

B.1 Statement of the problem

As we go to finer grid scales (10 km and below), the humidity convergence field computed by the model represents not only synoptic-scale convergence but also meso-scale effects. On this scale, we cannot expect the assumption of equilibrium between humidity convergence and convection intensity to hold. Similarly, on the small scale the triggering of convective precipitation should probably not be linked any more to the presence of humidity convergence. Convection should be allowed to become 'active' in the sense that it creates its own humidity convergence.

The problem of the diurnal cycle of convective precipitation (the precipitating stage is reached too early in the models) is well known. Previous studies with ALADIN have shown that using the prognostic deep convection scheme of L. Gerard tends to improve the mesoscale structures but does not solve the timing problem as long as the trigger function is kept unchanged. Simply using CAPE triggering does not solve the problem. It appears that an improved trigger function needs to address more explicitly the convective development process from Cu to Cu-cong into Cb.

CAPE is an important parameter in the deep convection parameterization and a useful tool in convection prediction. Although general agreement between prognostic and measured values of CAPE exists there are great differences in many individual cases caused by inaccuracy in predicted surface temperature and humidity. The importance of these differences will be investigated with respect to performance of deep convection parameterization and practical prognostic usage of forecasted CAPE.

B.2 Link to the ALADIN research plan

The proposed project deals with the high-priority topic 'investigation of problems in the triggering of convection' in the area 'use of new prognostic variables'.

B.3 Method, means

Radar observations will be the most important type of data for evaluation of the current scheme and any modified scheme. Until the beginning of the convective season (May 2003), a system will be established that allows quasi-operational verification of ALADIN convective precipitation forecasts, both qualitative and quantitative (S. Greilberger). This will include direct overlay of the trigger conditions (CAPE, moisture convergence) with radar images. It is also planned to compare CAPE computed from modelled and observed T2m,Td2m (T. Kovacic). Risk=1.

For a number of cases, ALADIN will be re-run on finer scale (7 km, 4 km) to evaluate the resolution dependency of the trigger problem. On these scales it will be crucial to study the convective precipitation not in isolation but in combination with the resolved one. During summer 2003, first experiments with modified trigger/closure assumptions should be carried out, based on the experience gathered (T. Kovacic, S. Greilberger, T. Haiden). Risk=2.

Necessary tools: Combined radar/model data visualization system (under development), ALADIN, satellite observations supplementing radar.

Proposed contributors (months): M. Bellus (2), T. Kovacic (6), S. Greilberger (3), T. Haiden (1). Total person x months: 12. Stays: 1 month at ZAMG, to be financed by LACE (M. Bellus).

Workshop: In Sep 2003, a short work meeting of the people involved should be organized, possibly at ZAMG, to exchange&discuss results (LACE travel funding?)

B.4 Interactions with other WGs and ALADIN groups

E-mail exchange, in particular with L. Gerard and D. Banciu, and with colleagues at MF.

B.5 Connection with AROME

The problem of deep convection triggering has not been solved satisfactorily in MESO-NH either. The scheme used involves several rather empirical tuning constants. Thus the results of this project will be of interest to the AROME group as well, and some fruitful e-mail exchange on the problem is anticipated.

B.6 Expected results, operational implementation

- As a result of the diagnostic study using radar data, a much clearer description of the trigger problem, and its dependence on resolution, will be available. By the end of 2003 we should have already made a number of tests with alternative trigger and/or closure schemes, to be used operationally in the convective season 2004.

- The importance of errors in CAPE due to errors in surface temperature and humidity in model will be documented.

- Build-up of LACE WG Physics expertise on deep convection triggering and closure

C. Orographic drag

C.1 Statement of the problem

The envelope orography which is used to parameterize sub-grid scale orographic drag, has the disadvantage of 'filling up' valley atmospheres almost up to ridge level. As a result, many processes that occur in mountain valleys and basins cannot be properly represented, e.g. cold air pools. It would be desirable to get rid of the envelope provided one can compensate for its benefits in the parameterization of subgrid-scale orographic effects.

Preliminary studies on this topic (D. Drvar) have shown that dropping the envelope has a beneficial effect on surface wind and precipitation in some cases. More extensive investigations are however needed.

C.2 Link to the ALADIN research plan

'Tuning of the envelope' is a high-priority topic of the area 'Improvement of basic parameterizations' in the ALADIN research plan.

C.3 Method, means

Case studies with and without envelope, on different resolutions, down to 4 km. Comparison of modelled orographic precipitation, with and without envelope, with observations (D. Drvar). Tests of the combined effect of the Lopez microphysics scheme and non-envelope setting (Y. Wang). Risk=1.

Necessary tools: ALADIN, sfc obs, radar.

Proposed contributors (months): D. Drvar (2), Y. Wang (1). Total person x months: 3

Meeting: 1-2 short work meetings in 2003, to exchange&discuss results (LACE travel funding?)

C.4 Interactions with other WGs and ALADIN groups

E-mail exchange and interactive work with colleagues from MF, particularly Jean-Francois Geleyn.

C.5 Connection with AROME

E-mail exchange on the problems associated with sub-grid orography, and on the question of below which resolution it becomes obsolete.

C.6 Expected results, operational implementation

- An alternative setting to the current envelope, with verified forecast improvements, should be available at the end of 2003.

- Build-up of LACE WG Physics expertise on the parameterization of sub-grid orographic effects

Other tasks

Physics/dynamics interface

Design a flexible physics/dynamics interface that can accomodate new microphysics (new types of variables), and takes into account the existing ARPEGE/ALADIN constraints (e.g. use of fluxes). This is also an essential preparation step for later AROME developments.

First analysis has shown that the use of MESO-NH physics routines in the ALADIN system is non-trivial due to subtle differences e.g. in the definition of moist variables. These differences are partly due to the fact that MESO-NH uses anelastic rather than fully compressible dynamics as in ALADIN. Thus, MESO-NH physics routines linked to cloud processes cannot be simply plugged into the ALADIN system. Risk=1.

Proposed contributors (months): M. Bellus (1.5), L. Kullmann (3), J.-F. Geleyn (supervisor). Total person x months: 4.5, in the form of stays in Toulouse (Apr-July 2003)