07.08.2006

A SURVEY ON EDUCATION IN ATMOSPHERIC NUMERICAL MODELLING IN SOME EUROPEAN COUNTRIES

INTRODUCTION

According to the plans of the NetFAM-project, one of its objectives (5) is “to promote the exchange of information and best practices on curricula and training on atmospheric simulation, fine-scale modelling and surface-atmosphere exchange”.

To implement this goal, the work-plan states that a review of the present status of the NWP education in NetFAM institutes will be performed, in order to form a basis for recommendations for further development and coordination.

In this perspective, all partners surveyed courses on the topic of “Numerical Modelling” that are delivered in Universities in their country and in their institution. The survey included the following aspects:

- name of the course,
- how many hours,
- level of the course (1st, 2nd,… year of University and/or part of Master, Lis/DEA, Doctoral studies)
- any other complementing information

ANALYSIS OF THE SURVEY RESULTS

Information on nine countries (Denmark, Estonia, Finland, France, Iceland, Lithuania, Norway, Russian Federation, and Sweden) was provided. The overall results are displayed in Table 1 of the Annex. One should however note that this survey had no intention to be exhaustive (in terms of countries, institutions and information), since dealing with education curricula matters is not the core activity of this scientific network. Education is anyway one important upstream condition for the continuous delivering good scientists in the field of atmospheric numerical modelling. The survey therefore provides an interesting snapshot of the situation in a few European countries where meteorology has anyway had long traditions and credentials.

The survey was performed for the sake of informing the meteorological institutions involved in the project on the situation in those countries for further brainstorming if necessary between responsible education departments. This survey has no intention of benchmarking the various curricula or to serve as a guide for students.

Although the results display some heterogeneity between countries, there are yet some commonalities. It appears that courses on numerical modelling are delivered in most countries and generally are delivered only at the 3rd or 4th year of University education. According to the title of the courses or their brief summary, it also appears that the all courses address similar topics with the same progression. This reflects the common needs for numerical modelling capacities in European atmospheric community. The French case seems the most structured and comprehensive. It reflects the fact that MeteoFrance is one of the major meteorological services in Europe and has a dedicated school for meteorological education.

On the other hand, the volume (number of hours) of the courses varies greatly. This implies that the degree of details by which the rather common topics are addressed differs from one country to another. It also seems that there is no common textbook for education in numerical modelling, and thus the variable emphasis given to specific topics may rest greatly on the personal experience and interest of the teachers.

An important incentive and asset for further developing education in numerical modelling has to be based on stronger partnership between universities and meteorological services in order to take better into account the various theoretical, technological and practical requirements inherent to the field. This would also ensure the necessary flexibility for educating both forecasters and users of numerical models as well as developers or model theoreticians.

This yields to the need to have a good modern introductory-level text book. Back in the 70's and 80's, there was general use of Haltiner's book or later Haltiner/Williamson. But since then, there has not been published a fully adequate or comprehensive Numerical Weather Prediction book including all the recent important but quick developments in the field. Kalnay's book is too difficult and comprehensive (it is good on the graduate level), while Holton's book is too short.

An important addition in the last two decades has been the organisation of various training courses on specific numerical modelling topics in the premises of the European Centre for Medium-Range Weather Forecasts (ECMWF) in Reading. This is a consequence of the emergence of the ECMWF as a major global player in numerical modelling both for theoretical and application developments. These courses are generally accompanied by thorough lecture notes. Though very timely and expert, these lecture notes still lack however the overall perspective and deeper theoretical insight of a text book.

Another problem is the fact that meteorological or atmospheric sciences departments in European universities are rather small with the staff distributed over various topics. This yields a lack of man power for dedicated development of education material. The still heterogeneity of the national education systems with national languages makes it more difficult to achieve concrete and practical cooperation, at least at bachelor and master levels.

Haltiner G. J., 1971. Numerical Weather Prediction. John Wiley & Sons Inc). 326 p. ISBN: 0471345806

Haltiner G. J., Roger T. Williams, 1980. Numerical Prediction and Dynamic Meteorology (2nd Edition). Wiley & Sons; 496 pages **ISBN:** 0471059714

Holton, J. R., 2004: An Introduction to Dynamic Meteorology, 4th edition, Vol. 88, International Geophysics Series, Elsevier, 535 pp., ISBN: 0-12-354015-1

Kalnay, E., 2003: Atmospheric Modeling, Data Assimilation and Predictability, Cambridge University Press, Cambridge, U.K., 341 pp., ISBN: 0-521-79179-0

ANNEX

TABLE 1: Overview of numerical modeling courses in NETFAM countries

COUNTRY / Institution	NAME OF THE COURSE	OBJECTIVE/CONTENT	Number of Hours	LEVEL (years after start of university)
DENMARK / University of Copenhagen	Introduction to numerical weather prediction (NWP)	The course gives an introduction to data-assimilation, principles of numerical models with examples of weather predictions	30 h	+2 (part of master degree)
	Interpretation of weather maps and NWP products	This course is dedicated for education of operational forecasters in the practical usage of NWP products. Estimated first launch 2006-07	Comprehensive course with specific details decided through negotiations	+3
	Numerical methods in meteorology and oceanography	This is an introductory course to numerical methods. Some key words are: discretisation, grids, spectral representation, finite difference, finite volume, stability, semi-implicit, semi-Lagrangian. The course also gives an overview over fundamental methods being employed in existing models and over the most recent methods being considered. Will be launched first time in spring 2007	63 h (within a 7 weeks period)	+4 (master degree and for doctoral students
ESTONIA / Tartu University	Numerical models of atmosphere	Introduce students to the basics of numerical modeling of atmosphere. Students have the possibility to try out through practical exercises the basic approaches to physical parameterization and numerical solving of the equations. After passing the course, student should be able to put together simpler numerical models by oneself. Understanding of the basics of numerical modeling of atmosphere is essential when working with actual complicated numerical models of atmosphere or weather prediction	16h lectures + 16h exercises (2h per week), every second year	+4 (Master level)
FINLAND / University of Helsinki	Numerical Meteorology I	Dynamics: basic material about NWP & GCM (Course attendance implies mastering Holton's first 5-6 chapters) - Use xerox lecture notes (in Finnish)	28h + 14 h exercises	+3 (compulsory for MSc)
	Numerical Meteorology II	The course is more about data assimilation and 4D-VAR - Uses xerox lecture notes (in Finnish)	28h + 14 h exercises	+4 (optional)

FRANCE / MeteoFrance	Numerical Analysis	Various numerical methods and their application (essentially, methods for solving linear systems and partial derivative equations).	42h	+3
	Data Assimilation	Goals of assimilation. Types of treated observations. Insertion of these data into the operational suite. Concepts and methods enabling data assimilation.	16h	+3
	Numerical Forecasting (NF)	Activities embedded in NF. Notions on empirical methods, physical parameterisations, the assimilation cycle, predictability. Limitations of NF.	20h	+3
	Numerical Forecasting	Characteristics of the different models (ECMWF, UKMO, ARPEGE, ALADIN…)	2h	+3
	Numerical Forecasting	Control of models. Control of sensible weather.	2h	+3
	Oceanic Modelling	Oceanic numerical models. Modelling the state of the sea.	2h	+3
	Pollutant Modelling	Dispersion modelling. Modelling of atmospheric chemistry and greenhouse effect. Modelling of stratospheric ozone.	4h	+3
	Modelling Project	Solve a concrete modelling problem by using theoretical meteorological knowledge.	6 weeks	+3
	Hydrological Modelling	Prediction of floods. Rain-discharge, hydro-meteorological models.		+3
ICELAND / Meteorological Institute		No formal courses on the subject Teaching of graduate students on individual basis (MS + PhD)		
LITHUANIA / Vilnius University	Introduction to NWP	This an introductory course includes basics of the dynamic meteorology and general description of the main NWP modules: model physics, physical parametrization, assimilation and verification	48 h +32 h (practice)	+3 (part of Master, Lis, Doctoral studies)
	Introduction to GCM	An introductory course for climate models, their main parts, coupling, differences with NWP and possible interpretation	48 h	+3 (Part of Master degree)
NORWAY / University of Oslo	Numerical models of the atmosphere	Coordinate systems. Finite-difference methods. Truncation error and stability analysis. Objective analysis of weather maps. Outline of numerical weather prediction. Parameterization of clouds, precipitation, boundary layer, radiation and surface exchange of energy, mass and momentum.	4 hours per week of lectures, seminars and exercises.	+4 (for Master and Ph.D students)

RUSSIAN Federation / RSHU	NWP-1	Dynamics, numerical grid-point schemes	72 h	+4
	NWP-2	Physical Parametrisation	36 h	+5
	NWP-3	Spectral methods	18 h	+5
	Data assimilation	Theory	72 h	+5
	Chemistry-Climate Interaction Modelling	Theory	36 h	+4
	Middle Atmosphere Modelling	Theory	48 hours	+4
SWEDEN / Stockholm University/ Dept. Meteorology/	Modelling of large scale flow in atmosphere and ocean	Provides advanced knowledge in dynamical meteorology and physical oceanography. Especially similarities and differences between the dynamical systems represented by the atmosphere and the ocean. Dynamical phenomena like the Gulf stream, Rossby waves and storm development are studied from theoretical aspects as well as by support from numerical models. Practical use of simplified numerical models and the use of an operational weather forecasting model are central items of the course. Data assimilation and observational systems are also parts of the course	42 h	+4 (part of Master studies)
SWEDEN /SMHI	Interpretation of NWP outputs	Ad-hoc courses		