1 Introduction

The contributions to this Newsletter are mainly summaries from the presentations given by COSMO staff during the 8th General Meeting in Bucharest (from 18.-21. September 2006). In this meeting, several units were organized as parallel sessions for the Working Groups and the Priority Projects. While it was difficult on the one hand, to choose, which session to attend, this procedure on the other hand gave most contributing scientists the opportunity to present and discuss their work in detail. During the plenary sessions we had an invited presentation by Terry Davies from the UKMO. He reported about *MOGREPS*, the *Met Office Global and Regional Ensemble Prediction System* and the plans of the Office for high resolution data assimilation.

After the Bucharest Meeting, an important change happened for the name of the model. Because all COSMO partners were very creative in finding names for their special applications of the *Lokal Modell*, the model was merely known as *aLMo*, *LAMI*, *LME* or *LMK*, resp. To make it more known as a common product of COSMO, the Consortium for Small-Scale Modelling, we decided to refer to it as the *COSMO-Model*. Applications of the COSMO-Model will be denoted by two additional letters or digits: COSMO-XX. This new convention is not yet obeyed to closely in the contributions of this Newsletter, but we hope that the new name will be accepted more and more by all COSMO scientists in the near future.

Figure 1: Participants of the 8th COSMO General Meeting in Bucharest

Nearly two years have passed since the publication of the last COSMO Newsletter in July 2006. The intention to have the publication shortly after the COSMO General Meetings in September surely has failed for this issue, but it better should be late than never. We are already in the progress of editing the publications from the last General Meeting in Athens and we hope to have the next Newsletter published a bit earlier.

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Strategy for COSMO

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1 Introduction

COSMO is one of several Consortia in Europe dealing with the development, evaluation and improvement of a limited area model for numerical weather prediction. Triggered by several external factors – such as recent enhanced collaboration between two other consortia in Europe (HIRLAM and ALADIN), or the foreseeable end of the current EUMETNET Programme on Short-Range Numerical Prediction – the Steering Committee (STC) has worked out a long-term strategy for the COSMO countries. This contribution aims at outlining the background of this strategy and its essential elements.

2 Background

In Europe the number-one global (medium range) weather forecast centre is undoubtedly the ECMWF. Its declared strategy is a reduction in their deterministic models horizontal resolution to 10 km by 2015, and a resolution of 20 km for their EPS system. With this there are no plans to enter the "non-hydrostatic world" within the next decade, but the resolution will be about as close as possible.

Plans are strong in all global modelling centres in Europe to improve the assimilation of more and more data, notably from satellites and other remote sensing instrumentation.

In the long run the strategy for (global) meteorological models aims at including non-meteorological aspects of the environment such as air quality or hydrology. Hence meteorological models will eventually become environmental prediction (or diagnostic) systems. This will, on the one hand, be natural due to including radiative information through atmospheric constituents in the assimilation cycles. On the other hand, it will enlarge the scope and applicability of (global) meteorological models.

3 Strengths and Weaknesses of the COSMO Model

The COSMO Model[1] is a non-hydrostatic meso-scale numerical model with full physical parameterisations suited for weather prediction applications (Steppeler et al. 2003). As such it is similar to many other meso-scale numerical models for atmospheric flows (e.g., RAMS, ARPS, MM5, WRF) and the models of the other European consortia (ALADIN/AROME;

[1]Note that the model has recently obtained a new generic name: COSMO. Before it has been known as *Lokal Modell (LM)*, *aLMo*, *LAMI* and other variants referring to specific applications of the model.

LACE, HIRLAM, UM). Being the primary tool for official duty at the COSMO Weather Services, however, special focus is put on operational stability as well as efficiency and portability, suitability for moist processes and suitability for particular processes of special interest to COSMO members. Lately, experiments have been performed on introducing a z-coordinate rather than the still operational "terrain influenced" sigma coordinate system (Steppeler et al. 2006). Boundary and initial conditions can be obtained from either the GME (global model of DWD) or the IFS (from ECMWF). Assimilation of observations is performed on the basis of the nudging approach. Some satellite data can be assimilated using a 1d-variational scheme.

Ever since its operational start in 1999, the COSMO Model was operated at one of the highest spatial resolutions for operational NWP worldwide. Presently most COSMO countries run it at 7 km horizontal resolution (Kaufmann et al. 2003) and projects are rather mature for reducing the resolution to some 2-3 km (2.8 km at DWD: operational since May 2007; 2.2 km at MeteoSwiss). With this COSMO will again lead the "resolution competition" in Europe (other consortia have announced plans to go down to 4-5 km in the same time frame). In terms of length of the operational record, the COSMO-Model has the longest for non-hydrostatic models, which is advantageous for verification purposes as well as possible improvements.

The COSMO Model also has a number of special features. These include the prognostic snow model, a lake model and the latent heat nudging (LHN) scheme for the assimilation of radar data (e.g., Leuenberger, 2005). Also COSMO has an up-to-date two-moment microphysics scheme at disposition (not yet operationally used). With the so-called "prognostic precipitation" (i.e., various hydrometeors such as rain, snow and graupel as prognostic variables) the COSMO Model is up-to-date in the simulation of precipitation.

Employing the COSMO Model, a local ensemble prediction system (COSMO-LEPS) has been developed within COSMO (Molteni et al. 2001, Marsigli et al. 2001). This is presently being operated as a Member's Time Critical Application at ECMWF. It has a resolution of 10 km, is integrated over 144 h and the COSMO-LEPS domain covers most of Europe. Again with its LEPS, COSMO has developed the best-resolved local ensemble prediction system and has been instrumental in devising procedures to downscaling the global EPS.

As any modelling system the COSMO Model has also weaknesses. In terms of performance the most severe weakness is certainly the precipitation forecast. Although the introduction of prognostic precipitation variables has considerably improved the performance (especially in the lee of mountains) the COSMO Model still strongly overestimates precipitation, especially in winter and over mountains. In summer magnitudes are better, but the timing is weak. Also, near-surface variables (e.g., 2m temperature or wind gusts) are often (i.e., on average) largely off. The model has problems to maintain specific synoptic situations, especially low-wind situations resulting in cold pools (e.g., in the Swiss "Mittelland") and associated fog situations.

In terms of the chosen modelling approach, the most essential limitation of the COSMO modelling system is the restriction to nudging as an assimilation tool. Even if it might be highly questionable whether variational approaches are suitable for very high resolution (on the order of 1 km), there are only limited means to test this important decision-leading implication.

Finally, *in terms of individual parameterisations* and in view of the high resolution employed and envisaged, the weakest component of the COSMO model at present is probably the manner in which the soil (including and explicitly also the soil moisture) and near-surface exchange is treated. In terms of problems related to high resolution, COSMO has those of radiation treatment and resolved vs. parameterised convection in common with all the other models.

4 Challenges for the COSMO Model

Given the strengths of the COSMO Model and the development of the global meteorological models as briefly outlined in the previous sections, the vision for a meteorological model with a scope of weather forecasting on the local scale must be as follows:

> The COSMO Model will be supported and optimally developed to operate on the short to very-short range and with very high (km-scale) resolution.

For the specific characteristics of the COSMO model this overall strategy has a number of implications:

- It is necessary to investigate which assimilation approach is appropriate and successful at the very high resolution. Given the fact that variational approaches are theoretically sound, but have problems due to linearisation requirements at high resolution, and nudging is modifying the flow properties in a not necessarily balanced manner, research should go into approaches, which attempt to overcome these limitations such as the SIR (Sequential Importance Re-sampling) Filter (van Leeuwen 2003) that can possibly be combined with the presently used nudging scheme.
- The description of surface information and exchange has to improve according to the enhanced model resolution. This is important for permanent characteristics (surface types - number and detail of classes, parameters etc.), slowly changing information (for example hydrological characteristics such as soil moisture) as well as for the detail and treatment of the surface exchange parameterisation.
- Efforts will have to be made to better exploit satellite information on the local scale, especially from EUMETSATs *Satellite Application Facilities* (e.g., the Hydro SAF, Land Surface SAF, CM SAF).
- Ongoing efforts to diagnose and improve the forecast quality will have to include verification approaches to reflect specific problems at high resolution (e.g. “double penalty”), such as in the “fuzzy verification” approach by Ebert (2006).

Hand in hand with the improved resolution of the COSMO Model, a high resolution and short range ensemble prediction system is desirable. For this, methods to perturb initial conditions and thus generate ensemble members, possibly in combination with perturbed physics at these scales need to be developed and tested.

For the time being considerations on stability and national security suggest that every COSMO country operates its own regional scale model version. This, however, should be done with the highest degree of collaboration and interaction possible. A first step into more efficient use of the COSMO human resources has been made with introducing the system of Priority Projects in 2005. It will be necessary, however, to increase especially the efforts of acquiring funding from external sources (research projects at national and international level) in order to successfully reach the above mentioned aims.

5 Strength and weaknesses of the Consortium

The efforts of the COSMO partners result in a model-system that is quality-wise on par with the models of the other European consortia (QPF-Verification of Limited Area Models performed by the UK Met Office). At the beginning of the co-operation the contribution of each partner was not rigorously defined. There was no prioritisation regarding the area of Research and Development resulting in a quite ineffective cooperation. With the definition of Priority Projects the cooperation began to be focussed on important research areas.

COSMO itself has no budget at its disposal. This hinders cooperation and hampers the exchange of experts. There is no dedicated COSMO development team that solely concentrates on the development of the COSMO Model system. COSMO experts, whose resources are partly dedicated to the priority projects, often have operational duties, which in case of "normal emergencies" regularly override their commitment to the priority projects.

Currently the Scientific Advisory Committee of COSMO (SAC) consists of the Work Package Coordinators and the Scientific Programme Manager. Although the expertise in the SAC is sound, it is a COSMO internal group and it would be beneficial to COSMO to add external expertise.

The COSMO-Consortium has no plans to admit additional members in the near future except those that already have an applicant status. Since there is a considerable external interest in the COSMO Model, the consortium members are willing to make the COSMO Model system available to others through licensing for an annual fee.

6 Summary and Strategic Goals

From the above the following strategic goals can be derived for COSMO over the next years:

- Increase of forecast quality at very high resolution (km-scale), in particular for precipitation, fog and "cold pool" situations.
- Development of a short-range ensemble prediction system (SREPS) that builds on the experience of COSMO-LEPS, extends its applicability into day one to three and has a correspondingly high spatial resolution.
- The co-operation within COSMO needs to be strengthened by going on with the Priority Projects approach on the one hand and closer exchange of results and direct collaboration on the other hand. For the latter it is necessary to have more resources, over which COSMO as a consortium can dispose.
- An important goal will be the successful collaboration among the consortia in a future European network, i.e. the possible follow-on programme to the EUMETNET SRNWP that ends by 2007. This should promote exchange of software and tools, enabled through joint procedures and generally accepted standards on formats (interoperability). Also common verification procedures, standards and exchange of approaches should be fostered. Finally, the capability of many countries' computing facilities should be exploited in order to devise joint (i.e., similar or complemental, or both) European ensemble prediction systems, possibly within the framework of TIGGE-LAM.
- Make the COSMO-Model available to third parties by offering a commercial license.
- Try to establish a budget for COSMO at its own right to support travel expenses and expert visits.

- Establish a Scientific Advisory Committee of external experts.
- As a final goal – to reach all the above and make it available to the community – COSMO (the consortium as well as the model) needs more visibility, be it through peer reviewed publications, conference contributions or representation in project consortia.

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