UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION
INTERNATIONAL ATOMIC ENERGY AGENCY
INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS
I.C.T.P., P.O. BOX 586, 34100 TRIESTE, ITALY, CABLE: CENTRATOM TRIESTE

SMR/941 - 10

"Third ICTP/WMO International Workshop on Tropical Limited Area Modelling"
21 October - 1 November 1996

"Developing a New LAM Centre"

J. R. MUKABANA
University of Nairobi
Department of Meteorology
Kenya

Please note: These are preliminary notes intended for internal distribution only.

DEVELOPING A NEW LAM CENTRE

Before defining the requirements of a new limited area modelling (LAM) centre, it is better first to understand what happens at developed operational weather forecasting centre [e.g., the Deutscher Wetterdienst (DWD) Offenbach/Main, Germany]

At DWD three model chains are run simultaneously. These models consist of the global spectral model (GM) for the large-scale predictions, the regional model (EM) for synoptic and meso-α scale and the high resolution meso-β scale model (DM) as the main short-range weather forecasting tool for the country (see Table 1).

The global model is used to:

- supply a regional (or LAM) model with initial and lateral boundary values
- give forecasts in the global domain
- give forecasts in the medium-range
- set a universal research tool

The main goals of the regional and LAM system are:

- To give more detailed forecasts of weather parameters close to the ground (like 2 m temperature and 10 m wind gusts) and a better simulation of clouds and precipitation.
- To prepare meteorological output fields for environmental applications e.g. modelling of air pollution or sea state, trajectory and chemical transport, road condition, etc.
- To serve as a research tool for process studies in local weather or regional climate modelling and even teaching at a university.

The GM has high resolution in the upper layers to resolve the large-scale meteorological waves whereas the LAM has high resolution close to the surface to resolve the near-surface meteorological variables (see Figure 1).

The GM data can be accessed and down loaded to a high speed workstation computer at a remote location through the file transfer protocol (ftp) facility. These data can serve as Initial and Boundary values for LAM. This method makes it possible for many national weather services (NWS) to install operational limited-area model to meet the growing demand by the public for detailed weather forecasts.

SYSTEM OVERVIEW

Figure 2 displays the components of a typical local numerical weather prediction (NWP) system and the data flow which begins at the data collection and ends at the distribution of the forecast products to the various users. To run a NWS NWP system operationally the following steps are required:

STEP 1: HUMAN RESOURCE AND EXPERIENCE

To run the LAM operationally requires the services of three to five scientists with NWP experience and competent programmers.

STEP 2: INSTALLATION OF THE LIMITED-AREA MODEL

The first step is to install the LAM on your computer system. Run different test cases and try different compiler options to increase efficiency.

STEP 3: DECIDING ABOUT THE MODEL CONFIGURATION

Depending on the speed of the computer system and your envisaged operational schedule, the size of your model domain must be fixed by defining the following variables:

- Number of gridpoints in the West-East (or X) direction
- Number of gridpoints in the North-South (or Y) direction
- Number of vertical layers (Z-direction)
- Mesh size

The results of the test runs performed in the preceding step should help in the decision of the number of gridpoints.

STEP 4: DERIVE A TOPOGRAPHICAL DATA SET FOR YOUR MODEL DOMAIN

After defining the limited-area domain of your interest (e.g. in terms of its horizontal extent, pole of rotation, mesh size, number of gridpoints and vertical layers) you need to provide topographical data for the model domain bound.

A typical LAM system requires the following topographical parameters:

- Orography i.e. the height of the gridpoint above mean sea level; the mean height of the grid box may be used
- Land/Sea mask (or land fraction)
- Soil type (10 cases)
- Roughness length

The vegetation parameters to be used, when available, include the following:

- Plant cover for the vegetation period and for the time of rest.
- Leaf-area index (LAI) for the vegetation period and for the time of rest.
- Root depth of the plants (only for the vegetation period).

If the topographical data file does not contain any vegetation parameter, simple default values representative of the climatological conditions of the local domain should be used.

STEP 5: INITIAL ANALYSIS DATA FOR LAM

(i) An initialized data set can be prepared based on the real local observations; for instance by using multivariate optimum interpolation scheme to objectively analyze locally gathered data from the limited-area domain.

(ii) You can also initialize your LAM with interpolated data from the GM analyses accessed through the ftp facility at either 00 UTC or 12 UTC.

EXAMPLE OF REAL-TIME LIMITED-AREA OPERATIONAL NWP USING GM DATA ON THE FTP-SERVER OF THE DWD OFFENBACH, GERMANY

The EM/DM workstation version can use interpolated GM analyses and forecast fields as initial and boundary data respectively. These data are provided on the ftp-server at DWD. The data sets consist of the DWD's global model (GM) with a spectral resolution of T106 (~190 km mesh size) and 19 layers in the vertical. The data reside in several directories on the ftp-server and are based on 00 UTC and 12 UTC forecasts for the steps from +0 h (i.e. the initialized analysis) up to +84h at 6-hourly intervals. To keep the file size small, not all spectral variables (e.g. vorticity, divergence, temperature, specific humidity, logarithm of pressure) corresponding to one forecast step are put in one file, but are distributed into six different files with sizes ranging from 23 kbytes to 513kbytes. The total amount of data to be transferred is about 35 Mbytes for all the 15 GM forecast steps (+0h, +6h,....., +78h, +84h) for on one run e.g. for 00 UTC.

- The program module gm-pp calculates GM values from spectral space to gridpoint space on the Gaussian grid using the spectral coefficients from the ftp-server.
- The program gmtoem-ws interpolates the GM data to the grid of LAM and adapts the fields to the higher resolution topography. The data serve as initial and lateral boundary data for the LAM.

For operational applications, the lateral boundary data are usually taken from the GM forecast 12 hours earlier i.e. from 00 UTC GM run for the 12 UTC run of the LAM. Thus, a 72-h forecast of the LAM can be performed using the GM forecast from step +12h up to +84h. Therefore, only the transmission of the GM analysis which can start as early as 04.13 (16.13) UTC is time-critical whereas the time period for transferring the lateral boundary data is almost 10 hours i.e. from 06.21 UTC until 16:13 UTC. Thus, an Internet connection with a speed of 8kbit/second speed should permit the complete transmission of 35 Mbytes of GM data in time.

(i) The workstation version of EM/DM is a versatile tool for regional modelling. Operationally, it is currently applied at resolution of 0.5°(~55km) over eastern Atlantic and Europe (EM), at 0.125°(~14km) over Germany and its surrounding (DM) and at the same resolution over Switzerland and its surrounding (SM, Fig. 3).

(ii) In research applications, model runs have been performed successfully for India, Brazil, North America and Kenya using a rotated (or unrotated for equatorial regions) spherical grid.

(iii) It is possible to set up a model chain at a local station i.e. to drive a higher resolution version of EM/DM by a course resolution one. The program module emtohm-ws takes care of the necessary interpolation of the lateral boundary values for the higher-resolution LAM.

STEP 6: POSTPROCESSING

A program module (emdpp-ws) is available to interpolate variable from the hybrid model layers to pressure levels and allows the creation of vertical cross-sections. The interpolated values can be smoothed slightly by the application of a digital Shapiro filter to ease the graphical display of the results. Mean sea level pressure and the relative humidity are also products of this module.

STEP 7: GRAPHICAL VISUALIZATION

The graphical representation of LAM NWP system in particular, animation is a valuable and attractive presentation of the forecasts to the public.

For the graphical visualization of your LAM output:

(i) You may use your local graphics package.

(ii) But the EM/DM provides the interface to two public domain visualization packages namely, GRADS and VIS5D. Both graphical software allow the user to generate horizontal and vertical sections, contour plots and coloured shading as well as animation.

STEP 8: STATISTICAL FILTERING

Current regional and limited-area models are not yet resolving the topography in sufficient detail to really match the local observing station and its surrounding. Moreover, they have difficulties in the proper representation of soil and boundary layer processes which may lead to systematic errors of the forecasts, especially of near surface variables like the temperature at 2m or the winds at 10m. A simple Kalman filter can be used to eliminate these errors to a large extent. Also MOS (Model Output statistics) techniques may be applied to correct systematic errors and also derive parameters like visibility which are not directly forecasted by the LAM.

STEP 9: APPLICATION MODELS.

The hourly forecasts of LAM's serve as meteorological input for a wide variety of application models like trajectory calculation, lagrangian particle dispersion model, complex chemical modules, sea state, water level and road condition prediction, hydrological and agrometeorological as well as biometeorological applications.

STEP 10: MONITORING, DIAGNOSTICS AND VERIFICATION

To improve the quality of LAM steadily, three tools, namely monitoring of the observation, a diagnostic of the modelling system and verification of the forecasts i.e. a direct comparison to observations are indispensable. Build-in diagnostics in EM/DM allow the detailed study of the spin-up phase and long terms trends. The verification system concentrates on clouds and near-surface parameters.

COMPUTER REQUIREMENTS

The minimum resources for the operational use of the LAM consist of a workstation with 96 to 196mByte disk space, a DAT unit (4mm DDS) for archiving, with a processor (e.g. SGI Challenge SR5000, IBM Risc system / 6000 model 390, etc.) With a speed of about 50 to 100 MFlops for the LINPACK benchmarks. A console plus two X-terminals (each 17" to 20", colour monitor), A laser printer A4, black/white, an inkjet (colour). For software requirements, the UNIX system V operating system (Korn or POSIX Shell) plus a C and FORTRAN Compiler is needed. The source code of the model is managed via SCCS (Source Code Control System) make to keep track of the history of the program. Full

Internet Connectivity is the precondition for retrieving the GM data from the ftp-server at DWD. The total price of such a system (i.e. hardware and software) may be as low as US$ 30 000 to 50 000 and is thus affordable by most regional centres running LAM.

TIME DURATION FOR INSTALLATION OF A LAM.

The complete NWP system like that based on EM/DM (excluding the preparation of an initial state based on the local observations i.e. the true analysis Step) may be installed at your institution in about three to four months depending on human resource and experience. To implement the complete analysis system including the interface to your local database may take a bit longer, approximately an additional nine months period.

HOW TO APPLY FOR EM/DM FORECASTING SYSTEM.

In case you are interested in the EM/DM workstation version please write to :
The President of the Deutscher Wetterdienst
Mr. Udo Gartner
Zentralamt
Postfach 10 04 65
63004 OFFENBACH/MAIN, Germany.

* During an initial test phase of several months duration, the use of DM/EM will be free of charge. But for later commercial applications some small license fees will have to be paid. However, the use of the DM/EM for specific research will be free.

NWP Model Chain of the Deutscher Wetterdienst

Model	Type	Mesh size	Number of layers	Domain	Lateral boundary	Initial state	Start time UTC	Forecast length
GM	Spect.	T106 ~200km	19	Global atmosphere	-	4d data assimil. 6h cycle OI NMI	00 12	168 h 168 h
EM	Grid	0.5° ~ 55km	20	Europe and North Atlantic	GM	same as above	00 12	78 h 78 h
DM	Grid	0.125° ~ 14km	20	Germany and surroundings	EM	same as above	00 12	36 h 36 h

TABLE 1

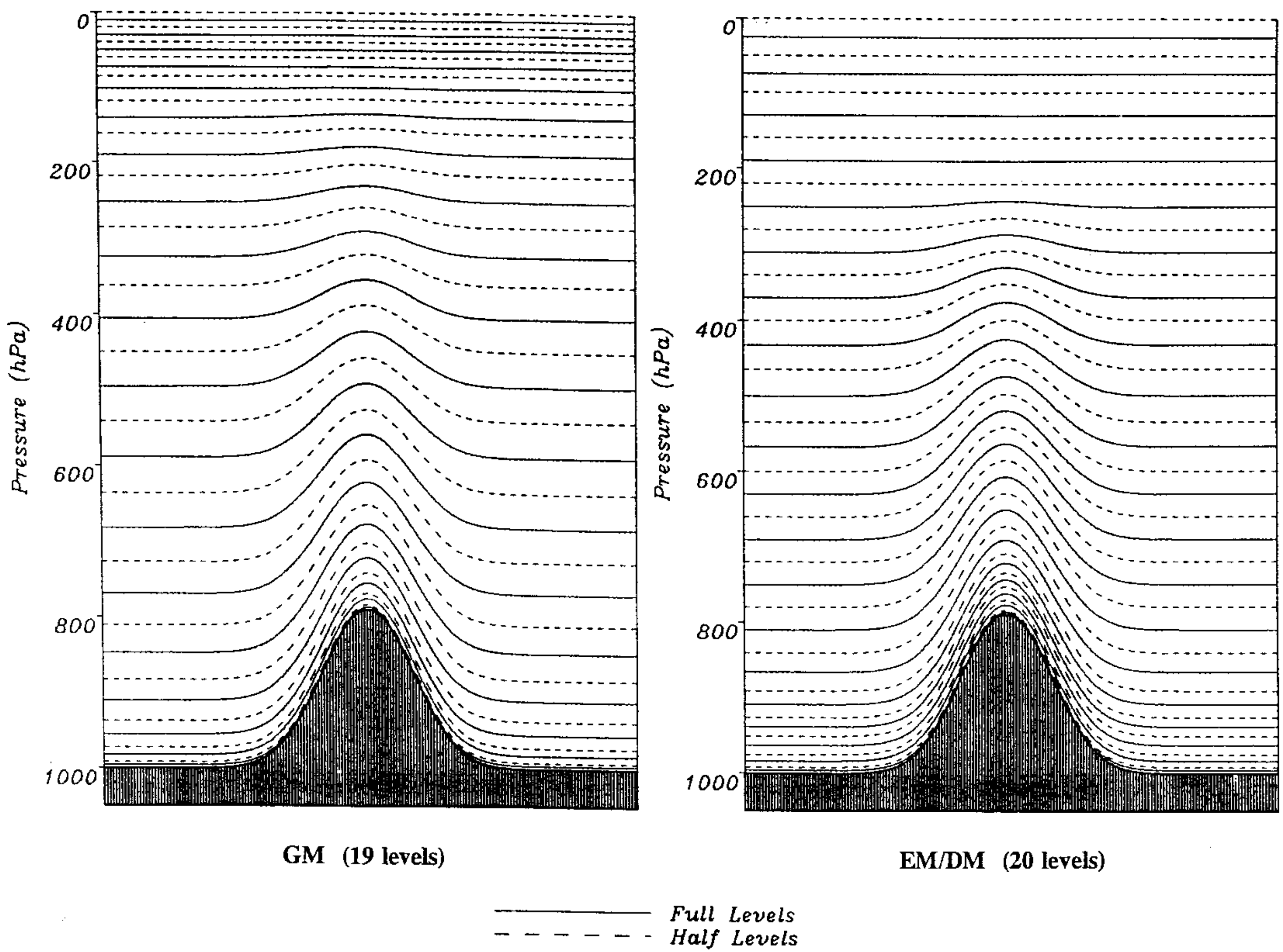

Fig. 1 Model levels of the models GM (left) and EM/DM (right).

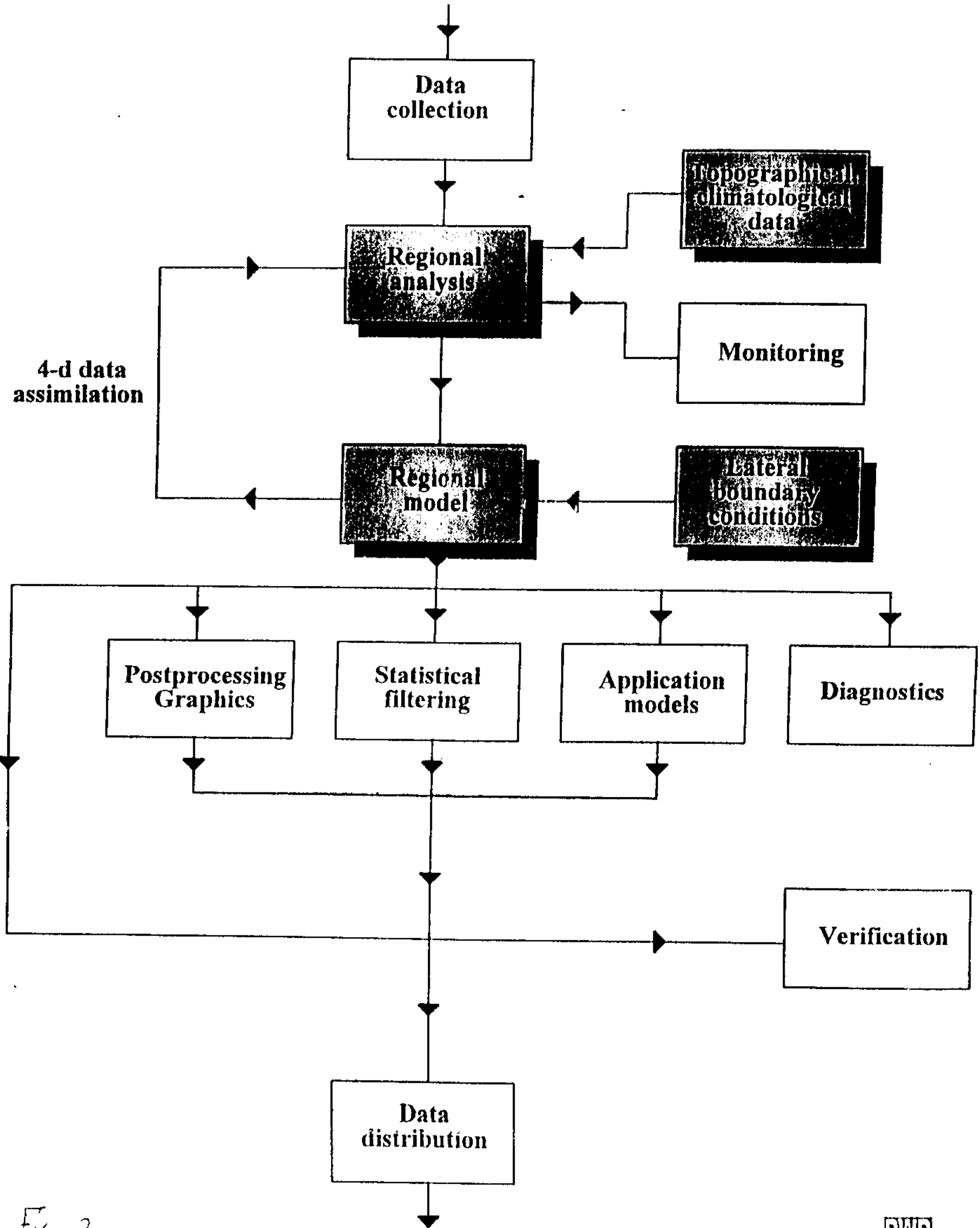
Data collection
Topographical, climatological data
Regional analysis
Monitoring
4-d data assimilation
Regional model
Lateral boundary conditions
Postprocessing Graphics
Statistical filtering
Application models
Diagnostics
Verification
Data distribution
DWD

Fig. 2

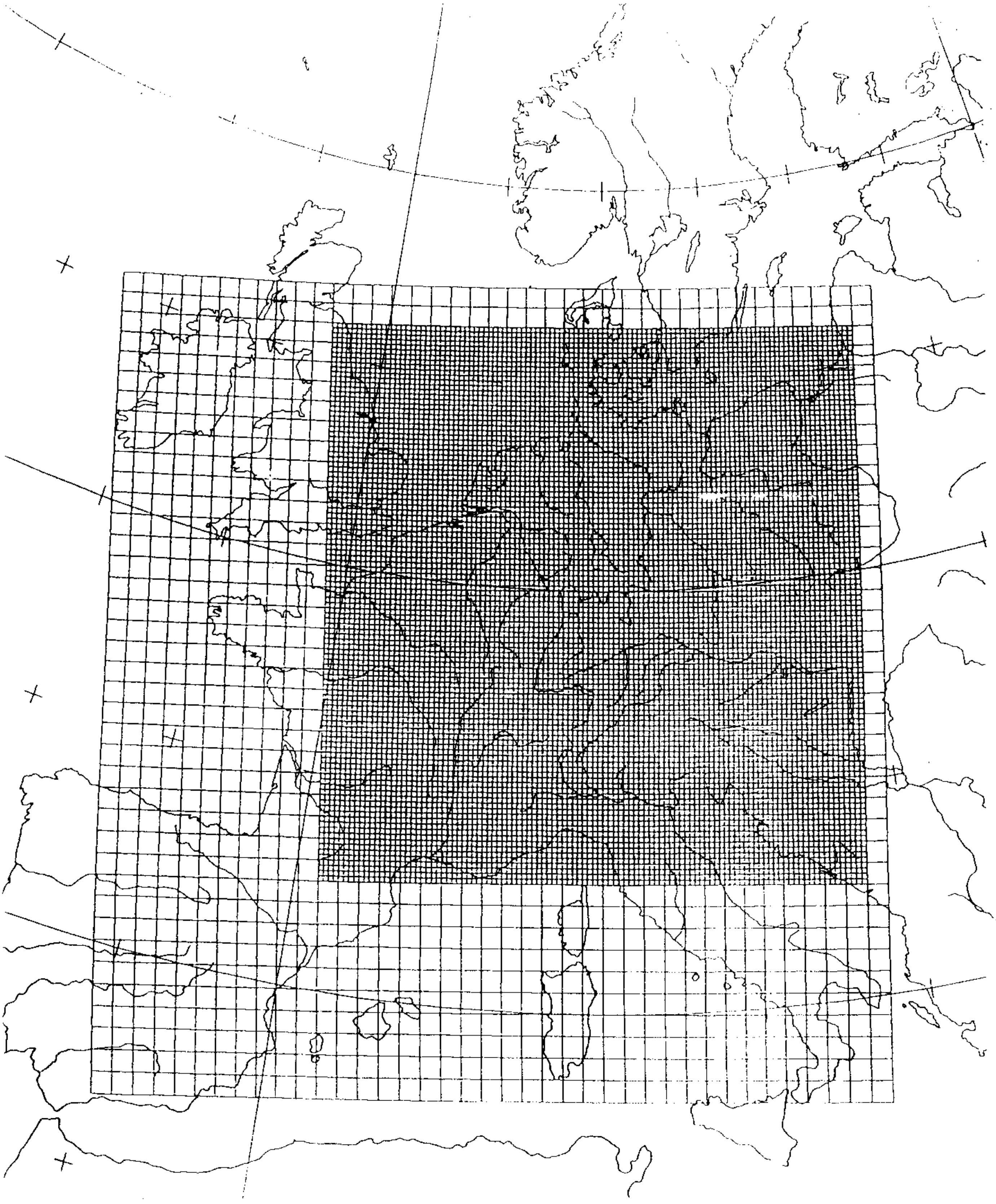

Fig 3. Domain of the Deutschland-Modell (DM) and the sub-domain of the Europa-Modell (EM) providing the boundary values for DM and the Swiss Model (SM).