Medium-Range Weather Prediction

Austin Woods

Medium-Range Weather Prediction

The European Approach

The story of the **European Centre for Medium-Range Weather Forecasts**

Forewords by Professor Anton Eliassen, President of the ECMWF Council, Dominique Marbouty, Director ECMWF, and Professor Francesco Fedi, President of the COST Committee of Senior Officials

With 19 Figures, 9 in Full Color

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Foreword from the President of the ECMWF Council — Prof. Anton Eliassen

Meteorologists have long recognised the need for greater co-operation between the different European states. Eventually, in 1967, following an initiative from the Council of the Commission of the European Communities, at the time a community of only six countries, a group of visionaries drew up a list of scientific and technical challenges in which "the possibility of international co-operation could be discussed". By the end of that year, a proposal had been made for the establishment of a "European Meteorological Computing Centre". This far-sighted initiative lead to setting up the European Centre for Medium-Range Weather Forecasts (ECMWF), which on 1 November 2005 reaches its 30th anniversary.

I am proud of ECMWF. I can say with confidence that all those who have been associated with this most successful scientific and technical European organisation share this pride. Under the guidance of the Council and its Committees, and with the hard work of its talented and capable staff, the Centre has achieved much of what was envisaged. It has developed areas of research and applications that could not have been foreseen at the time of its establishment.

The public has become accustomed on Monday or Tuesday to being presented with a normally reliable outlook for the coming weekend's weather. Thirty years ago, this would not have been possible. The Centre's medium-range predictions have been of benefit at times of natural disaster, for commercial activities, in planning power supply, in planning sporting and marine activities, and much more.

ECMWF is a fine example of the advantages of international co-operation in science and technology. At the time of writing 25 countries support the Centre. We hope that our family of states will grow in the coming years.

I wish the Centre well in tackling the major scientific and technical challenges that it is facing.

Prof. Anton Eliassen
President of the ECMWF Council

Foreword from the Director ECMWF

Early in 2003, Lars Prahm, then President of the Council of the European Centre for Medium-Range Weather Forecasts, proposed to David Burridge, then the Director, that with the 30th anniversary of the Centre coming up on 1 November 2005, it was time to record the history of the Centre. It has been the practice of other European scientific and technical organisations, such as CERN, JET and EUMETSAT, to record the story of their early days while those involved were able to contribute their memories.

In June 2003, the Centre's Council supported the proposal. David Burridge commissioned Austin Woods, who had been at the Centre since 1978 and served as Secretary to the Council since 1984, to carry out the work. The book was started with the intention of writing the history of a highly successful European scientific and technical organisation. It is however not that history.

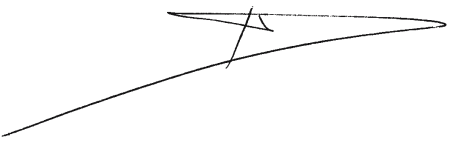
In autumn 2003, the Centre's first Director Professor Aksel Wiin-Nielsen was informed of the intention to write the history of the Centre. He objected strongly! His objection was entirely reasonable. One cannot sensibly write the history of a relatively young, and active, institution. At the time of writing, major construction is under way to increase the size of the Centre's Computer Hall and to provide much-needed new office space. The Centre's work is expanding to include monitoring of the global environment for important, but non-meteorological, purposes. Current affairs cannot be treated as history.

The history of the Centre will undoubtedly be written sometime in the future, when in Wiin-Nielsen's words: 'the people concerned have left this planet'. Instead, in this book we have a record of the Centre's beginning and of its work during its first 30 or so years.

The Centre is widely acknowledged to be the world leader in its field. The contribution of the staff to the Centre's success has to be emphasised. Without names, this book would be a dry read. However is not possible to name all who contributed. Indeed we would have to name many in addition who were not on the staff at all, but in the Member States and even elsewhere. A quick calculation suggests that a minimum of well over 1,000

individuals should in justice be named, clearly an impossibility! To list the scientific awards granted to Centre staff, their work as journal editors, their efforts as members and Chairs of international committees, their publications in the scientific and technical literature . . . would leave us I think with an unexciting book. Thus, the omission of a name from this book cannot be seen as neglect, nor inclusion as recognition.

I thank Austin Woods for his work in putting this record on paper. I am confident that the record of the beginnings of this successful and exciting European co-operative enterprise will interest many outside the world of meteorology.



Dominique Marbouty, Director
European Centre for Medium-Range Weather Forecasts

ECMWF

Foreword from the President of the COST Committee of Senior Officials — Professor Francesco Fedi

COST — the acronym for European **CO**operation in the field of **S**cientific and **T**echnical Research — is the oldest and widest European intergovernmental network for cooperation in research. Established by a Ministerial Conference of 19 European states in November 1971, COST is at present serving the scientific communities of 35 European countries to co-operate in common research Actions supported by national funds.

"Bottom up approach" (the initiative of launching a COST Action comes from the European scientists themselves), "à la carte participation" (only countries interested in the Action participate), "equality of access" (participation is open also to European countries not belonging to the European Union) and "flexible structure" (easy implementation and light management of the research initiatives) are the main characteristics of COST.

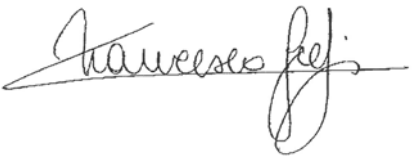
As precursor of advanced multidisciplinary research COST has a very important role for the realisation of the European Research Area (ERA) anticipating and complementing the activities of the Framework Programmes, constituting a "bridge" towards the scientific communities of emerging countries, increasing the mobility of researchers across Europe and fostering the establishment of scientific excellence in many key domains such as: Physics, Chemistry, Telecommunications and Information Science, Nanotechnologies, Meteorology, Environment, Medicine and Health, Forests, Agriculture and Social Sciences.

Today there are more than 200 ongoing COST Actions and there have been many hundred of Actions over the years. The scientific importance and relevance of COST results is well recognised by scientific communities outside Europe and, in particular, in the USA, Canada and in Asia. The Actions have also contributed to European competitiveness through their many contributions to normative and standardisation bodies, the many small enterprises originating in Europe from COST activities at the frontiers of modern technology and by the many examples of transfer of results to the European industry.

COST Action 70 "European Centre for Medium-Range Weather Forecasts" is a very good example of such achievements through its evolution to become an independent international organisation with its own structure and headquarters.

COST is proud to have been associated with the success and the growing importance of this European Centre. The key roles played by COST in establishing ECMWF are reflected in the many files in our archives from the period 1970 to 1975. They included arranging the many meetings of working groups and expert groups that lead to the decision to establish the Centre. It was at these meetings that the text of the Convention was agreed, the United Kingdom chosen as host country and the Centre's first Director appointed.

Therefore, in my capacity as President of the COST Committee of Senior Officials, I am particularly pleased, on the occasion of the 30th anniversary of its foundation, to be able to wish the Centre, its Director and its Council, the very best of luck for the future, especially in maintaining the outstanding traditions established in the past 30 years.



Professor Francesco Fedi

Preface

About 450 million people live in the 18 States that set up the European Centre for Medium-Range Weather Forecasts. Thirty years ago, they established an independent institution with a clearly defined objective. It was not to be a university-type institute for research, neither was it to be an operational weather forecast office. It would combine the scientific and technical resources of its Member States to use the most powerful computers in order to extend the range of weather forecasts beyond two or three days, the limit of useful forecasts at that time.

It would be small; the work force was to be limited to about 150, including administrative and other support staff. In 2005, 30 years after the Convention was signed, the staff totalled about 160. The Centre attracted the best talent in its specific field of endeavour. Each year about ten scientists left, to be replaced by newcomers bringing younger minds and fresh ideas. It is not surprising that it quickly became a world leader in its field. It is widely recognised as having maintained its leading position.

This book considers how the Centre was conceived in the confusing and difficult political period of the 1960s in Europe. It summarises the political, scientific, technical and financial discussions that led to the drafting of its Convention, and how it came to be built 60 km west of London, England. It tries to convey to the reader how it was that with friendly help the Centre 'hit the ground running'. The Centre's early and formative years are reviewed in Chapters 1 to 7. The development of its science and technology over the following thirty years is reviewed in Chapters 8 to 17. Chapters 18 to 20 deal with commercial issues, staff and the outlook. I hope this book will convey a sense of what it was like to be a participant during the exciting time at the beginning, and over the years as the Centre matured.

In 1985 the Centre's Scientific Advisory Committee considered 'the reasons for the undoubted success of the Centre':

- The aims of the Centre were focused on a single objective, which was at the same time important, attainable and scientifically challenging.
- Scientists, including visiting scientists, of the necessary calibre, have been attracted by the challenge.

- The latest supercomputers and high quality computer scientists have been available at the Centre.
- Since the Centre did not grow out of an existing organisation, it could build on the best technology and techniques available and establish its own mode of operations.
- The size of the Centre and the juxtaposition of research and operational work have aided interaction, given a sense of unity and spurred the research effort.
- Its Member States consistently supported the Centre, in particular by the provision of trained staff, and regarded its work as complementary to that of their own weather services, rather than competing with them.

The reader will find out how this has worked in practise. You will note as well the long time required — many years, with more than a decade not unusual — to bring a well-formulated plan for a scientific and technical project to operational fruition. Examples include the establishment of the Centre itself, and the implementation of ensemble prediction, seasonal prediction, ocean wave forecasting and new methods of data assimilation.

The meteorological world has seen major, some would say astounding, technological advances in satellites and computers, hand in hand with impressive scientific advances, during the last decades. The Centre developed within the framework of that process. It has benefited greatly from, and has been a major contributor to, those advances. The wonderful tradition of international co-operation in meteorology is exemplified in the story of this European organisation.

The text of the Convention, and details of the Centre's models, forecasts, archives, data services and much more are available on www.ecmwf.int.

The European Centre is an interesting place with an interesting history. The fault is mine if the reader finds any part of its story uninteresting. This book is not a formal history of the Centre. While based on documents and interviews, it reflects my personal thoughts, memories and ideas.

Austin Woods

Acknowledgements

When summarising past events, one has to rely in large part on documents written at the time by others. Plagiarism is copying someone else's work. Using material from many contemporary documents can I hope be called 'research'. Much of this kind of research has gone into this book.

I could not have written this book without help. The enthusiasm of those associated with the Centre at the prospect that its story would be recorded was evident. I thank all those who gave of their time and otherwise assisted me. I thank Dr Lars Prahm, at whose suggestion I started to write this book. I hope that I have not disappointed anyone with the resulting work.

I express particular gratitude to Dr Erich Süssenberger who gave me a great deal of practical help and answered many queries. He was kind enough to extend his encouragement to my writing. He had reached the normal retirement age of 65 on 13 February 1976, but his continuing interest in and enthusiasm for the Centre was clear when we met in late 2004.

The Centre's past Directors Prof. Aksel Wiin-Nielsen, Mr Jean Labrousse, Prof. Dr Lennart Bengtsson and Dr Martin David Burridge CBE, and the current Director Mr Dominique Marbouty, were generous with their time and support, and patient in dealing with questions and queries. So also were Sir John Mason, Director-General of the UK Meteorological Office when the Centre was being established, and Mr Michel Jarraud, Secretary-General of the World Meteorological Organization and a former member of the Centre's staff.

The COST Secretariat in Brussels and the German Weather Service DWD kindly made their invaluable archives available to me. Detlev Frömming of DWD gave me a great deal of practical assistance. The UK Met Office also made contemporary documents available. Prof. Anton Eliassen and Mr Magnús Jónsson helped to clarify issues relating to Norway and Iceland respectively.

John Wilmot of the UK Ministry of Supply 1945-47 said: "What I like about scientists is that they are a team, so that one does not need to know their names." Many current and former staff members of the ECMWF team, delegates to the Centre's Council and its Committees, and others within and

outside the Centre, allowed me to interview them or provided documentary material. Some gave particular help in supplying important and useful material, and improving the text as it progressed: Tony Hollingsworth, Adrian Simmons, Martin Miller, Walter Zwieflhofer, Philippe Bougeault, Gerd Schultes, David Anderson, Tim Stockdale, Sakari Uppala, Peter Janssen, Horst Böttger, Tim Palmer, Manfred Klöppel, John Hennessy, Roberto Buizza, Mariano Hortal, Bob Riddaway, Anabel Bowen and Rob Hine. I thank them all.

Austin Woods

Contents

Chapter 1

The first Director

Professor Aksel Wiin-Nielsen, the ideal candidate for Director of the soon-to-be-established European Centre for Medium-Range Weather Forecasts (ECMWF), was not particularly interested in the post. This was regrettable. However, it was understandable.

Wiin-Nielsen was in an enviable position. He had had an interesting and productive career. His working life started as a secondary-school teacher in his native Denmark, before joining the Danish Meteorological Institute in 1952. In 1955 he went to the International Meteorological Institute in Stockholm, Sweden as a student. Within six months of his arrival, he was invited to present lectures. One of his students was Lennart Bengtsson from Sweden, who was to become the first Head of Research of ECMWF and later its third Director.

Wiin-Nielsen went to the United States in 1959, first to Suitland, Maryland to join the staff of the Joint Numerical Weather Prediction unit. He moved to Boulder, Colorado as scientist at the new Laboratory for Atmospheric Science (LAS). This was part of the new National Center for Atmospheric Research (NCAR), which at the time owned neither buildings nor computers. Years later, he was to recall his time as Assistant Director of LAS: "there were so many practical things of building and changing and getting equipment and installing it . . . and we were all equally inexperienced in all these things". But what excellent experience for the future first Director of ECMWF!

Wiin-Nielsen had moved to Michigan in 1963. In 1969, when in his mid-40s, he first heard of the plans to establish the Centre. He was visiting professor at Copenhagen University for a year, on sabbatical leave from his post as Professor and Chairman of the prestigious Meteorological Department of the University of Ann Arbor, Michigan. The Department had several full Professors specializing in specific areas of atmospheric sciences.

His wife Bente and three daughters were settled in the USA. Life was pleasant in these American university towns in the 1960s. Schools were good; his daughters were progressing through the system. Cultural interests were well catered for, with visits from renowned European and American orchestras, artists and theatrical groups. Leisure activities included tennis, a favourite exercise for Wiin-Nielsen; he played tennis regularly with his grandchildren well into the new millennium, when he was in his late 70s.

He had an excellent professional and family life in the USA. The Beach Boys put it well: "This is the way I always dreamed it would be". The activities concerning the planning for ECMWF had registered as only a small blip on Wiin-Nielsen's personal radar, especially as progress was slow. Suggestions were tentatively made that he consider becoming Director of the planned Centre. He twice rather firmly turned them down.

The choice of Director was discussed on 8–9 May 1973 at the third informal conference of the Directors of the National Meteorological Services of the States interested in COST — European Cooperation in Scientific and Technical Research; we will discuss this further in Chapter 3. This was two months after the decision to site the Centre in the United Kingdom. At the invitation of Dr John Mason, later Sir John, the Director-General of the UK Meteorological Office, the conference was held at the Headquarters of the Meteorological Office at Bracknell. The conference expressed the wish that the Centre be set up quickly and efficiently. It was decided that a provisional Council of the Centre should be established, if possible before 1 August, to act as ruling body. This would remove responsibility for the Centre from the COST Senior Officials, who up to now had carried responsibility for establishing the Centre. The provisional Council could then make the decision on the Director, on the basis of technical and scientific criteria. If the Council had not been established, the COST Senior Officials would decide. Now who should be chosen, and how?

The world of meteorology has always been rather small, well informed and well connected. It had been recognised that "above all [of the other essential conditions which had to be fulfilled to establish a viable Centre], an outstanding and particularly energetic scientist had to be appointed Director of the planned institute". All the researchers in the field, all conceivable candidates, were well known to COST. No advertisement of the vacancy was required.

Three possible candidates all well qualified in the field were considered: Prof B. Döös from Sweden and Prof F. Wippermann from Germany as well as Prof Wiin-Nielsen. However, the general opinion of the conference "was in favour of Professor Wiin-Nielsen". There was agreement that a group

should be set up as soon as possible to provide the nucleus of the staff of the Centre. This would comprise the provisional Director and four others. These would be experts in the fields of numerical prediction, computers, telecommunications and administration, also to be appointed provisionally.

Mr C. L. Silver, President of the COST Senior Officials, noted that the "support for Wiin-Nielsen was very much greater than that for the other two". Döös and Wippermann requested that their names be withdrawn.

Wiin-Nielsen's position now left those planning the Centre with a real problem. It was not simply that he was the best candidate. In a sense, we see that he was now in fact the only candidate.

It would appear that the choice of Wiin-Nielsen was made without any political considerations. Some readers may perhaps find it beyond credibility that any major European decision can be made without political considerations. For their benefit, we can find just a flavour, just the smallest hint, of politics. We will see in a later Chapter that in the vote on the site for the location of the Headquarters of the Centre, Denmark was in second place after the UK. Perhaps not entirely coincidentally, the decision was made that the Headquarters of another European organisation — the European Patent Office — would go to another hopeful contender, Germany. Now what about Denmark? Would it not be entirely appropriate that the first Director would come from Denmark?

Lennart Bengtsson, who was visiting the USA at this critical time, was aware of Wiin-Nielsen's reluctance. Knowing Wiin-Nielsen to be "a competent and born leader", he visited him in Ann Arbor. Bengtsson informed Wiin-Nielsen that he, Wiin-Nielsen, had been nominated for the post of Director of ECMWF, and frankly told him that one of the objectives of the visit was to encourage him to apply.

Meanwhile, for Wiin-Nielsen, times and circumstances were changing. In early summer 1973, he had been offered the position as Department Head at the National Center for Atmospheric Research in Boulder, a position created by the departure of Philip D. Thompson. In addition, George Benton, Deputy Director of the Environmental Science Services Administration (ESSA), successor to the US Weather Bureau, wanted Wiin-Nielsen as Director of the various research laboratories under ESSA, which would also have meant him moving back to Boulder.

Wiin-Nielsen had been at the University of Michigan for ten years. After much reflection, he decided that it was time to move on; there was now a growing sense of inevitability about it. He decided that "if I am going to move anywhere, it has to be to ECMWF".

He had always had a special interest in setting up new institutions: "in one way, it's easier: you don't have to fit in with something that already exists". In addition, the new Director recruits his own staff. He does not have to "take over a group of people who have been used to someone else's style". Wiin-Nielsen felt that "you avoid having to take on the weight of the past, which can be hard to bear at old institutions".

Not quite sure how best to proceed, on 31 July 1973, Wiin-Nielsen wrote to Mr Silver at COST. He informed him that he was aware that he had been nominated for the post of Director of the projected Centre. He expressed his great interest in being considered, being "fully inclined to accept the post if it was offered". He was aware that it was planned that a group, including the Director-designate, would be established in late summer or early autumn 1973 to make initial plans for the Centre. Wiin-Nielsen enquired into the state of the project, and requested any other information judged useful.

The reply from Silver on 14 August was positive, and outlined the reason for the delay in completing the work on the Convention. Matters concerning the organisation, its programme and its financing had all been settled. What remained was without great significance to the Centre itself, but had assumed great importance to some future Member States, given the precedent that could be set for future organisations: the determination of the official and working languages of the Centre. [Some thirty years later, when consideration would be given to amending the Convention for the first time, the same question of languages was to prove the most difficult to resolve.] Since little would normally be accomplished in Europe in the summer period, the matter was unlikely to be resolved before mid-September at the earliest. The signing of the Convention could be expected soon after the problem was resolved, and the Director appointed provisionally a few weeks thereafter. He was not in the position to tell Wiin-Nielsen the date on which the post would be offered, nor even that it would be offered to him. However, he did inform Wiin-Nielsen that "you are held in very high esteem by all the experts in the field", and that "they would be greatly disappointed if you would accept another post that would exclude the possibility of you taking on this important function".

Soon after, Wiin-Nielsen was invited to go to Brussels for a meeting. From his sources, he was aware that the other two potential candidates had withdrawn their names from consideration. He knew that either they could nominate him or they would have to advertise the position. It also became clear that these were serious negotiations: he was told he should bring an assistant with him. The Danish mission to the European Economic

Community (EEC) in Brussels offered Mr Henrik R. Iversen to assist at the negotiations, an offer accepted by Wiin-Nielsen with gratitude. This would turn out to be a wise decision.

Dr John Mason of the UK Meteorological Office wrote asking Wiin-Nielsen to stop off in Britain en route to Belgium, so he could see where the new Centre would be built and the temporary offices that would be made available immediately.

The negotiations in Brussels lasted only a day. In the morning, Wiin-Nielsen met with Dr Süssenberger, Director of Deutcher Wetterdienst (DWD) — the German Weather Service, Dr Schregardus, Director of the Royal Netherlands Meteorological Institute (KNMI), Mr Gosset, Deputy Director of Météorologie Nationale, France, and Mr Zipcy, administrator of COST. They summarised: if terms could be agreed, the job was Wiin-Nielsen's. Iversen was well prepared. He had earlier briefed Wiin-Nielsen on the outcome of enquiries he had made on salaries given to others in comparable positions. When the question of the salary arose, Wiin-Nielsen produced a document stating the required salary, with reasons for the figure proposed. Eyebrows rose on the other side of the table. It was clear they had not thought of a figure of this magnitude. Iversen asked "So how much had you been thinking of?" When this much smaller figure was put forward, Wiin-Nielsen received a slip of paper from Iversen: "Say no". This he did. The parties agreed to have lunch separately, to give time to think things over.

Discussions started again after lunch. The negotiators were willing to accept the well-researched demands, and the remaining issues were quickly resolved. Wiin-Nielsen could say that he was ready to start in January 1974.

As the first person to be recruited for the Centre, Wiin-Nielsen now had to take on the task that would face many future staff members: making arrangements to move his family to the United Kingdom. The list of issues to be tackled would become familiar to many later recruits: temporary and later permanent housing, schooling for the children in a new system with the unusual British O and A Level examinations and where the "public" schools were very much private, separation of all the family members from their friends of long standing, and more. One difficult change had already been made: his family was already living in an English-speaking country.

The day after conclusion of the negotiations in Brussels, Wiin-Nielsen travelled to Denmark to visit his parents and his close family. He then returned to Ann Arbor, where he had many discussions with his wife Bente as to how to arrange the family move to the UK. Their eldest daughter Charlotte had already started university at Ann Arbor, and was in her first year.

Marianne their next daughter was in her last year at high school, and the youngest, Karen Margrete, was at the same school. It soon became clear that they would stay at Ann Arbor for the rest of the academic year at least. Bente would stay with them until they had sorted themselves out, after which she would join Wiin-Nielsen in England. She stayed with them until March, when she sold the house and rented an apartment their children could share.

On 9 January 1974, the COST secretariat was able to send a note to the COST Members:

> *On 21 December 1973, Professor Aksel C. Wiin-Nielsen informed the Secretariat that he agreed to take up the post of Director of the European Centre for Medium-Range Weather Forecasts on the basis of the terms of appointment dawn up by the Interim Committee and approved by the Committee of Senior Officials on Scientific and technical Research. He took up his duties on 1 January 1974.*

Wiin-Nielsen was at this stage the Director-designate; he did not formally become Director until 4 November 1975, when he was appointed by the first Council session. He spent his first few weeks in his new position in Brussels, to familiarise himself with the procedures of the COST secretariat. Initially the Centre would function under COST, since the new organisation would not come into existence as a legal entity until sufficient States had become Member States by ratifying, accepting or approving the Convention. This could take some time, and in fact was completed only on 1 November 1975, almost two years after Wiin-Nielsen's appointment. In the meantime, the future Member States were keen for preparations to proceed with deliberate speed. The different bodies, the steering committee — the precursor to the Council — and supporting advisory committees, were to be set up and running, with financial support coming officially through COST for the interim period.

While staying in Belgium, Wiin-Nielsen lived at the Hotel Metropole on the Place Brouckère. He knew when he arrived that he would be there for some weeks, and he insisted on choosing a room himself; he would need furniture that would allow him to work from the room. The hotel was well known in scientific circles, as it had been the location for many of the famous Solvay scientific conferences of the early decades of the 20th century, which brought together many distinguished physicists in Europe. The Solvay conferences on physics were particularly noted for their role in the development of theories on quantum mechanics and atomic structure. In this hotel, many important discussions between Bohr and Einstein had

taken place. Pictures of the scientists who had attended the meetings were available for purchase in the hotel lobby.

During these few weeks, the Danish mission to the EEC, which was close to the building where COST was based, provided an office at its premises for Wiin-Nielsen's use.

Wiin-Nielsen's contact at COST, Mr Moys from the UK, acted as an administrator for the first few months until the Centre received its own budget during the course of 1974. Wiin-Nielsen found his knowledge and experience in dealing with the bureaucracy in Brussels to be most helpful. Wiin-Nielsen and Moys made rapid progress, and submitted budget proposals, which were considered at the first meeting of the interim Council, so that Wiin-Nielsen could start working from England.

In his first weeks in Brussels, Wiin-Nielsen and Moys arranged the first meeting of the temporary Scientific Advisory Committee, to which Dr Heinz Reiser of Germany was appointed Chairman. This was very helpful to the recruitment process Wiin-Nielsen was due to start once he moved to England. The Committee members could support him in a number of respects, especially since at this time Wiin-Nielsen was not that familiar with European meteorologists. He was glad to note that the Committee members were both highly interested and very helpful, even if some of them appeared at times to be rather upset. Wiin-Nielsen suspected that they would perhaps have liked to be considered for some of the posts themselves!

At the beginning of February, Wiin-Nielsen moved to Bracknell. This town is 15 km east of Shinfield Park, Reading, where the Centre building was to be constructed. The top two floors of Fitzwilliam House, an office building about 10 minutes' walk from the headquarters of the UK Meteorological Office, had been set aside for temporary use by the future staff of the Centre. At the beginning of course there was only Wiin-Nielsen. The accommodation was above the local government offices of the Department of Health and Social Security (DHSS), so there was constant activity in the building.

Wiin-Nielsen arrived in Britain in the middle of the first major oil crisis. There were restrictions on use of electricity and heat. Wiin-Nielsen remembered the DHSS caretaker keeping a close eye on his use of power! As it was winter, there was sometimes not enough light. He used an east-facing office in the morning and moved to a west-facing one after lunch. He was invited to take his lunch in the cafeteria at the Meteorological Office, in the separate room for higher civil servants, irreverently known to junior staff as "the Golden Trough". That suited him: it meant he could do some shopping, and visit the bank and Post Office, en route between the two buildings at lunchtime.

At the beginning, he wrote his own letters and documents, until he employed a secretary, Jane Khoury, who, he recollected, "must have been one of the best typists in the world". The financial regulations were still to be adopted. Initially, no funds were available for capital expenditure, only for consumables. He couldn't for example buy typewriters; the financial constraints were such that he had to hire them. Following long discussions in the Finance Committee, this was done, but with the option to buy during the first two years.

He stayed at the Royal Ascot Hotel, but soon rented a small terraced house on the south side of Ascot. His wife Bente arrived in the spring. They started looking for a family house immediately, and found a suitable one in Finchampstead. It would be June before his finances were sorted out; as a foreign national he could not use the standard UK mortgage arrangements. Finally, Barclays Bank arranged a suitable loan. They had moved into the house by the time their children came from Ann Arbor, one by one over the course of the summer. The two eldest had arranged summer vacation jobs there.

Wiin-Nielsen was determined that the Centre would not become dedicated solely to meteorological research. He agreed with the objective that the Centre would instead move as quickly as possible to become an operational source of real-time weather forecast information for the benefit of the National Meteorological Services of the Member States. He believed that there was no point in re-inventing the wheel, so to speak. Instead of planning to spend the first decade developing its own model, he set a target date of August 1979 for the first operational forecasts, using whatever means were available.

His first difficult task was to assemble a well-qualified group for the development work ahead. He took the view that he wanted people who could in principle join the permanent staff once the Convention came into force. Talent is rare, and he knew that he needed to attract the best in their fields from among the scientific and technical staff of the future Member States. As the Centre was to be both a scientific and an operational institution, Wiin-Nielsen decided there should be three Departments: Research, Operations and Administration.

It was time for the COST secretariat to be relieved of responsibility for the Centre. An early priority was given to getting administrative assistance. James Clark of the UK Meteorological Office was appointed temporarily to help deal with administrative issues.

It was clear that Lennart Bengtsson was very interested in coming to work at the Centre. Wiin-Nielsen had known him very well over the years.

A graduate of the Universities of Uppsala and Stockholm, he had been interested in meteorology from his teens. For his military service, he had taken advantage of a new arrangement set up by Prof Carl-Gustaf Rossby, under which two months of basic military service was followed by academic studies under "excellent and inspiring teachers" including Bert Bolin, Bo Döös and Aksel Wiin-Nielsen. Bengtsson remembered Wiin-Nielsen teaching him the Fjørtoft Graphical Technique, a manual method of numerical weather prediction. After a spell as assistant to Tor Bergeron at the University of Uppsala, Bengtsson joined Bo Döös in setting up a numerical weather prediction unit at the Swedish Meteorological and Hydrological Institute (SMHI).

In the 1960s Bengtsson became involved with planning for the First GARP Global Experiment (FGGE), visiting the United States several times. He explored the need for global data assimilation and collection of the global data for FGGE. Another of his activities was being Chairman of the World Meteorological Organization (WMO) Working Group on Numerical Weather Prediction. In addition he had published a number of papers on numerical forecasting, and had been involved in the Global Atmospheric Research Programme (GARP). Bengtsson was an ideal candidate for the post of Head of Research at the Centre. While Wiin-Nielsen and Bengtsson rapidly agreed on terms, his appointment formally had to await Council approval.

Meanwhile, Jean Labrousse of France had been highly recommended to head the Operations Department. Like Bengtsson, Labrousse had been an active member of the Interim Planning Staff for ECMWF. When Wiin-Nielsen approached him, however, he was non-committal on the telephone; Labrousse appeared to be somewhat reluctant to take a post at the Centre. During a visit to Paris, Wiin-Nielsen and Labrousse got down to serious negotiations. Labrousse explained that while he wanted to come to the Centre, there were two problems. One was that his immediate superior Mr Mittner was unwilling to grant the leave of absence required. The other was Madame Labrousse, Janine, who perhaps understandably couldn't imagine living isolated in the British countryside! Wiin-Nielsen made an appointment with Mr Mittner and Mr Gosset, who was deputy to the Director-General. Mittner argued that he couldn't do without Labrousse, because they were on the brink of moving the department to Toulouse. Gosset explained that the transfer wouldn't happen for at least some two years, and Labrousse was given leave of absence for that period. He agreed with his wife that they would live in an apartment in west London. Labrousse would "reverse-commute" against the flow of traffic, leaving London in the early morning and returning in the evening.

Wiin-Nielsen was highly satisfied with the appointments. The three worked together outstandingly well on building up the Centre in the next few years. They complemented each other excellently. It was clear that Bengtsson was not happy at the beginning about the idea of living in Britain, as there were major differences between general attitudes in Britain and Sweden. He frequently referred to an article in the Swedish press, which said that any Swede who had lived in Britain for two years or more could never go back to Sweden, because he would have lost all his efficiency! Wiin-Nielsen was amused to note that Bengtsson eventually retired to live in England, continuing his research at the University of Reading, in an office just a couple of miles from the Centre.

Labrousse always envisaged going back to France after a short time, but in fact he stayed at the Centre for close to eight years, before returning to become Director-General of Météorologie Nationale, the French Meteorological Service. Perhaps we can look ahead to a party in December 1981, when the Council bade farewell to Labrousse. The Council President Dr E. Linglebach from Germany, having recognised Jean Labrousse's "great skill and ability" in recognising the important problems, noted: "you have always found workable solutions", and further: "j'ai admiré votre logique française et votre humeur gallic!"

Bengtsson and Wiin-Nielsen were working on getting the experimental forecasting up and running. In line with his objective to start operational forecasting soon, Wiin-Nielsen contacted two groups in the USA, who were well advanced in terms of model building. One was at the University of California, Los Angeles (UCLA), led by Professor Yale Harvard Mintz, "the only person I know" said Wiin-Nielsen "who was named after two universities!" The other was at the Geophysical Fluid Dynamics Laboratory (GFDL), under Dr Joseph Smagorinsky. Both of them agreed to make their modelling and other software available, on condition that the Centre sent a scientist to work with their groups for a few months, to gain a full understanding of the complex software. This was agreed, and Robert Sadourny, at the Centre on leave from the Centre National de la Recherche Scientifique (CNRS), went to Los Angeles. Also Tony Hollingsworth, who was a newly recruited scientist and later became Head of Research, went to Princeton.

In the meantime, Labrousse was working on getting temporary use of a computer for installation at Bracknell. A Service Agreement with Control Data Limited came into effect on 26 August 1975. The hired CDC 6600 was slow, and although far from satisfactory for the requirements, it had enough capacity to allow trial forecasts. It was installed in John Scott House, a building close to Fitzwilliam House. In December the Service

Agreement was changed to a Lease Agreement, giving unlimited access to the computer. In addition, time was purchased on the IBM 360/195 at the Meteorological Office.

Recruitment of staff from Member States for the Research and Operations Departments continued. All were conscious that the spin-up time allowed for the entire complex system to get to fully operational forecasting was very short — too short, in the opinion of some.

When it came to appointing the Head of Administration, Germany strongly supported Dr Wolfgang Dieter von Noorden for the post. He replaced Mr Clark, who if given the choice would have liked to continue. It is fair to say that the working styles of von Noorden and Wiin-Nielsen were very different. Wiin-Nielsen needed to make a myriad of decisions large and small in a rather short period and while under pressure to produce results quickly. Von Noorden's background in the larger and more bureaucratic administration of the Federal Republic of Germany did not match well with Wiin-Nielsen's requirements at the time. Discussions on administrative and legal matters were at times difficult, even heated. After a relatively short time, von Noorden left the Centre, to take up an appointment with INMARSAT in London.

Committee meetings moved from Belgium to Britain. Conference rooms of sufficient size and with the required facilities for simultaneous interpretation were unavailable in Bracknell. Suitable premises were found at the Headquarters of the International Coffee and Cocoa Organisation in London. Those who attended the meetings remembered them for the four different kinds of excellent coffee, always provided for free! Centre staff gradually gained more experience with meetings. The underlying papers got shorter and better, thanks largely to the precision and brevity of the original English documents, whose preparation was handled by Ernest Knighting (normally referred to simply as "K"), a consultant who had recently retired from the Meteorological Office. K did a "marvellous job" of introducing Wiin-Nielsen, Bengtsson and Labrousse to the sometimes subtle nuances of the British system. Labrousse later referred to him as "une figure, très intelligent, très fin, avec un esprit critique très acerbe et au final très constructif."

At an early stage, an estimate was needed of how many members of staff would finally be required. A surprisingly small number — just over 30 — was allowed for the Administration Department. An international organisation has heavy requirements for administrative personnel including recruitment of international staff, and for translation, as well as general services, building maintenance and liaison with the authorities of the host

country. The Operations Department became the largest; it was clear that the Centre would work round the clock. Many technical staff would be required to supervise and maintain the computer and telecommunications installation, the software and other technical equipment. These were estimated to total about 65. Around 35 scientists would be required for the Research Department. The total was thus taken to be around 130. The architect assigned to the building project, Mr Kidby, needed these numbers, even though they were a shot in the dark at that early stage.

Kidby also needed an estimate of how many square metres would be needed for computing equipment and other technical installations. That was more difficult, as the planning staff still had no idea what computers might be acquired in the years to come. The most pessimistic assumption had to be made that the largest machines then available would be installed. This proved to be wrong, as the Centre's choice, a CRAY computer, was highly compact. On the other hand, the more usual problem of the building being too small was avoided; later there was adequate space for replacement mainframe computers, which would run in parallel with those already installed. Furthermore, space was available for a large archive and for the many magnetic tapes used by the computer system in the 1970s. It was not until more than 30 years later that the Computer Hall would need to be extended; a contract for this extension was signed in July 2004.

The architect also needed to know how many of the staff would be men, and how many women; this would affect the number of toilets required. Wiin-Nielsen looked him in the eye and told him that there would be equal numbers of each. Kidby proceeded accordingly.

Working with Kidby went well on the whole. Kidby said that it was good working with precise people, but there was one point of serious disagreement. There was an energy crisis at the time in the UK. As the electricity supply might fail, it was important for the Centre to have two large diesel generators, which could provide the Centre with the backup supply required, and some large batteries to ensure that computing would continue uninterrupted if the power supply failed. This was absolutely essential, as it would take up to 30 minutes to get the diesel generators up and running. Data could therefore be lost, and the programs running adversely affected. Kidby agreed to all this, but when Wiin-Nielsen said the batteries should be in the basement below the computer room, Kidby disagreed: "We don't do basements in Britain". The reason for this was that they were always damp and hence unusable. Wiin-Nielsen explained there were basements in the Netherlands and Denmark in areas below sea level. But the answer was the same: "We do not do basements". There was a deadlock. One weekend

Wiin-Nielsen, Bengtsson and Labrousse visited the site and visualised the finished building in drawing form. They realised that if the whole complex was rotated through a few degrees, the computer room would be on a sloping section of the site, so there would be room for two floors on the low side and one on the high side. Wiin-Nielsen suggested this at the next meeting. Agreement was reached, and the batteries were installed on the ground floor under the computer room, which was strictly speaking no longer a basement.

A separate wing held an excellent lecture theatre seating 126, and a large conference room for the Council, its Committees and other groups, containing an oval table large enough to accommodate the Chairman, 42 delegates and 40 advisers. Five interpreters' booths allowed for simultaneous interpretation to and from the five official languages of the Centre. There were also smaller meeting rooms. The final wing contained the offices, with the library on the top floor.

It was necessary to have discussions with the UK government on matters concerning the Centre, such as negotiating the Headquarters Agreement between the Centre and the UK, which laid down the rights and obligations of the Centre; Wiin-Nielsen was given a contact at the UK Foreign Office, Miss Phyllis Smith. She helped greatly with many issues raised, and wrote the first draft of the Headquarters Agreement. This was based on similar agreements with other organisations, but contained one perhaps rather unusual provision. The Centre was granted a 999-year lease on the land free of charge, with the condition that, when the land and buildings reverted to the UK, the buildings had to be in the same condition as received. Wiin-Nielsen was intrigued; he asked Kidby how long he thought the building would last. The answer was that they "didn't build for centuries any more, only perhaps for 60-70 years". After a little discussion, he and Wiin-Nielsen agreed that this would be a problem for others to worry about! Wiin-Nielsen signed the Agreement for the Centre.

In the two weeks 1–12 September 1975, the first of what was to become an annual series of ECMWF Seminars was held at the Met Office College in Shinfield Park. Prof Pierre Morel from Laboratoire de Météorologie Dynamique (LMD) France dealt with data and its assimilation in numerical models, Dr Kiku Miyakoda from GFDL reviewed how physical processes were modelled, as well as numerical methods. Dr Cecil Leith from NCAR described progress in understanding uncertainties in the initial state and in the representation of physical processes. More than forty participants attended from the Member States. This was the beginning of the Centre's major programme of advanced training. Each year since, the Centre has organised

well-attended Training Courses in meteorology and computing, as well as Seminars and Workshops.

At the first Council session on 4–6 November 1975, Wiin-Nielsen presented his first report to Council. (The role of the Council and its Committees is outlined in Annex 2.) Contracts with the Centre staff had expired the preceding Saturday, but had been extended to cover the period of the Council session! However, he noted that with the Convention coming into force, and the adoption of staff regulations and financial regulations, the days of improvisation were over; the Centre was now on a sound footing. He noted the importance of the forthcoming major First GARP Global Experiment (FGGE) exercise, planned for about the time that the Centre would be ready to begin operational forecasting.

The Centre's headquarters building was opened on 15 June 1979 with speeches from His Royal Highness Prince Charles, Prof Lauri Vuorela of Finland, who was Council President at the time, and Wiin-Nielsen. Dr E. Süssenberger, first Council President, and as we shall see later a key figure in planning the Centre from the beginning, was among the guests invited to attend the opening ceremony.

While the contract for the Centre's computer was put out to tender, in reality there was no credible competitor; this was a one-horse race. The contract was negotiated and signed with Cray Inc. Such a major purchase had to be approved by the Council, taking into account the opinions and recommendations of the Finance Committee. Labrousse was outstanding in presenting the issue to the Committee and Council. He had considered all the possible clauses of the long and complicated contract and answered questions clearly. The representative in Europe of Cray Inc, Mr Peter Appleton Jones, was also of great help. The Centre had the first prototype CRAY-1, later replaced by a completely new machine. It — and the same was true for its successors — was surprisingly reliable for such complicated hardware and software. Before the start of operations, foreseeing the absence of a backup mainframe computer, Member States were advised to plan for the loss of perhaps one forecast per week, or two or three a month, to allow for unexpected hardware or software problems. In the event, only a handful of forecasts were partially or completely lost in the first operational year from 1 August 1979. These were later re-run to maintain a full archive. Operational forecasting seven days per week began on 1 August 1980; none of the forecasts were lost after that date and delays were few.

Wiin-Nielsen left the development of the science to Bengtsson and his staff in the Research Department. They made rapid and substantial progress in creating the Centre's own forecasting model. Studies of the model software obtained from the USA, and the experience gathered from other institutions,

as well as their own substantial stock of experience, all contributed. The task, quite simply, was to put together a model consisting of the best components from the scientific literature or created in-house. Bengtsson was a driver; he demanded, and demanded again, more and more of his staff. He was impatient with doubters. He never accepted "luck" as an explanation for success, or "bad luck" as an explanation for failure. He peppered his staff with questions, constantly raising the level of expectation. He had "the vision thing". Perhaps more important, he had the staff who were able and willing to carry out the necessary research. It was common to find Centre staff working late into the evening, and at weekends and holidays. Years later, when Bengtsson was Director, the prospect was raised by the Administration Department of keeping account of staff hours worked. Bengtsson vetoed this rapidly. He knew that if staff realised just how much time they were putting in, this would likely have resulted in a reduction of the hours worked!

In spite of his administrative and management responsibilities, Wiin-Nielsen maintained a close personal interest in the scientific work. Sakari Uppala, a Finnish scientist working on the FGGE data at the Centre, remembered Wiin-Nielsen regularly coming into the FGGE office, pulling up a chair, lighting one of his famous low-tar cigarettes, and asking: "OK now, what's new today?"

There was one major subject on which Wiin-Nielsen felt very strongly, and which led to some intense, even difficult, discussions between him and the staff of the Research Department. That was the use of the mathematical "semi-implicit scheme" in a global forecast model. This — to allow longer time steps in the model — was a major gamble taken on Bengtsson's insistence. He needed to use this numerical formulation to allow the use of a high-resolution global model. Semi-implicit time differencing is relatively more stable and allows larger time steps than the explicit time differencing then used. A model with a time step of 20 minutes would need only one-quarter of the computing resources required by a model with a five-minute time step. He planned to use David Burridge's experience of the semi-implicit scheme already in use at the UK Meteorological Office.

Burridge had been one of the first recruits to the Centre in May 1975 as a member of the Interim Planning Staff. He had been at Florida State University for a year from September 1979, when he had been awarded his PhD in mathematics by Bristol University. He had come to the Centre following five years' experience as a scientist involved in forecasting research at the UK Meteorological Office, working as part of a strong team headed by the legendary Fred Bushby. They had developed a 10-level model with 100 km horizontal resolution extending over the Northern Hemisphere, which was designed to predict frontal development and rainfall. Burridge went on

to become the Centre's Head of Research, and later its longest-serving Director, holding that post from January 1991 until his retirement in June 2004. In 1995, Queen Elizabeth II awarded Burridge the prestigious title of Commander of the British Empire (CBE) for his services to meteorology.

Burridge was given overall responsibility for the numerical aspects of the first model. Bengtsson was convinced that successful medium-range prediction would require a resolution of at least 2° in latitude and longitude. This could not sensibly be achieved without replacing the explicit scheme with a semi-implicit scheme. Wiin-Nielsen was concerned that the scheme would in fact lead to a running time of the forecast that would be longer than operationally feasible, and that errors would be introduced into the forecasts. Bengtsson and his staff stuck to their guns. Experiments showed that only insignificant differences were introduced in the forecasts when the more efficient semi-implicit scheme was used. Eventually Wiin-Nielsen, after being shown the experimental evidence of the benefits, reluctantly agreed. The scheme was used in the model. The first version of the model was tested in 1977, when the CRAY-1 was installed. Testing continued throughout 1978. The Centre was ready to start operational forecasting in 1979, as planned.

The results were promising. Compared with forecasts produced in the USA, Britain, France, Sweden and Japan, the Centre's trial forecasts were clearly best. By 1979/80 the Centre was already providing forecasts useful on the average for up to 5 or 6 days ahead — a wholly remarkable achievement.

One of the keys to Wiin-Nielsen's effectiveness as Director and Chief Executive Officer of the Centre was his admired natural ability to forge creative working relationships: first between the Centre staff in its three Departments of Administration, Research and Operations, and then between the secretariat of the Centre, the Council, its Committees and various Working Groups. His ability to manage Council and Committee sessions became the stuff of legends. It was said that he would allow discussions to proceed, listen to the national delegates state their positions, and when discussion reached an impasse, would produce his own well-prepared proposal, to the relief of those sitting around the table, who were happy to approve it.

Wiin-Nielsen was proud to be able to say that the Centre and its staff, with their efforts, had delivered the forecast products on time, and with high quality. Wiin-Nielsen later noted that for him, this was the greatest experience of his life: to be allowed to head this major project, which required scientific insight, technical ability, practical action and a good working relationship with Council and its Committees. He recognised that this could never result from the work of one man. It called for collaboration, respect for other people's opinions and abilities, and above all constant, unyielding hard work with a definite aim kept clearly in focus. Wiin-Nielsen noted that