



# FRIEND

Flow Regimes from International Experimental and Network Data

*Projects H-5-5 (IHP IV) and 1.1 (IHP V)*

Third report : 1994-1997



**Cemagref**  
EDITIONS



## FRIEND

### Flow Regimes from International Experimental and Network Data

**Projects H-5-5 and 1.1**

*Projets H-5-5 et 1.1*

**Third report : 1994 - 1997**

*Troisième rapport : 1994 - 1997*

June 1997

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***supported by the FRIEND Groups, the GIS AMHY, the GIP HydroSystèmes, Cemagref, et alter***

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## Preface

*A. Szöllösi-Nagy*

FRIEND (Flow Regimes from International Experimental and Network Data) began in 1985 based on an idea by Dr John Rodda, then Secretary General and now President of IAHS. At the instigation of a few European hydrologists, a group of European countries started sharing data and skills with a view to developing research activities on flow regimes at a regional scale with the aim of gaining a better understanding of the spatial and temporal variability of hydrological regimes. By 1989, thirteen countries had taken part with substantial benefits in regional-scale analysis of hydrological regimes and the detection of trends due to climate change and human impact. In view of the continued interest shown by the Member States of UNESCO in the FRIEND project it was decided by the IHP Intergovernmental Council to include it in the plan for the Fifth Phase of the International Hydrological Programme (Theme 1: Project 1.1).

The encouraging results obtained, presented at the first FRIEND Conference in Bolkesjø, Norway, 1989, combined with the flexibility of the project organization and implementation, led to the establishment of other FRIEND projects in the Mediterranean region (FRIEND AMHY), Africa, South-East Asia and the Nile region. FRIEND projects are structured around four-year periods concluded by a Conference where the main results are presented and discussed and eventually published.

Since 1985, a great deal of progress has been made in the understanding of spatial and temporal variability of hydrological regimes. The FRIEND project has also developed an important training component which contributes to improving the skills of hydrologists and to the strengthening of the capacity of national hydrological services to assess their water resources.

FRIEND today represents a network of expertise covering Western and Eastern Europe, the Mediterranean region, Africa, Asia, the Pacific and will soon include Latin America.

This publication is being issued in connection with the third FRIEND Conference which is taking place in Postojna, Slovenia, 1-4 October 1997. It includes the main research results obtained during the period 1993-1997 by FRIEND Northern Europe and FRIEND AMHY as well as contributions from the Southern Africa and Western/Central Africa Groups.

I would like to express my thanks to all the hydrologists who have contributed to the success of the FRIEND project, and, in particular, to Dr Guy Oberlin, Coordinator of the FRIEND/AMHY Group who edited this Report, on behalf of the FRIEND Report Committee.

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# Préface

*A. Szöllösi-Nagy*

FRIEND (Flow Regimes from International Experimental and Network Data) a débuté en 1985, à partir d'une idée de John Rodda, alors Secrétaire Général et maintenant Président de l'AISH. A l'initiative de quelques hydrologues, un groupe de pays européens se lança dans des échanges de données et de méthodologies, en vue de développer des actions de recherches sur les régimes d'écoulement à l'échelle régionale, et dans le but de mieux comprendre les variabilités spatiales et temporelles de ces régimes hydrologiques. Vers 1989, treize pays avaient participé, et avec des progrès significatifs en matière d'analyses régionales des régimes et de détection des tendances induites par les changements climatiques ou les actions anthropiques. Compte tenu de l'intérêt persistant manifesté par les pays membres de l'UNESCO vis à vis de ce projet FRIEND, il a été décidé par le Conseil Intergouvernemental du PHI de l'intégrer dans la cinquième phase de ce Programme Hydrologique International (Thème 1 : Projet 1.1).

Les résultats encourageants présentés à la première Conférence FRIEND de Bolkesjö, Norvège, 1989, associés avec l'adaptabilité des procédures d'organisation et d'implantation du projet, ont conduit à l'établissement d'autres Groupes FRIEND dans les régions méditerranéennes (FRIEND AMHY), en Afrique, dans le Sud-Est asiatique, et dans la région du Nil. Ces Groupes FRIEND sont programmés par phases de 4 ans, terminées par une Conférence où les principaux résultats sont présentés, discutés et éventuellement plus largement diffusés.

Depuis 1985, une grande part de progrès a ainsi été assurée dans la compréhension des variabilités temporelles et spatiales des régimes hydrologiques. Le projet FRIEND a aussi développé un important volet de formation, qui contribue à améliorer les compétences des hydrologues, et à renforcer les capacités des services hydrologiques nationaux à mieux évaluer leurs ressources en eaux.

FRIEND représente aujourd'hui un réseau d'expertise couvrant l'Europe occidentale et orientale, la région méditerranéenne, l'Afrique, l'Asie, le Pacifique, et bientôt l'Amérique Latine.

Ce Rapport est en étroite liaison avec la troisième Conférence FRIEND qui se tiendra à Postojna, Slovénie, du 1 au 4 octobre 1997. Il comprend les principaux résultats de recherche obtenus sur la période 1993-97 par les Groupes FRIEND NEF (Europe du Nord) et AMHY (zone méditerranéenne), ainsi que des contributions des Groupes d'Afrique occidentale, centrale et australe.

Je voudrais exprimer mes remerciements à tous les hydrologues qui ont contribué au succès du projet FRIEND, et en particulier à Guy Oberlin, Coordinateur du Groupe AMHY, qui a édité ce Rapport, au nom et sur mandat du Comité du Rapport FRIEND.

## Acknowledgments

The present report was prepared under the responsibility of the FRIEND Report Committee (FRC), chaired by Guy Oberlin. It must be noticed that, after the author's tasks (the basic contributions) and before the Report Editor's ones (report finalizing and editing), a very important role was played by the Chapter Editors.

Each of the Chapter Editors was in charge of the first drawing up of one chapter (first improvement of the edition with the authors, writing of a short introduction and a short conclusion, contacts with the Report Editor...). So, the FRC thanks particularly the following people for their work :

H. Zebidi (Introduction)

G. Rees (Chapter 1 - International FRIEND Group Databases)

N. Arnell (Chapter 2 - Regimes and Regional Hydrology)

A. Bullock (Chapter 3 - Low Flows and Droughts)

P. Versace, E. Ferrari (Chapter 4 - Floods)

C. Llasat (Chapter 5 - Heavy rains)

P. Seuna, A. Lepistö (Chapter 6 - Physical processes of runoff formation)

A. Afouda (Chapter 7 - Long series : models and trends)

A. Gustard, P. Givone, G. Oberlin (Chapter 8 - Integrated water management, & futures for FRIEND)

P. Hubert (Conclusions)

The authors having prepared one or several contributions are listed at the end of the report, with their coordinates. The Chapter Editors are obviously present in the list.

J. Rodda and D. Ellis have improved the english of several contributions.

E. Desbos and G. Oberlin have ensured the re-reading of the chapter introductions and conclusions, the translation in french, and the basic edition of the Report itself. J. Baudel has finalized the edition for the printer.

In addition, the FRIEND Report Committee would like to thank the following organisations for contributing financial resources and project facilities : Cemagref, GIP HydrOsystemes, GIS AMHY, UNESCO, European Commission.

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## Remerciements

Ce Rapport a été préparé sous le pilotage du Comité du Rapport FRIEND (CRF/FRC), présidé par Guy Oberlin. Il faut préciser qu'entre les tâches initiales des auteurs des contributions, et les tâches finales des éditeurs du Rapport, un rôle intermédiaire important a été joué par des Editeurs de Chapitres. Chacun d'eux était en charge de la première mise au point du Chapitre : édition homogénéisée des contributions en contact avec les auteurs, brèves introduction et conclusion du Chapitre, contacts avec l'éditeur du Rapport, etc... Le Comité du Rapport FRIEND remercie donc tout particulièrement, pour cette tâche :

H. Zébid,	pour le chapitre : Introduction
G. Rees,	pour le chapitre 1 : Bases de données internationales FRIEND
N. Arnell,	pour le chapitre 2 : Régimes et hydrologie régionale
A. Bullock,	pour le chapitre 3 : Etiages et sècheresses
P. Versace, E. Ferrari,	pour le chapitre 4 : Crues
C. Llasat,	pour le chapitre 5 : Fortes pluies
P. Seuna, A. Lepistö,	pour le chapitre 6 : Processus physiques de la formation des écoulements
A. Afouda,	pour le chapitre 7 : Longues séries, modèles et tendances
A. Gustard, G. Oberlin, P. Givone,	pour le chapitre 8 : Gestion intégrée des eaux, et quelques futurs de FRIEND
P. Hubert,	pour le chapitre : Conclusions

Les auteurs de ce Rapport, qui y ont présenté une ou plusieurs contributions, sont cités à la fin du volume, avec leurs coordonnées. Les Editeurs de Chapitre y sont évidemment présents.

J. Rodda et D. Ellis ont amélioré l'anglais de certaines des contributions.

E. Desbos et G. Oberlin ont relu et homogénéisé les différentes introductions et conclusions de chapitres, assuré les traductions en français, et réalisé l'édition proprement dite du Rapport. J. Baudel a finalisé cette édition pour l'imprimeur.

Enfin, le Comité du Rapport FRIEND voudrait remercier les organisations suivantes qui ont contribué au financement du Rapport ou soutenu les conditions matérielles de son édition : Cemagref, GIP HydrOsystemes, GIS AMHY, UNESCO et Commission Européenne.



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The chapter introductions and conclusions, the titles, and the figure and table legends, are written both in english and in french.

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Les introductions et conclusions de chapitre, les titres, et les légendes des figures et tableaux, sont édités en anglais et en français.

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# Introduction

## FRIEND presentation

### Présentation du projet FRIEND

*H. Zebidi*

The FRIEND project (Flow Regimes from International Experimental and Network Data) is a project within the International Hydrological Programme. Its aim is to improve knowledge of flow regimes under different hydrological conditions. The FRIEND project started in 1985 under the third phase of the IHP (1984-1989) ; it was then continued in IHP's fourth phase (1990-1995), and, following the request of UNESCO's Member States, is being continued in the fifth phase of the IHP (1996-2001) as project 1.1

## 1 Objective

The aim of the FRIEND project is to develop knowledge of flow regimes on a regional scale through the analysis of data from experimental basins and hydrological networks. The idea of the FRIEND project arose from the fact that, despite the development of experimental and representative basins, surface water data is found to be unevenly distributed across the regions, which makes it difficult to develop simulation on flow regimes. The idea is to put together, in the regions, data collected from the surrounding countries and for the related countries to work together to improve knowledge about river flow regimes.

## 2 Expected results

The FRIEND project is expected to help improve knowledge on hydrological parameters for the design of hydraulic structures. It will also contribute to the extrapolation of the results obtained to ungauged basins situated in the same hydrological conditions. The overall benefit of the FRIEND project is the availability of reliable information for the rational management of surface water resources at watershed level and national level.

In addition to the development of research activities, it was found necessary, in some regions, to include a training component for :

- the introduction of new methodologies for hydrological research
- the upgrading of softwares used for hydrological data analysis
- the strengthening of the capacity of hydrological services to assess and manage their national surface water resources.

## 3 Organization

Each FRIEND Group is organized around a **Coordination Centre** established in one of the countries of the region. The Coordination Centre is in permanent co-operation with the **focal points** of the

project in each related country and receives scientific, technical and funding support from several international, regional and national institutions. There are in fact several players in a FRIEND project which may be summarized as follows :

#### **Coordination Centre**

- Provides a Project Coordinator
- Ensures the Secretariat of the project
- Hosts the Regional Database
- Receives, processes and stores data from the countries for use in research activities

#### **Countries in the region**

- Nominate a focal point for the project
- Nominate national experts to take part in research activities
- Contribute selected data to the regional Database

#### **Co-operating Institutions**

- Provide scientific and technical contributions
- Contribute towards funding the activities
- Take part in selected activities

## **4 Implementation of the FRIEND project**

To take part in a FRIEND project, each country is expected to contribute selected data to the Regional Database : this is the rule of the game. The countries then meet together to select a research programme of interest to their scientific and technical needs, composed in general of a limited number of topics. For each research topic, a research group is established and a leader nominated to co-ordinate the related activities. The implementation of the activities of each FRIEND Group is directed by a **Steering Committee** chaired by the Coordinator and composed of the leaders of the research topics, as well as the representatives of UNESCO and other institutions involved. The Steering Committee meets at least once a year. Short scientific seminars to discuss the first results obtained are sometimes organized in conjunction with the Steering Committee meetings.

A **FRIEND Conference** is convened every four years and at which the main results obtained by the different FRIEND Groups are presented and discussed. The output of these conferences is the publication of :

- the Conference Proceedings
- a Special Report including research activities selected from the different FRIEND Groups.

Two FRIEND Conferences have already been organized :

- First Conference: Bolkesjo (Norway), April 1989
- Second Conference: Braunschweig (Germany), October 1993

The Third FRIEND Conference will be held in Postojna, Slovenia, October 1997.

## **5 The FRIEND Family**

Six FRIEND Groups are already active :

**FRIEND Northern Europe.** Includes twenty-two countries. Its Coordination Centre is the Institute of Hydrology, Wallingford, UK.

**FRIEND/Alpine and Mediterranean region (AMHY).** Composed of thirteen countries with a Coordination Centre established at CEMAGREF, Lyon, France.

**FRIEND/Western and Central Africa.** Thirteen countries are involved and the Coordination Centre is in the *Sous Direction de l'Hydrologie, Abidjan, Côte d'Ivoire.*



**FRIEND/Southern Africa.** Includes eleven countries; the Coordination Centre is the Department of Civil Engineering, University of Dar-es-Salaam, Tanzania.

**FRIEND/Nile.** Established in March 1996 with six countries and a Coordination Centre established at the University of Dar-es-Salaam.

**FRIEND/Hindu Kush Himalayan region/HKH.** Set up in March 1996.

The following groups are in the process of being established :

**FRIEND/South East Asia**

**FRIEND/Latin America**

## 6 Conclusion

The FRIEND project is a co-operation research exercise developed at regional level to improve knowledge on flow regimes as a basis for the reliable assessment of surface water resources and their rational management. We expect that the development of several groups in the different regions of the world will lead to the establishment of an international network of expertise in the framework of the International Hydrological Programme.

## **Northern European FRIEND. The first FRIEND group : inception and progress**

## **FRIEND Europe du Nord. Le premier groupe FRIEND : origine et évolution**

*A. Gustard*

### **1 Introduction**

The FRIEND - Flow Regimes from International Experimental and Network Data - research programme is an international collaborative study into regional hydrology. It was first established by UNESCO in 1985 as part of the International Hydrological Programme to improve cooperation in research in regional hydrology. The primary objective of the FRIEND project has been to improve the understanding of hydrological variability and similarity across time and space in order to develop hydrological science and practical design methods. To achieve this it has been essential to permit hydrological research to cross national boundaries. This has been done in two ways. First, by developing international hydrological data bases of time series and spatial data including catchment boundaries, climate, land use and soil type held in vector or raster form. Second, by establishing project groups that could exchange models and analysis techniques and interpret the results using a common approach to analysing data derived from different hydrological regions.

The FRIEND project was initially established in Northern Europe, but such has been the interest in the project that groups have now been established in the Mediterranean and Alpine region of Europe, in Southern Africa, in West Africa, in the Hindu-Kush Himalayan region, in Asia-Pacific and research programmes are being planned in South America and the Nile region, as shown in Figure 1. The wide geographic extent of involvement in FRIEND research is further demonstrated by Table 1, which lists the countries within each FRIEND group. The Northern European FRIEND group with 22 countries liaises closely with the AMHY (Alpine and Mediterranean) group, which is flourishing with 15 countries actively contributing data. Switzerland and France are represented in both groups. Links between all international FRIEND groups are close and are maintained by international FRIEND Coordination Committee meetings.

### **2 Inception of Northern European FRIEND**

The Northern European FRIEND project was initiated in 1985 by the IHP Committees of the UK, Germany, The Netherlands and Norway who seconded full time scientists for a period of three years to collaborate in an international project group based at the Institute of Hydrology in Wallingford. They were soon joined by hydrologists seconded for shorter periods from a number of European countries and the project was supported by the provision of hydrological data from all European countries in the project area. The first phase of the project was completed in 1989, when the data base contained river flow data from 1350 gauging stations from 13 countries. The second (completed in 1993) and third phases of the project have extended the geographical area to eastern Europe and increased the data base to include data from over 4000 catchments in 25 countries.

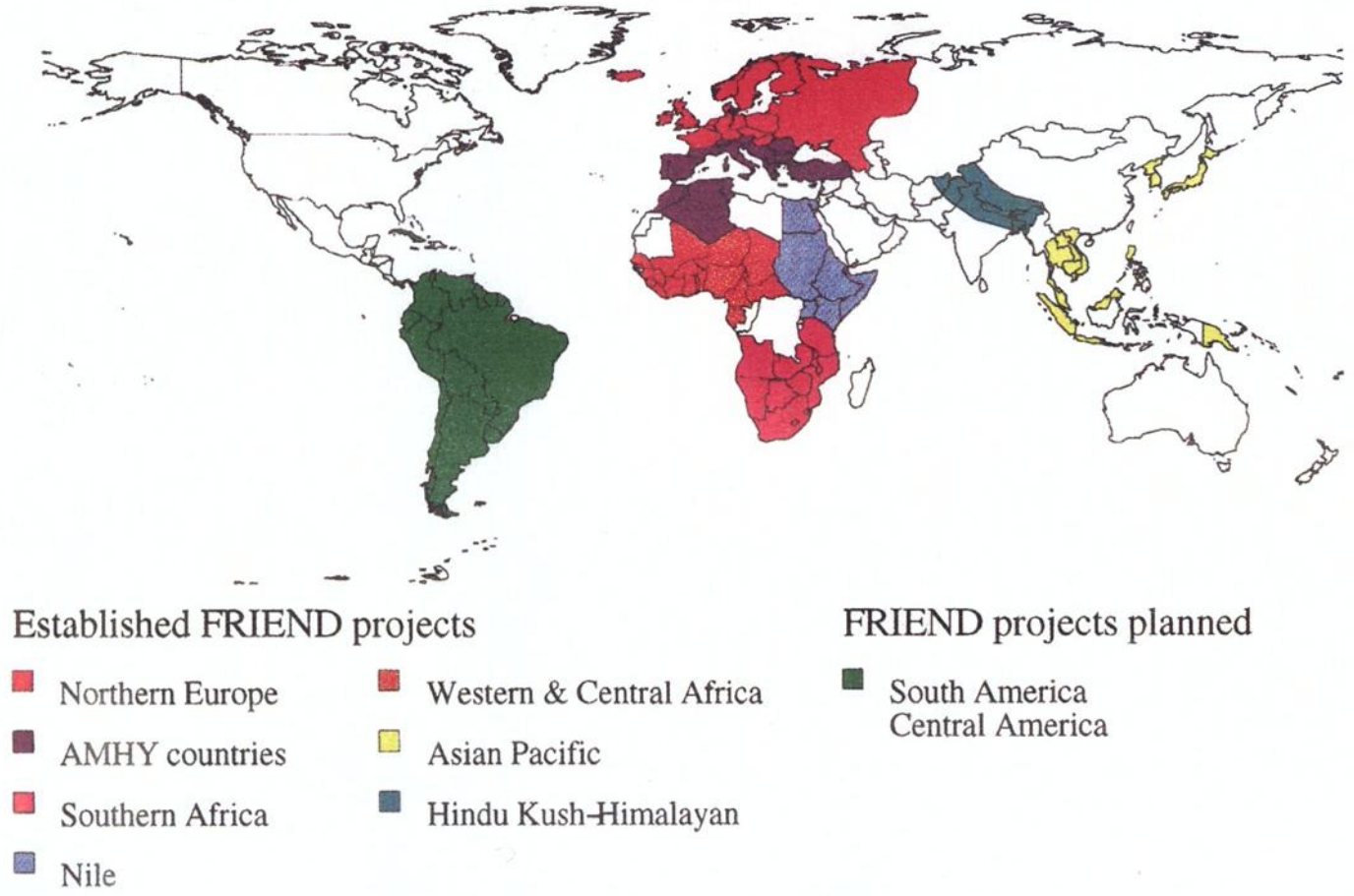


Figure 1 : Global Perspective on FRIEND participation  
Figure 1 : Perspective globale sur la participation à FRIEND

**Table 1 : Countries within FRIEND Groups****Table 1 : Pays participant aux Groupes FRIEND**

Northern Europe	Austria Belarus Belgium Czech Republic Denmark Estonia	Finland France Germany Hungary Iceland Ireland	Luxembourg Netherlands Norway Poland Russia	Slovak Rep. Sweden Switzerland Ukraine UK
AMHY	Albania Algeria Austria Bulgaria	France Greece Italy Morocco	Portugal Romania Spain Switzerland	Tunisia Turkey Former Yugoslavia
Hindu Kush-Himalayan	Afghanistan Bangladesh	China India	Myanmar Nepal	Pakistan
West & Central Africa	Benin Cameroun	Côte d'Ivoire Ghana	Guinea Mali	Nigeria
Southern Africa	Angola Botswana Lesotho	Malawi Mozambique Namibia	Rep. S. Africa Swaziland Tanzania	Zambia Zimbabwe
South East Asia	Australia China Indonesia	Japan DPR Korea Rep. Korea	Malaysia New Zealand Papua New Guinea	Philippines Thailand Vietnam

The results of the Northern European FRIEND project have been presented in the proceedings of two conferences. The first was held in Norway in 1989 and was published in IAHS Publication No. 187 (Roald *et al.*, 1989), the second was held in Germany in 1993 and published in IAHS Publication No. 221 (Seuna *et al.*, 1994), and in a report series (Gustard *et al.*, 1989; Gustard, 1993). The results of the third phase will be presented at an international conference in Postojna, Slovenia in October 1997.

### 3 Development of FRIEND research

The FRIEND research programme is essentially a coordinated collection of individual research projects, undertaken by international groups with staff drawn from three or more countries. There are five individual project groups in the Northern European FRIEND, each with approximately 10 participants, as follows :

- Database
- Low flows
- Large scale variations
- Techniques for extreme rainfall and runoff estimation
- Processes of streamflow generation in small basins

These projects are overseen by the FRIEND Steering Committee which meets annually and is made up of country representatives, nominated by national IHP committees, and representatives from UNESCO, WMO, GRID (the Global Resource Information Database of the United Nations Environment Programme (UNEP)) and the European Environment Agency. The project secretariat is based at the Institute of Hydrology and coordinates the activities of the project groups and provides administrative support to the steering committee. The main research activities of each group are summarised in general terms below :